SOLARIS: Bright light at the end of the tunnel. Keep your fingers crossed!

H. Oyanagi, A. Kisiel, W. Rypniewski, C. Bocchetta, and M. Stankiewicz
tell us about the future of the Polish synchrotron

High brilliance and good investment

Hiroyuki Oyanagi

[W.P.] Do the users need 1.5 GeV synchrotrons?

If the current storage rings are categorized, there are three types. First, high energy (6-8 GeV) storage rings to achieve high brilliance x-rays over a wide energy range, 5 – 60 keV using higher harmonics radiation of undulator (Category I). The concept is based on the principle that ultra low emittance is achieved by a large circumference, a function of number of bending magnets. The same concept is now achieved by improved focusing technology, rendering the required storage ring energy much lower, i.e., 3 – 3.5 GeV with a lower high energy limit. As the cost performance is best in this second category (Category II, medium-energy-class light sources), the recently built storage rings were mostly based on this design rule. The third category (Category III) is a more compact medium-low energy machine (1.2 – 1.5 GeV) which is also popular as it offers an energy-saving cost-effective machine. In fact, the upgrading plan of SPring-8 downgrades the energy from 8 GeV to 4.5 – 6 GeV. Beijing's new storage ring will be 5 GeV.

The choice of storage ring energy is a result of the power balance between spectroscopic users who prefer lower energy (<30 keV) and crystallographers who require higher energy (<60 keV). Thus the Category III machines try to extend the high energy limit, making special efforts such as higher harmonics of undulator radiation, a superconducting wiggler or a superbend. The last category (Category IV) is a low energy (<1 GeV) compact VUV light source. The last category is dedicated to spectroscopy users and the high-energy limitations do not exist. Machine people often aim at the highest specifications such as ultimate synchrotron radiation (USR) but the realistic specifications must reflect the user community's demand.

Unfortunately, reflecting the current and future economic situation, high-end machines (Category I) are unlikely to be planned. Moreover, the same brilliance is now available by the use of the in-vacuum undulator and the need for Category I light sources is decreasing. That is the reason why so many 3 GeV storage rings have been constructed recently and are, proliferating all over the world. Spectroscopy users may prefer even lower energy 1.2 – 1.5 GeV and by using undulators their energy range preference is easily covered, while extending the higher energy limit is a matter of negotiation with crystallographers. Higher harmonics of the undulator, superconducting wiggler or superbend technologies can be used, depending on the requirements of crystallographers. Currently, in Japan there are two recently-built Category II machines, SAGA Light Source (1.5 GeV), and Aich SR (1.2 GeV). They are based on the same design rule, which limits the storage ring energy to Category II and the extended energy limitation by superconducting wiggler and superbend, respectively. The HALS (Hefei Advanced Light Source, 1.5 GeV) is also based on the same category policy, higher harmonic undulator radiation that makes the use of hard x-ray (<8 keV) with an ultra low emittance (<1 nmrad) and even hard x-ray below 10 keV from a bending magnet.

[W.P.] How many thousand users are in Japan?

Both Photon Factory and Spring-8 have about three and five thousand proposals per year, respectively. There are seven other facilities for open use and the total number of proposals could be about ten thousands. The number of registered members of synchrotron radiation society is about one thousand. The number of users and helpers is roughly ten times that of society members, which is roughly in agreement with the number of proposals.

[W.P.] But there are also occasional helpers, students... The total number is certainly higher.

The number of proposals is equivalent to the number of experimental leaders. Usually one experimental group consists of about five on-site experimenters for whom (?) the collaborators (sample preparation group) are not counted, a safe estimation is about ten times that of the number of proposals, which is about hundred thousands.

[W.P.] Experienced people...

In the beginning (start-up period), experienced researchers design the beamlines and stations to which some motivated users should give support representing a research community. It is necessary for the facility to understand the requirements directly from users to avoid over-specification of the instrumentation. Usually a station- or beamline-base working group is formed and the specifications are determined. Staff (if the number of motivated users is too small) should carefully evaluate the proposed specification and make the final decision. Because of the travel budget, the facility site should be decided taking transport into account.

[W.P.] Do you think that SOLARIS is a good investment for our country?

Yes, I think so. Please note that synchrotron radiation facilities can be a driving force of science and industry, not only giving them solutions but also finding new problems. I would like to stress that the latter cannot be replaced by spending money on other investments. It can be called an investment in knowledge, which should never end.

[W.P.] I agree. Thank you very much.

Broad cooperation and new horizons

Andrzej Kisiel

[W.P.] What is the situation of Polish experimental physicists in Poland? Just from the point of view of a researcher who initiates research here, using the synchrotron beam as a tool?

[A.K.] In my view, the situation of Polish physicists using synchrotron radiation is favorable. First of all, we have already developed a "personal base". Many well-educated professionals in Poland carry out and develop broad scope of research requiring the use of the synchrotron. It seems that this trend in experimental physics is likely to continue.

[W.P.] How can you assess the accessibility, to Polish researchers, of synchrotron facilities: both the foreign facilities and – in future – the Polish source?

[A.K.] When it comes to foreign sources, the matter is dynamic, due to the ever-changing rules for granting access to synchrotron radiation. Therefore, the demand for the Polish synchrotron beamtime may be significant.

[W.P.] But can that satisfy our needs?

[A.K.] Certainly, development of experimental physics using synchrotron requires continuous activity by researchers. In retrospect, Polish researchers who moved early to synchrotron radiation facilities were often highly valued as initiators of new ideas and research directions, which were later developed by them and by the collaborating synchrotron radiation staff. This happened in many cases. In the 1970s and 1980s, Poland was very active providing new ideas in materials science and technology. New specialized materials were developed in several laboratories of universities and in institutes of the Polish Academy of Sciences. In this regard, the leading role was played by the Institute of Physics of Polish Academy of Sciences, developing new technology for crystal growth of various single crystals of compound semiconductors. The availability of these new unique materials was a seed of many very valuable research ideas. These ideas were transposed to very modern laboratories – the centers using synchrotron radiation produced very tangible results for both parties and the concept-research accomplishment time was very short. Currently, I think, the situation has not changed very much, since material science in Poland is still very strong. New projects based on the possessed technology continue that effective cooperation. I think that it is an opportunity that will be further exploited.

[W.P.] What can the SOLARIS source give Polish scientists?

[A.K.] First of all, the source will enable us to undertake (i) a series of investigations and (ii) test studies before still more advanced measurements abroad. But it also has the advantage, not to be underestimated, of an important training center.

[W.P.] An educational center?

[A.K.] Yes. It fulfills also educational tasks. Often for financial reasons, the graduate or doctoral students cannot be sent to work abroad at synchrotron radiation facilities. However, you can afford to send them to the national source, where they can do adequate measurements and will learn synchrotron radiation techniques. SOLARIS will have the potential to be a training centre for those who require stronger sources.

[W.P.] Can SOLARIS attract foreign scientists?

[A.K.] In my view, it is absolutely necessary. We have to engage in very serious work that encourages outside researchers to participate in research programs in Poland. At this moment, the current number of Polish specialists using synchrotron radiation is not large enough to fill the beamtime at SOLARIS. A good example of solving this problem has been the Polish-Italian cooperation with professor Franco Bassani, director of the Italian program PULS, that started at the ADONE storage ring in Frascati. He came to Kraków in 1975 and persuaded the rector of the Jagiellonian University to prepare and sign an agreement granting access of the Institute of Physics of the Jagiellonian University to the PULS program. Given that the program PULS was supposed to start in 1979, it was an early step in the right direction.

[W.P.] But did both parties profit from this?

[A.K.] Yes. From the start of the studies in 1979, the Polish program was part of PULS and the first results were already published just 2.5 years after the start of the x-ray experimental beamline. So it seems that this type of pre-emptive move is necessary to fill the beamtime schedule of the Polish synchrotron right from the start.

[W.P.] Can the synchrotron beam be seen as a better source of light to improve existing research capabilities, or rather as a tool to open up new research horizons. Or both?

[A.K.] The answer is "yes" to both questions. Of course, synchrotron radiation in all spectral regions is a much better source of light than the standard sources. Therefore, through this versatility it is easier to correlate studies in different fields of physics. An example would be the use of EXAFS analysis of the local structure of the diagnostic material. The local structure can also be studied through the analysis of the phonons in the far-infrared – also using synchrotron radiation. In fact, two distinct measurement techniques meet to analyze related properties of a solid.

However, when we look for new horizons, undoubtedly a synchrotron opens the door to modern technology. This opening lays in the fact that synchrotron radiation sources have a very large modern experimental base. The beamlines incorporate modern peripheral devices operating quickly, reliably and with huge scope for a range of possible uses. This is one of the reasons that scientists, physicists, chemists, biologists, doctors are grouped around these very modern measuring lines and they use the latest technology which is constantly stimulated by new advances.

[W.P.] And how important is the interaction of different groups from different countries who meet at the beamlines?

[A.K.] Obviously – it is very high. They meet to exchange ideas and build closer cooperation. However, the cooperation requires an active attitude. Each participant brings his/her own individual research skills that result in great interaction and advances of the research programs.

[W.P.] Would you say that the work at the synchrotron beamline stimulates the collaboration between centers?

[A.K.] Yes. In the past – a lot. Use of the synchrotron radiation often generated an exchange between research groups. The same researchers could use beamlines at different synchrotrons. It has stimulated strong cooperation between centres. Currently, due to better and more versatile beamlines this kind of joint research has become obsolete.

[W.P.] As concerns the 90's?

[A.K.] Yes, then the "scientific tourism" meant mixing of communities and transfer of experience. There are a number of examples. The one already given concerns the excellent semiconductor material technology of the 60s – 70s in Poland. It has resulted in a number of research programs using a variety of techniques at many synchrotrons in the world. The photoemission studies explored good quality materials from national laboratories. Similarly, in the field of X-rays, XANES, EXAFS and in the electronic structure vacuum study in ultraviolet. It should be stressed that the advanced studies using synchrotron radiation require a vast theoretical base.

Good quality experimental results are obtained relatively quickly. Theoretical development often requires prominent experts in the field and time-consuming calculations. This is an important point in the overall research design. To overcome this the interaction between experimentalists and theoreticians is necessary. We need theorists who, in addition to the general own interests are working to resolve the specific theoretical problems raised by the results of advanced experiments. For example, in the analysis of the electronic structure of a material, difficult theoretical band structure calculations have to complement the experimental results, to compare and understand them e.g. for the ultraviolet optical reflectance spectra obtained in the vacuum and for XANES. These must be really very good and advanced theoretical calculations. In short, a close relation between research of the experimentalist and theorist is necessary.

[W.P.] Besides these questions, would you like to add something in the context of Polish synchrotron, or to comment-on other issues?

[A.K.] I would wish for this synchrotron to open and run according to the schedule, within the designed technical parameters. Here I recall a significant problem observed in the activity of new foreign synchrotrons. Always at some point the policymakers financing the construction and maintenance of synchrotron start to demand a lot of results and publications as the accountable results of these studies. They convert the funds spent to scientific results and calculate activity and efficiency. Therefore, it is in fact essential to build two types of experimental beamlines:

1. beamlines used for routine analysis of materials by X-ray diffraction or X-ray absorption spectroscopy (EXAFS and XANES methods). For this type of research there is still a huge demand for all synchrotrons in the world and the scientific value of these studies is very high.

2. the experimental lines, which by definition have very high and ambitious requirements leading to specialized scientific results. These lines are generally more expensive and are used by highly specialized advanced groups.

[W.P.] Type 1 may require an extended comment: is it important to have automated access, so that the standard samples can be quickly measured automatically?

[A.K.] Yes, but it is not absolutely necessary in the first phase of the Polish synchrotron. You can try to gradually automate the line that is very heavily exploited.

[W.P.] When we are building a beamline, how to plan its future staffing? Is just one scientist on one line a good choice, or maybe we need a group that will take care of all experiments and, also, perform its own research?

[A.K.] This is a very complex issue. From my observations you need a rather large group of people who work together on a regular basis. Such a group of more than 10 may include interns and outside regular collaborators supplying fresh ideas. Then, the cooperation is most effective.

[W.P.] From my observations, a good beamline has three experienced researchers and several interns, young people who are learning there, and only then the beamline produces a true scientific output.

[A.K.]You are right. A few scientific beamline caretakers are required. The working experience on the line should be provided by people who work there on a permanent basis. This is particularly important in the 24-hour and 12-hour work cycles at beamlines. Those who come for measurements for a short time, have a little experience. Effective progress is achieved when good ideas come from regularly collaborating teams. It is best if the research ideas come from groups that have a strong theoretical background. Then the results are processed in a short time. I know cases where the results obtained on the synchrotron line waited for the theoretical elaboration for nearly five years.

[W.P.] This is disadvantageous...

[A.K.] Yes. The long delay in publication is very unfortunate. It may happen that very similar experimental results are published sooner by someone else, because others also come up with similar ideas. The ideas in science are derived from the state of science at the time. This is why the "hot topics" usually attract collaboration of more groups to speed up the solution. If someone comes up with a good idea today, it is very likely that someone else already has the first results of the study.

Light for biology and medicine

Wojciech Rypniewski

[W.P.] How do Polish molecular or structural biologists view the construction of the Polish synchrotron? Or how do you see it? It is important that we have a synchrotron in Poland or do we already have access to such good sources, so that it is unnecessary?

[W.R.] It is very important and it is good that you ask a biologist, because biologists are a major part of synchrotron users everywhere in the world. It is hard to imagine the Polish synchrotron without biological applications. It is fair enough that physicists have the initiative in initiating the synchrotron project, but I am happy that you remember about the biologists.

[W.P.] And what difference will the Polish synchrotron make to biologists? You already have some access to other light sources, so will things improve for you? Is ready access important for you and is it needed?

[W.R.] It is needed and in the future it will be necessary, because the sources that we have been using, were generously supported by international programmes in the past, which made the beamlines available to us for free and in addition refunded our travel costs. Those international programmes are now changing into national programmes...

[W.P.] You mean, the programme Calipso which provides financial support for the next three years is just temporary?

[W.R.] All these programmes are temporary and depend primarily on the EU policy. We have got used to them but the truth is that the EU sees itself as an organisation that initiates certain projects but when they start working well, the EU withdraws support. EU does not provide constant support but rather acts as a catalyst until the supported project starts to live its own life. Then EU stops supporting it. This is what we are witnessing now. The EU turns to other projects and the synchrotrons, which really played an essential role in structural science, will have to find other ways to finance their operations.

[W.P.] Don't we need access at the same level as the Japanese, which have a synchrotron for every 7 million people, whereas we have 40 million and no synchrotron ay all!

[W.R.] It's an important point, that in our part of Europe there is no synchrotron. And we have to ask why. You can draw a line going north to south, through Lund, Berlin and Trieste, and to the east of this line there are no synchrotrons in Europe.

[W.P.] Except in Russia. The Russians have some but their synchrotrons do not work very well.

Yes, there are some in Russia but we don't use them. It's not so simple. We need our own synchrotron for several reasons. And once we have it, we'll have good access and we'll certainly use it well.

[W.P.] We are talking about biology but probably we should consider medical applications. The progress in medicine is important and strongly promoted by the European governments, including our own.

[W.R.] Certainly. You have to remember, though, that there is no clear borderline because biologists' work in biomedical fields even if they are not medics.

It is important to have a synchrotron for several reasons. Our community of biological researchers using synchrotrons is growing very fast in Poland. When heard several years ago that we could have a synchrotron, we made a quick calculation how we could use a beam line if we had it to ourselves. It turned out that we could use it then. Today I think it would be fully occupied.

[W.P.] It will be crowded...

[W.R.] And in a few years it will be overcrowded. You see, such facilities are really needed. There are two aspects to consider. People who make scientific policy in developed countries take two approaches. They look at the current needs or they look strategically into the future and decide which facilities should be developed. It is called technology-driven research. We also need to look strategically. The synchrotron will catalyse developments, it will generate need and it will make people think in new ways.

[W.P.] Like with space or military technologies – they offer new possibilities and even if we cannot foresee how they will be applied, they will certainly find uses in the future.

[W.R.] And this will really place us in a good way on the map of Europe, in the fields of physical and biological research.

[W.P.] Perhaps it will remove the traces of the Iron Curtain?

[W.R.] Yes. And another issue: I was a synchrotron scientist in Hamburg for 10 years. When you are only a user travelling from elsewhere, you plan your experiment, you know what you can do, you mount your samples, you measure them one by one because every hour is precious. On the other hand, when you are working at the synchrotron, when it is at hand, you begin to think in different ways. You think of experiments that are impossible to do in 8-hour shifts. This is a different kind of research, more long-term.

[W.P.] If you had a synchrotron beam line, what kind of staff would you need and how many?

[W.R.] For continual support of users and also to ensure that the staff are not just providing service but carry out their own research, you need approximately five scientists per beam line.

[W.P.] Counting both, permanent staff and Ph.D. students?

[W.R.] You need different kinds. A couple of experienced scientists and a few junior ones. This is a place of learning and exchanging knowledge and experience.

SOLARIS: Cost effectiveness at the forefront

Carlo Bocchetta

[W.P.] Why is SOLARIS better, how can you compare it to others you've constructed?

[C.B.] Solaris is based on MAX IV technology, which is state of the art, and we are building a replica. It is a very bright source for the size of its circumference, the optics of the machine is exceptional, and it is extremely cost effective. The technology being used at MAX IV is highly innovative, especially for the magnets, vacuum chamber and radio frequency system. The new technology also means we can build the accelerator on a reduced budget. When we switch it on, it will be at the forefront of accelerators of comparable size both in Europe and in the world.

[W.P.] I noticed that Solaris will be commissioned before the MAX IV ring. Will it be a test for MAX IV?

[C.B.] Yes and no, MAX IV is concentrating on the 3 GeV ring first because their facility at MAX-lab already serves the users with light from their old accelerator. So here we will be building their new 1.5 GeV while they first concentrate on the 3 GeV ring. Our two projects benefit from sharing common resources in Poland and Sweden. Of these two projects the first ring to be switched on will be Solaris here in Poland.

[W.P.] But how do you compare this ring to other ones you have constructed already? Is there big progress?

[C.B.] Huge progress, it is the future of light sources. The ring uses innovative technology that has been designed in research facilities and developed in industry over the last twenty years. The technologies have evolved greatly in this time and so this ring is very different from the ones before it. But Solaris and the MAX IV rings will be the working prototypes for future light sources.

[W.P.] Can we call it "4th generation"?

[C.B.] 4th generation is the Free Electron Laser. Solaris is a very good 3rd generation light source, however, it has the possibility of becoming 4th generation since the facility and injector have been designed with this future goal in mind.

Atomic and molecular surgery

Marek Stankiewicz

[W.P.] What are the real prospects for putting the Polish synchrotron into service? What is the timetable? And what will happen later?

[M.S.] The project completion date is the end of 2014. Next year the building should be finished.

By the end of 2012 it should be under sealed conditions. At the end of 2013, we will begin the installation of the first pieces of equipment. At the end of 2014 we will start up the synchrotron. I hope that it will be functional at the beginning of 2015 and, if all goes well, the first experiments on the first beamline included in the project budget will begin in 2015.

I also assume that there will be opportunities to finance additional beamlines and the synchrotron at the beginning of 2015 will have 3 – 4 lines instead of just the one provided for in the budget.

[W.P.] Who should look for funding for the new beamlines? I do not mean the projects, but the financing. Should the initiatives come from the grassroots, or should they come from the synchrotron administration?

[M.S.] I expect them to come from the grassroots but coordinated jointly by the coordinating body, you can call it a scientific committee. However, they should match the requirements of the scientific environment, which should also be aware of the potential of the synchrotron.

[W.P.] Can the synchrotron beam be seen as a better source of light to improve existing research capabilities, or rather as a tool for opening new research horizons? Something completely new?

[M.S.] Both, but the second is more important. Sure, you can treat it in some applications as a better source of light than the existing traditional sources. By the light we understand here the entire range of electromagnetic radiation. But it also opens up completely new opportunities due to its characteristics, e.g. the collimation and intensity.

[W.P.] Can you give a striking example of new opportunities to convince our readers that this is very important?

[M.S.] Let us consider the protein crystallography – this is only possible with synchrotrons, as well as just any type of "molecular surgery" and "atomic surgery" studies when we can address the energetic transitions in molecules very precisely and see what reactions are triggered by such transitions. This is provided by synchrotron radiation wavelength tunability.

[W.P.] Probably also the physics of very small objects.

[M.S.] Of course.

[W.P.] Returning to the funding, what are the prospects of financing the experimental beamlines in the context of the economic crisis in the European Union and at the same time, the rather good state of the Polish economy?

[M.S.] I would wish I could say something, but it is rather difficult. It seems to me that the atmosphere is not bad and money for the research, for the research infrastructure, exists.

[W.P.] Here or in the European Union?

[M.S.] Here it is not so bad, the synchrotron can be a good example. The budget of the synchrotron is small in the scale of spending on the whole research infrastructure. The problem is to channel that money well, so it goes to the flagship projects. Synchrotron is present on the map of the Polish research infrastructure, on the road map, and I hope that soon this presence will have expected consequences. Up to now – one year has passed and there has not been even the slightest effect. However, it looks like the signs are being noticed by the right people, that the consequences will be positive and that there will be special funding of the projects which are on the road map.

[W.P.] Would you say that the synchrotron costs as much or less than a stadium? The shape is similar...

[M.S.] Much less than one stadium, at the moment I do not remember what the costs of the National Stadium were, which was the flagship project for EURO 2012.

[W.P.] Hundreds of millions.

[M.S.] Maybe even a billion. Here we have 140 million PLN (40 million EUR), it is comparable with the cost of four kilometers of a highway.

[W.P.] There will also be the operational costs but you have to consider the fact that we will educate new people, new staff members, it is difficult to convert this into money.

[M.S.] I hope that the public accepts this type of spending, and doesn't just look at the construction of highways.

[W.P.] A final comment?

[M.S.] Please keep your fingers crossed that everything is going well. Let there be no external trouble, such as a period of bad weather...

[W.P.] An earthquake...

[M.S.] Or an earthquake...!

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