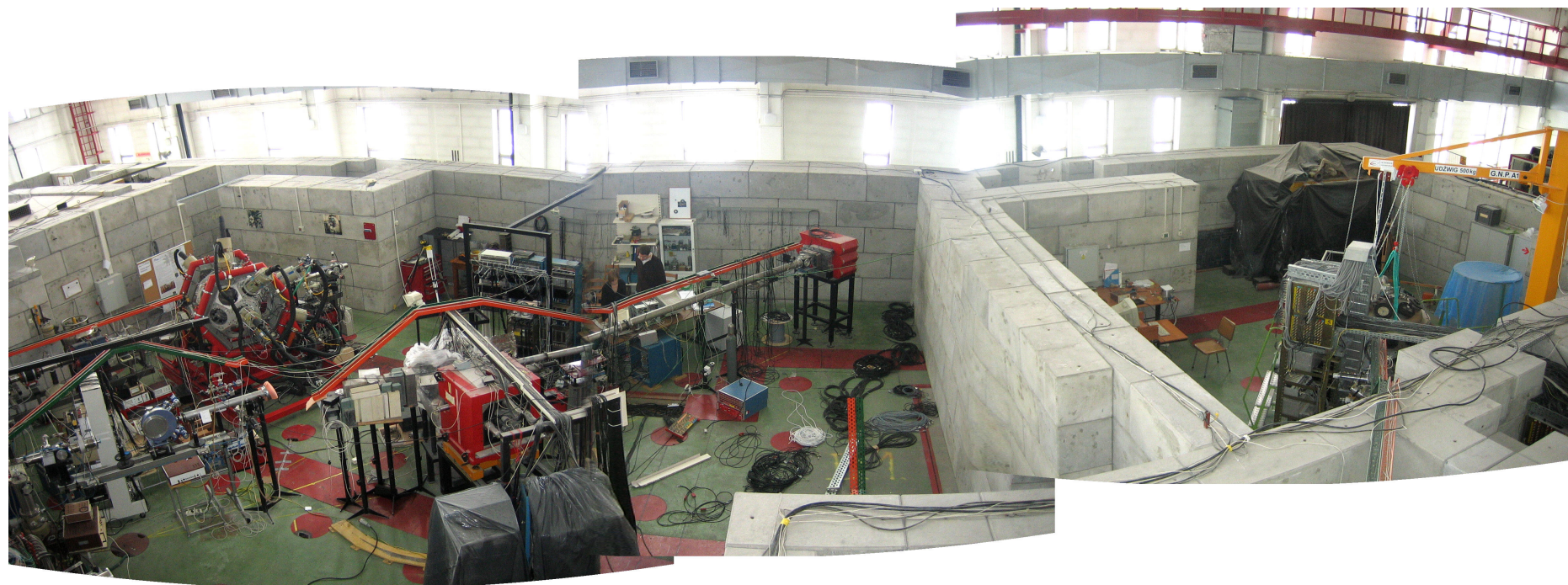


# Heavy Ion Laboratory, University of Warsaw

an overview

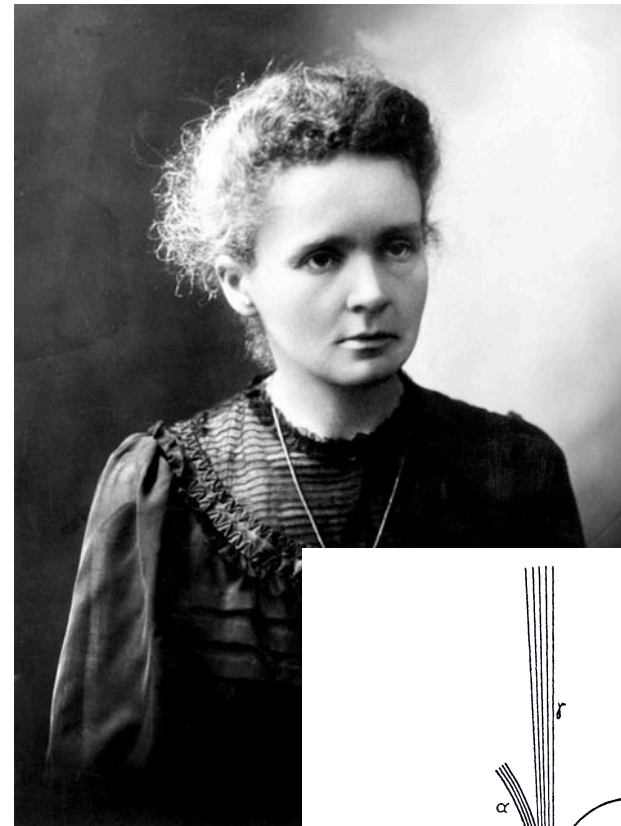
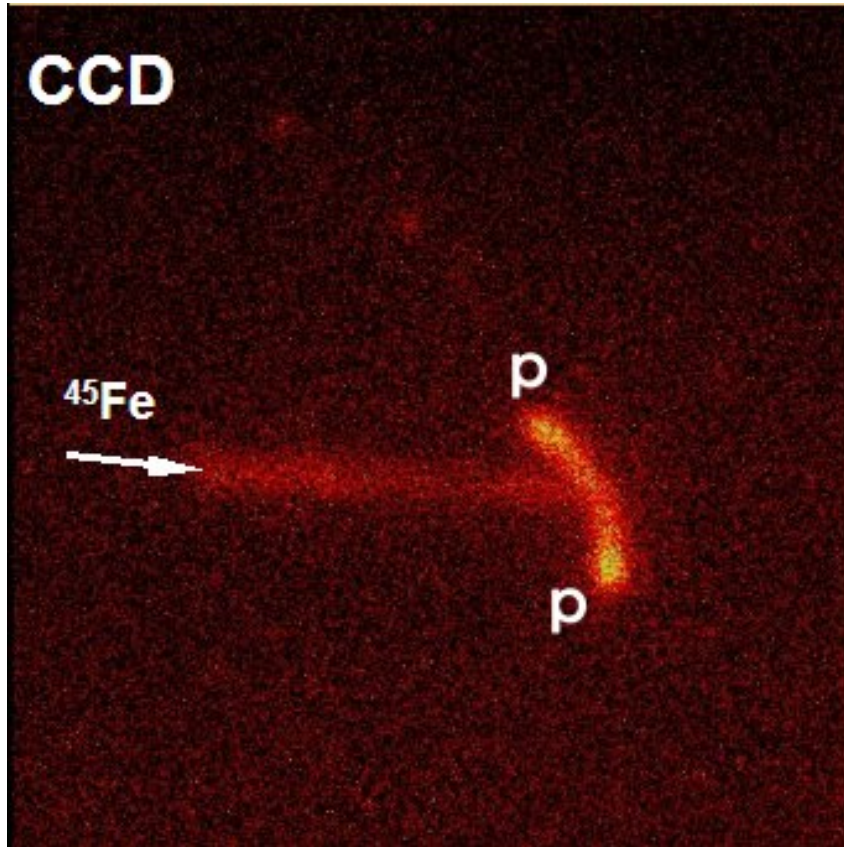
Krzysztof Rusek



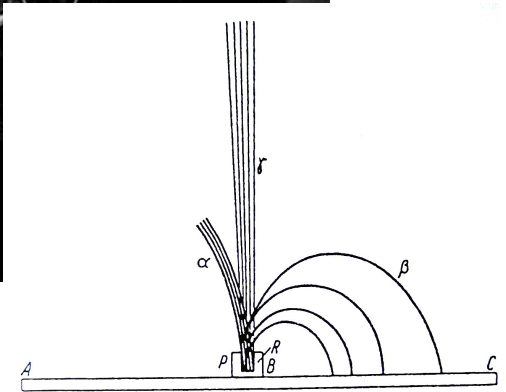
## Heavy Ion Laboratory, University of Warsaw :

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

# Radioactivity



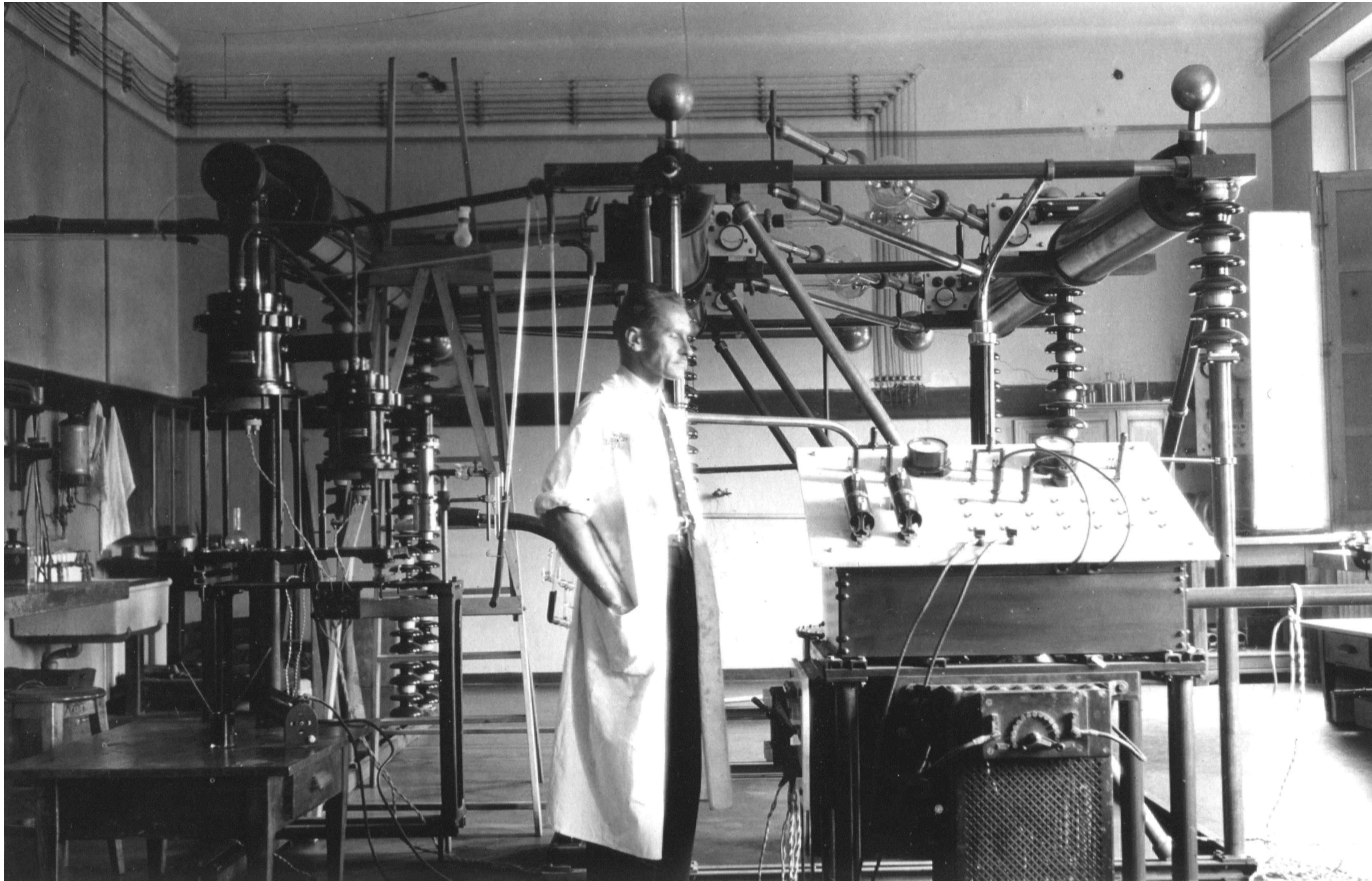
M. Pfützner et al.



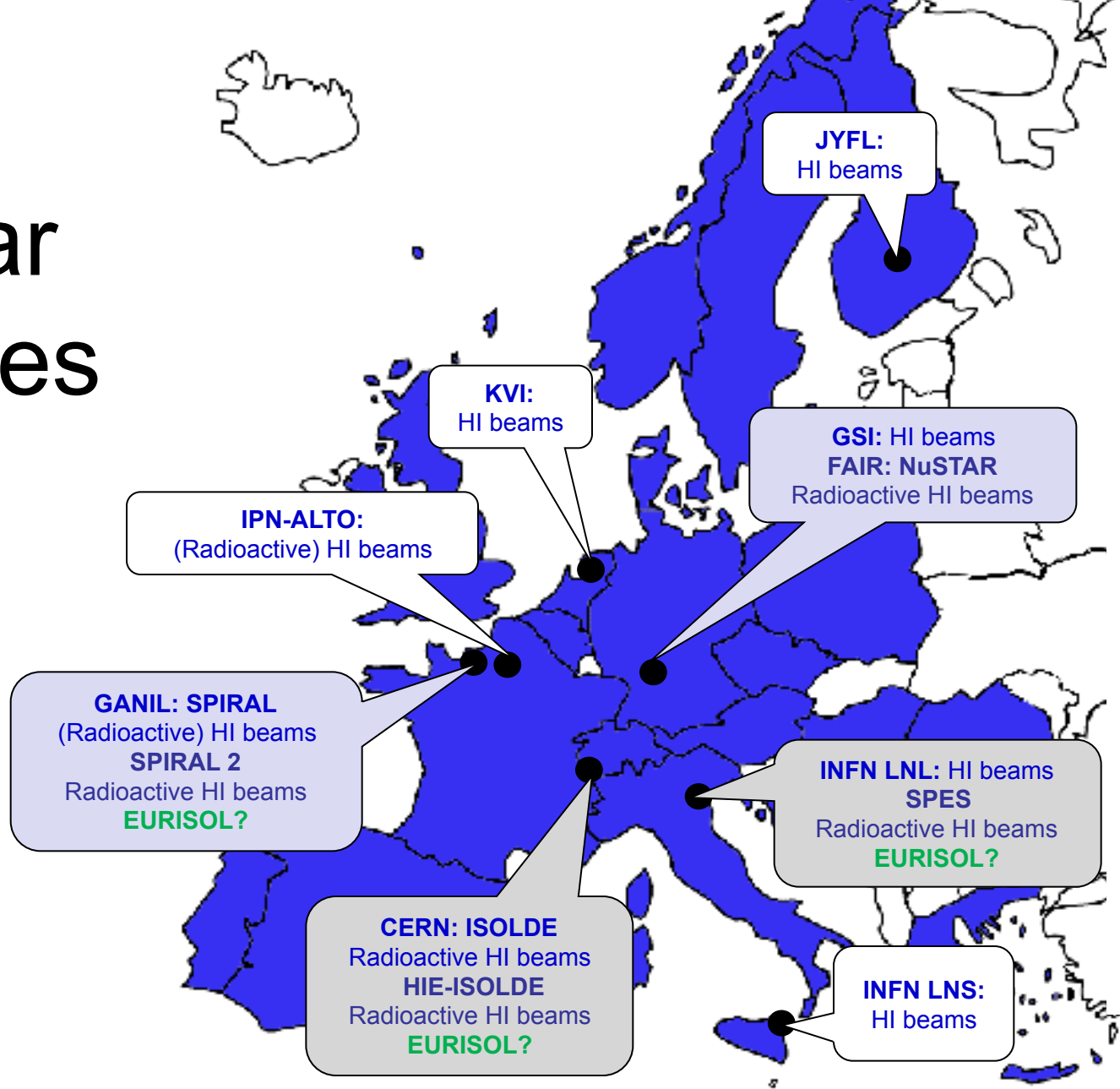
# First Nuclear Physics Lab in Poland

Hoża 69, prof. A. Sołtan (1937)

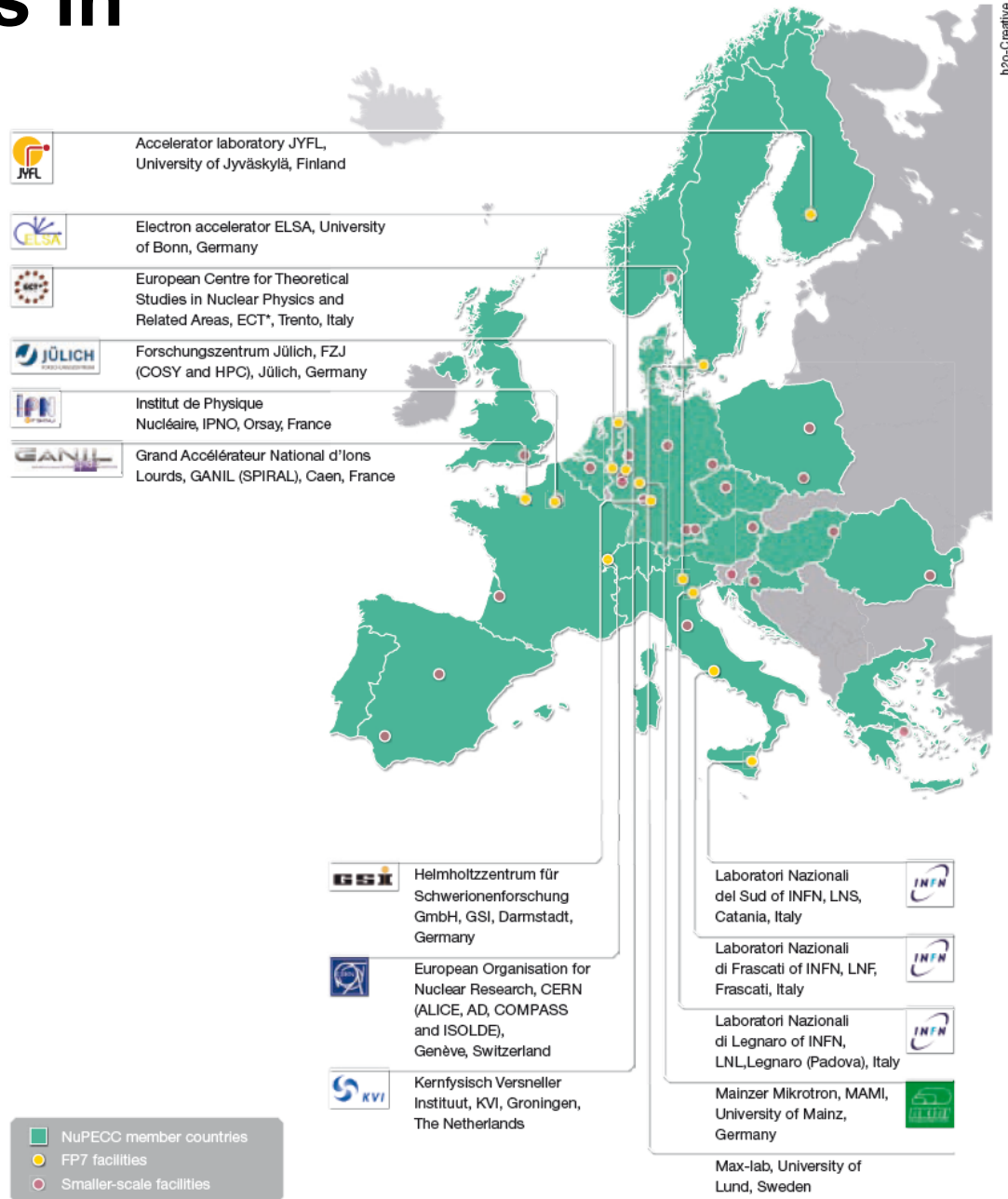
deuterons 0.4 MeV, I up to 200  $\mu$ A



# Large Nuclear Facilities



# Nuclear facilities in Europe:



## NuPECC Long Range Plan

# Nuclear Facilities in Poland



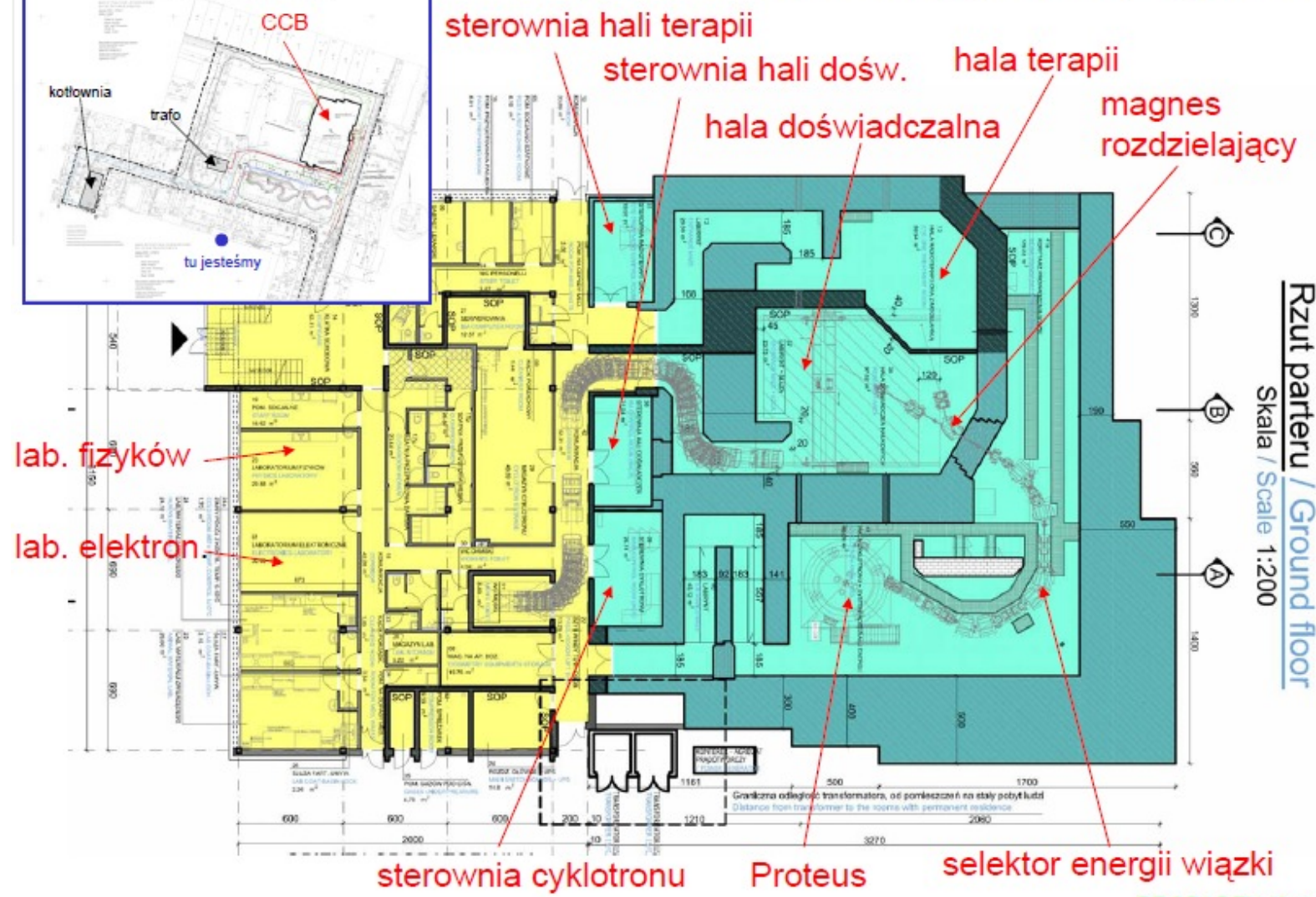
# Cyclotron Centre Bronowice, Cracow



W. Męczyński, IFJ PAN, Kraków, 28 kwietnia 2011 r.



# Budynek CCB: przekrój poziomy - parter



Rzut parteru / Ground floor  
Skala / Scale 1:200

# ELBRUS at Szczecin Univ.





# Science Campus Ochota

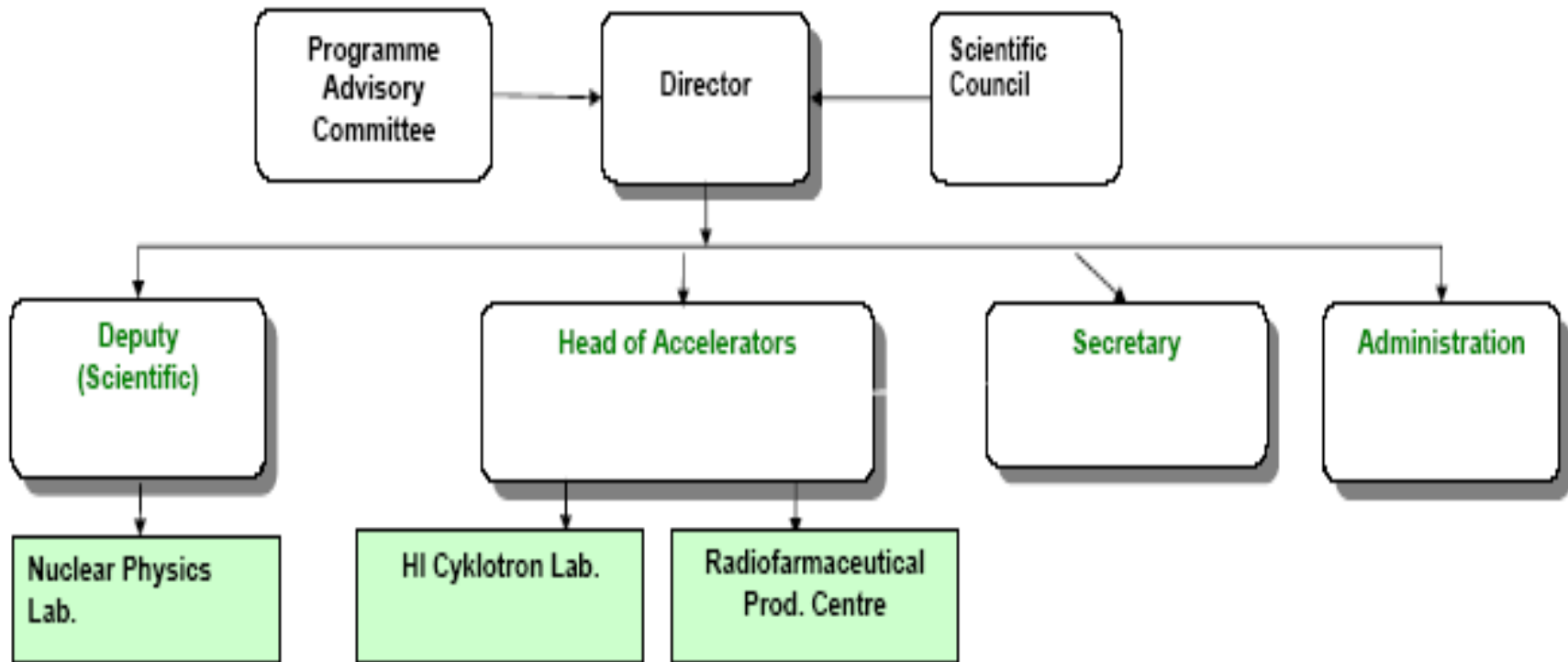


# First oncological hospital in Poland

29.05.1932



# Heavy Ion Laboratory UW - a national lab.



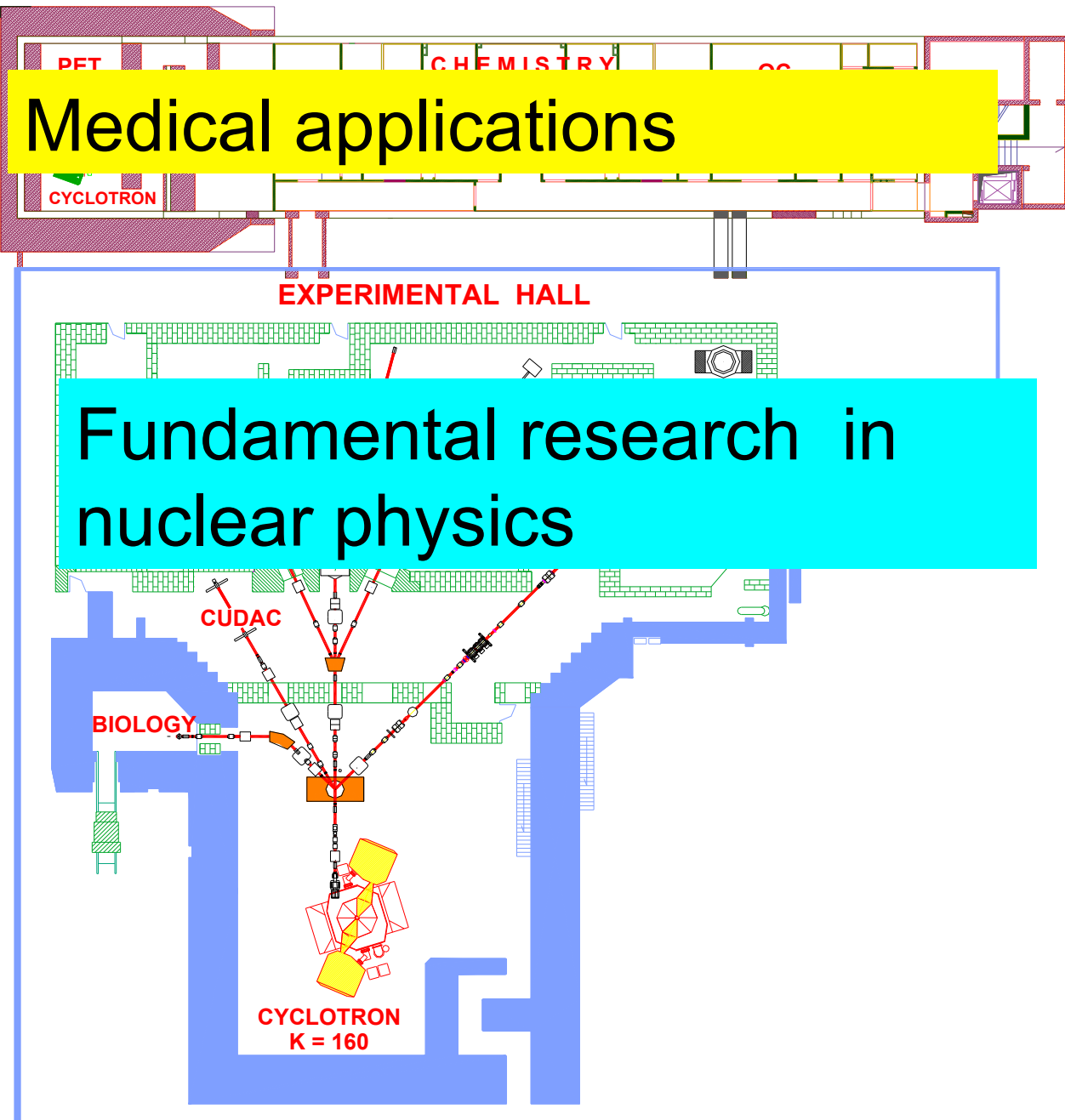
# Staff

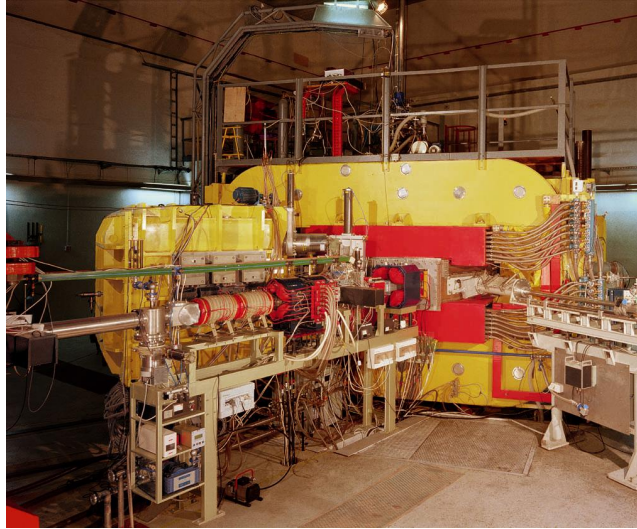


**Scientists – 13**  
**PhD students – 7**  
**Technicians – 35**  
**Administration - 8**

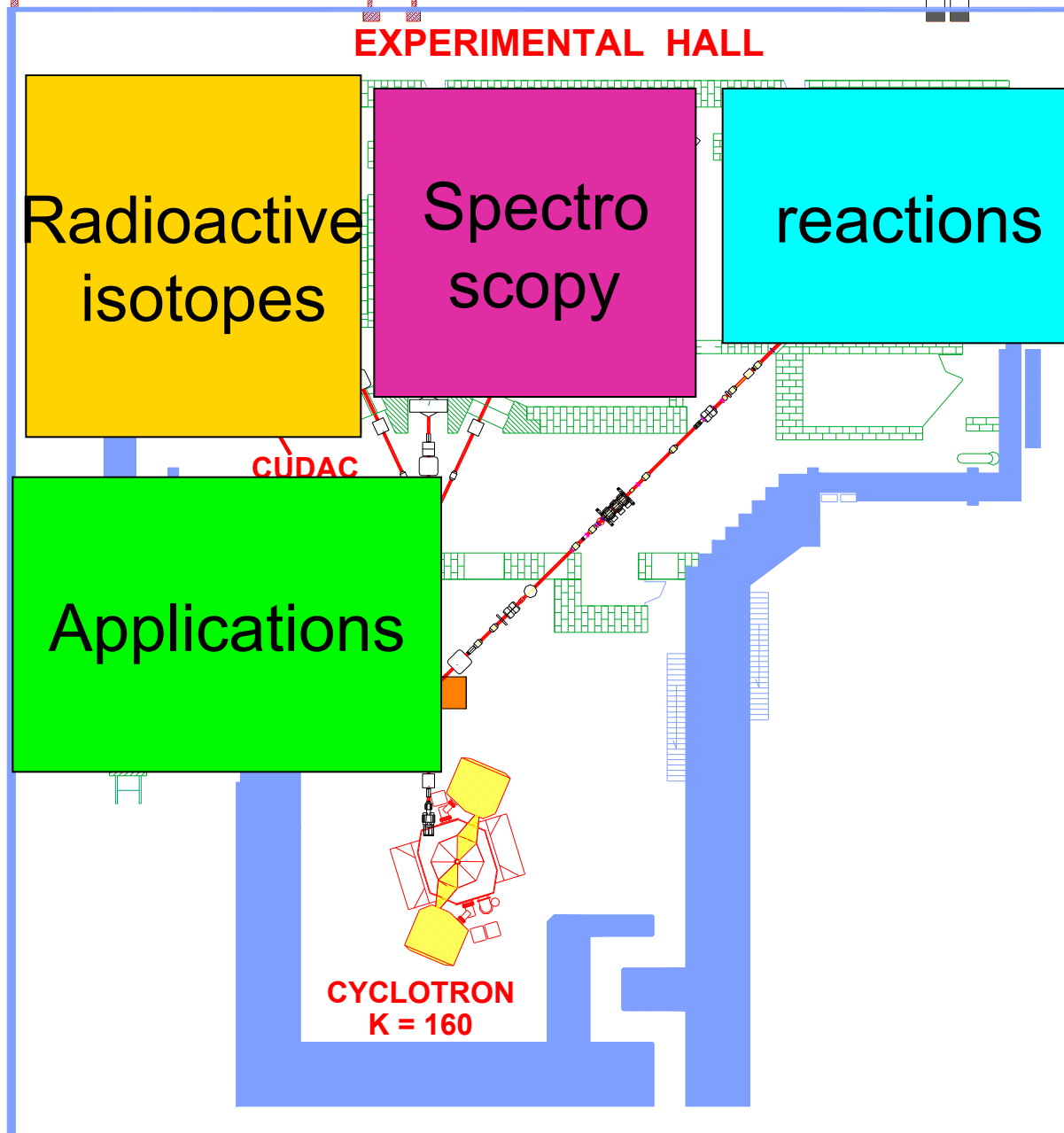
# Medical applications

## Fundamental research in nuclear physics



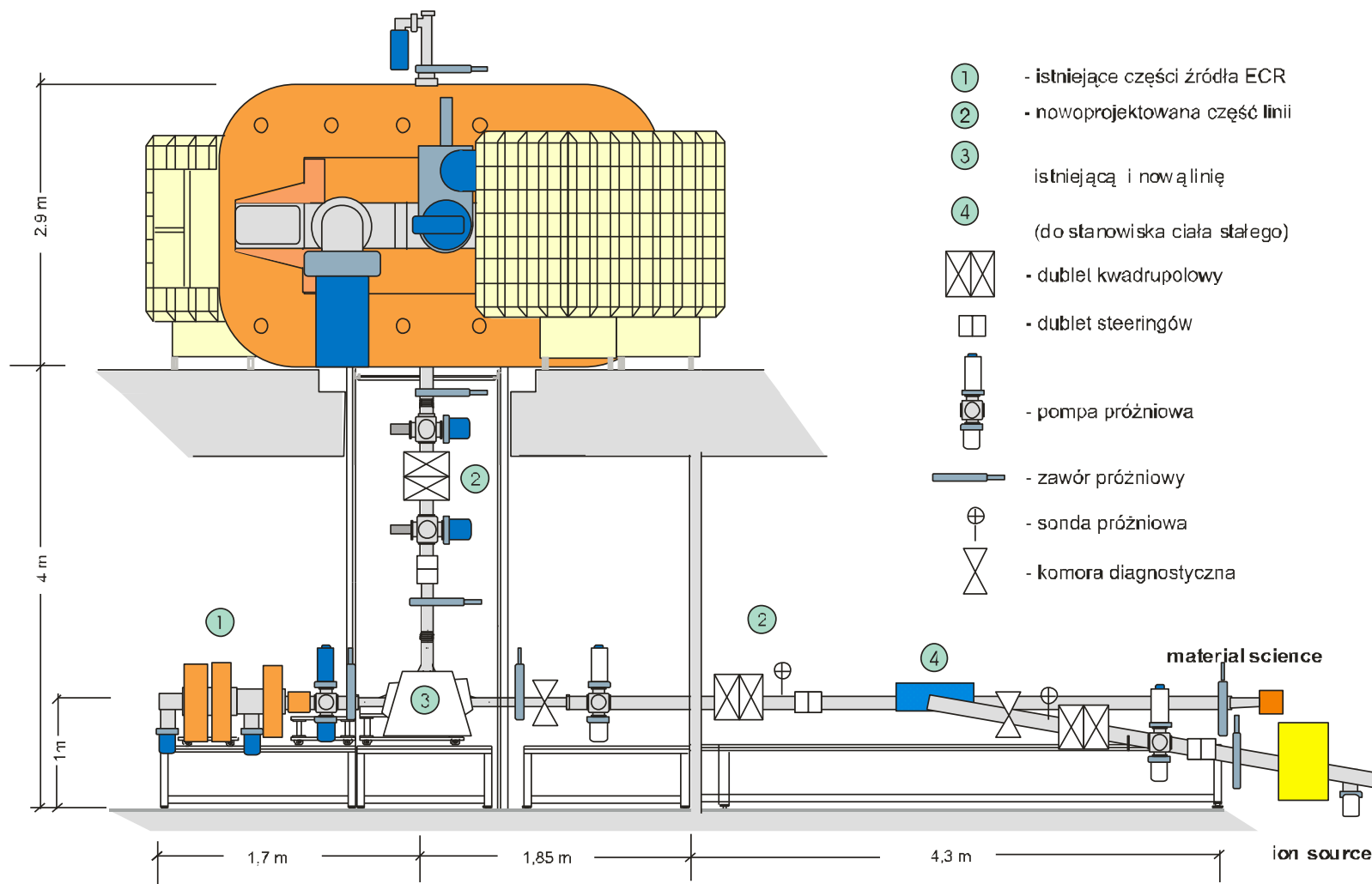


Energies 2 ÷ 10 MeV/A

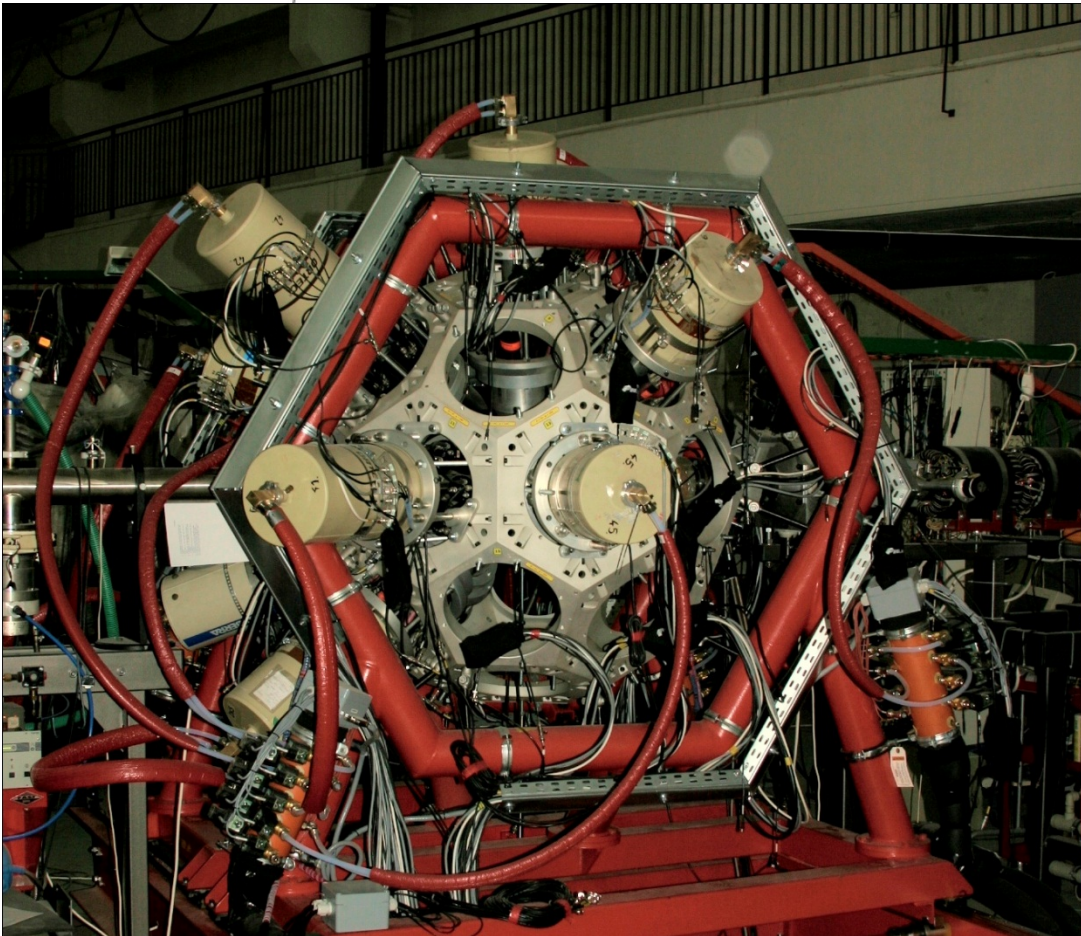




# Cyclotron U-200 and ion sources



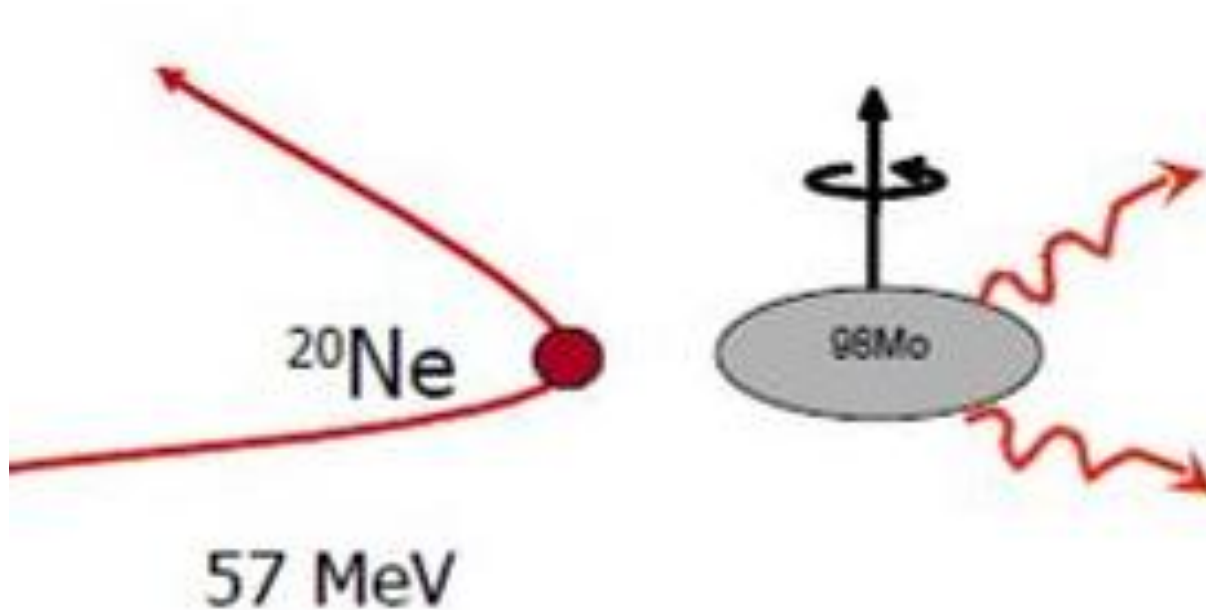
# EAGLE $\gamma$ - spectrometer



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

# Electromagnetic properties of nuclei

(dr P. Napiorkowski, dr J. Srebrny...)



# GOSIA Code

- Standard tool for Coulomb excitation data analysis
- Used worldwide, maintained and developed at HIL
- GOSIA Workshop – organised at HIL in April 2008

## ISOLDE (MINIBALL), CERN:

J. Cederkäll, A. Ekström –  $^{108,110}\text{Sn}$ ,  $^{108}\text{In}$

J. Iwanicki -  $^{88}\text{Kr}$ ,  $^{92}\text{Kr}$

A. Hurst -  $^{70}\text{Se}$

I. Stefanescu –  $^{68}\text{Cu}$ ,  $^{70}\text{Cu}$

J. Van de Walle –  $^{74}\text{Zn}$

E. Clément –  $^{96}\text{Sr}$

A. Petts, N. Bree -  $^{182,184,186,188}\text{Hg}$

## GANIL (EXOGRAM), FRANCE:

E. Bouchez –  $^{76}\text{Kr}$

E. Clément –  $^{74,76}\text{Kr}$

M. Zielińska –  $^{44}\text{Ar}$

## JAEA, TOKAI, JAPAN:

M. Koizumi -  $^{66}\text{Zn}$ ,  $^{68}\text{Zn}$

T. Hayakawa –  $^{78}\text{Se}$

A. Osa -  $^{84}\text{Kr}$

Y. Toh –  $^{70}\text{Ge}$

M. Zielińska –  $^{96,98}\text{Mo}$

## JYVASKYLA, FINLAND

F. Becker –  $^{78}\text{Kr}$

M. Hackstein –  $^{128}\text{Xe}$

## ANL (GAMMASPHERE), USA

A. Hayes –  $^{178}\text{Hf}$

## HIL, Warsaw, Poland

J. Iwanicki –  $^{165}\text{Ho}$

M. Zielińska –  $^{96,98}\text{Mo}$

K. Wrzosek-Lipska -  $^{100}\text{Mo}$

## **Upcoming experiments – GOSIA used for simulations**

### ISOLDE (MINIBALL), CERN:

B. Bastin –  $^{198,202}\text{Po}$

M. Scheck –  $^{220,222}\text{Rn}$ ,  $^{222,224}\text{Ra}$

### HIL WARSAW, POLAND

M. Scheck –  $^{94}\text{Zr}$  (Mar 2010)

M. Zielińska –  $^{104}\text{Pd}$  (May 2010)

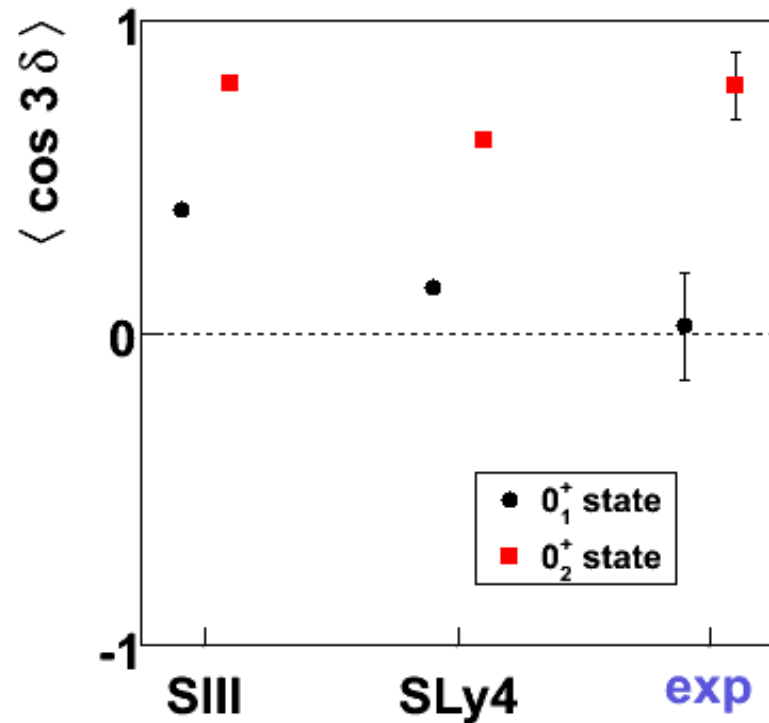
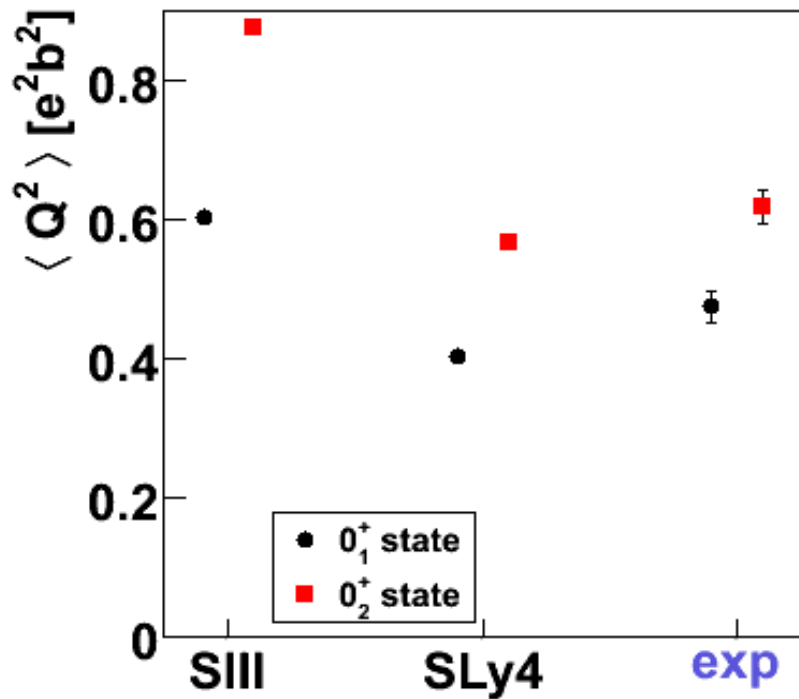
# Deformation of $^{100}\text{Mo}$ g.s. and $0^+$ exc. state

Theory:

L. Próchniak

Int. J. Mod. Phys. E19 (2010) 705,

L. Próchniak, S. G. Rohoziński, J. Phys. G: Nucl. Part. 36 (2009) 123101

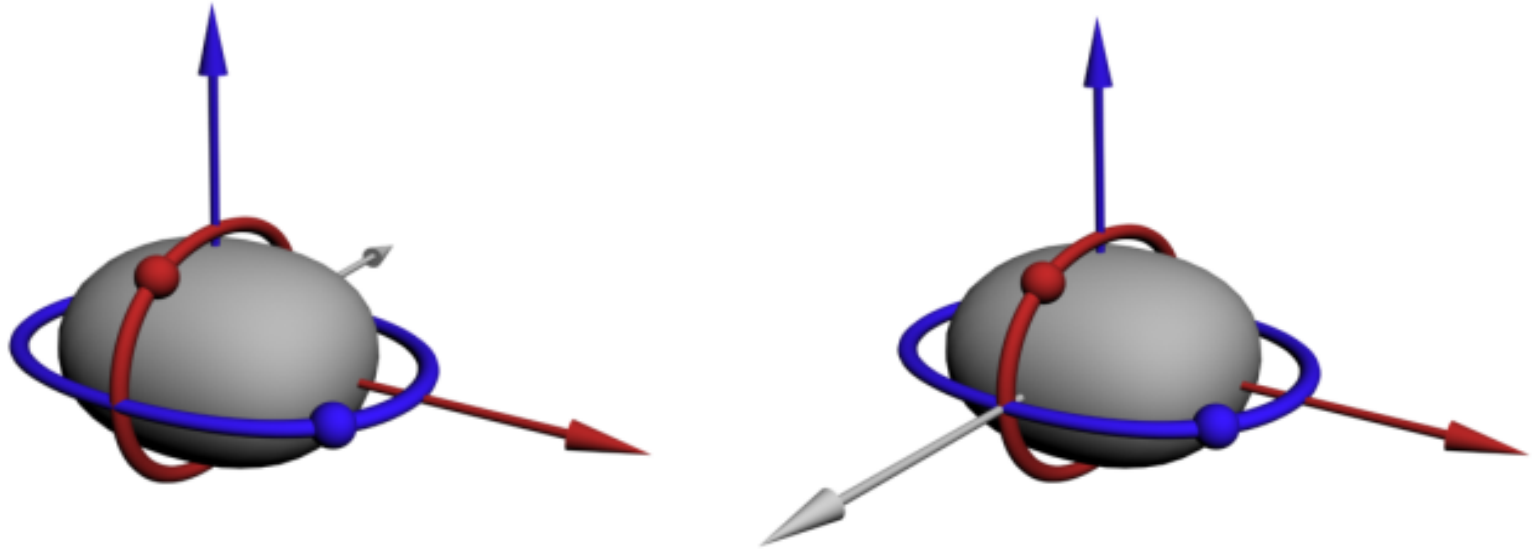


triaxial



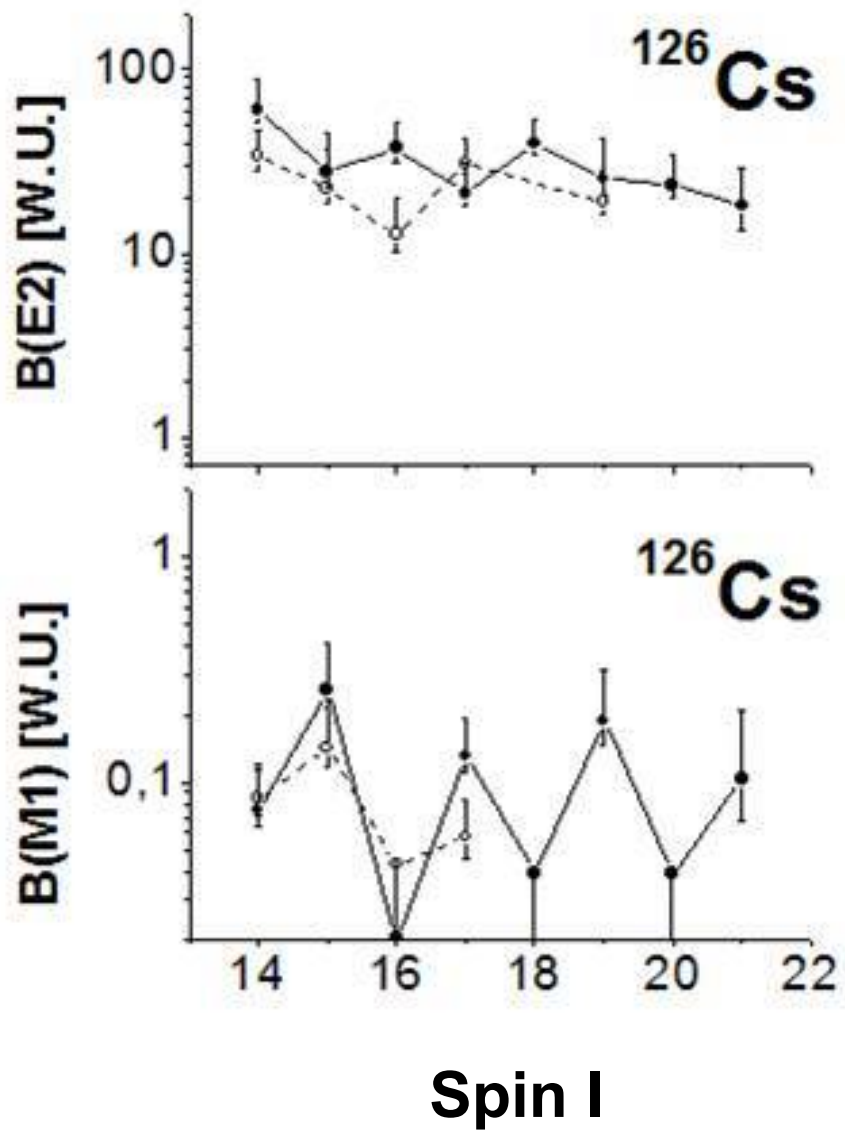
# Symmetries and nuclear structure

( Dr J. Srebrny, dr E.Grodner...)



Studies of identical bands in  $A \sim 130$  nuclei

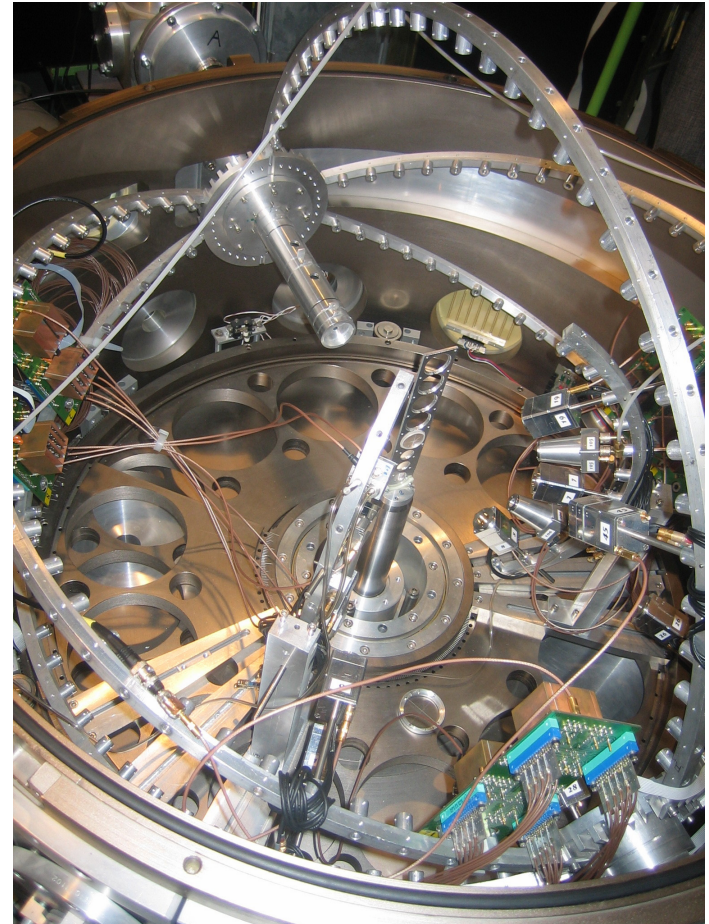
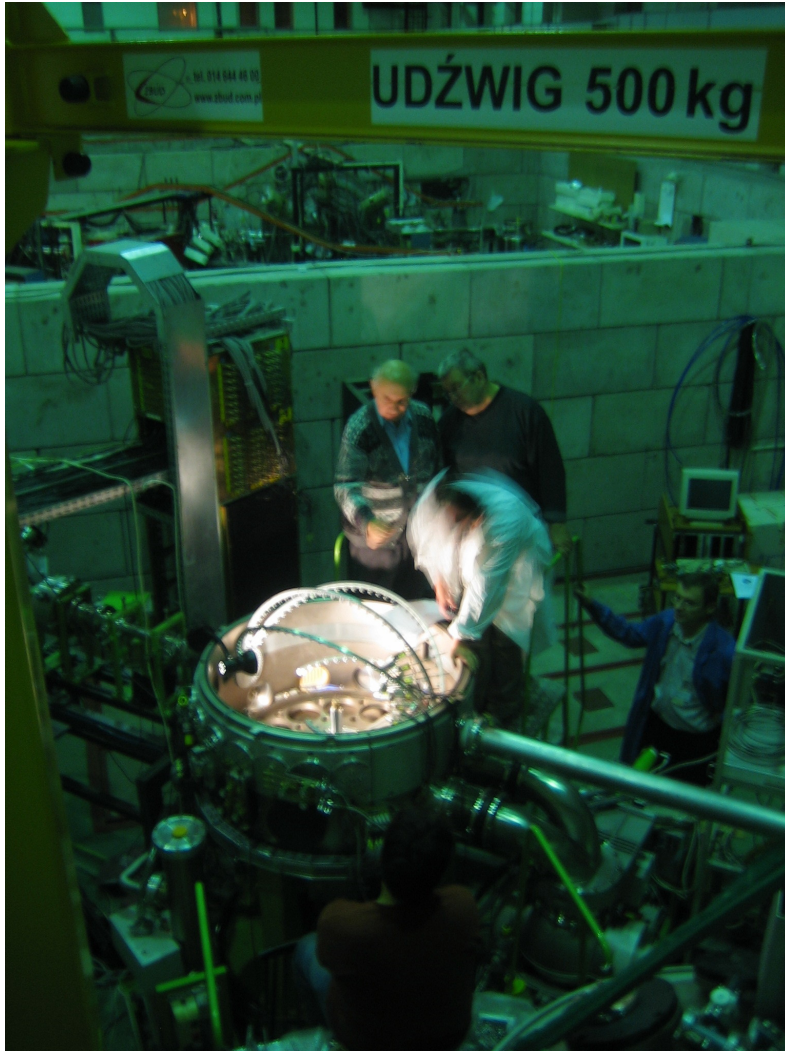
# Results:



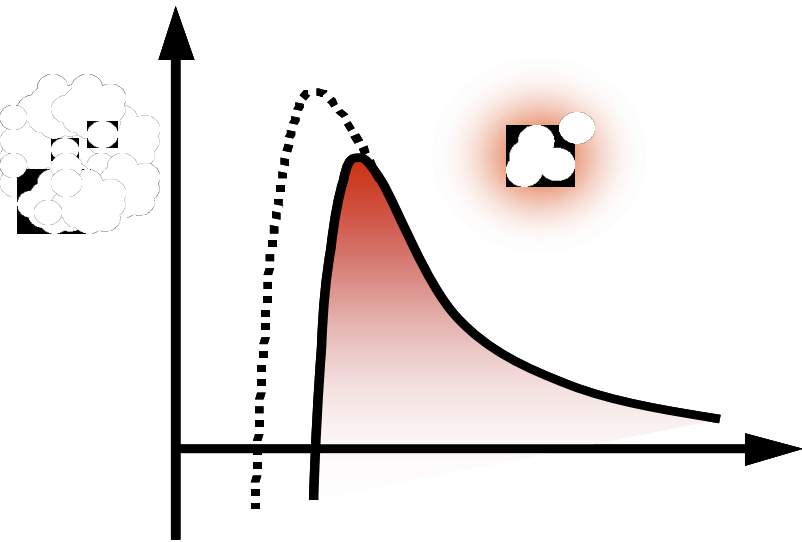
Solid curve – g.s.  
band

Dashed curve –  
side band

# ICARE large scattering chamber

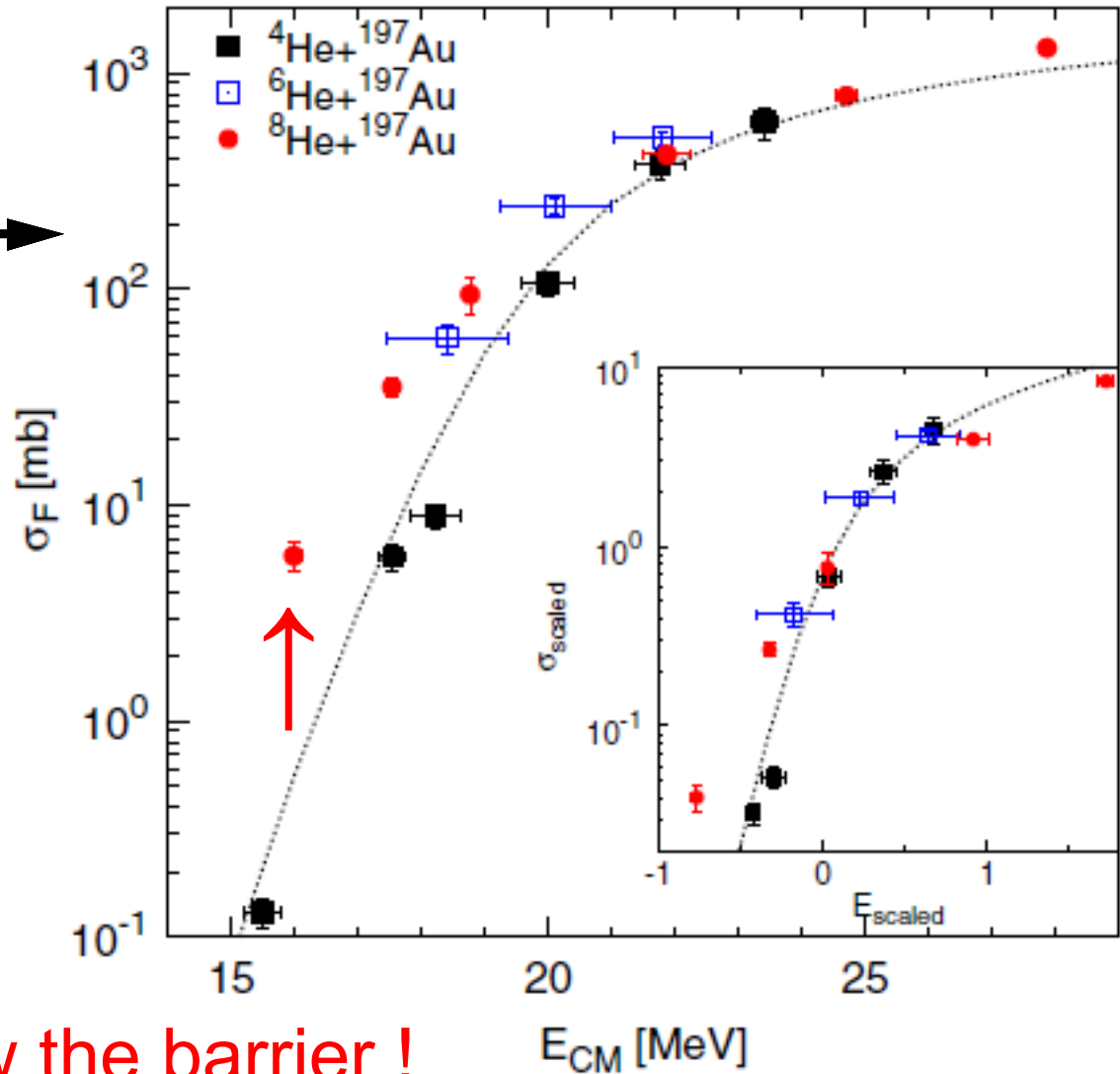






A. Lemasson et al. PRL  
103 (2009) 2327701

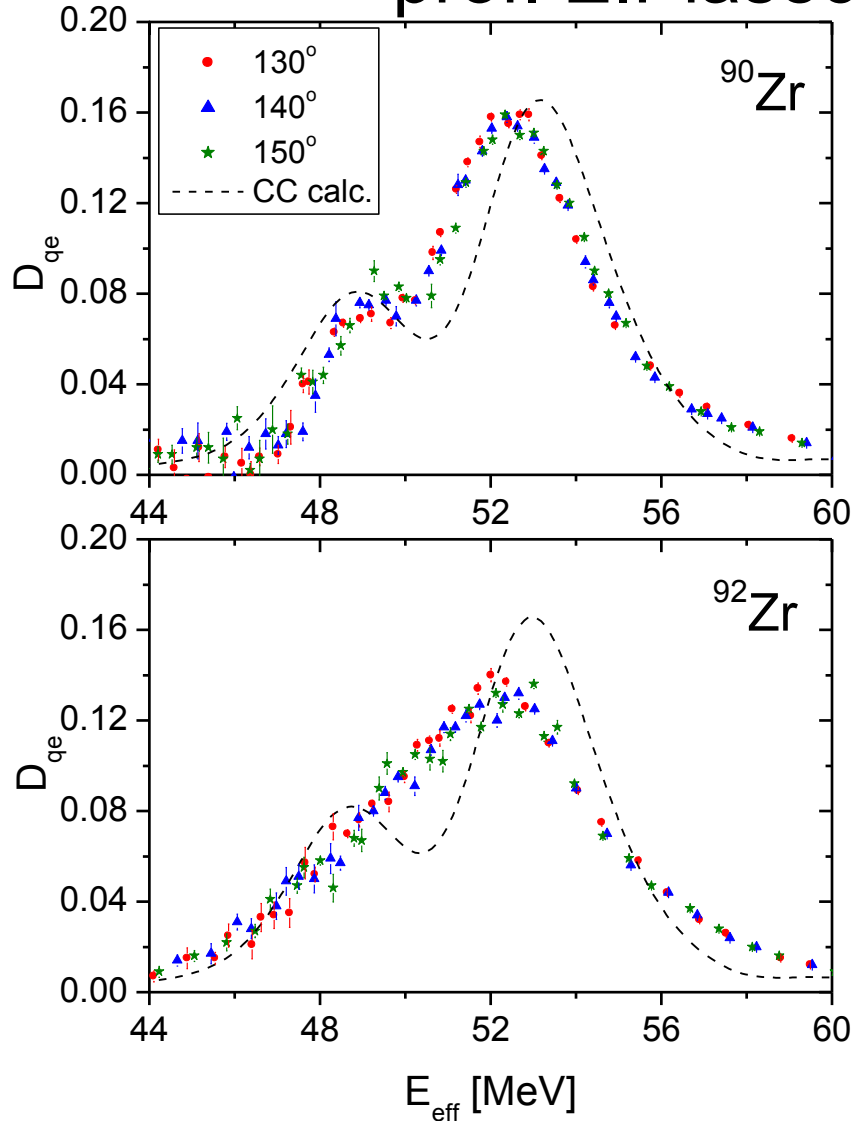
# Tunneling



Enhancement below the barrier !

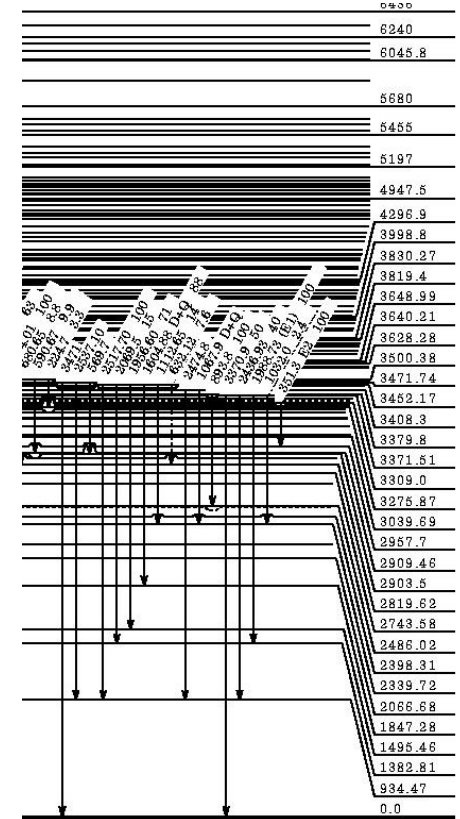
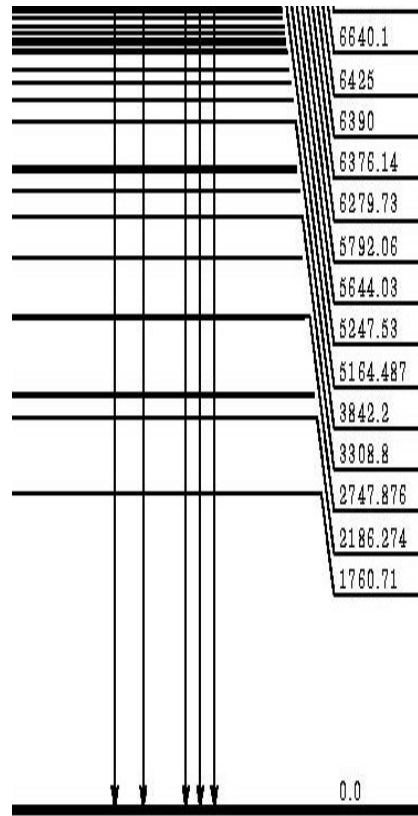
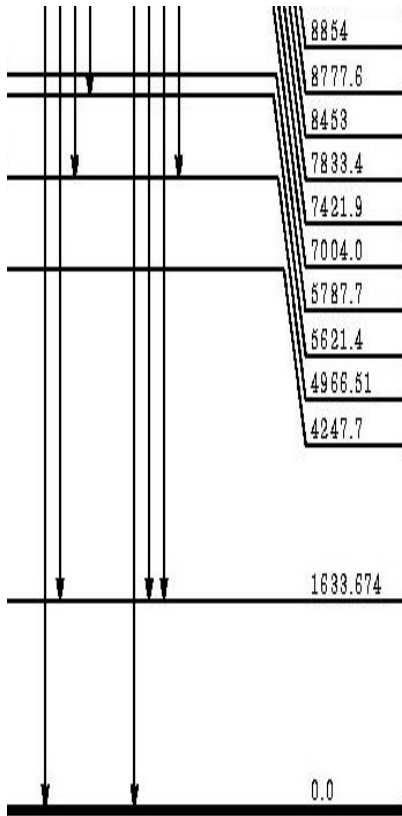
# Coulomb barrier distribution

prof. E. Piasecki, dr A. Trzcinska



Exp:  $^{20}\text{Ne} + \text{Zr}$

# Structure dependence



$^{20}\text{Ne}$

$^{90}\text{Zr}$

$^{92}\text{Zr}$

# $\alpha$ -structure of light nuclei



*M.C. Morais, R. Lichtenthaler / Nuclear Physics A 857 (2011) 1–8*

Table 2

Alpha spectroscopic factors for  $^{16}\text{O}_{gs}$ .

Work	Reaction	$S_\alpha$
This work	$^{12}\text{C}(^{16}\text{O}, ^{12}\text{C})^{16}\text{O}$	1.45–1.58
Refs. [22,23]	$^{12}\text{C}(^6\text{Li}, d)^{16}\text{O}$	7.6–10
Ref. [24]	$^{12}\text{C}(^7\text{Li}, t)^{16}\text{O}$	0.38
Ref. [25]	$^{12}\text{C}(^6\text{Li}, d)^{16}\text{O}$	0.34
Ref. [26]	$^{16}\text{O} \rightarrow \alpha + ^{12}\text{C}$	5.41
Refs. [9,19]	$^{12}\text{C}(^{16}\text{O}, ^{12}\text{C})^{16}\text{O}$	1.0–2.0

Experiments in HIL – A. Pakou et al. University of Ioannina, Greece

N. Burtebayev, University of Almaty, Kazakhstan

# Interaction of exotic nuclei

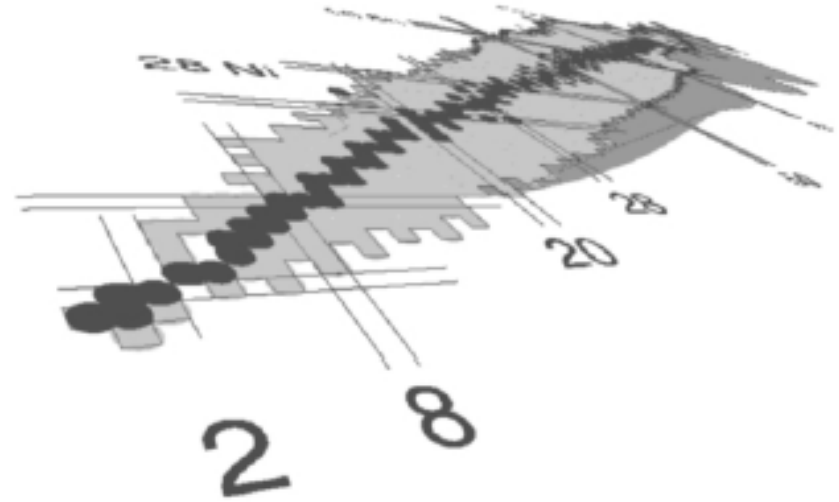
**New „magic” numbers**

**Nuclear halo**

**Three body forces**

**Clustering**

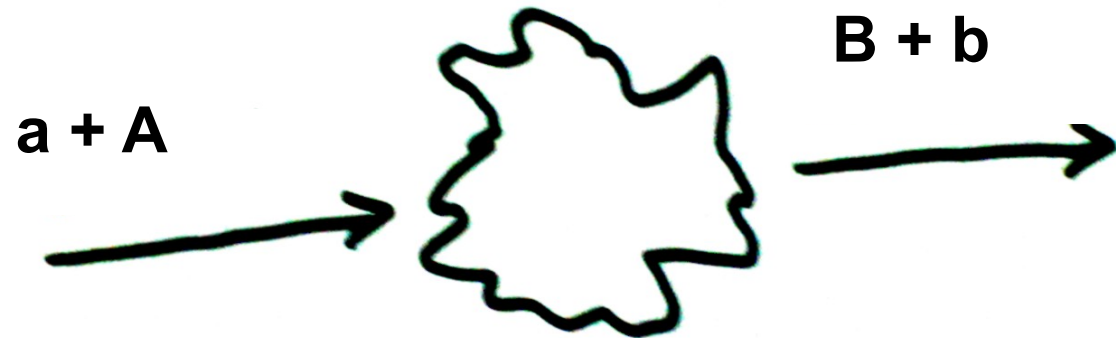
**etc.**



**What about an effective optical potential??**

# Interaction of exotic nuclei

prof. Adam Rudchik, IBJ UAN Kiev



Probability: optical potential  $a + A$

+ structure

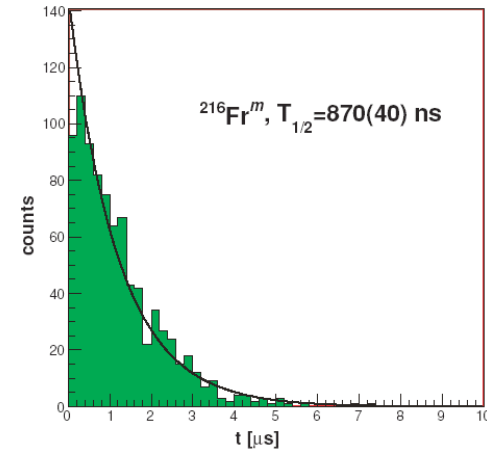
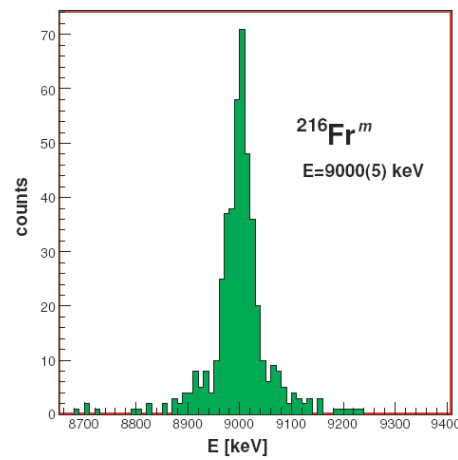
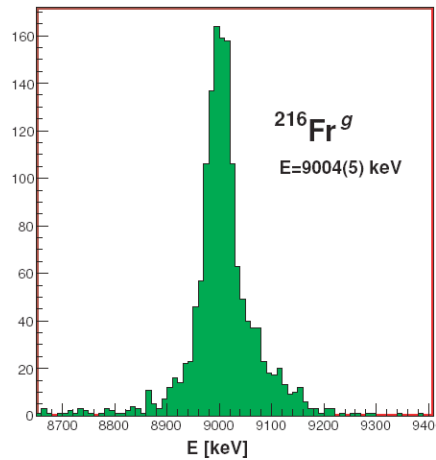
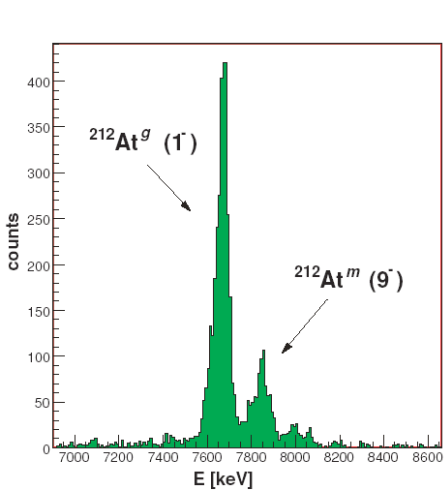
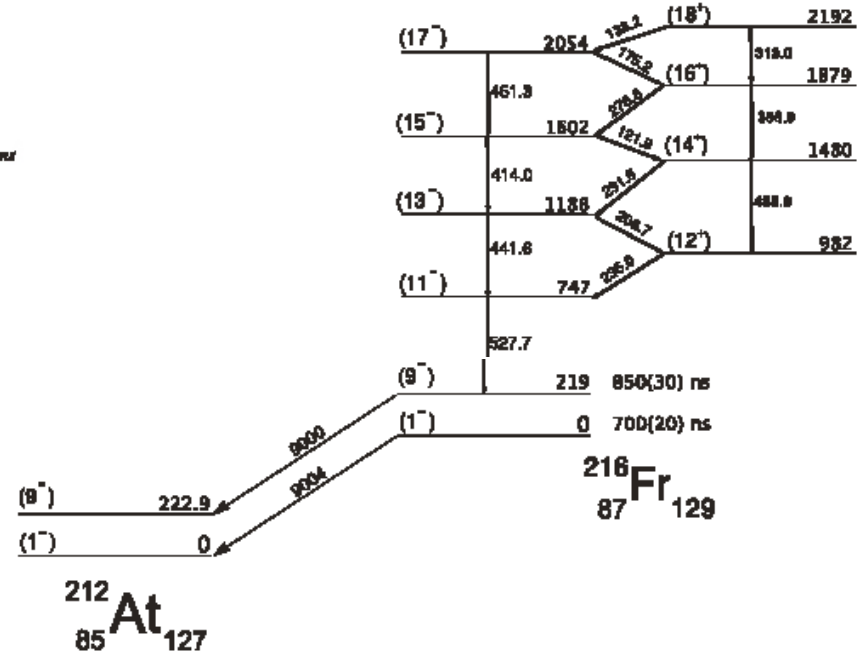
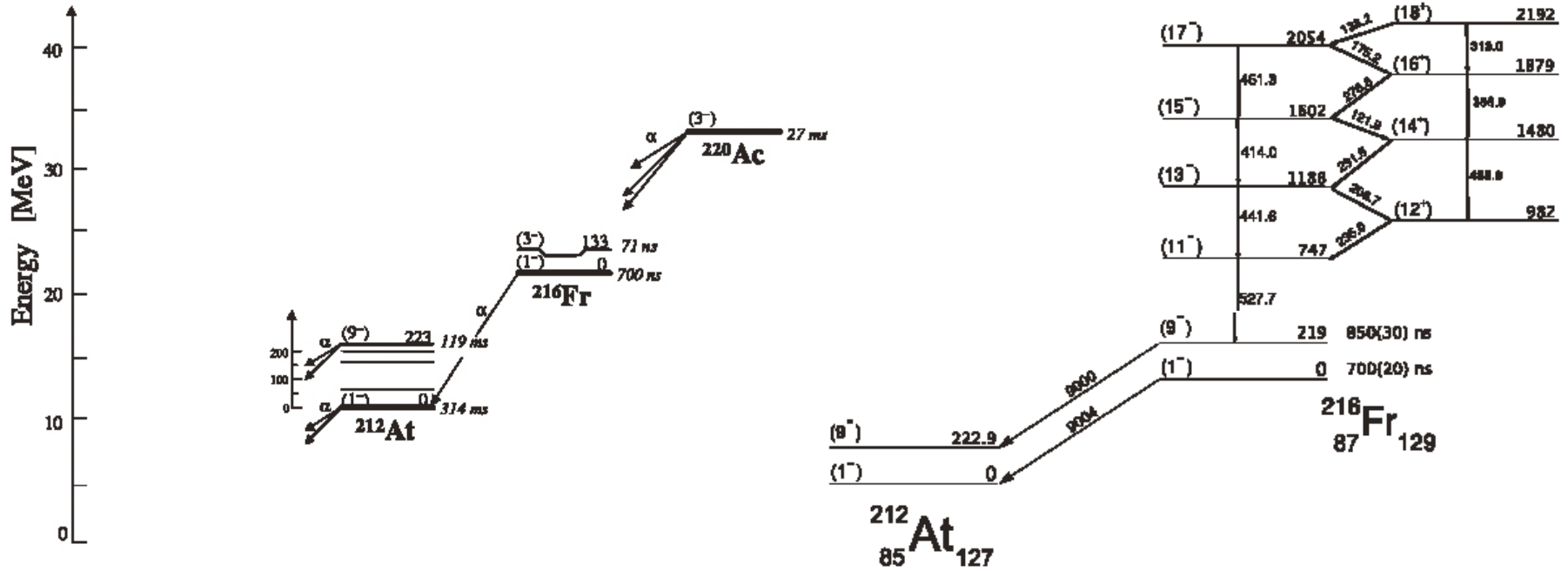
+ opt. potential  $b + B$

# IGISOL – magnetic spectrometer



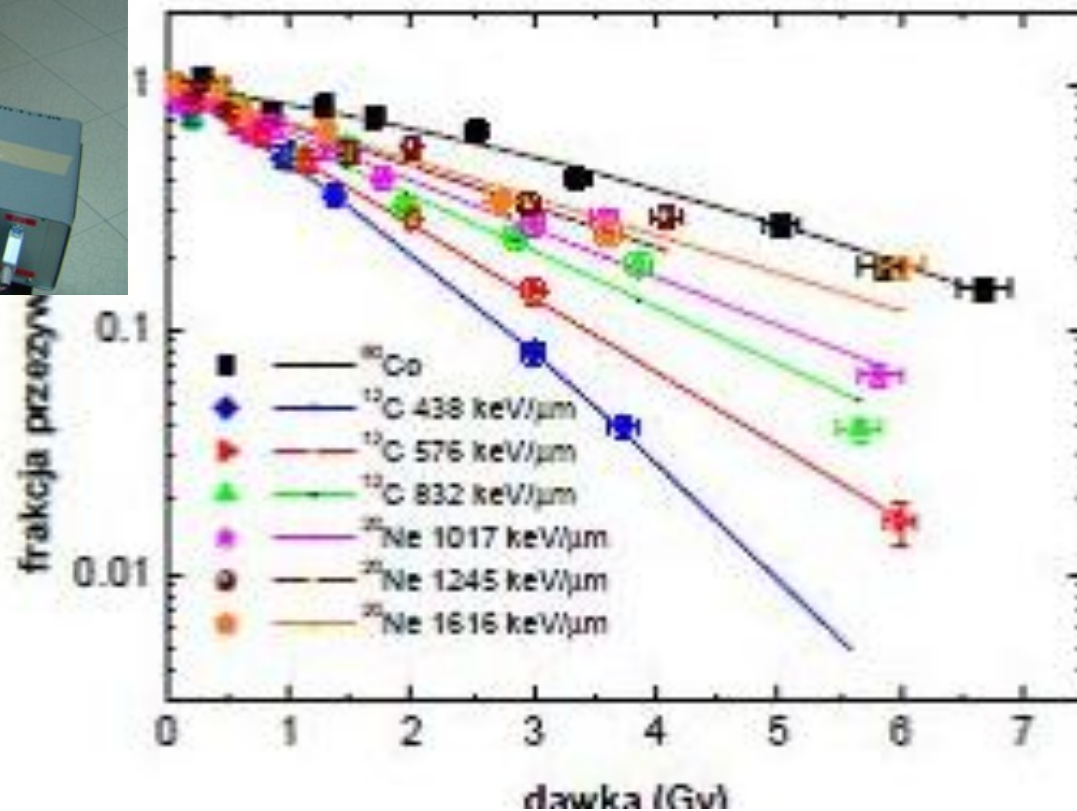
- Trans – lead nuclear isomers investigated by isotope separation on – line

*J. Kurcewicz et al. Phys. Rev. C76(2007)054320*

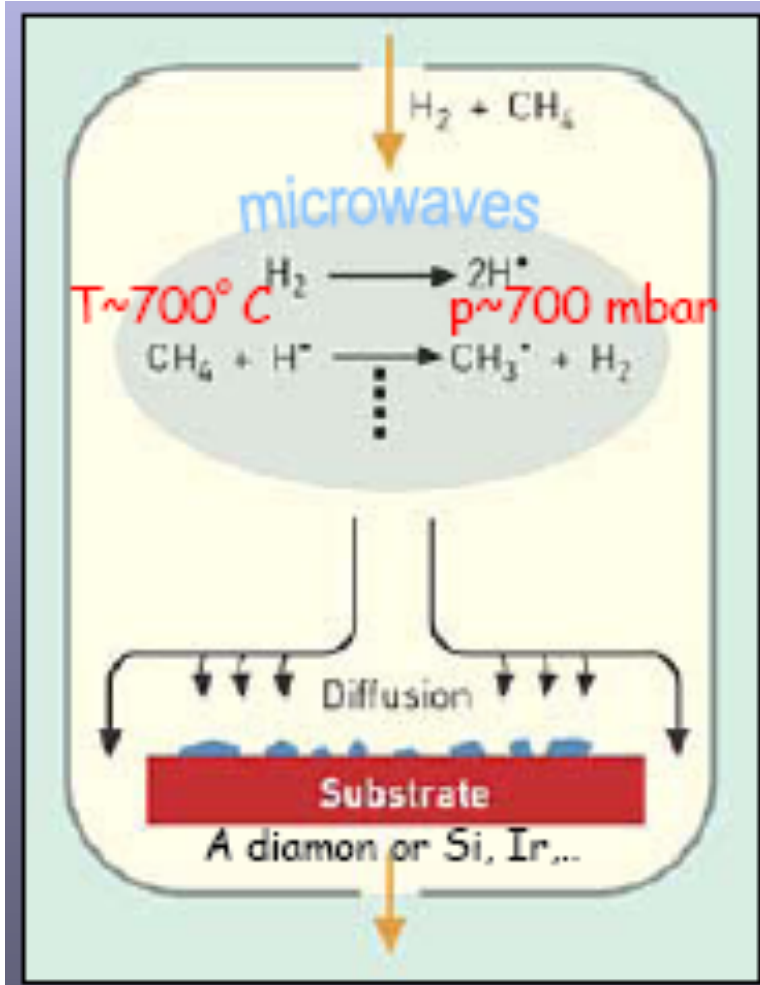




# Survival of irradiated cells (dr z. Szeflinski...)

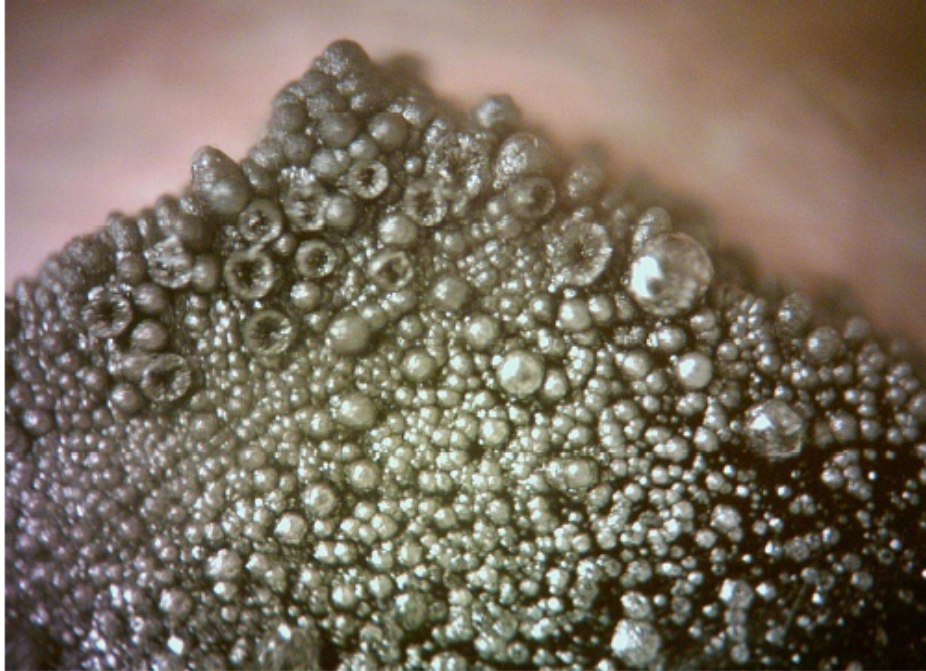


# Detector laboratory



prof. A. Kordyasz

# Diamond detectors



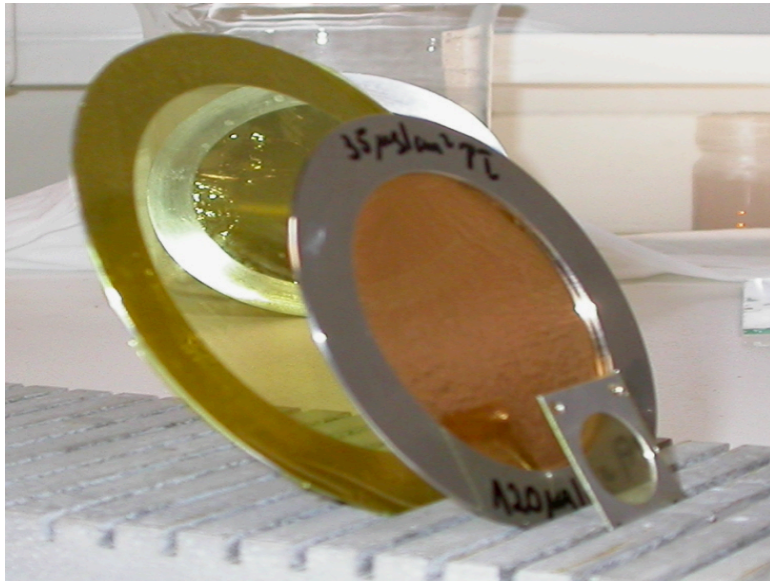
# Target laboratory

dr Anna Stolarz



Head of *International Nuclear Target Development Society*

[www.intds.org](http://www.intds.org)



**polyimide (C<sup>22</sup>H<sup>10</sup>N<sup>2</sup>O<sup>4</sup>)<sub>n</sub>**

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



## Education

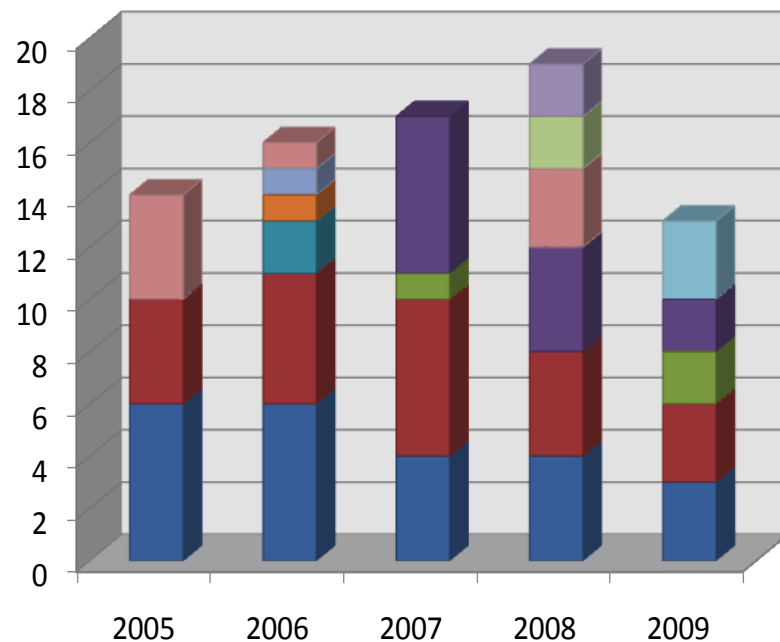
### *One-week workshop for undergrad. students*

Środowiskowe Laboratorium Ciężkich Jonów, Uniwersytet Warszawski.

***Warszawa, 20 - 25 April 2009 r.***

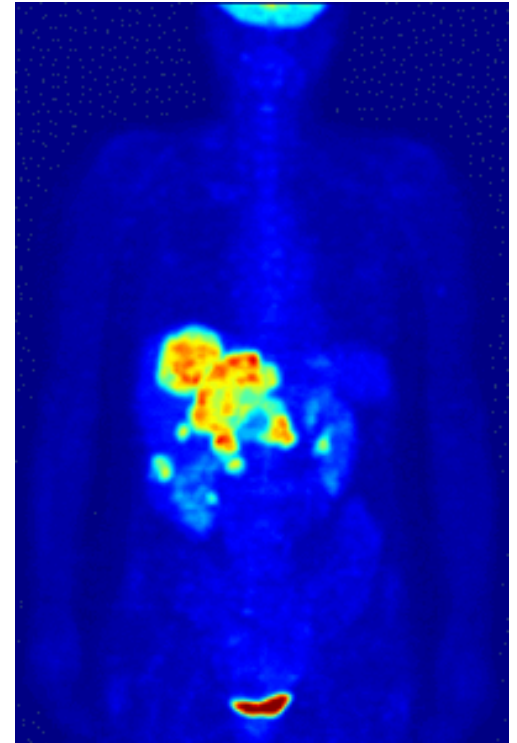
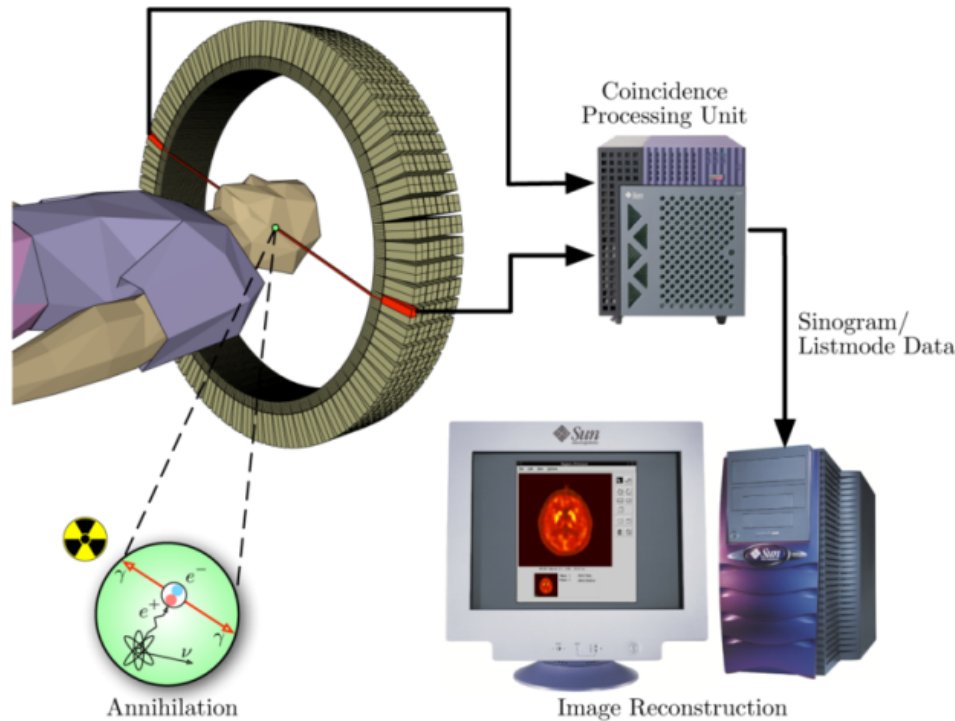


- UAM w Poznaniu
- Uniwersytet Śląski
- Uniwersytet Szczeciński
- UMCS w Lublinie
- UMK W Toruniu
- Politechnika Warszawska
- IPJ w Świerku
- Uniwersytet Warszawski
- Uniwersytet Wrocławski
- Politechnika Gdańska
- Uniwersytet Łódzki



# Positron-Emitting Tomography

- During 80 and 90s mostly a research tool
- Since 2000: standard technique in large hospital in EU/US for diagnosis of cancer



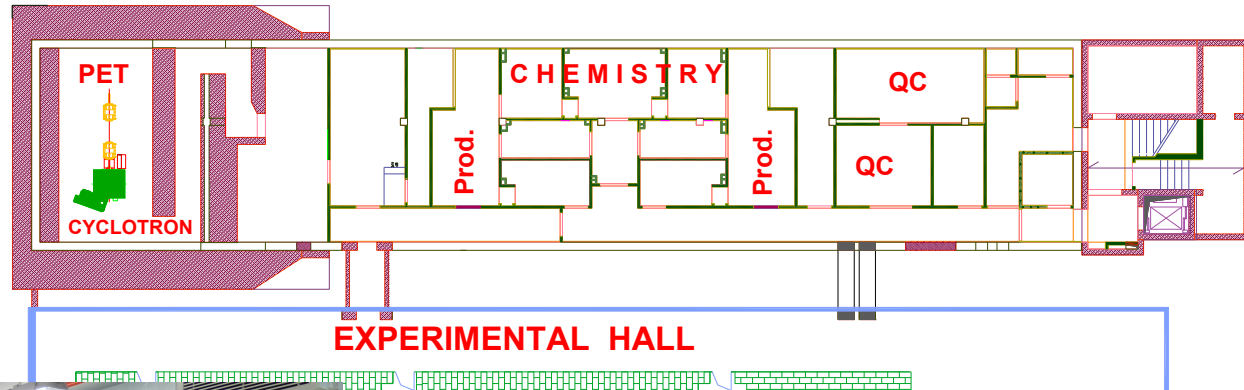
# Isotopes

Nuclid	$T_{1/2}$ (min)	$E_{\max}$ (MeV)	Range y (mm)	Target	Reaction
$^{18}\text{F}$	109,7	0,635	0,2	$^{18}\text{O}$ water Ne gas	$^{18}\text{O}(p,n)^{18}\text{F}$ $^{20}\text{Ne}(d, \alpha)^{18}\text{F}$
$^{11}\text{C}$	20,4	0,96	0,4	$\text{N}_2$ - gas	$^{14}\text{N}(p,\alpha)^{11}\text{C}$
$^{13}\text{N}$	9,96	1,72	0,8	$^{16}\text{O}$ water	$^{16}\text{O}(p,\alpha)^{13}\text{N}$ $^{12}\text{C}(d,n)^{13}\text{N}$
$^{15}\text{O}$	2,07	1,19	0,5	$\text{N}_2$ - gas	$^{14}\text{N}(d,n)^{15}\text{O}$
$^{68}\text{Ga}$	68,3	1,9	1,2		Generator (from $^{68}\text{Ge}$ )

# Radiopharmaceutical production centre (dr J. Choinski, dr K. Kilian..)

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

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





INTERNATIONAL CONFERENCE  
**POSITRON EMISSION TOMOGRAPHY**  
in Research and Diagnostics

WARSAW  
16-19 MAY 2012

organised by



Department of Nuclear Medicine  
Warsaw Medical University



Radiopharmaceuticals Production  
and Research Centre,  
Heavy Ion Laboratory, University of Warsaw

UNDER THE AUSPICES OF



Honorary Presidency

Prof. Katarzyna Chałasińska-Macukow  
Rector Magnificus of the University of Warsaw

Prof. Marek Krawczyk  
Rector Magnificus of the Warsaw Medical University

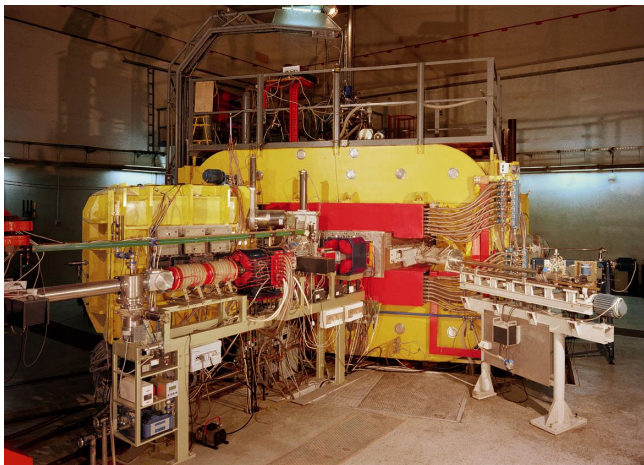
# Therapy using $\alpha$ -emitters

(prof. J. Jastrzębski, dr J. Choinski...)

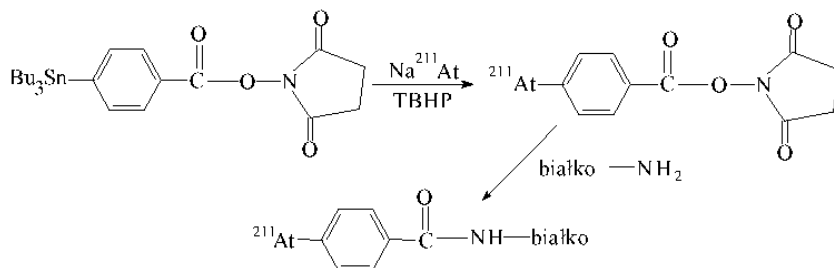
- $\alpha$ 's strongly interact with matter
- Have short range – do not kill healthy cells
- Perfect therapy for small cancers

$\alpha$

$^{211}\text{At}$ ,  $^{225}\text{Ac}$ ,  $^{212,213}\text{Bi}$ ,  $^{223,224}\text{Ra}$ ,  $^{212}\text{Pb}$ ,  
 $^{226}\text{Th}$



isotope  
production

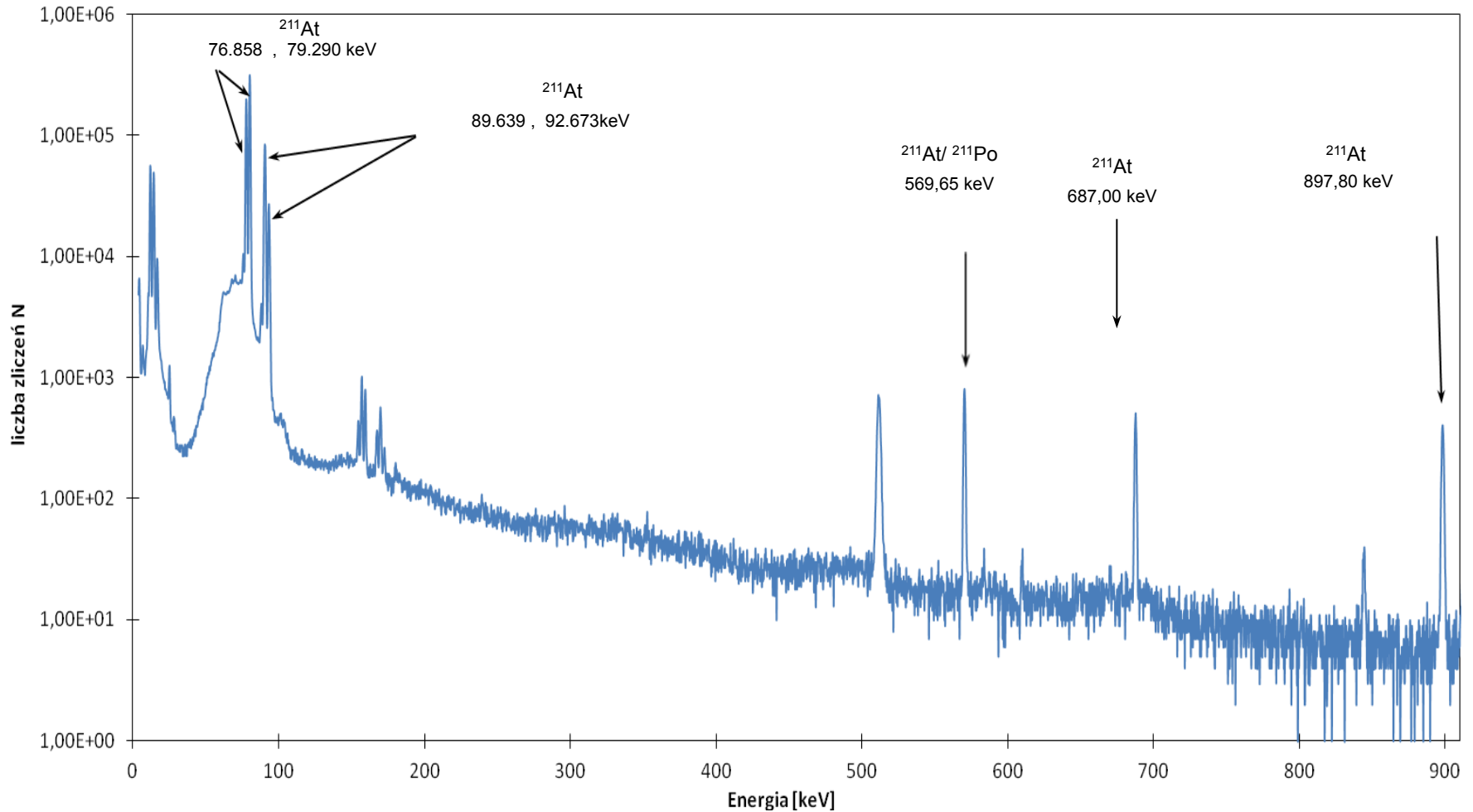


chemistry

drug



# Gamma spectrum from $\alpha$ irradiated Bi target



# Summary

Heavy Ion Laboratory, University of Warsaw :

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