

# Analysis of tail-catcher data

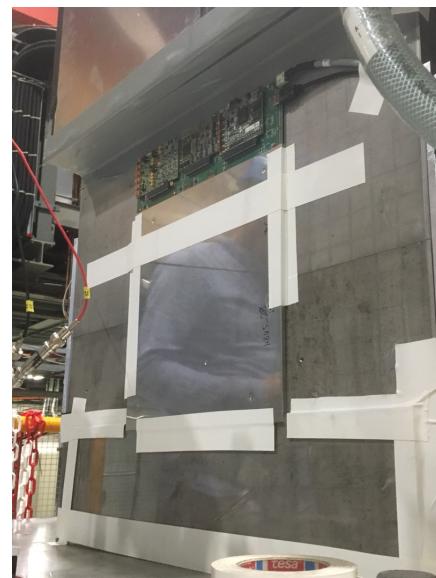
Tatsuro Torimaru

ICEPP, The University of Tokyo

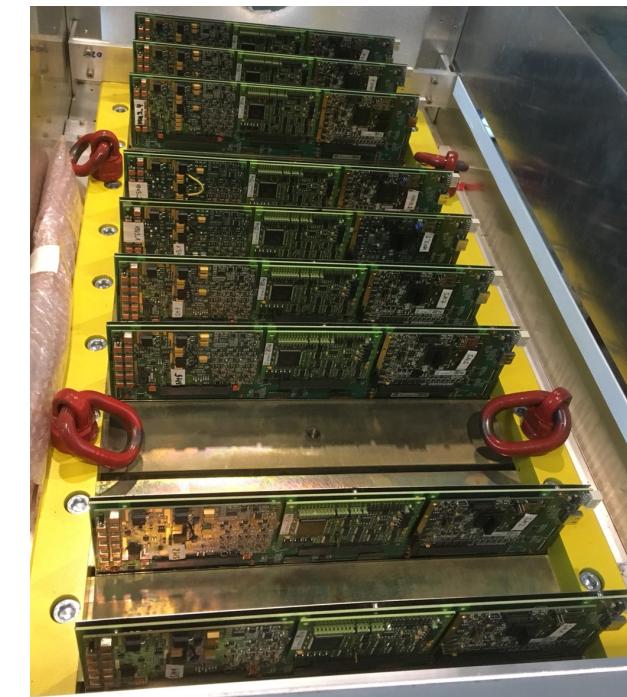
Tokyo Testbeam Analysis Workshop, Aug. 6-24<sup>th</sup>, 2018

# Geometry and Purpose

- The following modules are added in second testbeam.
  - Tokyo module -> Naoki's talk
  - Preshower detector
    - $1 \times 1$  HBU
    - Check if the shower starts before it comes to the AHCAL
  - Tail-catcher
    - $1 \times 1$  HBU and 12 layers
    - $\sim 74$  mm absorber
    - Measure the shower which starts later
    - Check how much energy leaks out from the main stacks



Preshower detector



Tail-catcher

# Database and Steering File in this Analysis

## ● Steering file

- /nfs/dust/ilc/user/huonglan/Testbeam2018/2018\_SPS\_June\_AHCAL/Rec  
o/steering\_reco\_withTailCatcher\_2018juneCern\_LanDB.xml
- **This study should be redone with the latest analysis tools**

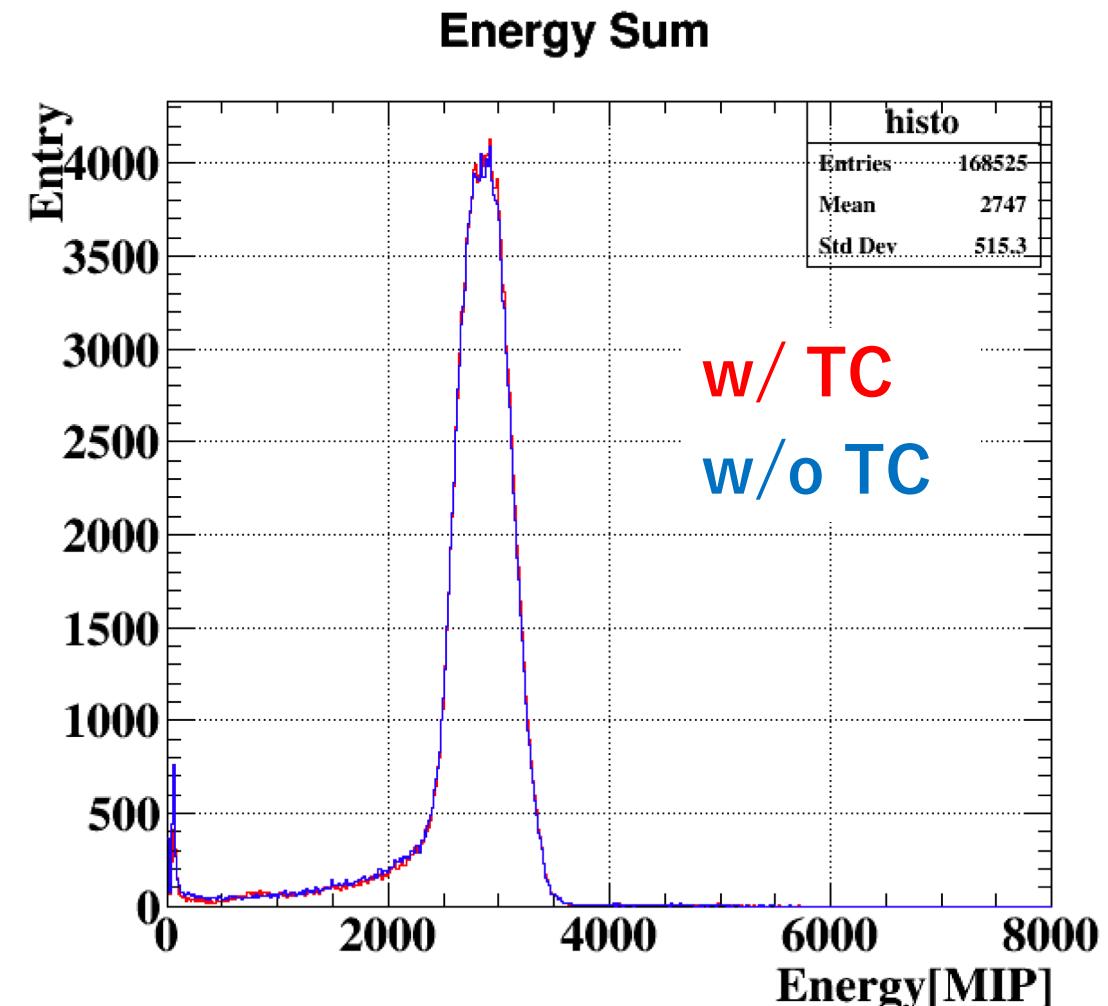
```
<!-- XXX: change to correct database entries and tags-->
<processor name="GeoConditions" type="ConditionsProcessor">
  <parameter name="DBInit" type="string" value="flccaldb02.desy.de:caliceon:Delice.1:3306"/>
  <parameter name="DBCondHandler" type="StringVec">
    Ahc2ModuleDescription          /test_lan/Ahc2_June2018/ModuleDescription      HEAD
    Ahc2ModuleConnection          /test_lan/Ahc2_June2018/ModuleConnection      HEAD
    Ahc2ModuleLocationReference   /test_lan/Ahc2_June2018/ModuleLocationReference HEAD
    Ahc2HardwareConnection        /test_lan/Ahc2_June2018/HardwareConnection   HEAD
    Ahc2DetectorTransformation   /test_lan/Ahc2_June2018/DetectorTransformation HEAD
    E4DPedestal                  /test_lan/Ahc2_June2018/Pedestal           HEAD
    E4DGainConstants             /test_lan/Ahc2_June2018/gain_constants     HEAD
    E4DGainSlopes                /test_lan/Ahc2_June2018/gain_slopes       HEAD
    E4DMipConstants              /test_lan/Ahc2_June2018/mip_constants     HEAD
    E4DMipSlopes                 /test_lan/Ahc2_June2018/mip_slopes       HEAD
    E4DDeadCellMap               /cd_calice_Ahc2/TestbeamMay2018/DeadCellMap HEAD
    E4DSaturationParameters      /cd_calice_Ahc2/TestbeamMay2018/SaturationParameters HEAD
    E4DIntercalibration          /cd_calice_Ahc2/TestbeamMay2018/Intercalibration HEAD
    E4DPhysicsCalibIntercalibration /cd_calice_Ahc2/TestbeamMay2018/PhysicsCalibIntercalibration HEAD
    E4DTimeSlopes                /cd_calice_Ahc2/TestbeamMay2018/TimeSlope      ahc2_006
    E4DTimeOffset                 /cd_calice_Ahc2/TestbeamMay2018/TimeOffset      ahc2_006
  </parameter>
</processor>
```

Steering file



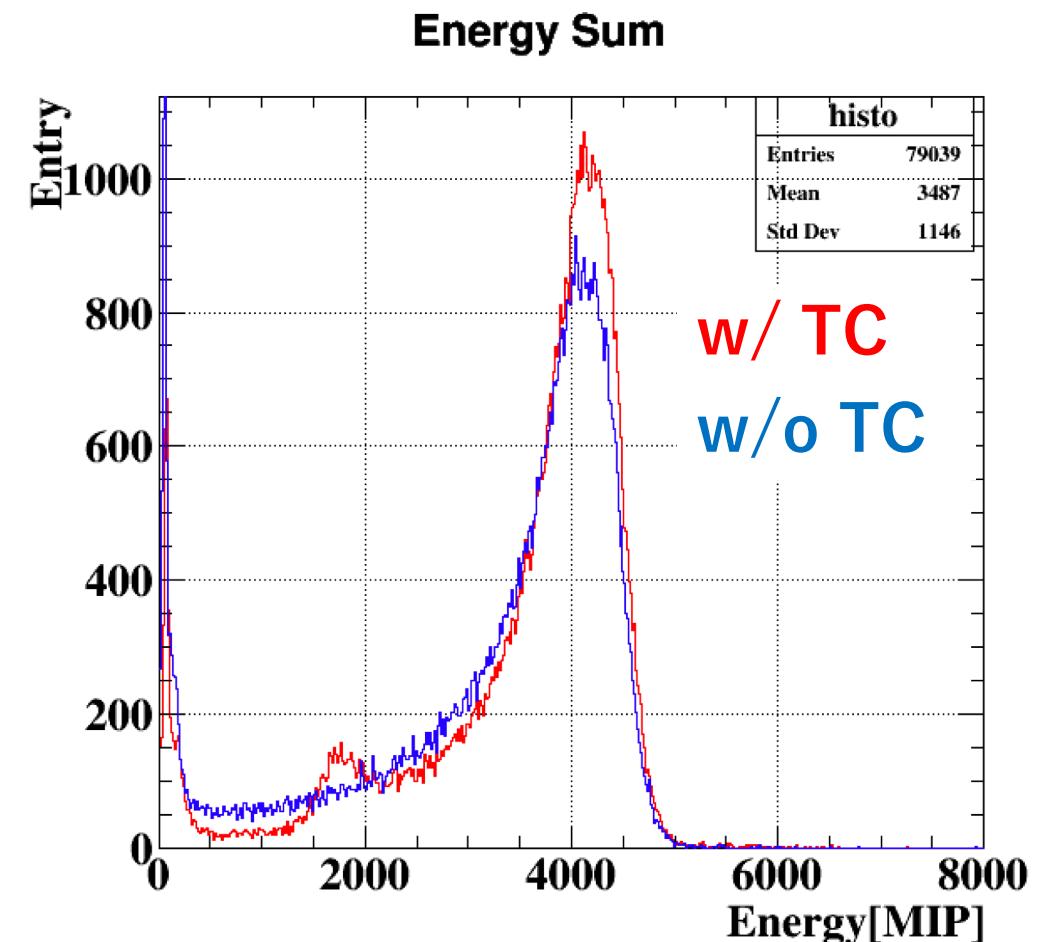
# Energy Sum for 100 GeV Electron

- Run 061217
- Comparison between EnergySum w/ and w/o Tail-Catcher
- Almost no difference.
  - Electromagnetic shower which is almost fully contained in the main stack.
  - Most electrons cannot arrive at tail-catcher.



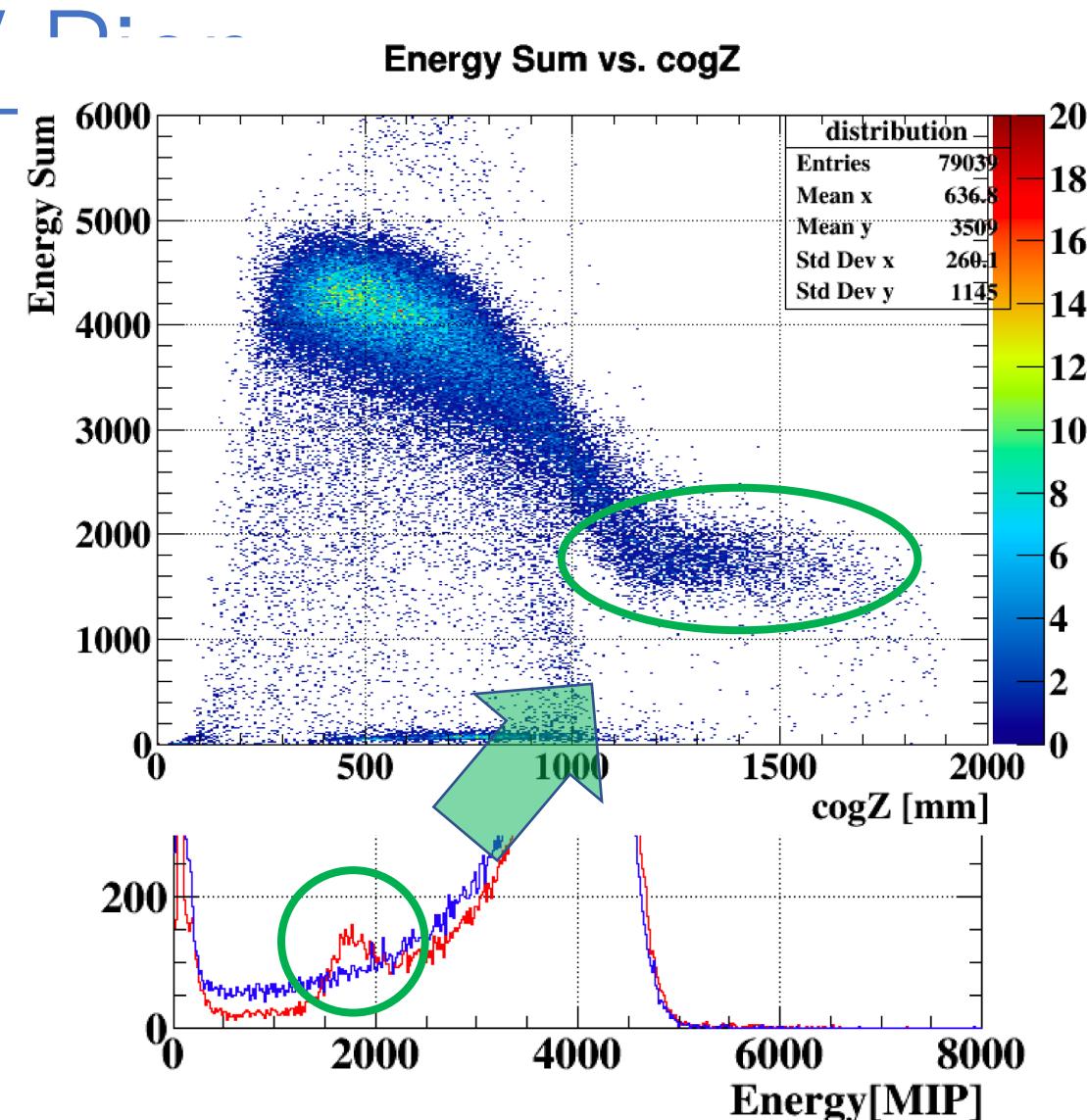
# Energy Sum for 100 GeV Pion

- Run 061230
- Comparison between EnergySum w/ and w/o Tail-Catcher
- There are some differences
  - Peak position
    - w/ TC > w/o TC
  - Width
    - w/ TC < w/o TC
  - Bump
    - Red one has a bump around energy ~ 1800[MIP].



# Energy Sum for 100 GeV

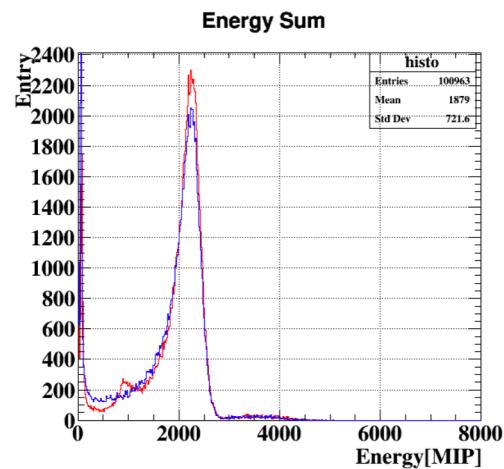
- Run 061230
- Comparison between EnergySum w/ and w/o Tail-Catcher
- There are some differences
  - Peak position
    - w/ TC > w/o TC
  - Width
    - w/ TC < w/o TC
  - Bump
    - Red one has a bump around energy ~ 1800[MIP].
    - There are many events energy is ~1800[MIP] in the range where cogZ is in tail-catcher.



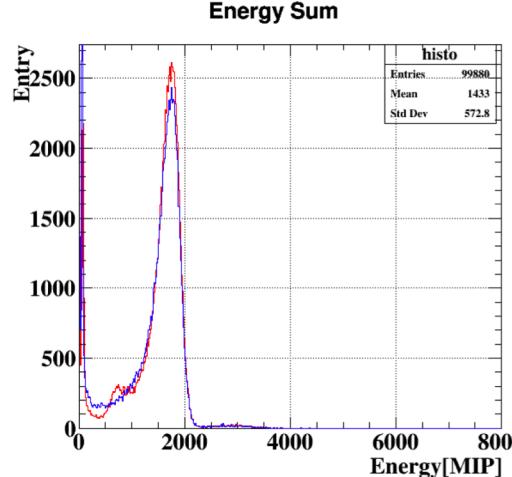
# Energy Sum for Several Energy Pions

- Comparison between EnergySum w/ and w/o tail-catcher
- Width becomes thinner than the case contains tail-catcher in each energy data.
- The more energy is high, the more peak shift and change of width become clear.

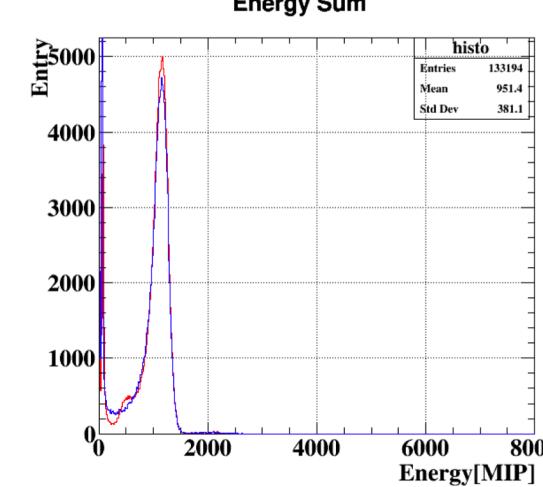
80 GeV(Run 061280)



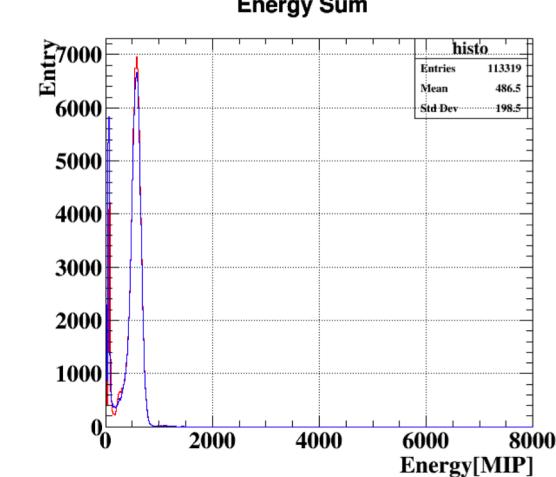
60 GeV(Run 061395)



40 GeV(Run 061275)



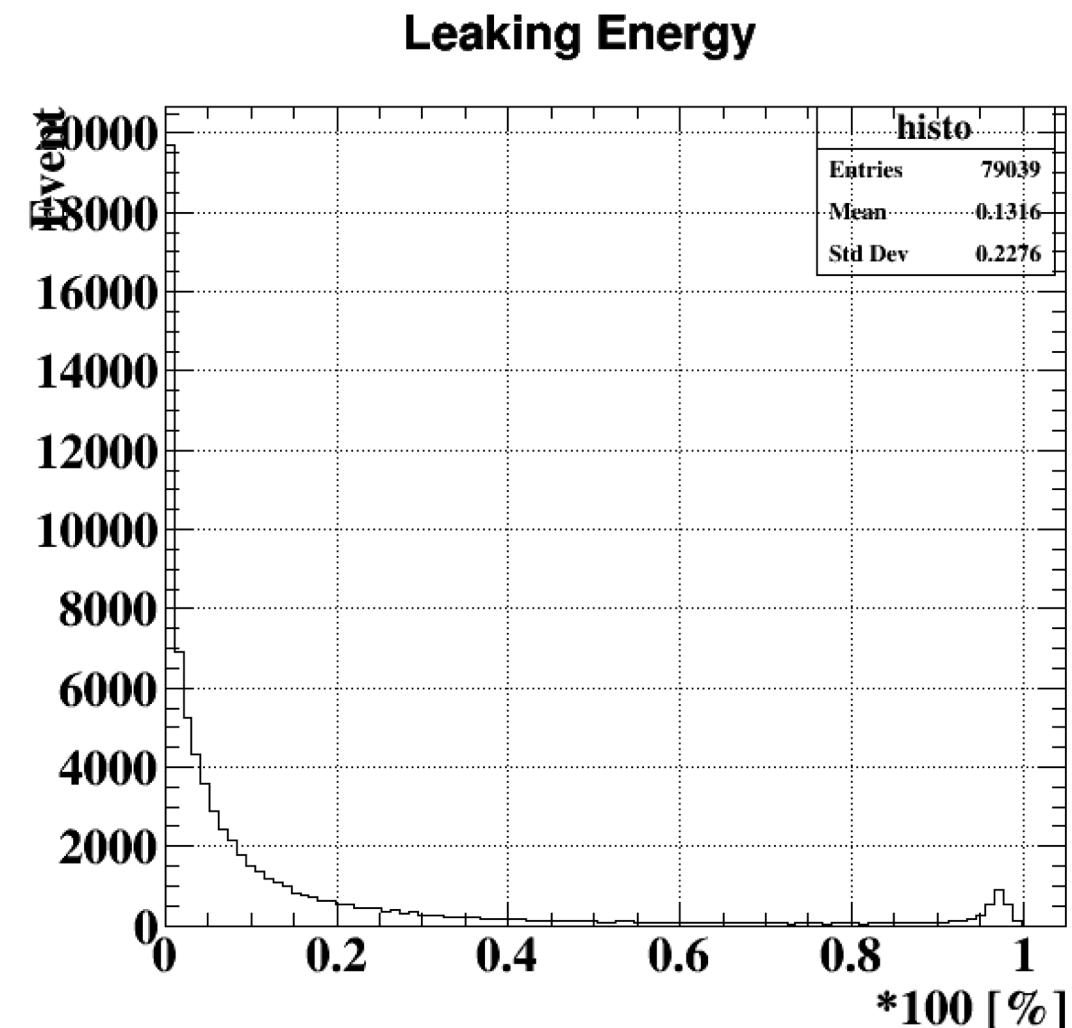
20 GeV(Run 061271)



w/ TC  
w/o TC

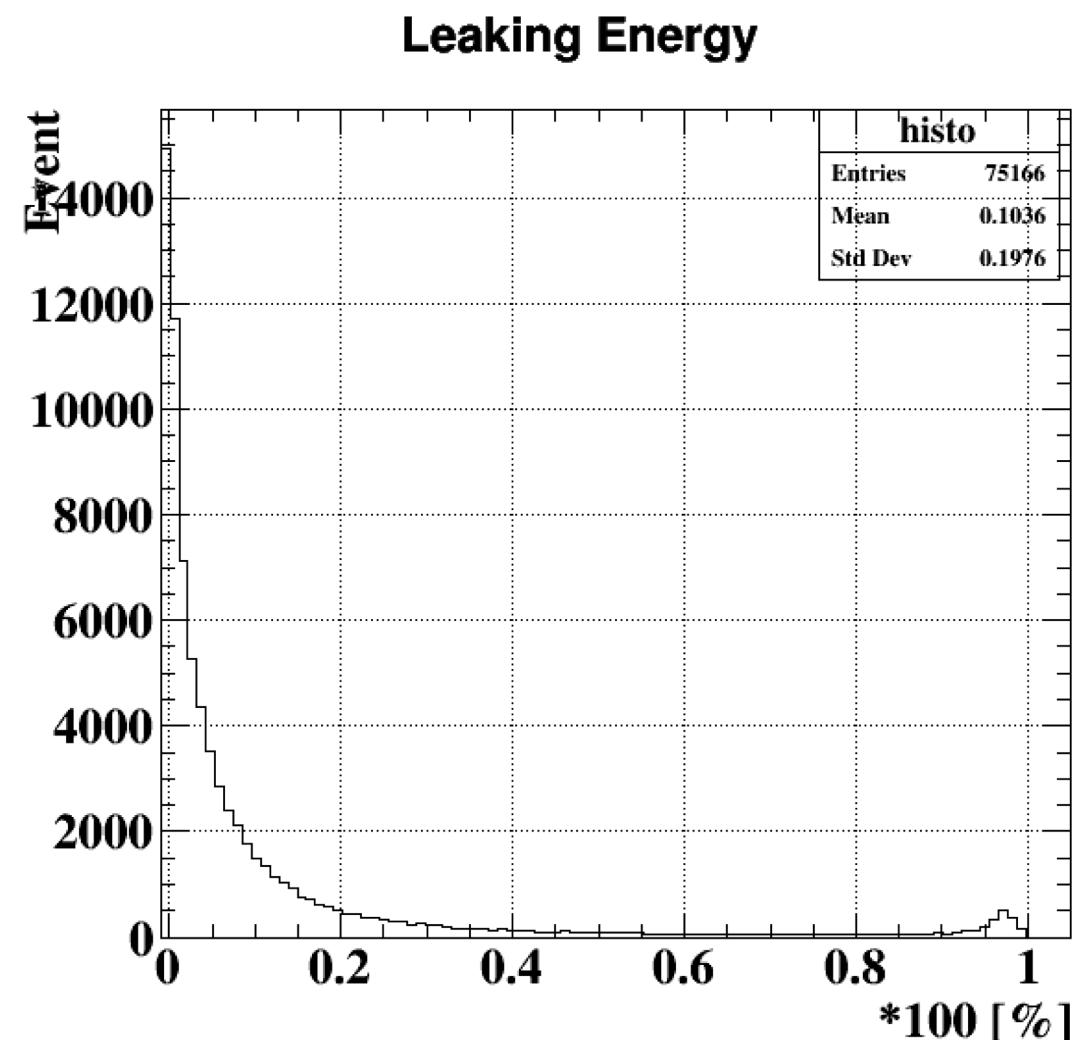
# Leaking Energy

- Run 061230(100 GeV Pion)
- Energy leakage from the main stacks
  - Fractional energy in TC = A/B
    - A : Energy which tail-catcher obtains
    - B : Energy sum
  - Leaking energy  $\sim 0$   
-> Main stacks get all energy
  - Leaking energy  $\sim 1$ 
    - Shower starts in TC.



# Leaking Energy

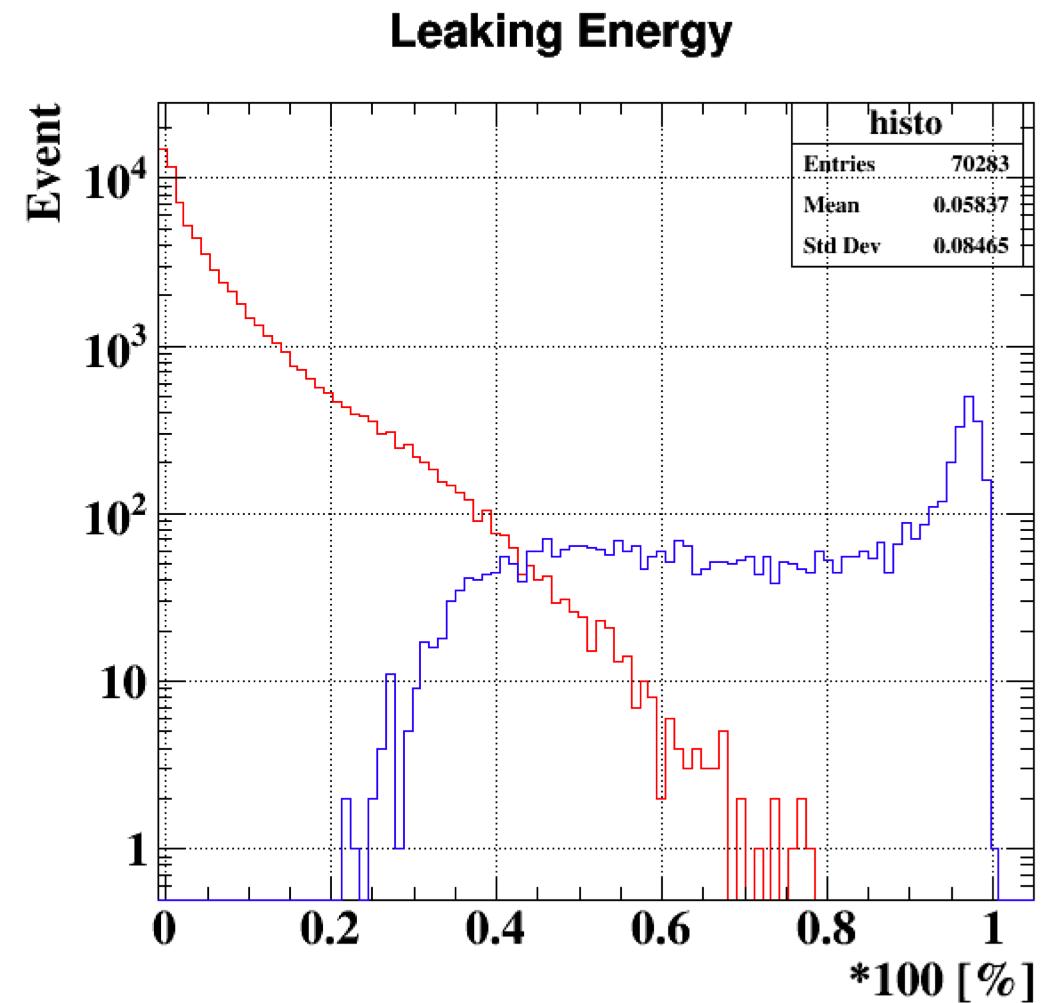
- Run 061230(100 GeV Pion)
- Energy leakage from the main stacks
  - Fractional energy in TC = A/B
    - A : Energy which tail-catcher obtains
    - B : Energy sum
  - Leaking energy  $\sim 0$   
-> Main stacks get all energy
  - Leaking energy  $\sim 1$ 
    - Shower starts in TC.
    - Removed muon contamination  
(nHits<70)



# Leaking Energy

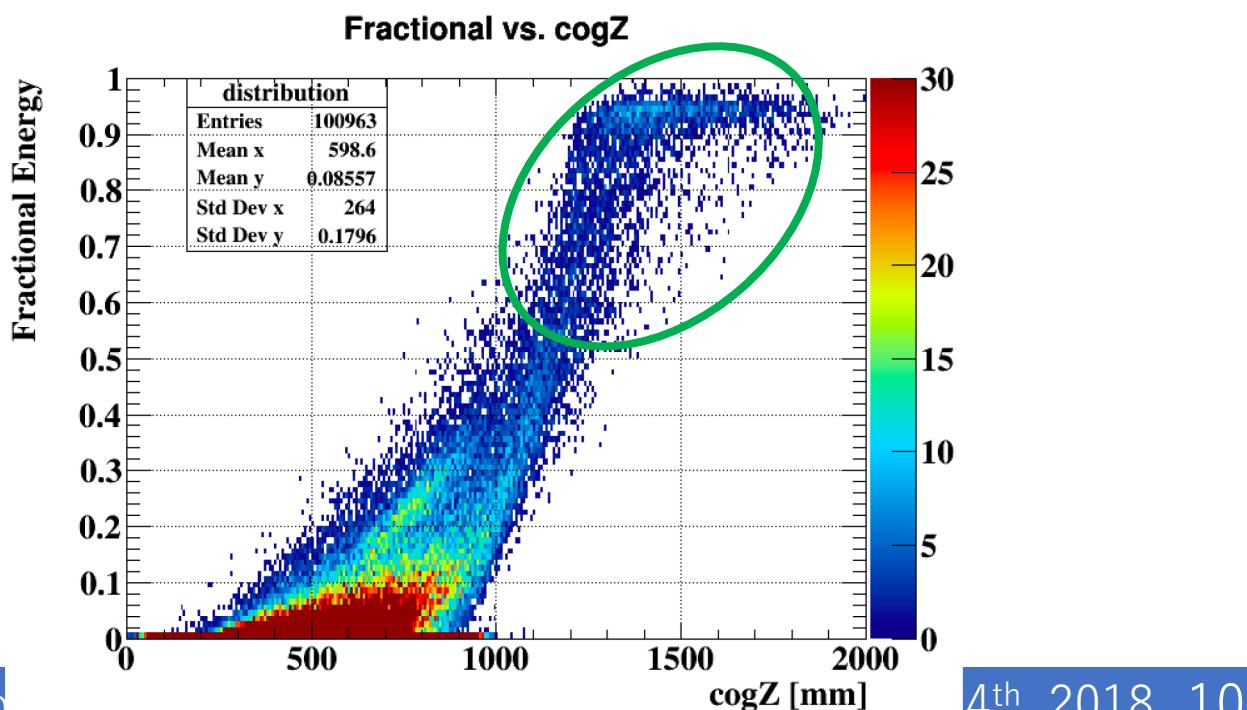
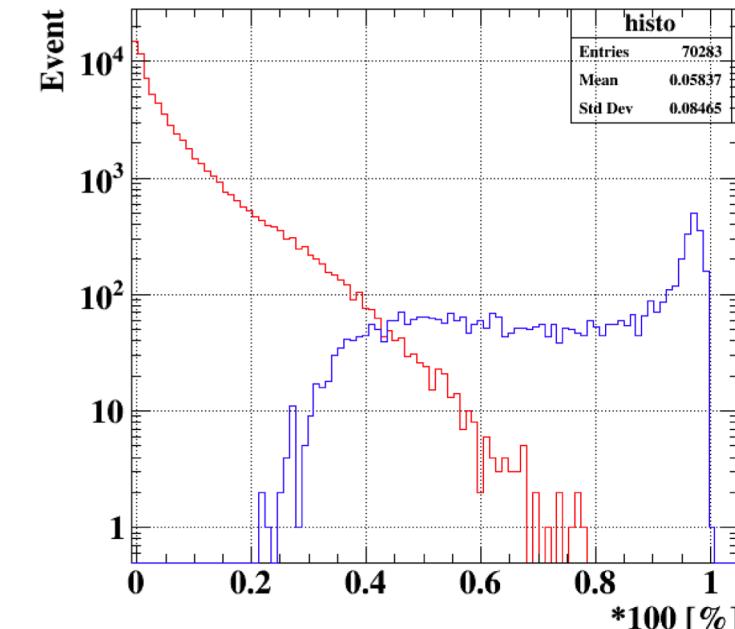
- Run 061230(100 GeV Pion)
- Leaking energy  $\sim 1$ 
  - Blue :  $cogZ > 1070$
  - Red :  $cogZ < 1070$

-> The peak comes from showers start later



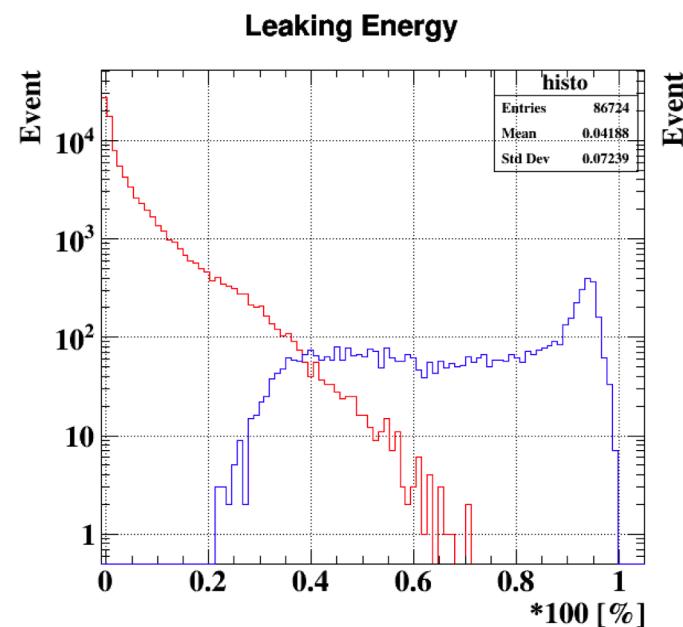
# Leaking Energy

- Run 061230(100 GeV Pion)
- Leaking energy  $\sim 1$ 
  - Blue :  $cogZ > 1070$
  - Red :  $cogZ < 1070$
- > The peak comes from showers start later
- $6.5\%(\text{Blue events}/(\text{Blue events} + \text{Red events}))$  of all events start to shower very late.

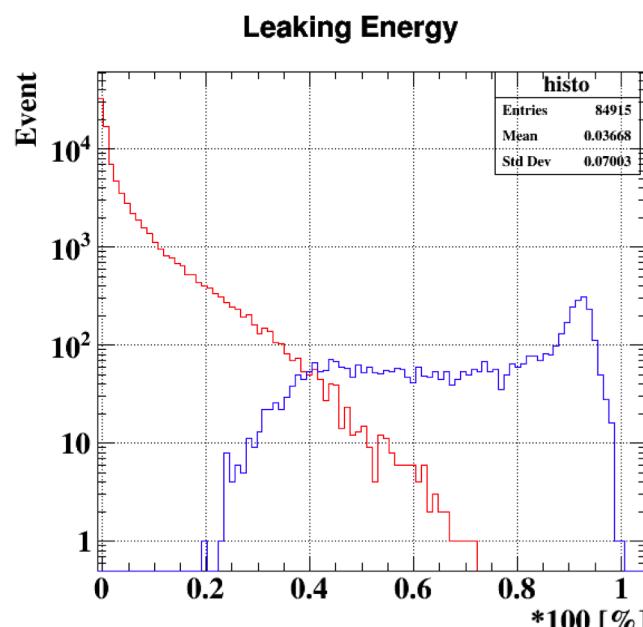


# Other Energies

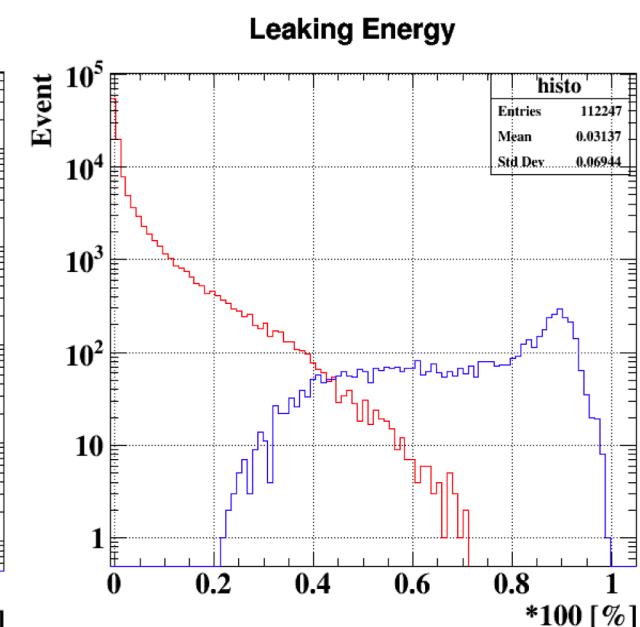
80 GeV(Run 061280)



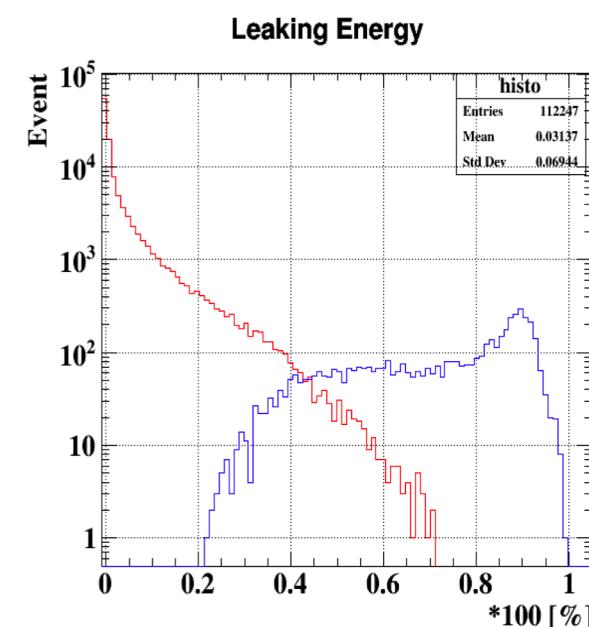
60 GeV(Run 061395)



40 GeV(Run 061275)



20 GeV(Run 061271)



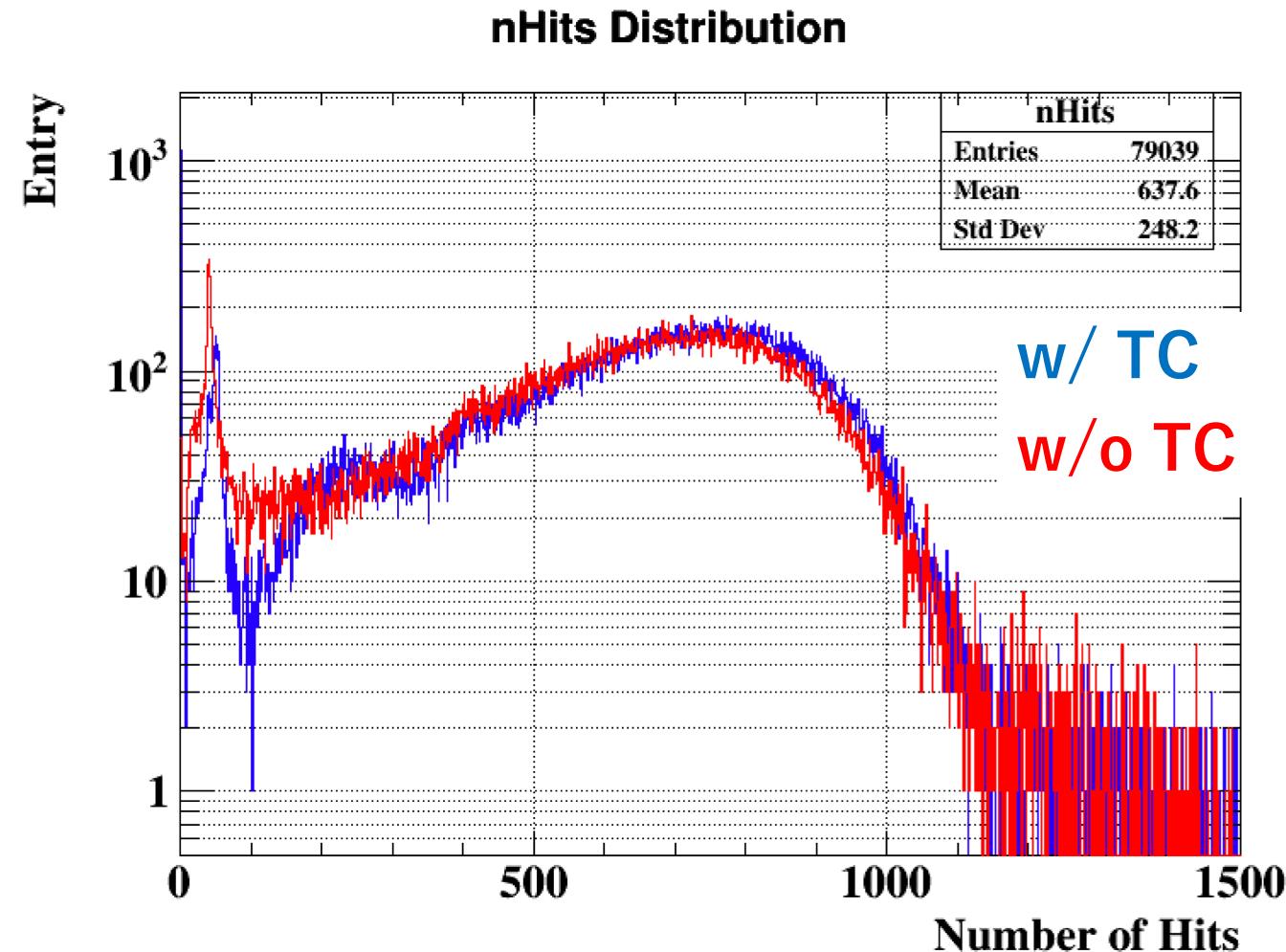
# Leaking Energy Summary

- High energy pions make showers more late.

runNumber	Energy[GeV]	cogZ<1070	cogZ>1070	ratio
61230	100	70283	4883	0.065
61280	80	86724	5273	0.057
61395	60	84915	4543	0.051
61275	40	112247	5080	0.043
61271	20	94284	2409	0.025

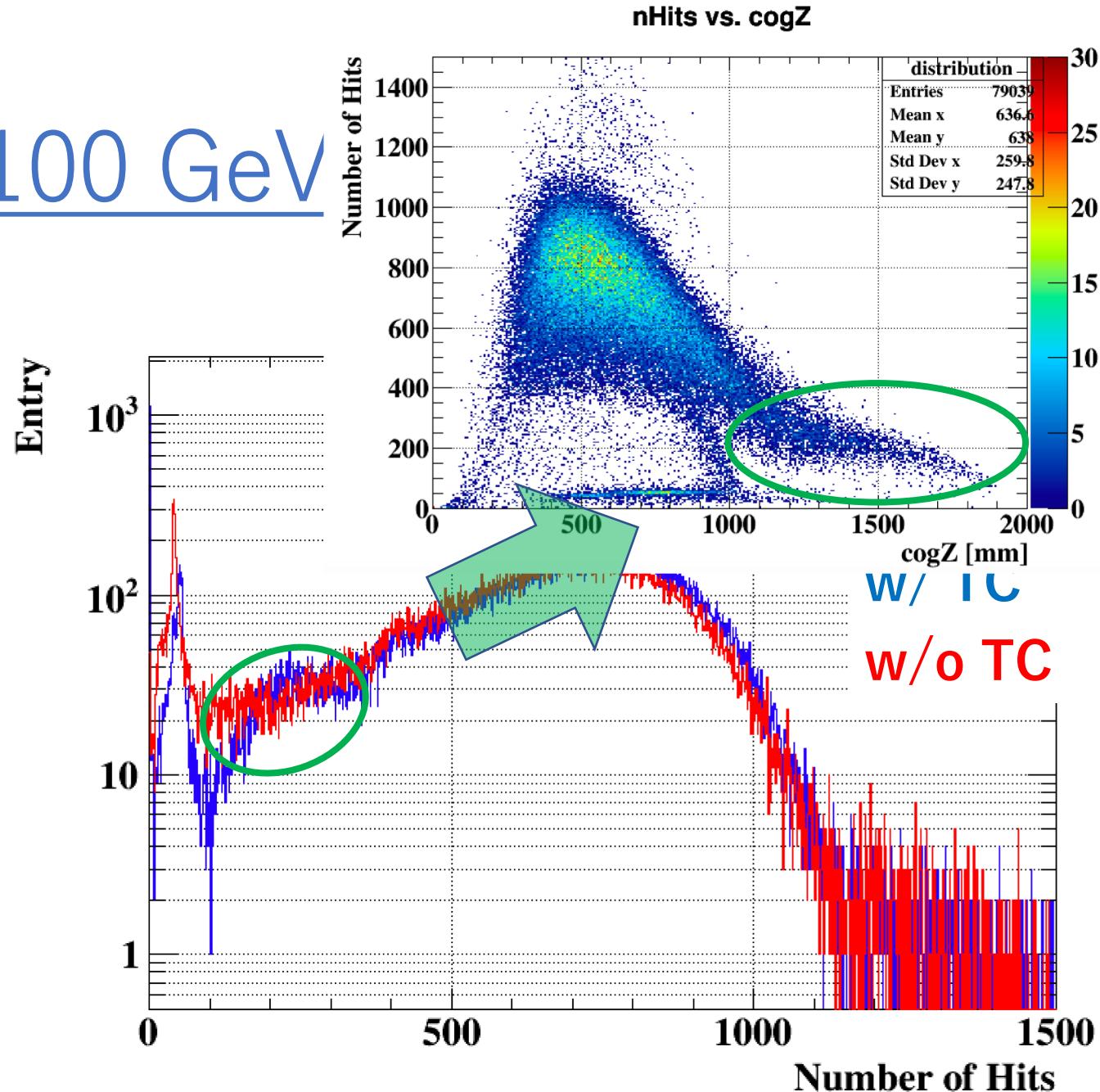
# Number of Hits for 100 GeV Pion

- Run 061230
- In order to check, we can also discuss with nHits instead of energySum.
- Distribution is shifted to left a little.
- Blue one has a bump.
  - nHits ~ 200



# Number of Hits for 100 GeV

- Run 061230
- In order to check, we can also discuss with nHits instead of energySum.
- Distribution is shifted to left a little.
- Blue one has a bump.
  - nHits  $\sim 200$
  - There are many events in the range where cogZ is in tail-catcher.



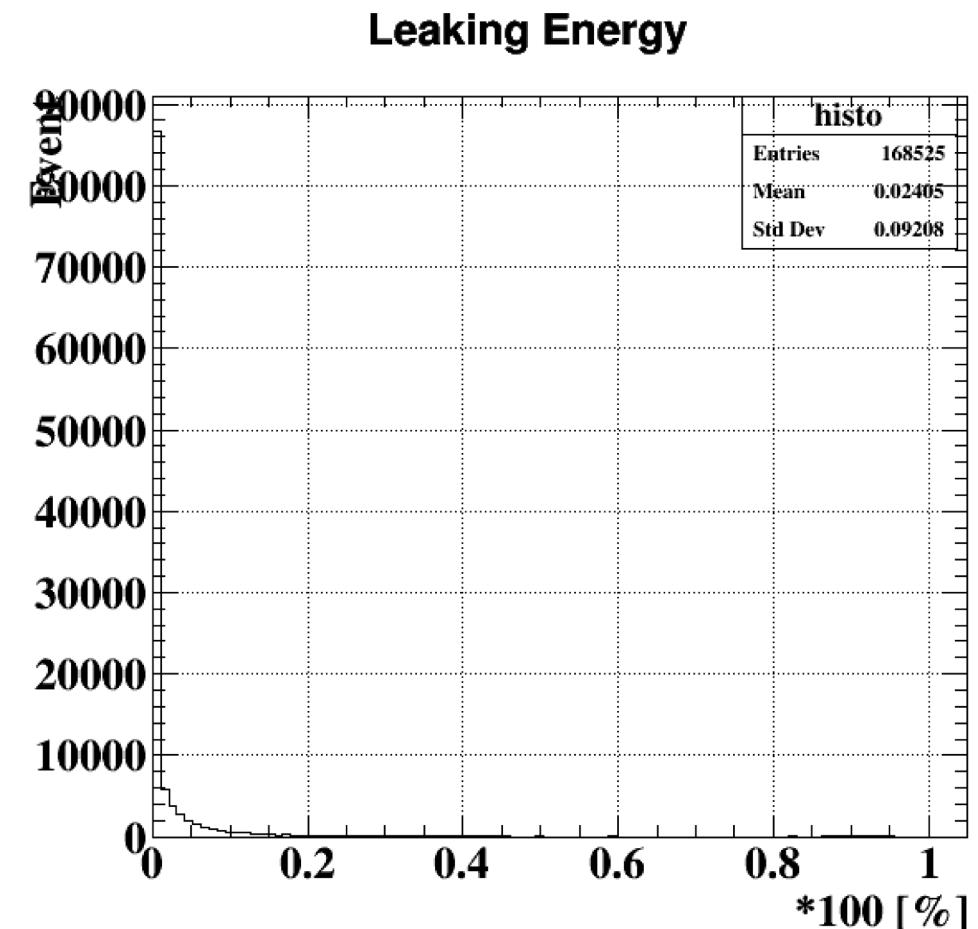
# Prospect and ToDo

- Redo with the latest analysis tools(correct geometry and so on..)
- Consider weighted energy sum between main stacks and tail-catcher because tail-catcher has  $1 \times 1$  HBU and different thickness absorbers from main stacks.
- Check other data with higher particle energies.

# backup

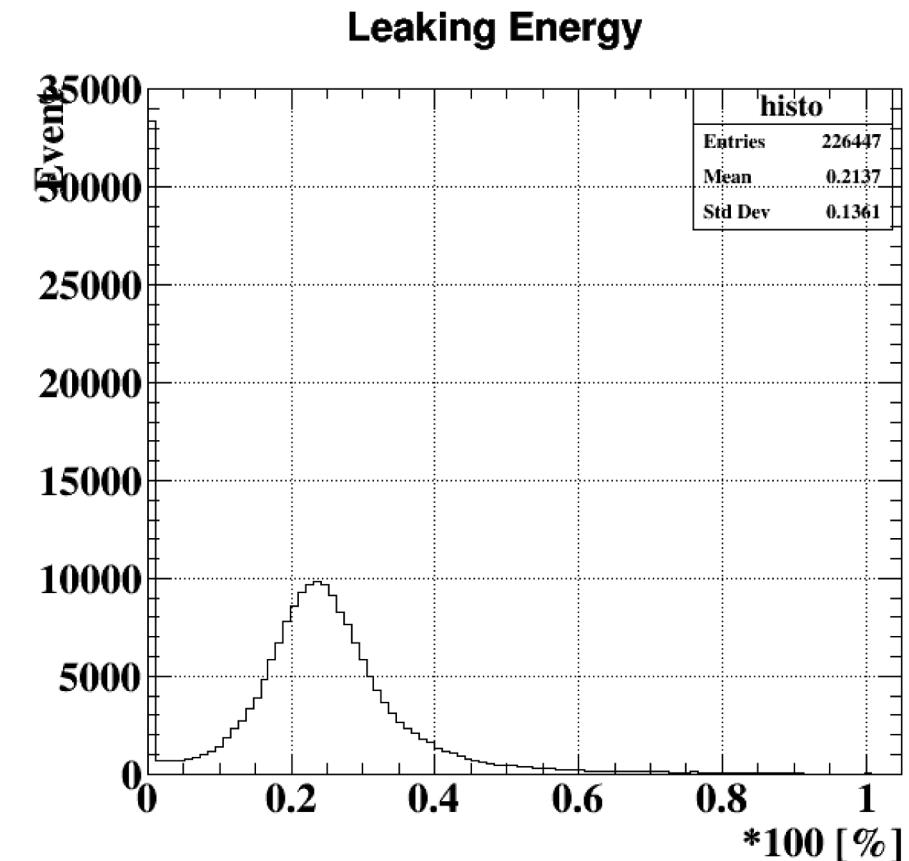
# Leaking Energy for 100GeV Electron

- Run 061217
- Energy leakage from the main stacks
  - Fractional energy in TC = A/B
    - A : Energy which tail-catcher obtains
    - B : Energy sum



# Leaking Energy for 40GeV Muon

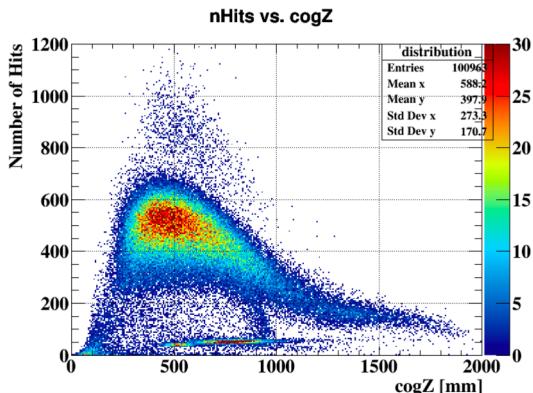
- Run 061189
- Energy leakage from the main stacks
  - Fractional energy in TC = A/B
    - A : Energy which tail-catcher obtains
    - B : Energy sum



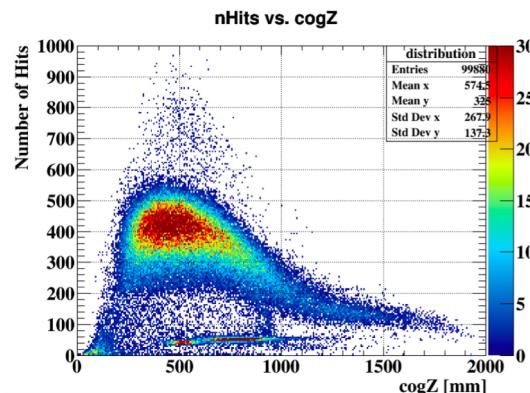
# Various Number of Hits vs. cogZ

- As of now, I finished checking data of 100, 80, 60, 40, and 20 GeV

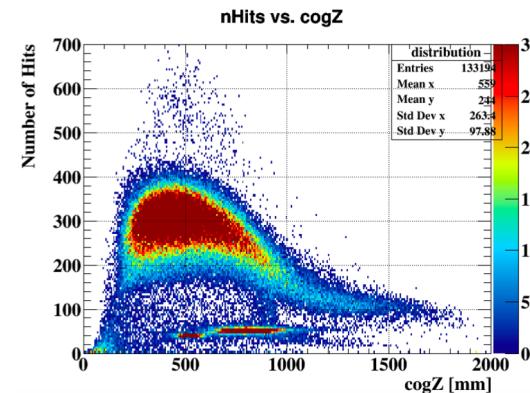
80 GeV(Run 061280)



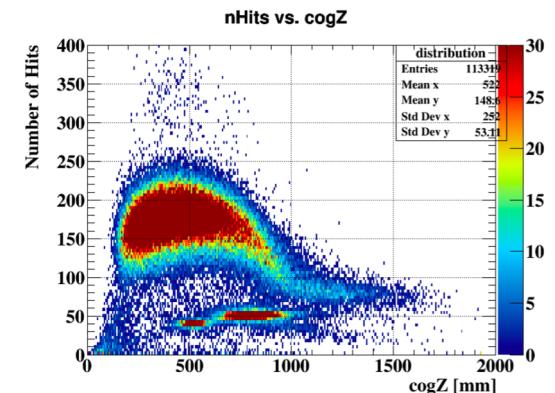
60 GeV(Run 061395)



40 GeV(Run 061275)



20 GeV(Run 061271)

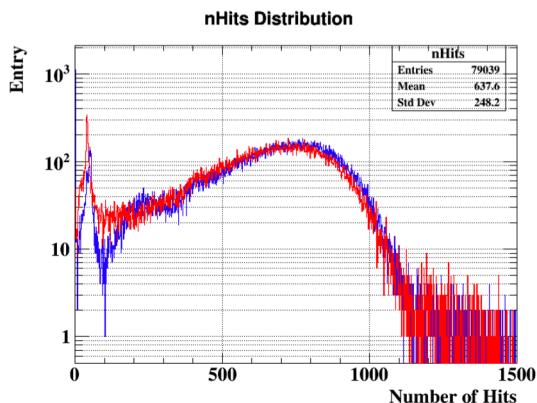


- Apparently, the lower energy becomes, the less nHits decreases.
- Muon contamination -> nHits ~ 50 in each case

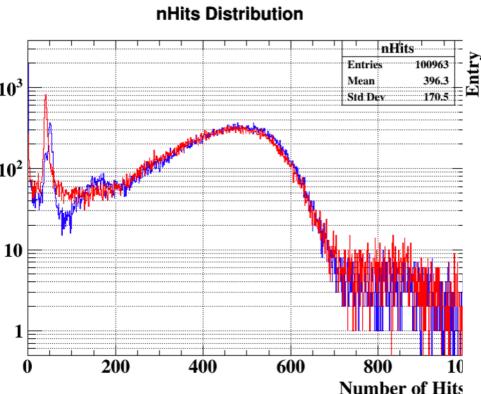
# Number of Hits for Several Energies Pion

- The number hits
- Distribution is shifted to left a little.
  - The bigger energy is, the larger these distributions are shifted because higher-energy pions can enter tail-catcher than lower ones.

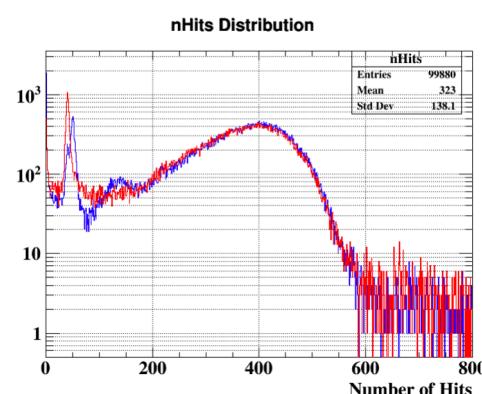
100 GeV(Run 061230)



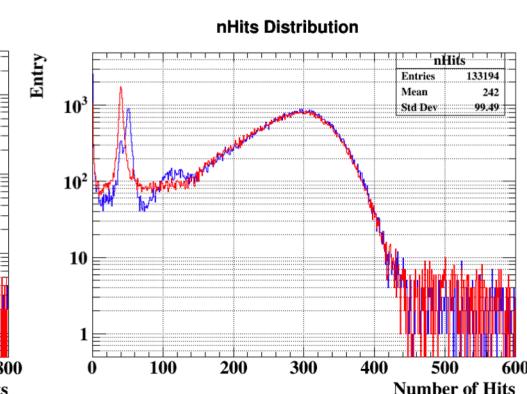
80 GeV(Run 061280)



60 GeV(Run 061395)



40 GeV(Run 061275)



20 GeV(Run 061271)

