Exploration of Homogenous Crystal ECAL for CEPC

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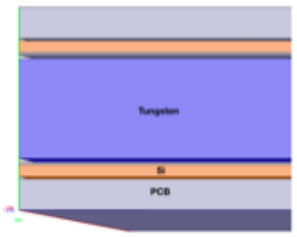
Motivation & Geometry

CDR Baseline ECAL

Sampling, PFA Oriented, 3D Readout

Two schemes:

Silicon-Tungsten Sandwich ECAL



Basic Unit

2 symmetric sensitive **silicon layers**
- glued on a PCB
- equipped with readout ASICs

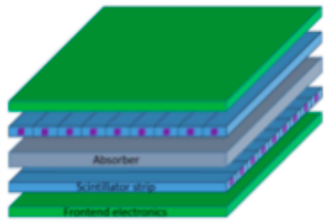
1 **tungsten plate**

Scintillator-Tungsten Sandwich ECAL

Basic Unit

2 layers of **plastic scintillator strip**
- 2mm thick, 5×45mm² large
- perpendicular to adjacent layer
- attached to SiPM

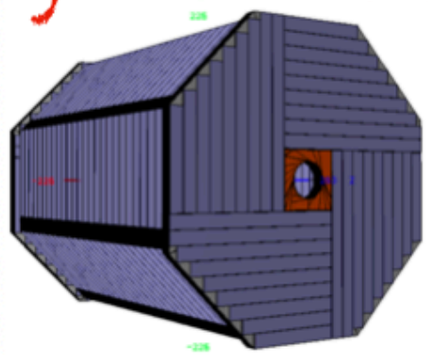
1 **tungsten plate**



Defects:

1. Limited **Energy Resolution**, especially for Low Energy Photon.
2. **Cost**, **Power consumption** and **Cooling**.

Why a new ECAL?



ECAL Geometry in CEPC CDR

New ideas about ECAL

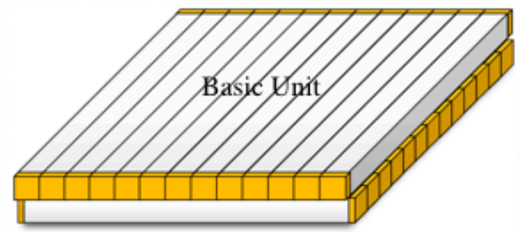
Full Crystal, Fast Timing, 2D Readout

Basic Module

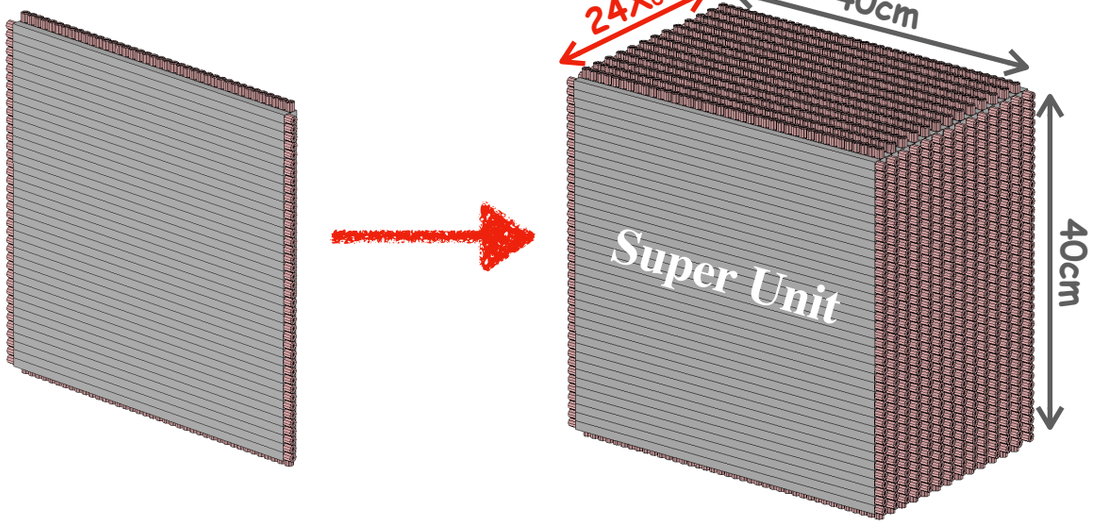
Crystal Scintillator (eg. BGO, LYSO…)

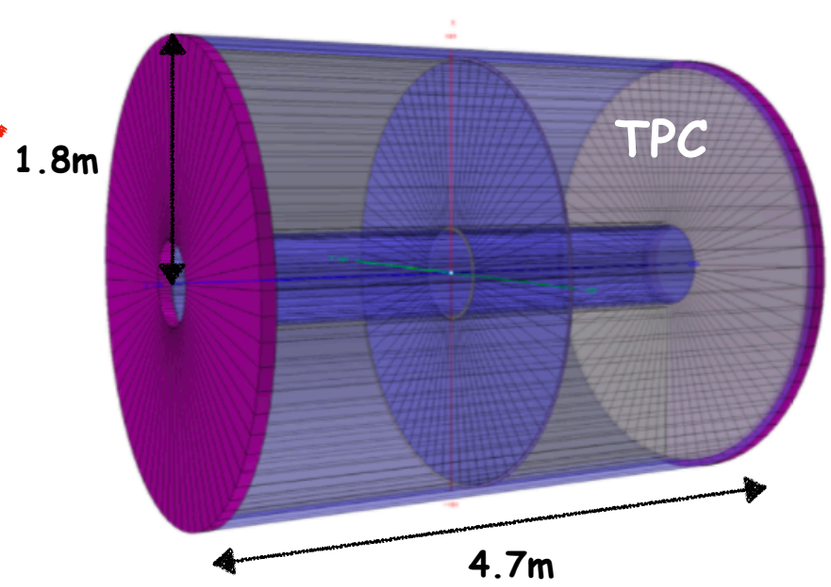
1x1x40cm³

Photodetectors (eg. FPMT, SiPM…)



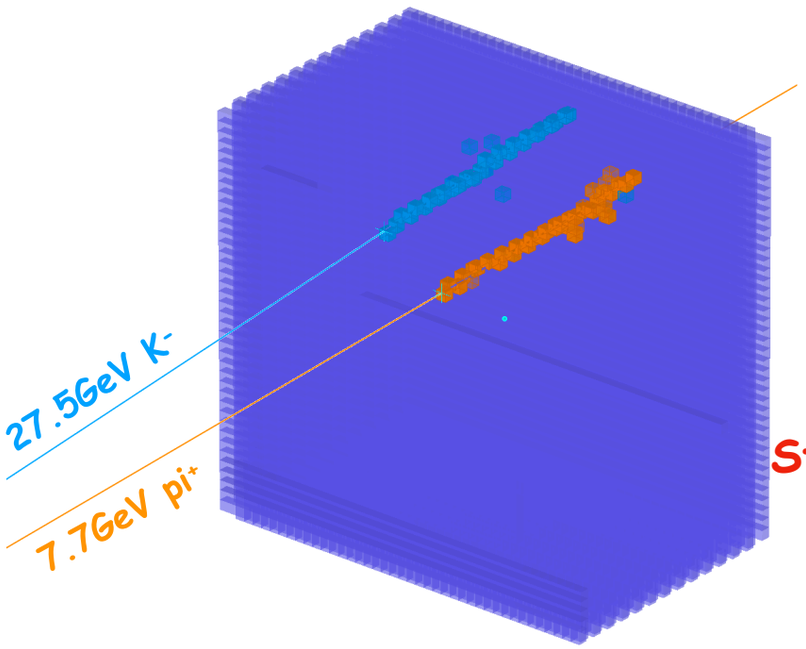
In order to reduce the number of electronic readout channel, **precise time measurement** is expected.



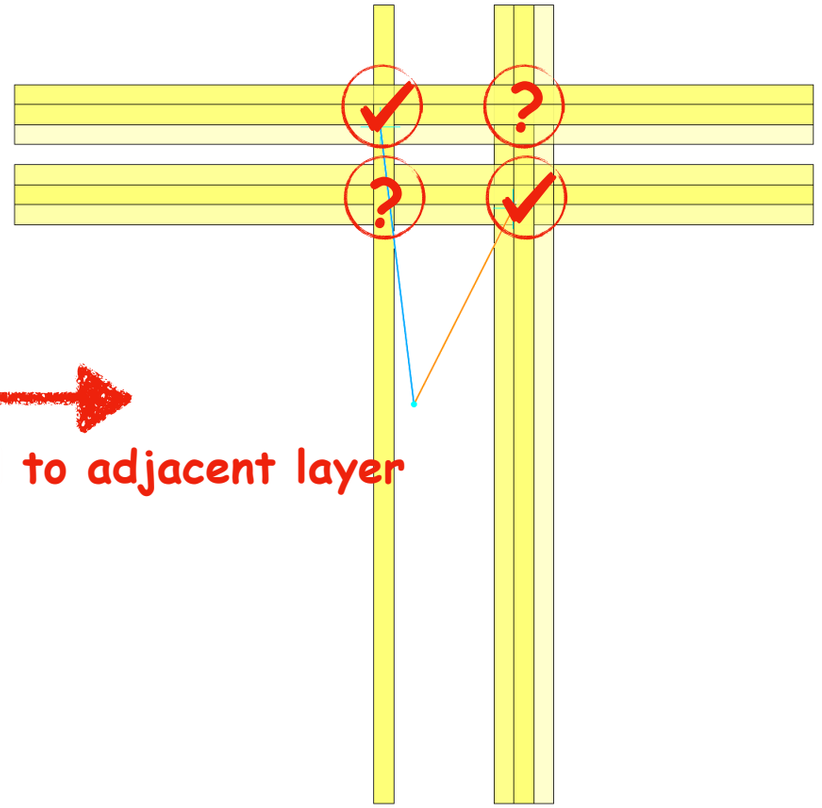


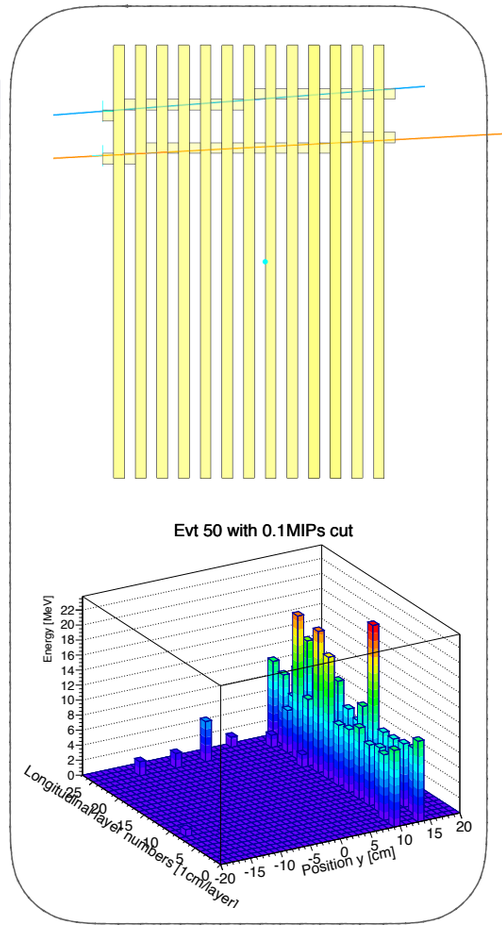
In the case of BGO, Number of readout channels ~ 1.4M << 25M (Si-W ECAL)

Key issue: separation of multi-particle shower

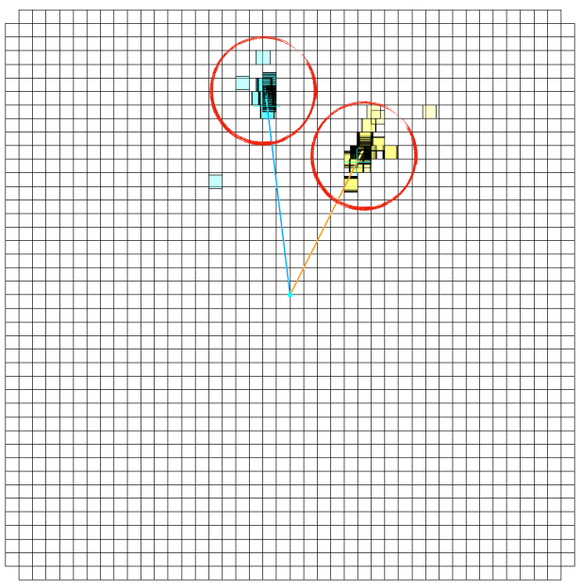


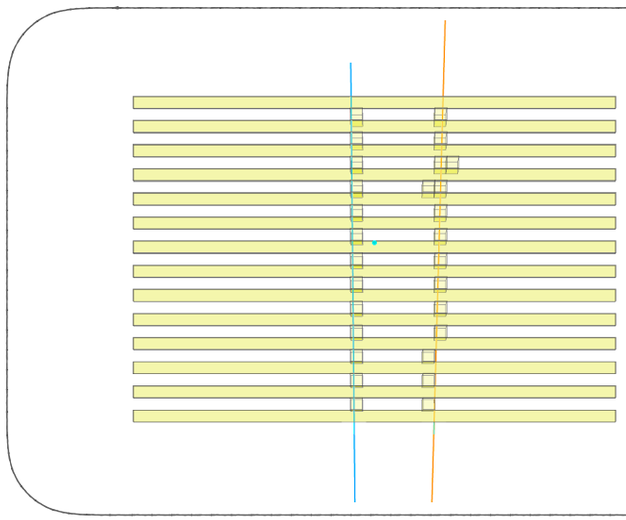
Strips vertical to adjacent layer

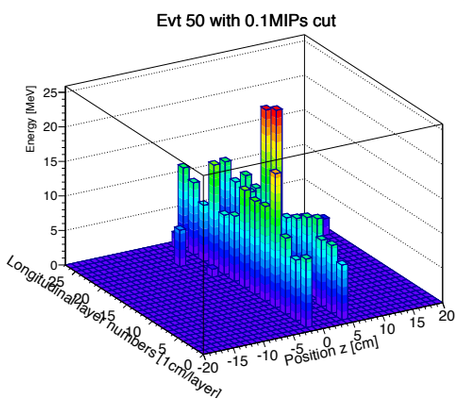




Traditional transverse segmented finely

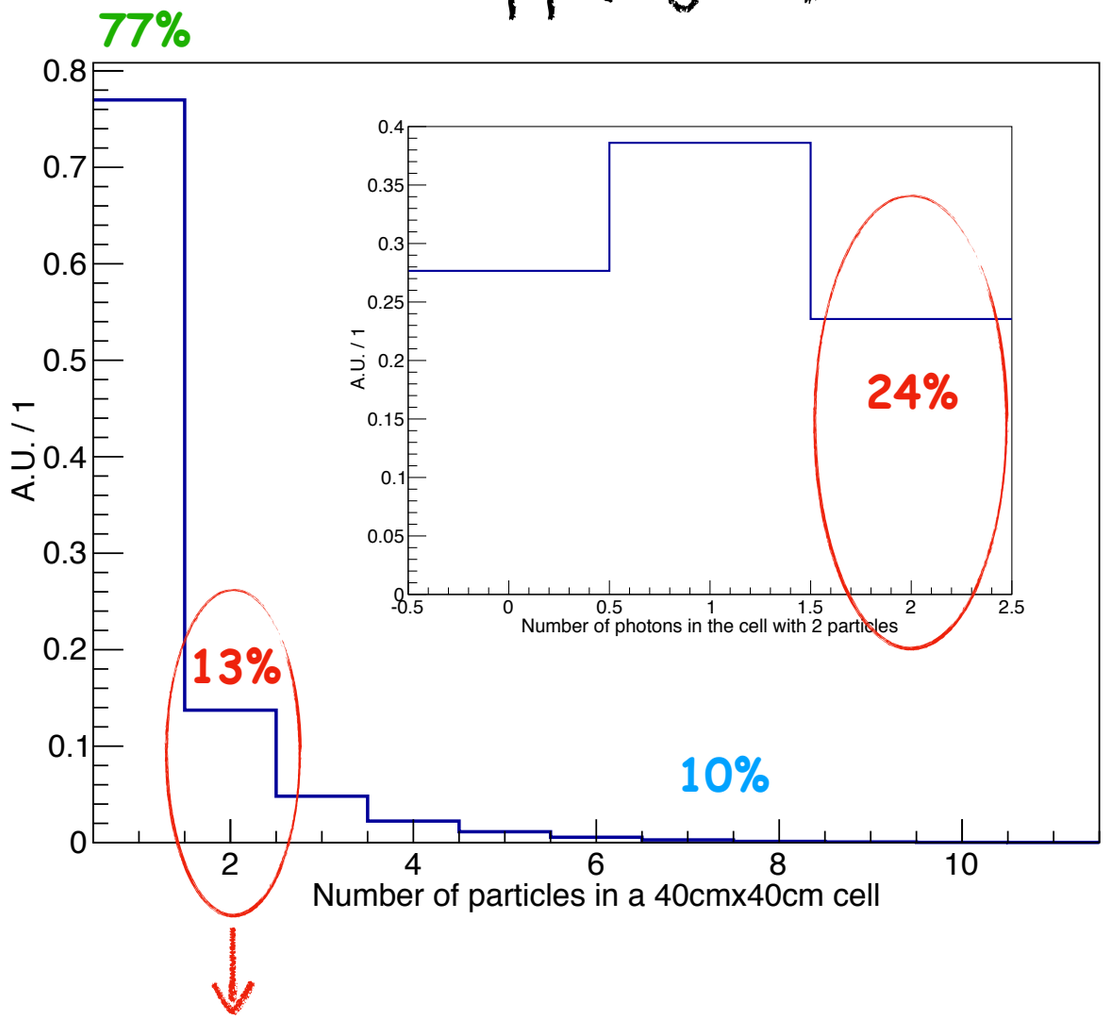




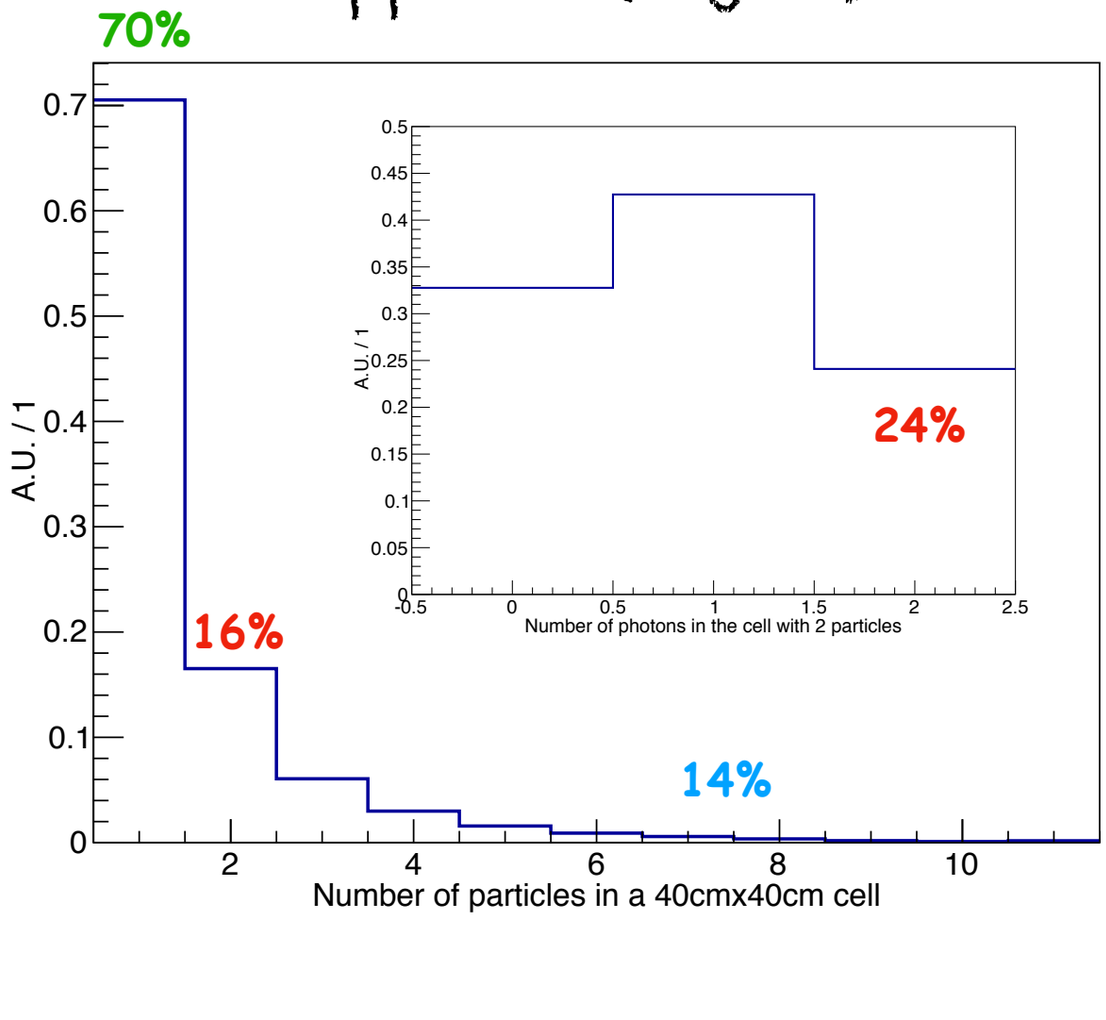


Physics requirement of separation

Z->qq (2 jets)



qqH->bb (4 jets)



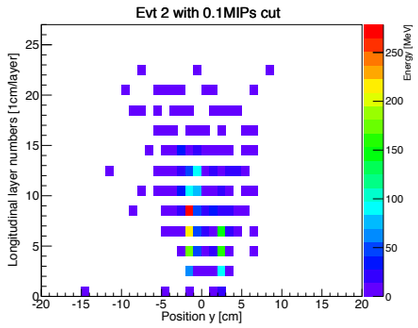
Charged + Charged → Tracker

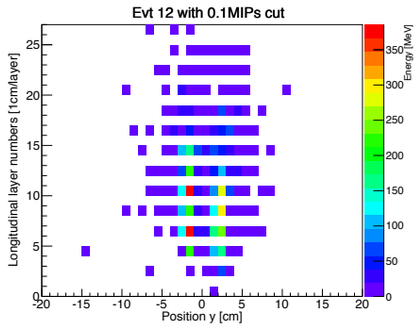
Charged + Neutral → Tracker

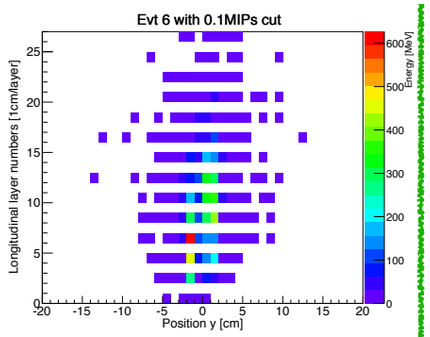
Neutral + Neutral → Only Calorimeter

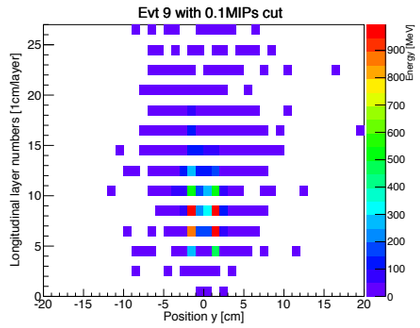
γ + γ (more than 80%~85% decayed from π^0) -> Reconstruction of π^0

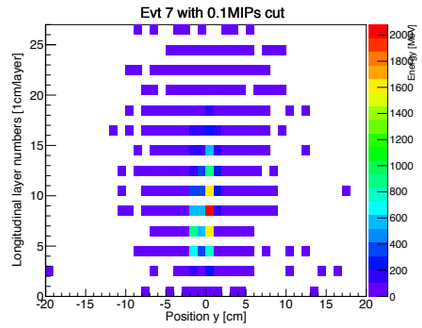
π^0 -> $\gamma\gamma$ at different energy

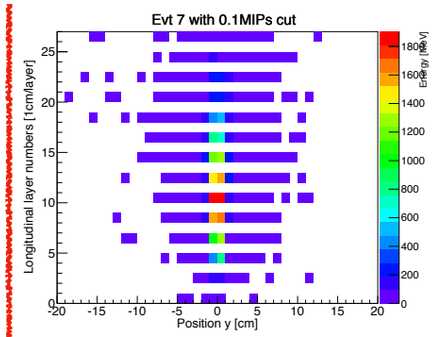


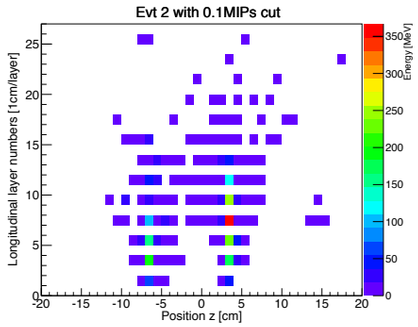


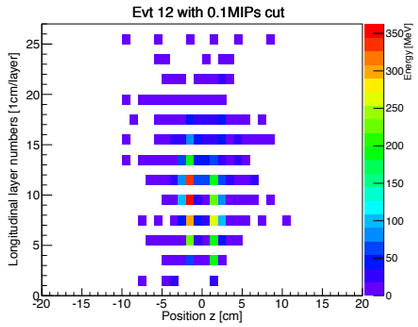


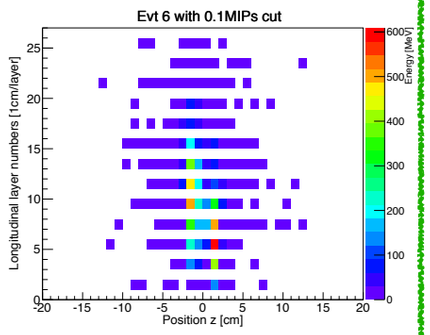


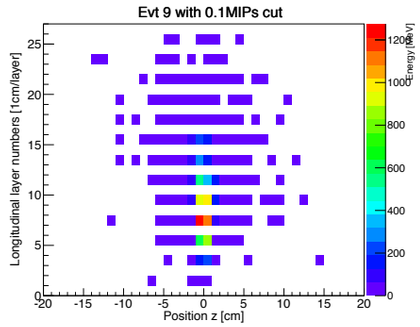


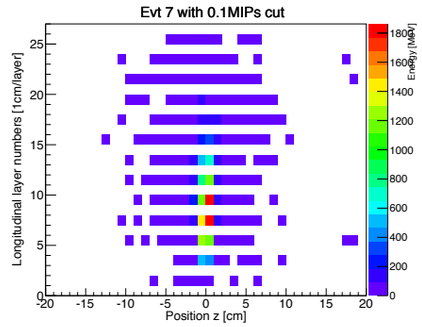


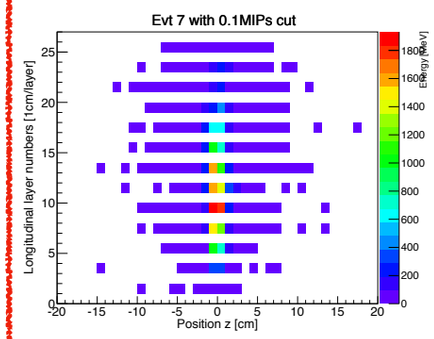


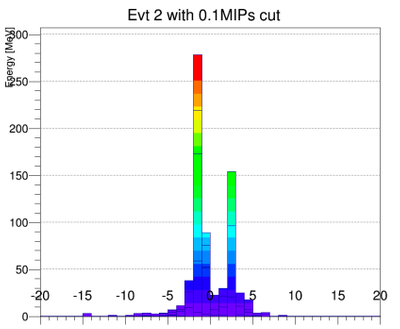


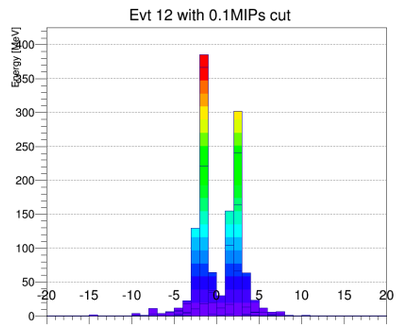


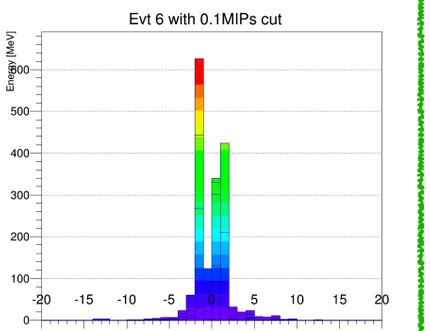


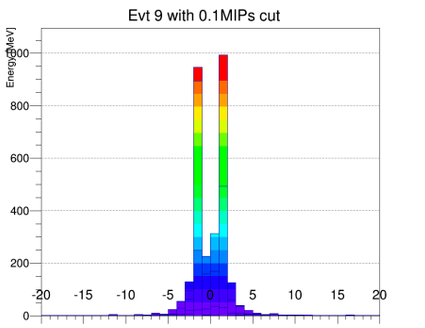


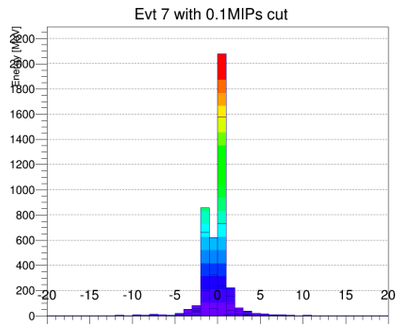


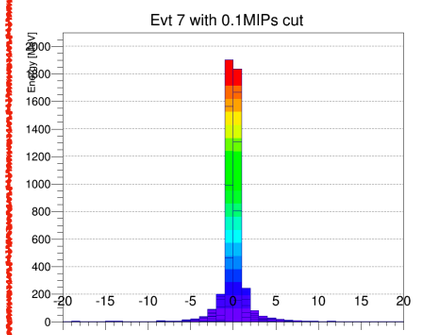


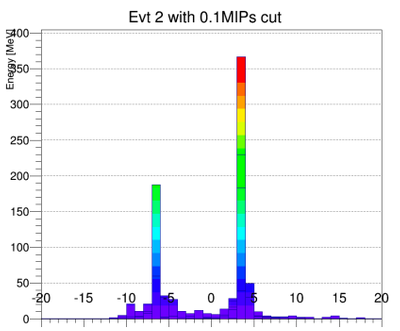


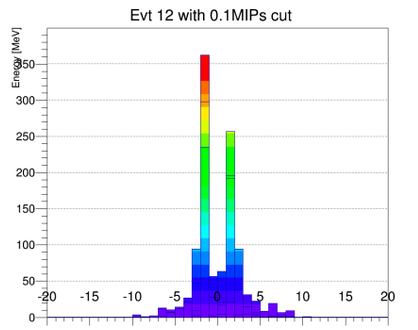


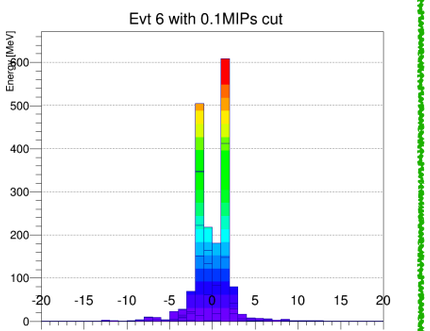


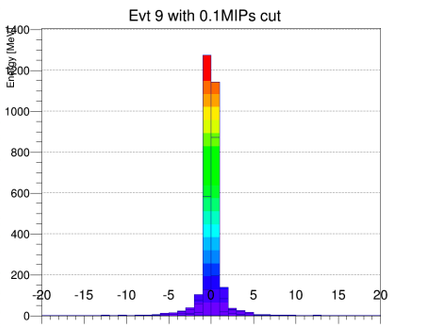


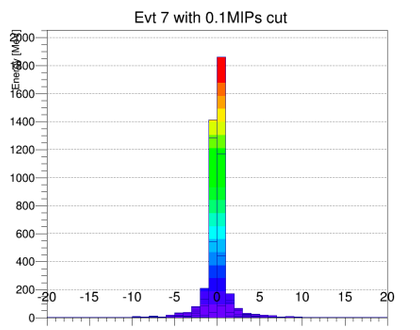


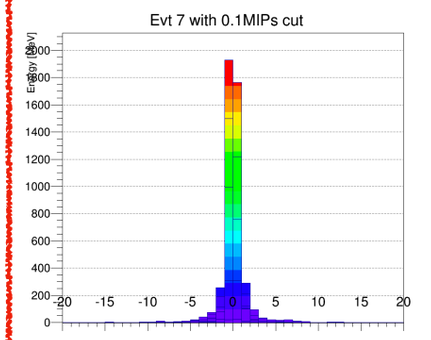


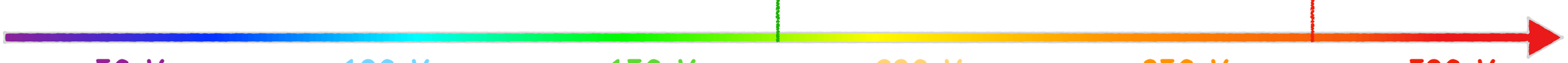








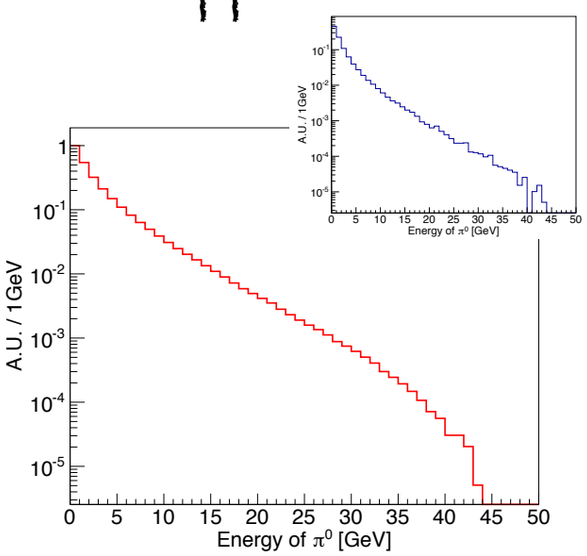


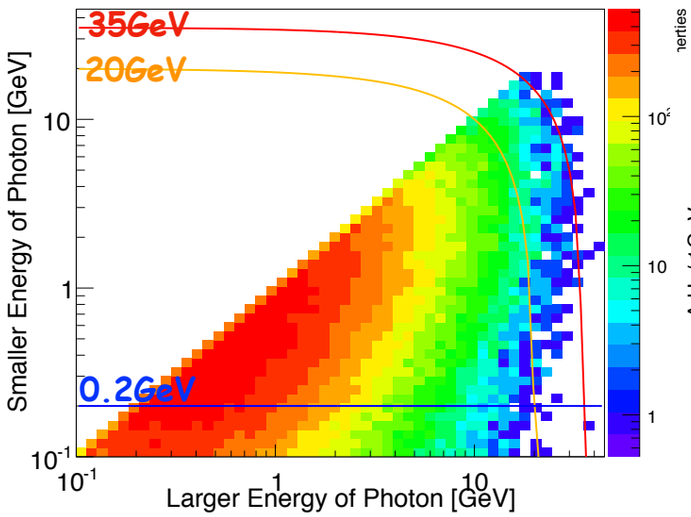


5GeV 10GeV 15GeV 20GeV 35GeV 50GeV

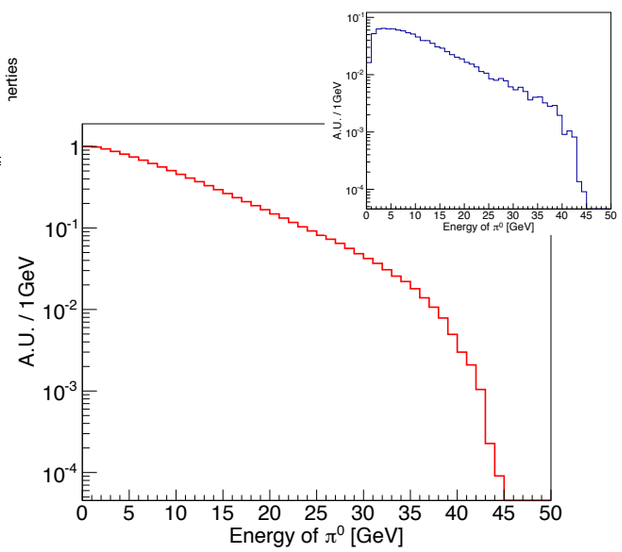
Proportion of different energy π^0

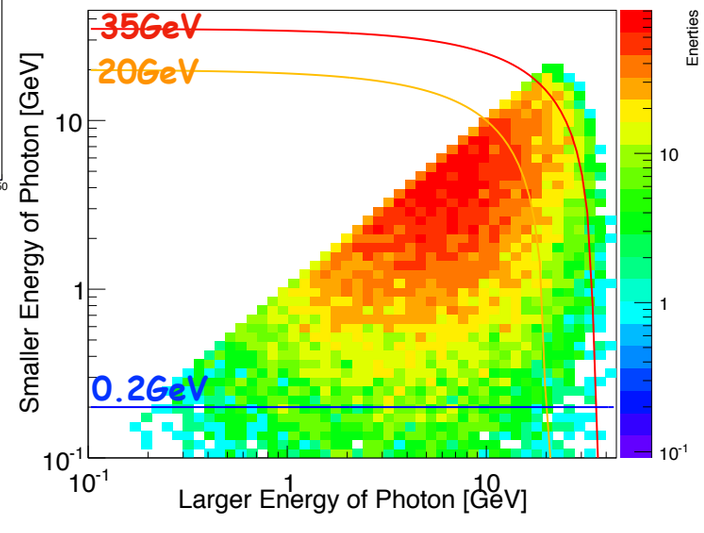
Z -> qq



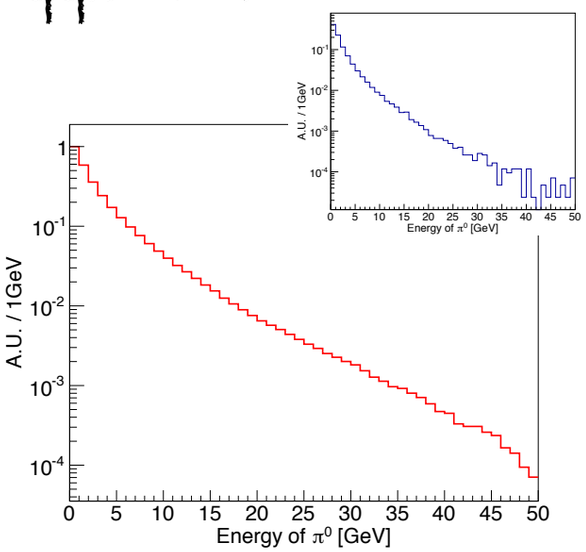


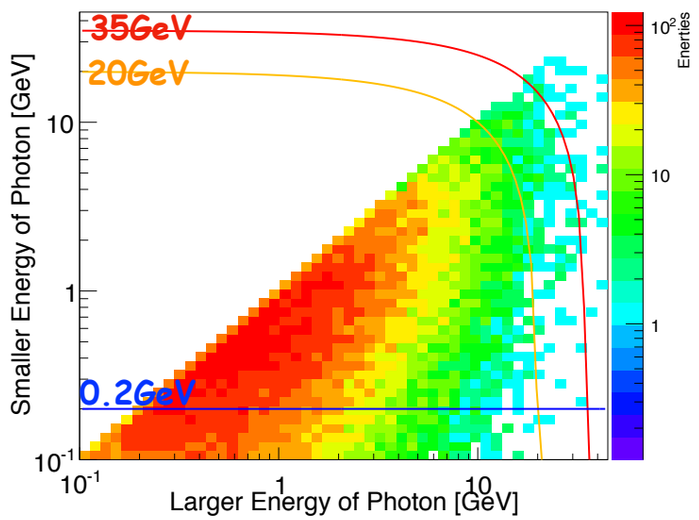
Z -> TT





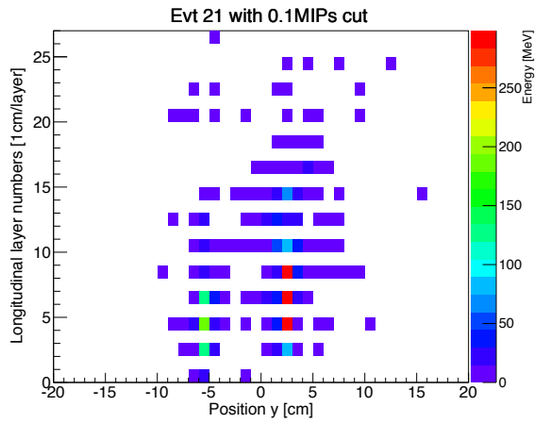
qqH -> X

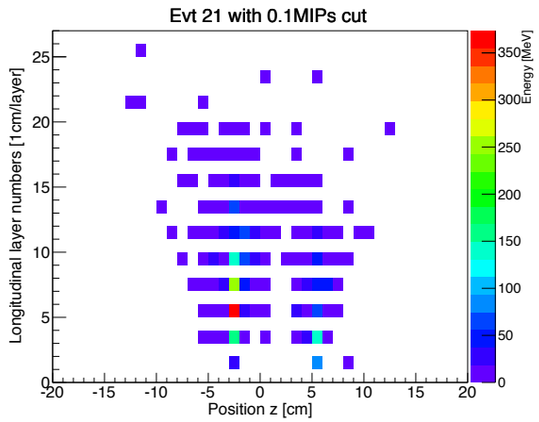


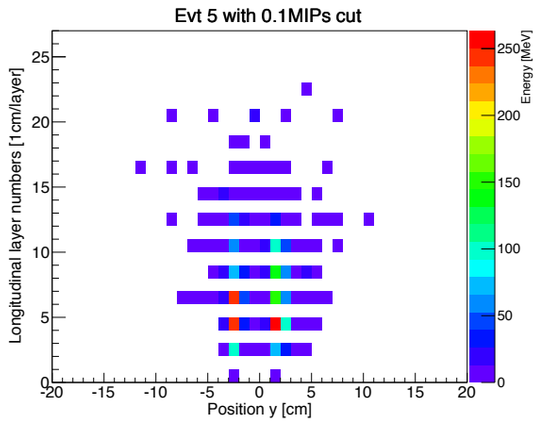


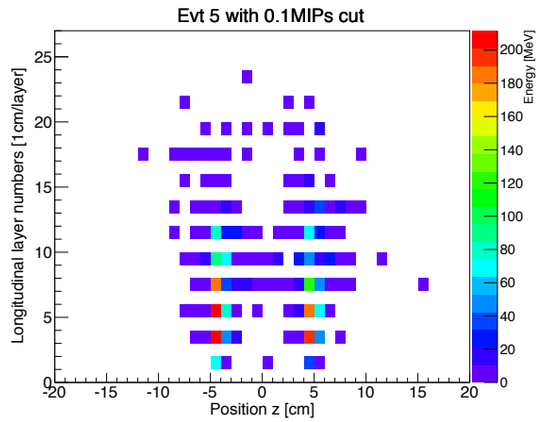
	Z->qq	qqH->X	Z->TT
$E_{\pi^0} > 20GeV$	0.42%	0.66%	14.9%
$E_{\pi^0} > 35GeV$	0.02%	0.1%	1.8%
$E_\gamma < 0.2GeV$	45%	42%	7.5%

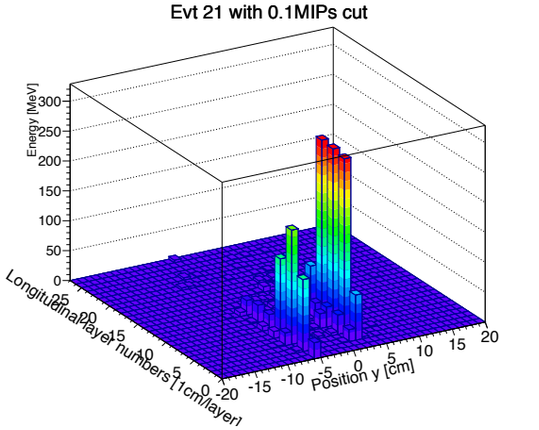
$\pi^0 \rightarrow \gamma\gamma$ at 5GeV

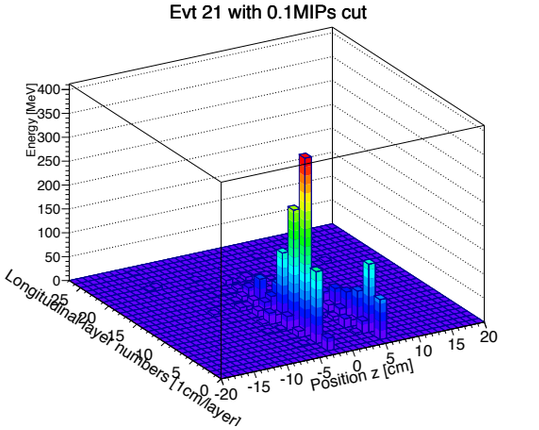


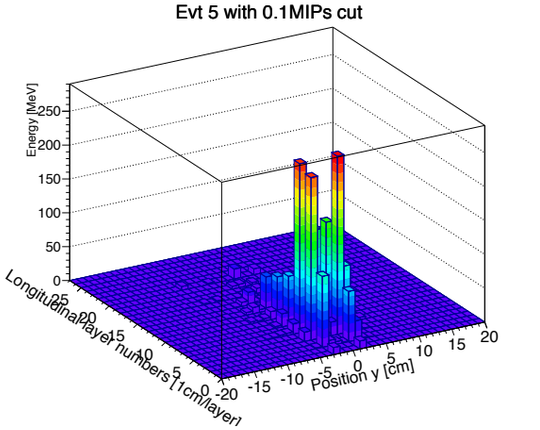


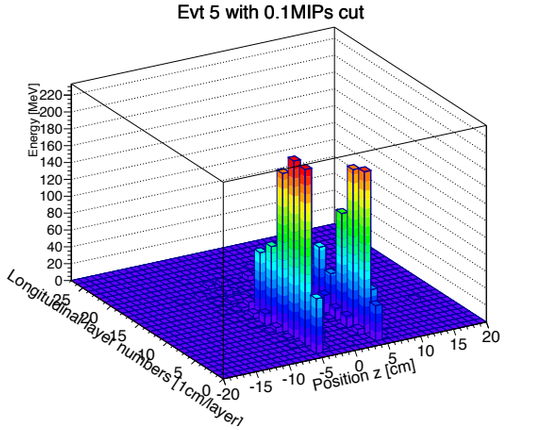


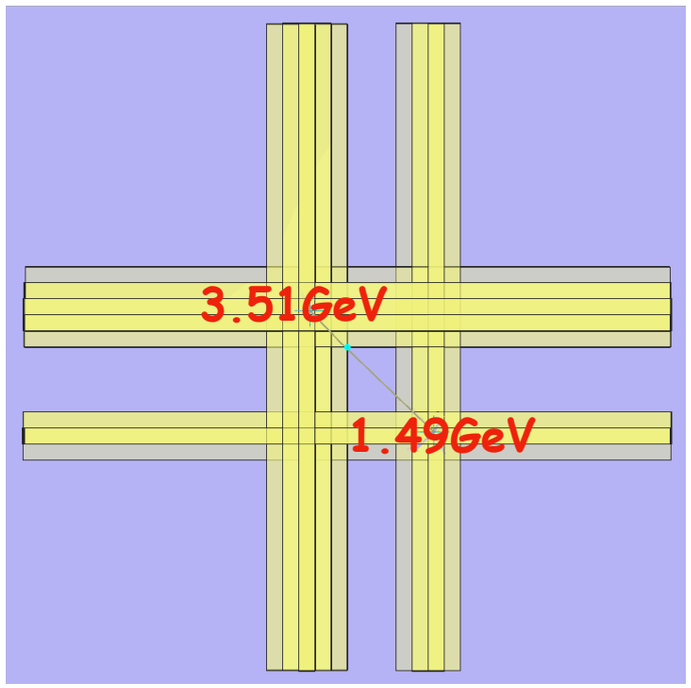


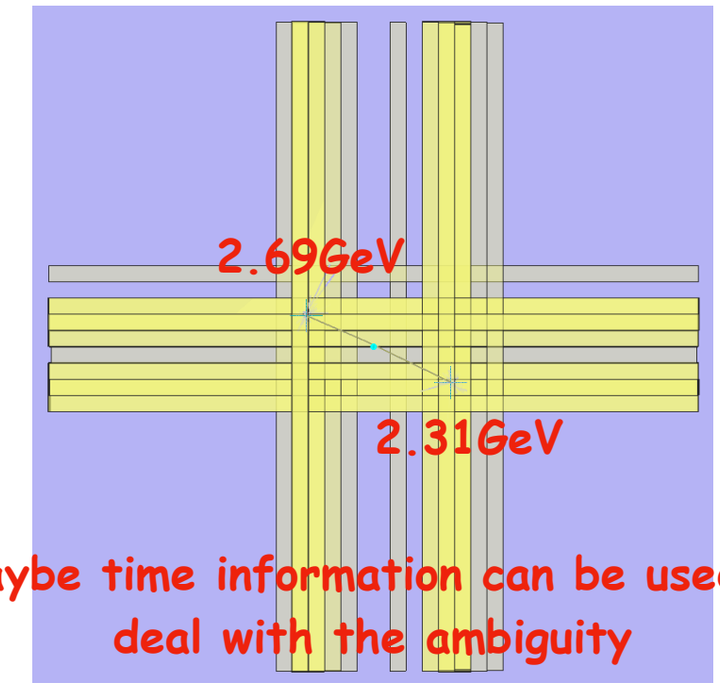






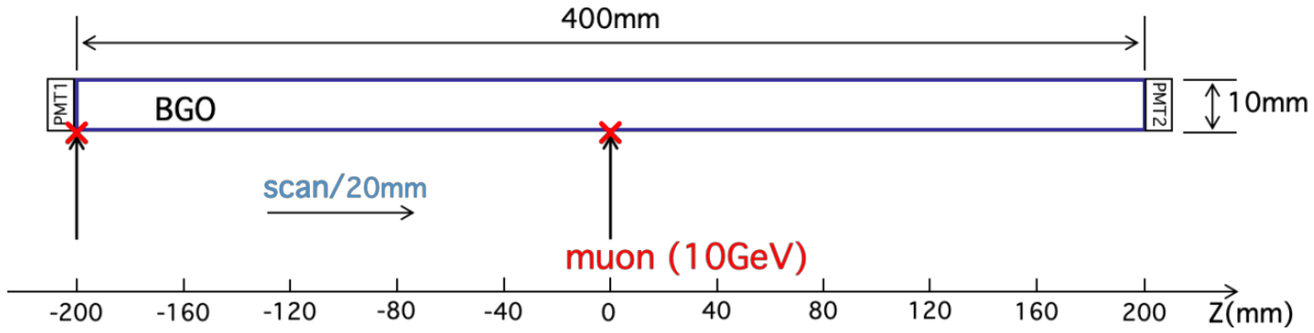




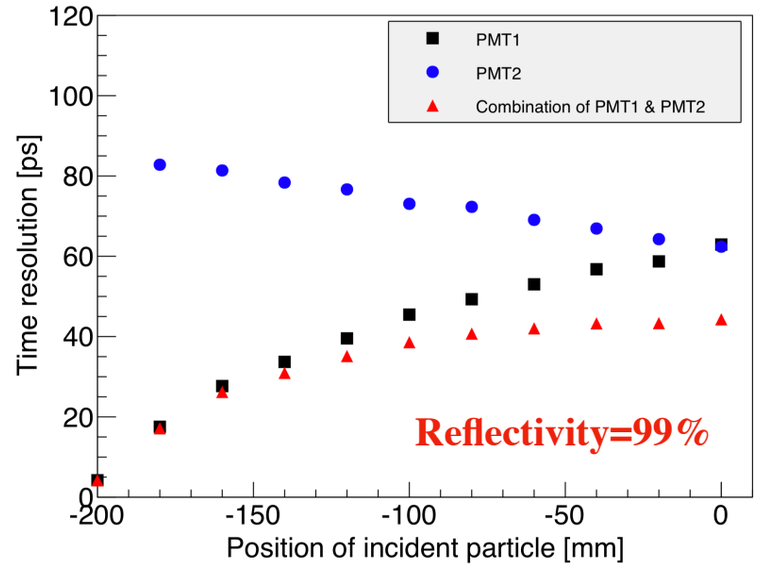


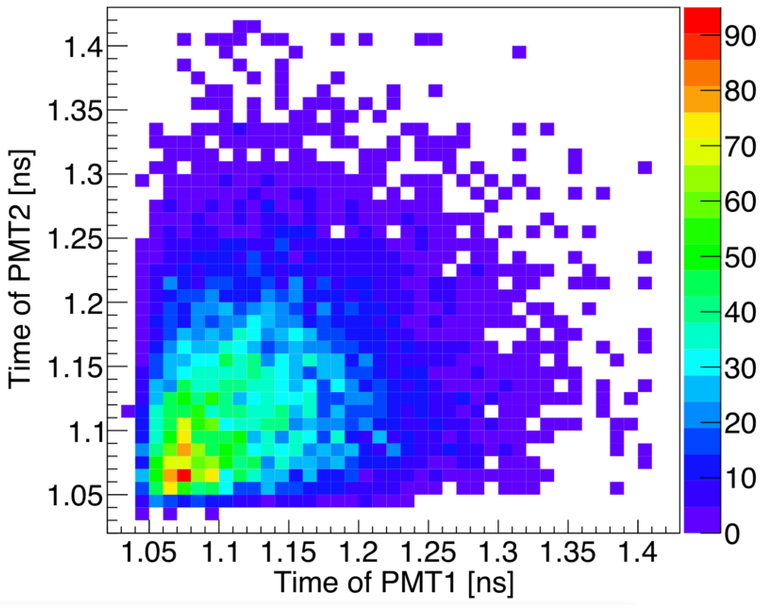
Maybe time information can be used to deal with the ambiguity

Time measurement



Parameter	Value
发光光谱峰位能量 Photon Energy	2.59eV (480nm)
发光光谱半峰宽 Photon Energy Width	0.6987eV (420-550nm)
快成分时间常数 FastTime Constant	60ns
慢成分时间常数 SlowTime Constant	300ns
光衰减长度 Absorption Length	7-15m
光产额 Scintillation Yeild	9000-10000/MeV
折射率 Refractive Index	2.15





Independent time measurement

Intrinsic time resolution of 1×1×40cm³ BGO crystal:

- **Single-ended readout, 5 - 90ps**
- **Double-ended readout: 5 - 45ps, effective position resolution, ~7mm**

Summary

Homogenous crossing strip crystal ECAL

✓**Reduce the number of readout channels to a certain extent**

✓**Homogenous structure can offer a more precise energy measurement**

→**Separation problem of multi-particle shower is not so severe**

Multi-dimensional information, (E, x, t)

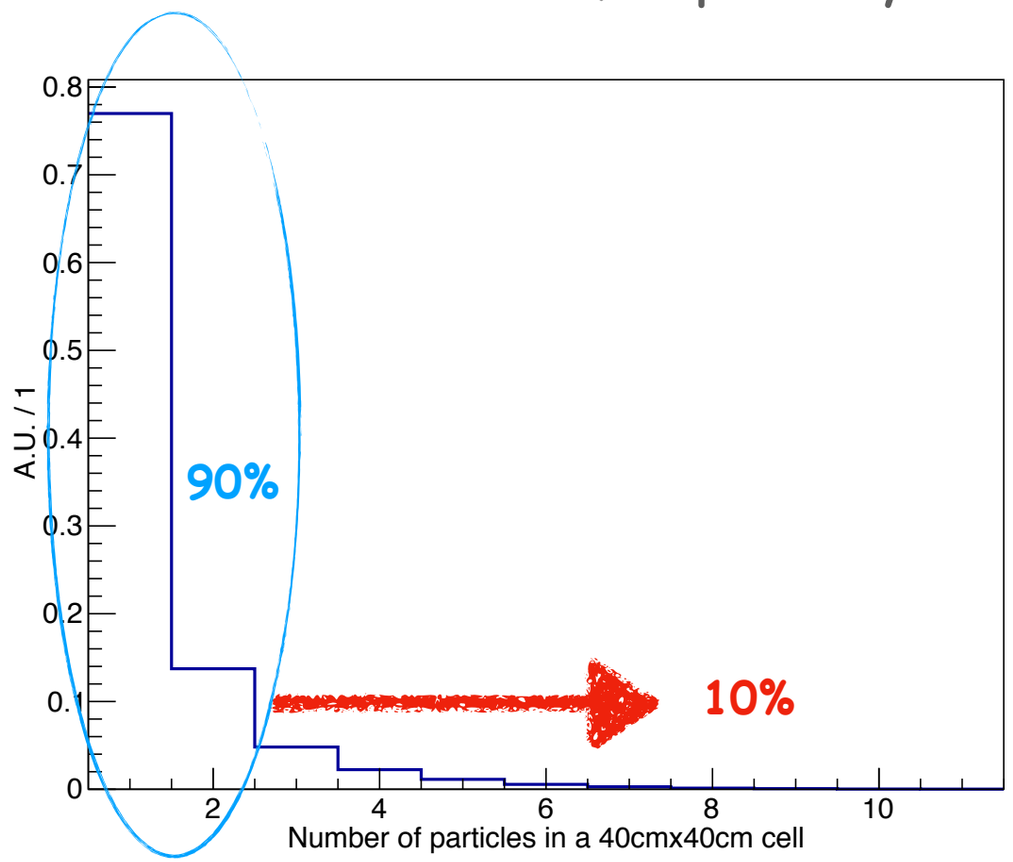
Explore the potential of fast time measurement & Digitization

A new smarter reconstruction algorithm

First deal with the separation of 2 particles in a 40x40cm cell, especially the reconstruction of π^0;

Then move to multi particles;

Finally the separation of particles in jet with the help of other sub-detectors



Thanks!