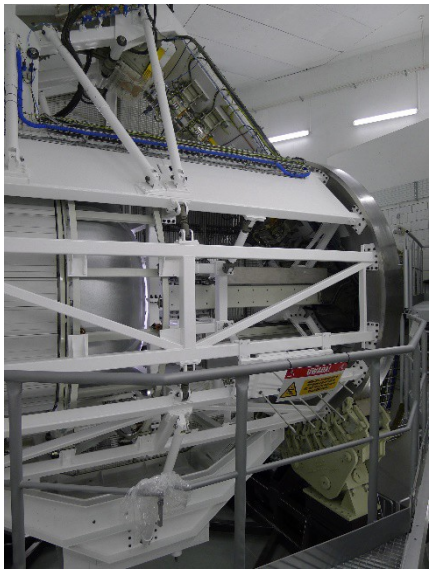
Cyclotron Centre Bronowice (CCB) - facility for proton therapy and applications

Paweł Olko
Institute of Nuclear Physics PAN, Kraków, Poland

Construction of the CCB (2011- 2015)

- **Financed** from the EU Operational Programme Innovative Economy 2007-2013

- **The project supported** by major Universities and Institutes in Poland



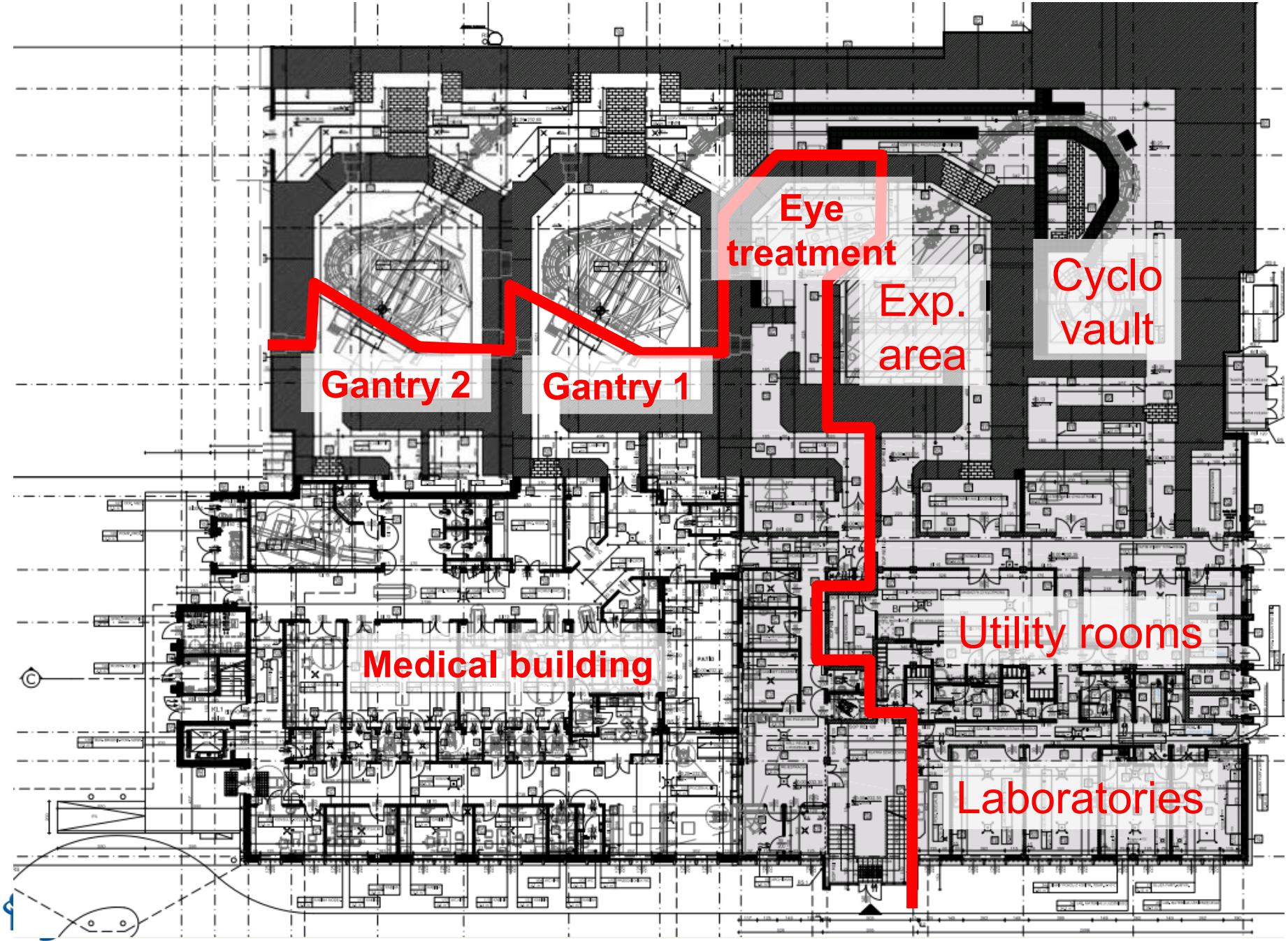
Cyclotron project: 30 M€

- signing the contract	08.2010
- start of the construction	03.2011
- installation of the cyclotron	05.2012
- starts of experiments	01.2013

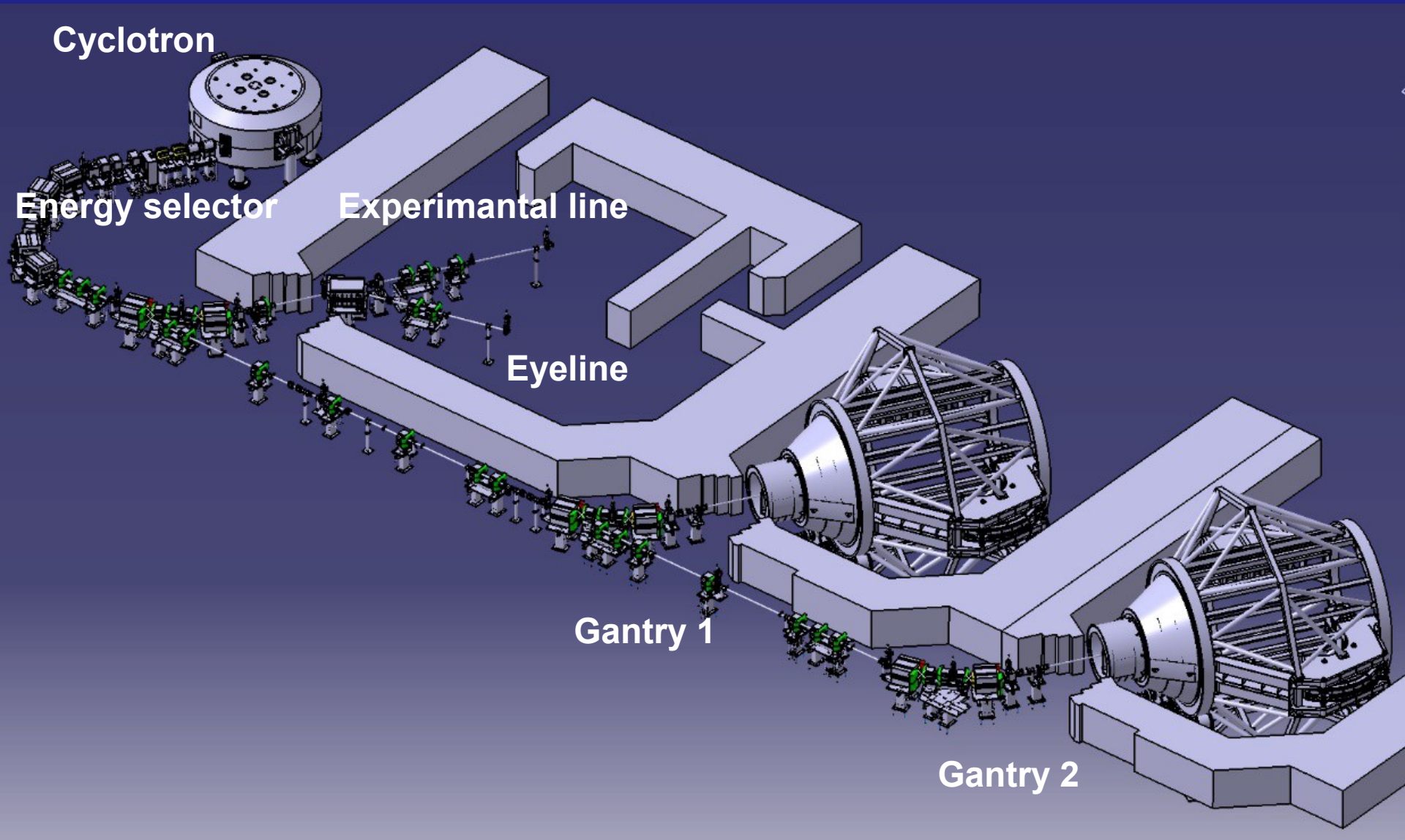
Gantry project: 35 M€

- gantry 1 operational	06.2014
- gantry 2 operational	06.2015
- end of the contract	09.2015

General layout of CCB

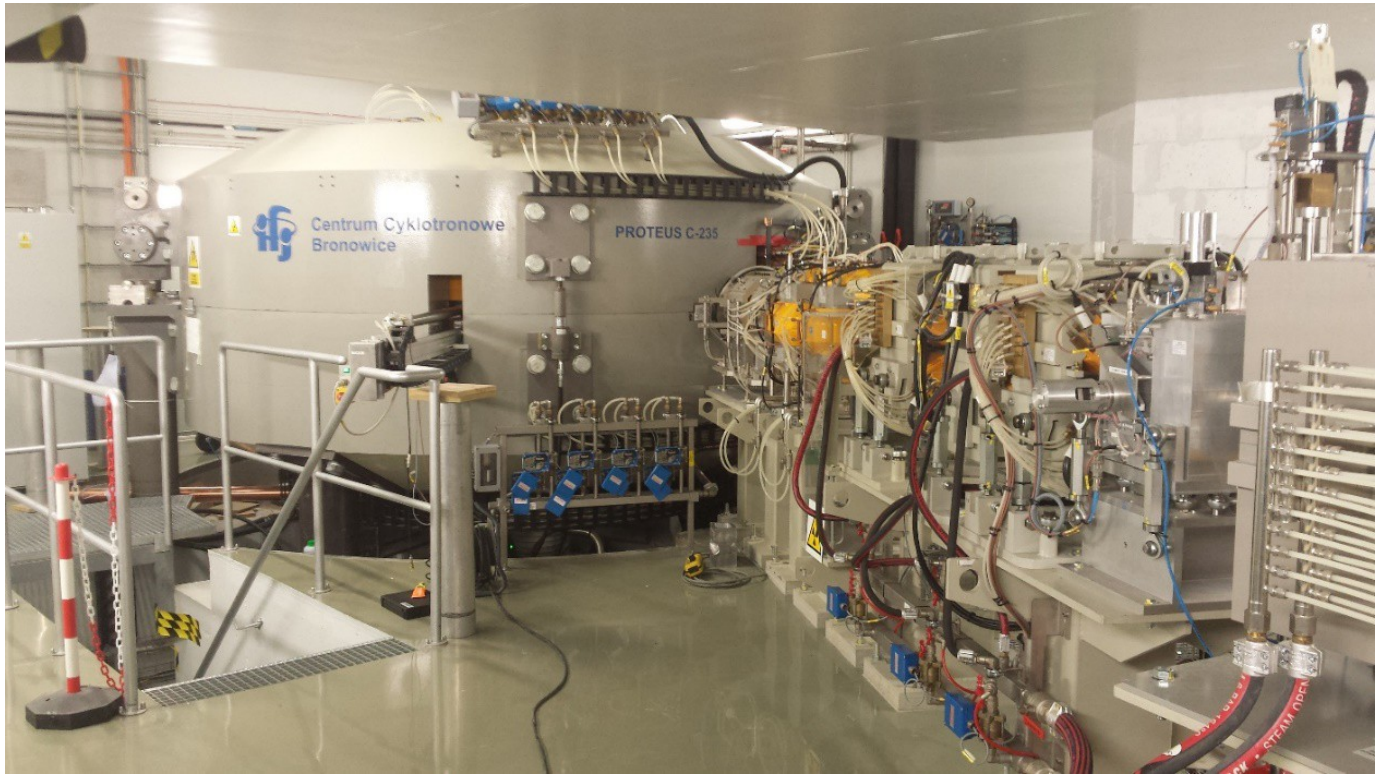


Beam lines at CCB



C-235 Proteus cyclotron at CCB - IFJ PAN

Producer:
Ion Beam Applications S.A. (IBA), Louvain-la-Neuve, Belgium

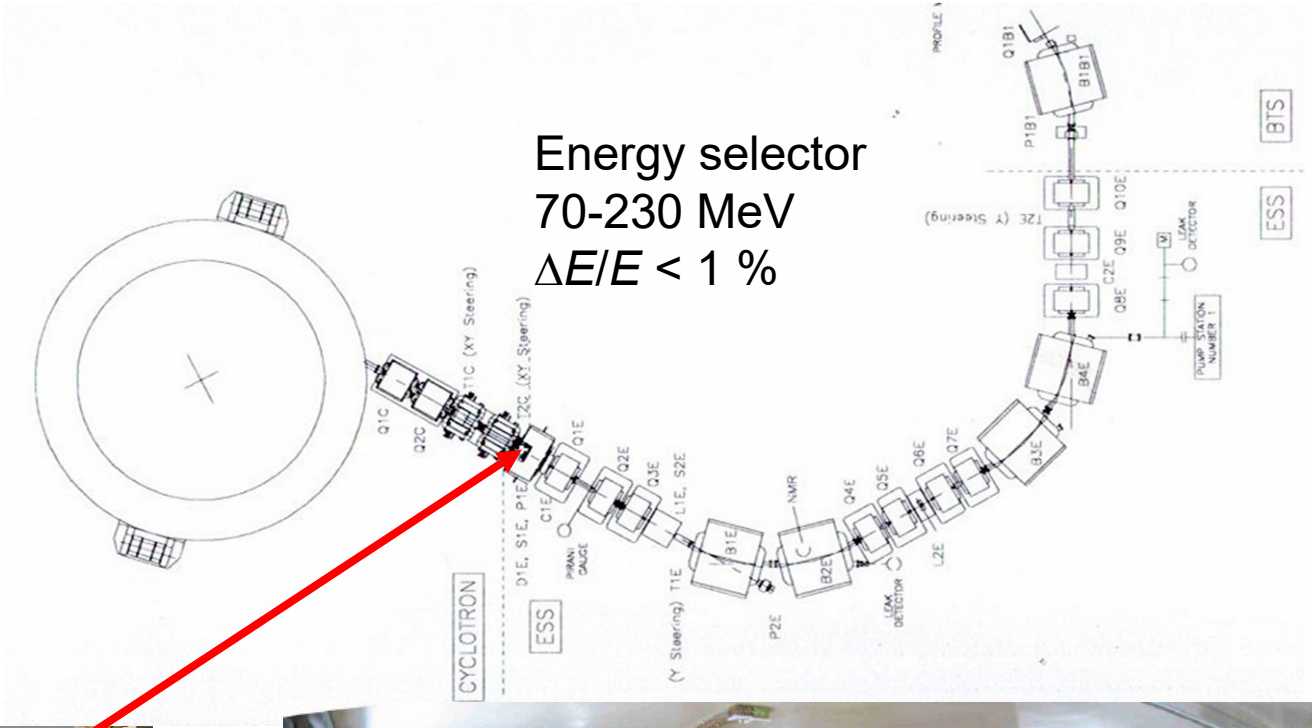


SIZE, WEIGHT:
diameter 434 cm
height: 210 cm
weight: 240 T

cyclotron:	**isochronic, 4-sectors, CW**
particles	**protons**
ion source:	**P.I.G with hot cathod**
proton energy:	**230 MeV (β = 0.596, γ = 1.245),**
energy dispersion:	**$\Delta E/E$ < 0.7%**
beam intensity:	**600 nA (3.6 x 10^{12} p/s) – 0.1 nA (6 x 10^{8} p/s)**

Proton energy selector

Energy selector
70-230 MeV
$\Delta E/E$ < 1 %

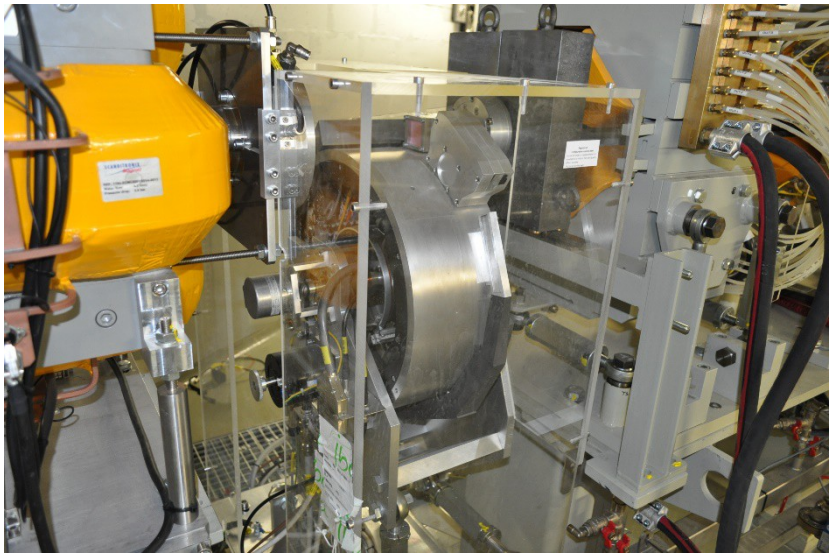


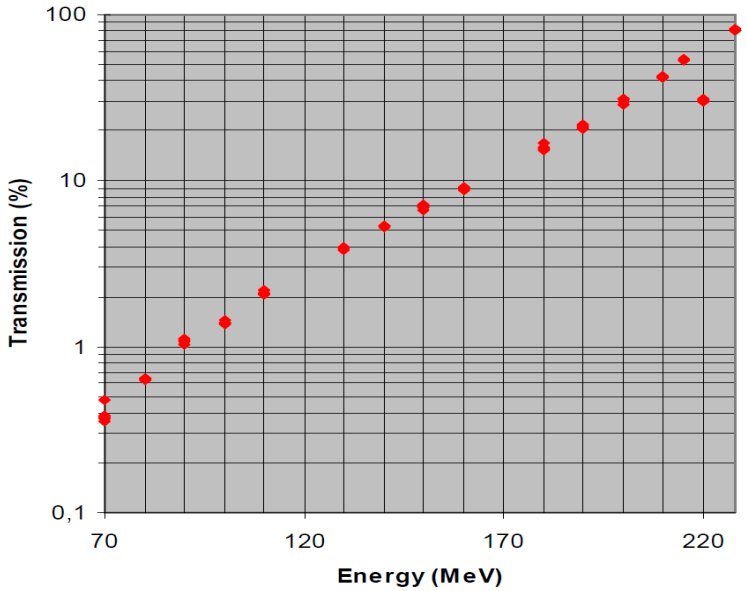
Beryllium absorber for degrading the beam energy

Set of slits and magnets for monochromatization of the scattered beam

Proton energy selector

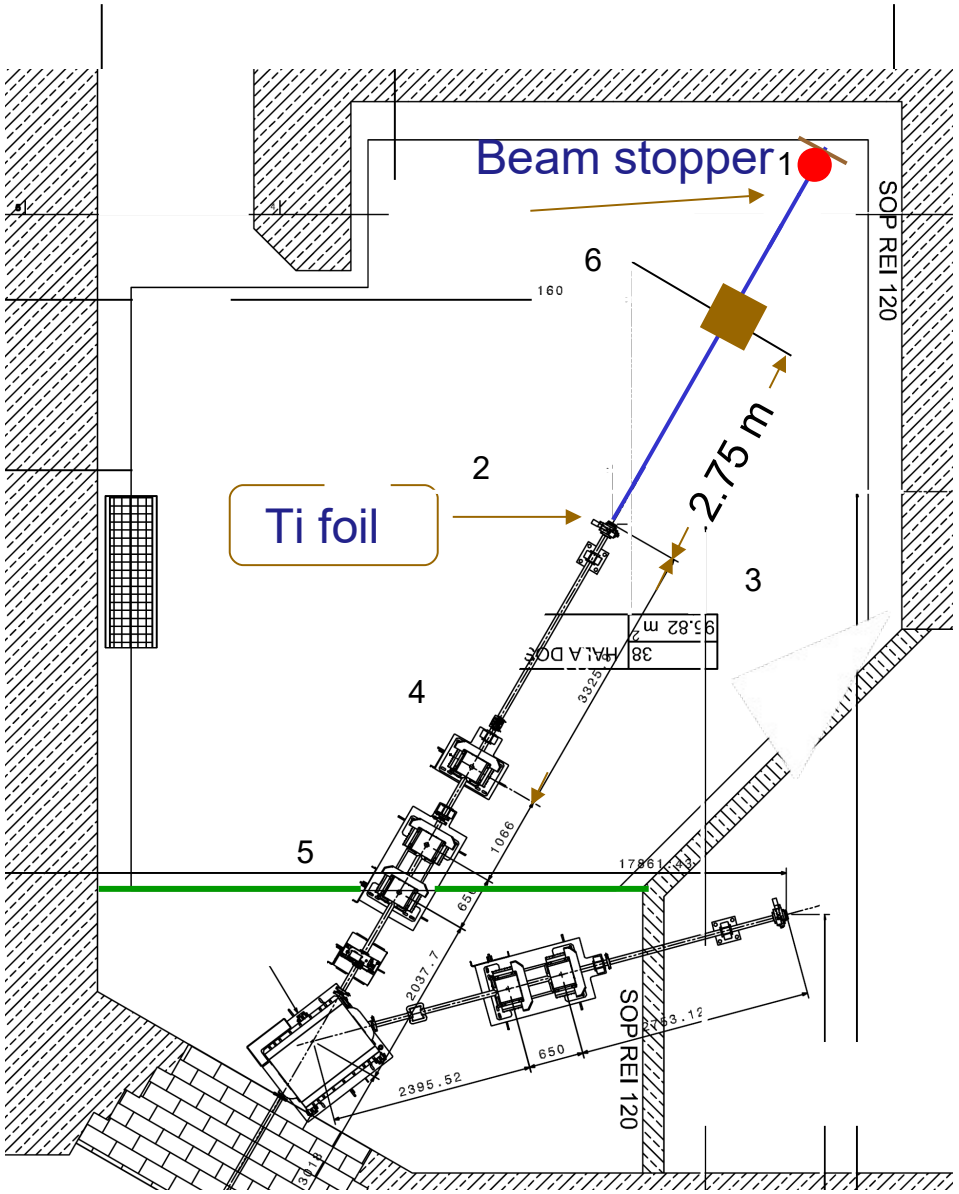
- maximal proton current at E=230 MeV I= 500 nA
- transmission 0.4% (for Be degrader) for energies from 230 MeV to 70 MeV
- 70 MeV, 2 nA, distal fall-off < 2 mm
- possible $\Delta E/E < 1$ %



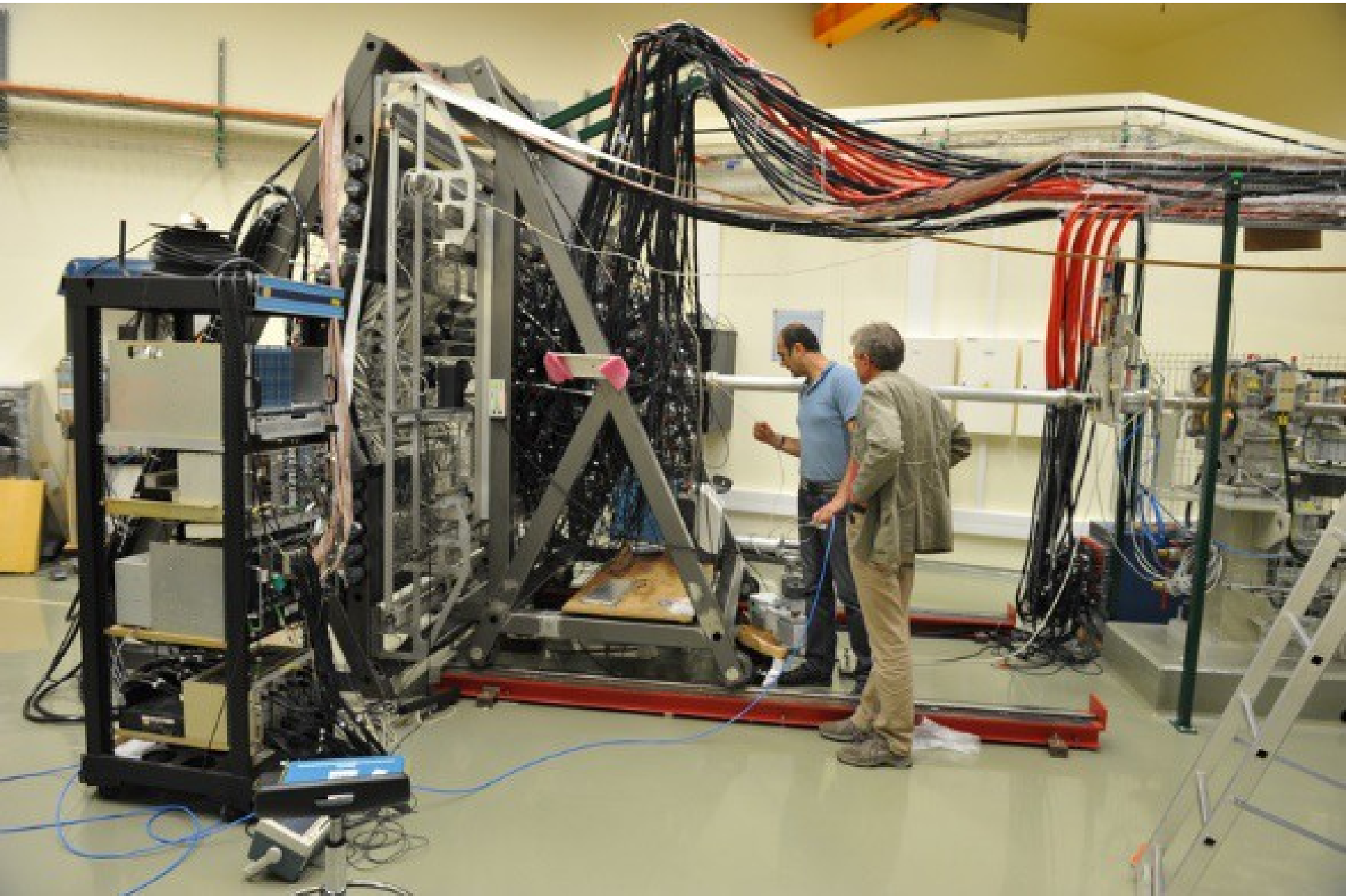


Experimental room

- 95 m^2
- single beam line, 60 mm in diameter
- 150 cm above the floor level
- distance (Ti foil –wall) ~ 450 cm
- air conditioning
- channels for installations and LN
- brigde crane



Installation of BINA detector at the experimental room 2013



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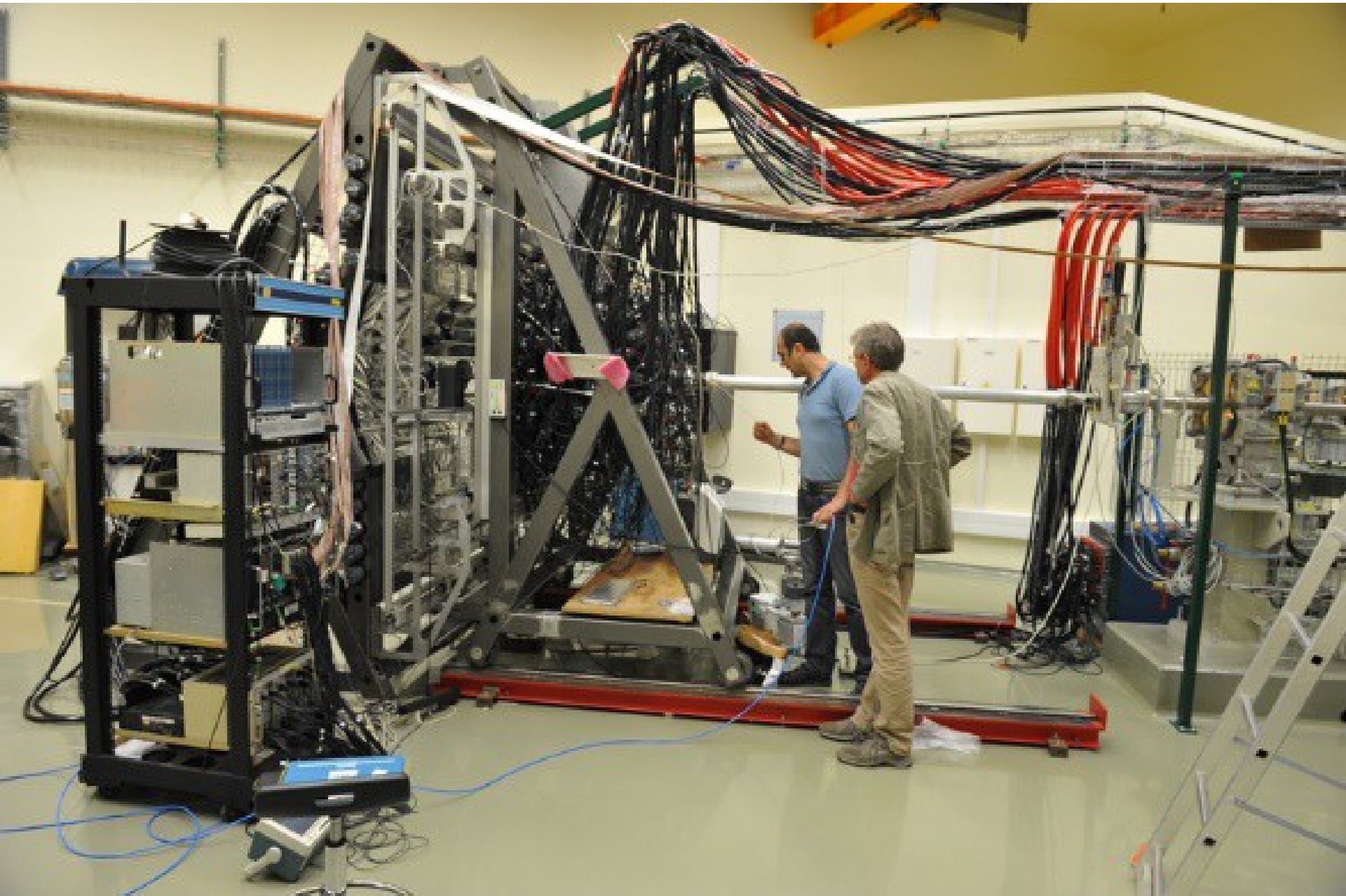
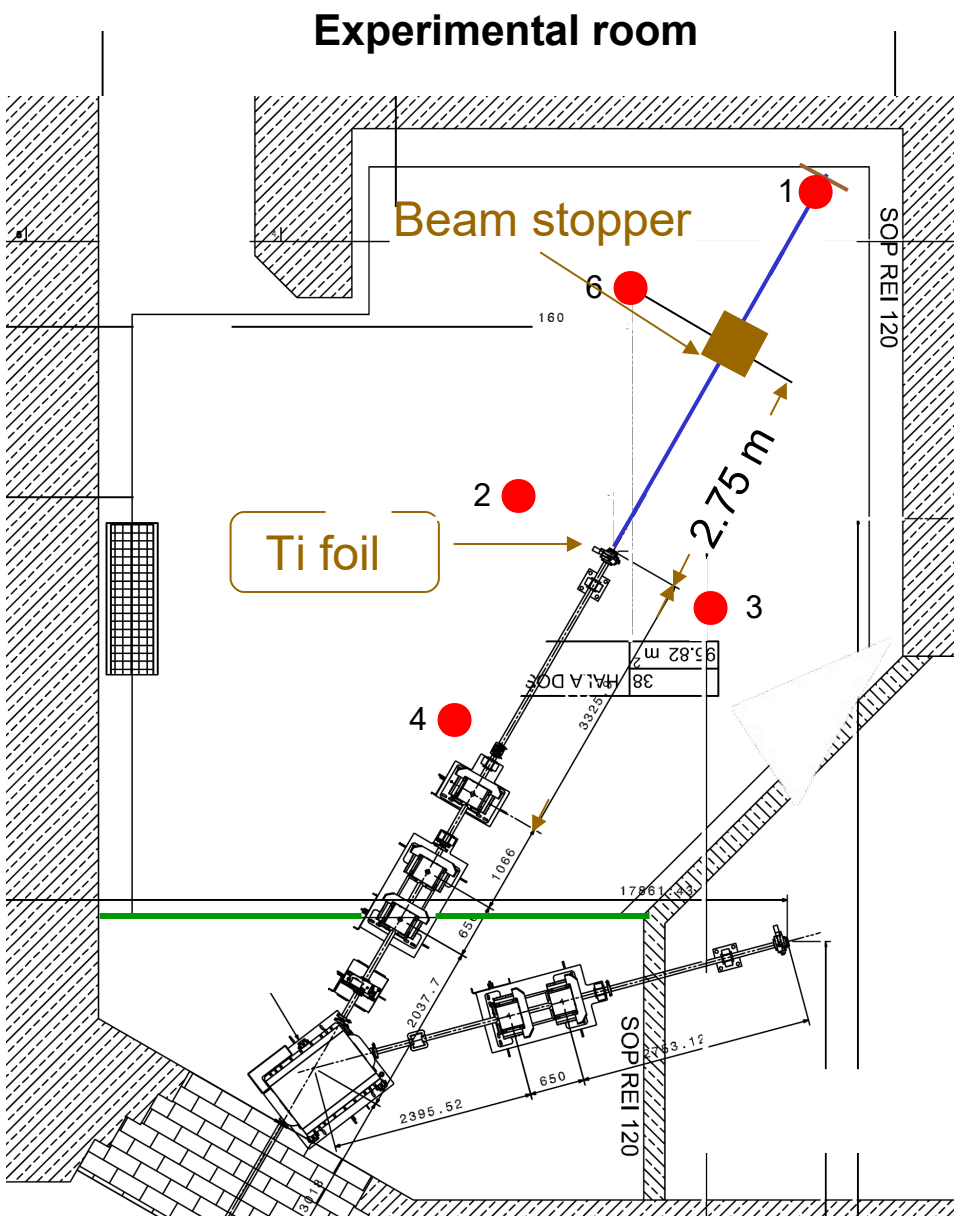


Neutron dose rate in the experimental room

W. Meczynski, K. Zbroja



protons: 70 – 230 MeV, ~1 nA,

In air:

Scattering foil- Ti 50 μm
Beam stopper - graphite block

39x39x24.5 cm3

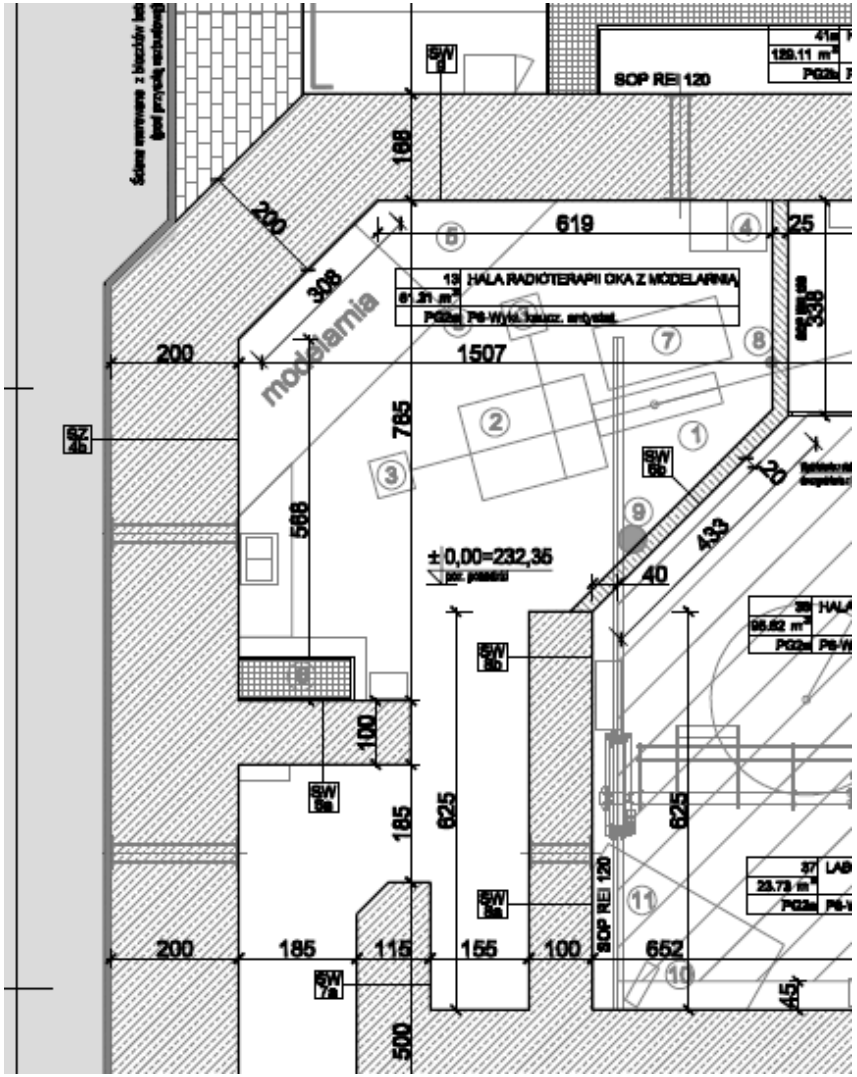
neutrons:

FHT762 Wendi-2 rem-meter

	70 MeV	180 MeV	230 MeV
Point		[μS/h]	
1	500	10 600	13 000
6	470	3 650	3 600
2	420	1 600	1 500
3	-	-	1 420
4	840	1 680	1 820

Eye treatment room

- developed by group of J. Swakon (IFJ PAN)
- CE marking by IFJ PAN (Ł. Góra) in collaboration with IBA
- horizontal beam line
- beam shaping: single scattering + 40 mm collimator
- nominal energy used for eye treatment: 70 MeV
- dose rate: ~10 Gy/min
- isocentric treatment chair (HEPHA BFI, France)



First eye patient treated at new faility at CCB in February 2016

Proton therapy of eye was performed at IFJ PAN on AIC-144 cyclotron in 2011-2016
126 patients have been treated

Preperation rooms for radiobiology and physics

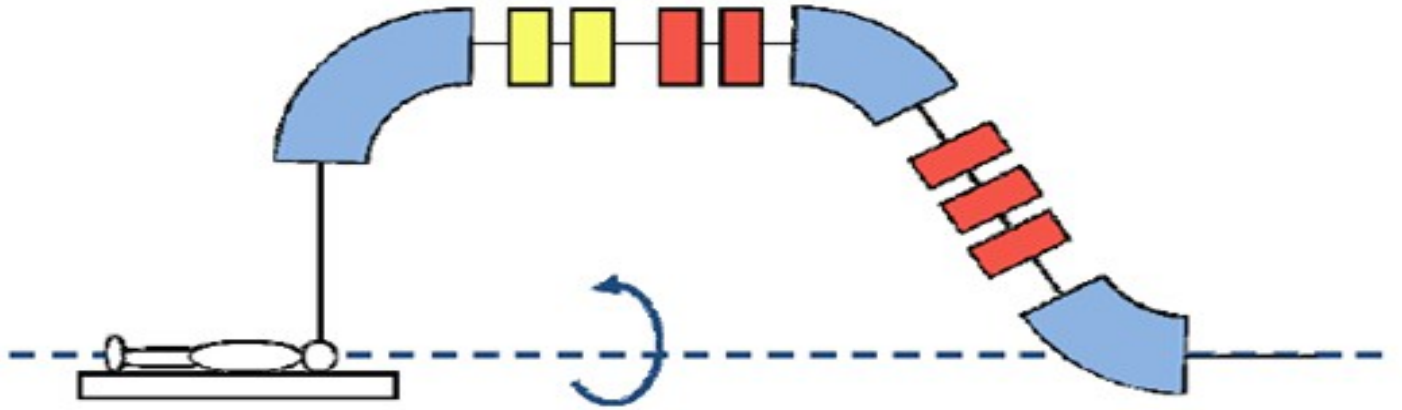
Two radiobiology rooms for human and animal material:

- 2 x 30 m^2
- cold room (+4 - +8 C)
- a laminar flow cabinet,
- chemical hood,
- deep freezers (-20 and -80 C), incubator with CO_2
- epifluorescence and optical microscopes.

Two rooms for preparation of physical experiments:

- 2 x 30 m^2
- Connections with experimental room

The concept of the gantry for proton therapy

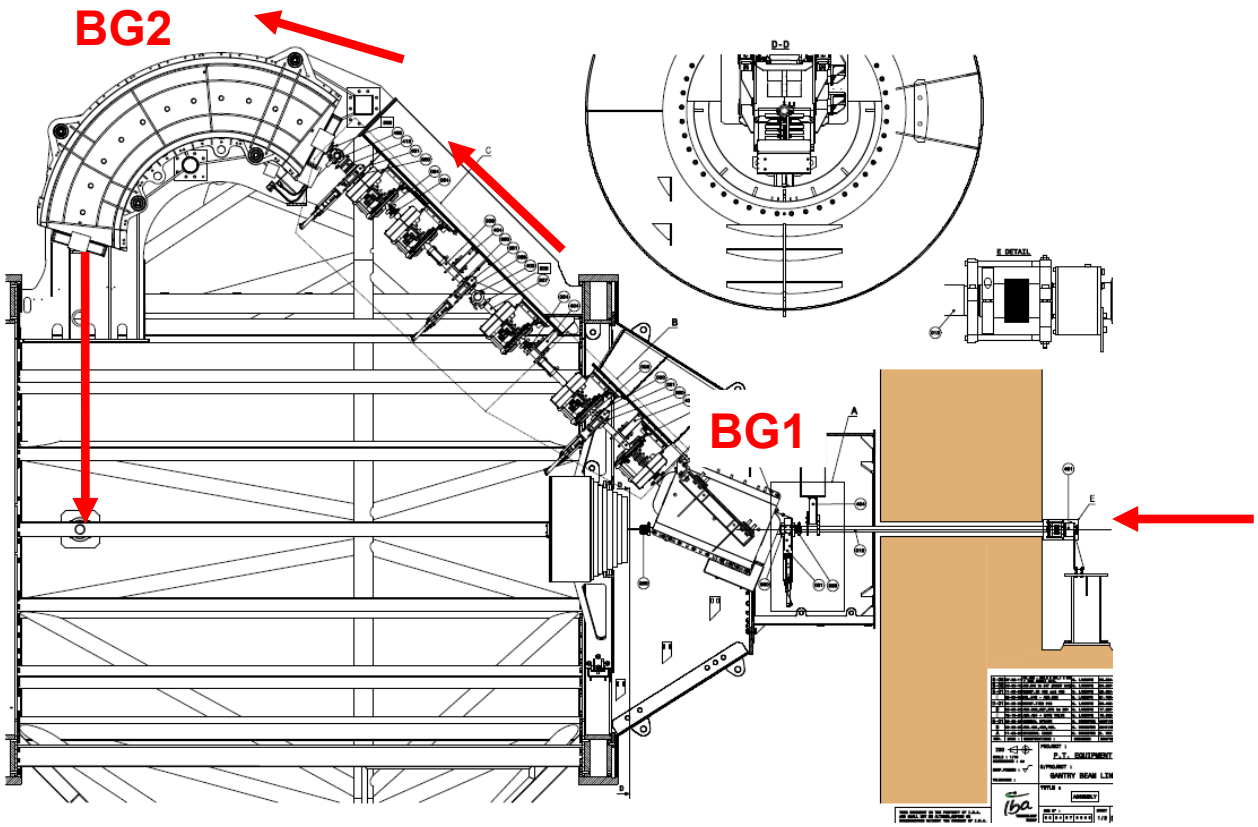


Parameters of IBA dedicated gantry at IFJ PAN

Source Axis Distance
SAD-X - 1848.1 mm
SAD-Y - 2229.0 mm

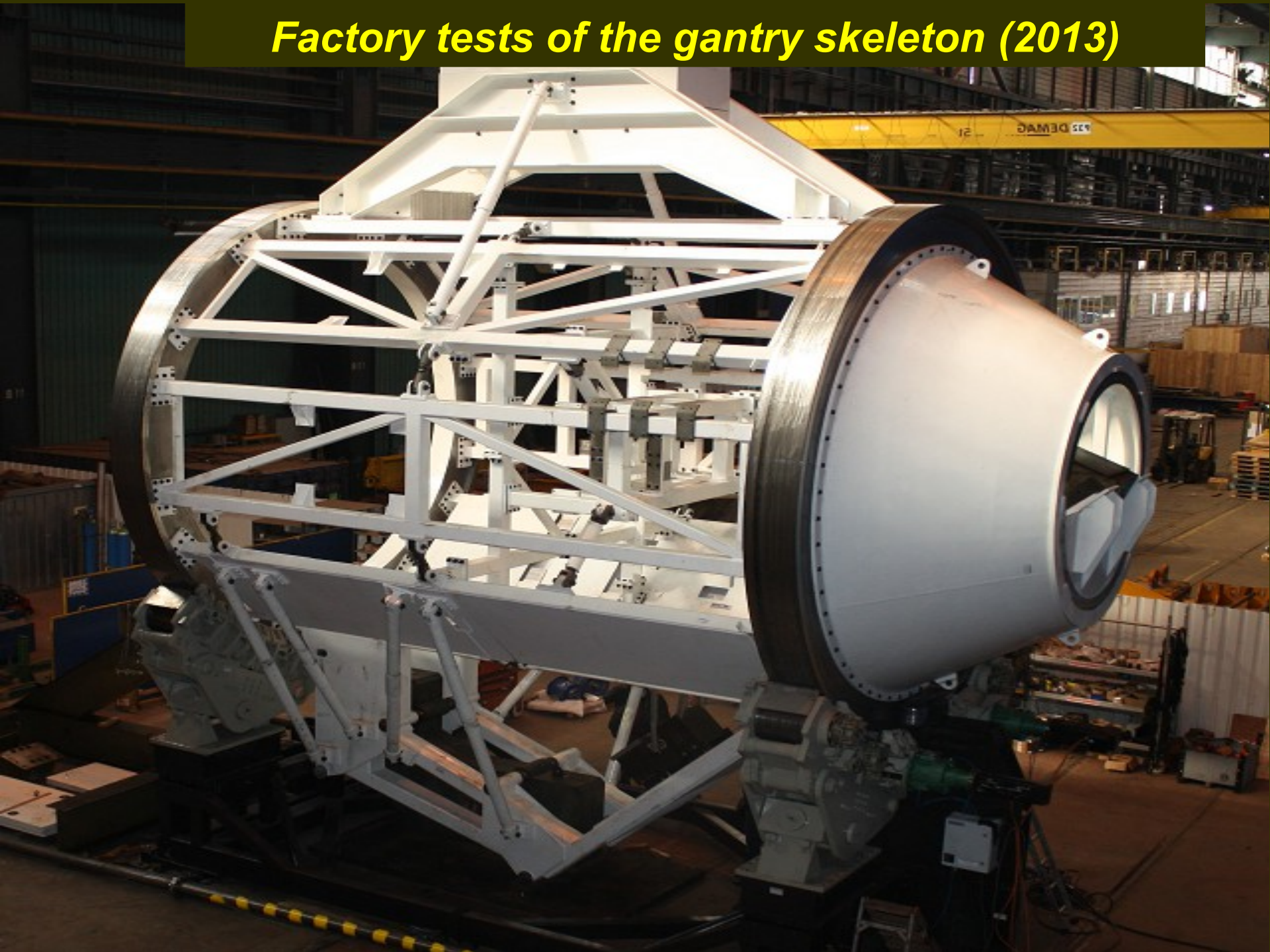
Radius of the bending magnet:
ρ= 1468.5 mm

Total weight (inc. magnets):
W= 120 T



Energy (MeV)	Range (g.cm^{-2})	B1G2		B2G2	
		Current (A)	Field (T)	Current (A)	Field (T)
98.40	4.00	155.39	0.81772	165.39	0.84105
140.10	14.00	226.54	1.17675	239.75	1.20743
191.09	24.00	279.06	1.38966	292.37	1.42410
230.22	33.00	332.45	1.54071	343.86	1.57598

Factory tests of the gantry skeleton (2013)

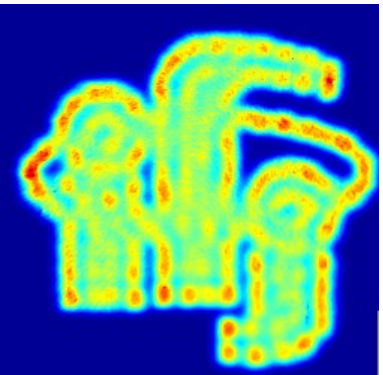


Two gantries with Pencil Scanning Beam (PBS)

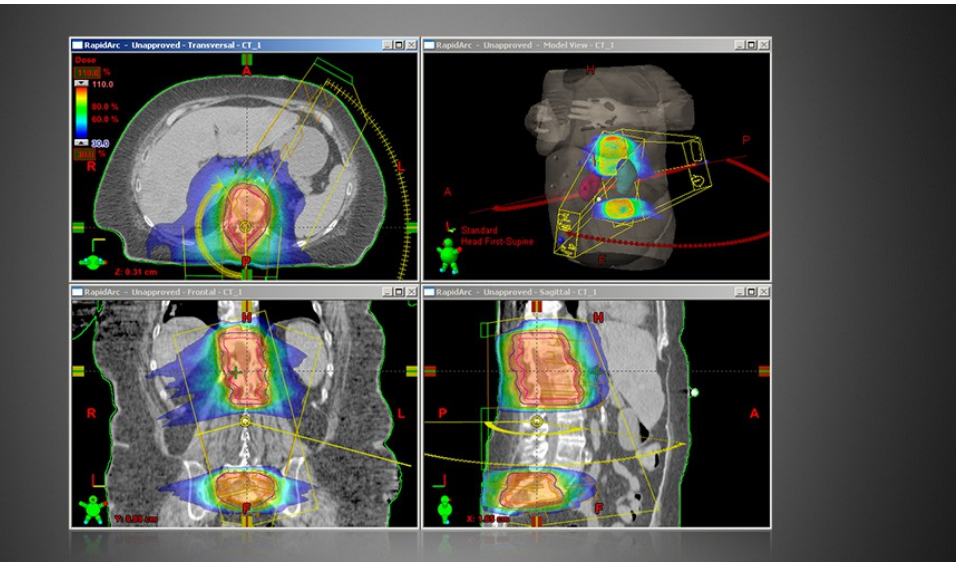
- 2 spot sizes 1 σ = 2.7 mm and 4 mm (at 230 MeV)
- irradiat. 1 liter volume to 2 Gy in less than 60 s
- max. field 30 cm x 40 cm
- robotic treatment table, 6 degrees of freedom
- orthogonal kV X-rays positioning
- Vision RT optical positioning
- gating
- anesthetic arm


Gantry 1


Gantry 2



Treatment Planing System and CT Scanner



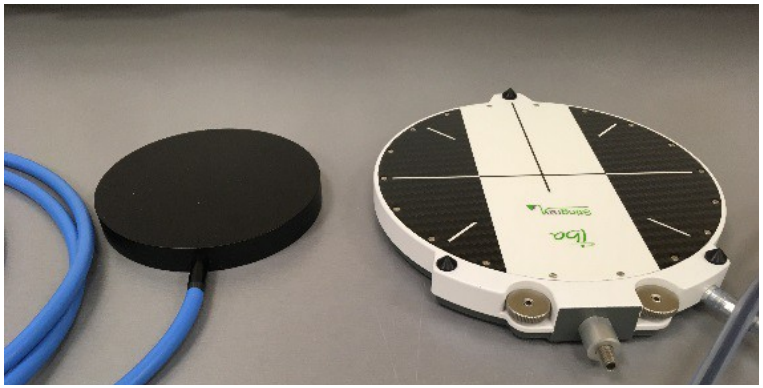
- Eclipse Protons for PBS v. 13.6 (Varian)
- ARIA Oncology Information System (Varian)
- Cytrix remote access for collaborating partners

- Siemens Somatom Definition AS Open
- Wide bore 80 cm
- 64 slices
- Qfix kVue CT overlay
- Metal Artifact Reduction
- Single Source Dual Energy
- Care Dose 4D

Dosimetric Equipment at CCB

Fully equipped with dedicated dosimetry and Quality Assurance tools :

-Ionization chambers
-Bragg Peak Chambers
-Blue Phantom
-MatriXX Ion Chamber Array (2-D dosimetry)
-DigiPhant PT
-Lynx scintillation system (2-D dosimetry)
-Giraffe (Bragg peak measurement)
-Gafchromic reader
-TLD system
-Alanine system



Ph. D. degrees in medical physics at CCB

Gabriela Mierzwińska Opracowanie systemu dozymetrii alaninowej wiązek hadronowych dla celów klinicznych (2015)

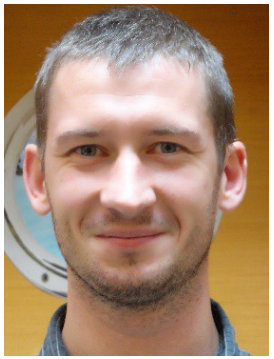
Jan Gajewski Rozwój dwuwymiarowego, termoluminescencyjnego systemu dozymetrycznego dla zapewnienia jakości w jonoterapii nowotworów (2016)

Magdalena Kłodowska Application of Monte Carlo methods in transport modelling of the therapeutic proton beam (2018)

Natalia Mojżeszek Dozymetria i kontrola jakości skanującej wiązki protonowej na stanowisku gantry (2018)

Małgorzta Liszka Dozymetria referencyjna skanującej wiązki protonowej z zastosowaniem komór jonizacyjnych (2019)(in review)

N. Mojżeszek



J. Gajewski

M. Kłodowska

G. Mierzwińska

M. Liszka

M. Rydygier

Operation of CCB

CCB is fully operated and maintained by the IFJ PAN staff

-15 engineers and IT Staff
-17 medical physicists (6 with specialization)
-9 Technicians (RTT)
- 1 Ph.D. student (physics)

Head of CCB : dr Renata Kopeć

Summary

- Cyclotron Centre Bronowice with 230 MeV Proteus C-235 proton cyclotron, offers horizontal experimental beam for research, horizontal eye line and two Pencil Scanning Beams at the dedicated rotating gantries
- The energy selector allows to work with the semi-monoenergetic proton beams in the energy range from 70 MeV to 230 MeV with decreasing current from the maximal 500 nA at 230 MeV to about 2 nA at 70 MeV.
- Experimental hall and dedicated rooms are available for preparation of physical and biological experiments.
- The CCB is used for experimental work since January 2013 and for patient treatment since February 2016.

Thank you for your attention