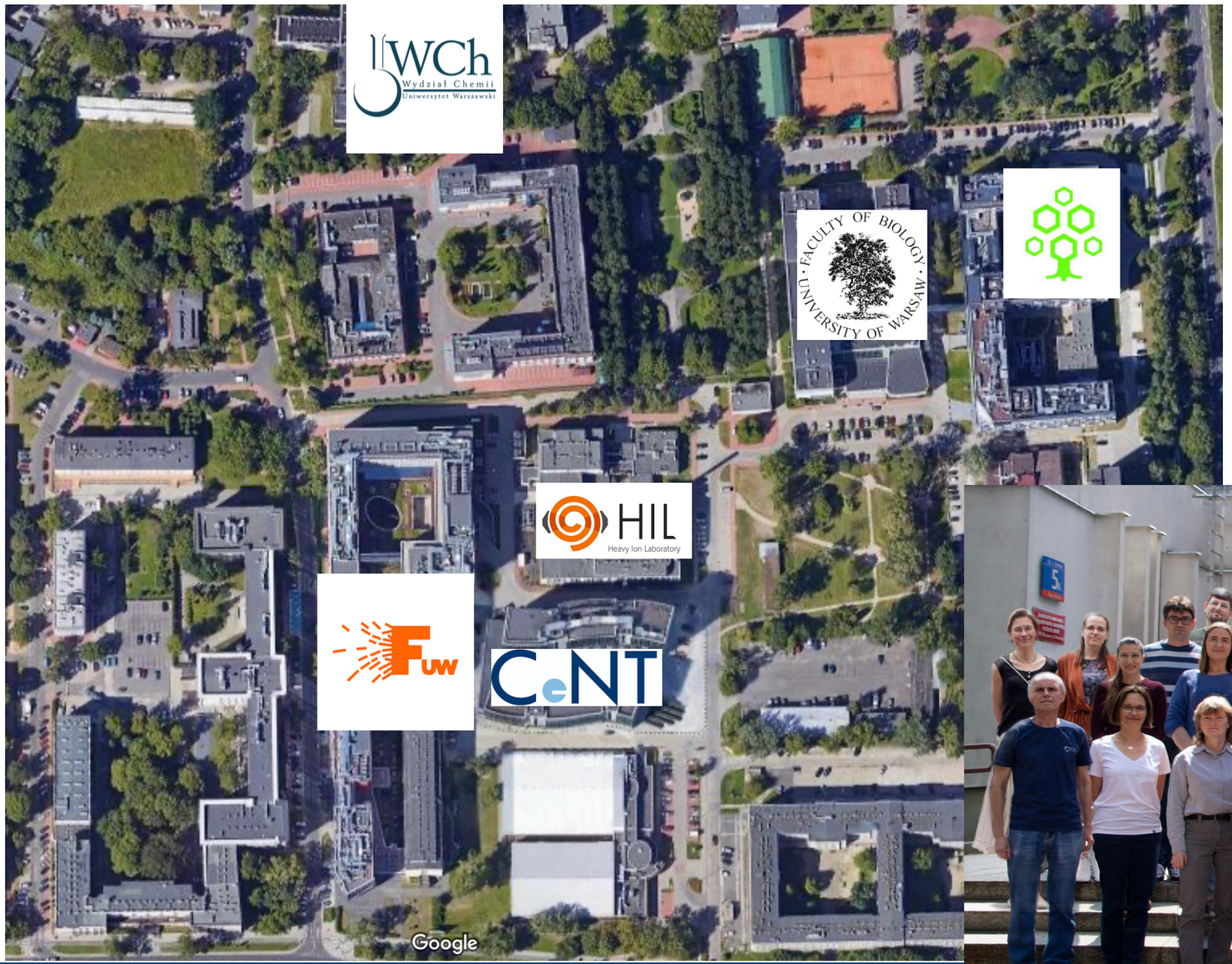
UNIVERSITY OF WARSAW

HIL

Heavy Ion Laboratory at University of Warsaw for the FAZIA collaboration - new ideas.

Paweł J. Napiorkowski

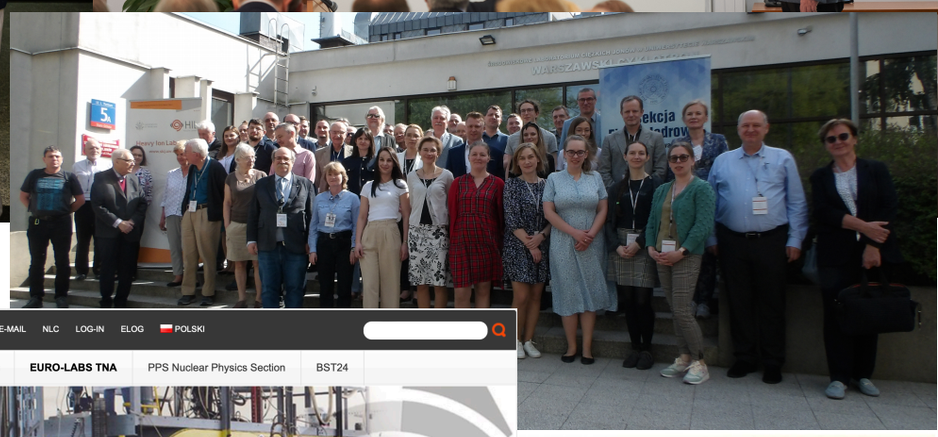
Heavy Ion Laboratory at University of Warsaw



- research unit of the University of Warsaw
- national level nuclear physics laboratory for fundamental research
- open for external users (~100/year)

30 YEARS Anniversary

Warsaw, 8th of April 2024



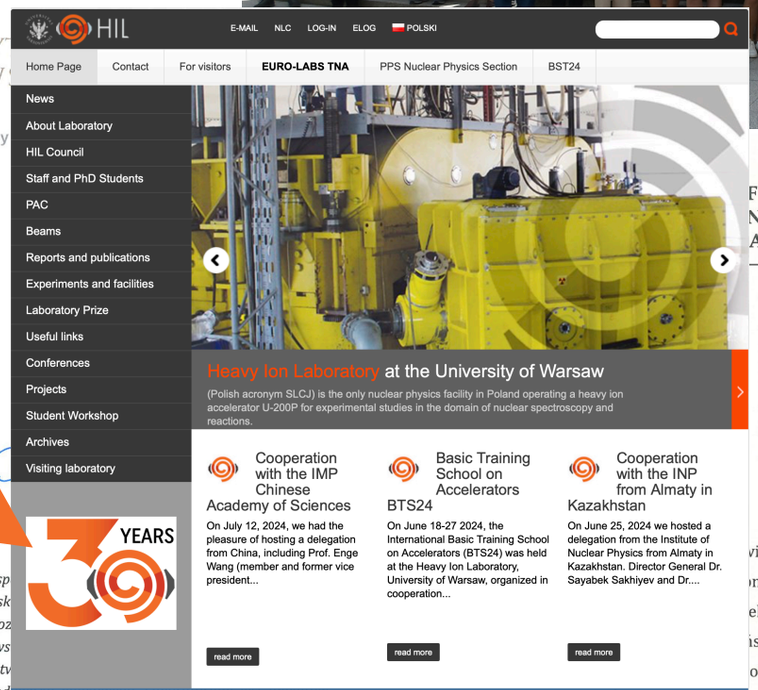
UNIVERSITY OF WARSAW | HIL

UNIWERSY
WARSZAW

Rektor
prof. dr hab. Alojzy

w imieniu własnym oraz c
ręce Pana Dyrektora serdeczne g
jonów z Warszawskiego Cyklotronu.

Od wielu lat grupy eksp
o wyspecjalizowaną aparaturę Środowisk
otwartości, wiedzy i zaangażowaniu roz
badawczymi w kraju i za granicą. Powst
naukowe oraz organizowane przez Państw
dla studentów cieszą się uznaniem środowiska naukowego. Laboratorium jest unikatow



FIZYKI JĄDROWEJ
Niewodniczańskiego
AKADEMII NAUK

Kraków, 5 kwietnia 2024 r.

Szanowny Pan
Dr Paweł Napiorkowski
Dyrektor
Środowiskowego Laboratorium Ciężkich
Jonów Uniwersytetu Warszawskiego

…więtuje w tych dniach kierowane przez Pana
…onów Uniwersytetu Warszawskiego, proszę
…ekcji, Rady Naukowej, Pracowników Instytutu
…iskiego PAN, a w szczególności pracowników
…obiście. Uroczystość jest tym bliższa naszemu

Narodowe Laboratorium Cyklotronowe
National Laboratory of Cyclotrons

together
since 2010

EURO-LABS

- Consortium of 34 institutions
- 15 research infrastructures
- NLC/SLCJ: **After ~3 years**
  1000 beam hours (~3088 delivered)
  8 projects (done)
  40 users (paid)

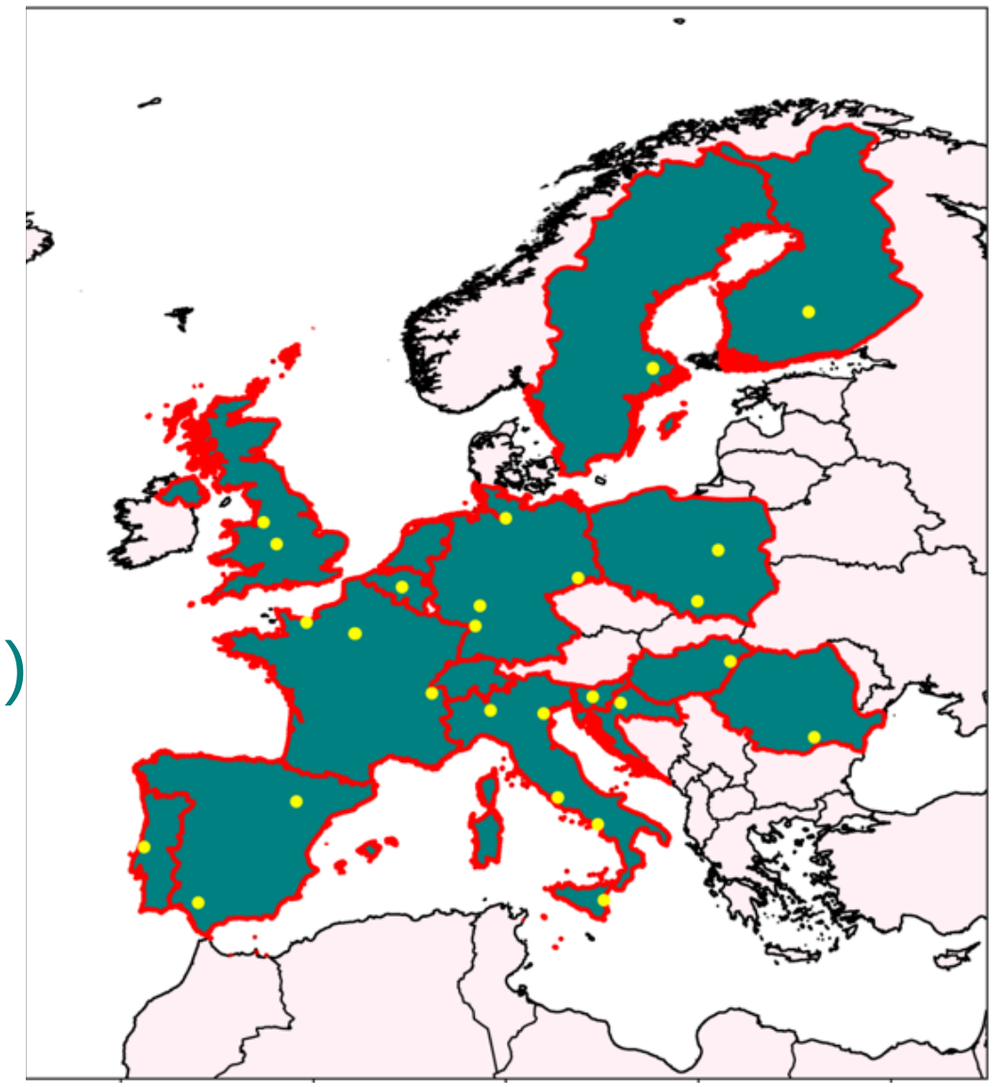
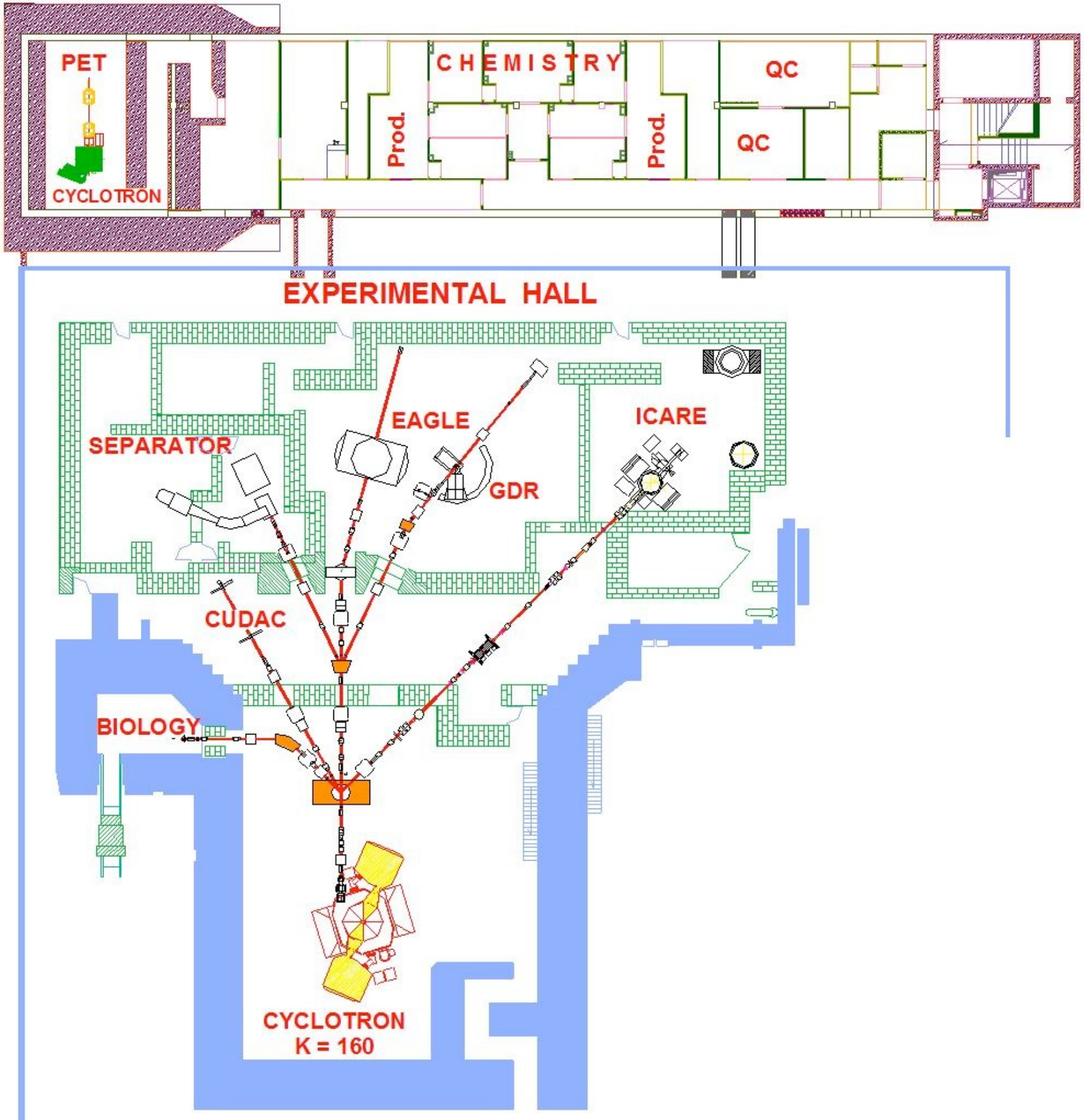
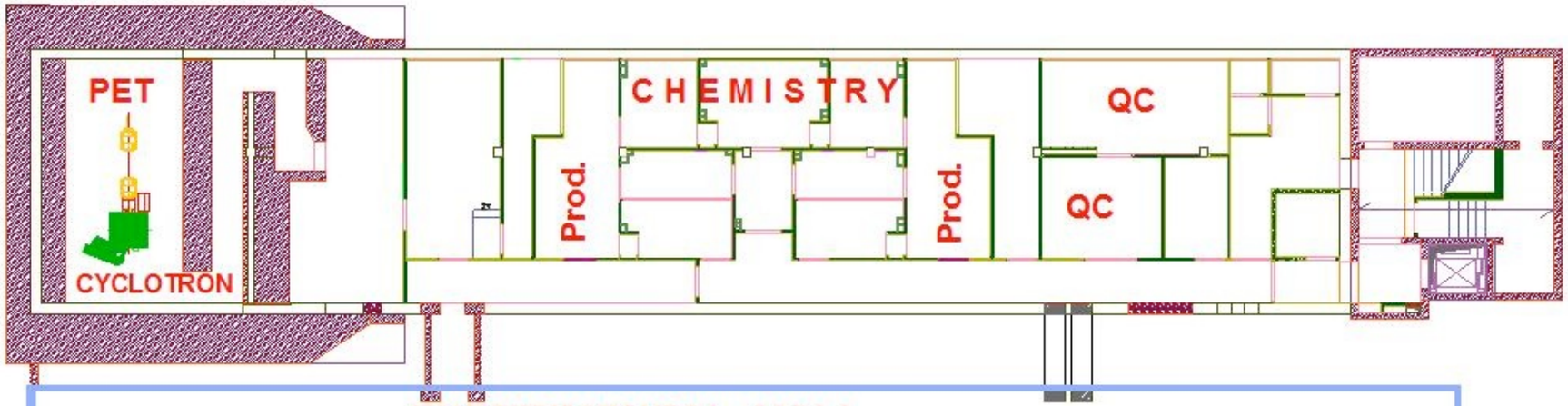
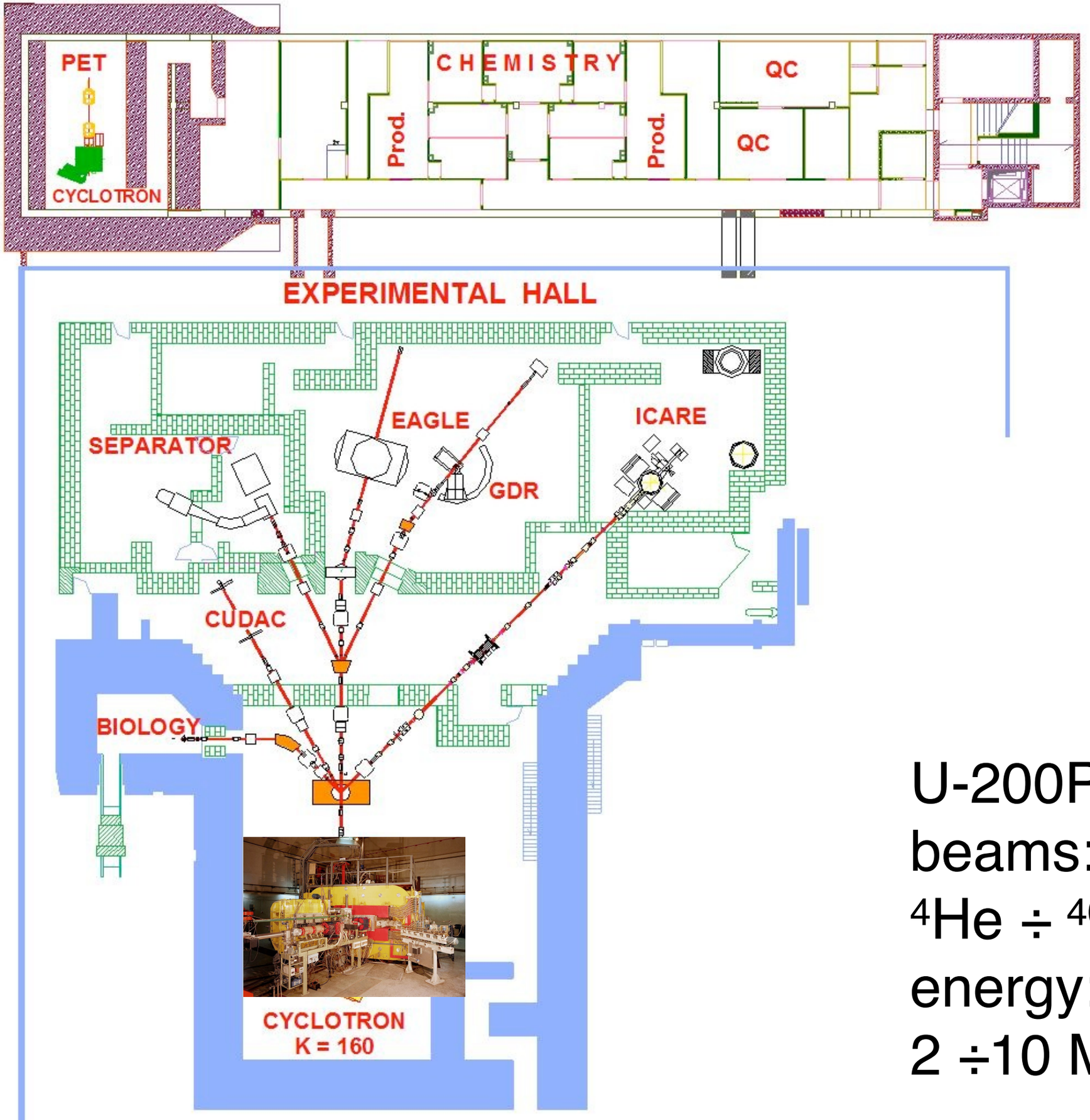


Figure 1 - Map of participating RIs in EURO-LABS


PET
CYCLOTRON
CHEMISTRY
Prod.
Prod.
QC
QC
EXPERIMENTAL HALL
SEPARATOR
EAGLE
GDR
ICARE
CUDAC
BIOLOGY
CYCLOTRON
K = 160



U-200P
beams:
$^{4}He \div {}^{40}Ar$
energy:
2 ÷10 MeV*A



U-200P
beams:
$^{4}He \div {}^{40}Ar$
energy:
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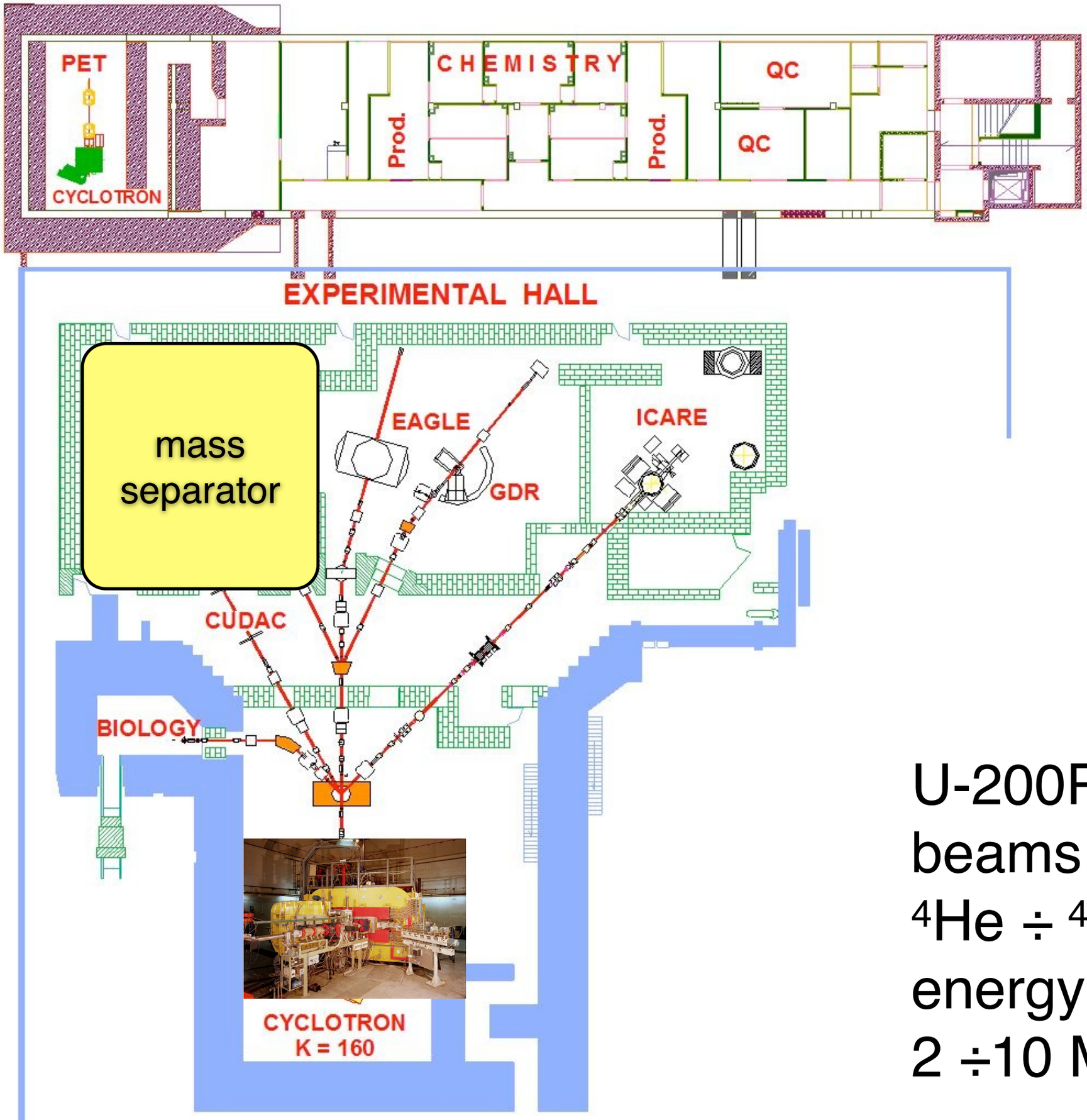

U-200P
beams:
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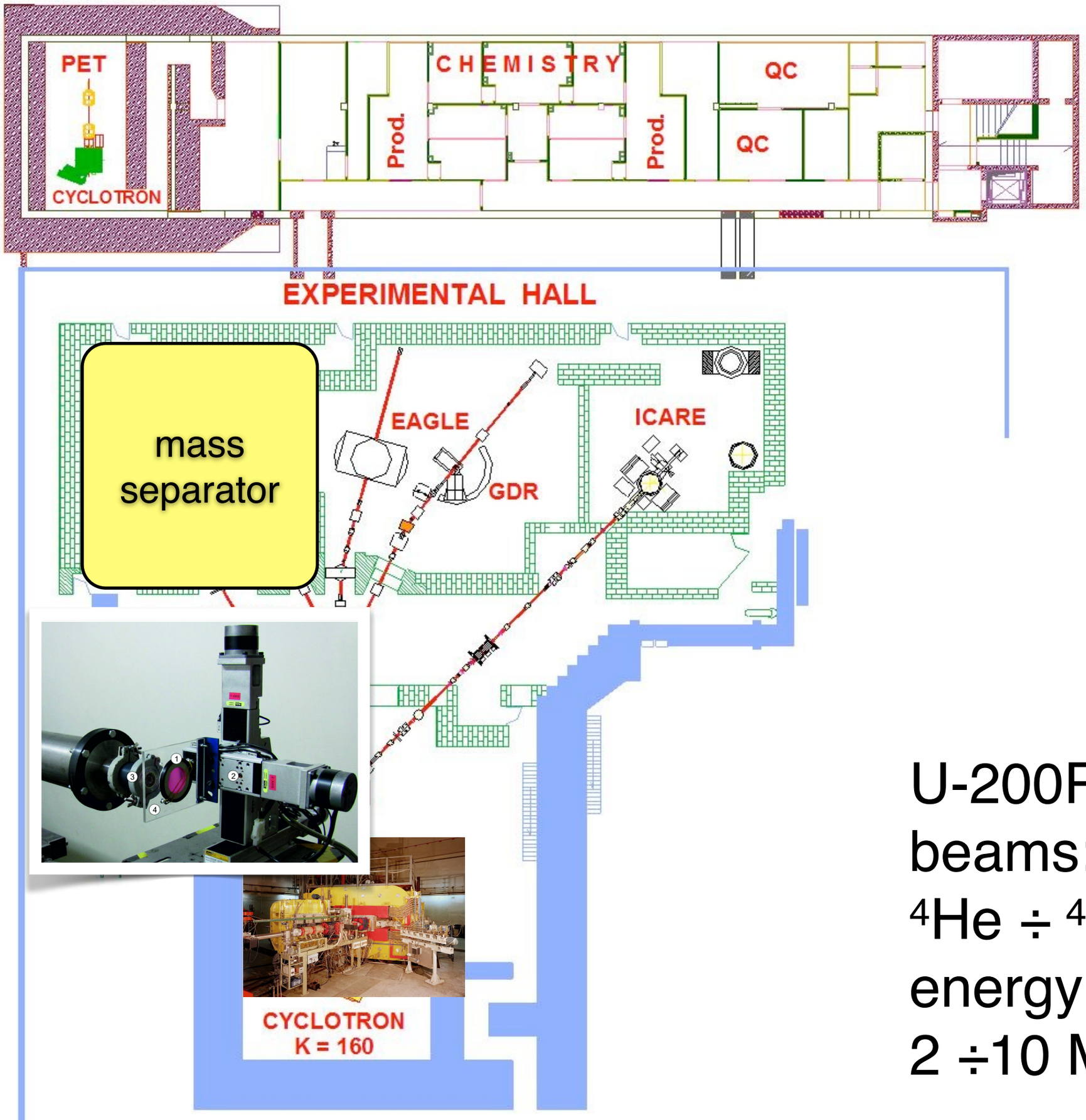
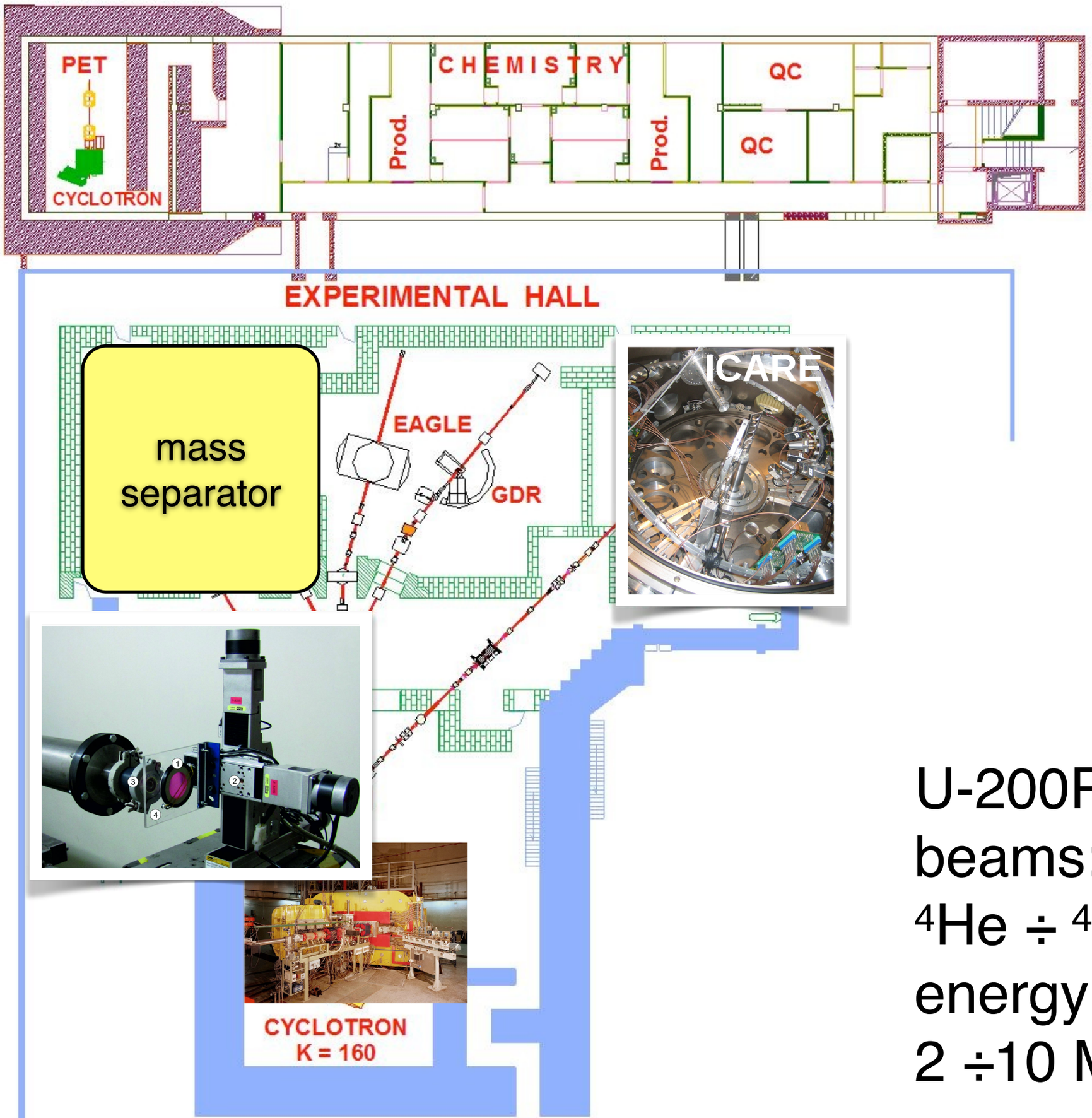
energy:
2 ÷10 MeV*A

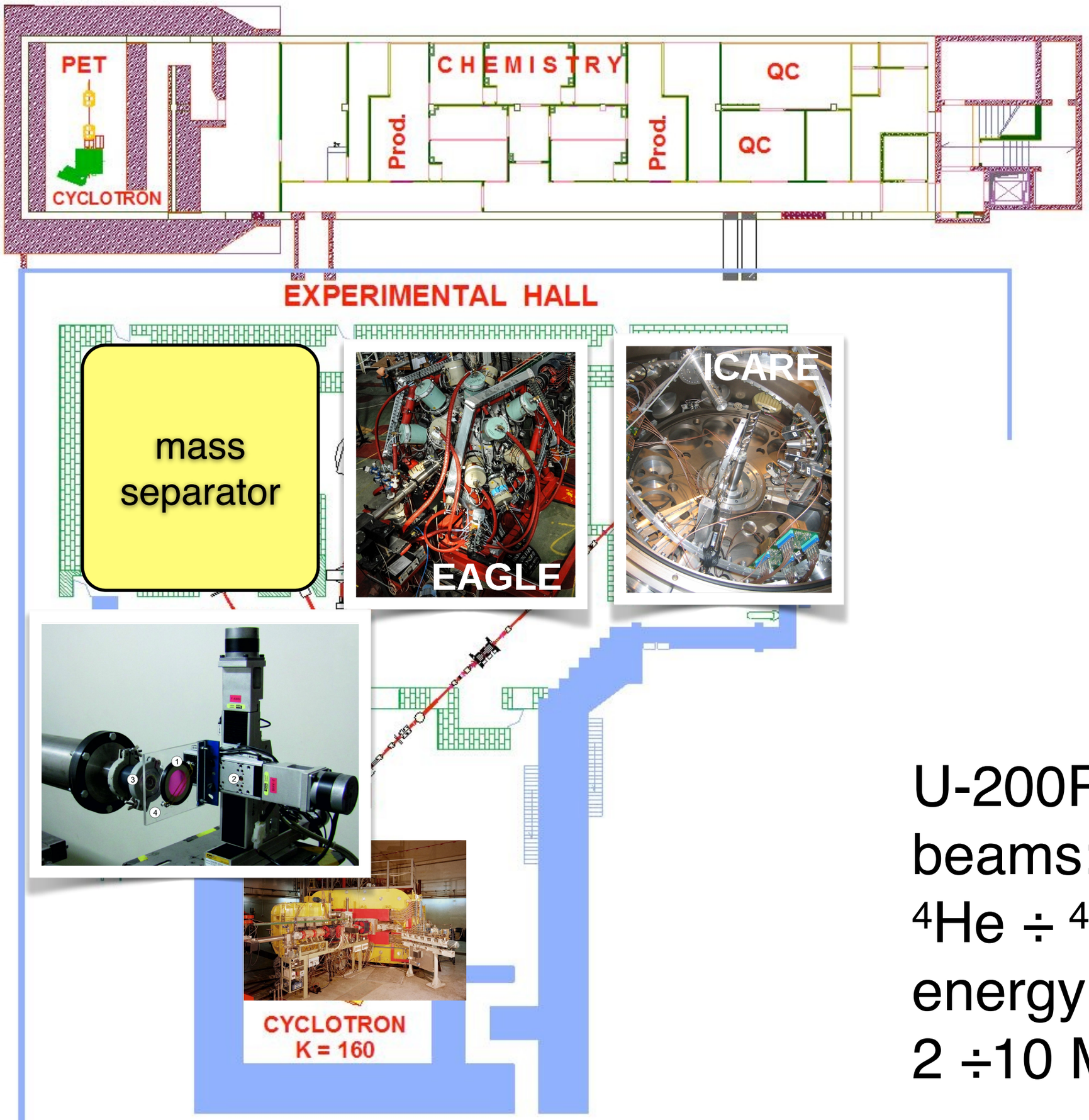


U-200P
beams:
$^{4}He \div ^{40}Ar$
energy:
2 ÷10 MeV*A

P.J.Napiorkowski

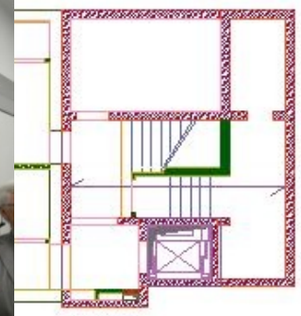


U-200P
beams:
$^{4}He \div ^{40}Ar$
energy:
2 ÷10 MeV*A

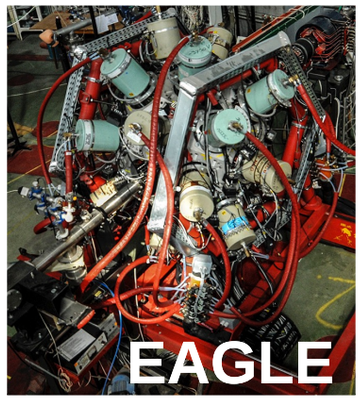


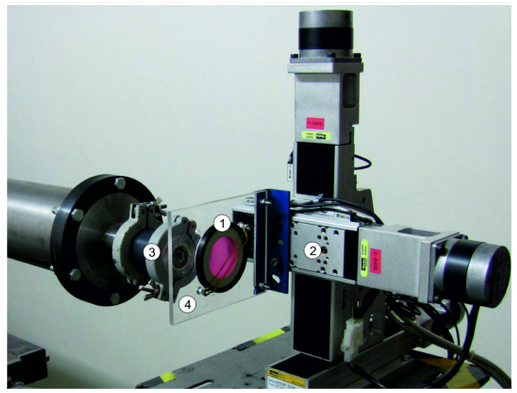
U-200P
beams:
$^{4}He \div ^{40}Ar$
energy:
2 ÷10 MeV*A

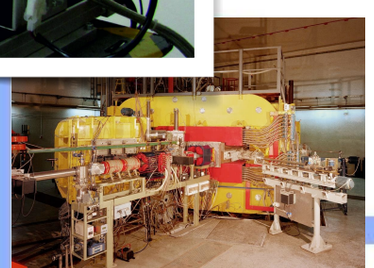
GE PetTrace
beam:
protons -16.5 MeV
deuterons - 8 MeV



mass
separator







CYCLOTRON
K = 160

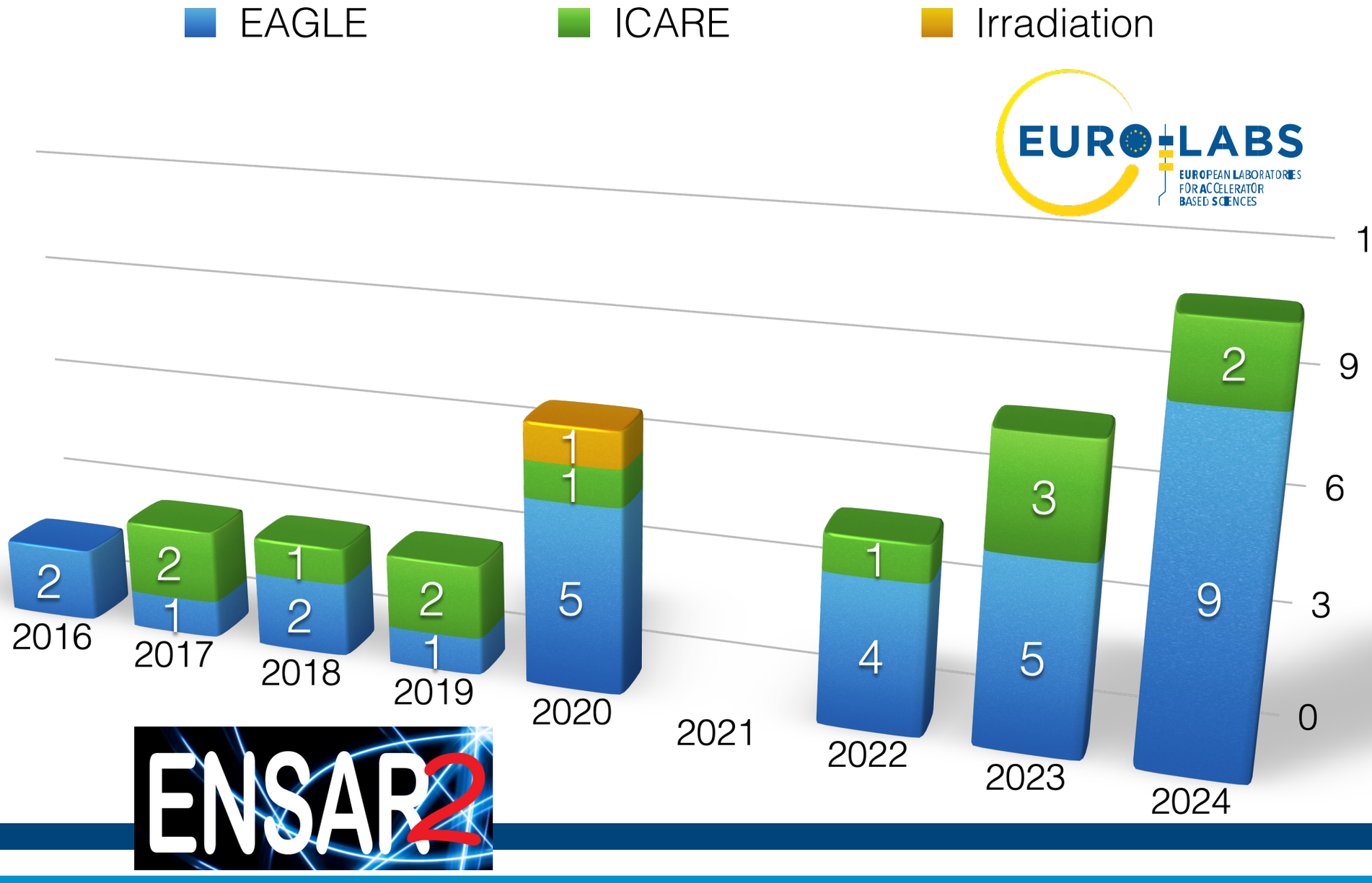
U-200P
beams:
$^{4}He \div {}^{40}Ar$
energy:
2 ÷10 MeV*A

Senior researchers: 9
Researchers: 21
PhD Students: 3
Voluntary scientists: 3

Engeneeres: 10
Technicians: 16
Administration: 10
Service: 10

Total: 76 + 6

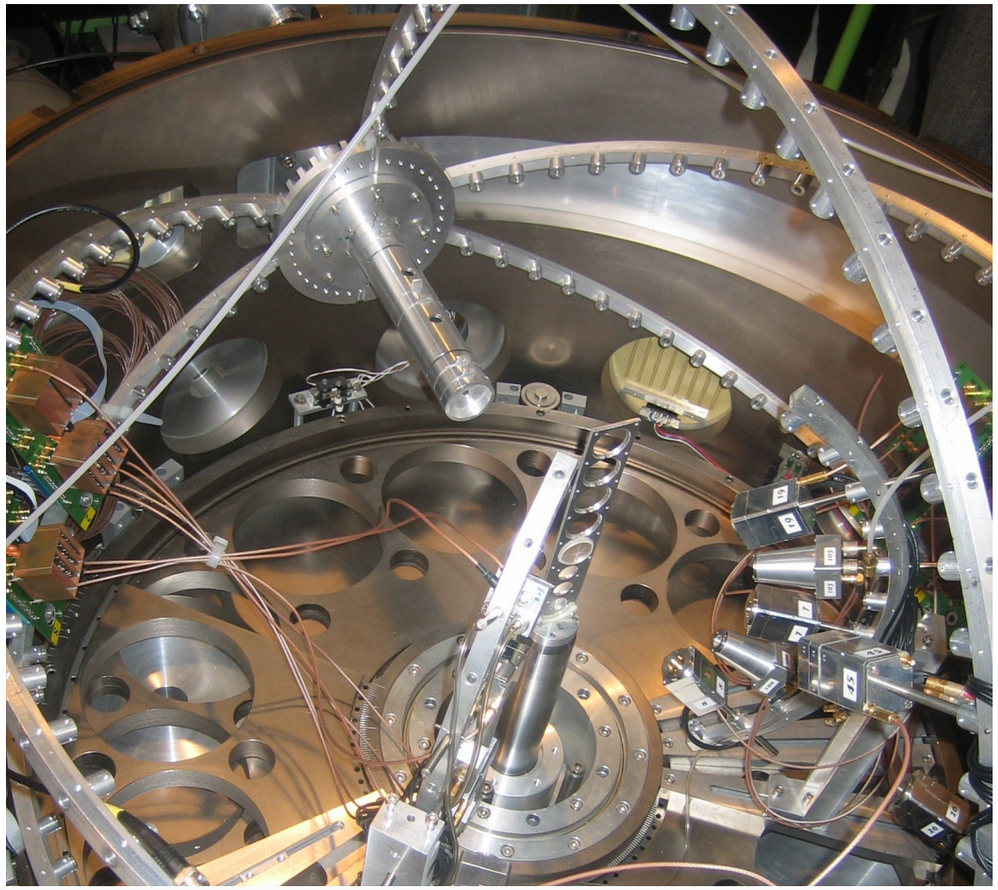
International projects submitted to the HIL PAC



Nuclear Reaction Studies with ICARE

- ICARE Particle Spectroscopy Chamber from IReS Strasburg, France
  Form 2007 at HIL.

- Scientific program:
  - barrier distributions measurements
  - reaction mechanism studies
  - **novel detectors' tests**



HIL122 N. S. Martorana / E. Geraci
T-INSIDE (Timing Investigation in SiC Detectors)
HIL123 B. Gnoffo
MoReNA Test (Molecular states Resolution with NarCoS)

Andrzej Kordyasz for Fazia

size: 1cmx1cm

orated contact from detector surface as an effect of heavy ion irradiation. Increase of charge collection efficiency of thin self-biased detectors manufactured by the low-temperature

2 Technology of production of thin self-biased silicon

Andrzej Kordyasz for Fazia

- **Recently**
  Radiation hardness
  21 μm Si detectors
  on ^{14}N beam @ 100 MeV from Warsaw Cyclotron
  (A.Kordyasz *et al.*,
  Eur. Phys. J. A (2024) **60**: 235
  and to be published).

- **Currently**
  further development
  21 μm Si detectors
  size: 1cmx1cm

Eur. Phys. J. A (2024) 60:235
https://doi.org/10.1140/epja/s10050-024-01454-9

THE EUROPEAN PHYSICAL JOURNAL A

Special Article - New Tools and Techniques

Investigation of very high radiation hardness of 21 μm silicon self-biased detectors

**Andrzej J. Kordyasz[1], Monika Paluch-Ferszt[1,a], Zygmunt Szefliński[1], Katarzyn
Michał Kowalczyk[1], Andrzej Bednarek[1], Paweł J. Napiorkowski[1], Ł.ukasz Kordya
Konrad Krzyżak[3], Michał Gajewski[3]**

[1] Heavy Ion Laboratory, Warsaw University, L. Pasteura 5a, 02-093 Warsaw, Poland
[2] Sonictech, Mokra 3c, 05-092 Kiełpin, Poland
[3] Institute of Microelectronics and Photonics, al. Lotników 32/46, 02-668 Warsaw, Poland

Received: 16 September 2024 / Accepted: 12 November 2024 / Published online: 27 November 2024

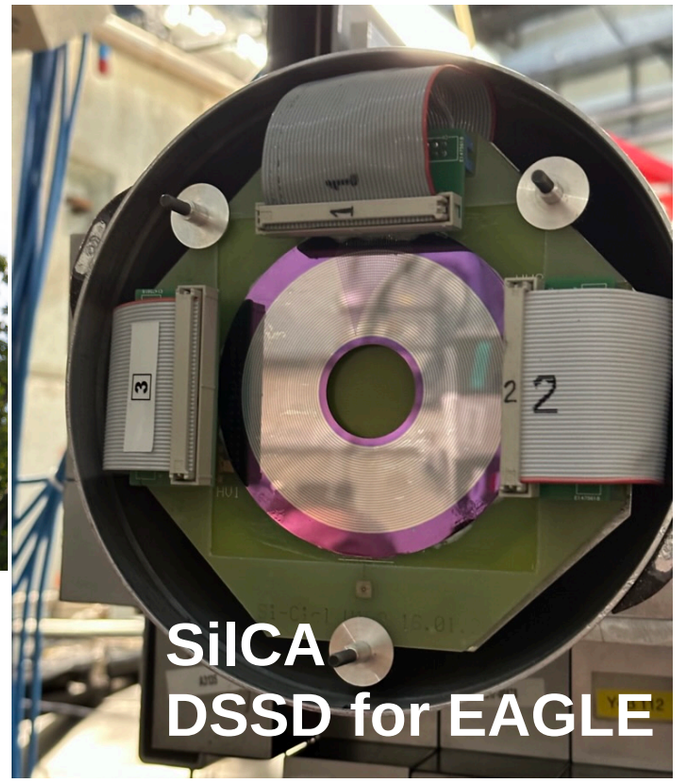
Communicated by Alessia Di Pietro

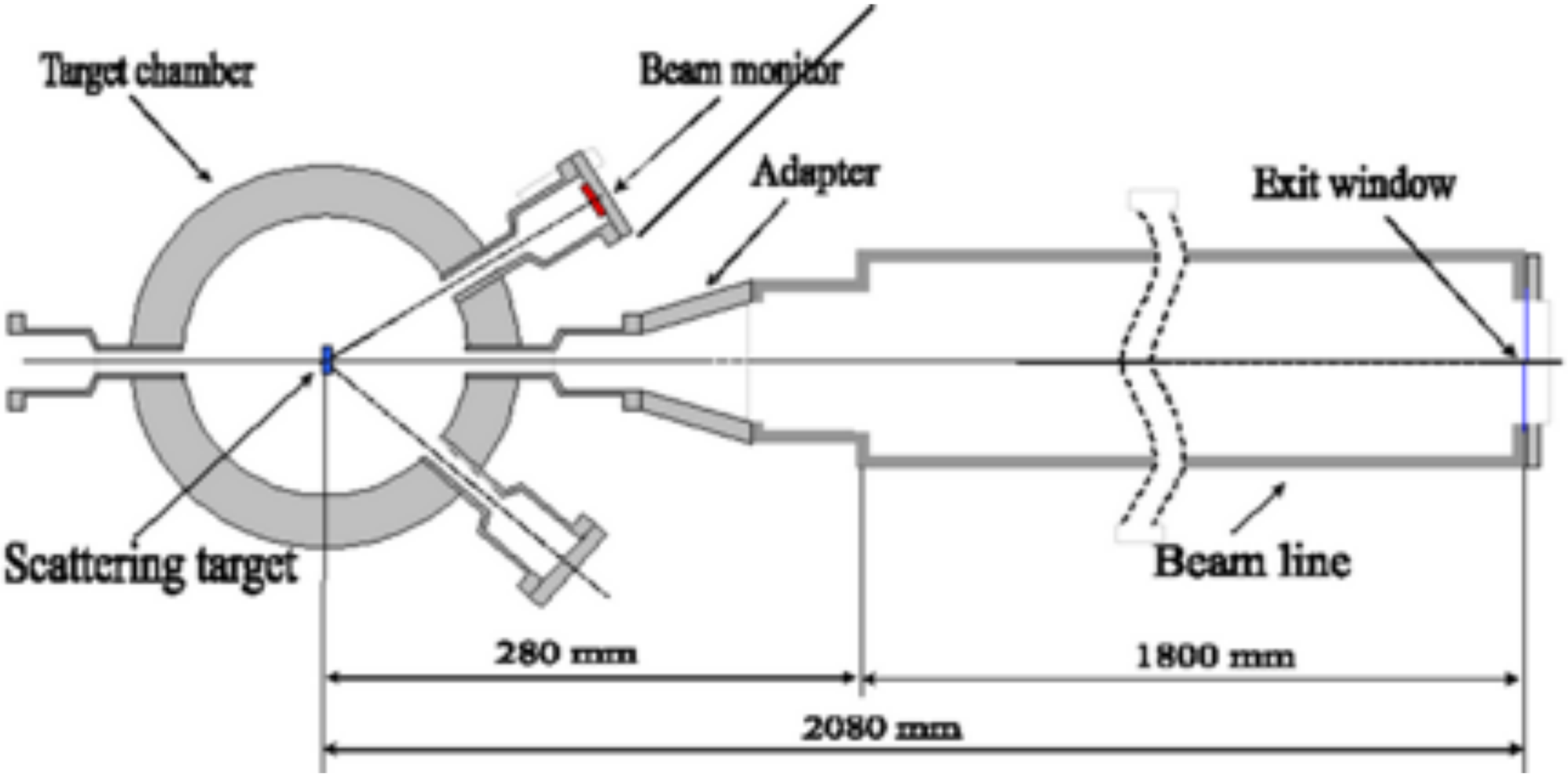
Abstract The radiation damage of 21 μm thick self-biased epitaxial ΔE detectors were tested as a function of fluence of 90 MeV ^{14}N ions. Technology of production and technique of measurements of ΔE detectors were described. A new technique of soldering contact to thin detector is shown. In the present work the 21 μm thick self-biased detectors marked as d4 and d5 show proper operation with the fluence about $4{\cdot}10^{15}$ ions/cm^2 and the fluence about $8{\cdot}10^{15}$ ions/cm^2, respectively. The charge collection efficiency of thin d5 ΔE detector was increased about double at fluence about $8{\cdot}10^{15}$ ions/cm^2. The charge collection efficiency of thin d4 ΔE detector was increased about 35% at fluence about $4{\cdot}10^{15}$ ions/cm^2 followed decrease about 70% of detector counting rate registration from fluence $9.1{\cdot}10^{15}$ ions/cm^2 to fluence about $5{\cdot}10^{16}$ ions/cm^2 due to partially removing of Al evaporated contact from detector surface as an effect of heavy ion irradiation. Increase of charge collection efficiency of thin self-biased detectors manufactured by the low-temperature

In an attempt to impr
cial detector technologie
or silicon carbide [2] h
detectors are used to the
and for laser induction fu
silicon detectors were de
however, our works are
con detectors [6,7]. It se
damage due to the extrer
the internal built-in-field
ness. Decreasing the ene
the detector improves the
detector thickness preve
since no heavy ions stop

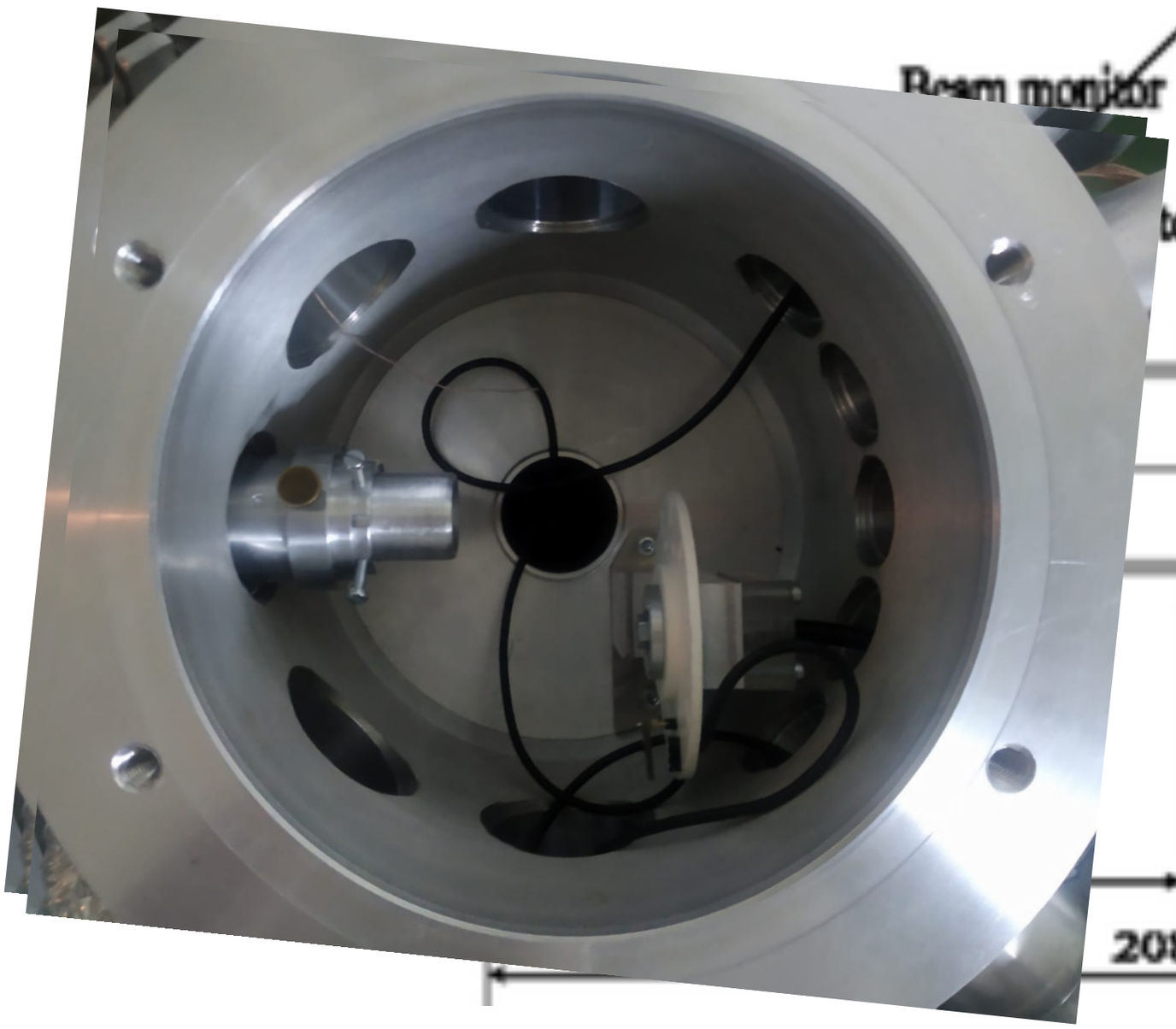
2 Technology of produ

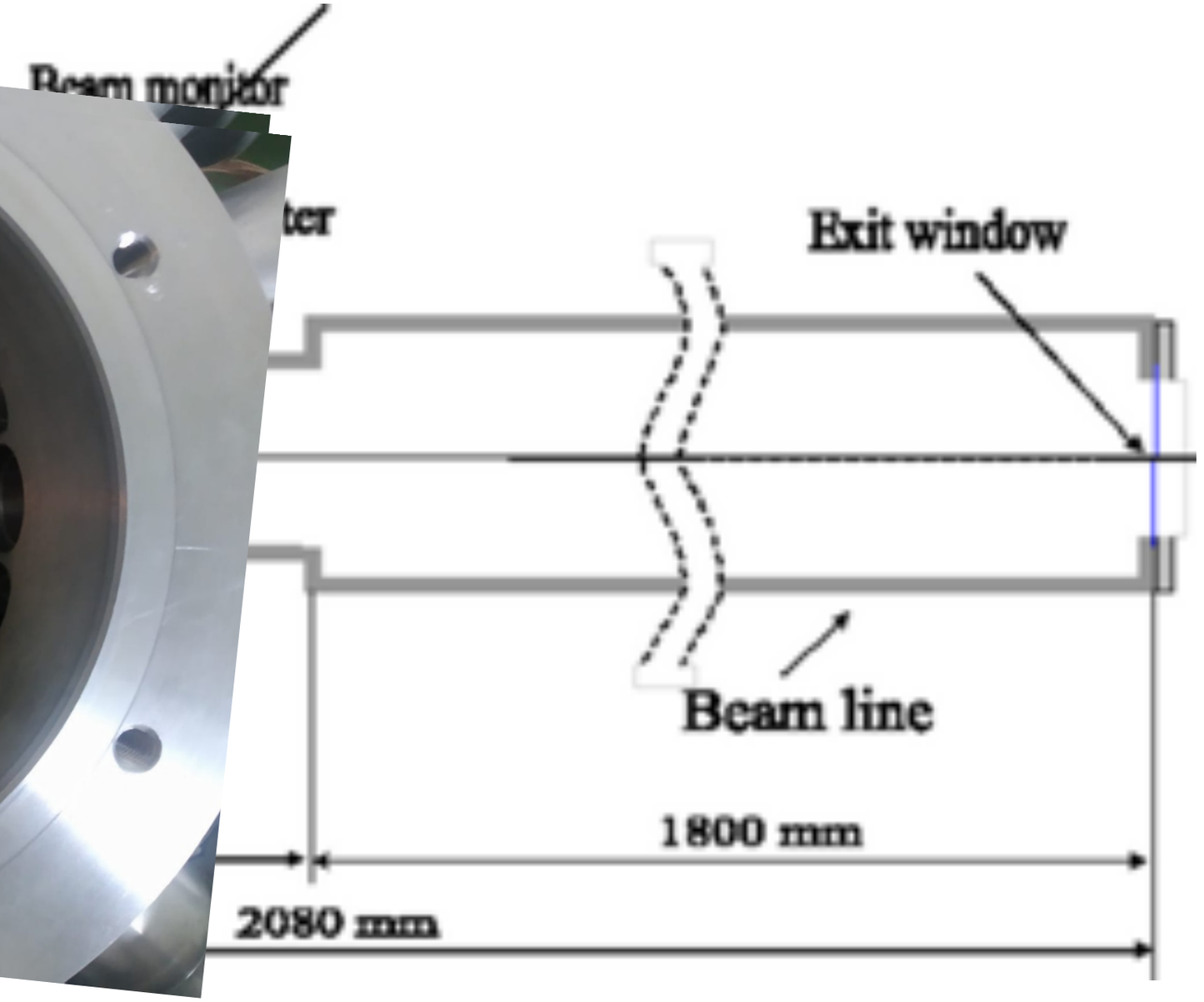
Detectors for COULEX





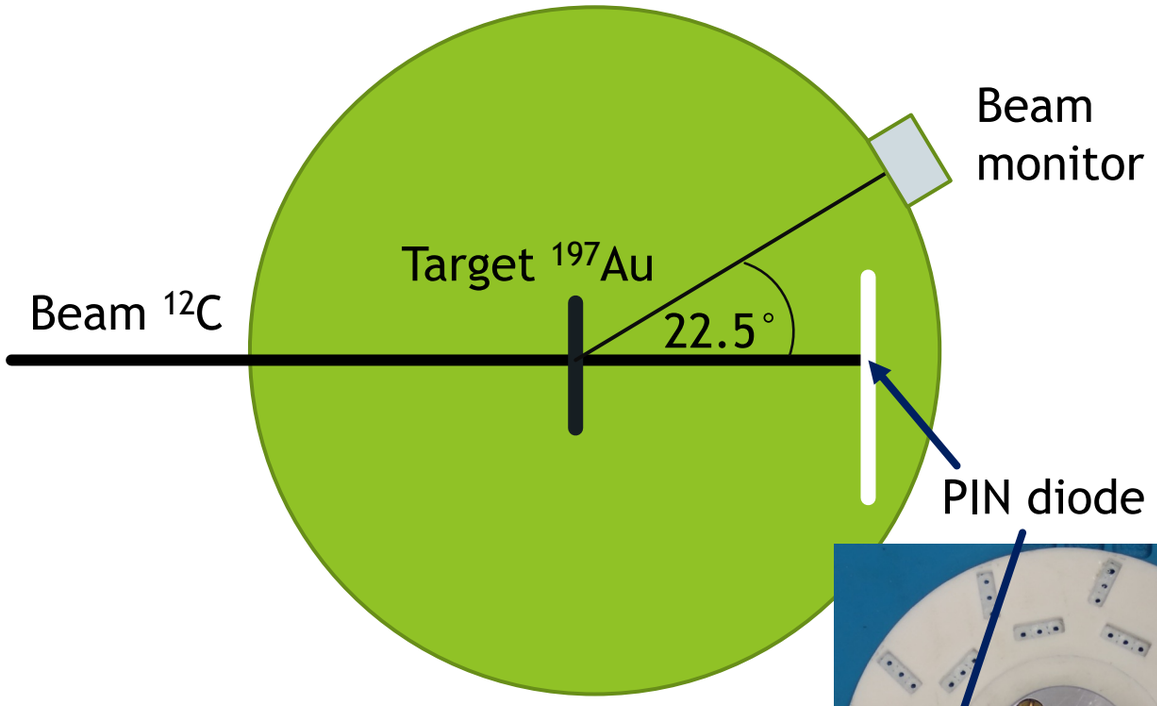
Radiobiology set-up



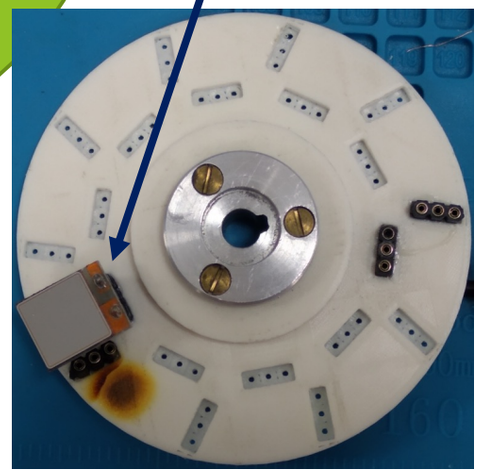


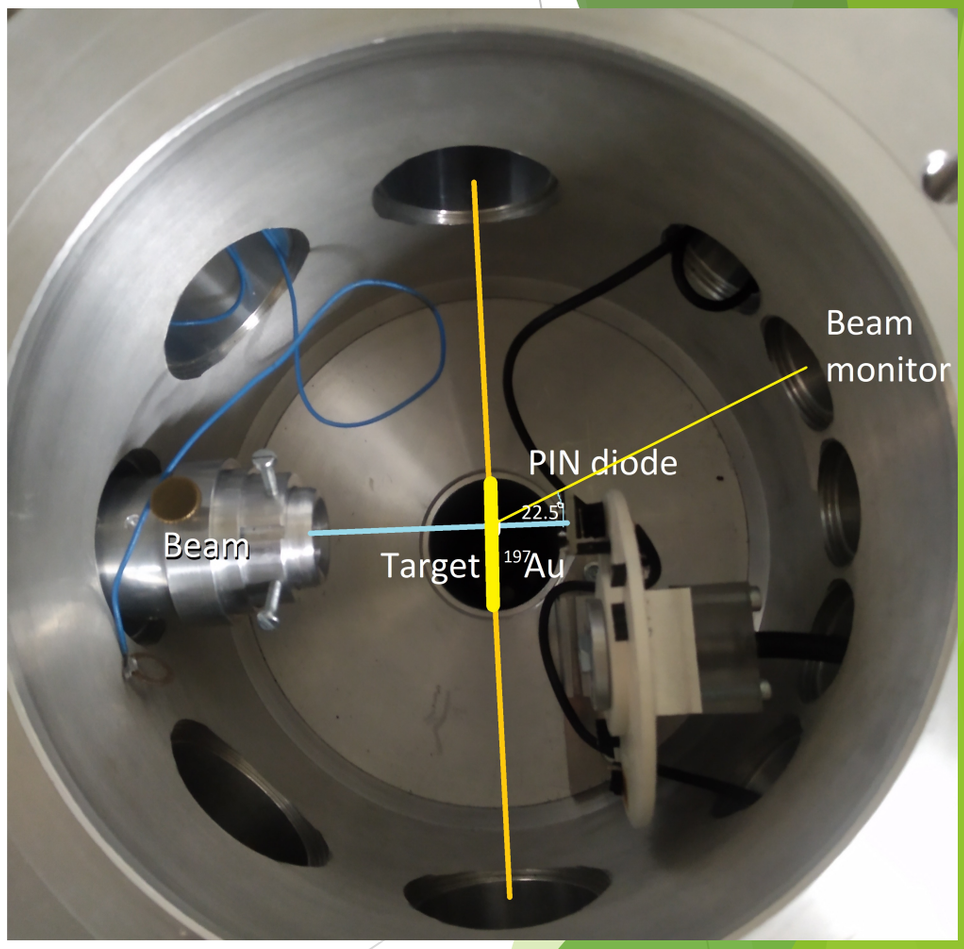
Radiobiology set-up

Controlled destruction of the PIN diode detector - open view chamber



Scheme of experimental setup.





Top view of the chamber.[6]

Material irradiation

Courtesy of K.Krutul-Bitowska

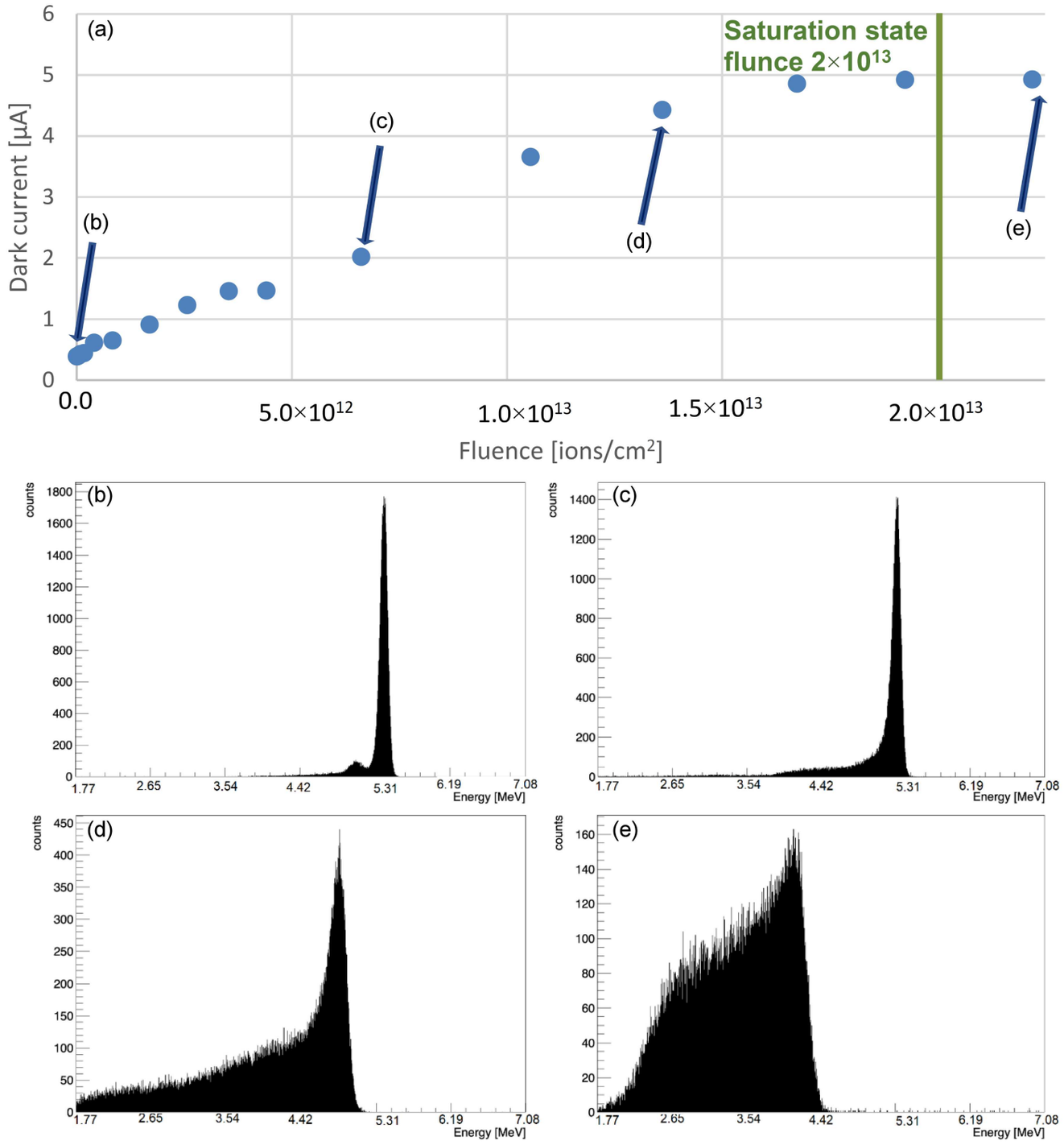


Fig. 1. Fluence-dependent evolution of PIN diode dark current measured in the PIN diode detector irradiated with the ^{12}C beam (a). The ^{241}Am alpha particle spectra obtained in different stages of the detector destruction process (b–d), collected immediately after cutting the beam flux off, compared to the spectrum collected for the final dark current saturation level (e).

Positron lifetime annihilation spectroscopy

- Positron spectroscopic annihilation is a method to study defects in the crystalline structure
- For the first time it was used to study defects that arise in silicon detectors
- Digital PALS setup: BaF_2 - based detectors and APU8702 unit
- Positron source: ^{22}Na with activity of 1 MBq enveloped into a 5 μm Ti foil
- Spectra including 10^6 counts were deconvoluted with lifetime code, substracting the background and the source components

collaboration:
Paweł Horodek, Krzysztof Siemek
IFJ PAN, Cracow

Courtesy of K.Krutul-Bitowska

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ACTA PHYSICA POLONICA A No. 6 Vol. **142** (2022)

Proceedings of the XIII International Conference "Ion Implantation and Other Applications of Ions and Electrons"

Radiation Resistance Studies of PIN Diode Detectors Irradiated with Heavy Ions

K.Z. Krutul-Bitowska[a,*], P.J. Napiorkowski[a], K. Hadyńska-Klęk[a], P. Horodek[b], M. Komorowska[a], A. Olejniczak[c], M. Paluch-Ferszt[a], K. Siemek[b], Z. Szefliński[a], M. Wróbel[d] and K. Wrzosek-Lipska[a]

[a] *Heavy Ion Laboratory, University of Warsaw, Pasteura 5A, 02-093 Warsaw, Poland*
[b] *Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Krakow, Poland*
[c] *Nicolaus Copernicus University, Gagarina 11, 87-100 Torun, Poland*
[d] *Faculty of Metals Engineering and Industrial Computer Science, AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Krakow, Poland*

Doi: 10.12693/APhysPolA.142.783 *e-mail: k.krutul@uw.edu.pl

The controlled destruction of the PIN diode detectors, SIEMENS SFH 870/F170 and SFH 871/F171, by the 35 MeV beam of the ^{12}C and by 24 MeV of the ^{14}N, respectively, was characterized using nuclear spectroscopy, the surface profile measurements, and the positron annihilation spectroscopy technique. The beam fluence was in the range of 10^{12}-10^{14} ions/cm^2. It has been shown that the fluence of 10^{12} ions/cm^2 of the ^{12}C beam did not allow it to destroy the PIN diode detector. For this purpose, one needs the fluence of at least 4×10^{12} ions/cm^2 for the ^{14}N ions beam and 2.2×10^{13} ions/cm^2 for the ^{12}C ions one. The presence of divacancies in the irradiated sample was detected by the positron lifetimes measurements, with the fraction significantly higher for the ^{12}C implanted sample. Furthermore, it was found that the surface roughness changed drastically following the implantation.

collaboration:
Paweł Horodek, Krzysztof Siemek
IFJ PAN, Cracow

Courtesy of K.Krutul-Bitowska

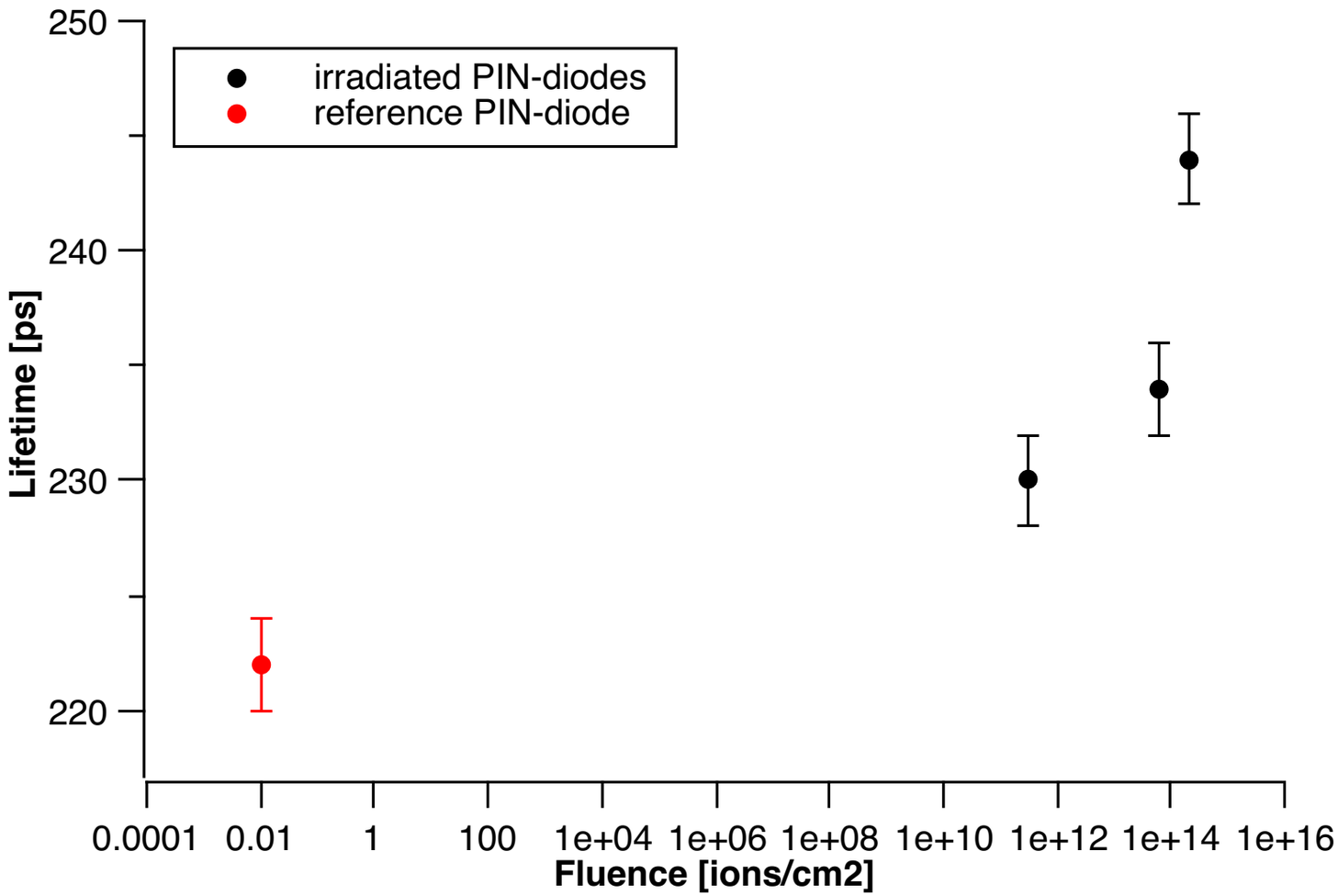
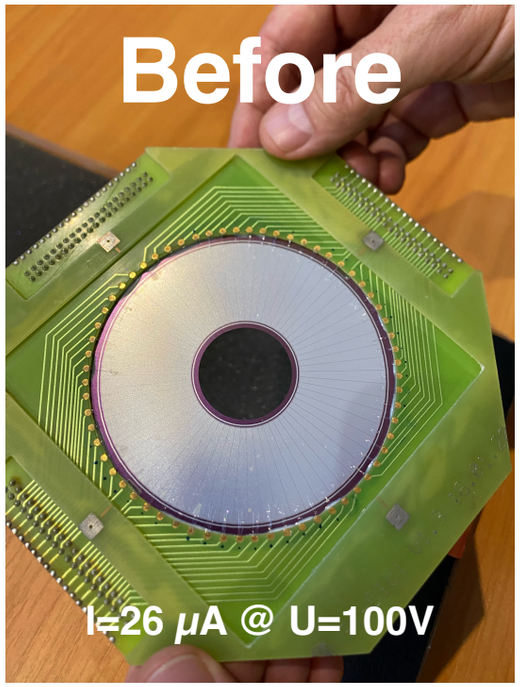


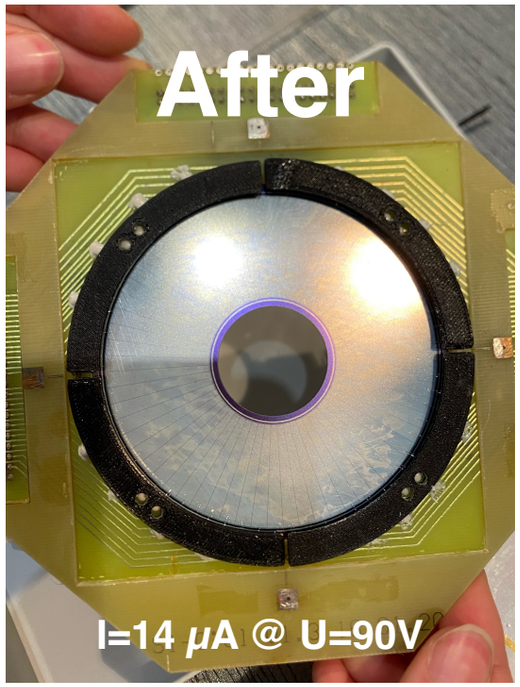
Fig. 5. (Colour on-line) The results from the positron annihilation spectroscopy — the positron lifetimes observed for irradiated samples (marked in black) as a function of the fluence. Grey/red point corresponds to the reference PIN diode which was not exposed to the high-flux heavy-ion beam.

K.Krutul-Bitowska et al. Acta Physica Polonica B Proceedings Supplement 13 (2020) 861

,

Radiation Damaged
- Let's ~~Anneal~~ Bake @130°C





Vacuum oven available at HIL

- Temperature 10-250°C
- Vacuum <133 Pa (1 Torr)

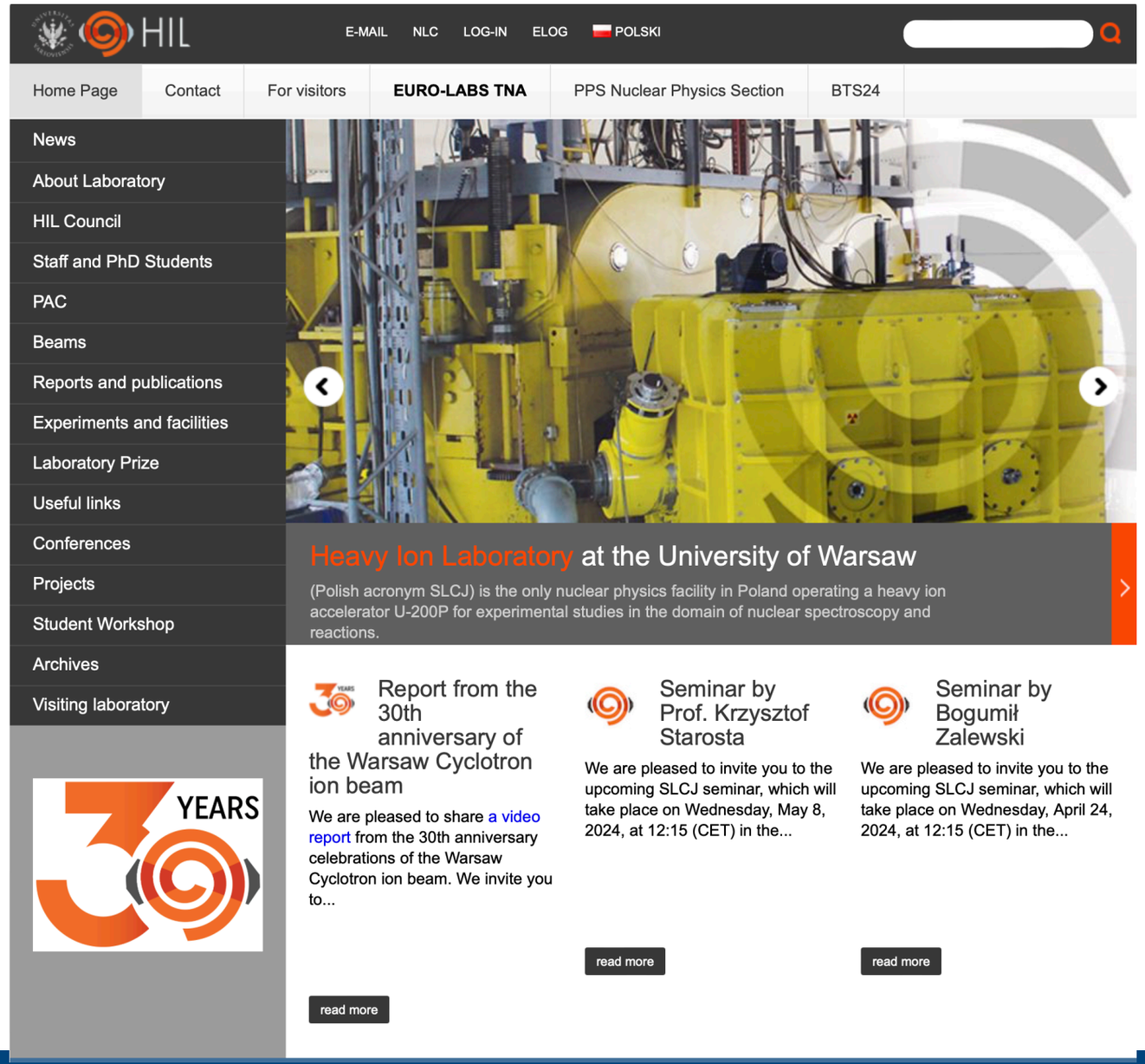
Summary

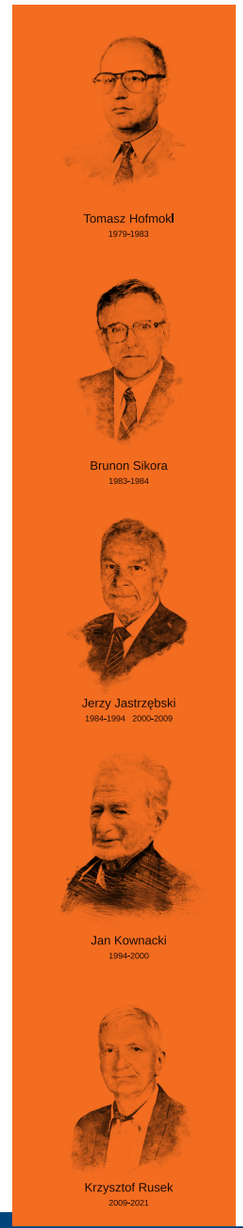
- HIL is European facility - we use various experimental stations equipped thanks to European collaborations.

- The EURO-LABS Transnational Access programme makes the HIL a part of European Research Area; most of the HIL users are international teams nowadays

- Detector development and maintenance may be a continuation of HIL's cooperation with FAZIA

www.slcj.uw.edu.pl





Heavy Ion Laboratory

ANNUAL REPORT 2024

30 YEARS

Available soon

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30 YEARS | UNIVERSITY OF WARSAW | HIL

P.J.Napiorkowski