Preliminary Simulations of the XLZD Outer Detector

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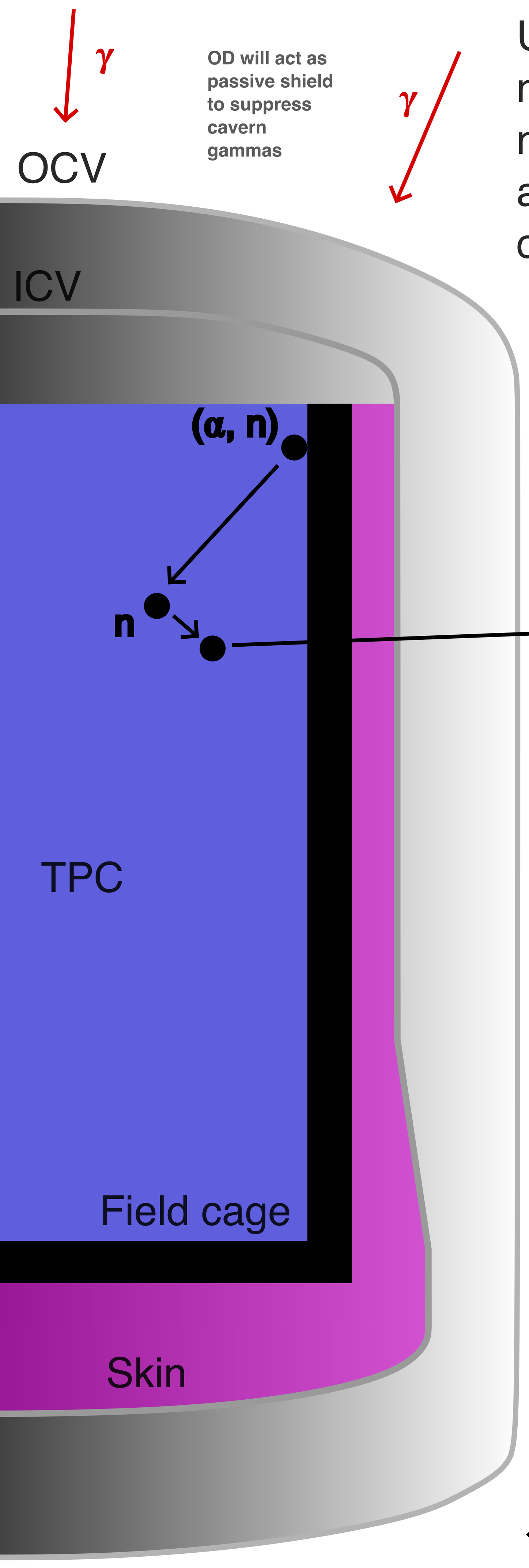
The Outer Detector and Background Paradigm

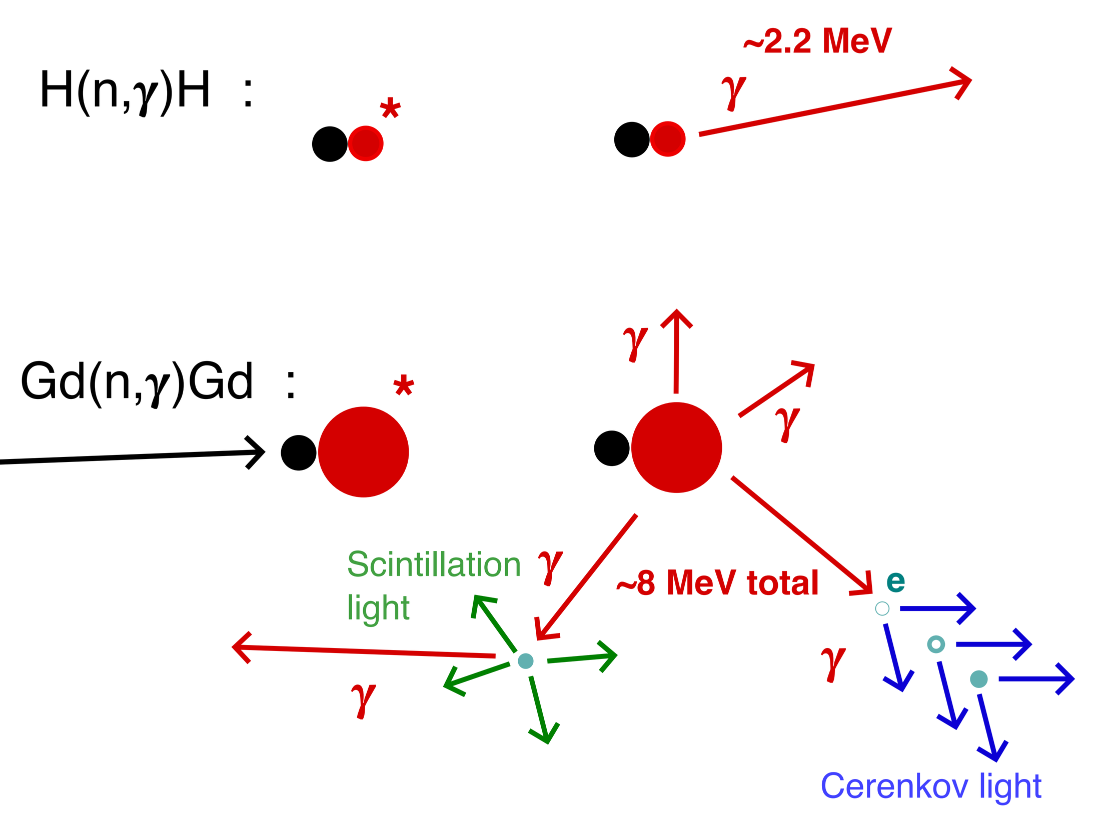
Possibly with internal containment

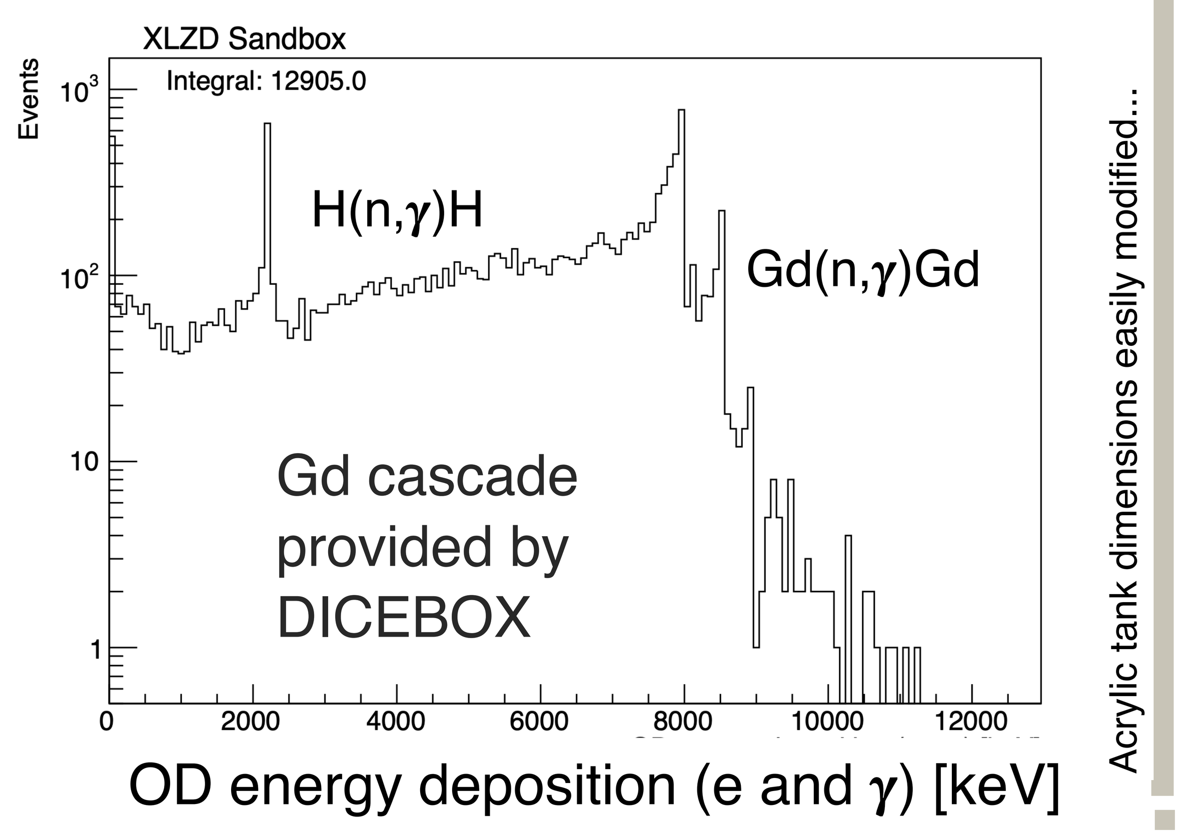
XLZD will be a low-background observatory. **Neutron** backgrounds are mitigated through optimal material selection, multiple scatters and **veto systems.** The outer detector is one such system. It completely surrounds the cryostat, and could consist of either **Gd-Water**, **Gd-WbLS** or **Gd-LS**.

Neutrons scatter elastically off nuclei, producing WIMP-like NR signals in the LXe-TPC

Unlike **WIMPs**, neutrons often scatter multiple times, but a single scatter neutron would be indistinguishable from a **WIMP**. To veto these, captures in the outer detector on Gd or H are desired:







To maximise neutron veto efficiency - acrylic tank should span ~1m from cryostat

The XLZD Sandbox

Geant4 sandbox has been developed to easily simulate different detector geometries in Geant4 - goal of maximising physics potential of the OD.

Low number of dependencies: namely Geant4, Boost and ROOT.

Geometry is defined via inputted JSON file

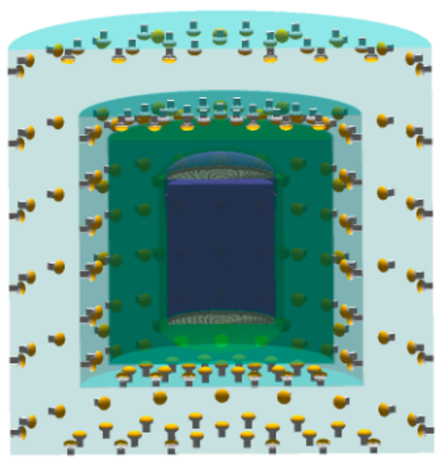
Most dimensions in the detector can be modified via inputted JSON.

Several examples include:

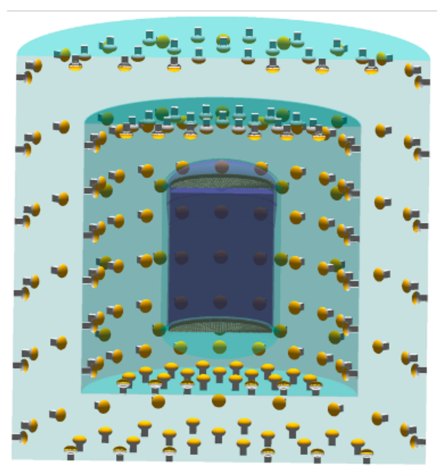
- Type of PMT
- Number and location of PMTs
- Size of vessels
- Acrylic tank
- OD Medium
- Gd concentration

OD LZ simulation PMTs implemented

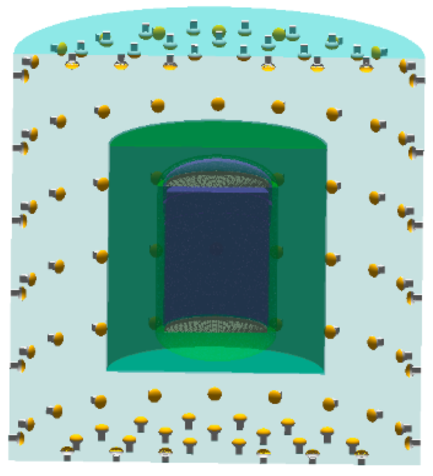
R5912



Neutron veto, muon veto and acrylic tank



Neutron veto and muon veto



Gd Scintillator tank only

With XENONnT Style placement

Physics inputs

Inbuilt into the simulation is the ability to freely switch between OD media. The Gd concentration can also be modified. G4Cerenkov class handled the Cerenkov process. A modified G4Scintillation class taken from BACCARAT is used to handle the scintillation process.

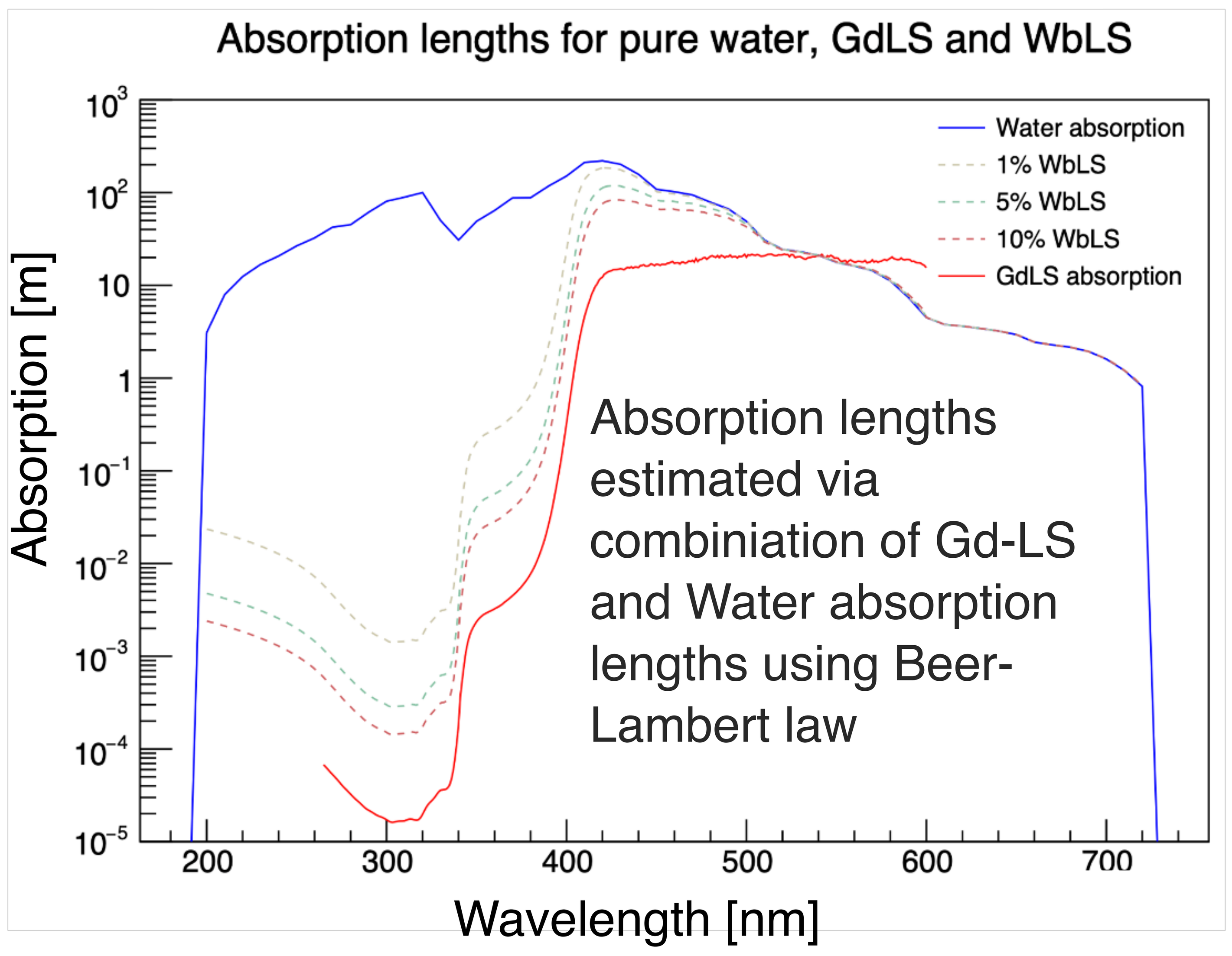
PMT QE applied

Tyvek reflectivity applied to walls (lambertian)

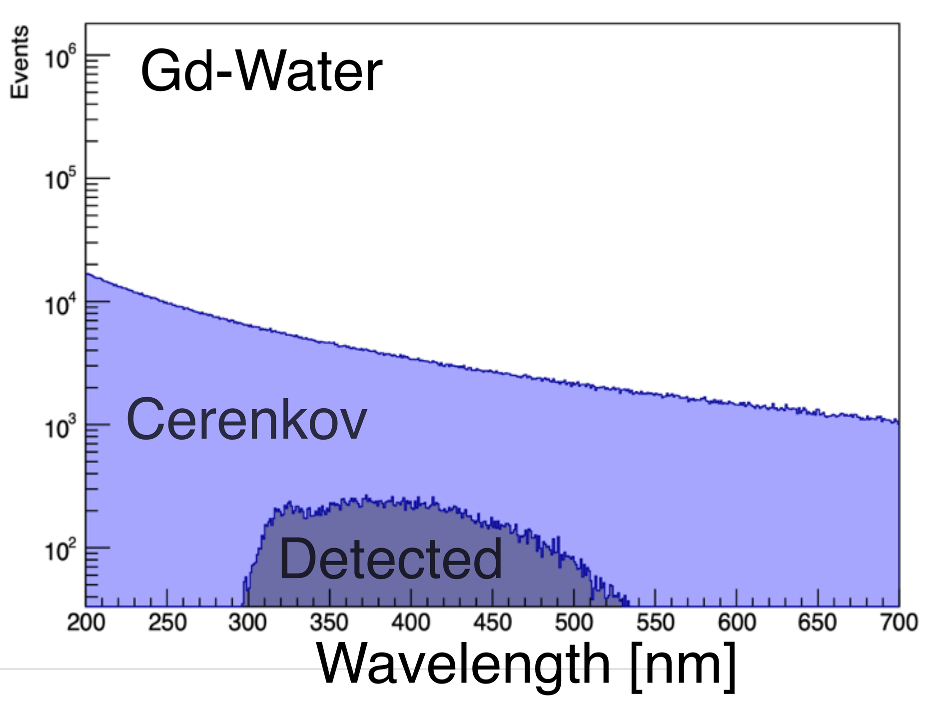
Scintillation properties of WbLS are taken from CHESS characterisation Eur. Phys. J. C 80, 867 (2020). 1% Gd-WbLS light yield taken to be around 100 photons/MeV. Gd-LS properties are taken from tuned LZ simulations.

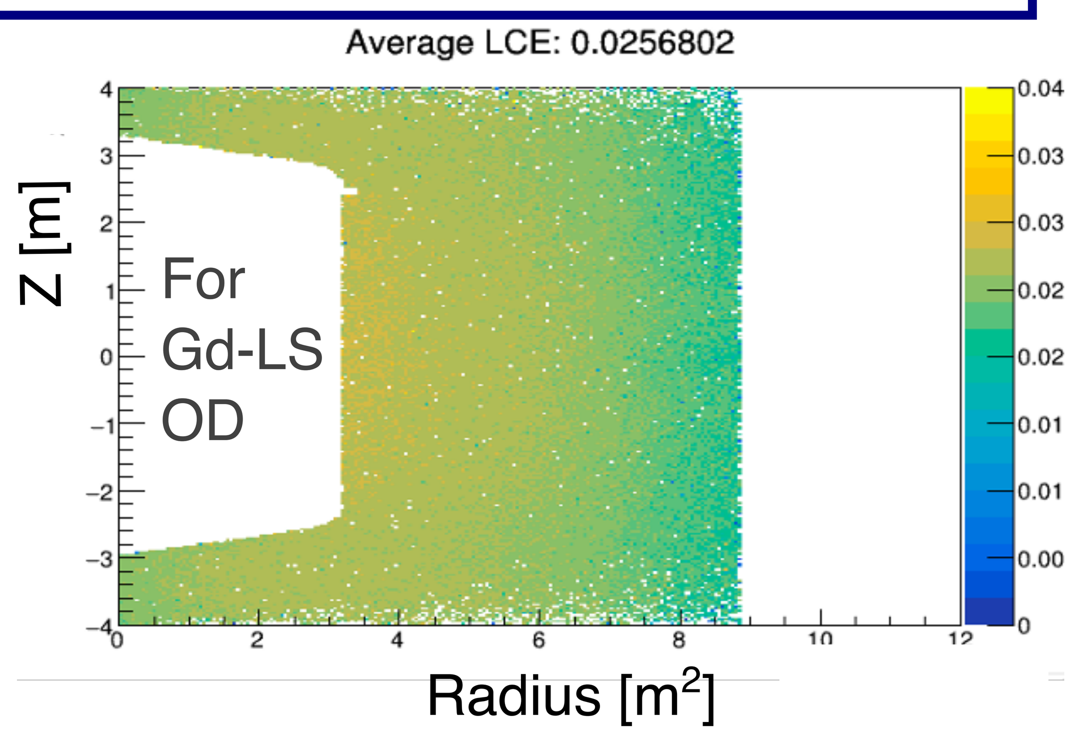
Numbers include Cerenkov and Scintillation light

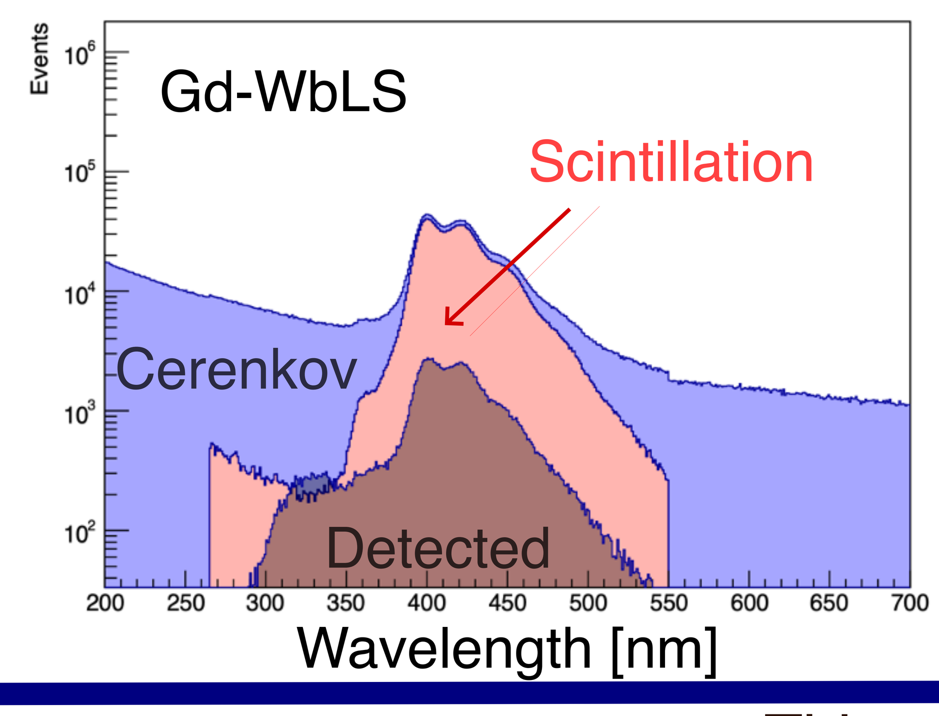
WbLS concentration	Light yield, photons/MeV	Fast time constant, ns	Slow time constant, ns
1%	234 ± 30	2.25 ± 0.15	15.10 ± 7.47
5%	770 ± 72	2.35 ± 0.13	23.21 ± 3.28
10%	1357 ± 125	2.70 ± 0.16	27.05 ± 4.20

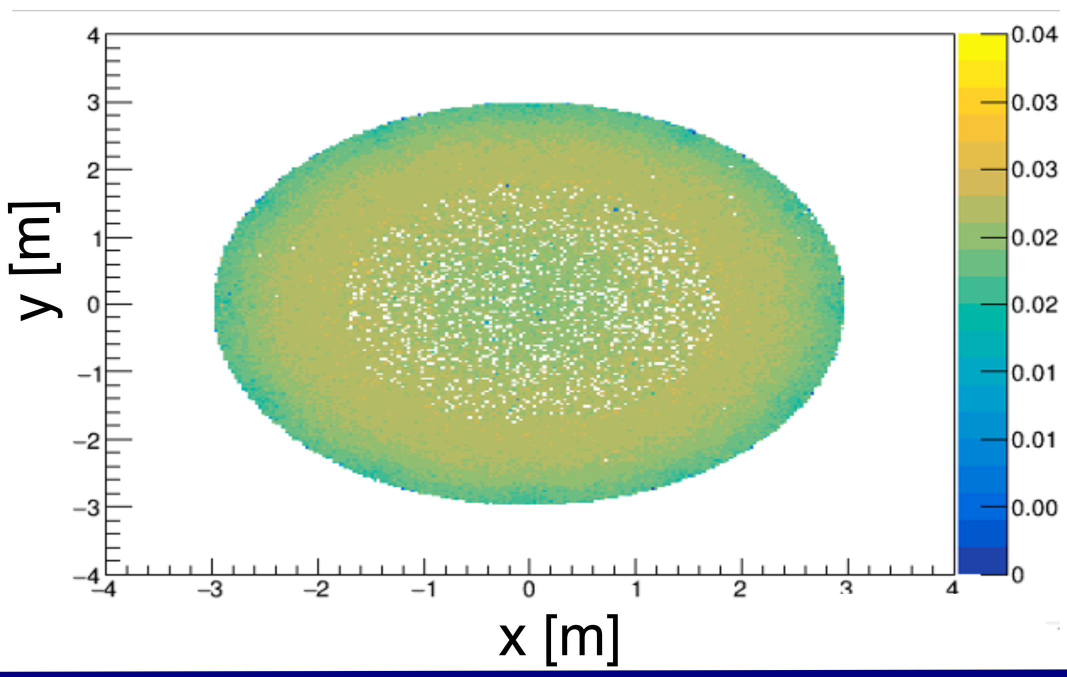


Light Collection Efficiency and Optics









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