# Transport of Calibration Constants

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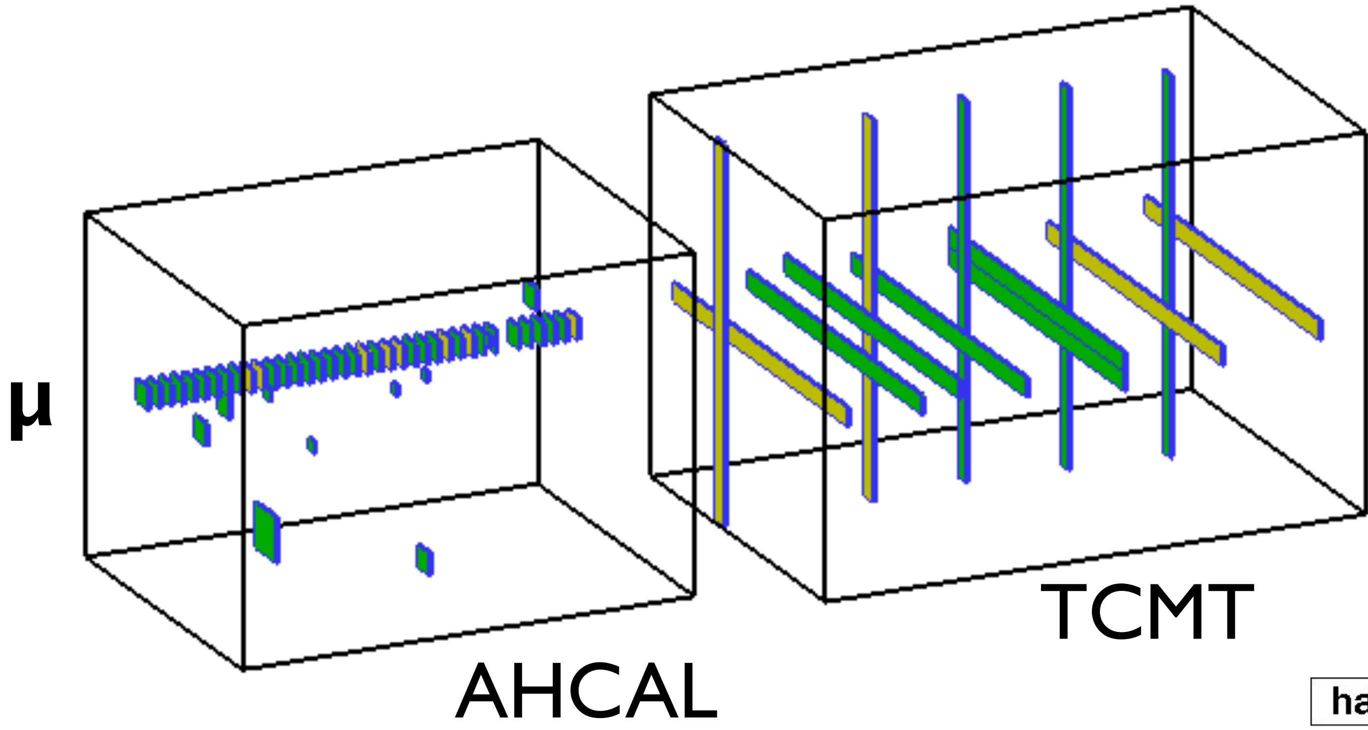
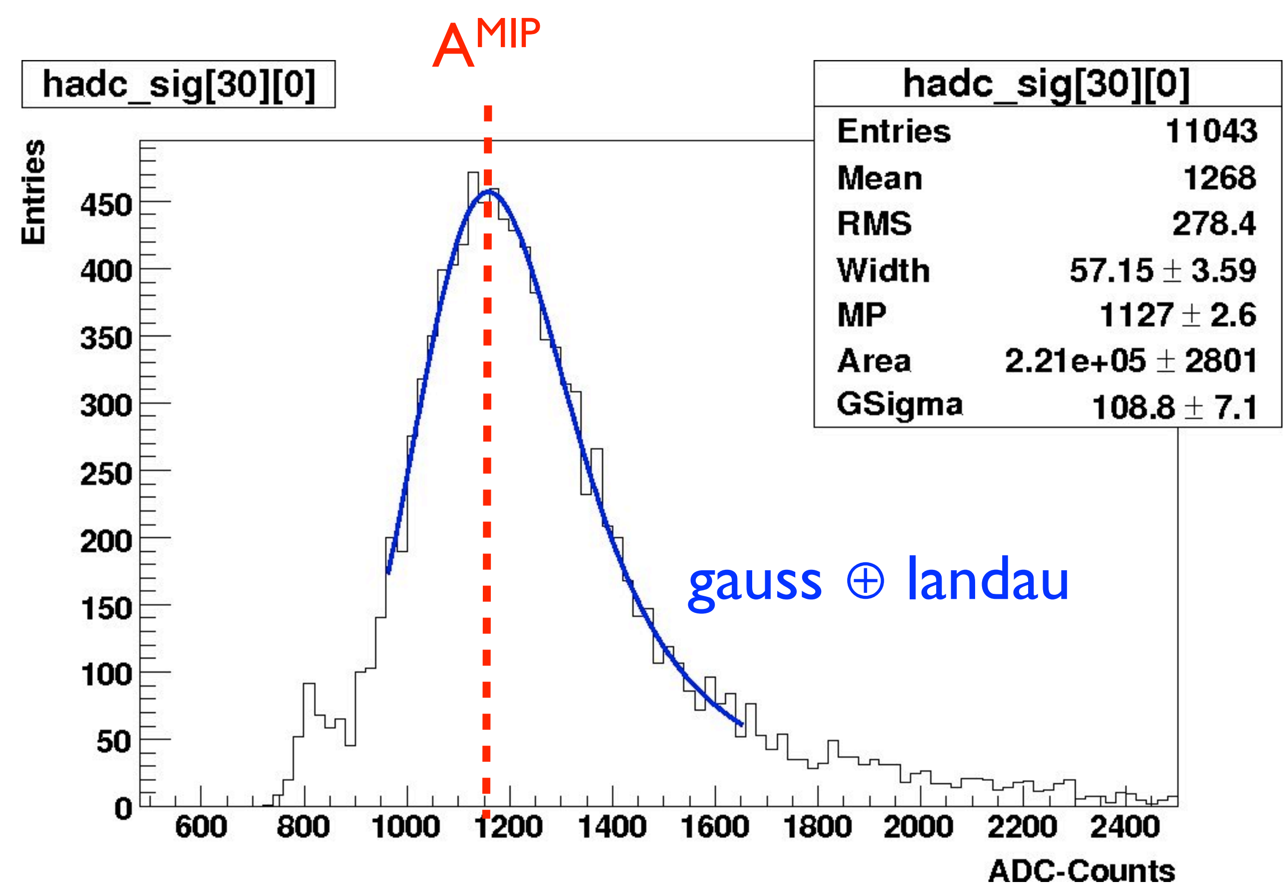
# Outline

- Muon Calibration Sets
- Dependence of Muon Calibration on Operation Conditions
- Transport Calibration Sets FNAL → CERN
- Summary & Outlook

# AHCAL Muon Calibration

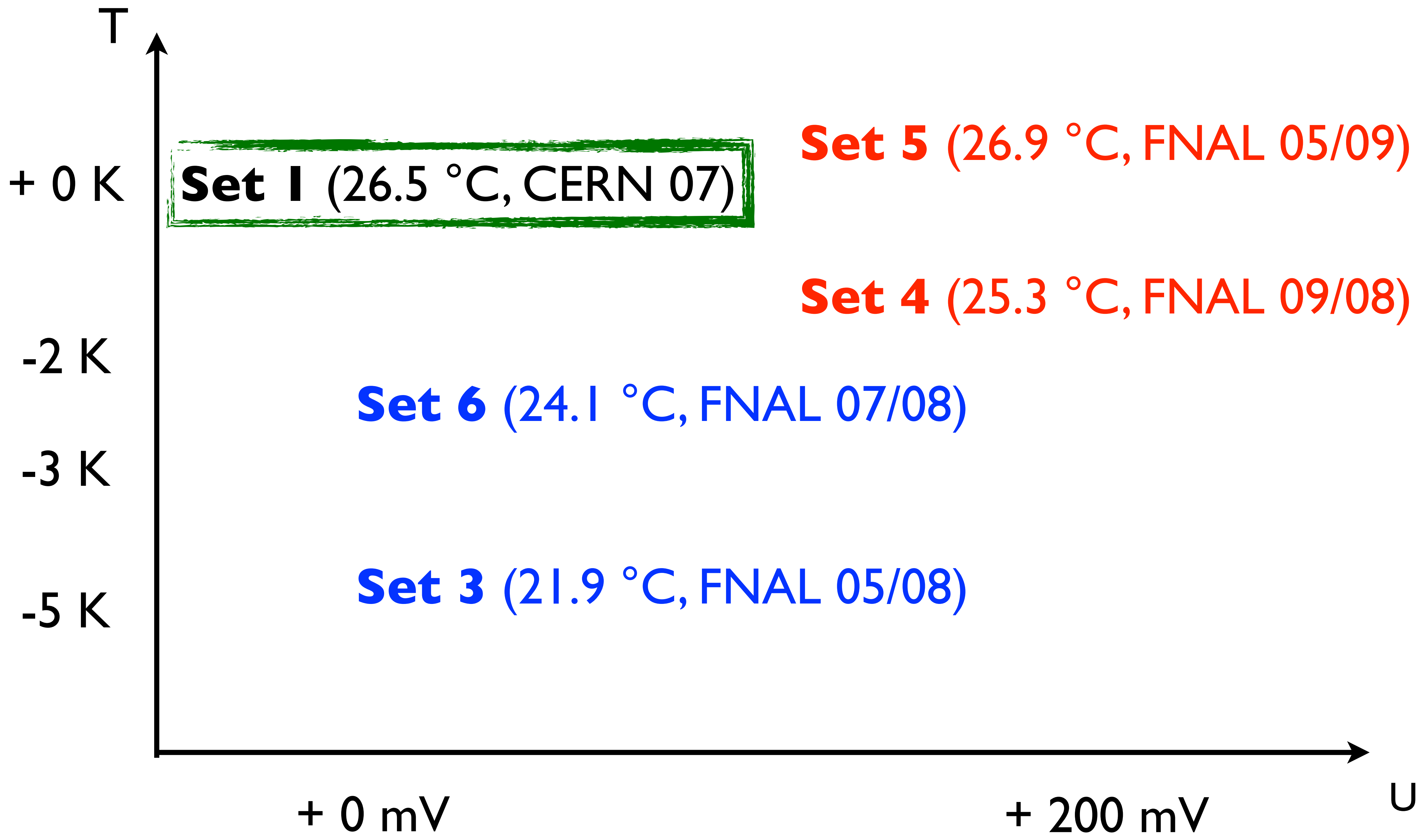



$A^{MIP}$

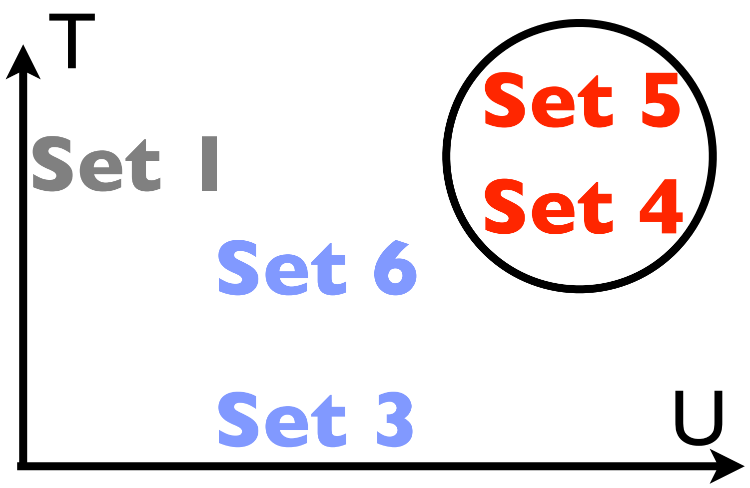
- needed for each cell
- equalizes cell responses
- provides physics reference scale
- ~ operation voltage U, temperature T

# Muon Calibration Sets




**Goals:**
- establish and check procedures to shift $A^{MIP}$ to different U,T
- apply FNAL calibration to CERN runs → linearity? resolution?

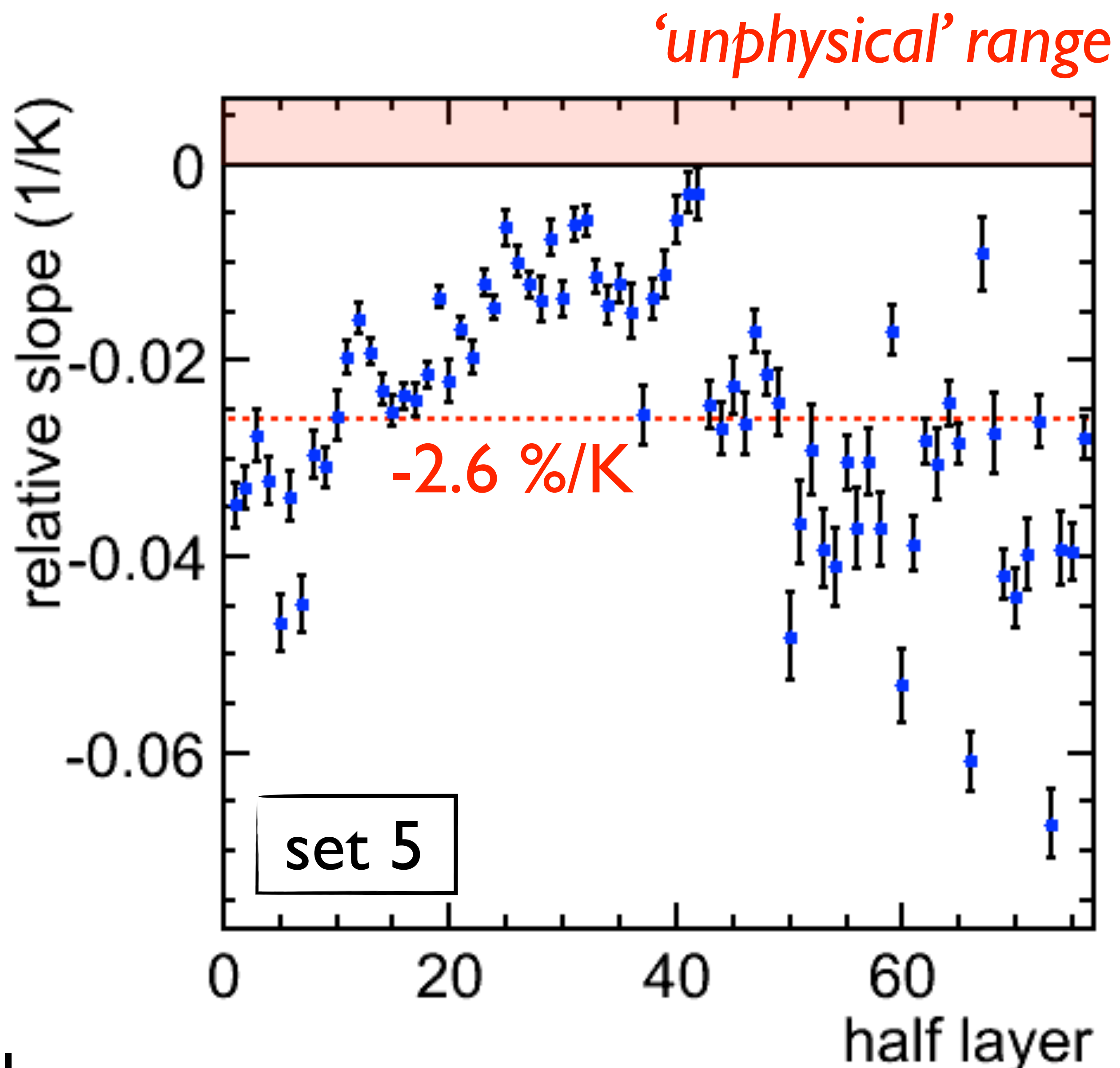
# FNAL: Temperature Dependence of $A^{MIP}$



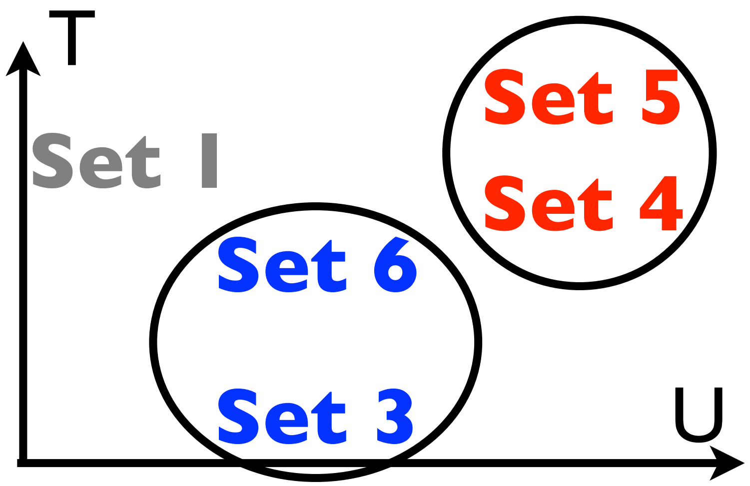

- each channel:

$$\frac{1}{A_5}\frac{dA_5}{dT} = \frac{A_5 - A_4}{A_5} \cdot \frac{1}{T_5 - T_4}$$

- half-layer means: large spread, only use detector average usable



# FNAL: Temperature Dependence of $A^{MIP}$




Set 4: $$\frac{1}{A_4}\frac{dA_4}{dT} = \frac{A_5 - A_4}{A_4} \cdot \frac{1}{T_5 - T_4}$$

Set 6: $$\frac{1}{A_6}\frac{dA_6}{dT} = \frac{A_6 - A_3}{A_6} \cdot \frac{1}{T_6 - T_3}$$

Set 3: $$\frac{1}{A_3}\frac{dA_3}{dT} = \frac{A_6 - A_3}{A_3} \cdot \frac{1}{T_6 - T_3}$$

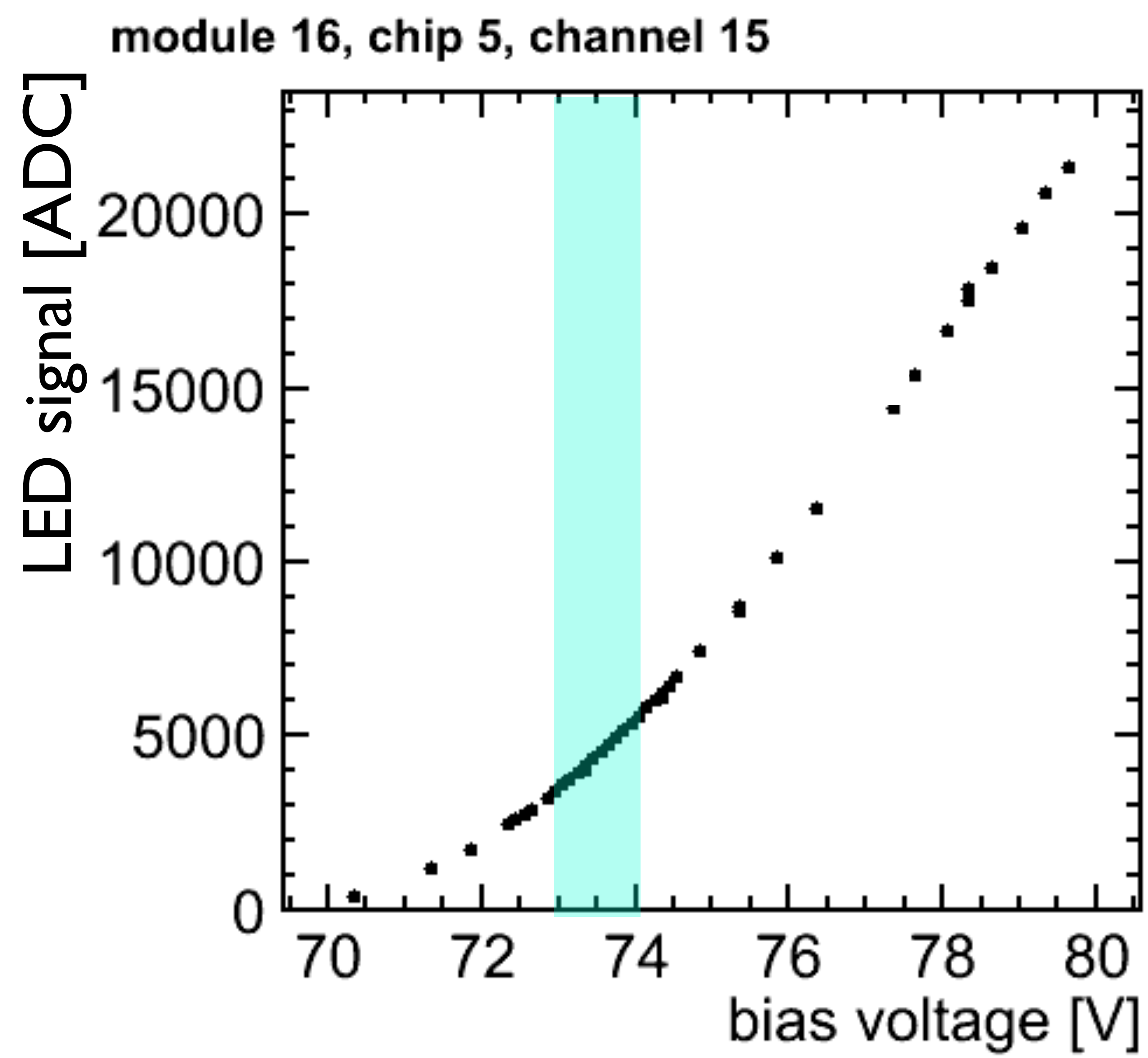
| Set | 1/A dA/dT | 1/A dA/dU |
|---|---|---|
| 1 | -3.7 %/K | 5.6 %/100mV |
| 3 | -3.1 %/K | 4.8 %/100mV |
| 6 | -3.6 %/K | 5.5 %/100mV |
| 4 | -2.3 %/K | 3.5 %/100mV |
| 5 | -2.6 %/K | 4.0 %/100mV |

- dA/dU = (dA/dT) / (- $dU_{bd}$/dT)
- $dU_{bd}$/dT = 65 mV/K

- sets 1, 3 and 6: dA/dT consistent, difference due to reference A
- sets 4 and 5: different dA/dT? → More data taken under controlled conditions could improve understanding!

# Non-Linearity of $A^{LED}$

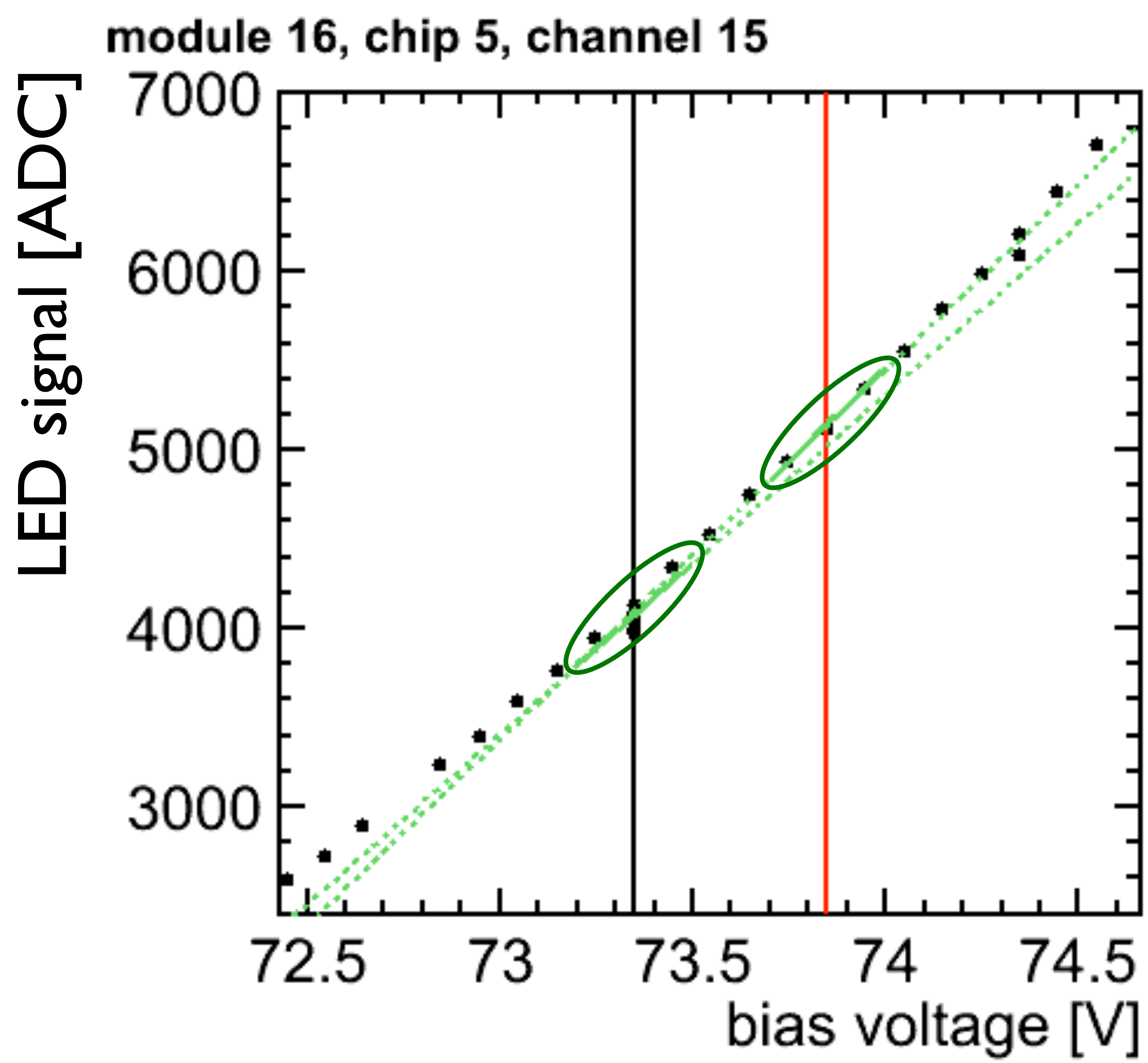

**DESY: LED**
**(17°C, ΔU -3 V ... +6 V)**




- linear approximation in operation range looks reasonable
- saturation of $A^{LED}$ only far above operation range

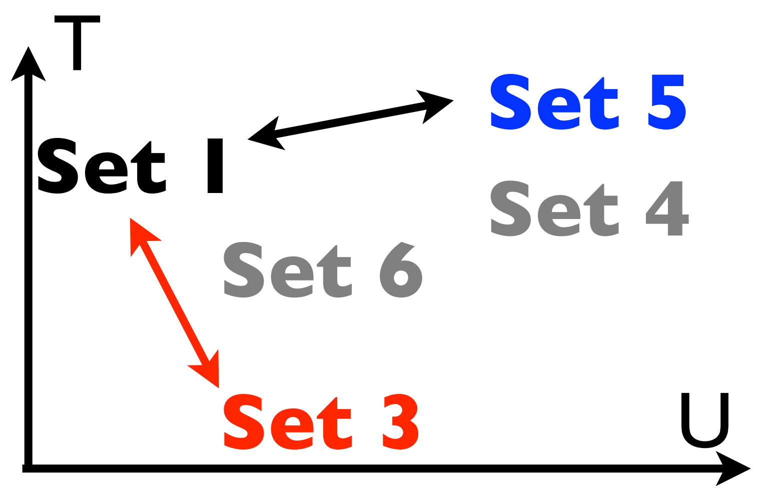
# Non-Linearity of $A^{LED}$


**DESY: LED**
**(17°C, ΔU -3 V … +6 V)**



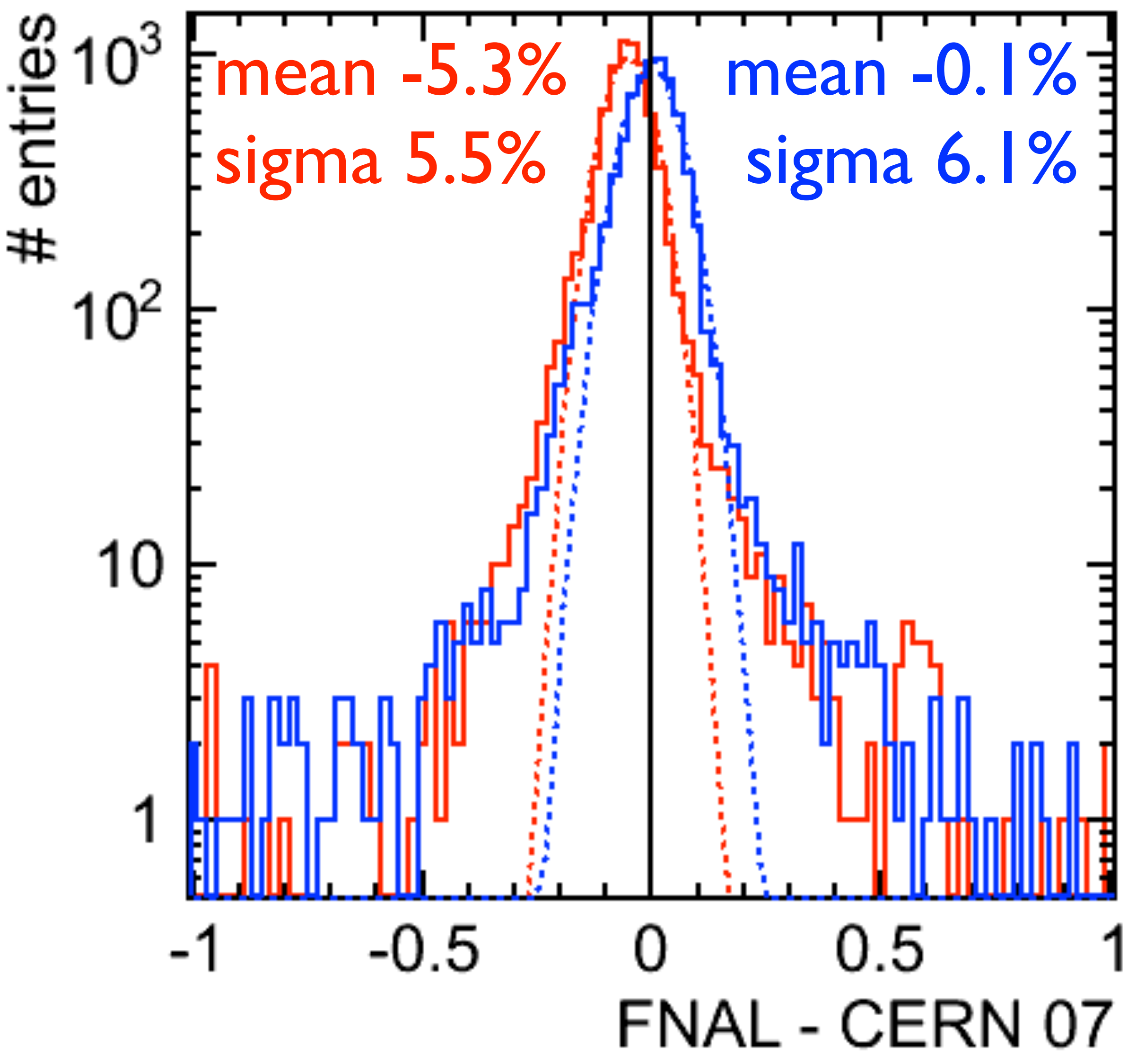

- Change in dA/dU for 200 mV bias voltage increase: + 10%
- Need to investigate more cells!

# Transport FNAL → CERN

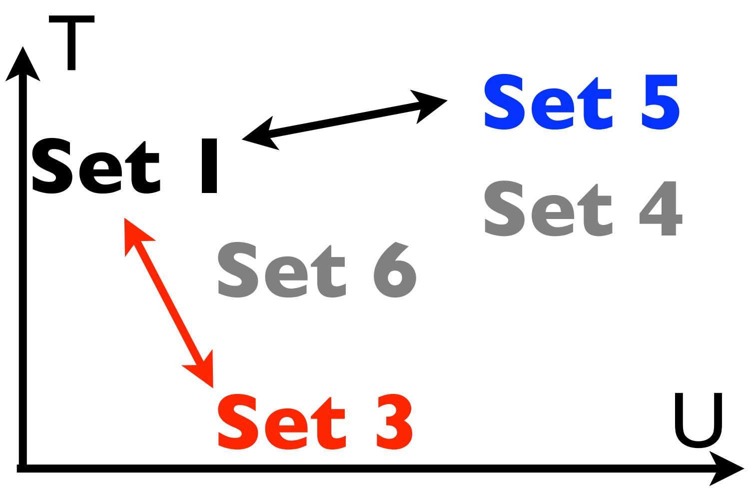



U,T correction: **detector average**

set 3 - set 1, set 5 - set 1

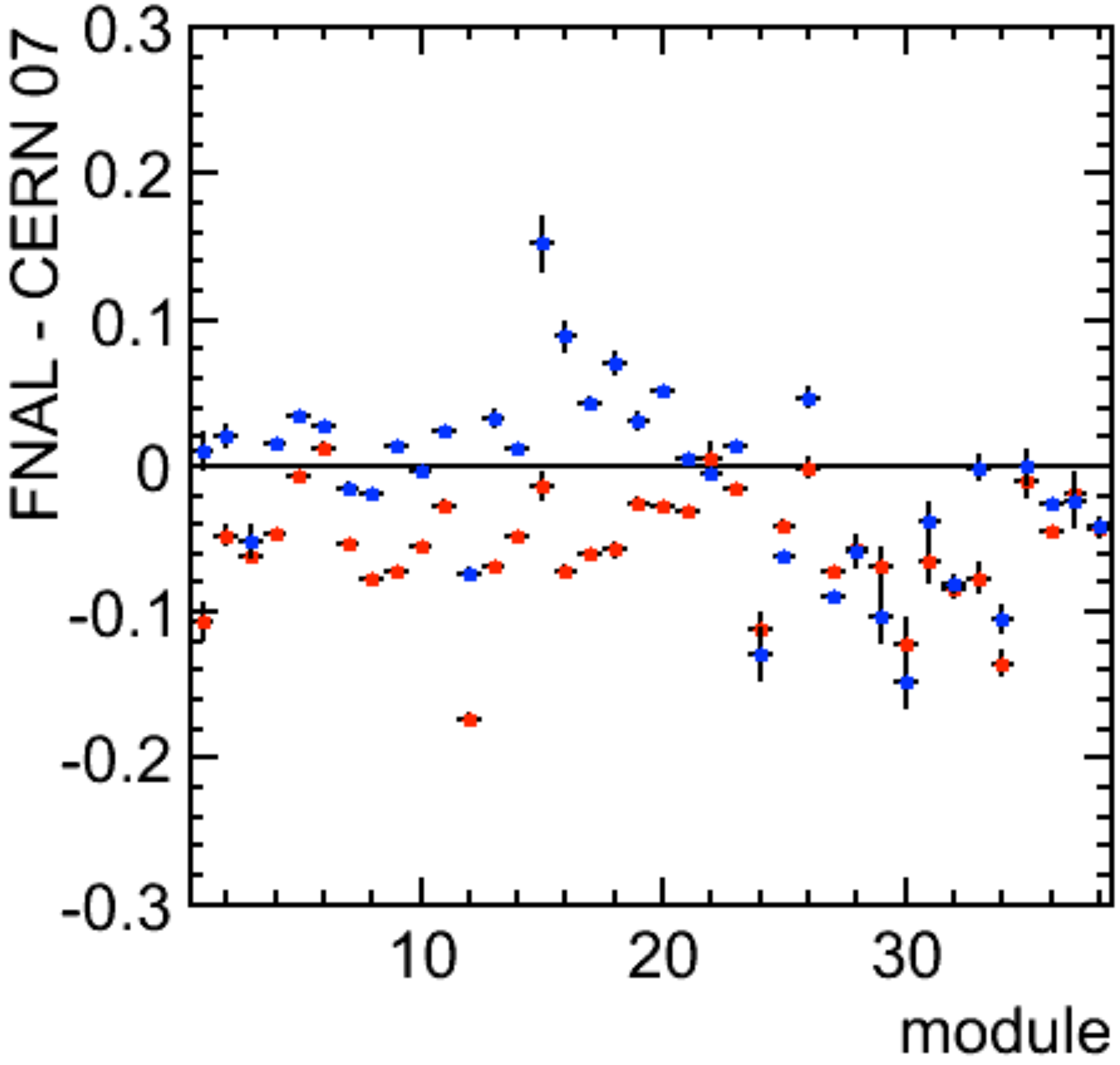


# Transport FNAL → CERN

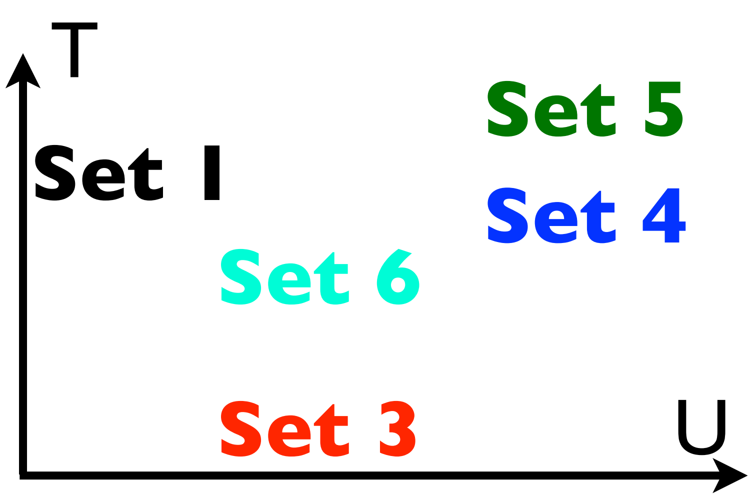


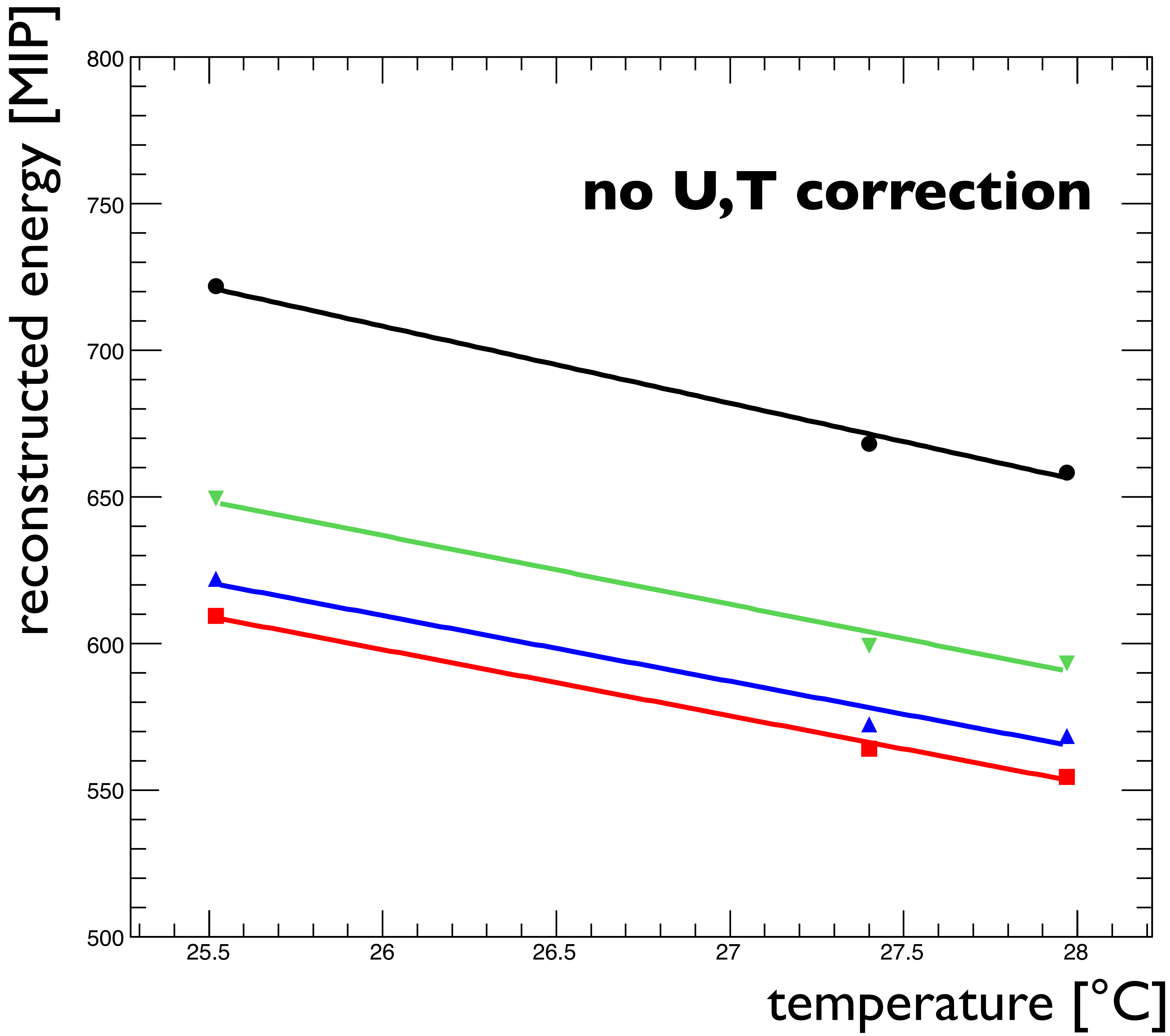

U,T correction: **detector average**

set 3 - set 1, set 5 - set 1



# CERN - 20 GeV Data



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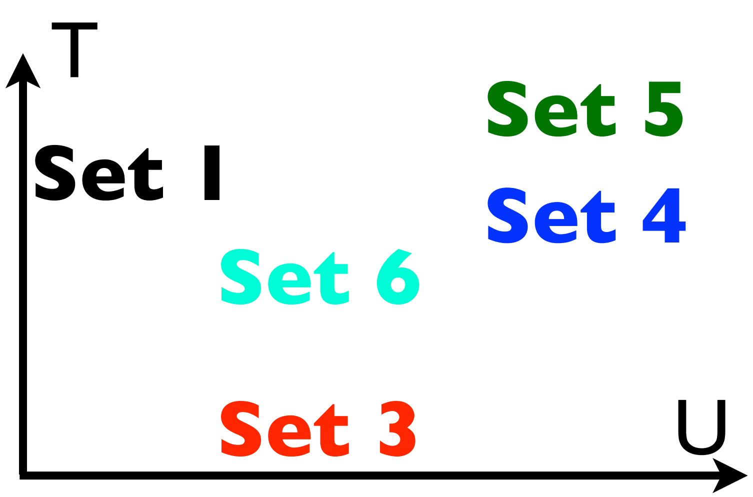
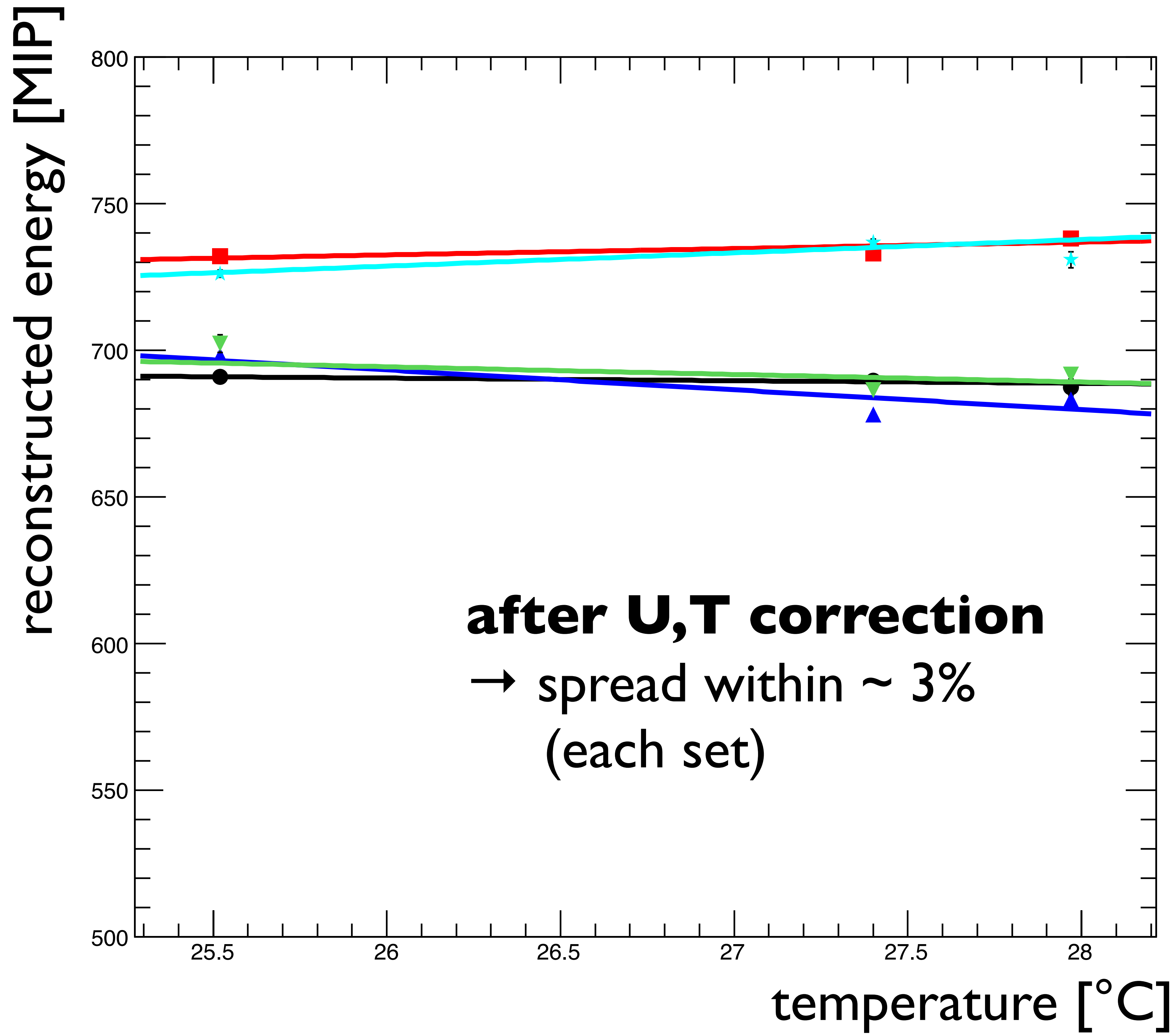
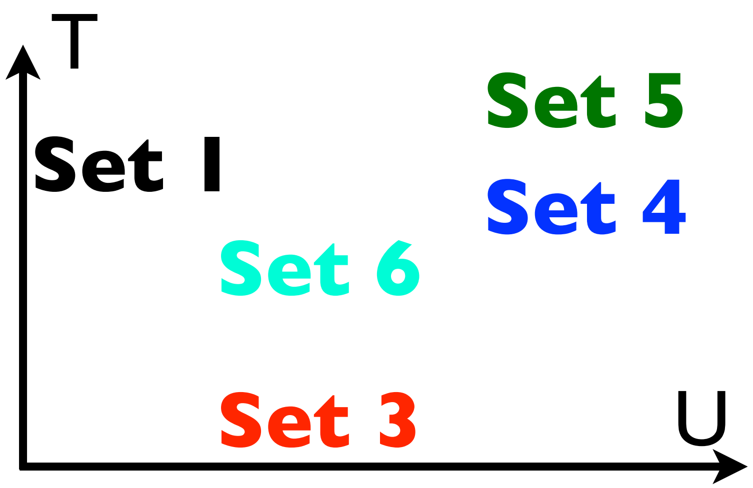
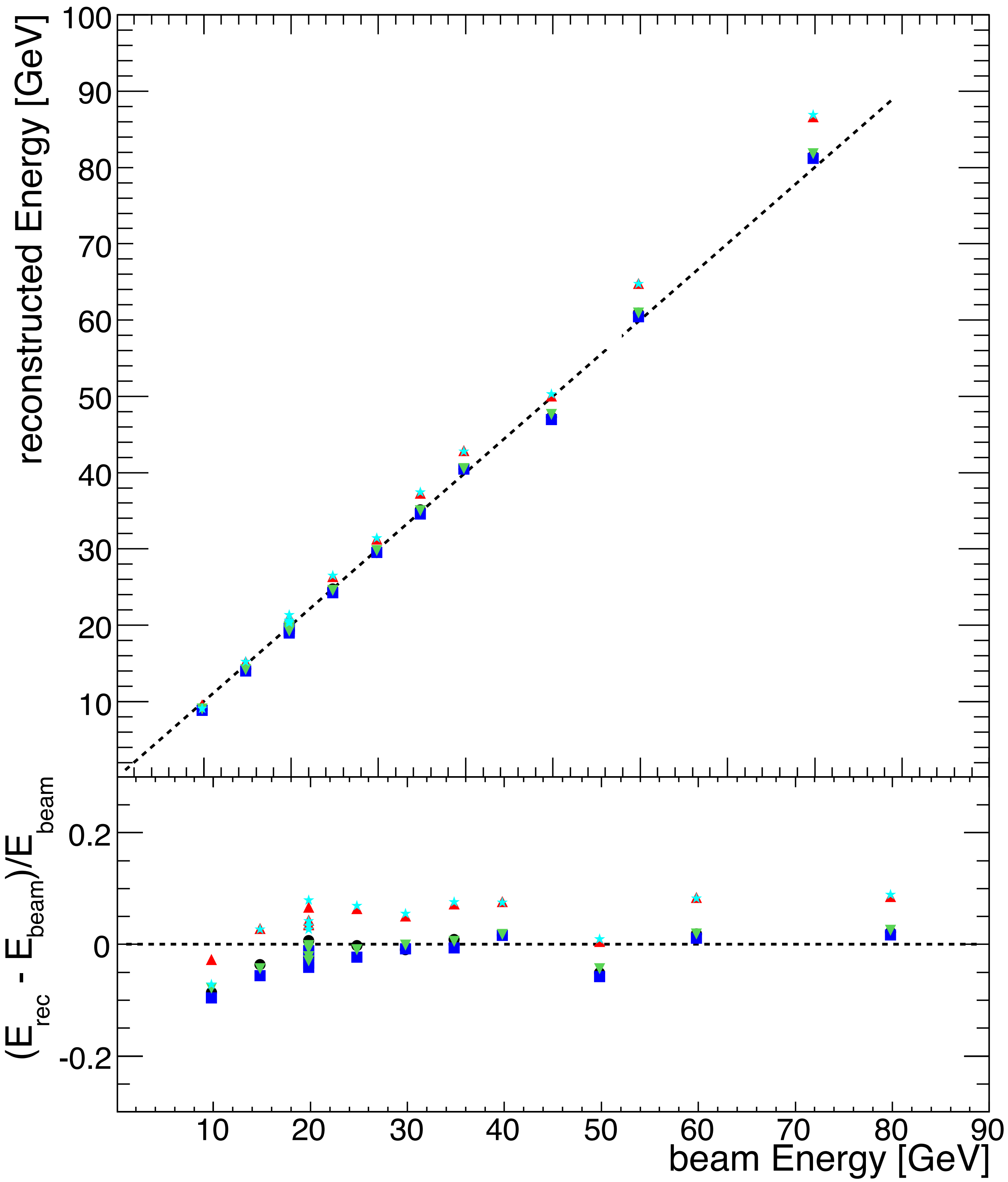



- U,T correction: use **detector average** for each set



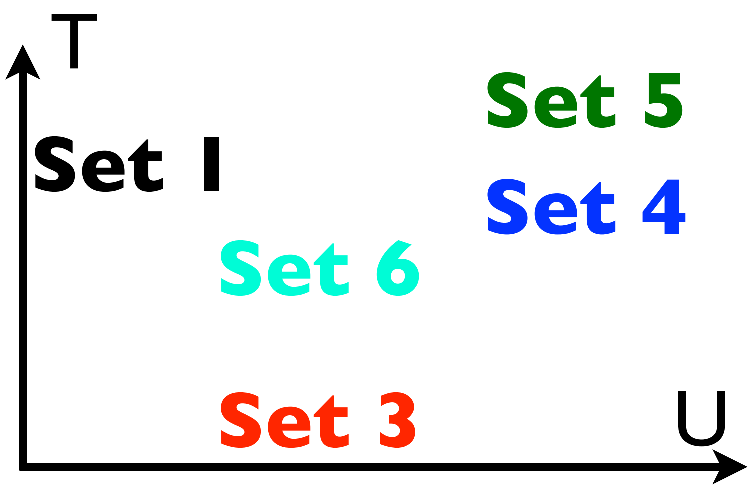
# AHCAL Linearity

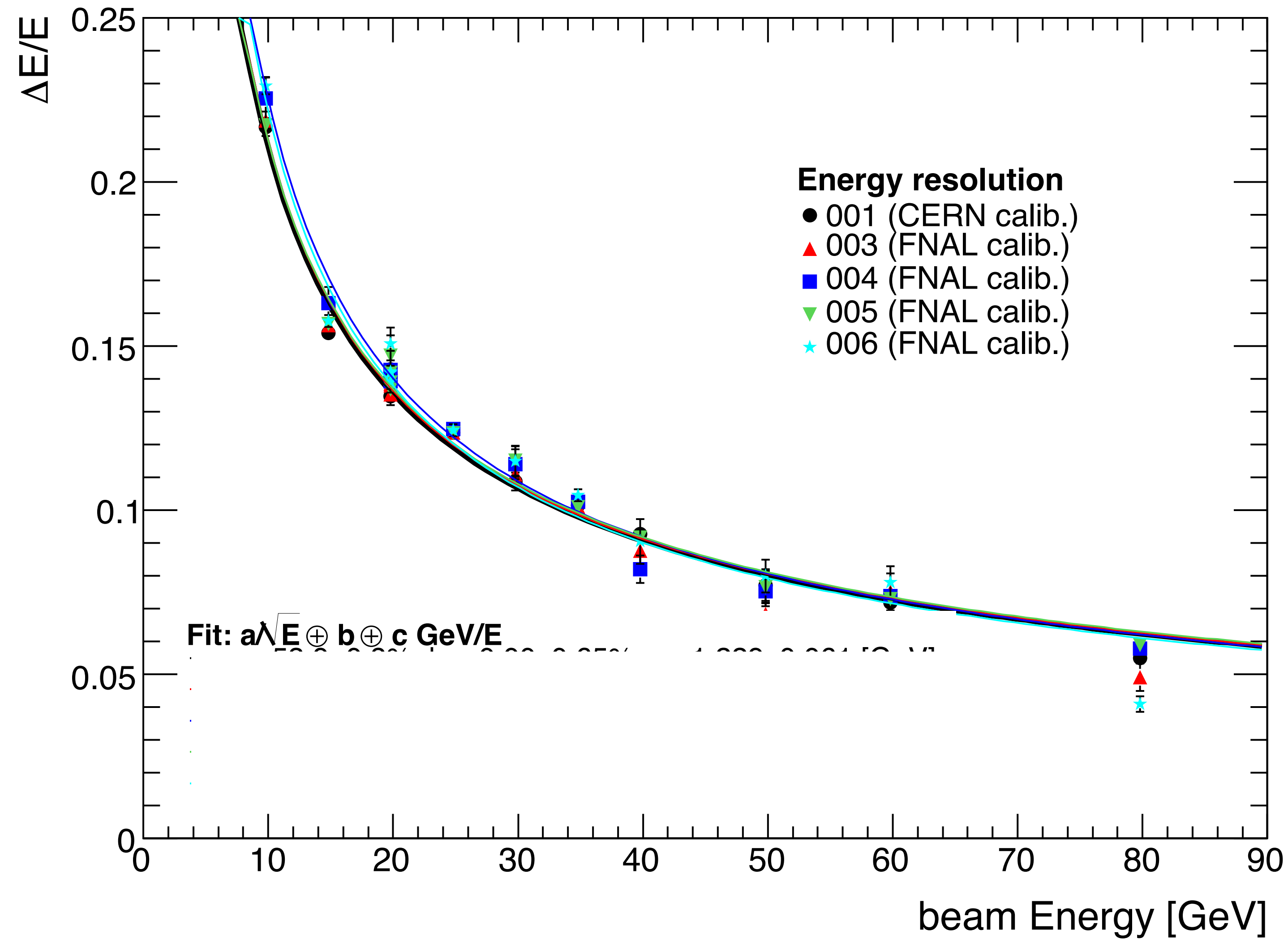



- 0.028 GeV/MIP fixed
- Reduce beam energy by 0.2 GeV (energy loss in ECAL)
- U,T correction: **detector average**
- use ECAL → improvement < 20 GeV

# AHCAL Resolution




- 0.028 GeV/MIP fixed
- Reduce beam energy by 0.2 GeV (energy loss in ECAL)
- U,T correction: **detector average**

→ Consistent results for using CERN or FNAL calibration for CERN runs

# Summary

- Temperature correction works **within 3%** for energy sum (all studied calibration sets)
- Shifting FNAL calibration sets to CERN conditions possible
  - mean remaining offset: 0% - 5%
  - spread of offset between layers: 10%
  - **no significant impact on resulting linearity or resolution**