Experimental Nuclear Physics in Mexican Facilities

Daniel José Marín Lámbarri

18/06/2024

Instituto de Ciencias Nucleares UNAM

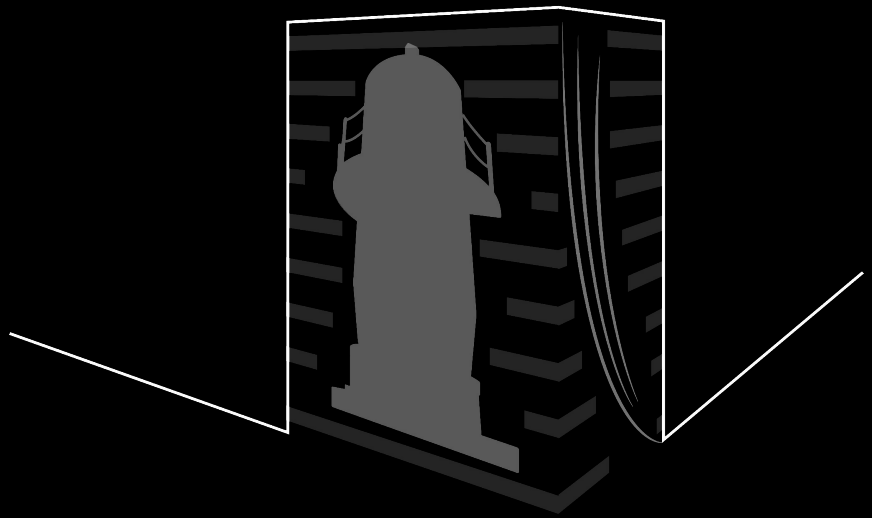
Instituto de Física UNAM

ININ

smf SOCIEDAD MEXICANA DE FÍSICA

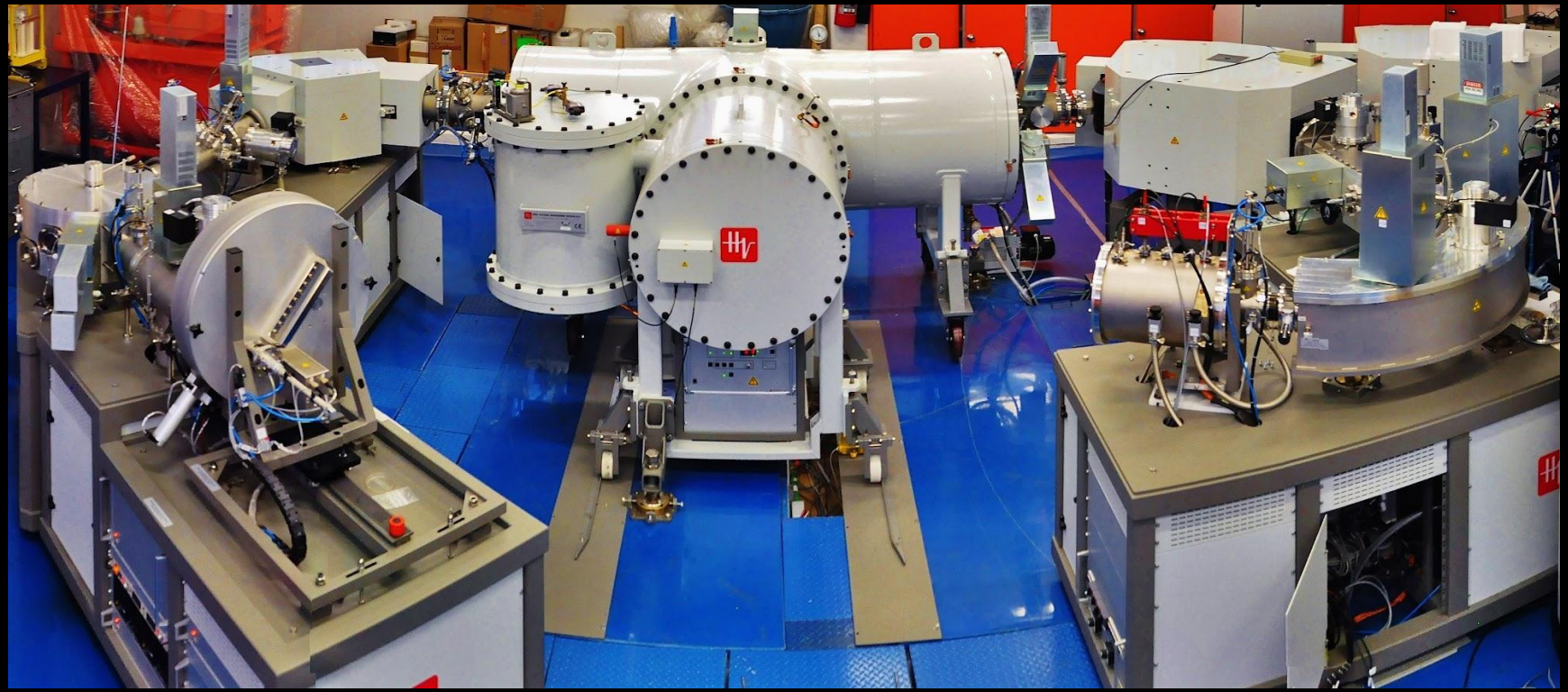
Outline

1. Accelerators in Mexico
2. Experiments @ the 5.5 and LEMA
3. Ongoing projects



LEMA IF

Laboratorio de Espectrometría de Masas con Aceleradores (LEMA) 1 MV Tandetron



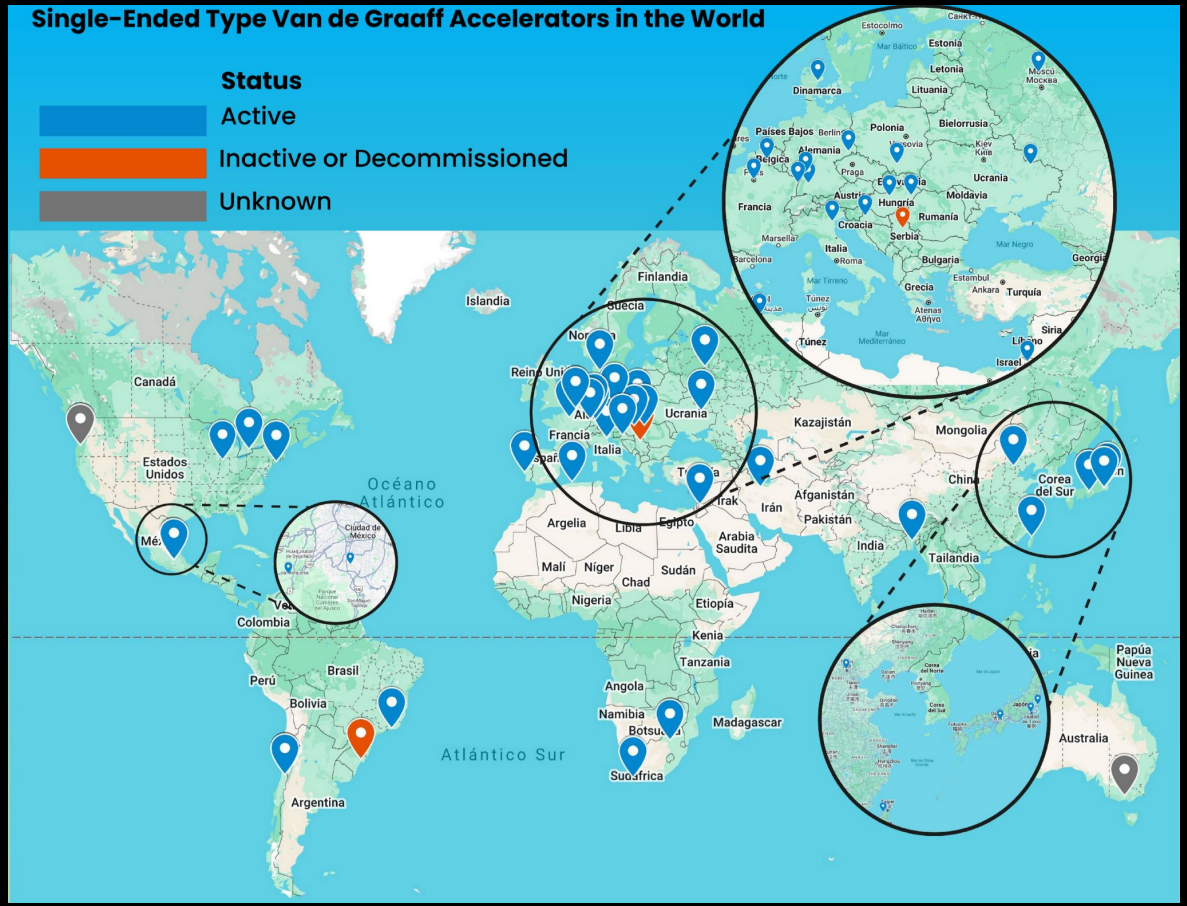
LEMA

2 MV Tandetron (2000) @ ININ

4 MV Tandem Pelletron (2005)

5.5 MV Single-ended CN-Van de Graaff (1988)

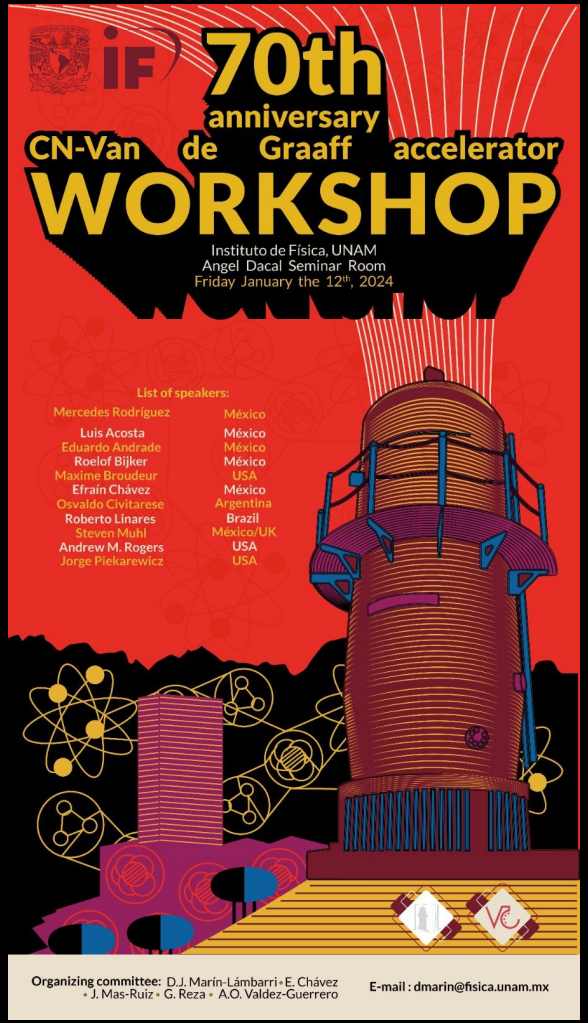
6 MV Tandem (1969) @ ININ



Taken from: E. Chávez presentation @ 70th anniversary CN-Van de Graaff accelerator WORKSHOP, January 2024

Was born in

1954!!!!!!!!!



Single-Ended 5.5 MV CN-Van de Graaff

Beams: p, d, ^{3}He, ^{4}He
I ≤ 10 μA

Logo: Alan Valdez

Over a 100 publications on Ion Beam Analysis (RBS, PIXE, NRA, ERDA) of surfaces and thin films (1990-2010)

Professor Eduardo Andrade

Supersonic gas jet target station.
E. Chávez, F. Favela

Monochromatic fast neutron production
E. Chávez, A. Varela.

Positron source:
O. de Lucio

Nuclear Astrophysics; far subbarrier fusion reactions:
L. Barrón

Atomic Physics and Material characterization by PIXE:
J. Miranda.

Ion Beam Analysis: RBS, ERDA, NRA.
E. Andrade.

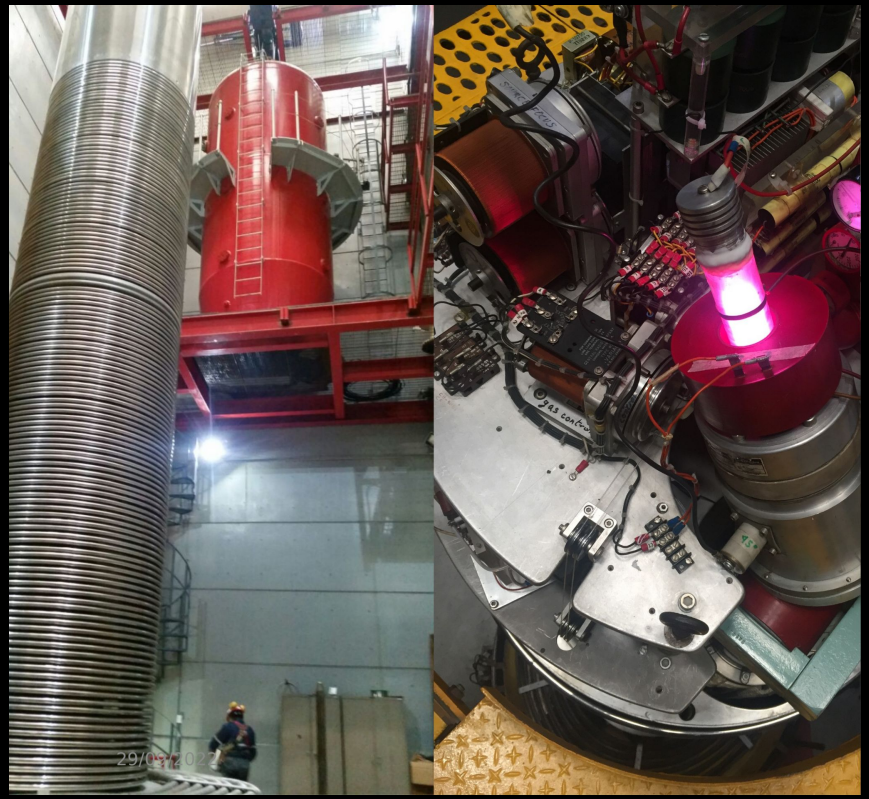
Taken from: E. Chávez presentation @ 70th anniversary CN-Van de Graaff accelerator WORKSHOP, January 2024

In 2023 a new configuration of the ion source allowed the injection of heavier ion beams

$E^{max}_{5.5}(^{132}Xe^{3+}) = 16$ MeV

C. G. Puigvert-Angulo, R. Espejel, C. Valencia, A. O. Valdez-Guerrero, J. Mas-Ruiz, R. Gleason, D. J. Marín-Lámbarri, H. Cruz-Manjarrez, J. C. Pineda, A. Huerta, E. Andrade, D. Belmont, R. Pérez-Damián, G. Reza, S. Sandoval-Hipólito, A. B. Zunun-Torres and E. Chávez **"Upgrading of the CN-Van de Graaff accelerator at IFUNAM", JINST, 16 (2021) T08013**

In 2017 the ion source suffered an incident



Taken from: E. Chávez presentation @ 70th anniversary CN-Van de Graaff accelerator WORKSHOP, January 2024

Activation Followed by Accelerator Mass Spectrometry (AFAMS)

Experiments @ the 5.5 MV single-ended CN-Van de Graaff:

Cross-section measurements using the Activation Followed by Accelerator Mass Spectrometry (AFAMS) protocole:

Samples are irradiated with ions (accALErators) or neutrons (Nuclear Reactors) and therefore analysed by the Accelerator Mass Spectrometry (AMS) technique.

$^{28}Si(d,\alpha)^{26}Al$
$^{13}C(n,\gamma)^{14}C$
$^{9}Be(n,\gamma)^{10}Be$

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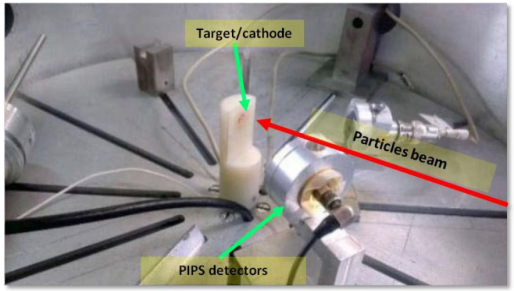
$^{28}Si(d,\alpha)^{26}Al$ @ the 5.5 and ININ



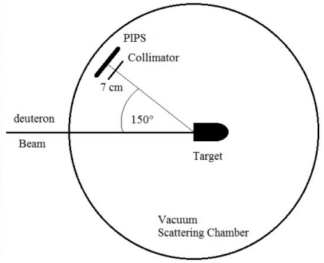
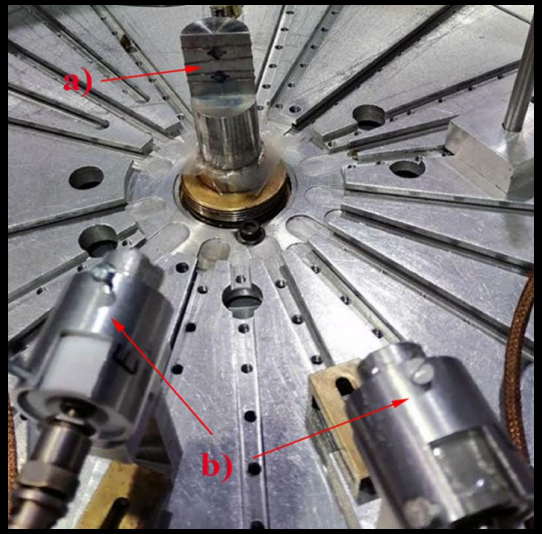


Fig. 2. Experimental setup for the first step of the technique, where a deuterium beam irradiates the target to produce ^{26}Al. Picture (left panel) and sketch (right panel). (see the text for details).



V. Araujo-Escalona, L. Acosta, E. Andrade, L. Barrón-Palos, O. de Lucio, F. Favela, A. Huerta, E. López, P. Santa Rita, C. Solís, E. Chávez, **The $^{28}Si(d,\alpha)^{26}Al$ reaction. J. Phys. CS 730, 012003 (2016)**

V. Araujo-Escalona, L. Acosta, E. Andrade, L. Barrón-Palos, O. de Lucio, F. Favela, A. Huerta, E. López, P. Santa Rita, C. Solís, E. Chávez, **Study of the $^{28}Si(d,\alpha)^{26}Al$ nuclear reaction at low energies. Phys. Procedia 90, 421–428 (2017)**

L. Acosta et al., Reaction production+AMS: an alternative method to study low energy reactions. **^{26}Al as a test case. Eur. Phys. J. W. C 165, 01001 (2017)**

G. Reza, A. B. Zunun-Torres, S. Padilla, J. Mas-Ruiz, **D. J. Marín-Lámbarri,** L. Acosta, P. Amador-Valenzuela, E. Andrade, D. Belmont, L. E. Charón, A. Huerta, D. Godos-Valencia, J. N. Martínez, C. G. Méndez, E. Moreno, G. Murillo, R. Policroniades, M. Rodríguez-Ceja, S. Sandoval-Hipólito, V. R. Sharma, C. Solís, A. Varela, P. Villaseñor and E. Chávez **"AMS cross-section measurement for the $^{28}Si(d,\alpha)^{26}Al$ reaction near the Coulomb barrier", Eur. Phys. J. Plus 135, 899 (2020)**

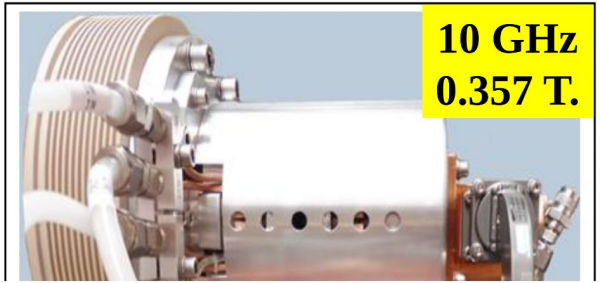
LEMA iF

Ongoing project to design and construct an
Electron Cyclotron Resonance Ion Source
(ECRIS)
High intensity light ions and high energy heavy ions

Professor Efraín Chávez

ECR ION SOURCE

Model SO-150

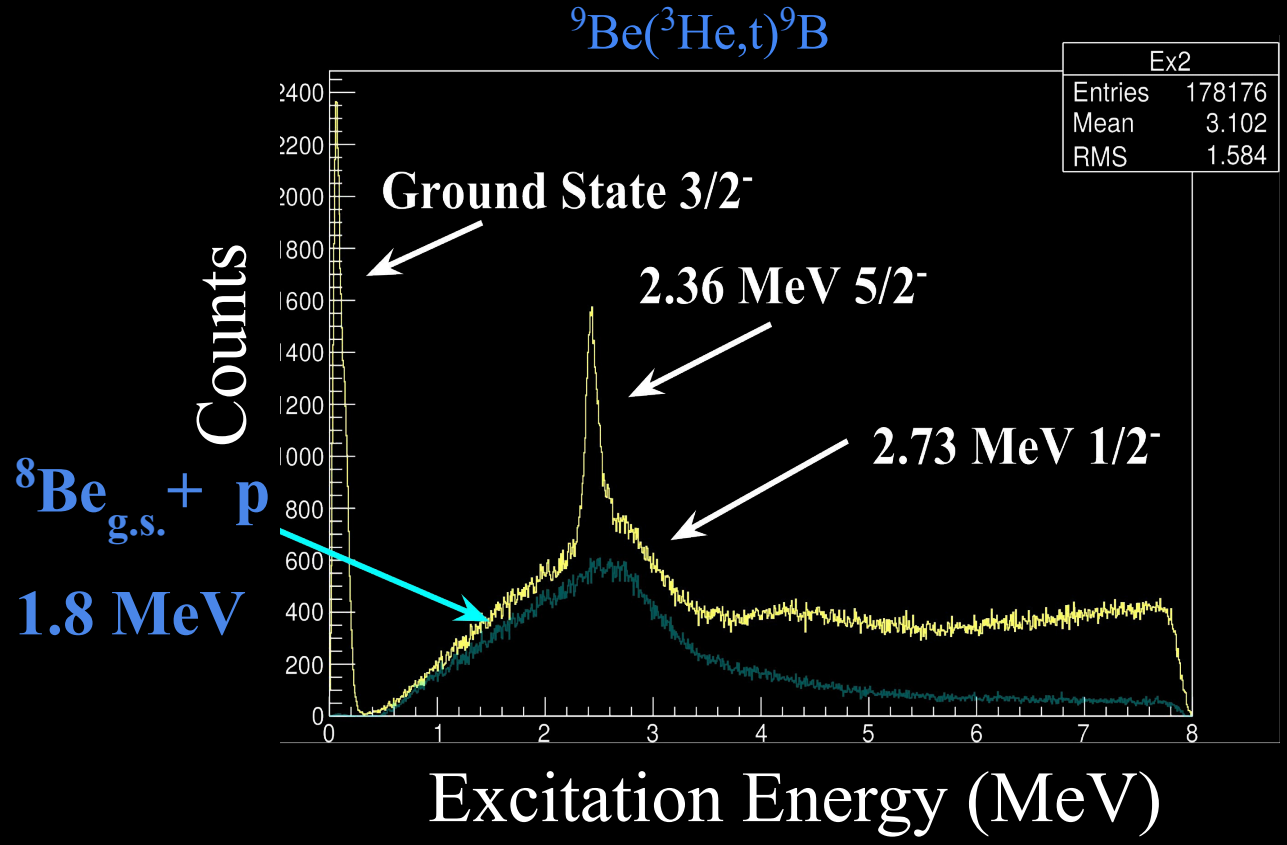


Features

- High ion beam currents
- Positive ions
- Reliable operation
- Low maintenance
- Full permanent magnet
- Low power consumption
- Compact design
- Light weight

Specie	Electrical current	Specie	Electrical current
$^{1}H^{+}$	> 3 mA	$^{16}O^{+2}$	400 µA
$^{4}He^{+}$	> 3 mA	$^{16}O^{+4}$	50 µA
$^{4}He^{+2}$	300 µA	$^{40}Ar^{+4}$	100 µA
$^{12}C^{+}$	700 µA	$^{40}Ar^{+8}$	40 µA *
$^{12}C^{+2}$	200 µA	$^{129}Xe^{+8}$	20 µA
$^{12}C^{+4}$	5 µA	$^{129}Xe^{+12}$	3 µA
$^{16}O^{+}$	> 1.5 mA		

Taken from: E. Chávez presentation @ 70th anniversary CN-Van de Graaff accelerator WORKSHOP, January 2024



D. J. Marín-Lámbarri et al.. *"Investigation of the low-lying excitation region in ^{9}B" - South African Institute of Physics,* **(2018), 107-111.**

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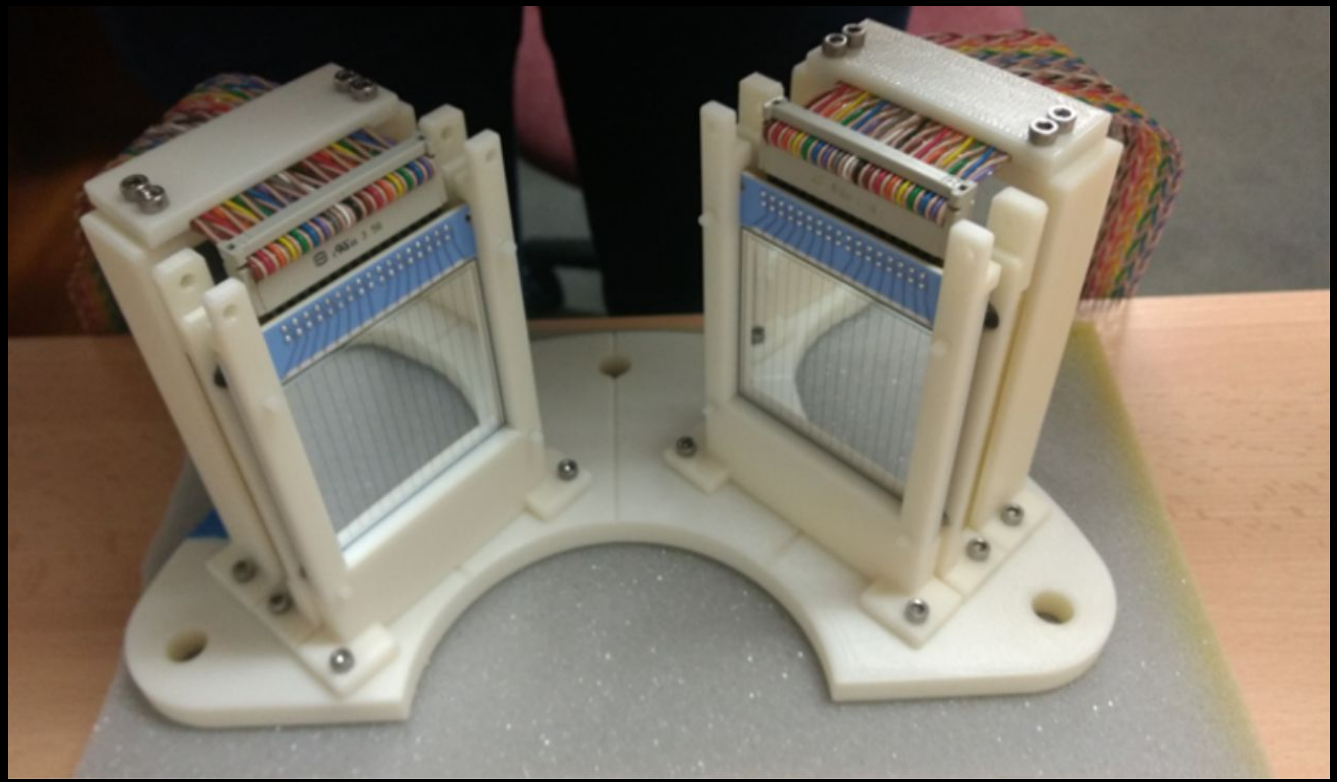
Experimentos (estructura nuclear)

Estudio de la reacción $^{9}Be(p,n)^{9}B$ con la finalidad de observar conclusivamente el primer estado excitado de ^{9}B.

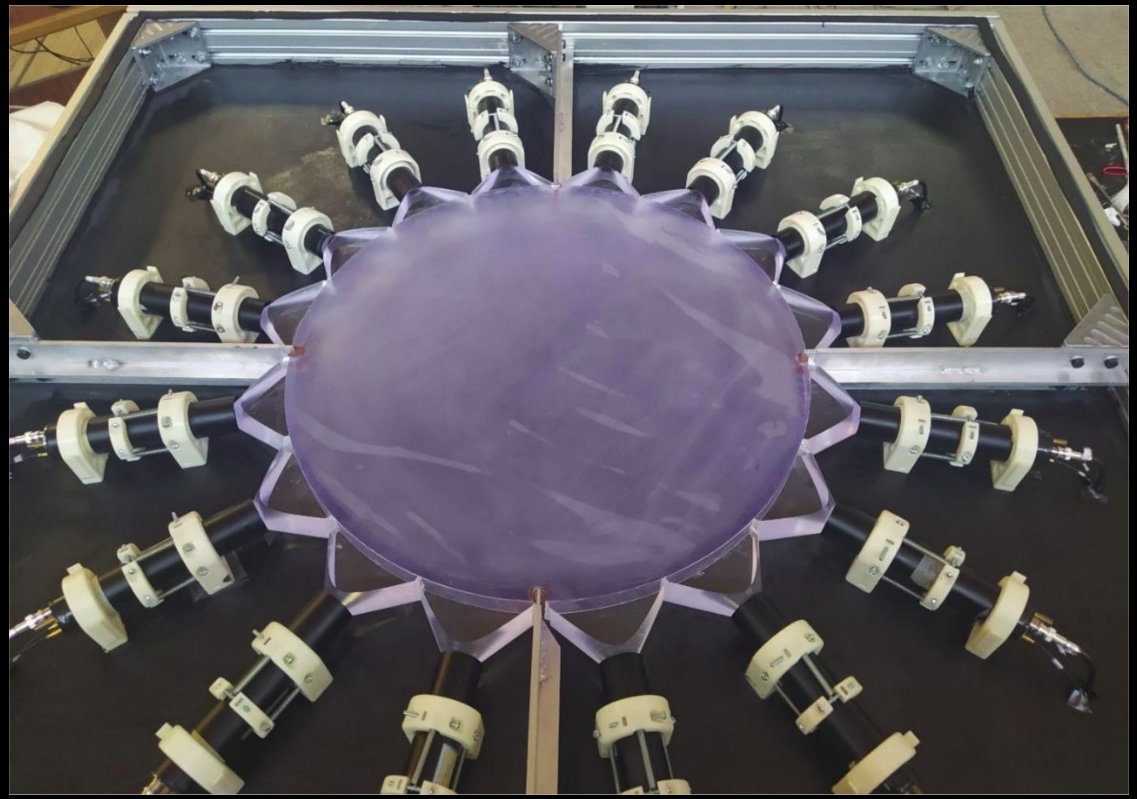
MOmentum Neutron DEtector II
MONDE II
&
SIstema Móvil de Alta Segmentación
SIMAS

LEMA IF

SIstema Móvil de Alta Segmentación
SIMAS



MONDE II



Poster session: Luis Yaid Reyes Miranda

Laboratorio de Espectrometría de Masas con Aceleradores (LEMA) 1 MV Tandetron

Main goal @ LEMA is ^{14}C, ^{10}Be, ^{26}Al dating

When the big bosses are not around

Experiments @ the 5.5 MV single-ended CN-Van de Graaff:

Cross-section measurements using the Activation Followed by Accelerator Mass Spectrometry (AFAMS) protocole:

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$^{28}Si(d,\alpha)^{26}Al$
$^{13}C(n,\gamma)^{14}C$
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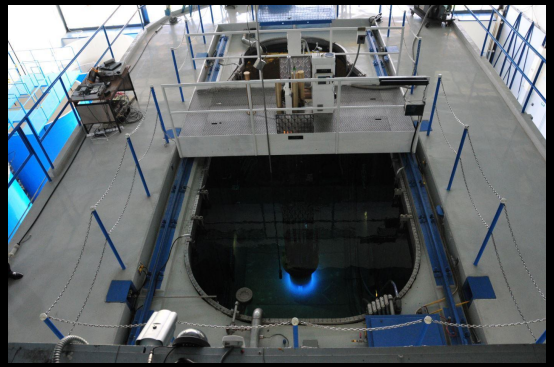

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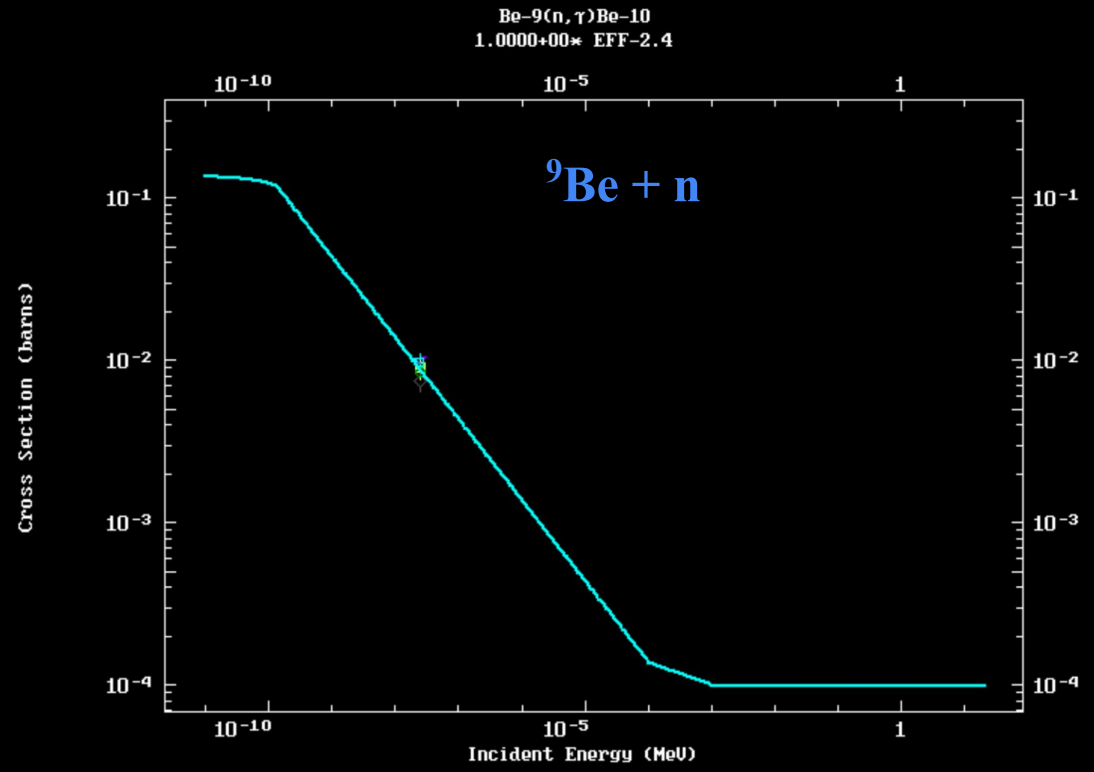

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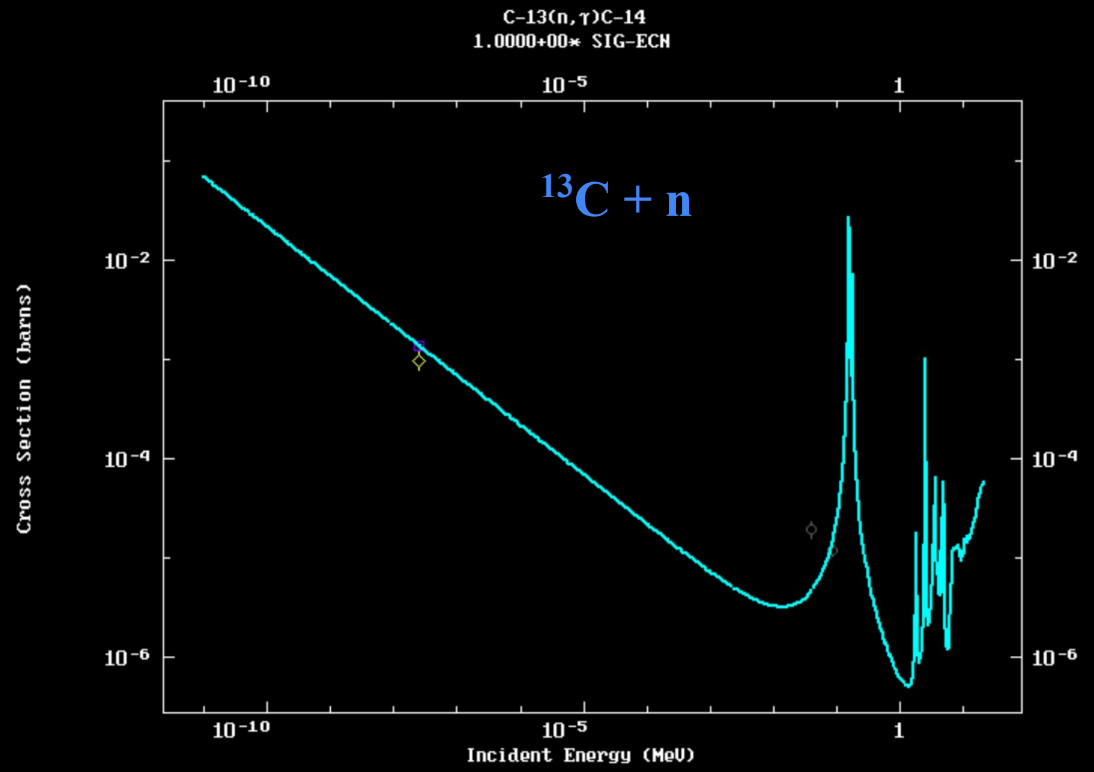
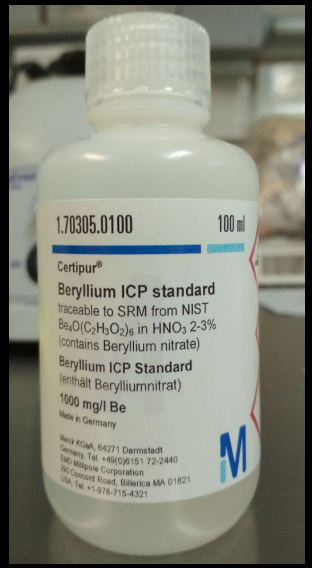
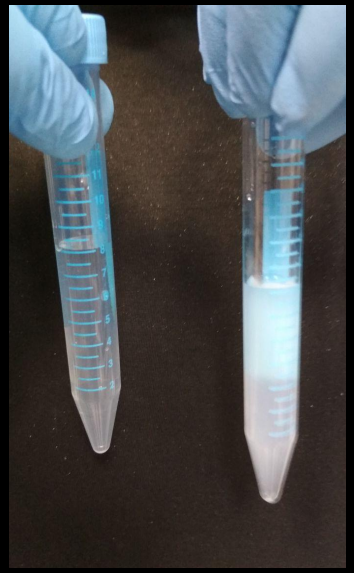
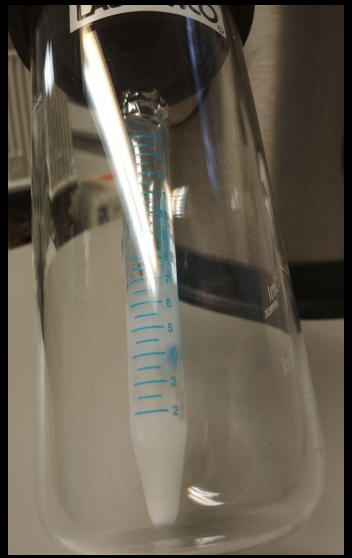


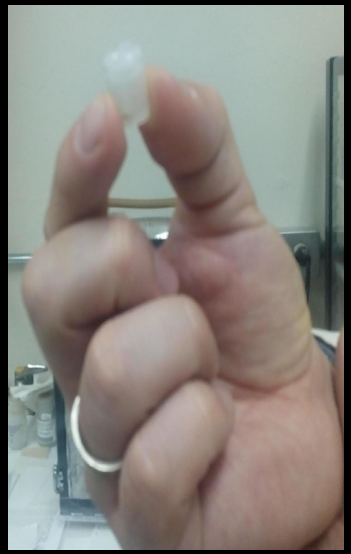
LEMA iF

Sample Preparation
Cosmogenic Isotopes Laboratory @ LEMA)





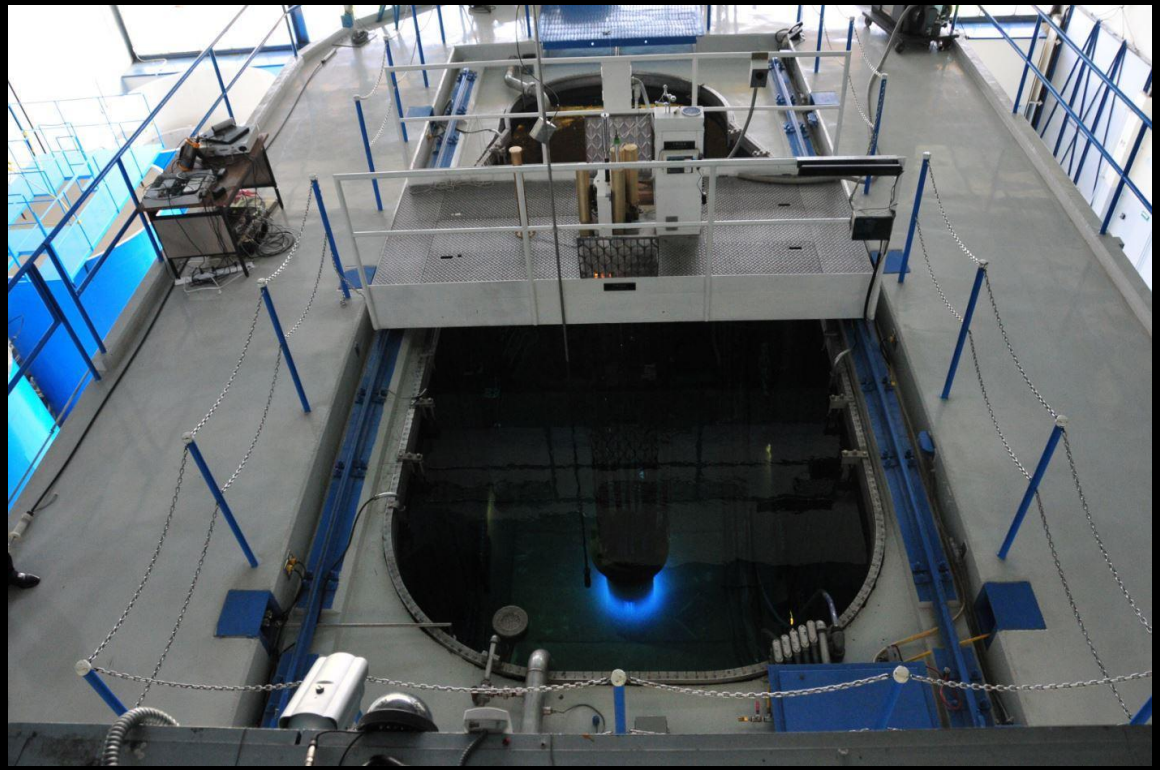




Dra. G. Méndez
Dr. Santiago Padilla

LEMA iF

TRIGA MARK III Instituto Nacional de Investigaciones Nucleares (ININ)



LEMA iF

Irradiated sample inside the cathode, prepared by **Sergio Martínez González**

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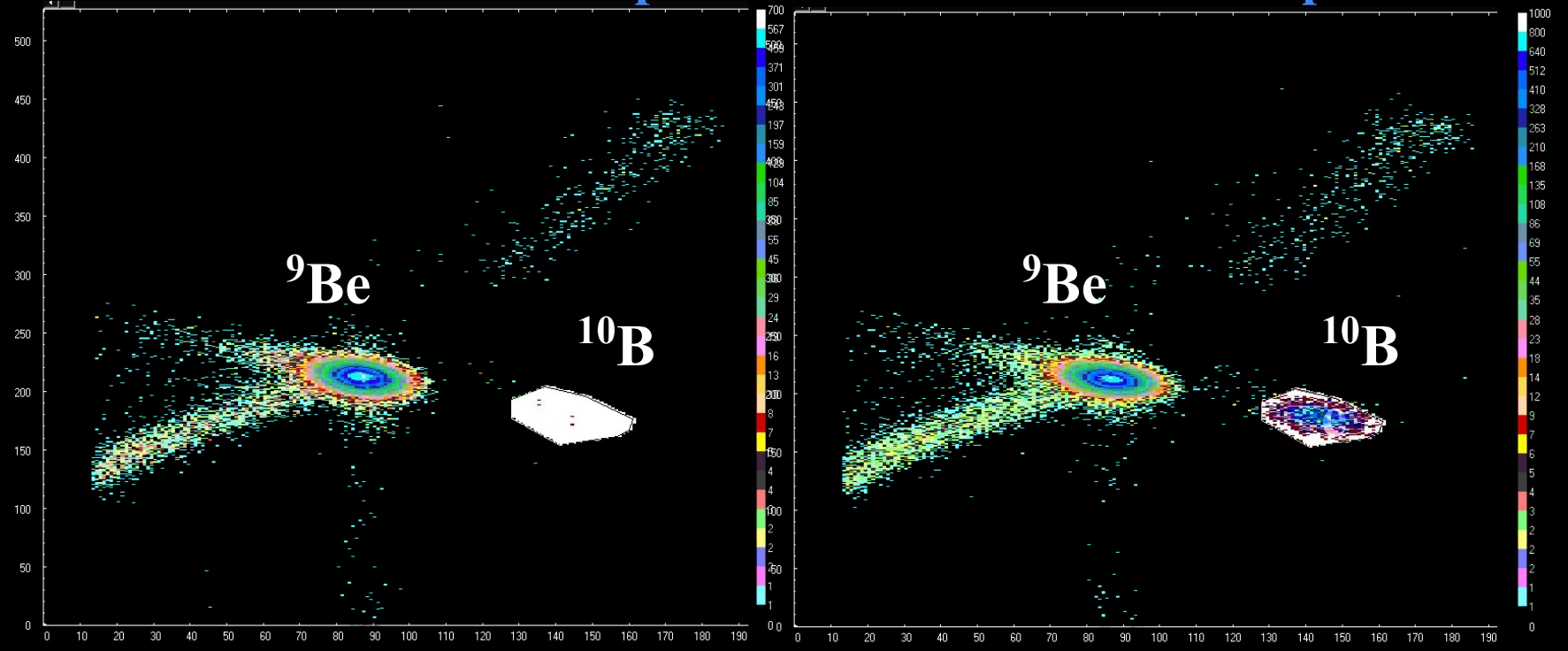
Laboratorio de Espectrometría de Masas con Aceleradores (LEMA) 1 MV Tandetron

Non Irradiated Sample

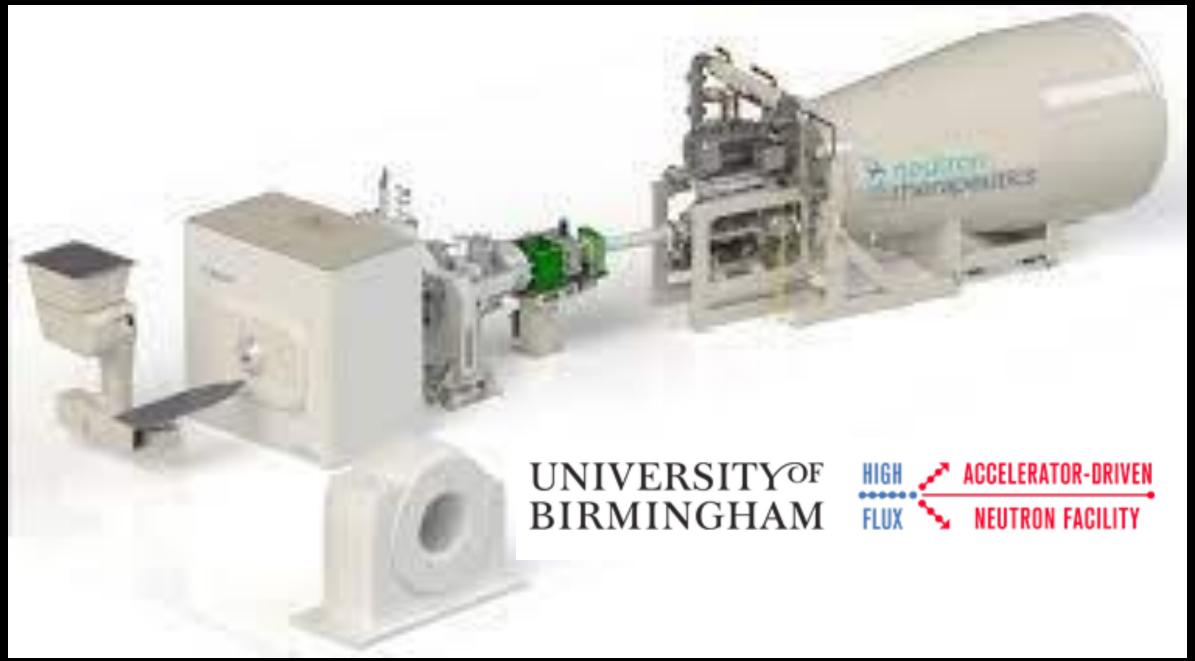
Irradiated Sample



D. J. Marín-Lámbarri, et. al., Phys. Rev. C, 102, 044601 (2020)

LEMA

High Flux Accelerator-Driven Neutron Facility, University of Birmingham, UK



Extension of the project, near future.

LEMA iF

$^{14}C/^{12}C$ Isotopic Ratio of a Research Nuclear Reactor Graphite Control Bar

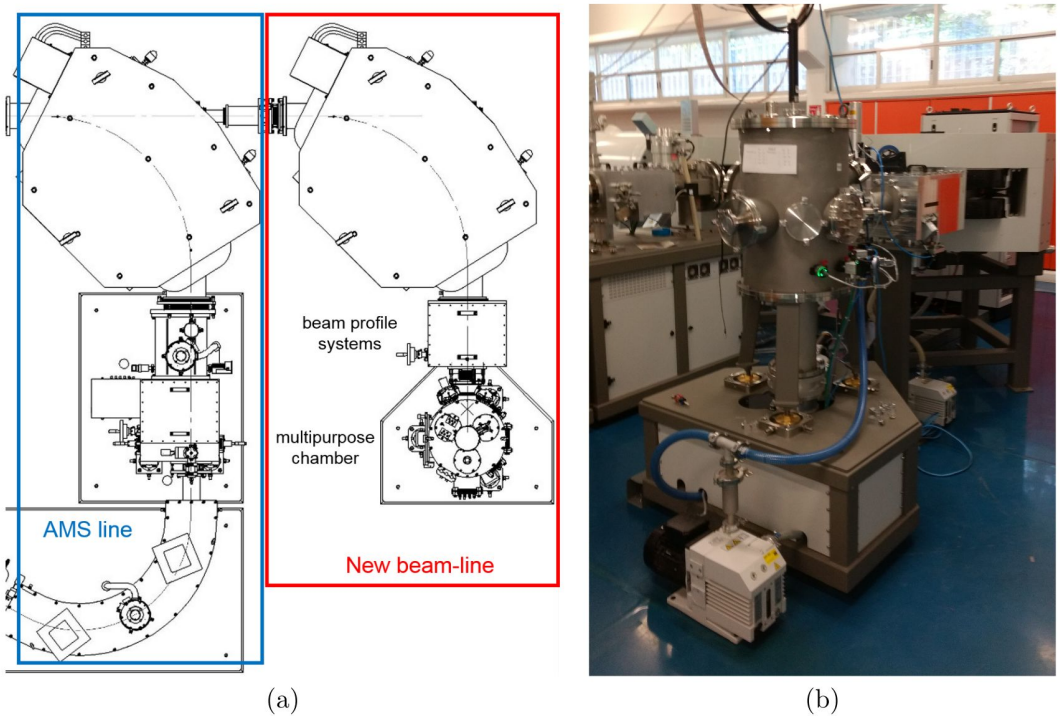
D. Belmont, D. J. Marín-Lámbarri, et al. **"$^{14}C/^{12}C$ Isotopic Ratio of a Research Nuclear Reactor Graphite Control Bar", Nucl. Instrum. Methods Phys. Res., Sect. B, 485 (2020) 10–12**

LEMA iF

Laboratorio de Espectrometría de Masas con Aceleradores (LEMA) 1 MV Tandetron

In 2017 a New Beam Line was commissioned

Nuclear Physics Beam Line @ LEMA



(a) (b)

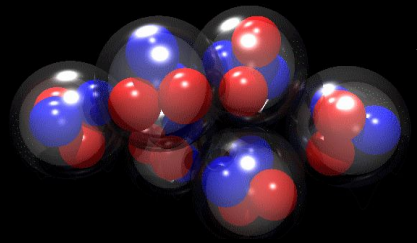
Figure 1. The new LEMA beam-line (a) Layout of LEMA-lines (top view); on the left the previous AMS line and on the right the new beam-line (bending+monitors+chamber). (b) Picture of the new LEMA beam-line where the multi-purpose chamber an all its accessories can be seen.

L. Acosta *et al.* **"Perspectives for low energy reactions measurements at the new LEMA beam-line" J. Phys.: Conf. Ser. 1643 012029 (2020)**

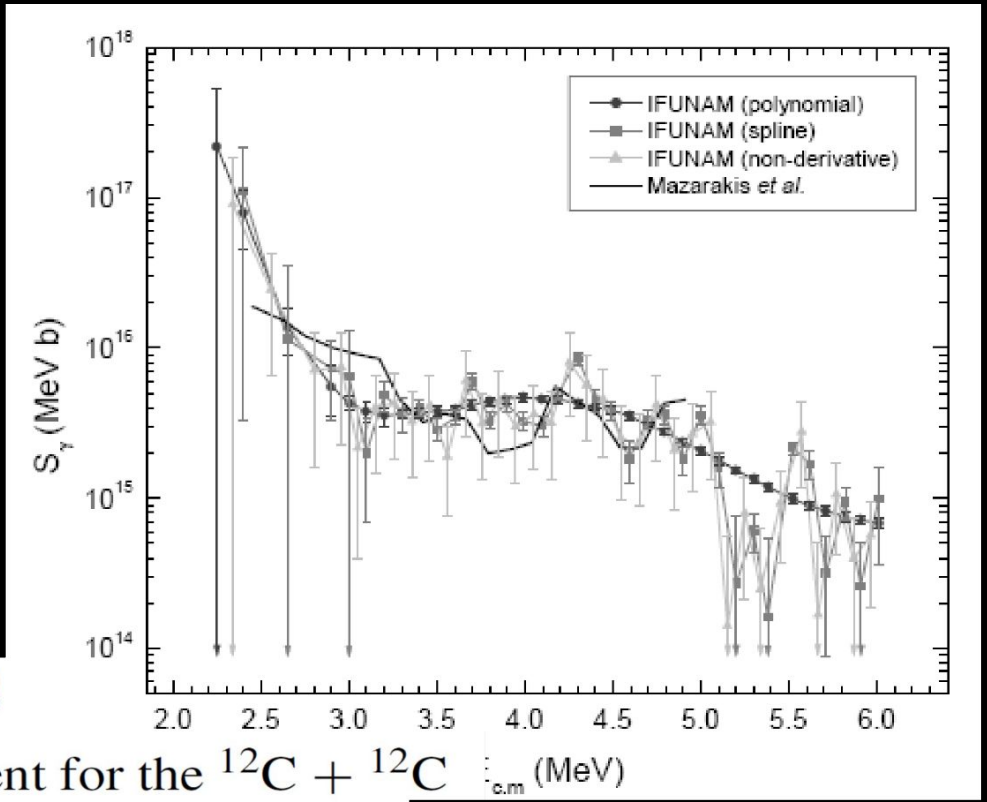
LEMA

Present projects @ LEMA

$^{12}C + {}^{12}C$ reaction



^{24}Mg



Nuclear Physics A 779 (2006) 318–332

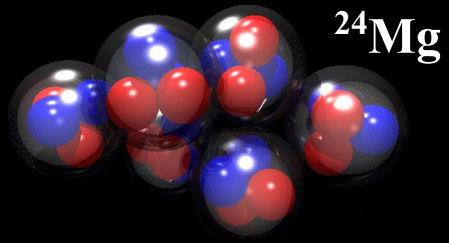
Absolute cross sections measurement for the $^{12}C + {}^{12}C$ system at astrophysically relevant energies

L. Barrón-Palos [a,*], E.F. Aguilera [b], J. Aspiazu [b], A. Huerta [a], E. Martínez-Quiroz [b], R. Monroy [a], E. Moreno [b], G. Murillo [b], M.E. Ortiz [a], R. Policroniades [b], A. Varela [b], E. Chávez [a]

-Instrumentation development for gamma-ray measurements:

$^{12}C + {}^{12}C$ reaction

Prototype:

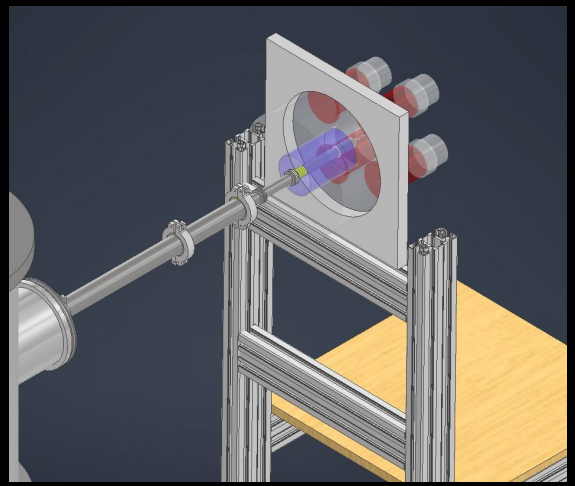


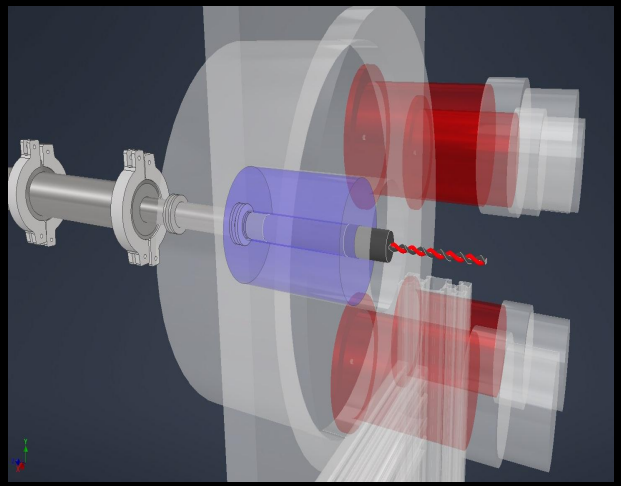
Design a detection array composed by a LaBr3/HPGe immersed in a NaI/organic scintillator as an active shield, immersed in a led shielding.

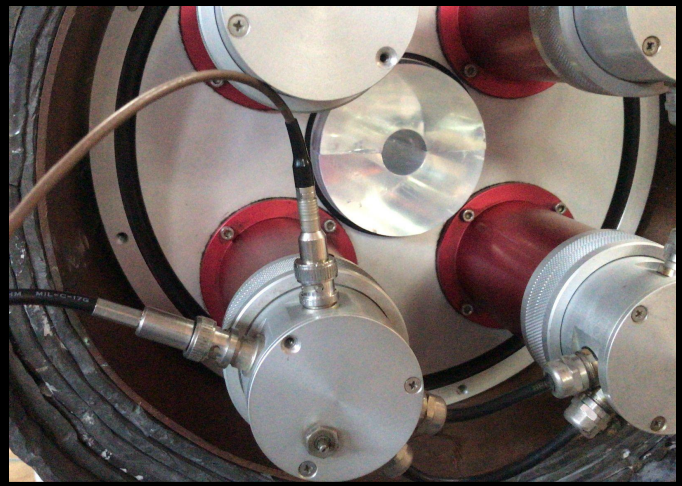
Poster Session: Frida Quintero and Jonathan Méndez

LEMA iF

LaBr3 detector immersed in an organic scintillator **BC-408, immersed in a NaI** (prototype II).



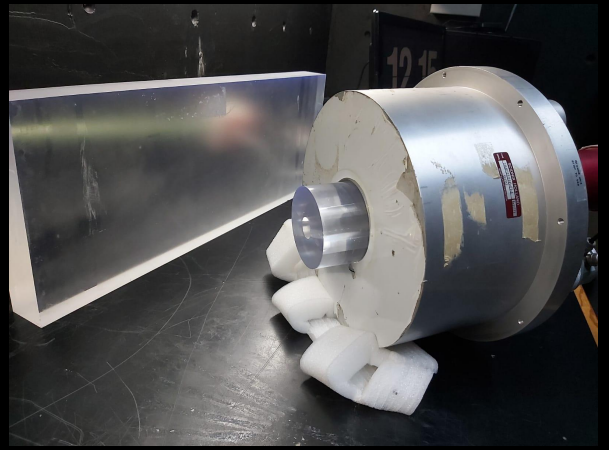


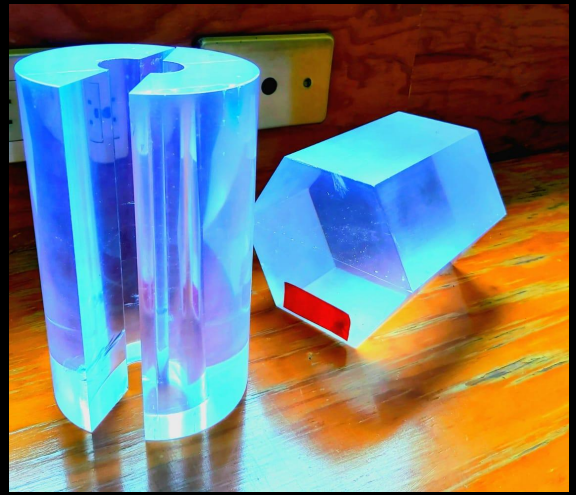


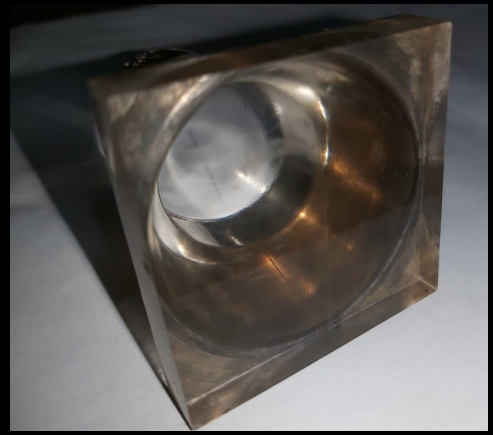
Render por Ing. Carlos Valencia

LEMA iF

Maquinado en el **Taller del IFUNAM** y plateado en el **Taller del Instituto de Astronomía.**





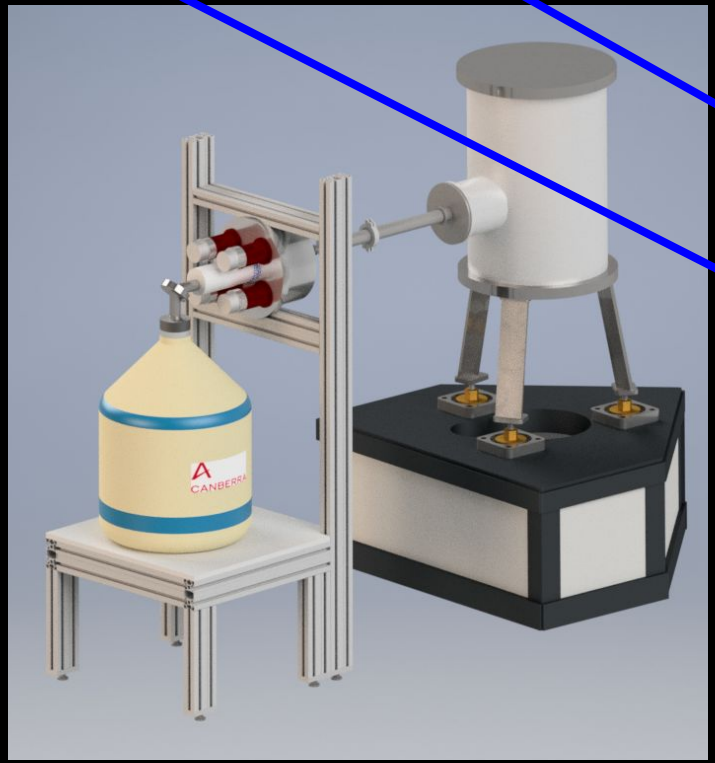


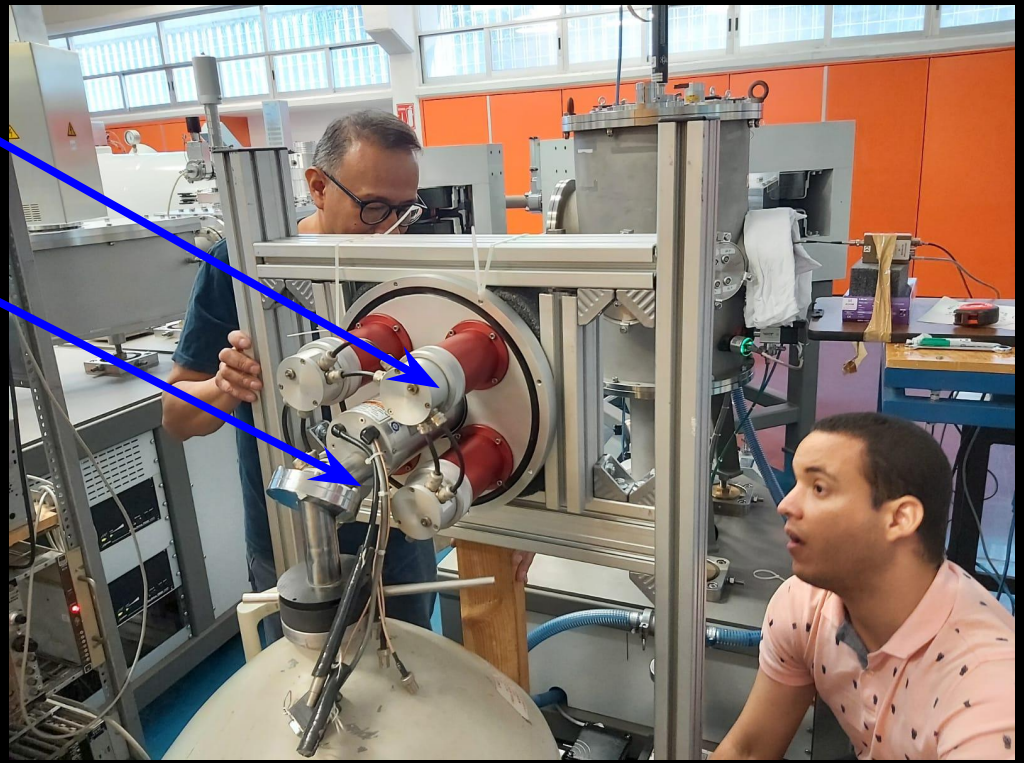
Gerardo Meza

Jesús Galindo

@ LEMA

High Purity Germanium detector immersed in an **inorganic scintillator NaI** (prototype I).





Render: Ing. Carlos Valencia

Test $^{nat}Mg(p,\gamma)$ reaction

Jonathan Méndez García

Luis Enrique Martínez Navarro

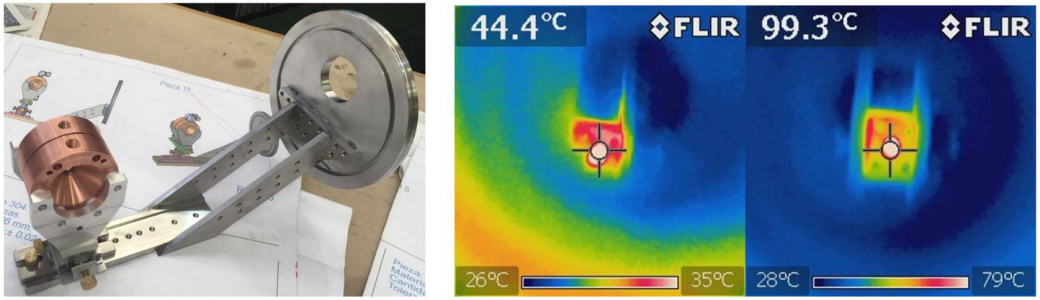
Frida Quintero Villegas

Oscar Eduardo López López

Arcadio Huerta, Accelerator operator @ LEMA

LEMA IF

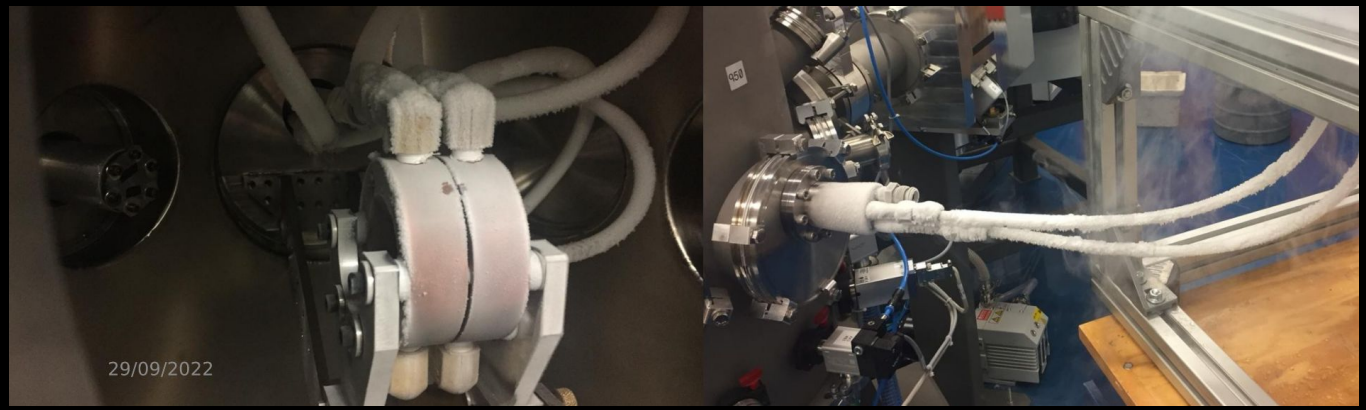
L. Acosta *et al.* **“Perspectives for low energy reactions measurements at the new LEMA beam-line” J. Phys.: Conf. Ser. 1643 012029 (2020)**



(a) (b)

Figure 3. Experiment for target tolerance to high beam intensity. (a) The cooling target holder performed for the experiment. (b) Pictures taken with a thermo-camera showing the heating of target due to the beam interaction for 44°C and 99°C without cooling (see the text for details).

NUMEN Collaboration



LEMA

J. Mas Ruiz, K. Gutierrez Zayas-Bazán, P. G. Zayas-Bazán, A. Huerta, J. Sastré-Hernández, D. J. Marín-Lámbarri, L. Acosta, E. Andrade, C. Solís and E. R. Chávez Lomelí. **"Probing the Elastic Scattering Differential Cross Section for Al + p at Backward Angles in a Low Energy Regime"**, **Universe, 9, 438 (2023)**

universe

MDPI

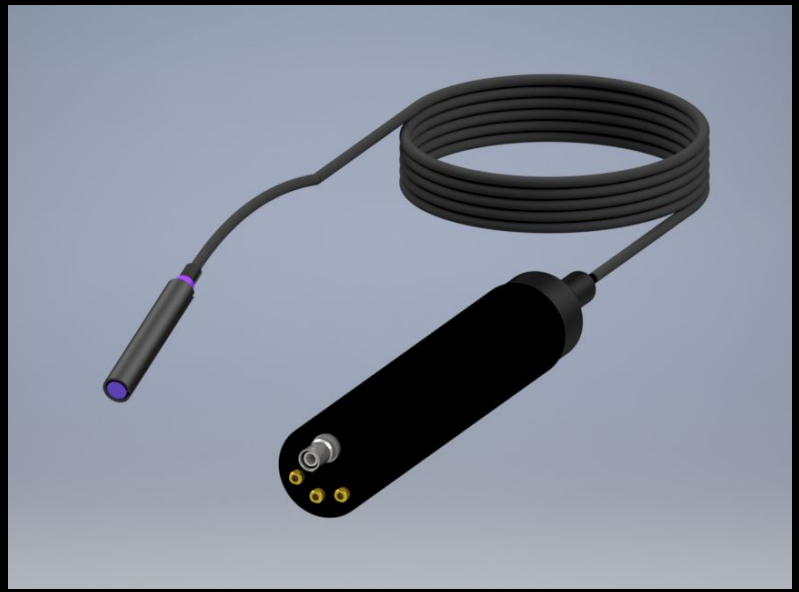
Article

Probing the Elastic Scattering Differential Cross Section for Al + p at Backward Angles in a Low Energy Regime

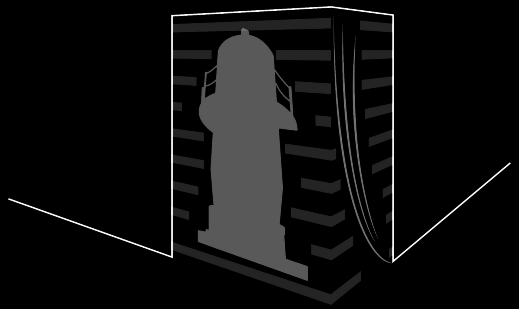
Javier Mas Ruiz [1,*], Karla Gutierrez Zayas-Bazán [2], Patricia G. Zayas-Bazán [3], Arcadio Huerta [4], Jorge Sastré-Hernández [5], Daniel José Marín-Lámbarri [4], Luis Acosta [4], Eduardo Andrade [4], Corina Solís [4] and Efrain R. Chávez Lomelí [4]

Poster Session: Luis E. Martínez

In situ measurement of intense gamma radiation fields using an organic scintillator



¡Gracias!



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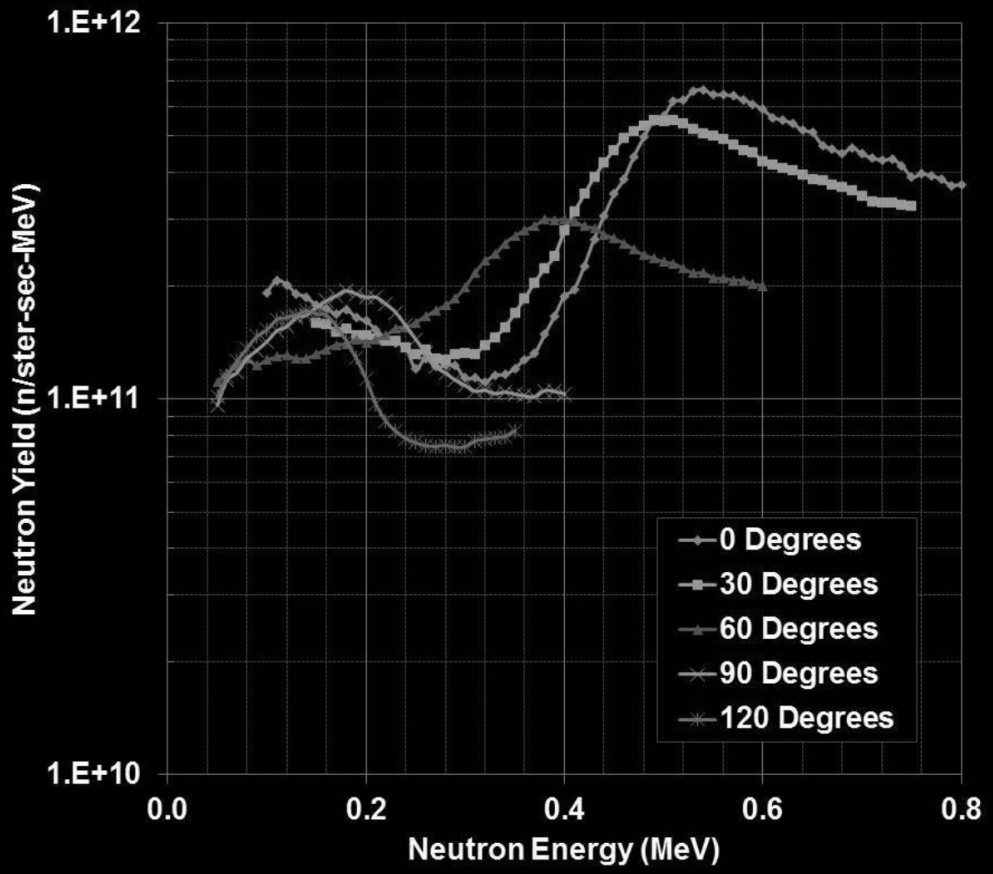
Appendix Figure 2: Neutron Flux Comparison



Results from MCNP6 calculations normalised to 1 mA.

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