Update on neutron flux measurement and NID analysis

General CYGNO meeting 5th July 2024

E. Baracchini

Neutron flux measurement

The interest of the scientific community, especially at LNGS

N. Mont-Geli - HENSA at Laboratori Nazionali del Gran Sasso (LNGS): characterization of the neutron flux
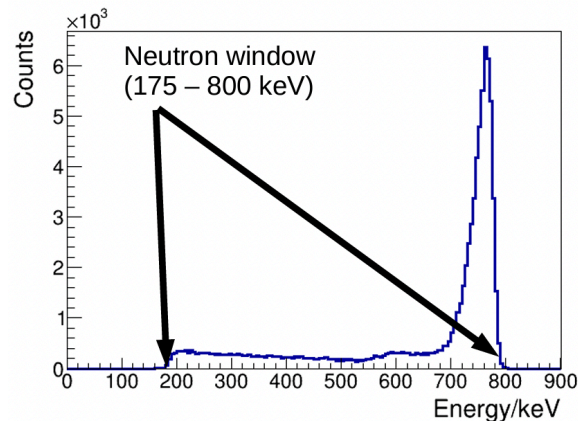
3 July 2024
LNGS
Europe/Rome timezone

Neutron detection in He-3 proportional counters

HENSA
High Efficiency Neutron Spectrometry Array

HENSA collaboration at Laboratori Nazionali del Gran Sasso (LNGS)

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH — Institut de Tècniques Energètiques — UPC

INFN LNGS

IFIC INSTITUT DE FÍSICA CORPUSCULAR — VNIVERSITAT D'G VALÈNCIA — CSIC Consejo Superior de Investigaciones Científicas

UNIVERSIDAD DE GRANADA

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Actual ROI of ³He counter..
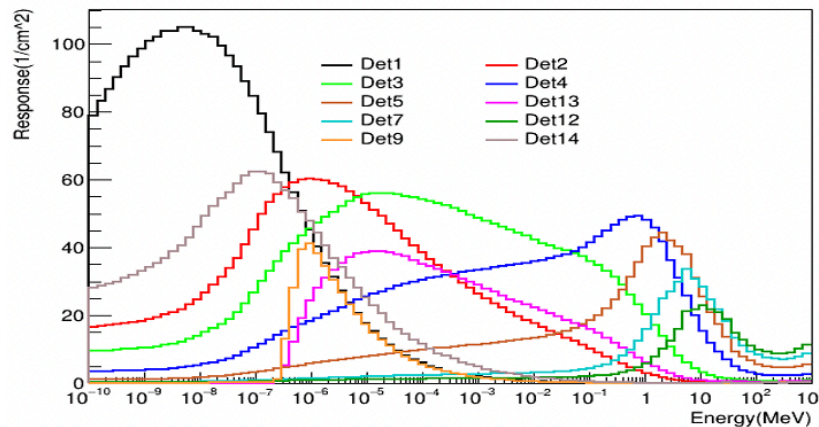
Neutron window
(175 – 800 keV)

- 10 He-3 thermal neutron counters (2.54 cm diameter, 60 cm length)
- HDPE shielding with variable sizes (HDPE thickness from 32 to 380 mm)

HENSA version 2022

Setup at LNGS Hall A Aprl 2024

…which through the use of Bonner spheres and decovolution correspond to this neutron energy range

Det1   Det2
Det3   Det4
Det5   Det13
Det7   Det12
Det9   Det14

Neutron flux measurement

The interest of the scientific community, especially at LNGS

Current HENSA plans at LNGS

- Short measurements (2 – 4 months) at different locations:
  - Hall A, since late April 2024.
  - Inside the new STELLA facility (begin in mid-July until late September/October).
  - Other locations: hall B, hall C.
- Long-term monitorization of the neutron flux (minimum 1 year).
  - Location to be decided.

Status of the neutron data at LNGS   *From HENSA talk*

I have compiled ten different previous works related with neutrons (1985 – 2019).

Only two works provides a "complete" spectrum (from thermal to fast energies):
- Belli (1989) using a HENSA-like setup (but no unfolding) in hall A.
- Arneodo (1999) direct energy measurement (proton recoil) in hall C.

Moreover, discrepancies between measurements. Example in hall A:
- Fast flux (cm^-2 s^-1):
  - Belli (1989): 0.32(14) E-6 (contribution above 2.5 MeV)
  - Aleskan (1989): 0.78(4)E-6 (only above 3 MeV)
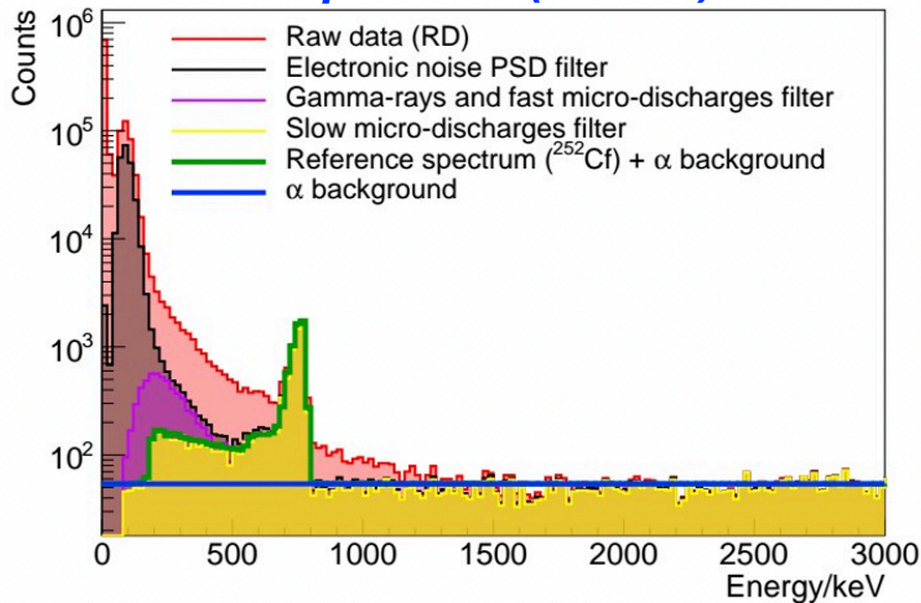 - Cribier (1995): 0.09(6)E-6 (only above 2.5 MeV)

Neutron flux measurement
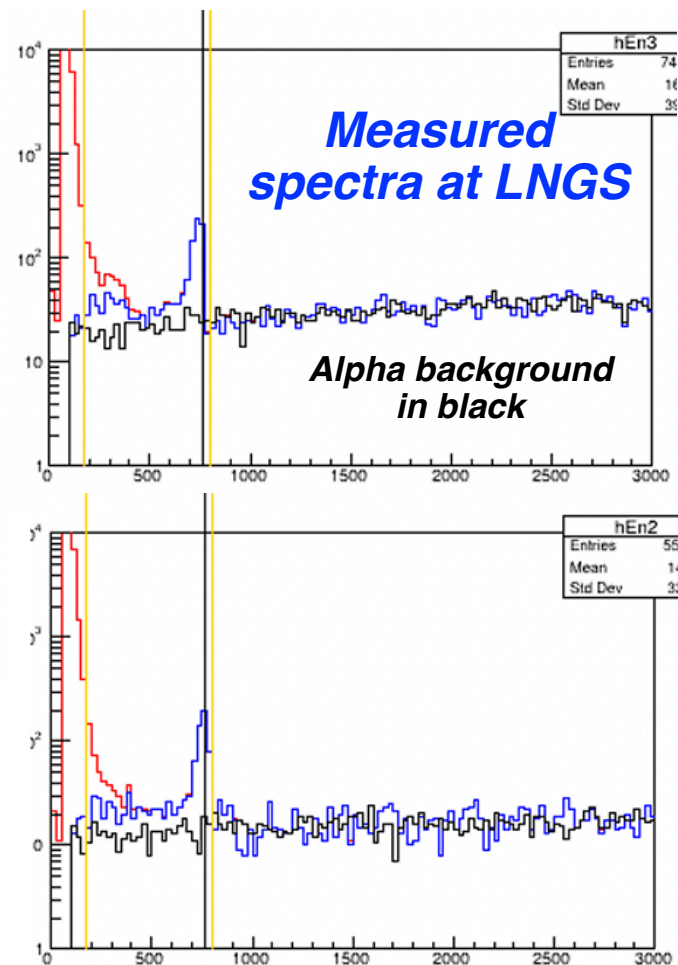## The interest of the scientific community, especially at LNGS

N. Mont-Geli - HENSA at Laboratori Nazionali del Gran Sasso (LNGS): characterization of the neutron flux

The alpha background is our main limitation!

Typical spectrum composition (at LSC)

Raw data (RD)
Electronic noise PSD filter
Gamma-rays and fast micro-discharges filter
Slow micro-discharges filter
Reference spectrum (^{252}Cf) + α background
α background

Measured spectra at LNGS

Alpha background in black

Please note: large systematics expected (from both deconvolution and experimental techniques), not yet evaluated

About 250 events neutron-flux related/ month in the entire 175-800 keV range, on top of a very large alpha background, constituting their main limitation and systematics as from their own admission

Neutron flux measurement
update on development within CYGNO

- Melba is simulating the expected NR induced by the external neutron flux in LIME necessary to test and develop the deconvolution algorithm

  - Simulation by Flaminia not usable for digitisation purpose and larger sample needed

- Zahoor and Melba are looking into the deconvolution algorithm functioning

- Stefano is looking into the feasibility and performances of NR fiducialisation through shape variables (i.e. tgaussigma)

Negative Ion Drift measurement
Update

- After the many questions and doubts raised by the collaboration, we performed a significant amount of additional measurements

    - Varying He content in NID mixtures (total of 4 NID mixtures) —>all displayed below thermal diffusion

    - Varying gas pressure with standard ED mixture and comparing with Garfield++ prediction

    - Varying LY in both NID and ED measurement

    - Comparing different reconstruction code output

- We had some issues and had to repeat some of the measurement more than once

- We are still finalising all these comparisons and analyses

    - I take the main responsibility for this delay, having been overwhelmed with PhD theses correction from December 2023 to end of May 2024.