



LIME Simulations – Internal Background

A.F.V. CORTEZ, G. D'IMPERIO, G. DHO, E. BARACCHINI

GRAN SASSO SCIENCE INSTITUTE & INFN

OUTLINE

- Objectives
- Simulation Results - Internal Background
 - No shielding
 - Camera body
 - Camera lens
 - Shielding
 - Camera body (preliminary results)
- Conclusions and Future work

Objectives

Test technology underground with some shielding to verify we can suppress the background as much as possible for the CYGNO 1 m³ detector -> **Zero events inside the detector**

Test the technology with some small shielding to have a significant number of neutrons interacting inside the detector, but with very few gammas -> **Measure the neutron flux**

From last presentation we've seen that...

Due to practical reasons (space availability at LNGS) this might be a problem (depending on the internal background, in particular of the camera).



Simulations focused on the camera radioactive background which is the major source of unavoidable natural radioactivity.

LIME Internal Background

LIME Internal Background

- Internal background of the camera body and lens measured at LNGS.

```
=====
sample:      camera, Hamamatsu, orca-flash4.0, 2.1275 kg, CYGNO
number:      1
live time:   83383 s
detector:    GeMPI
```

radionuclide concentrations:

```
Th-232:
Ra-228:      (2.1 +- 0.2) Bq/pc
Th-228:      (2.1 +- 0.1) Bq/pc
```

```
U-238:
Ra-226       (1.8 +- 0.1) Bq/pc
Pa-234m      (7 +- 2) Bq/pc
```

```
U-235:      (0.4 +- 0.1) Bq/pc
```

```
K-40:       (1.9 +- 0.3) Bq/pc
```

```
Cs-137:     (0.09 +- 0.03) Bq/pc
```

```
Co-60:      < 0.012 Bq/pc @ start of measurement: 12-JUL-2018
```

upper limits with $k=1.645$,
uncertainties are given with $k=1$ (approx. 68% CL);

Ra-228 from Ac-228;
Th-228 from Pb-212 & Bi-212 & Tl-208;
Ra-226 from Pb-214 & Bi-214;
U-235 from U-235 & Ra-226/Pb-214/Bi-214

```
=====
sample:      objective of Hamamatsu orcaflash4.0, 213.5 g (with plastic cap), CYGNO
number:      1
live time:   504104 s
detector:    GePaolo
```

radionuclide concentrations:

```
Th-232:
Ra-228:      (0.077 +- 0.009) Bq/pc
Th-228:      (0.078 +- 0.006) Bq/pc
```

```
U-238:
Ra-226       (0.41 +- 0.02) Bq/pc
Pa-234m      (0.9 +- 0.3) Bq/pc
```

```
U-235:      (0.031 +- 0.008) Bq/pc
```

```
K-40:       (11 +- 1) Bq/pc
```

```
Cs-137:     < 0.0057 Bq/pc
```

```
Co-60:      < 0.0099 Bq/pc @ start of measurement: 10-JUL-2018
```

```
La-138:     (0.52 +- 0.04) Bq/pc
```

upper limits with $k=1.645$,
uncertainties are given with $k=1$ (approx. 68% CL);

Ra-228 from Ac-228;
Th-228 from Pb-212 & Bi-212 & Tl-208;
Ra-226 from Pb-214 & Bi-214;
U-235 from U-235 & Ra-226/Pb-214/Bi-214

Main contributions
identified.

LIME Internal Background

- Internal Background Camera Body is originated mainly by:

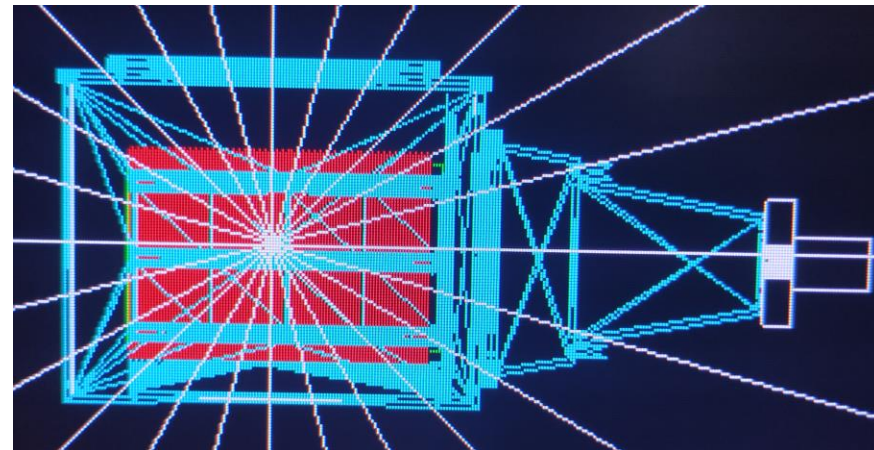
- Th-232 (0.98 Bq/kg)
- U-238 (18.72 Bq/kg)
- U-235 (0.188 Bq/kg)
- K-40 (0.893 Bq/kg)

Simulations:

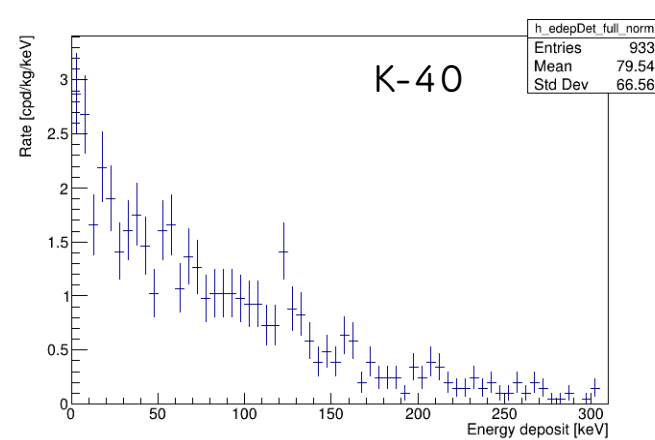
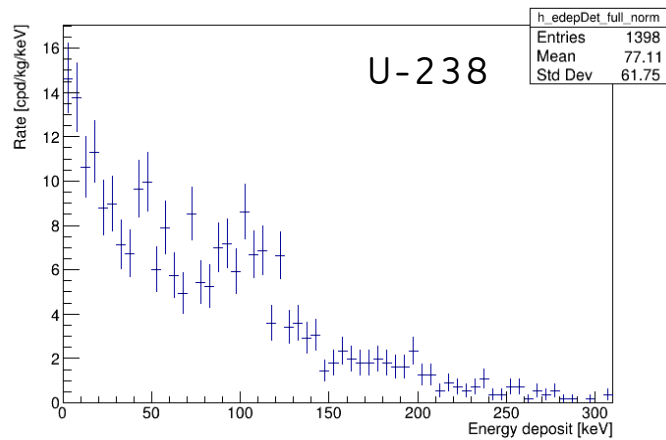
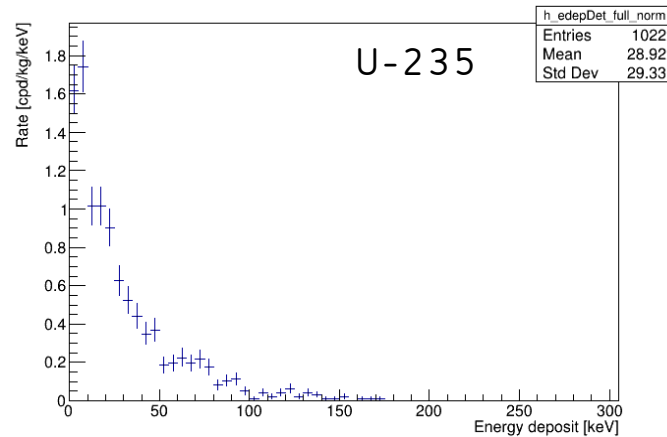
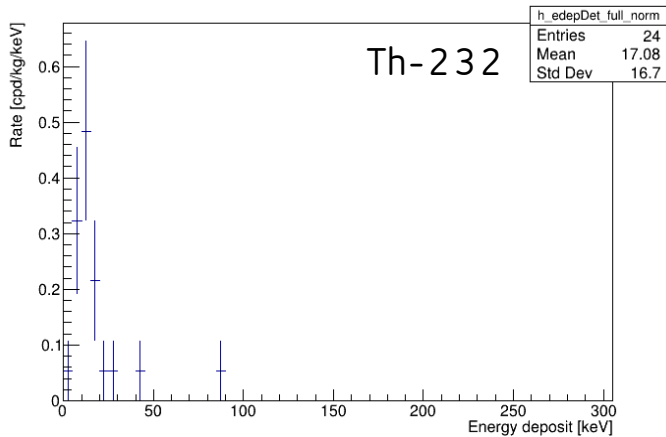
- 10M events per radioactive isotope
- Camera and Lens (treated separately)
- No shield plus camera shield (20 mm and 45 mm of Cu)

- Internal Background Camera Lens is originated mainly by:

- Th-232 (0.726 Bq/kg)
- U-238 (6.15 Bq/kg)
- U-235 (0.145 Bq/kg)
- K-40 (51.5 Bq/kg)
- La-138 (2.44 Bq/kg)



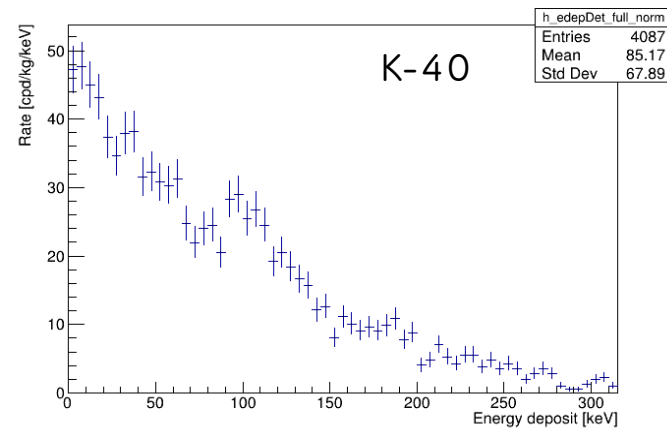
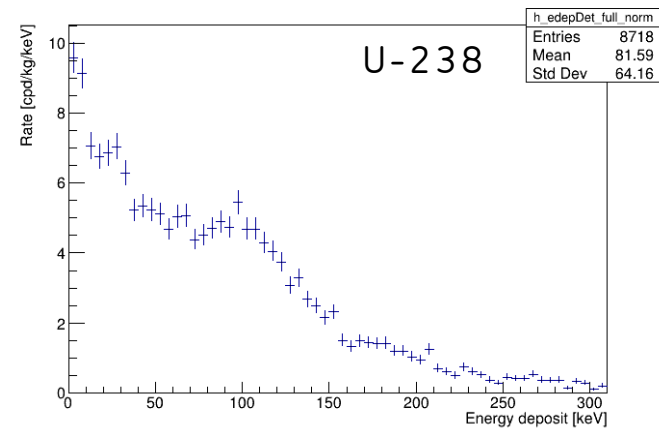
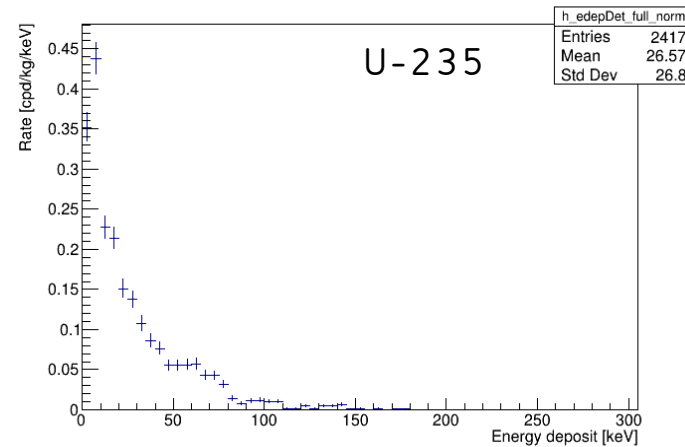
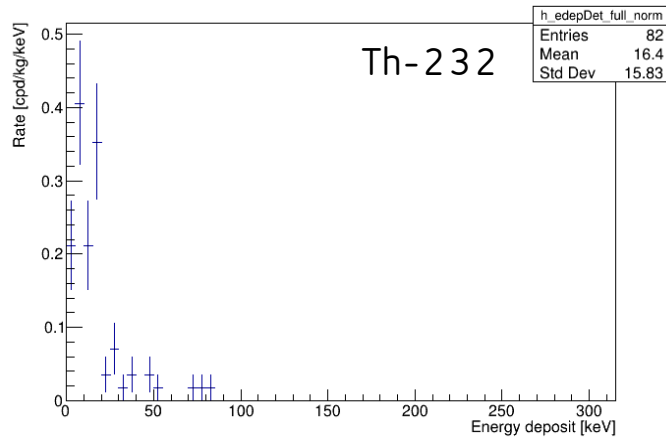
LIME Internal Background – Camera Body



Camera body mass: 2.1272 kg

Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.98 Bq/kg	139
U-238	18.72 Bq/kg	6312
U-235	0.188 Bq/kg	676
K-40	0.893 Bq/kg	1178
Total	20.781 Bq/kg	8305

LIME Internal Background – Camera Lens

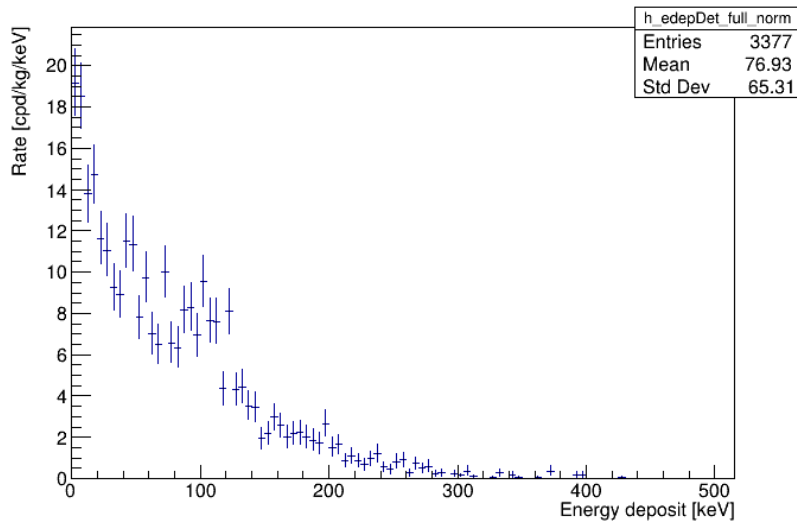


Camera lens mass: 0.2135 kg

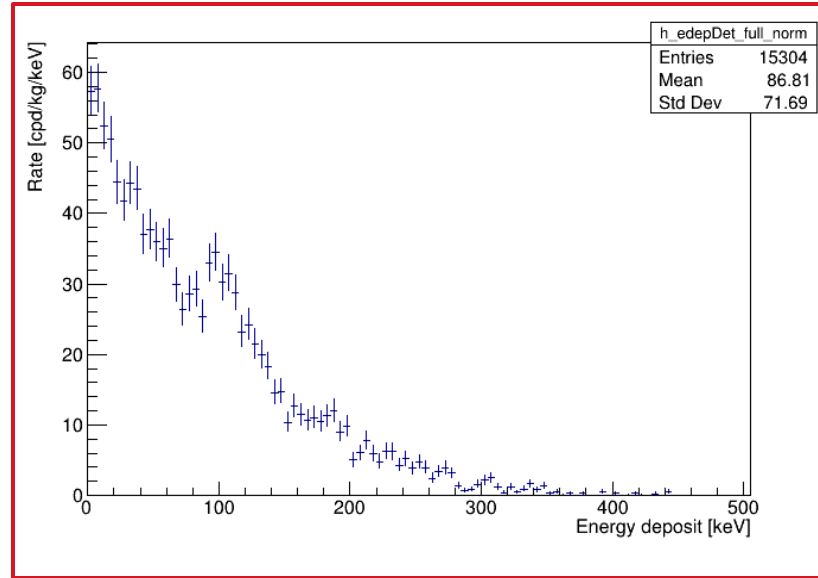
Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.726 Bq/kg	148
U-238	6.15 Bq/kg	4076
U-235	0.145 Bq/kg	154
K-40	51.5 Bq/kg	22961
La-138	2.44 Bq/kg	0
Total	60.961 Bq/kg	27339

LIME Internal Background – Camera body + lens

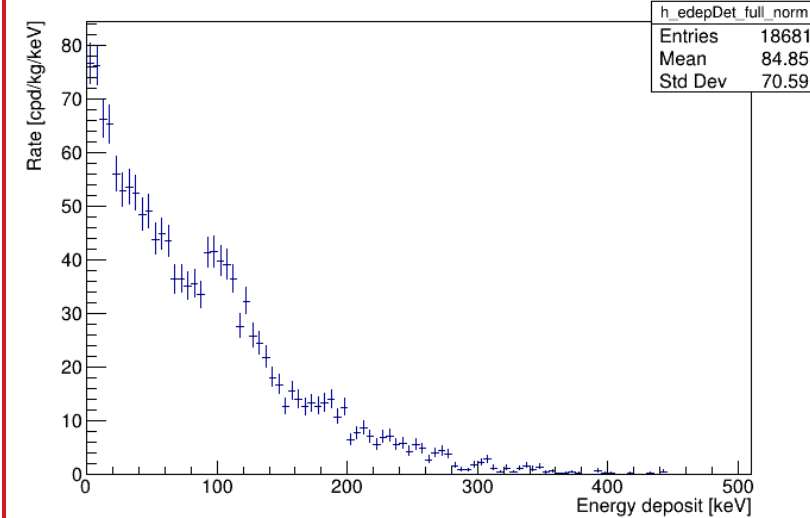
Energy deposit rate (Camera body)



Energy deposit rate (Camera lens)



Energy deposit rate (Full camera)



Major radioactive source from the camera.

Counts [0-20] keV	
Total	35644

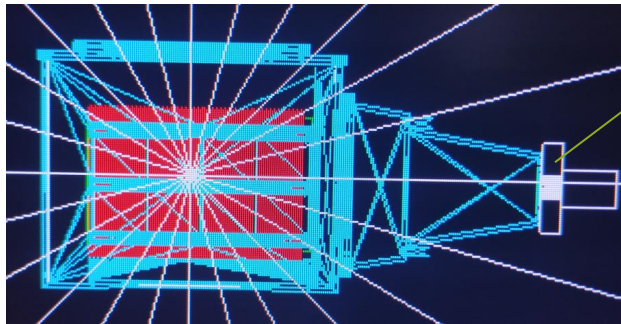


Close to the goal 10^4 events/year

LIME Internal Background – Camera body shield

Preliminary results (Pa-234 decay missing* - files were corrupted)

- Simplistic approach used.



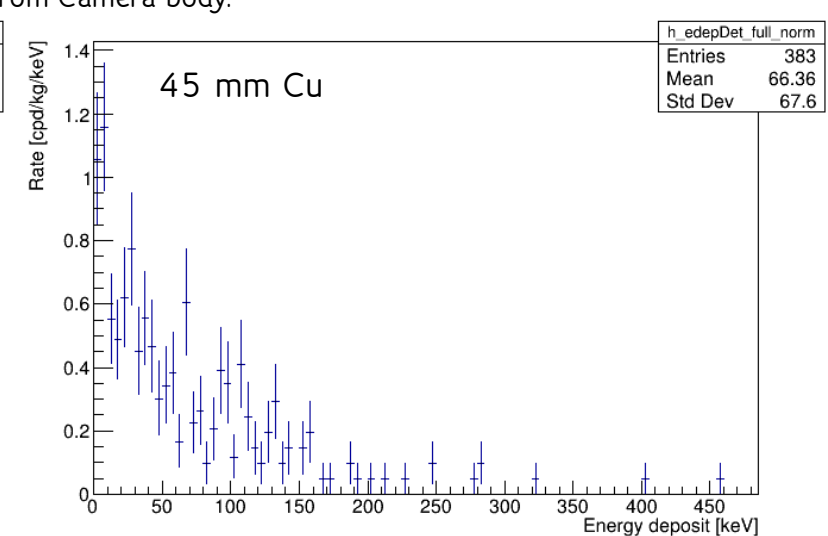
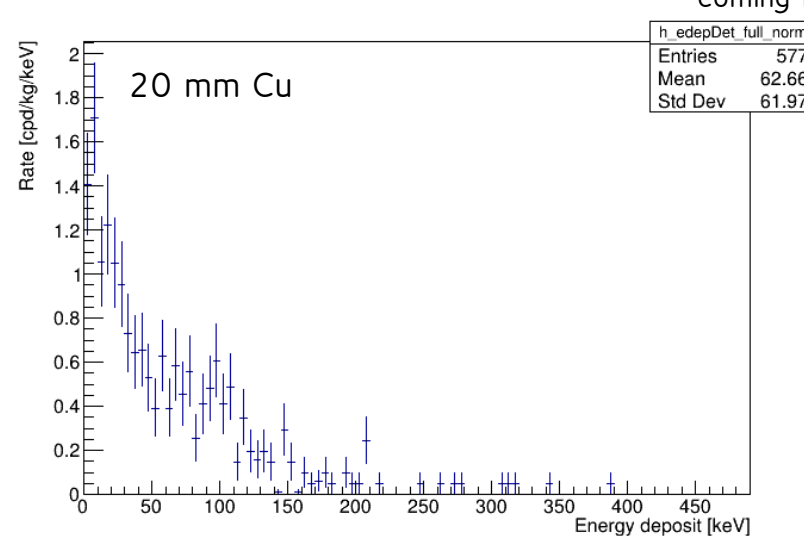
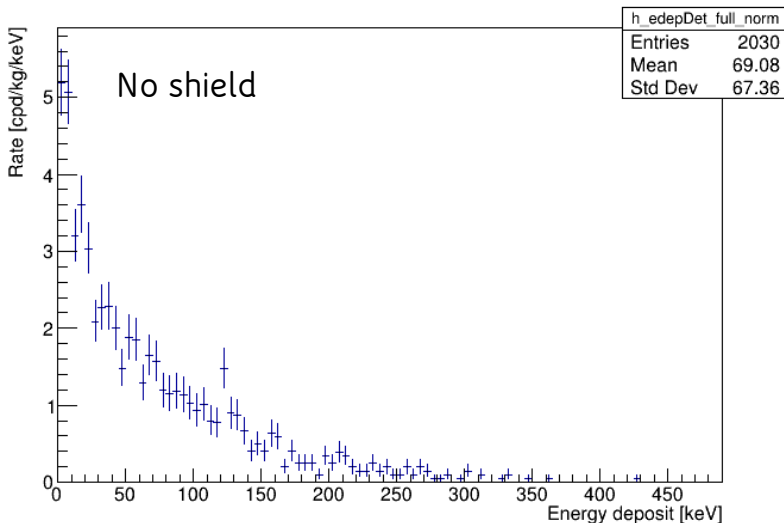
Cu Shielding with opening for the camera lens

- 20 mm
- 45 mm (aprox.)

Note: shielding for the lens not included here.

	Counts [0-20] keV*	Attenuation Factor
No Shield	2139	1
20 mm Cu	676	3
45 mm Cu	378	5

Note: mPa-234 corresponds to about 75% of the events detected coming from Camera body.



Conclusions and Future work

- Simulation of LIME internal background started;
- First results for the camera background without shielding completed;
- Values obtained suggest that we are close to the objective (close to 10^4 events/year) full camera without shielding;
- Major source of the background is the camera lens (about $\frac{3}{4}$ of the entire background produced);
- Results seem to be in accordance with what is expected for CYGNO 1 m³ (about 10^6 events/year);
- Shielding for the camera body implemented for LIME;
- First results point to the possibility of attenuating the background from the camera body by a factor between 3 and 5 (needs to be confirmed).

- Complete the simulation for the camera body with shielding (Cu) for the different thicknesses (mPa-234 missing)
- Resume with the simulation of the GEM structure, field rings, cathode and support structures (already started);
- Optimize the shielding considering the space available;

Thank you!