

# Recent Progress in MoPS & ToTD

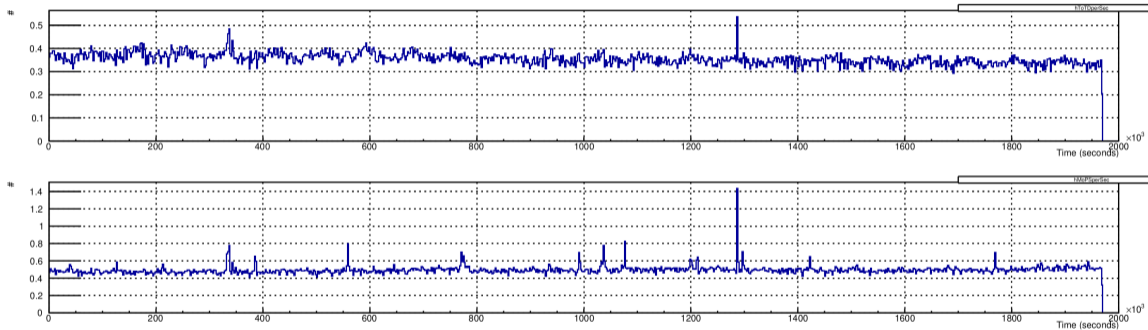
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June 3, 2024

# Tests Performed on Tanquito Jr. and Feche

- Recently we have been running a special program (not in CDAS) to record MoPS & ToTD T2s taken in Tanquito Jr. and Feche on a memory stick.
  - Data is available in iRods at [/pauger/AugerPrimeAux/UubT2s](#)
  - There are currently several hundred files containing 10,000 traces each.
  - Software is available at KIT GitLab in directory [...uub/firmware/trigger/linux.test.code/t2s/](#)
- Not understood why rate is higher in Feche.
  - Example of symptom of highly disparate ToTD and MoPS rates between different stations.

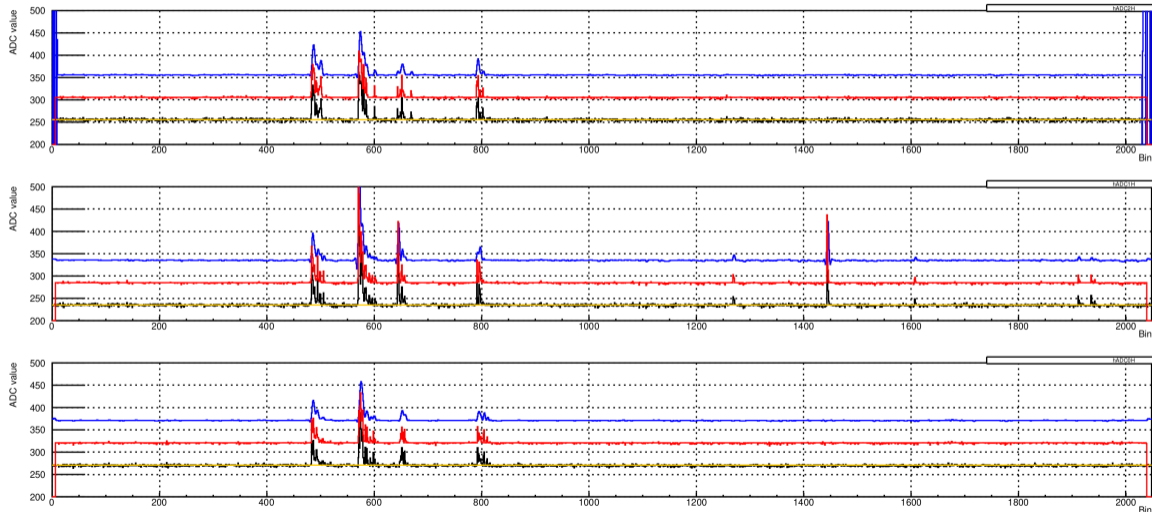
# Example Data from TanquitoJr



Top: ToTD rate

Bottom: MoPS rate

# Zoom in on a High Rate Region: Good Trace



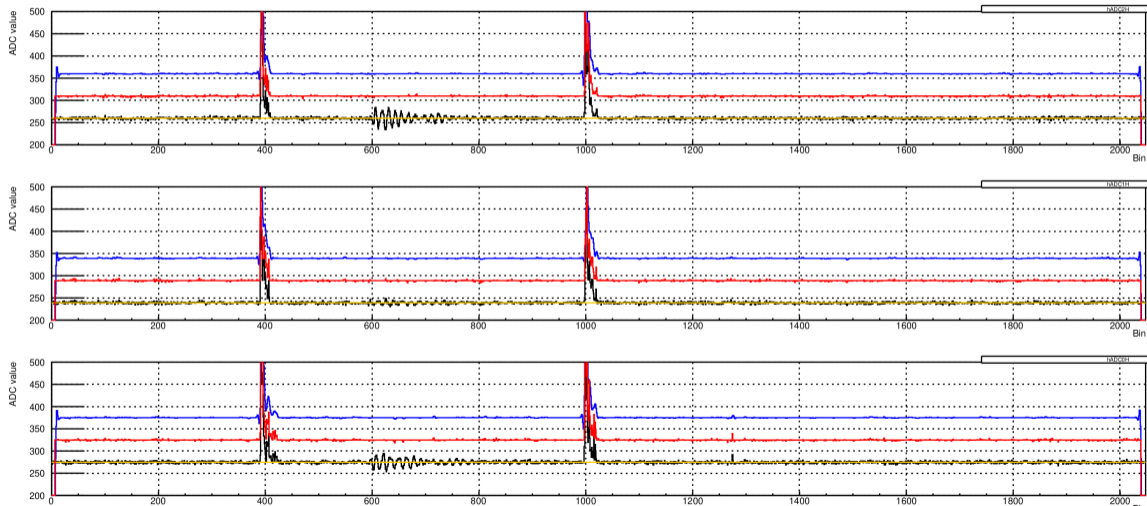
Black: Raw trace

Red: Trace cleaned in software

Blue: Cleaned & Filtered by software

Orange: Baseline

# Zoom in on a High Rate Region: A “Bad Trace”



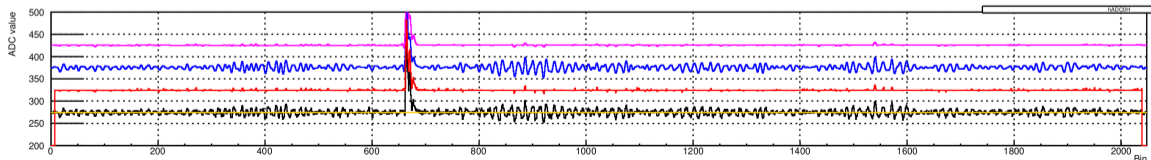
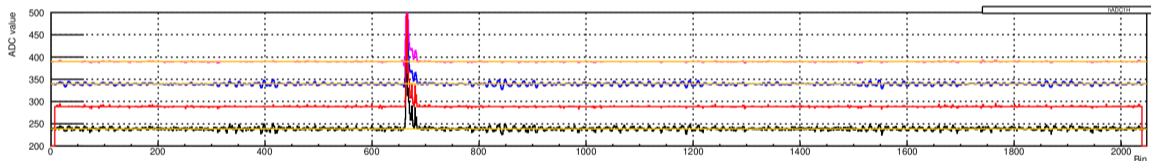
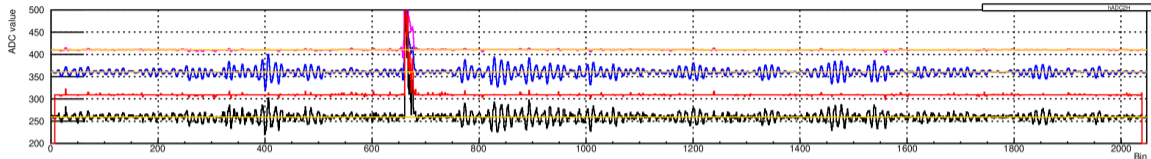
Black: Raw trace

Red: Trace cleaned in software

Blue: Cleaned & Filtered by software

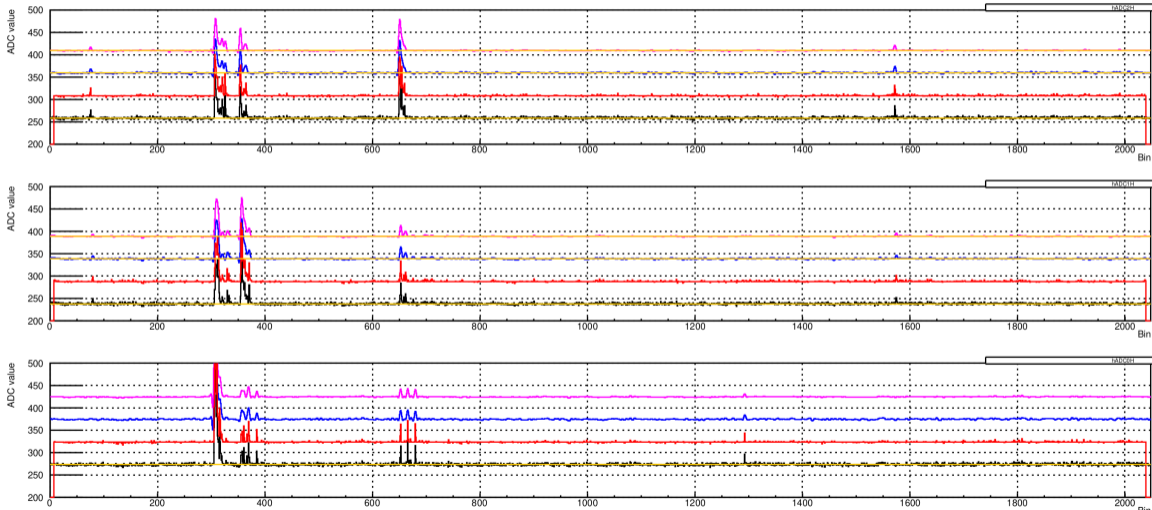
Orange: Baseline

# Another Example of a “Bad Trace”



Black: Raw trace    Red: Trace cleaned in software    Blue: Cleaned & Filtered by software    Orange: Baseline

# An Example of a “Good Trace”



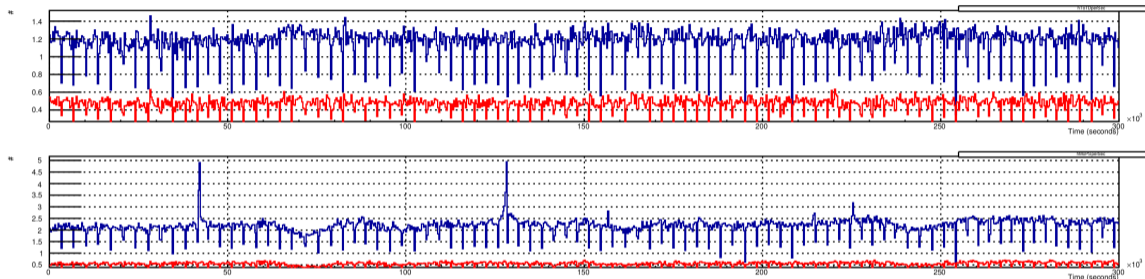
Black: Raw trace

Red: Trace cleaned in software

Blue: Cleaned & Filtered by software

Orange: Baseline

# Overview of some Data from Feche

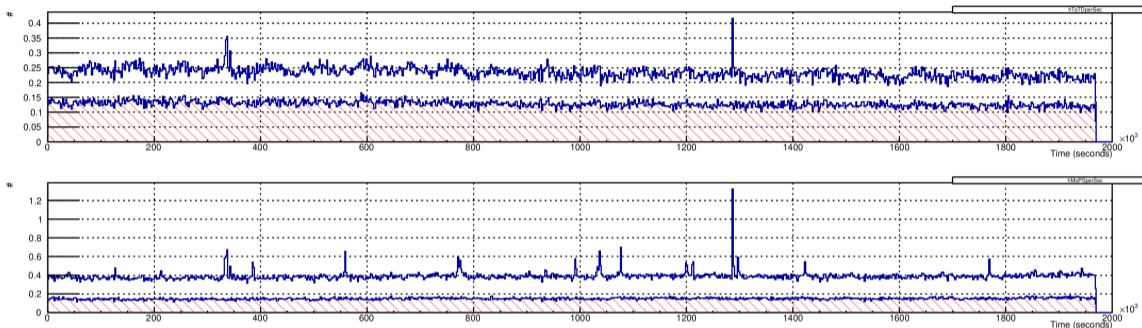


Top: ToTD rate    Bottom: MoPS rate    Blue: No trigger conditioning    Red hatch: With trigger conditioning

- This is data taken with special UUB firmware that triggers on both conditioned and unconditioned signals.
- The dips are when data is written to the memory stick and the code is dead to triggers
- This is more pronounced in Feche than in Tanquito, probably because the rate is higher



# Overview of “Replayed” Data from TanquitoJr

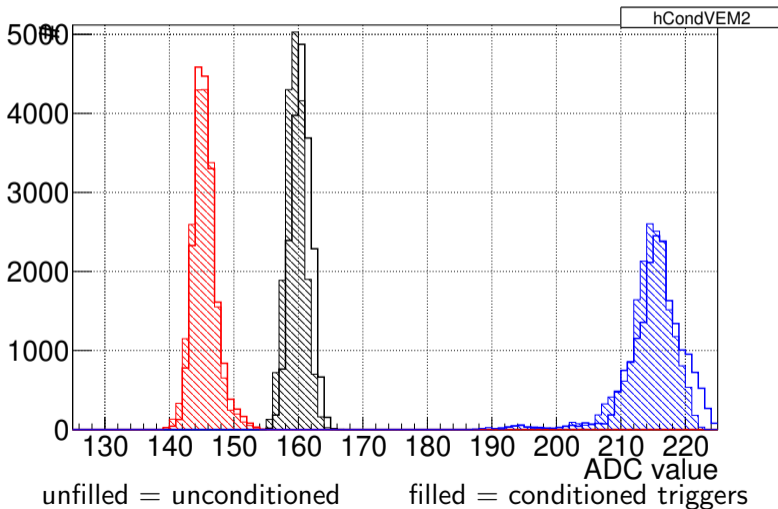


Top: ToTD rate    Bottom: MoPS rate    Blue: No trigger conditioning    Red hatch: With trigger conditioning

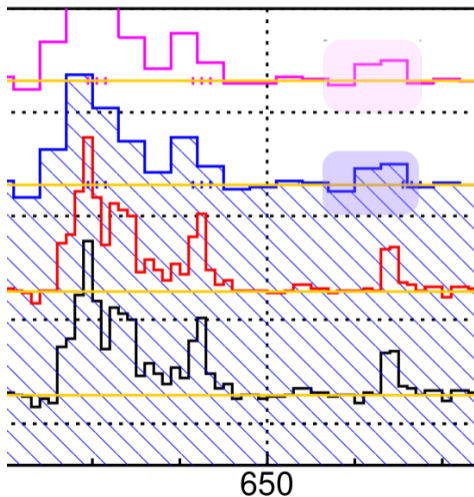
- The T2 rate is lower even in “quieter periods” after conditioning in this data.
- Is trigger conditioning too aggressive?
- Does this affect the T3/T4/T5 rate?
- Does this affect the VEM calibration?

# Some VEM Data from Feche

No significant difference in VEM calibration



# Why Is Trigger Rate Lower with Trigger Conditioning?



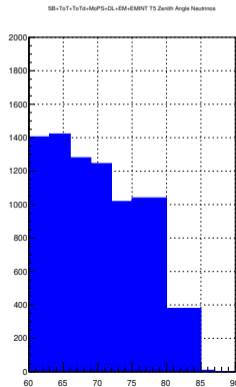
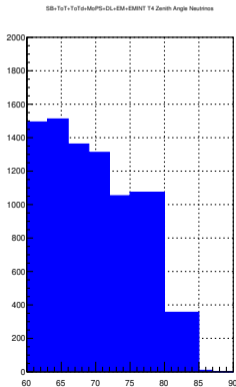
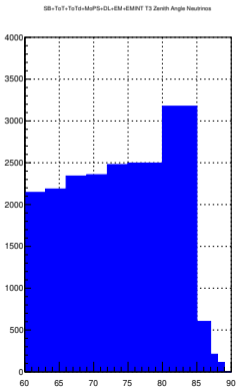
- Negative fluctuation before signal reduced by trigger conditioning reduces MoPS step
- Integrated signal falls just below integral constraint threshold after conditioning
- Are the missing triggers just noise or real signals we want to trigger on?
- Perhaps trigger conditioning is too aggressive?
- Try several alternatives of less aggressive trigger conditioning

# Some Tests with Less Aggressive Trigger Conditioning

- Things tried:
  - || vs && for wings on other side of baseline
  - Tweaking rounding
  - Adding dead band around baseline which trigger conditioner ignores
  - Tracking of baseline sag
- The first 2 tests made insignificant differences
- Unfortunately, I have not yet gotten the Verilog code with the 2nd two tests to work.
  - Verilog does not handle signed registers well; working with negative numbers is quite tricky and is best avoided
  - For example with standard register definitions,  $2 > 1$ , but also  $-2 > 1$  because by default all registers are unsigned
- Thus for checking T3/T4/T5s with and without trigger conditioning I use the aggressive algorithm in the following slides
  - Vertical scale is just number of events with no correction for slant depth or zenith angle bin width

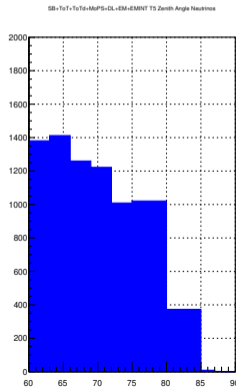
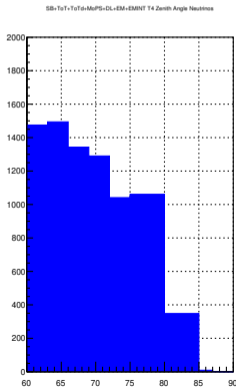
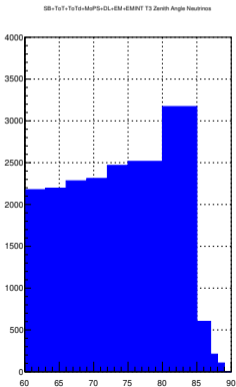
# Check T3/4/5 Rate with Offline Simulations (3.0 EeV $\nu$ ) without Trigger Conditioning

Important: The baselines were obtained using randoms data from Nadia during March 16, 2023 during which lightning was sometimes present.



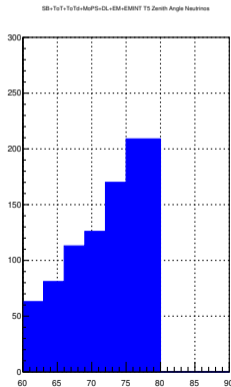
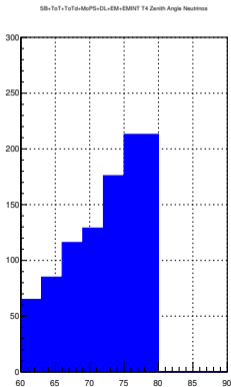
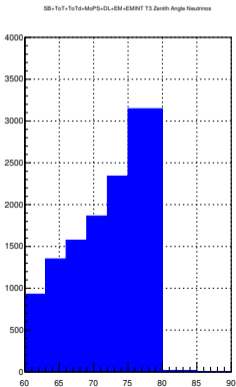
# Check T3/4/5 Rate with Offline Simulations and Aggressive Trigger Conditioning (3.0 EeV $\nu$ )

Important: The baselines were obtained using randoms data from Nadia during March 16, 2023 during which lightning was sometimes present.



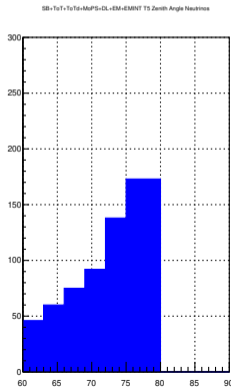
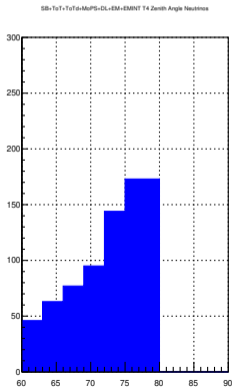
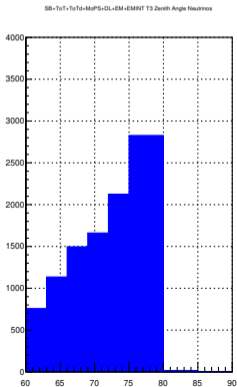
# Check T3/4/5 Rate with Offline Simulations (0.1 EeV $\nu$ ) without Trigger Conditioning

Important: The baselines were obtained using randoms data from Nadia during March 16, 2023 during which lightning was sometimes present. Expect some extra triggers due to noise.



# Check T3/4/5 Rate with Offline Simulations (0.1 EeV $\nu$ ) and Aggressive Trigger Conditioning

Important: The baselines were obtained using randoms data from Nadia during March 16, 2023 during which lightning was sometimes present.





# Summary

- ① Trigger conditioning removes rate spikes in ToTD and MoPS triggers
  - ① At least in TanquitoJr and Feche
- ② Even with very aggressive trigger conditioning:
  - ① VEM calibration is not affected by trigger conditioning
  - ② Simulated T3/T4/T5 rates not significantly affected in 3.0EeV  $\nu$  simulations
  - ③ Simulated T3/T4/T5 rates only modestly affected in 0.1EeV  $\nu$  simulations.
    - ① This is not surprising since a lower energies there are fewer stations triggered
    - ② But the number of stations triggered by single muons and small shower remain constant
    - ③ Some of the noise triggers are removed by trigger conditioning