Why Fundamental Science?

Is it Worth it in Terms of Human and Material Resources?

NordicSpace's Baard Kringen talking to

President of the CERN Council,

Professor Torsten Åkesson

Some areas of scientific research, such as particle physics and cosmology, seem remote from our everyday life and unlikely to bring immediate practical applications for the society. Is this type of research wasted resources or is such research a necessary step to continue the evolution of the society?

The European Organization for Nuclear Research (CERN) is possibly the European organisation that spends most resources on such "fundamental science".

CERN is run by 20 European Member States, each with delegates to the CERN Council. The CERN Council is the highest authority of the organisation and is responsible for all important decisions. The Council, assisted by the Scientific Policy Committee and the Finance Committee, approves programmes of activity, adopts the budgets and reviews expenditure.

The current President for the CERN Council is Torsten Åkesson, from Lund University in Sweden.

NordicSpace asked Torsten Åkesson why such basic research is so important, but first we enquired him of his professional background, as well as his way to his current position of President of the CERN Council.

"I am an engineer in engineering physics, and a have a PhD in physics. Today I am a professor at Lund University. My research area is experimental elementary physics and I am engaged in the ATLAS project at LHC. I worked for several years in the international management of ATLAS. In 2005 I became chairman of the European Committee for Future Accelerators (ECFA), a committee that works with planning for future accelerators in Europe and following up the research in particle physics in the CERN Member States. As chairman of ECFA I was asked by the CERN Council to co-chair a Working Group that formulated a European Strategy for Particle Physics. This Strategy was adopted by the CERN Council in 2006. Upon completion of that I was nominated to be President of the CERN Council, thus, I was elected and started in 2007.

• *Europe spends massive sums of money as well as other resources building and managing large research facilities such as the one at CERN. Does this live up to your expectations in terms of results and progress for the future?*

Firstly, Europe has pooled its resources for the research within the field of particle physics resulting in that most of the installations for such research are placed at a common world leading facility near Geneva, Switzerland. When the resources from all countries are pooled to one common effort, then that effort sticks out of course. So, instead of smaller national installations that would not raise much attention, those resources are put together to make one world leading laboratory.

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Secondly, this will enable us to gain a better understanding of the micro-cosmos; the fundamental constituents of matter and the forces between them. This also gives us insight on how the early Universe evolved since that is governed by these constituents and forces; basic knowledge for us and future generations. Let me give you an interesting example. In the beginning of the previous century, Einstein introduced the General Theory of Relativity. Today, this is used in GPS navigation. I'm sure that at the time when the General Relativity was published by Einstein, everyone thought that this would have no practical applications what so ever.

"The Industry is then Trained in Building Instruments or Components with High-tech Specifications ....."

So, the basic knowledge obtained with such research make us humans understand the world we are in; it delivers to us intellectual value. We cannot say what part of that knowledge that will also deliver to us materialistic value. History tells us that it will, but we cannot today say how that will be done.

Thirdly, execution of this research is technology driving. The research program requires innovations, new technologies and industrialization of state of the art technologies. The researchers knows that R&D is a necessity for finding the answers to the fundamental questions, and this creates a very strong incentive for a pursuing a successful technology programme. This creates as well a technology training programme. There is a large turn-over of doctoral students, engineering-students and post doctors that participate in these R&D activities and then leave the field and enter other activities in society; often industry.

"The Most Well Known Products are the World Wide Web and the Grid"

Finally, to build experiment facilities and equipment requires that industry gets involved; this is a necessity for the large scale production. The industry is then trained in building instruments or components with high-tech specifications beyond what they are used to and high demands on quality control, an activity developing the capacity of that industry.

The activity at CERN and similar centres thus paves the way for technology developing, training of researchers, engineers and the industry. If we look at the exchange of personnel, I believe that about one thousand well educated and well trained persons leave CERN every year to take posts in different positions within the society. They have, in addition to the technological qualifications, experiences in working in an international community, and have a network of contacts all over Europe and the world.

Besides, commercial products can be developed and created based on knowledge from this research area. The accelerator techniques were mainly developed particle physics for scientific use, but the techniques have also a number of other applications. Knowledge from particle physics and its particle accelerators has provided a basis for cancer treatment with protons and light ions, a treatment that allows a much more local radiation treatment strongly reducing the damage of healthy tissues. This requires dedicated large facilities of which several are being constructed across Europe.

At many hospitals one finds different types of radiation instruments, or equipment requiring strong magnetic fields, building on technologies developed by institutes like CERN.

The research area, photon science with synchrotron light sources comes from accelerators constructed for particle physics. The first such sources were re-use of old particle physics accelerators, but also the most recent such sources, like XFEL under construction in Germany, is a result from R&D for a particle physics accelerator.

To guide the particles around in the circular ring at the LHC one must generate very strong magnetic fields. That was only possible with the use of super conducting magnets. The cables required for mass producing such magnets were developed and industrialized for previous particle physics accelerators. This product would not have been available today for super-conducting magnets for e.g. medical purposes if the particle physics programme had not taken place.

The most well known products are the World Wide Web and the Grid. The first was developed to make scientific data accessible for the researchers at CERN's previous accelerator, but well over a decade later, the service has become a "must" for the whole world. The Grid techniques provide the research community with pooled data and computing capacity around the world for extensive calculations, thus saving communities all over the world from investments in larger computer capacity.

"Europe Hold the Position as World Leader in This Field."

The "European Strategy for Particle Physics" was approved in 2006. Might this strategy provide Europe with a leading position within this scientific field?

I will express myself even stronger. Today, Europe hold the position as world leader in this field. We have seen that very clearly through the considerable numbers of researchers from other parts of the world who come to Europe. About 1400 researchers from the USA are involved at the LHC project. Canada has a strong and increasing activity; the same goes for countries such as Japan, Russia and China. CERN is on the way to be the "World Centre" for particle physics. One underlying reason for this is that CERN is an international organisation, while all the other institutes around the world are operated on a national basis.

The Nordic countries have a 10 percent share of the budgets at CERN. Do they have a similar share in terms of activities?

If we look at the number of researchers who come from the four Nordic countries then the activity is in proportion to their investments. For obvious reasons Switzerland, as a host country, has a very high activity within the research, other countries again, have somewhat under the level based on what the investment might indicate. My claim is that Nordic researchers also are placed in the upper part, professionally speaking. However, it is desirable that the Nordic countries increase the activities further, to utilise the investment at a maximum level. Students, researchers and engineers that have stayed at such a large international research facility for a while, undoubtedly obtain valuable knowledge and a network of contacts they can utilize when they go back to their own institutes. I believe that the countries could benefit from an increased flow of people to go to the centre to achieve just that.

"CERN has its Own Programme for Exchanging Knowledge ....."

There are several thousands of scientists who carry out research at, or in connection with the facilities. How do you prevent that great research does not end up in the desk drawer, or in the bookcase?

It is a duty to pass the results to the society in general. Here "mobility" plays an important part. Mobility is a priority task, not only for CERN, but also for all international research. After having stayed at a research facility for a time, the researchers ideally move to a new post, thus, distribute their knowledge to other communities. Publications of research results electronically or as print is another way. Another mechanism is training of teachers in order to increase the contact between the research and the educational community. CERN has its own programme for exchanging knowledge, where teachers stay a while at the centre, follow the research, have contact with the researchers, ask questions etc., and later take this knowledge back to their own institution.

Finally, another type is publication of information to the society through brochures, videos, Web-pages, lectures etc. Thus, the community can communicate directly with the society about their activities, the results etc. It is, as I said, a duty to inform the society how the research community spends the hard earned money they taxpayers provide.

The communication and knowledge transfer activities increase all the time, as it should.

How Many Member States? How is Their Interest Reflected?

Totally we have twenty member states of which five come from the Eastern Europe, and the sixth is in the preparatory phase as candidate country to become the 21st. There are other countries that probably will apply for membership in the very near future. From the member states there are 6700 researchers at CERN. In addition, 2770 researchers come from the so- called observer states and 700 from other states. All continents are represented, but until now only a few from Africa, even though some countries are represented.

CERN is now in the developing phase for the next generation of accelerators, the Compact Linear Collider, CLIC. What is the time schedule?

We think in long terms here, and I believe that the time schedule indicates sometime after 2020. First and foremost we must make the best possible use of LHC. Then LHC may possibly be upgraded once in the next decade before a decision to build a new accelerator will be made. I predict that such a construction can start sometime between 2020 and 2030. However, the R&D for the next generation will require significant resources, and have to be done before construction decisions can be taken. Before deciding on such a significant investment, one must be completely sure that it is the right step to take, from the scientific point of view.

"MAX is a Very Successful Facility and is Used by Many Different Institutions Around the World."

Sweden has also large facilities for fundamental physics in Lund in Southern Sweden. What is the difference between the facility in CERN and the facility in Lund?

The facility MAX-lab[1] at Lund University is in the field of Photon Science[2]. That is another branch of research. This research does not study the fundamental constituents of matter and the forces that act on them, but with e.g. material science. It also serves life sciences and the development of medicine. MAX is a very successful facility and is used by many different institutions around the world. The next step is proposed for construction, MAX IV, which would be an excellent state of the art facility for photon science.

Sweden has invited Europe to place ESS [3] in the same area. Do you see the Øresund region as a potential centre for basic research in Europe?

Sweden has proposed to place the European Spallation Source (ESS) to this region. This is a project directed at designing constructing and operating research facility for using neutrons. Three different places in Europe have been proposed, and the Lund region is one of them. This centre will also revolve around the field of material physics, medical applications and industrial applications. There exists a strong technological connection between a type of linear accelerator that is being developed at CERN and the type that will be used at ESS. Hence, the ESS can strongly profit from working with CERN in the development of the accelerator and target. There is an agreement between ESS Scandinavia and CERN for this purpose, and today there are a number of people connected to ESS Scandinavia placed at CERN who work with accelerator techniques for simultaneously preparing the ESS and the so-called SPL accelerator at CERN. If the decision is that ESS is to be placed in Scandinavia, Sweden has offered to contribute with a third of the cost. The remaining resources must of course be obtained from other countries by forming a collaboration to build such a facility. The decision about the placing will probably be taken during the first part of this year.

Conclusively, how can the activity connected to CERN contribute to the aim of making Europe a leading region within knowledge based economy?

CERN cooperate closely with the EU and the European Commission to ensure that the knowledge that is acquired is made accessible to Europe at such a broad basis as possible. Thus, physicists contribute to fulfil the vision to provide Europe with a knowledge based economy. Ultimately, with the knowledge that is acquired at CERN and the applications connected to this research, not to mention the mobility the researchers have; I am sure the community of physicists will contribute at a positive way.

Footnotes.

1) MAX-lab, located at the northern campus of Lund University, Lund, Sweden, is a synchrotron light source facility and a Swedish National Laboratory. The lab operates three storage rings; MAX I (550 MeV, opened 1986), MAX II (1,5 GeV, opened 1997) and MAX III (700 MeV, will open for experiments in 2008). MAX-lab supports about 600 users from over 30 countries annually. The facility operates 14 beamlines with a total of 19 independent experimental stations, supporting a wide range of experimental techniques such as macromolecular crystallography, electron spectroscopy, nano litography and production of tagged photons for photo-nuclear experiments.

The next generation synchrotron radiation source in Lund, MAX IV, is currently under preparation in the Swedish Ministry of Education and Research and the Swedish Research Council.

2) Synchrotron light is electromagnetic radiation produced by bending magnets and insertion devices (undulators or wigglers) in storage rings and free electron lasers. The major applications of synchrotron light are in condensed matter physics, materials science, biology and medicine. A large fraction of experiments using synchrotron light involve probing the structure of matter from the sub-nanometer level of electronic structure to the micrometer and millimeter level important in medical imaging. An example of a practical industrial application is the manufacturing of microstructures by the LIGA process.

3) The European Spallation Source is a project to design and construct a next generation facility for research with neutrons.

Neutrons can see inside the material: they penetrate deep into matter, and reveal “where atoms are and what atoms do”. ESS will be a fantastic and the brightest source of neutrons that will be used for experiments to look inside the materials. It will be the best neutron source worldwide for practically all classes of instruments.