

Test stand MC simulation

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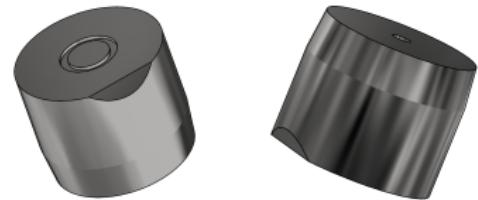
LEGEND



IC160A detector and FCCD

IC160A detector shows:

- **cut** on the bottom;
- **tapered** shape on the top.



In addition to the fully active volume (FAV), around the surface there are:

- **dead layer** = zero charge collection;
- **transition layer** = partial charge collection.

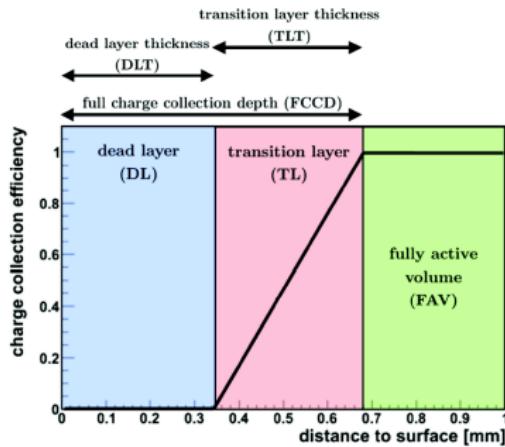


Figura 1: Figure from B. Lehnert's PhD thesis

Database structure for g4simple

```
https://github.com/legend-exp/legend-g4simple-simulation
/lfs/l1/legend/detector_char/enr/hades/simulations/legend-g4simple-simulation

|- README
|- IC-legend/
  |- general_geometry/
    |- all "define" xml files and "children" gdml files
  |- IC160A/
    |- Am241/
      |- collimated/
        |- side/
          |- all raw root file
        |- geometry/
          |- link to the required children files and define files
          |- mother gdml file
      |- macro/
        |- all macro files
        |- qsub file
        |- run.sh
        |- log/
          |- output files
      |- top/
      |- uncollimated/
        |- Th228/
  |- IC160B/
  |- IC162B/
  |- IC166B/
  |- IC-gerda/
    |- general_geometry/
    |- IC48A/
    |- IC48B/
    |- IC50A/
    |- IC50B/
    |- IC74A/
```

Example of gdml file

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE gdml [
<!ENTITY define_detector SYSTEM "define_detector.xml"
]>
<gdml xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://service-spi.web.cern.ch/service-spi/app/releases/GDML/schema/gdml.xsd">

<define>
    &define_detector;

    <quantity name="Alcap_z" type="length" value="Alcap_height" unit="mm"/>
    <quantity name="Alcap_radius" type="length" value="Alcap_width/2" unit="mm"/>

    <quantity name="Alcap_cavity_radius" type="length" value="(Alcap_width-2*Alcap_thickness)/2" unit="mm"/>

    <quantity name="start_cavity_z" type="length" value="position_Alcap_cavity_fromTop" unit="mm"/>
    <quantity name="end_cavity_z" type="length" value="(Alcap_height-position_Alcap_cavity_fromBottom)" unit="mm"/>

</define>

<materials/>

<solids>

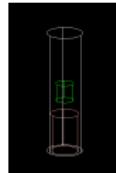
    <polycone name="Alcap" startphi="0" deltaphi="TWOPI" aunit="rad">
        <zplane rmin="0" rmax="Alcap_radius" z="0" />
        <zplane rmin="0" rmax="Alcap_radius" z="start_cavity_z" />
        <zplane rmin="Alcap_cavity_radius" rmax="Alcap_radius" z="start_cavity_z" />
        <zplane rmin="0" rmax="Alcap_radius" z="end_cavity_z" />
        <zplane rmin="0" rmax="Alcap_radius" z="Alcap_z" />
    </polycone>
</solids>

<structure>
    <volume name="AlCap">
        <materialref ref="G4_Al"/>
        <solidref ref="Alcap"/>
    </volume>
</structure>

<setup name="Default" version="1.0">
    <world ref="AlCap"/>
</setup>

</gdml>
```

Visualization of HADES setup



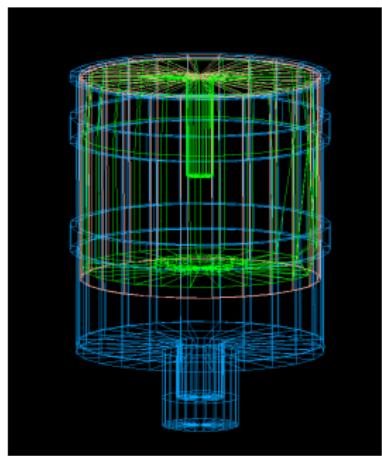
Inside the lead castle:

germanium **detector**

- teflon wrap
- aluminium holder
- aluminium cryostat

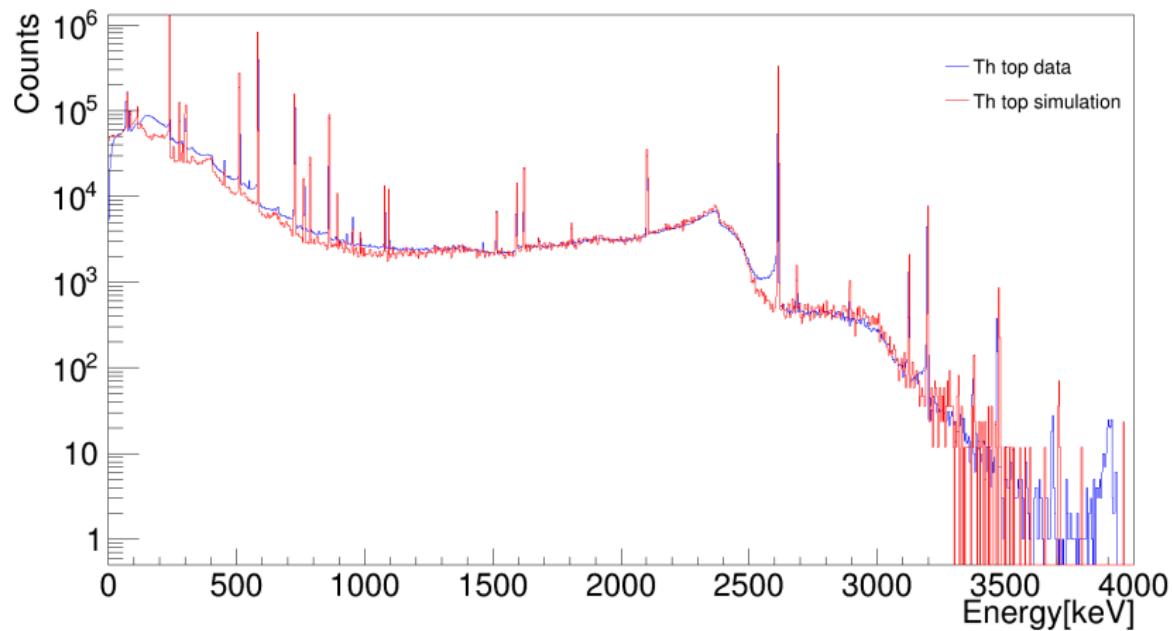
silicon dioxide **source**

- stainless steel capsule
- epoxy window (Th source)
- (Cu collimator)



Energy spectrum - ^{228}Th top

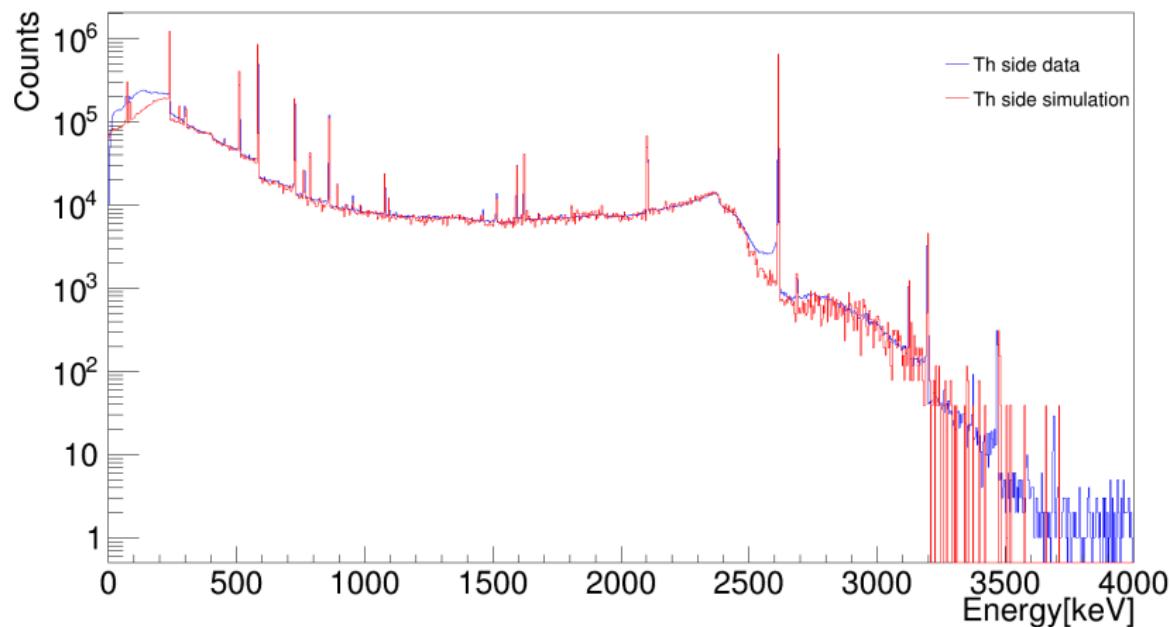
Uncollimated Thorium at the top - source at 4.2 cm over the cryostat.
Between the source and the detector there is the **cryostat** (Aluminium).



Energy spectrum - ^{228}Th side

Collimated Thorium at the side - Copper collimator.

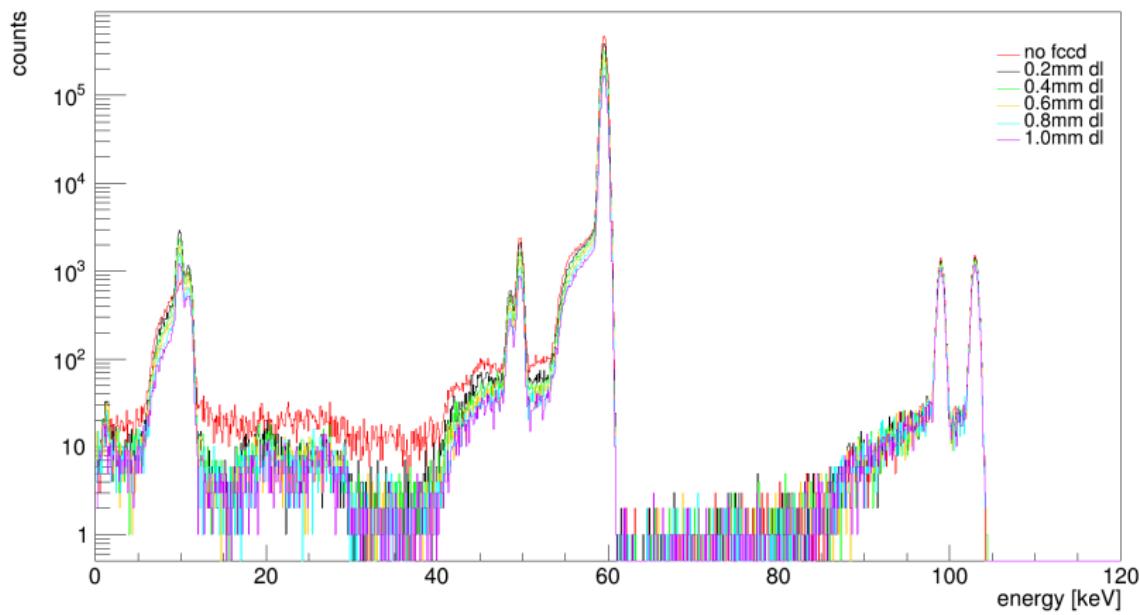
Between the source and the detector there are **cryostat** (Aluminium), wrap (Teflon) and **holder** (Aluminium).



Energy spectrum - ^{241}Am Top - dead layer

Collimated americium at the top - source at 2.9 cm over the cryostat - Copper collimator.

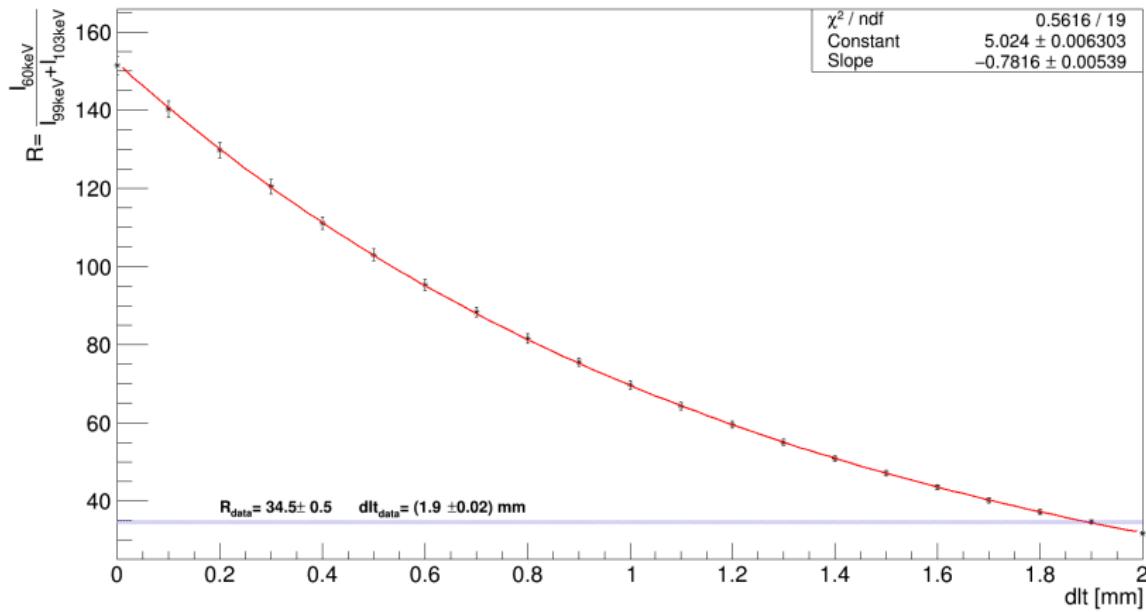
The source is not centered on the cavity of the detector.



^{241}Am Top - peak ratios vs dead layer

The peak ratio $R = \frac{I_{60\text{keV}}}{I_{99\text{keV}} + I_{103\text{keV}}}$ is shown as a function of dead layer thickness (dlt).

The computed dead layer for data is not equal to what expected (~ 1.0 mm).



What's next?

The geometries of the setup for Inverted Coaxial detectors are ready for g4simple.

g4simple gave several unsolved problems with simulation and analysis.

What's next?

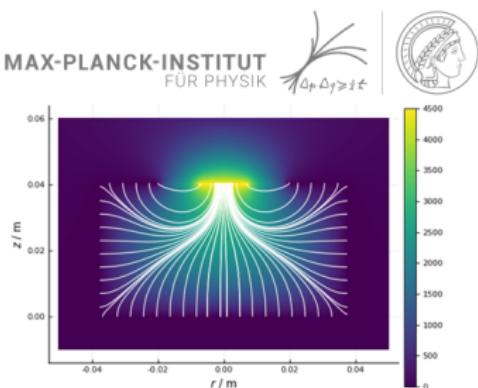
- simulation in MaGe;
- complete ^{241}Am analysis for dead layer;
- ^{133}Ba analysis for dead layer.

Simulation software SSD



Contribution from **Lukas Hauertmann**

- Arbitrary (segmented) detector geometry (CSG – Geant4 like) including surroundings, like holding structures, cryostats or even multiple detectors (LEGEND detector strings)
- 2D & 3D: Cylindrical or Cartesian Coordinates
- Fast: Multi-threaded and SIMD-accelerated
- Arbitrary impurity density profiles, depletion handling
- Capacitance calculation
- Arbitrary charge drift models including temperature and impurity density dependency, defaults provided (e.g. ADL/Bruyneel)
- Arbitrary surface charges and surface drift modulation
- Modular and Open Source: GitHub (PR's are welcome)
- Automatic package testing including comparison to analytical solutions
- Geant4-Simple interface, support SigGen config files



Work in Progress:

- GPU support
- Geometry import from STL-Files
- Further performance improvements
- Extend documentation and examples



<https://github.com/JuliaPhysics/SolidStateDetectors.jl>