



# **Nuclear Physics and its medical applications at the Polish National Cyclotron Laboratory (Warsaw/Cracow)**

**Krzysztof Rusek**

# NuPECC Long

# Range Plan 2010



Accelerator Laboratory JYFL,  
University of Jyväskylä, Finland



Electron accelerator ELSA, University  
of Bonn, Germany



European Centre for Theoretical  
Studies in Nuclear Physics and  
Related Areas, ECT\*, Trento, Italy



Forschungszentrum Jülich, FZJ  
(COSY and HPC), Jülich, Germany



Institut de Physique  
Nucléaire, IPNO, Orsay, France



Grand Accélérateur National d'Ions  
Lourds, GANIL (SPIRAL), Caen, France



Helmholtzzentrum für  
Schwerionenforschung  
GmbH, GSI, Darmstadt,  
Germany



European Organisation for  
Nuclear Research, CERN  
(ALICE, AD, COMPASS  
and ISOLDE),  
Genève, Switzerland



Kernfysisch Versneller  
Instituut, KVI, Groningen,  
The Netherlands



Laboratori Nazionali  
del Sud of INFN, LNS,  
Catania, Italy



Laboratori Nazionali  
di Frascati of INFN, LNF,  
Frascati, Italy



Laboratori Nazionali  
di Legnaro of INFN,  
LNL, Legnaro (Padova), Italy



Mainzer Mikrotron, MAMI,  
University of Mainz,  
Germany

Max-lab, University of  
Lund, Sweden

- NuPECC member countries
- FP7 facilities
- Smaller-scale facilities



JINR Dubna

IPN Kiev

IPN Almaty

# National Cyclotron Laboratory





## Heavy Ion Laboratory, University of Warsaw :

- National nuclear physics laboratory open for external users
- Involved in teaching
- developing medical applications



# Scientific Campus Ochota



# Staff



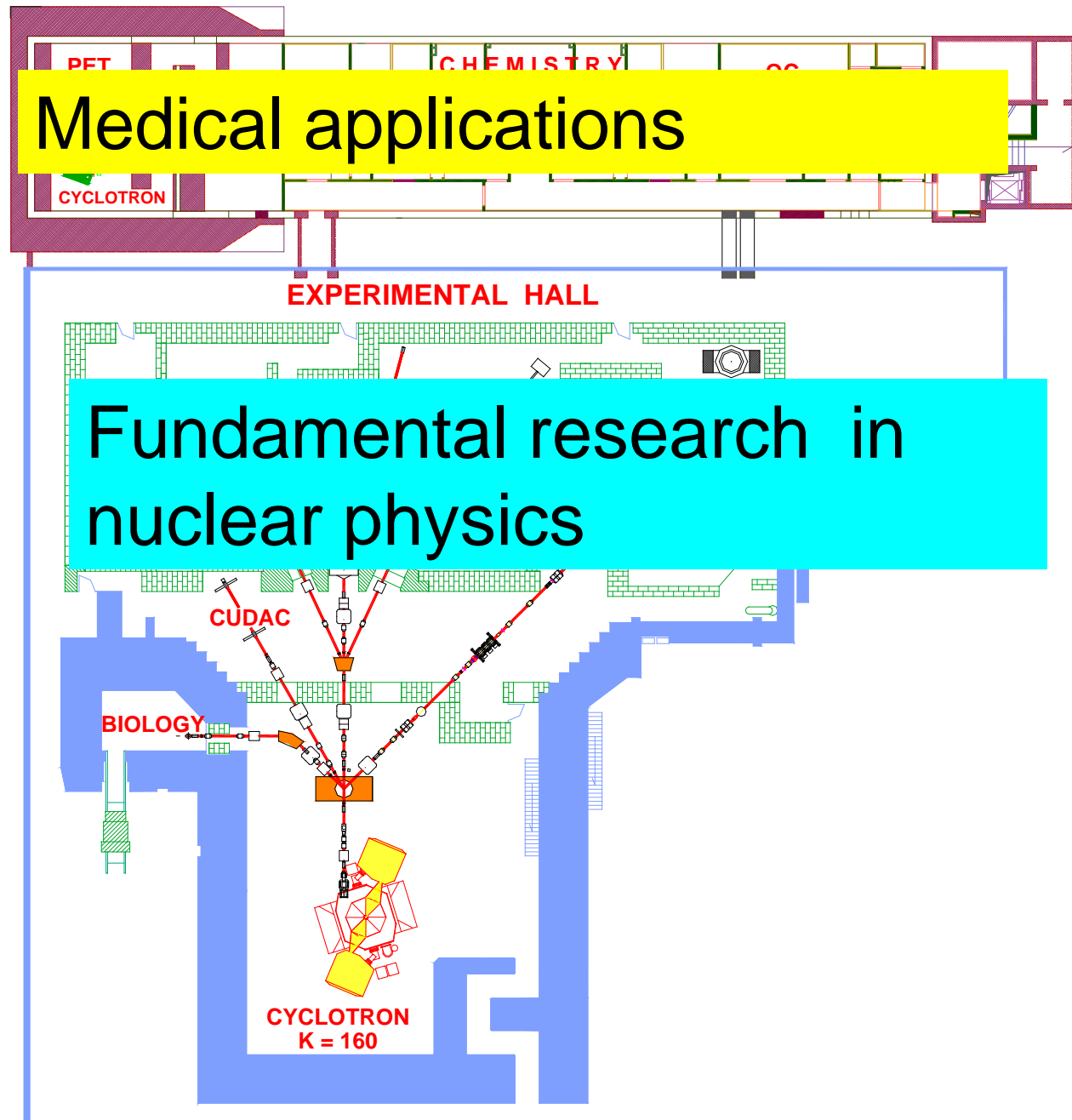
**Scientists – 13**

**PhD students – 7**

**Technicians – 35**

**Administration - 8**

# Medical applications



# Heavy Ion Laboratory, experimental hall





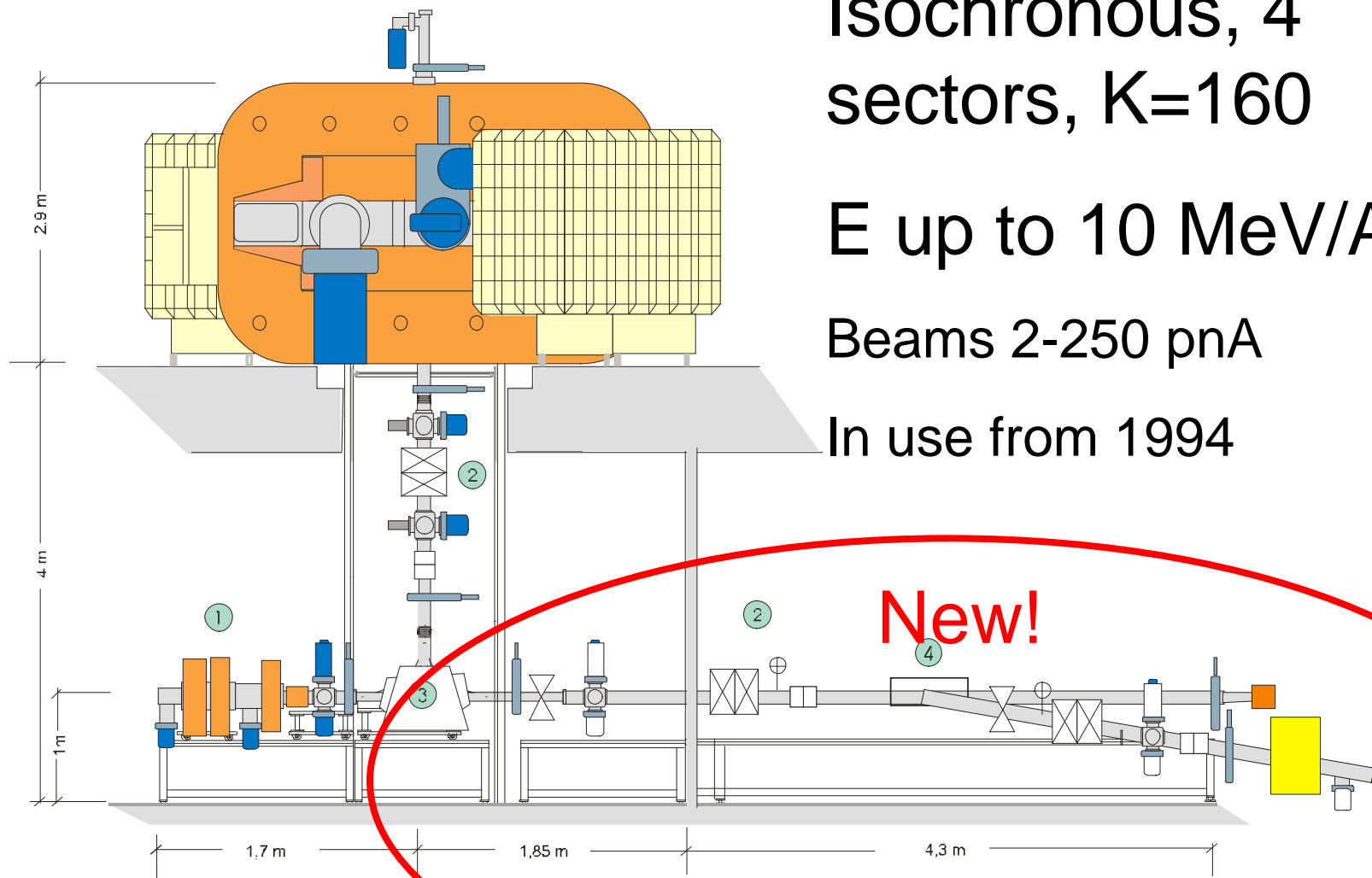
# Cyclotron U-200 and ion sources

Isochronous, 4  
sectors,  $K=160$

E up to 10 MeV/A

Beams 2-250 pA

In use from 1994



ECR, Home made, ions He-Ar

ECR,,Nano gun Pantechnik, ions up to Xe



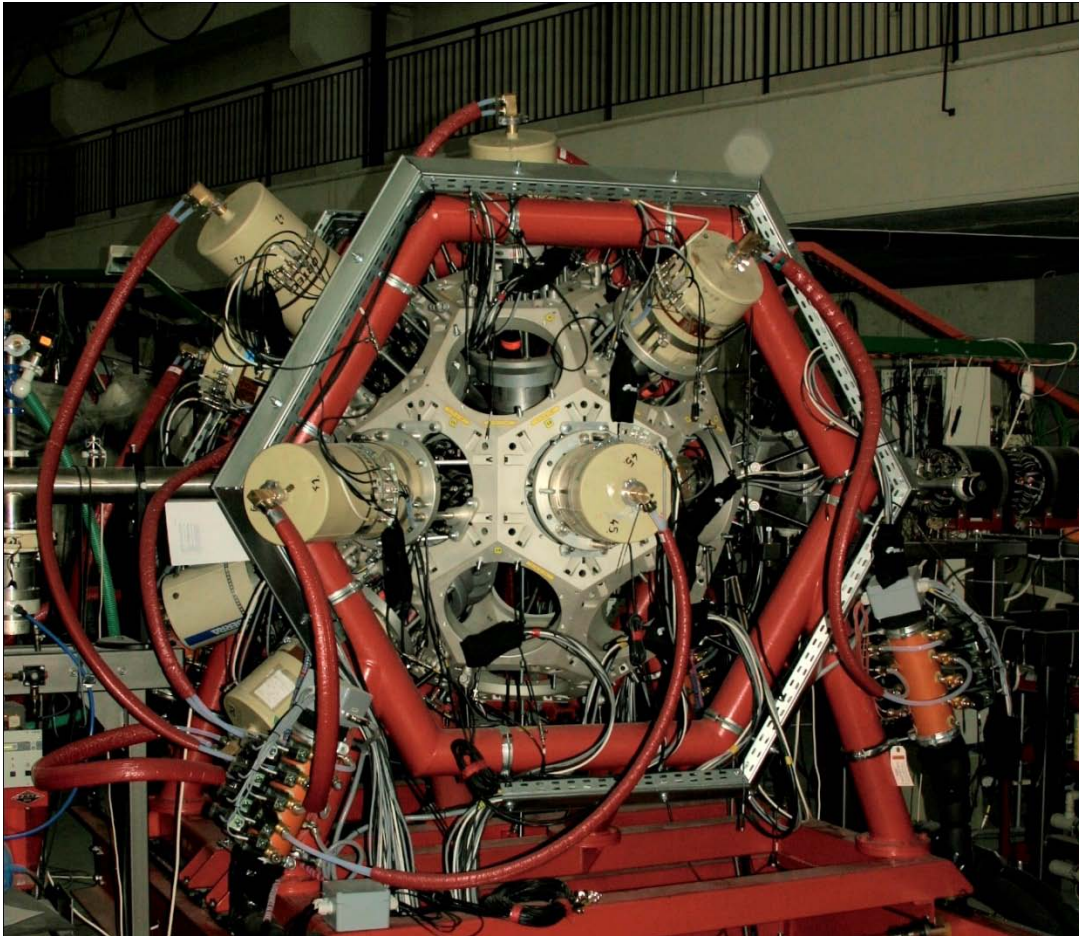
# HF generators

Problems with the spare parts for the existing (thanks to our friendly collaboration with JINR Dubna HF is still working)

New HF generators will be installed till the end of 2013 (grant of Ministry of Science and Higher Education of Poland )



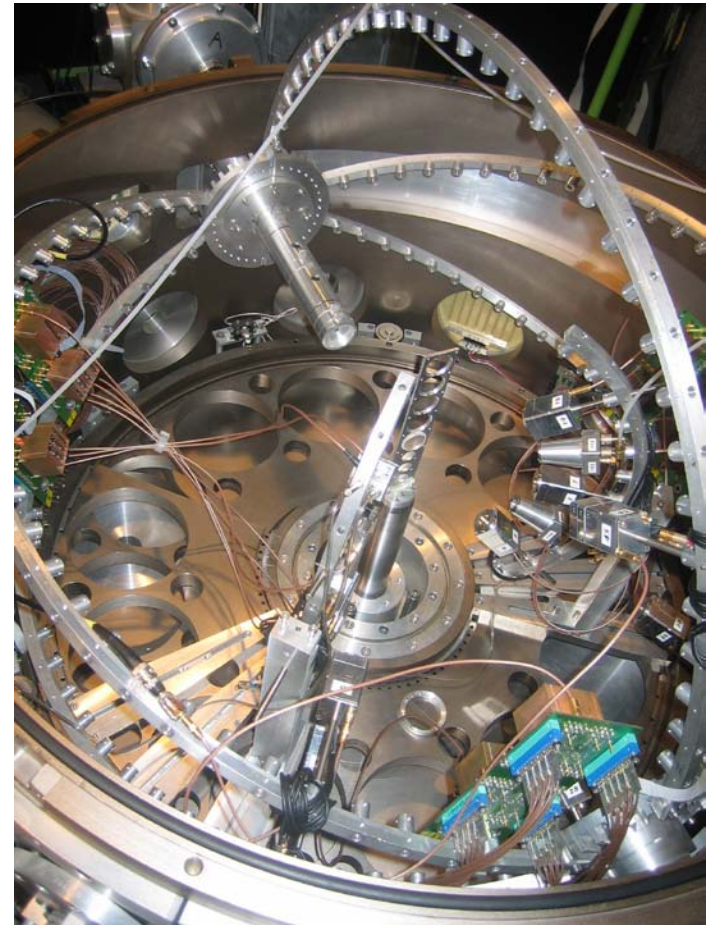
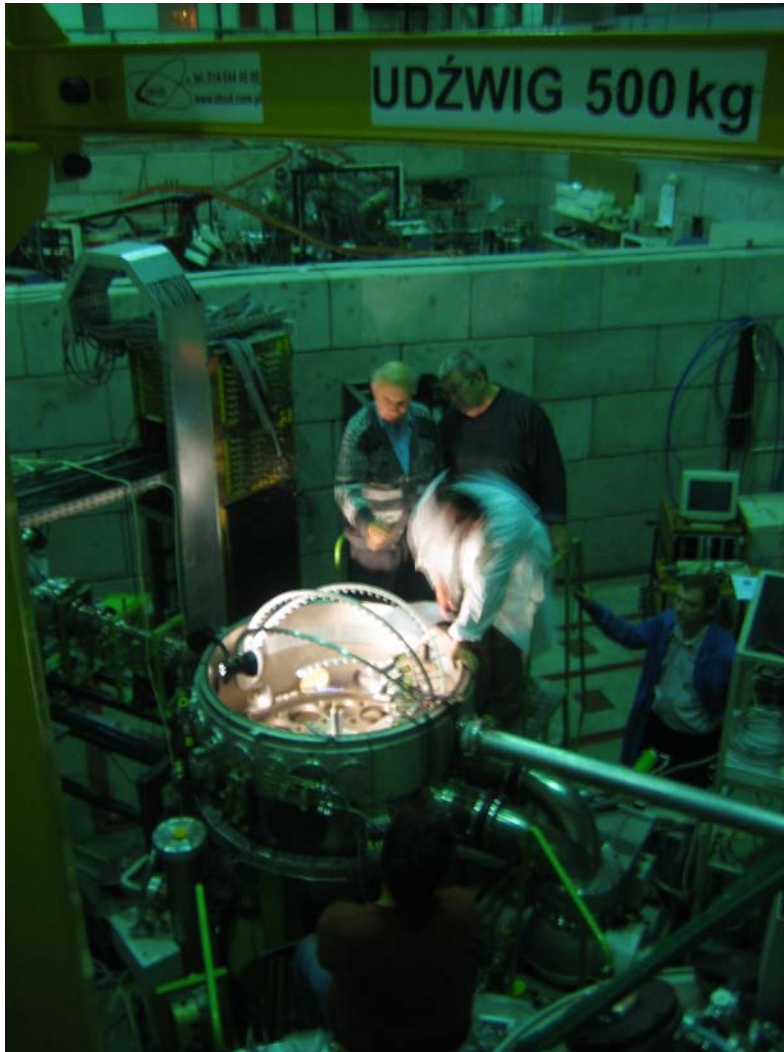
# EAGLE $\gamma$ - spectrometer



- up to 30 HP Ge detectors coupled to:
  - ◆ Internal conversion electron spectrometer
  - ◆ Scattering chamber with charged particles detectors

Recently equipped with 20 GAMMAPOOL detectors from IPN Orsay

# ICARE large scattering chamber



From IReS Strasbourg, 2007 first experiments

# IGISOL set-up

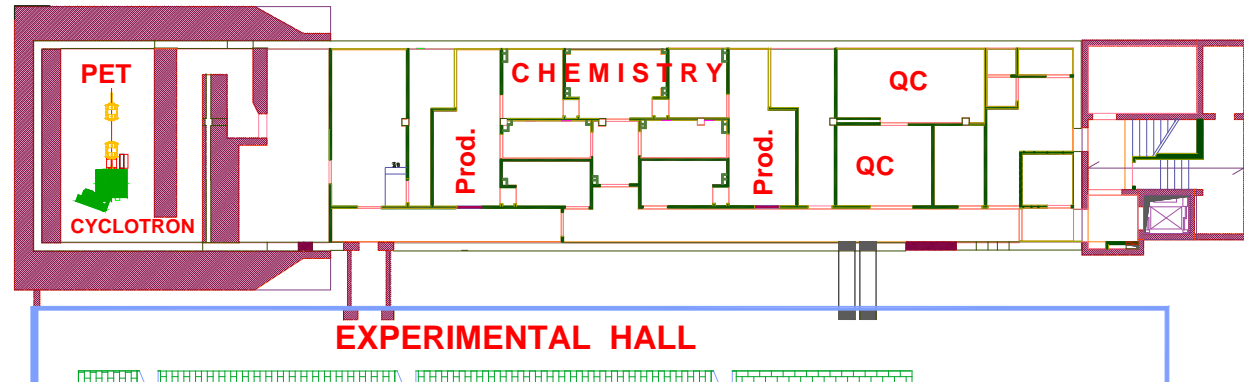
- Ion source
- Helium jet
- Mass separator
- Detection system



# Radiopharmaceutical reserach and production centre

p / d cyklotron  
16/8 MeV  
(General Electric)

> 75  $\mu\text{A}$  p  
> 60  $\mu\text{A}$  d



# Opening ceremony, 15.05.2012







## Radiobiology for treating cancer

### 1. Radiobiology

- Is the RBE for scanning beam equal to RBE for scattered beam?
- Is for scanning beam the bystander effect observed?
- Is the higher RBE at the end of Spread Out Bragg peak clinically relevant?
- Probability of secondary cancer

### 2. Nuclear physics

#### Collaboration

- Centre of Oncology Kraków
- Jagiellonian University
- IFJ PAN and others

**Scientific programme**



## 1. Radiobiology

## 2. Nuclear physics

### Experimental Physics Case

- Dynamics of few-nucleon systems
- Particle and gamma decays of high-lying resonance states by inelastic scattering of 200 MeV protons
- Giant Dipole Resonances in hot nuclei
- Search for the Giant Pairing Vibrations
- Isomers populated in proton induced fission of  $^{238}\text{U}$

### Collaboration

- Jagiellonian University, Kraków
- Warsaw University, Warszawa
- Silesian University, Katowice
- INFN and University of Milano (Italy)
- IPN Orsay (France)
- KVI Groningen (Netherlands)

**Scientific programme**

# *Proton radiotherapy of eye melanoma*

*First patient: February 2011*

**Cyclotron:** AIC-144 at IFJ PAN

**Beam:** 60 MeV protons

**Patients:** 15 patients till March 2012

Waiting for financing from the National Health Found

The regular patient treatment expected from January 2013



The first patient treated at IFJ PAN facility

# ***Cyclotron Centre Bronowice***

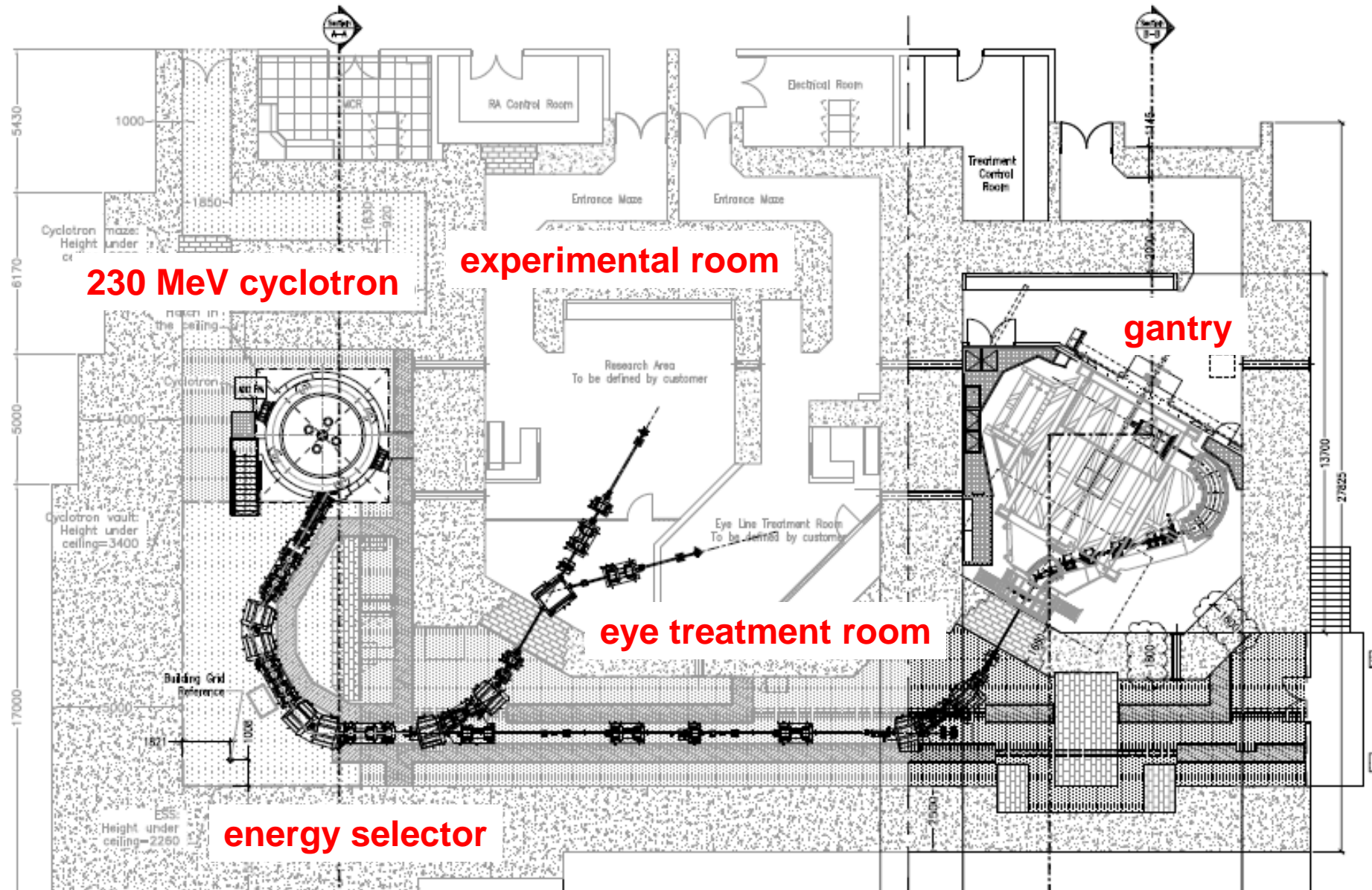




# Location



# What is foreseen in NCRH – CCB?



# Proteus C-235 cyclotron with energy selector

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



cyclotron:	isochronic, 4-sectors, CW
particles	protons
ion source:	P.I.G with hot cathode
proton energy:	230 MeV ( $\beta = 0.596$ , $\gamma = 1.245$ ), constant
energy dispersion:	$\Delta E/E < 0.7\%$
beam intensity:	<b>600 nA (<math>4 \times 10^{12}</math> p/s) – 0.1 nA (<math>6 \times 10^8</math> p/s)</b>
emittance	horizontal - $11 \pi$ mm mrad,

cyclotron

energy selector:

70-230 MeV

$\Delta E/E < 1 \%$



# *Timetable of NCRH – CCB*



- |                                       |            |
|---------------------------------------|------------|
| - signing the contract                | 2.08.2010  |
| - building permission                 | 10.02.2011 |
| - start of the construction           | 17.03.2011 |
| - installation of the C-235 cyclotron | 05.2012    |
| - acceptance tests                    | 11.2012    |
| - medical building                    | 06.2013    |
| - installation of gantry              | 07.2013    |
| - end of the contract                 | 06.2014    |



11 May 2012





# Programme

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- Nuclear physics
- Proton therapy (~ 400 persons/year)

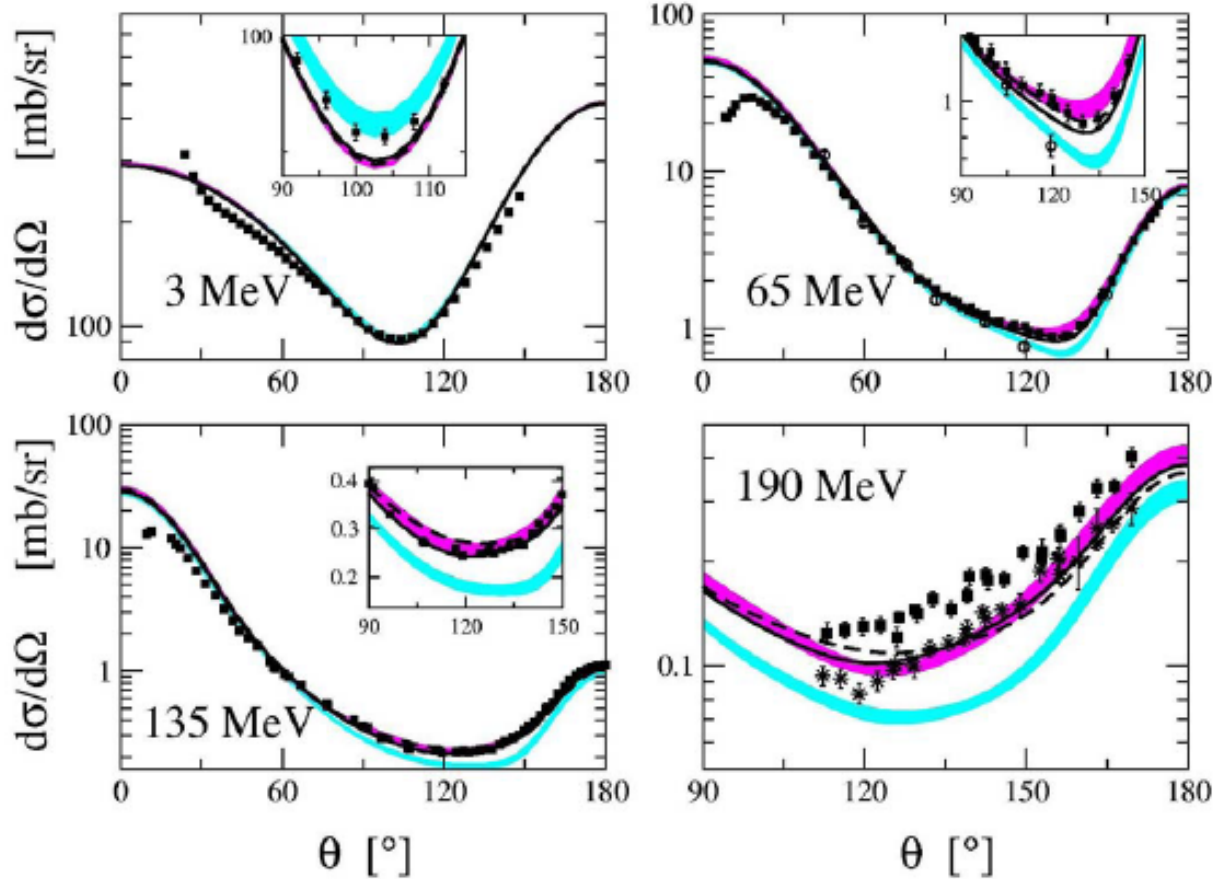


# Effects of 3-body forces in nuclear reactions

S.Kistryn et al.

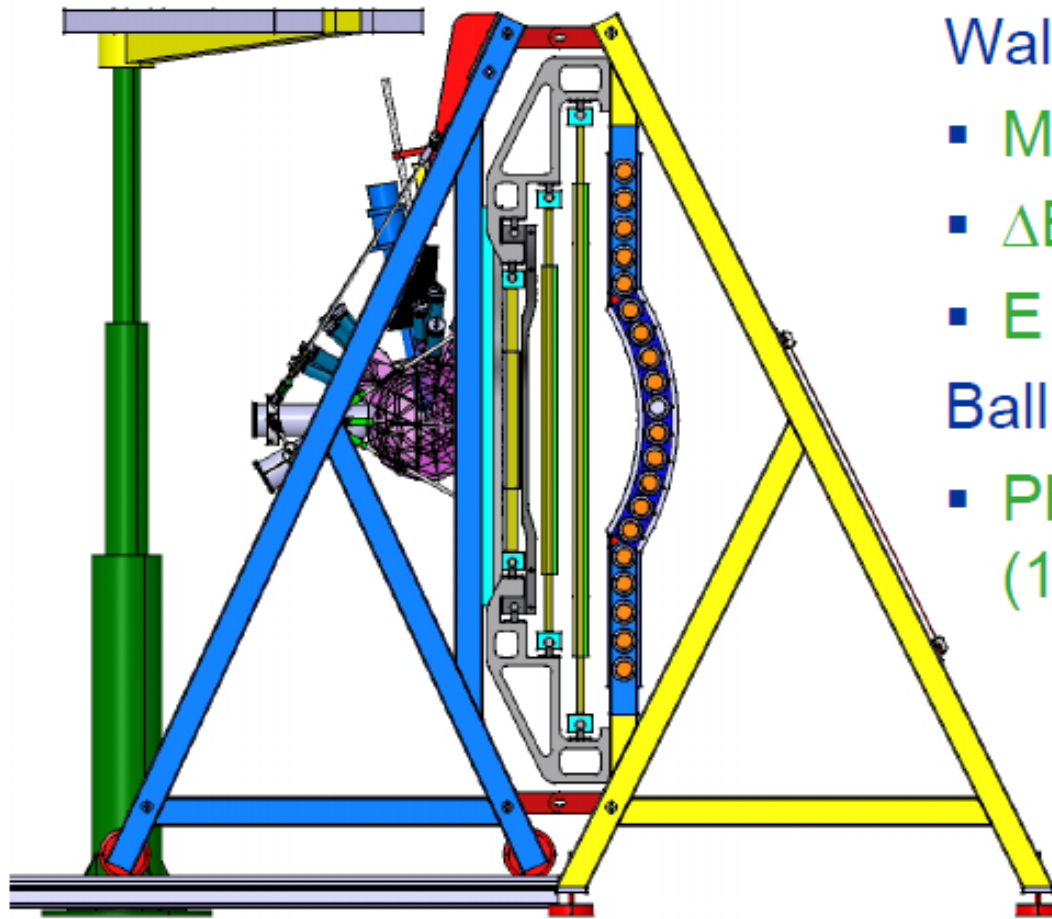
p,n + d elastic scattering

— 2N  
— 2N + TM99  
— AV18 + UIX



# Detektor BINA

## Big Instrument for Nuclear reaction Analysis



Wall:

- MWPC (3 planes)
- $\Delta E$  (24 x 2 mm)
- E (20 x 120 mm)

Ball:

- Phoswich  
(149 x 90/30 mm)

# Summary

National Cyclotron Laboratory is a two – centre, nuclear physics institution operating 4 cyclotrons and involved in medical applications – production of radiopharmaceuticals and hadron therapy.

A possible place for ECOS test ground.

More on: [www.slcj.uw.edu.pl](http://www.slcj.uw.edu.pl)

[www.ifj.edu.pl](http://www.ifj.edu.pl)

# Collaboration between stable beam facilities

We should better know each other :

- Visits to the small scale facilities
- Int. workshops in these laboratories
- .....