Karlsruhe Institute of Technology

Update on an algorithm for the online determination of the MIP peak in the UUB DAQ

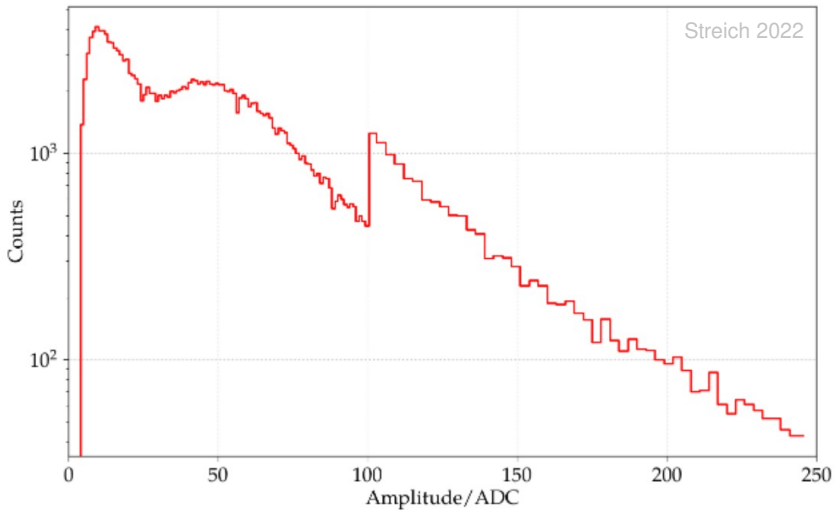
PIERRE AUGER OBSERVATORY

Paul Filip, David Schmidt

Idea & terminology

WCD offline calibration algorithm

- Fit peak of muon histogram



WCD online calibration algorithm

(1) Start with a value of $I_{\mathrm{VEM}}^{\mathrm{est.}} = 50\,\mathrm{ch}$.
(2) Measure, for each PMT, the rate of events satisfying the calibration trigger by counting these events for a time t_{cal}, initially set to 5 s.
(3) If, for a given PMT, the rate is above $70 + \sigma\,\mathrm{Hz}$, increase $I_{\mathrm{VEM}}^{\mathrm{est.}}$ by δ. Likewise, if the rate is below $70 - \sigma\,\mathrm{Hz}$, decrease $I_{\mathrm{VEM}}^{\mathrm{est.}}$ by δ, with $\sigma = 2\,\mathrm{Hz}$ and $\delta = 1\,\mathrm{ch}$ initially.
(4) If the rate of any single PMT is more than $10\,\sigma$ away from 70 Hz, adjust $I_{\mathrm{VEM}}^{\mathrm{est.}}$ by 5 ch in the appropriate direction, set t_{cal} to 10 s, $\delta = 1\,\mathrm{ch}$, and repeat from step (2).
(5) Otherwise, if $t_{\mathrm{cal}} < 60\,\mathrm{s}$, increase t_{cal} by 5 s. If $\delta > 0.1\,\mathrm{ch}$, decrease δ by 0.1 ch, and repeat from step (2).

doi.org/10.1016/j.nima.2006.07.066

Idea & terminology

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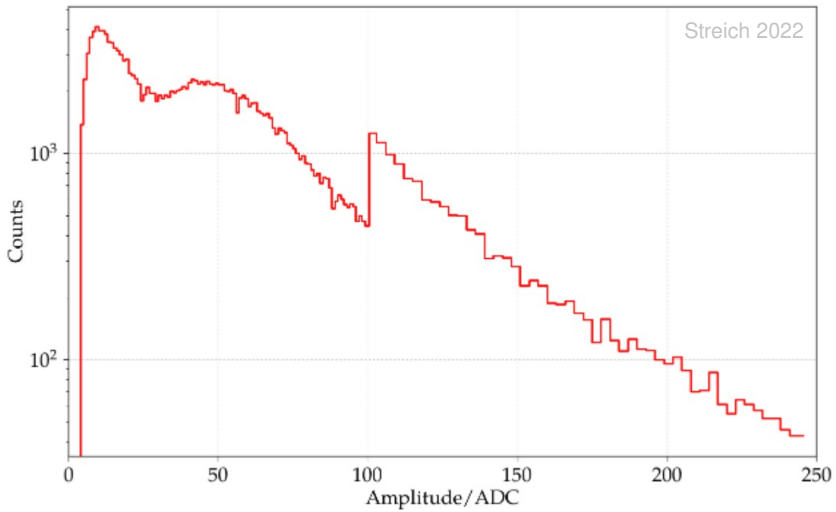

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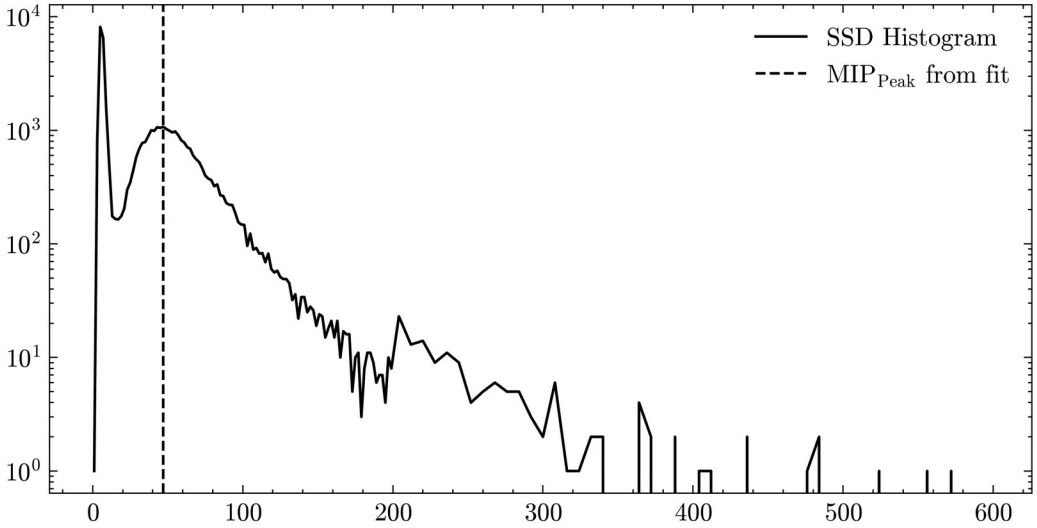
LACK THIS ALGO-RITHM FOR SSD!

Data

- T3 from {Mar, Jun, Sep, Dec} 2022/23 for 11 (10) stations ~ 150k (50k) SSD histograms
- Bootstrap muon events according to event histogram and fit MIP



- Characteristic shape

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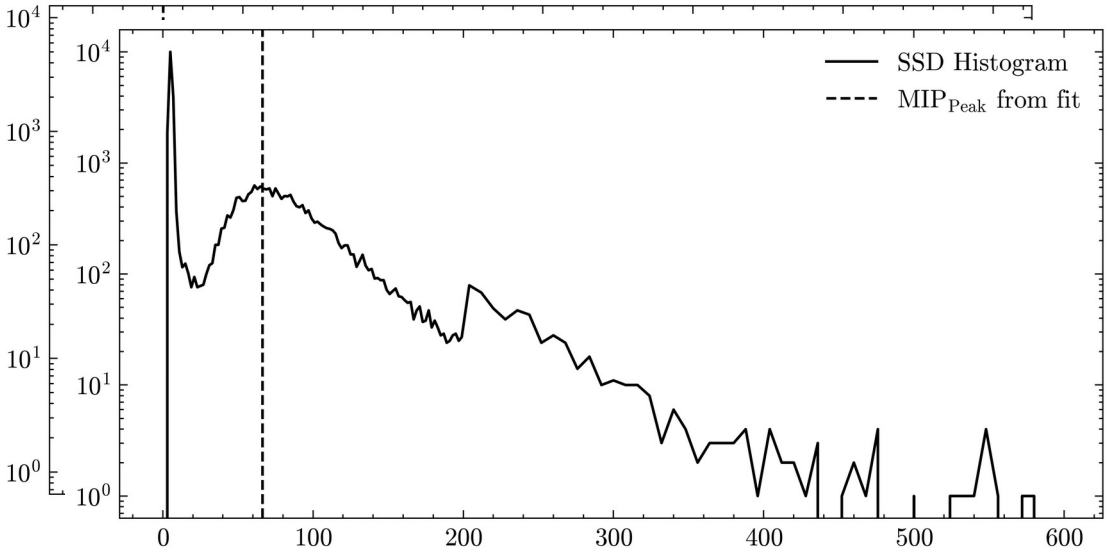

- Characteristic shape
- Differences across stations

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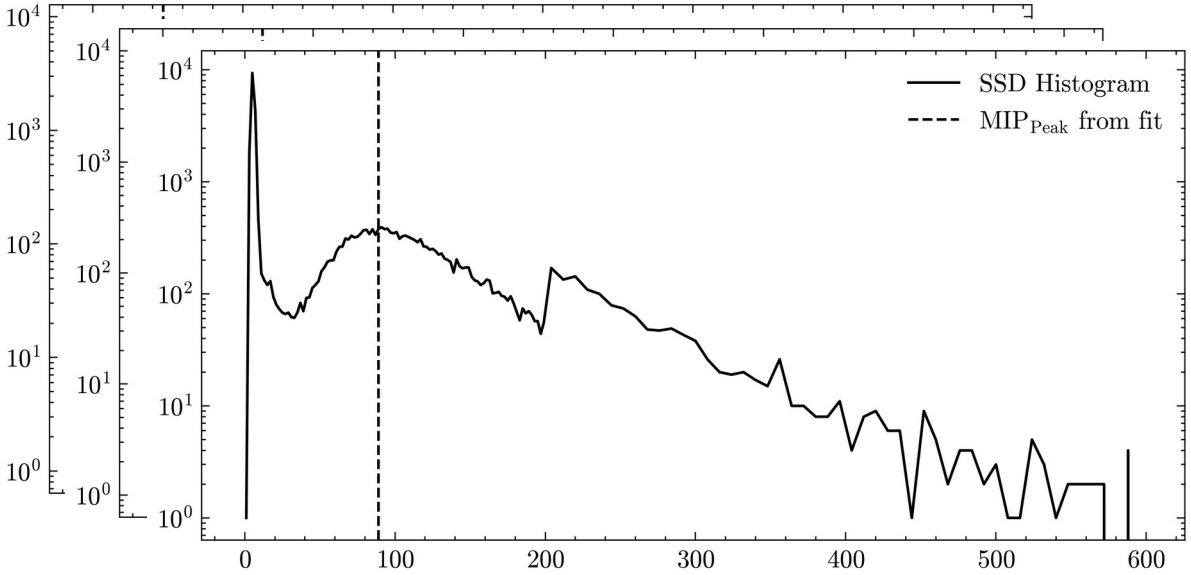
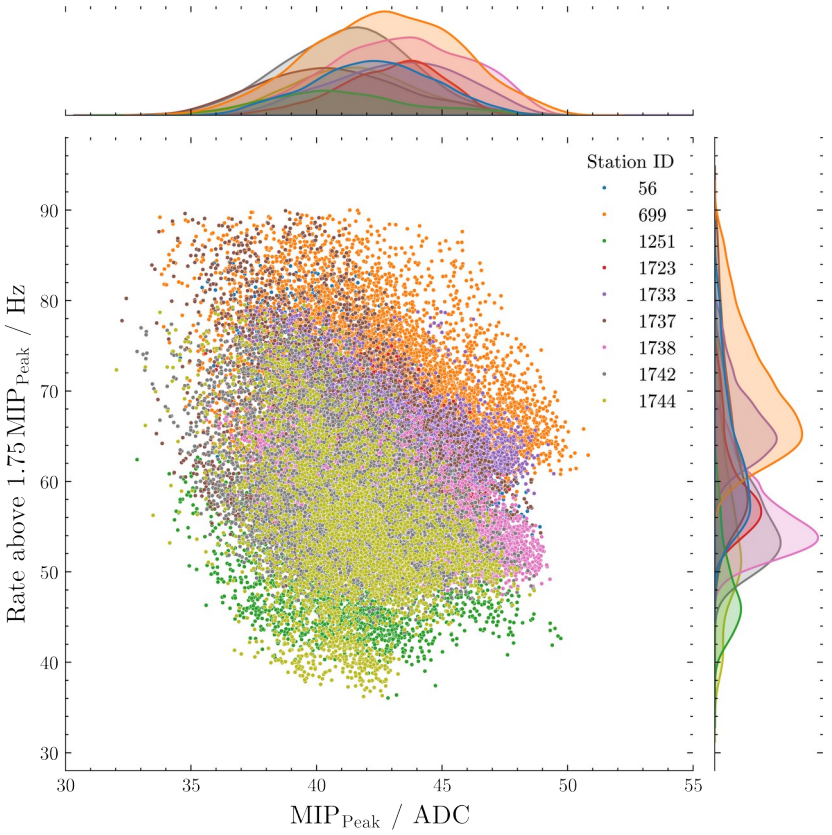


- Characteristic shape
- Differences across stations
- MIP value determined by:
  - Weather
  - Electronics
  - ???
- Does there exist a stable threshold/rate relationship?

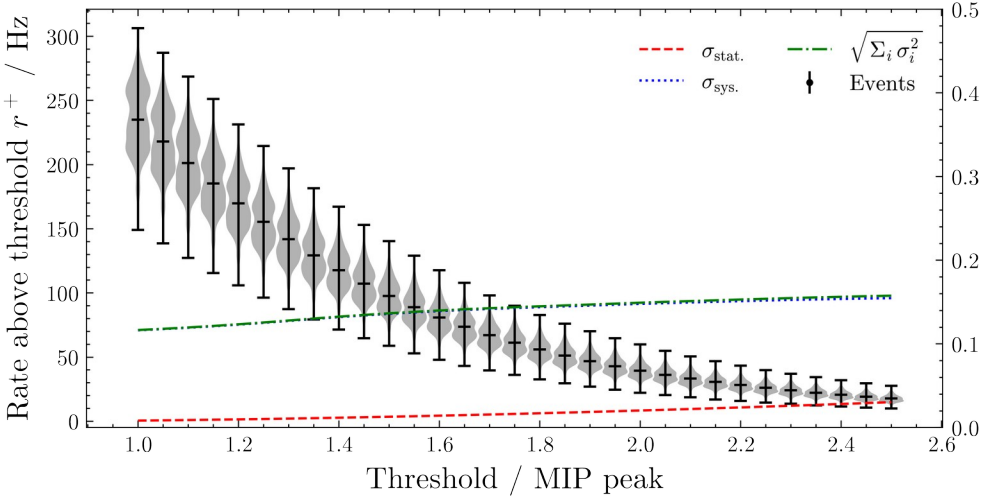
MIP → Rate

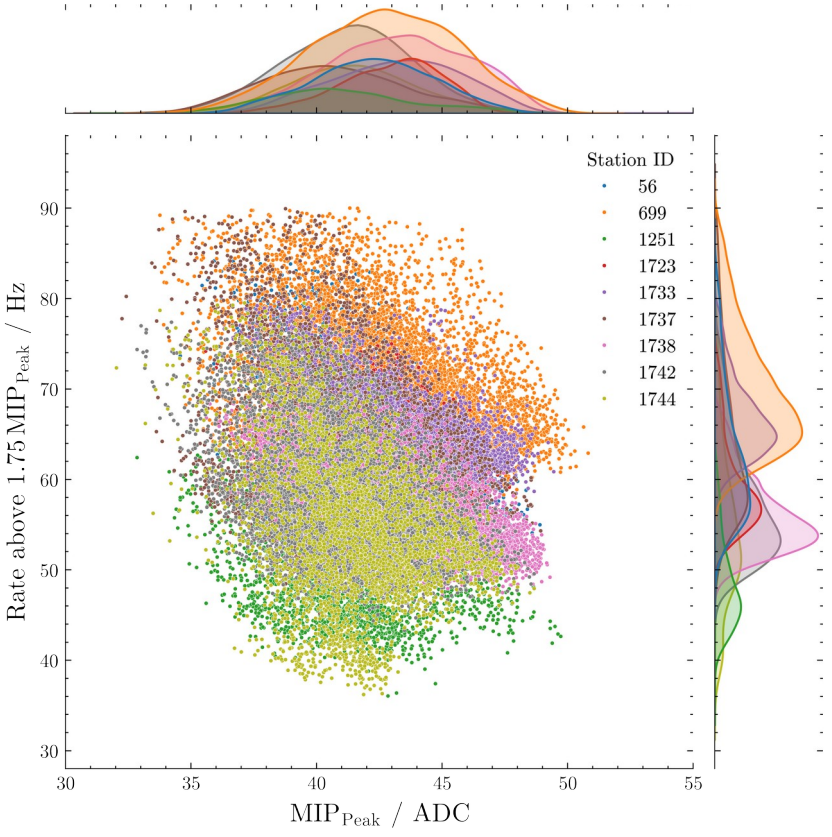
- Fit MIP from histogram
- Count all entries above threshold to calculate rate



MIP → Rate

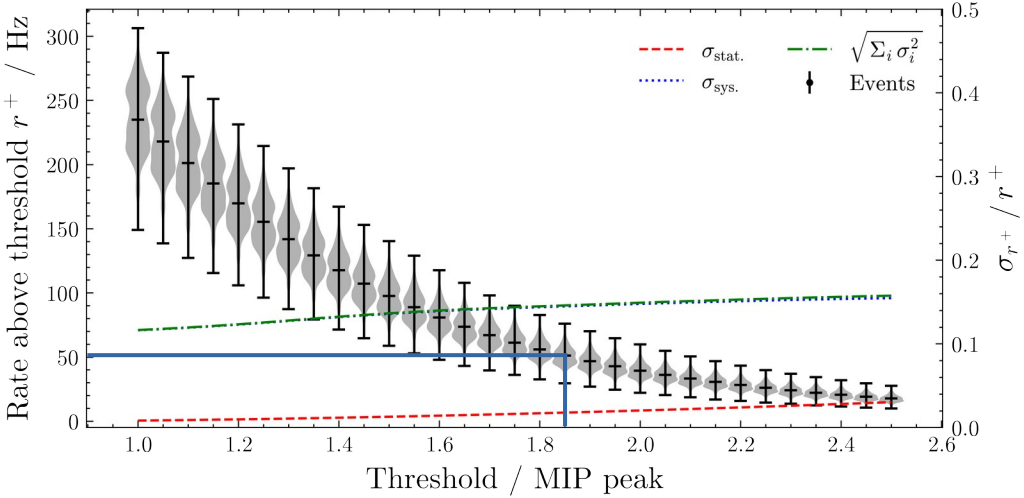
- Fit MIP from histogram
- Count all entries above threshold to calculate rate
- Average per-station rate over multiple stations
- Rate spread rather big (+10%), but not greatly dependant on set threshold





Rate → MIP

- Setup threshold/rate relationship from plot below
- Determine **threshold** for 50 Hz rate is observed
- (online) MIP is then (e.g.) **threshold** / 1.85



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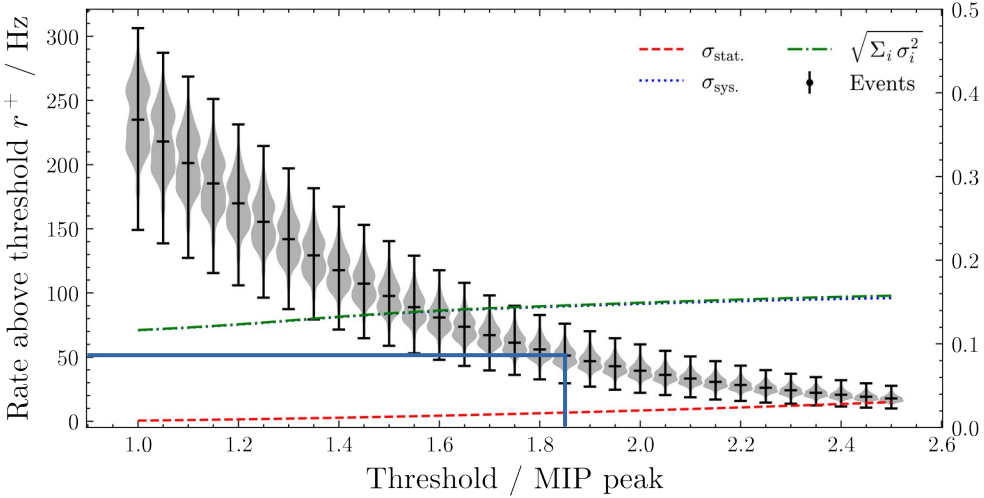
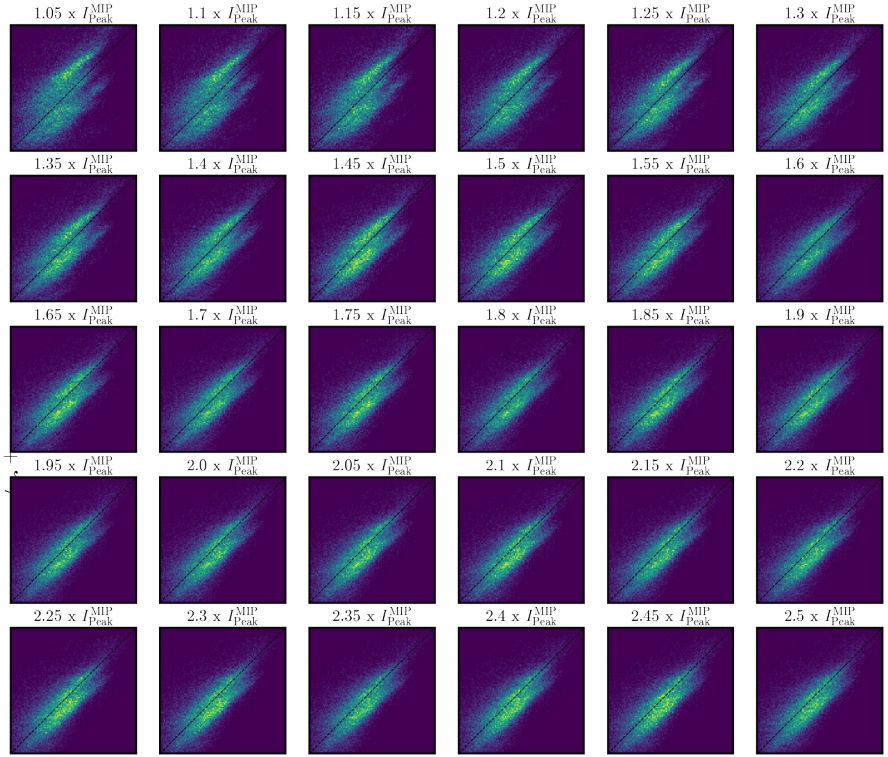
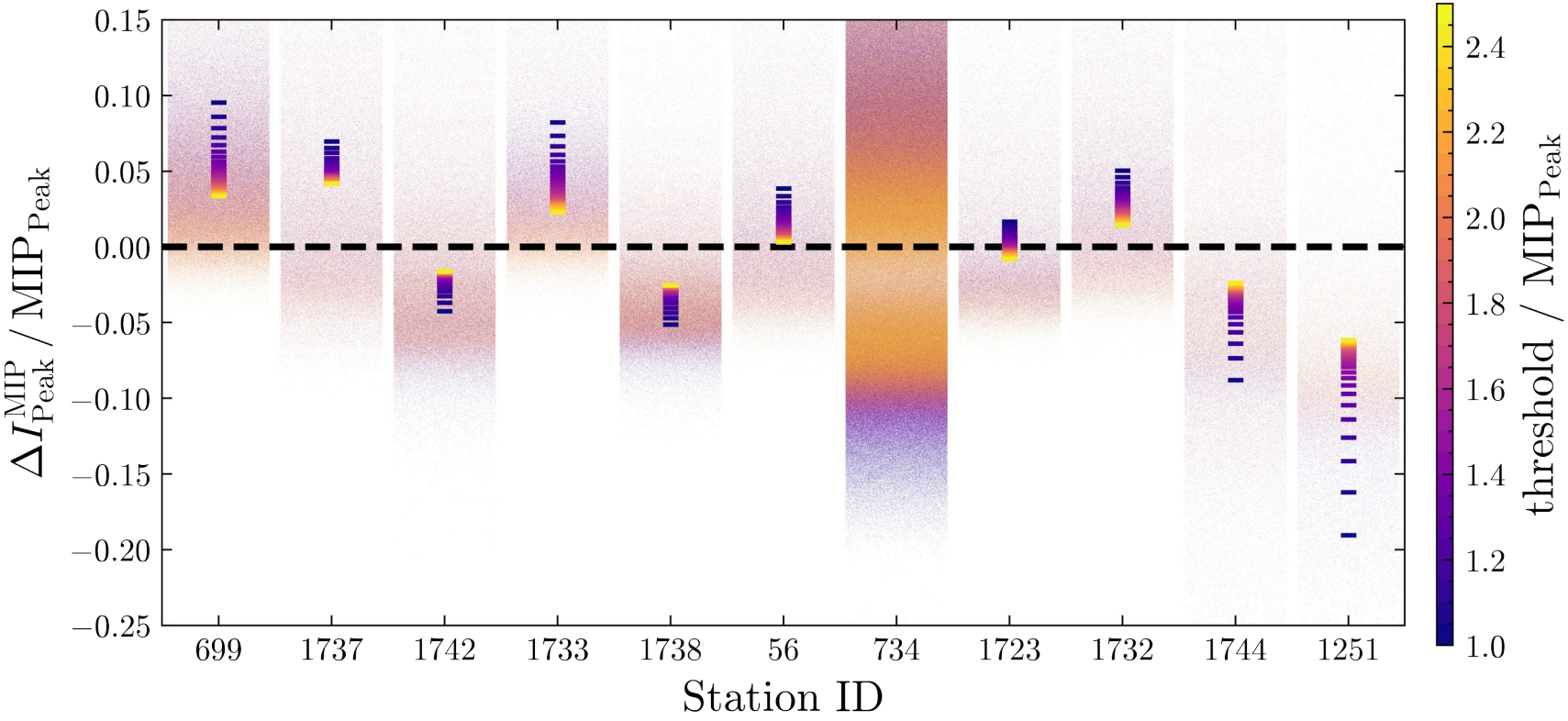
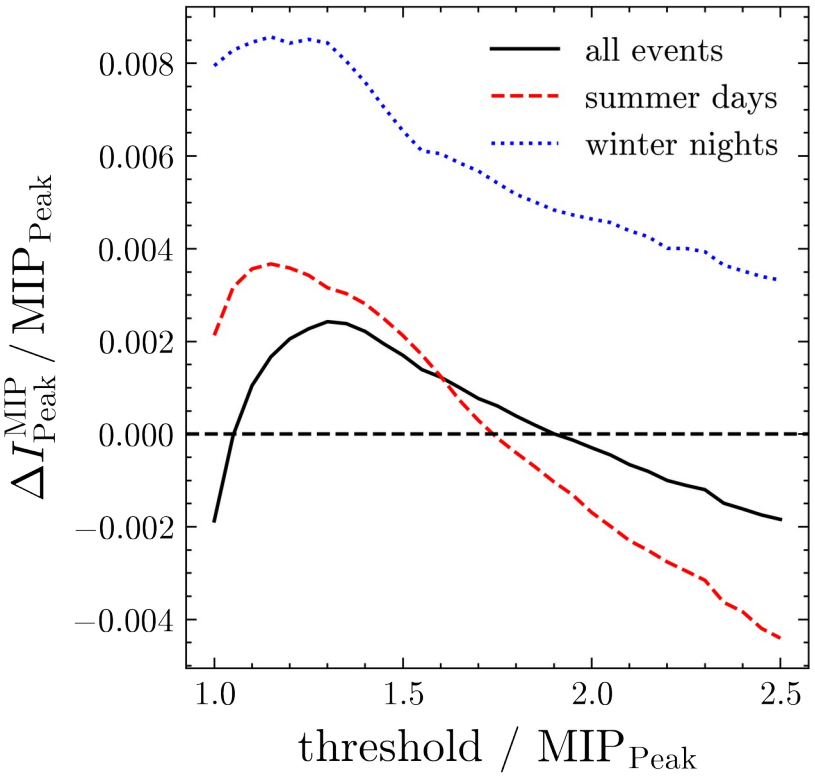


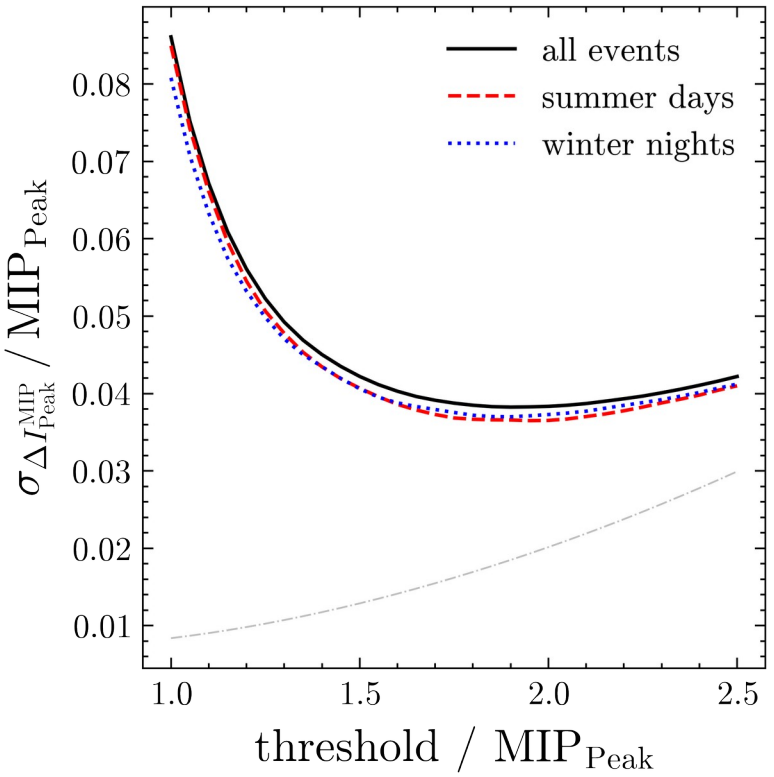


Rate → MIP


0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
$\Delta I^{\mathrm{MIP}}_{\mathrm{Peak}}$ / $\mathrm{MIP}_{\mathrm{Peak}}$
699
1737
1742
1733
1738
56
734
1723
1732
1744
1251
Station ID
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
threshold / $\mathrm{MIP}_{\mathrm{Peak}}$

Rate → MIP


all events
summer days
winter nights
0.008
0.006
0.004
0.002
0.000
−0.002
−0.004
1.0
1.5
2.0
2.5
$\Delta I^{\mathrm{MIP}}_{\mathrm{Peak}} / \mathrm{MIP}_{\mathrm{Peak}}$
threshold / $\mathrm{MIP}_{\mathrm{Peak}}$


all events
summer days
winter nights
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1.0
1.5
2.0
2.5
$\sigma_{\Delta I^{\mathrm{MIP}}_{\mathrm{Peak}}} / \mathrm{MIP}_{\mathrm{Peak}}$
threshold / $\mathrm{MIP}_{\mathrm{Peak}}$

Next steps

- Repeat analysis with more stations (ongoing)