Status of Radiological Model v3 for HD and VD

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SOUTH DAKOTA MINES

DEEP UNDERGROUND
NEUTRINO EXPERIMENT

DUNE Collaboration

Low Energy Physics Group

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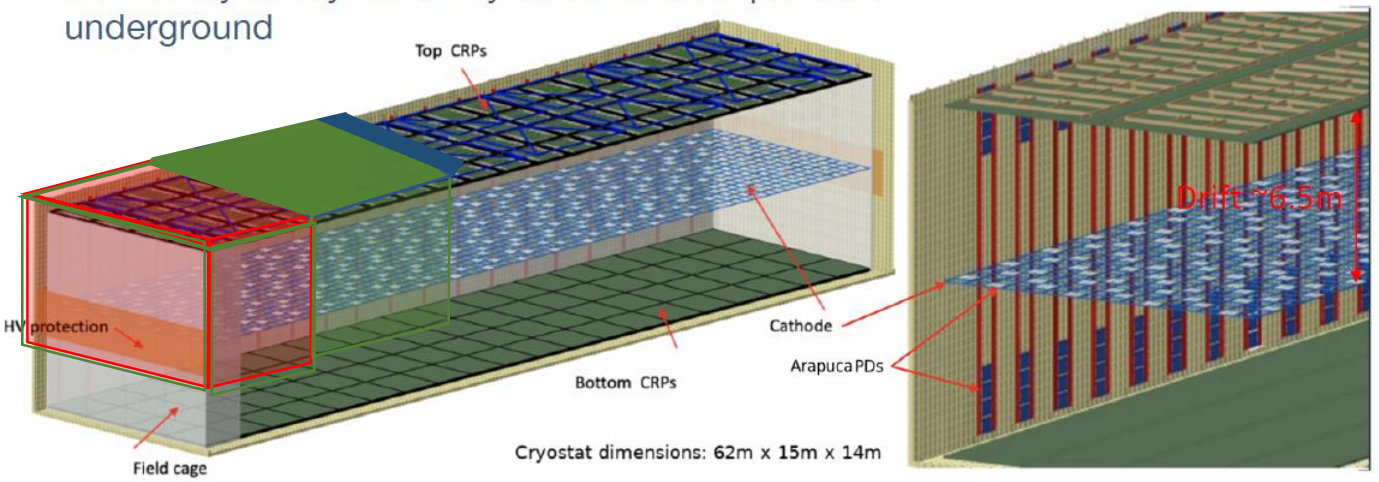
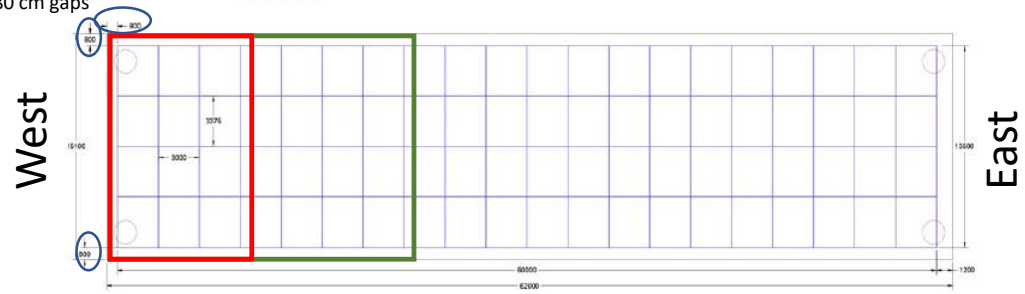
Fine-Tune Placement of External Backgrounds for VD 1x8x6 and 1x8x14

FD2 Vertical drift proposed layout

- CRP= 3x3.375 m^2 readout units (anode)
- Modularity manly driven by max size transportable underground



80 cm gaps



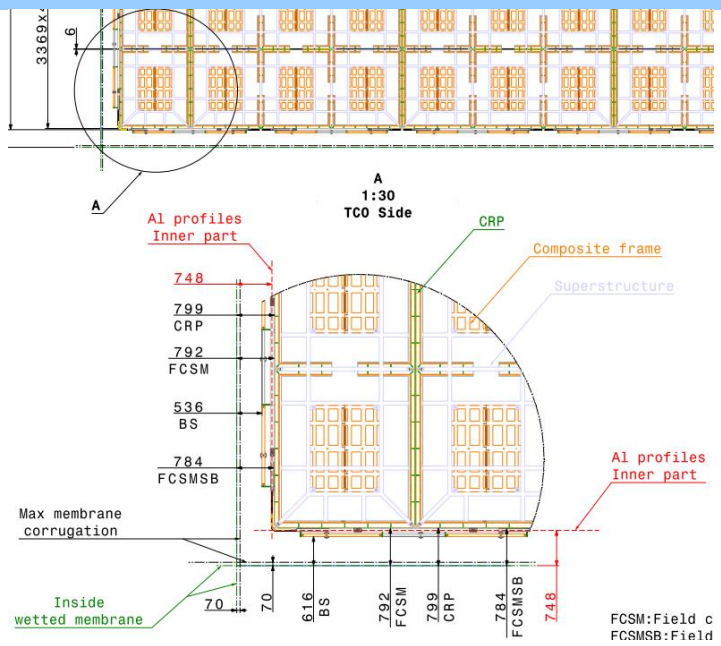
- ✓ 160 CRP units (80 on top, 80 on the bottom)
- ✓ Drift active volumes 2*5'265 m^3 = LAr 14.74 Ktons
- ✓ Photon detectors on cathode and cryostat walls (up to 14% coverage)

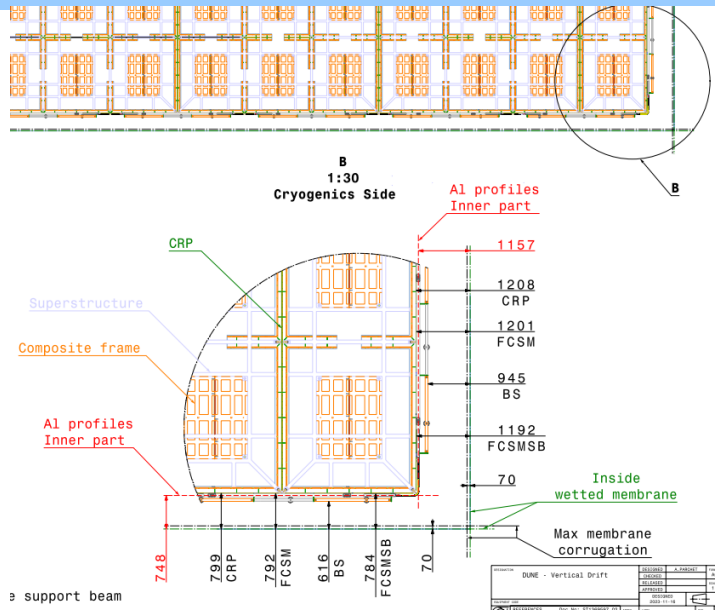
⇒ But fine-tuned upper z-positions

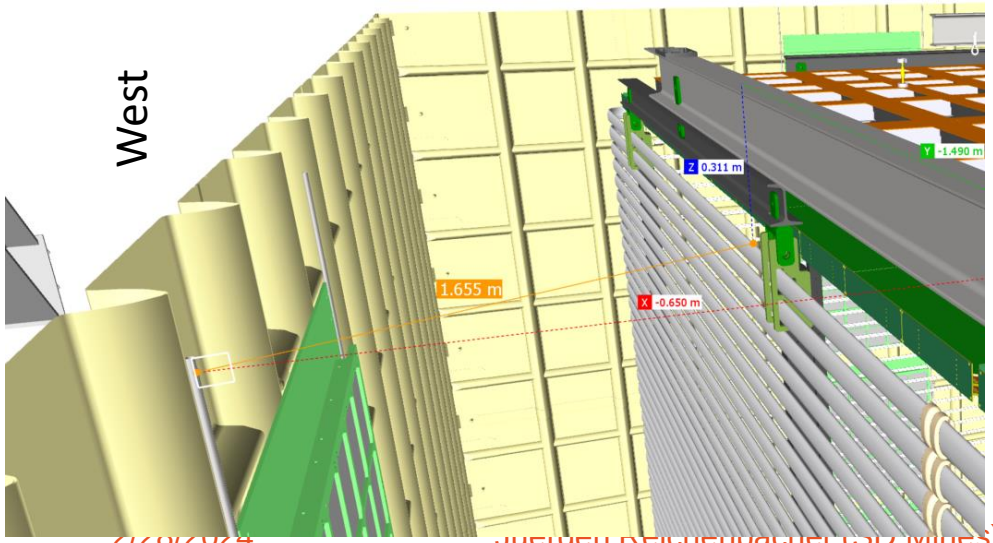
⇒ Went with 78 cm 'inactive LAr gap' for VD 1x8x6 and 1x8x14

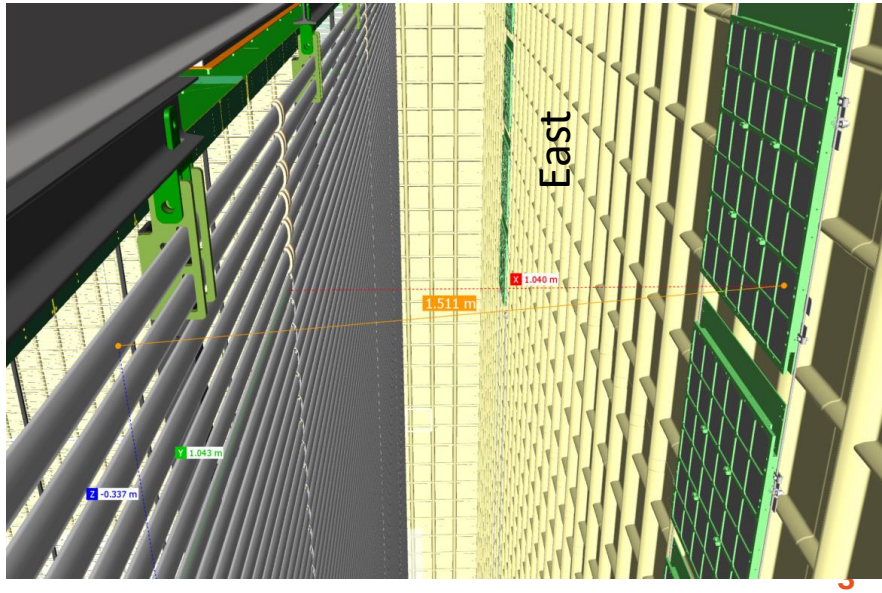
⇒ 25 cm above Anode, but no external backgrounds plane underneath Cathode (shielded)

In VD GDML Mis-Placed Wall Arapucas on East and West Face (cf. VD_Detector_Layout_Top-View.pdf (cern.ch))

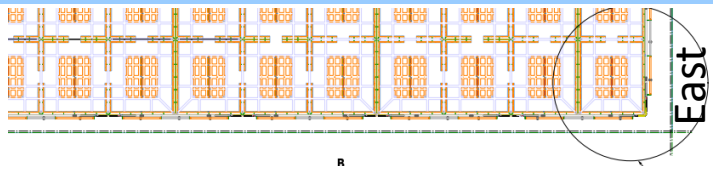






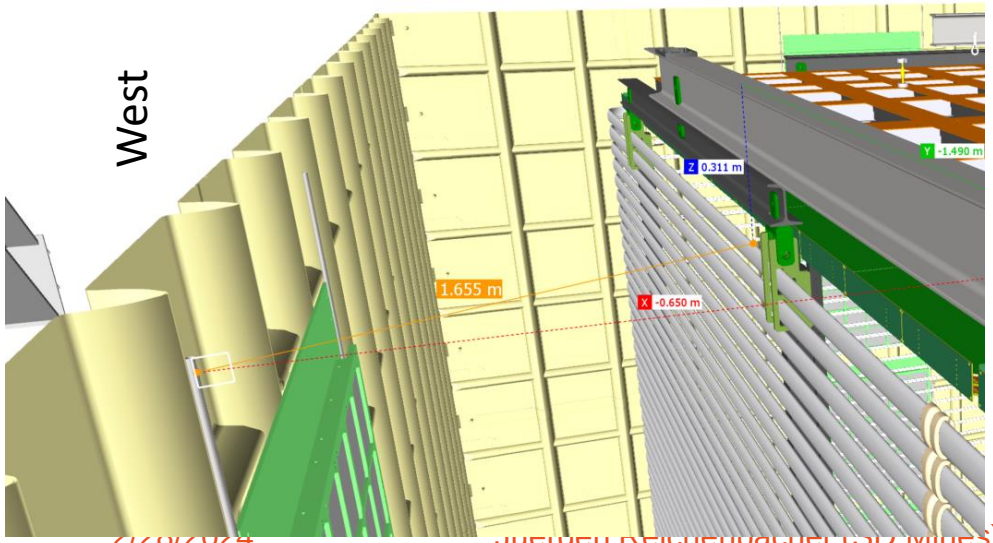


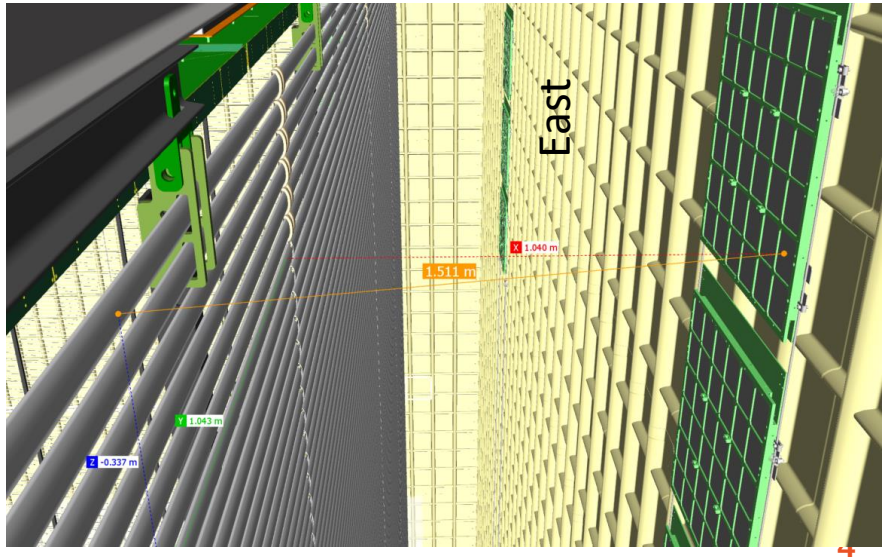
In VD GDML Mis-Placed Wall Arapucas on East and West Face (cf. VD_Detector_Layout_Top-View.pdf (cern.ch))



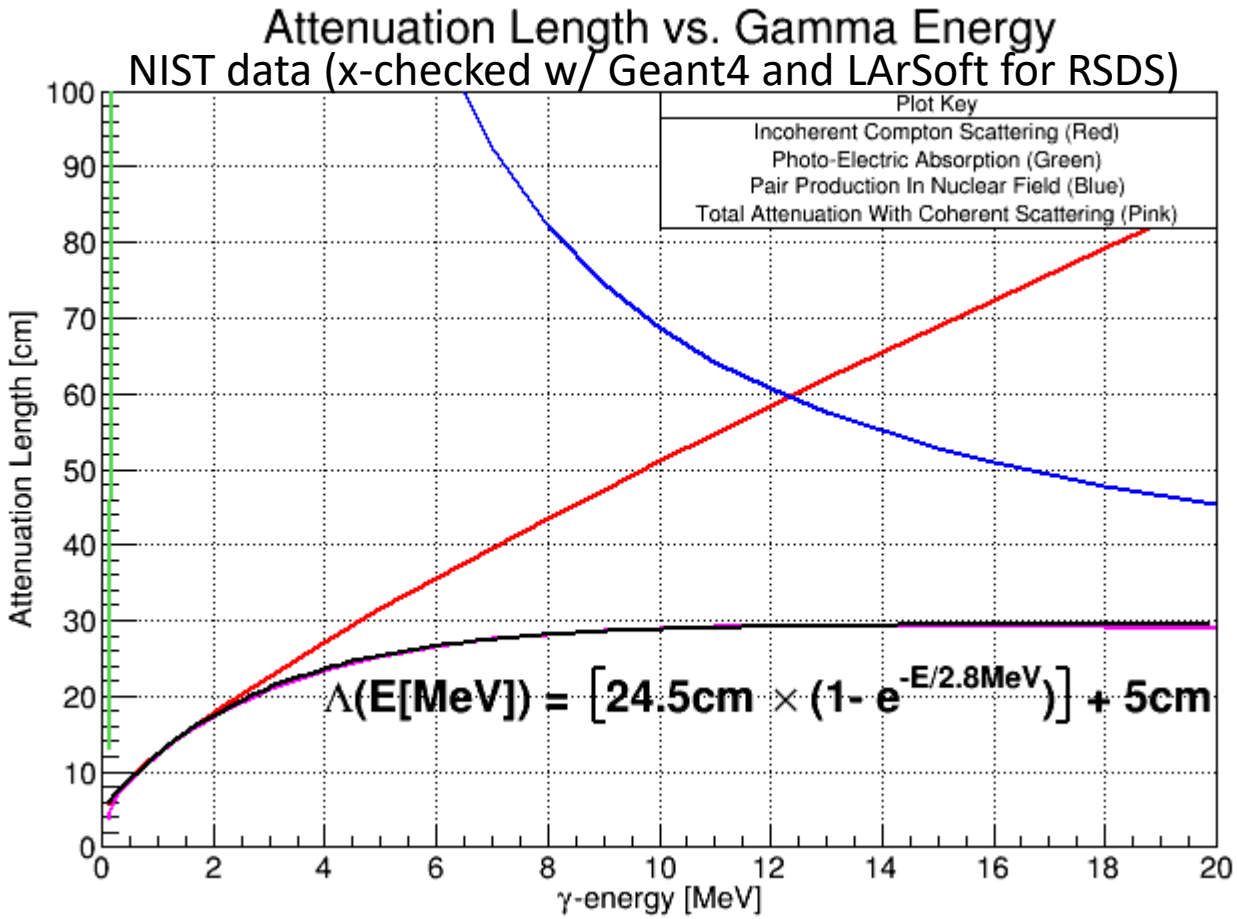
That means in both the VD 1x8x6 and VD 1x8x14 the Arapucas on the West wall (short face) are 32 cm (= 97 cm is - 65.0 cm should be) too far out.

On the East wall (short face) the Arapucas are in the VD 1x8x6 instead 10.5 cm (= 93.52 cm is - 104.0 cm should be) too close.
For the VD 1x8x14 they are even 15 cm (88.88 cm is - 104.0 cm should be) too close (on the East wall).





Correcting γ-Backgrounds for the VD GDML Mis-Placed Wall Arapucas on East and West Face



I(x,E) = I_0(E) * e ^ (-x/Lambda(E)) for downscaling BGs

I(x,E) = I_0(E) / e ^ (-x/Lambda(E)) for upscaling BGs

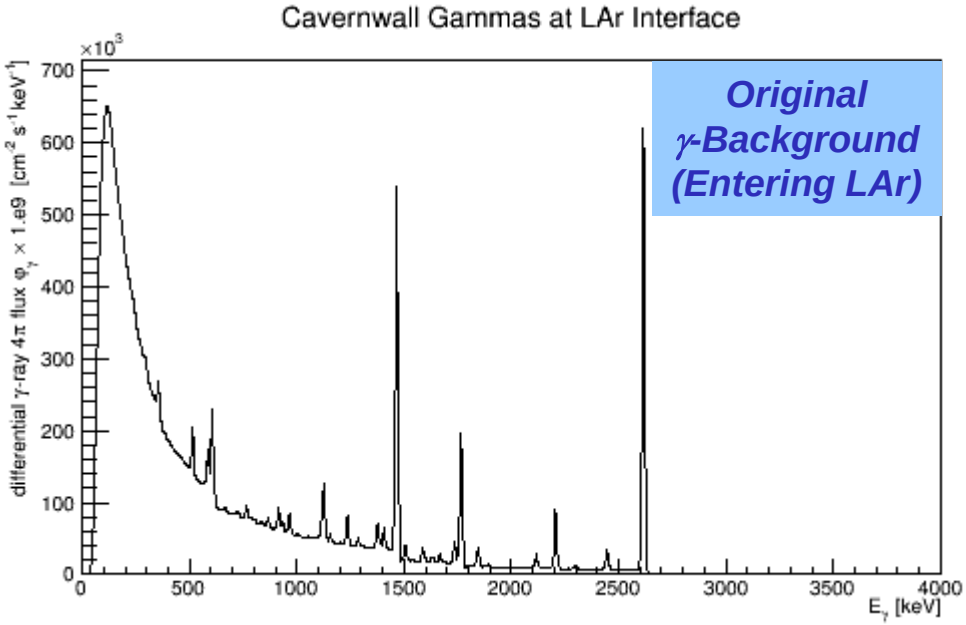
Correcting γ-Backgrounds for the VD GDML Mis-Placed Wall Arapucas on East and West Face

So, on the **West wall (short face)** the distance between the inside of the field cage (FC) and the Arapucas (PD cable) on the corrugation should be 65.0 cm
and thus the distance between the inside of the FC to the flat of the corrugation should be 74.5 cm (65.0 cm + 9.5 cm)
which compares to 103 cm in the gdml's, thus being 28.5 cm too far out and BGs need to be **upscaled** for that West face.

On the **East Wall (short face)** the distance between the inside of the field cage (FC) and the Arapucas (PD cable) on the corrugation should be 104.0 cm
and thus the distance between the inside of the FC to the flat of the corrugation should be 113.5 cm (104.0 cm + 9.5 cm)
which compares to 100 cm (and 95 cm, respectively for the VD 1x8x14) in the gdml's, thus being 13.5 cm (and 18.5 cm respectively for the VD 1x8x14) too close and BGs need to be **attenuated** for that East face.

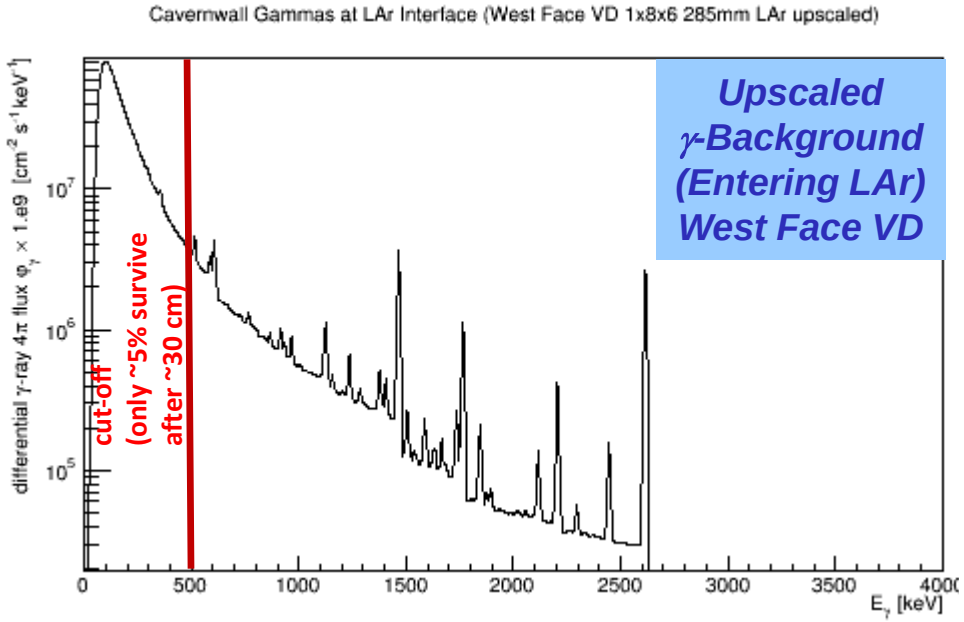
$$I(x,E) = I_0(E) * e^{(-x/\Lambda(E))}$$ for **downscaling BGs**

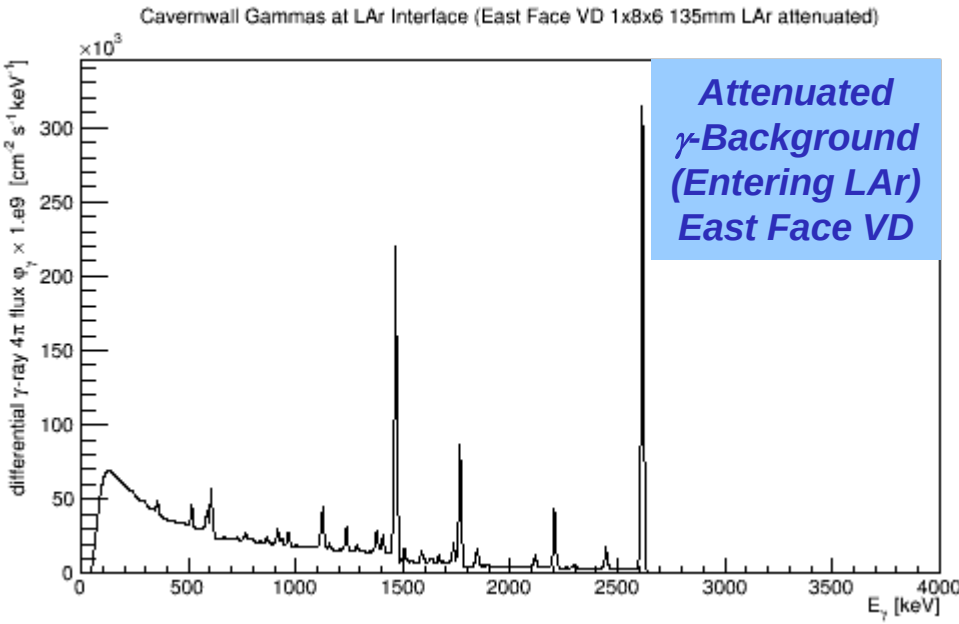
$$I(x,E) = I_0(E) / e^{(-x/\Lambda(E))}$$ for **upscaling BGs**

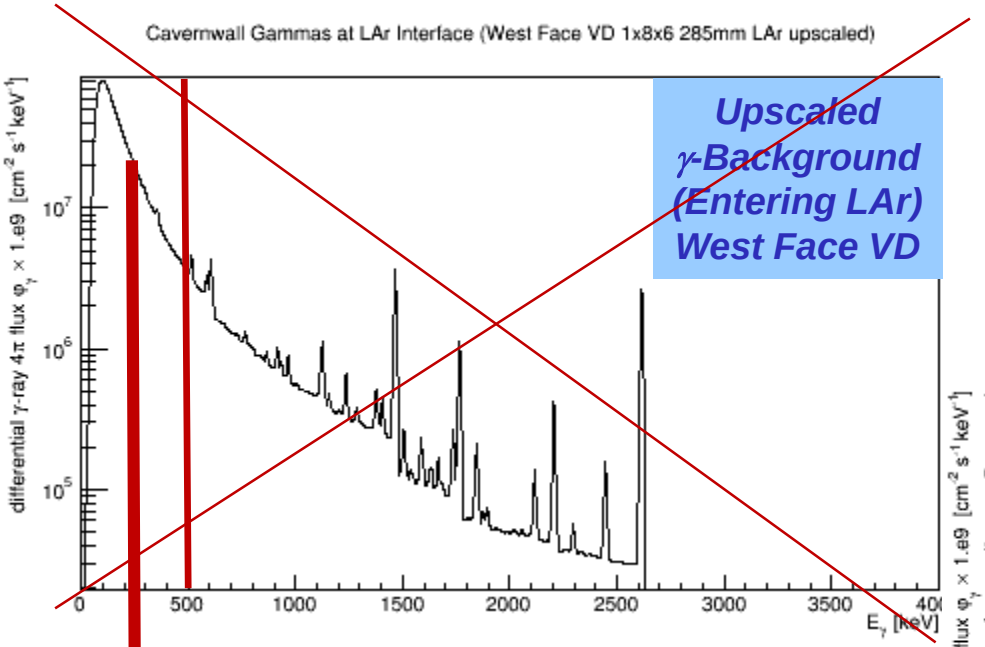


-> 0.5 MeV cut needed

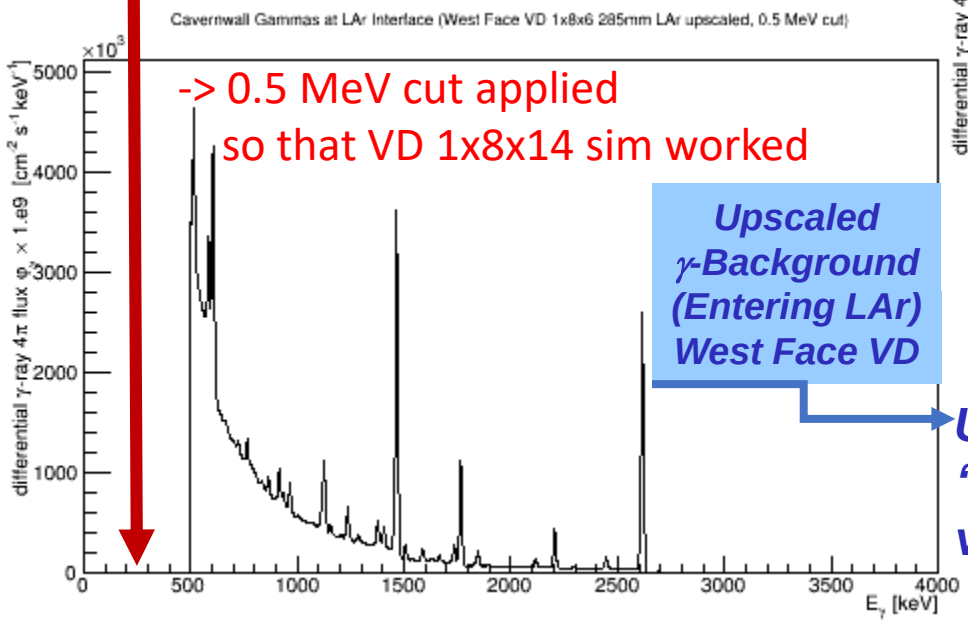
so that VD 1x8x14 sim can run through





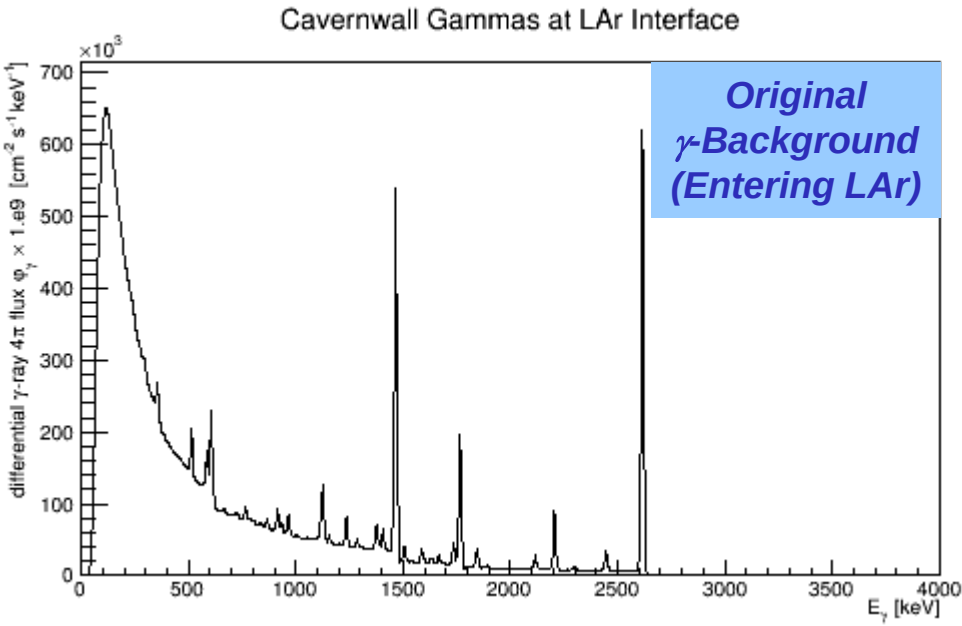


Upscaled γ-Background (Entering LAr) West Face VD



-> 0.5 MeV cut applied
so that VD 1x8x14 sim worked

Upscaled γ-Background (Entering LAr) West Face VD



Original γ-Background (Entering LAr)

Used as new input for my test FHiCL: "dune_radiological_model_decay0_v3_5_vd_for1x8x14_testHalfMeVcut.fcl"

Validation for VD 1x8x14 Test with 0.5 MeV Cut: "dune_radiological_model_decay0_v3_5_vd_for1x8x14_testHalfMeVcut.fcl"

Sergio ran one event successfully:
output of this test run in this common location:
/pnfs/dune/persistent/physicsgroups/dunele/smanthey/dunevd10kt_1x8x14_3view_30deg/prodbackground_radiological_decay0_v3_5_testHalfMeVcut/

Gleb ran one event successfully:
one event for the full sim/reco chain took 1h:26m:26s,
with the output being 320 MB. Most of that is G4 output at 296 MB.

Rates and placements of external cavern gammas make sense as checked by Gleb:

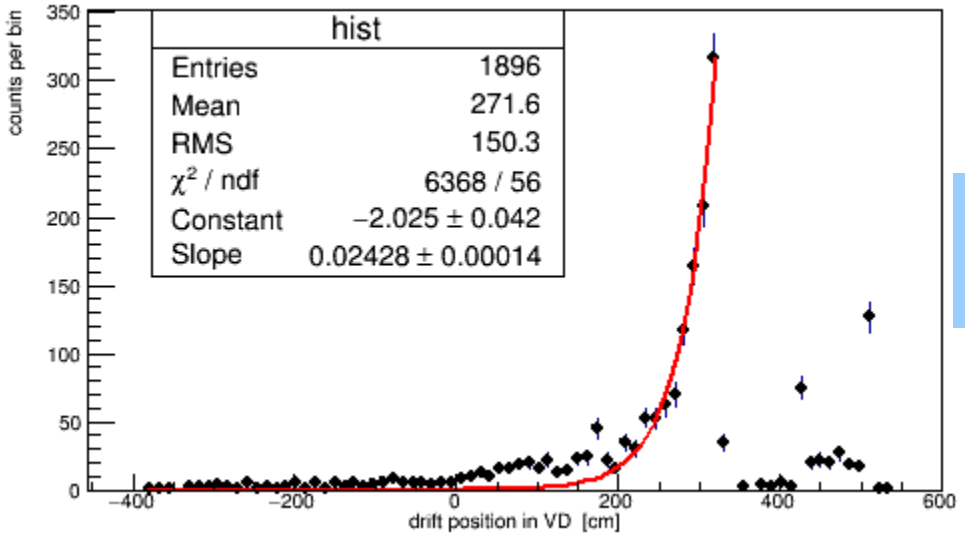
at X = 350 cm, ~32,000 primaries, 32000/(0.004285 s*2) = 3.7 MHz,
expecting (1.05104 Bq/cc +0.0441274 Bq/cc)*1 cm*750 cm*2*(2195 cm+103 cm) = 3.8 MHz;

at Y = +/-751 cm, ~16,500 primaries, 16500/(0.004285 s*2) = 1.9 MHz,
expecting (1.05104 Bq/cc +0.0441274 Bq/cc)*1 cm*(350 cm+420 cm)*(2195 cm+103 cm) = 1.9 MHz;

at Z = -105 cm, ~46,500 primaries, 46500/(0.004285 s*2) = 5.4 MHz,
expecting (4.65254 Bq/cc +0.0441274 Bq/cc)*1 cm*(350 cm+420 cm)*750 cm*2 = 5.4 MHz;

at Z = 2195 cm, ~2,000 primaries, 2000/(0.004285 s*2) = 0.23 MHz,
expecting (0.147498 Bq/cc +0.0441274 Bq/cc)*1 cm*(350 cm+420 cm)*750 cm*2 = 0.22 MHz.

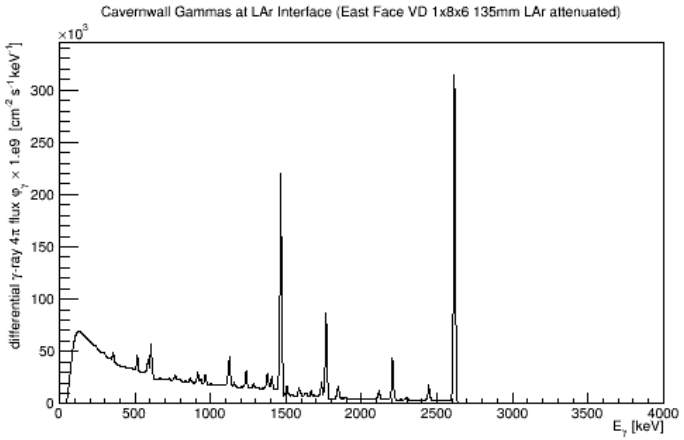
HD 1x2x6 (and 1x2x2) Corrected Center APA γ- and Neutron-Backgrounds for 40 cm of 'Dead' Wall LAr



Propagated External Neutron Background (Fitted Exponential on Sergio's Produced Plot)

Fitted Neutron Attenuation Length of 41 cm

=> reduced APA neutron background rate in sim by 1/e (due to 40 cm of 'dead' wall LAr)



⇒ ***Attenuated all APA γ-backgrounds (energies and rates) by equivalent of 40 cm of 'dead' wall LAr***

FHiCL Files Status for v3_6
HD 1x2x6 (and 1x2x2) and
VD 1x8x14 (and 1x8x6)

- prodbackground_radiological_decay0_v3_5_vd_dune10kt_1x8x14_testHalfMeVcut
- dune_radiological_model_decay0_v3_5_vd_for1x8x14_testHalfMeVcut
- prodbackground_radiological_decay0_v3_6_dune10kt_1x2x2_lowBgAPA
- dune_radiological_model_decay0_v3_6_for1x2x2_lowBgAPA
- prodbackground_radiological_decay0_v3_6_dune10kt_1x2x2
- dune_radiological_model_decay0_v3_6_for1x2x2
- prodbackground_radiological_decay0_v3_6_dune10kt_1x2x6_lowBgAPA
- dune_radiological_model_decay0_v3_6_for1x2x6_lowBgAPA
- prodbackground_radiological_decay0_v3_6_dune10kt_1x2x6
- dune_radiological_model_decay0_v3_6_for1x2x6