Start Counter: HDGeant

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What's in HDGeant Now?

HDGeant/hitStart.c

```
void hitStartCntr(float xin[4], float xout[4], // in and out coords of hit step
                  float pin[4], float pout[4], // in and out momentum of hit step
                  float dEsum, // deposited energy in scintillator for this step
                  int track, int stack, int history, int ipart)
```

Reads the following constants from database:

START_COUNTER/start_parms:

```
START_ANGLE_COR          1.17     //
START_ATTEN_LENGTH     150.00     // mm
START_BENT_REGION       50.00     // mm
START_C_EFFECTIVE       15.00     // cm/ns
START_LIGHT_GUIDE      140.00     // mm
START_MAX_HITS         100.00     //
START_PHOTONS_PERMEV   200.00     //
START_SIGMA              0.30     //
START_THRESH_MEV         0.15     // MeV
START_TWO_HIT_RESOL     25.0      //
```

dE/dx Calculations

- Mean position and time are calculated for the current hit

$$x^\alpha = (x^\alpha_{in} + x^\alpha_{out})/2$$

$$x^\alpha = (\vec{x}, t)\,(\text{cm, ns})$$

- The length of the track in the scintillator is then determined:

$$dr^2 = \sum_{i=0}^{3} \left(x^i_{in} - x^i_{out}\right)^2$$

- $\frac{dE}{dx} = \frac{dE_{sum}}{dr}$ is computed if $dr > 0.001$ cm:
- However, this dE/dx is never used again in the code!

Attenuation

- The global coordinates are transformed into start counter local coordinates
- The path length the light has to travel through the scintillator and light guide is calculated:

```
if (xlocal[2] >= START_BENT_REGION) {
  dbent = (xlocal[2] - START_BENT_REGION) * START_ANGLE_COR;
  dpath = START_LIGHT_GUIDE + START_BENT_REGION + dbent;
} else {
  dpath = START_LIGHT_GUIDE + xlocal[2];
}
```

- Energy and time attenuation is calculated:

$$E_{corr} = dE_{sum} e^{-l/\tau}$$

$$t_{corr} = t + \frac{l}{v_{eff}}$$

- l = dpath
- τ = START_ATTEN_LENGTH
- v_{eff} = START_C_EFFECTIVE

Truth Hit Tree

- The physics of the current hit step is stored in "StcTruthHit"
- Truth hits store the response of tracks in the detector geometry
- The following information is stored for each hit:
  - Corrected time: t_{corr}
  - Corrected energy: E_{corr} (stored as dEdx, why?)
  - Mean position of hit: (r, z)
  - Azimuthal angle of the hit: ϕ
  - The 4-momentum of the track as it entered into the scintillator: $(E, \vec{p})$
  - The paddle hit
  - Track history and particle type

Hit Multiplicity

Multiple hits in the same paddle:

- Loops through all existing hits in the same paddle and finds the hit that is within the two-hit resolution of current hit: $|t_{corr} - t_i| < \sigma_{2hits}$
- σ_{2hits}: START_TWO_HIT_RESOL from database
- Merges the time of the current hit with the existing hit found above by weighting it with the energies of the hits:

$$t_{merged} = \frac{t_{corr}E_{corr} + t_iE_i}{E_{corr} + E_i}$$

$$E_{merged} = E_{corr} + E_i$$

- Otherwise, E_{corr} and t_{corr} are stored as energy and time for a new hit

MC Smear

- Smears the hits and adds noise
- The time of the hit is smeared using a randomly generated gaussian distribution with resolution obtained from database (σ: START_SIGMA) centered at 0.0 ns:

$$t' = t + Random(e^{-x^2/2\sigma^2})$$

- The energy of the hit is also smeared using the following prescription:

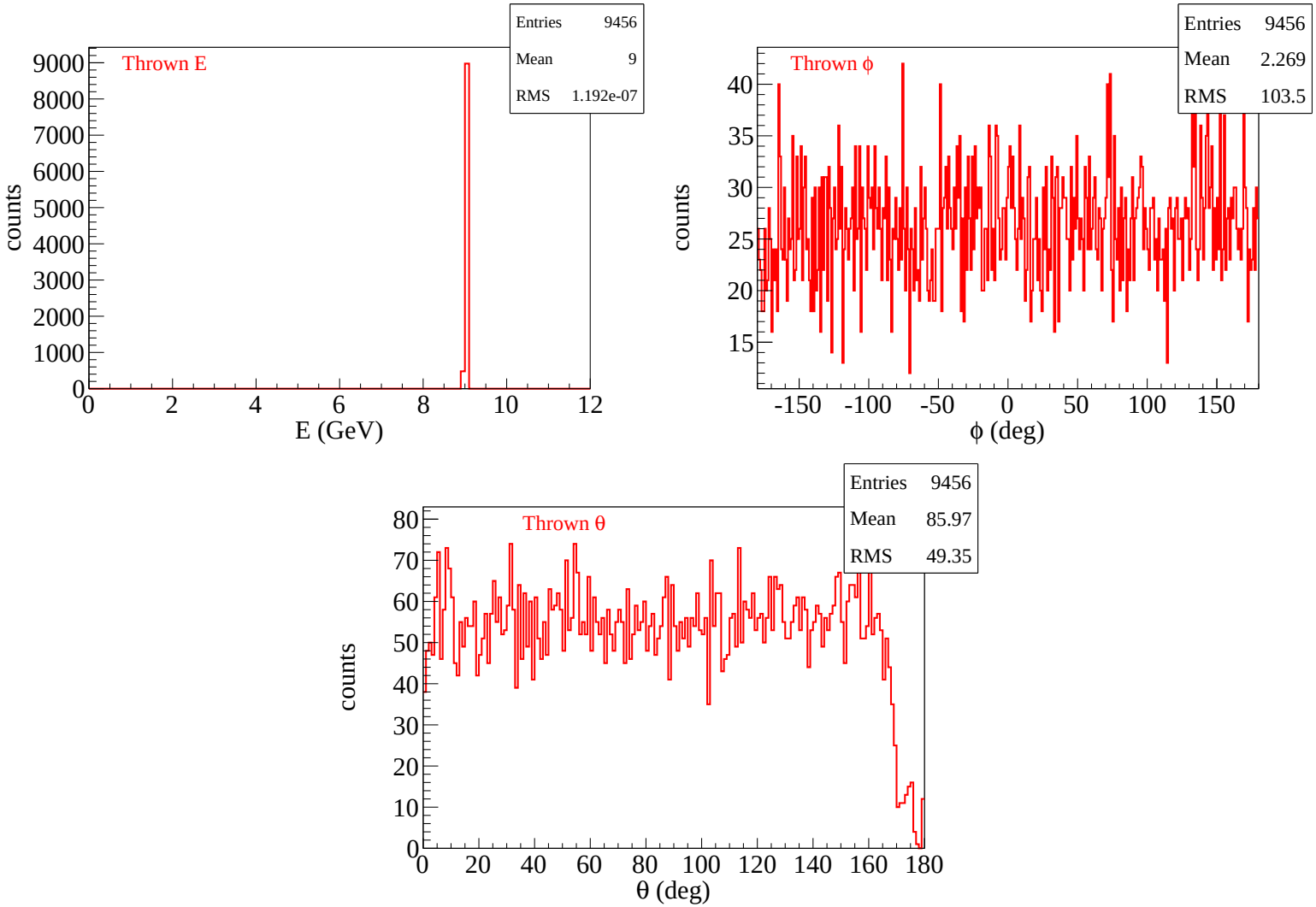
$$nphe = E \times 1000\,\text{MeV}\,\frac{\#\gamma s}{\text{MeV}}$$

$$nphe' = nphe + Random(e^{-x^2/2nphe})$$

$$E' = nphe' \times \frac{1\,\text{MeV}}{\#\gamma s}\,\frac{1}{1000\,\text{MeV}}$$

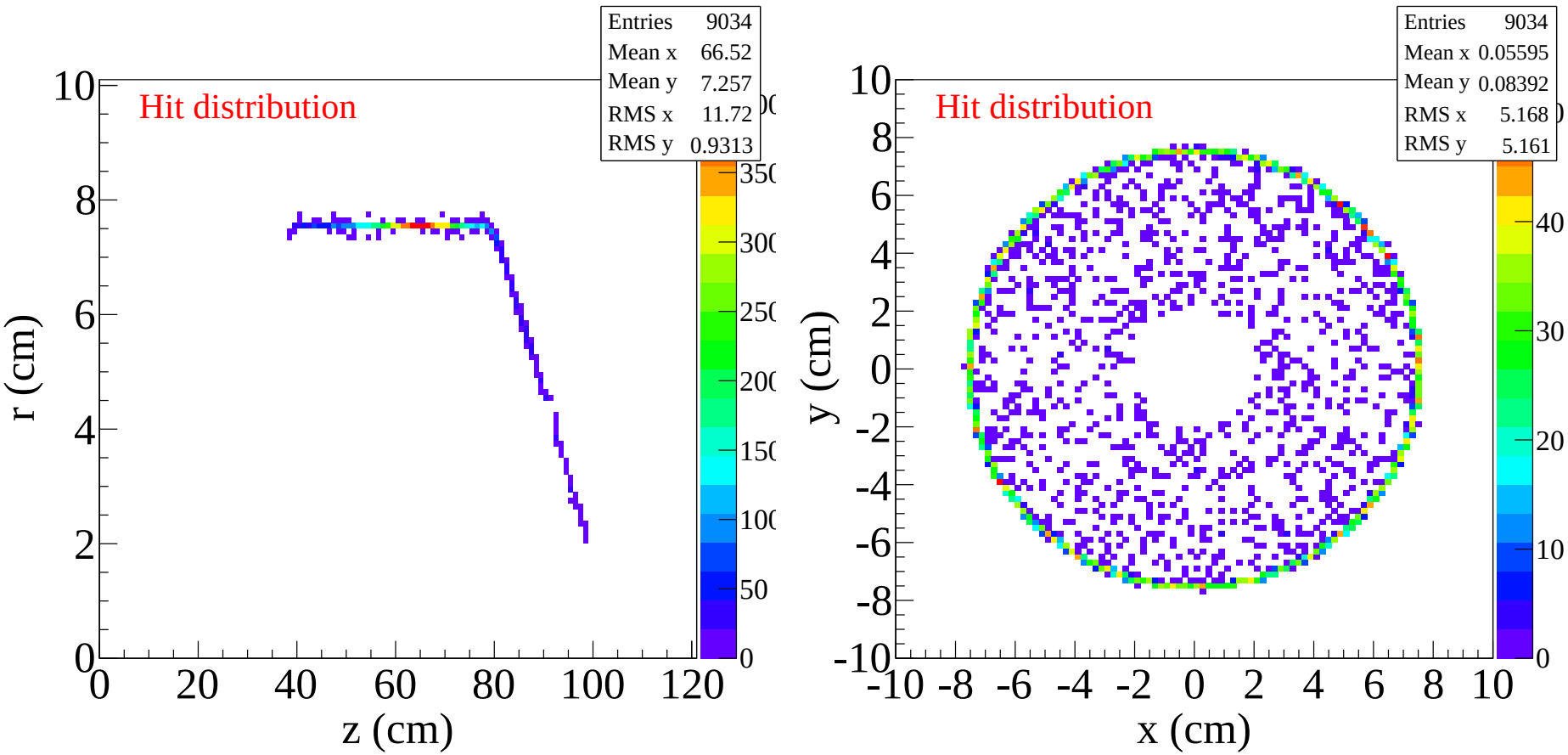
  $\#\gamma s$/MeV: START_PHOTONS_PERMEV from database
- The modified energy and time are stored in a separate tree: "StcHit"

Thrown Kinematics



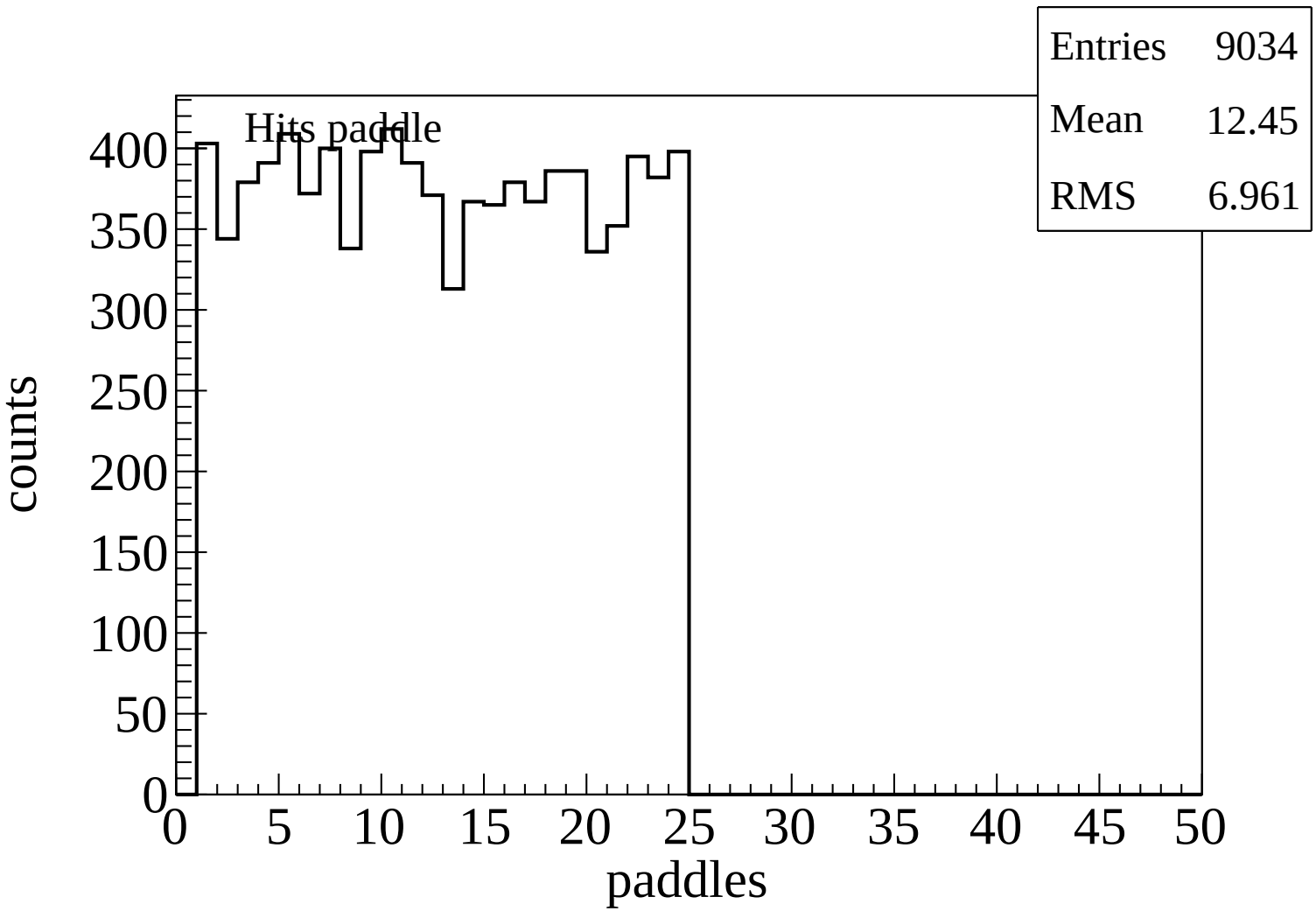
Thrown/Generated event kinematics for 10000 events

Simulated "Truth" Events



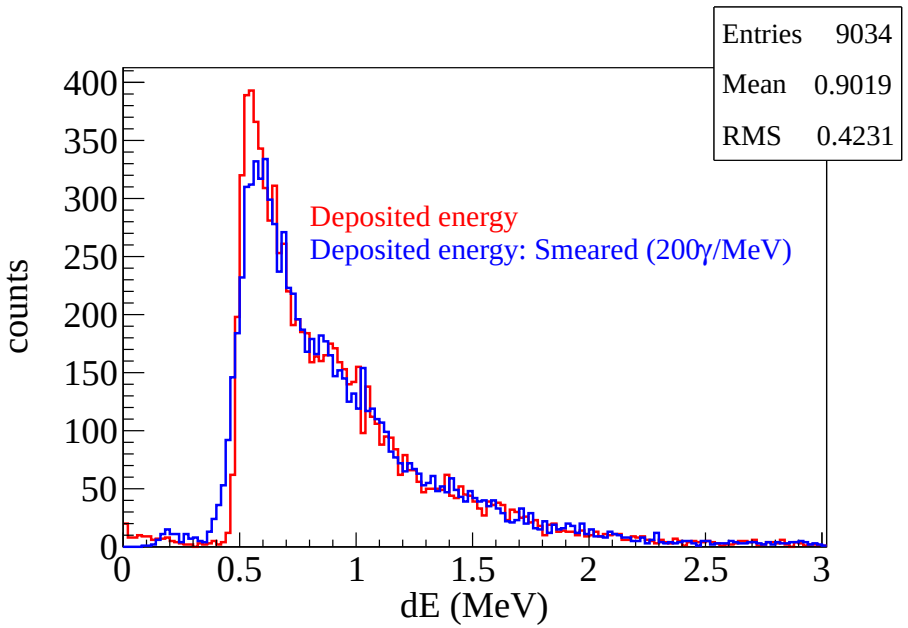
Start Counter Hit distributions in HDGeant

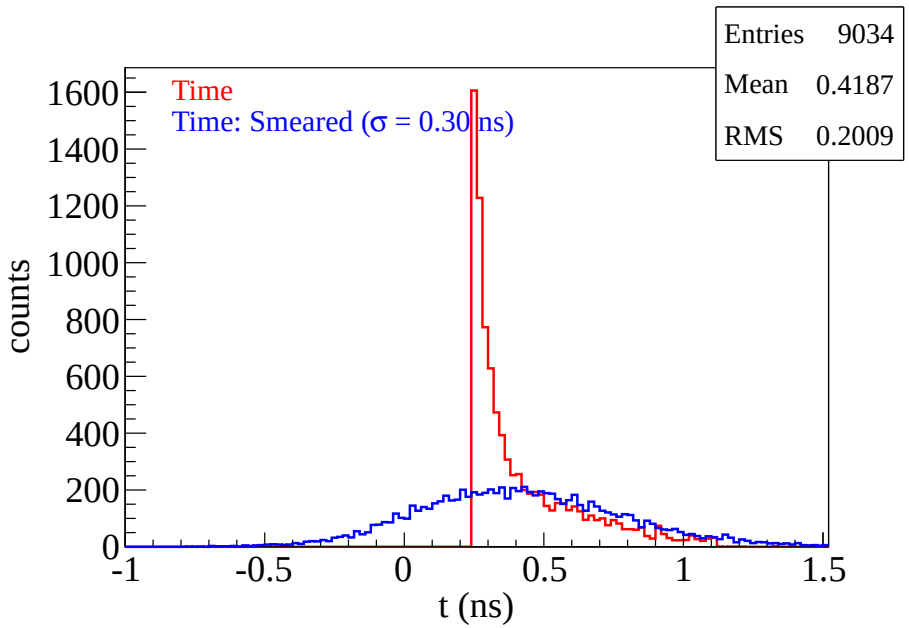
Simulated "Truth" Events



Paddle Occupancy

Simulated "Truth" Events



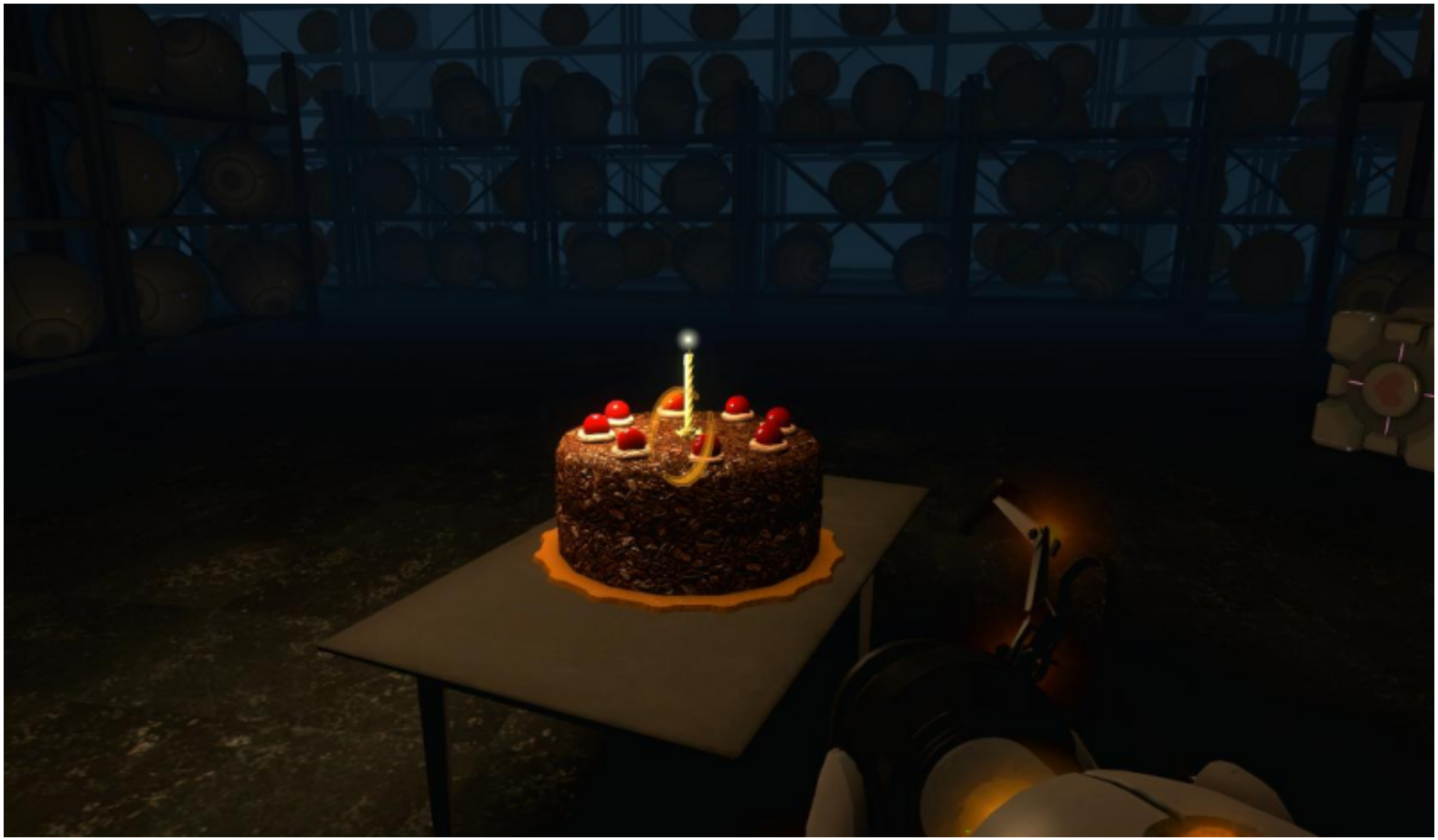


Deposited energy and time
No attenuation included

Things To Do

- Constants on database or hard coded or read from geometry file?
- Finalize what info should go in "factories"
- Check/modify attenuation calculation
- Use different model for smearing
  - Nphe as a function of dE, θ, Poisson distribution, etc.
  - Include attenuation in smearing or HDGeant
- Digitization (ADC, TDC)
- Reconstruction
- Implement final Start Counter design

The End



"The cake is a lie." - *Portal*