

**Minutes of the meeting of the International Advisory Committee of Cyclotron Centre  
Bronowice (CCB) held at Institute of Nuclear Physics of the Polish Academy of Sciences  
Kraków, Poland  
29 August 2014**

**IAC members present:** F. Azaiez, A. Bracco, B. Fornal (Deputy Chair), Zs. Fülöp, M.N. Harakeh (Chair), R.V.F. Janssens, S. Kistryn, M. Lewitowicz, A. Maj, K. Rusek, H. Sakai, C. Scheidenberger, N.V. Zamfir

**Absent with notification:** W. Zipper

**Ex-officio:** M. Jeżabek, P. Olko

### **Open session**

The second meeting of the International Advisory Committee (IAC) of the Cyclotron Centre Bronowice (CCB) was held at the Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) on 29 August 2014 (see Appendix I for a detailed agenda of the meeting). At the beginning of the open session, M. Jeżabek, Director IFJ PAN, welcomed all present and thanked in particular the IAC members for their help in assessing the research opportunities of CCB and for their valuable advice on the course to follow regarding technical developments and future scientific programmes. Following this introduction, staff members of IFJ PAN gave overviews of the status and various developments regarding the cyclotron, gantry and different experimental set-ups at the CCB facility. In particular, P. Olko presented the progress made regarding the “National Centre of Hadron Radiotherapy”. He informed the IAC of the decision to stop eye treatment with 60-MeV protons from the old AIC-144 cyclotron sometime after September 2015. This treatment will be moved to the new facility around the Proteus C-235 Cyclotron. Furthermore, the first proton gantry was finished in May 2014, and the second one will be completed around September 2015. The IAC appreciates this and congratulates IFJ PAN on this great progress.

A. Maj presented an overview of the fundamental and application-oriented research programmes at the Proteus-235 Cyclotron, including an overview of the experimental set-ups that will be used in pursuing these programmes. Some statistics on users since the start of experimental research programme in March 2013 through August 2014 have been accumulated. In addition to the Polish users, there have been 50 users from other European countries. This is especially important since CCB at IFJ PAN and HIL (Heavy-Ion Laboratory) at Warsaw University have applied together for transnational access in the ENSAR2 project within the Horizon2020 Programme. Following this overview, staff members of IFJ PAN presented the progress made on the various technical projects connected with beam development, transport and dump as well as on the status of the separate detection set-ups that will be used in the experimental programme.

During the second part of the open session, presentations were given of the experimental proposals and letters of intent (LoIs) that have been submitted to CCB. These were discussed together with the presentations given in the first part during the closed session. The reports on these and the recommendations, agreed upon during the closed session, are given below.

## **Closed session**

### ***Laboratory presentation – status reports***

#### **Status of the CCB**

(P. Olko)

The IAC of CCB was impressed by the developments made at CCB since the previous meeting that was held a year ago. These rapid developments include the therapy part and the basic science part as well. The installation of the infrastructure evolved very fast and by now the Centre faces the first problems of the beam-time distribution and assignment to either proton therapy or fundamental and applied physics programmes. The first scientific and industrial connections have also been established. In addition, it is foreseen, from the report given, that the second gantry will be operational in due time in 2015.

#### **Status of the beam line setup**

(B. Szpak)

#### **Beam dump and Faraday cup**

(B. Wasilewska)

The IAC was impressed by the progress made over the last year in instrumenting the dedicated beam line for nuclear physics experiments. The team should be commended for securing a grant in the amount of 450 k€ from the Ministry of Science and Higher Education with which the following activities were supported: purchase and installation of vacuum equipment and of a beam-profile monitor, design of a target chamber that is presently under construction, development of a beam dump, procurement of equipment for beam-current measurements, and installation of additional electrical power as well as of supply lines for gases. It is clear to the Committee that the funds have been used effectively and that, as a result, the beam line has the required flexibility to accommodate the large variety of instrumentation being planned for the facility. The IAC was presented with the first design of the beam dump. It is worth noting that the effort is carried out in collaboration with a commercial company that is also providing funding for the activity. While a large number of simulations have been carried out, more work appears to be required in this area. Specifically, simulations including the walls of the experimental area and focusing on the shielding required to prevent backscattering of neutrons from the beam dump into the experimental equipment need to be pursued further (see also below). The IAC points out that it may be desirable to contact people who have designed or are in the process of constructing such beam dumps at other facilities such as GANIL, for example. Finally, the design of a proper Faraday cup should be started as soon as possible. As this cup will be located inside the beam dump, it is important to incorporate various possible designs in the simulations in order to assess potential problems with neutron backscattering and gamma-ray background that could potentially affect experiments and could impact the design of the beam dump in the direction of the target (a conical section might be necessary). Furthermore, since absolute cross-section measurements with accuracies in the few percent range are planned, proper care should be urgently taken of electrical insulation, suppression of secondary electron emission, etc.

## **Beam profile studies**

(W. Meczynski)

A few sets of measurements of beam dimensions have been made with the use of a home-developed Beam Imaging System (BIS; used at the OPTIS beam line). The results have been obtained in air, at two positions along the beam line and at three energies. Several positions of beam-defining slits have been studied. The conclusions confirm predictions by the "Transport" code of the beam-envelope dependence on the studied parameters. The IAC appreciates the efforts undertaken by the CCB crew and encourages further studies of the details of the beam cross section at various places along the beam line. Special care has to be taken not only to determine the shape of the beam core area, but also to obtain accurate information on a possible beam halo. Even if test measurements with BINA seem to exclude the existence of a large halo, one should study its possible presence at higher beam currents. Excluding the presence of a significant beam halo may turn out to be crucial for planning future precision experiments.

The studies should be performed in vacuum, along the beam line all the way down to the Faraday cup. Scaling of halo with the beam current should be established, as well as possibilities to reproduce the findings by calculations. In that context, the IAC would like to recall a suggestion made earlier to study also the reproducibility of the beam parameters after cycling among energies and slit settings; here also an improved storage of beam settings should be provided in the control system.

The Committee endorses acquiring a standard Beam-Profile Monitor (BPM) from IBA and incorporating it into the control software in the near future. The readouts from that device should be confronted with those from the more accurate BIS in order to allow accurate future beam-profile measurements to be based on the BPM only. It should be considered whether another BPM would be worth the investment for performing the experiments.

## **Status of the HECTOR array**

(M. Kmiecik)

The IAC appreciates the advances made in preparation of the HECTOR array for future experiments at CCB. The IAC congratulates and encourages the collaboration for pursuing the remaining phases of the preparation with the following actions:

- Refurbishing and mounting of the crystals and PMTs of HECTOR;
- Merging the DAQ systems of HECTOR and KRATTA and in-beam tests.

The Committee recommends that the collaboration pays special attention to the gamma-background and especially encourages it to play an active role in measuring gamma background with the future beam dump.

## **Status of the BINA detector**

(A. Kozela)

The collaboration has in the last year accomplished several tasks that were necessary to get the BINA detector ready for experiments with proton beams from the Proteus C-235 Cyclotron. The multi-wire proportional chamber (MWPC) with a central hole for beam passage was installed and tested in beam, in conjunction with the  $\Delta E$ -E scintillator Forward Wall and the Backward Ball detector consisting of 149 phoswich detectors. The MWPC performed very well, demonstrating at the same time low beam-related background due to either beam halo or other beam-induced events. This was achieved after a study of beam focussing and beam-movement calibration allowing excellent centring of the beam thereby

reducing the background events by an order of magnitude. Other tasks included calibration and readout of Faraday-cup current which has to reach high precision if one is to determine the cross sections with the better than 5% precision needed. CH<sub>2</sub> and CD<sub>2</sub> targets have been used during the test measurements demonstrating good particle identification of protons and deuterons in the Forward Wall and Backward Ball. Nevertheless, work has already started to have a functioning liquid target involving a He compressor.

Following the accomplishment of the above-mentioned tasks and the successful tests, one can conclude that the BINA detector is operational and is ready for use in experiments. The IAC endorses the extra steps that need to be taken to ensure that the scattering chamber and Ball are vacuum tight and that the various detection elements are functioning properly, especially some of the phoswich detectors for which damage has been reported. The collaboration should also make sure that the better than 5% precision can be attained through thoroughly understanding the liquid-target thickness and the accuracy in the measured beam current. The IAC would like to congratulate the collaboration on all the progress made in the installation and successful testing of the complex BINA detector.

### **Status of the KRATTA array**

(J. Łukasik)

A major step forward in the instrumentation of CCB was achieved with KRATTA: this array was set up during the last year and is now available for experiments. This telescope is built as a modular array (which can be used in different configurations); it covers a broad energy range of protons that can be detected (~3 to 260 MeV) and provides mass resolution up to mass number A~10. Its performance was demonstrated in several beam tests and it will be very useful for many experiments that will be performed at CCB.

Besides the application to experiments, the IAC recommends to implement further improvements, *e.g.*, position sensitivity; this will require investments, but it will also help to increase the energy resolution. Further beam tests will be needed to improve and characterise the detector in more detail, *e.g.*, improve the pulse-shape analysis, measure the response (linearity, light collection efficiency, quenching, etc.), integrate it in a vacuum chamber, etc.

A number of letters of intent and proposals for experiments at the proton PROTEUS C-235 cyclotron at CCB IFJ PAN were submitted to the CCB IAC (they are listed below). They have been evaluated by the IAC and the results of evaluation were communicated to the spokespersons.

### List of physics experiments

- **The gamma decay from high-lying states and giant resonances excited via  $(p,p'\gamma)$  at beam 70-200 MeV** (F. Crespi, M. Kmiecik *et al.*)
- **Dynamics of few-nucleon systems** (E. Stephan, A. Kozela *et al.*)
- **Study of deeply bound 1s-proton-hole state decay in  $^{11}\text{B}$  and  $2\alpha$ -cluster wave function in  $^{12}\text{C}$  by using  $^{12}\text{C}(p,2p)^{11}\text{B}$  and  $^{12}\text{C}(p,p\alpha)^8\text{Be}$  reactions** (A. Bracco, B. Fornal, N. Cieplicka *et al.*)
- **Investigation of the mechanism of proton-induced reactions leading to the continuum** (B. Kamys, D. Mancusi, C. Schmitt *et al.*)
- **Physics of the bremsstrahlung photons in nuclear processes** (S. Maydanyuk *et al.*)

### List of experiments related to applications

- **Proton irradiation of CALIFA detection modules at CCB** (D. Cortina-Gil, J. Cederkall, B. Szpak *et al.*)
- **Investigation of gamma emission in experimental modelling of hadron therapy** (A. Magiera, A. Wrońska *et al.*)

### *Date and topics of the next meeting of the IAC*

The **next meeting** of the IAC will consecutively follow the fifth international COMEX5 conference, which will be held in Kraków from 14 to 18 September 2015. The IAC meeting will start on Friday afternoon, 18 September and end on Saturday noon, 19 September 2015.

**Appendix I**  
**Meeting of CCB International Advisory Committee**  
Institute of Nuclear Physics of the Polish Academy of Sciences  
Kraków, Poland

<b>Friday, 29 August 2014</b> (Conference Room at CCB)		
<b>Morning session - open</b>		
<b>Status of the CCB experimental programme</b>		
9:00 - 9:05	Welcome	Marek Jeżabek
9:05 - 9:20	Status of the CCB Project	Paweł Olko
9:20 - 9:35	Research at the Proteus-235 Cyclotron – overview	Adam Maj
9:35 - 9:50	Status of the beam line setup	Bartłomiej Szpak
9:50 - 10:05	Beam profile	Witold Meczynski
10:05 - 10:20	Beam dump	Barbara Wasilewska
10:20 - 10:35	Status of the HECTOR array	Maria Kmiecik
10:35 - 10:50	Status of the BINA detector	Adam Kozela
10:50 - 11:05	Status of the KRATTA array	Jerzy Łukasik
11:05 - 11:30	<b>Coffee break</b>	
<b>Presentation of LoI and Proposals</b>		
11:30 - 11:50	Innovative perspectives for studies on proton-induced spallation at CCB	Davide Mancusi
11:50 - 12:10	Investigation of the mechanism of proton-induced reactions leading to the continuum	Bogusław Kamys
12:10 - 12:30	The gamma decay from high-lying states and giant resonances excited via $(p,p'\gamma)$ at beam 70-200 MeV	Fabio Crespi
12:30 - 12:50	Study of deeply bound 1s-proton-hole state decay in $^{11}\text{B}$ and two-alpha cluster wave function in $^{12}\text{C}$ by using $^{12}\text{C}(p,2p)^{11}\text{B}$ and $^{12}\text{C}(p,p\alpha)^8\text{Be}$ reactions	Natalia Cieplicka
12:50 - 13:10	Dynamics of few-nucleon systems	Adam Kozela
13:10 - 13:30	Investigation of gamma emission in experimental modelling of hadron therapy	Aleksandra Wrońska
13:30 - 13:50	Proton irradiation of CALIFA detection modules at CCB	Bartłomiej Szpak
13:50 - 14:10	Physics of the bremsstrahlung photons in nuclear processes	S. Maydanyuk
14:20 - 15:30	<b>IAC working lunch</b>	
<b>Afternoon session - closed</b>		
15:30 - 18:30	Discussion	