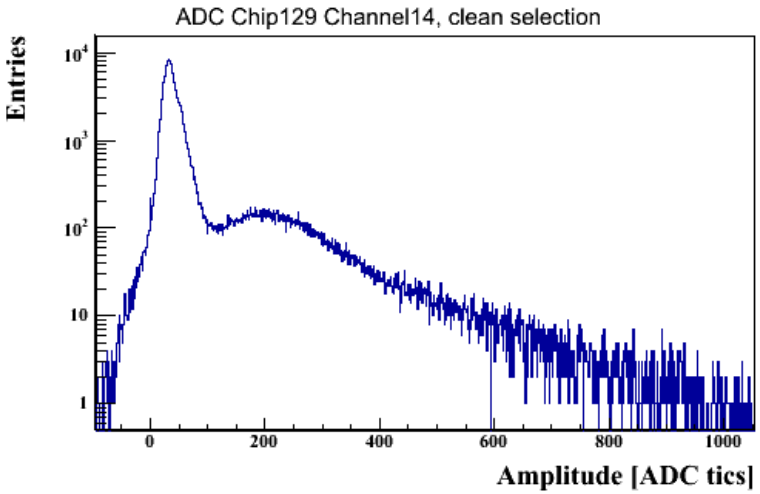
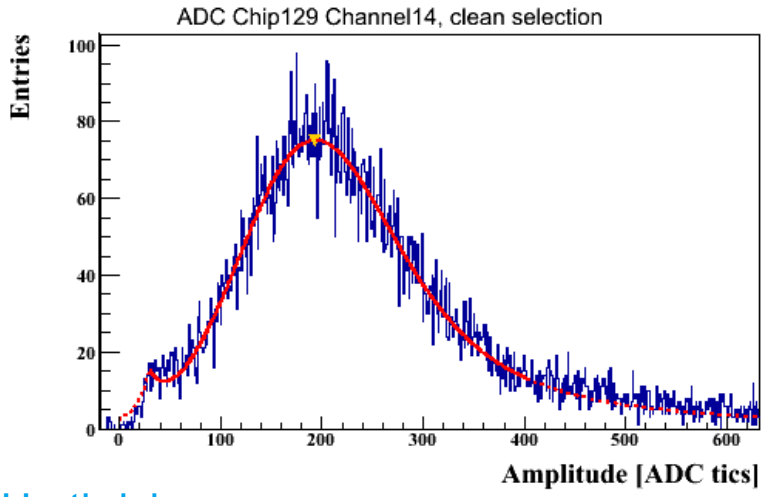
MIP fits with the AHCAL.

Data taking, event selection, MIP fitting





Oskar Hartbrich
AHCAL Main Meeting
09.12.2013

HELMHOLTZ ASSOCIATION

BERGISCHE UNIVERSITÄT WUPPERTAL

Universität Hamburg

DESY

How to do MIP calibration with the new prototype?

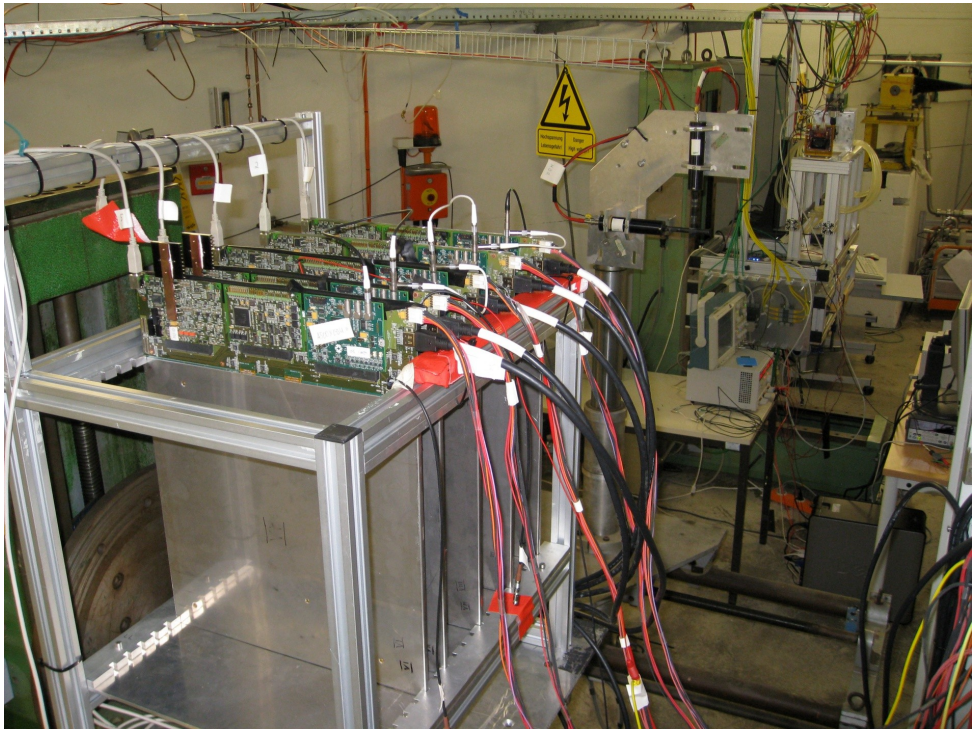
- MIP calibration is the fundamental step in calorimeter calibration

New prototype, new challenges:

- How to configure detector for MIP calibration
  - Self triggered operation → threshold setup
- How to adapt to different beam environments
  - Taking CERN muons is different from DESY electrons
- How to extract best possible MIP spectra
  - Online software for run quality control
  - Offline analysis strategy using SPIROC features
  - Optimal fit for obtained spectra

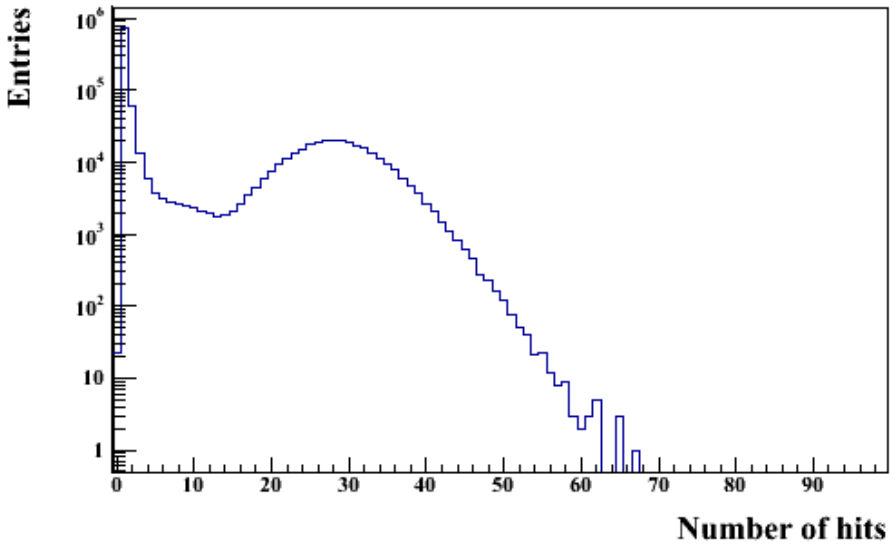
Setup

- 4 HBU2 layers in DESY TB22
  - Boards VI, VII, VIII, X (board IX not usable at the time)
  - Mounted in airstack
  - Simultaneous MIP calibration of all layers
  - 3GeV positrons
- Scanned inner 10*10 tiles
  - ~5000 cycles per run (~5min)
  - Pedestals generated from same runs



Setup

- Offline threshold setup:
  - Measure trigger rate without beam
  - Measure beam rate
  - Calculate threshold such that $r_{beam} > r_{noise}$
  - Minimal online retuning required
- Common threshold per chip
  - No threshold adjustments during scan
- Very low resulting threshold
  - Large number of noise hits in data



DESY

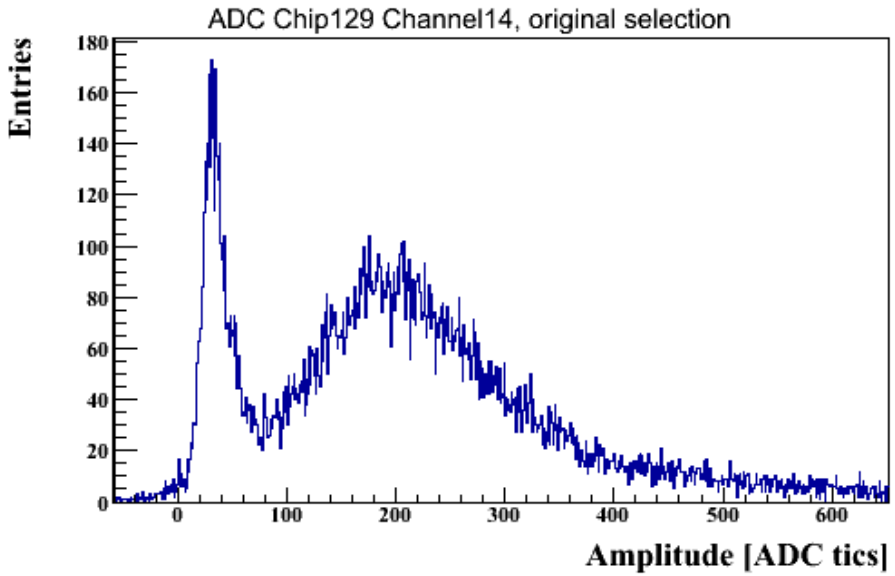
Selection Strategy

Strategy based on two properties of MIP like particles:

- MIPs generate straight tracks
  - This setup: (nearly) perpendicular to layer structure
  - Only need to know where
  - Selection based on spatial distribution
- MIPs move fast
  - Hits from same particle narrowly distributed in time
  - Noise has uniform time behaviour
  - Selection based on hit timing distribution (SPIROC feature)

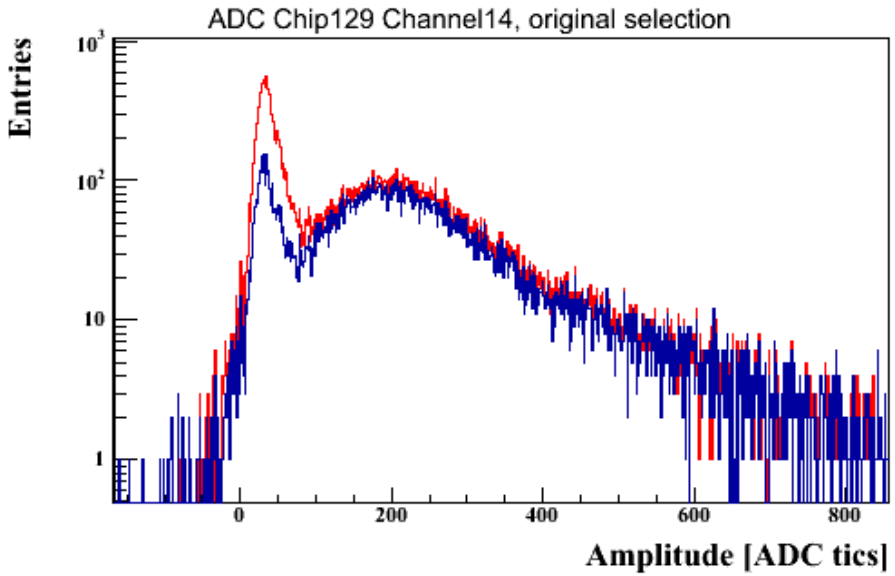
Spatial Selection: Beam Position

- Selecting hits at (known) beam position
  - Nice Separation of signal and noise contributions
- Losing signal statistics
  - Beam spot larger than tile
  - Acceptable here, but:
- Does not work for larger beam spot
  - e.g. CERN muons
- Need dynamic tower finding
  - Track fit optimal but complicated
  - Looking for simpler methods



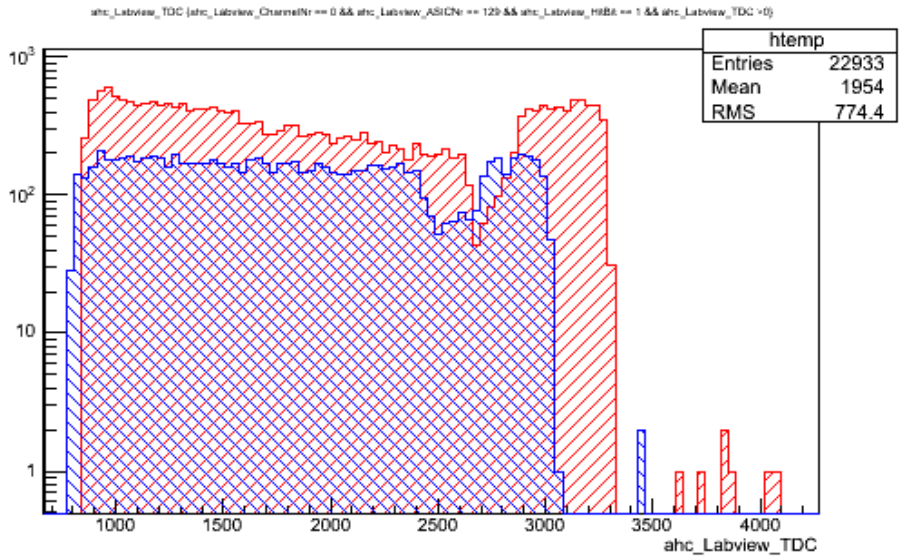
Spatial Selection: Single Tower Finder

- Idea: find best tower per event
  - Maximize number of hits in tower
  - No prior knowledge of actual beam position
- Performs worse than previous selection
  - Marginal increase in MIP statistics
  - Factor 3 increase in noise
  - Mainly ambiguities in tower findig
- Work in progress
  - Automatically improves with increasing number of layers
  - 3*3 towers considered to find slightly diagonal tracks
  - Also needs adjustments in setup of validation scintillators



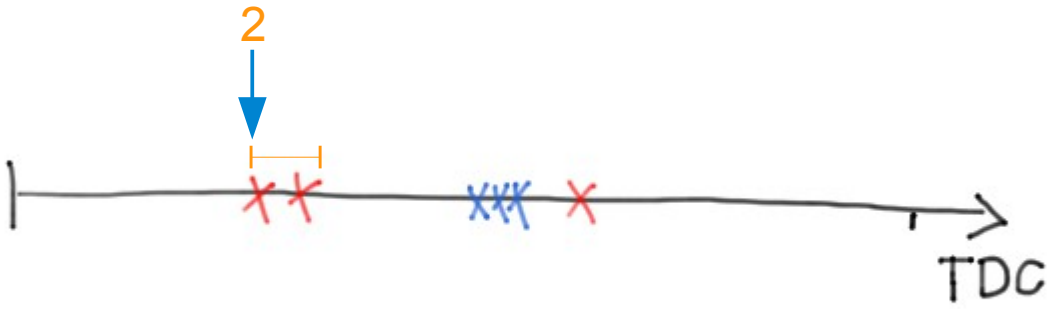
Timing Selection: Calibration

- TDC range differs from channel to channel
  - Hit timing selection needs TDC calibration
- Simple calibration employed
  - Edge detection on TDC spectra
  - Min-max mapping
  - Works directly from data
- Full TDC calibration
  - In progress for hadron shower timing data
  - Not easily transferable



Timing Selection: Idea

- Use hit timing distribution in event for further noise reduction
  - Beam hits are simultaneous, noise is uniform
  - Searching for spikes/clusters in TDC spectrum
  - Working on spatial preselection, event by event
- Time clustering:
  - Sliding window approach
  - Maximize number of hits within window of width W_{max}



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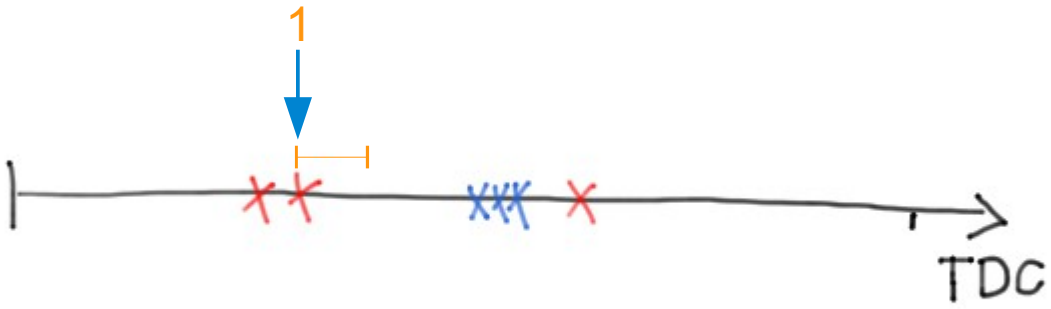

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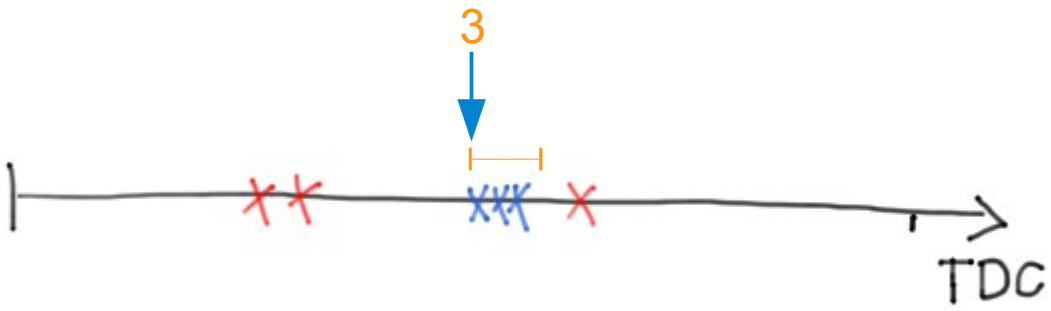

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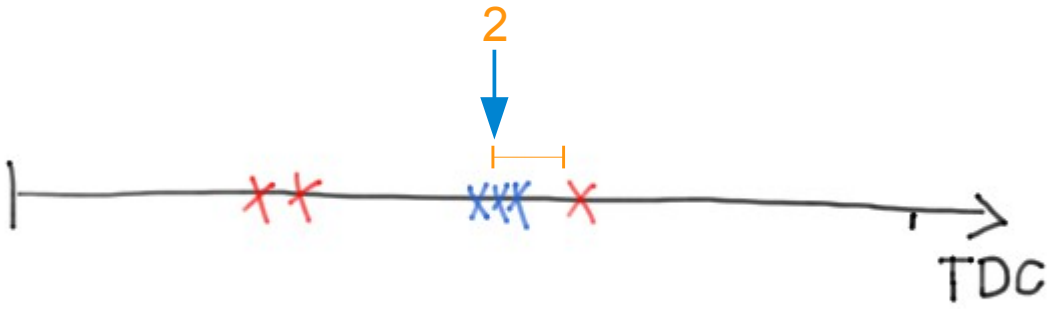

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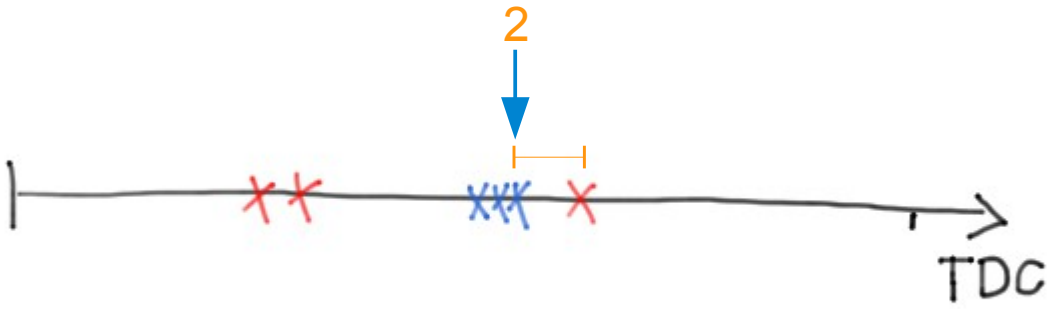

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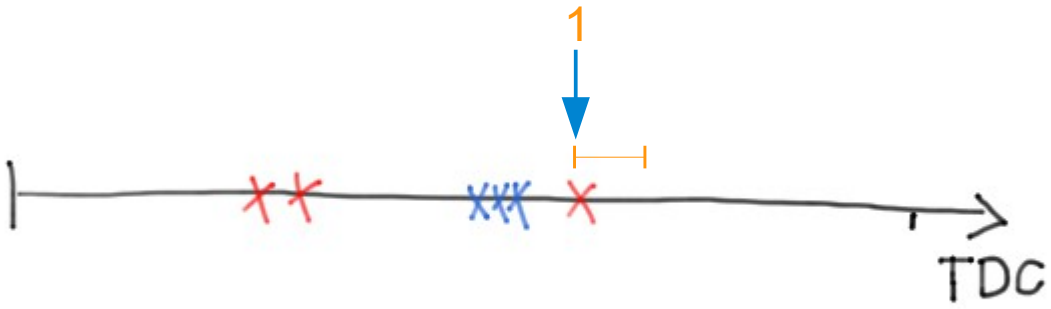

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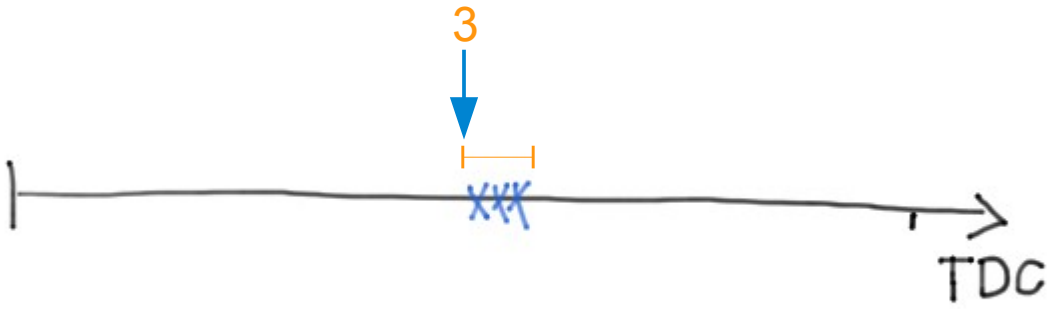
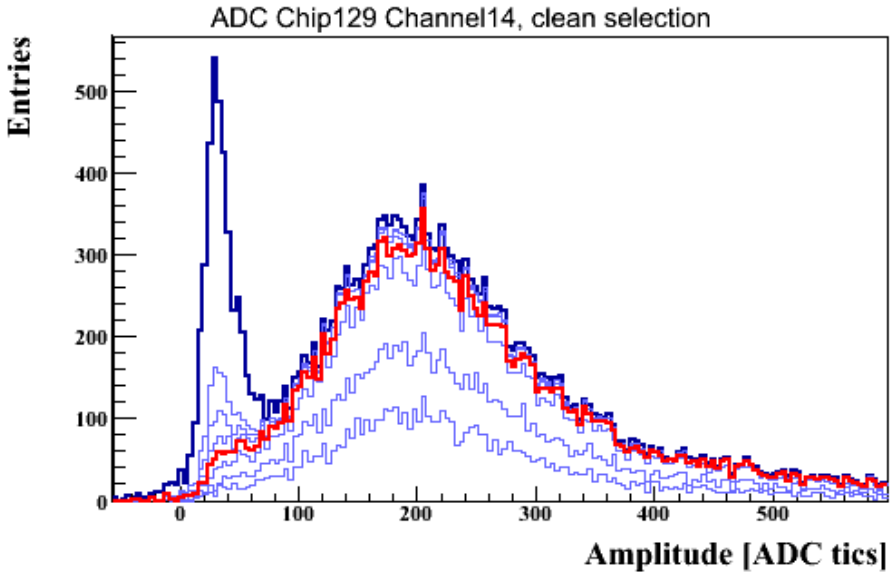


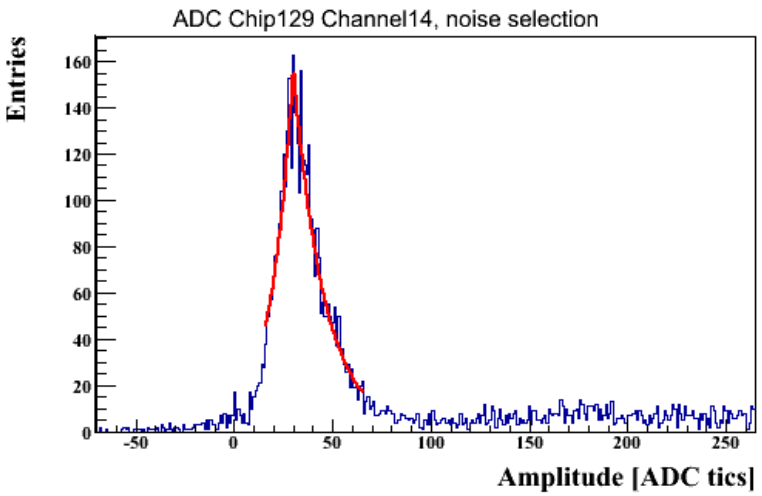
Timing Selection: Cut Parameter Variation

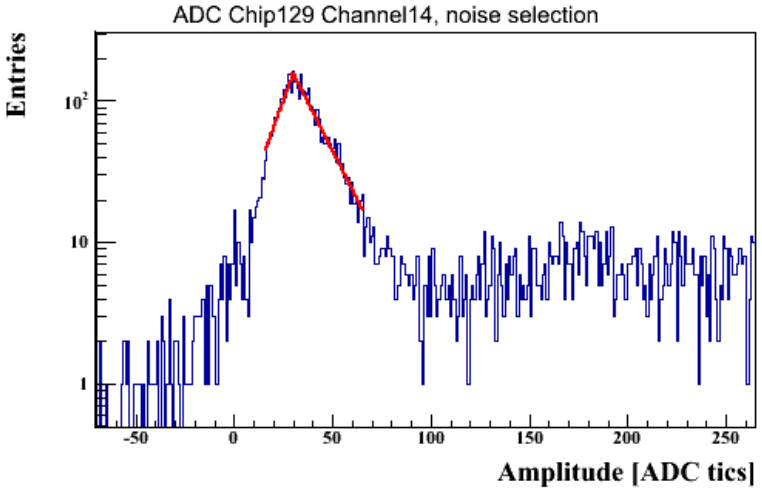
- Variation of W_{max}: 400ns, 200ns, 100ns, 50ns, 20ns, 10ns, 5ns
  - No significant loss of MIP statistics down to W_{max} = 50ns
  - Optimal setting of W_{max} depends on quality of TDC calibration
- Nearly noise free MIP sample!
  - Inverse selection yields noise sample



Fit: Parametrising the Noise Peak

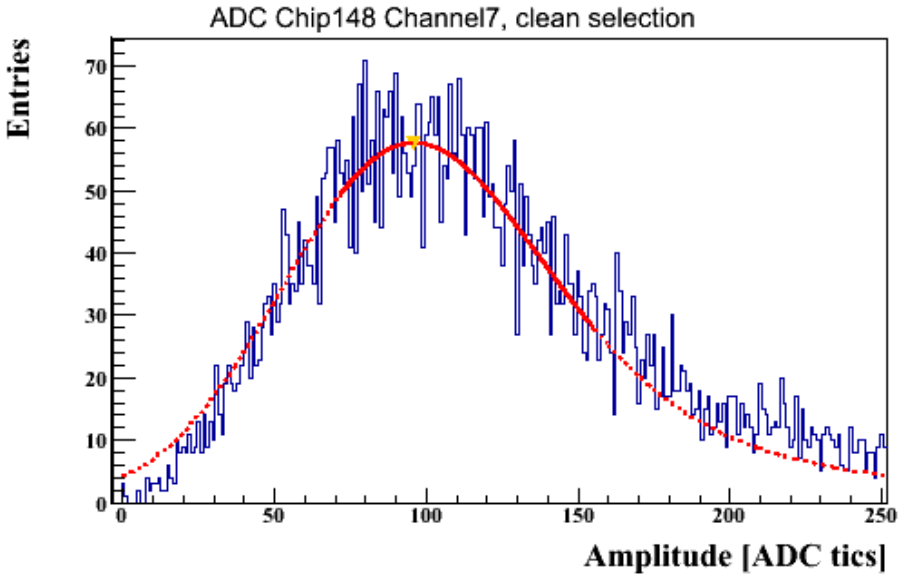
- Noise sample from inverse selection
- Parametrisation with double-sided exponential
  - Right side: Exponential drop of noise amplitude
  - Left side: Exponential trigger edge behaviour
  - Threshold position defined by meeting point





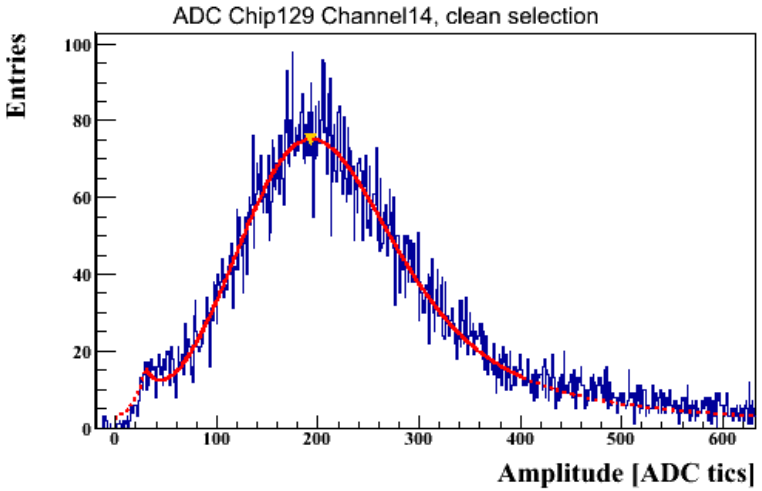
Fit: Prefitting MIP

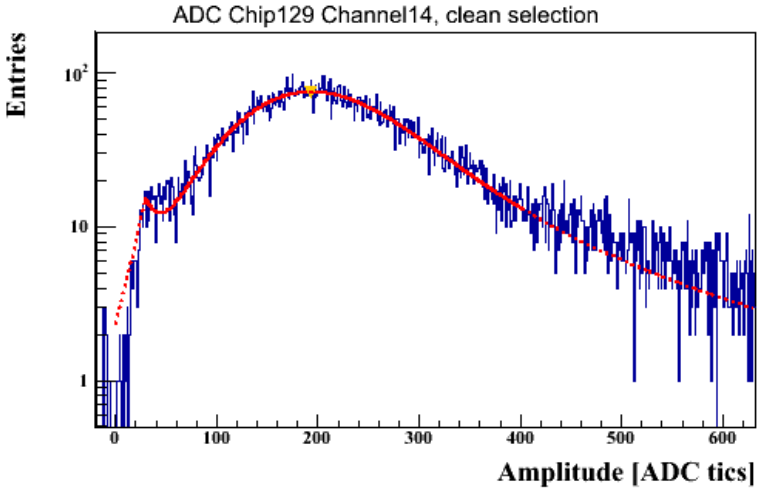
- MIP prefit performed on clean spectrum
  - Scaled noise shape subtracted additionally
  - Fit range determined from Amplitude ("Vasiliy method")
  - LandauGauss fitted to rebinned spectrum
  - Already good description of total spectrum
  - Used as parameter preset for final fit
- Used as fallback if final fit fails



Fit: Final Fit

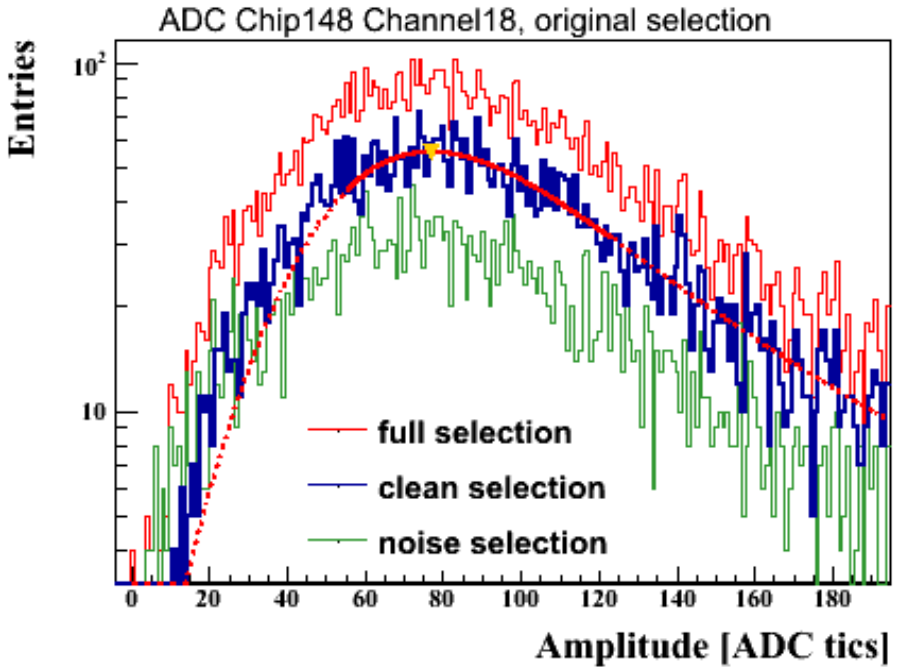
- Full DoubleExp+LandauGauss fit over large range
  - Lower fitrange from threshold position
  - Upper fitrange from amplitude
  - Starting parameters from prefits
  - Noise shape fixed, only noise amplitude fitted
- Excellent description of measured spectra
  - Slight underestimation of tail
  - Multi-particle contributions?
  - Limitation of LandauGauss parametrisation?
  - 3GeV electron is not a MIP





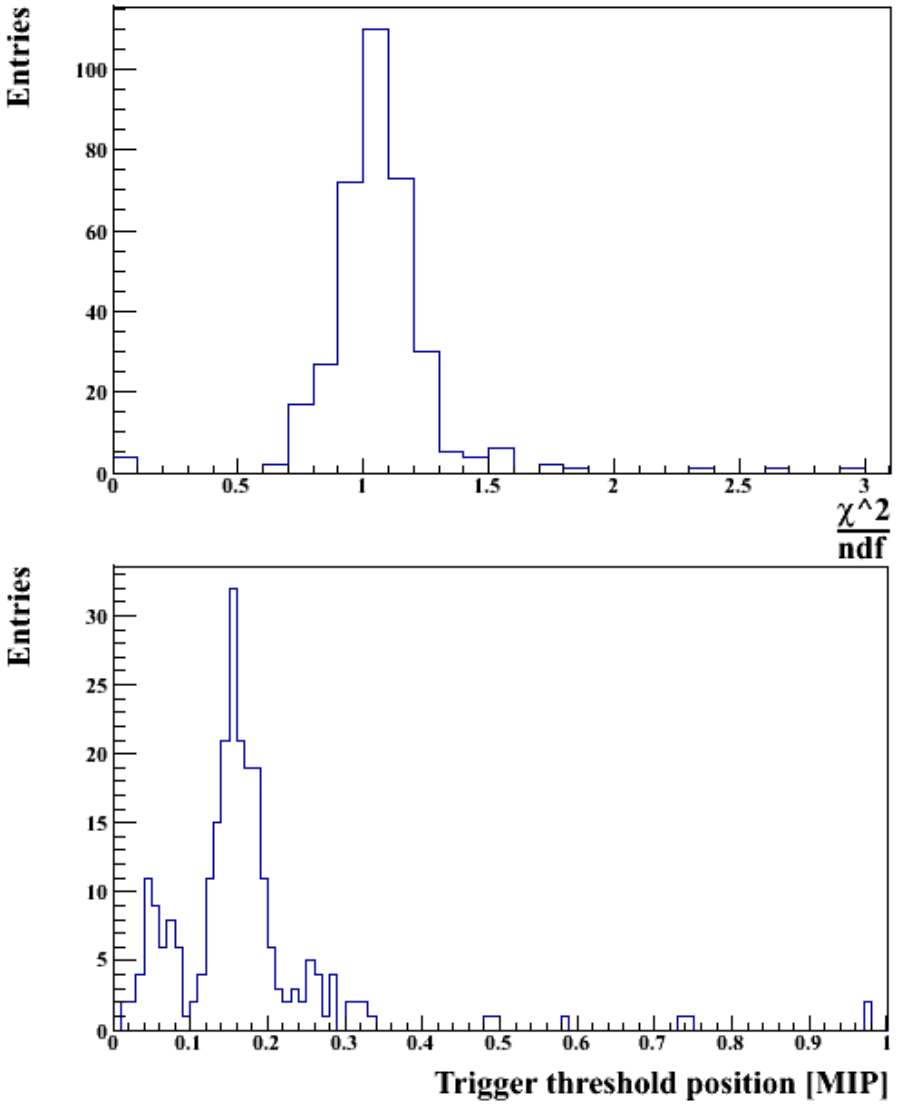
Fit: Fallback Fit

- Some channels show no clear noise peak in original preselected spectrum
  - Tile MIP response too low
  - Misconfiguration of exchanged chips
- If shape of noise selection too similar to clean selection:
  - Noise parametrisation would bias MIP position
  - Use simple fit without noise parametrisation
  - Reduced range → MIP prefit



Fit: Statistics

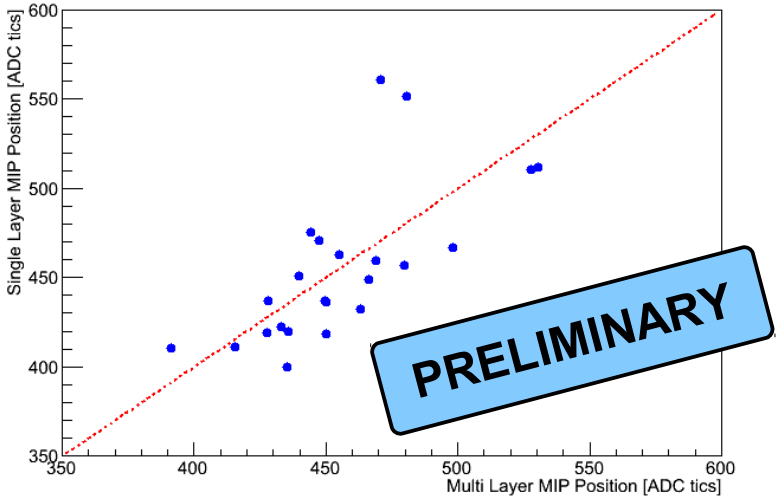
- 363/400 channels show signal
- 254/363 channels fitted “in full glory”
  - Most failed full fits on exchanged chips
- 356/363 fits give $Chi^2/ndf < 2$
  - Mean 1.059
- Mean threshold position: 0.16MIP
  - Only full fitted channels considered

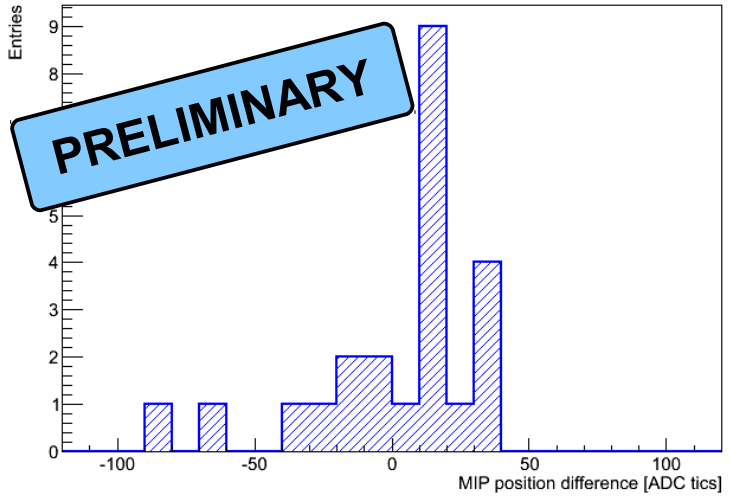


Results: Previous Single Layer Calibration

- Boards VI..IX were calibrated in single layers as preparation for CERN beam
- Comparison to MIP positions from this beam
  - No pedestal subtraction performed
  - No temperature correction implemented yet
  - Older calibration done at significantly higher trigger thresholds, no timing selection → less stable fits
  - Several chips have been exchanged but were not recalibrated yet (IDAC, preamps)

HBU2_VI, chip 1





Summary

- Multi layer: new capabilities for clean selection of MIPs
  - Using hit timing information
  - Dynamic MIP track finding will improve with more layers
- Current total selection: ~95% noise suppression with minimal signal loss
- Stable fitting of MIP spectra
  - Large fitrange due to parametrised noise shape
  - Excellent Chi^2/ndf

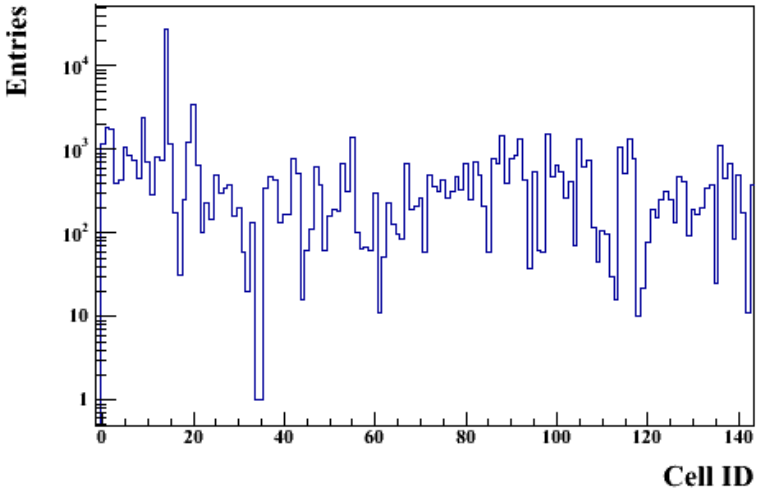
Conclusions for Next Beamtime

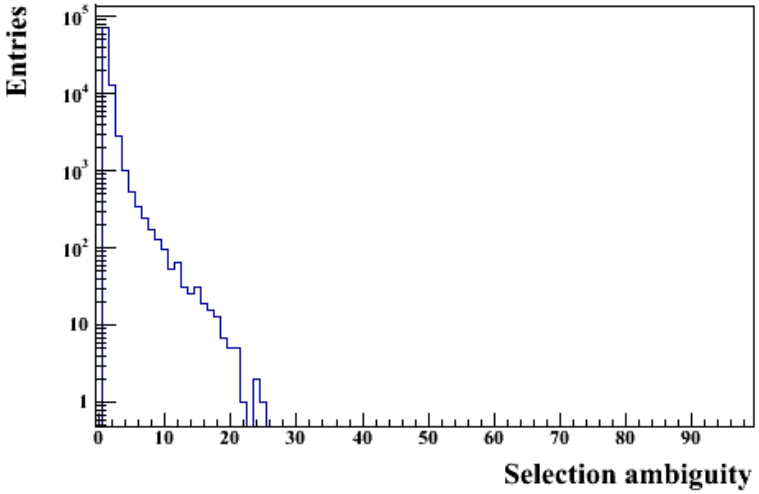
3.5 weeks of beam time starting today:

- Recheck viability of threshold setup
  - Current thresholds too low?
  - Inefficiencies in data taking (~20% of hits used per r/o cycle)
- Trigger scintillator positioning
- Check exchanged channels after IDAC recalibration
  - Board IX fully recalibrated
- Calibrate temperature readout

Spatial Selection: Single Tower Finder Issues

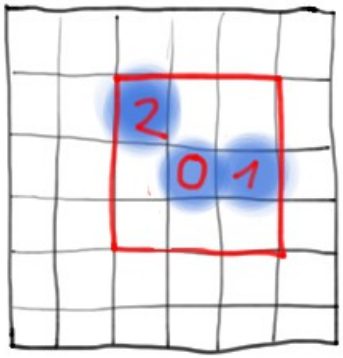
- Algorithm often selects wrong tower
  - Correct tower still most chosen
  - Loss of statistics from picking wrong tower
  - Added noise from wrong tower picks in other runs
- Several towers might have same number of hits
  - “selection ambiguity” not easily resolvable
  - Automatically improves with more layers
- Performance only slightly worse than using beam position
  - Does not select tracks traversing two towers (airstack angle misalignment)

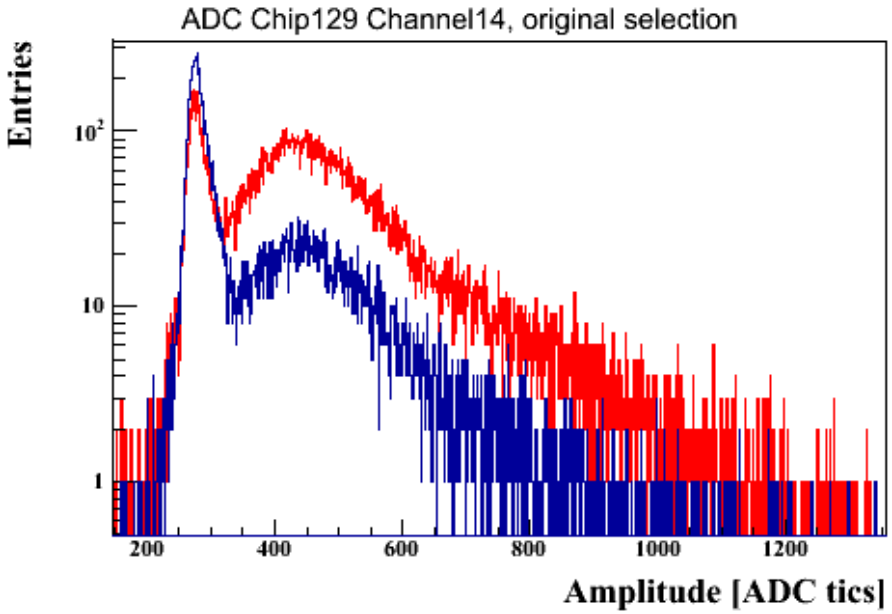




Spatial Selection: 3*3 Tower Finder

- Find best 3*3 tile tower per event
  - Can also select slightly diagonal tracks
- Hits in tower weighted by squared distance to tower center (RMS^2)
  - Best tower: lowest RMS^2
- Problem: weighting favors less hits overall
  - Best tower is single hit in one layer
- Does not work yet
  - More noise, less signal than beam position selection
  - Might scale better than single towers for more layers
- For this analysis: use known beam position selection





Timing Selection: Validation Gap

- Validation gap: unvalidated hits are accepted at the end of each bunch cycle
  - Noise hits accumulate at the end of the TDC spectrum
  - Simple cut to TDC value
- Barely effective method
  - S/N marginally improved, but losing 20% MIP statistics
  - Low thresholds → noise is validated
  - Validation tscintillator is smaller than tile → some real beam hits not validated
  - Move validation scintillators upstream?