



Nuclear Physics in Spain: Applications

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I will use a rather wide meaning for “Applications” and try to review the activity of Spanish Nuclear Physics groups in:

- Environmental radioactivity
- Applications to other fields (material analysis, dating, ...)
- Medical applications
- Nuclear data for nuclear technology, astrophysics and other fields
- Underground physics
- Metrology, instrumentation

Environmental radioactivity:

~20 groups and ~100 people, but only a fraction are nuclear physics groups, most of the groups participate in

U. Extremadura
U. I. Baleares
U. Salamanca
U. Santiago C.
U. Sevilla
CIEMAT

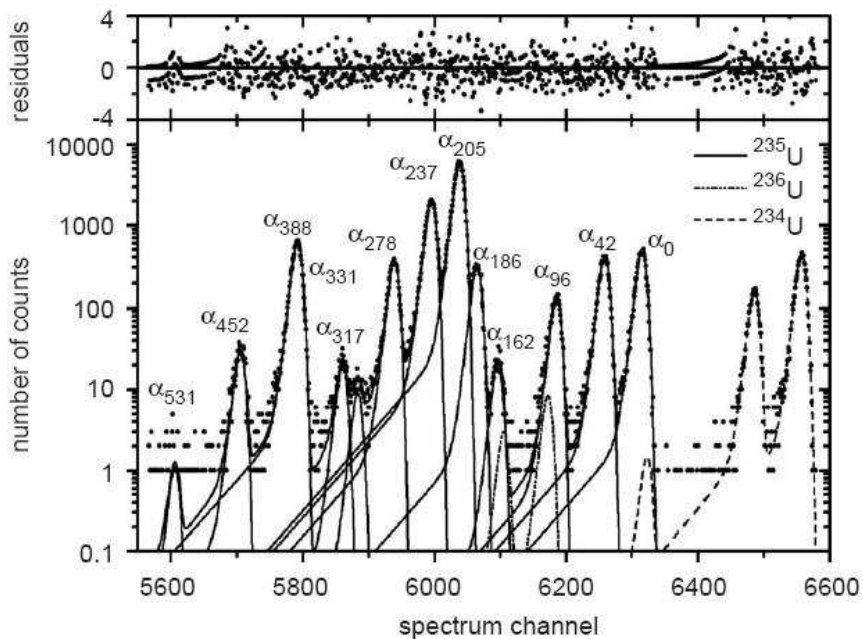
National Monitoring Network:
Collaboration with CSN
(Nuclear Security Council)
<http://www.csn.es>

Comunidad Autónoma	Laboratorio
ANDALUCIA	U. GRANADA. Laboratorio de Radioquímica y Radiología Ambiental. Departamento de Química Inorgánica. Facultad de Ciencias
	U. MALAGA. Laboratorio de Radiactividad Ambiental. Departamento de Física Aplicada. Facultad de Ciencias
	U. SEVILLA. Departamento de Física Atómica, Molecular y Nuclear. Facultad de Física
ARAGON	U. ZARAGOZA. Departamento de Física Teórica Facultad de Ciencias
ASTURIAS	U. ASTURIAS. (Oviedo) Laboratorio de Energía Nuclear. E. T. S. Ingenieros de Minas
BALEARES	U. ISLAS. BALEARES Dpto. de Física (Física Atómica, Molecular y Nuclear) y Departamento de Química Facultad de Ciencias
CANARIAS	U. LA LAGUNA. (Tenerife). Departamento de Medicina Física y Farmacología. Cátedra de Física Médica. Facultad de Medicina
CANTABRIA	U. CANTABRIA. Laboratorio de Radiactividad Ambiental. Cátedra de Física Médica. Facultad de Medicina
CASTILLA - LA MANCHA	U. CASTILLA LA MANCHA (Ciudad Real). Centro de Instrumentación Científica, Análisis y Tecnología
CASTILLA - LEON	U. LEON. Laboratorio de Radiactividad Ambiental. Departamento de Física, Química y Expresión Gráfica. Facultad de Biológicas
	U. SALAMANCA. Laboratorio de Radiactividad Ambiental. Cátedra de Física Nuclear. Facultad de Física
CATALUÑA	U. POLITÉCNICA DE CATALUÑA Instituto de Técnicas Energéticas
EXTREMADURA	U. EXTREMADURA (Badajoz). Cátedra de Física Atómica, Molecular y Nuclear
	U. EXTREMADURA (Cáceres). Laboratorio de Radiactividad Ambiental. Departamento de Física. Facultad de Veterinaria
GALICIA	U. LA CORUNA. (Ferrol) Departamento de Química Analítica. Escuela Universitaria Politécnica
MADRID	U. POLITÉCNICA. Laboratorio de Ingeniería Nuclear. Departamento de Hidráulica y Energética. E. T. S. I. Caminos, Canales y Puertos
PAIS VASCO	U. PAIS VASCO. Departamento de Ingeniería Nuclear y Mecánica de Fluidos. E. T. S. Ingenieros Industriales y de Telecomunicación
VALENCIA	U. DE VALENCIA. Edif. Investigación. Laboratorio de Radiactividad Ambiental
	U. POLITÉCNICA DE VALENCIA. Laboratorio de Radiactividad Ambiental. Servicio de Radiaciones. Dpto. de Ingeniería Química y Nuclear
Organismos Nacionales	
CEDEX	CENTRO DE ESTUDIO DE TÉCNICAS APLICADAS
CIEMAT	DEPARTAMENTO DE IMPACTO AMBIENTAL DE LA ENERGIA

Some research projects:

- Radiological impact from NORM in industry (U. Sevilla, U. Huelva. CIEMAT)
- Use of radiotracers in oceanography (U.A. Barcelona)
- Metrology applied to environmental ionizing radiations (CIEMAT, U. Extremadura)
- Radioactive dating of ecological systems (U. Sevilla, U. Huelva)
- Radon survey mapping in Spain (U. Cantabria)

CIEMAT, UNEX, ... ♦ EUROMET



U. Santiago C.



α -emission standardization ^{235}U , ...

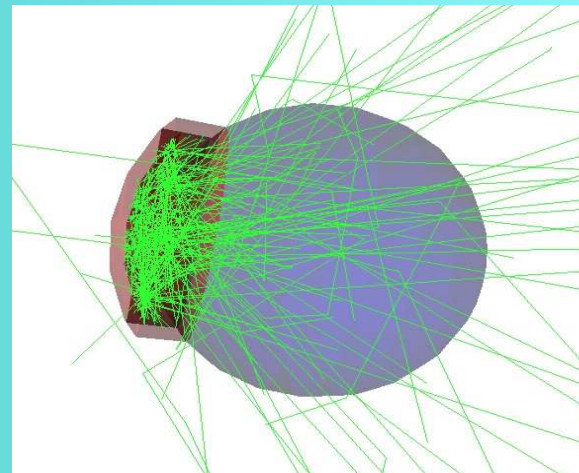
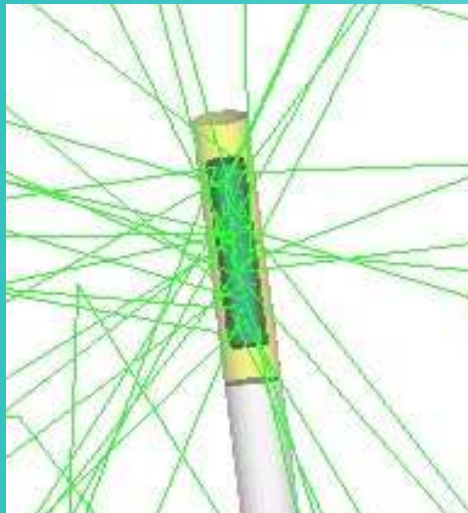
Radon map of Galicia

Medical Applications:

Growth of activity, mainly from non-NP

IFIC (U. Valencia)

**Monte Carlo dosymetry
of brachytherapy sources**



Design of applicators



CIEMAT

IFIC-Valencia

U. A. Barcelona

U. Complutense (Madrid)

U. Granada

U. Santiago C.

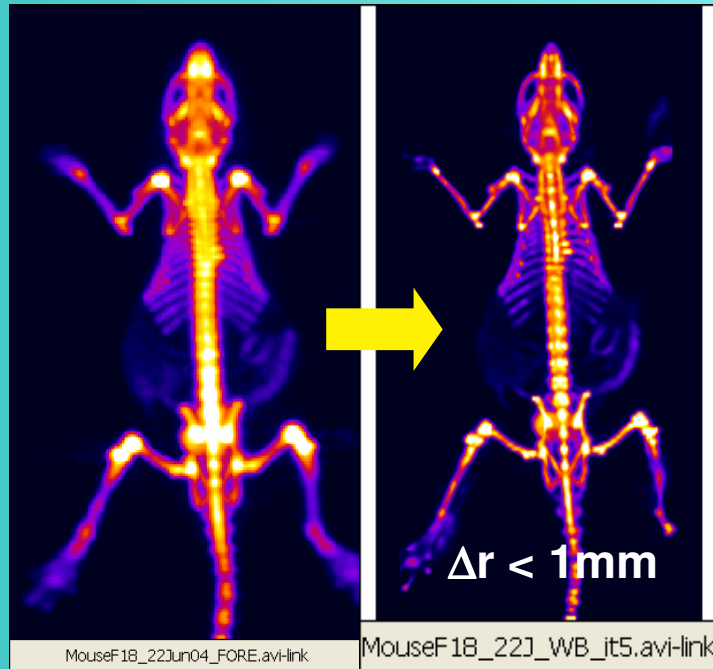
U. Sevilla

U. Sevilla

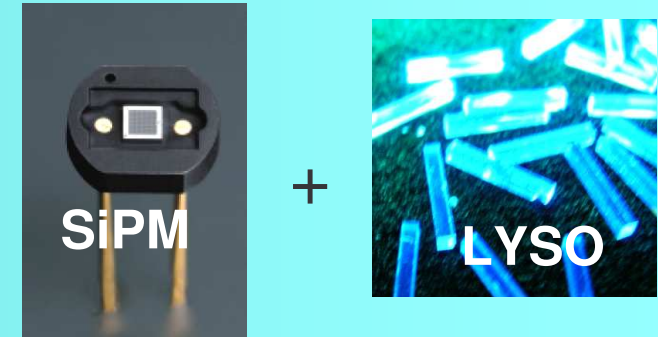
**Monte Carlo for hadron therapy: evaporation,
equilibrium and fragmentation models**

U. Complutense Madrid

Image reconstruction algorithms

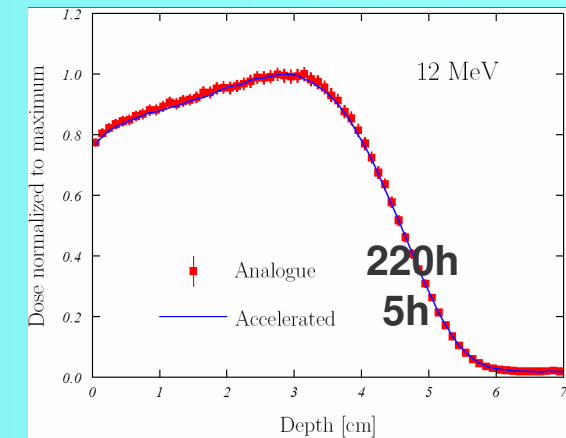
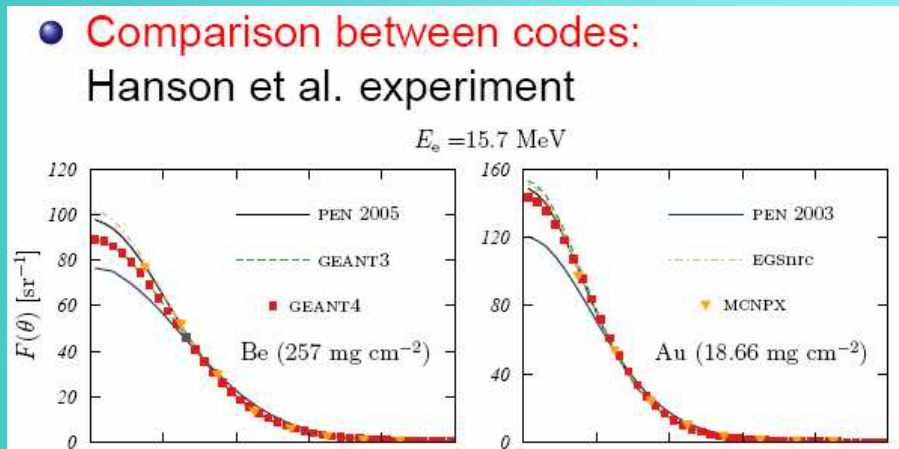


PET sensors



U. Granada

Monte Carlo simulations in dosymetry



Introduction of MC acceleration techniques

Applications in material science, art and archeometry,
environmental sciences, industry...

Centro Nacional de Aceleradores (CNA-Sevilla)

U. Sevilla
U. Huelva

- 3 MV Tandem van de Graaff
- 1 MV Tandetron
- 18 MeV p Cyclotron



3MV van de Graaff

IBA techniques:
RBS, NRA, ERDA, PIXE, PIGE, μ beam,...

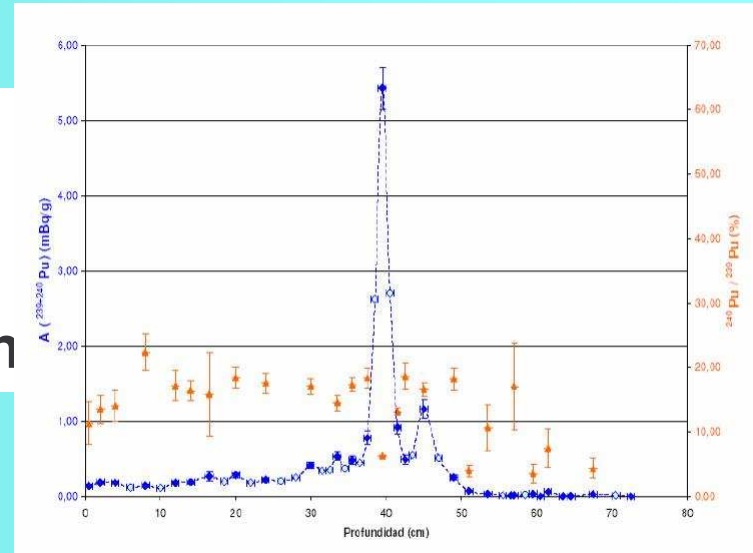
Archeology: Tartessus civilization



Accelerator Mass Spectrometry

mostly dating but also oceanography, climate, radiation monitoring, ...

Palomares
H-bomb
residual
contamination



1MV Tandatron



18MeV-p Cyclotron



radiopharmacy

Small animal PET



Nuclear data for astrophysics ...

Centro de Micro-Analisis de Materiales (CMAM-Madrid)

5 MV Tandem



IEM (CSIC-Madrid)

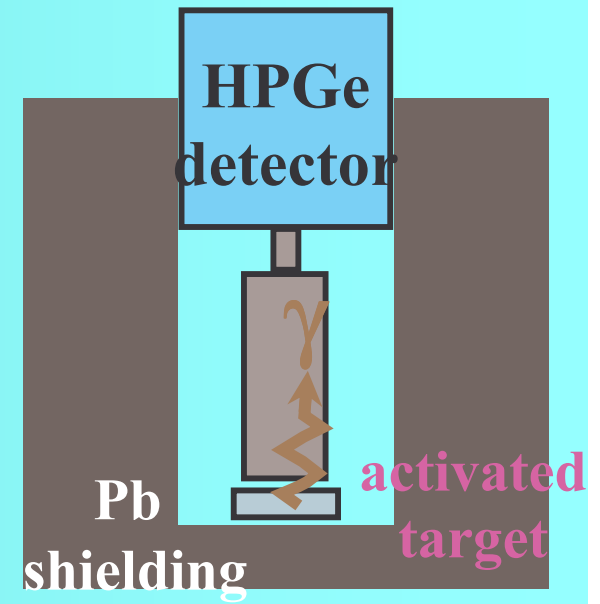
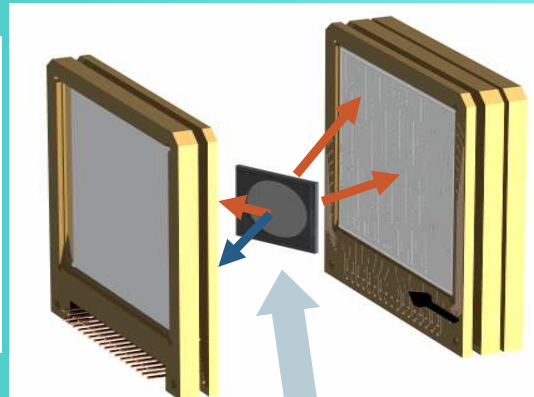
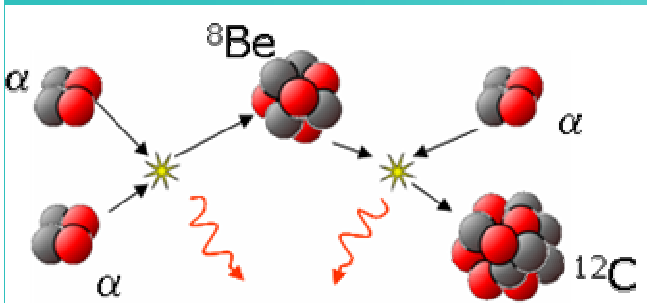
p-process

IEM-Madrid
U. Huelva
U. Sevilla

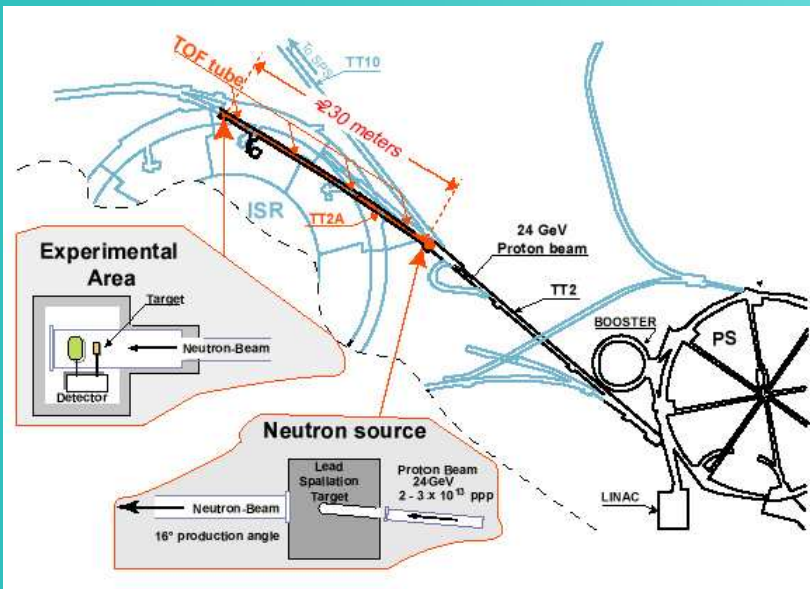
5-15 MeV α $^{92}\text{Mo}(\alpha,\gamma),(\alpha,p),(\alpha,n)$

3 α -process

2.45 MeV $^3\text{He} + ^{10}\text{B} \rightarrow 3\alpha + p$



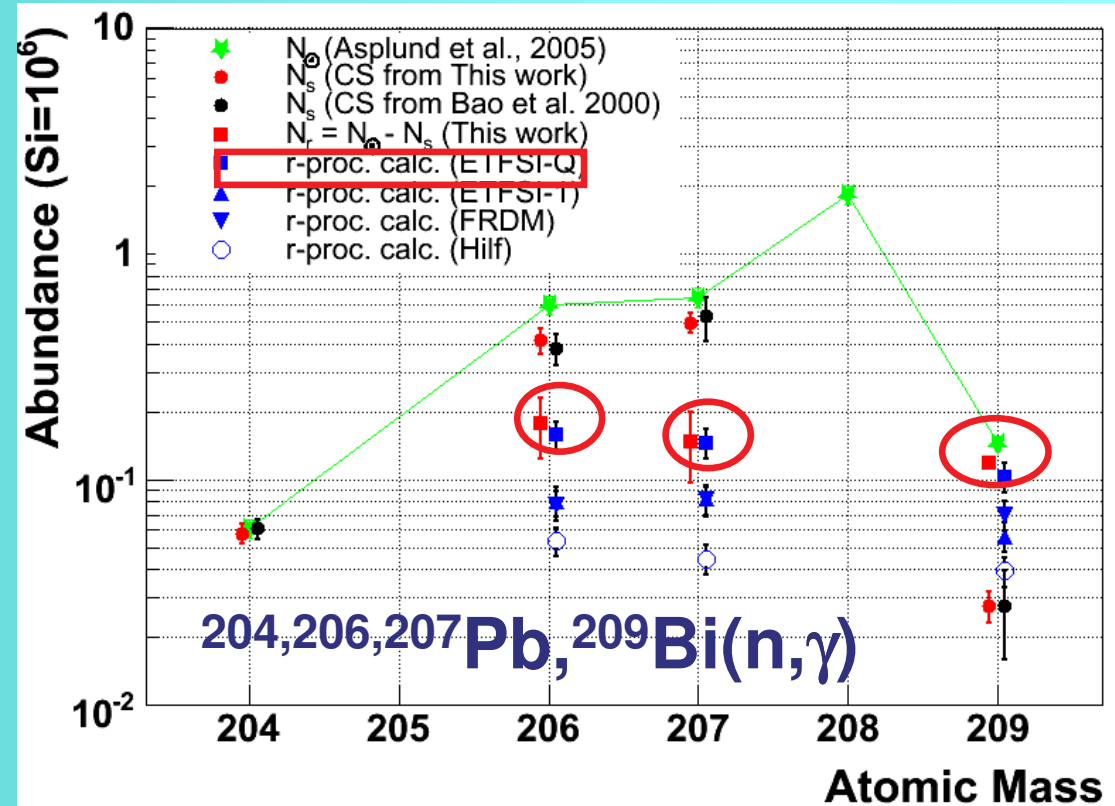
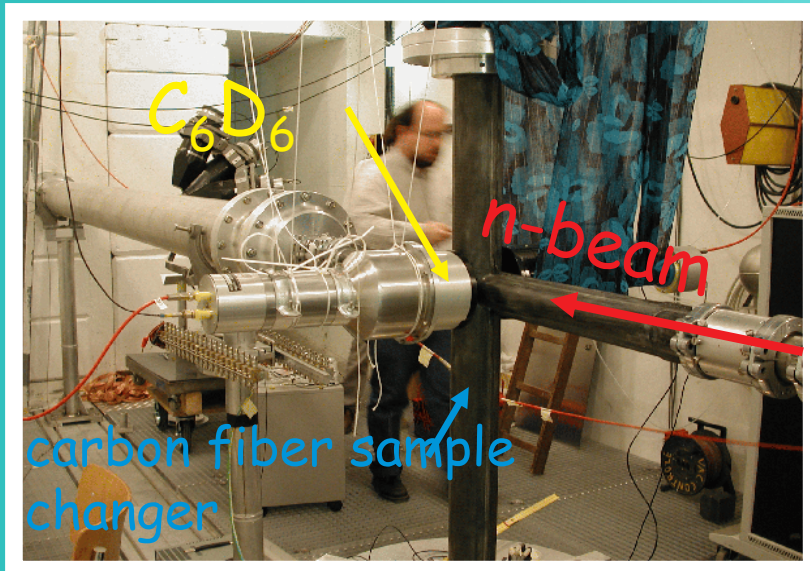
n_TOF: Neutron Time of Flight facility @ CERN



CIEMAT-Madrid
 IFIC-Valencia
 U.P.C-Barcelona
 U. Santiago de C.
 U. Sevilla

IFIC (CSIC-Valencia)

s-process end-point

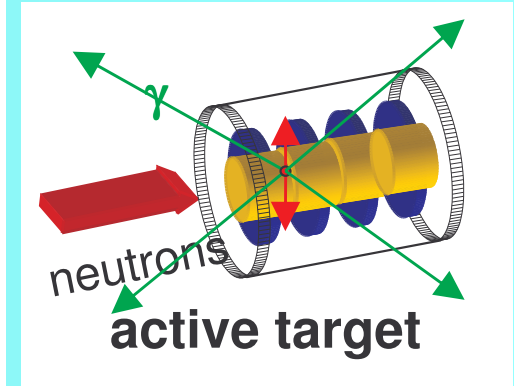
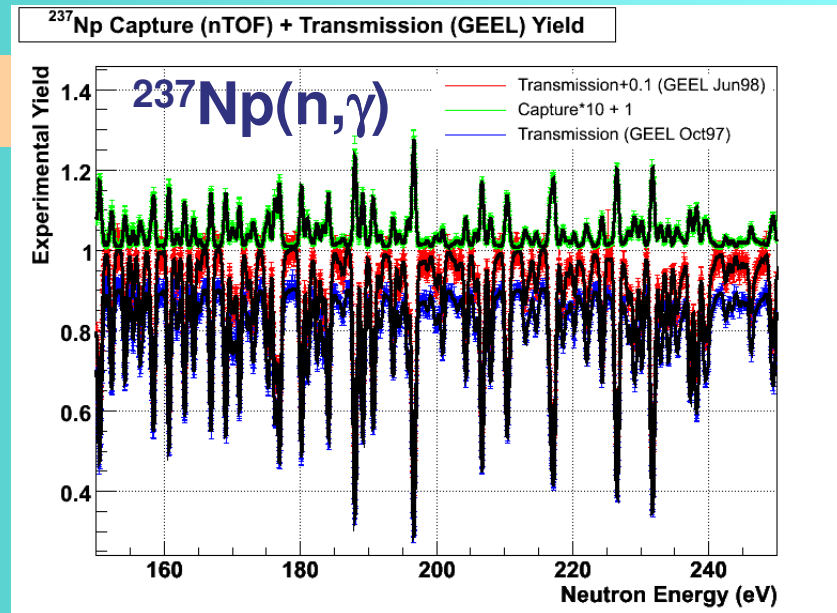


... and nuclear technology

ADS transmutation

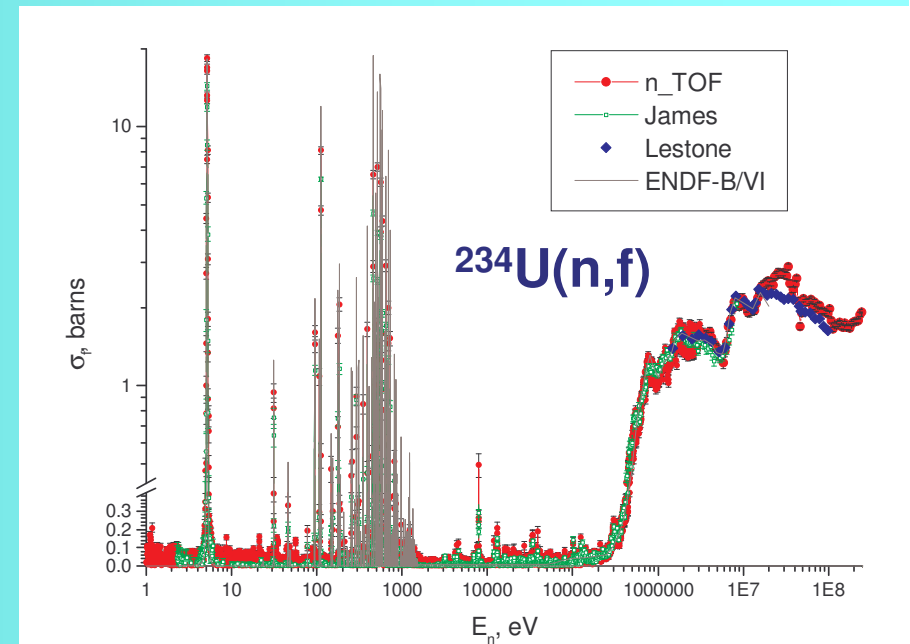
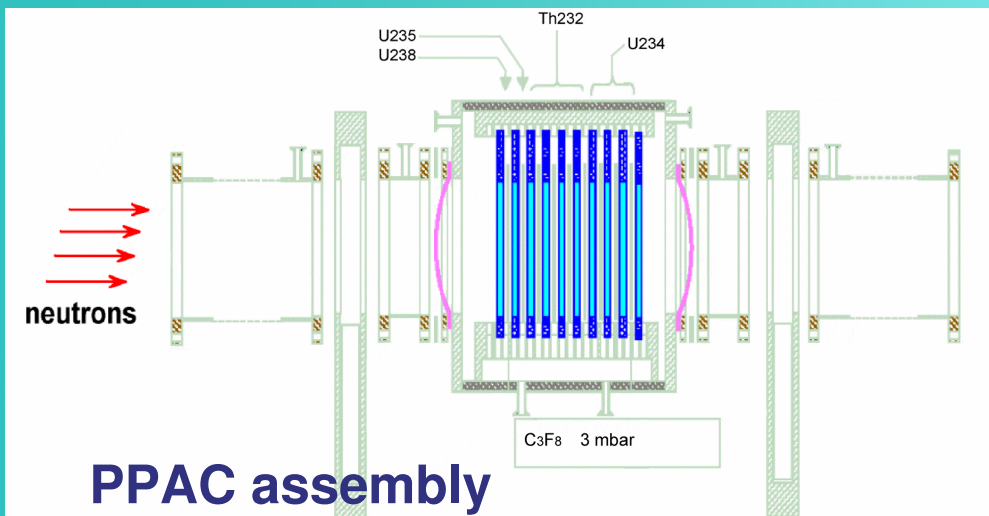
CIEMAT-Madrid

(n,γ) in Minor Actinides



U. Santiago C.

(n,f) in U



JYFL: Laboratory of the Cyclotron @ Univ. Jyvaskyla



JYFLTRAP

IFIC-Valencia
CIEMAT-Madrid
UPC-Barcelona

β -decay data for reactor
decay heat calculations

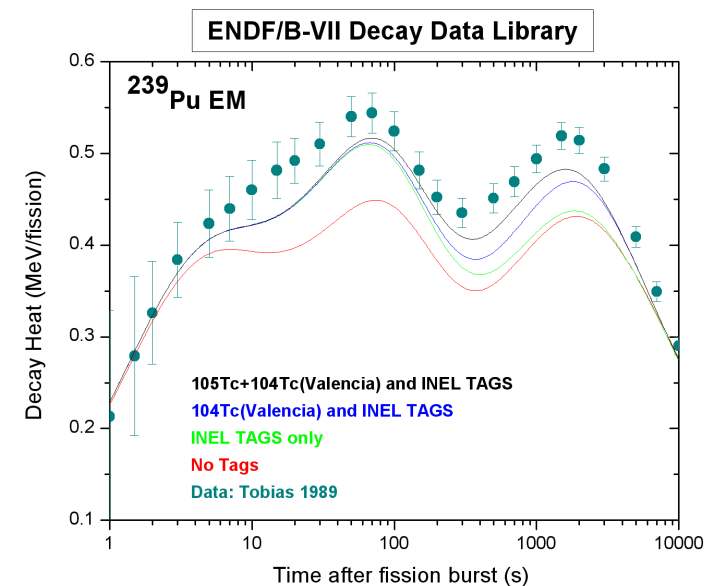
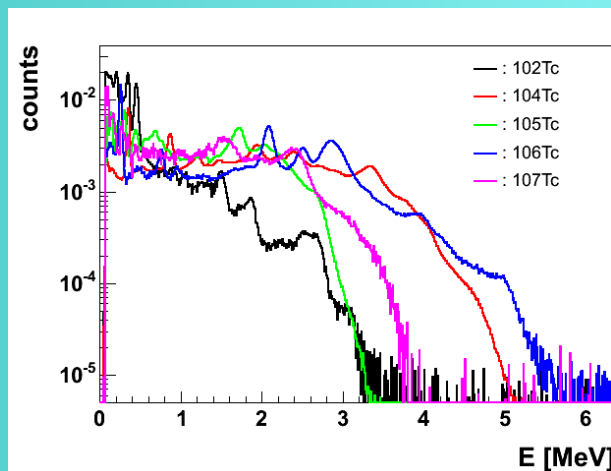
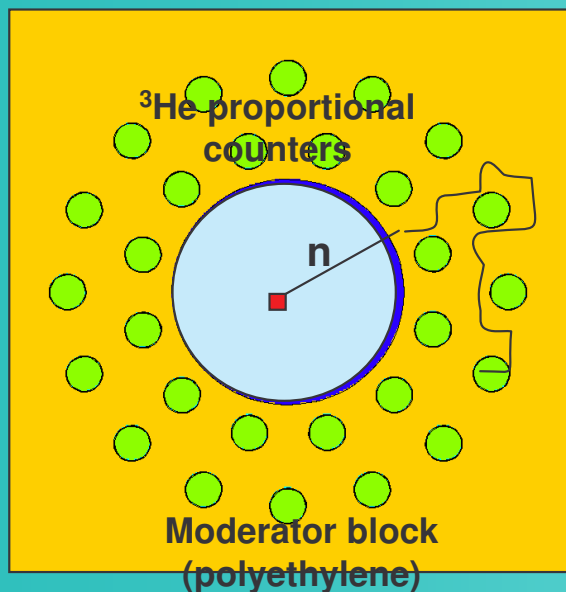
Delayed-neutron data
for reactor kinetics

UPC-Barcelona



TAS

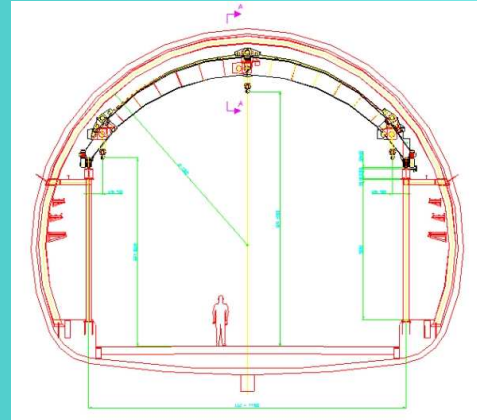
IFIC (CSIC-Valencia)



Underground physics

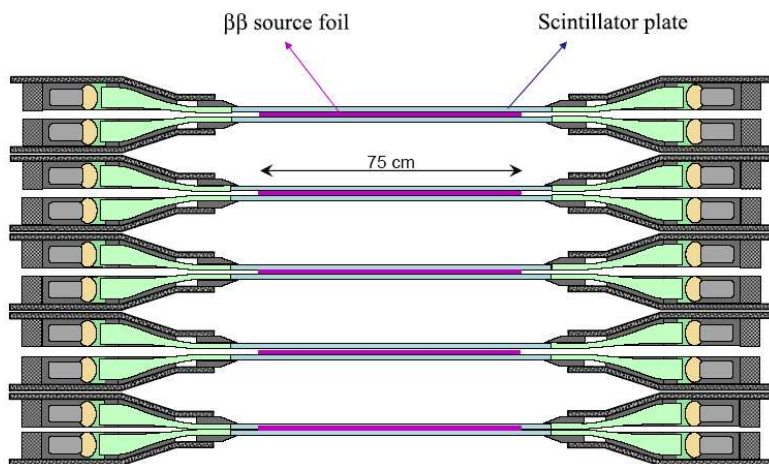
one NP group involved

LSC: Laboratorio Subterraneo de Canfranc



IFIC (U. Valencia)

BIPO: a very low radioactivity monitor

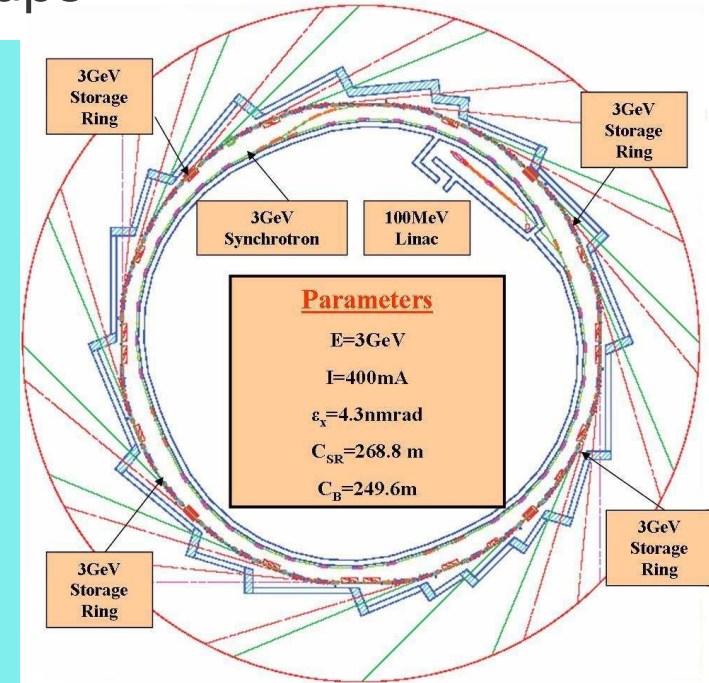
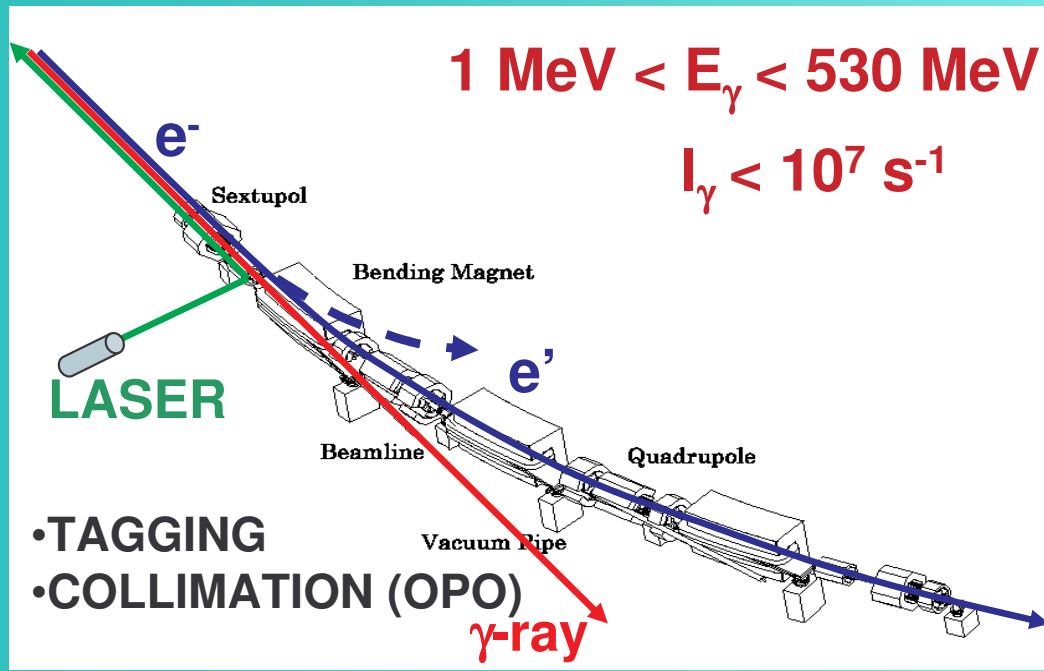


**Bi, Po activity
~100 μ Bq/kg**

**radio-purity of 2β emitters
for SUPERNEMO**

Future possibilities:

- A gamma-ray beam line at the Spanish Synchrotron ALBA, if accepted proposal by 14 Spanish groups

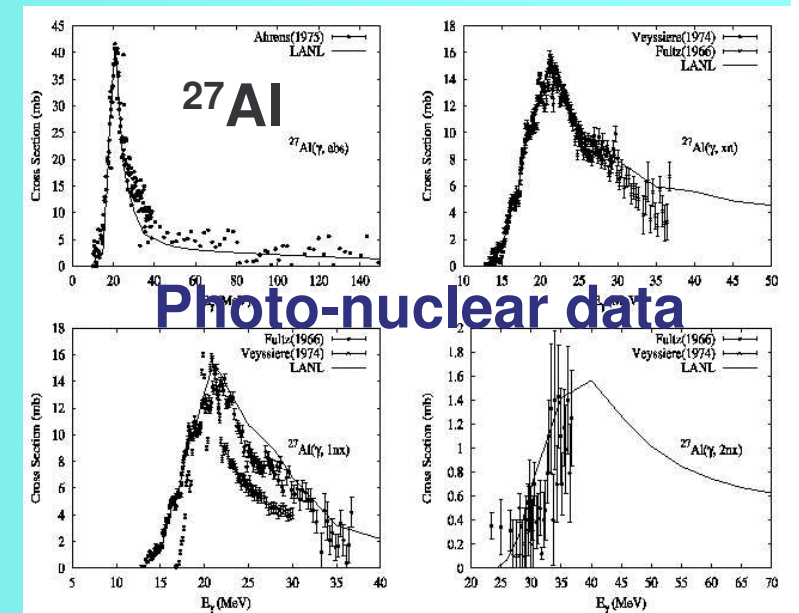


Industrial gammagraphy

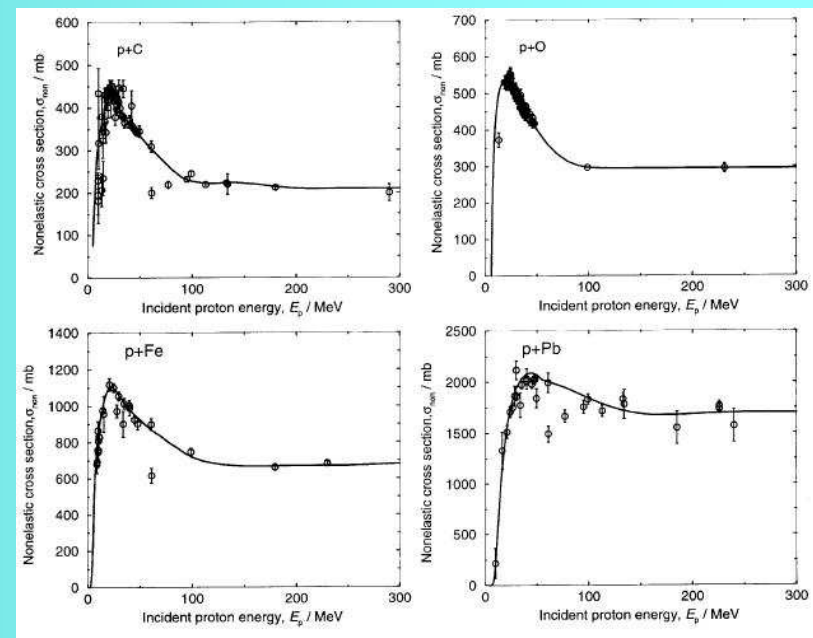
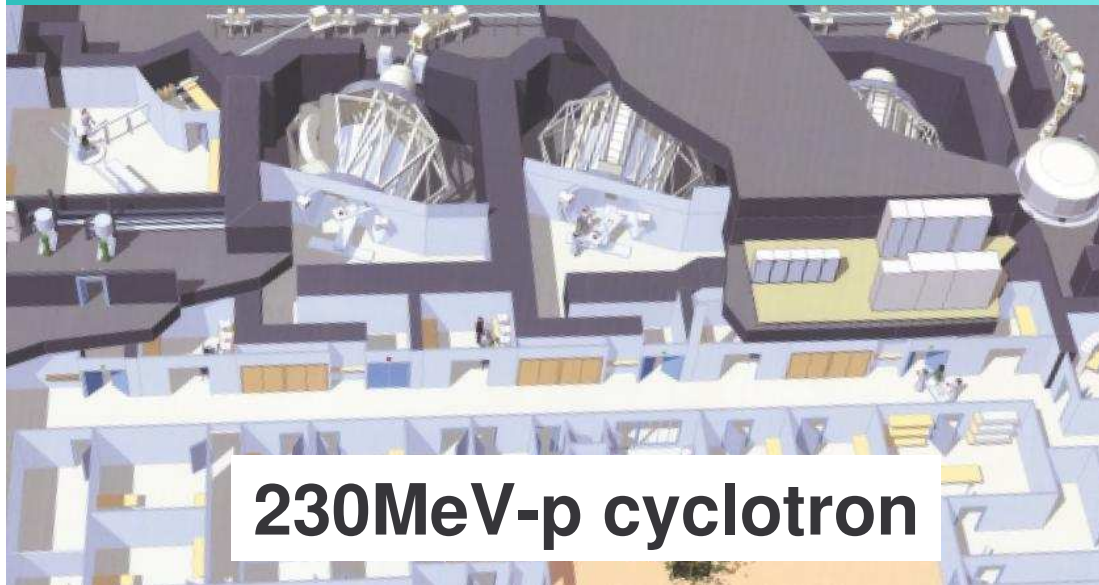
ラジオグラフィ (10 MeV)

30 min coarse scan
 150 × 225 mm²
 3 mm/sec

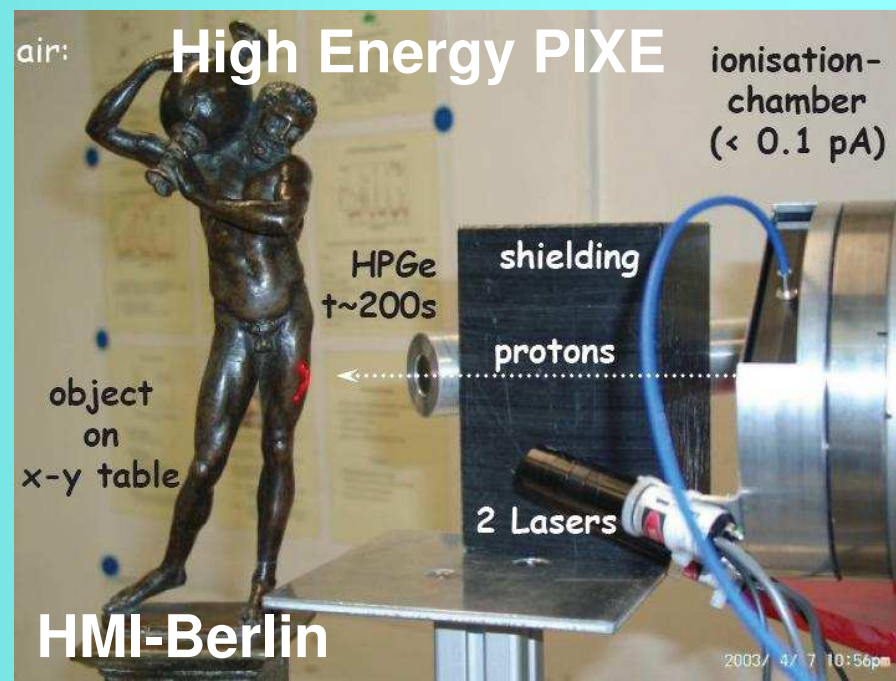
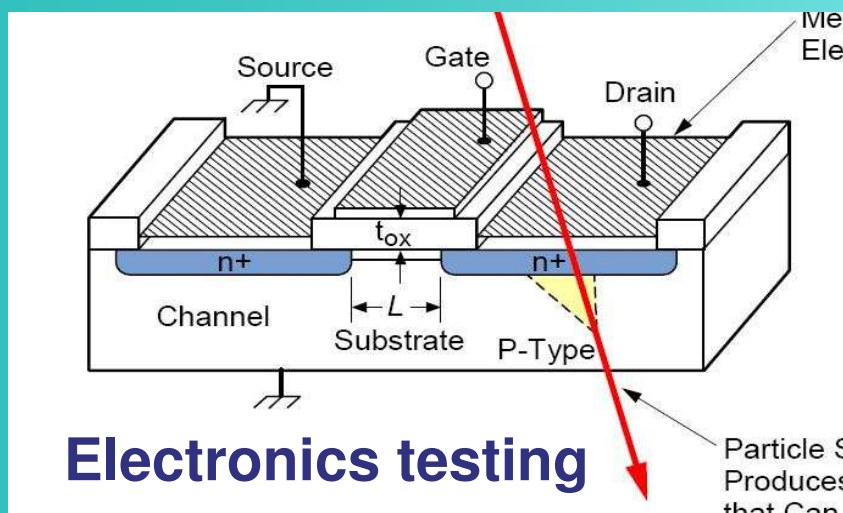
2 hrs fine scan
 100 × 70 mm² 0.5 mm/sec



- R&D on hadron therapy and medical imaging at Medical Physics Institute (IFIMED-Valencia), if funded



p and n beams for applications



- Nuclear Physics activities at the European Spallation Source, if it comes to Spain
- R&D on transmutation at the High Level Waste Temporal Centralized Repository (ATC), if the Associated Research Laboratory is funded



A list with links to Spanish groups in: <http://ific.uv.es/gamma/refinu/>

