Event Phase Reconstruction

- Raw TDC
- Event time used for monitoring
- Event phase
  - TBPhaseRec
  - TBPhase

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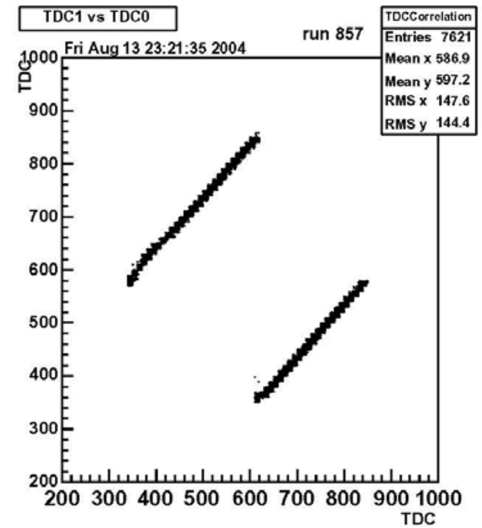
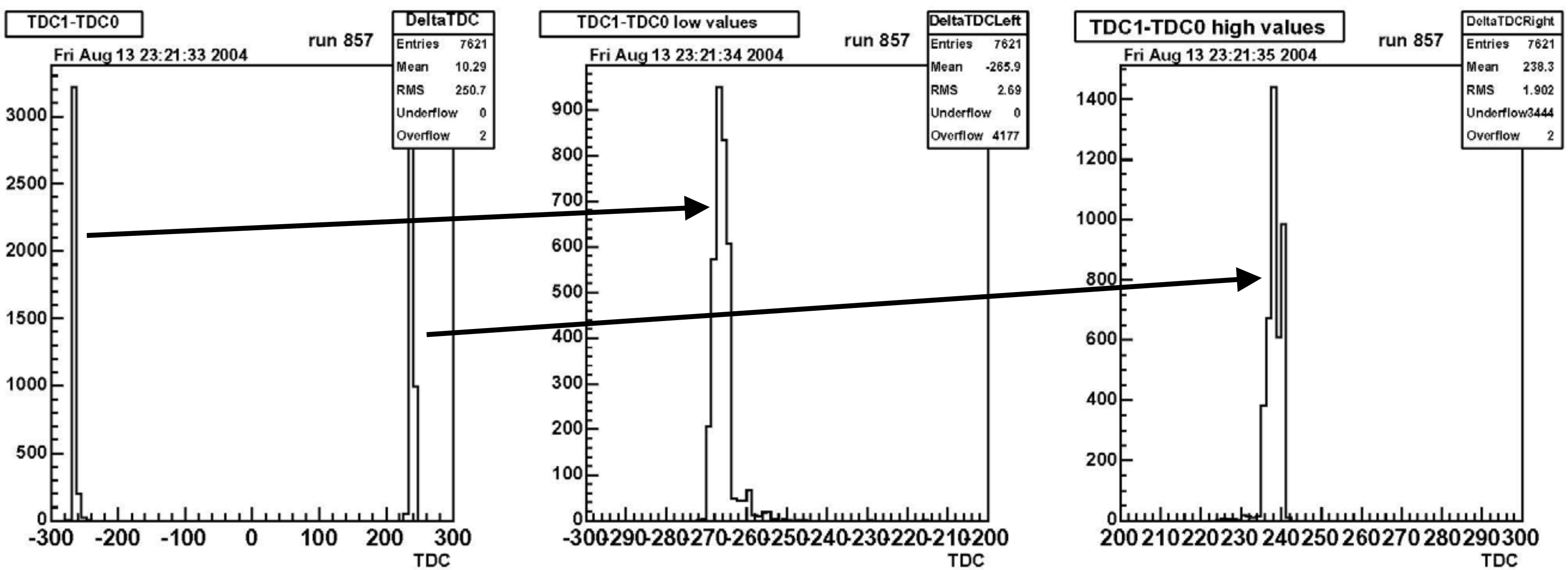
TDC's for event phase in H6

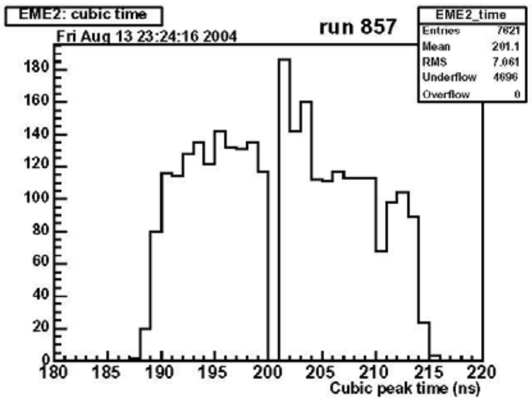
- Two TDC's are used, about 13ns apart
- Their difference allows for an estimate of their time resolution and ns/tdc calibration

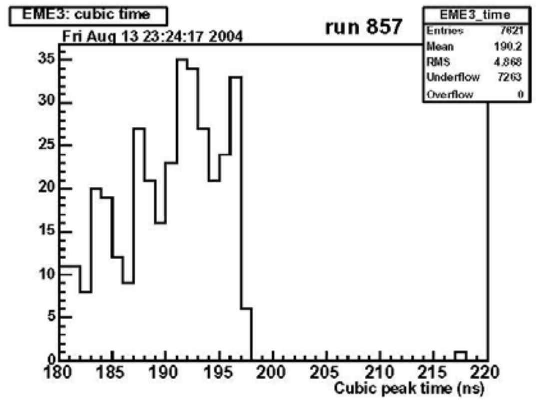




Event time estimate for monitoring

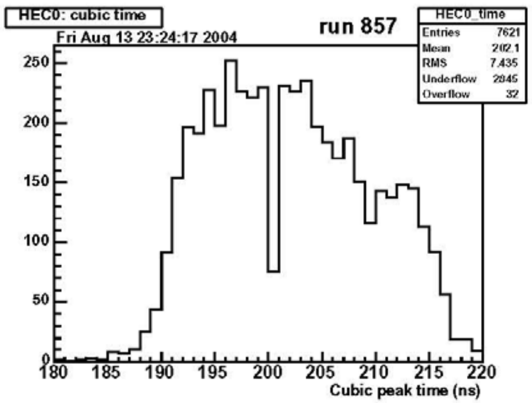
- For EMEC and HEC monitoring, the cell time is obtained from a cubic interpolation. For each event, we use an energy weighted mean of the cell times over all relevant CaloCell's (for example in a given sampling) for which cubic interpolation was successfully applied
- Example for run 857 (run I), 120 GeV π^+ hitting the EMEC

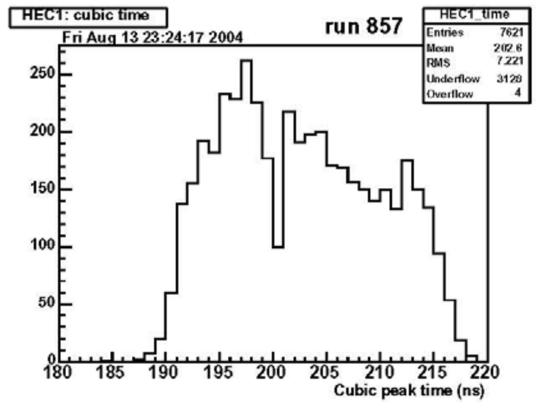


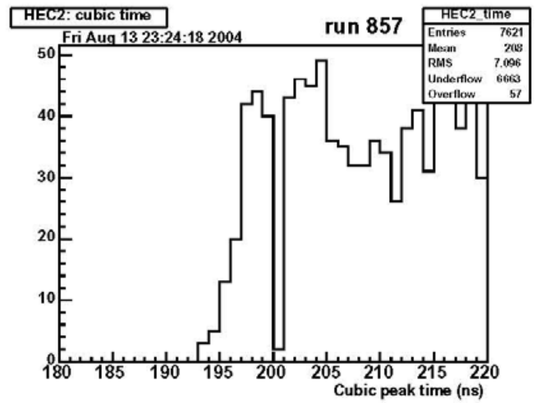


These distribution should be flat, but hey are not, indicating a bias in the time reconstruction. Nothing new.

The dip at 200 ns is caused by a known LAr software feature that needs to be improved

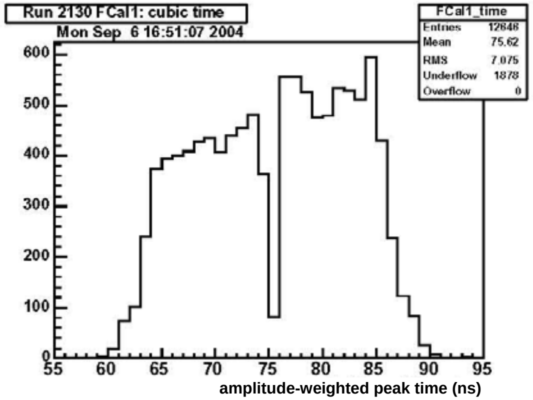


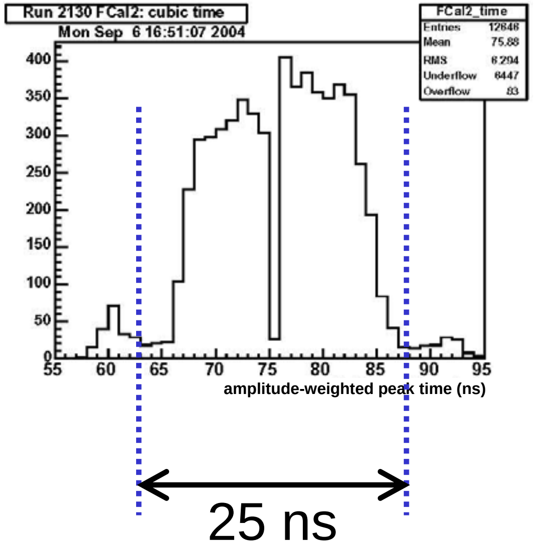




Event time estimate for monitoring

- For FCAL monitoring, the cell time estimate is an amplitude-weighted time average around the signal peak. For each event, we use an energy-weighted mean of the cell times over all relevant CaloCell's (for example in a given sampling).
- Example for run 2130 (run II), 150 GeV π^- hitting the FCAL
- the event time reconstructed for FCAL2 spans less than 25 ns (bias in reconstruction?), and has small populations "repelled" from the time edges



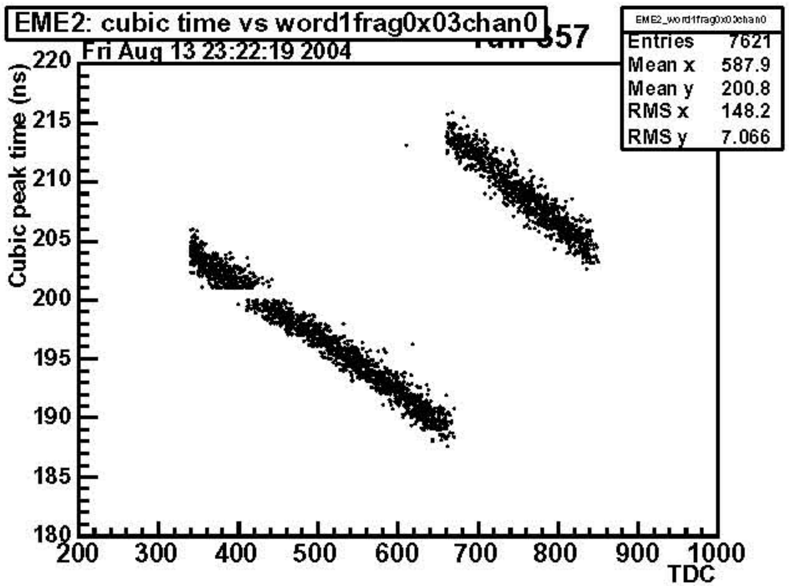


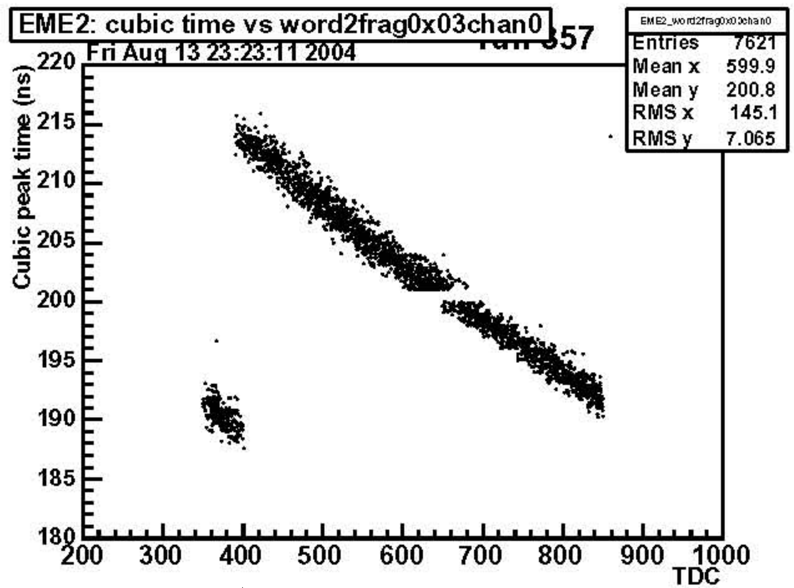
These distribution should be flat, but hey are not, indicating a bias in the time reconstruction.

The dip at 200 ns is caused by a known LAr software feature that needs to be improved

TDC and event time

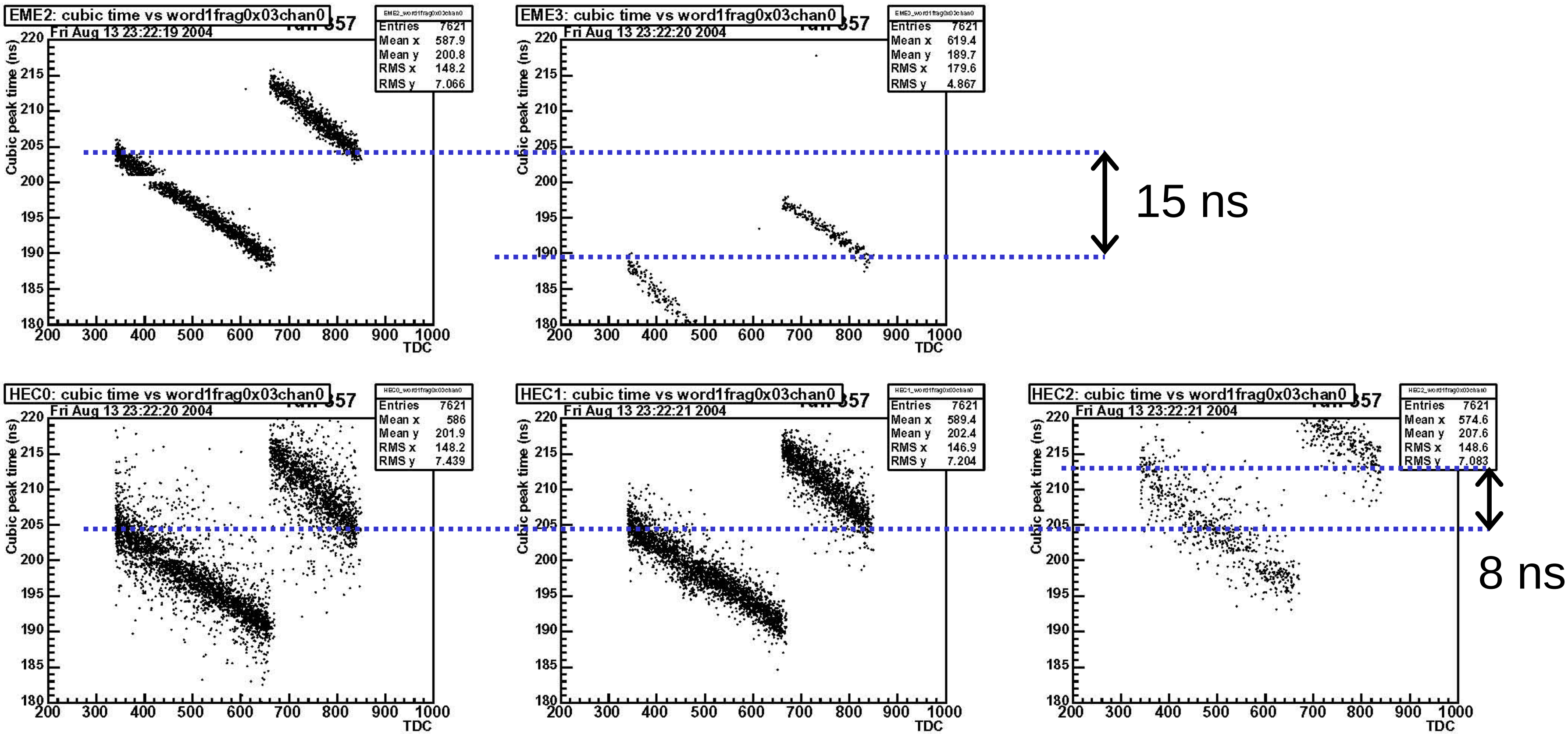
- The raw TDC values are well correlated with the mean cubic peak time. The negative slope indicates that the TDC is started by the trigger and stopped by the next phase of the clock (after some fixed wait time), not the other way around.
- Example for run 857 (run I), 120 GeV π^+ hitting the EMEC, EME2 sampling
- Each TDC has its own wrap-around-constant (wac)





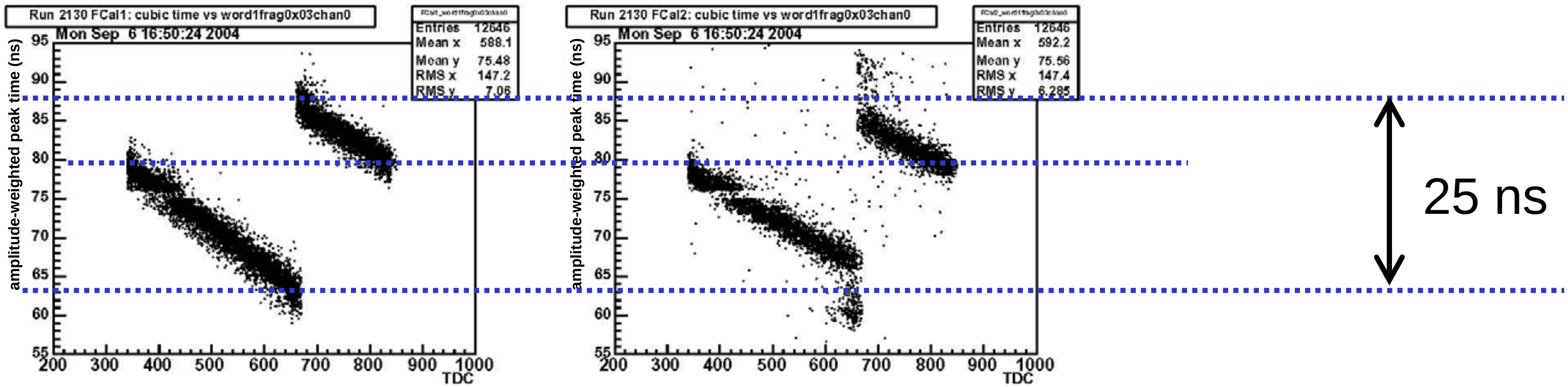
wac1 ≈ 660 wac2 ≈ 400

Relative timing of samplings



- Example for run 857 (run I), 120 GeV π^+ hitting the EMEC
- EMEC: the rear sampling signal is about 15 ns earlier than the front
- HEC: the rear sampling signal is about 8 ns later than the front

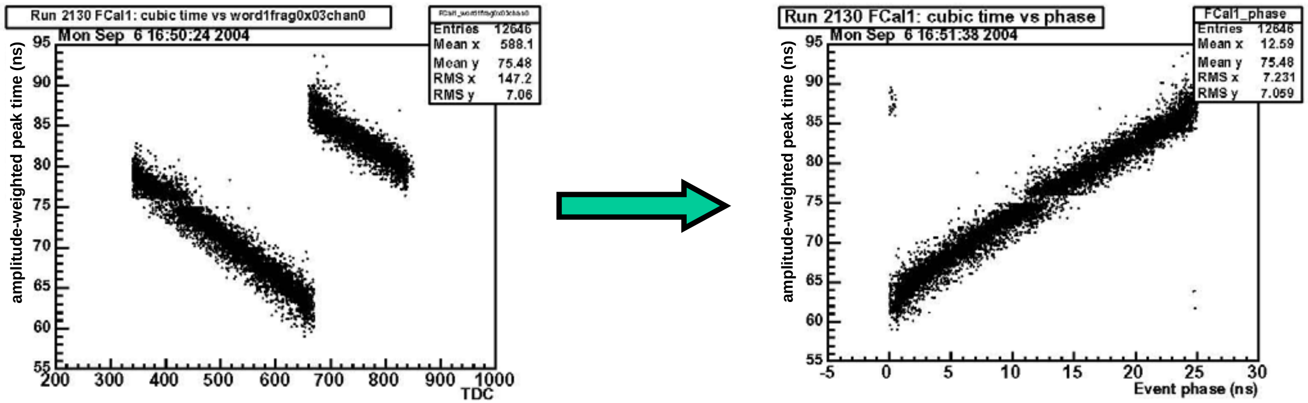
Relative timing of samplings



- Example for run 2130 (run II), 150 GeV π^- hitting the FCAL
- FCAL: both samplings seem synchronized, but the event time reconstructed for FCAL2 spans less than 25 ns (bias in reconstruction?)
- The small populations “repelled” from the event time edges are located near the TDC wrap-around (for both TDC’s)

Event phase: TBPhaseRec

- The event TBPhase is produced by Testbeam/TBrec/TBPhaseRec

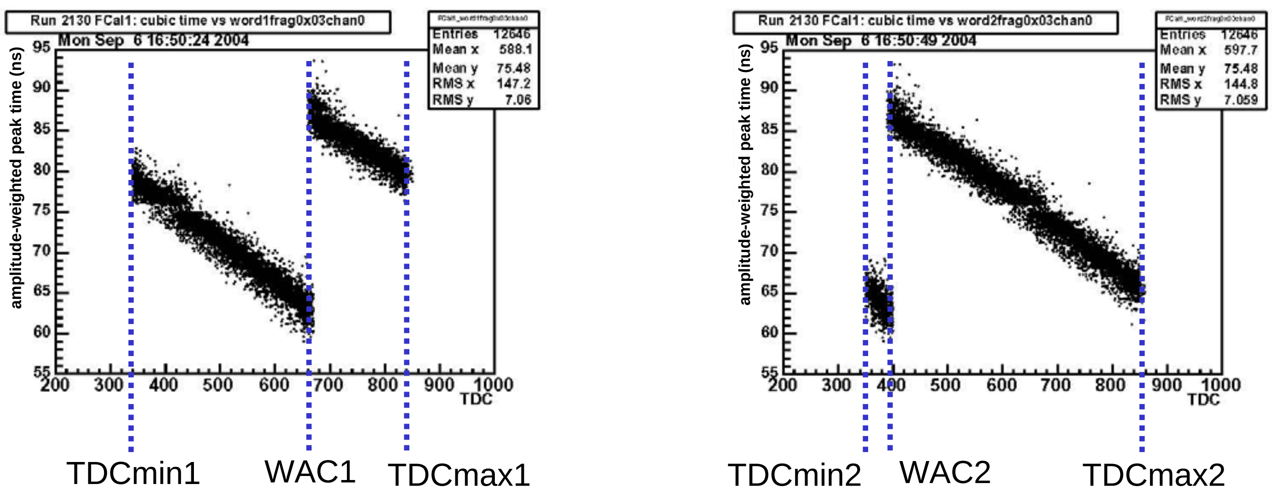


- The goal of TBPhaseRec is to produce a phase (0.0 to 25.0 ns) related to the event time as in the right figure, given at least one raw TDC value, as in the left figure.

Event phase: TBPhaseRec

- Two TDC are used in H6 for event phase reconstruction
- Currently, TBPhaseRec uses the TDC with the highest “Quality” Q to reconstruct the event phase
  - TDC “Quality” is defined as the shortest distance (in TDC units) between the event TDC value and one of TDC_{min}, WAC and TDC_{max}

$$Q = \min\left[\left|TDC_{min} - TDC\right|, \left|WAC - TDC\right|, \left|TDC_{max} - TDC\right|\right]$$



Event phase: TBPhaseRec

- Unfortunately, it is found that if the quality is set by |WAC-TDC|, then it will be about the same (and small) for both TDC's... which means that we should really veto events with small quality, as was done before in H6 using a TDC guard region about the WAC value.
- Consider the following example, from a typical event from run 2130, taken using the DEBUG flag:
  - TDC0 value = 662; tdc quality: to tdcMin = 342; to tdcMax = 158; to tdcwac = 2; final = 2
  - TDC0 value = 662; reconstructed phase = 24.9 ns
  - TDC1 value = 391; tdc quality: to tdcMin = 71; to tdcMax = 429; to tdcwac = 9; final = 9
  - TDC1 value = 391; reconstructed phase = 0.45 ns
  - best quality for TDC1, with reconstructed phase = 0.45 ns
  - Phase = 0.45 ns; phase index = 0
- Here the quality of each TDC is small (2 and 9) due to the proximity of the TDC value to the WAC, FOR EACH TDC. In this example, the reconstructed phases are at each end of the [0, 25ns] range... The one finally chosen (here 0.45 ns) may not be the right one because of the limited accuracy of the WAC and because of time jitter.

TBPhaseRec jobOptions

```
# assume two TDCs for H6
TBPhaseRec.TDCNames = ["word1frag0x03chan0“,
                       "word2frag0x03chan0"]
TBPhaseRec.TDCToTime = [-0.05*ns, -0.05*ns]
TBPhaseRec.TDCwac = [    660.,     400.]
TBPhaseRec.TDCMin = [    320.,     320.]
TBPhaseRec.TTCClockPeriod = 25.*ns
TBPhaseRec.TimeBins = 25
TBPhaseRec.TBPhaseKey = "TBPhase"
```

```
# assume two TDCs for H6
TBPhaseRec.TDCNames = ["frag0x12chan0”]
TBPhaseRec.TDCToTime = [-0.0036*ns]
TBPhaseRec.TDCwac = [ 565.]
TBPhaseRec.TTCClockPeriod = 25.*ns
TBPhaseRec.TimeBins = 25
TBPhaseRec.TBPhaseKey = "TBPhase“
TBPhaseRec_NeverReturnFailure = TRUE
```

- TDCToTime: negative because of the slope of the event time vs TDC values, namely in H6 and H8 the TDC is started by the trigger and stopped by the next phase of the clock (after some fixed wait time), not the other way around.
- TDCwac: wrap around constants
- TDCmin: only needed if there are more than one TDC used for event phase reconstruction
- TimeBins: the number of intervals the TTCClockPeriod is to be divided to produce the phase index
- NeverReturnFailure: default FALSE. controls when StatusCode::FAILURE can be issued in execute().

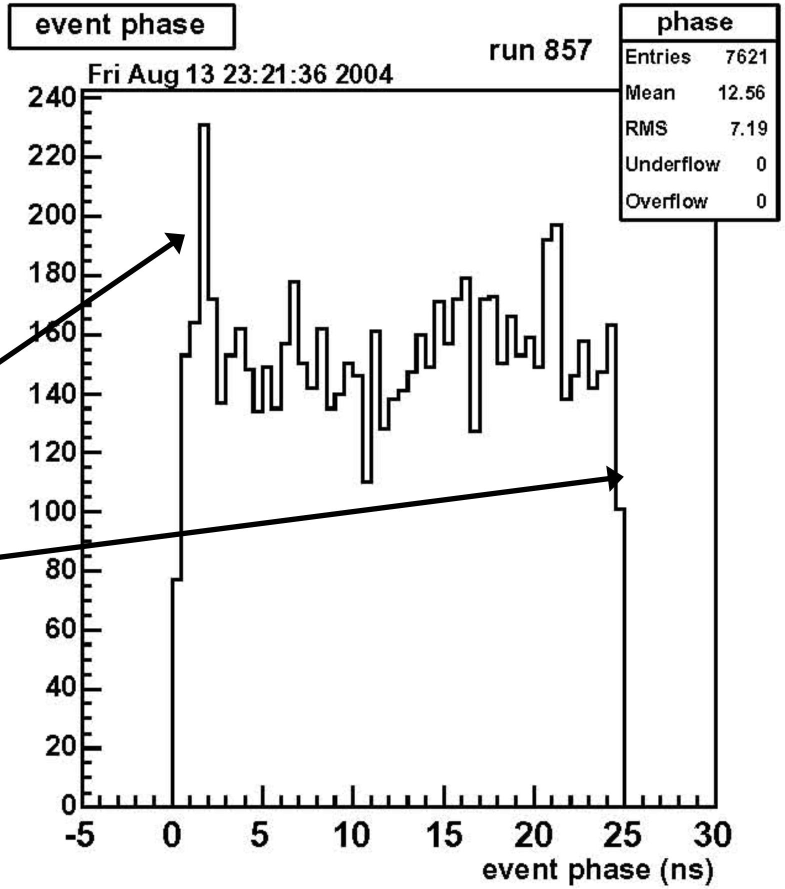
Event phase: TBPhase

- Currently, the TBPhase object has two data members:
  - float m_phase   the event phase [0, TTCClockPeriod]
  - short m_phaseInd   the phase index [0, TDCBins-1]
- It would be useful to add a data member, say m_quality, that would contain the quality of the TDC value used. This could allow rejection of events with for low quality TDC values: such events may have a phase reconstructed using a TDC value close to a WAC, which results in a ≈0ns ↔ ≈25ns swap. This will be more severe if the WAC values are poorly estimated.

Event phase

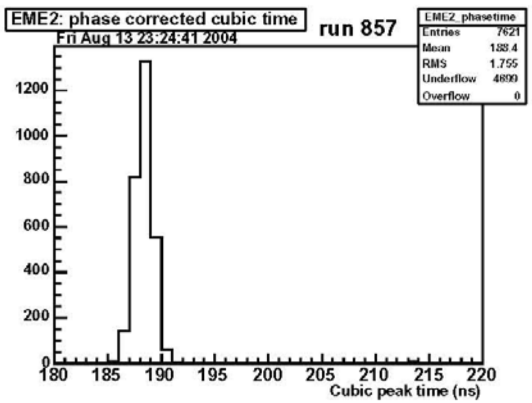
- In the case where two TDC's are available for the event phase reconstruction (as in H6), a simple criteria is applied to decide which TDC to use.
- The event phase is found to be almost flat in H6.

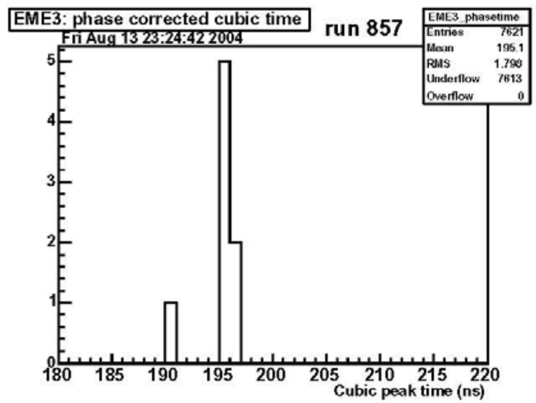
probably due to
TDC close to WAP

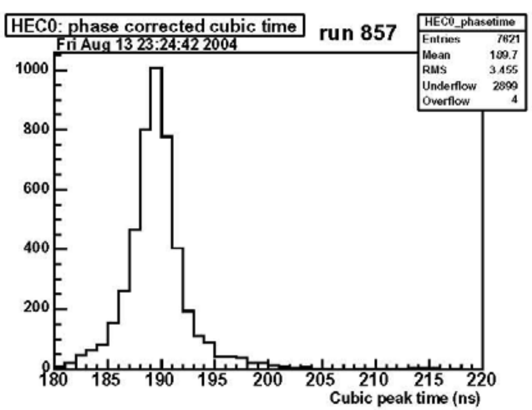


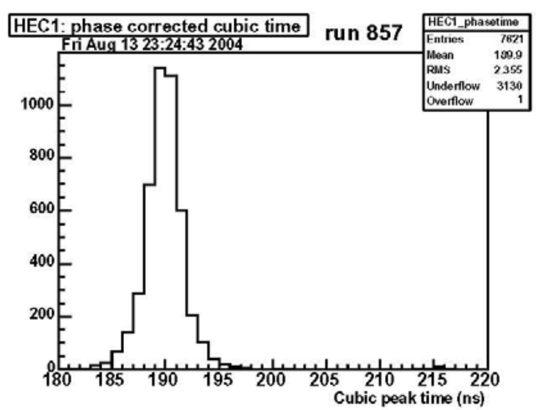
TDC corrected event time

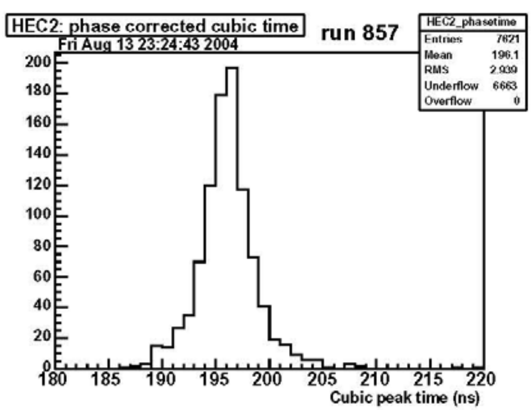
- EMEC and HEC, example for run 857 (run I), 120 GeV π^+ hitting the EMEC
- Ideally, these distributions should be delta functions: their width is a measure of the overall timing precision
    - event phase, cubic peak time and cell-to-cell timing differences





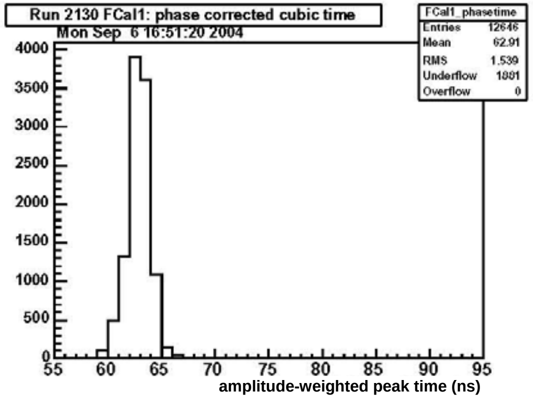


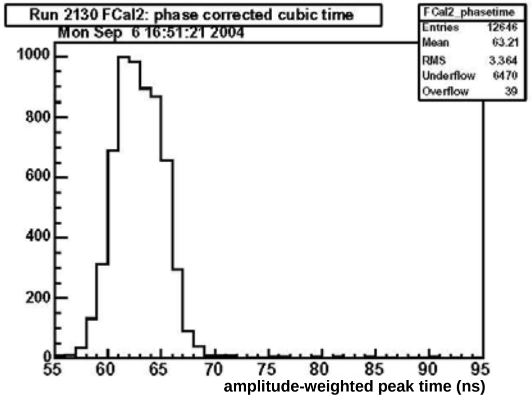




TDC corrected event time

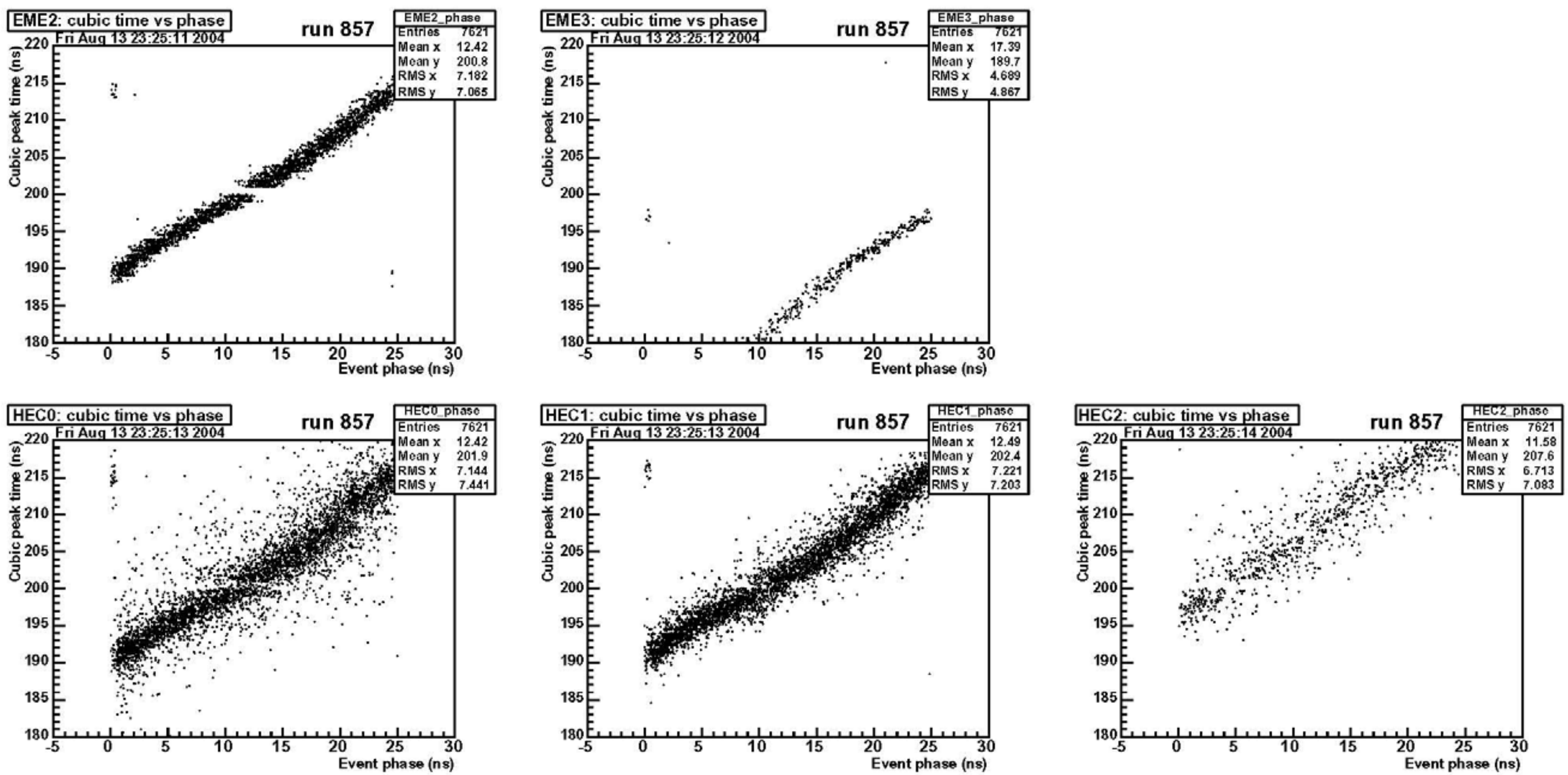
- Example for run 2130 (run II), 150 GeV π^- hitting the FCAL
- Ideally, these distributions should be delta functions: their width is a measure of the overall timing precision
  - event phase, cubic peak time and cell-to-cell timing differences





Calorimeter time vs event phase

- EMEC and HEC, example for run 857 (run I), 120 GeV π^+ hitting the EMEC
- We notice some non-linearity, probably mainly caused by the cubic interpolation.
- We clearly see timing differences between samplings



Calorimeter time vs event phase

- FCAL, example for run 2130 (run II), 150 GeV π^- hitting the FCAL
- Same features for FCAL2