Analyses of the AugerPrime Engineering Array

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PIERRE AUGER OBSERVATORY

GEFÖRDERT VOM
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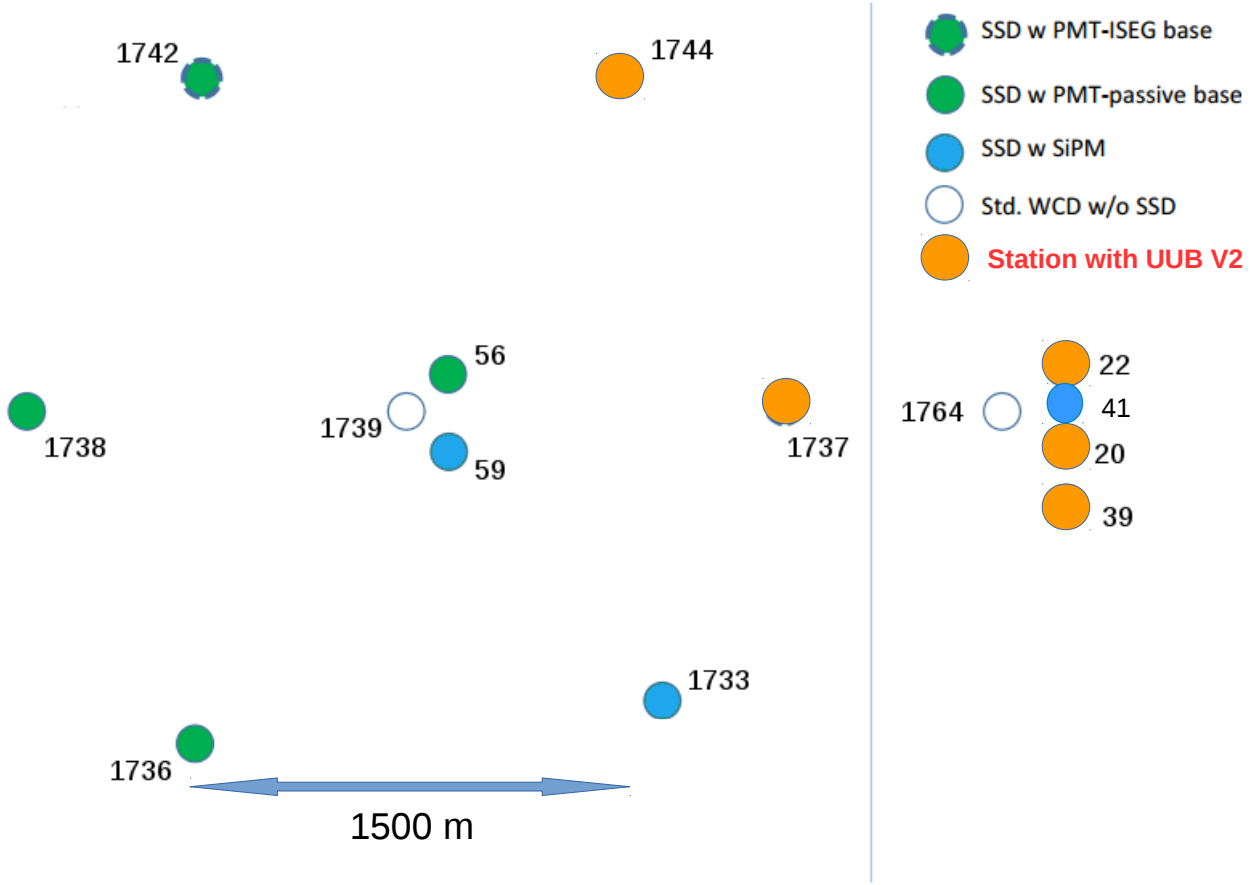
Surface Scintillator Detector (SSD)

plastic scintillator detector on top of SD stations as part of upgrade 'AugerPrime'

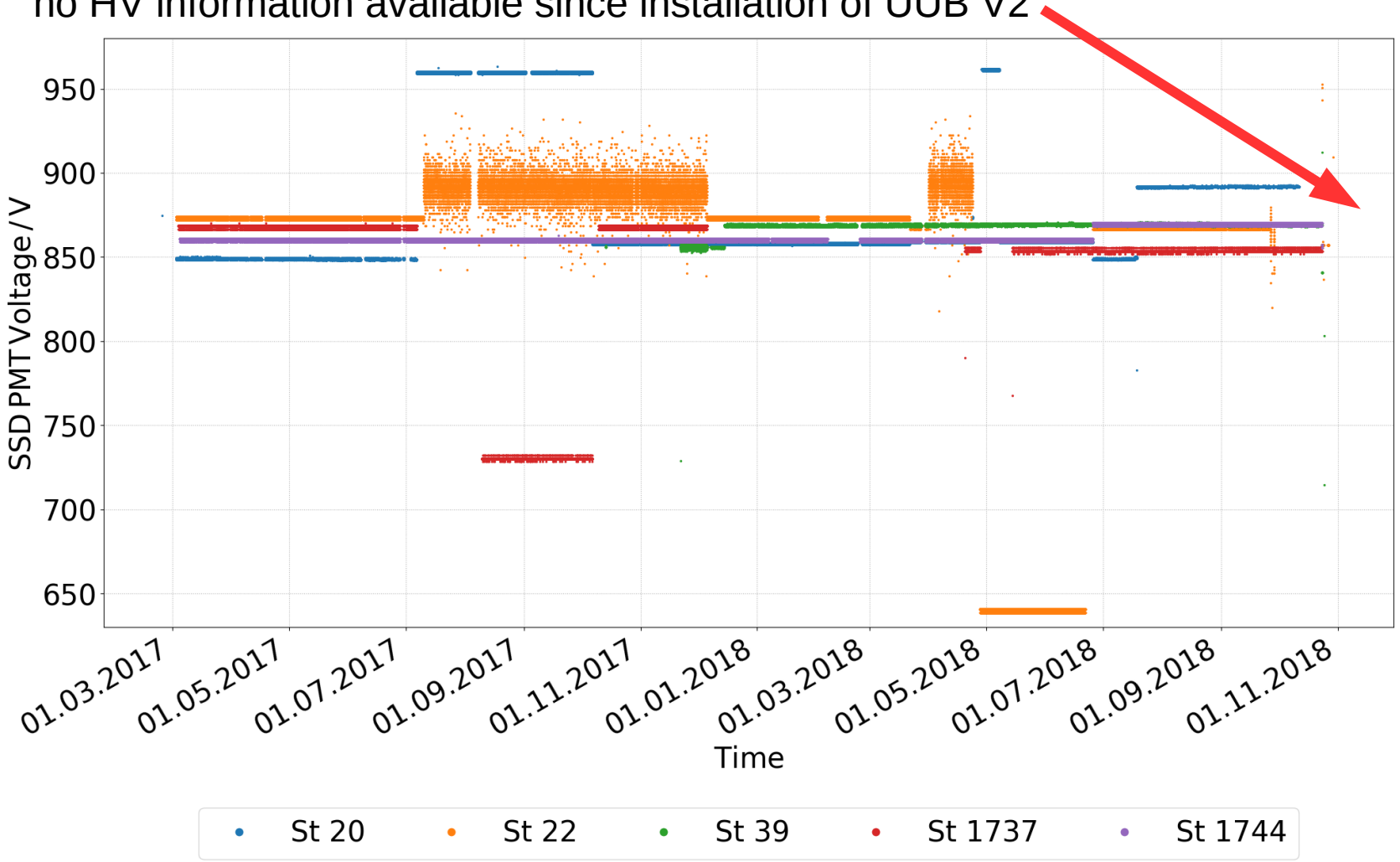
→ Engineering Array (EA) with 12 stations in field, currently taking data



Surface Scintillator Detector (SSD)

Engineering Array continuously undergoing changes, i.e,SSD PMT HV

no HV information available since installation of UUB V2



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SSD Signal Traces

signal in SSD in form of time trace

charge calculation

- integrate ADC charge with baseline correction
- stop when signal drops below baseline

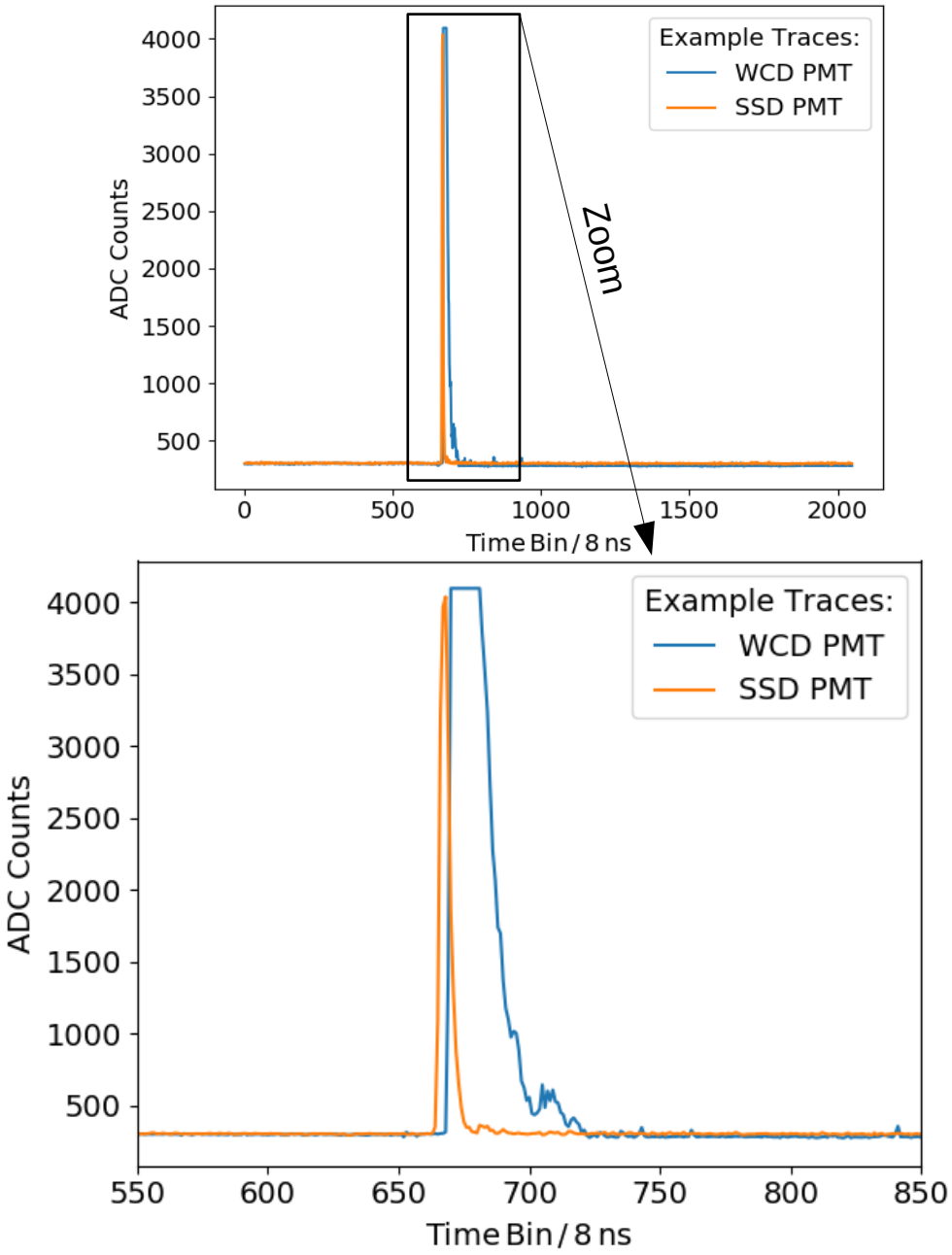
sampling rate :

- 120 MHz FADC

→ time bins of 8 ns

High & Low Gain (HG,LG)

- HG/LG ratio = 128



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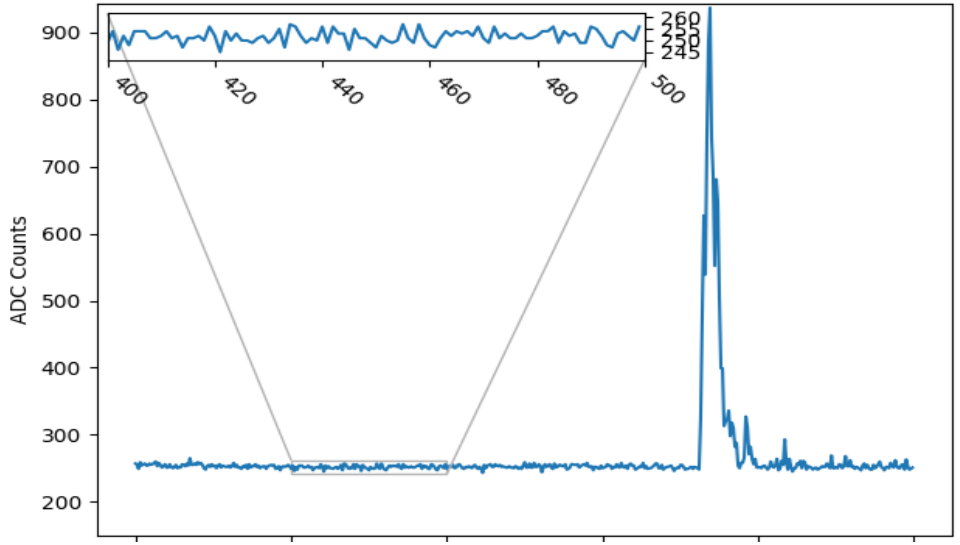
SSD Traces – UUB V1 vs. V2

direct comparison of traces:

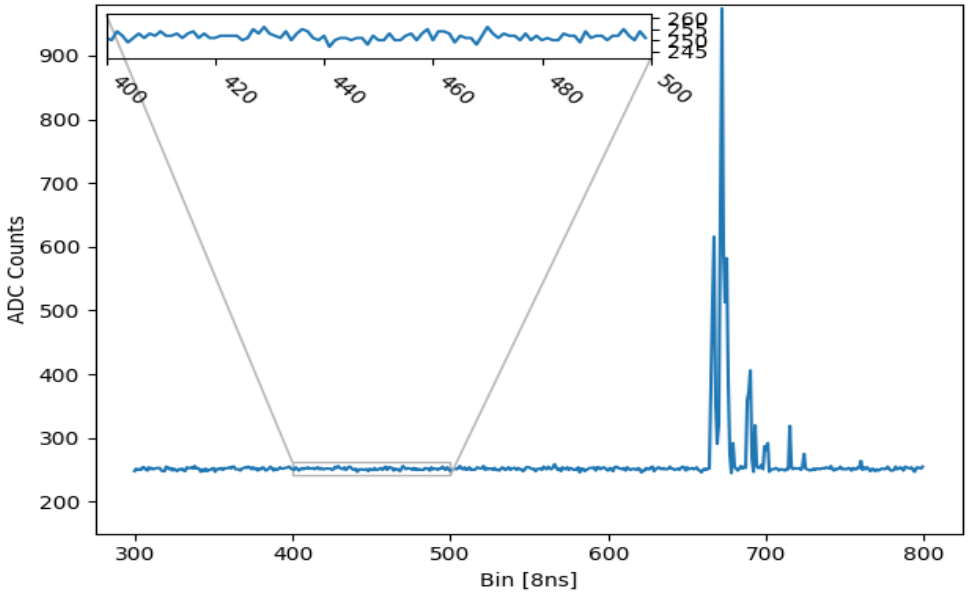
- station 20 before and after switch of UUB versions
- similar characteristics such as height of signal peak

reduction of baseline noise in UUB V2 already visible by eye

HG Trace UUB V1



HG Trace UUB V2

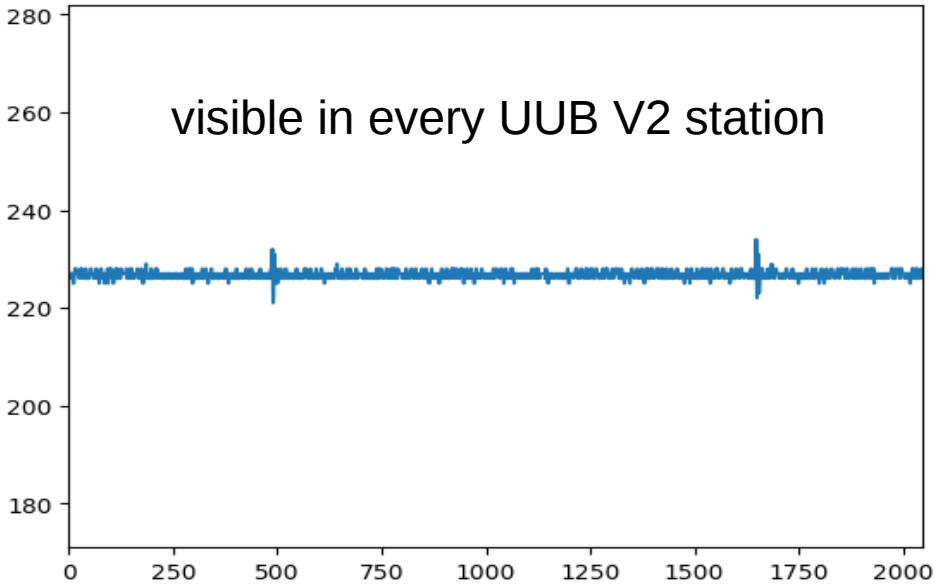


SSD Traces – UUB V2 LG Spikes and 1744 modulation

LG traces of events recorded with UUB V2 show spikes in **all** stations

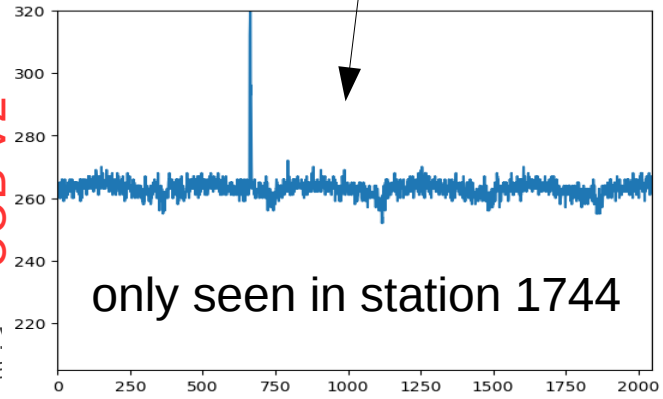
- constant spacing of spikes
  ~ 9716 ns (St 20)
  ~ 9708 ns (St 22)
  ~ 9725 ns (St 39)
  ~ 9716 ns (St 1737)
  ~ 9850 ns (St 1744)
- also seen in radio data
- origin most probably from board itself

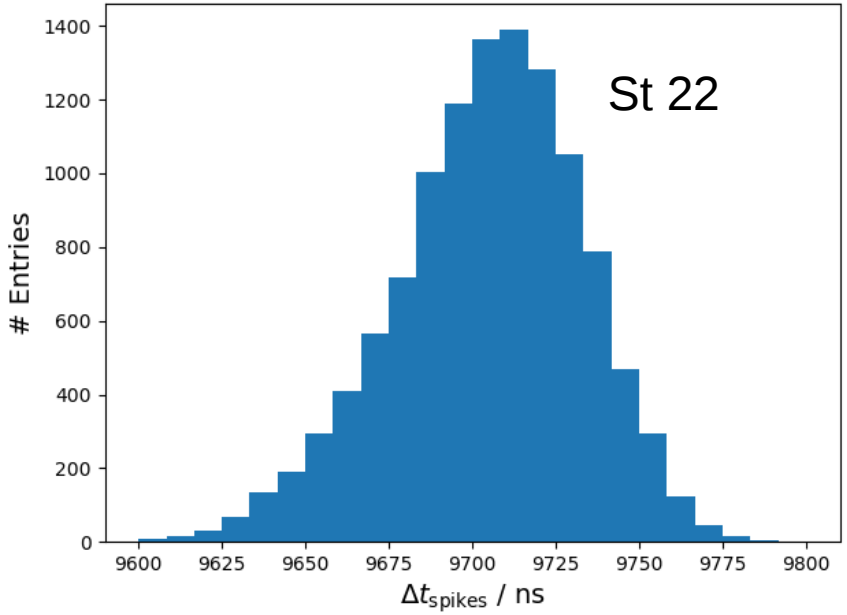
LG Trace UUB V2



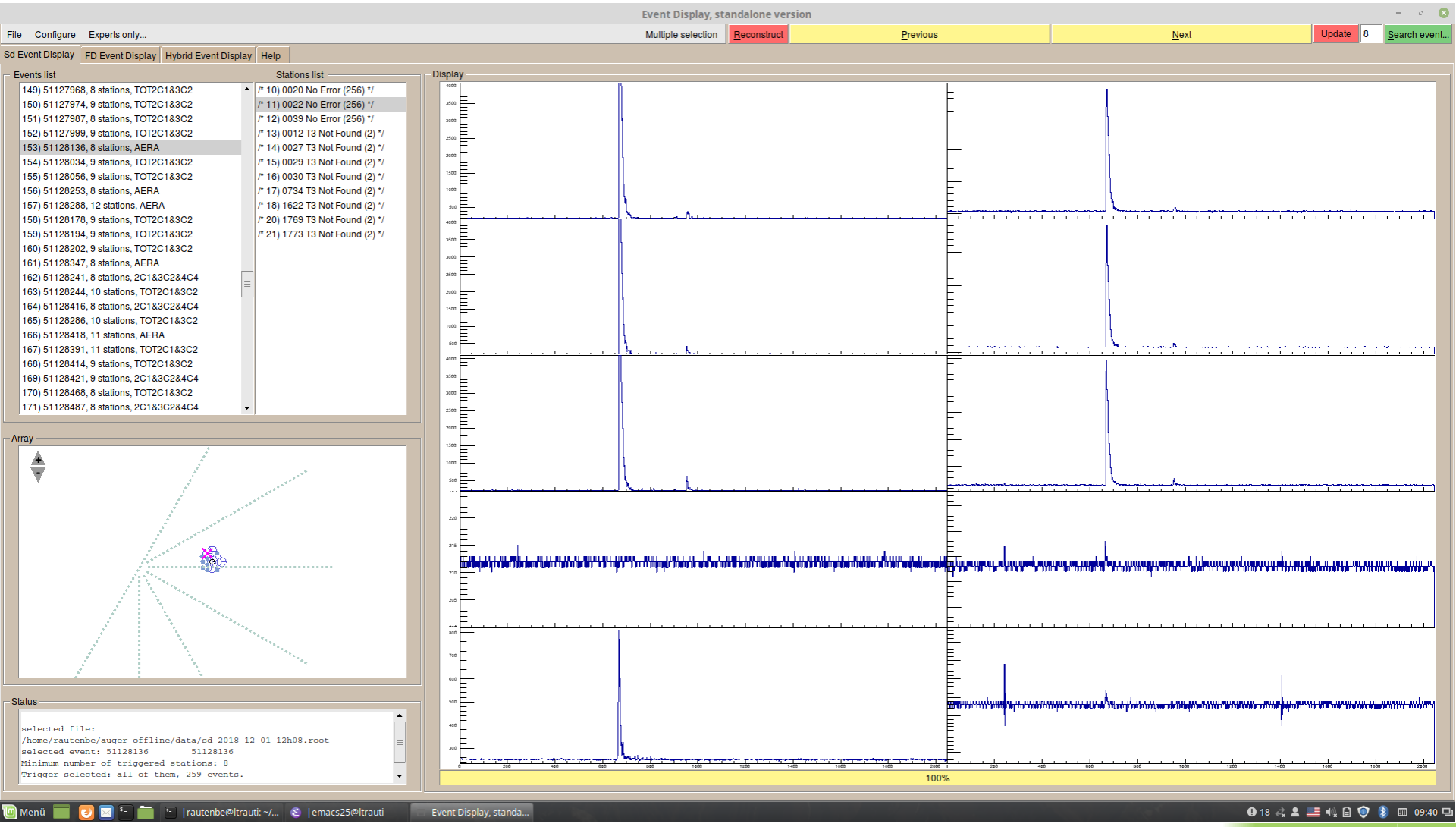
HG traces of station 1744 show modulation after switch to UUB V2

HG Trace UUB V2





SSD Traces – Screenshot from ED

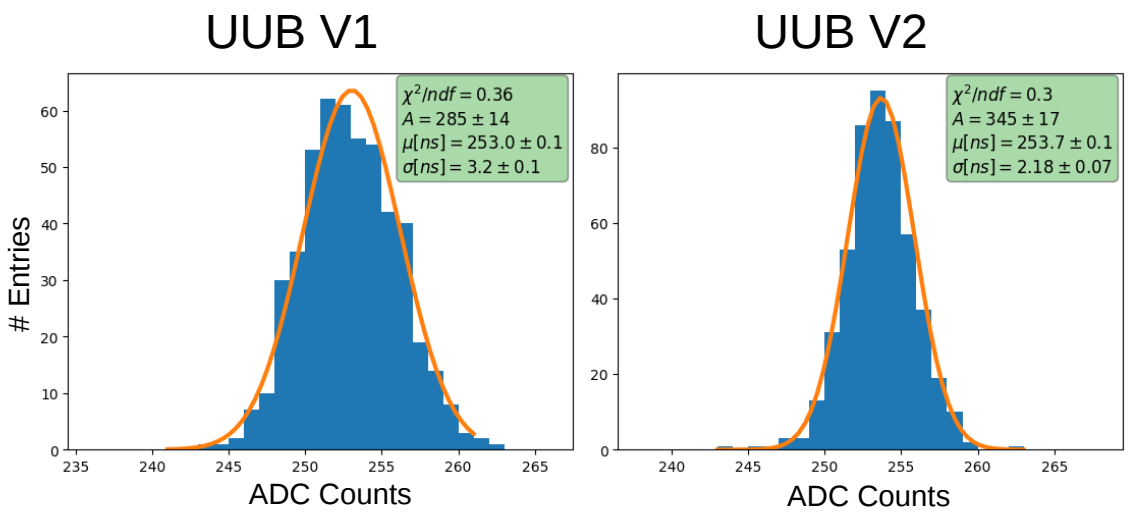


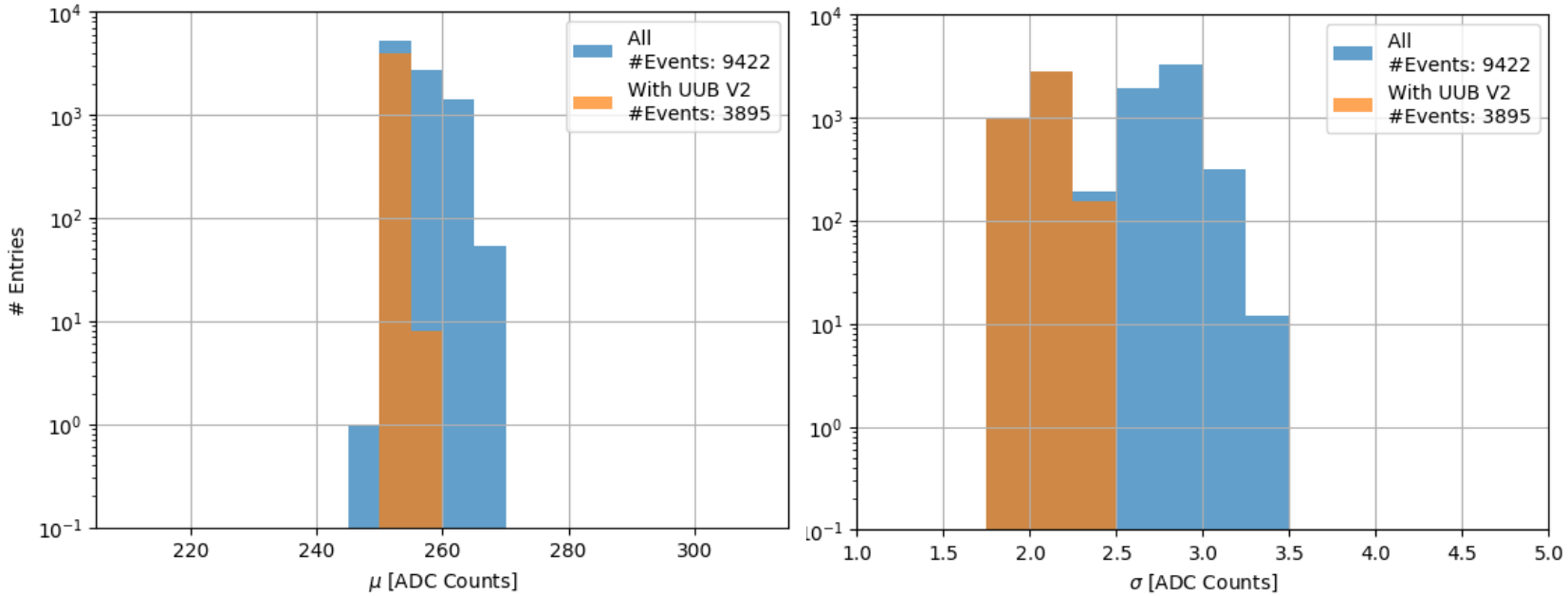
SSD Traces – UUB V1 vs. V2 Baseline + Noise

histogramming first 500 bins of each trace and fitting with a gaussian

→ calculation of baseline μ and baseline σ

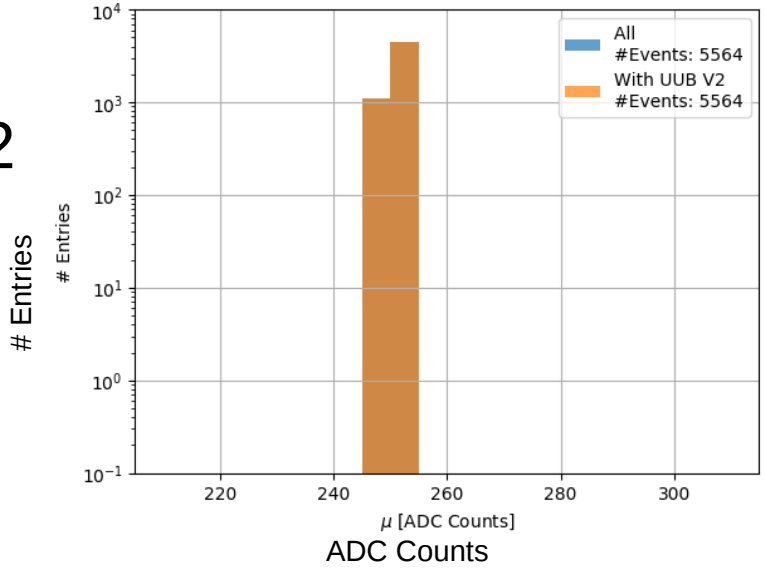
- spread of μ reduced
- overall smaller spread (σ) of baseline noise

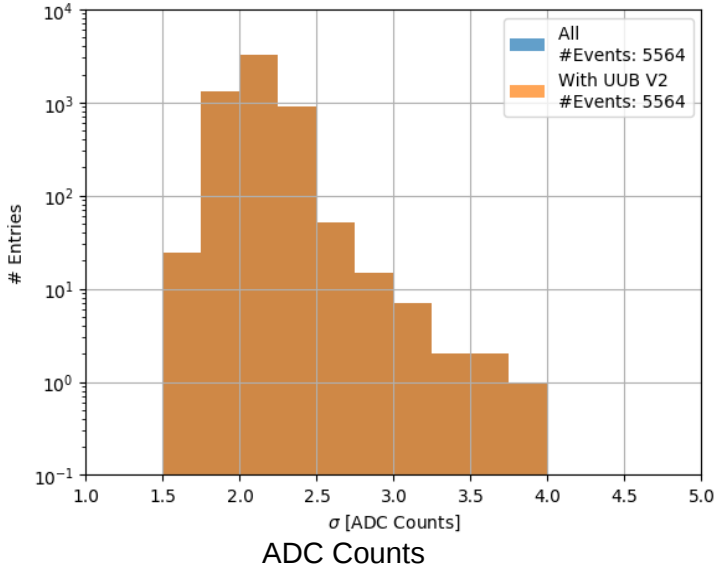




SSD Traces – UUB V1 vs. V2 Baseline + Noise

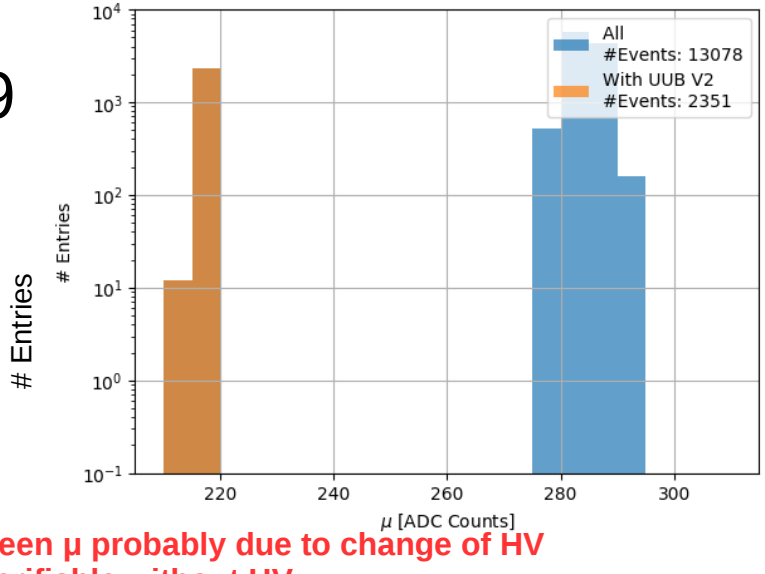
22

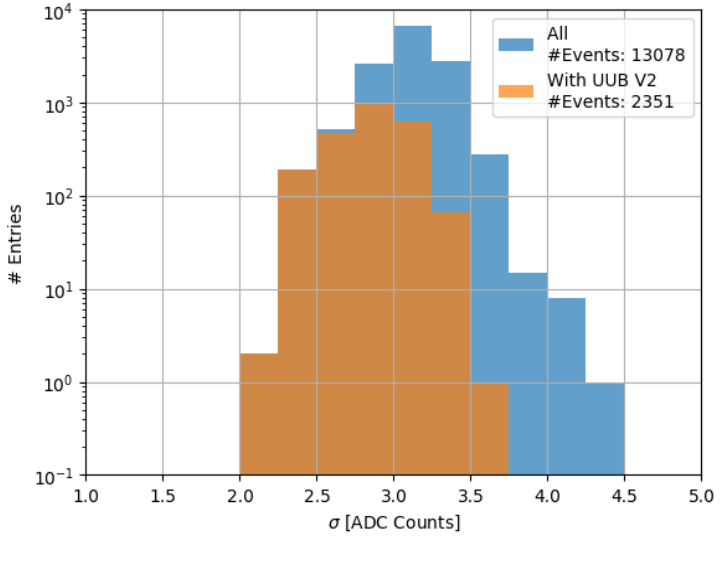




ADC Counts ADC Counts

39



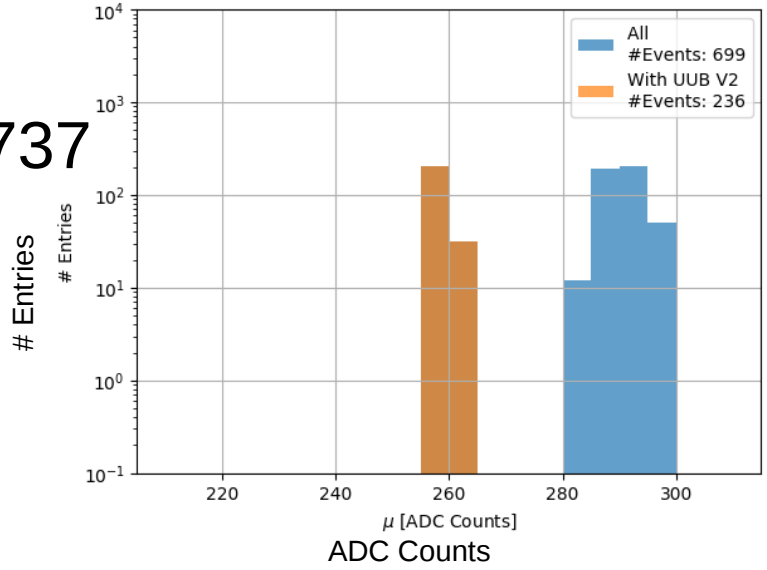


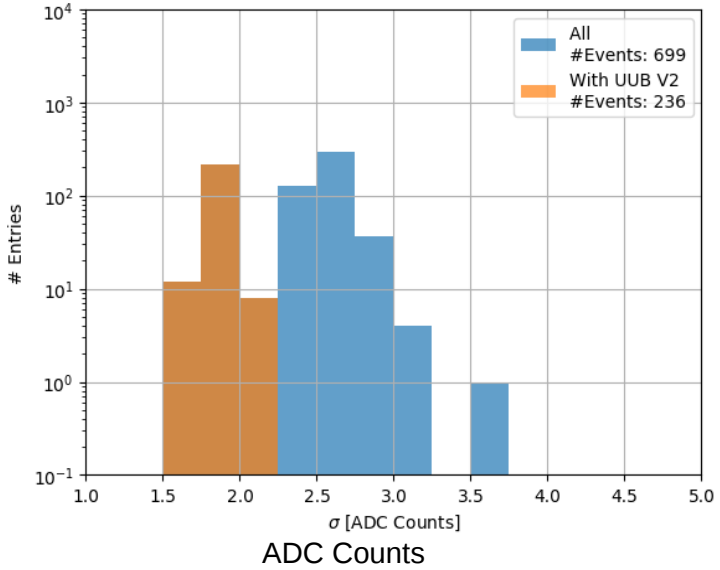
gap between μ probably due to change of HV but not verifiable without HV

ADC Counts ADC Counts

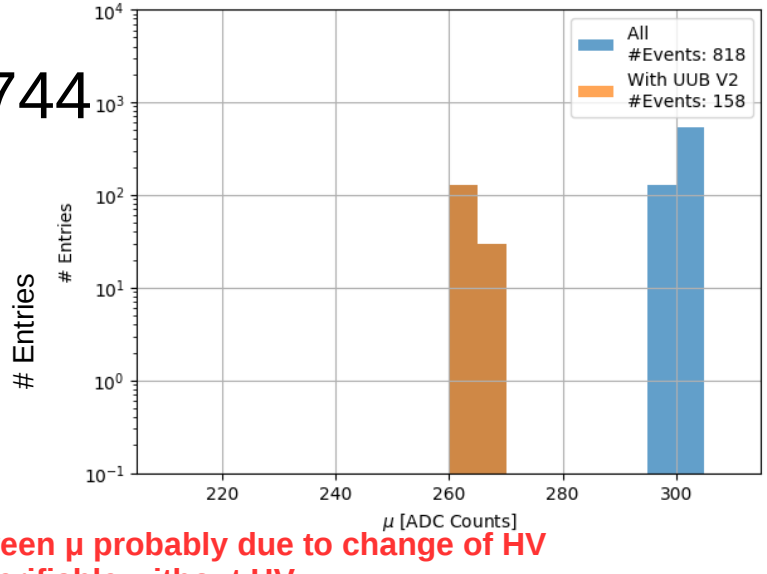
SSD Traces – UUB V1 vs. V2 Baseline + Noise

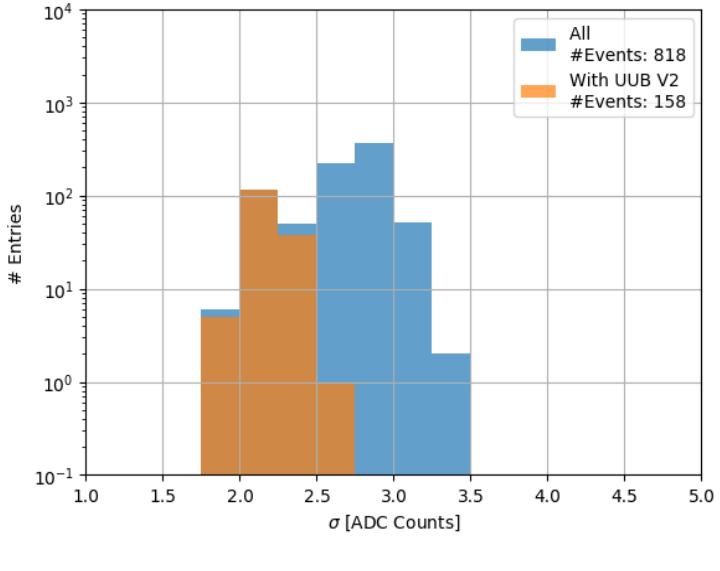
1737





1744





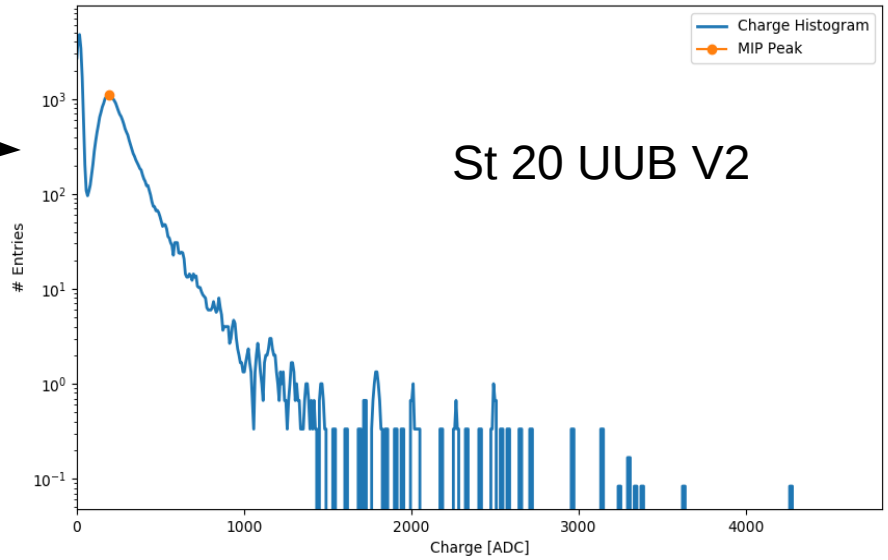
gap between μ probably due to change of HV but not verifiable without HV

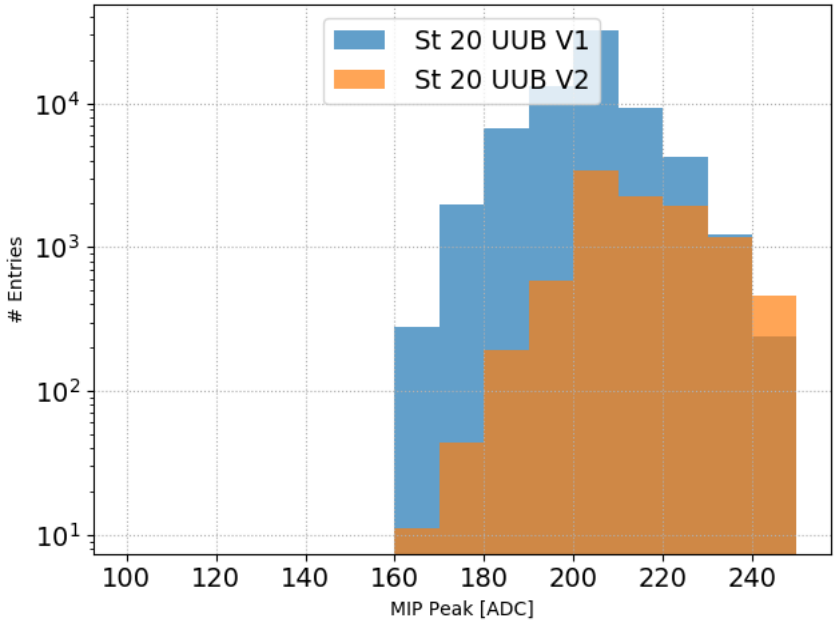
SSD Traces – MIP Peak UUB V1 vs. V2 (HG only)

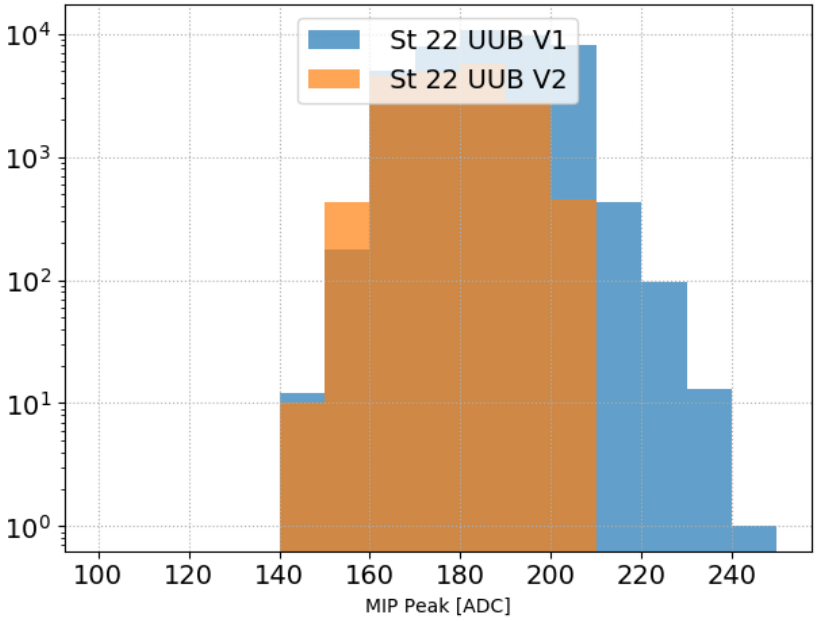
calculating MIP peak via charge histogram

no significant differences between V1 and V2

calibration not available for station 1737







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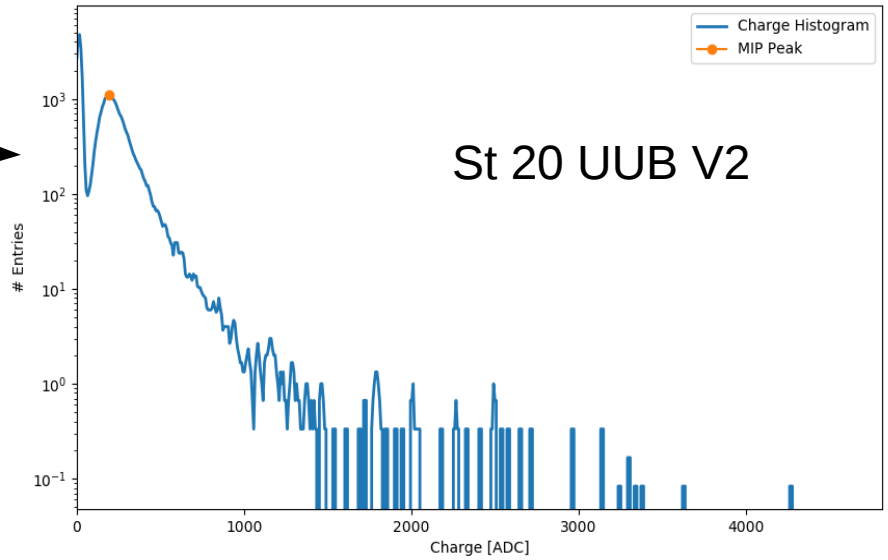
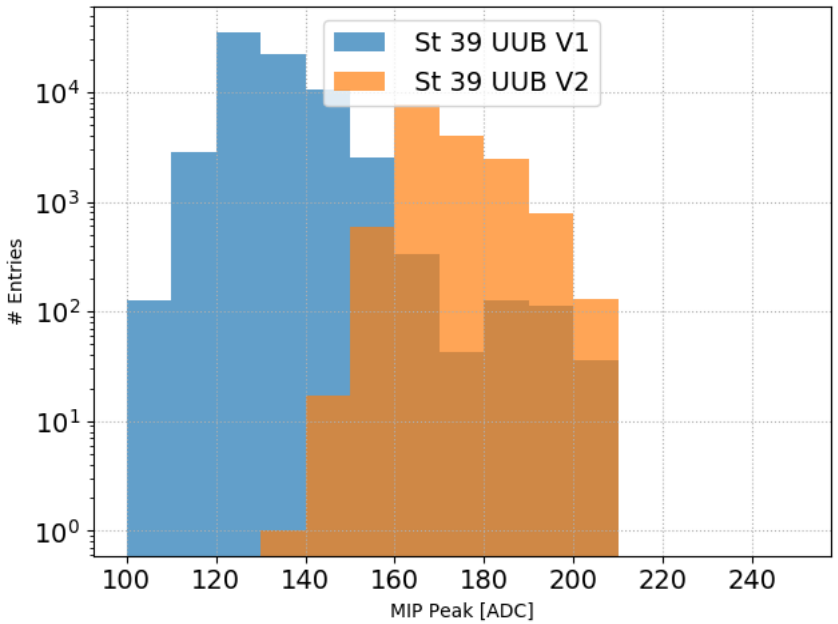
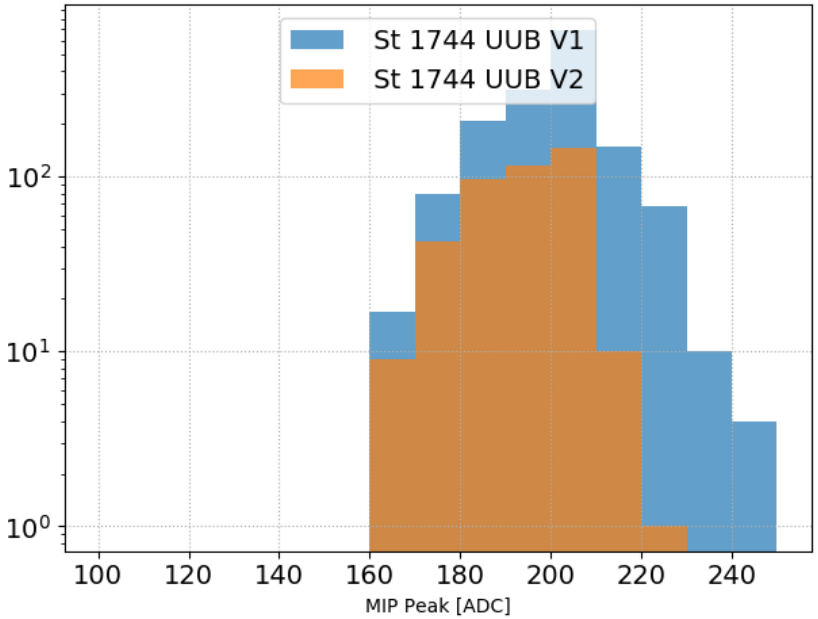




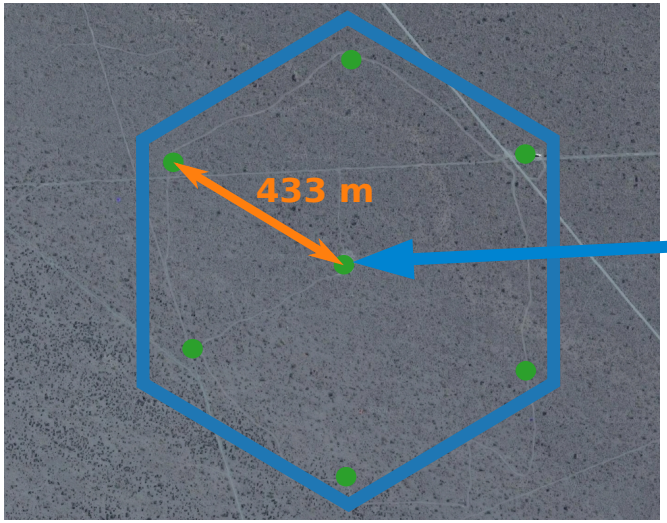


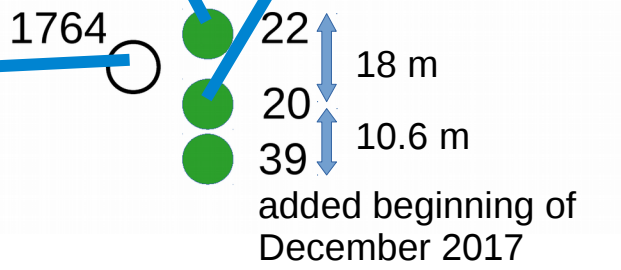
Denser Array and Triplet Stations

hexagon (7 SD stations) with reduced spacing of 433 m

- lowest energy threshold:
  Energy ≥ $10^{16.5}$ eV
  (regular array: ~10^{18} eV)
- high event rate

Twin Stations (20,22) in center of denser array





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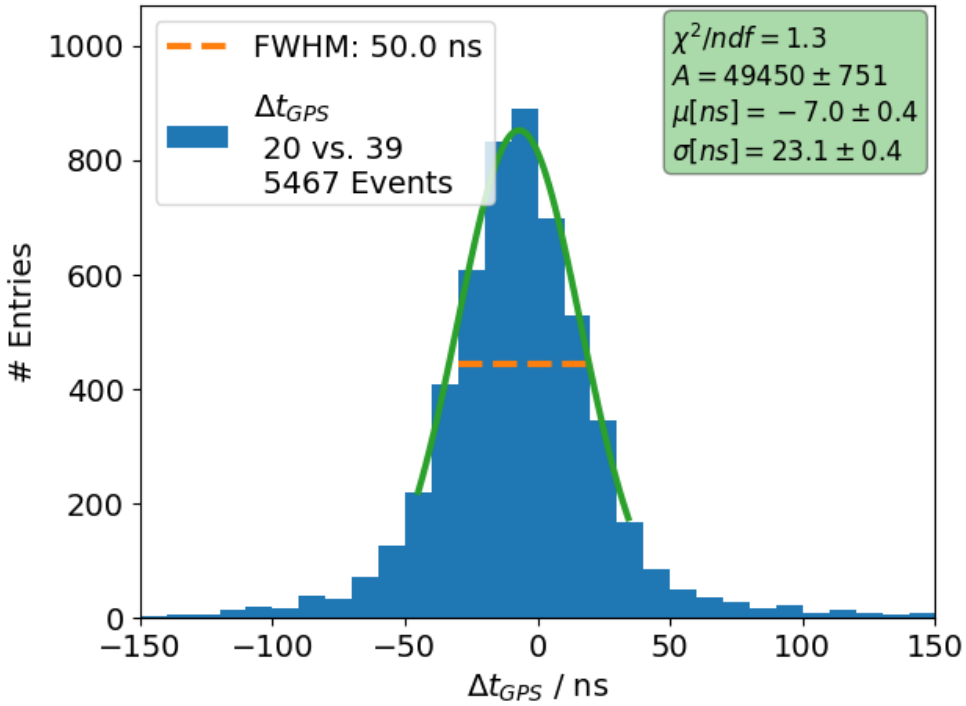
SSD Twin Station Timing

differences in arrival time of shower vital for direction reconstruction

check timing of Twin Station SSDs based on Δt of **GPS triggertime in WCD**

only events with successful SD_{433} reconstruction



using data from

12/2017 to 11/2018

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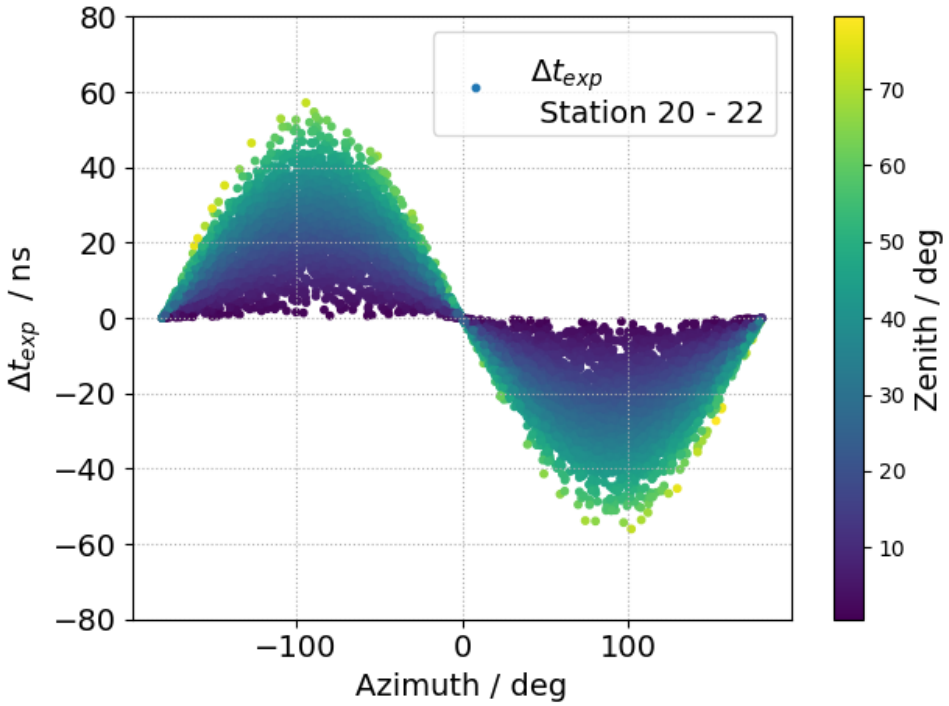
SSD Twin Station Timing

obtain Δt_{exp} from reconstruced shower direction (zenith (θ) & azimuth (φ) angle)

→ $\Delta t_{\mathrm{exp}} = \frac{-\vec{d}\,\vec{n}}{c}$, assuming planar wavefront

$\vec{d}$: station distance

$\vec{n}$: shower direction



→ larger Δt for larger θ

→ larger Δt for φ around +/- 90°

SSD Twin Station Timing

obtain Δt_{exp} from reconstruced shower direction (zenith (θ) & azimuth (φ) angle)

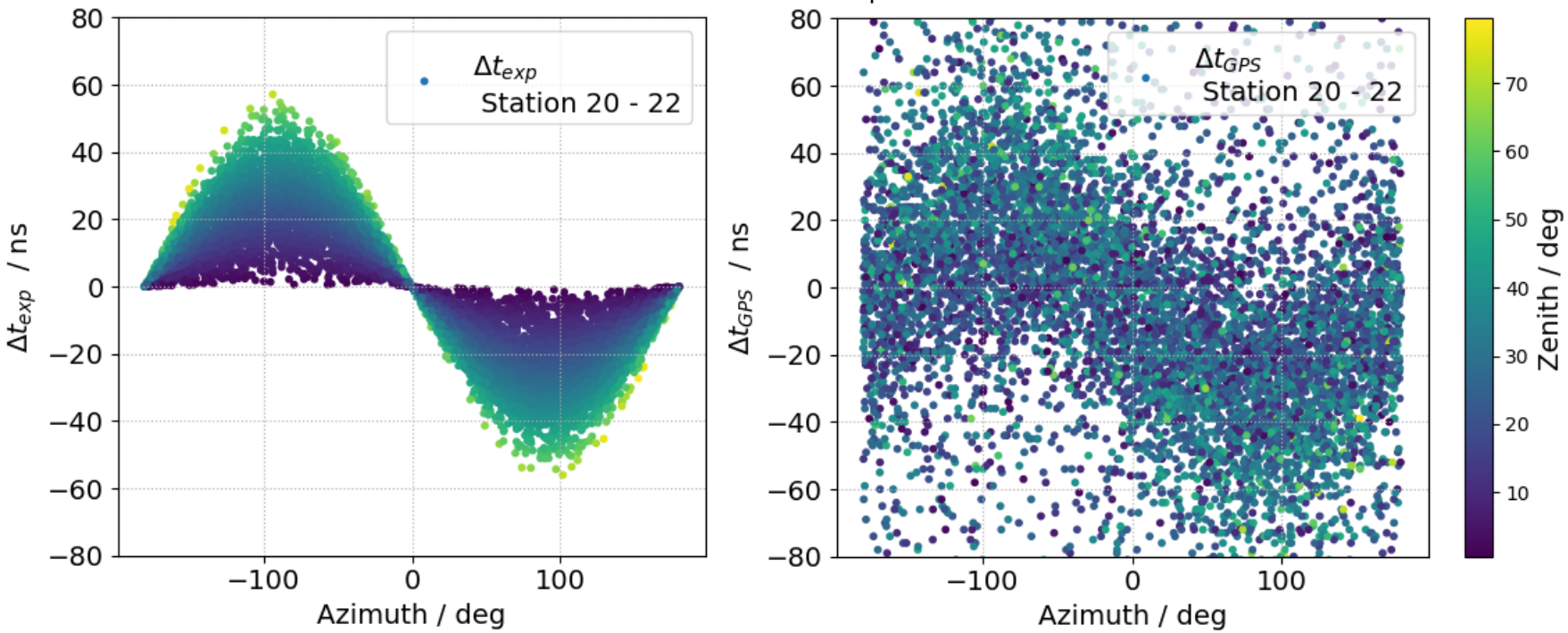
→ $\Delta t_{\exp} = \frac{-\vec{d}\,\vec{n}}{c}$, assuming planar wavefront

$\vec{d}$: station distance

$\vec{n}$: shower direction

Δt_{GPS} showing similar shape as Δt_{exp} → correct Δt_{GPS} for arrival direction:

$$\Delta t_{corr} = \Delta t_{GPS} - \Delta t_{exp}$$



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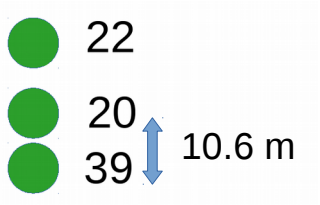
SSD Twin Station Timing

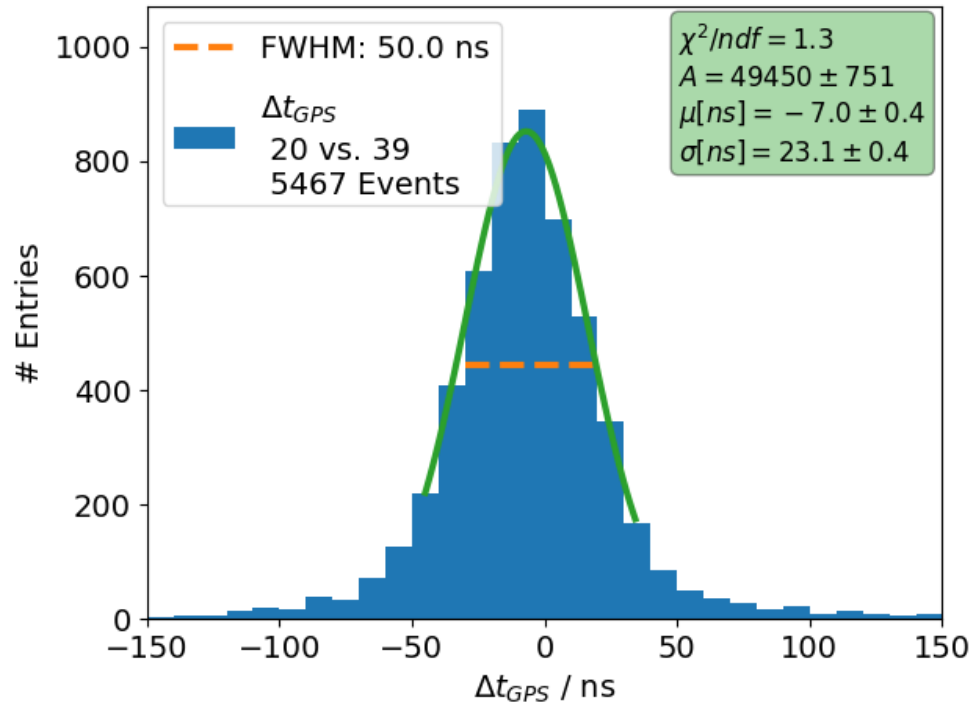
calculating Δt_{corr} for stations 20 & 39 also yields promising results

current σ for timing difference of Station 20 and 39 is now:

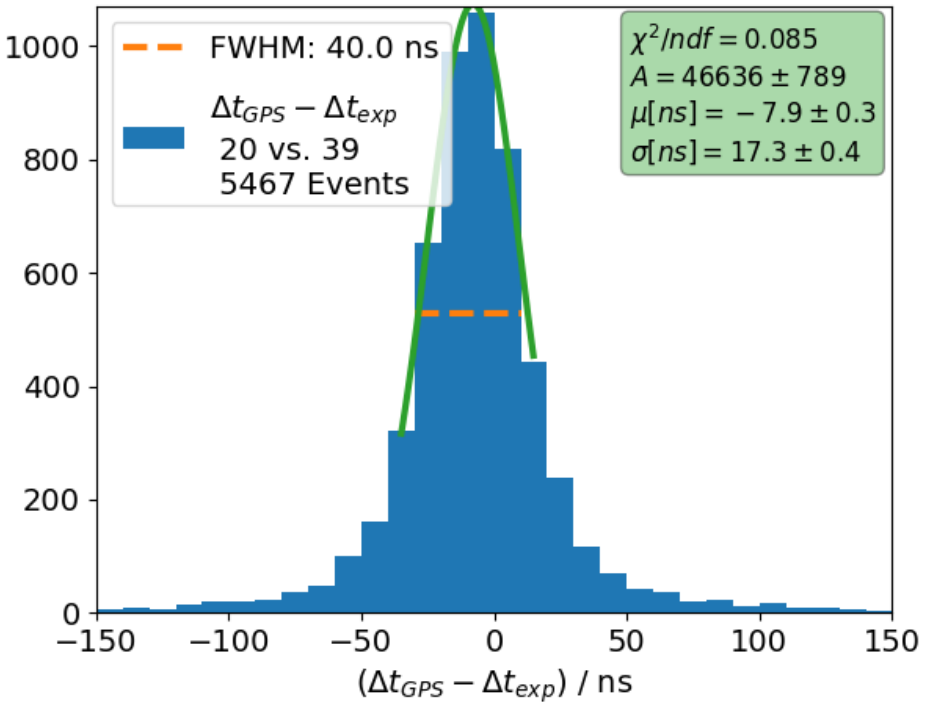
$$\sigma = (17.3 \pm 0.4)\ \text{ns}$$



before correction



after correction



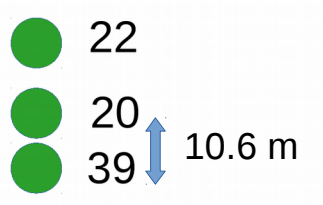
SSD Twin Station Timing – Full Bandwidth Trigger

from 20/04/2018 to 09/05/2018: Full Bandwidth Trigger (120MHz) in place

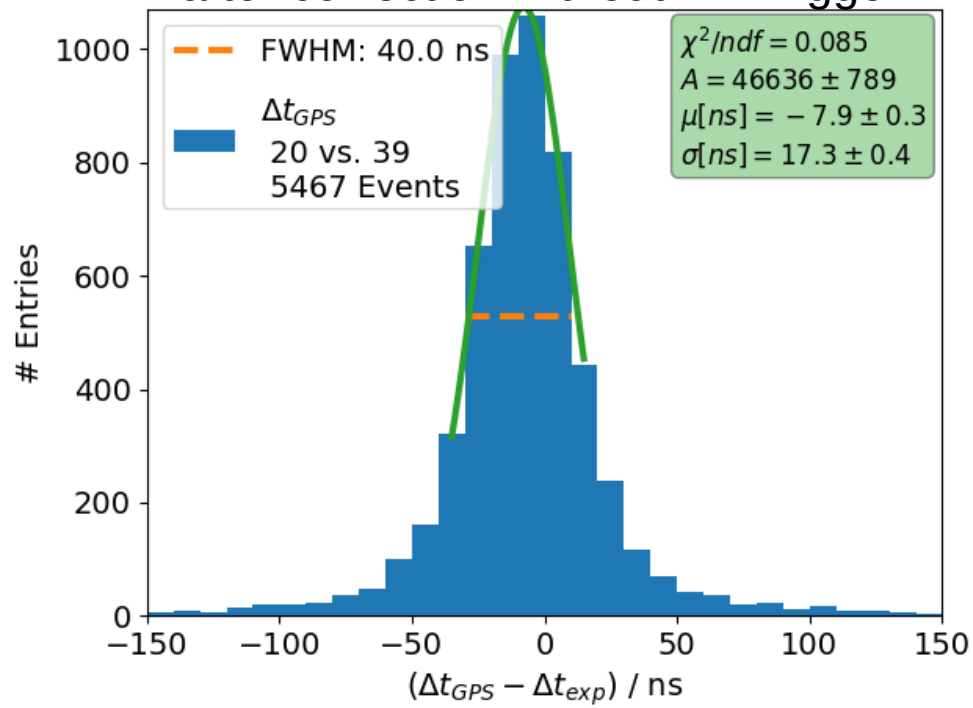
hints at further improvement in precision of timing

$$\sigma = (14 +/- 1)\ \text{ns}$$

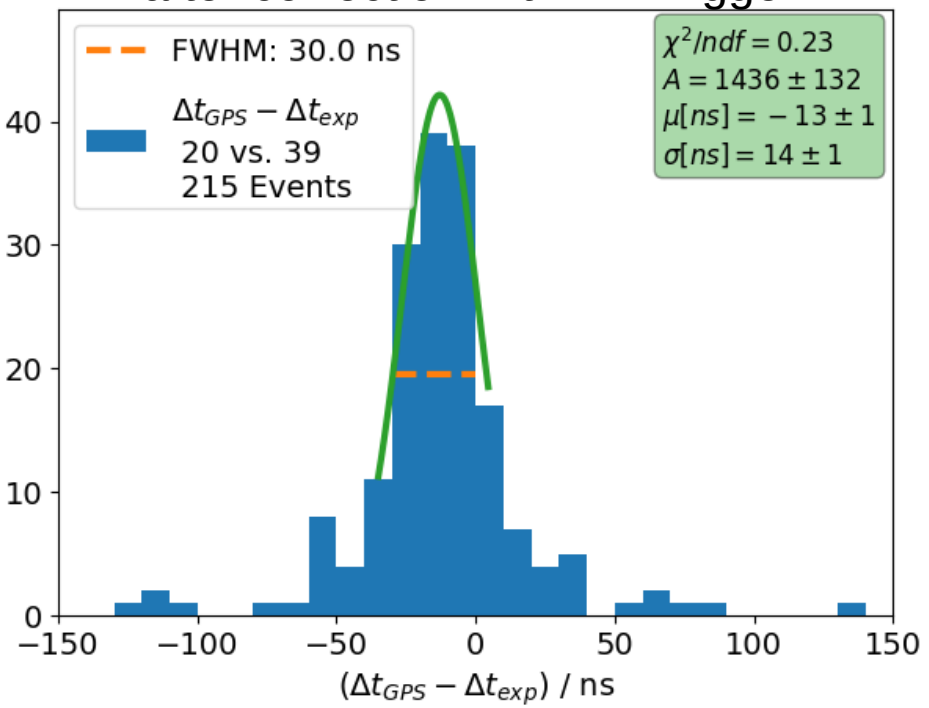
however, more statistics needed



after correction without FB Trigger



after correction with FB Trigger



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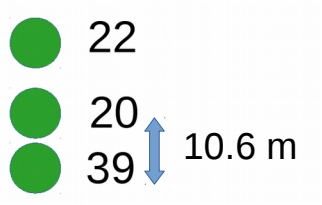
SSD Twin Station Timing – New GPS Receiver

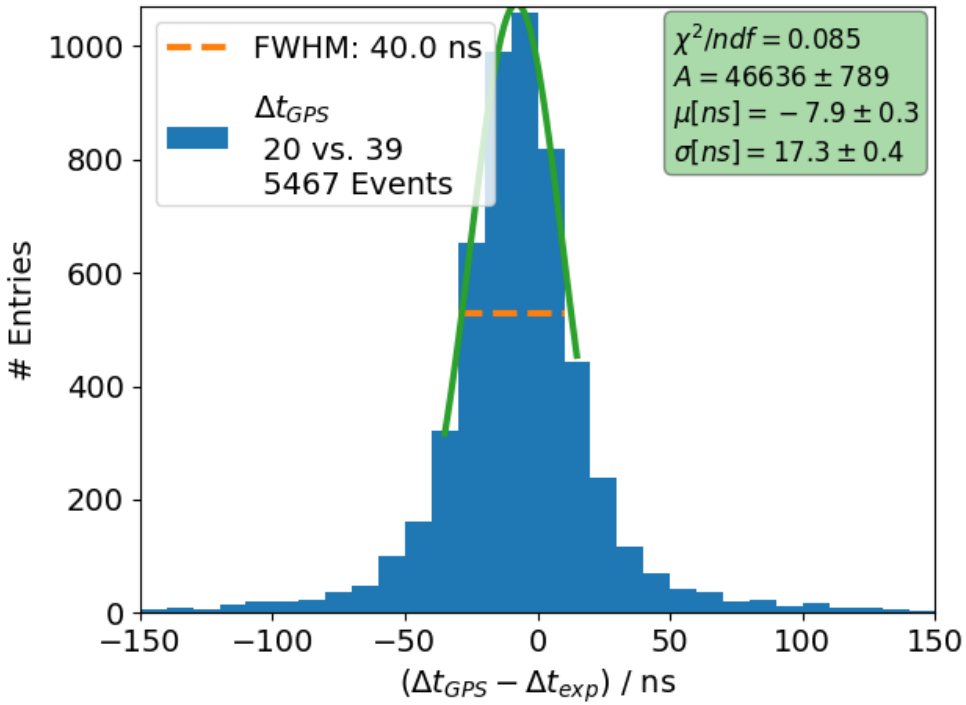
from 17/07/2018 onwards new GPS receivers (SSR 6T) were installed in station 20 & 39

provides further improvement in precision of timing

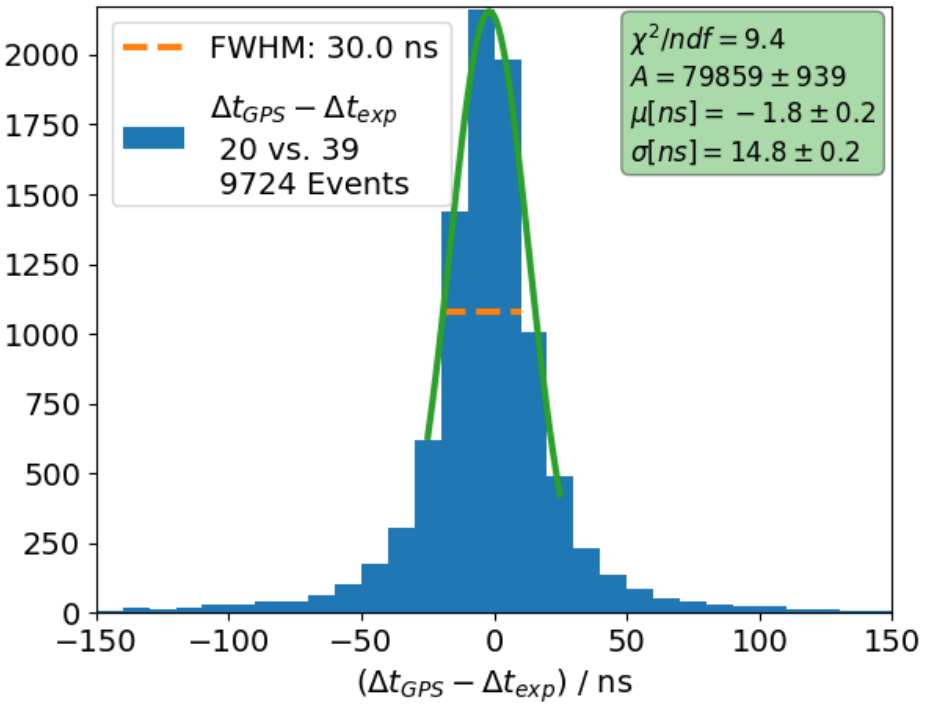


σ = (14.8 +/- 0.2) ns

after correction with old GPS receiver



after correction with new GPS receiver



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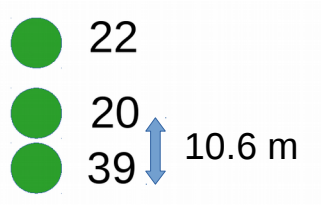
SSD Twin Station Timing – UUB V2

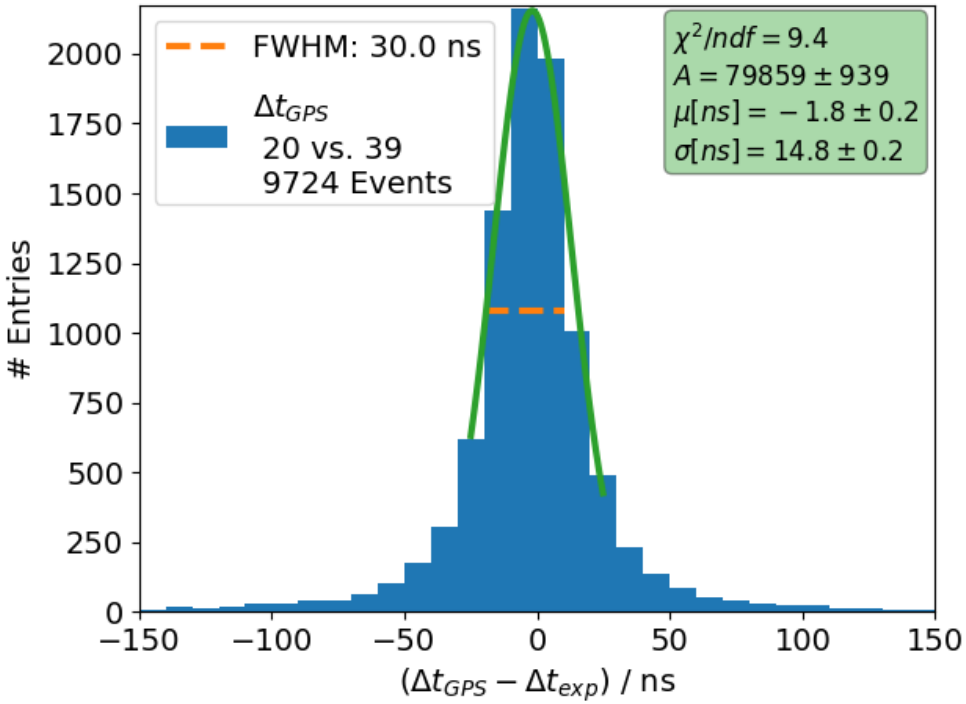
from 24/10/2018 station 20 & 39 were equipped with UUB V2

value slightly increased, might be due to much lower statistics

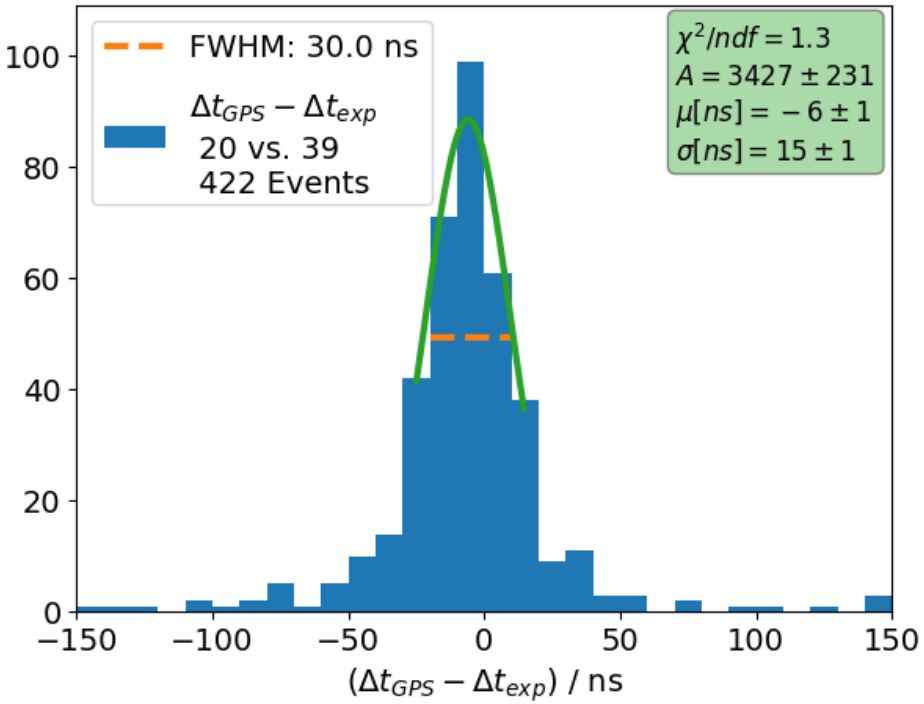
σ = (15 +/- 1) ns



after correction with UUB V1



after correction with UUB V2

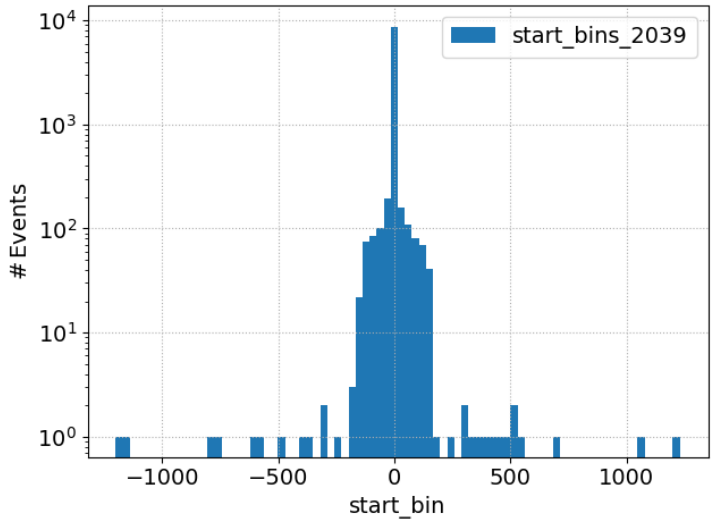


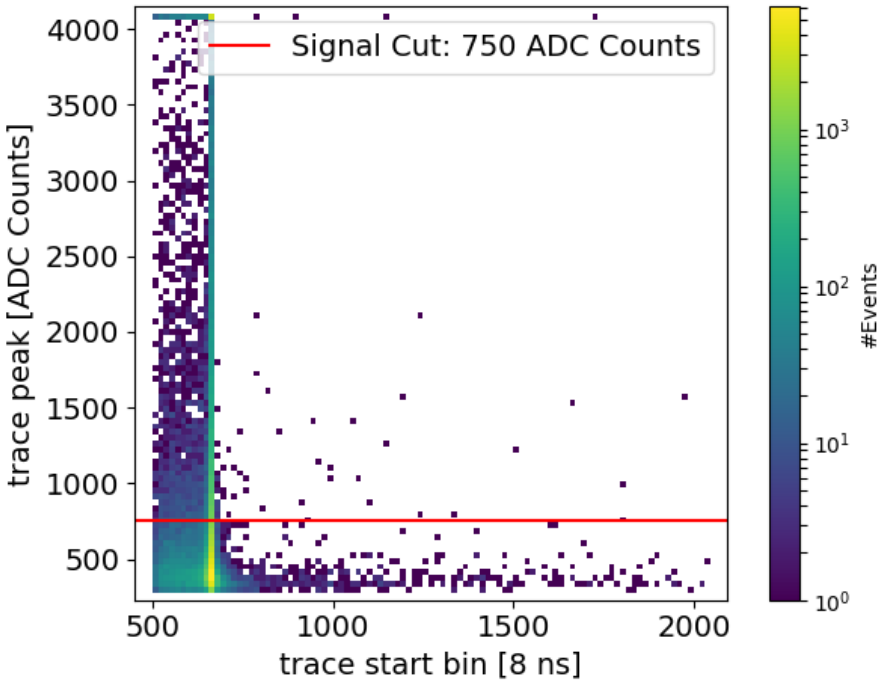
SSD Twin Station Timing – CDAS trace t_0

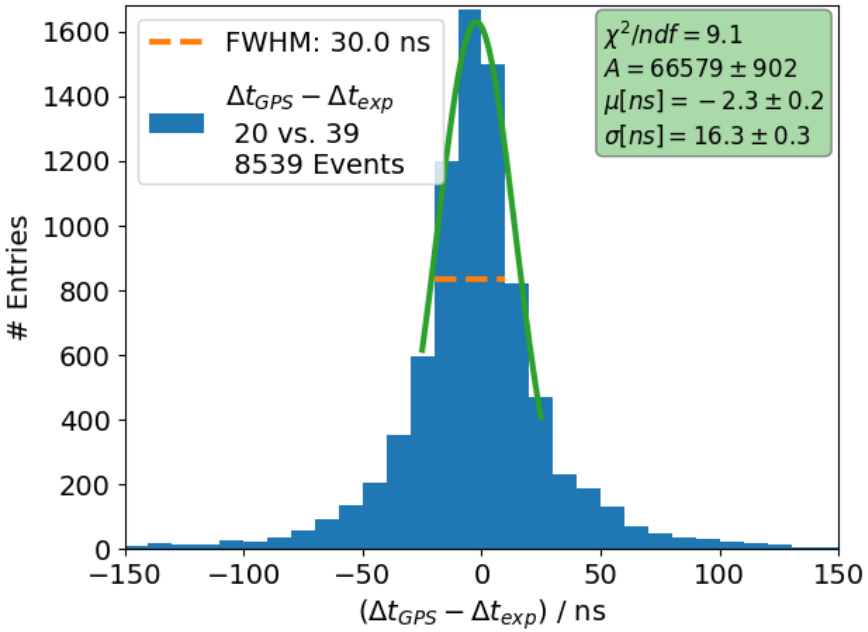
start bin calculation from CDAS on station 20 & 39: two consecutive bins above threshold (here $3\sigma_{baseline}$ above baseline)

slight increase in width of timing distribution

→ try risetime implementation from Offline







Summary and Outlook

data from stations with new UUB V2 showing good quality and promising results

- significant reduction of spread of baseline μ and spread of baseline noise (σ) visible
- no HV information visible to cross-check for influences on trace
- spikes visible in all LG traces, with spacing of ~ 9712 ns (for station 22)
- MIP peak stable, however no calib. data for St 1737

study of timing resolution

- improvement of timing with arrival direction correction and especially new GPS receiver
- further improvement a possibilty with new UUB V2 and “risetime” information of SSD (from Offline)

  → however: more statistics needed!