Simulated Output of The 2GeV Electron Beams at FTBF Validation Test

Minseok Oh
Seoul National University

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Introduction

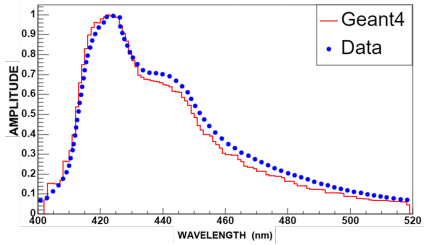
Motivation

- Neutron background is a major issue in DAMSA due to the ECAL damage it causes, as well as bkg photons from neutron capture and other related effects.
- DAMSA Stage-0 neutron background measurement experiment had been completed.
- Now I'm doing a Geant4 simulation to quantitatively interpret the result of experiment.

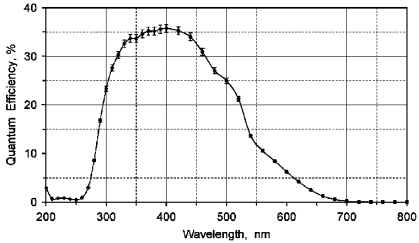
Content

- Validated EJ301 pulse shape of my Geant4.
- Simulated single electron beam(=1EOT) case for different target length.
- Checked background multiplicity and opticalphoton pulse.

Geant4 EJ301 Pulse Shape Validation



(a) Validation of my EJ301 pulse shape

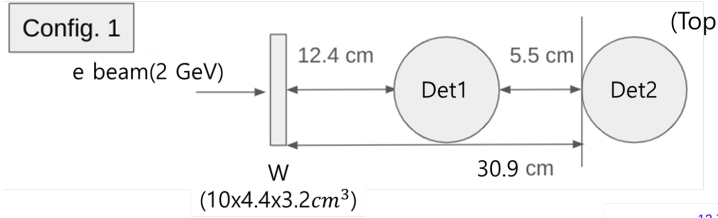


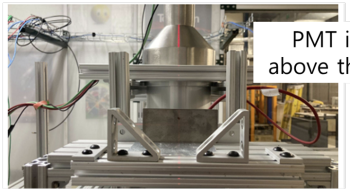
(b) Q.E of Hamamatsu PMT

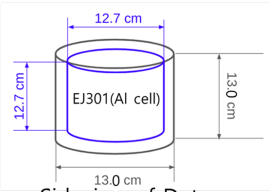
My pulse shape follows the same trend but with a slightly higher amplitude.

Since I didn't apply Q.E. in my simulation, some differences are expected due to this.
But I can apply it immediately once the quantum efficiency (Q.E.) for our model is available.

Simulation Configuration for Bkg Multiplicity Check



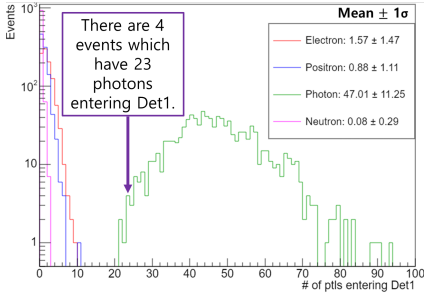




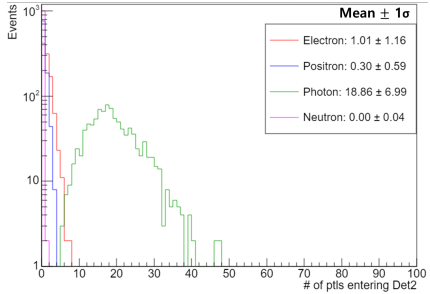
Sideview of Det

Electron beam starts at 1m before target (at t=0ns) in my simulation.

Single e Beam Background Multiplicity (10^3 Events)



(a) Det1 Bkg w/ 0.1MeV cut

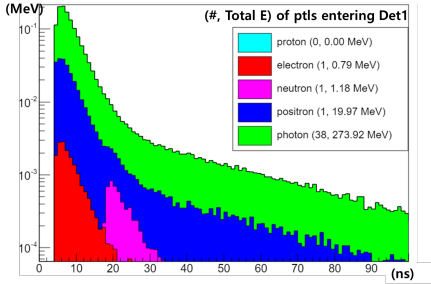


(b) Det2 Bkg w/ 0.1MeV cut

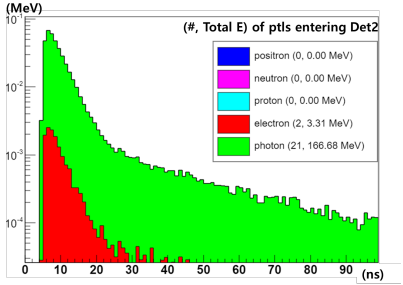
X-axis: Event-wise multiplicity. -> Each particle type has 1000 events (entries).

Photons are dominant as expected and there are at least 20 photons entering Det1 per event.

Opticalphoton Pulse from Best Single Event



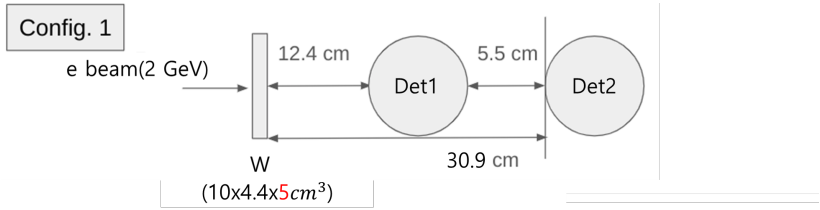
(a) Det1 opticalphoton pulse w/ no cut



(b) Det2 opticalphoton pulse w/ no cut

Time-Energy distribution of opticalphotons collected at the celling of detectors. Neutron signals are buried by photons.

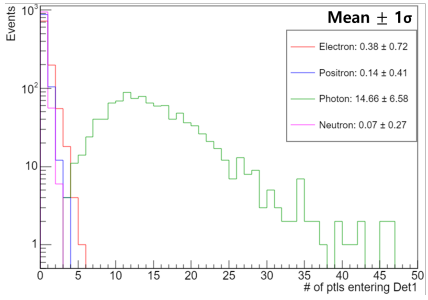
How about Thicker Target Case? - 5cm



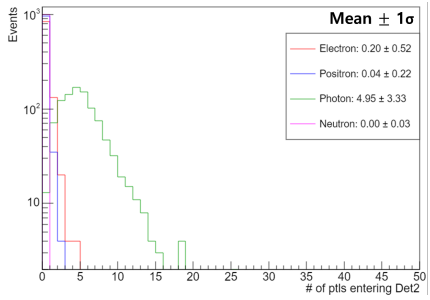
Thicker target will produce more neutrons and shield more EM particles.

So thicker target can be better at neutron bkg measurement when we do further experiments.

Single e Beam Background Multiplicity - 5cm (10^3 Events)



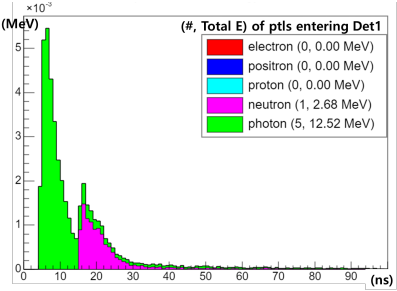
(a) Det1 Bkg w/ 0.1MeV cut



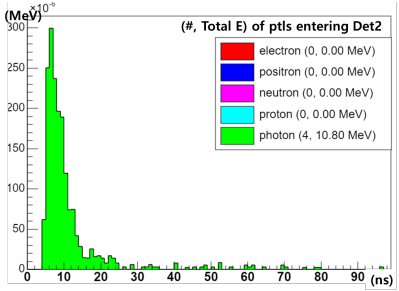
(b) Det2 Bkg w/ 0.1MeV cut

EM backgrounds are reduced as expected but most of neutrons are also shielded. And still photons are dominant which is undesirable.

Opticalphoton Pulse from Best Single Event - 5cm



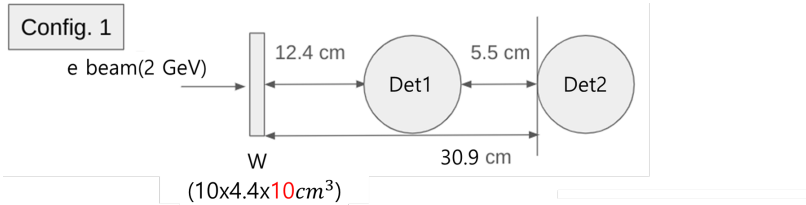
(a) Det1 opticalphoton pulse w/ no cut



(b) Det2 opticalphoton pulse w/ no cut

Time-Energy distribution of opticalphotons collected at the celling of detectors. Second pulse peak from neutrons emerged.

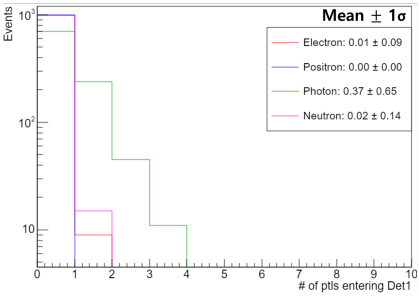
How about Thicker Target Case? - 10cm



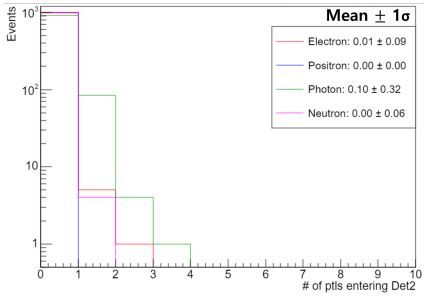
Thicker target will produce more neutrons and shield more EM particles.

So thicker target can be better at neutron bkg measurement when we do further experiments.

Single e Beam Background Multiplicity - 10cm (10^3 Events)



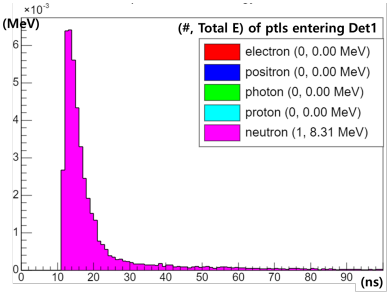
(a) Det1 Bkg w/ 0.1MeV cut



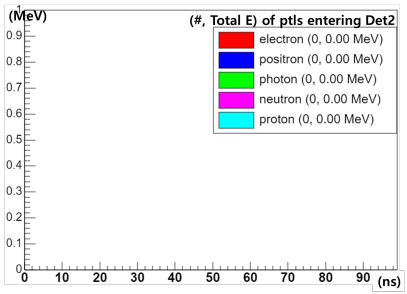
(b) Det2 Bkg w/ 0.1MeV cut

EM backgrounds are reduced as expected but most of neutrons are also shielded. And still photons are dominant which is undesirable.

Opticalphoton Pulse from Best Single Event - 10cm



(a) Det1 opticalphoton pulse w/ no cut



(b) Det2 opticalphoton pulse w/ no cut

Time-Energy distribution of opticalphotons collected at the celling of detectors. Single neutron pulse event finally exists(10 events out of 1000).

Neutron Acceptance (10^3 Events)

	Number of neutrons entering Det1					Others
	Only 1		More than 1		No neutrons	
Total E(MeV)	0.1∼1	1∼10	0.1∼1	1∼10	0	
3.2cm Target	38	22	2	5	930	3
5cm Target	34	21	3	3	938	1
10cm Target	9(5)	6(5)	0	1(1)	984	0

Number in ( ) in 10cm target is number of events which have only neutron bkgs.

Typical Valid Neutron Energy Ranges for PSD:
1. Organic Scintillators (e.g., EJ-301, EJ-331, BC-501A, liquid scintillators)
- Threshold: 100 keV – 200 keV
- Upper Limit: 10 MeV – 20 MeV
- Best Performance: 1 MeV – 10 MeV (strong separation between neutrons and gamma rays)

Summary and Further Plan

Summary

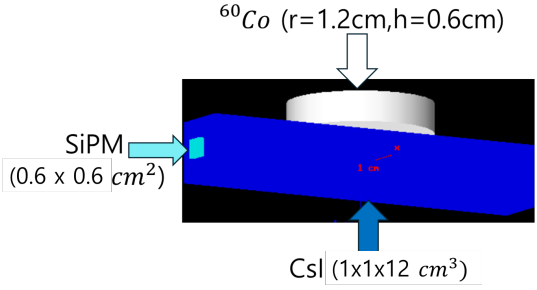
- Validated EJ301 pulse shape of my Geant4 and further improvement can be done with Q.E data of our PMT.

- Based on my simulation, a longer target is necessary for us to investigate the single neutron signal.

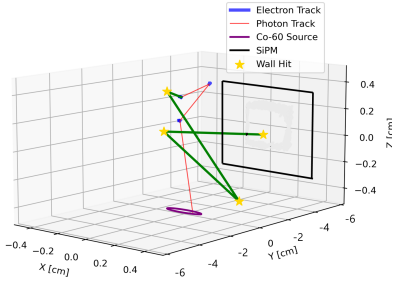
Further Plan

- Apply Q.E and other details to my Geant4 so that results are consistent with experimental data.

Further Plan - Single CsI Crystal Bar Simulation



(a) Simulation configuration



(b) 3D figure of interactions inside CsI

20 CsI crystal bars(1x1x12cm^3) have been delivered to SNU and are currently being tested.
To quantitatively interpret the test results, I am conducting detailed Geant4 simulation of the crystal.