Procedure(s) of visualization: tracking the processes of knowledge production in particle physics experiments during the twentieth-century.

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1. Introduction and general aim

Recent scholarship in the history of science has put forward that, more than be seen as the juxtaposition of matter theories and their conceptual development one the one hand and of experimental practice involving scientific artifacts on the other, scientific development should be understood as formed by different layers mostly independent each other but presenting, however, certain stabilizing connections: in this sense, (matter) theory tradition, (atomistic) iconography tradition and object (artifacts) tradition comprise structures of knowledge which are invariant (and so basically autonomous) with respect to the great revolution happening in the neighborhoods. By working on a selection of the artefacts of the Deutsches Museum, the scholar Arne Schirrmacher investigated to what extent the history of artefact could claim autonomy and power to define knowledge structure with respect to other traditions for our understanding of matter: his conclusions concern the key-role of artefacts like the Ultramicroscope, the Debye-Scherrer camera, the Lenard's cathode ray tube and The Franck-Hertz tube in illuminating the process of establishing new theories, models and images of the atom between the 1872 and 1914-15.

The present project aims at broadening this research framework by investigating - through a further selection of objects and instruments of the twentieth century belonging to the Collection of the Deutsches Museum - a fourth layer of the scientific development and investigating its stabilizing connections with the others: the one of the experimental procedure. Pioneering researches on experimental procedure, have been carried out but Peter Heering working on the models of solar microscope. After sketching the framework of historical researches on experimental procedures in physics (§2), I will introduce the topic of the project and the research questions (§3). In §4 I will report the results of a preliminary exploration carried out with the help of the curators of the Deutsches Museum – in particular, a bubble chamber and some demonstrative Wilson-like apparatus – and finalize the research questions. In §5 I report the schedule of the project.


A recent paper by Peter Heering discusses the interaction between experimenter and instrument: in contrast to the image of automata operated by anonymous characters that might be derived from traditional accounts of experiments, the relationship appears to be complex and variable. In the paper, historical case studies illustrate how – in some cases - the experimenter’s performance can be heavily shaped by the apparatus while – in other cases - experimenter’s practise is not completely

determined and there is room for personal choices in the performance the experiment. In still other cases then, neither the instrument nor the experimenter can be identified as central for deciding “how to perform the experiment” but social, political or epistemological criteria intervene. Within this framework, procedure, turns to be that 'additional' knowledge – usually unwritten in laboratory reports or accounts/manuals, untold to “others”, acquired in the daily practise of the research – ruling the interaction between experimenter and instruments, i.e. allowing the anonymous character to become a human scientist with skills and expectations, the automata to be a flexible apparatus for creative researches and the cultural environment an active agent on scientific practise.

Interesting research on procedures adopted by scientists in particle physics experiments during the twentieth century have been carried out by Wolfgang Engels at the University of Oldenburg: by re-enacting experiments on Alfa particles tracks working with a full-scale replica of the Wilson’s cloud chamber of 1911, the scholar shows to what extent - in spite of the objective and self-evident character usually attributed to the cloud chambers photographs of the events (the “automatic-generated labour-book”) - the procedure and the methods adopted by Wilson implied choices related to a specific ideal of representation – artistic, more than scientific – to which the scientist were subjected. The research shows to what extent processes of knowledge production were involved in the study of the microscopic events and to what extent the instrument itself – the so-called 'Wilson cloud chamber‘ – can be considered, historically, a reality-creating apparatus.

3. Investigating the procedure(s) of visualization: research questions

Wilson's photograph – which became so famous for allowing to observe, for the first time, the tracks of the Alfa particles - are an early manifestation of a tradition of visualization of micro-world events. This tradition held for the whole twentieth-century physics in spite of the paramount progresses of particle physics on scale and power of experimental machinery, which led to the particle accelerators of the Big Science era passing through instruments like the bubble and spark chambers. In the quoted research, by comparing drawings of discharge tube phenomena reported in popular German encyclopedia published between 1906 and 1909 and an OPAL event taken in 1998 at CERN Schirrmaker identifies the same essential elements which characterize the imagery of modern particle physics - tracks coinciding in one point at different angles, their shape according to electric and magnetic fields and different colours identifying different physical entities.

5 Historians of science have pointed out how the issue turns to be hard to investigate from a traditional perspective: exemplary is a laboratory book by Robert Millikan where he pretends to refer about measurements carried out on hundreds of oil drops but, actually, reports only a description of the instruments and the behaviour of the oil drop, with no reference to “how to do it” (A. Millikan, “The Isolation of an Ion, a Precision Measurement of Its Charge, and the Correction of Stokes’s Law,” Physical Review, 1st Ser., 1911, 32:349 –397.).

The work of Engel is framed within the replication-method applied and tuned by the Oldenburg group in the course of the last three decades which foresees the re-doing the experiment in accordance with information provided in the source documents: the self-reflexiveness of the historians in (re)doing the experiment allows she/he to develop a deep understanding of the experimental procedures, of the skills involved in performing them and of the evolution of the actions in the course of the interactions. Then, the interaction experienced with the instruments allows her/him to re-read the historical sources from an entirely different perspective and shed new light on the original experimenter's results (see, Olaf Breidbach, Peter Heering, Matthias Muller, and Heiko Weber, Experimentelle Wissenschaftsgeschichte (Munich: Fink, 2010))
In Schirrmaker's analysis, “looking into” the matter is a way characterized by “bombardment method”, the use of known particle as probe, the selective study of the properties of the still unknown objects and, most important for the present project, the representational character of the experimental outcomes/data. Already at the beginning of the twentieth century, “looking into devices” as the Lenard's cathode ray tube or the Franck-Hertz experiment put forward the issue of visualizability against the one of visibility of earlier instruments of the “looking at” tradition (like the ultra-microscope or the Debye-Scherrer camera).

In this regard, my research interests – and so the general research questions of the project - concern the understanding of:

a) which kind of procedures - in terms of similar choices employed on data taking, elaboration and presentation - allowed to maintain this stable and permanent iconography of visualizability across the growing variety of the “looking into instruments” which starts with Wilson's photographs and ends (?) with computer-generated images of accelerator, LHC, event;

b) which kind of representational ideal, if any, has been underlying these procedures/choices and what form is assumed by the processes of knowledge production in the representational domain;

c) which kind of “physical-reality” is being created when the iconography of visualization belonging to the research environment becomes “iconography for explanation” to non scientists, i.e. once the photos of latest LHC events, tunnels, magnets, ... become the iconographic apparatus of newspapers articles or textbooks or when demonstrative/teaching versions of original research apparatus are produced and circulated within schools and museums.
4. Selected objects from the Collection of the Deutsches Museum and specific aspects of the project

A previous contact with Dr. Johannes-Geert Hagmann brought me to know about the existence of the following objects belonging to the collection of the Deutsches Museum:

1) Inv.Nr. 53247 Apparat nach Wilson zur Sichtbarmachung der Alpha Teilchen (Leybold), ca. 1925

2) Inv.Nr. 61618 Apparat zur Demonstration der Bahnen der à-Strahlen des Radiums, nach C.T.R. Wilson Fabr.-Nr. C 72743; ca. 1928

3) Inv.Nr. 81241 Diffusions-Nebelkammer (Phywe), ca. 1987

4) Inv.Nr. 74661 Wilson - Kammer (Leybold), ca. 1959

5) Inv.Nr. 1978-389 Zwei-Meter-Blasenkammer Bj. ca. 1964

6) Inv.Nr. 1978-386 Auswertetisch für Aufnahmen der Blasenkammer; Bj. 1964;

These instruments are not actually in displayed and a close look to them in storage must be planned with the necessary preparation as confirmed by Dr. Christian Sicka with whom I had a brief exchange on the matter.

Objects 5) and 6) are a bubble chamber and its reading table for recording. The bubble chamber has been donated by CERN to the Deutsches Museum in 1979. The chamber, 4 mx 4 mx 8 m, 40 tonnes weight, is considered a milestone of experimental High Energy Physics: having been operative from 1964 to 1977, it served for detecting high energy charged particles in 40.5 meters of images. 50 different institutions in collaboration with CERN evaluated images and tracks through complex procedures and documented them in around 600 publications7.

The object is of central interest for the present project, in particular with respect to research questions a) and b). It challenges the historical research on experimental procedure and specify further the research questions under several aspects. One of these aspects is the dichotomy between individual vs collective dimension of experimental procedures: Peter Galison – working on an analogous CERN bubble chamber, Gargamelle - already investigated the collective dimension of the “discovery”: in “How experiments end” he shows how the different communities of physicists working on Gargamelle came to the consensus that ONE “golden event” could be considered as THE “evidence” for the existence of the neutral currents8. The present project, intends to understand how the experimental procedure - meant as agreement on tacit knowledge, research skills acquired in the daily practise of the research allowing experimental results to be achieved and not necessarily reported in papers - can be studied and what form is assumed by the processes of knowledge production – meant as personal choices made in , choices made in treating data and representing results – when “performing an experiment” assumes a so marked collective dimension. When the stages of preparation, detection, analysis, elaboration are no more relying on the work of a single experimenter (say – Wilson) or a single group and when the automatically-generated “labour-book” is constituted by runs and computer-based treatment of the data. With regard to the study of experimental procedure for this object, the previous considerations lead also to understand what role can be played by still-in-working similar apparatus which, although they are not “replica” providing re-enactment of the original experiments. In the issue, I will try to connect the present project with others already running in Germany: a particularly interesting one is certainly

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7 Physikalische Blätter Volume 35, Issue 4, 1979, p.173
Epistemology at LHC carried out at the Wuppertal University and Technical University in Berlin. A third specific aspect concerns the study of this under the profile of **flexibility vs prescriptivity**: upon the occasion of the enactment of the 2 RUN of the LHC in June 2015, newspapers reported how this could be the dawn of a new kind of physics. Considering that, with the detection of the Higgs boson in 2012, an essential element of the Standard Model has just been discovered, it becomes evident how issues of flexibility or prescriptivity concern also Big Science experiments and need to be taken into account.

Apparatus 1) – 4) are demonstrative apparatus and are of particular interest for answering to research question c).

In this part of the project I will exploit the experience that I am carrying out as Humboldt Research Fellow at the University of Flensburg; the project concerns the reconstruction of the transition of cloud chambers and Geiger-Muller counter from the context of the research to the context of teaching or demonstration in classroom or museum. In this regard, I am studying different models of apparatus - conserved at Whipple Museum, Science Museum, Fondazione Scienza e Tecnica Firenze – manuals, school textbooks and catalogue of instruments maker. Beside the technological-embedding aspect - which allow recalcitrant laboratory instruments to be become “portable and friendly” for the use of teachers and students - the project search for the procedural aspects involved in their enactment: the interesting aspect is to understand which kind of knowledge – meant mainly as opportunity for teaching - these apparatus still offer and/or require when they are brought so far from their context; which kind of mathematical models they stimulate about micro-world events or “physical-reality” they create in the imaginary of their users. I would enlarge this analysis with the apparatus conserved at the Deutsches Museum.

Last consideration concern the museological outcomes of the present research. Beyond their historical interest I believe that the project can be insightful also from a museological perspective since it aims at bringing into light what kind of “additional” knowledge characterizes the artefacts of twentieth century physics. In the issue, a preliminary research on question of displays regarding also the Deutsches-CERN bubble chamber has been carried out by Christian Sichau and presented at the Symposium of the Scientific Instrument Commission in 2005.

### 5. Schedule and further information

For the present research I ask a period of 12 months. I am actually following intensive courses of German at the University of Flensburg so as to acquire a fluent reading and understanding of it for the beginning of the scholarship in order to exploit at best the archival resources and talking with the staff.

In months 1-3 I will collect and analyse the material within the Deutsches Museum with the assistance of curators and archivists; months 3-9 will be devoted to a close study of the objects, to tune my research with the on-going research at national and international level and to answer to the specific research questions; months 9 -12 will be devoted to prepare publications and present results in appropriate contexts.

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11 Sichau (2005). Title of the presentation: Things that once were new are getting old - and other Problems of 20th Century Science in the Museum