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Preliminary results from thick-target measurements of the 27Al(alpha,n)30P reaction cross-section using miniBELEN-10A

By Nil Mont Geli

On behalf of the MANY collaboration

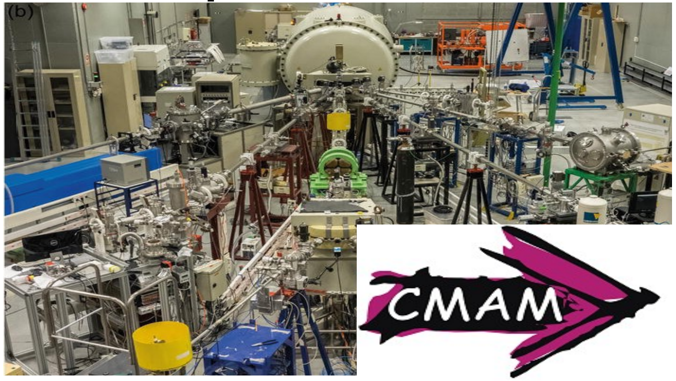
Institut de Tècniques Energètiques – Universitat Politècnica de Catalunya (INTE - UPC))

Institute of Energy Technologies – Technical University of Catalonia

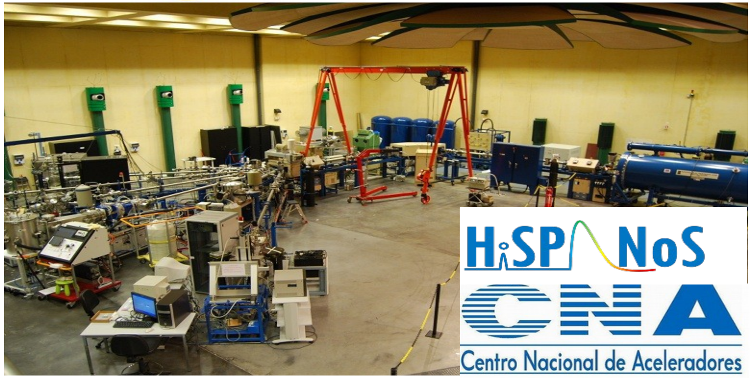
The MANY Collaboration

Two Spanish facilities

Infraestructuras Científicas y Técnicas Singulares



CMAM



HiSPANoS
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Centro Nacional de Aceleradores

UPC

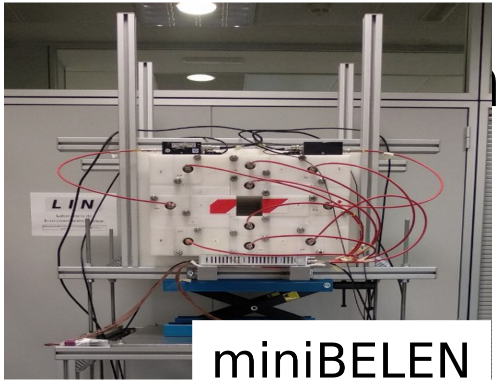
Universidad de Sevilla

IFIC
Institut de Física Corpuscular

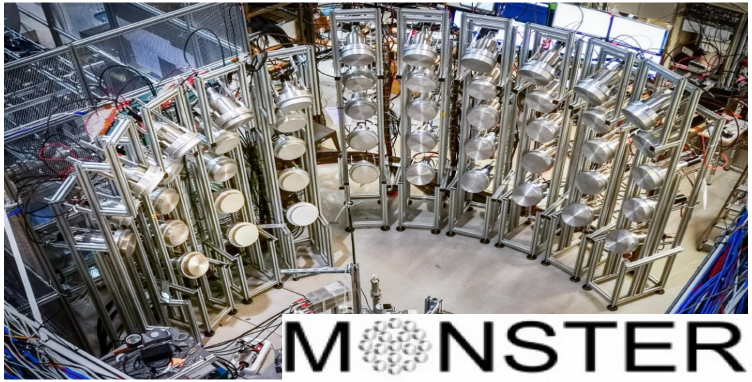
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Universidad Complutense Madrid

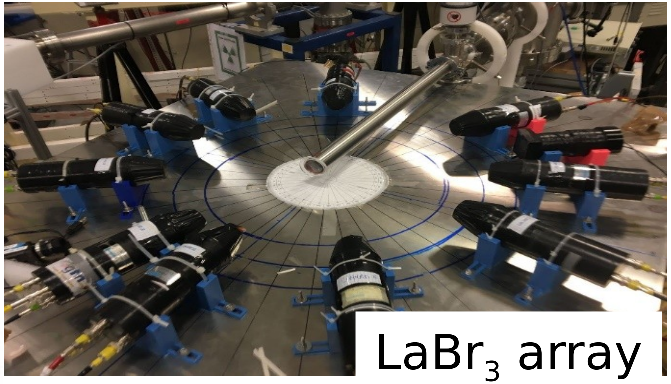
IEM
Instituto de Estructura de la Materia



miniBELEN



MONSTER



$LaBr_3$ array

miniBELEN-10A

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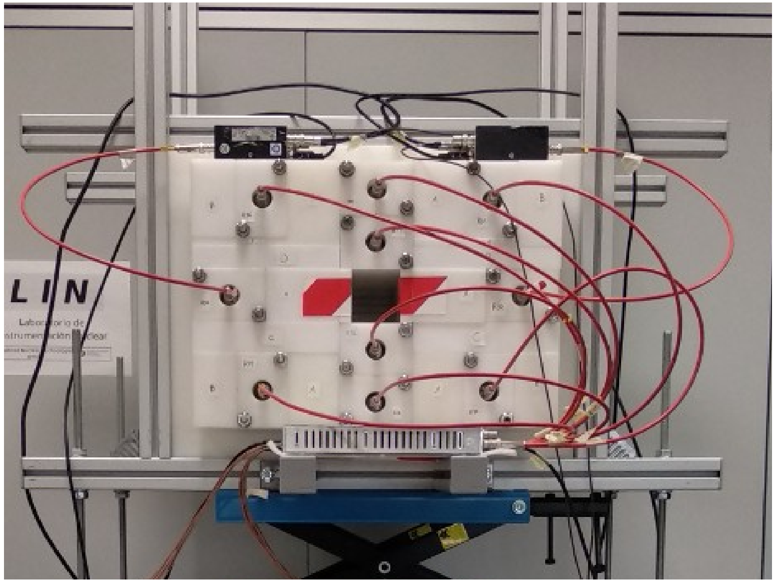
Main characteristics

- Long counter tehcnique: thermal neutrons counters (^{3}He) + moderator (hihg density polyethylene).
- Detection efficiency nearly independent from the neutron energy (**<u>flat response</u>**) up to 8/10 MeV.
- Modular moderator.



N. Mont-Geli *et al.*, EPJ Web of Conferences (2023)

miniBELEN-10A

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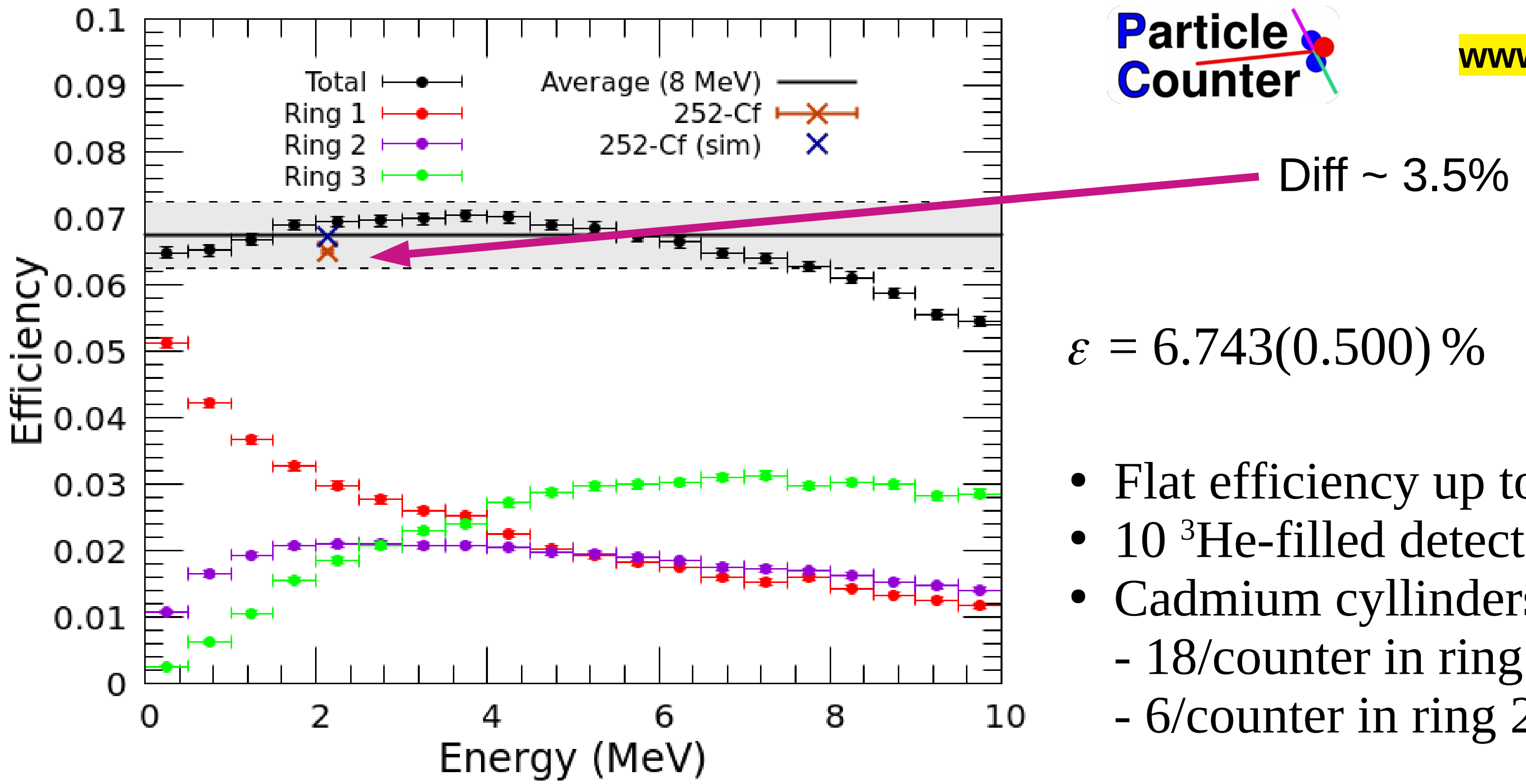


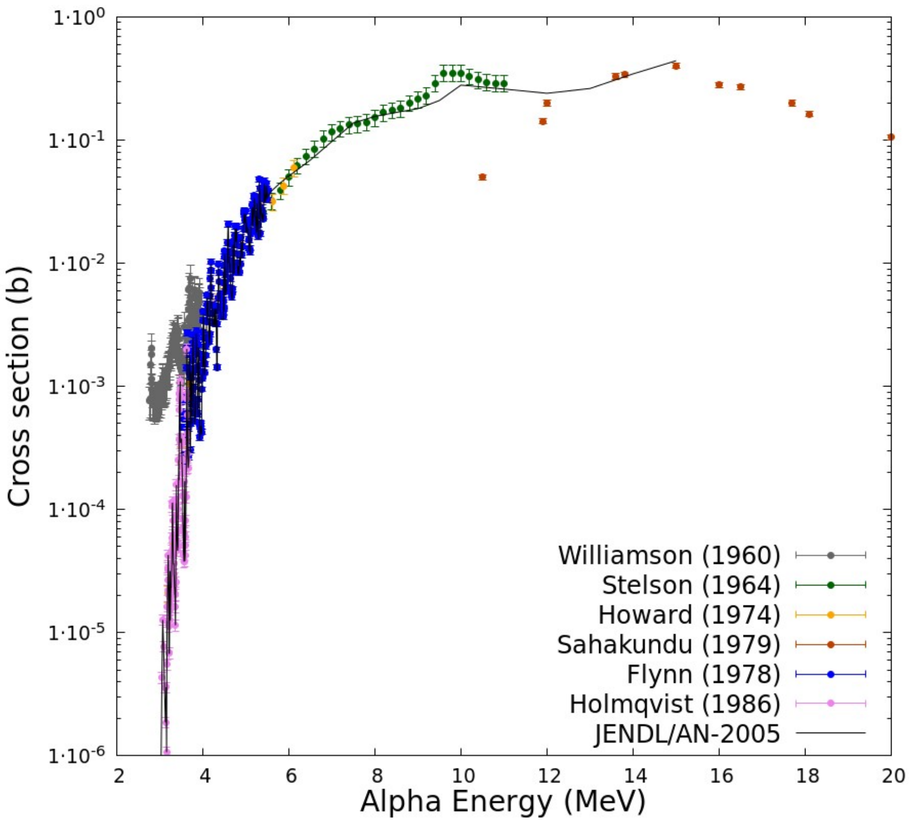
Particle Counter

www.particlecounter.net

$$\varepsilon = 6.743(0.500)\,\% \qquad \delta\varepsilon = \frac{\varepsilon_{max} - \varepsilon_{min}}{2}$$

- Flat efficiency up to 8 MeV.
- 10 ^{3}He-filled detectors.
- Cadmium cyllinders:
  - 18/counter in ring 1 (60% coverage).
  - 6/counter in ring 2 (20% coverage).

$^{27}Al(\alpha,n)^{30}P$ cross-sections



$^{27}Al(\alpha,n)^{30}P$ cross-sections

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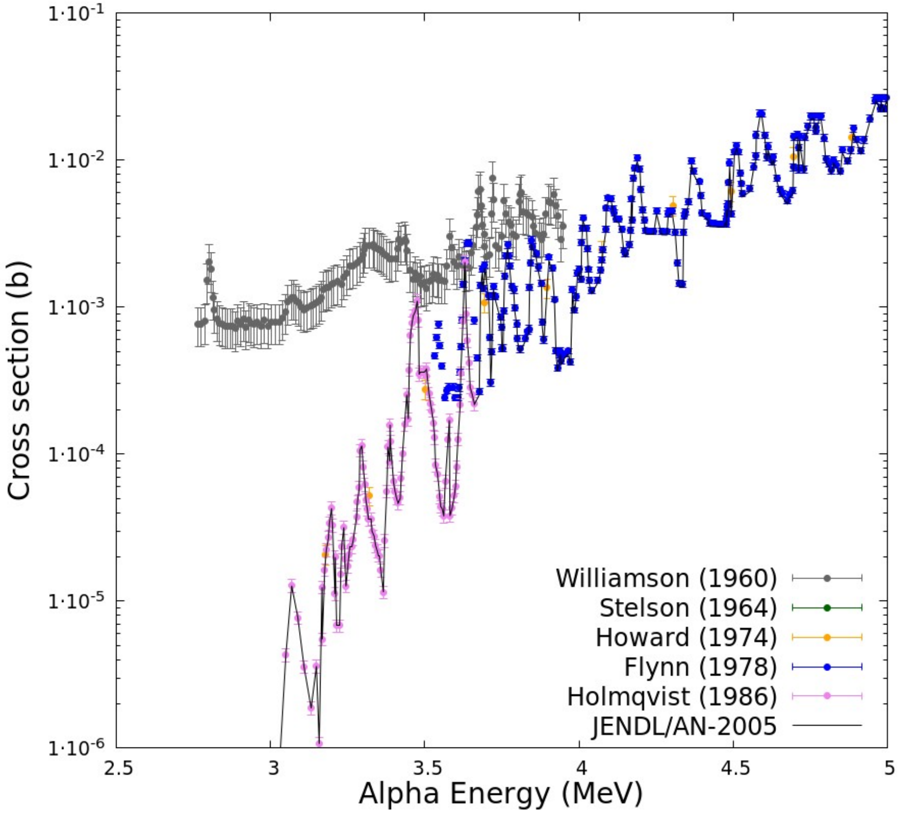

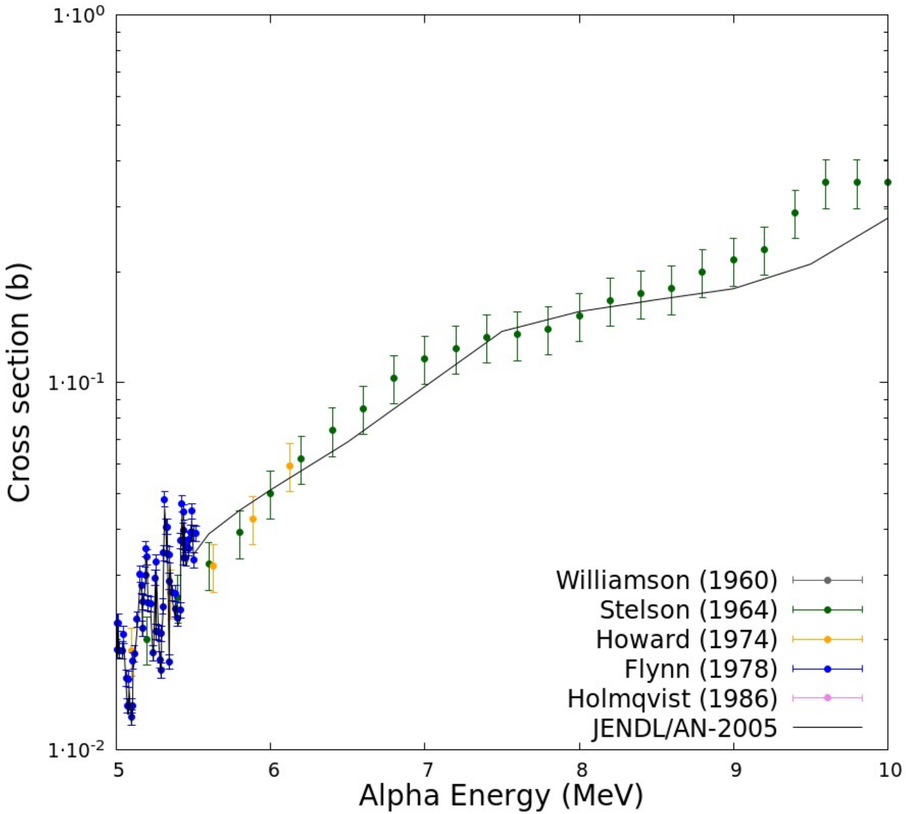

Experimental setup

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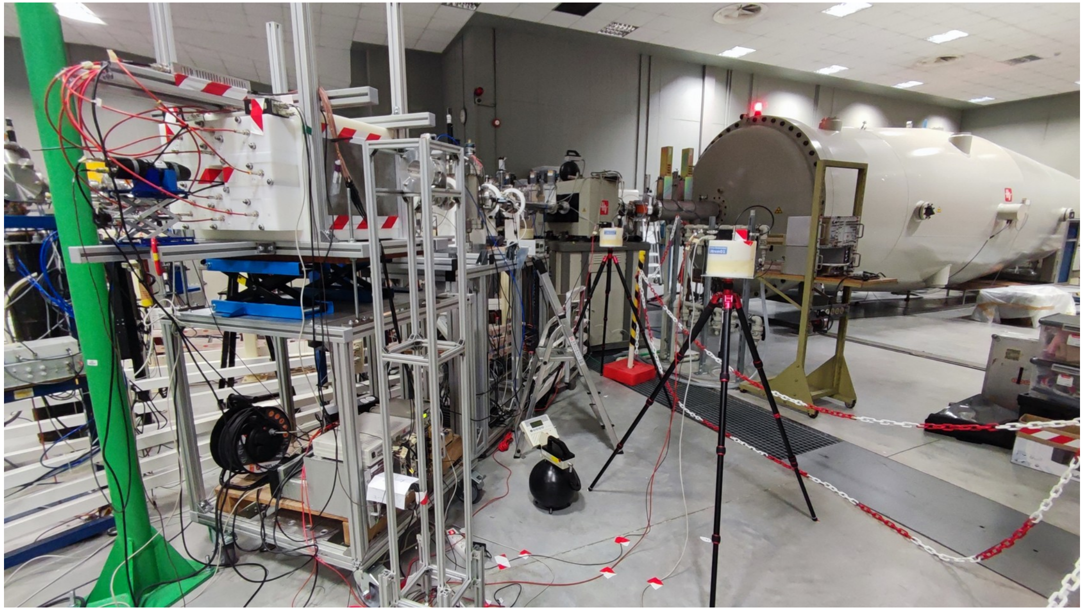
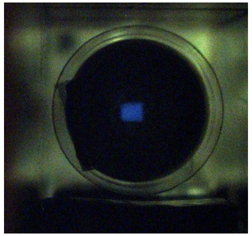
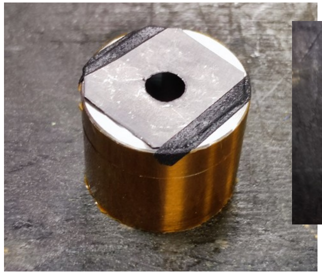
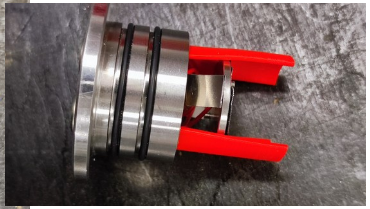
Centro de Micro-Análisis de Materiales (CMAM, Madrid)

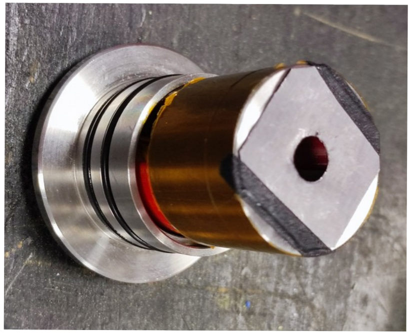
- 5 MV Tandem accelerator. Beam particles: ^{4}He (q = +2).











Neutron yields (thick target)

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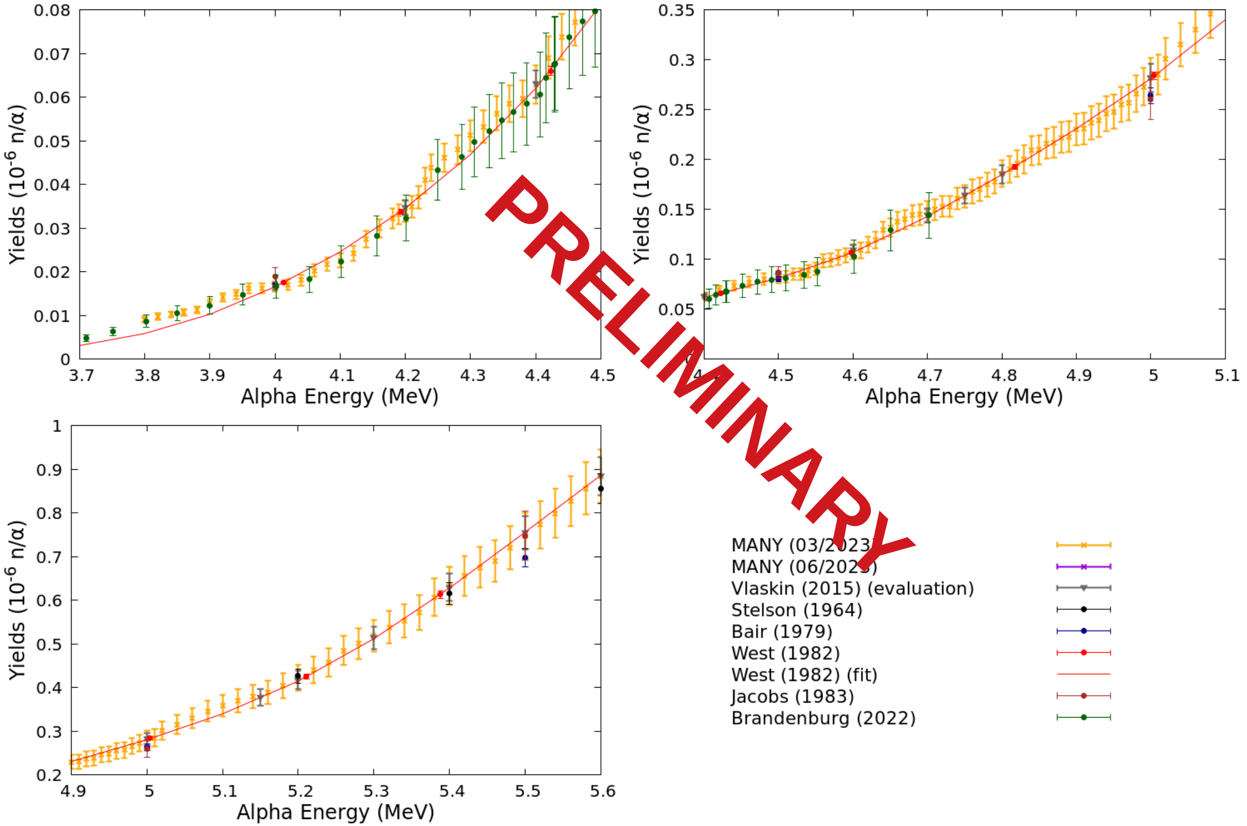
Neutron yields

$$Y = \frac{R}{I \cdot \varepsilon}$$

- Y = neutron yield
- R = miniBELEN neutron rate
- I = beam current (particles/s)
- ε = miniBELEN neutron efficiency

Background estimations using a dummy natural tantalum target (threshold ~ 10 MeV)

Uncertainty: systematic from the efficiency flatness hypothesis



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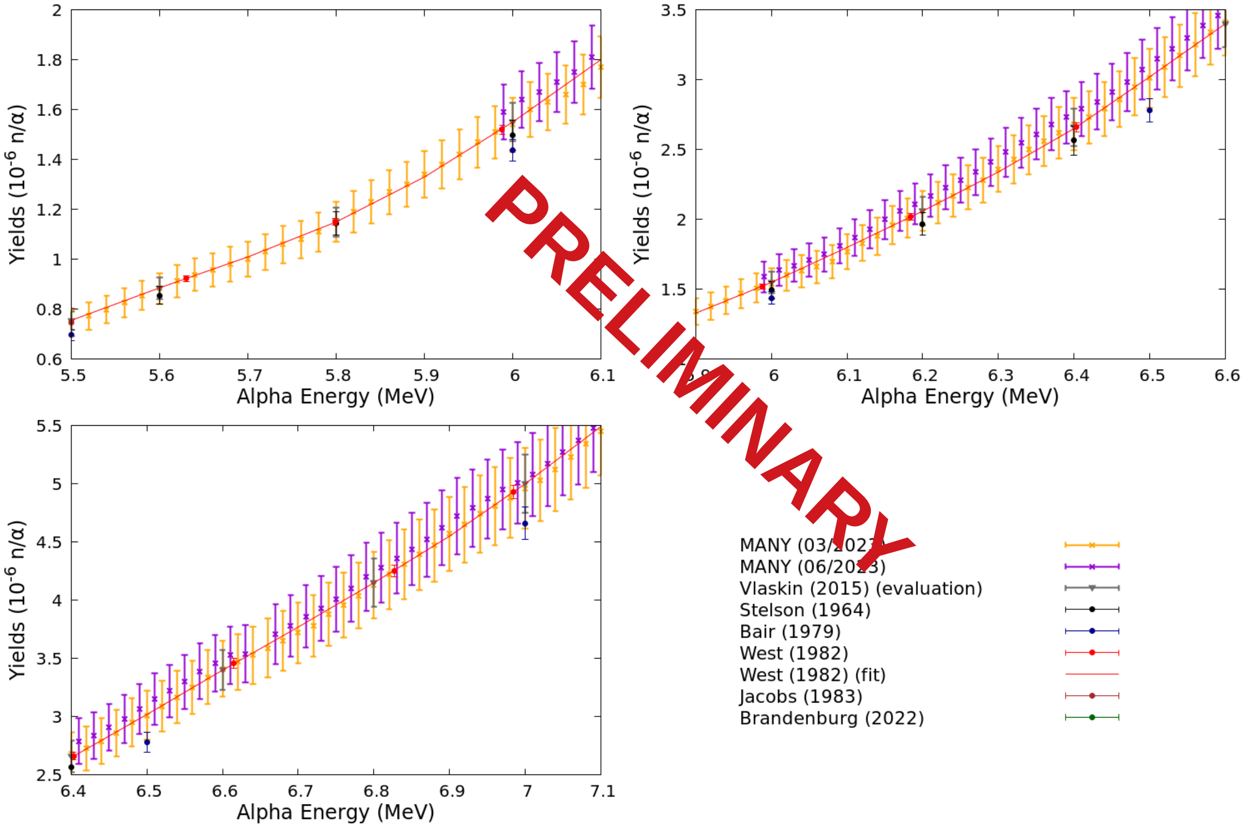

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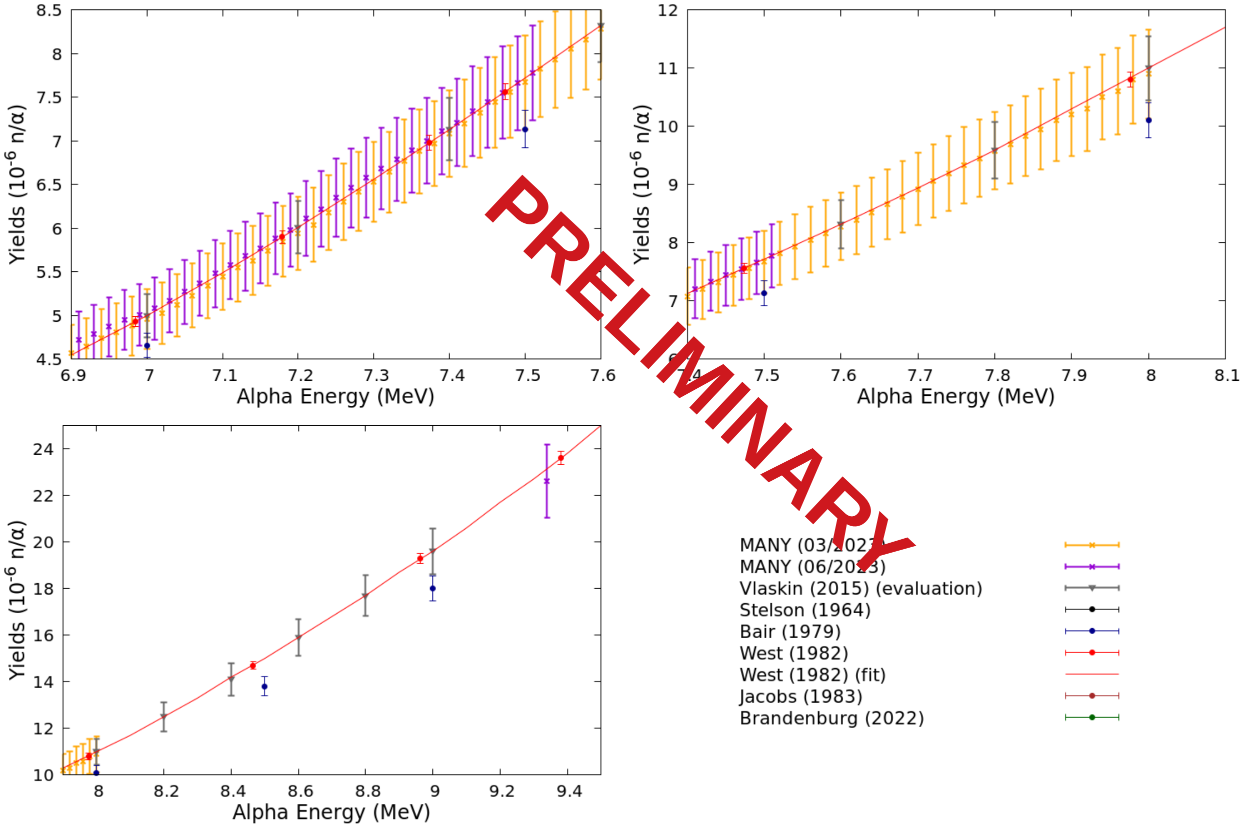

Neutron yields (thick target)

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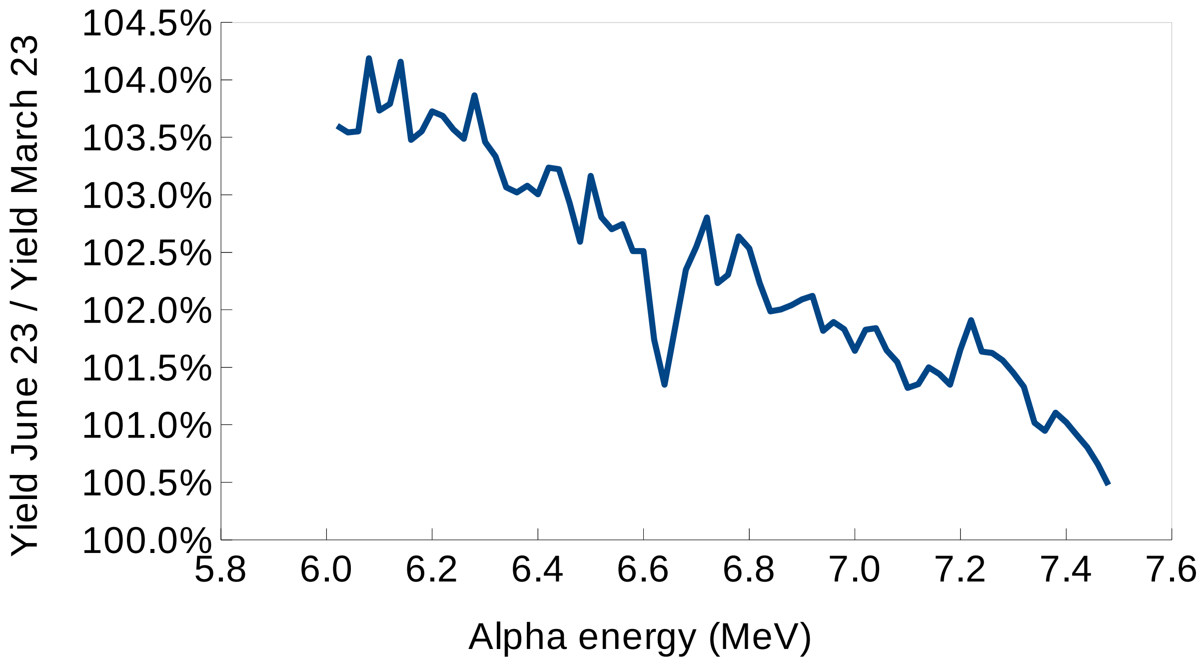
Neutron yields (june vs march 2023)

Background estimation:

March 2023: YES
June 2023: NO

Larger Background in June 23???



Cross section

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$$\sigma(E_\alpha) = \frac{N_A}{A_t} \frac{dY(E_\alpha)}{dE} \cdot \frac{dS}{dx}$$

σ = cross-section
N_A = Avogadro number
A_t = target atomic mass
dS/dX = stopping power
dY/dE = derivative of the neutron yield
E_α = beam energy

In this talk I will evalaute the effect of:

- Determination of the neutron yields (June vs March 2023 campaigns).
- Methodologies to estimate the yields derivative.
- Stopping powers.

Estimate the derivative

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Method 1: difference quotient

$$f'(x)=\frac{f(x+h)-f(x)}{h}$$

Method 2: symmetric derivative

$$f'(x)=\frac{f(x+h)-f(x-h)}{2h}$$

Cross sections

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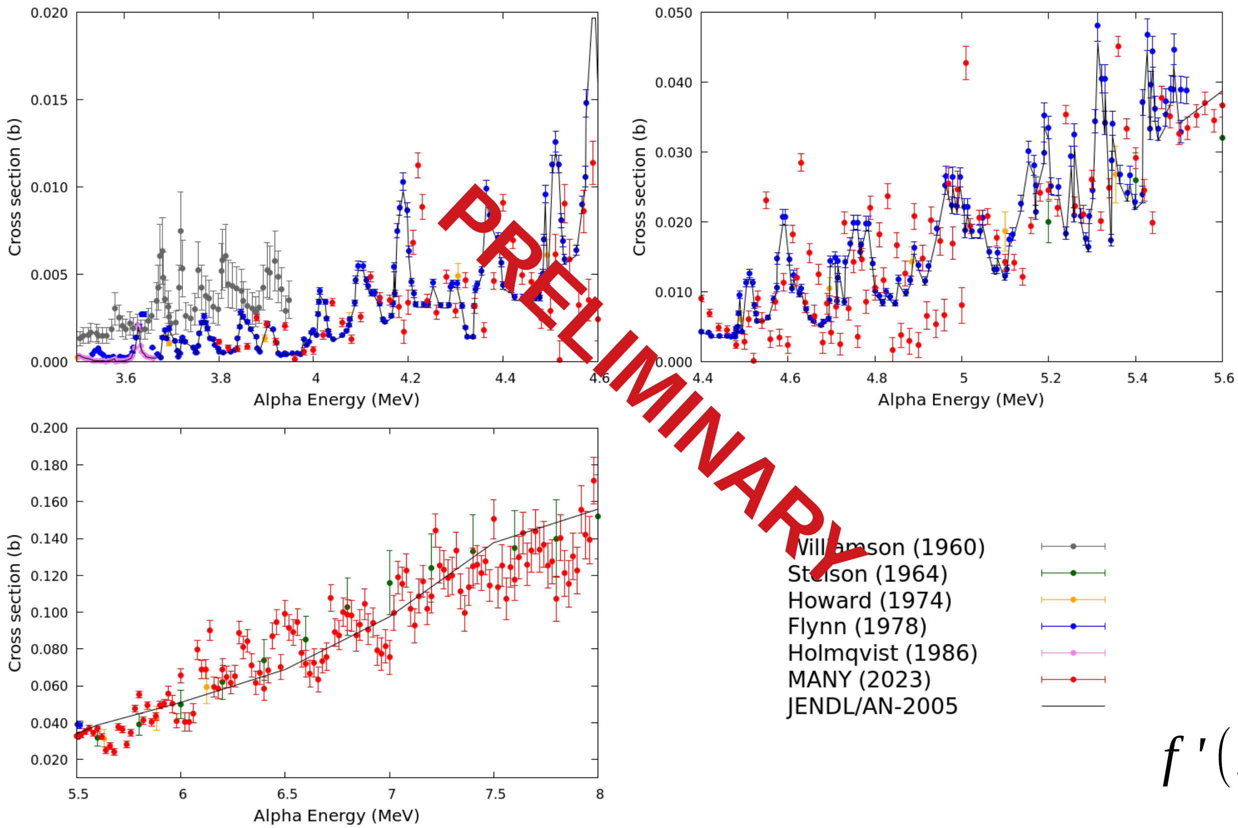
Only statistical uncertainties are shown



$$f'(x) = \frac{f(x+h) - f(x)}{h}$$

Cross sections

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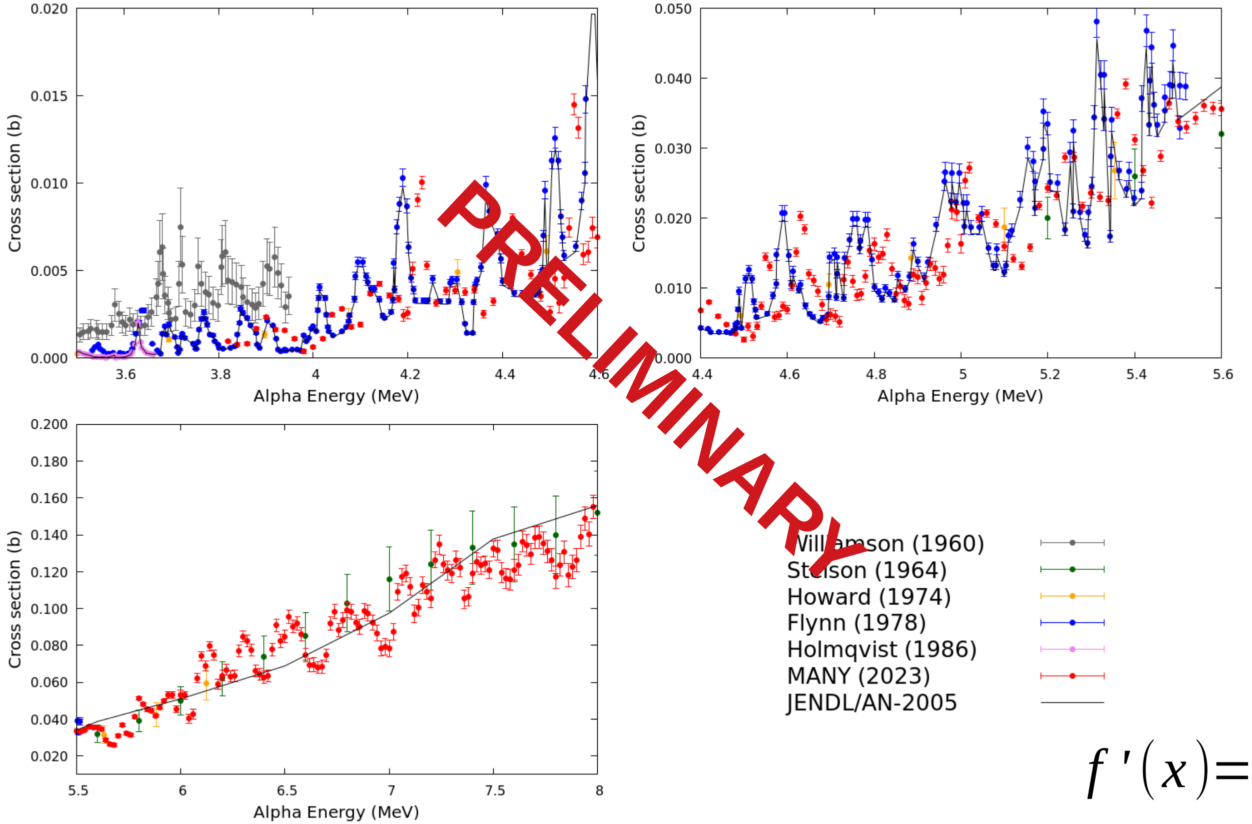


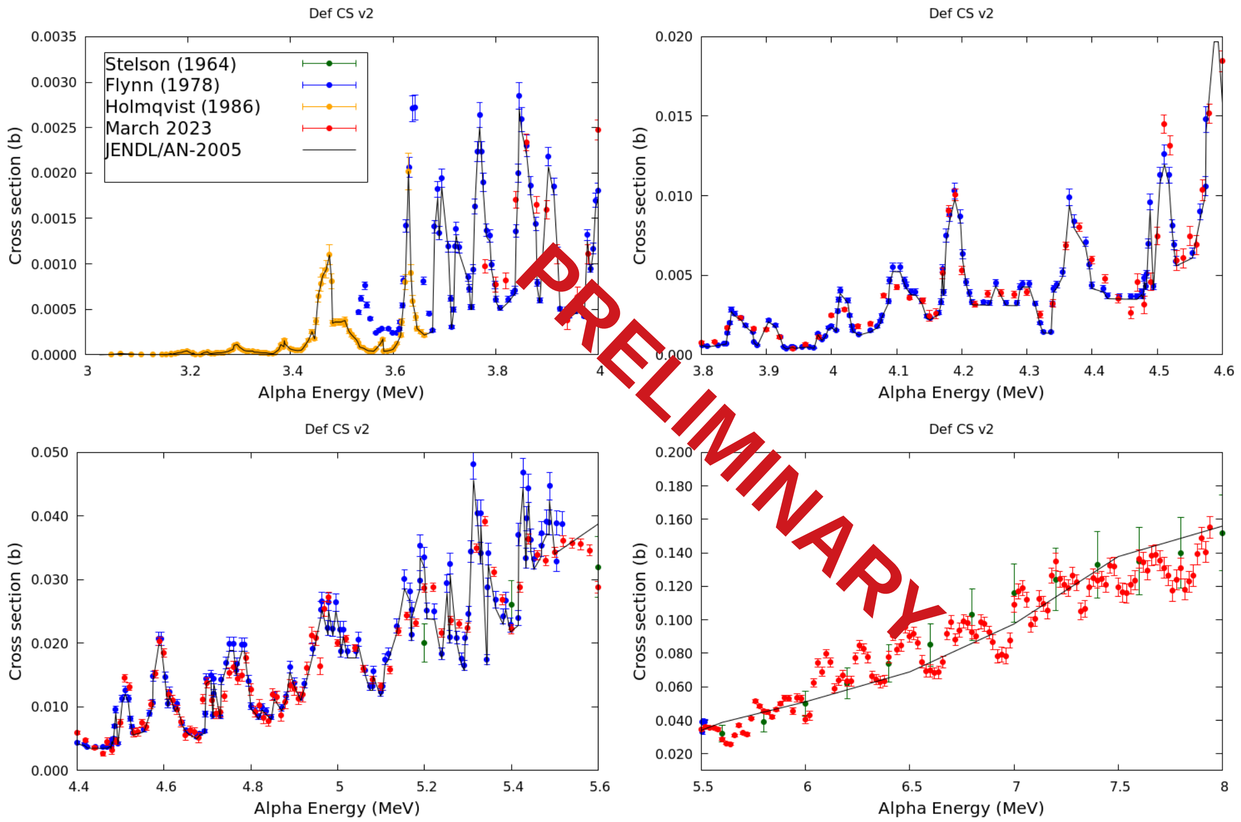
$$f'(x)=\frac{f(x+h)-f(x-h)}{2h}$$

Cross sections

Applying a -40 keV correction on the beam energy in the MANY data

Conclusion:

40 keV shift between our data and the Flynn data



Data consistency

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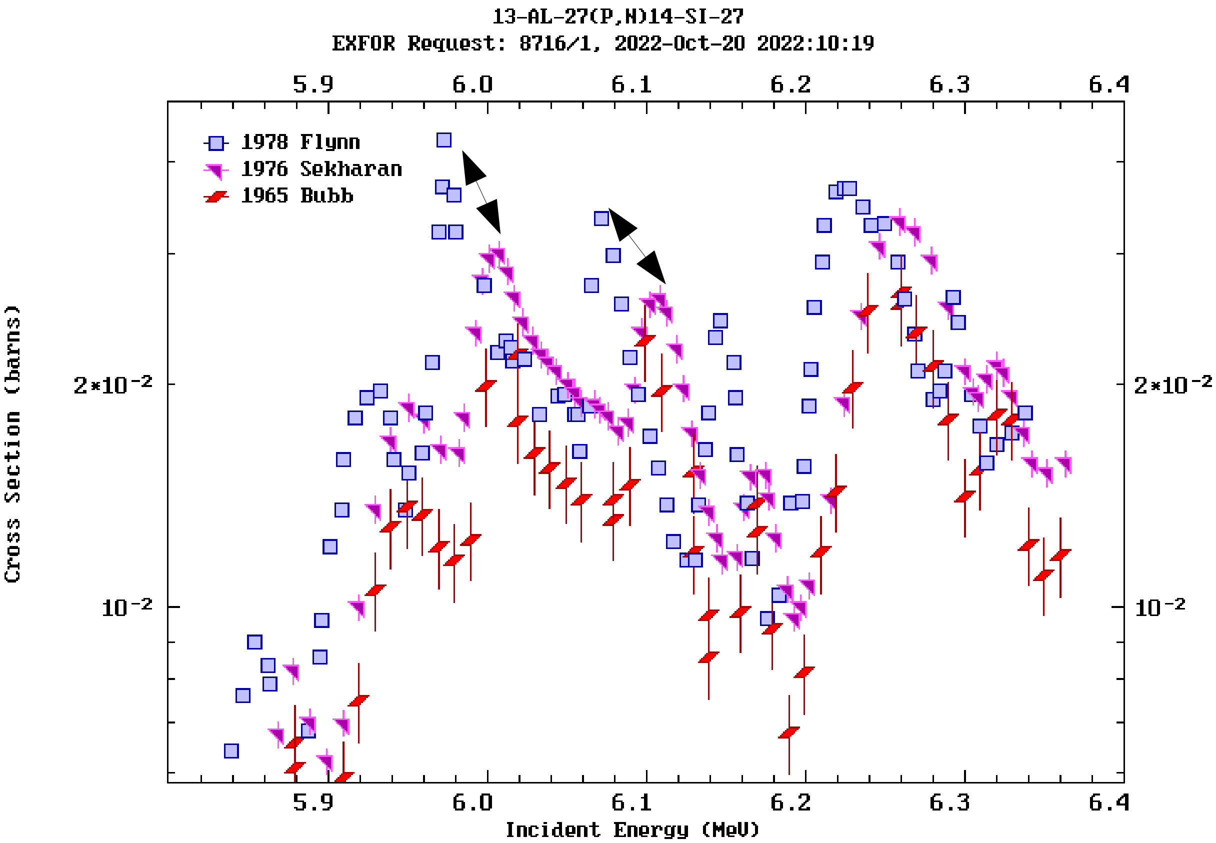
Cross-sections (p,n)

Flynn data on (p,n) reactions also present a negative ~ 50 keV shift with other data in the literature



Reproducibility

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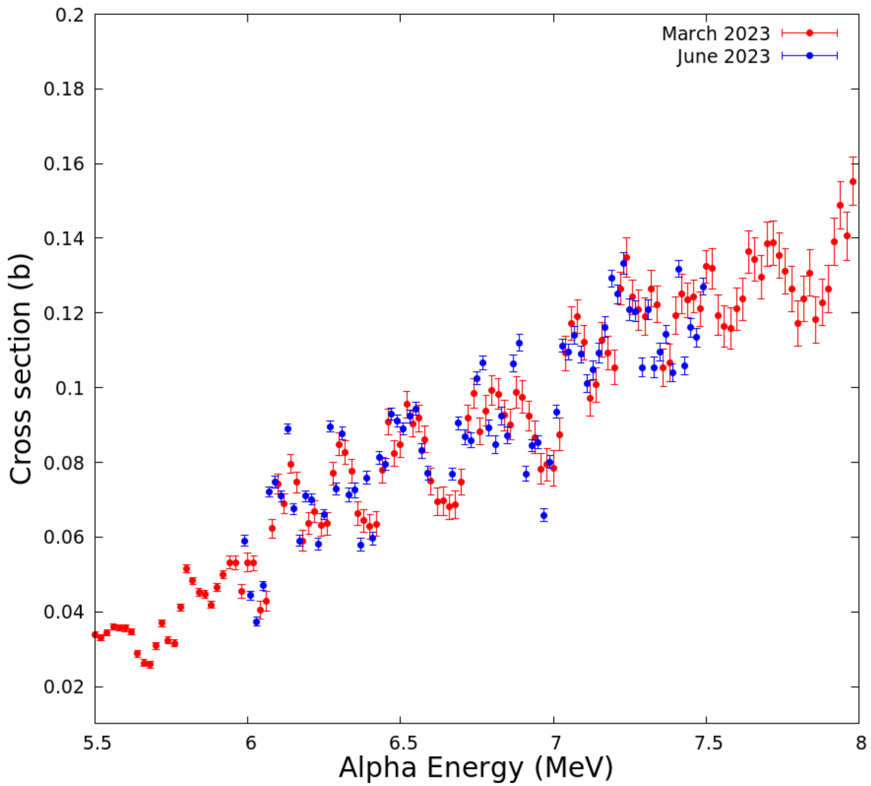
Cross sections from June 2023 are consistent with values from the March 2023 measurement.

June 2023: method 1
March 2023: method 2

Better statistics reduces the error-bars in the cross sections.

Can we merge the yields from both measurements?

Future: estimate a bakcground correction for June 2023



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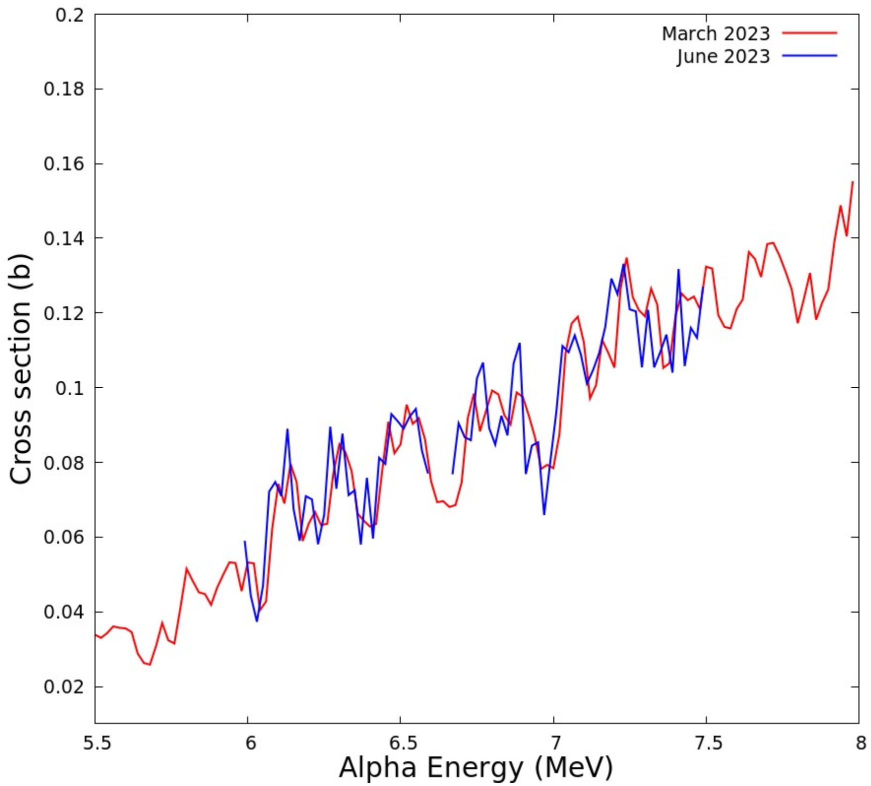

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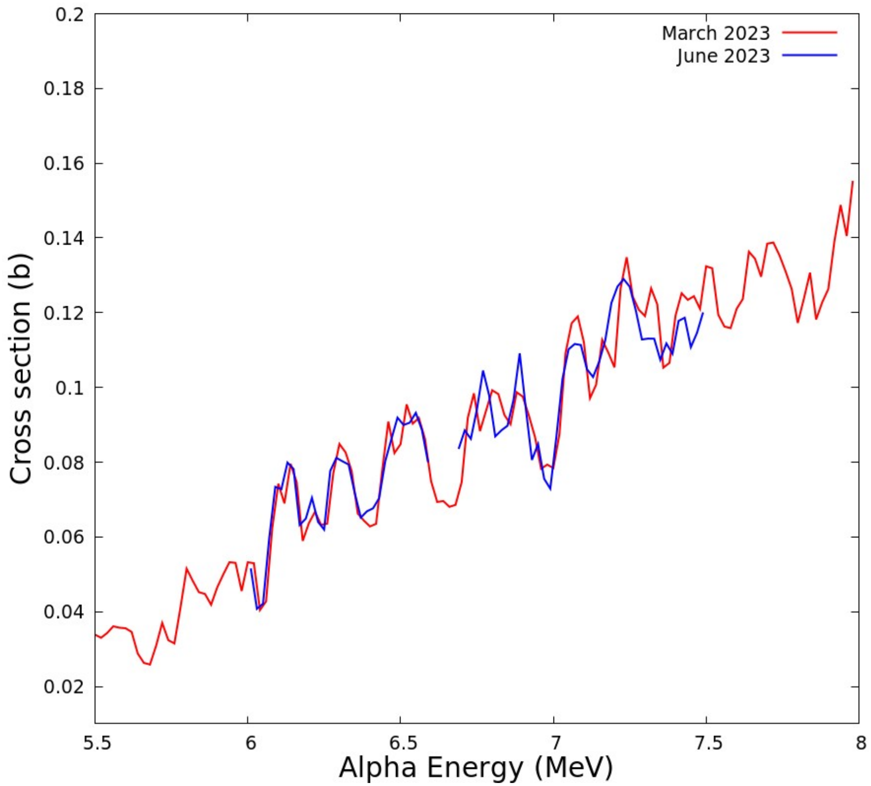

Stopping powers

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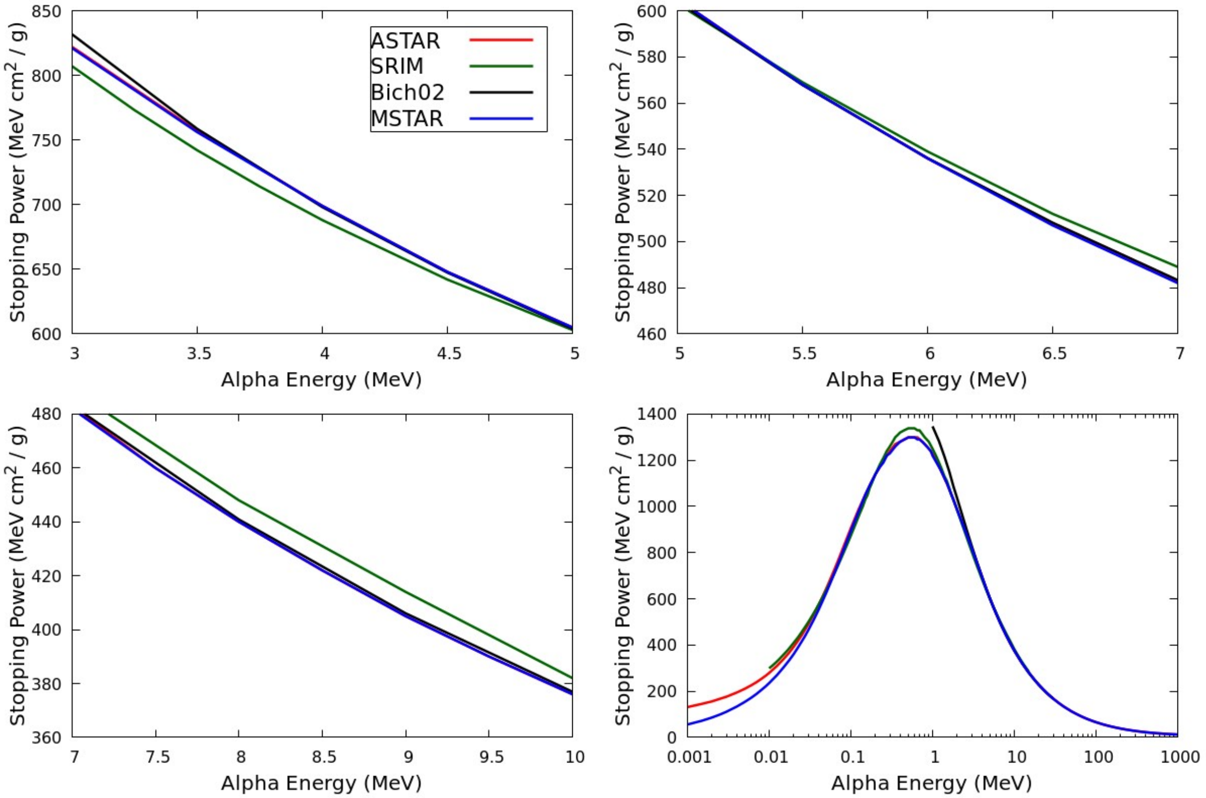

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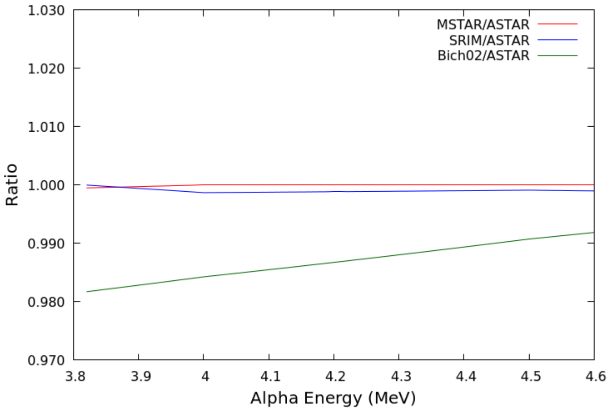

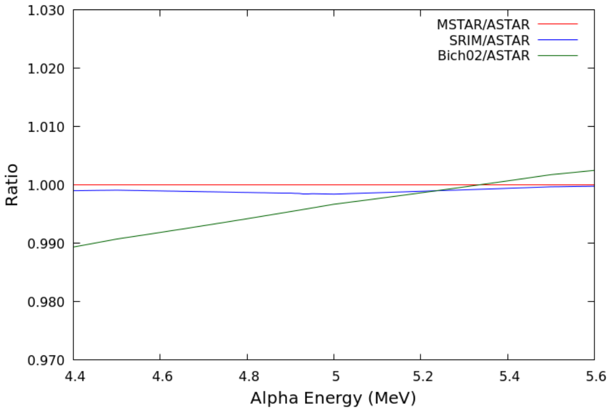

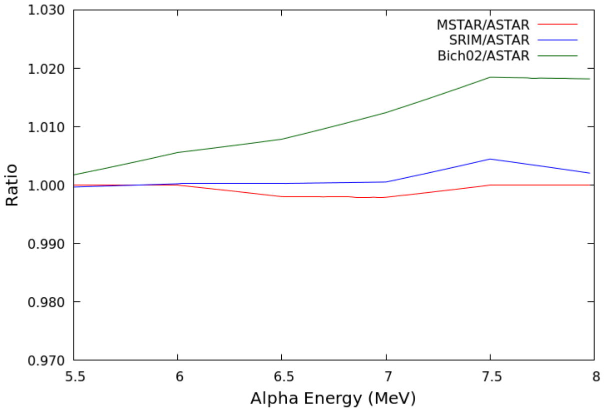

Precicison on the CS measuremetns is of about 4 – 5%

Larger differences of about 1 – 2%

Summary

- Measurement of the $^{27}Al(\alpha,n)^{30}P$ reaction cross section from 4 up to 8 MeV from thick-target yields using a moderated neutron counter.

- Assessment of the effect of using different methodologies to compute the derivative of the yield and of using different models for the Stopping Power.

- Reproducibility of the data: effect of the neutron background.

- Future: data near the reaction trheshold (october 2023)

List of collaborators

INTE-UPC: *N* Mont-Geli, *M* Pallàs, *G* Cortés, *F* Calviño, *A* De Blas and *R* Garcia.

IFIC – UV – CSIC: *A* Tarifeño-Saldivia, *E* Nácher, *J L* Tain, *A* Algora, *J* Balibrea-Correa, *C* Domingo-Pardo, *J* Lerendegui-Marco and *S E A* Orrigo.

GFN – UCM: *L M* Fraile, *O* Alonso-Sañudo, *J* Benito, *M* Llanos, *V* Martínez-Nouvilas, *J R* Murias, *J M* Udías and *V* Sánchez-Tembleque.

CMAM – UAM: *S* Viñals and *G* García.

IEM – CSIC: A Perea, *M J G* Borge, *J A* Briz and *O* Tengblad.

CIEMAT: *V* Alcayne, *D* Cano-Ott, *E M* González-Romero, *T* Martínez, *A* Pérez de Rada, *V* Pesudo, *J* Plaza, *A* Sánchez, *R* Santorelli, and *D* Villamarín.

CNA – US: *B* Fernández, *J* Gómez-Camacho, *C* Guerrero and *J M* Quesada

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