



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



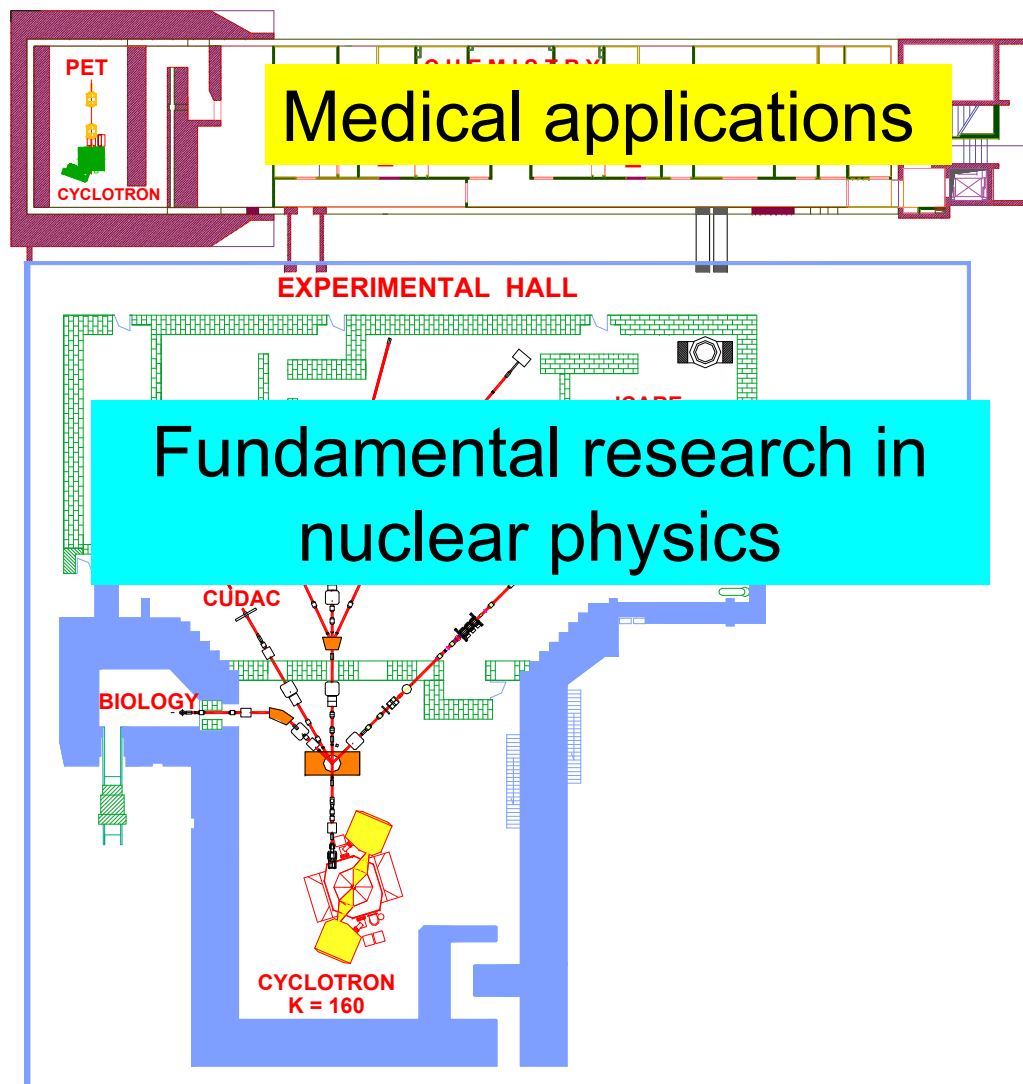
UNIVERSITY OF WARSAW

Science Campus Ochota



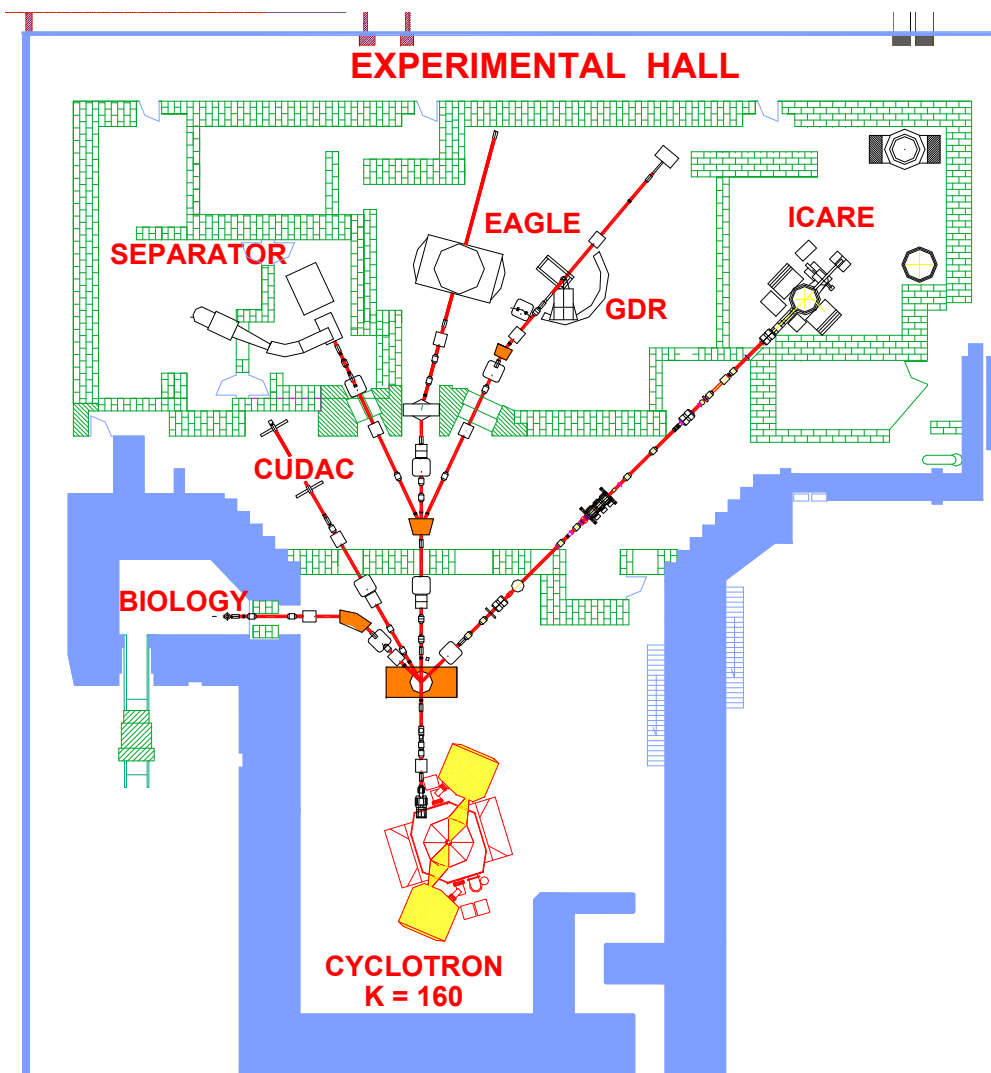
Medical applications

Fundamental research in nuclear physics



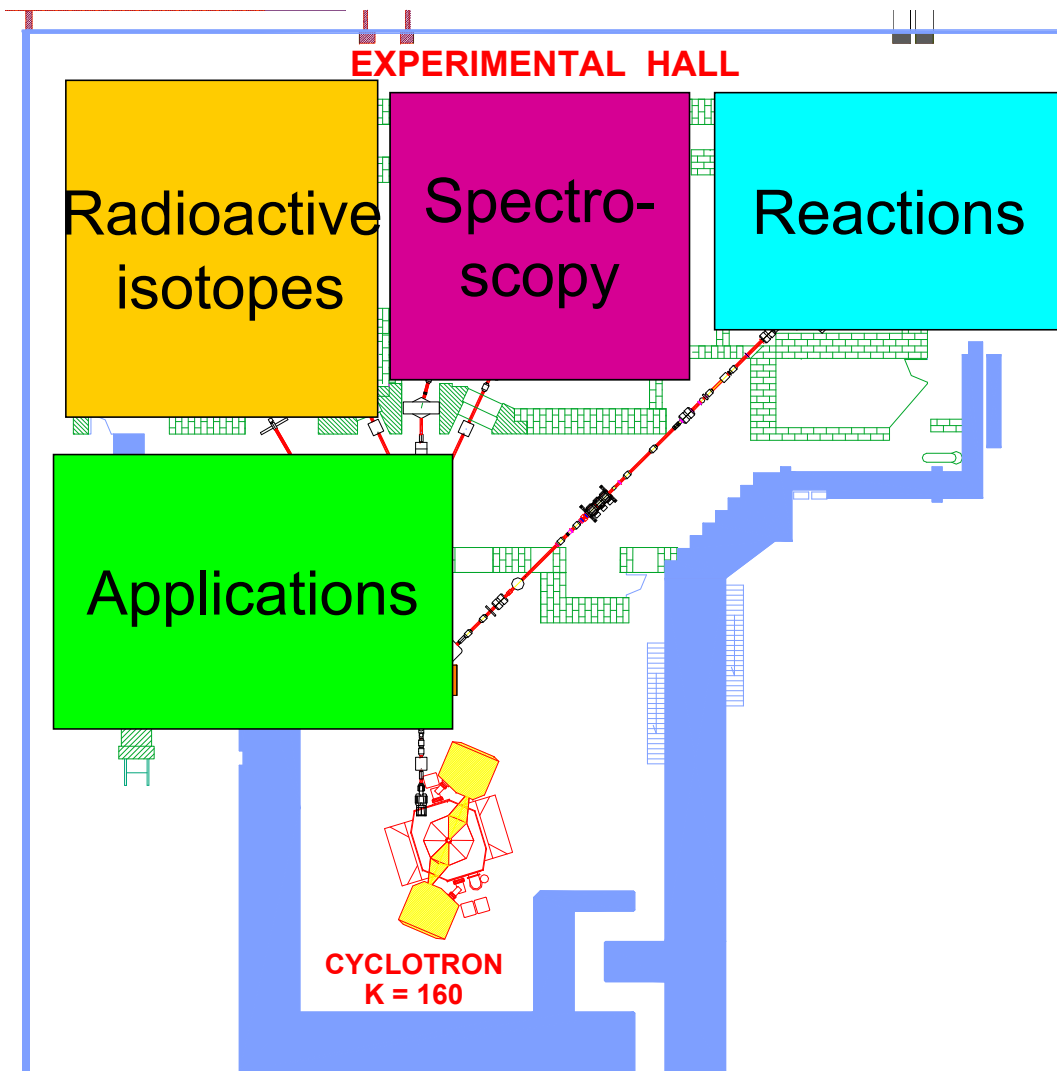


about 3300 h/year
about 100 users/year

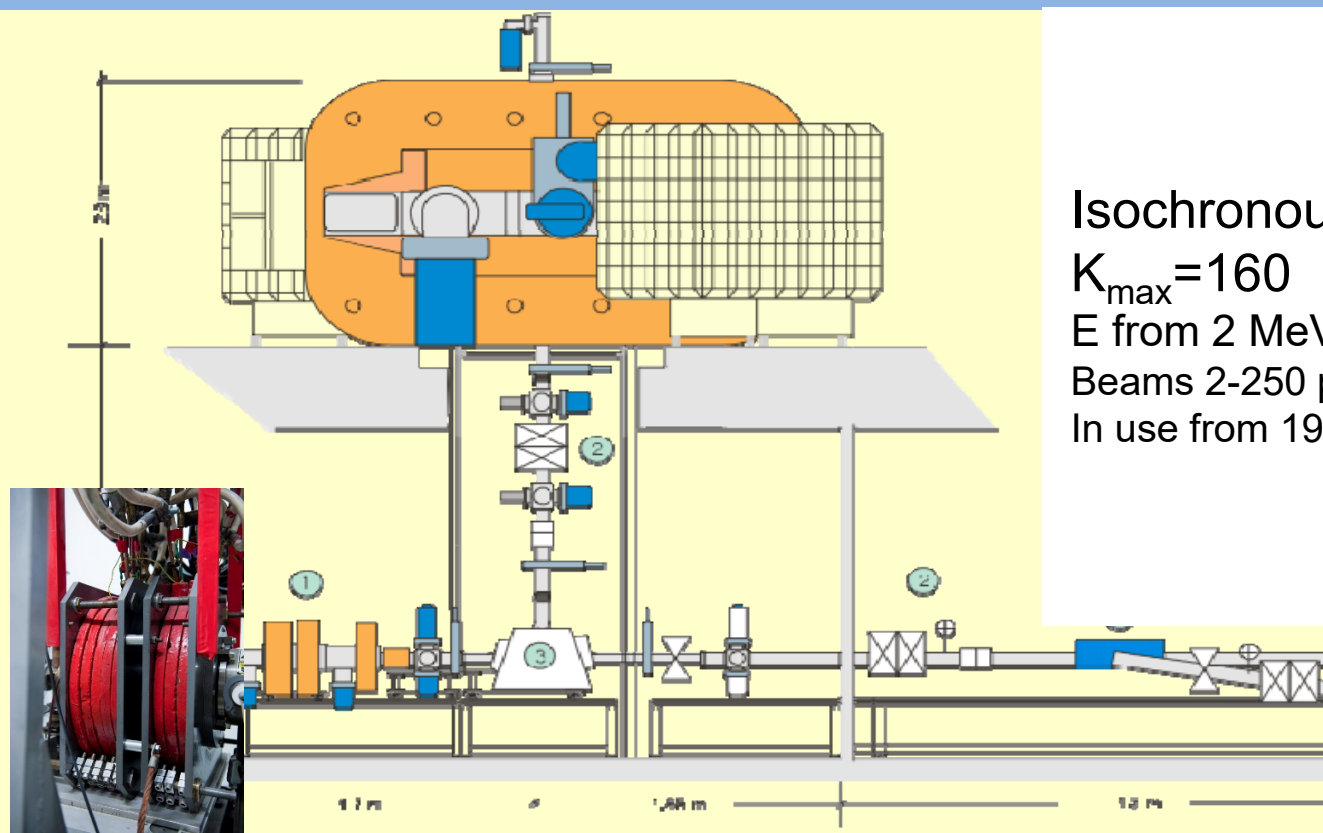




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Cyclotron U-200P and ion sources



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

Present ECR ion source
 ECR - Home made, ions He-Ar

ECR – "Supernanogun" Pantechnik,
 ions up to Xe



Fundamental research



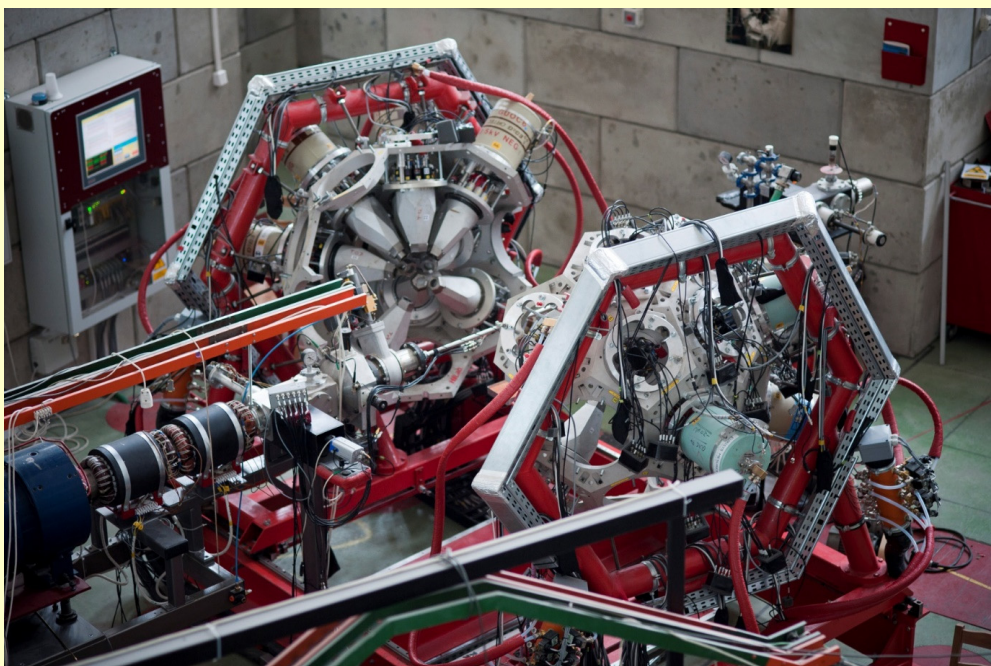
- Coulomb excitations
- Life time measurements
- K-isomers
- Coulomb barrier distributions
- Transfer reactions
- Time reversal spontaneous symmetry breaking (chirality)
- Electron conversion spectroscopy
- Atomic clusters, nanodosimetry
- Exotic alpha-emitters
- Biology - surviving of irradiated cells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

Experimental Hall



EAGLE

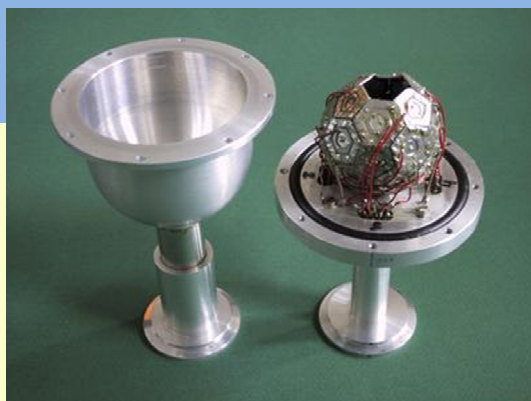
Central European Array for Gamma Levels Evaluation



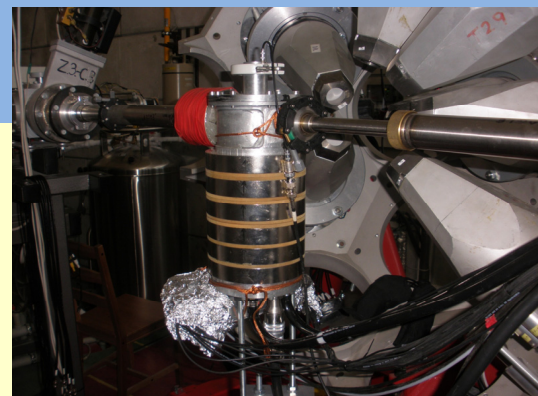
- multi-detector gamma-ray spectrometer
- up to 30 HPGe detectors with ACS
- many ancillary detectors
- can employ Phase-I EUROBALL detectors from Gammapool

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

EAGLE



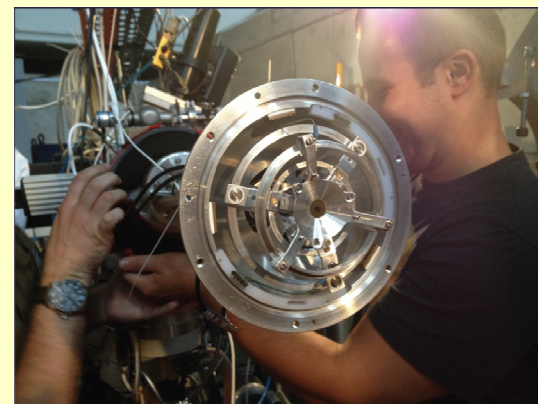
4 π Si-Ball
(by A. Kordyasz, HIL, Warsaw)



ULESE
(University of Łódź electron spectrometer)



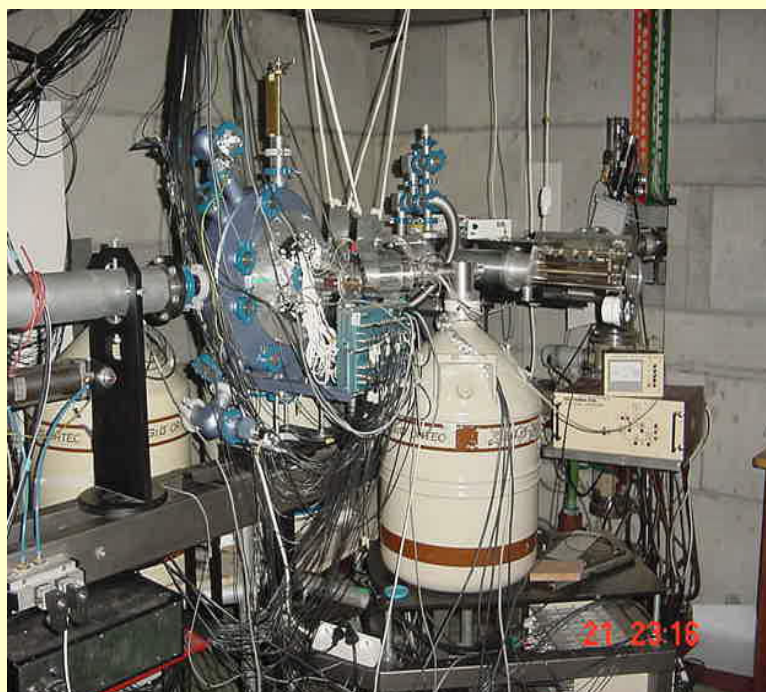
„The Munich chamber”
48 PiN diodes (max. 110)



Bucharest plunger
collaboration with IFIN-HH

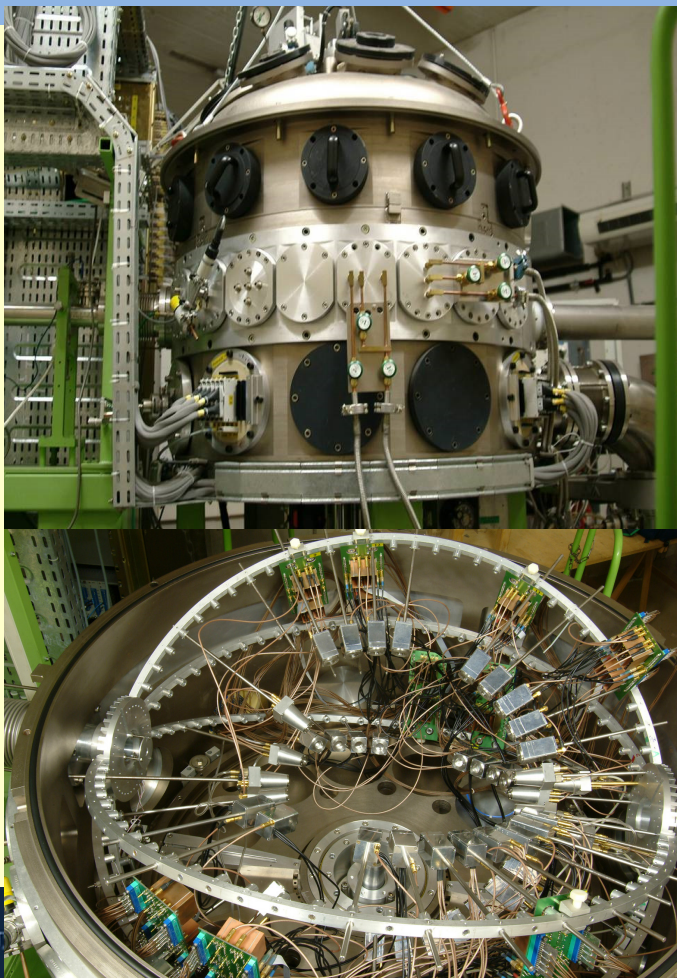
- Main research domain: nuclear structure studies with the use of γ -spectroscopy:
 - γ - γ angular correlations with **EAGLE** HPGe array;
 - e- γ spectroscopy with **ULESE** spectrometer;
 - **DSAM** (Doppler Shift Attenuation Method) and **RDDS** (Recoil Distance Doppler Shift technique) lifetime 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.



*Identificateur de **C**harges **A** **R**endement **E**leve*

- 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 Strasbourg, France
Form 2007 at HIL.
- Scientific program:
 - ☑ barrier distributions measurements
 - ☑ reaction mechanism studies
 - ☑ novel detector tests

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 (β - γ - γ : Ge, Si(Li), BaF₂ detectors)
- miniorange spectrometer



Applications

Internal target station



Radioisotopes presently investigated

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

Applications

Targeted Alpha Therapy (TAT)



- ^{211}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}At is extracted from the Bi target and chemical research consisting of binding ^{211}At to substance P, a peptide with high affinity to the receptors of glioma cancer cells are conducted.



$^{72}\text{Se}/^{72}\text{As}$ 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}Se can be produced by the (p,4n) reaction or (α ,2n) 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 α -particle production route.

Applications

^{43}Sc , ^{44}Sc and $^{44\text{m}}\text{Sc}$ production



Expected applications of 3.9h Sc radioisotopes

- ^{43}Sc - longer than ^{18}F living PET radioisotope, with substantially increased uptake characteristics for some cancers, similar to much shorter living ^{68}Ga ;
- ^{44}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



Applications

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

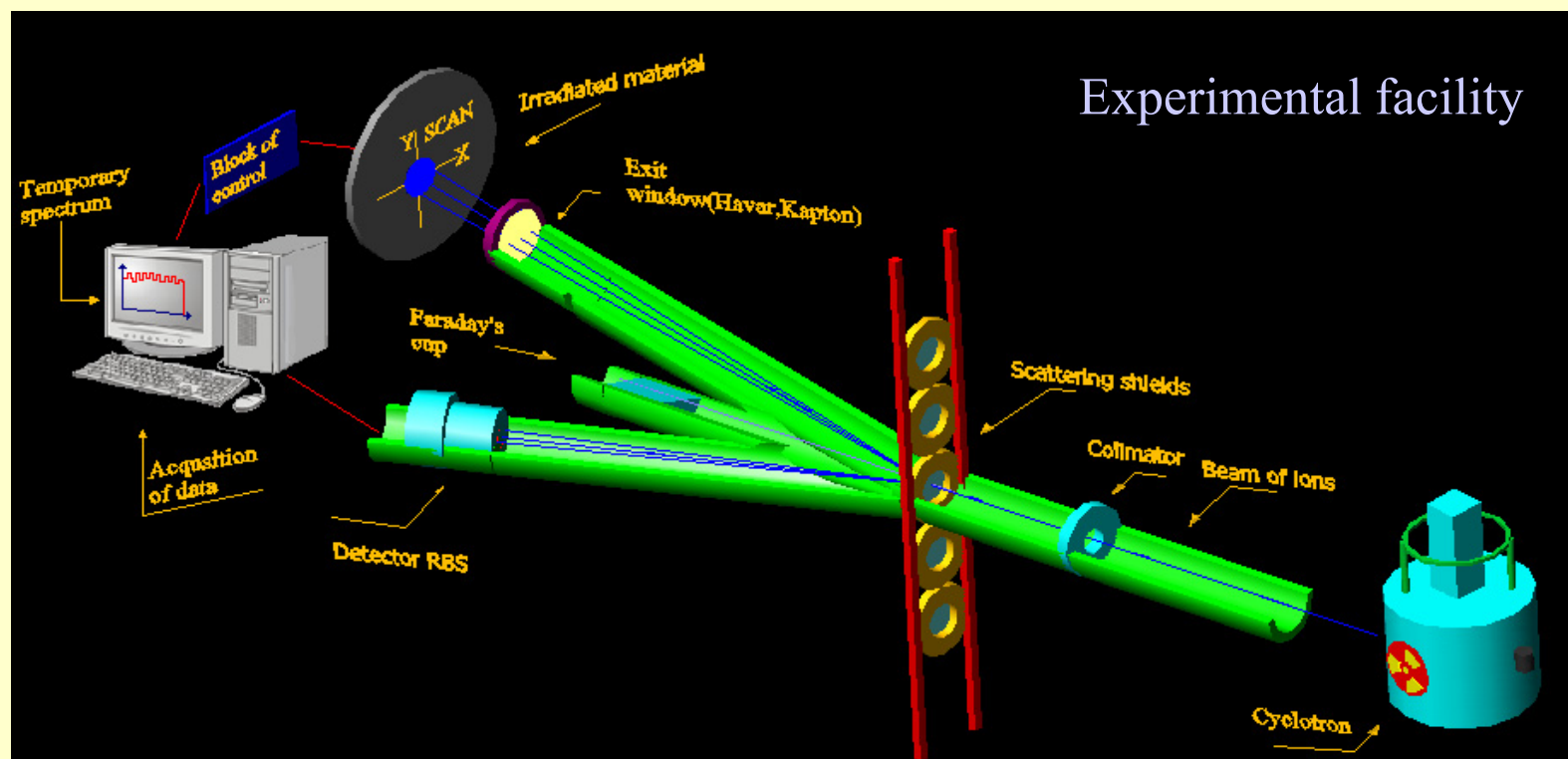


Target holder



Applications

X-Y scanner (moving target)

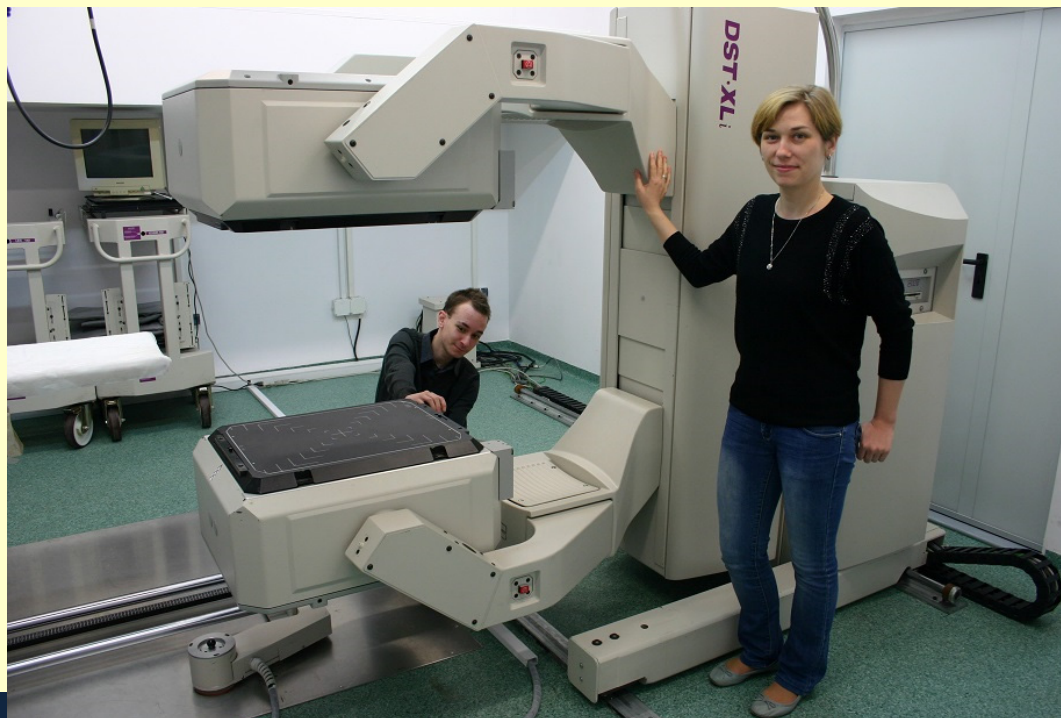


Applications

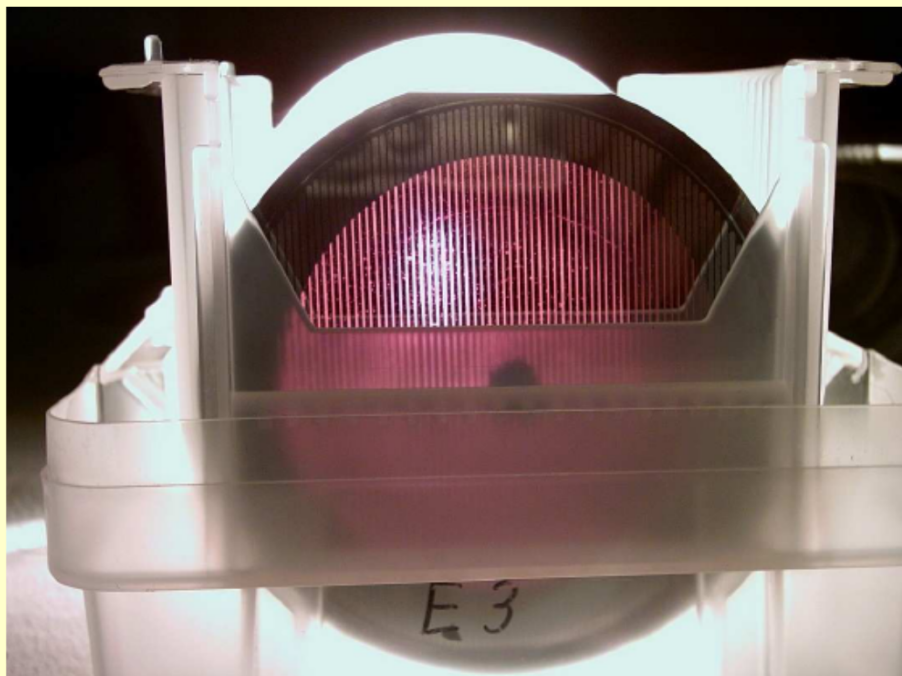
Laboratory of Medical Imaging Gamma camera DST-XL



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



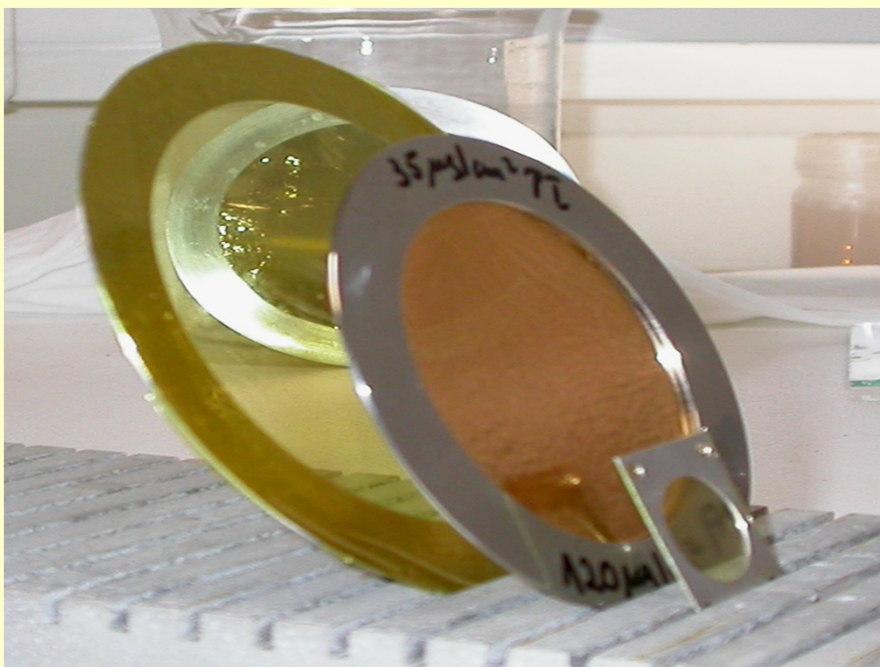
Detector laboratory



4 inch, 7.3 μm Si strip detector

Head prof. A. Kordyasz

Target laboratory



polyimide $(C^{22}H^{10}N^2O^4)^n$

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

Head prof. Anna Stolarz



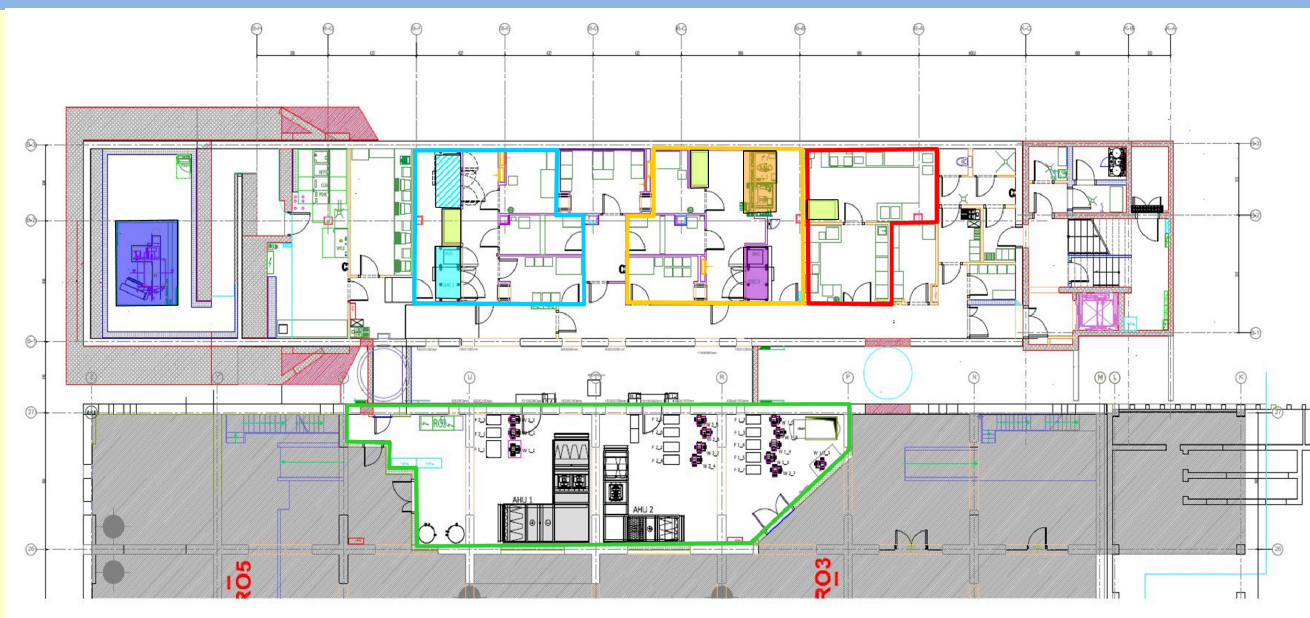
**Radiopharmaceuticals Production and Research Center
(RPRC)
at
Heavy Ion Laboratory
University of Warsaw**

has been constructed.



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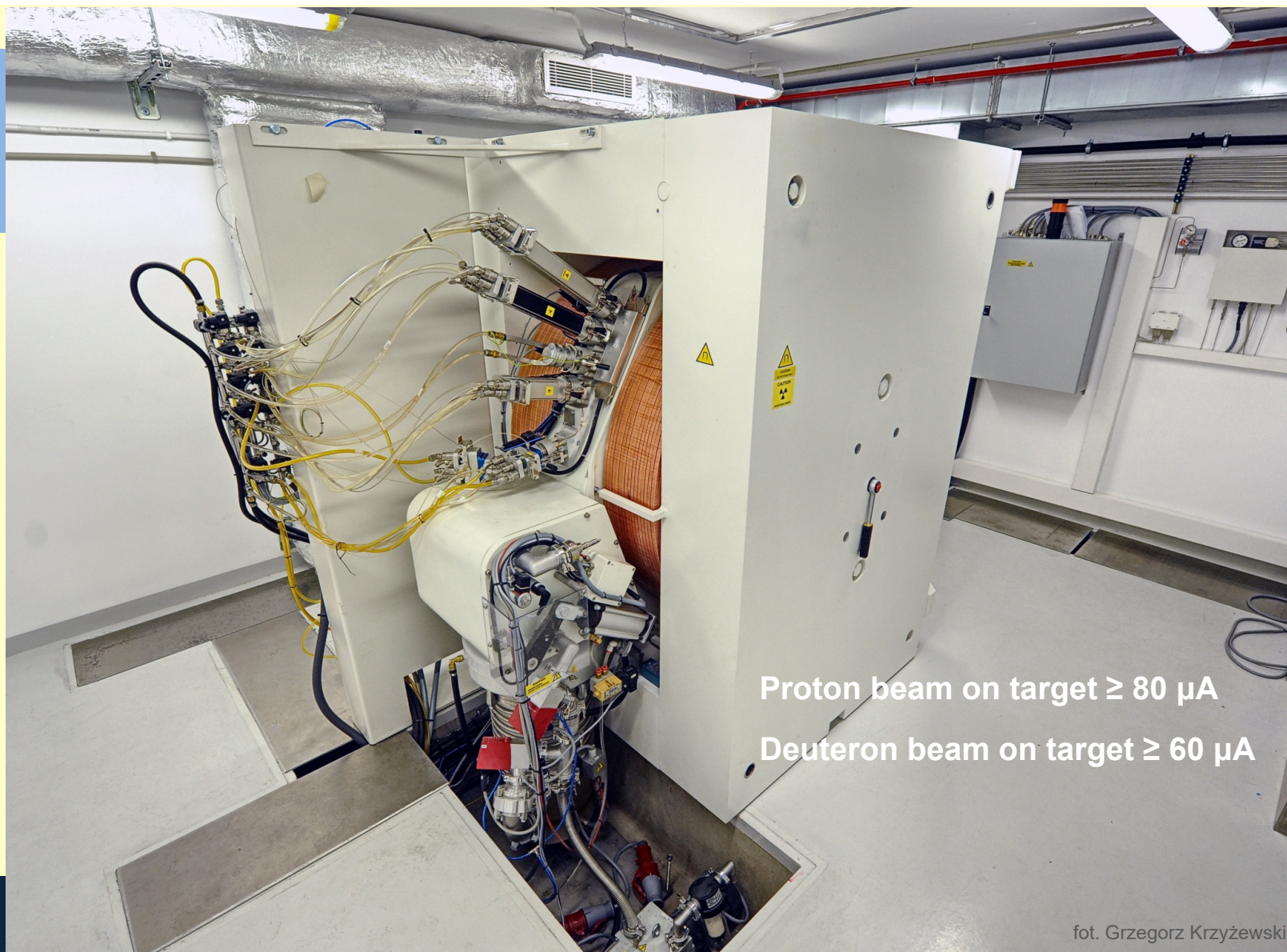
The layout of the RPRC



Layout of the Radiopharmaceuticals Production and Research Centre

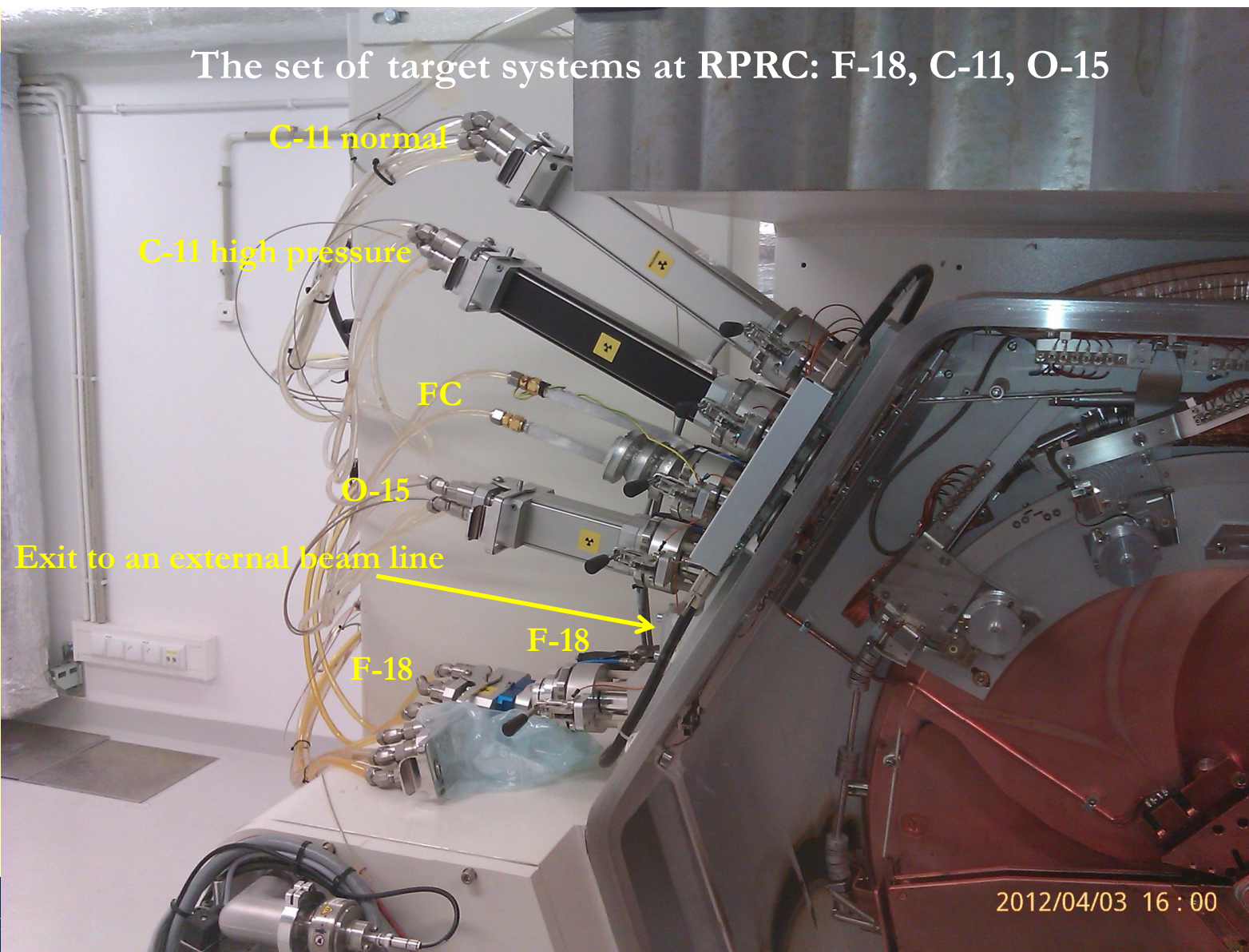
- | | |
|----------------------|-------------------------------|
| FDG production area | GE PETtrace |
| R&D area | Hot cells for FDG |
| Quality Control area | Future FDG hot cells |
| Technical area | Hot cells for F-18 |
| | Laminar Flow |
| | Hot cells for ^{11}C |





Proton beam on target $\geq 80 \mu\text{A}$
Deuteron beam on target $\geq 60 \mu\text{A}$

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



FDG lab



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

fot. Grzegorz Krzyżewski





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

Agreement No PBS1/A9/2/2012

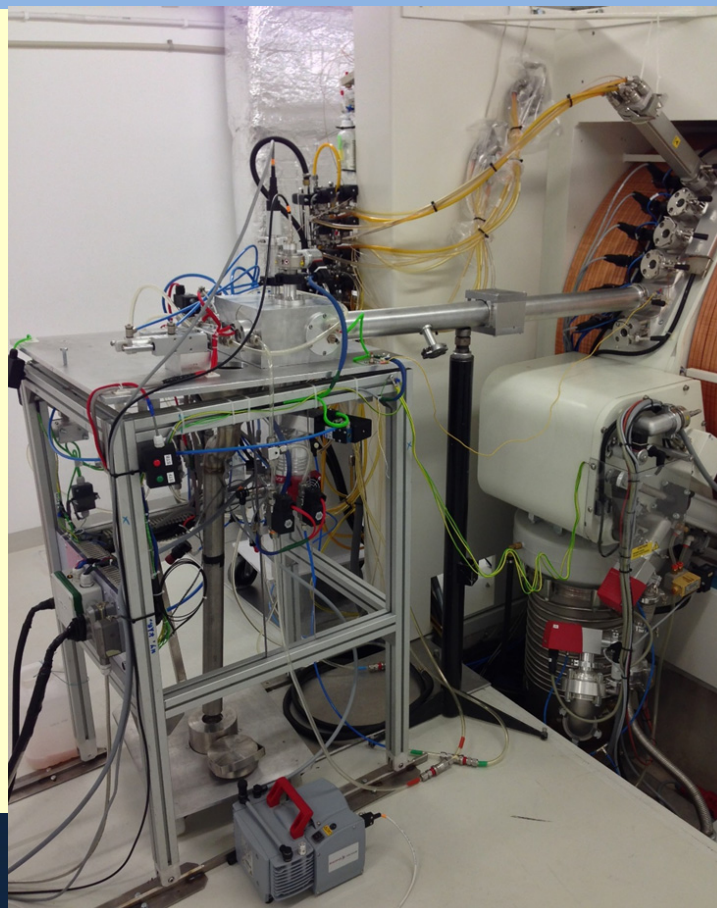
consortium of
the Institute of Nuclear Chemistry and Technology
the Polatom – National Centre for Nuclear Research
the University of Warsaw

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.



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)

HIL Team



Scientists – 13

PhD students – 7

Technicians – 35

Administration - 8

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 !