ISA

Institute for
Synchrotron Radiation
Aarhus University

Newsletter No. 3. November 1991

Light in Aarhus

The huge electric switch which the three gentlemen in the picture are pulling was used in the old days when the power company "Midtkraft" wanted to turn on the lights in half of East Jutland.

On April 24, 1991, the switch was used again, but the light turned on now was of a quite different kind. It was the intense beam of synchrotron radiation from ASTRID in Aarhus as shown on the picture to the right.

The three gentlemen who pulled the switch were the guests of honour at the inauguration, namely: Professor Carlo Rubbia, the Director General of CERN, Geneva, dr.techn. J. Rostrup-Nielsen, the Research Director of Haldor Topsøe, a high technology firm in Denmark, and Professor Ruprecht Haensel, the Director General of ESRF, Grenoble.

With a tug on the lever of the switch, they marked Denmark's entrance into the select company of countries which can offer to basic research and to industry the important new research tool of synchrotron radiation. Several hundred guests attended the ceremony, and a number of speakers congratulated Aarhus and Denmark on the new facility, whose existence is the result of the enthusiasm and perseverance of a group of Aarhus physicists.

The inauguration of ASTRID is described more fully in the following.

ASTRID's great day of celebration

Wednesday April 24 was a day of celebration for the Institute of Physics at Aarhus University. Many years of persistence, enthusiasm, sacrifice, and hard labour were celebrated with the official inauguration of the Aarhus Storage Ring Facility, ASTRID.

The first part of the facility, the storage ring for heavy ions, had already been taken into use in the spring of 1990. The celebration marked that the second part, synchrotron radiation, was now also ready for use.

Guests from home and abroad, from research, industry, and central administration attended the inauguration and everywhere could be sensed a happiness and pride that this facility had succeeded in pushing Danish research and development an important step forward.

At the moment there are only five synchrotron radiation facilities in Europe and no other facility in the world combines as ASTRID does the storage of heavy ions and production of synchrotron radiation.

The morning's activities, which took place in the Institute of Physics' Auditorium, were reserved for the three invited speakers: the Director General of CERN, Carlo Rubbia, lectured on high energy physics in the nineties; Research Director Jens Rostrup-Nielsen from Haldor Topsøe A/S talked about the cooperation between industrial and academic research; and the Director General of ESRF, Ruprecht Haensel, described the planned joint European facility for synchrotron radiation at Grenoble.

In the afternoon, several hundred people gathered in a marquee outside the institute to watch on a television monitor as the current to the facility was switched on. Afterwards the speakers' podium was freely available and several people took the opportunity to congratulate the Institute of Physics and to compliment it for the huge effort that had brought ASTRID into existence.

A superb idea

The speakers of the morning session discussed the connections between national and international research and between academic and industrial research.

Carlo Rubbia began by expressing his congratulations on the inauguration of the storage ring.

He described the combination of the storage of heavy ions and the production of synchrotron radiation in the same machine as a superb idea. He also stated that small machines like ASTRID are just as necessary and fundamental as large machines. He pointed out the need for accelerators of many different sizes.

"One can never know where the next fundamental discovery will take place. It might just as well happen in a small machine as in a large", he said.

Thereafter he talked about the future of high energy physics. In the 19th century there was much interest in electrical and magnetic phenomena, which culminated in Maxwell's formulation of the theory of electromagnetism. Similarly, the 20th century has been notable for studies of atoms, nuclei, and elementary particles, and the understanding of these particles is summarized in the so-called Standard Model, which therefore can be thought of as the result of the 20th century.

But the Standard Model cannot be the ultimate theory - it contains 27 free parameters, and that seems to be a lot. Even though the search for free quarks (with an electric charge of 1/3 or 2/3 elementary charge) continues it would be embarrassing if they were found as they would cause a breakdown of the Standard Model.

The detection of the particle postulated by Higgs and others is not without problems either - the direct result of its existence would be that particle mass is no longer conserved. The solution will possibly be found in the concept of super symmetry, which includes a whole new family of particles.

Super-symmetrical particles could also lead to the "Grand Unification" of all types of forces, and to an explanation of why it has not been possible to detect the decay of the proton, since the super-symmetrical particles would increase the lifetime of the proton by 10000 times to 10^{35} years, and therefore take the phenomenon outside the limit of sensitivity of existing detectors. These considerations play a central role in the discussion of the construction of the LHC accelerator.

A good instrument

Jens Rostrup-Nielsen, whose company is the largest industrial user of DESY in Hamburg, stressed that industry should carry out its own basic research. This is essential, he said, because if industry does not participate, then it has nothing to talk about with the scientific world, and will not be in time to discover what's hiding around the next corner.

At the time of the inauguration, Rostrup-Nielsen was still chairman of the Government's Council for Research Policy - a position from which he stepped down on May 1 - and he took the opportunity to express his opinion on how the collaboration between academic and industrial research should occur:

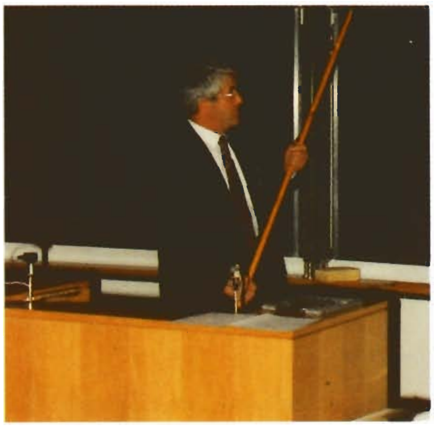
"Seen from the point of view of industry, the most important, the second most important, and the third most important thing is that the universities supply us with highly qualified and ambitious graduates. Here I believe that ASTRID will be a good instrument. We need people who understand modern physics".

"On the other hand the universities should not perform industrially relevant research. That is the best way to loose money. Politicians must realize that basic research should be free. We should not have too many research programs, but rather invest our money in the good research teams".

Basis for education

Ruprecht Haensel described the background for the joint European facility in Grenoble, which will receive the first users in 1994, and he described the great challenges that lie in the building of a facility with a radius of 850 meters.

The intensity of the radiation at ESRF will be a decided improvement in comparison with that of existing facilities, but the size of the facility is also a consequence of the requirement for room for many beam-lines. ESRF expects to receive 2000 researchers a



year when the facility is completed.

"USA and Japan are building facilities of similar capacity and intensity and it is of the utmost importance for Europe that an inter-European collaboration occurs in this field, not only in the construction of ESRF but also between the large and small facilities", he said.

"Therefore, I would like to bid ASTRID welcome, and I hope for a close collaboration with you in the future. I am certain that you have created a strong basis for the education of young researchers, whom we will also have the pleasure of".

Gambling on a winner

When the current to the facility was switched on and the words "Energy 496 MeV" had appeared on the television monitor in the marquee, the chairman of the institute, Bent Fastrup, stepped up to the podium to praise the inventiveness, energy, and drive behind the construction of a facility costing 75 million kroner.

He expressed his thanks to the two people who had led the work, dr.scient. Erik Uggerhøj, the appointed director of ISA, and engineer Robert Stensgaard, who led the technical planning.

The former chairman of the Danish Natural Science Research Council, professor Hans Henrik Andersen, expressed his congratulations, as did the present chairman, lektor Mogens Nielsen. Both had been involved in granting money for the construction of ASTRID.

"There is always a certain element of gambling when a research council hands out money to something new, but I believe that we have gambled on a winner here", said Mogens Nielsen.

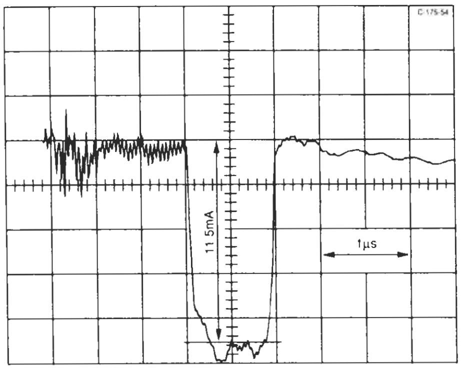
"One of the unique aspects of this project is that knowledge as a motivation and knowledge as a tool go hand in hand here".

Marianne Hofstätter

Electron Storage

The microtron

The microtron reached its design energy of 100 MeV in December of 1990. The pulse current produced was about 5 mA in a 1 µs pulse with a repetition rate of up to 20 Hz. This was used for the first ASTRID electron storage.



During the summer of 1991, microtron performance has been greatly improved. The pulse current is now 11.5 mA in an almost square pulse profile as shown on the figure and small losses from one turn to the next. The current injected into the microtron from the electron gun is about 100 mA, of which the majority is lost due to bunching in the first passage through the accelerating cavity. The microtron has thus fully met its design values.

Niels Hertel

The ring

In the first months of 1991, an electron beam was for the first time stored in ASTRID. In March 1991, RF was applied and the stored current was accelerated from the injection energy of 100 MeV up to 496 MeV without any significant losses of current. The lifetime of the 496 MeV beam was in the order of 20 hours at a ring pressure of a few times 10^{-11} torr, and no increase due to beam-induced outgassing was observed. The low pressure was a large advantage during the injection, since lifetimes of the stored 100 MeV beam was 20 minutes. The RF power applied was a few kilowatt.

As shown on the front page, synchrotron radiation was observed via a window in one of the bending magnet vacuum chambers.

The next electron storage attempts will start in October of 1991, and it is expected to reach a substantially higher current during the following months. This is due to the improved quality of the electron beam from the microtron, proper focusing in the injection beamline, much better beam diagnostics, and a much improved stacking procedure in ASTRID.

ASTRID will run as an electron ring until the beginning of 1992.

Søren Pape Møller

Ion Storage and Laser Physics

During the first experiments (described in details in newsletter 2) very low temperatures of about 1 mK were obtained for metastable $^7Li^+$ ions at 100 keV. In addition, an unexplained plasma phenomenon (the "edge") was observed during the cooling.

In the spring of 1991 it was found, that the prime reason for the "edge" effect was a higher order vertical resonance in the beam, which first showed up 1 s after injection and led to a substantial particle loss. By tuning the ring away from the design tune to a slightly different operating point, where no resonance occurred, the "edge" disappeared and laser cooling proceeded without complications. Unfortunately the final temperatures without the particle loss were significantly higher (200 mK). This is partly due to the higher diffusion from more ions. A significant contribution might also come from another property of the resonance. It leads to cooling of the whole beam, which helps the laser cooling. This was found by laser spectroscopy of the beam with and without the resonance. A drop from 2000 K to 500 K is observed just after the resonance. We believe this may be an indication of a very simple cooling process, evaporative cooling. This is primarily what happens to your coffee, when you drink it too slowly! It has never been observed for ion beams before. Beams always tend to heat up.

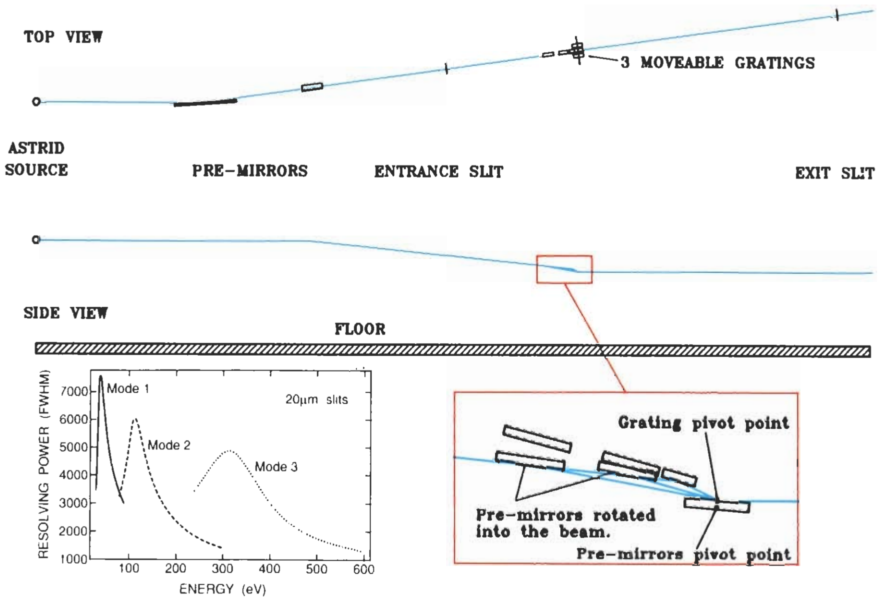
Ove Poulsen

Spherical Grating Monochromator (SGM)

In collaboration with Daresbury (Dr. Padmore & Dr. Mythen) a new type of high resolution SGM has been designed and is under construction for one of the ISA-beamlines.

In the present design we have overcome the cumbersome problem in an ordinary SGM where the focus moves when the energy is changed. This has been accomplished by tuning the included angle.

The monochromator consists basically of two slits and a spherical concave grating. The pre-mirrors are used to focus the radiation horizontally on the exit slit and vertically on the entrance slit. The entrance slit acts as a line source for the spherical grating. The diffracted image of the source is projected on the exit slit.



The 30 eV - 600 eV photon energy range covered by this monochromator is split into 3 parts in order to optimize throughput and resolving power. Each mode uses a grating with different radius of curvature, included angle and line density. The energy tuning is done by rotation of the grating. The distance to the focus is kept fixed for all energies by scanning the included angle on the gratings. This is achieved by a mechanical principle shown in the close-up window. Plane "folding mirrors" are inserted between the entrance slit and the grating. These folding mirrors are mounted on a frame which is rotated about the pivot point shown in the figure.

The rotations of grating and folding mirrors are done by computer controlled sine bars. Change of the gratings and adjustment of the slits is done manually. The acceptance angle is 25 mrad.

Performance

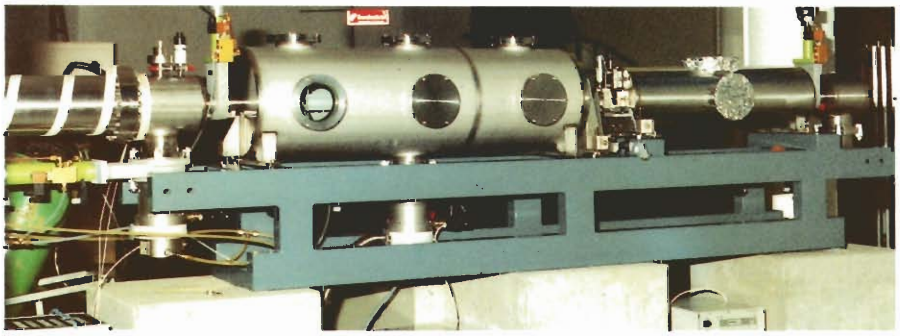
The resolving power is estimated from the theory of optical aberrations.

The throughput will be typically 10^{11} photons/(s 100mA ΔE) with 40 μm entrance slit. This is calculated by multiplication of the various coefficients of reflection, grating efficiencies, estimated loss due to apertures and the synchrotron source output.

The whole beamline with SGM will be finished in the spring of 1992. Interested users are most welcome to contact us for further information.

In addition to the SGM, our SX-700 monochromator will be moved from BESSY, Berlin to ASTRID in the spring of 1992.

Brian Norsk Jensen



Xray microscope

A description of the microscope was given in newsletter 2. The microscope has been completed and the chamber containing the microscope is shown on the picture.

From the inauguration

Call for proposals

International and national groups are welcome to submit proposals both for the heavy ion and the synchrotron radiation program.

Interest in ASTRID should be expressed to

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