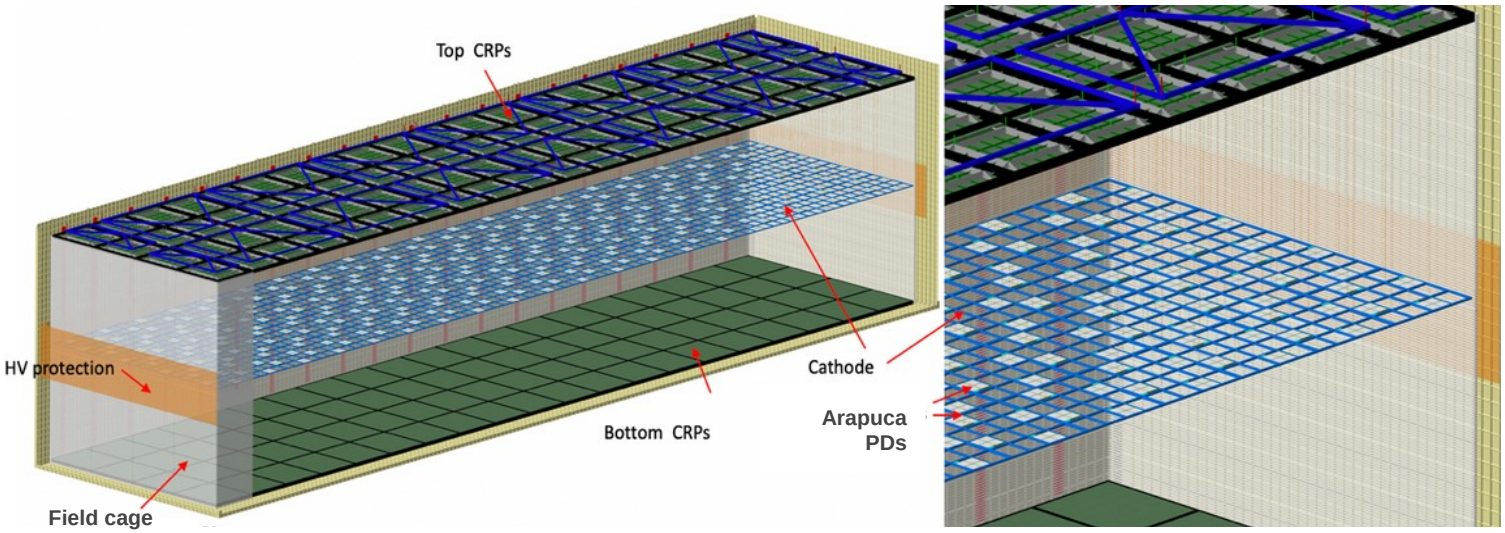
Proposal for a new VD geometry in LArSoft



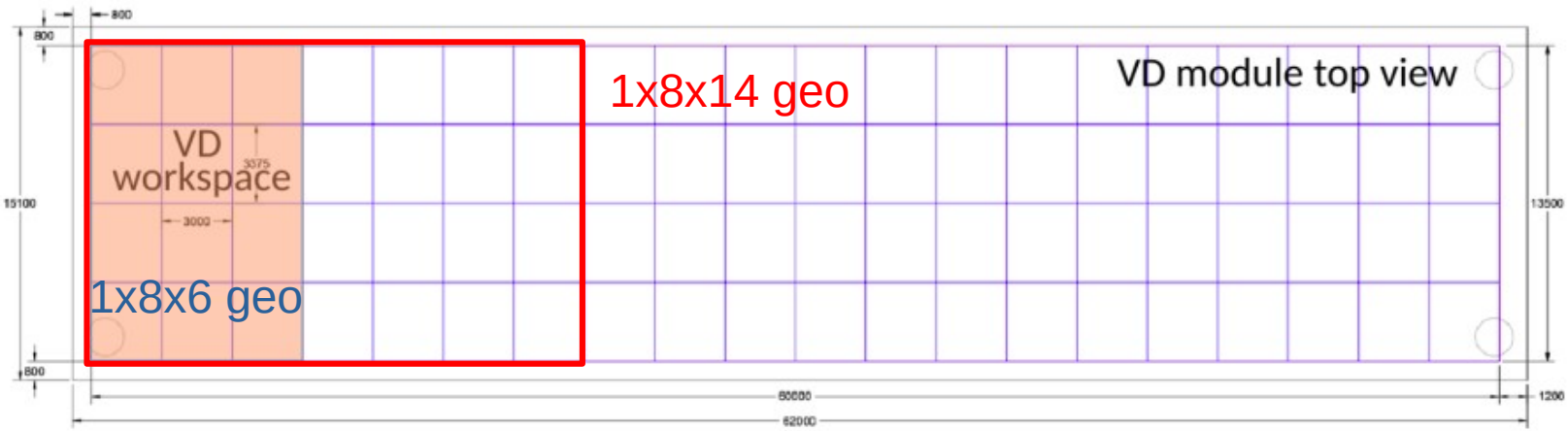
Laura Paulucci, Franciole Marinho

FD Sim/Reco Meeting

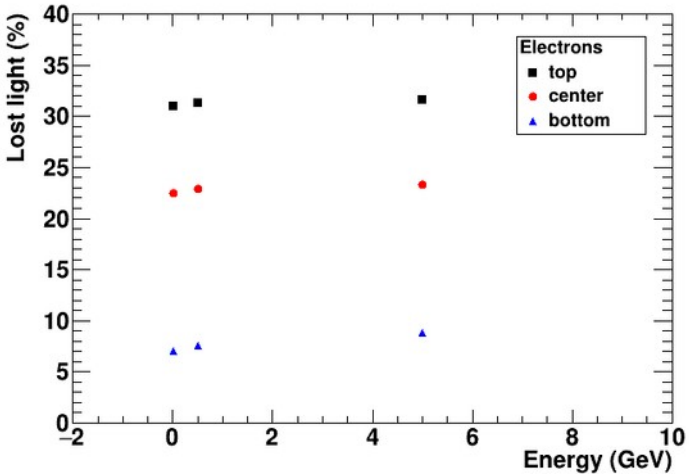
April 11 2022

VD Simulation: The geometry issue

- Full size geo is “too big” (memory consumption, run time)
- ROOT I/O limitation of max 1 GB per serialised object



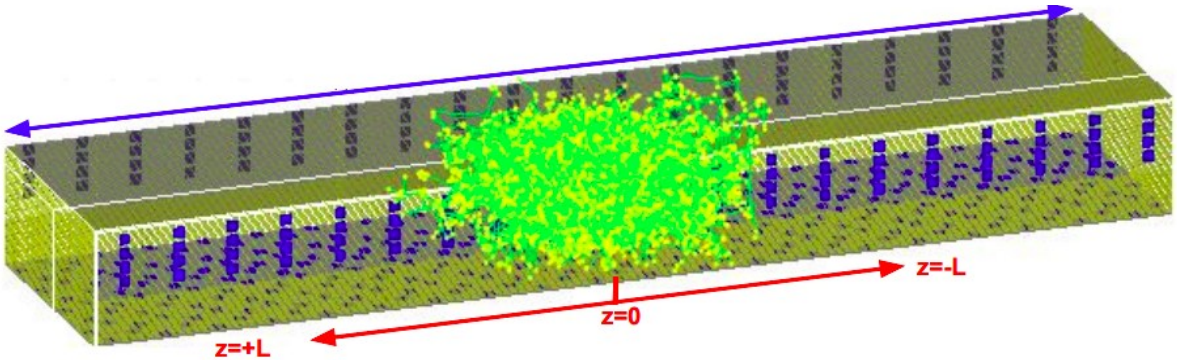
- With LArSoft: comparison of light reaching PDS in 1x8x6 vs 1x8x14
  - Electron source at z and y center of geometry and different heights



VD Simulation: The geometry issue

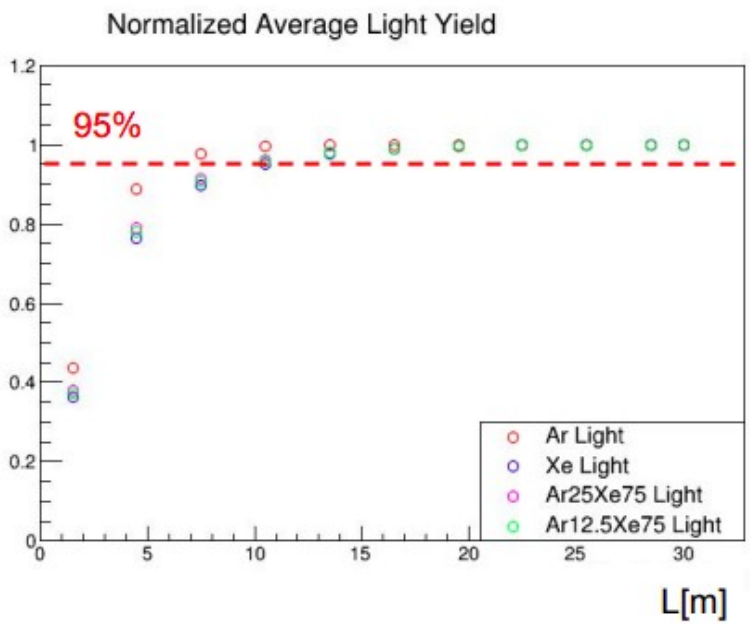
- With Standalone Geant4 Sim

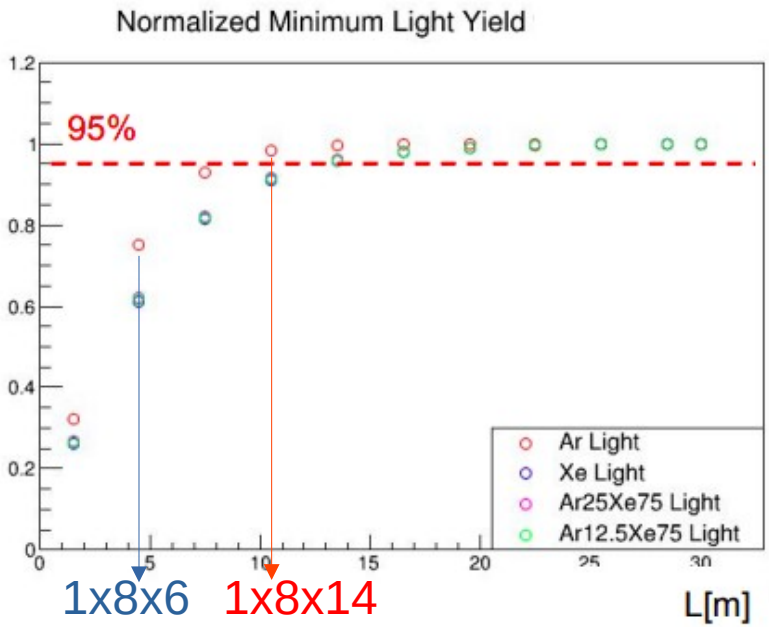
Jiangmei Yang,
Dante Totani



LY study, limiting the detector size:
L= {**30,** 28.5, 25.5, 22.5, 19.5, 16.5, 13.5, 10.5, 7.5, 4.5, 1.5} m
(L=30m means full size).

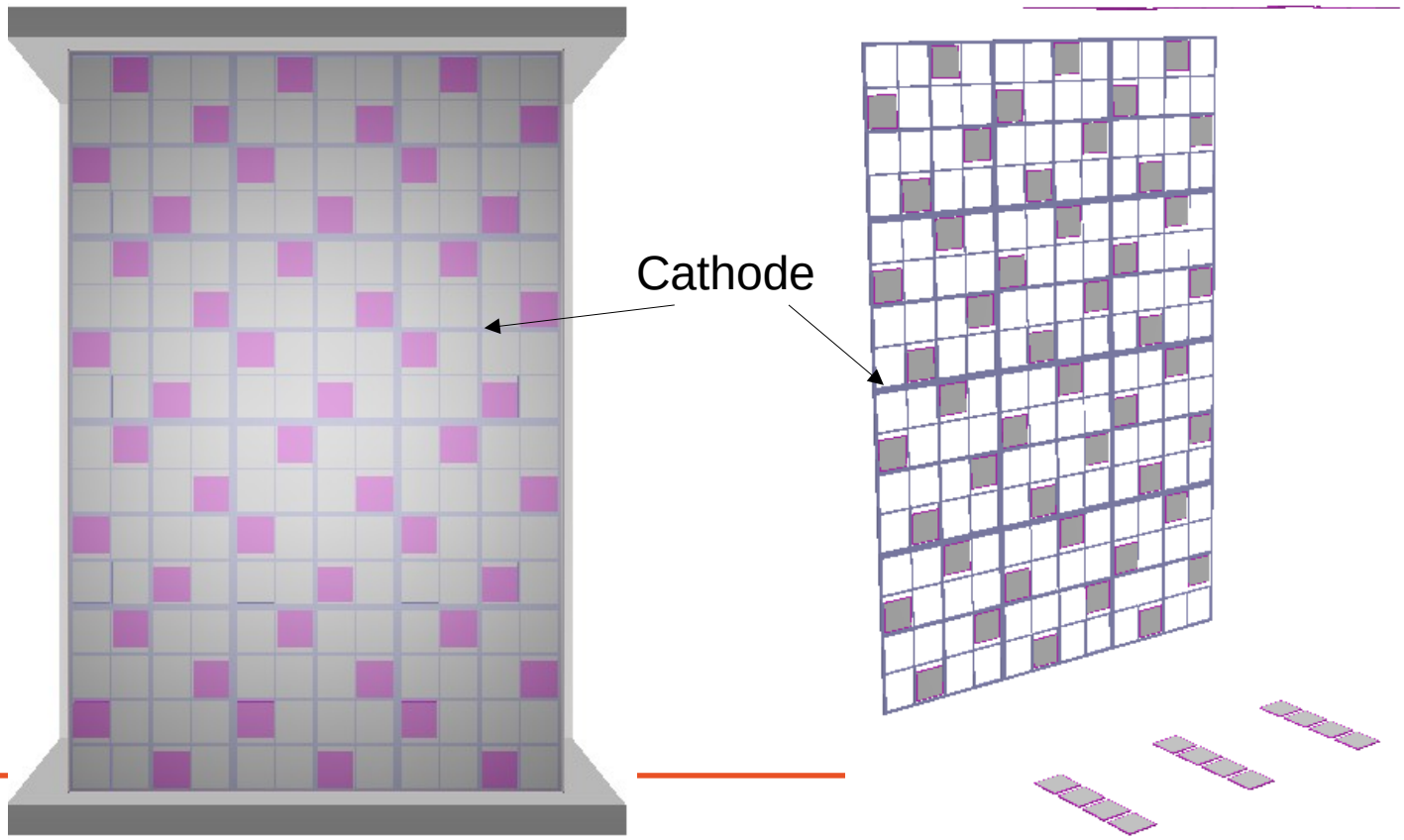
2





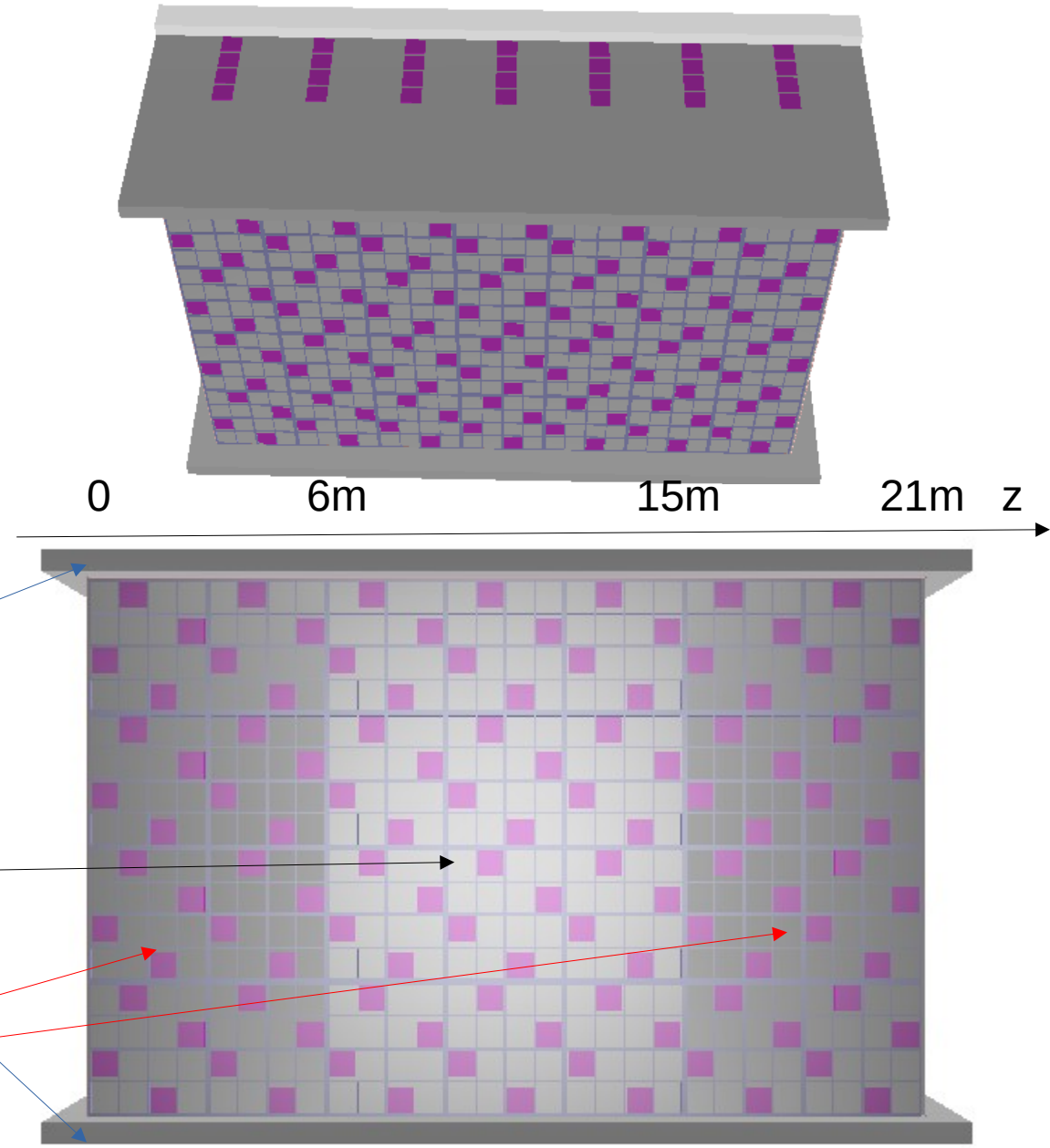
VD Geometry

- Inclusion of cathode structure
  - Important for background model
  - Already available for the 1x8x6 3view and 3view-30deg geo



New VD Geometry

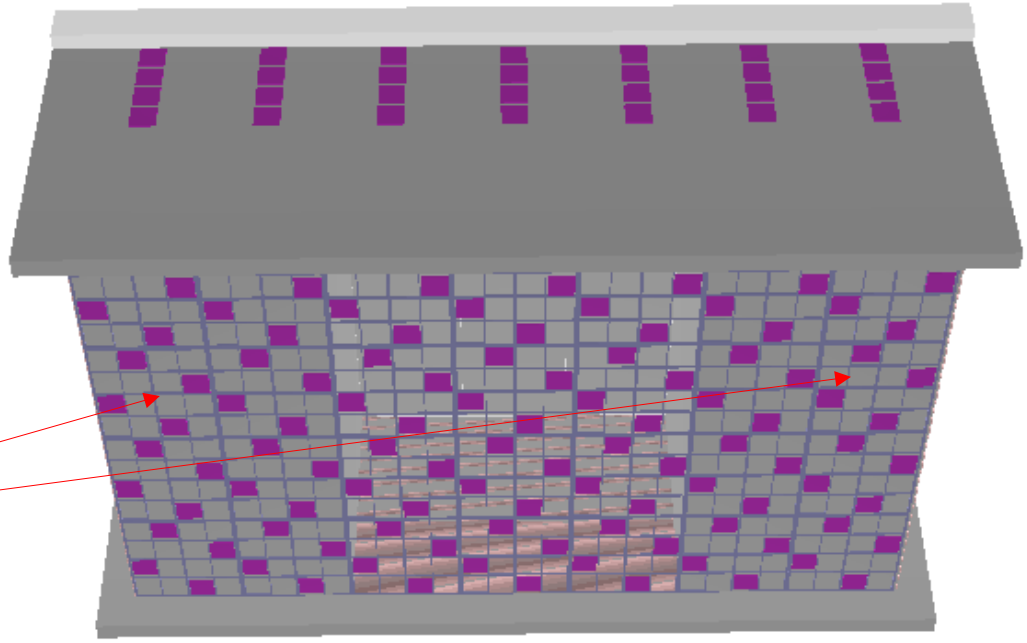
- Proposal
  - Light readout 1x8x14
  - Charge readout 1x8x6 (center of volume)



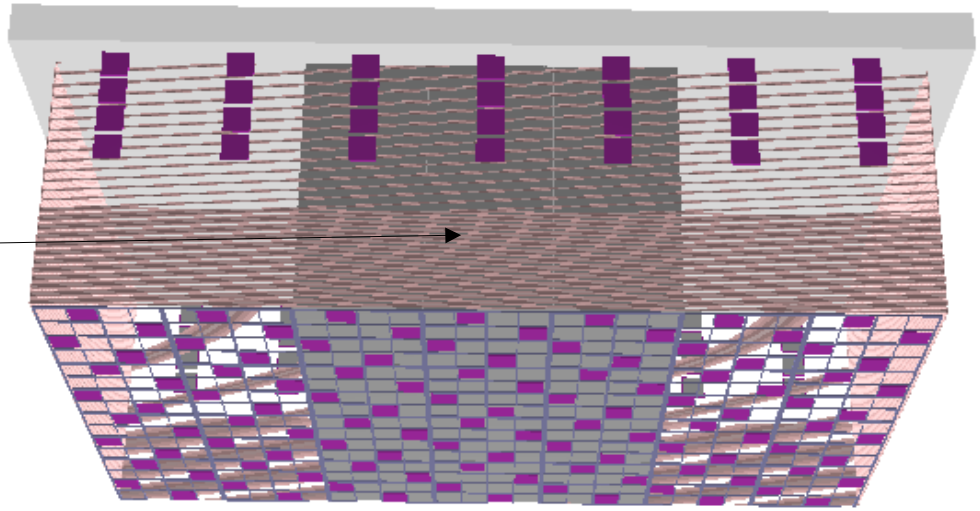
New VD Geometry

- Proposal

Internal
active



TPC
active



New VD Geometry: Configuration

- Changes in fhicl files (feature branch lp_vdsim)
  - dunesim/LArG4/IonAndScint_dune.fcl

```
# DUNE FD VD specific
# active volume
dunefdvd_ionandscint: @local::dunefd_ionandscint
dunefdvd_ionandscint.Instances: "LArG4DetectorServicevolTPCActive;LArG4DetectorServicevolInternalActive"
# external laterals volume
dunefdvd_ionandscint_external: @local::dunefd_ionandscint_larql
dunefdvd_ionandscint_external.Instances: "LArG4DetectorServicevolExternalActive"
```

  - dunesim/Simulation/larg4services_dune.fcl

```
dunevd10kt_1x8x14_3view_larg4detector:
{
    category      : "world"
    gdmlFileName_ : @local::dunevd10kt_1x8x14_3view_geo.GDML
    volumeNames   : ["volTPCActive", "volExternalActive", "volInternalActive"] # list of volumes for which the stepLimit should be set
    stepLimits    : [0.4, 0.4, 0.4]            # corresponding stepLimits in mm for the volumes in the volumeNames list
}
```

New VD Geometry: Configuration

- Changes in fhicl files (feature branch lp_vdsim)
  - duneopdet/PhotonPropagation/PDFastSim_dune.fcl

```
# Hits & Timing parameterization for DUNE VD, Ar scintillation
dunevd_pdfastsim_par_ar:                        @local::standard_pdfastsim_par_ar
dunevd_pdfastsim_par_ar.VUVTiming:              @local::dunevd_vuv_timing_parameterization
dunevd_pdfastsim_par_ar.VUVHits:                @local::dunevd_vuv_Argon_hits_parameterization
dunevd_pdfastsim_par_ar.OnlyActiveVolume:        false

# As above, but fast-only scintillation for high Xe concentration
dunevd_pdfastsim_par_ar_fastonly:               @local::dunevd_pdfastsim_par_ar
dunevd_pdfastsim_par_ar_fastonly.DoSlowComponent: false

# Hits parameterization for DUNE VD, Xe scintillation, 10ppm
dunevd_pdfastsim_par_xe:                        @local::standard_pdfastsim_par_ar
dunevd_pdfastsim_par_xe.DoFastComponent:        false          # Only slow Xe light
dunevd_pdfastsim_par_xe.VUVHits:                @local::dunevd_vuv_Xenon_hits_parameterization
dunevd_pdfastsim_par_xe.VISHits:                @local::dunevd_vuv_Xenon_anode_hits_parameteriszation
dunevd_pdfastsim_par_xe.IncludeAnodeReflections: true             # include Xenon light reflections f
dunevd_pdfastsim_par_xe.IncludePropTime:        true
dunevd_pdfastsim_par_xe.GeoPropTimeOnly:        true                        # Xe propoagation time geom
dunevd_pdfastsim_par_xe.VUVTiming:                          @local::dunevd_xe_timing_geo
dunevd_pdfastsim_par_xe.ScintTimeTool:          @local::ScintTimeXeDoping10ppm
dunevd_pdfastsim_par_xe.OnlyActiveVolume:         false
```

New VD Geometry: Tests

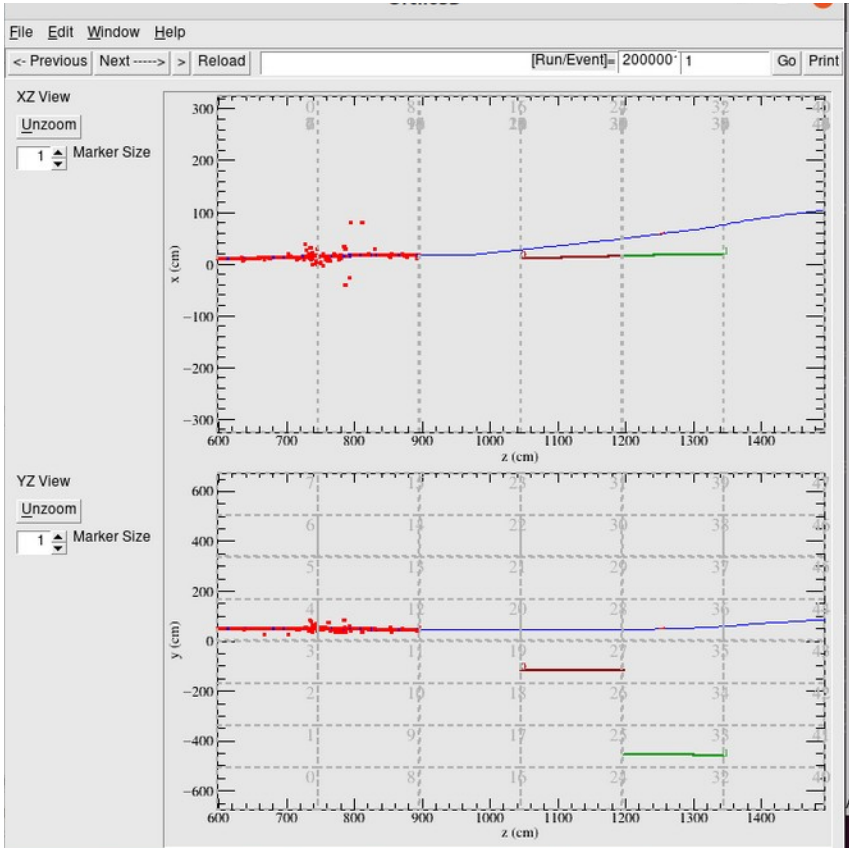
- Warnings in G4 stage

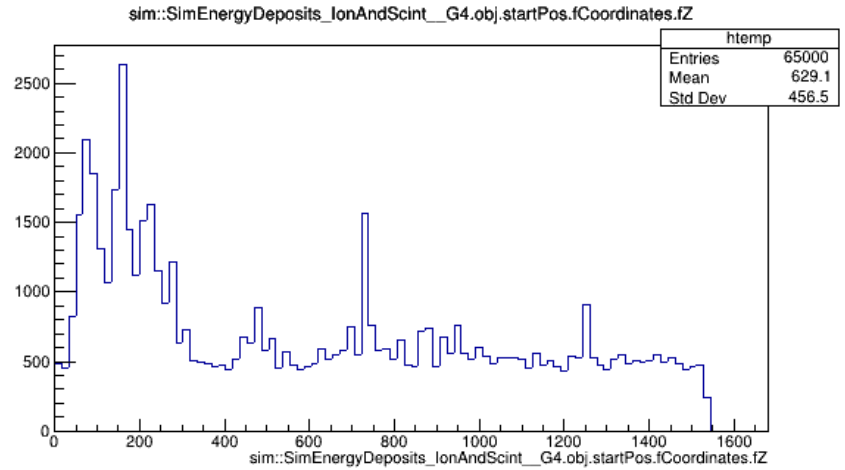
```
---- GeometryCore BEGIN
  Can't find any TPC at position (165.883,-111.937,1506.8)
---- GeometryCore END
```

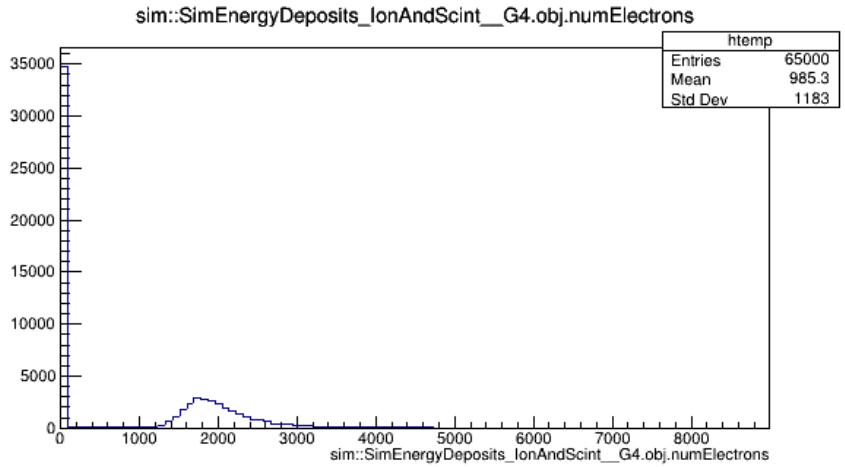
- Tests were done without changing the charge service configured in 1x8x14 option
- 100 $\nu\mu$ events from beam (prodgenie_nu_dunevd10kt_1x8x14_3view.fcl), starting point z=9.05m, available at /pnfs/dune/scratch/users/lpaulucc/1x8x14vdrift/reco_numu

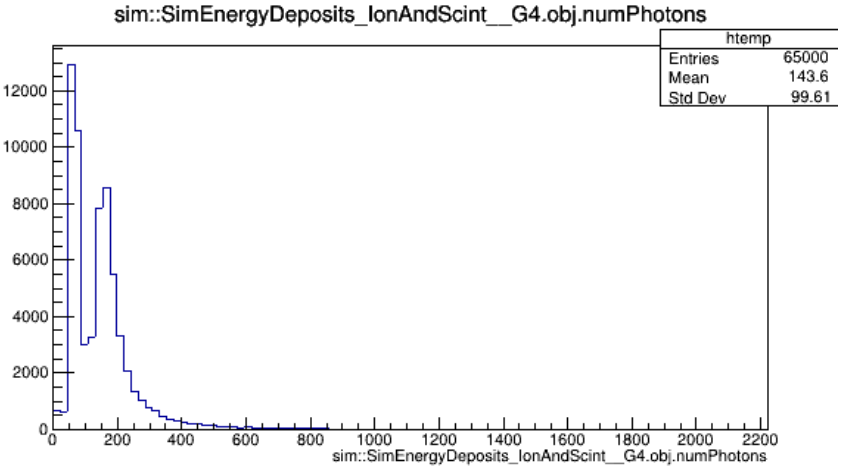
New VD Geometry: Tests

- Muon, starting point z=0



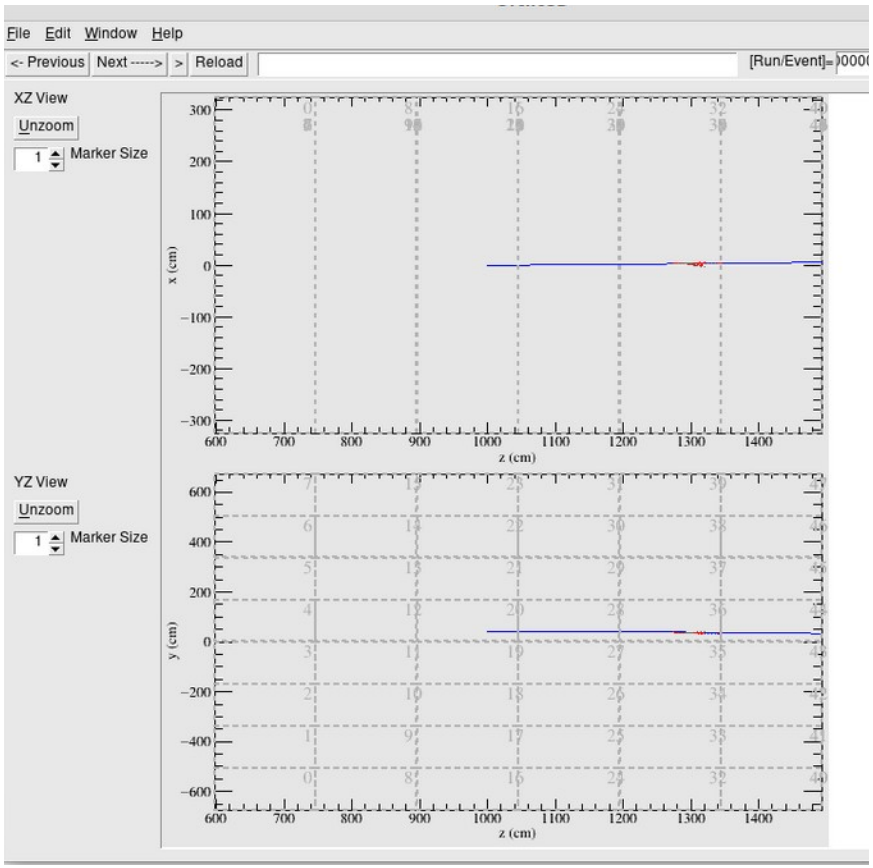


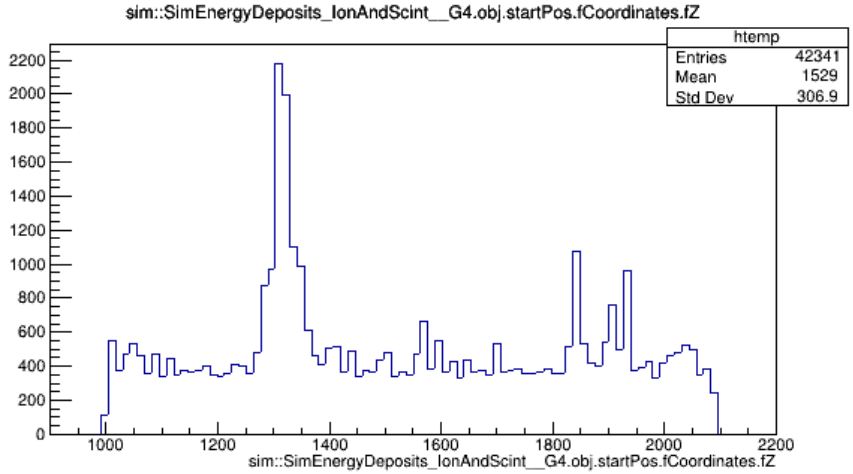


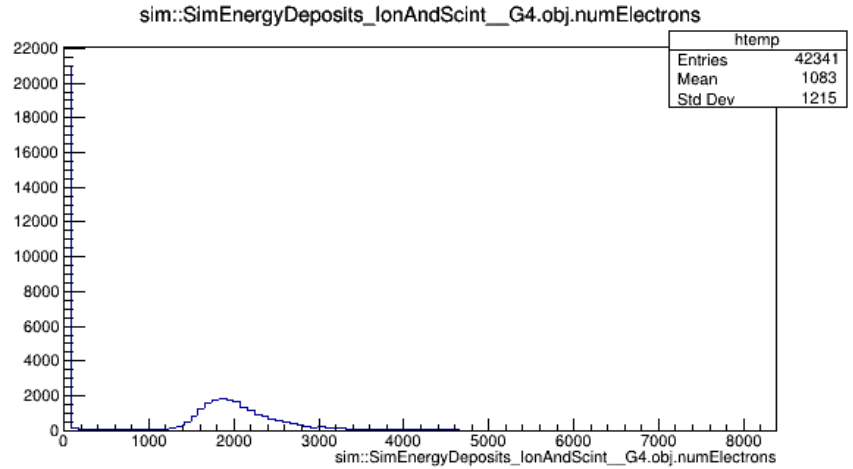


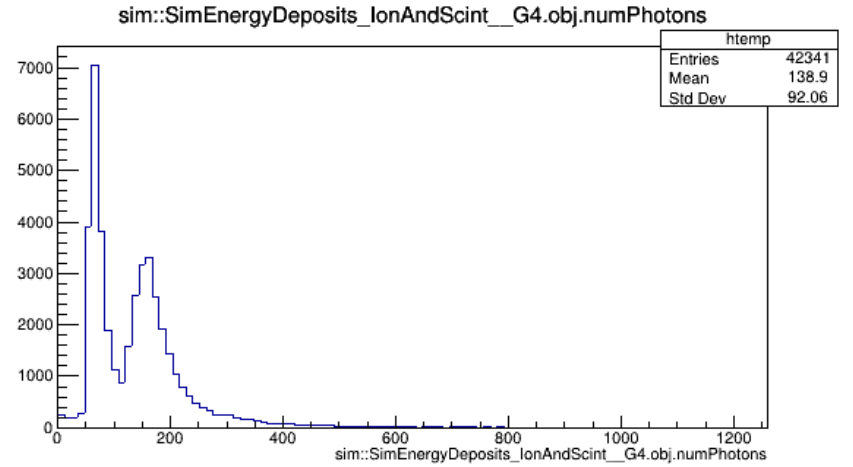
New VD Geometry: Tests

- Muon, starting point z=10m



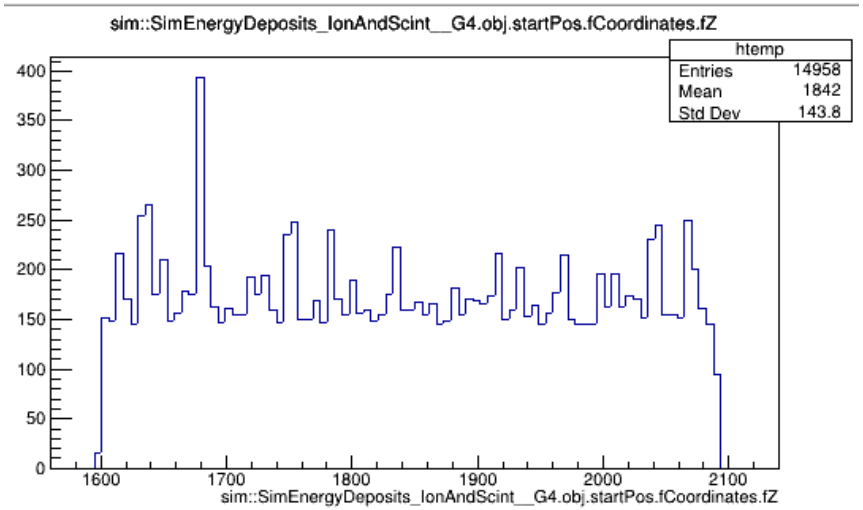


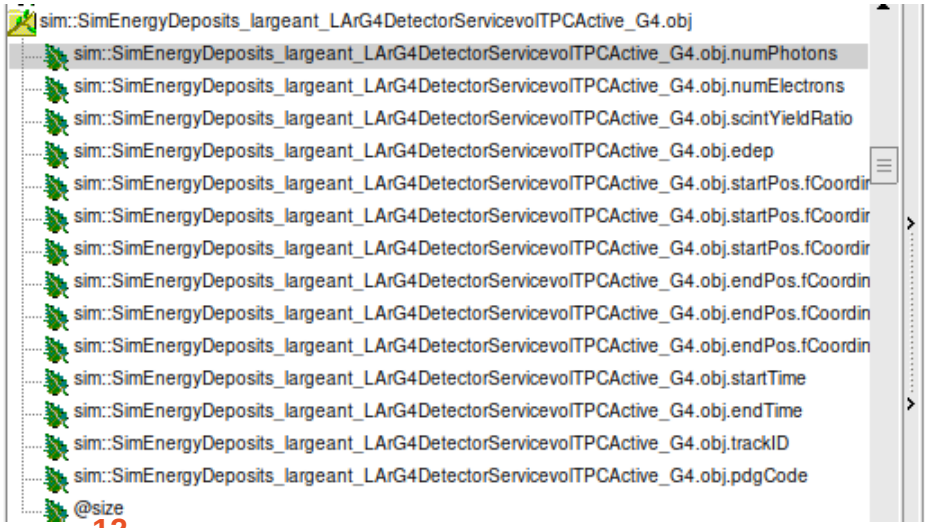


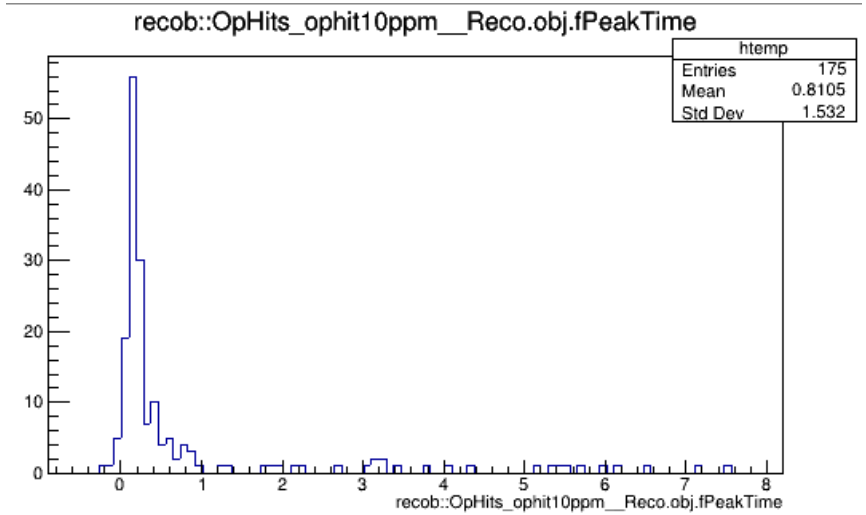


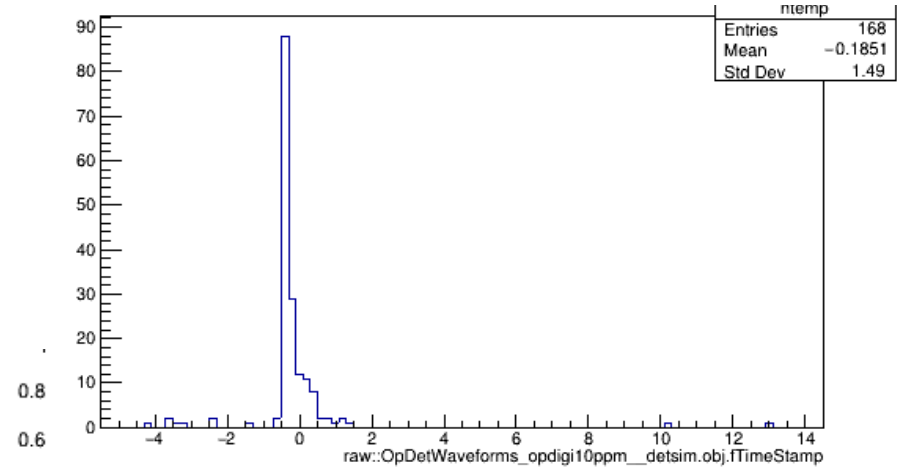
New VD Geometry: Tests

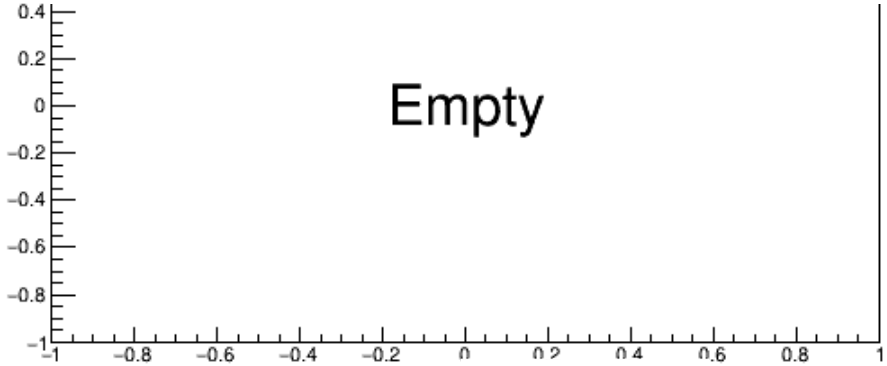
- Muon, starting point z=16m







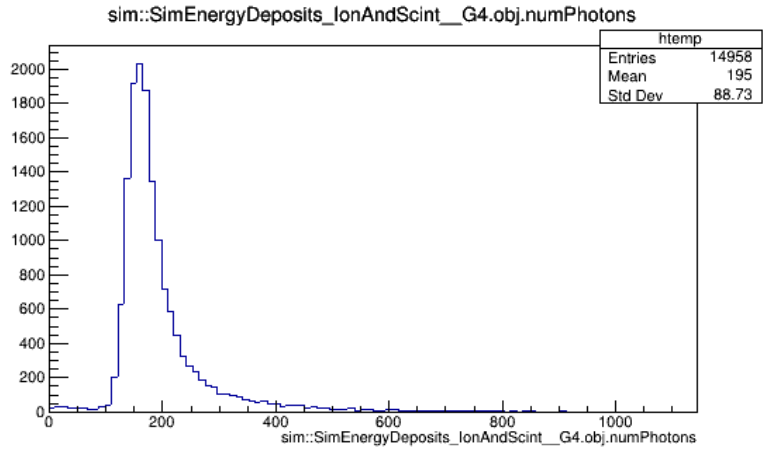


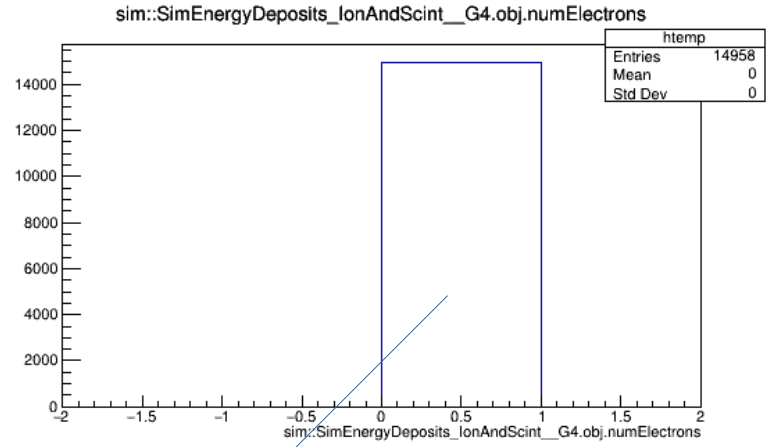


New VD Geometry: Tests

```
<volume name="volInternalActive">
  <materialref ref="LAr"/>
  <solidref ref="InternalActive"/>
  <auxiliary auxtype="SensDet" auxvalue="SimEnergyDeposit"/>
  <auxiliary auxtype="StepLimit" auxunit="cm" auxvalue="0.5208*cm"/>
  <auxiliary auxtype="Efield" auxunit="V/cm" auxvalue="500*V/cm"/>
  <colorref ref="green"/>
</volume>
```

- Muon, starting point z=16m

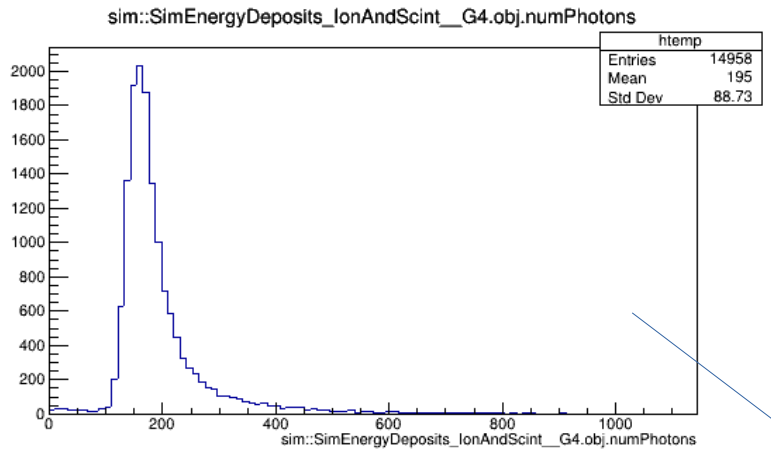


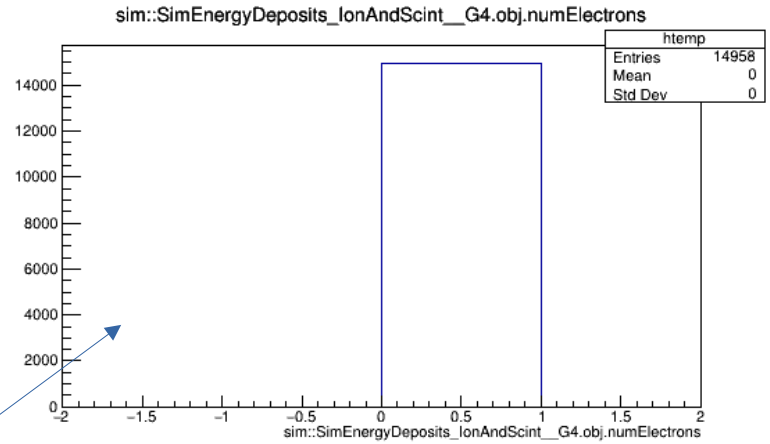



```
ISCalcCorrelated::EFieldAtStep(double efield, sim::SimEnergyDeposit const& edep)
{
  //electric field outside active volume set to zero
  if(!fISTPC.isScintInActiveVolume(edep.MidPoint())) return 0;

  //electric field inside active volume
  if (!fSCE->EnableSimEfieldSCE()) return efield;

  auto const eFieldOffsets = fSCE->GetEfieldOffsets(edep.MidPoint());
  return efield * std::hypot(1 + eFieldOffsets.X(), eFieldOffsets.Y(), eFieldOffsets.Z());
}
```

New VD Geometry: Tests

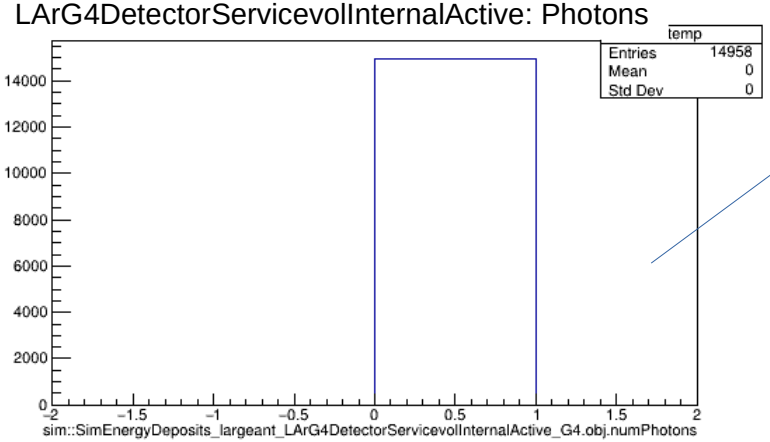
- Muon, starting point z=16m



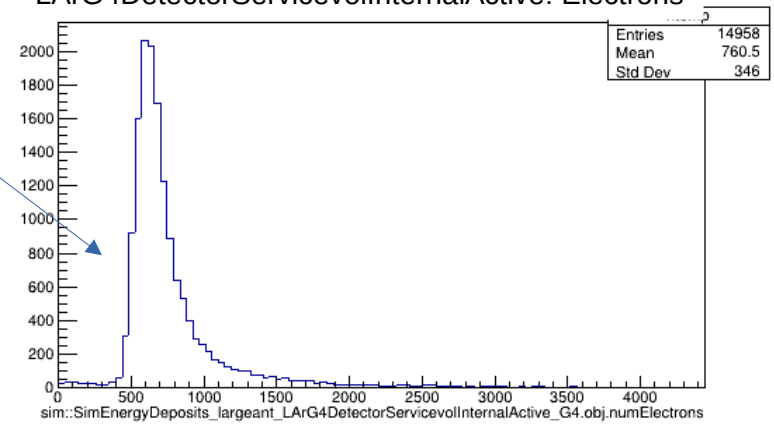


???

LArG4DetectorServicevolInternalActive: Photons

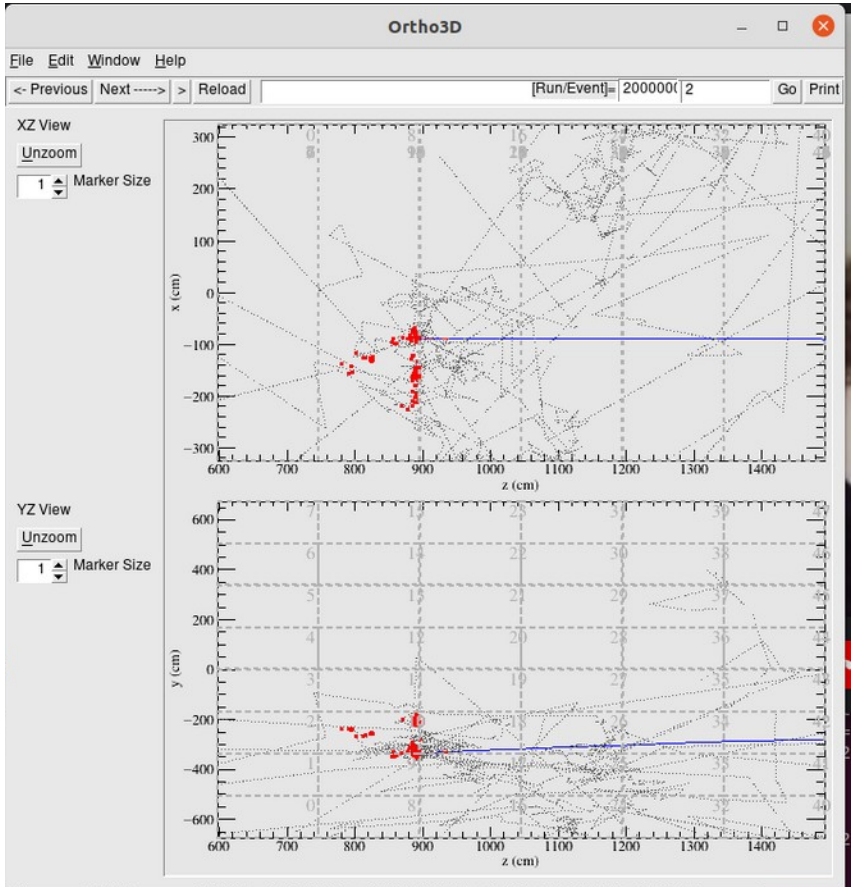


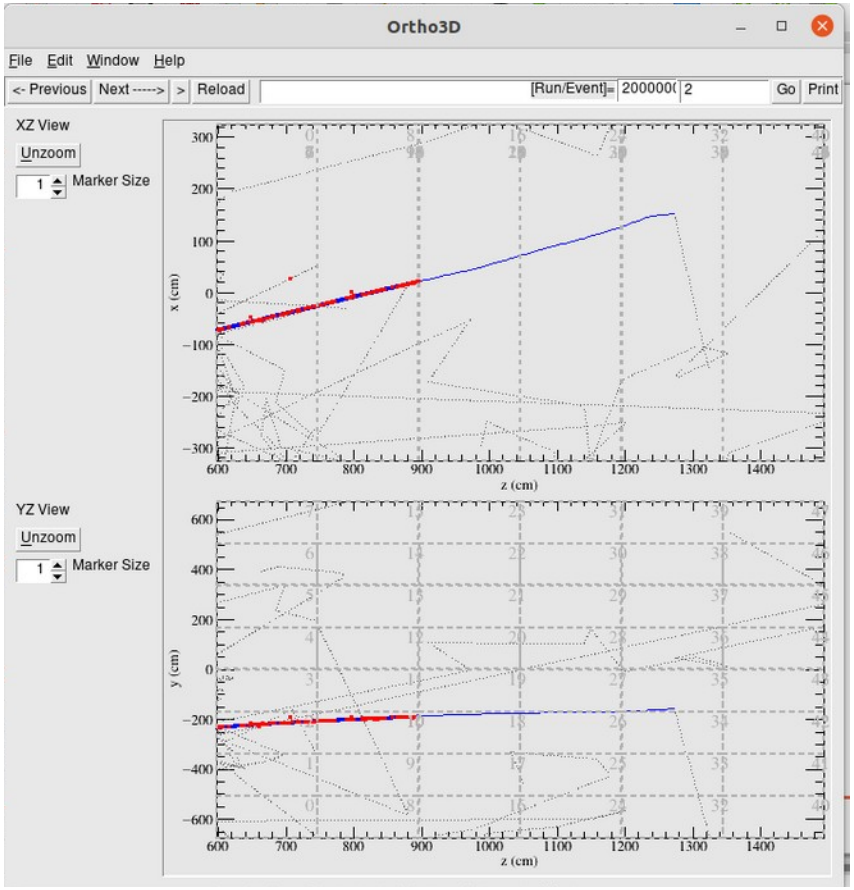
LArG4DetectorServicevolInternalActive: Electrons



New VD Geometry: Tests

- νμ, starting point z=9.05m





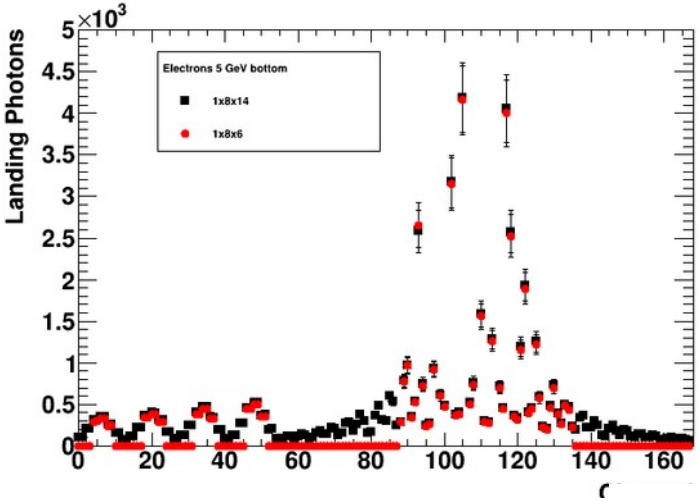
Summary

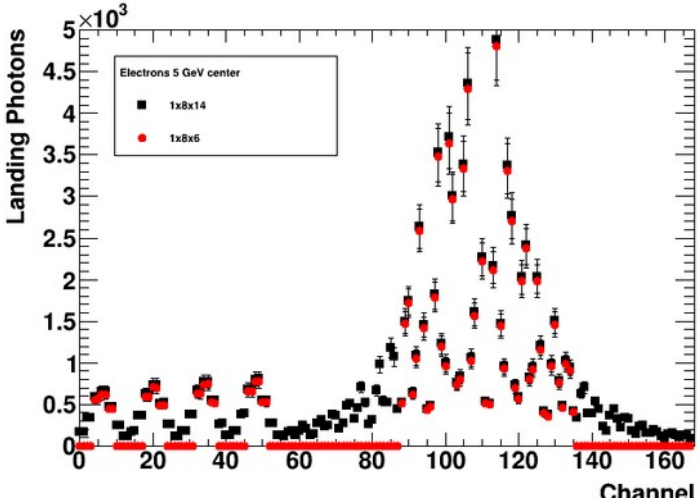
- Cathode added to geometry (important for background model)
- “Mixed” geometry (1x8x6 for charge and 1x8x14 for light) seems to be working
  - Need to check charge and light production in the volInternalActive
  - Advantage: no need of separate light only simulation
  - Possibility to have charge and light analysis combined
- Charge sim/reco may need changes?
  - Changes in branch lp_vdsim (dunesim, duneopdet, and dunesw)

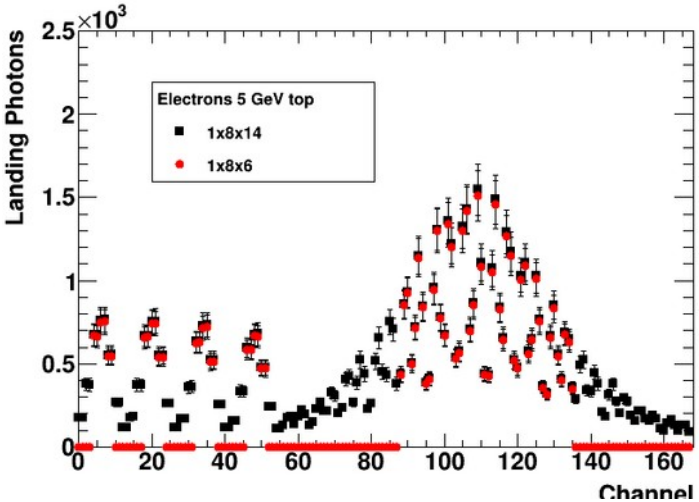
BACKUP

Comparison of light output for 1x8x6 and 1x8x14

- Electron source at z and x center of geometry and different y







VD Simulation: MC samples available (pure signal)

1. Beam events: light + charge in standard geometry (top volume, full width, full drift, **9 m in Z**)

2. Marley events: light + charge in standard geometry

3. Marley events: light only output in larger geometry (top volume, full width, full drift, **21 m in Z**)

Goals:
1. Tuning of reconstruction parameters
2. Evaluate the need of changes in reconstruction codes
3. Create and test new reconstruction algorithms

https://wiki.dunescience.org/wiki/PDS_Physics_and_Simulation_Working_Group#Monte-Carlo_samples