Technical Meeting on (alpha,n) Reaction Nuclear Data Evaluations and Data Needs

Status and perspectives of thick target measurement of (alpha,n) reactions using the miniBELEN detector

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On behalf of the
MANY collaboration

OUTLINE

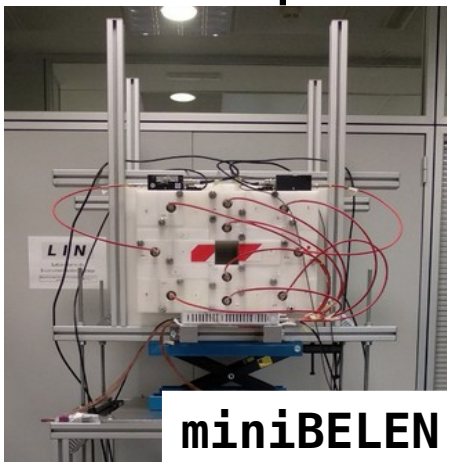
- The MANY collaboration
- The miniBELEN-10A detector
- Commissioning of miniBELEN-10A at CMAM
- Production yields for 27Al(alpha,n)
- Perspectives

The MANY Collaboration

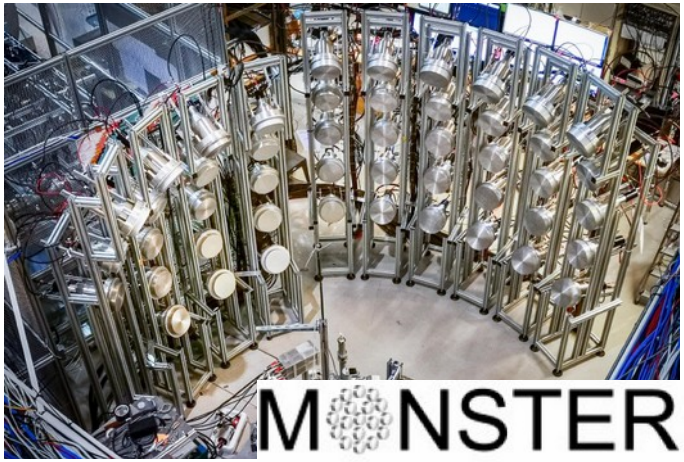
Two Spanish facilities

C Guerrero's slides

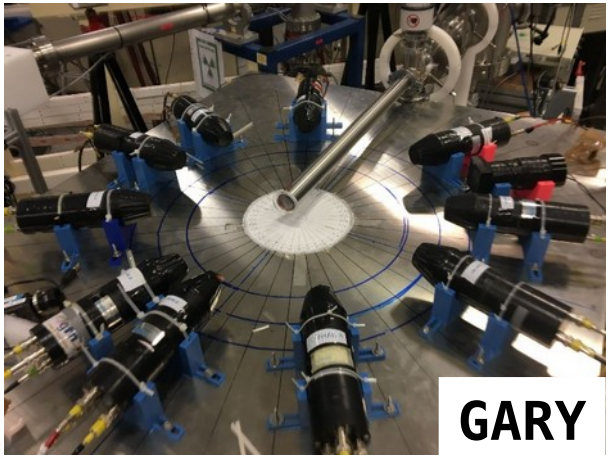
Three Spanish detectors



N. Mont's slides



A Pérez de Rada's slides

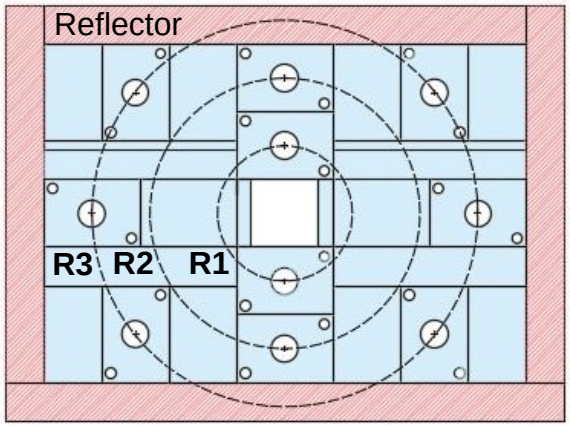


LM Fraile's slides

The miniBELEN detector: conceptual design

- Neutron counter based on a *modular High Density Polyethylene (HDPE) moderator*.
- MC calculations using ^{3}He-filled proportional counters (60 cm active length and 10 atm).
- Optimized design for (alpha,n) reactions producing neutrons up to 8-10MeV.
- Flat neutron efficiency is achieved by weighting the contribution of each detector group to the overall detection efficiency (composition method).
- Flexible system: re-configurable for 3 optional setups

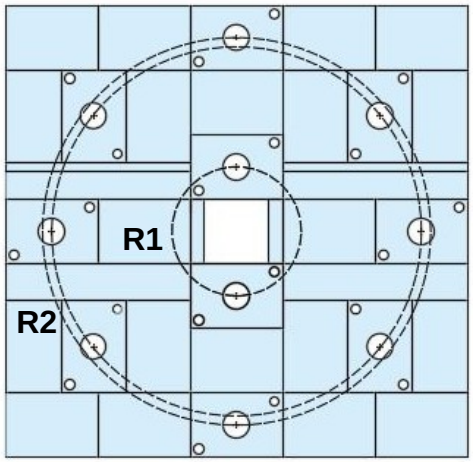
N. Mont, Master thesis, U. Sevilla, 2020.
N. Mont et al. arXiv:2205.02147 (2022)



MiniBELEN-10A:

- 10 ^{3}He-tubes, 3 rings
- Moderator: 58x43x70cm^3
- Reflector 4cm thickness
- Nominal efficiency up to 8 MeV:

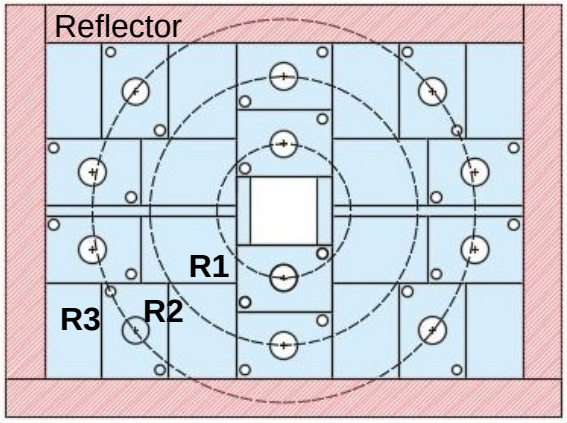
$\varepsilon_{nominal}$ = 7.0 ± 0.5 %



MiniBELEN-10B:

- 10 ^{3}He-tubes, 2 rings
- Moderator: 50x49x70cm^3
- Nominal efficiency up to 8 MeV:

$\varepsilon_{nominal}$ = 5.4 ± 0.3 %



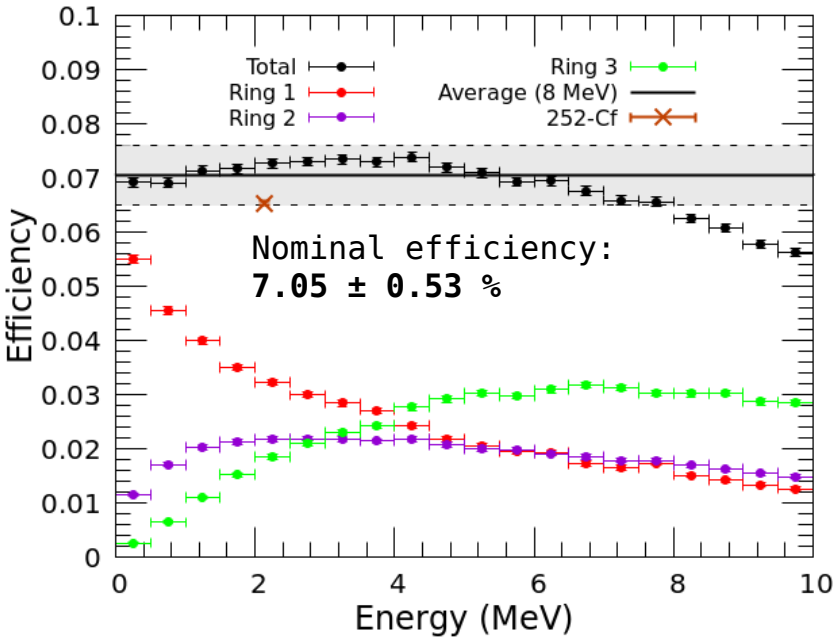
MiniBELEN-12:

- 12 ^{3}He-tubes, 3 rings
- Moderator: 50x35x70cm^3
- Reflector 4cm thickness
- Nominal efficiency up to 8 MeV:

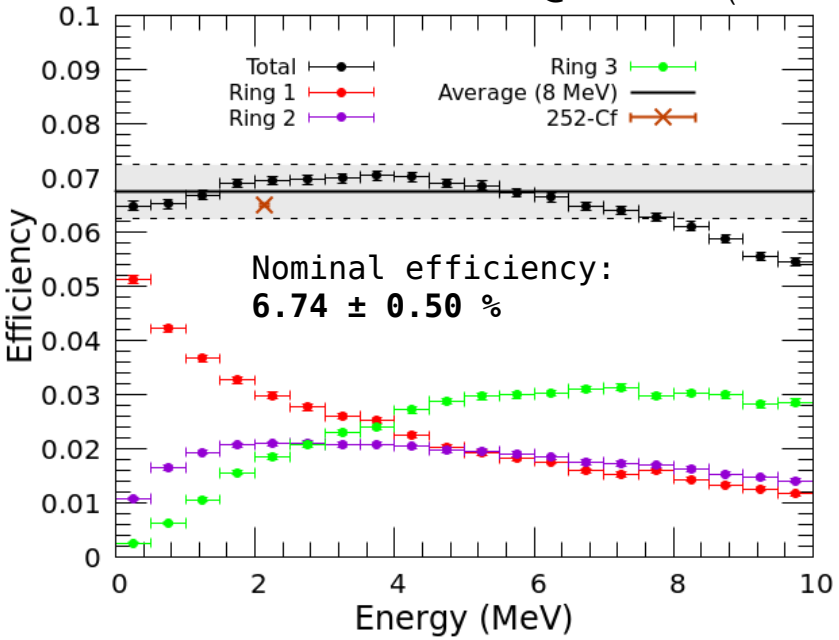
$\varepsilon_{nominal}$ = 8.4 ± 0.6 %

MiniBELEN-10A: final assembly

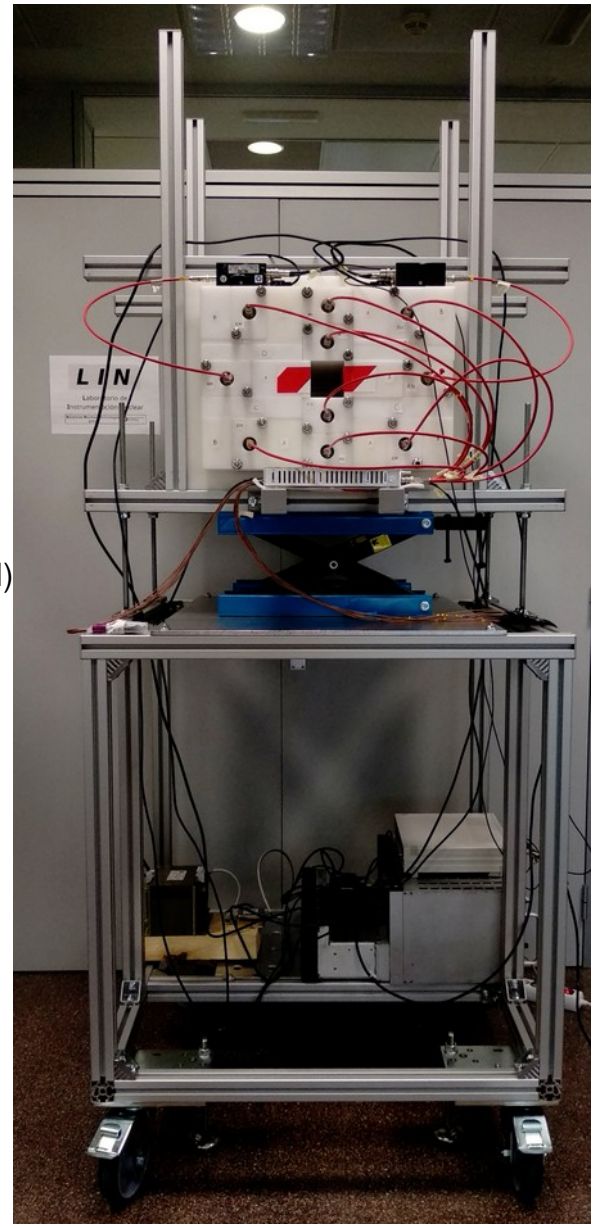
MB-10A version 2021: ^{3}He-tubes @ 7x 10 atm, 1x 4/8/20 atm



MB-10A version 2022: ^{3}He-tubes @ 10x 8 atm (BRIKEN)



MC simulations by the Geant4 application ***ParticleCounter***.



UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
Institut de Tècniques Energètiques

- Detector assembled and operative since Jan 2021.
- Nominal efficiency fully determined by MC simulations (GEANT4).
- Experimental characterization by means of NMC with ^{252}Cf source. ***Good agreement with G4 simulations.***
- Detector table designed to be compatible with beamlines at CMAM and CNA.

N. Mont, PhD thesis (UPC)

MiniBELEN-10A: commissioning at CMAM

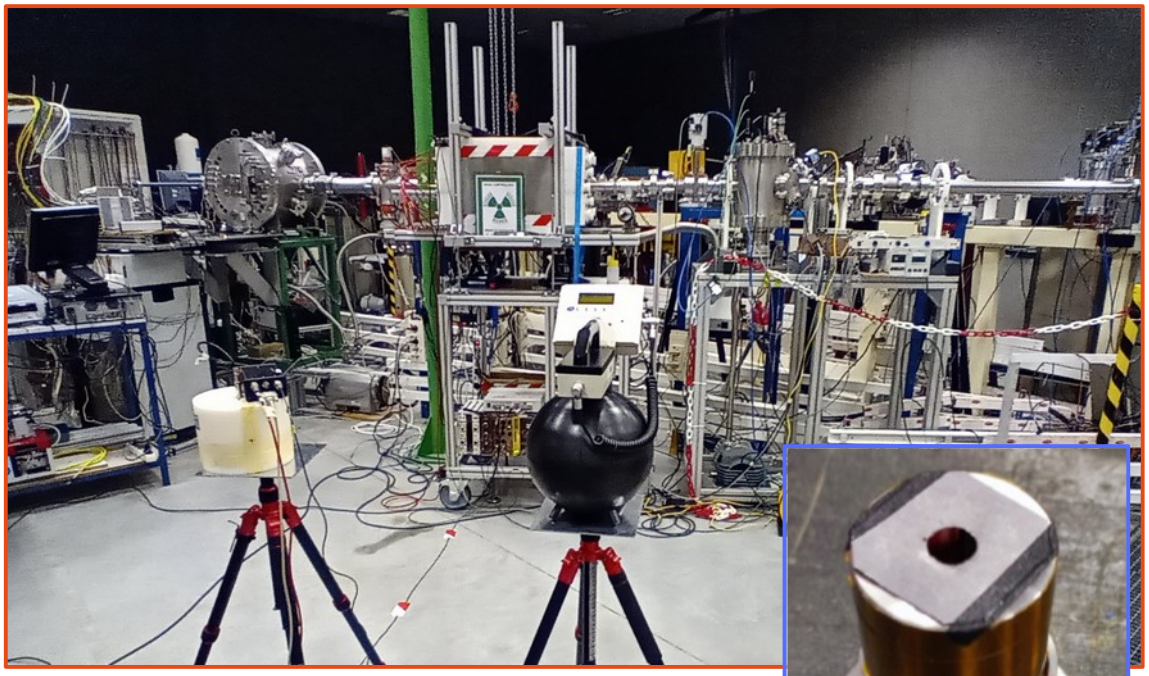
miniBELEN-10A commissioning test @ CMAM:

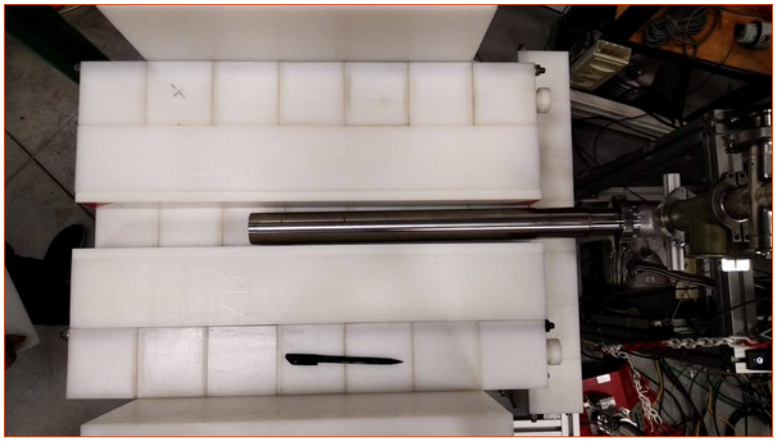
MiniBELEN-10A (neutron counter):
- HDPE moderator.
- Versions: 2021 & 2022.
- External cadmium and boron shielding.
- Shielding in beam (removable).

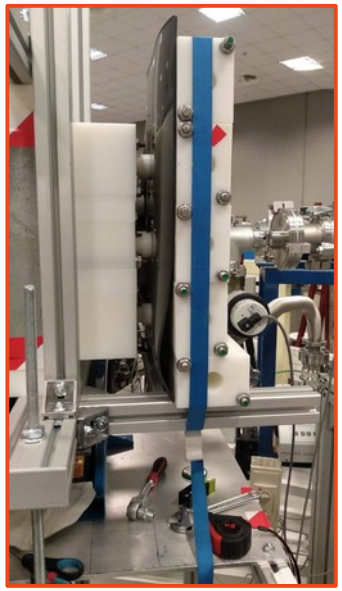
Ancillary detectors:
- LaBr3 or HPGe detector (gamma detectors).

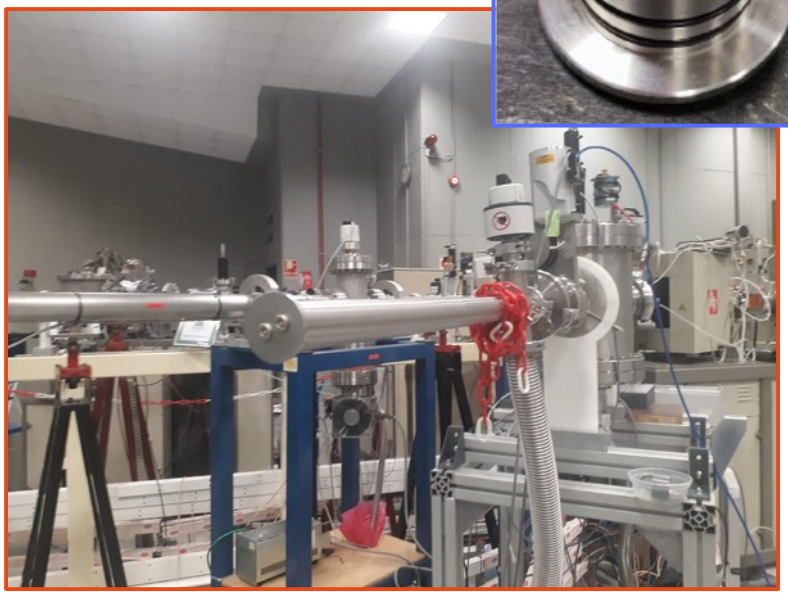
Target & Faraday Cup (FC):
- Al, Be and Ta thick targets (100 um). Ta is used for background assessment.
- Current integrator: Ortec 439.
- FC with 7 mm diameter Ta collimator.
- +300 V current supressor.

CMAM accelerator (α-particles, q = +2).









Commissioning: data acquisition

GASIFIC7: IFIC Digital AcQuisition system

SIS3316 Characteristics:

- 250MHz sampling digitizer 125MHz Band width
- 64MSamples memory/channel (in two swap pages)
- Readout simultaneous to acquisition
- 14-bit resolution (12 effective bits)

Portable digital acquisition system:

- Based on the digitizer Struck SIS3316.
- Controlled by GASIFIC70 via ethernet conection.
- 16 channels, triggerless mode.
- Online and offline acquisition modes.
- Pulse height analysis by using digital trapezoidal filter.
- Internal timestamp, ideal for data sorting and correlation analysis.
- For use with neutron counters, silicon detectors, HPGe, scintillators, etc.
- Dead-time is determined by software (trigger gate length).

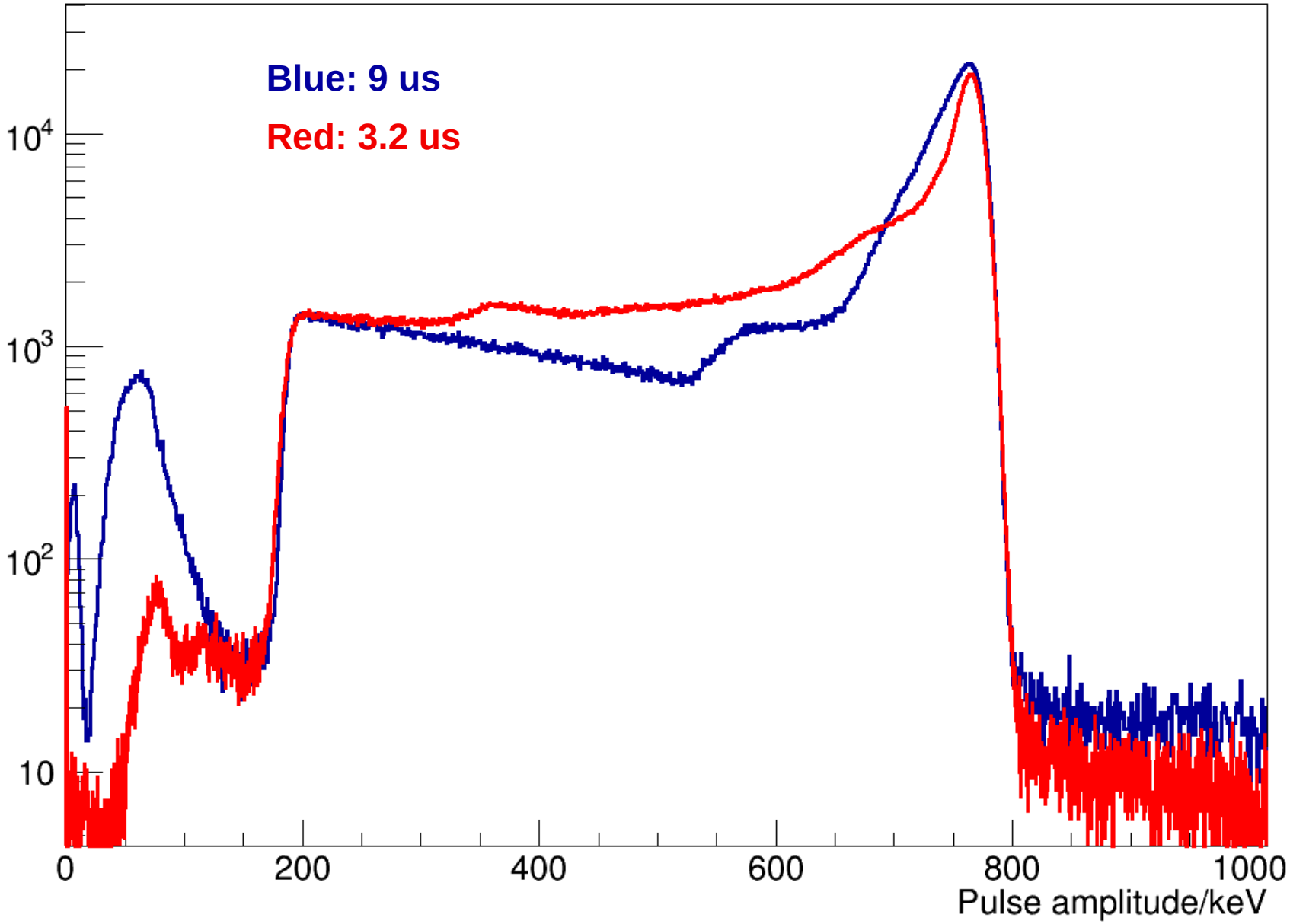
During the commissining at CMAM we have tested two possible DAQ configuration on the trigger gate length:

- 9 us (MB-10A/v2021)

- 3.2 us (MB-10A/v2022)

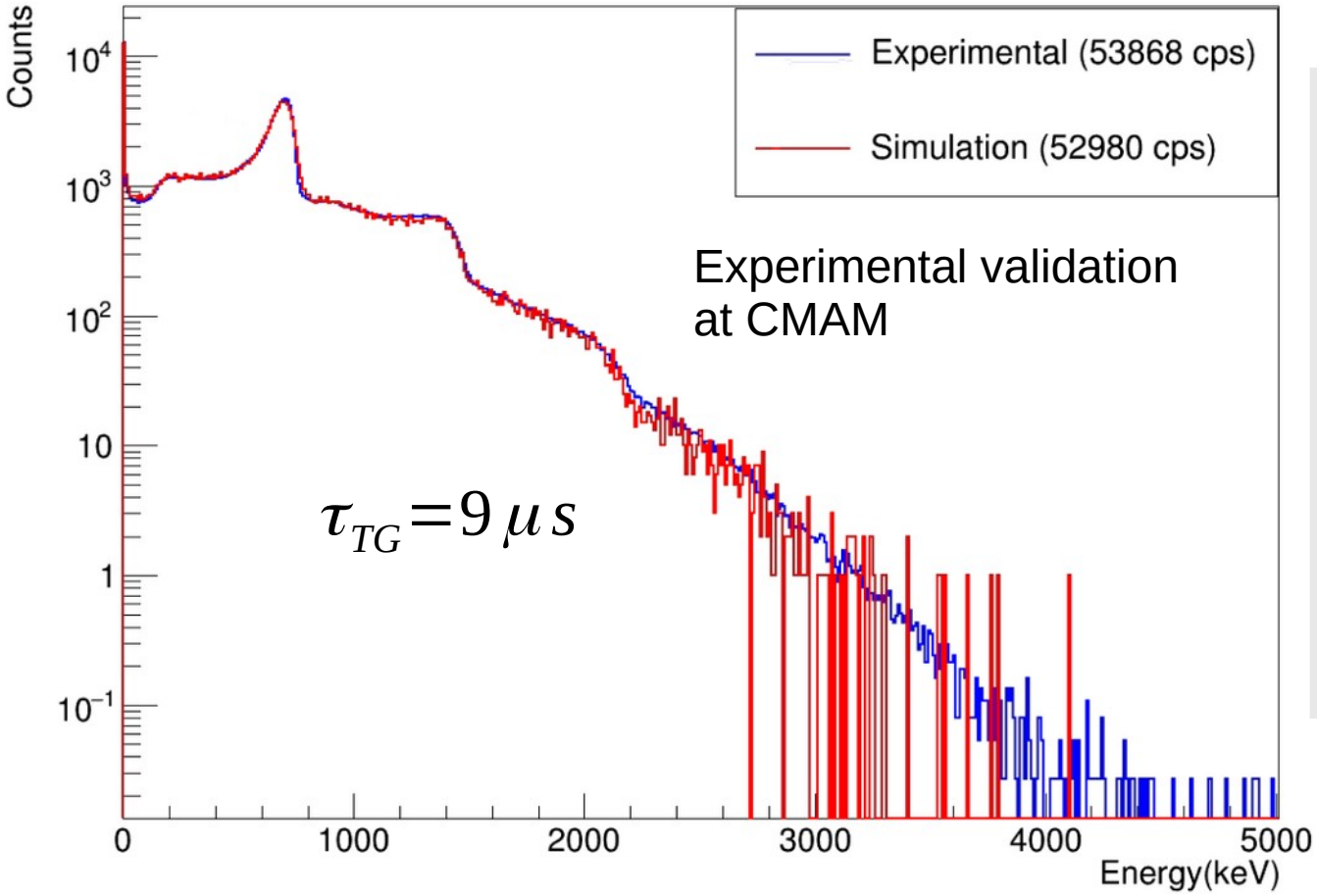
GASIFIC7 is described in Agramunt et al. NIMA (2016) 69-78

Commissioning: data acquisition



Commissioning: dead-time & pile-up effects

- Our DAQ (GASIFIC7) is a non-paralizable system by construction.
- We successfully emulate the firmware.
- The data stream is reconstructed by assuming a event time difference distribution ~ Exp(-R·t).
- The true event rate (R) is obtained by fitting the experimental amplitude spectrum of the neutron counter.



Good agreement with the reconstruction at large counting rates (>100 kcps)!

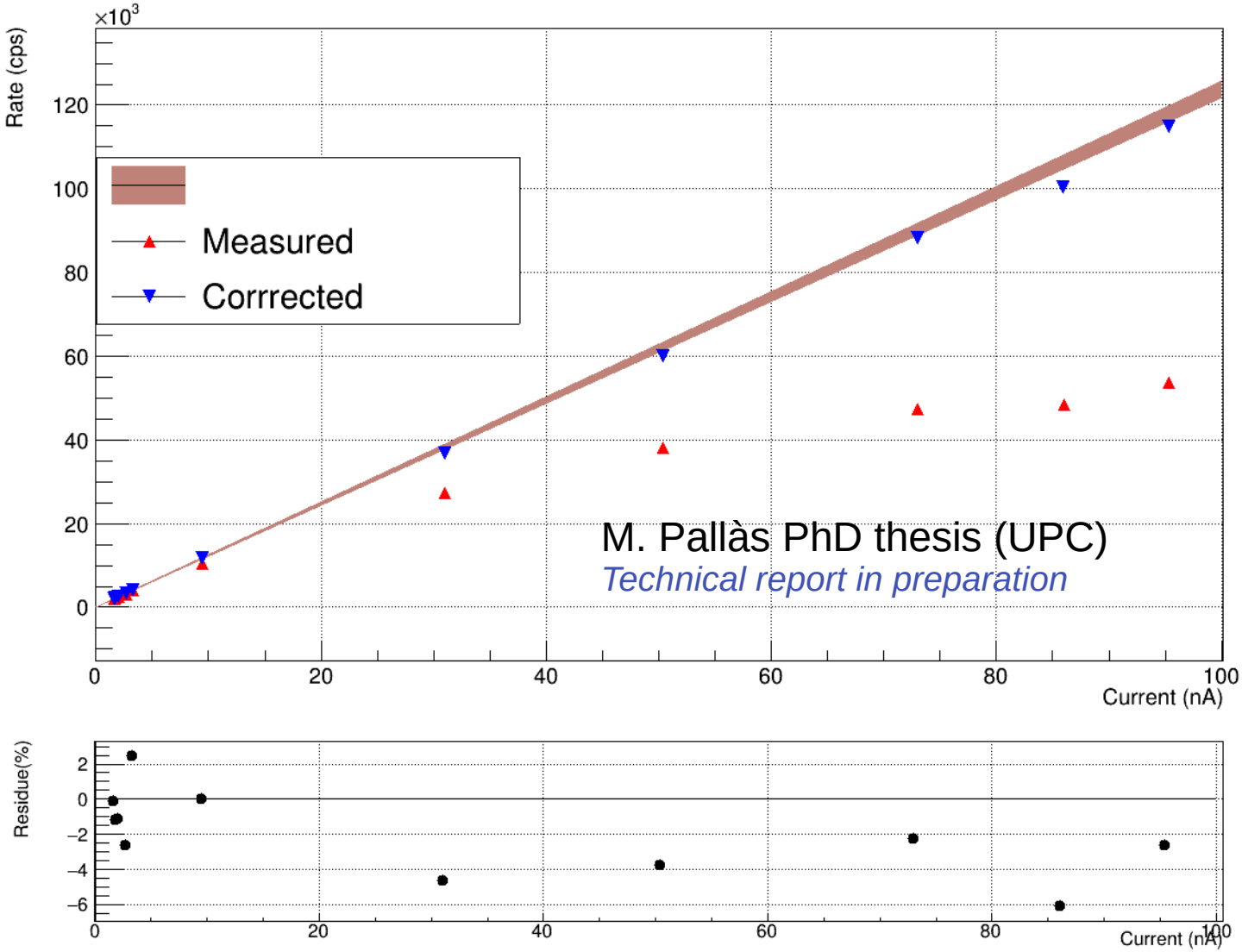
Experimental observed rate: 53868 cps

Simulation observed rate: 52728 cps

Estimated true rate: 111985 cps

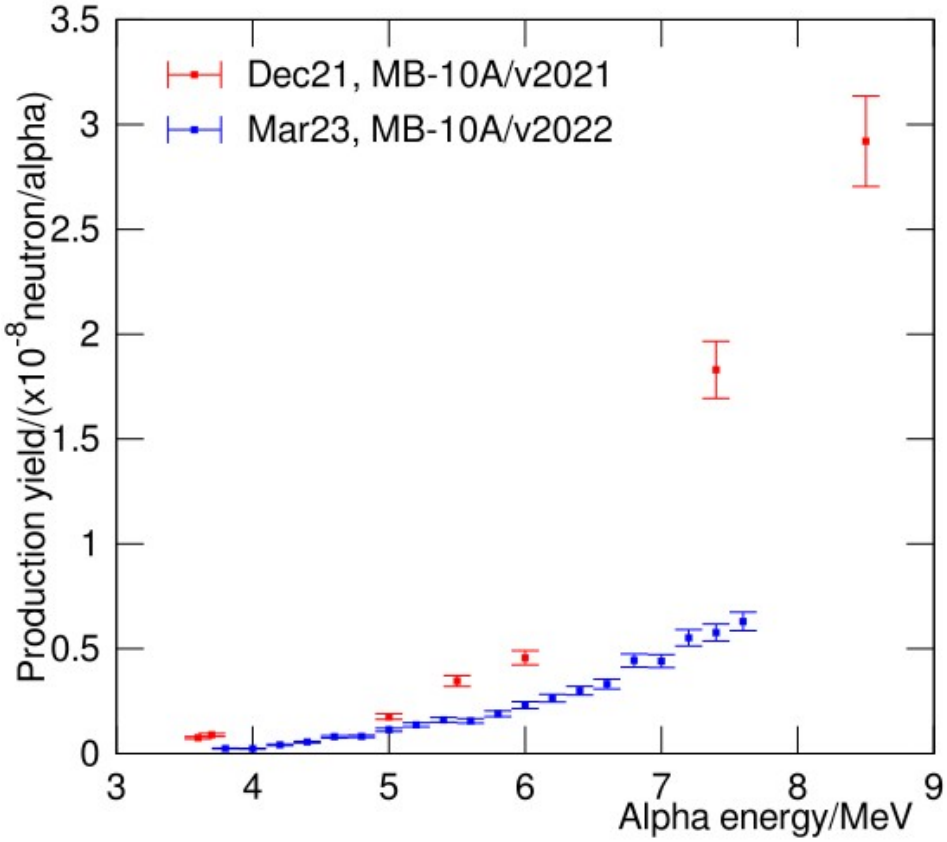
M. Pallàs PhD thesis (UPC)
Technical report in preparation

Commissioning: dead-time & pile-up effects

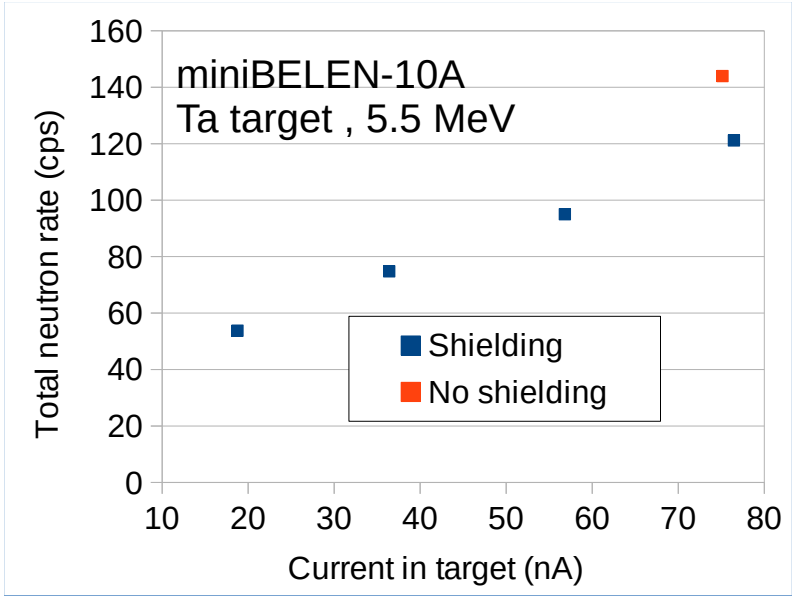


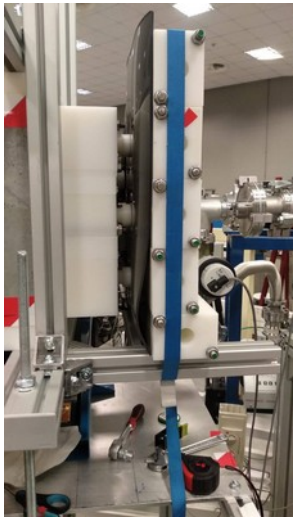
Commissioning: background

Background yield



In-beam background





Commissioning: 27Al(alpha,n) production yields

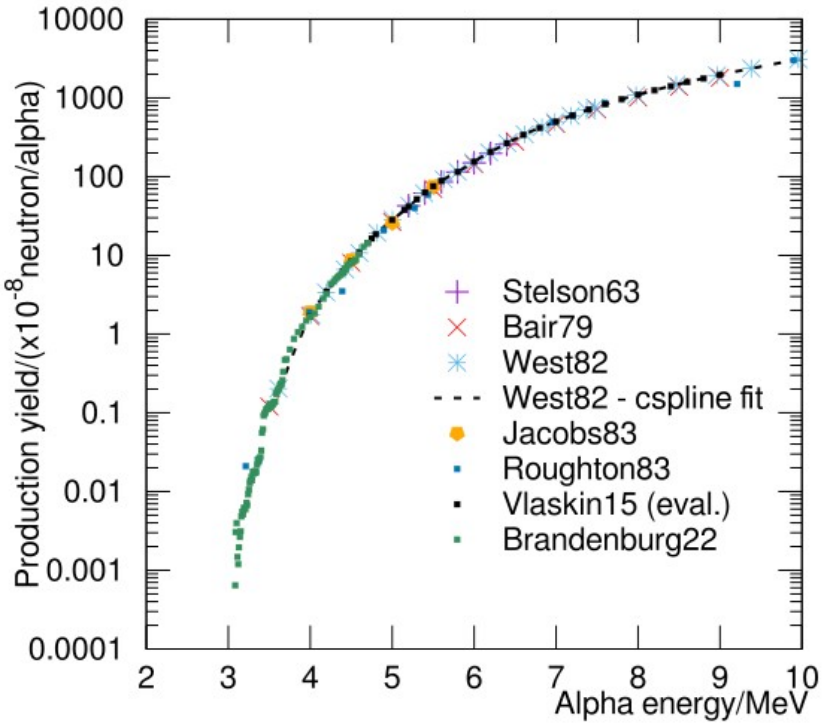
$$^{27}Al\left(\alpha,n\right)^{30}P$$

- Stable isotope, 100% natural abundance, non toxic, god conductor, **accessible target!**
- One of the better known alpha production yields. Latest evaluation from 2015 (Vlaskin et al.)
- Relative low reaction threshold:

^{27}Al + α

Reaction Products	Q-Value (keV)	Threshold (keV)
^{30}P + NN	-2642.41 *8*	3014.81 *9*

- It has been suggested as a **candidate for reference (α,n) cross sections** for use in relative measurements, and beam monitor cross sections needed to determine the incident alpha-particle flux (INDC(NDS)-0836).



Neutron yield from direct neutron counting using miniBELEN-10A

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

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

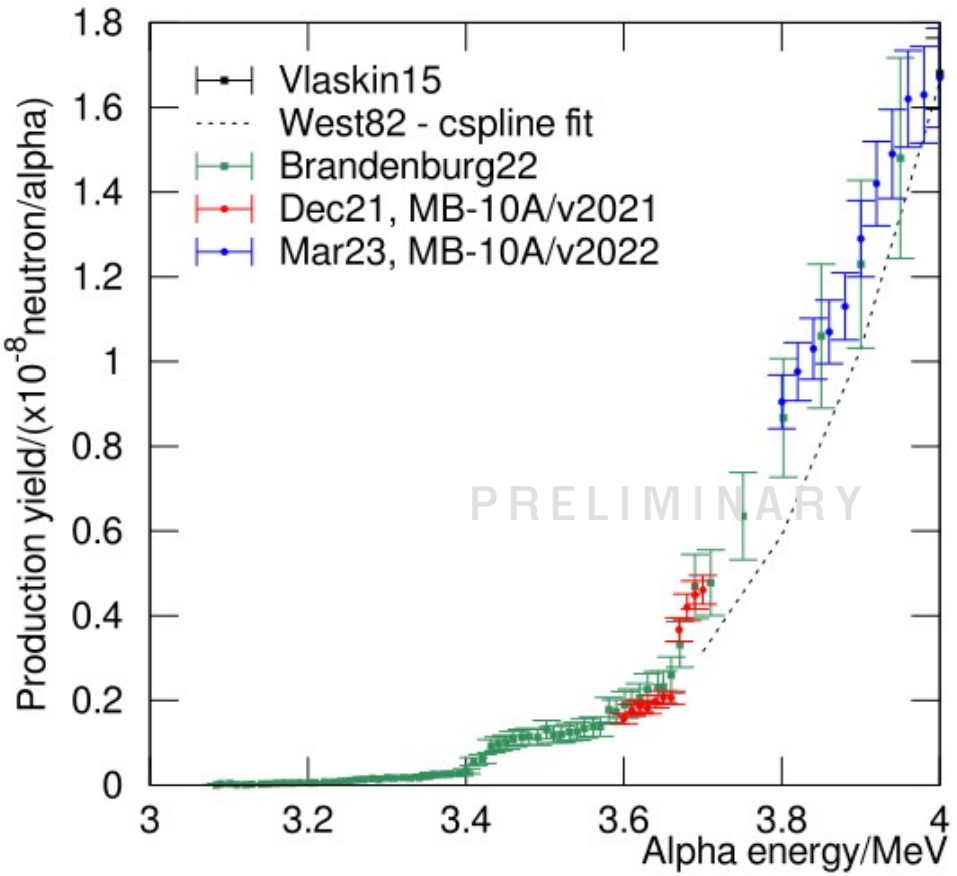
Neutron counting rate

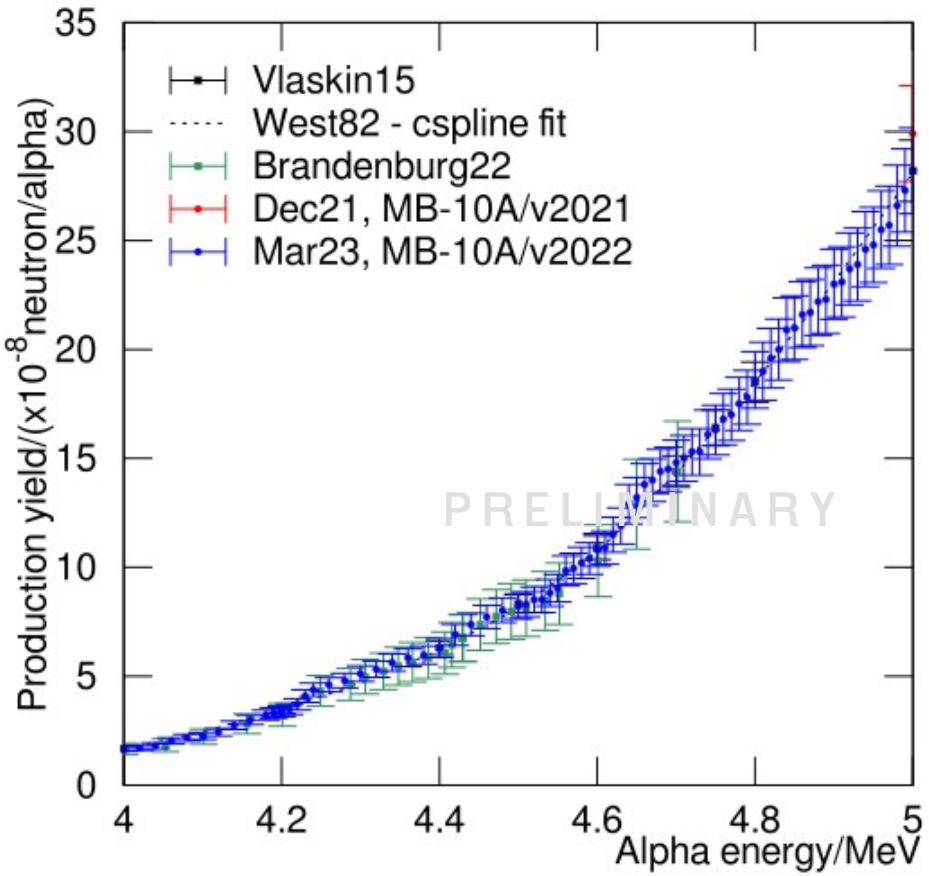
Nominal efficiency determined from MC simulations (contributes to the systematic!)

Determined from the current integrator

- We assume low sensitivity to angular distributions in MB-10A.
- The ratio *R/I* is determined in real-time, so that we can reduce systematic due to beam fluctuation.

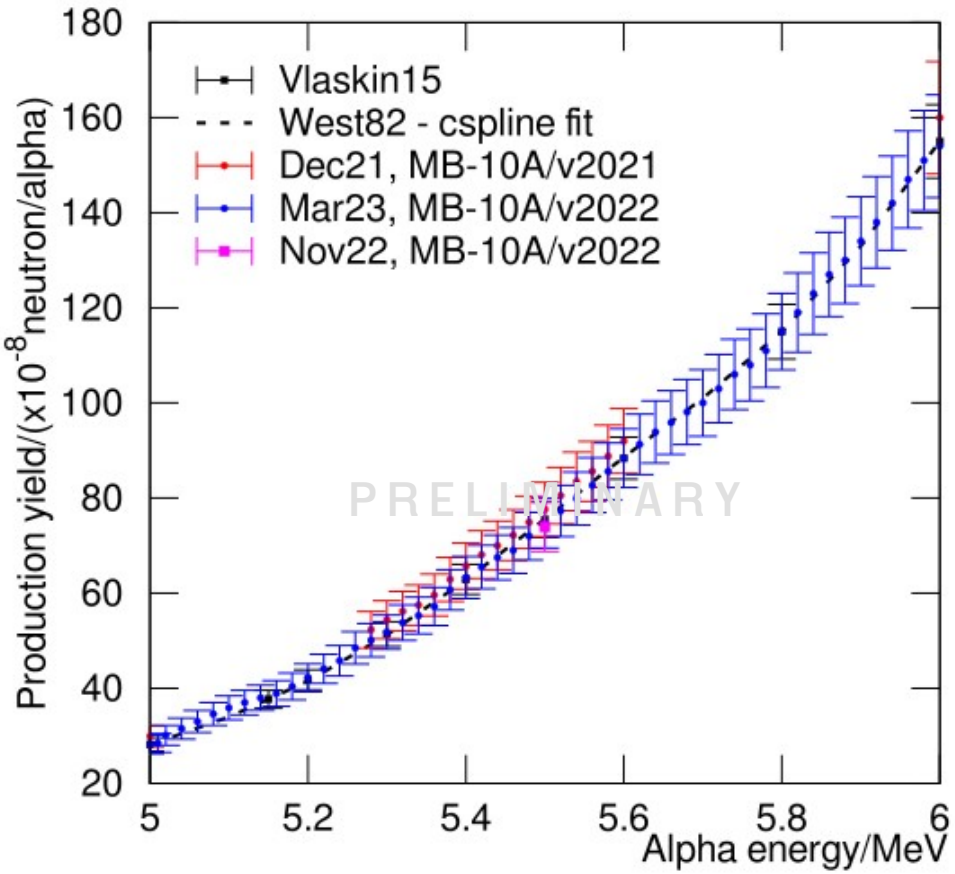
Commissioning: 27Al(alpha,n) production yields

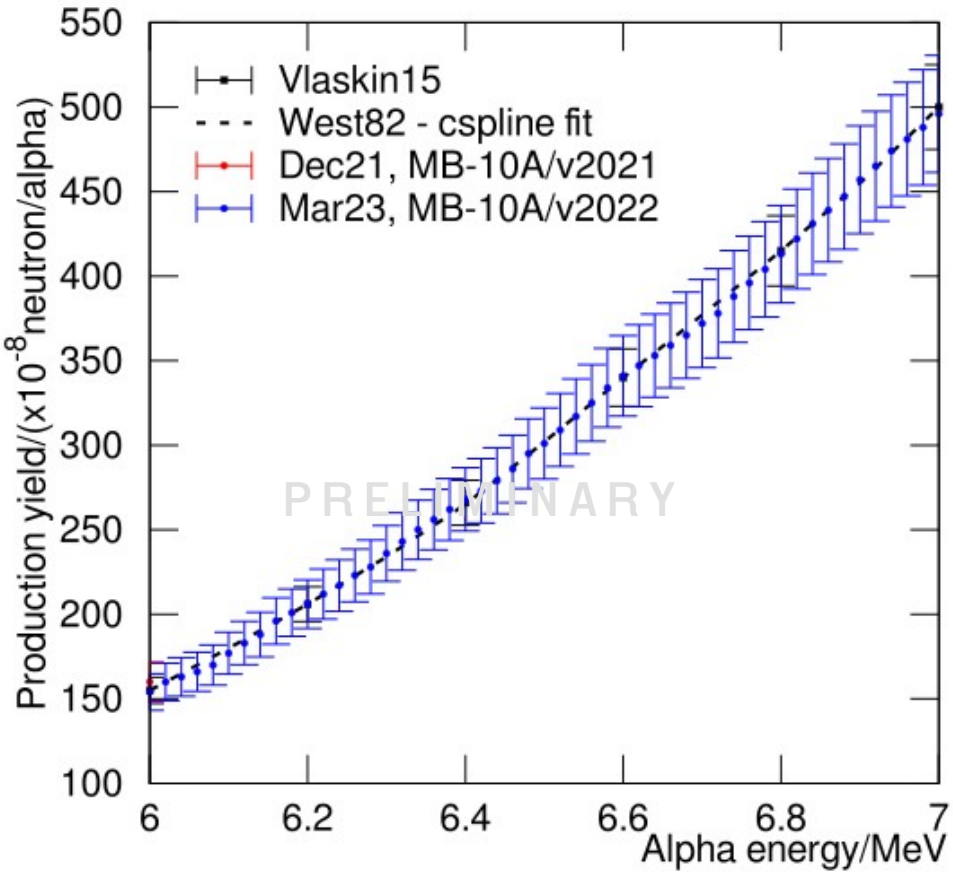




N. Mont-Geli, PhD thesis (2024)
Preliminary results: N. Mont-Geli et al. (2023) arXiv:2304.07311
MiniBELEN-10A commissioning full manuscript in preparation.

Commissioning: 27Al(alpha,n) production yields





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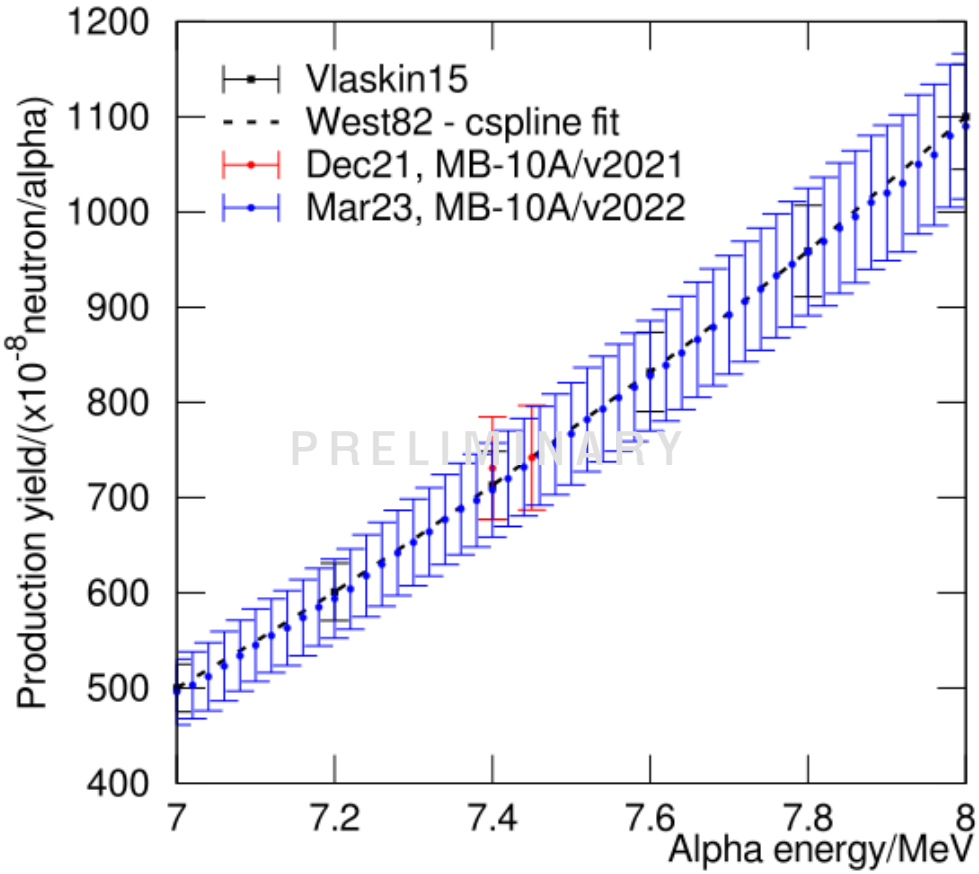
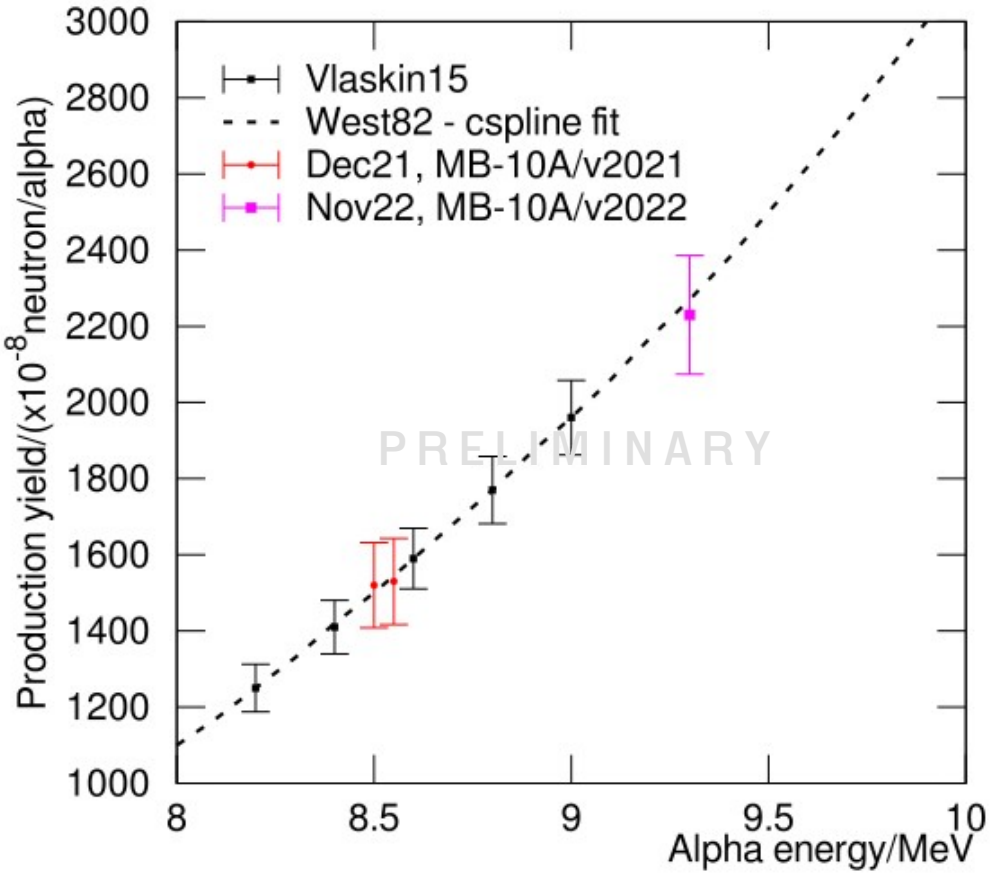




N. Mont-Geli, PhD thesis (2024)
Preliminary results: N. Mont-Geli et al. (2023) arXiv:2304.07311
MiniBELEN-10A commissioning full manuscript in preparation.

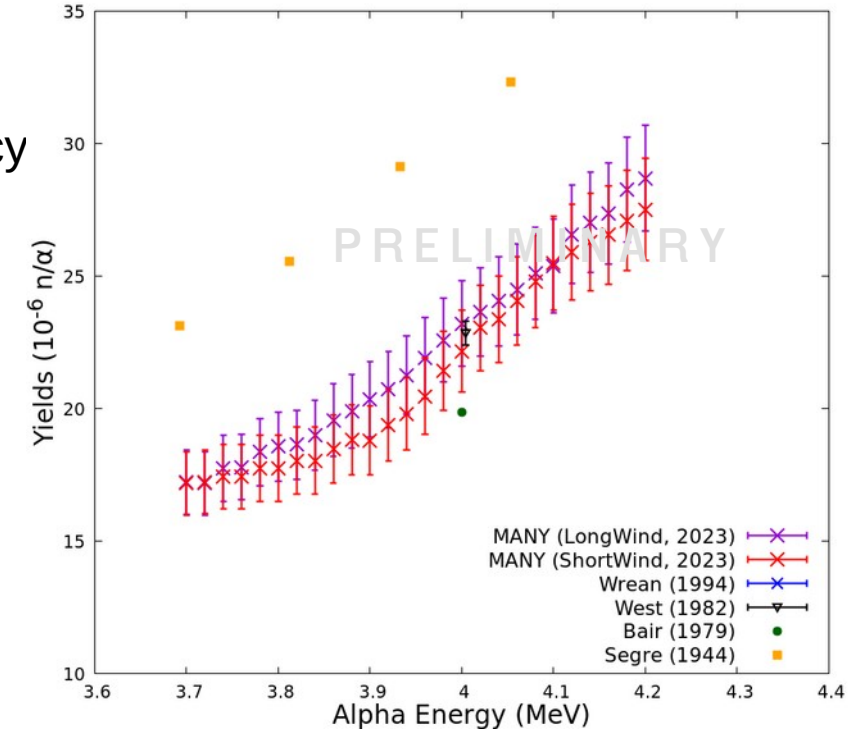
1) "First" physics measurement is on-going:
- 27Al(alpha,n) cross section derived from thick target yields (see N. Mont's slides)

2) Next isotope to be measure:

$^{9}Be + \alpha$

Reaction Products	Q-Value (keV)		Threshold (keV)
^{12}C + NN	5702.0	*1*	0

- Target is already available (purity 99.99%).
- First test has been already performed at CMAM.
- Preliminary results suggest the need of low efficiency setup in order to reduce systematics.



3) Instrument development:
- Low detection efficiency setup from MB-10A, Target efficiency ~2%.
- A new sample holder allowing to interchange samples without the need of breaking vacuum.

4) Commissioning of miniBELEN-10A at CNA beamline
(see C. Guerrero's talk)

The MANY collaboration:

V. Alcayne[6], A. Algora[2], O. Alonso-Sañudo[3], J. Balibrea-Correa[2], J. Benito[3], M. J. García-Borge[5], J. A. Briz[3], F. Calviño[1], D. Cano-Ott[6], G. Cortés[1], A. De Blas[1], C. Domingo-Pardo[2], A. Espinosa[3], B. Fernández[7], L. M. Fraile[3], G. Garcia[4], R. García[1], V. García-Tavora[4], J. Gómez-Camacho[7], E.M. González-Romero[6], C. Guerrero[7], A. Illana[3], J. Lerendegui-Marco[2], M. Llanos[3], T. Martínez[6], V. Martínez-Nouvilas[3], E. Mendoza[6], N. Mont-Geli[1], JR. Murias[3], E. Nácher[2], A. Nerio-Aguirre[5], V. V. O. Onecha[3], S. Orrigo[2], M. Pallàs[1], A. Perea[5], A. Pérez de Rada[6], V. Pesudo[6], J. Plaza[6], J.M. Quesada[7], A. Sánchez[6], V. Sánchez-Tembleque[3], R. Santorelli[6], J.L. Tain[2], A. Tarifeño-Saldivia[2], O. Tengblad[5], J.M. Udías[3], D. Villamarín[6] and S. Viñals[4]

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THANKS!