Simulations: BULLKID-DM setup at Gran Sasso and demonstrator

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Gran Sasso setup

- 616.3 g in 15 Si wafers

Wafers: 5 cm radius, 5 mm thickness

11 x 11 dices

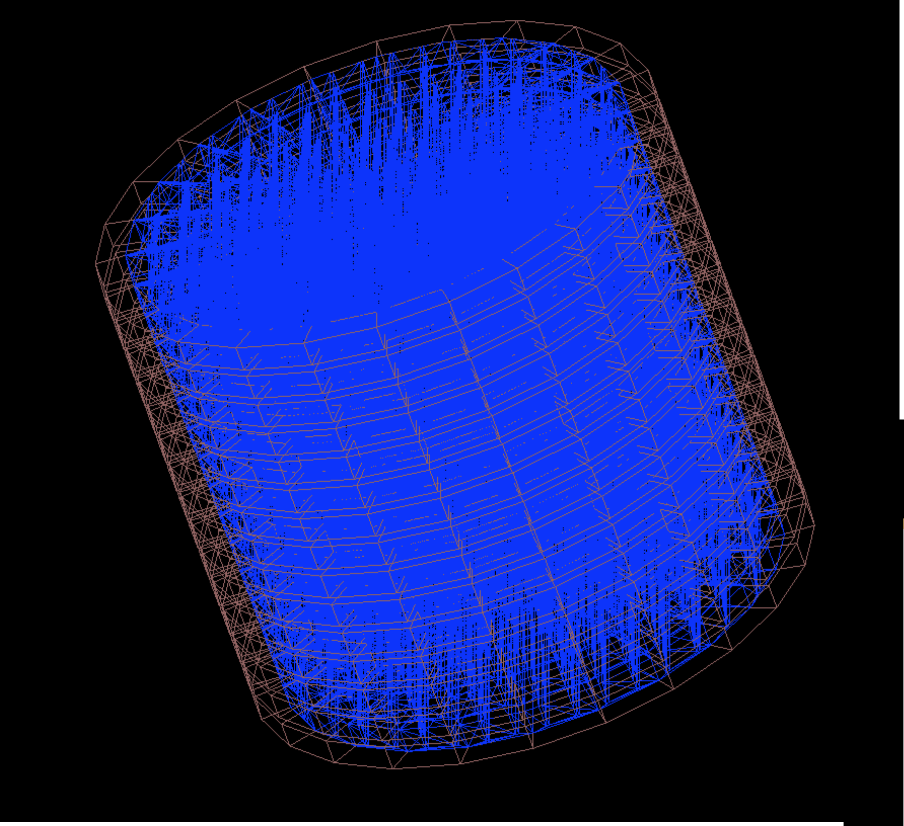
- In new Gran Sasso cryostat

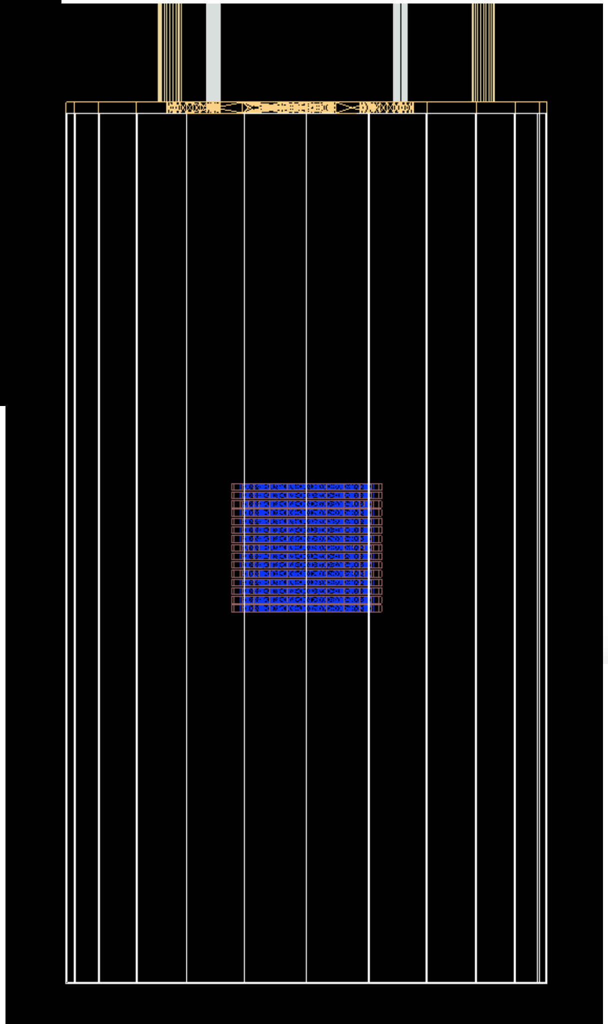
- External backgrounds:

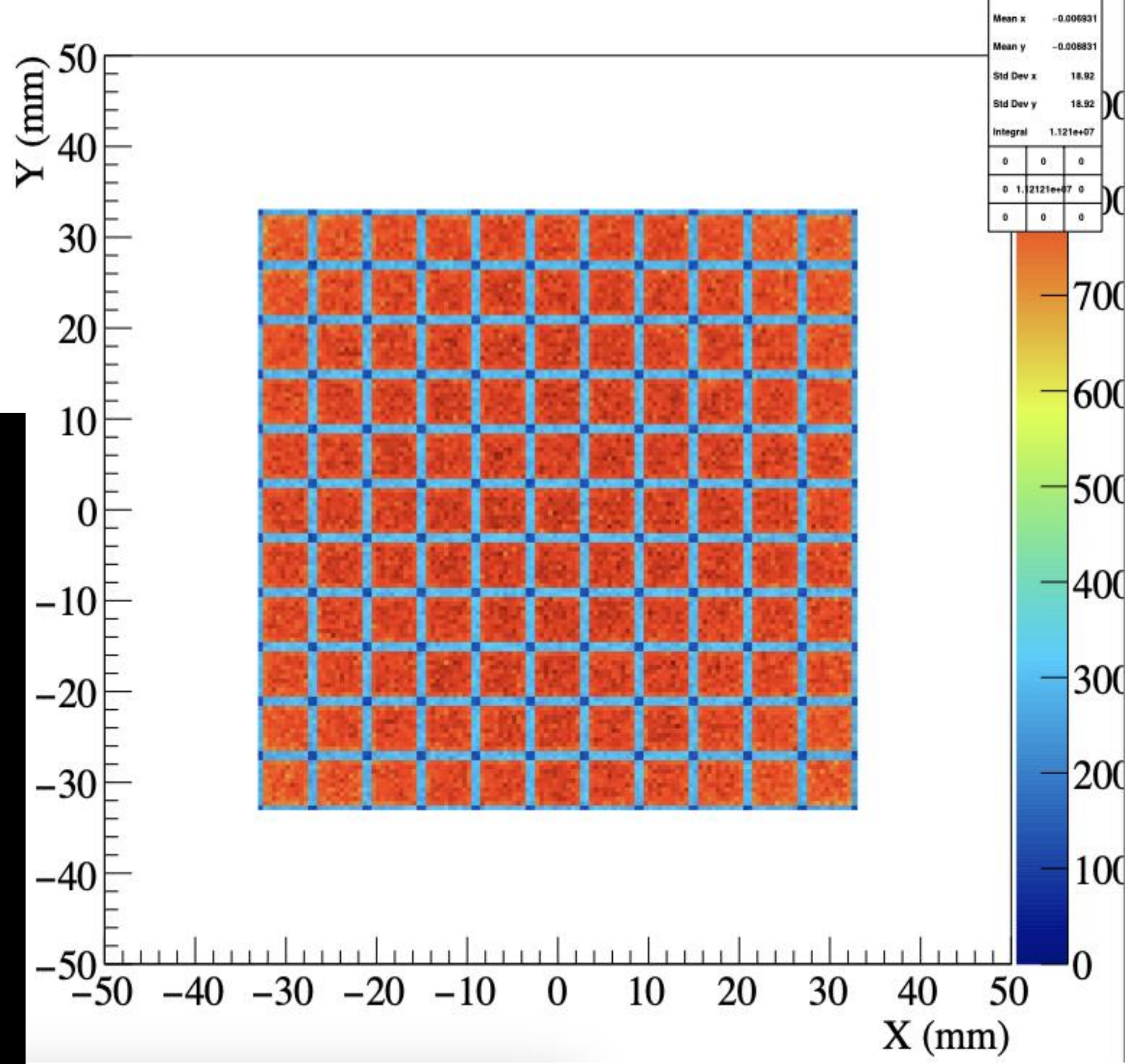
✓Gammas

✓Muons

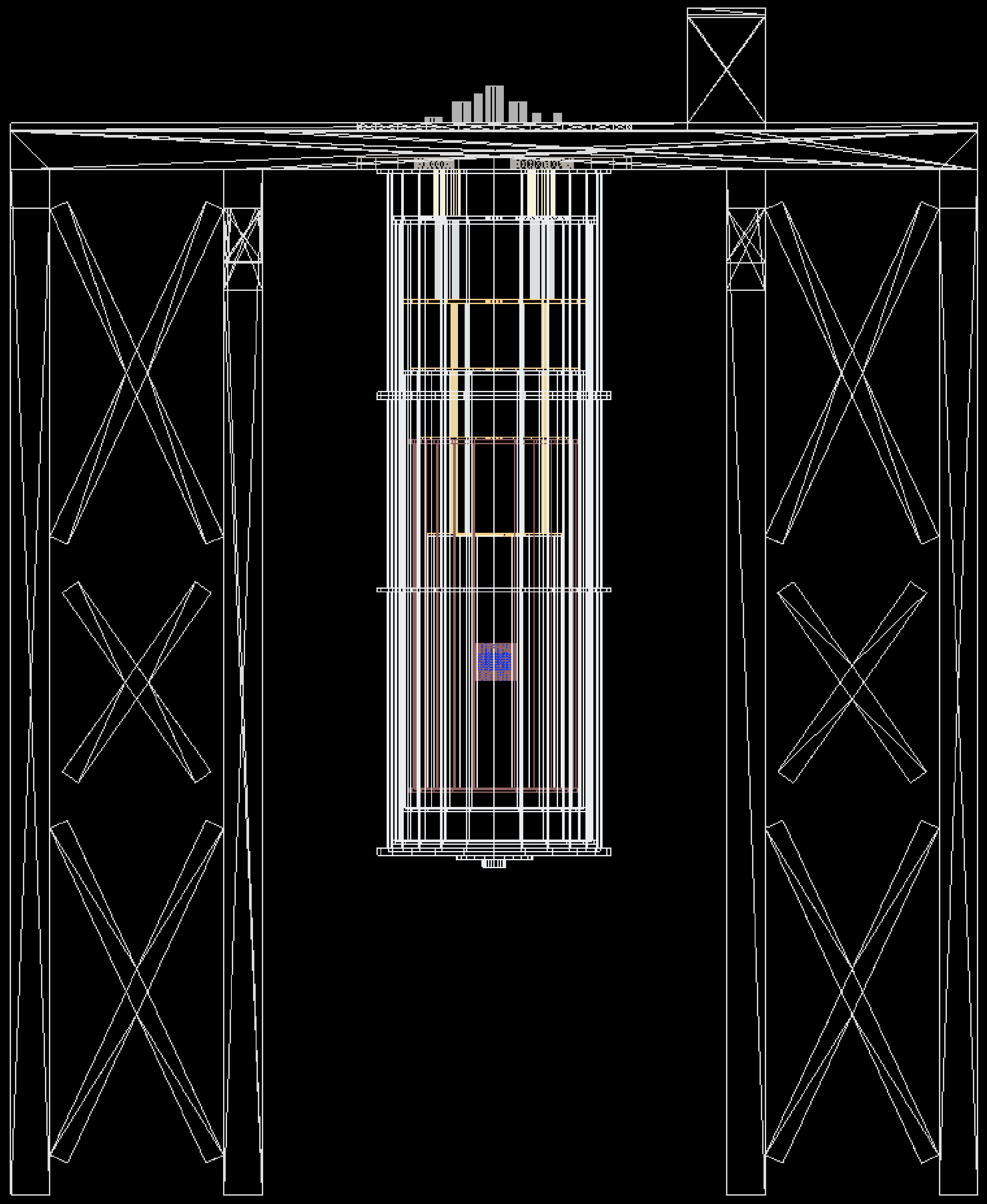
✓Neutrons

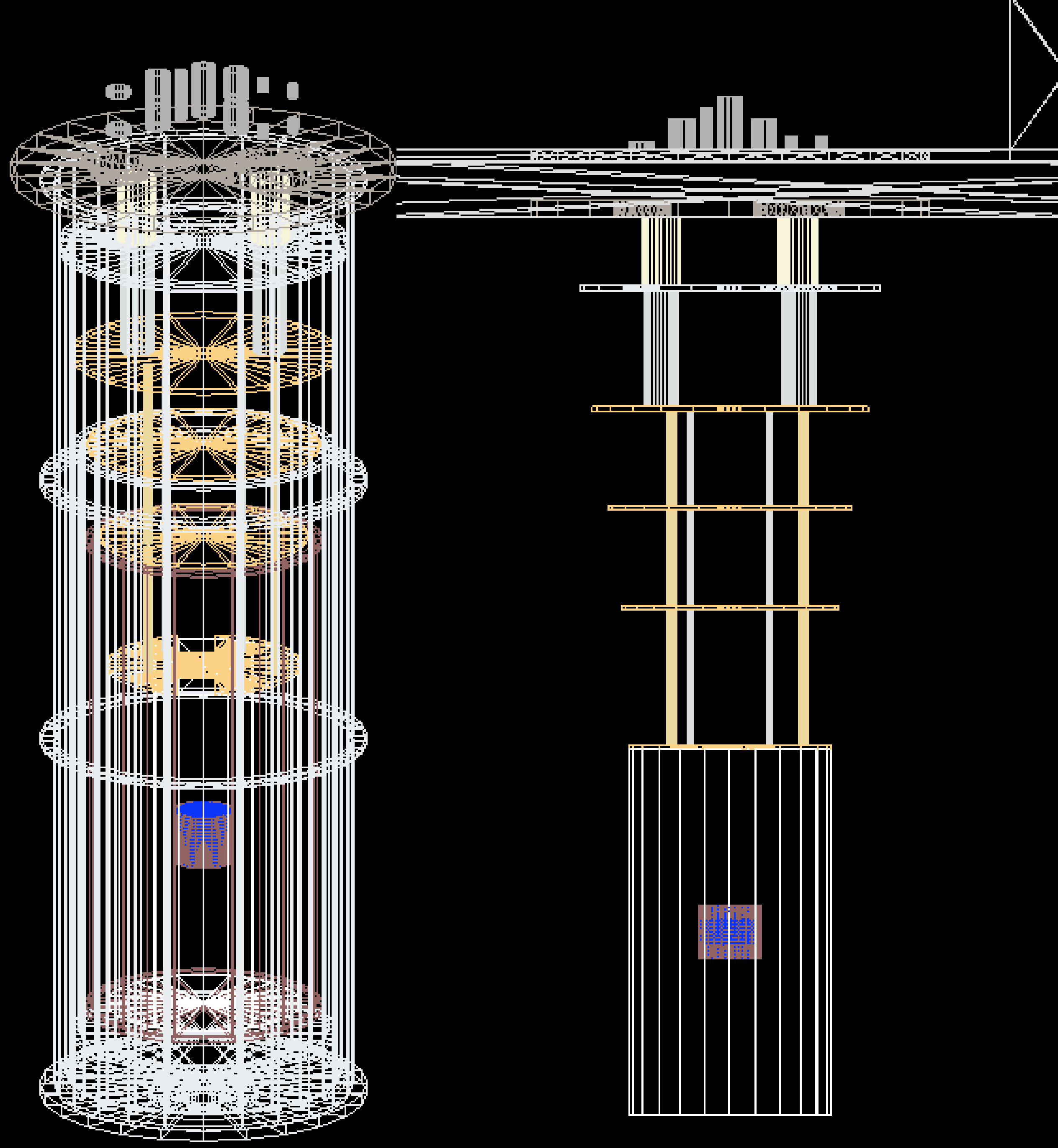


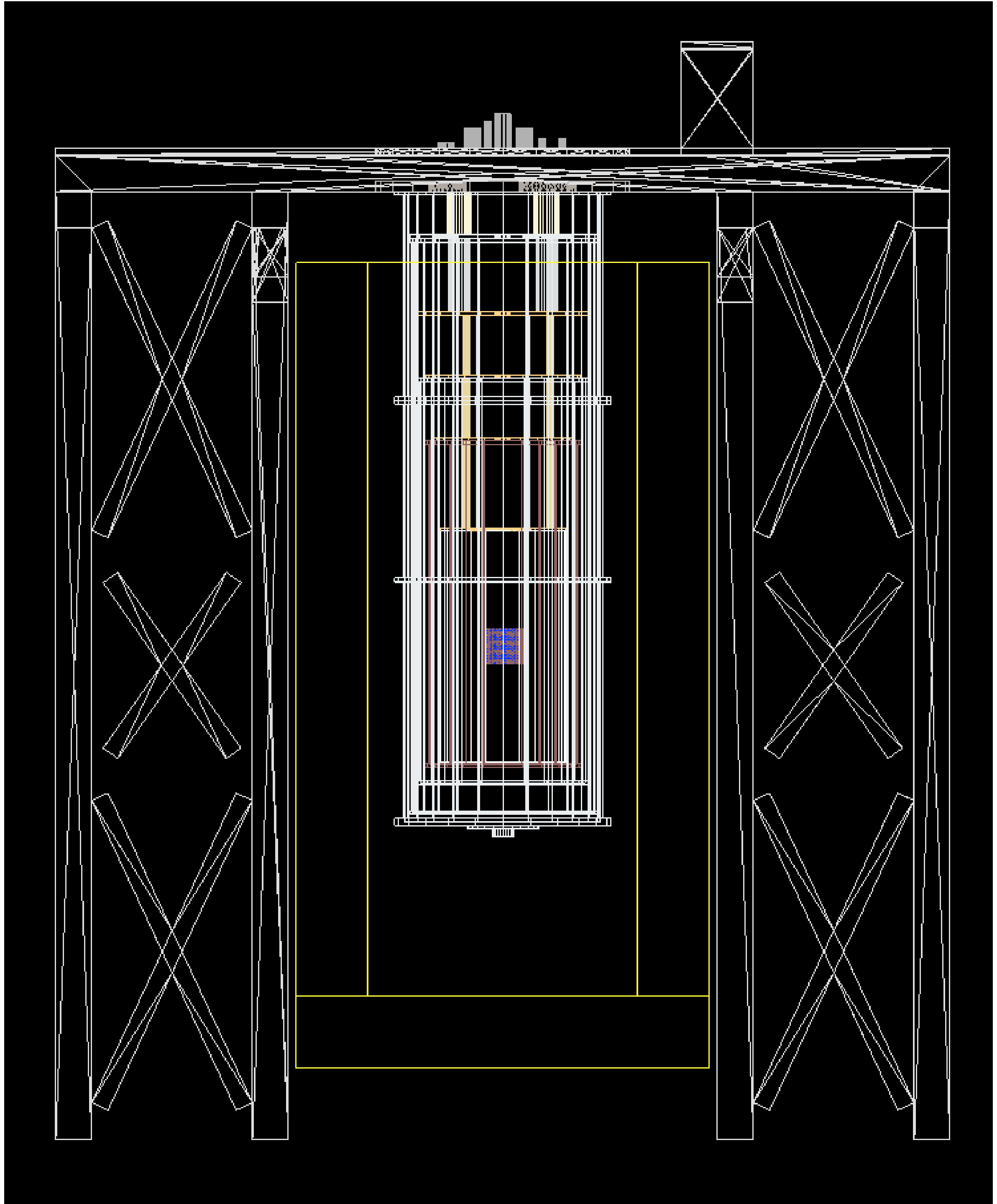
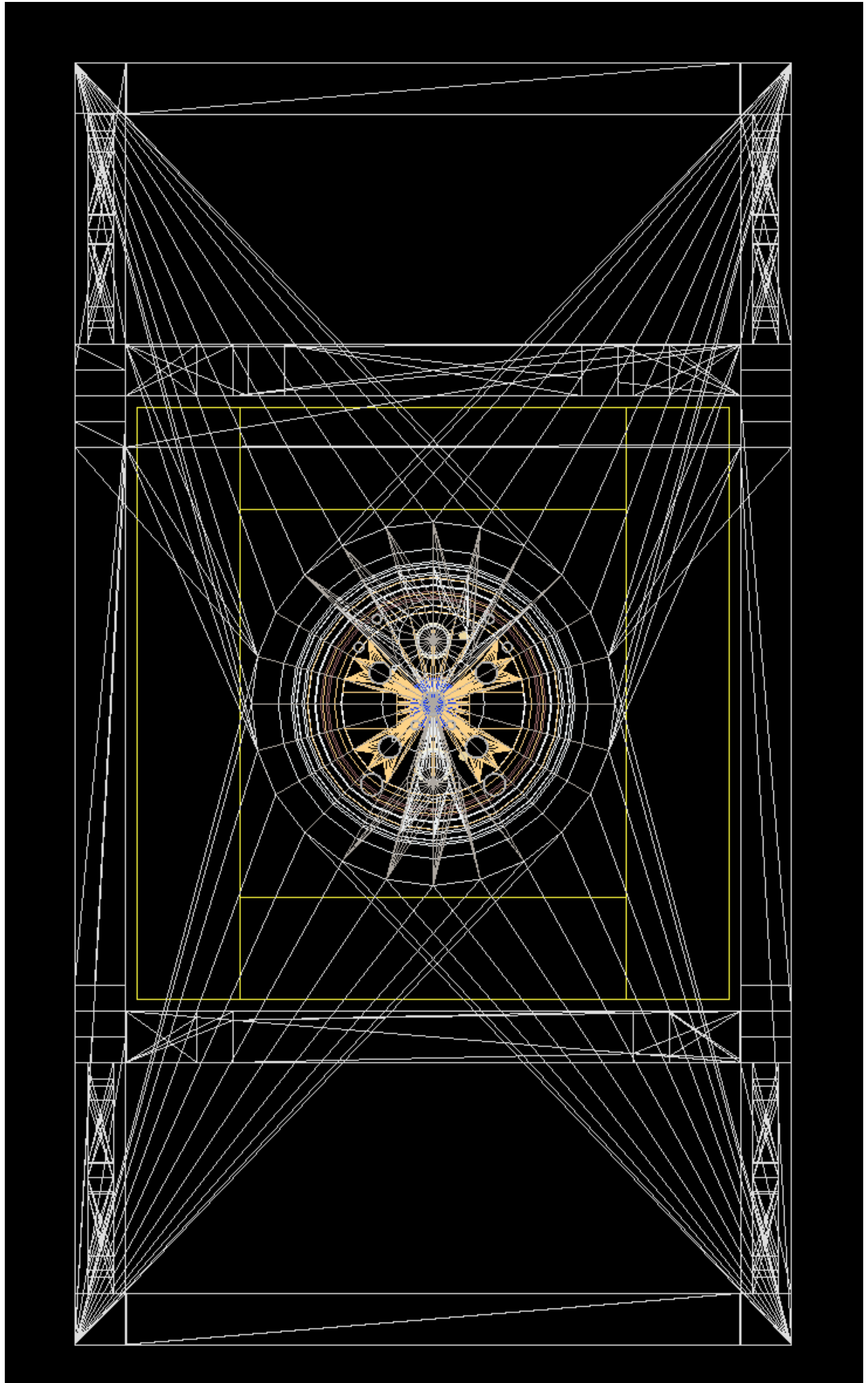




Events in the Si sensors





Backgrounds from Monte Carlo simulations using GEANT4

What we have now

Two GitHub repositories:

Experiment at Sapienza:

https://github.com/ericvj/BULLKID_Sapienza

Experiment at Gran Sasso:

https://github.com/ericvj/BULLKID_GranSasso ericvj / BULLKID_GranSasso

Code | Issues | Pull requests | Actions | Projects | Security | Insights | Settings

BULLKID_GranSasso

Private

Unwatch 1 | Fork 0 | Star 0

main | 1 Branch | 0 Tags | Go to file | Add file | Code

Eric Vazquez Jauregui Add PWO energy only for events in silicon to save disk space 724c1ce · 3 days ago | 7 Commits

GranSasso	Add PWO energy only for events in silicon to save disk sp...	3 days ago
Makefile	Update directories and fix errors with extra directory	last week
README.md	First commit with geometry at Gran Sasso	last week
geant4-v11.1.3.tar.gz	First commit with geometry at Gran Sasso	last week

README

BULLKID at Gran Sasso with GEANT4.11.1.p03

About

Code for Monte Carlo simulations for BULLKID at Gran Sasso

- Readme
- Activity
- 0 stars
- 1 watching
- 0 forks

Releases

No releases published

Create a new release

Packages

No packages published

Publish your first package

Languages

C++ 98.6% Other 1.4%

What we have now

- How to use in one-two-three:

1. clone: gh repo clone ericvj/BULLKID_GranSasso or
   git clone git@github.com:ericvj/BULLKID_GranSasso.git
2. cd BULLKID_GranSasso
3. make

provides compilation of GEANT4 and Gran Sasso experiment

- You need a github account, request access to GEANT code

Ready and working!

Backgrounds at
Gran Sasso

Gammas, muons, and neutrons

Gammas

More intense gamma lines from K40, U238, and Th232 chains simulated

Underground flux:

0.729 gammas/cm^2/s

Table 2. Intensity of the main gamma lines ($\gamma/m^2/day$) measured in the underground Hall A of LNGS. Only lines with intensity higher than $10^6\ \gamma/m^2/day$ are listed. These are due to ^{40}K, and to the ^{238}U and ^{232}Th chains.

Energy [keV]	Isotope	Intensity [$\gamma/m^2/day$]
238.6	^{212}Pb	$2.8 \cdot 10^6$
295.2	^{214}Pb	$3.8 \cdot 10^6$
352	^{214}Pb	$7.9 \cdot 10^6$
583	^{208}Tl	$3.0 \cdot 10^6$
609	^{214}Bi	$1.3 \cdot 10^7$
911	^{228}Ac	$3.1 \cdot 10^6$
934	^{214}Bi	$2.1 \cdot 10^6$
968	^{228}Ac	$2.1 \cdot 10^6$
1120	^{214}Bi	$6.3 \cdot 10^6$
1238	^{214}Bi	$2.8 \cdot 10^6$
1460	^{40}K	$2.9 \cdot 10^7$
1764	^{214}Bi	$8.2 \cdot 10^6$
2204	^{214}Bi	$3.1 \cdot 10^6$
2614	^{208}Tl	$7.8 \cdot 10^6$

Muons

Muon energy and angular distributions from Mei and Hime

Underground flux:

3.2×10^{-8} muons/cm^2/s

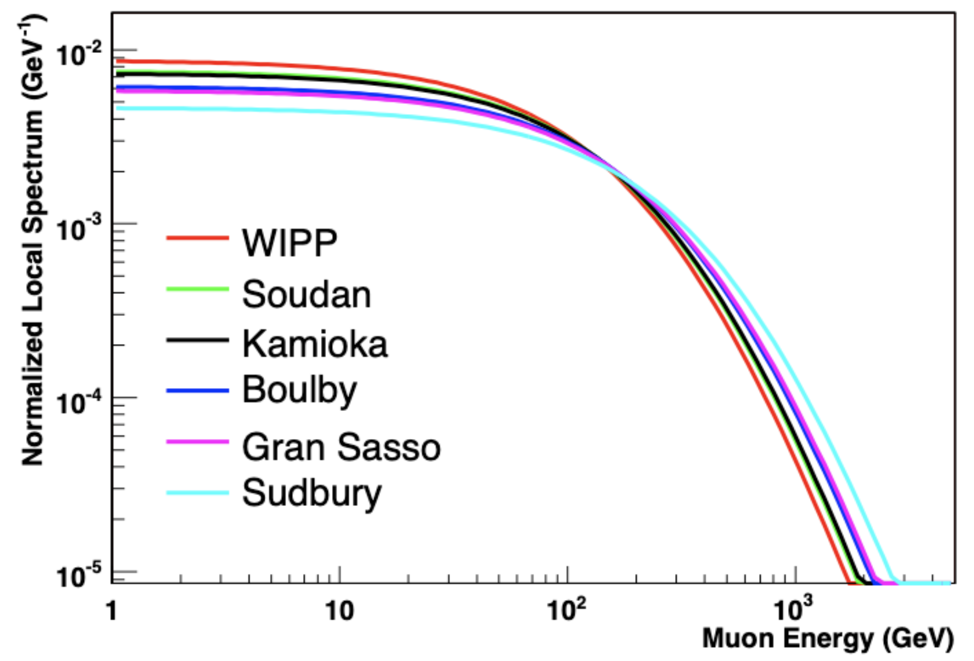


FIG. 6: The
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der the curve
for compariso

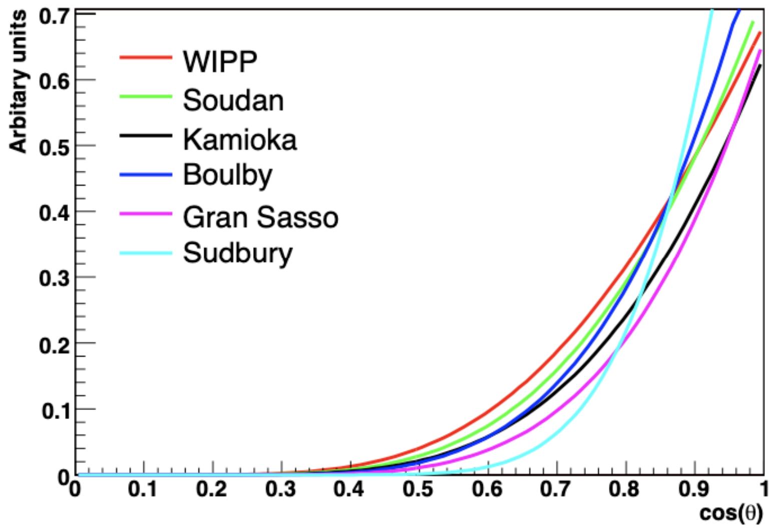


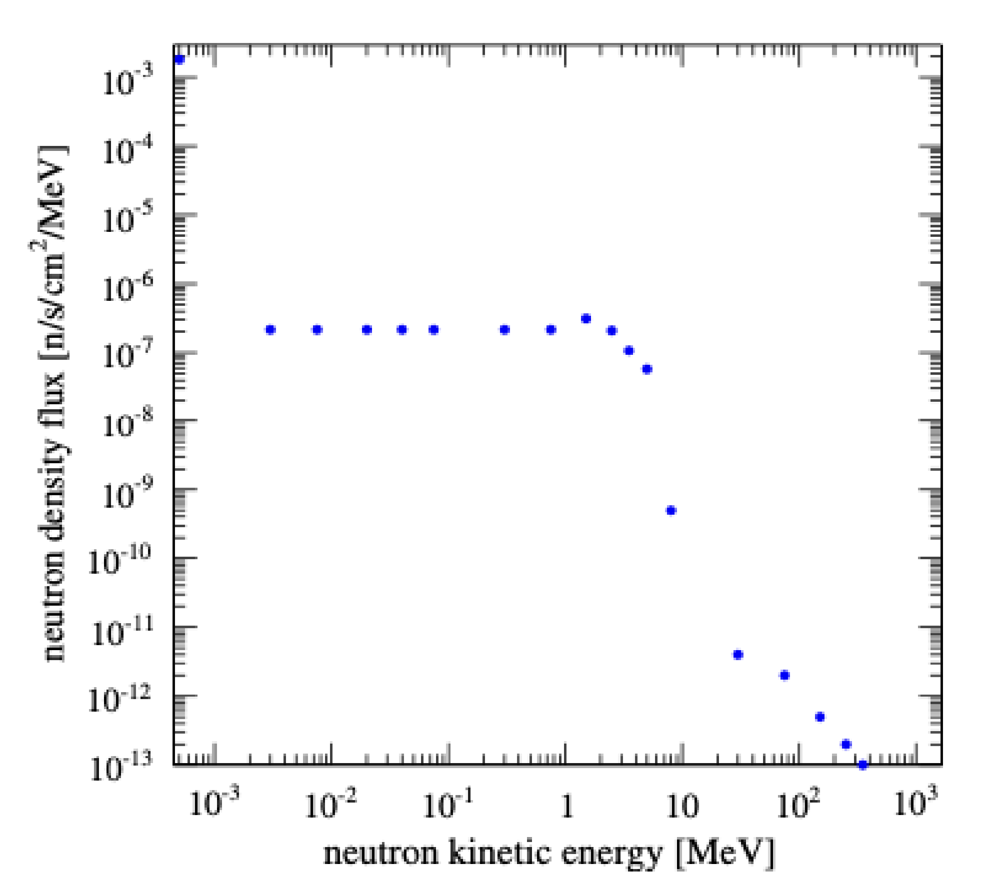
FIG. 7: The muon angular distribution local to the various underground sites based on equation (3). All curves have

Neutrons

Neutron energy distribution from several sources for 3 regions:

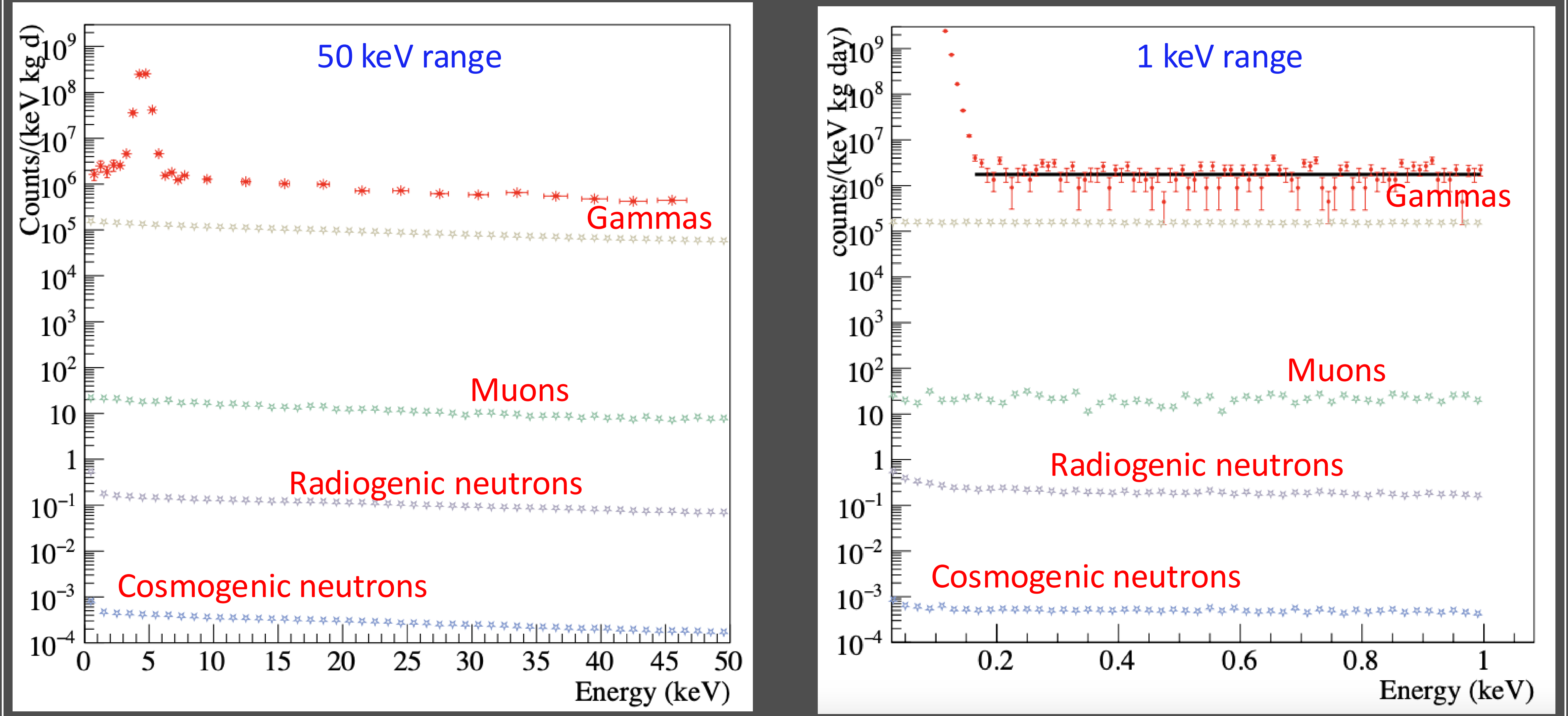
- Thermal
- Radiogenic
- Cosmogenic

E interval (MeV)	Neutron Flux (10^{-6}cm^{-2}s^{-1}) Ref. [1]	Ref. [2]	Ref. [3]	Ref. [4]	Ref. [5]	Ref. [6]
$10^{-3} - 0.5$						
$0.5 - 1$			0.54±0.01			
$1 - 2.5$		0.14±0.12	(0.53±0.08)			
$2.5 - 3$		0.13±0.04	0.27±0.14			
$3 - 5$			(0.18±0.04)			2.56±0.27
$5 - 10$		0.15±0.04	0.05±0.01 (0.04±0.01)	3.0±0.8	0.09±0.06	
$10 - 15$	0.78±0.3	$(0.4 \pm 0.4) \cdot 10^{-3}$	$(0.6 \pm 0.2) \cdot 10^{-3}$ $((0.7 \pm 0.2) \cdot 10^{-3})$			
$15 - 25$			$(0.5 \pm 0.3) \cdot 10^{-6}$ $((0.1 \pm 0.3) \cdot 10^{-6})$			

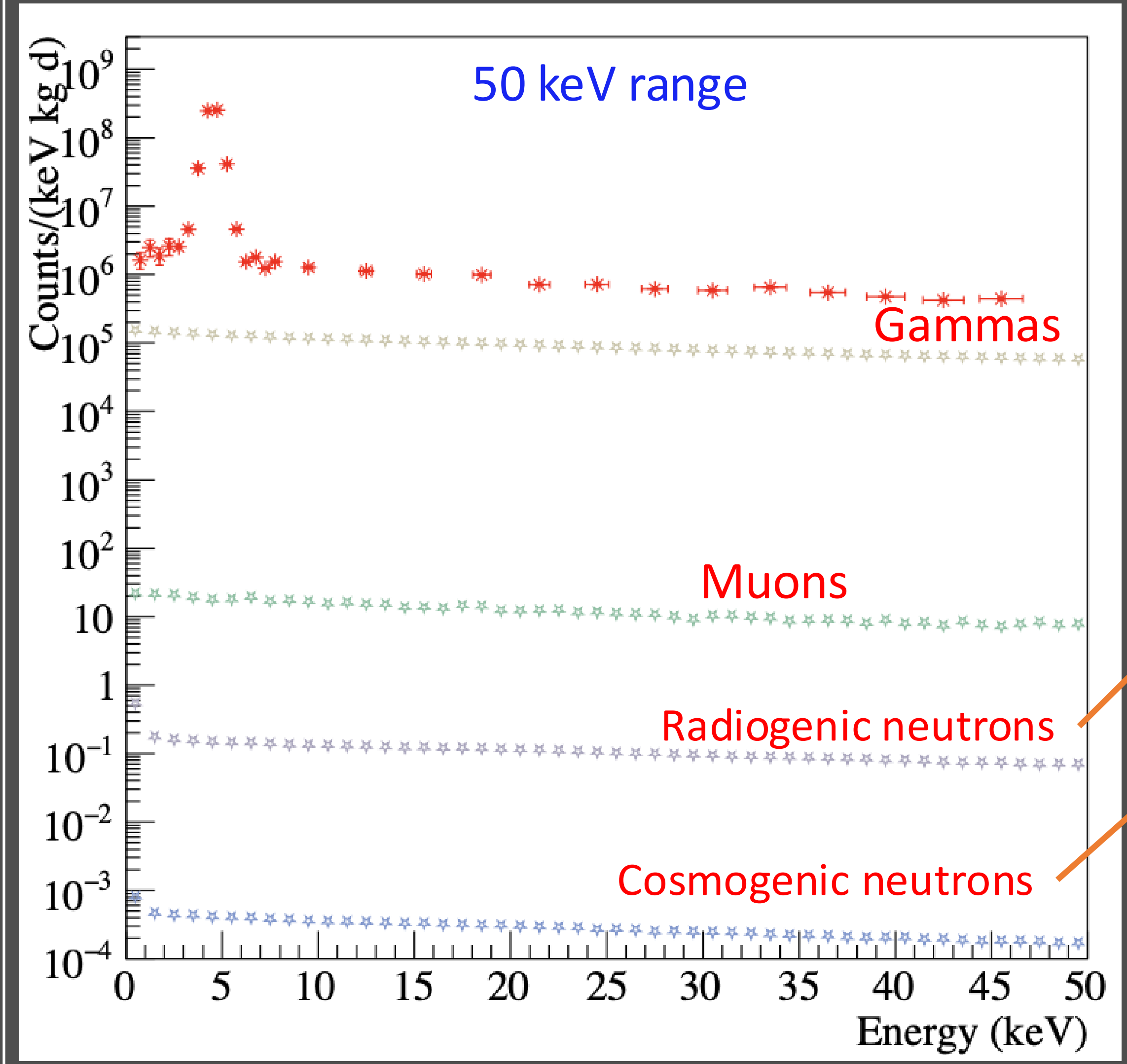


Results: with and without shielding

No shielding



All backgrounds: No shielding



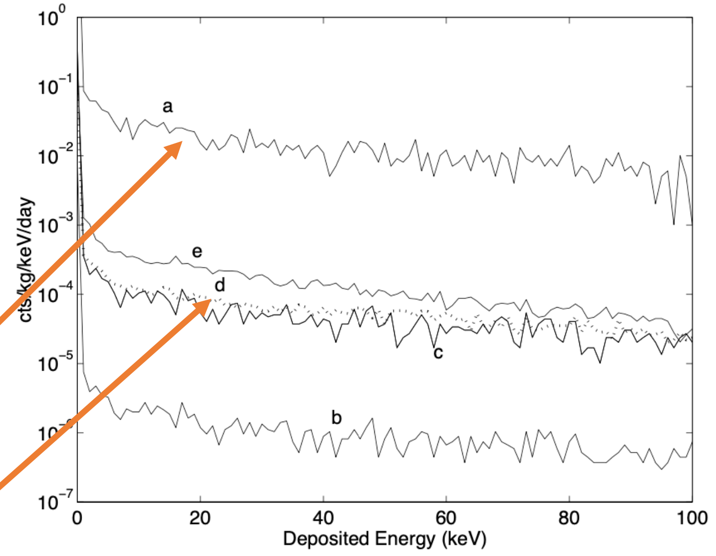
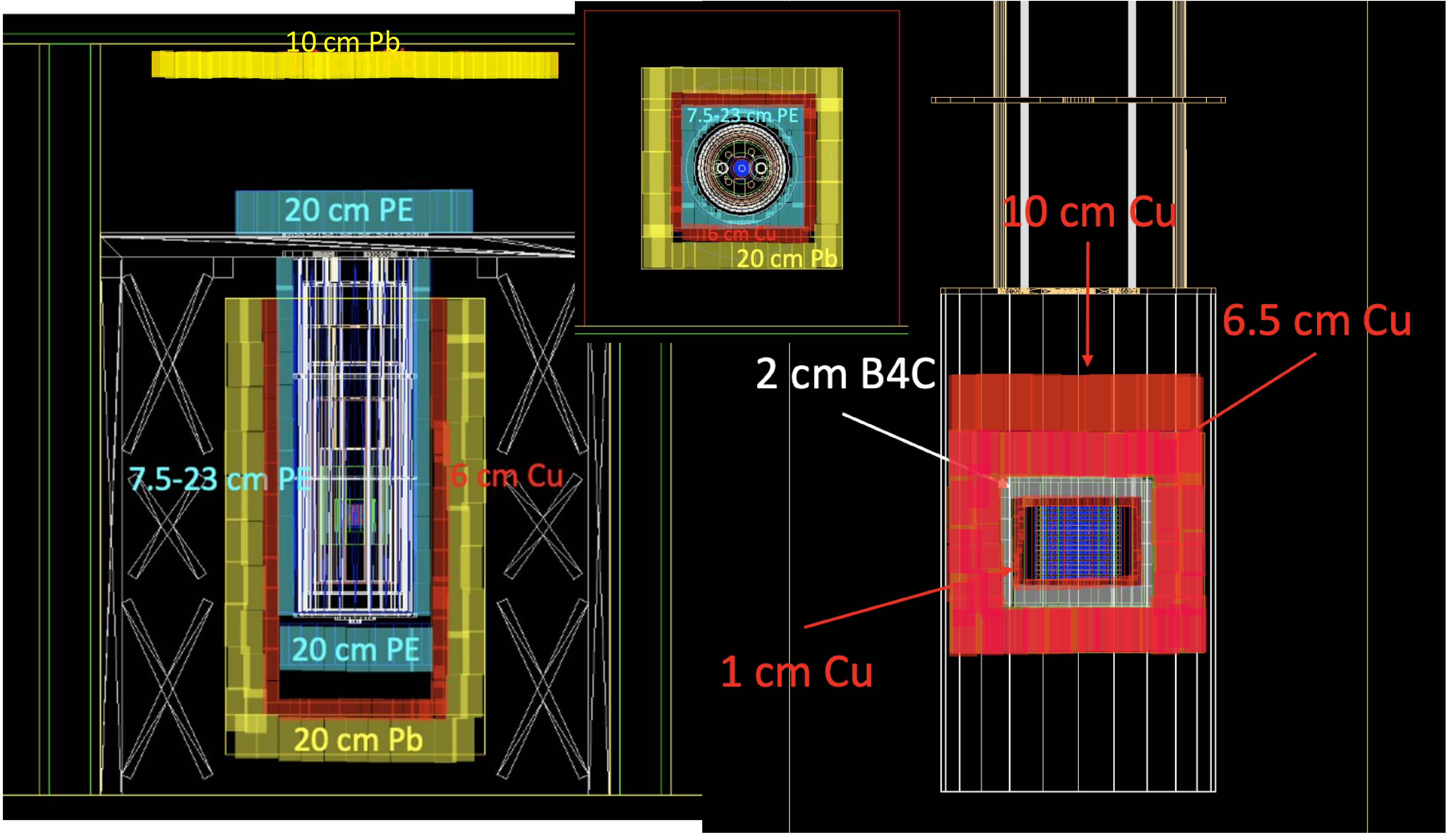
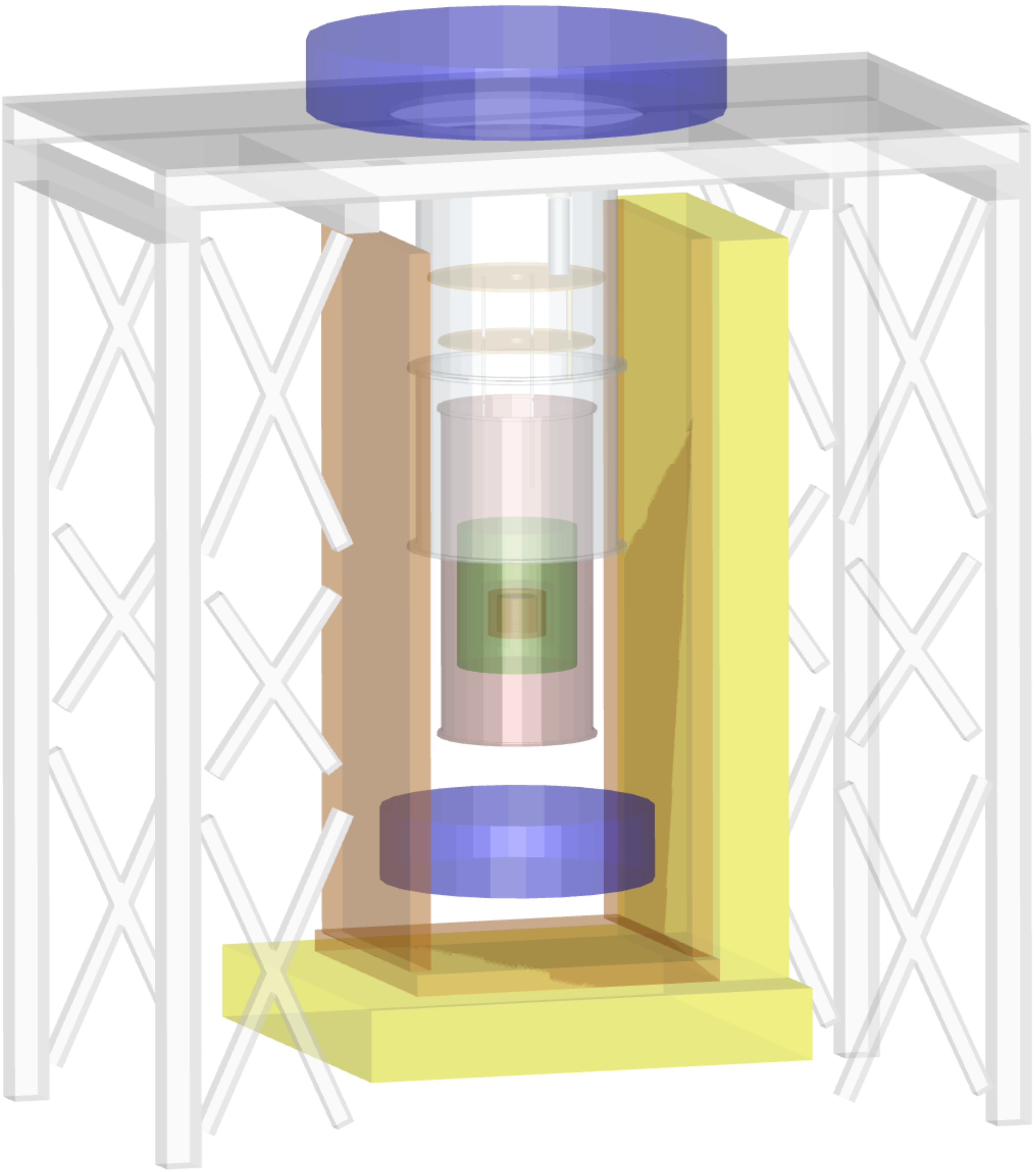


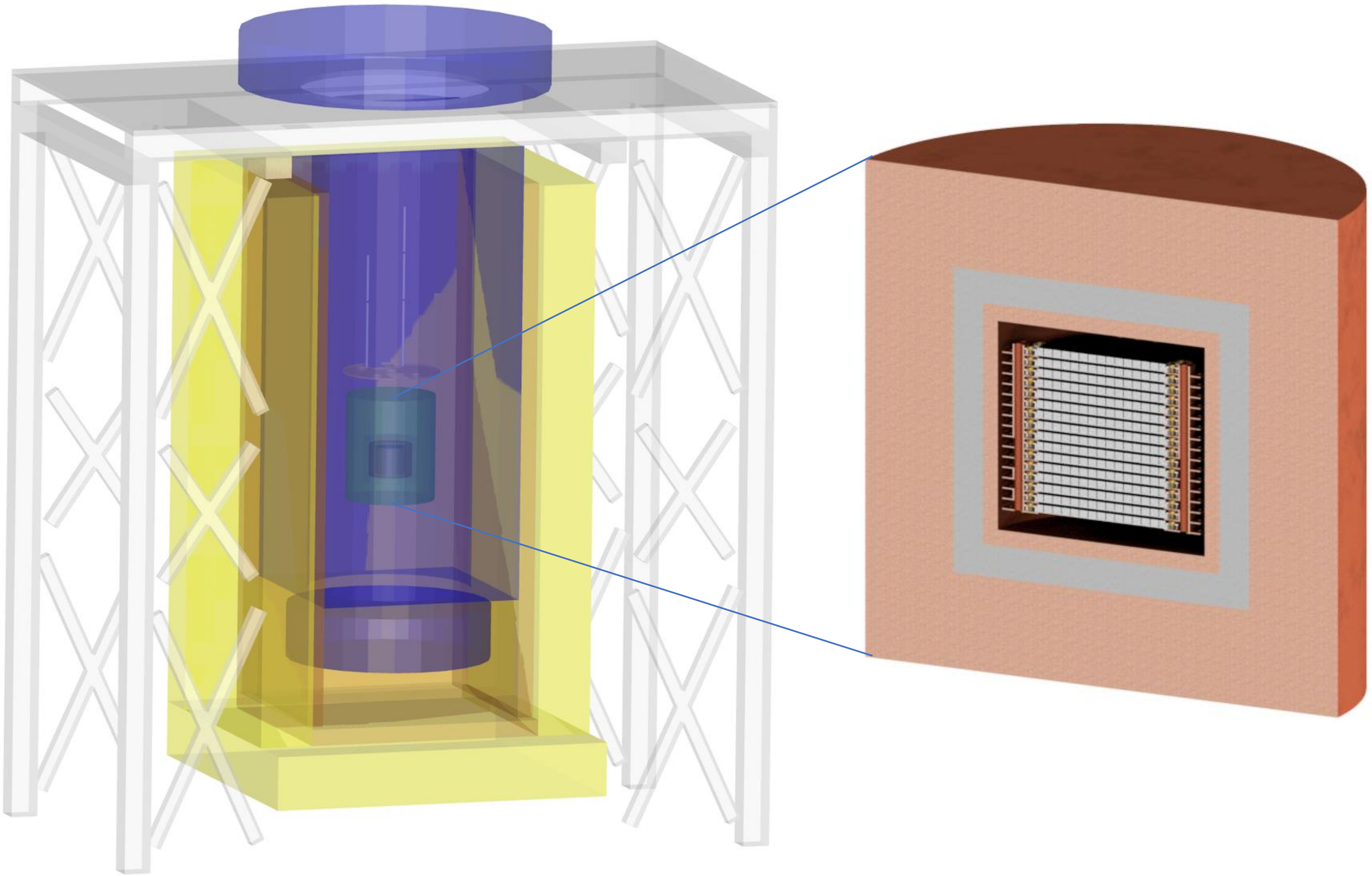
Fig. 6. Recoil spectra in a $CaWO_4$ detector induced by neutrons from different origins: (a) low energy neutrons from the rock/concrete, no neutron moderator, (b) low energy neutrons from the rock/concrete after being moderated by 50 cm polyethylene, (c) low energy neutrons from fission reactions of 0.1 ppb ^{238}U in the lead shield, (d) high energy neutrons induced by muons in the rock and (e) high energy neutrons induced by muons in the experimental setup.

Comparison with CRESST

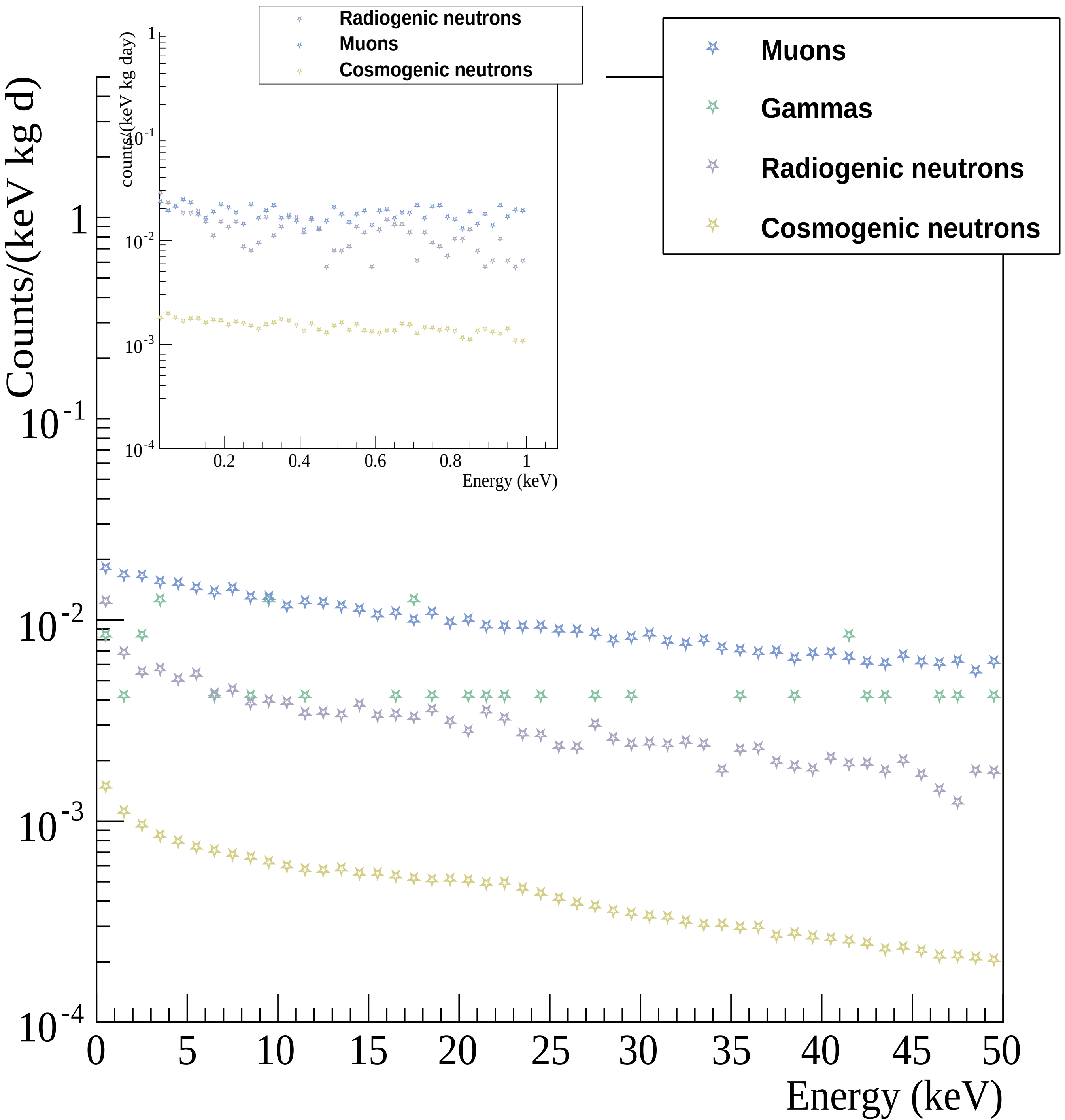


10 cm Pb
20 cm PE
7.5-23 cm PE
6 cm Cu
20 cm PE
20 cm Pb
7.5-23 cm PE
6 cm Cu
20 cm Pb
10 cm Cu
6.5 cm Cu
2 cm B4C
1 cm Cu





With shielding



Possible scenarios for the Demonstrator

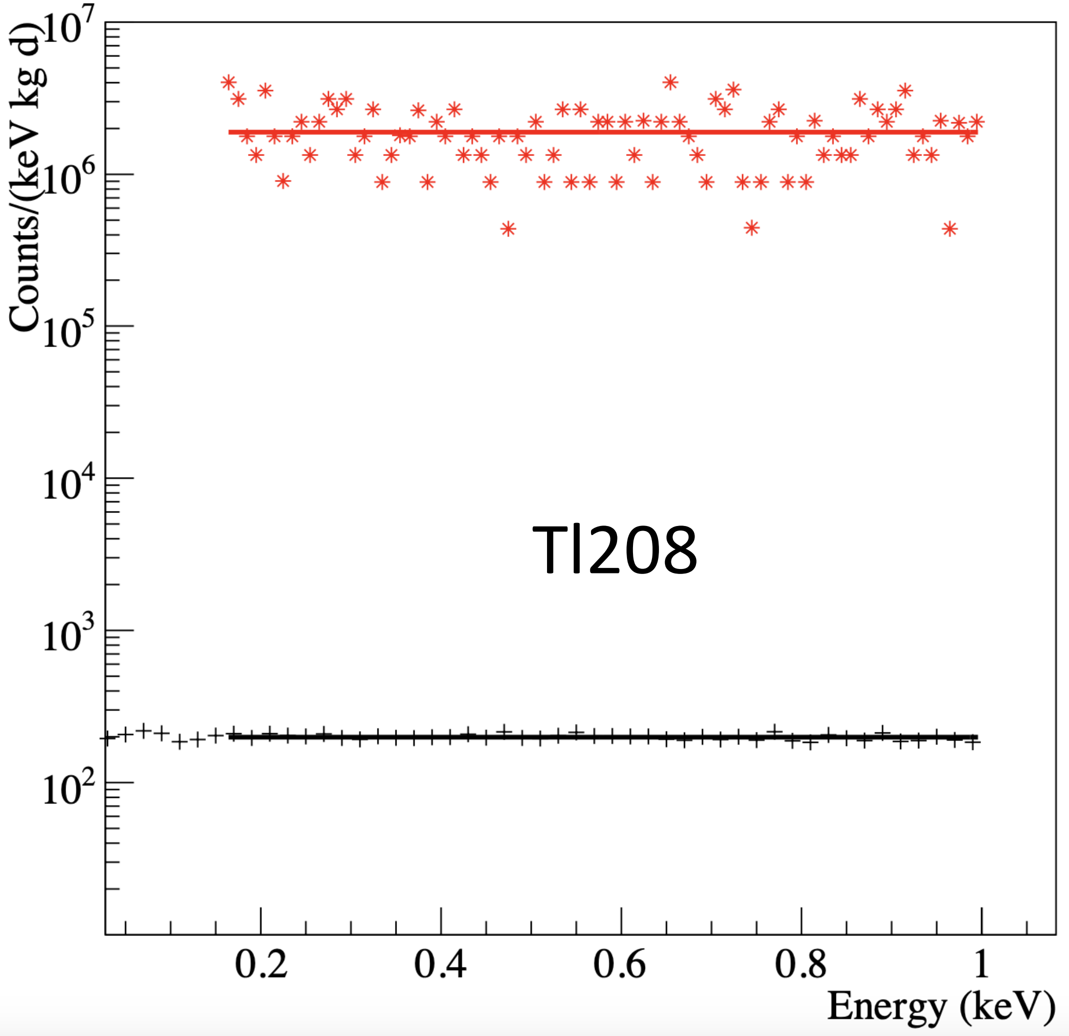
- Room temperature shielding:
- 1) Lead
- 2) Copper
- 3) Polyethylene
- Cold shielding:
- 4) outer copper shielding
- 5) B4C or similar
- 6) inner (purer) copper shielding

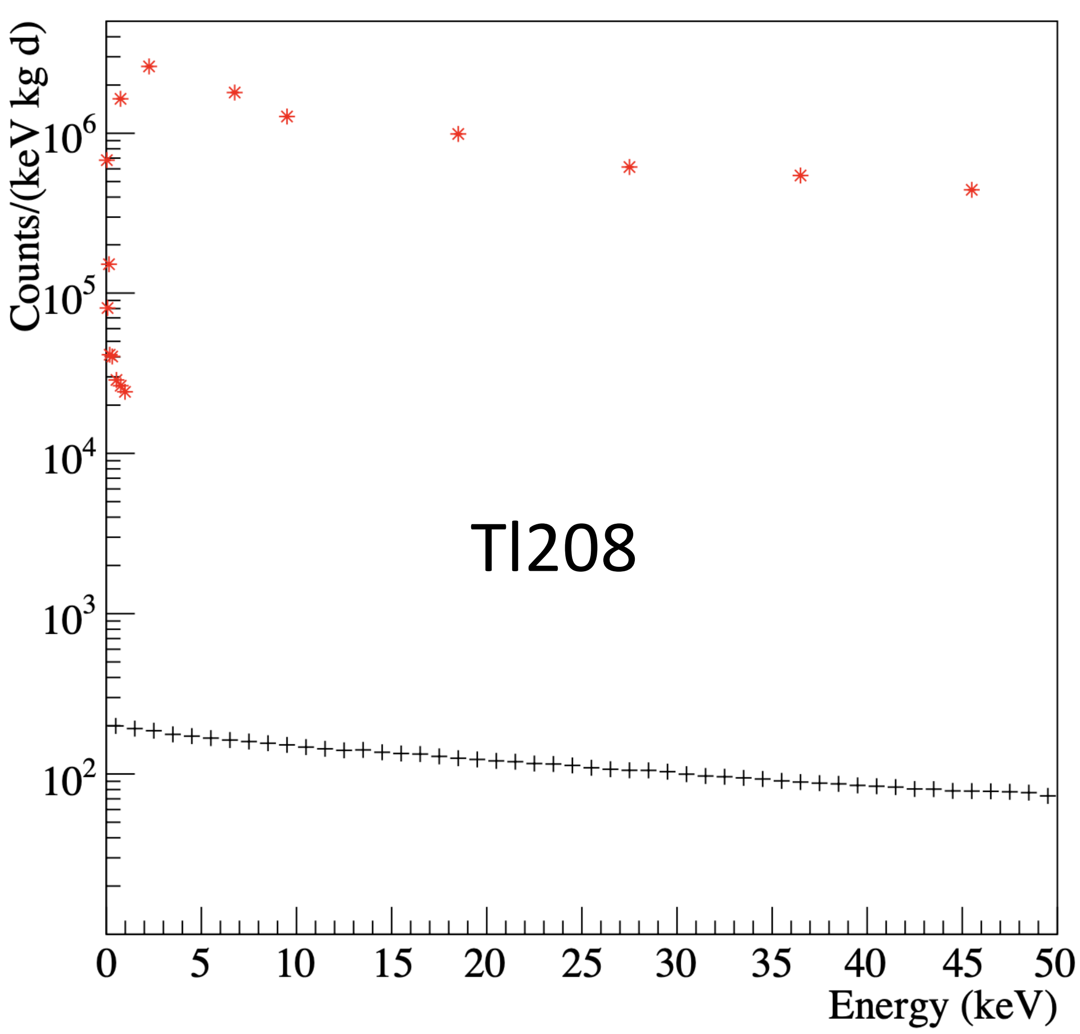
- Possible configurations for the demonstrator:
- **A) Worst case: 4 + 5 + 6**
- B) Baseline : 1 + 2 + 4
- c) Baseline + poly: 1 + 2 + 3 + 4

Demonstrator without external shielding

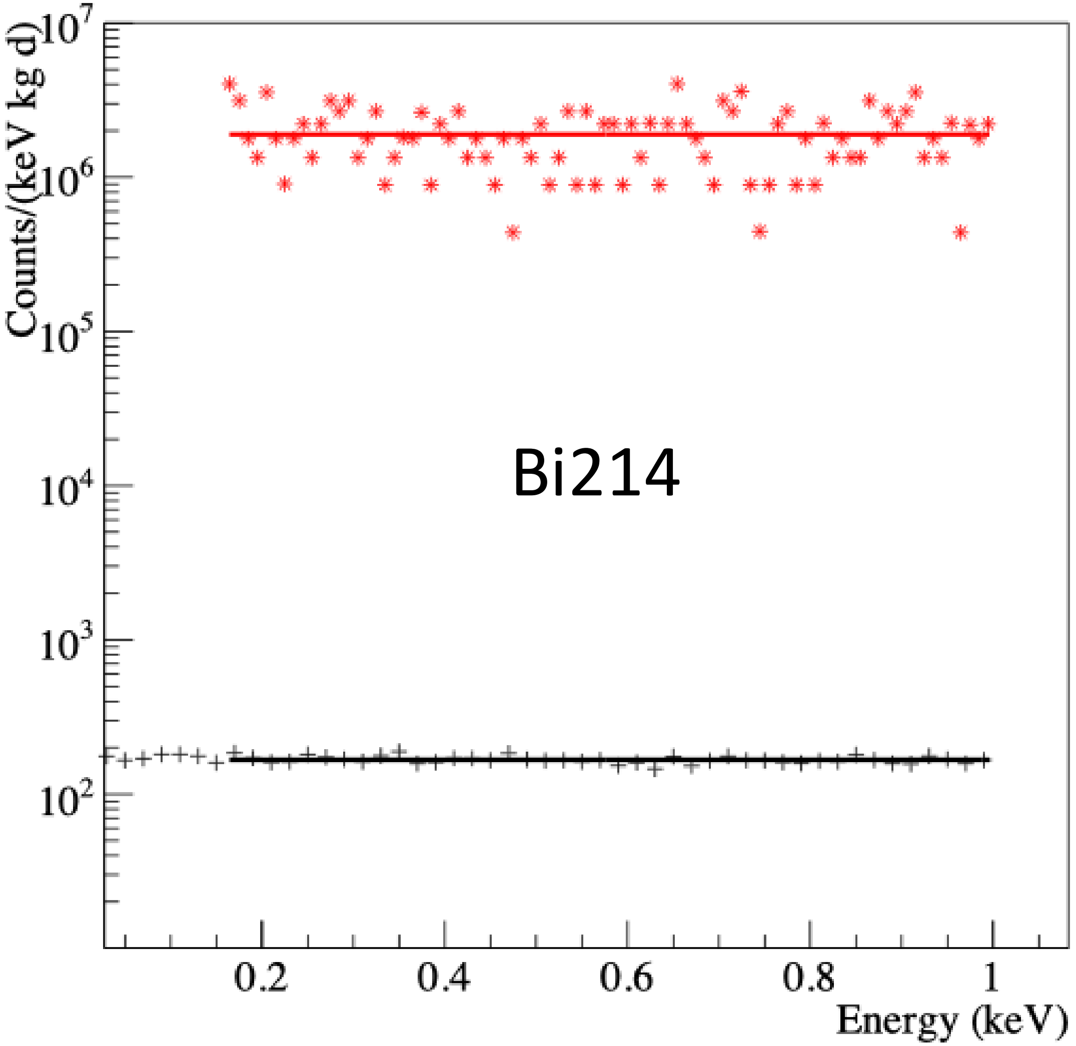
✓Muons and neutrons below 50 d.r.u. without any shielding

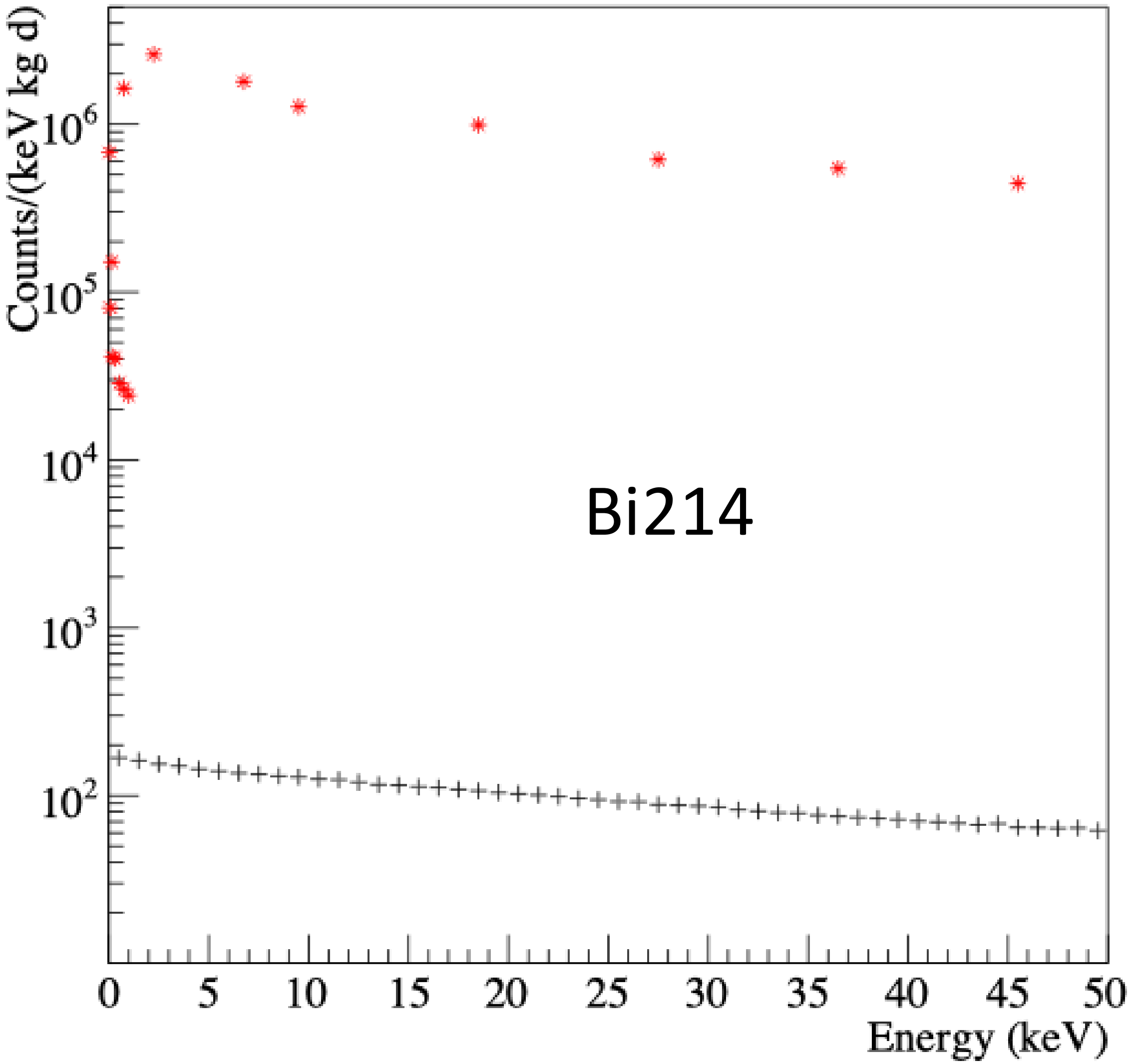
✓ Inner shielding with 4+5+6 scenario would reduce gammas from 1E5 to approx. 1E3 d.r.u.





Demonstrator without external shielding





Summary and Conclusions

- ✓ Demonstrator could reach approximately 1E3 d.r.u., pending simulation of internals, with only the inner cold shielding
- ✓ Need to define configuration of external shielding to reach target, in collaboration with Gran Sasso
- ✓ Full time PhD student at UNAM will be running next set of simulations: Alberto Acevedo Rentería