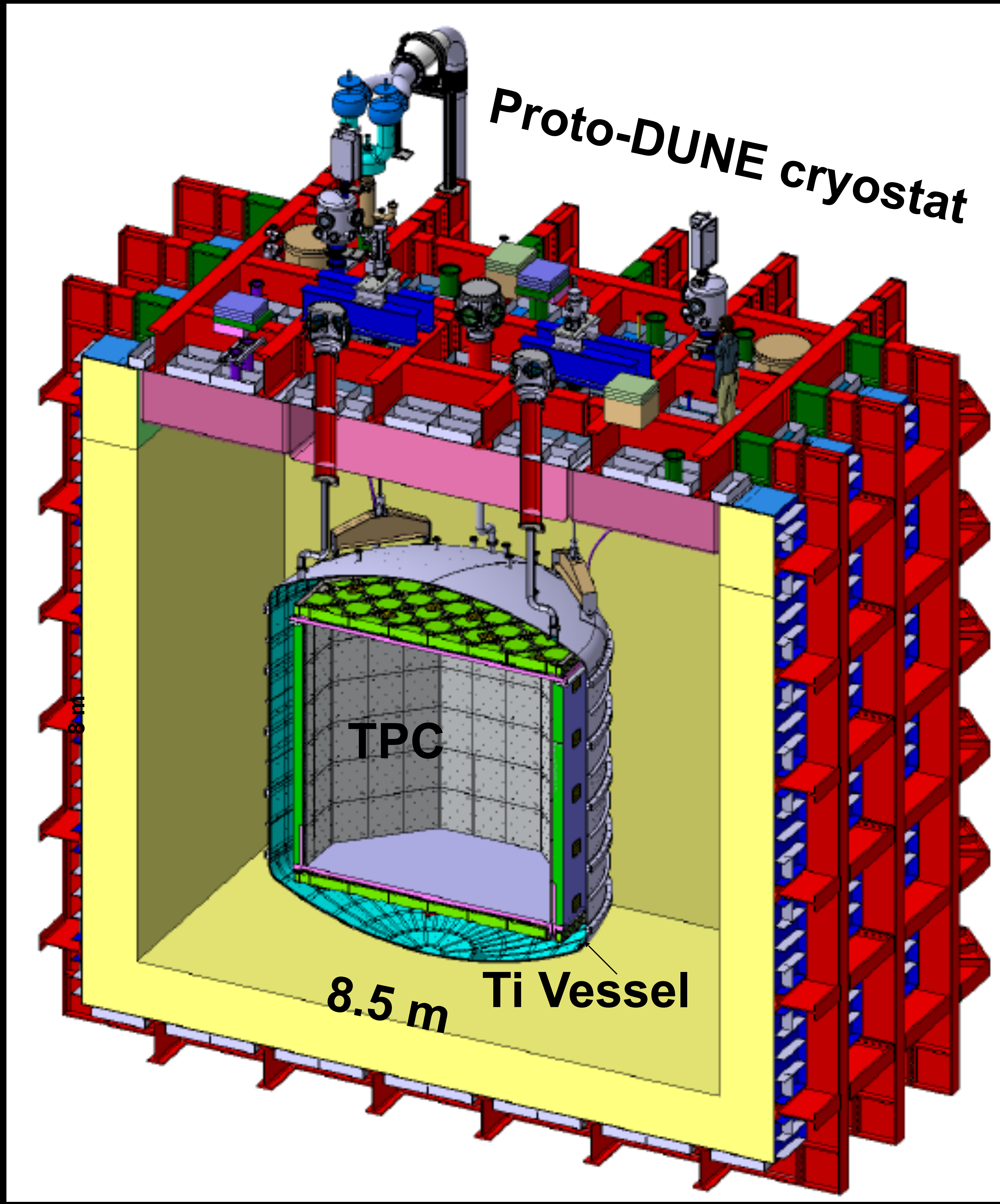

Simulation work : derive a strategy of calibration for DS20k's TPC

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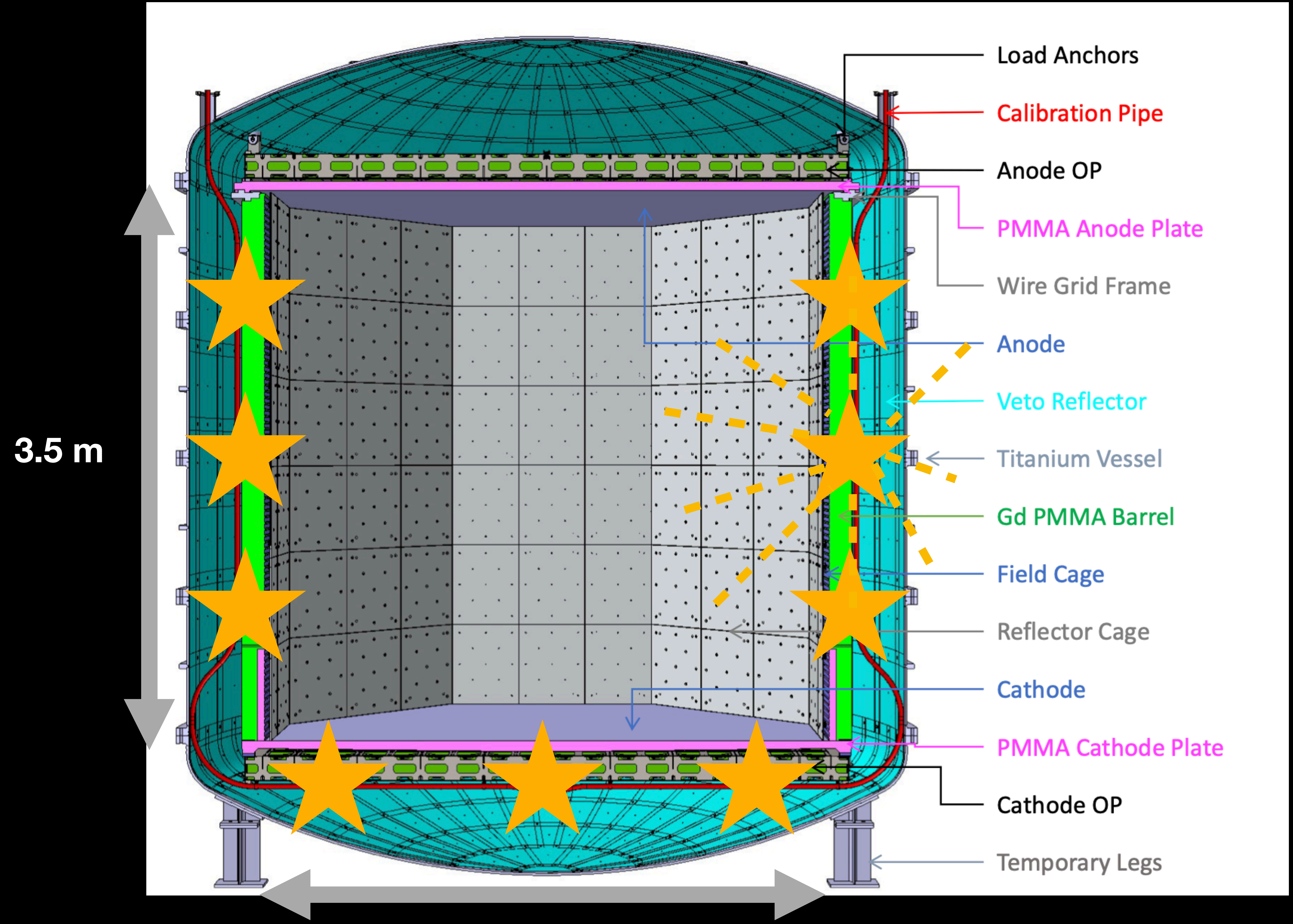
CPPM

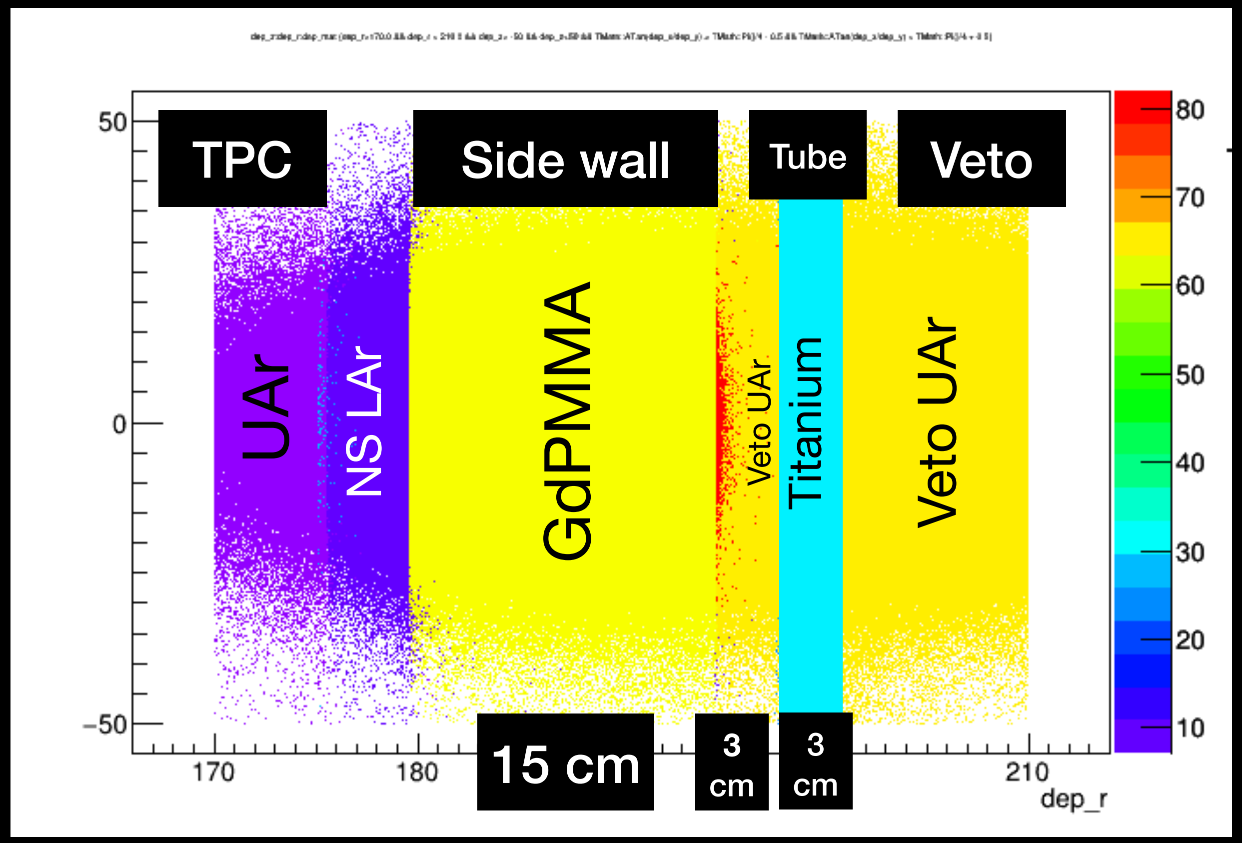
Main goal



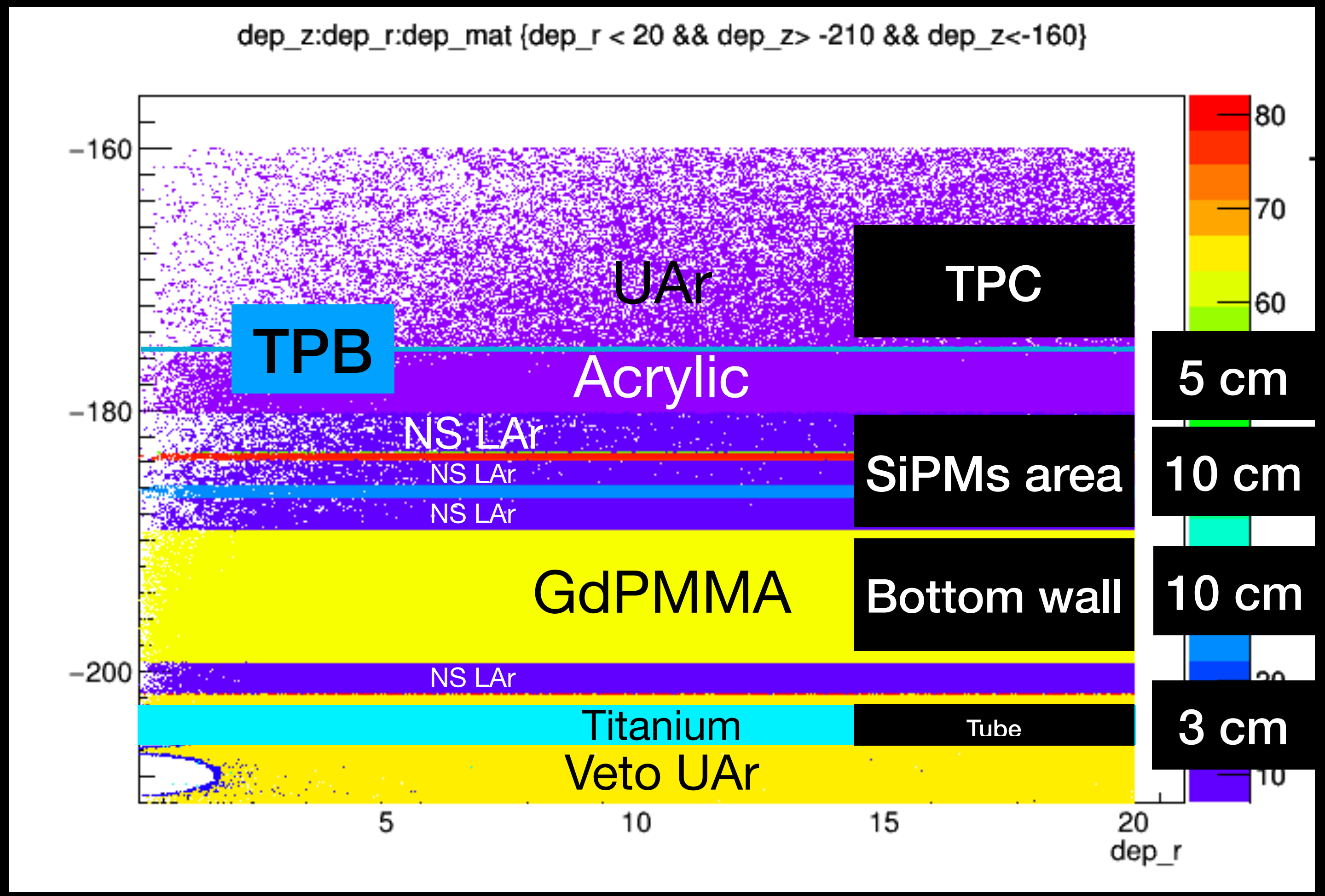
- Goal: position precisely (≈ cm precision level) photons and neutrons sources around the TPC -> *achievable precision will be checked thanks to the mockup*
- Photons and neutrons sources will be of different energy to calibrate the DS20k TPC response

Stakes coming with the guide tubes

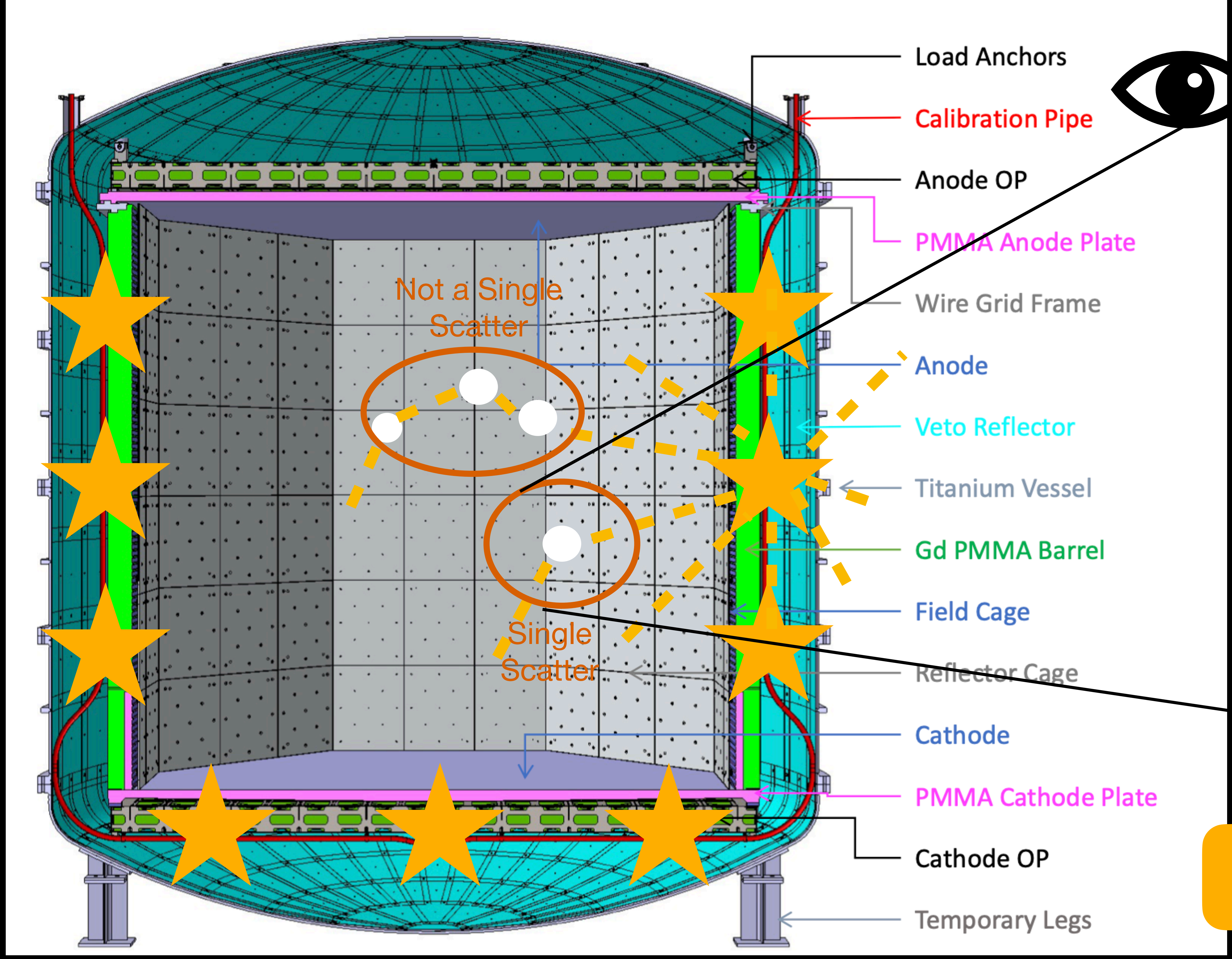
Side walls of the TPC and the tube



Bottom wall of the TPC and the tube

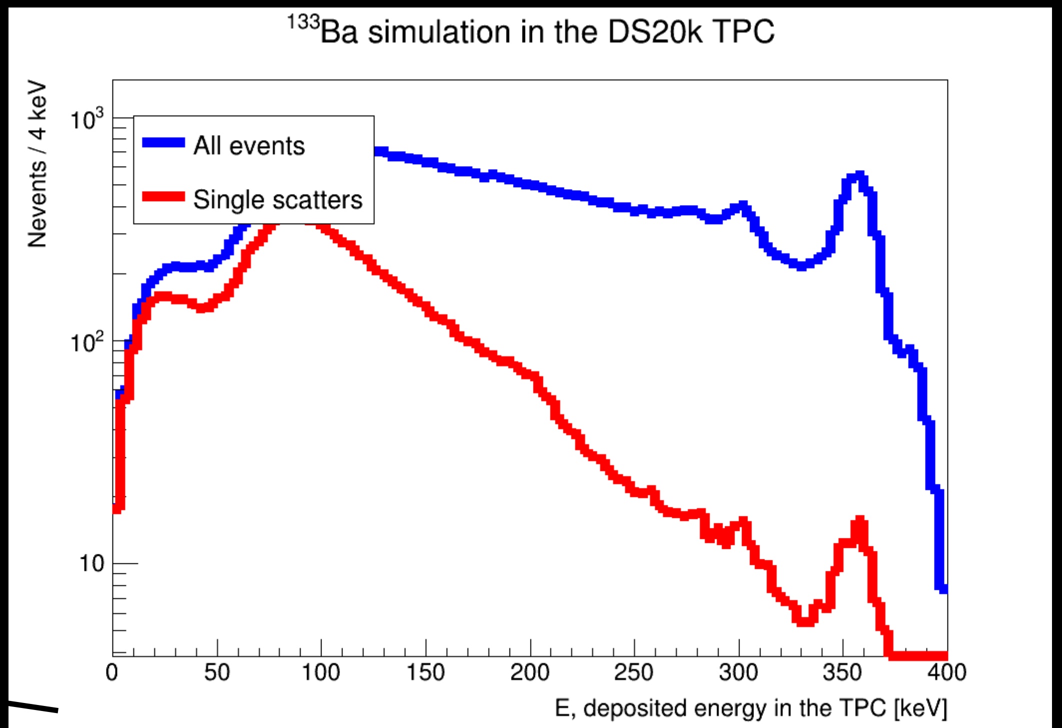


1 Make the TPC calibration as efficient as possible



Play with the hypothesis to reach an affordable time for the calibration runs

Find the best way to calibrate



2 Tubes dived inside the veto buffer

Impact (to minimize) on the light collection efficiency of the veto buffer

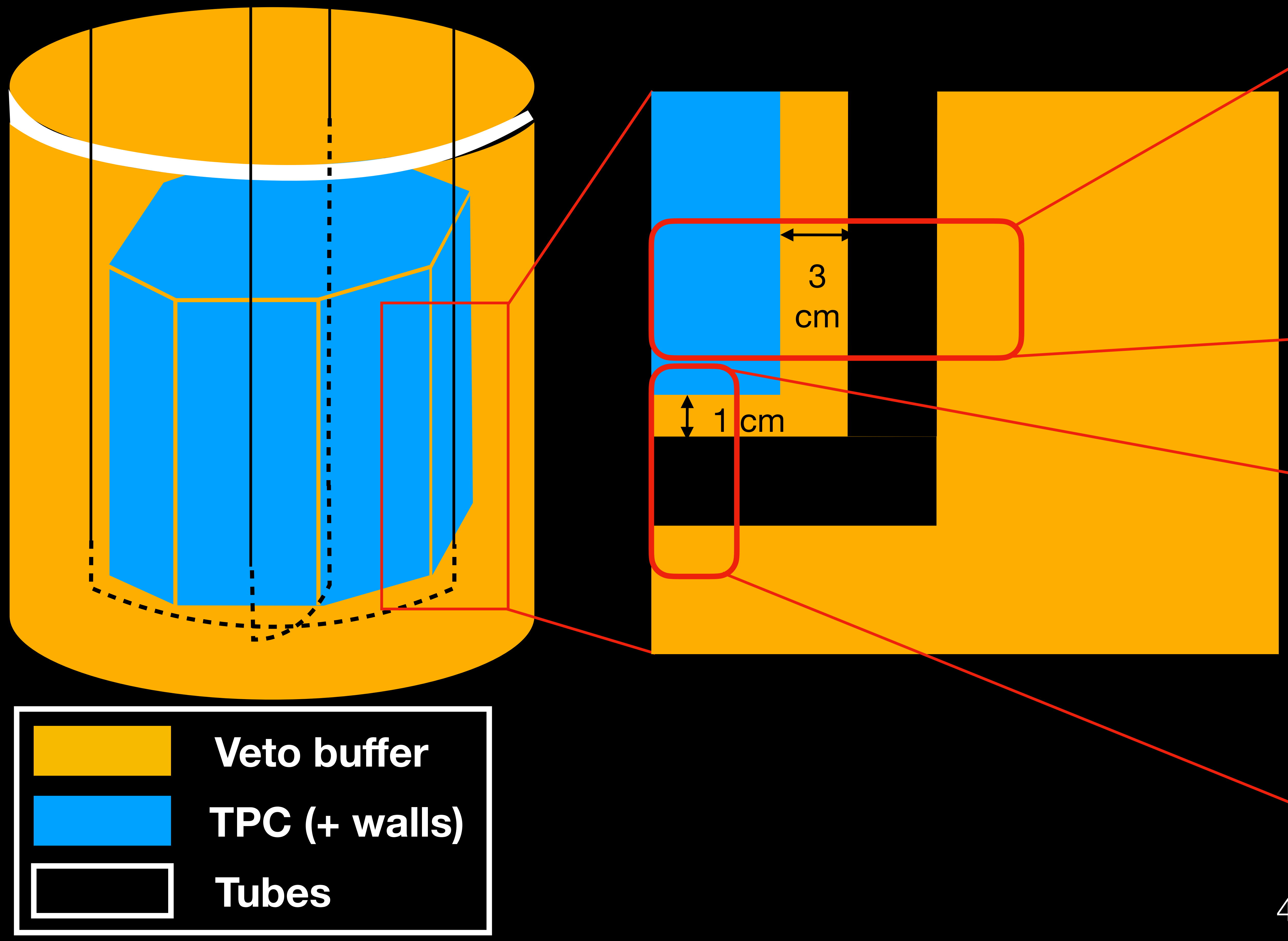
3 Tubes close to the TPC: background induced ?

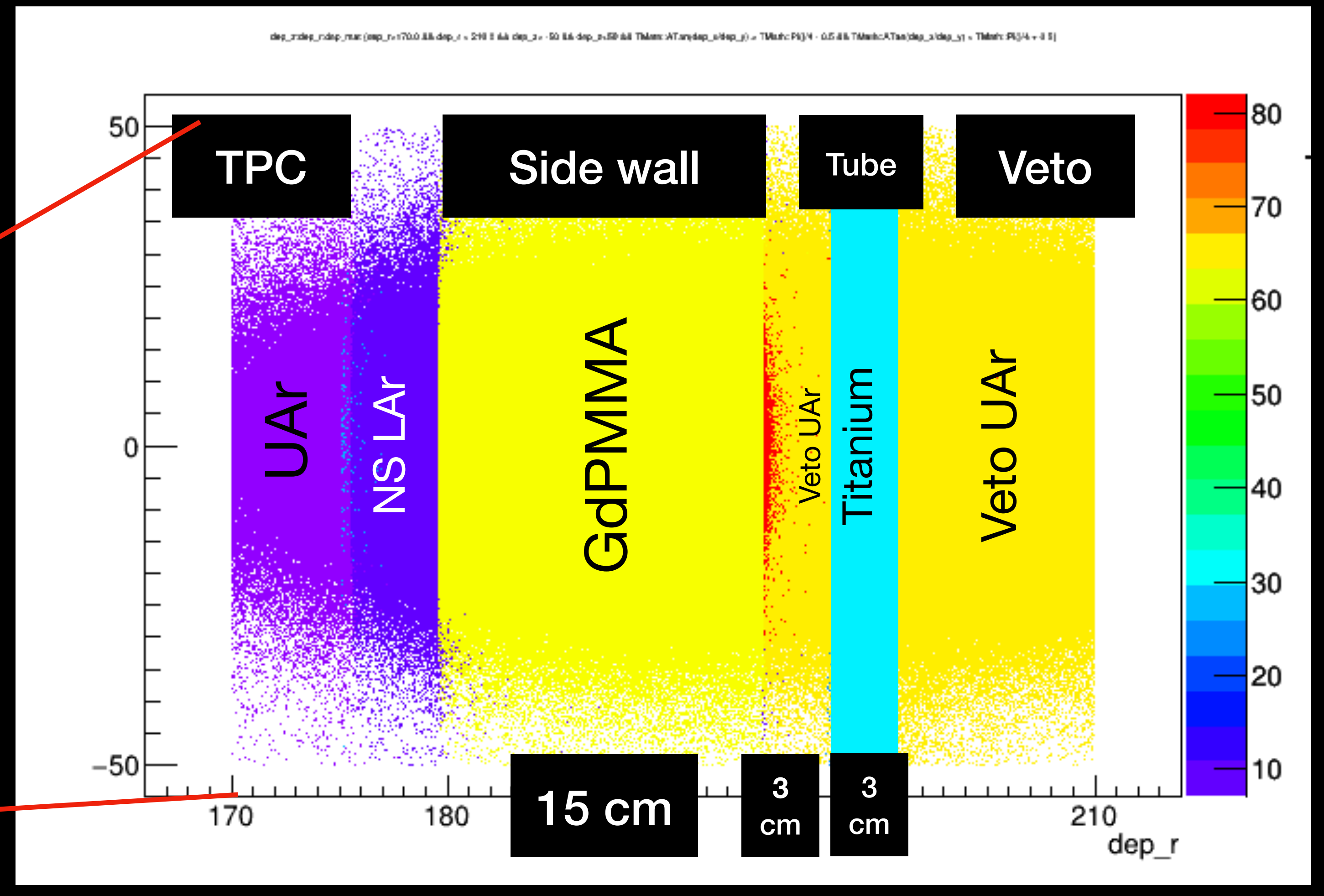
Fig from TDR

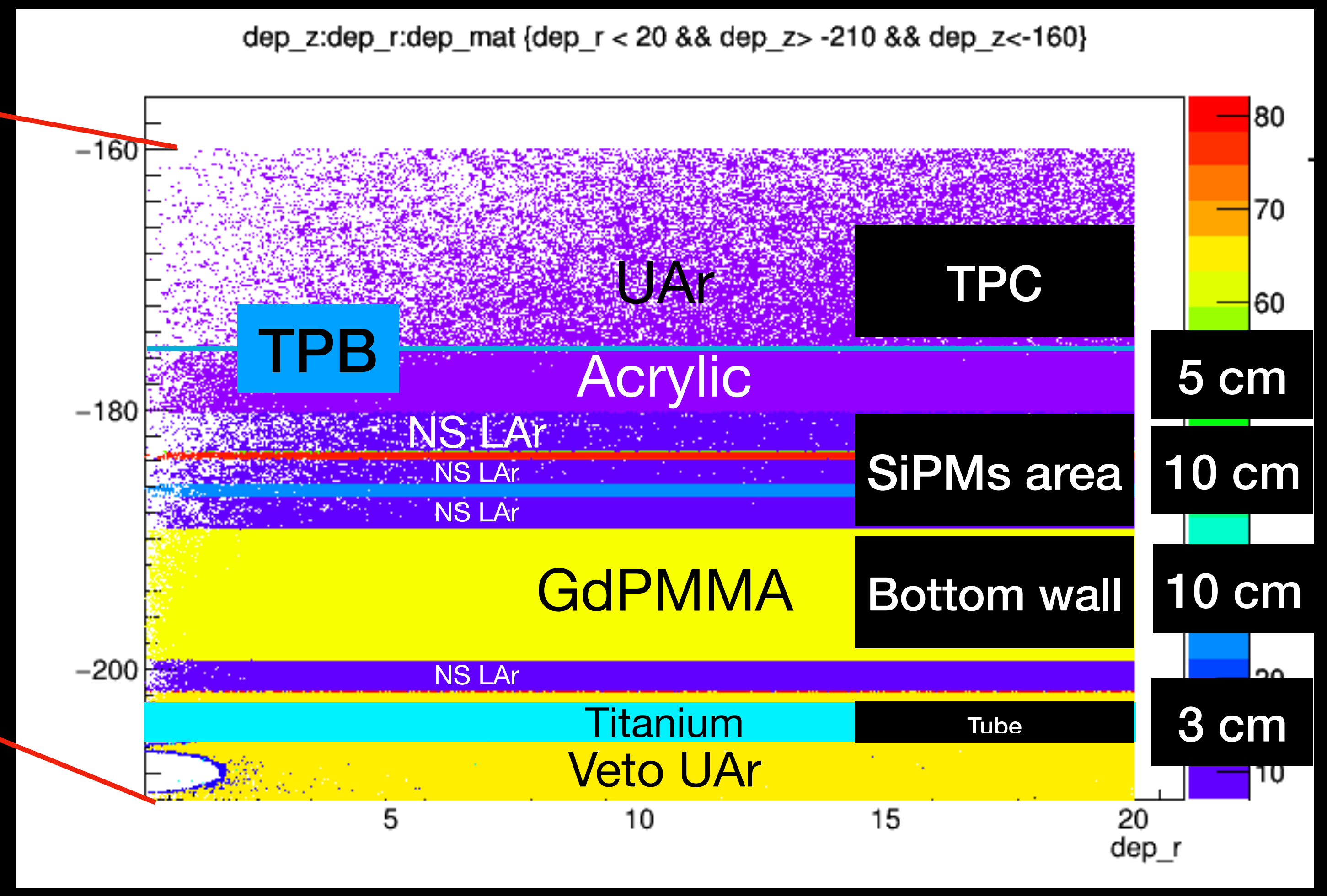
How much background is induced because of the tubes ? Is it negligible ?

The TPC calibration set up inside g4ds

- 2017: first DS20k design proposal
- 2019: new design of DS20k, complex veto, design called « plan A »
- Dec. 2021: **TDR froze the geometry of DS20k** -> redo all the simulations made for plan A

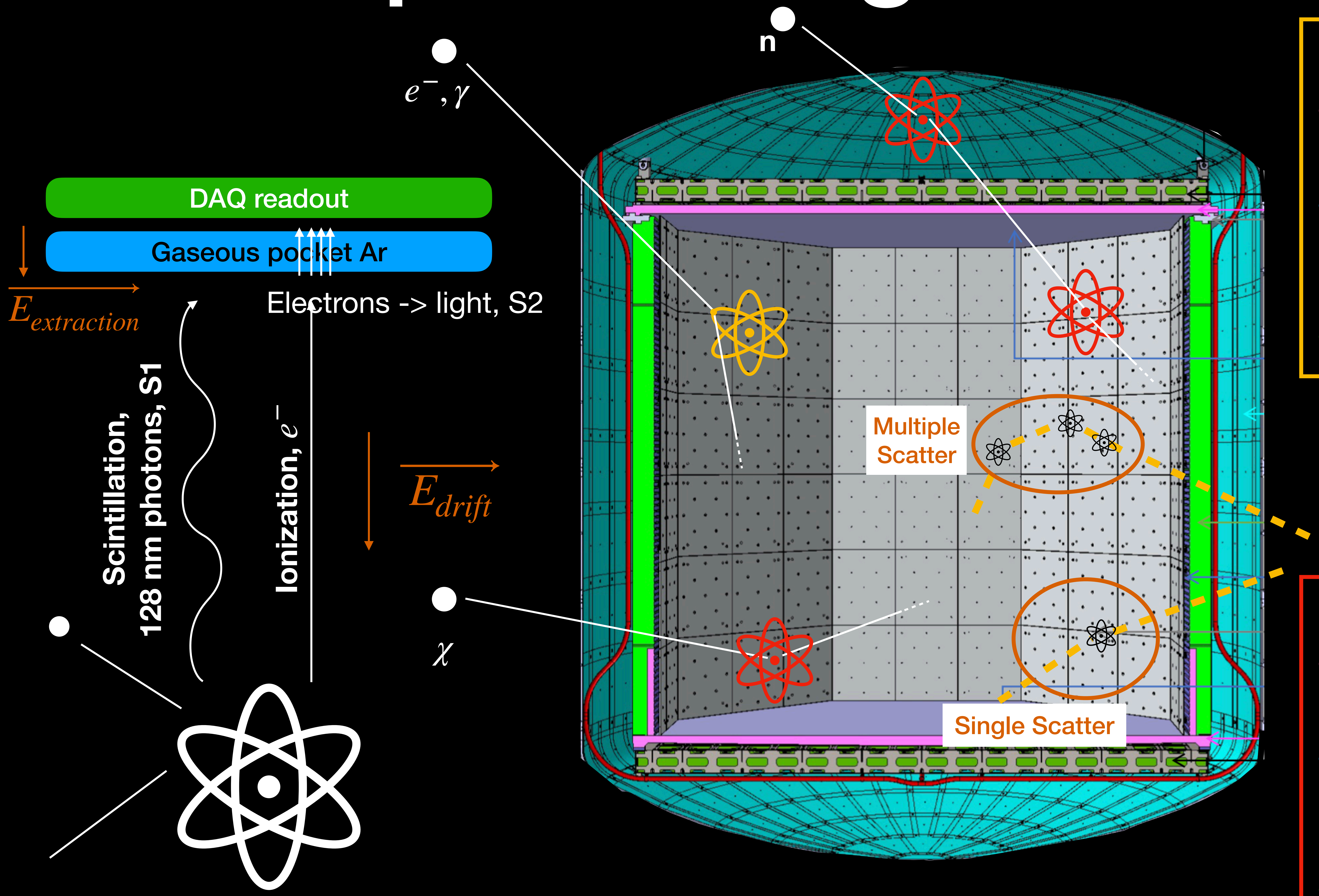






Geometry of the detector as it is implemented in g4ds, a GEANT4-based software applied for the DarkSide20k experiment

Expected signals in the TPC



ER signal

- Electronic recoil
- Comes from electrons and photons (residual background)
- Slow S1 / high yield of S2

LAr => very good separation between both

NR signal

- Nuclear recoil
- Comes from neutrons (residual background) and WIMPs (signal)
- Fast S1 / few S2

Simulation of the response to photon sources exposure (ER)

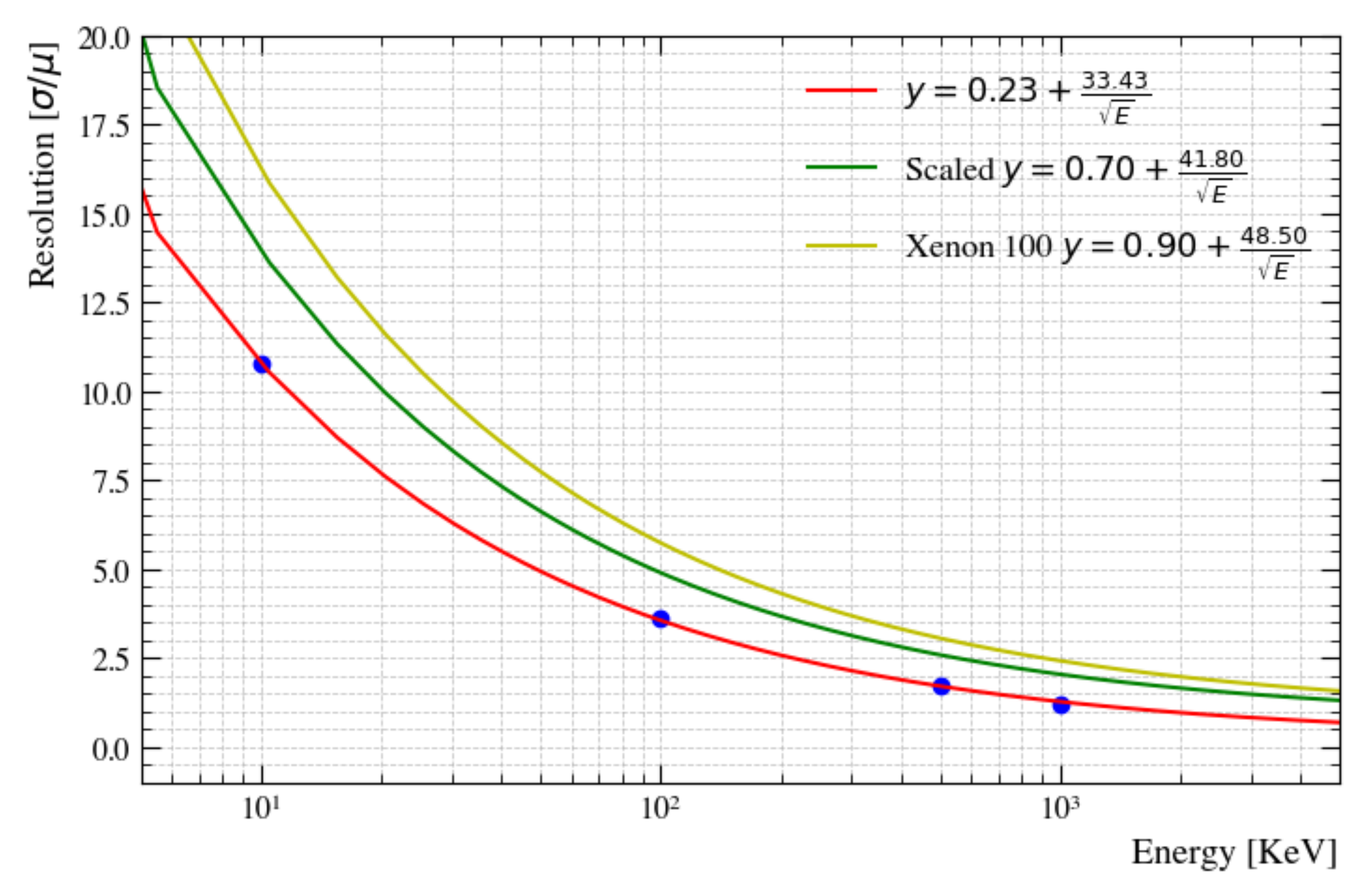
- ER : expected to be mainly background (photons, electrons)
- g4ds : Use of five monochromatic sources of photons: ^{57}Co, ^{133}Ba, ^{22}Na, ^{137}Cs, ^{60}Co

From 122 to 1173 keV

- Most important signal to reconstruct for the calibration: **pure ER single scatters**

WIMPs' signature

Takes all the physics of the detector into account



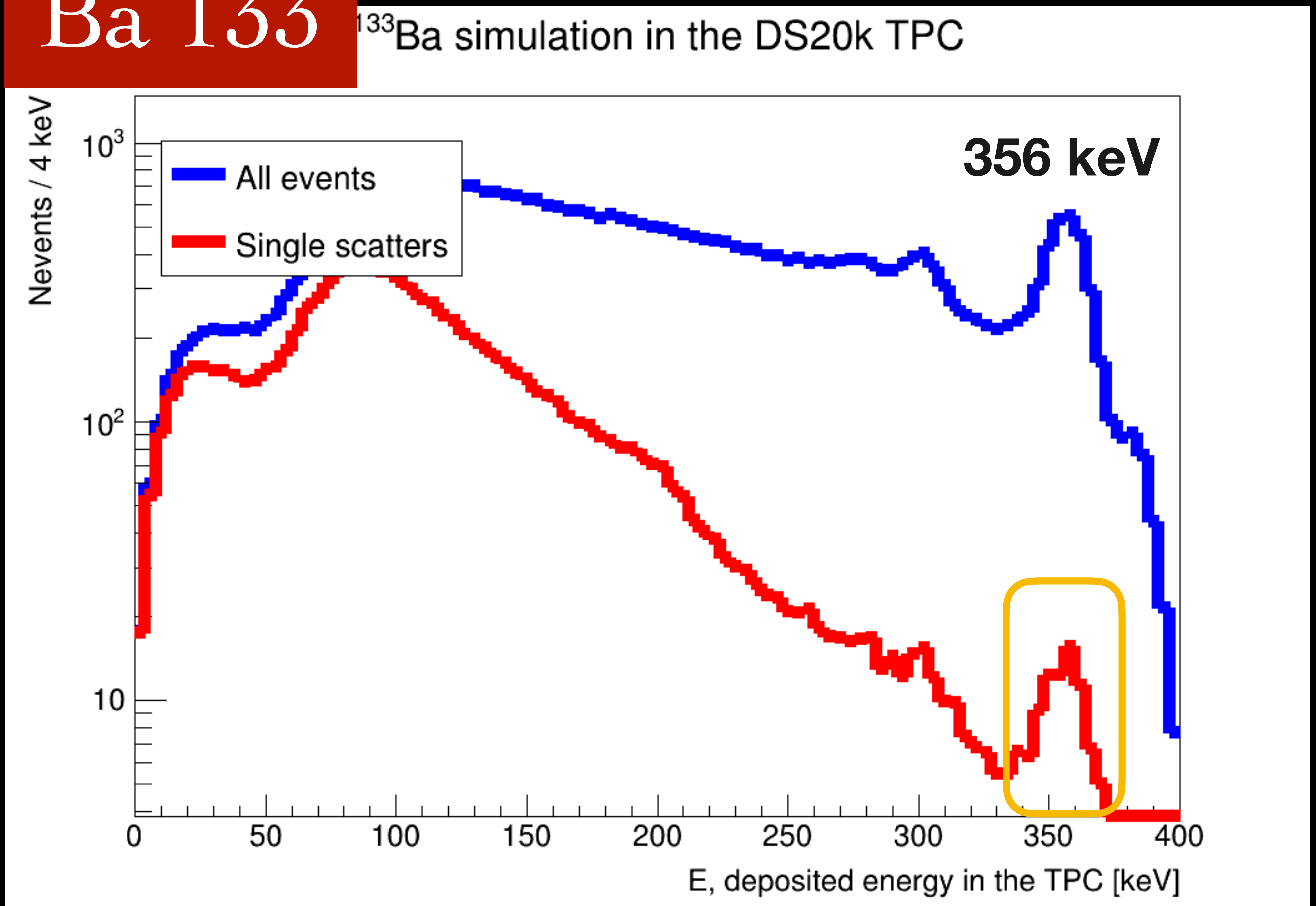
DS20k resolution = 0.0023 + 0.334/sqrt(E)

Spectrum normalized to 10 000 pure ER SS events

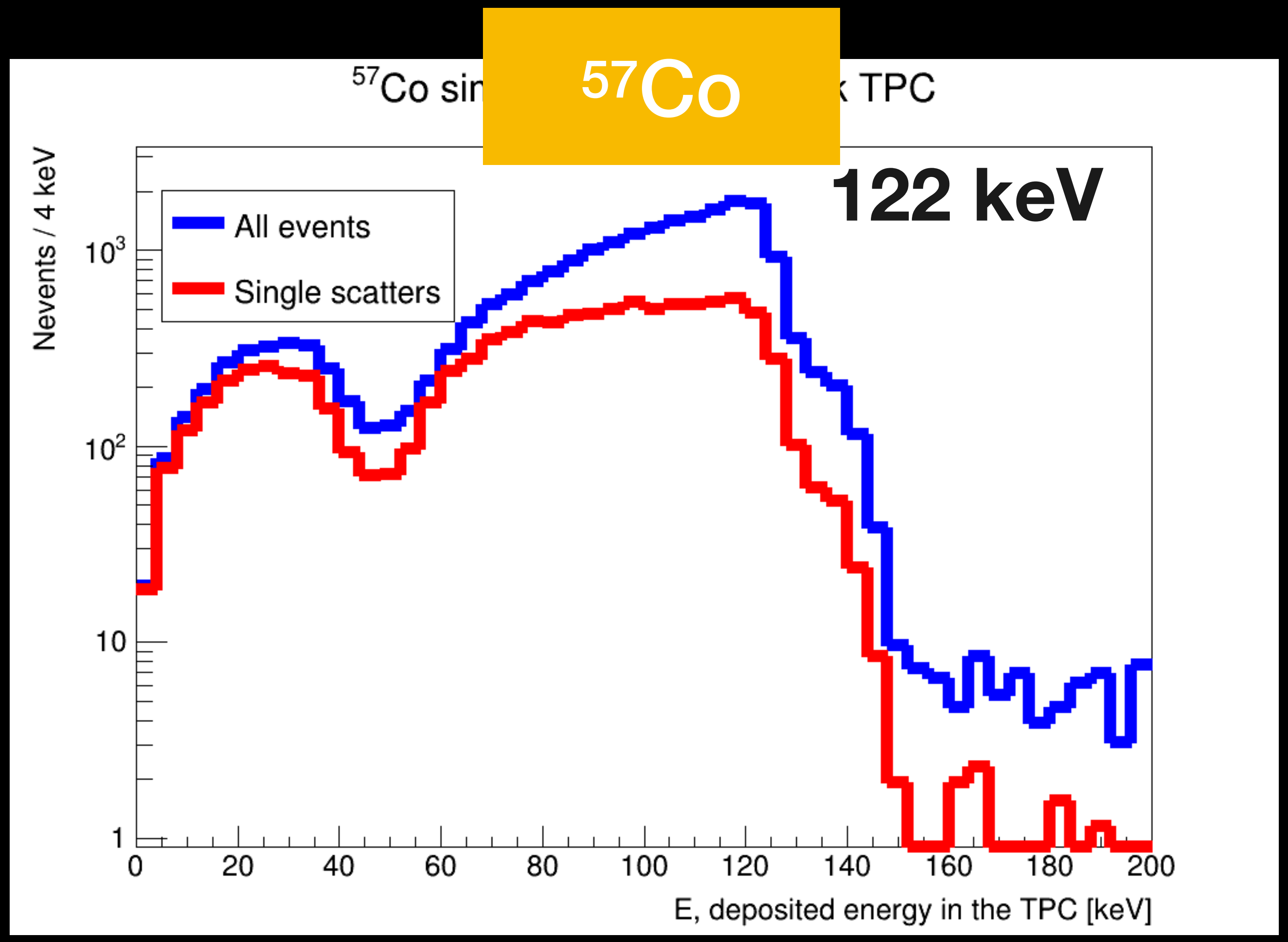
All events | Pure ER SS

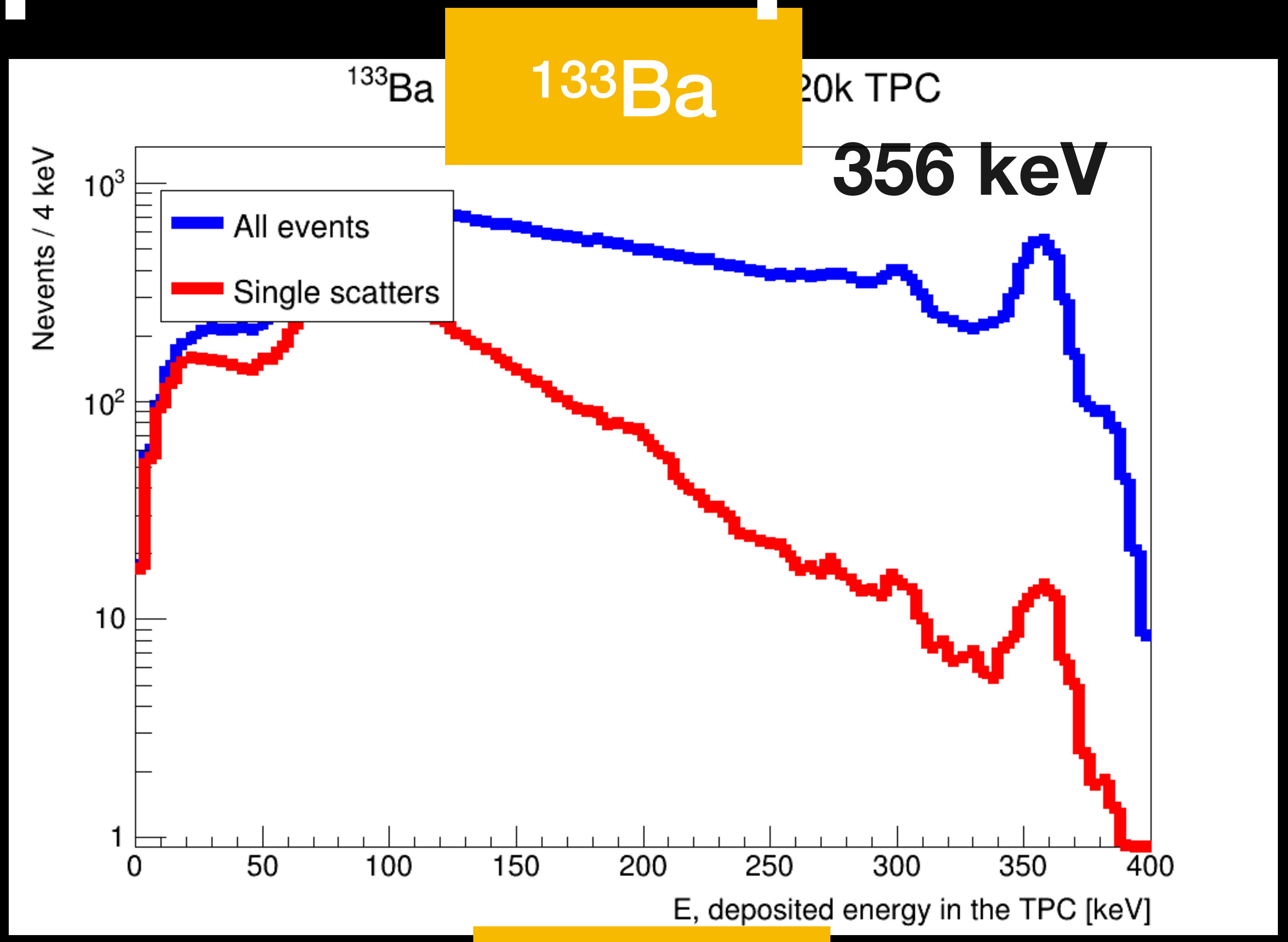
From these spectra: computation of the **rates of interesting events** inside the TPC per decay of the source located in the tubes

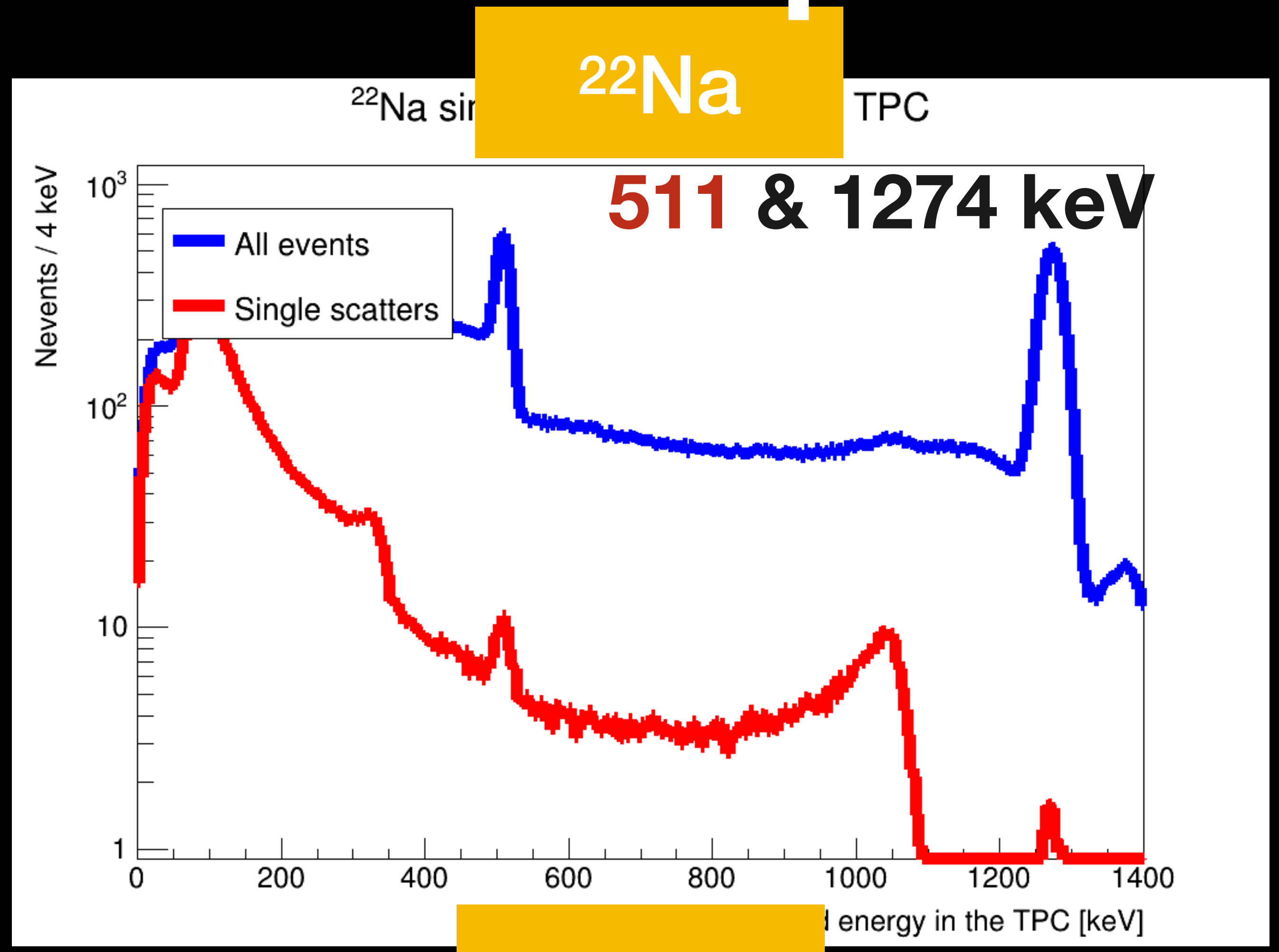
Ba 133



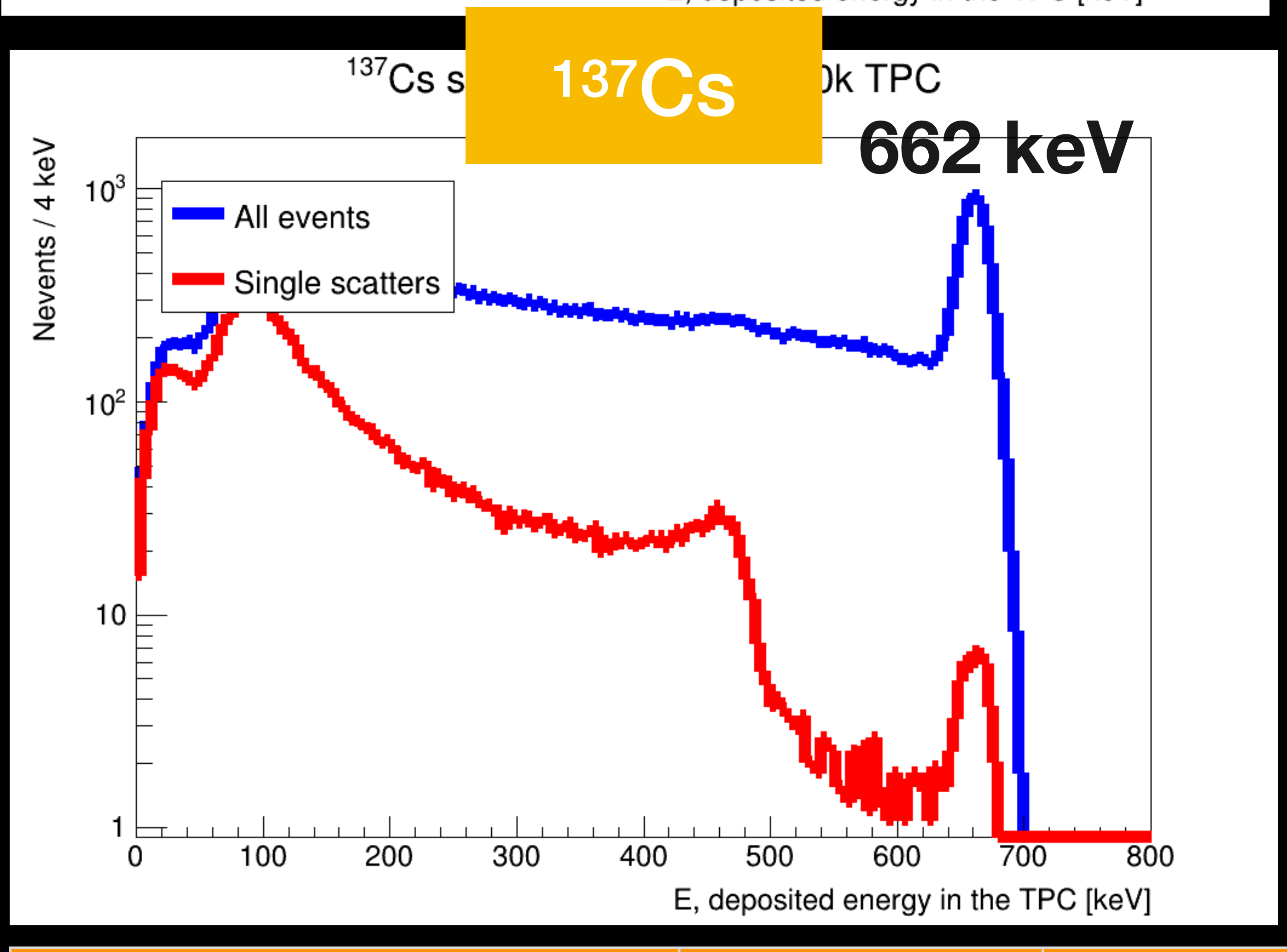
Simulation of the response to photon sources exposure

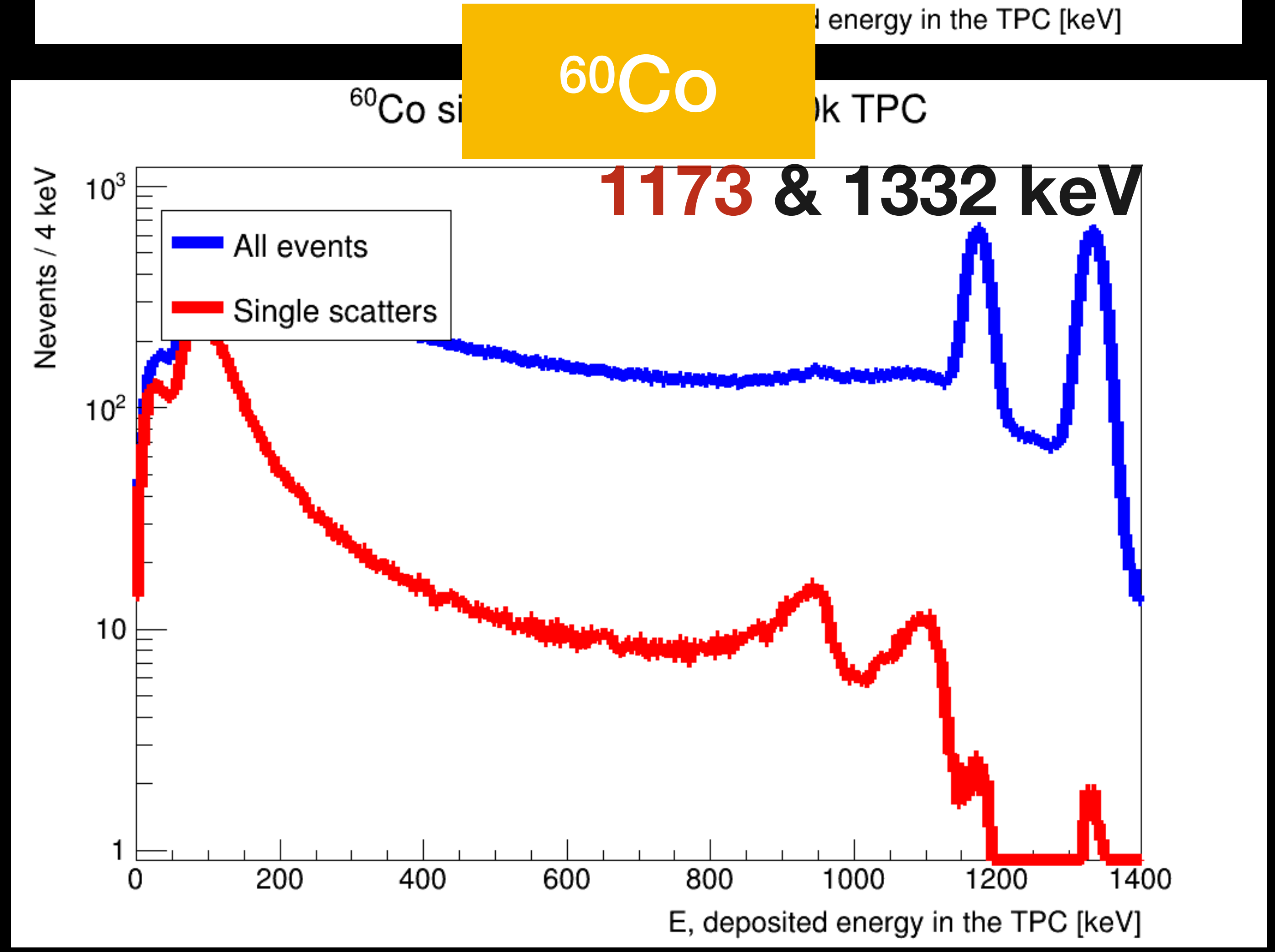






From these spectra: computation of the **rates of interesting events** inside the TPC per decay of the source located in the tubes



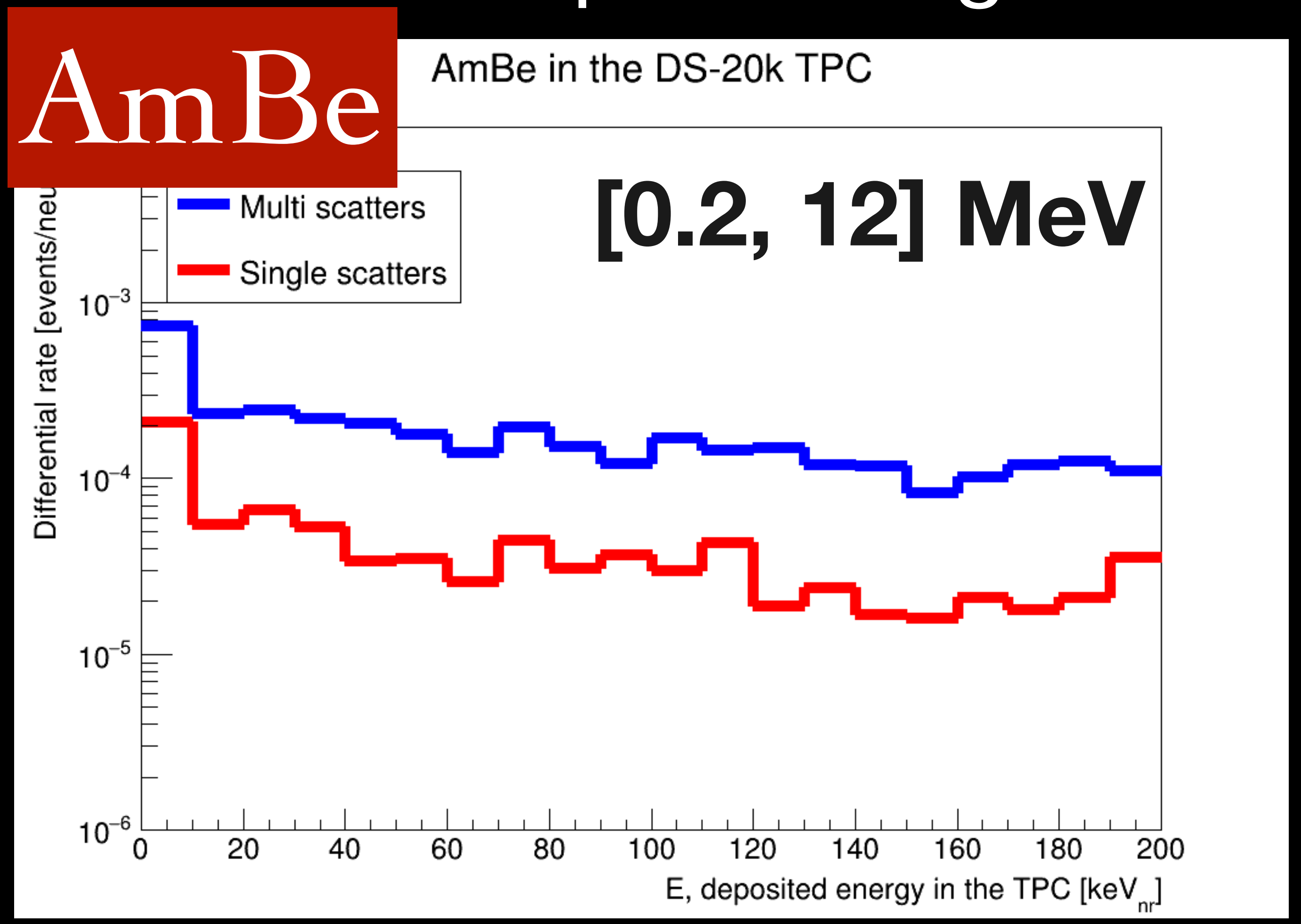


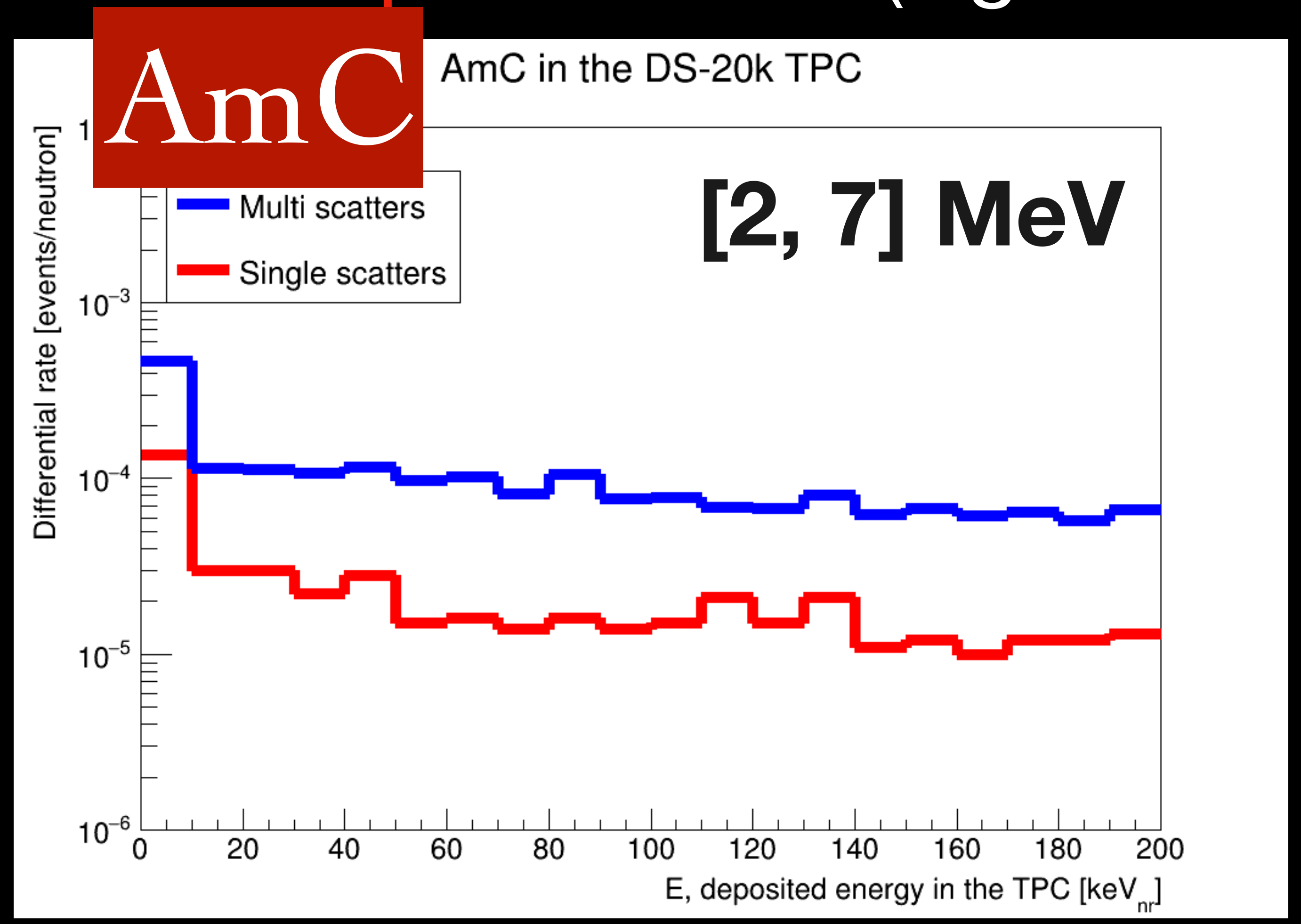
- Rates ∈ [1.2 e-5, 6.2 e-4] evts/decay
- Asking for 1e3 pure ER SS in the photoelectric peak, it leads to ≈ 1 week of ER calibration

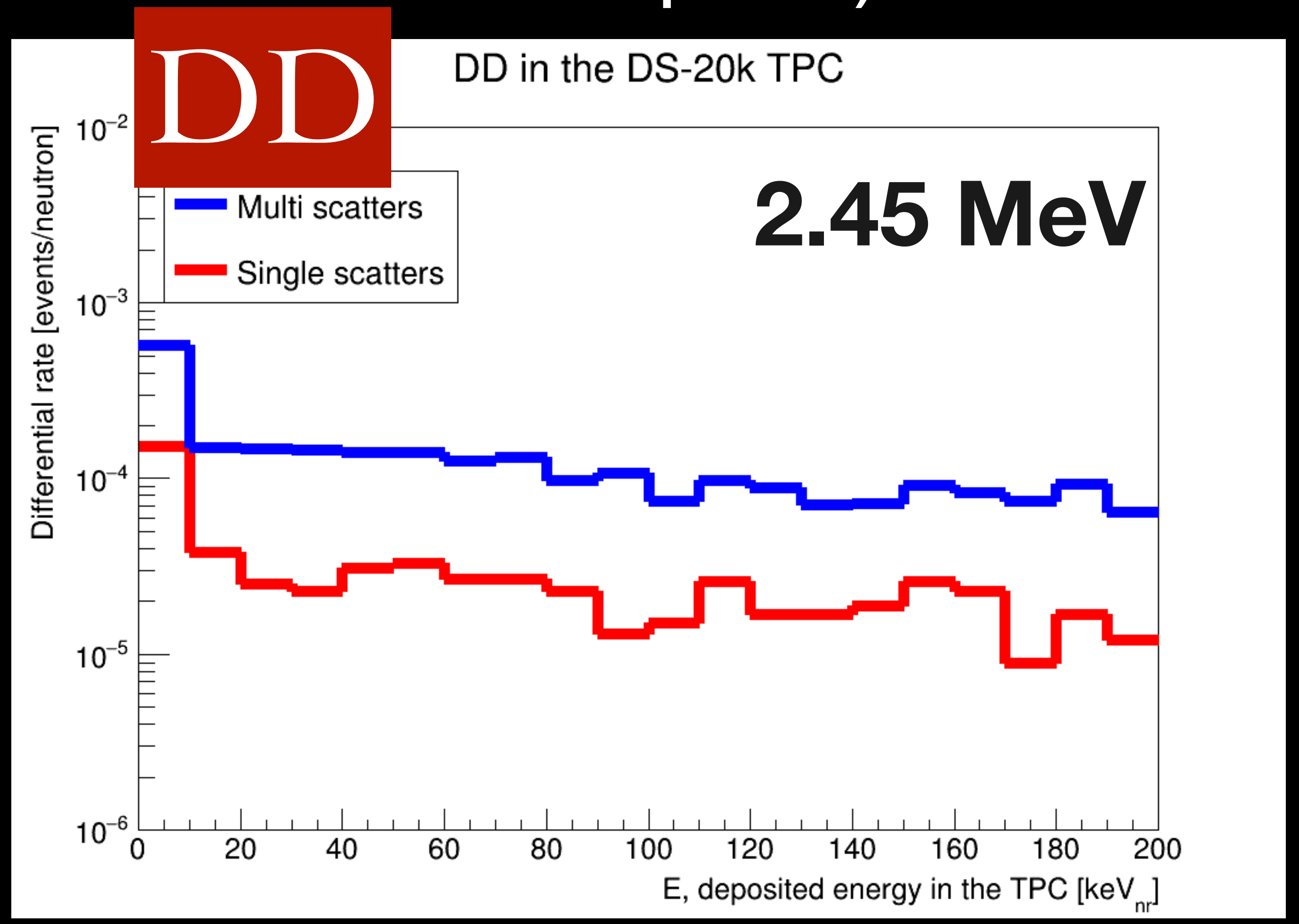
Interesting events	^{57}Co	^{133}Ba	^{22}Na	^{137}Cs	^{60}Co
Side	6.2 e-4	1.1 e-4	3.7 e-4	4.0 e-5	1.0 e-4
Bottom	8.4 e-5	2.6 e-5	1.6 e-4	1.2 e-5	5.2 e-5

Simulation of the response to neutron sources exposure (NR)

- NR : can be background (neutrons) or signal (WIMPs) **NR calibration = really at stake**
- g4ds : use of three radioactive sources of neutrons: AmBe, AmC, DD gun (monochromatic source of 2.45 MeV neutrons)
- Most important signal to calibrate = pure NR SS (signal that WIMP should deposit)







All events

Pure NR SS

Gold plated events	AmBe	AmC	DD
Side	1.1 e-3	6.4 e-4	6.5 e-4
Bottom	6.5 e-4	6.1 e-4	6.4 e-4

- Rates ≈ 1-6 e-4 evts/decay
- Asking for 1e4 pure NR SS, it leads to ≈ 1 month of NR calibration

Some tricks could fasten the calibration

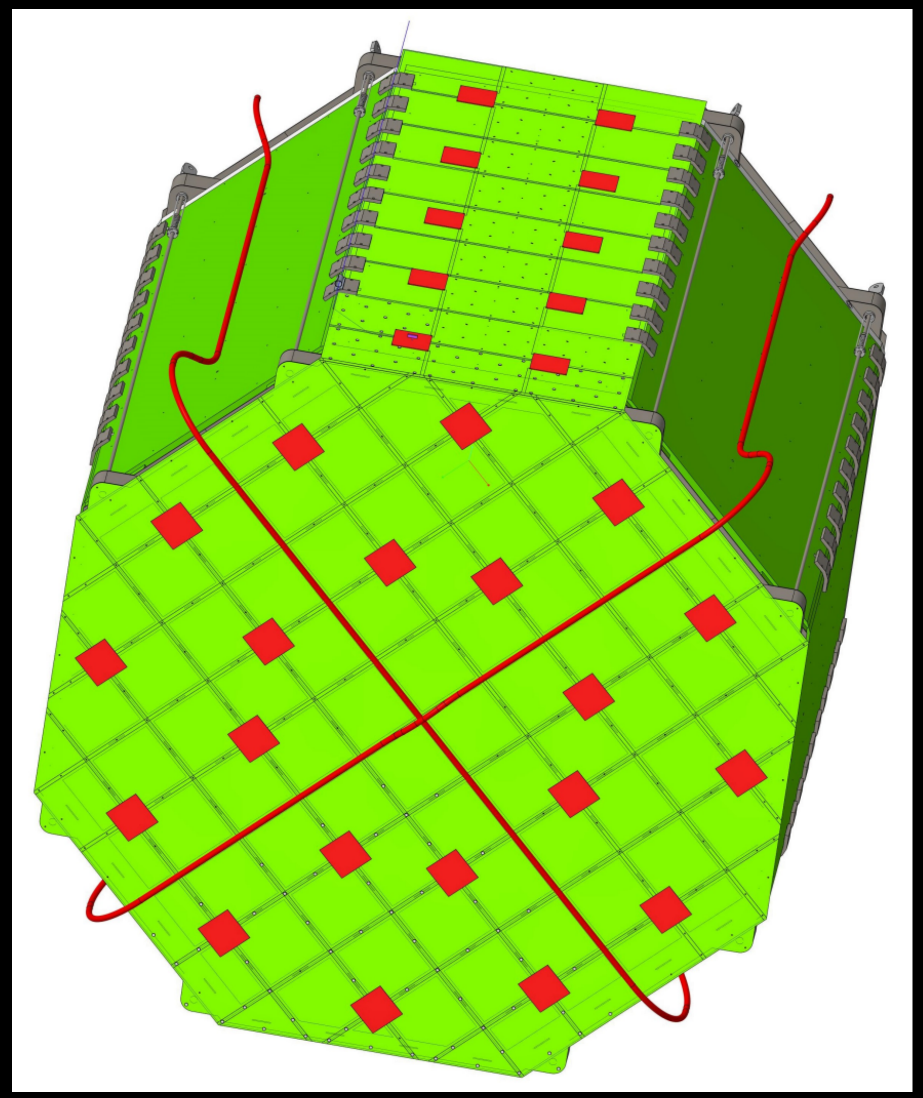
Crave a window in the wall

Perform the calibration where the Gd wall is thiner

Impact of the tubes on the detector

The preparation of the TPC calibration was the main goal of the simulation work. Yet, as the presence of the pipes can have a negative impact on the rest of the detector, simulations were performed in order to check how much impact the tubes have

Veto's Light Collection Efficiency (LCE)



- Tubes can absorb the light emitted by the argon when scintillating: this could lower the veto LCE
- Simulations were performed in order to test different optical boundaries so as to minimize the loss of LCE
- Best solution = **reflector-wrapped** titanium tubes : 4% LCE, 1% loss compared with then case without pipes

Veto and TPC background induced by titanium

^{238}U ^{235}U ^{232}Th ^{40}K ^{46}Sc

- **DS20k background budget = 0.1 events/10years**

NR

- Represents less than 0.01% of the budget : fully negligible

ER

- S1/S2 ratio + PSD: will be fully negligible