
# Preliminary results from CALCE Scintillator-based ECAL especially on a temperature correction

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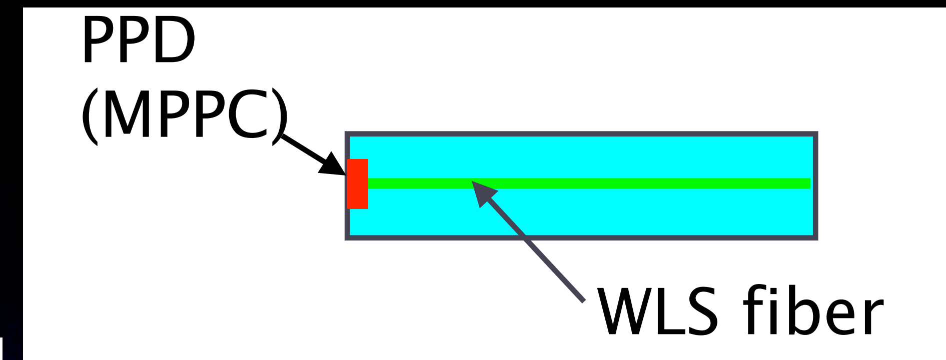
on behalf of CALICE-ASIA and CALICE group
Katsushige Kotera, KEK/DESY

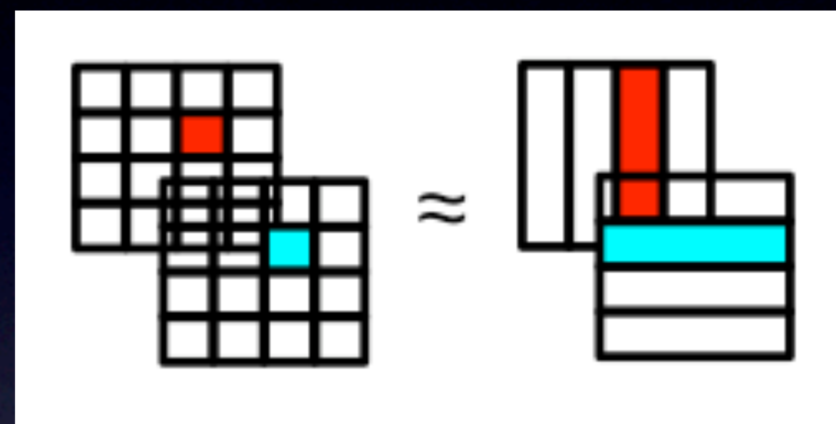
# Out line

- Introduction of Scintillator-based ECAL for ILD,
- CALICE FNAL TB in Sep. 2008 and May 2009,
- Results of 2008 data,
- Temperature condition in 2009,
- ADC/MIP conversion factor (ADC/MIP.conv.factor ) depending on temperature,
- Results of 2009 data,
- Comparison between 2008 and 2009 results ( MIP/GeV ),
- Summary and plan.

# Scintillator strip ECAL for ILD

- Requirments
  - Energy resolution
  - Linearity
  - Uniformity
  - Granularity
  - Robustness
  - Low cost
  - Magnetic field tolerance

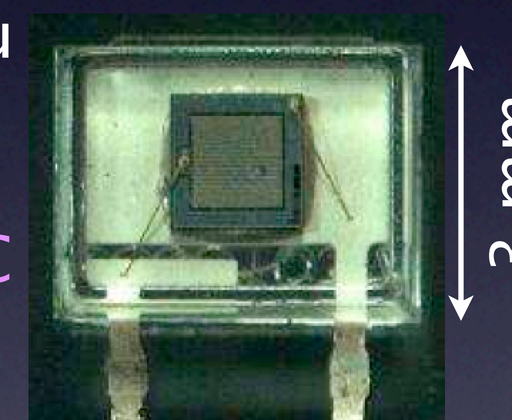


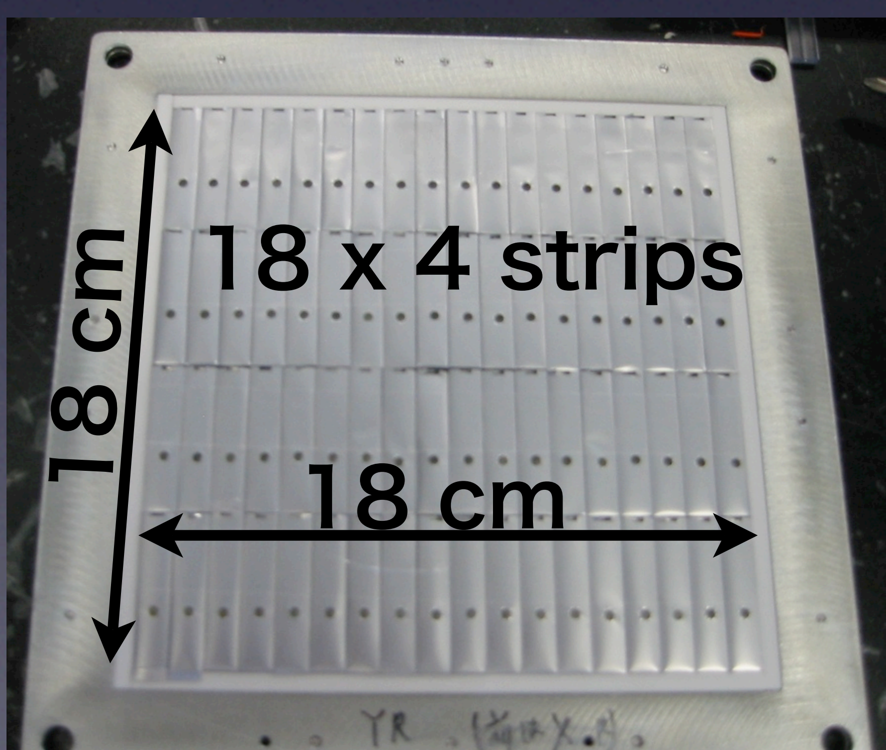



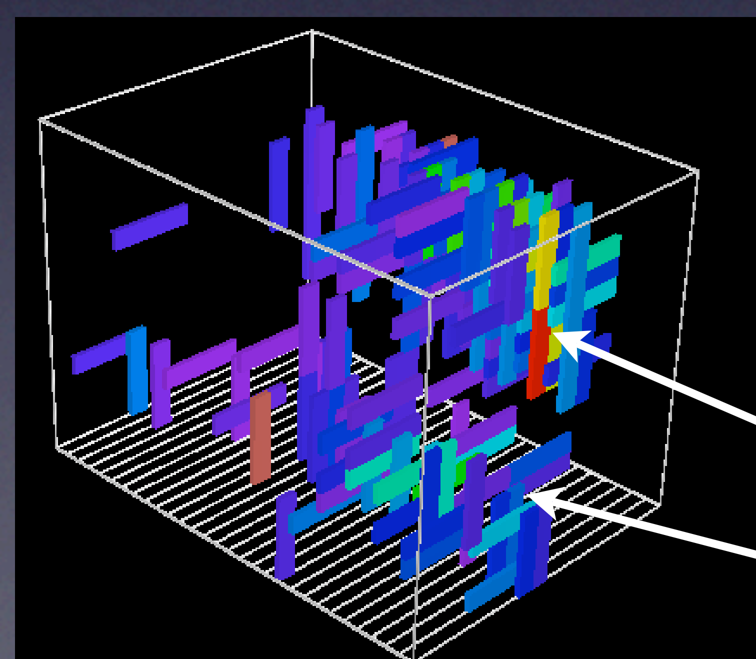

Plastic scintillator 10mm x 45 mm x 3mm

1mmΦ WLS fiber

Hamamatsu
1600 pixel
1 x 1 mm
PPD = MPPC
in Plastic
package



$\pi^0 \rightarrow \gamma\gamma$

# CALICE ScECAL/AHCAL Test beams @ FNAL

Sep 2008 → **7.5 months** → May 2009

**Energy scan**

Sep 2008:

$e^-$ Uniform: 1,3,6,12,16,25,32 GeV
Center: 1,3,6,12,16,25,32 GeV

$\pi^-$ Center: 3,6,12,16,25,32 GeV

May 2009:

$e^-$ Center:
1,2,4,8,12,15,20,30,32 GeV

$\pi^-$ Center:
2,4,12,15,20,32,60$^{(+)}$ GeV

**Position scan**

Sep 2008: $e^-\pi^-$ mixed 32 GeV

May 2009: $e^-$ 15 GeV

**Tilt angle scan**

Sep 2008:

10°: $e^-$ 1,3,6,16,25,32 GeV
$\pi^-$ 3,6,16,25,32 GeV

May 2009:

20°: $e^-$ 2,4,8,15,20,32 GeV
$\pi^-$ 8,15,32 GeV

**$\pi^0$ run**

Sep 2008: $\pi^-$ 16, 25, 32 GeV

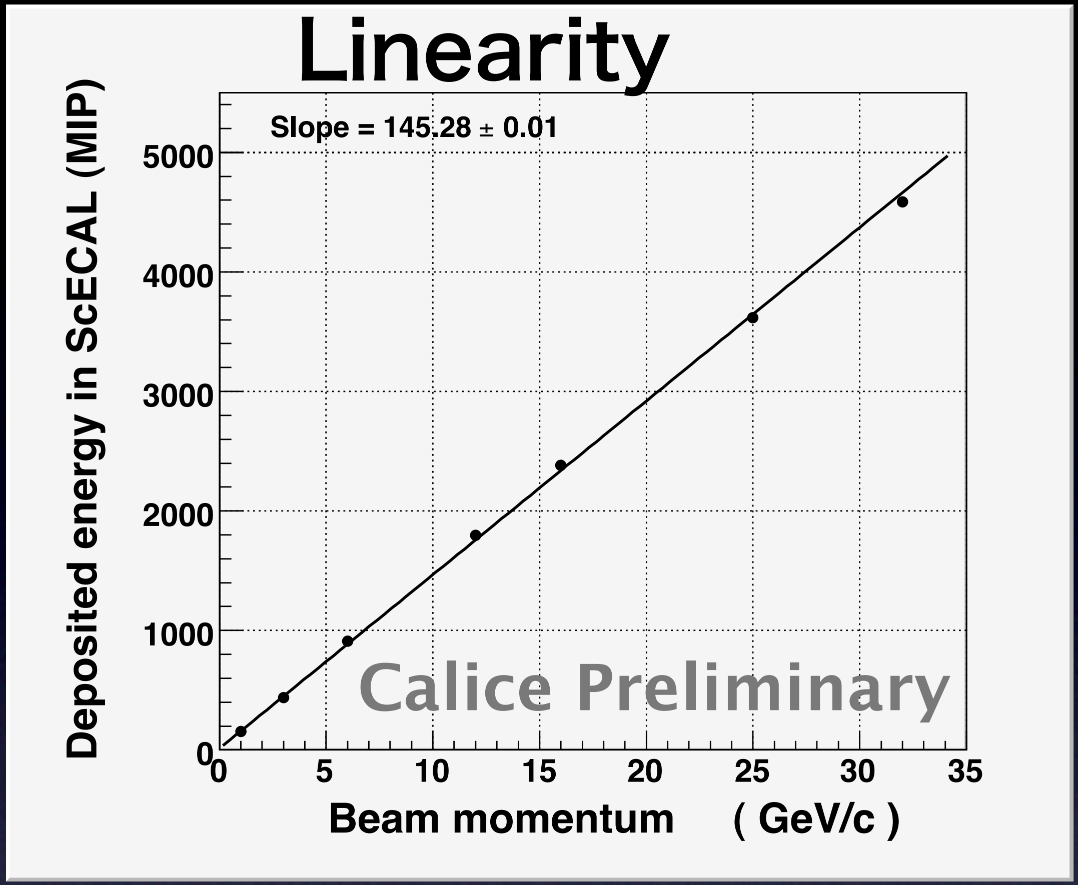
May 2009: $\pi^+$ 60 GeV
- cluster separation
- $\pi^0$ kinema. cut

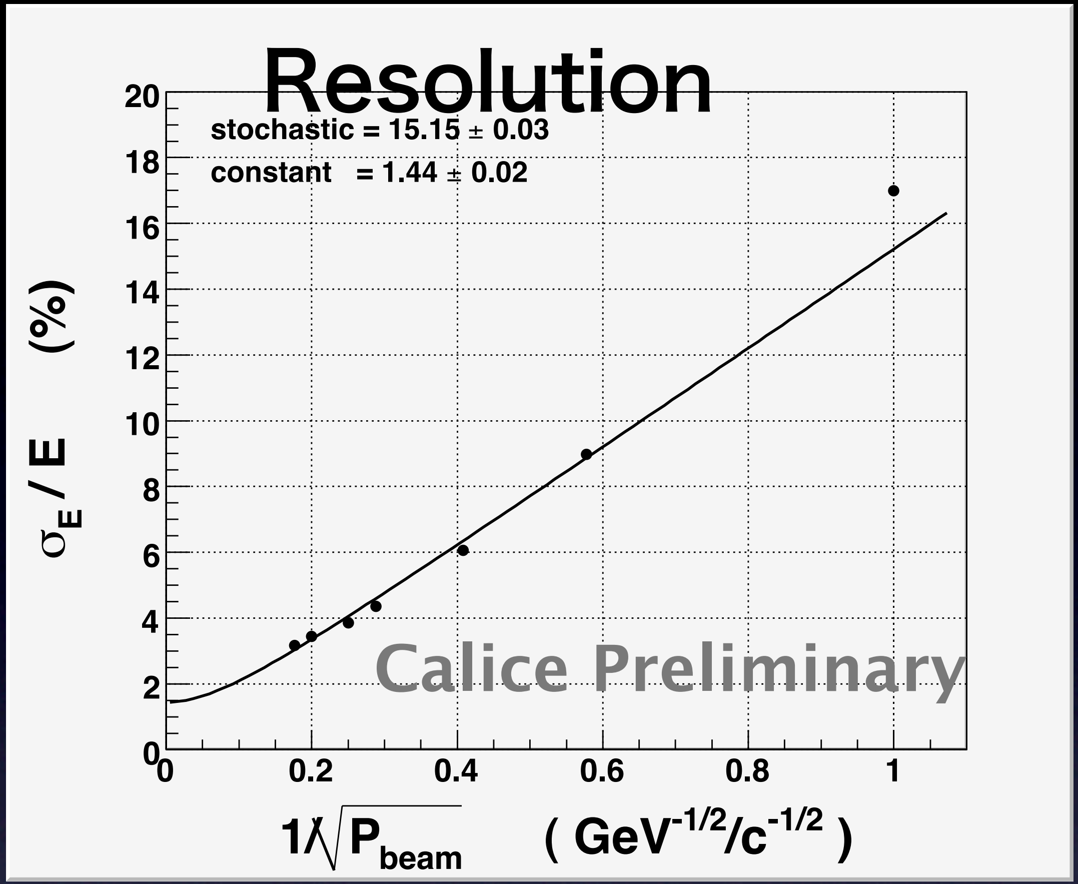
**MIP calibration 32GeV $\mu$**

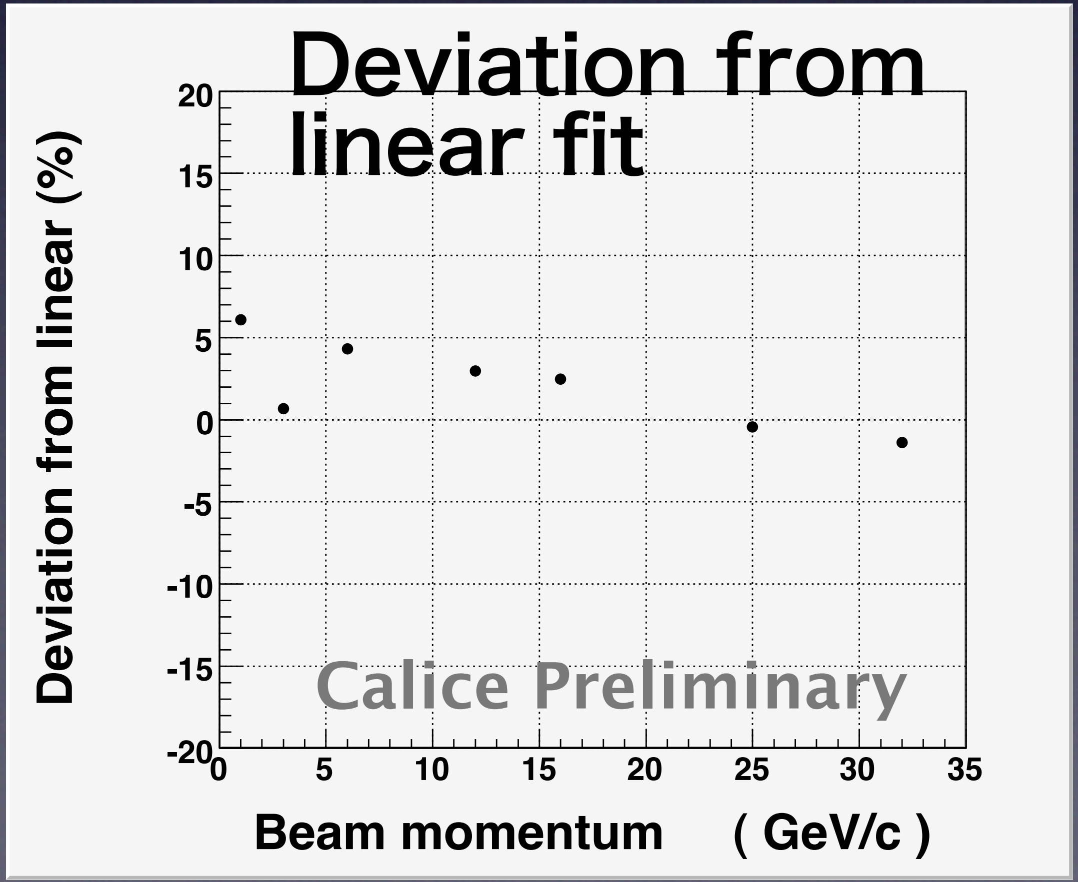
Sep 2008: ~ @ 20°C

May 2009: @ 20°C, 25°C,
Tilt angle 20° @ 20°C

# Sep. 2008 electron results



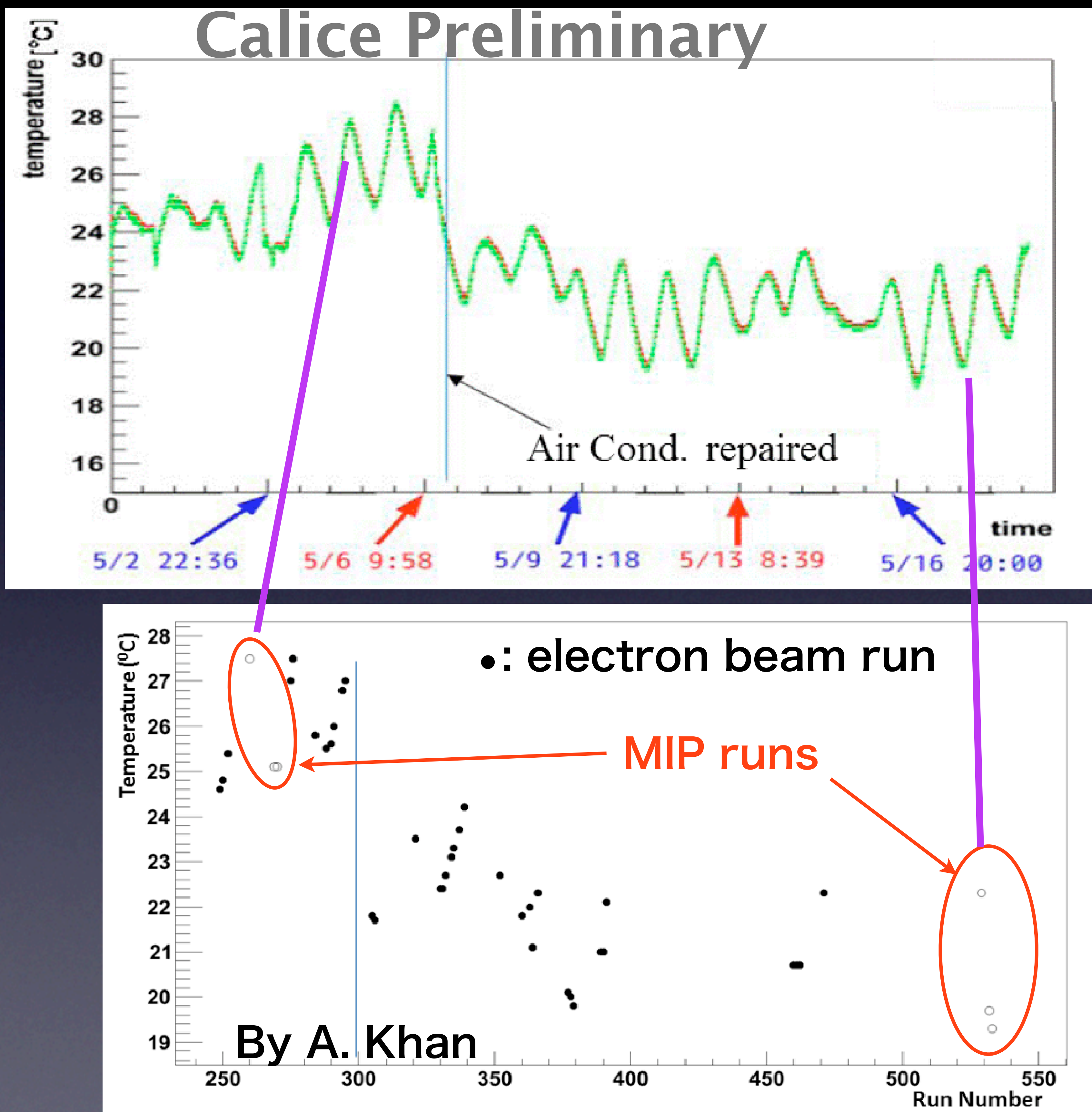

- Calice preliminary

| | |
|---|---|
| constant term | 1.44±0.02% |
| stochastic term | 15.15±0.03% |

* only statistic errors

- Temperature monitor malfunctioned ▶ w/o temperature correction.

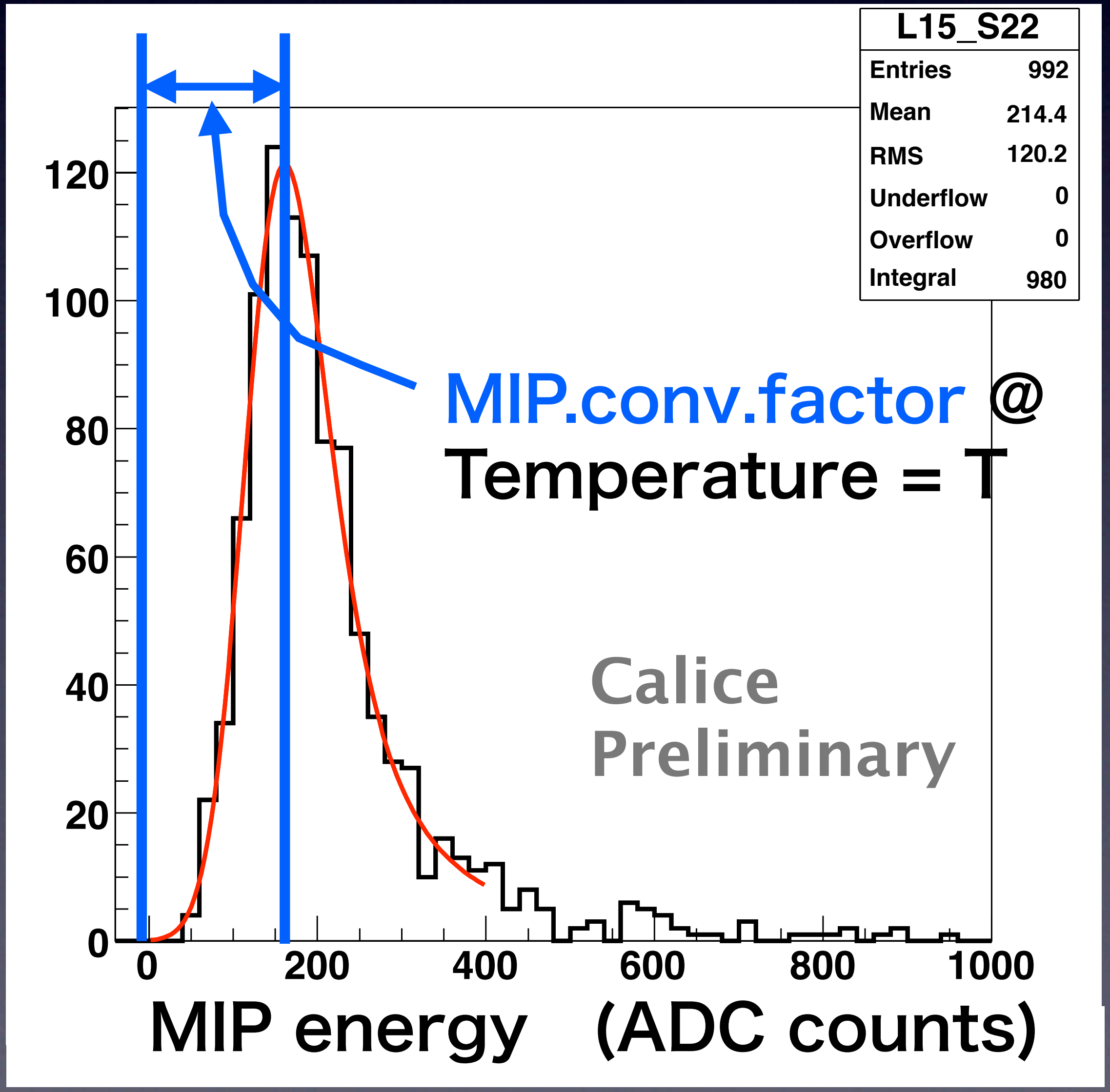
# May 2009 : Large Temperature fluctuation

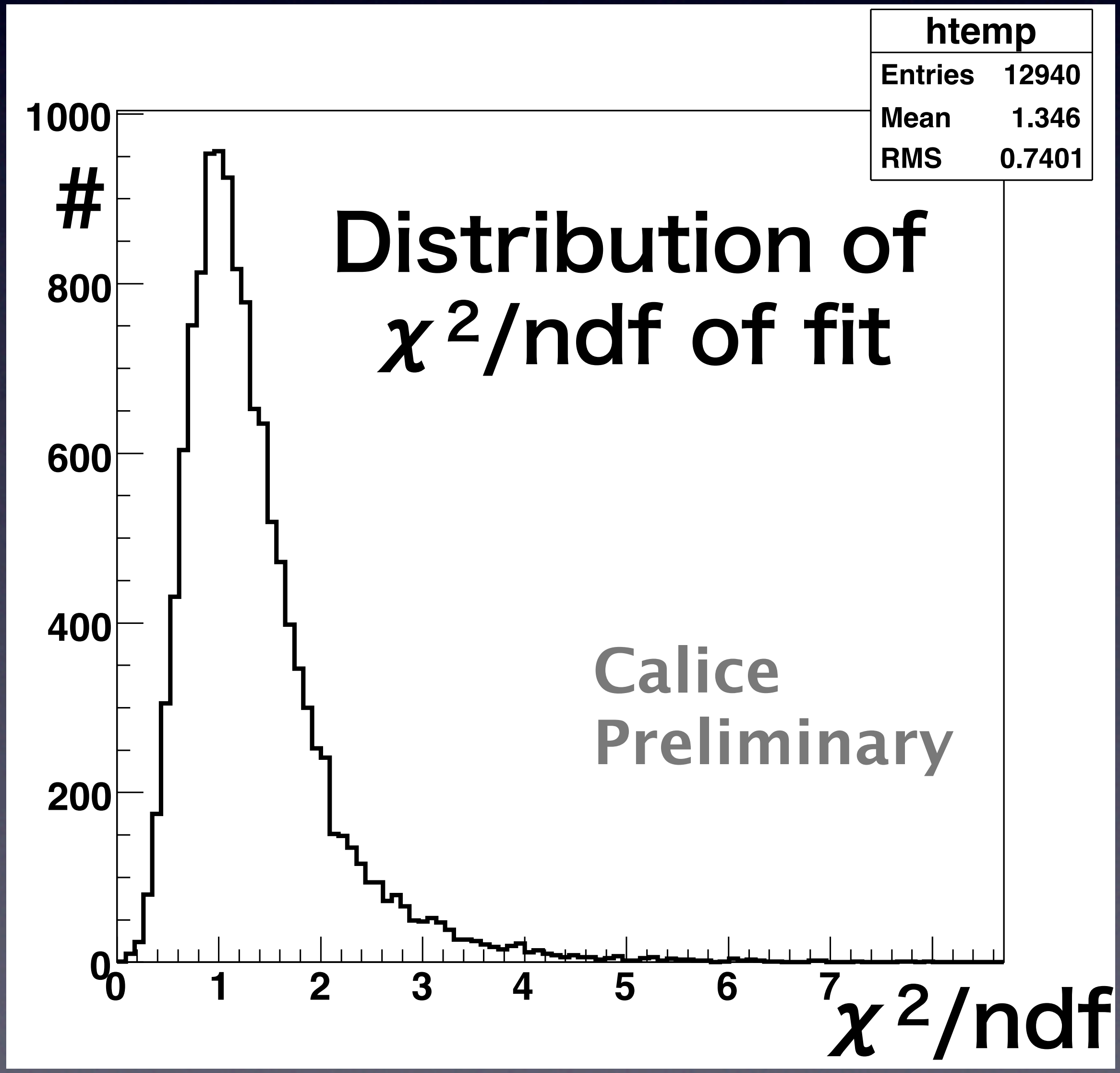



- Temperature varied 19℃ ~ 28℃,
- Chance to study temperature effect,
- First order temperature correction was applied in this study through ADC/ MIP.conv.factors for each channel.

# ADC/MIP.conv.factor

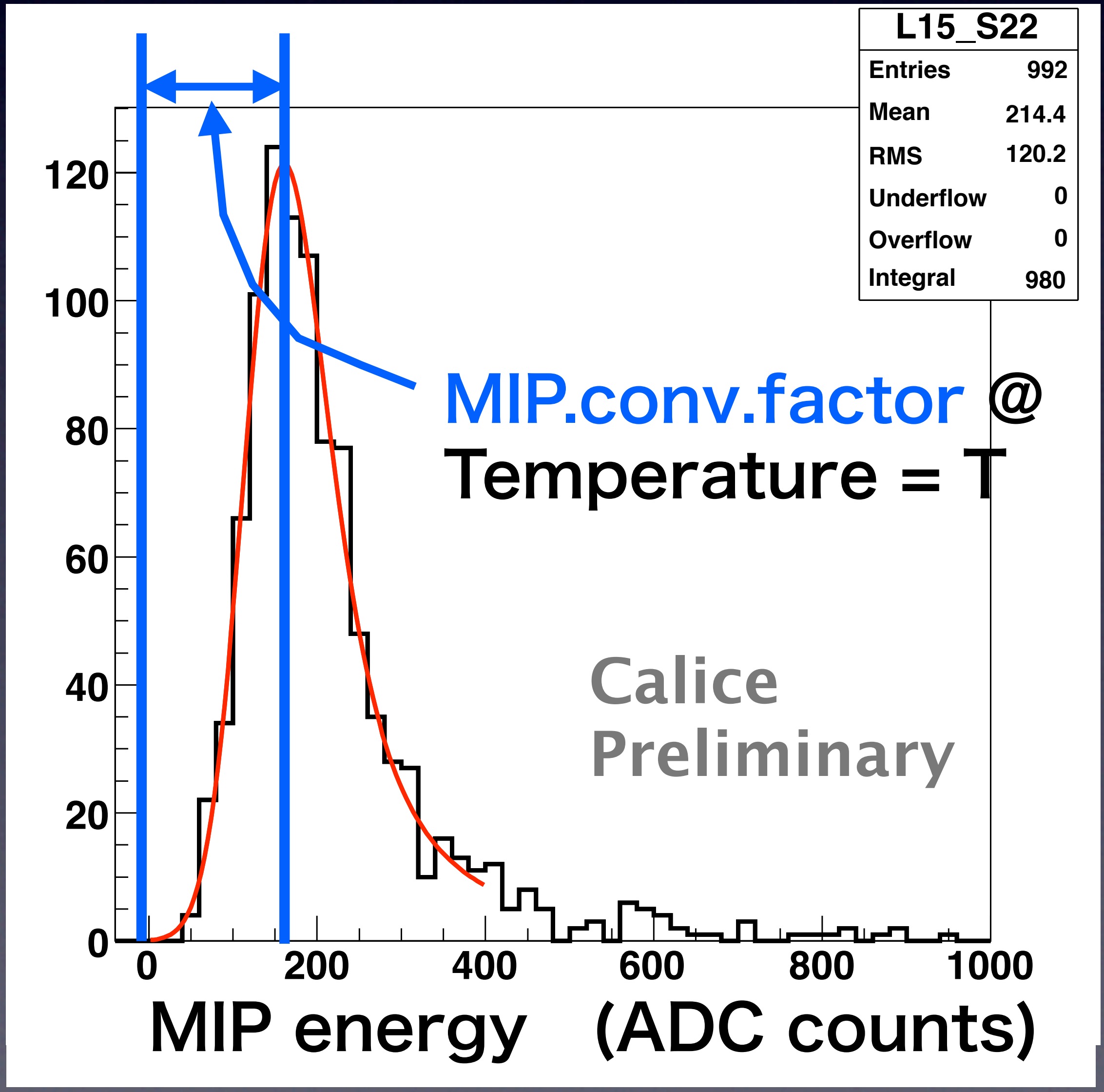
- To calibrate each channel, muon beams are used,
- ADC/MIP.conv.factor = “ADC counts”/“MIP”,

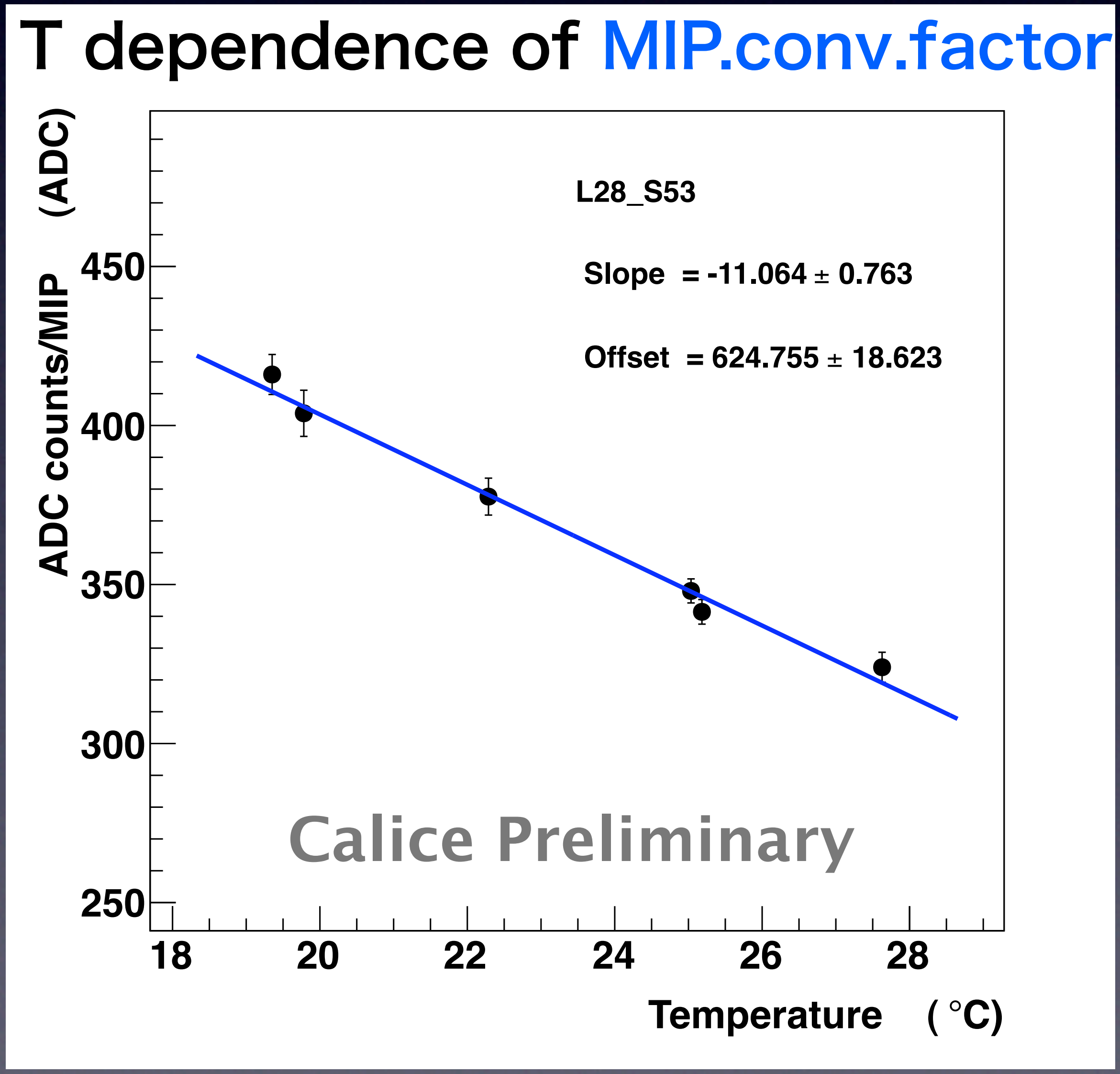


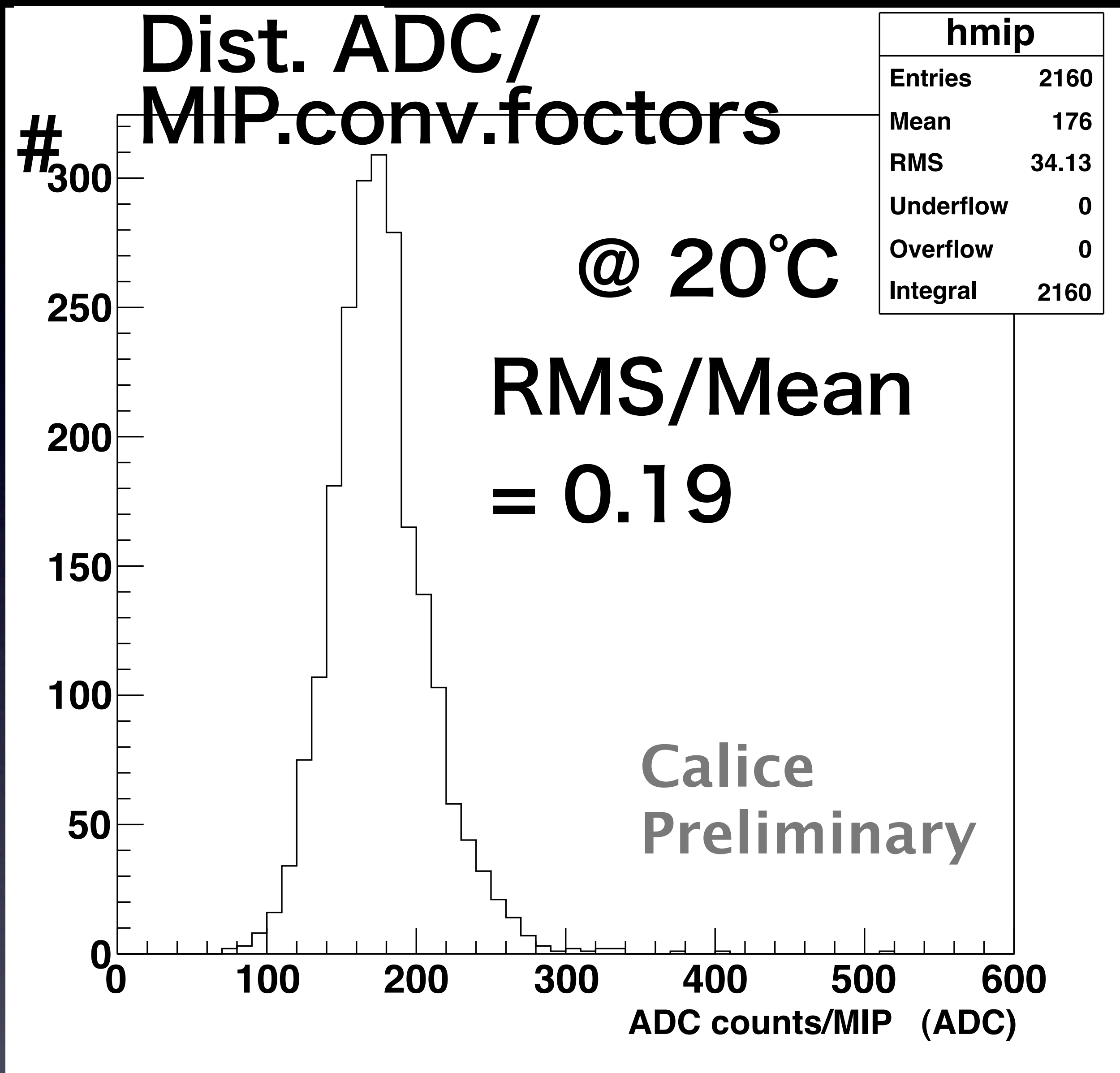
# ADC/MIP.conv.factor

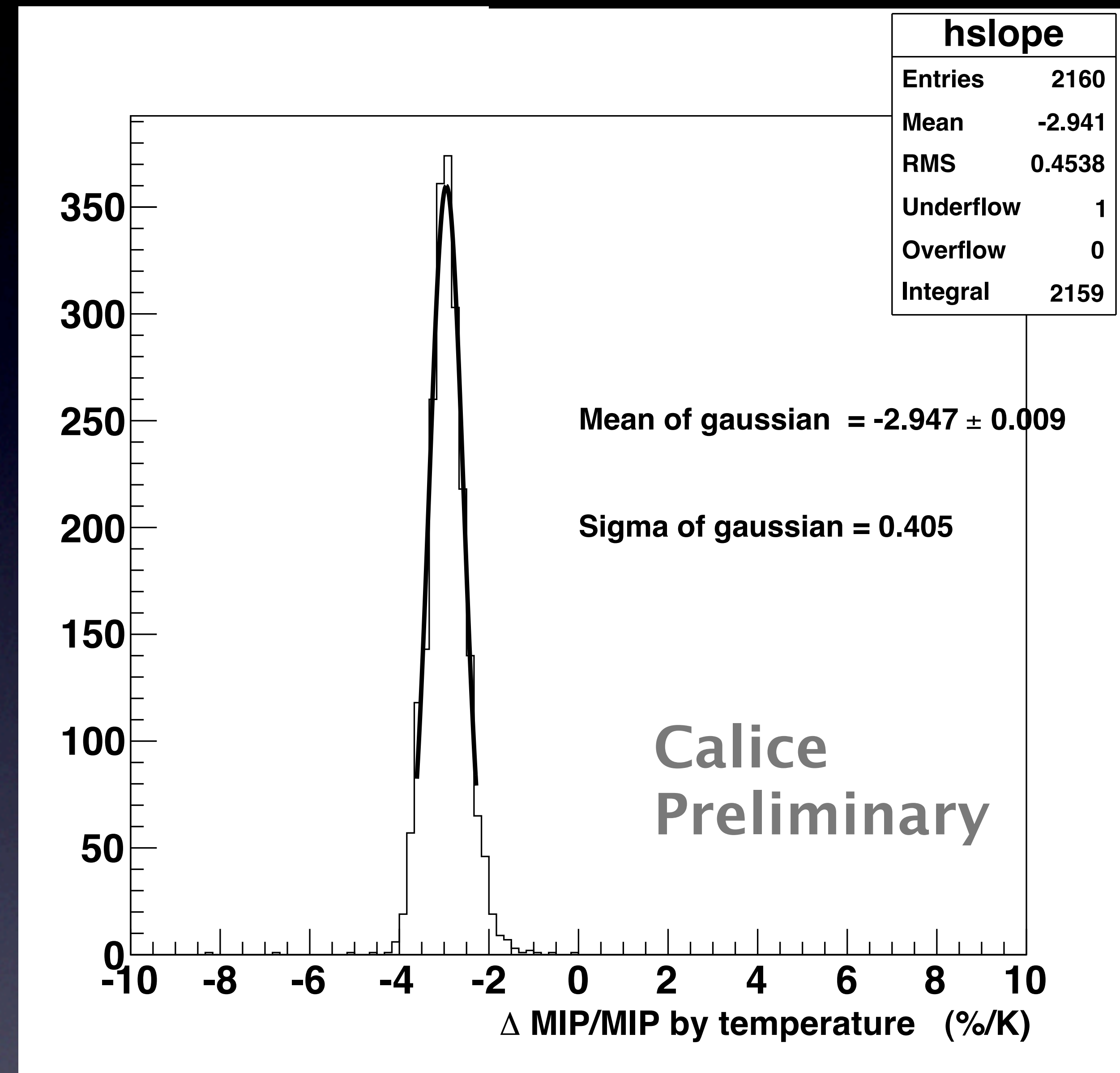
- To calibrate each channel, muon beams are used,
- ADC/MIP.conv.factor = “ADC counts”/“MIP”,
- Temperature dependence of ADC/MIP.conv.factor is expressed as a function of temperature well.



# Distribution of ADC/ MIP.conv.factors and slopes



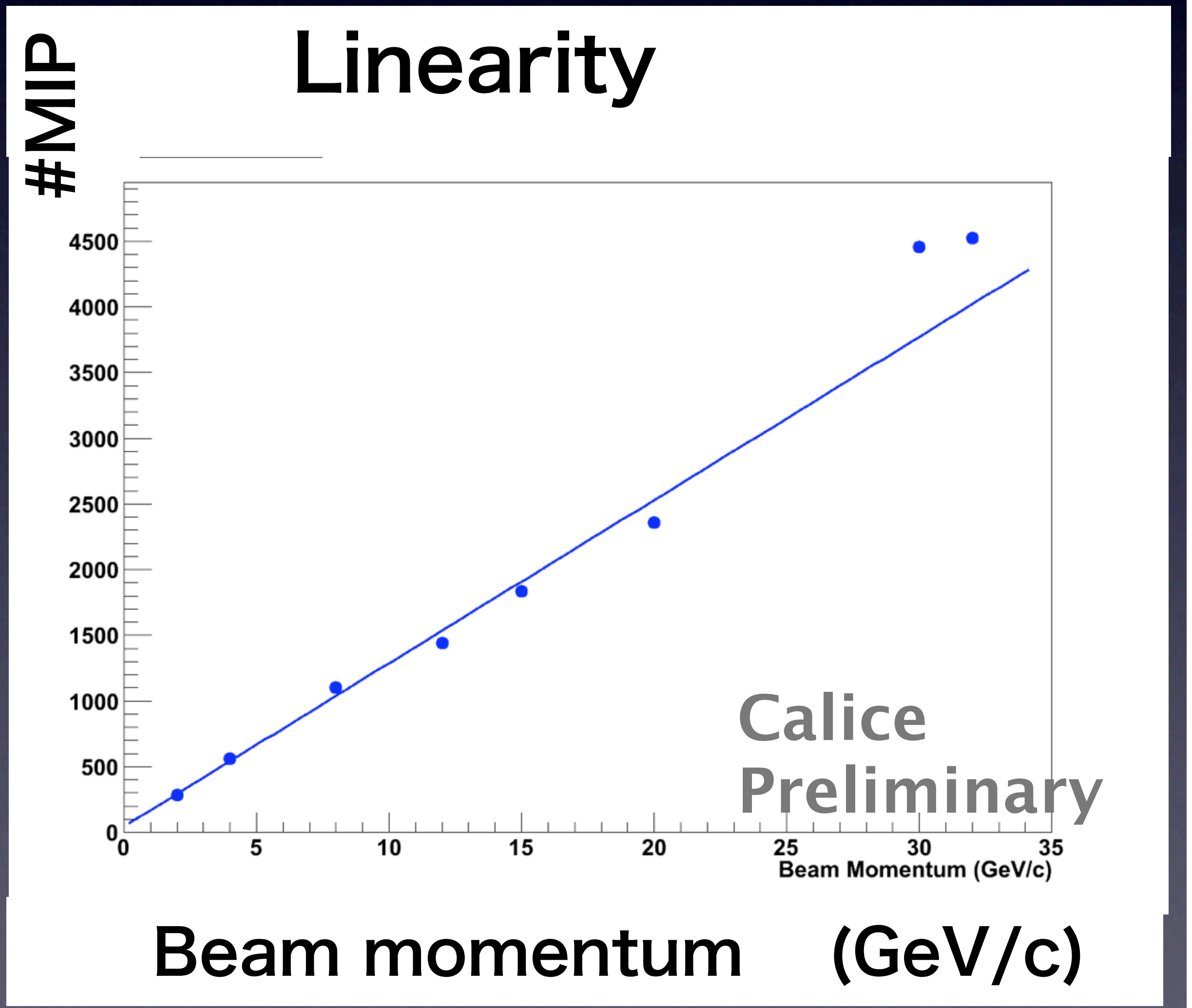

- Variation of ADC/MIP.conv.factor is 19%, ▶ This comes from Scintillator WLS fiber system (variations of scintillator quality, MPPC fiber miss matching and so on.) ∵ Variation of MPPC gains is less than a few%
- except 3 channels( noisy ) slopes of 2157 channels are in this narrow distribution

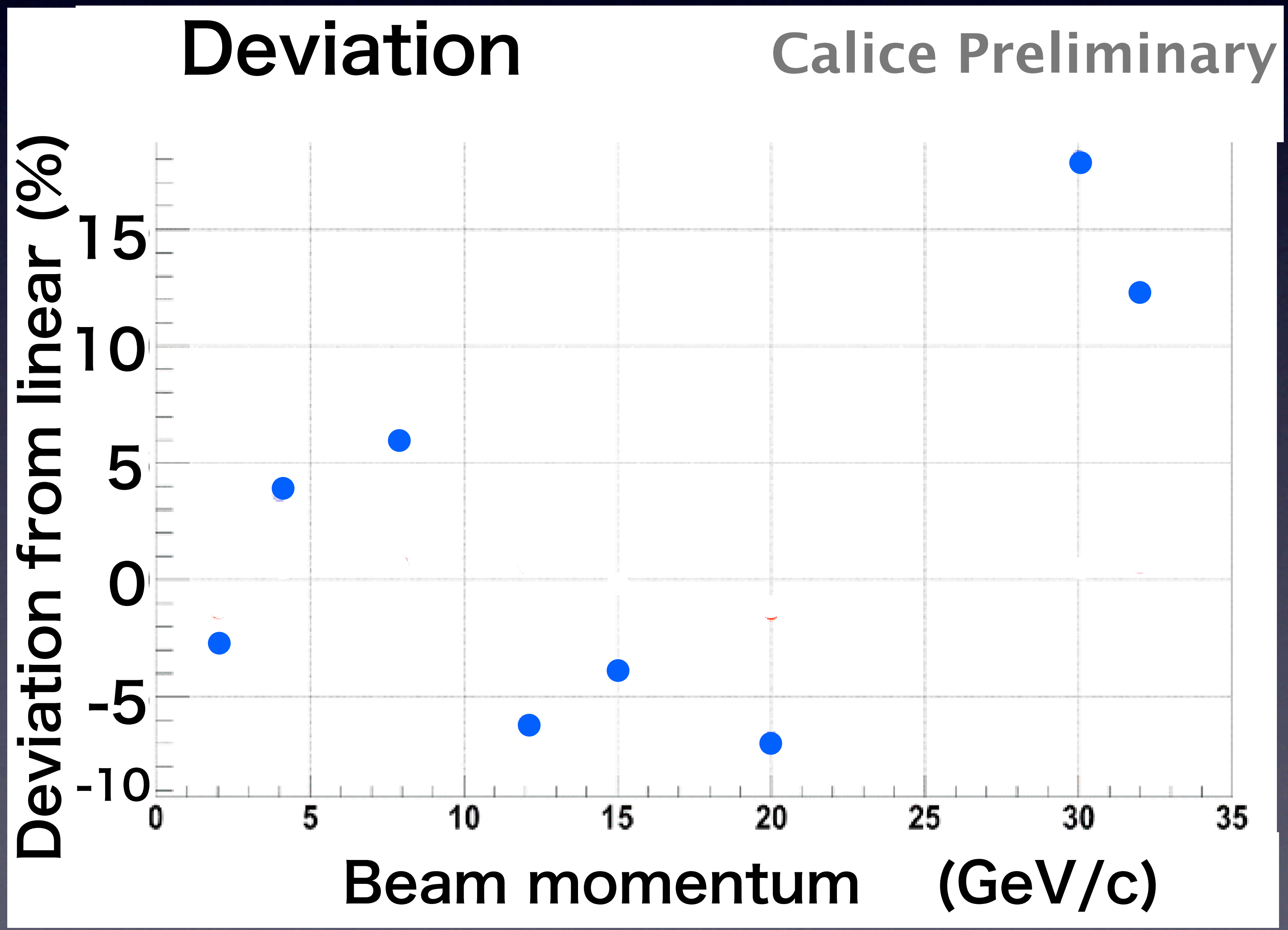
# Electron energy response (2009)

## Case: w/o temperature correction

Don't care temperature

$$\text{energy sum expressed in \# MIP} = \Sigma \frac{\text{ADCs by a hit on a channel}}{\text{ADC/MIP.conv.factor of a channel}}$$



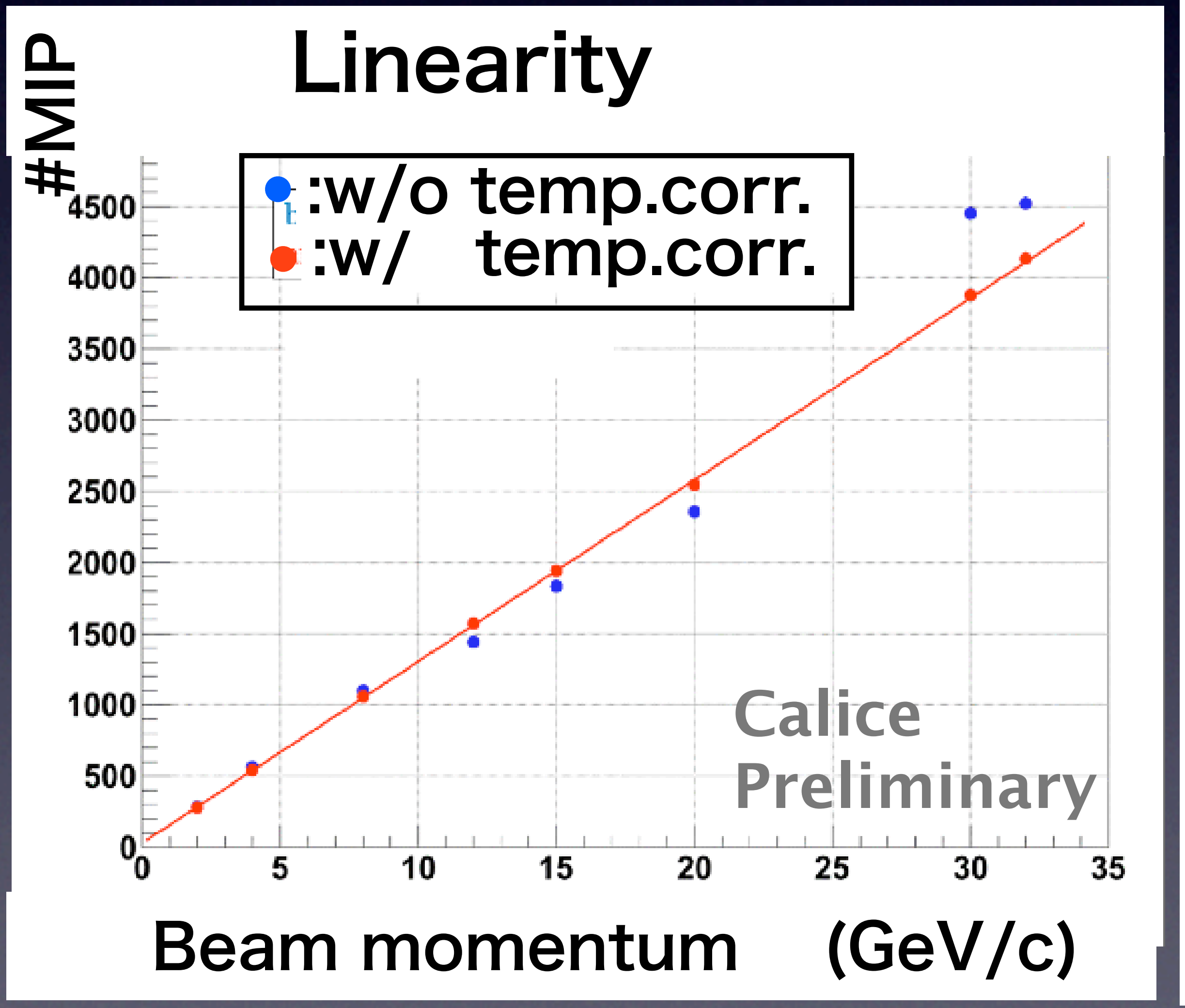



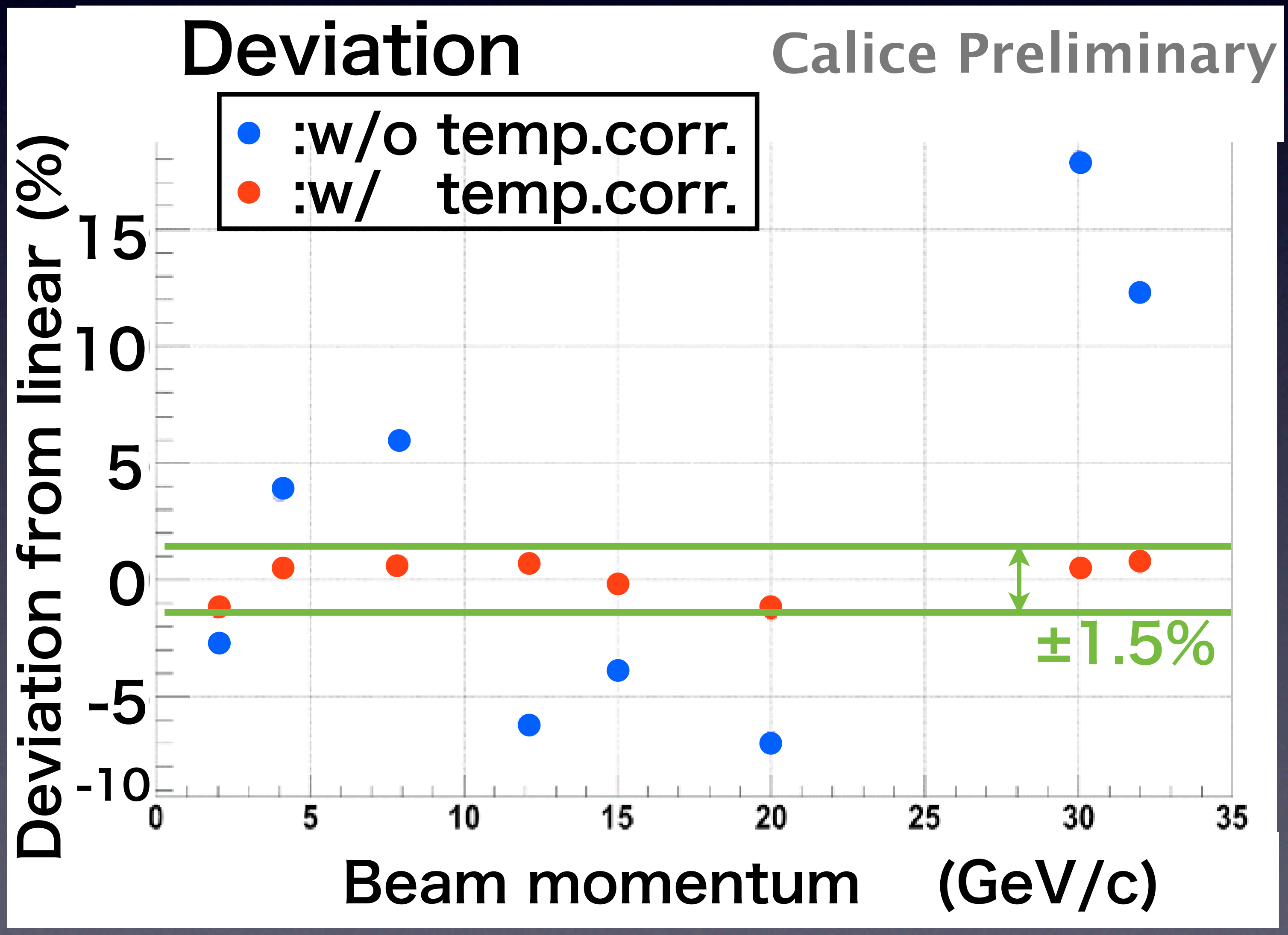
# Electron energy response (2009)

## Cace: First order temperature correction

Using same temperature

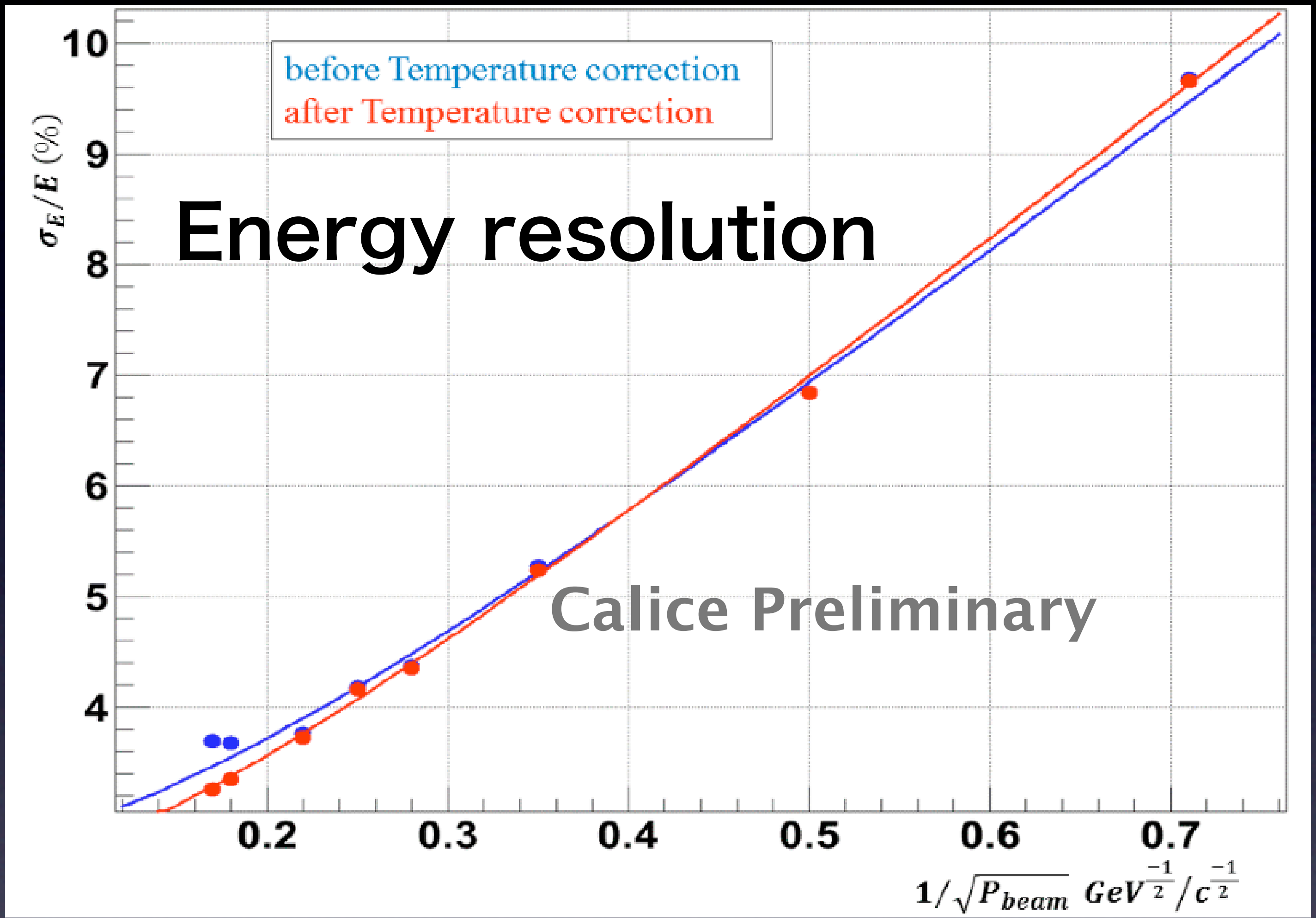
$$\text{Temp. corrected energy sum expressed in \# MIP} = \Sigma \frac{\text{ADCs by a hit on a channel at Temp.}}{\text{ADC/MIP.conv.factor of a channel (Temp.)}}$$




Temperature correction drastically improves linearity

# May 2009
# electron energy resolution



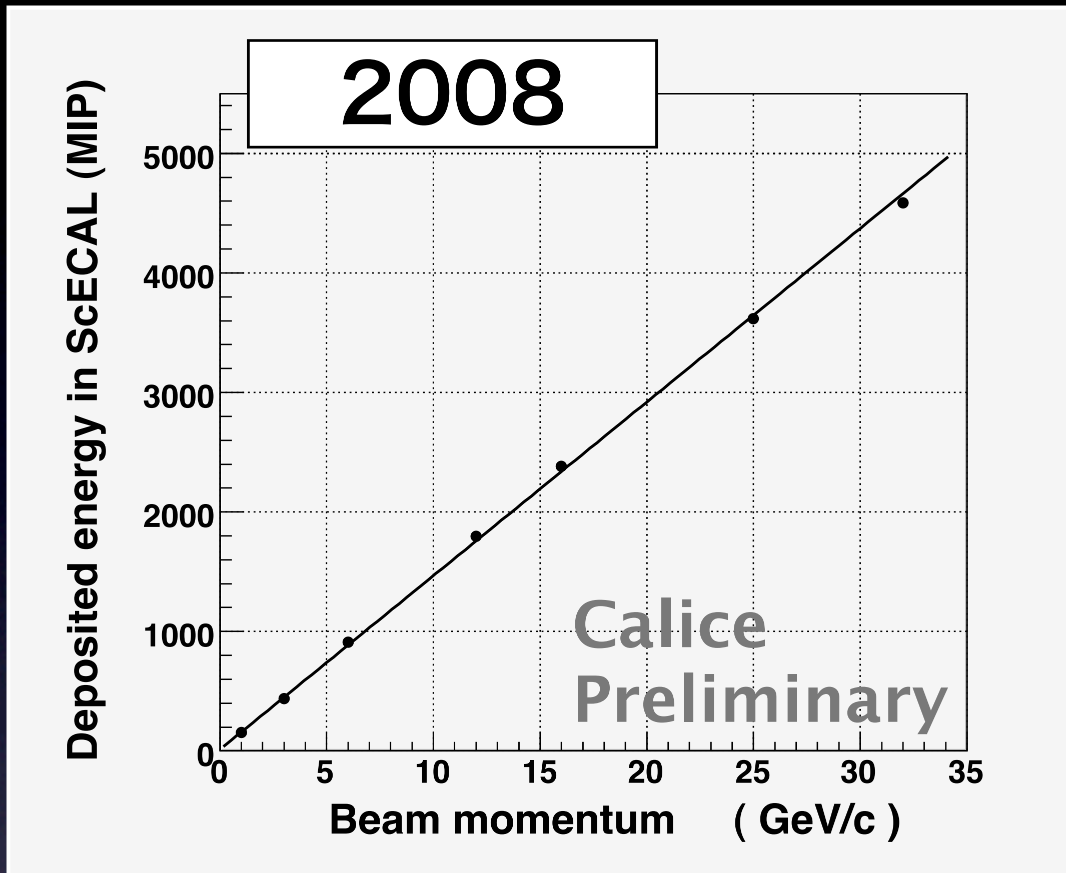

- Calice preliminary

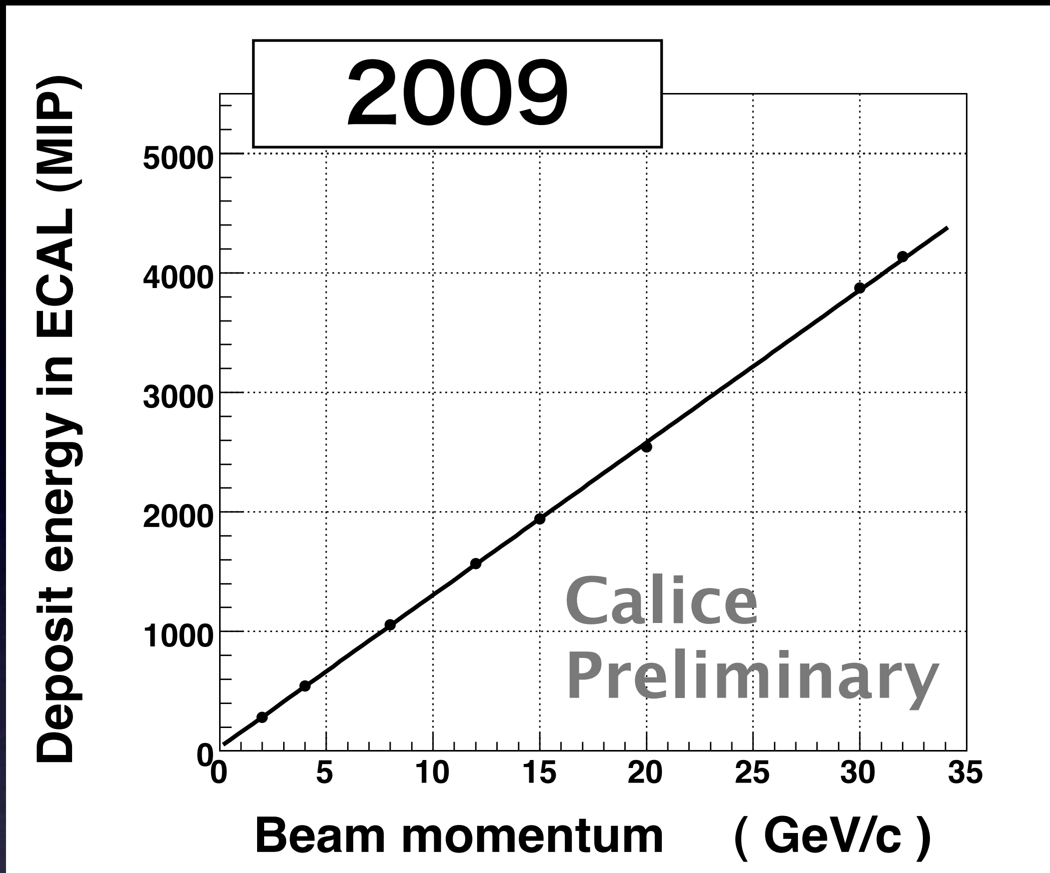
| | |
|---|---|
| constant term | 2.32±0.02% |
| stochastic term | 13.16±0.04% |

* only statistic errors

Temperature correction improves energy resolution,
in this case, temperatures during data taking of 32 GeV and 30 GeV are very different from those of averaged temperature of MIP runs.

# Comparison of MIP/GeV between 2008 and 2009




MIP/GeV ▶ 2008: 145.3 MIP/GeV,   2009: 127.6 MIP/GeV

- 2009,
  No temperature effect after temperature correction.
- 2008,
  Difference of temperature btwn electron data taking and MIP data taking(ADC/MIP.conv.factor)▶Changes slope
  - We can estimate ΔTemp(electron : MIP) = 4.0℃

# Summary

- ScECAL, May 2009 @ FNAL data were analysed,
- First order temperature correction has been applied,
  - Temperature dependence of ADC/MIP.conv.factor was measured ▶ ADC/MIP.conv.factor as a function of temperature is successfully extracted for each channel in whole of our detector by linear fit,
  - ADC/MIP.conv.factor(T) was applied to calibrate each hit energy at T,
- Temperature correction drastically improves linearity of energy response,
- Temperature correction has clear effect also on the energy resolution.

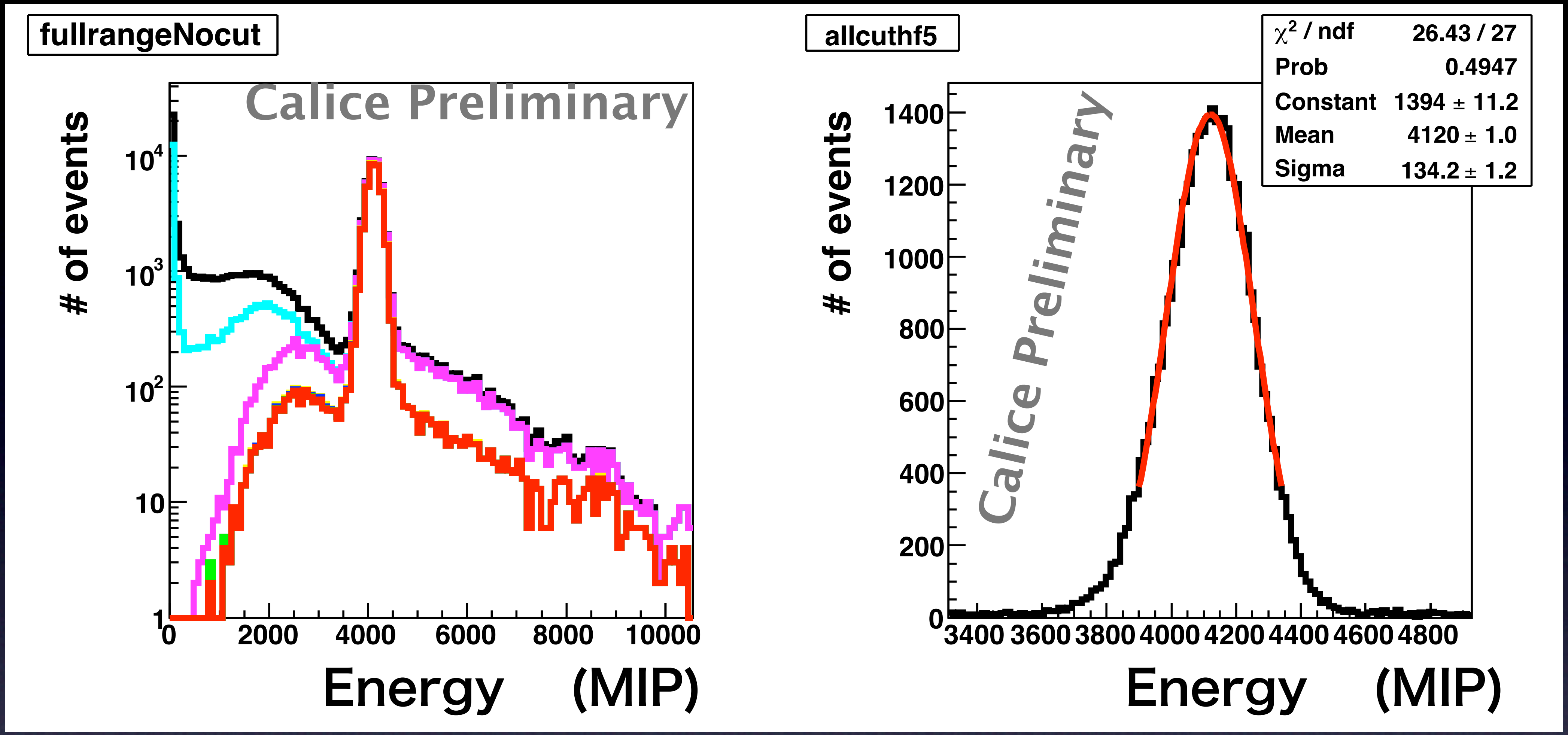
# plan: on temperature issues

- Second order temperature correction = Temperature correction in the saturation correction,

- Estimate temperatures in 2008 from LED runs.

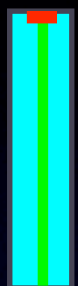
# Backup

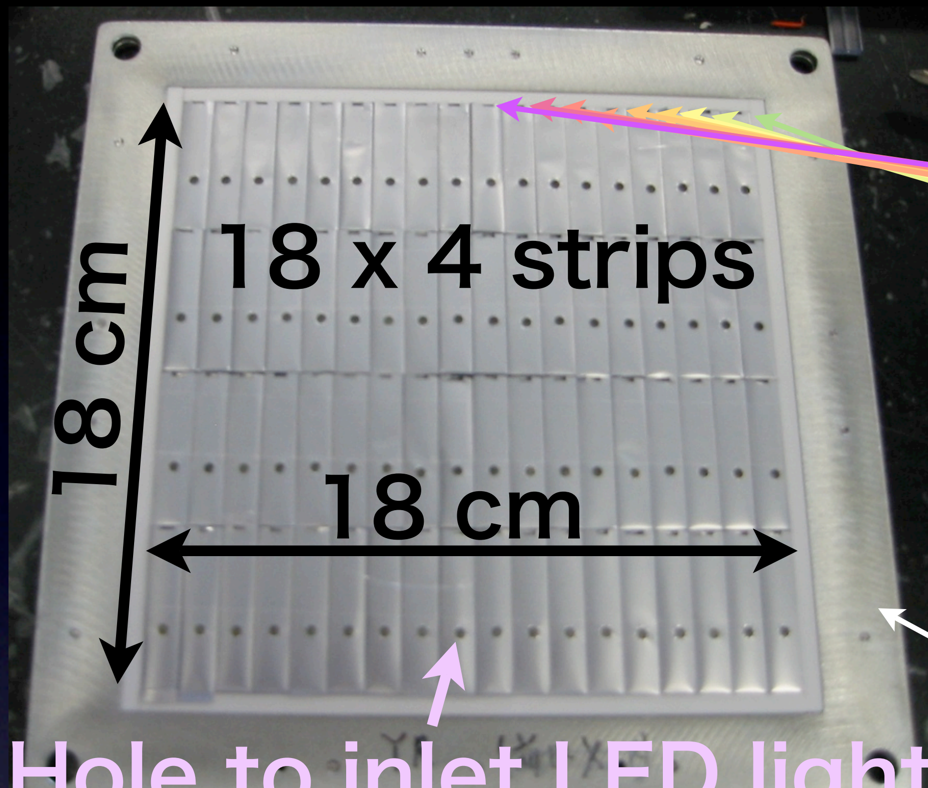
# Electron energy spectrum



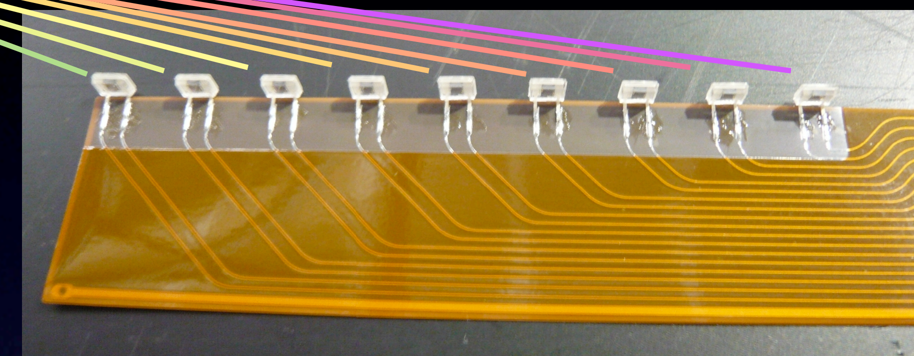

| |
|---|
| Using Čelenkov counter |
| Shower max. in ScECAL < 20 th layer |
| Energy of shower max layer > 200 MIPs (32 GeV/c) |
| Energy of shower max layer in AHCAL < 20 MIPs |
| Energy on most down stream layer in AHCAL < 0.4 MIP |
| center of shower in ScECAL \|x(y)\| < 40 mm |

# Prototype of ScECAL



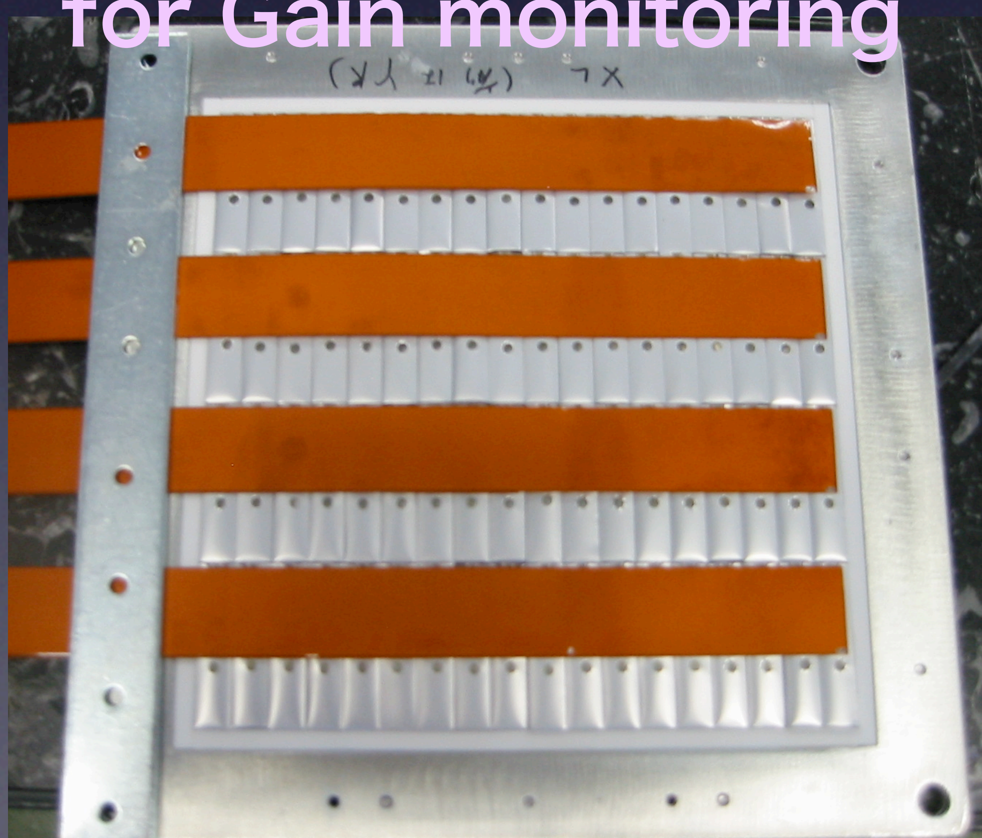


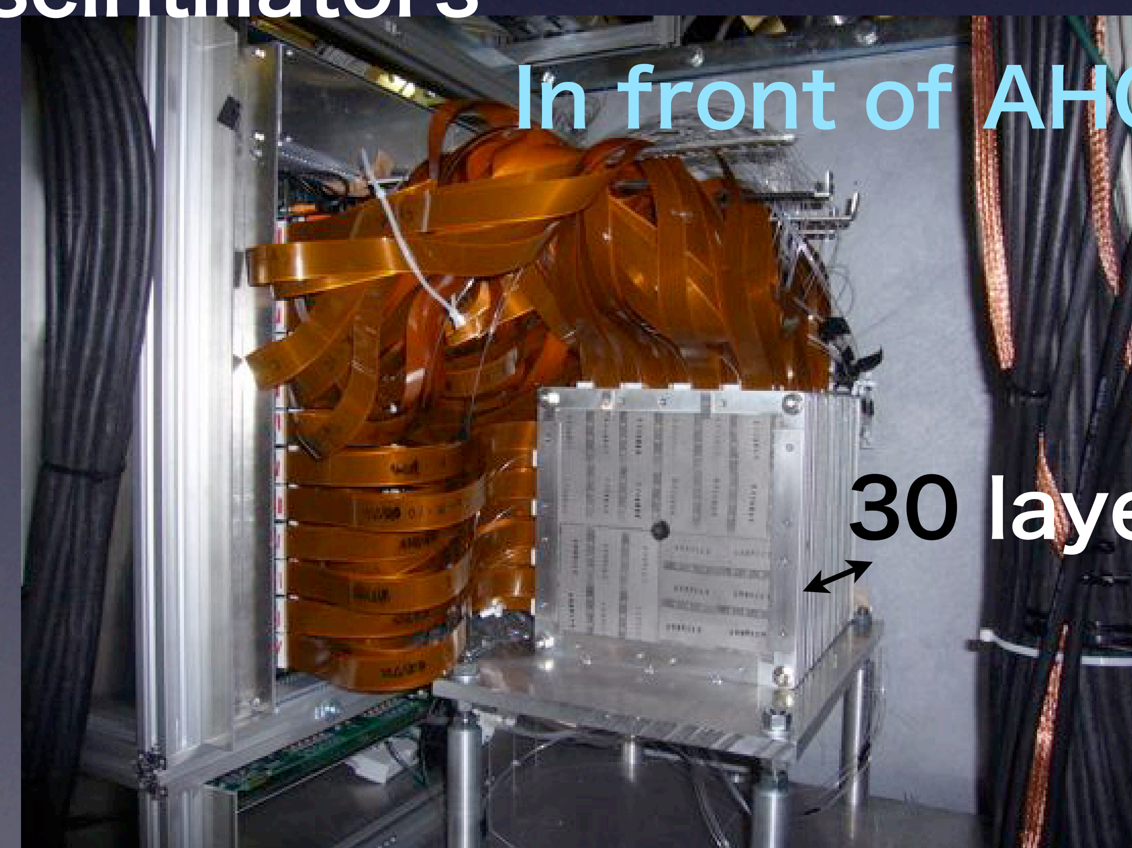

9 PPD(MPPCs) on a flat cable



Holding W absorber (3.5 mmT) behind the strip scintillators

Hole to inlet LED light for Gain monitoring

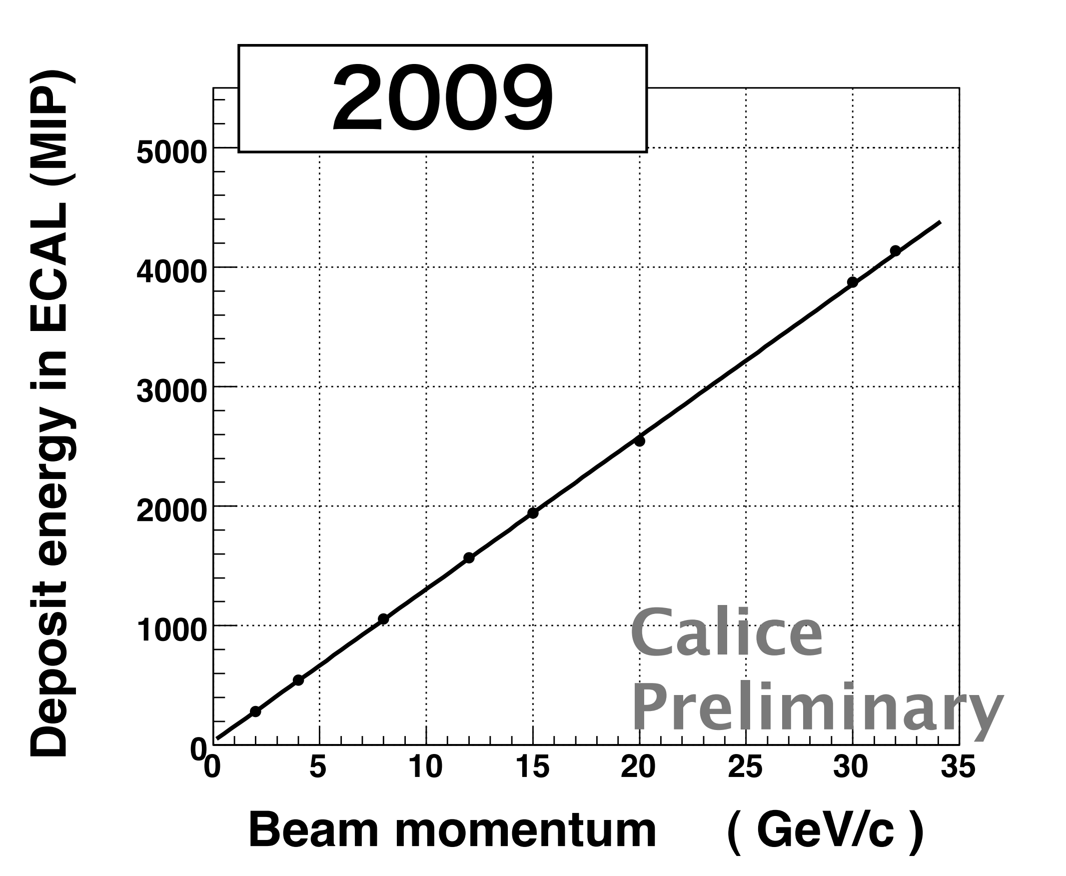


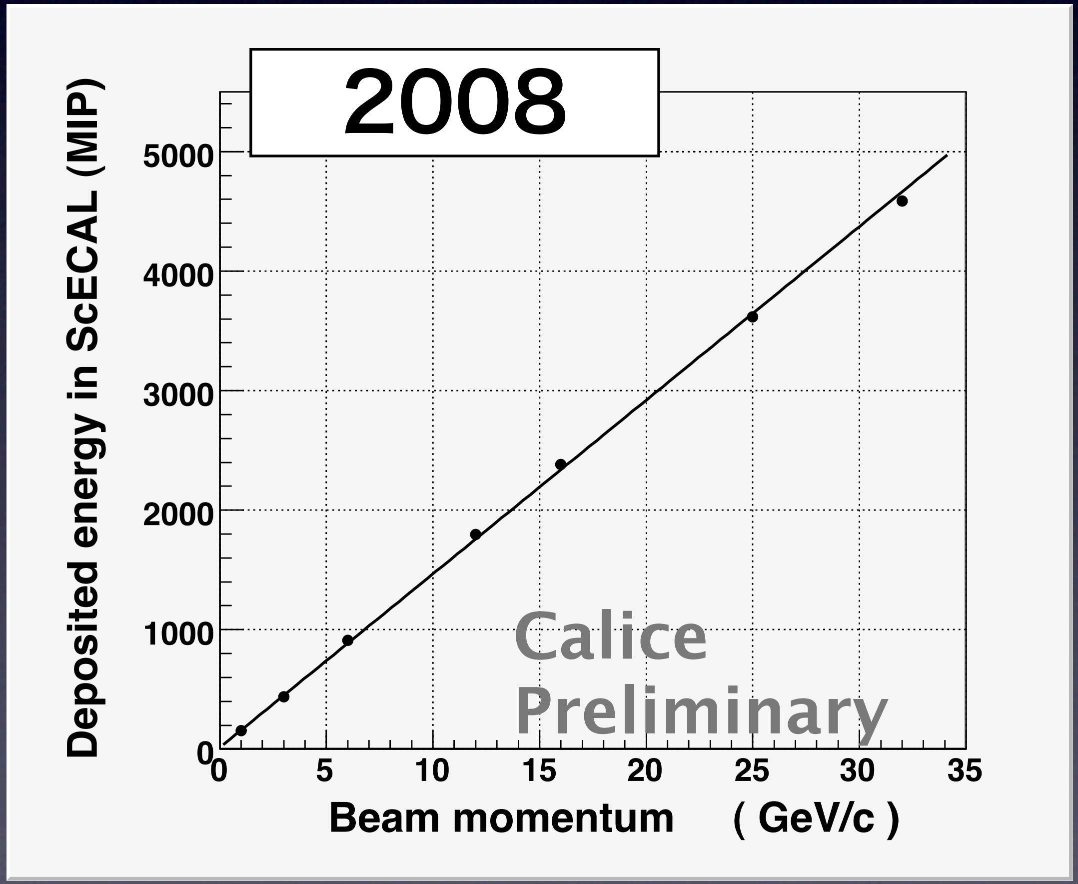


# #MIP/G 2008 and 2009

Case in 2009, there is no temp. gap between electron data and calibration, because of temperature correction :MIP/GeV = 127.6

We do not know temperature difference between electron data taking and MIP data taking for 2008 :MIP/GeV = 145.3



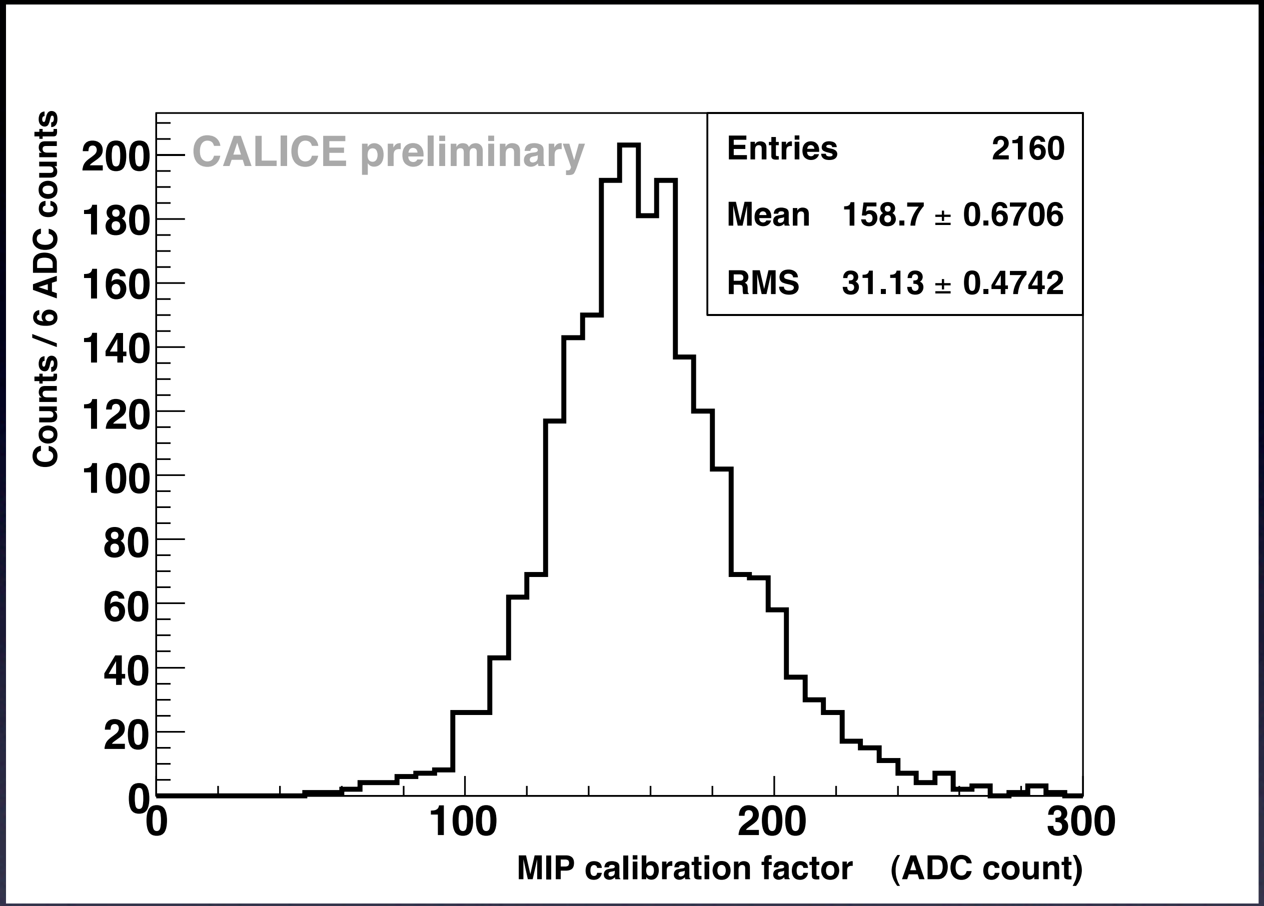



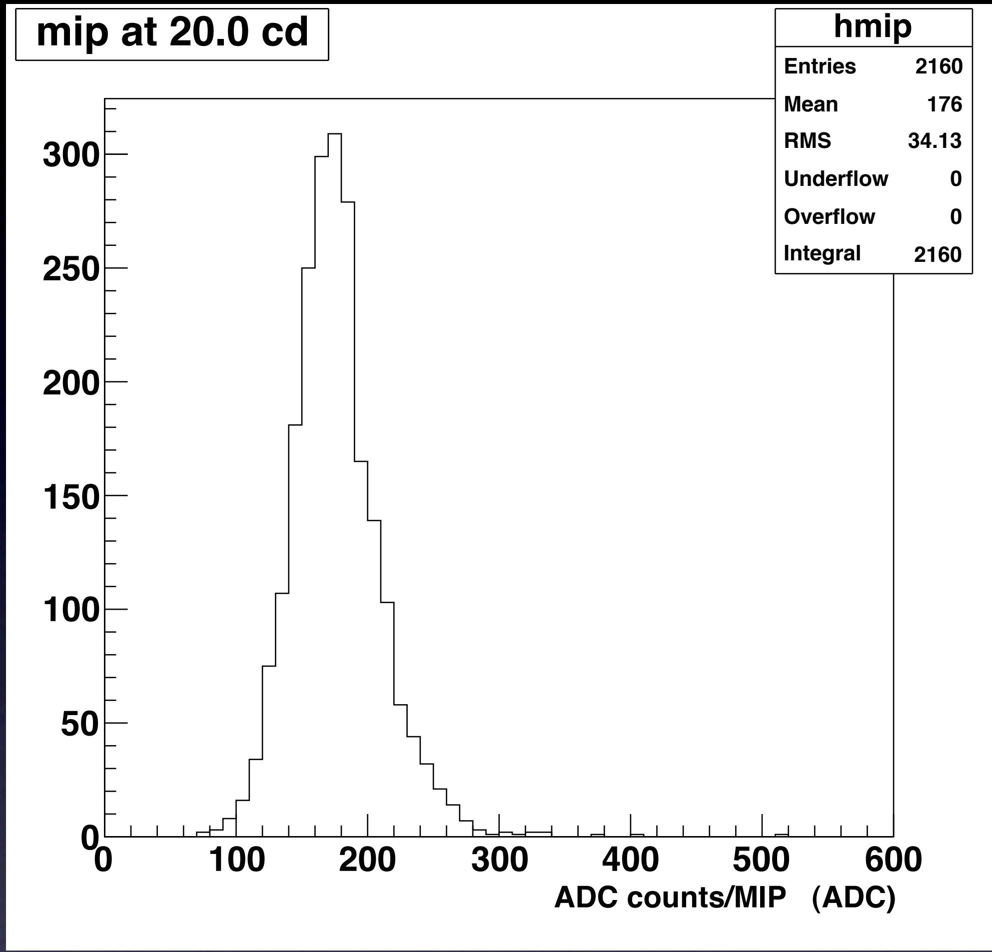

From this difference $\Delta$(MIP/GeV) = 127.6 - 145.3 we can estimate $\Delta$Temp(electron : MIP) at 2008

# $MIP_{coefficients}$ 2008 and 2009

MIPcoeff @2008 = 158.7

MIPcoeff @ 20℃ 2009 = 176.0




$$dMIP_{\mathrm{coeff}}/dT = -5.122\ adc/K$$

$$T(2009) - T(2008) = \frac{MIP_{\mathrm{coeff.2009}} - MIP_{\mathrm{coeff.2008}}}{dMIP_{\mathrm{coeff}}/dT} = -3.39°\mathrm{C}$$

$$(176.0 - 158.7)/(-5.122) = -3.378$$

$$\text{Averaged } T(2008) = T(2009) + 3.39°\mathrm{C} = 23.4°\mathrm{C} = T'$$

# Estimation of T of Electron data 2008

2008 : #MIP/GeV = 145.3　　　2009 : #MIP/GeV = 127.6

$$\#MIP/G = adc_{\rm depoE}(T)/MIP_{\rm coeff}(T')/G$$

where, $adc_{\rm depoE}(T)$:ADC counts of deposit energy by beam,

$MIP_{\rm coeff}$:"$ADC/MIP$.conv.factor", $G$: beam momentum in $GeV$.

for 2009 : $T = T'$, by Temperature correction

for 2008 : $T \neq T'$, without correction

$$\Delta\#MIP = adc_{\rm depoE}(T'')/MIP_{\rm coeff}(T') - adc_{\rm depoE}(T'')/MIP_{\rm coeff}(T'')$$

where, $adc_{\rm depoE}(T)/MIP_{\rm coeff}(T) \sim adc_{\rm depoE}(T'')/MIP_{\rm coeff}(T'')$

$T'$ : $T$(muon data 2008), $T''$ : $T$(electron data 2008).

$$\Delta\#MIP/G \sim -\#MIP/G \frac{dMIP_{\rm coeff}/dT}{MIP_{\rm coeff}(\frac{T'+T''}{2})}(T' - T'')$$

$$\Delta\#MIP/G = 145.3 - 127.6,\ \#MIP/G = 127.6,$$

$$dMIP_{\rm coeff}/dT = -5.122,\ MIP_{\rm coeff}(T') = 158.7,$$

$$T' - T'' = 4.0°C.$$