LIME background simulation summary

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GOAL:
assess LIME shielding configuration for underground operations

Goal & context

- We focused on the [0,20] keV energy range since from literature (measurements and simulation) ER background discrimination is expected to exceed 10^6 at 20 keV
- LIME background assessment towards CYGNO development
  - Neutron + gamma shielding (5 cm Cu or more) allowed by available space
  - We know the available space will not allow external radioactivity reduction at the level we can expect for CYGNO
  - We need to reduced external radioactivity left after background discrimination enough to characterise internal gamma backgrounds for additional material screening and MC simulation towards a realistic estimate of CYGNO sensitivity that properly includes background
- Neutron flux measurement:
  - no neutron (i.e. water) shielding
  - Faraday cage only (2 cm Cu) or gamma shielding acting also as Faraday cage (Shield cage, 5 cm Cu or more)
  - NR induced by external and internal radioactivity needs to be negligible w.r.t. expected neutron yield
  - Can allow larger gamma background at low energies after background discrimination (which we assume we can reach O(10^4) at keV energies) w.r.t. WIMP searches since the requirement to reach very low energy threshold is reduced in this context

All the numbers shown are BEFORE background discrimination

Expected significant NR contribution from GEMs, not shown here since we assume we can discriminate through fiducialization (all events contained in 5 cm distance from the GEMs)

- Internal background of the camera body and lens measured at LNGS (*initial estimates)

ER/yr 1-20 keV	CYGNO	CHINOTTO*	LIME*
Camera body	3.20e6	6.32e5	7.9e4
Camera body shield	4.46e5	8.81e4	1.1e4
Camera lens	9.83e5	1.94e5	2.4e4
Camera lens silica	6.68e1	1.32e1	1.65
GEM	5.09e5	1.01e5	1.26e4
Total (no shield)	4.69e6	9.27e5	1.16e5
Total (low rad)	9.55e5	1.89e5	2.36e4

Internal background contribution is about 0.5-1 x 10^5 gamma/year in [0,20] keV

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Background assessment for CYGNO: full shielding

From external neutrons:

Shielding – 50 cm water plus 5 cm Cu

Number of events in [0-20] keV: 0.035963±0.0078479 cpd/kg/keV
Resulting in about 18.0445±3.93764 events/year

ER coming from secondary gammas

No NR expected (0 events/yr)

For each additional 25 cm water the secondary gamma flux decreases about a factor of 3.

Shielding	Evts/yr [0-20 keV]
5 cm Cu	464000
10 cm Cu	54100
15 cm Cu	6771
20 cm Cu	970

From external gammas:

Shielding – 50 cm water plus 5 cm Cu

Number of events in [0-20] keV: 924.815±19.8165 cpd/kg/keV
Resulting in about 464023±9942.84 events/year

With 5 cm Cu might be difficult to fully characterise internal background

With 10 cm Cu (faraday cage + additional 5 cm external shielding) and slightly reducing water shielding, external background can be suppressed of ±1 order of magnitude w.r.t. internal

Neutron flux measurement: Faraday cage only 2 cm Cu

Not exactly the final configuration

Still large gamma background, but here considering only [0,20] keV range

Analysis needs to be studied and optimised on full energy range

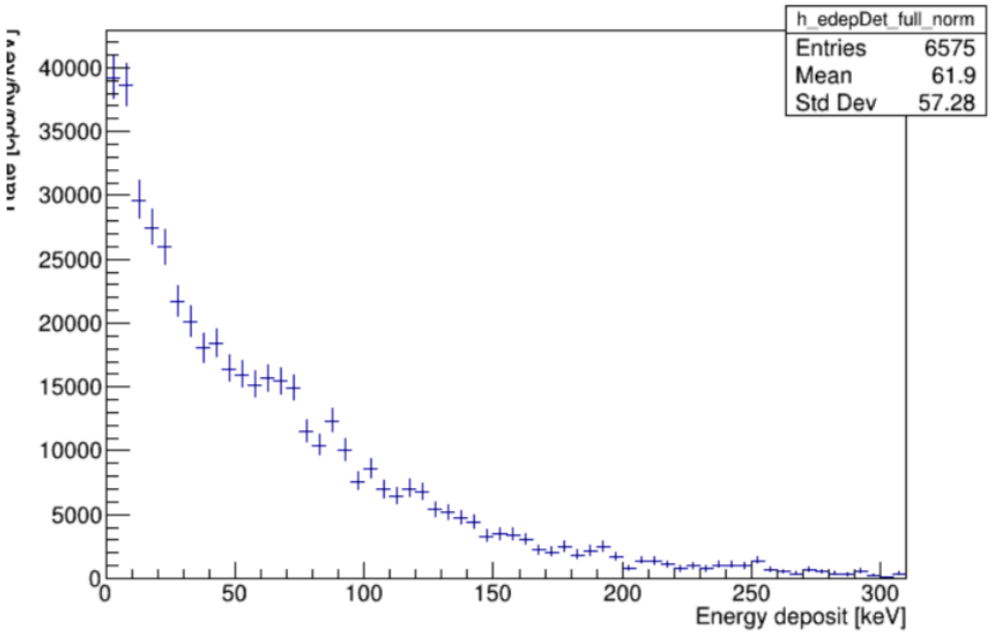
Flaminia working on this

From external gammas:

Number of events in [0-20] keV: 33749.2±789.792 cpd/kg/keV
Resulting in about 1.69335e7±3.96276e5 events/year

ER: about 1.69e7 events/yr (with only 2 cm of Cu from the Faraday Cage)

For each additional 5 cm copper the gamma background decreases about a factor of 4.



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Conclusions & recommendations

- We focused on the [0,20] keV energy range since from literature (measurements and simulation) ER background discrimination is expected to exceed 10^6 at 20 keV

- LIME background assessment towards CYGNO development
  - 40-50 cm H_2O + 2 mm Al (Faraday cage) + 10 cm Cu gamma shielding (5 cm + 5 cm) to suppress external background below internal background

- Neutron flux measurement:
  - 2 mm Al (Faraday cage) + 5 cm Cu gamma shielding
    - (+ possibly other 5 cm Cu, analysis needs optimisation)
  - Still large gamma background at low energies, but no need to get to 1 keV threshold
  - Analysis needs to be optimised for neutron flux measurement, Flaminia working on this