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Master Thesis in Science Communication

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Experiencing Science in Action:
The Use of Exhibition Techniques in Guided Tours to a Scientific Laboratory

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Contents

Abstract

The current paper presents a study conducted at CERN, Switzerland, to investigate visitors' and tour guides' use and appreciation of existing panels at visit itinerary points. The results were used to develop a set of recommendations for constructing optimal panels to assist the guides' explanation. Panels present on the experimental sites differ from exhibition panels at museums and science centres. The recommendations served as a basis for the building of two sets of panels - one at a new visit itinerary point on the tour programme of CERN, and the other for the Open Day, a celebration of the 50 years of CERN's existence. The paper is a description of the research and the construction process. It shortly presents the guided tour programme at CERN, compares it with research on guided tours in general, and discusses matters connected to the use of explanatory material for assistance in a guided tour. The results can be used in future for work on panels at CERN, but should, it is suggested, only serve as guidelines for museums and science centres, due to the special character of CERN's guided tour programme. The dissertation covers the three-month process in the spring of 2004.

Keywords: exhibition techniques, guided tours, guides, panels, visual explanations, complex issues, visitor observations, interviews, questionnaires, interactivity, CERN.

1. Introduction

Explaining complex facts and communicating abstract information is not an easy task. A topic like elementary particle physics certainly belongs to this category. At CERN (Organisation Européenne pour la Recherche Nucléaire; the European Organization for Nuclear Research) on the Franco-Swiss border close to Geneva, visitors are being given a unique opportunity to explore the world's largest particle physics centre. As a scientific laboratory, CERN provides guided tours for groups, as well as a small science centre, Microcosm, to explore further the fundamental building blocks of the universe, the elementary particles. During the guided tours, the visitors come in close contact with the tools used in the research - the particle accelerators and detectors - they experience science in action. The tours are led by guides, usually employees at CERN, who show the facilities and explain the research to uncover the nature of the elementary particles. But how does one explain something so complex and unfamiliar to the common visitor, presumably not an expert scientist? And what instruments does one use? The use of panels, tangible objects and other exhibition techniques unquestionably eases the process. The accelerators and detectors at CERN are of enormous dimensions, the numbers and the results dealt with are normally either too big or too small to be grasped. With the help of panels, which show the structures as detailed drawings, dimensions such as weight and height ordered and explained, as well as other important issues at CERN, the guide can make the world of elementary particle physics and the phenomenon of CERN understandable for the visitors, at least to a certain degree. But guides work differently; different guides explain different things in different ways. How can panels be constructed to optimise the assistance for the guide's explanation? What should appear on the panels? What should not? How many panels, how big? Text or no text?

The current paper presents an analysis to answer these questions. It describes the study, consisting of research and a construction process; and its results can be used for future panel developing. Besides struggling with what the panels should show and how, the construction process contained another challenge, namely two sets of panels had to be developed: one for a new visit itinerary on the guided tour, and the other as a panel explained by volunteers at a special event (The CERN Open Day), but with an independent exploration possibility for the visitors. The latter panel will after the event be used as a part of the present visit itinerary. This created challenges in matters of how much text, how many pictures, how complex information, etc. should appear on the panel. In this paper, discussions and guidelines for the two sets of panels are presented separately, but compared in the final discussion. The road leading to the ultimate conclusions can be divided into two parts: firstly, determining what the panels should show in order to be of the best assistance to the guides' explanations is attempted. Secondly, through the study and discussion of research, an effort to establish how this can be done is undertaken. The first part of the paper consists of presentations and

discussions of themes including guided tours at museums and science centres, a review of the CERN guided tour programme, some theories on explanations and an attempt to constitute the complexity of issues dealt with at CERN's guided tours. Many minor conclusions are reached already at this stage. The second part introduces the study - the methods used, a quantitative and qualitative analysis of the results, a discussion of these, as well as a short evaluation of the construction process. To be used at CERN, the results were transformed into 'best practice' guidelines for constructing panels. These guidelines, with a discussion, are included in the Appendix. The paper ends with an examination of the results from the study that have not yet been discussed, and an overall conclusion.

In this paper, the term 'theoretical physics' is used for the theoretical field of research dealing with mathematical descriptions of the world of elementary particle physics. This includes, among others, quantum mechanics, quantum field theories, special and general relativity, and other – not yet 'proved' – models, such as the Higgs theory. The research at CERN, the work with accelerators and detectors, is based on these models, and some of it includes working on these theories. The term 'theoretical physics' is meant to contrast the more 'practical' work at CERN, the 'experimental physics', such as the building, running, operating and maintenance of the accelerators and detectors, and the collecting and the analysing of the results. These analyses can strengthen or falsify the before mentioned theories. Some people might disagree with this usage of 'theoretical physics.' This can only be apologized, but for expediency the term is used in this sense.

I would like to thank everybody at the Visits Service at CERN, in particular my supervisor Delphine Dalencon and Emma Sanders, the head of the Visits Service, for reading through and commenting on the first draft of this paper, as well as for working with me on the panel construction. The co-operation with the responsible scientists, in particular Richard Jacobsson, Phillipe Gavillet, Rolph Lindner and Nathalie Grub of LHC-b and Peter Schmid, Sylvia Schuh and Helfried Burckhart of ATLAS, was extremely fruitful, and gave an insight into the fantastic research at CERN. The Interlibrary loan service at CERN deserves gratitude for supplying (almost) every book and article I needed on museums and guided tours in a world of particle physics literature. I am greatly indebted to Pille Urmsalu of Tallinn Pedagogical University for her invaluable comments on all drafts of this paper. Finally, a big 'thank you' goes out to Prof. Nico Keilman at the University of Oslo for finding some hard-needed articles.

2. Guided Tours

Before an overview and analysis of the CERN guided tour programme can be offered, a look at research on guided tours to museums and science centres in general is necessary, including their importance for the museums and visitors, and their role in supporting classroom activities. The role of guides and their importance will also be reviewed.

2.1 The Importance of Guided Tours

The guided tour plays an essential role in making visitors aware of what is to be found in the museum. It is one of the ways of providing an opportunity to physically guide the visitors through the collections, hereby increasing their understanding and enjoyment of these collections. The whole of the educational and informative function can be dubbed the museum's 'docent function' (Rayward and Twidale 1999). According to this view, a guide would be a 'human docent.' Throughout this paper, the designation *guide* is used for a person who leads or directs a group of visitors through a site (museum, science centre or other) in a structured and well-planned manner, exhibiting points of interest (*Webster's* 1913 Dictionary, adapted for museum purposes).

Research has shown that people remember guided tours, often school trips, for a long time after the visit is completed (Falk and Dierking 1992; Falk and Dierking 1997). They seem to make an impact on the visitor, not just remembering what they have seen, but also things they have learned, which they are later able to connect to other experiences and situations (Falk and Dierking 1997: 216). The guided tour can be part of a learning environment outside the school. It normally lasts for a day, usually just a morning or afternoon. This is in contrast with the immersive environments, such as summer camps or residential programs, which can last for days or even weeks (Noel-Storr 2004). The immersive environments can be viewed as places where people spend periods of time outside the classroom, immersed in scientific experimentation, investigation and thought. This is in accordance with newer recommendations for science education reform, which emphasises the importance of everybody being enabled, through their education, to develop a scientific worldview, learn and use the principles of scientific enquiry and understand scientific enterprise. The guided tours to museums or science centres can have the same educational role, but on a much shorter basis. Both the immersive environments and the guided tour programmes are considered either informal education, which many claim can and should complement the science learning that takes place in schools (ibid.: 4), or of a more formal character, which maintains the knowledge and formal skills as its primary goal (ibid.: 5; Grinder and McCoy 1985: 45). The formal environment may act either as a booster for classroom instruction, or as an accelerator, to allow deepening into

subjects not usually taught at the appropriate level in schools. Informal environments, on the other hand, 'allow for much more individual exploration, and *complement* formal education, rather than aiming to provide direct support' (Noel-Storr 2004: 5)

With the highly science- and technology-driven community life of today, many see it preferable that every individual thinks and works effectively. Some claim that this is achieved when young people discover that they can develop their own understanding in a variety of ways (although this can be extended to also including adults, since learning should be considered a life-long process); and this they can only learn through a diverse range of experiences, formal and informal (ibid.: 6).

2.2 The Structure of Guided Tours and Their Educational Value

A successful visit to a museum should include: planning for learning during the visit; consideration of the unique learning opportunities of the institution rather than mirroring school-type behaviours; variation in the activities during the visit; sparing and/or careful use of worksheets (Griffin and Symington 1997: 765); and emphasis on first-hand experience and observation (Price and Hein 1991). Some studies point out the importance of preparing the visit (Gennaro 1981; Grinder and McCoy 1985; Koran *et al.* 1984; Reynolds 1984), while it is shown that without orientation and preparation, learning is seriously harmed (Falk and Balling 1982). Other suggestions for successful visits are: to add more hands-on activities, to increase student interaction and to provide more time for students to explore exhibit halls freely (Cox-Petersen *et al.* 2003: 207). Recommendations from educational standards suggest that museums and science centres can contribute greatly to the understanding of science and encourage students to further their interests outside of school (Cox-Petersen *et al.* 2003: 202). Yet, when studied closely, it was discovered that school visits differ greatly from what the literature advises (Griffin and Symington 1997). Findings see the guided tours as 'a structured, narrative, docent-directed experience in which students and teachers moved together as a whole group' (Cox-Petersen *et al.* 2003: 205). 'Docents guided the students throughout exhibits highlighting different facts related to the objects or specimens', while 'the scientific and historical vocabularies used were often too advanced for students' (ibid.: 206). 'Tours were fast-paced, covering displays and providing information. Much of the information during the tour was fact based and did not focus on overarching ideas or concepts within the exhibits' (ibid.: 210). As it is pointed out by Falk and Dierking, 'the way a guided visit is organized is the major determinant of its effect' (1992: 63)

What does the literature propose, then? How should a tour be structured to meet the suggestions from research and official recommendations? Cox-Petersen *et al.* describe a tour, where:

> Students would have time for talk and exploration, thereby giving them time for personal reflection and connections and acknowledging the

> personal context of the visit. Small group activities would provide for social interactions among teachers, students, docents, and chaperons, thereby enhancing the sociocultural context of the visit. This tour also provides time for students to become acquainted with and explore the physical aspects of the exhibits in greater depth...Students are given time to make personal connections as they examine exhibit content and discuss their findings.
>
> (Cox-Petersen *et al.* 2003: 213)

The suggested changes to the tour experience 'encourage more active involvement in learning, purposeful manipulating of objects, meaningful links between exhibits and ideas, and sharing learning with peers and experts' (ibid.: 214). The keyword here is freedom. More freedom to move around as desired, to manipulate objects in an individual manner. This is also something recognised by the visitors themselves (Griffin and Symington 1997: 775). In addition to this, the attitude of the group leader, usually a teacher, affects the attitude towards the excursion and learning in the venues. 'If the teacher had a clearly defined purpose and an enthusiastic, positive attitude to the day, the students often reflected similar attitudes' (ibid.: 774). The same factor can also be extended to the guide, as shown in the next section.

2.3 The Guide

The guide, or human docent:

> is of critical importance to the guidance and educational functions of the museum. Docents directly engage the attention and interest of the members of a tour group. They can answer questions. They can ask questions. They can encourage and guide discussion and debate. They can respond effectively to random or unexpected incidents. In effect they have a performative function in engaging with and offering interpretations calibrated to a particular group or the individuals in a group.
>
> (Rayward and Twidale 1999: 35)

In other words, the guide's function cannot be praised enough. Although there is little theoretical writing on the role and function of docents (ibid.: 31), and thereby also on guides:

> the anecdotes of science centre practitioners and the workshops held during international conferences prove beyond doubts: the explainers, guides, interpreters or whatever you may call them are a key-characteristic of a successful science centre
>
> (Alfonsi 2001: 10)

In one specific study (Wanless 1990), not only did the visitors praise the guides (or in this case, the explainers), but guides also realised their own importance (p. 77).

What are the main tasks of guides? Rayward and Twidale (1999: 31) state some:

- Docents plan and offer tours;
- They work mostly with groups;
- They offer informed commentary;
- They are asked and answer individual questions;
- Proactively, they also often ask questions and facilitate dialogue among the participants in their tour groups to help create a discussion from a variety of perspectives about the items being examined.

Particularly the last point, it can be argued, is central to a guide's role and visitor understanding and learning.

While the objectives of guides might seem simple and few, this is not the case with the guides' backgrounds. Guides have different levels of specialist expertise. They are often mature-aged volunteers, bringing useful ancillary knowledge to their work, or students. They are nearly all either part-time and unpaid, or receive a small sum of money or other benefits. Inevitably they will bring attitudes and opinions to their work. They will form judgements and offer comments that can be surprising or problematic on challenging exhibitions, or on particular items that are displayed for special attention because of their significance. Guides must be selected and trained; therefore most museums offer a period of special classes and tuition. To be effective, guides should have a number of desirable characteristics (Rayward and Twidale 1999: 32): retentive memory, well-developed expository skills, a good appearance, outgoing, flexible, comfortable with the public and a high level of general education. Other characteristics included in this list should be experience, a passion and desire for the work they perform. Only then can a guide make the tour into something else than just a presentation of facts. When the guide includes his or her own work experience into the narrative, combined with the love the guide feels for the subject, the facts will come alive, with a personal touch. Undeniably, the guide's motivation while interacting with visitors is crucial (Alfonsi 2001). In this way, the experienced guides are able to know instinctively a kind of tacit knowledge, what is likely to be most interesting to a particular person or group and how to adapt their narratives accordingly (Rayward and Twidale 1999: 33).

Guides also experience limitations to their work, both in the extent of their knowledge and the opportunity tours provide for the knowledge they have. Usually tours are of short duration, and guides may not have the 'opportunity to deploy quite extensive knowledge in answer to questions or in relation to particular items or collections' (ibid.: 33). Other restrictions involve the narrow backgrounds of the guides in connection with the content of the exhibition and physical restrictions on access to a museum's collection. If a visitor asks a question to which the guide is not sure to be able to provide a correct answer, all he or she can do is to response to 'the best of his or her ability and guide the questioner to general sources of information about something of interest' (ibid.: 37).

Despite these limitations, the guide is quintessential to the museum's educational programme and makes the public aware of the opportunities that are found behind its doors. Not just one particular museum will gain from employing guides and providing guided tours, but since a guide is concerned with answers to questions, and pointers to additional information, he or she can inspire future visits to this museum, or even other museums.

3. The CERN Guided Tour Programme

CERN came formally into being on the 29th of September 1954, when sufficient ratifications of the establishing Convention were obtained from the Member States (Jacob 1981). The Swiss city of Geneva was eventually chosen because of Swiss neutrality, the tradition of hosting international organizations and the centrality within Europe (Hermann *et al.* 1987: 241). Many important discoveries have been reached and much ground breaking research conducted at CERN, most notably the neutrino experiments in the 1960s, which started a fruitful area of neutrino research (Hermann *et al.* 1990) and Carlo Rubbia's and Simon van de Meer's contribution to the study of the weak interaction, which lead to the 1984 Nobel Prize in physics (Krige 1996).

Following the request of both some staff members and the general public, the CERN public visit programme started in 1956. At that time, it was not structured, but organised on request, conducted on foot, and mainly kept to a small area. Over the years, the programme developed. Weekday visits on request became official in 1960; between 1967 and 1968 a regular visit programme for weekdays and Saturdays was created. From the very beginning, the main educational objectives were (Catapano 2003: 3) 'to learn what we are made of, what matter is made of and how the Universe was born.' It was noted that 'visitors left with a sense of wonder about what they had learned...' while 'the image of CERN conveyed by these visits was essentially one of international collaboration and gigantic machines used to study the infinitely small' (ibid.).

In 1994, the programme was boosted and professionalized. The guides were given a structured programme; the public was given the opportunity to go 100 metres underground, touring one of the LEP detectors (see Appendix A1). During shutdowns, the visitors could walk along on a section of the 27-kilometre long particle accelerator. Such visits were an important part of CERN's communication strategy (Catapano 2003: 4). The present programme offers tours to the experimental areas of the laboratory from Mondays to Saturdays, arranged by the Visits Service and free of charge. The latter is also responsible for deciding on the details of the itinerary, establishing the theoretical content, training the guides and ensuring the overall success of the visit. Tours are offered regularly in four languages - French, English, Italian and German - and in other languages if needed. Visits are booked in advance, and the waiting time varies according to the language. Guides are volunteers recruited from the scientific and technical staff, and most have a background as physicists, with engineers coming second (ibid.: 6). The visitors mostly come from Italy, France, Switzerland, Germany and the UK (ibid.: 7), and a large number of them are school classes, either elementary school or higher education. Because of the present construction works at CERN, the main visit itineraries are the CMS detector site (Appendix A2) and the ATLAS assembly halls (Appendix A3). Due to these construction works, visitors no longer have the possibility of going underground.

3.1 Objectives of The Guided Tour Programme

In 2001, a group was put down to come up with messages that the CERN guided tour should transmit to all visitors, irrespective of origin or education. These messages are divided into 'essential messages', which every visitor should get, and 'supplementary messages', which should be communicated if appropriate. It is encouraged to space the messages naturally through the visit rather than all at once, believing they will have a greater impact. The messages have been dealt with in detail elsewhere (Catapano 2003: 10-12), and therefore only the most interesting statements for the purpose of this paper are mentioned here. The first important issue of the 'essential messages' is fundamental research. It should be clear to the visitor that fundamental research often leads to unexpected discoveries, which add to the cultural heritage of civilisation, and eventually results in improvements of the quality of life. Connected to the fundamental research are the subjects of particle physics and the origin of the Universe. The visitors should see that particle physics studies the inner workings of the basic constituents of matter and the origin of our Universe, and that it unifies the infinitely small with the infinitely large into a single set of physical laws that made our existence possible. Further on, the visitors should be told what CERN is, does, and what is its impact on society. International collaboration is at the heart of CERN, and should be much emphasised. Also, the fact that the World Wide Web was invented at CERN is significant. It is important to realise that CERN is only a provider, and does not profit in any way on its research. CERN is a leading figure in developing new technology in partnership with industry. Finally, the transition period between the LEP and the LHC should be mentioned during the tour. In this period, physicists, engineers and technicians at CERN develop, build and test new technologies. This, too, is an international joint venture. The 'supplementary messages' give the visitor a picture of the strategy, results and diversity of CERN research; the complexity of projects developed at the frontier of science, how LHC succeeds LEP, what can be expected from the new LHC data, and the tools used in the research, such as detectors.

General recommendations for each visit itinerary are (ibid.: 13; excerpts, italics added):

- Convey the fundamental messages and provide visitors with the right image of CERN
- Enrich the visit by support tools such as visual aids, 3D projections, posters and handouts for each part of the itinerary.
- Consider the main target to be the general public – *visits are not a teaching tool but a communication tool.*

3.2 Structure of the Tour

Some subjects should be offered before starting the guided tour. As Catapano has dealt with these elsewhere (2003: 12-13), only the most important issues are presented here. Most significantly the visitor should receive a clear view of what CERN's mission is, the subject of CERN's research, and how this research is being performed. Also, they should be presented to the experiments and collaborations as well as the status today. Every tour is preceded by an introductory seminar, which presents the visitor with general information about CERN. It is recommended that the introduction confines itself to very few simple messages, last no more than 15 minutes[1], is not designed as a lecture unless requested and is supported by tools that can stir the emotions and interest/curiosity of the visitor or at least relate to their daily world.

The structure of the tour is as following. The visiting group arrives at the CERN reception, where the visitors are provided with brochures, leaflets and other documentation. They proceed into the room where the guide holds the introduction. After the speaker ends his or her theoretical introduction, a video about CERN is shown to the audience. The group is then transferred to the experimental site, usually by private busses, sometimes CERN transport. There is normally some interaction between the guide and the individuals, and the guide is free to inform the group about any matter. This journey can last from 5 to 20 minutes, depending on the location of the itinerary. While touring, it should be noted that all experiments related to the LHC accelerator are under construction, and the visitors come in contact with workers, scientists and engineers working on different parts of the detector and the associated infrastructure. The visitors are, if necessary, divided into smaller groups - CERN safety regulations do not allow guides to have groups larger than 12 visitors - and each group is led by a guide through the different stages of the itinerary. After a certain time, depending largely on the interaction between the guide and the group, the visitors return to the CERN reception, where they can complete their visit, if desired, with a tour of CERN's interactive exhibition, Microcosm. The total duration of the visit is normally between 2.5 and 3 hours. Visits usually start at 0900 and 1400.

3.3 Participants of the Tour

Studies of the visitors (De Pasquale 2003: 3-9) have shown that males and females are equally represented, 51.5 % against 48.5 %, respectively. 63.1 % are 11 to 19 years, 4.2 % are between 20 and 29, while 32.6 % are more than 30 years of age. 62.5 % are classified as students (high school and university), 4.1 % as teachers, while 33.3 % are

[1] Some reports (internal CERN documents) recommend 25 minutes. Nevertheless the main point is to keep it short and simple.

other visitors, mainly elderly people or non-students of all ages. 70 % of all visitors come in groups, usually school classes, while only 2.4 % come alone. The rest are group leaders, or people not coming by their own choice (children accompanying parents, etc.). 95.4 % are first-time visitors. The visiting students are mostly from scientific education (67.3 %), although it should be observed that 29.5 % come from humanities or social science education. The teachers come mainly from scientific colleges (60.5 %), but again it is interesting to note that 21.1 % have a background from the humanities. 18.4 % are teaching in training schools. The majority of teachers teach mathematics (38.9 %), followed by physics and natural sciences (both 13.9 %). Of the other visitors, 36.8 % are retired, making up 10 % of the total amount of visitors. The rest are either employed (28.6 %), self-employed (16.4 %), students not coming with their class (9.7 %) or housewives (8.6 %). The educational level is equally distributed between high (31.1 %), medium (31.9 %) and low (37 %). 50 % have followed physics classes for two or three years, 31.2 % for four or five years, 9.1 % for more than five years, while 11.3 % have never had physics classes at school.

When asking for the visitors' motivation and general expectations (ibid.: 10-14), it was found that 73.4 % come to CERN because of a general interest in scientific research. 10.4 % are interested in something else than research at CERN, (e.g. the possibility of vocational training or employment), 7.4 % are interested in a specific area of research at CERN, and a not too discouraging 4.6 % are not interested in the visit. The rest come out of curiosity or follow the others. It can be said that the visiting school groups come prepared. 51.4 % have either briefly discussed the research done at CERN, or dealt with one of the subjects of the visit, while for 24.3 % it will be discussed later. The visitors expect mainly to see what kind of research is done at CERN (24.9 %) or to get an overview of CERN (14.4 %). This shows that visitors expect to have concrete information about science and research. Finally, nearly 60 % claim they know little or nothing about what is done at CERN, while 38.1 % claim they know something and 2.4 % answer they have good knowledge.

Ethnographic observations of the tour (De Pasquale and Giampietro-Barczyk 2004: 7-19) showed that visitors displayed a reasonable degree of attention during the introduction, which varied between 20 and 60 minutes, and that the guides could influence the involvement of the audience. The video seemed interesting to all visitors, with an emphasis on the quantitative information. When the introduction was too long, a low level of attention, probably reflecting the tiredness of the audience, was observed. Analysing the reaction of each group studied, the time spent at the experimental site seemed very interesting for the visitors, even if they did not follow the explanations of the guide, but instead went around to see all the parts of the scientific apparatus. At the experimental site, things were often chaotic, with lots of background noise, dust, and other sources of discomfort that easily disturbed the concentration of the visitors. The observers concluded that visitors seemed to appreciate the way the visit was organised, its content and what they were able to see. The visitors showed interest in what the guides were saying, and more adults than students had a fruitful interaction with the guide. Results from questionnaire answers about the visit (De Pasquale 2003: 26-33) show that 55.5 % of the students, 94.1 % of the teachers and 81.9 % of other visitors ask questions

to the guide, while almost 50 % of the students and other visitors ask questions to accompanying visitors. The results of the questionnaire show that visitors appreciate the possibility of asking questions, and they also seem satisfied with the adequacy of the answers and the clarity of the information provided by the guide. 95 % finds the possibility of seeing what kind of research is done at CERN the most interesting aspect of the visit, followed by getting an overview of CERN, which is appreciated by 86.6 %. 64.9 % think they have learned something about the consequences of particle physics, a low number according to the report. When asked why they found a particular facility the most interesting, respondents stated that they were impressed by the hugeness of the installations. More concerning results are that as many as 17.7 % of the visitors do not remember which installation they had just visited. One reason for this could be the large number of acronyms used (CMS, LHC, etc). A worrying 70.7 % does not visit Microcosm after the visit.

The visitors were also interviewed (ibid.: 22-45), and this revealed that more than half of the visitors were *very* satisfied with the visit. The main reasons for this being the chance to learn more about the branch of scientific research at CERN and the helpful role of the guides. Almost half of the visitors expressed amazement at the size of the experimental parts, and more than 25 % were surprised by the size of the challenge, in particular referring to the complexity of the research projects at CERN. The guides were praised by nearly all visitors for their explaining quality. Some visitors expressed disappointment for being unable to see the LHC tunnel or the detector at work. Through the visit, the visitors seem to get a general idea of CERN, which can be considered close to reality, except for the fact that few visitors see the guide as a researcher. The report shows that the degree of satisfaction is very high among the visitors and the role of the guides is very important. Other studies (De Pasquale 2004) found that the visit seems to have a ‘quite positive effect with regard to the increase of visitors' knowledge of the research center’ (p. 51) and it affected the visitors’ opinion about science and physics. Yet, the report notices that the results were in certain cases rather contradictory, especially in the case of an increase in scientific knowledge.

Based on these studies, the same report states some reflections and recommendations. It asserts the principal aims of the visit to be (ibid.: 53):

- Familiarise the public with the laboratory and the *raison d'être* in order to put it in its context with respect to society,
- Familiarise the public with the research carried out in order to motivate the research and make the visitors discover how science is a part of our culture and daily lives,
- Transmit a basic level of knowledge and messages about the research to allow the public to follow better the developments in the field and to increase their possibilities of assimilating scientific information aimed at the lay public,
- Stimulate interest and excitement about the particular field with the hope of increasing the visitors' scientific cultural consumption and enhance their view of science,
- Reply to the questions from the public.

The report also identifies the strength and weaknesses of the existing programme (ibid.: 53-54):

- It does not only cover the research from a purely theoretical point of view, but also the wide spectrum of technology involved and the social aspects of being a world collaboration.
- The CERN guides are not professional communicators but CERN researchers with a particular interest in devoting a fraction of their time to outreach.
- The guides are therefore not always pedagogically competent, but the public gets the chance to meet real scientists with true enthusiasm for their work and direct insight into the research.

The report recommends the following (ibid.: 55, excerpts):

- Put more emphasis on the fact that CERN guides are real scientists,
- Give guides basic training in communicating skills, and the liberty to transmit their fascination and particular angle of research,
- The visit should not be a pure lecture, but contain a high level of interactivity to make the visitors feel involved in the visit and to adapt the contents to the level of the visitors and their questions.

3.3 Why is the Guided Tour at CERN Different from Standard Tours to Museums and Science Centres?

From the above overview, a summary of the CERN guided tour programme can be made, and it can be compared to guided tours at museums in general. First of all, it is important to keep in mind that CERN is not a museum, that CERN employees or guides are not museum workers or even communicators, and that they are not supposed to be. Perhaps the CERN guided tours and Microcosm could be characterised as what Nissley and Casey (2002: 35, citing Danilov) call a 'corporate museum'; defined as a 'corporate facility with tangible objects and or/exhibits, displayed in a museum-like setting, that communicates the history, operations, and/or interests of a company to employees, guests, customers, and/or the public'. And, as Roberts (1997: 78) indicates, guides can play an important role in this transmission. Yet, CERN is not a company or factory, but has a duty towards the general public - who supports its existence through tax money - to open up its sites and experiments for visits free of charge. Only Microcosm presents particle physics, as well as CERN itself and its history of research in a museum-like setting. Displaying tangible objects or exhibits communicating *interests* of CERN is not the aim of Microcosm. Still, it can be argued that the guided tours might add to what is called 'organizational identity', being 'the perception by those outside the organization' (Nissley and Casey 2002: 40). Museums do this by regulating and shaping the attitudes and behaviour of their clients:

> ...visitors are told what to see and what they should know. Most museums direct the attention of visitors to, and create their active physical and cognitive participation in, what the individual museum has to 'say' about the phenomena that are its concern...
>
> (Rayward and Twidale 1999: 29)

Therefore it can be claimed that the CERN guided tours serve the same purpose as museums when it comes to presenting an identity to the public, by means of structured visits presenting objects of relevance.

Furthermore, the CERN guided tour is not a lecture, aiming at teaching about accelerator- or particle physics, but an opportunity for people to get an insight of how fundamental research is done through international collaboration and which instruments are used[2]. At museums, 'exhibits generally are intended to convey an educational intent or theme' (Grinder and McCoy 1985). At CERN, the objects seen at the experimental areas are not static, unchangeable exhibits, like mock-ups in museums, but ever-changing instruments being assembled, used as tools in real science. The infrastructure changes, and the scientists, engineers and technicians present at any moment give the site liveliness and add colour to the visit. The objects are not, except in a few cases, interactive objects used in an explanation, possible to touch and manipulate. They are the purpose of the explanation itself. The aim of the visit, similar to what many find an important purpose of museums in general (Hogan 2000; Osborne *et al*. 2003; Schauble and Bartlett 1997), is to give an understanding of the enterprise of science. A visit to CERN gives an insight into the 'distal knowledge' of science; the protocols, practices and products of the professional scientific community (Hogan 2000: 52). According to Osborne *et al.* (2003: 694), 'science education attempts to wrestle with three conflicting requirements' :

- It wants to demonstrate the tremendous liberatory power that science offers – a combination of the excitement and thrill that comes from the ability to discover and create new knowledge and the emancipation that science offers from the shackles of received wisdom,
- Achieving its aims, in contrast, science relies on a dogmatic and authoritarian education in which students must accept what they are told as 'unequivocal, uncontested and unquestioned',
- It should provide its students with some picture of the inner workings of science – knowledge, that is, of science-in-the-making – and knowledge, moreover, which is essential for the future citizen who must make judgements of reports about new scientific discoveries and applications.

From what has just been described about the aims of the CERN guided tour programme, it is easy to see that it strongly contributes to the first and last of the above mentioned

[2] It is interesting to contrast this observation, together with the objectives of the CERN guided tour programme, to the intentions of Sir Jack in Julian Barnes' "England, England", where people should not *become more knowledgeable*, but *feel less ignorant* (p. 90; Norwegian translation: H. Aschehoug & Co, Oslo 1990).

requirements and gives an alternative to the second. Issues found important for inclusion in the science curriculum (ibid.: 705-6), such as scientific method and critical testing, creativity, diversity of scientific thinking, analysis and interpretation, as well as science and certainty, cooperation and collaboration are all introduced to the visitor during the CERN visit. This should leave little doubt about the informal educational value of the tour, complementing classroom education in some cases, although this is not the main objective.

Comparing to the planning of a specific science gallery, it was interesting to contrast some of the goals of the gallery to the objectives of the CERN guided tour programme. Among others, their goals were:

> exciting visitors about science; helping visitors envision themselves in careers concerning science and technology; educating citizens about the role of science in everyday life; and providing a base for understanding to support scientifically informed decisions about public issues...
>
> (Schauble and Bartlett 1997: 782)

It is clear that a visit to CERN can contribute greatly to achieving these goals, especially because CERN emphasises the spin-offs of fundamental research, or as Schauble and Bartlett call it, 'cross connections' (1997: 786). The result of the fundamental research being conducted at CERN can be found in many fields, such as medicine and biotechnology, for example. It is not restricted to the field of particle physics; thereby showing the visitor that science is not made of isolated disciplines, but can be regarded as a linked network.

When analysing the general recommendations for guided tours treated earlier, it should be noted that CERN has difficulties meeting some of the demands, such as more time for individual inquiry (Cox-Peterson *et al.* 2003: 207; Griffin and Symington 1997: 775), less structured and more visitor centred (Cox-Peterson *et al.* 2003: 210), or that educational interests should have a priority over security, as well as preservation and conservation of the museum objects (ibid.: 211). Safety regulations are strict at CERN; the visitors cannot and should not move around freely. The tour is of limited durance, and has therefore little time for individual exploration. Since many of the experimental areas have restricted access and much costly equipment is present, the safety has the priority over educational value. As education is not the main objective of the tour, it is the obvious looser.

The visit to CERN should give the visitor a sense of wonder and excitement about the scale and complexity of the projects and its involved parts. Safety regulations limit the access to experimental areas, and the ongoing construction work is sometimes a disturbing factor. Nevertheless, the visitors seem to appreciate the opportunity the tour gives them. It meets their needs and satisfies their expectations. They are pleased with what they see, the guides' explanation, and the general structure of the visit. The visitors get to meet scientists who work at CERN, who have a passion for their work, they experience science in action. According to Grinder and McCoy (1985: 6), 'one of the greatest benefits of the guided tours for visitors is the opportunity to interact with

someone who has facts and insights and who can answer questions in understandable ways.' The visitors leave with a general idea of CERN corresponding to reality, boosted interest in science, and a clearer opinion about science and physics, even though it seems that the visitors do not remember all details. In general, this applies to museums as well, as Falk and Dierking have noted: 'Organized groups…tend to leave the museum without taking with them many of the messages intended' (1992: 151). But remembering details should not be the aim either. 'The role of informal institutions such as museums should be to spark curiosity and engage interest in science' (Cox-Peterson *et al.* 2003: 215). To this the CERN guided tour contributes immensely.

In this chapter, a comprehensible picture is acquired of the CERN guided tour programme. The objectives of the visit were presented, as well as what the visitors expect of the tour and how these expectations are met. The differences between the CERN guided tour programme and guided tours at museums in general have been discussed. But, in order to fully be able to describe how to optimise panels and other exhibition material for explanatory purposes at CERN guided tours, a discussion of the complexity of explanations at CERN guided tours is needed. This is the intention of the next chapter.

4. Explaining Complex Issues

Before talking about how the panels in an optimal way can assist the guide in explaining a complex issue, it is in order to establish what a *complex issue* is and what it means to *explain* something. Citing *The Concise Oxford* 1982 edition, *an explanation* is a 'declaration made with view to mutual understanding or reconciliation; statement or circumstance that explains.' *To explain* is 'to make known in detail; to account for.' *Difficult* is presented as 'needing much labour to do or practise; troublesome; perplexing.' For *complex* the dictionary gives a synonym: complicated. The much bigger 1998 edition of *The Oxford English Dictionary* describes *an explanation* as 'the action or process of explaining; that which explains or accounts for; a method explaining or accounting for; a statement that makes things intelligible.' *To explain* is 'to make plain or intelligible; to make clear the cause, origin or reason of; to account for.' Something is *difficult* when it is 'not easy; requiring effort or labour; hard to do, perform, carry, or practise.' *Complex* is 'not easy analysed or disentangled', while *complicated* is 'consisting of an intimate combination of parts or elements not easy to unravel or separate; involved, intricate, confused; the opposite of simple.' To site some other sources, *The Free Definition Online Glossary and Encyclopaedia* (www.free-definition.com) presents *an explanation* as 'a statement which points to causes, context and consequences of some object (or process, state of affairs etc.), together with rules or laws which link these to the object. Some of these elements of the explanation may be implicit. Explanation can only be given by those with understanding[3] of the object which is explained.'

Having established this basis, it is easy to see that to explain accelerator physics, a subject consisting of abstract and technical concepts, is difficult to grasp and the language used us unlike the everyday language. Thus it might, from time to time, involve complex elements. Before determining exactly how complex the issues explained at the guided tours are, it is necessary to go deeper into how explanations are carried out, and therefore some theories of what an explanation is will be presented.

In the philosophy of science, the discussion on what an explanation is dates back to the famous 1948 paper by Carl G. Hempel and Paul Oppenheim, 'On the Logic of Explanation' (Hempel and Oppenheim 1948). Since the discussion evolves mostly around scientific explanation, it will not be presented here in depth, but it is interesting to notice their definition: 'an explanation is the scientific explanation of why some event or phenomenon should have been expected on the basis of natural laws' (Wright 2002: 34). Hempel and Oppenheim hold that *an explanation* is divided into two major constituents,

[3] According to the same source, *understanding* is 'a psychological state in relation to an object or person whereby one is able to think about it and use concepts to be able to deal adequately with that object'.

the explanandum and the explanans. The explanandum is the sentence describing the phenomenon to be explained (i.e. not the phenomenon itself), while the explanans is the class of those sentences that are adduced to account for the phenomenon. This means that the explanandum must be a logical consequence of the explanans, the explanans must have empirical content (viz. be capable of test by experiment or observation), and the sentences constituting the explanans must be true.

To be able to obtain a more pragmatic picture of an explanation, more recent literature is consulted. Wright (2002: 36) argues that an explanation is an answer to questions beginning with interrogative words, such as 'what', 'how', or 'why', thereby ascertaining why a conclusion C is true. Hence, 'explaining why C is true is the very same thing as giving a reason to think C is true' (ibid.: 37). In the particular case of explaining at CERN, statements are needed that say something about the functions of the tools used at CERN for research ('what do we do', and 'how do we do it'), statements justifying the previous and ongoing research ('what have we done' and 'why do we do it') and statements about the results of this research ('what have we found' and 'what can we expect'). The explanations will be answers to these questions. But, since the phenomena being explained involve highly scientific terms and technology at the edge of understanding, a question of complexity arises. This question is treated in the next section.

4.1 How Complex are the Issues Explained at CERN's Guided Tours?

The guided tour programme at CERN has been described earlier, but in order to establish a concise view of what purpose the panels should serve, the main outlines will be repeated here.

At the CERN guided tour, the visitors are shown the work site where the detectors are built. Before they go to see this place, the visitors are given an introductory talk about CERN and particle physics. Usually, only one site is shown. At the site, the visitors get a closer look at the detector parts and the construction area. They are being explained the overall detector purpose, the purpose of the different parts, and sometimes the construction process up till now, but also in the future. All these issues include the usage of highly technical terms, even scientific terms, if the guide chooses to include some theoretical physics into the explanation. Numbers of monstrous dimensions, amazing sizes and building blocks meet the visitor. Yet, the detector is so complex to the smallest detail, and this needs to be taken into account when trying to understand the function of the instruments. Therefore, the visitors need to realize that the gigantic parts they see are made of a huge number of extremely small and detailed elements. It is not the goal of the guided tour to make the visitor an expert in accelerator physics and detectors, or particle physics, but to show some of the work going on at CERN by trying to answer questions as 'what do we do here?', 'why do we do it?' and most significantly 'how do we do it?' By seeing the instruments used at CERN, the visitor can get a certain insight into how

scientists work in order to answer some of the most fundamental questions of modern research.

From this analysis it can be concluded that the issues being explained at CERN's guided tours can be defined as complex and difficult. The numbers, sizes and sometimes even the purposes are not easy to understand, since they are far away from every day concepts. It certainly requires effort to understand the things seen and concepts being explained, noticing the amount of technical and scientific terms it involves explaining these things. During the tour, especially in the beginning, the visitor might feel perplexed and even confused, something that hopefully will change as the visit evolves. It is also not easy for the guide to make these issues understandable; this necessarily involves some effort, too.

It might be determined, then, that the panels and other exhibition material serve one overall purpose: to be part of the link between what the visitors see and hear from the guide, and their understanding of the issues being explained. Other parts of this link might be the guide's language, the rethorics and semantics[4], the visitor's pre-understanding and effort to understand, or other exhibition techniques and visual media, such as video or computers. These points will not be discussed any further in this paper, except for the latter part. The exhibition material serves as a complement to the guide, assisting their explanation by visual means. They are explanatory, because they are containing or helping to an explanation[5]. They must illustrate what the visitor sees and what the guide explains, all in a way, hopefully, to leave the visitor with a certain understanding of how research is carried out at CERN, and what results are desired and expected. It will now be discussed how this can be done.

4.2 What Should be Said, and How?

The construction of exhibition material is based on two credos: it should give the guide a freedom to provide the guided tour with personal characteristics, and the guided tour should give the visitors an insight into how research is conducted at CERN, as well as amaze and excite them about the various complex processes this research entails. The latter, as seen from previous discussions, is in agreement with the official objectives of the guided tour programme. The CERN guided tour, therefore, is different from the guided tours to museums and science centres in general. The recommendations from the literature are hence not always valid for the CERN guided tour. CERN as an enterprise cannot be seen as a supplement to classroom activity. In fact, visitors do not come to CERN to learn something in the educational sense; they come to CERN to get an insight into fundamental research, to see how this research is conducted at CERN, what tools are used, and what the consequences of this research are. As it was noticed before, the visitors themselves, too, expect to be given an insight into what CERN does. When later

[4] The guide's language, rethorics and semantics are summarized when Love states that 'a good guide is a good conversationalist' (Love 1994: 5)

[3] Which is in agreement with the definition of explanatory, offered by the 1989 2nd edition of the *Oxford English Dictionary*.

asked about what was the most interesting thing during the visit, most visitors answered exactly this – the chance they were given to obtain the insight. The tour is considered formal; it is planned, guide-driven, and leaves little or no time to experiment or discover. Although the recommendations emphasise that tours should make more space for individual freedom, 'highly structured visits appeared to result in greater cognitive learning' as Falk and Dierking (1992: 50) have noted. Even though the main objective of the CERN guided tour is not to educate, the learning process is not completely left out.

Since much of the research conducted at CERN is unknown to the layman, the visitor might experience a certain feeling of awe before the tour. In fact, it is noted that 'for most visitors feelings of awe exist before the visit, are enhanced during the visit, and persist after the visit' (Falk and Dierking 1992: 93). This should be the main objective for the guided tours at CERN: to create a feeling of awe and amazement over the various subjects experienced. The theoretical side at CERN is important, this cannot be denied. But, during a guided tour, it is more likely that theoretical physics cannot be connected to what visitors are seeing and experiencing. The real-life objects, both the tangible and the 'untouchable' ones such as the detectors, are at the core of the guide's explanation, because they visually connect what the visitor is experiencing to what the guide is explaining, and because they are examples of the science in action that the visitors come to see. This is not the case with the theoretical physics, existing mostly on paper in the form of mathematical abstractions. Although one should never underestimate the audience, most of the CERN visitors *are* non-experts, and therefore, the 'scientific knowledge must be explained, rather than presumed' (Ravelli 1996: 368). But still, when explaining, it can be assumed that most visitors will have difficulties with understanding particle or accelerator physics. These themes cannot be connected to what the visitors experience visually, making them hard to understand. The visitor should leave CERN with an exciting feeling of having seen a close-up of fundamental research of such an international and complex scale as being conducted at CERN, not as experts in theoretical physics. The latter is most likely doomed to fail, the former is an obtainable goal.

Technology is a major part of CERN, and this technology is cutting-edge. It will therefore most likely constitute the main part of the explanation. Studies (Sandifer 2003) have shown that technological novelty in a museum exhibition keeps the visitors attention for a longer time. How can the panels in an optimal way use this feature and make the technology understandable for the layman? First of all, exceptions to general recommendations for text writing in museums are in place. The text for museum labels should not consist of isolated facts (Ravelli 1996: 373). But since at CERN the guide does the talking, not the labels, it is found appropriate that for the panels used at the guided tours, the text *can* be a list of isolated facts; they will mainly serve as a reminder for the guides. Further on, technical terms should be introduced and defined carefully (ibid.: 374). At CERN, since the text should be kept to a minimum, there is no room for this. The text should rather support the guide in his or her definition of those terms. But, in both cases, the technicality or 'correctness' of the explanation cannot be compromised (ibid.: 374).

Because the technology used at CERN is cutting-edge, and so is the international collaboration, much of which is new and valid at some point, might have changed at another. When talking about technology, the Social Issues Research Centre (SIRC 2001: 4) recommends that preliminary or inconclusive results should be handled with care. This entails that the text on the panels should be of such a character that it does not deal with changing facts. The information should be established knowledge. The collaboration status might change, so when presenting the collaborating countries, the list or drawing should be dated. Deadlines for projects might be extended, so finishing dates should be handled with care. Weight, height, and length are most likely not to change, so they can be mentioned without further discretion. At any time, it is not just important to provide the correct information; it will also enhance the reputation of the research at CERN, the individual experiments, and even the researchers.

It is preferred that the guide does most of the talking, feeling free to converse in any manner he or she wants in order to make the tour lively. But by doing that, one problem might be encountered. Most of the guides are employees at CERN, with much inside knowledge into the research, and it is probably a common fact that 'the skills needed to inform others about technology are altogether different from the skills needed to acquire that wealth of wisdom in the first place' (Frey 1995: 24). But if the panels are made in such a way that they inspire to communicate this wisdom in the right way, much of this complaint can be discarded. After all, the guides 'are usually considered to be the interface between the visitors and the science centre' (Alfonsi 2001: 10). Still, the guides are more than this; they 'represent a way of showing science as a process' (ibid.). How can the panels be inspiring for the guides? The big advantage written communication has over oral is that written communication is less likely to be misunderstood (Frey 1995: 24). One has the chance to review the material, unlike the demand of getting it right the first time when one speaks. A guide unsure about his or her abilities or knowledge is affecting the rest of the group, since 'visitors often become uneasy when they sense that guides are uncertain about information' (Love 1994: 5). So the demand for support from the panels might be said to be strong. How can panels meet this demand? The first thing to be aware of is that visitors most often need to orientate themselves. 'All visitors want to know where they are and where they are going…' as Falk and Dierking advocate (1992: 88). Therefore, it is appropriate to have some information presentable about the visitors' position, their destination, and what they will see. Secondly, it is desirable to describe a subject in terms of its history (Frey 1995: 25). When talking about accelerators, one can start with explaining how accelerators have evolved over time. Thirdly, one needs the visual connection to what one is explaining. When one talks about a detector, for example, show the detector itself (ibid.: 25). In the present construction phase at CERN, this might be difficult, but as much as possible, the rule should be followed. Here the panels are of valued support, since they can provide schematic drawings.

The similar rule also applies to smaller parts. The visitors should be able to see the small components of the various detectors when the guide talks about them, and some might even be used as tangible objects. In fact, a study of visitors to CERN's interactive science centre Microcosm revealed that 50 % of the visitors preferred interactivity (Hascouet

2001), something that is also recognised by others (Roberts 1997: 68). The tangible objects should give the visitor a feel of the new technology, since 'nothing reinforces the experience like involvement of the senses' (Falk and Dierking 1992: 154). According to Love, 'objects acquire powerful attraction when presented in museum settings, whether or not visitors understand the subject or theme of the exhibit' (1994: 43). The power of these supplementary visual materials should not be underestimated. Photographs supplement the schematic drawings; video, virtual reality (VR) or a camera system can present things that otherwise might not be available, such as seeing the detector once it is operating. Grafe *et al.* observe:

> New technologies are increasingly used, like for example multimedia presentations which convey information in form of animated sequences of pictures, videos and texts. Visitors highly appreciate these new technologies.
>
> (Grafe *et al.* 2002: 1)

Especially VR should be considered a good alternative to the original, since 'VR technology offers great advantages particularly if the real exhibit does not exist anymore…or if a stay at a specific place is not possible or too dangerous for the visitor' (ibid.).

The fourth essential thing about communicating technology is breaking the main topic into subtopics, thus making the presentation much easier to follow (Frey 1995: 25). For the panels, this does not only mean that the explanation should be divided into subtopics, each preferably presented on a panel, but also that the panels should be scattered around. If the placement of the panels follows the logical order of the explanation, starting with the general, ending with the more particular, the tour will get a more narrative look (Roberts 1997: 137), making it lively and flowing, and less lecture-like. Research has shown that exhibit placement in museums will affect the visitors' understanding (Falk 1993). Although not all results are applicable to the CERN guided tour, for reasons already known, the fact that panels should be placed in a logical order to make sense to the visitors, is considered important here. At CERN, this placement still has to be flexible, since groups can be broken down, and not all groups will follow the same track at the same time. Therefore, the panels should be so that they can be used independently from each other *as well.*

The last noteworthy point is to use contrasts and comparisons, applying the familiar to illustrate the new (Frey 1995: 25). The panels should provide the right information for the guides to enrich their explanations with the correct contrasts, comparisons, metaphors and analogies, in order to enhance the visitors' understanding. If the panels can list some technical facts, accompanied by the right analogy, much of this work is done.

As for the use of technical language, such as mathematics, it should be avoided at all time. 'Most people do not want to think about mathematics' Goeller (1996: 491) promotes, and concludes: 'Successful explanation of technology should be based on verbal descriptions and specific examples' (ibid.). It is important to recognise that 'ideas

that cannot be presented concretely should not be presented at all' (Falk and Dierking 1992: 154). Roberts argues: '...the recognition that to reach most visitors, basic skills of processing information would be more applicable and relevant than specific facts' (1997:52). Although the panels should mainly list technical facts, they will all be familiar notions to the visitor, such as length or weight. Technical terms should be avoided, and certainly mathematics must not be used – unless one wants to illustrate the mathematical complexity, or perhaps simplicity, of the underlying theories. It should be left to the guide to define and explain difficulties. This leads to the conclusion that all that is technical, abstract and unfamiliar to the visitor should be handled with care, and this, of course, includes a topic like theoretical physics.

Keeping these conclusions in mind, together with the knowledge of the preceding chapters, a firm base of what the panels should explain has been established. How the panels should explain has been touched upon, but study results are needed to verify these suggestions. The next chapters will present the study, and the results, which was conducted at CERN to determine how to construct the explanatory panels, and to establish the guidelines for making them an optimal tool to assist the guide's explanations.

5. Methods

The methods used in the study are divided into two parts: research and construction process. The main field work of the research was conducted over a three-week period in April 2004, consisting of four parts: visitor group observation, visitor questionnaires, open-ended guide interview and guide questionnaire.

In the tracking, the groups were followed without intervening, and were chosen to include as many different guides as possible. During three weeks, a total of 55 tours were arranged, with a total of 1636 visitors of various nationalities and languages. Out of these 55, 7 different tours were followed, being, for language reasons, only tours in English or Swedish. The number of visitors in the studied tours was 163, making up close to 10 % of the total number of visitors. The reason for this particular number of tours is that, although the total number of tours in English and Swedish was more than 7, there were days without any tours in these languages, some days had several tours at the same time, and some tours were guided by the same guides as before. To get a broader view, every tour followed had a different guide. Relevant observations of visitor and guide interaction with panels were noted down. Signs of usage by the guide and the visitors were particularly interesting, as well as whether visitors studied[6] the panels on their own, i.e. without the guide focusing their attention to them. These results were later compared with answers from the questionnaires handed out to the visitors.

During the three-week period, 10 guides were interviewed, but the process extended into the following weeks. Thus a total of 13 guides were interviewed. The interviews were open-ended, conversation-like, starting with the question 'How can panels assist your explanations as a guide in an optimal way?' and developed from there. The issues were mainly based on findings from the observations - what panels the guides used, how they used them, etc. Topics like panel size, quantity, text, picture size and overall content were also discussed. The main outcomes of the interviews were noted down. Interviews lasted from 10 up to 45 minutes, depending on the guide's experience and devotion to the work he or she was doing. The number of guides to be interviewed was not established from the beginning, but interviews were conducted until a pattern was found. When no new issues were raised, further interviews were not seen as needed. The key features were extracted from the results and transformed into a questionnaire, in which an agreement or disagreement with the statements could be shown. The questionnaire was put up on the CERN guides' homepage, and all guides were encouraged to answer it, in order to discover a general agreement or disagreement with the claims. At the end, a question about the guide's background was added, to see if there is any connection between what the guide sees as important properties of the panel and the guide's professional

[6] *Usage* will be defined later in the section, *studying* in the results chapter.

occupation at CERN. A total of 16 guides returned the questionnaire. A paper version of the questionnaire can be found in Appendix A4.

The first section of the guide questionnaire consisted of 4 general claims:

- Guides should be involved in the evaluation of new panels;
- The panels are an essential part of the guided tour;
- There should not be more than 3-4 panels per visit itinerary;
- Panels should not, if possible, be collected in one place.

The following section was about panel content, containing 9 claims:

- The schematic drawings and overviews of the detector and its main parts are essential, and should be illustrated on one (or several) panel(s);
- The construction process is very important (e.g. LHC construction, detector construction and LHC/detector space construction), and should be illustrated on a panel;
- It is important to illustrate the LHC complex, both above and under ground, on a panel;
- Collaboration is very important, and should be illustrated on a panel;
- The text on the panels serves mainly as a reminder for the guides. The panels should, therefore, contain as little text as possible, mainly presenting the dimensions of the detector and the detector parts, and other technical information;
- It is not the aim of the guided tour to teach particle physics. Therefore, there should be no panels on particle physics, and particle physics should only be included if it is absolutely necessary for understanding;
- The panels should provide the possibility always to refer back to the general picture (e.g. by also showing the whole detector when presenting its main parts);
- The drawings on the panels should be big and simple.

The last claim in this section was whether guides preferred few big pictures on the panels, many small, or other, where a suggestion could be given.

The next section was dubbed explanatory material, and contained 3 claims:

- Touchable objects, e.g. detector parts or other illustrative material, are essential and should be included at the visit itinerary;
- Video projections, such as at CMS, are very helpful and illustrative, and should be included, if possible, at the visit itinerary;
- To be able to illustrate issues difficult for panels (such as LHC, when operating), objects or video projections, a Virtual Reality or camera system would be a good alternative.

In the last two sections, the guides could rate the existing panels at the visit itineraries to CMS, ATLAS, PS and AD[7], by ticking the appropriate box from 'very good', through 'good', 'neutral' and 'bad', to 'very bad', as well as inform about how much they use the existing panels at the same point, by answering either 'always', 'sometimes' or 'never'. Finally, space was given for suggestions, and the background of the guide was asked for.

The questionnaire gives a good picture of the guides' use of existing panels, how much they use them and how well they rate them. It must be noted that the panels at the existing itineraries differ greatly. At AD, the panels contain questions, and no facts or schematics on the complex. At PS, the panels were not made by the Visits Service; they contain lots of information and advanced schematics. The panels of ATLAS and CMS, made by the Visits Service, are described closer in the next section. All in all, the questionnaire was designed to give definite answers to questions about the use and appreciation of panels by guides, how they prefer them to be, what should be on them, what is important to present during the guided tour, and how panels should optimally do this.

A total of 106 questionnaires were handed out to visitors, of which 104 were returned. The questionnaires were handed out only to groups observed, always after the visit, usually either on the bus ride to the CERN reception, or at the CERN reception. This was done to prevent the visitors focusing their attention on the panels, and not to intervene with the flow of the tour. Before filling in, the visitors were shortly reminded of the panels. Complications in connection with this will be discussed later in this section. Two types of questionnaires were used, both to be found in the Appendix, one for the visitors whose educational background was known (Appendix A5), and one for those whose educational background was not yet known (Appendix A6). The first questionnaire (Q1) contained 6 questions:

(1) 'When you entered a new site (e.g. when the guide stopped to show or explain something), what was the first thing you noticed?';
(2) 'Did you read the text on the panels?';
(3) 'Did you use (e.g. read, study, look at) the panels even when the guide did not focus your attention to the panels?';
(4) 'Were the panels of any assistance to illustrate what the guide explained?';
(5) 'Do you feel you learned something from the panels besides what the guide told you?'

In the last question, (6), the visitors were encouraged to write down a short comment about the panels and any suggestions they might have for improvement.

In the second questionnaire (Q2), the 6th question became the 7th, while the new 6th question stated: 'What is your highest level of scientific education?' Question (1) was open-ended, questions (2)-(5) had yes/no options, question (6) on Q1 / (7) on Q2 was

[7] CMS, ATLAS, PS and AD are the Compact Muon Solenoid, A Toroidal LHC ApparatuS, Proton Synchrotron and the Antiproton Decelerator, respectively.

open-ended, while (6) on Q2 had the options ‘High School’, ‘1-3 year University’, ‘>3 year University’ or ‘None’.

Question (1) was meant to investigate whether the panels were (solely or partially) part of the first impression of the visitor when entering a new site of the guided tour. Some guides turn directly to the panels when starting to explain something, while other guides first leave some time for an initial impression of the site, and then turn to the panels for explanation. Questions (2) and (3) were used to investigate the visitor use of the panels, and to compare their own view of usage with the observed view. Questions (4) and (5) served the purpose of outlining visitor appreciation of the panels, by asking if they regarded the panels as useful and if they saw they learned something from them. Question (6) on Q1 / (7) on Q2 was used actively in the development process to see the panels from the visitor's point of view, thereby including some of their needs. Question (6) on Q2 was used to note the visitor's different background on a tour consisting of tourists, hence seeing if background has an influence on the use and appreciation of the panels. Still, while it has been noticed that the panels are mainly for the guides, and not to be studied alone by the visitors, many visitors suggested adapting the panels for their usage, viz. by including more text, more languages, etc. Anyway, the questionnaire gives a picture of what the visitors expect to find on a panel, thereby making it possible to incorporate their needs even more into the panel-making process.

It should be considered that the visitors were notified that the questionnaire dealt with the panels used during the guide's explanation. This might account for the fact that many visitor answered they noticed something about the panels in questions (1). Nevertheless, some visitors claimed to have noticed specific details on the panels (e.g. picture size, number of pictures, text, numbers, etc.), showing that they did not neglect the panels completely. In question (2), *use* was left free for the visitor to choose, with some options suggested. Some visitors underlined *look at* in the questionnaire, and this should be taken as the foremost interpretation from the visitors’ side, something which will be seen later when discussing the observations. *Learning* in question (5) can be interpreted in a myriad of ways, which will not be used here, but the visitor is regarded as knowing what it implies *to learn* something, and although it has been established that learning should not be the main goal of the CERN guided tour, still it might indicate whether it satisfies the curiosity of the visitor, one of the main reasons for coming to visit CERN. An interesting aspect not traced further here would be to investigate how strong the memory of the panels is after a visit. Hence, a question like ‘name one (two, three) things you remember from the panels’ could stimulate further research into the area of what impression the panels gave the visitors during the tour.

The second part of the study was the construction process. The process was a close collaboration with scientists from the unit being exhibited and exhibition designers at CERN. Including guides in the evaluation process was planned, but since the panels were not ready when this paper was written, this was not realized. The construction of the panels is described in the next chapter.

6. Results

In this chapter, an attempt is made to structure the mostly quantitative data obtained from the study process. The first section presents the results from the observations of the guided tours; the second section shows the results of the questionnaires handed out to the visitors; the third section displays the results of the guide interviews; the fourth section exhibits results from the questionnaire based on the findings of those interviews, while the last section describes the construction process. Most of the results will be discussed in this chapter; some deserve a closer examination, and are treated in the next chapter.

The visitor ages are, according to the guided tour plan used at CERN, divided into three categories: 15-19 years, 20-30 years and 31 and older. The age profile of *all visitors* at CERN guided tours during the three weeks is presented in figure 6.1. Figure 6.2 shows the age of the studied visitors. It is seen from both figures that the majority of visitors are 19 years or younger. With every age group follows a description of the background of the visitor, e.g. student, tourist, etc, and if they have had an introduction to CERN before the visit, i.e. besides the introductory talk given at CERN prior to every guided tour. Their educational level is also given by the guided tour plan used at CERN, but in one case this had to be achieved from the questionnaire. The number of guides and the language of the tour are given, but the background of the guides was not explored. This was done because in the tracking stage non-interventional observation was regarded as most important. In the guide questionnaire, on the other hand, the background was intentionally asked for, thus here it was enabled to discover if there exists a connection between the guide's background and his or her view on panel content.

During the description of the observations the word *studying* is used, which for the purpose of this research was defined as a behaviour where the attention is focused away from the guide to the panel for more than 2 seconds, the person observed is in readable

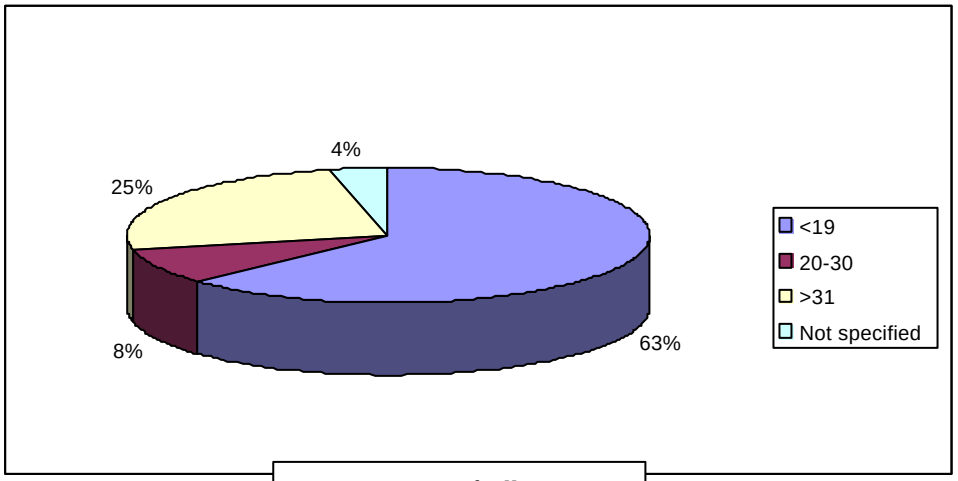

Fig. 6.1: Age of All Visitors

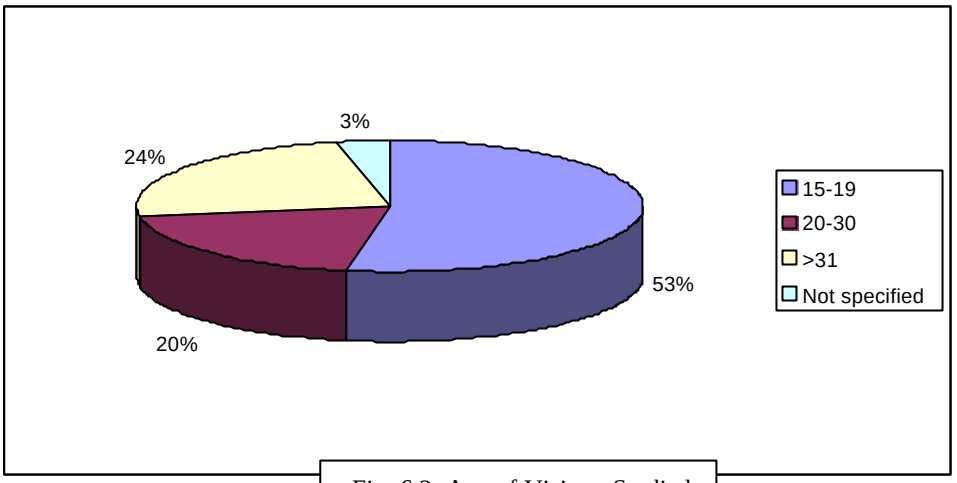

Fig. 6.2: Age of Visitors Studied

close contact with the panel, and observed to notice several parts of the panel, i.e. not just staring at one particular part.[8]

6.1 The Visitor Observations

In the first 2 tours studied, the author also took part in the introductory seminar preceding every guided tour. Even though the introduction will not be presented any further here than already done above, it has to be taken into account when discussing the content of the panels. This will be done in the following chapter. Because of the author's limited language knowledge, only tours in English and Swedish were followed. The actual number of nationalities of the visitors making up the groups was much bigger. Figure 6.3 shows the nationalities of the groups followed. Naturally, English and Swedish visitors constituted the majority. If a group exceeded 12 persons, it was divided into smaller parts, each with one guide. If it is not specified otherwise, only one group with one guide was followed. Other aspects than panel use will not be presented. A description of the panels present at the experimental sites of ATLAS and CMS is included in Appendix A7.

The first tour followed was given to 24 first-year high school students (elementary particle physics) from two separate schools in Sweden. The age category of the group was 15-19. The group had a short introduction before coming to CERN, and was led by two guides. The introductory talk was very short and concentrated, focusing mainly on particle physics and general information about CERN. This might have scared off any

[8] The *Oxford English Dictionary 1989* ed. gives the following definition of *studying* (as an action of the verb *to study*): 'To make a close study of...; to read...with close attention; to examine in detail, seek to become minutely acquainted with or to understand...; to look at as if examining minutely.'

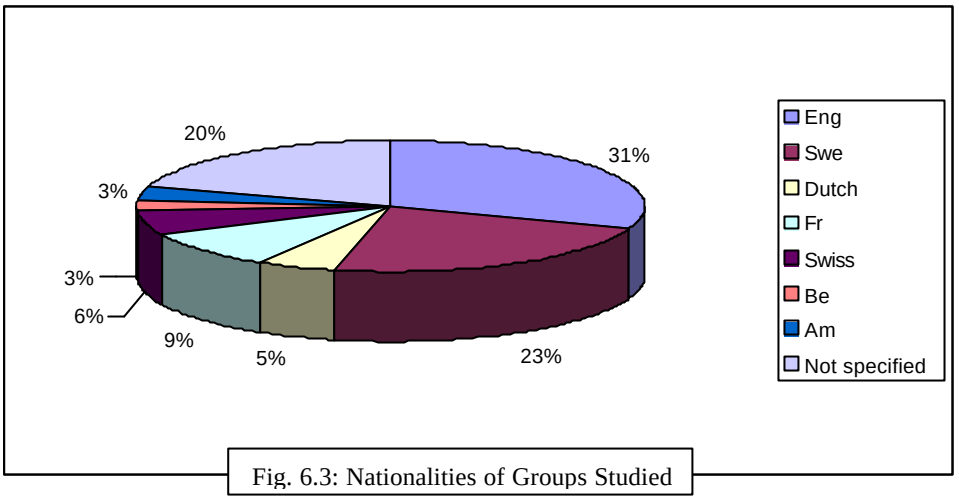

Fig. 6.3: Nationalities of Groups Studied

potential questions, even during the tour, although it was clearly emphasised that questions should be asked at any time. The tour was to the ATLAS construction site, where the panels were placed among building material, and some - not made by the Visits Service and not used by the guide - were noticeably damaged. There was much background noise, which sometimes made it hard to hear to guide. The guide used the panels actively, pointing at them while explaining. He only used panels showing schematic drawings of the detector and its main parts. Two students were observed reading some panels alone, panels that were not pointed at by the guide. Students did not ask any questions related to information displayed on the panels.

The second group was made up of two Swedish high school classes, consisting of 36 last-year physics students, in the age group 15-19. They also had a short introduction before coming to CERN, and were led by three guides, one Swedish-speaking and two English speaking. The introduction, in Swedish, was followed, as well as the tour by the Swedish-speaking guide. On some occasions, though, when possible, two groups were observed simultaneously. The findings will be described together. The tour was to CMS, and as with ATLAS, only the panels showing schematic drawings of the detector were used by the two guides observed. One guide also used a general panel on CERN, showing a picture of the area. One teacher was observed asking a question about the CERN panel, while pointing at it. Another teacher studied one of the structure panels, as well as the panel on the installation process. None of the students were observed to study any of the panels on their own, or asking questions about the information related to the panels. The objects showing detector parts were used actively by both guides, and visitors touched and used the objects independently, even after the guide had moved on to another location. Here also it was sometimes hard to hear the guide due to background noise.

The third visit was on a Saturday, when there was no work going on at the site. This made it very easy to hear the guide. The visitors taken to ATLAS formed an international group of 15 tourists in the age category 31 and more, and an English high school class of 12 students in the age category 15-19. Two guides were leading the groups, and a selection of 10 international tourists was followed. They had not been given any

introduction to CERN, and according to the guide 'some don't know what is going on here.' Outside the building of ATLAS (Building 180), the guide started with a very good explanation of what a detector is. Once inside, the guide focused on the panel right away. One visitor was observed studying pictures next to the panel, on a separate board. This person continued studying the collaboration part of the ATLAS panel. Two visitors took photos of the panel, where one poses seemingly explaining something, pointing at the ATLAS structure. No other people were observed studying the panels alone. The group moved on into Building 190, where the same person studying the previous panel continued studying the panel present here. Again, the guide focused on the panel immediately. No other people studied the panel after the guide left the building. Nobody was observed reading any text. The guide only used structure panels in the explanation. The guide introduced an object of the ATLAS detector, which was not observed in the first tour to the site, and the visitors were interested. A panel accompanied the object, but visitors were not observed to pay any attention to it, except for one elderly man, who stepped away a bit and studied the panel alone.

The fourth group was composed of 30 university students, age group 20-30, completing a diplomat education. According to the group leader, they were at CERN to 'study international relations and collaboration.' In other words, they had no scientific background whatsoever, at least not of higher educational level. Three guides accompanied the group; the tour was to CMS. The guide of the group followed hardly used any panels, but mainly focused on the parts of the detector present on the construction site. On two occasion panels were used, a schematic panel explaining particle reactions inside the detector, and a schematic drawing of the detector. The group seemed more interested in each other, and taking photos (of each other) than the content of the tour. Only 4 students were observed studying the panels on their own (the 'collaboration' and 'introduction' panel on the platform, and a schematic drawing on the ground floor), while the guide was talking. The visitors seemed, on the other hand, very interested in the objects on the platform, and the guide used these objects actively in the explanation. Again, much background noise made it hard to hear the guide.

The fifth group consisted of 20 Swedish high school students (age group 15-19) and two teachers in the natural science direction, and was led by two guides to CMS. They had been given a short introduction to CERN, and here, several students were observed studying the panels on their own (the panel showing the underground structure of the LHC and schematic drawings of CMS). The guide used the general CERN panel, as well as the schematic drawings, but focused mainly on the real detector parts. The objects were used actively, and the visitors eagerly tried them on their own. The visitors seemed very interested in a video of the future assembling of the CMS detector shown at the end.

The sixth visit was for a group of 18 engineer students at university level, age group 20-30. Two teachers were included and two guides led the group to CMS. They had acquired some good information about CERN before. The guide of the group followed first took them outside to see the 'Pit'[9], where a panel showing the underground structure of the complex, the way down and the tunnel system was displayed. On the platform the guide

[9] A view down into the cavern being constructed

focused on the 'Collaboration' panel, 'LHC: the underground microscope' panel, and the general CERN panel. The guide started the video, and after some time three visitors started studying the 'Higgs' panel (more out of boredom than necessity, it seemed). One visitor also studied the LHC structure panel, a second one studied a schematic drawing panel. When the guide got deeply involved in a theoretical discussion with a teacher, many visitors tested the objects.

The seventh and last visit was to ATLAS. A group of 20 English high-school students, studying elementary particle physics (age group 15-19), with two teachers were led by two guides. The group had been introduced to CERN before the visit. The guide of the group followed used actively the structure panel. Possibly due to the background noise, the students seemed rather uninterested. The teacher used one of the panels in her own explanation to some students. Some objects displaying detector parts, again not earlier seen at the site, were used actively by the guide and enjoyed by the students. The teacher focused on the text of one panel, and later again explained something to a few students by means of a panel. The guide used pictures besides the panel in Building 180, showing the detector-parts transport process. In the end, the guide gave the visitor time to study the panels by themselves, something the students seemed to appreciate very much.

From these seven observations, several interesting conclusions can be drawn. Firstly, deducing from how often they were used, other panels than the ones showing detector structure, accelerator structure, building structure, or real-life pictures, etc., do not seem useful to the guides in their explanation. Secondly, the visitors are hardly ever observed to study panels on their own. Thirdly, the use of objects seems important to the guides and is appreciated by the visitors. Fourthly, allowing visitors some time to study panels on their own answers some questions they might have or fills possible gaps in their understanding. Fifthly, contradicting the fourth observation, the speed of the tour gives the visitor no time to read the text on the panels, and the text seems like a distraction, drawing the attention away from the guides' explanation in an attempt to read some words. Since time is limited, and safety regulations are strict, giving room for individual study cannot be prioritised. Allowing this should only happen when there is time in the end, e.g. when the transport is late, or the tour takes shorter time than anticipated.

Turning now to the questionnaires handed out to the visitors, to see if any confirmation of the observation that almost no visitors study by themselves panels, other than the ones the guide focuses on during the explanation, can be found. An investigation of the suspicion that the text on the panels is a distraction for the visitor, although the visitor may not take it as one, is also needed.

6.2 The Visitor Questionnaires

The visitor questionnaires were handed out to 5 different groups, a total of 106 questionnaires, out of which 104 were returned and analysed. The age profile and nationalities of the visitors' are given in fig. 6.4 and 6.5, respectively. The nationalities

are obtained from the CERN guided tour plan, and were not asked for in the questionnaire.

Most of the respondents were students and teachers, but in the analysis this is not taken into account, everybody is treated as a visitor. Another matter not found important to the overall result is gender. Only for one group of visitors, a question specifically asking for education was included, since in all the other groups the educational background was already known. Although in these groups there is an obvious educational difference between teachers and students, this was not found important to the overall result. The questionnaires were meant to give a picture of the visitors' own point of view regarding their use and appreciation of the panels, and later this was compared to the observations already treated. The most frequently mentioned and particularly interesting results and suggestions were brought up during the guide interview, and will be dealt with here. In one questionnaire, a visitor had refused to answer all but the last question. In that question, asking for suggestions, she praised the guide. Her reason for not answering the questionnaire was, she told when approaching the author after the tour, that she was not interested in the panels, but in the guide's explanation. This must be taken as a sign of obvious misunderstanding from the visitor's side regarding the purpose of the questionnaire. The form was discarded, so the total amount of analysed questionnaires was reduced to 103.

Question (1) aimed at finding out what a visitor noticed first when entering a new site, and the visitors were notified before the visit that the questionnaire will be about the panels present at the site and used in the guide's explanation. Out of the 103 visitors returning a completed questionnaire, 30 admitted they noticed something about the panels first, of which 15 mentioned the panels in general. 9 noticed the pictures on the panels, 3 mentioned the drawings (i.e. the schematics of the detector or accelerator ring), while 3 stated other things (the large numbers, the lack of languages and colour details). One answer was doubtful but rather interesting. The visitor first wrote 'nothing specific', but then mentioned the panels. One mentioned 'looking for the panels', while one was looking for interactivity. The author suspects an element of bias in these answers, introduced when it was made clear that the questionnaire was about the panels. Some

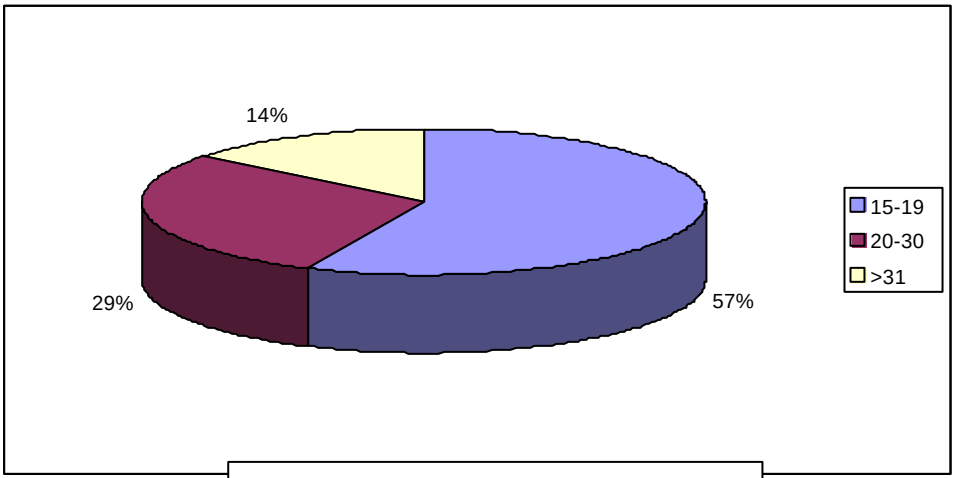

Fig. 6.4: Age of the Questionnaire Respondents

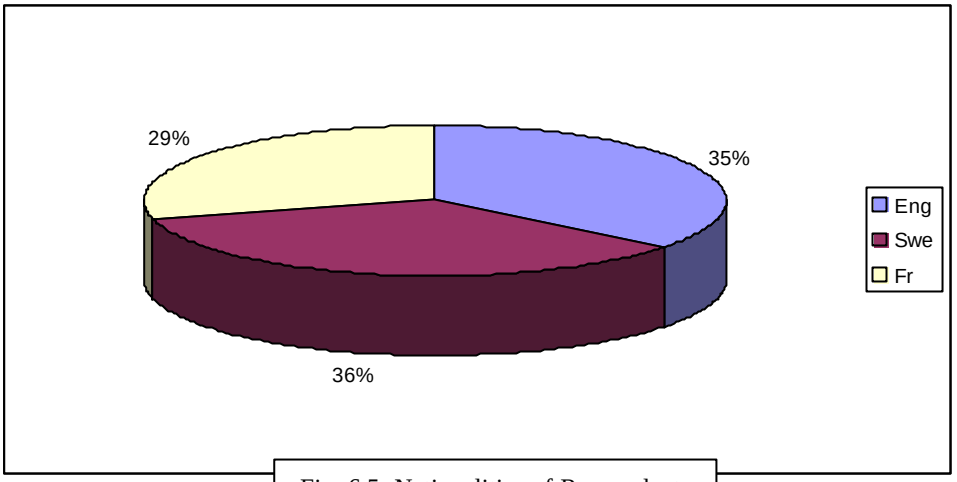

Fig. 6.5: Nationalities of Respondents

visitors might have thought that question (1) was asking for the first thing noticed on the panels. The sites visited are huge with impressive material and constructions, something that can be seen from other answers to question (1). 52 visitors mentioned something about the site, mainly that they were impressed by the size. 17 visitors answered 'nothing', 'nothing specific', 'nothing in particular', 'don't know' or gave no answer at all. One visitor praised the guide. Although only 29 % of the visitors claimed to have noticed the panels or something about the panels when first entering a new site, half of them could give specific details, such as pictures, drawing, colours, etc. This shows that they must have had an impression of the panels before being reminded of them again when answering the questionnaire. And considering the number of distracting elements at the site, such as the impressive size, equipment, noise or even temperature (which could be quite low), this is a positive sign. Finally, there was no connection between a guide focusing on the panels immediately when entering a new site, and the number of visitors noticing the panels or details on the panels first.

Questions (2) – (5) were answered by ticking the appropriate yes/no box, and the results are shown in fig. 6.6. It is visible that 68 % of the visitors claim they read the text, 78 % say they study the panels even when the guide is not focusing their attention on them, 96 % find the panels of assistance to the guide's explanation, while 78 % declare they learned something from the panels besides what the guide told them. From the overwhelmingly positive answers to the last two questions, we can see the visitor appreciation of the panels. Almost all visitors find the panels of assistance to the guide's explanations. This fact, combined with some of the comments by visitors strengthening this positive attitude, is a clear sign of the necessity of visual assistance for the guide. Although learning is not the main focus of the CERN guided tour, the fact that 78 % of the visitors claim they have learned something from the panels besides what the guides told them is interpreted as the panels having an explanatory value in themselves, not just complementing the guide. Some issues connected to this result will be discussed in the next section. In general, the more the visitors feel they learn, the more this should be taken as a bonus for the objectives of the CERN guided tour programme.

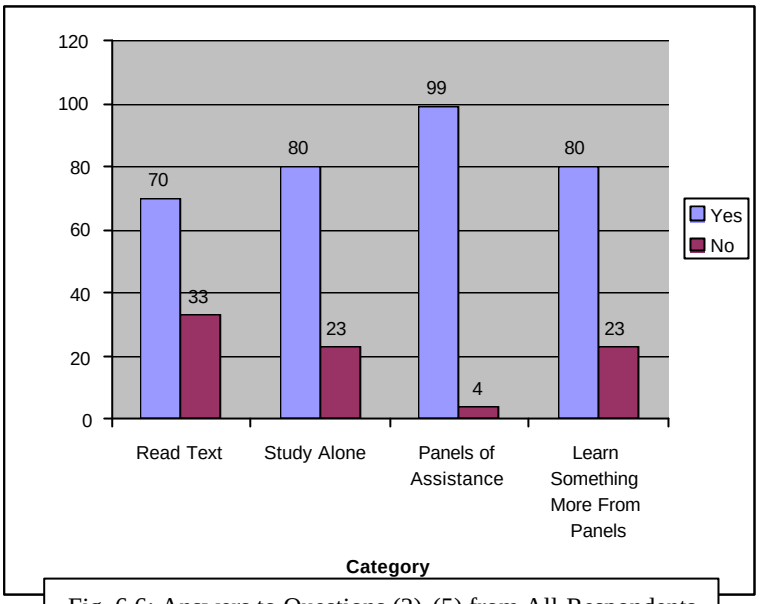

Fig. 6.6: Answers to Questions (2)-(5) from All Respondents

For the group consisting of tourists, a different questionnaire was prepared. They were asked for information about their scientific education. The profile is shown in fig. 6.7. Compared to the other questionnaires, the analysis of this special group revealed no difference from the general opinion of the visitors. This strengthens the original argument that all visitors can be treated the same, regardless of education, gender, or age.

A large number of comments and suggestions were written down by the visitors under the last question. The obvious, for this study, non-interesting opinions such as 'good guide', 'a lot of noise', etc. were filtered out. The remaining comments can be divided into five subclasses (comments are the originals from the questionnaires):

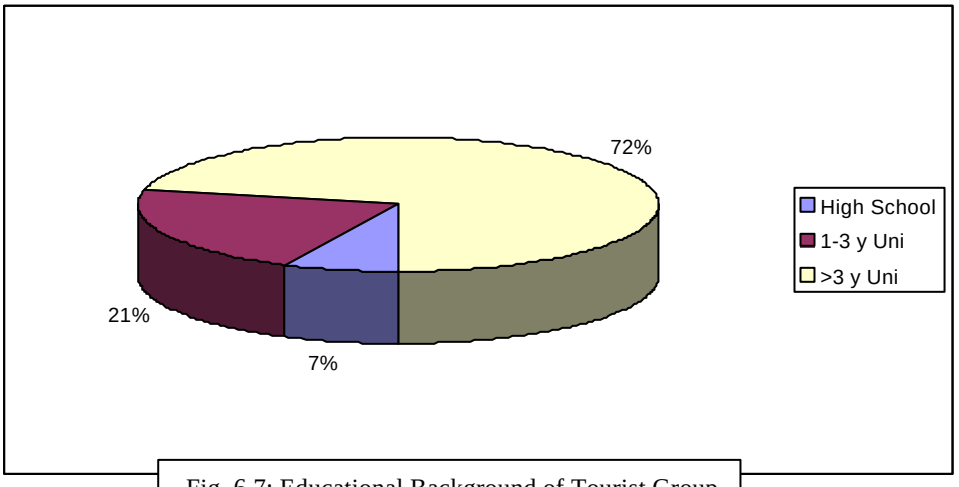

Fig. 6.7: Educational Background of Tourist Group

? **Praising the panels** (e.g.: ‘I think [the panels] were of good assistance to understand what the guide talked about. Good pictures’; ‘[The panels] were very good, the pictures explained a lot. Easy to understand and you got a good overview of the CMS different parts’; ‘The guide could use the pictures of the panels to visualise what he or she was telling’; ‘The panels are an interesting medium to complete what the guide is saying, because a graphic explanation is sometimes more understandable than speech’)

? **Criticising the panels** (e.g.: ‘Text is too small’; ‘Options for more detail, [...], more detailed graphics’; ‘It should have more explanations for non-scientists’; ‘[...] Shorter text in larger typing [...]’; ‘Maybe more pictures’; ‘Too informative, cut down on the text or place them further away from each other so that the info doesn’t feel so massive...’; ‘[...] should include digital feature for amusement’; ‘Panels could have more detail on structure of the detectors’)

? **Asking for more time to read** (e.g.: ‘The pictures were of assistance to understand what he [the guide] was talking about, but I did not read any text. We were not there so long to be able to read yourself’; ‘Allow more time to read them – it was rushed’; ‘Characters are a bit small – hard to read but ok. The visit was a bit fast for us to read more’; ‘It's pretty hard to focus on what the guide is explaining, while looking at the panels. Having few more minutes to examine those panels could be a good idea.’; ‘[...] much more time would be needed to appreciate the panels in addition to listening to the guide’)

? **Clear suggestions for change** (e.g.: ‘More languages (Dutch, Scandinavian, etc.)’; ‘Cross section schematics can be better replaced by 3D-image, to be understood by people with no technical background’; ‘Add basic definitions of the scientific terms. The panels are of an obvious usefulness. It helps to understand the functioning and the goal of the global system. It would be good to simplify the approach for the people who are not used to these subjects’; ‘Make a global scheme of the LHC (tunnel, detectors) to visualise the whole constructive on one panel (?)’; ‘More colours and less text, e.g. more interactive parts! Learning by doing’; ‘Clearer label arrows, more diagrams of particle activity rather than just the diagrams of the machine’)

? **Other** (e.g.: ‘The model showing the difference between heavy glass and your “cubes” was good, I'll remember it’ (about objects showing different detector parts at CMS); ‘More interaction with tour – i.e. team exercise or task’; ‘I assumed the guide explained the most important [things], and did not therefore study the panels that specific’)

Altogether, of the comments found interesting for this study, 24 were of praising character, 30 of criticising character, 8 were asking for more time to read, 12 gave specific suggestion for change, while 3 were other comments. Even though such a large number was of criticising character, these comments were not completely negative. At most, they pointed out details, such as more pictures, bigger text, etc. Nobody

characterised the panels as redundant or superfluous. From the specific suggestions, it is interesting to notice that visitors are asking for more languages. This is an important issue in the panel-making process and will be dealt with in the next chapter. Connected to it is the need for more time to read, a request from a considerable amount of visitors. Another interesting concept is the interactivity desired by some visitors, something that will also brought up in the next section.

From the visitor questionnaires, a clear view is gained of the visitors' own point of view on their use and appreciation of the panels. Many visitors claim they read the text, even more claim they study the panels on their own, without the guide focusing their attention on them (although *to study* turned out to be an ambiguous term). Visitors find the panels very useful, proved by the 96 % seeing the panels as useful to assist the guide's explanation and the 78 % feeling they learnt something from the panels besides what the guide told them. When asked to comment on the panels, a considerable number of visitors found them praiseworthy, be it in terms of assistance to the guide's explanation, or their own explanatory value. The criticism on the panels is mainly about details, such as pictures or text. Especially important issues, such as bigger text and more time to read, as well as interactivity, are requested by a number of visitors that cannot be neglected, and needs therefore to be taken into account when constructing and employing the panels. But these issues need to be confronted with the guided tour objectives, something done at the next chapter. First the guide interviews are presented, which are largely based on the findings from the observations and questionnaire results.

6.3 The Guide Interviews

The number of guides interviewed was 13, all male, and all conducting tours in English. The guides were contacted and interviewed right before or after their visit. The interview was unstructured, conversation-like and open-ended. It normally started with the question 'how can panels in the best way assist your explanations as a guide?' and a discussion was developed from there. The interviews were stopped after a pattern in the topics discussed was recognised, and no new issues were brought up. The interviews are considered to give an insight into the guide's point of view regarding the panels.

It became evident from the interviews that the single most important issue for the guides was the text. All guides found large amounts of text on the panels unnecessary. Some even questioned the visitor's ability to read the text, with the speed of the tour and the distance to the panel. The guides see the panels mainly useful for themselves and their explanation, and they consider the text that should be on the panel nothing else but a reminder for themselves, in case they forget one or several facts, and not something to read for the visitor. Having the visitors reading the text is a distraction, focusing the visitors' attention away from the guide's explanation. Neither should the visitors be encouraged to study the panels on their own, since this, according to many guides, destroys the flow of the tour. Only in the end, and when there is time, could the visitor be given time to study the panels alone. It was also said by the guides that the text should

not be too technical, and mainly connect the information given to more familiar situations, by means of the right analogies.

Another essential issue for the guides was having the possibility to refer back to the general picture, thereby putting things into perspective. If they are explaining about the detector in general, they want to have the possibility to show the detector's place in the accelerator complex, preferably both above the ground and under. If they are talking about some detector parts, they want the possibility to show the detector part in the whole detector structure. The visitor might easily get lost in the big hall between all the huge parts and complex technology, and it is good to remind the visitors of where they are, where they are going and what they will see. Although many of the general issues considering CERN are brought up during the introductory seminar, the visitors can have a tendency to forget about these. Therefore, panels showing general information about CERN are not useless, but they should not be too numerous, and not give too much information. Again, they should serve as a reminder for the guides. This statement is pursued further in the next chapter.

Turning to the panel content, the most important part of the panel was, according to the guides, the structural schematic drawings showing the detector and its parts. The guides saw them as essential and clear, but some also saw the need to change to three-dimensional drawings, instead of the two-dimensional drawings mainly used in the existing panels. They thought such 3D drawings were more understandable and explanatory. The colours on the panels should correspond with the real colours; otherwise an obvious confusion might arise for the visitor. Other 3D schematic drawings the guides wanted were of the accelerator complex and the detector space above the ground and under. The guides also wanted photographs of detector parts, to supplement the drawings and give real-life documentation of e.g. the assembling of the detector or the constructing of the detector space and underground cavern. The pictures and drawings should be detailed, yet simple to understand, always put into perspective. This strengthens the possibility to refer back to the general picture.

A key issue at CERN is the collaboration between the various countries, institutions and participants involved in the different projects. According to the guides the panels should emphasis this collaboration. The complexity of the project is enormous, and the panel should highlight this. The visitor should leave CERN with a feeling of amazement and excitement, and the panels should be made so that they contribute to this feeling. In direct contrast to this, what the guides did not want too much of on the panels, is theoretical physics. They found this too hard for the visitor to understand, and for them it was not the most important thing to explain. Therefore, theoretical physics should only be included on the panels *if absolutely necessary for understanding.*

The number and placement of the panels was also discussed during the interviews. The guides stressed that not too many panels should be put up; otherwise the focus on the 'real' visuals, viz. the detector and detector parts, as well as the construction area, would disappear. Some guides mentioned 3-4 panels, although this number is dependent on the length of the tour, the number of stops during the tour, and the guide's freedom to use as

many panels as he or she likes. Still, the fact that too many panels can make the tour into a blackboard lecture is important, and should be taken into consideration. The placement of the panels is also connected to the number. The guides wanted the panels in the proper illustrative places, where they explain something that the panels show. They did not want the all the panels in one location, but scattered around at various spots of the tour. This, again, prevents all the information coming at once, thereby not having any tools for explaining when stopping at other sites. It also gives the possibility to refer back to the general picture, as long as the panels allow this.

Loosely connected to the panels, but, according to the guides, very important for the tour, was the use of illustrative objects to support certain explanations. If possible, they wanted to have access to detector parts, material, or other objects to visualize what they were talking about. If one talks about the complexity of a cable, the weight, material it consists of, etc., it is convenient to be able to show it to the visitors, to let them feel it and compare it to a 'normal' cable, for example.

Lastly, some guides asked to be included in the panel-making process. Some early sketches could be presented to the guides for evaluation. One guide asked for a seminar when starting tours to a new site. Since many guides are experts on their own projects, and not familiar with other work, this could be a good idea to prevent giving out vague and even wrong information during the visit. This kind of incompetence might result in many unanswered questions, leaving the visitor with the feeling of having participated in an incomplete visit. The involvement of the guides in the panel construction and the thought of a guide seminar is, though, already recognised by the Visits Service.

The interviews revealed the guides' appreciation of the panels. They consider the panels important for themselves and their explanation, with the main focus on illustrative drawings and pictures. The latter should be detailed yet simple, preferably 3D, in corresponding colours. Text should be kept to an absolute minimum, and only serve as a reminder for the guides. The visitors should not read and not be encouraged to read the text. Guides ask for the right analogies to connect the facts given on the panel to more familiar situations. This might be useful, but it is rather recommended that the guides themselves provide these analogies when explaining the particular topic, again to avoid including too much text. The panels should give the opportunity to refer back to the general picture, by showing the visitors where they are, what they will see, where they are going, how what they will see is placed in the complex and what they will see when moving on to a new place, maybe even how they will go there (viz. above/underground and how this looks like in the accelerator complex). A site should not have too many panels, and they should not be collected in the same place. According to the guides, the panels themselves have an important explanatory value, but their explanation must be supplemented by real-life objects, to illustrate even more what the visitor sees and hears about. The guides want to be included in the panel-making process, and the thought of a seminar for guides to a new site was introduced. All these topics, save the last which falls outside the scope of this study, were transformed into a questionnaire put up on the CERN guides' web page, to get the guides' opinion about the main themes surrounding the use of panels at guided tours. On the web page, all guides were asked to fill in the

questionnaire, and they could state their background. This would give an answer to whether guides with different backgrounds expect different things from the panels, in particular referring to the theoretical physics issue. It is now appropriate to turn to the results of these questionnaires.

6.4 The Guide Questionnaires

The guides' questionnaire was terminated after three weeks, and a disappointing 16 guides returned an answer. Considering the fact that CERN employs 200-300 guides, the group of guides that filled in the questionnaire is less than 10 % of the overall guide body. A reason for this might be that few guides actually read the guides' web page[10]. Therefore, the results are considered less than representative, but they still give an overview of the guides' opinion on panels at guided tours. It is recommended that these issues be investigated further.

Compared to the guides' professional background as stated by Catapano (2001: 6), the breakdown into the backgrounds as given in the questionnaire shows an agreement. Physicists are the largest group, constituting 7 persons, or 44 % (Catapano: 51 %). 6, or 38 % are engineers (Catapano: 29 %), while 1 mathematician, 1 chemist, and 1 administrative personnel make up the remaining 18 % (Catapano also included technicians and computer scientists; no guides answering the questionnaire stated these). The guides' backgrounds are shown in figure 6.8. For convenient use, physicists, mathematicians and chemists are combined to make scientists. This gives the following categories:

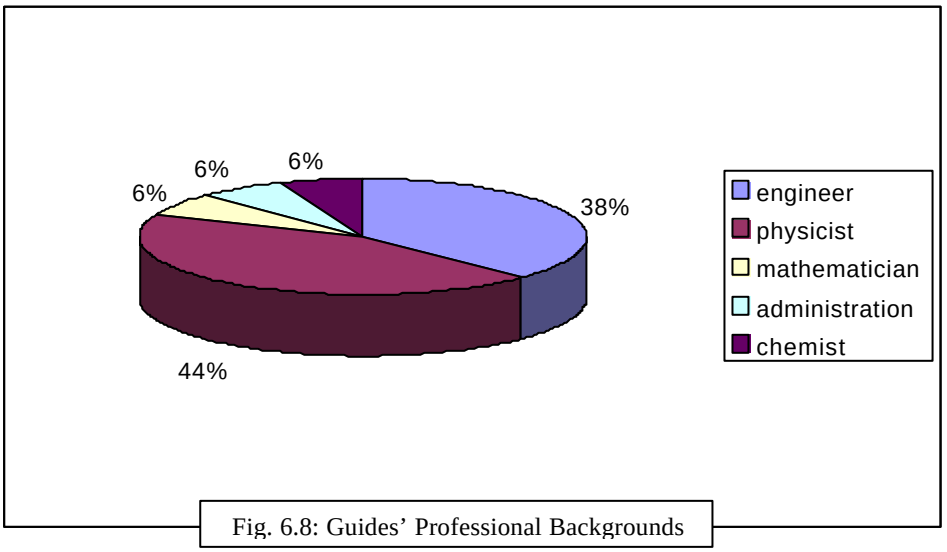

Fig. 6.8: Guides' Professional Backgrounds

[10] Something the Visits Service is fully aware of.

? Scientists (9 persons, or 56 %)
? Engineers (6 persons, or 38 %)
? Administrative personnel (1 person, or 6 %)

When the answers to the claims are analysed for all the guides, they mostly agree with the findings of the guide interviews. As can be seen in fig. 69, there seems to be little disagreement that guides should be involved in the panel making process (question 1), and that the panels are an essential part of the guided tour (question 2). The guides' opinions are different on the number of panels, with a slightly higher percentage agreeing that 3-4 panels are sufficient for a guided tour (question 3). Most guides agree that panels should be scattered around the visit itinerary (question 4).

On panel content, the guides again agree on many claims. Only when asked whether to include particle physics in the tour, the guides' views split, as it can be seen in fig. 6.10, with a slightly higher percentage disagreeing that particle physics is of less importance and should not be emphasised (question 6). All or nearly all guides agree that schematic drawings (question 1), the construction process (question 2), the LHC complex (question 3) and collaboration (question 4) are important and should be included on the panels. They, too, see the text mainly as a reminder for themselves (question 5). They want to have the possibility to refer back to the general picture (question 7), and the drawings should be big and simple (question 8). Finally, all guides agree that the panels should have a few, big drawings (question 9). As for explanatory material, it is observed in fig. 6.11 that the guides acknowledge the importance of tangible objects (question 1), their opinions are equally divided on the use of video (question 2), and future suggestions such as VR or a camera system are welcomed by a little more than 60 % of the guides (question 3).

When the backgrounds are broken down into categories, a few interesting points arise. The engineers agree with most claims, except for the one about text as a reminder for the guides. Here they are equally divided, unlike the issue of particle physics, where they show some disagreement with the claim. They also largely disagree that video projections, VR, or a camera system is of any use during the guided tour. The scientists are divided on the claims about the number of panels per itinerary. They, to some extent,

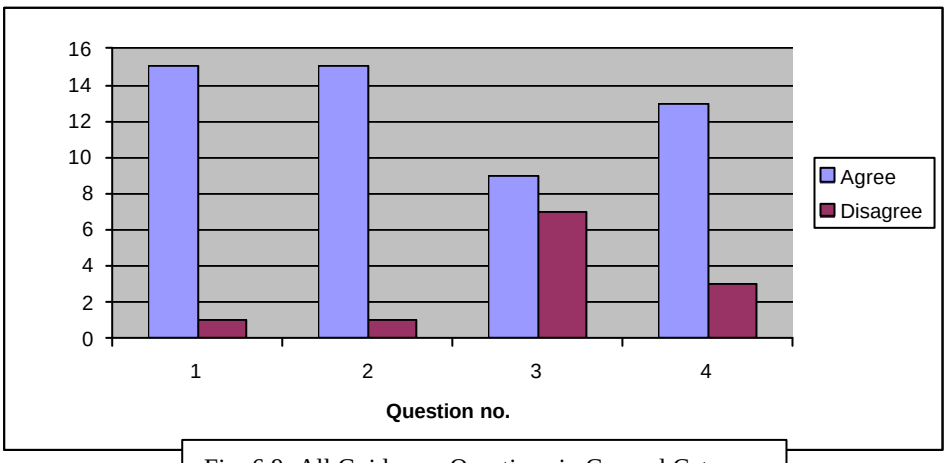

Fig. 6.9: All Guides on Questions in General Category

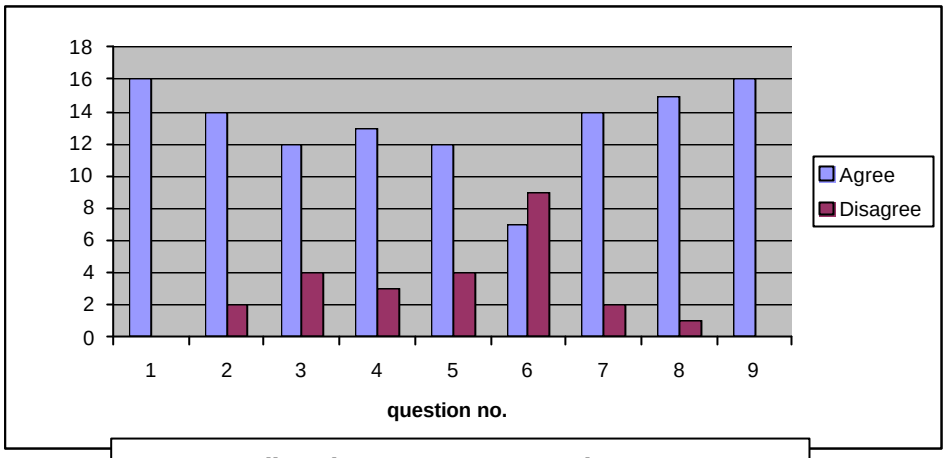

Fig. 6.10: All Guides on Questions in Panel Content Category

disagree with the claim that particle physics is not an essential part of the guided tour content, but mostly agree on all the other claims. There is full agreement on the issues such as guide involvement in panel making, the importance of schematic drawings and construction process on the panels, but also that the panels provide the chance to refer back to the general picture, the importance of tangible objects, and the size of the drawings. The one answer coming from the administrative personnel gives no big surprises. The administrative guide agrees with all claims, except on the issue of particle physics, and whether video, VR or a camera system is useful during the guided tour. Also for this guide, a few, big pictures on the panels are preferable.

When comparisons are made between the guides with different backgrounds, the first thing noticed is that, although during the guide interviews it was revealed that none of the interviewees preferred talking about particle physics during the tour, many guides disagreed with this claim on the questionnaire. It was expected that physicists and even other scientists would disagree with the claim, but, since the interviewed guides were engineers, it was not expected that so many engineers (66 %) would disagree. Another surprise was that 4 out of 9 scientists agreed with the claim that theoretical physics would be inappropriate during the tour. Regarding the guides' background and interest, this

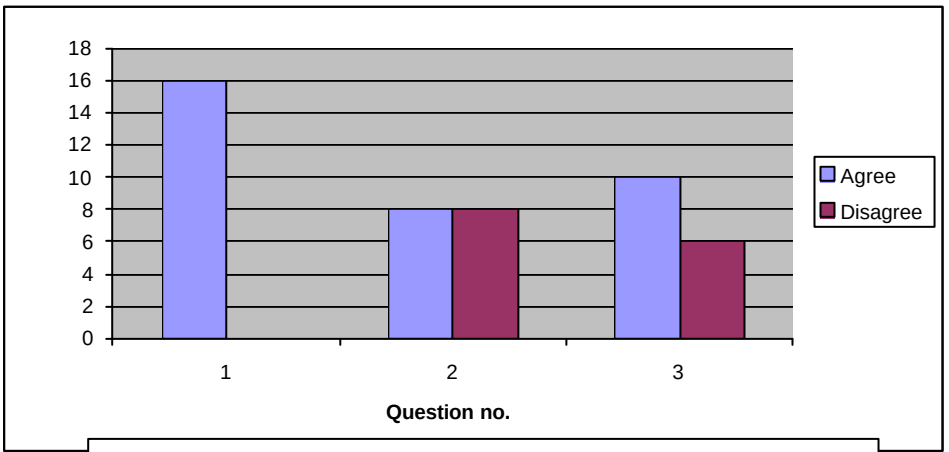

Fig 6.11: All Guides on Questions in Explanatory Material Category

seems a high number. Scientists, more than engineers, saw the alternative of having VR or a camera system as useful, nearly 90 % of the scientists against only 33 % of the engineers.

The results of the guide questionnaire have revealed what the guides think of the panels, their value and content. The guides see the panels as essential to the guided tour, and they want to be involved in making them. They want to have the panels scattered around the visit itinerary. Regarding the panel content, the guides agree that they should contain schematic drawings, explain the construction process, illustrate the LHC complex, both above and under the ground, as well as collaboration. The text should only serve as a reminder for the guides and should present technical information, generally as little text as necessary. The panels should give the guides the possibility to refer back to the general picture, and have a few, big and simple, drawings. Tangible objects are a must for the guided tour, but suggestions of video projections, VR, or a camera system are not as popular. The opinions are divided on the matter of theoretical physics and in what amount it should be mentioned on the panels, and on the number of panels per itinerary. The results present no surprises except for the large number of engineers disagreeing that theoretical physics should be kept to a minimum, and the amount of guides in total not seeing video, VR or a camera system as a good support during the guided tour. Such options might be an advantage for the CERN guided tour; for example, due to safety regulations some areas might not be accessible. It is recommended that these possibilities be explored further.

It is interesting to compare what the guides think of how panels should be with how they think the existing panels are, and how much they use them. Fig. 6.12 shows the opinions of all guides on existing panels. Of all guides, concerning CMS, 3 thought they were ‘very good’, 9 judged them as ‘good’, 3 were ‘neutral’, while 1 rated them ‘bad’. For Atlas, 8 thought they were ‘good’, 5 ‘neutral’, while 2 rated them ‘bad’. AD was seen as ‘good’ by 2 guides, ‘neutral’ by 5, ‘bad’ by 3 and ‘very bad’ by 2. For PS, 1 thought they were ‘very good’, 3 thought they were ‘good’, 3 ‘neutral’, and 4 thought they were ‘bad’. CMS and ATLAS are hence seen as the best panels by all guides. If the guides are divided into their respective backgrounds, there are no noticeable changes. The fact that

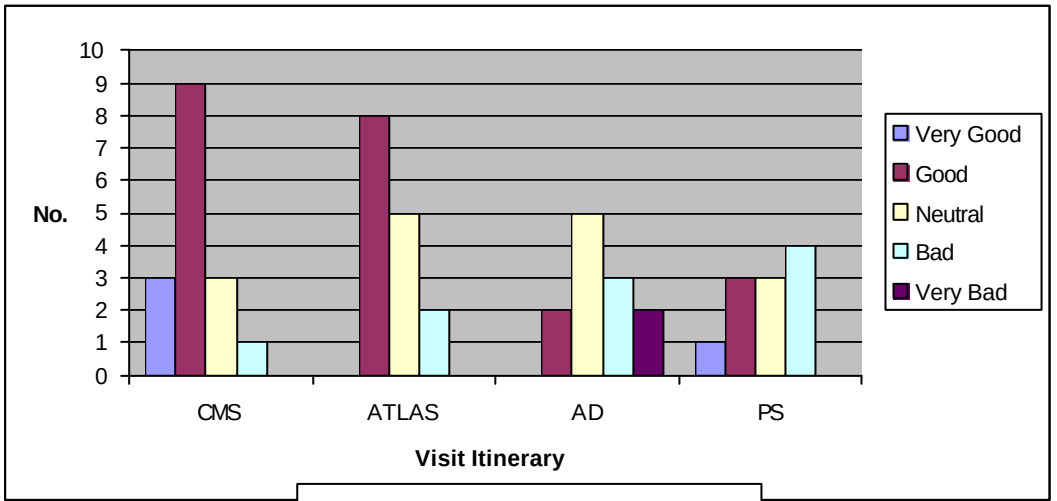

Fig. 6.12: All Guides on Existing Panels

many judge the AD panels as ‘neutral’, ‘bad’ or ‘very bad’ (83 % of the guides altogether) might be because the panels do not have the content that the guides, in the questionnaire, agreed on. The two guides rating the panels as ‘very bad’ were an engineer and a physicist. The panels at ATLAS and CMS largely have this content, and are therefore judged as ‘good’ or ‘very good’ by 75 % (CMS) and 53 % (ATLAS) of the guides. For PS, more tend to see the panels as ‘neutral’ or ‘bad’ (64 %) than ‘very good’ or ‘good’ (36 %). The guide rating the panels ‘very good’ was the mathematician. The panels at PS contain lots of small, complicated pictures, and much advanced text. Not surprisingly, it seems that the panels that have the content the guides agreed on in the questionnaire are rated better than the ones that do not have this content.

Stating their use of the existing panels, 15 out of all guides claim they ‘always’ use the panels at CMS when leading a guided tour there, while one claims he or she ‘sometimes’ uses them. For ATLAS, 9 ‘always’ use them, 4 ‘sometimes’ use them, and 1 ‘never’ uses them. At AD, 3 ‘always’ use them, 3 ‘sometimes’ use them, while 3 ‘never’ use them. Finally, at PS, 2 ‘always’ use them, 6 ‘sometimes’ use them, while 2 ‘never’ use them. By background, the scientists are the most frequent users of the CMS panels (100 % always use them), while the engineers use the ATLAS panels the most (100 % always or sometimes use them), closely followed by the scientists (89 % always or sometimes uses them). The one guide from the administration is not considered here. The AD panels are always or sometimes used by 75 % of the scientists and 50 % of the engineers, while for PS the numbers are 100 % and 75 %, respectively. This causes some interesting relations. Although 64 % of the guides rate the panels at PS ‘neutral’ or ‘bad’, 80 % still use them. Especially the engineers seem to use the panels although they rate them bad; 100 % rate the panels at AD ‘bad’ or ‘very bad’, but still 50 % always or sometimes uses them. For the physicists, the numbers are 66 % and 75 %, respectively. This shows that the guides are dependent on the panels for their explanation, which was also reflected by the 94 % seeing the panels as an essential part of the guided tour.

These results strengthen the claims of the questionnaire regarding panel content. The guides seem to prefer the panels with schematic drawings, little text and big pictures. Even though some panels are rated bad, the guides still use them; this is because they see them as an important part of and good support to their explanation. In spite of the small number of guides who answered the questionnaire, it still gave some support to the points revealed from the guide interviews. It is suggested that these tendencies are investigated further, and that it is asked why the guides rate the existing panels the way they do. It would also be interesting to explore deeper the guides’ view and the possibility of using other visual material, such as video, computers or virtual reality.

6.5 The Construction Process

The construction process was first meant to last for 9 weeks, but it was extended for another 3 weeks. This was done because, although expected in the beginning, it became clear that the panels would not be ready in time for the whole construction team to see.

Since this paper was finished before the whole construction process was ended, only the first 9 weeks will be described. It can be argued, though, that this was the most important period. The construction of panels is based, as much as possible, on the conclusions reached from the discussions above.

The first set of panels is meant to be installed at a new visit itinerary point, LHC-b (see Appendix A8). Unlike many of the other existing itineraries, at LHC-b the visitors can go underground. This is considered a major advantage, since it will contribute to giving the visitor a feeling of amazement, as well as showing them all sides of the research conducted at CERN, and not just the assembly phases above the ground. Relying on the conclusion of the studies, it was necessary to convince everybody involved in the panel-making process that, among other things:

- The panels should mainly serve as reminders for the guides
- The panels should not contain too much theoretical physics
- The panels should not contain too much text
- The panels should be designed and placed so that they always give the possibility to refer back to the general picture, thereby showing where the visitors are, where they are going, and what they are going to see.
- Acronyms should be avoided.

In other words, the panels should give the guide as much freedom as possible to deliver his or her own explanation, and not let the panels dictate what should be said. If the guide had a more specialised group of visitors, e.g. visiting physicists, the guide should not be without any visual support to explain about theoretical physics. But the guide should neither feel the need to stop at one panel with theoretical physics, and explain something he or she would judge incomprehensible. All panels should be used during any kind of tour, and no panels should be redundant in any case.

The responsible scientists from LHC-b had many good ideas, and an agreement was achieved as to the number of panels, the content, placement and the amount of text. It is normal CERN policy to have text in both English and French, since these are the two official languages at CERN, and it covers the majority of visitors. There would be one panel giving an introduction to the theoretical background of the LHC- and the LHC-b experiment, basic enough to be understood by the layman, but not limiting the guide from explaining more if he or she guides a more expert group. The title of this panel is 'Answering the Mysteries of the Universe.' The second panel would show the LHC-b collaboration, through a world map with the countries participating outlined and the names of the institutes mentioned, as well as the LHC-b's place in the LHC complex, and zooming out from there to show a general schematic overview of the LHC-b cavern and detector (title - 'LHCb: An International Research Facility'). These panels will be installed above ground, serving as an introduction to the LHC-b, and explaining where the visitors are, where they are going, and what they are going to see. Since the LHC-b detector is installed in the same cavern as the previously operating DELPHI detector, once downstairs, there would be a panel showing a schematic overview of the DELPHI

detector, with a picture of the disassembly process, a picture of an event[11] that occurred in the detector when it was still operating, and a stamp from Macau, dedicated to the DELPHI detector (title - 'Delphi: Past Experiment and Current Data'). This panel should be made so that it would be easy to compare DELPHI to LHC-b, pointing out similarities and differences. The last two panels would be dedicated to showing how the LHC-b operates, i.e. what is being detected where (title for both – 'Hunting Down B-Quarks'). Since the detector consists of many small parts with individual functions, it would take many panels to explain all these parts. So it was decided to focus on what was measured in the detector rather than how every part functioned. The first panel shows the sections responsible for the tracking of the particles and measuring the momentum of the particles[12]. The second panel shows the sections responsible for measuring the energy of the particle and the identification of the particles. Each panel shows a 3D schematic drawing of the detector, with the sections focused on highlighted from the rest of the detector. All of this could be done on one long panel, but to preserve the correct scale of the detector, it was decided to use two panels. Zooming out from the detector drawing would be a schematic drawing of a part in this section and a photograph of an element connected to the parts described, two on each panel. At the moment of writing, it is still not decided whether the photographs should show one of the parts responsible for the measuring, or an important element in the part. But what is principal is that photographs will support the explanation of the measuring functions of the detector. It was not decided either whether it was possible to display some tangible objects.

Regarding the text, the first panel contains pieces of text, explaining in one or two lines the four stages of the development of the Universe. The panel shows the Big Bang, followed by 10^{-12} seconds after the Big Bang. At this point, the LHC comes in, by recreating the condition present in the Universe at that time. The third stage is 380 000 years after the Big Bang, when the Universe became transparent, while the last stage is now. Accompanying each of these text boxes is a question regarding the stage, on the subject of why conditions were like they were, or why something particular happened. These questions are meant to stimulate further questions from the visitors to the guide, and give the impression that science does not have answers to everything, but many puzzles still remain unsolved. It is indicated that with the LHC we hope to answer, or at least see the beginning of an answer to, some of the questions. This panel is considered to be all what is needed to give the necessary background for the visitors to understand the functions and purpose of the LHC and the LHC-b detector.

On the second panel, only one text box appears, expressing an interesting fact. To give the visitor a feeling of excitement, the text, too, contributes to this. The guide can use this text as the foundation for his or her explanation. The third panel, on DELPHI, has 4 text boxes: one giving a fact about the DELPHI detector in the same manner as for the LHC-b on the second panel, and three boxes accompanying the pictures, explaining in one

[11] An event is generated when two particles collide, producing a range of new particles. In a detector, this is recorded and later analysed by the scientists.

[12] 'Tracking a particle' is nothing more than the detector noticing that something passed, leaving a trace of its direction and velocity. 'Momentum' is the quantity of motion in a moving body, expressed as the product of its mass and its velocity.

sentence what is seen. Here also the text aims at being a basis for the guide's explanation. On the last two panels, two text boxes explaining how the measurements occur are present. The number of panels is 5. They will be placed at two stages, one upstairs for an introduction and explanation while waiting to go down, and one downstairs, with a possibility to visually realise what is seen and explained on the panels. It is anticipated that most of the time will be spent upstairs.

In accordance with the results of the study, the panels give the guides the freedom to base the tour on their own explanation, not letting the panels do the talking. The panels always give the possibility to refer back to the general picture, they contain little text and the amount of theoretical physics is kept to a minimum. The schematic drawings are detailed yet easy to understand, and when possible, accompanied by photographs. Only on one thing the panels are in disagreement with the results of the study, namely corresponding colours. Since the colours of the different parts of the detector are not known at this point, it was decided to give the schematic drawings colours which made it easy to separate the different parts. Still, some colours were known, and these were incorporated in the drawings. The visitors' wish to have bigger text and more languages, as emerged from the visitor questionnaire, cannot be granted. First of all, the attention will easily be drawn to the text, the visitors will try to read and they focus away from the guides' explanation. The guides want to avoid this. Secondly, bigger text and more languages will give less space on the panels, and cases of 'information overload' might appear (Grinder and McCoy 1985: 85). The panels should be kept simple, and in order to achieve this, the text must be kept to a minimum. Some visitors also requested more time to read. While deciding on this is outside the scope of this paper, it is, following the guides, recommended that this wish is granted only when the tour is finished, and there is still some time available. It is not necessary to interrupt the flow of the tour so that visitors can study the panels on their own, since the panels are present primarily to assist the guides' explanation.

The other set of panels, 2 in total, are different than the panels for LHC-b. As it was remarked earlier, these panels are initially not part of a guided tour, but will be later. They are constructed for ATLAS to be used during the Open Day at CERN. It should be possible for visitors to read them on their own, but a volunteer will be present to explain. It was therefore decided that the text could be slightly more advanced, and the amount of text could be bigger. Also here the text is in both English and French. The first panel shows an event in the ATLAS detector (title not yet decided). It shows the detector in different sections, and how different particles interact in different sections, also which particles interact where. Above every section is a drawing of the detector with the corresponding part highlighted. In between is a text box for the part, explaining shortly how the reaction comes about, and how the detector registrates it. There are four different sections, and four different text boxes on the sections. One additional text box is dedicated to explaining what an event is, while a second text box explains the different particles. Besides the 'event drawing' is a picture of the detector with the magnets highlighted, as well as a text box describing these. In front of the panel, there will be tangible objects from each part corresponding to the order on the panel.

The second panel is the last part in a series of 9 panels on the ATLAS detector and collaboration in general. This panel will show and describe the civil engineering process of excavating and building the cavern in which the ATLAS detector will be installed (title – '…In One of the Largest Experiment Caverns Ever Built'). The panel contains a sequence of 5 pictures showing different stages of the process. Pictures containing people at work were chosen deliberately to show sizes and scales. Each of these five pictures is accompanied by a text box of no more than two sentences. As a background, a photograph of the beam pipe is shown, with people in it. Finally, the dimensions of the ATLAS cavern are given in a text box.

These two sets of panels presented different challenges, for the text and sometimes also the drawings and photographs. The panels for LHC-b are used for guided tour purposes *only*; they therefore contain schematic drawings, little text and little theoretical physics. They are made in a way that gives the guide the possibility to refer back to the general picture, and enough freedom to make the tour something else than a lecture. The ATLAS panels, on the other hand, are also for study-alone purposes. They therefore have some more text, which is a bit more advanced, and the panels are also more aesthetic. But both sets of panels follow to a large degree the results from the study, when this was possible.

All in all, the collaboration with responsible scientists was fruitful, due to the ideas and enthusiasm they presented for the project. The real major disagreement mostly arose when writing the text. Ravelli notices that 'the process is likely to break down after the editing stage, if the scientific and education staff disagree as to the best version of a text' (370). Some recommendations are in place now:

- The collaboration was fruitful *because* of the many ideas that the scientists had, but it should be made sure that they actually have them when the project starts;
- When presenting drafts and/or suggestions, make sure they are ready; this leaves minute space for criticism other than constructive, and little time is wasted on going back and forth between small details;
- It is easier to ask the scientists what they want to say, and then turn that into something understandable. In this way, what everybody wants to say is preserved optimally in the best way of saying it;
- The text should be accessible, meaning that it should not presume a high level of scientific knowledge (Ravelli 1996: 371), but neither compromise the scientific integrity of the information needed to be conveyed.

7. Discussion and Conclusion

Throughout this paper, some rules have been established for making optimal panels and employing other exhibition techniques to be used at CERN guided tours. This was done by examining literature on guided tours in general, describing the CERN guided tours and comparing these to the ones at museums and science centres. The expression *to explain* was discussed, matters explained at CERN guided tours were presented, and the literature on communicating such issues was reviewed. This completed the picture of what the explanatory panels should present. In the second part, the study investigating the guide and visitor use and appreciation of existing panels and other techniques was presented. From this study, it can be concluded how subjects at CERN guided tours can optimally be explained by means of explanatory material. Many less general topics have already been discussed and conclusions have been reached. In this chapter, the remaining results of the study will be discussed and an overall conclusion will be offered.

The results on which the making of the panels is based, come from two sources: the discussion of what the panels should explain in part I of this paper, and the study in part II, which revealed how this should be done so that the panels would be of optimal assistance to the guide. It has already been concluded that the panels are an essential part of the guided tour, both the visitors and the guides recognise this. What the guides find important to the content of the panels has already been mentioned, and a summary of this, as well as the whole study in general, can be found in the 'best practice' guide (Appendix A9), which was presented to the Visits Service at CERN. Still, some topics remain to be discussed. These are: the visitors' view on *studying* the panels, the result that many visitors feel they learned something from the panels besides what the guides told them, the guides' wish to be included in the panel-making process, the usage of the term 'theoretical physics' and how much of the information already given at the introductory seminar should be repeated on the panels and during the guided tour.

During the guide interviews, it was quickly established that the main purpose of the panels is being of assistance to the guide. The visitors should not read the panels alone - this would destroy the flow of the tour, focusing the attention away from the guide, who is the main source of information. From the visitor observations it was concluded that the visitors do not seem to study the panels. While answering the questionnaire, though, they claim that they do read the text and study the panels without the guide focusing their attention on them. Even more, the visitors want to be given the time and opportunity to study the panels. They want bigger text on the panels in different languages. Although the visitors might interpret *study* differently than was intended, these questionnaire results are in disagreement with the observations. But this is not surprising, since label reading is extremely hard both to observe and to self-report, as McManus (1989) points out. It is therefore concluded and must be expected that some visitors will always at least try to

read the text. As Falk & Dierking (1992: 70) note: 'All visitors capable of reading read some labels; no visitor reads all labels.' The text on the panels must hence be so that it serves as a reminder for the guides in case of a forgotten fact, but not so much that it will serve as a distraction for those visitors who do try to read the text. Following the recommendations of Serrell (1996: 84), sentences no longer than 30 words are preferred, and so is only one paragraph. The text on the panels limits itself only to the most essential facts for understanding and giving a coherent explanation, usually no more than two sentences. 'The texts must work *as text*' as Ravelli (1996: 369) notes. Since the information presented at the tour should not be too difficult, neither should be the text. The main facts like height, length or weight, and perhaps something awe-inspiring, accompanied by the right analogy to make it understandable (although this might not always help), is all that is needed. The rest of the talking should be left to the guide. Studies have shown that labelling improves visitor's concept development, even when relatively briefly exposed (Falk 1997). Thus, as much as possible, the panels should contain a 'headline', giving a brief summary of the panel's messages or 'big idea'. This, too, should serve as a reminder for the guide, mostly for knowing what to say when, without thereby limiting the guide's freedom of explaining.

From the visitor questionnaires, it was found out that 78 % felt they learned something from the panels besides what the guides told them. This is a very good result; it shows that the panels, although it is not their main purpose, have an explanatory value in themselves in addition to being a support tool for the guides. Some aspects should be noted, however. First of all, it is possible that the visitors did not think clearly enough about 'besides what the guide told them', meaning that they answered 'yes' to the question if they felt they *remembered* something from the panels, e.g. a fact or a drawing. Secondly, since the visitors knew the questionnaire was about panels, and they felt very satisfied with the tour (which, as studies have shown and was mentioned above, they largely do), they wanted to give some sort of praise. Since a 'no' to the question would have been of negative value, the visitors were tempted to answer the opposite. Thirdly, the expression *to learn* was not specified, and the visitors might have interpreted it differently that the author of the questionnaire. Nevertheless, these considerations are not conclusive, and when regarding the panels and even other explanatory material this result is still taken positively, but with caution.

The guides' wish to be included in the panel-developing process finds support in the literature. As Alfonsi states: '...when asked to express their opinions interpreters ask to become part of the creative processes, or at least to know more about them' (2001:11), while Wanless (1990:68) found that explainers wanted to be included in exhibit design. According to Falk and Dierking (1992: 143), 'this is a positive approach to exhibition design; ultimately, the human link between the exhibit and the visitor is likely to be the most important determinant of public understanding and learning.' The guides' experience and background is very valuable when deciding what should be on the panels, and perhaps, too, how it should be communicated. As Roberts (1997: 67) notices: '...interpretation [is] about communication; and effective communication requires bridging the world of the expert and the world of the layperson with language that [is] intelligible to the latter without being a misrepresentation of the former.' Consequently,

the panel construction is seen as a harmonic co-operation between scientists, guides and science communicators, and the construction process confirmed this.

Some tension can be found in the usage of the term 'theoretical physics'. The purpose of the term was presented in the introduction of this paper, and it was explained during the guide interviews. The interviewees all agreed on the usage of the terms 'theoretical' - and 'particle physics', and no misunderstandings were encountered. Still, from the questionnaires it was found out that the number of engineers disagreeing with the statement that theoretical physics should not be an important part of the guided tour, or the panels, was higher than expected. Much of these results can be connected to a misunderstanding of the term 'particle physics' as used in the questionnaire. Some hold, most plausibly, that CERN is all about particle and theoretical physics. Certainly, CERN does rest its foundations on these fields of research, but the science in action that visitors experience has little to do with this abstract background. The visitors see the detectors, they are explained the purpose and functions of these, and what experimental results can be expected. Of course, particle physics should not be left out wholly, since, besides being based on the theories, the results from the experiments conducted at CERN will, most likely, strengthen many of the theories that constitute the theoretical part of the research. But the crucial point is that the theoretical part should be kept to a minimum, it should be used only if absolutely necessary for understanding. This theoretical part of physics is not the science in action that the visitors come to see, and not what they will experience when they visit CERN.

In the introductory seminar to a guided tour, the visitors are given general information about CERN: the subject of CERN's research and how it is achieved, CERN's mission, the international collaboration, the importance of fundamental research and its impact on society, and some theories of particle physics. The introduction contains a lot of information, often quite abstract and complex. The visitor will, here as well as at the experimental sites, gain many impressions during a short time. It cannot be expected that the visitor will remember all of this information. Therefore, some samples of the information presented during the introductory seminar can be mentioned again on the panels and during the guided tour. Topics such as the collaboration and how the research is conducted at CERN will naturally be a part of the guide's explanation. Some of the information about particle physics given to the visitors during the introduction can, if necessary for understanding, be repeated, but not on a whole panel. Here the general recommendation on theoretical physics applies. It is hence not redundant to repeat some of the information given during the introductory seminar, as long as this information does not challenge the visitors' understanding too much, and it follows the logical order of the tour.

To sum up the study and literary background, the panels should give the guide, regardless of profession, knowledge, level of scientific comprehension of the visitors or other features, the complete freedom to develop the tour as he or she desires. The panels should inspire the guide to talk from own experience, devotion and passion for the research being conducted at CERN. This goal is reached by making the panels not more than a support tool in the guide's explanation. In the end, the whole character of the explanation

relies on the guide, and the panels are there only to assist. The panels do not direct the guide's explanation, but inspire at the right point and remind of essential information. The crux of the CERN guided tour is to communicate what is done, how it is done, what goals should be reached and who is participating. The visitors want to see science in action, and they are given this opportunity at CERN. The objectives state that the tour is not a learning tool, but a communication tool. It is important that this is clear from the beginning, since, as Love (1994: 53) indicates, 'they [objectives] constitute the framework of the tour.' The visitors will get an insight to research at CERN, the guide will explain about the research, and the panels will assist this explanation. By keeping the panels simple, the guide will get the necessary freedom of explanation. The panels are kept simple by having little text and a few big pictures. The number of panels is not too big, so that no more time than necessary is spent in front of them, and they are scattered around, making the tour flowing rather than a static lecture. It is only necessary to communicate the most basic facts on the panels; the guide will do the rest. The guides have expressed a wish to be included in the panel-making process; this wish should be granted.

When the new sets of panels for LHC-b and ATLAS were constructed, it was attempted to follow the results of the study as much as possible, and in the end, it was done successfully. The results compile the guides' opinion about what should be on the panels, the visitors' use and appreciation of the existing panels used during a guided tour, as well as observations of guide and visitor use of these panels. In the course of the study it was established what should be explained, and how this should be done. As said, these results were used, as much as possible, as the basis on which the panels were constructed in order to optimally assist the guides' explanation, leaving enough freedom to make the tour a lively experience for the visitors.

It was observed and concluded that the CERN guided tour, or a guided tour to any other scientific laboratory, differs much from guided tours to museums and science centres in general. Therefore, it cannot be said that the results obtained from this study are applicable to the latter. Based on the results of the conduced study, a set of 'best practice' guidelines was developed for use at CERN. The study on exhibition techniques used during guided tours to scientific laboratories has been both front-end and formative. An evaluative study to confirm the validity of the results and the usefulness of the panels is a natural next step.

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Appendix A1: CERN

As a reaction to the building of powerful accelerators in the US after WWII, the creation of a European Laboratory was recommended at a UNESCO meeting in Florence in 1950, and less than three years later a Convention was signed by 12 countries of the Conseil Européen pour la Recherche Nucléaire. CERN was born, the prototype of a chain of European institutions in space, astronomy and molecular biology, and Europe was poised to regain its illustrious place on the scientific map. As ratified by the parliaments of the member states, the Convention specified that the laboratory be officially called the 'Organisation Européenne pour la Recherche Nucléaire' or 'European Organization for Nuclear Research'. However, the name of the Council stuck to the organization, which is why it is referred to in the literature as simply 'CERN.'

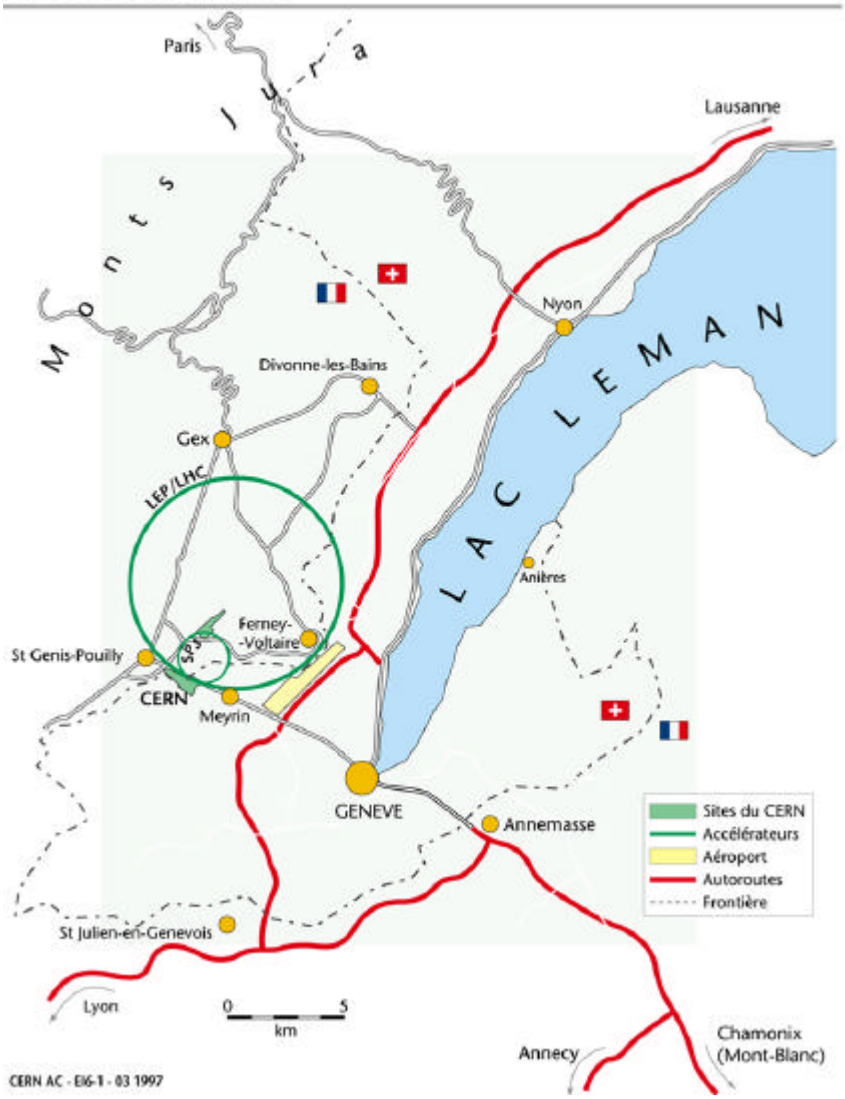
CERN exists primarily to provide European physicists with accelerators that meet research demands at the limits of human knowledge. An accelerator is a machine in which beams of charged particles are accelerated to high energies. In the quest for higher interaction energies, the Laboratory has played a leading role in developing colliding beam machines.

CERN houses a small hands-on science centre, Microcosm, which exhibits models, videos, computer games and original pieces of equipment. The permanent exhibition Microcosm opened in 1990, and was given a complete facelift in 1997, updating the contents, introducing more interactive displays and adding many new exhibits. Microcosm attempts to explain the basic principles of high energy physics in a way which is easy to understand and enjoyable to all. It explains the basic principles of high energy physics in a way which is easy to understand and enjoyable to all. The science centre attracts over 20 000 visitors each year.

LHC

LHC is the abbreviation for Large Hadron Collider, the successor of the Large Electron-Positron Collider (LEP) at CERN. LEP's scientific programme came to an end in October 2000 after 11 years of activity. The years 2000-2007 will see the installation of LHC in the former LEP tunnel. The LHC is an accelerator that brings protons and ions into head-on collisions at higher energies than ever achieved before. This will allow scientists to penetrate still further into the structure of matter and recreate the conditions prevailing in the early universe, just after the Big Bang. The LHC will be built astride the Franco-Swiss border west of Geneva, at the foot of the Jura mountains, in front of the Alps.

Carte de situation

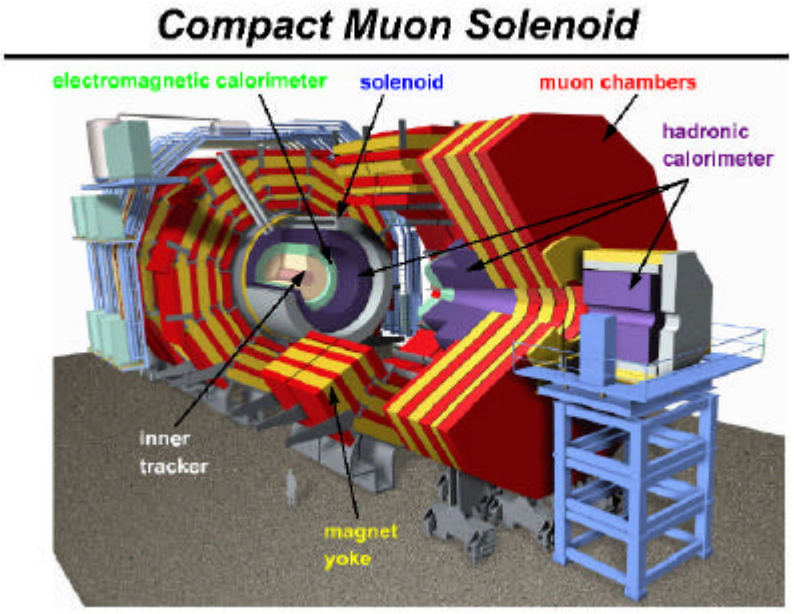


Appendix A2: The CMS Experiment

CMS (Compact Muon Solenoid) is a general purpose Proton-Proton detector (a detector is a device used to measure properties of particles) designed to run at the highest luminosity at the LHC. The total weight is 12500 tons, double that of the ATLAS detector, even thought ATLAS is about 8 times the volume. The CMS magnet will be the largest solenoid ever built, and the maximum magnetic field supplied by the solenoid is 4 Tesla - approximately 100000 times the strength of the magnetic field of the earth. The amount of iron used as the magnet return yoke is roughly equivalent to that used to build the Eiffel Tower in Paris, and the energy stored in the CMS magnet when running at 4 Tesla could be used to melt 18 tonnes of solid gold.

The CMS detector is one of the largest international scientific collaborations in history. As of February 2003 there are 2300 people working for CMS, 1940 of which are scientists and engineers. These people come from 159 institutes in 36 countries, spanning Europe, Asia, the Americas and Australasia.

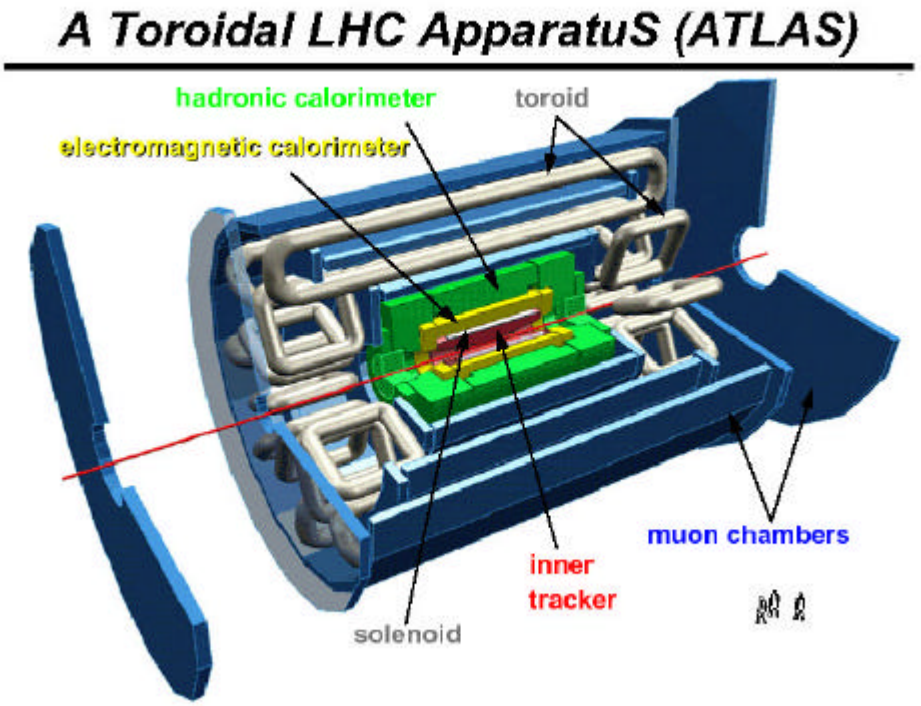
In total CMS will have 15.000.000 individual detector channels, all of which will be controlled by powerful computers. At the LHC, bunches of protons will pass through each other 40 million times a second, and with each bunch crossing, 20 proton-proton collisions will occur on average, making 800 million collisions per second.



Appendix A3: The Atlas Experiment

The ATLAS (A Toroidal LHC ApparatuS) Experiment is a very large collaborative in the physical sciences. 2000 physicist from more than 150 universities and laboratories in 34 countries are participating. The ATLAS detector is currently under construction at the CERN laboratory, and will, when completed, be about the size of a five-story building.

One of the main goals of the ATLAS program is to discover and study the **Higgs particle**. The Higgs particle is of critical importance in particle theories and is directly related to the concept of particle mass and therefore to all masses.



Appendix A4: The Guide Questionnaire

Dear Guides,

New visit points will soon be opened to the public, in particular to LHCb. The Visits Service is in the process of preparing the panels and, where possible, exhibition areas to illustrate the explanations. This questionnaire is intended to provide us with the guide's point of view – please take the time to fill it in, we value it very much. Some of the results will be used as part of a Master Thesis by an administrative student.

The first part is about the panels in general; the second part refers to the panel content, the third to explanatory material for use at the guided tours, while in the last part we ask you to give your opinion about panels at existing visit itineraries.

General

1. Guides should be involved in the evaluation of new panels:

☐ Agree ☐ Disagree

2. The panels are an essential part of the guided tour:

☐ Agree ☐ Disagree

3. There should not be more than 3-4 panels per visit itinerary

☐ Agree ☐ Disagree

4. Panels should not, if possible, be collected in one place:

☐ Agree ☐ Disagree

Panel Content

5. The schematic drawings and overviews of the detector and its main parts are essential, and should be illustrated on one (or several) panel(s):

☐ Agree ☐ Disagree

6. The construction process is very important (e.g. LHC construction, detector construction and LHC/detector space construction), and should be illustrated on a panel:

☐ Agree ☐ Disagree

7. It is important to illustrate the LHC complex, both above and under ground, on a panel:

☐ Agree ☐ Disagree

8. Collaboration is very important, and should be illustrated on a panel:

☐ Agree ☐ Disagree

9. The text on the panels serves mainly as a reminder for the guides. The panels should, therefore, contain as little text as possible, mainly presenting the dimensions of the detector and the detector parts, and other technical information:

☐ Agree ☐ Disagree

10. It is not the aim of the guided tour to teach particle physics. Therefore, there should be no panels on particle physics, and particle physics should only be included if it is absolutely necessary for understanding:

☐ Agree ☐ Disagree

11. The panels should provide the possibility always to refer back to the general picture (e.g. by also showing the whole detector when presenting its main parts):

☐ Agree ☐ Disagree

12. The drawings on the panels should be big and simple:

☐ ☐

Agree Disagree

13. The layout should be so that there are: Other:_____

☐ ☐ _____

Few, big pictures Many , small pictures

Explanatory material

14. Touchable objects, e.g. detector parts or other illustrative material, are essential and should be included at the visit itinerary:

☐ ☐

Agree Disagree

15. Video projections, such as at CMS, are very helpful and illustrative, and should be included, if possible, at the visit itinerary:

☐ ☐

Agree Disagree

16. To be able to illustrate issues difficult for panels (such as LHC, when operating), objects or video projections, a Virtual Reality or camera system would be a good alternative:

☐ ☐

Agree Disagree

Existing panels

17. How would you judge the existing panels at:

CMS:	☐	☐	☐	☐	☐
	Very good	Good	Neutral	Bad	Very bad
ATLAS:	☐	☐	☐	☐	☐
	Very good	Good	Neutral	Bad	Very bad
AD:	☐	☐	☐	☐	☐
	Very good	Good	Neutral	Bad	Very bad
	☐	☐	☐	☐	☐

PS:

Very good Good Neutral Bad Very bad

18. Do you use the panels at:

CMS: ☐ Always ☐ Sometimes ☐ Never

ATLAS: ☐ Always ☐ Sometimes ☐ Never

AD: ☐ Always ☐ Sometimes ☐ Never

PS: ☐ Always ☐ Sometimes ☐ Never

19. Additional comments or suggestions:

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20. Please state your background (e.g. engineer, physicist, computer scientist, administration, etc.)

Thank you for your help!

Appendix A5: Questionnaire – Panels (Q1)

1. When you entered a new site (e.g. when the guide stopped to show or explain something), what was the first thing you noticed?

---

2. Did you read the text on the panels?	☐ YES	☐ NO
3. Did you use (e.g. read, study, look at) the panels even when the guide did not focus your attention to the panels?	☐ YES	☐ NO
4. Were the panels of any assistance to illustrate what the guide explained?	☐ YES	☐ NO
5. Do you feel you learned something from the panels besides what the guide told you?	☐ YES	☐ NO

6. Please write down a short comment about the panels, and any suggestion you might have for improvement:

Thank you!

Appendix A6: Questionnaire – Panels (Q2)

2. When you entered a new site (e.g. when the guide stopped to show or explain something), what was the first thing you noticed?

---

2. Did you read the text on the panels? ☐ YES ☐ NO

3. Did you use (e.g. read, study, look at) the panels even when the guide did not focus your attention to the panels? ☐ YES ☐ NO

4. Were the panels of any assistance to illustrate what the guide explained? ☐ YES ☐ NO

5. Do you feel you learned something from the panels besides what the guide told you? ☐ YES ☐ NO

6. **What is your highest level of scientific education?** ☐ **High School** ☐ **1-3 year University** ☐ **>3 year University** ☐ **None**

7. Please write down a short comment about the panels, and any suggestion you might have for improvement:

Thank you!

Appendix A7: ATLAS and CMS Panels

BÂT. 180:

Main ATLAS detector panel – ***Recreating the conditions just after the Big Bang***

Showing the ATLAS detector, describing the tracking detector, magnet, calorimeter and muon spectrometer

A spectacular piece of engineering

Describing what can be seen at the assembly site

BÂT. 191:

A spectacular piece of engineering…to solve some of the mysteries of the universe…through international collaboration

More general on the ATLAS experiment, with some theoretical background (Antimatter, Dark matter, The Higgs particle etc.). One drawing showing collaboration overview.

Other panels on ATLAS site Bât 180 (not made by the Visits Service**):**

- ? LHC: Accelerator Chains of CERN
- ? LHC: The Natural Successor of LEP
- ? LHC: Some Major Technological Breakthroughs
- ? Physics
- ? The Magnet System
- ? Installation of the Atlas Detector
- ? Overview and Performance

All found on the opposite wall of Main ATLAS panels, some damaged

CMS Panels (BÂT. 3585)

Visitor platform:

1. The Higgs Particle
2. CERN
3. LHC: Underground Microscope
4. Compact Muon Solenoid
5. Installation
6. From the Big Bang to Stars
7. CMS Collaboration
8. Transverse slice through CMS

8 on opposite wall of 1-7, objects located below 8.

CMS hands-on objects:

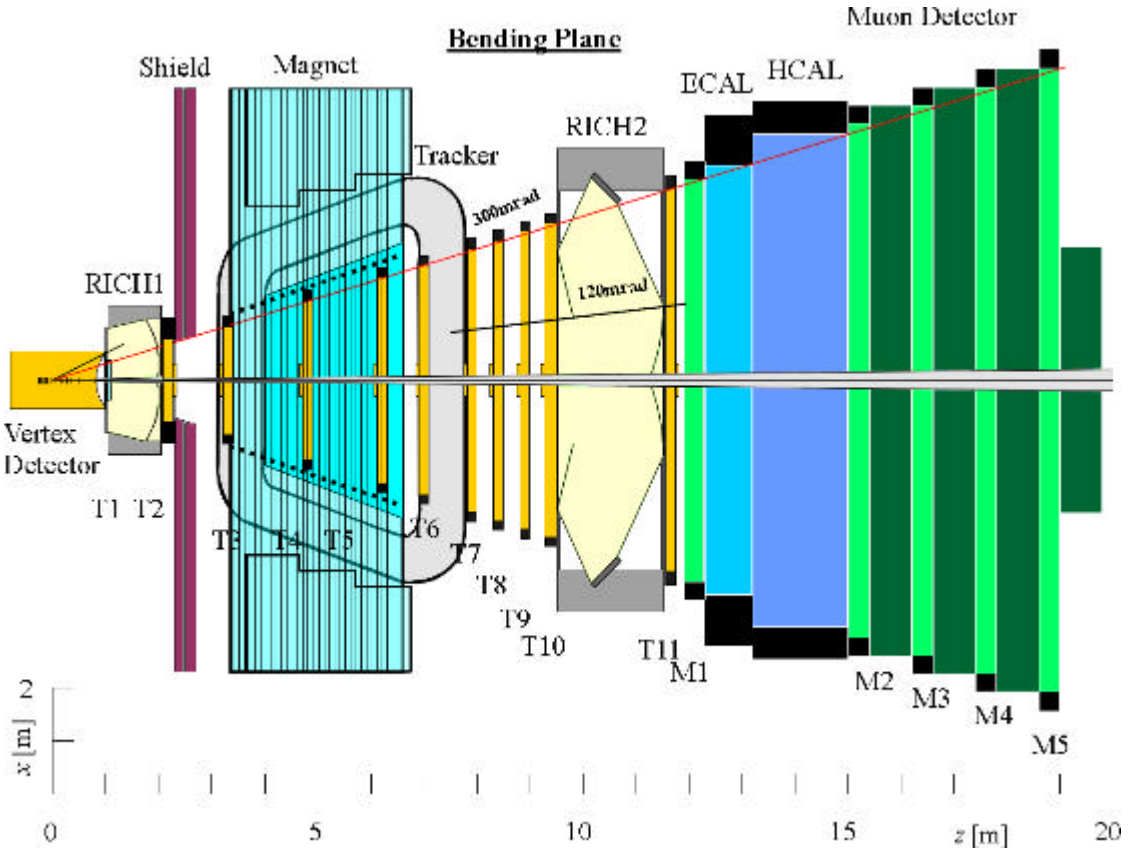
1. Superconductive piece of the solenoid/wire of CMS
2. Crystal (to feel difference between normal crystal and CMS crystal, made of Lead Tungstate)
3. Fiberoptic cables

Appendix A8: The LHCb Experiment

The **LHCb** detector is a specialized tool designed with one goal in mind. That makes it less complex than the big general purpose LHC detectors, ATLAS and CMS, and allows the collaboration to concentrate its efforts on building the best possible detector for studying CP violation and other rare phenomena in decays of hadrons with heavy flavours, in particular B mesons. Interest in CP violation comes not only from elementary particle physics but also from cosmology, in order to explain the dominance of matter over antimatter observed in our universe, which could be regarded as the largest CP violation effect ever seen.

565 scientists from 47 universities and laboratories from 15 countries are involved in the design and construction of LHCb, with support from many hundreds of technicians and engineers. The LHCb apparatus will be the most sensitive instrument ever created to detect tiny differences between matter and antimatter.

LHCb detector: Top View



Appendix A9:

Findings of a Study Focusing on the Use and Appreciation of Existing Panels by Guides and Visitors

The 'Best Practice' Guide

Thomas Keilman

CERN
April-June 2004

Contents

1. Introduction

In this paper, I present the findings of a study conducted to investigate the use and appreciation of existing panels at CERN guided tours. A more thorough description and analysis of the study exists in my Master Thesis, and here only the main findings are brought out. The creation of two sets of panels, one at LHC-b and one at ATLAS, are already based on the findings of the study. The results are intended to serve as 'best practice' guidelines for the Visits Service at CERN. The study was conducted in the spring of 2004 at CERN, as part of a Master Thesis in Science Communication at Högskolan Dalarna, Sweden.

The recommendations in this paper are by no means rules. They can be interpreted by anyone as he or she wishes and considered as suggestions based on the findings of the study. These recommendations can serve as inspiration, adapted to the panel purpose.

2. Background

Panels are considered to be an essential part of a guided tour. They assist the guides in their explanation, serve as a reminder in case something is forgotten, and make abstract facts visible and more understandable for the visitor. But the panels used at the various itineraries differ in form and content. Panels put up by the Visits Service are very different from panels put up by the scientists or engineers working at an experimental area. Sometimes it seems as if the scientists and engineers want to say as much as possible, use as many figures and as much math as possible, without considering how this affects the tour. The panels developed by the Visits Service, on the other hand, are aesthetic, more picture-based, colourful and present easily digestible information. But do these panels show enough, or show the information they should in the right way? Guides also have different backgrounds. Some are engineers and love to talk for hours about technical details. Some are physicists and cannot be happy without having included at least a considerable amount of Higgs theory. Some are computer scientist, or administrative staff. Some are not involved in the project they present and may therefore lack confidence in their own knowledge. How can we make panels that serve all these purposes? Should we make panels that serve all these purposes?

I based my study on the credo that 'the guide should do the talking, not the panel'. The panel should serve as an inspiration for the guide, as a reminder when he/she forgets something, and as a visual tool for his and her explanation. The panel should not dictate what is to be said, how, and when. Only the guide can make the tour flow and alive. Only the guide can give the tour a character that will make the visitor remember it positively. Therefore, when making the LHC-b and ATLAS panels, I tried to leave space to give as much freedom as possible for the guides to present the visitors their own individual explanation, shaped by their personality and experience. All guides are different, and all guides explain different things in different ways. This should be taken into account when developing panels. The guides are also scientists or engineers, and they carry along a unique gift that they can pass on to the visitor. The visitor gets an insight into how work is conducted at CERN and what the daily life of a CERN employee is like. The guide is the only one who can give the visitor this information. No panel could ever do that.

What should the panels explain? In my thesis, I try to answer this question. The panel assists the guide in his or her explanation. The panel presents what the visitor sees and hears from the guide. According to the objectives of the guided tour programme at CERN, the tour is not a learning tool, but a communication tool. Many visitors are not considered educated scientists. Many will never understand the Higgs mechanism, and do they really have to understand it? Is it then necessary to dedicate a panel to it? By observing guided tours, I discovered what guides explained, and how they did it. And, it must be admitted, not many said much about the Higgs boson. It should not be expected that visitors leave CERN after the guided tour with a full understanding of accelerator

physics. The tour should give them an insight into the research at CERN, excite with the size of the tools used, and amaze with the complexity of the collaboration. It should give a better understanding about the nature of international scientific research and an interest in science.

The panels are a part of the guided tour. They are not, at least in most cases, stand-alone panels that are studied independently by the visitors. Some guides expressed the concern that visitors studying panels on their own would destroy the flow of the tour. Time is limited and safety regulations are strict. We do not want visitors wandering off alone, doing and touching what they want. For me, the text is a main issue. Visitors will always try to read the text. A lot of text might encourage, conscientiously or unconscientiously, visitors to keep reading on their own for a longer time. This should be avoided, because a visitor reading on his and her own will understand less. And as we all know, understanding creates a positive feeling. To have visitors leaving with this kind of positive feeling, I wanted to make it nearly impossible for the visitors to be distracted from the guide's explanation.

To find answers to these questions, and more, I conducted a study where I tracked groups of visitors, asked visitors to answer questionnaires, interviewed guides and prepared a questionnaire for the guides. Some of the parts were more successful than others, but they all provided useful information about the use and appreciation of the existing panels. In the next chapter, a short summary of the study and the results are presented, as well a description of the construction process.

3. The Results

The study mainly consisted of two parts: the tracking and questioning of visitors and the interviewing and questioning of guides, as well as the construction process. Since the study is thoroughly described in my thesis, I will only summarize it here.

In the tracking process, I followed 7 groups of visitors participating in a guided tour, noting down any signs of usage of the panels, both by visitors and guides. All of the tours were to either ATLAS or CMS. It provided me with useful information about what panels guides use, what panels seem to interest the visitors most, which panels are used in which explanation, if visitors study panels actively, and so forth. Although, as I discuss in my thesis, it might be difficult to observe if visitors *study*[1] panels, the tracking gave a picture of the visitors' usage of panels, as well as the guides'.

Hardly any visitor was observed studying the panels. In one situation, a man clearly studied the panels on his own. Other features about this man were an obvious interest in the subject and a smaller interest in listening to what the guide had to say. In another case, during the same tour, an elderly gentleman was observed studying one panel on his own. His female companion later told me that his English was rather bad. Maybe this was the reason, he didn't understand the guide and discovered on his own. Again, at the same tour, one person posed in front of a panel pretending to explain something, while another person took a picture. This might not be considered the optimal usage of panels, but at least it indicates an interest. I concluded that the majority of visitors do not study the panels.

The guides used panels actively; the latter seemed essential to the explanation. But what interested me more besides this (obvious) fact was what panels the guides used. It was quickly revealed that other panels than detector overview and structure, accelerator overview, construction process, real-life pictures of the experiment and everything associated with it, etc. were of less interest to the guide. Only in one case, a theoretical physics panel was used, even then not to its full potential. In other words, panels showing schematics were important, other panels seemed secondary.

104 questionnaires were handed out to visitors right after their visit, usually on the bus ride to the reception, or at the reception. 103 were completed, and the answers gave an insight into the visitor appreciation of the panels. It became clear that visitors saw the usefulness of the panels: some noticed them first while entering a new site (30 % of the returned questionnaires), nearly all (96 %) found them of assistance to the guides explanation and a considerable amount (78 %) thought they learned something from the panels besides what the guide told them. More interesting, though, was the fact that many visitors (68 %) claimed they read the text; even more (78 %) claimed they studied the

[1] In the discussion, 'read' was the issue, not 'study'. I believe that 'study' is a stronger notion than 'read', and can be easier to observe. If this is true or not, I leave for the reader to decide.

panels without the guide focusing their attention on them. In my paper, I try to discuss the meaning of 'study', but what can be concluded from this is that visitors do *try* and *want* to read the text. This was also visible from the numerous comments on the questionnaire. The same fact was in disagreement with my initial stance that visitors should not read the text. At both ATLAS and CMS the panels contain an amount of text that cannot be neglected, and this strengthens the suggestion that the text should be kept to a minimum.

Yet, it is not the visitors, but the guides, for whom the panels are made. They are present for the guide to use in his or her explanation, not for the visitors to be read individually. So I expected the most interesting results to appear from the guide interviews and questionnaire. I interviewed guides until a pattern was found, no new issues were brought up, and points were repeated. The most important properties that guides asked for from the panels were:

- An opportunity to refer back to the general picture. If the detector is shown, also show its place in the LHC complex. If a sub-detector is shown, show its place in the detector itself.
- The visitors should know where they are, where they are going and what they are going to see. Especially when entering a new site, for example, include a picture of the LHC accelerator sowing them where they are, and a picture of the detector they are going to see.
- Do not include large amounts of text on the panels. Text should serve as a reminder for the guides, and not for the visitors to study on their own. Include dimensions (with appropriate metaphors, naturally) and other 'dry' facts, not discourses on various abstract themes.
- If possible, schematic drawings should be 3D, and the colours on the drawings should correspond to the real colours. Photographs are useful to supplement these schematics, giving a feeling of how things look like in reality.
- The international collaboration at CERN is very important and should be emphasised on (at least) a panel.
- The abstract scientific background, the theoretical physics, on which the experiments at CERN are based, is hard to understand for the visitors, and it takes to much time to grasp. Leave it out unless *absolutely necessary for understanding*.
- Have few panels (3-4 was a frequent number), with a few big pictures, preferably not collected in the same place.
- Real-life objects, e.g. parts of the detector, are very illustrative, and the visitors also seem to appreciate them[2]. They are essential and should be included at any itinerary.
- Guides appreciate if they are included in the panel-making process, e.g. the evaluation of sketches or other drafts.

One fact that should be considered is that all the interviewed guides were engineers. This might account for the view on theoretical physics. In the guide

[2] Something I also discovered during the tracking.

questionnaire, guides were asked to state their background, so that we could get a picture of panel content and usage in relation to professional occupation.

The above-mentioned themes, and more, were transformed into 19 statements to which the guides could answer 'agree' or 'disagree'. The questionnaire was put up on the guides' web page, and guides were encouraged to fill it in. When this paper was final, only a discouraging 16 questionnaires had been returned. Whether guides do not find the time, do not understand the purpose, or do not find the subject of any interest is hard to tell. Few might visit the web page or the questionnaire might have been too long. But concluding from the guide's interview, they must see the importance of this work. Some interviews went very well, the guide showed an obvious interest in discussing the panels. Others were more reluctant, giving short answers. But no one left the impression that talking about it was a waste of time. Then again, it is easier to say 'no' electronically than face-to-face. I will leave the speculation here.

Although answers to the questionnaire were few, they largely supported the main points extracted from the interviews. In the questionnaire, it was specifically asked for the guide's background, to see if there are any interesting tendencies, especially regarding the amount of theoretical physics during the tour. Starting from the beginning, the guides agreed that:

- Guides should be involved in the panel-making process
- Panels are an essential part of the guided tour
- Panels should not be collected in the same place
- Panels should have schematic drawings and overviews of the detector and its main parts
- Construction process, the LHC complex both above the ground and under, and the collaboration are important enough to be emphasised
- Text should mainly serve as a reminder and be kept to a minimum
- Panels should give the guide the possibility always to refer back to the general picture
- Panels should have a few pictures, big and simple.
- Touchable objects are very important as support for the guide's explanation

On these issues, 75 % or more of the guides stated their agreement. Never did the guides disagree on such a large scale. The three issues where the guides were divided, the number of agreement and disagreement being around 50 %, were:

- There should be no more than 3-4 panels per visit itinerary
- Explaining particle physics is not an essential part of the guided tour
- Video, Virtual Reality (VR) or a camera system are or can be good support during the guided tour

The second issue did not come as a surprise.

Analysing further, I especially looked at the background when a guide revealed his or her opinion on particle physics. Physicist and other scientists disagreed with the claim, although only 55 %. I expected the percentage to be slightly higher. What I did not expect, was that 66 % of the engineers *disagreed* with the claim. It would be more likely that engineers emphasise technical details or facts, not the theoretical scientific background.

When asked to rate the existing panels, the guides rated the ones highest those that had the features mentioned favourably in the interviews. This largely means the panels at ATLAS and CMS. Respectively 53 % and 75 % rated them 'good' or 'very good'. The panels at AD and PS were rated worse, in both cases more rated them worse than better, and it looks truly dark for AD; 83 % rated them 'neutral', 'bad' or 'very bad'. Dividing by background did not give noticeable changes. We also asked the guides to state how much they use the existing panels. The panels at CMS were used ('always' or 'sometimes') by 100 %, at ATLAS by 93 %, at AD by 66 % and at PS by 80 % of the guides questioned. So even though the guides rate the panels as bad, they still use them. This strengthens the claim that the panels are an essential part of the guided tour, and that the guides see them as an important support to their explanation. By background, the physicists were the most frequent users of the CMS panels, and the engineers of the ATLAS panels.

The guide questionnaire has clearly shown what the guides prefer to have on the panels, strengthening the claims already extracted from the interviews. By their rating of the existing panels, these claims get even clearer. As for the explanatory support, such as touchable objects, video, VR or a camera system, all being positive to the first, few were positive to the latter three. These issues are more thoroughly discussed in my thesis, and I recommend reading the discussion there.

To summarize the study, the most important results are connected to the panel content. The panels should always have the possibility to refer back to the general picture. They should not have too much text, and the text should mainly serve as a reminder for the guides, refreshing their memory with facts, numbers and details. But, as with normal label writing, the text should be linked to something seen on the panel. If you write about the detector, show the detector. If you write about quark-gluon plasma and the LHC, show this. The schematic drawings, if possible, should be 3D in corresponding colours. Overview of the detector, construction process, and the LHC above the ground and under are the most important issues. Use photographs to supplement these drawings, showing how things look in real life. Include the international collaboration at CERN. Do not plan too many panels, 3-4 is enough, and scatter them around, rather than collecting them at the same place. To give a feeling of the modern technology used, have objects to illustrate things seen by the visitor and explained by the guide. At a certain stage, include the guides in the evaluation process. But the bottom line is: *the panels should contribute to giving the visitor a sense of amazement and wonder of seeing such an exciting place as a CERN experimental site.*

4. Checklist

This checklist serves the purpose of being an inspiration. The following questions I asked myself when constructing the panels at LHC-b and ATLAS. If you want to follow all of them strictly, feel free to do so. But rather than being dogmas, I want them to be a source of inspiration, interpreted by the independent panel-developer.

- Do the panels and the pictures on the panels give the guide the opportunity to refer back to the general picture?
- Do the visitors know where they are, where they are going to and what they are going to see?
- Are the schematic drawings easy to understand and in corresponding colours?
- Are photographs included to supplement the schematics?
- Is the text a reminder for the guide on important facts, and not serving as a distraction for the visitor?
- Can the text be linked to something visual on the panel?
- Is the international collaboration clearly shown?
- Is the theoretical physics necessary for understanding, and not superfluous?
- Is the number of panels kept to a minimum, without taking away the guide's visual aid?
- Are the panels scattered around, in proper places, corresponding to what is seen?
- Are objects present, in proper places, to supplement the explanations, illustrating details of things seen?
- Are guides consulted during the panel-making process?