EMC Timing Model and Rad. Bhabha Background Rate in Full/ FastSim

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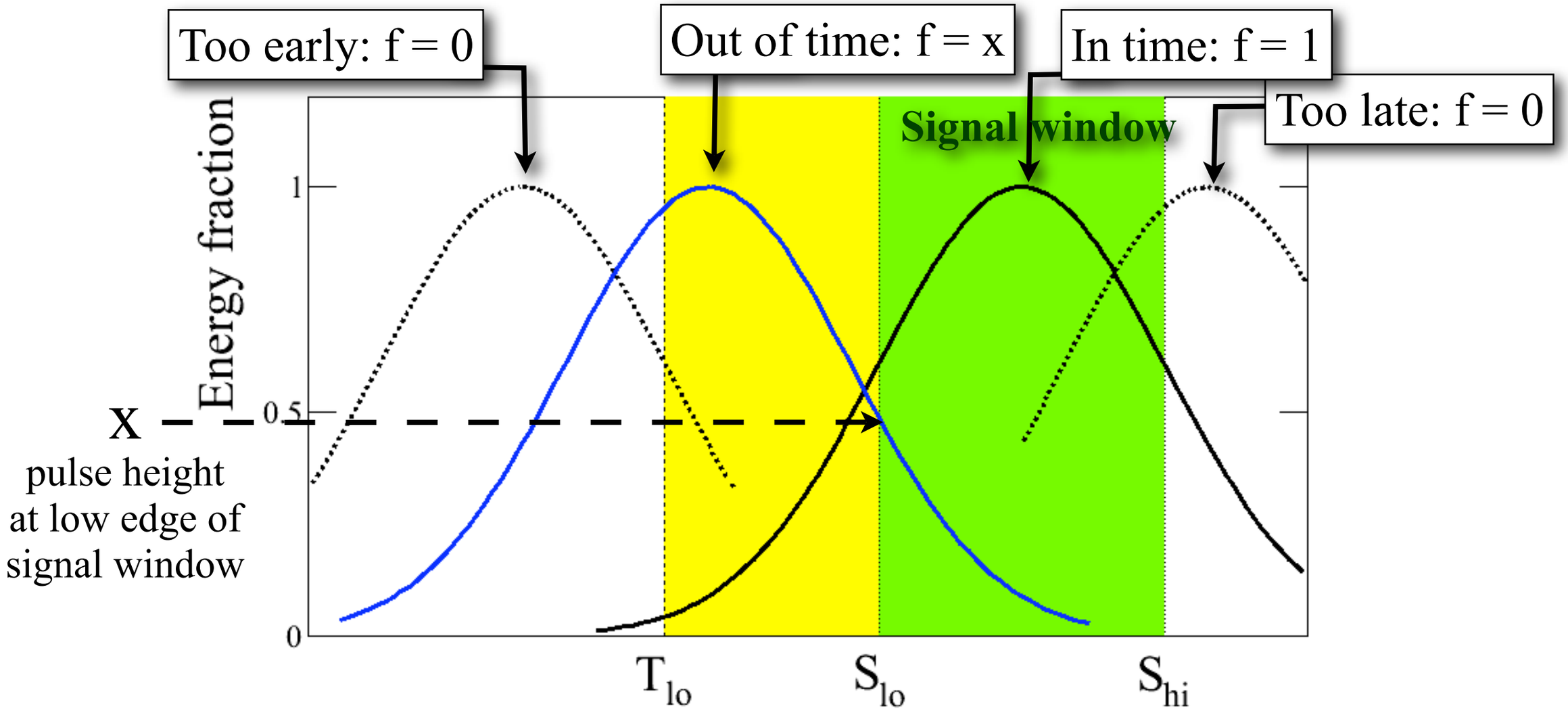
Current waveform modeling

- Babar EMC signal is sampled every 270ns.
- A maximum is found in the signal window and a fit to it and its two neighbors is performed to determine time and pulse height, which is converted to energy.
- Waveform is modeled by a gaussian of mean t0 (simhit time) and σ.
- The energy used to create fastsim cluster depends on the time.

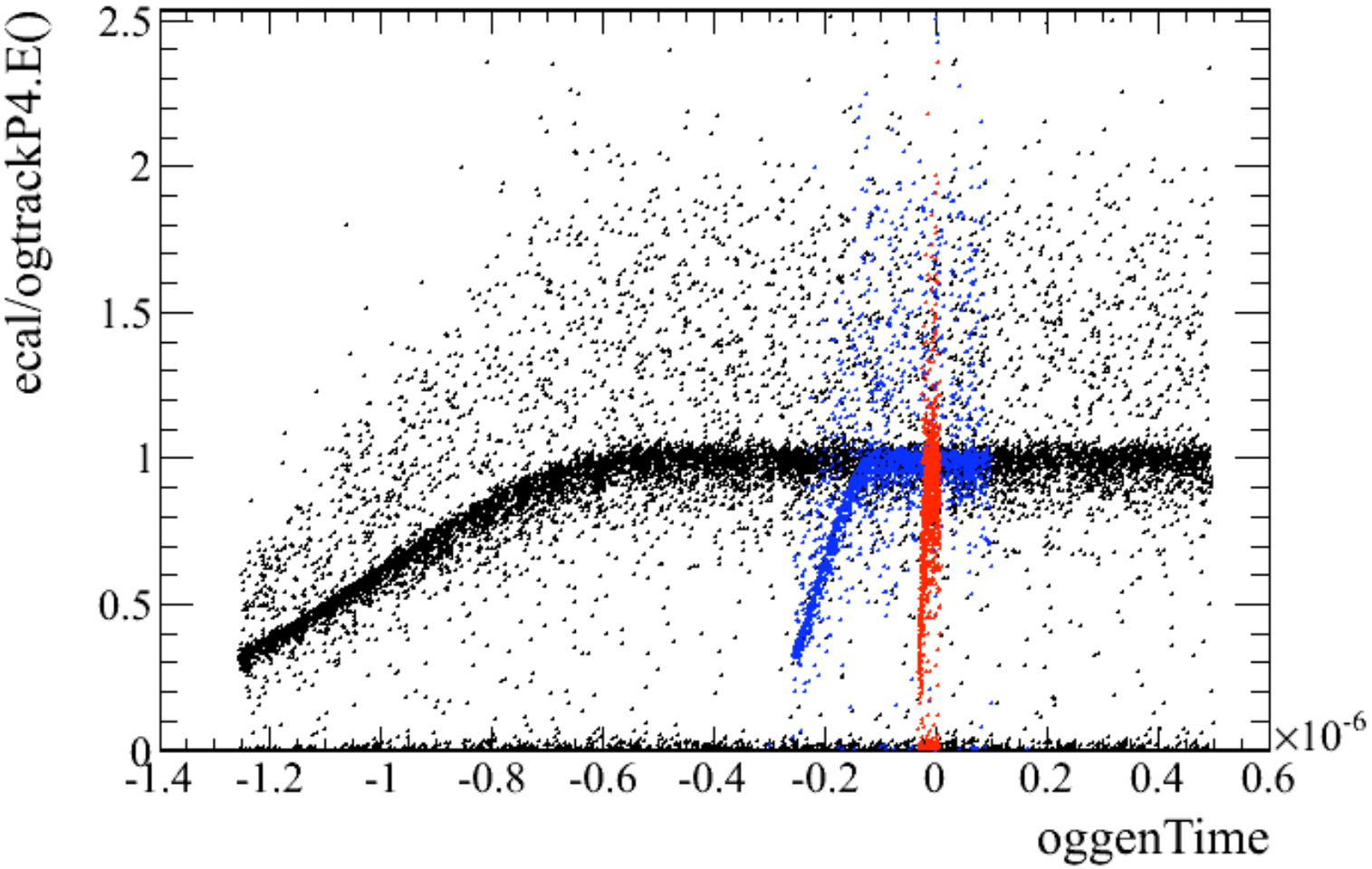


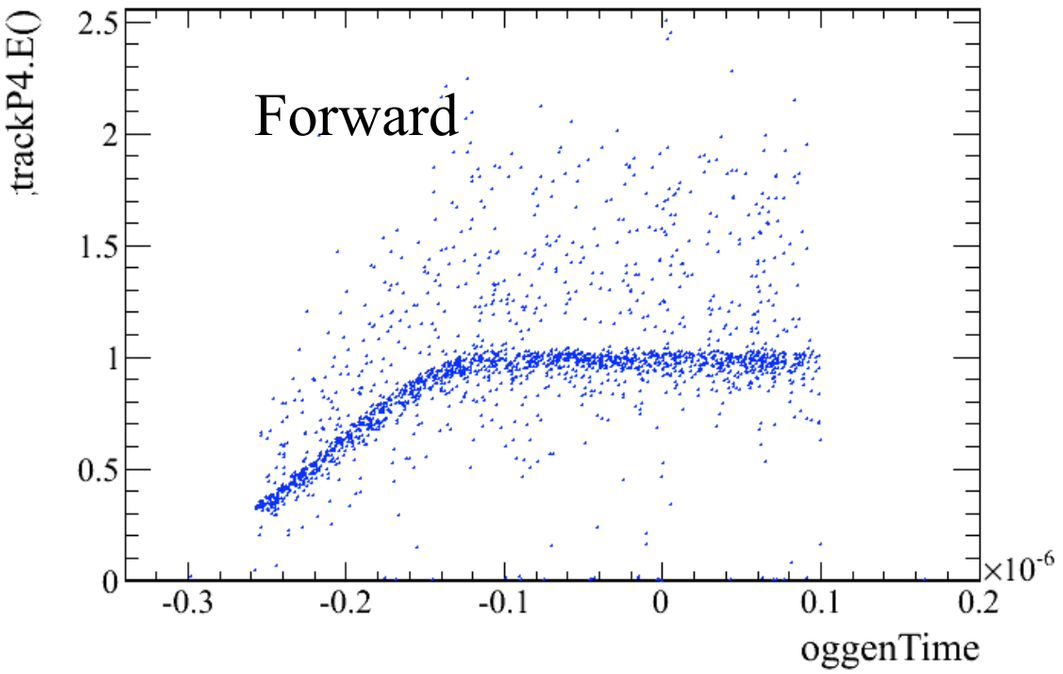
Feb.2010 produciton fastsim parameters

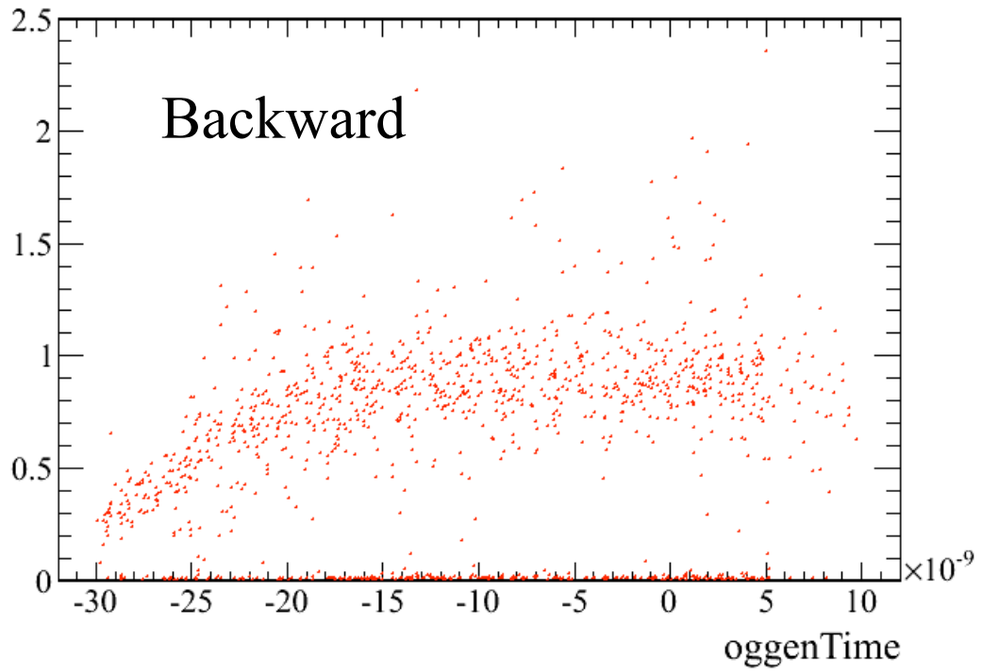
- Assume we cannot remove background if it is within1.5σ below the signal window, but can remove it completely if it happens ealier than that.
  - Reality is probably somewhat in between. We don't know.
  - These parameters are used in February production.

unit = ns	Fwd	Barrel	Bwd	
σ	100	500	10	
S_hi	100	500	10	+1σ
S_lo	−100	−500	−10	−1σ
T_lo	−250	−1250	−25	−2.5σ

Energy fraction vs. particle gen. time







neutrino events with bkg mixed

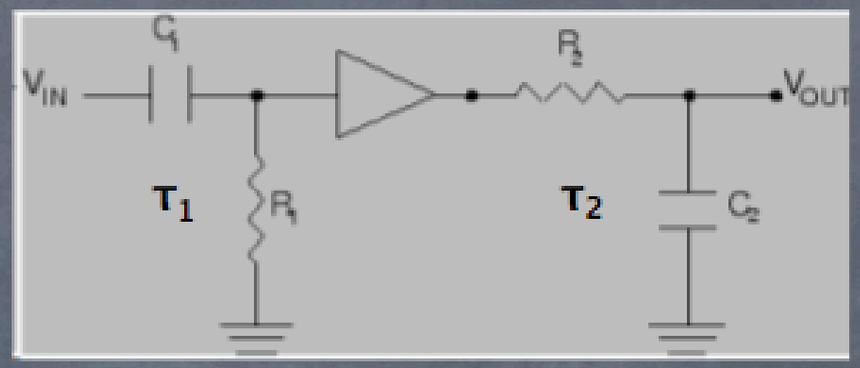
Problems with this model

- Babar records all digis within ±1μs of trigger in raw data. An energy-weighted time t_0 over all EMC digis is calculated. During reconstruction, digis outside t_0±120ns are removed. (Sometimes an out-of-time Bhabha dominates the EMC and the EMC info of the entire physics event is thrown out.)
- Should we simply use tracking t_0 instead?
- Current signal window of ±500ns plus additional 750ns below the signal window is clearly too wide.
- Gaussian waveform is not realistic. May need to use more realistic model considering scintillator light decay time, shaping times, or perhaps even sampling time.
- May need to consider better way to add energy of different times.

EMC pulse response to a filter

- Use CR-RC filter to model (*BABAR* CsI(Tl) actually uses CR-RC^2)
  - Step function response

$$V_{out} = \frac{\tau_1 (e^{-t/\tau_1} - e^{-t/\tau_2})}{\tau_1 - \tau_2}$$



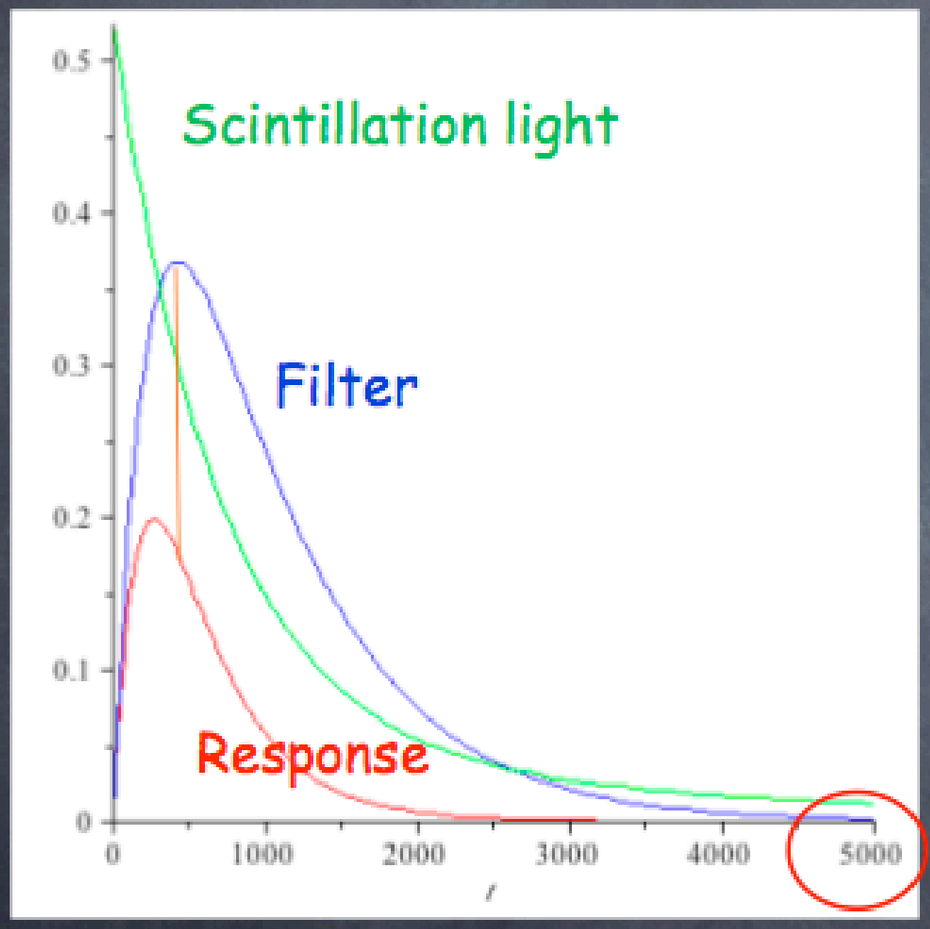
- In our case the light has an exponential decay time (or two)
- CsI: 64% @ 680ns + 36% @3340ns
- LYSO: 41ns

$$V_{out} = (1 - e^{-t/\tau}) \frac{\tau_1 (e^{-t/\tau_1} - e^{-t/\tau_2})}{\tau_1 - \tau_2}$$

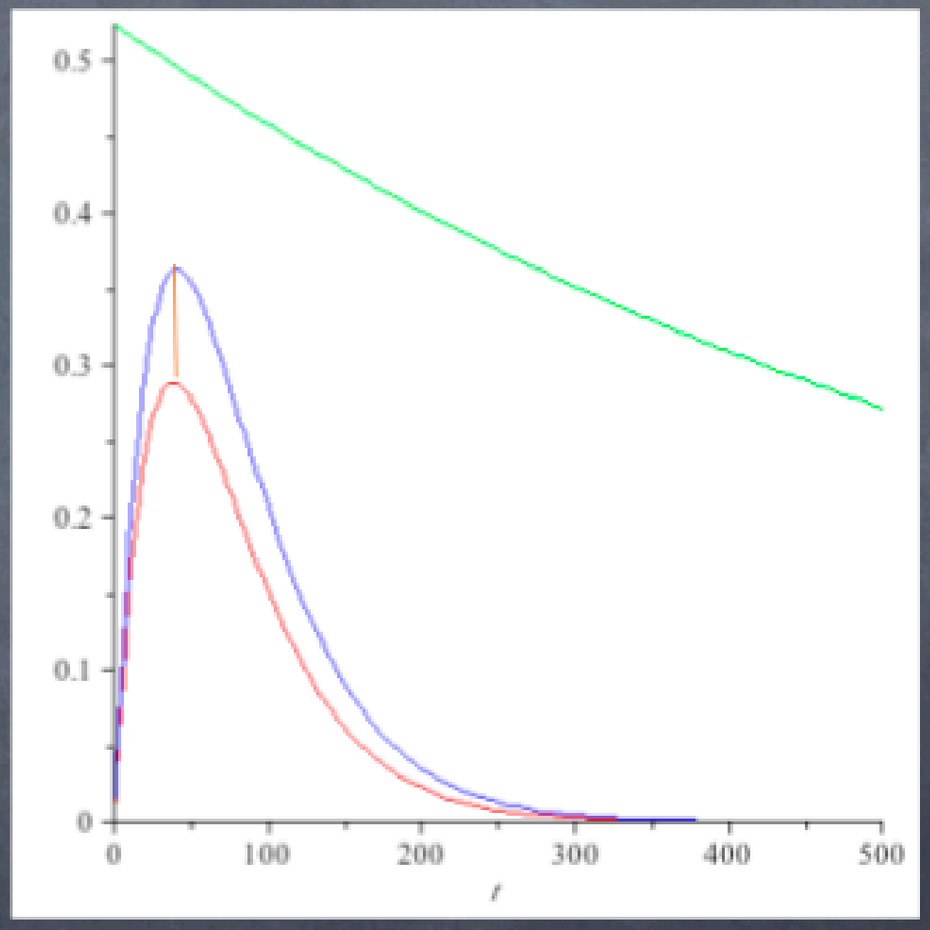
CsI(Tl) readout

- We can shorten the shaping time, with some loss of light

Barrel – *BABAR* shaping
(τ_1=680ns, τ_2=250ns)



Barrel – *SuperB EC* shaping
(τ_1=40ns, τ_2=40ns)



- Still need to quantify loss of light

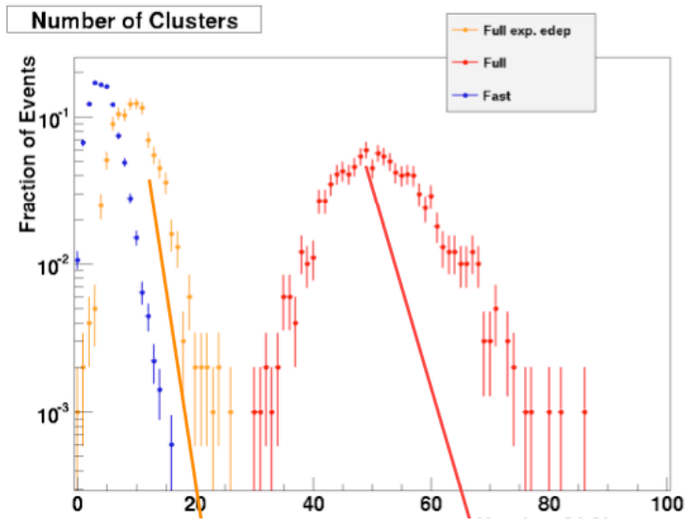
Plan for EMC timing model

- Use pulse shape in D.Hitlin's slides.
  - use actaul decay times and shaping times as parameters
- To model the pile-up more precisely, need to consider time difference when adding up energy in the same digi.
- Calculate global EMC t_0 (as done in Babar) and test cut at $t_0 \pm 120$ns.

EMC full/fastsim discrepancy

Stefano Germani, March 25, 2010

Fast - Full sim comparison: Number of Clusters



Number of Clusters in 1 μs

CAVEAT

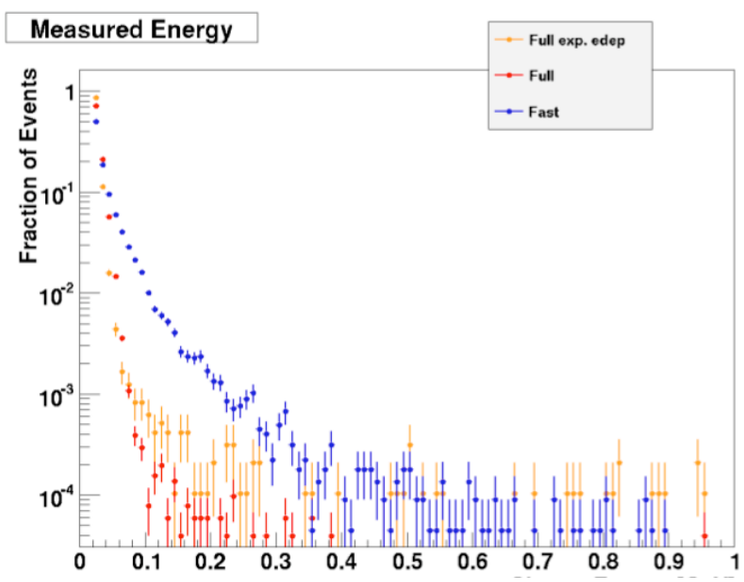
–FastSim entries related to candidate photons

–FullSim entries related to ECAL Clusters

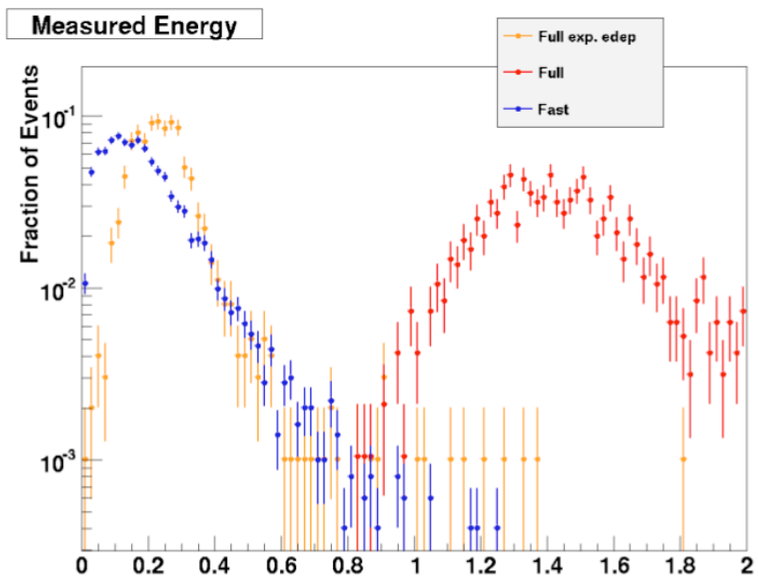
- May be produced by any kind of particle (not only gammas)

Blue: Fastsim neutrino events with Bruno rad. Bhabha bkg input.
Red: G4 EMC model, using particles scored at EMC boundary from Bruno.

Cluster E>20 MeV are kept.



Cluster Energy



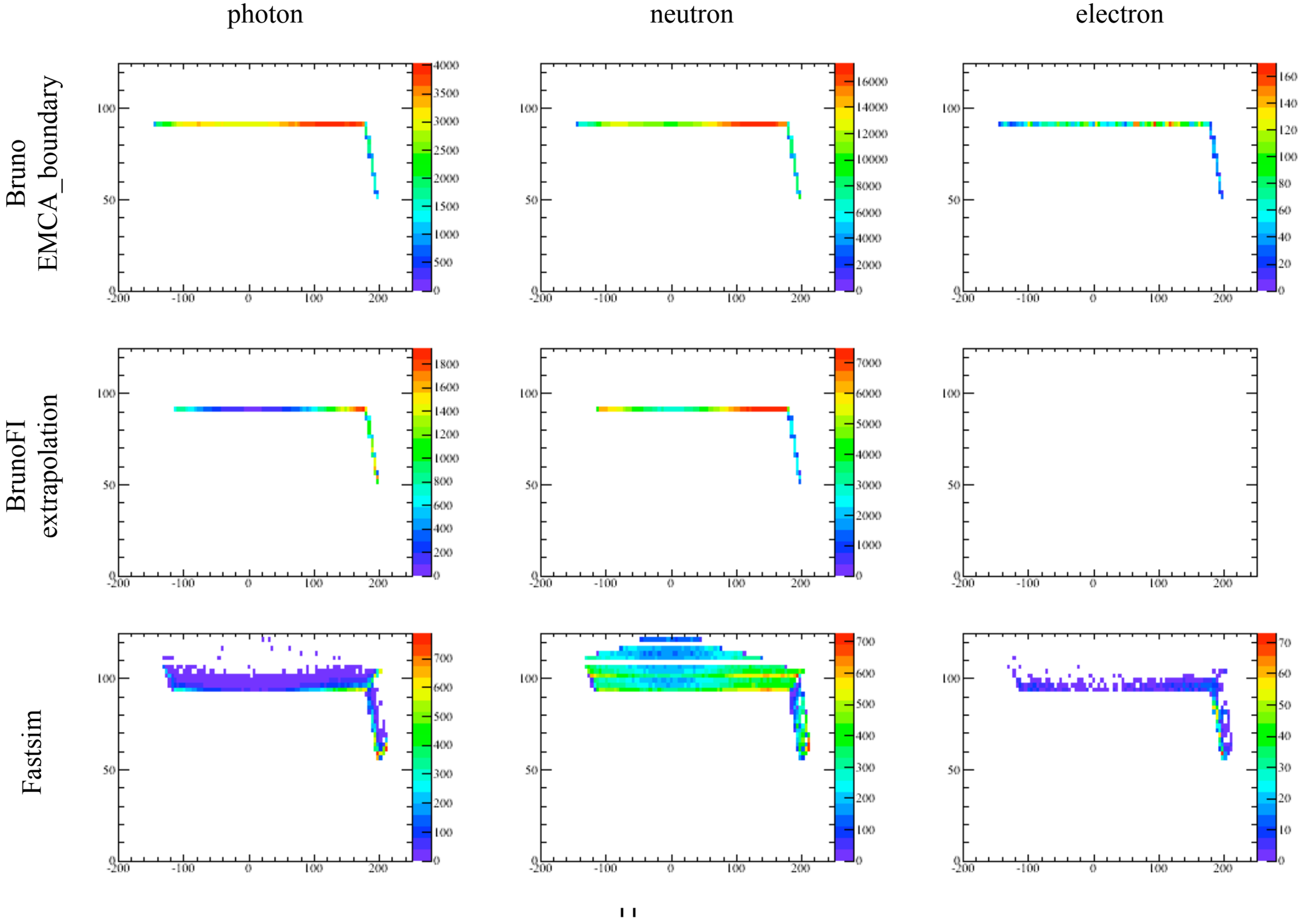
Total Energy in One Event

- There are a lot more clusters in an event (1μs) in full sim than in fast sim.
- Full sim cluster energy spectrum is softer.
- The total energy in an event is much higher in full sim than in fast sim.

Compare the sources

- I compare the particles (flux, energy) that go through the EMC front surface in three sources:
  - Bruno output T tree branch EMCA_boundary (only select the front surface, not the outside boundary).
  - BrunoFI tree branch Particles used as background frames of FastSim production. Extrapolate the particle momenta to the front surface of EMC (for photons and neutrons only).
  - Run fastsim (neutrino), enabling background mixing, recording particles at the first measurement at EMC.
- Plots shown later are for 200,000 bunch crossings.

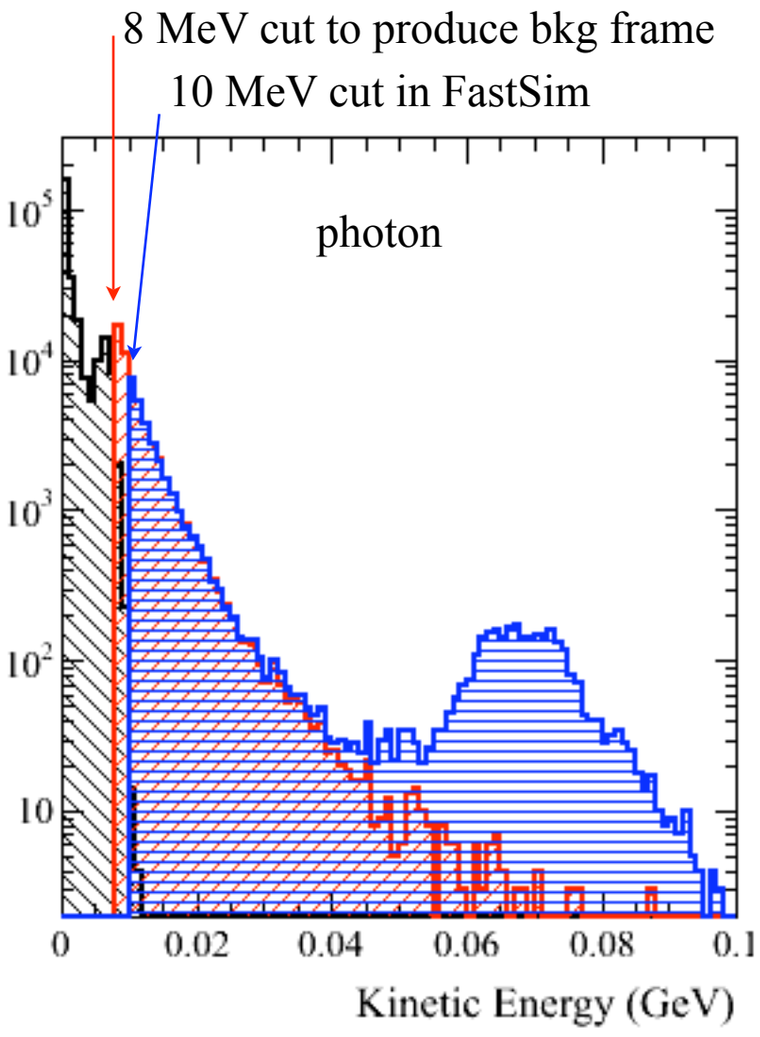
Particle flux (not normalized)

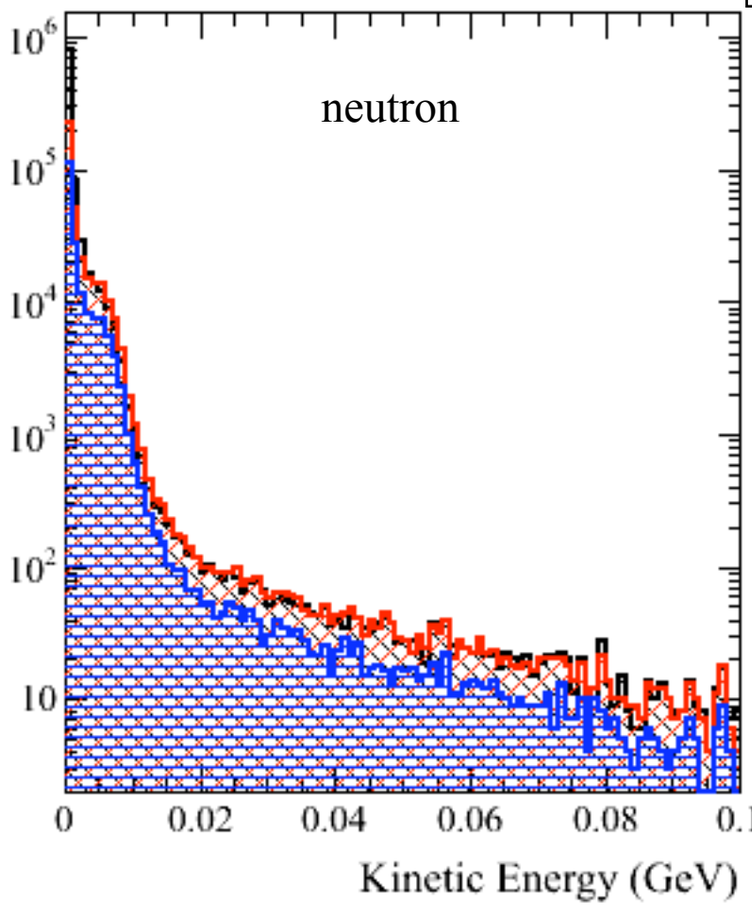


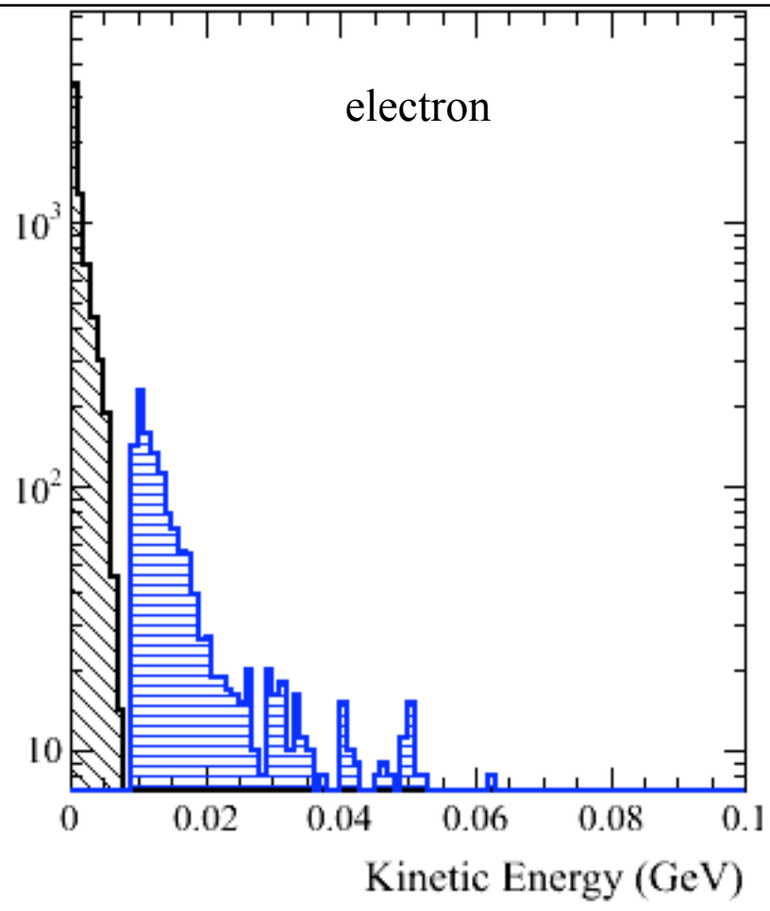
Kinetic energy

- Photons and electrons do not go higher than 10 MeV in Bruno EMC boundary, why?
- Neutron shapes match up quite well. FastSim loses a certain fraction, probably because some of them don't interact.

- **Black**: Bruno EMCA_boundary
- **Red**: BrunoFI extrapolation
- **Blue**: FastSim







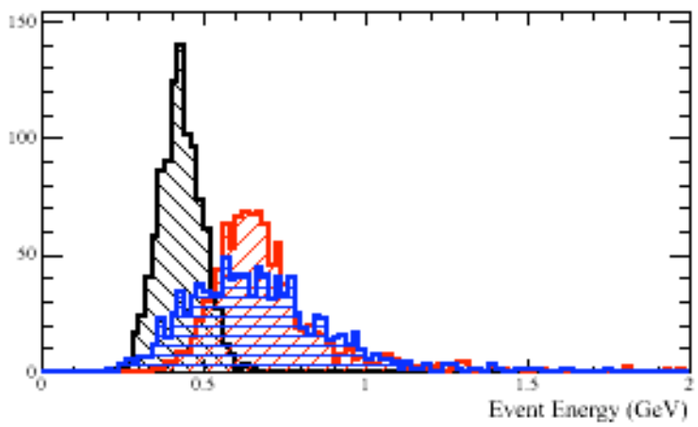
Energy per 200 bunch crossings

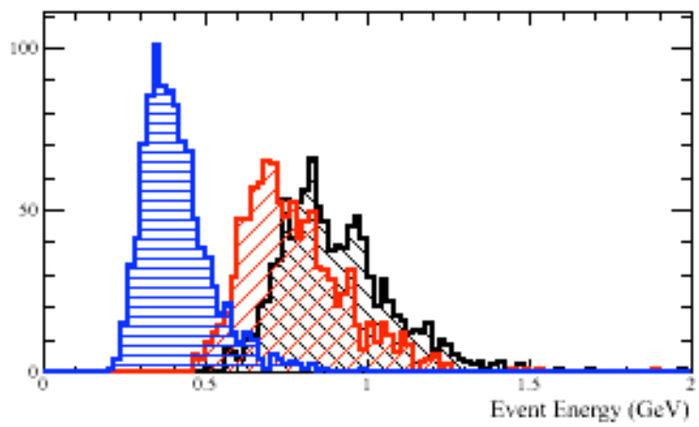
photon

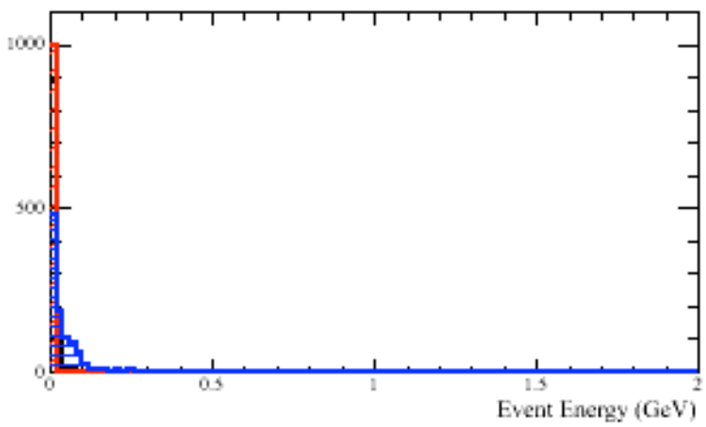
neutron

electron

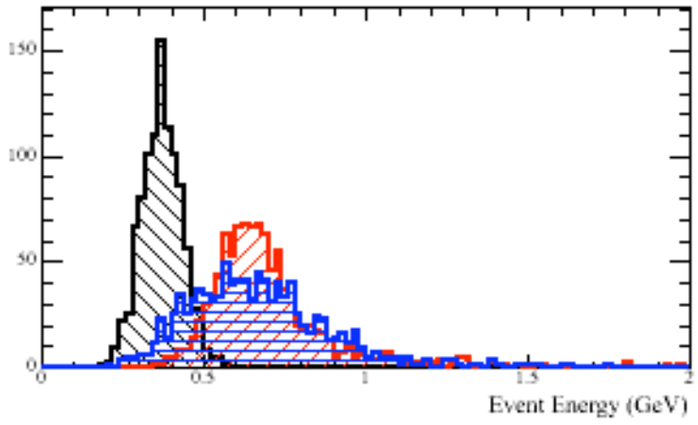
E > 0

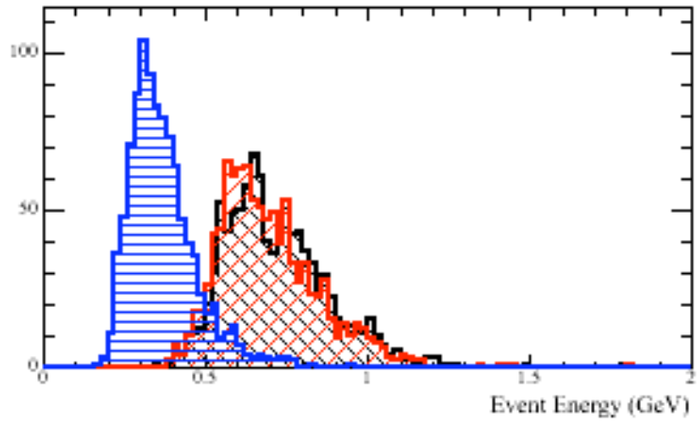


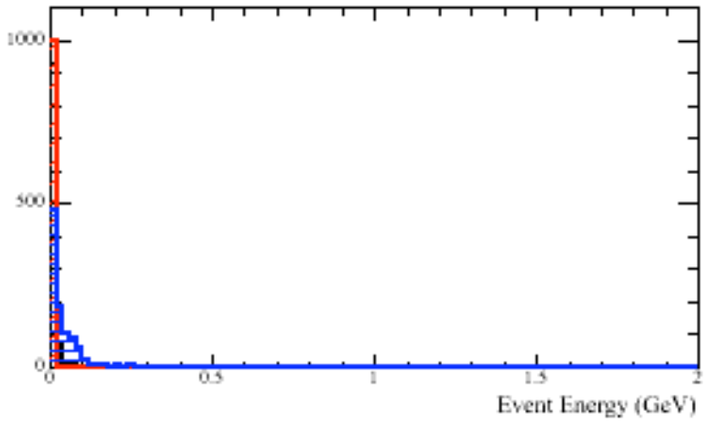




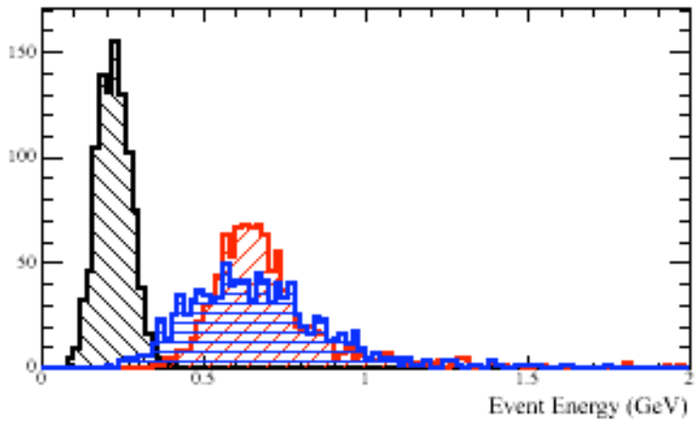
E > 1 MeV

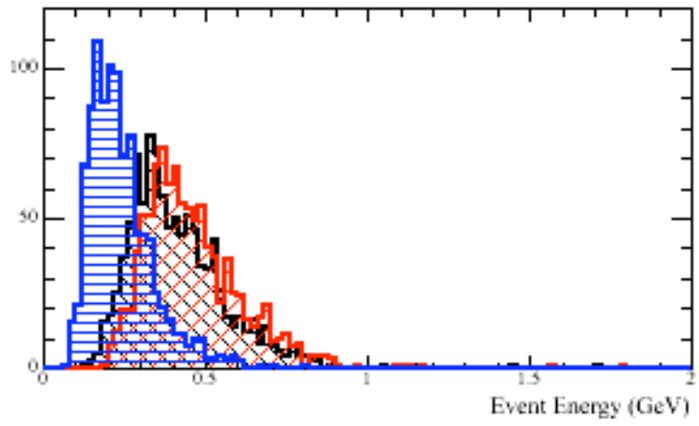


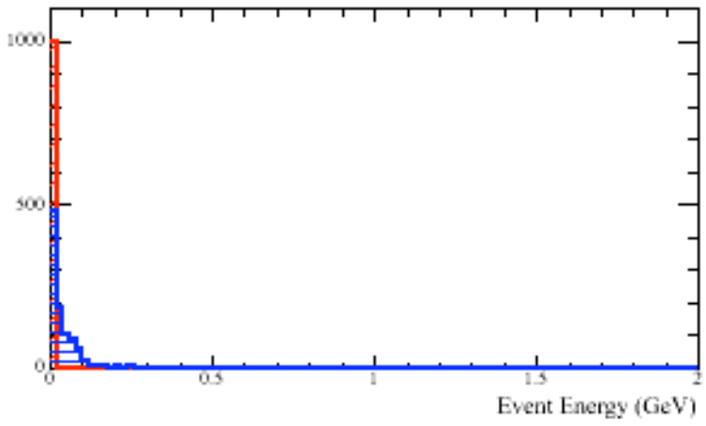




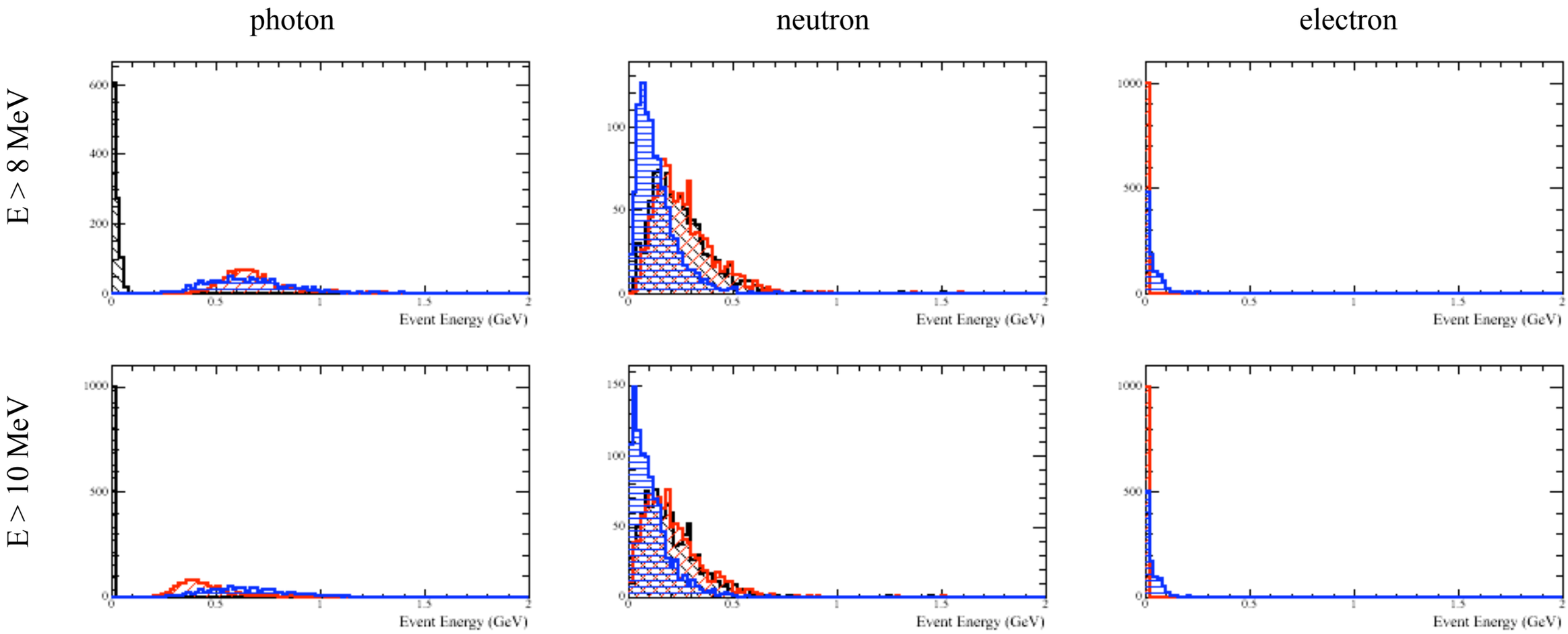
E > 5 MeV



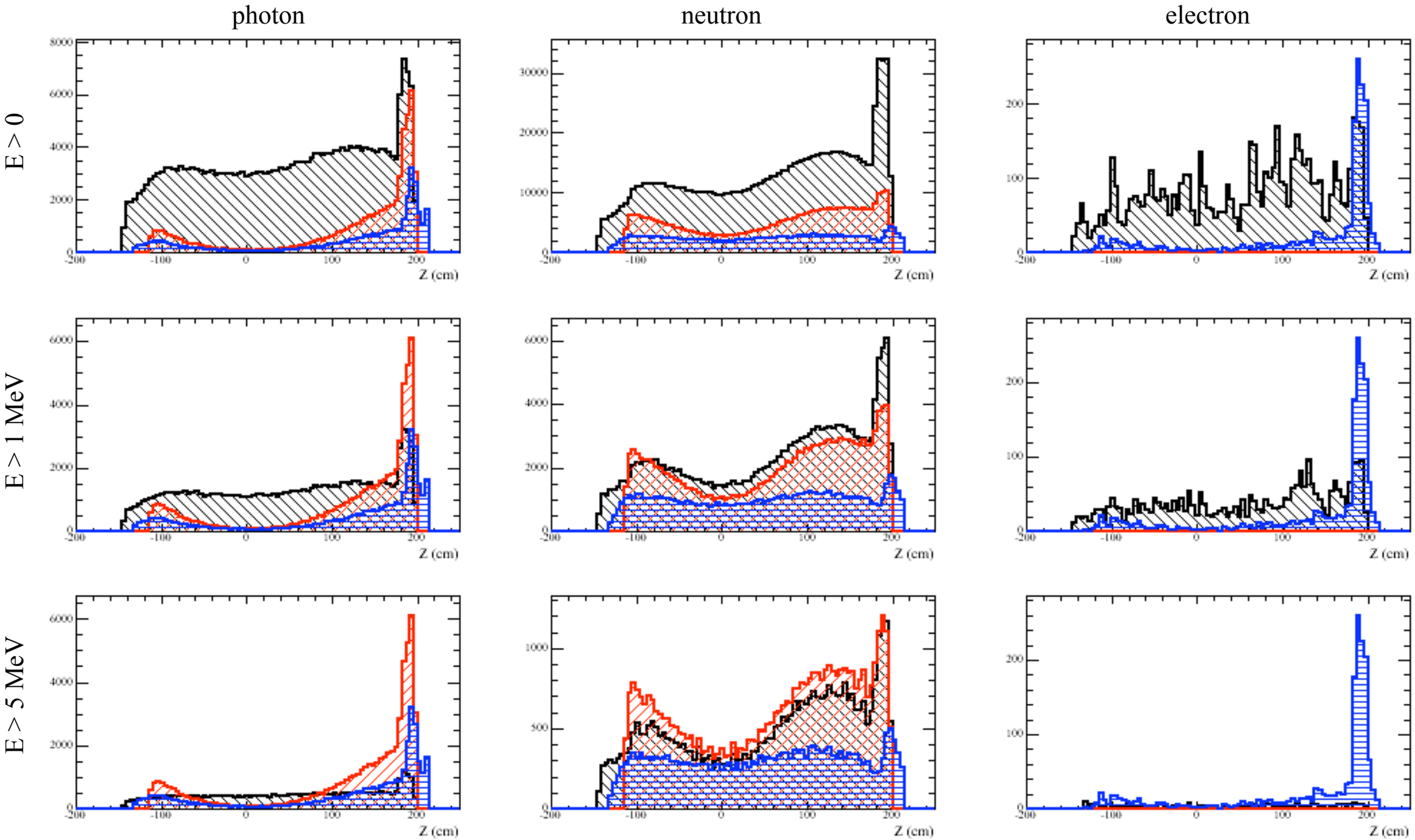




Energy per 200 bunch crossings



Z distribution



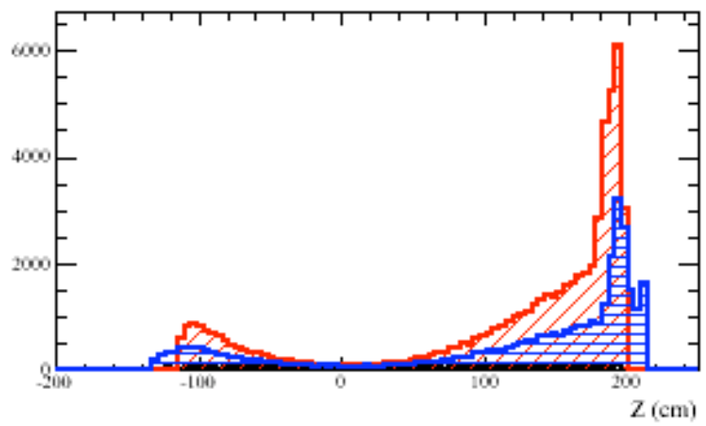
Z distribution

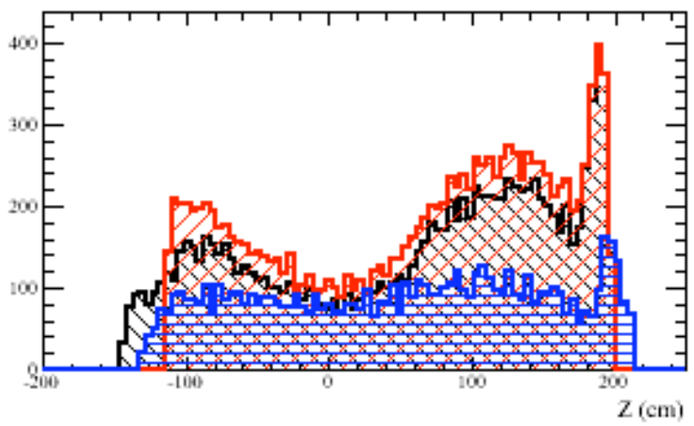
photon

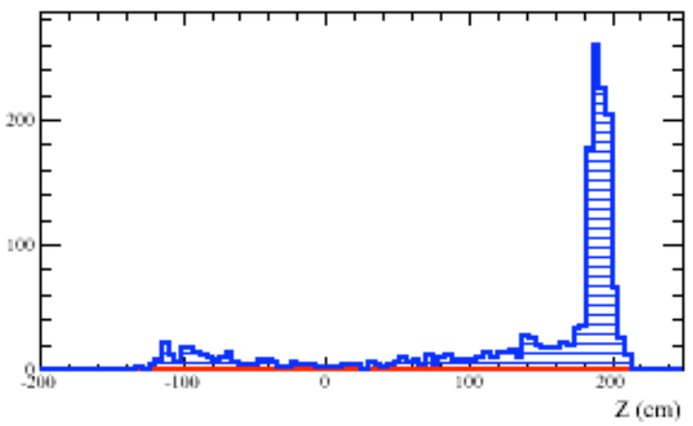
neutron

electron

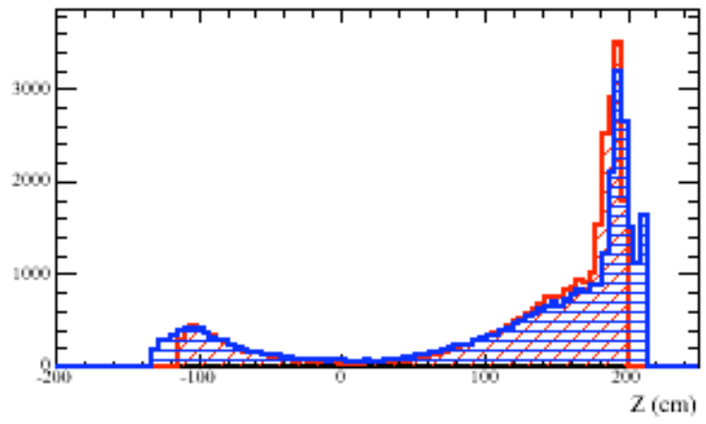
E > 8 MeV

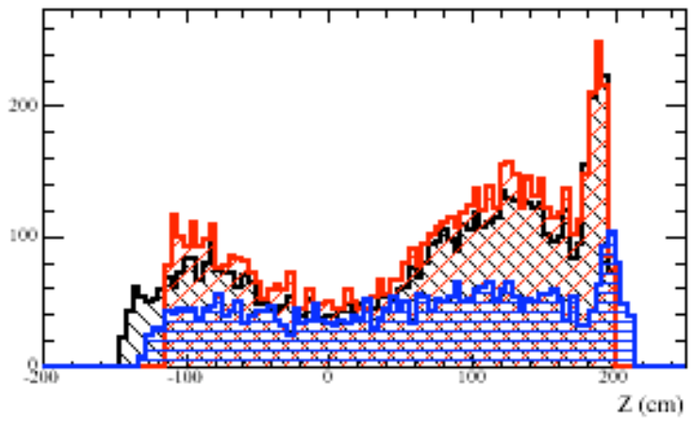


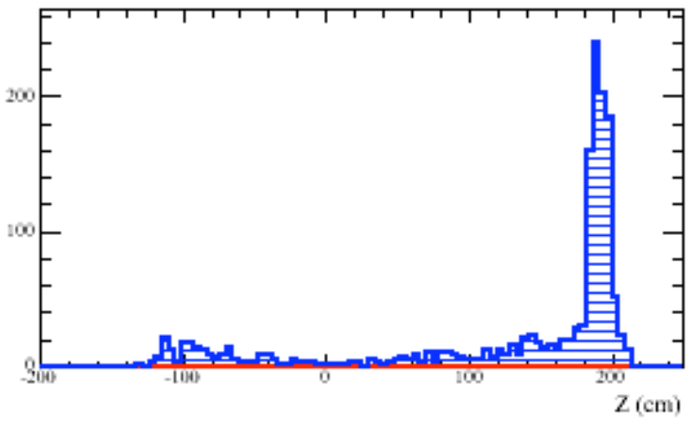




E > 10 MeV







Questions of full/fast sim comparison

- FullSim Bruno EMC boundary photons are all lower than 10 MeV, why? This goes in the opposite direction from the discrepancy in p.9 (Stefano's comparison).
- Not all neutrons going through EMC interact (not a problem).
- Did we underestimate hadronic shower? (Did I even turn on neutrons?)
- Does the clustering algorithm have any significant effect in Stefano's comparison?