

Effects of Teflon Reflectivity on S1 Signal

University of Wisconsin

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LZ Group Meeting

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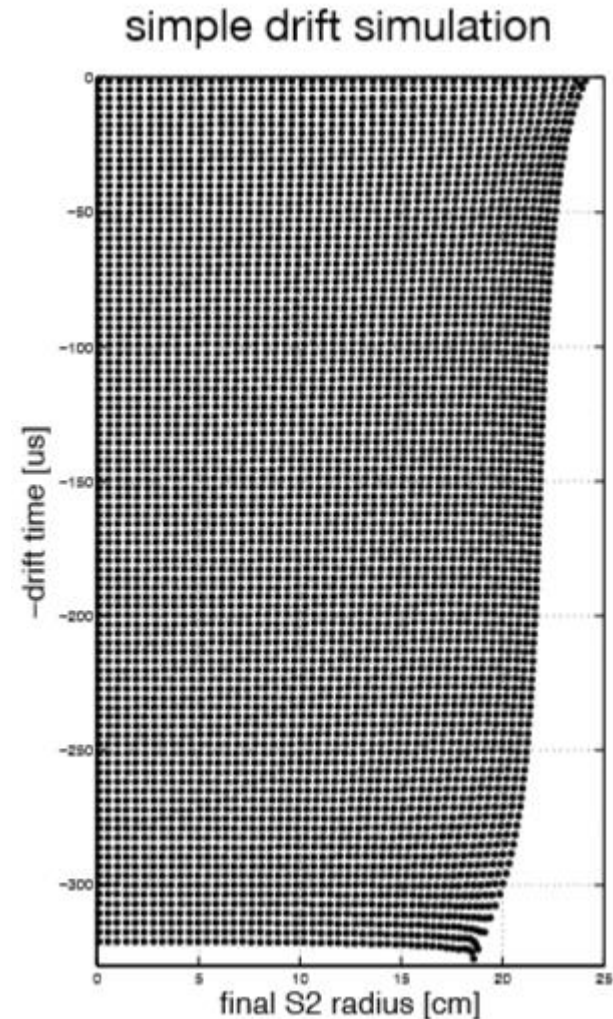


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UNIVERSITY OF WISCONSIN-MADISON



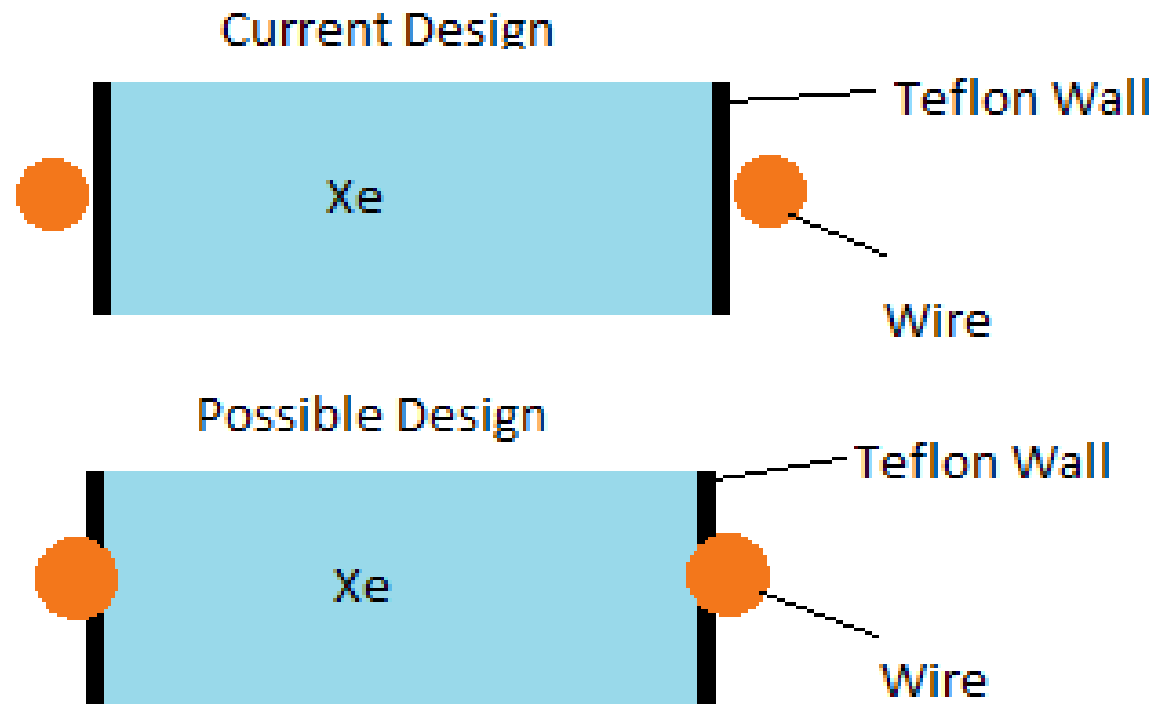
Background

- Would like to have a uniform electric field throughout the drift region of the TPC.
- Field shaping rings are meant to accomplish this, but despite the rings, the field in LUX still became distorted. Likely due to charge build up (Jeremy Chapman's Thesis 6.3.1.1, 7.3.1.1).



Lifted from Chapman's
Thesis (Pg 180)

- Possible solution: redesign these rings to expose metal to the interior, allowing us to control the electric field more effectively.
- Possible problem: rings are not as reflective as the Teflon, so we will lose sensitivity.
- How much?



Method

- Generate S1 photons.
- Create Macros which vary the teflon reflectivity (/LUXSim/materials/LXeTeflonReflex) from 0 to 1 (current step size .05).
- Propagate S1 photons and record how many reach the PMTs in each case.

Compare 3 different methods of Generating S1 photons

- Geant4 GPS method
 - /gps/particle opticalphoton
 - /gps/ene/type Gauss
 - /gps/ene/mono 6.97 eV
 - /gps/ene/sigma 0.23 eV
 - /gps/pos/type Volume
 - /gps/pos/shape Cylinder
 - /gps/pos/centre 0 0 740 mm
 - /gps/pos/radius 738 mm
 - /gps/pos/halfz 738 mm
 - /gps/ang/type iso
- ScintPhotons Generator method
 - /LUXSim/source/set LiquidXenonTarget ScintPhotons 1 Bq
- WIMP Generator method
 - /LUXSim/source/set LiquidXenonTarget Wimp 1 Bq 60 GeV
 - /LUXSim/physicsList/useOpticalProcesses true
 - /LUXSim/physicsList/driftElecAttenuation 0 m

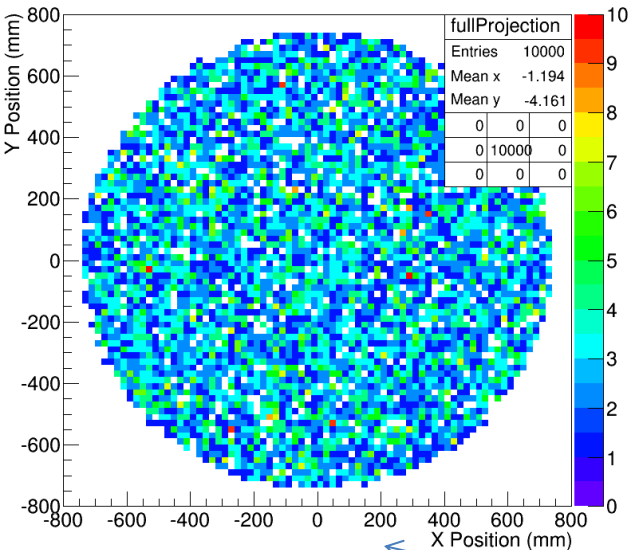
Primary Particle Distributions

Geant4 GPS Method

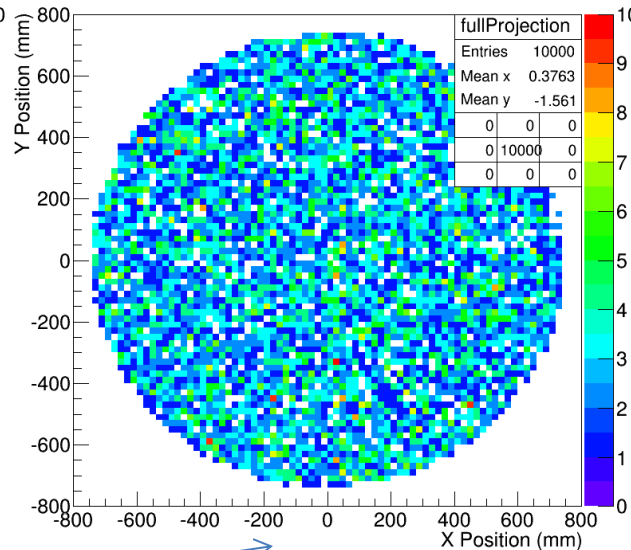
ScintPhoton Generator Method

WIMP Generator Method

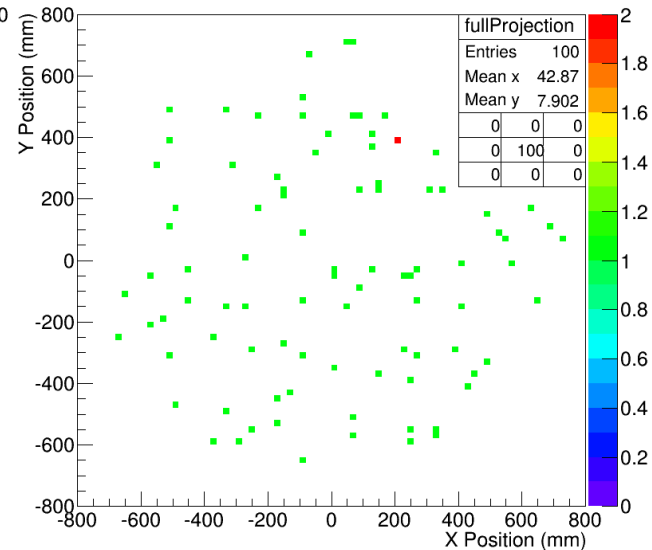
Projected XY Distribution



Projected XY Distribution

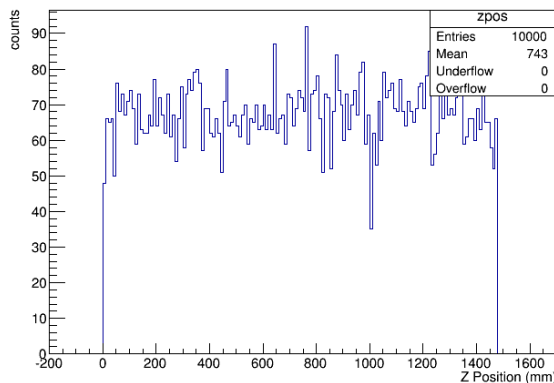


Projected XY Distribution

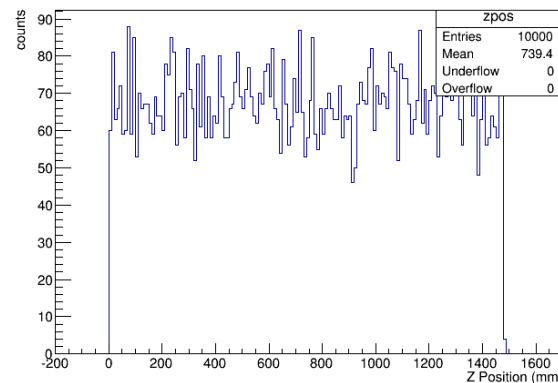


Optical Photons

Primary Z Distribution

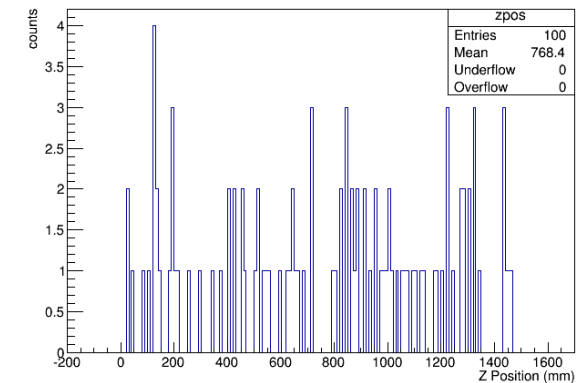


Primary Z Distribution



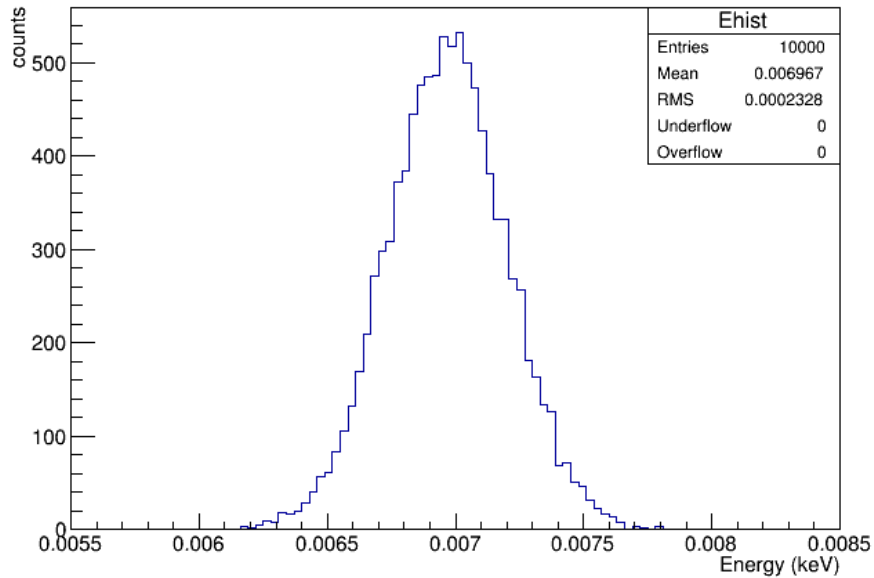
Xenon that scintillates Optical Photons

Primary Z Distribution



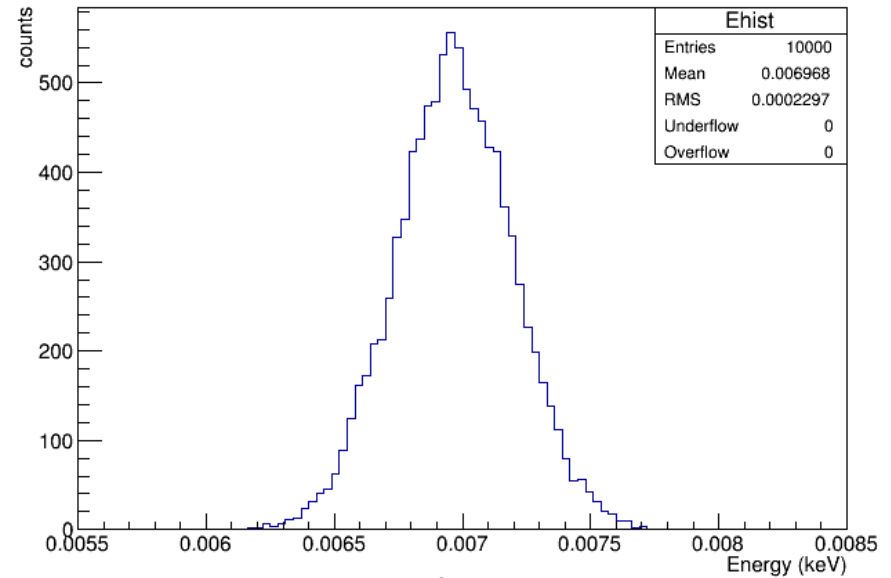
Optical Photon Energy Distributions

Primary Optical Photon Energies

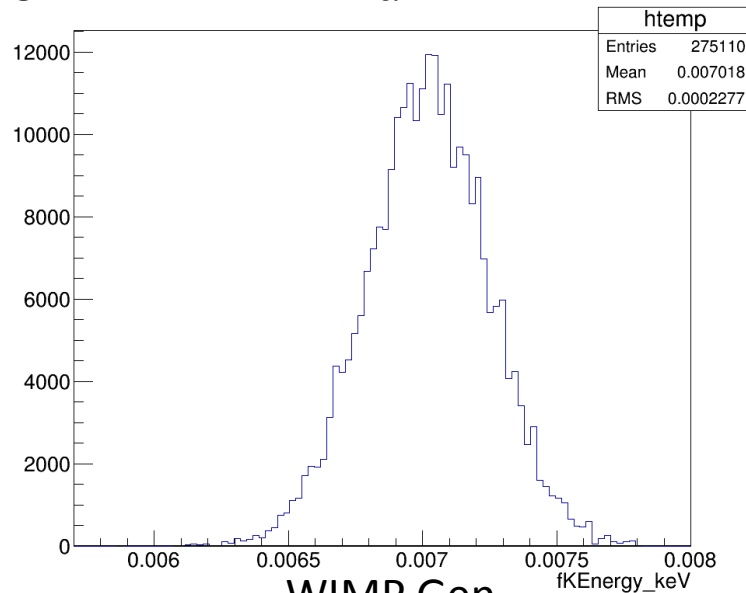


Geant4 GPS

Primary Optical Photon Energies



ScintPhoton Gen



WIMP Gen

Plow ahead with ScintPhotons Generator

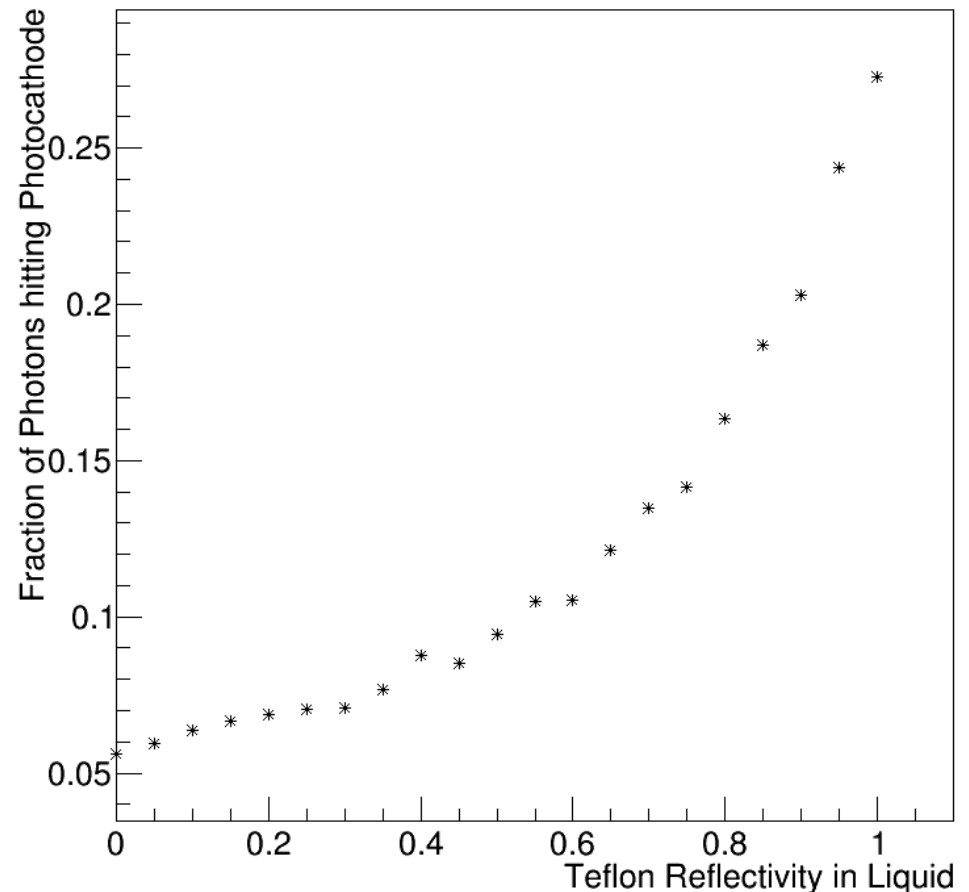
- Most hassle-free option
- Some weird stuff going on with WIMP Gen so not completely sure yet that it would produce the same results.
- The energy distribution at least seems ok though, so I'm going with it.

S1 Signal vs. Teflon Reflectivity

Seems to drop very rapidly with reflectivity, to the point where if the Teflon is not at all reflective, only ~6% of the photons make it (~20% of when Teflon is perfectly reflective). This is the same trend found by Slava's study.

http://teacher.pas.rochester.edu:8080/wiki/pub/Lz/LzDB0000005/2013-11-19_Slava_LZLightCollBulk.pdf

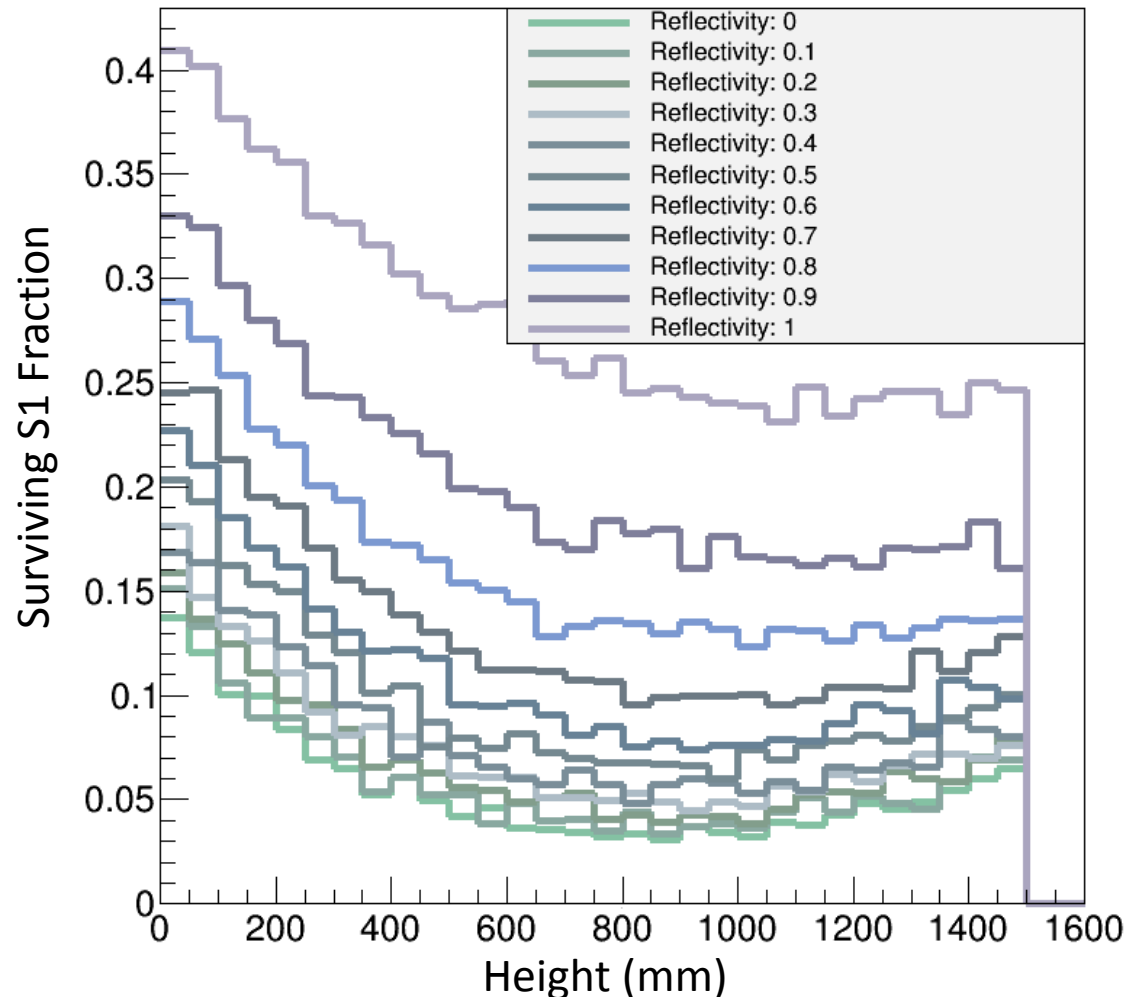
Recorded S1 Photons vs. Reflectivity



Fraction of Photons Detected vs. Height and Reflectivity (in liquid)

Fraction of S1 Photons Propagating to Photocathode vs Height Above Cathode Grid

Higher rate at lower heights since they are close to PMTs and the photons originating from higher in the detector have to cross the liquid-gas interface to reach the upper PMTs

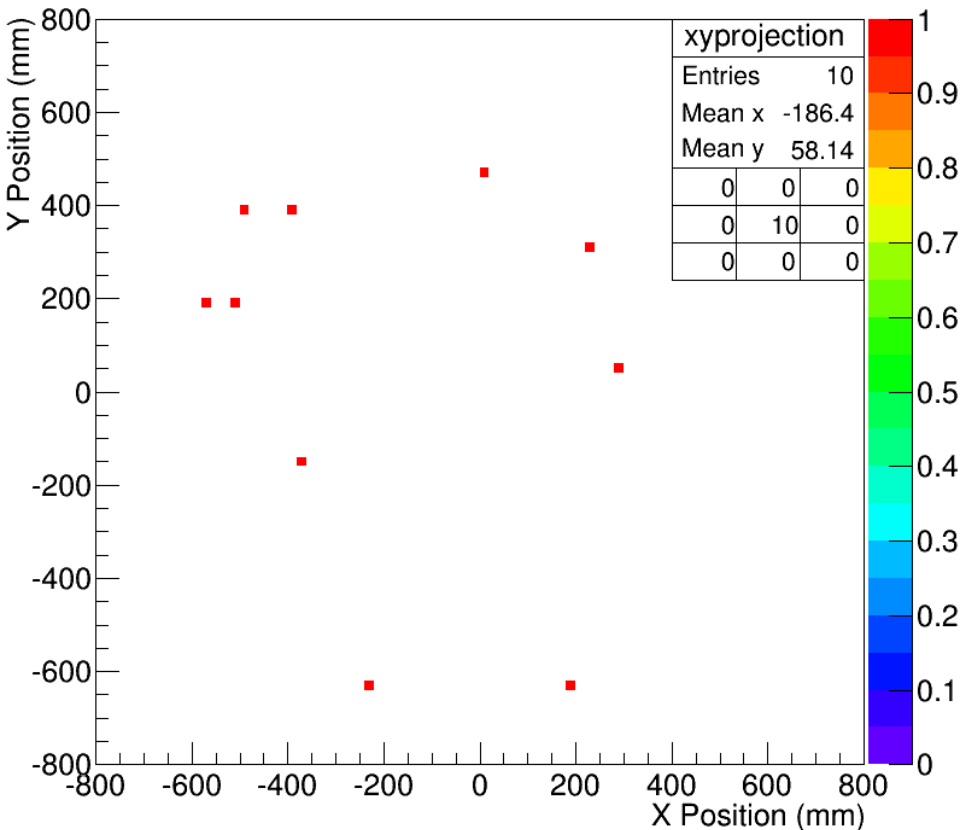


How many times to Photons actually reflect before being detected (or not)?

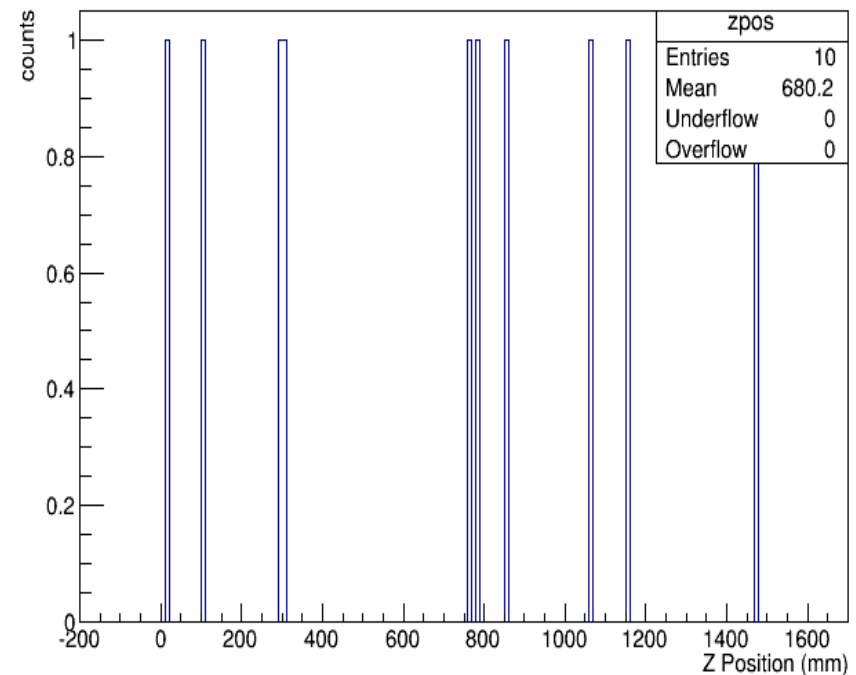
- Information only available via
 - /tracking/verbose 1-4In the form of a text file.
- Example
- Create a program that reads this file and saves the information displayed in the text.
- Store: starting positions, number of reflections on the walls, number on other surfaces, position, process, and volumes where photons stop propagating, and the total distance traveled by each photon.

Primary Particle Positions (using parser) (10 particles)

Projected XY Distribution

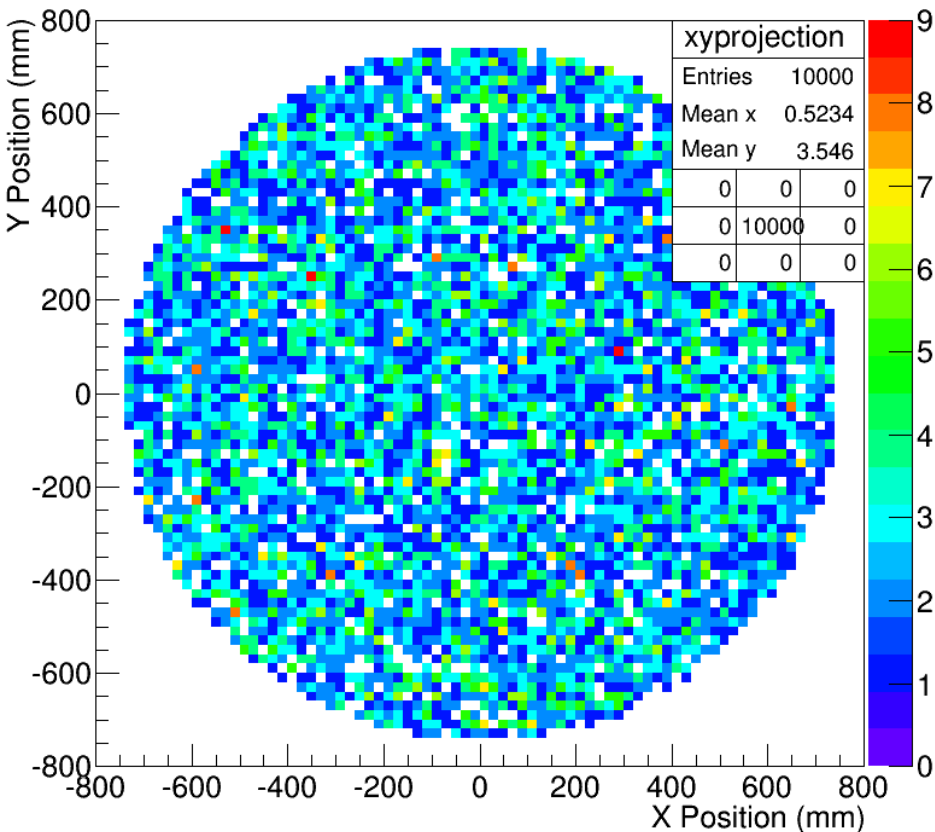


Primary A Distribution

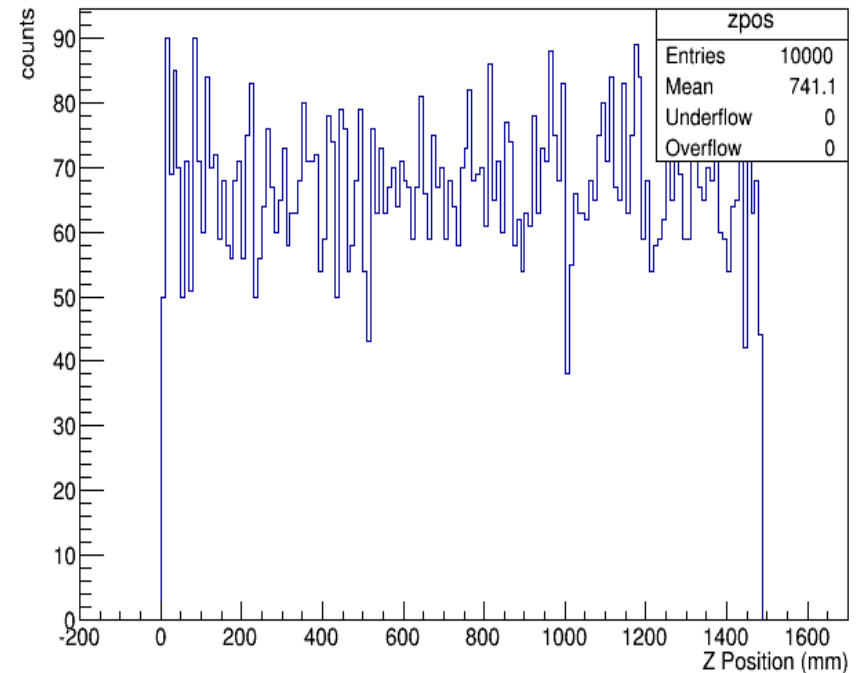


Primary Particle Positions (using parser) (10,000 particles)

Projected XY Distribution

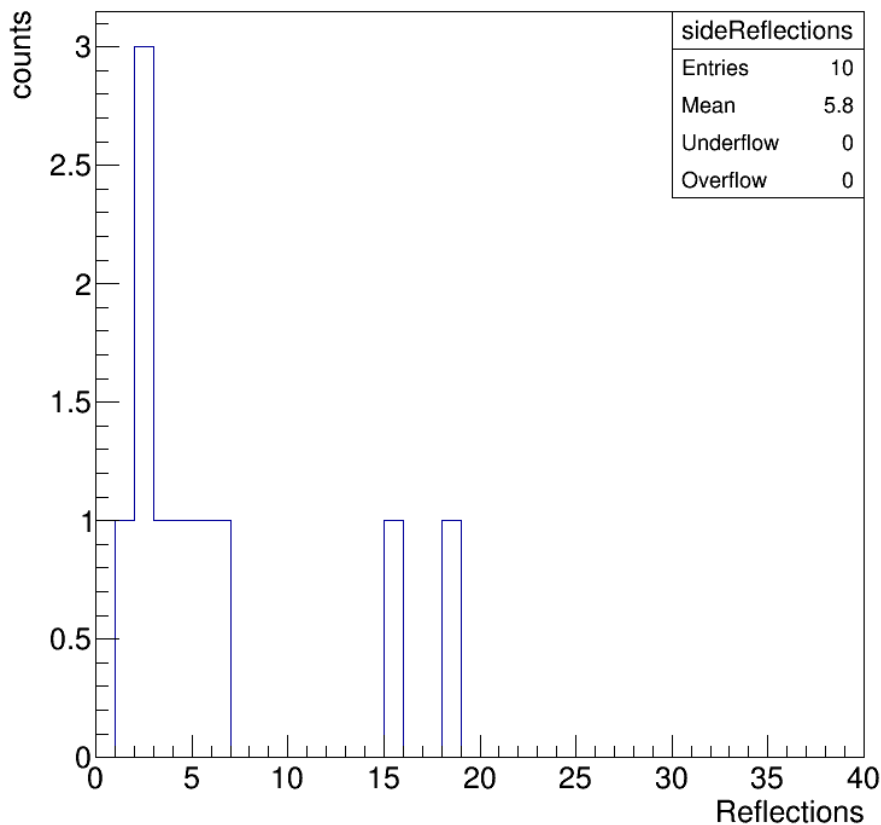


Primary A Distribution

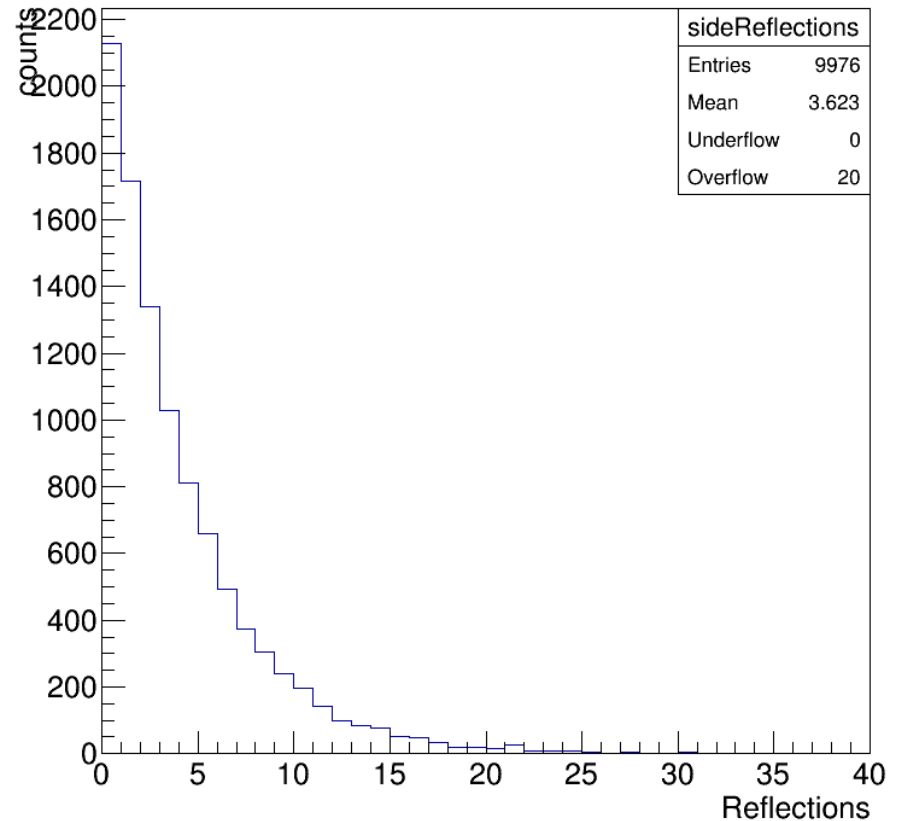


Number of Reflections off of Walls

10 Particles
Number of Wall Reflections



10,000 Particles
Number of Wall Reflections

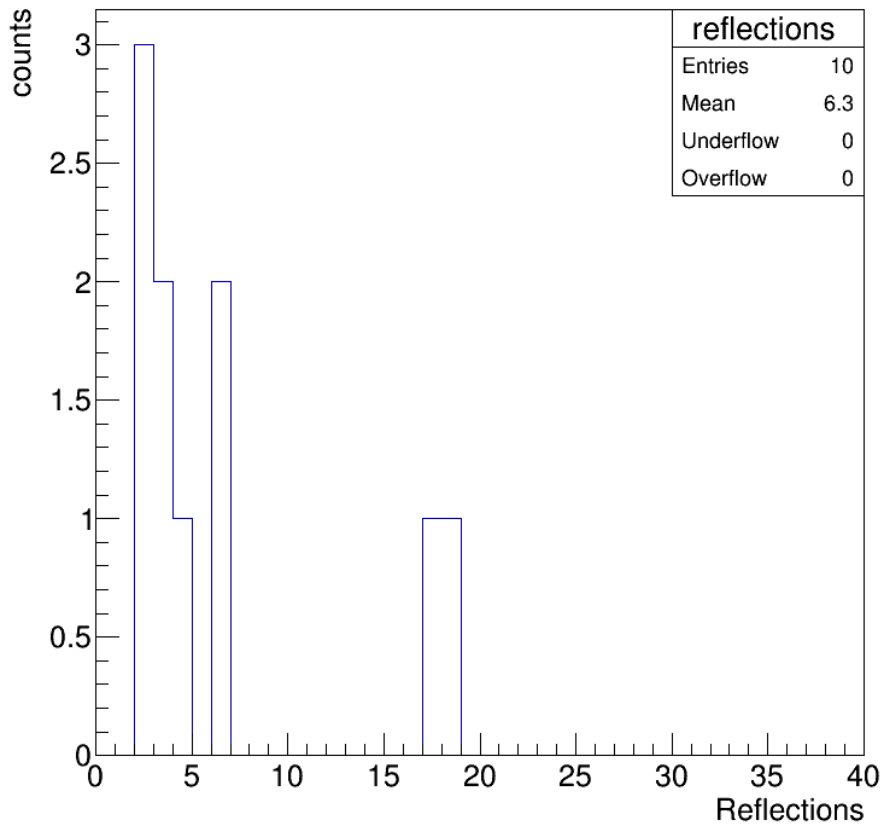


Not sure why it only adds up to 9996 at the moment...

Number of Total Reflections

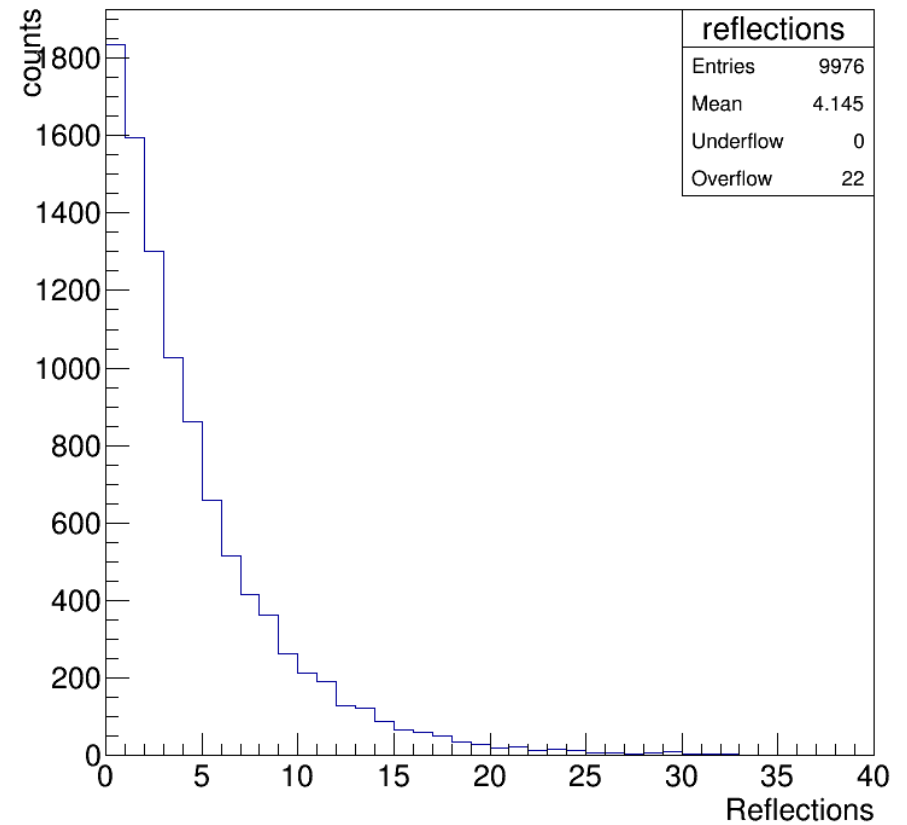
10 Particles

Number of Reflections



10,000 Particles

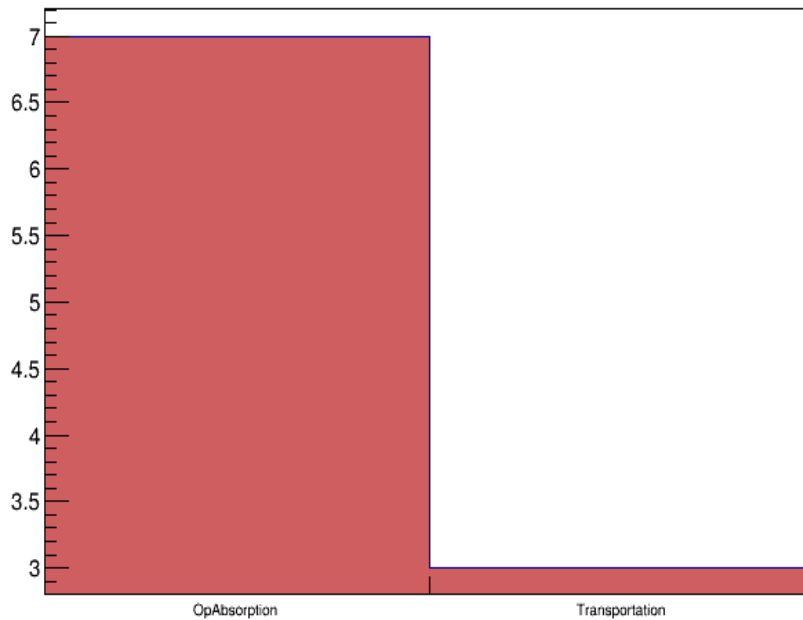
Number of Reflections



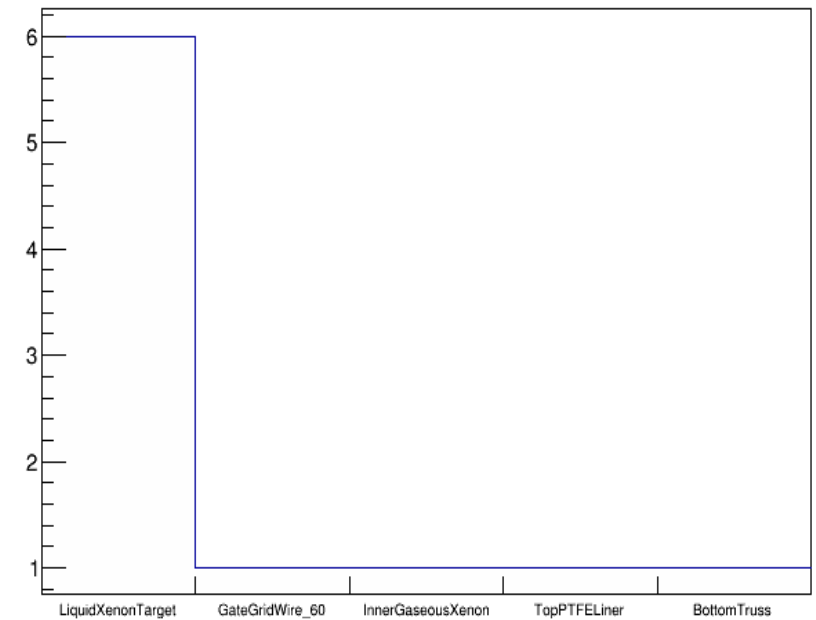
Still missing 2...

Fate Processes and Volumes (10 particles)

Final Fate Process

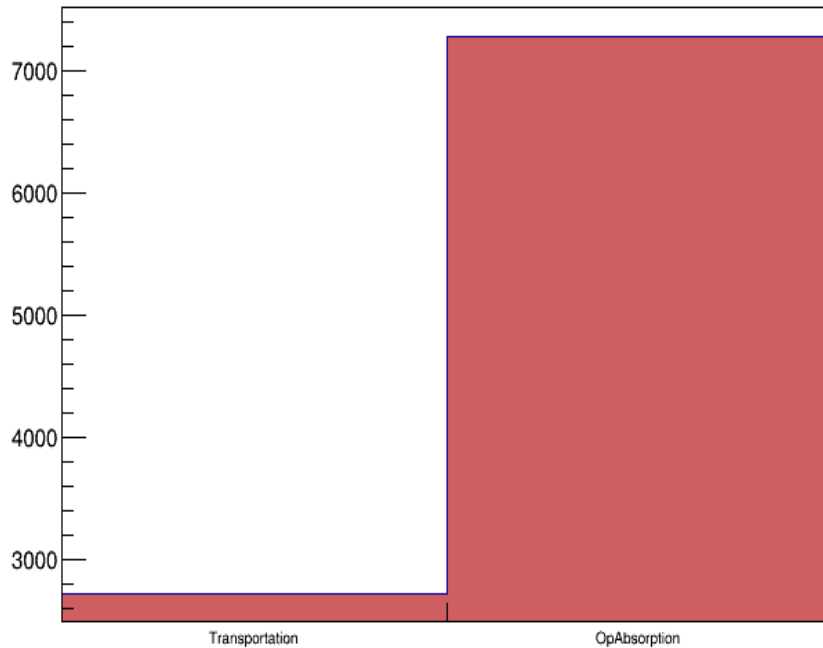


Final Fate Volume

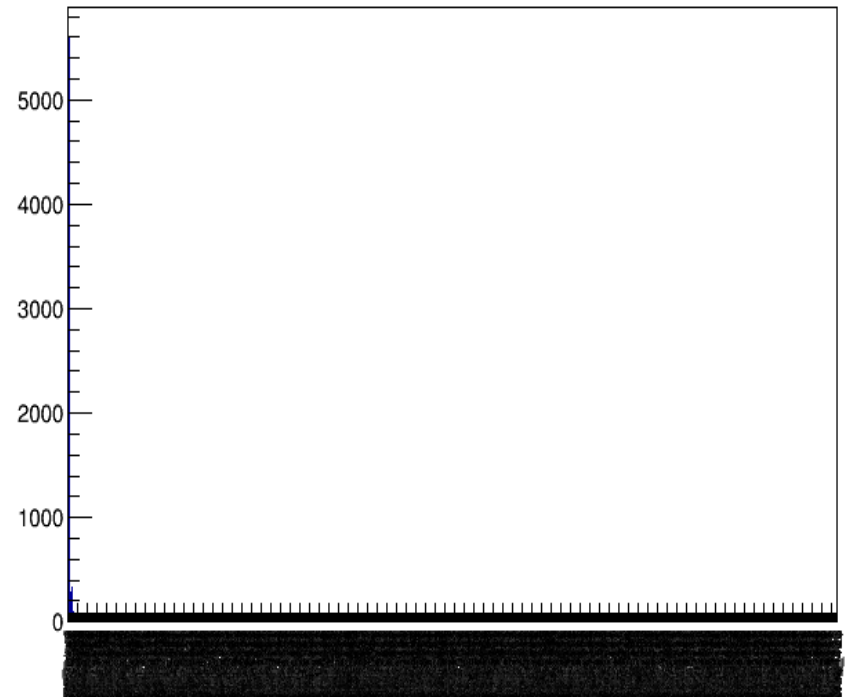


Fate Processes and Volumes (10,000 particles)

Final Fate Process

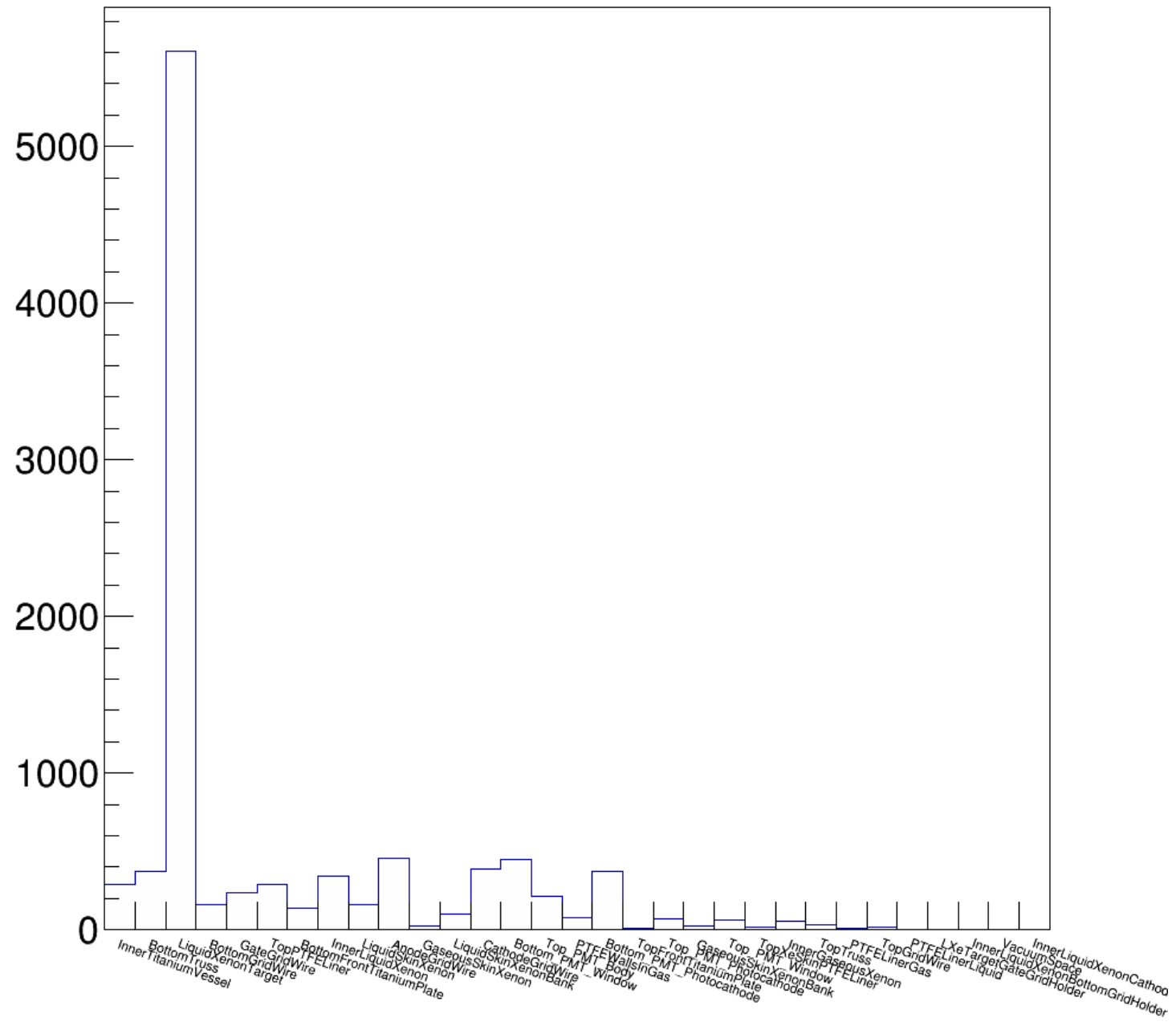


Final Fate Volume



Consolidated all volumes with multiple subvolumes (or at least volumes with multiple different numbers following them).

Final Fate Volume



Turn absorption length and reflectivities all the way up.

Final Fate Volume

