New measurement of the neutron flux at the Modane Underground Laboratory

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Neutron Helium-3 detector

\[ n + ^3\text{He} \rightarrow p + ^3\text{T} \text{ (very high cross section for thermalised neutrons)} \]
\[ Q = 764 \text{ keV} \]

\[ \rightarrow \text{Polyethylene moderator to measure fast neutrons} \]

planned: wrap PE in Cadmium-109 foil to filter thermal neutrons

- 4 Helium-3 counters: gas mixture of 400 kPa $^3\text{He}$ and 500 kPa $^{40}\text{Ar}$
  \[ \Phi 31 \text{ mm } \times 860 \text{ mm work length (signal wire } \Phi 28\mu m) \]

Stainless tube covered inside by 50-60 $\mu$m Teflon and 1$\mu$m electrolytic Copper against alpha background
Detector description

Electrical scheme of the module

Counters have identical response
-> read together

Views of the module
Electronic response

Shape of signal after preamplifier  
(HV=1600V)

Check using a generator:  
575 pulses on the input preamplifier

Shape of signal after ORTEC572 amplifier (gain 100, shaping time 2ms)

The gaussian fit provides:
  -> 552(24 events)
  -> resolution of 3.1% (electronics + generator)

  -> Expected peak seen
Spectrum using a PuBe Source

$$n + ^3\text{He} \rightarrow p + T$$

Q = 764 keV

p = 573 keV

T = 191 keV

Log scale!

Efficiency of detection has to be estimated with MC simulation but should be very good: Using a $^{238}\text{U}$ source of activity $15.2 \pm 1.3$ n/s placed directly on the surface of the module $\rightarrow 1.00(6)$ Hz in detector

Near surfaces the P or T may leave only part of their energy in the detector Fraction?

Counts per 1h per 0.78 keV

Energy (keV)

1h run with PuBe source

$191\text{ keV}$

$573\text{ keV}$

$764\text{ keV} (p+T)$
Detector installation in LSM

Detector placed in the Edelweiss area, near the ground floor

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Workshop Identification of Dark Matter Rhodes, September 11-16, 2006
First measurements in LSM (July 2006)

237 hours (about 10 days)

Bin width 0.7 keV
Resolution = 4%

-> Clearly identified peak with low background
-> 157±5 detected neutrons per day!
Time dependance of the neutrons

Neutron rate per 3 hours

1 day spectrum

\( \chi^2 / \text{ndf} = 43.05 / 51 \)
\( p_0 = 19.78 \pm 1.212 \)
\( p_1 = -0.001962 \pm 0.0129 \)

\( \rightarrow \) No significant time dependence
Internal alpha background rate

From extrapolation of region above peak

-> 0.8(±0.1) counts per day in the peak region : 764±45 keV
-> background 200 times lower than signal
-> planned : measurement of internal neutrons with thick PE shielding
Neutrons as a AmBe neutron source entered the Lab

21-23 July NEMO used 200kBq neutron source for calibration

21 hours with AmBe source on top of NEMO

→ linearity of the energy scale
Conclusions and Outlook

- First measurements with new Helium-3 detector at LSM
- Very promising results:
  - rate about 150 n/day with good time stability
  - alpha background 200 lower than neutron signal

Future ideas and plans:
- Use of 109Cd to disentangle thermal and fast neutrons
- Use of thick PE shielding to measure internal neutron background
- Move the detector in different parts of the lab
- Monte-Carlo simulation of the detector to estimate neutron flux
- Use scintillator around of counters instead of PE moderator.
  (maybe OPERA-like scintillator rods to measure directly the neutron spectrum without unfolding)
- Use of additional modules
- Coincidence with Muon-Veto of Edelweiss-II