LArIAT Light Readout

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Introduction

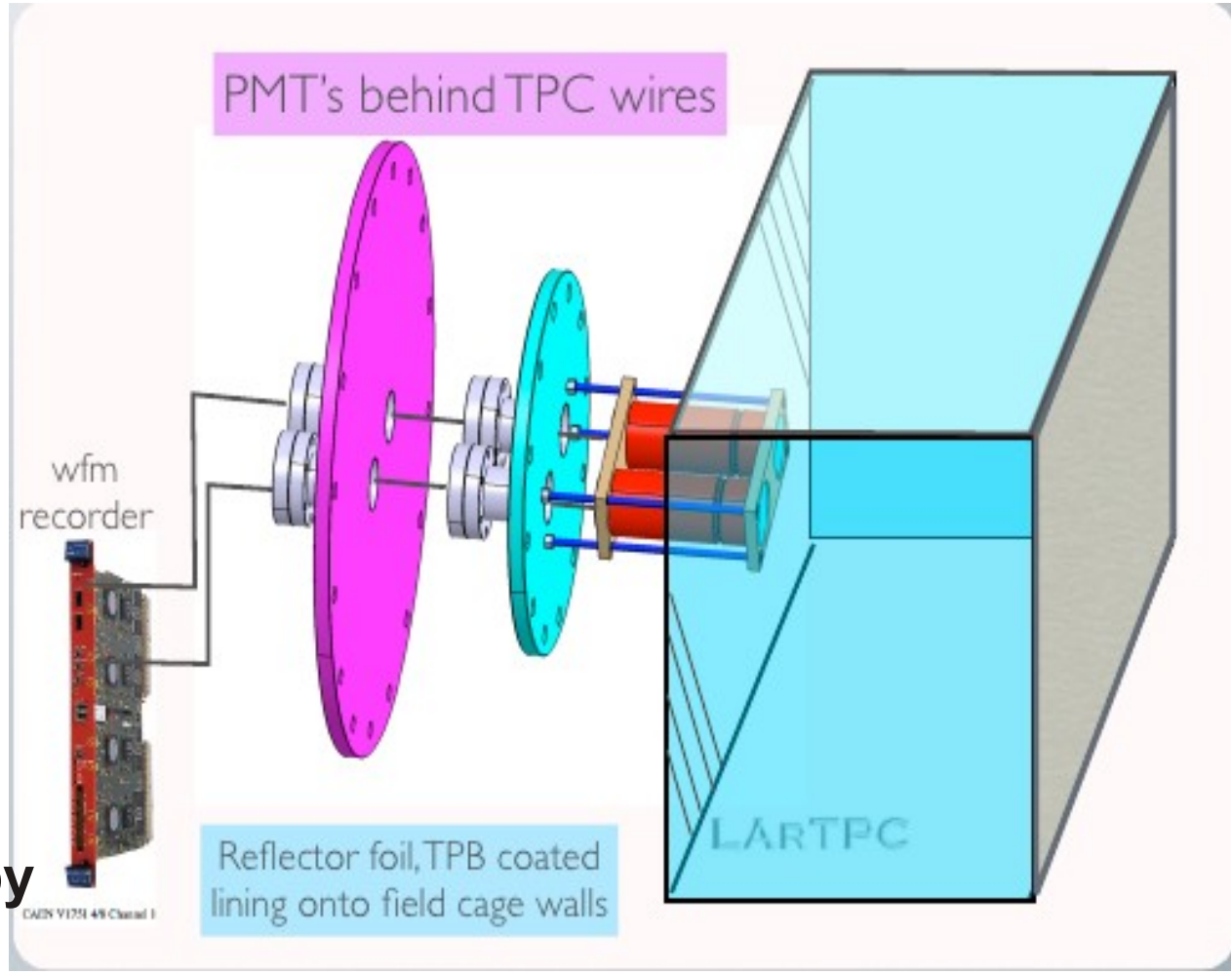
- Most Neutrino detectors use LAr Scintillation light as an indication of t_o and as a hint of the track location.
- There is a lot information in there, that we are leaving behind.
- Dark Matter detectors use scintillation for calorimetric reconstruction.
- Could we combine that measurement with that usually obtained by TPC?
- LArIAT is a TESTbeam experiment, so we can try to see what can be done.

The Light Readout System in LArIAT

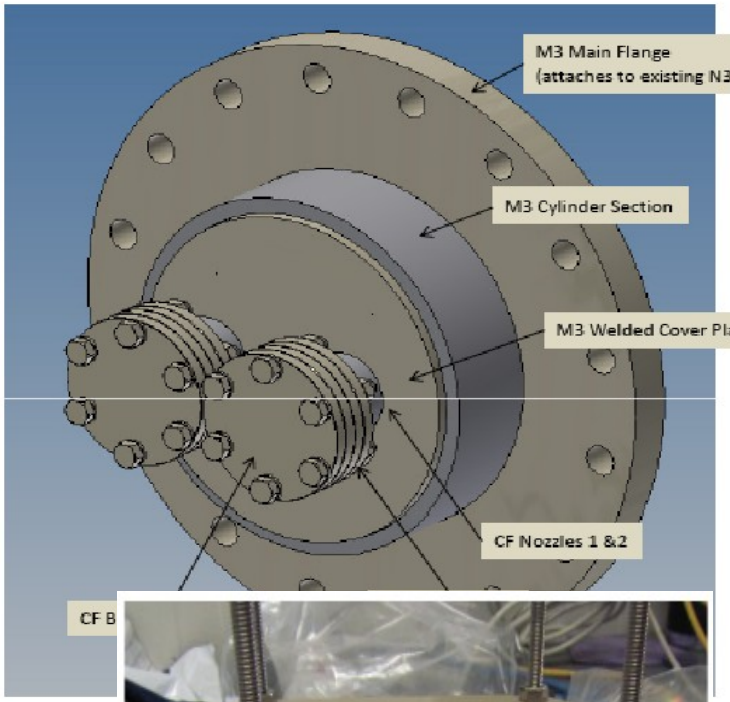
- ArgoNeuT planned to install PMTs in its second run.
- LArIAt has inherited the Cryostat and TPC and so we can work with what was designed for that system.
- The system is small enough so we can hope to cover large parts of it with Wavelength Shifter + reflector foils increasing the uniformity of Light Collection.
- We want to collect much more light than typical neutrino experiments and digitize it fast enough to differentiate fast and slow light.

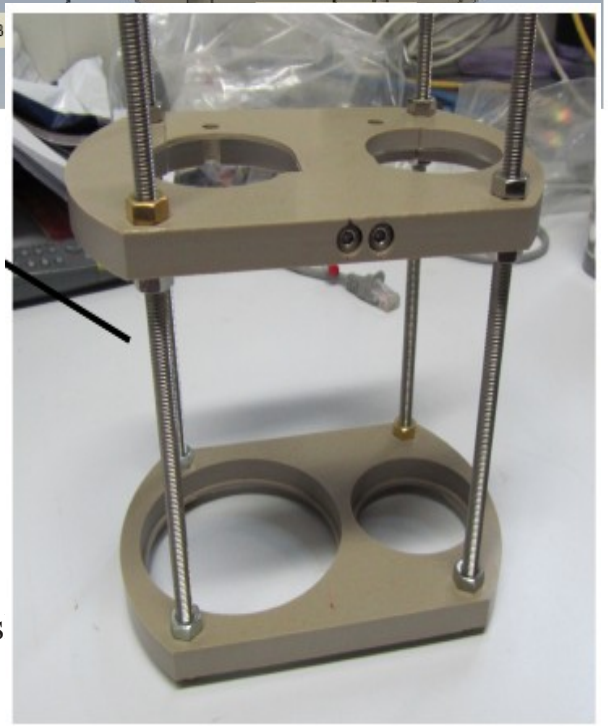
The System

- **an array of 2 PMTs, operating at cryogenic temperature,**
- **highly reflecting foils (VIKUITY) coated by a thin TPB film on the inner surfaces of the field cage**
- **In this setup the scintillation VUV photons are wl-shifted into visible photons when hitting the TPB and then reflected from the mirror surfaces beneath, up to collection by the PMTs.**



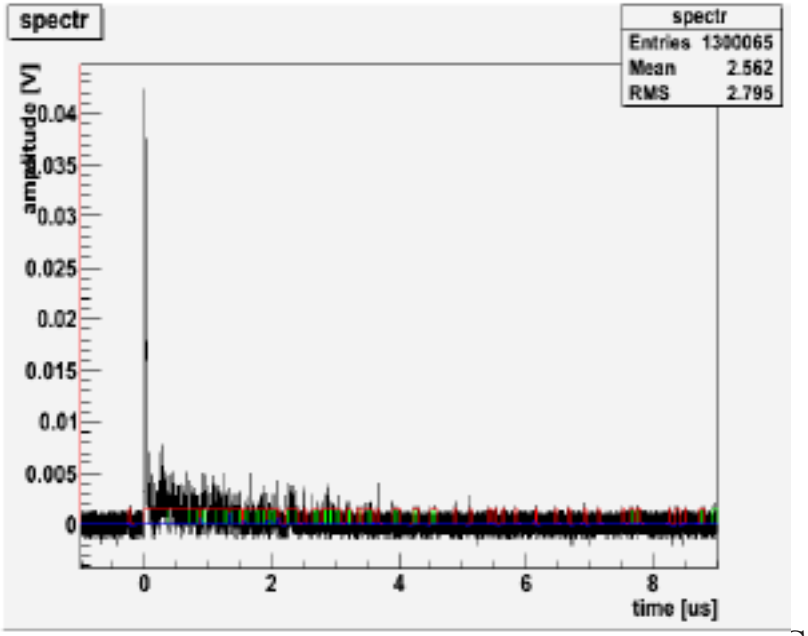
Mounting the PMTs

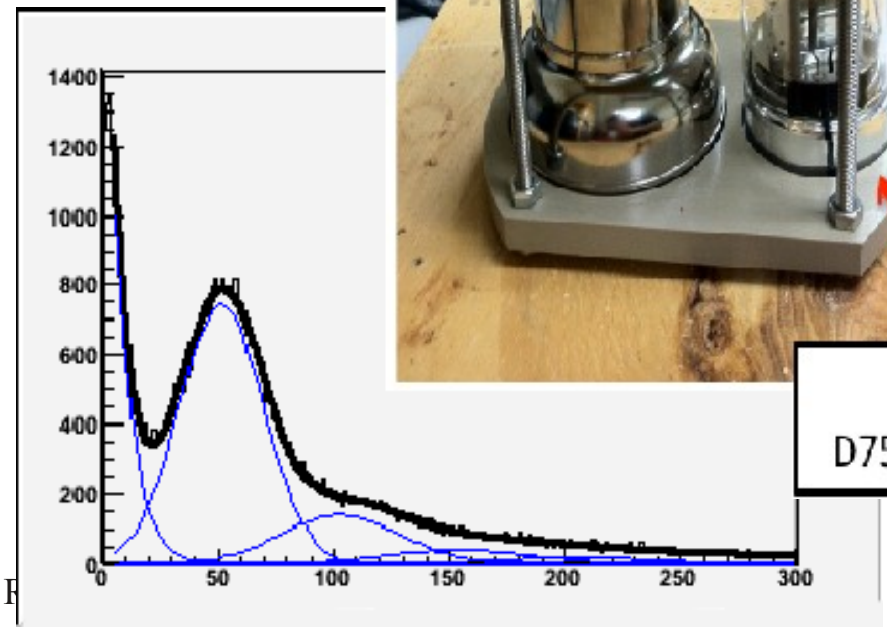


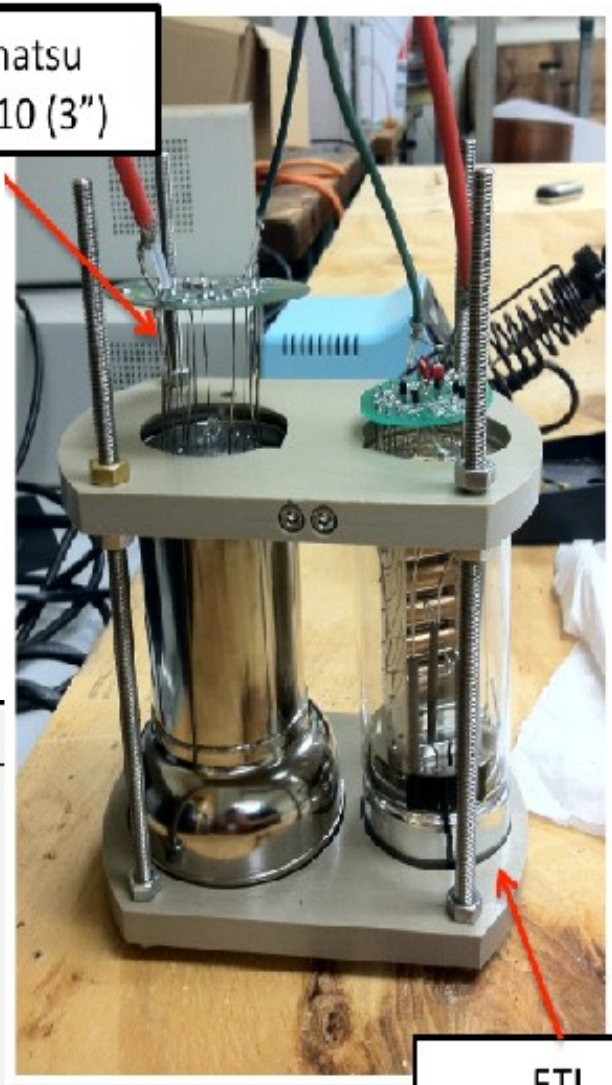


DAQ + readout

- Readout using a CAEN V1751 fast ADC
- Have used a board like this and have code ready.
- Extracing single phels from the tail of the signals



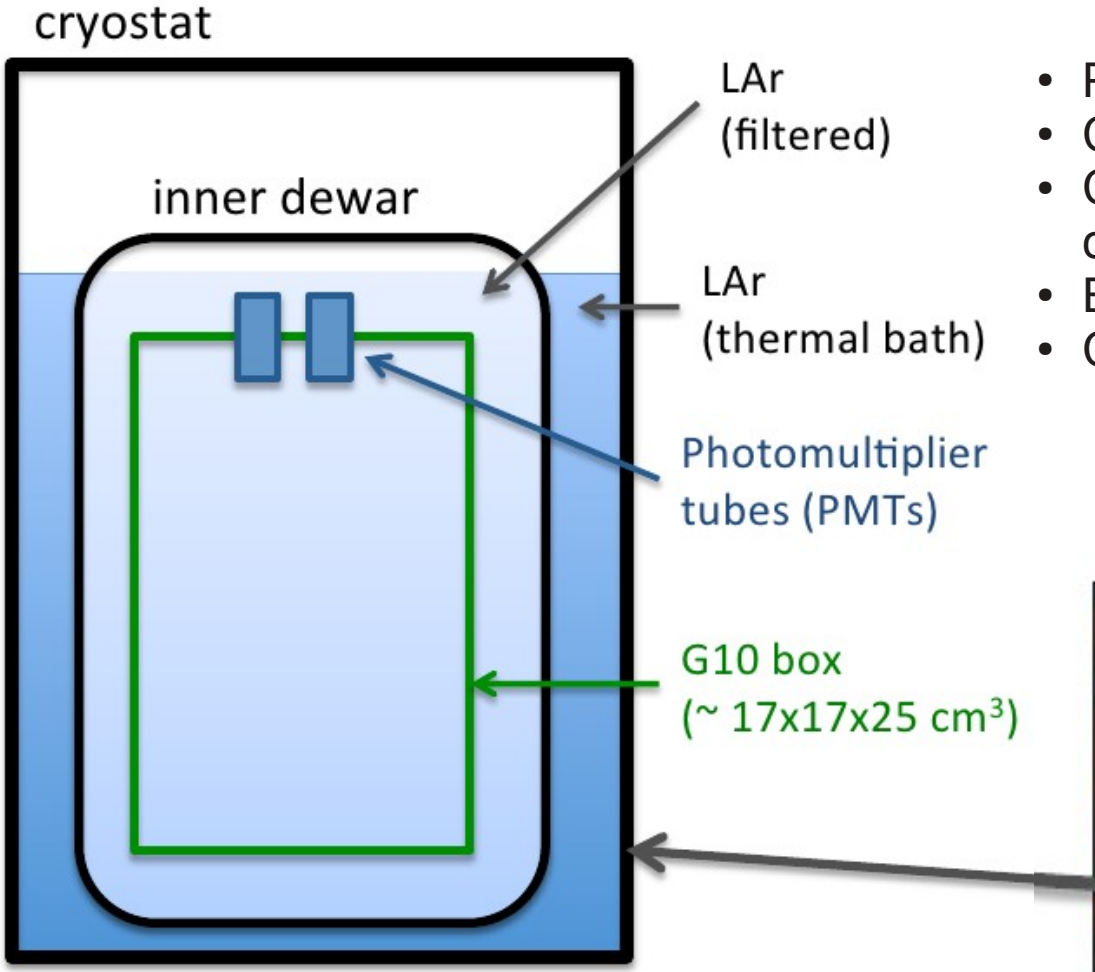




Tests With a Small Chamber

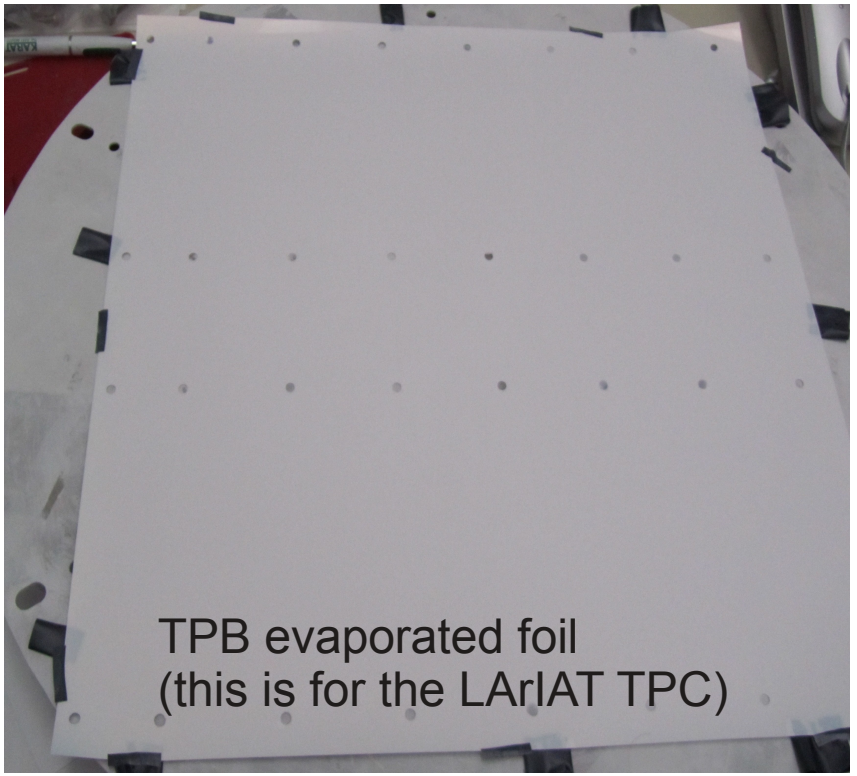
- Before we put this setup into the LArIAT cryostat we would like to make sure it works.
- Will test the components with a smaller chamber at University of Chicago.
- Building a small mock-TPC out of the G10 used to construct the actual ArgoNeuT/LArIAT TPC.
- Test will serve to make sure that the system is plug-and-play when we install in M-Center
- And constrain some of the parameters of our MC simulation.

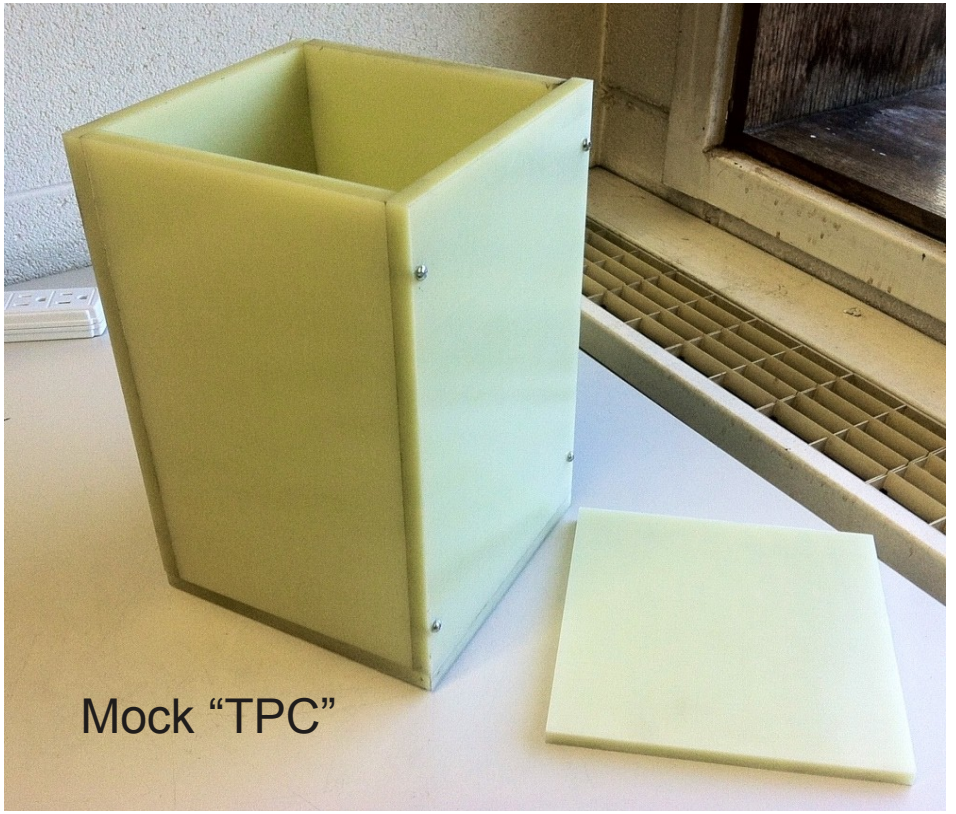
The Components(1)



- PMTs inside a vacuum pumped dewar
- Cooling via external bath
- Constructed G10 box, which will be covered with TPB covered foils.
- External Muon paddles as trigger.
- Can trigger internally on coincidence.

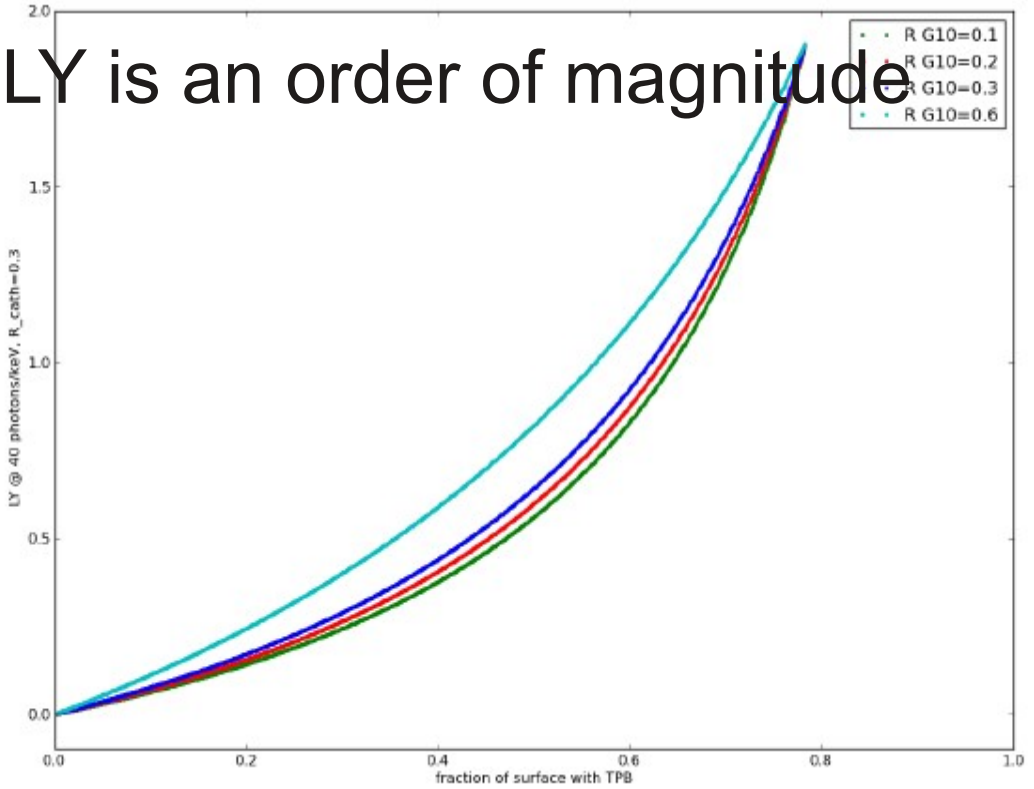
The Components (2)



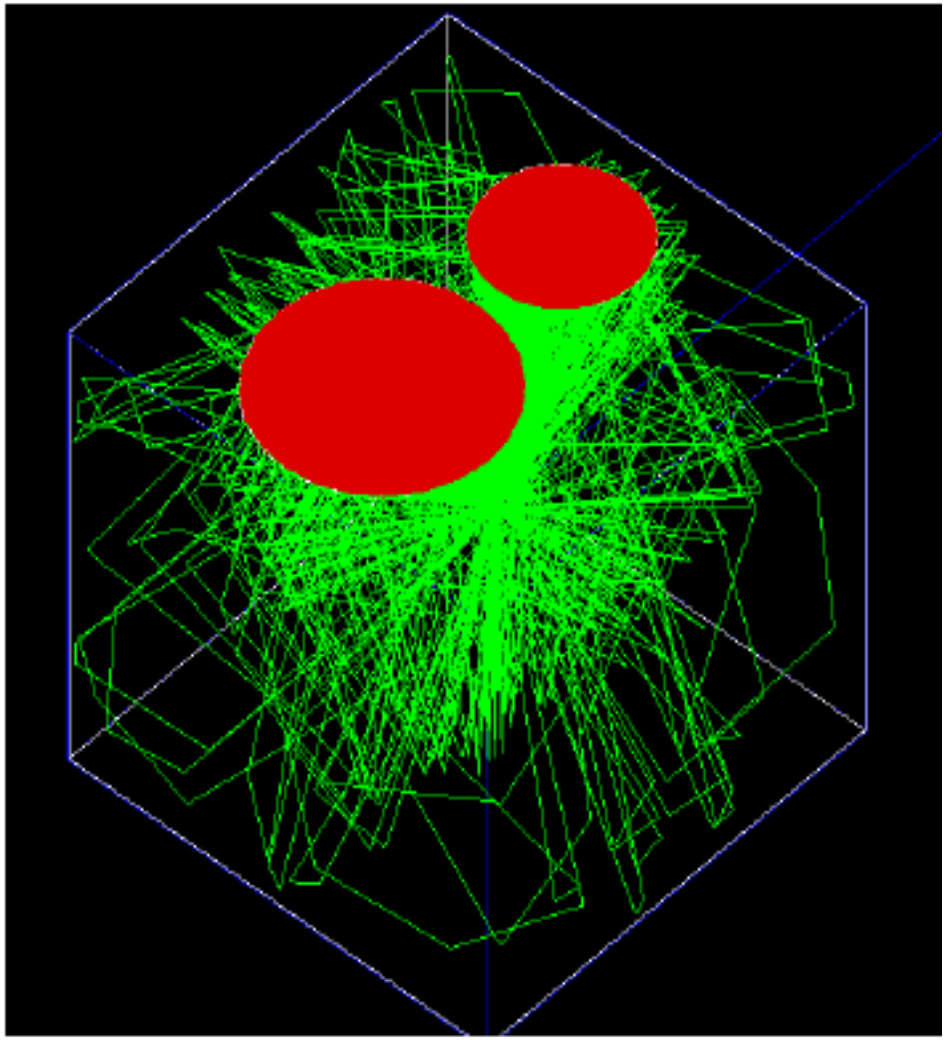


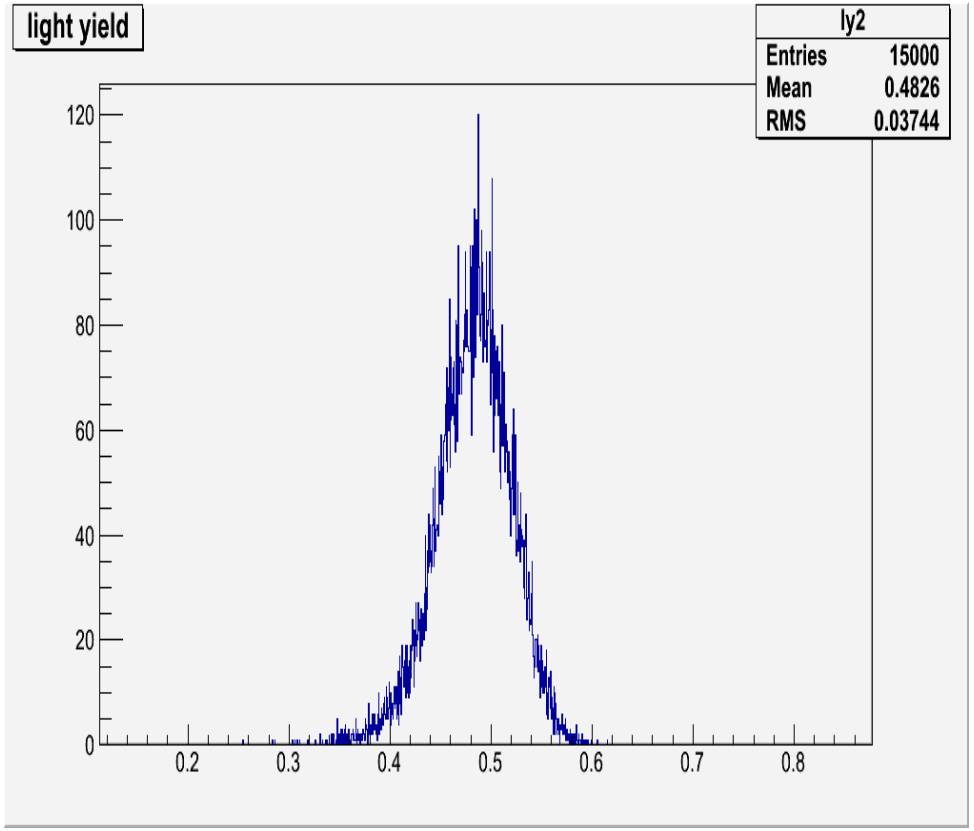
MC Simulations

- Light Yield is hard to estimate and simulate.
- First try using analytic method: *Ettore Segreto, 2012 JINST 7 P05008*
- Gives ~50 phel/MeV for LarIAT
- For the small box, the LY is an order of magnitude more.



Stand-alone simulation in Geant4





Implemented in the MC Simulation

- Emmision/absorption spectrum of LAr (+fano factor, fast/slow component)
- Properties and surfaces of TPB, copper, photocathodes
- PMT efficiency
- Energy spectrum of incident electrons smeared via the gauss distribution
- Smearing of the momentum x.y component
- Considering different physics lists
- Considering backpainted surface instead of currrent "fake shifter " approach (F. Di Pompeo)
- Still problems when modifying surfaces (too much details for surface totally ruins the result)
- Soon start to work on digitization simulation. Shape of single phe known.
- Planning to modify existing geometry of LARiAT and further simulations (need to switch to gdml geometry description to be compatible)

Conclusions

- LArIAT will have a “Dark Matter-like” light readout system.
- This should give us the capability to enhance our calorimetric reconstruction and look at pulse shape discrimination.
- The system is constructed of components that we've used already, so should be straightforward to run.
- The tests with the prototype at UChicago should start in about a month and should clarify the design and allow refining of our simulation for the full detector.

Back-up Slides

Measurements of G10 reflectivity

- One of the unknowns in the simulation is the reflectivity of G10.
- There is a possibility to measure it using an integrating sphere at the Cracow University of Technology.
- A relatively simple measurement could help constrain the MC results.