Photon-Neutron Separation with BCal

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GlueX BCal Segmentation Meeting, October 31, 2011

The Problem

We'd like to separate photon-caused and neutron-caused showers of the same energy deposited in BCAL fibers.

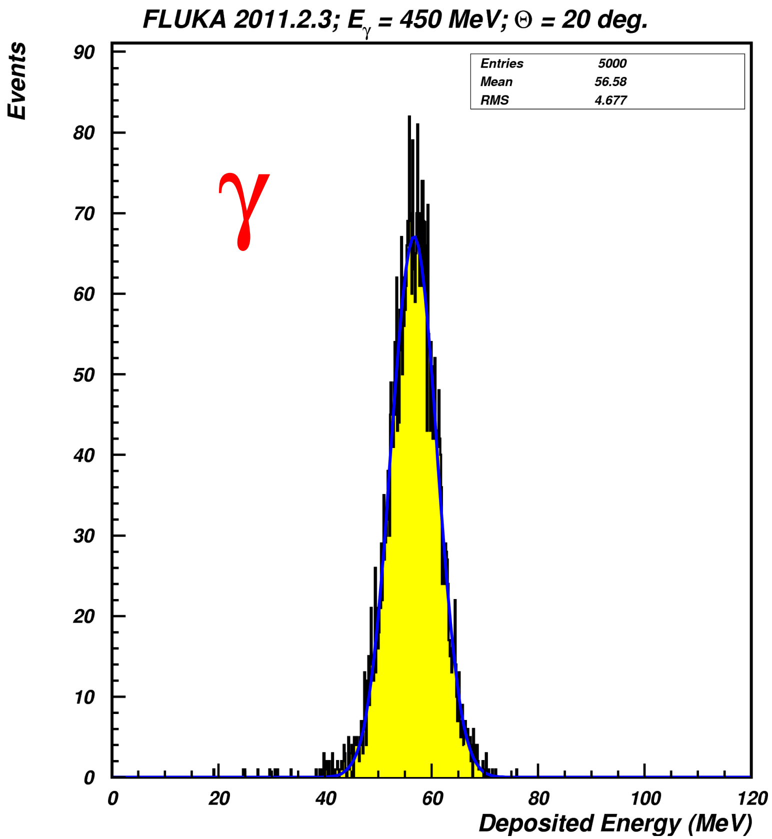
Original Solution

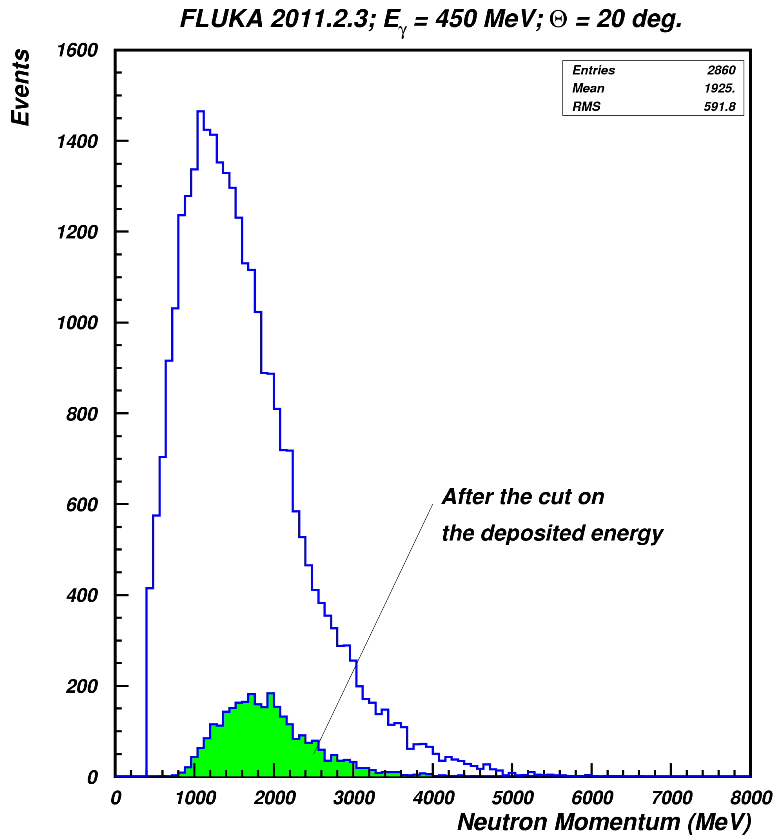
The photon-caused EM shower is developed “earlier” and located inside BCAL module with the maximum of deposited energy in the inner part of the calorimeter.

The hadronic shower from neutron is developed “later” and significant part of the shower energy leaks out of back of the module; the maximum of the energy deposited in BCAL is shifted to the outer part of the calorimeter.

The ratio of the energies deposited in the most inner and the most outer readout layers can be used for photon-neutron separation.

Selection of Neutron Events





NOTE: Kinetic energy of selected neutrons (of about 1200 MeV) is significantly larger than the energy of correspondent photons.

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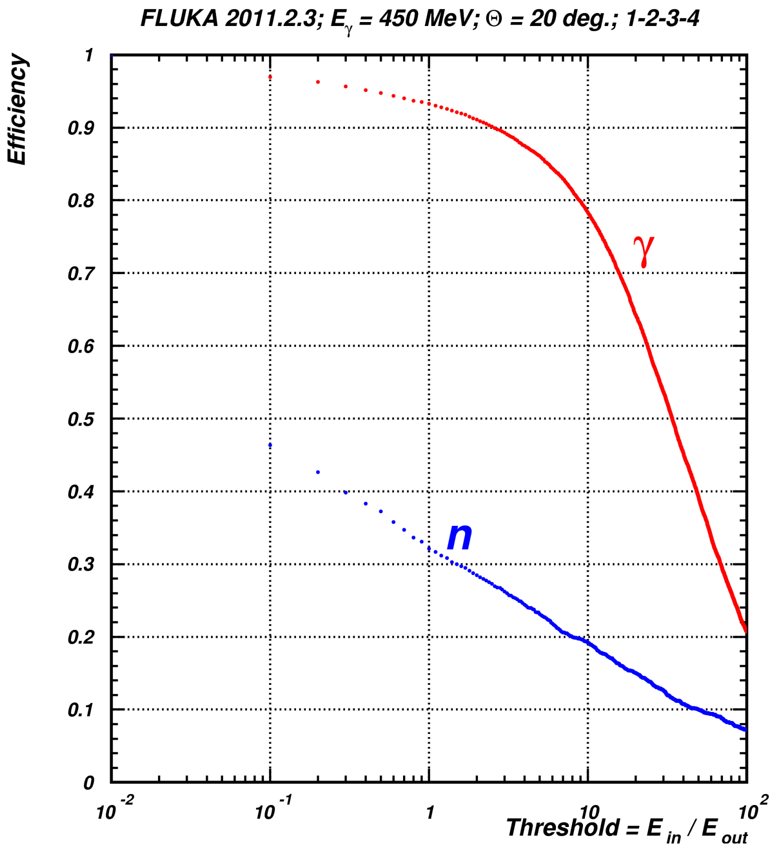
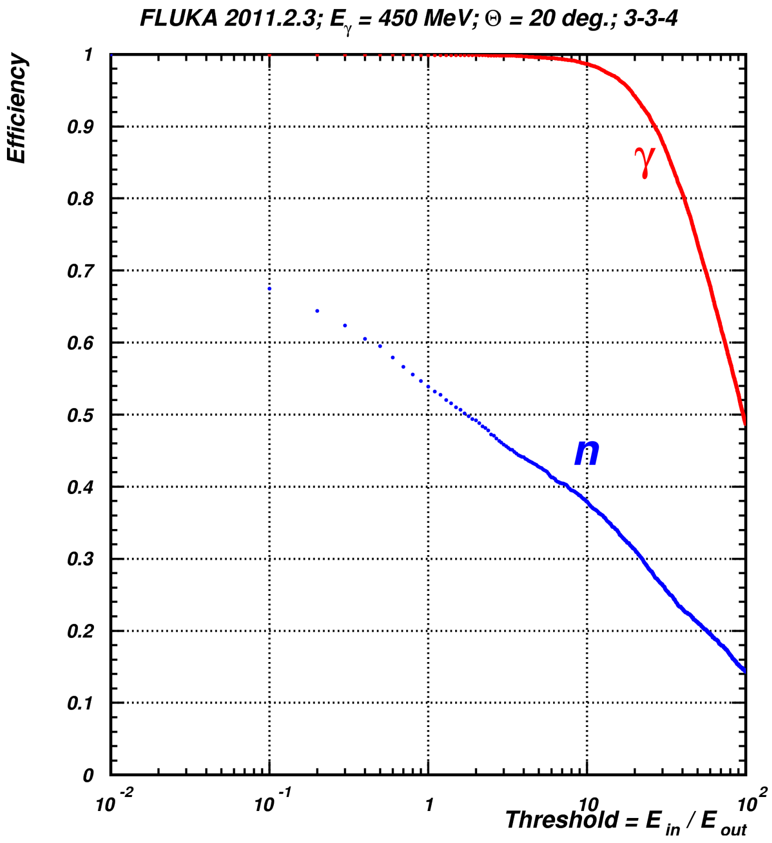
Neutron ID Efficiency with IN/OUT Ratio





Suppression of neutrons by factor of about 2.5 is achievable without reducing the photon efficiency

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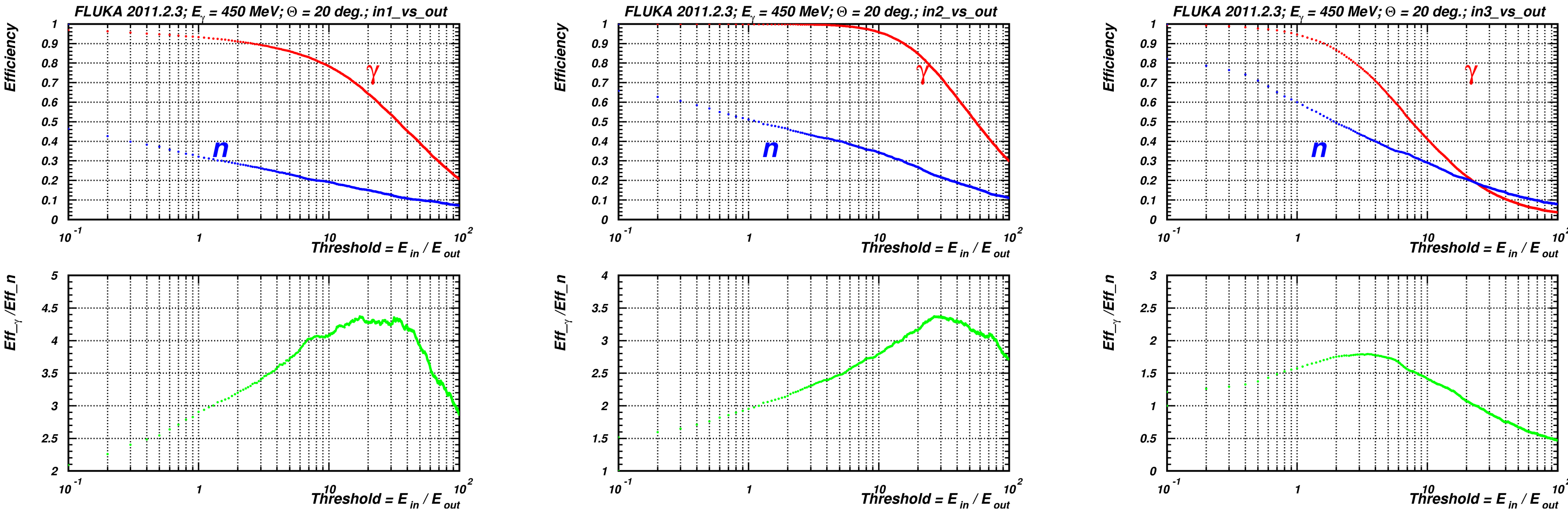
Neutron ID Efficiency with All Ratios (1-2-3-4 Readout)



Suppression of neutrons by factor of about 2.5 is achievable without reducing the photon efficiency

Correlations between the energy depositions in the calorimeter layers should be taken into account to estimate overall neutron suppression

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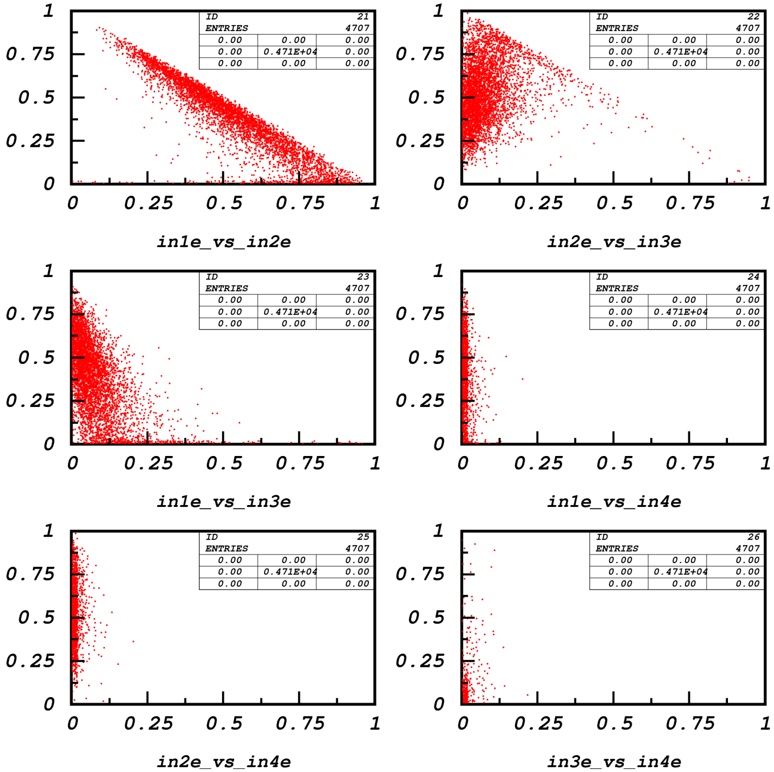
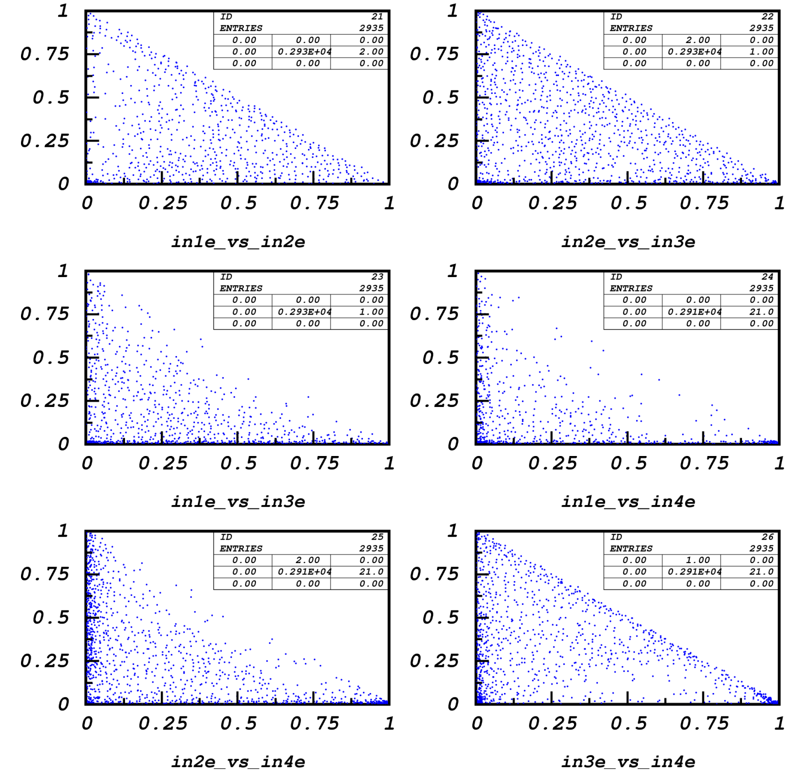
Layer-to-Layer Deposited Energy Fraction Correlations (1-2-3-4)



Photons



Neutrons

Energy depositions from the photon-induced shower are correlated; energy depositions from neutron-induced shower have almost no correlations.

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Simplified Method

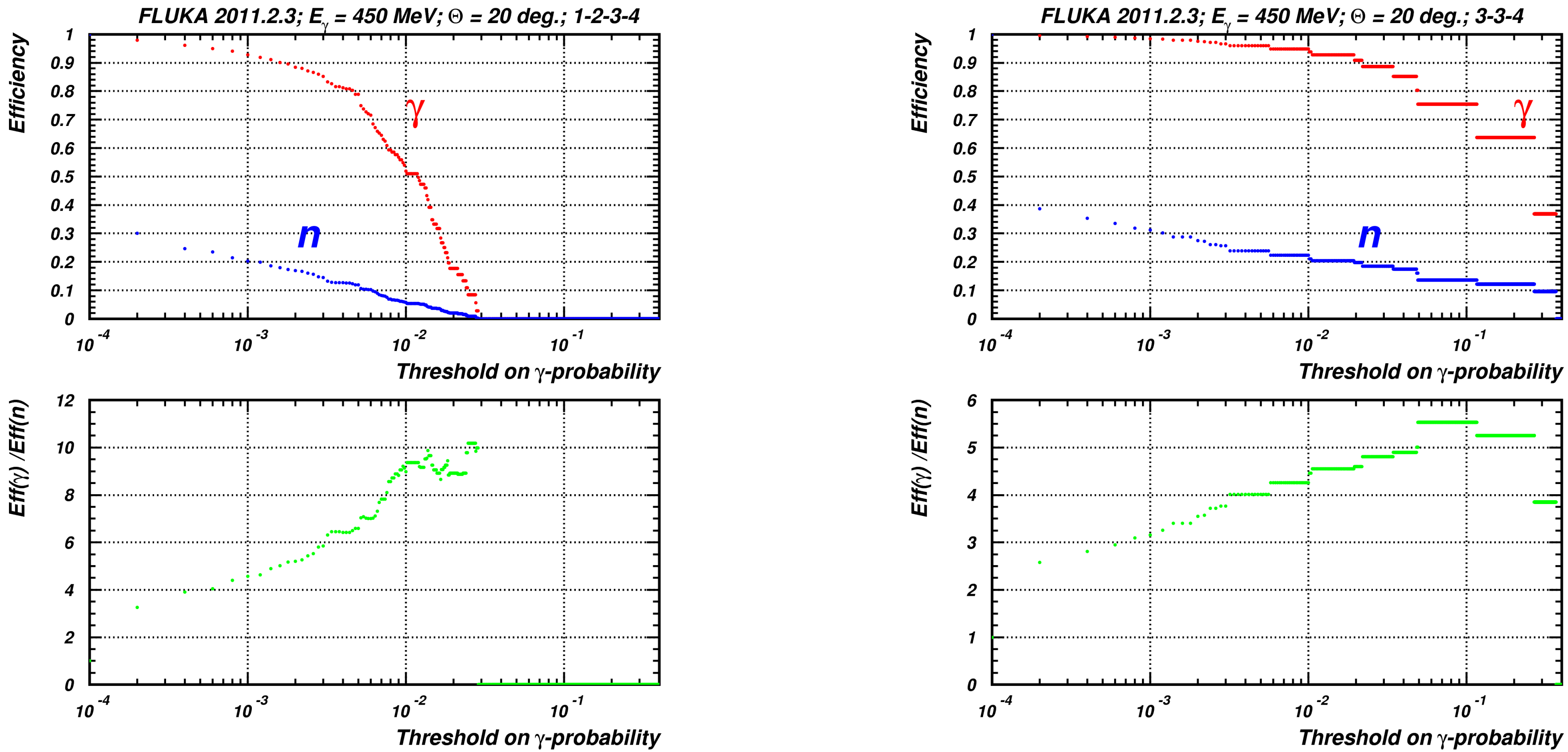
For each of the readout layers, we divide the “possible-ratio” range [0-1] on 20 bins.

Using simulated photon showers, we found the frequency for each combination of bins in 4 (3) layers; these frequencies estimate the probabilities that the photon-induced shower will have the certain combination of energy depositions in the readout layers.

For each photon- or neutron-induced shower event, we have now the “probability that this event came from the photon”.

We compare the efficiencies to exceed the certain threshold in these probability for photon- and neutron-induced showers.

Neutron ID Efficiency



1-2-3-4 readout segmentation provides much more clear neutron-photon separation for 50% photon-induced-shower subset compared with 3-3-4 case.

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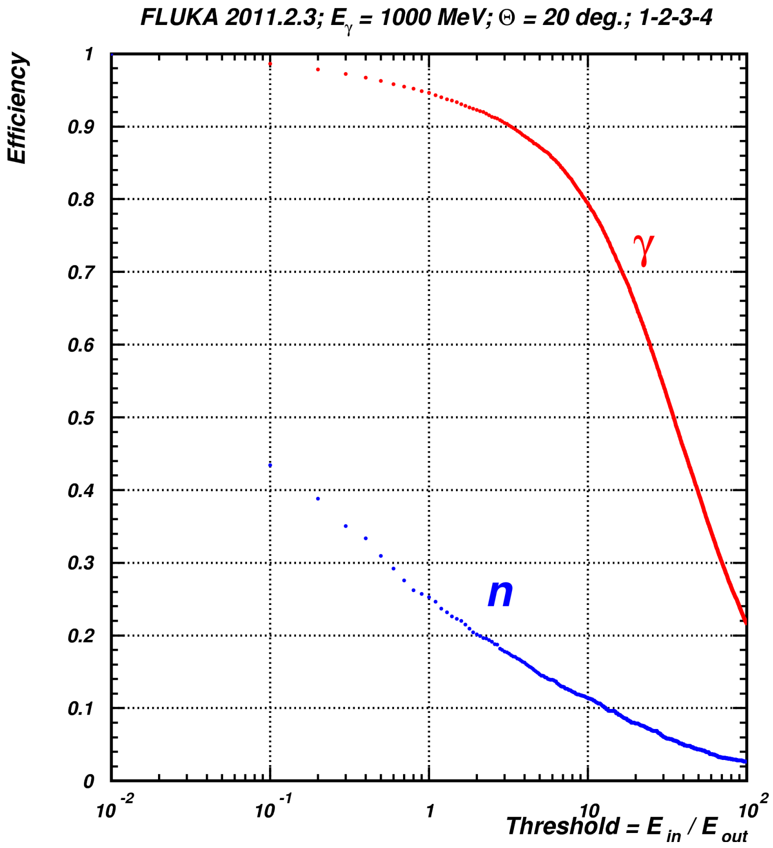
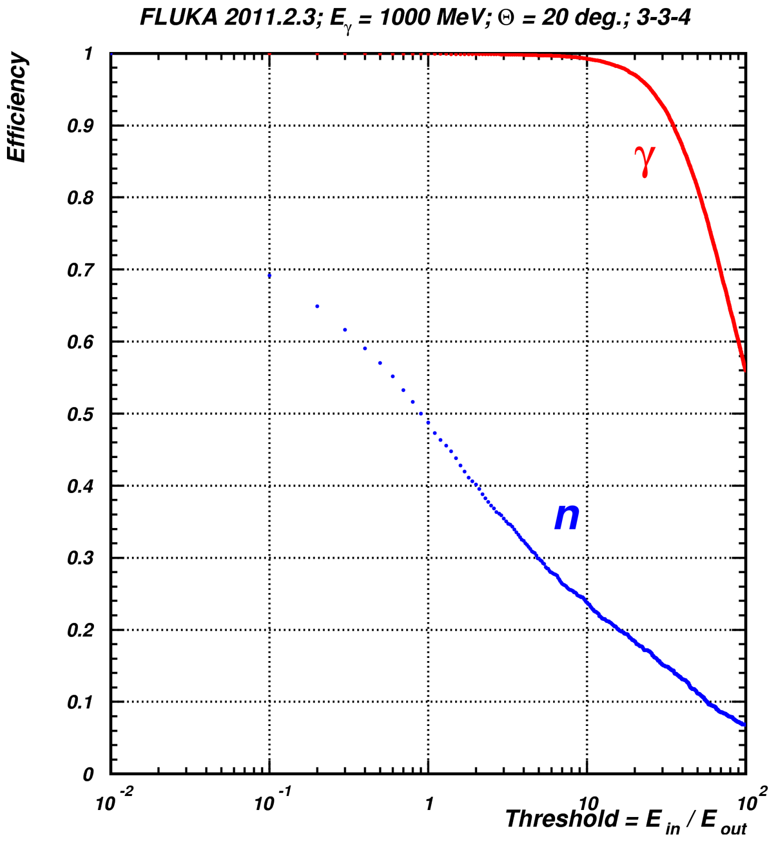
Neutron ID Efficiency with IN/OUT Ratio at 1000 MeV





Suppression of neutrons by factor of about 4 is achievable without reducing the photon efficiency

NOTE: the higher neutron energy (viz., the more difficult the use of TOF), the better the suggested separation method works

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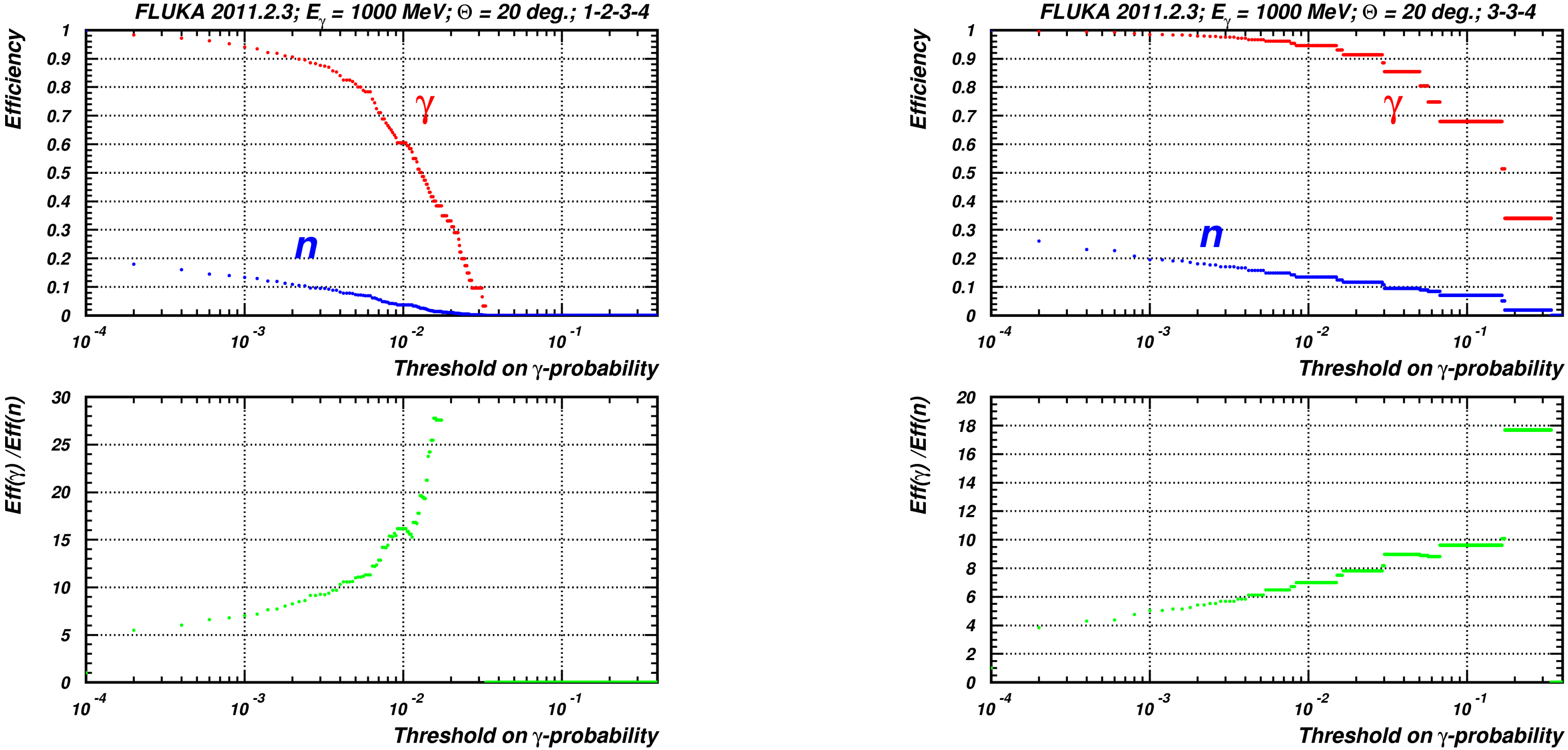
Neutron ID Efficiency at 1000 MeV



1-2-3-4 readout segmentation provides much more clear neutron-photon separation for 50% photon-induced-shower subset compared with 3-3-4 case.

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Neutron ID via Time-of-Flight

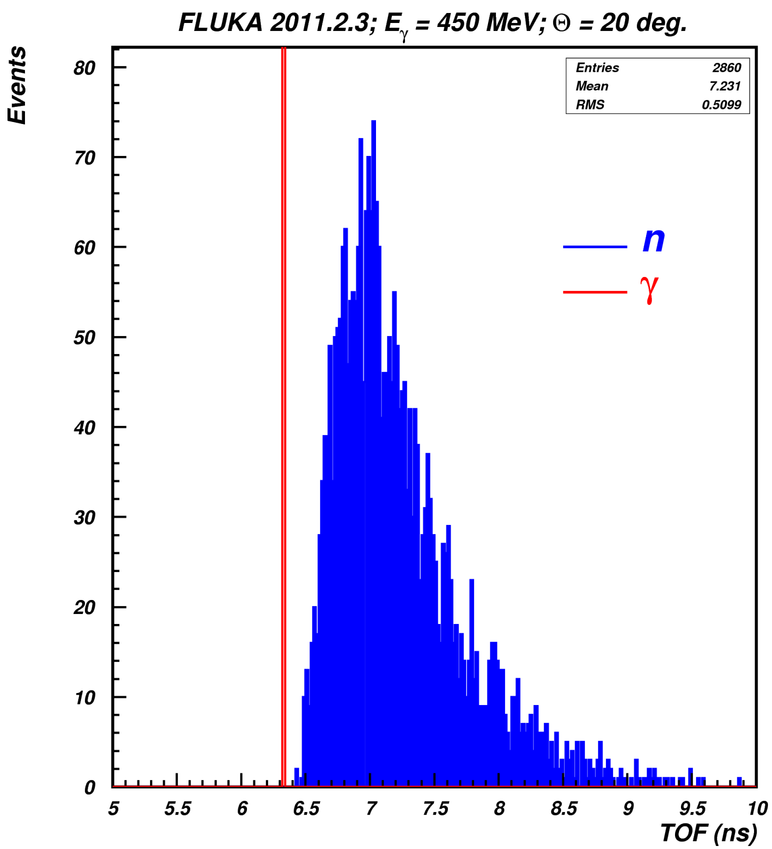
- To have no photon loss, the window of 3σ window on photon shower TOF (viz., about ± 300-450 ps) is required; it comparable with the gap in between photon and correspondent neutron TOF.

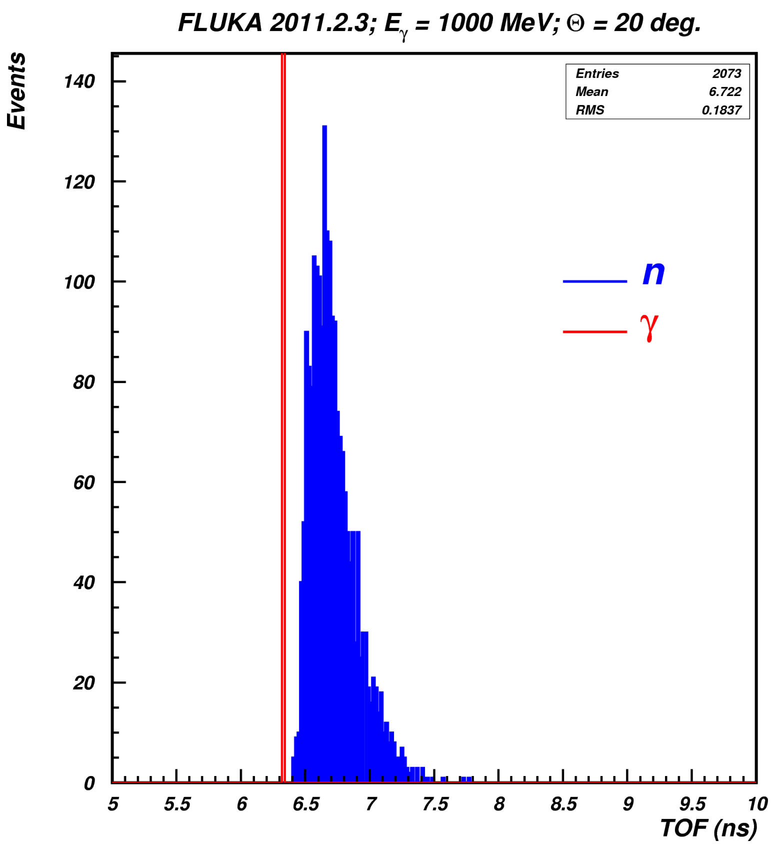
- Because the most of energy deposition from neutrons is located in the outer layers of BCAL while the time measurements are planning for the inner layers only, the accuracy of TOF measurements for neutrons will be significantly worse than for photons.

- Taking into account the mentioned above, the TOF for significant fraction of neutrons (up to 50% => "neutron suppression factor" of about 2) will overlap with the selection cut for photons. (Simulation is required to establish the exact value.)

- The proposed neutron selection method (that is independent of TOF) will improve significantly the overall identification of neutrons.

Neutron ID via Time-of-Flight





NOTE: No resolution on time measurements is shown here.

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Conclusions:

The ratio of the energies deposited in the most inner and the most outer readout layers can be used for photon-neutron separation; suppression of neutrons by factor of 2.5-4 is achievable without loss of photon efficiency

The method used correlations of the energy deposited in the readout layers of BCAL allows achieve neutron suppression factor of 4-6 for all showes; 1-2-3-4 readout segmentation allows achieve neutron suppression of 10-15 for 50% subset of photon showers that is NOT achievable with 3-3-4 case

The higher neutron energy (viz., the more difficult the use of TOF), the better the suggested separation method works

The proposed neutron selection method (that is independent of TOF) will improve significantly the overall identification of neutrons

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