



# **Heavy Ion Laboratory, University Of Warsaw – A Unique Research Center In Poland**

**Jarosław Choinski**  
Przemysław Gmaj

13th International Conference on Heavy Ion Accelerator Technology  
RIKEN Nishina Center, Yokohama, Japan, September 7-11, 2015



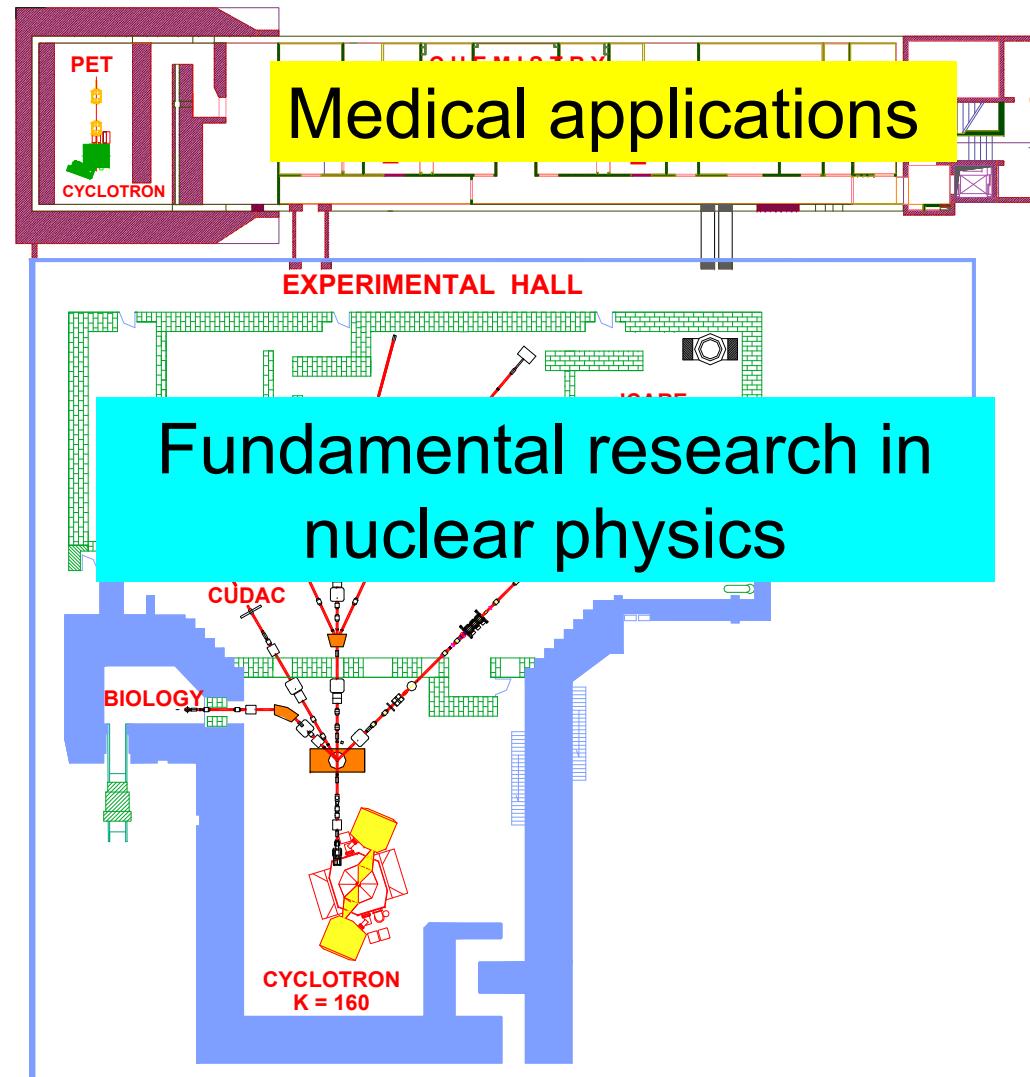
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# Science Campus Ochota



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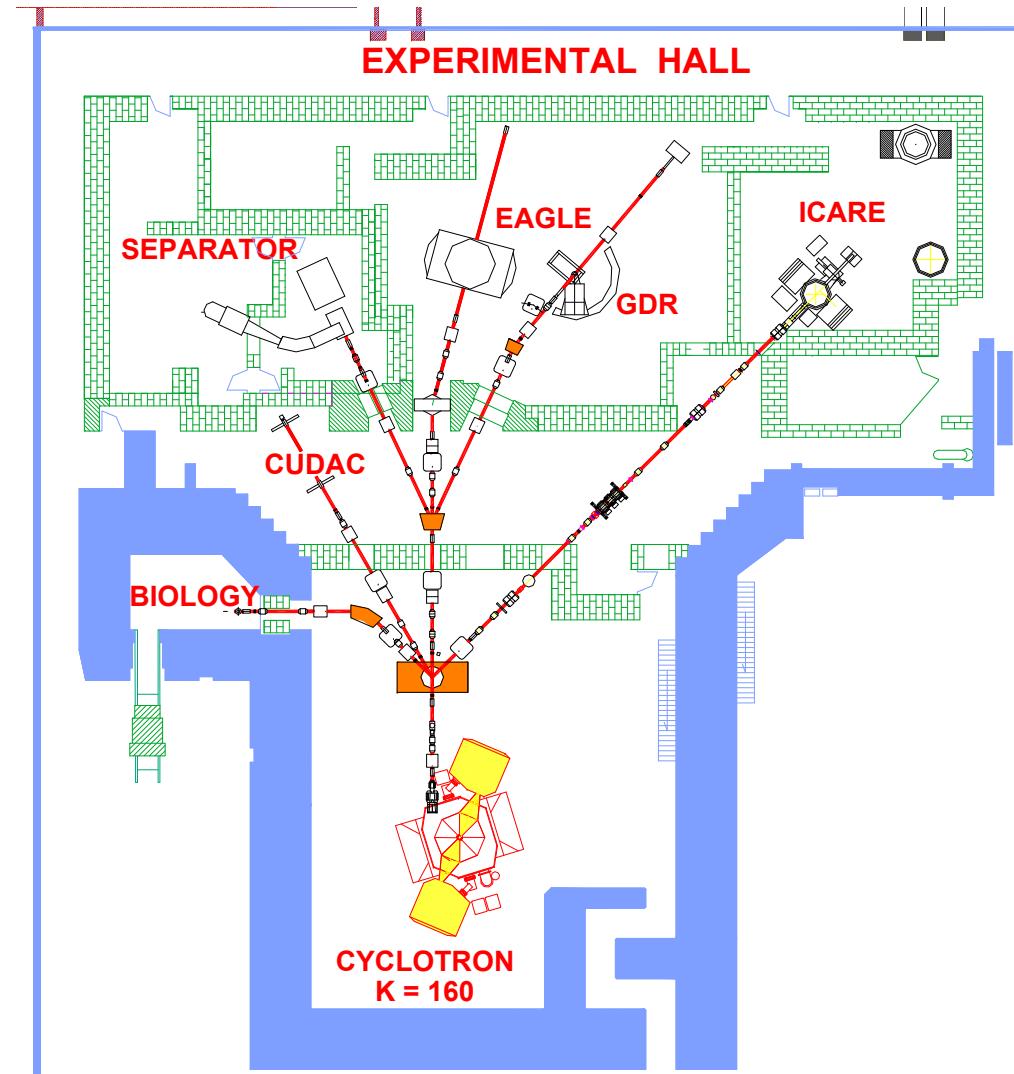


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about 3300 h/year

about 100 users/year

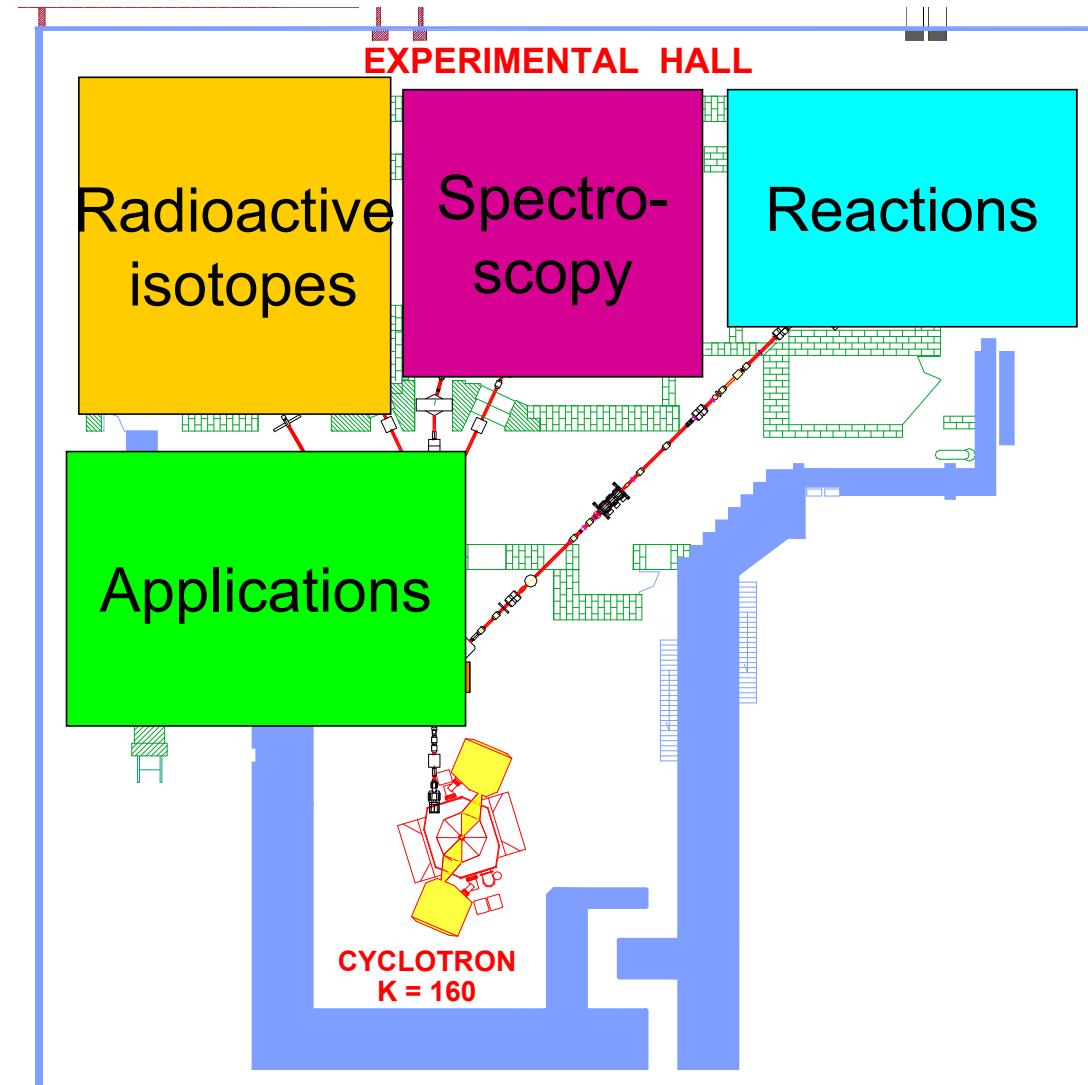


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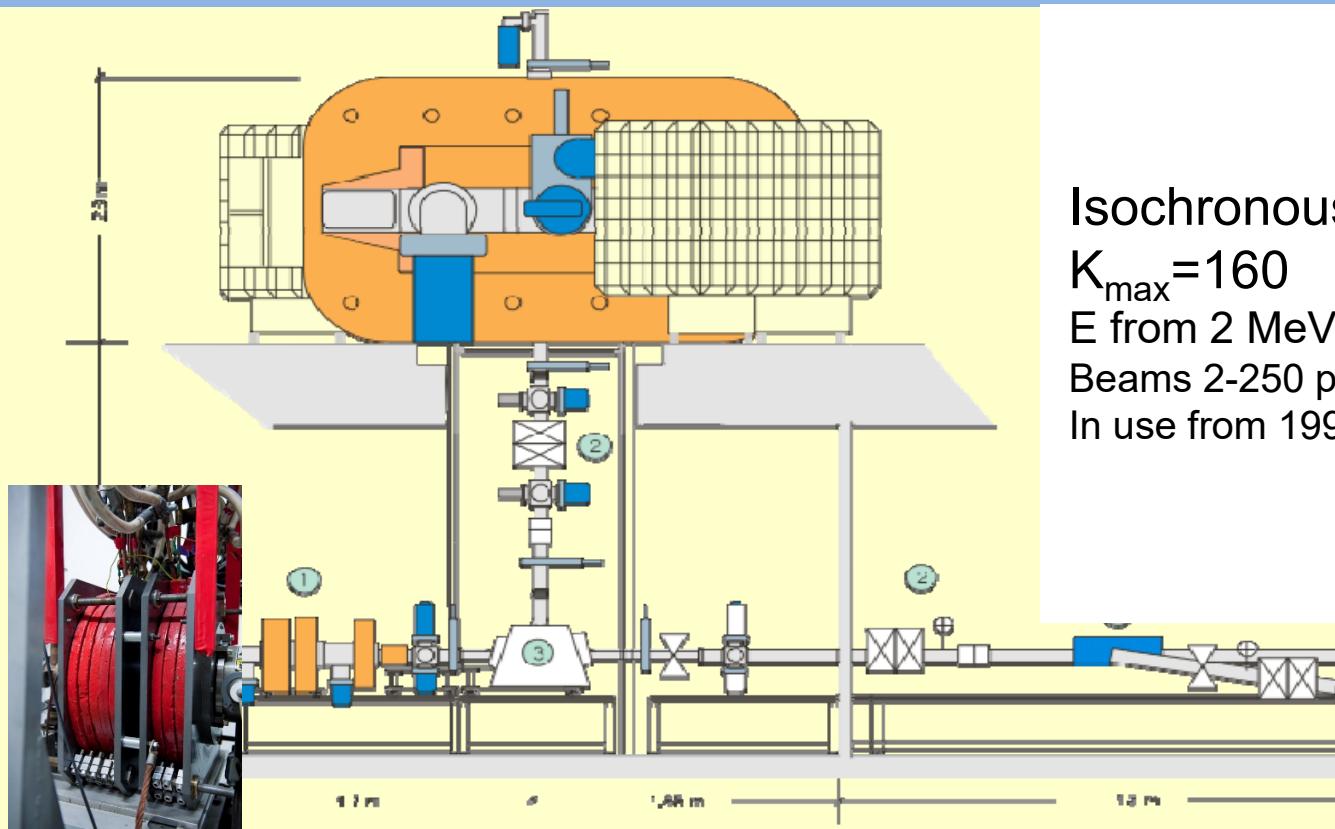
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# Cyclotron U-200P and ion sources



Present ECR ion source

ECR - Home made, ions He-Ar

Isochronous, 4 sectors,  
 $K_{\max} = 160$   
E from 2 MeV/A to 10 MeV/A  
Beams 2-250 pnA  
In use from 1994



ECR - "Supernanogun" Pantechnik,  
ions up to Xe

# Fundamental research



- Coulomb excitations
- Life time measurements
- K-isomers
- Coulomb barrier distributions
- Transfer reactions
- Time reversal spontaneous symmetry breaking (chirality)
- Electron conversion spectroscopy
- Atomic clusters, nanodosimetry
- Exotic alpha-emitters
- Biology - surviving of irradiated cells
- New radiopharmaceuticals





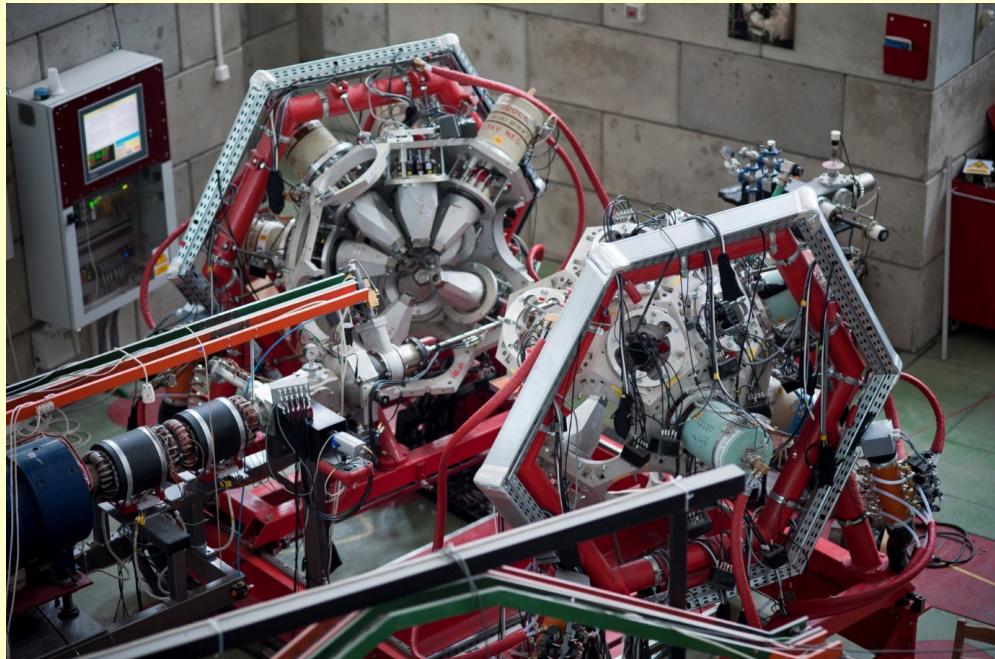
# Experimental Hall



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# EAGLE

Central European Array for Gamma Levels Evaluation



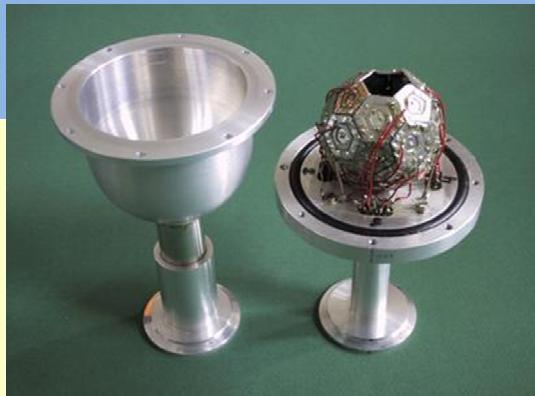
- multi-detector gamma-ray spectrometer
- up to 30 HPGe detectors with ACS
- many ancillary detectors
- can employ Phase-I EUROBALL detectors from Gammapool

*J. Mierzejewski et al., NIM A659 (2011)84*



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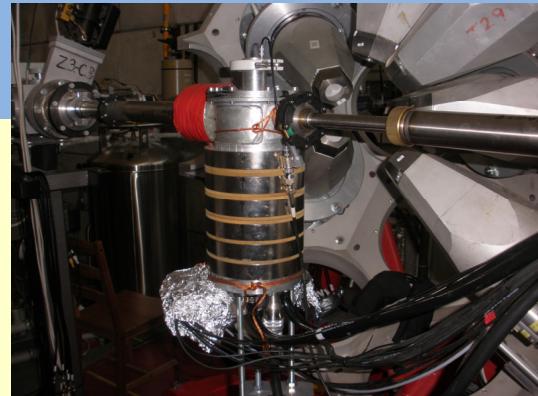
# EAGLE



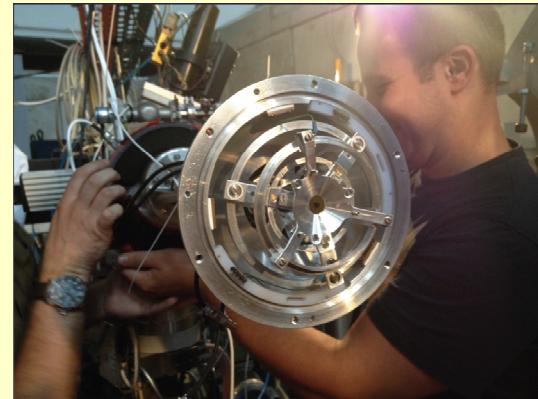
**4 $\pi$  Si-Ball**  
(by A. Kordyasz, HIL, Warsaw)



„The Munich chamber”  
48 PiN diodes (max. 110)



**ULESE**  
(University of Łódź electron spectrometer)



**Bucharest plunger**  
9 collaboration with IFIN-HH

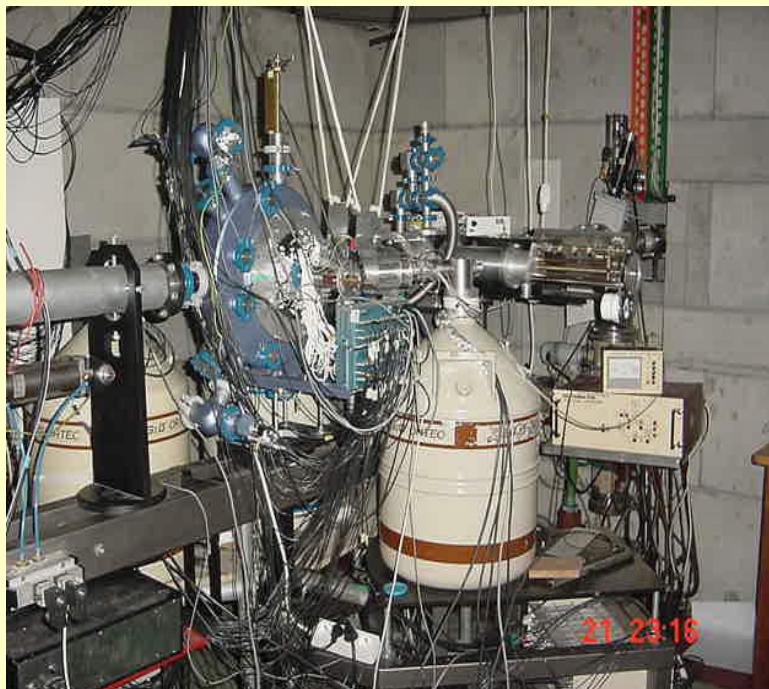


# EAGLE



- Main research domain: nuclear structure studies with the use of  $\gamma$ -spectroscopy:
  - $\gamma$ - $\gamma$  angular correlations with **EAGLE** HPGe array;
  - e- $\gamma$  spectroscopy with **ULESE** spectrometer;
  - **DSAM** (Doppler Shift Attenuation Method) and **RDDS** (Recoil Distance Doppler Shift technique) lifetime measurements;
  - complex **Coulomb excitation** experiments relevant for nuclear structure physics
- Complementary to RIB experiments performed e.g. at ISOLDE in CERN
  - ➔ additional experimental data derived from independent experiments crucial when going towards more exotic nuclei with e.g. HIE-ISOLDE.

# CUDAC

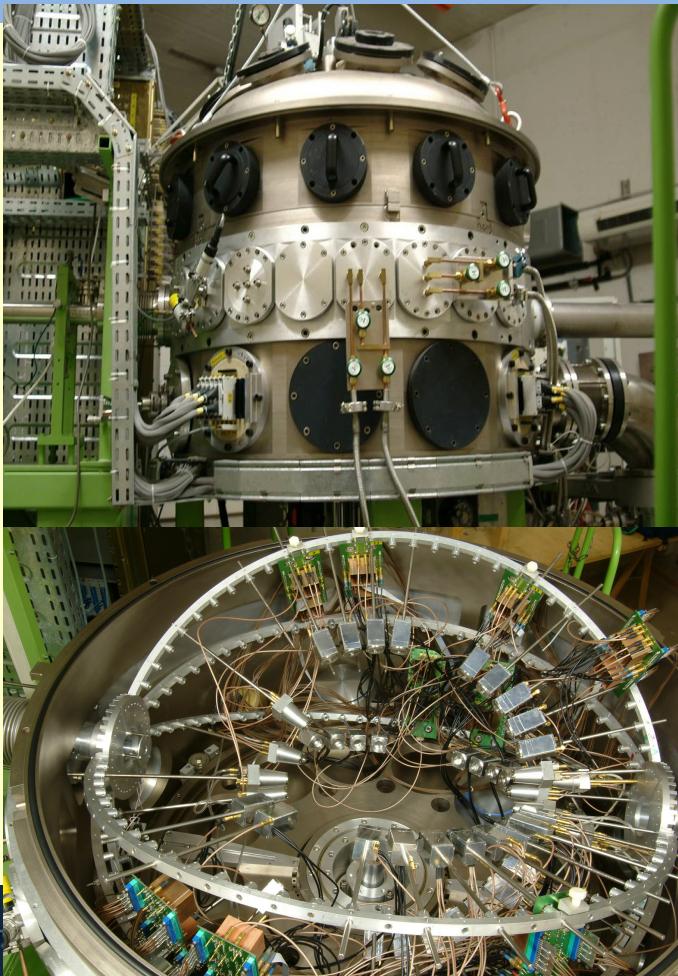


A small scattering chamber, equipped with an array of backward hemisphere semiconductor detectors (PiN diode type) and forward hemisphere monitoring Si counters.

Used for Coulomb excitation studies and measurements of fusion barrier height distributions.



# ICARE



## *Identificateur de Charges A Rendement Elevé*

- Reaction chamber ( $\phi 1.0 \times 0.7\text{m}$ )
- 48 telescopes for charged particles detection & identification, energy measurements:
  - 8 tel.:  $\Delta E(\text{gas}) + 500\mu\text{E}(\text{Si})$
  - 24 tel.:  $40\mu\Delta E(\text{Si}) + 2.5\text{cm E}(\text{CsI})$
  - 16 tel.:  $40\mu\Delta E(\text{Si}) + 300\mu\Delta E(\text{Si}) + 2.5\text{cm E}(\text{CsI})$



- ICARE Particle Spectroscopy Chamber from IReS Strasburg, France Form 2007 at HIL.
- Scientific program:
  - barrier distributions measurements
  - reaction mechanism studies
  - novel detector tests



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by courtesy of A.Trzcińska

# On-line mass separator IGISOL



- **Mass separation:**
  - acceleration voltage 40KV
  - analyzing magnet 55 deg.
  - mass resolution 260-700

## Detection setup:

- tape station
- advanced time delay system ( $\beta$ - $\gamma$ - $\gamma$ : Ge, Si(Li), BaF<sub>2</sub> detectors)
- miniorange spectrometer



# Applications

## Internal target station



### Radioisotopes presently investigated

- $^{211}\text{At}$  with the reaction  $^{209}\text{Bi}(\alpha, 2n)$ ;
- $^{43}\text{Sc}$   $^{40}\text{Ca}(\alpha, n)$ ;
- $^{44}\text{Sc}$   $^{42}\text{Ca}(d, n)$ ;
- $^{72}\text{Se}/^{72}\text{As}$   $^{42}\text{Ca}(\alpha, 2n)$ ;
- $^{99m}\text{Tc}$   $^{44}\text{Ca}(p, n)$ ;
- $^{70}\text{Ge}(\alpha, 2n)$ ;
- $^{100}\text{Mo}(p, 2n)$ .

# Applications

## Targeted Alpha Therapy (TAT)



- $^{211}\text{At}$  produced using U-200P cyclotron, internal target station,  $^{209}\text{Bi}(\text{He}^{+1}, 2\text{n})^{211}\text{At}$  reaction at 30MeV bombarding energy.
- The produced activity is transported to the Institute of Nuclear Chemistry and Technology, where the  $^{211}\text{At}$  is extracted from the Bi target and chemical research consisting of binding  $^{211}\text{At}$  to substance P, a peptide with high affinity to the receptors of glioma cancer cells are conducted.



# Applications

## $^{72}\text{Se}/^{72}\text{As}$ production



## $^{72}\text{Se}/^{72}\text{As}$ radionuclide generator

- $^{72}\text{Se}/^{72}\text{As}$  EC/positron emitter generator for PET applications is one of many generators listed in the IAEA report (2010);
- $^{72}\text{Se}$  can be produced by the  $(\text{p},4\text{n})$  reaction or  $(\alpha,2\text{n})$  reaction;
- The research on the properties of this generator are presently conducted by the Inst. of Nucl. Chemistry and Technology in collaboration with HIL team using the  $\alpha$ -particle production route.





## Expected applications of 3.9h Sc radioisotopes

- $^{43}\text{Sc}$  - longer than  $^{18}\text{F}$  living PET radioisotope, with substantially increased uptake characteristics for some cancers, similar to much shorter living  $^{68}\text{Ga}$ ;
- $^{44}\text{Sc}$  - the favourite candidate for the three photons PET technics.

*"The development of methods for production of new radiopharmaceuticals based on Sc radionuclides used in positron tomography (PET)" [PET-SKAND]*

Agreement No PBS3/A9/28/2015

*consortium of*

**the Institute of Nuclear Chemistry and Technology, the Polatom – National Centre for Nuclear Research and the University of Warsaw**



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by courtesy of J.Jastrzębski

# Applications

Biology - survival of irradiated cells,  
X-Y scanner (moving target)

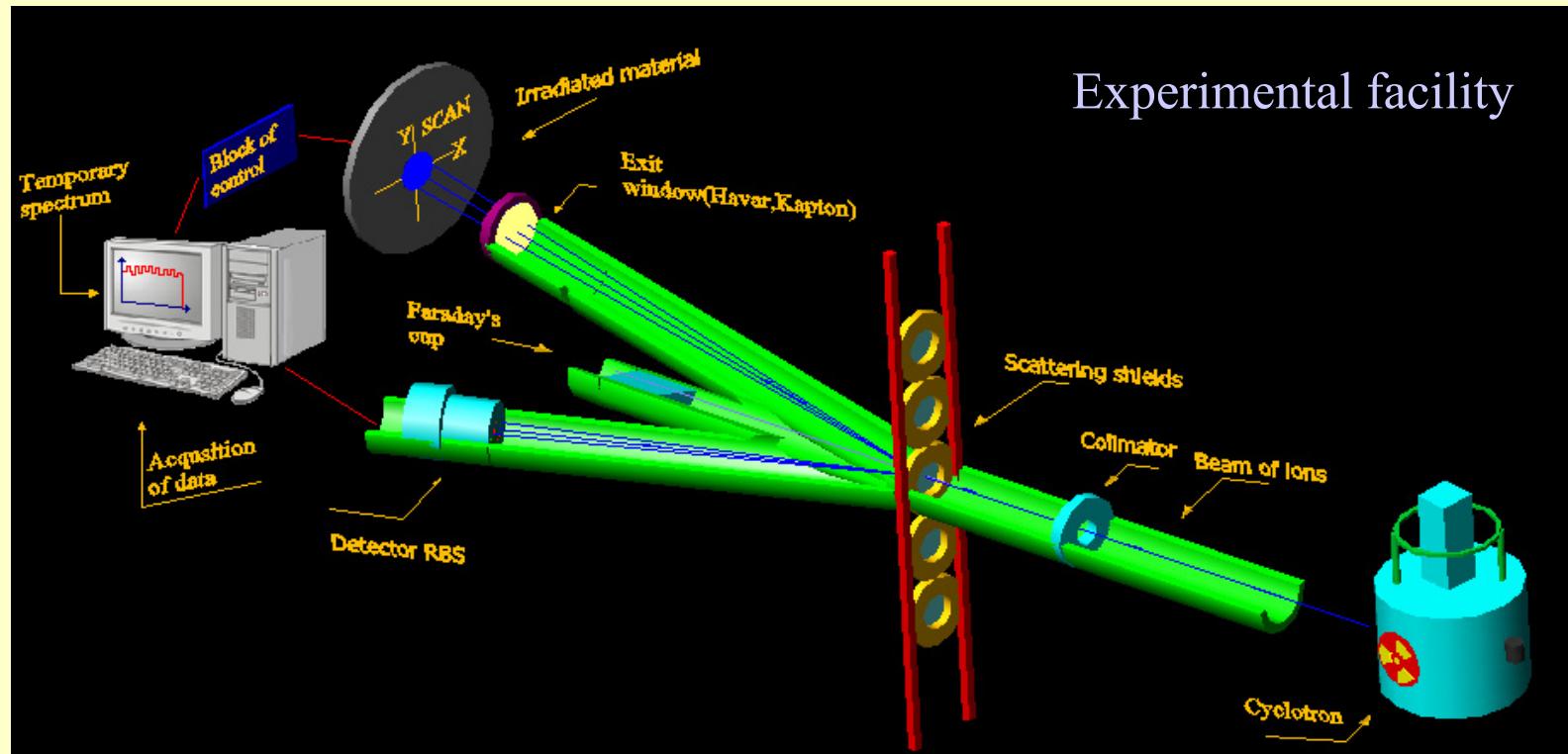


Target holder



# Applications

## X-Y scanner (moving target)



# Applications

## Laboratory of Medical Imaging

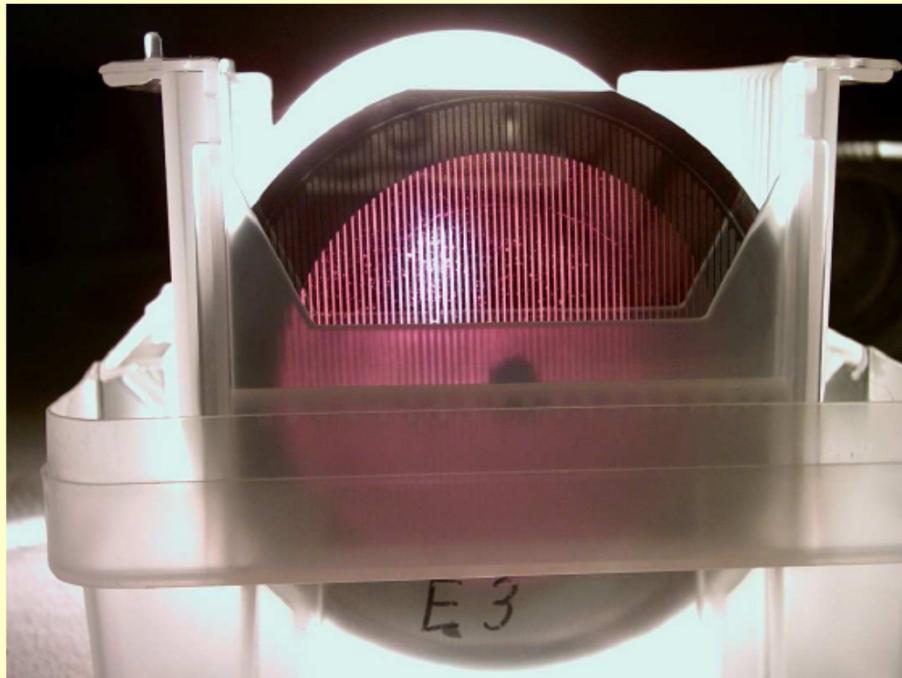
### Gamma camera DST-XL



- Research in medical applications of nuclear physics
- Student Laboratory (specialization – Medical Physics, bachelors studies from 2009/10 at Faculty of Physics)



# Detector laboratory



4 inch, 7.3  $\mu\text{m}$  Si strip detector

Head prof. A. Kordyasz



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# Target laboratory



**polyimide ( $C^{22}H^{10}N^2O^4$ )<sup>n</sup>**

**Perfect mechanical properties,  
high chemical resistance, low  
radiation damage**

Head prof. Anna Stolarz



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**Radiopharmaceuticals Production and Research Center  
(RPRC)  
at  
Heavy Ion Laboratory  
University of Warsaw**

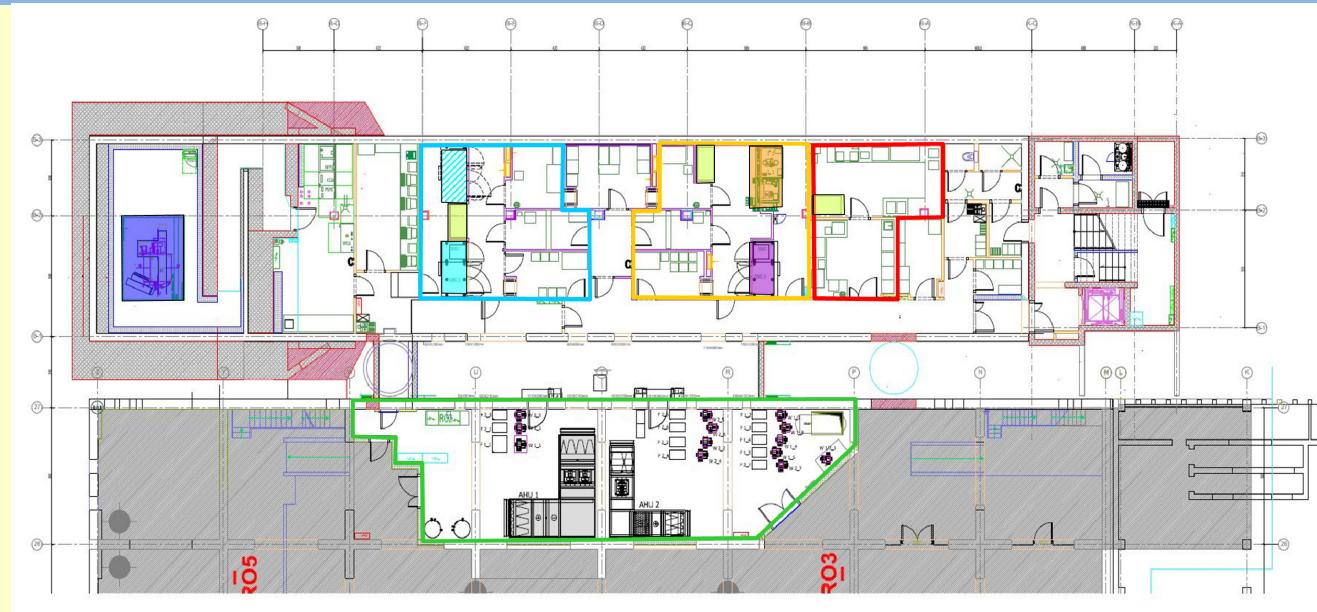
has been constructed.



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# The layout of the RPRC



Layout of the Radiopharmaceuticals Production and Research Centre

- |                                       |                      |                                       |                      |
|---------------------------------------|----------------------|---------------------------------------|----------------------|
| <span style="color: cyan;">□</span>   | FDG production area  | <span style="color: purple;">□</span> | GE PETtrace          |
| <span style="color: yellow;">□</span> | R&D area             | <span style="color: cyan;">□</span>   | Hot cells for FDG    |
| <span style="color: red;">□</span>    | Quality Control area | <span style="color: cyan;">□</span>   | Future FDG hot cells |
| <span style="color: green;">□</span>  | Technical area       | <span style="color: purple;">□</span> | Hot cells for F-18   |
- 
- |                                       |              |  |                               |
|---------------------------------------|--------------|--|-------------------------------|
| <span style="color: orange;">□</span> | Laminar Flow | <span style="color: light green;">□</span> | Hot cells for $^{11}\text{C}$ |
|---------------------------------------|--------------|--|-------------------------------|

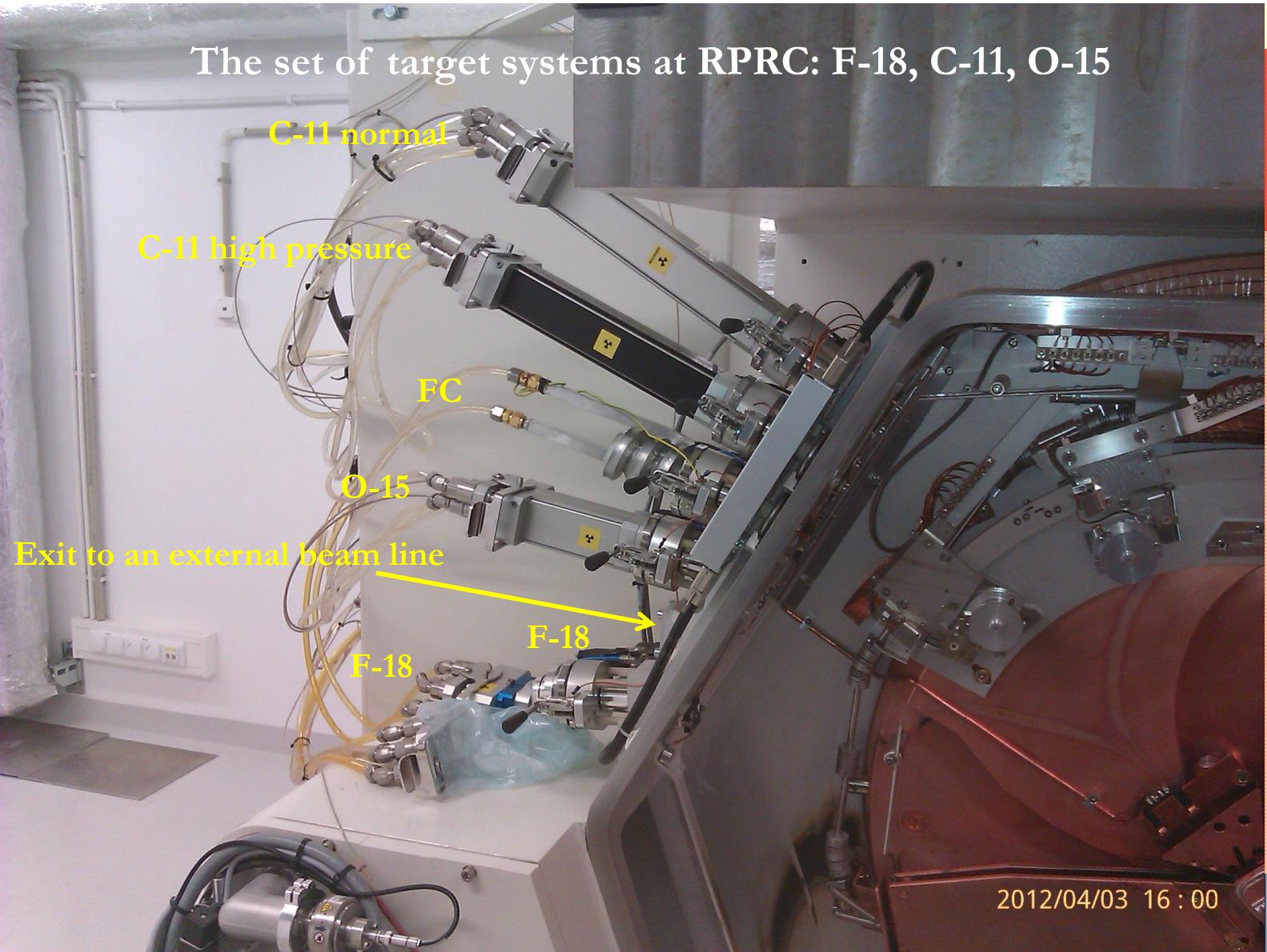


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fot. Grzegorz Krzyżewski

## The set of target systems at RPRC: F-18, C-11, O-15





Currently the site for commercial activity is leased to ADVANCED ACCELERATOR APPLICATIONS POLSKA (AAA Polska)



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fot. Grzegorz Krzyżewski



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# „The development of an alternative method for $^{99m}\text{Tc}$ production”

*Agreement No PBS1/A9/2/2012*

consortium of  
the Institute of Nuclear Chemistry and Technology  
the Polatom – National Centre for Nuclear Research  
the University of Warsaw

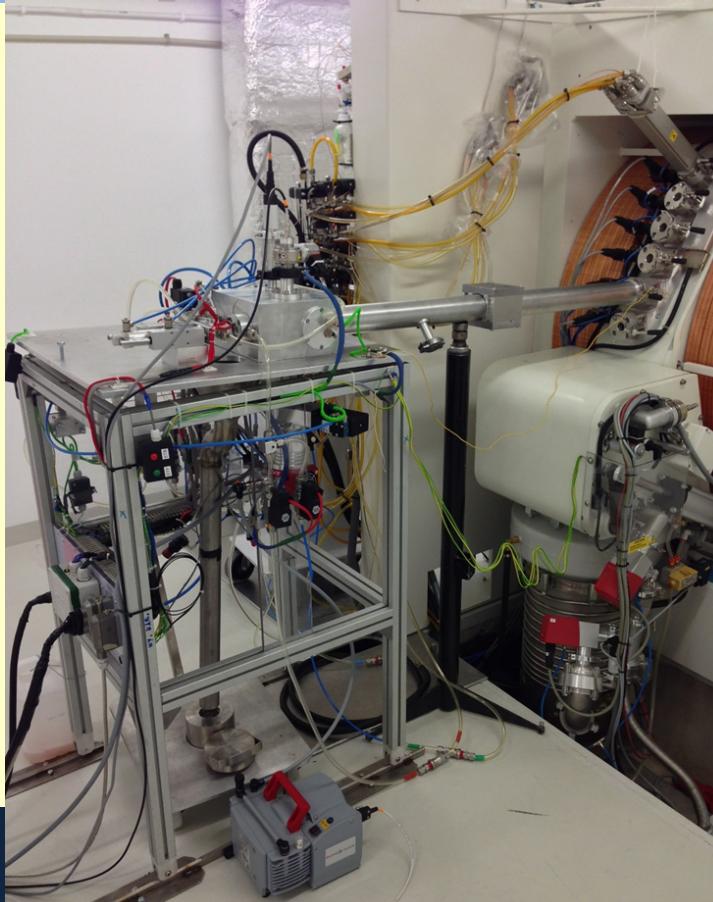
01.11.2012 – 31.10.2015



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One of the outcome of this program is construction of  
an external solid state target station.



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# Teaching



- National and international workshops for undergrad. and graduate students
- Bachelor, Master and PhD students from  
Univ. of Warsaw, Warsaw Univ. of Technology, Silesian Univ., National Centre  
for Nuclear Research  
(~ 10/year)



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# HIL Team



**Scientists – 13**

**PhD students – 7**

**Technicians – 35**

**Administration - 8**



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# Summary



- the unique Polish nuclear physics center
- European Transnational Access Facility
- place for research, education and applications
  
- National nuclear physics laboratory open for external users
- Involved in teaching
- Developing medical applications



**Thank you for your attention !**



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