# LARSOFT FAST OPTICAL SIMULATIONS

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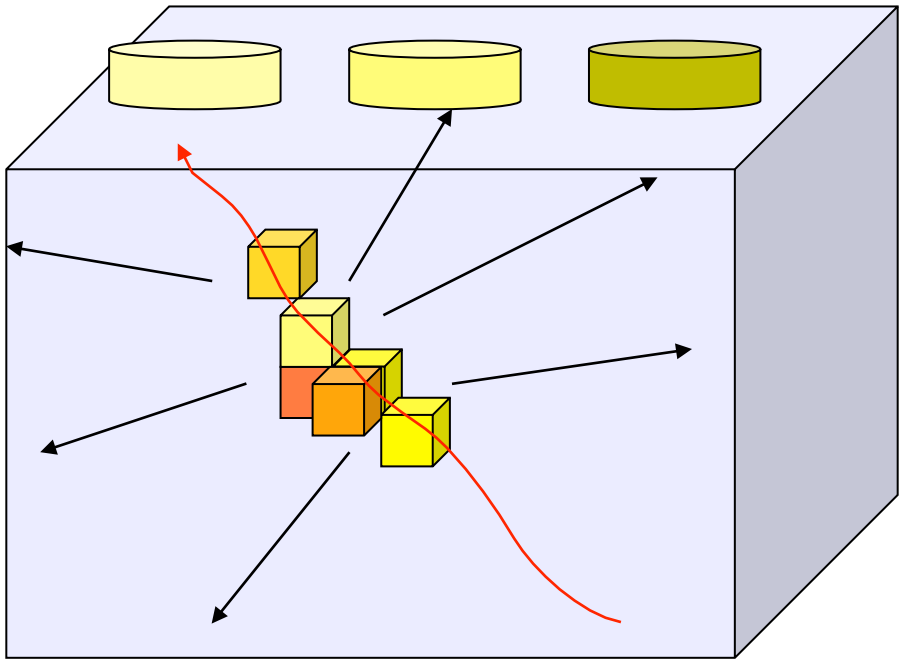
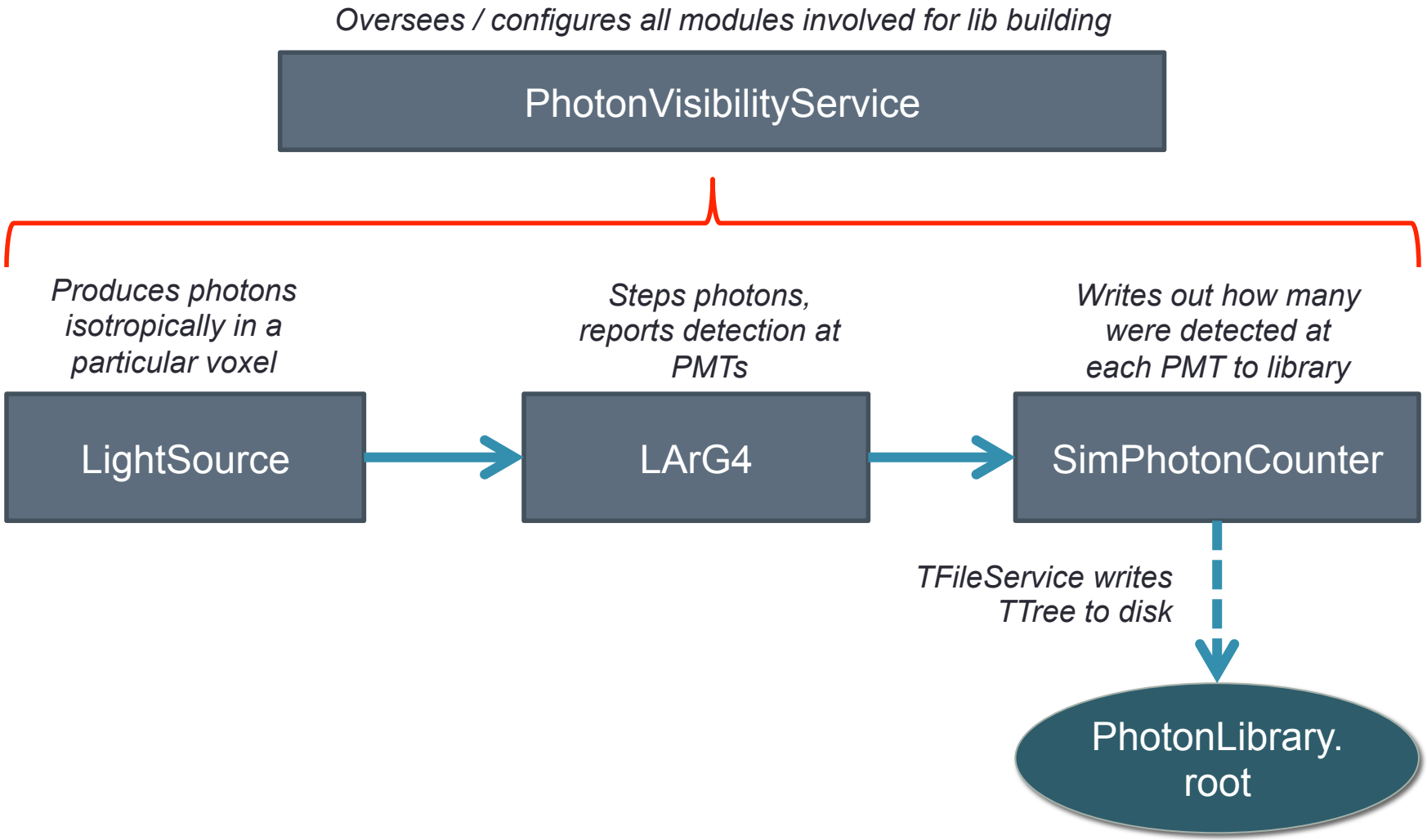
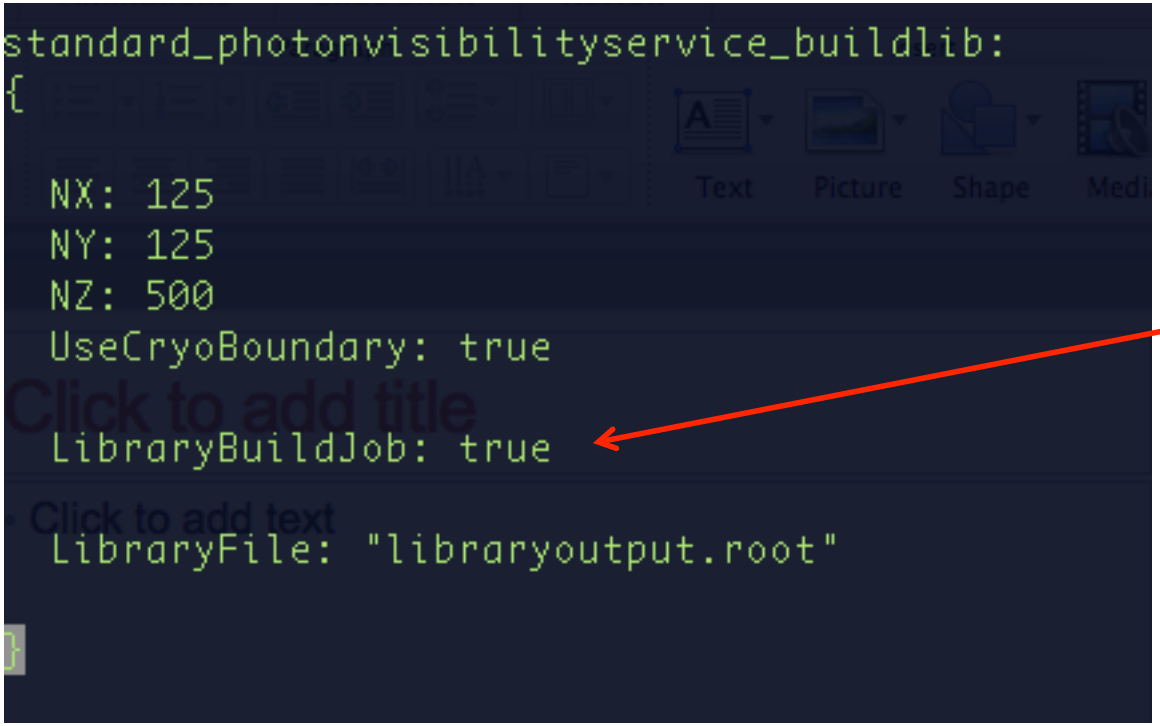
# Optical Simulations in LArSoft

- Geant4 photon stepping sim has existed for some time in LArG4
- Very slow – at full photon yield, one event takes days
- Solution : fast voxel sampling simulation



# Library Building Tools






This being true sets light source event generator and SimPhotonCounter to interface with PhotonVisibilityService to build library entry for a specified set of voxels

# Library Building Tools – Grid Stuff

## root / trunk / PhotonPropagation

| Name | Size | R |
|---|---|---|
| LibraryBuildTools | | |
| GNUmakefile | 998 Bytes | |
| PhotonLibrary.cxx | 3.3 kB | |
| PhotonLibrary.h | 867 Bytes | |
| PhotonLibraryAnalyzer_module.cc | 5.8 kB | |
| PhotonVisibilityService.h | 2.2 kB | |
| PhotonVisibilityService_service.cc | 7.5 kB | |
| photpropservices.fcl | 614 Bytes | |

## root / trunk / PhotonPropagation / LibraryBuildTools

| Name | Size | Revision | Age |
|---|---|---|---|
| AssembleSingleFile.C | 1.9 kB | 3452 | 14 days |
| CombineIntoLibrary.sh | 508 Bytes | 3446 | 15 days |
| CopyScript.sh | 302 Bytes | 3446 | 15 days |
| OpticalLibraryBuild_Grid.sh | 4.1 kB | 3446 | 15 days |
| SubmitCommand.sh | 422 Bytes | 3446 | 15 days |
| prodsingle_buildopticallibrary.fcl | 3.2 kB | 3446 | 15 days |

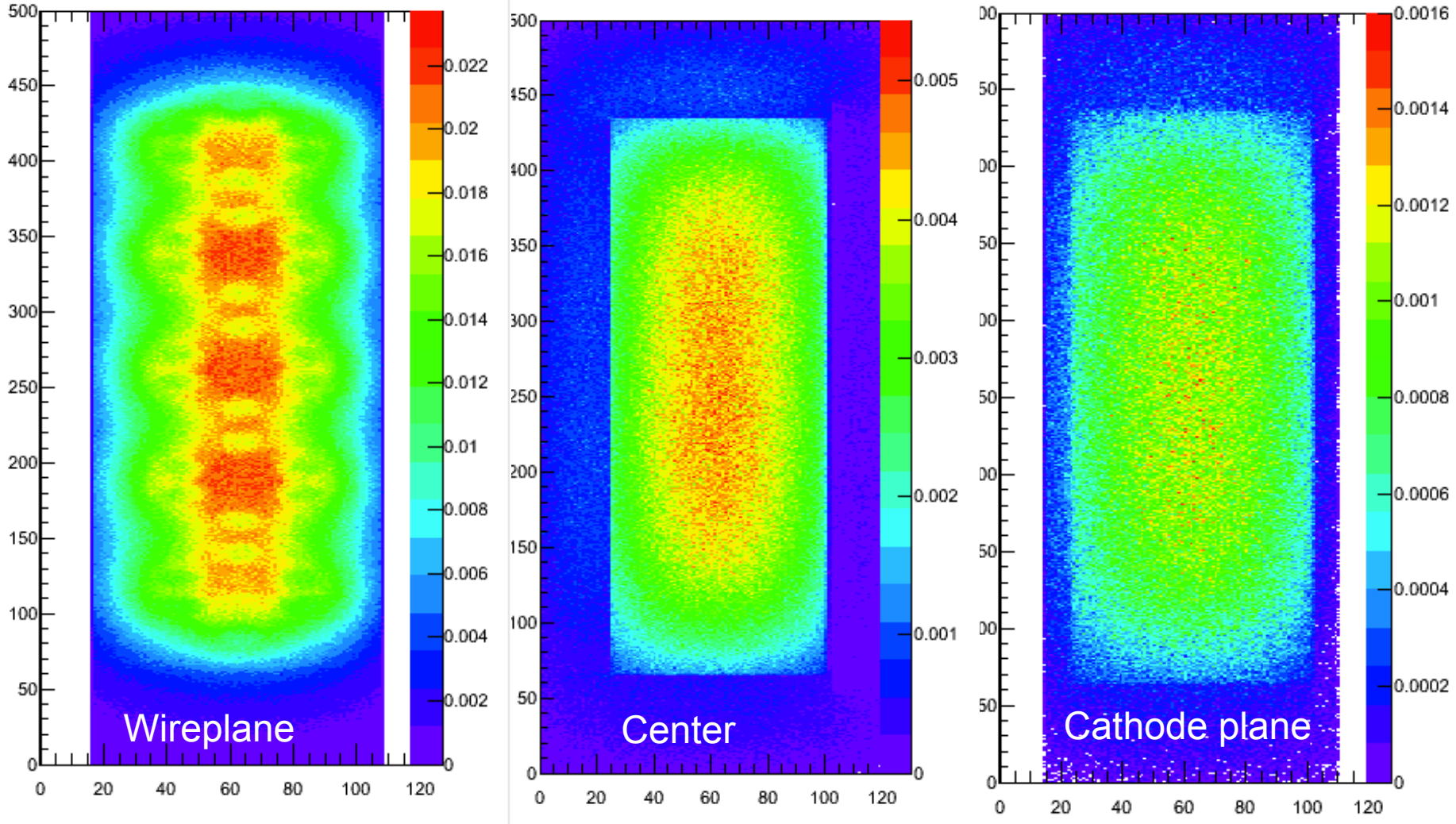
# Big Grid Job

- 1.2 trillion photons simulated, 220,000 cpu hours.
- Job submitted in 3 batches. Each batch is 50,000 photons per voxel (~3cm x 3cm x 3cm).
- After all jobs completed, all library output files are zipped into one big root file, representing whole detector (120mb)

- First batch finished completely successfully. Second and third had missing files due to frozen release problems.
- Results so far use only the first batch.
- This is fine, since all batches contain all voxels.

root / trunk / PhotonPropagation / PhotonLibraryAnalyzer_module.cc

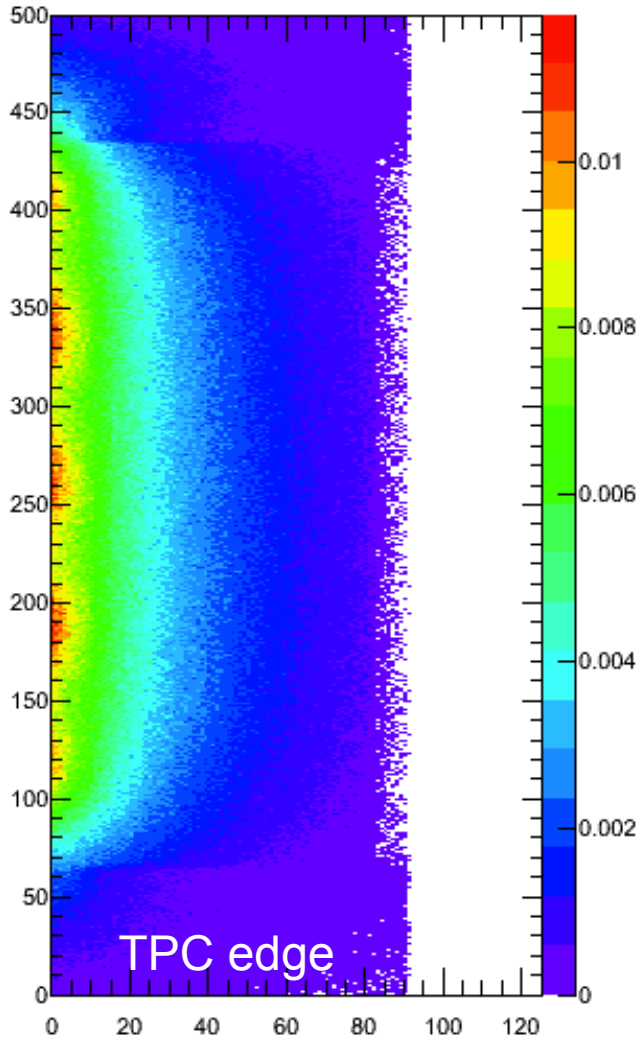
History | View | Annotate | Download (5.8 kB)

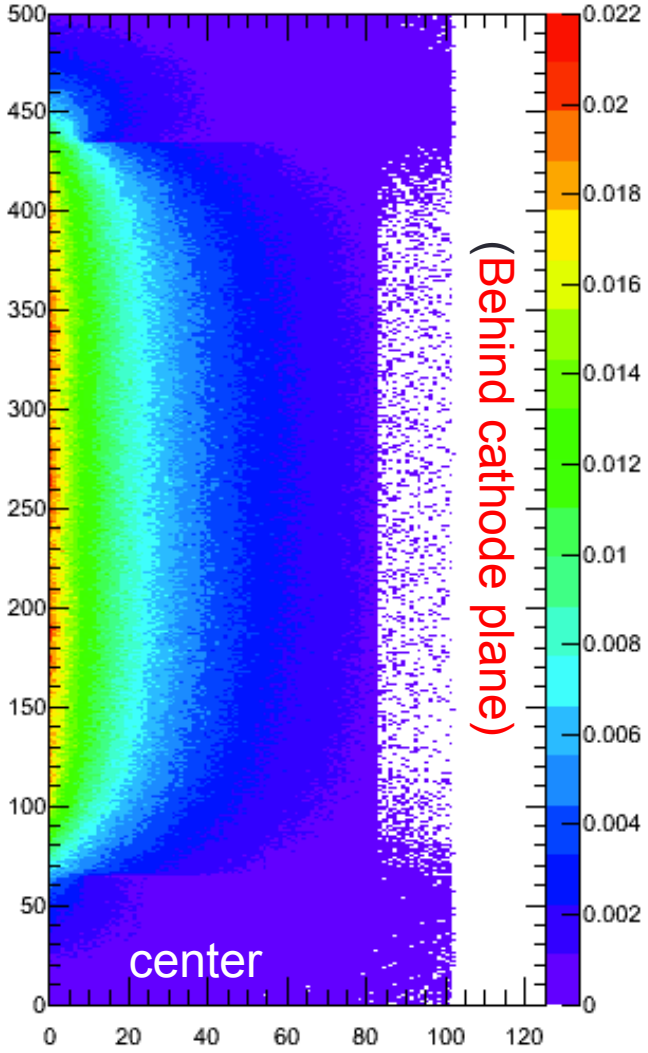



**Library analysis tool – X slices**

# root / trunk / PhotonPropagation / PhotonLibraryAnalyzer_module.cc

History | View | Annotate | Download (5.8 kB)

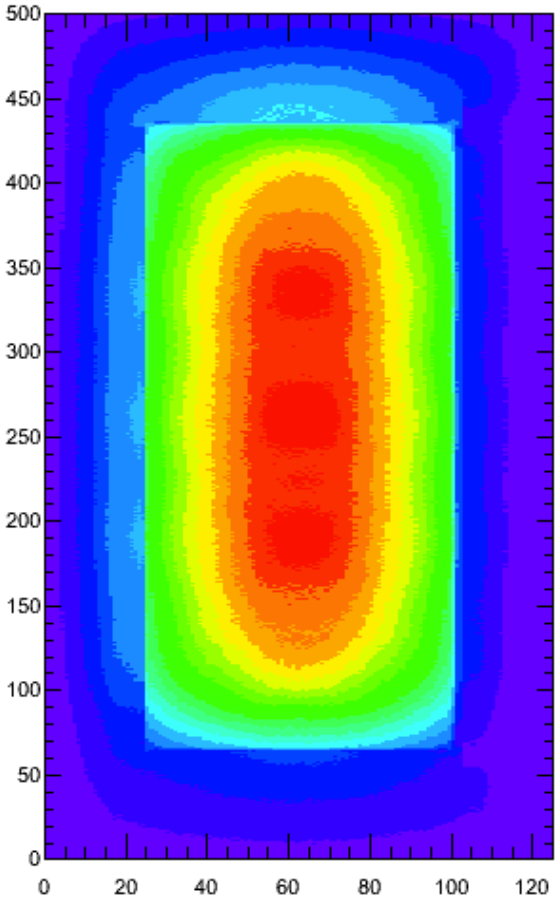


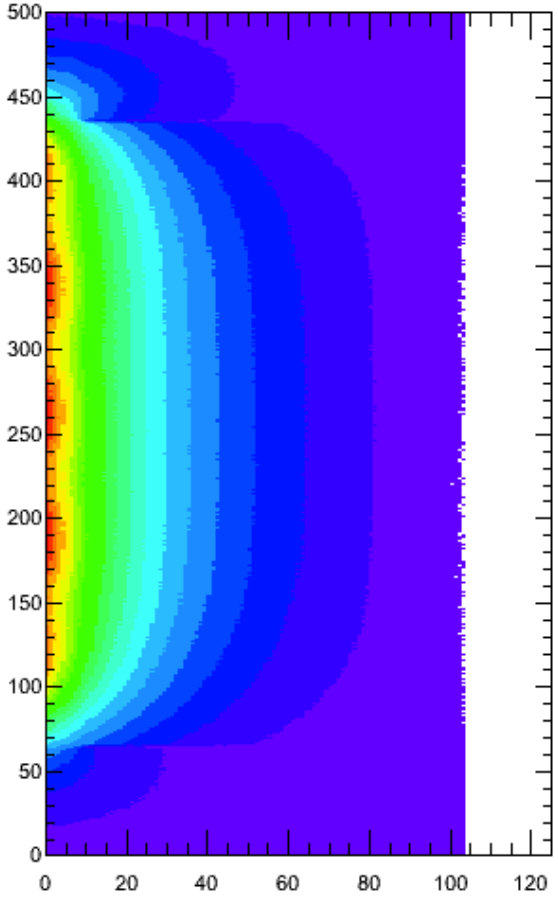



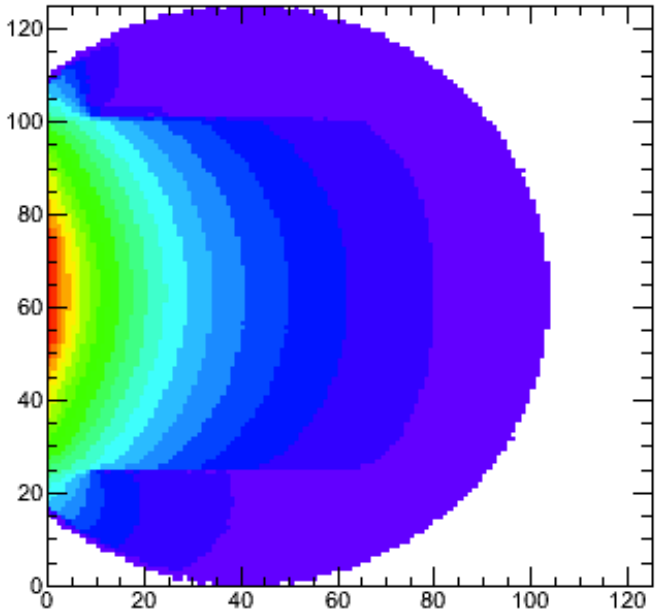

**Library analysis tool – Y slices**

# root / trunk / PhotonPropagation / PhotonLibraryAnalyzer_module.cc

History | View | Annotate | Download (5.8 kB)




*Note the x shift – apparently I have a slight coordinate system issue.*

**Library analysis tool - XYZ projections**

*So no data yet for particles behind wire plane.*

# Library Sampling Routines

**PhotonPropagation:**

- All library sampling is handled via the PhotonVisibilityService, which owns a PhotonLibrary object.
- The PhotonLibrary is loaded at startup if the PhotonVisibilityService is enabled. Loading takes about 2-3 minutes.
- In future we can discuss trading load-time for voxel size.

**LArG4:**

- A new physics constructor, FastOpticalPhysics, has been added to LArG4. Also a new physics process, OpFastScintillation.
- OpFastScintillation samples the PhotonLibrary, rather than putting photons on the geant4 stack
- Also a rehash of how LArG4 keeps track of detected photons / sensitive detectors (technical details, no need to report today)

# OpFastScintillation

- OpFastScintillation process is based on Geant4 G4Scintillation.
- But now it's a LArSoft class, we have more opportunity to control the physics. In particular, added ability to control scintillation yields:

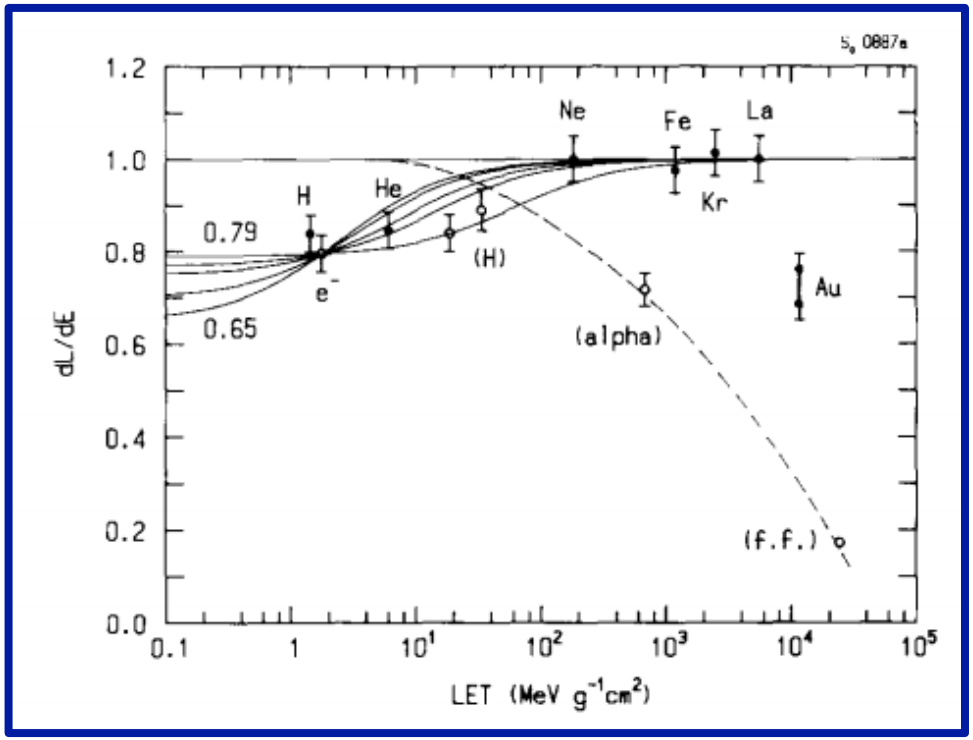
**Supplied in LArProperties, fed through G4 via MaterialPropertiesLoader**

```
ScintByParticleType:   false          #
                                      #

# Scintillation yields and fast/slow r

MuonScintYield:           24000
MuonScintYieldRatio:      0.23
PionScintYield:           24000
PionScintYieldRatio:      0.23
ElectronScintYield:       20000
ElectronScintYieldRatio:  0.27
KaonScintYield:           24000
KaonScintYieldRatio:      0.23
ProtonScintYield:         19200
ProtonScintYieldRatio:    0.29
AlphaScintYield:          16800
AlphaScintYieldRatio:     0.56


EnableCerenkovLight: true        # whet
```

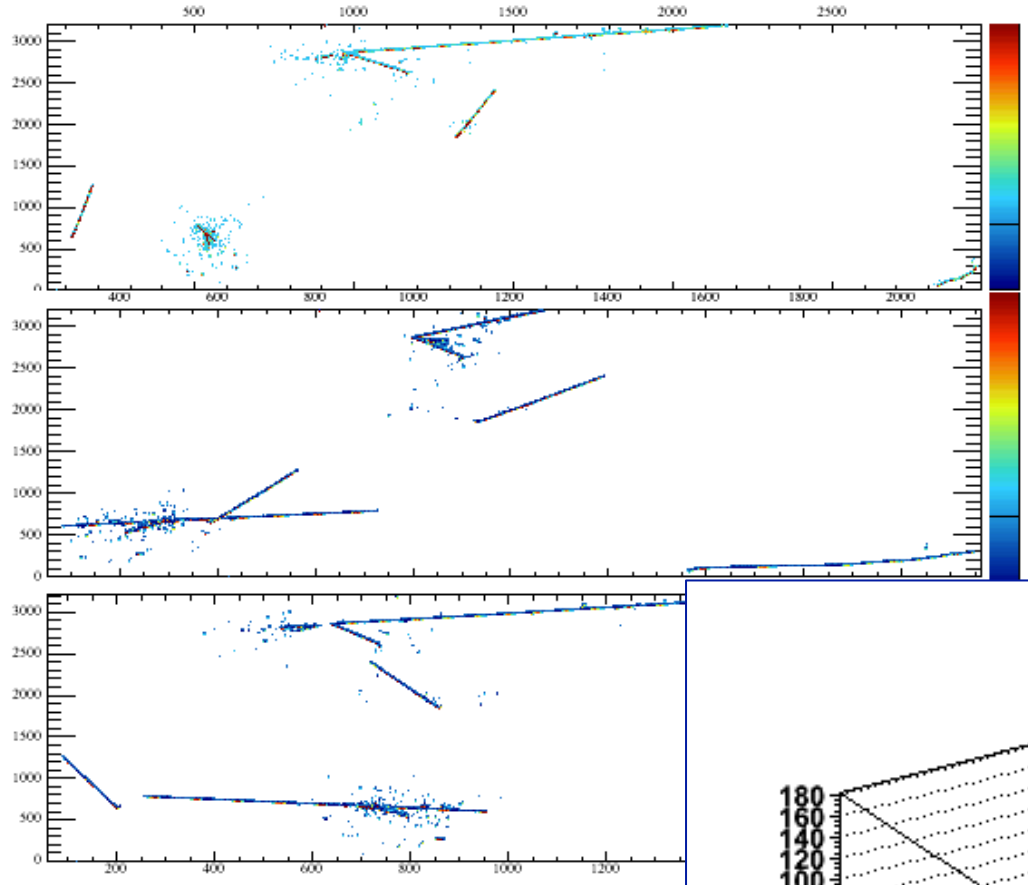


# How Fast Is Fast?

- Benchmarked with single particle event generator

- **No Light:** 19.8 s
- **Full Sim:** > 6 h
- **Fast Sim, No Cerenkov:** 28.2 s
- **Fast Sim, With Cerenkov*:** 140.8 s

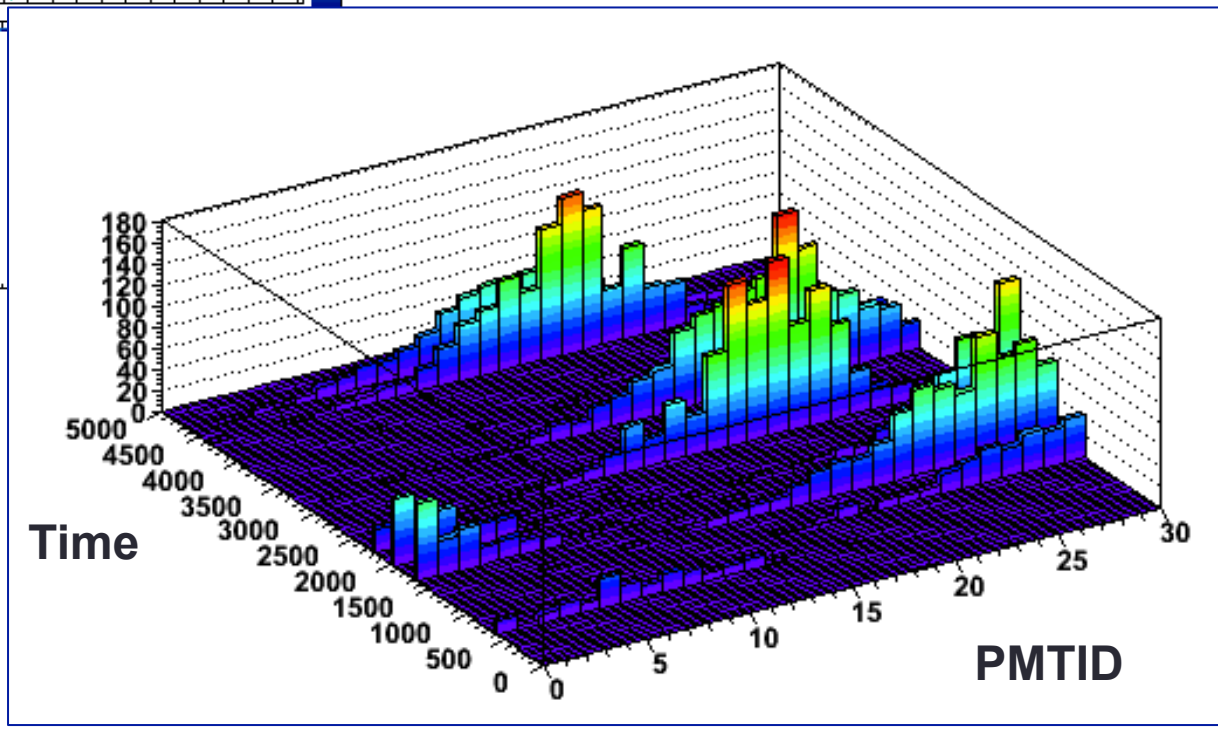
- * Caveat : Cerenkov light not being produced over entire spectrum. This needs fixing.



# Test Event

Thanks to Sarah L for providing overlaid cosmics + neutrino events

Simulated light from all particles over 3 frames

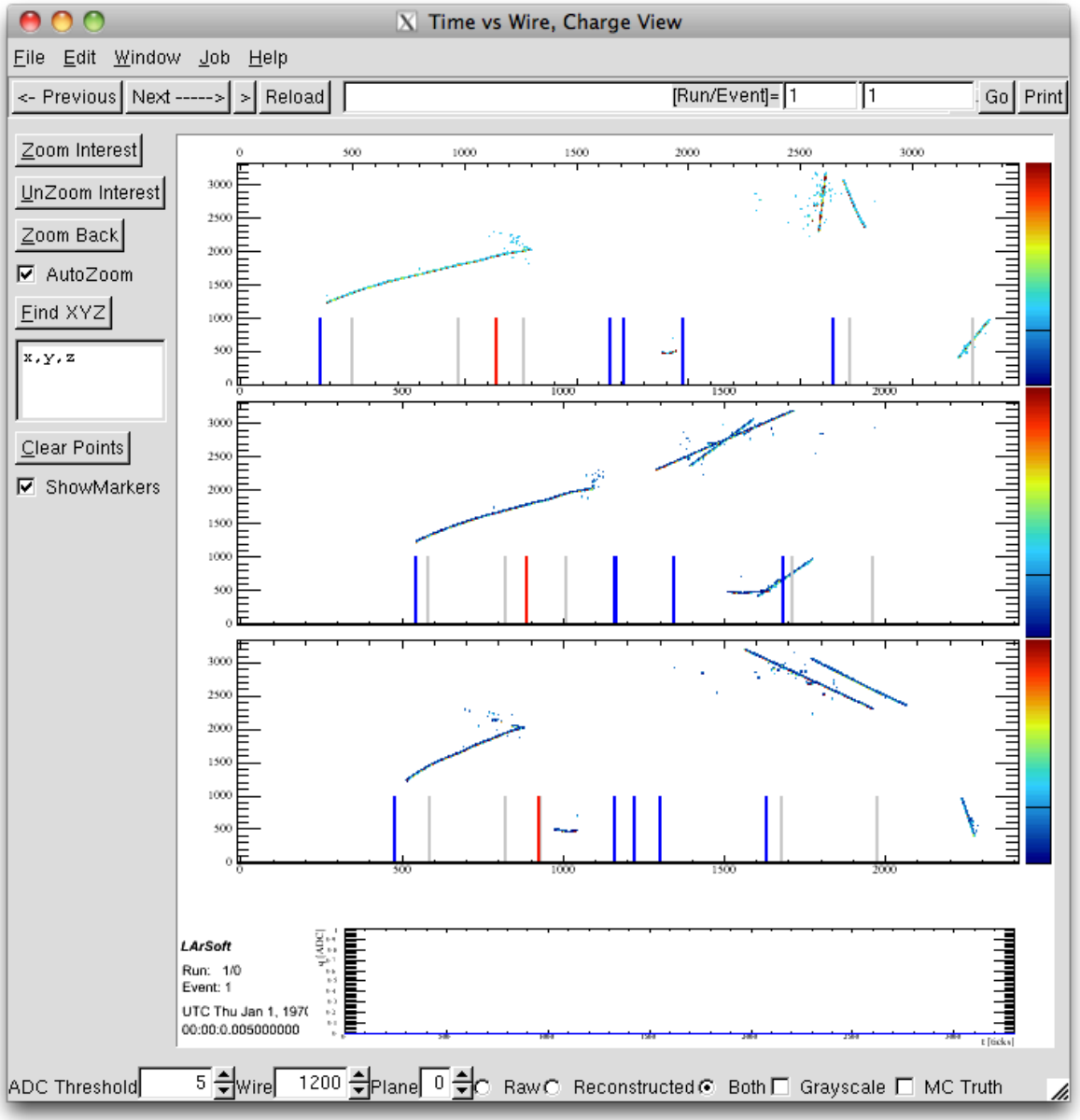


# Flash Finding

Geometrical center of on-beam-time flash shown in RED

**This has gone through the entire chain of simulation, signal digitization, deconvolution, hit finding, and flash finding.**

Not perfect. But not bad for a first pass.



# Next up:

- Tune up of digitization, hit finding, flash finding modules
- Work with Sarah to insert optical reconstruction code into cosmic rejection modules
- Quantitative studies of light from important event classes (CCQE, e/gamma, etc)
- On target to have light MC in standard uboone MC chain by Christmas.