LASPD simulation

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SPD Simulation

- LASPD scintillation and photon transport
- Two options:
  - G4Scintillation
  - post-GEMC simulation: Make use of the current GEMC simulation output.

post-GEMC simulation

- Using the hit information of the GEMC output
- Photons generated uniformly along the particle path and isotropic emission
- Number of generated photoelectrons is reduced by a couple factors:

  - Collection factor: assume the effective area of PMT to the scintillator end area as 0.6 (can be optimized later with a comparison to the data or simulation)

  - Assumed QE of 0.15

  - Attenuation: Simulated according to the probability of $1 - \exp(-l_{pro}/\lambda_{pro})$

post-GEMC simulation

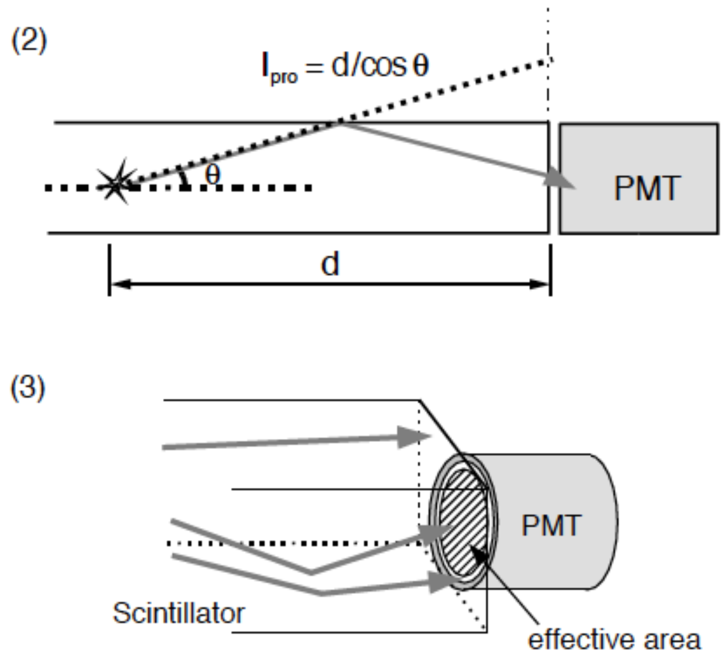


Fig. 7. Light propagation in a scintillator counter.

A detailed Monte Carlo simulation for the Belle TOF system
(NIM(A) 491 (2002) 54-58)

- We assume perfect internal reflection on the surfaces except for two PMT end sides.
- Light with its emission angle < critical angle can reach to the PMT.
- For the scintillator used in this study has the refractive index of 1.58, and therefore we get the critical angle of ~39.2 degree.

post-GEMC simulation

- Time information:
  - time = $t_{traj} + t_{emit} + t_{pro} + t_{TT}$

t_{traj} : time for the particle trajectory (currently using the average time information of the particle in the SPD)

t_{emit}: light emission time. Simulated using the emission time probability function

$$E(t_{emit}) = \frac{1}{1+R}\left(\frac{e^{-t_{emit}/\tau_2} - e^{-t_{emit}/\tau_1}}{\tau_2 - \tau_1} + \frac{R}{\tau_3} e^{-t_{emit}/\tau_3}\right)$$

t_{pro} : light propagation time in the scintillator. tpro = n_{scin} * l_{pro} / c

t_{TT} : transit time of a single p.e in the PMT (Gaussian smearing with a mean of PMT transit time (TT) and rms transit time spread (TTS). For R9779, TT is 20 ns and TTS is 0.25.)

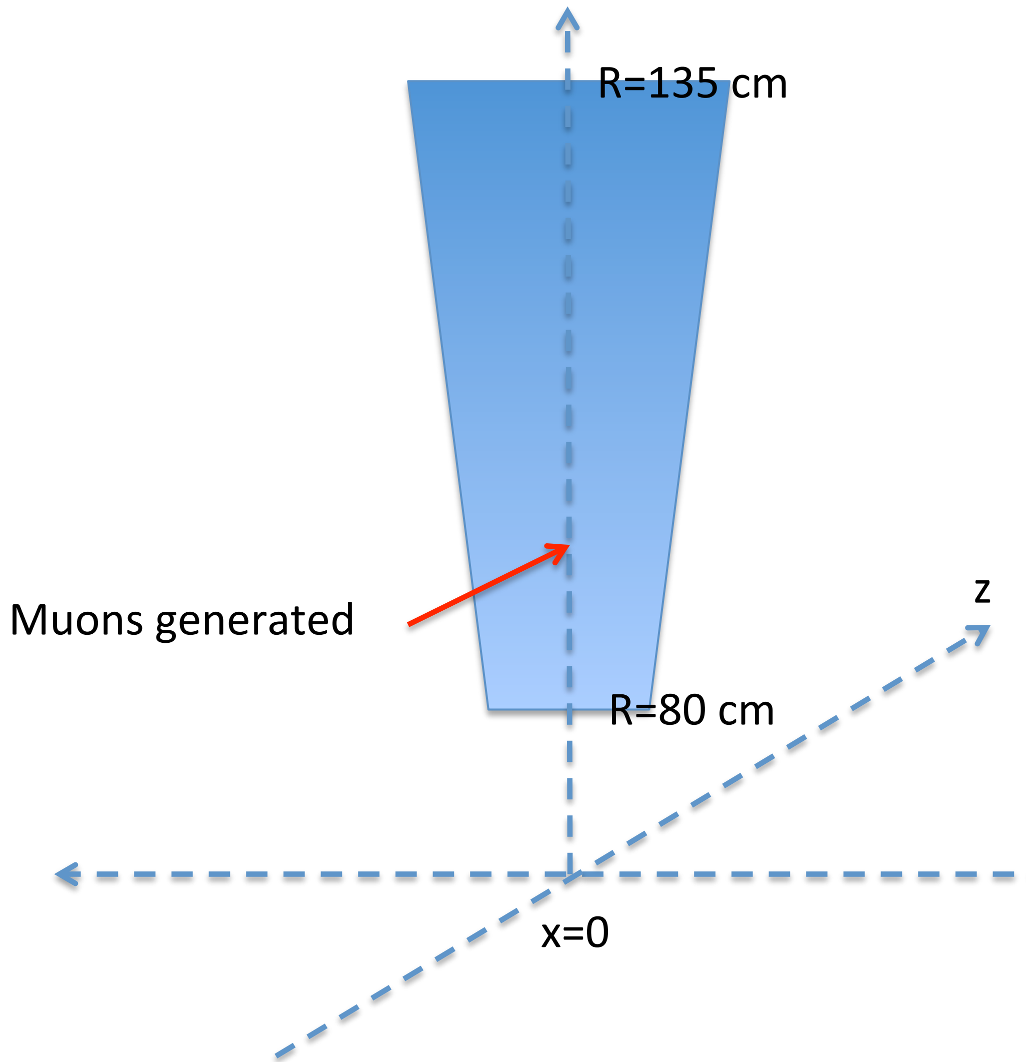
Scintillator specification (EJ-200)

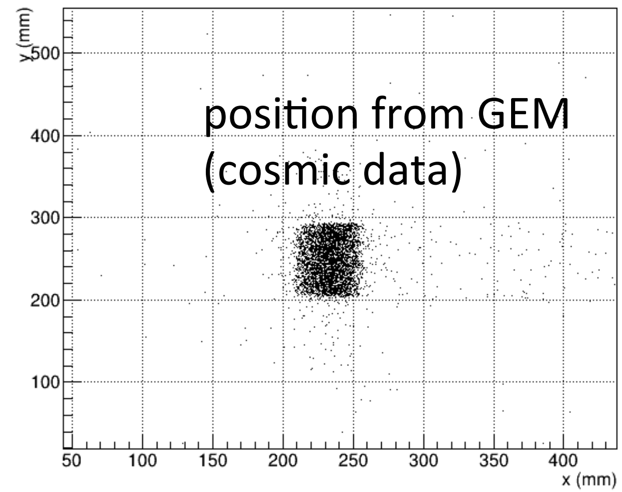
- Dimension: 20x83 to 20x140x570 mm

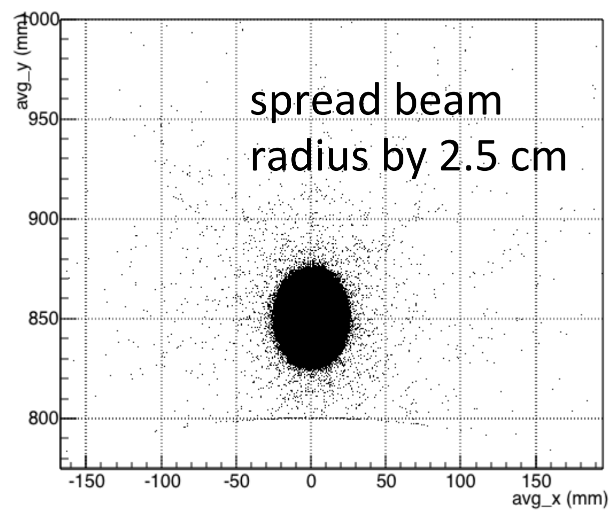
PMT: Hamamatsu PMT R9779 on both sides

Parameters	
Density (g cm-3)	1.302
Refractive index	1.58
Light output (64% anthracene)	0.64 * (17400 / MeV)
Rise time of fast components (ns)	0.9
Decay time of fast components (ns)	2.1
Decay time of slow components (ns)	14.2
Slow to fast Ratio R	0.27
Light attenuation length (cm)	380

Single muon generation



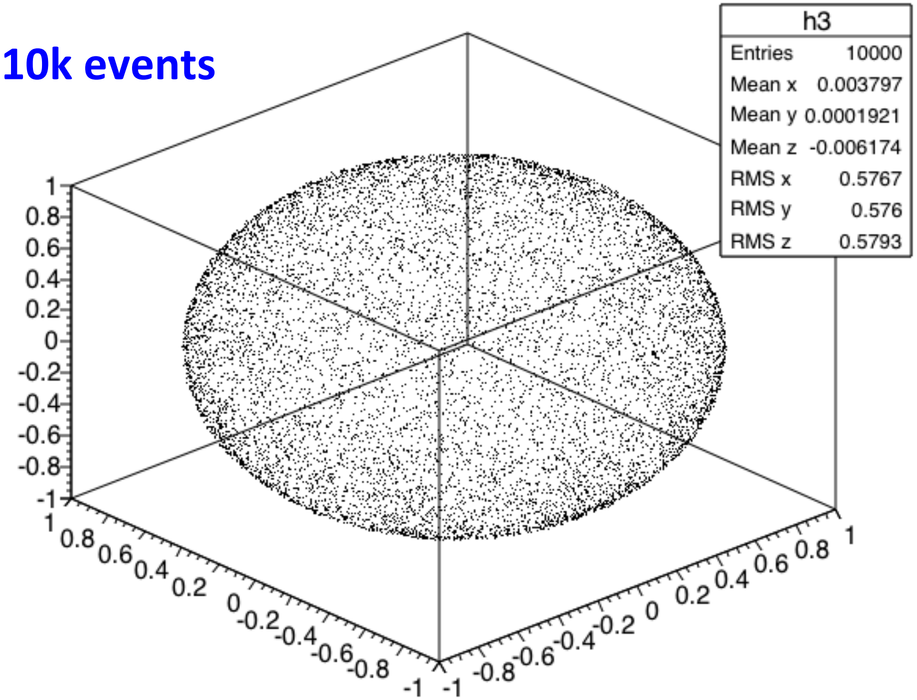


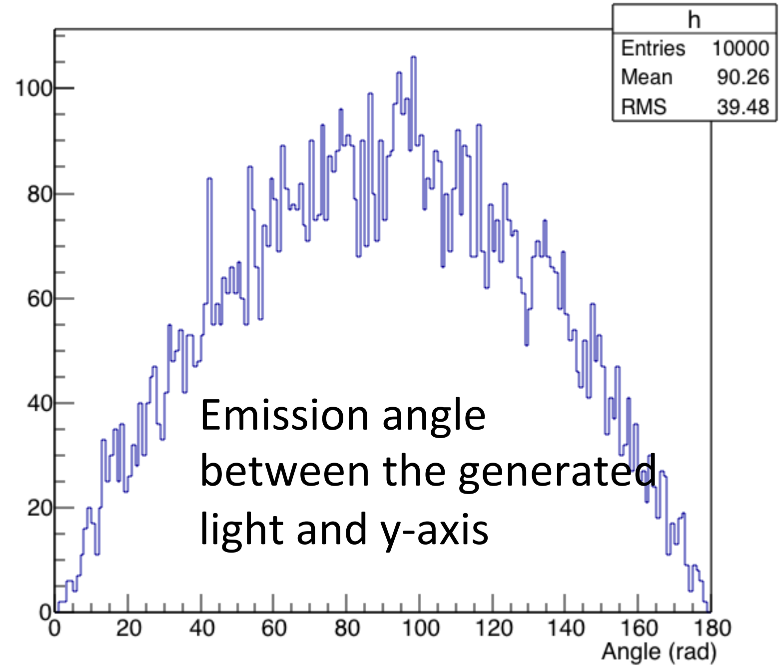


Generate photons

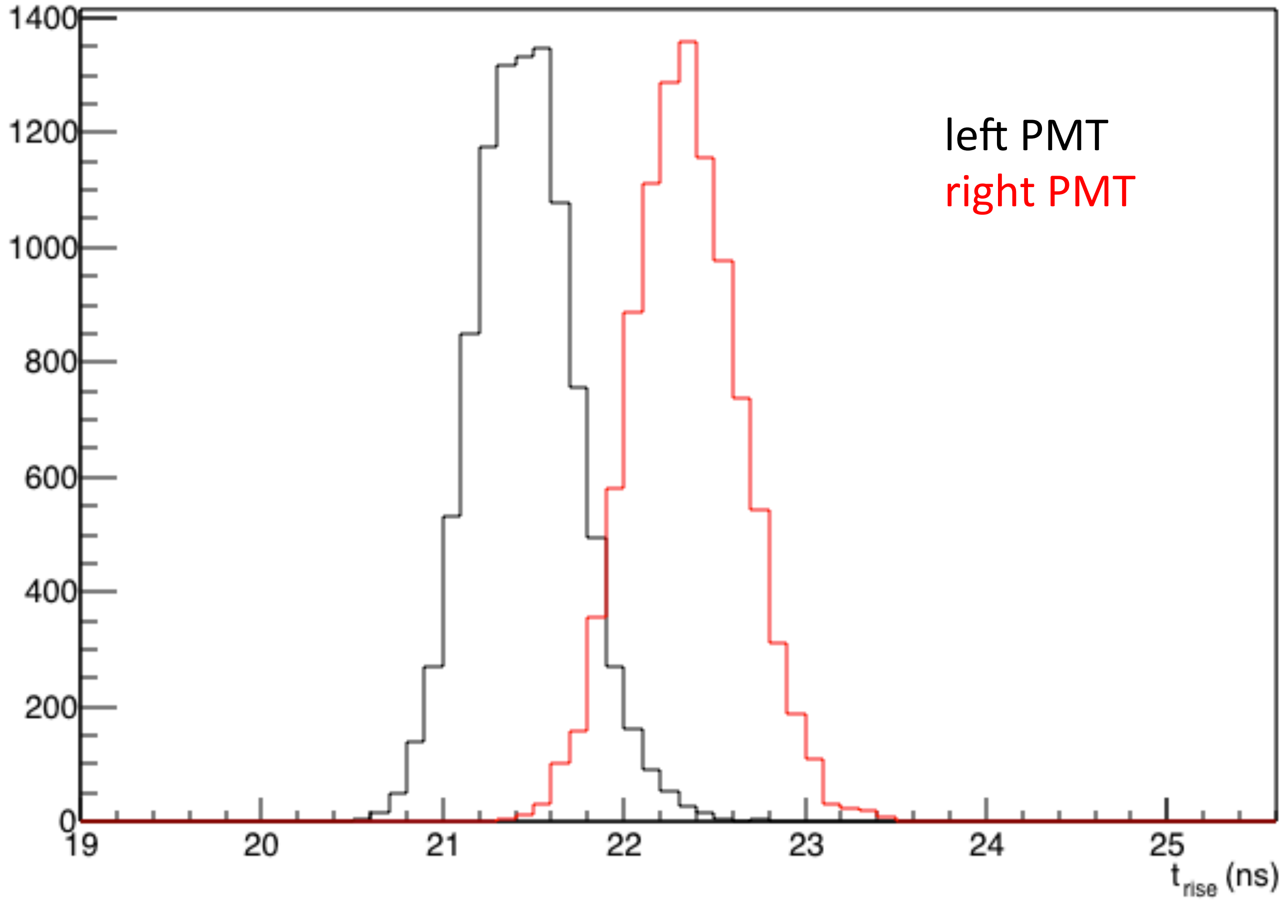
- Uniformly distributed along the particle path
- Isotropic emission

10k events

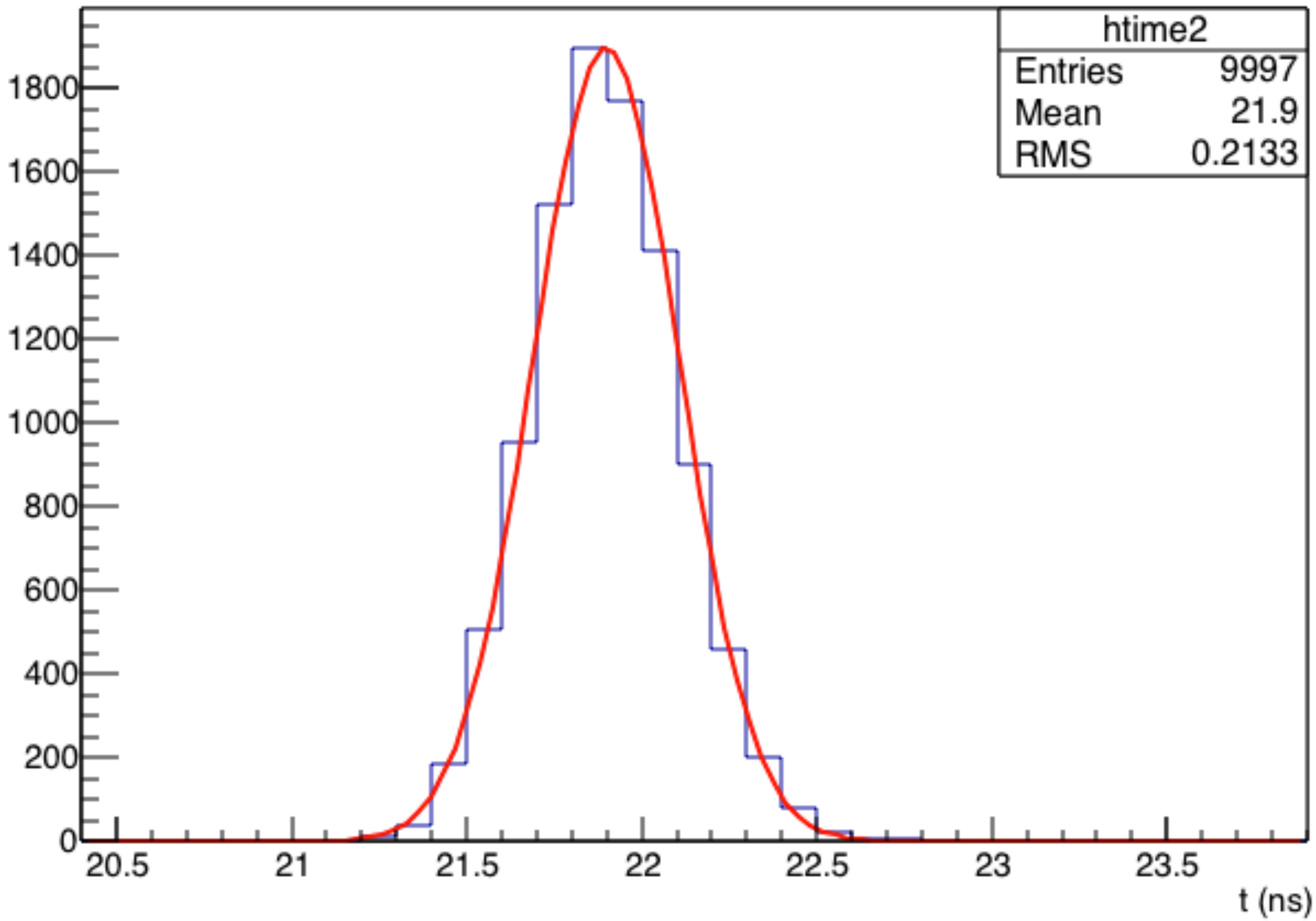




Simulation output

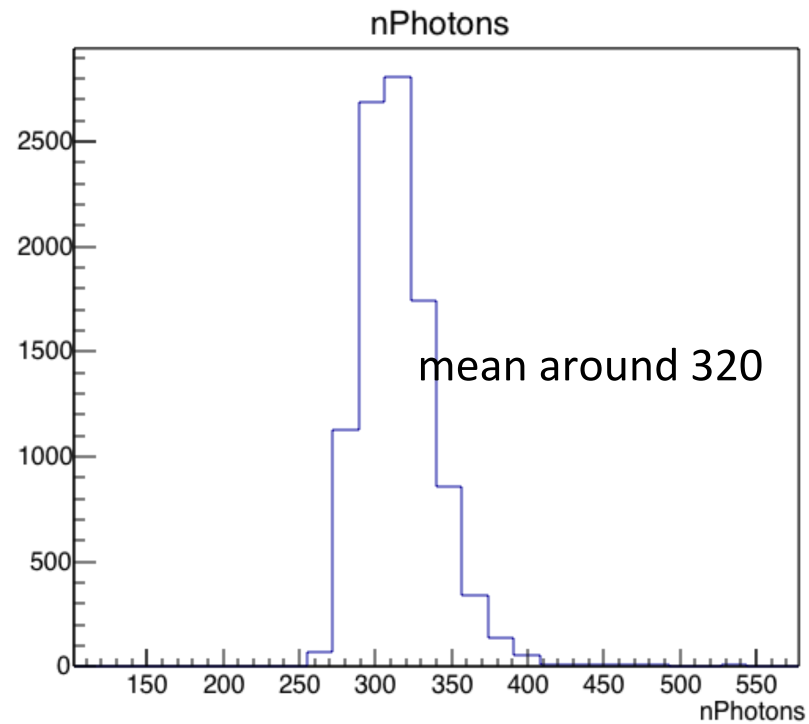


Average SPD time



Simulation output

- Previously, calculated photon yield assuming ~1.E4 photons/MeV (given by manufacturer resulting several thousands of initial photons
- JP suggested to check the previous discussion as well as talking to Ye.
- Previous study used 1E3 photons/MeV



of p.e.

Direct light readout simulation (for SPD, cross-check with other TOF, S2 etc)

The simulation for SPD timing and light yield is done as follows:

1. Using SG crystal properties: rho=1.032g/cm3, n=1.58,
   A. BC404 (for CLAS12 TOF): attentuation length 140cm(bulk 160cm), rising time 0.7ns;
   B. BC408 (for SoLID): attenuation length 210cm (bulk 380cm), rising time should be 0.9ns but here I used 0.7ns by mistake;
2. PMT specification as follows:
   A. QE: typically use 15%
   B. Timing:
      a. from these 3 references: CLAS note 91-003 (measured sigma with 200 photoelectrons); or Photonis catalog; or Hamamatsu website (datasheet):
      b. In Photonis catalog, open cathode TTS (listed in sigma) includes the center-edge difference, so the larger center-edge diff must be the full range (I think).

   D. Using Hamamatsu R9779 timing specifications: TTS 250ps, rising time 1.8ns, QE 15%
3. Original photon yield: assuming scintillator efficiency of 0.003 (fraction of energy converted to UV and visible photons) or 1E3 photon/1MeV assuming 3eV/photon. This was deduced from :
   1. An earlier CLAS TOF test (nucl-ex/0506020) which claimed a MIP yield of 685+/- photoelectrons/4.4MeV, divided by 15% of QE and multiplied by (3eV) of average photon energy.
   2. Our Preshower yield (however the preshower is a different scintillator) showed roughly 4E-3 of energy conversion.
   3. Some online searching, for example Table 1 in http://iopscience.iop.org/0295-5075/95/2/22001/pdf/epl_95_2_22001.pdf, showed BC408 with 10000 photon/MeV. This is 10 times higher. However there is no original reference from Saint-Gobain to prove this.

http://hallaweb.jlab.org/experiment/PVDIS/SoLID/EC/meetings/spd/SPD%20simulation%20for%20JLab%20SoLID.html

Summary

- A simple post-GEMC LASPD simulation is under its test.
- Waiting for Ye's measurement

backup

Simulated transit time using the Gaussian model