Status of and perspectives for the study of (α,n) reactions at CNA HiSPANoS

(by means of activation and time-of-flight)

Carlos GUERRERO on behalf of *The MANY Collaboration*

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(α,n) reactions

Relevance and status of (α,n) reactions

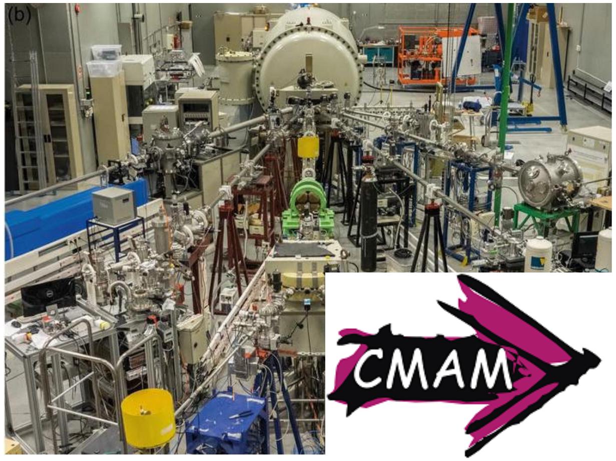
See Nil Mont Geli's talk:

"Measurement of the ^{27}Al(α,n)^{30}P thick target yields and differential cross-sections at CMAM using the miniBELEN neutron counter"

The MANY Collaboration

- Two Spanish facilities

Infraestructuras Científicas y Técnicas Singulares



UPC

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

IFIC
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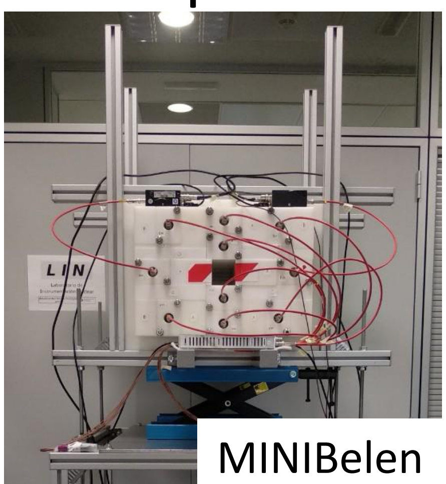
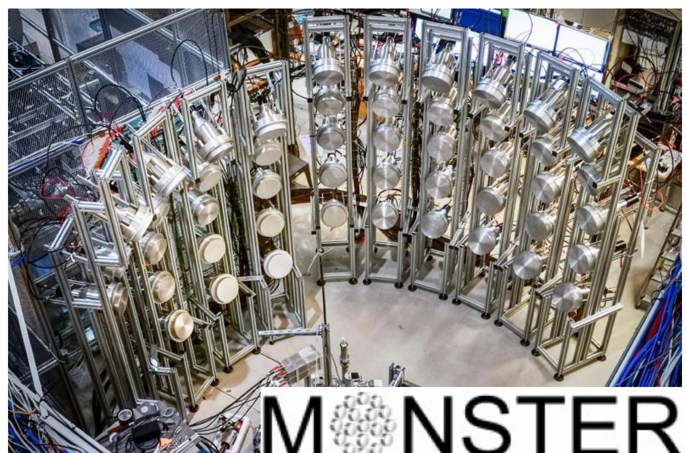
- Two Spanish detectors



MINIBelen



MONSTER

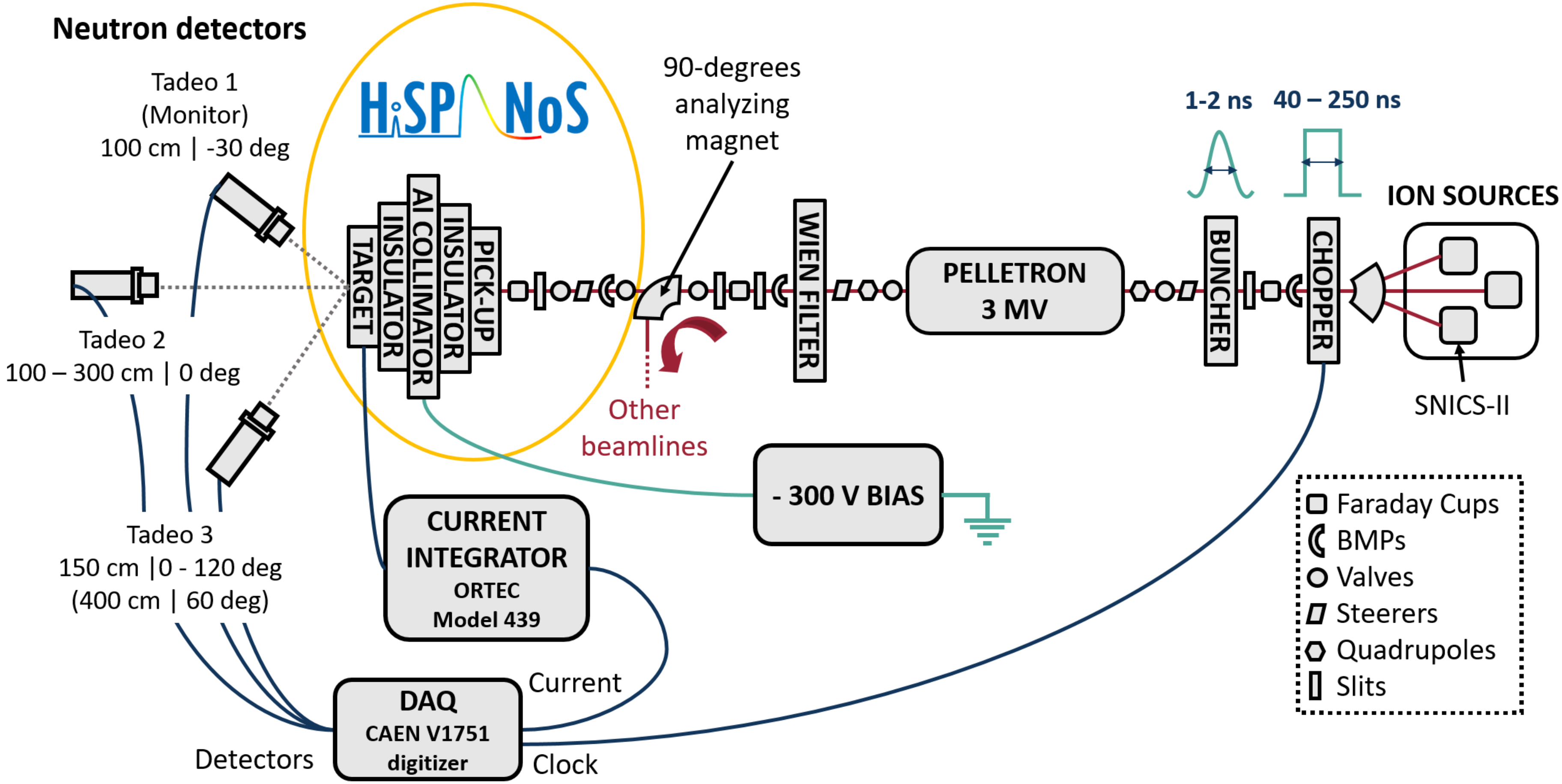
UNIVERSIDAD COMPLUTENSE MADRID

IEM
Instituto de Estructura de la Materia

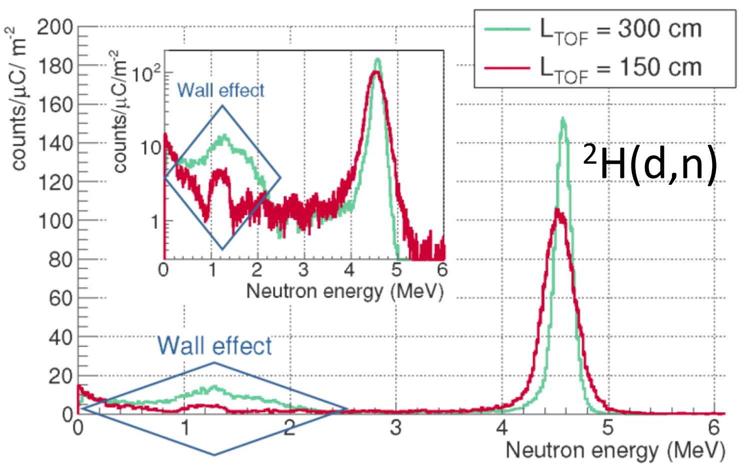
UNIVERSIDAD DE SEVILLA

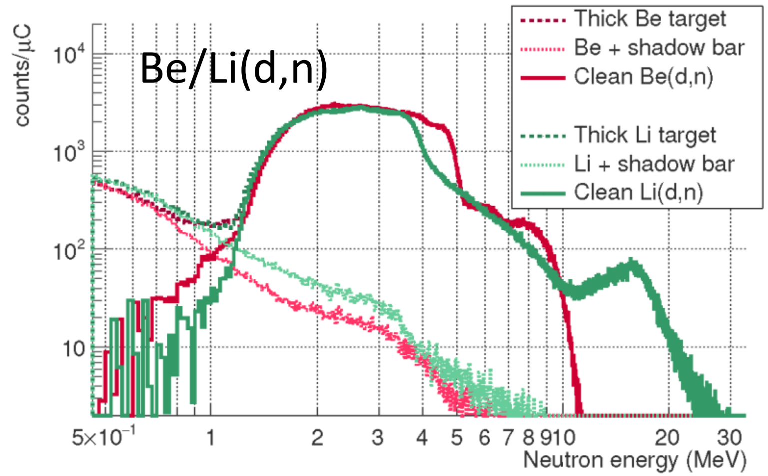
The HISPANOS neutron facility at CNA

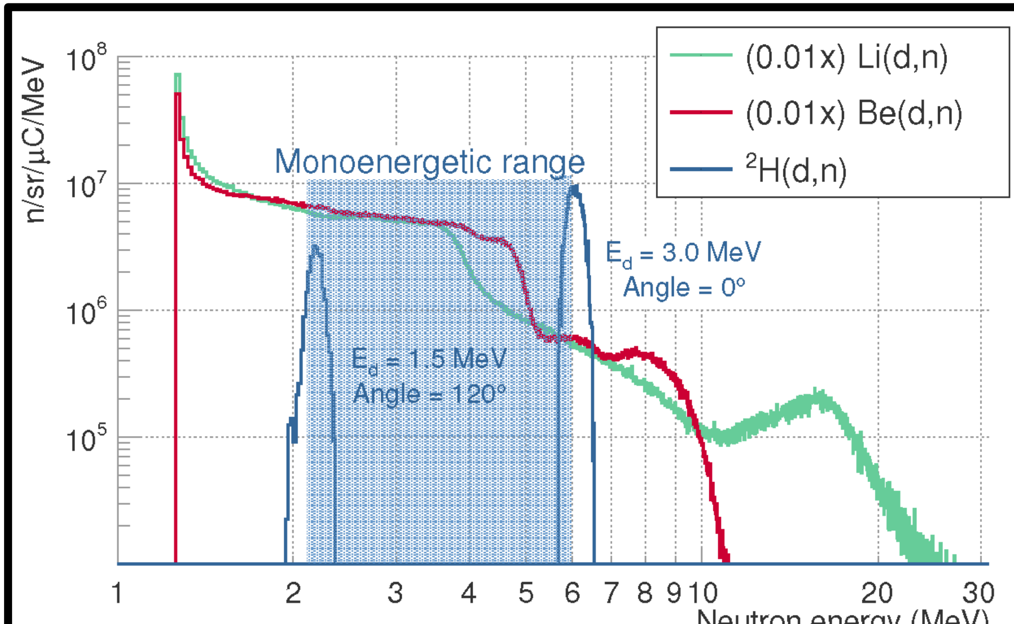
The HiSPANoS neutron facility at CNA



Fast neutron beams at HiSPANoS







M. A. Millán-Callado et al., "*Continuous and pulsed fast neutron beams at the CNA HiSPANoS facility*", Rad. Phys. and Chem. (accepted)

HiSPANoS in a nutshell

Fast neutron energy ranges:
- Monoenergetic: 2 to 6 MeV
- Broad beams: up to 10/15 MeV

Fast neutron fluxes:
- Monoenergetic: 10^6 n/sr/µC
- Broad beams: 10^{10} n/sr/µC

Energy resolution $R(L_{ToF})$:
- 4% at 4 m flight path
- 11% at 1 m flight path

Test experiment on $^{27}Al(\alpha,n)$

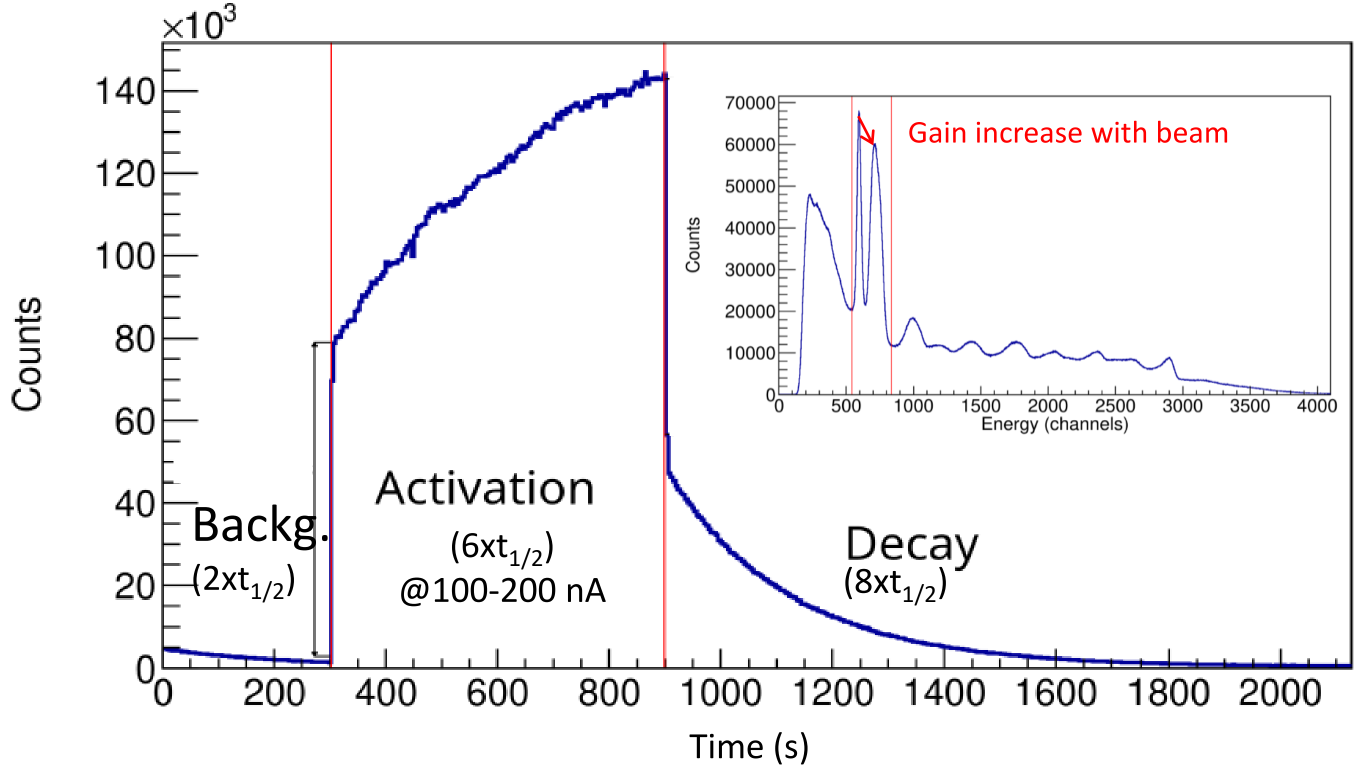
Experimental set-up

Activation measurement

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

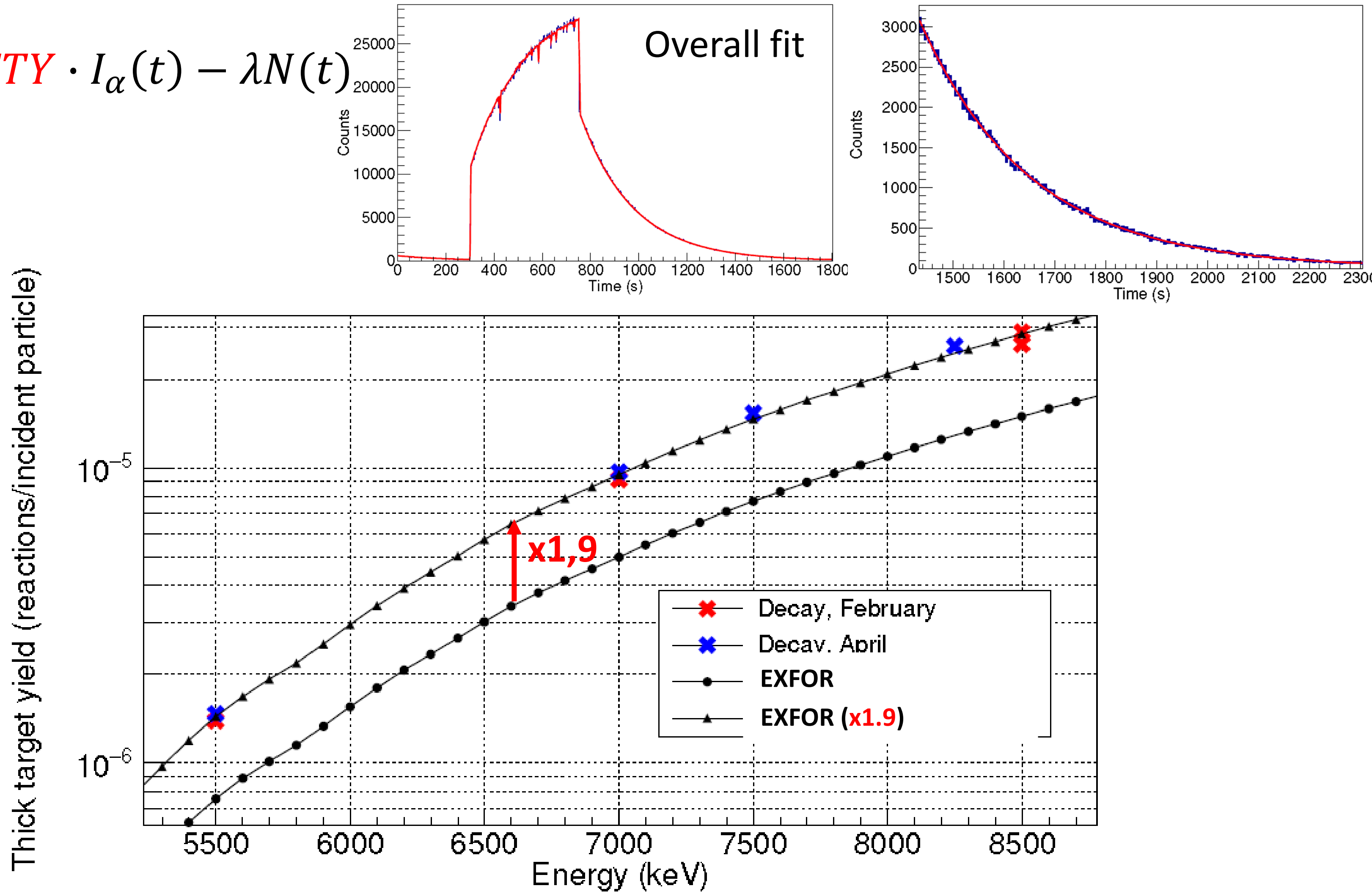
β^+ (100%) with ($t_{1/2}$=2,498 min)

^{30}Si



Activation results

$$\frac{dN(t)}{dt} = TTY \cdot I_\alpha(t) - \lambda N(t)$$



The 1.9 factor difference can not be justified: we'll repeat the experiment soon

ToF measurement: MONSTER

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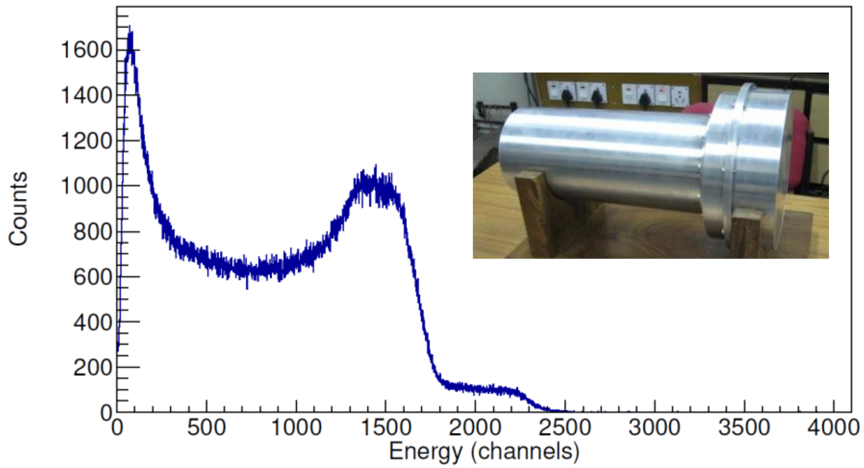
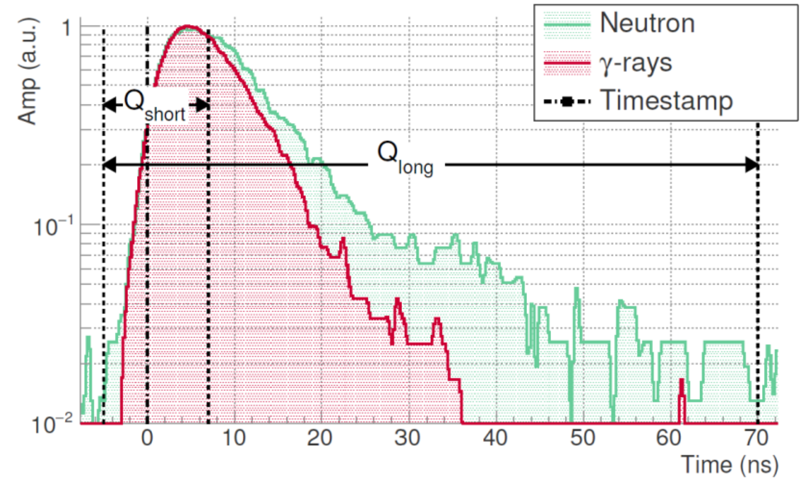
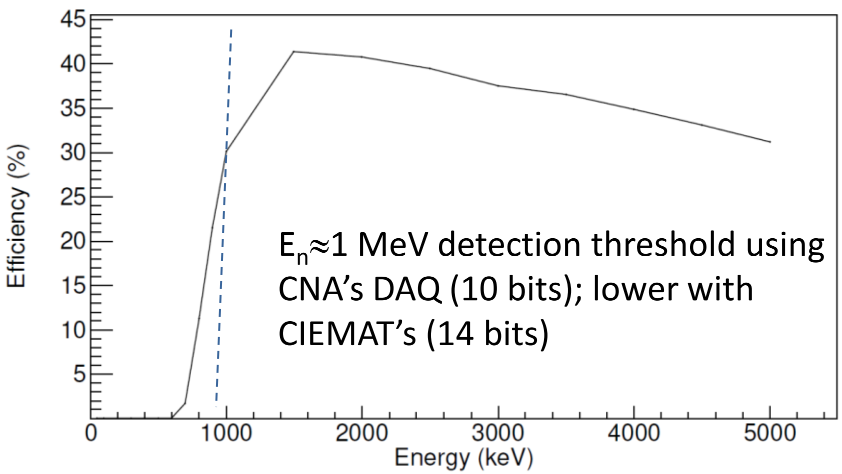
Response to a ^{60}Co source



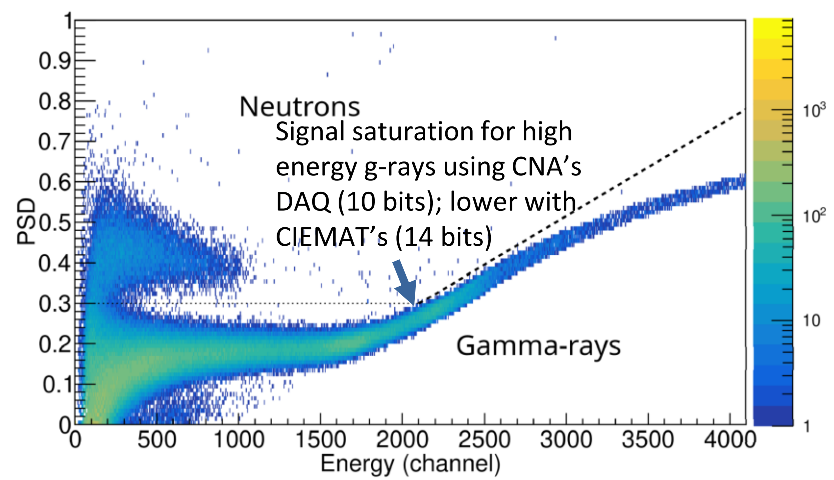
Signals shape



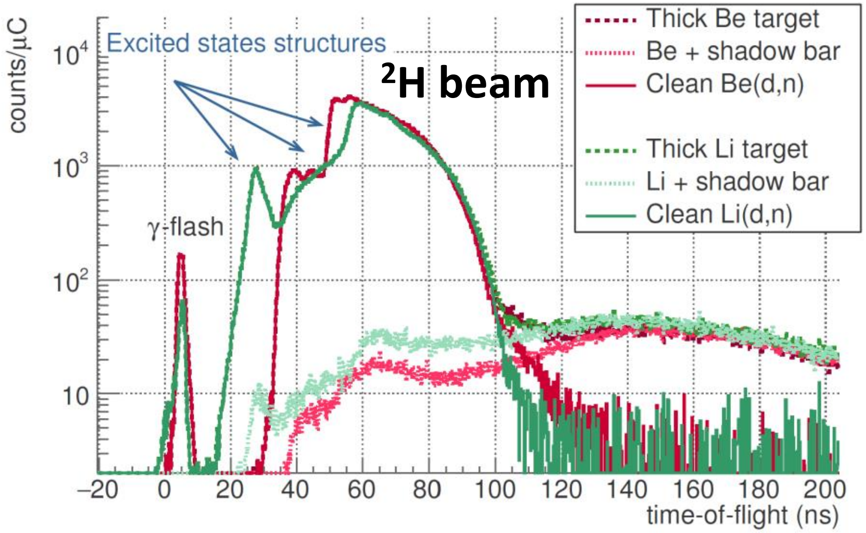
Efficiency from Geant4 simulations by CIEMAT



Pulse Shape Discrimination (PSD)



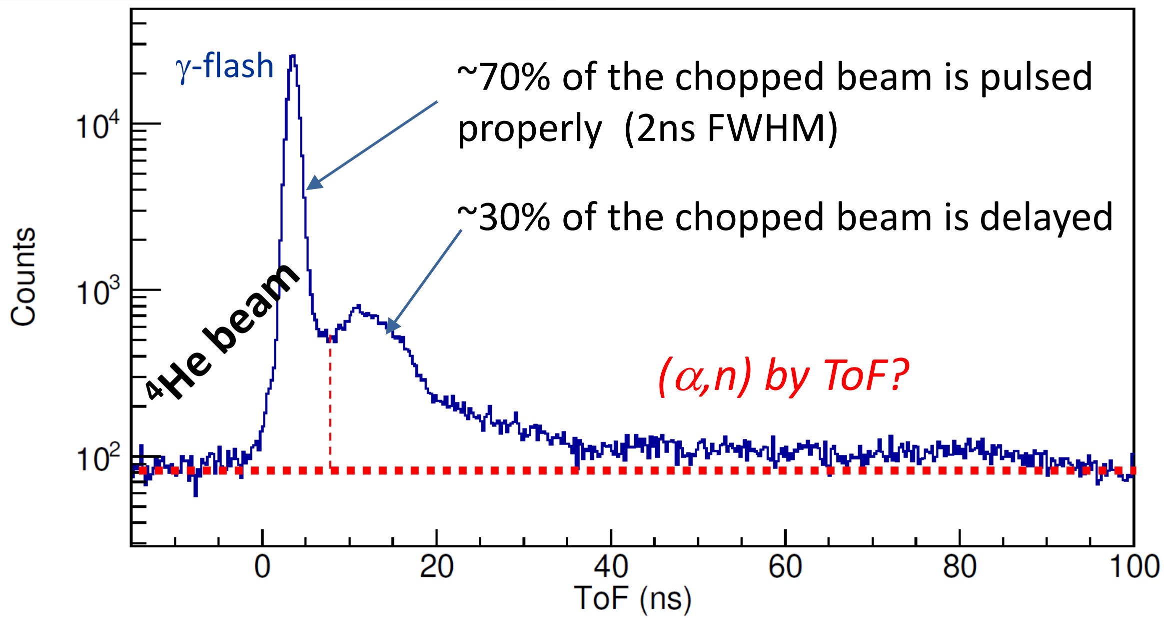
ToF measurement: the pulsed α beam



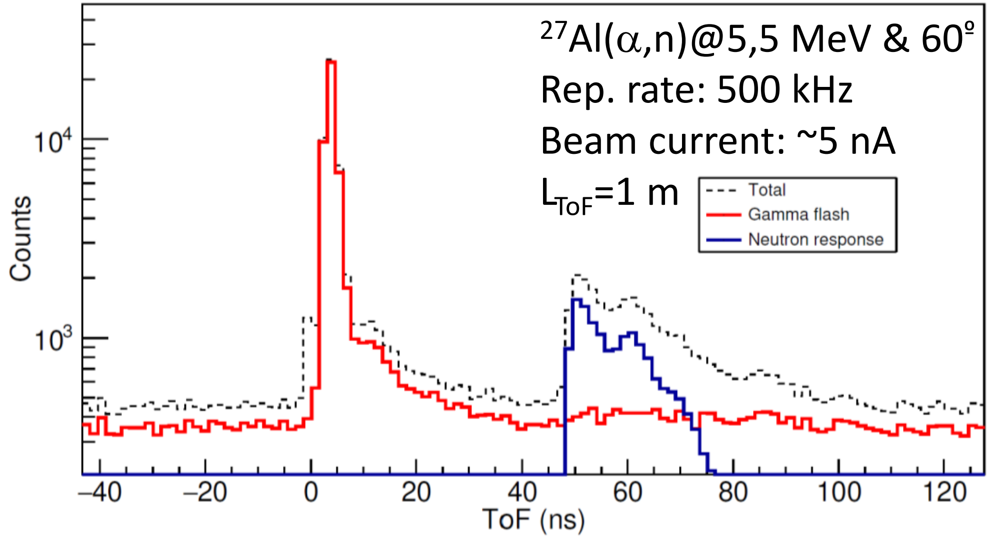
The buncher is designed only for "*p*" and "d".

Bunching α requires a modification by the manufaturer (NEC): ongoing.

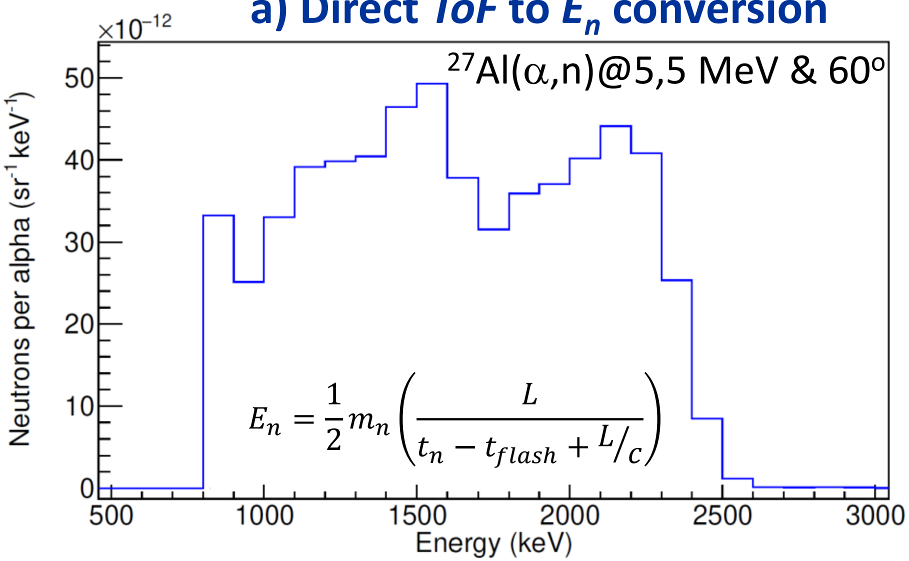
What can we do as of now so far?



ToF measurement: data analysis (I)



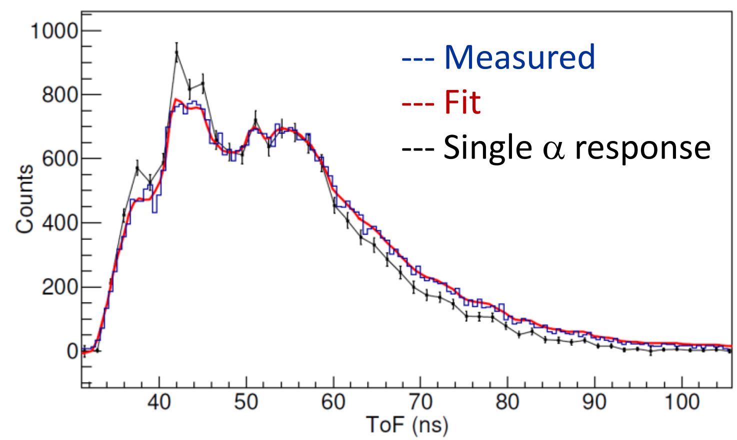
a) Direct *ToF* to E_n conversion



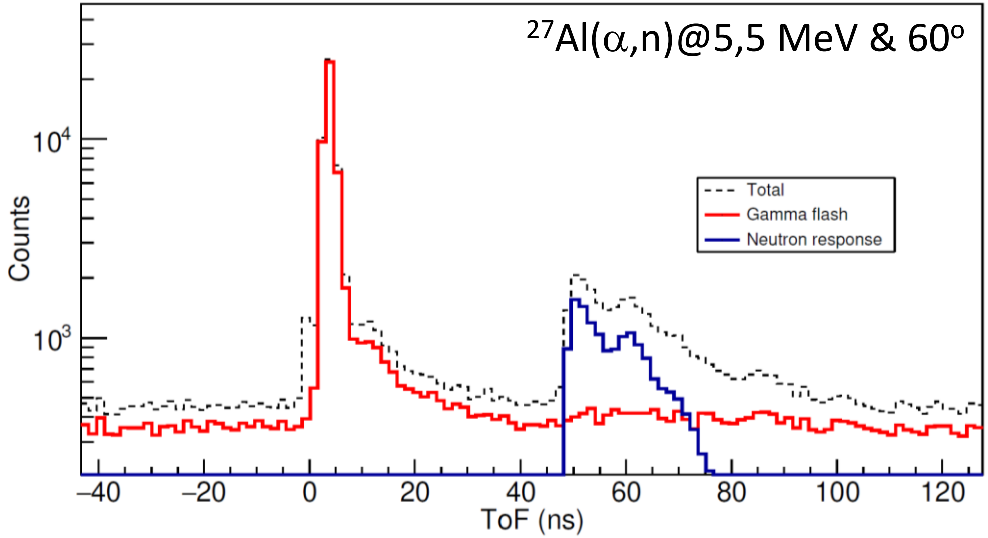
$$E_n = \frac{1}{2} m_n \left(\frac{L}{t_n - t_{flash} + L/c} \right)$$

b) Inverse problem / deconvolution

- 50 parameter ToF distribution for a single "α" particle
- Runs over γ-flash and "fits" the measured ToF distribution



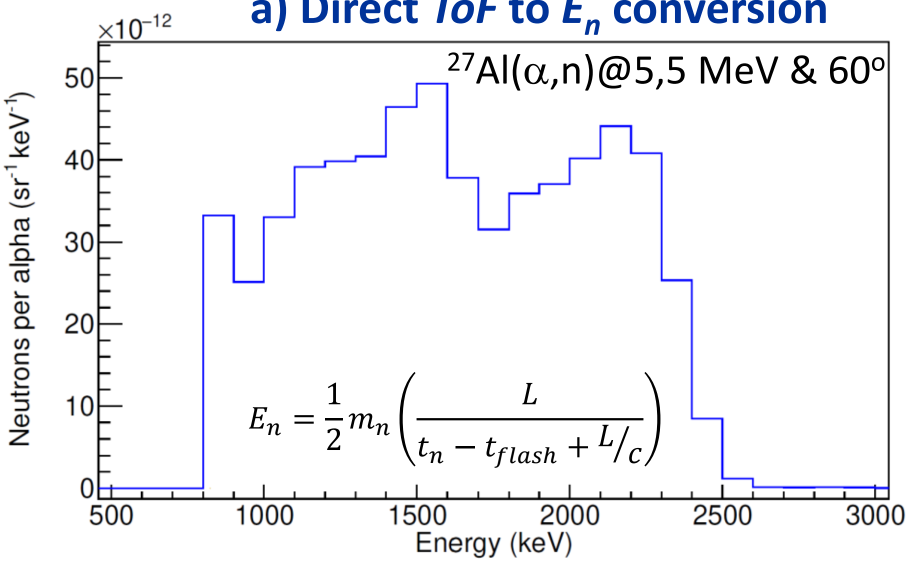
ToF measurement: data analysis (II)



Strategy:
- ToF measured simultaneously with CNA's & CIEMAT'S DAQs.
- Analysis and spectrum deconvolution made independently by CNA and CIEMAT for internal cross check and comparison.

=> Results presented herein correspond to CNA's análisis.

a) Direct *ToF* to E_n conversion



$$E_n = \frac{1}{2} m_n \left(\frac{L}{t_n - t_{flash} + L/c} \right)$$

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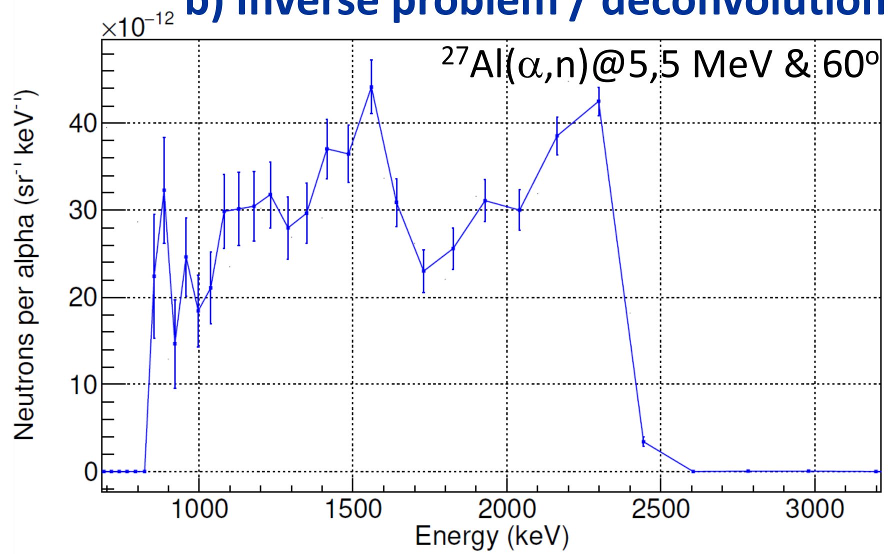
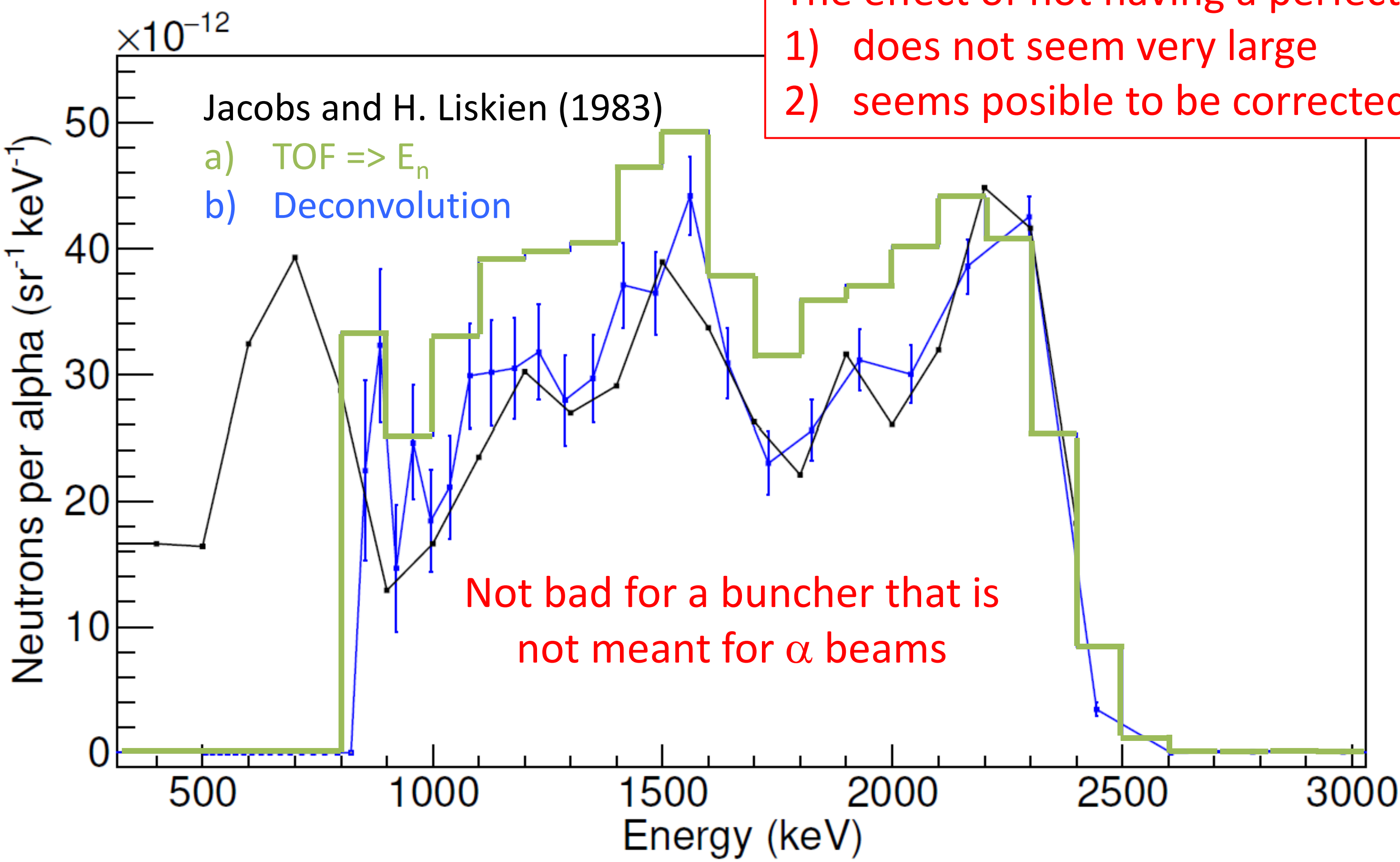


ToF measurement: results @ 5,5 MeV

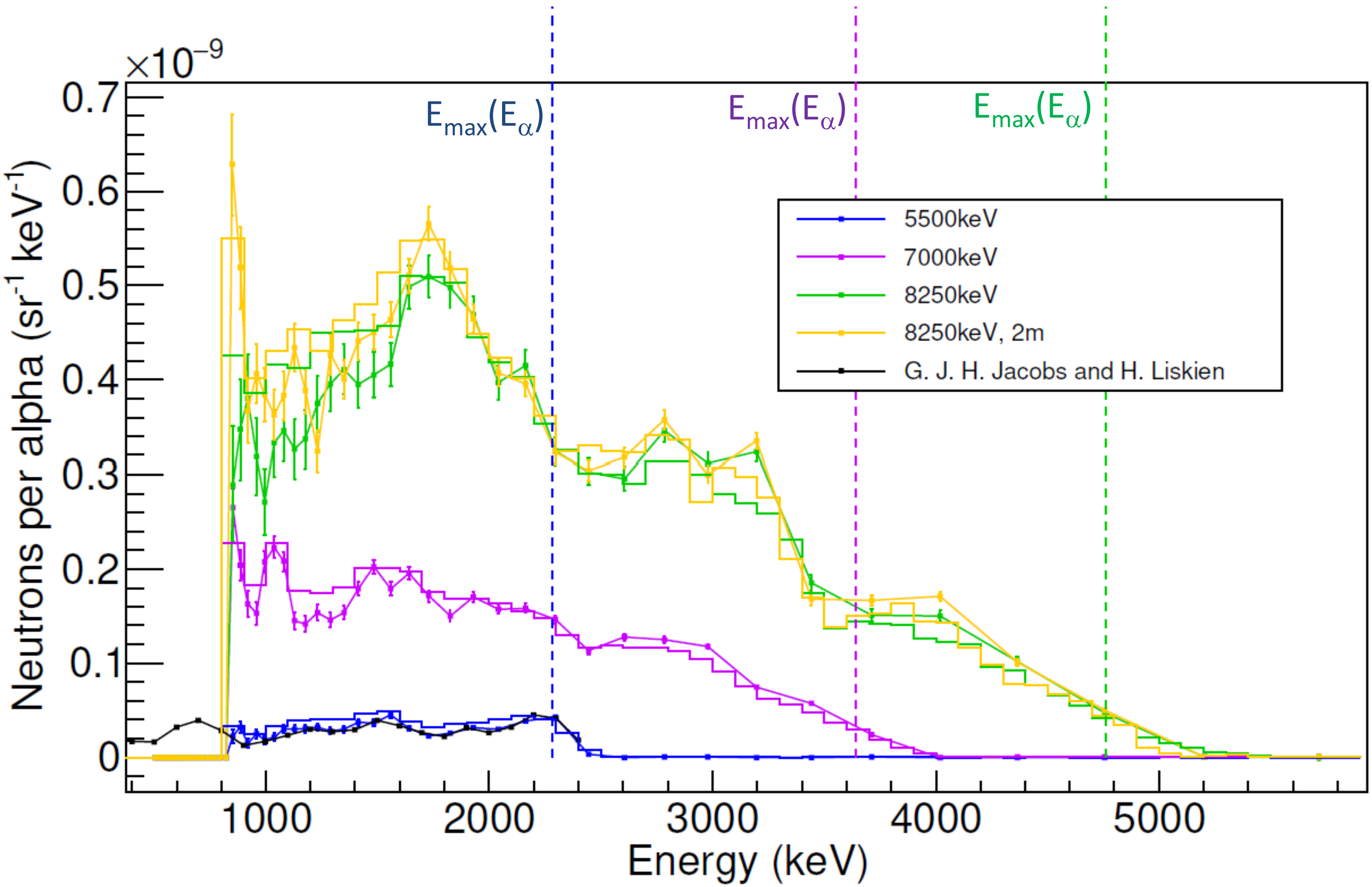
Very good agreement in both absolute value and neutron energy with the only experiment available in the literature.

The effect of not having a perfect bunching:
1) does not seem very large
2) seems posible to be corrected for



Not bad for a buncher that is not meant for α beams

ToF measurement: results @ 5,5 to 8,5 MeV

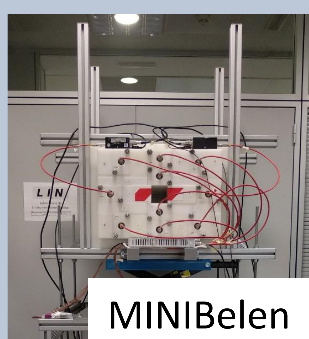


Summary, conclusions and Outlook MANY@HiSPANoS CNA

Summary, conclusions and outlook

- Neutron production through (α,n) reactions is of interest in many applications, and is the aim of **The MANY Collaboration**.
- At the **CNA HiSPANoS** facility both **Thick Target Yield (TTY)** and double differential energy and angle **cross sections** measurements are feasible through **activation** and **time-of-flight**.
- The current buncher produces α pulses with ~30% unbunched...
- First ^{27}Al(α,n) measurement with $LaBr_3$ & a CIEMAT's **MONSTER** module
- Results from CNA's analysis:
  - **TTY:** Good E_α dependence but a factor of 1.9 overestimation (experTBD).
  - **$\sigma(E_\alpha,\theta)$**: Good agreement with data at 5,5 MeV.
- **(α,n) ToF measurements feasible** => but new buncher by **end of 2024**.

Next:



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