# Background Simulation at aMore

## $5^{th}$ International Workshop at High-1

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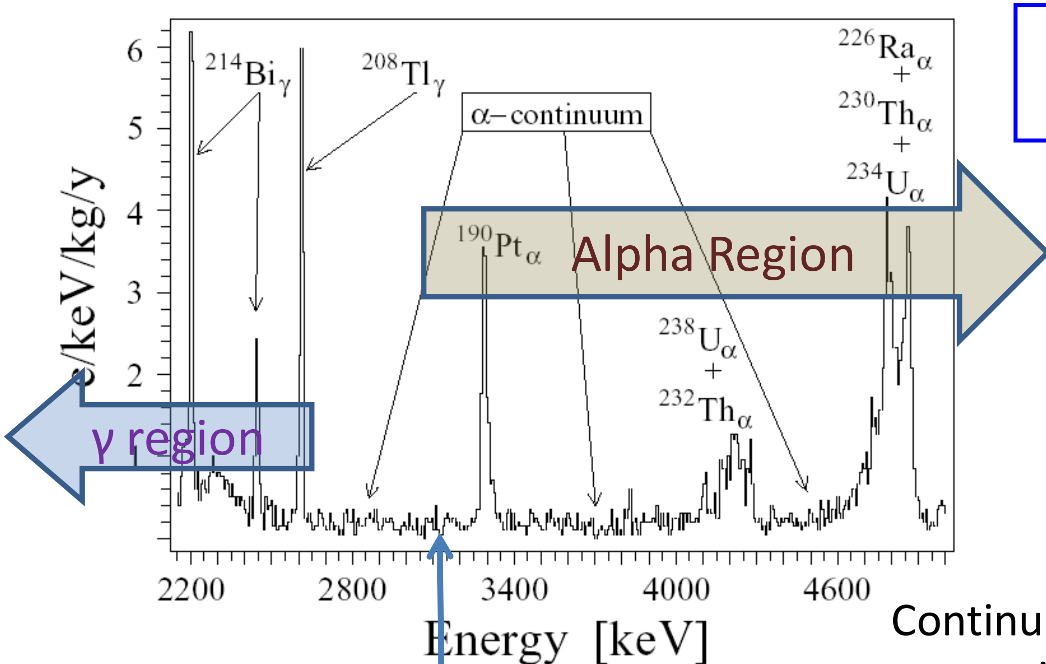
**SNU**

Contents:

- Energy spectrum simulation for cryogenic detector.
- Energy  deposit signal for signal and background.
- Light signal.
- Cryostat Design not discussed.

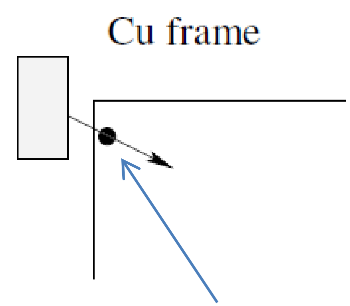
# Background spectrum in bolometric detector for 0vDBD search




0vDBD for $CaMO_4$

**CUORICINO 0vββ background**
**0.18 ± 0.02 c/(keV kg y)**

Internal or Surface α contaminations

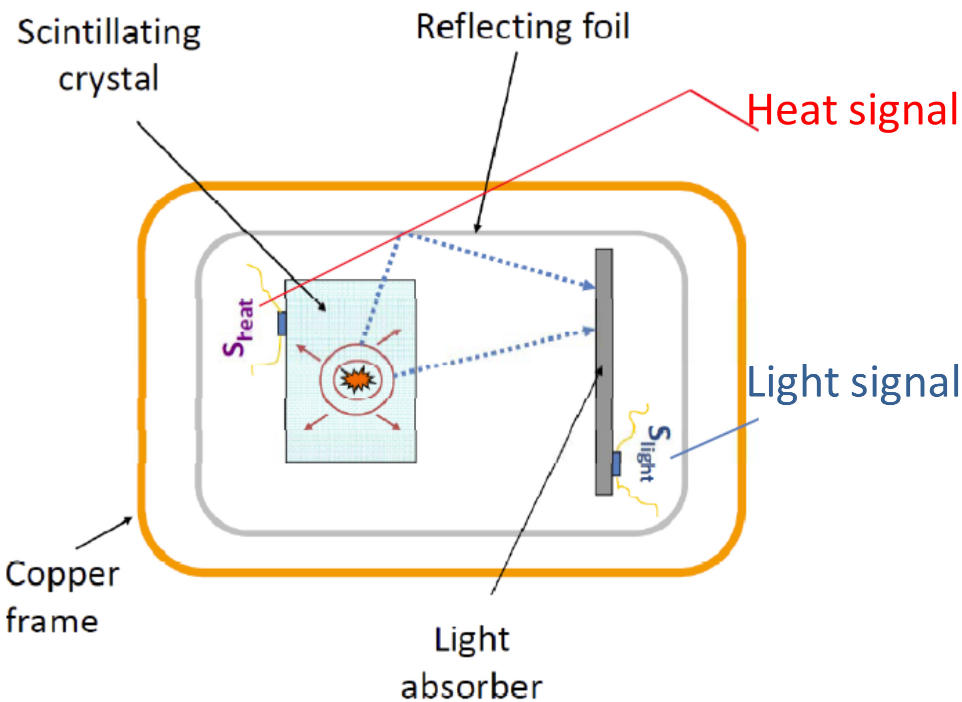



Continuum due to shallow surface α contaminations (e.g. $^{210}Pb$) of supporting materials

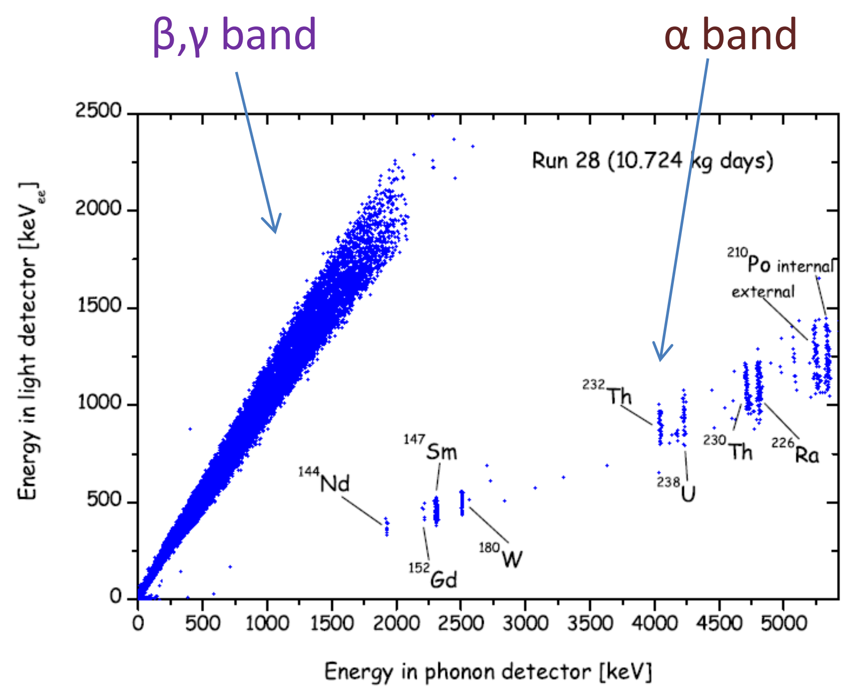
Very Difficult to reduce it below 0.05c/keV kg y

# How to kill Alpha particles?

Scintillating bolometer



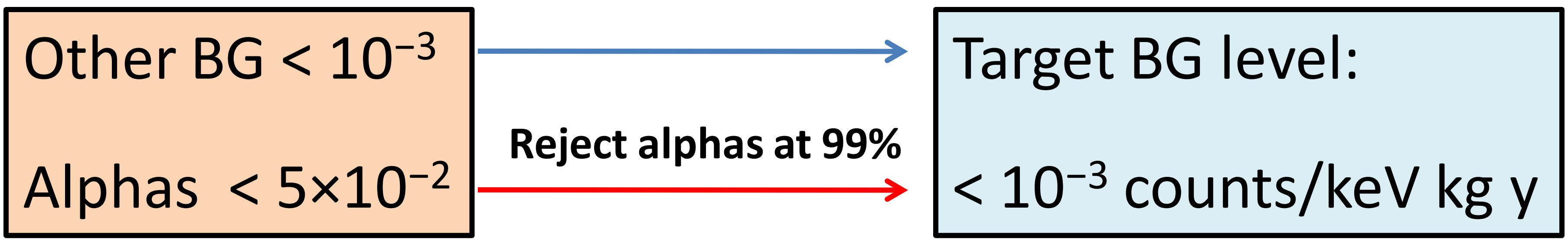

For example: $CaWO_4$ crystal




**This Idea brings aMore**

# Target background level

Many techniques of surface cleaning can reduce the contribution from surface alphas **to 5×10$^{-2}$ counts/keV kg y**, around the 3 MeV 0vDBD region.



# How to simulate the energy spectrum?

- Bulk and surface contamination from chains and and isotopes. ($^{48}Ca$ in $CaMO_4$ crystal)
- Bulk contamination due to cosmogenic activation.
- Neutron, muon and gamma flux from Lab environment.

We need:
•Contamination levels for CaMO4 and surrounding Copper, Lead.
•Crystal size.
•Surface contamination density profile (~1 μm).
•Detector assembly structure.
•Other geometric information.

For example:

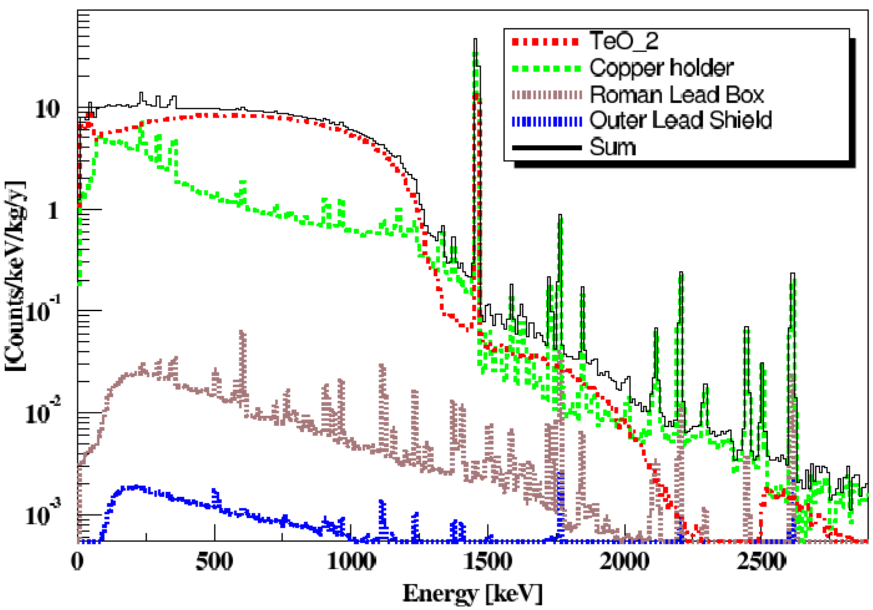
| **Contaminant (ppt)** | **$^{232}Th$** | **$^{238}U$** | **$^{40}K$** |
|---|---|---|---|
| $CaMO_4$ | 0.5 | 0.1 | 1 |
| Copper | 4 | 2 | 1 |

It can be done in GEANT4.
S.Myung has experience in it.

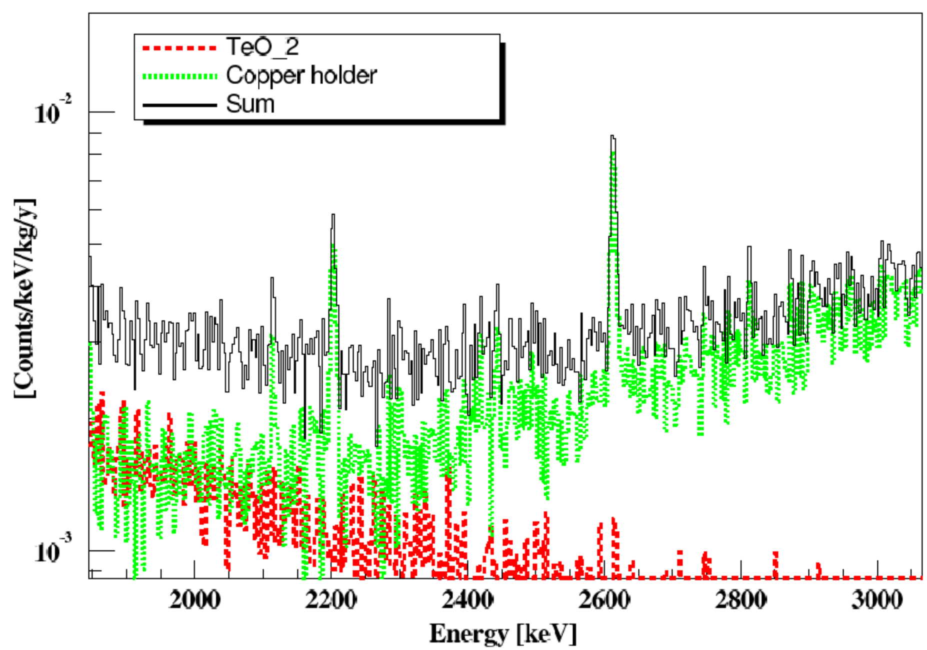
# Example simulation results (CUORE)

**Anti-coincidence spectrum**

Bulk contamination




Surface contamination
(Assuming 20 times reduction from CUORICINO by using low-radioactive polishing powder for crystal, and low contaminated liquids for copper surface treatment.)

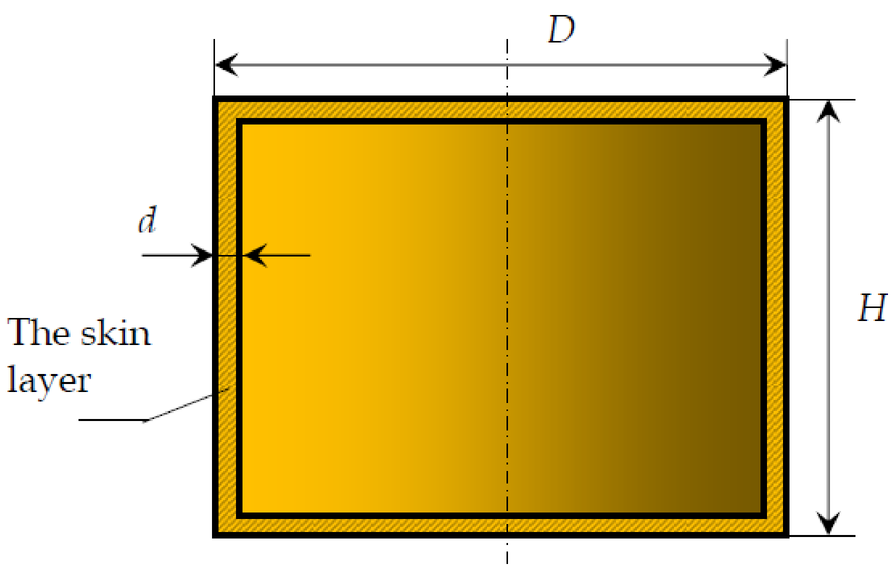


# Energy absorption efficiency for signal

V.V. Kobychev has simulated absorption efficiency the with GEANT.

His study shows that the efficiency does not depend much on all reasonable sizes: Efficiency rages within 5% around $\varepsilon = 84\%$.

Also, by introducing a concept of skin layer:




The in-efficiency $p_L$ can be parameterized as with a constant skin layer depth d=2.0mm and k=0.0339:

Skin layer volume

$$p_L = k\left(\frac{\delta V}{V}\right)^{0.62}$$

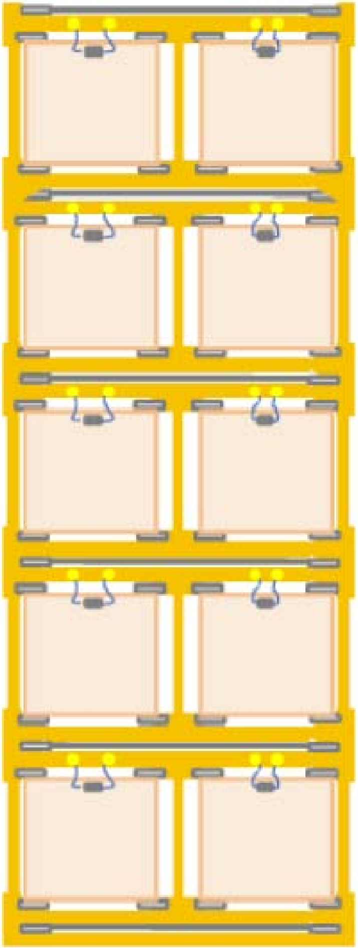
Total volume

# aMore Detector Structure

We can choose any detector array structure.
Some considerations:

- ❑Optimize crystal size.
- ❑Assemble in basic modules.
- ❑Both sides of the light detector to detect light signal.
- ❑Minimize the mass of the frame.
- ❑Use PTFE or TEFLON stand-offs.

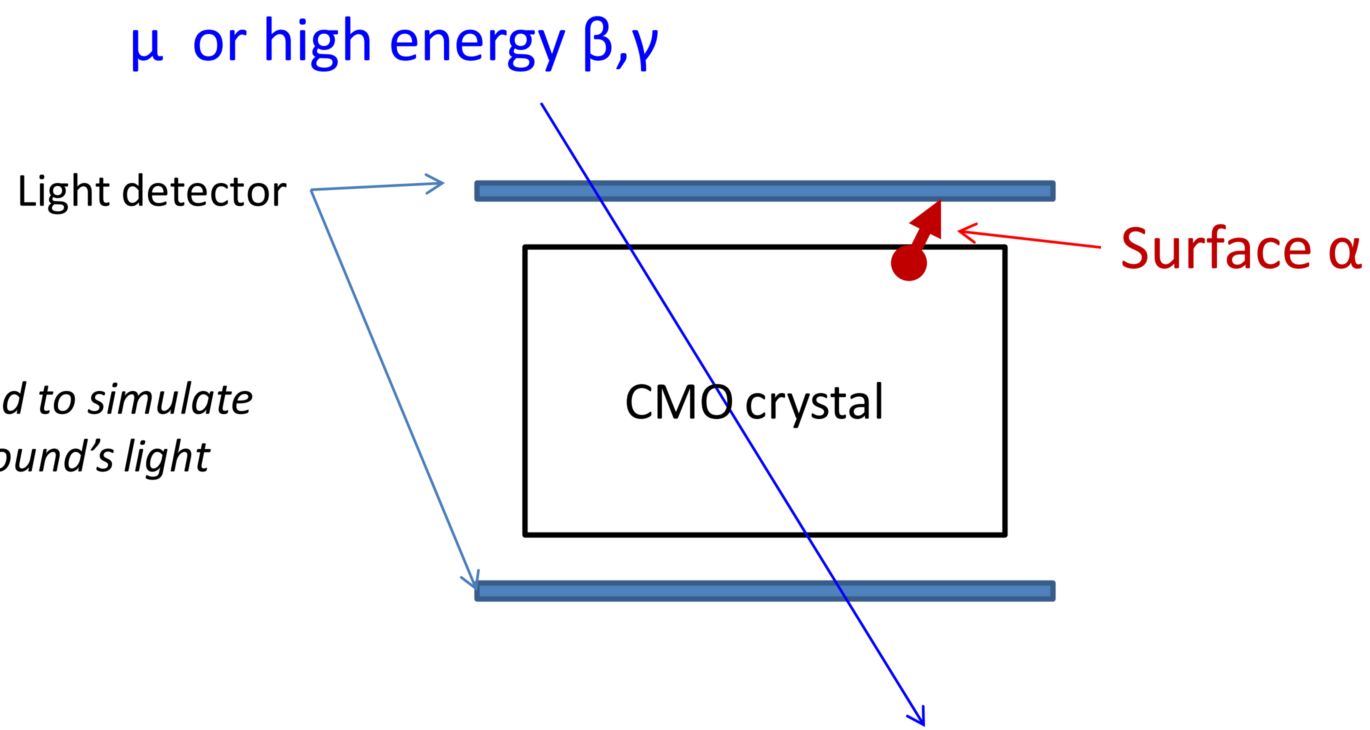
**LUCIFER structure**



# Simulation about the Light signal

Light detection efficiency can also be simulated.

- Light signal spectrum affects the alpha rejection efficiency.
- Alpha, muon, β,γ ,, may hit the light detector directly.
- **Triple-hit** coincidence may reduce the direct-hit background.
- Also, the light transport inside the crystal.




*We need to simulate background's light signal.*

$L_Q + L_{Pl}$

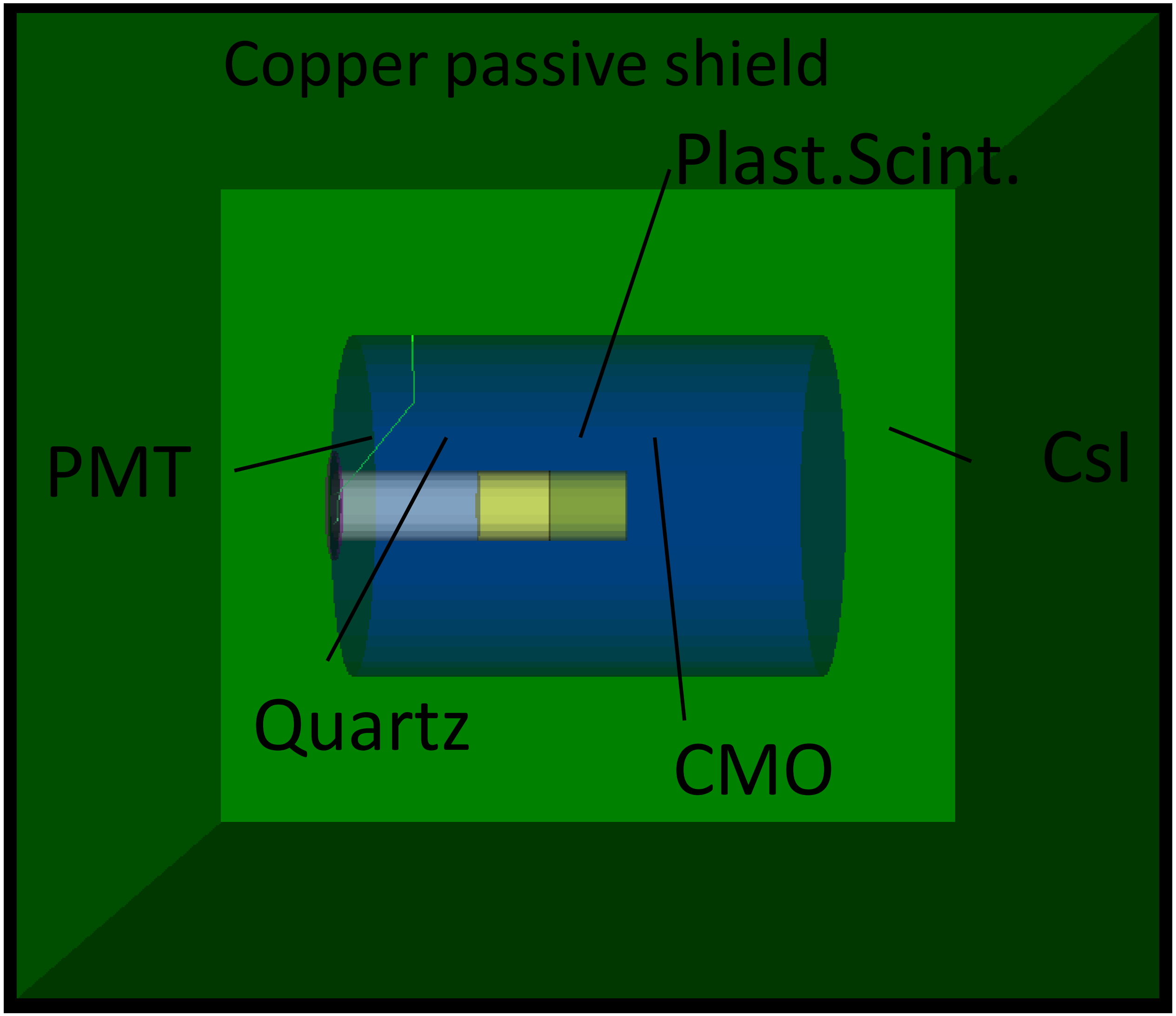
20 = 20+0
20 = 15+5
20 = 10+10
20 = 5 +15
20 = 0 +20

15 = 15+0
15 = 10+5
15 = 5 +10
15 = 0 +15

10 = 10+0
10 = 5 +5
10 = 0 +10

[cm]

**V. Kobychev's BG simulation**




CMO: o5.0x5.4 cm; LG o5.0 cm; CsI layer thickness is 9.5 cm

# Summary

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