Laser Pulse Width

ECAL Test Beam and Pre-calibration Meeting, CERN

J. Veverka, A. Bornheim, C. Rogan, Y. Ma
California Institute of Technology

March 22, 2007

Outline

- Review of the laser monitoring issues
- Results of the measurements of the correlation between APD/PN and laser pulse width

Review

Laser Monitoring Issues

Laser Monitoring

- *Purpose*: measure the ECAL crystal transparency change due to irradiation during the LHC running
- *Goal*: ~1 ‰ APD/PN stability
- *Need*: understand systematic correlation between APD/PN laser pulse
  - Width
  - Timing
  - Amplitude
- *Here*: concentrate on the width issues

APD/PN-Width Dependence

- Simulated as a convolution of the laser pulse shape and electronics response:
  "*The dependence observed in data can be reproduced based on the properties of the pulses alone.*"
  — Adi Bornheim, TB meeting, 20 Sep 2005
  "*Slope (normalized APD/PN vs. width) : 2 ‰/ns*"
  — Adi Bornheim, TB meeting, 3 Nov 2005
- Measured for a few channels of the 2004 SM10 data to be linear with a slope of around 2.5 ‰/ns. For details, see talk by Adi Bornheim, TB meeting, 3 Nov 2005.
- Expected long-term width stability ~1-2 ns
- *Implication*: The effect is larger than required precision, a correction is needed.
- *Here*: Measure the effect for the 2006 TB data on a larger scale

New Results

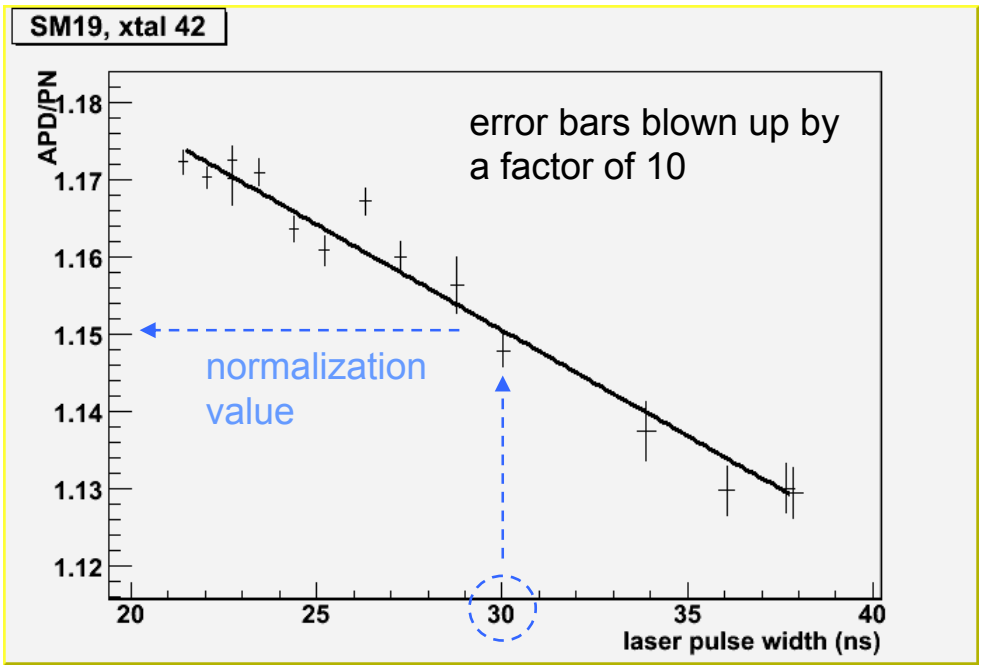
APD/PN and Laser Pulse Width Correlation Measurements

Used Data

- APD/PN data
  - Pulse width scans for 7 SMs: 2, 4, 13, 17, 19, 20, 22 (1700 channels each)
  - Total of ~90 useful laser runs (600 events each)
  - Standard online laser code used for reconstruction
  - Gaussian fit for each channel of each run:
    - APD/PN value = mean of the fit
    - APD/PN value error = (sigma of the fit) / $\sqrt{600}$
- Laser pulse width data
  - Fast Monitor in the laser barracks used
  - All 2006 laser runs reconstructed and matched
  - Gaussian fit for each run:
    - Width value and its error = same as for the APD/PN

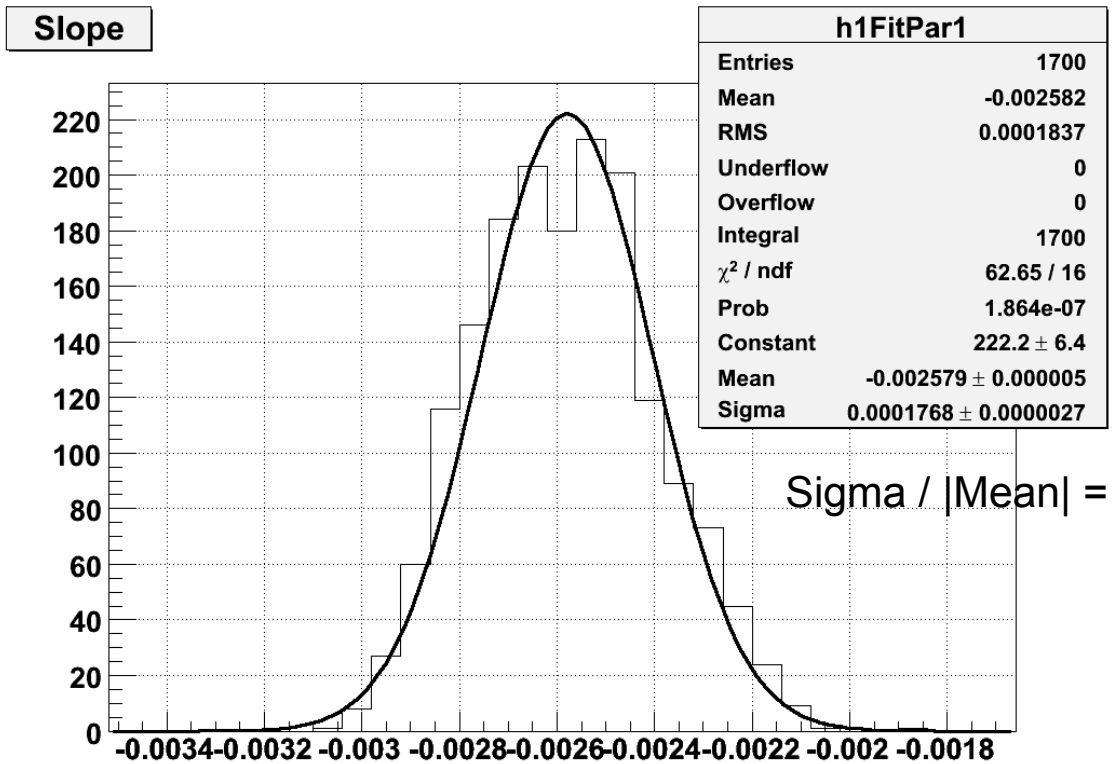
APD/PN-Width Linear Fits

Example



- Linear fit of the APD/PN-width dependence for each channel of each SM
- Normalize APD/PN by the fit value at width = 30 ns
- Distributions and crystal maps for the slope, intercept, chi2, etc. of the linear fits for the *normalized* APD/PN values

Slope Distribution Example - SM17



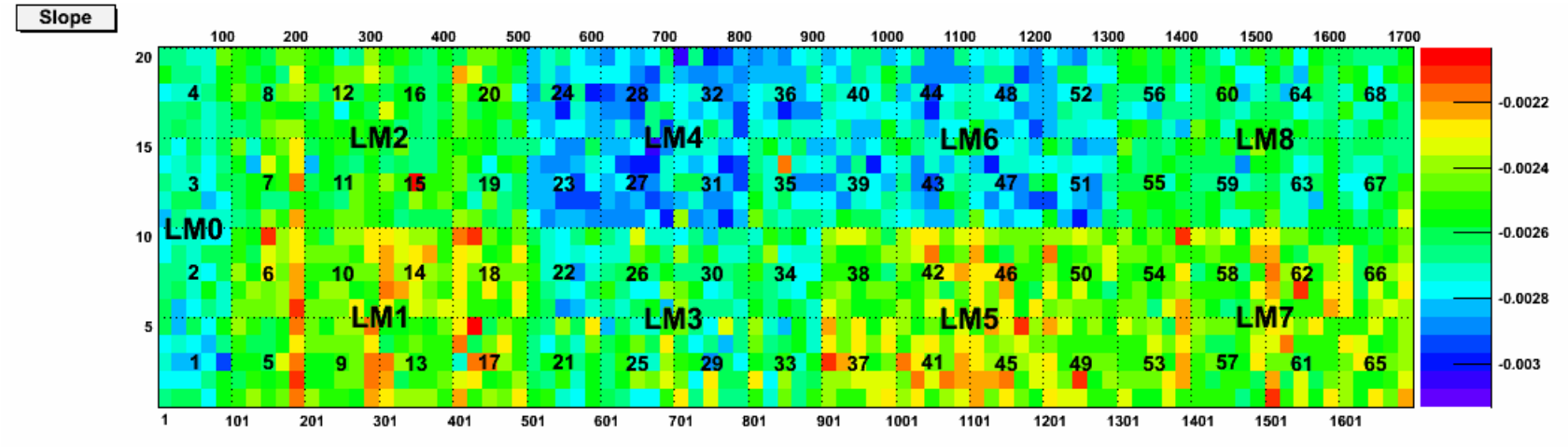
Sigma / |Mean| = 6.9(1)%

Max. single-value correction error ~ (0.18 ‰/ns)×(2 ns) = 0.36 ‰ < 1 ‰

For more plots like this one, see

http://ultralight.caltech.edu/hepwiki/PulseWidthSystematics

Slope Crystal Map Example - SM17



- Noticeable LM structures
  - Their scale is small compared to the slope values
  - They are a general feature of the APD/PN-width dependence for more or less all studied SMs
  - Interesting but not yet thoroughly investigated
- For more plots like this one, see http://ultralight.caltech.edu/hepwiki/PulseWidthSystematics

Results

SM	*# Runs*	*Run Numbers**	*Stand*	*Slope (err) [‰/ns]*
04	15	25067-81	H4 cosmic	**-2.01(16)**
13	14	19811-24	H4 cosmic	**-2.91(12)**
17	5	20753-57	H4 cosmic	**-2.58(18)**
19	15	21683-99	H4 cosmic	**-2.28(11)**
20	9	23254-63	H4 cosmic	**-2.39(13)**
22	13	13582-96	H4 test beam	**-2.04(41)**

*Some run numbers in the range might be excluded

- Legend:
  - Slope = mean of a Gaussian fit to a distribution of 1700 values as in slide #9
  - Err = sigma of the Gaussian fit
- Note that the slope values are compatible across the different SMs
- Two SMs measured incidentally with improper intensity settings – results not listed here since the slope values are not usable.
- Assuming single-value correction for all SMs, it's maximum error would be roughly (0.5 ‰/ns) × (2 ns) = 1 ‰ → might/might not be good enough, evaluation needed

Summary

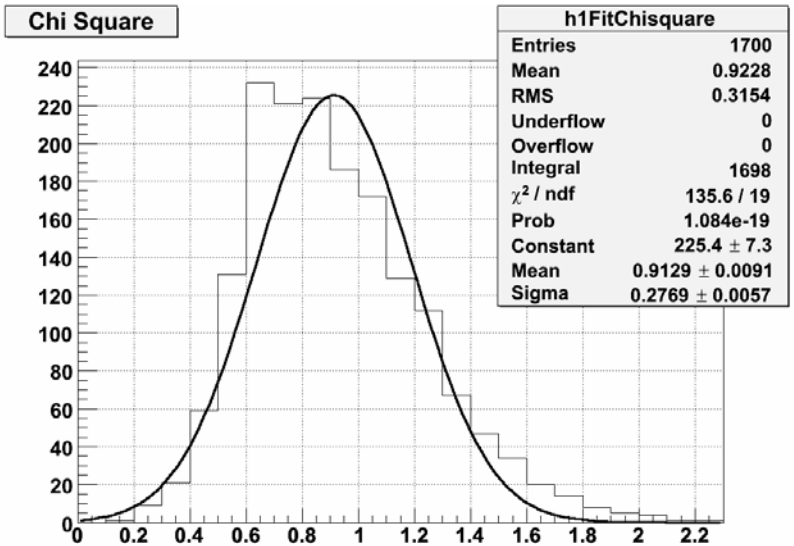
- Correlation of APD/PN and laser pulse width measured for all channels of 7 super modules – linear dependence observed
- Results are consistent with expectations based on laser-pulse-shape and electronics convolution simulation
- Some LM systematic structures observed

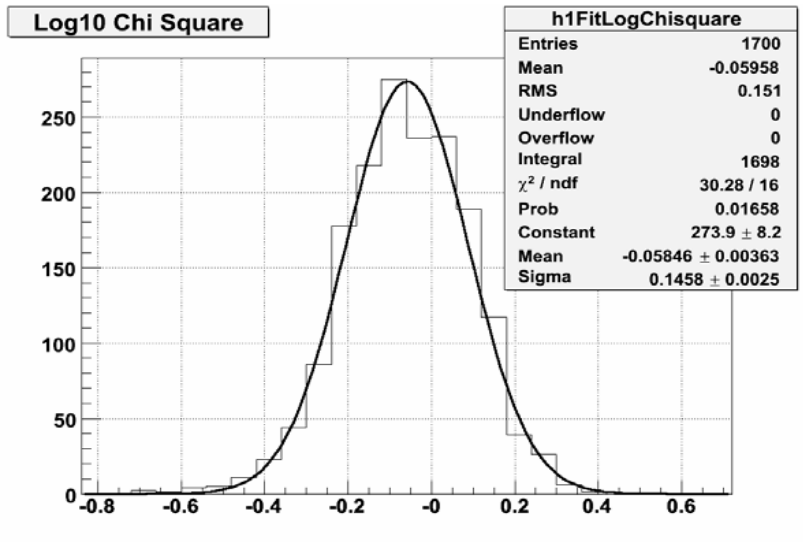
Outlook

- Apply width-based correction to TB data
- Significant APD/PN stability improvement expected
- Stay tuned for new results

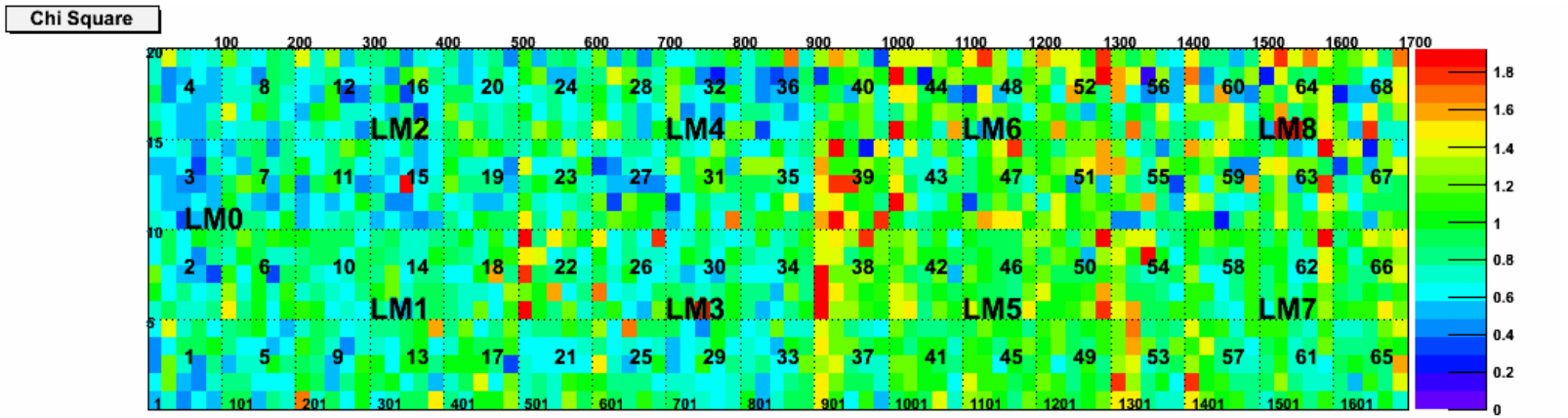
Backup Slides

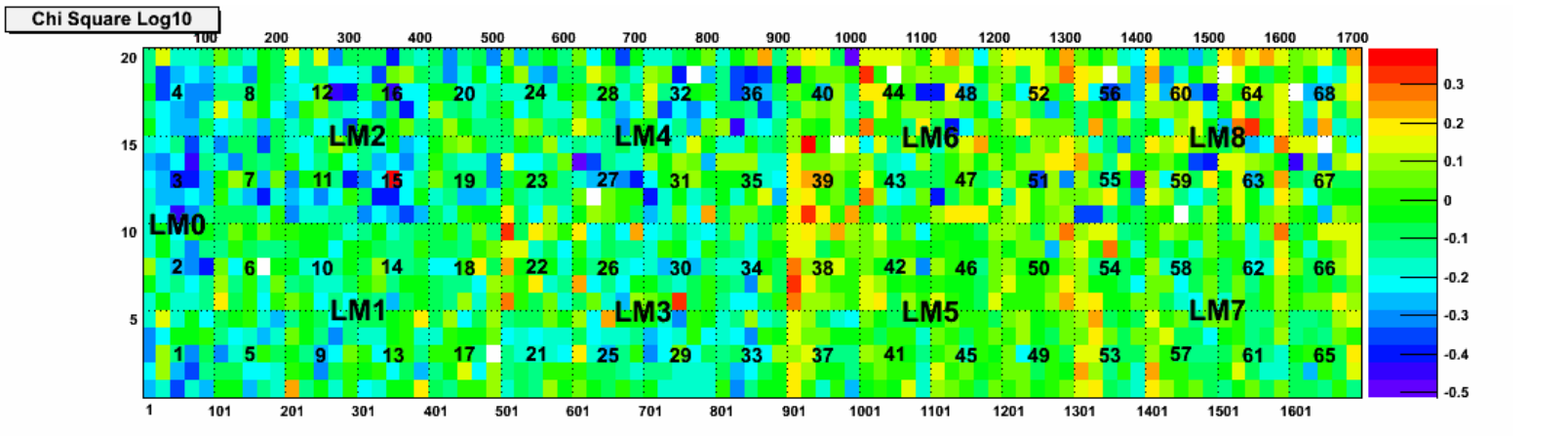
Chi2 and Log10(Chi2) for SM17





Chi2 and Log10(Chi2) for SM17

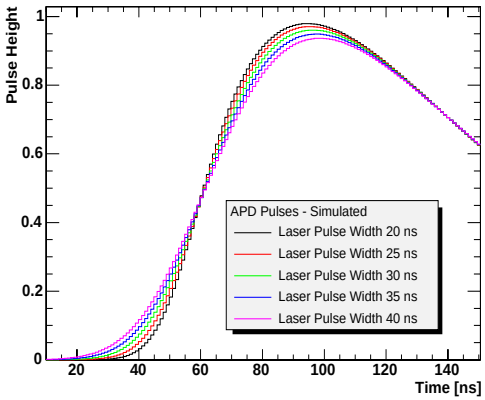


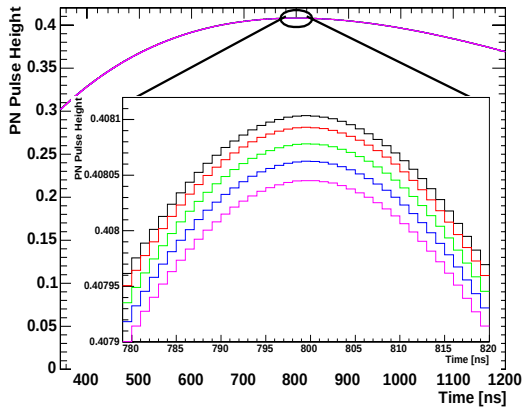


Review: Width

Review of APD/PN and Laser Pulse Width Correlation

Pulse Shape Convolution

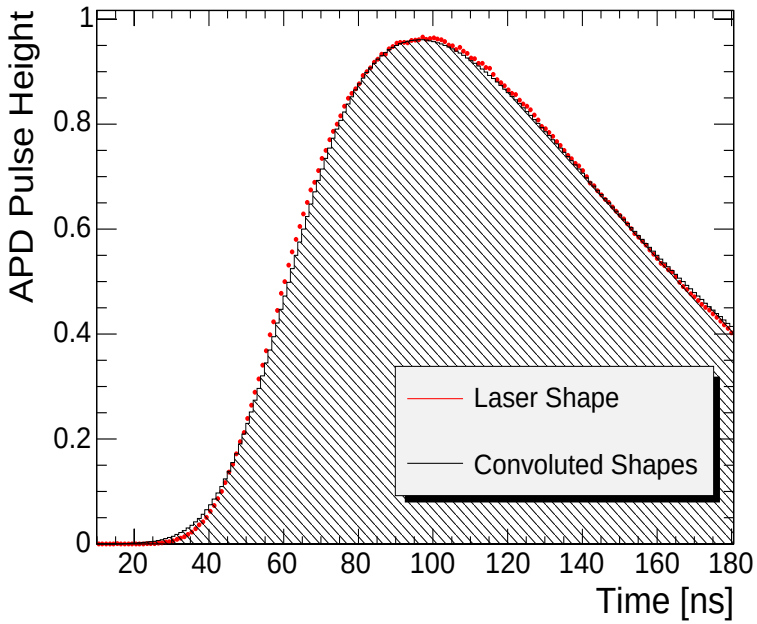




Reminder :

Pulse shape is a convolution of the electronic shape and the 'line shape' of the light. In case of a laser pulse, essentially a gaussian with FWHM of 20 – 40 ns.

Details : See talk on 20 Sep. 2005.



Remaining issue :

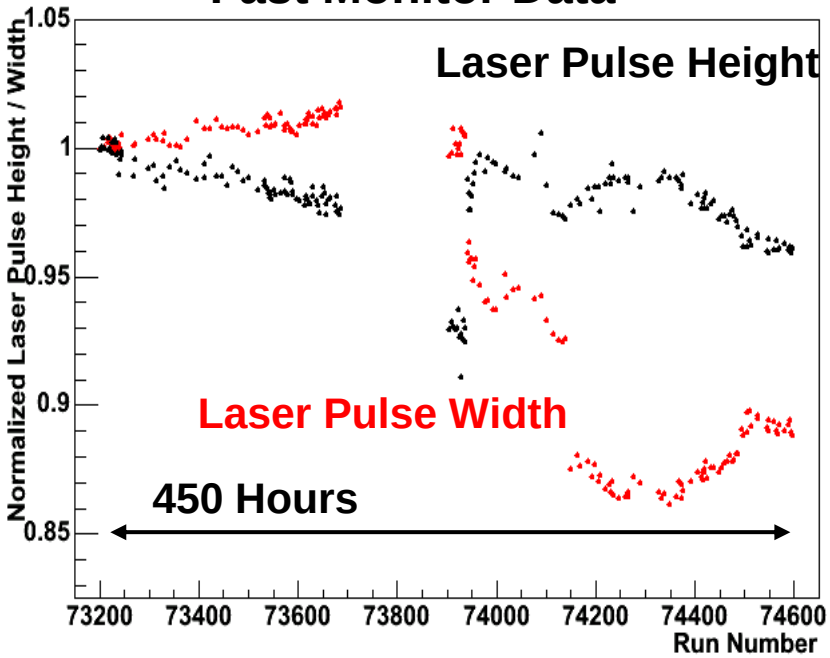
The pulse width dependency extract from simulated shapes depends strongly on the a priori unknown electronic shape. This makes it difficult to predict the actual pulse width dependency.

Solution :

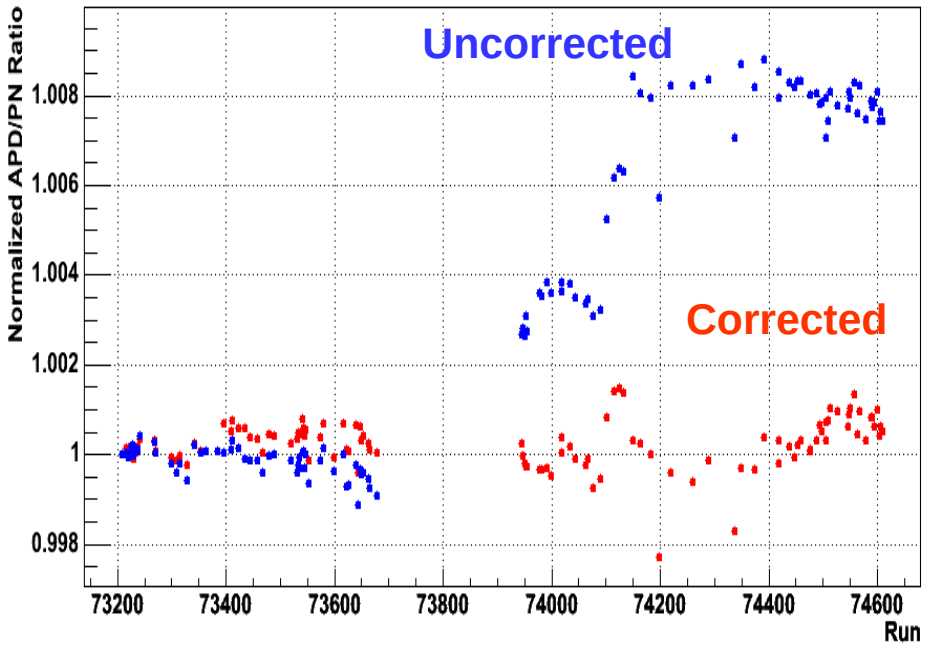
Tune the convoluted shape such that it matches the shape in data.

Pulse Width Correction on SM10 in 2004

Fast Monitor Data



ECAL APD/PN, Single Channel Monitoring History



Data analysed :

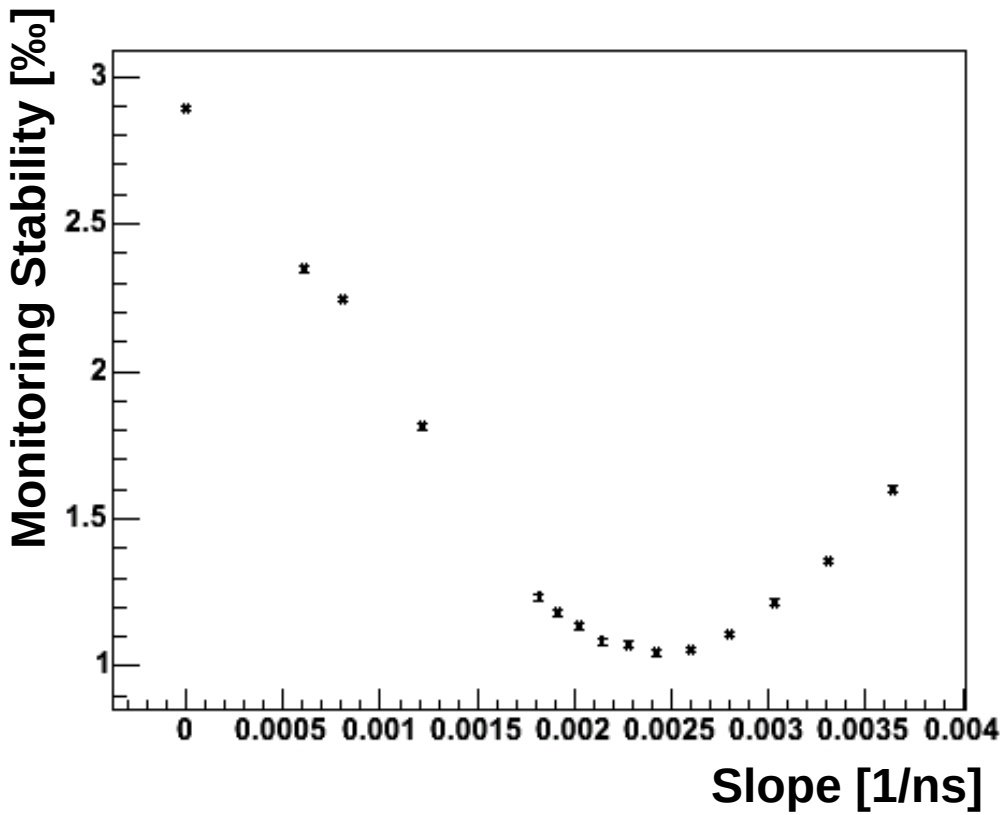
Part of Period 1 (not all the data was re-reprocessed to fix PN data) and Period 3. Period 2 is problematic - and thus not used.

Pulse width correction :

$$APD/PN\_cor = APD/PN + c \cdot PW\_Laser$$

Monitoring Stability vs Pulse Width Correction

With a linear correction we can vary the slope to study the sensitivity :

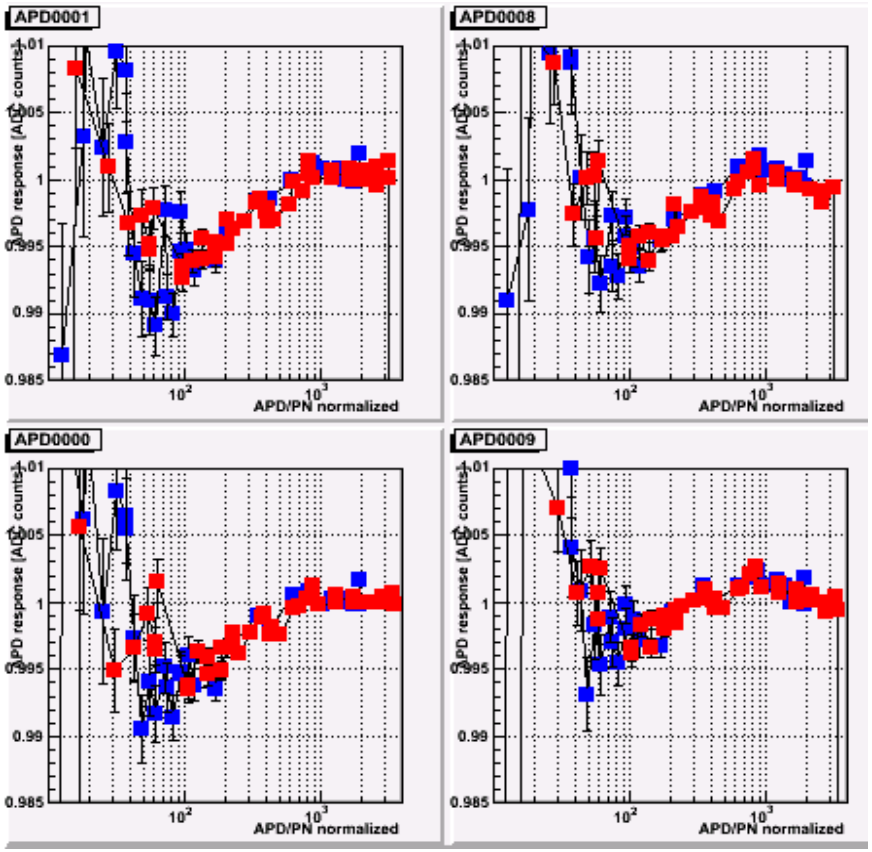


From SM10 data it appears that we don't have to know the slope with great precision.

Review: Amplitude

APD/PN and Laser Pulse Amplitude Correlation

APD [ADC Counts] vs APD/PN for SM22



- Plots by Marc Dejardin as recently presented at a TB meeting by Nadia Pastrone
- For the SM22 PW scan, the intensity changes between 2000 and 4000 ADC counts. For that the APD/PN changes ~3.0 %
- From the linearity scan with the laser above we see that the nonlinearity as a function of the pulse intensity is of the order of ~0.1 %.