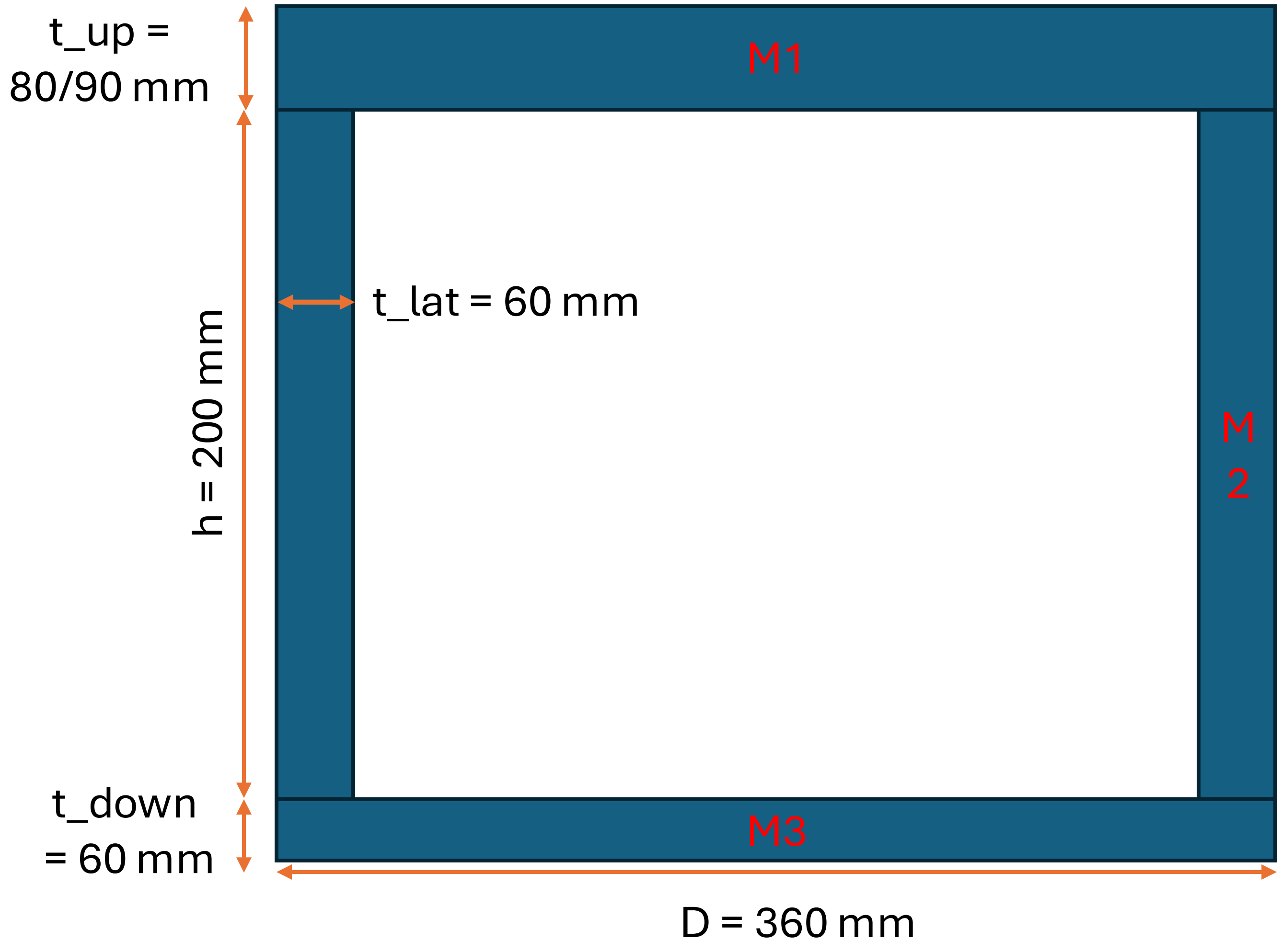
Questions for the simulations group

September 2, 2025

BULLKID @ Gran Sasso

- (maximum) horizontal footprint: 360 mm
- maximum TOT weight: 250 kg
- approximate weight of detector + internal shields (Cu_1cm and B4C or similar): 30 kg
- maximum weight for the external shield: 220 kg
- height of detector: 160 mm
- height of the cylindrical part of the external shield: 160 mm (detector) + 60 mm (height of B4C + Cu)+ 30 mm (tolerance) = 250mm

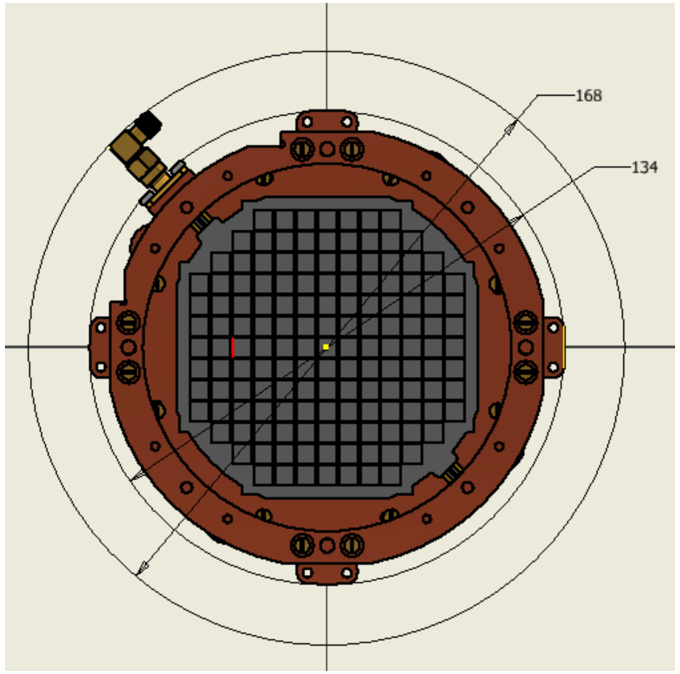


$M1 = pi*(D/2)^{2}*t\_up = 73.0/82.3$ kg

$M2 = pi*[D/2\hat{}2-(D/2-t\_lat)\hat{}2]*h = 101.3$ kg

$M3 = pi*(D/2)^{2}*t\_down = 54.7$ kg

M_TOT =229 / 238 kg

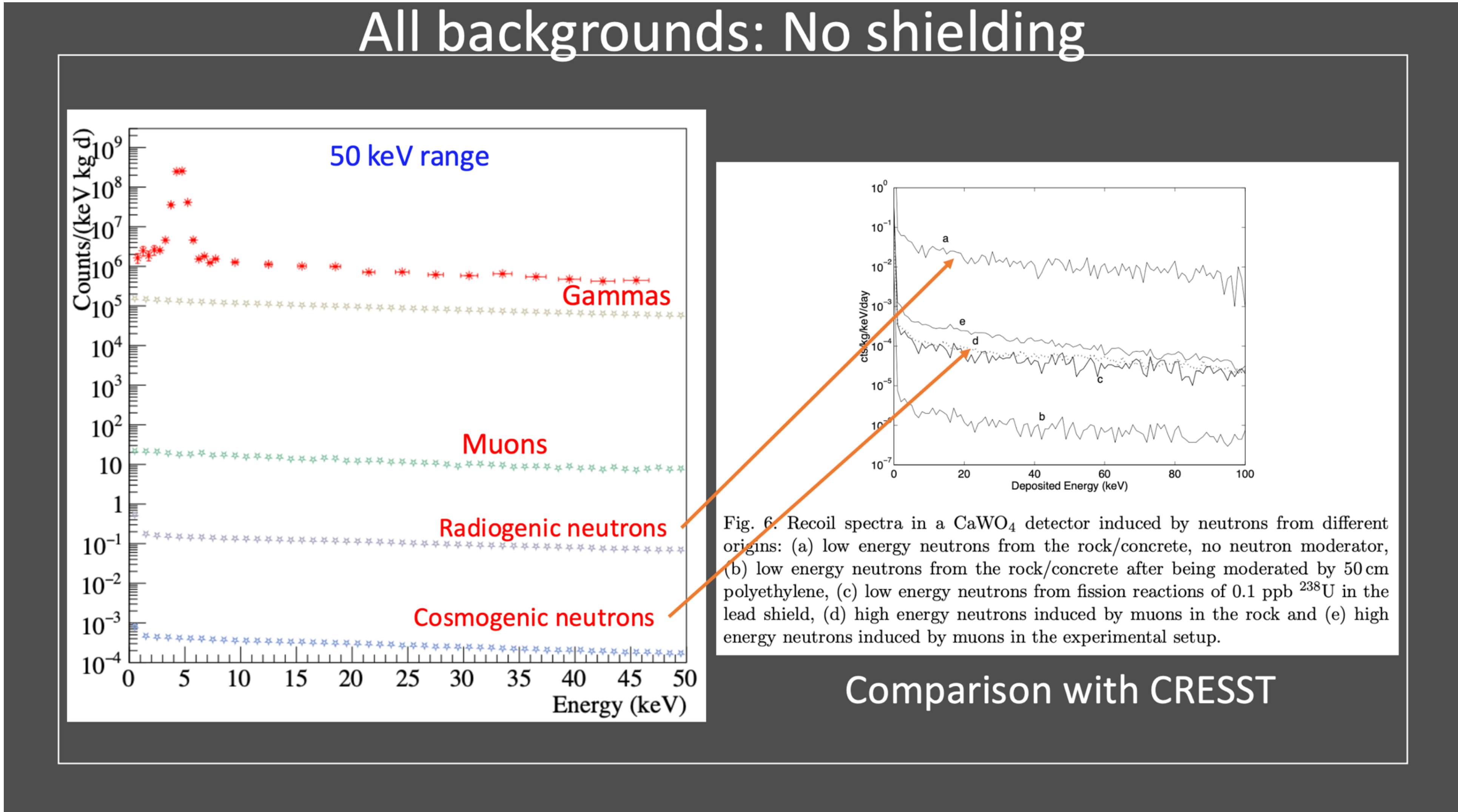


From Angelo and Daniele

As you may recall, we promised a level of the order of 10^4 DRU, considering that the external RT Pb-Cu shielding is not yet ready.
Their questions are basically:

- Which will be the main contributors to the bkg in this configuration?

Gammas will still be the dominant background

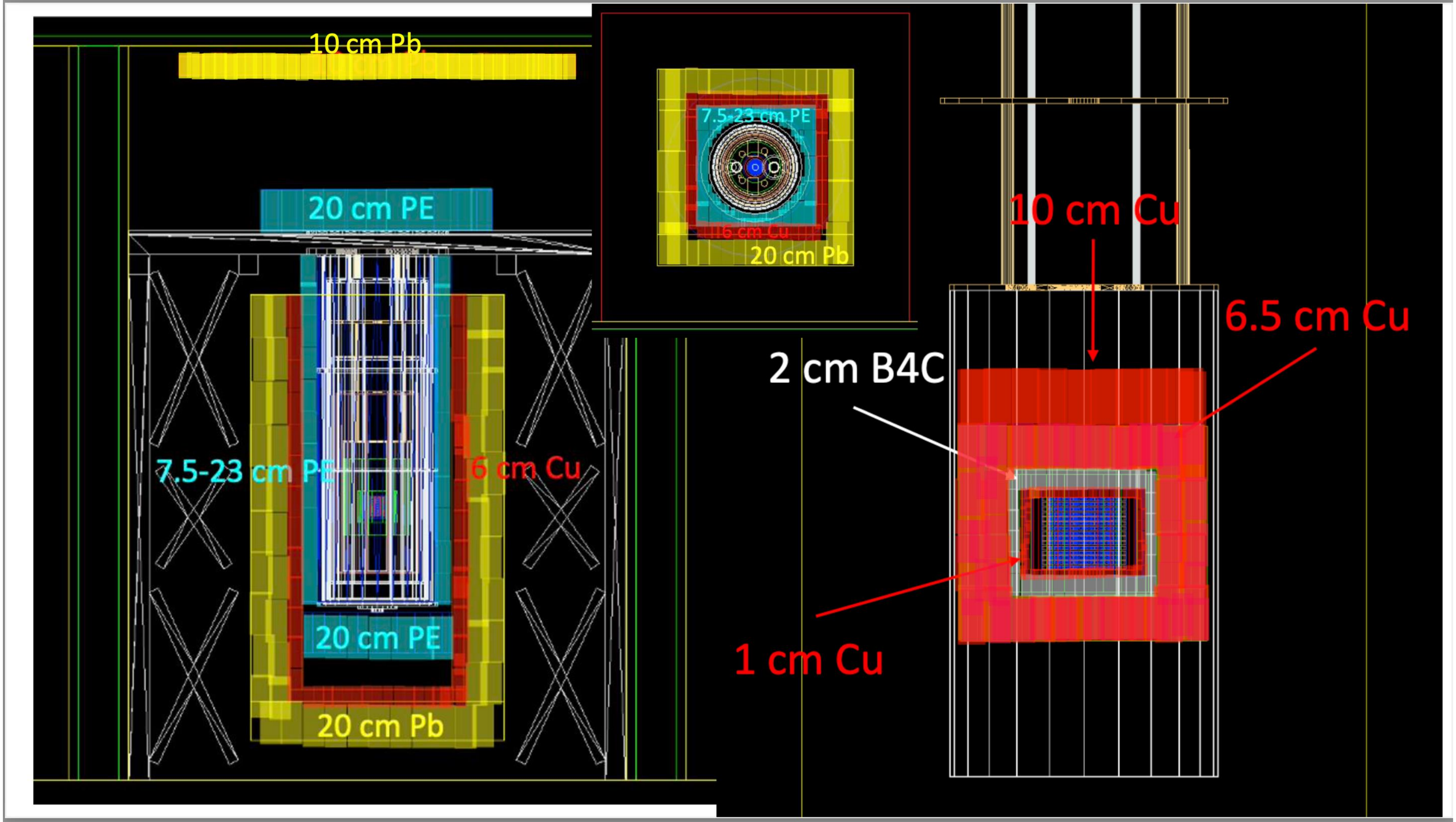


BULLKID @ Sapienza

- *How does it happen that we improve of about 6 order of magnitude, adding some gamma and neutron shielding.*

- We remove more than 6 orders of magnitude of gammas with the Pb and Cu (this is the main effect).
- Muons are also reduced with the gamma and neutron shielding.
- Neutrons are reduced by at least one order of magnitude with the neutron shielding.

Keep in mind this is with the old, initial shielding from the CDR



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

BULLKID @ Sapienza

- Am i missing some component of neutrons?

We have simulated radiogenic (rock) and cosmogenic neutrons (results agree with CRESST simulations).

- It seems like with proper gamma shielding underground, we may reach 10 DRU or lower (ignoring internal). Is it right?

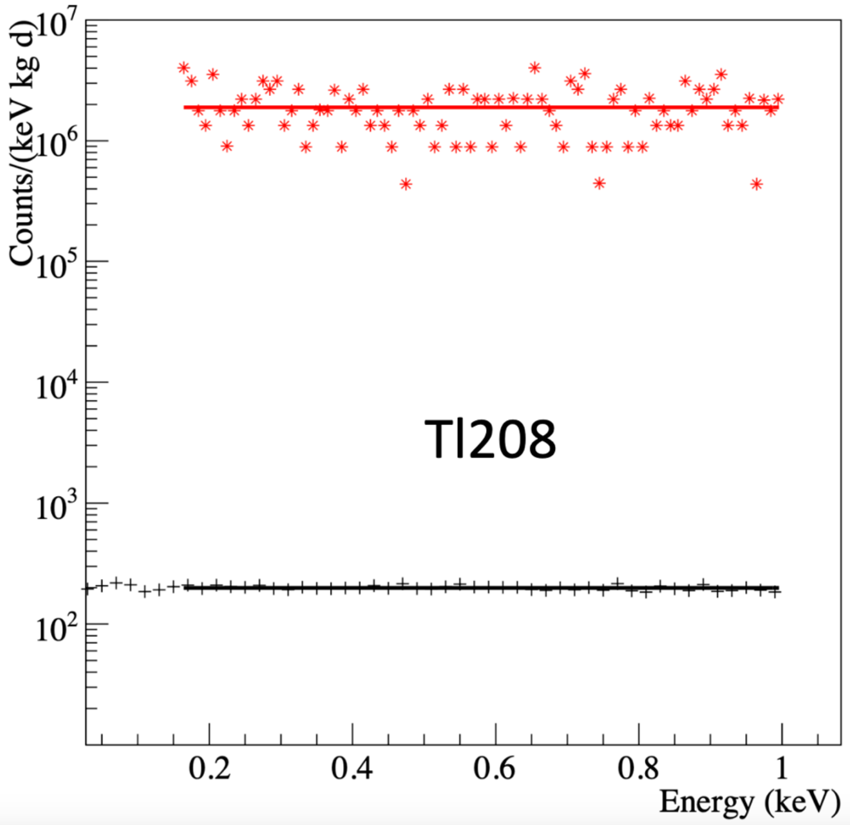
Yes, with proper gamma shielding (external and internal) we can easily reach ~10 DRU. We are still ignoring internal contributions (holders, connectors, cables, etc), we would need to make sure they are not above this value.

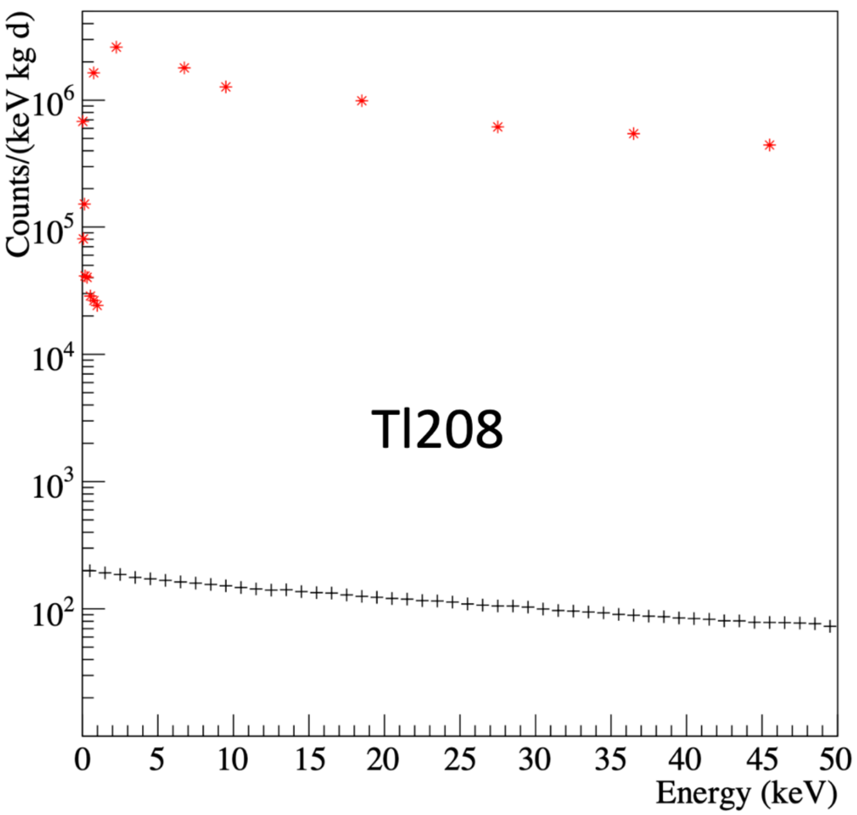
Without external shielding, we will be very likely above 10^3 DRU, close to 10^4 DRU

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.





Other questions

- The role of thermal neutrons: looking at slide 5 of your old presentation of Feb 19, it seems that they are (very!) relevant, but then in the next presentations they are no longer there.

Those simulations were done without any shielding in the detector; once the shield is in place, there shouldn’t be any thermal neutrons entering the cryostat.

The simulations were done by generating neutrons towards the inside of the cryostat, which is not entirely correct.

Other questions

- Why the contributions of cosmic and radiogenic neutrons are so different above and below ground (check in example this old presentation (15th Jan) where they account for few 10s to few 100s DRU).

Cosmogenic neutrons on the surface are much higher than underground. They are produced by muon showers and spallations, so they are a subleading contribution at LNGS.

Similarly, for radiogenic neutrons, the flux is different. On the surface, the flux is 3.4E-3 /cm^2 s, while at LNGS is ~1E-6 /cm^2 s.

Other questions

- Should we also take into account neutrons generated secondarily by gamma interactions, or is this negligible given the typical gamma energies?

This is a background that we haven’t simulated, but we must include it. Photonuclear reactions are always a subleading contribution, but we need to quantify them for the final shielding design. There will be some produced, but the threshold for many of the photonuclear reactions is high, above 10 MeV.

Summary

- External shielding is defined, implemented in the model for any simulations.

- Internal shielding has to be defined and re-simulated: changes pose a high risk to the background budget

- Internal contribution from components is important to assess: need to develop a plan for measuring the radiopurity of all internal components.