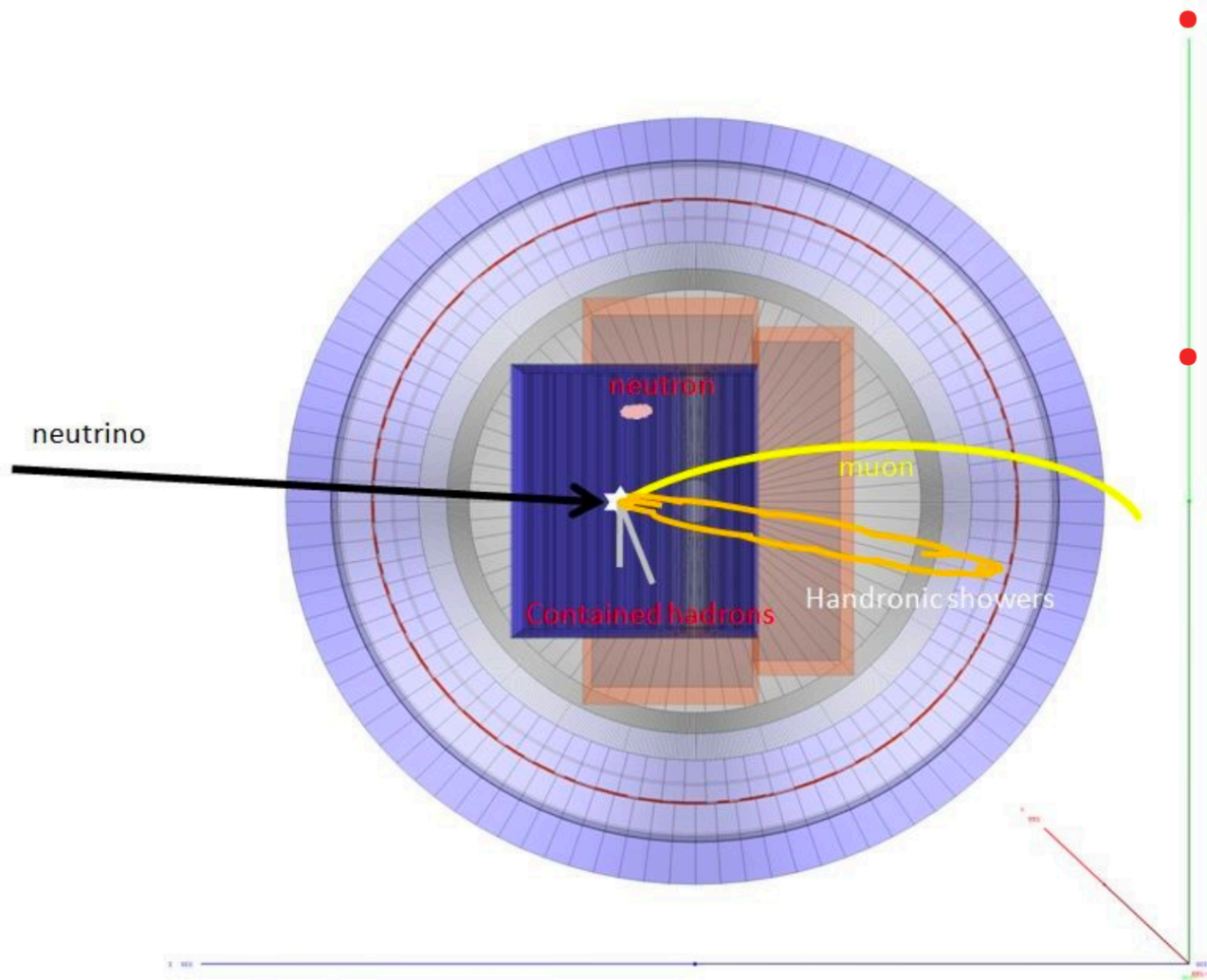
Secondary background in 3DST

Sunwoo Gwon, Guang Yang
Kim Siyeon, ChangHyon Ha

Reminder



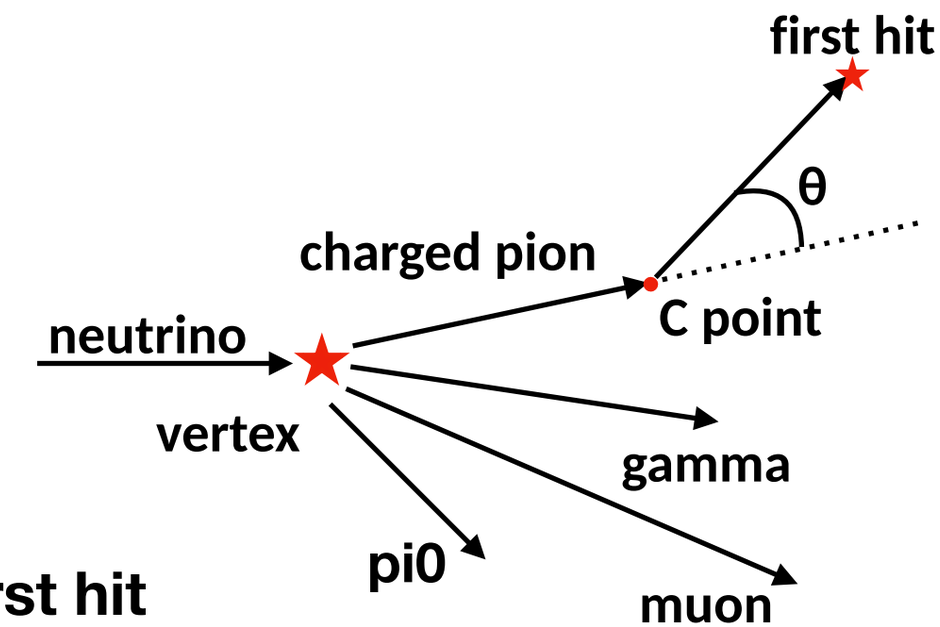
- **We are looking at CC event inside 3DST.**
  - **Signal: primary neutron**
  - **Background: secondary neutron + gamma**

- **We want to study with neutron, like STV, low-nu etc.**
  - **These can constrain the flux and help us to do cross section tuning.**

Reminder

- Assumption: we can select exclusive channels, CC1Pi+- 0P xN 0Pi0, CC0pi+-1PxN0pi0, CC0pi+-0PxN0pi0, x in integer.

- 4 categories:
  - primary neutron: neutron from vertex
  - secondary neutron: other neutron
  - primary gamma: gamma from vertex
  - secondary gamma: other gamma



- 7 variables
  - lever arm: distance between vertex and the first hit
  - time of flight: time difference between vertex and the first hit
  - CubeE: total energy inside the first cube
  - number of cube: number of fired cube cluster including the first cube
  - beta: relativistic beta, speed of particle/speed of light
  - angle: θ in the figure
  - distance between C point and hit

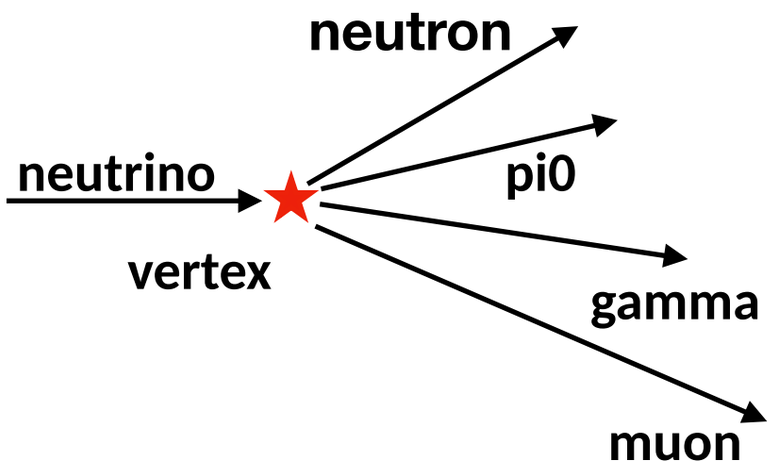
- Training sample for BDT:
  - signal (primary neutron)
  - background (secondary neutron+primary gamma+secondary gamma)
- bugs fixed

CDR discussion

- **Previous result: https://indico.fnal.gov/event/43906/contributions/189023/attachments/129986/157981/20200616.pdf**
- **At the moment the above result needs to be improved to go into CDR**
- **Editor would prefer us to include the pi0 channel**
  - **Mike Kordosky is okay with the selection for muons, charged pions and protons.**
  - **But he asked to include pi0 and NC as a potential background source.**
- **Therefore we study channels with pi0 and NC included.**

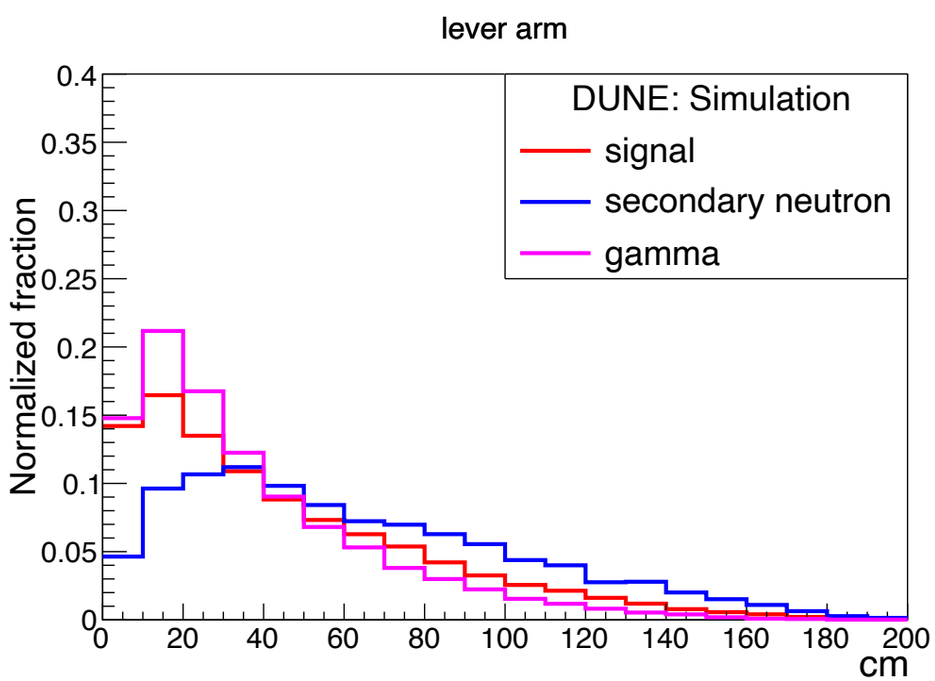
Channel with pi0 included

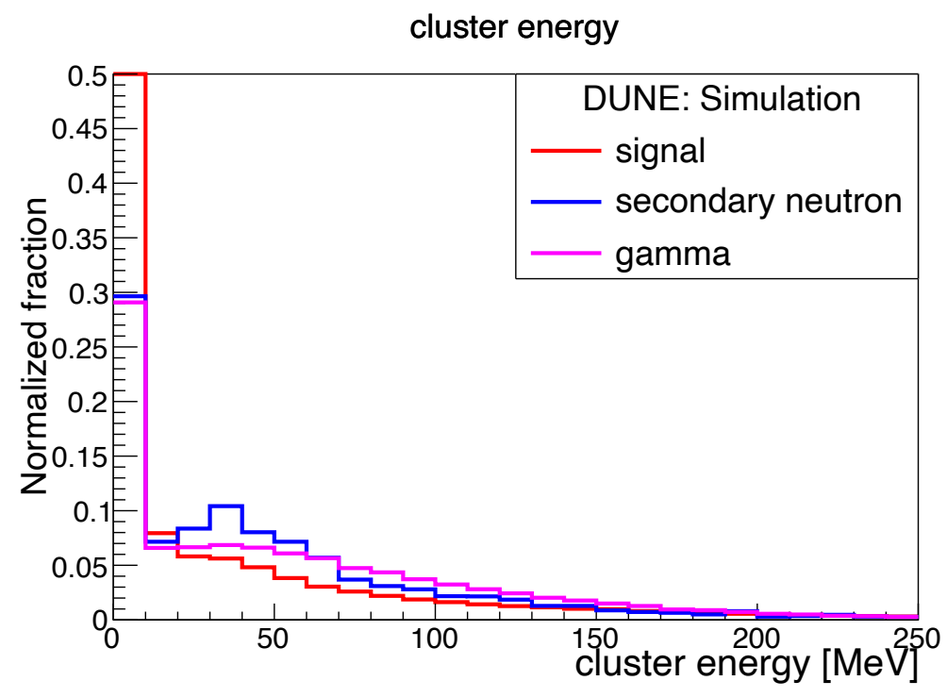
- **Channel for BDT training: CC0Pi+-0PxNyPi0 + NC1Pi+-0P0NyPi0**
  x and y are integer and x >0 :

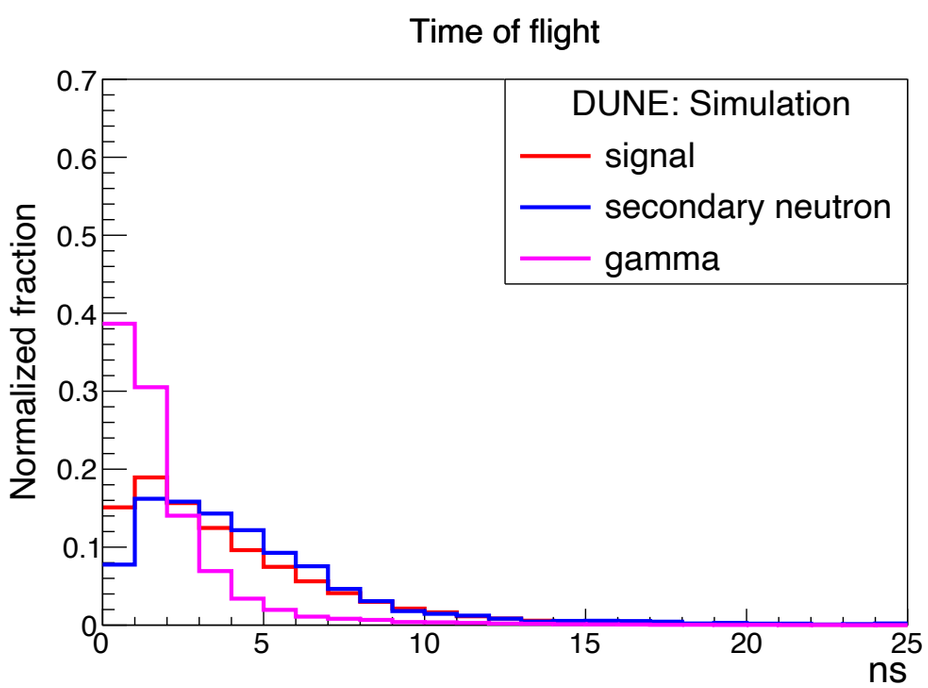


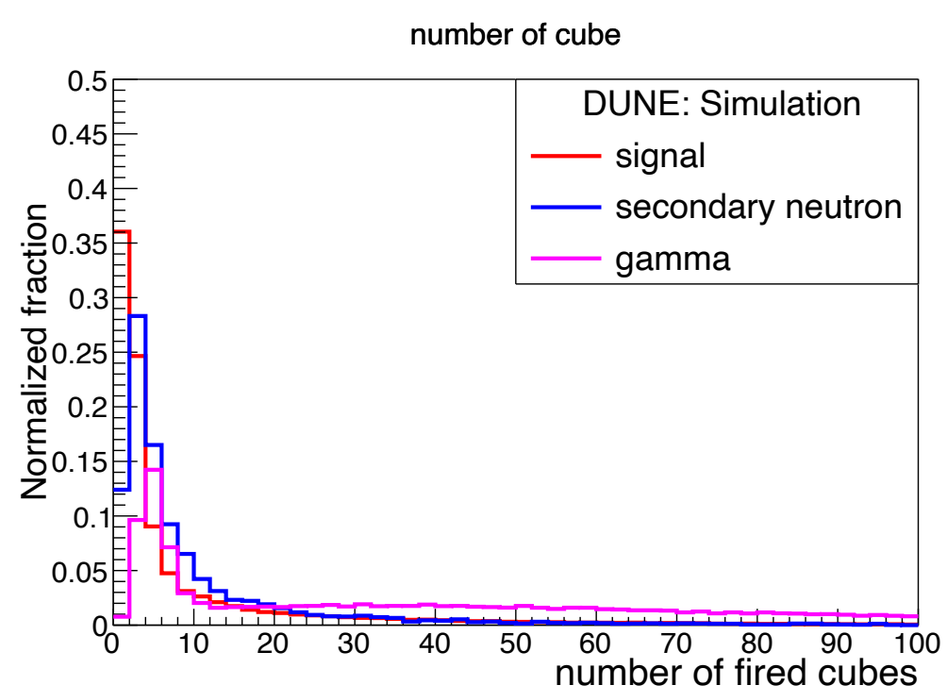
- **4 variables as an input of BDT training**
  - lever arm: distance between the first hit and the vertex
  - time of flight (TOF): time difference between the first hit and the vertex
  - number of cubes: number of fired cube cluster including the first cube
  - cluster energy: sum of energy deposit in the cube cluster

Updated variable distributions

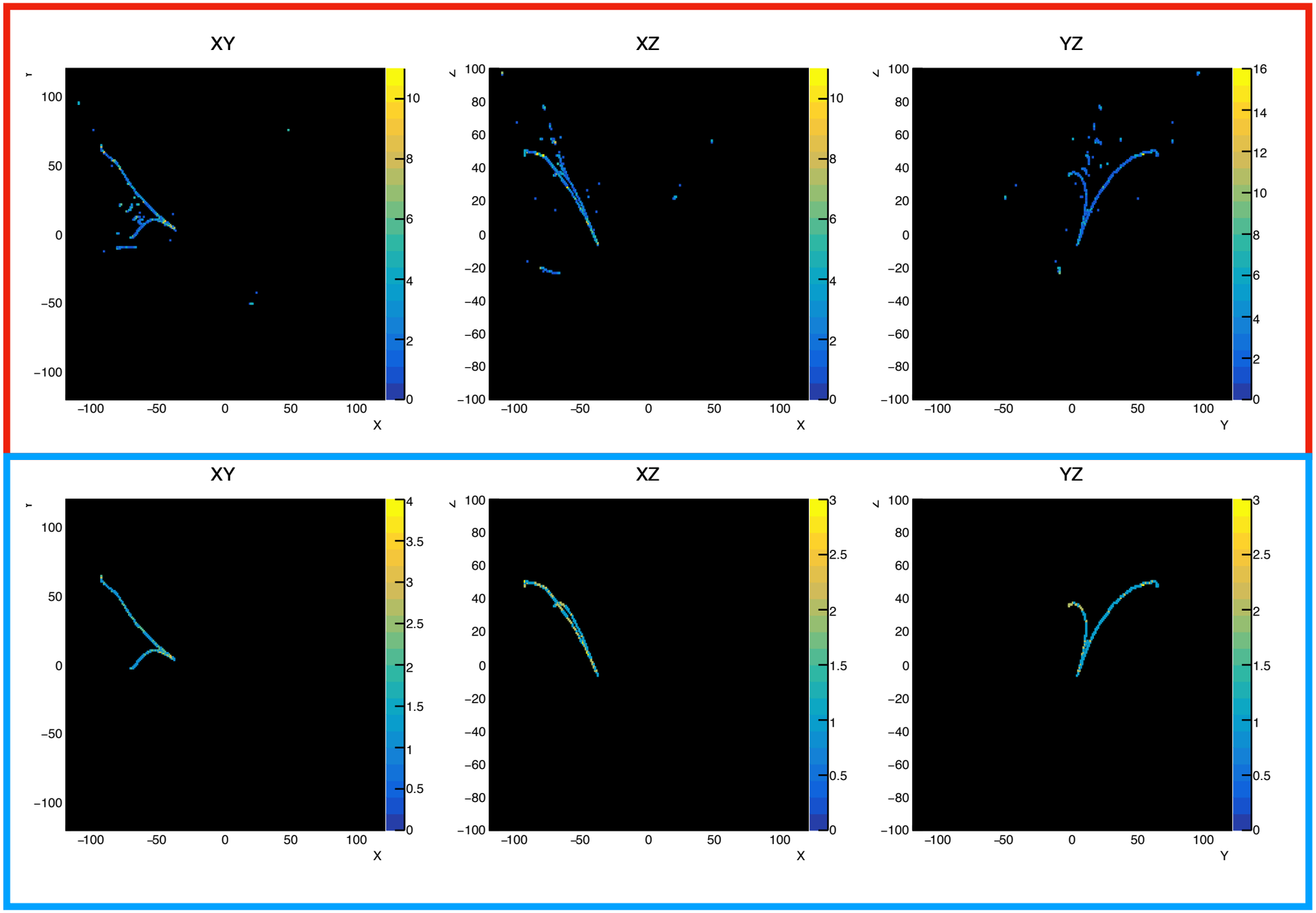








gamma event #1



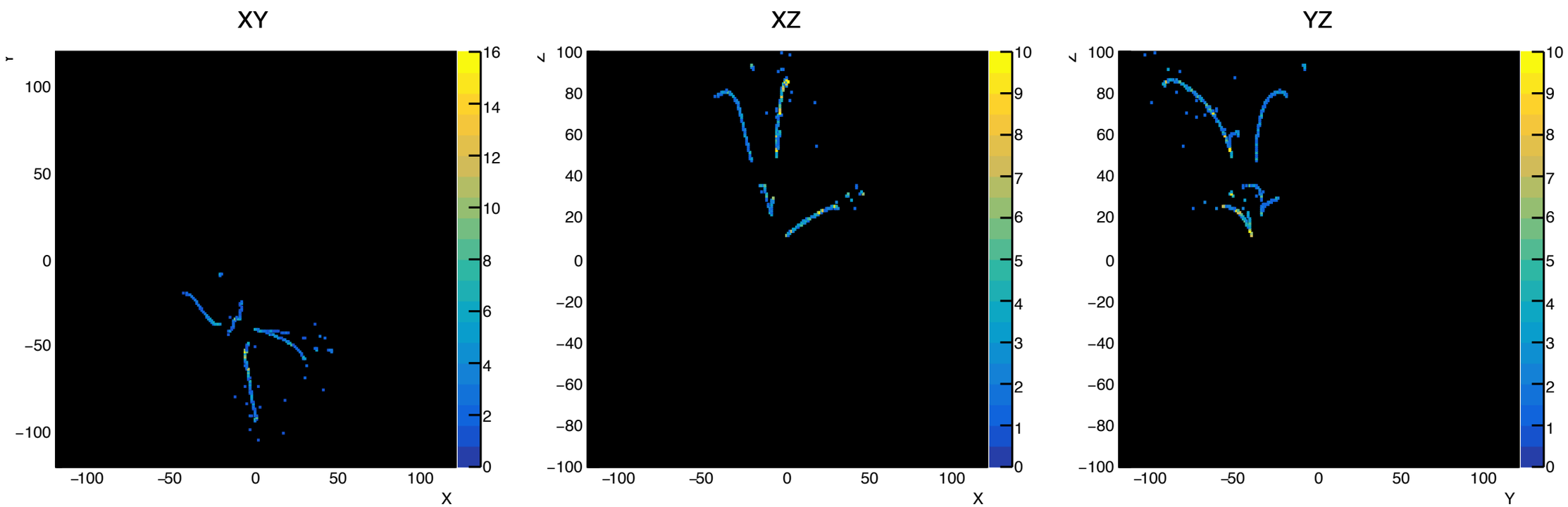
before clustering

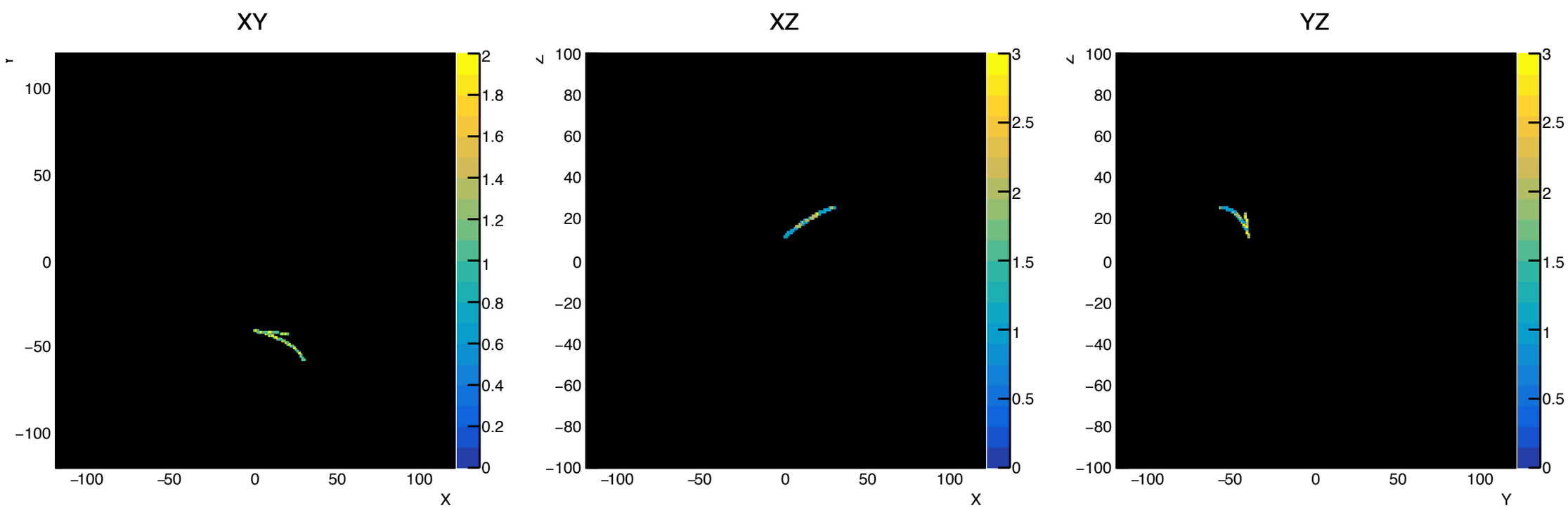
after clustering

long track

중앙대학교
CHUNG-ANG UNIVERSITY

gamma event #2

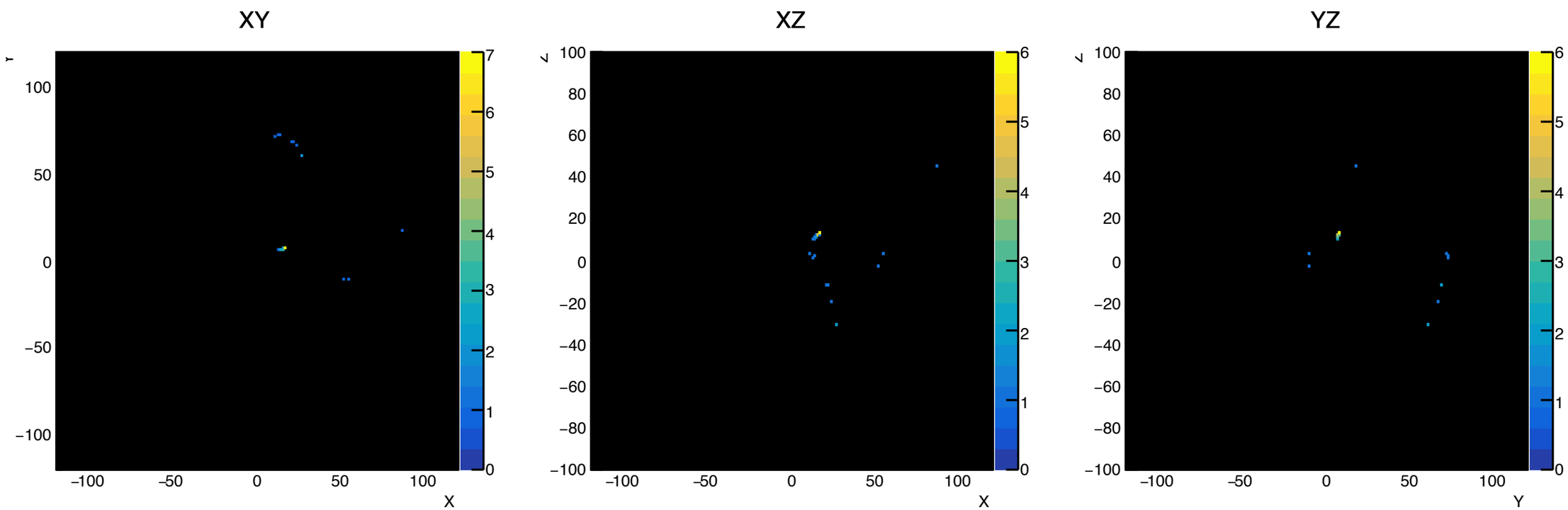


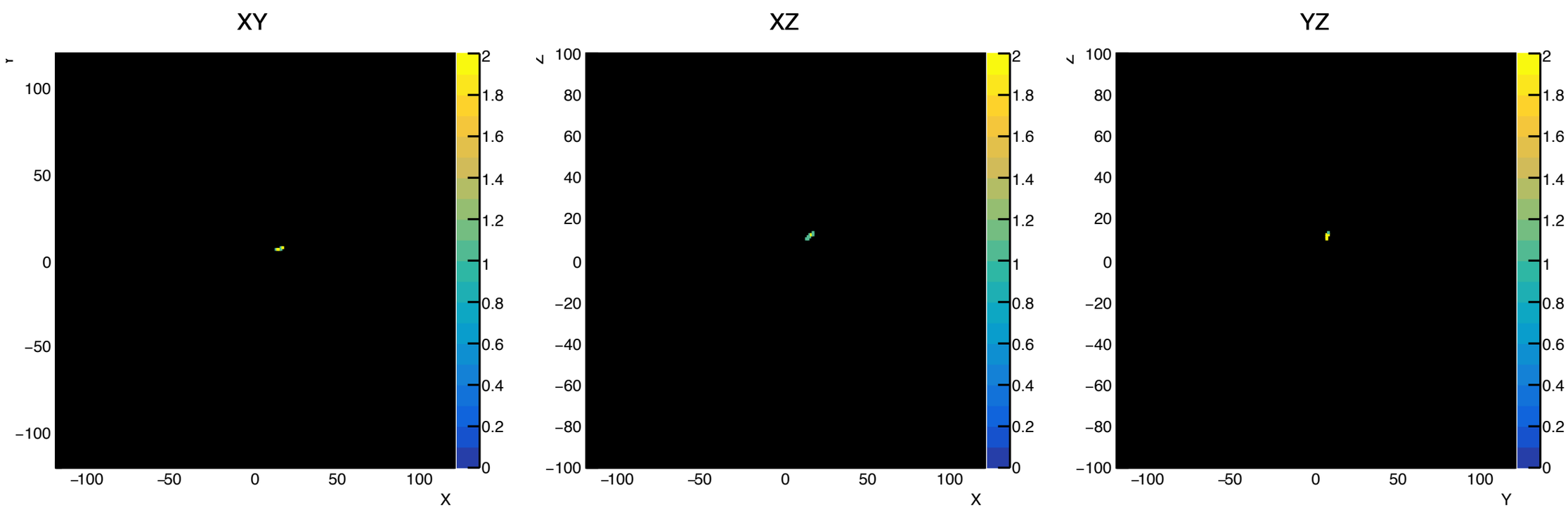


long track

중앙대학교
CHUNG-ANG UNIVERSITY

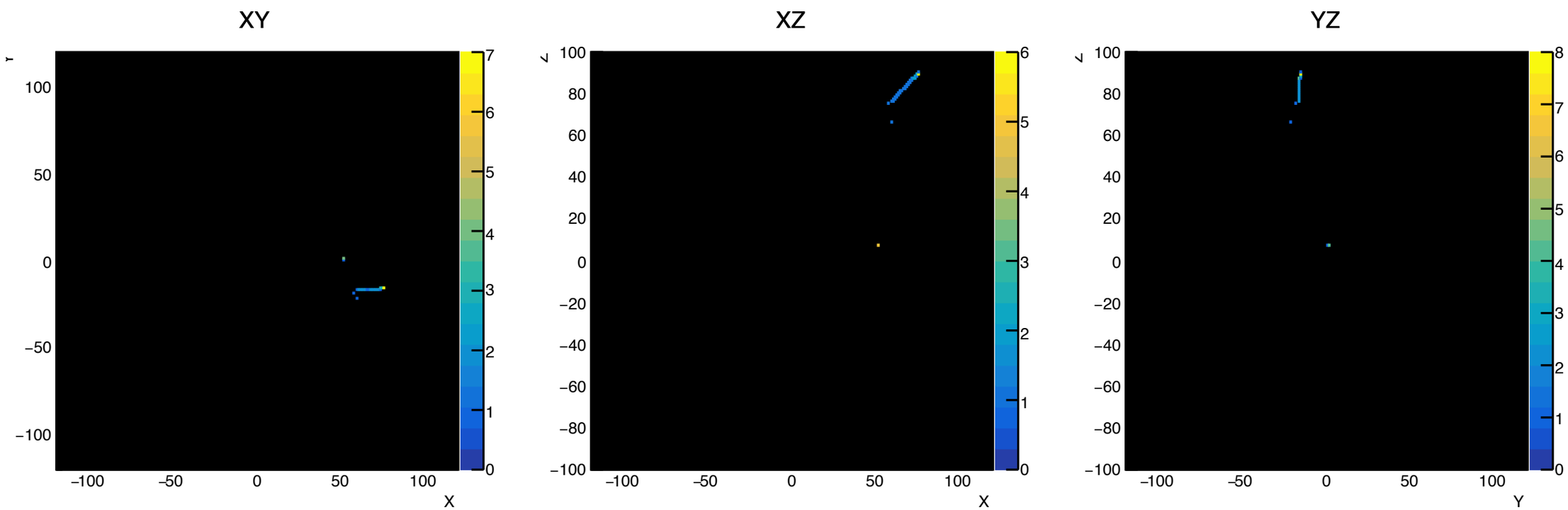
neutron event #1

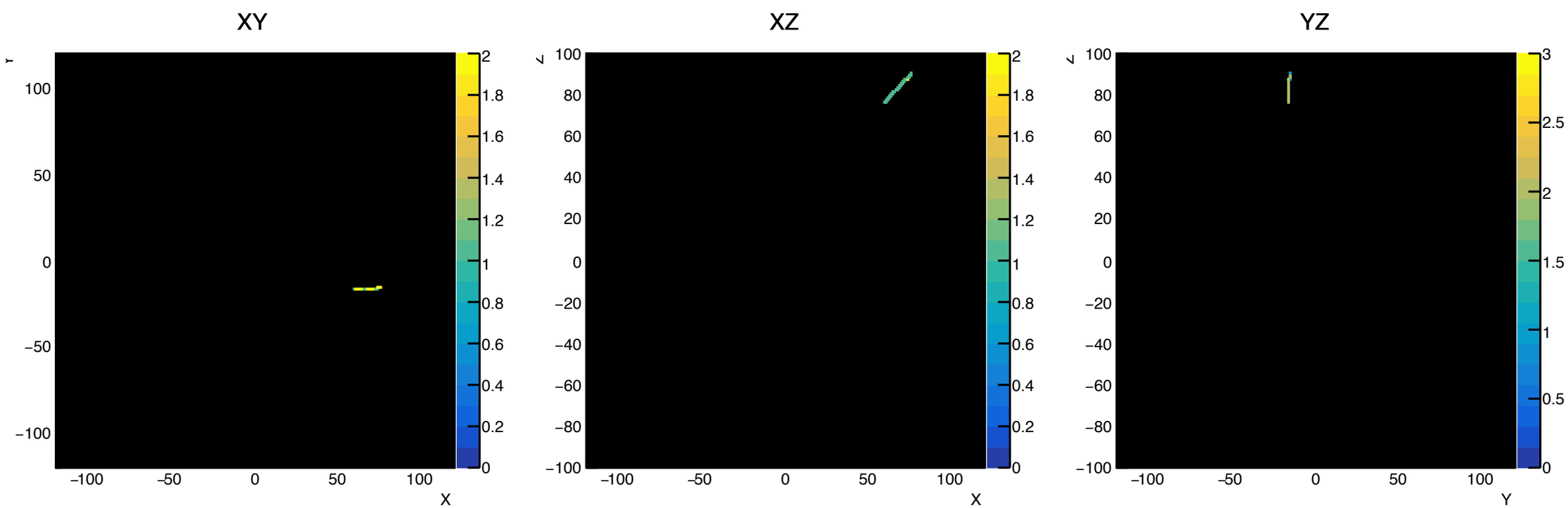




short track

neutron event #2

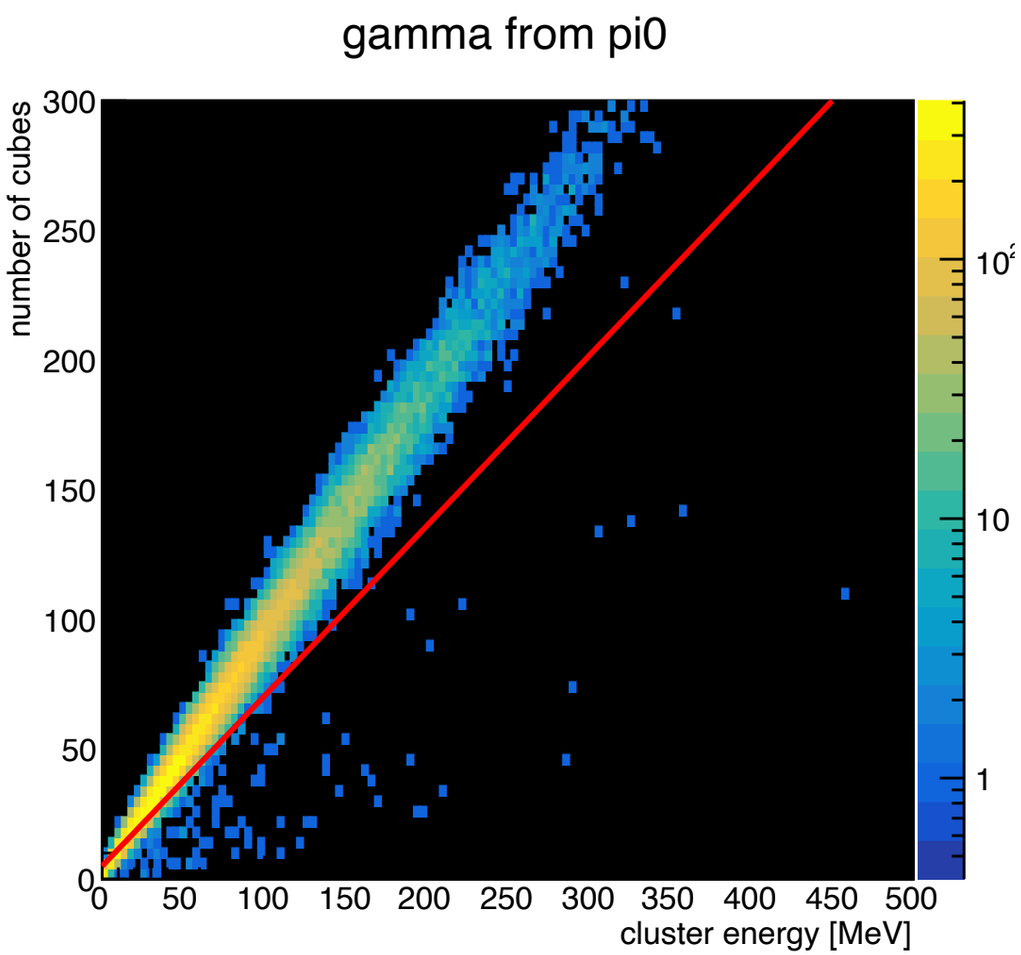


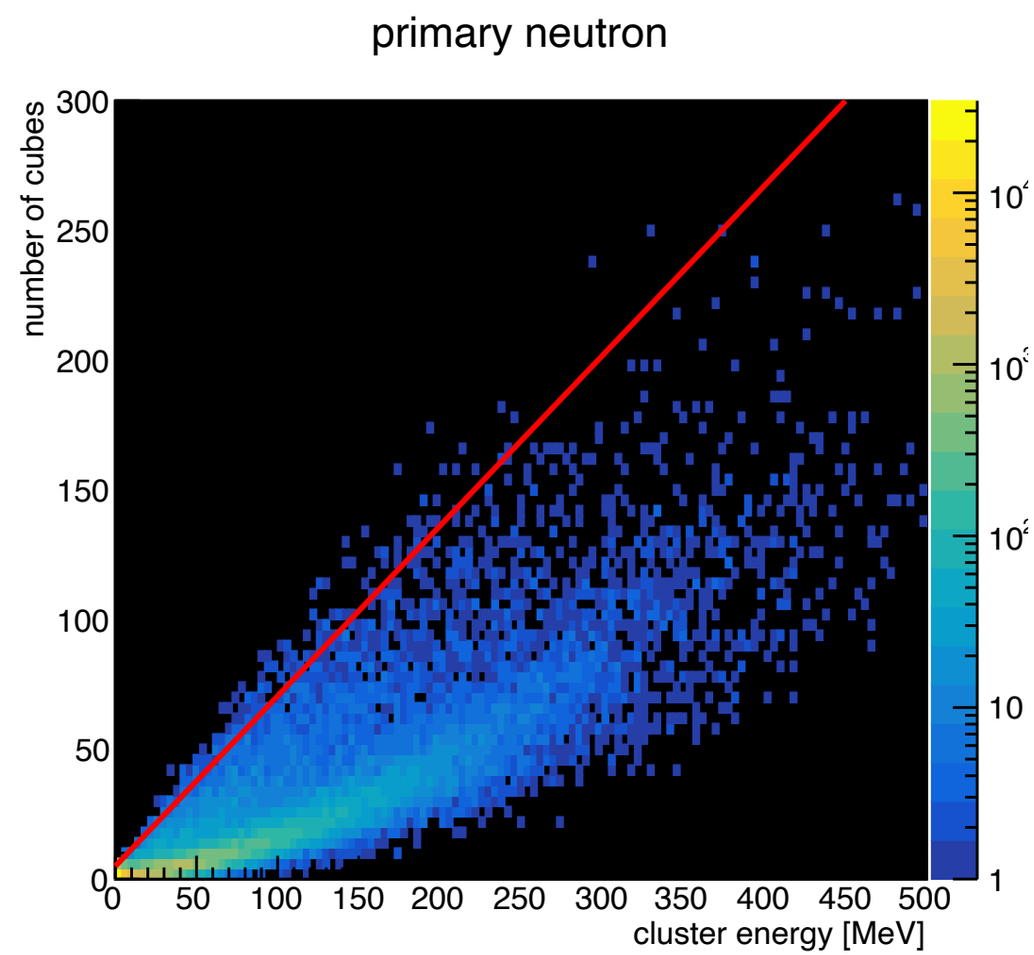


short track

중앙대학교
CHUNG-ANG UNIVERSITY

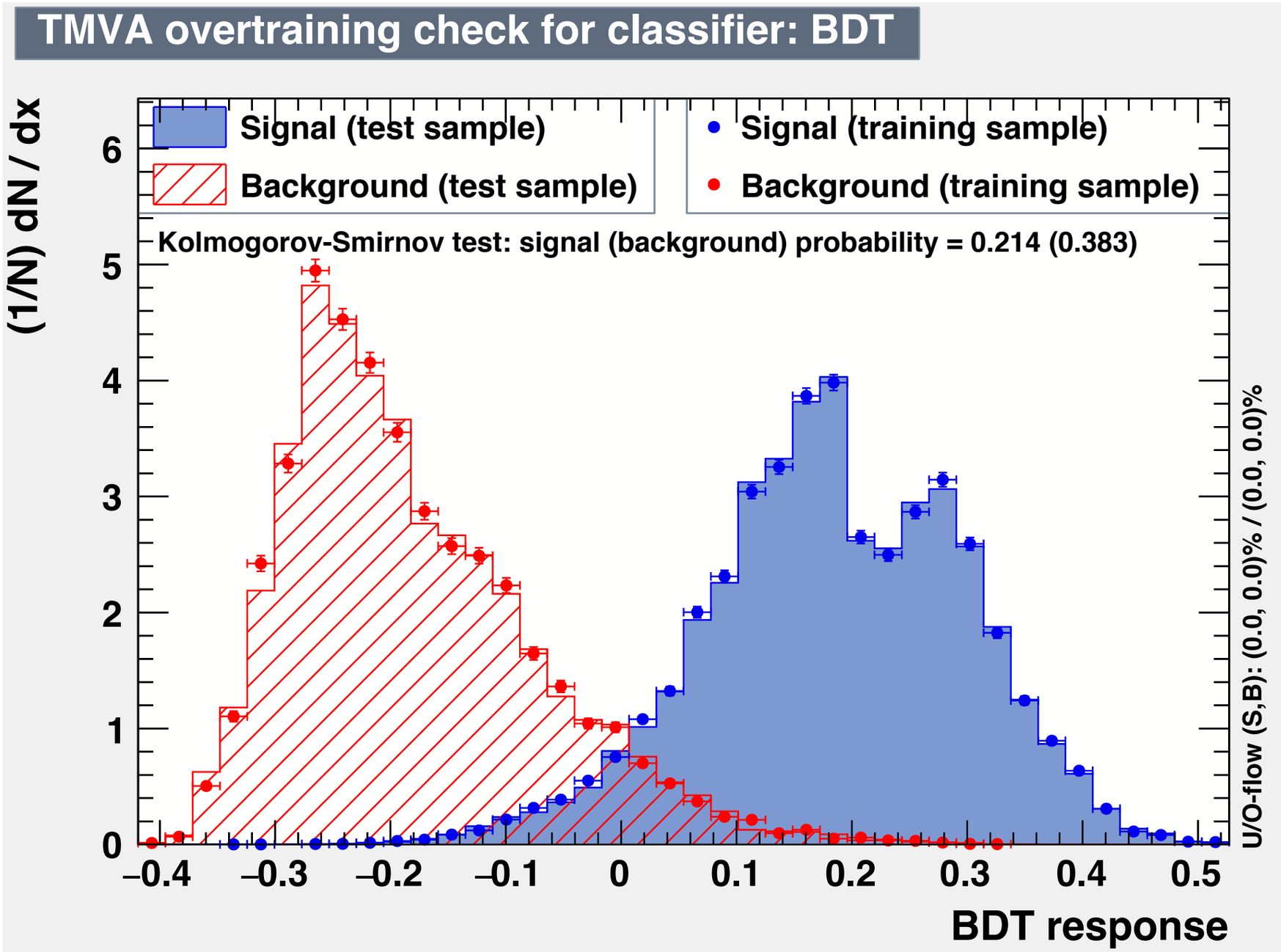
simple discrimination between gamma and neutron





- **gamma: CC1Pi0, neutron: CC1N**
- **We applied a 2D cut (the red line) and we got 99.7% for neutron and 9.7% for gamma with the cut.**
- **2662 gamma, 82176 neutron in the below-cut region**

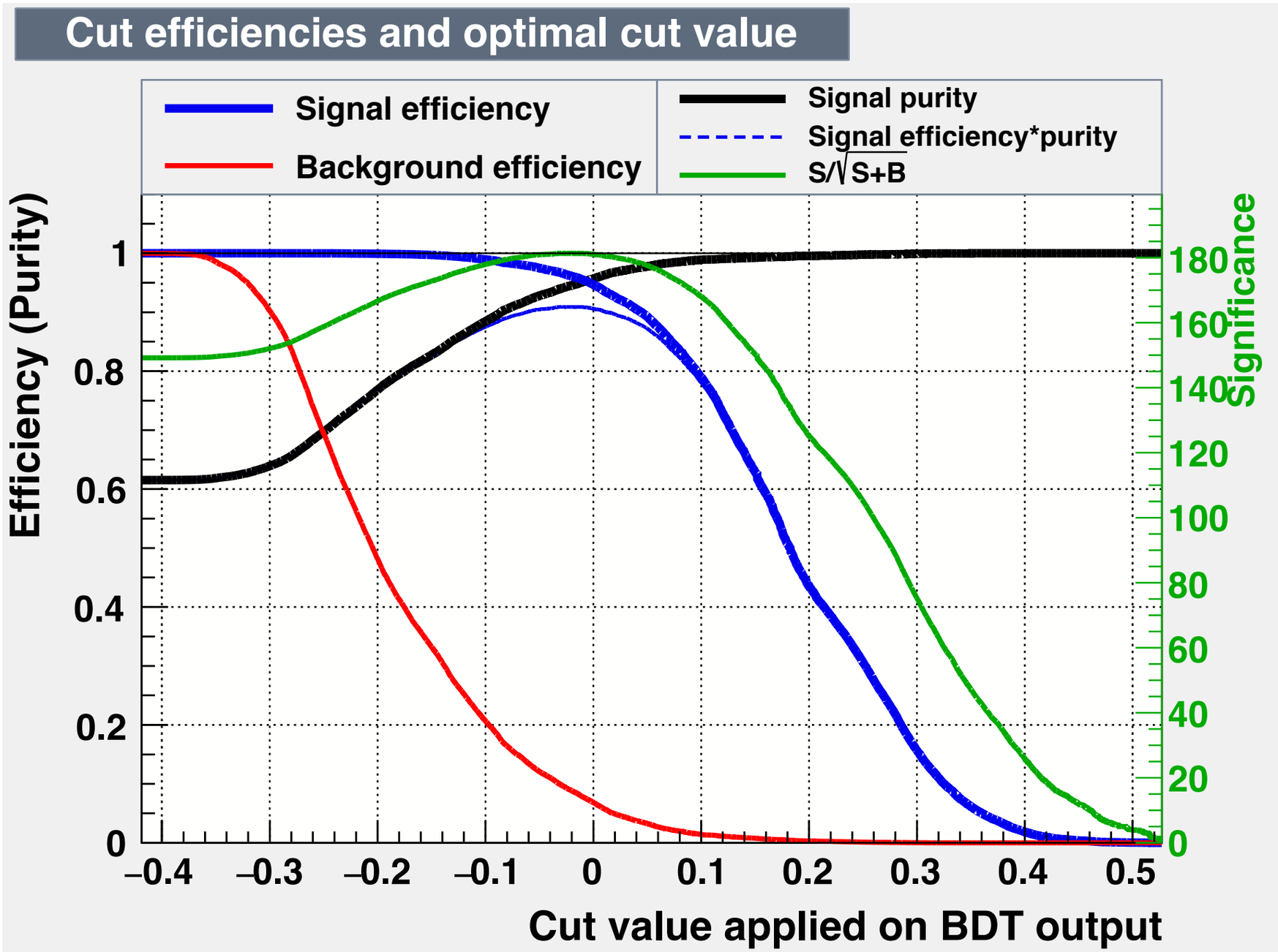
BDT result



signal: 36174
background: 22625

중앙대학교
CHUNG-ANG UNIVERSITY

BDT result



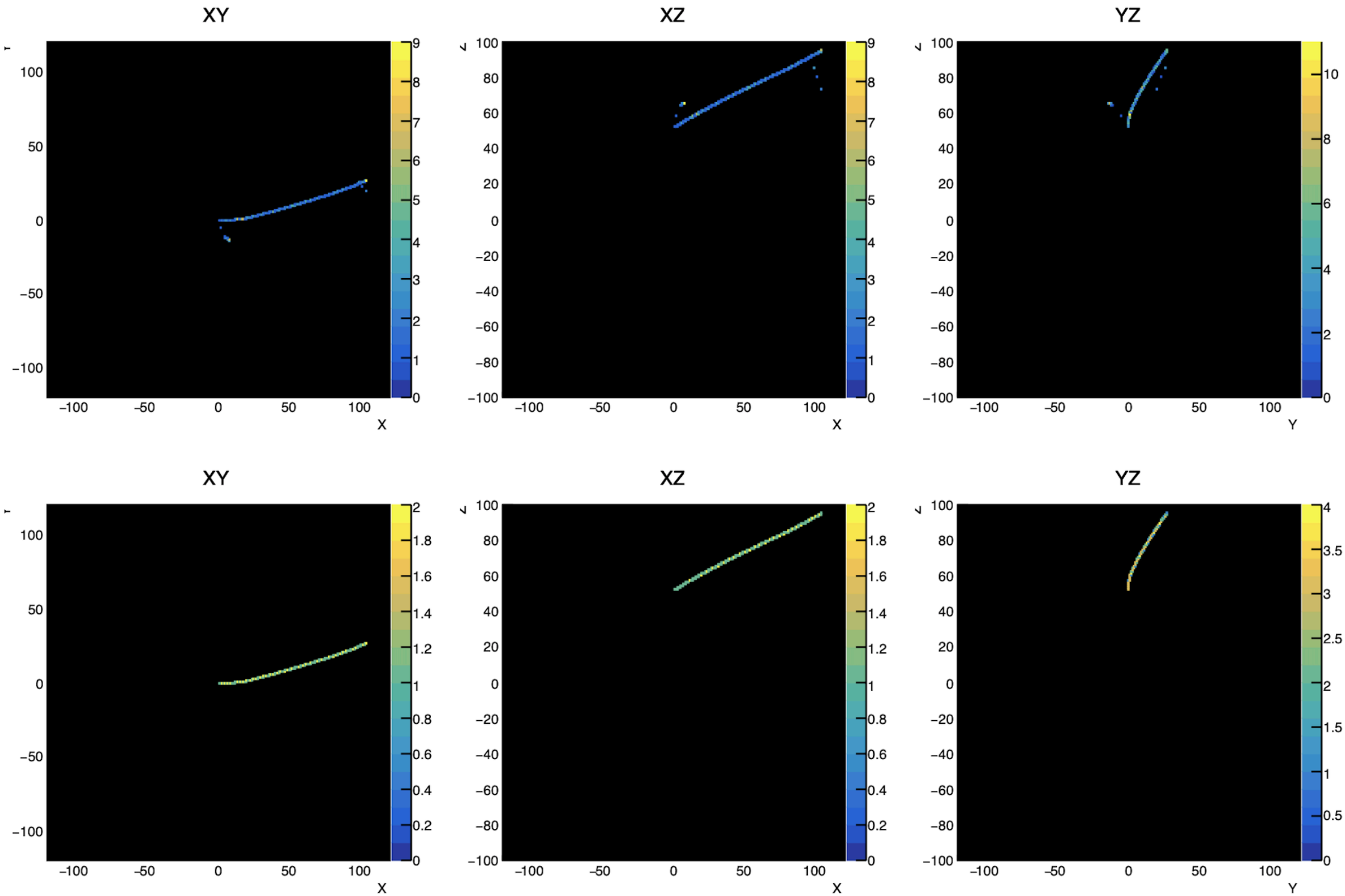
Signal: primary neutron + secondary neutron
Background: primary gamma + secondary gamma

Summary

- **We studied a channel with pi0 and NC included according to CDR editor's suggestion**
- **gamma from pi0 and neutron are clearly separated.**
- **BDT also confirms the separation.**
- **We want to send back the new result to the editor.**

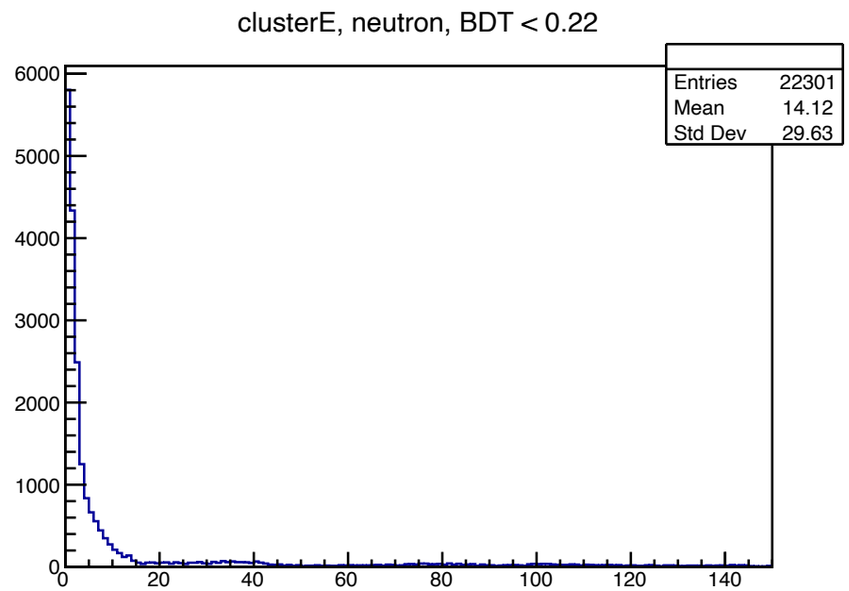
back up

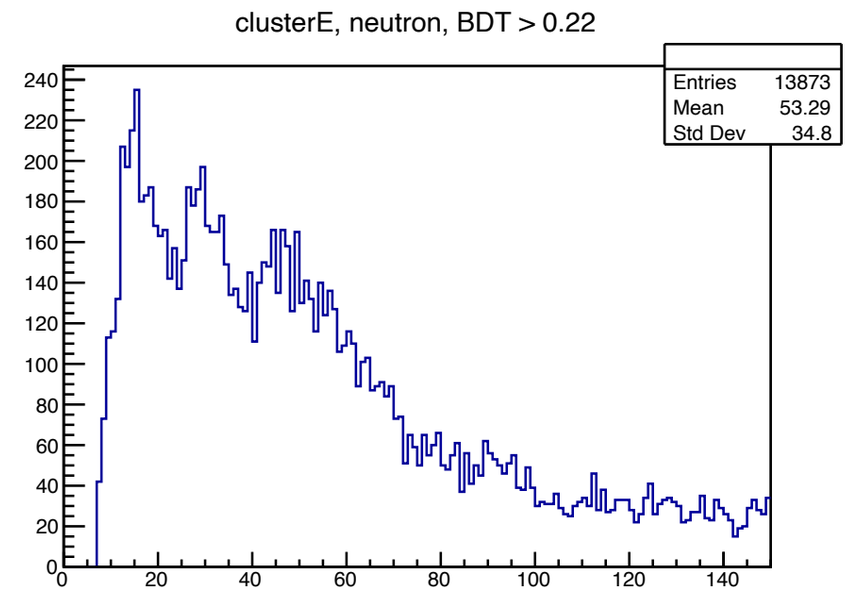
neutron event, 150 < nCube

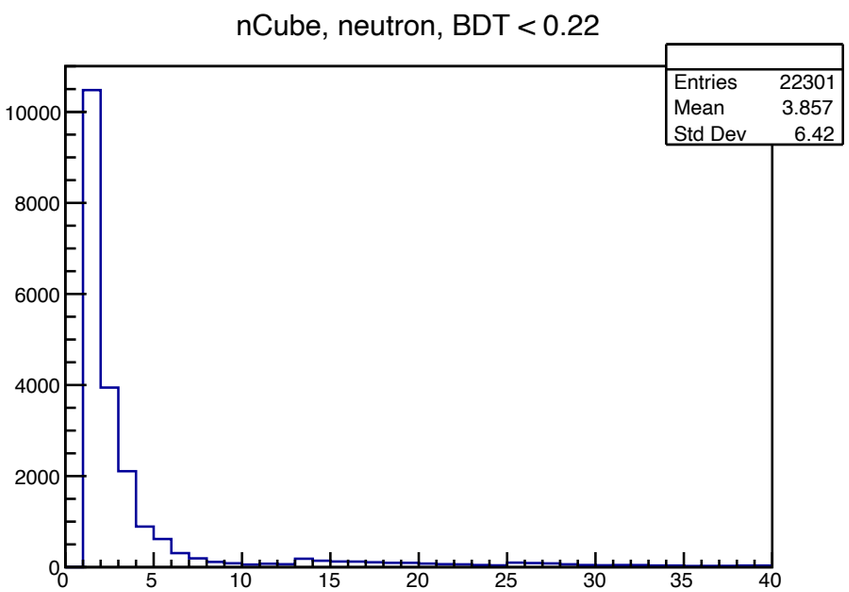


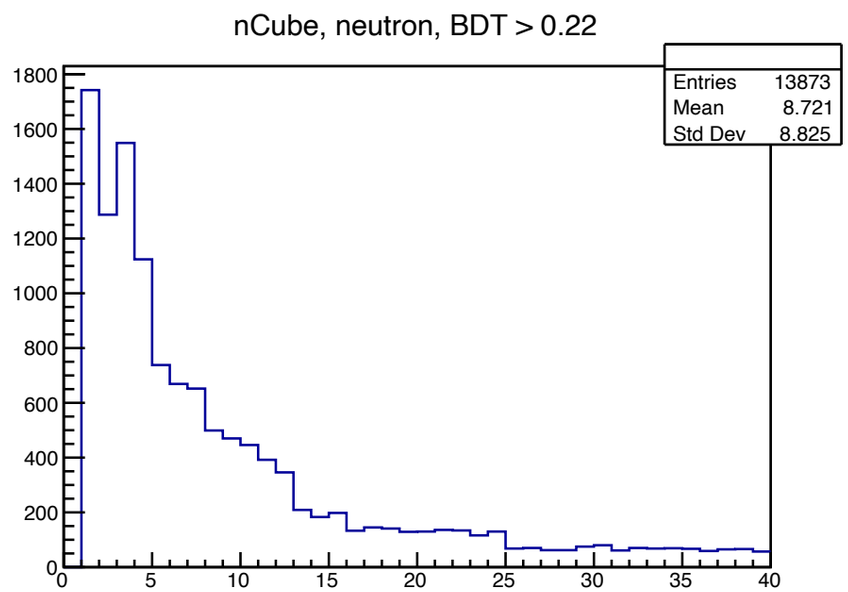
neutron could have long track

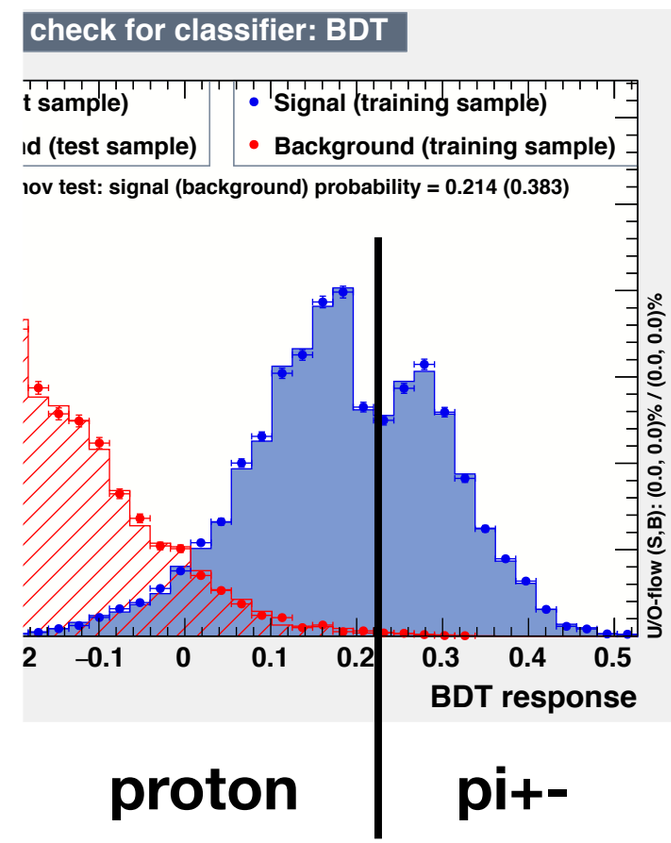
중앙대학교
CHUNG-ANG UNIVERSITY







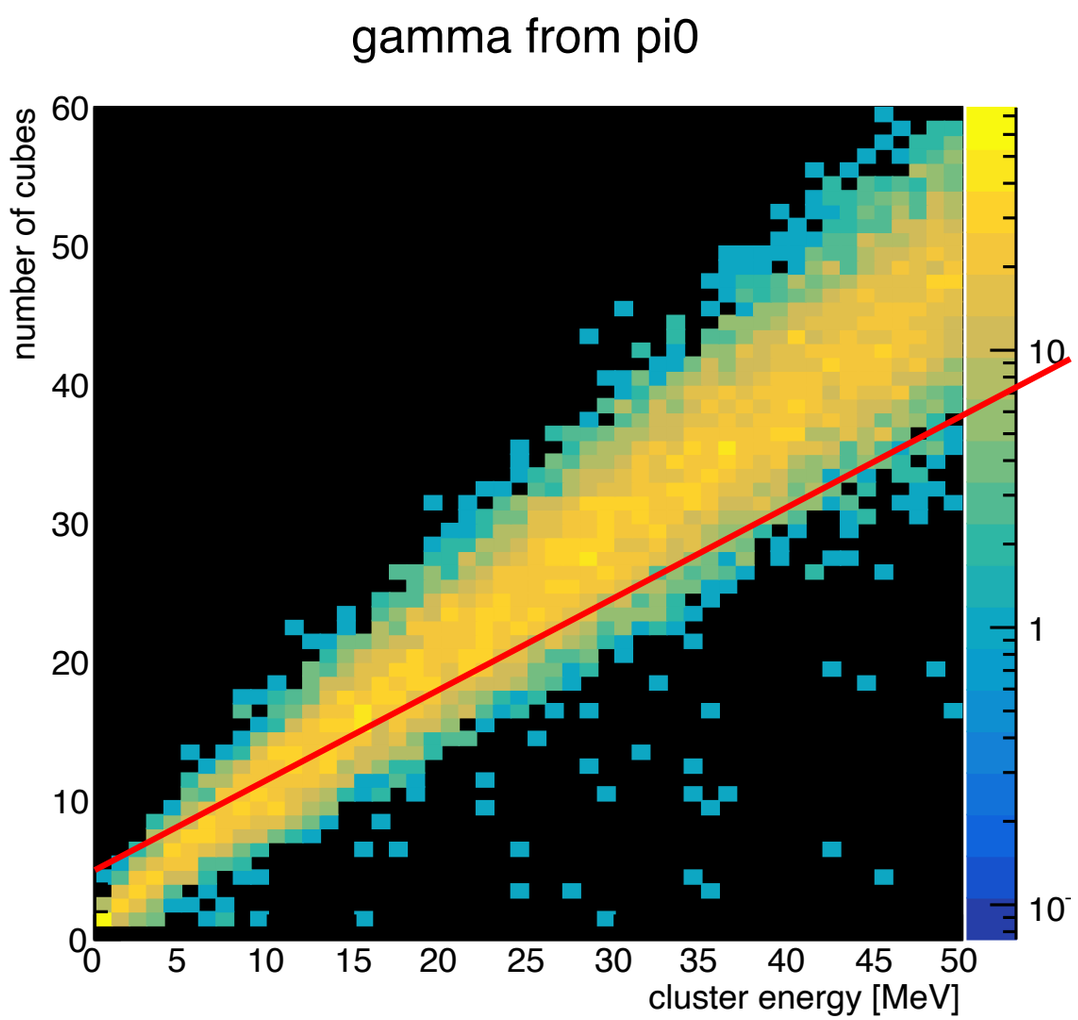


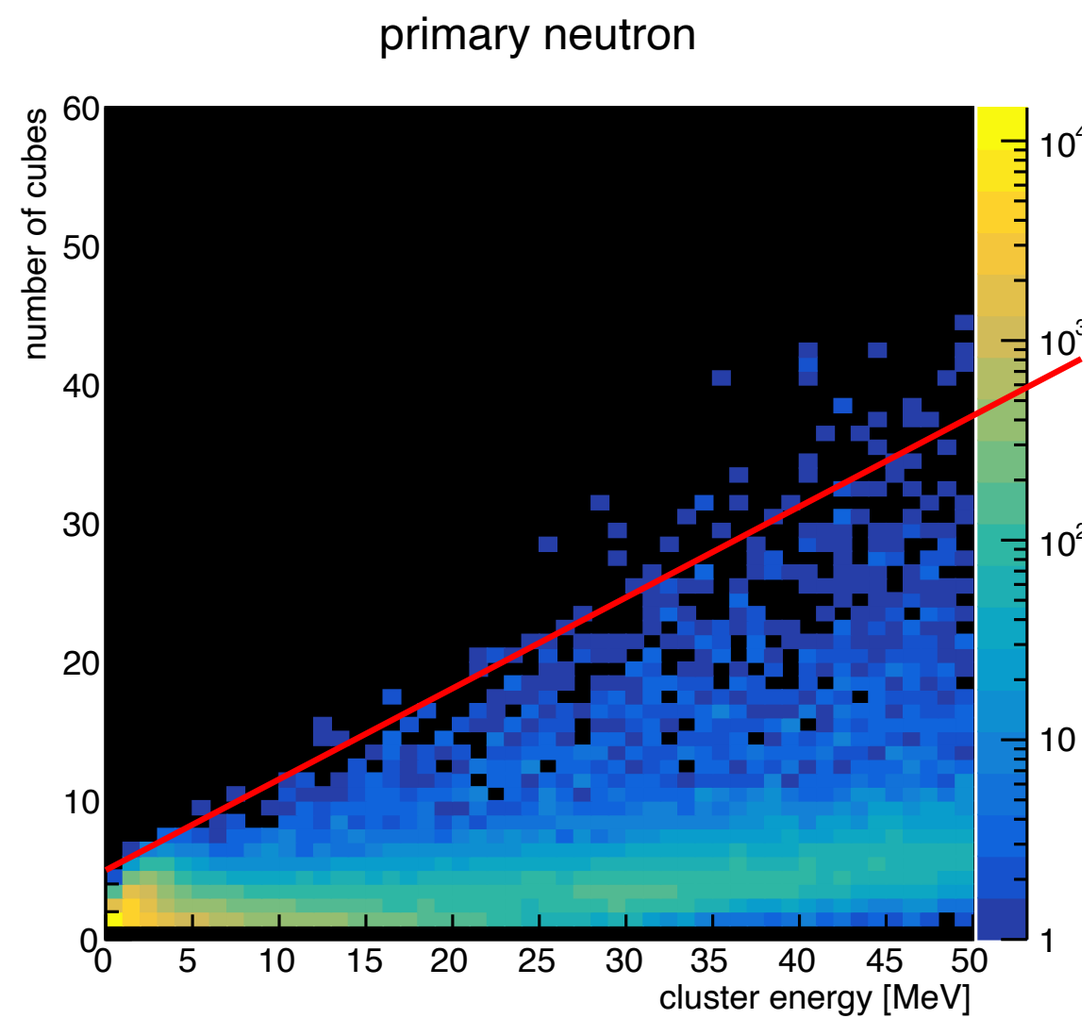


clusterE, nCube with BDT = 0.22 cut

BDT > 0.22 region: neutron induced charged pion
BDT < 0.22 region: neutron induced proton

simple discrimination between gamma and neutron





중앙대학교
CHUNG-ANG UNIVERSITY