



The Henryk Niewodniczański Institute of Nuclear Physics
Polish Academy of Sciences, (IFJ PAN)

*Irradiation possibilities with proton beams
at IFJ PAN*

Jan Swakoń

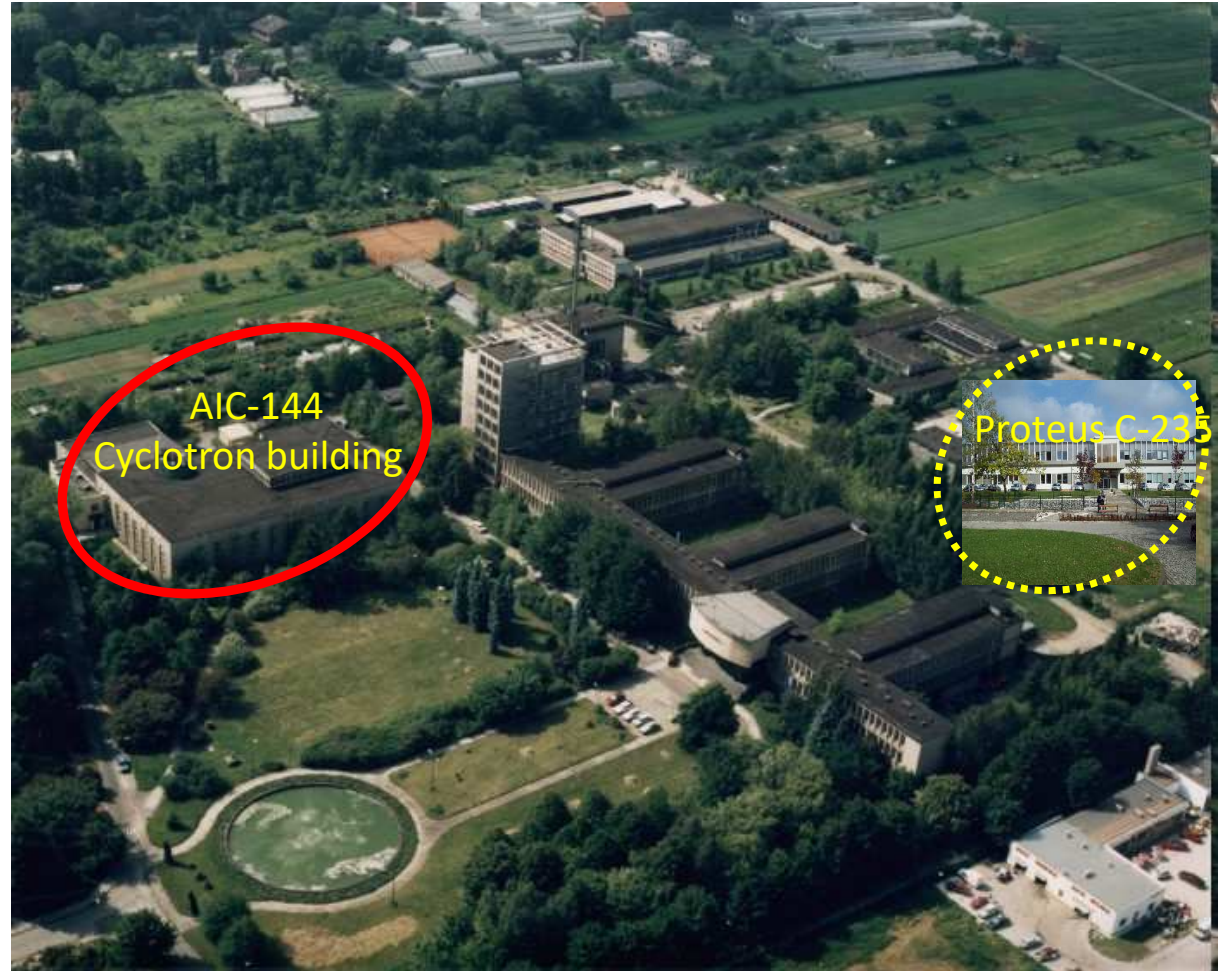
*Department of Radiation Research
and Proton Radiotherapy*





The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, IFJ PAN

- established 1955
- 550 employees (220 with Ph.D. degree)+70 Ph.D. students
- main interest:
 - particle physics (CERN)
 - nuclear physics
- applied research:
 - 60 MeV proton cyclotron
 - 230 MeV Proteus IBA
 - 2 MeV proton V-d-Graaff
- proton radiotherapy
 - Cyclotron Centre Bronowice



Proteus C-235

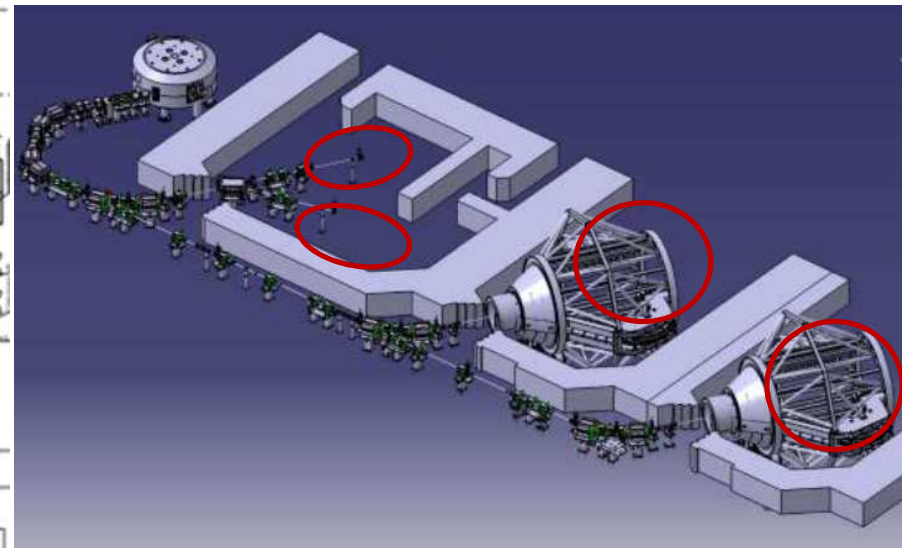
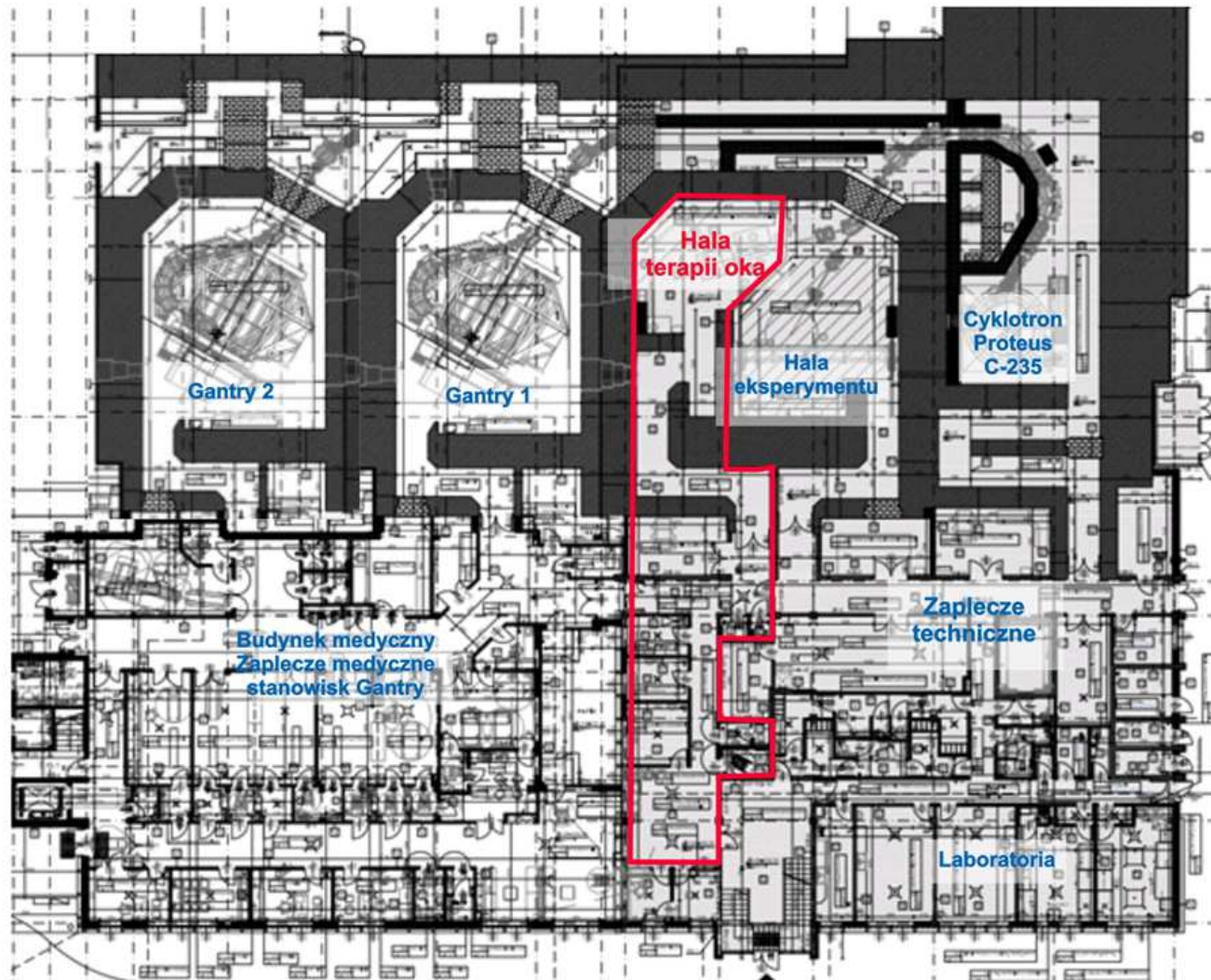


BEAM PARAMETERS:

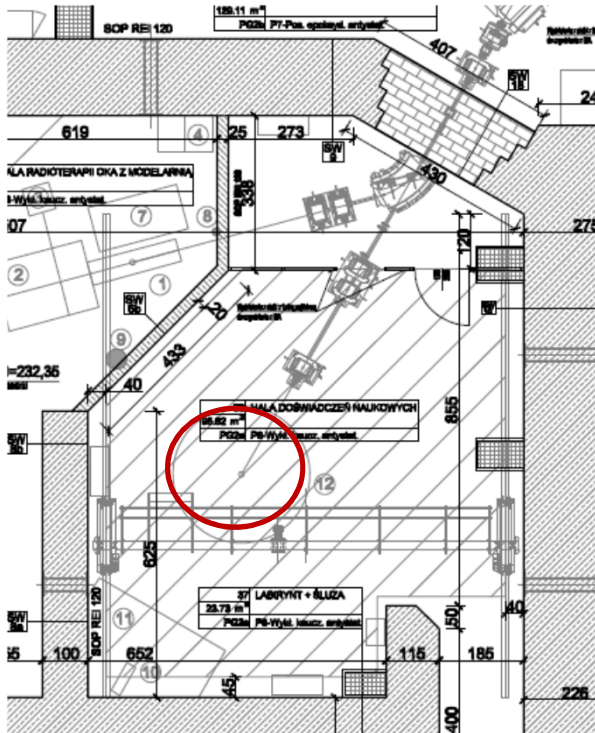
Energy 230 MeV; RF 106 MHz;

quasi continuous beam; beam current 500 nA (for 230 MeV);

CCB infrastructure



Experimental room (CCB Proteus C-235 building)



Proton beam energy:

70MeV – 230MeV;

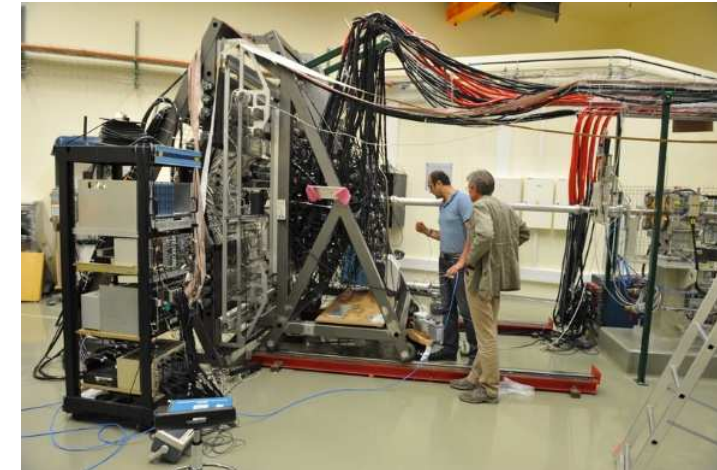
Beam current:

1nA - 100nA for 230MeV;

do 2nA for 70MeV;

Spot size: 5.5 mm (1σ);

Energy less than 70MeV after degradation;

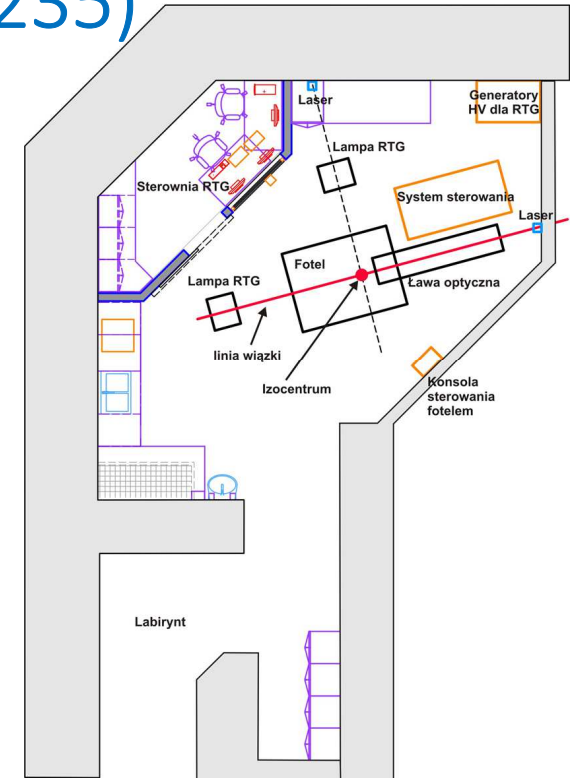


Difficult access due to experiments in nuclear physics;
It is not possible to deposit high doses.

Proton eye therapy room ELTR in CCB (proton beam from Proteus C-235)



Energy : 0 - 60 MeV;
Precise Energy regulation in range 10 MeV – 60 MeV
Dose rate: 0.001 – 0.3 Gy/s (measured in water);
Single scattering;
Field size: ≤ 40 mm;
Beam field homogeneity $\geq 5\%$;
Irradiation in SOBP available;
Sample positioning precision (> 0.1 mm);
It is not possible to deposit high doses (> 1 kGy);



Eye therapy room

Difficult access to the room due to medical applications

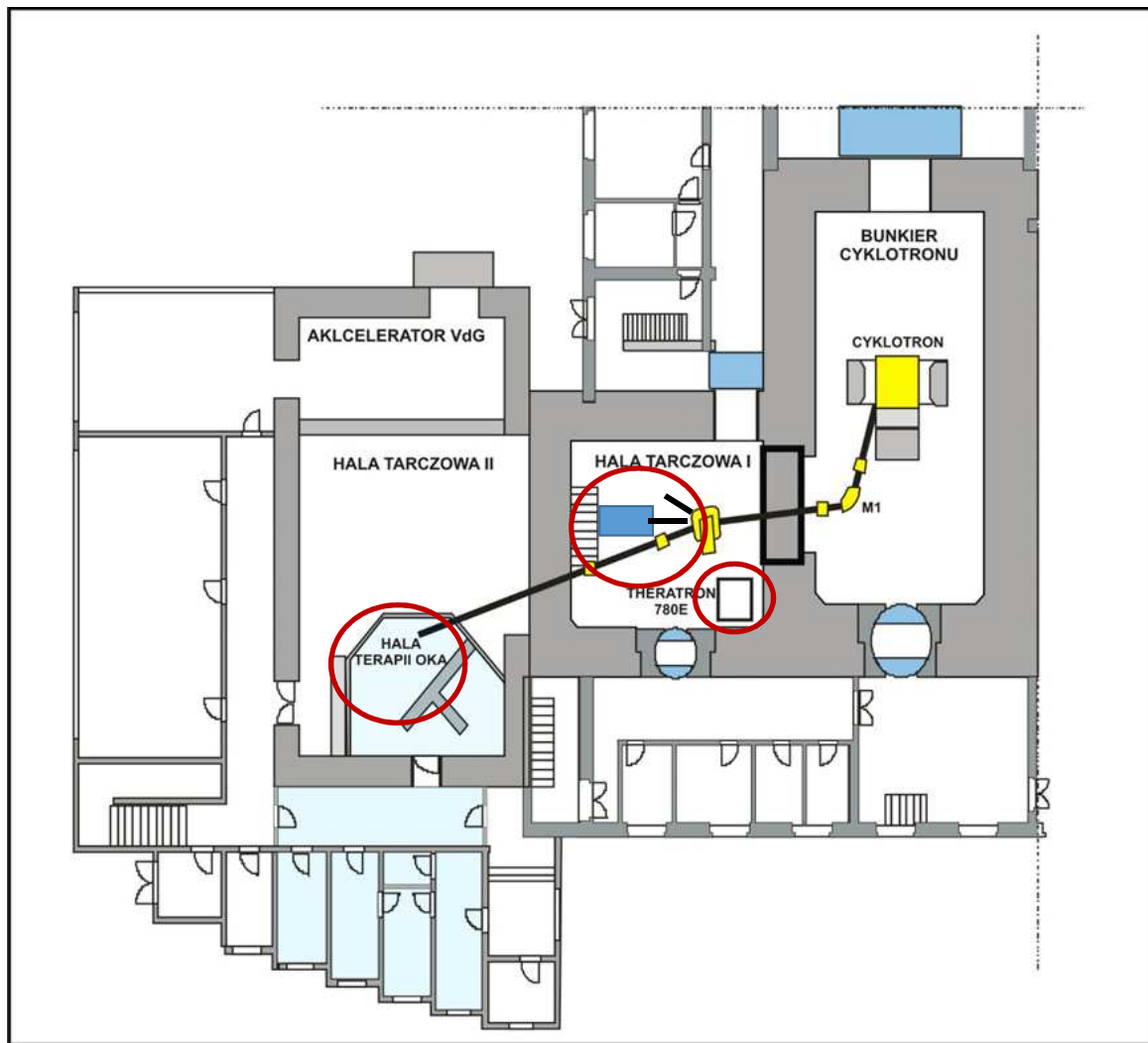
Gantry (GTR3, GTR4)



Energy range: 70 MeV – 230 MeV;
Spot size: 3 – 7 mm (1σ);
Field size(scanning beam): 30cm x 40cm;
Field homogeneity: $\leq 2\%$;
Dose rate: 2Gy delivered into 1 litre volume in 90 s;
Irradiation in SOBP available;
Sample positioning precision(> 0.1 mm);
It is not possible to deposit high doses (>1 kGy);

Difficult access to the room due to medical applications

AIC-144 cyclotron facility



Beam lines



Scattering foil (*tantalum 25um*)

AIC-144 isochronous cyclotron

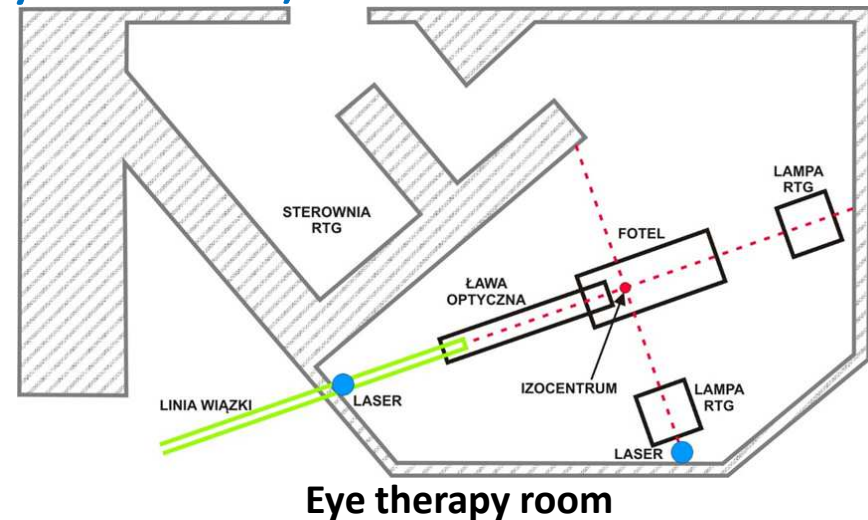


BEAM PARAMETERS:

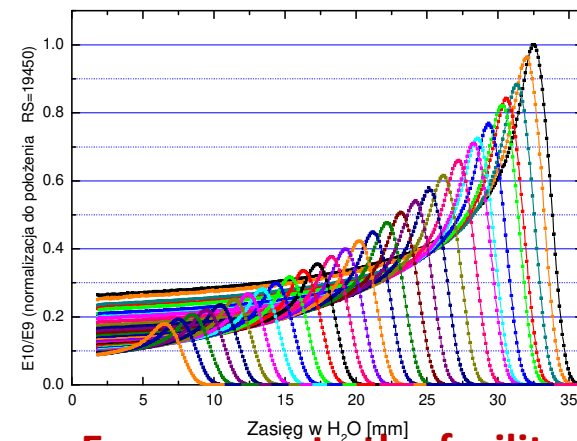
Energy 60 MeV; RF 26,26 MHz;

Beam macro structure 50 Hz, macro pulse length 0.5 ms, beam current 80 nA (*110nA*);

Irradiation facility with horizontal beam line (AIC-144 cyclotron)

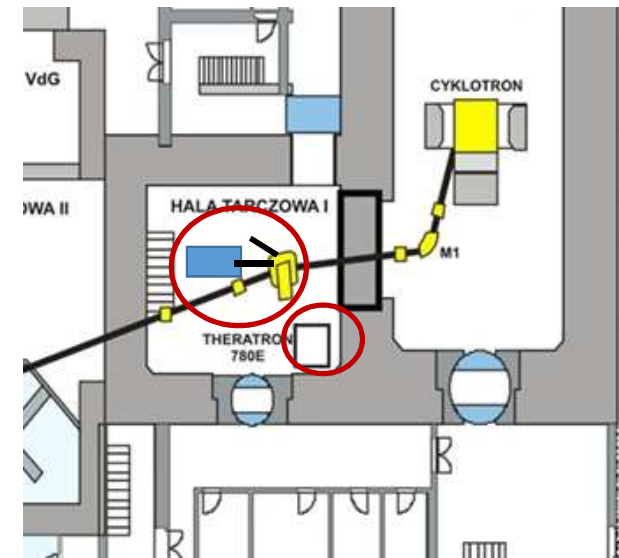


Energy: 0-58 MeV;
Dose rate: 0.001 – 1 Gy/s (measured in water);
Single scattering;
Beam field size: ≤ 40 mm;
Field homogeneity $\geq 5\%$;
Min flux of protons: 5×10^5 p/cm²·s (50MeV);
Typical flux: 10^8 – 10^9 p/cm²·s;
Irradiation in SOBP available;
Sample positioning precision (> 0.1 mm);
It is not possible to deposit high doses (> 1 kGy);



Easy access to the facility

Optical line at the experimental room at the AIC-144 cyclotron building



Energy: 60 MeV (10MeV-60MeV);
Proton beam current: 2nA – 100nA;
Spot size: ~ 10mm (1 σ , estimated);
Possible Energy degradation to the 10 MeV;
Irradiation field diameter < 12 cm;
Flatness $\geq 15\%$ ($\pm 10\%$);
High beam and irradiation field configuration flexibility

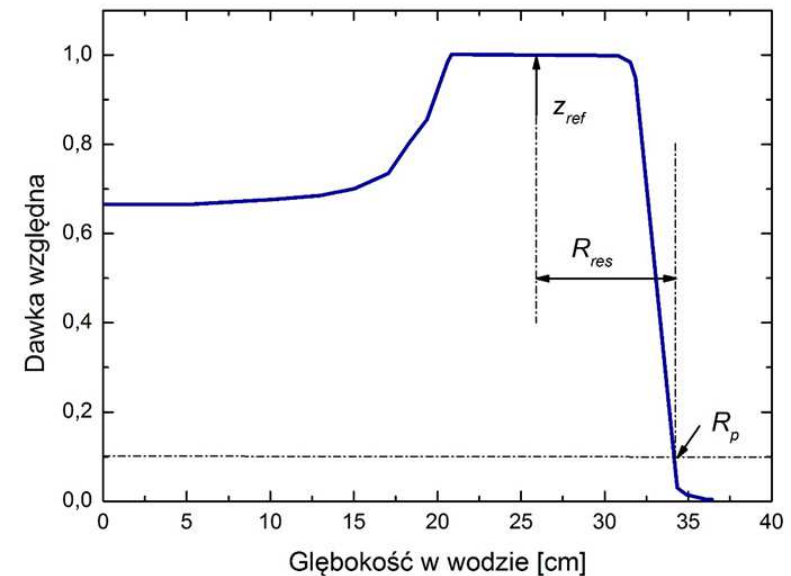
**Facility dedicated to low energy protons (10-60MeV)
and high beam intensity (10-20 Gy /s);
Possibility to deposit very high doses (> 120kGy in H2O);**

Easy access to the beam

Beam dosimetry for electronics radiation hardness tests

Proton beam reference dosimetry based on the recommendations of the IAEA TRS-398 Code of Practice protocol

*dose measurement with ionization chambers calibrated in the Co-60 radiation field,
dose measurement performed in a water phantom*



$$D_{w,Q} = M_Q \cdot N_{D,wQ_0} \cdot k_{Q,Q_0}$$

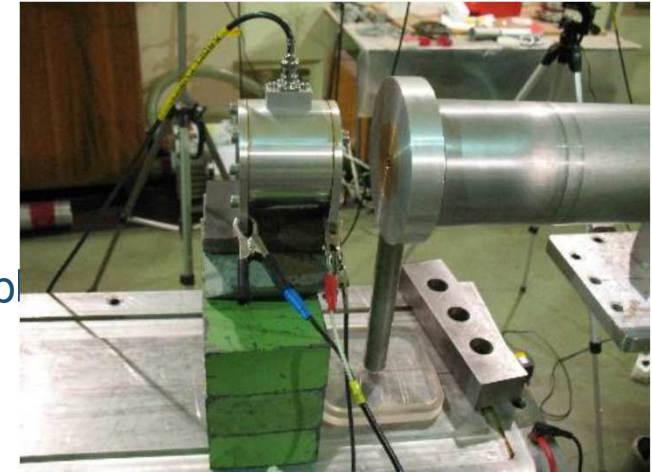
Dosimetry methods

Dose and proton beam current measurements:

- Ionisation chambers: semiflex IC, Markus IC, transition parallel IC;
- Diamond detectors semiconductor diodes;
- Reference class electrometers: PTW UNODOS, PTW UNIDOS Webline;
- Water phantoms, solid state phantoms, (PMMA, RW3), anthropomorphic p

Beam current measurements:

- Faraday cup, Keithley electrometers;



Beam current measurement with Faraday cup

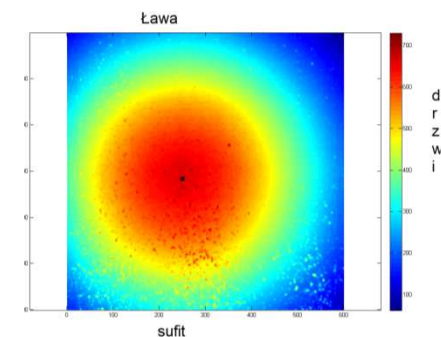
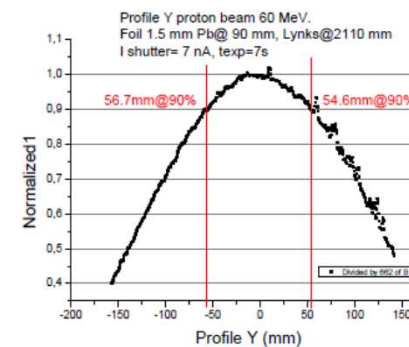
Measurement of transverse profiles and imaging of beam transverse distributions

(scintillator +CCD camera):

- ProBimS:
- Lynx;

Passive:

- Gafchromic EBT3;
- TLD, 2DTLD dosimeters;
- Alanine pellets



LynX beam profile measurements

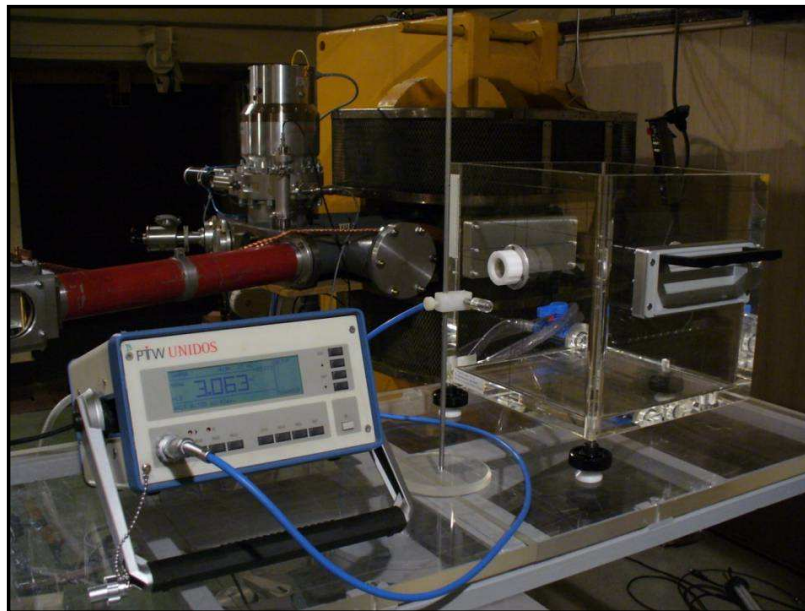
THERATRON 780E

^{60}Co γ -rays 237 TBq

Dose rate 0.5 -2 Gy/min

Field size 20 cm x 20 cm;

Traceability: Secondary Standard
Laboratory, Centre of Oncology Warszawa
($\rightarrow$ IAEA)



How to make irradiation at IFJ PAN at Krakow?

As part of the [INfraStructure in Proton International Research](#) INSPIRE project (HORIZON 2020), our centre offers free beam access for research related to proton radiotherapy.

The support of the infrastructure includes:

- ·Free use of the infrastructure facilities (in agreement with any potential applicable national laws, local safety and health regulations, or other conformity rules)*
- ·Administrative and logistical support*
- ·Technical and scientific support*
- ·Specific training (for use of the infrastructure and/or instrumentation).*

For details see:

<https://inspire.ifj.edu.pl/en/index.php/dostep-do-infrastruktury-badawczej/>

For electronic tests please contact us directly: email: jan.swakon@ifj.edu.pl

Thank you for your attention