FastSim EMC Energy Resolution

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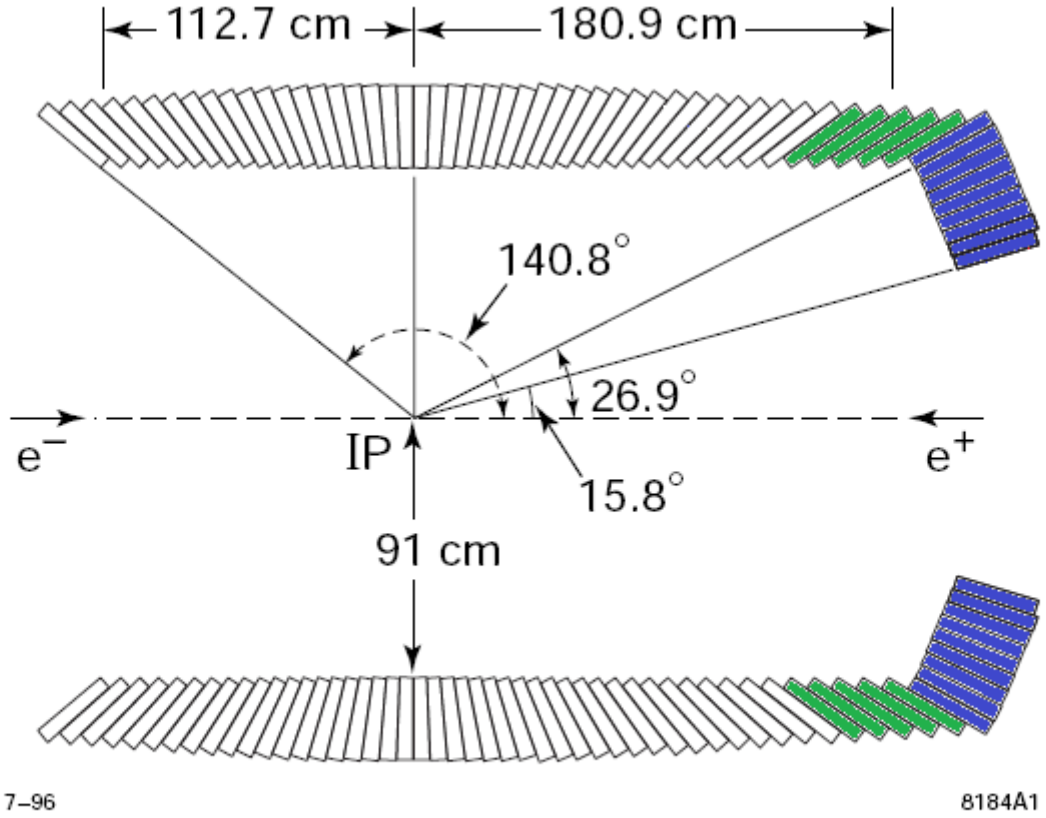
Overview

- The purpose is to study the energy resolution in different regions of the EMC with FastSim.
  - Understand the resolution degradation due to pileup.
  - Difference between nominal and five times background level.
- Endcap: Compare different crystal technologies; specifically, pure LYSO and hybrid configurations.
- Barrel: Compare different preamp electronic shaping times; specifically, the default Babar shaper and the new shaper circuits.

EMC REGIONS



Forward Barrel

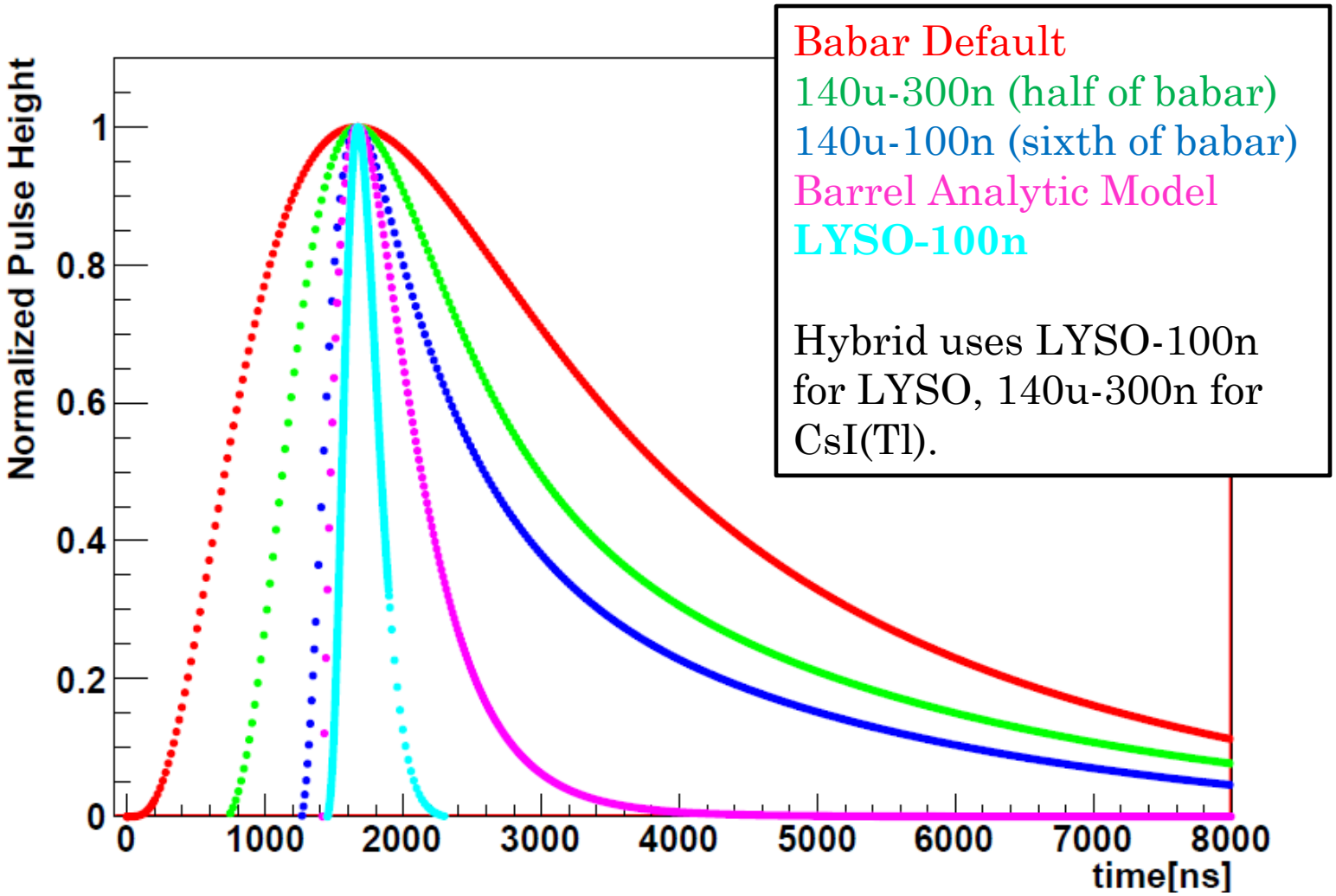
Endcap

Figure 3-11. *The EMC layout: Side view showing dimensions (in mm) of the calorimeter barrel and forward endcap.*

FastSim Configuration

- Background frames updated to Elba 2012 production. Additional changes to configuration files:
  - Sensitive time window to background particles extended to 6μs.
  - Extended *backgroundWindowTLow* far beyond the duration of the electronic pulses.
- Simulated background particle energies lowered:
  - Neutrons KE: 0.1 MeV.
  - Electrons and Photons: 0.1 MeV.
- Other relevant configuration file parameters:
  - *simTrkKEThresh*: 10 MeV
  - *ecutoff*: 0.1 MeV

Preamp Electronic Pulses



Nominal Background: Method (1)

- Data Generation: For each EMC configuration of interest, i.e. endcap type, shaping time,
  - Generate 10,000 mono-energetic photons that uniformly illuminate target area (scaled by solid angle).
  - Perform this experiment twice for a given configuration, once with background frames turned on, and the other turned off.
- Data Visualization:
  - Histogram the highest energy photon cluster from each event. This cluster must stay within the confines of the target region.
  - Fit a crystal ball to the histogram. If the background is too high, fit a gaussian. Use FWHM / 2.354 as the energy uncertainty.

Nominal Background: Method (2)

- Analysis:

$$\sigma_{\text{res}} = \sigma_{\text{nobkg}} \oplus \sigma_{\text{pileup}}$$

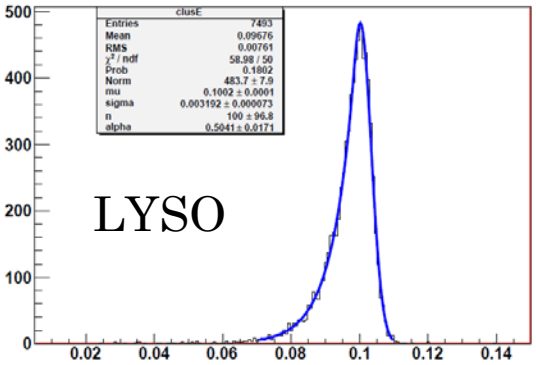
$$\sigma_{\text{pileup}} = \sqrt{\sigma^2_{\text{res}} - \sigma^2_{\text{nobkg}}}$$

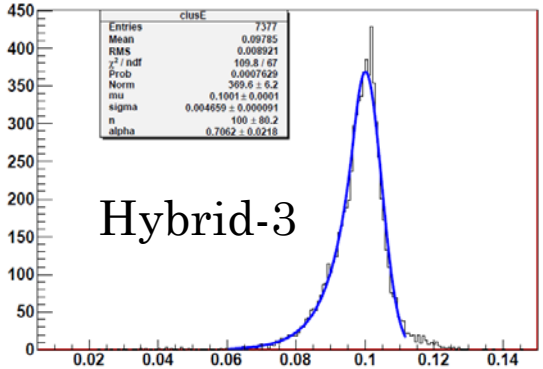
$$:= \sigma_{\text{diffquad}}$$

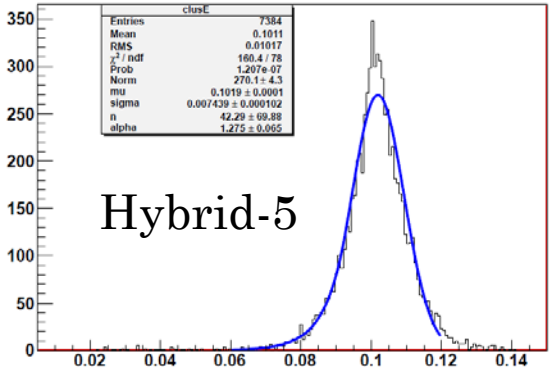
  - We take the difference in quadrature of the energy uncertainties, normalized by the generated photon energy. Call this the *pileup contribution to resolution*.
    - This is a direct assessment of the energy resolution degradation coming from pileup, and should be the basis of all comparisons and evaluations.
  - The no background resolution model in FastSim is known to be inaccurate:
    - This is not a terminal problem, since we are only interested in the pileup degradation.
    - We take the hypothesis that the pileup contribution, i.e. the difference in quadrature, is modeled correctly.

Nominal Background: Cluster Energy Fits. 100 MeV Photons, backgrounds on.

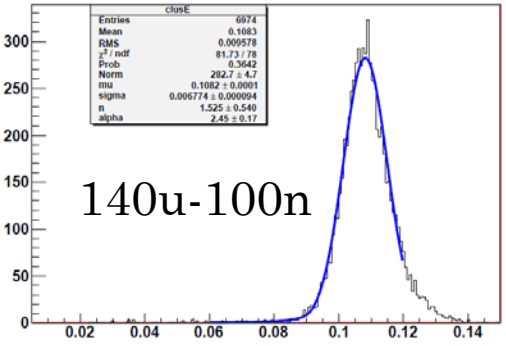
- Endcap: Nothing peculiar.

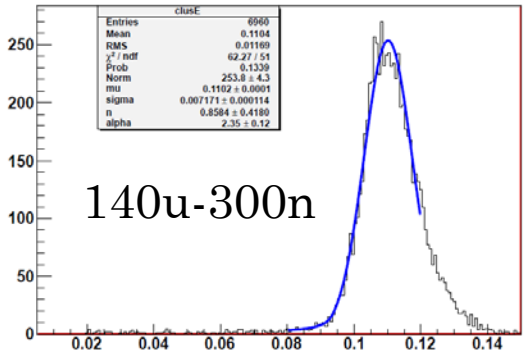


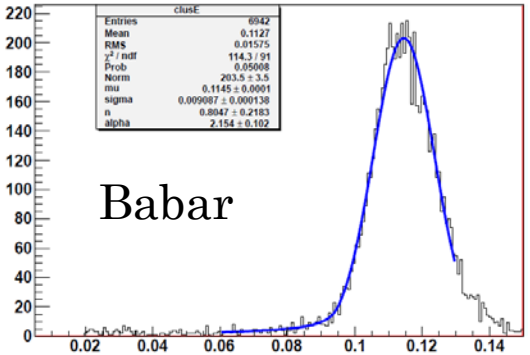




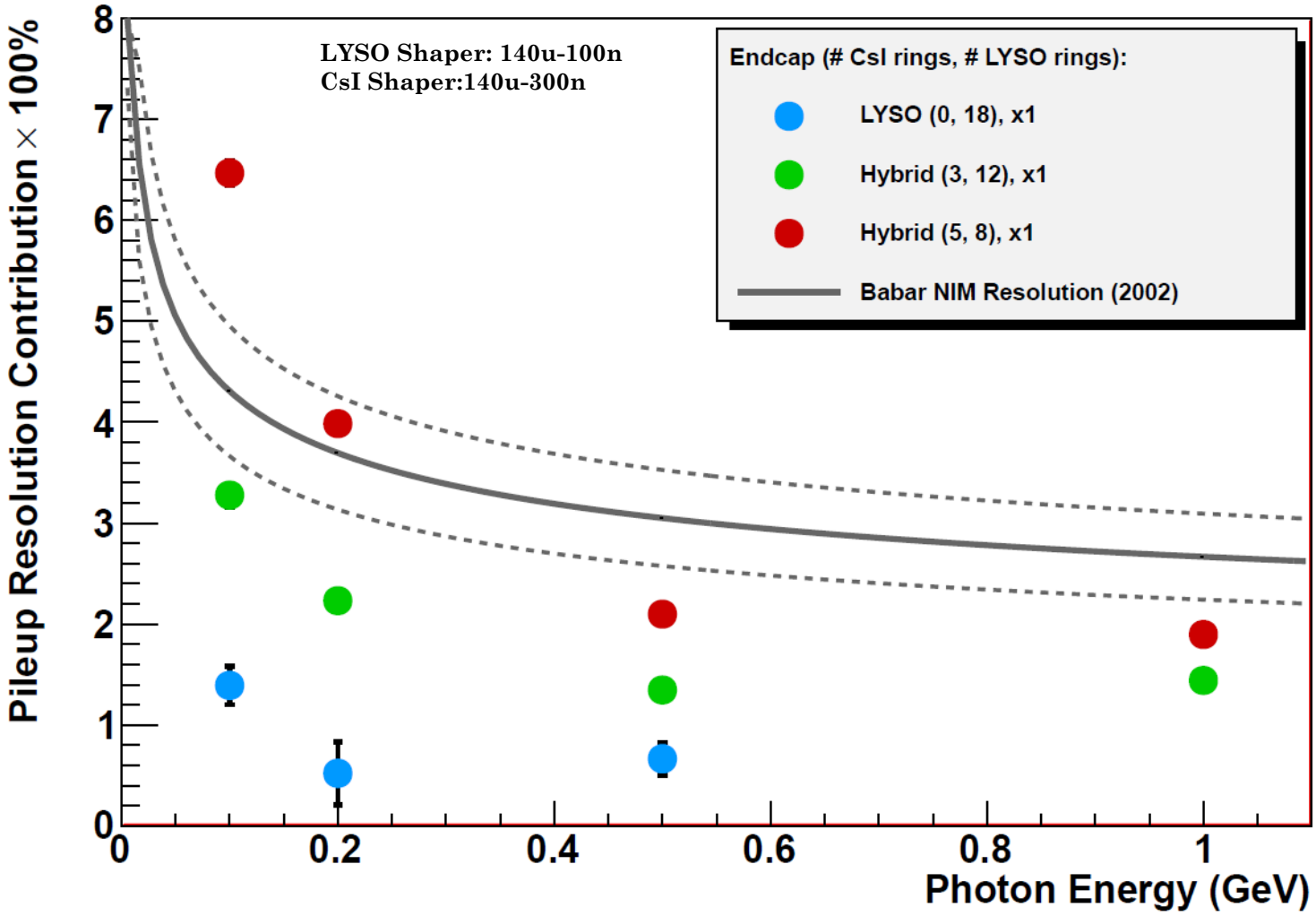
- Barrel: Nothing peculiar.



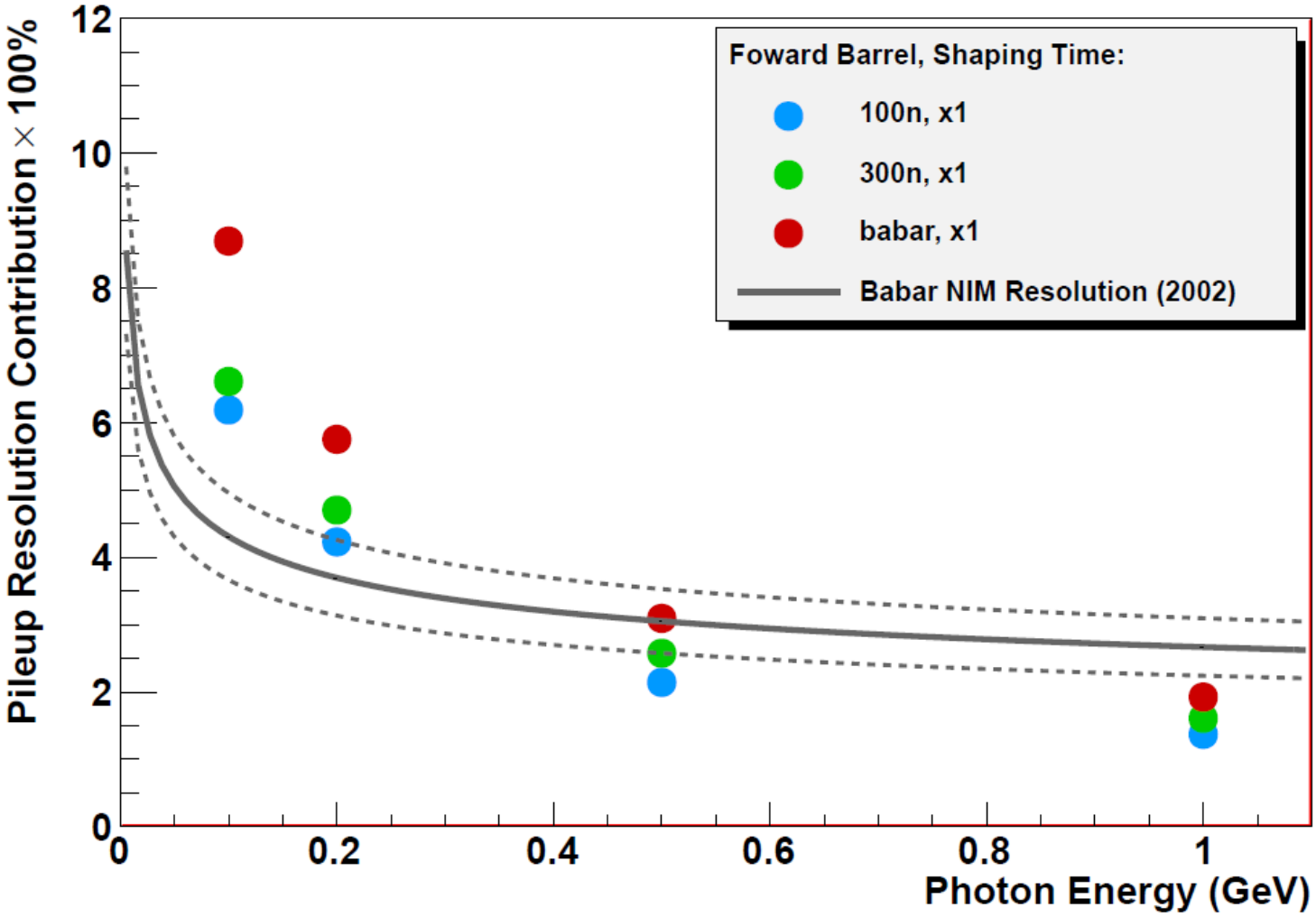




Nominal Background: Pileup Contribution, Endcap



Nominal Background: Pileup Contribution, Barrel



Times five background: Method

- Data Generation:
  - Perform the same experiment, but do the background trials for neutrons and photon/electrons separately.
  - Running both backgrounds together as before causes memory problems due to high volumes of background particles.
- Analysis:

$$\sigma_{\text{res}} = \sigma_{\text{nobkg}} \oplus \sigma_{\text{pileup}}$$

$$\sigma_{\text{pileup}} = \sigma_{\text{radpile}} \oplus \sigma_{\text{neupile}}$$

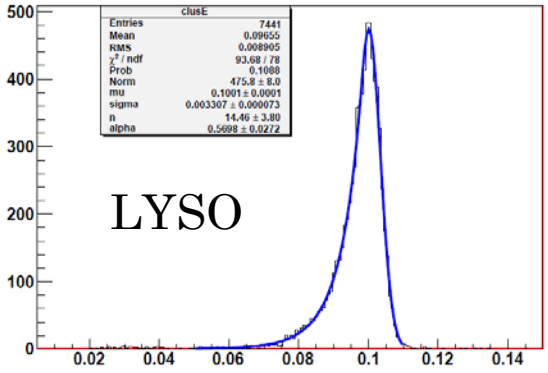
$$\sigma_{\text{radbha}} = \sigma_{\text{nobkg}} \oplus \sigma_{\text{radpile}}$$

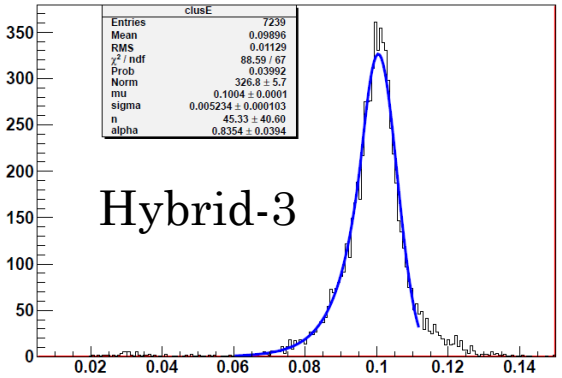
$$\sigma_{\text{neutron}} = \sigma_{\text{nobkg}} \oplus \sigma_{\text{neupile}}$$

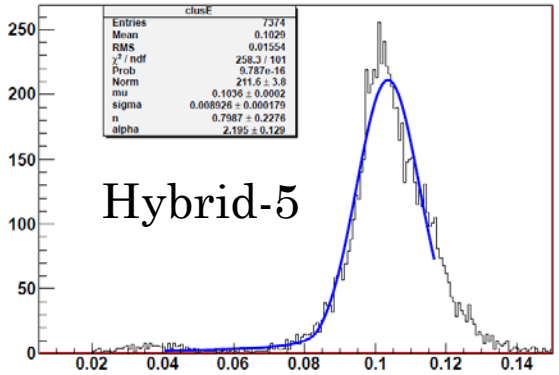
  - Same as before, but analyze the neutron and photon/electrons separately. Combine the uncertainties in quadrature to get the total pileup contribution.

Times Five Background: Endcap Cluster Energy Fits, 100MeV, backgrounds

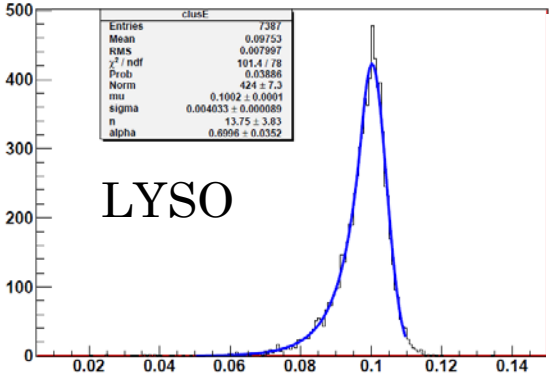
- Photon/Electron background: Nothing peculiar.

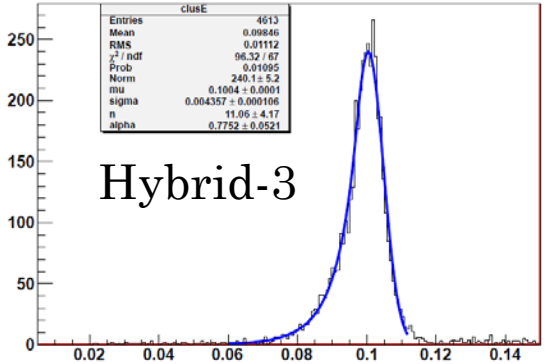


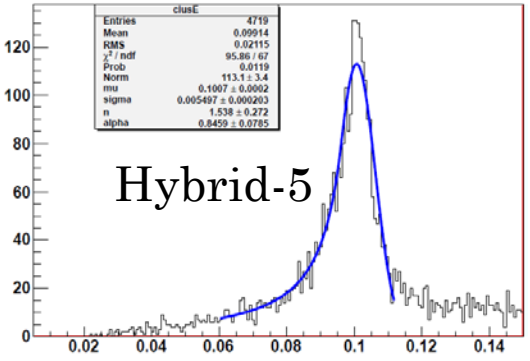




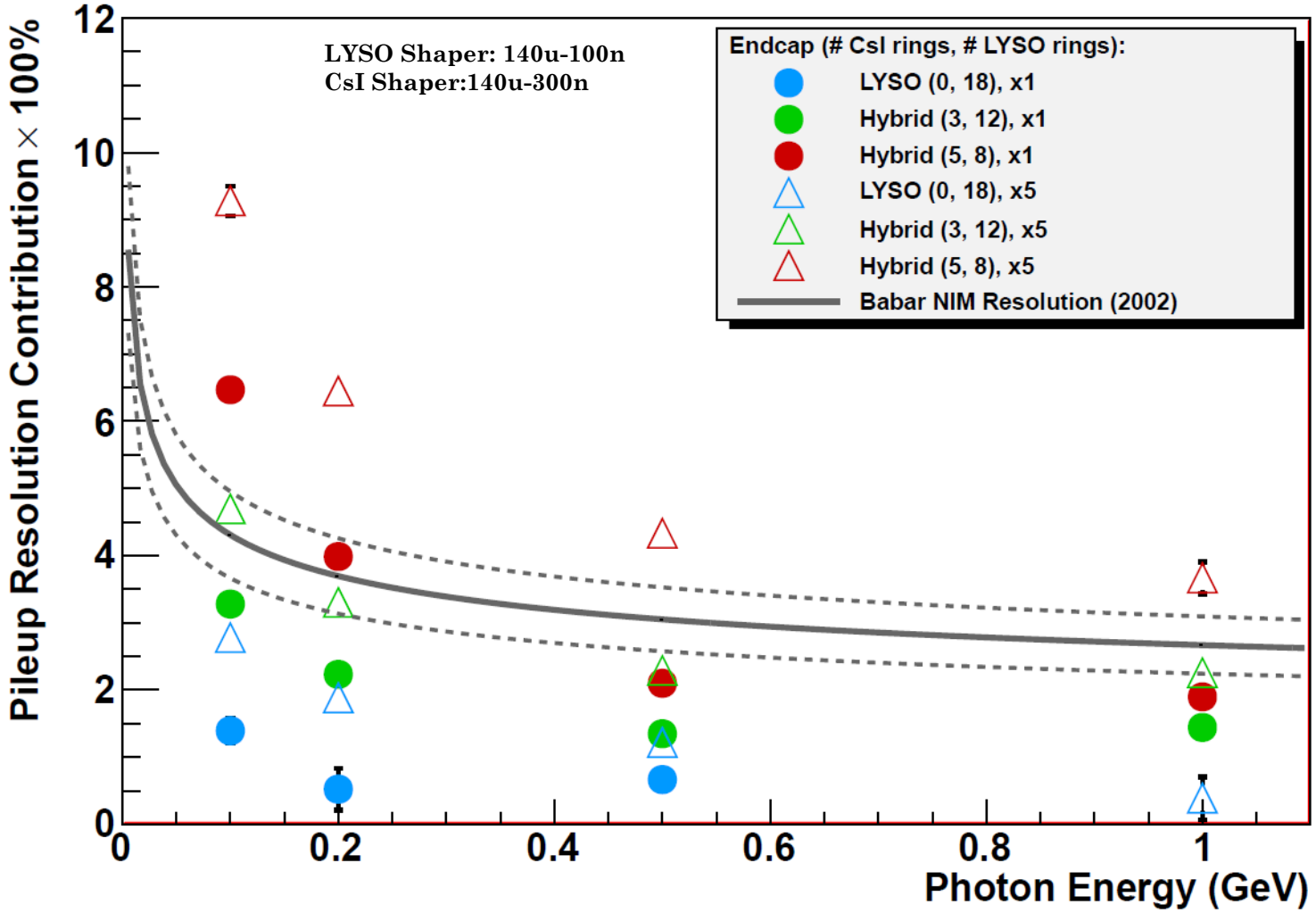
- Neutron background: High tail for 5 ring hybrid.



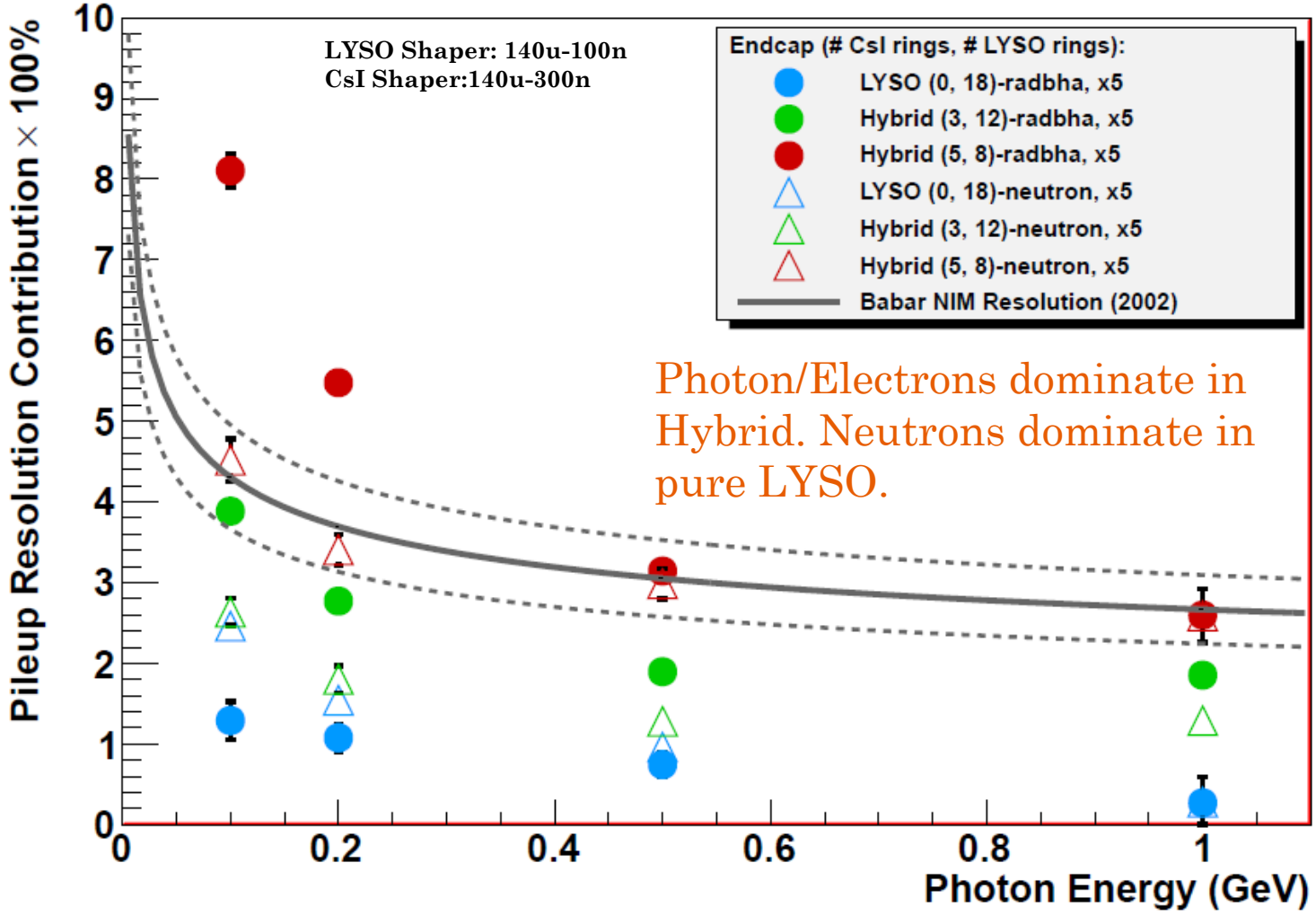




Times five Background: Combined Pileup Contribution, Endcap

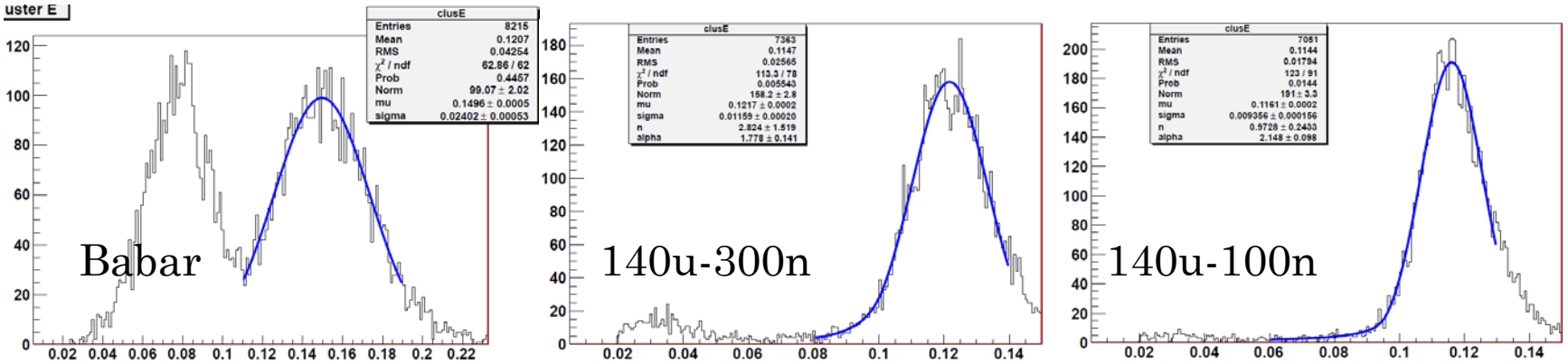


Times Five Background: contribution from separate components. Endcap

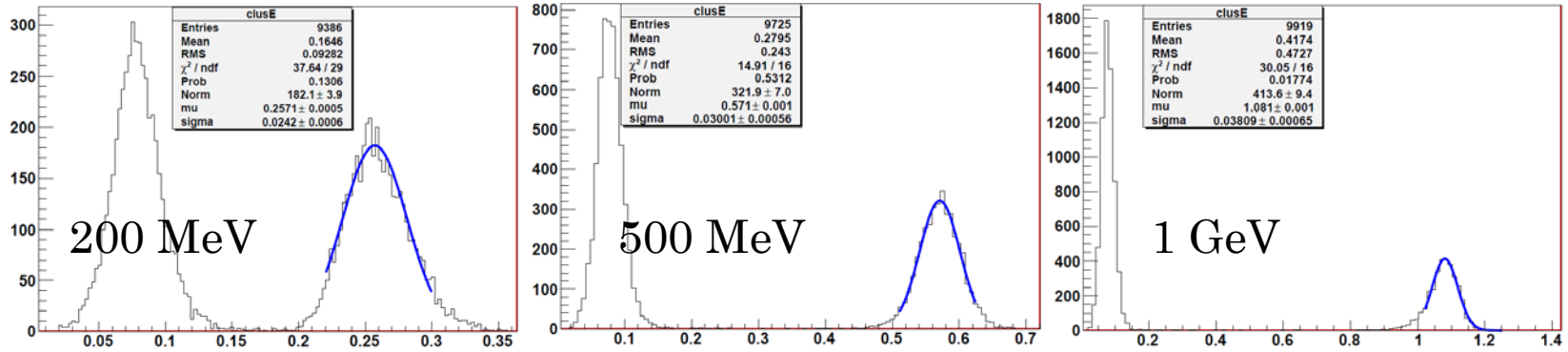


Times Five Background: Forward Barrel Cluster Energy Fits, Photon/Electron background

- 100 MeV: Peaks starting to merge for Babar. Noticable peak shift.

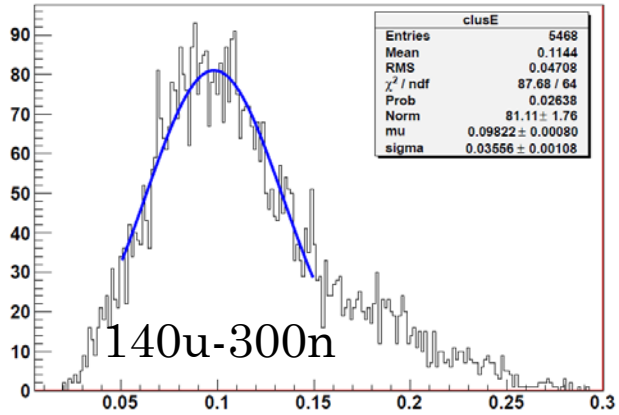


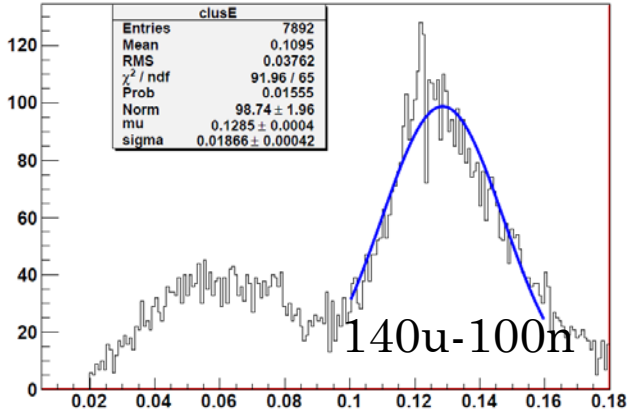
- Babar Shaper: Other energies.



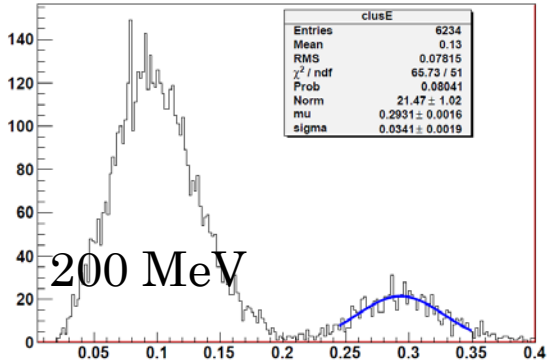
Times Five Background: Forward Barrel Cluster Energy Fits, Neutron background

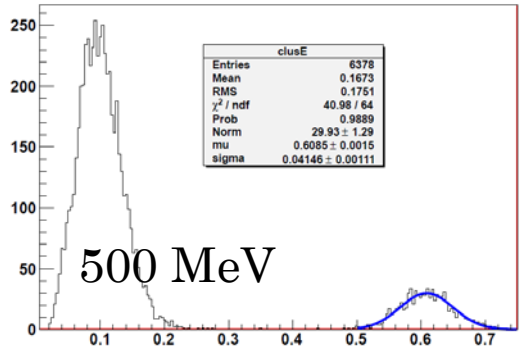
- 100 MeV: Peaks completely merge for140u-300n. Babar shaper crashes from memory issues, indicating *severe* background levels.

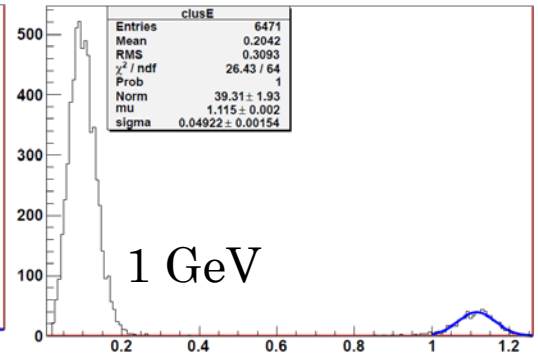




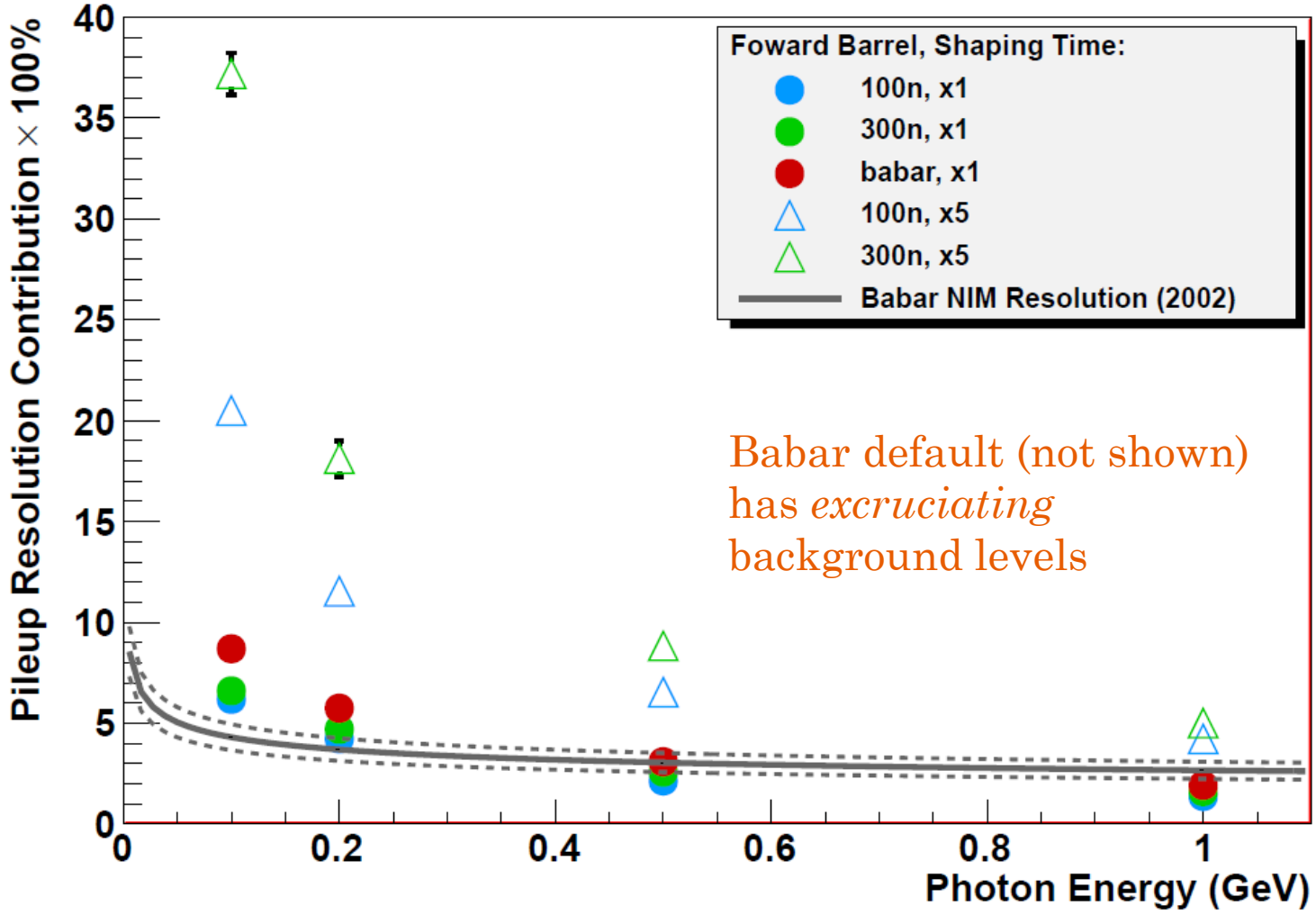
- 140u-300n: Other energies. Large peak shift.





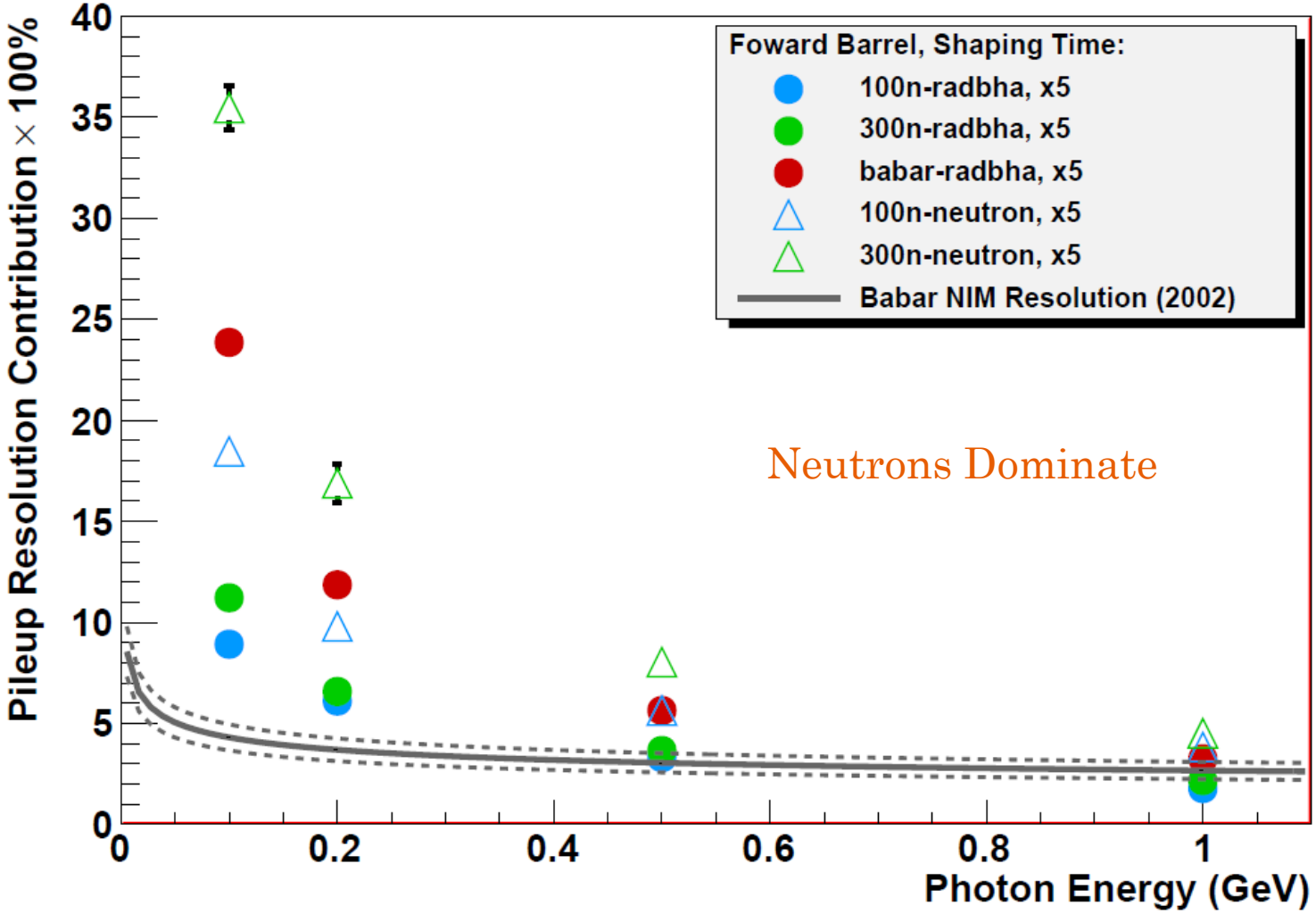


Times five Background: Combined Pileup Contribution, Forward Barrel



Babar default (not shown) has *excruciating* background levels

Times Five Background: contribution from separate components. Forward Barrel



Conclusion

- Endcap does fine under times five for pure LYSO and 3 ring Hybrid technologies.
- Forward barrel does very poorly with the default Babar shaper electronics. Changing the electronics greatly improves the situation.
- Different regions/configurations of the EMC receive different contributions from the separate background components:
  - LYSO endcap: Neutron dominates.
  - Hybrid endcap: Photon/electrons dominate.
  - Forward Barrel: Neutron dominates.