

TOP TRG Status / Current Problems / Priorities

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Previously: managed to get slot-level TOP TRG efficiency as high as 92% with timing resolution of 8ns...

BUT only for cosmic events (very clean events, no noise / background, can wait for the first signal hit)

Efficiency of TOP TRG for hadronic events was barely ~20% (for higher-luminosity hadronic events)

Realized that such algorithm could not possibly work for collisions in presence of beam background

Concluded that no standalone ECL-like TOP-based trigger with reliable timing is possible for collisions

Since a year ago have been using a sliding window slot-level algorithm (imperfect, has problems also)

Concluded that we need to match TOP slots with CDC tracks at TRG, this remains to be our main focus

Results reported today are based on XILINX's iSim which uses waveform TOP TRG data from collisions

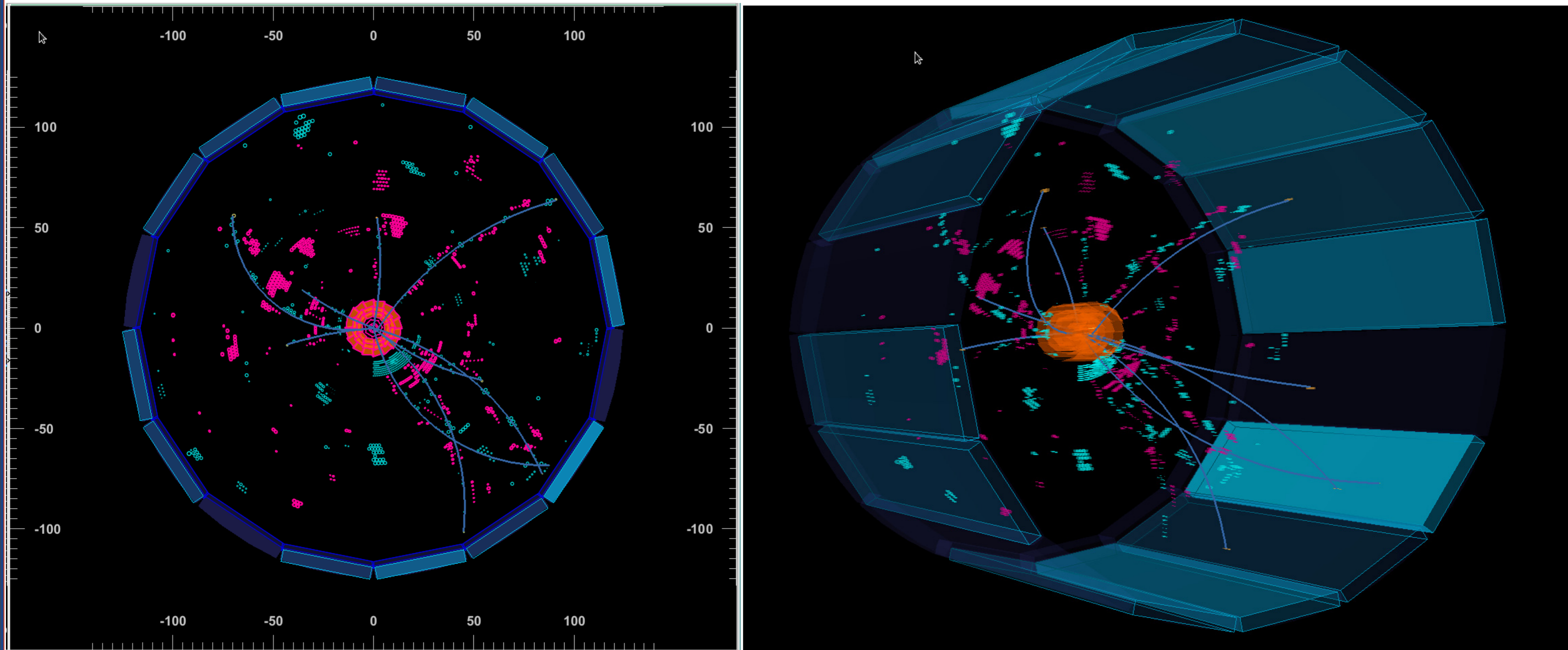
Using hadronic events to understand the current efficiency and timing, and what needs to be done

TOP-CDC Matching

part 1

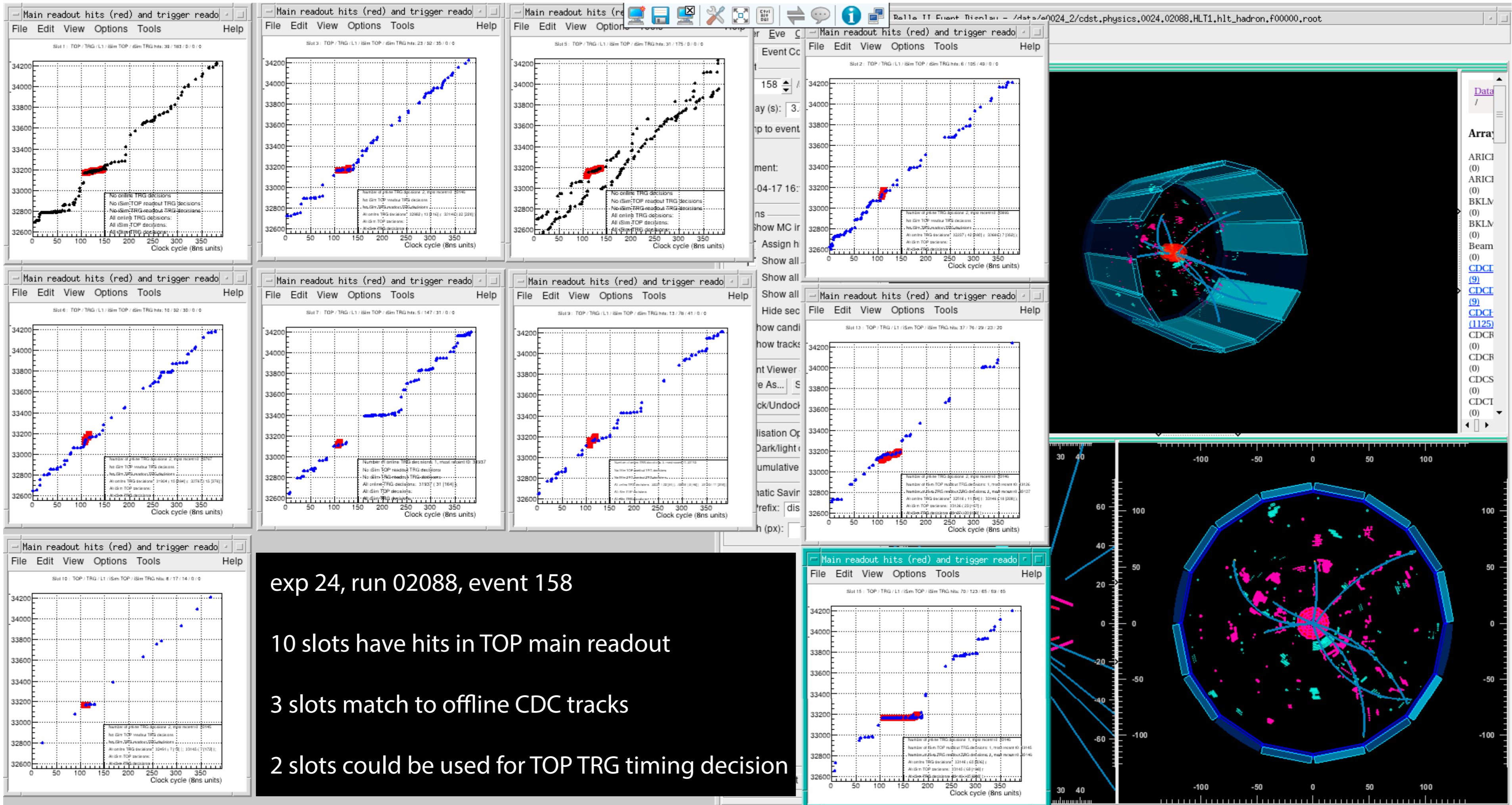
a look at the data

Representative Hadronic Event (exp 24, run 02088)

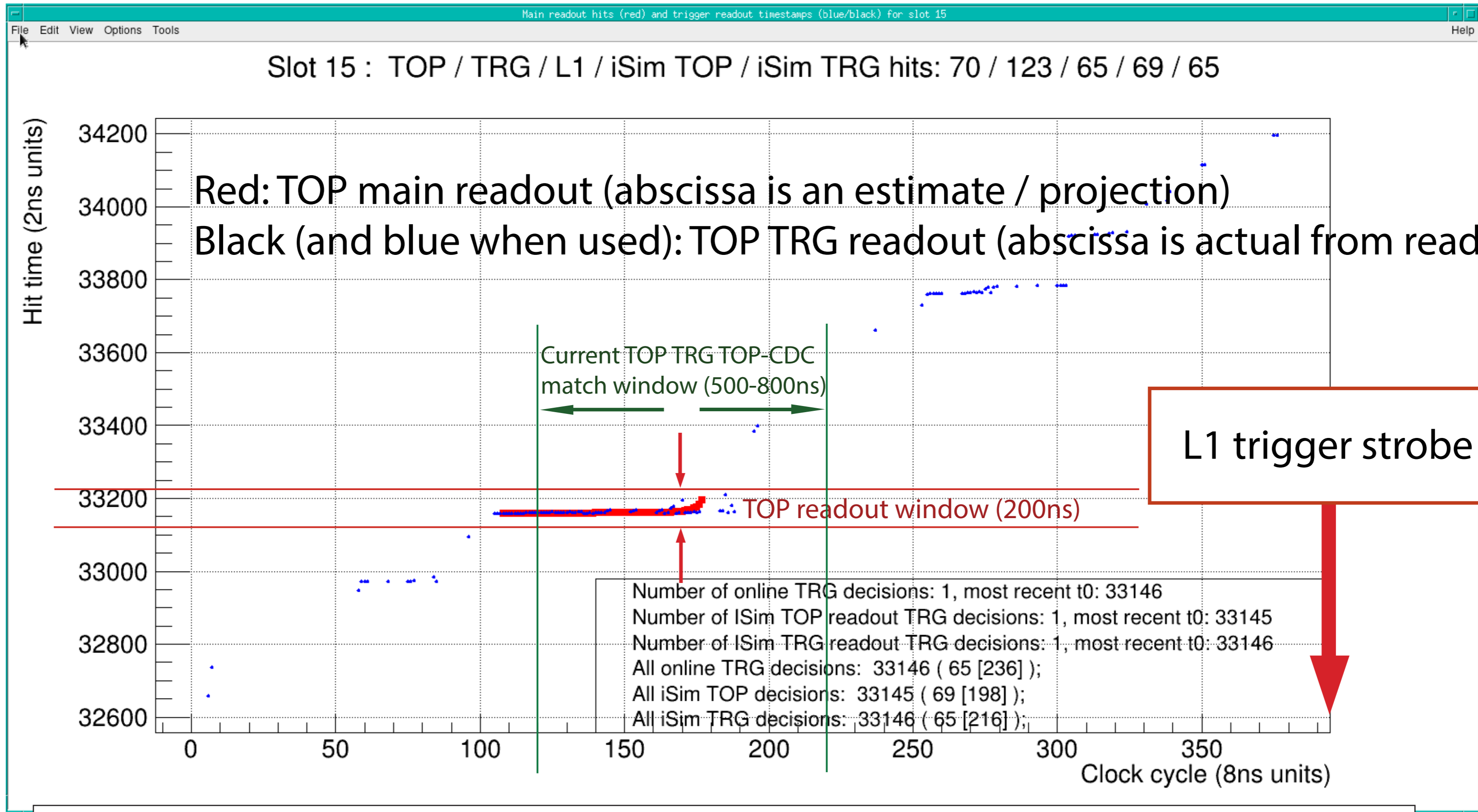


We are using CDC tracks reconstructed offline because these allow us to fully explore the best we would ever be able to do online with 2D tracks. 3 slots match to tracks in this event. However, slot 2 has only 6 hits in TOP readout, which means that there is no chance to trigger on this slot ($N_{\text{TOP TRG hits}} \leq N_{\text{TOP hits}}$)

Information recorded from TOP TRG readout

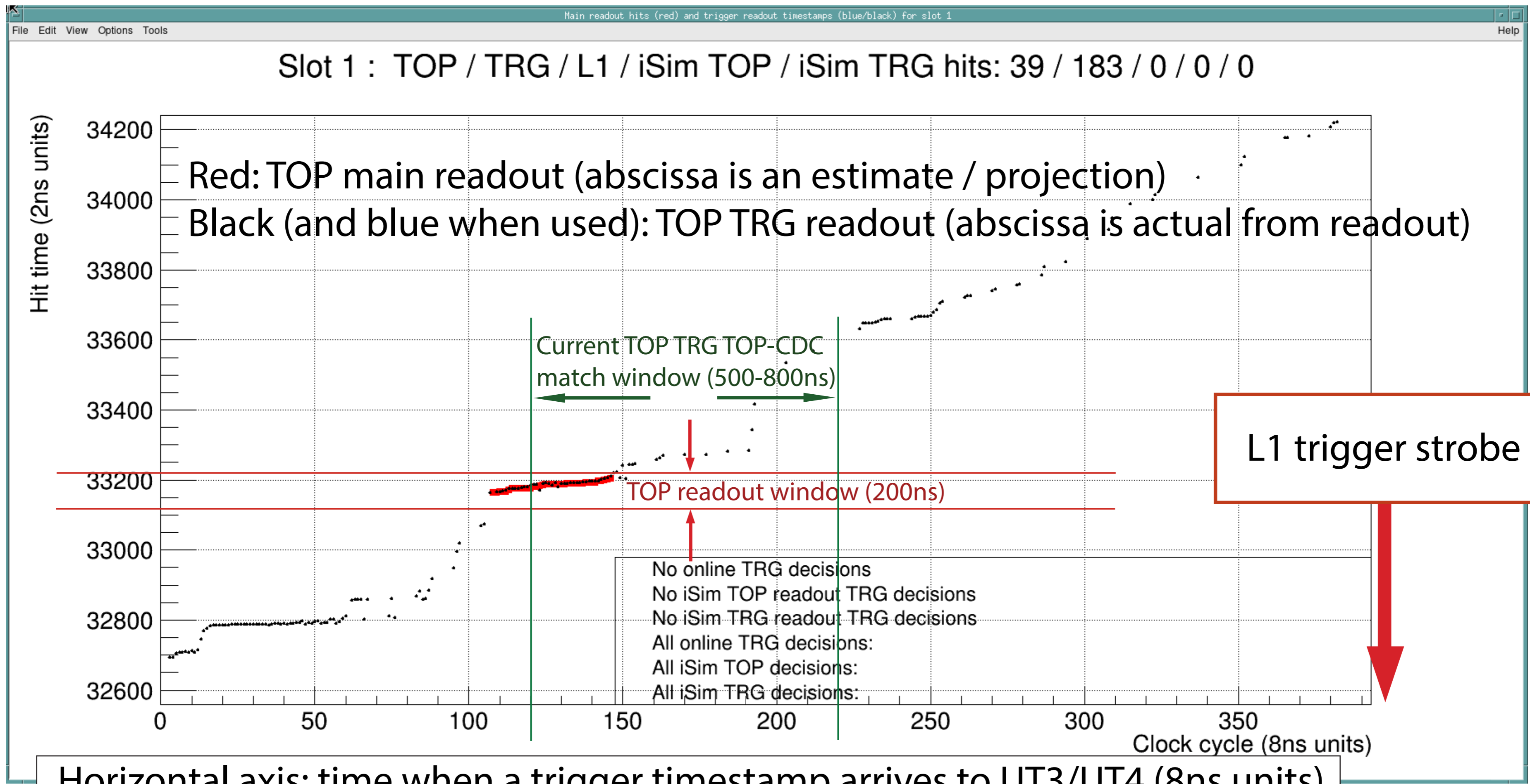


Information recorded from TOP TRG readout



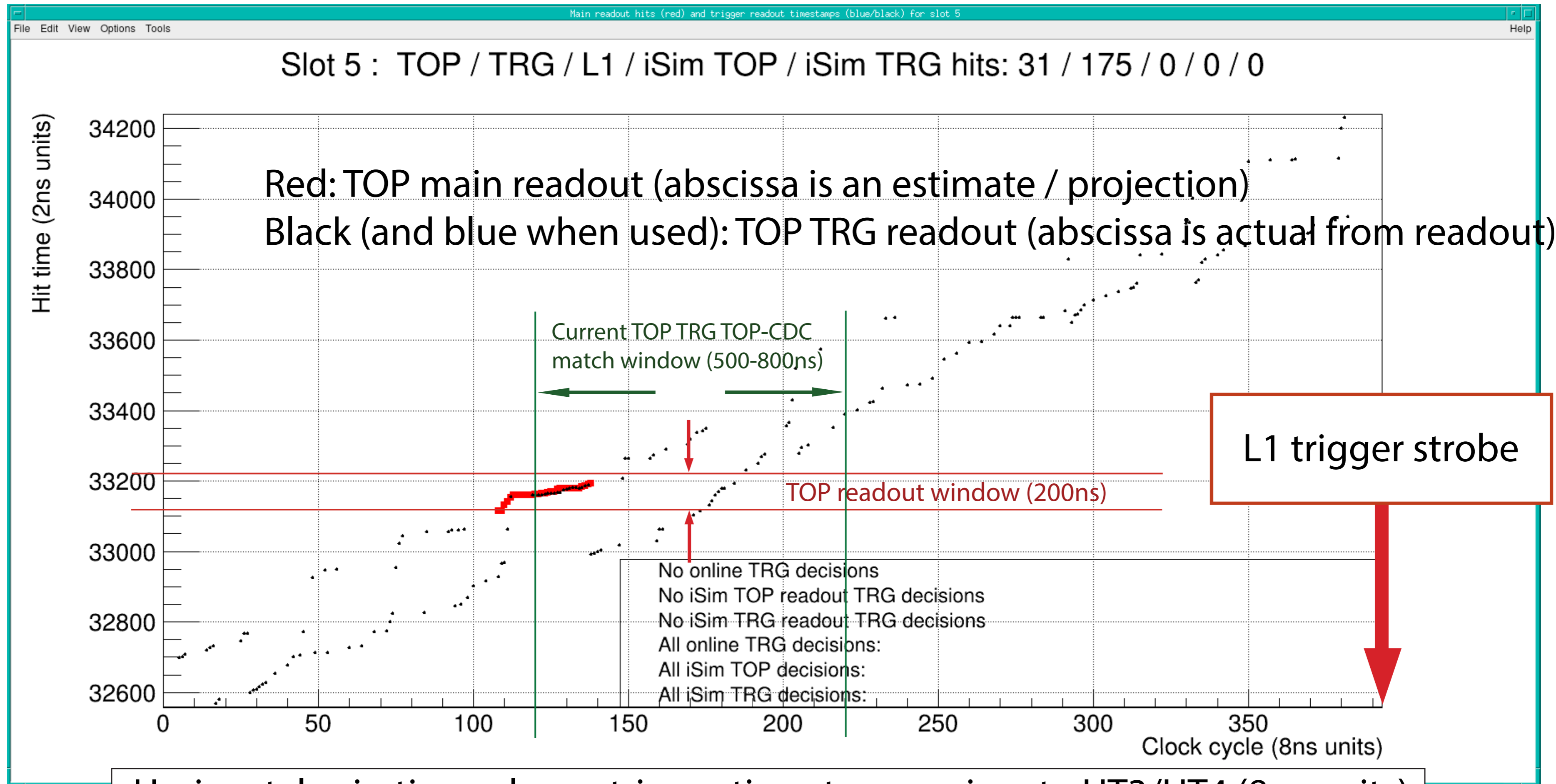
Horizontal axis: time when a trigger timestamp arrives to UT3/UT4 (8ns units)
Vertical axis: the value of a trigger timestamp (time of the PMT hit, 2ns units)
Note that these two TIMES are (i.e., should be, on average, 100% correlated!

Information recorded from TOP TRG readout



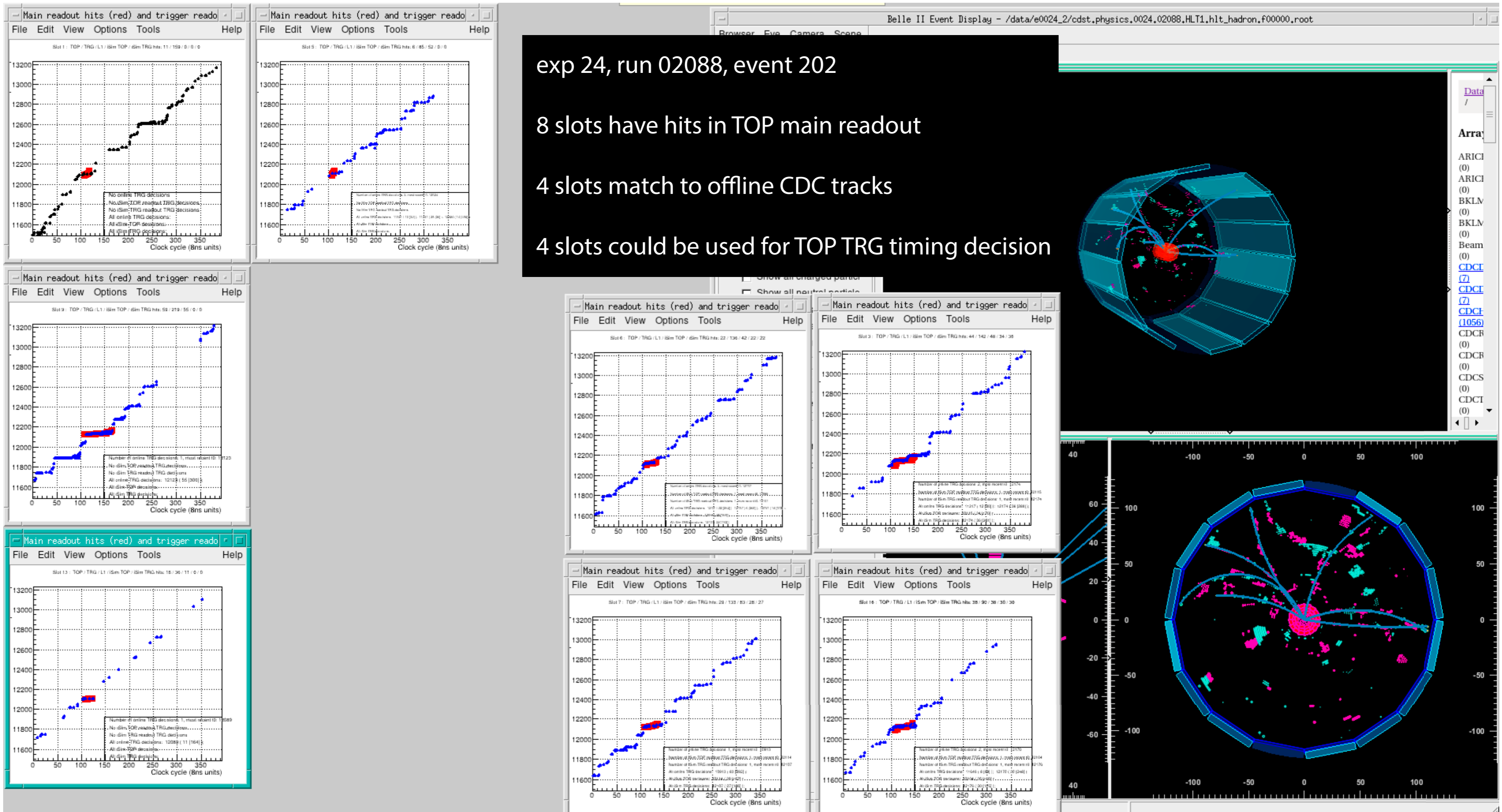
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Information recorded from TOP TRG readout

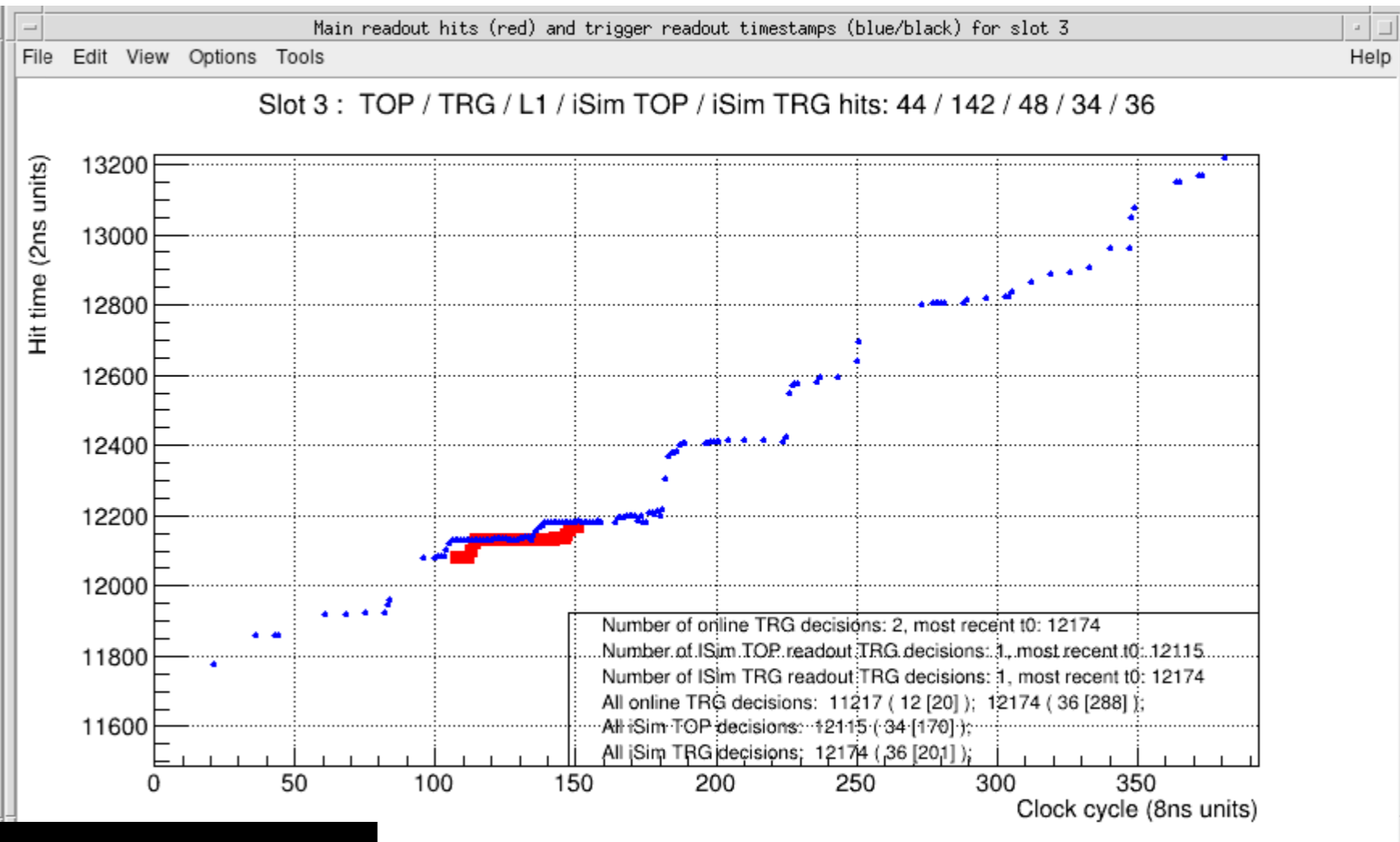
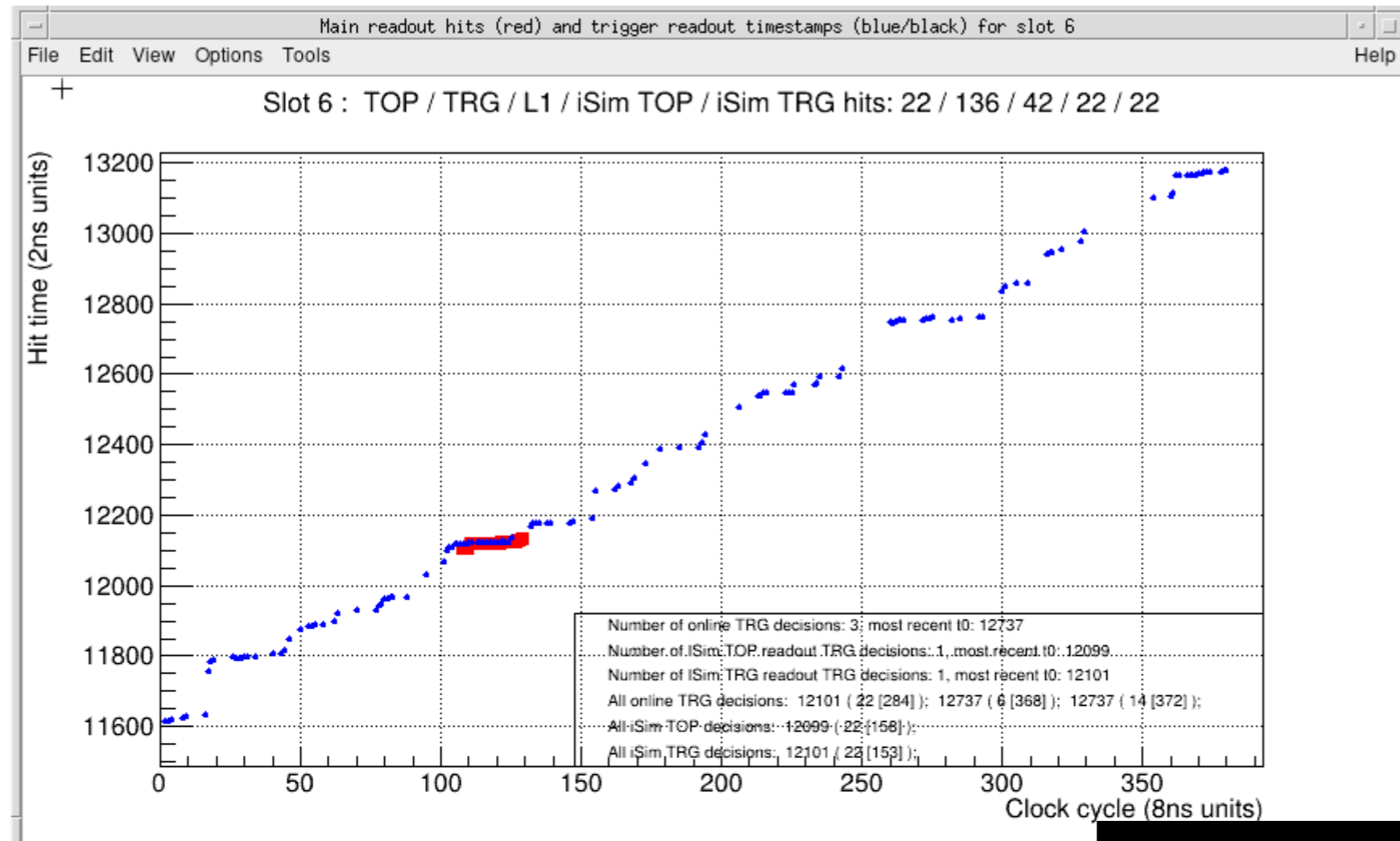


Horizontal axis: time when a trigger timestamp arrives to UT3/UT4 (8ns units)
Vertical axis: the value of a trigger timestamp (time of the PMT hit, 2ns units)
Note that these two TIMES are (i.e., should be, on average, 100% correlated!

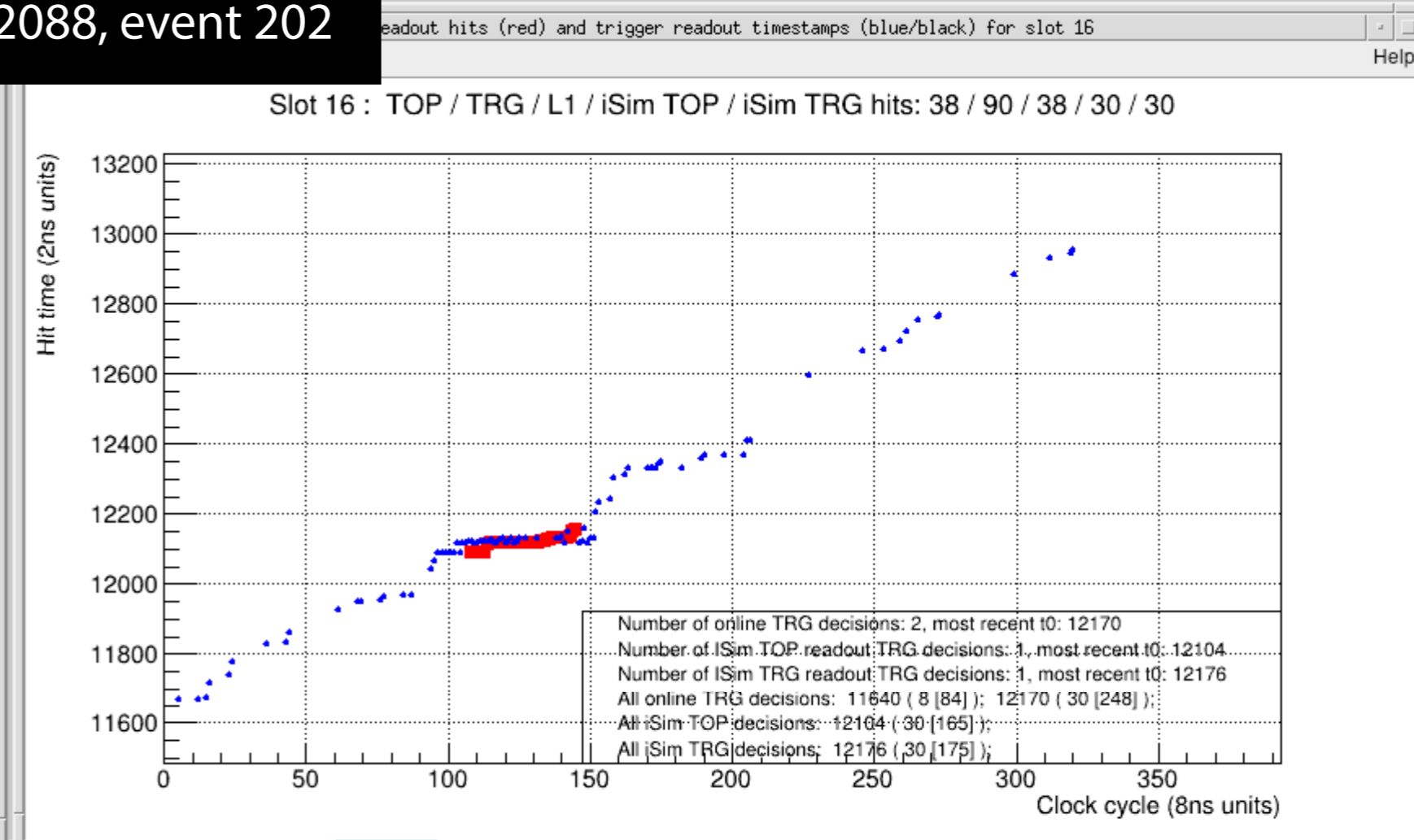
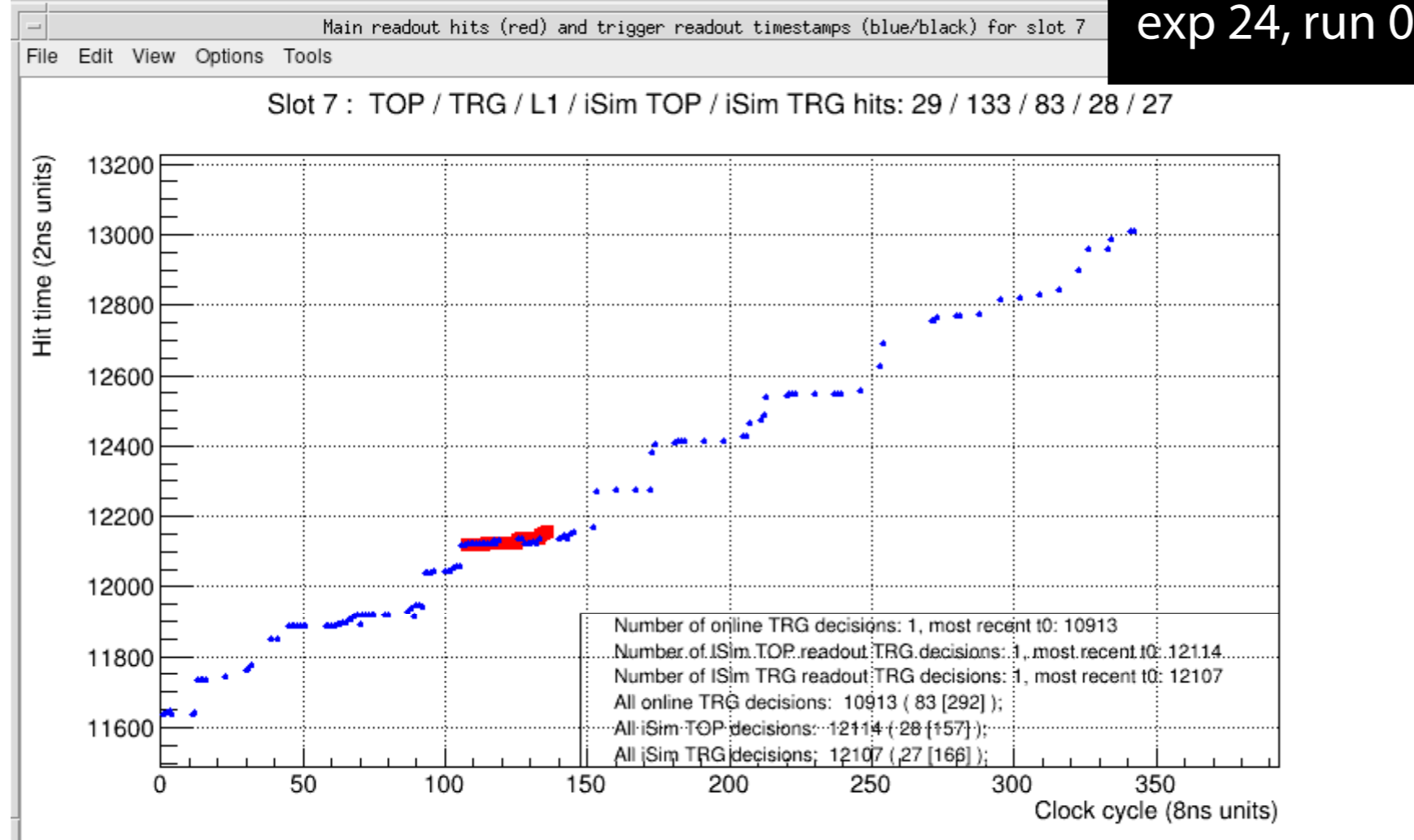
Information recorded from TOP TRG readout



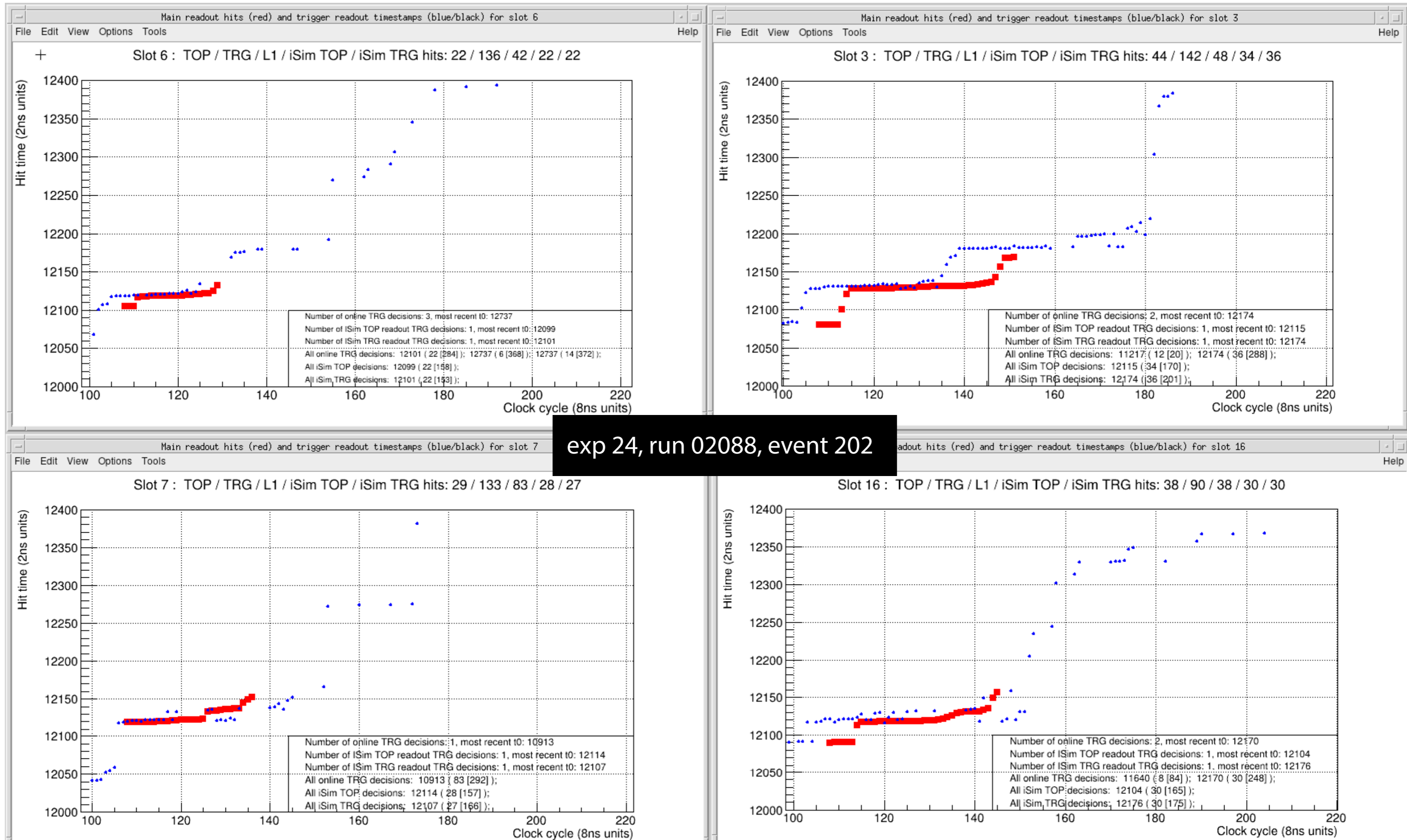
Information recorded from TOP TRG readout



exp 24, run 02088, event 202



Information recorded from TOP TRG readout



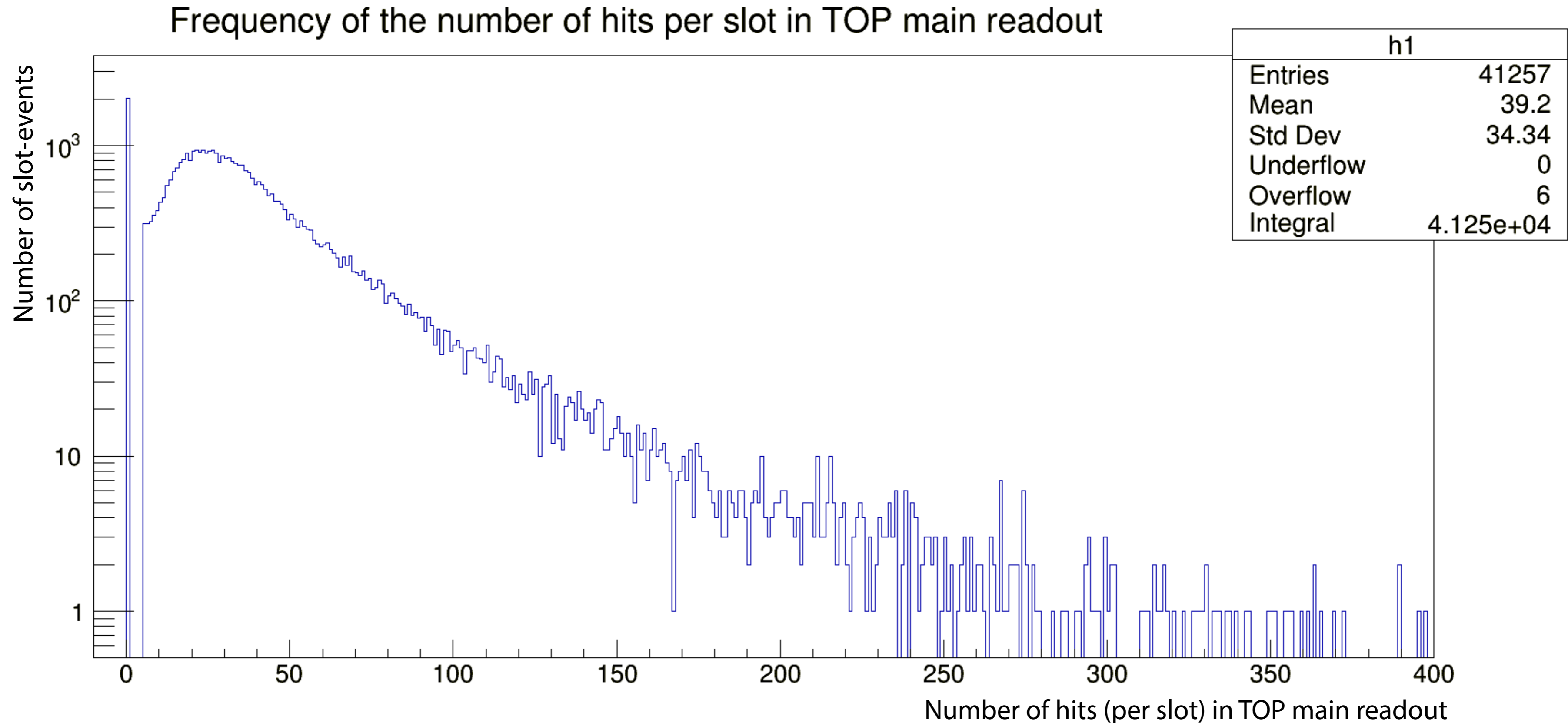
exp 24, run 02088, event 202

TOP-CDC Matching

part 2

trigger efficiency limit

Number of Signal Hits and Upper Limit on TOP TRG Timing Efficiency Per Slot

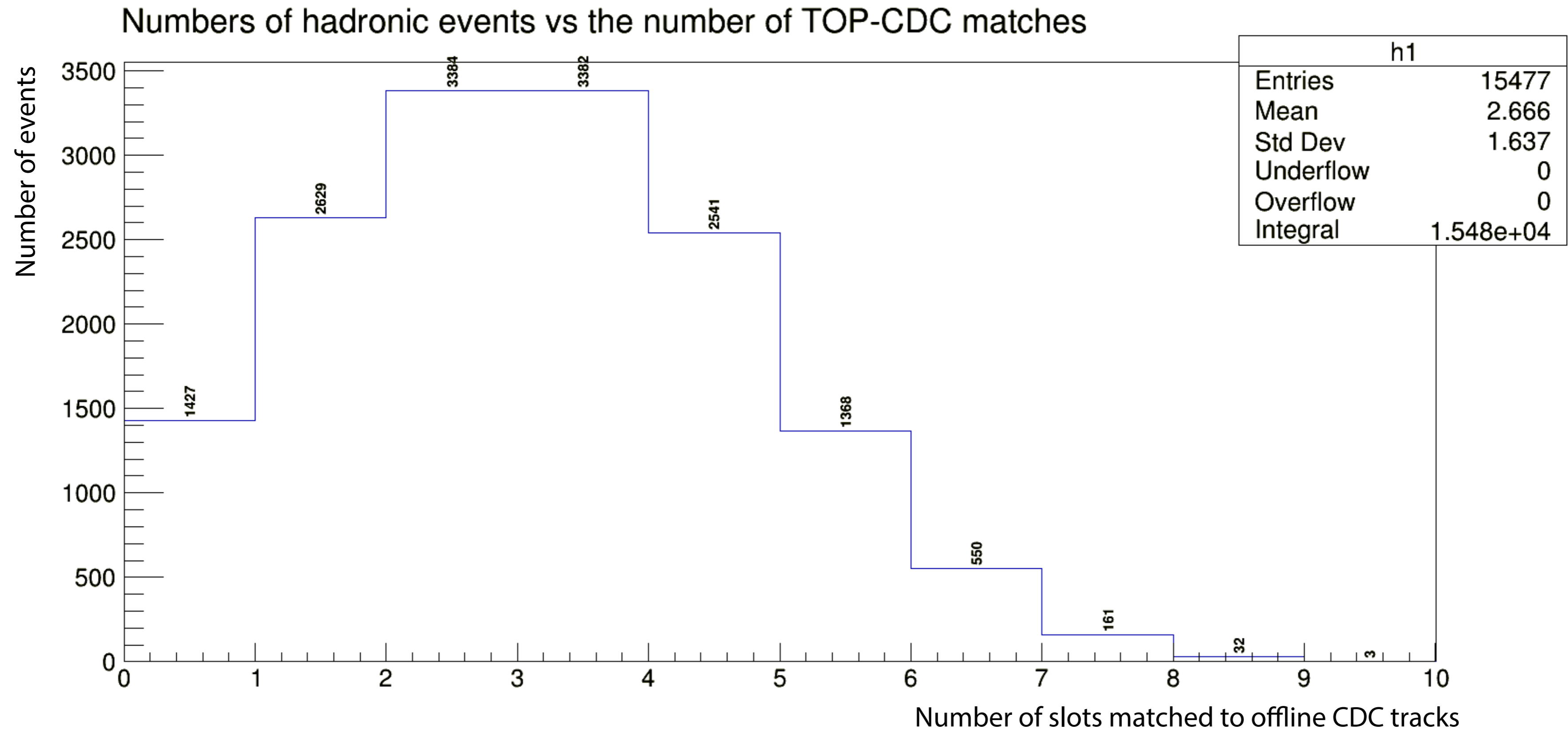


Currently, to have a chance to produce a reliable value of TOP timing we need at least 15 timestamps

Upper limit on TOP TRG timing efficiency **per slot** because of this requirement: $34812 / 41257 = 84\%$

Lowering the cut to 10 timestamps: $37542/41257 = 91\%$. This is similar to what we previously achieved for cosmic events

Number of slots matched to CDC in TOP main readout



This distribution is for the number of hits per slot > 5

Estimate of the upper limit on TOP TRG timing efficiency **per event**: $(15477 - (1427 + 2629 \cdot (1.0 - 0.9))) / 15477 = 89\%$

Maybe we can try to use some of the slots not matched to tracks to improve this efficiency, but our current main problems are different

Performance of TOP TRG

part 1

Slot-level timing resolution

Timing Resolution and Efficiency

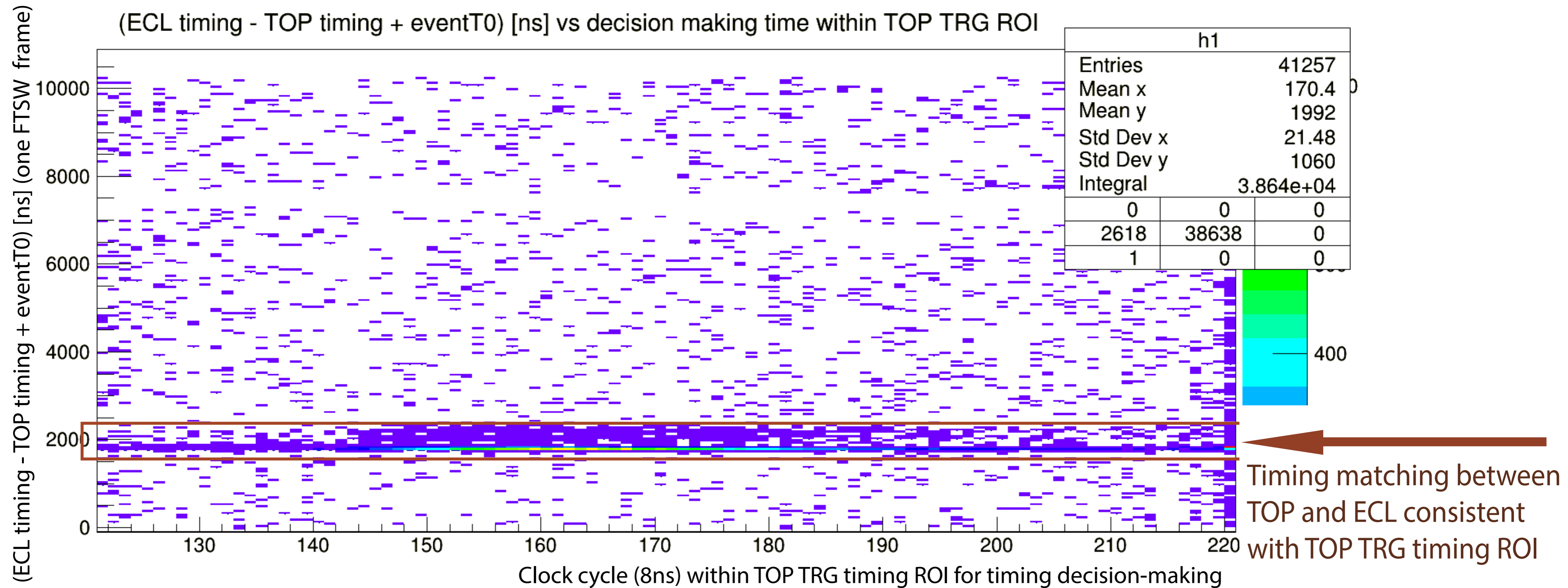
To define efficiency requires to include timing resolution into account:

Let us assume that TOP TRG is 100% efficient

But (non-Gaussian) resolution is such that the timing from TOP TRG is outside of specs half of the time (or even worse)

Then the result would be a poor timing resolution and a 50% efficiency

Quality of TOP TRG timing for slots matched to offline CDC tracks

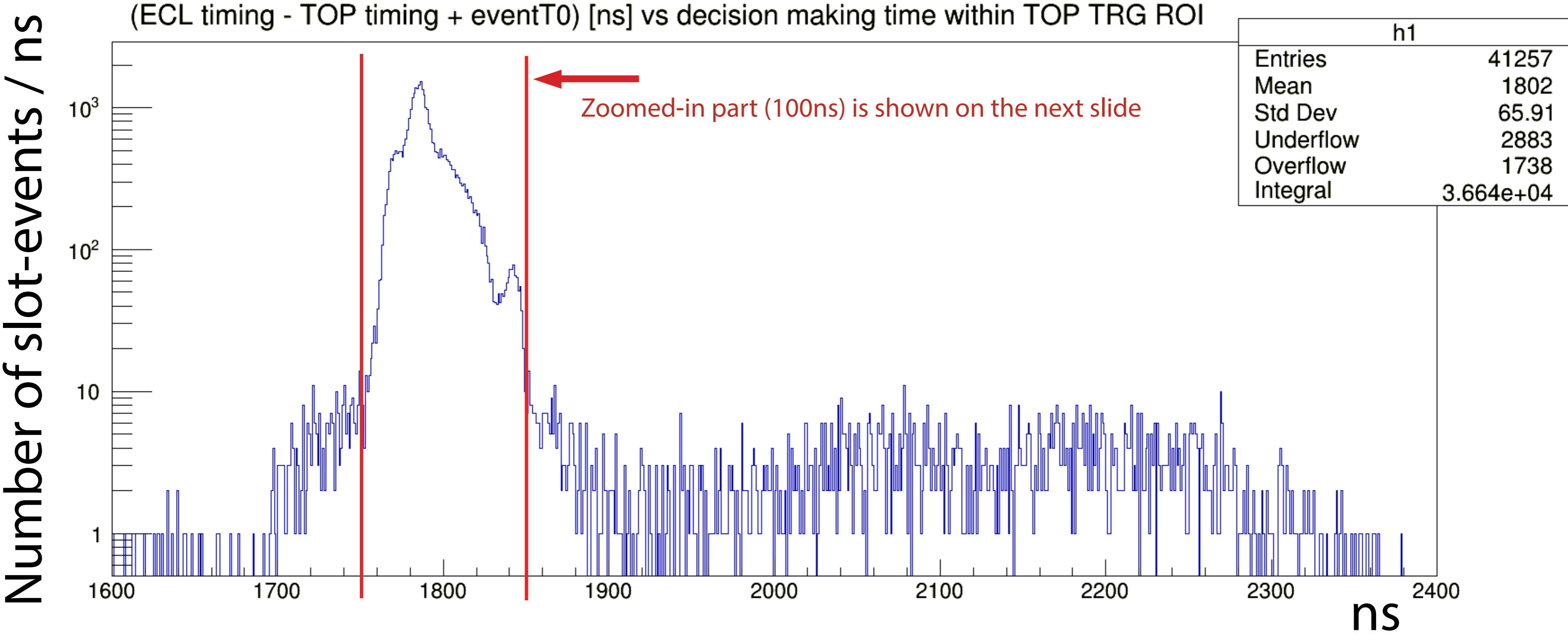


2618 slot-events are outside of shown area because no slot-level trigger decision was made for these slots in iSim, this fraction is $2618/41257 = 6\%$

Besides that, a significant fraction $(2883+1738)/41257 = 11\%$ of slot-level timing decisions are outside of the expected ECL-TOP consistency window!

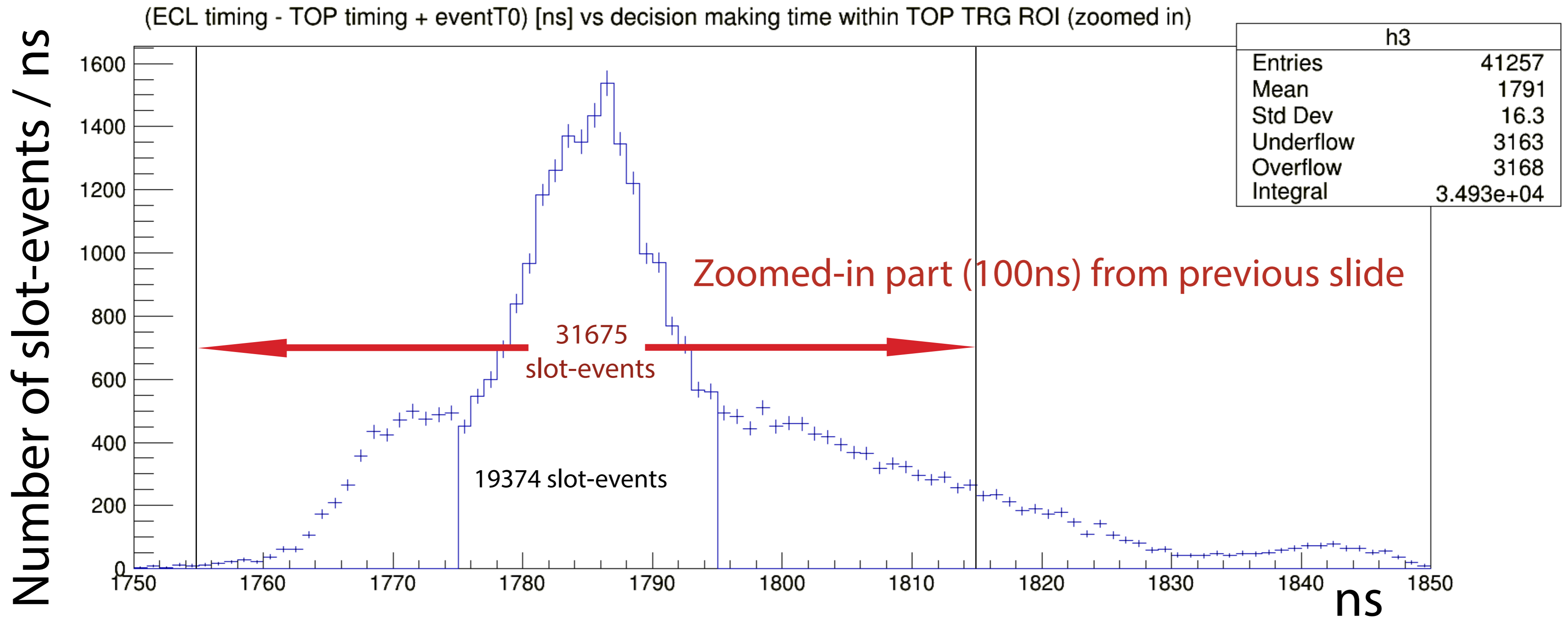
This last problem is currently being investigated. These two effects alone reduce per-slot TOP TRG efficiency to below 85% already.

Quality of TOP TRG timing for slots matched to offline CDC tracks



Fraction of slot-events within ± 30 ns of the main peak: $31675/41257 = 77\%$

Quality of TOP TRG timing for slots matched to offline CDC tracks



Fraction of slot-events within ± 10 ns of the main peak: $19374/41257 = 44\%$

Fraction of slot-events within ± 30 ns of the main peak: $31675/41257 = 77\%$

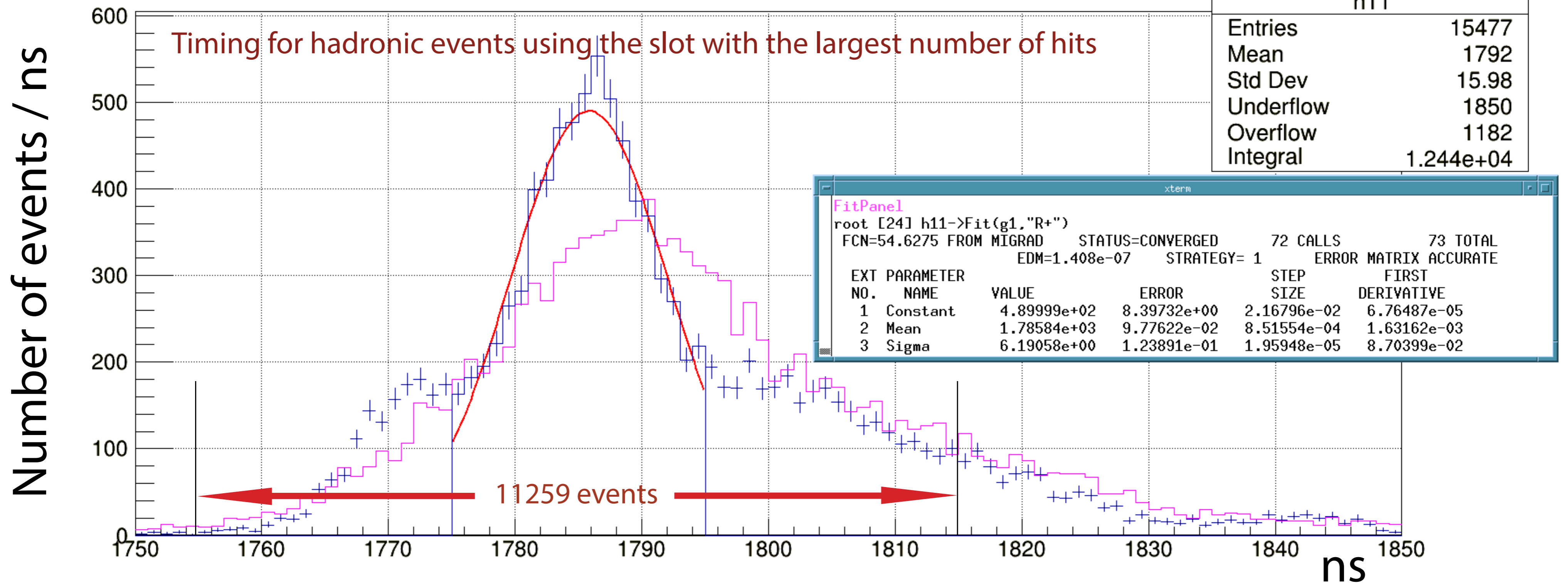
Performance of TOP TRG

part 2

Event-level efficiency

TOP TRG Timing Resolution

(ECL timing - TOP timing + eventT0) [ns] vs decision making time within TOP TRG ROI (zoomed in)



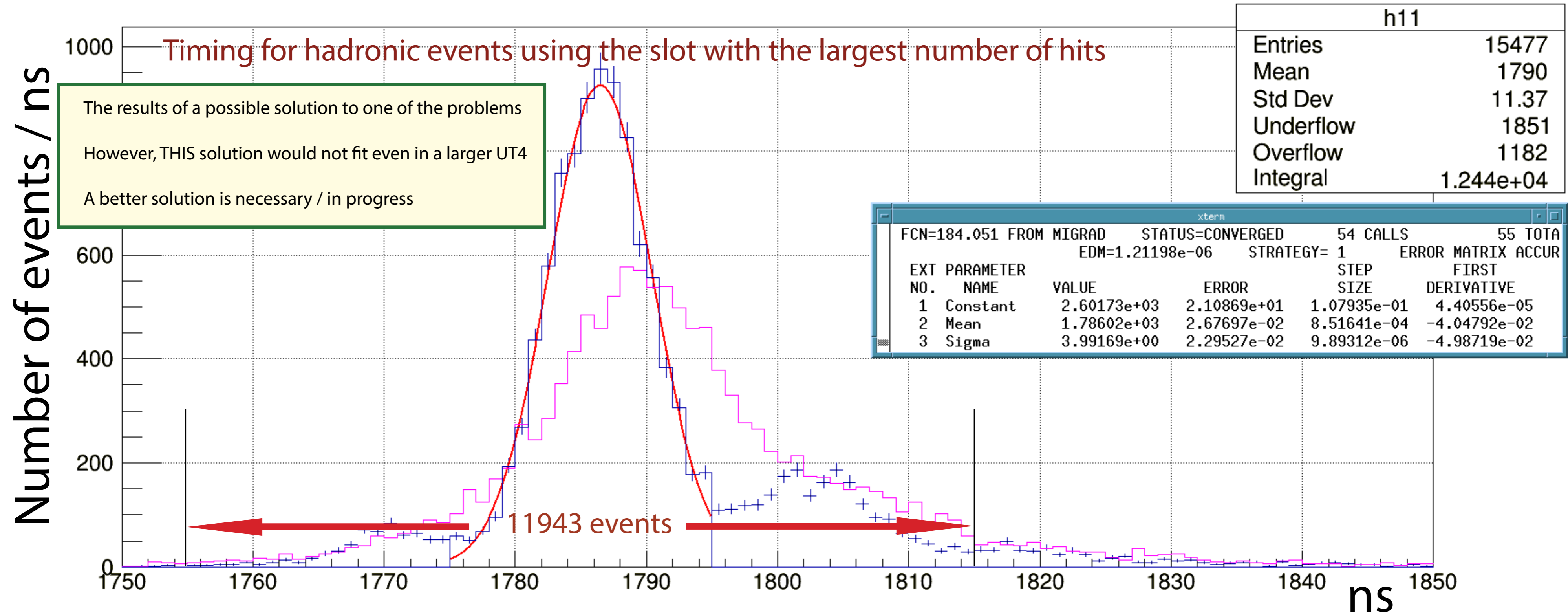
Just for comparison the histogram in magenta color shows (ECL timing - TOP timing) [ns] before eventT0 correction

Fraction of events within ± 10 ns of the main peak: $6829 / 15477 = 44\%$

Fraction of events within ± 30 ns of the main peak: $11259 / 15477 = 73\%$

TOP TRG Timing Resolution (an attempt to improve)

(ECL timing - TOP timing + eventT0) [ns] vs decision makingroot [26] in TOP TRG ROI (zoomed in)



Just for comparison the histogram in magenta color shows (ECL timing - TOP timing) [ns] before eventT0 correction

Fraction of events within ± 10 ns of the main peak: $9143 / 15477 = 59\%$

Fraction of events within ± 30 ns of the main peak: $11943 / 15477 = 77\%$

Conclusions

Since the end of June 2022 we had been focusing primarily (though only fraction of our time) on

transition to UT4s and infrastructure upgrade (workstations, VME etc - successful)

VME readout, belle2link readout, full slow control implementation with UT4 (in progress)

Improvements in analysis software (continuously in progress)

Recently we started to refocus on our actual problems / restarted the development

The main focus now is on

figuring out the reasons for specific types of problems in timing decisions in FW (to improve efficiency)

producing realistic PDFs from data using hadronic events (to improve resolution)

figuring out how to combine slot-level timing decisions (to improve resolution for event-level timing)

The plan is to get a working UT4-based TOP TRG in place by the end of LS1