SSD online calibration

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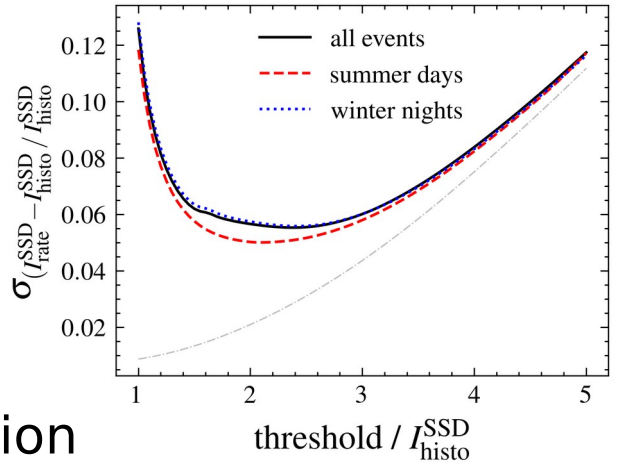
Outline

- Introduction
- First point
  - Discussion
- Second point
- Summary and outlook

Motivation + Review



- Require SSD online calibration for Phase II
- Enable monitoring + triggering on scintillators

- Propose rate-based algorithm for SSD online calibration
- First results on expected performances in GAP2024-023
  - Build algorithm from rate/threshold-relationship in muon histos
  - Bias resolution on online MIP peak of ~6% for **all** SD-1500 stations

- **But!** Muon histos acquired from triggers in WCD
  - Only have fraction of data measured by SSD (coincidences with WCD)
  - Hidden problems from adopting WCD systematics/calibration?

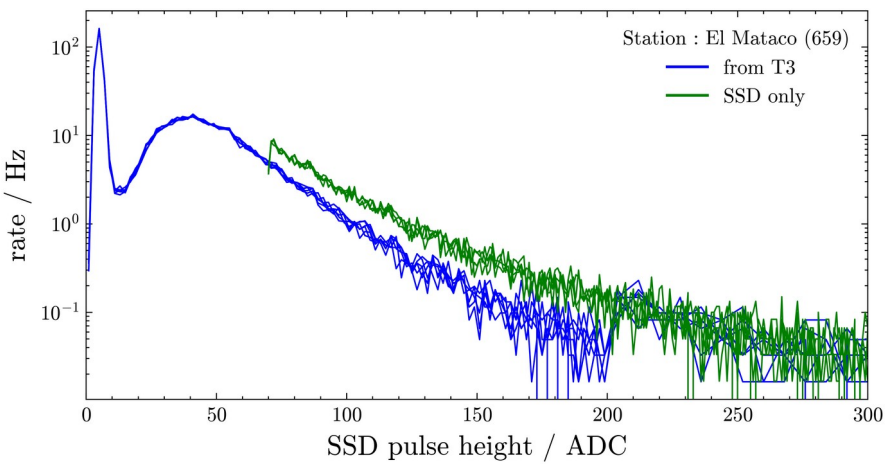
WCD independent online calibration of the SSD

- Different detectors! MIP peak shouldn’t rely on WCD
  - Calibration events currently selected from triggers in WCD
  - Headaches from dealing with masked WCD PMTs?

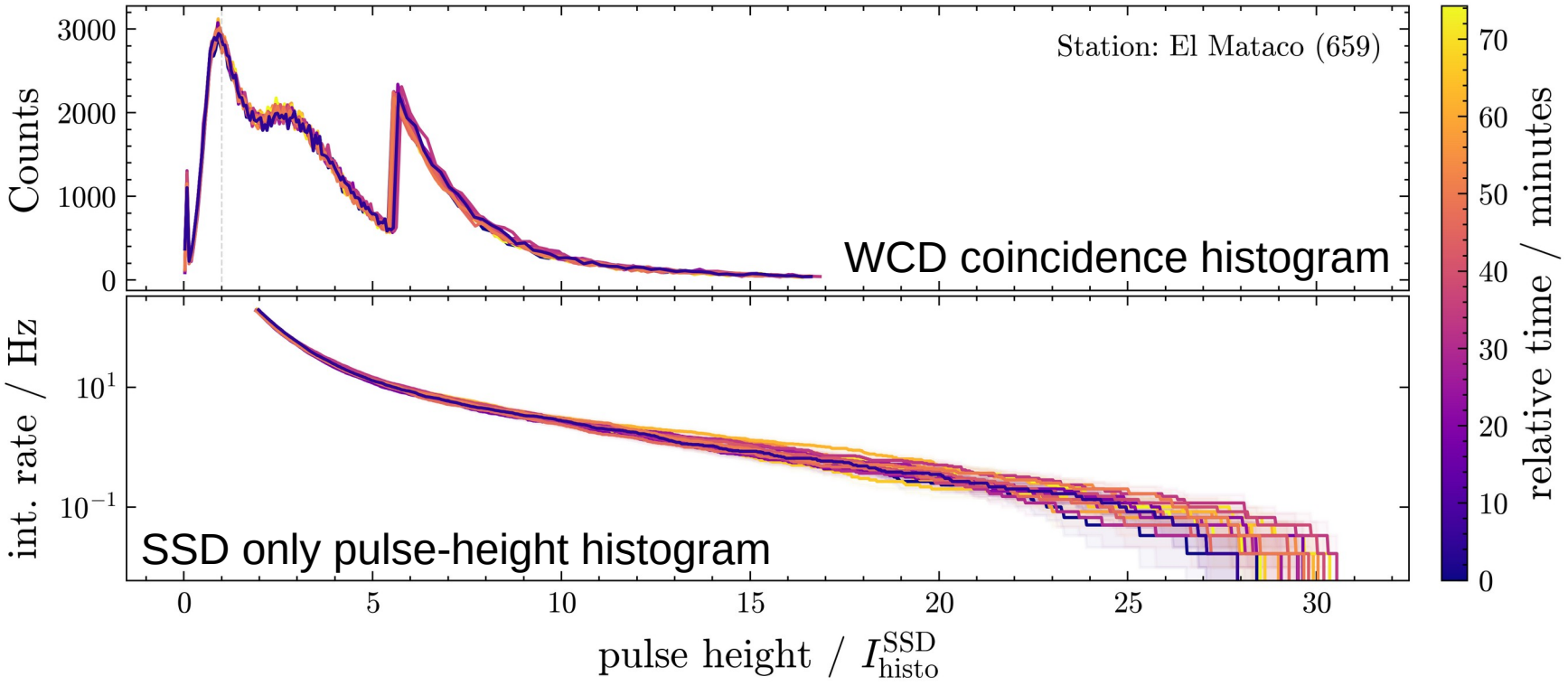
- MIP peak more variable than VEM peak
  - SSD more sensitive to EM component
  - Fluctuations too large to allow reliable calibration?
  - Only option to rely on WCD calibration?

MuonAcquisition in Malargue

- Connect 8 Infill stations to separate CDAS instance
- Raise some standard muon histograms via forced T3
- Run special program on individual stations
  - Enable 2nd trigger mode (SSD only) on FPGA
  - Read out **muon histogram**
  - Save **SSD pulse-heights**
- Use **SSD only pulse-height histogram** for rate/threshold relationship and online MIP



Sanity checks on measured data



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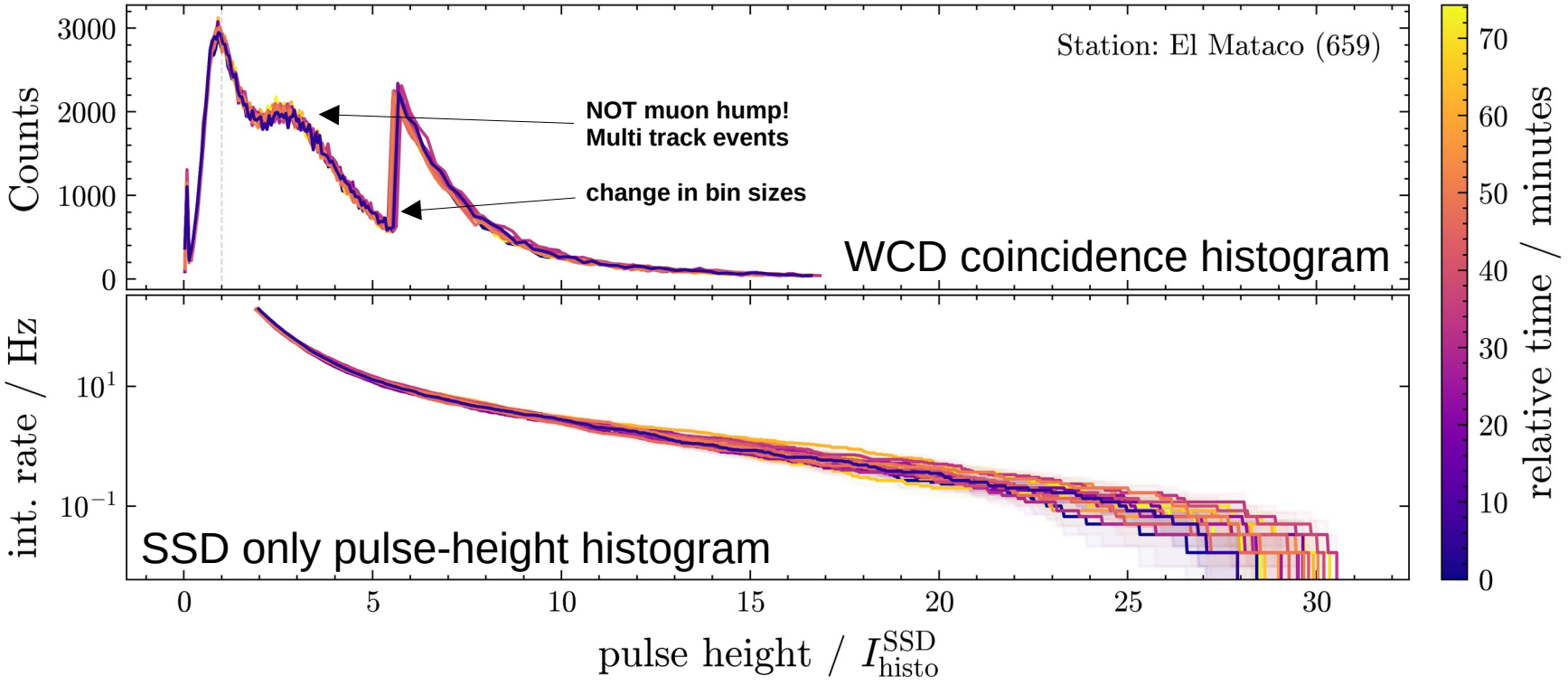
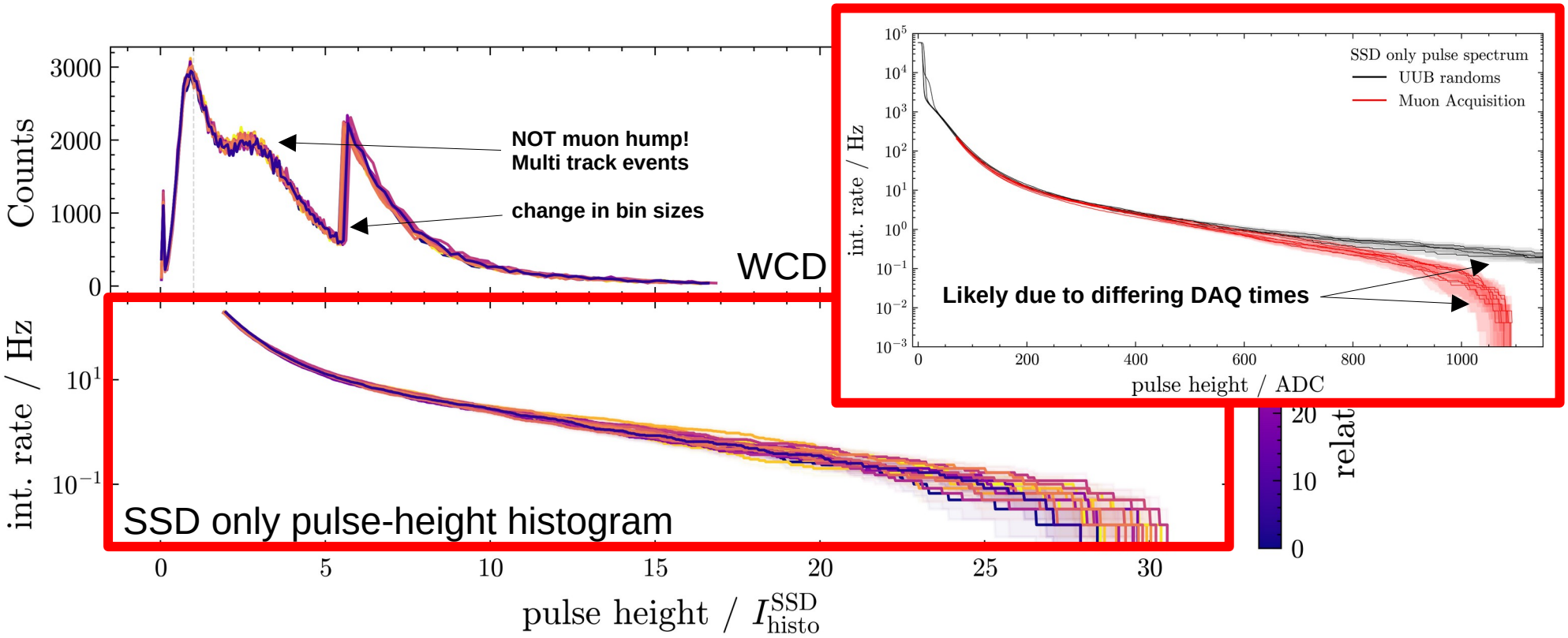
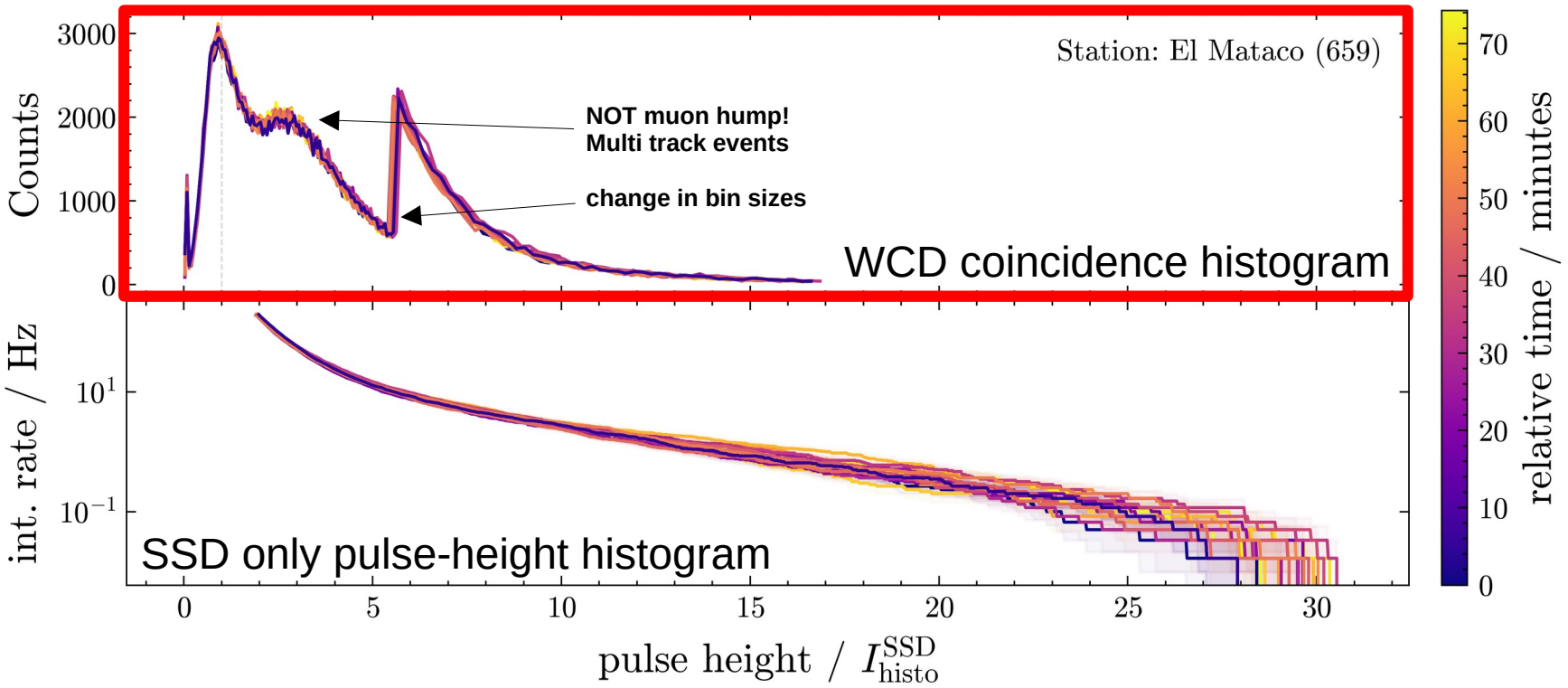


Sanity checks on measured data



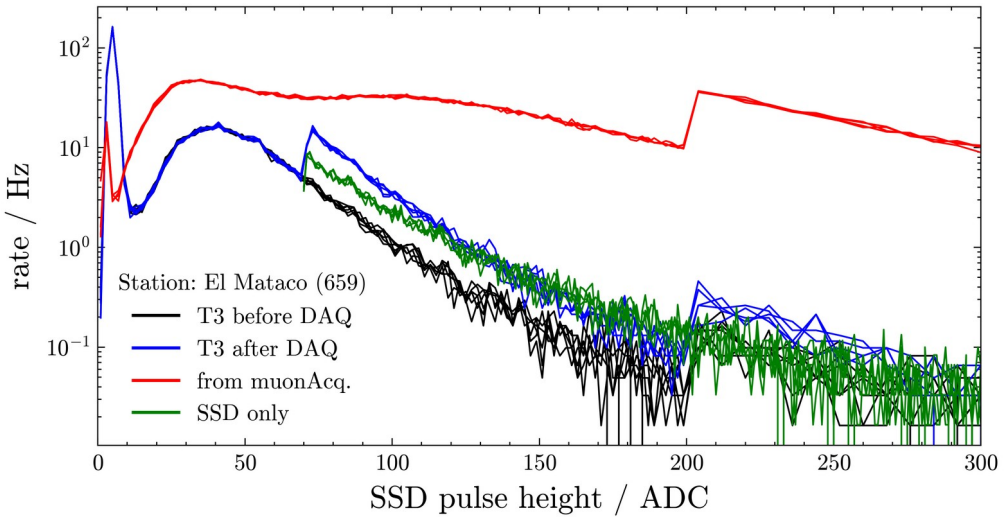
- SSD only histograms look as expected from UUB randoms

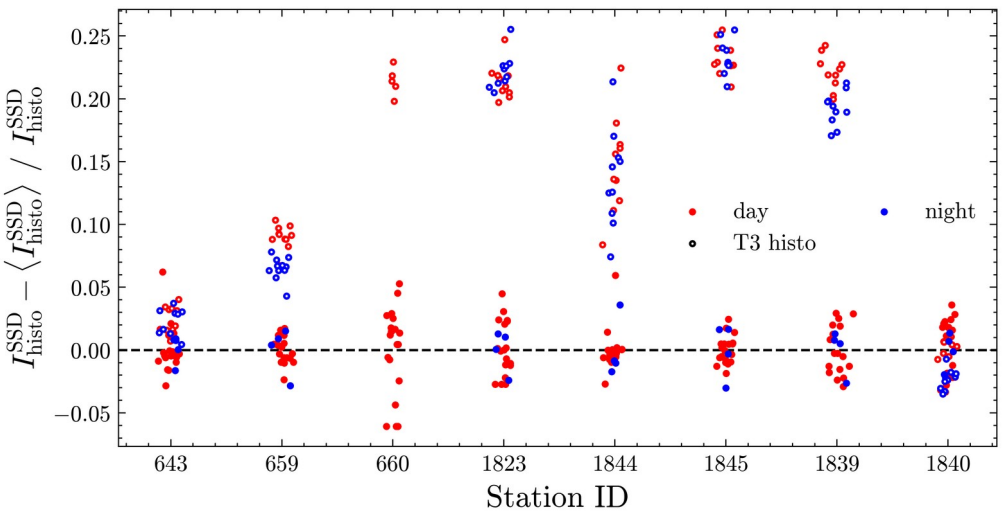
Sanity checks on measured data



- WCD coincidence histogram differ from T3 histograms

Sanity checks on measured data

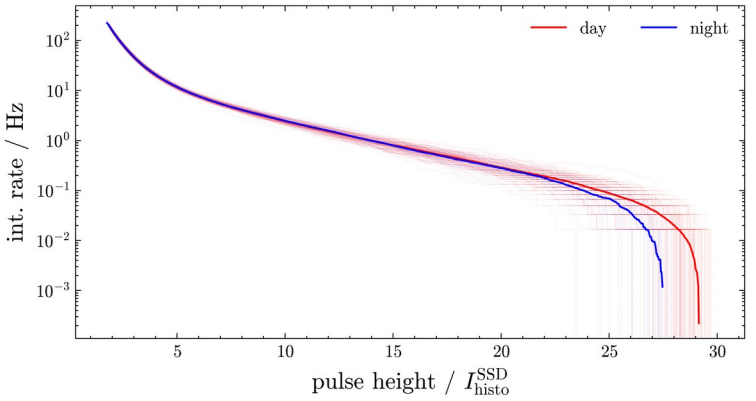




- Significant difference between histograms from **muonAcquisition** and T3s **before**/**after** DAQ
  - Station dependent bias of location of MIP peak?
  - Ongoing investigation of what went wrong

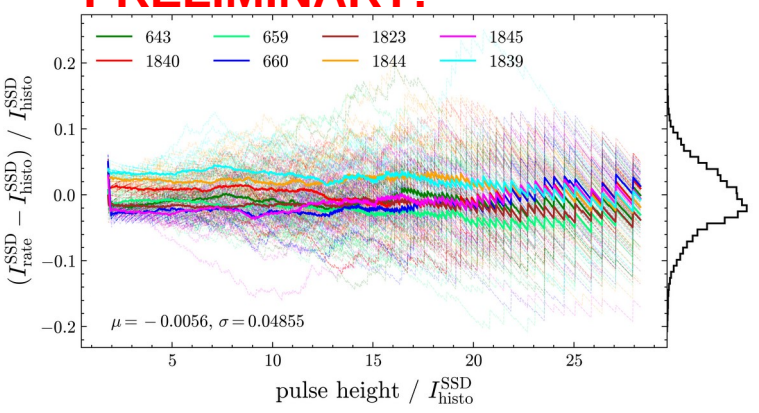
WCD independent online MIP

- Little variation between day/night
  - Lower counts at high pulse-heights expected for lower temperatures



- Use relationship to estimate MIP
  - Unbiased estimator by definition
  - Very good resolution (~5%)
  - Aliasing effects at very high pulse-heights, no trustworthy resolution
  - Resolution below 5 MIP @ ~2%

PRELIMINARY!



Summary

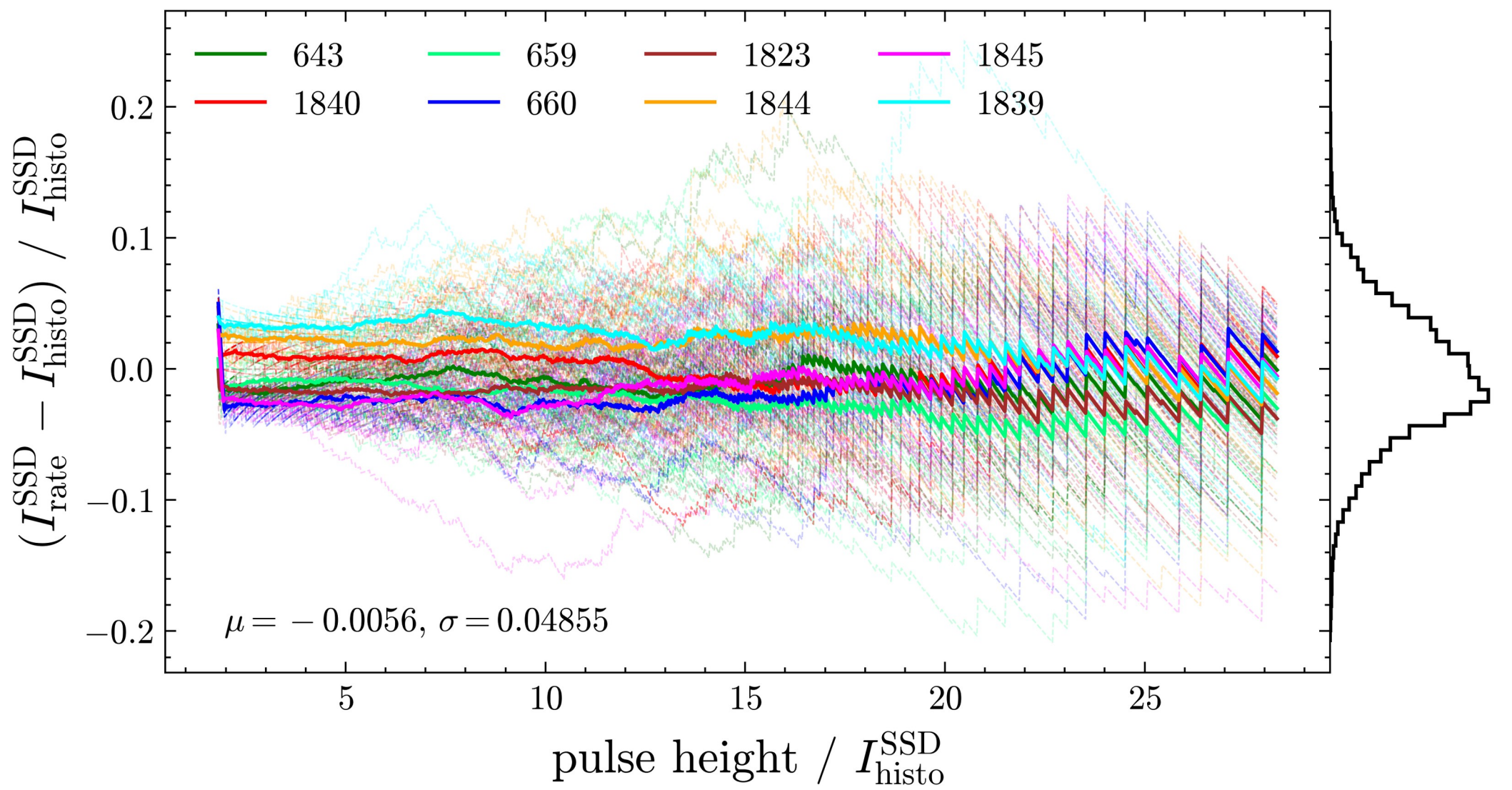
- Desire to decouple online calibration algorithms
  - Status now: everything relies on WCD triggers
  - Change in UUB DAQ software required

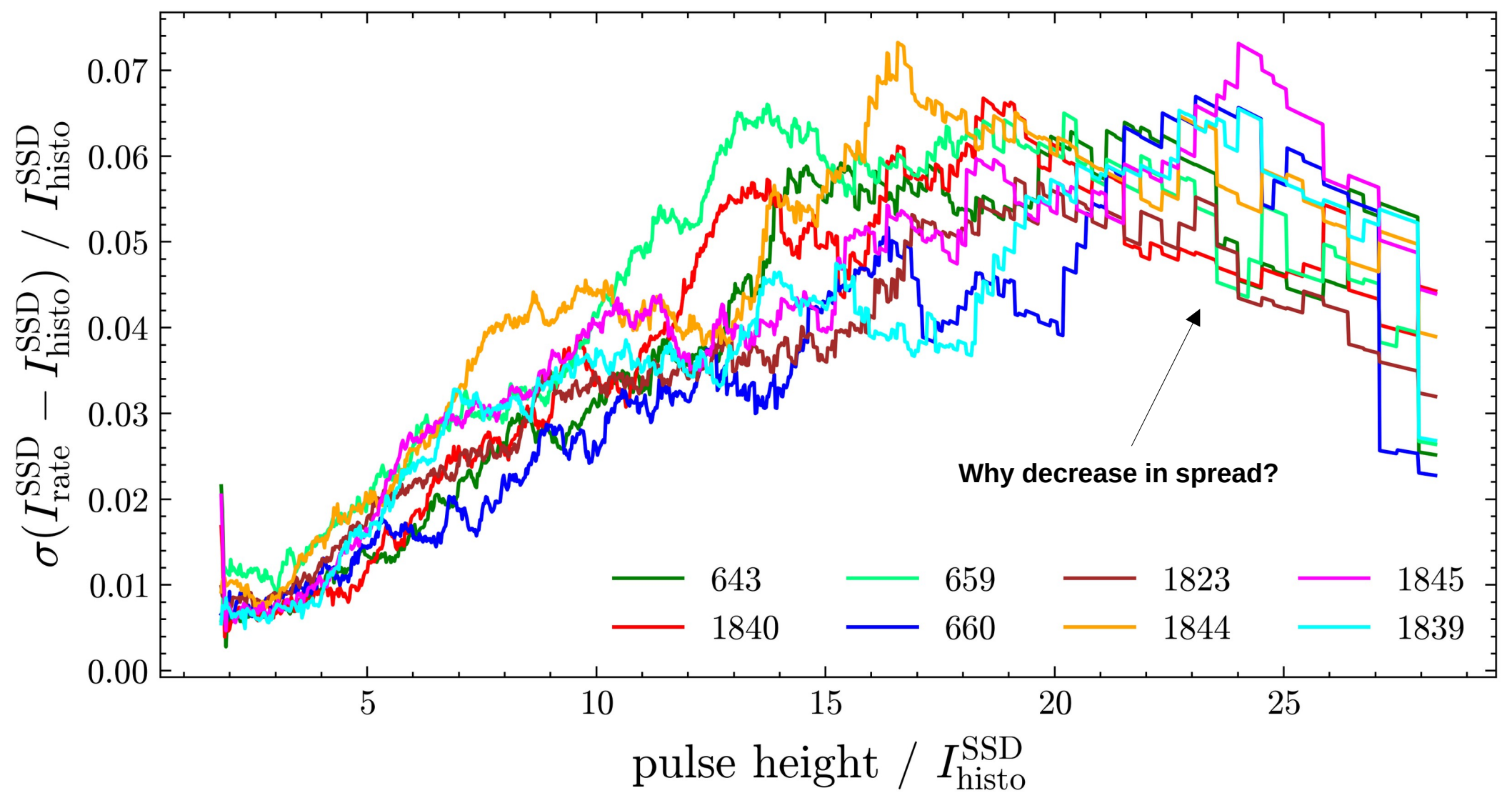
- WCD independent rate-based SSD calibration seems possible
  - Field tests show performances on par with WCD calibration
  - Bias resolution of <5% observed for selection of infill stations
  - Some phenomena not yet fully understood. Need further tests!

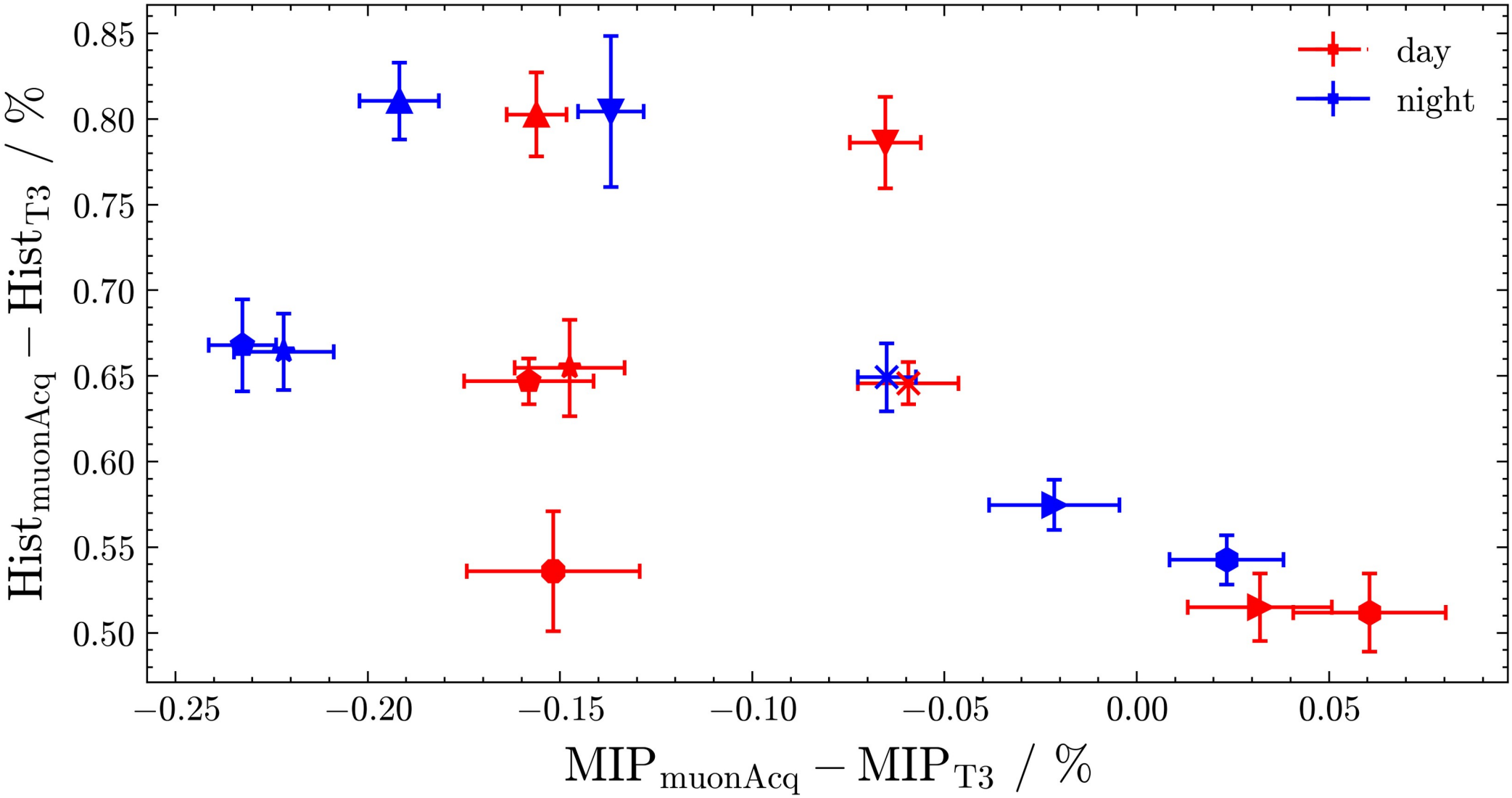
Outlook + Roadmap

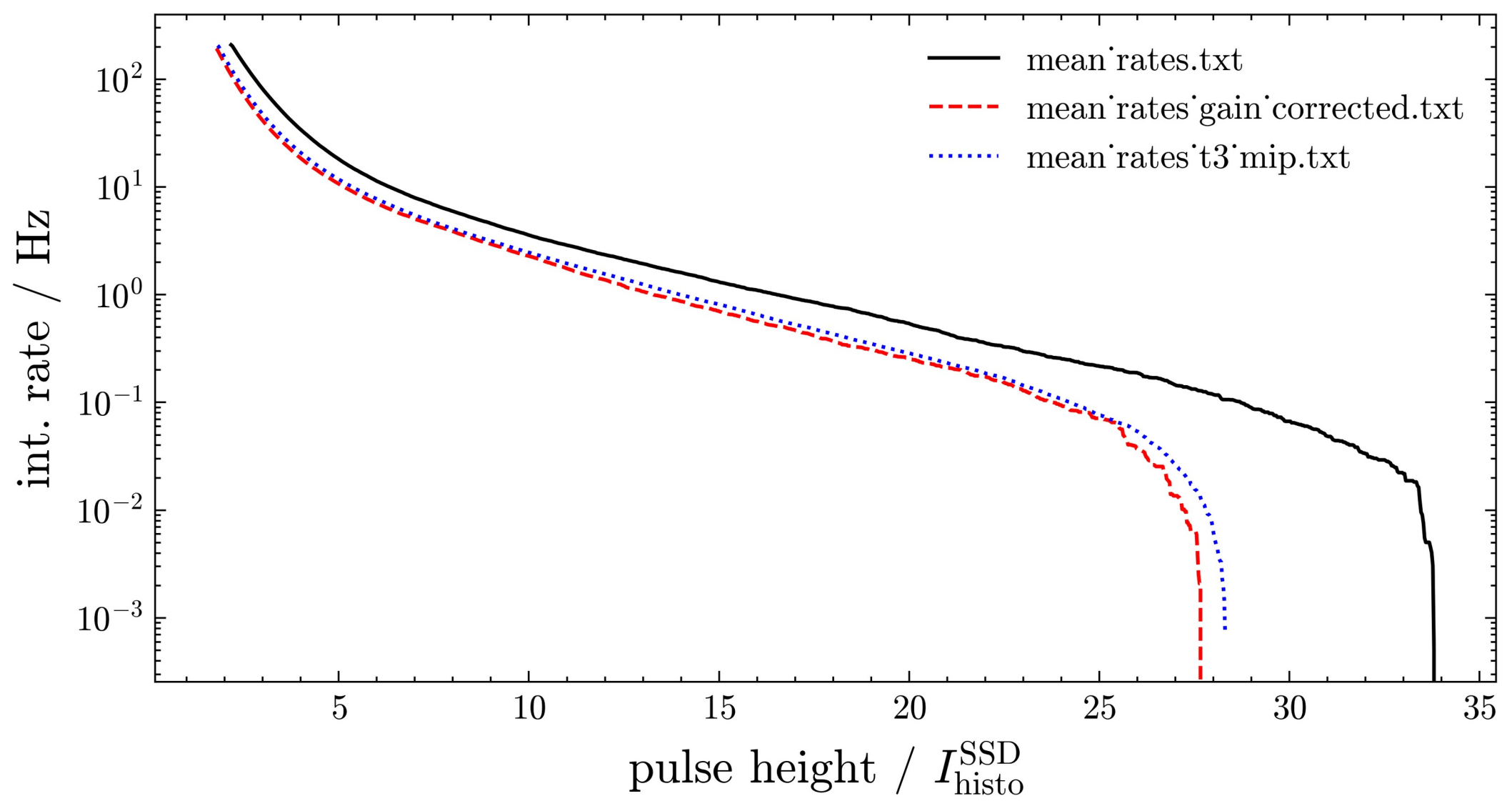
- Implement prototype SSD online calibration...
  - **... in UUB DAQ → ~2 months (before Aug.)**
    - Add event counter in **`MuonFill`** process
    - Perform rate-based estimation of MIP peak
    - Add calculated online MIP peak to Events
    - Send calculated online MIP peak to FPGA
  - **... in CDAS → ~4 months (before Nov.)**
    - Package online MIP peak in monitoring data
    - Handle change in sent data packages on CDAS side

Backup


643
659
1823
1845
1840
660
1844
1839
0.2
0.1
0.0
−0.1
−0.2
$\mu = -0.0056,\ \sigma = 0.04855$
5
10
15
20
25
$\left(I^{\mathrm{SSD}}_{\mathrm{rate}} - I^{\mathrm{SSD}}_{\mathrm{histo}}\right) \ / \ I^{\mathrm{SSD}}_{\mathrm{histo}}$
pulse height / $I^{\mathrm{SSD}}_{\mathrm{histo}}$

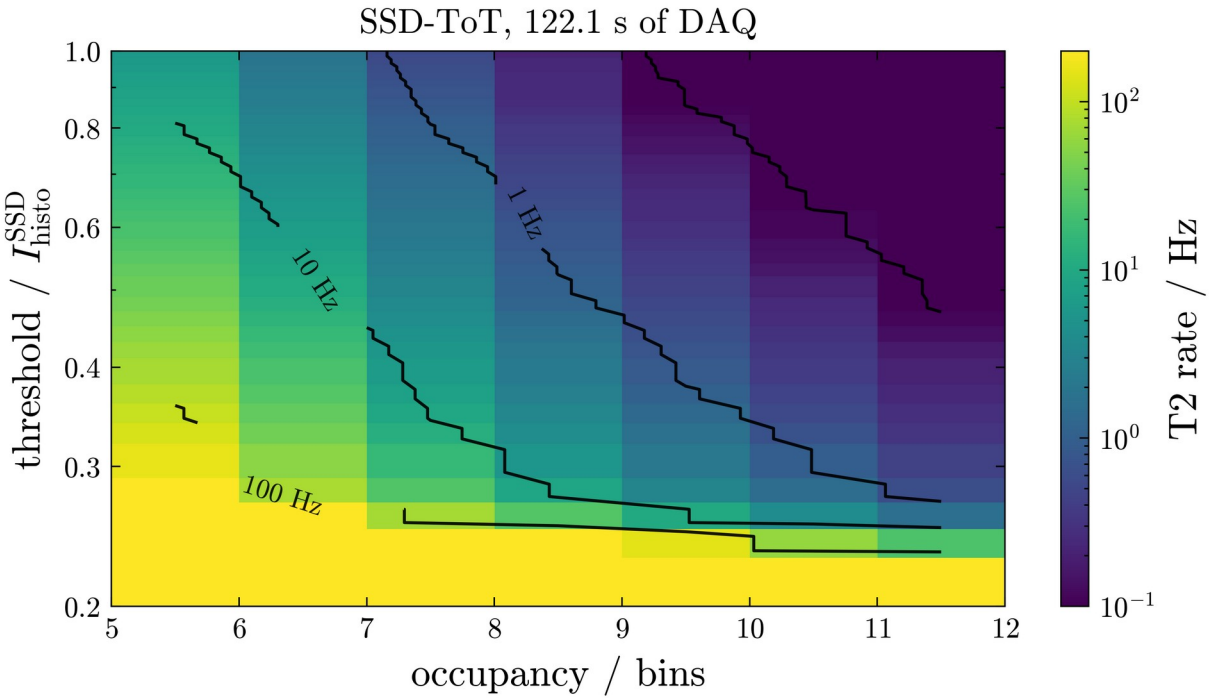

$\sigma(I^{\mathrm{SSD}}_{\mathrm{rate}} - I^{\mathrm{SSD}}_{\mathrm{histo}}) \;/\; I^{\mathrm{SSD}}_{\mathrm{histo}}$
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
5
10
15
20
25
pulse height / $I^{\mathrm{SSD}}_{\mathrm{histo}}$
Why decrease in spread?
643
1840
659
660
1823
1844
1845
1839


day
night
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
$\mathrm{Hist}_{\mathrm{muonAcq}} - \mathrm{Hist}_{\mathrm{T3}}$ / %
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05
$\mathrm{MIP}_{\mathrm{muonAcq}} - \mathrm{MIP}_{\mathrm{T3}}$ / %


mean˙rates.txt
mean˙rates˙gain˙corrected.txt
mean˙rates˙t3˙mip.txt
int. rate / Hz
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
5
10
15
20
25
30
35
pulse height / $I^{\mathrm{SSD}}_{\mathrm{histo}}$

Plan for SSD triggers

- Implement SSD triggers → **November onwards**
  - ToT-like trigger, thresholds TBD from UUB randoms



WCD ToT+ToTd rates from UUB randoms