First results and impressions

from the

PEBS / ACC testbeam at CERN T9 beam

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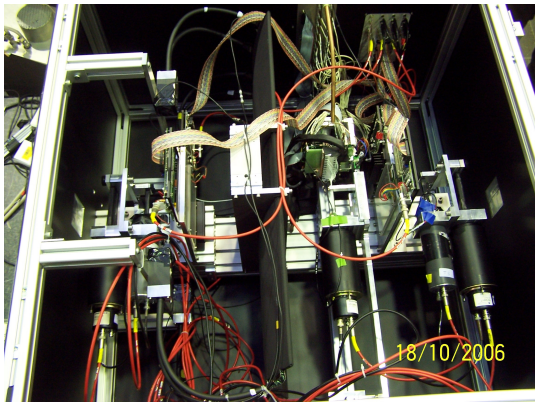
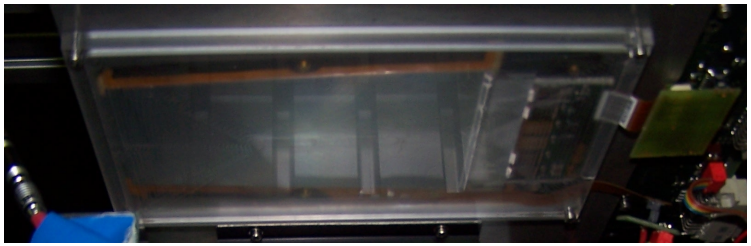
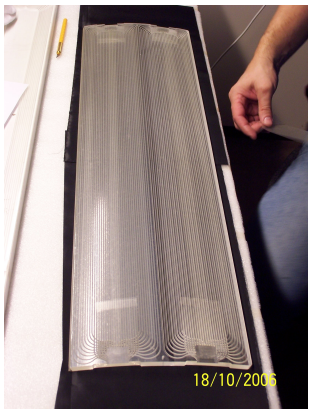
Hausseminar, 24 November 2006

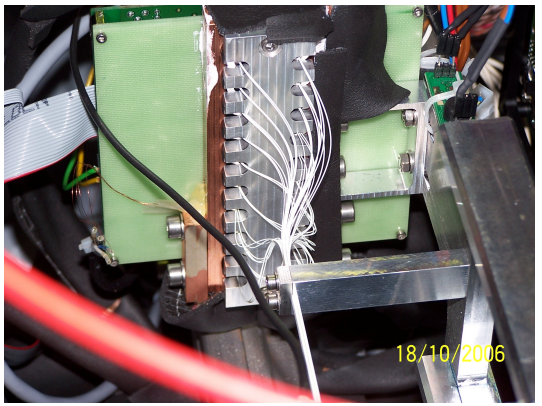
Overview

- Experiment description
- Impressions from the testbeam
- Beam telescope performance
- SiPM / fibre results
- ACC results









Acknowledgements

- Beamtest crew:
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  St. Schael, G. Schwering
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- Engineering:
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  M. Kosbow, H. Schmoll

Motivation

Previous measurements of cosmic-ray positron fraction: deviations from expected shape, but large errors.

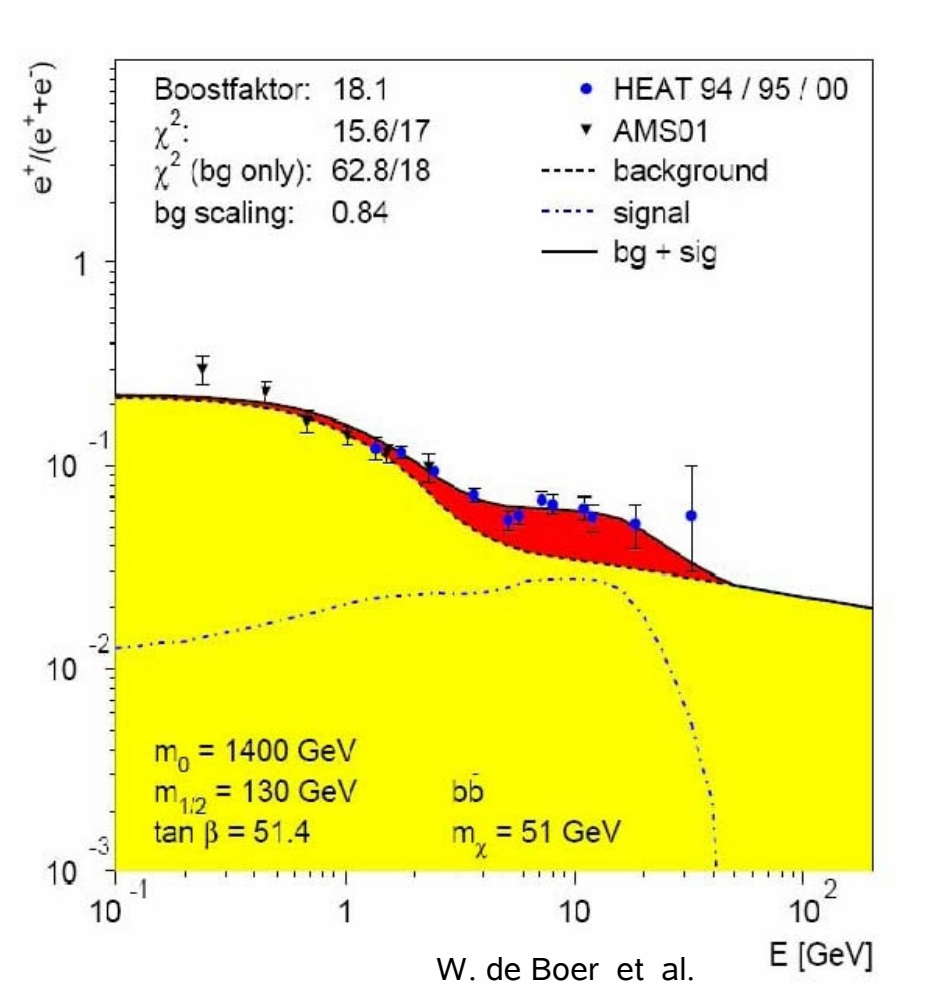
No primary source for positrons known: probe for new physics.

Dark Matter Candidate: SUSY-Neutralino χ

Annihilations can occur, e.g. in the galactic halo:
$\chi\chi \rightarrow bb, W^+W^-, \ldots \rightarrow \ldots \rightarrow e^+e^- \ldots$ (stable)

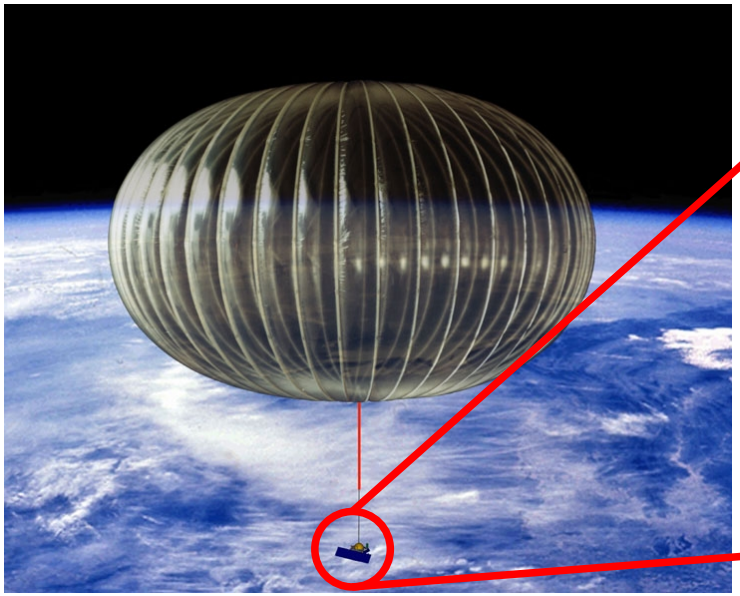
Primary source of positrons in cosmic rays!

Secondary background arises from hadronic interactions of cosmic ray protons and subsequent decays.

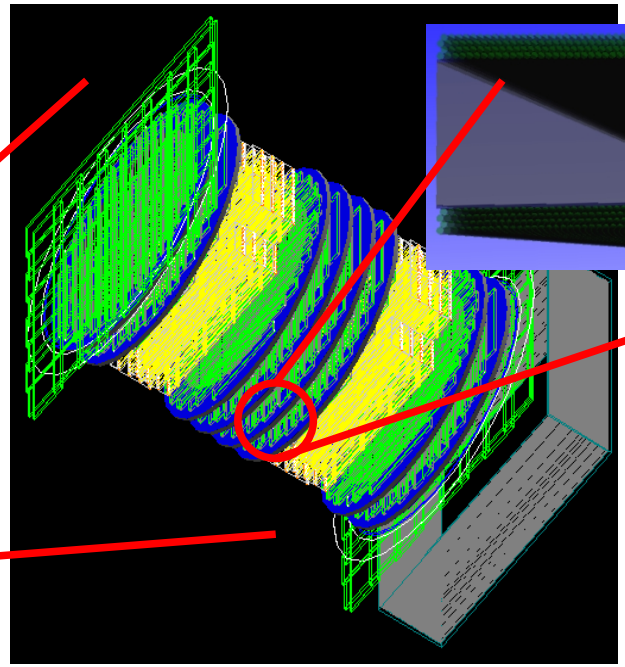


Atmosphere inhibits ground-based measurement: $20X_0$, $8\lambda_I$, therefore use high altitude balloon as carrier. Advantages: Reproducibility, post-flight calibration possible. Background by atmospheric secondaries must be considered.

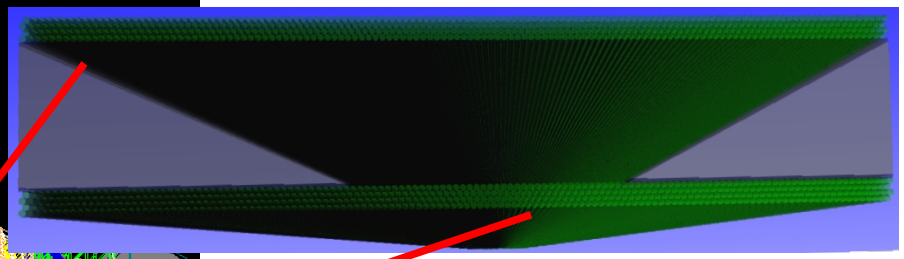
Reminder: PEBS



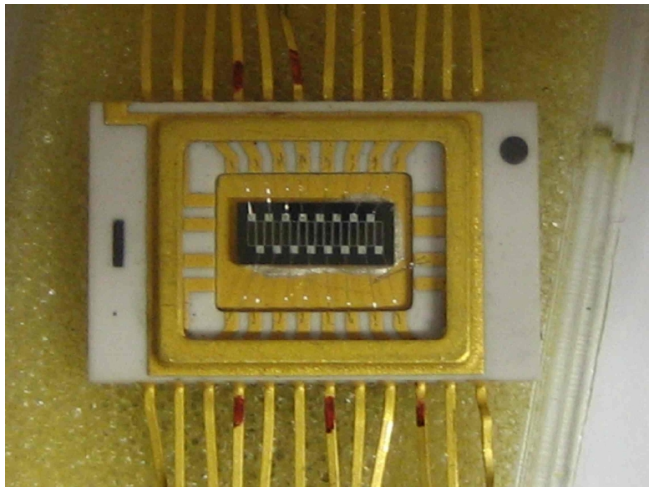
Balloon experiment to measure cosmic-ray positron fraction.
Flight campaign of 20 days planned from Svallvard balloonport.
Huge geometrical acceptance of 0.4 m^2sr foreseen.



Time of Flight + trigger system
Scintillating fibre tracker
Transition radiation detector
Electromagnetic calorimeter

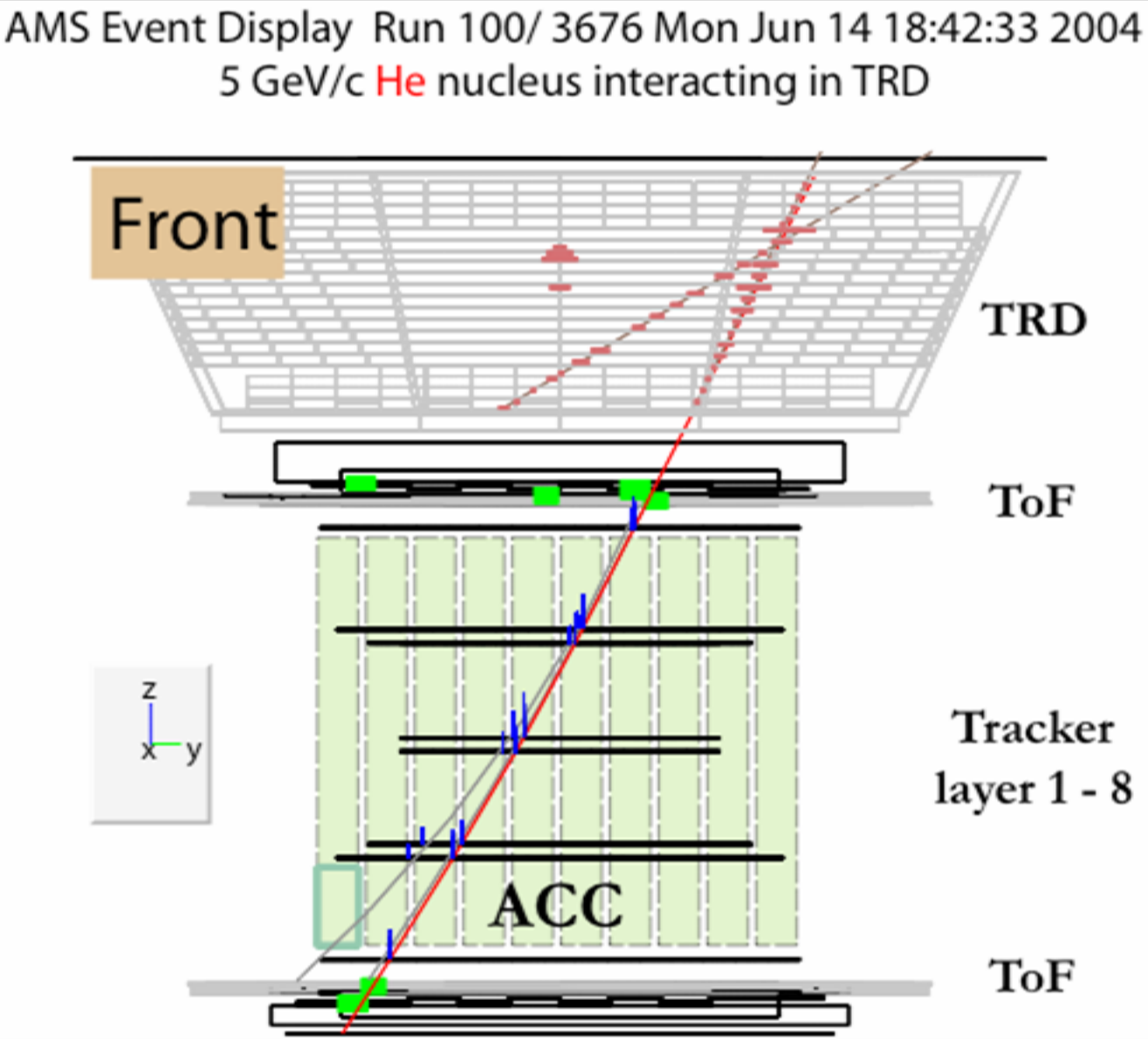


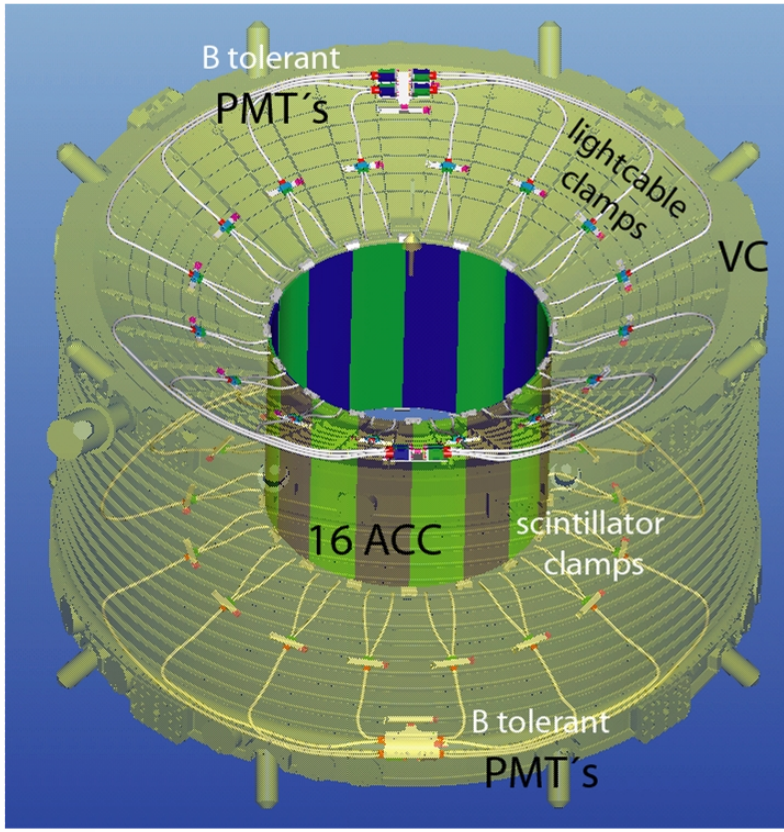
Tracker module of 250µm scintillating fibres.
To be read out in bunches by Geiger-mode silicon avalanche photo-diodes.



Testbeam goal: Measure performance of scintillating fibre bundle with SiPM readout

Reminder: ACC





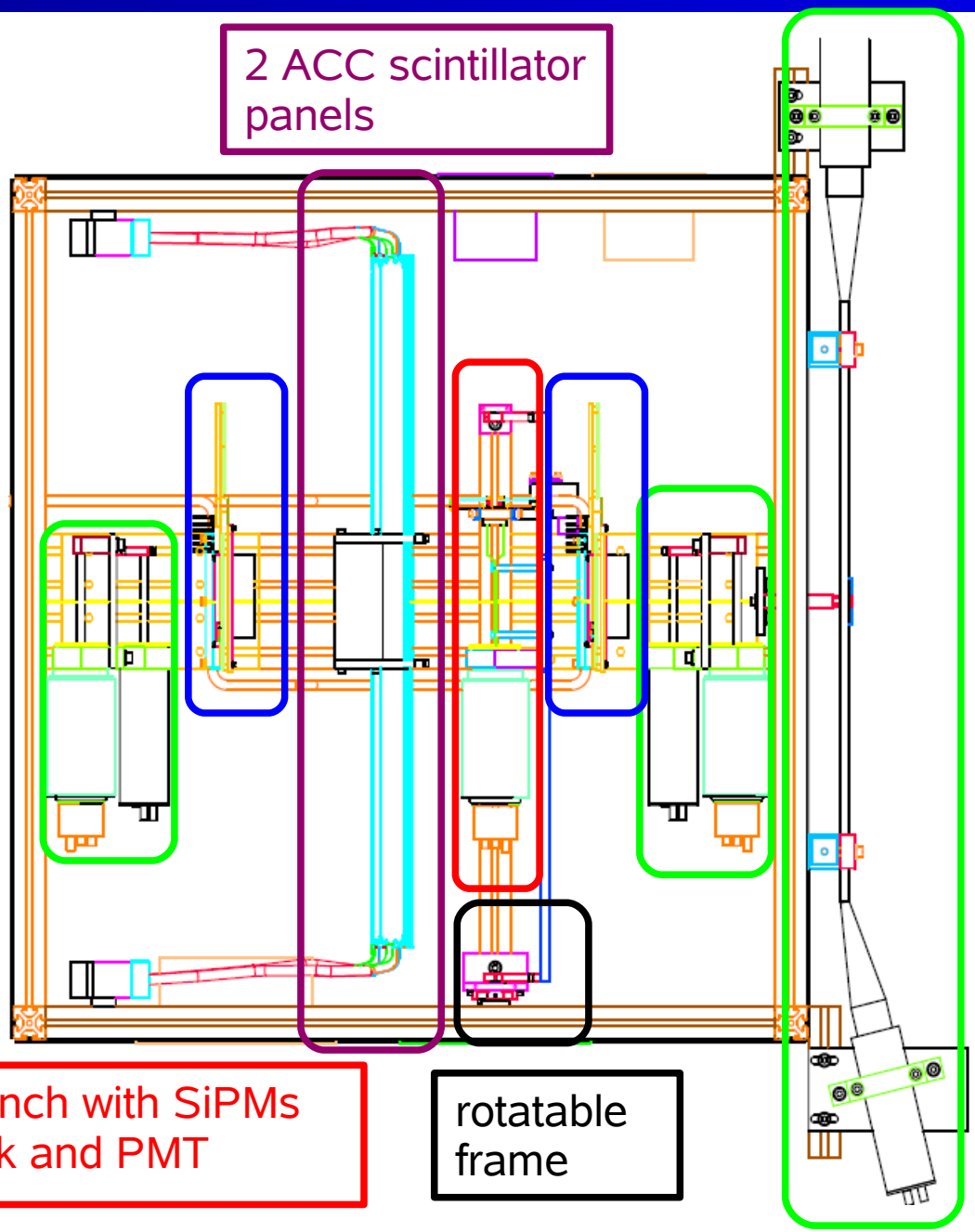
ACC needed for veto against stray particles traversing magnet, leading to wrong charge reconstruction

Setup: Mechanical drawing

Trigger scintillators:
2 10x10cm² panels
2 10cm x 10mm "finger" panels
veto panel

beam telescope:
4 CMS TEC Ring4 modules with ARC readout

2 ACC scintillator panels

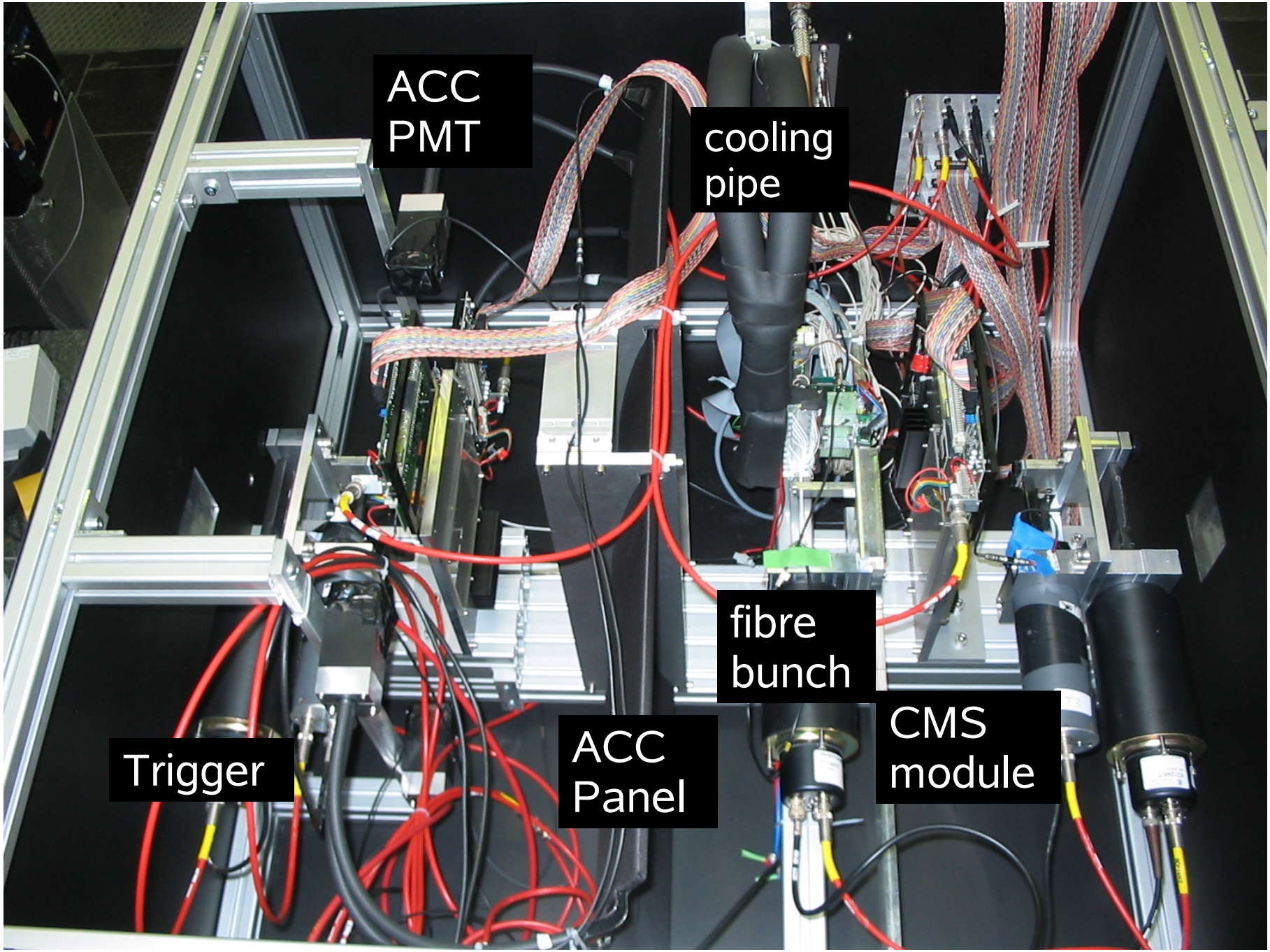


10 GeV protons

PEBS fibre bunch with SiPMs in copper block and PMT

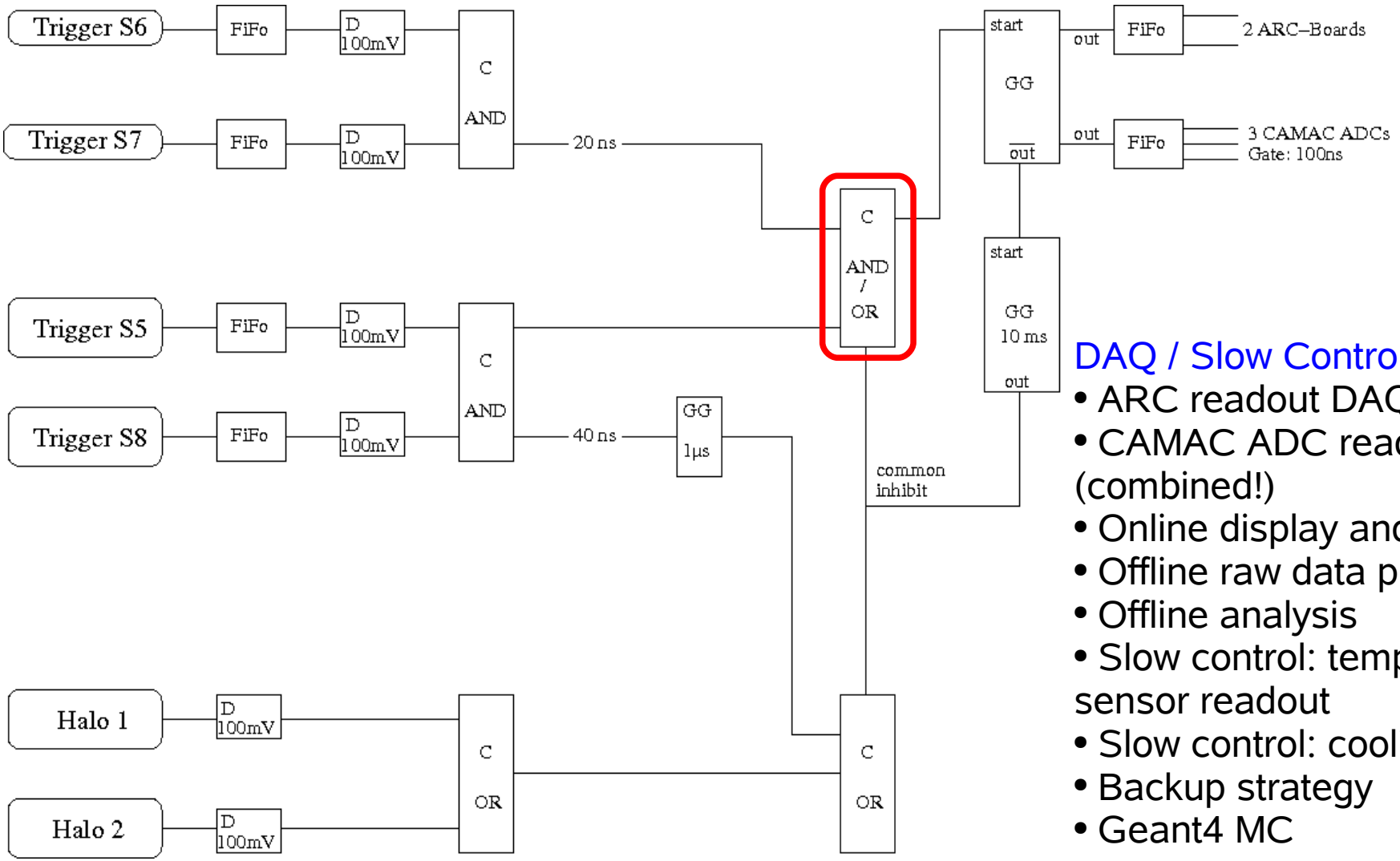
rotatable frame

Setup



veto panel

Trigger and DAQ



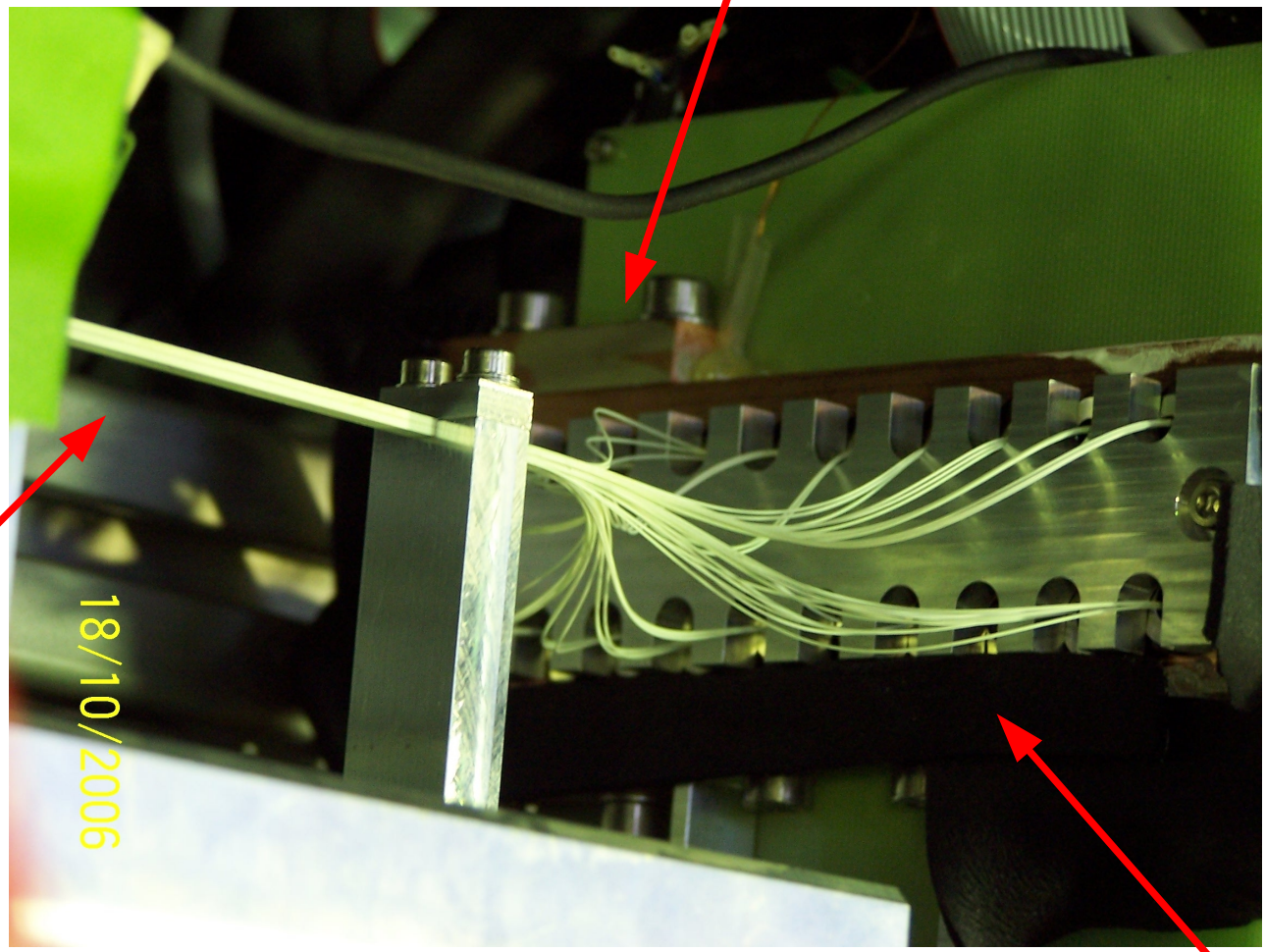
trigger on four-fold coincidence (for fibre and ACC gap studies)
or on two-fold coincidence of larger trigger panels (for ACC studies)

DAQ / Slow Control challenge:

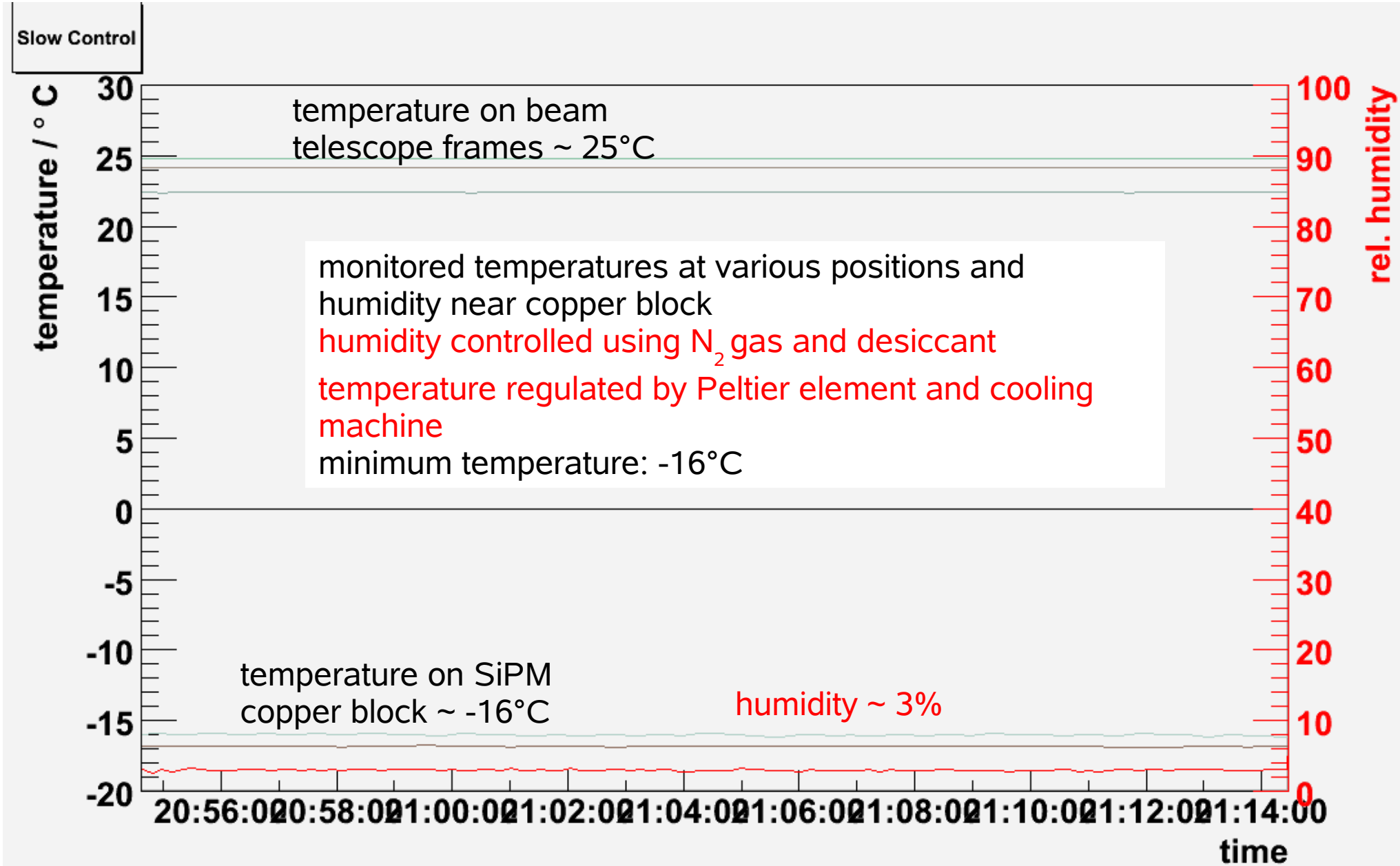
- ARC readout DAQ
- CAMAC ADC readout (combined!)
- Online display and data storage
- Offline raw data processing
- Offline analysis
- Slow control: temperature sensor readout
- Slow control: cooling machine
- Backup strategy
- Geant4 MC

~23000 lines of code (500 A4 pages)

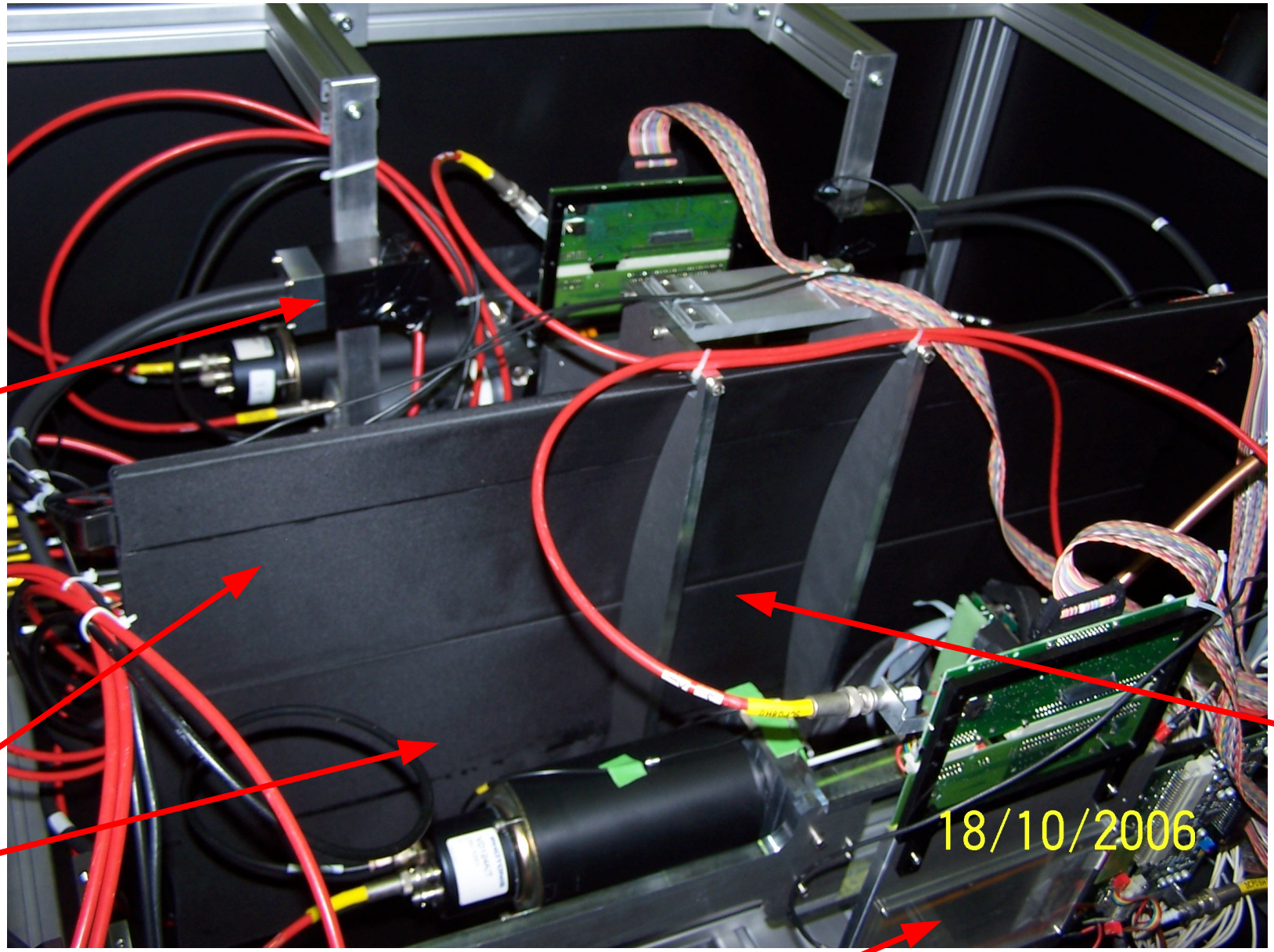
Fibre bunch up close



Slow control performance



ACC panels up close

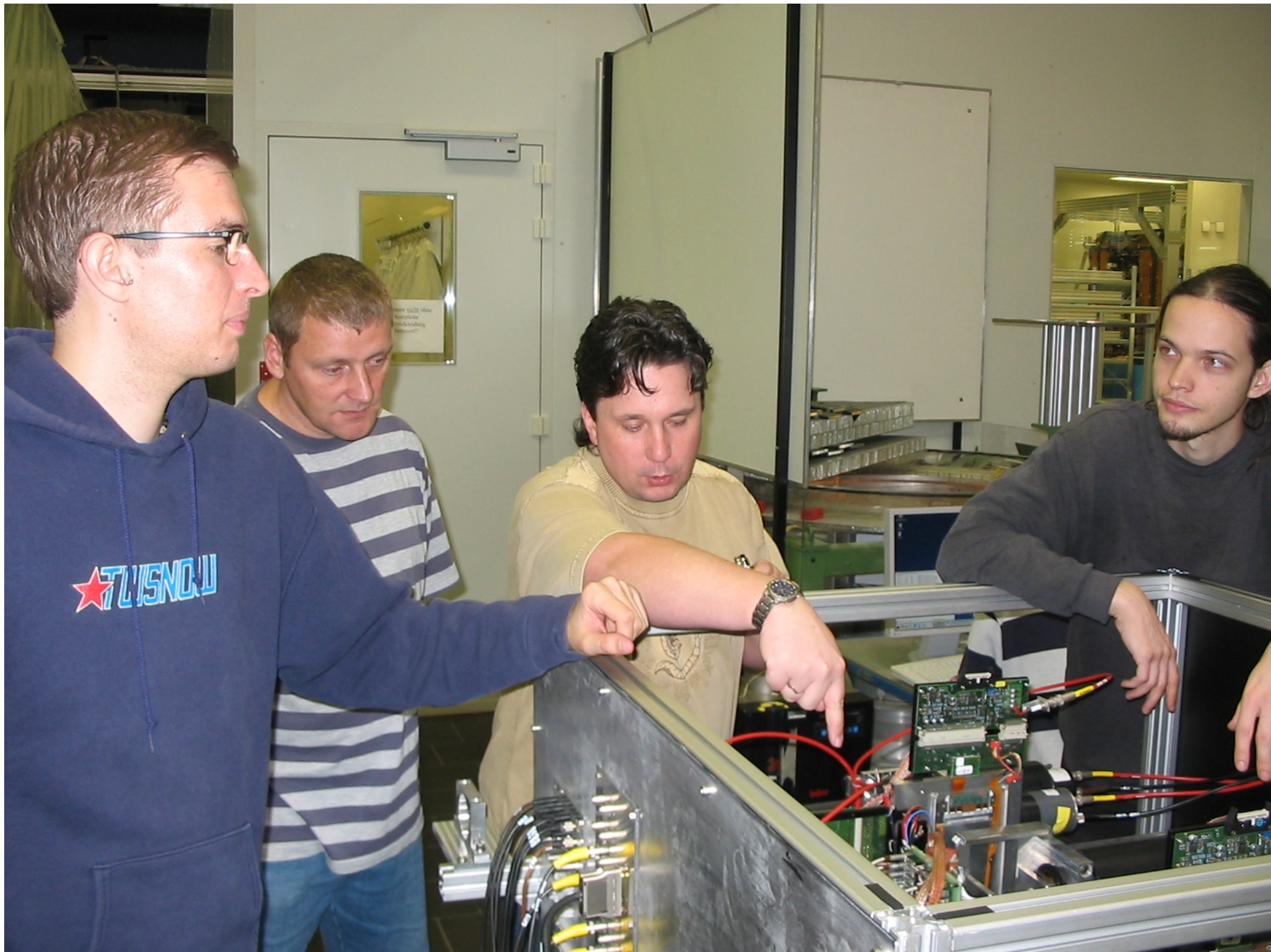


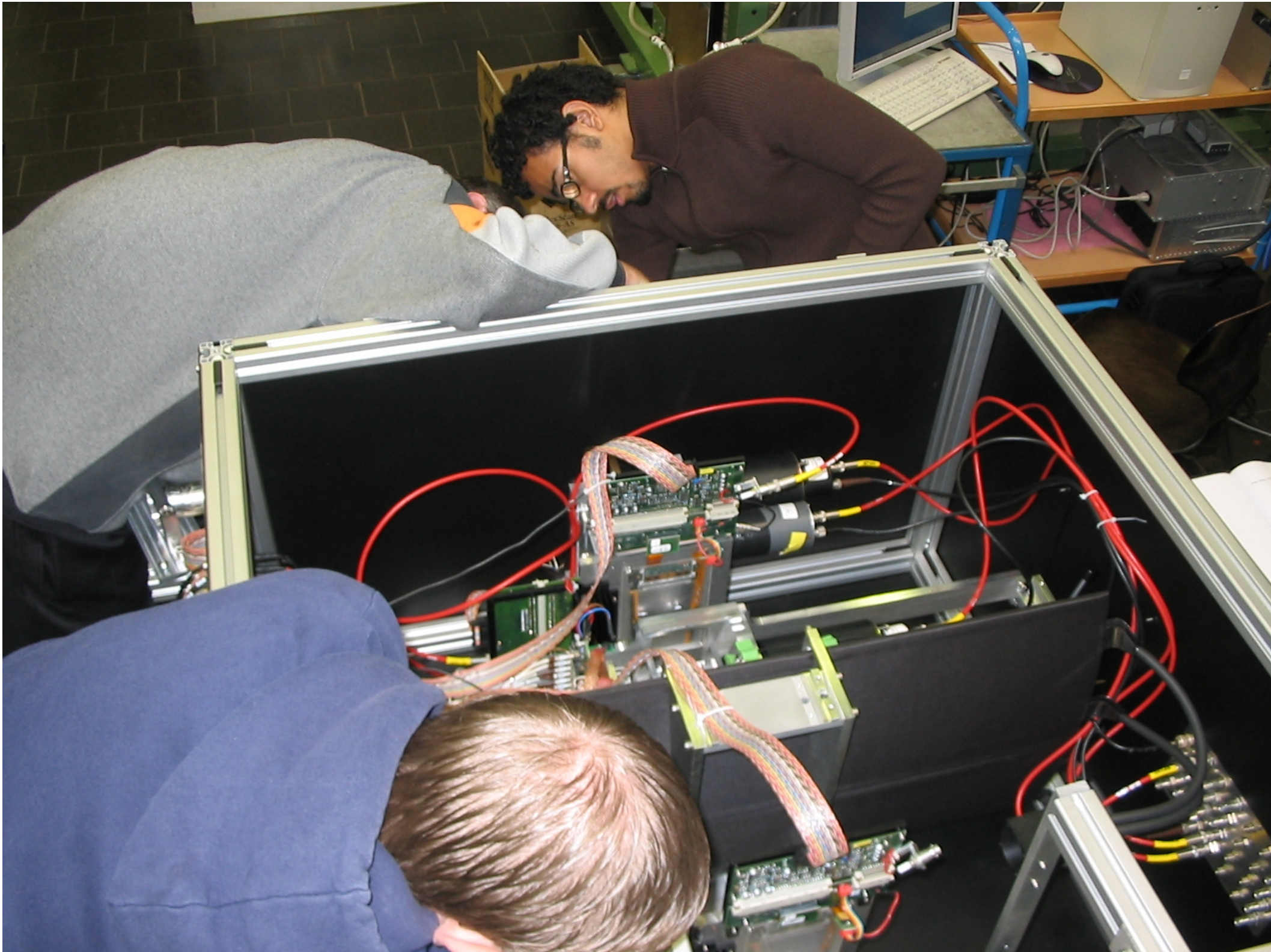
ACC PMT

ACC panels

slot and key region

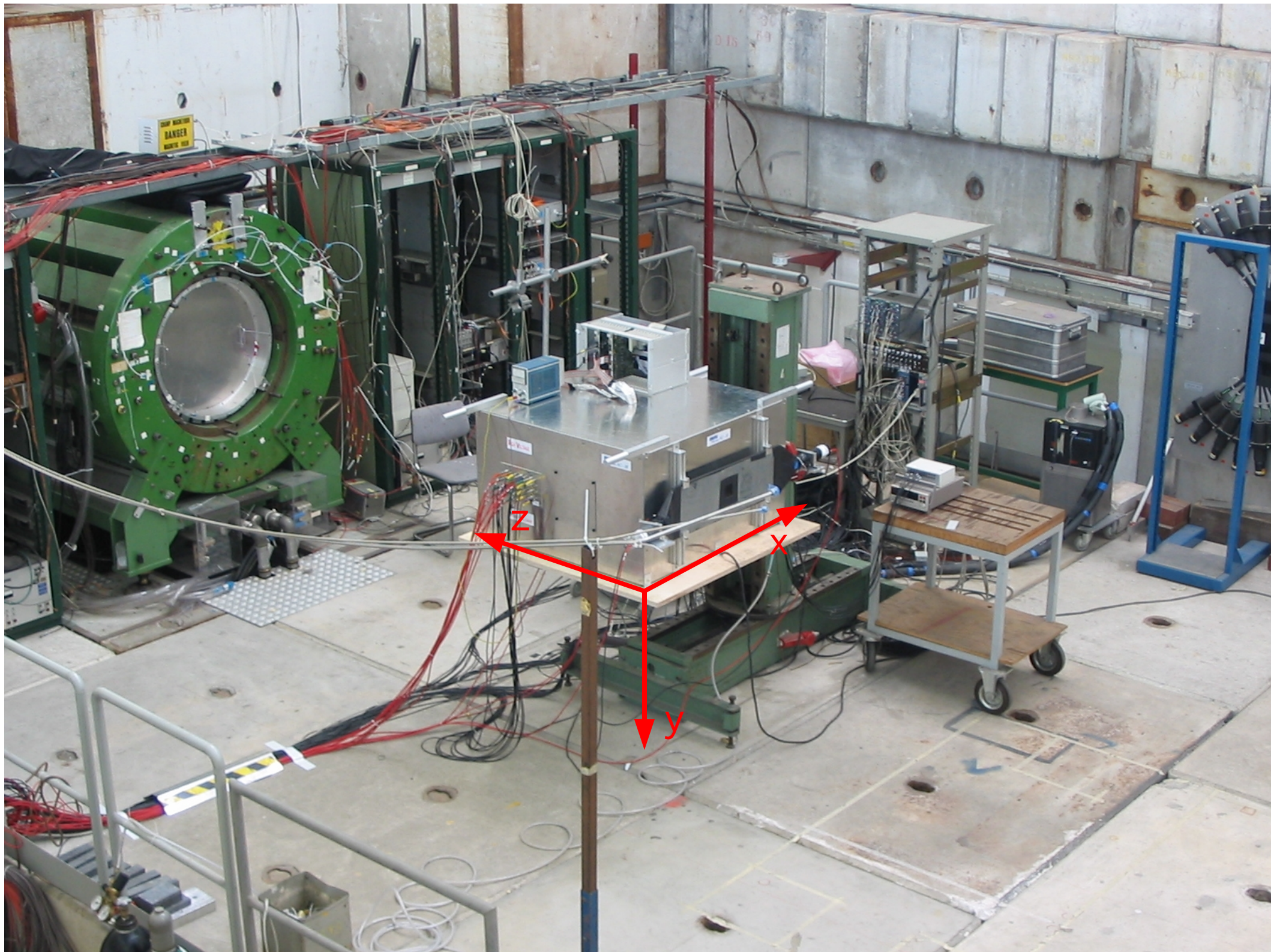
beam telescope module





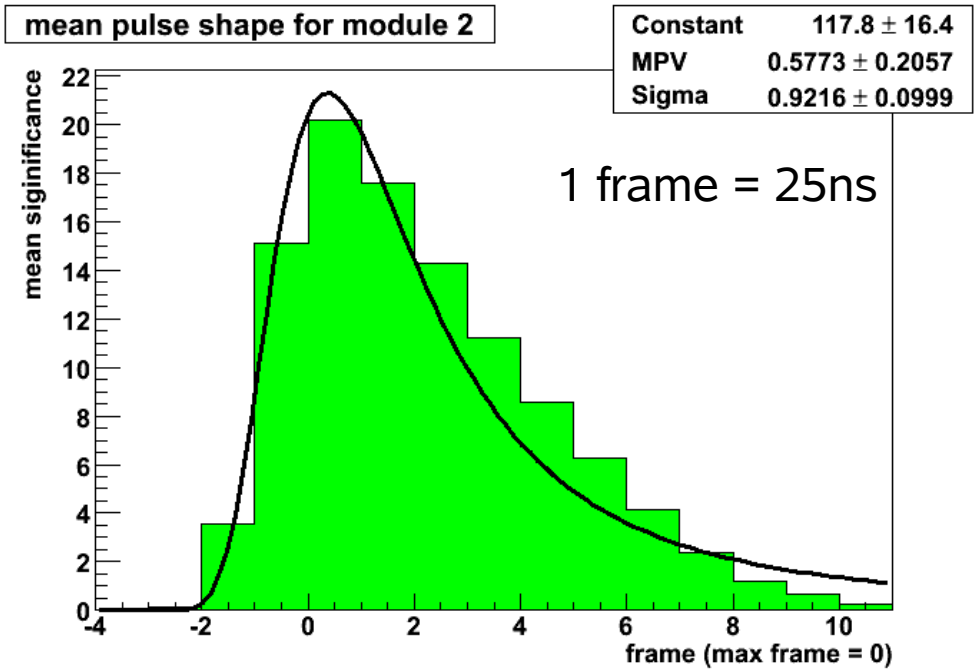

18/10/2006
FlexScan
L768-AS

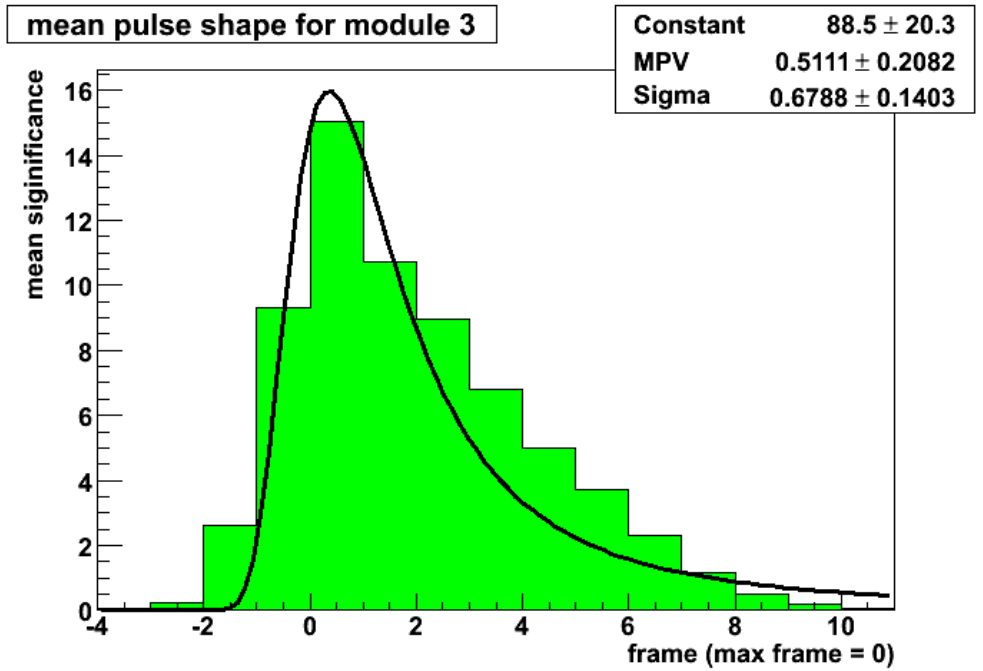

FUR
FAL

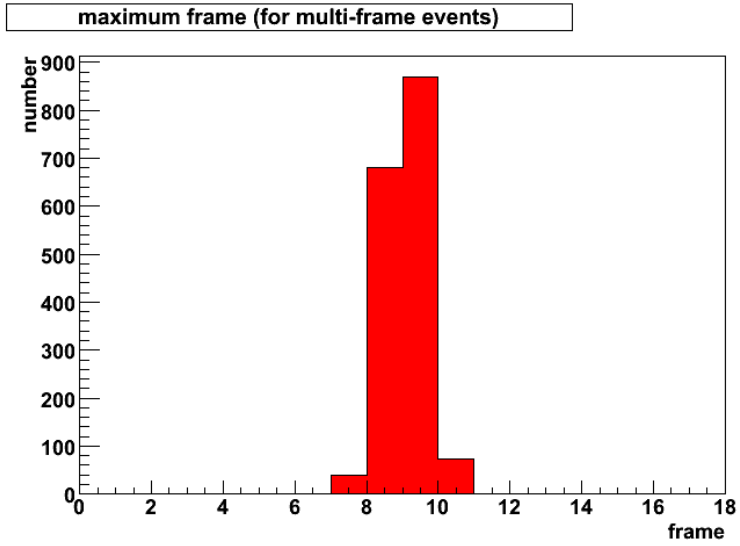

z
x
y

Meanwhile...

Beam telescope pulse shape





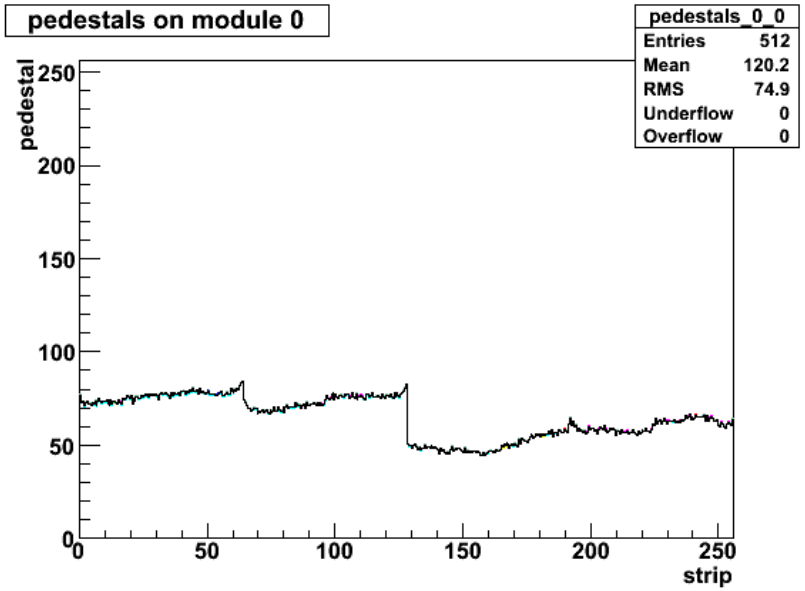


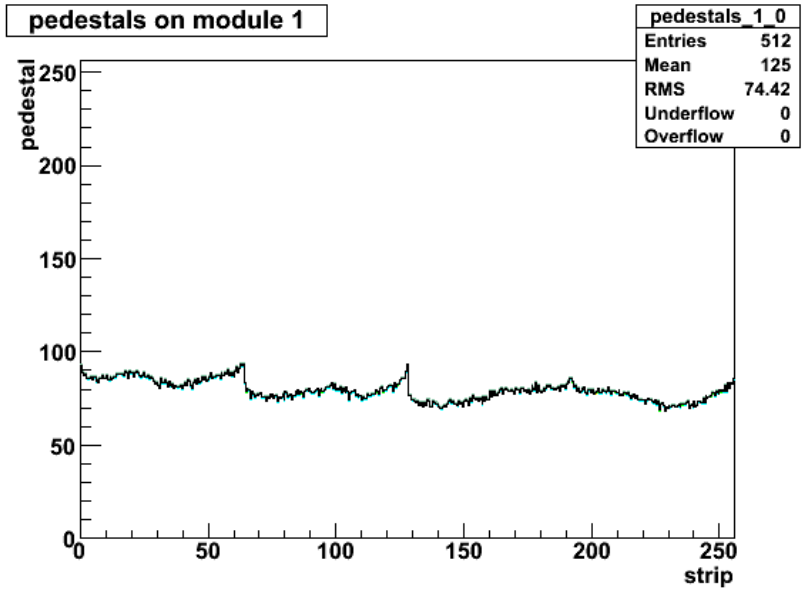
relative to latency setting of APV

CMS silicon modules operated in peak mode

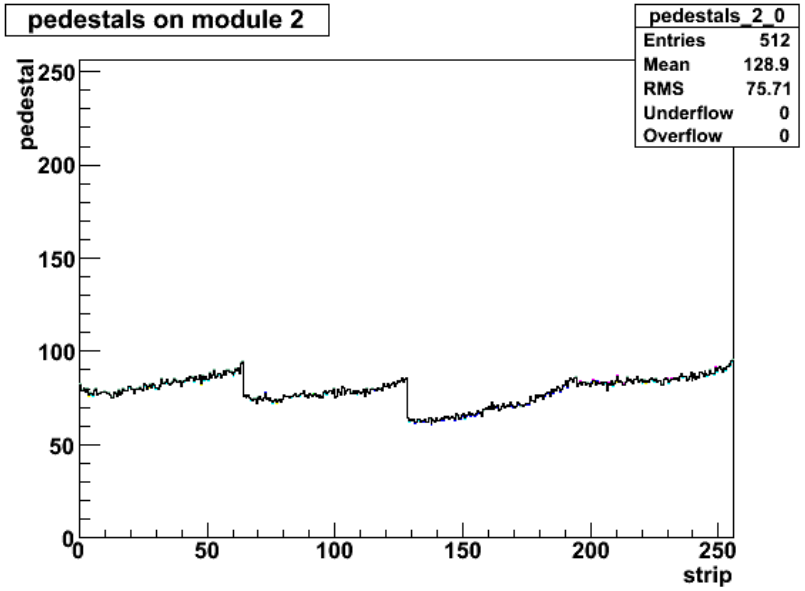
automatic determination of latency setting in offline software

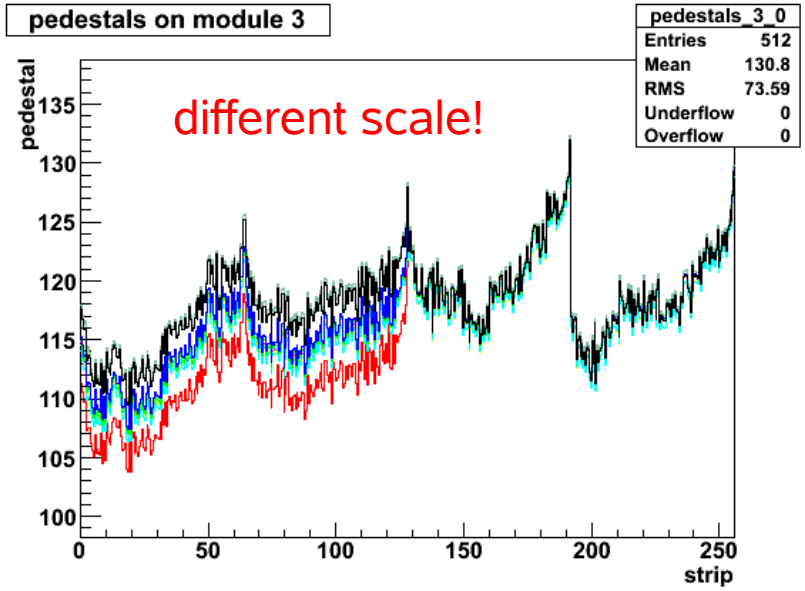
Beam telescope: pedestal variation



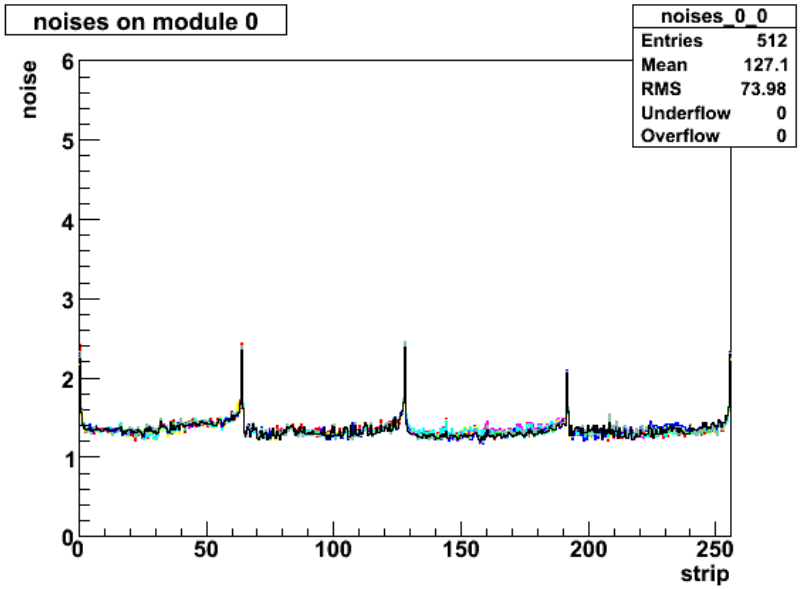


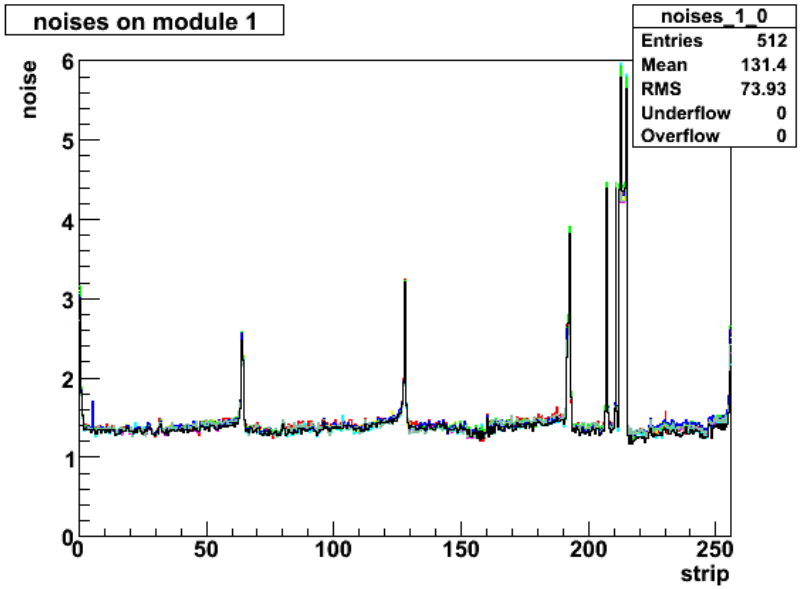
pedestals in ADC counts



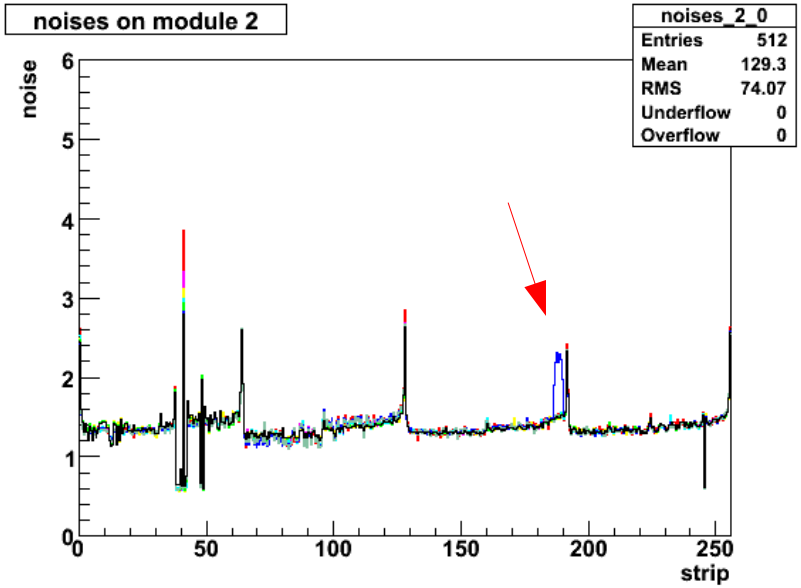


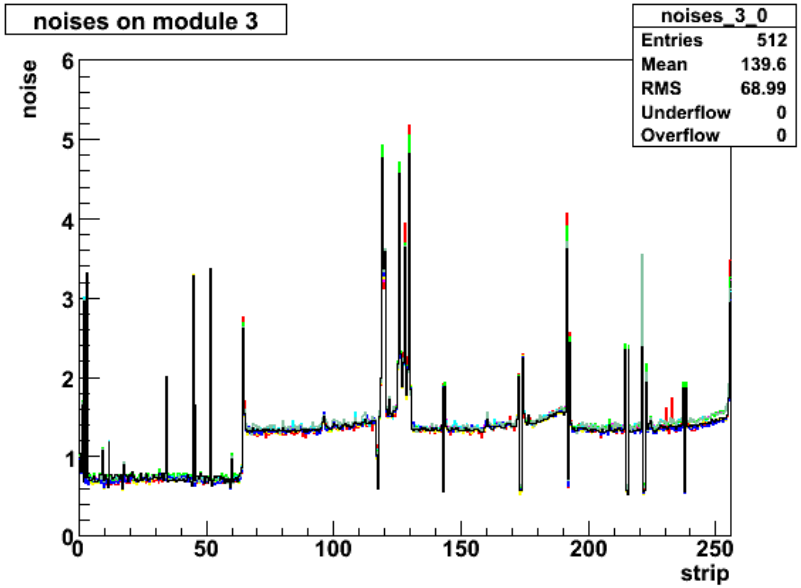
Beam telescope: noise variation





noise = standard deviation of pedestal distribution

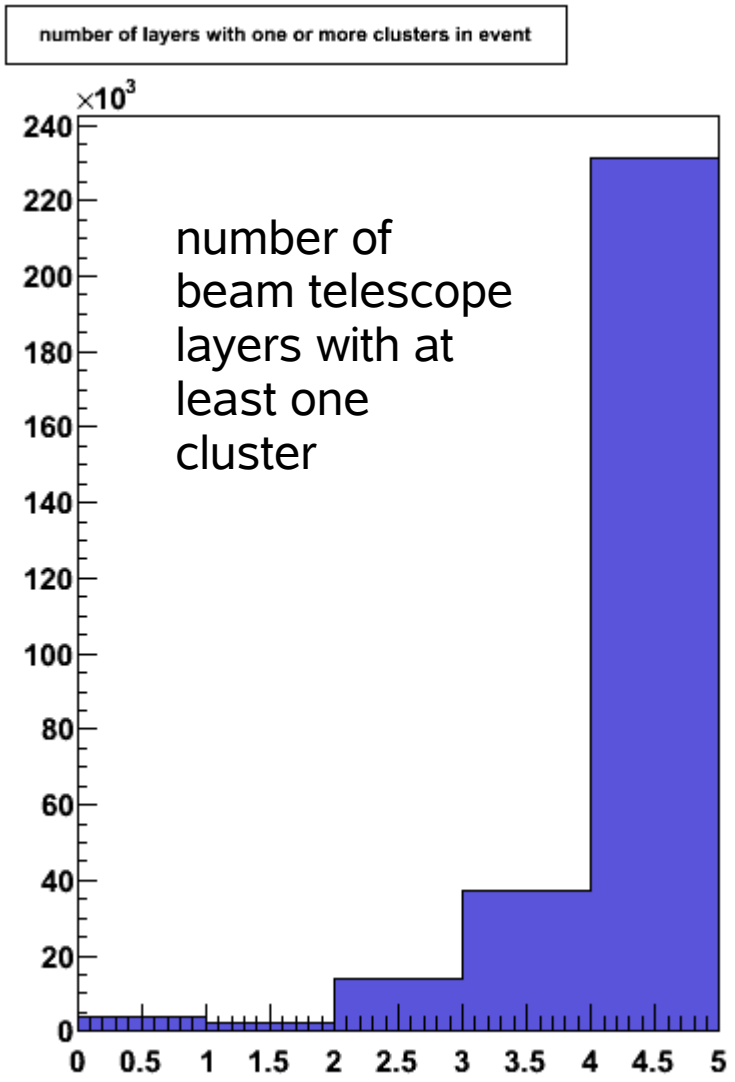


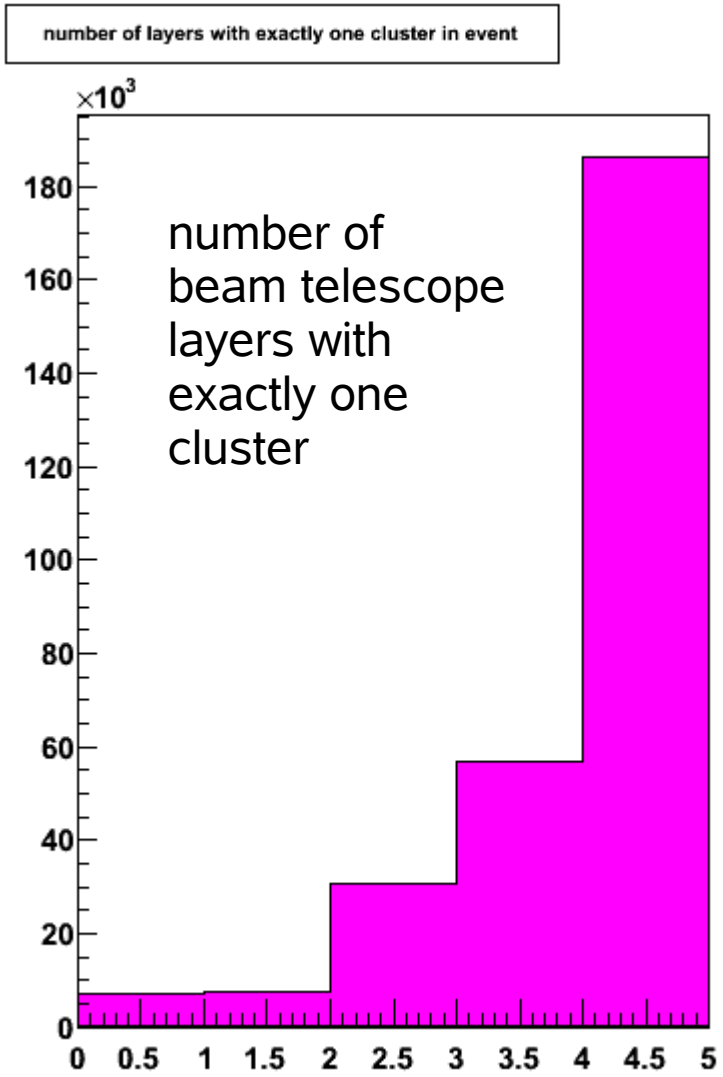


small scale variations → create pedestal data base

dead APV – some noisy strips

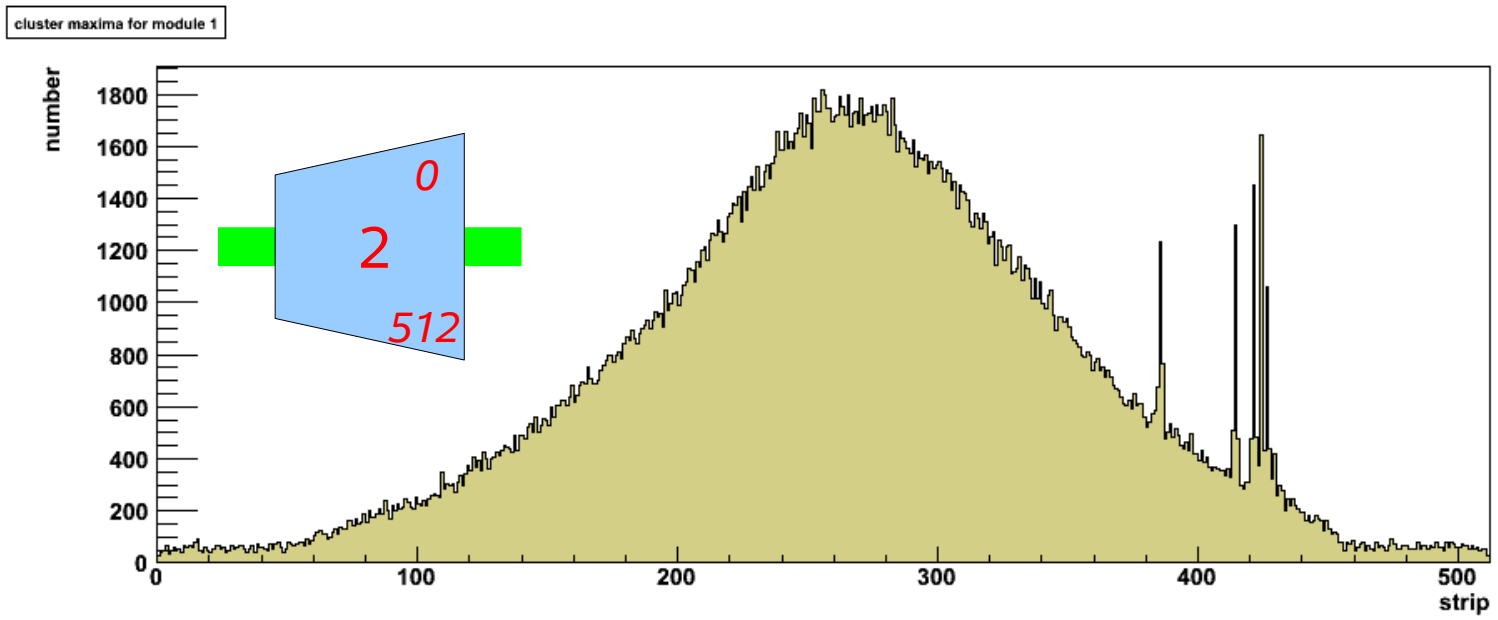
Beam telescope statistics

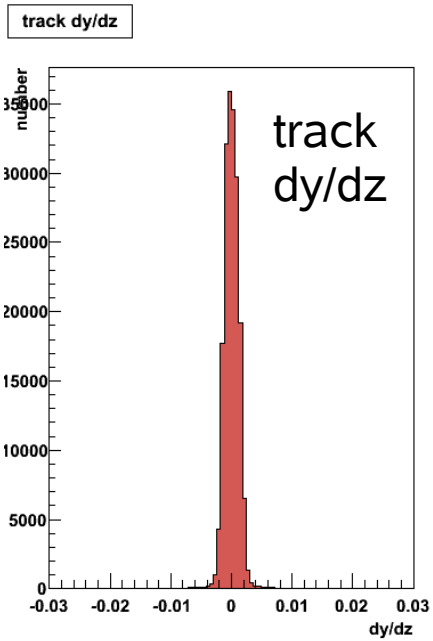




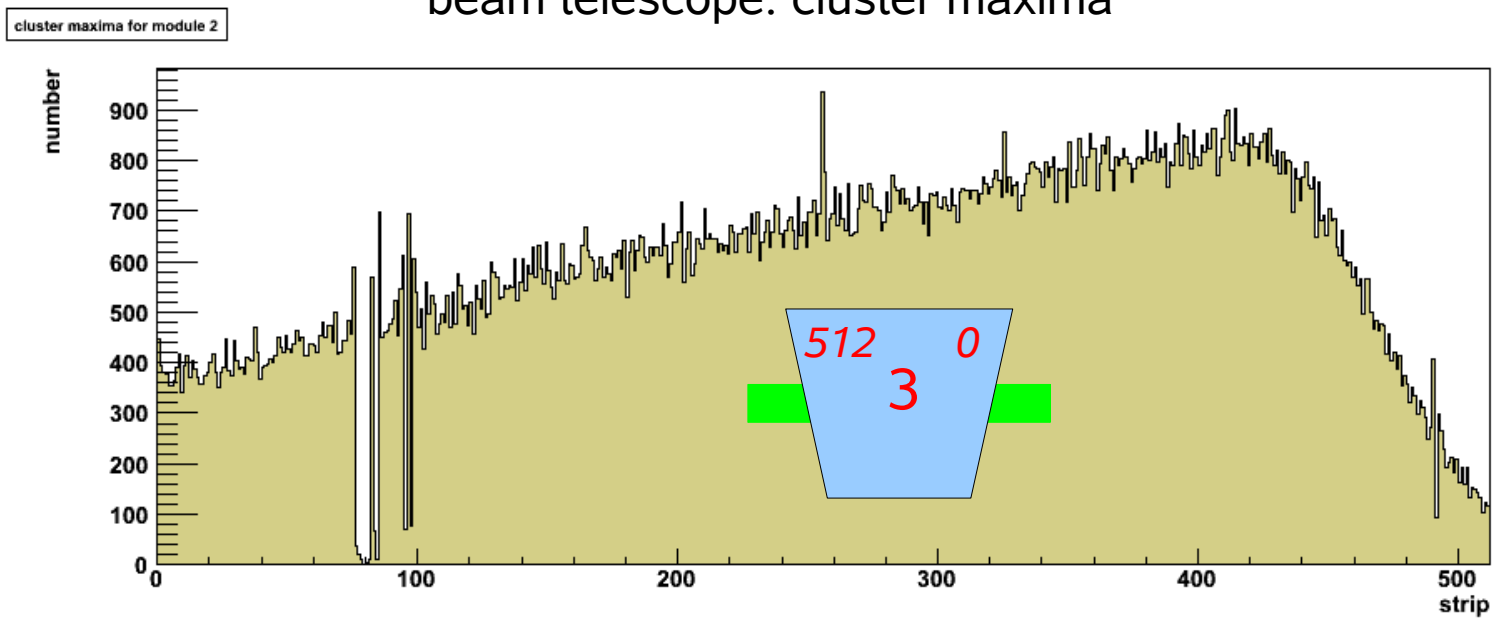
65% of events with exactly one cluster on every layer in the beam telescope

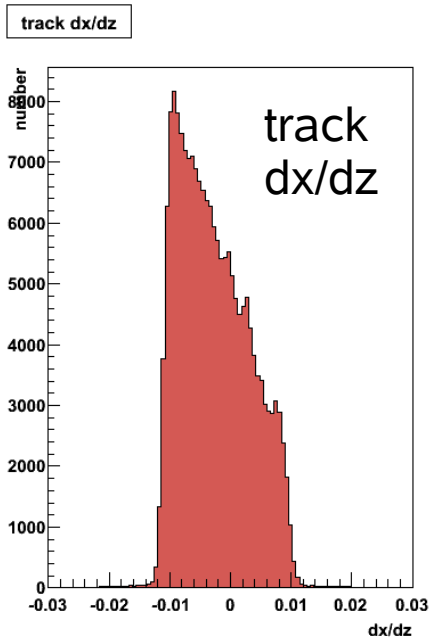
Beam characteristics



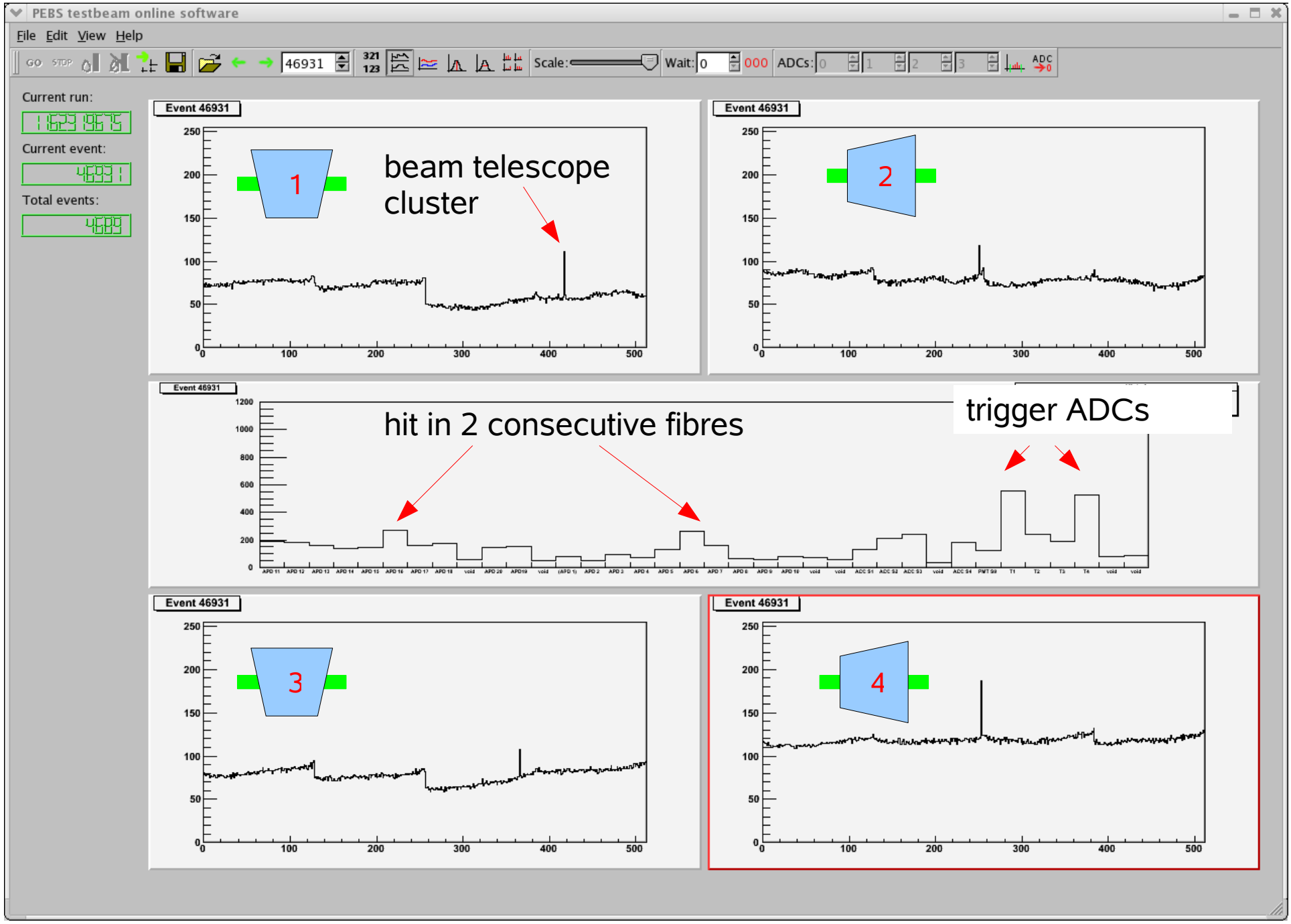


beam telescope: cluster maxima

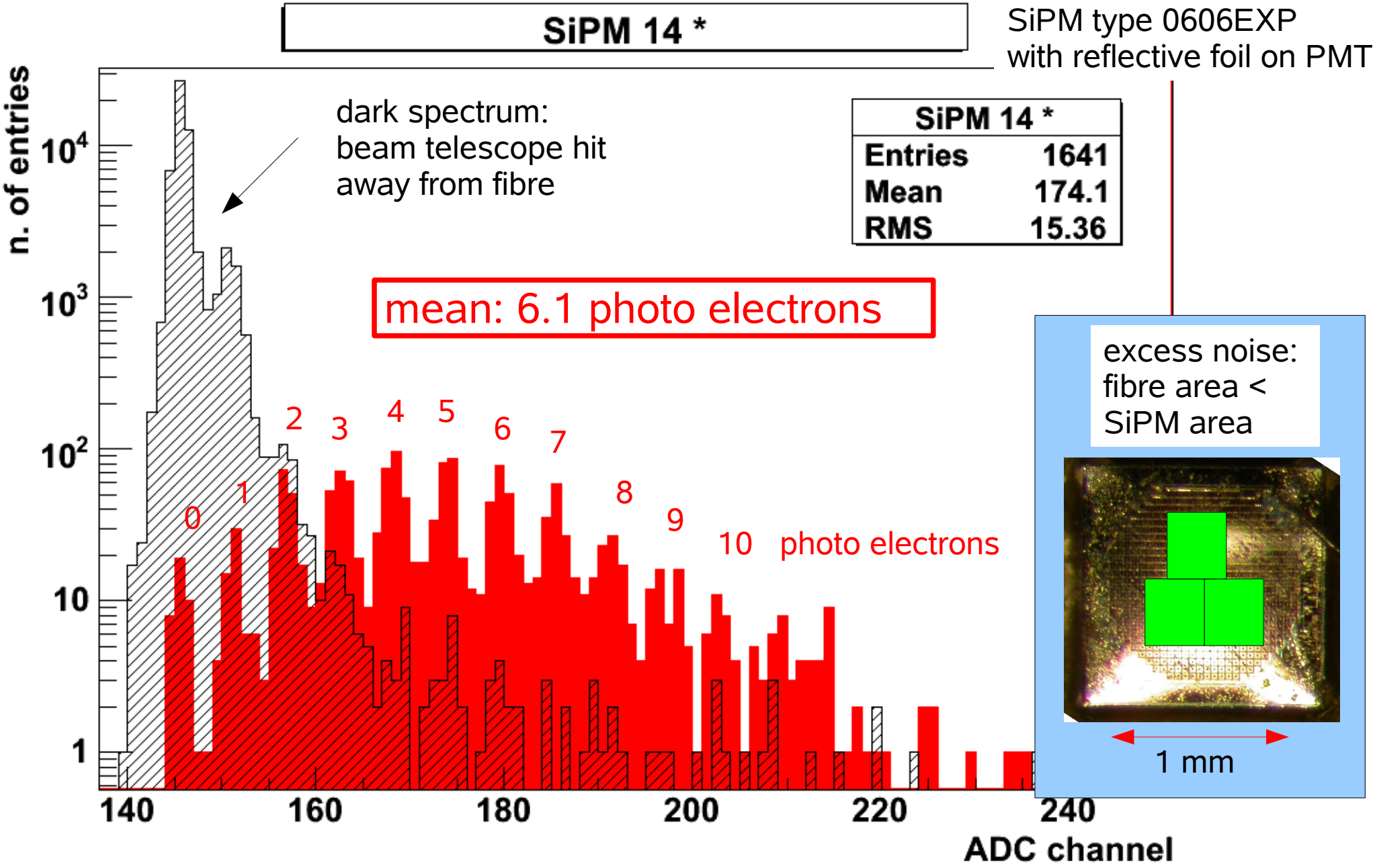




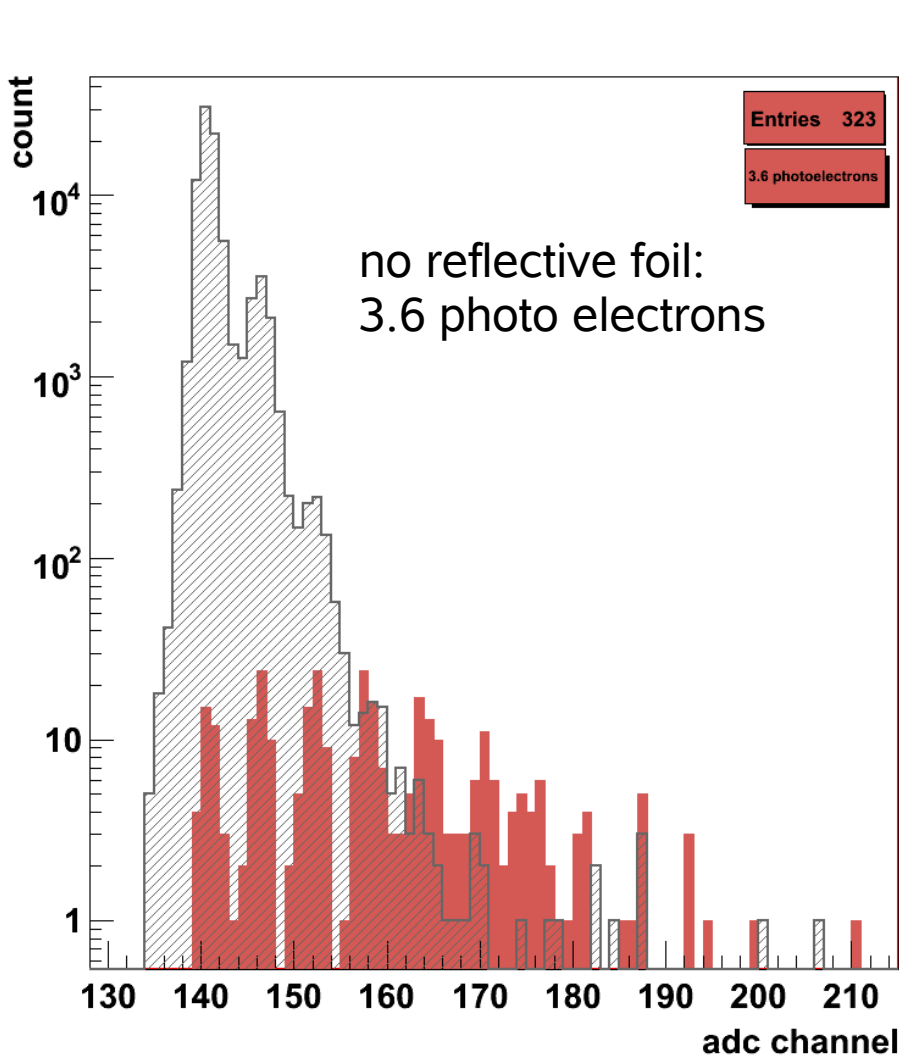
PEBS results: Event display

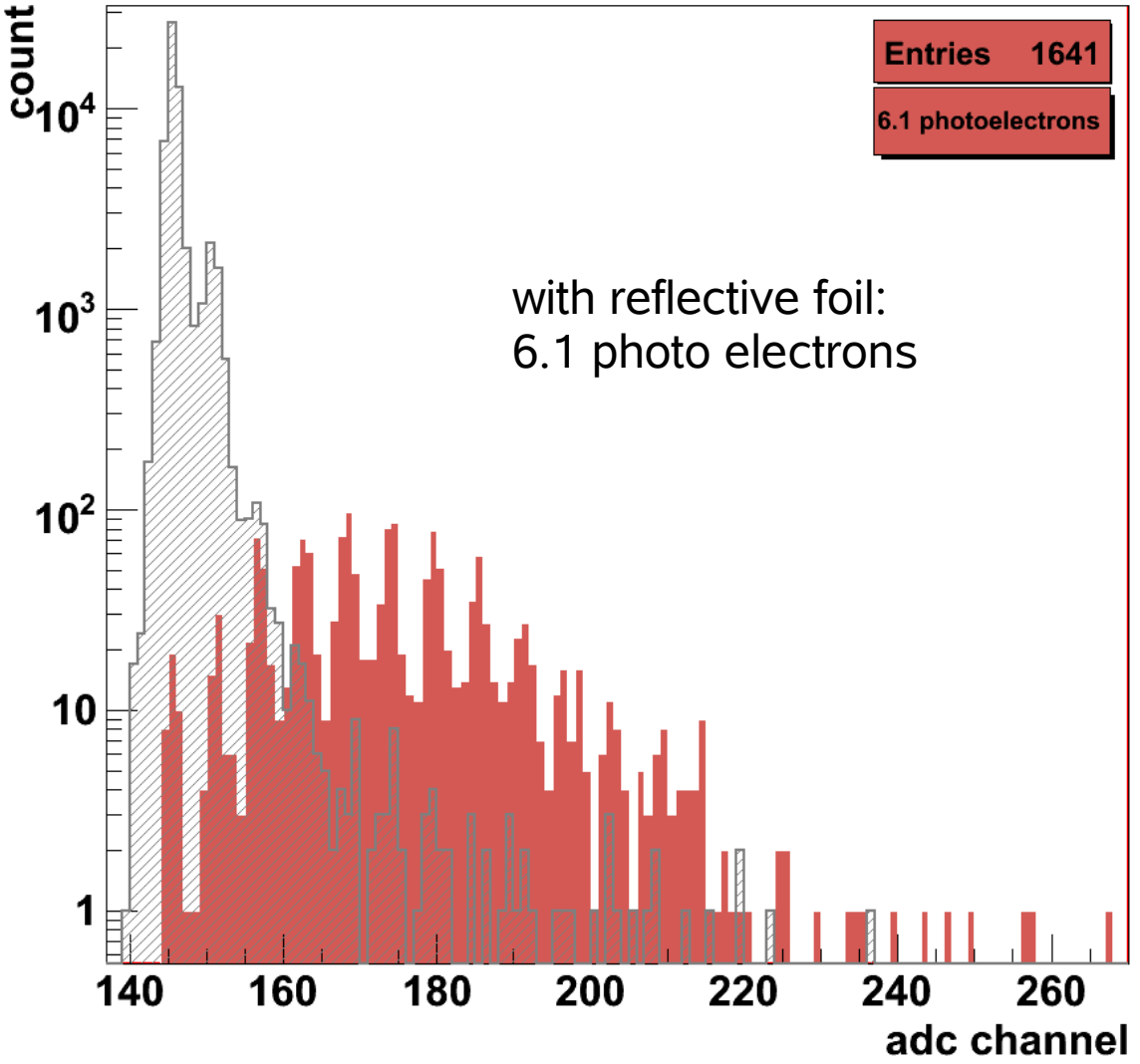


SiPM: example of a MIP spectrum



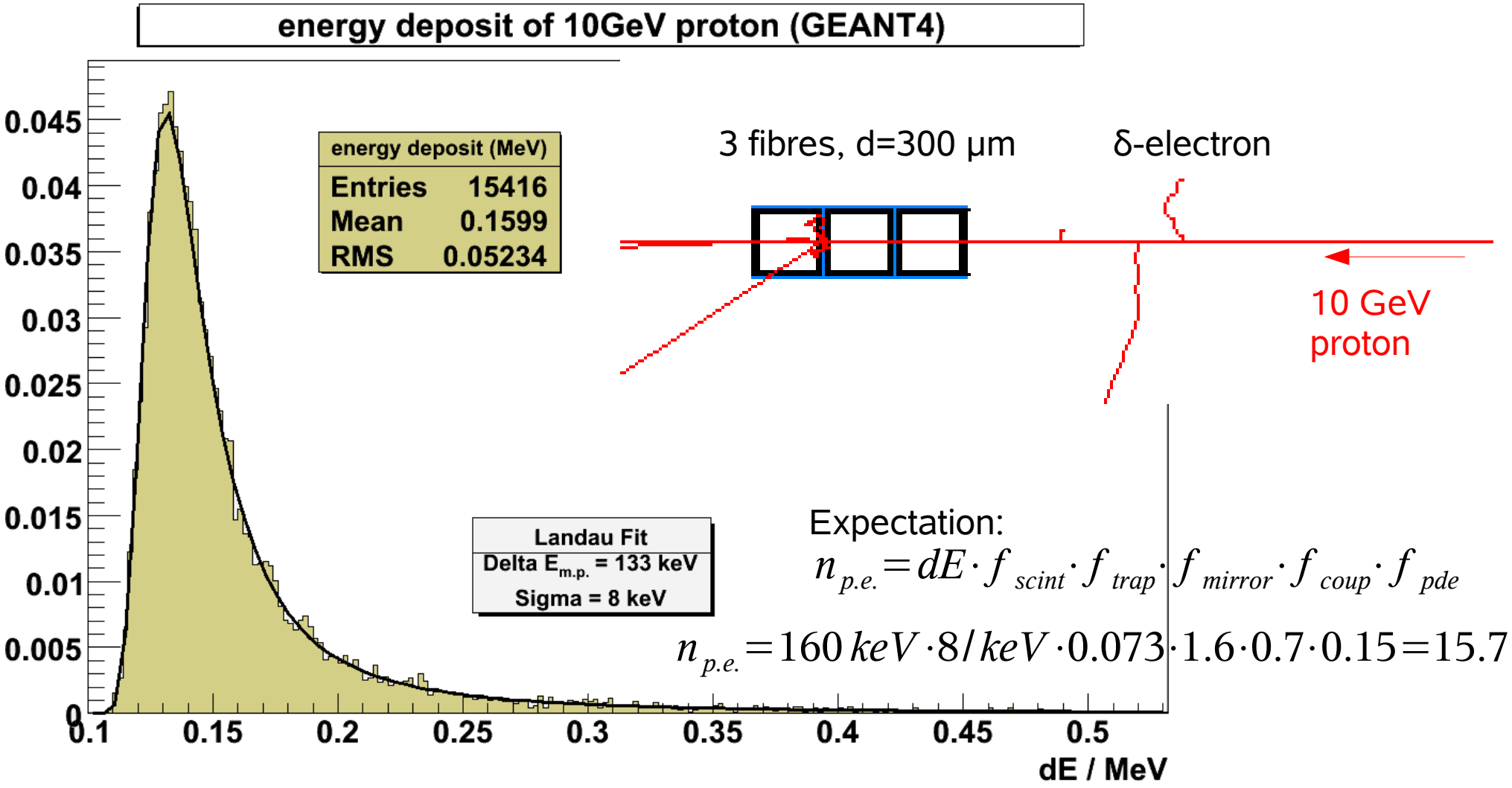
Effect of relective foil





Comparison to simulation

GEANT4 simulation of 300µm fibers

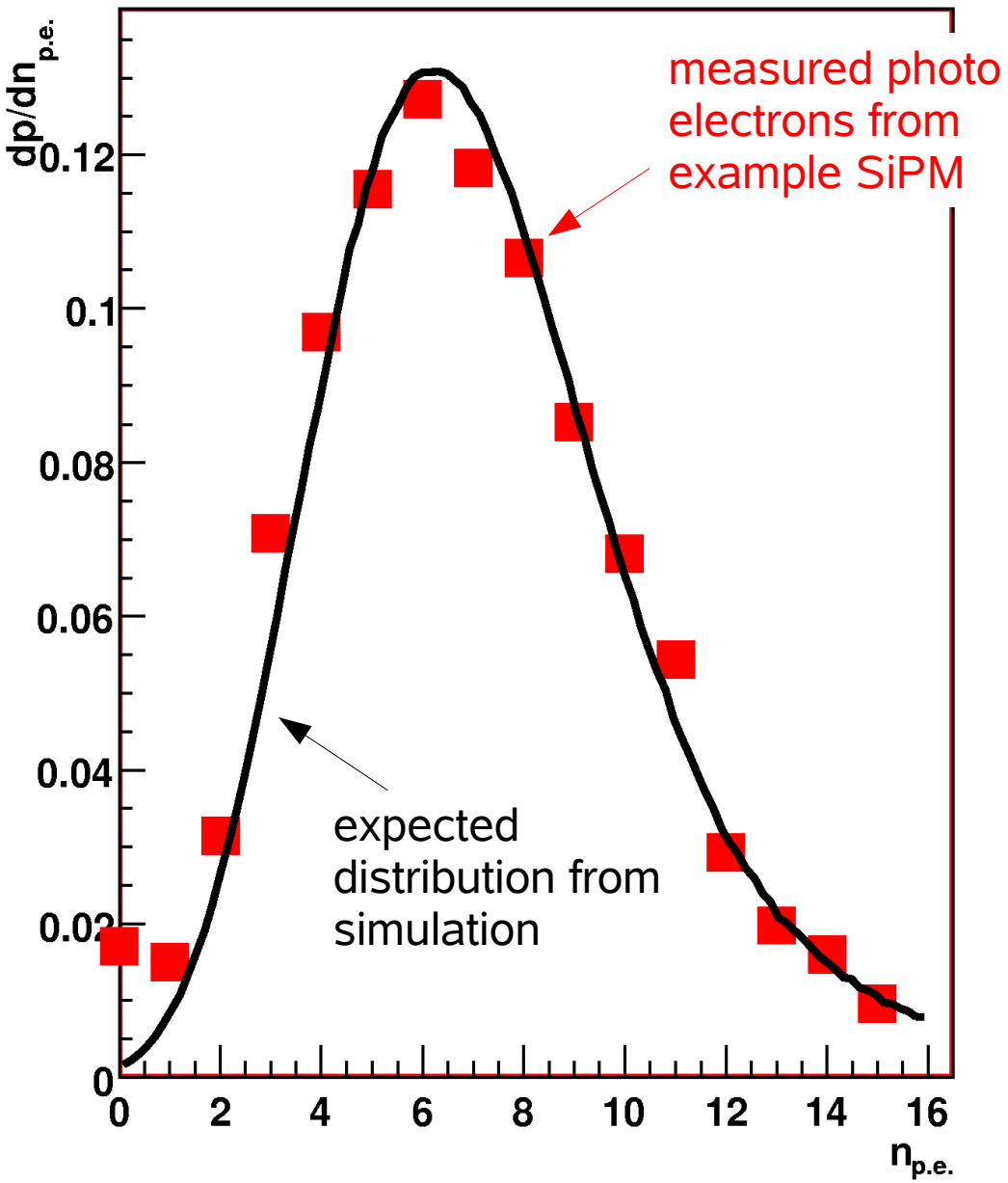


Expectation:

$$n_{p.e.} = dE \cdot f_{scint} \cdot f_{trap} \cdot f_{mirror} \cdot f_{coup} \cdot f_{pde}$$

$$n_{p.e.} = 160\,keV \cdot 8/keV \cdot 0.073 \cdot 1.6 \cdot 0.7 \cdot 0.15 = 15.7$$

Fit of Landau-Poisson-Convolution



Fitted parameters of convolution of Landau- & Poisson-Distribution match GEANT4 results:

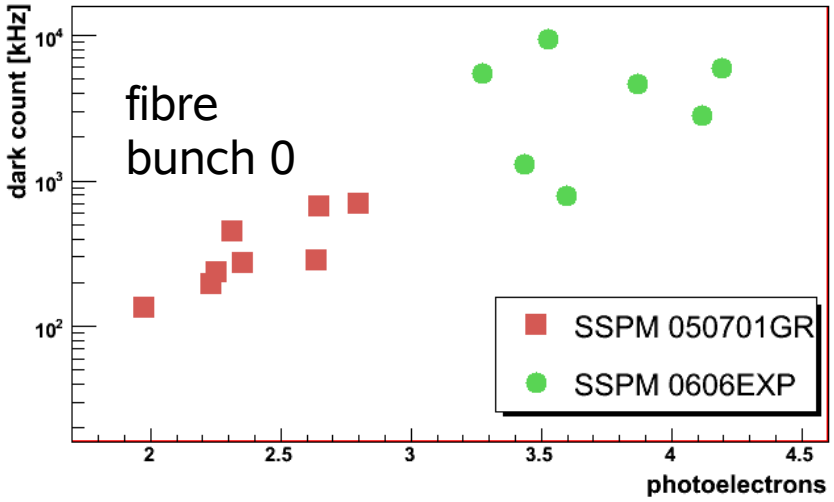
Measured spectrum matches expected MIP spectrum

Fit does not match values for trapping efficiency and photodetection efficiency from manufacturers:

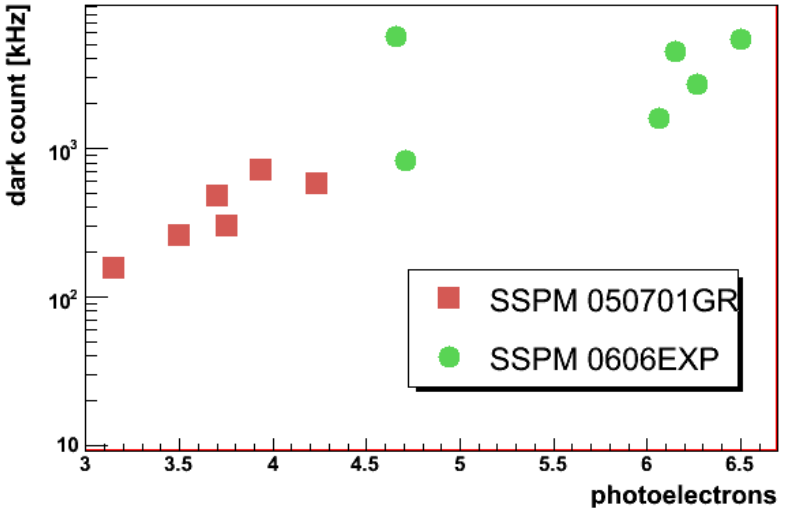
Photoelectron-output is 60% lower than expected

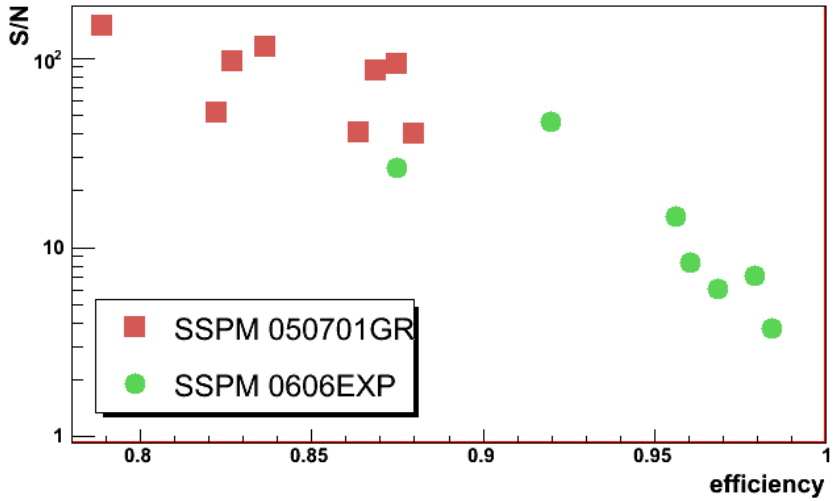
Properties of scintillating fiber/SiPM detector

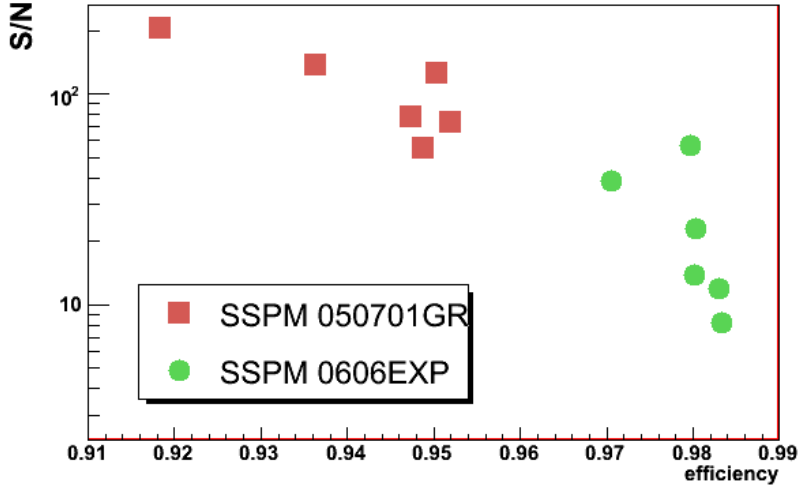
without reflective foil



with reflective foil





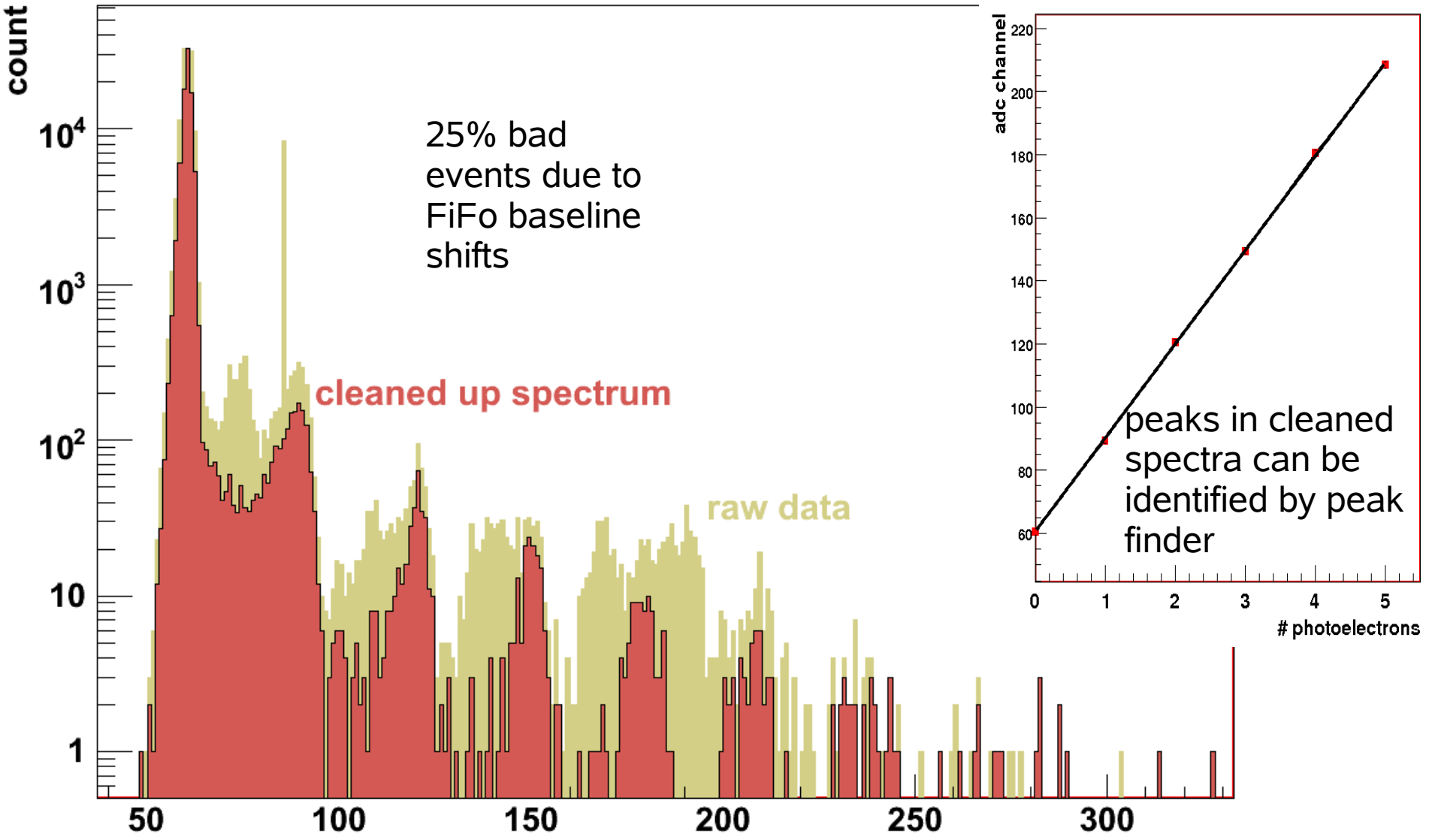


1 p.e.

reflective foil at one end of fibers increases photon-output by 60%

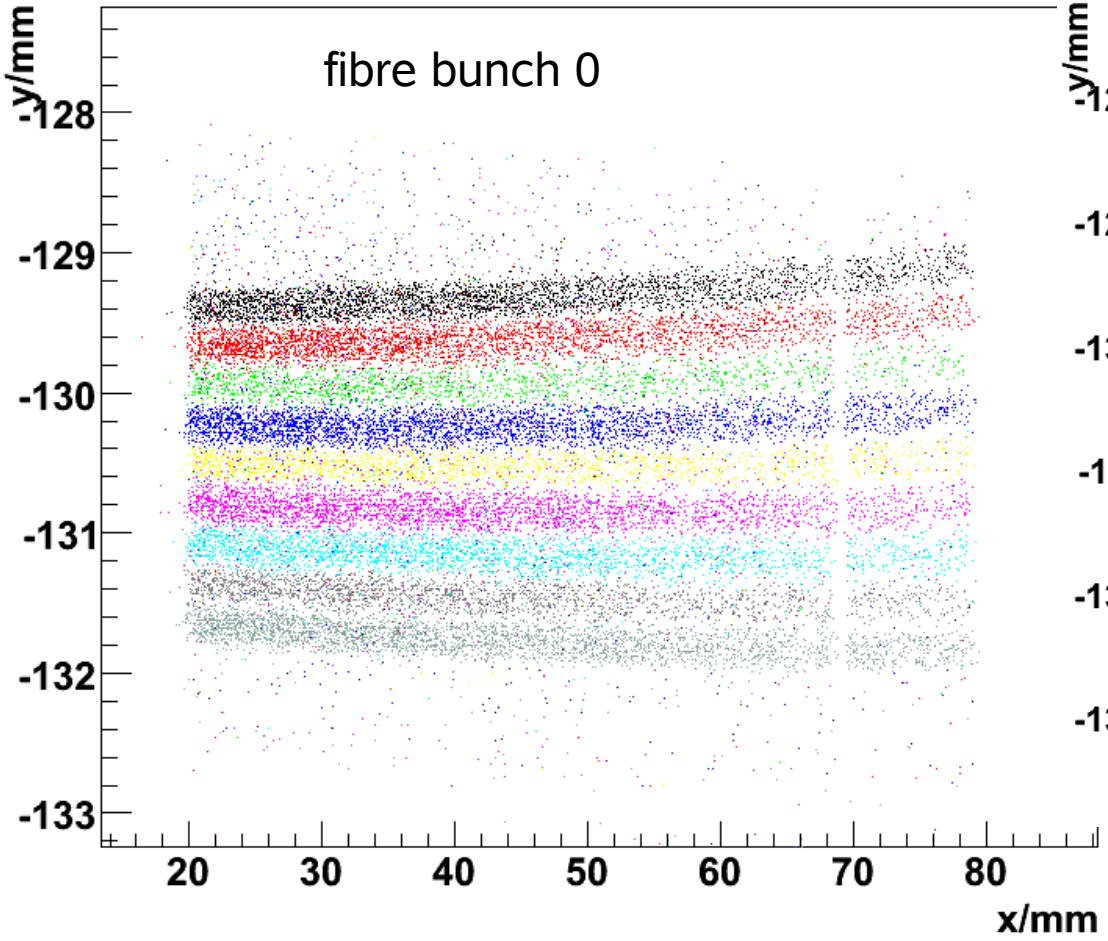
efficiency and signal to noise for SSPM-0606EXP with reflective foil near acceptable levels

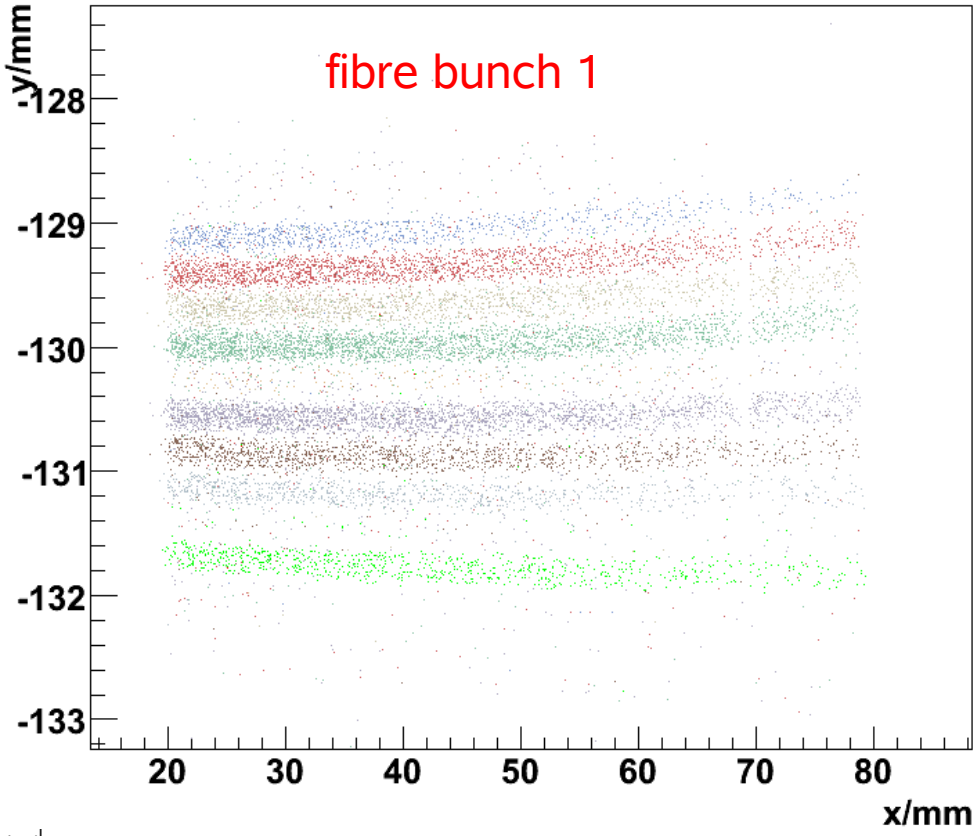
Data preprocessing



filter identifying “good” and “bad” events cleans up spectrum

Position measurement of scintillating fibres

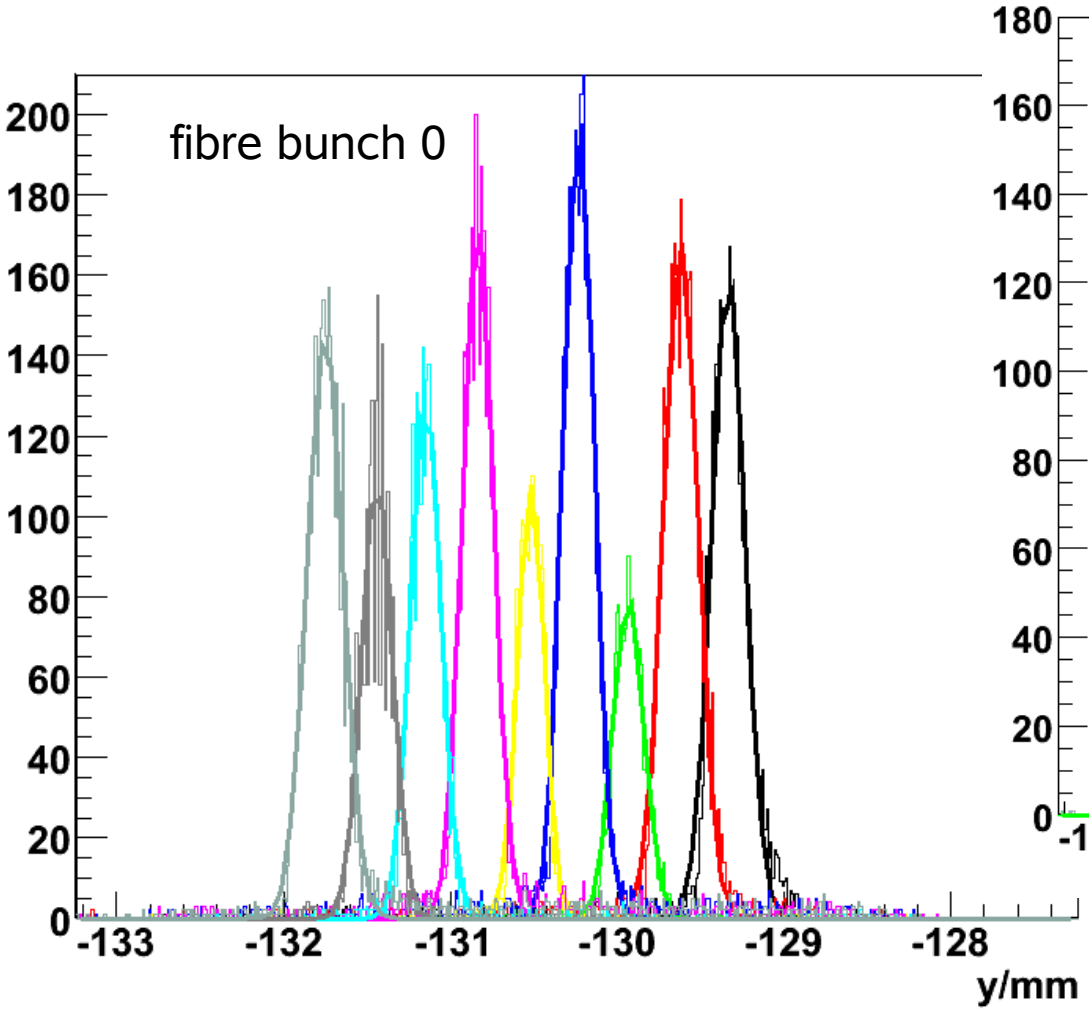


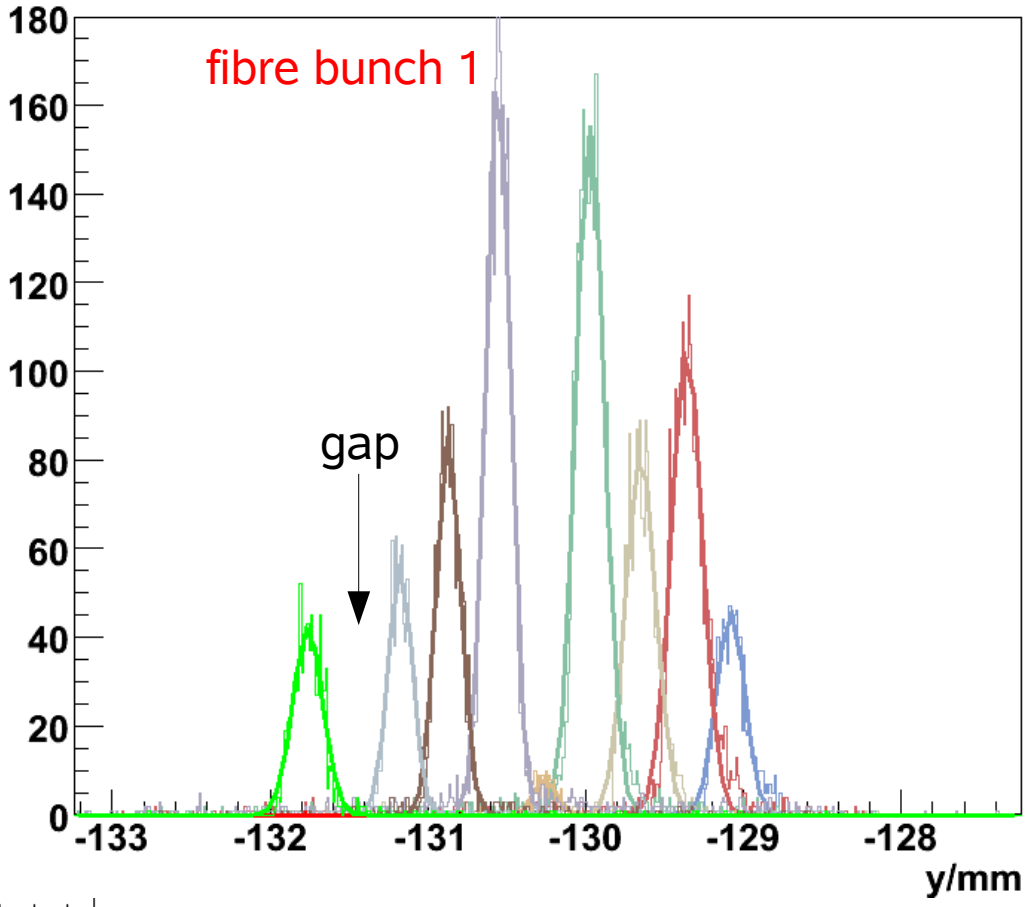


beam telescope coordinates for fibres with amplitude > (manual) ADC cut

Principle of scintillating fibre tracker works!

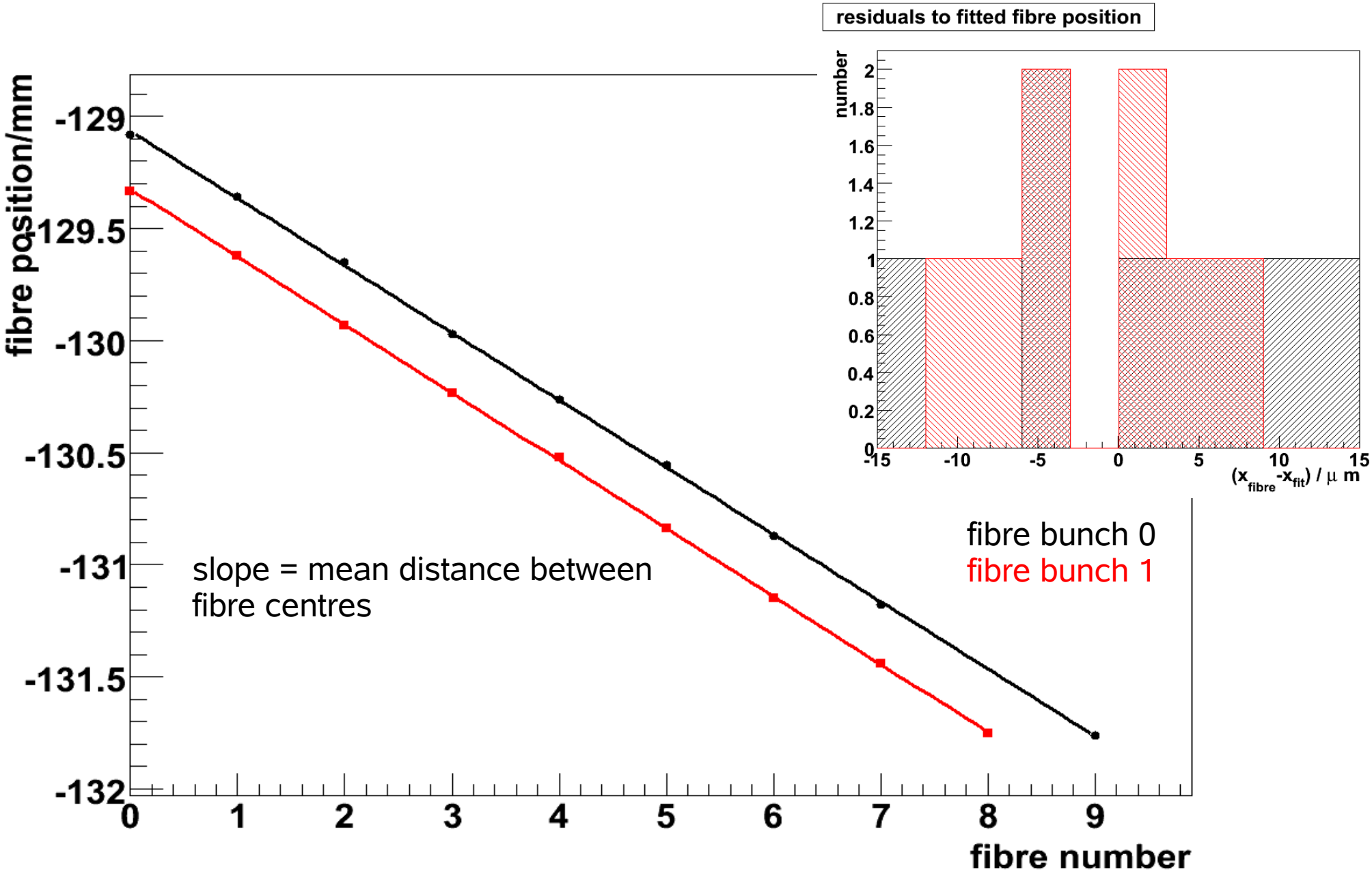
Determination of fibre positions



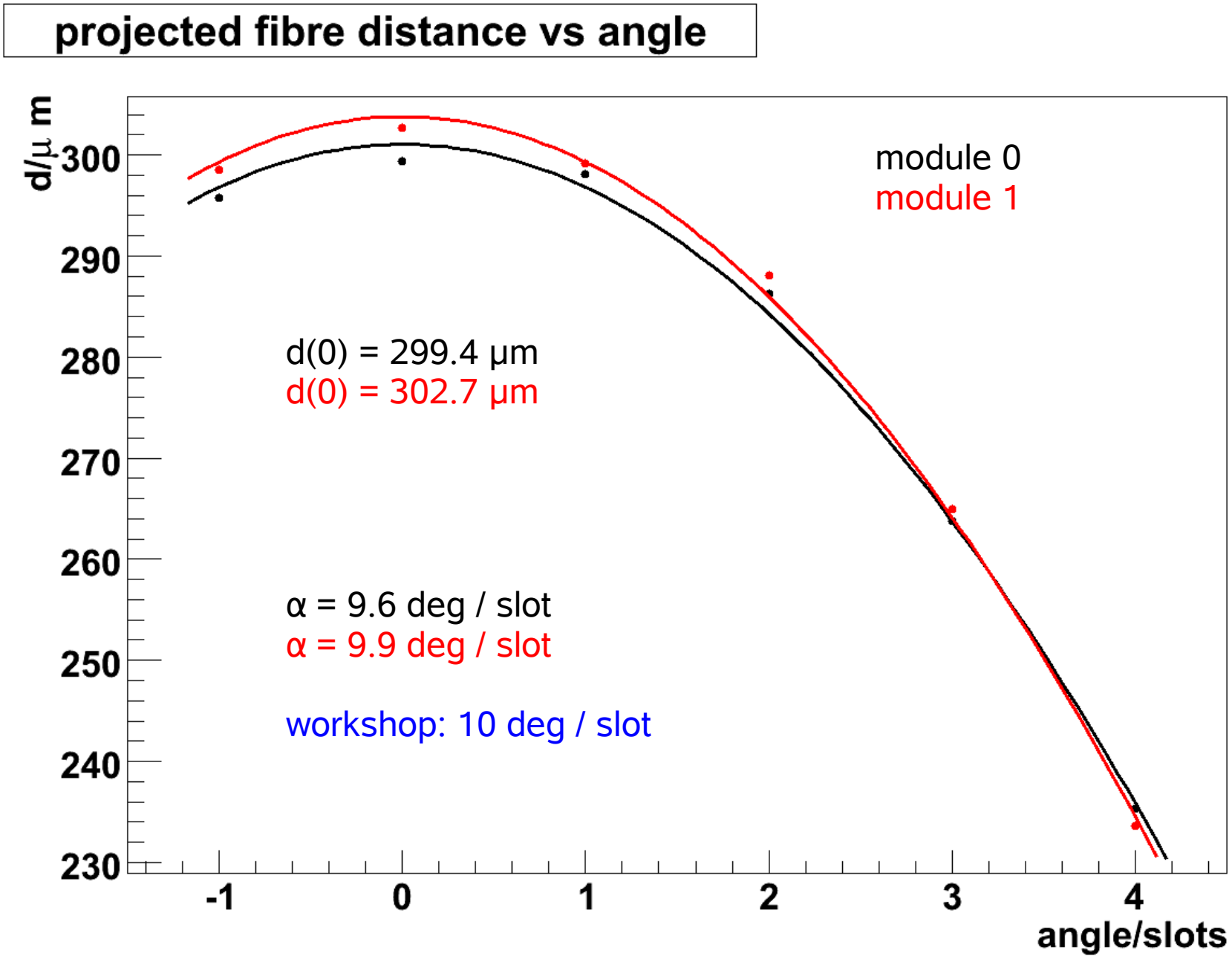


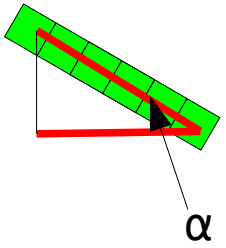
Gaussian fits to distributions of fibre positions along y

Accuracy of fibre positions



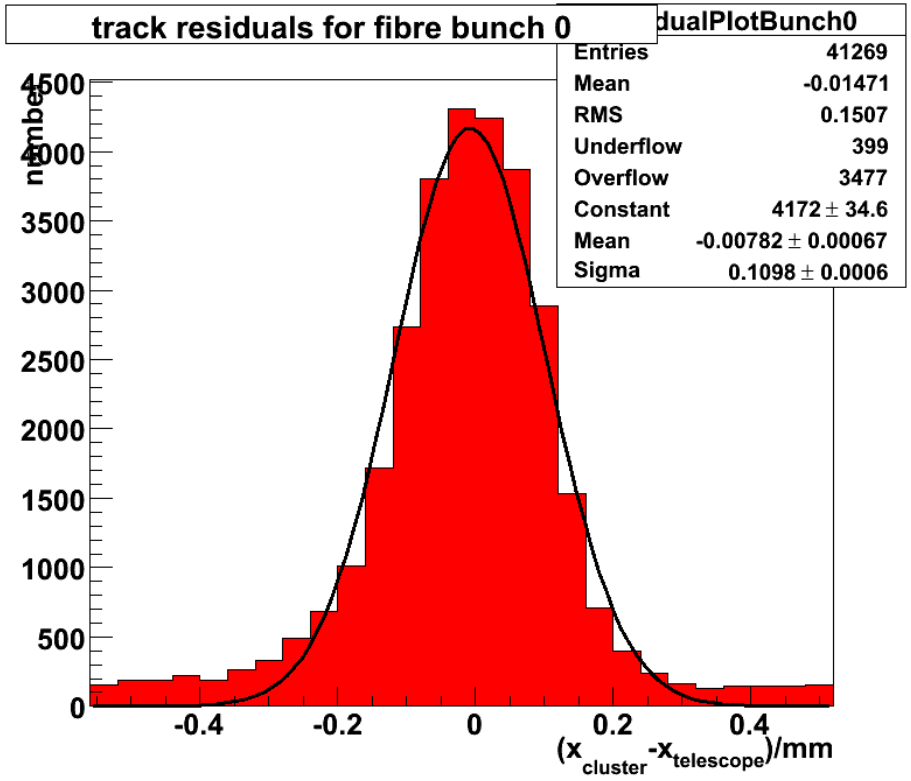
Projected fibre distance *vs* angle of incidence



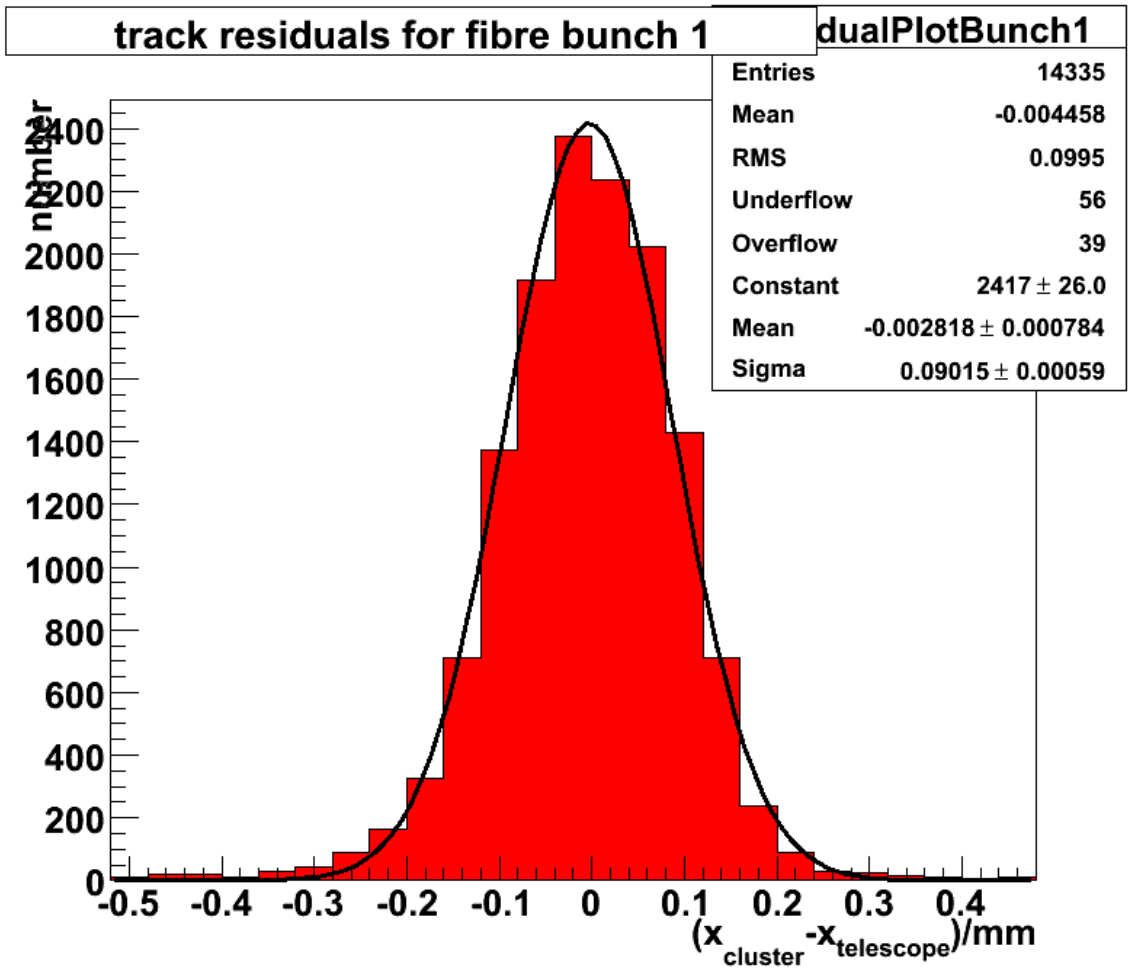


$d = d(0) \cdot \cos(\alpha)$

Spatial resolution for perpendicular incidence

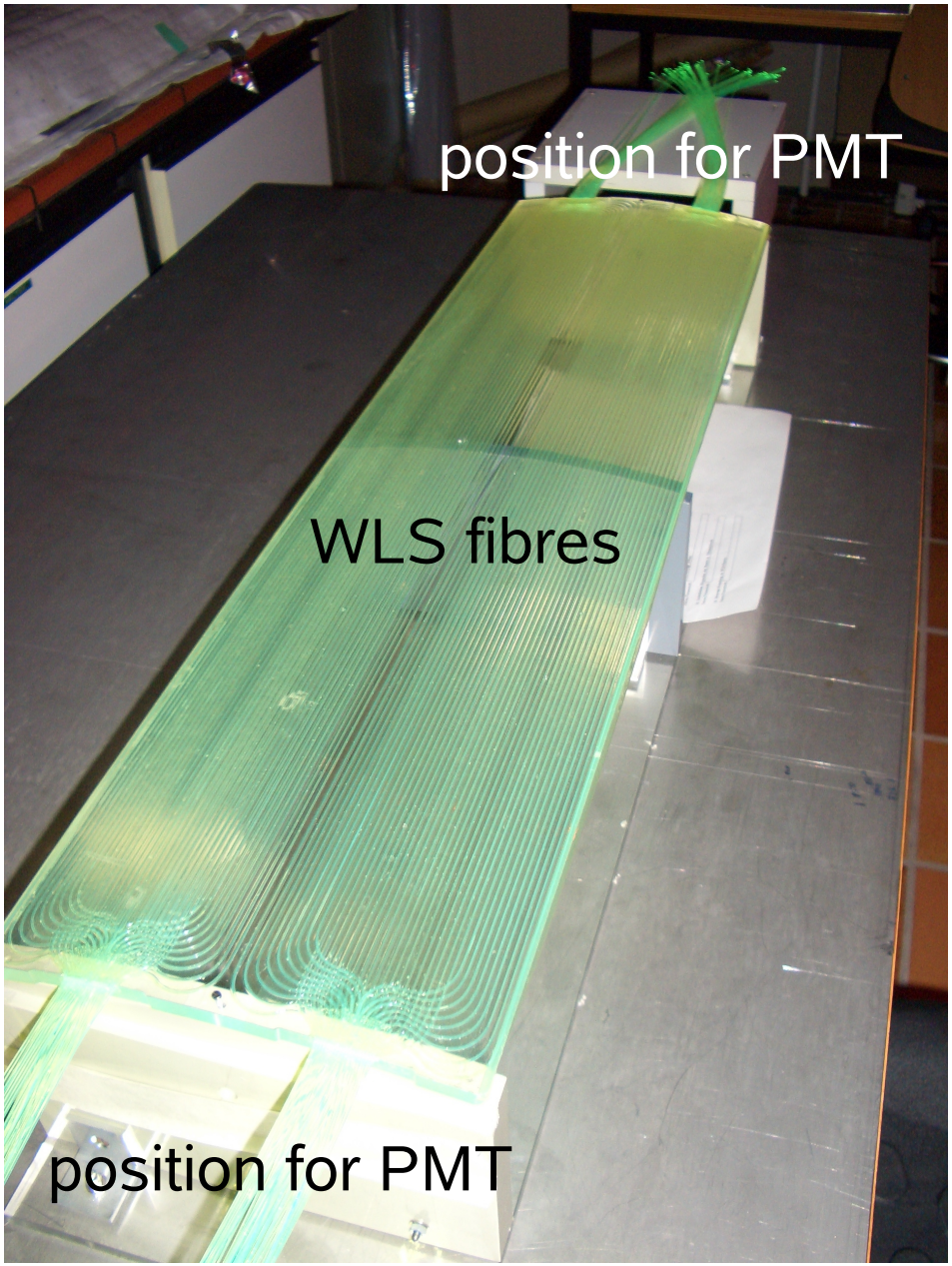


fibre bunch 0 has σ = 110 µm
due to higher noise level



σ = 90 µm in case of perpendicular incidence

ACC principle & testbeam goals



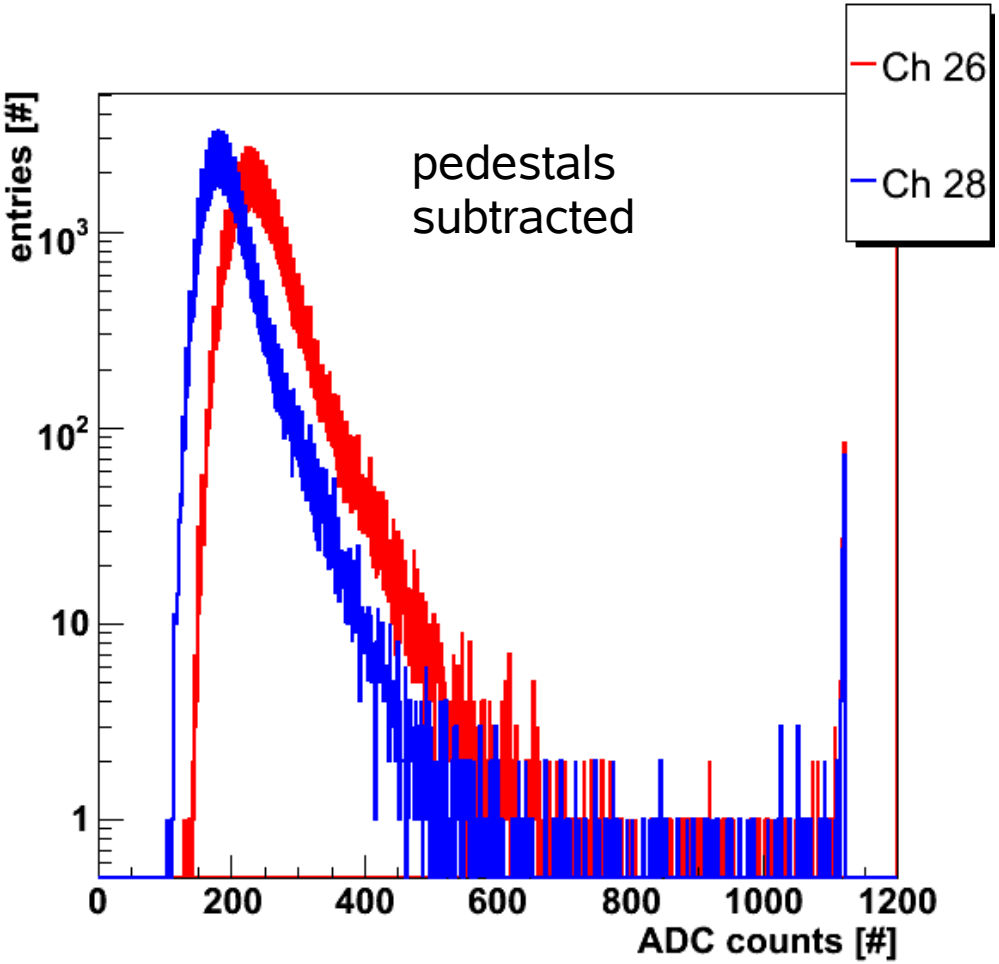
ACC principle:

- light emission in scintillator
- absorption and guiding with wave length shifting fibres (WLS)
- coupling to clear fibre (max. 2m)
- detection with photomultimpliers on each end (PMT)
- important to know: **What is the hit detection efficiency?**

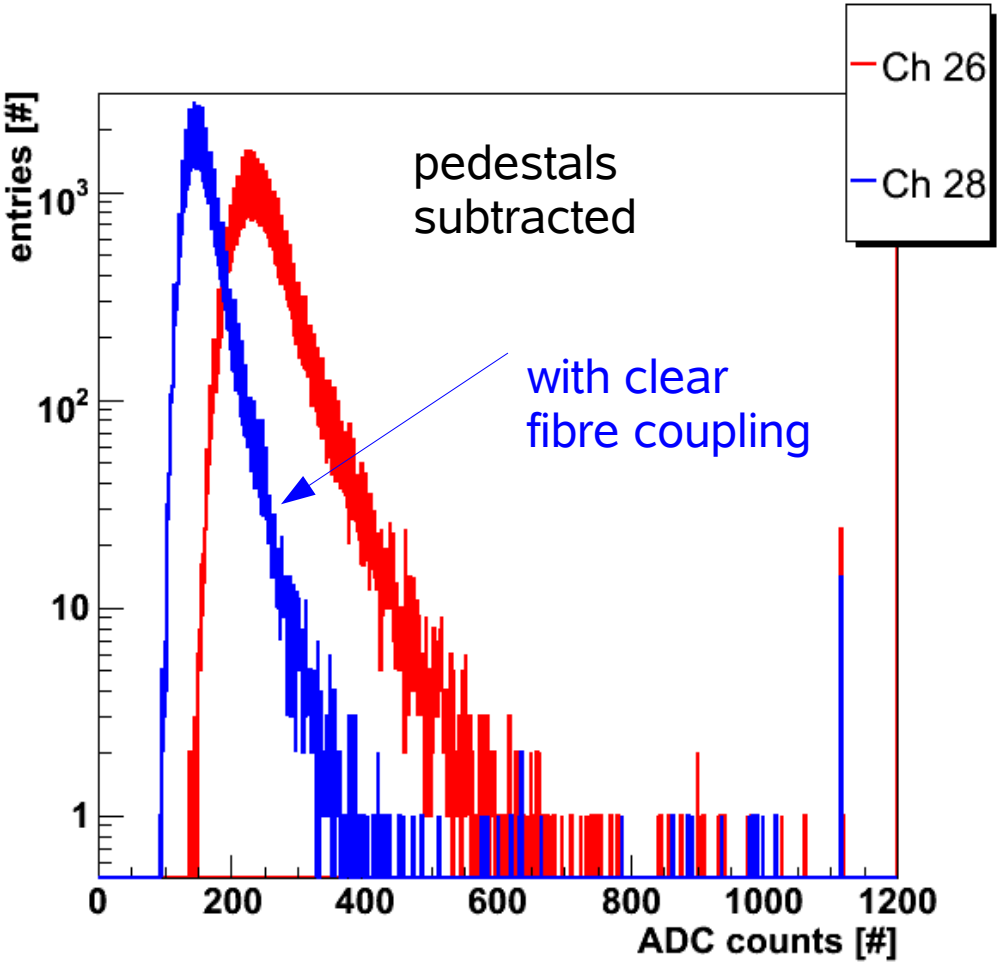
Testbeam goals:

- determination of efficiency with CAMAC ADC and beam telescope for a single panel and for the slot region between 2 panels
- determination of efficiency with oscilloscope (full pulse shape)
- influence of WLS->clear fibre coupling

ACC results: Single ACC in centre region

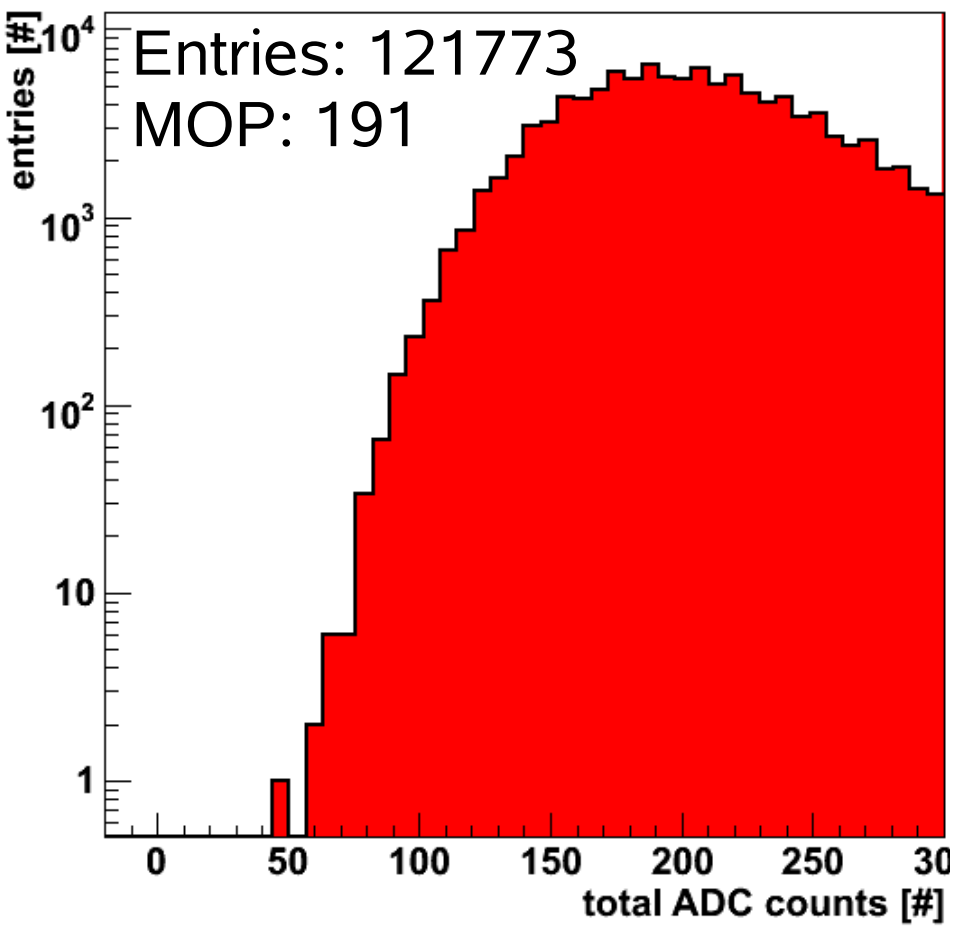


trigger in ODER position
WLS -> PMT

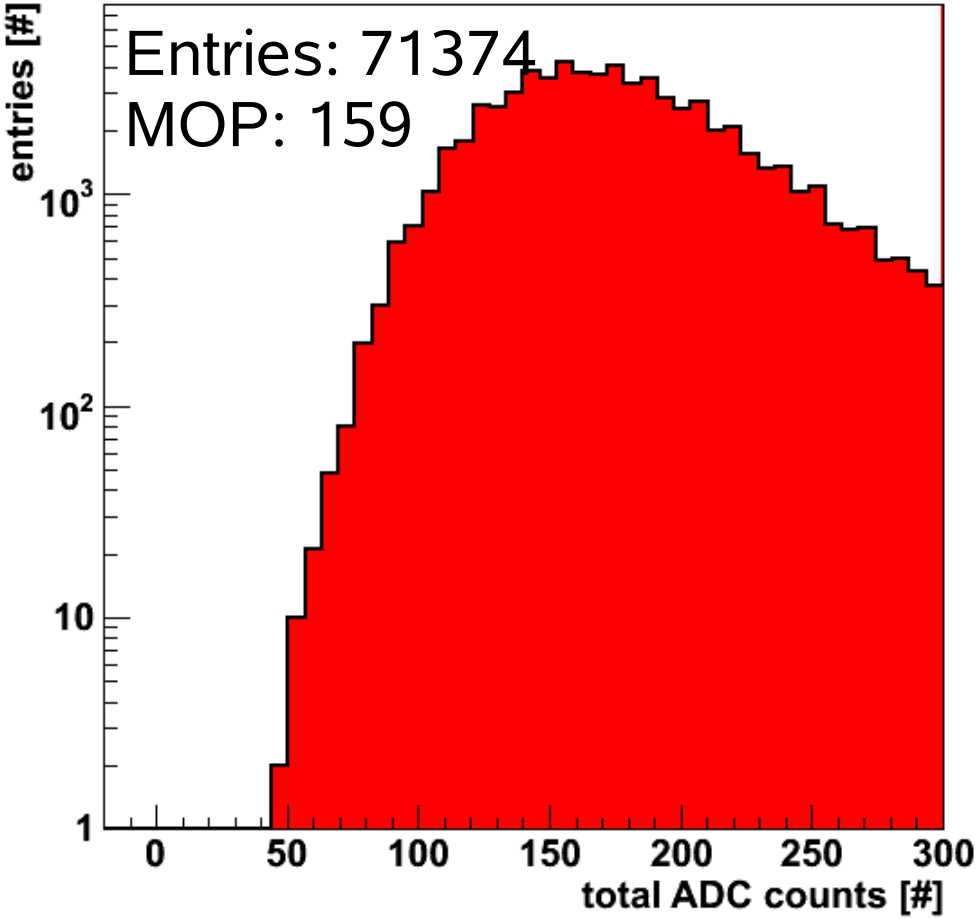


trigger in UND position
WLS -> clear fibre -> PMT

Total ADC counts (ped. corr.): PMT1 + PMT2



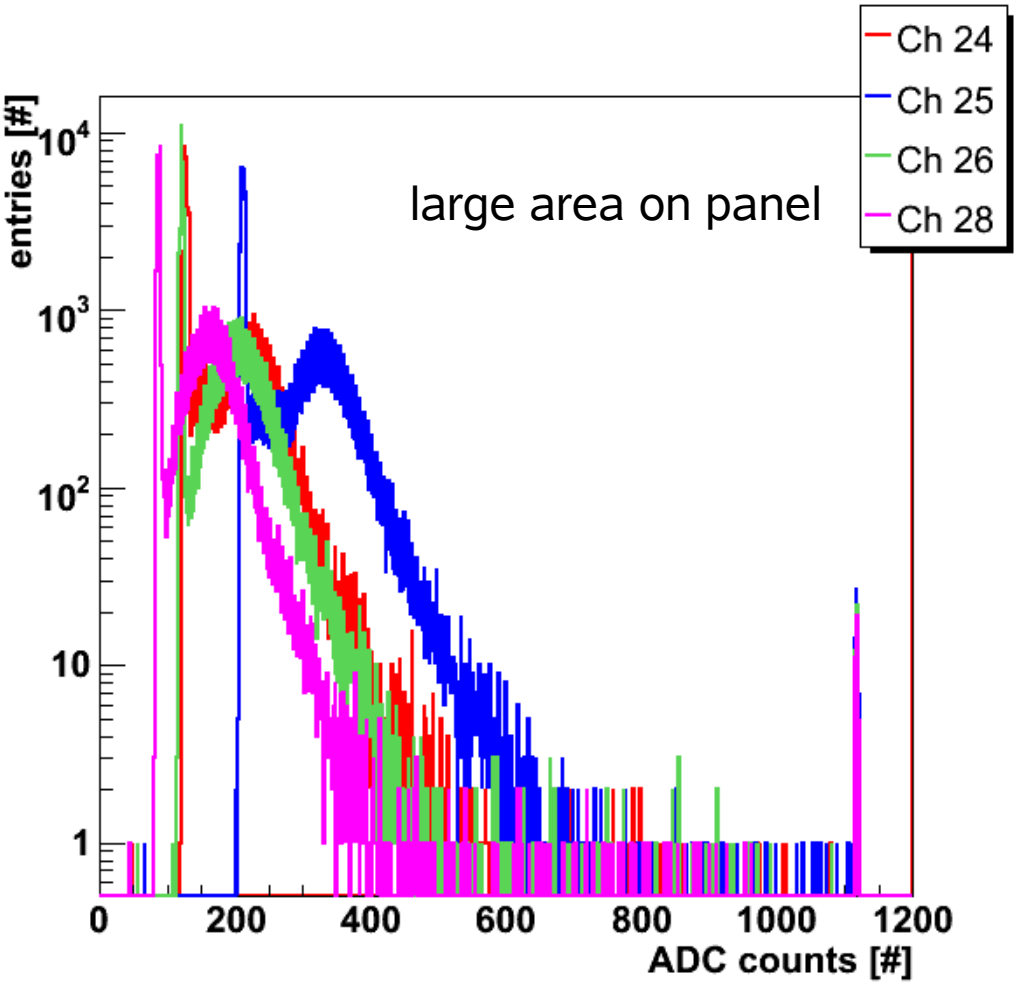
trigger in ODER position
WLS -> PMT
0 hits out of 121773 missed

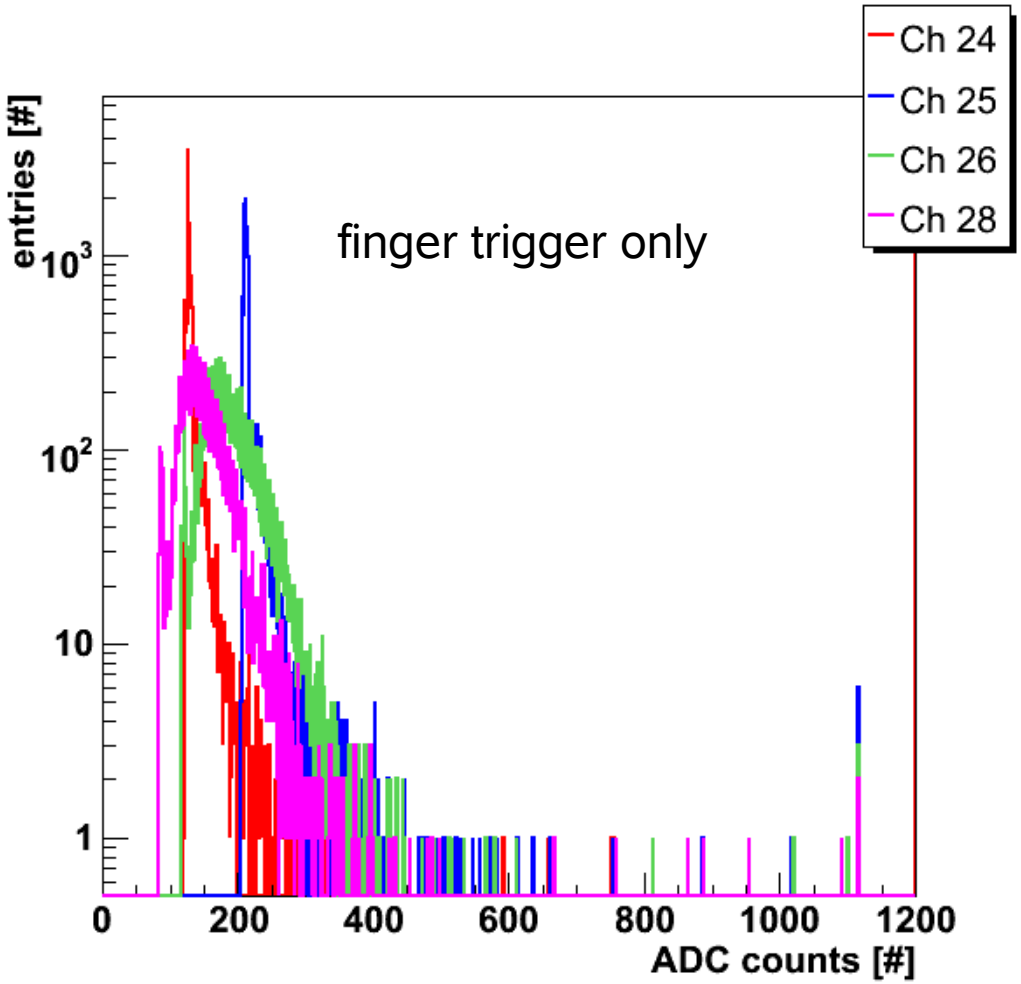


trigger in UND position
WLS -> clear fibre -> PMT
0 hits out of 71374 missed

coupling lowers signal by roughly 34%

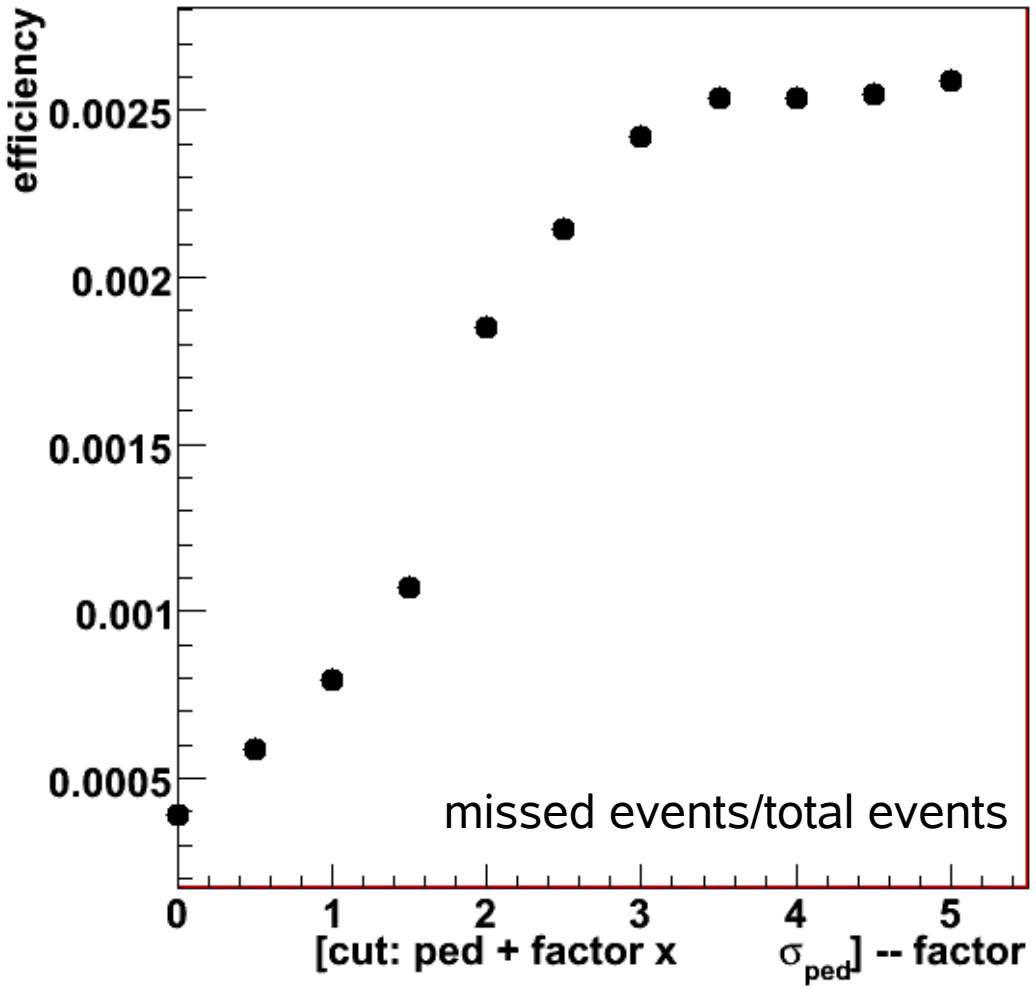
2 ACCs connected with spigot and groove to analyse slot region

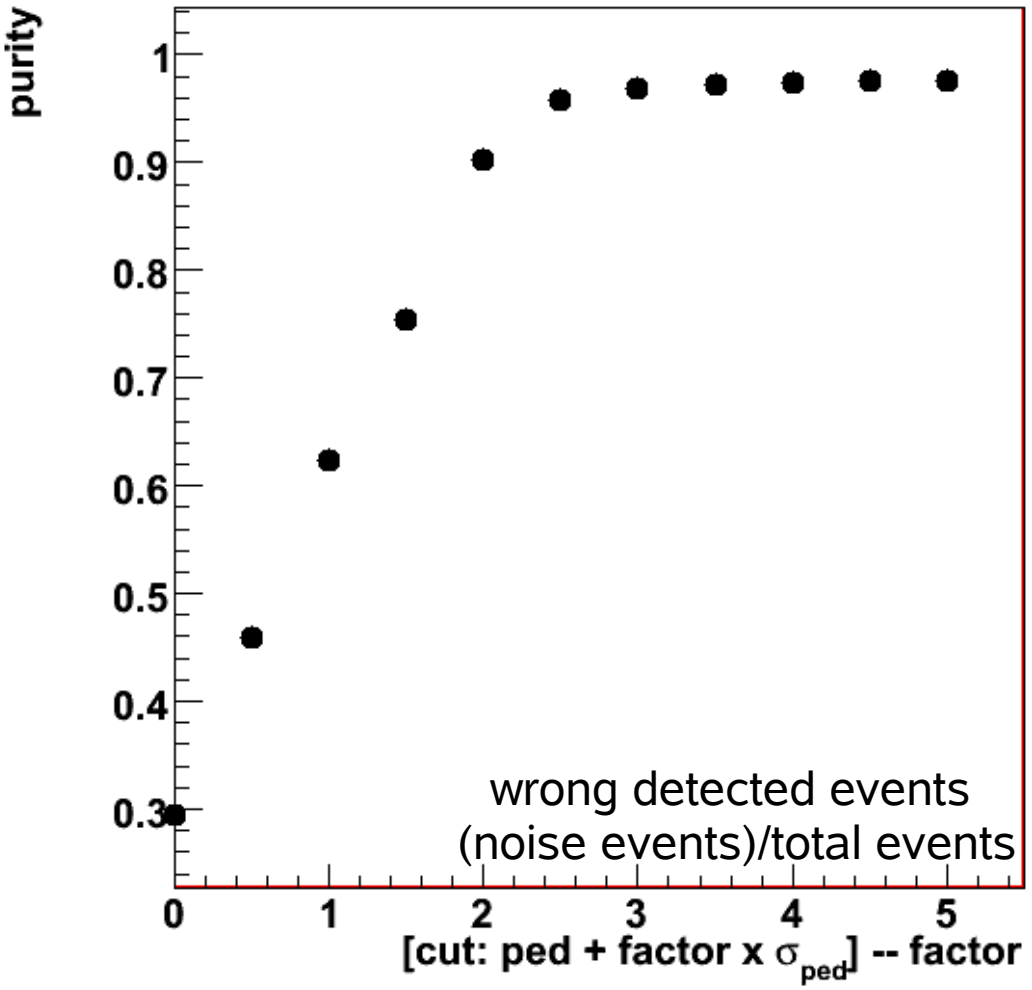




pedestal position overlaps with signal region
-> worse behaviour than expected beforehand
-> more noise

Cut dependent efficiency and purity (**no** slot region!)

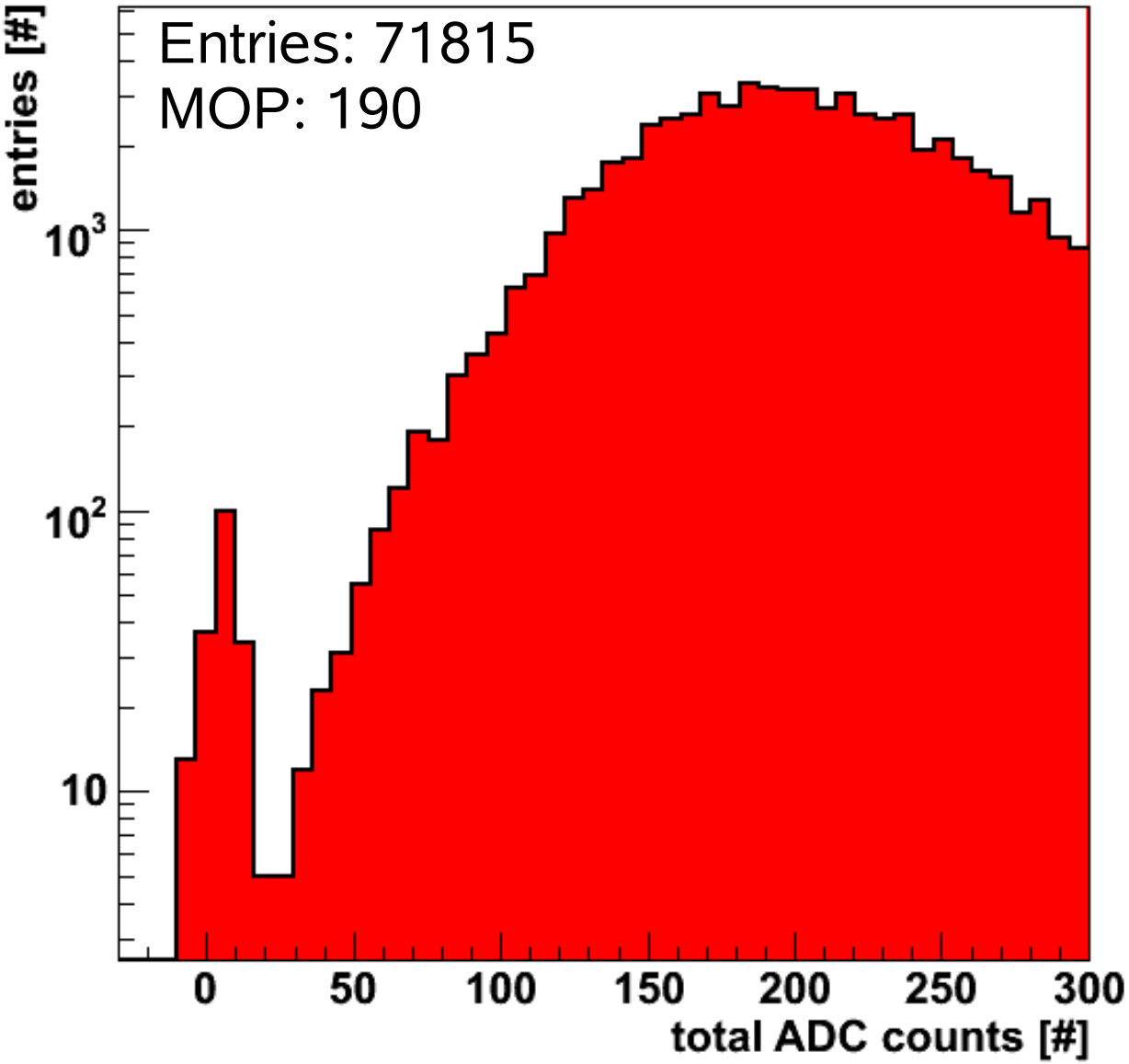




definition of a hit based on pedestal fit (+single track):

- signal has to be at least larger than mean of pedestal
- cut variation is done in units of pedestal width

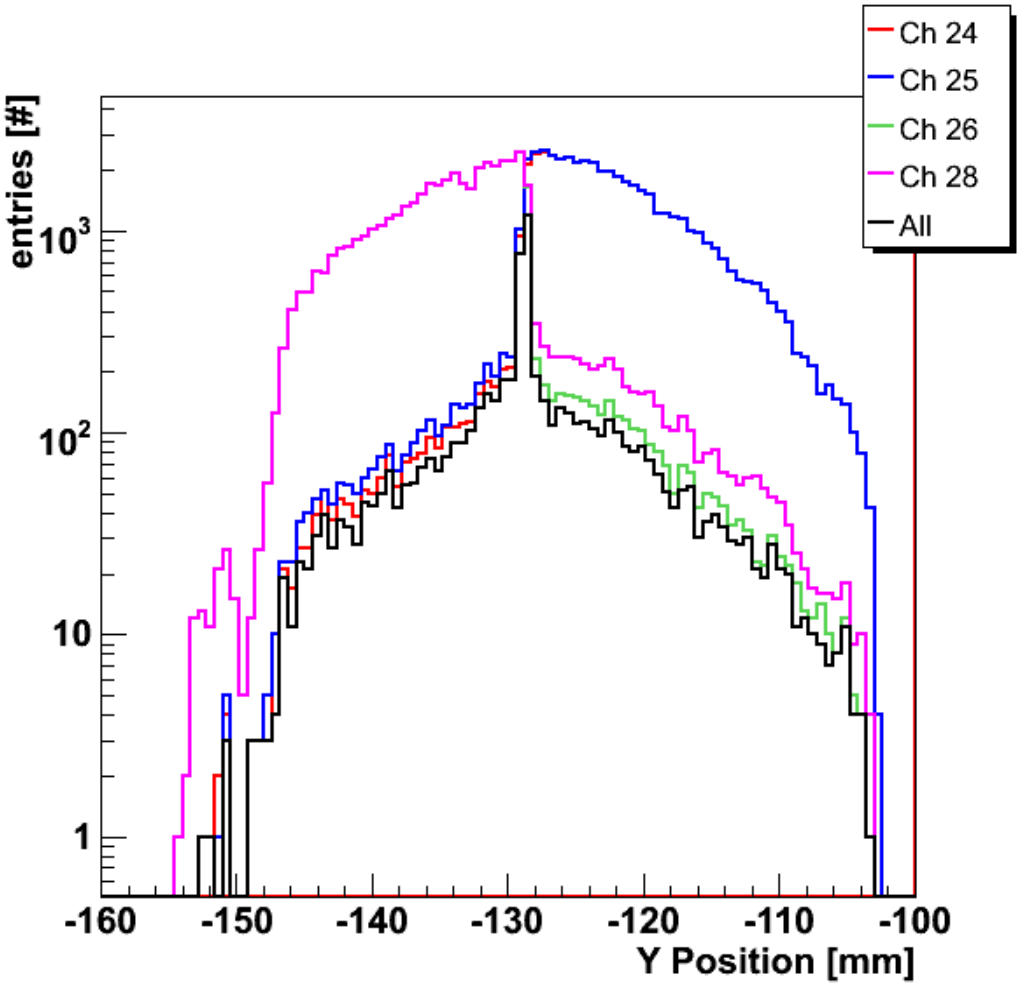
Total ADC counts (ped. corr.) - both panels

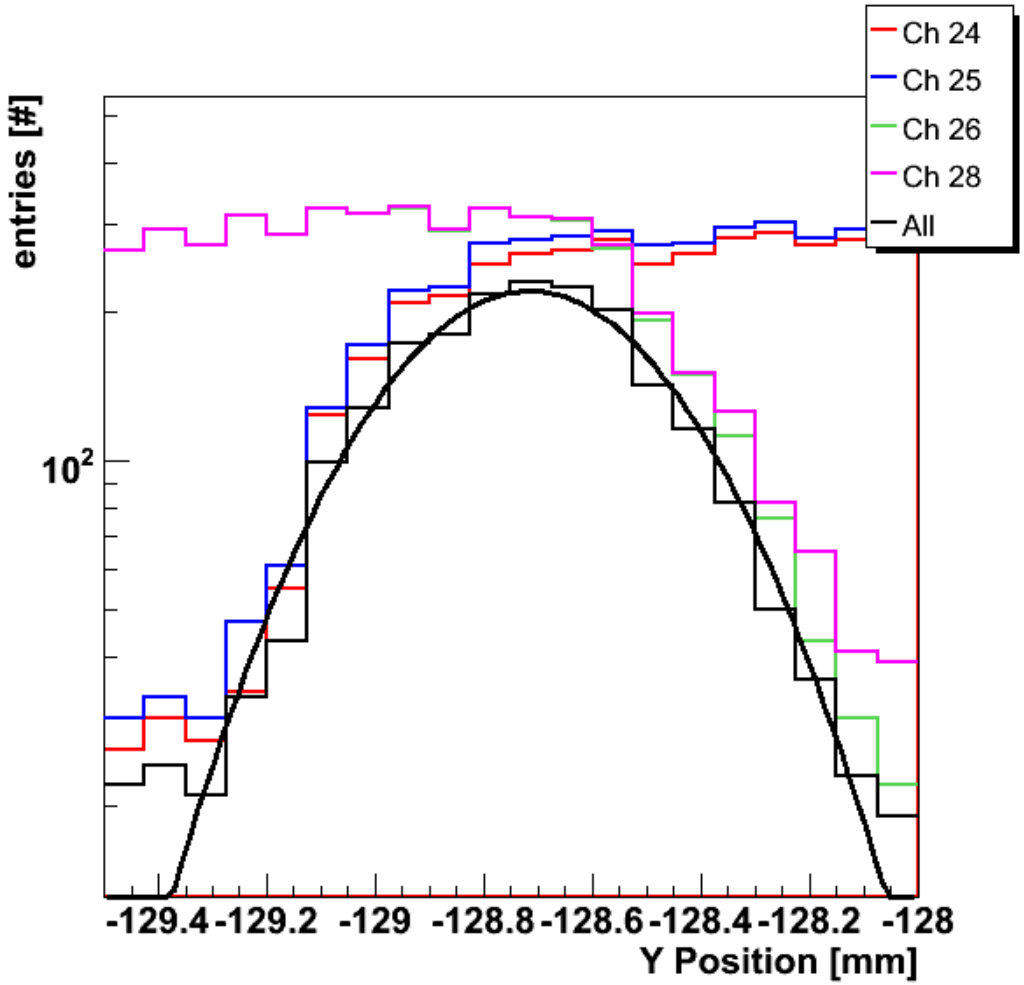


pedestal position overlaps with signal:

- only hits outside of slot
- more missed hits (depending on cut)
- more noise (90% purity)
- efficiency: ca. 2e-3

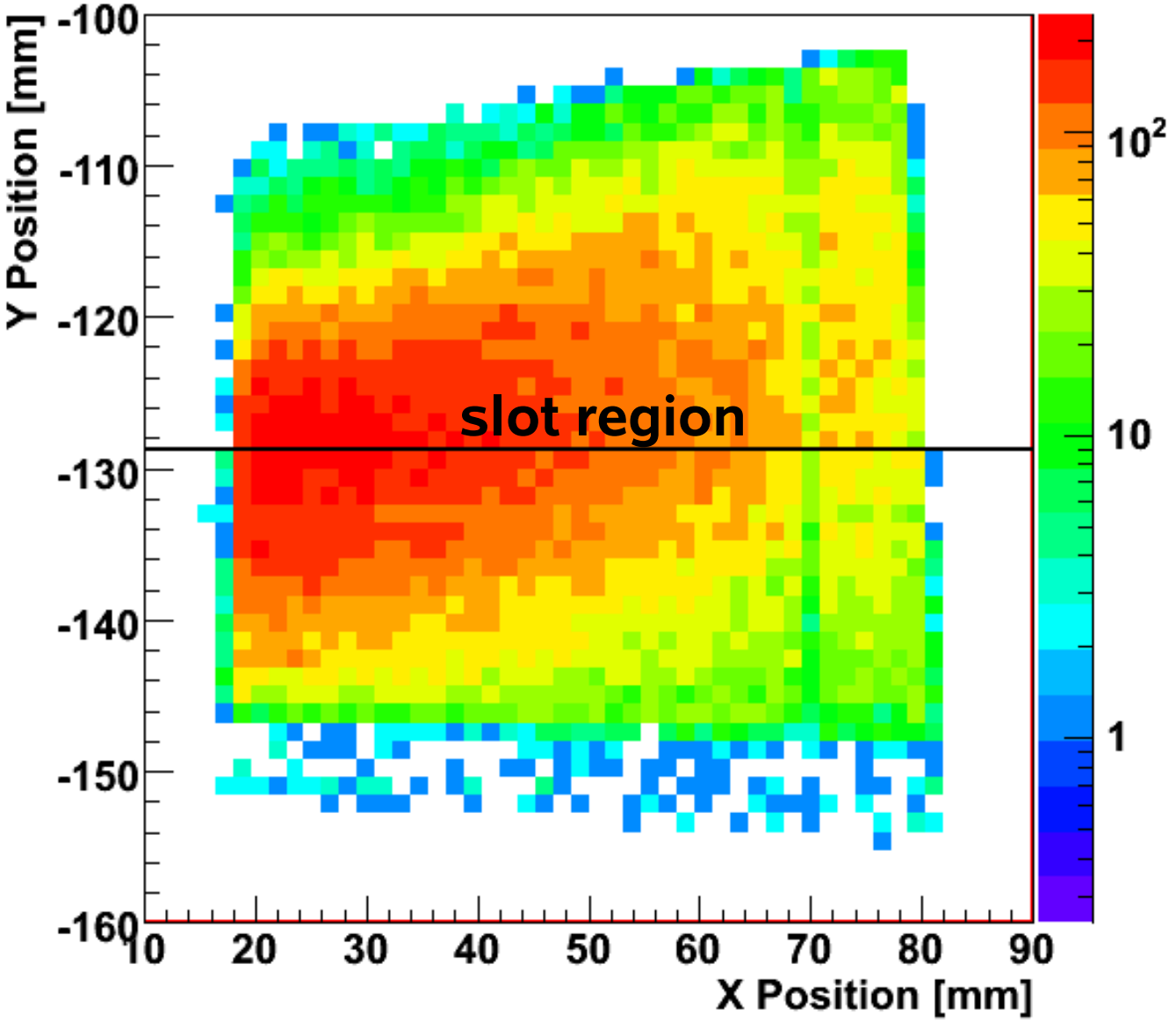
Find slot region between ACCs





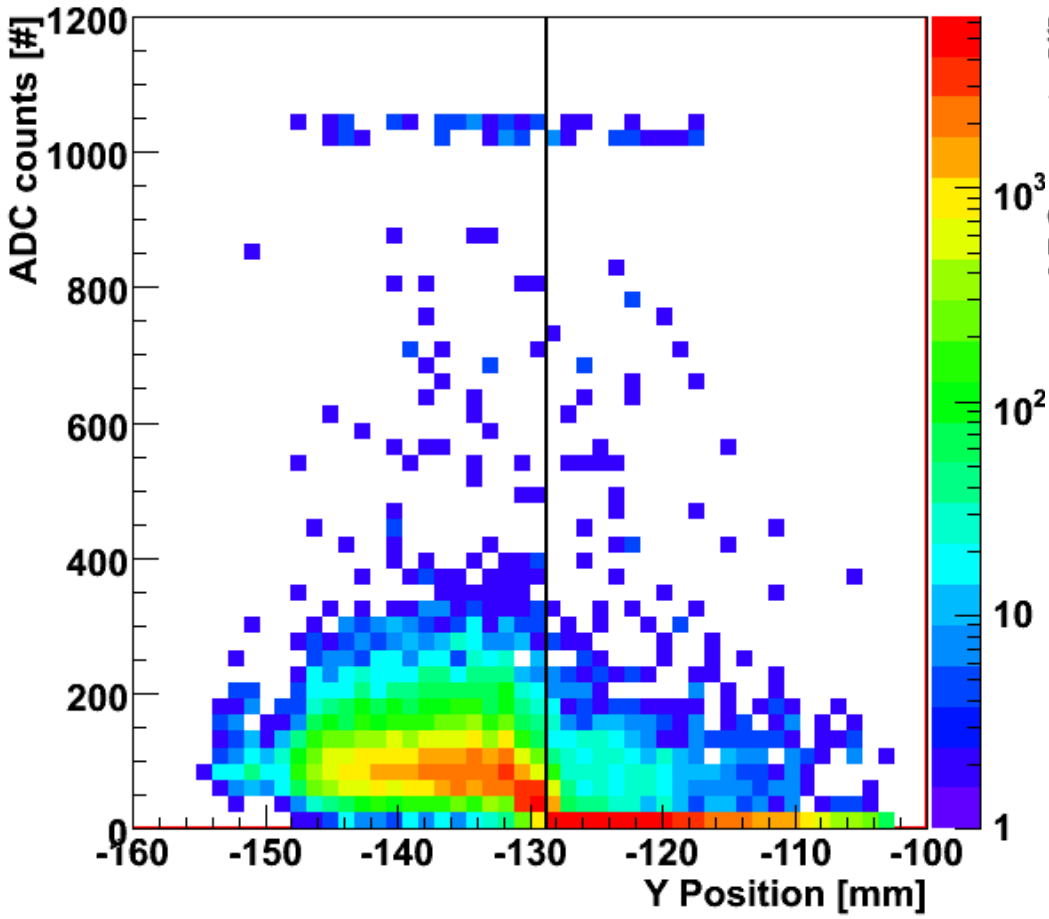
Fit to region where all 4 PMTs have a simultaneous signal: position: -128.7mm

Beam Profile in ACC position

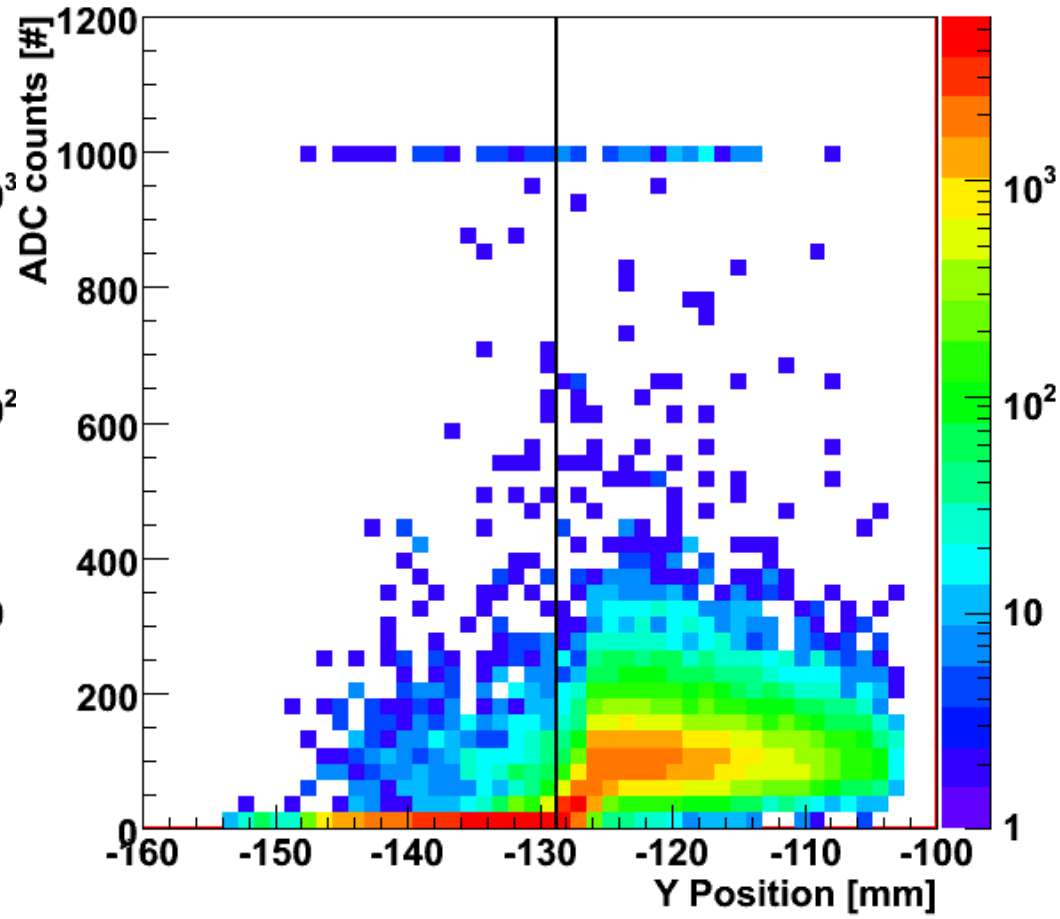


ADC counts vs. y-Position (perpendicular to slot)

upper panel in box

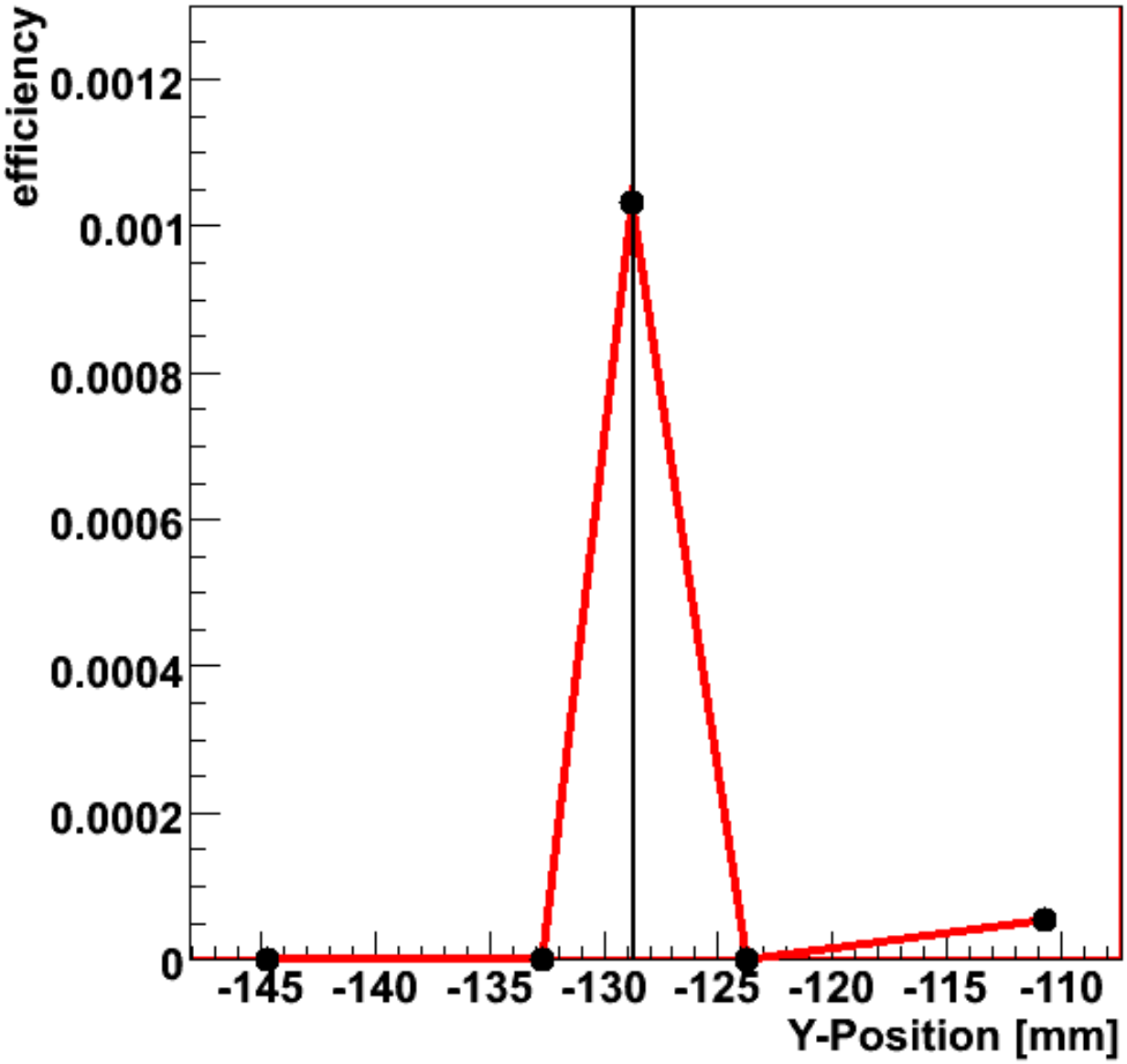


lower panel in box



Number of ADC counts clearly defines the transition between the 2 ACC panels

Y-position dependent efficiency @ 90% purity

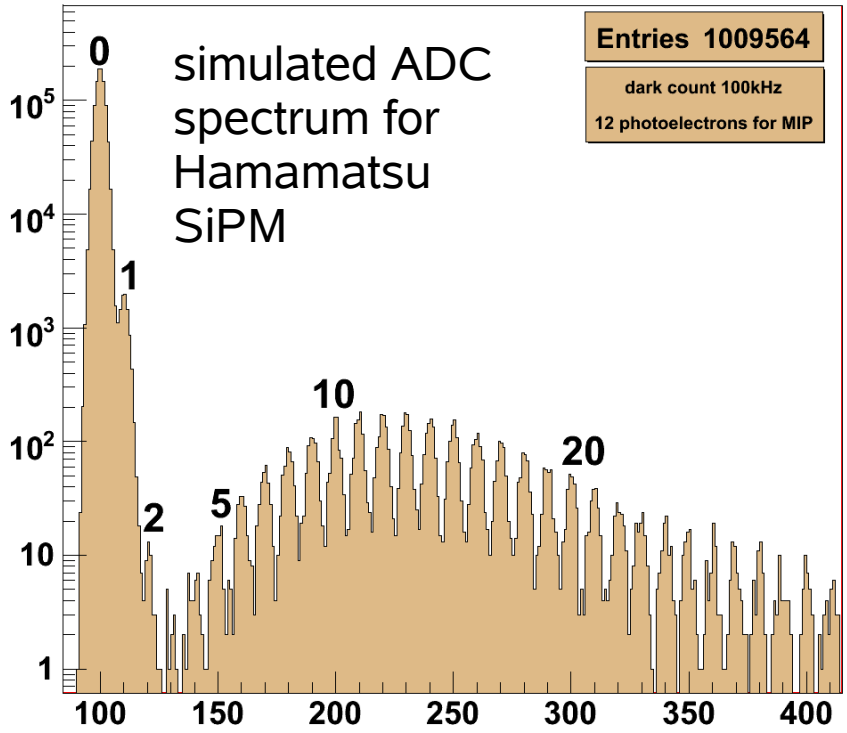


clear definition of slot due to worst efficiency

Conclusions and outlook

PEBS

- first testbeam of PEBS fibre/SiPM prototype has been completed smoothly and successfully
- in current configuration (3 fibres per APD), 6.1 photo electrons per SiPM are reached for perpendicular incidence
- spatial resolution of 90 µm is achieved for perpendicular incidence



- continue analysis of testbeam data
- include results in PEBS Monte Carlo

ACC

- in single ACC configuration (central incidence): no hits missed (out of 190000)
- influence of coupling is not too large (34%)
- ACC works in connected configuration
- slot is well defined, and inefficiency at slot increases

- use of full statistics
- determination of photo electron number and fit with poisson-landau-convolution
- analysis of 1.5TB(!) oscilloscope data