Light Collection Efficiency in SUE

(Phase 1 of the SLAC LZ System Test Platform)

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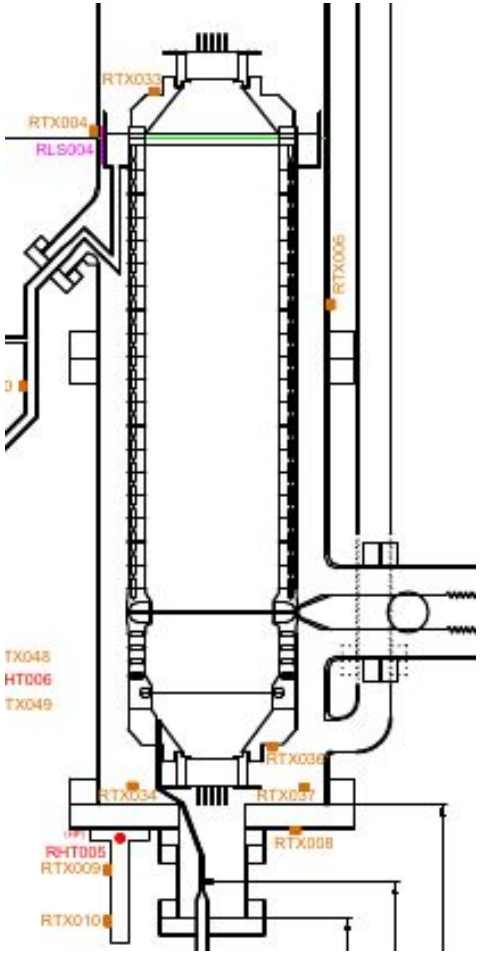
Outline

- Overview of system test phase 1
- Challenges
- SPE calibration
- Simulation
  - Weighting
- Data correlation
- Fitting and comparison to NEST simulation
- Conclusions
- Future work

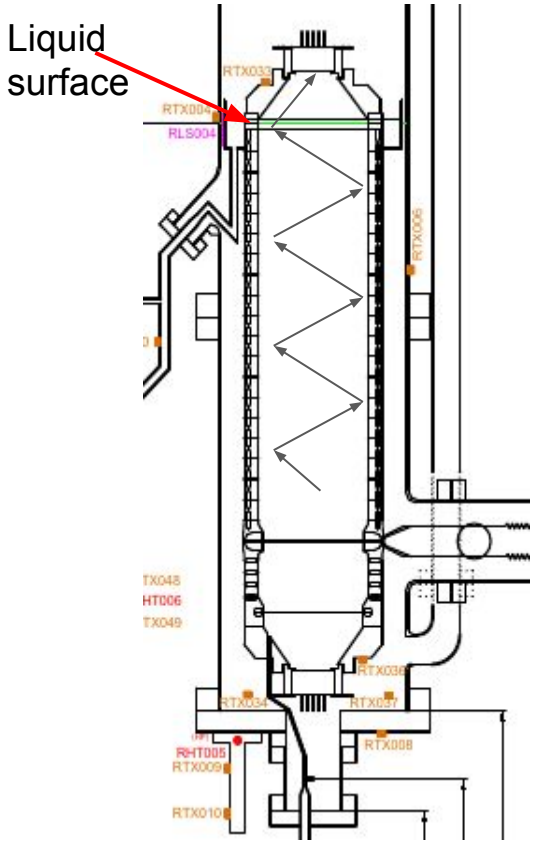
System test Phase 1

- Phase 1 of the LZ system test is a scaled down version of the LZ detector design
  - ~50 cm tall, 14 cm radius
  - Originally with single top and bottom PMT.
- Used for testing:
  - Grid high voltage , and grid emission
  - Circulation and purification system
  - Instrumentation
  - Slow control
- Can also be used for other more basic detector physics measurements.

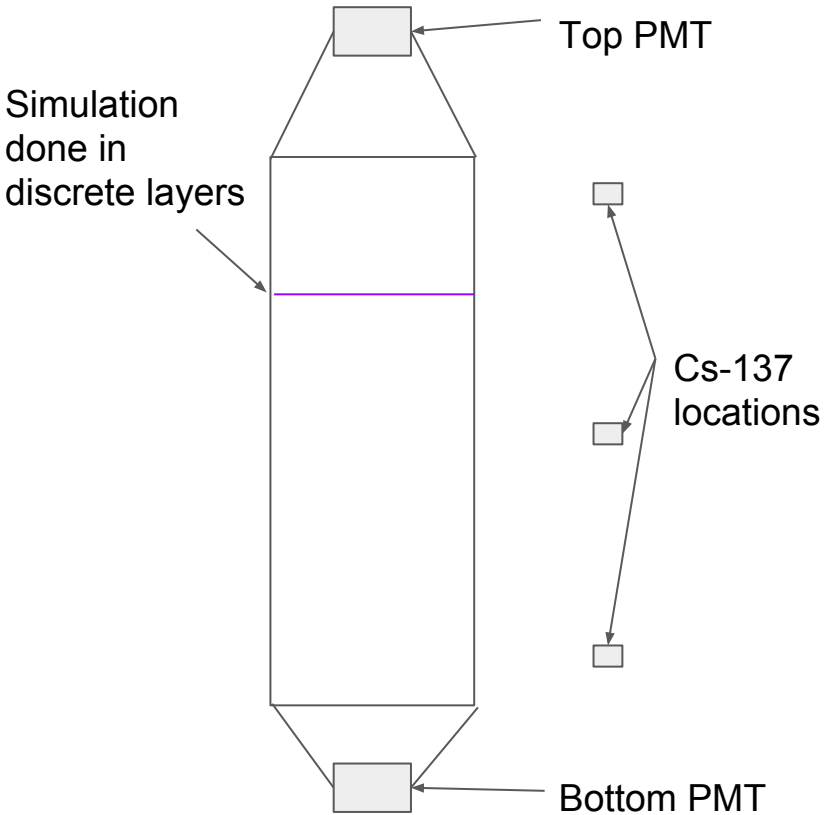


Geometric Effects on the Photon Detection Efficiency

- Tall aspect ratio gives a high probability of reflections off of the teflon surface.
  - Making the detector more sensitive to the teflon reflectivity
- By iterating between measured data and simulations we can refine our simulation parameters.
- I’m attempted to do a first pass of a measurement of the PDE using a limited early dataset and analysis tools



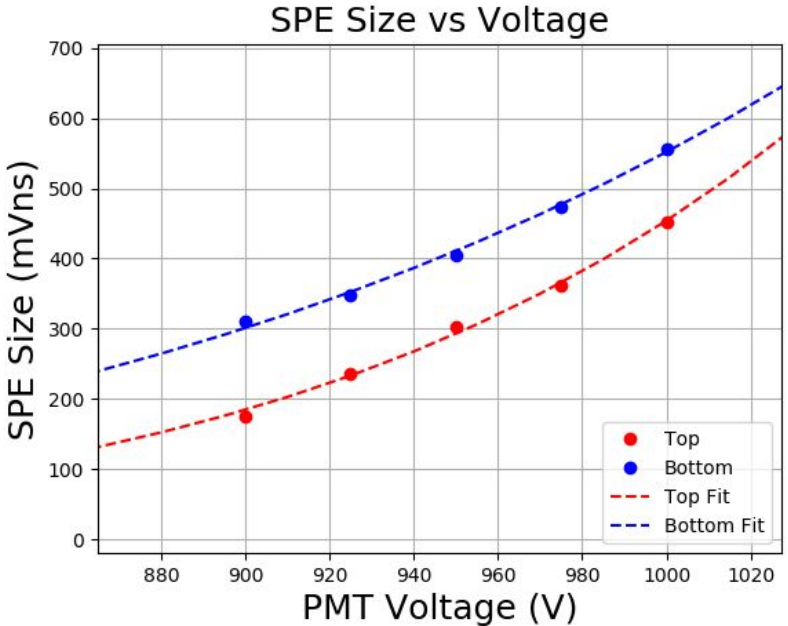
Context / Challenges



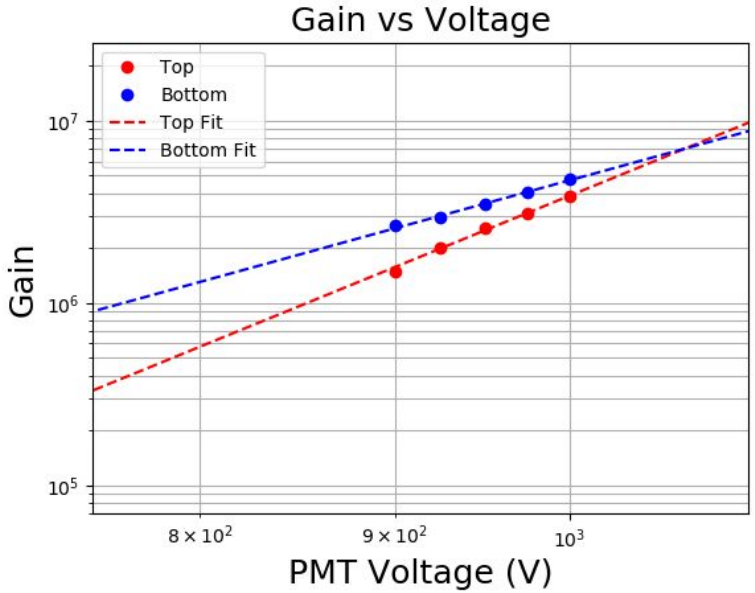
- Goal: confirm that the simulations accurately predict the PDE
  - Optical simulation using BACCARAT / GEANT4
- Simulations
  - Photon bomb style optical simulations done in discrete layers.
- Data
  - Only two older PMTs with ~15% QE gives much lower expected PDE, ~ 1% total
  - S1 only no grids biased while data taking
  - Cs-137 source was uncollimated
  - No SPE calibrations done on PMTs

SPE size and check Using 2-D fit

- Size vs. Voltage fits exponential
  - Found using pulsed blue LED
  - Top ~175 mVns at 900V
  - Bottom ~ 310 mVns at 900V

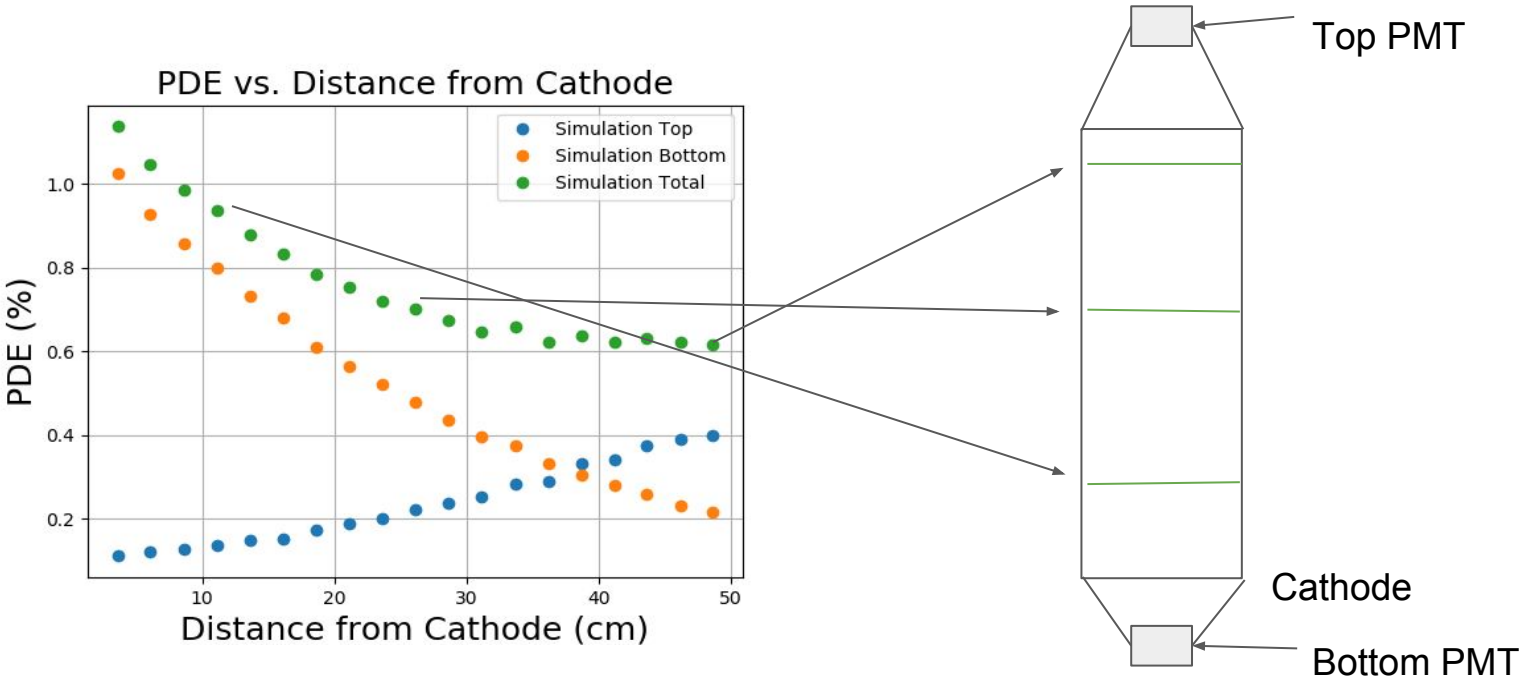


- Also Gain fits to equation given by Hamamatsu
  - $G = A*V^{(k*n)}$



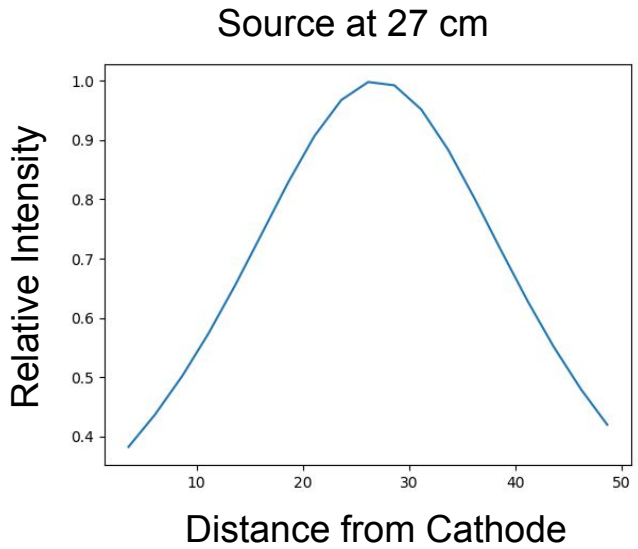
Simulated data

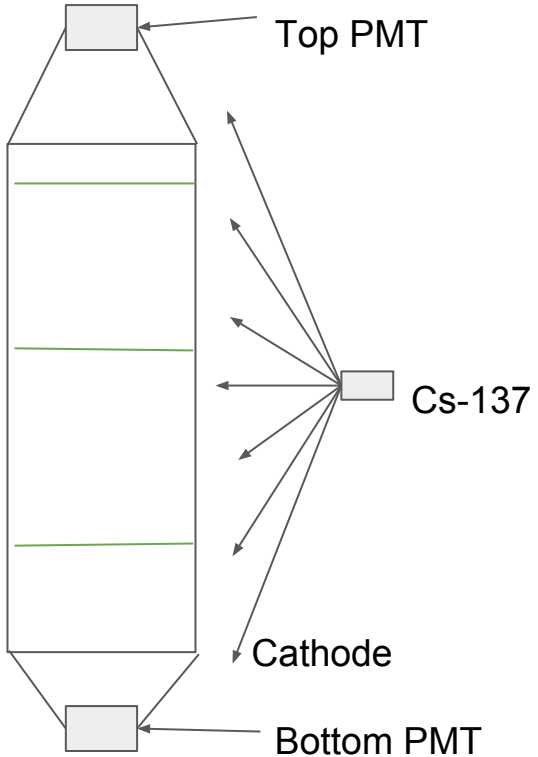
- Simulated data gives the PDE vs height for specific slices of the detector



Cs-137 source data

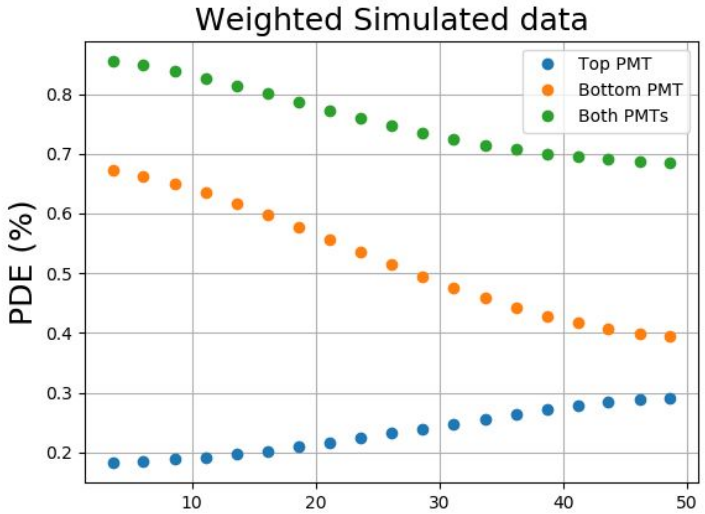
- S1 only data taken at three different source positions
- No collimation so intensity should be ~1/r^2

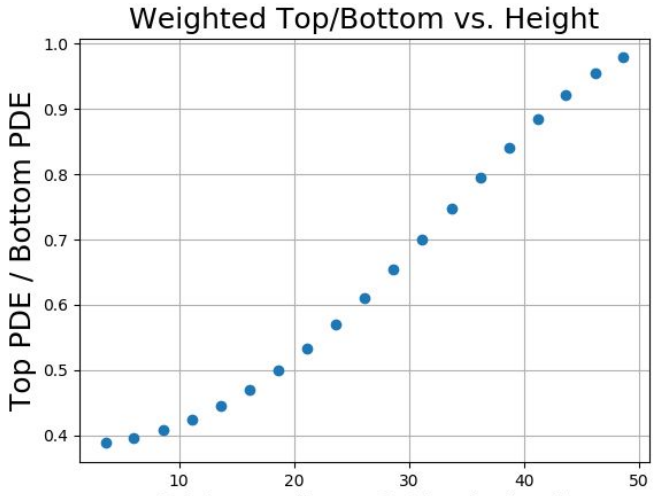




Weighted Simulated Data

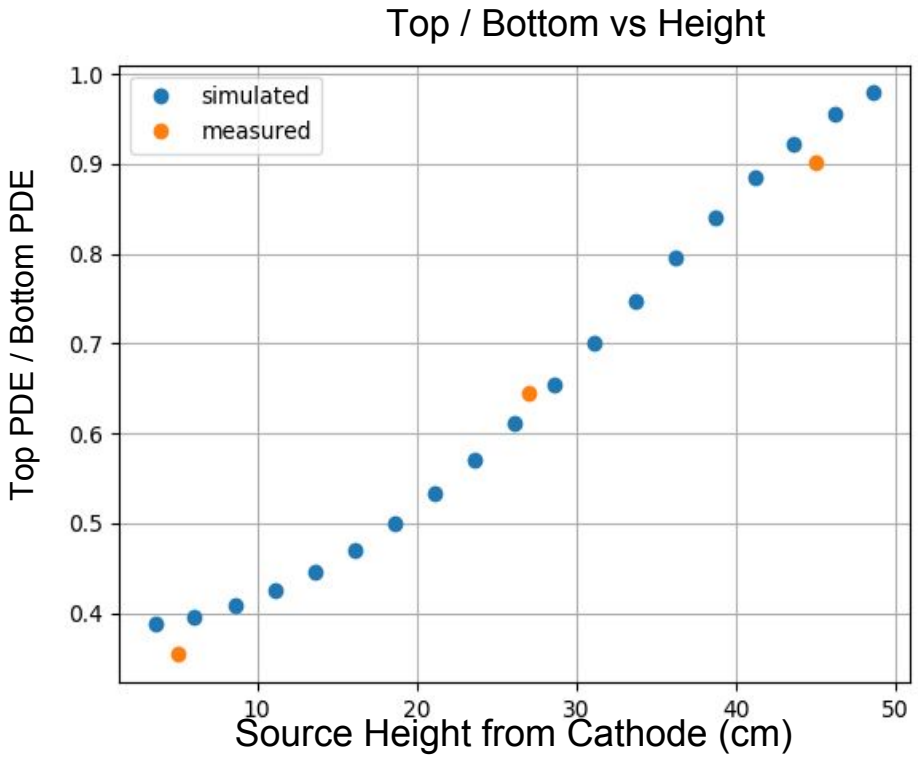
For each point in Z I generate a 1/r^2 weighting function and take the weighted average across the detector slices in the original simulation. This gives me the expected PDE for different source positions. Instead of the PDE for different event heights.





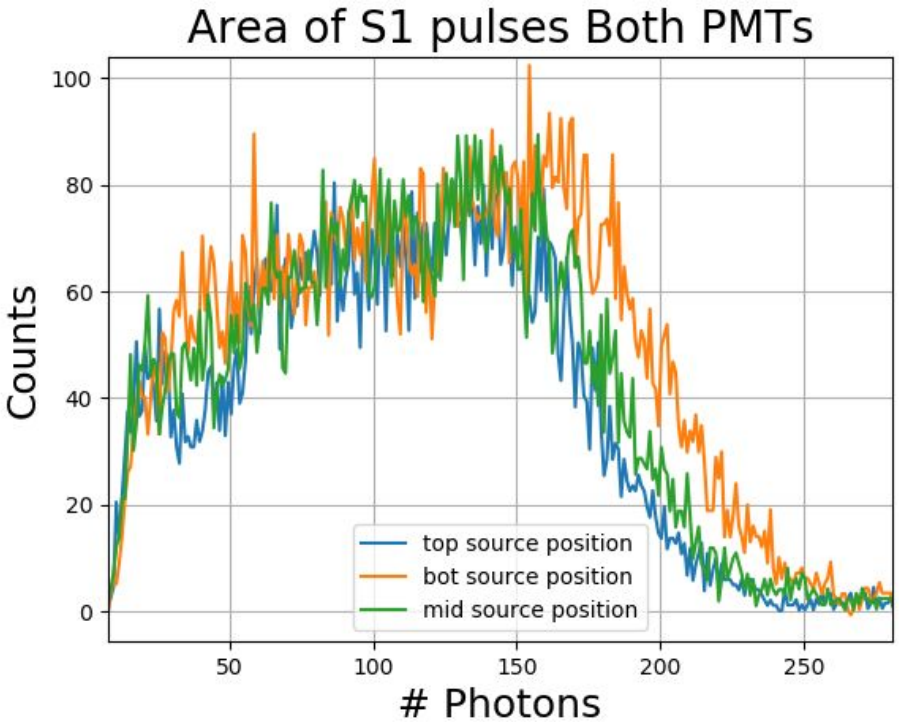
Event by Event Comparison

- Found coincident S1s in the data and directly calculated the ratio of the number of photons in the top and bottom PMTs
- On the right the average Top / Bottom ratio for each source position. Plotted with the expected values from the simulation.
- Very good agreement



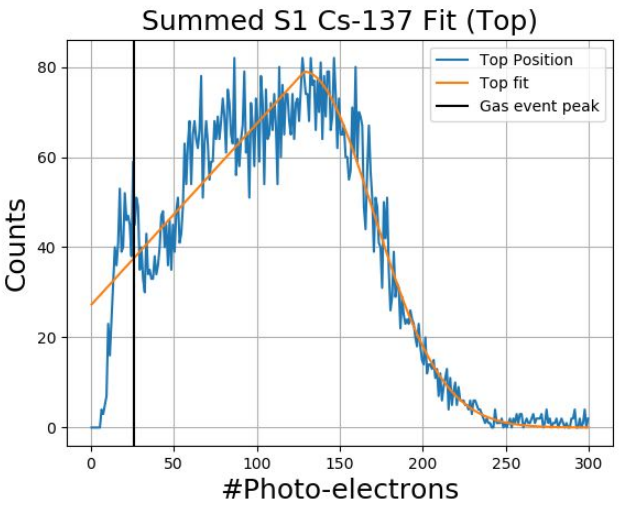
Summed pulses and event by event comparison

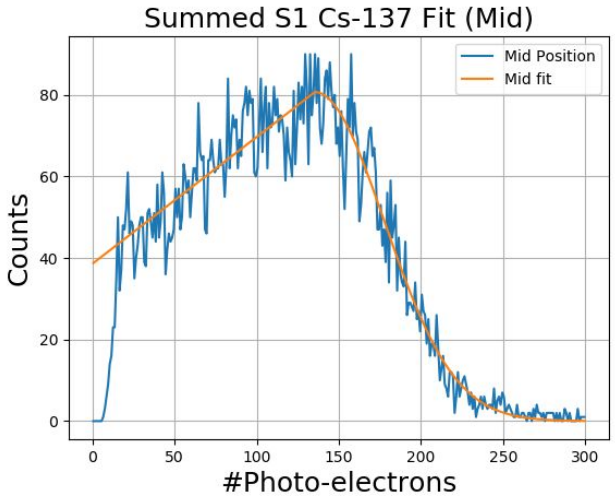
- By finding the correlated S1s I was also able to record the total number of photons from each event
- Cs-137 spectrum from the data for all three different positions on the right.
  - ~10000 events
- I expect that the peak here corresponds to the full energy peak in the Cs-137 spectrum and that the rest is muddled by the low PDE

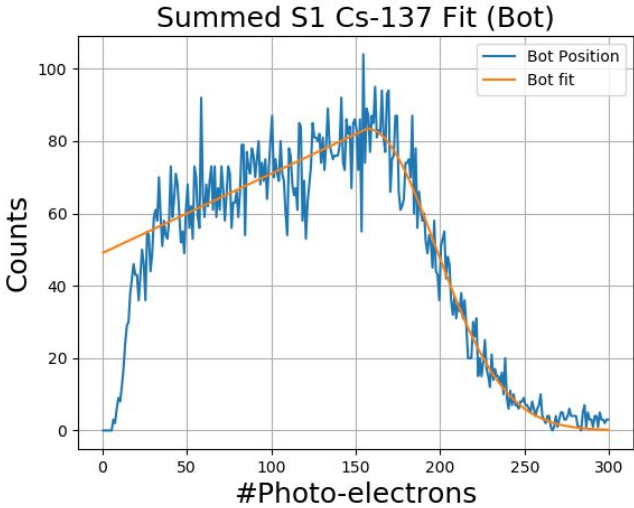


Fit of Summed S1 data to find full energy peak

- Fit each of the source positions to a gaussian+a slope to find the peak
  - Function not physical chosen just to fit the shape and find the peak

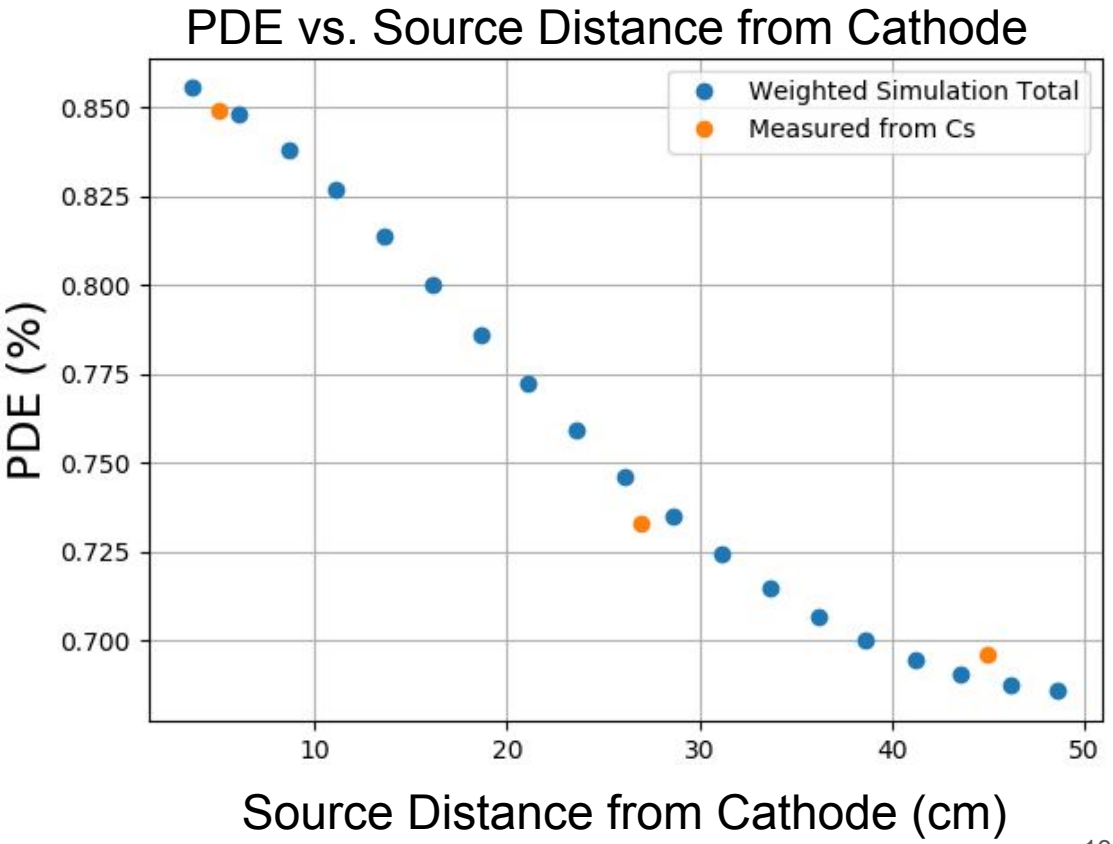






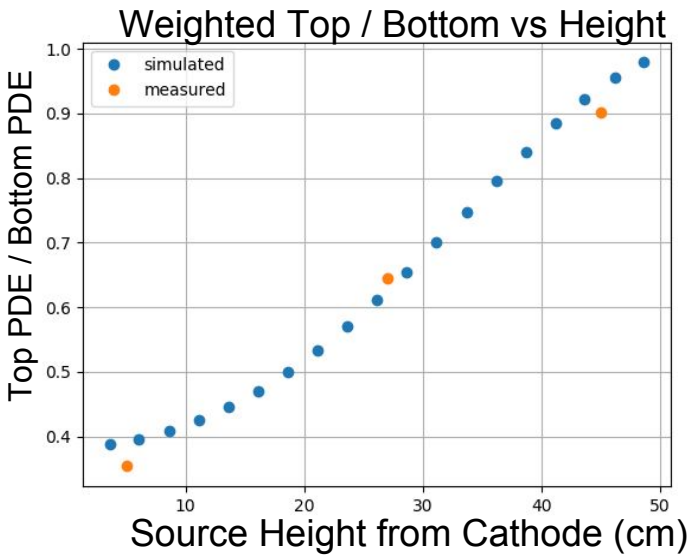
Comparison to simulation

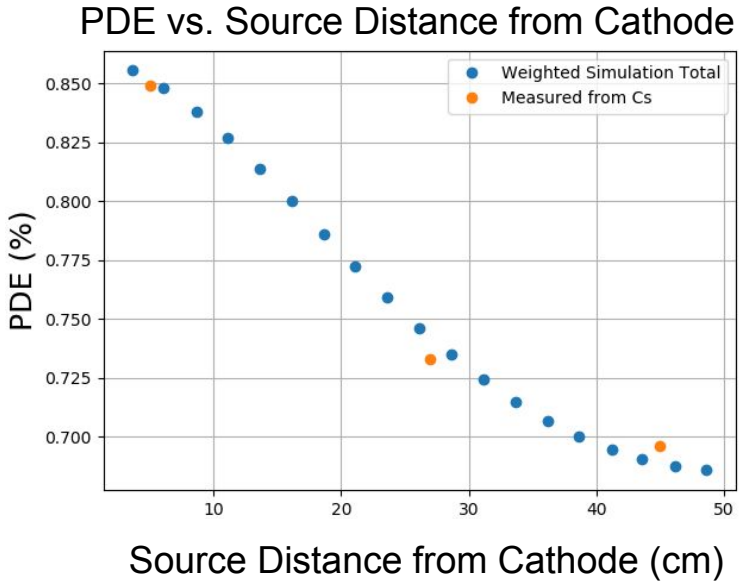
- Used NEST to determine the mean number of photons generated in a full energy Cs-137 S1
- I Divided the number of photons seen in the fitted peak by the number from NEST to get the PDE for that source position.



Conclusions

- Our simulations appear to fit the expected data very well giving us a good starting point for future work
- Can test optical parameters without knowledge of the source rate.
- We were able to get some use out of a very limited dataset





Future Work

- Will continue refining this measurement with the upgrades that have been done to the Phase system
  - Hardware
    - 32 PMT top array
    - Single LZ bottom PMT
    - 6 Skin PMTs top and bottom
    - Grid upgrades
    - New DAQ
  - Moving to LZap the LZ analysis toolchain
    - Faster
    - More support
  - Simulation geometry updated to be more detailed