Calibration Sets for IDAG Studies

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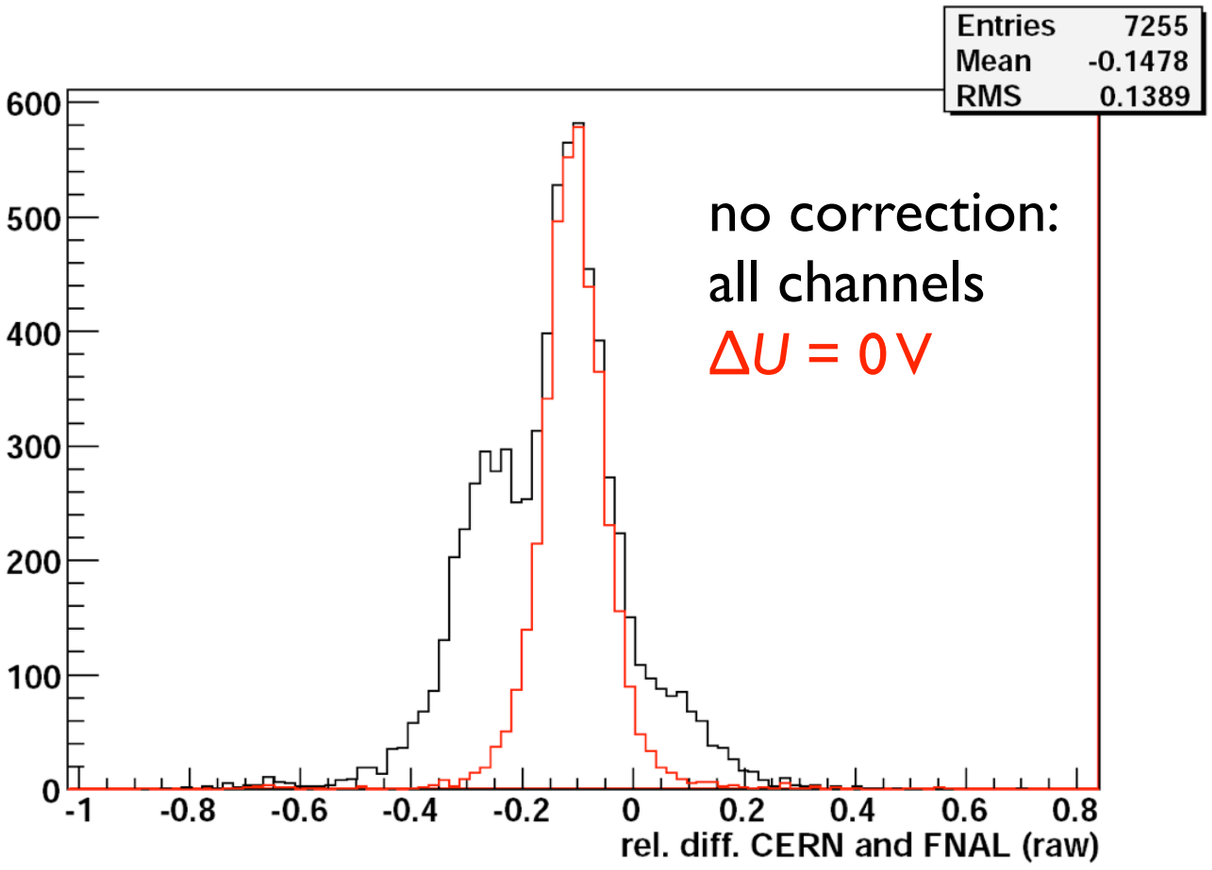
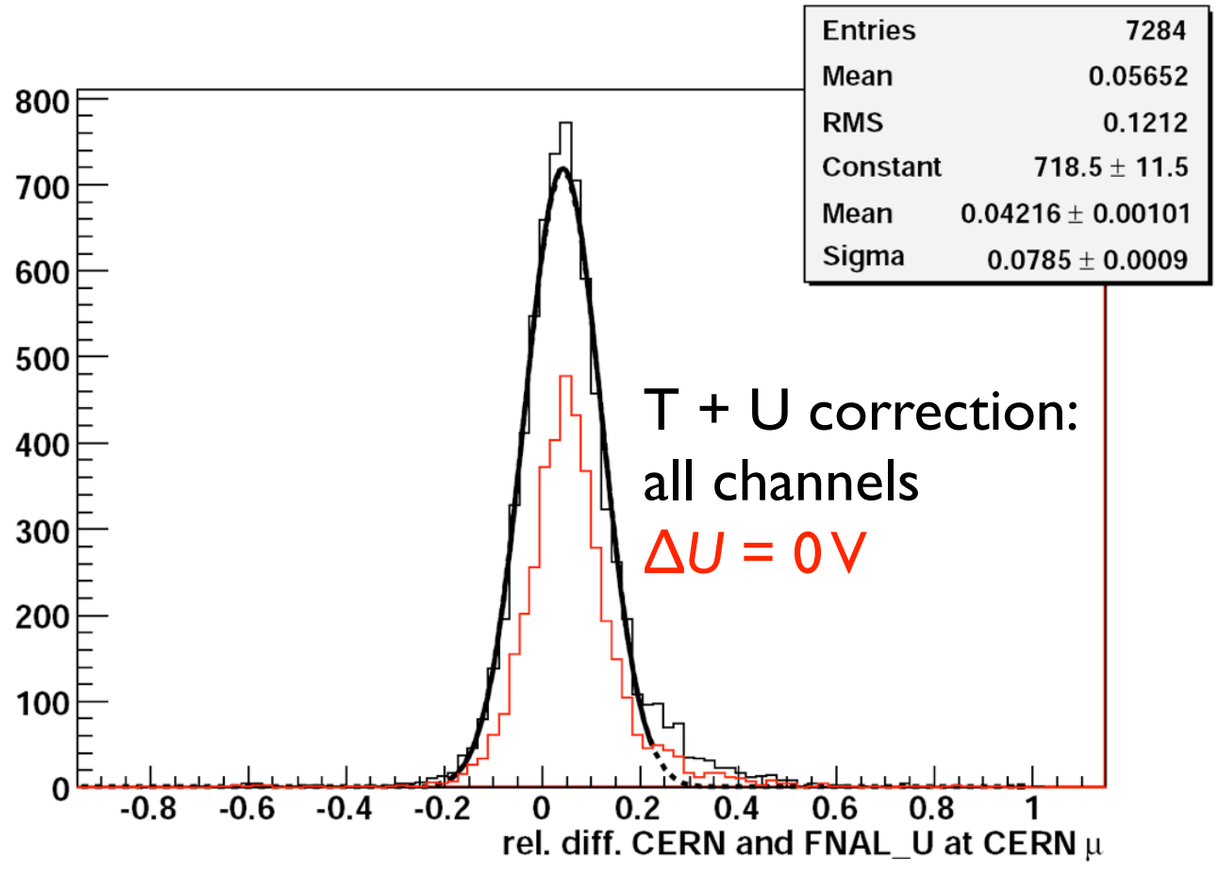
Outline

The IDAG question:
transport FNAL muon calibration (“testbeam run”)
to CERN operation conditions (“collider run”)
→ possible? impact on energy resolution?

- *T* + *U* Correction: IDAG Status and Changes
- FNAL: *T* + *U* Dependence of Muon Calibration
- Shift FNAL Calibration to CERN Conditions
- Summary & Outlook

IDAG Status





- ΔT = 4.5 K

- IDAG report: Remaining difference due to different muon energy

  → **not valid!** (would explain shift of mean, not of MPV)

relative difference	mean	sigma
T + *U* correction	4.2%	7.8%

IDAG Reloaded

	IDAG (2009)	**IDAG reloaded (now)**
Mip calibration	chi^2 fit	likelihood fit
T + U correction	each channel: individual slope	detector average
	absolute slopes (CERN)	relative slopes (CERN)

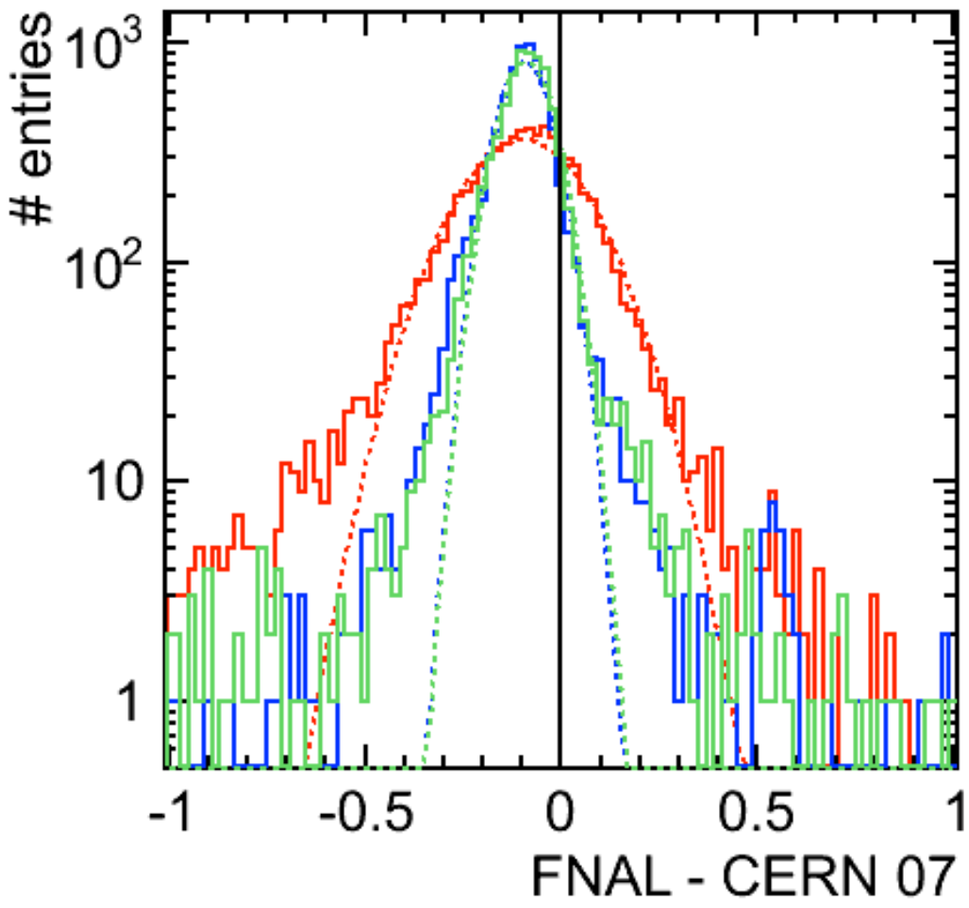
- Gain *G*, Geiger efficiency ε ~ *U*, *T* (in operation range)
- Response *A* ~ *G* (*U*,*T*) · ε (*U*,*T*)

simplifications:

- SiPM response *A* ~ *U*, *T*
- All SiPMs and operating conditions:
  - 1/A dA/dT = -3.7%/K
  - 1/A dA/dU = 5.6%/100mV

Δ*T* = -4 K: 1/A ΔA = 15%
→1/*A* d*A*/d*T* = 3.2%/K
→2% shift for *A* over 4 K!

IDAG Reloaded



- Shift FNAL calibration to *T*, *U* of CERN muon calibration using
  - 1/A dA/dT = -3.7 %/K
  - 1/A dA/dU = 5.6 %/100mV

relative difference (corrected)	mean	sigma
FNAL 0508/2	-9.7%	15%
FNAL 0508/3	-9.5%	6.5%
FNAL 0908	-8.9%	6.6%

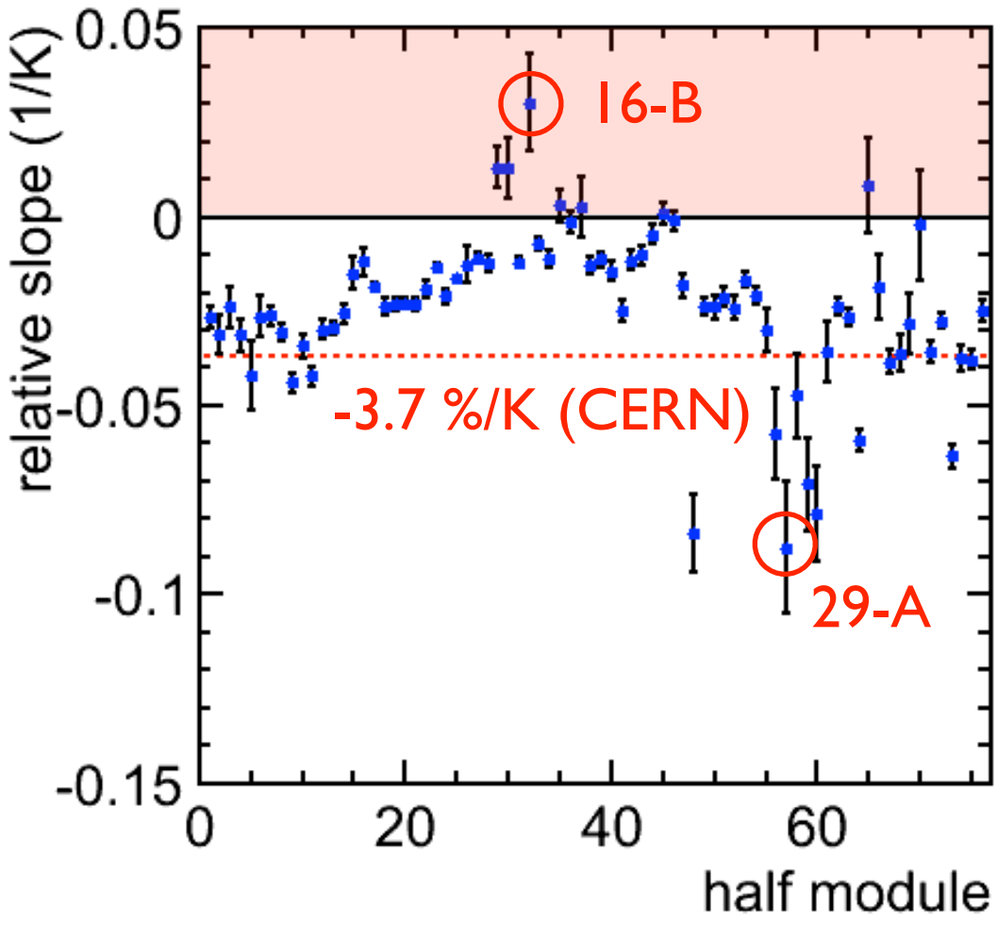
→ Step back and re-evaluate assumptions / simplifications!

T-Dependence at FNAL

- Mip calibration: FNAL 0509, FNAL 0908
  - ΔU = 0 V
  - ΔT = 1.6 K (mean)
- each channel:

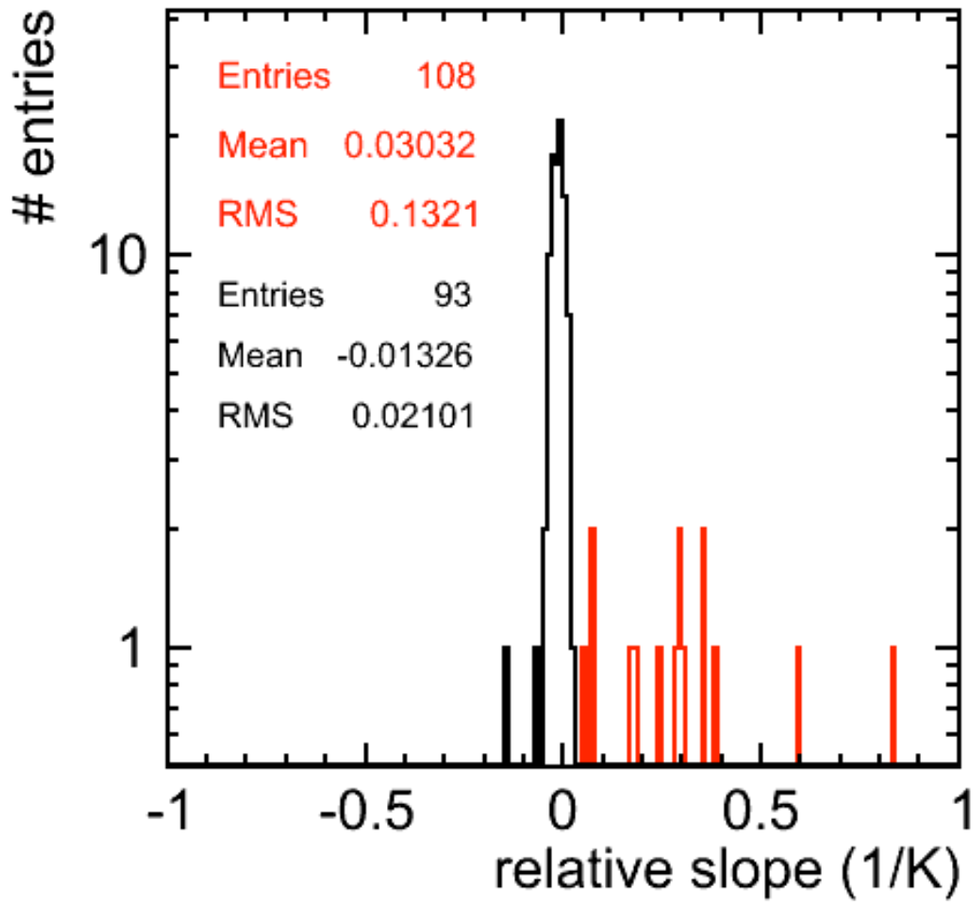
$$\frac{1}{A}\frac{dA}{dT} = 2 \cdot \frac{A_1 - A_2}{A_1 + A_2} \cdot \frac{1}{T_1 - T_2}$$

- half-module means:
  - strong fluctuation
  - outliers

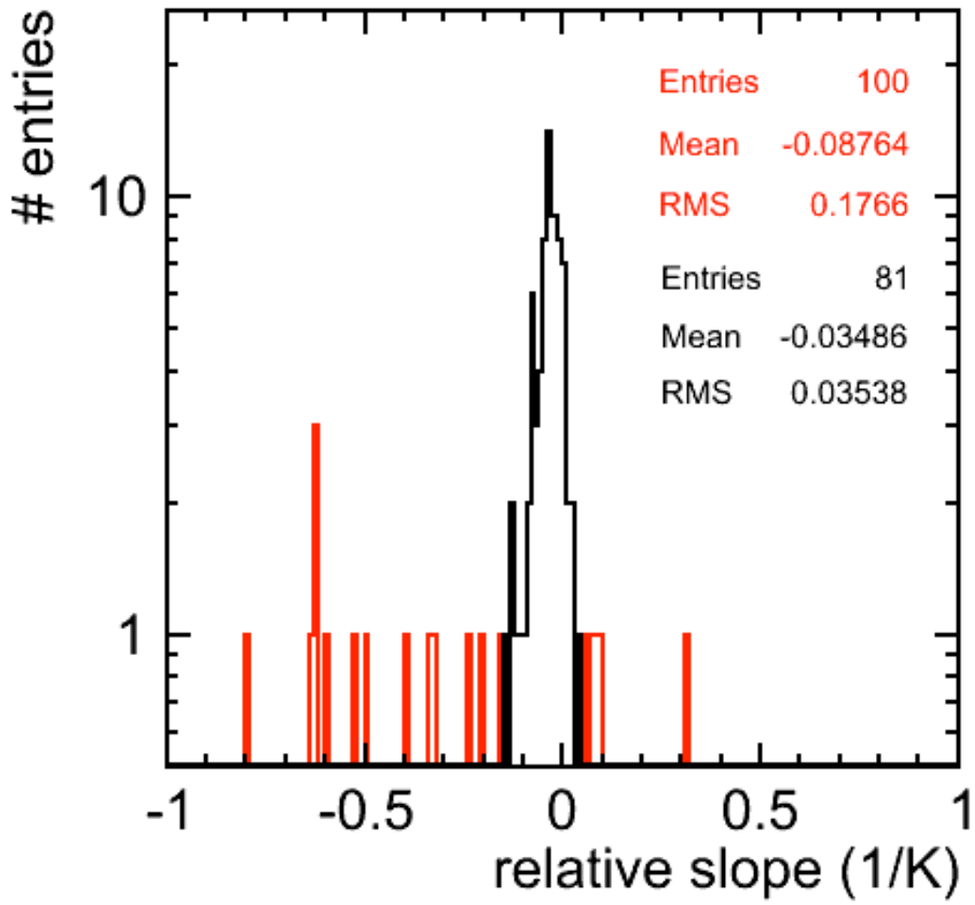


Outlier Rejection

module 16-B: positive slope

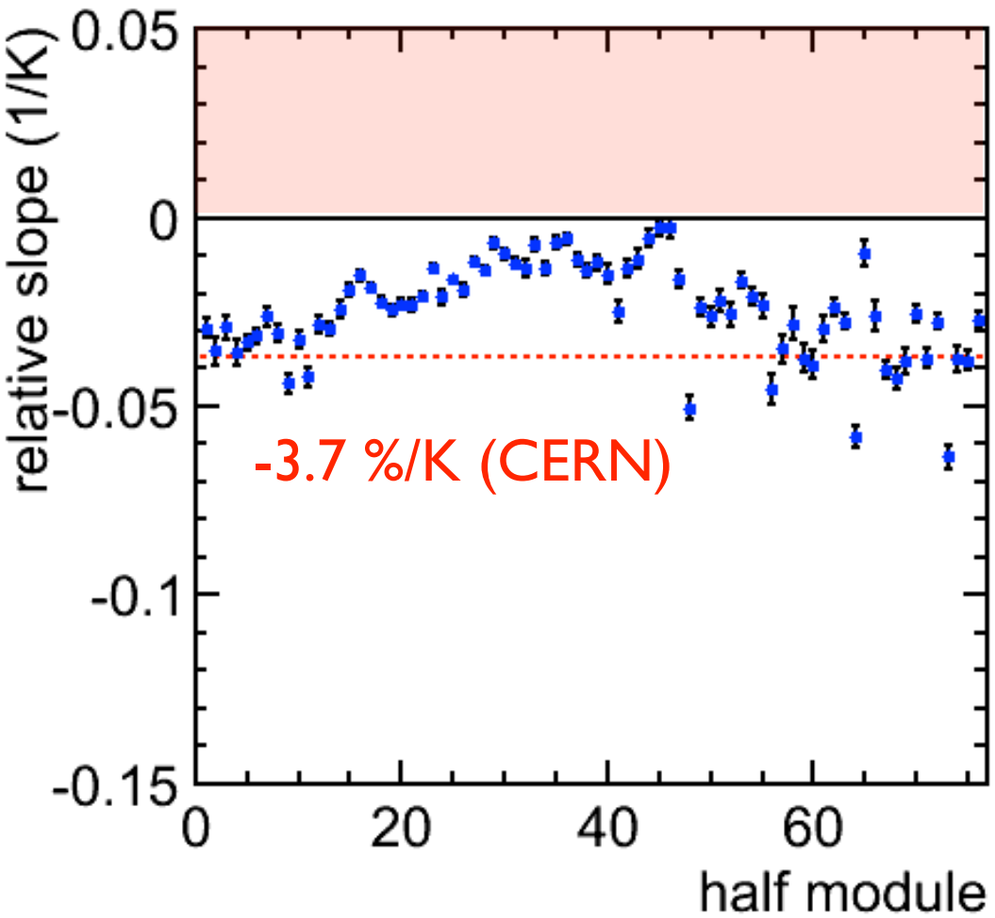


module 29-A: strongly negative slope

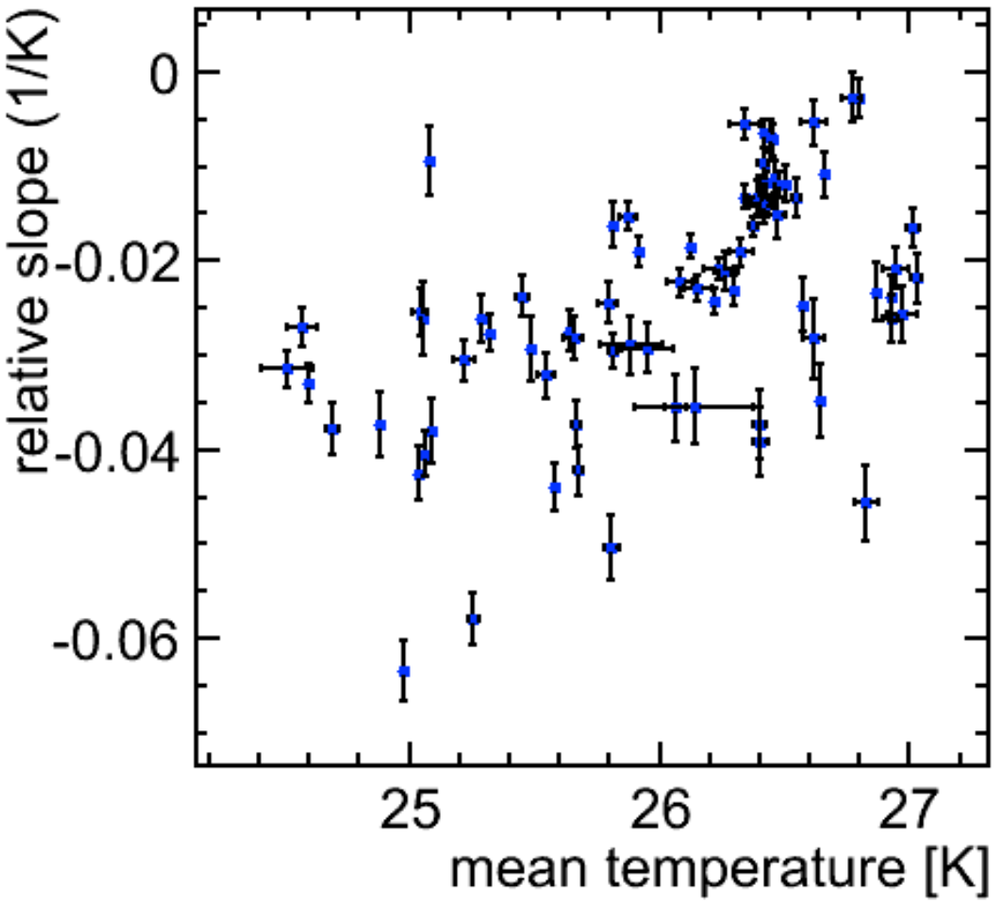


- cut outliers: include only channels with -0.15 1/K < 1/A dA/dT < 0.05 1/K
- reduce # channels from 7433 to 7221 (3 %)

Average *T*-Dependence



- average relative slope: **-2.4 %/K**
- spread between modules (RMS): 1.3 %/K



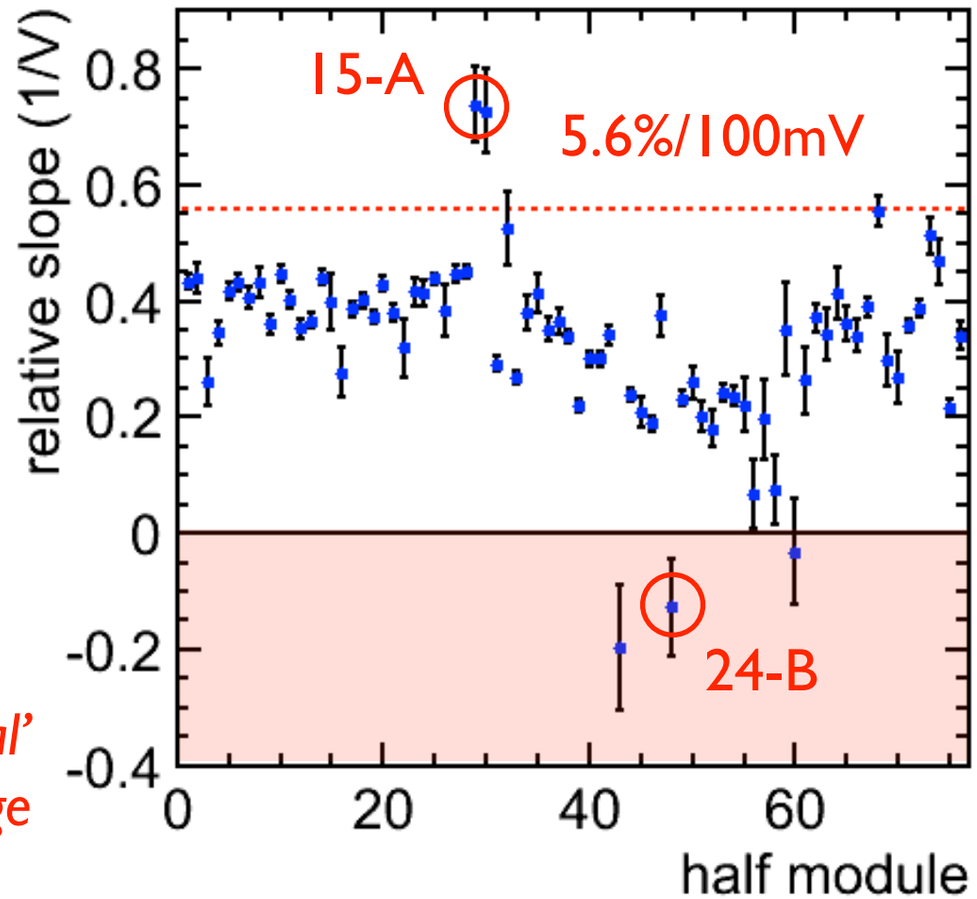
- correlation between average relative slopes and temperatures: **51%**

U-Dependence at FNAL

- Mip calibration: FNAL 0508/3, FNAL 0908
  - ΔU = 200 mV
  - ΔT = 3.4 K (mean)
- shift FNAL 0908 to T(FNAL 0508/3) using 1/A dA/dT = -2.4 %/K
- each channel:

$$\frac{1}{A}\frac{dA}{dU} = 2 \cdot \frac{A_1 - A_2}{A_1 + A_2} \cdot \frac{1}{U_1 - U_2}$$

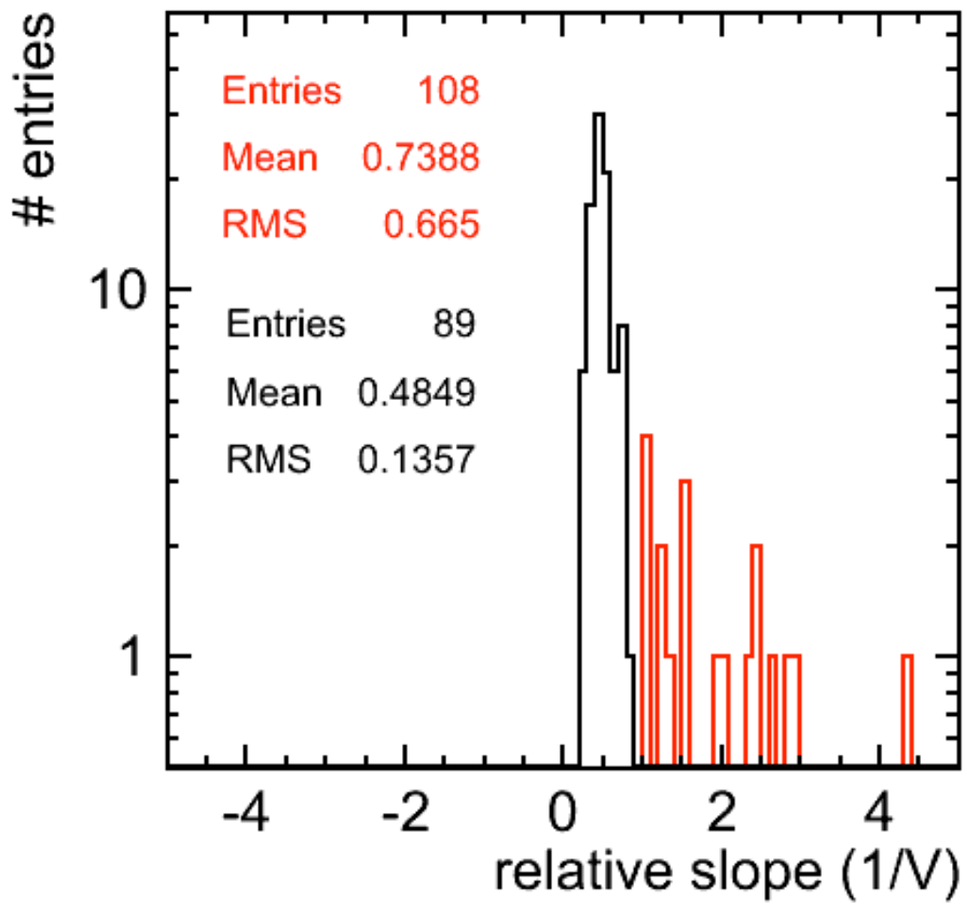
- half-module means:
  - strong fluctuation
  - outliers



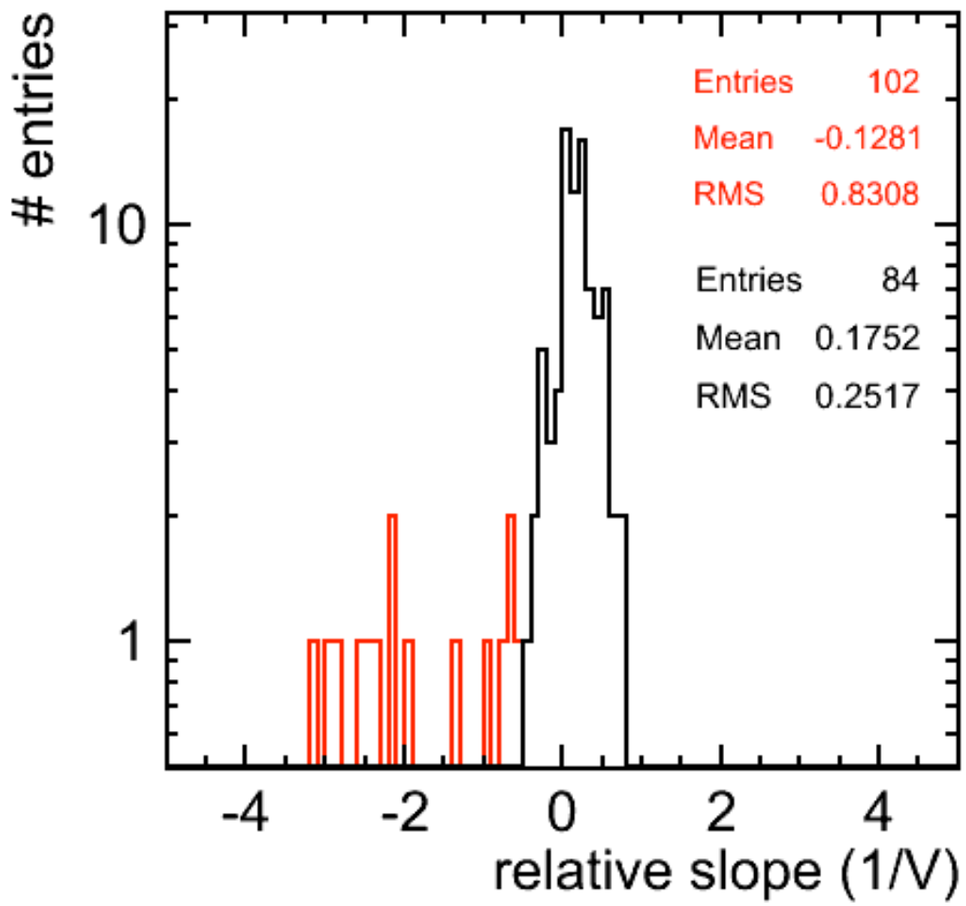
'unphysical' range

Outlier Rejection

module 15-A: strongly positive slope

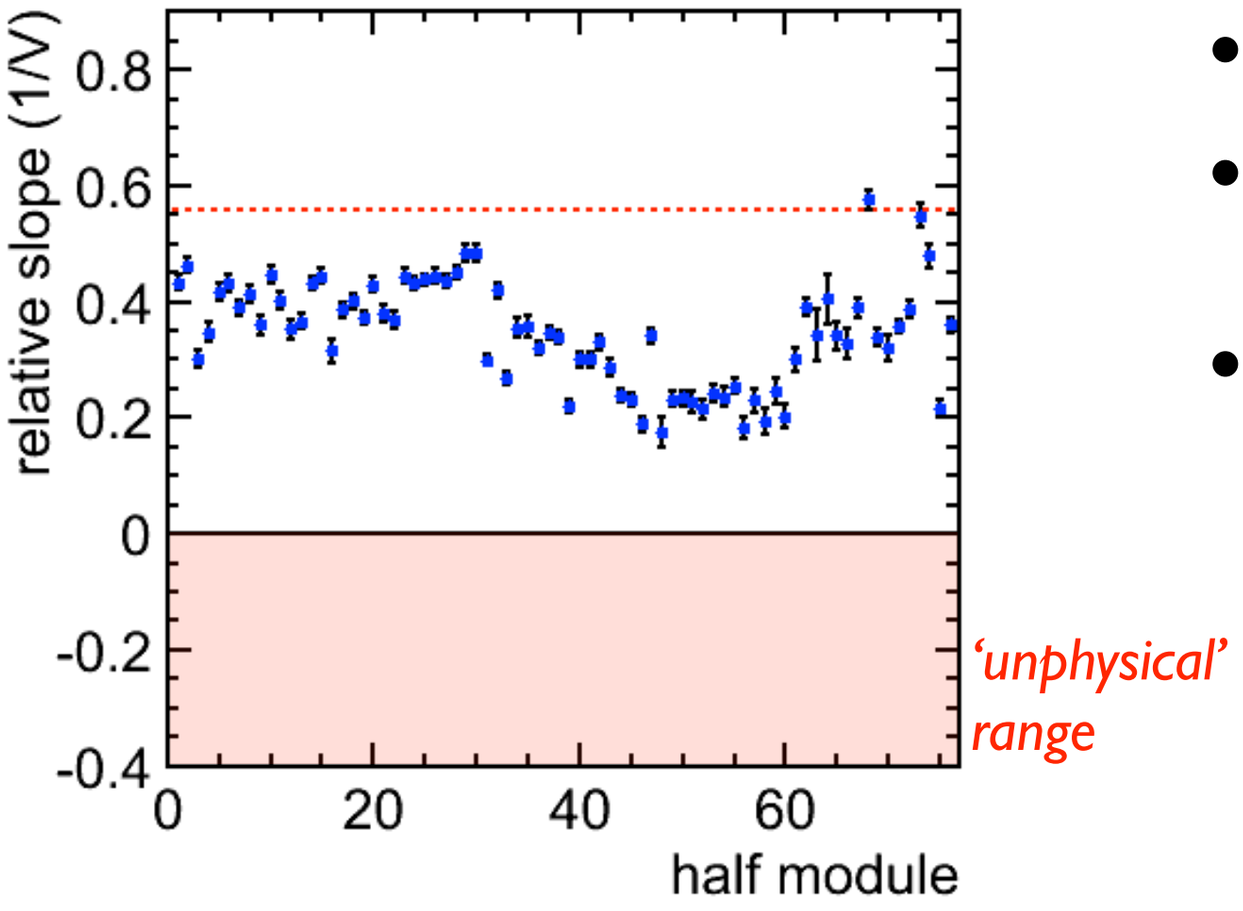


module 24-B: negative slope



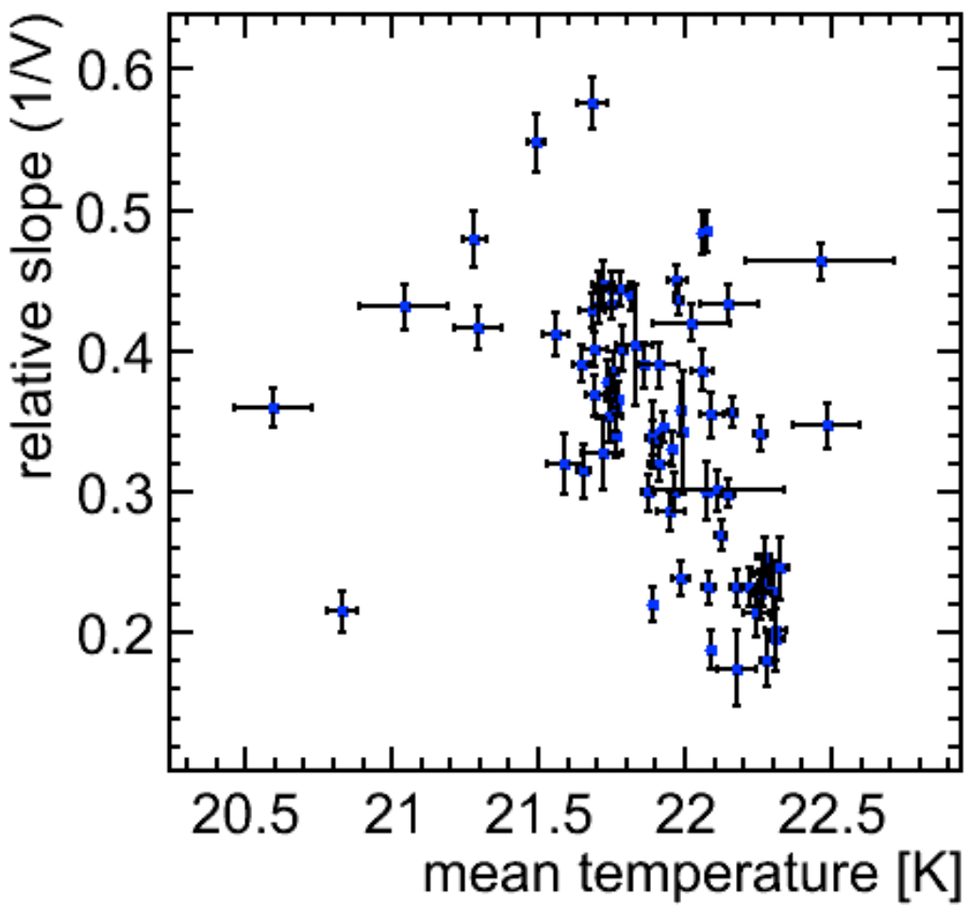
- cut outliers: include only channels with -0.5 1/V < 1/A dA/dU < 1.0 1/K
- reduce # channels from 7427 to 7232 (3 %)

Average *U*-Dependence



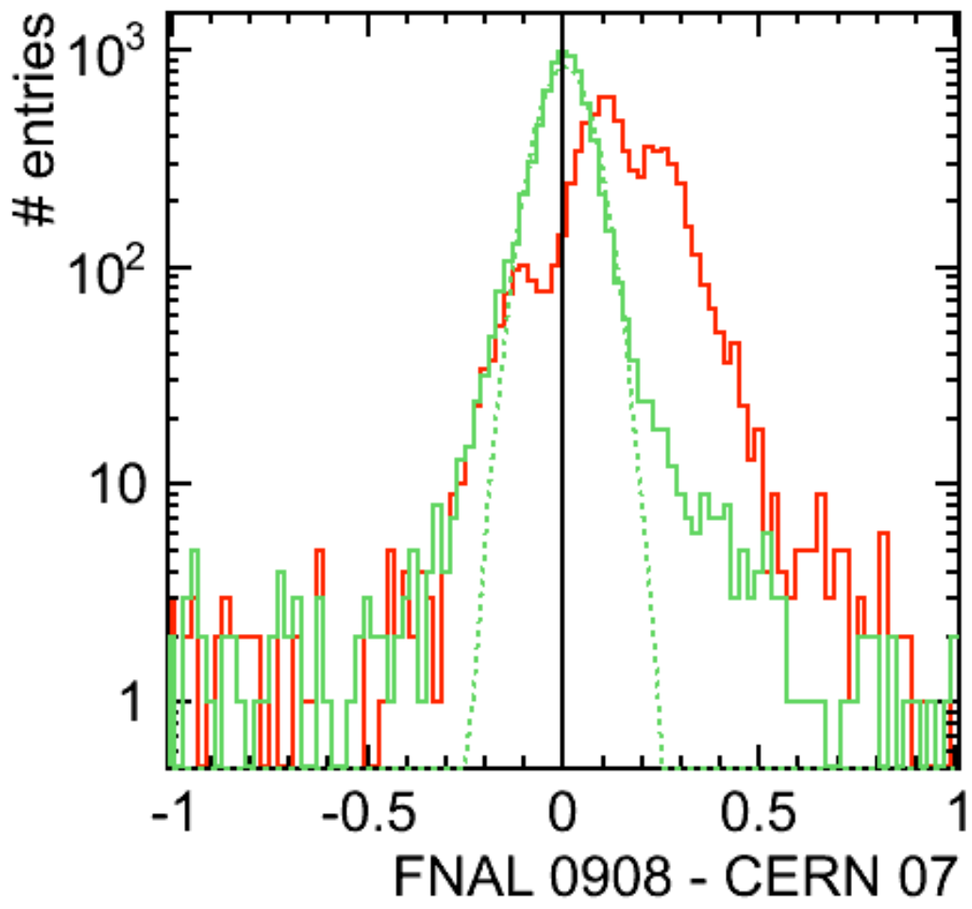
'unphysical' range

- average relative slope: **3.5 %/100mV**
- spread between modules (RMS): 0.9 %/100mV
- correlation between average relative slopes and temperatures: **-40%**



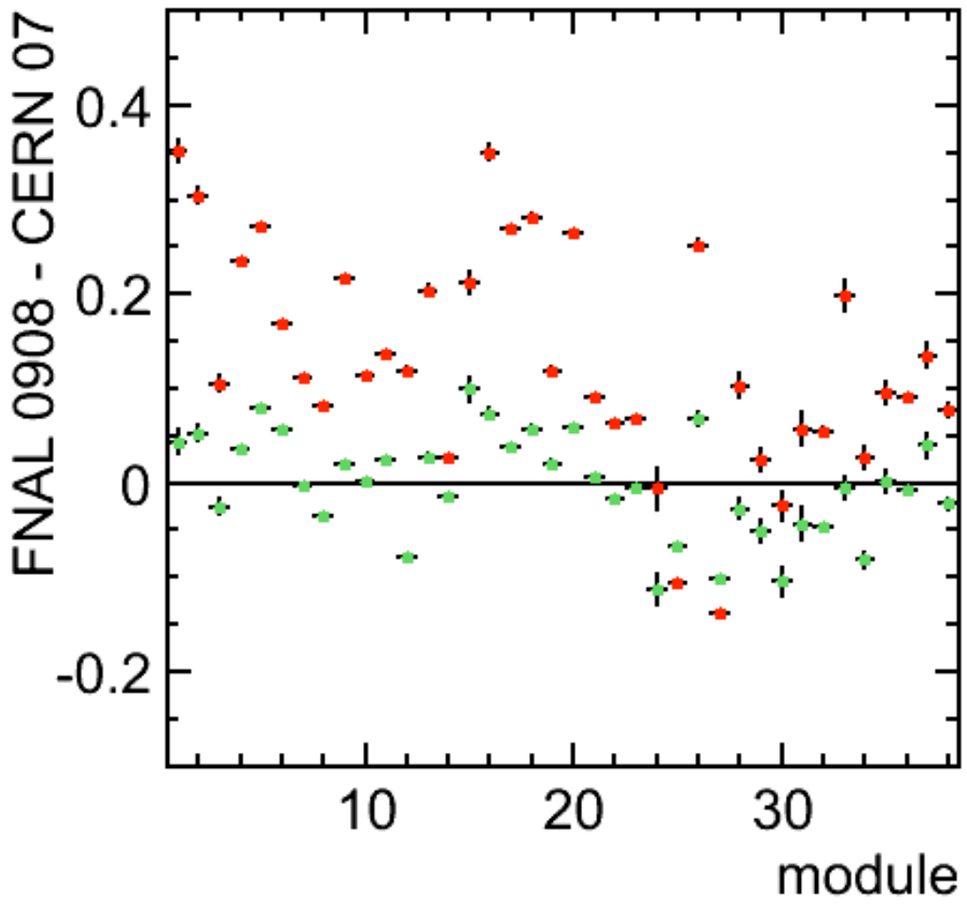
	I/A dA/dT [%/K]	I/A dA/dU [%/100mV]	ratio [mV/K]
CERN	-3.7	5.6	-66
FNAL	-2.4	3.5	-69

Transport FNAL → CERN

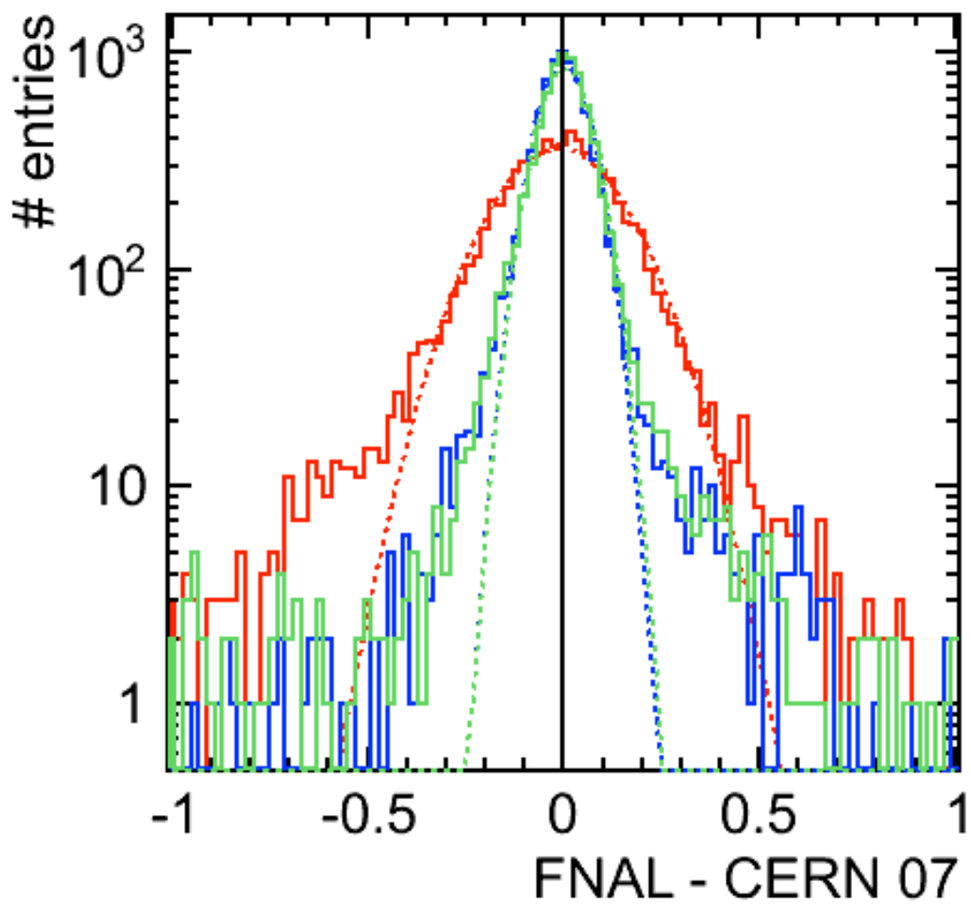


relative difference	mean	sigma
FNAL 0908	0.3%	6.4%

- $\Delta U \leq 0.7$ V (main groups 0.2 V and 0.5 V)
  $\Delta T = 1$ K
- use 1/A dA/dT = -2.4 %/K
  and 1/A dA/dU = 3.5 %/100mV
  - Mean looks good!
  - single modules up to 10% off

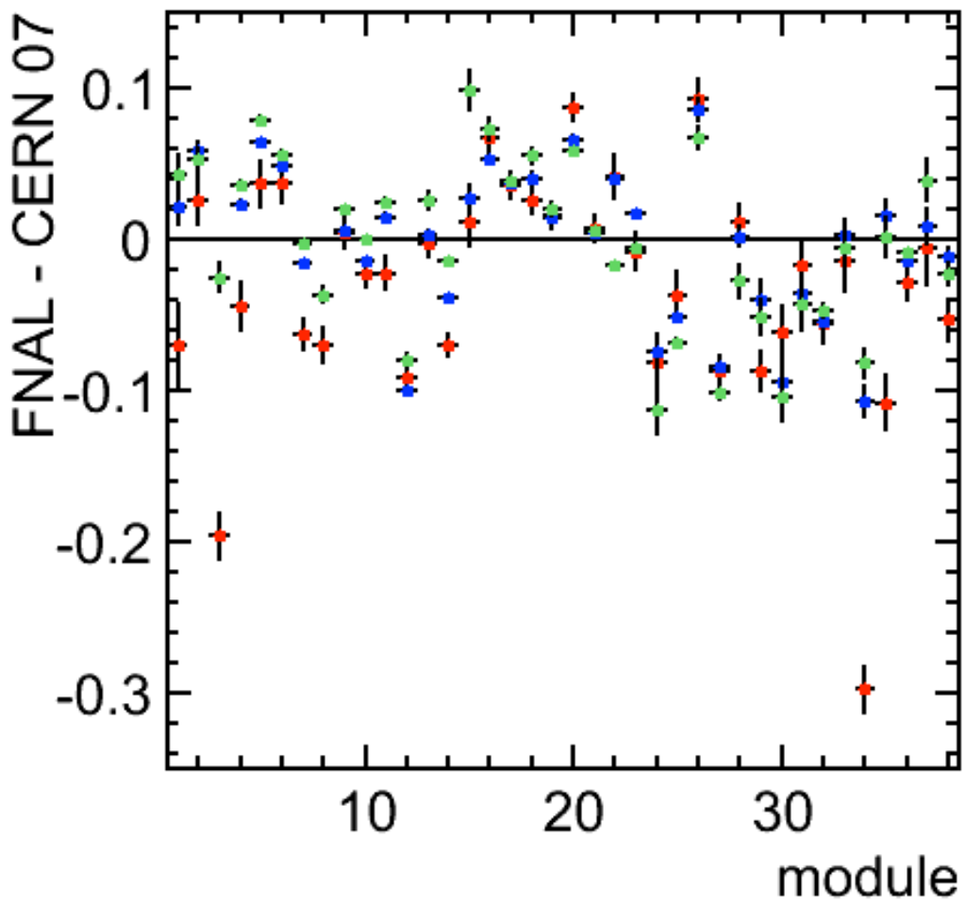


Transport FNAL → CERN



- use 1/A dA/dT = -2.4 %/K
  and 1/A dA/dU = 3.5 %/100mV
- best for subsequent studies:
  - FNAL 0508/3 (ΔT = 4.3 K)
  - FNAL 0908 (ΔU = 0.2 V … 0.5 V)

relative difference	mean	sigma
FNAL 0508/2	-1.2%	16%
FNAL 0508/3	-0.2%	6.3%
FNAL 0908	0.3%	6.4%



Summary & Outlook

- Significant improvement in transporting mip calibration FNAL → CERN using *U* + *T* correction w.r.t. IDAG report
  - use detector average: 1/A dA/dT = -2.4 %/K
  - use detector average: 1/A dA/dU = 3.5 %/100 mV
  - remaining shift < 0.5%, spread < 7%
- Next steps:
  - need to reduce spread
    - use half-module averages for *U* + *T* slopes
    - transport calibration using SiPM gain (*G* correction)
  - improve understanding of *U* + *T* correction using more muon data
    - dedicated *U*, *T* scans with high statistics at next test beam?
  - quantify correction impact on detector resolution

Backup Slides

Mip Calibration Sets