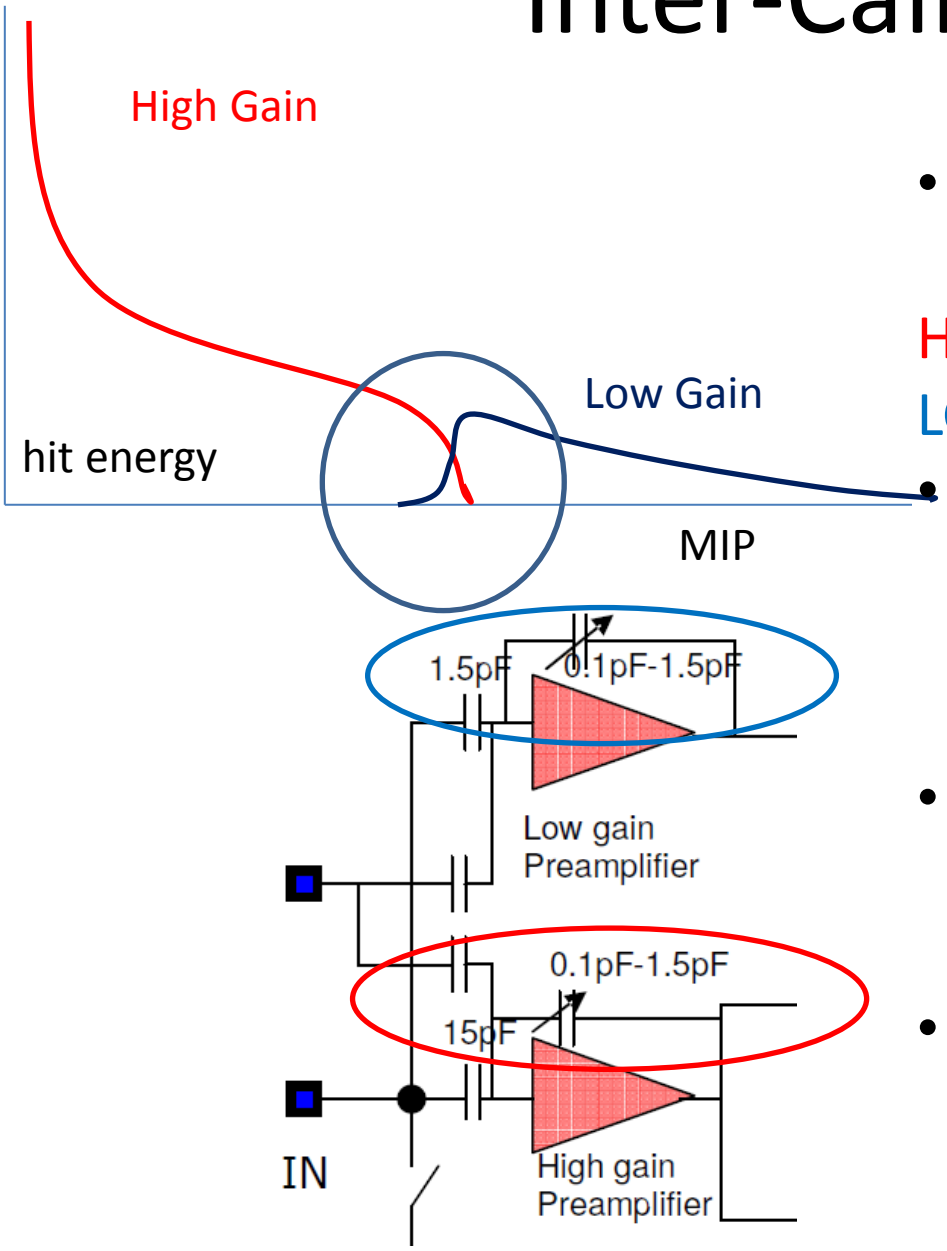
HG/LG Inter-Calibration

08.08.2018

AHCAL Analysis Workshop at U. Tokyo

Yuji Sudo

Inter-Calibration



- SPIROC2B has 2 signal output lines. High Gain and Low Gain

HG -- small deposited energy hits

LG -- large deposited energy hits

- In principle, IC factor is constant and depends on ratio of capacitors because of the circuit design. (IC ~20 June 2018)
- In the real world, IC factor is different for each channel →IC for HG-LG is important
- After inter-calibration, HG and LG output should be connected smoothly

Methods to extract IC factor

LED runs

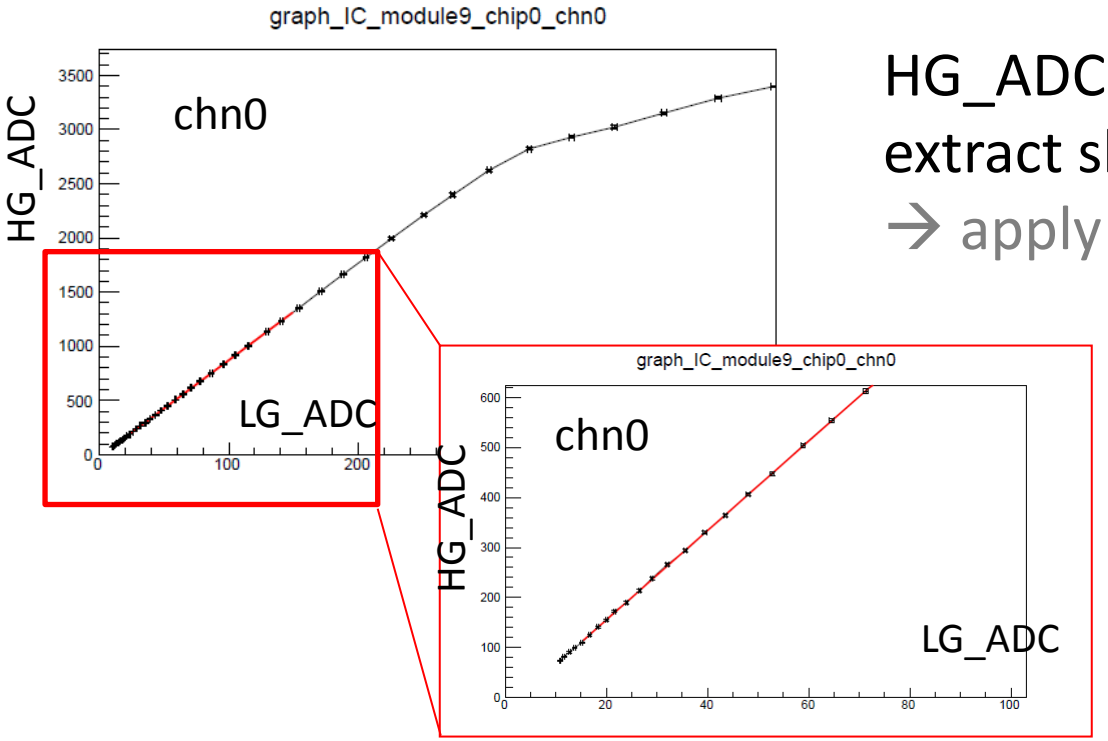
- slope of HG_ADC vs LG_ADC
- ΔHG_ADC/ Δ LG_ADC

Beam runs

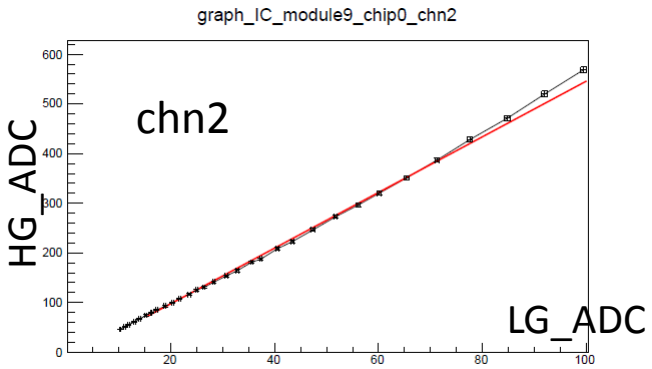
- Muon Run with IC mode (HG/LG)
- shower data

IC factor from LED runs slope of HG_ADC vs LG_ADC

gain calibration led run in the commissioning phase
module 9, PA HG=600fF, LG=600fF, IC ~10



HG_ADC = **IC***LG_ADC + α
extract slope → calc. correction
→ apply correction



starting point of LED V higher than chn0

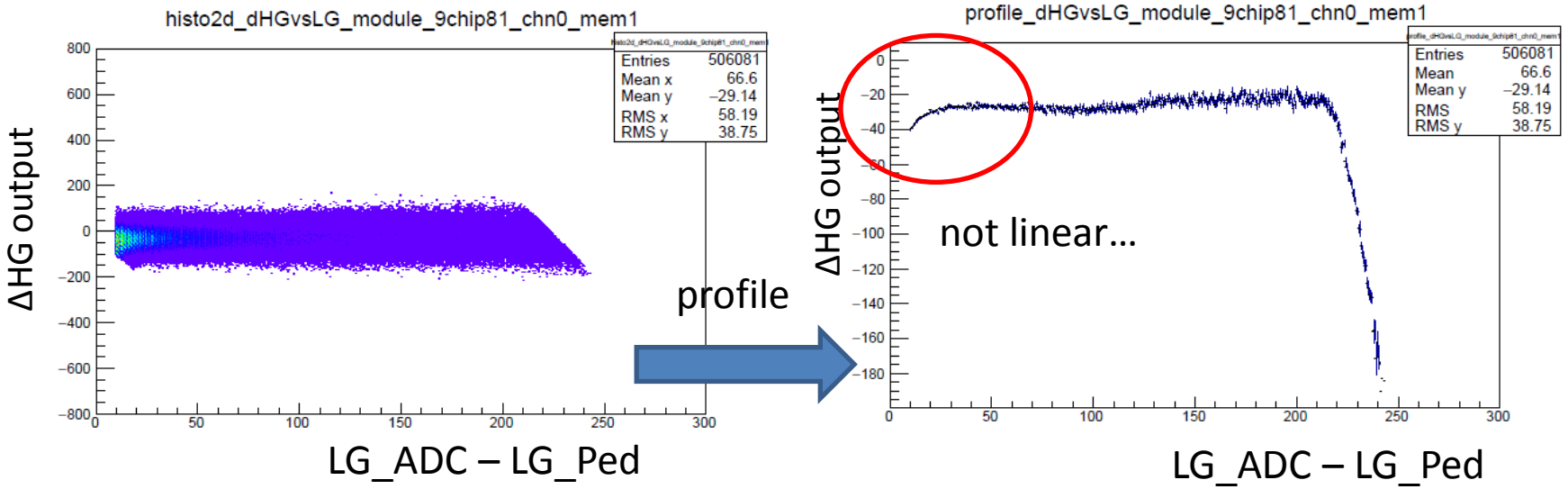
- HG/LG IC factor from first fit ~9-10

IC factor from LED runs correction : ΔHG output ms LG_ADC

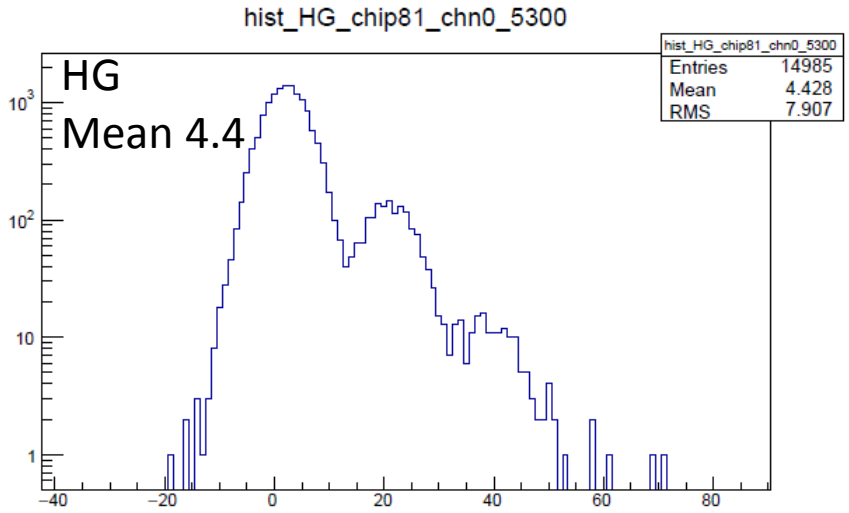
gain calibration led run in the commissioning phase
module 9, PA HG=600fF, LG=600fF, IC ~10

ΔHG output= (HG_ADC – HG_Ped) – IC*(LG_ADC – LG_Ped)

HG_ADC = **IC***LG_ADC + α
extract slope → calc. correction
→ apply correction



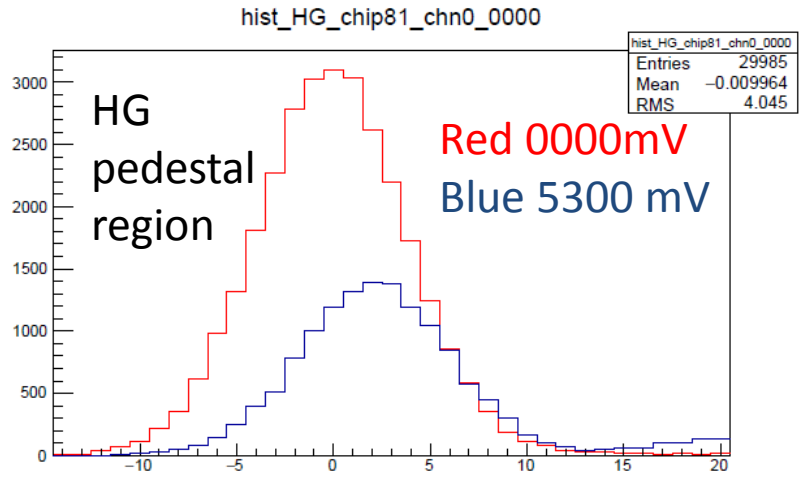
Pedestal shift
commissioning LED run module9

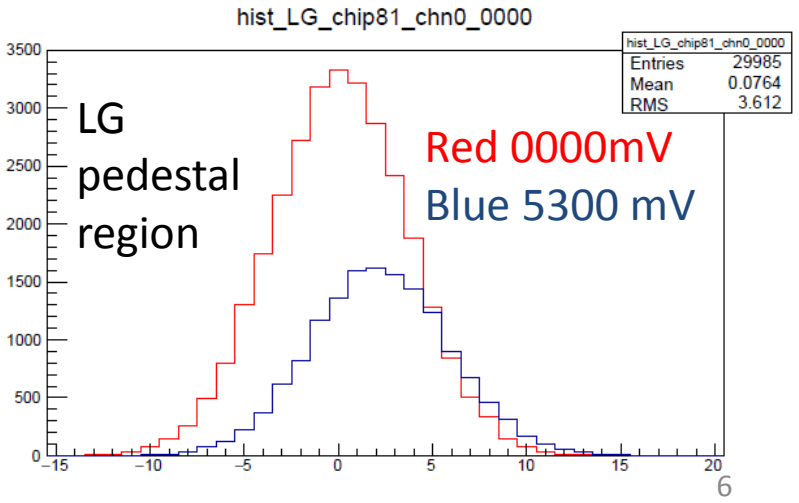


- pedestal shift

HG ~+2 ADC

LG ~ +2 ADC





IC factor from LED runs
dHG_ADC/dLG_ADC

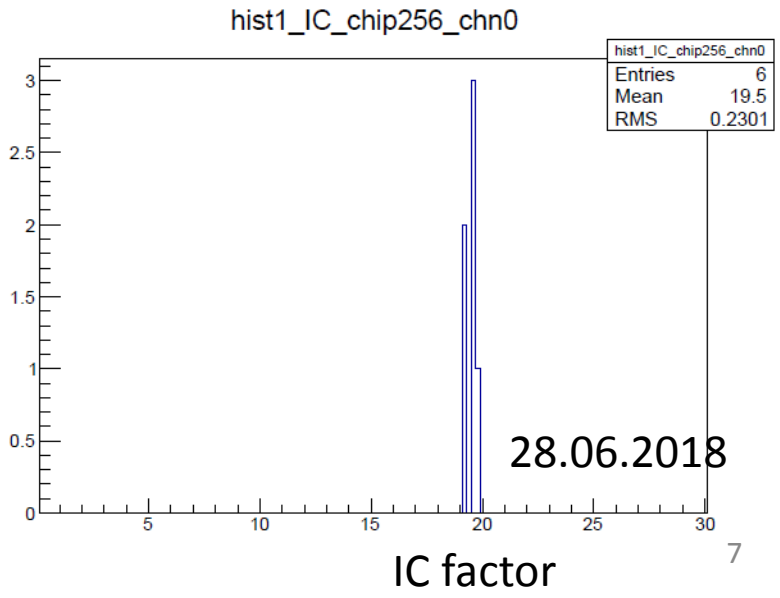
ΔLigit yield * HG_Gain = $(HG\_ADC_{i+1} - HG\_ADC_i)$
ΔLigit yield * LG_Gain = $(LG\_ADC_{i+1} - LG\_ADC_i)$

IC = HG_Gain/LG_Gain = $(HG\_ADC_{i+1} - HG\_ADC_i)/(LG\_ADC_{i+1} - LG\_ADC_i)$

calculate the IC factor mem. by mem. and take mean value for consecutive LED V data

Event selection

- $HG\_ADC_i > HG\_ADC_0$
- HG_ADC_i and $HG\_ADC_{i+1} > 10$
- HG_ADC_i and $HG\_ADC_{i+1} < 1500$
- $HG\_ADC_{i+1} - HG\_ADC_i > 100$
- HG_RMS_{i+1}-HG_RMS_i >0
- LG_RMS_{i+1}-LG_RMS_i >0



IC factor from LED runs
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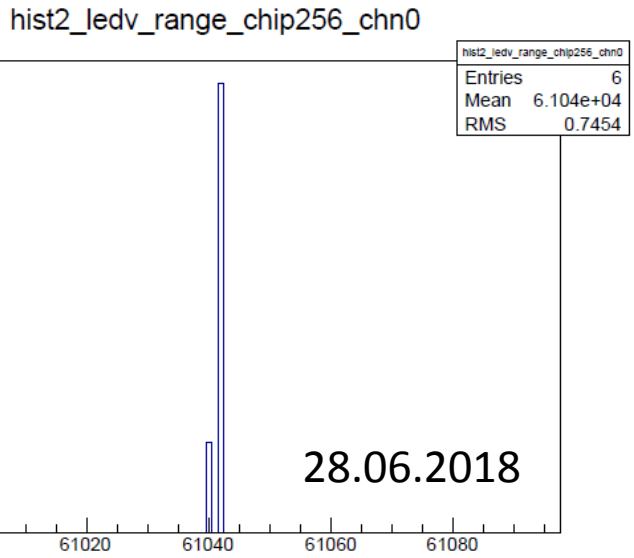
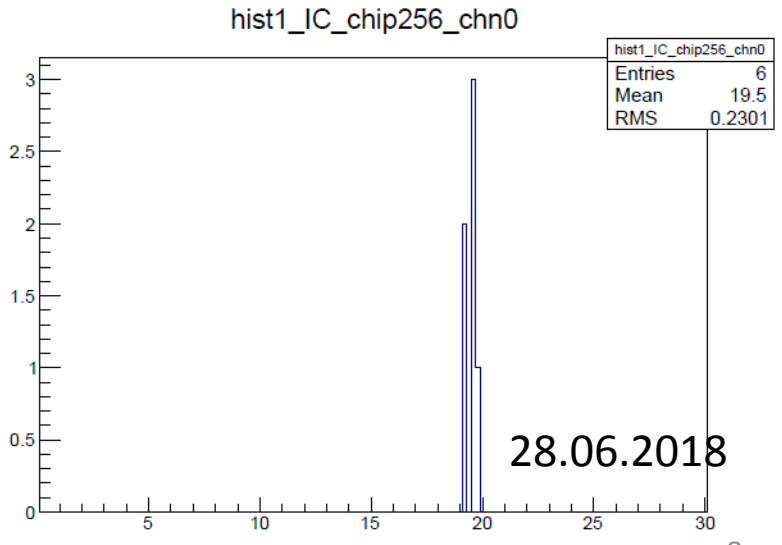
calculate the IC factor mem. by mem. and take mean value for consecutive LED V data

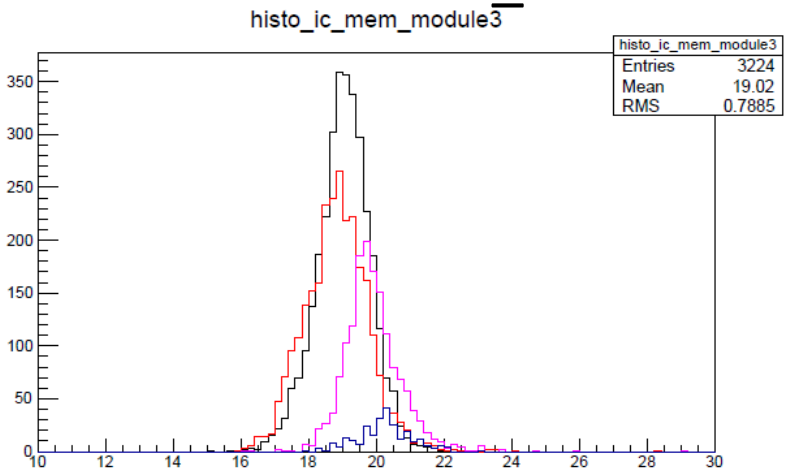


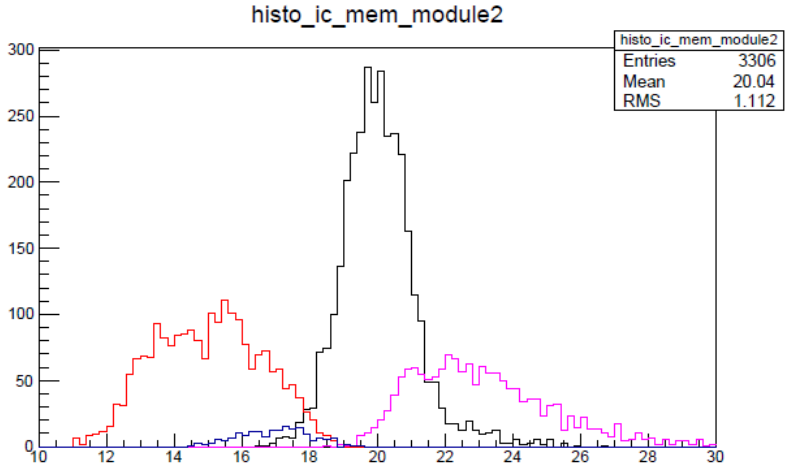


IC factor from LED runs dHG_ADC/dLG_ADC

IC = HG_Gain/LG_Gain = $(HG\_ADC_{i+1} - HG\_ADC_i)/(LG\_ADC_{i+1} - LG\_ADC_i)$
$(HG\_ADC_{i+1} - HG\_ADC_i > 50)$

LED Run 20180521_LG1200



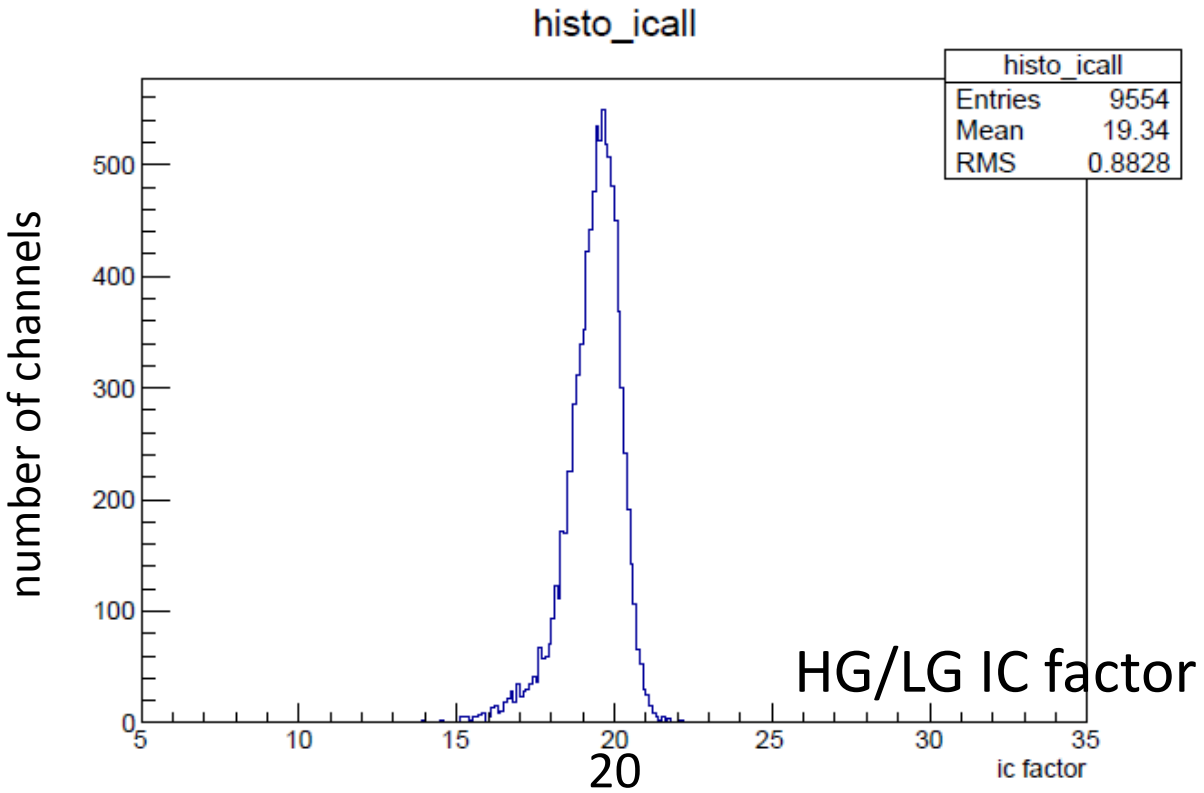


blue LEDV 5720 - 5700
pink LEDV 6020 - 6000
red LEDV 6220 - 6200
black LEDV 6420 - 6400

- IC factor ~19 and the shape looks not bad except module 2.
- IC factor looks depending on LEDV (light yield)

IC factor of all extracted channels

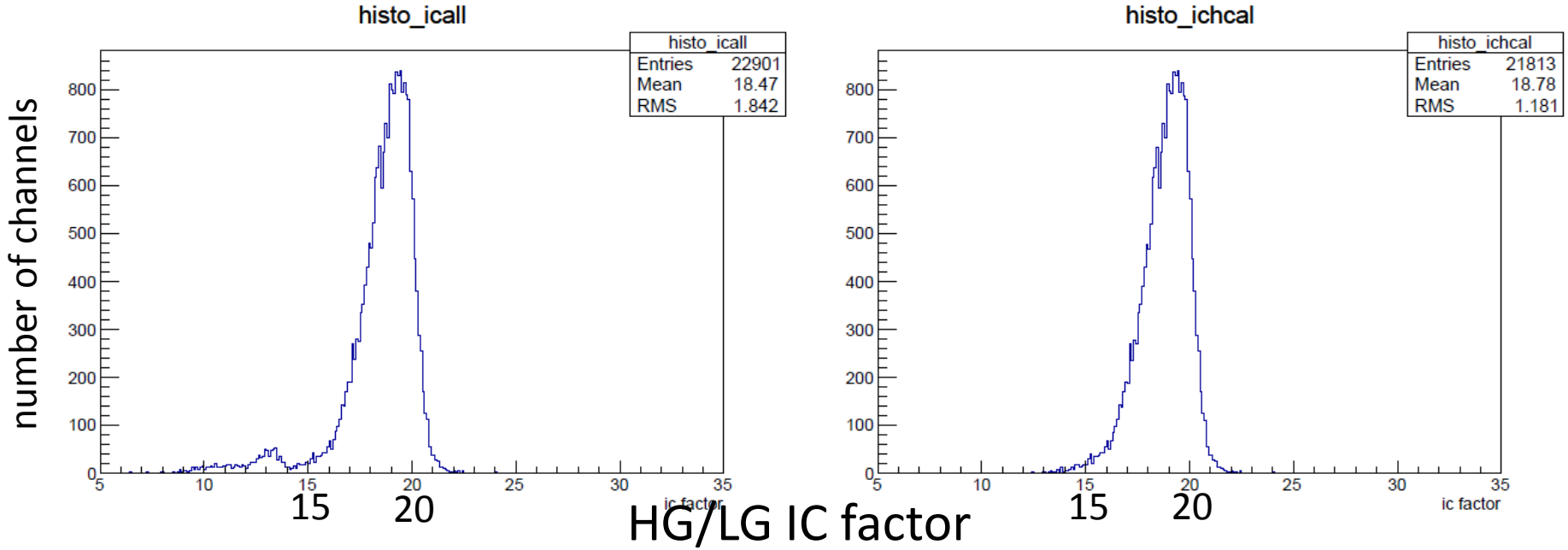
- long LED run data 28.06.2018
- dHG_ADC/dLG_ADC
- LED V : 20mV steps (5000mV – 7000mV)
- Mean of IC factor is 19.3, almost same as result of TB in May
- only 9554 channels are calculated



20

IC factor of all extracted channels

- LED V: 40mV steps (5000mV – 7000mV)
- LG of the tail-catcher seems 600 fF (28.06.2018)
- have to confirm which SC files are used for tail-catcher
- >20000 channels
- Mean of IC factor lower than the value with 20mV steps
- probably pedestal shift on HG ADC degrade IC factor

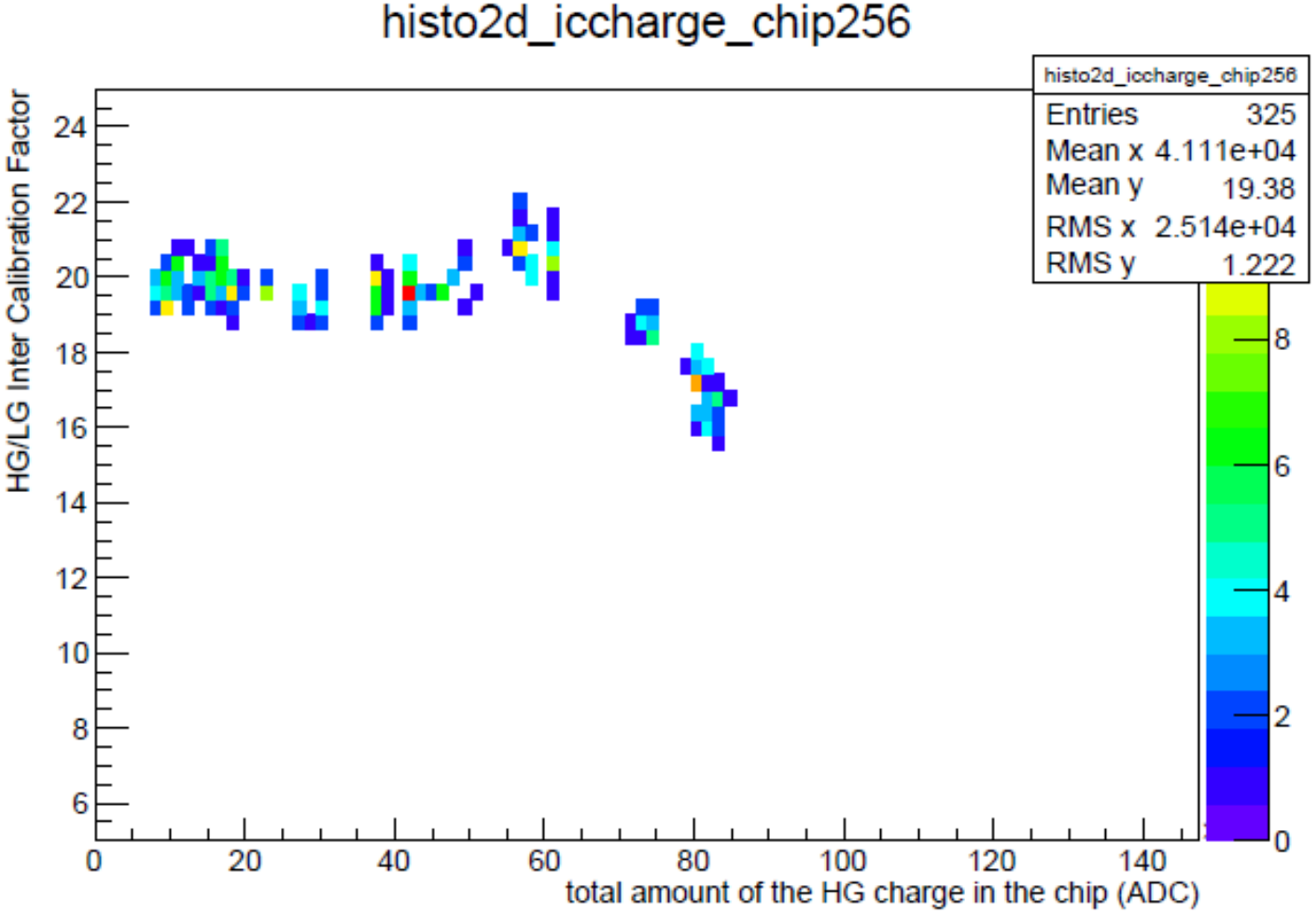


HG/LG IC factor

all modules include tail-catcher

all modules of the AHCAL

IC of channels on a chip
vs
total amount of the HG charge on the chip



IC of channels on a chip
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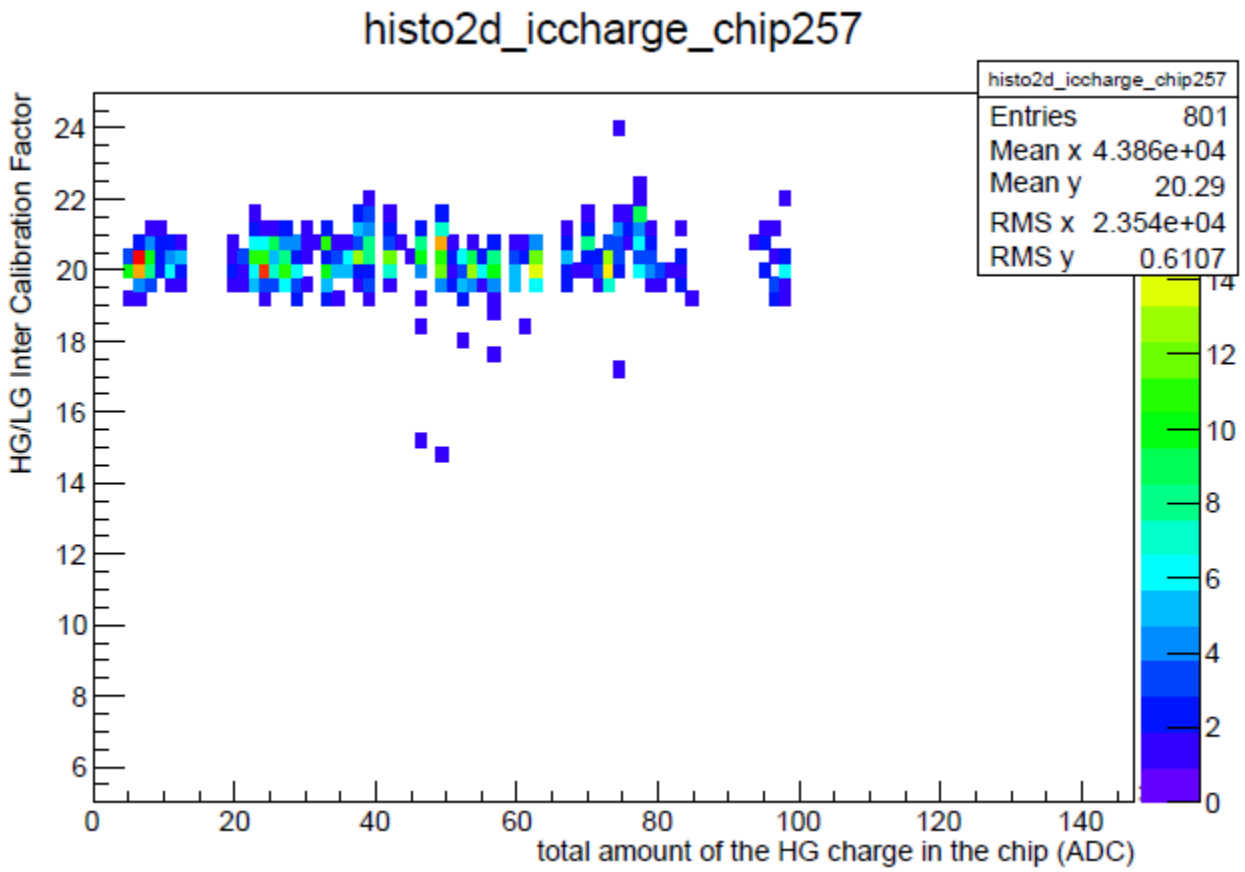
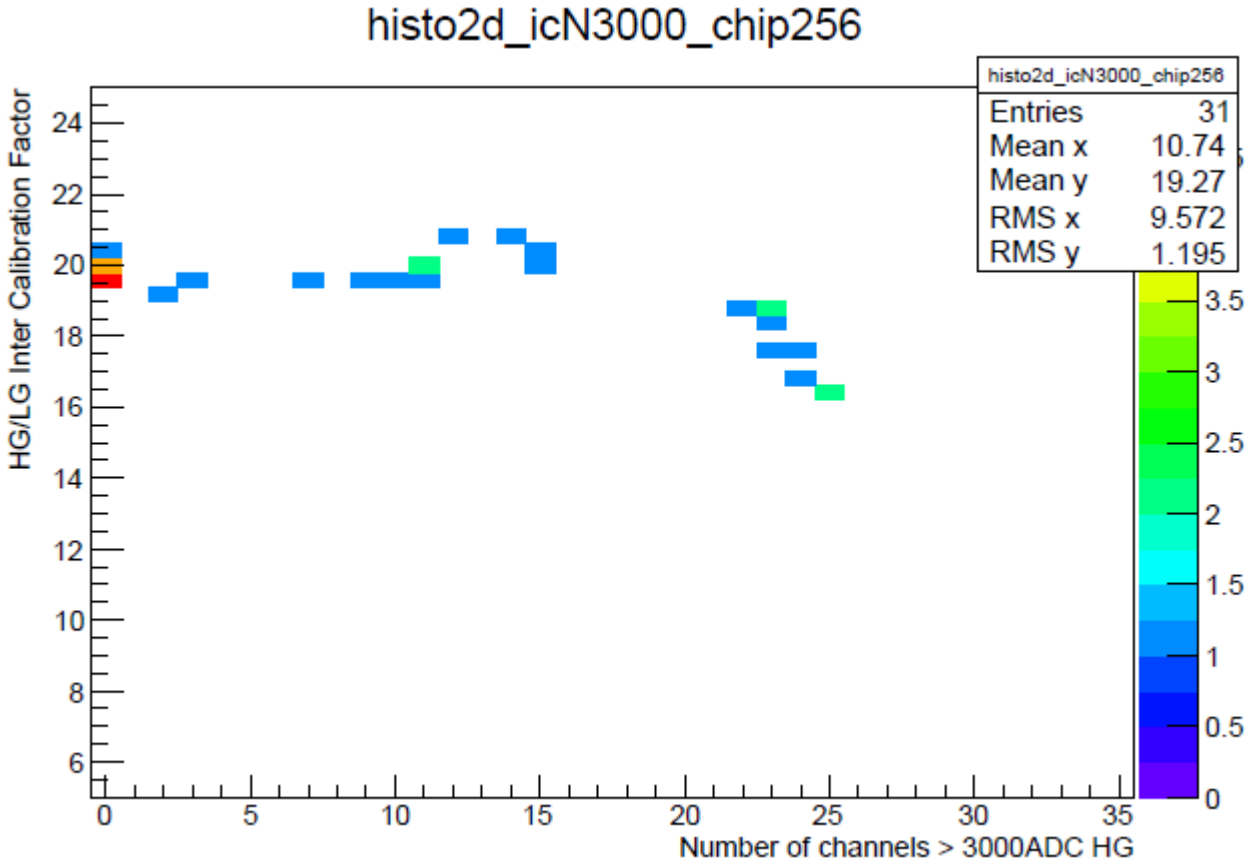
total amount of the HG charge on the chip



average IC of a chip
vs
Number of channels > 3000 ADC (HG)



average IC of a chip
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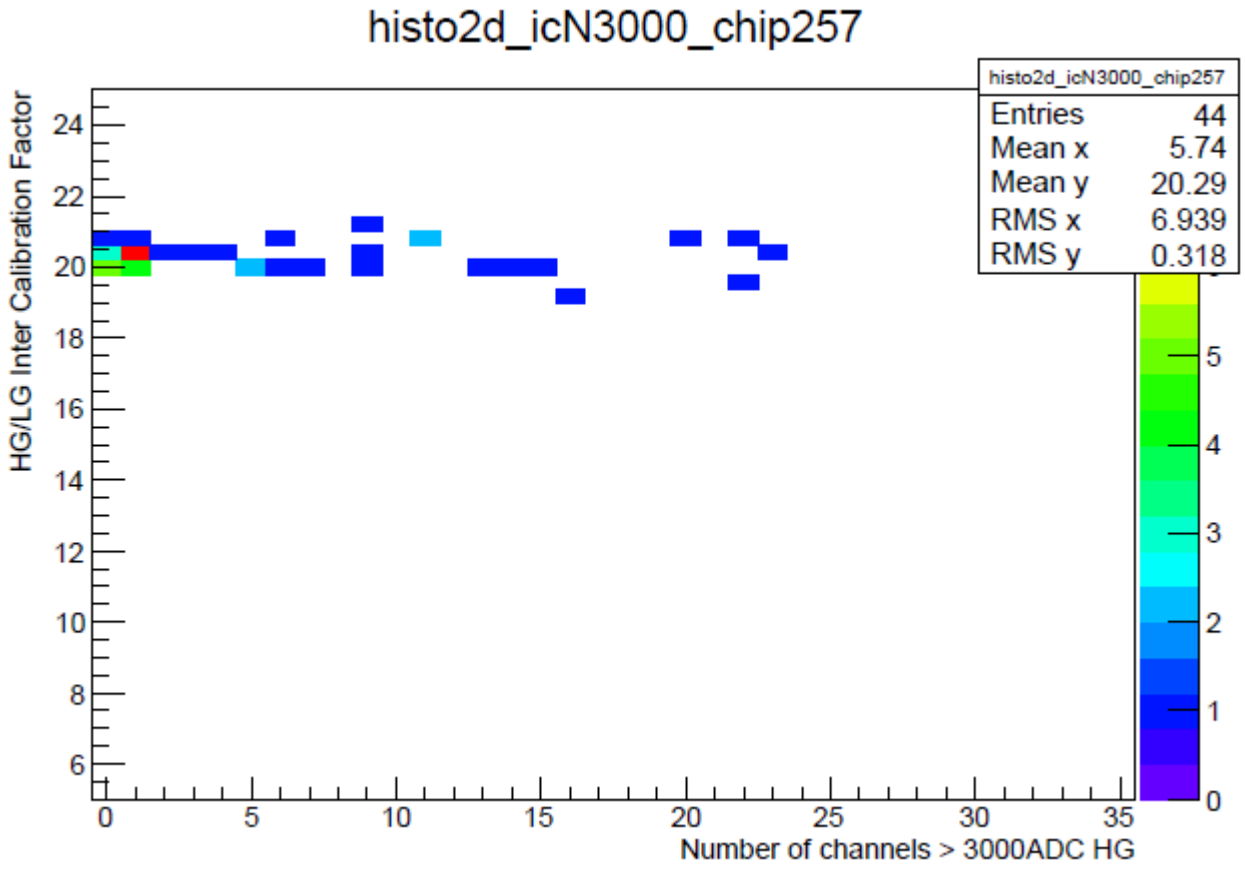
Number of channels > 3000 ADC (HG)



Summary of LED runs

- slope of HG vs LG and ΔHG_ADC/ΔLG_ADC methods seems good

(If the total amount of charge on a chip is small)

slope of HG vs LG

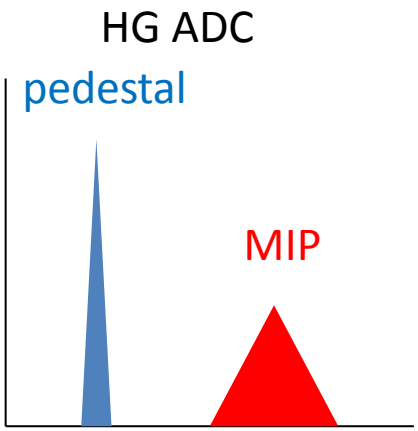
- ok to extract a slope
- (maybe) difficult to complete the same method as 2015 data analysis

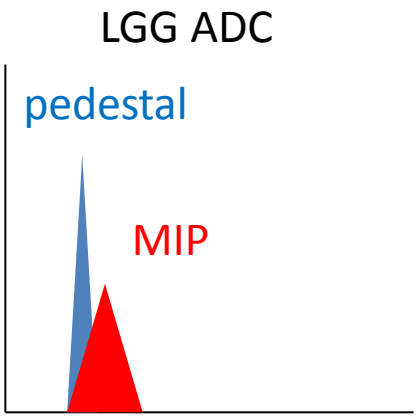
ΔHG_ADC/ΔLG_ADC

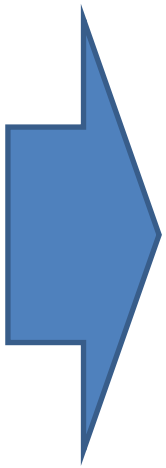
- ~5% difference between results with 20mV and 40mV steps

- systematic uncertainty will be estimated by the difference of those two methods

IC factor from 40 GeV Muon Run

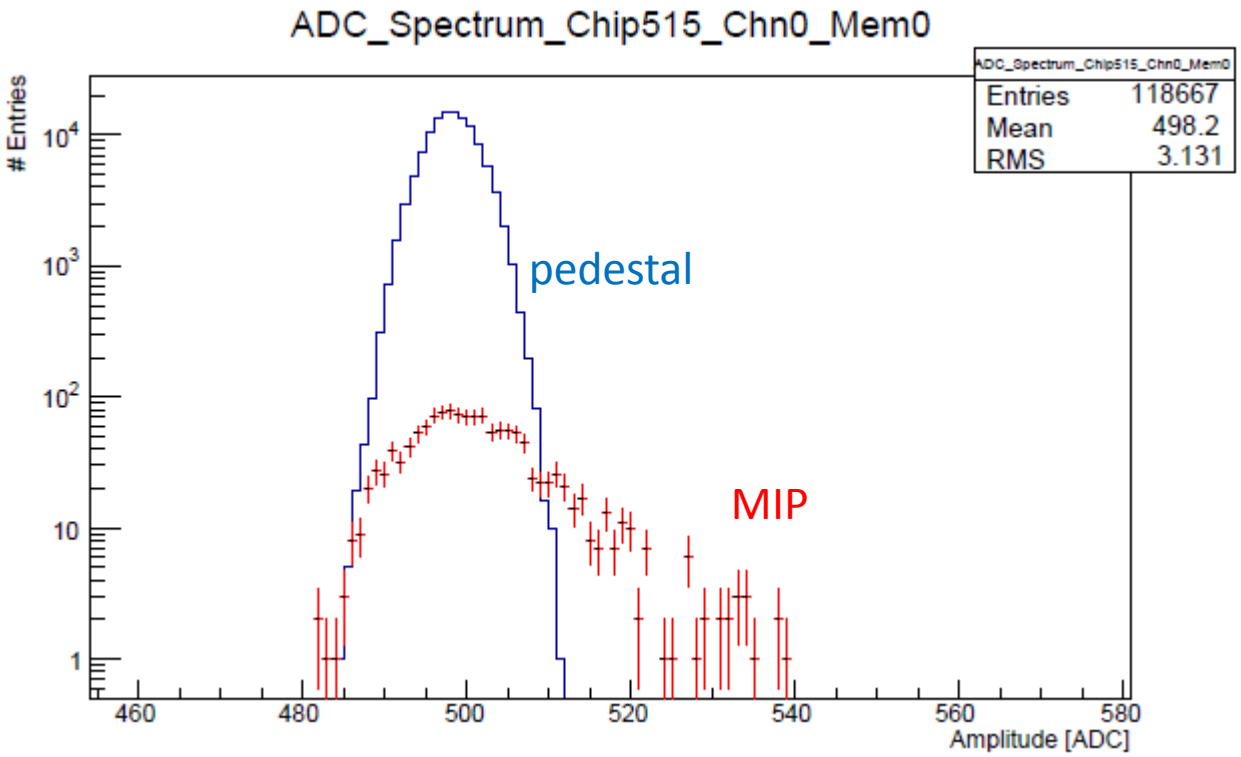






MIP_HG/MIP_LG = HG/LG IC factor

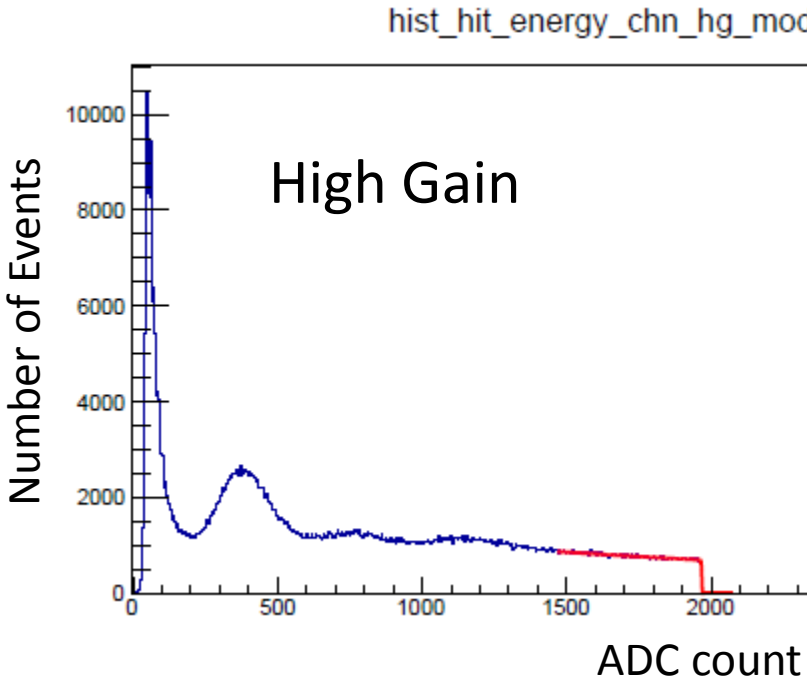
IC from 40 GeV Muon IC Run

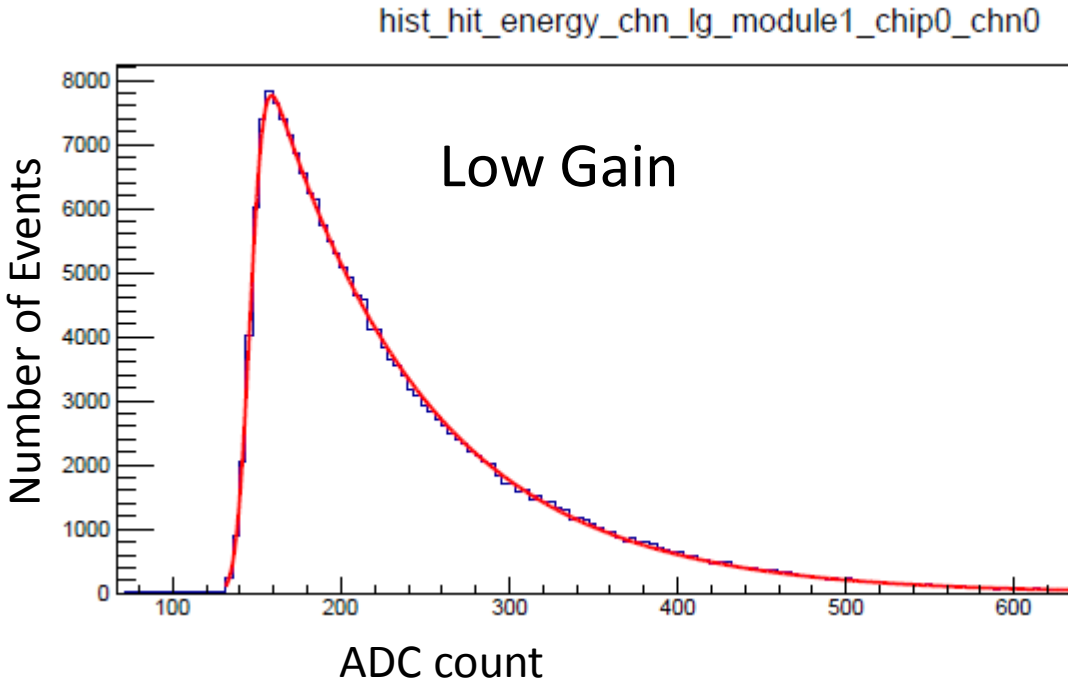


MIP signal populates around pedestal position….
a few modules are checked and show same behavior

→ need pedestal correction? → IC factor should be extracted from LED run

IC factor from shower data





after pedestal subtraction

- Fit an edge of a distribution by the complementarity error function and original shape.

High gain: right hand side shoulder (auto-gain threshold)

Low gain : left hand side shoulder

e.g. electron beam data

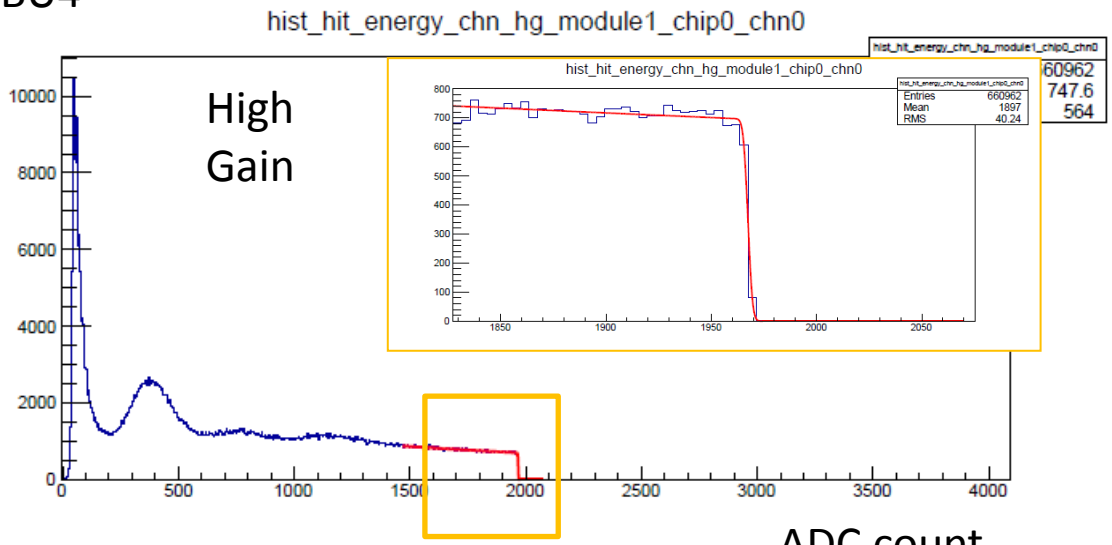
original shape: A*exp(-Bx)

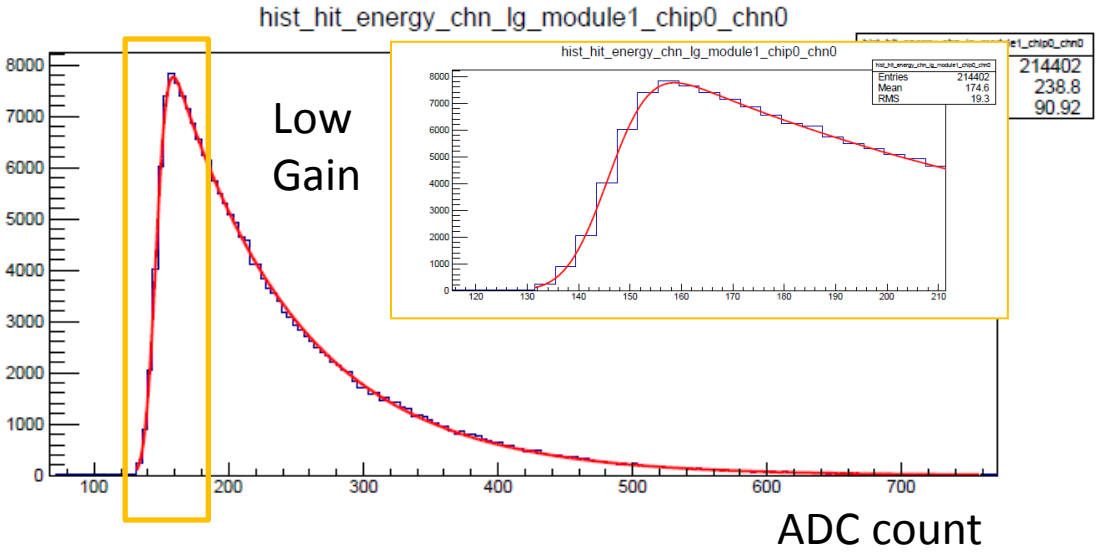
Erfc((x-C)/(D*$\sqrt{2}$))

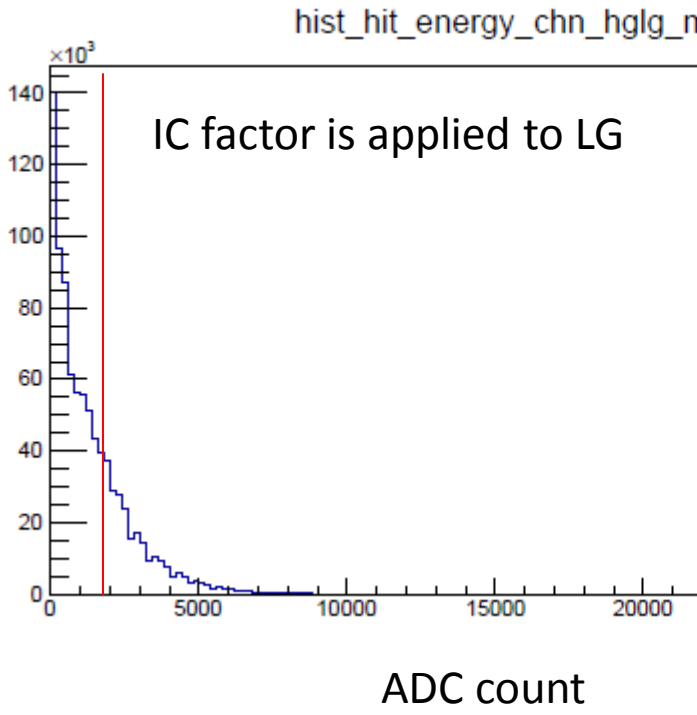
fit function: A'*exp(-Bx)*Erfc((x-C)/(D*$\sqrt{2}$)) → IC factor = C_{HG}/C_{LG}

layer 1
chip0, chn0
HBU4

Beam data in ADC unit



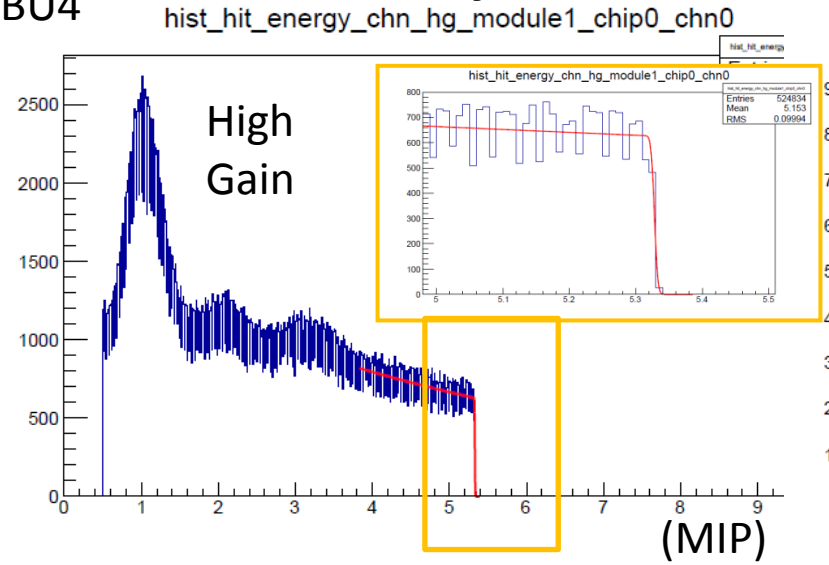


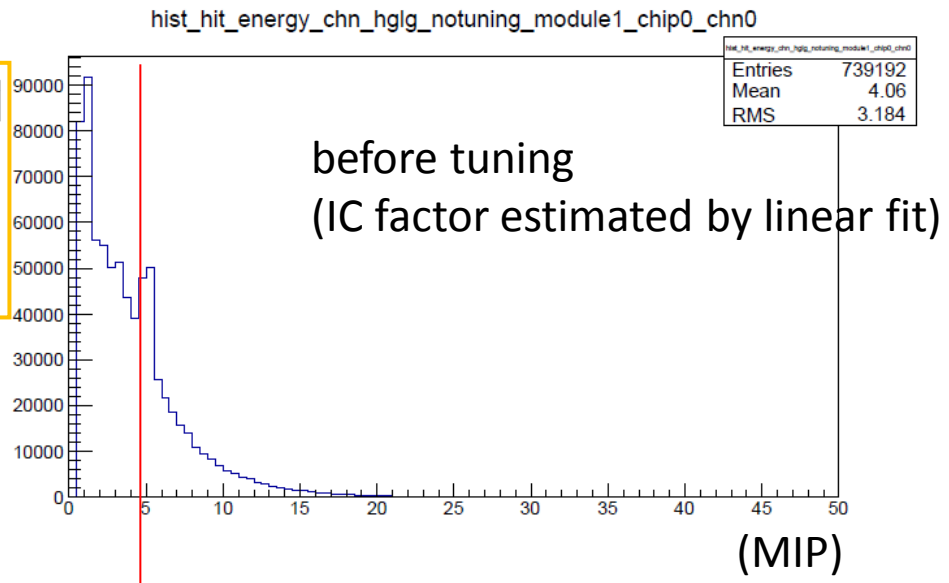


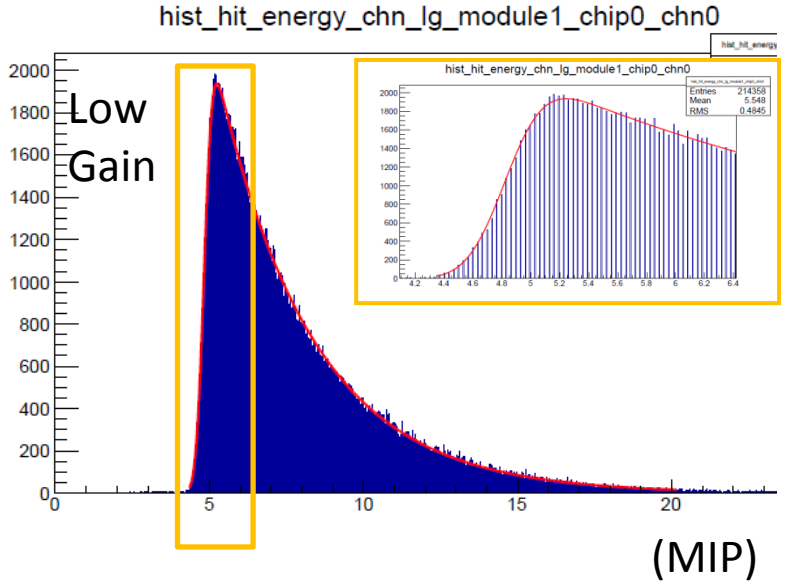
Beam data in MIP unit, HBU4

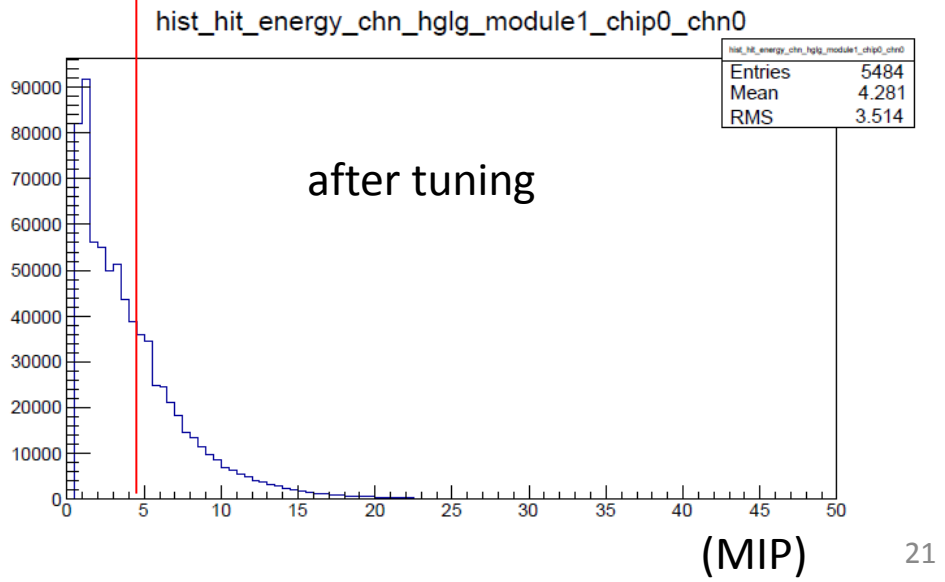
layer 1
chip0, chn0
HBU4

already converted to MIP from ADC





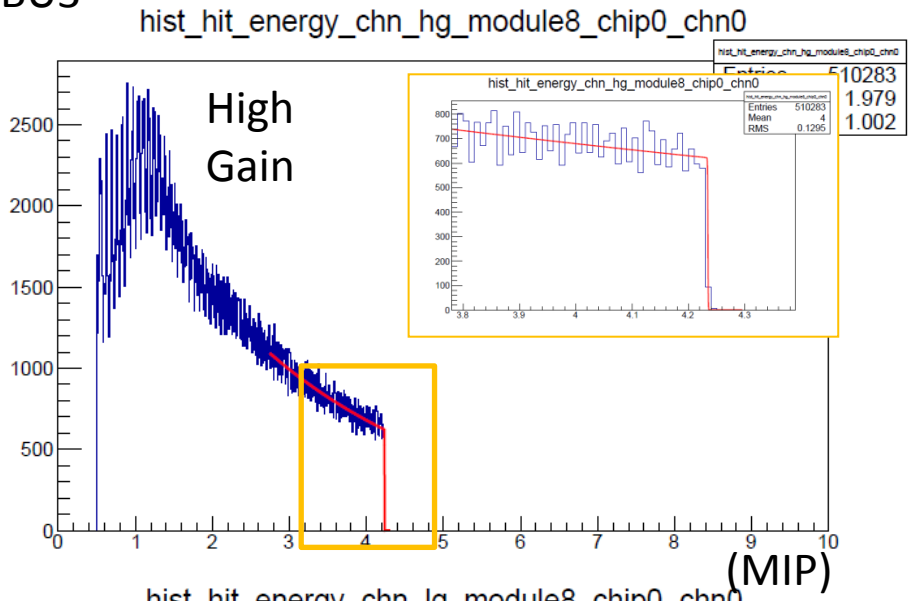


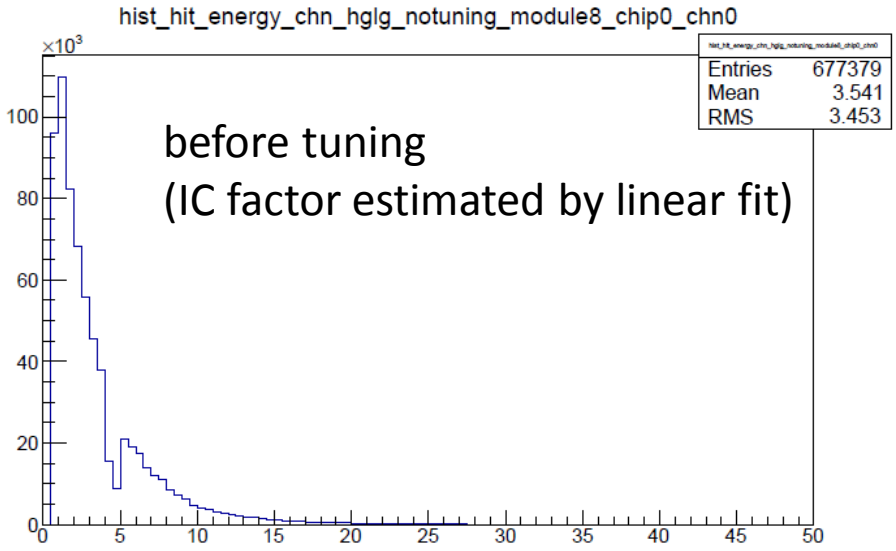


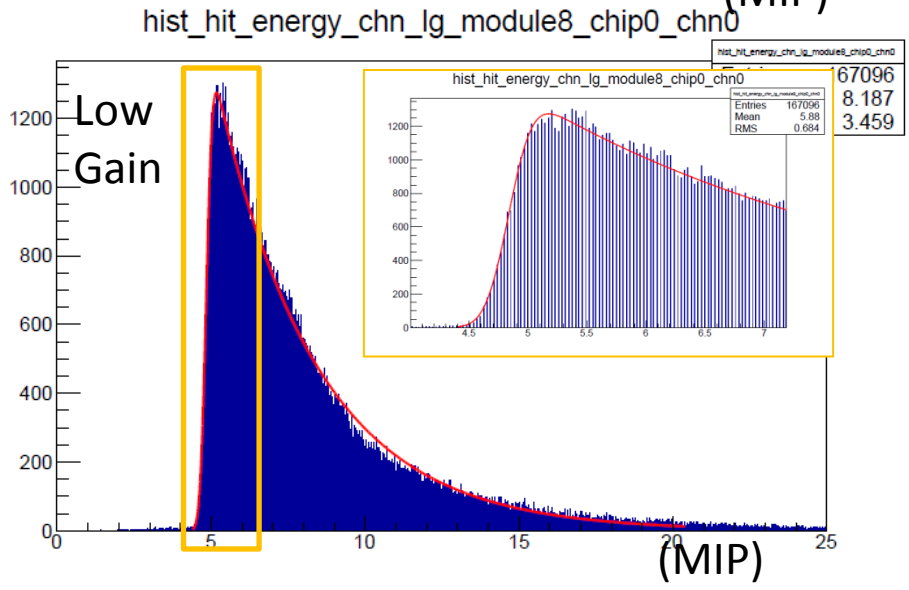
layer 8
chip0, chn0

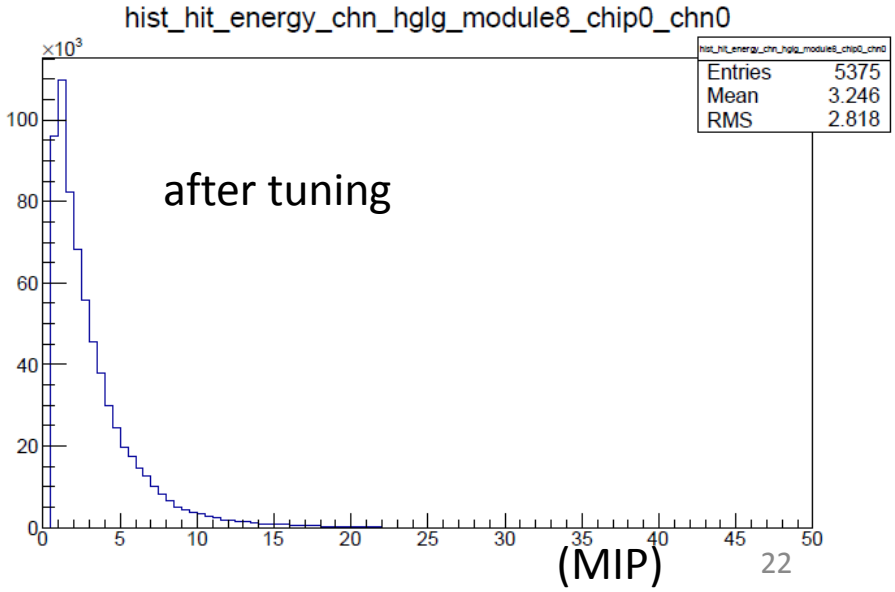
HBU3

Beam data in MIP unit, HBU3



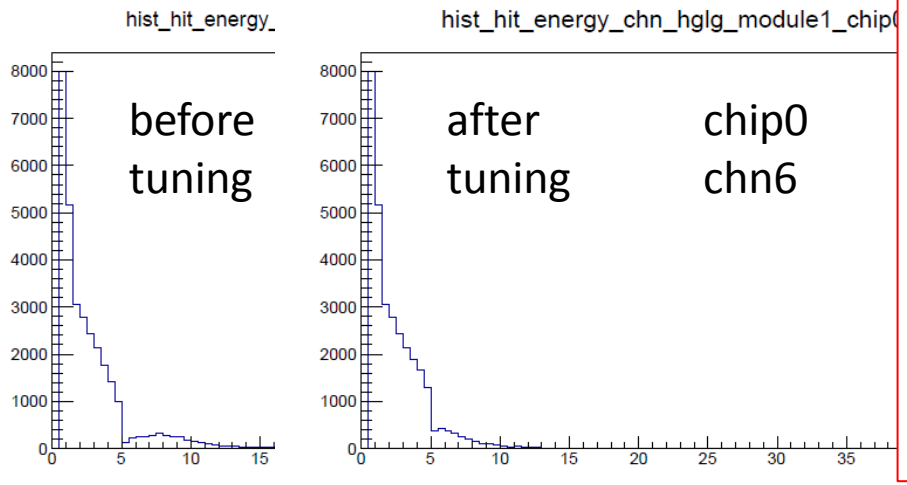






merit and demerit of the new method

- merits
  * beam and LED data are available
  * AT and ET are available
  * auto-gain is used → much similar or exactly same situation as physics run
  * much less effect from pedestal shift by the total amount of charge in a chip (there are no saturated channel)
  * at least 1 or 2 LED V points



- demerits
  * good estimation of original shape is needed → **need large statistics**

-- In the case of beam data
  * useful for channels placed **near by beam center**
  * high beam energy

  * **pedestal shift** due to a signal of particle, auto-trigger, auto-gain and unknown reason

-- In the case of LED run
  * adjust the LED V corresponding to threshold of auto-gain
  * many LED V points are probably required to find auto-gain threshold.
  * total amount of charge in a chip