

Nuclear Physics Laboratories in Poland

IFJ PAN

+

HIL (SLCJ)

**Institute of Nuclear Physics
of the Polish Academy of Sciences
Kraków**

**Heavy Ion Laboratory,
University of Warsaw**

Bogdan Fornal

*Institute of Nuclear Physics,
Polish Academy of Sciences
Krakow, Poland*

ECOS Facility Meeting
16 May 2013, Orsay, France

Nuclear physics laboratories in Poland

National Cyclotron
Laboratory



Kraków





Heavy Ion Laboratory, University of Warsaw



(Środowiskowe Laboratorium Ciężkich Jonów – **SLCJ**)

(courtesy of Krzysztof Rusek)

- National nuclear physics laboratory open for external users
- Involved in teaching
- Developing medical applications

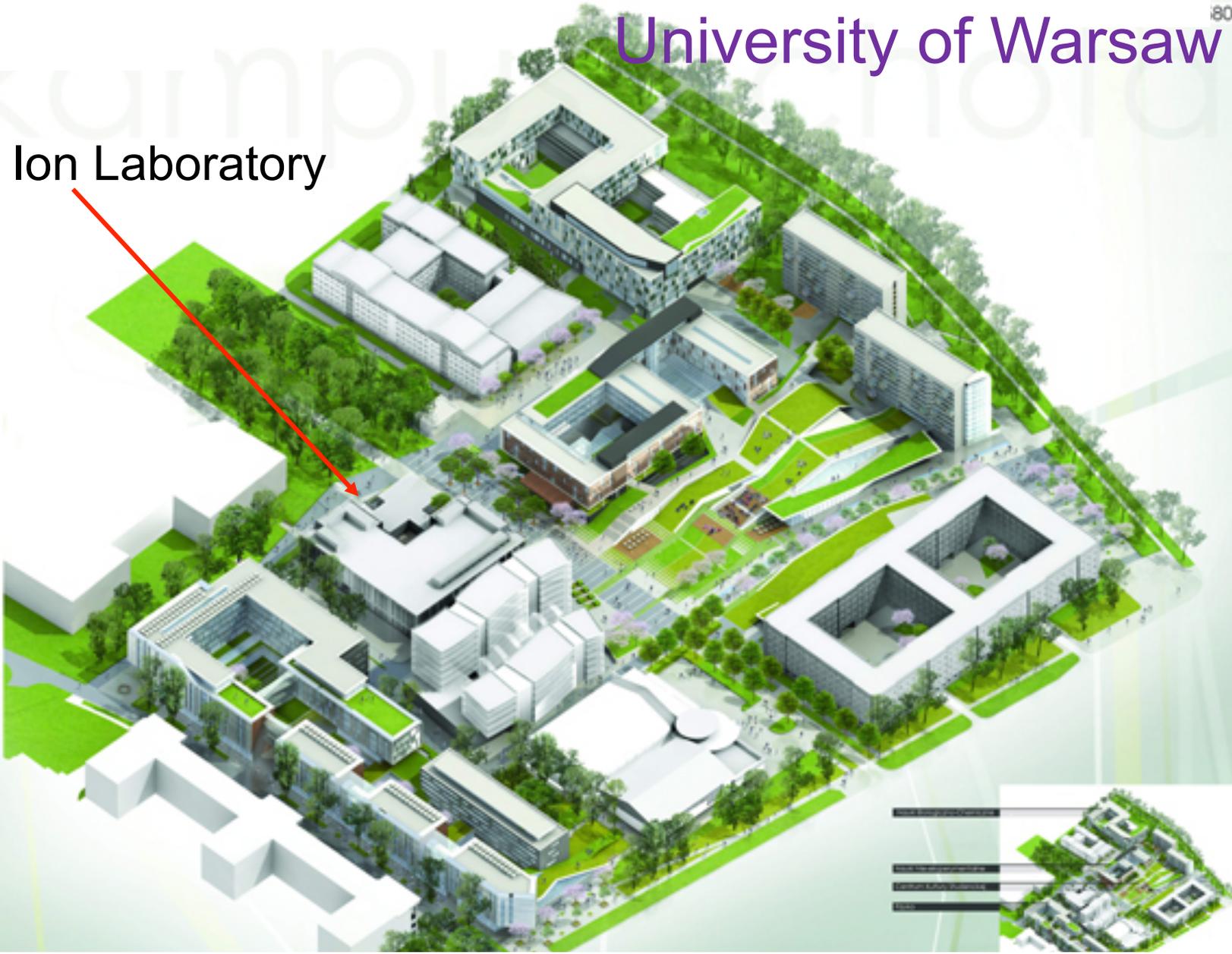




Scientific Campus Ochota

University of Warsaw

Heavy Ion Laboratory





Staff

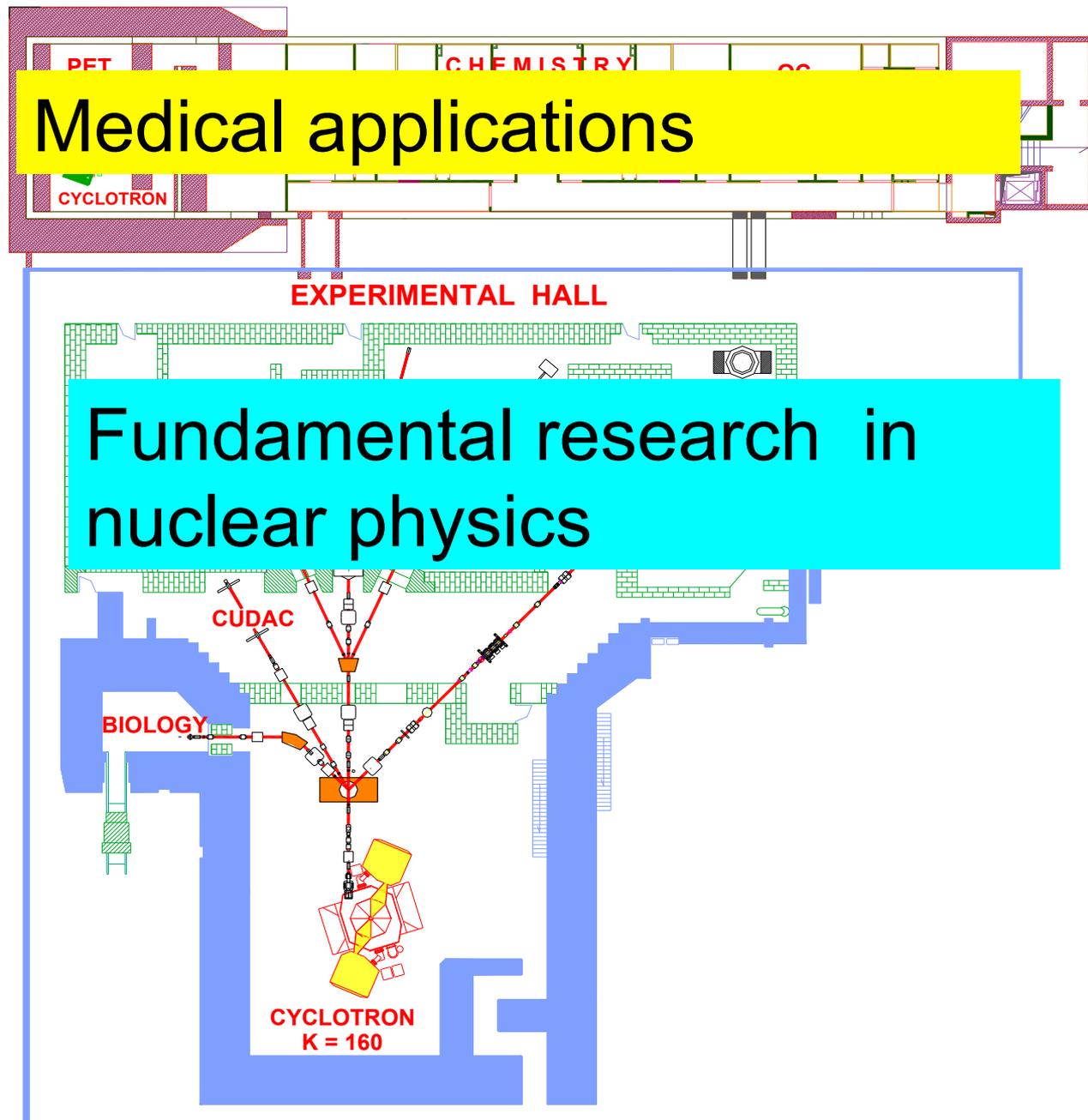
Scientists – 13 (physicists and chemists)

PhD students – 7

Technicians – 35

Administration - 8





„User Facility”:
~ 160 users
per year

national (80%)
foreign (20%)

Cyclotron U-200 at the Heavy Ion Laboratory, University of Warsaw



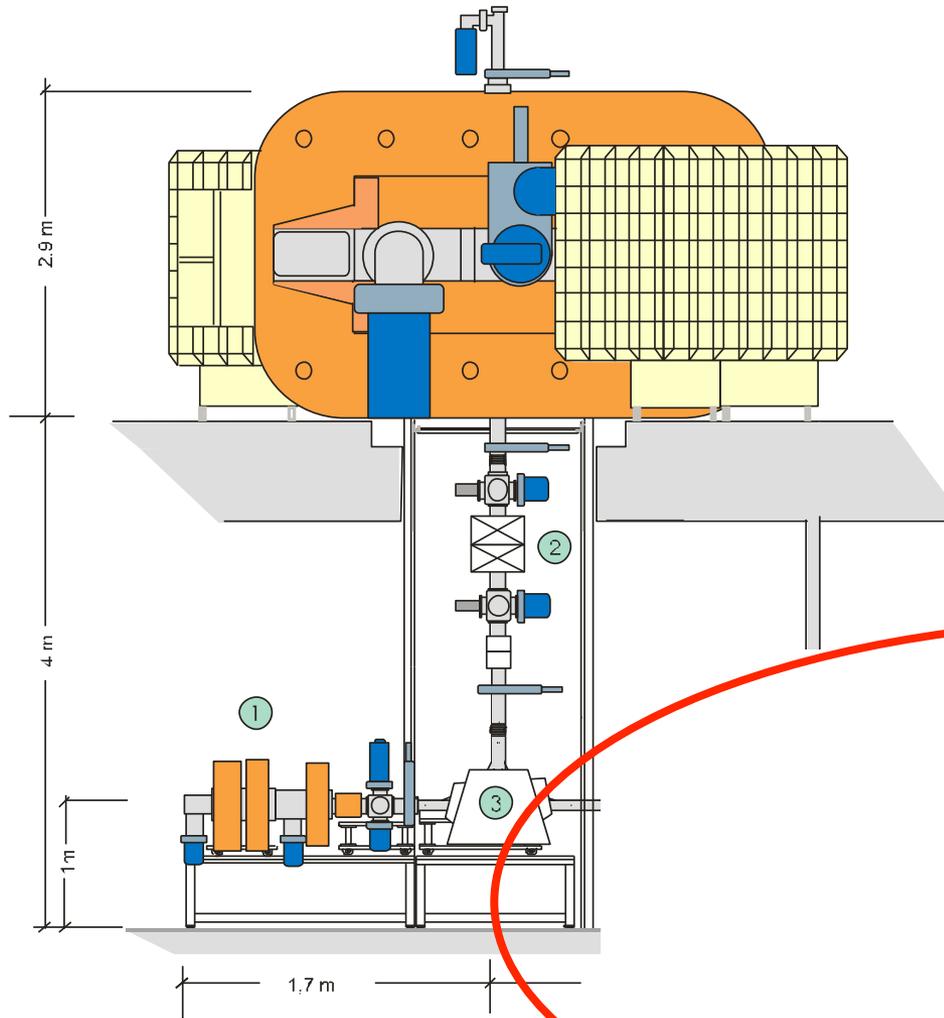
Isochronous cyclotron

- diameter **200 cm**; $K_{\max}=160$
- in operation since **1994**
- ion source: **ECR, 10 GHz**
- beams: from **B to Ar**;
- energy range **2 – 10 MeV/nucl.**

~ **2600 hours** of beam time per year

~ **90%** for nuclear physics experiments

Cyclotron U-200 and ion sources



New!

ECR, Home made, ions He-Ar

Cyclotron U-200 - HF generators

Problems with the spare parts for the existing HF generators (help from JINR Dubna)

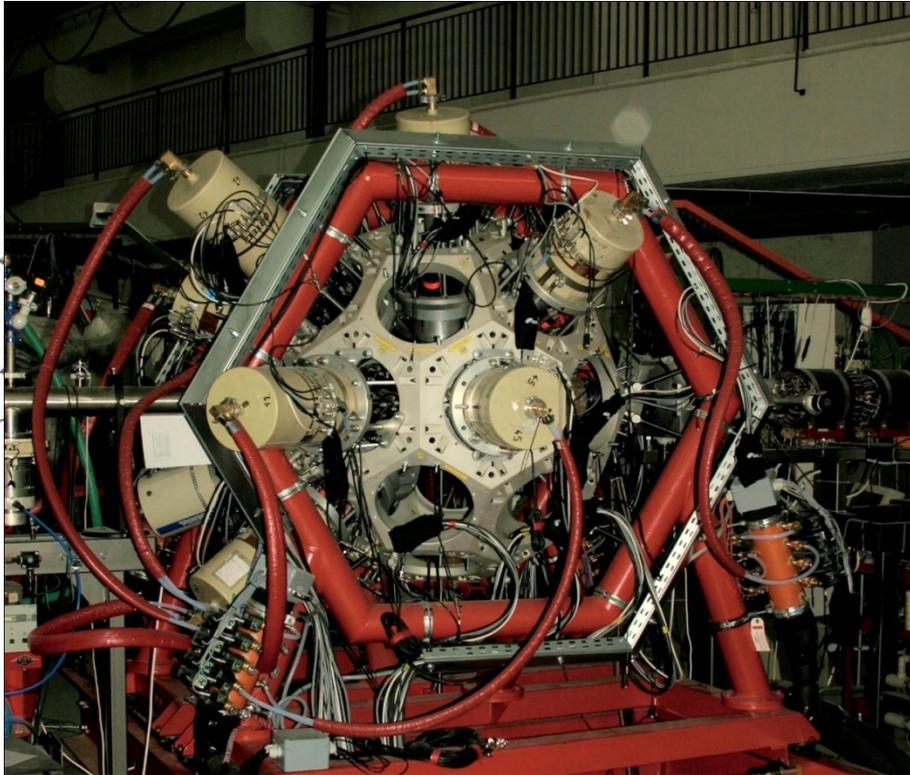
New HF generators will be installed before the end of 2014 (grant of Ministry of Science and Higher Education of Poland)



The detector systems at SLCJ, Warsaw

EAGLE γ -ray spectrometer

(central European Array for Gamma Levels Evaluations)



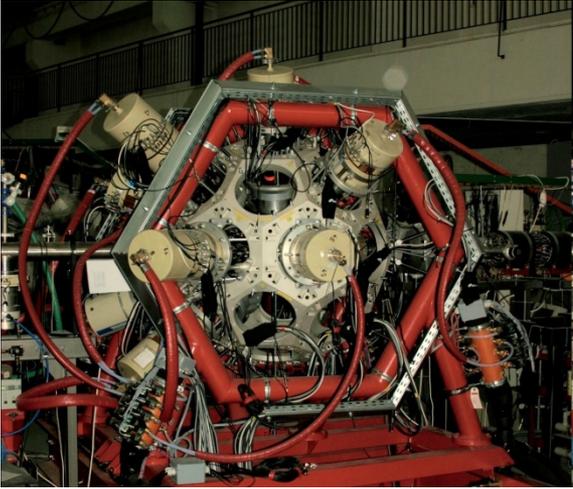
**EAGLE can host
up to 30 HP Ge detectors**

**EAGLE can be coupled
to:**

- ◆ Internal conversion electron spectrometer
- ◆ 60-element BaF_2 gamma-ray multiplicity filter
- ◆ Scattering chamber with 100 PIN-diode charged particle detectors
- ◆ 4π charged particle multiplicity filter (Si-ball)

**In 2012 equipped with 20 GAMMAPOOL
detectors from IPN Orsay**

Research program with EAGLE



Lifetime measurements by using Doppler shift methods

Coulomb excitation studies

Studies of chirality in nuclei

Gamma-ray spectroscopy of the light Sn isotopes

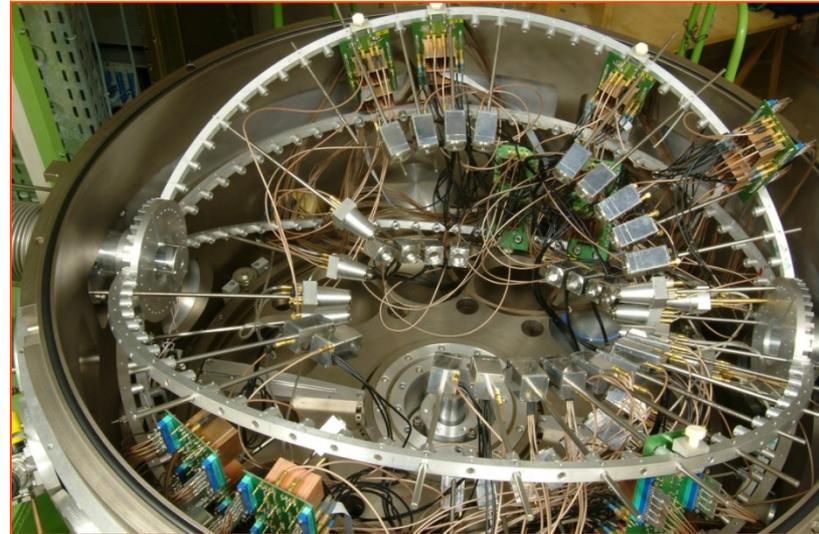
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Charged particle detector system **ICARE**

8 telescopes ΔE
(gas) + E(Si)

ICARE²⁴ telescopes ΔE (Si)
+ E(CsI)

16 telescopes ΔE (Si)
+ ΔE (Si) + E(CsI)

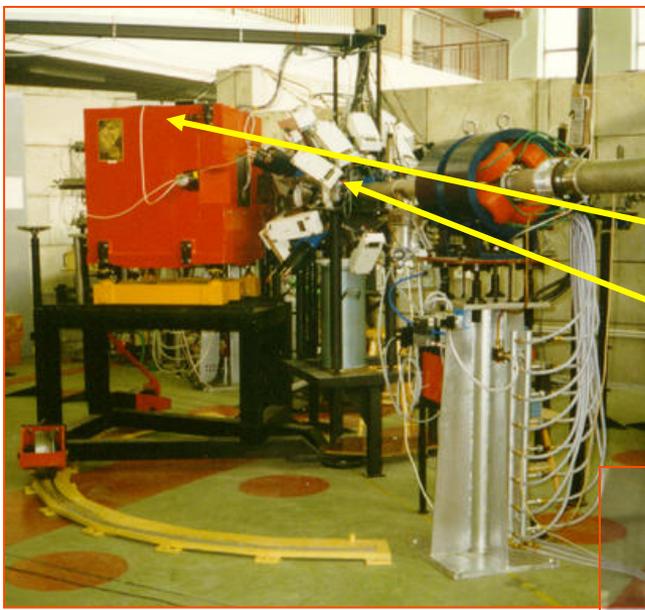


Research program

- Studies of fusion barriers height distribution
- Investigations of reactions with light nuclei

From IReS Strasbourg, first experiments in 2007

Other detection systems at SLCJ



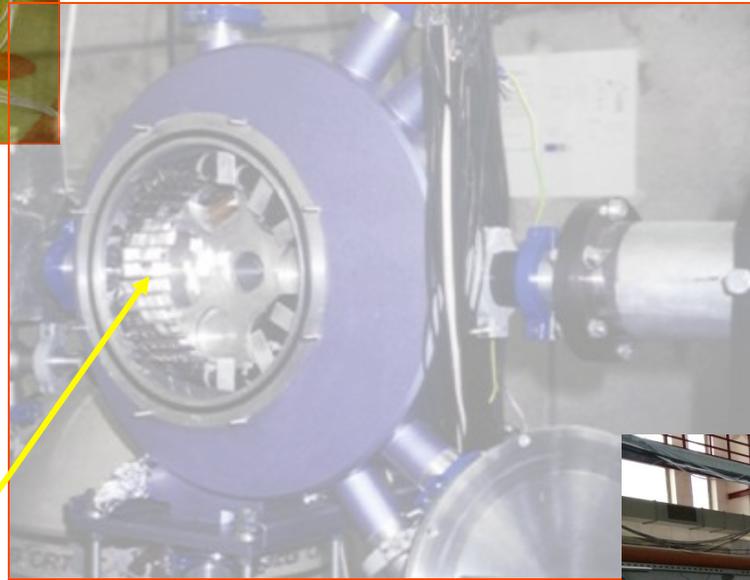
- large NaI(Tl) crystal
- 32-element multiplicity filter

JANOSIK

for detection of high-energy gamma rays

CUDAC

PIN-diode charged particle detector array



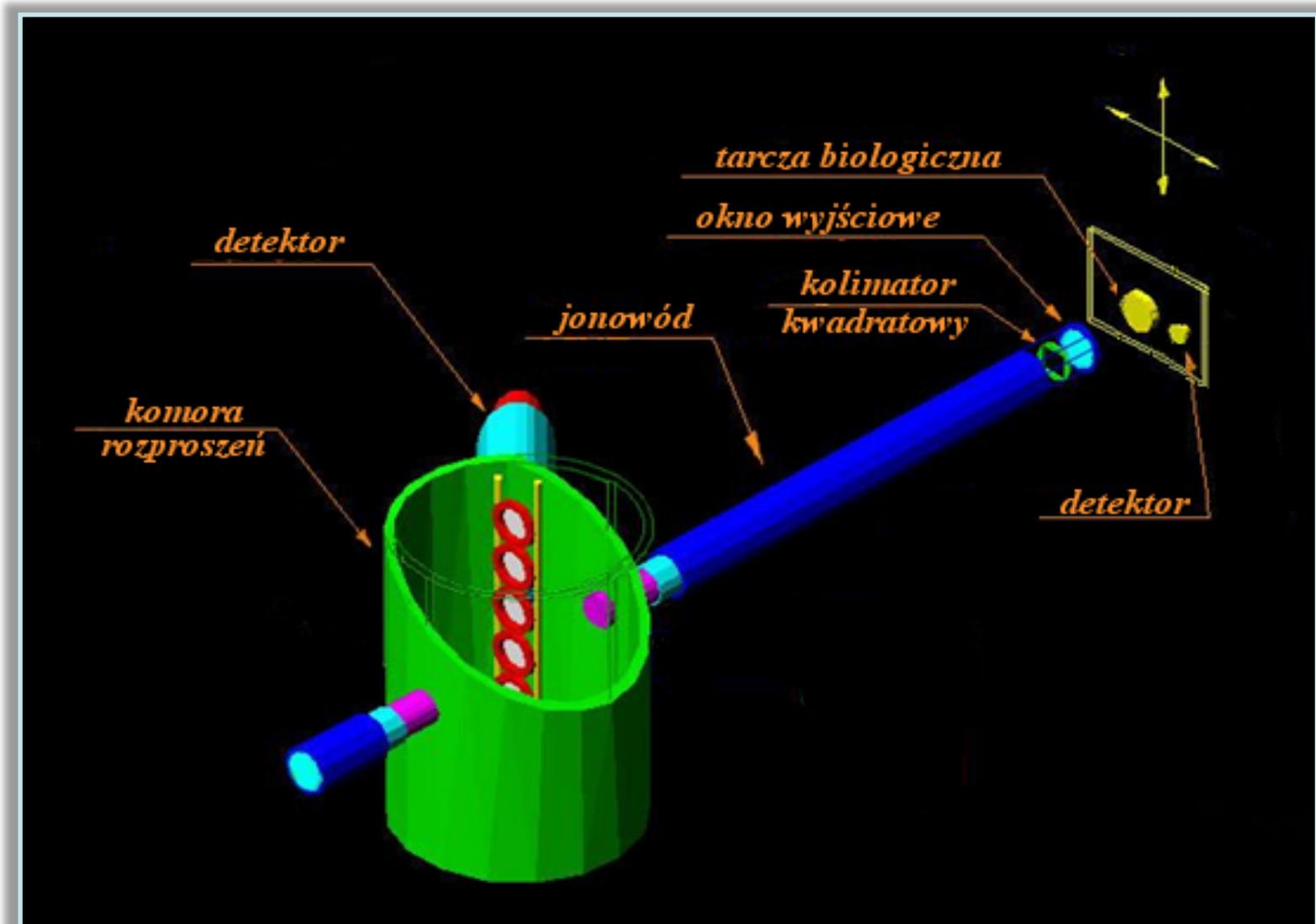
IGISOL

Isotope Separator On-Line

- Ion source
- Helium jet
- Mass separator
- Detection system



Experimental set-up to scan biological samples



Beam time is allocated by the SLCJ Director based on the recommendation of the international Programme Advisory Committee

PAC Members:

Dimiter Balabanski (Univ. of Sofia, Bulgaria)

Konrad Czerski (Univ. of Szczecin, Poland)

Bogdan Fornal (IFJ PAN)

Gilles de France (GANIL, Caen, France)

Andres Gadea (Univ. of Valencia, Spain)

Zenon Janas (Univ. of Warsaw, Poland)

Nicholas Keeley (NCBJ, Poland)

Rainer Lieder (Univ. of Bonn, Germany)

Piotr Magierski (Warsaw University of Technology, Poland)

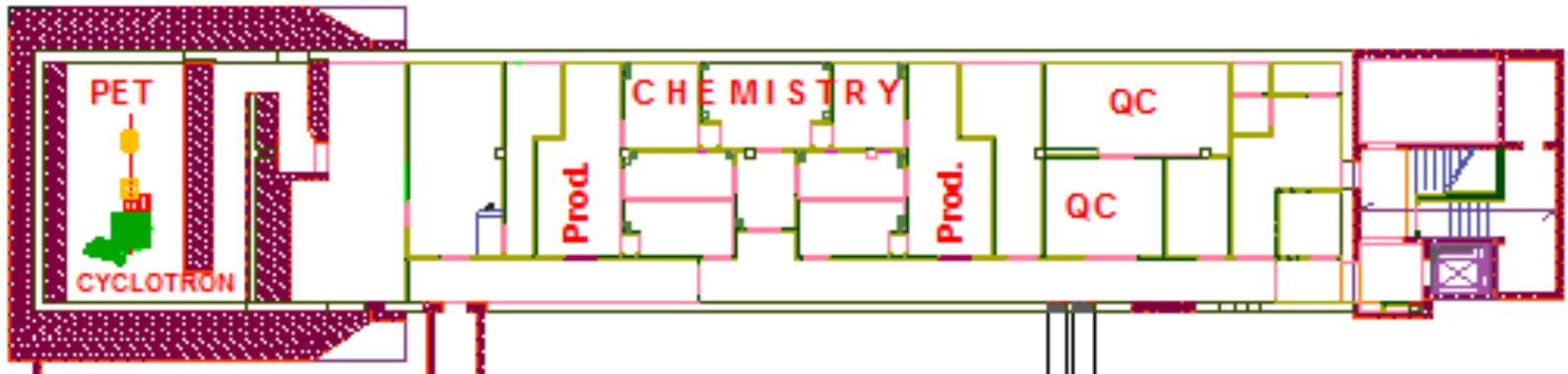
Leszek Próchniak (Maria Curie-Skłodowska Univ., Poland)

Brunon Sikora (Univ. of Warsaw, Poland)

Wladyslaw Trzaska (Univ. of Jyväskylä, Finland)

Radiopharmaceutical research and production centre

Opened 15.05.2012



GE PET-trace Cyclotron

p / d cyklotron
16/8 MeV
(General Electric)

> 75 μA p
> 60 μA d



Education

- Teaching the UW students
- **International Workshops on Acceleration and Applications of Heavy Ions, duration: two weeks, 2011, 2012, 2013**
- **Summer School on Acceleration and Applications of Heavy Ions, duration: one week, 2012, 2013**
- **Polish Workshops on Acceleration and Applications of Heavy Ions, duration: one week, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013**



Heavy Ion Laboratory, at the University of Warsaw, is a nuclear physics institute operating 2 cyclotrons, involved in research, teaching and medical applications.

More on: www.slcyj.uw.edu.pl

XXXIII Mazurian Lakes Conference on Physics Frontiers in Nuclear Physics Piaski, Poland, September 1-7, 2013

Topics

- Super-heavy nuclei
- Towards the drip lines
- Nuclear physics near Coulomb barrier
- From direct reactions to heavy-ion fragmentation
- Nuclear structure and astrophysics
- New facilities
- Applications

Programme Advisory Board

Juha Äystö (Jyväskylä)
Georg Bollen (MSU)
Maria J.G. Borge (ISOLDE CERN)
Angela Bracco (Milano)
Peter Butler (Liverpool)
Jerzy Jastrzębski (Warszawa)
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Witold Nazarewicz (Tennessee/Warszawa)
Jan Pluta (Warszawa)
Krzysztof Pomorski (Lublin)
Guy Savard (Argonne)
Christoph Scheidenberger (GSI)
Janusz Wilczyński (Swierk)

TASCA workshop:

Christoph Düllmann, (Mainz/GSI/HIM)
Alexander Yakushev, (GSI)

Further information:

e-mail: mazurian@fuw.edu.pl,
<http://www.mazurian.fuw.edu.pl>

Local Organizing Committee: K. Rusek (Chairman), K. Rykaczewski (Vice-chairman),
D. Chmielewska, K. Delegacz, M. Godlewski, S. Małek, C. Mazzocchi, L. Próchniak, M. Wolińska-Cichocka

Organized by: the University of Warsaw, National Centre for Nuclear Research, the Pro Physica Foundation



Institute of Nuclear Physics, Polish Academy of Sciences Krakow, Poland



In December 2012, a **new proton cyclotron** became operational at the **Institute of Nuclear Physics PAN in Kraków**. Together with the existing cyclotron AIC-144, it is a part of the **Cyclotron Center of Bronowice (CCB)**.

Although the primary objective of the facility is proton cancer therapy, an extensive research program at this cyclotron is planned in the field of nuclear physics, radiobiology, dosimetry and medical physics.



CCB at IFJ PAN – Feb. 2013



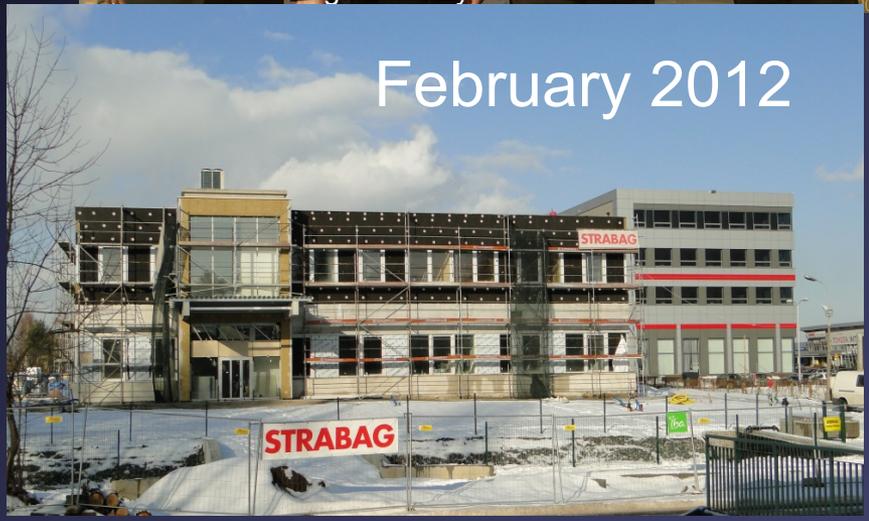
CCB – final stage



Cyclotron Center of Bronowice (CCB)

Phase I of the National Center for Hadron Radiotherapy

Cost: ~28 M€ + 18 M€

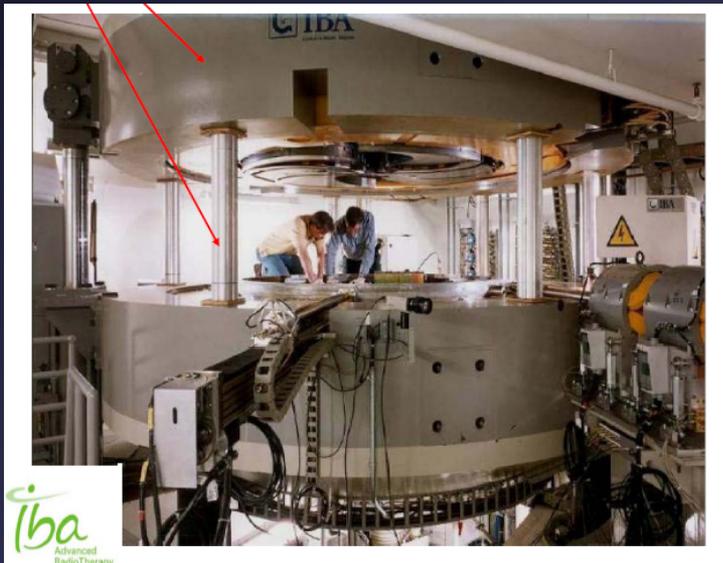


Cyclotron Center of Bronowice (CCB)

Phase I of the National Center for Hadron Radiotherapy

Cyclotron PROTEUS 235 (IBA Company)

beam: protons 60 – 230 MeV
beam current: 0.1 nA (6.6×10^8 p/s) - 500 nA (3.3×10^{12} p/s)



Research at CCB

Users Board

**Experimental
Program Committee**
(Coordinator: M. Kmiecik)

**Electronics and Data
Acquisition Group**
(Coordinator: M. Ziębliński)

**Infrastructure
Group**
(Coordinator: W.
Męczyński)

Institutions involved in research

- University of Milano,
- IPN Orsay,
- GANIL
- LNL Legnaro/Padova,
- KVI Groningen,
- Physikzentrum RWTH Aachen,
- ATOMKI Debrecen,
- RIKEN
- IPHC Strasbourg
- IEM CSIC of Madrid
- Univ. of Santiago di Compostela
- Tech. Univ. of Munich
- Nigde Univ., Turkey
- IFIN-HH Bucharest
-
- IFJ PAN
- Jagiellonian University (UJ),
- University of Silesia (US),
- University of Warsaw (UW),
-

Research at CCB IFJ PAN

Users Board

- Faical Azaiez (IPN, Orsay, France)
- Angela Bracco (University of Milano and INFN, Italy)
- Bogdan Fornal (IFJ PAN, Kraków, Poland)
- Zsolt Fulop (ATOMKI, Debrecen, Hungary)
- Muhsin Harakeh (KVI, Groningen, Netherlands)
- Robert Janssens (Argonne National Laboratory, USA)
- Stanisław Kistryn (Jagiellonian University, Kraków, Poland)
- Marek Lewitowicz (GANIL, Caen, France)
- Adam Maj (IFJ PAN, Kraków, Poland)
- Krzysztof Rusek (Warsaw University, Poland)
- Hideyuki Sakai (RIKEN, Japan)
- Nicolae Victor Zamfir (IFIN-HH, Bucharest, Romania)
- Wiktor Zipper (University of Silesia, Katowice, Poland)

Proposals of experimental studies at CCB

- **Dynamics of few-nucleon systems:**
Jagiellonian Univ., IFJ PAN, KVI, Univ. of Silesia
- **Studies of gamma decay of high-energy excitations (including resonances PDR, GDR, GPV, IAR) in reactions induced by the 70-230 MeV protons**
IFJ PAN, Univ. Milano
- **Studies of isomers populated in proton induced fission of heavy targets**
IFJ PAN
- **Investigations of (p,2p) reactions in order to identify deep single-particle proton-hole states**
Univ. Milano, IFJ PAN
- **Proton induced spallation with the Berliner Neutron Ball**
Jagiell. University, IFJ PAN
- **Investigations of nuclear reactions relevant to cancer therapy**
Jagiell. Univ., IFJ PAN, RWTH Aachen

Dynamics of few-nucleon systems

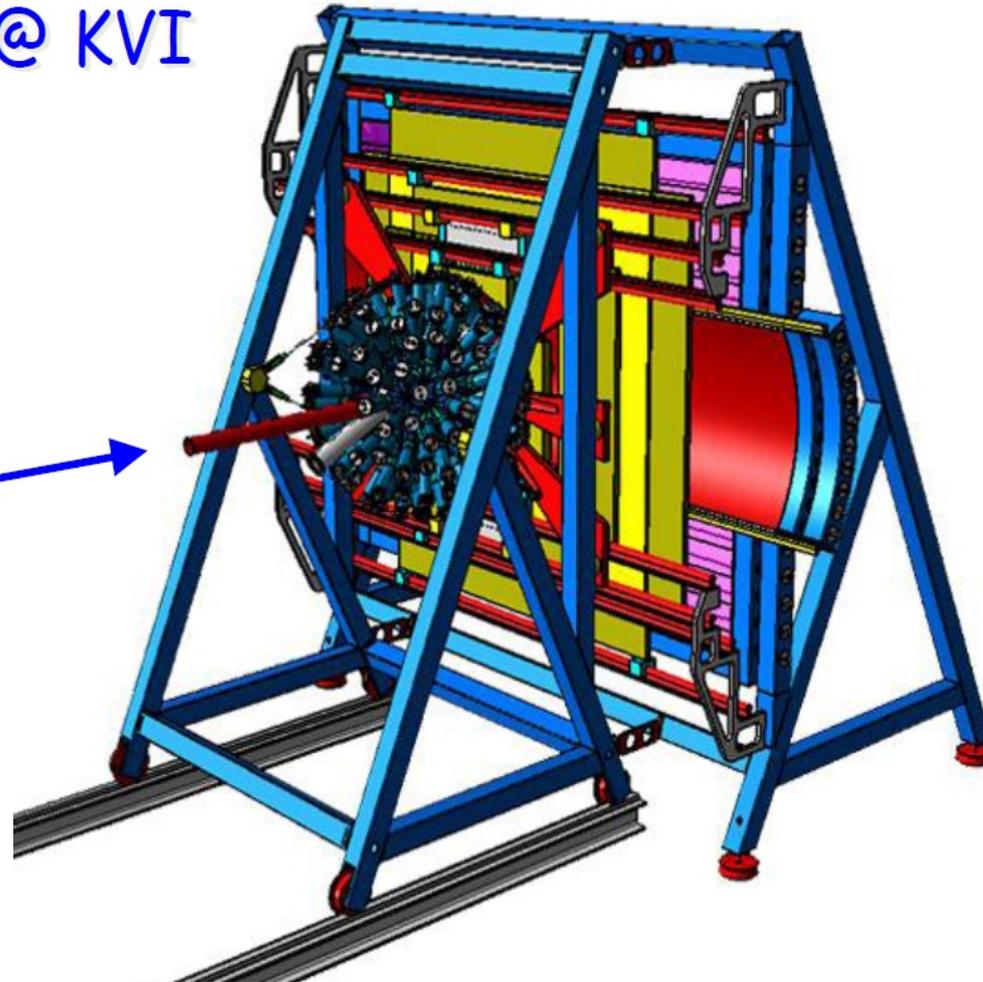
S. Kistryn, A. Kozela et al.

- *Jagiellonian University, Kraków*
- *IFJ PAN*
- *University of Silesia, Katowice*
- *KVI Groningen*

Big Instrument for Nuclear reaction Analysis (BINA)

BINA @ KVI

beam



~3 meters

Wall:

- MWPC (3 planes)
- ΔE (24 x 2 mm)
- E (20 x 120 mm)

Ball:

- Phoswich (149 x 90/30 mm)

Studies of gamma decay of high-energy excitations, including resonances PDR, GDR, GPV, IAR, in reactions induced by the 70-230 MeV protons

Maria Kmiecik et al.
IFJ PAN, Univ. Milano

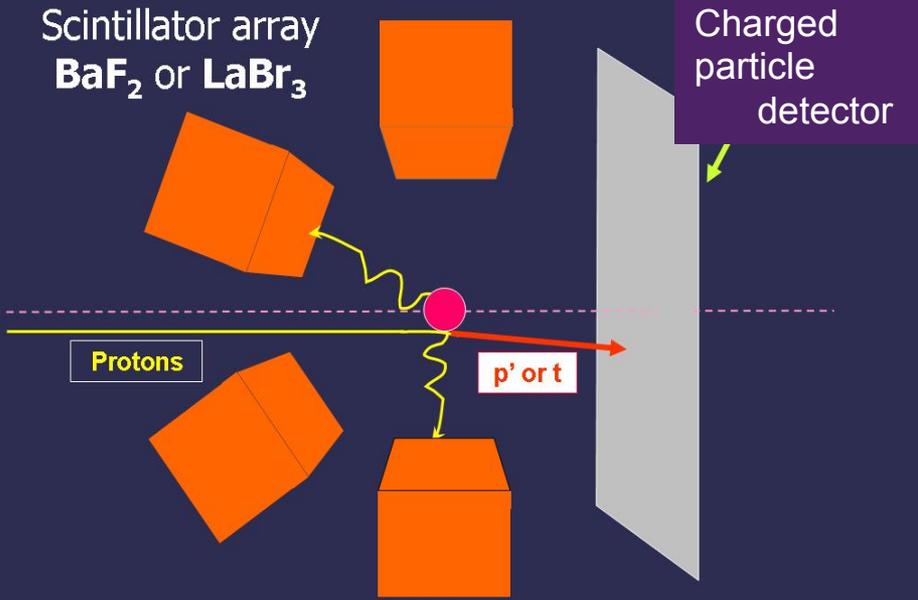
- (p,p')
- (p,t)
- (p,³He)

GDR at high temperature
- fusion-evaporation reactions

Experimental set-up for (p,p') or (p,t) reactions

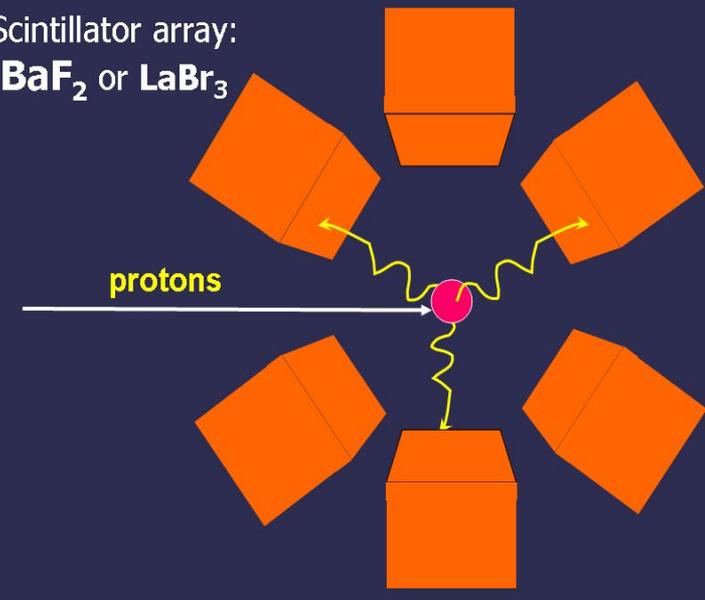
Scintillator array
BaF₂ or **LaBr₃**

Charged
particle
detector



Experimental set-up for p + ^AX fusion reactions

Scintillator array:
BaF₂ or **LaBr₃**



Possible systems:

p(70 MeV)+⁴⁵Sc → ⁴⁶Ti at T~3.5 MeV

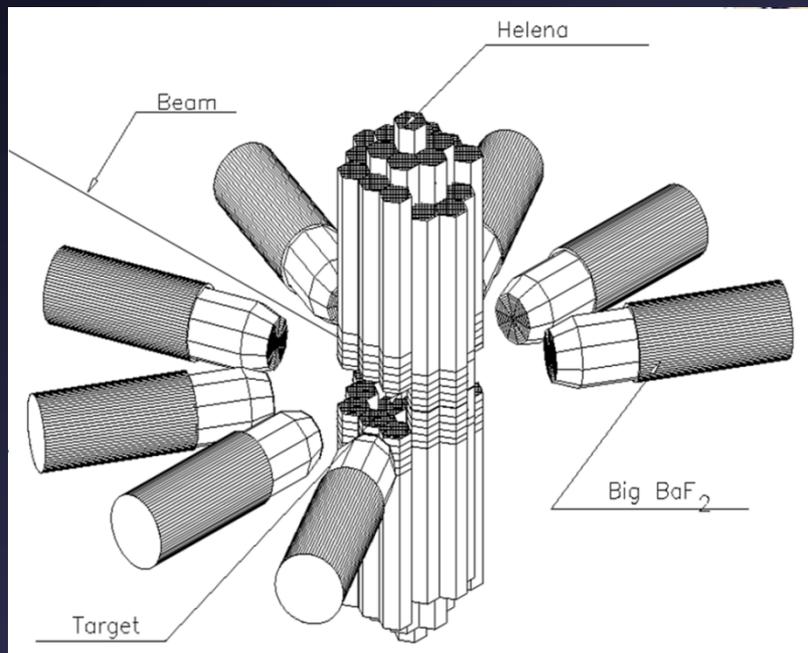
p(200 MeV)+⁴⁵Sc → ⁴⁶Ti at T~6 MeV

Study of gamma decay of resonance states (GDR, GPV) in the reactions

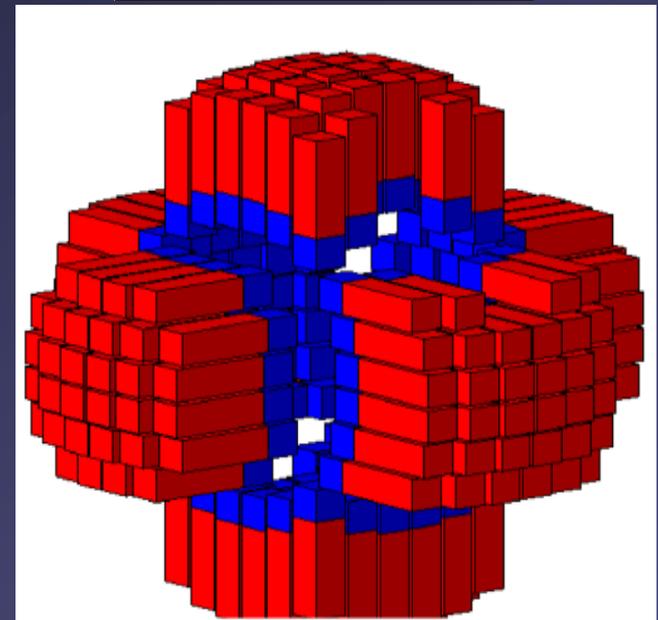
induced by 70-230 MeV protons

IFJ PAN, Univ. Milano

HECTOR array



PARIS array



Tests of various LaBr_3 detectors have been performed at CCB in March 2013.

38 physicists participated

IPN Orsay

IEM CSIC of Madrid

University of Milano

Tech. Univ. of Munich

IPHC Strasbourg

Univ. of Santiago di Compostela

IFIN-HH Bucharest

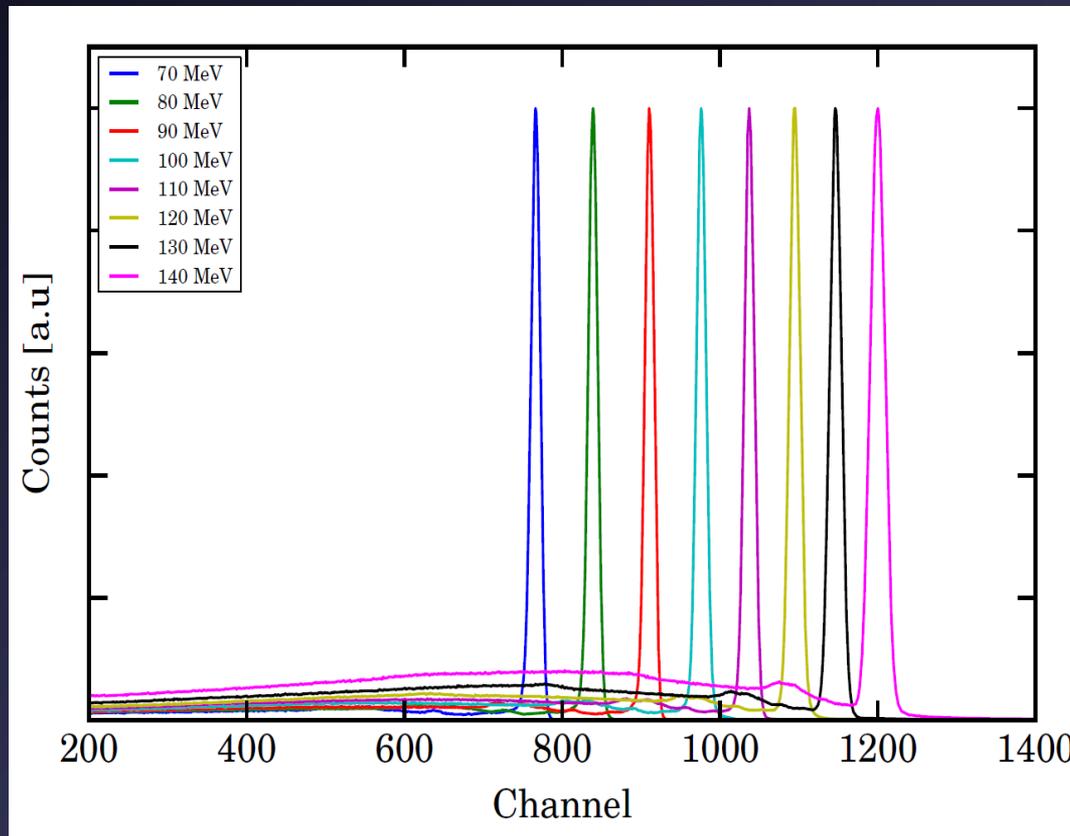
ATOMKI Debrecen,

Nigde Univ., Turkey

**Heavy Ion Laboratory,
Warsaw**

First proton spectra from the Ti(p,p') reaction measured at CCB with a LaBr₃ detector

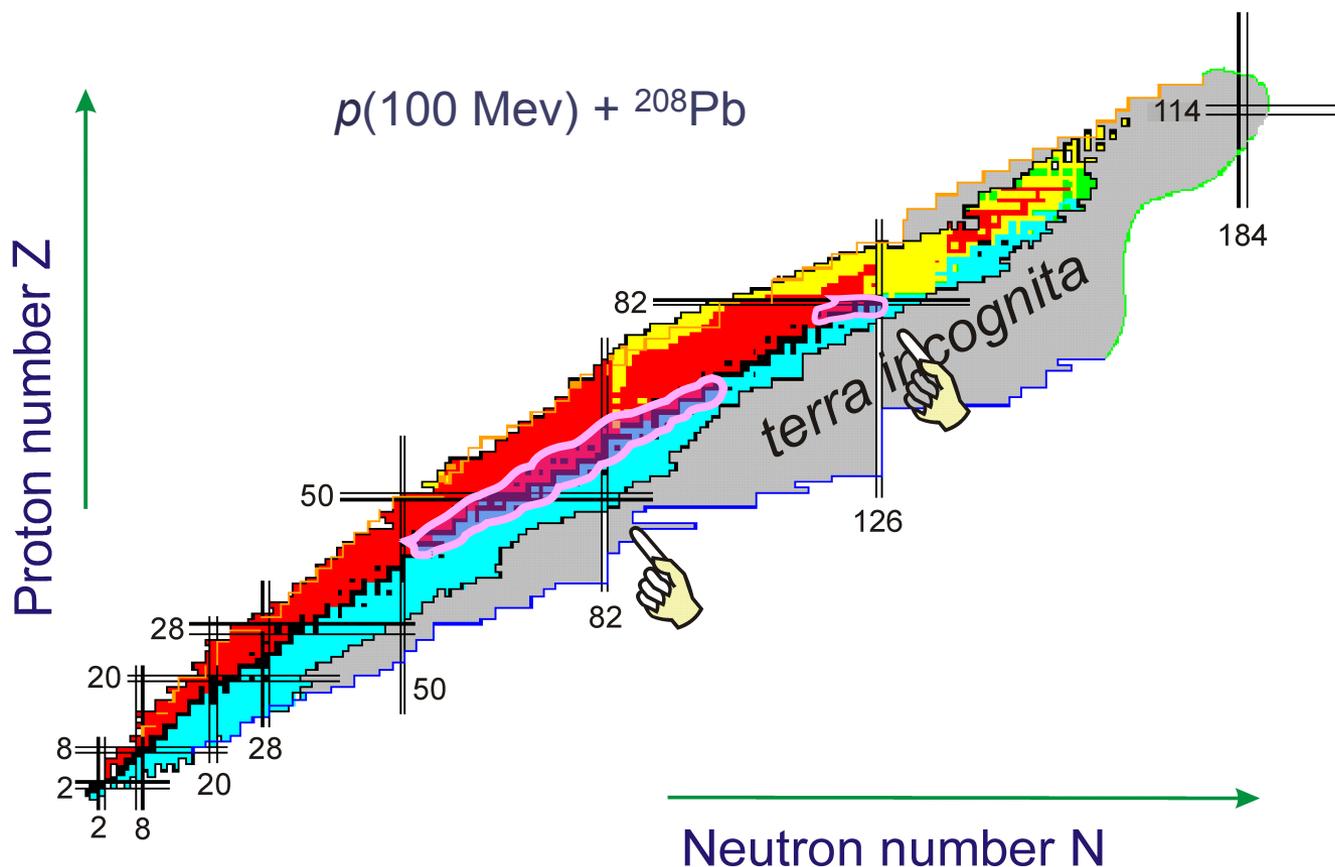
M. Ziębliński, B. Szpak, M. Krzysiek, A. Maj, W. Męczyński et al.,
IFJ PAN



Spectra of protons at different beam energies measured with a 2" x 2" x 2" LaBr₃:Ce crystal at 5 deg. relatively to the beam axis. The spectra are normalized to have the same height of a proton peak.

Studies of nanosecond isomers populated in proton induced fission of heavy targets

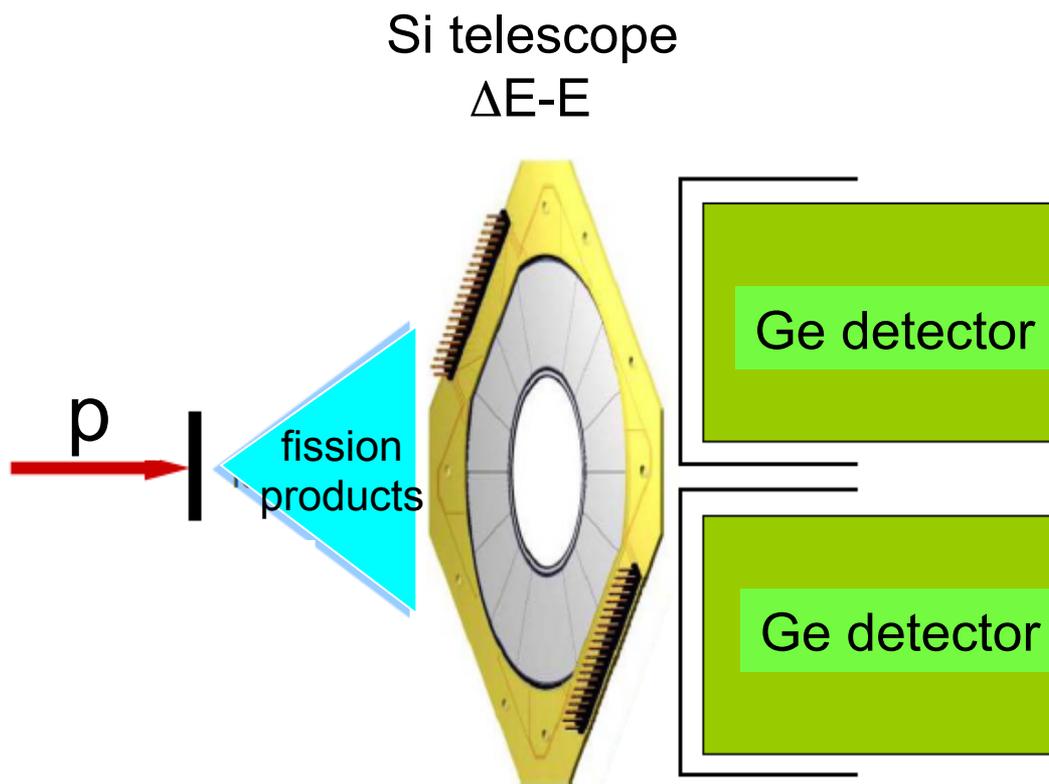
IFJ PAN



Studies of nanosecond isomers populated in proton induced fission of heavy targets

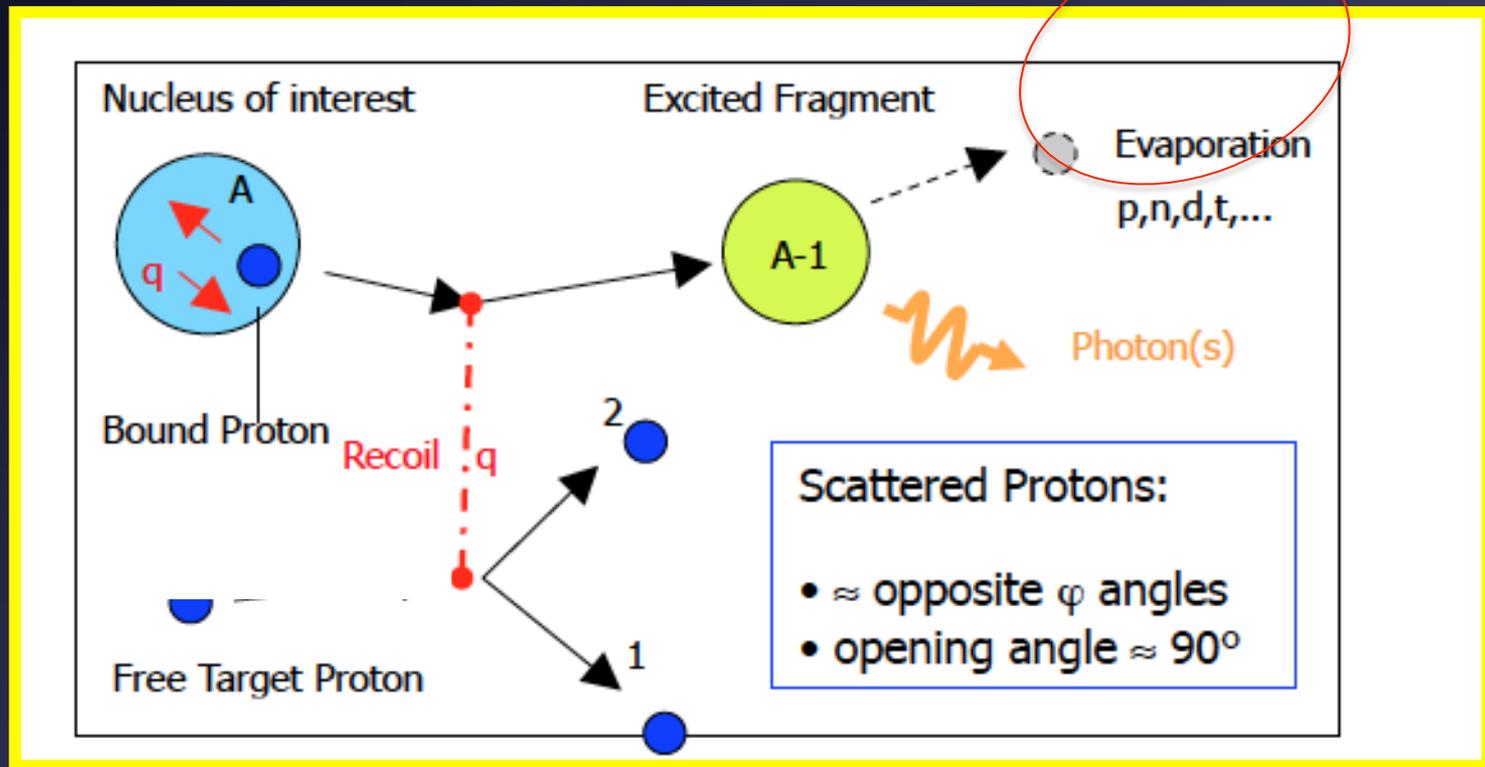
W. Królas et al., IFJ PAN

isomer-scope with „active catcher”

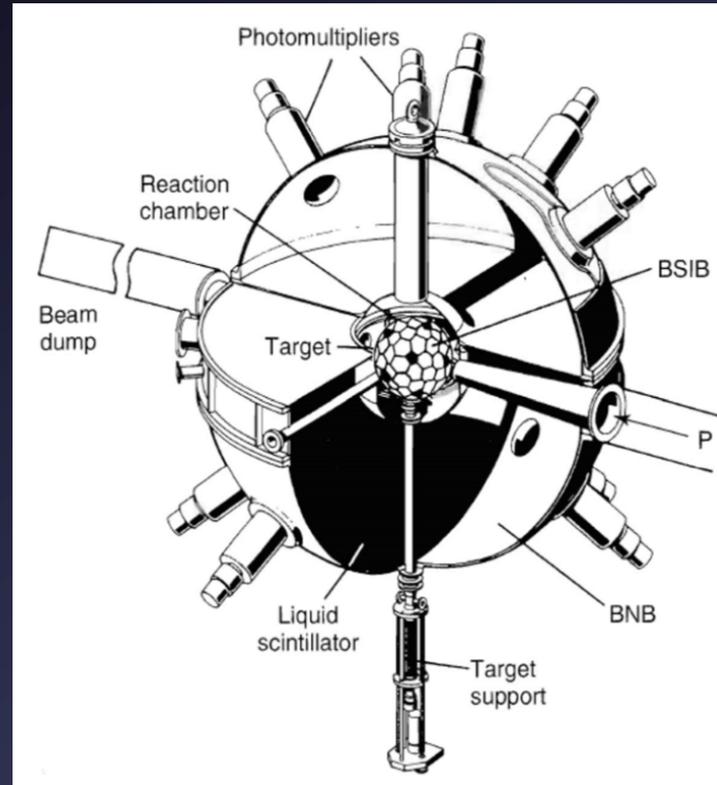


Investigations of (p,2p) reactions in order to identify deep single-particle proton-hole states

Univ. Milano, IFJ PAN



Proton induced spallation with the Berliner Neutron Ball



Systematic deviations of the data and simple spallation model predictions appear for light, medium, and heavy target nuclei in broad energy range – one can pursue more detailed tests of these models with the Krakow Cyclotron at CCB

The studies proposed at CCB will have important assets:

- quick alternation between different beam energies;
- excitation functions in a wide proton energy range: 70 – 230 MeV;
- long runs (at least at the beginning of the CCB activity);

EURISOL Topical Meeting Kraków, 1-3 July 2013



The two Polish nuclear physics laboratories, **SLCJ (HIL)** in Warsaw and **IFJ PAN** in Krakow, pursue fundamental research in nuclear physics and are heavily involved in medical applications of nuclear physics.

Recalling the thoughts of Richard Feynman from „The pleasure of findings things out”:

**SCIENCE CREATES A POWER THROUGH ITS KNOWLEDGE,
A POWER TO DO THINGS.**

You are able to do things after you know something scientifically.