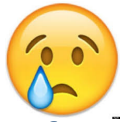
# Status Report ΔE-TOF Software + Analysis

Pisa group

# Introduction

- Pisa stand-alone ΔE-TOF software re-structured and improved
- Motivation:
  - Old code had a few problems that prevented us from analyzing 40 bars (CNAO March 2019 and GSI data April 2019)
    - Validated only for setup with 2 single bars. With 40 bars a different structure was necessary.
    - Charge distribution with spikes → energy calibration dubious (wrong, see next)
    - Number of entries in distributions unclear: no event-by-event structure→ Impossible to perform MC-data comparison
    - Only TW information was available, but no STC information → No Delta TOF available
    - Un-calibrated time stamps of TW itself
    - No direct plotting of waveforms and other useful information was possible
    - **No CNAO data calibration → No GSI energy and time calibration**
  - **Niccolo' leaving** 
- Today: quick summary of strategy to extract energy and TOF for system with 40 bars

# CNAO TOF data processing: OLD

Luca Galli, Stefan Ritt (PSI)

Data acquired: bin files

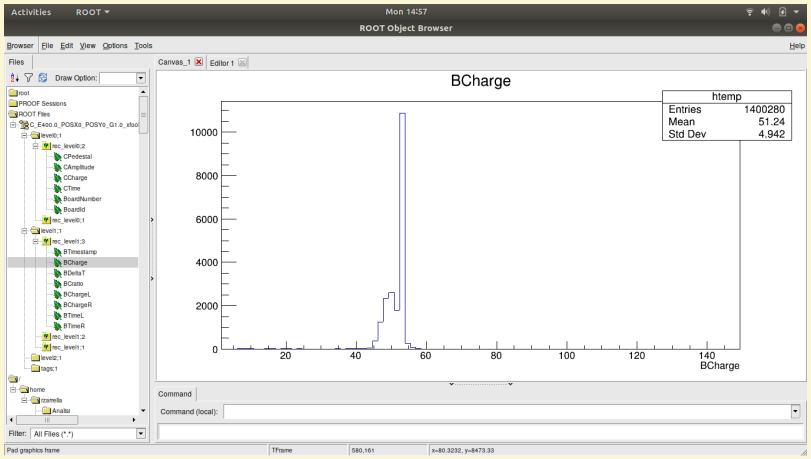
Decodication

Niccolo' Camarlinghi

Reconstruction of E and TOF
- Level 0
- Level 1
- Level 2

Analysis: Z, etc

Example problem:

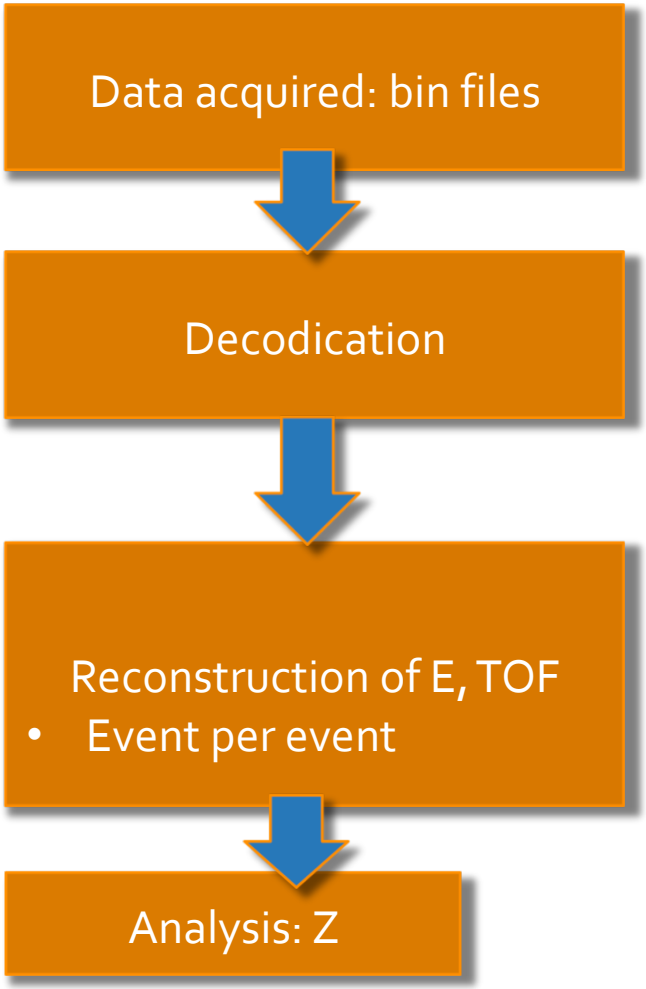



- Software was extensively used and validated for 2-bar setups at CNAO!
- But not appropriate and not tested for setup with 40 bars + STC.
- Was used as basis for implementation by Roberto Zarrella

# CNAO TOF data processing: NEW

Luca Galli, Stefan Ritt (PSI)

Roberto modifying Niccolo's framework



# Extracting the TOF: strategy

- Extract time stamp of TW:
  - **CFD method** implemented, applied to each channel.
  - Validation procedure:
    1. Check clock shapes for all channels.
       - Correct overflow effects
       - Noted that 1 board and 1 chip in another board had **hardware** problems: spikes → correct
    2. Check waveform shapes of all channels. Noted that 1 board and 1 chip in another board had **hardware** problems: spikes → correct
    3. Validate TW resolution for case where 2 bars were hit connected to the same clock (bars 9 and 29), so jitter correction irrelevant; check whether resolution is as expected (~40 ps)
    4. Apply jitter correction: evaluate TW resolution again, but for 2 bars hit that were not connected to the same clock. If done correctly, TW resolution should be the same as in step 1.
- Time stamp of STC (with help of Rome group):
  - Used CFD method applied to each channel (fit with Fermi-Dirac like function)
  - Extract time by calculating weighted mean (with resolution as provided by Rome group) of channels
- Apply corrections:
  - Jitter between STC and TW
  - Trigger cell
  - Cabling
- **Extraction of final TOF**

$$TOF = \frac{t_{TW,plane\ 1} + t_{TW,plane\ 2}}{2} - t_{STC} - t_{jitter} - t_{TriggerCell} - t_{Cabling}$$

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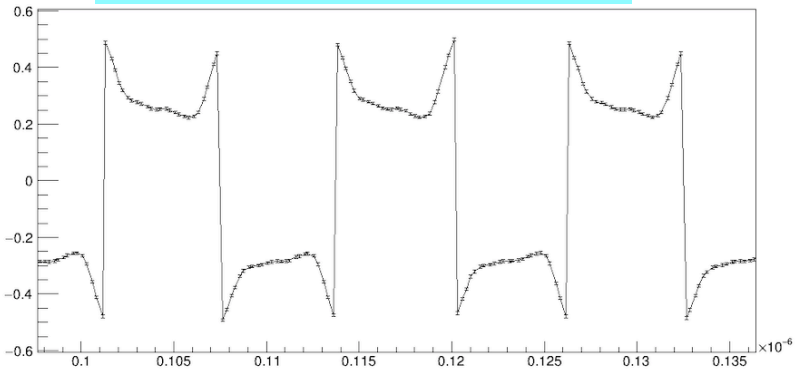
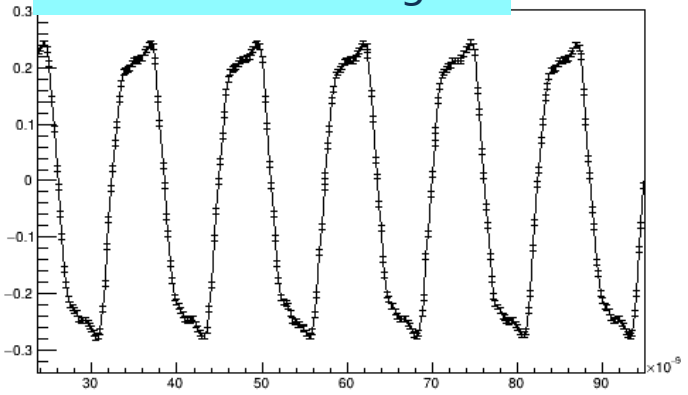
Uncorrected clock signal




Corrected clock signal



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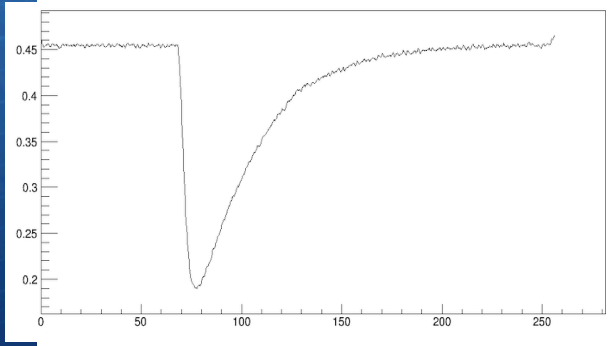
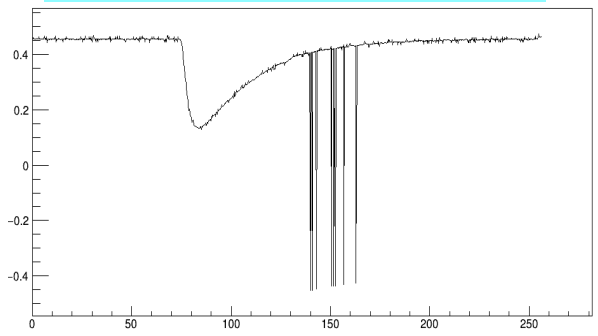
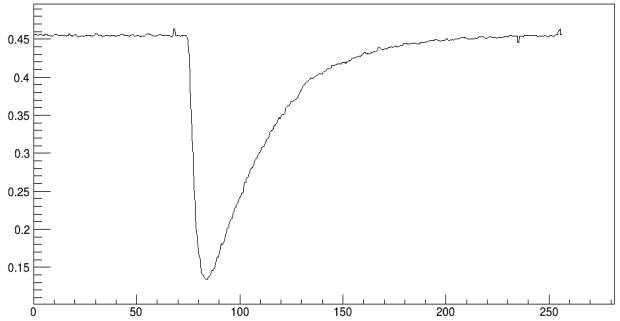
Good channel




Channel with hardware problems




Channel with hardware problems, corrected




BTW Not shown here, but same was noted for clock signals (but less 'damaging' for analysis)

**All channels successfully recovered!!**

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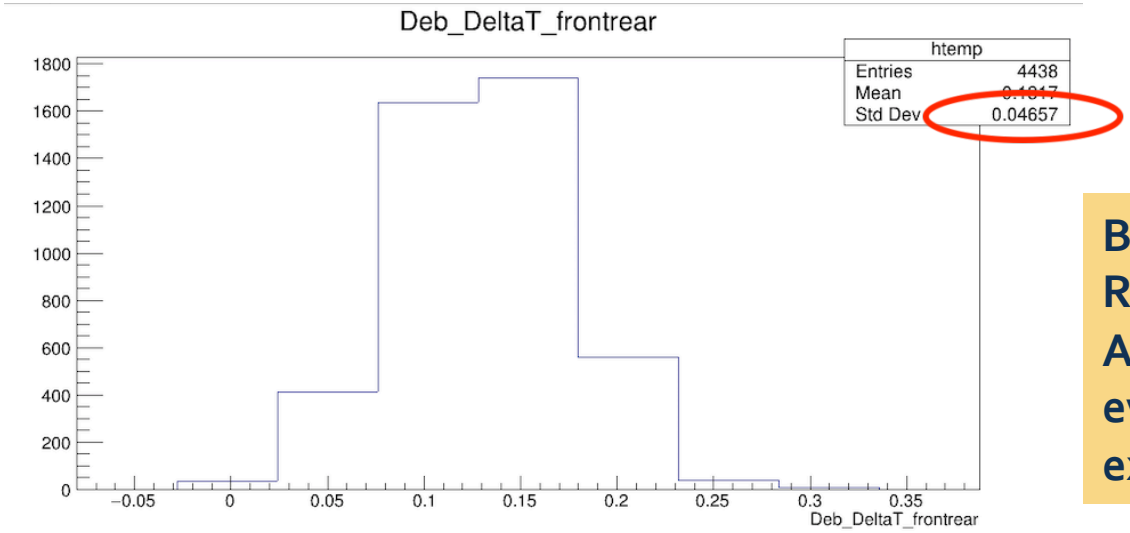


**Bug discovered in ReadBinary.C! After bug fix everything was as expected**

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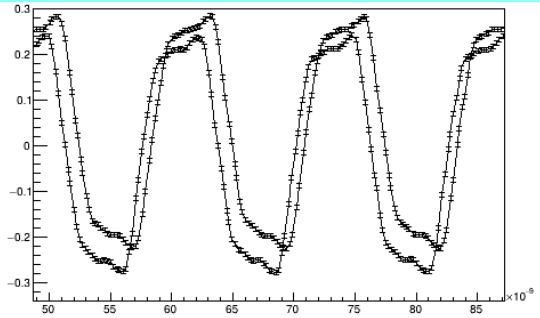
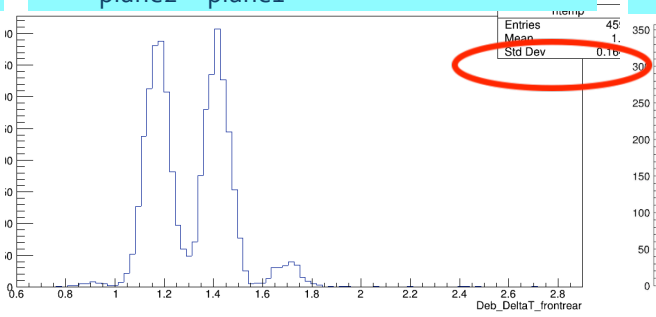
Misaligned clocks of 2 channels



$t=t_{plane2}-t_{plane1}$ (no correction)

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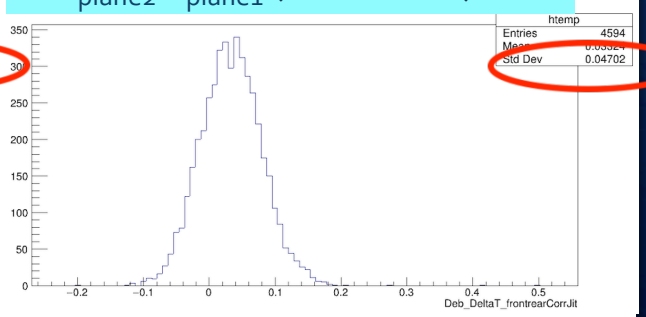
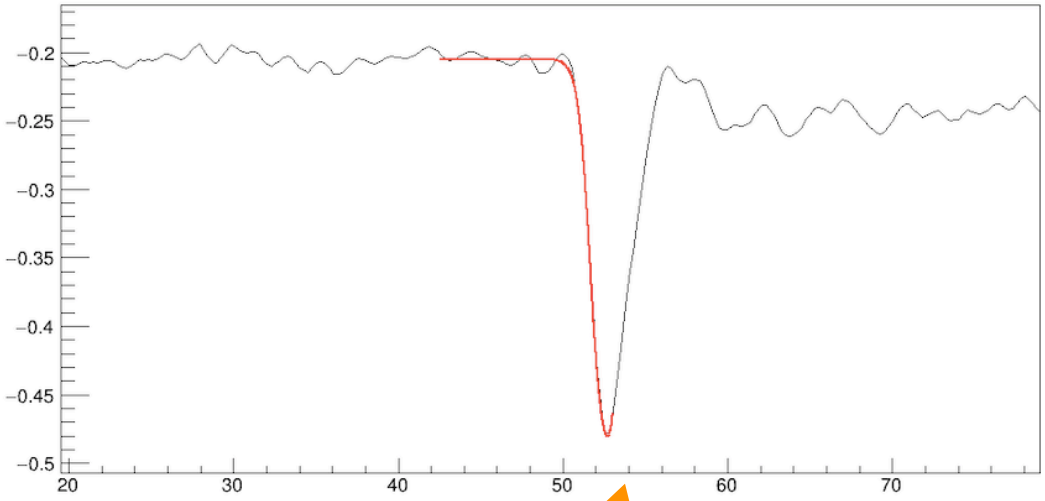



**Vertical and horizontal jitter correction implemented →resolution as expected!**

# Extracting the TOF: strategy

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- **Extraction of final TOF**

$$TOF = \frac{t_{TW,plane\ 1} + t_{TW,plane\ 2}}{2} - t_{STC} - t_{jitter} - t_{TriggerCell} - t_{Cabling}$$

# Extracting the TOF: strategy

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  - ✓ **CFD method** implemented, applied to each channel.
  - ✓ Validation procedure:
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- ✓ Apply corrections:
  - ✓ Jitter between STC and TW
  - ◆ Trigger cell: **now being done, almost ready**
  - ◆ Cabling: **each channel: data- MC**

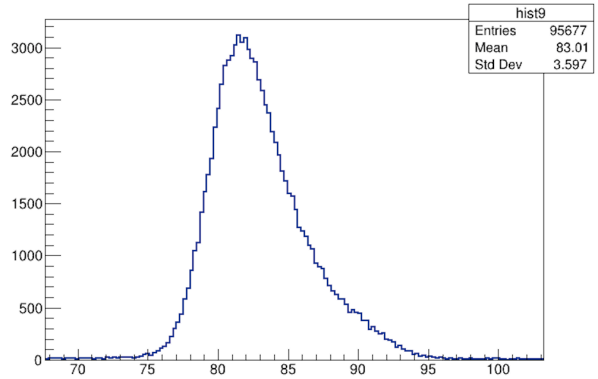
- ◆ **Extraction of final TOF**

$$TOF = \frac{t_{TW,plane\ 1} + t_{TW,plane\ 2}}{2} - t_{STC} - t_{jitter} - t_{TriggerCell} - t_{Cabling}$$

# Extracting Z

Z-analysis needs:

- TOF
- Energy:
  - Charge distributions should be calibrated. With actual framework and correct charge distribution for all channels, this is possible.




- ✓ No spikes
- ✓ Number of entries is number of events that had a non-zero energy deposit in that bar

- MC-data comparison on CNAO data
- MC-data comparison on GSI calibrated data

# Conclusion and plans

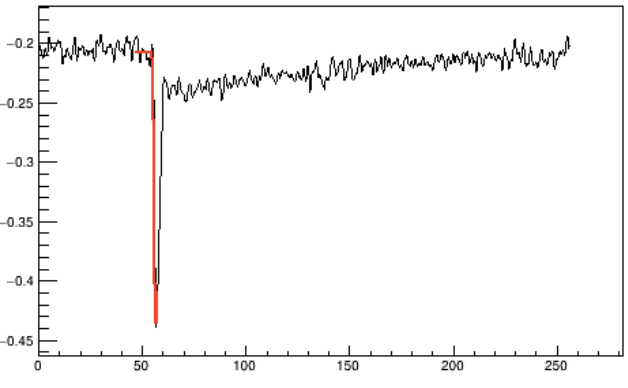
- ✓ Pisa stand-alone ΔE-TOF software re-structured and improved
  - ✓ 2-bar framework extended to 40 bars
  - ✓ Each step in analysis was thoroughly validated (various issues and bugs fixed)
    - ✓ Many results independently done by Matteo (now at IEEE!)
  - ✓ TOF extraction almost ready
  - ✓ Energy calibration being worked on
  - ✓ Allows for direct data-MC comparison (event-by-event structure)

→ will be used in all stand-alone data takings at CNAO and to check GSI data analysis with SHOE

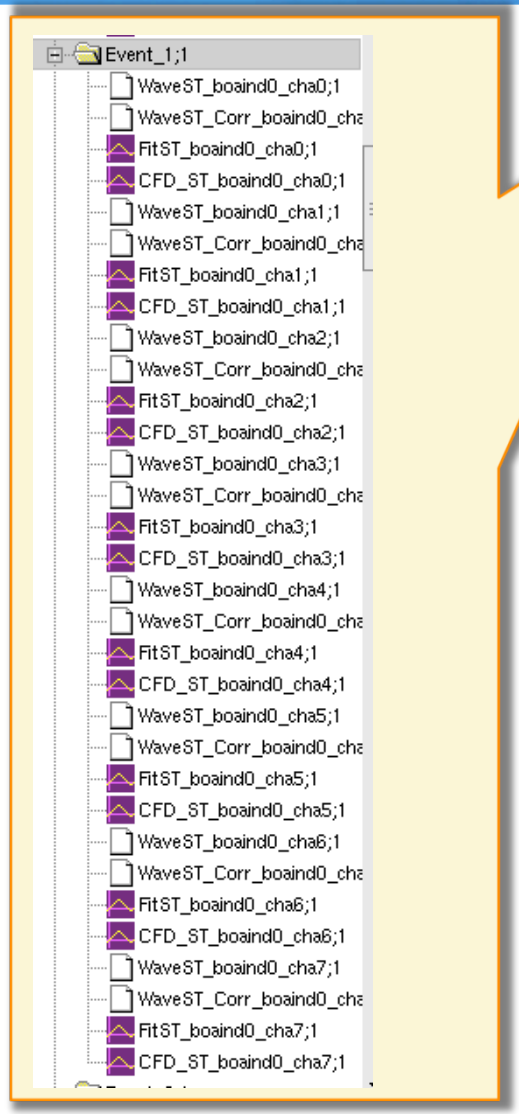
- To be done:
  - TOF: Finish trigger cell correction and cabling correction
  - Energy calibration
  - Z-extraction
  - MC-data comparison (Z, nbars hits, … )

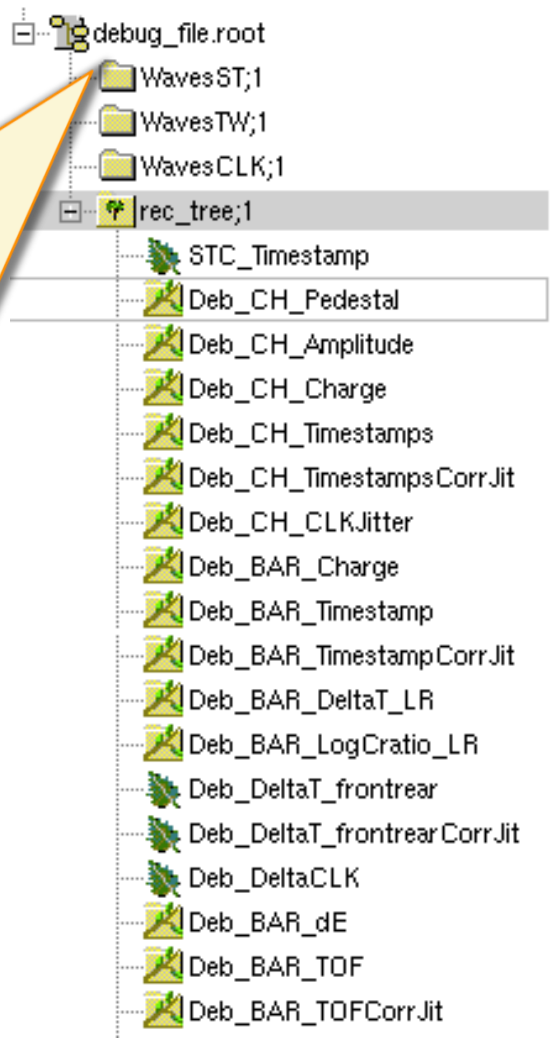
→ **Master thesis of Roberto Zarrella**

# CNAO TOF data processing: NEW




- Allows to plot for a given event(s) all info from all channels of STC
- Naturally will skip all these plots once procedure is fully validated and debugged!



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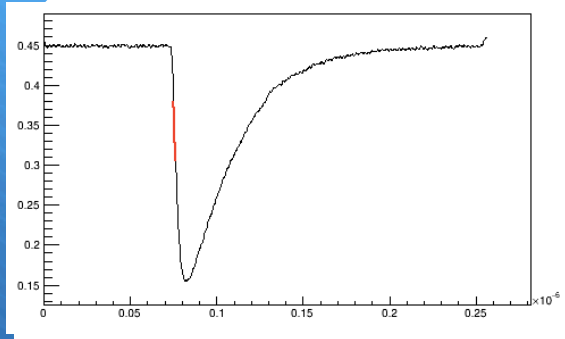


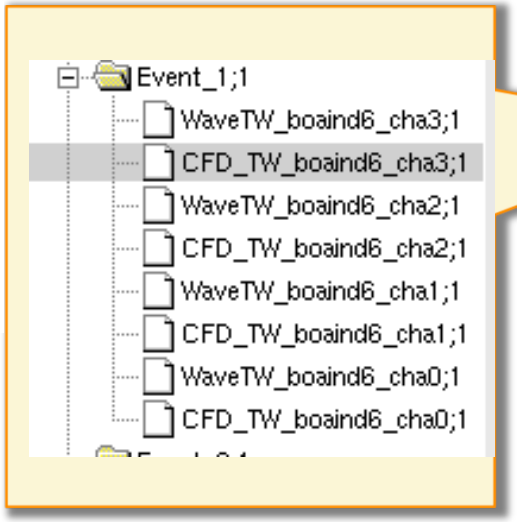


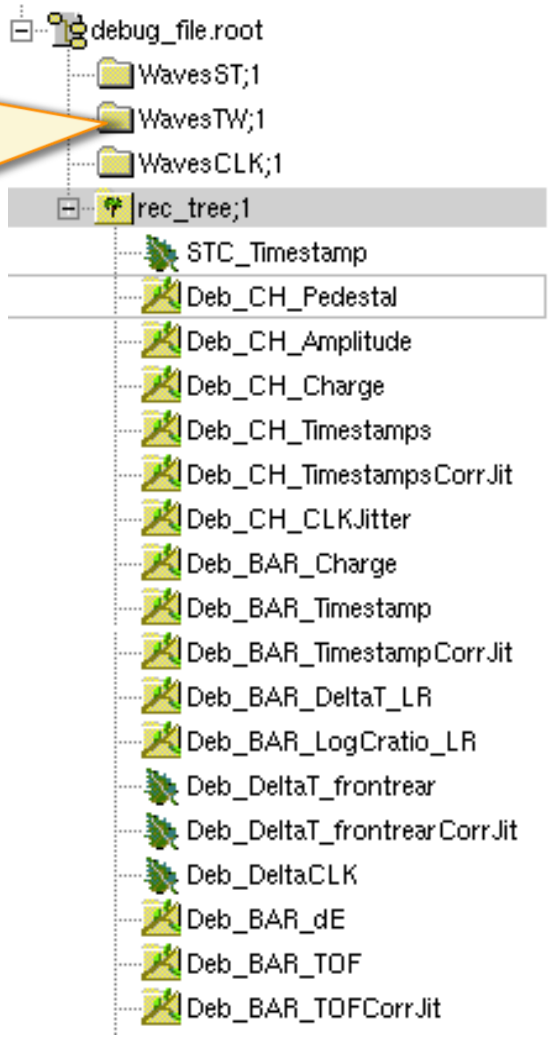


- Allows to plot for a given event(s) all info from all channels fired
- Details see next time
- Naturally will skip all these plots once procedure is fully validated and debugged!