LIME Simulations – Internal Background

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OUTLINE

- Objectives
- Simulation Results – Internal Background
    - Camera (body + lens)
        - No shield
        - Shield (20 mm and 45 mm Cu)
    - GEM
        - No shield
- Conclusions and Future work

Objectives

Test technology underground with some shielding **to verify** we can supress 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...

- Internal background is the major source of concern – in particular the one coming from the camera (body+lens);
- Some shielding will be necessary for the camera;

↓

- Initial option was the use of copper to reduce as much as possible the contribution from the camera body.

Another important thing is...

- Update LIME design to include:
  - Faraday cage;
  - Kentaro field cage;

LIME Internal Background

LIME Internal Background

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

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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
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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
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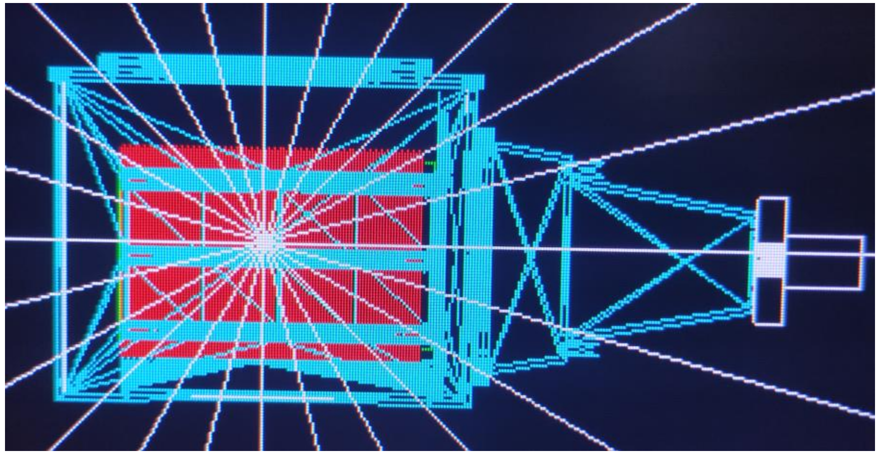
Main contributions identified.

LIME Internal Background

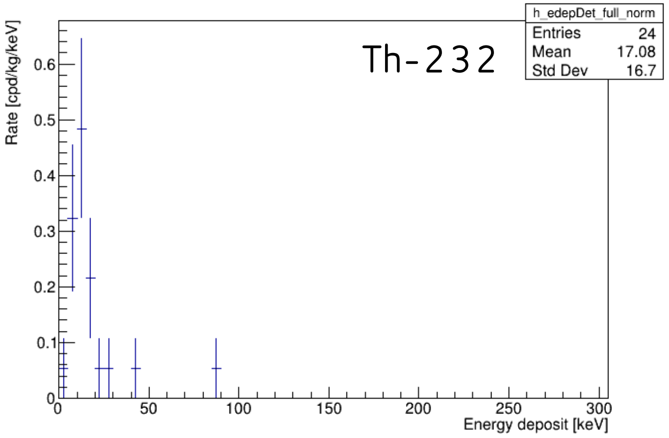
- Internal Background Camera Body is originated mainly by:
  - Th-232 (0.98 Bq/kg)
  - U-238 (18.72 Bq/kg)
  - U-235 (0.188 Bq/kg)
  - K-40 (0.893 Bq/kg)

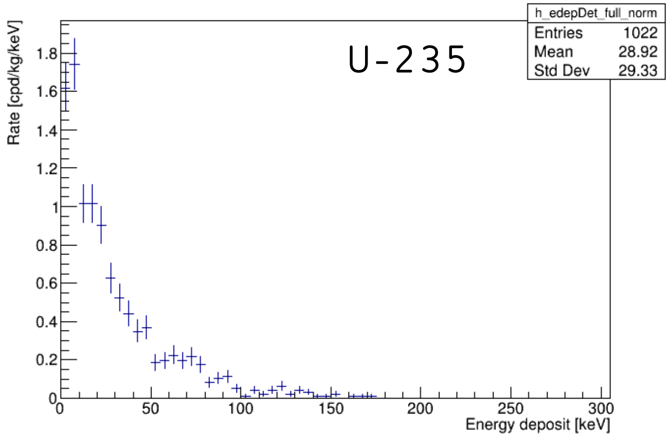
  Simulations:
  - 10M events per radioactive isotope
  - Camera and Lens (treated separately)
  - No shield plus camera shield (20 mm and 45 mm of Cu)

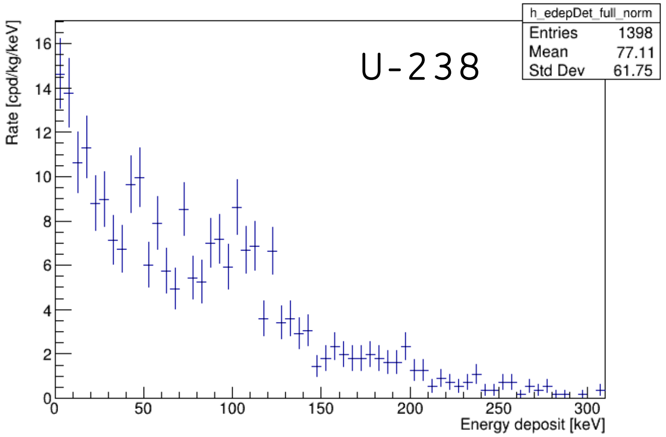
- Internal Background Camera Lens is originated mainly by:
  - Th-232 (0.726 Bq/kg)
  - U-238 (6.15 Bq/kg)
  - U-235 (0.145 Bq/kg)
  - K-40 (51.5 Bq/kg)
  - La-138 (2.44 Bq/kg)

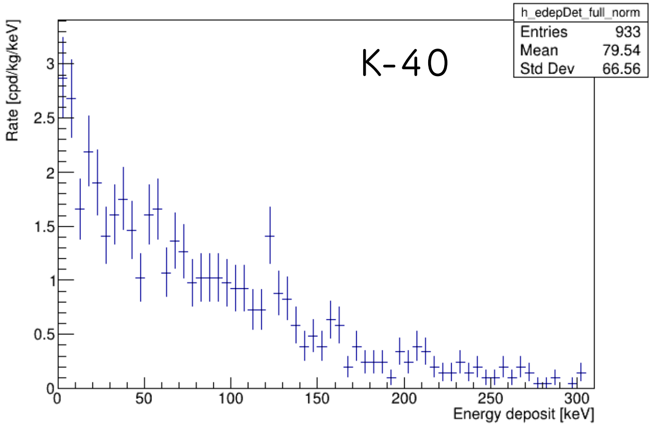


LIME Internal Background – Camera Body (No Shield)





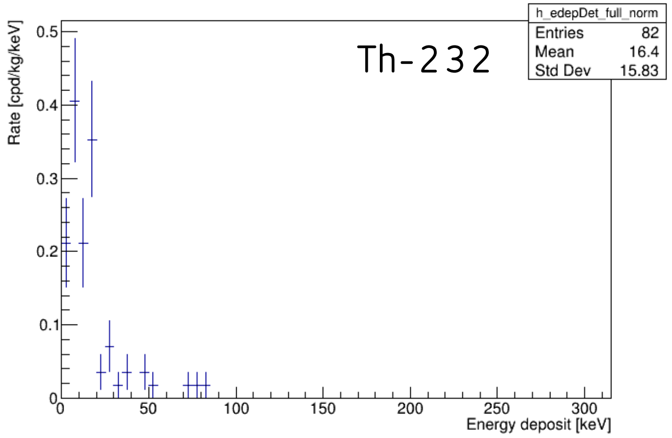


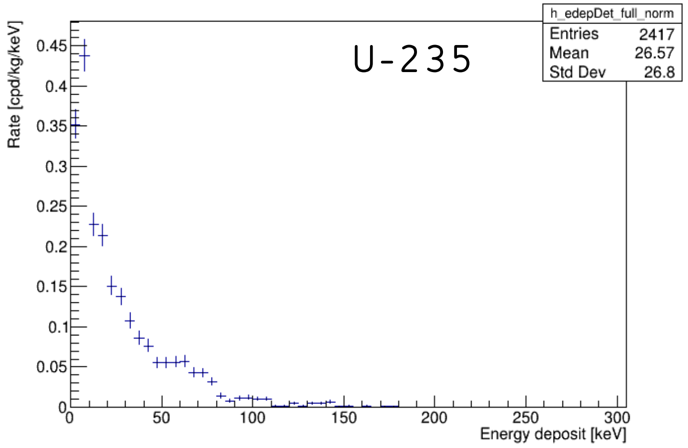


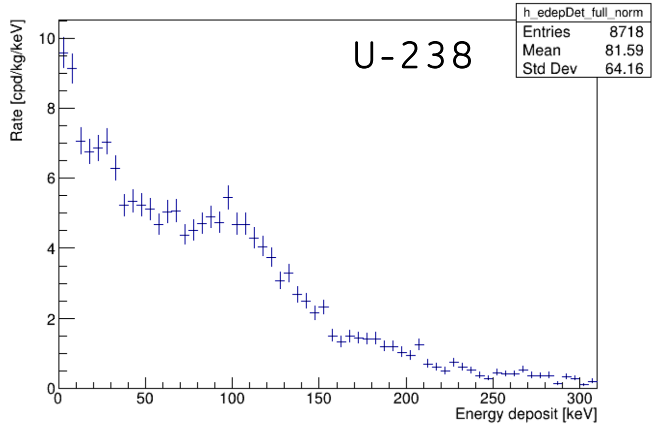
Camera body mass: 2.1272 kg

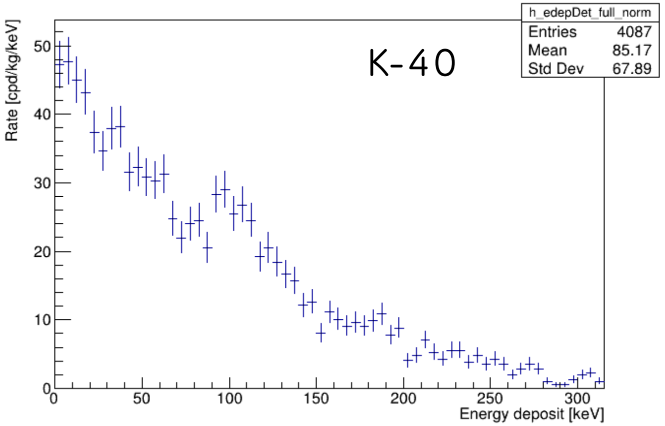
Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.98 Bq/kg	139
U-238	18.72 Bq/kg	6312
U-235	0.188 Bq/kg	676
K-40	0.893 Bq/kg	1178
Total	20.781 Bq/kg	8305

LIME Internal Background – Camera Lens (No Shield)







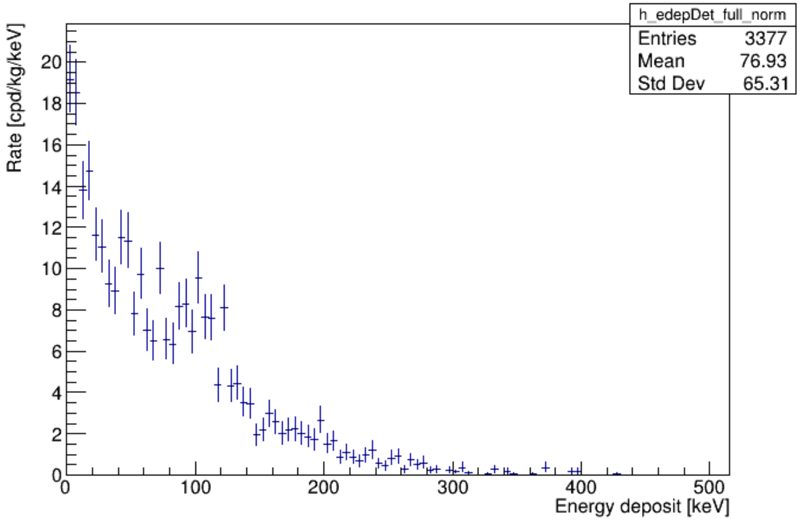


Camera ens mass: 0.2135 kg

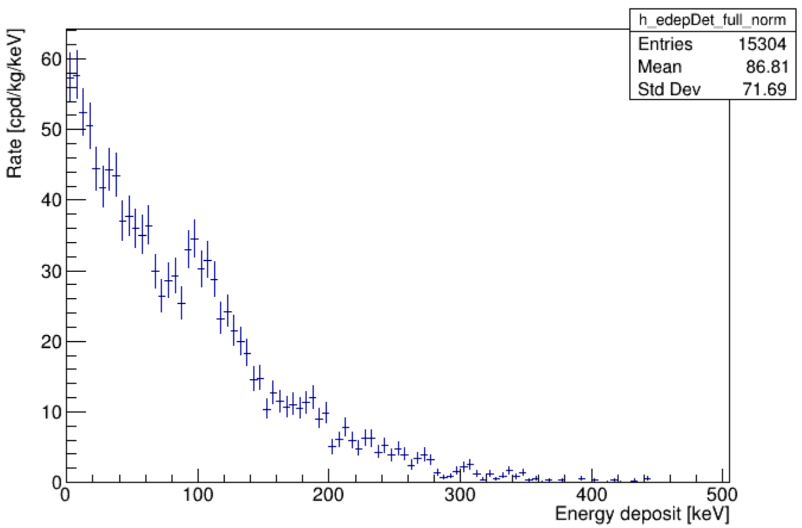
Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.726 Bq/kg	148
U-238	6.15 Bq/kg	4076
U-235	0.145 Bq/kg	154
K-40	51.5 Bq/kg	22961
La-138	2.44 Bq/kg	0
Total	60.961 Bq/kg	27339

LIME Internal Background – Camera body + lens (No Shield)

Energy deposit rate (Camera body)

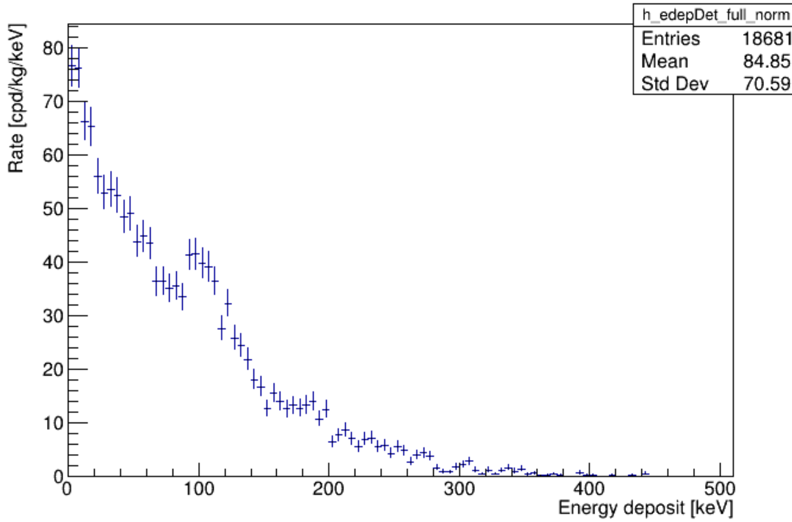


Energy deposit rate (Camera lens)



Major radioactive source from the camera.

Energy deposit rate (Full camera)

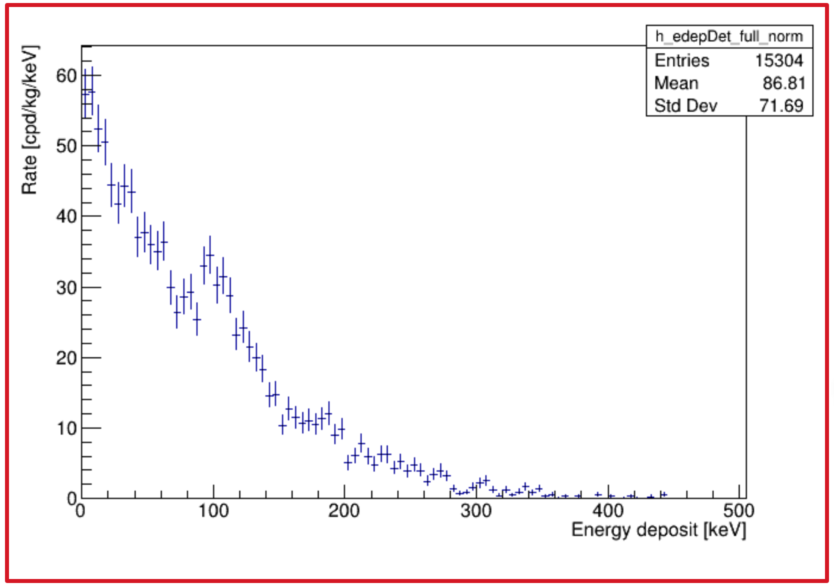


	Counts [0-20] keV
Total	35644

Close to the goal 10^4 events/year

LIME Internal Background – Camera body + lens (No Shield)

Energy deposit rate (Camera lens)



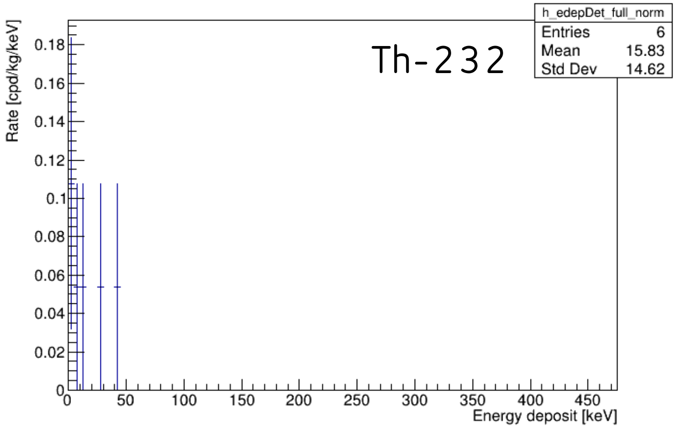
	Counts [0-20] keV
Total	35644

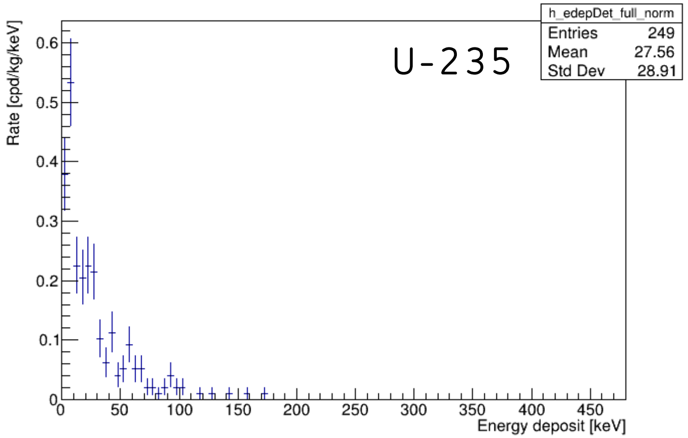
Major radioactive source from the camera.

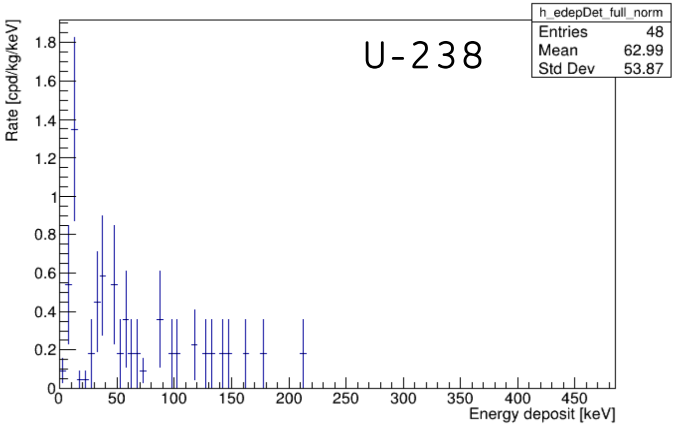
Alternatives for the lens are being consider.

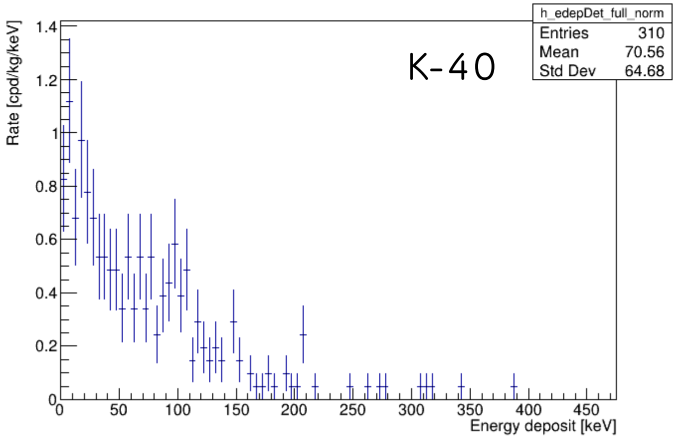
Might not be a problem after all.

LIME Internal Background – Camera Body (Shield) Copper Shielding - 20 mm





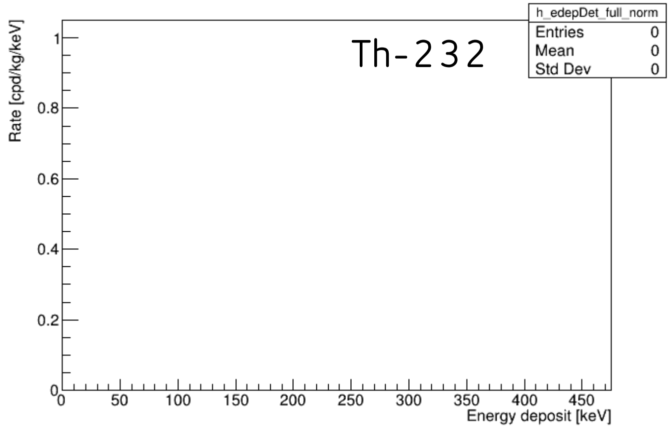


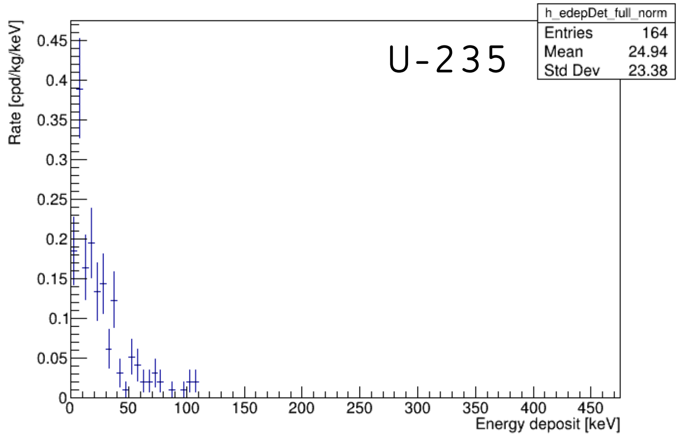


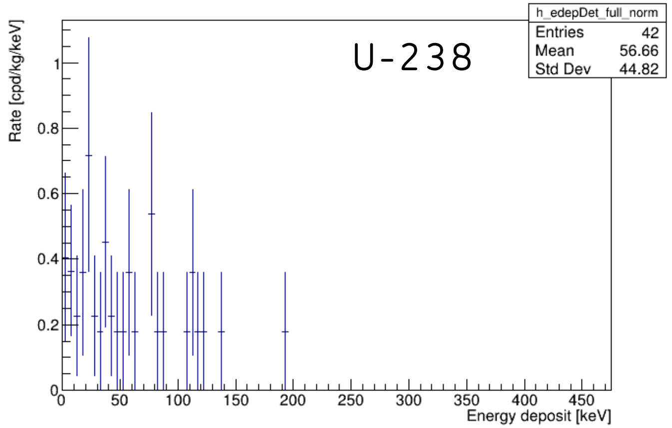
Camera body mass: 2.1272 kg

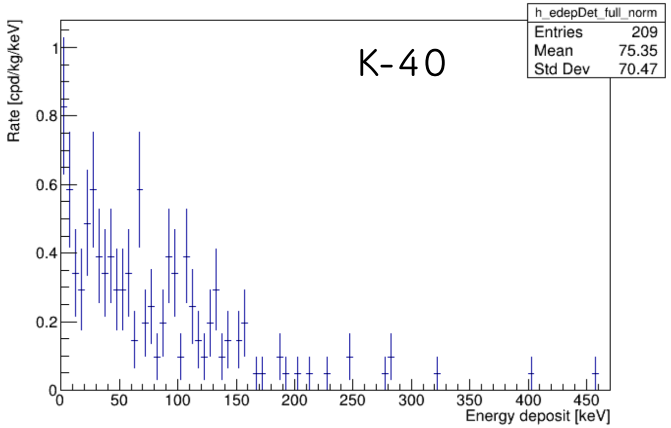
Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.98 Bq/kg	27
U-238	18.72 Bq/kg	254
U-235	0.188 Bq/kg	168
K-40	0.893 Bq/kg	452
Total	20.781 Bq/kg	901

LIME Internal Background – Camera Body (Shield) Copper Shielding – 44.9 mm









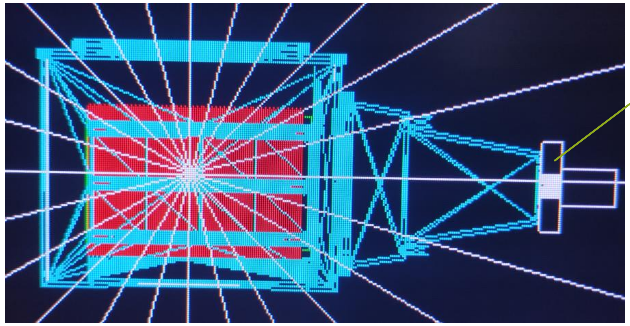
Camera body mass: 2.1272 kg

Isotope	Radioactivity	Counts [0-20] keV
Th-232	0.98 Bq/kg	0
U-238	18.72 Bq/kg	170
U-235	0.188 Bq/kg	117
K-40	0.893 Bq/kg	256
Total	20.781 Bq/kg	543

LIME Internal Background – Camera body shield

Results

- Simplistic approach used.

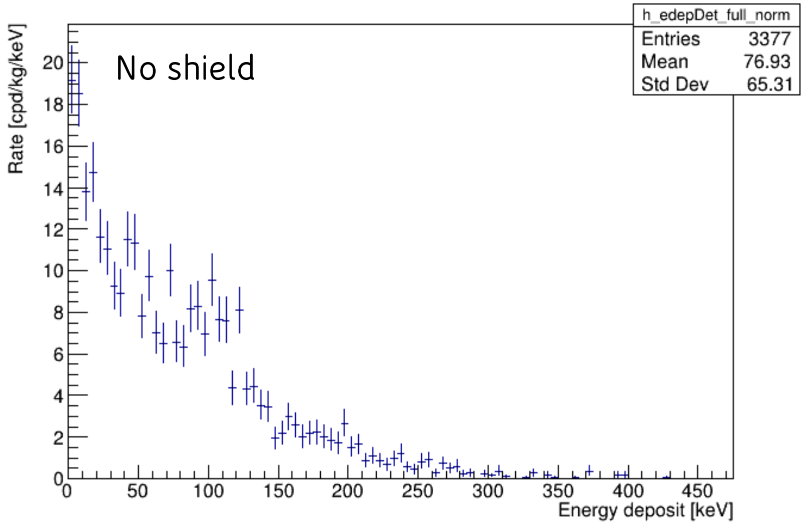


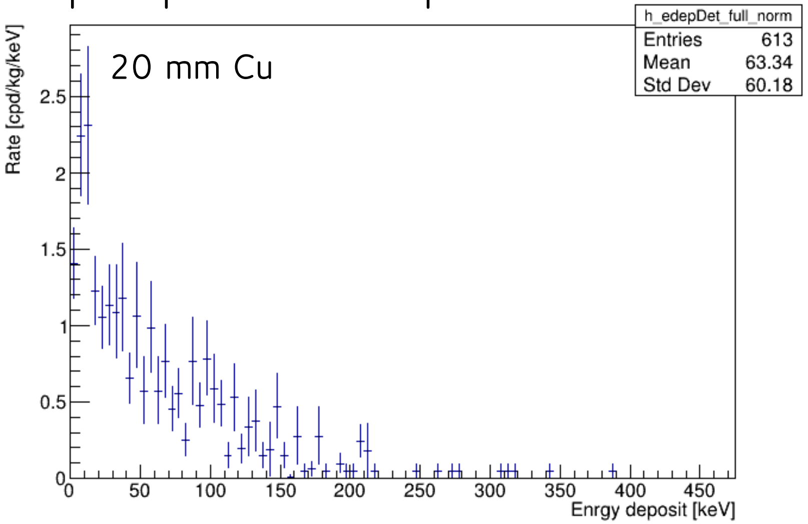
Cu Shielding with opening for the camera lens
- 20 mm
- 45 mm (aprox.)

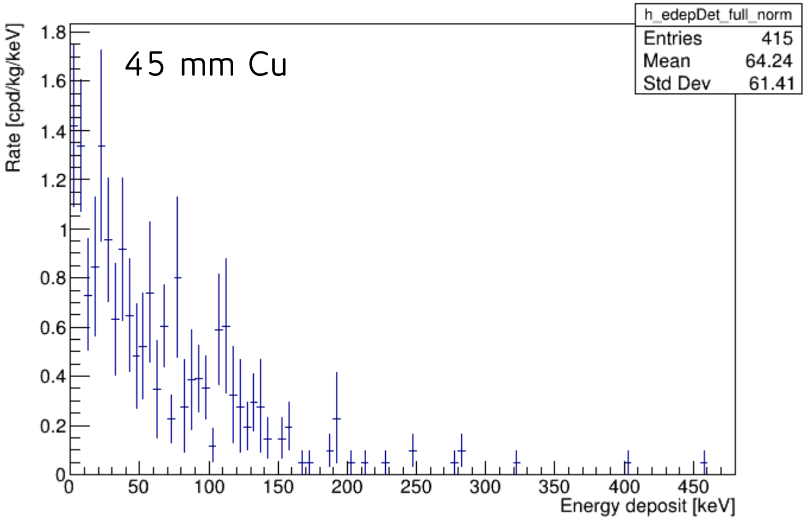
Note: shielding for the lens not included here, which in principle won't be a problem.

	Counts [0-20] keV*	Attenuation Factor
No Shield	8301	1
20 mm Cu	901	9
45 mm Cu	543	15

Note: Table was updated. mPa-234 was now included.







LIME Internal Background – Triple GEM

- Internal background of the GEM measured at LNGS.

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sample:         GEM, copper clad Kapton foil, 12.3 g, CYGNO
number:         2
live time:      1151359 s
detector:       BEGe

radionuclide concentrations:

Th-232:
Ra-228:              < 0.19 mBq/pc
Th-228:              < 0.096 mBq/pc

U-238:
Ra-226               (0.2 +- 0.1) mBq/pc
Th-234               (1.0 +- 0.4) mBq/pc
Pa-234m              < 5.0 mBq/pc

U-235:               < 0.097 mBq/pc

K-40:                < 2.2 mBq/pc

Cs-137:              < 0.050 mBq/pc

Co-60:               < 0.046 mBq/pc  @ start of measurement: 21-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
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Main contributions identified.

Internal Background from GEMs is originated mainly by:

- Th-232 (0.007 Bq/kg)
- U-238 (0.129 Bq/kg)
- K-40 (0.056 Bq/kg)

Simulations:

- 10M events per radioactive isotope;
- Whole Triple GEM simulated;
- No shield is possibe;

Main issues so far:

- Simulation time is impressive (more than 200 hours)
- Optimization is essential

LIME Internal Background – Triple GEM

Main issues so far:

- Issue with NR values obtained (seem to be wrong);
- Simulation time is impressive (more than 200 hours);
- Optimization is essential;

I assume that this is due to the hit/miss method employed by the particle generator - "gps"

Any ideas how to improve the computing time?

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xmaster.lngs.infn.it:
                                                                        Req'd    Req'd       Elap
Job ID                 Username    Queue    Jobname          SessID  NDS   TSK   Memory   Time     S   Time
---------------------- ----------- -------- ---------------- ------ ----- ------ ------ --------- - ---------
4703726.xmaster.lngs.i  cortez      gs       GEM_Tl208_part3.   5636     1      1  1000m 9999:00:0 R 220:35:05
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4703731.xmaster.lngs.i  cortez      gs       GEM_Tl208_part8.   5696     1      1  1000m 9999:00:0 R 220:35:04
4703732.xmaster.lngs.i  cortez      gs       GEM_Tl208_part9.   5708     1      1  1000m 9999:00:0 R 220:35:04
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4703818.xmaster.lngs.i  cortez      gs       GEM_Bi214_part5.   5689     1      1  1000m 9999:00:0 R 220:15:12
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4703840.xmaster.lngs.i  cortez      gs       GEM_Tl210_part7.   5497     1      1  1000m 9999:00:0 R 219:47:22
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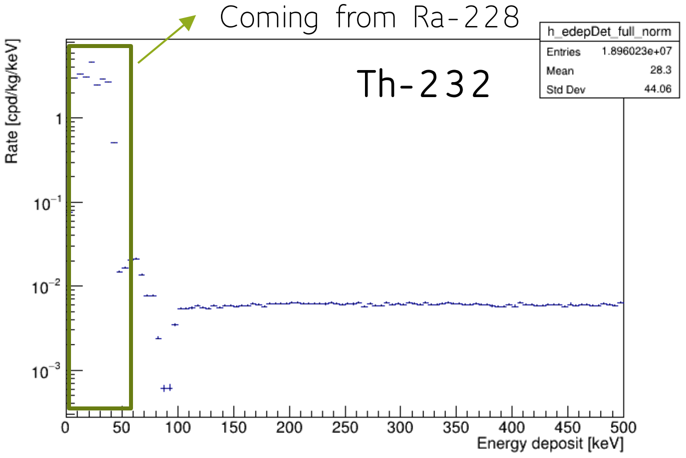
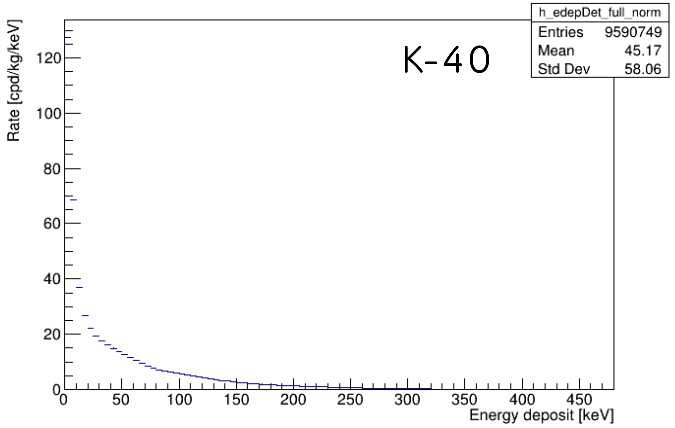
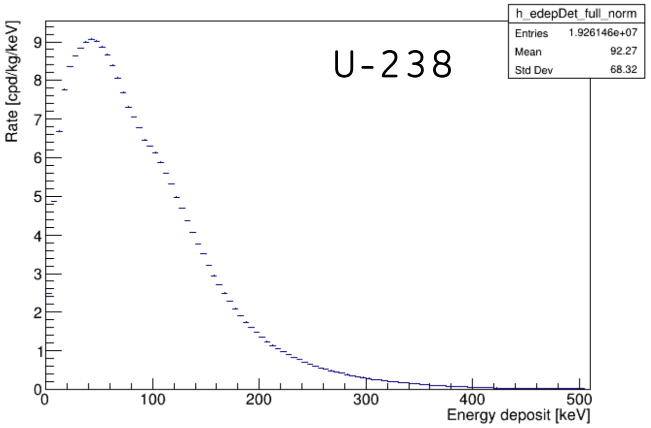
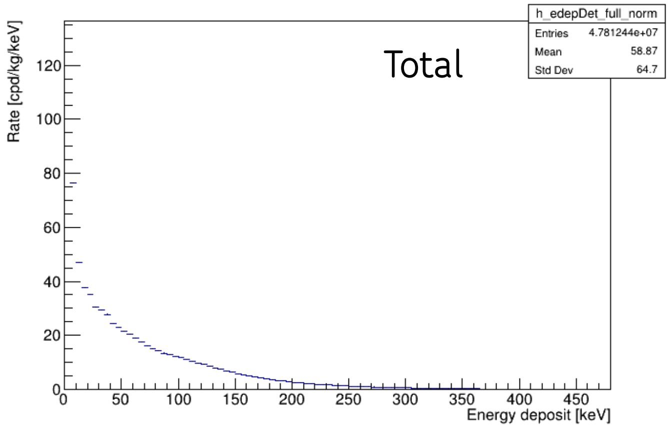
LIME Internal Background – Triple-GEM (No Shield)

Preliminary results (mPa-234 missing)





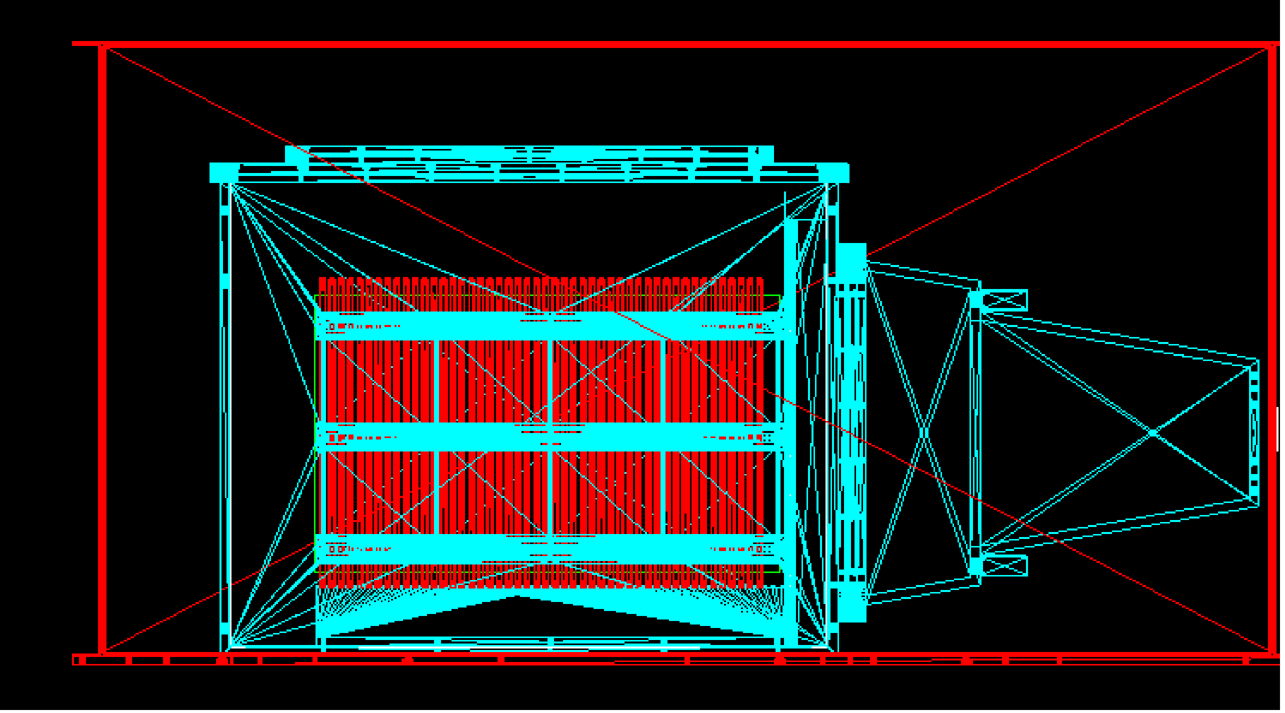


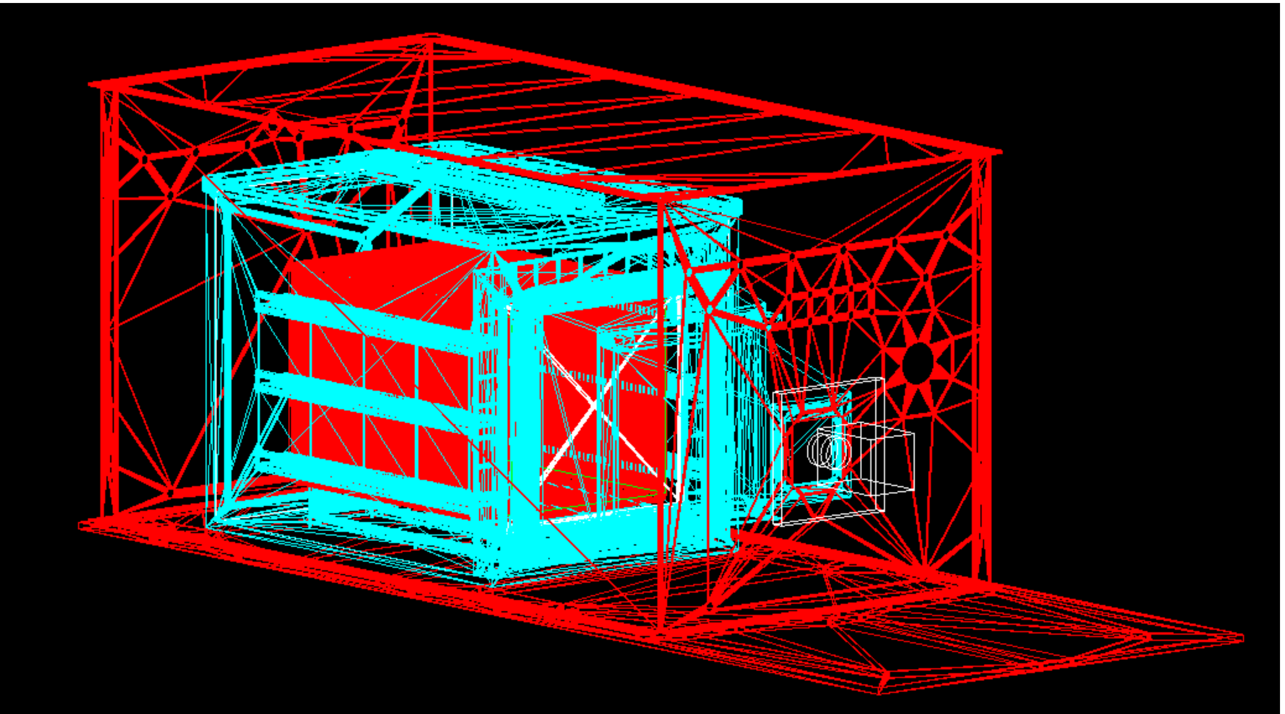


Triple-GEM mass: 0.039 kg

Isotope	Radioactivity	Counts [0-20] keV	NR Counts [0-20] keV
Th-232	0.007 Bq/kg	1193	7576
U-238	0.129 Bq/kg	2730	7674
K-40	0.056 Bq/kg	32576	0
Total	0.192 Bq/kg	36503	15250

- Results seem to be in agreement with CYGNO (a factor of about 18)
- Needs to be cross checked (in particular the number NR);
- Urgent to find viable alternatives for the materials used;





LIME Geometry Update – Faraday Cage

- A Faraday cage was implemented in LIME simulation (external red box);
- Block signal induction from external electromagnetic fields;
  - Although the original one (used now in LIME) is made of Aluminium in the design the option was to make it made of copper;
- Can be used for providing some additional shielding (needs to be evaluated);

- Still we need to…
  - Optimize it (thickness, additional shielding may be needed);
  - Study the effect of it for external background and different combinations with the camera body shield;

Conclusions and Future work

- Shielding for the camera body implemented for LIME;
- Simulation for the camera body with shielding (Cu) for the different thicknesses is complete (mPa-234 now included);
- Results point to the possibility of attenuating the background from the camera body by a factor between 10 and 15 (needs to be confirmed).
- No shield used for the lens (might not be a problem);
- Initial results obtained for the GEM contribution to the internal radioactivity – number of NR seems odd;
- Alternatives to the present GEM need to be evaluated;
- Faraday cage implemented in LIME configuration.

- Resume with the simulation of the field rings, cathode and support structures;
- Study the effect on the background using the Faraday cage to partially shield the detector;

⇩

- It will probably not be sufficient but alternatives such as copper box for the camera need to be evaluated;
- Optimize the shielding considering the space available;

Thank you!