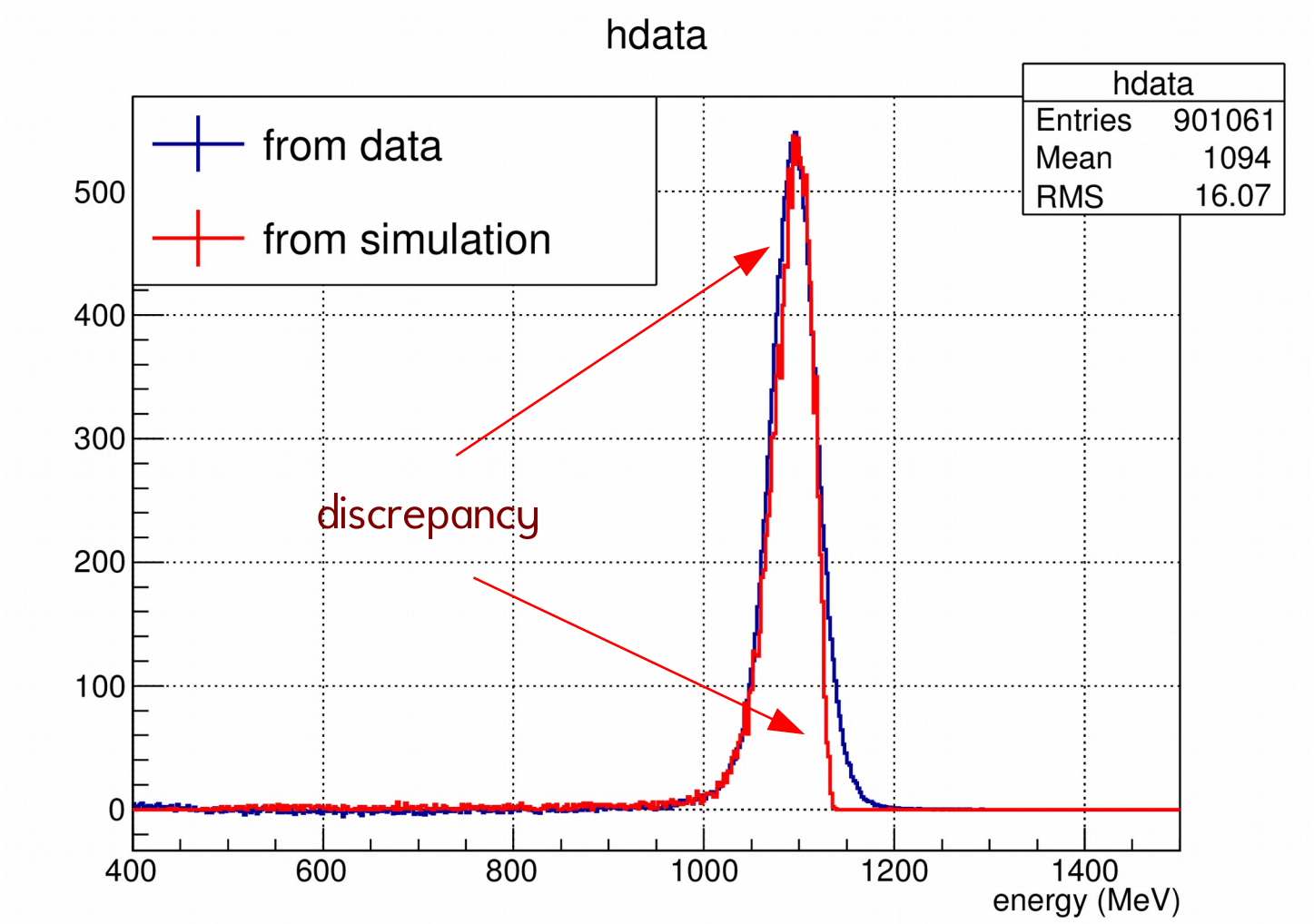
HyCal Digitization Update

Normal procedure

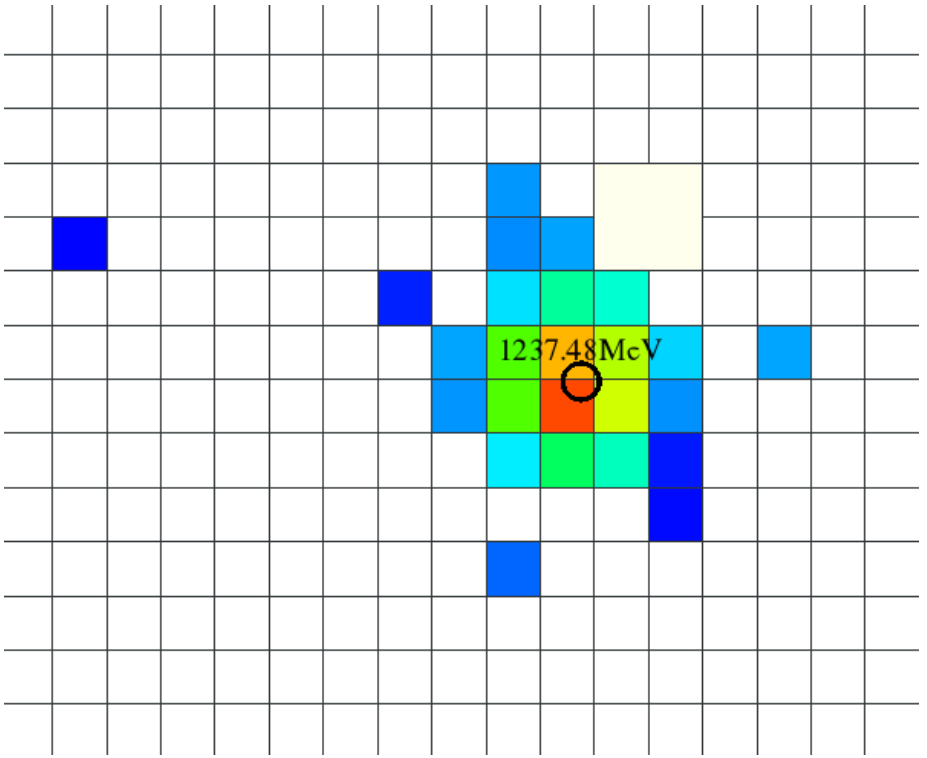
- No cluster profile (this is a compromise way anyway)
- Instead calculate energy deposit in each module
- Digitize energy deposit using calibration constants
- Using PRadAnalyzer to reconstruct HyCal clusters

Normal procedure



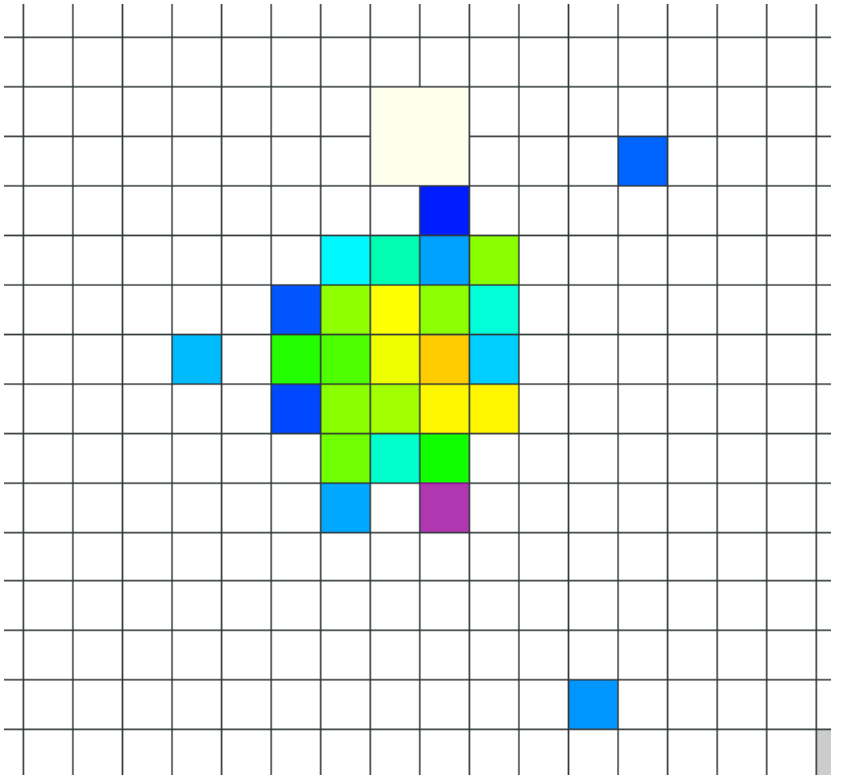
- Data was background subtracted
- e-p events cut: hycal cluster quantity == 1
- Central module energy from simulation: 30%

Normal procedure



Event from data

Central module: 70% total energy



Event from simulation

Central module: 30% total energy

Normal procedure

Adjust minimum energy threshold cut

- For each step, we track its Track energy
- If Track energy < 1 or 2 MeV, we don't want it continue deposit energy anymore.
- Geant4 fulfill this through SetCut() method in PhysicsList
- Default cut was 1.0 mm, correspond to 1.1 MeV cut-off energy for electron, 90 keV for photon.

- Scan values from 0.001mm up to 100mm.
- Geant4 still deposit energy even Track energy < cut-off energy.

- Basically no difference (even when you choose not to record this energy deposit). Doesn't work.

Production threshold

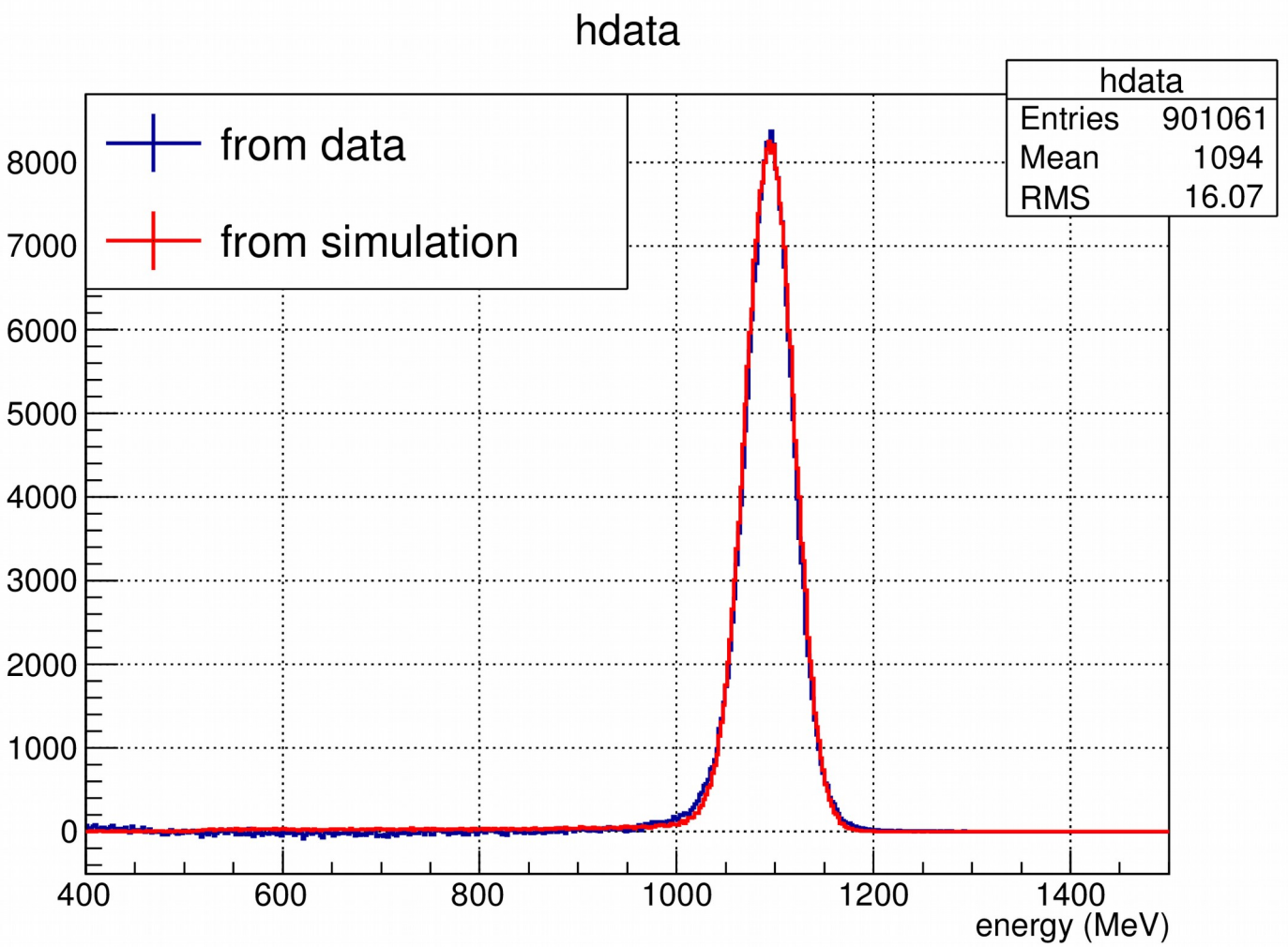
- In Geant4, there is no energy cut-off (a.k.a. tracking cut).
  - Tracks are always tracked down to a zero range/kinetic energy unless they are killed by other reasons such as decay or interaction.
- Only the production threshold exists in Geant4, and it is applied only for the processes which have infrared divergence.
  - Some EM processes have infrared divergences which lead to an immense number of smaller and smaller energy secondary gammas/electrons (e.g. in . Bremsstrahlung, δ rays production).
- The user specifies the production threshold in range (length) rather than energy.
  - Only the secondaries which can travel longer than this threshold are generated.
  - Lower energy secondaries are not generated and their energies are integrated in the energy deposition of the parent track along its trajectory.

Production thresholds = cuts in range

- Production threshold (i.e. range cut) represents the accuracy of location where energy is deposited.
  - Default value is 1 mm. You can set yours in your PhysicsList.
  - Only one value of range cut is needed for each of e+, e- and gamma for all materials. Then the range cut is interpreted into energy threshold for each material.
    - You may also define a cut for proton. It is used for all recoil ions by elastic scattering processes.
- Every track is tracked down to a zero kinetic energy. Thus, the stopping position is always correct.
  - If a track no longer has enough energy to produce secondaries above the production threshold, following things happen.
    - The discrete energy loss for this track ceases.
    - The parent track still looses its kinetic energy through the continuous kinetic energy.

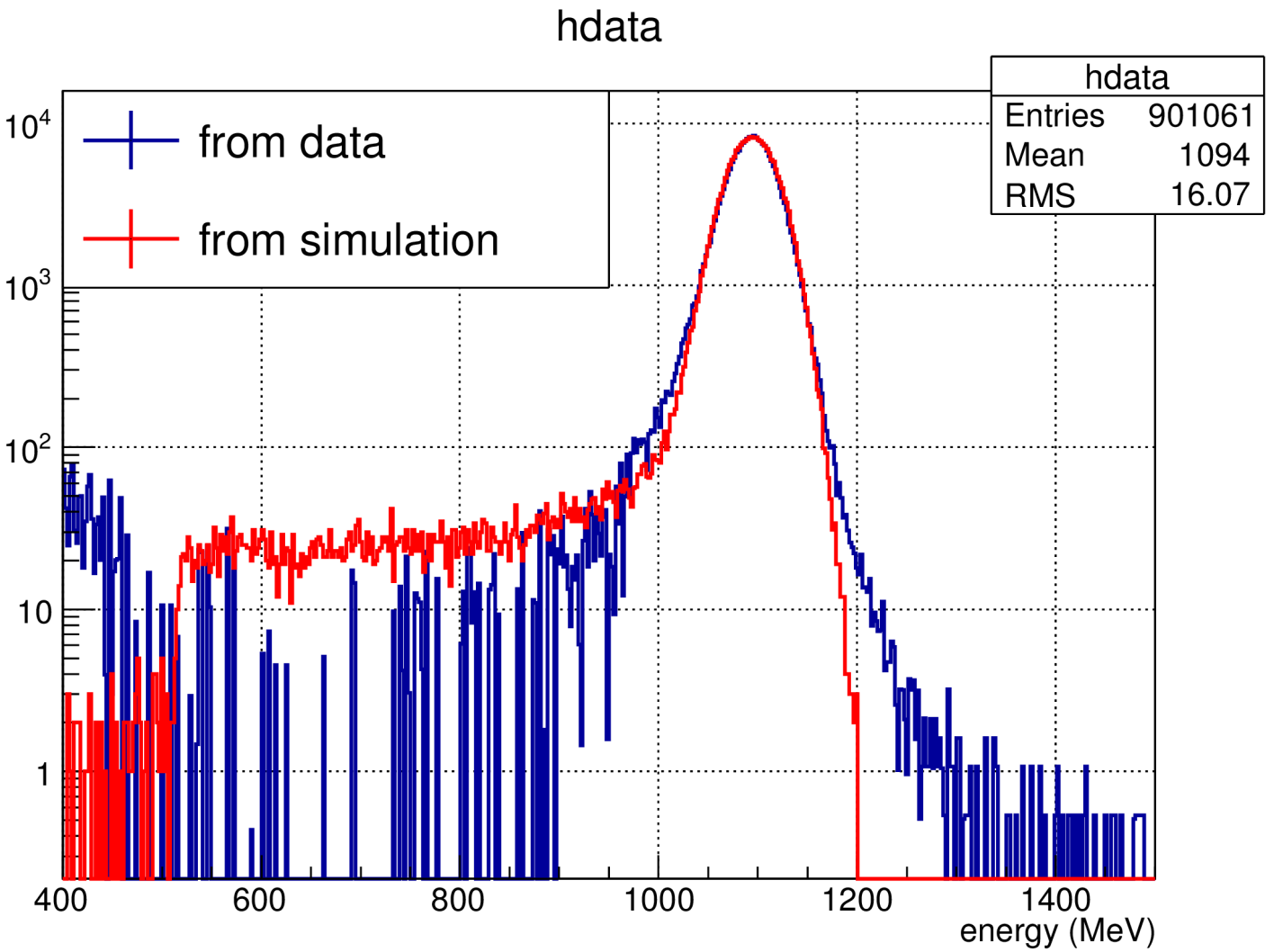
Revised procedure

- For each step, we track its Track energy
- If Track energy < 2 MeV, Kill this track, deposit all its energy to HyCal.



- Central module energy from simulation: 58%

Revised procedure



- Compare between simulation and data in log scale