Calibration methods for the Surface Scintillator Detector of AugerPrime

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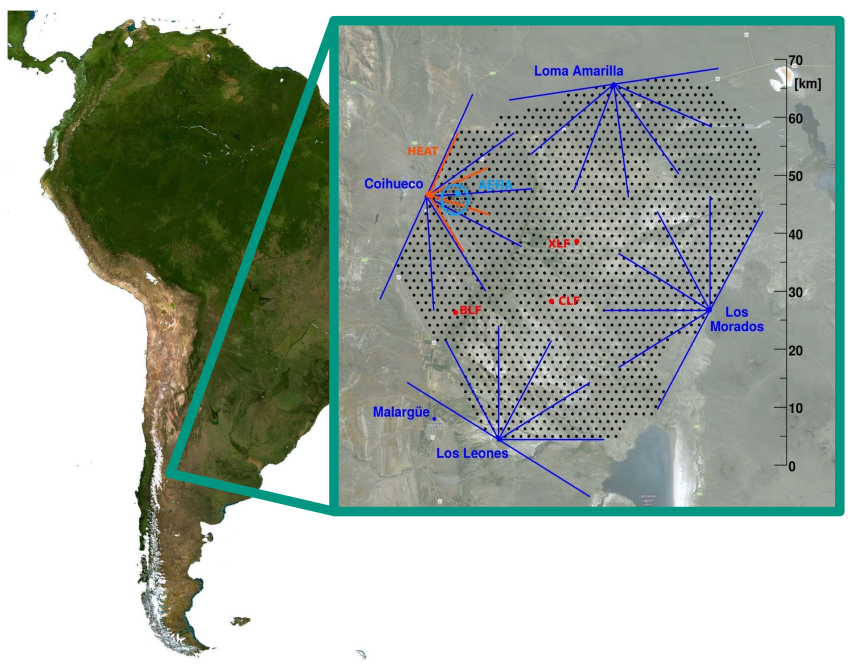
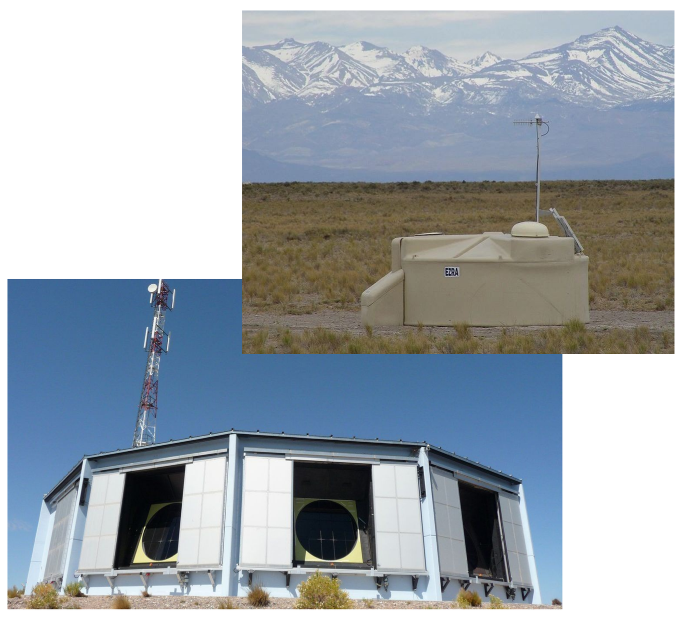
PIERRE AUGER OBSERVATORY

The Pierre Auger Observatory

Surface Detector [1]

- ~1660 surface detector stations
- daily autonomous operation
- Detect shower footprint on earth
- Multiple detection channels
- Cross-calibration via the FD





Fluorescence Detector [2]

- 27 Fluorescence telescopes
- Dedicated measurement shifts
- Observe longitudinal shower profile
- Sensitive to UV light from showers

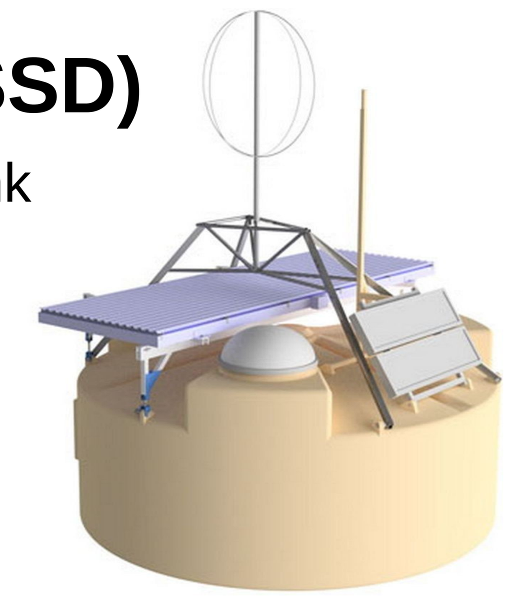
Surface Scintillator Detector

SD detector upgrade [3]

- 120 MHz sampling (was 40 MHz)
- 12-bit electronics (was 10-bit)
- Hardware: sPMT, Rd, UMD, **SSD**
- Better sensitivity to primary mass
- **See talk by D. Schmidt!**

Surface Scintillator Detector (SSD)

- Extruded polystyrene scintillator bars atop tank
- Signal readout via WLS fibers & PMT
- Very sensitive to EM component of shower
- Operated in slave mode to water tank (now)
- Dynamic range of 1 to 10 000 particles



Calib. motivation & Idea

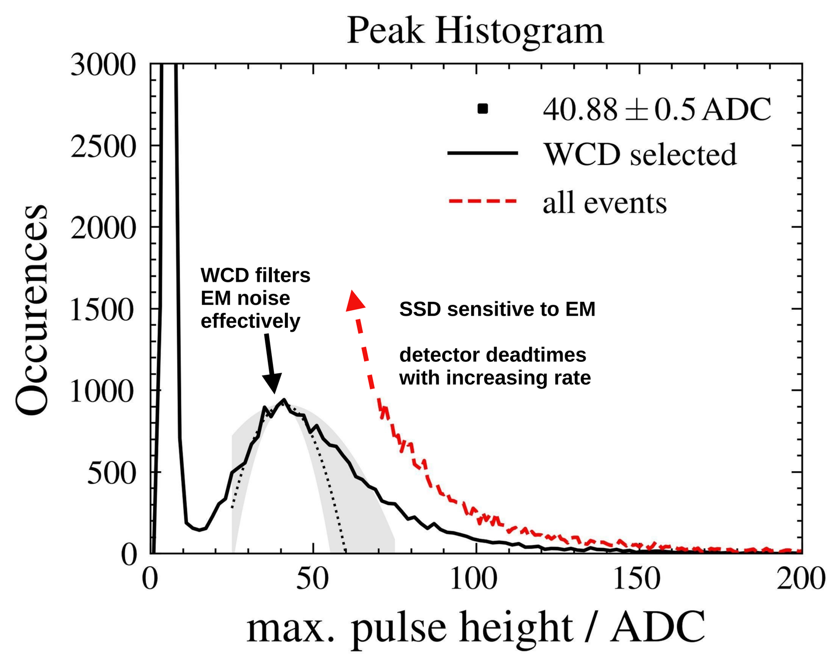
- (uncalibrated) SSD response fluctuates w/ environment
- Defines common ground during event reconstruction
- Enables monitoring + quantification of detector changes
- Allows use of SSD in trigger algorithms

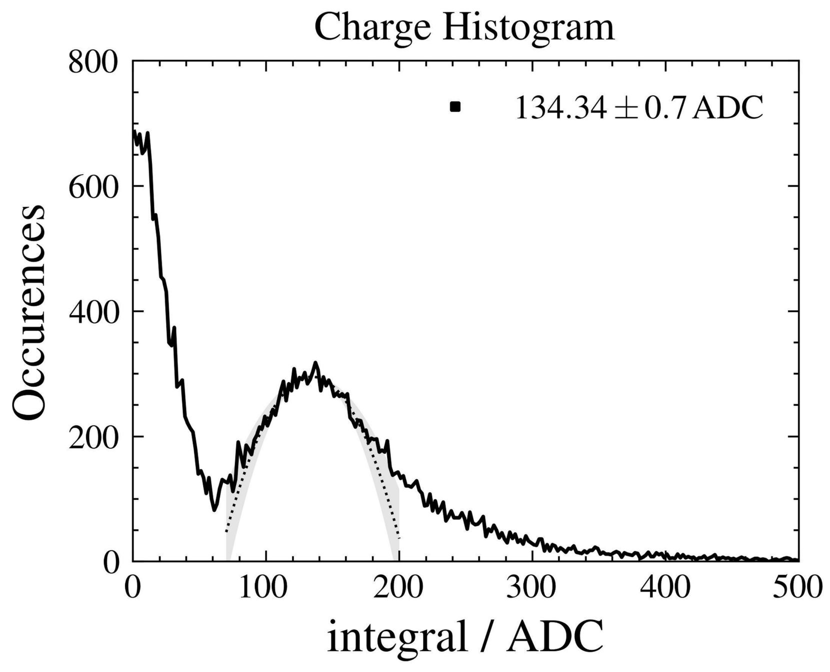
- Use atmospheric muon signals to calibrate detector
- Have sharp muon energy distribution, and good statistics

Histogram-based [4]

Building muon histograms

- Collect signals with >30 ADC in WCD
- Calculate max. pulse height (peak) and integral (charge) for each signal
- Log distribution of peaks and charges
- Restart process after set period of time



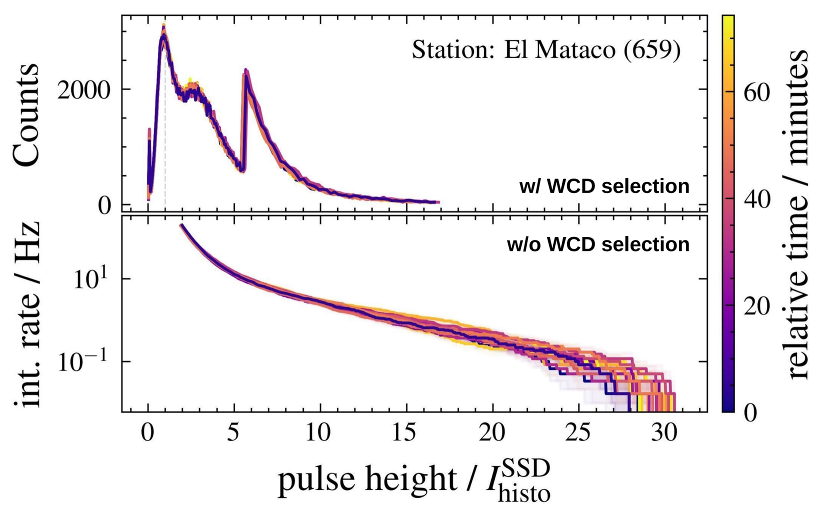


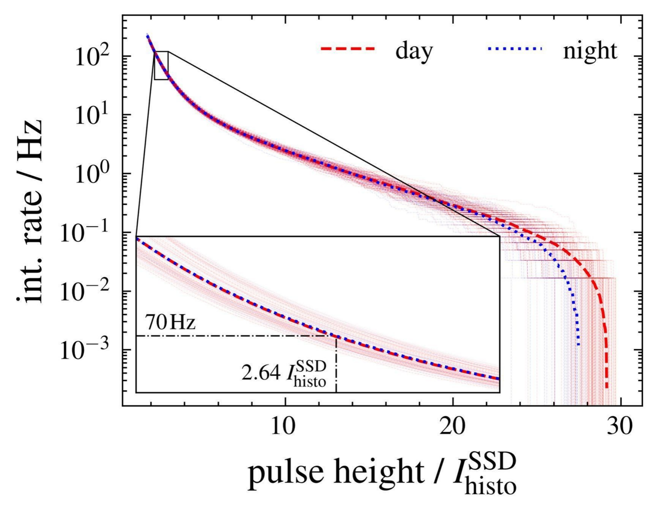
Fitting the muon hump

- Muons have characteristic energy deposit
- Visible in distribution of peak and charge
- Fit parabola to peak/charge distribution
- MIP given as vertex of parabola
- Statistical error of ~1% on fit result

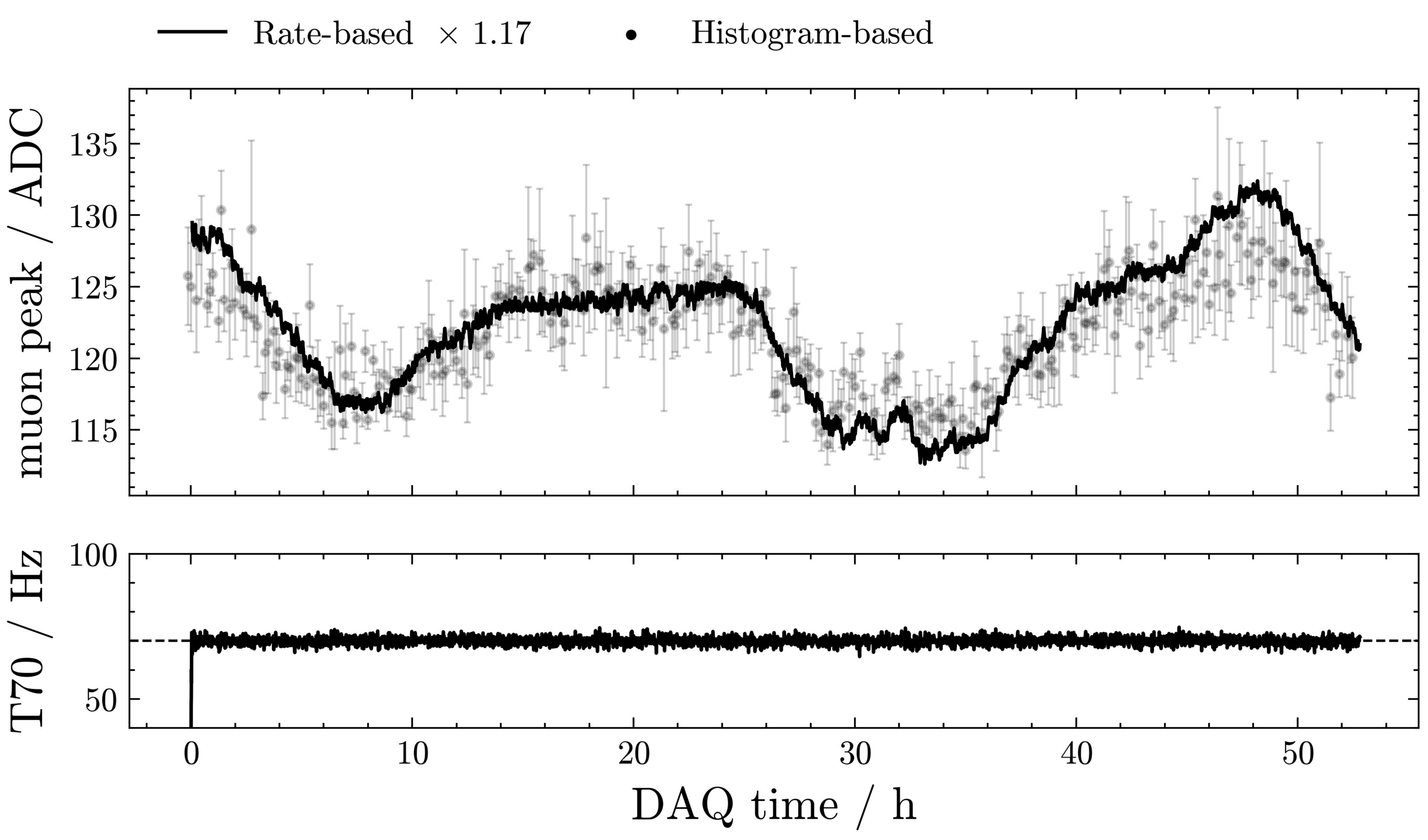
Rate-based

- Measure raw pulse spectrum of SSD events >70 ADC
- Find (calibrated) rate-threshold relationship is the same for different stations, times of day, temperature, etc.



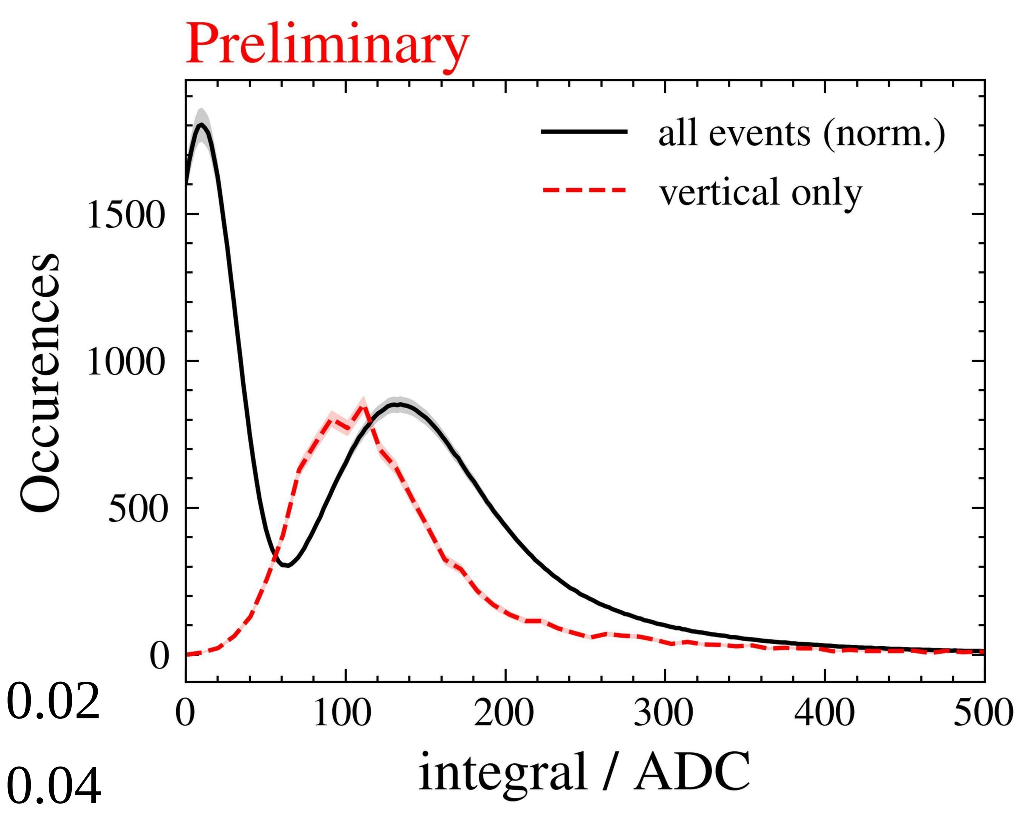


- Build calibration trigger with predefined target trigger rate
- Change calibration trigger thresholds until rate converges
- Read off MIP peak from rate-threshold relationship
- Need further testing/checks before final implementation



Vertical vs. Omnidirectional MIP

- Deposited signal (~ track length in SSD) dependent on arrival direction
- Have superposition of all arrival directions, omnidirectional MIP
- Determine conversion factor via coinc. measurements @ Gianni Navarra



- Correction factor peak: 1.16 ± 0.02
- Correction factor charge: 1.19 ± 0.04

References

[1] I. Alekotte et al., *Nucl. Instrum. Methods Phys. Res. A*, **586** (2008) 409-420
[2] J. Abraham et al., *Nucl. Instrum. Methods Phys. Res. A*, **620** (2010) 227-251
[3] A. Castellina [Pierre Auger Collaboration], *EPJ Web Conf.*, **210** (2019) 06002
[4] X. Bertou et al., *Nucl. Instrum. Methods Phys. Res. A*, **568** (2006) 839-846