Report on

NORDIC CONFERENCE ON SYNCHROTRON RADIATION

Gothenburg, June 9, 1975

Conference Organizer
and author of report:

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This report was originally written (in 1975) on paper by a typewriter. The document has in July 2015 been scanned, OCR-converted (except for appendices), and slightly modified by the author.

Background.

In October 1974 I set up a program committee consisting of nine people (appendix A) from the Nordic countries to organize a conference about synchrotron radiation. I obtained a grant (appendix B) for the conference from the Board for Nordic Accelerator-based Research ("Nordiska Samarbets-kommittén för Acceleratorbaserad Forskning"). The aim of the conference was to inform about present and possibly future research using synchrotron radiation and to have a preliminary discussion about realistic alternatives for the Nordic countries to participate in such research. All scientists were invited to participate and give contributions. The conference took place in Gothenburg on June 9, 1975 immediately preceding the Swedish Physics Conference. 41 registered people attended the meeting (appendix C).

The whole conference was tape recorded. These audio recordings have been transferred from the magnetic tape to two CD:s. You can have a copy of these CD:s from the author of this report (per-olof.nilsson@chalmers.se).

The present proceedings have been written mainly for two purposes: 1) as a report to the funding committee and 2) as information to those who did not attend the meeting.

Invited and contributed talks.

The meeting was opened by the organizer P.O. Nilsson, who among other things, said: "We are all aware of the rapidly increasing amount of research done where synchrotron radiation is used. So far most of the research has been performed under so called "parasitic" condition, i.e. the radiation has been taken from a synchrotron or storage ring used primarily by high energy physicists. The results of this research during the last decade have shown to be of very high quality and value. Furthermore the research extends over broad areas of science including physics, chemistry, biology, medicine and more. I think that these two characteristics of the activities are important reasons why today in many countries scientists feel the necessity to build storage rings to be used as light sources only. It means that we have come to a stage where comparatively cheap branches of science now require equipment of larger cost. This leads us to one question which could be discussed at the present meeting: Is there interest enough to have a synchrotron light facility located in a Nordic country?"

Three of the five invited speakers accepted to give talks, namely K. Codling, J.J. Thomson Physical Laboratory, Reading, UK, C. Kunz, DESY, Hamburg, West Germany, and R.E. Watson, Brookhaven National Laboratory, Upton, USA.

Two contributed talks were given by W. Stiefler, Lund University and T. Tuomi, Technical Research Center of Finland in Espoo.

Several people who should have an interest in the topic were not able to attend. No participant came from Uppsala, but K. Siegbahn from there sent a letter to the conference with his opinions. The letter is included in Appendix D.

In the following I first give short summaries of the talks. More information about the material presented can be found in the references given after each summary. Then I give a detailed reproduction of the following discussions and conclusions, obtained by listening to the tape recordings.

Invited talks

C. Kunz gave a detailed description of the properties of synchrotron radiation such as the wavelength and angular dependence of the intensity, the polarization and time dependence. In particular he emphasized the usefulness of the concept of brightness when comparing the intensity from different machines. He pointed out that the radiation has so far mainly been used in the UV and X-ray regions, although there is a potential possibility in the IR region. He then described what kind of experiments had been done so far and what equipment is needed. He described photoabsorption studies in the solid state, atomic and molecular physics including special variations such as modulation spectroscopy, Other experiments discussed were time dependence of fluorescence, extended fine structure in X-ray absorption, photoemission and diffraction.

For further information study e.g.: C. Kunz, Perspectives of Synchrotron Radiation in Vacuum Ultraviolet Radiation Physics, edited by E. E. Koch, R. Haensel and C Kunz, Pergamon Vieweg, Braunschweig, 1974, page 753,

K. Codling described the latest development in U.K. The British government has recently decided to fund a new storage ring for synchrotron radiation only. A committee established in 1972 had found a dedicated storage ring the only acceptable alternative. Other possibilities, such as converting the existing synchrotron, using conventional sources or going abroad was thus rejected. The ring is planned to be in operation in 1979. It will be a 2 GeV machine with high current (≈1 Amp.) and a spectrum extending below 1 Å. It will be a "national photon factory" with ten ports where about 30 scientists (mainly physicists) will be active. The estimated total cost including booster, building etc (but not the experiments) was in 1974 estimated to 2.7 million pounds. Many different experiments are planned such as radiometry, optical constants, photoabsorption in atoms and molecules and X-ray diffraction. Particularly secondary processes such as photoemission and fluorescence are of interest.

For further information study e.g.: K. Codling, Applications of Synchrotron Radiation to Atomic, Molecular and Solid State Spectroscopy, Physica Scripta 9, 247 (1974); Design Study for a Dedicated Source of Synchrotron Radiation; Science Research Council, Daresbury Laboratory, 1975.

R.E. Watson described the situation in USA. There are now two local efforts (Cornell and NBS) and two national users facilities (Stanford and Wisconsin). It is not clear what the development will be in the future with the two latter ones. One has therefore on the east coast considered the question what one can build from scratch. No unique choice was found but with certain experiments in mind the proposed machine is in the same class as that being built in U.K. The experiments would include photochemistry and spectroscopy. In the latter category Watson discussed

extended fine structure, fluorescence and angular dependence in photoemission. Also the interest by biologists and material physicists in low angle diffraction was pointed out.

A review by Watson et.al. can be found in Physics Today, 1, 30 (1974)

Contributed talks

W. Stiefler described the synchrotron light facility in Lund. The machine has the parameters E=1.2 GeV, B=1.1 T, R_{bend} = 3.65 meters ν =12.5 p/s, I≈ 20 mA. The machine is thus capable of producing a high intensity of photons (comparable with other sources in active use) down into the X-ray region. Experiments are now in progress.

Some information can be found in: P.O. Nilsson and W. Stiefler, Photoabsorption in Gd in the range 15 to 25 eV, Gothenburg Institute of Physics Reports, GIPR-108, 1975.

T. Tuomi talked about the use of synchrotron radiation in X-ray diffraction topography. A Laue transmission pattern could be taken in a few seconds instead of hours with conventional sources. Deformation experiments were also discussed. A panel discussion was organized.

Prediscussion

L. Hedin accepted to be the chairman for a discussion. He started the session by asking the audience if there were any questions left from the morning session with the overview talks.

B. Lundqvist wondered if there were any projects somewhere in the world to build a storage ring with a very small radius.

C. Kunz answered that in principle machines with small radii (say less than 50 cm) can be constructed. However, one will run into problems with the geometry for the attachment of beam lines, vacuum system, magnets etc. This means that such a machine would be more expensive than a larger machine of e.g. 5 meters diameter.

R.E. Watson and K. Codling agreed on this point.

S. Hagström pointed out that the important property of synchrotron radiation, when one compares with conventional light sources is the continuity, rather than the intensity. This property can e.g. be used in photoemission to study transition probabilities.

L. Hedin asked the panel about the feasibility to put in so called wigglers in the electron orbit, which would produce shorter wavelengths .

C. Kunz answered that according to specialists it is feasible. It has however never been used to produce synchrotron radiation.

R,E. Watson pointed out that a wiggler does not need to be placed in a straight section. If this however is done it is decoupled from the basic synchrotron, which thus can be run with or without the wiggler.

G. Arbman wondered how much money we were prepared to spend on the project to build a storage ring.

G. Brogren thought that 5-10 million crowns was not an unrealistic amount if there was a support from many laboratories. He stressed that it is extremely important that one can expect the machine to be fully used.

P.O. Nilsson did not want to fix an amount of money at the present stage. He said that one should first try to find out the scientific importance of the project and then try to get the required money.

Panel discussion

As there were no further questions or comments

L. Hedin wanted to start the intended discussion, namely about *proposals, which are realistic for the Nordic countries*. To focus the discussion he wrote down two questions on the blackboard. The first question was: "Do we need a Scandinavian light source, how many people would use it, and who?" Secondly: "Should the facility in Lund be developed or should a machine be built from scratch (placed somewhere)?" Two examples of the latter alternative were listed, namely *Source 1* for UV- and soft X-ray work, with E=0.6 GeV, R = 2.2 m, E = 500 eV and *Source 2*, including X-ray work such as diffraction and more, with E=2 GeV, R=6 m, and E_c=3 keV.

G. Brogren guessed that the best source for the Nordic countries would be alternative 1. Although there are several important areas in the X-ray region to investigate, it is not worth the amount of money to obtain the facility 2, because we have limited possibilities to utilize such a machine in a proper way. For spectroscopy in the soft X-ray region there are also many important problems to treat. A source extending up to 1-2 keV would be a good choice and also allow for some X-ray work.

C. Kunz commented that about 80% of the users at DESY were working below the X-ray region. Moreover, about 50% of the users are interested in energies below 30-40 eV, e.g. molecular spectroscopists. So one should include an alternative 0 in the earlier mentioned list.

R.E. Watson had however some doubts about the use of such a machine because of its limitations.

S. Hagström pointed out that a very important region extends up to 600-700 eV, where many core levels lie (e.g. oxygen at 552 eV). At higher energies, say 700-1000 eV, there are problems due to the complexity of the monochromators.

C. Kunz said that the advantage with a small machine, alternative 0, is that one can use a small injector, e.g. a 35 MeV one. This means a mobile machine, which still can serve perhaps half of the potential users. Alternative 1 needs a big injector, which may cost as much as the storage ring itself.

P.O. Nilsson had consulted E. Rowe, chief scientist of the Wisconsin storage ring, about the best choice if one excludes the hard X-ray region. E. Rowe had answered that they were giving some consideration to the design of a machine of 650 MeV with E_c=650 eV and an expected current of 100 mA. An injection energy of 50 MeV or higher would be needed. E. Rowe answered: "The cost of such a machine,

complete with the injector and a building would be in the range of 1-2 million dollars, depending on how imposing an edifice is constructed to house it".

H. Grimmeiss now wanted to return to the first questions: Do we need a Scandinavian light source? If yes: who will use it? How much money do we want to spend on it? How long time will it take to build it?

L. Hedin concluded that according to E. Rowe's answer the alternative 1 would cost 6 million crowns. He asked the panel how realistic this estimate could be.

R.E. Watson answered that the given figure sounded fair, but that one should note that the cost of the experimental equipment was not included. The time for building the source would be less than 2 years for alternative 1 and at least 3 years for alternative 2.

C. Kunz said that in the proposal for the storage ring at Daresbury, corresponding to alternative 2, they estimated 266 man-years. At a comparison one should however consider that in Daresbury they already have available all experts needed.

H. Grimmeiss wondered about the corresponding number for a smaller machine, say alternative 1.

R.E. Watson guessed that 5-10 man-years would be needed to reproduce the Stoughton machine.

R. Manne said that one central problem for the project is the financing. He thought that there would be a very small support from the various Nordic countries. He also thought that most universities would not be able to set up groups using a facility.

T. Åberg commented that in Finland 2-3 laboratories would be interested, but then in the X-ray region.

L. Hedin now wanted the audience to consider the various possibilities to use the facilities in Lund. One could think of 5 possibilities: 1) Use the Lund synchrotron LUSY, as it is, 2) Put a wiggler in the proposed electron accelerator MAX in Lund, 3) Use MAX as booster for a storage ring of alternative 1, 4) Use the existing synchrotron as a booster, 5) Convert the synchrotron to a storage ring.

W. Stiefler wondered in this connection if we really want to build a Scandinavian light source. The Lund synchrotron has, as it is at present, properties comparable with those of DESY and NINA, but none have used the machine until now.

K. Codling mentioned that in England there was the situation that there were about 30 scientists, as a base, who were prepared to go to work at the synchrotron NINA, with all its difficulties. This is obviously different from the present situation in Sweden.

S. Hagström asked how many of these scientists who were atomic, molecular and solid state physicists respectively.

K. Codling stated that until recently there was an equal distribution between the three groups and the energy region of interest was 10-200 eV. The emphasis is now turning towards solid state physics (e.g. PES) with increased emphasis also on the X-ray region (eg EXAFS).

R.E. Watson commented that interest is inspired by success. For example in U.S. 16 groups have expressed interest in doing extended absorption fine structure, EXAFS, after 2 groups had been successful. Watson agreed that the interest for X-ray work is increasing rapidly.

C. Kunz had also found that there is a trend to use the X-ray region more. He pointed however out that for this purpose big machines are needed, like e.g. Doris (5.5 GeV, 500 mA), which has an operating cost of more than one million dollars per year. As one cannot build such machines as light sources only one can imagine a physicist going to a big machine for e.g. a week taking EXAFS spectra and then going home to do the analysis for one year.

T. Åberg wondered what the operation cost would be for a smaller machine.

C. Kunz answered that if we disregard the injector (for instance if a new machine is added that in Lund) a 500 MeV machine would require a minimum of one engineer and one technician for the running and some improvement work.

L. Hedin wanted to know the actual cost for current, cooling etc.

C. Kunz said that the cost is not very big. The total microwave power, which goes as E^4, gets to its limitations only in the GeV region.

L. Hedin wanted to hear some points of view from the atomic spectroscopists.

L. Minnhagen told that they had in Lund prepared to go down to shorter wavelengths, i.e. below the 500 Å limit of the present monochromator.

L. Minnhagen wanted to know how the present Lund machine compares with the different proposals discussed here today.

R.E. Watson said there are several advantages with a dedicated storage ring. It is a stable light source which needs no monitoring. Also a dedicated source can be run specifically for the photon users.

L. Minnhagen mentioned that there might be the development in Lund that the machine is less used by the nuclear physicists and more by the synchrotron radiation people, which means that it would finally be dedicated. Minnhagen wondered if it then would be wise to dismantle the machine and build a new light source there or somewhere else.

K. Codling said that it all depends on the interest, which the panel cannot judge.

L. Minnhagen wondered if P.O. Nilsson had worked with any other machine than that in Lund.

P.O. Nilsson said that he had not. Nilsson wanted to comment the question raised several times, namely if there is an interest large enough in Sweden. He thought that there is a strong potential interest. As mentioned by Watson one successful experiment stimulates other groups. So, if we get a source working many groups will certainly use it. Only at the department of physics in Gothenburg the groups working with surface physics, optical properties, atomic

physics and photoemission would use it. In fact it seems necessary to adopt the use of synchrotron radiation, not to be out of the various fields very soon.

G. Brogren agreed that a dedicated source should be built. He did not find it wise to redesign the Lund machine. Experiences from work with synchrotron light at Stanford (G. Brogren, S. Hagström, I. Lindau) have shown what good possibilities one has with a suitable light source.

L. Hedin asked P.O. Nilsson if he thought that the groups in Gothenburg would be content with a small machine, e.g. alternative 1 above.

P.O. Nilsson had got the impression that the best choice would be a machine with a maximum photon energy of 1-2 keV.

G. Arbman agreed with Nilsson that there is a potential interest in Sweden for a source, but wondered what the disadvantages would be of going abroad and take data for a short period, as described by Kunz.

K. Codling commented that XAFS is a particular example where this can be done; however for e.g. photoemission spectroscopy this is not convenient. In England they have considered the possibility of going to ACO in Orsay, France. However, problems arose when the arrangement came down to details, so they found it better to put the money into their own source.

C. Kunz said that individuals are welcome to DESY to work there. However, the high energy physicists are very hesitant to give commitments to groups from other countries.

H. Grimmeiss thought that one point was that people may feel that it is more important that they get their money from the research councils for their own projects rather than putting the money into a project for which there is no strong enthusiasm. On the other hand, another point is that if we do not ask for the money we will not have them. Grimmeiss again wanted to go back to the question: Do we need a light source and who will use it?

L. Hedin asked Lindholm if he could answer that question for his group and perhaps comment for other groups in Stockholm.

Lindholm said that he had been working with spectroscopy of small and large molecules. He was pessimistic regarding the use of synchrotron radiation for such studies. The electron impact energy loss method gives exactly the same information as photoabsorption. Lindholm was very interested in some of the new results from DESY on photoabsorption on molecules, but he was not sure if people would show a continued interest in this area. In the case of photoelectron spectroscopy there are thousands of spectra which are not published because they cannot be explained. Lindholm concluded that he did not think that molecular physicists or physical chemists will be very interested in an expensive machine for synchrotron radiation. The motivation for such a machine must come from other fields, e.g. solid state physics.

K. Codling thought that to solve the problems in molecular physics an intense photon source is needed to do secondary type of experiments like photoelectron spectroscopy, mass spectroscopy, fluorescence etc.

E. Lindholm commented that photon impact combined with mass spectroscopy was regarded twenty years ago to be the solution of all problems in molecular

physics. Little has come out from this field and synchrotron light will not be any more valuable.

J.P. Dahl thought that synchrotron radiation will have a great future in dynamical work in molecular physics, studying kinetics, relaxation and so on.

C. Kunz pointed out it was not possible to do the discussed type of mass spectroscopy twenty years ago. Today we have much higher intensity, which should be of help for molecular physicists and chemists to find out information they cannot get in another way.

R. Manne said that as a theoretical molecular physicist he had no need for a Scandinavian light source.

S. Hagström stressed that the real problem is not to get a machine, the problem is to get continuous support. Also he said that one should not get too pessimistic at this stage. Before one knows what experiments can be done it is very difficult to create enthusiasm for the project. The meeting is only a preliminary discussion and we should keep on with the discussions. Further, one should note that several groups, which are important in this connection, are missing at this meeting.

L. Hedin wanted to know which people in Lund who would be interested in using a source of alternative 1.

H. Grimmeiss answered that he was very positive to a synchrotron light source. However, we have a limited amount of money and have to compare with other projects. The discussion has to go on so we can find out if there is a large interest.

L. Minnhagen wondered if Grimmeiss wants a better machine than the present one in Lund to go into research with synchrotron light.

H. Grimmeiss wanted first to know what the running cost would be in Lund if the nuclear physicists finish.

R. Alvinsson said that the cost depends on the utilization and estimated that shift operation would require five people and 50 000 crowns a year for maintenance.

H. Grimmeiss commented that a new machine might only require three people, which means a lower cost.

L. Minnhagen proposed that the present Lund machine could be used during the time a new machine is planned. In that way one could see the interest.

G. Brogren proposed that if there is an interest we should have a suitable source, i.e. not a synchrotron. We should start immediately working on a proposal about the design, location etc. Meanwhile Lund machine could be used as it is, but it should not be rebuilt. Brogren further said that he had found a lot of extremely interesting problems in X-ray physics to study. However, there is no economical possibility for a small country to build the required big machine, so we have to be guests at other places. There are also a lot of problems at lower energies for a small machine. The discussion should go on in a smaller group and we should see the results in six months.

L. Hedin asked P.O. Nilsson if he had found LUSY a suitable light source.

P.O. Nilsson answered that he, together with W. Stiefler, had done only a small pilot experiment there. However the intensity is quite satisfactorily and e.g. absorption spectra can easily be obtained. To continue research at LUSY, some

smaller improvements have to be done. In a long run however it is not wise to put too much effort into the facility; to compete with other laboratories a stable light source is required, i.e. a storage ring.

C. Kunz agreed that instability in synchrotrons is a problem, which years of experience to compensate for in the experiment.

L. Hedin asked I. Martinson about his interest.

I. Martinson wondered if lifetime experiments yet had been done.

K. Codling answered that this had only been done with molecules at ACO in Orsay.

I. Martinsson asked if atomic lifetimes of the order of 10 ns could be studied.

C. Kunz said that it should be possible with certain machines.

T. Åberg asked Kunz lf DESY now will be abandoned.

C. Kunz answered that it will not. The storage ring DORIS requires special equipment for the connection of the experimental apparatus because of the ultrahigh vacuum conditions. In "older" machines one can allow some contamination from e.g. aggressive gases.

End of discussion

L. Hedin now wanted to summarize the meeting. He stressed that it had been a preliminary discussion, which had shown potential interest in synchrotron radiation, the size of which however was difficult to judge. The relative small interest showed at the meeting may be due to the fact that people have not been aware of the possibilities. A small working group should study some alternatives and prepare for a proposal to funding agencies. It seems that in the first place a Swedish facility should be considered.

P.O. Nilsson added that he thought the best thing was to build the ring as a local project. It is probably easier for a small, local group to get thing effectively done than a committee with representatives from four countries. When finished of course anyone could use the facility and particularly people from the Nordic countries.

R.E. Watson said that the contribution from the other countries could be with the equipment at the photon lines.

R. Manne said that the problem with a Nordic funding is that there will not be interest from all Nordic countries, e.g. no Norwegian will probably use the facility.

O. Hunderi objected and said that there are groups in Norway, e.g. in Tromsö and Trondheim, which could be quite interested.

P.O. Gartland mentioned that one problem is that one problem is that the possibilities are not very well known in Norway.

G. Brogren proposed that a group should be formed working on the project without discussing the economic situation. When a suggestion exists the interest should be asked for. If the interest exists every possibility to get money should be tried.

L. Hedin said that the purpose of the panel discussion had been to clarify realistic possibilities of a synchrotron light source for the Nordic countries. The meeting is perhaps not the right forum to appoint a committee. The Swedish Physical Society could perhaps take care of the project. After a small sketch by a group the other countries could be asked for the interest, modifications etc.

G. Brogren had the opinion that the present meeting should appoint a committee of already interested people.

S. Hagström asked to whom the information was sent.

G. Brogren answered that information was sent to every physical laboratory in Scandinavia and some other.

P.O. Nilsson commented that the last information was sent out to 350 persons in Sweden. Some people may have been missed, but as usual there ought to have been other communication channels like announcements on boards, private communications etc.

L. Hedin concluded that there seemed to be interest enough to form a committee to further explore different choices.

S. Hagström suggested that P.O. Nilsson should do a prestudy of the project, taking contact with the people he feels needed. One possibility is that NPR asks Nilsson to do the study.

C. Kunz mentioned that he, Koch and an accelerator physicist will write up a feasibility study of a dedicated 500 MeV storage ring.

P.O. Nilsson accepted the idea and said that he will try to find some people to cooperate with on the project.

L. Hedin again stressed that the meeting was not deciding. As there were no objections to the summary given by him he thanked all contributors and closed the session.

Summary and comments

I think it seems pretty clear that the use of synchrotron radiation is and will be of great importance in several research fields like atomic and molecular physics, solid state physics, biology etc. A few Swedish groups (people from Gothenburg, Linköping, Stockholm and Uppsala) are already engaged abroad in such research. Experiments in Sweden are now in progress in Lund. Abroad one finds a strong tendency to build dedicated electron storage rings as light sources. In some countries this is already being done and in many other countries there are design studies and proposals. A small ring intended for UV work mainly (as that in Wisconsin, USA) can be built for a cost, which on a national scale is comparatively low. Machines for intermediate energies (as e.g. that now being built in Daresbury, U.K. which will extend down to 1 Å) is definitely a large national project. Rings extending far into the hard X-ray region can hardly be built for radiation users only, but may be dedicated as a result of high energy physicists abandoning them.

Synchrotron radiation is now used actively in France, Germany, Great Britain, Italy, Japan, Soviet Union and USA. In the Nordic countries the main interest seems to come from Sweden, where many groups are working with various kinds of spectroscopies. But also other countries could use a facility. For instance, in Finland there are groups in X-ray spectroscopy and in Norway UV-photoemission is studied.

There are also potentially in all countries several users because of the new applications coming up with the special properties of the radiation. Experience from abroad shows that when a source is established users appear.

Appendix A

Program committee

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