

Concluding remarks

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The XXXIII ECPM is the first meeting in the history of this conference series which takes place in Poland. The community came to Warsaw and Kraków to acknowledge the Polish efforts in cyclotron developments and operations, and I think I speak in the name of all of you when I state that we had an excellent and well organized meeting. Actually, this meeting does not start the cyclotron history in Poland. When I started nuclear physics in the sixties, we appreciated the results obtained at the Kraków U-120 cyclotron by Prof. A. Budzanowski and his colleagues with α -particle scattering and α -induced transfer reactions. Some of us joined the Mazurian Lakes summer meetings on nuclear physics which, for a long period of time, were the one and only meeting place for scientists from East and West. It was also in these meetings where we became aware of the big efforts and fighting for the now successful operation of the Warsaw machine. We were also glad to hear that the Kraków machine has started operations again.

So, Poland has a tradition in cyclotron operations. At the Mikołajki summer schools we could also experience the kind Polish hospitality which had been kept through the darkest times of the cold war, and, again I speak in the name of all of us by saying that we gratefully acknowledge the great hospitality at this meeting, too. So before reviewing the scientific part of the meeting, let me first cordially thank the local organizers, in particular Prof. J. Jastrzębski and his co-workers for organizing this meeting so extremely well. Our thanks also include Prof. A. Budzanowski and his colleagues for organizing the Kraków part, in particular the outstanding conference dinner at the Wawel castle. I think everything was just perfect. Though many people have contributed to make this meeting a successful conference, there was one person who has taken most of the heavy work load, who prepared all the necessary information, who answered all our necessary and unnecessary e-mails and took care of us also during the meeting. So let us thank in particular A. Stolarz. I also like to thank J. Choiński and his crew for all the work before and during the meeting.

This time we had a slightly different style of meeting than usually. In contrast to our more informal get-together, this ECPM became a real conference including an international scientific committee and a program committee. With this change of style the organizers hoped to obtain support from the European Union. The meeting became more scientifically structured as I will point out later, but this did not solve our monetary problem: according to the EU

referee's report, the meeting did not seem to catch on to the frontiers of science, one of these in his point of view being hadron radiotherapy, for example. The referee did not realize that we dedicated a full session to new machines for proton therapy. Obviously, in the opinion of the European community's referee, protons are no hadrons.

Let us see if we are so far behind the frontiers of science and look what has been contributed to this meeting. In the first invited talk, E. Baron gave us an excellent overview on the development of cyclotrons, the most compact particle accelerators. He demonstrated the steady evolution as well in cyclotron development as in cyclotron performance. We learned how new technologies increased the performance, and how modern tools allow better predictions for new machines. These may still not predict the full truth but will shorten development times. Nevertheless the final test is always the first extracted beam.

Cyclotrons are used continuously and most of them have a rather long live time, some of them need a rather long time until commissioning. But, once operating, they are very reliable and are steadily being improved. This was the message from the status reports from more than 10 institutions in Europe, Belgrade, Berlin, Catania, Dubna, Groningen, Helsinki, Jülich, Jyväskylä, Karlsruhe, Kraków, Villigen, and Warsaw. We were very glad to hear that the Belgrade project will be continued. They have had really a hard time, and we all hope that this time they will be able to commission a cyclotron for the Balkan area, finally. Berlin is doing well with all the applications and Catania has started eye tumour therapy and reported on progress of the EXCYT project. We heard that Dubna is producing exotic beams and Groningen got rid of a lot of hardware problems. They could more than double their beam time on target per year. In Helsinki a young team started a small cyclotron for isotope production and we wish them all the best. H. Jungwirth could show us a steady operation of the Jülich machine though he has still trouble with the deflector at extraction. The Jyväskylä crew demonstrated what can be done with an enthusiastic young team. We were also glad to hear that things have been settled in Karlsruhe. An old cyclotron has been reanimated. Eventually, the Kraków machine got 60 MeV protons extracted, extremely important for the Polish eye tumor therapy project. Our hosts in Warsaw presented an impressive record of delivered beams. At PSI in Villigen we find an outstanding cyclotron combination which continuously improves its performance

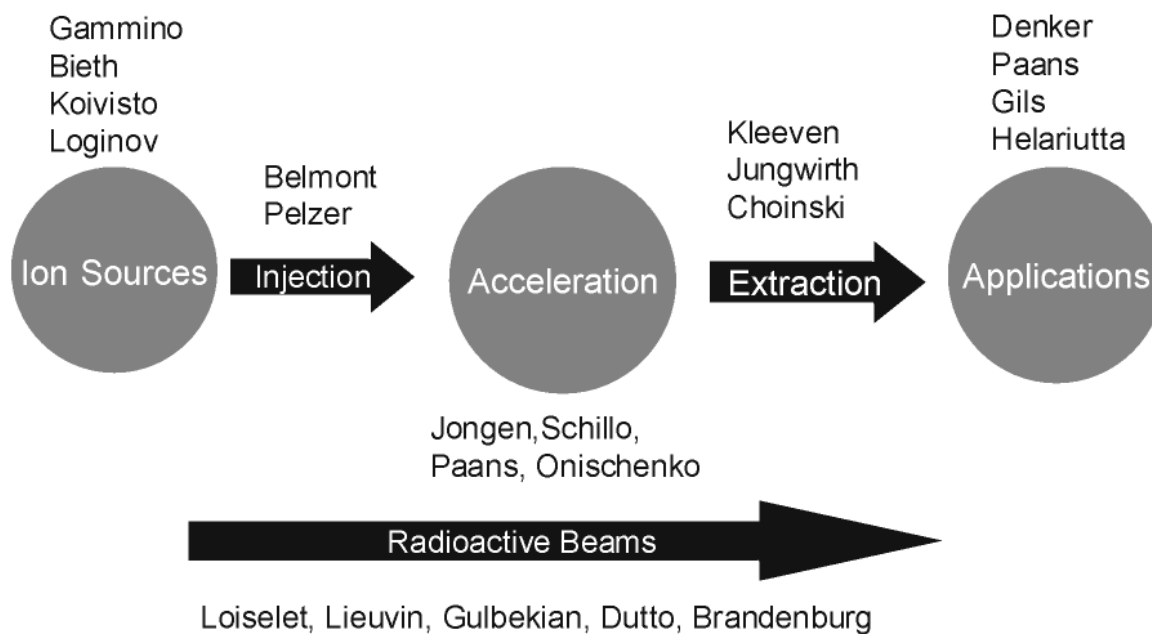


Fig. 1. Contributions to the ECPM XXXIII.

as spallation neutron source. So, to summarize the part of status reports, we have observed a lot new results since the Berlin meeting two years ago, and there is still a remarkable progress with respect to the MSU International Conference May 2001. Thus, the decision to keep the annual schedule of the ECPM meetings, made by the International Committee yesterday, was wise.

Practically all problems connected with the operation of cyclotrons were touched. An overview is shown in Fig. 1. As for ion sources, we heard the excellent introduction and a summary of the latest developments by S. Gammino. Sources with superconducting coils and higher frequencies for higher charge states will definitely play a major part in the near future. They may be fully or partially superconducting as it was shown by C. Bieth who presented design-work on a source with high temperature superconducting coils for the longitudinal field. Industry has also developed a lot of excellent sources, and many of us are happy that one can get a source by just sending out an order. While climbing up the Golovanevsky plot to higher electron temperatures at higher RFs, we should not forget that in the lower frequency regime many improvements are possible as shown by H. Koivisto from Jyväskylä for their 6.4 GHz ECR source. With the demonstration of the performance of the 14.5 GHz source, V. Loginov reported on the progress of the new cyclotron project for Bratislava.

Most of the problems, theoretical and very practical ones, connected with the beam injection into the cyclotron were covered by J.-L. Belmont's talk. In particular, the very complicated situation of axial injection was discussed. As a special example, improvements with the high current H^- injection were shown by P. Heikkinen. For heavy ions, W. Pelzer reported on problems and improvements of a RFQ-structure as a radial injector.

A special highlight of the meeting were the many reports on new machines and new concepts: there was the proof of principle for self extracting machines, the progress of the

proton therapy machines, both the already operating compact normal conducting machines by IBA and the design for a superconducting version under construction by ACCEL. There is hope that these machines will lead to a breakthrough of proton therapy and experience a comparable success that was found for the small compact machines used for isotope production preferentially for medical applications. The production of track membrane filter seems to become a major issue for accelerator developments. A first dedicated compact heavy ion machine has been put forward by L. Onischenko.

Extraction problems are different depending on the design of the machines and their appropriateness. As mentioned above, the proof of principle for self-extraction has been achieved by IBA as shown by W. Kleeven. J. Choiński demonstrated effective stripping extraction for light and heavy ions at the Warsaw machine.

The design of new machines and the reconstruction and improvements of existing ones is triggered by the various direct applications of cyclotron ion beams. At low energies and high currents, the production of radioisotopes mainly for medical applications is the main issue. Here, accelerator industries have opened an enormous and still growing market. We learned from an overview on the medical activities at General Electric, that it has turned out that PET is the only diagnostic tool to detect cancer in an early state. This leads to an enormous demand of PET isotopes producing machines world wide. IBA is producing a variety of high current proton machines to produce radioisotopes for a lot of different purposes. Proton radiotherapy for deeply seated tumors has started at two sites with the recently commissioned 235 MeV machines. ACCEL presented the design of a superconducting 250 MeV machine which is expected to start operation within the next two years.

A. Denker's completed the list of applications by presenting convincing examples of the use of fast, light and heavy ion beams in materials analysis and materials modifi-

cation. As it was stressed by all speakers the main challenges to cyclotrons involved in direct applications are easy operation, reliability and stability.

Another highlight of the meeting was the presentation of radioactive beam activities at the facilities at Dubna, Louvain-la-Neuve, Ganil and Vancouver. The operation of such facilities is best described with the German word *Gesamtkunstwerk* (synthesis of arts) because the different parts of accelerator components run at their limits. The long list of beams delivered at Louvain-la-Neuve has been augmented by those from the laboratories which started exotic beam operations quite recently, Dubna, Ganil, Groningen, and Vancouver. Thus, we may expect a lot of

new results in the near future. At all institutions, cyclotrons are involved in the production and/or acceleration of radioactive ions and thus have opened up new dimensions in nuclear spectroscopy.

In conclusion, we had a very lively meeting at the very front of science and technology, well organized by the local organizing committees at two different exciting cities in Poland. The operation and the development of cyclotrons will stay an important task in accelerator technology.

Research and development to all problems connected with cyclotron operations were presented. The figure lists the speakers contributing to the specific subjects.