Performance of the Tracker End Caps in the Slice Test (February - July 2007)

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for the TEC-Team

FSP-CMS Meeting, Zeuthen

26.9. - 28.9 2007

- Introduction
- The 'Slice'
- Commissioning
  - Gain Scan/Timing/Pedestal
- Temperature Evolution of Defects
- Noise Stability with Temperature
- Summary and Outlook

Beginning of the Slice Test

- Both TECs were inserted into the Tracker Support Tube (TST)

on 28.2 (TEC+)

and 21.3 (TEC−)

respectively

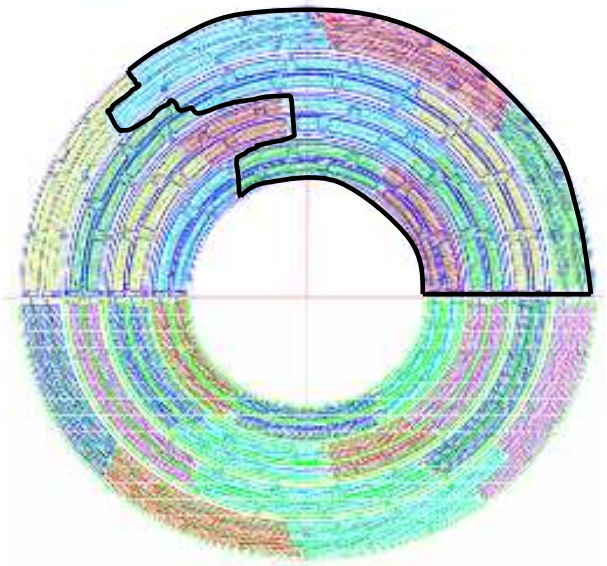
→Strip Tracker is completed

Goals of the Slice Test

- Operate a large ’slice’ of the tracker using
  - ’Detector Control System(DCS)’ (to control low and high voltage and to monitor voltages, leakage currents, temperatures and rel. humidity) and
  - ’Detector Safety System’ implementing software and hardware interlocks to ensure safe state of the detector at all times.
- Stable data taking with all subdetectors
  - Common Commissioning of all Subdetectors
    - Determine possible interference between subdetectors (crosstalk)
    - Measure at different temperatures, determine thermal properties of the tracker
  - Record cosmic muons with all subdetectors
  - Establish and test the read-out and reconstruction chain (transfer data to Tier1 center and run reconstruction chain, etc...)

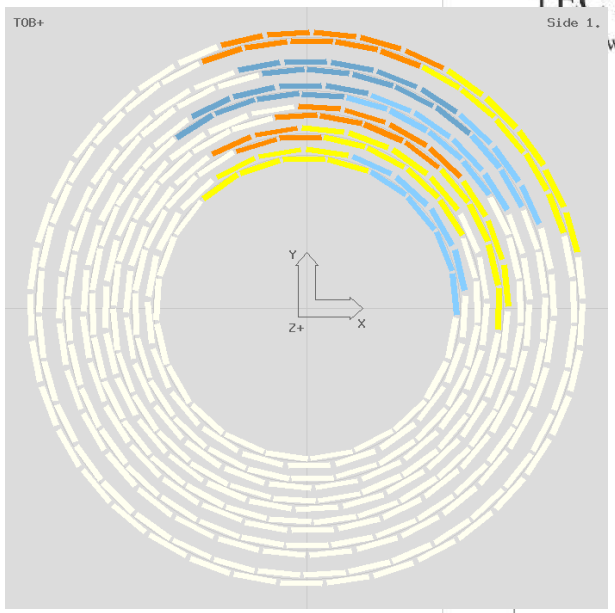
The 'Slice'

TIB

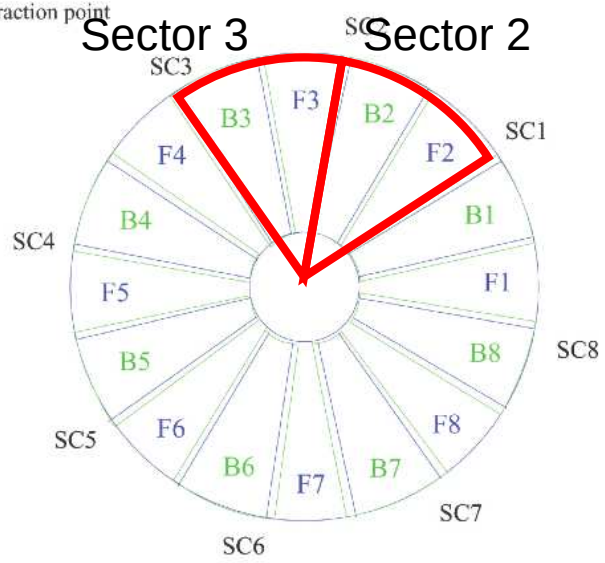


- 640 Modules
- +50% of TID+

TOB



- 720 Modules



- 2 Sectors (800 Modules)

Total: $>$2100 Modules, $\sim$25 m^2 of silicon

Slice Test: Schedule

Since Beginning of March: TIB/TOB/TEC read out together at room temperatur (chiller at +15° C)

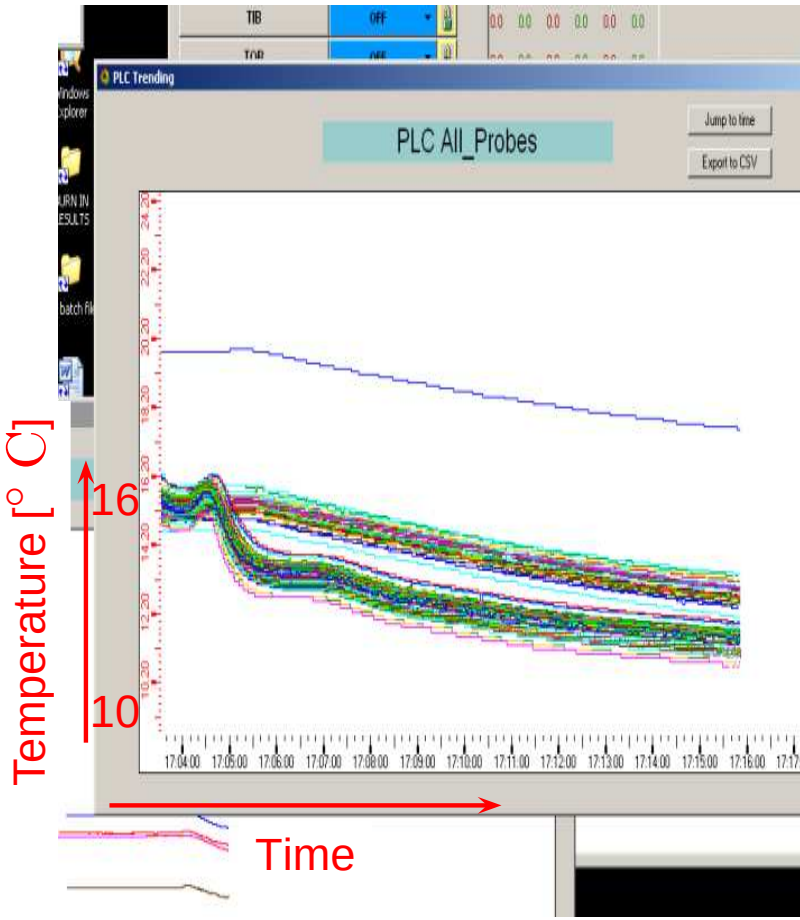
May 25th: Lowering chiller temperature to +10° C

June 5th: Lowering chiller temperatur to -0.5° C

June 15th: Lowering chiller temperatur to -10° C

June 25th: Lowering chiller temperatur to -15° C(Reduced Slice)

Juli 1st: Warming up to room temperature (Chiller +15° C)

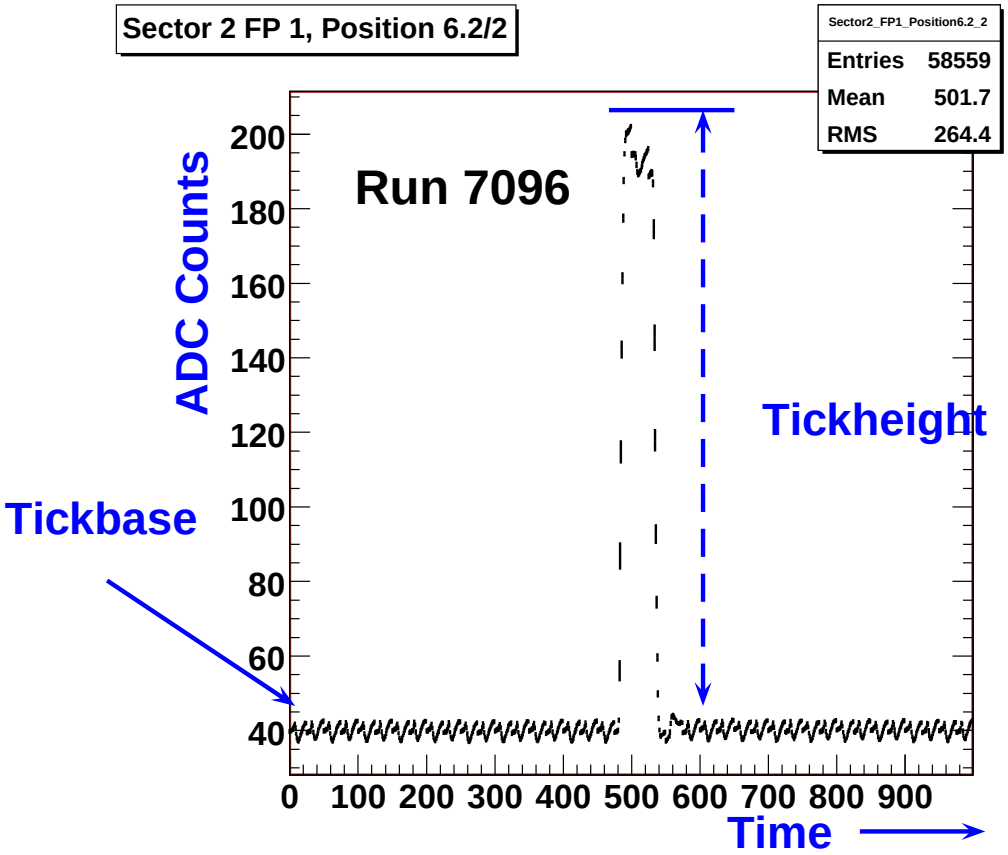


5 Steps in temperature, time at each step to check system and to take meaningful amount of cosmics (cosmics:see talk by G. Kaussen)

Commissioning the Tracker – Getting Ready for Data

several steps neccessary:

- Detect all connected modules
- Adjust laser amplification:
  - Strip tracker is read-out in analog mode
    $\longrightarrow$Information about signal height is available
  - Electrical signal is converted to optical signal
  - Laser has four amplification settings
  - Goal: make best use of dynamical range
- Ajust timing
  - Account for differences in cable length etc...
- Determine pedestal and noise ($\longrightarrow$2 slides)



conversion from ADC to Electrons:

Tick at input $\hat{=}$ 8 MIP signal ($2 \times 10^5 e^-$)

$$\text{noise}_{e^-} = \frac{2\times10^5}{\text{Tick Height(output)}} \cdot \text{noise}_{\text{ADC}}$$

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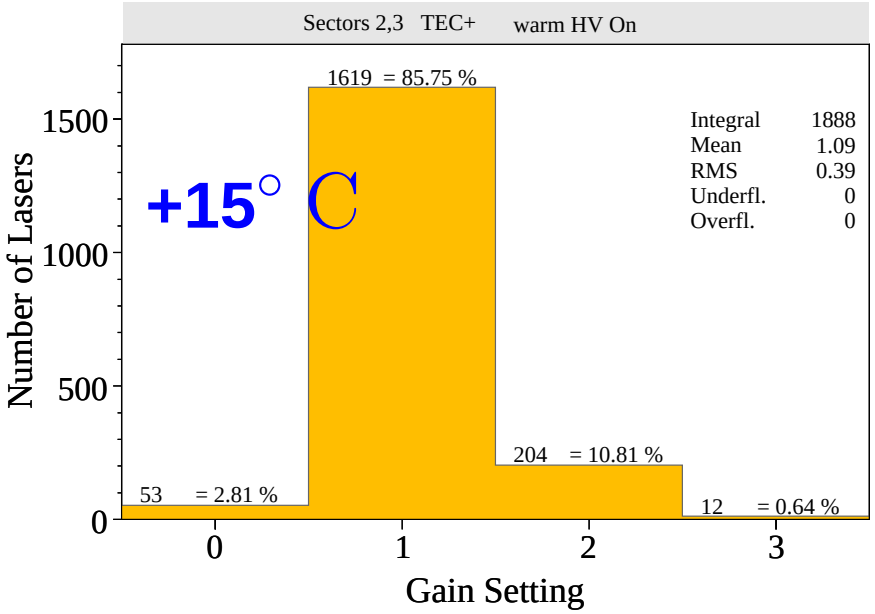
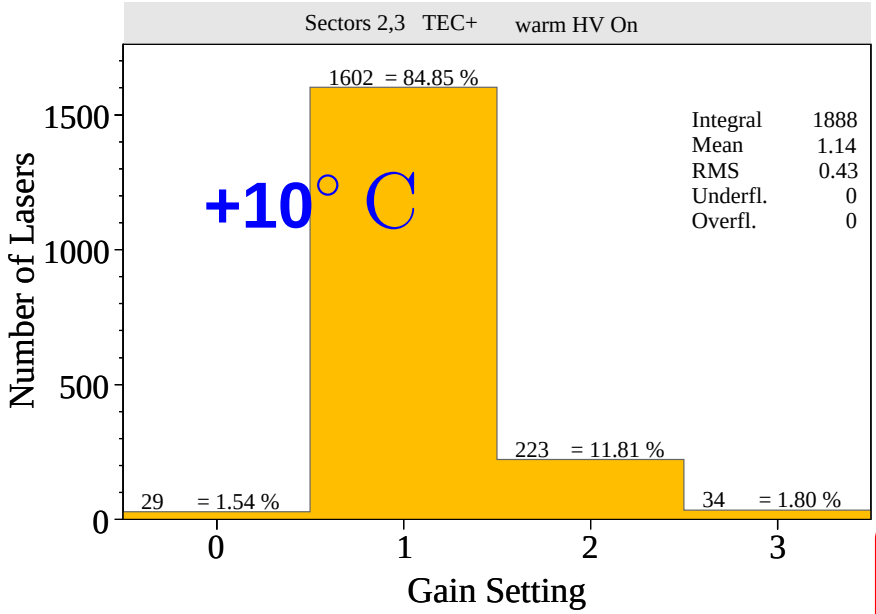
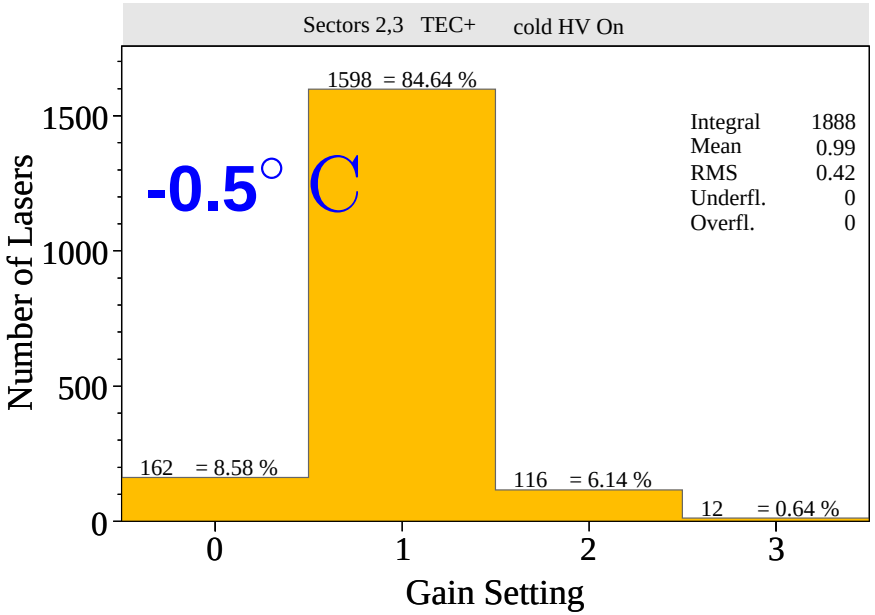
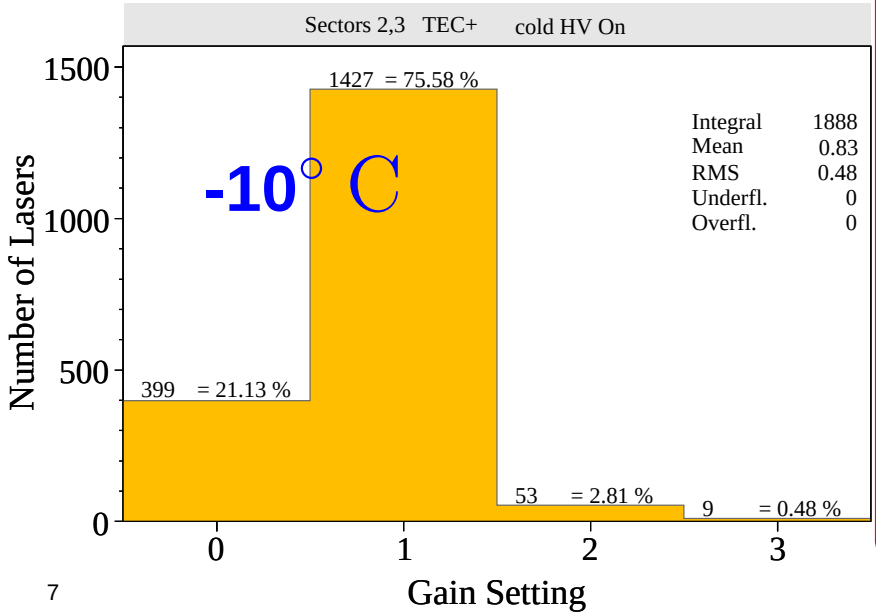
Distribution of Laser Gain Settings



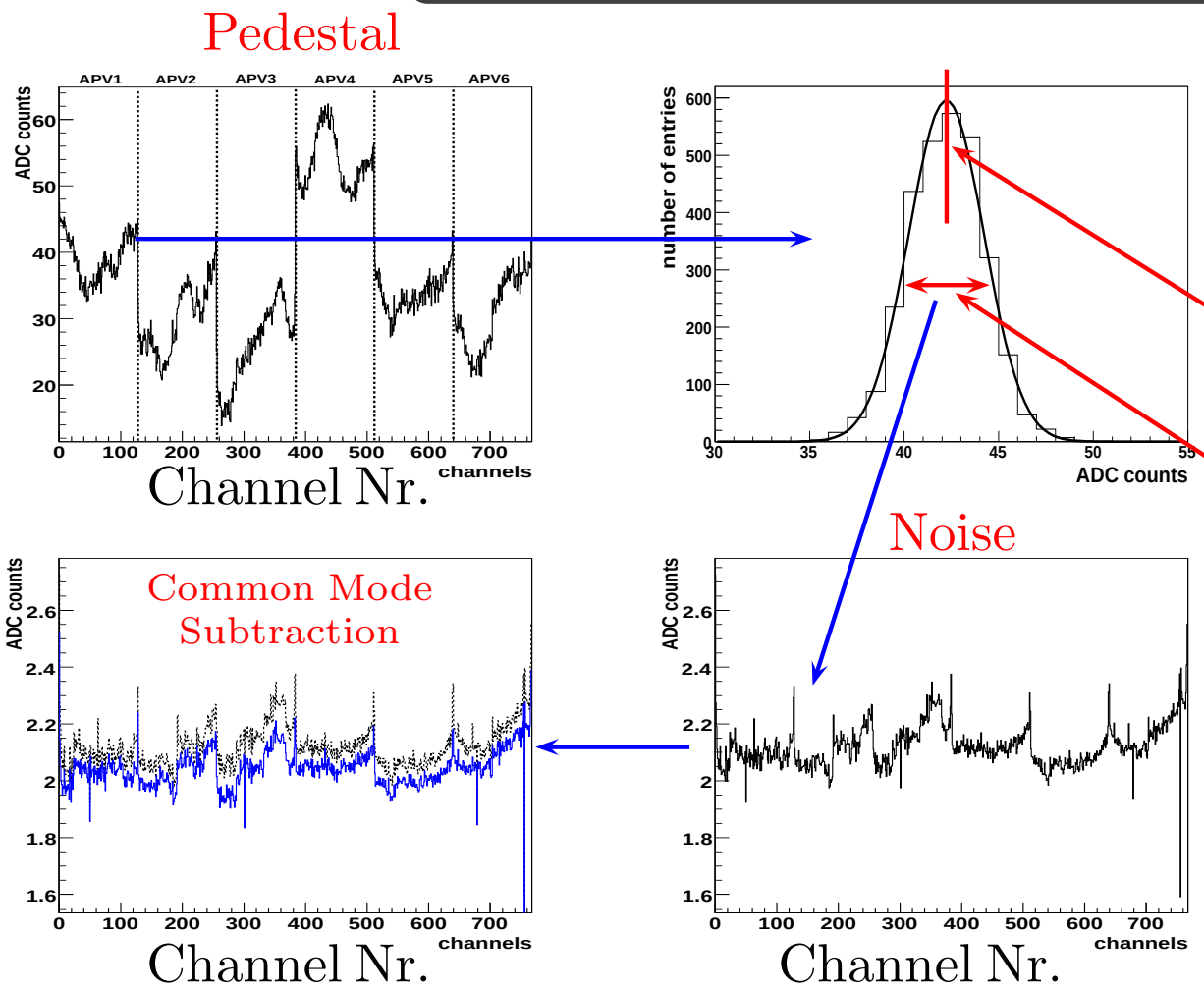






- changes with temperature as expected
- very few lasers in gain setting 3
- almost all reach desired gain

Pedestals: Data Analysis (Schematic)



- „Pedestal“ and „Noise“ Determination
- Subtract „Common Mode“

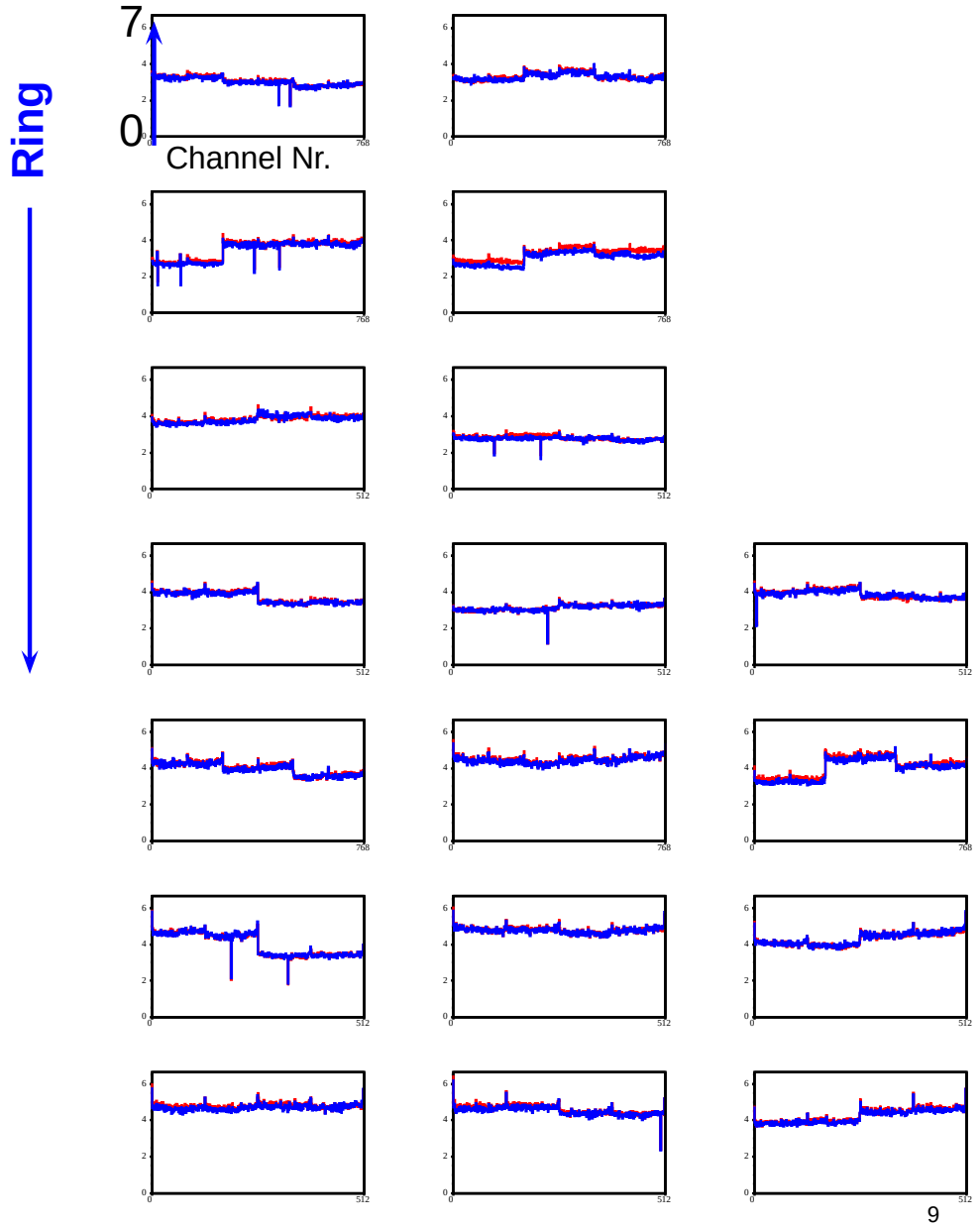
Pedestal: Mean for each channel for large number of events

Raw Noise: RMS of Pedestal distribution

Common Mode: For each event, for N channels take

$$\frac{1}{N}\sum_{i=0}^{N}\left(\mathrm{Raw_i}-\mathrm{Pedestal_i}\right)$$

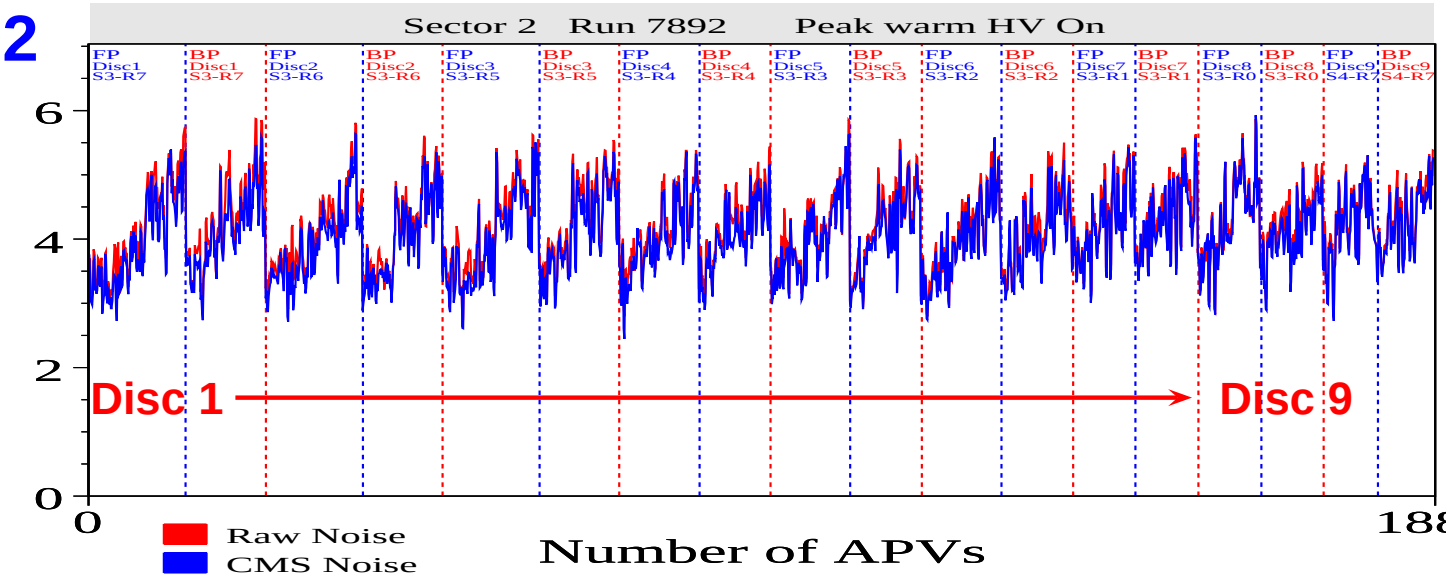
Noise of a single Petal – Sector 2/ Back Petal Disc 1



Noise on individual modules looks well

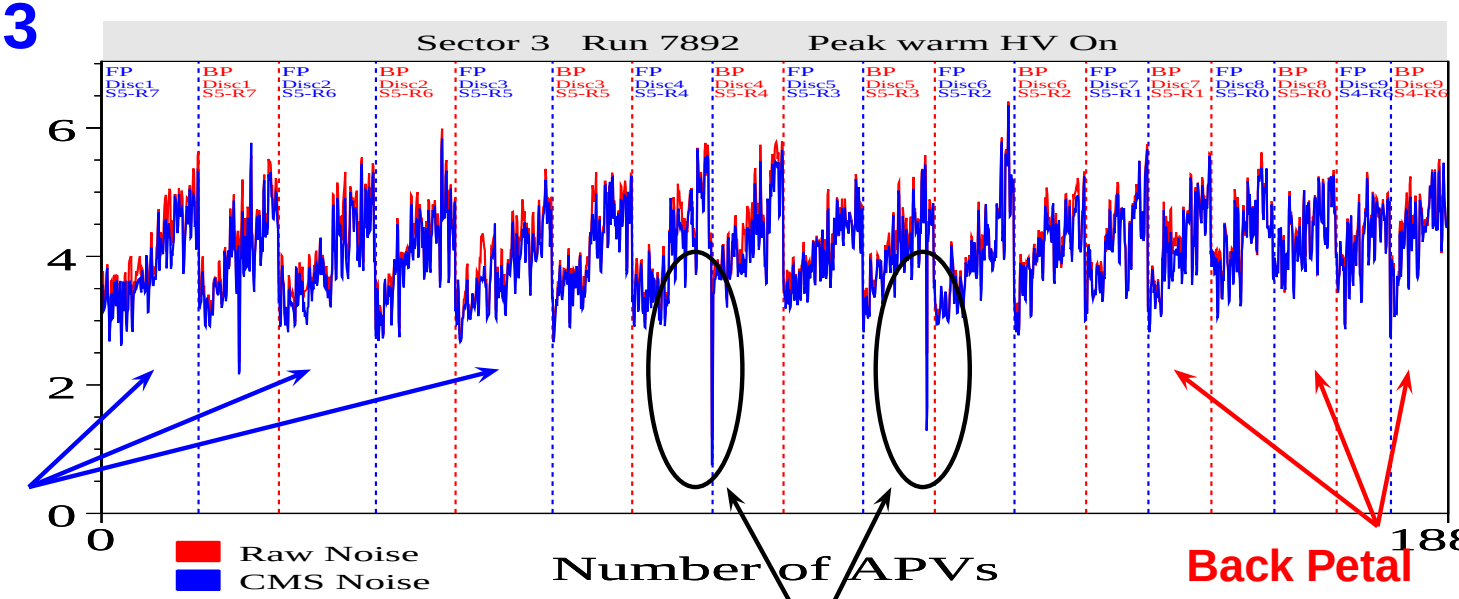
TEC+ Noise: Summary for both sectors during the slice test

Sector 2



Noise increases along each petal due to increasing strip length

Sector 3



- Noise looks well
- Small Common Mode
- few “features” can be seen

More on these later

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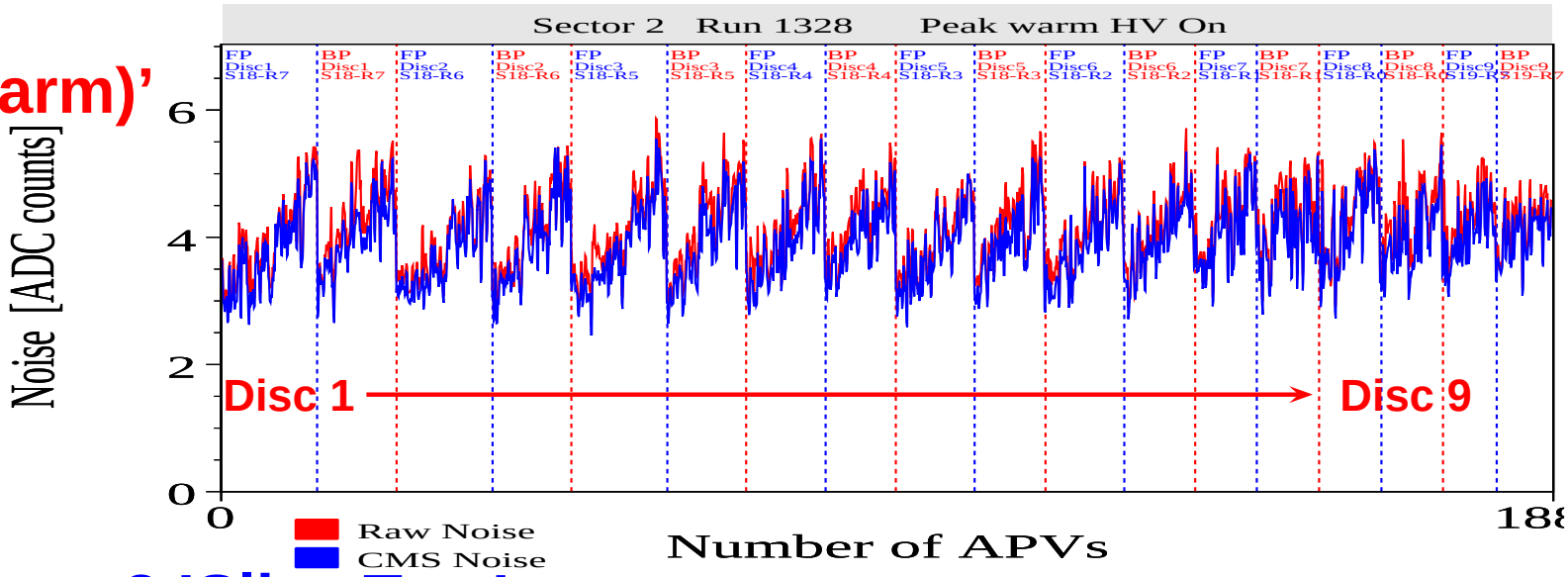
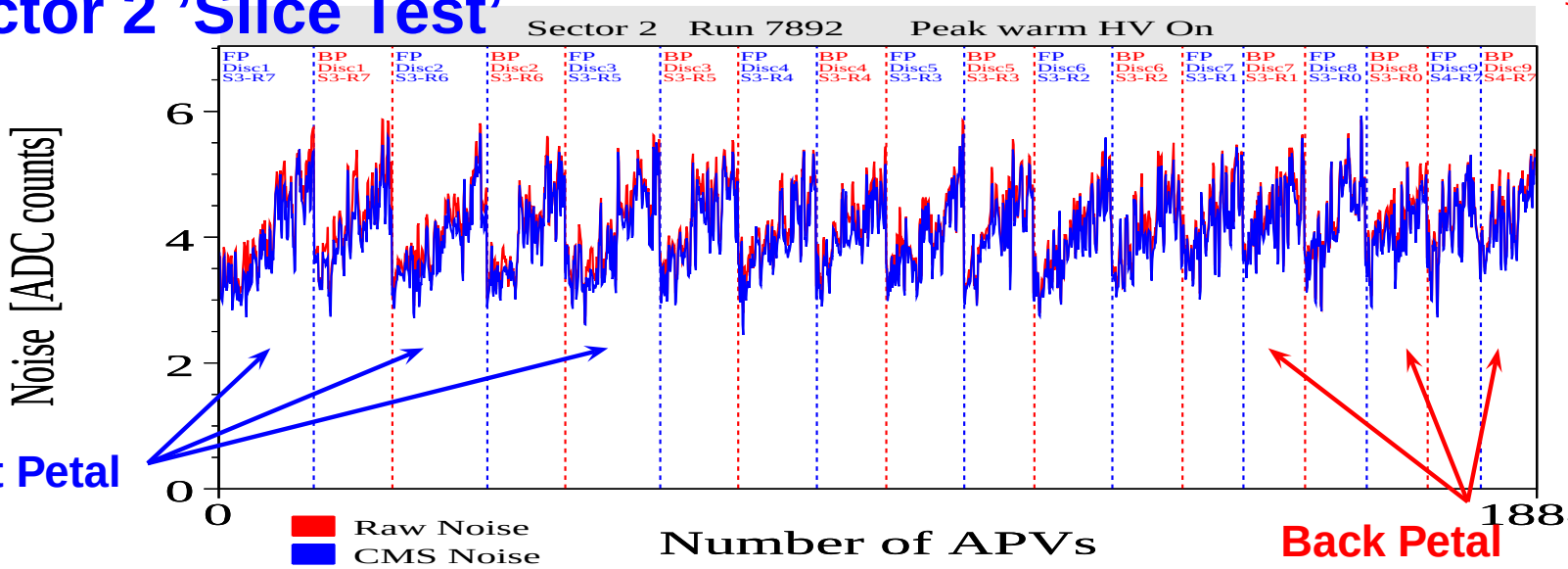
TEC+ Noise: Before and after insertion into the Tracker Support Tube

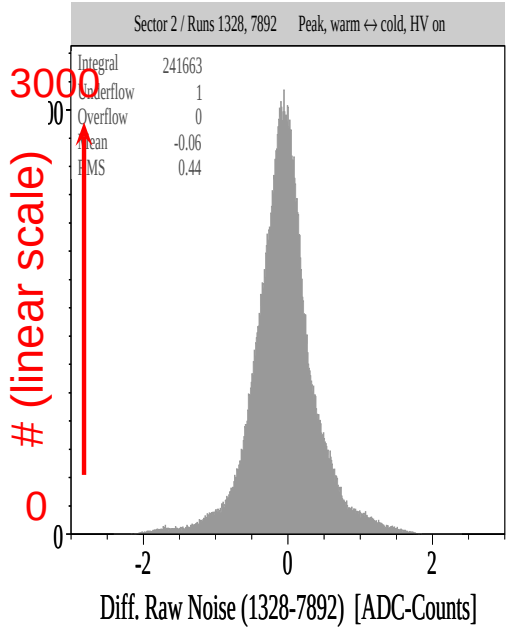
Sector 2 'Cold Test (Warm)'



Sector 2 'Slice Test'



Difference (ADC Counts) (strip-by-strip)



- μ =-0.06
- RMS =0.44

No change in noise after insertion

Defects/Troubles/Issues

- ∼0.7% faulty channels in the two TEC sectors
- Most of these are not randomly distributed, but are located on faulty APVs/Lasers/Modules

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- = counted as dead
- = more info to come

Defects/Troubles/Issues

	Defect	+15C	+10C	0C	-10C	-15C
●	S3 BP4 2.1/0 bad tick (known before slice test)	×	×	×	×	×
	S3 BP1 5.3/0 low tick	×	×	×	×	×
●	S3 BP5 7.3 two bad APVs (known since integration)	×	×	×	×	×
●	S3 BP3 4.3 1 bad APV (known since integration)	1	1	2	2	2
●	S2 FP3 1.4/0 laser with bad noise in dec. mode	×	3	4	×	n.c.
●●	S2 BP6 2.1/0 laser with bad noise in peak and dec. mode	×	×	×	—	—
●	S2 FP7 5.4 PLL not working	—	×	×	×	n.c.
	S2 FP8 3.2/2 laser with high noise	4	×	—	—	n.c.
●	S2 BP2 7.5/0 low noise & pedestal	—	—	—	—	×
	S3 BP4 7.2/2 very high base tick is saturated	—	—	—	—	×

× = defect is present — = defect is not present

1 = bad strips 2 = low noise

3 = no run in dec. mode av. 4 = not clear

Above defects affect

2944 channels (≈0.6%)

some definitely lost, others may recover

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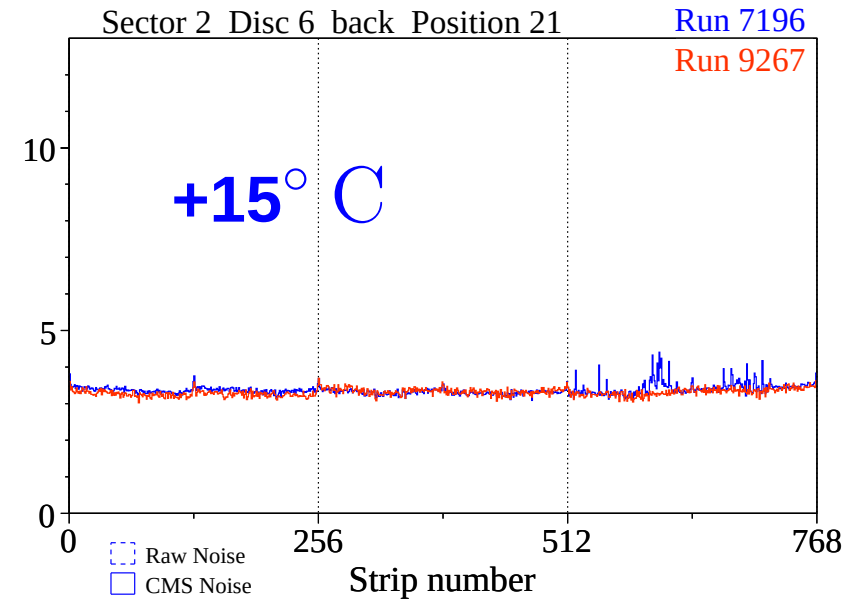
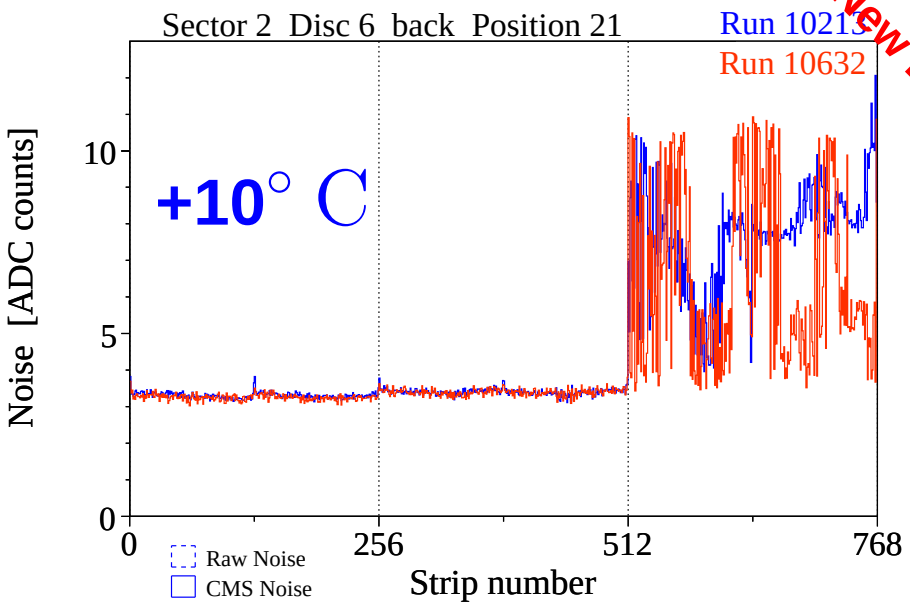
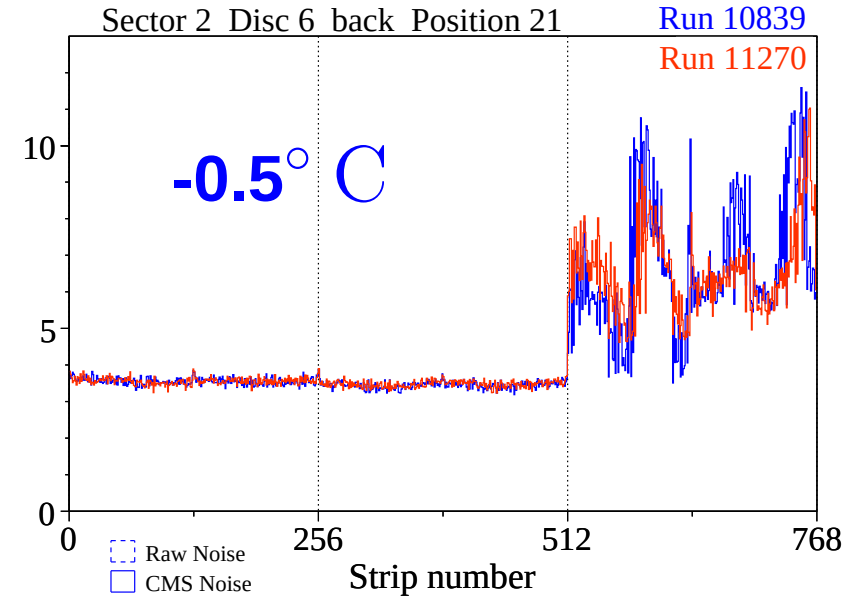
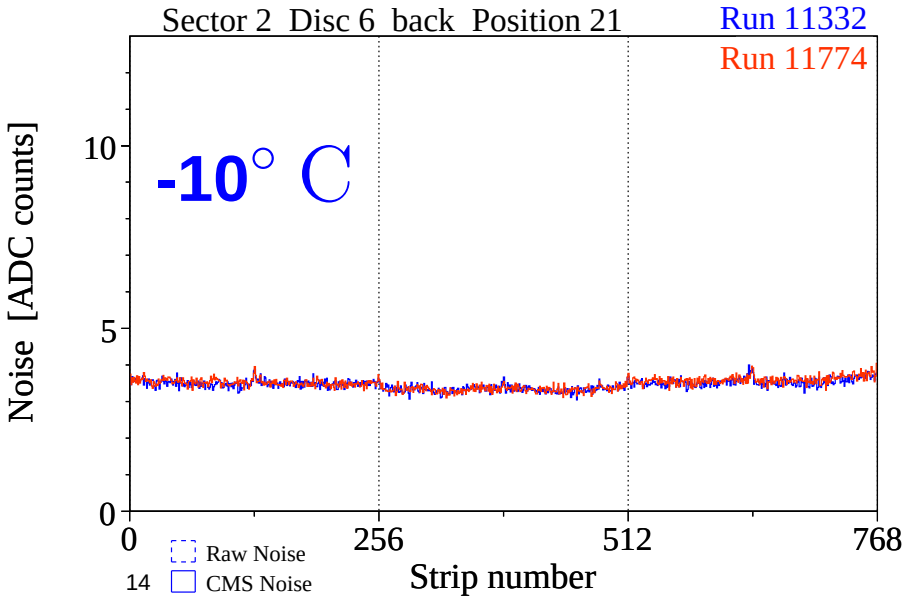
Defect Evolution with Temperature: S2 BP6 Pos 2.1 (Peak Mode)





New Defect during Slice Test





Behavior differs from run to run →can generate many fake hits in physics runs

Runs from beginning and end of each temperature step

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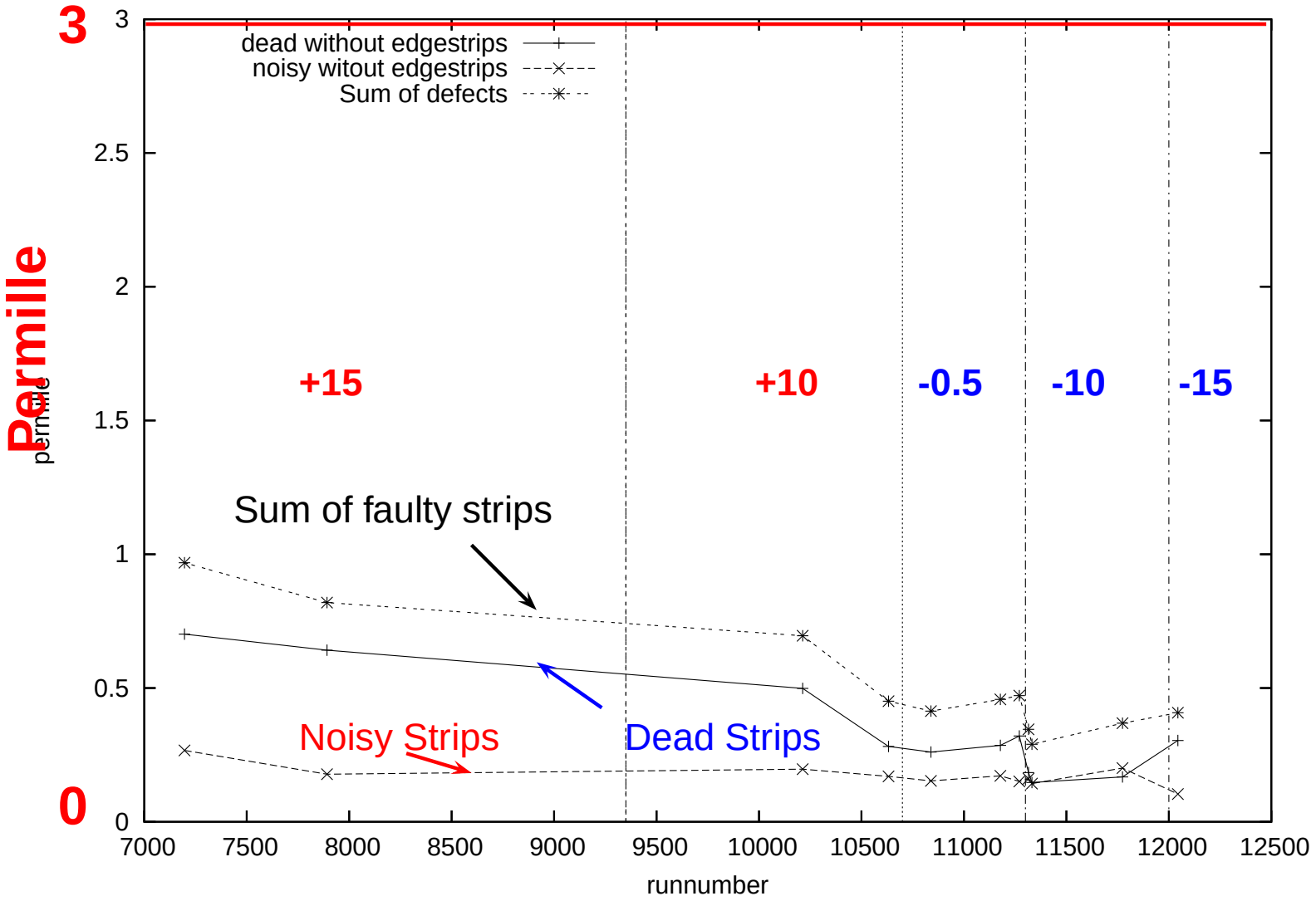
Remaining Dead and Noisy Channels

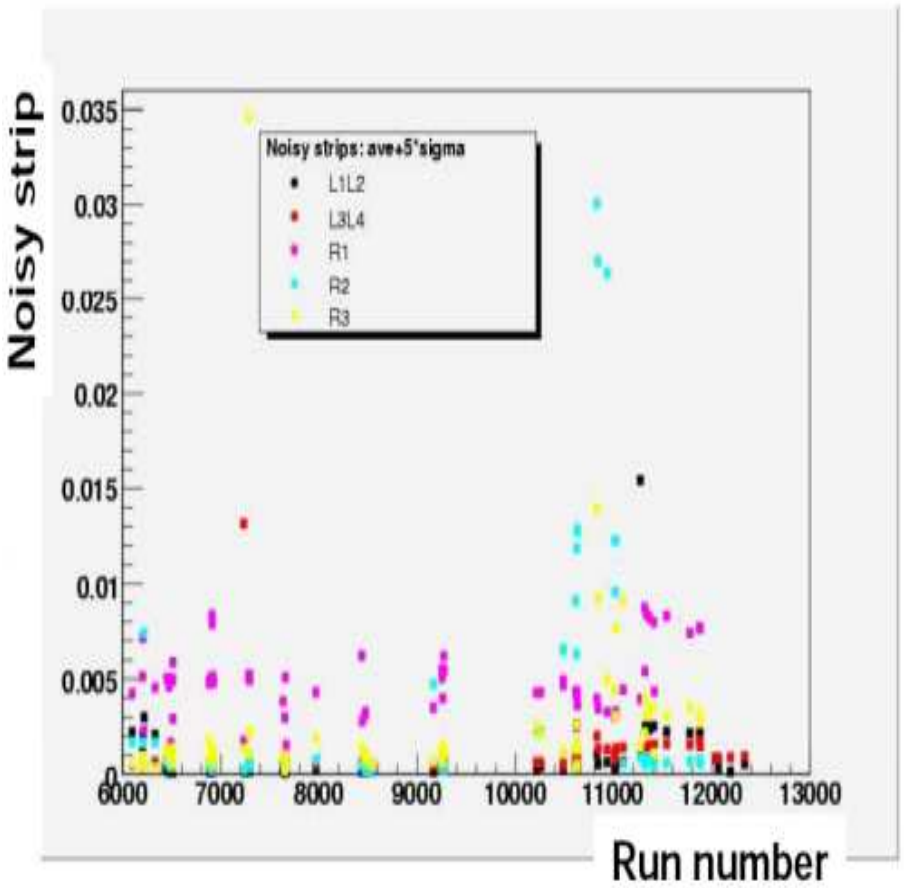


- Dead Strip: $< 5\sigma$ below APV average (128 Strips)
- Noisy Strip: $> 5\sigma$ above APV average (128 Strips)
- Defects from before taken out
- first and last chip of APV (edge strips) excluded $\rightarrow$need separate treatment

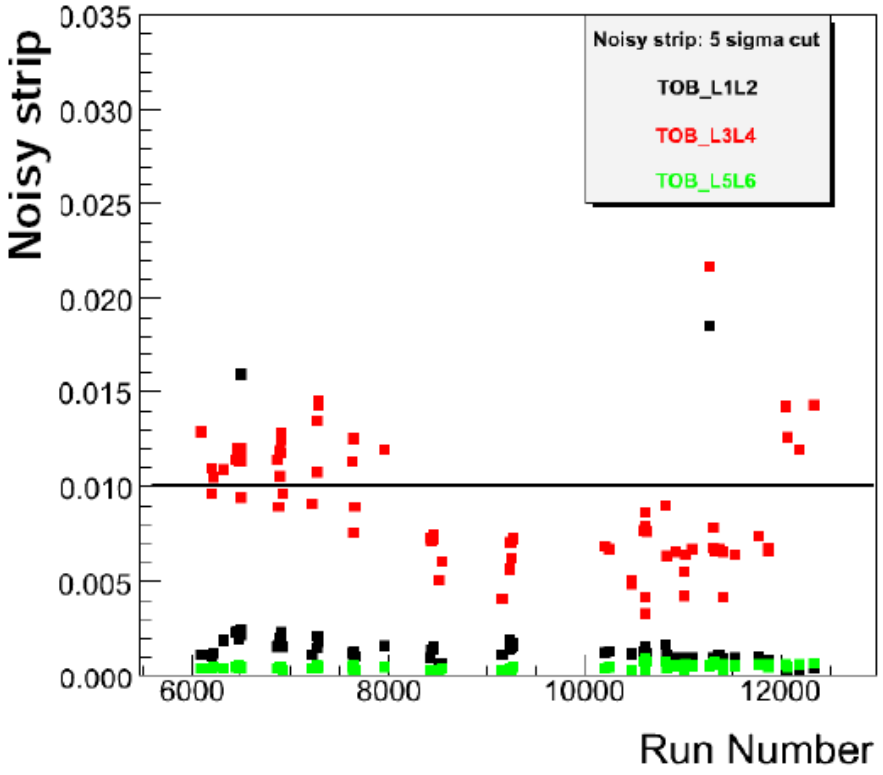
Goal <3 ‰ faulty (dead or noisy) strips

Dead and Noisy Strips – TIB & TOB

TIB



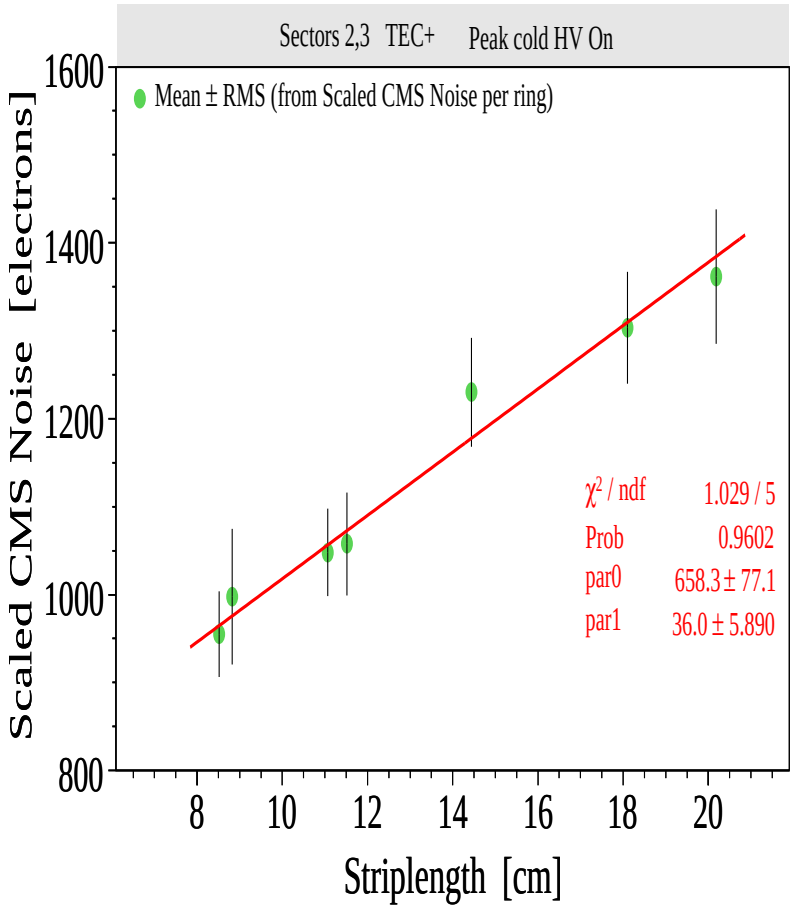
TOB



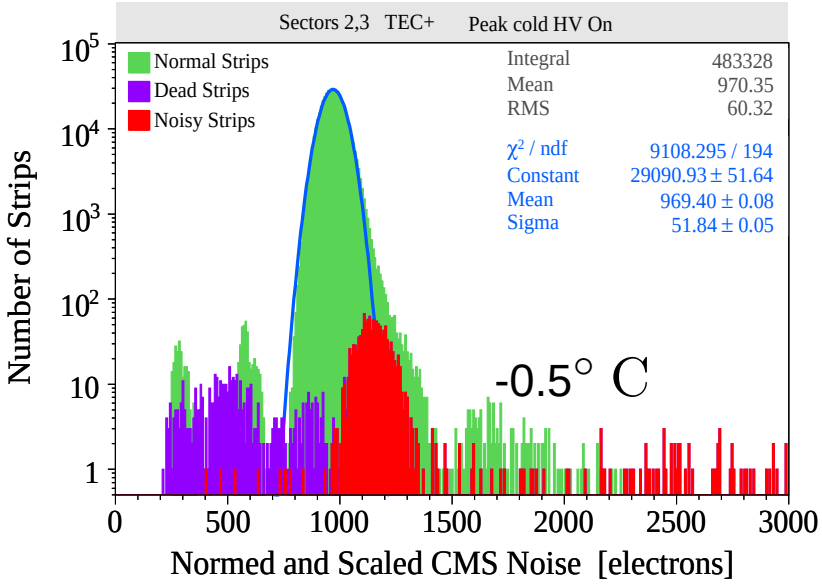
L.Borrello in Tracker QA Meeting 31st July 07

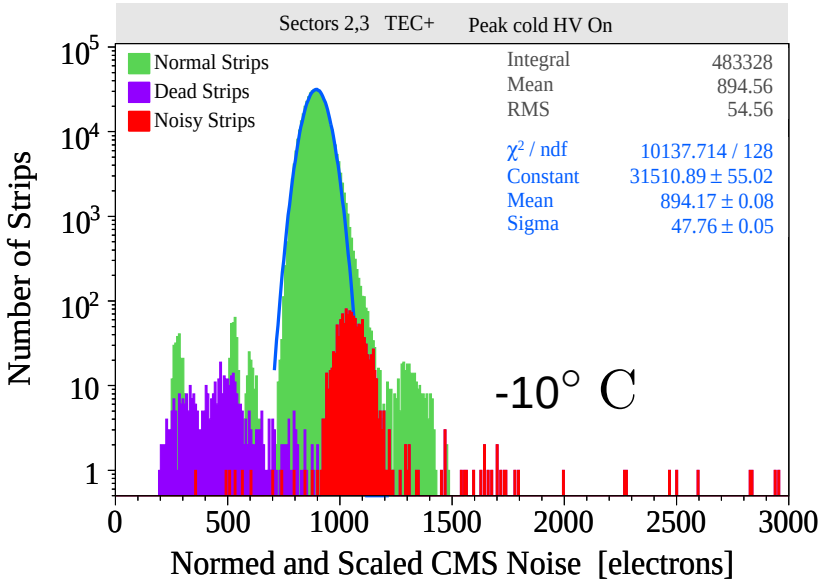
http://indico.cern.ch/getFile.py/access?contribId=2&resId=5&materialId=slides&confId=19478

Noise of Sectors 2&3 combined (−0.5° C& −10° C)



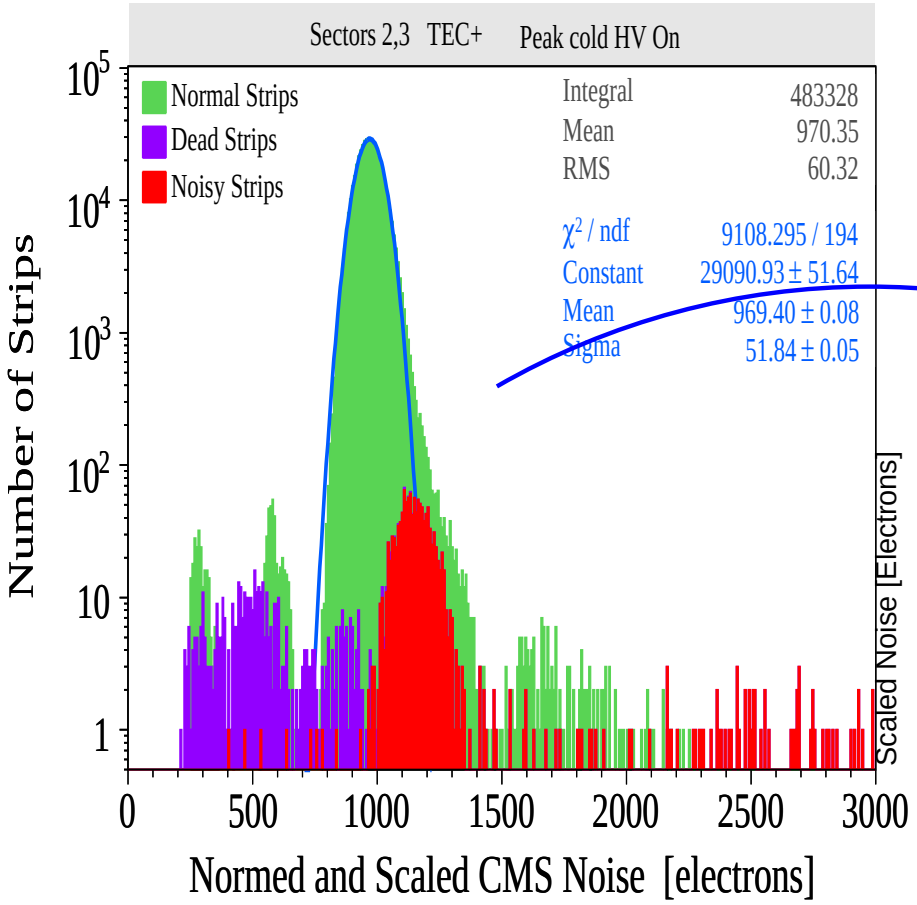
Noise scaling with striplength



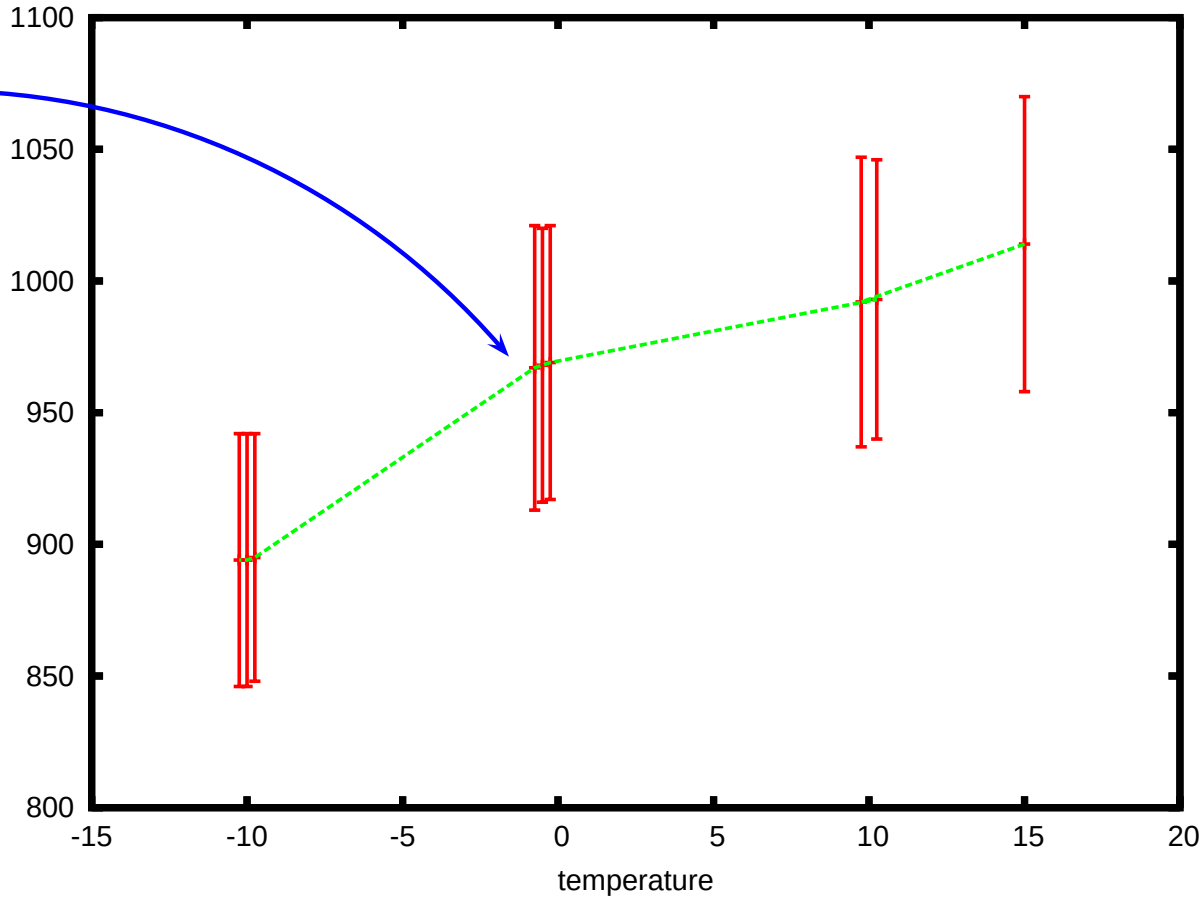


Normalized to length of ring 1

Temperature Dependence of Scaled Noise



Temperature of chiller, not of silicon



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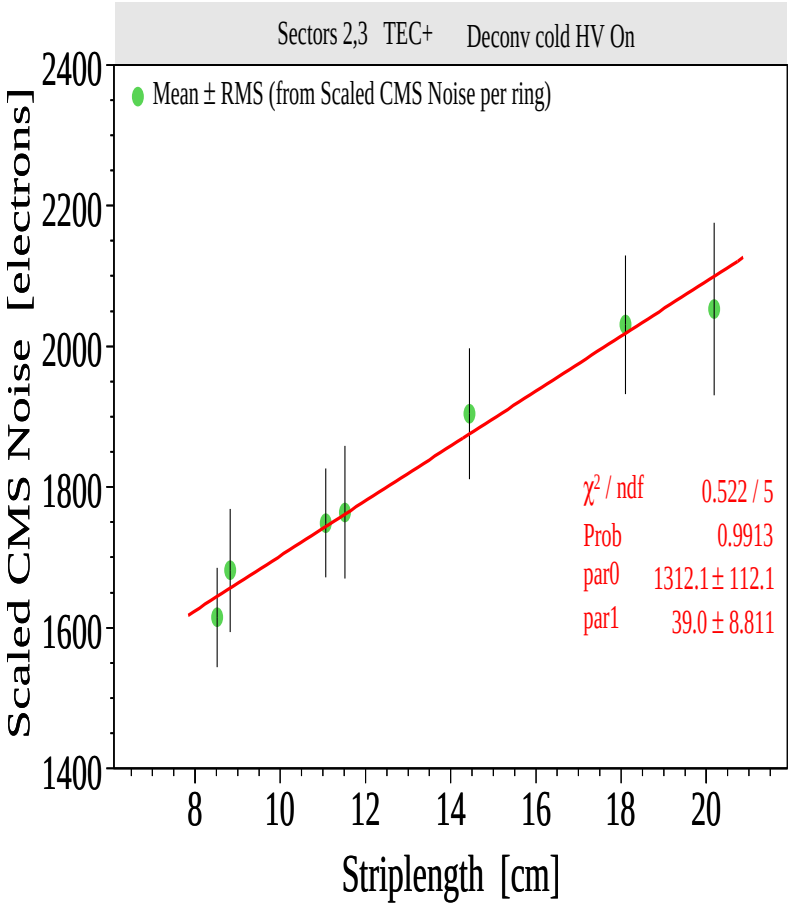
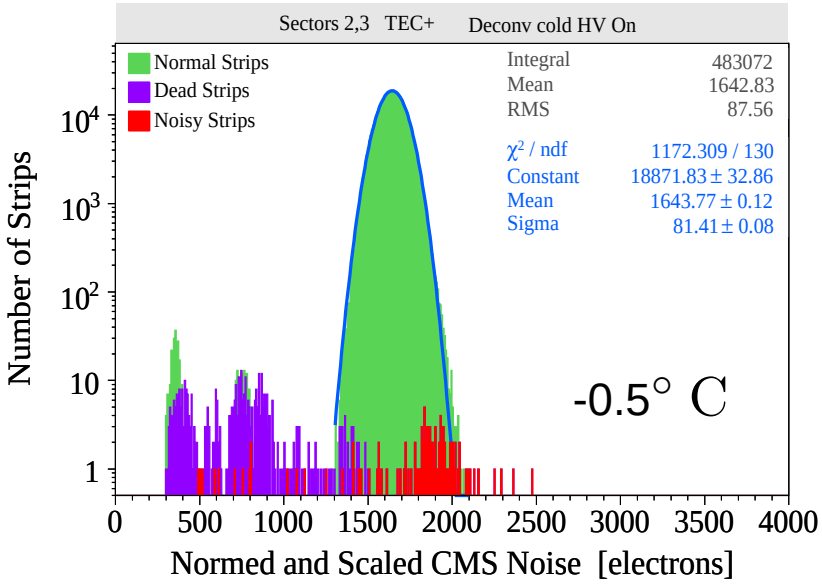
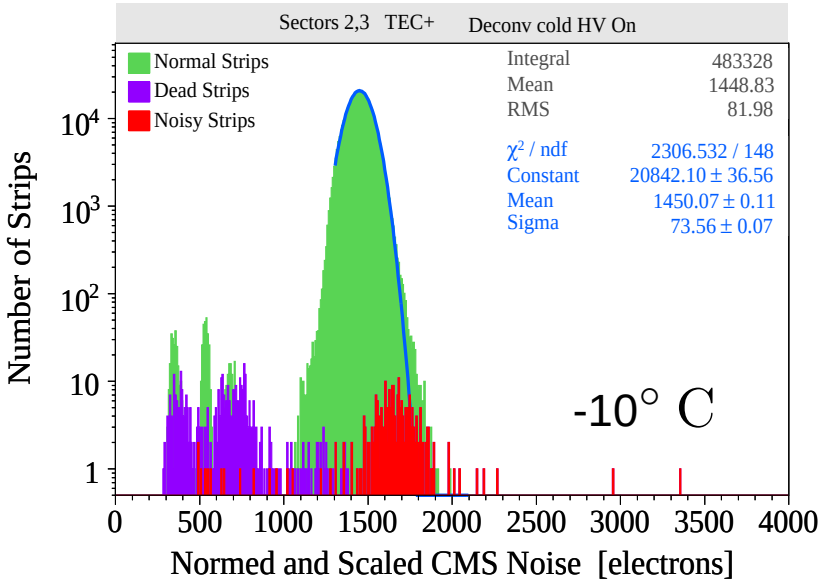
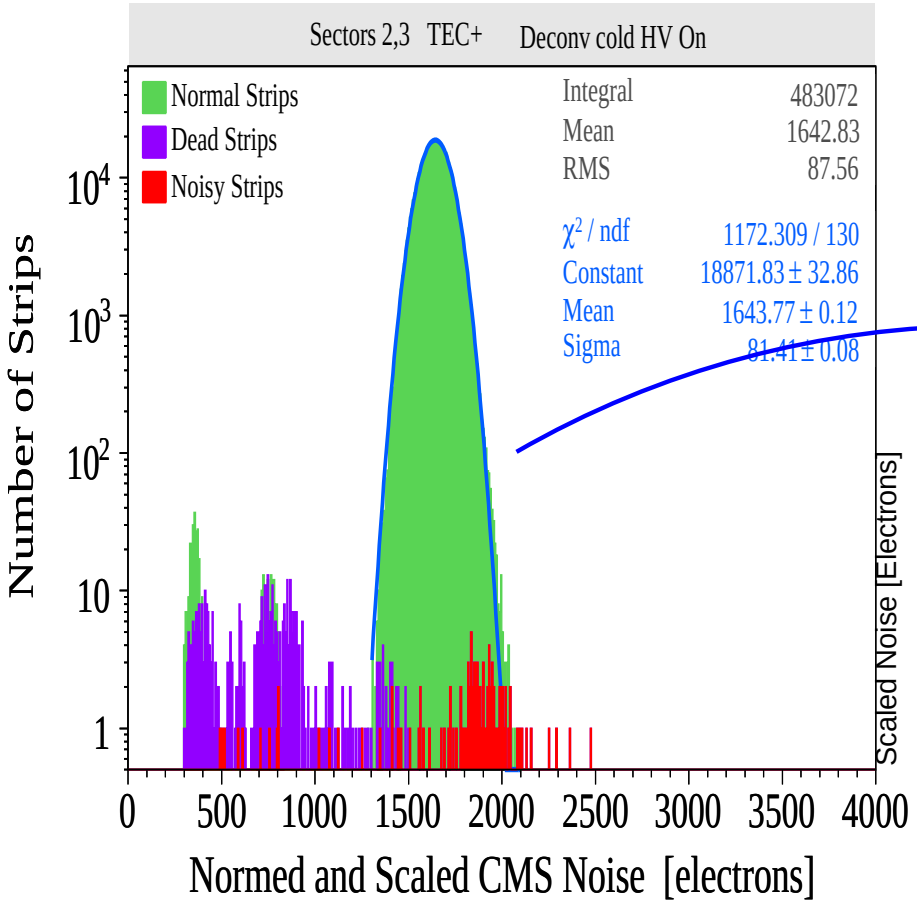
Noise of Sectors 2&3 combined (−0.5° C& −10° C) (Deconvolution)



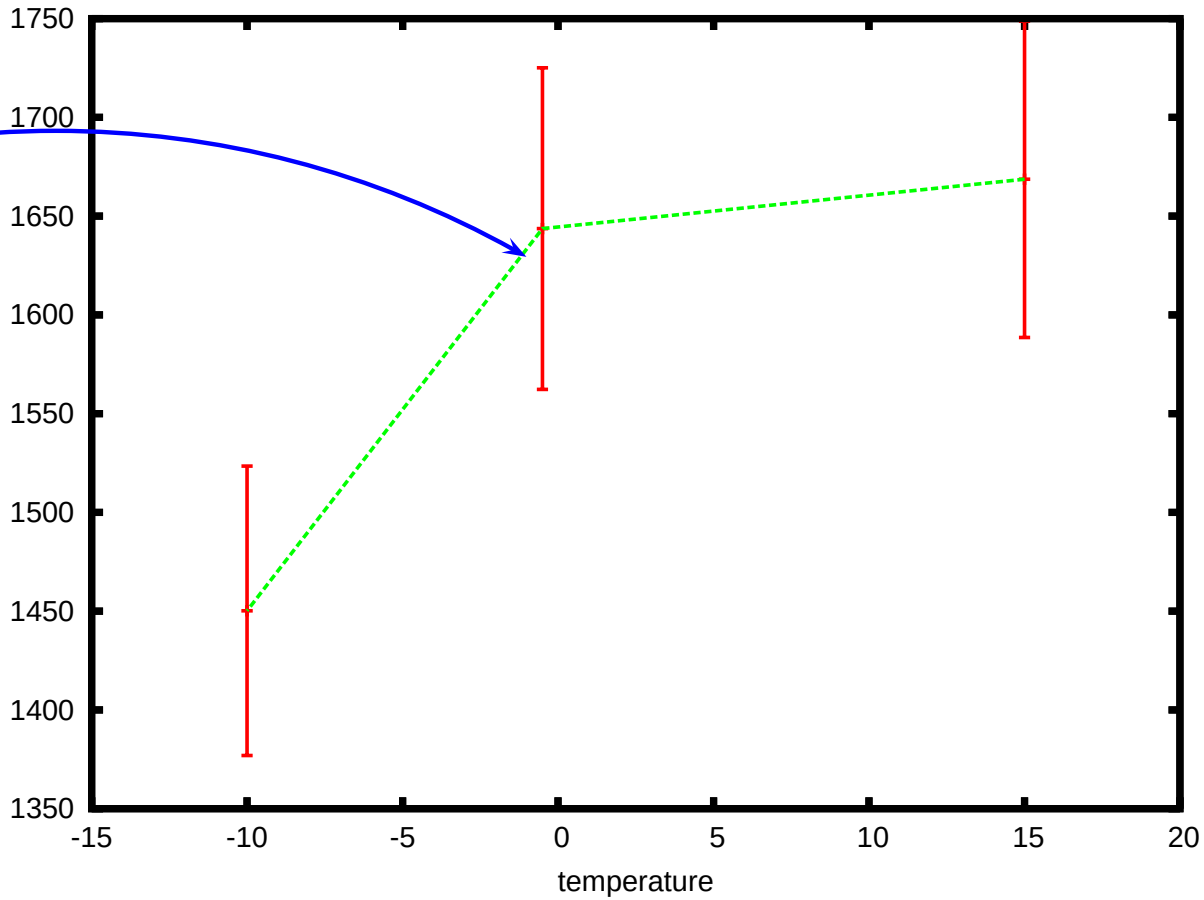




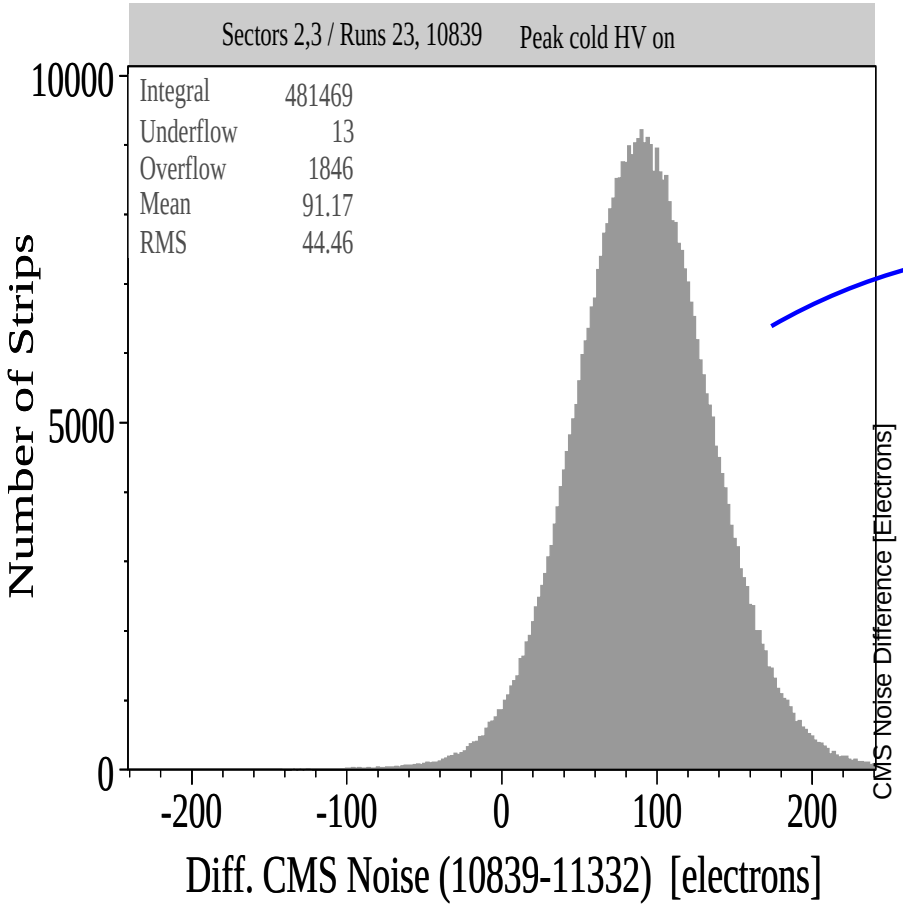
Temperature Dependence of Scaled Noise (Deconvolution Mode)



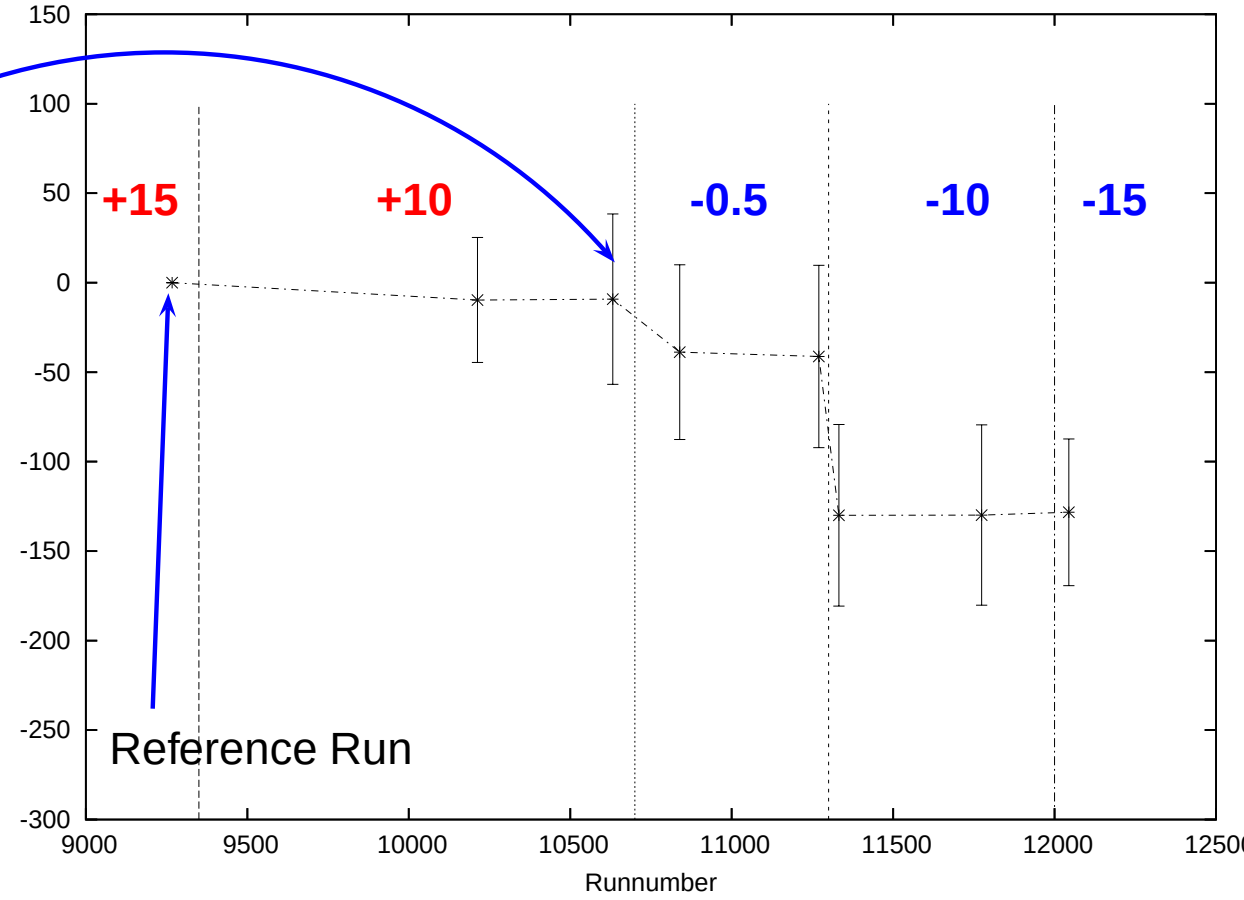
Temperature of chiller, not of silicon



Noise Difference for single channels (Peak Mode)



Look at Noise Difference for each channel at different temperatures



Noise decreases with temperature as expected and is stable in both magnitude and spread for a given temperature

Summary ...

- Slice Test (successfully) finished
- TECs are integrated into the Strip Tracker and are performing well
- Noise is stable after insertion and temperature evolution is well behaved (more detailed studies forseen)
- No negative influence of subsystems on each other has been found
- Common commissioning of all subdetectors together was achieved
- Situation of defects within the TEC sectors is good and persistent defects are identified and monitored
- Tracker is ready for the next step of commissioning and data taking at Point 5