

# **Simulation of Optical Boundaries in LArSoft**

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# OpBoundaryProcessSimple

- The default geant4 reflection process in LArSoft was swapped for a simpler custom boundary process

OpBoundaryProcessSimple

- In the constructor of OpticalPhysics what you find is:

```
fTheBoundaryProcess =  
    new OpBoundaryProcessSimple();
```

- This class invokes a simplified model of optical reflections at boundaries between different materials
- My understanding is that the only thing that you can simulate with it are reflections, but not refractions or what is more important for us, wavelength shifters.

# G4OpBoundaryProcess

- This last are the main reasons (more than more options and sophisticated ways for simulating reflections) we find to include in LArSoft the possibility of using the original geant4 class G4OpBoundaryProcess
- The implementation would be trivial, what we suggest is, instead of the current line in OpticalPhysics, the following:

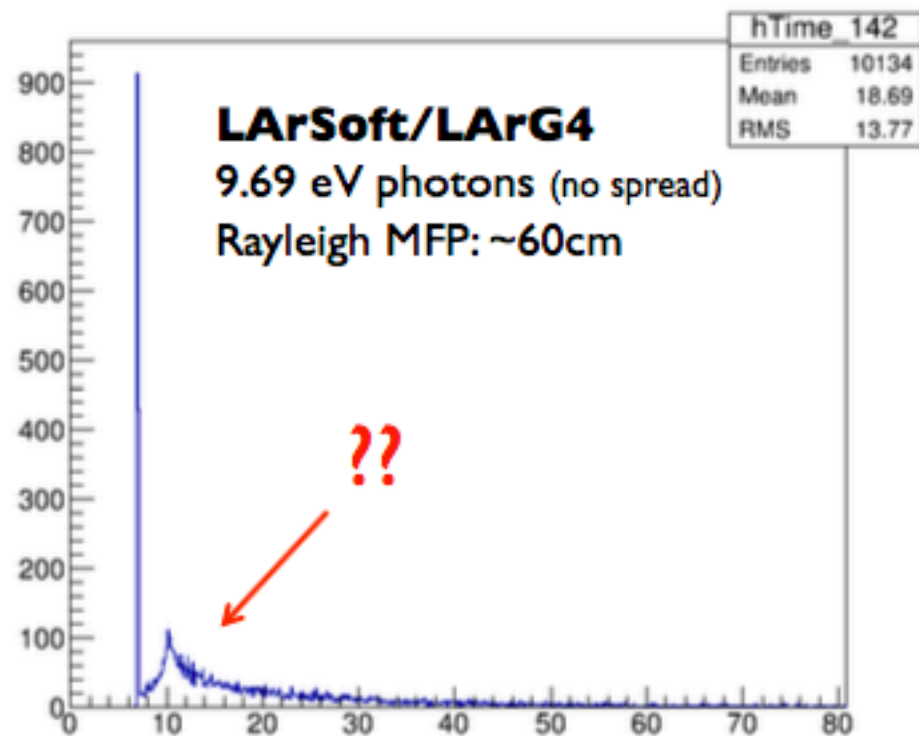
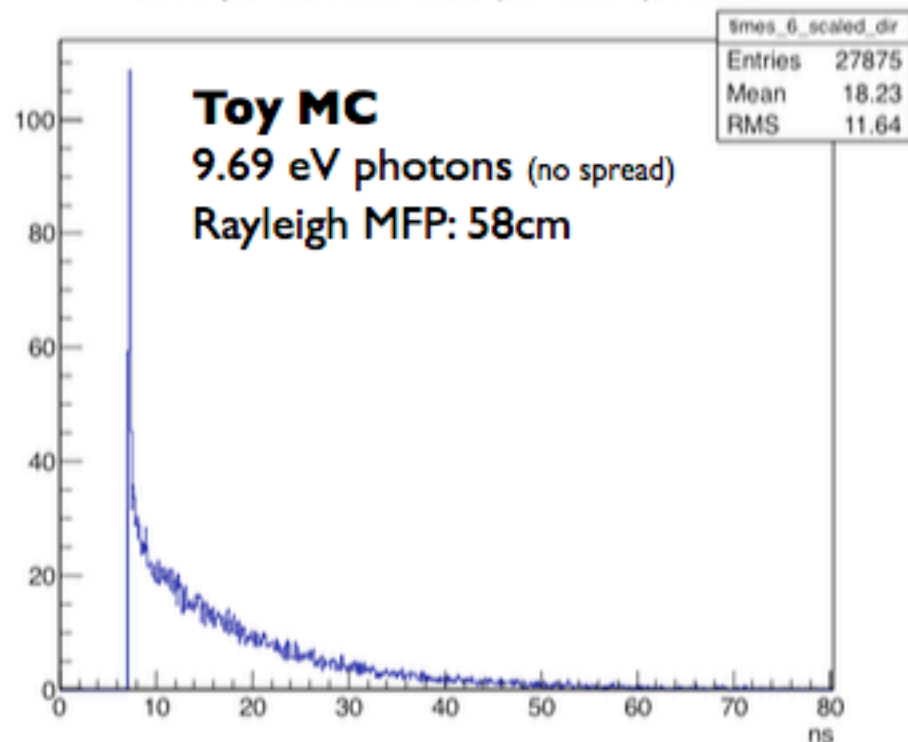
```
if ( larp->SimpleBoundary() )
    fTheBoundaryProcess
        = new OpBoundaryProcessSimple();
else
    fTheBoundaryProcess_g4
        = new G4OpBoundaryProcess();
```

- The model you want is set by a parameter defined in a configuration file (in larproperties.fcl)

Updated toy MC (variable  $v_g$  and Rayleigh scattering, see backup)

Simulated monoenergetic photon bomb in both toy and LArSoft

Direct photon arrival times (QE-scaled), PMT 6



# Looking at G4Step...

All photons started at (100cm,0cm,250cm) with E = 9.69±0.1 eV

PostStep position	Momentum direction	Velocity [cm/ns] (from G4)	Velocity [cm/ns] stepL/deltaT	Step length [cm]	Step time [ns]	Total track length [cm]	Global time [ns]
( 183.749, -60.831, 219.622)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 15.555967	stepL: 107.875636	deltaT: 6.934679	trackL: 107.875636	gTime: 6.934679
( 200.700, -64.933, 177.586)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 45.510318	deltaT: 4.333111	trackL: 153.385953	gTime: 11.267790
( 201.725, -65.181, 175.044)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 2.751907	deltaT: 0.262014	trackL: 156.137860	gTime: 11.529804
( 201.875, -65.217, 174.672)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 0.402718	deltaT: 0.038343	trackL: 156.540579	gTime: 11.568147
( 202.025, -65.253, 174.300)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 0.402718	deltaT: 0.038343	trackL: 156.943297	gTime: 11.606490
( 202.175, -65.289, 173.928)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 0.402718	deltaT: 0.038343	trackL: 157.346015	gTime: 11.644834
( 202.325, -65.326, 173.556)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 0.402718	deltaT: 0.038343	trackL: 157.748733	gTime: 11.683177
( 202.475, -65.362, 173.184)	dir: ( 0.372, -0.090, -0.924)	vel: 10.502920	velcalc: 10.502920	stepL: 0.402718	deltaT: 0.038343	trackL: 158.151451	gTime: 11.721521
( 109.045, 11.702, 218.783)	dir: (-0.393, -0.920, -0.002)	vel: 10.614936	velcalc: 15.678492	stepL: 34.543647	deltaT: 2.203251	trackL: 34.543647	gTime: 2.203251
( 75.979, -65.753, 218.620)	dir: ( 0.228, 0.917, 0.327)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 44.680833	gTime: 10.137186
( 83.080, -37.214, 228.805)	dir: (-0.902, -0.361, -0.239)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 54.818019	gTime: 13.069166
( 64.211, -44.762, 223.800)	dir: ( 0.734, -0.495, 0.465)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 64.955205	gTime: 15.040902
( 143.895, -98.543, 274.355)	dir: (-0.569, -0.424, -0.705)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 75.092391	gTime: 25.273437
( 108.842, -124.697, 230.902)	dir: (-0.979, 0.108, 0.175)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 85.229577	gTime: 31.081447
( 97.779, -123.476, 232.884)	dir: (-0.905, 0.145, -0.399)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 95.366763	gTime: 32.146476
( 84.634, -121.371, 227.090)	dir: (-0.500, -0.682, 0.534)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 105.503949	gTime: 33.514251
( 59.817, -155.241, 253.577)	dir: (-0.500, -0.682, 0.534)	vel: 10.614936	velcalc: 10.614936	stepL: 10.137186	deltaT: 0.967186	trackL: 115.641135	gTime: 38.191141
( 128.220, -38.782, 499.900)	dir: ( 0.111, -0.152, 0.982)	vel: 10.563841	velcalc: 15.622687	stepL: 24.334633	deltaT: 2.303223	trackL: 24.334633	gTime: 16.287923
( 128.249, -38.821, 500.151)	dir: ( 0.473, 0.848, 0.238)	vel: 10.563841	velcalc: 10.563841	stepL: 0.254413	deltaT: 0.024103	trackL: 24.589046	gTime: 16.312106
( 128.297, -38.735, 500.175)	dir: ( 0.473, 0.848, 0.238)	vel: 10.563841	velcalc: 10.563841	stepL: 0.191513	deltaT: 0.018193	trackL: 24.780559	gTime: 16.321716
( 146.328, -6.425, 509.224)	dir: (-0.049, -0.994, 0.102)	vel: 10.563841	velcalc: 10.563841	stepL: 0.138613	deltaT: 0.013011	trackL: 24.919172	gTime: 19.927531

Velocity for each first step of a new photon is not treated correctly

Disagreement between group vel. from G4 and stepLength/DeltaTime

```
// Temporary fix for problem where DeltaTime on the first step
// of optical photon propagation is calculated incorrectly. -wforeman
globalTime = step->GetTrack()->GetGlobalTime();
velocity_G4 = step->GetTrack()->GetVelocity();
velocity_step = step->GetStepLength() / step->GetDeltaTime();
if ( (step->GetTrack()->GetDefinition()->GetPDGEncoding()==0) &&
    (velocity_G4 != velocity_step) ) {
    // Subtract the faulty step time from the global time,
    // and add the correct step time based on G4 velocity.
    step->GetPostStepPoint()->SetGlobalTime(
        globalTime - step->GetDeltaTime() + step->GetStepLength()/velocity_G4);
}
```

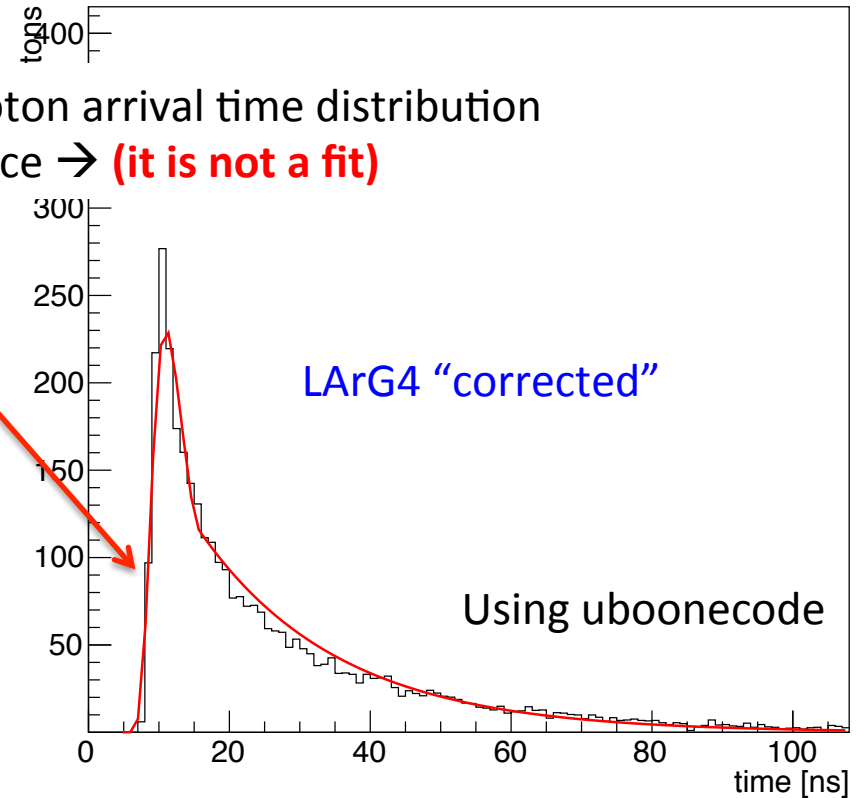
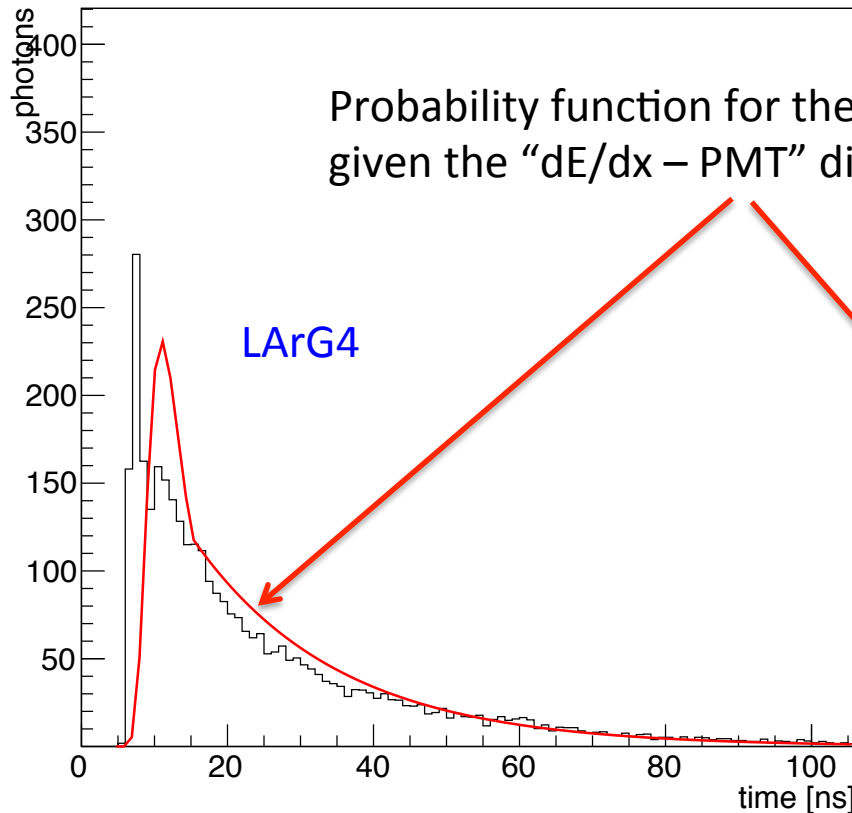
Temporary fix that checks for this at each step, and corrects the global time if necessary



# Optical Photon Time simulation in LArG4

VUV: 113.281 cm from the PMT 13, N=13905 hits

VUV: 113.281 cm from the PMT 13, N=13899 hits



Velocity for each first step of a new photon is not treated correctly :  
Disagreement between group velocity from LArG4 and stepLength/DeltaTime