CYGNO simulation plans

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CYGNO simulation meeting

Plans & to do

Spreadsheet with plans for analysis and simulations
https://docs.google.com/spreadsheets/d/1VOn-Bg8yWwewlNrvrwRRMhANpsuGGO86KuFhiPe5xMA/edit#gid=1362390939

WHAT	WHO	Already on it
Calibration		
Use NaI data to evaluate the rates of primary decays (U, Th, K) to cross check with the rates used for the current simulation;		Giulia
Cross check the attenuation factor evaluated with the simulation;		Giulia
Images		
2D and 3D Event maps;		
Evaluate detection efficiency vs E, x, y and z		
Produce distributions of: E, length, angles		
dE/dx vs E (2D, z, 3D)		
PMT		
Add the electron arrival time info to the digitisation		
Produce PMT waveforms		
PMT Efficiency		
Trigger Efficiency		

Analysis | Simulation

Flaminia ➜ analysis of LIME MC images and comparison with data

Pietro/Fabrizio + Rafael ➜ integration of PMT simulation in the digitization code

Pedro ➜ test on the cloud

External background in LIME

For LIME simulations we have **assumed a flux of 0.56 gammas/cm^2/s** from environmental background.

Spectrum is taken from a NaI measurement by SABRE collaboration.

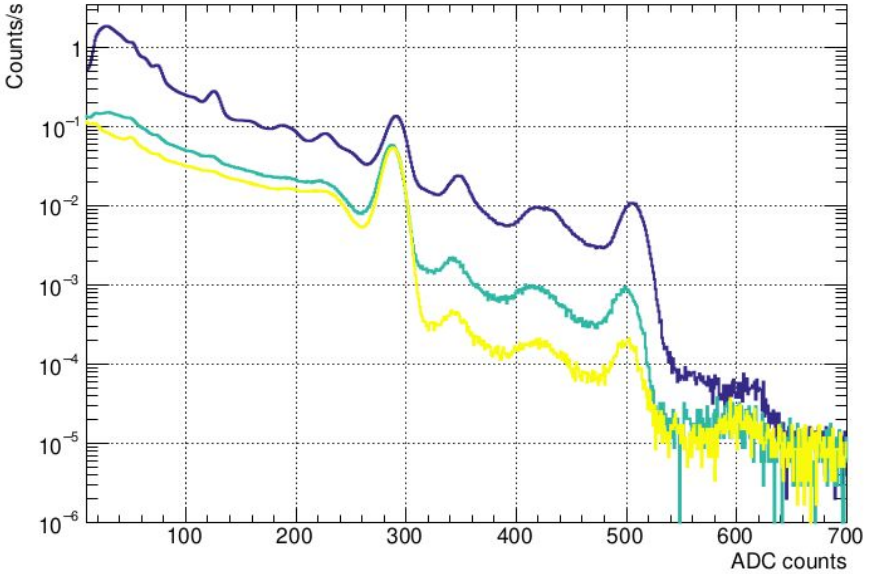
Summary of LIME MC rates (ER)

	External	Internal	Shield	Tot
	Rate Hz	Rate Hz	Rate Hz	Rate Hz
No shield	35.83	0.23	0.00	**36.15**
4 cm Cu	0.84	0.23	0.02	**1.09**
6 cm Cu	0.30	0.23	0.02	**0.55**
10 cm Cu	0.06	0.23	0.02	**0.31**
Full (water+Cu)	0.02	0.23	0.02	**0.26**

- Ratio between rates with different shielding options depends also on the internal background
- To compare LIME rates w/wo shielding with data we need to know the external (and internal) background more precisely
- Previous measurements with NaI suggest difference of factor 2 in gamma background between LNGS Halls

NaI data (3” crystal)

- We have direct measurements with NaI in LIME experimental area
- Raw data without shield (blue), 4 cm Cu shield (green), and 10 cm Cu shield (yellow)

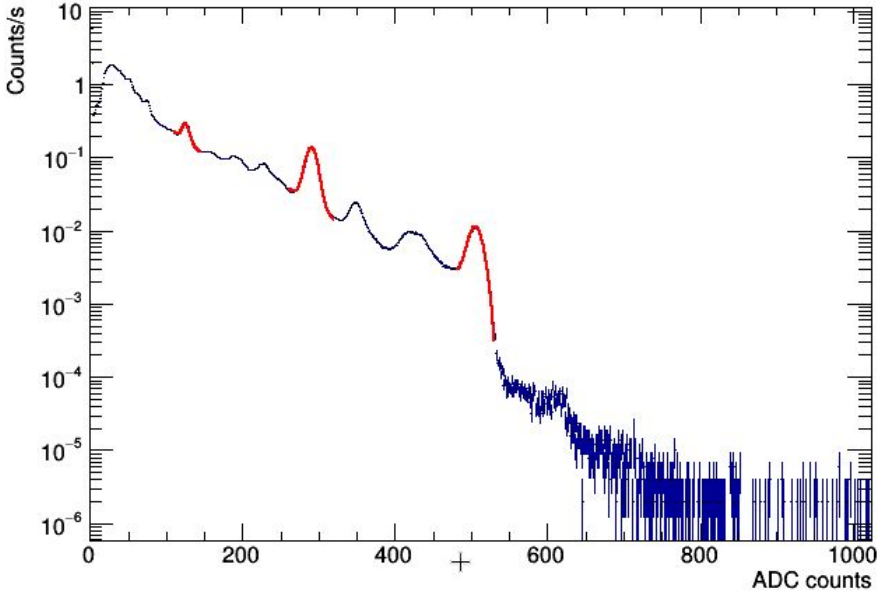


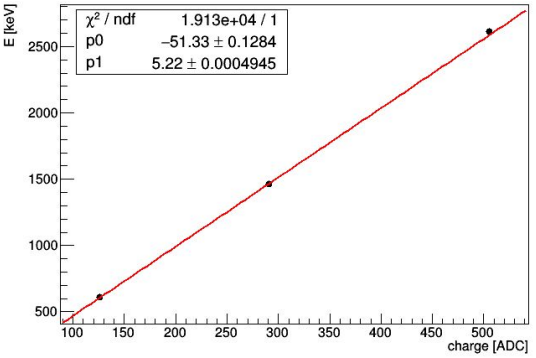
- Previous measurements by SABRE made with a NaI larger detector (4”x 4” x 16”)
- Difficult to compare directly these spectra (and rates) with previous NaI or LIME MC because:
  ➜ different detectors
  ➜ non-negligible internal background component, especially when we compare shielded spectra

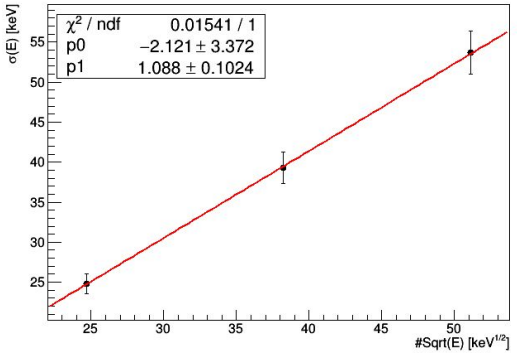
➜ need a MC simulation of the NaI

Calibrated data

- Calibrate using 3 lines (609 keV, 1460 keV, 2615 keV)
- Measure energy resolution

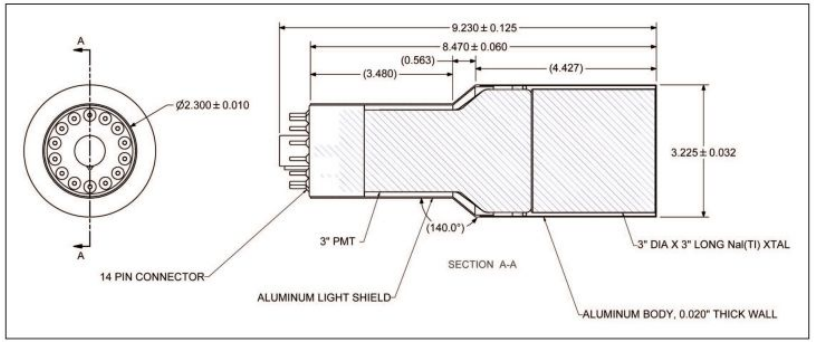


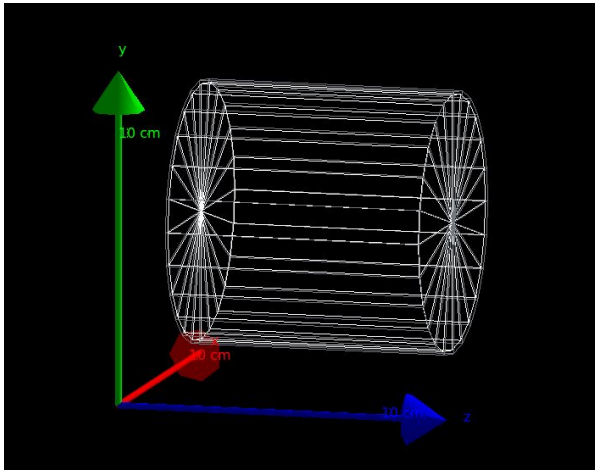




Simulation of NaI crystal

- 3”x3”cylindrical crystal with 0.5 mm Aluminum case

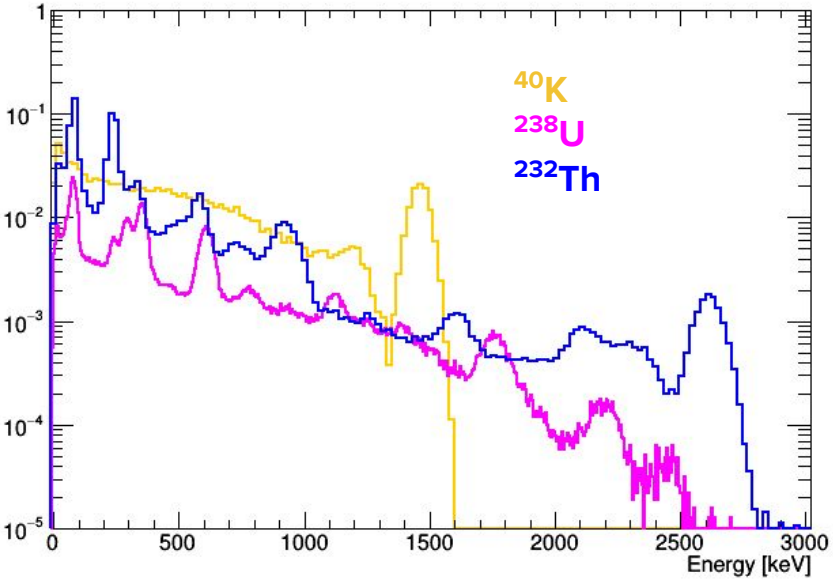


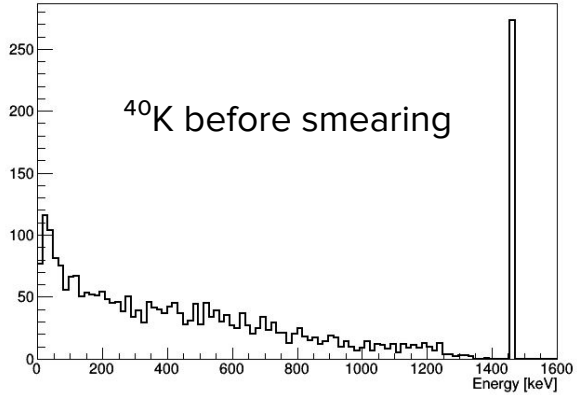


- Simulate decay of ^{40}K, ^{238}U chain and ^{232}Th chain (gamma emitters) from a spherical surface of 20 cm radius (isotropic angular distribution)

Simulation on NaI crystal

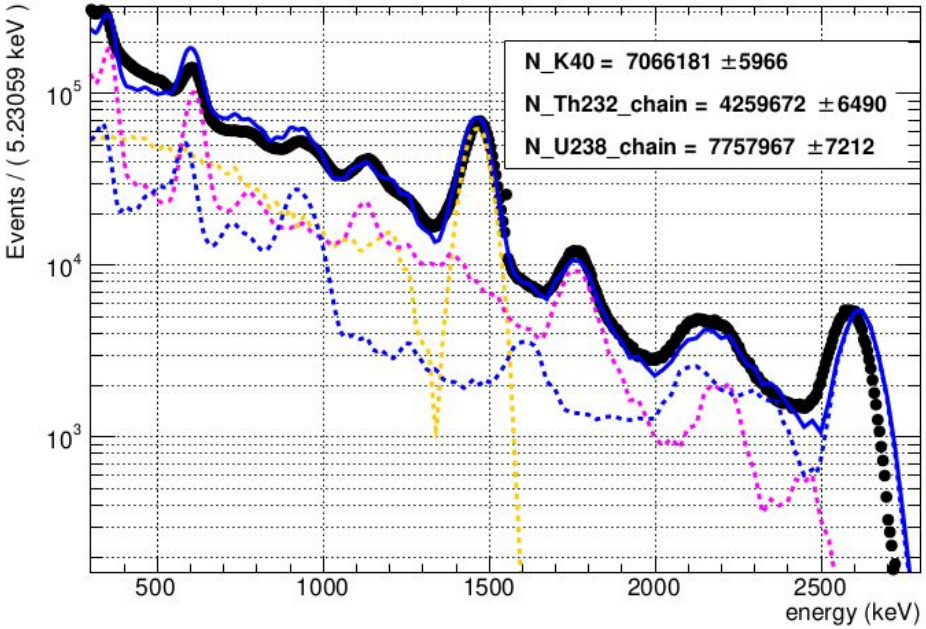
- Energy deposits in the NaI detector
- Apply experimental resolution to the simulated spectra





Fit data with simulated spectra

- Use dataset outside shielding (in LIME control room), ~6 days livetime
- Fit range from 350 keV to 2800 keV



Floating Parameter	FinalValue +/- Error
N_K40	7.0662e+06 +/- 5.97e+03
N_Th232_chain	4.2597e+06 +/- 6.49e+03
N_U238_chain	7.7580e+06 +/- 7.21e+03

Correcting for efficiencies and branching ratios the correspondent fluxes are:

- ^{40}K → 0.18 gammas/cm^2/s
- ^{238}U → 0.64 gammas/cm2/s
- ^{232}Th → 0.33 gammas/cm^2/s
- **Total 1.15 gammas/cm^2/s**

Summary

- Simulation of NaI detector for the “no shield” case seems reasonable and correspond to a gamma flux of **1.15 cm^{-2} s^{-1}**
  ➔ factor ~2 w.r.t. the number used in LIME simulations
  ➔ could this explain some discrepancies between data and MC rates?

- Same exercise can be repeated for NaI spectra inside 4 cm and 10 cm Cu
  ➔ internal NaI background non negligible, we need a measurement of internal background
  ➔ this would be a validation for our external gamma MC

- If we trust the MC rates for LIME we can understand better also the experimental rate in LIME data