Fastsim study report for forward endcap options

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EMC Parallel Session
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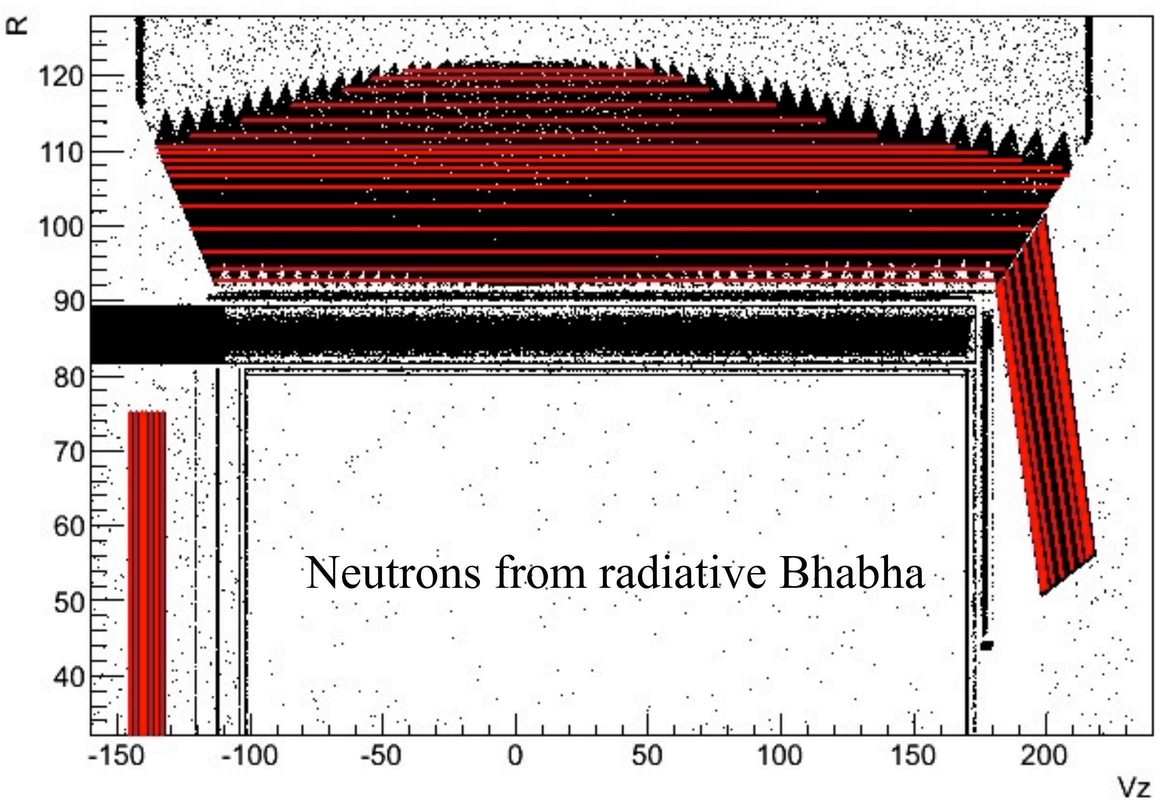
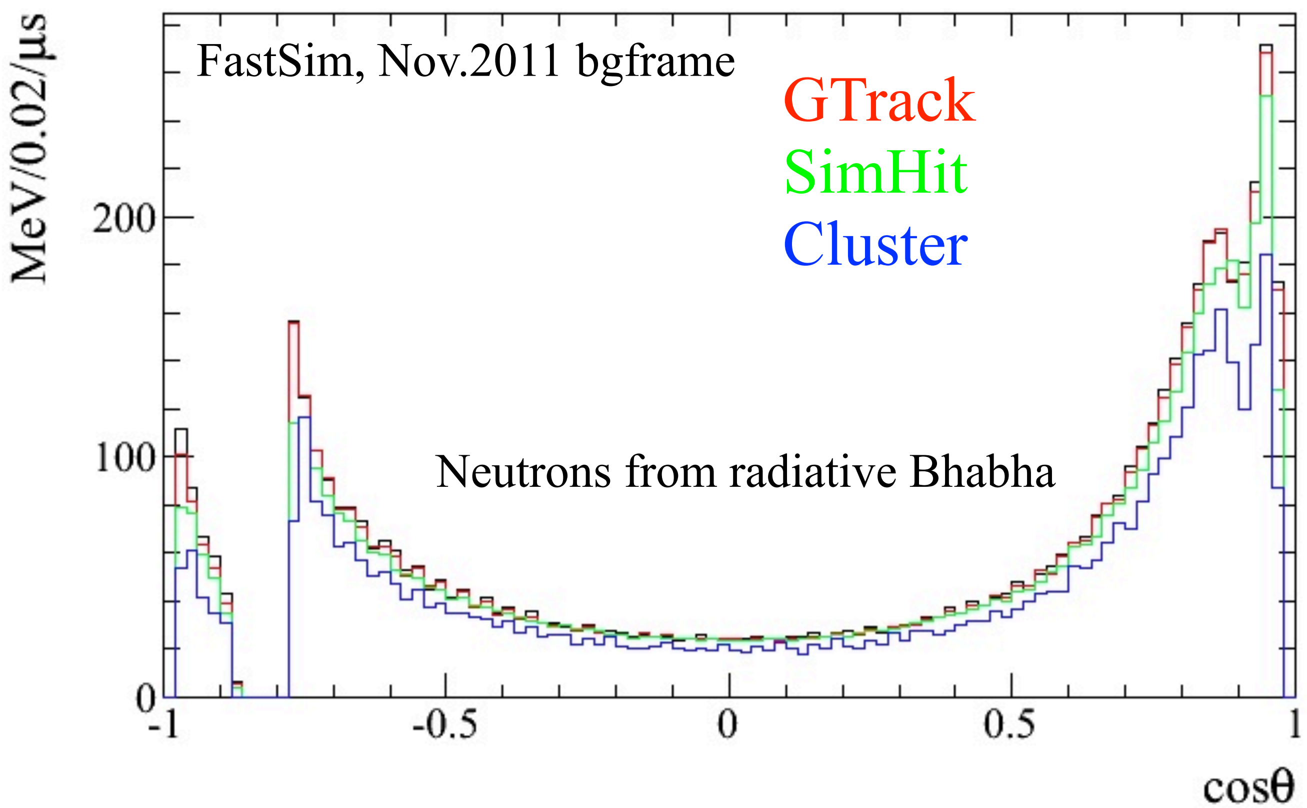
Outline

- *Radiative Bhabha* background radiation dose.
- Background effect on photon resolution.

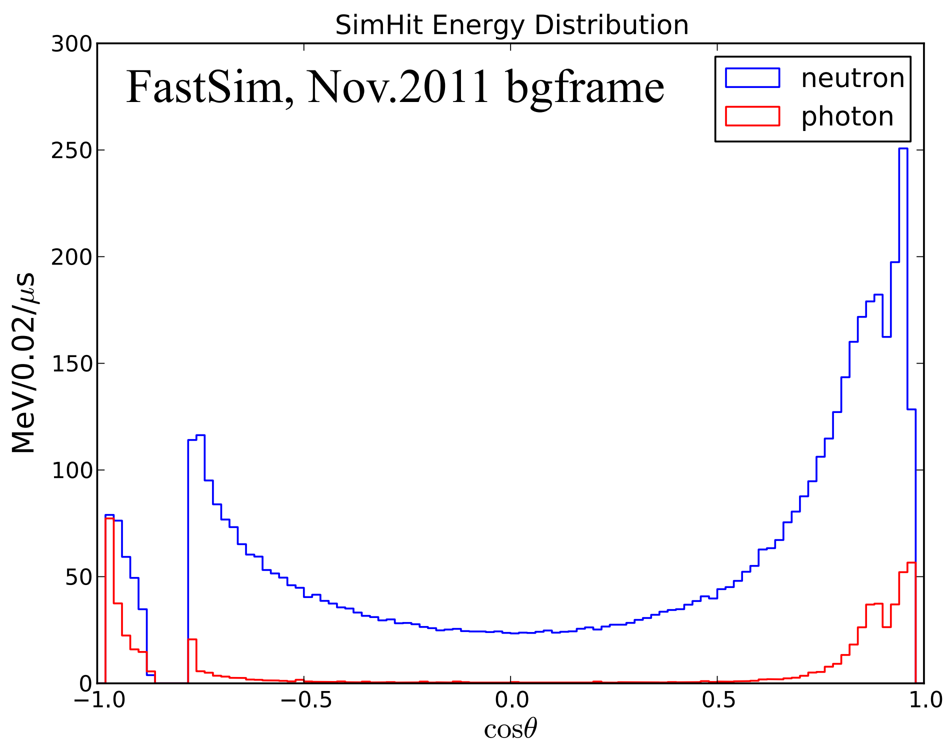
Background radiation dose

- From *Radiative Bhabha* background frames (November 2011).
  - Separate photon and neutron contributions.
  - Photon (neutron) energy cut off = 8 MeV (a few keV).
- Use FastSim to record incident particle energy distribution in EMC space, as well as energy distribution after showering/clustering.
- Results are *average of the entire crystal mass*; *disregard the dose non-uniformity*, e.g., front face may get much higher dose than back.

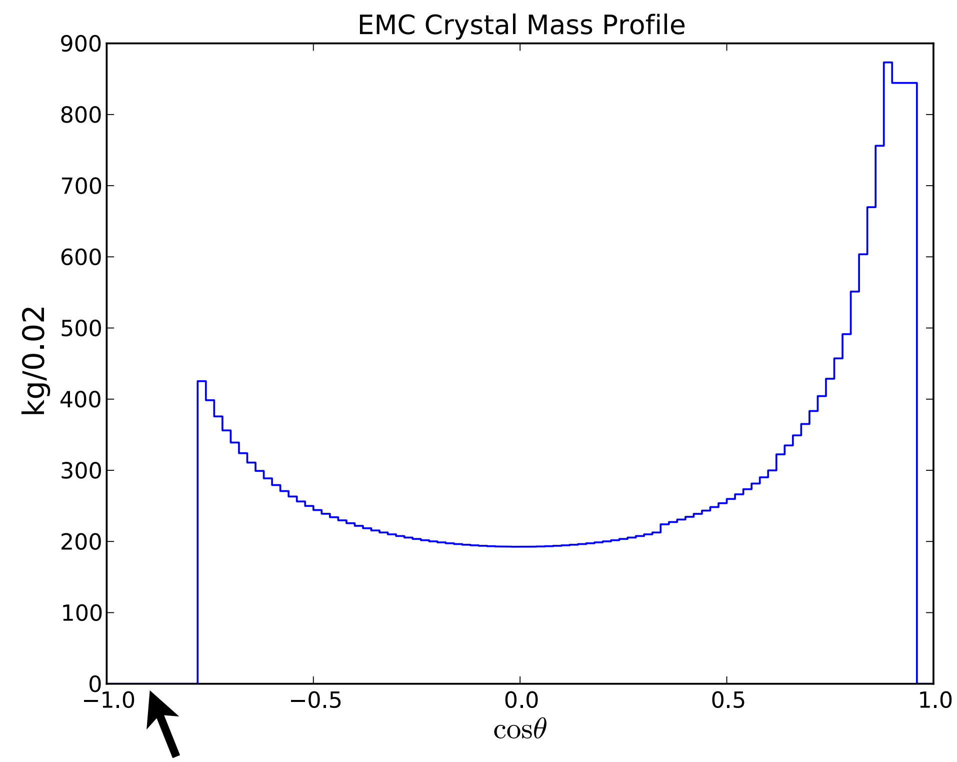




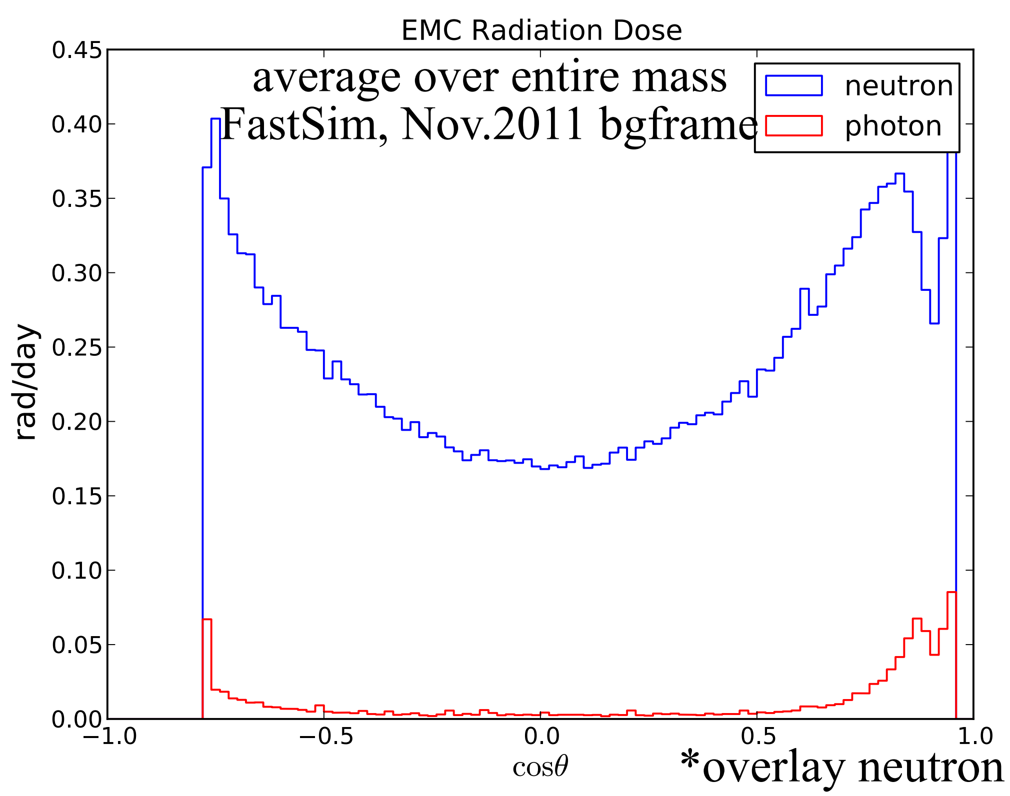
Incident background particle hit energy rate



divided by



ignore backward



1 MeV/μs = 1.6e-7 J/s = 0.0138 J/day

1 rad = 0.01 Gy = 0.01 J/kg

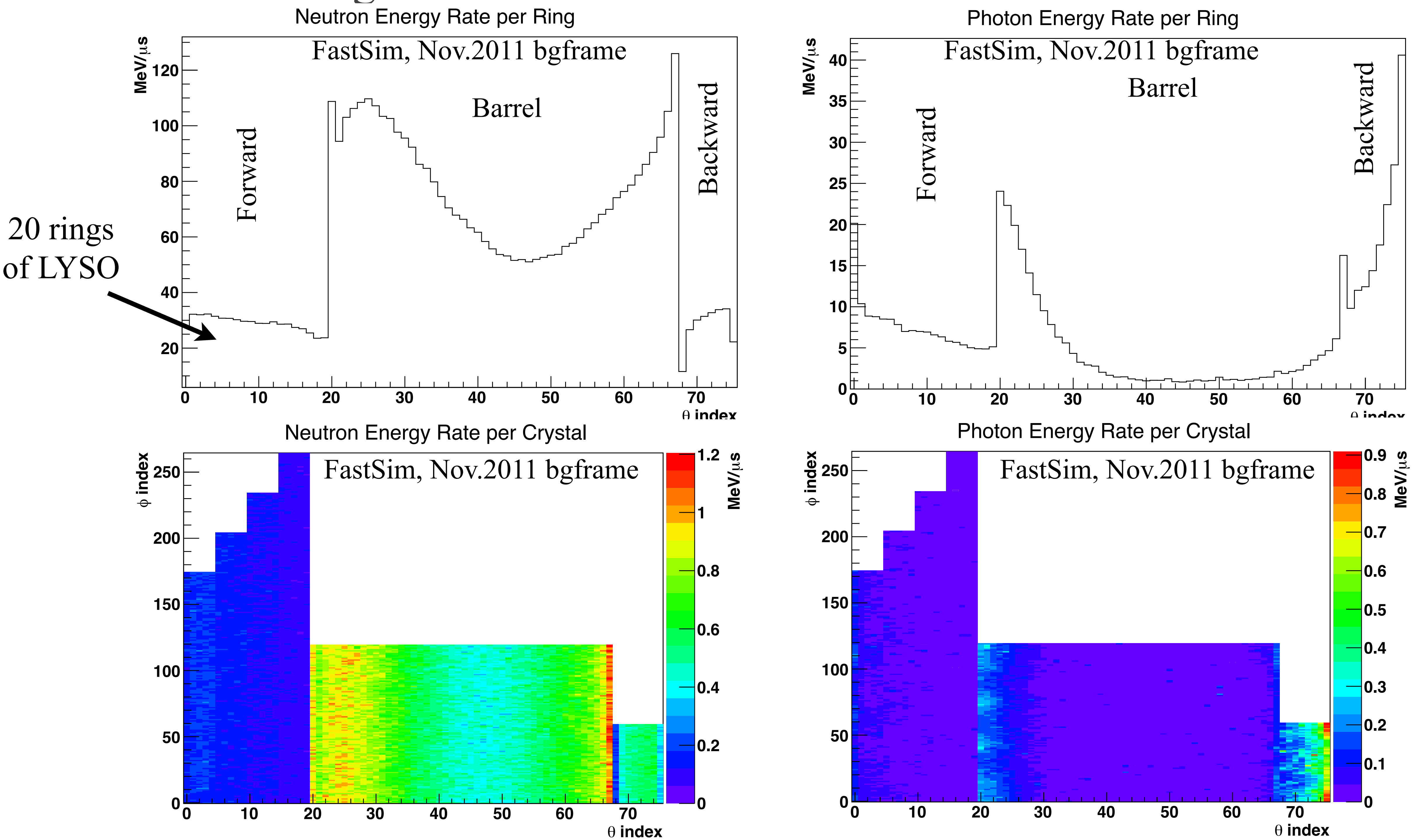
1 MeV/μs/kg = 1.38 rad/day

<~ 0.45 rad/day (!?)

*overlay neutron and photon, not stack

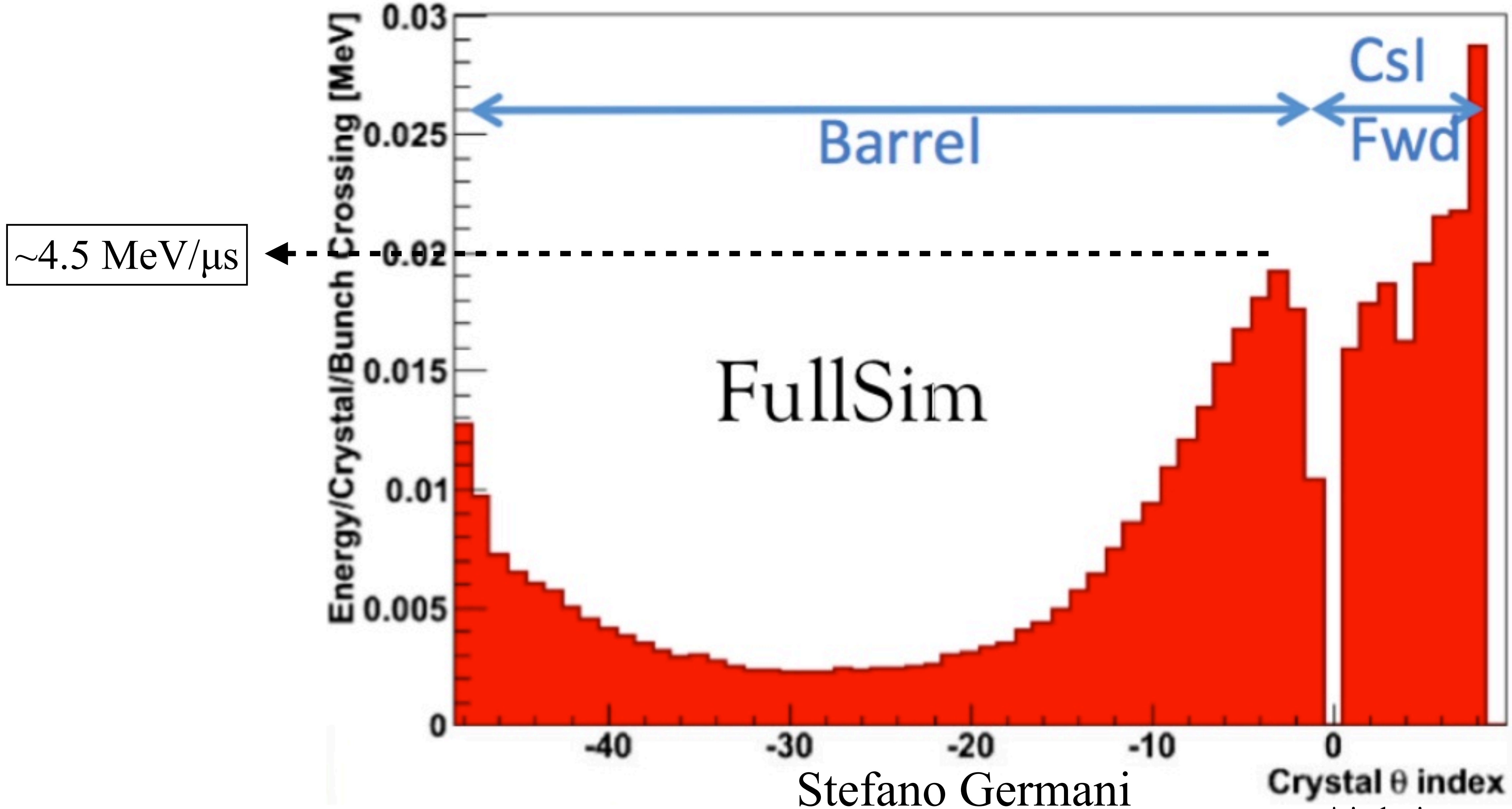
Energy rate per ring, per crystal

- After clustering



~ 1 MeV/μs/crystal at forward/backward ends of the barrel. ***A factor of 4-5 lower than FullSim.***

4-5x lower than FullSim



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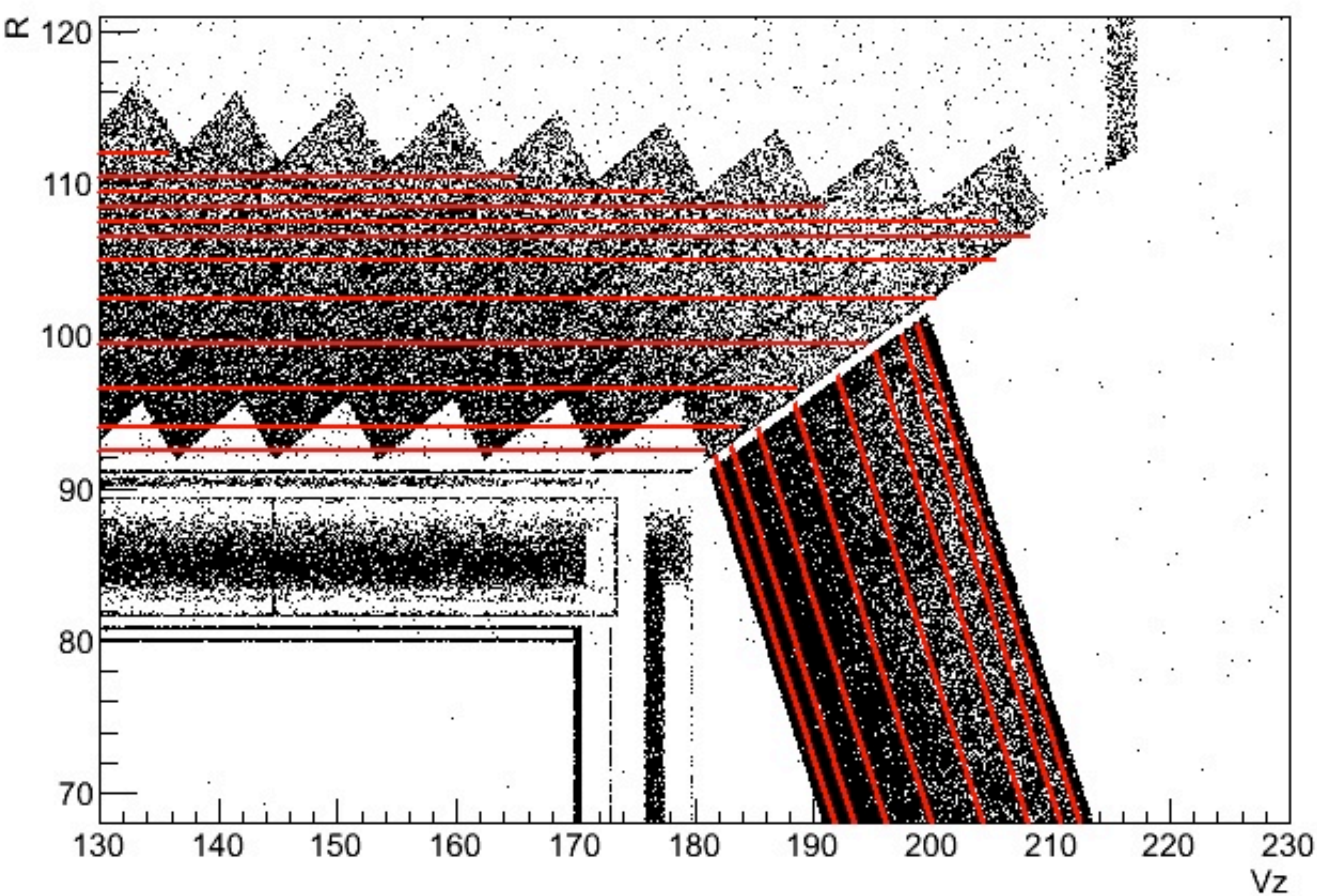
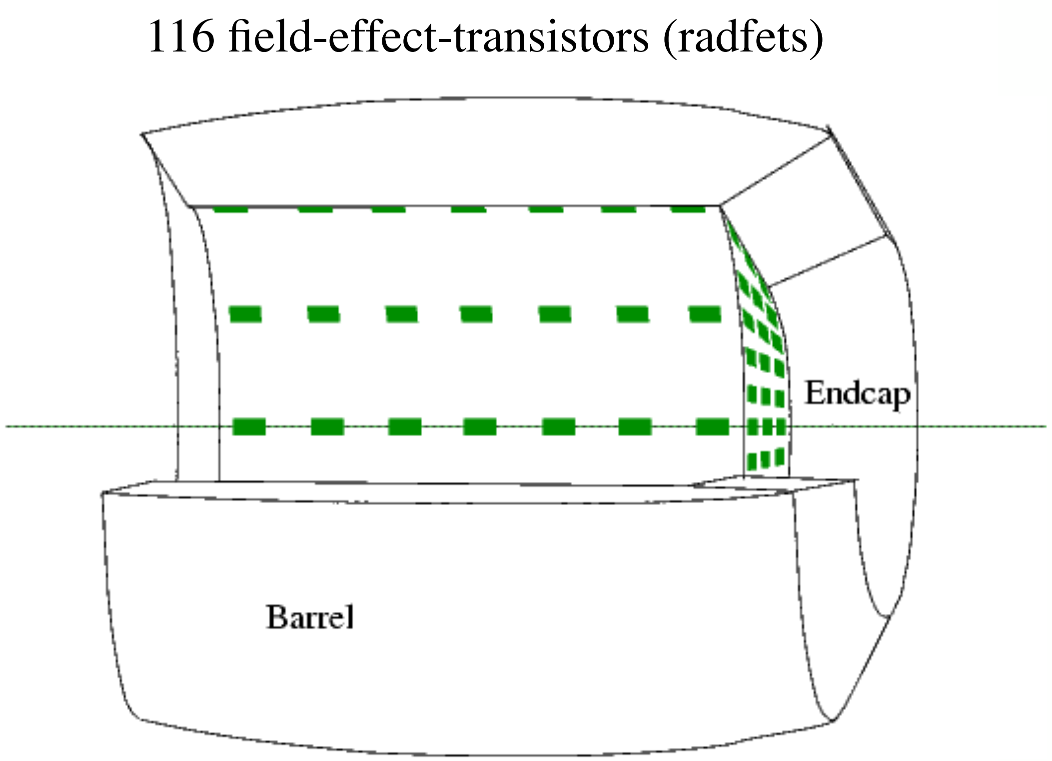
* indexing system is different (reverse order)

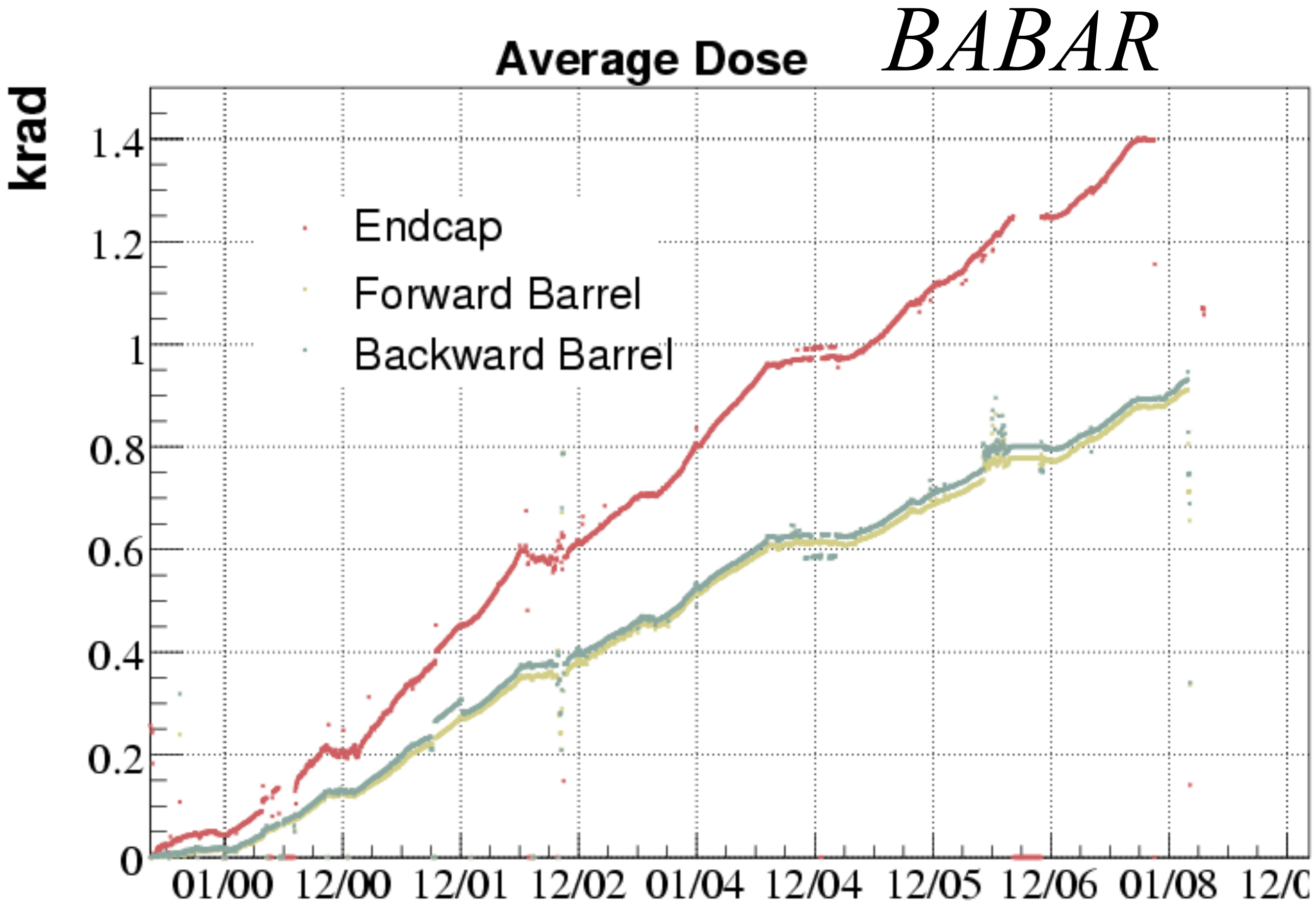
Probably due to the 8 MeV γ energy cutoff in bgframe production.

Neutrons from radiative Bhabhas



Compare with *BABAR*





- *BABAR* radiation measured by radfets at ***front face*** of the EMC.
  - Endcap ~0.85 rad/day, assume 200 days/year
- Super*B* Radiative Bhabha bgframe (Nov.2011) <~0.45 rad/day, **average over entire volume**.

Radiation dose summary

- Using radiative Bhabha background frame we found the background radiation is about 1 MeV/μs/crystal at the forward and backward ends of barrel, corresponding to ~0.4-0.5 rad/day if average over the entire crystal.
- This is about 4-5x lower than FullSim prediction, and 2x *lower* than *BABAR* radfets measurements !? (which measure the front face).
- *Neutrons* dominate.
- 8-MeV cut for photons is clearly too high.
- Radiation at outer rings of the forward endcap is on par with forward end of the barrel.

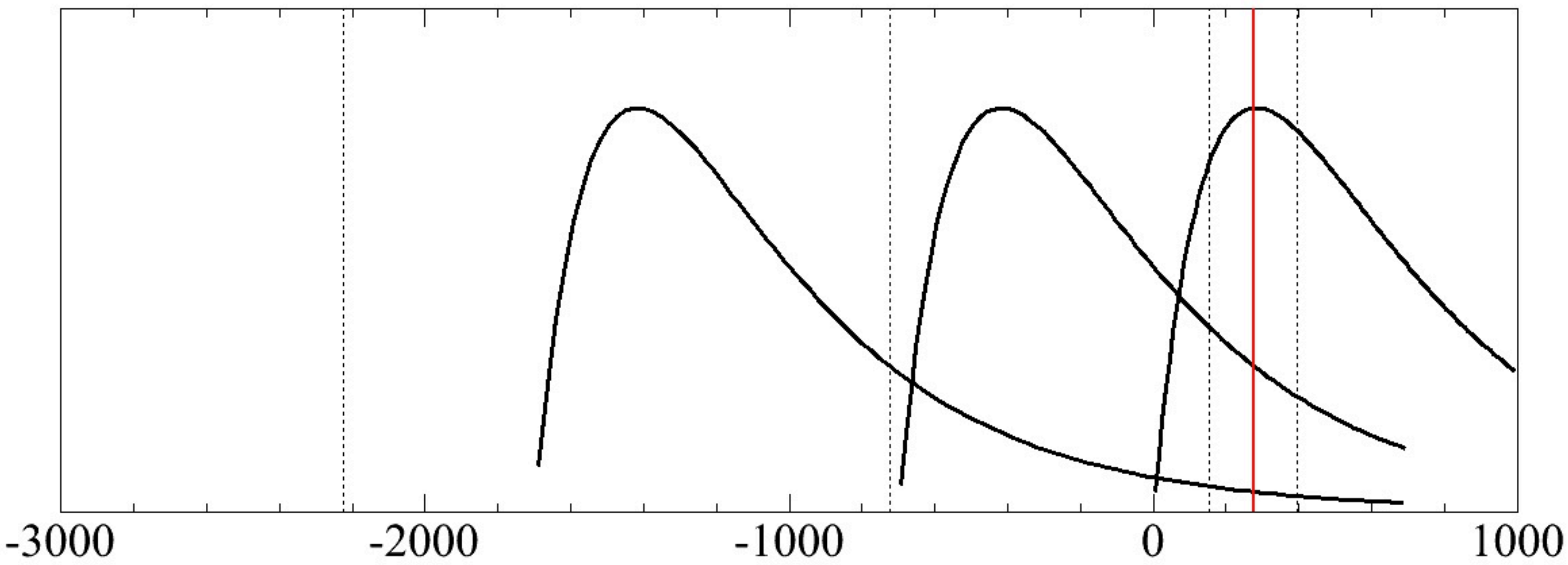
Background effects on photon resolutions

Introduction

- Monoenergetic single photon events are generated in FastSim, aiming at the entire forward endcap, uniform in $\cos\theta$.
- Cluster energy distribution is fitted with a Crystal Ball function; take FWHM/2.35 as the resolution, denoted as σ for convenience.
- The σ difference in quadrature between with and without background is a measure of additional contribution to resolution due to pile-up.
- Several energy points are used to fit a resolution dependence on energy.
- Compare among different forward endcap hybrid options, and with FullSim results, at 5x background.

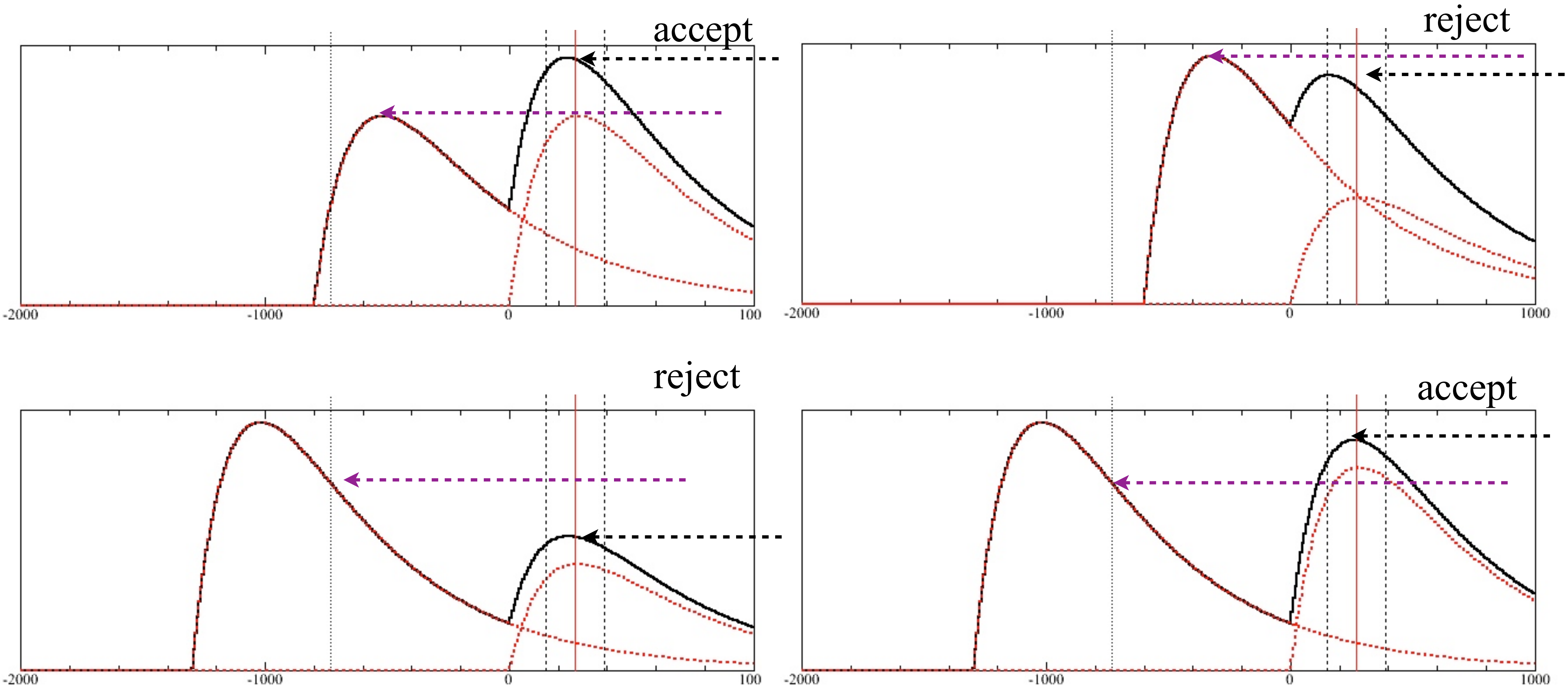
Background timing

- When reading in background frame particles, we define a sensitive window, which is used to calculate the number of beam crossings to read in and starting time of bkg particles is randomized within this window.
- Each detector has its own sensitive window, using particle time (randomized starting time + travel time (FullSim+FastSim)).



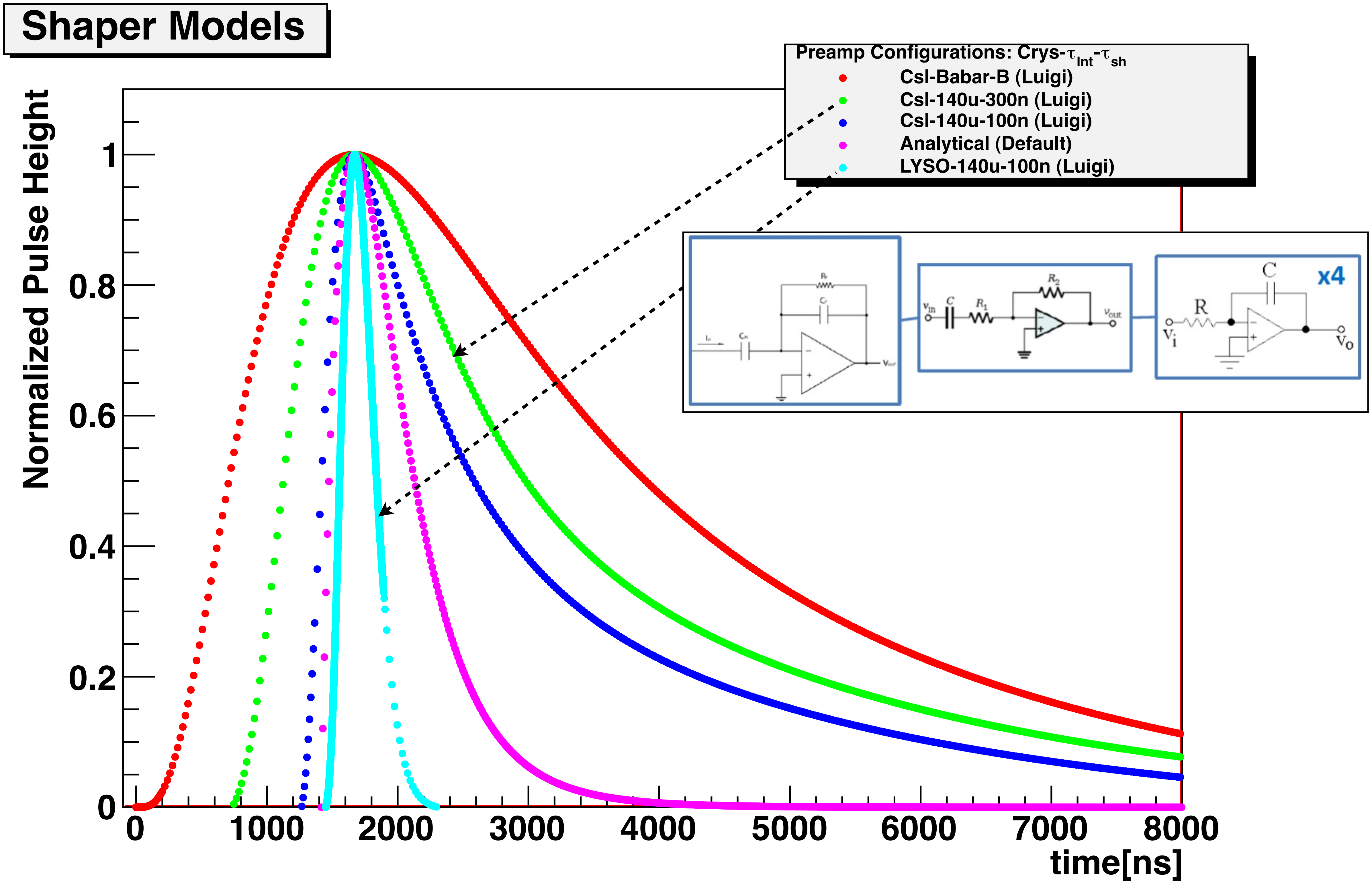
If only one particle contributes to a crystal, only those whose peak in within the signal window are accepted.

Merging with out-of-time background



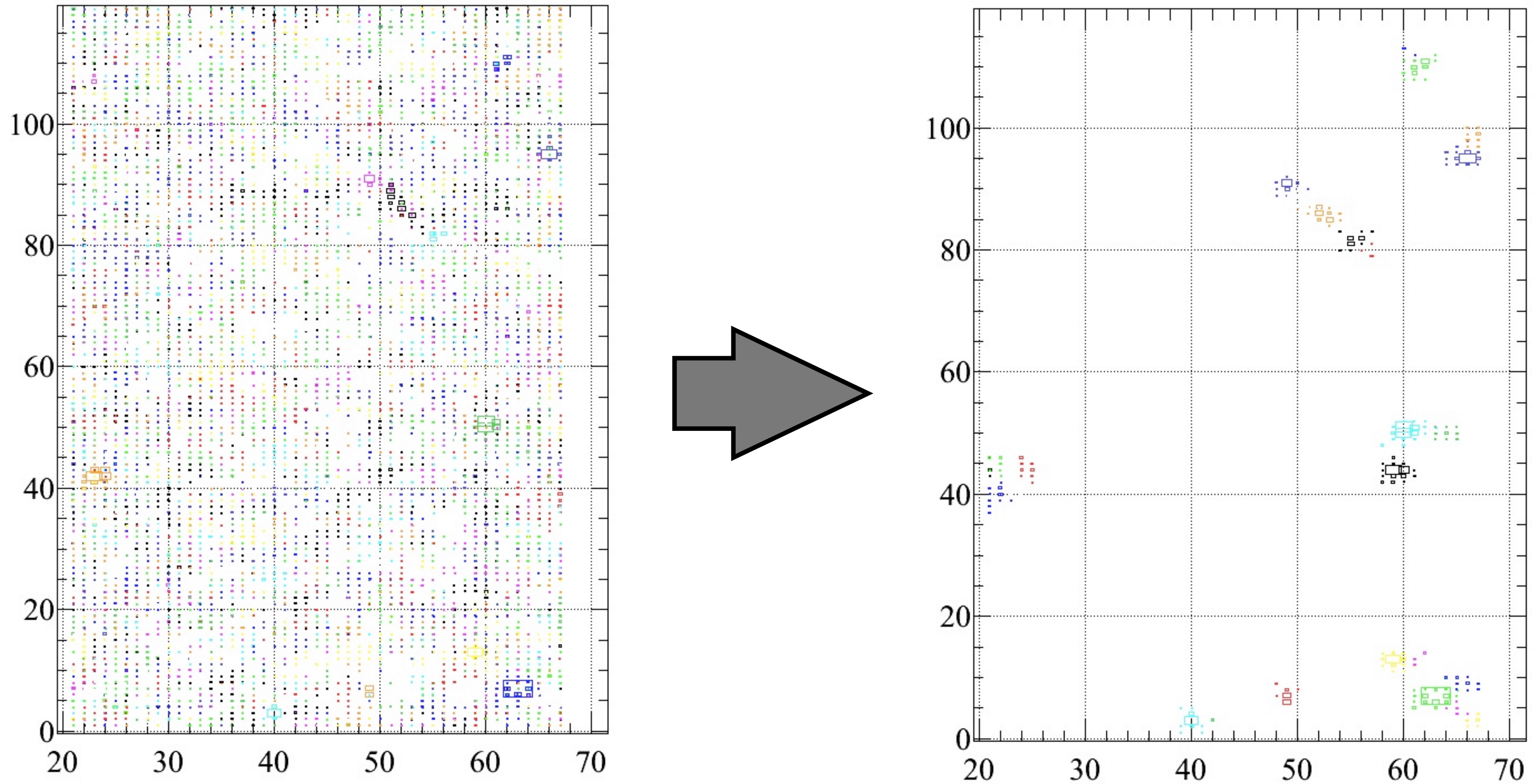
- Very simple minded waveform analysis.
- Can get complicated with many background particles.
- Need to revisit this issue

Shaper models



Clustering algorithm

- Select seed crystals above 20 MeV; starting from the highest one.
- Connecting adjacent crystals (once used, removed from the map).
- If a crystal is below 5 MeV and none of its neighbors is above 10 MeV, stop (this crystal is not used).
- Resulting clusters are then split into single bump clusters.



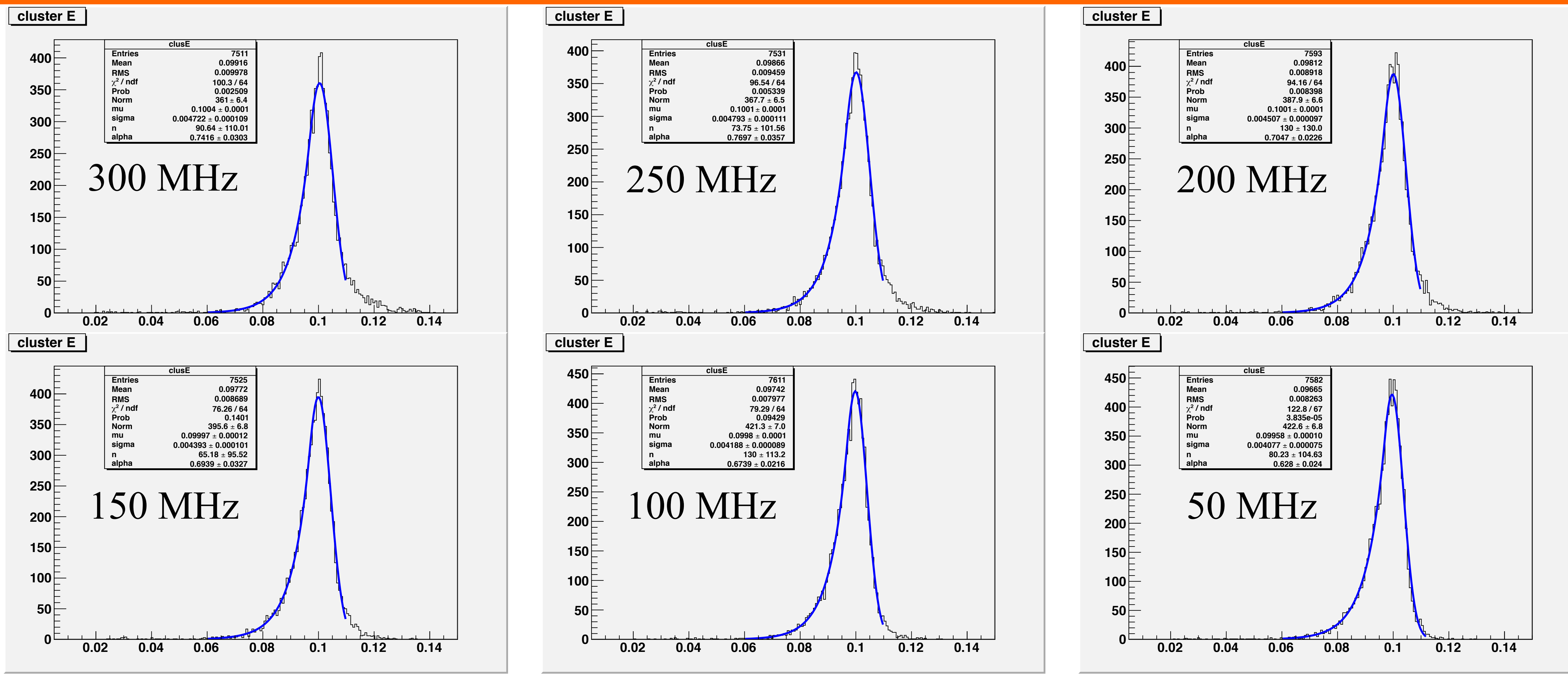
Extrapolate to 5x background

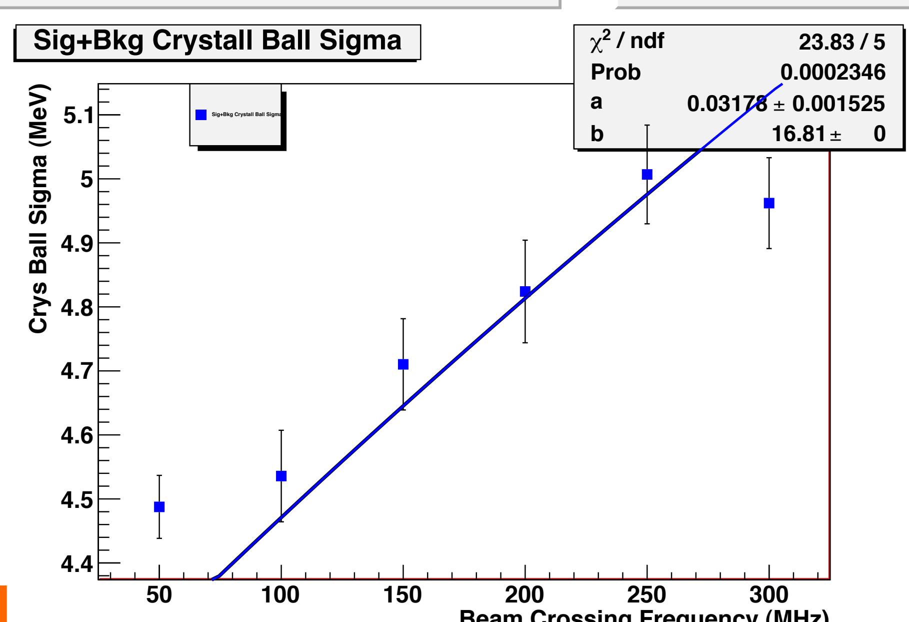
- Some technical difficulties prevented us to run 5x background directly. [likely due to memory leaks in background read-in module]
- Instead we run at many lower bunch crossing rates (50, 100, 150, 200, 250, 300) MHz and extrapolate the result to 1133.5 MHz (5x "nominal" (226.7 MHz) background).
- We assume the pile-up contribution ($\sqrt{\sigma_f^2 - \sigma_0^2}$) is proportional to sqrt(bkg), so

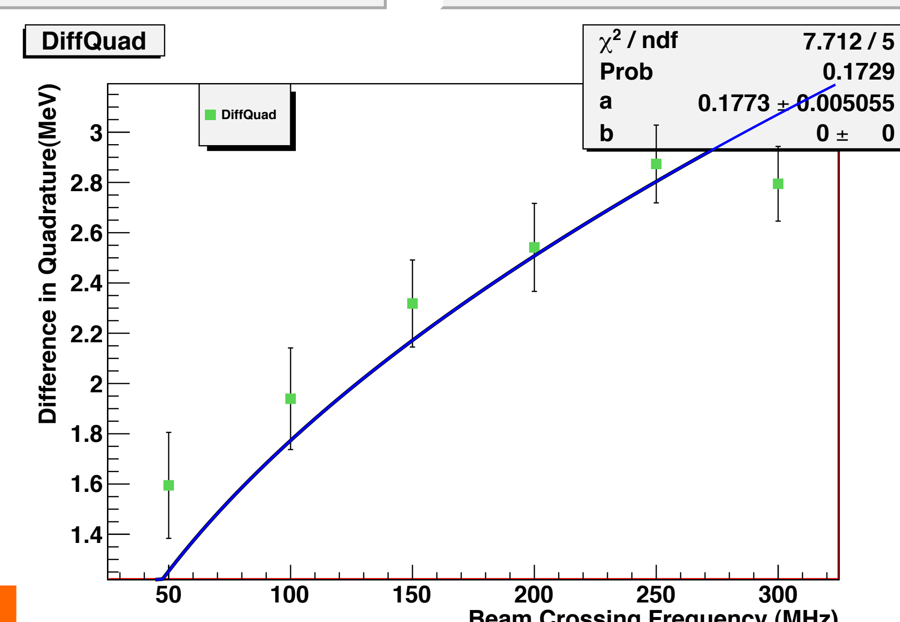
$$\sigma_f = \sqrt{a^2 f + \sigma_0^2}$$

- Fit σ_f as a function of f to get parameter a, and then extrapolate to 5x background, $\sigma_{f=1133.5\,\mathrm{MHz}}$

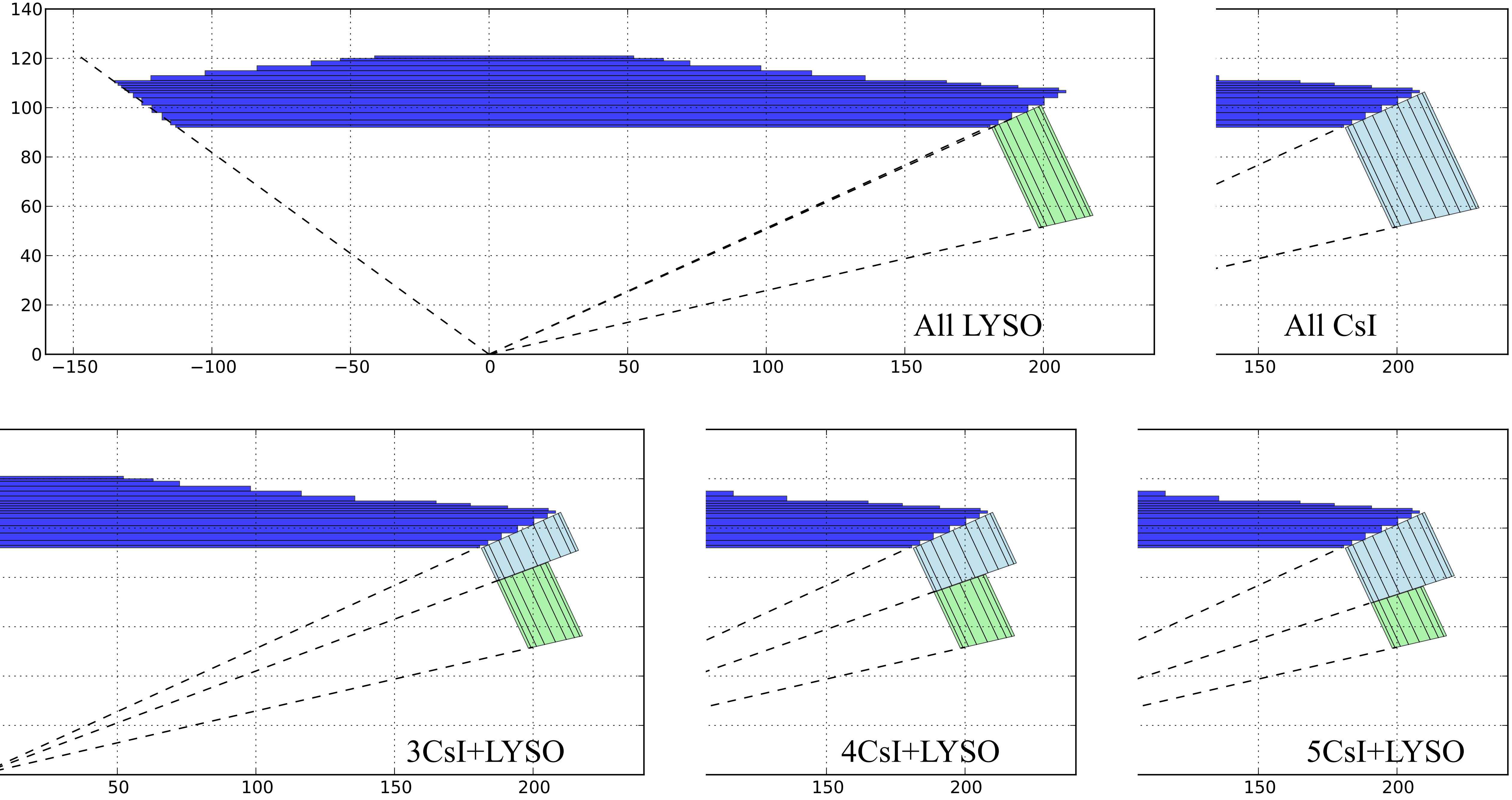
An example of extrapolation





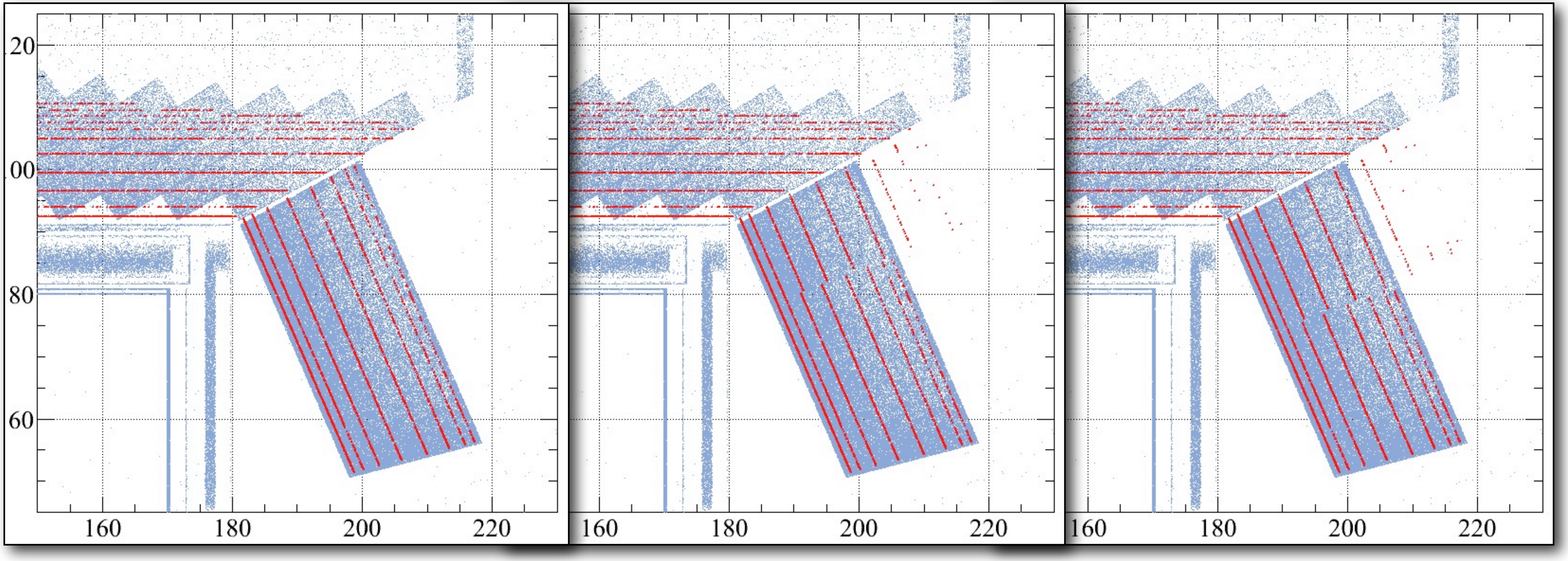


Hybrid forward endcap geometries



Hybrid forward endcap geometries

All LYSO | 3CsI+LYSO | 4CsI+LYSO

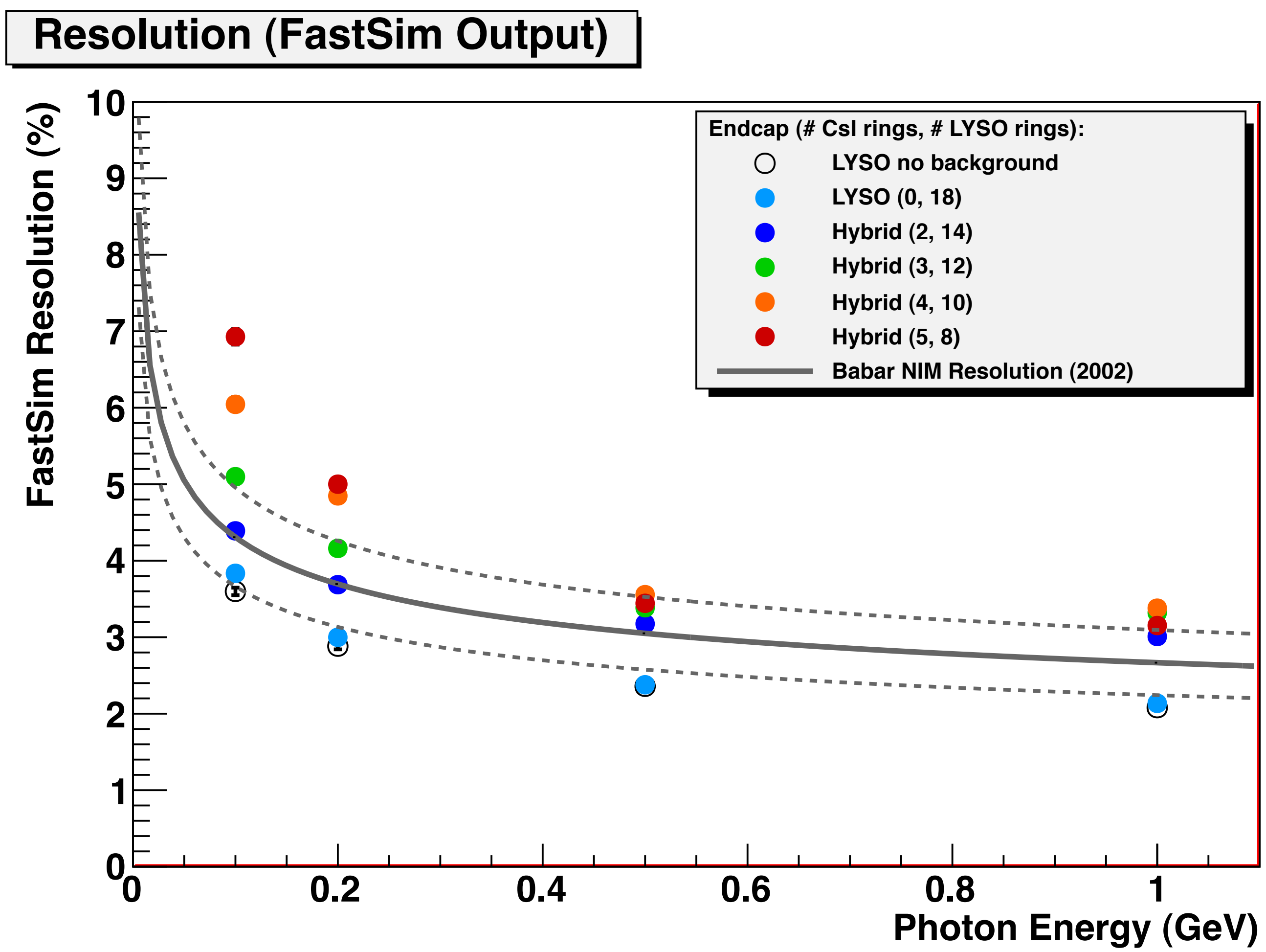


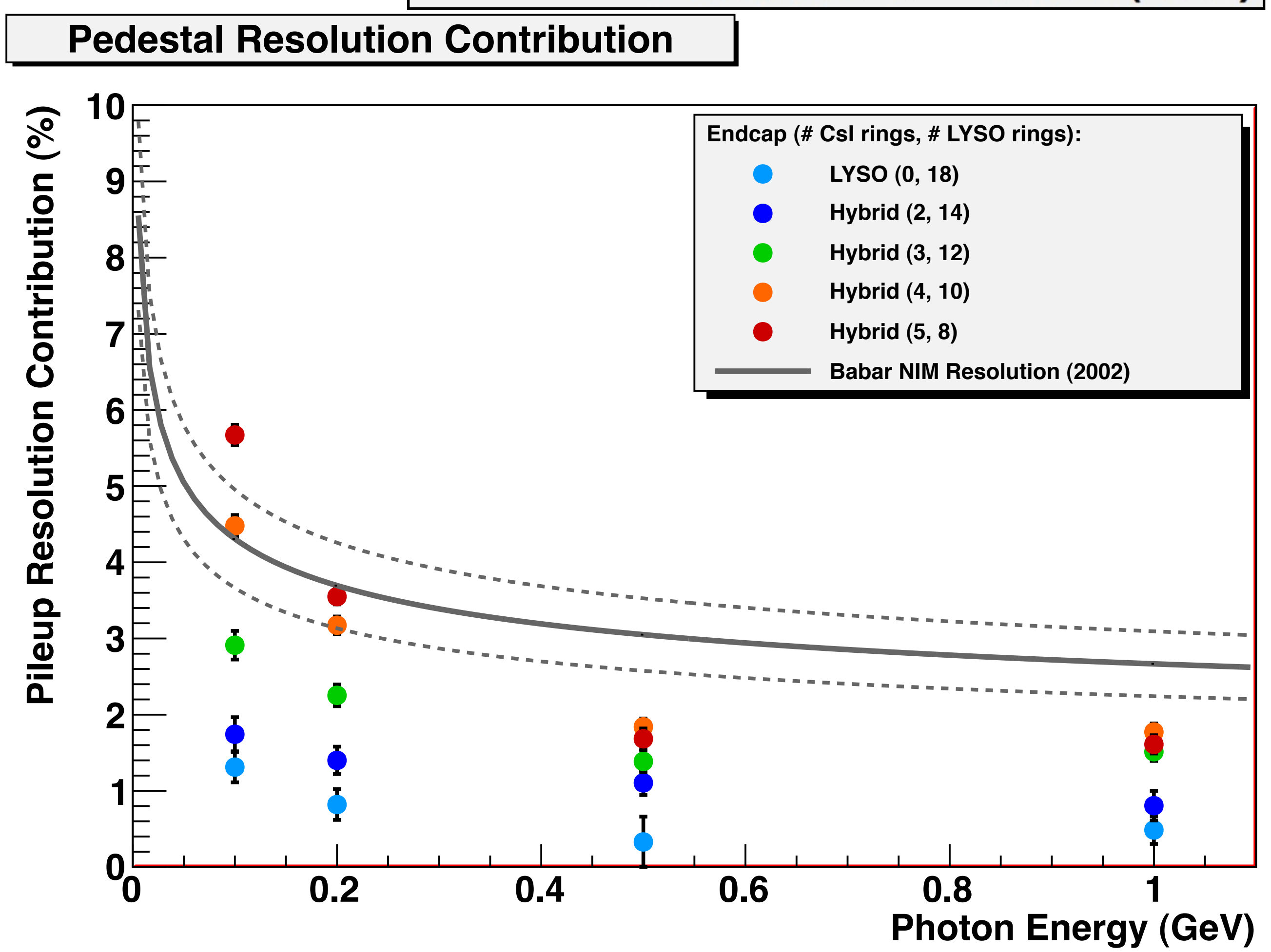
3 rings of CsI +
12 rings of LYSO
in 6 rings of old structure.

4 rings of CsI +
10 rings of LYSO
in 5 rings of old structure.

Resolution at 1x background

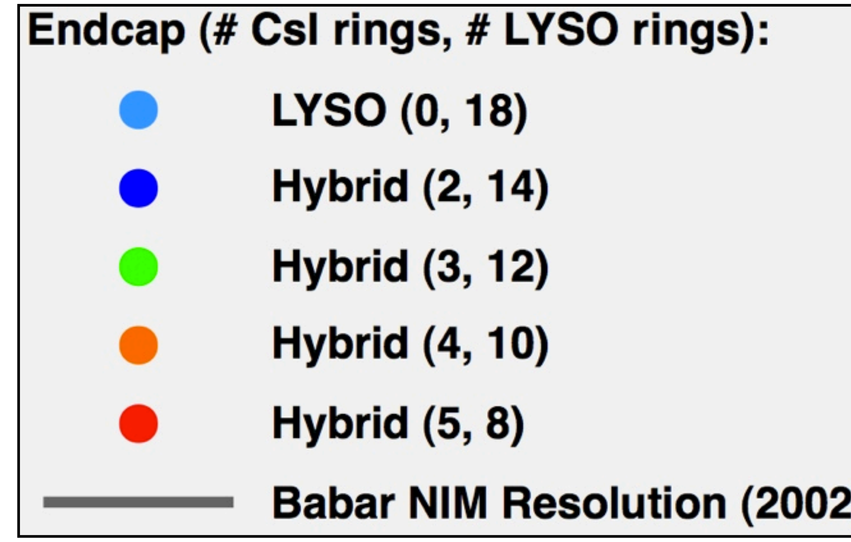
- Average over entire endcap

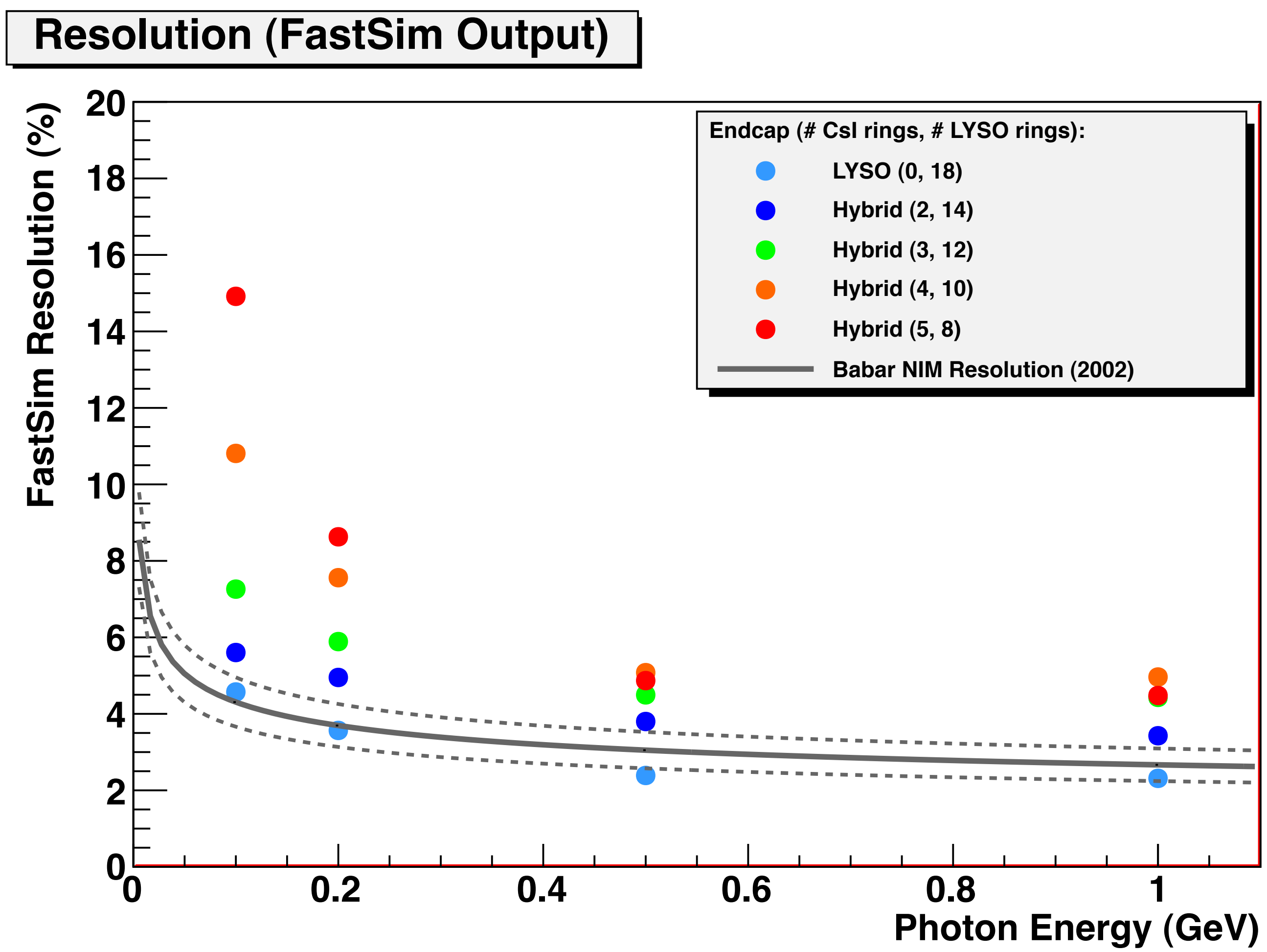


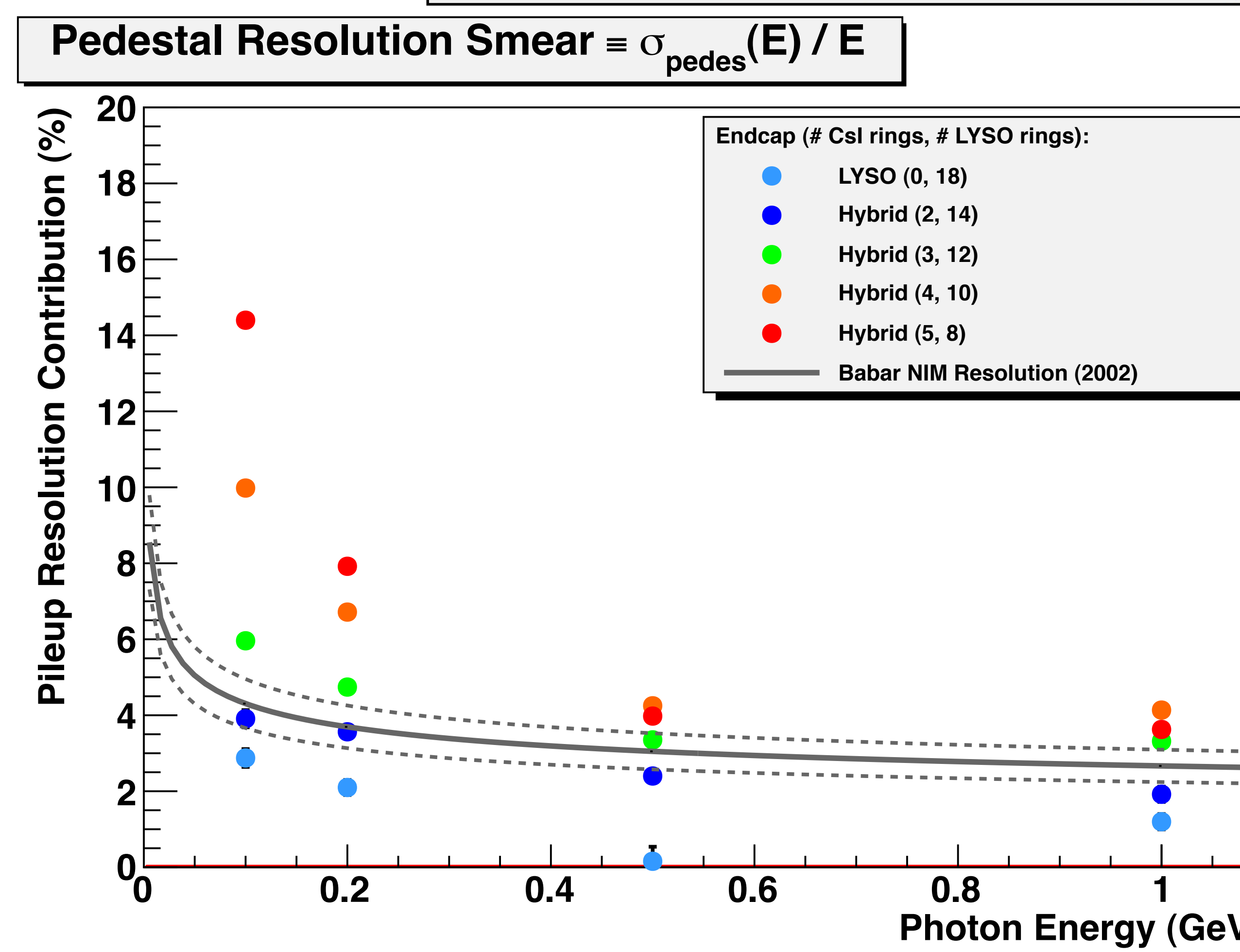


Resolution at 5x background

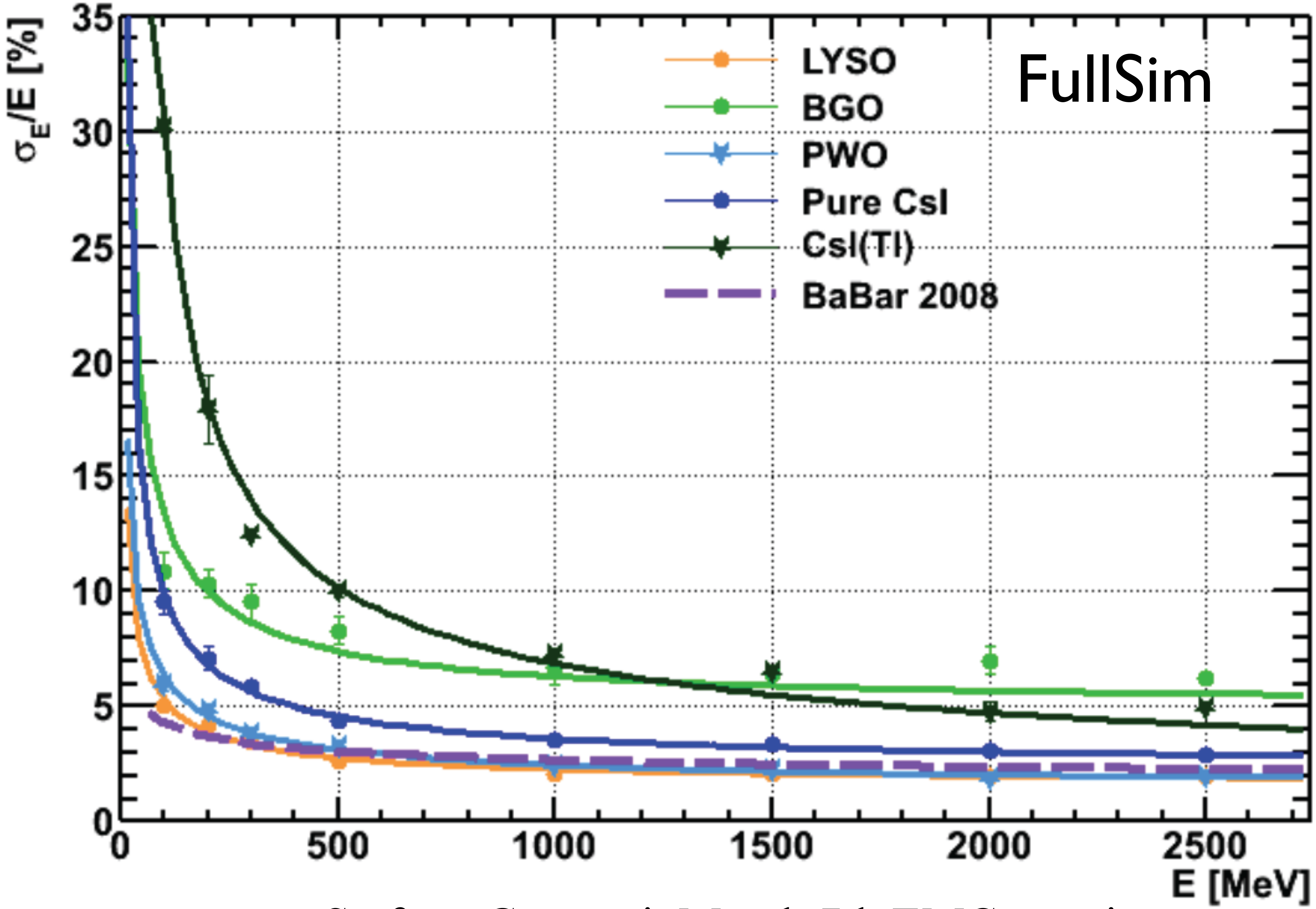
- Average over entire endcap







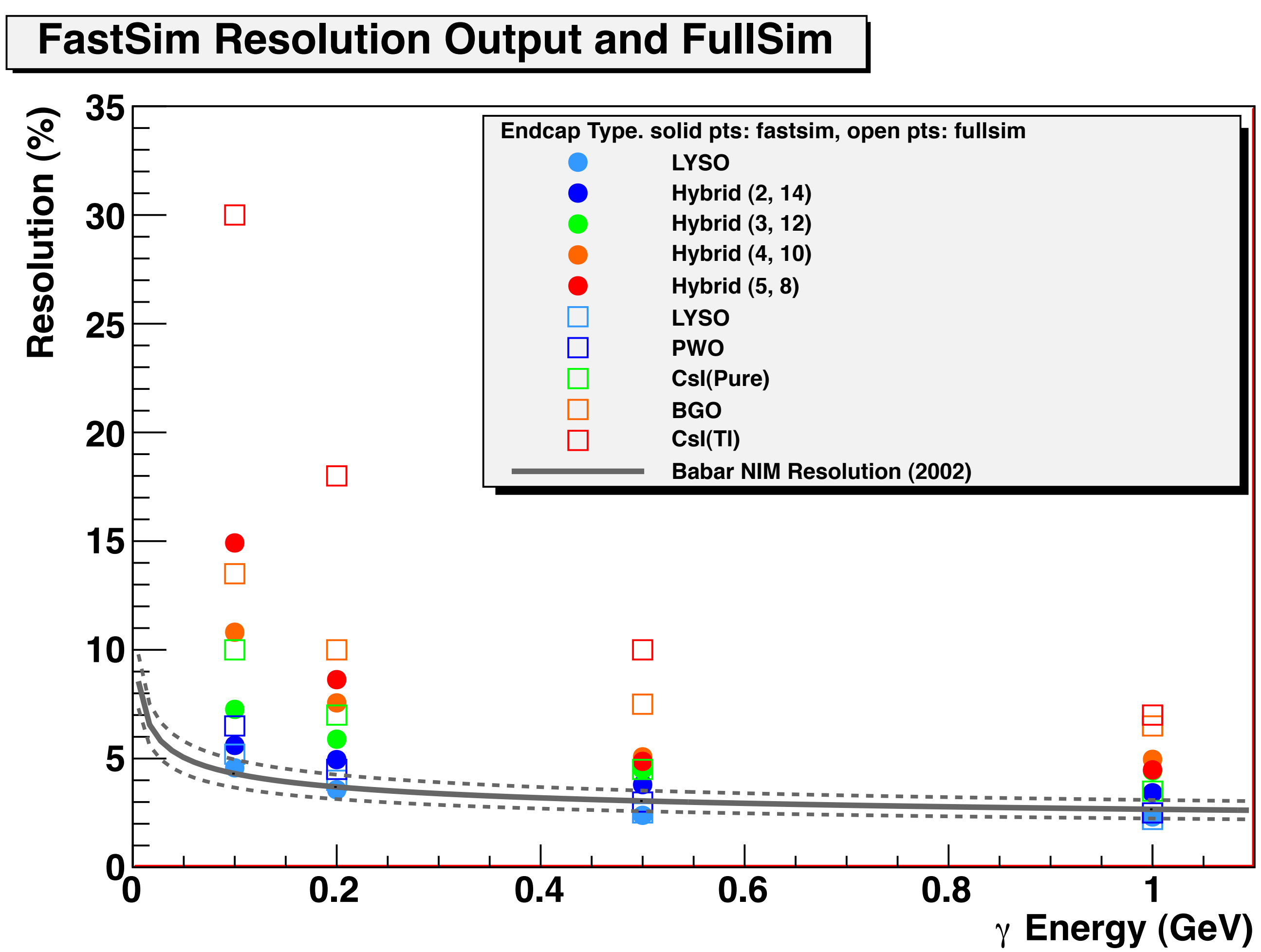
Comparison with FullSim

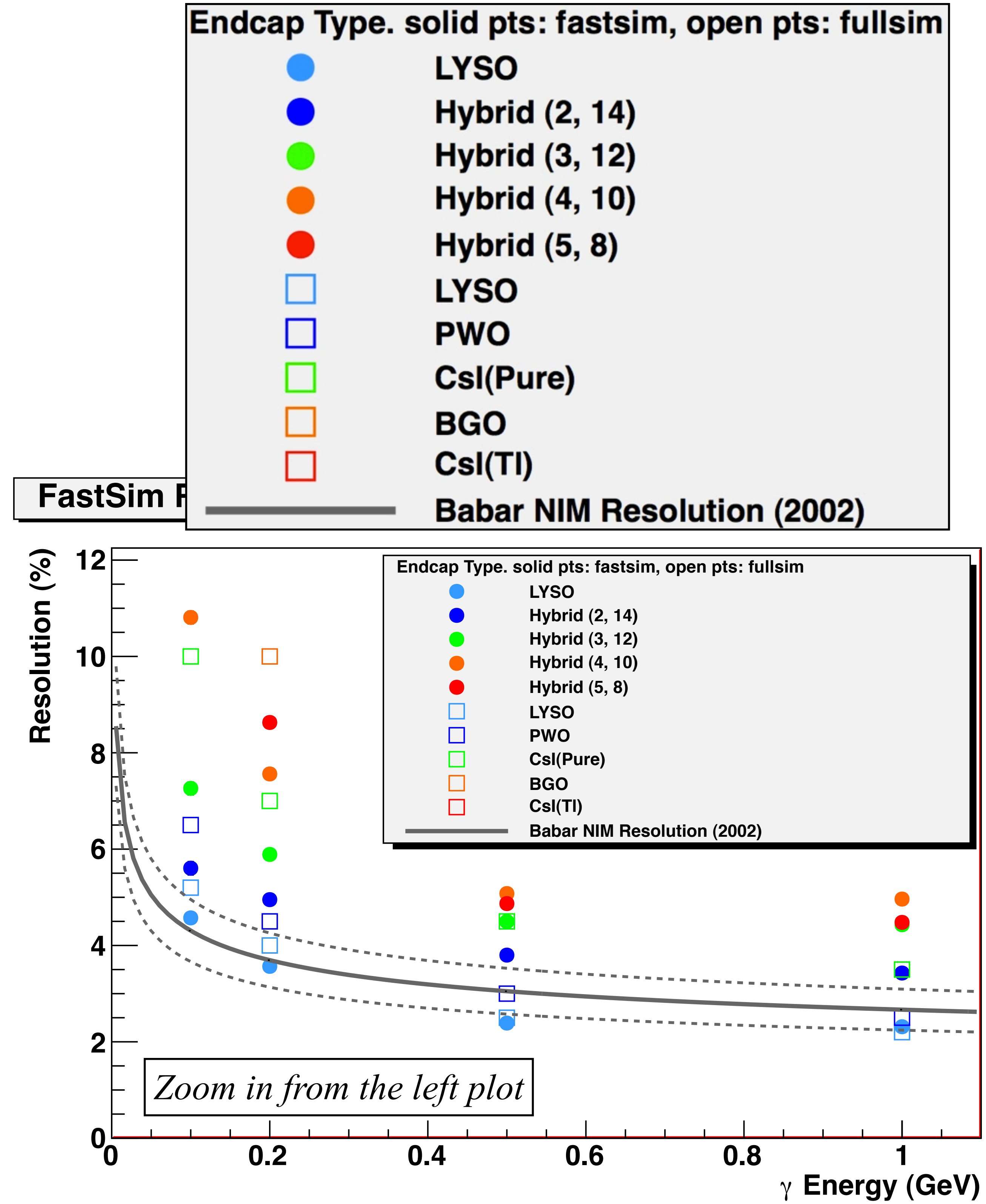


Stefano Germani, March 7th EMC meeting

Comparison with FullSim

- Average over entire endcap





Summary

- From radiative Bhabha background frame (Nov.2011), we found the energy rate is ~1MeV/μs/crystal at forward/backward ends of barrel, which corresponds to 4-5 rad/day (averaging over entire crystal).
- We believe it is grossly underestimated, likely due to 8 MeV photon energy cut.
- Energy rate in outer rings of the forward endcap is similar (or even slightly lower) than the very forward of the barrel.
- Background effect on photon resolution is studied with various endcap hybrid options.
- Performances are compared with other crystal options studied with full simulation.