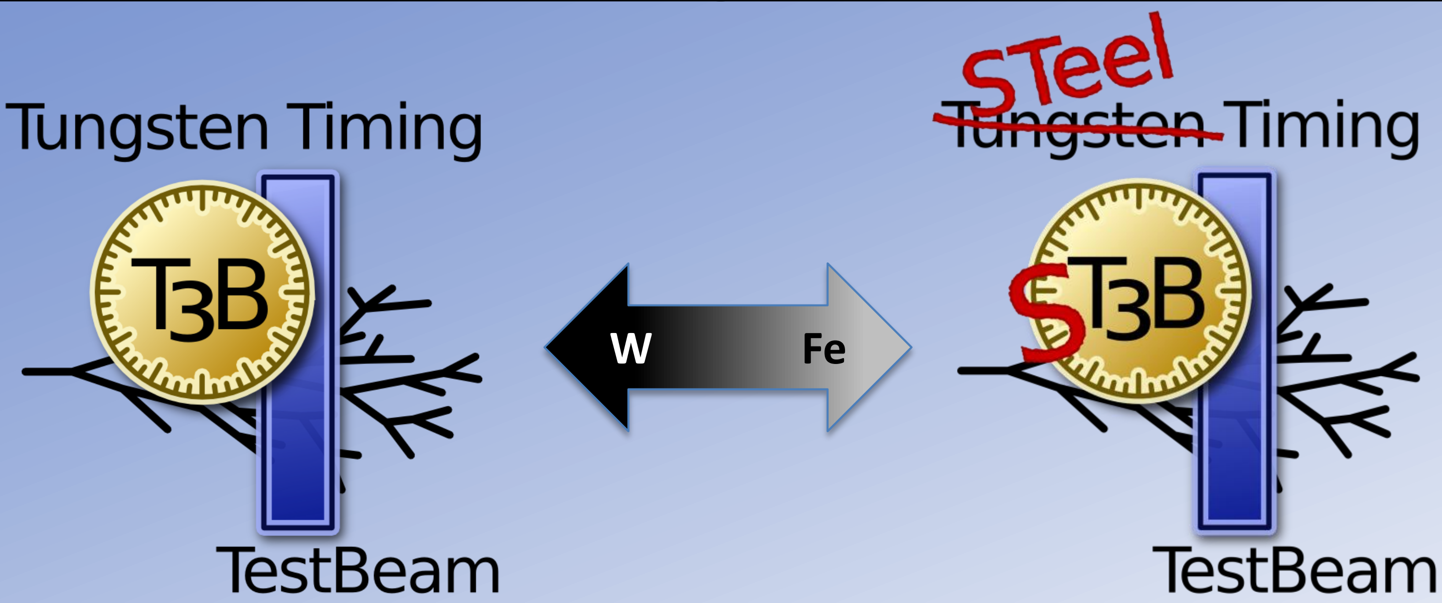
(s)T3B Update –
Calibration and Temperature Corrections



AHCAL meeting– December 13th 2011 – Hamburg

Christian Soldner
Max-Planck-Institute for Physics

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Excellence Cluster
Universe

CALICE
Calorimeter for ILC

Outline

- Introduction: CALICE and T3B
- Calibration to the MIP scale: Sr90 Data
- Verify Calibration Principle: TB Muon Data
- Roadmap

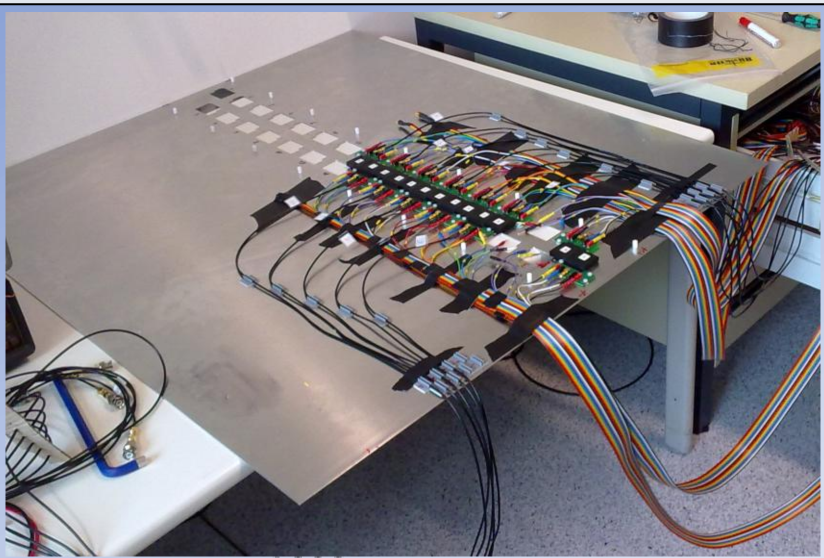
THE CALICE CALORIMETER AND THE T3B EXPERIMENT

The T3B Experiment

What is T3B?

- One row of 15 scintillator tiles
- Tile dimensions: 3 x 3 x 0.5 cm^3
- Light Readout by SiPMs: MPPC-50P
- Data Acquisition: 4 fast USB Oscilloscopes

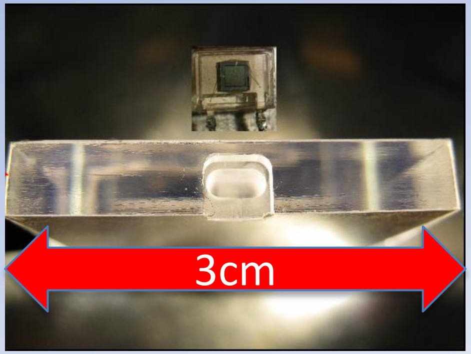
Setup optimized to observe the time development of hadron showers



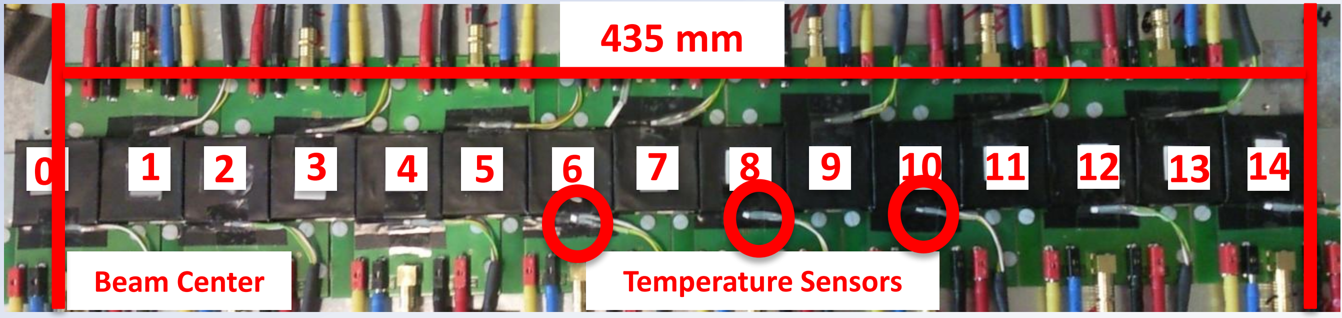
CALICE:

+ 3D reconstruction of hadronic shower shapes

- No timing information on the showers → (s)T3B



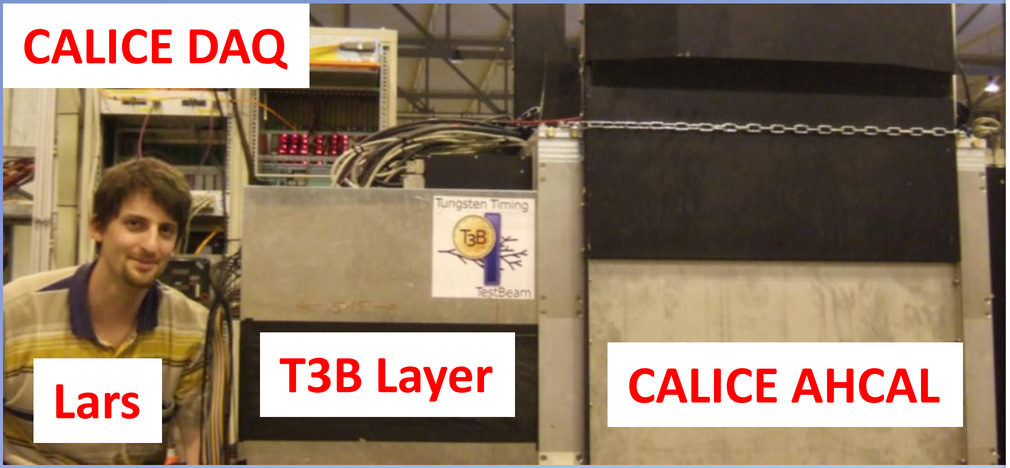
Tile geometry optimized for direct coupling



1 Temperature Sensor PT1000 for each T3B cell

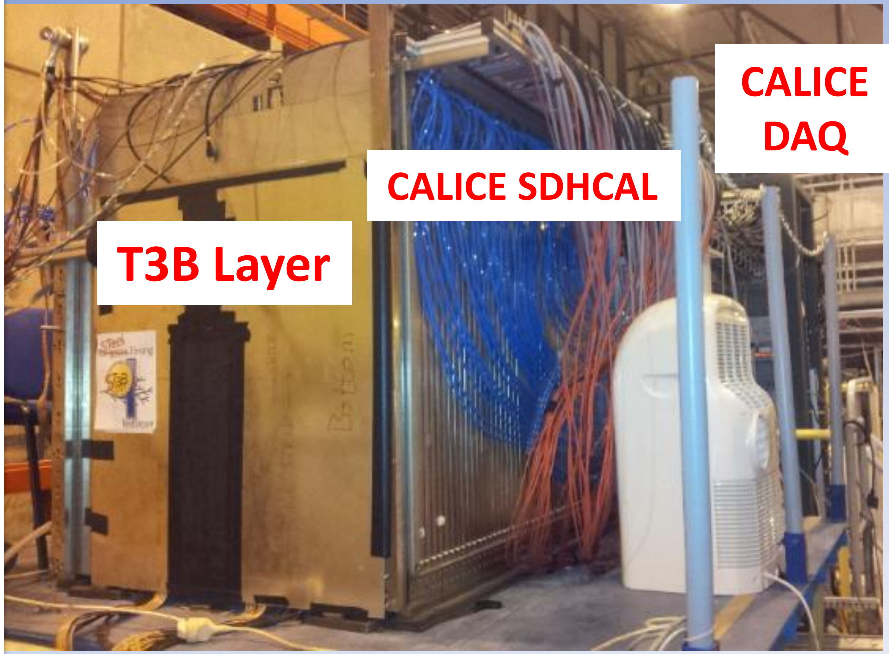
The T3B Experiment within the CALICE AHCAL

Tungsten AHCAL

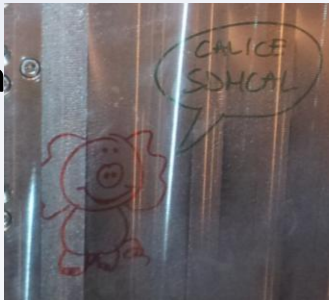


Run Periods:	PS: Nov 2010
	SPS: June/July/Sept 2011
Energy Range:	2-300GeV
Trigger:	CALICE Synchronous
Shower Depth:	~3λ_I (PS), ~5 λ_I(SPS)
Total Had. Events:	27 Million

Steel SDHCAL

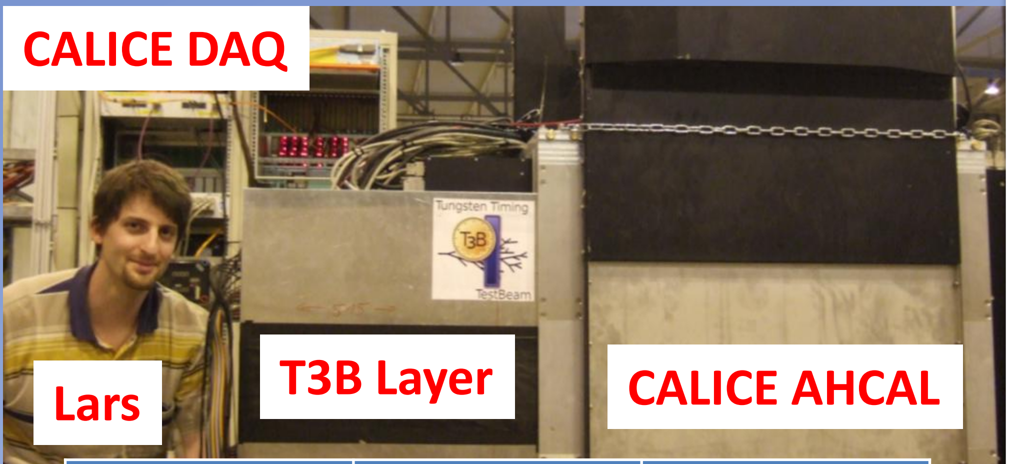


Run Periods:	SPS: October 2011
Energy Range:	40-180GeV
Trigger:	T3B Standalone
Shower Depth:	~6 λ_I
Total Had. Events:	5 Million



The T3B Experiment within the CALICE Calorimeters

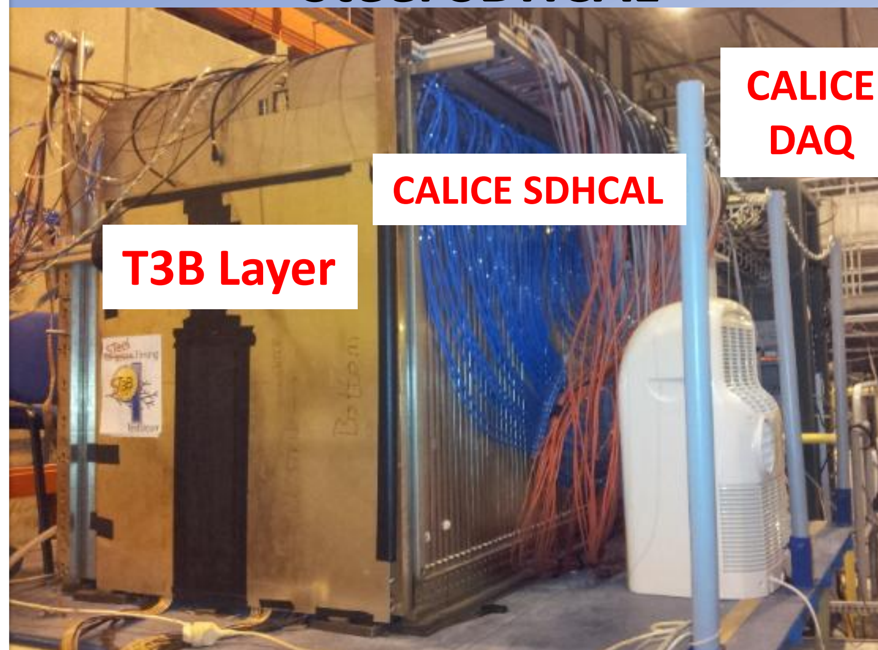
Tungsten AHCAL



Energy [GeV]	Calice-Sync + [MEv]	Calice-Sync - [MEv]
6	1,2	1,7
8	1,5	1,5
10		4,6
40	2,0	
50		1,7
60	4,1	
80	4,5	
150		1,2
180	0.9	0.7

W ⟷ Fe

Steel SDHCAL



Energy [GeV]	T3B Standalone + [MEv]
60	1,6
80	2,0
180	1,2

CALIBRATION TO THE MIP SCALE: SR90 DATA

T3B Calibration to the MIP Scale: Sr90 Data

During the Test Beam T3B monitors the SiPM Gain continuously

→ This data can be used to calibrate energy depositions to the MIP Scale

Assumption: The MIP MPV depends in first order only(!) on the Gain

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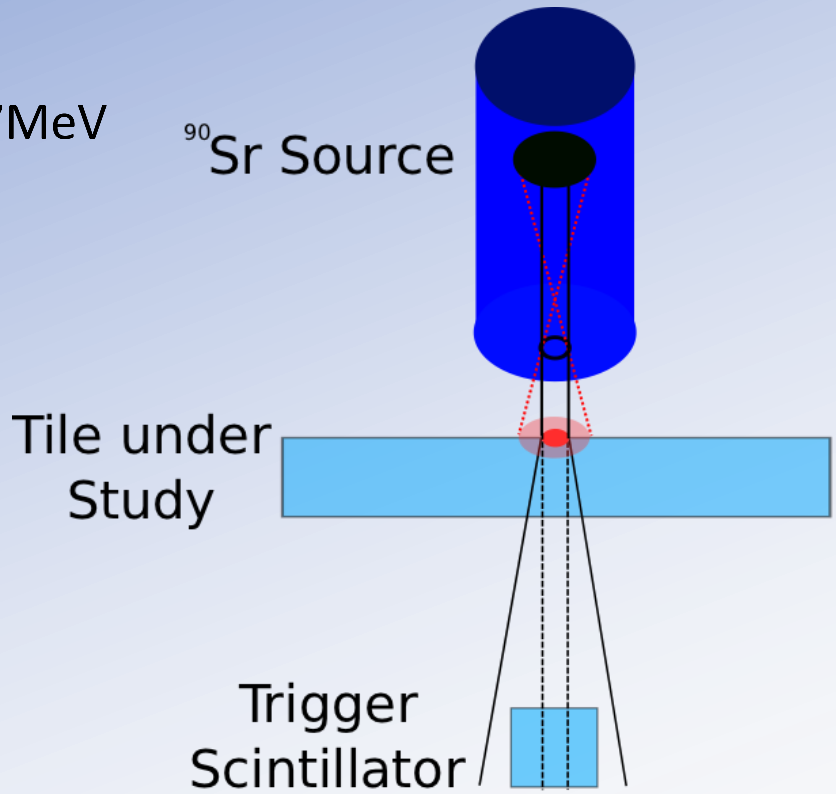
Offline Calibration Setup:

- Sr90 Source with end point energy of 2.27MeV
- Coincidence trigger to ensure penetration of tile under study
- Consecutive calibration of all T3B cells individually
- Use T3B DAQ: Acquire Sr90 and SiPM gain data at the same time
- Use climate chamber to ensure temperature stability



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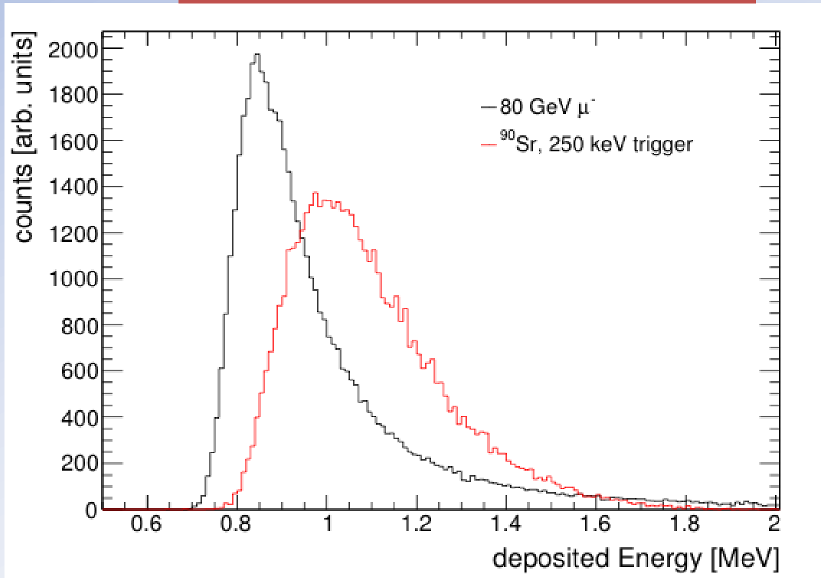
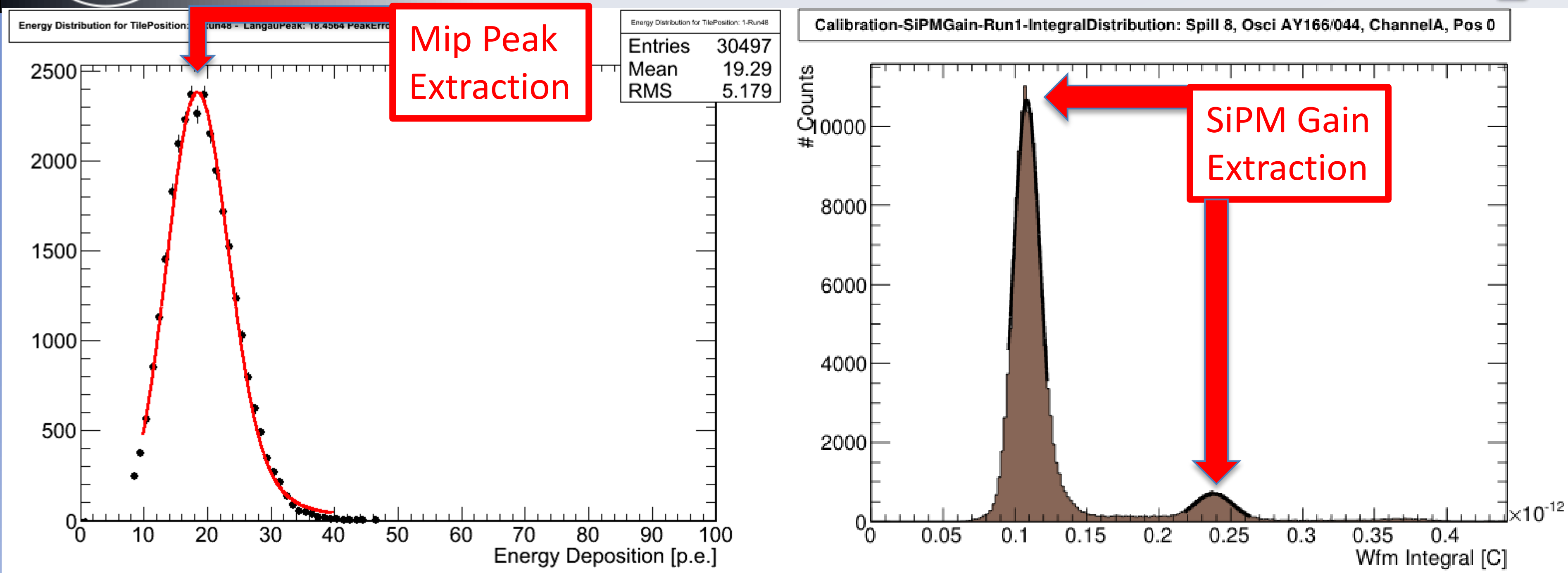
GEANT4 Simulation:
MPV (mu) = MPV(e)*0.825



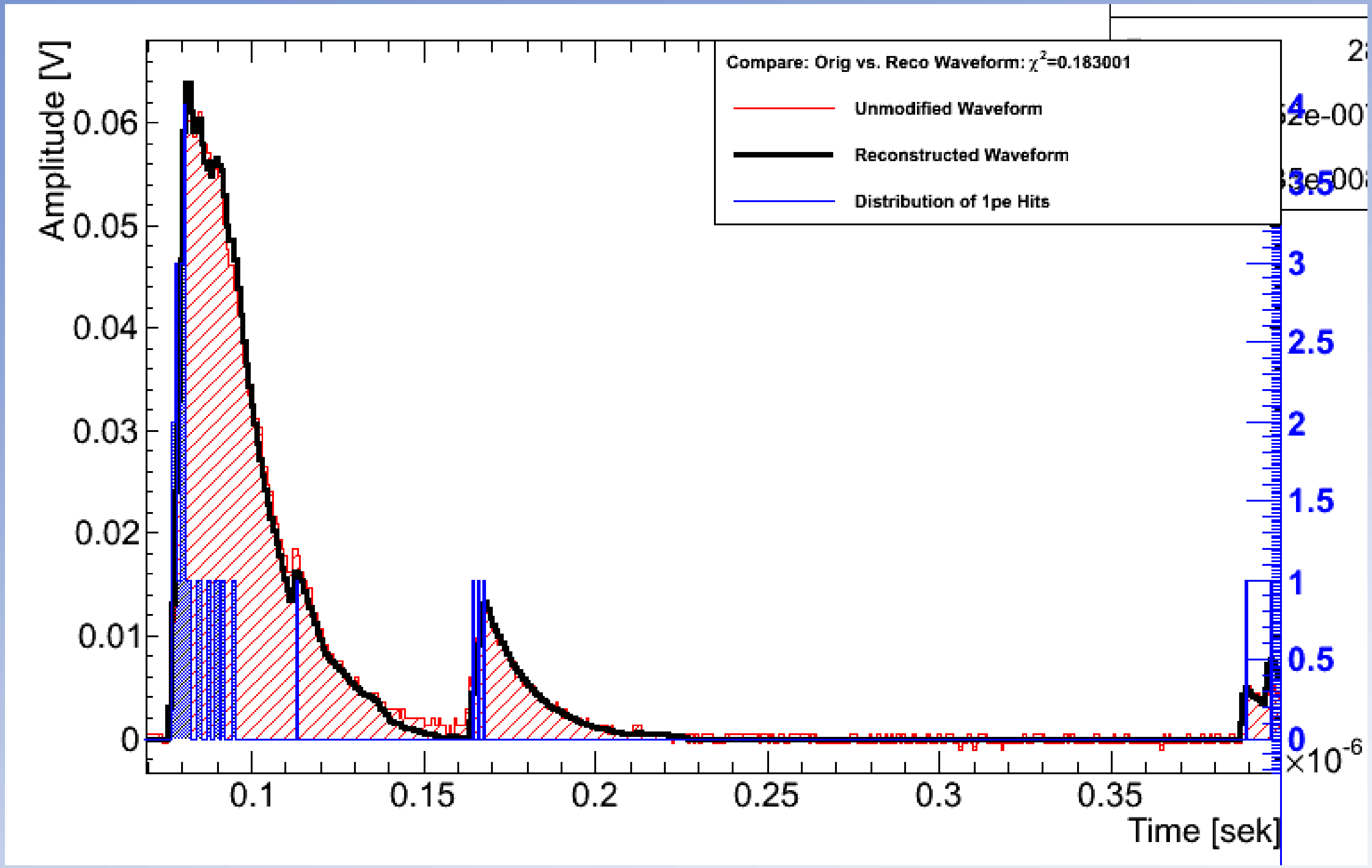
Note: Electrons are no perfect MIPs → need scale factor

T3B Calibration to the MIP Scale: Sr90 Data



Simultaneous extraction of
SiPM Gain and most probable value
of energy deposition of Sr90 electrons

The Time Integration Window

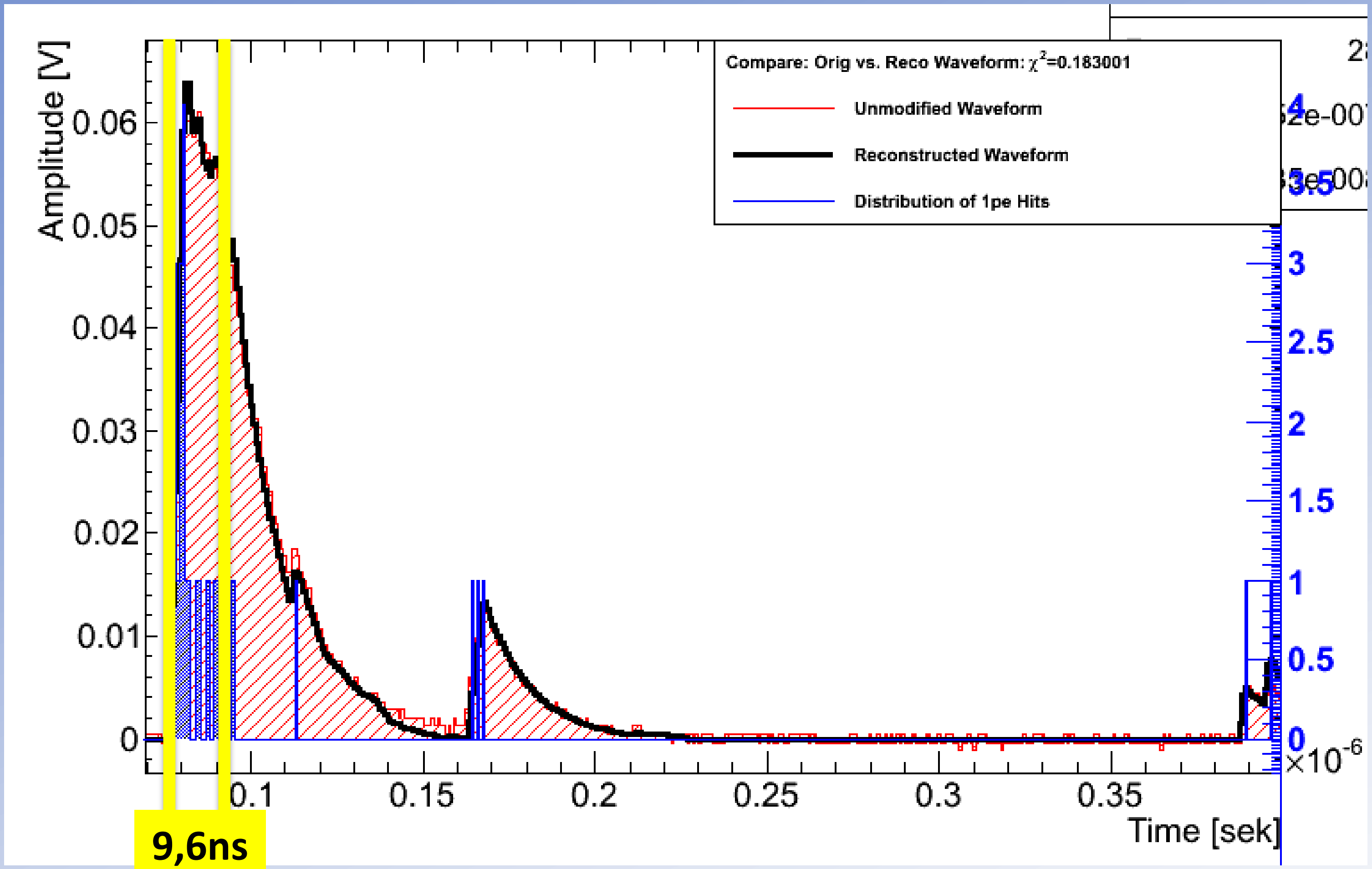


The MPV is very sensitive on the Time Integration Window

→ Dominant effect: SiPM Afterpulsing

- Separate afterpulsing from energy depositions
- Study the effect of afterpulsing

The Time Integration Window



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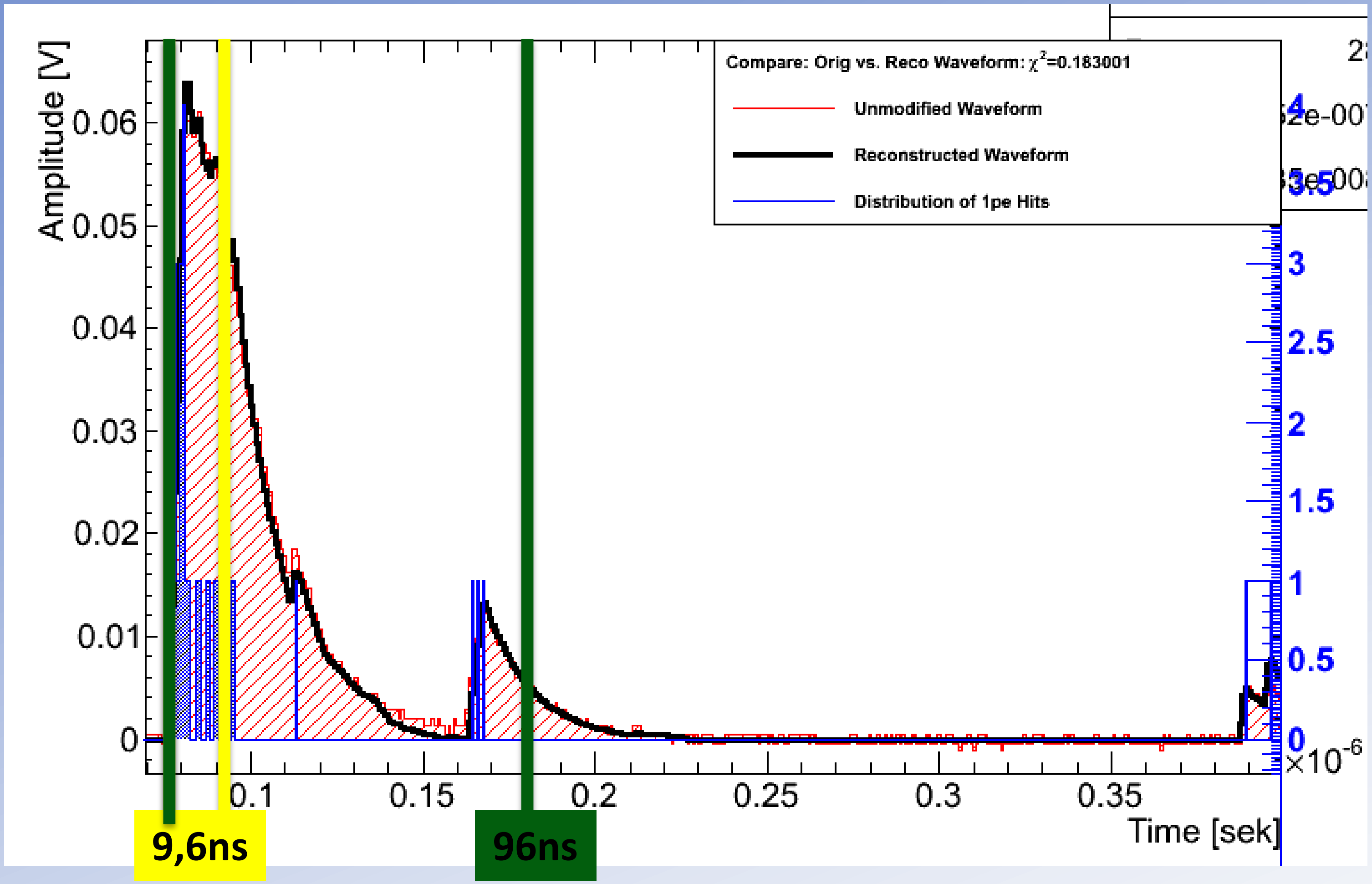

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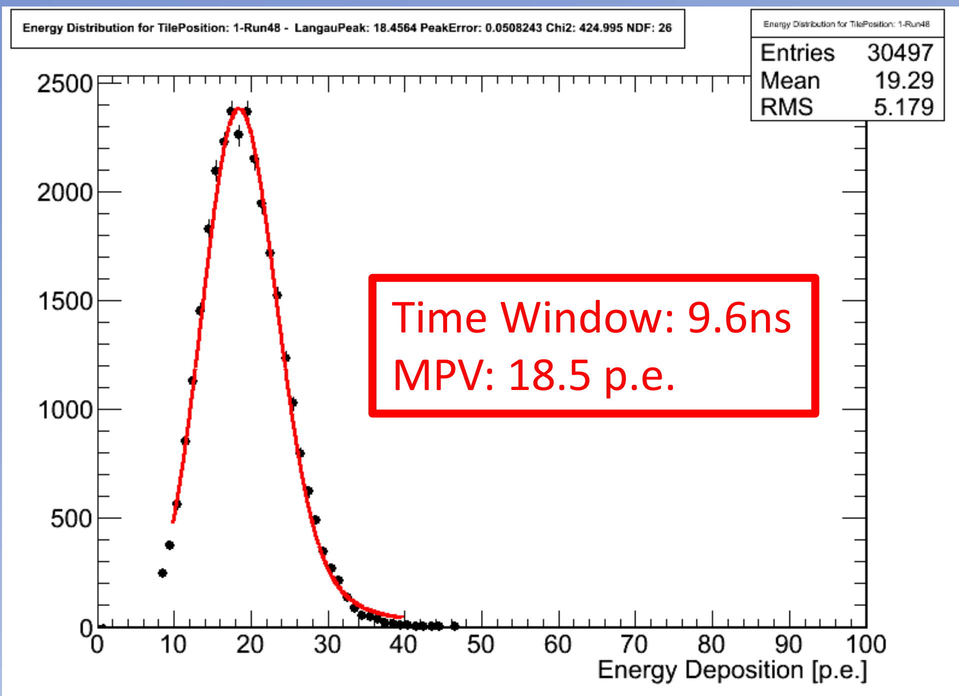

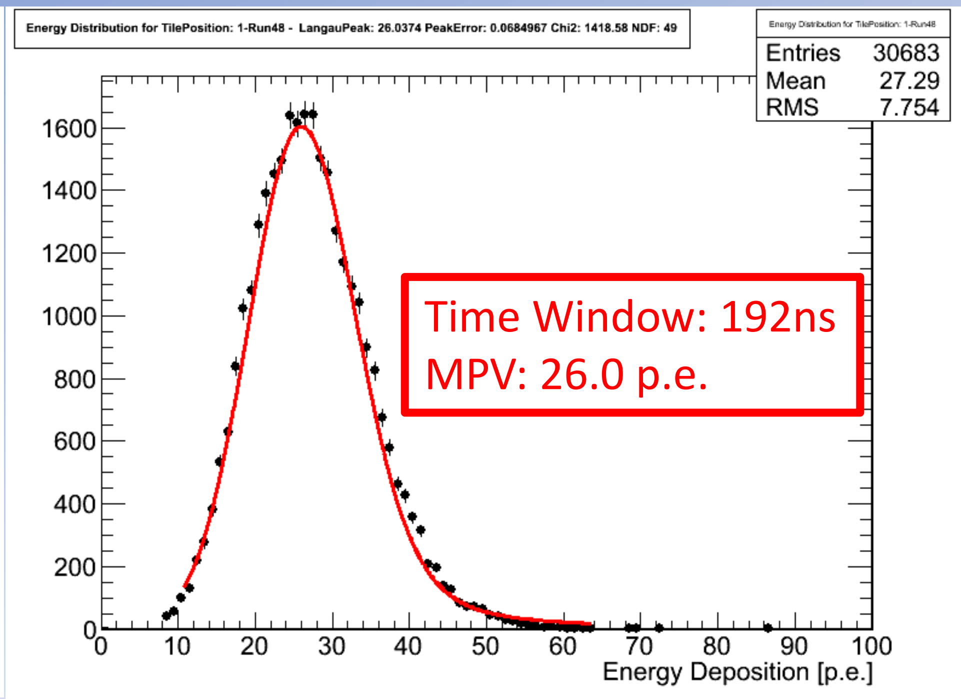

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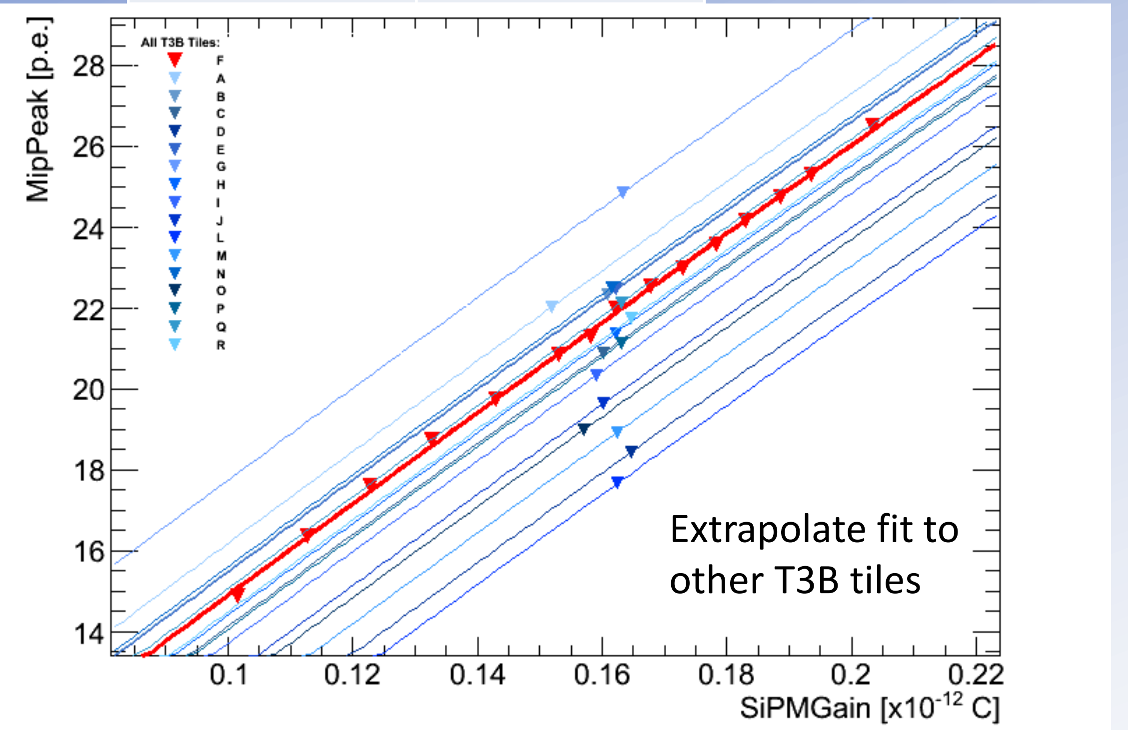
The Effect of Afterpulsing

Bias Voltage Scan for one T3B "Master Tile"
One Measurement for all other T3B tiles

Time Window	MPV-Gain dependence
9.6 ns	linear
307.2 ns	quadratic



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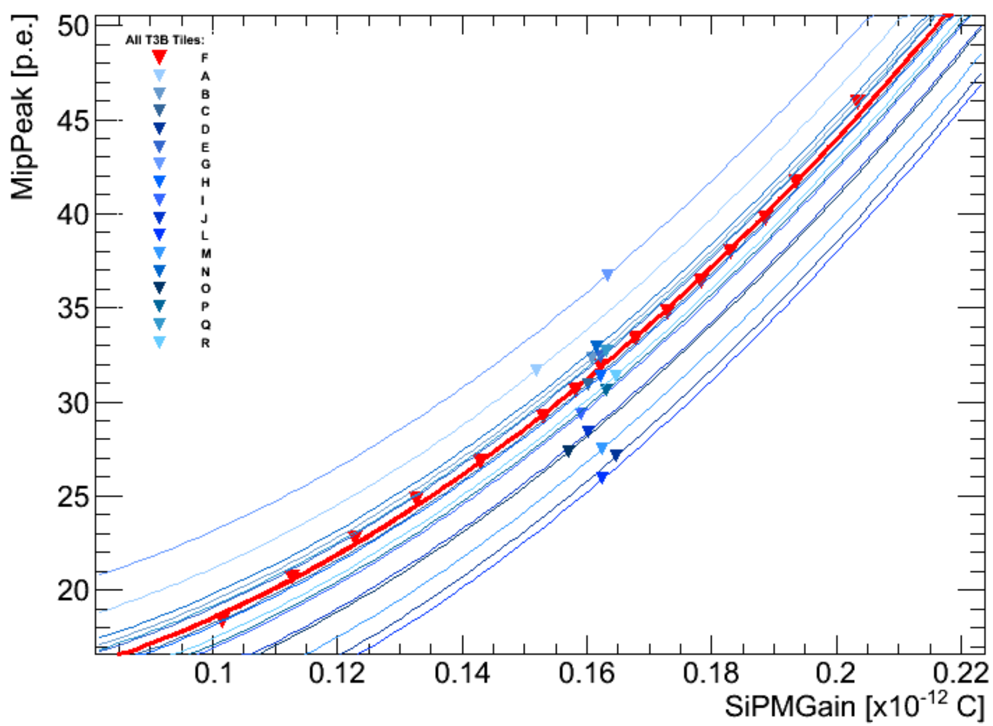

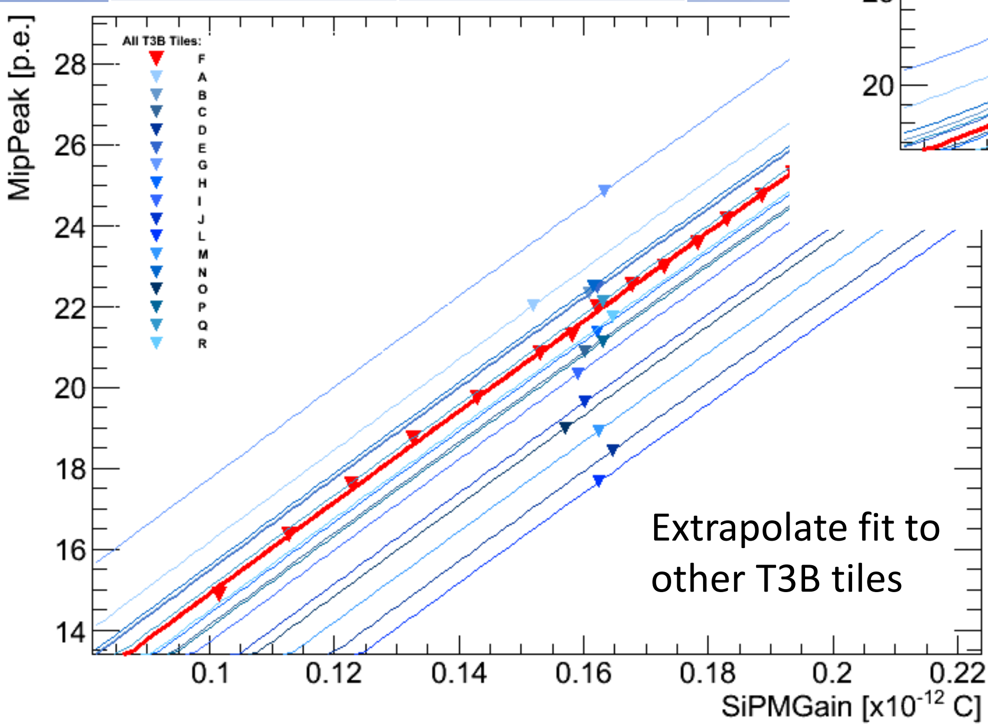

Extrapolate fit to other T3B tiles

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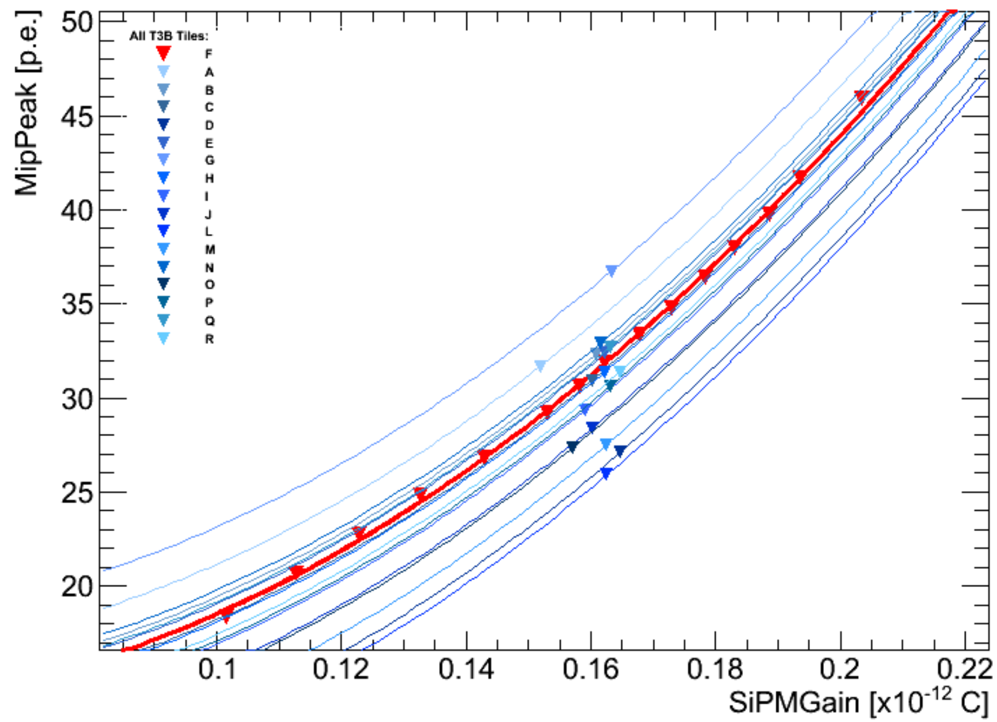

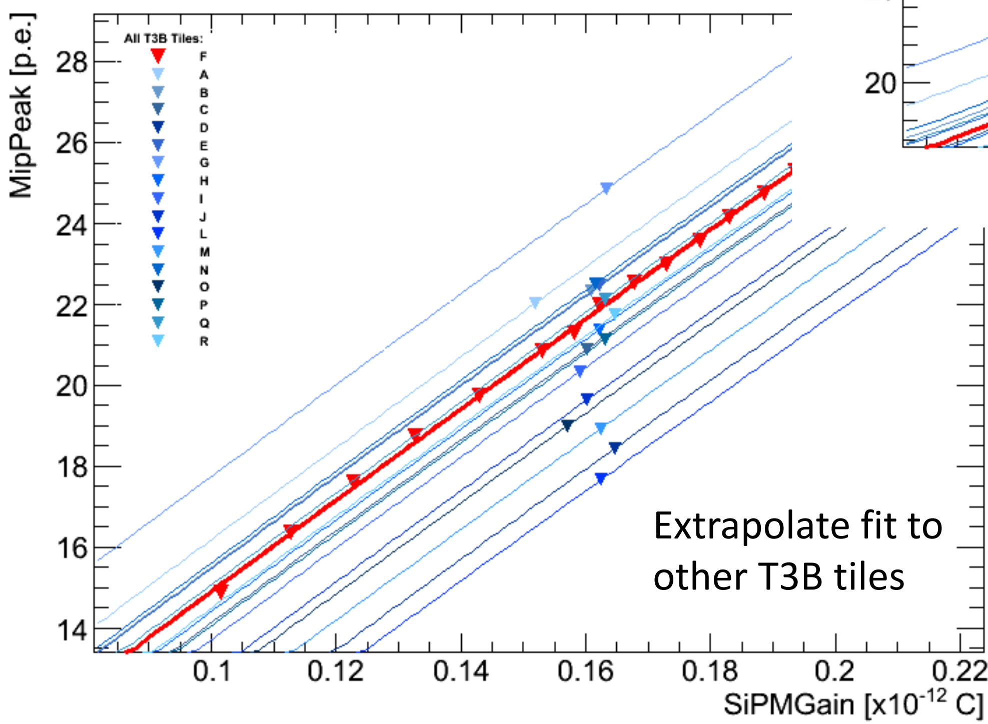

Extrapolate fit to other T3B tiles

Interpretation:

1. More afterpulsing is integrated
→ would just result in a constant offset
2. Higher Gain
→ Afterpulsing and Crosstalk probability increased
→ Increased MPV dependence

Needs to be taken into account in Calib

The Effect of Afterpulsing

Bias Voltage Scan for one T3B
“Master Tile”

One M

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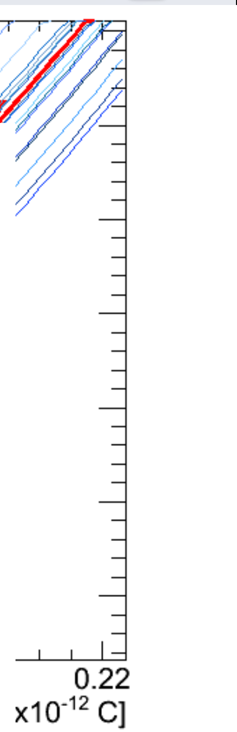
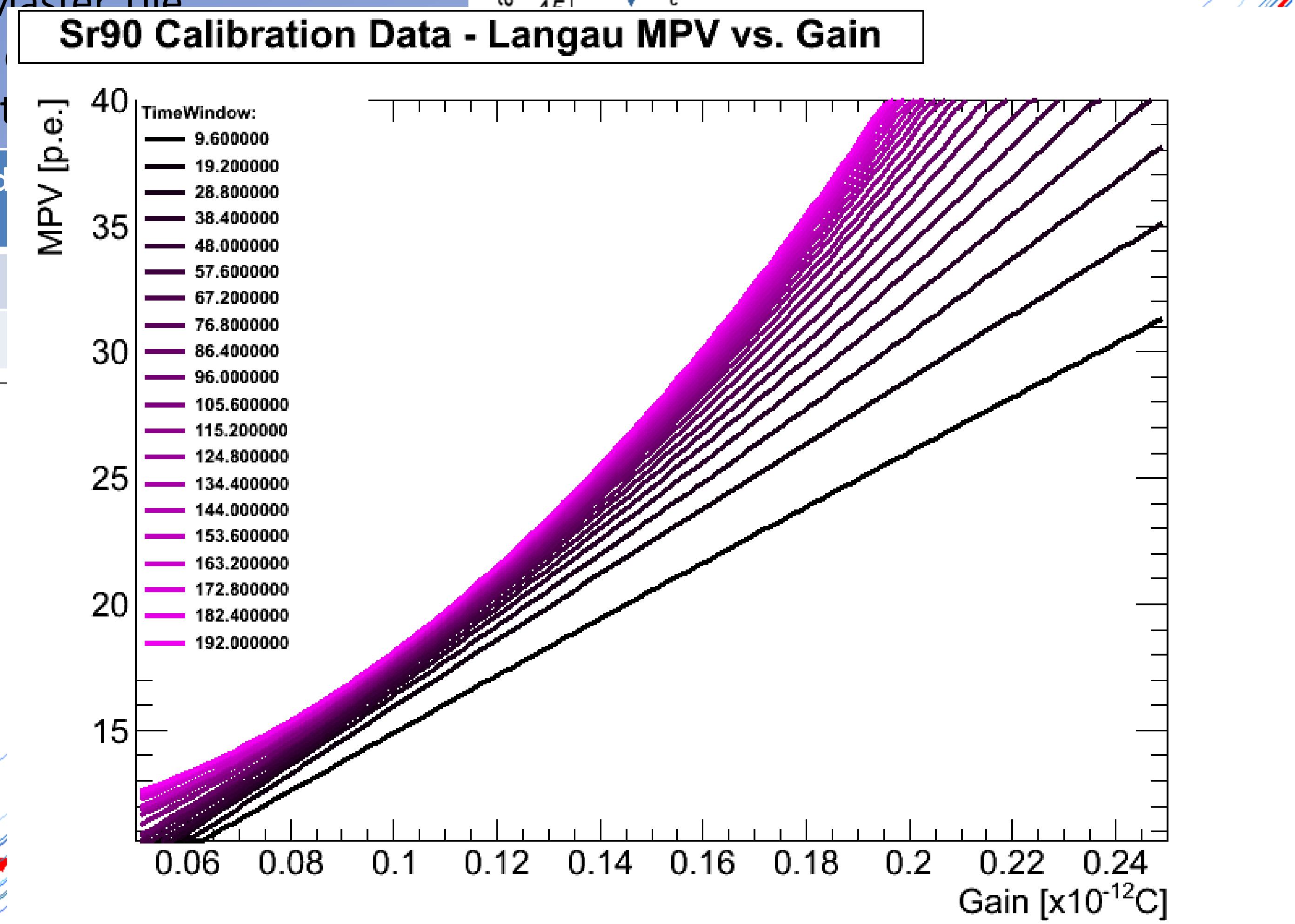
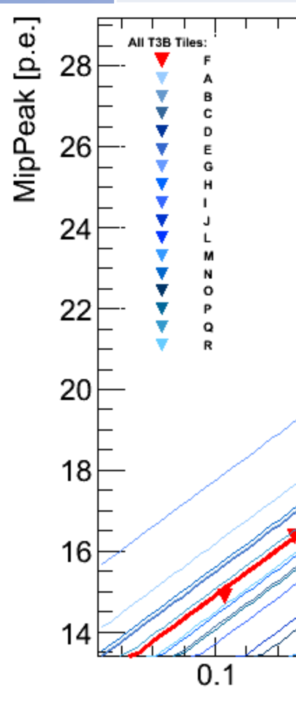
Time Wind
9.6 ns
307.2 ns







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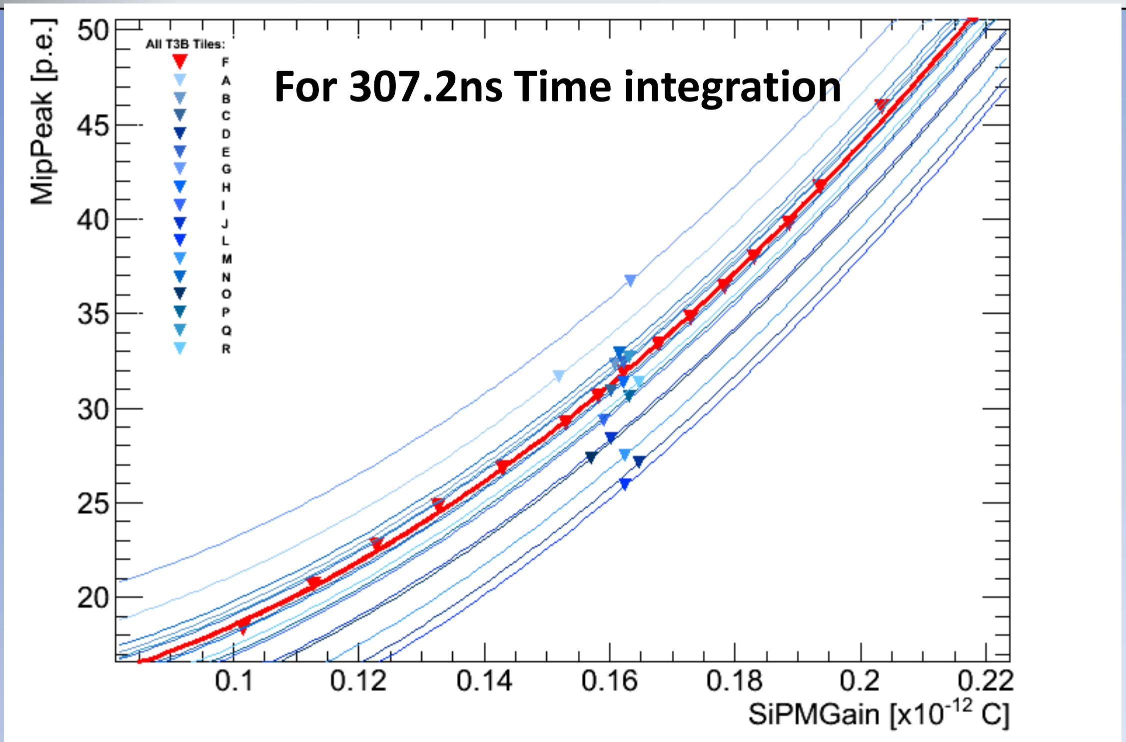
T3B Calibration to the MIP Scale



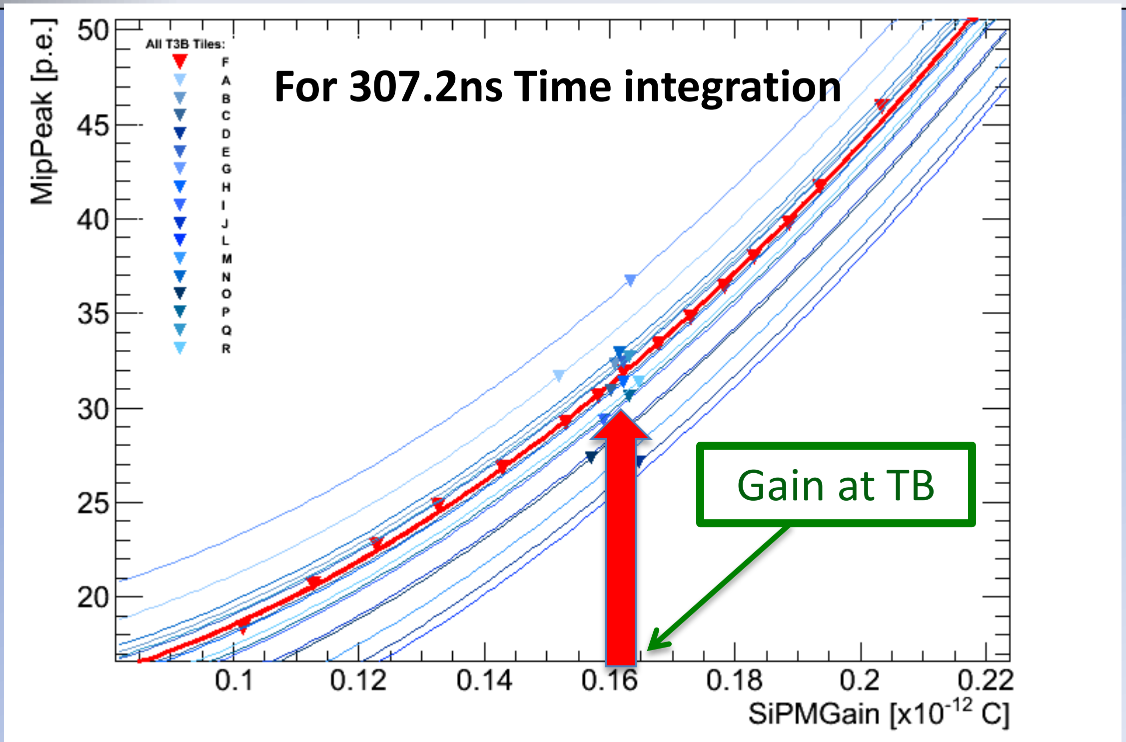
Obtain a dictionary:

Determine live SiPM Gain from testbeam data

Select MPV-Gain dependence for distinct time integration window

Obtain corresponding MPV of MIP distrib.

T3B Calibration to the MIP Scale



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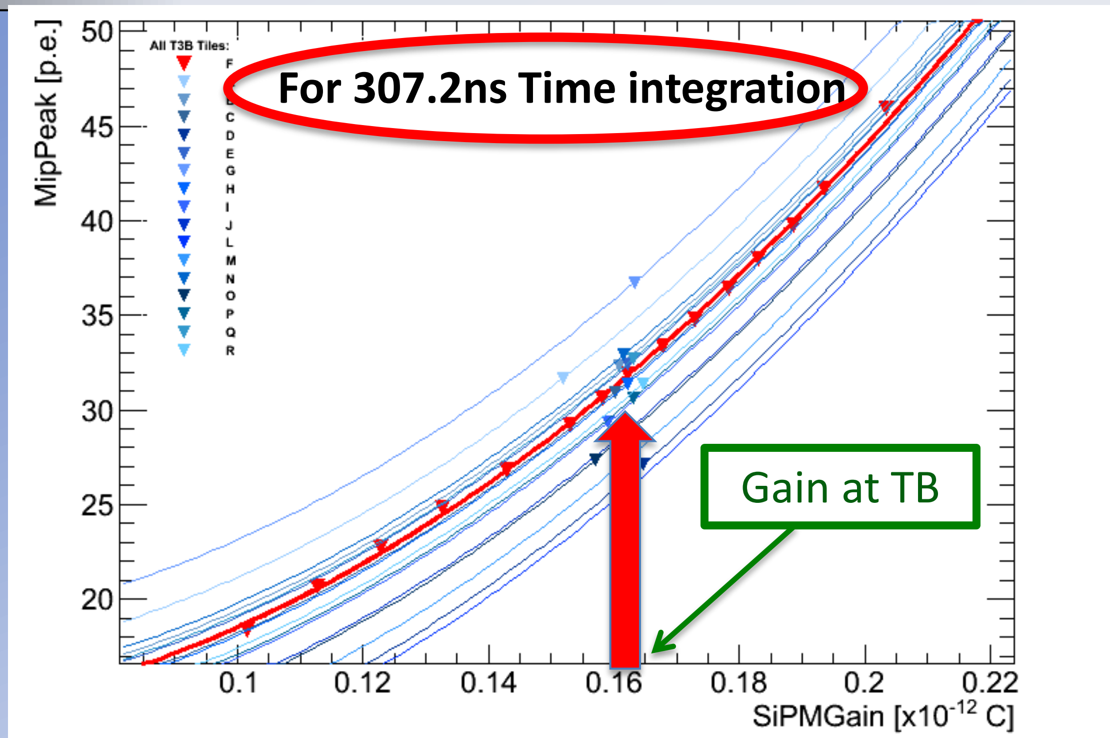

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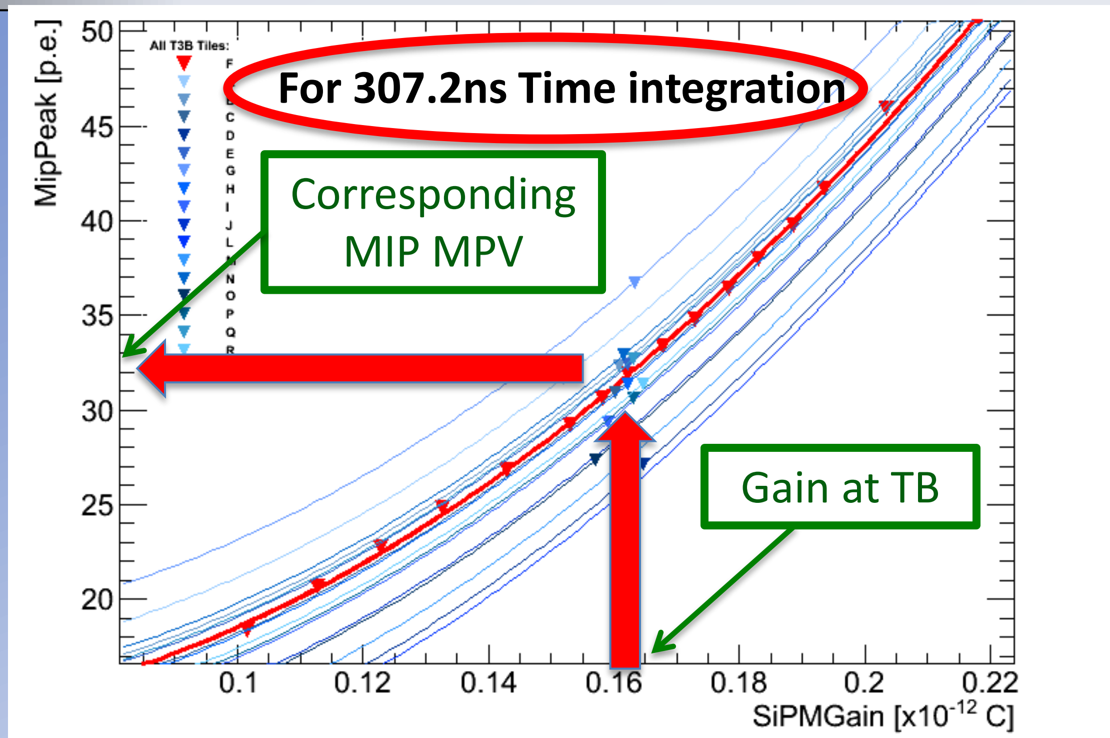

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VERIFY CALIBRATION PRINCIPLE: TESTBEAM MUON DATA

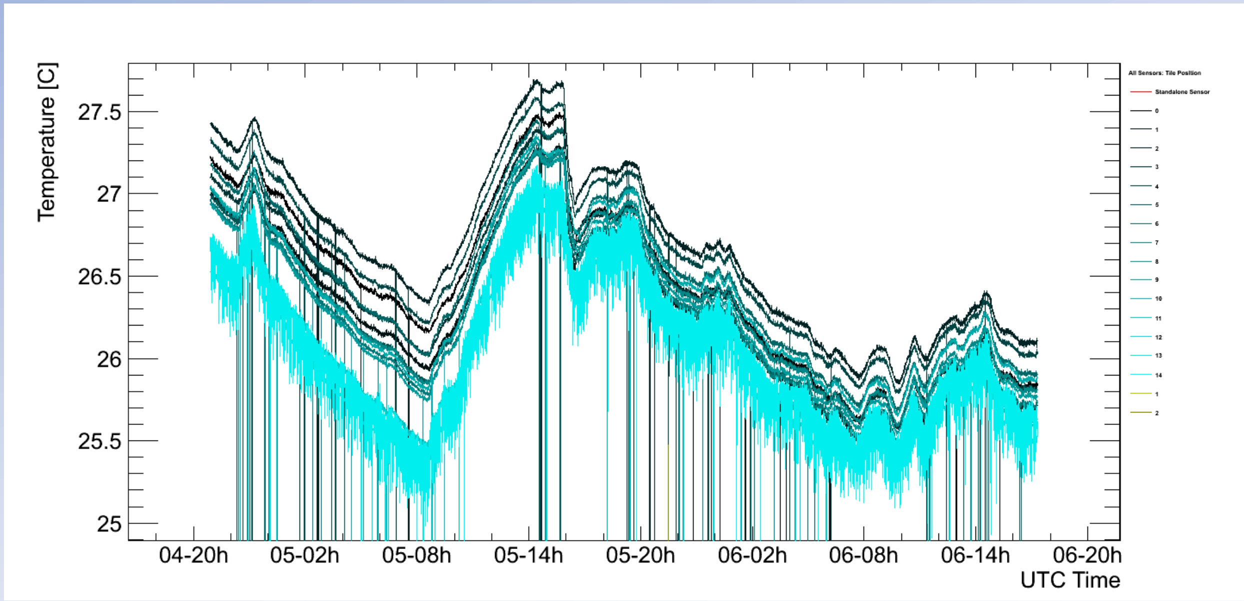
Verification of the Calibration Principle: Muon Data

During the commissioning of the SDHCAL we could take an excessive amount of muon data:

- 14 mio Muon Events
- 40 hours without interruption
- Day-night-cycle Temperature Range: ~25.5C to 27.5C

→ Enough to extract the Mip MPV-Temperature dependence

→ Then: Apply correction factor from Sr90 Data to eliminate the dependence (remember: We assume the MPV depends in first order only on the SiPM gain)



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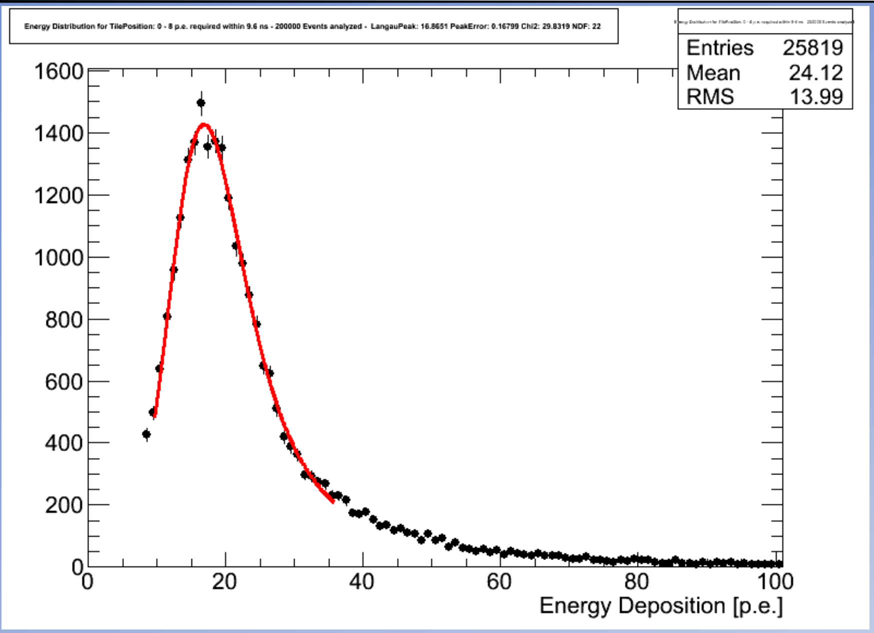
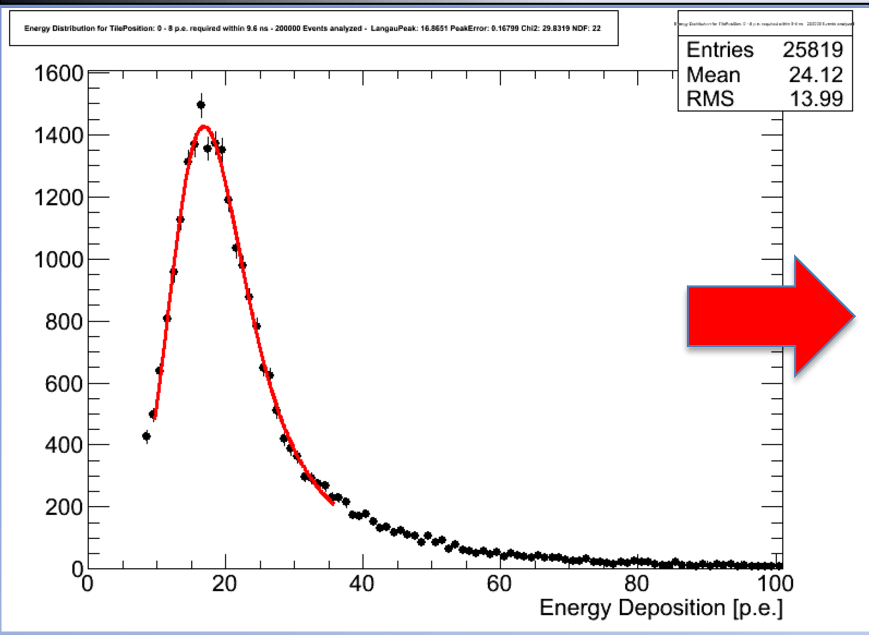
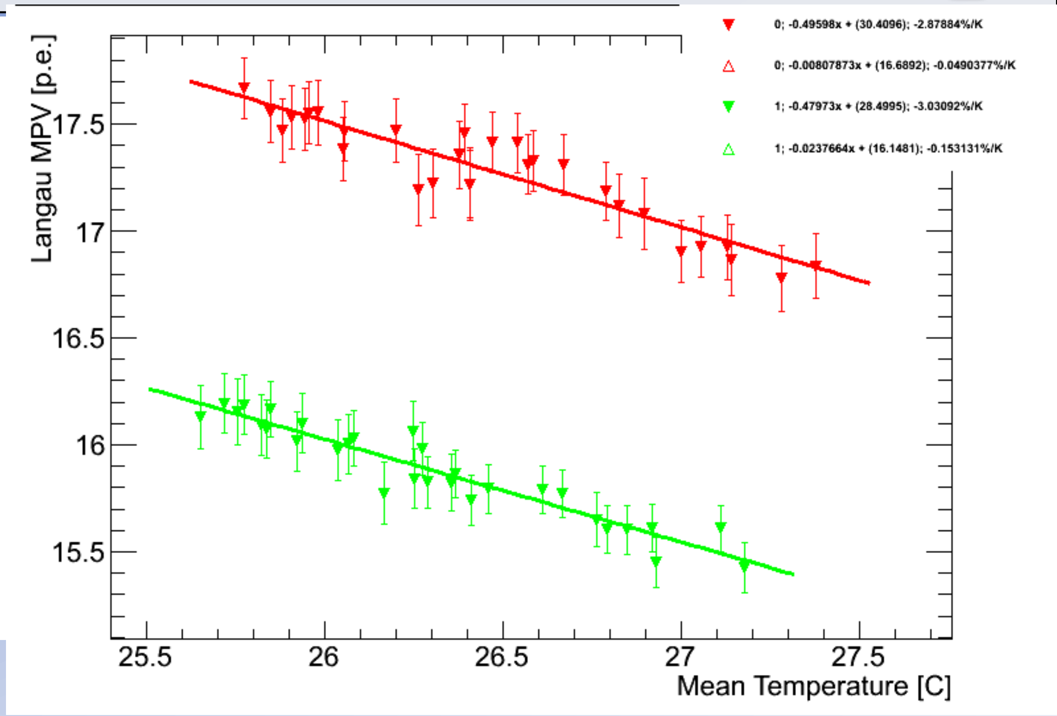


- T3B tiles hit in a small fraction of triggers
  → Determine MIP MPV every 200k events
- Time window of 9.6ns selected

Verification of the Calibration Principle: Muon Data





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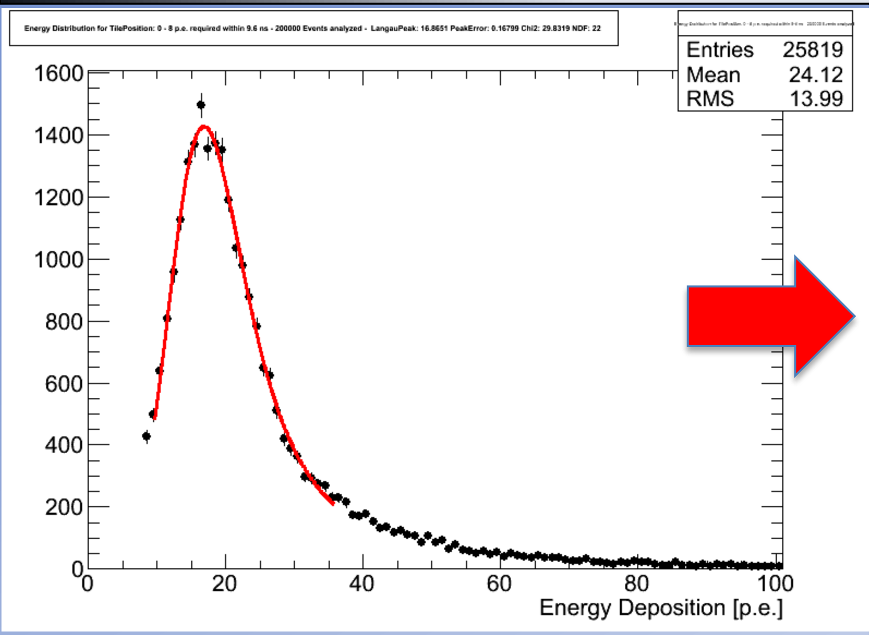

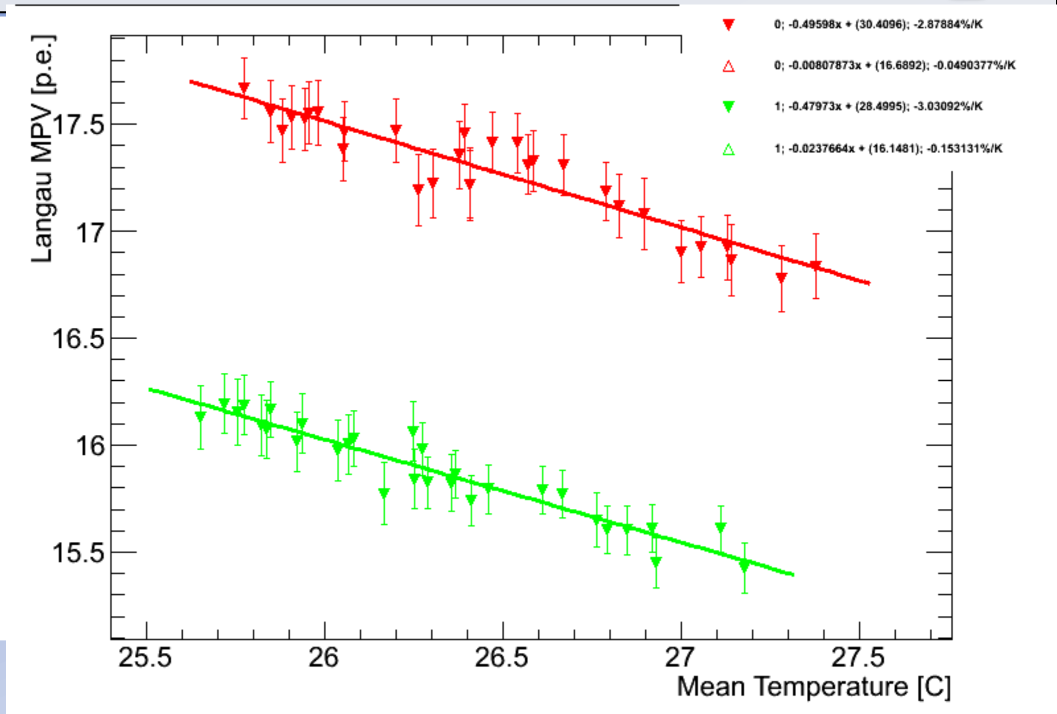

- Time window of 9.6ns

T3B Tile	MPV Drop	Slope
Center	-2.9 %/K	-0.5 p.e./K
Center + 1	-3.0 %/K	-0.48 p.e./K

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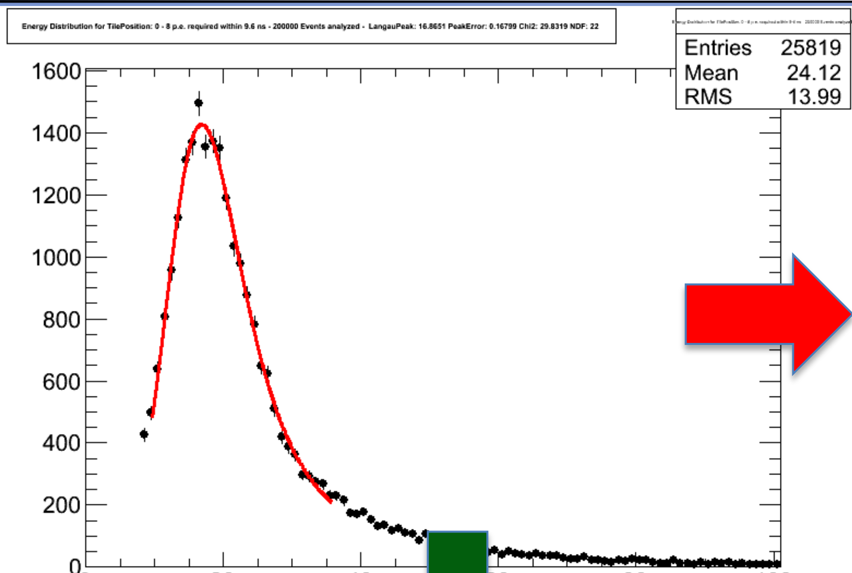

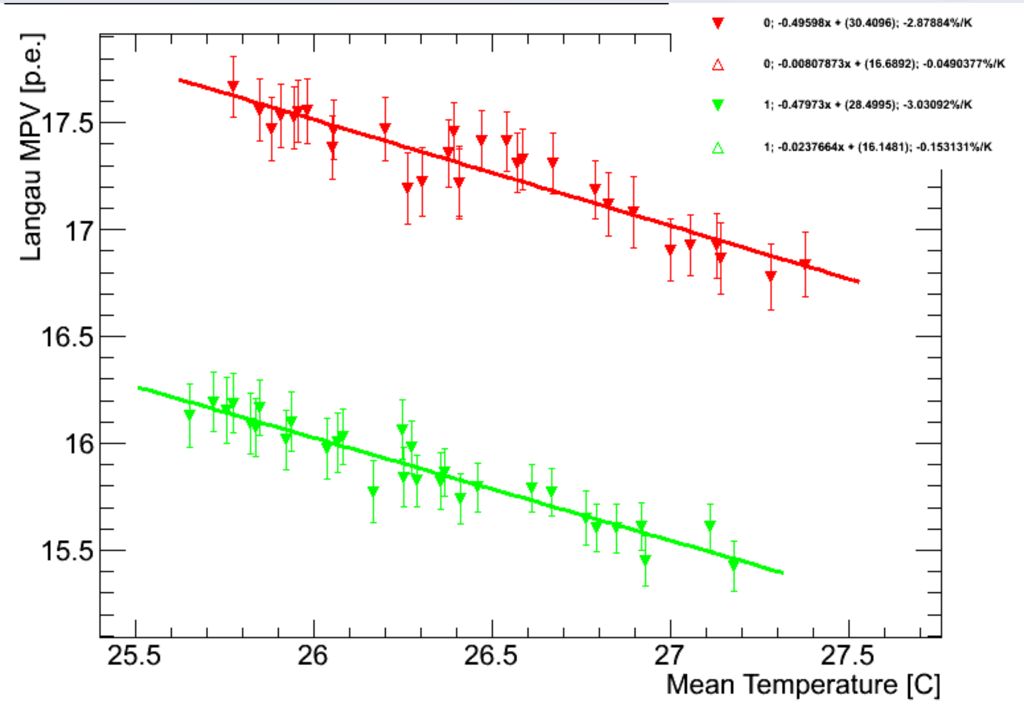

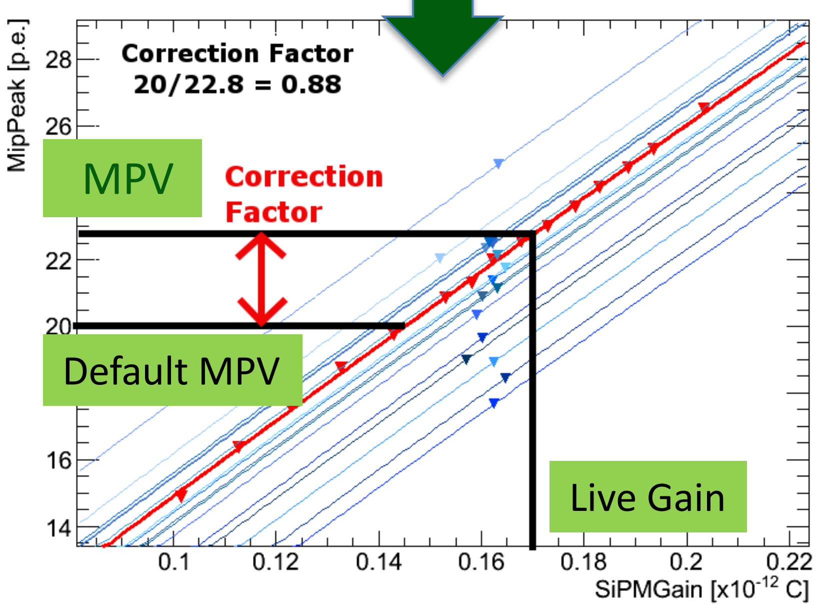

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- Get live gain from Intermediate RM
- Determine corresponding Sr90 MPV
- Choose default MPV of 20 p.e.→later 1MIP
- Obtain Correction factor

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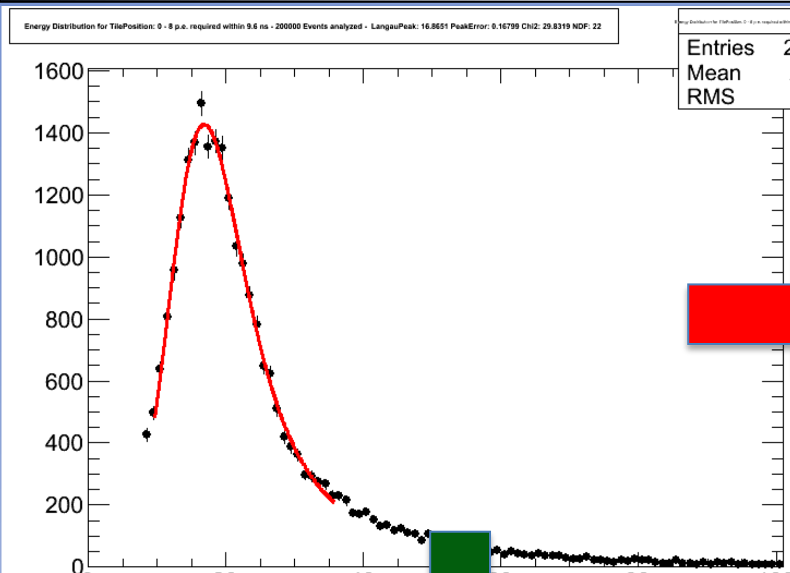

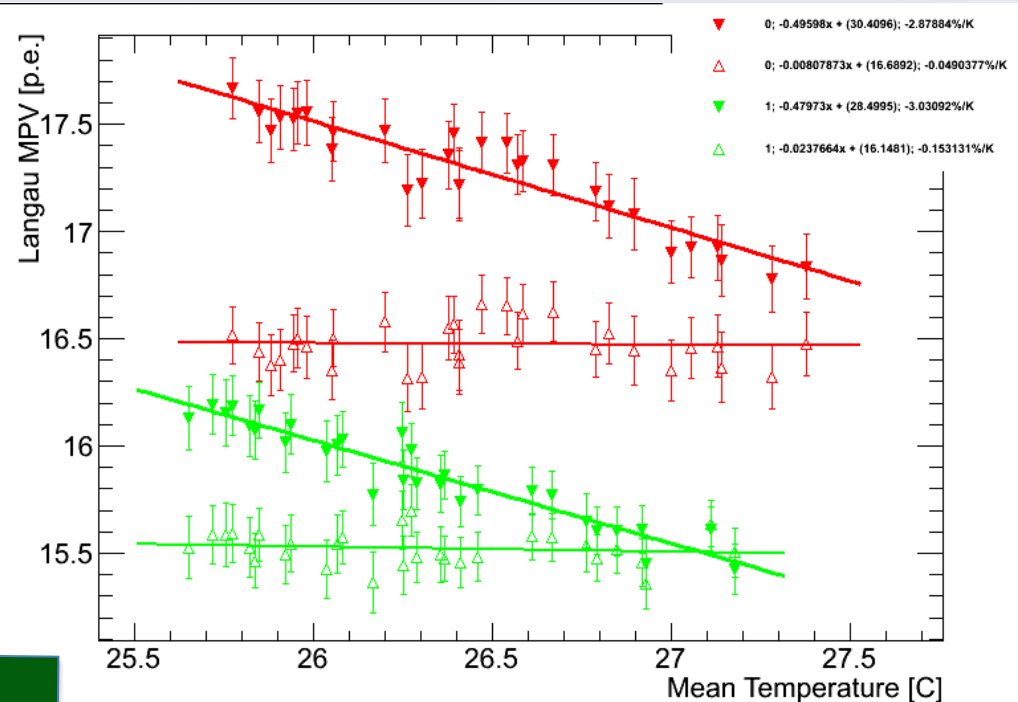

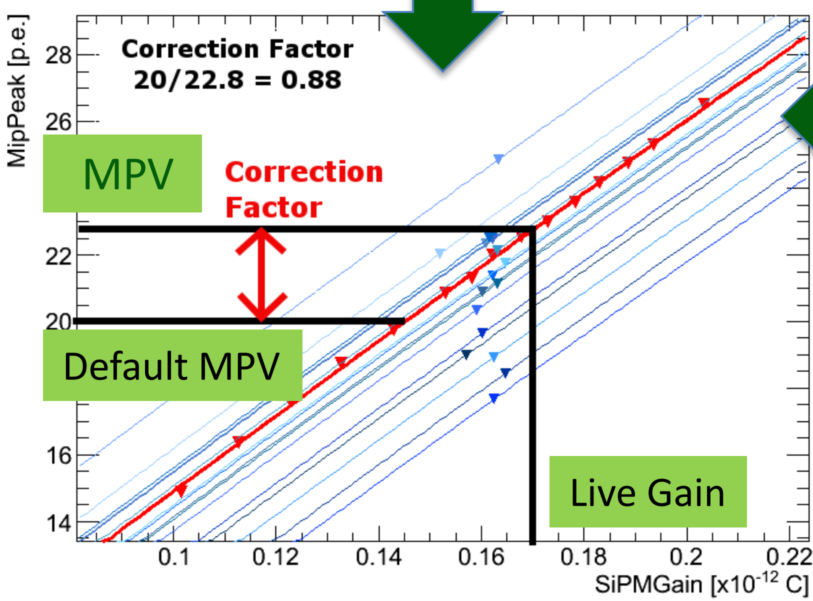

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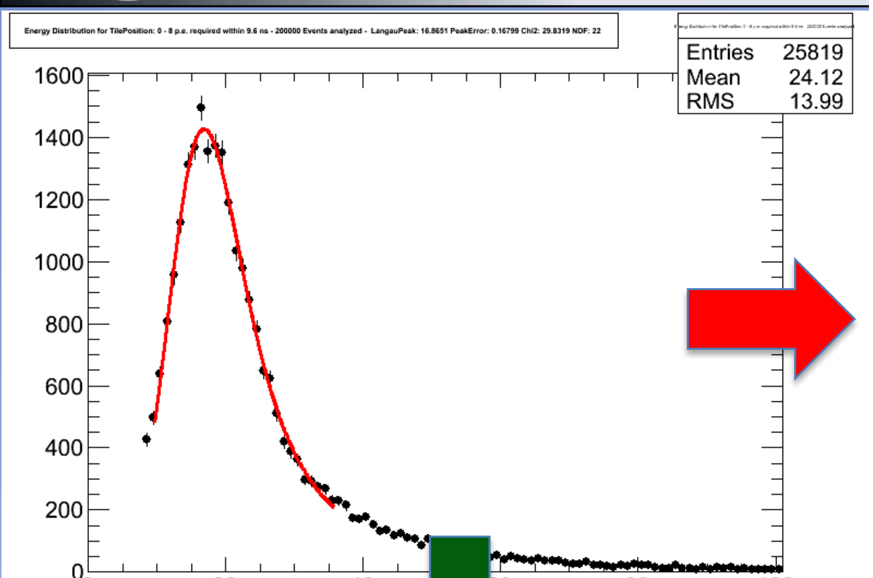
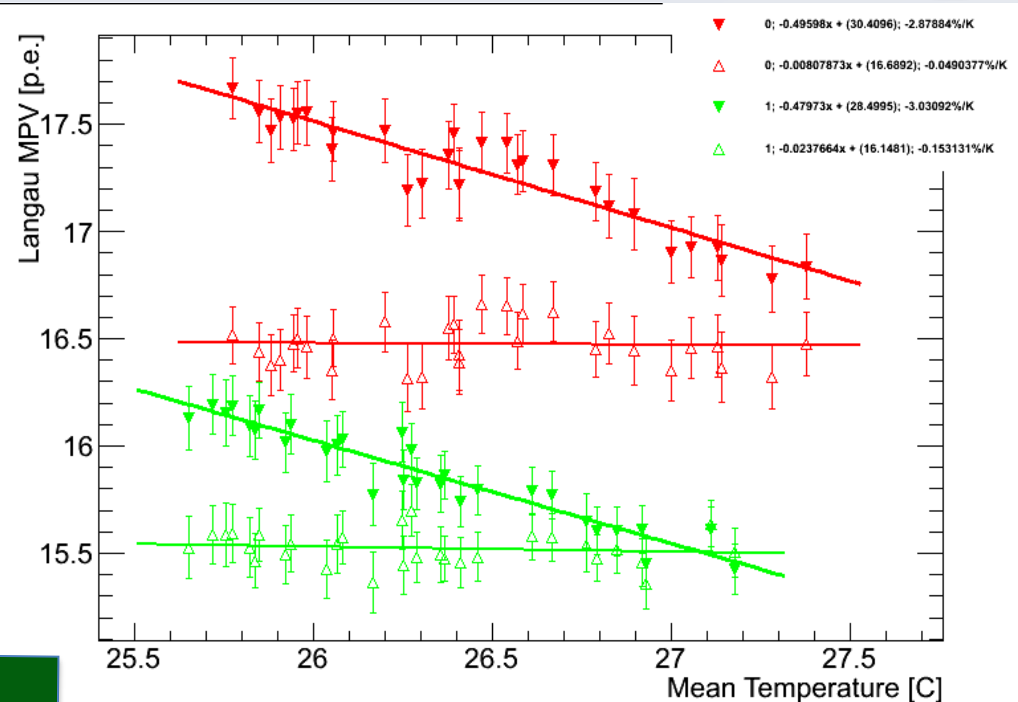
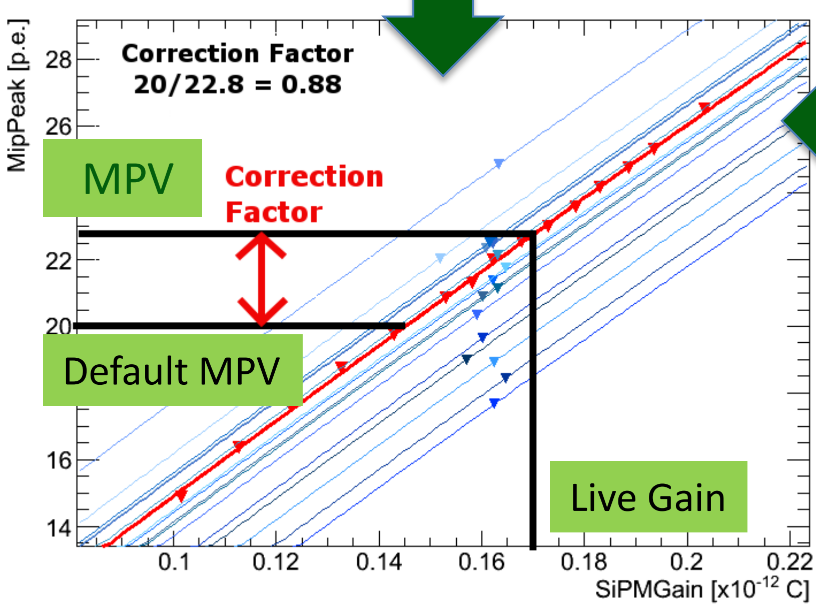




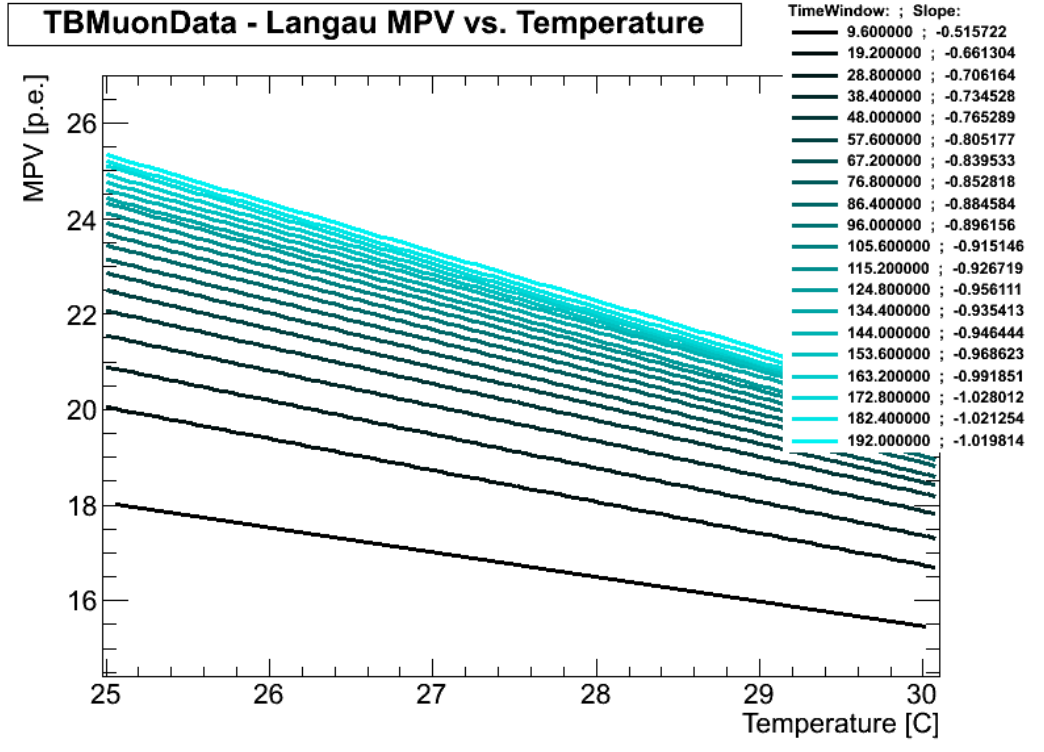


- Time window of 9.6ns

T3B Tile	MPV Drop	Slope
Center	-2.9 %/K	-0.5 p.e./K
Center + 1	-3.0 %/K	-0.48 p.e./K
Center corrected	-0.05 %/K	-0.008 p.e./K
Center + 1 corrected	-0.15 %/K	-0.024 p.e./K

- Obtain Correction factor

Verification of the Calibration Principle: Muon Data



Extracted MPV-Temperature dependence

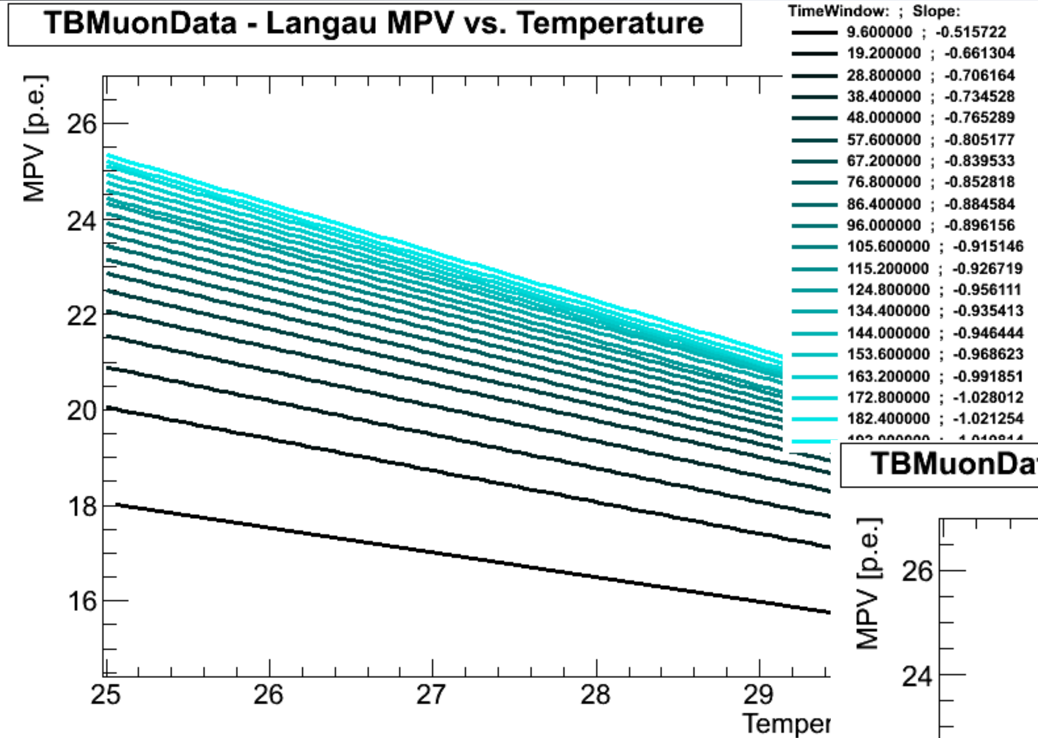
Time integration window: 9.6 ns – 192 ns

→ Lower Temperature equivalent to higher gain

→ As before: Results in higher Afterpulsing and Crosstalk Probability

Linearity due to low T-Range (2C)!?

Verification of the Calibration Principle: Muon Data



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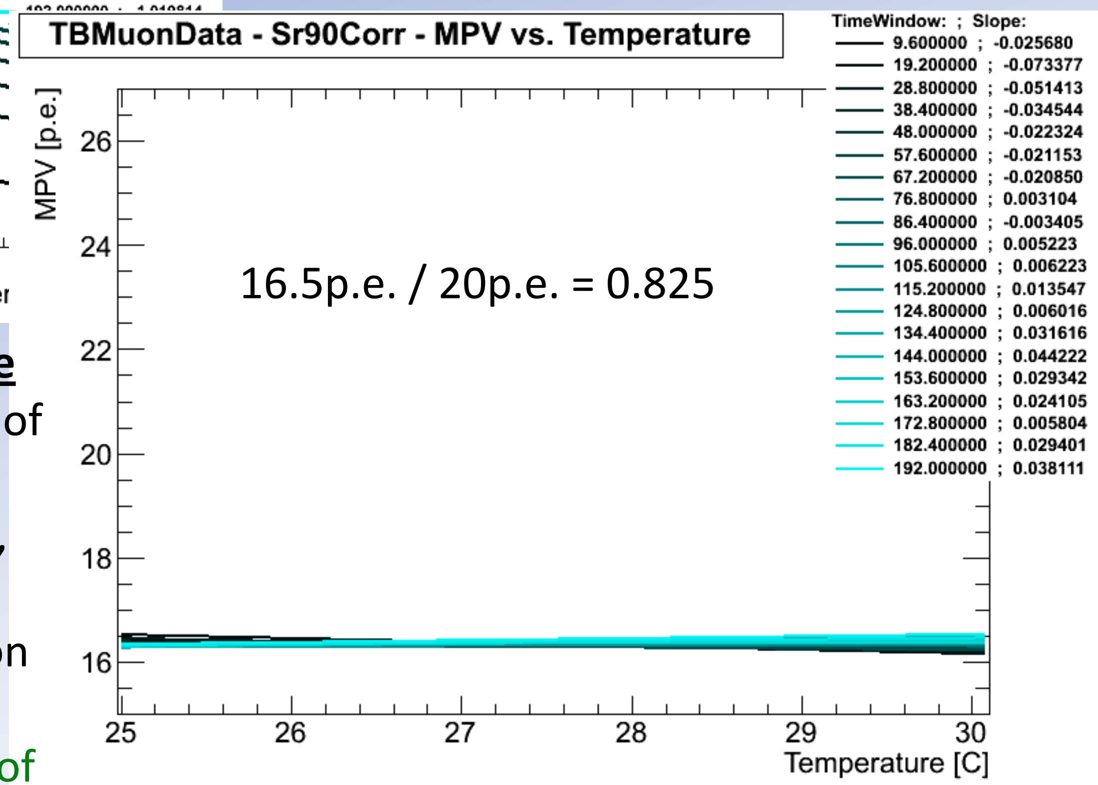


Corrected MPV-Temperature dependence

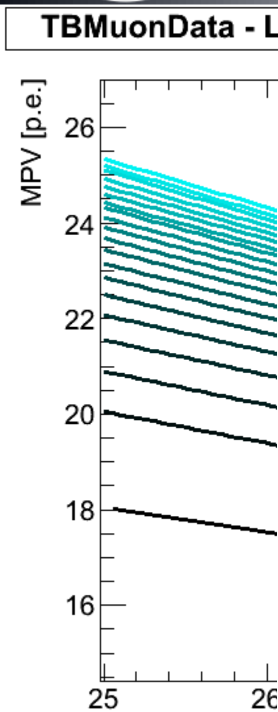
Calibration results in efficient elimination of the dependence

Note: Corrected MPV values at ~16.5 p.e., not at the 20 p.e. we corrected to.

Interpretation: 0.825 is the Sr90←→Muon MPV conversion factor

Matches simulations → Experimental proof

Verification of the Calibration Principle: Muon Data



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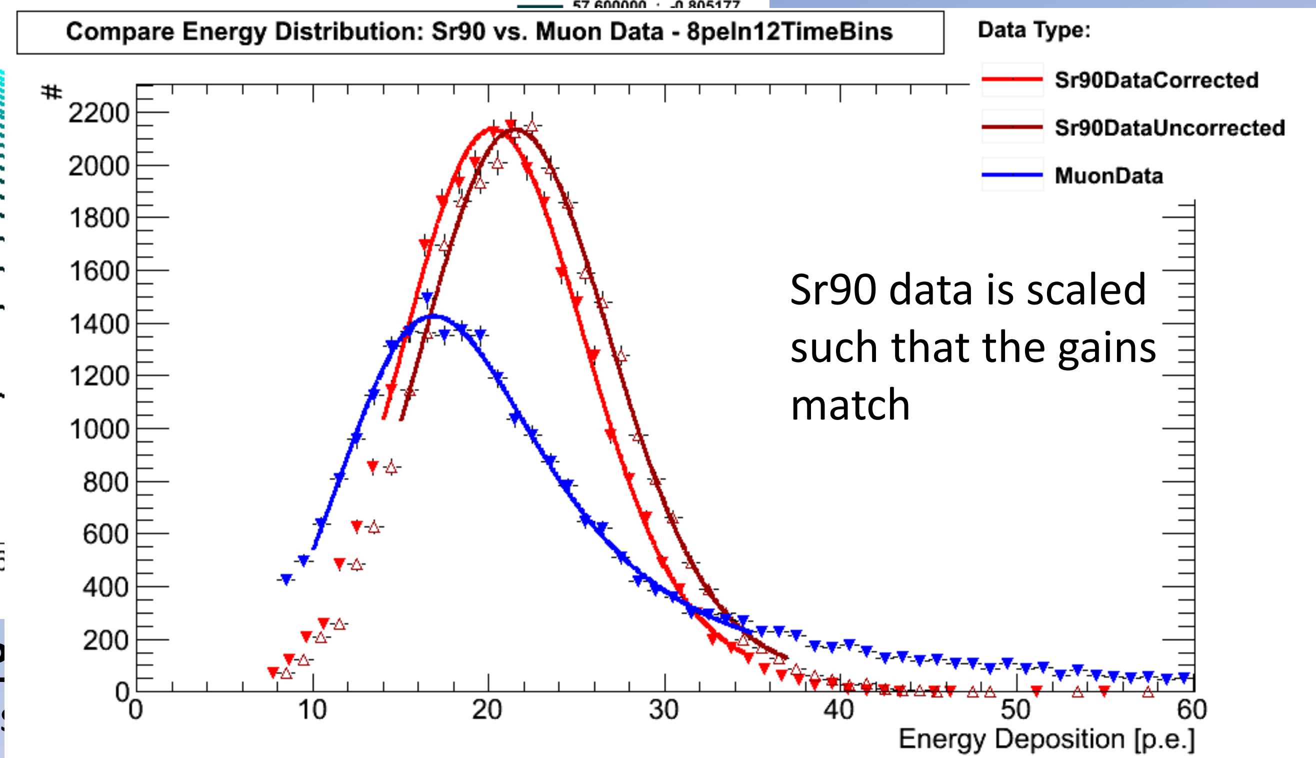
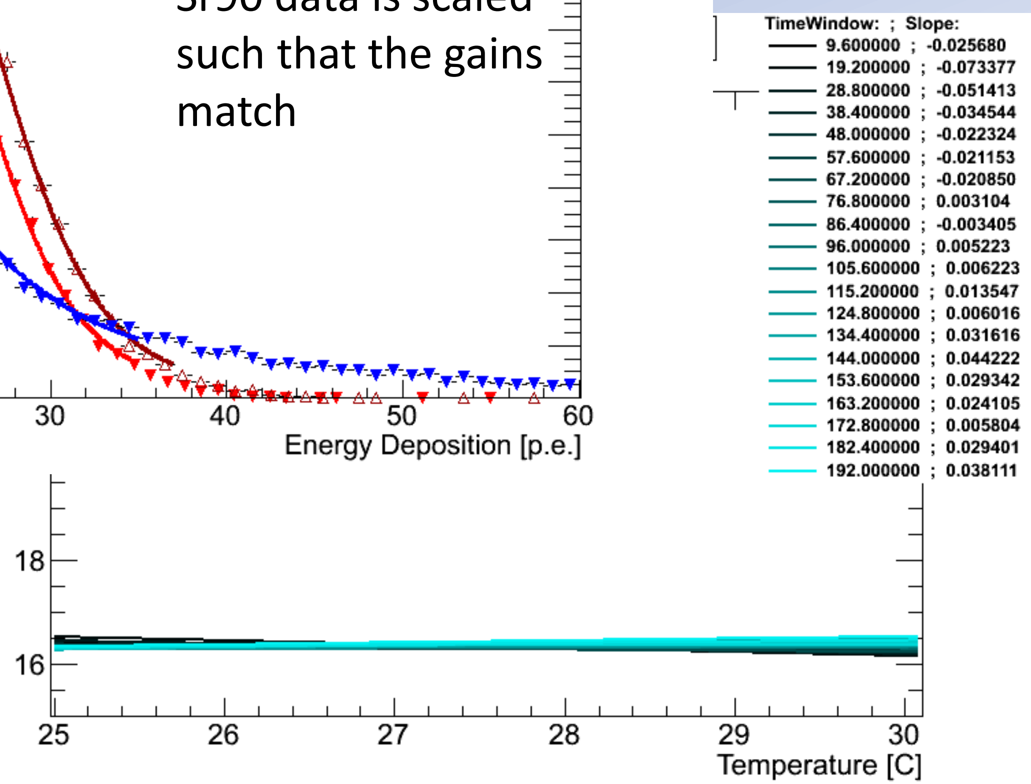




Corrected MP…

Calibration re…

the dependence

Note: Corrected MPV values at ~16.5 p.e., not at the 20 p.e. we corrected to.

Interpretation: 0.825 is the Sr90←→Muon MPV conversion factor

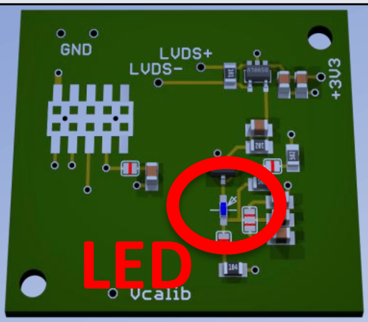
Matches simulations → Experimental proof

ROADMAP

Roadmap: Missing Calibration Steps

- **SiPM Saturation correction:**

Very promising results from Marco
with Wuppertal LED board and T3B tiles



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Missing Calibration Steps

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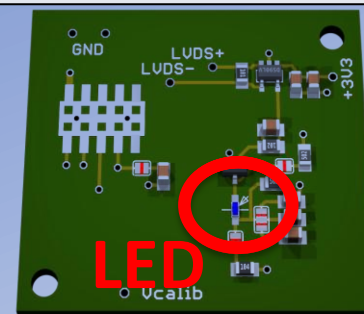
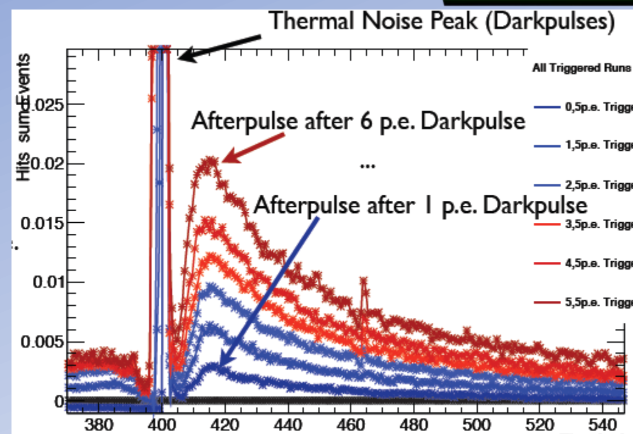
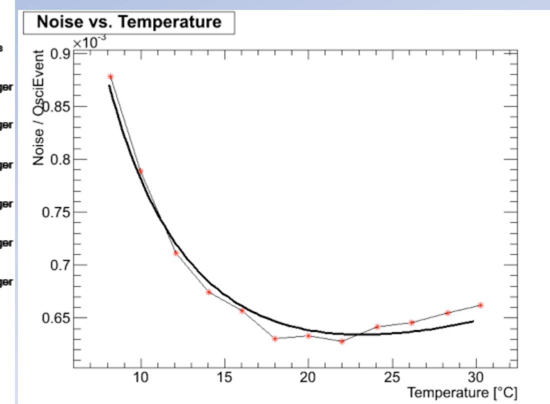


- <u>Correction for Afterpulsing:</u>

  → Need a dictionary: Which pulse height causes on average which afterpulsing contribution at a certain time after the initial pulse?

  → Promising results by Simon (also correction for darkrate)





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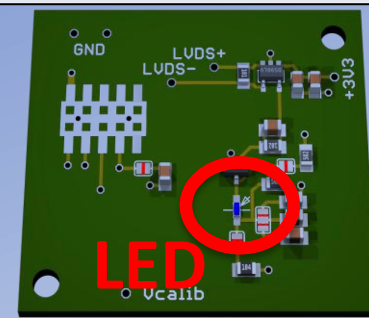

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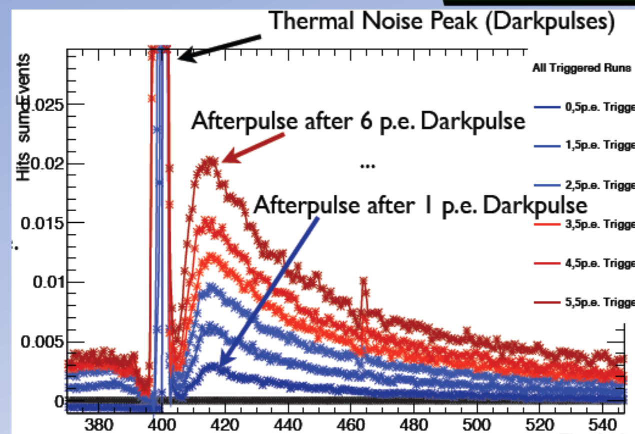
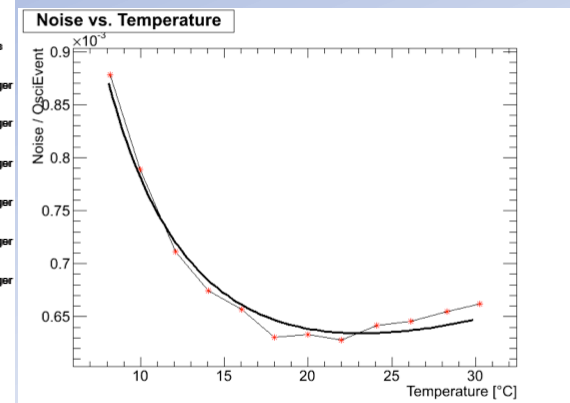


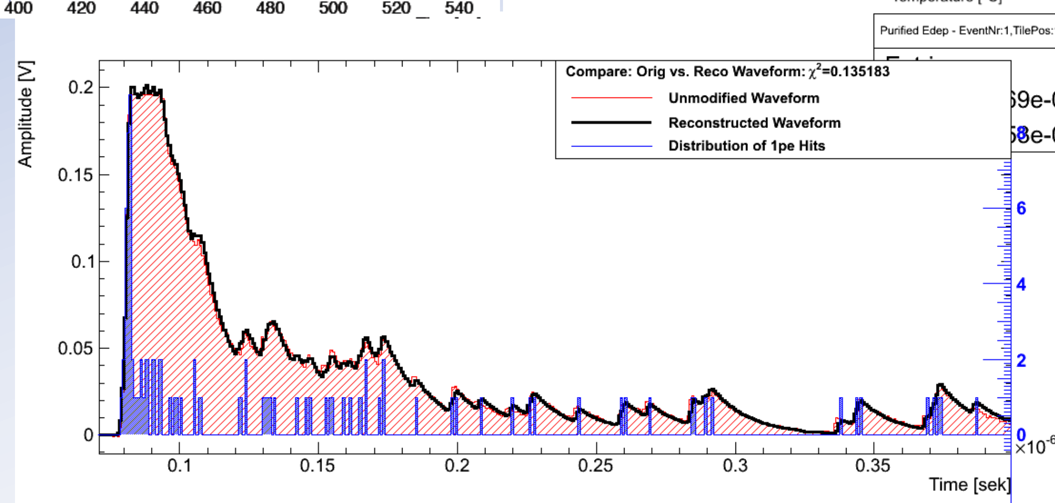


- **Clipping Correction:**

  Waveform decomposition can only work up to +-200mV range with an 8bit ADC

  →Higher energy depositions clipped

  → Original waveform probably recoverable from the signal shape



Roadmap: Run Quality Checks

T3B is a very high statistics experiment → need to concatenate all Runs at one energy

Processing power is no issue: Analyze ~ 15min/million events on a standard CPU

Developing procedure to identify suboptimal run conditions:

- CALICE Runlog → by eye ☹
- Use Particle ID (from Cerenkovs), Beam profile
  → needs T3B-Calice synchronization for most of the data → Lars ongoing…
- T3B Hardware (e.g. pedestal jumps…) → automated "Calibration Quality Check" exists

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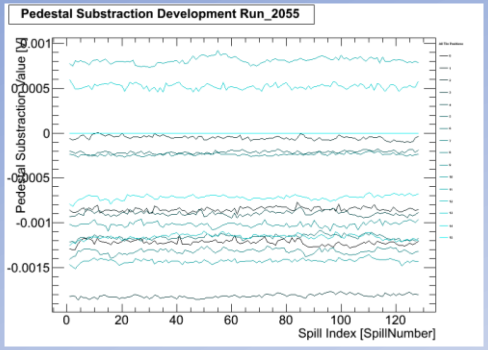

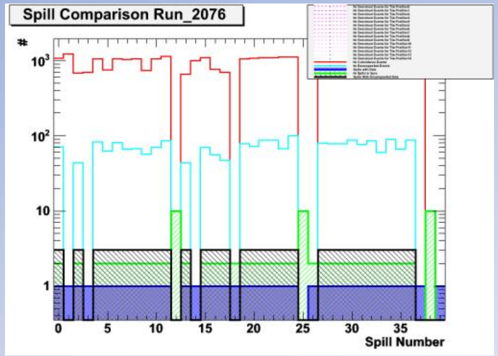

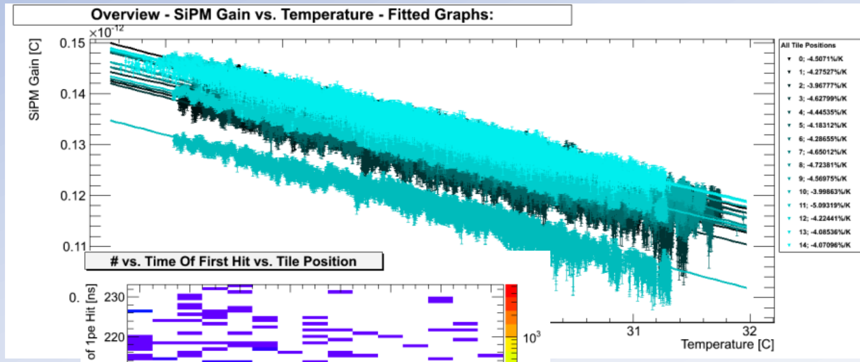

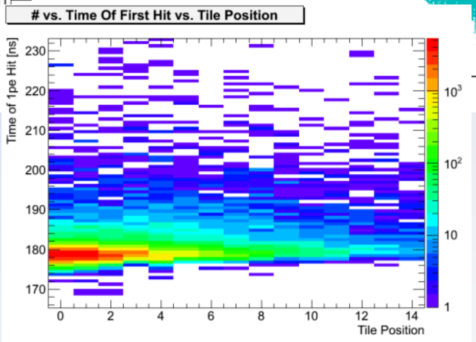

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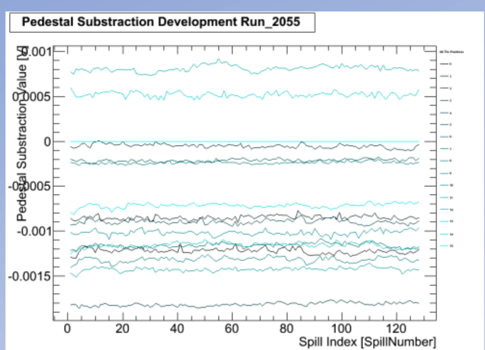

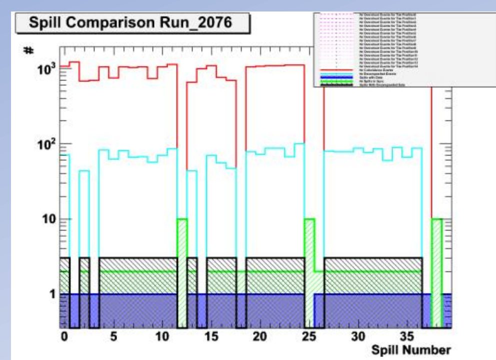

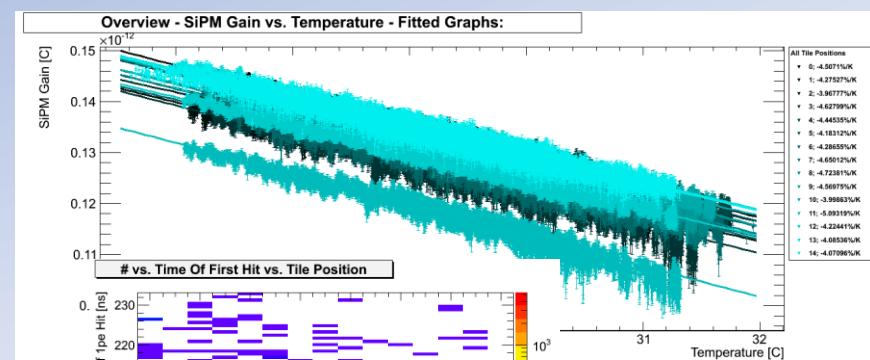

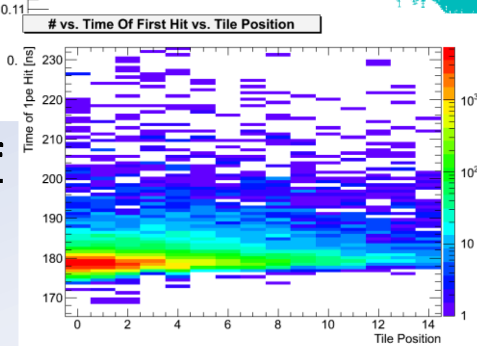

Final step → obtain timing results that are bullet proof

- Energy deposition vs. time
- Shower timing vs. particle energy
- Longitudinal timing of hadron showers
- …

There is still big potential in the T3B data → we look forward to a successful year 2012

BACKUP

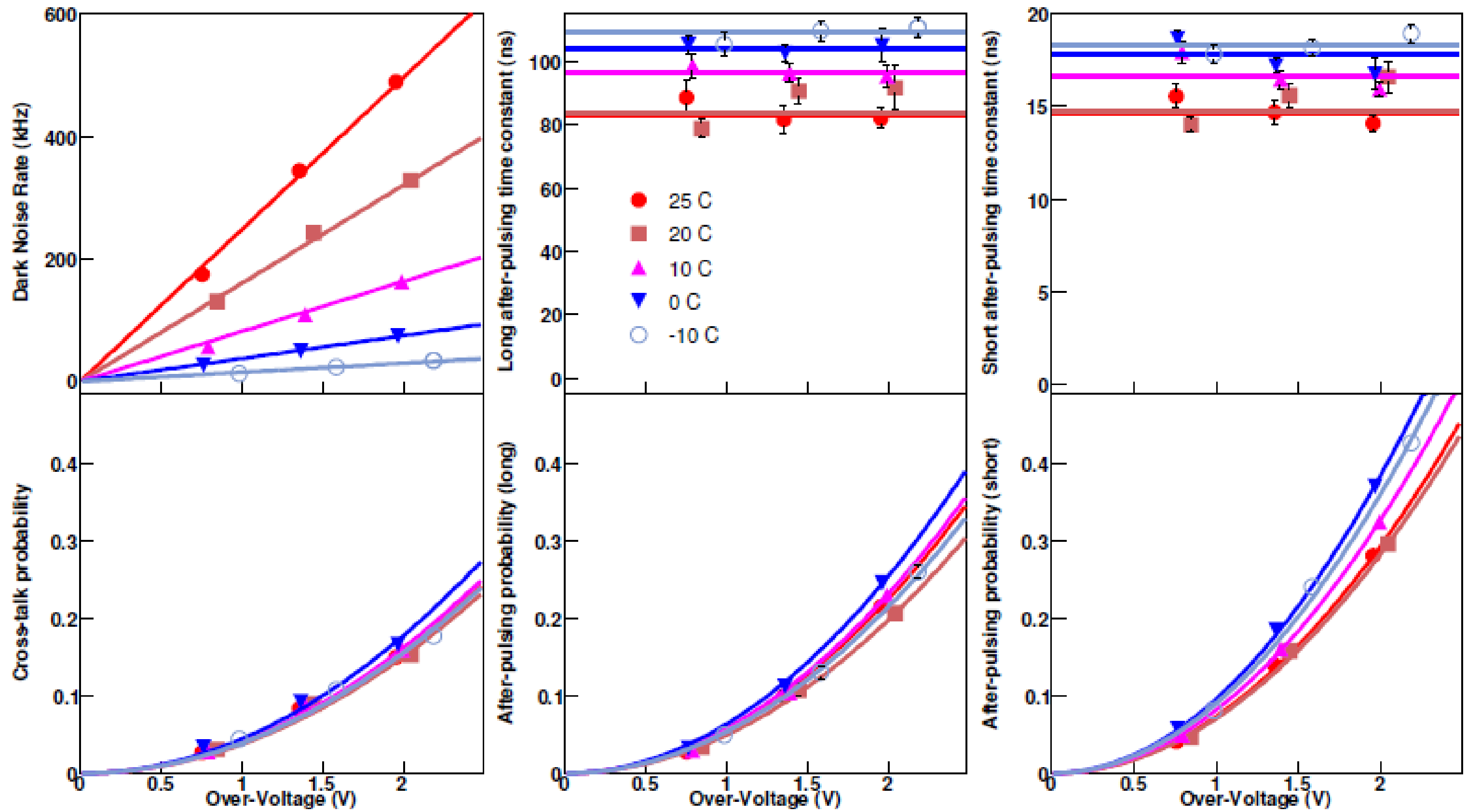

Fig. 1. Dependence of the dark noise rate, cross-talk probabilities and after-pulsing parameters on over-voltage and temperature, measured by triggering on thermally generated pulses

*trshare.triumf.ca/~fretiere/**T2K**/Talk/NDIP/FRetiere.ps*