

Turnaround: Analysis and possible improvements

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7th LHC Performance Workshop, Evian 2016



Turnaround

Precycle

Summary

Sources + Thanks

- A. Apollonio, L. Ponce, B. Todd
- Faults from the AFT team
- Analysis Scripts from the ABP Gang + Michi
- Input from D. Nisbeth, Matteo and many other colleagues
- + Timing Events (cals), elogbook

Lost in data ☹️



... and in the temptation to combine all of it...

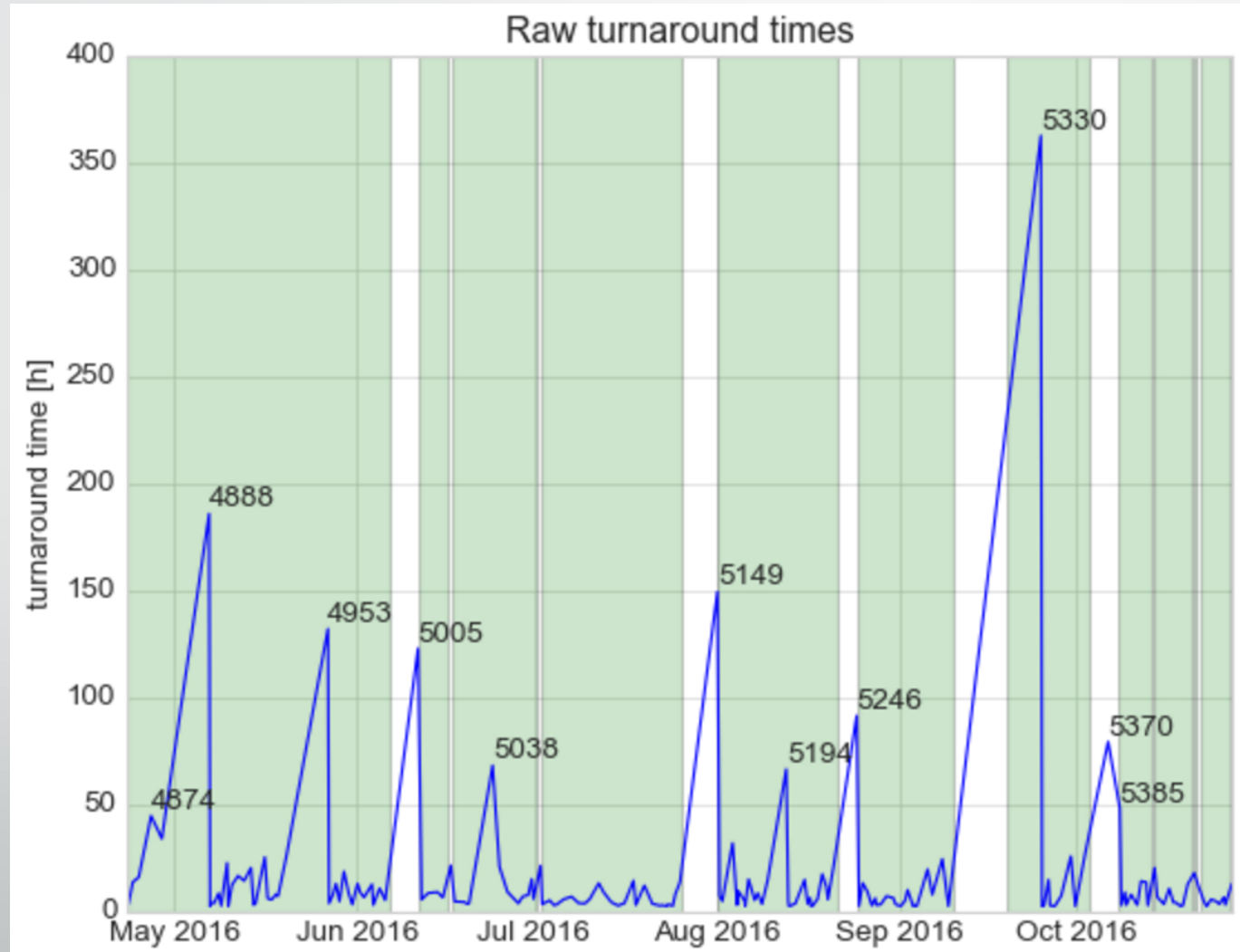


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A first glance



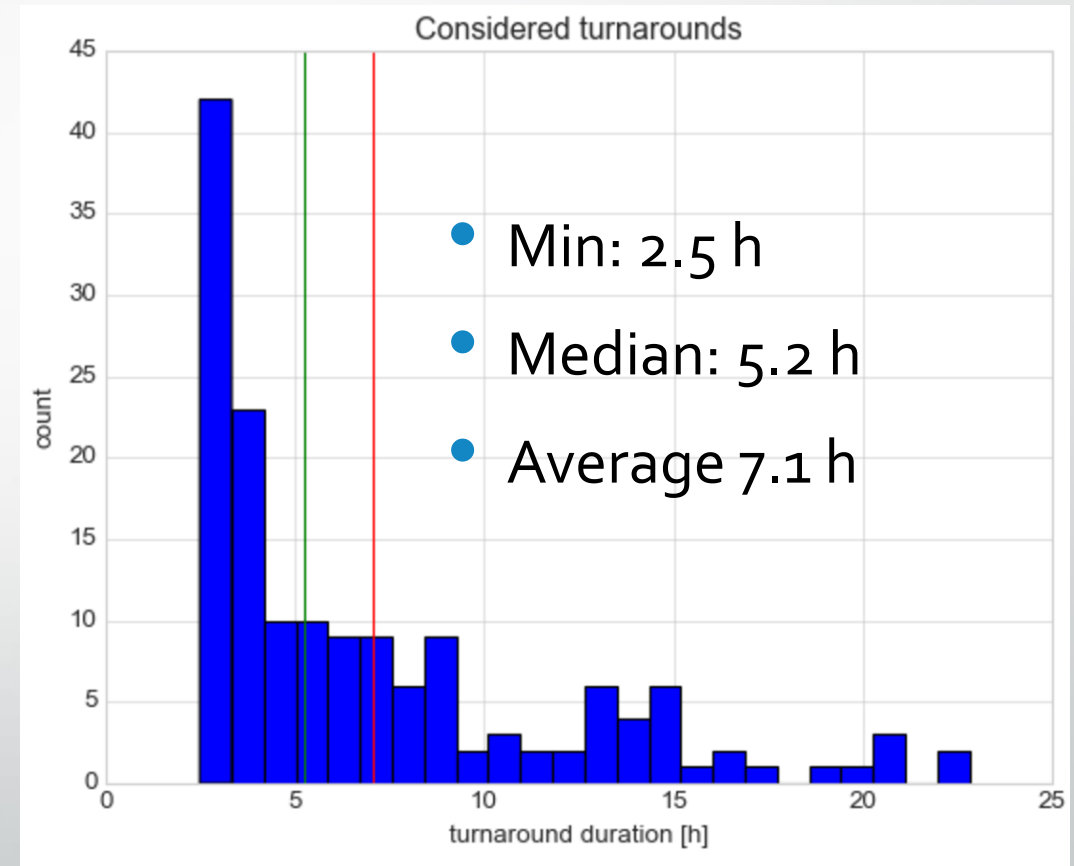
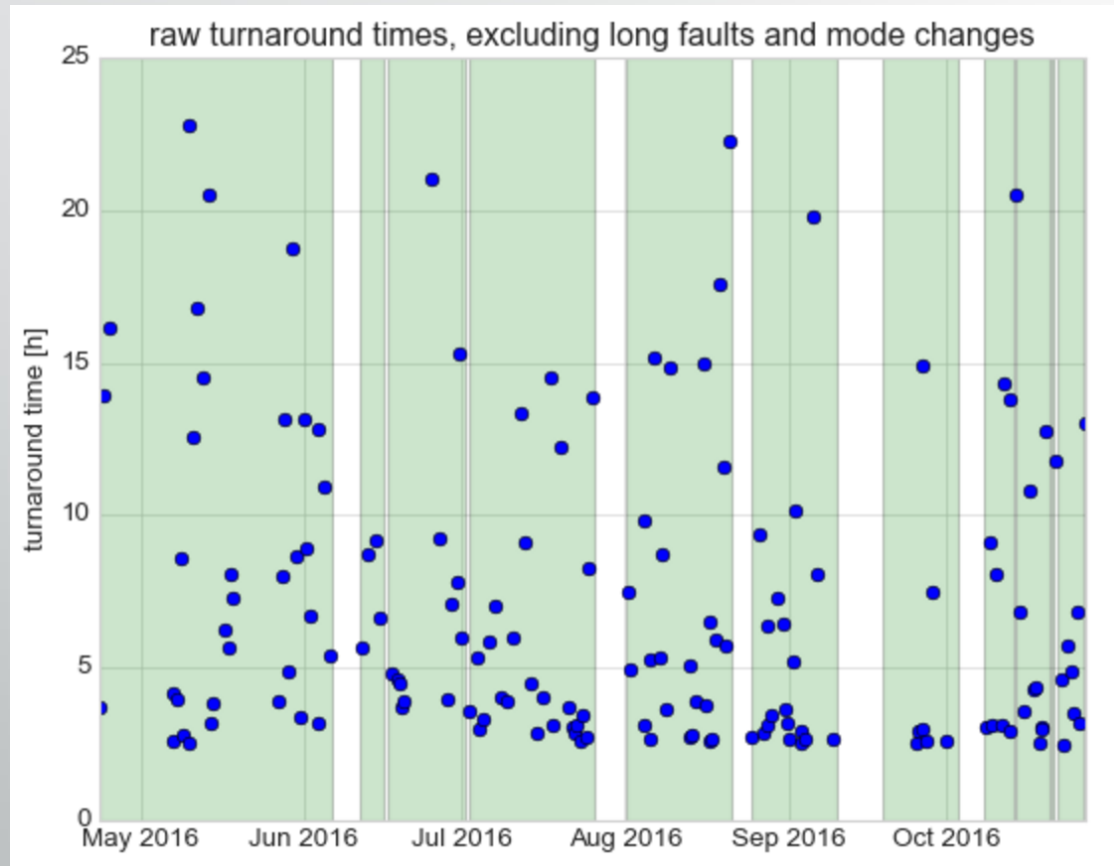
To make more sense out of it ...

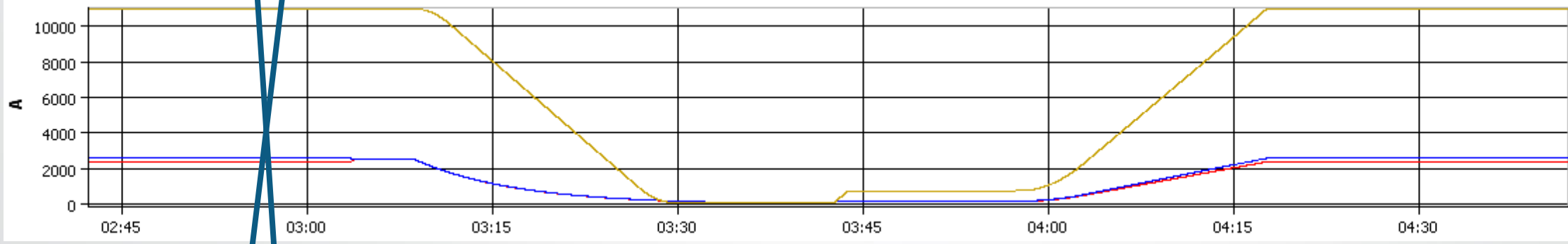
- Ignoring Faults > 24 h
- Fills following accelerator mode change have no associated turnaround:
 - Following the Restart (#4851, #4874)
 - Following Technical Stops (#5005, #5330)
 - Following Special Physics Commissioning (#5024, #5068, #5251, #5287)
 - Following Ion Cycle Commissioning (#5437)
 - Following Machine Development (#5149, #5246, #5385)

Courtesy: B. Todd, L. Ponce, A. Apollonio:

https://cds.cern.ch/record/2237325/files/awg_p+_acc_note_2016_0067.pdf?

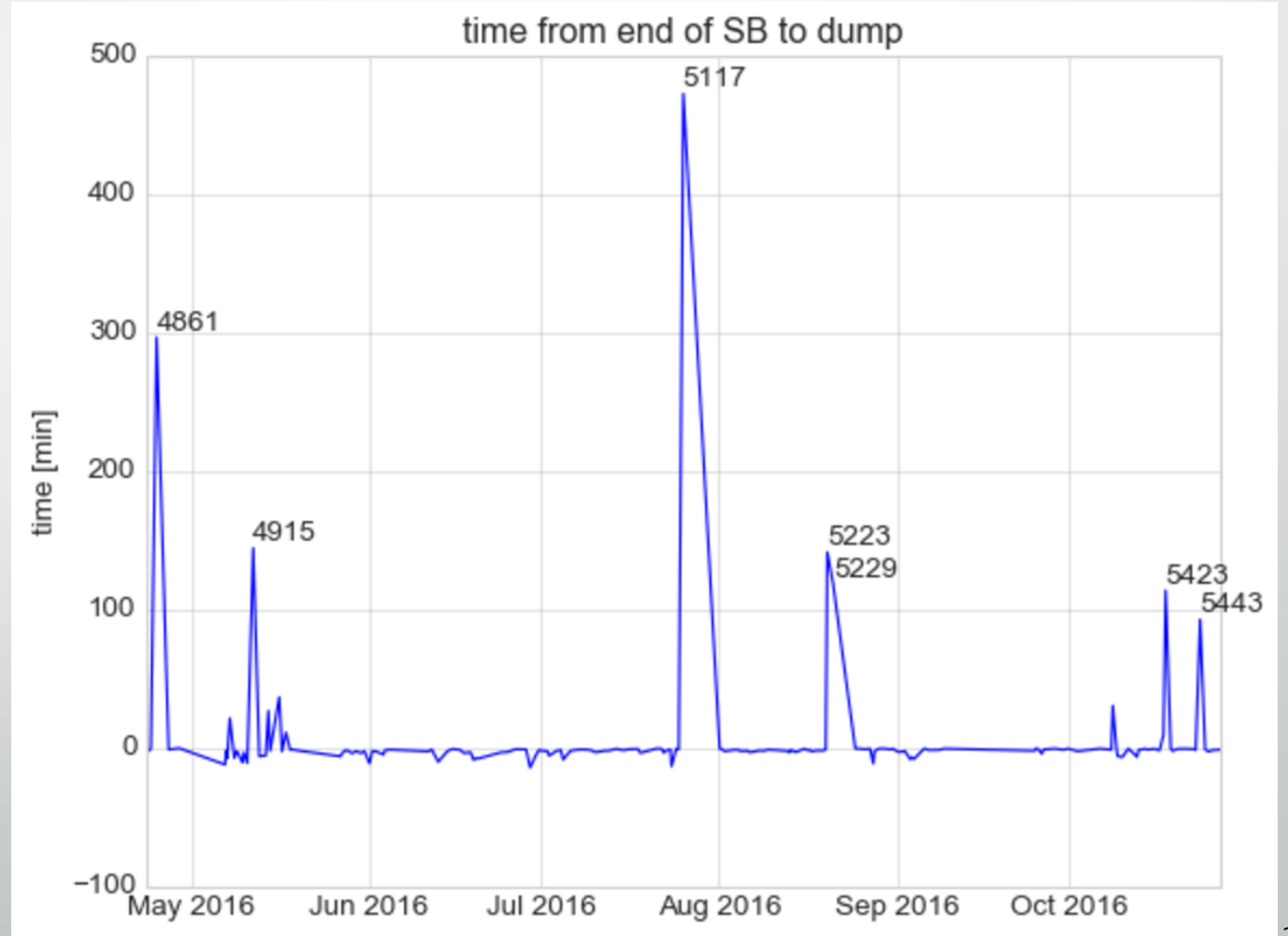
And we get ...



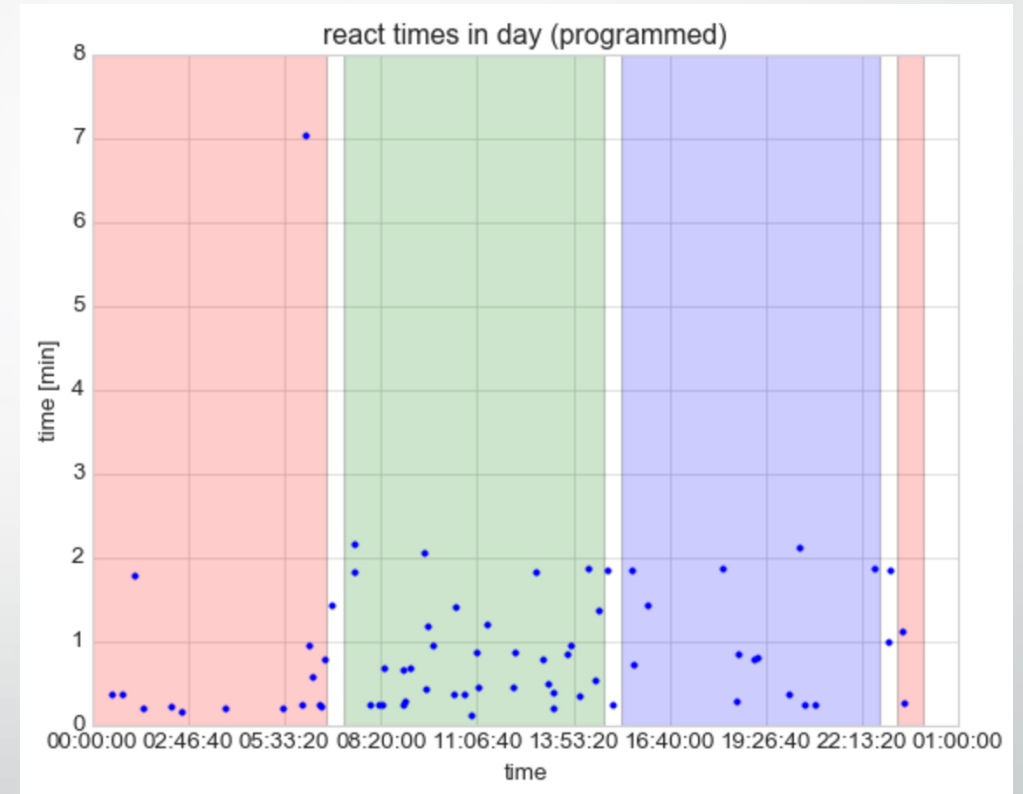
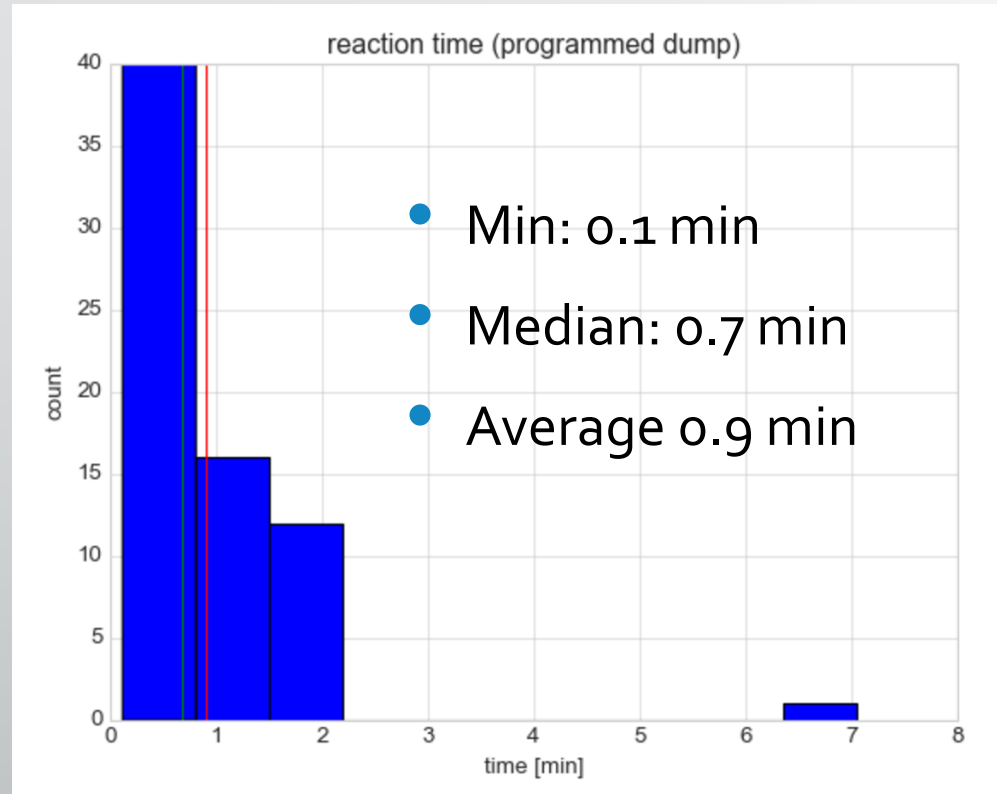


**End of Stable beams
vs.
Dump**

**High Values =
End of Fill MDs.**

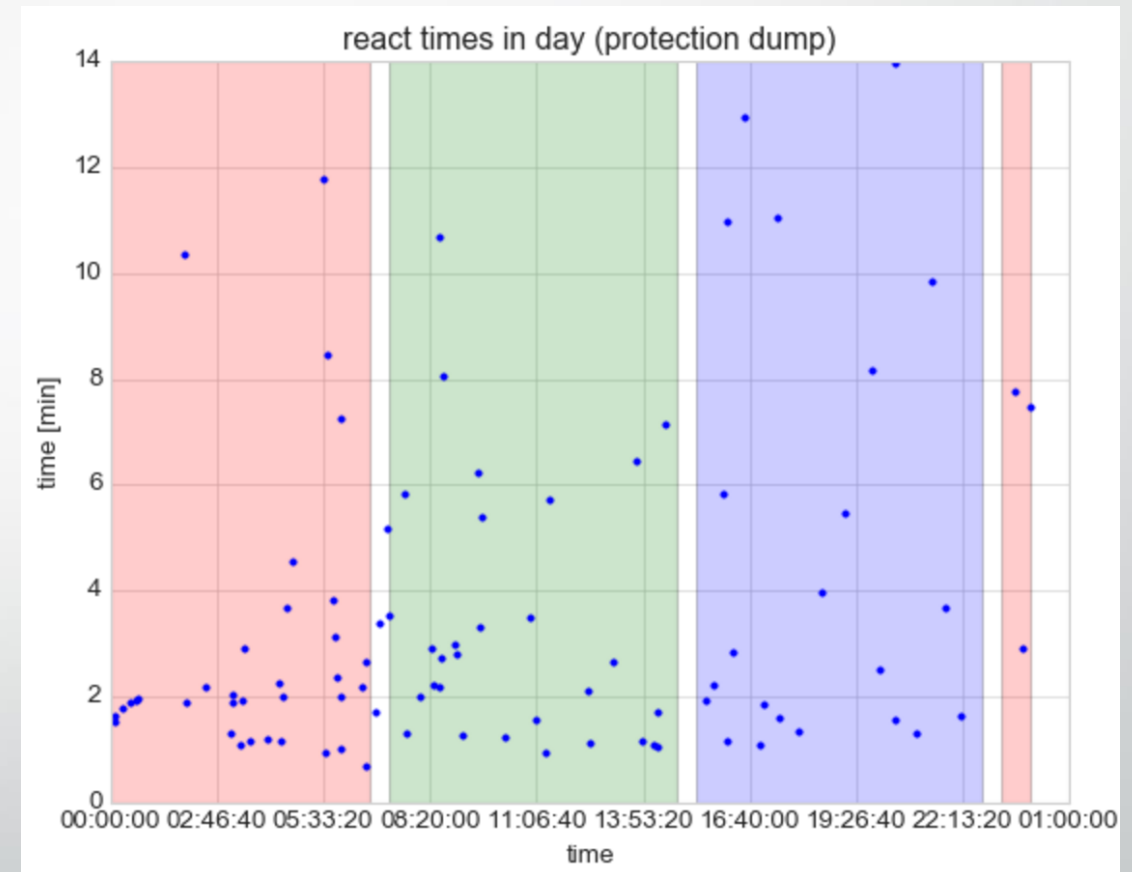
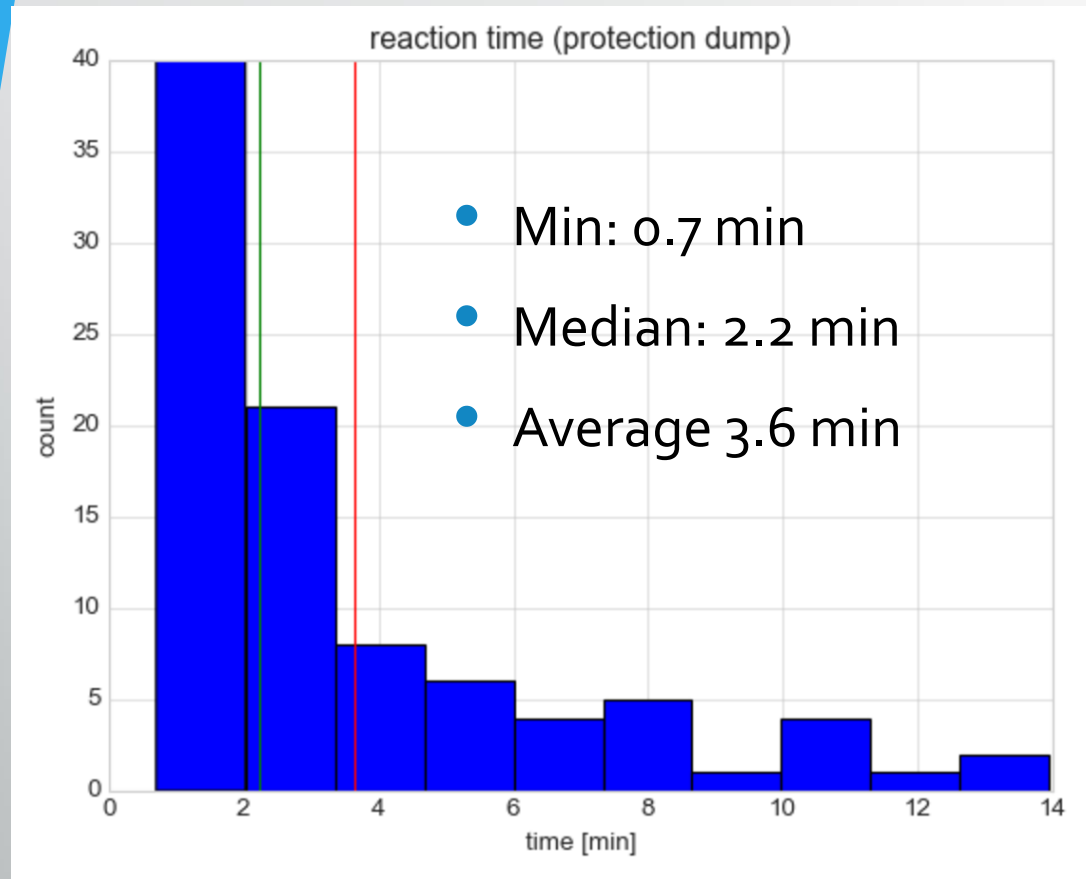


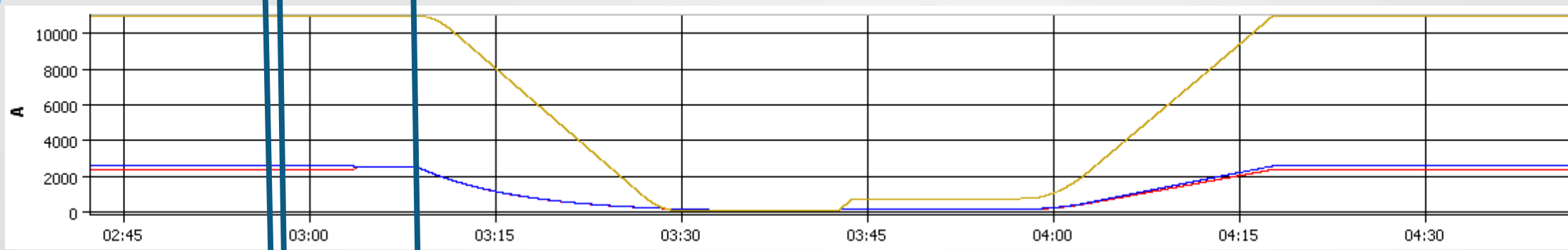
Dump -> End of SB (Programmed dump)



Sequence to be run before switching SB -> Beam dump.

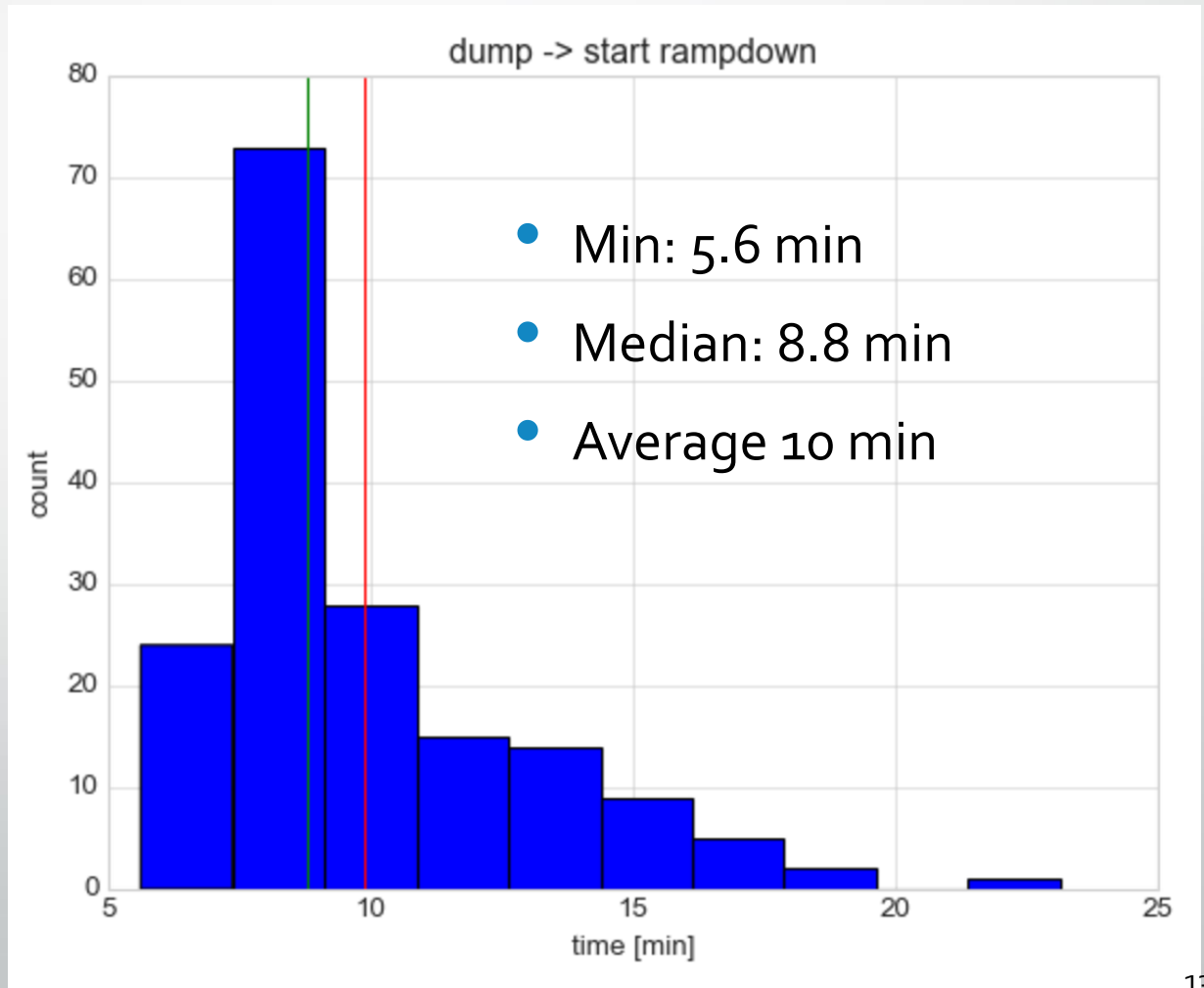
«Reaction time» (Protection dump)

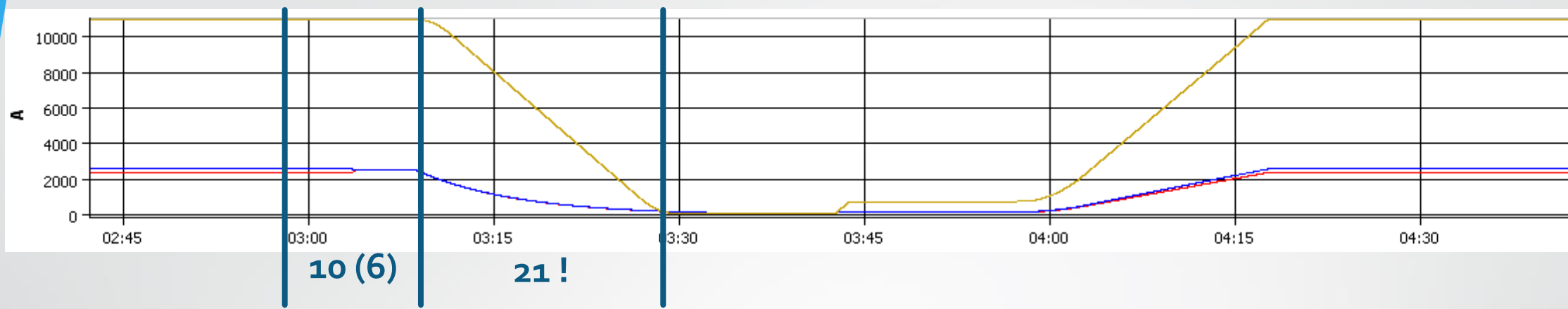




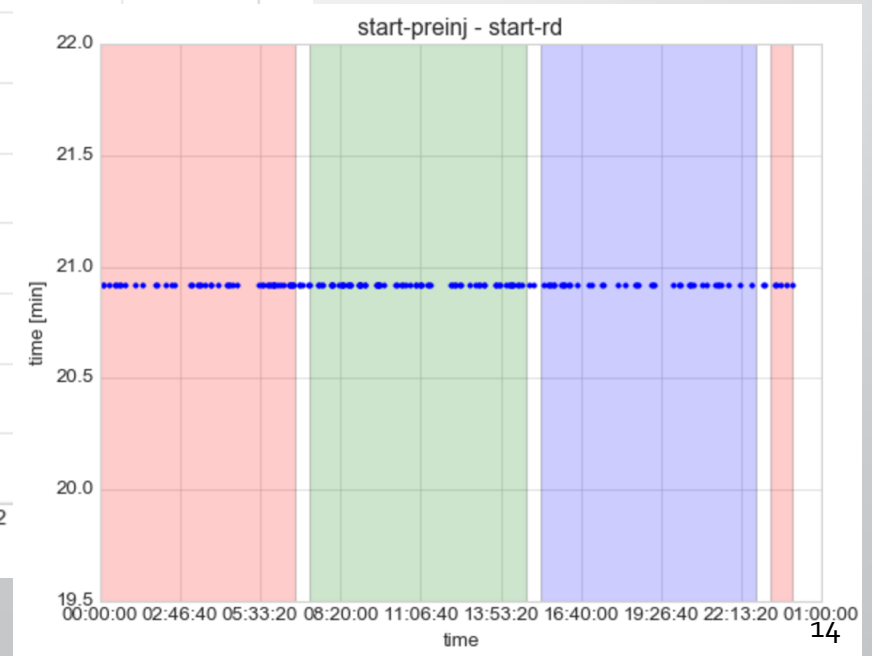
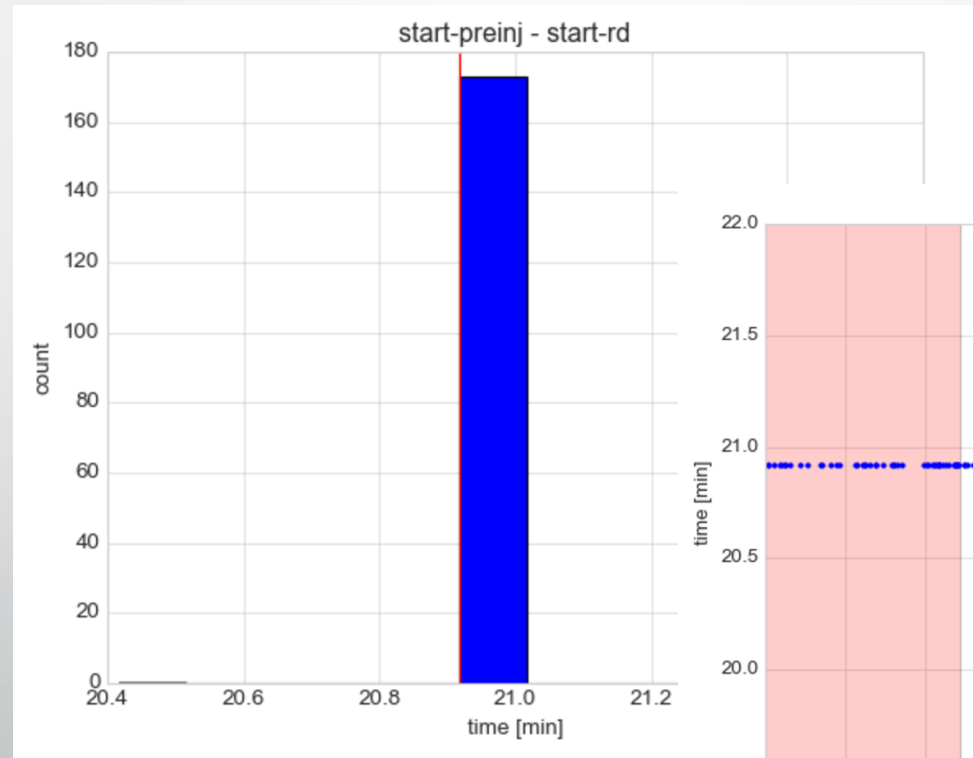
3.6 (0.7) Dump -> start
rampdown

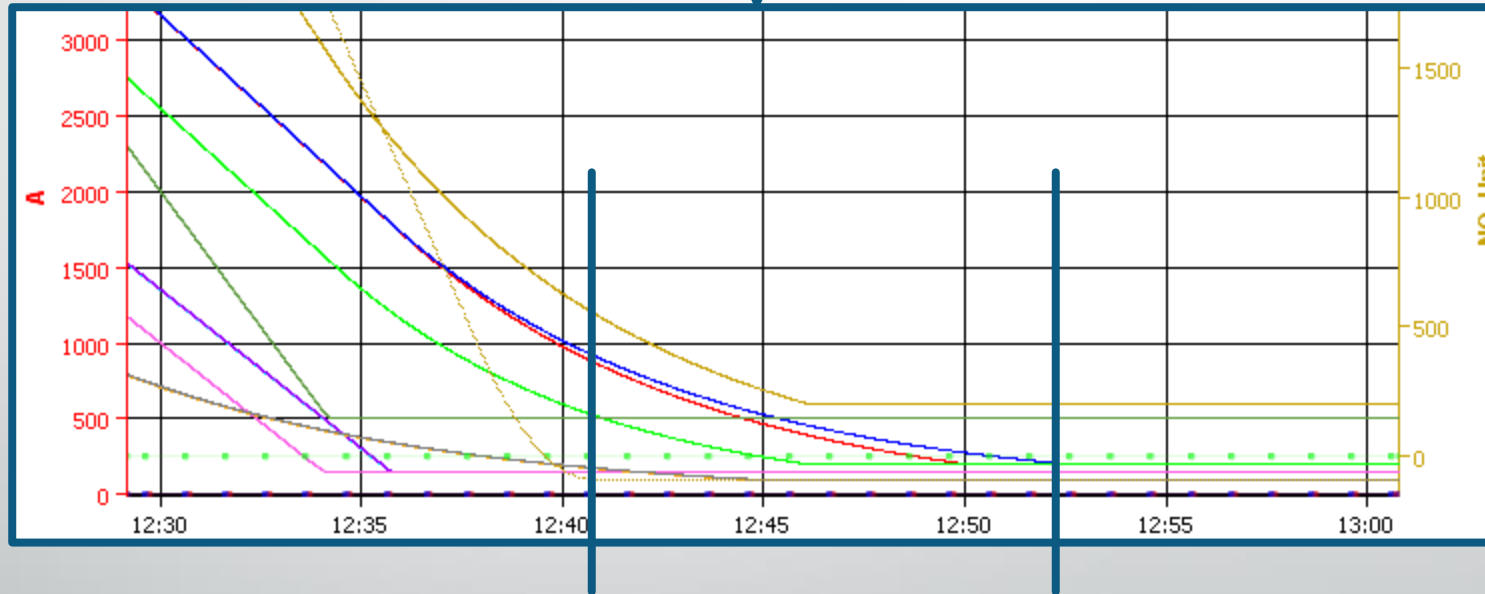
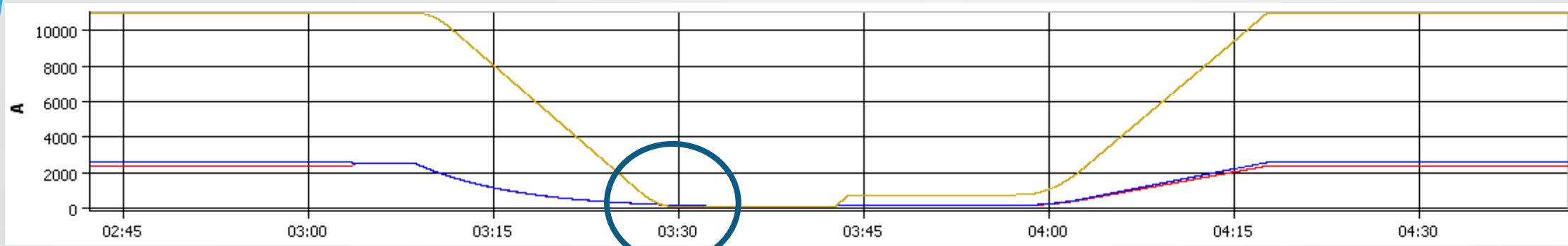
- Moving PCs to start point of rampdown



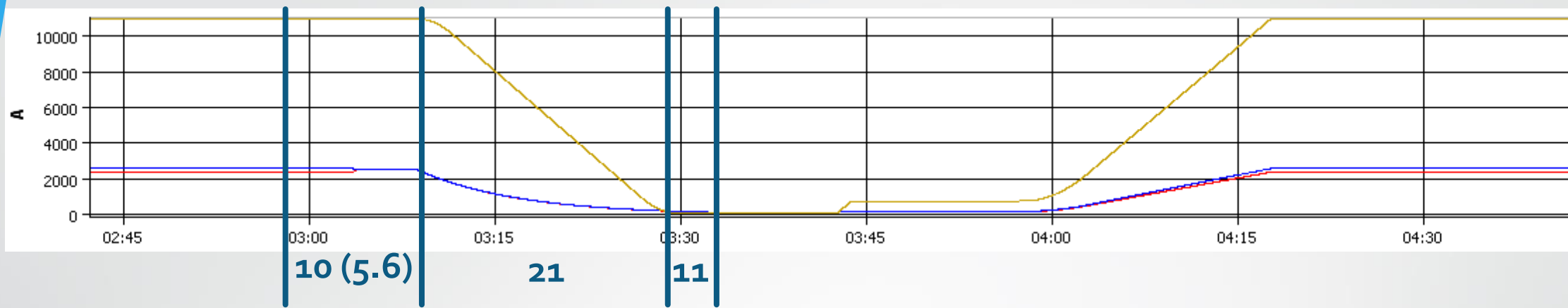


Timing System ;-)





Triplets are limiting -> + ca 11 min



And then the fun is over ☹️

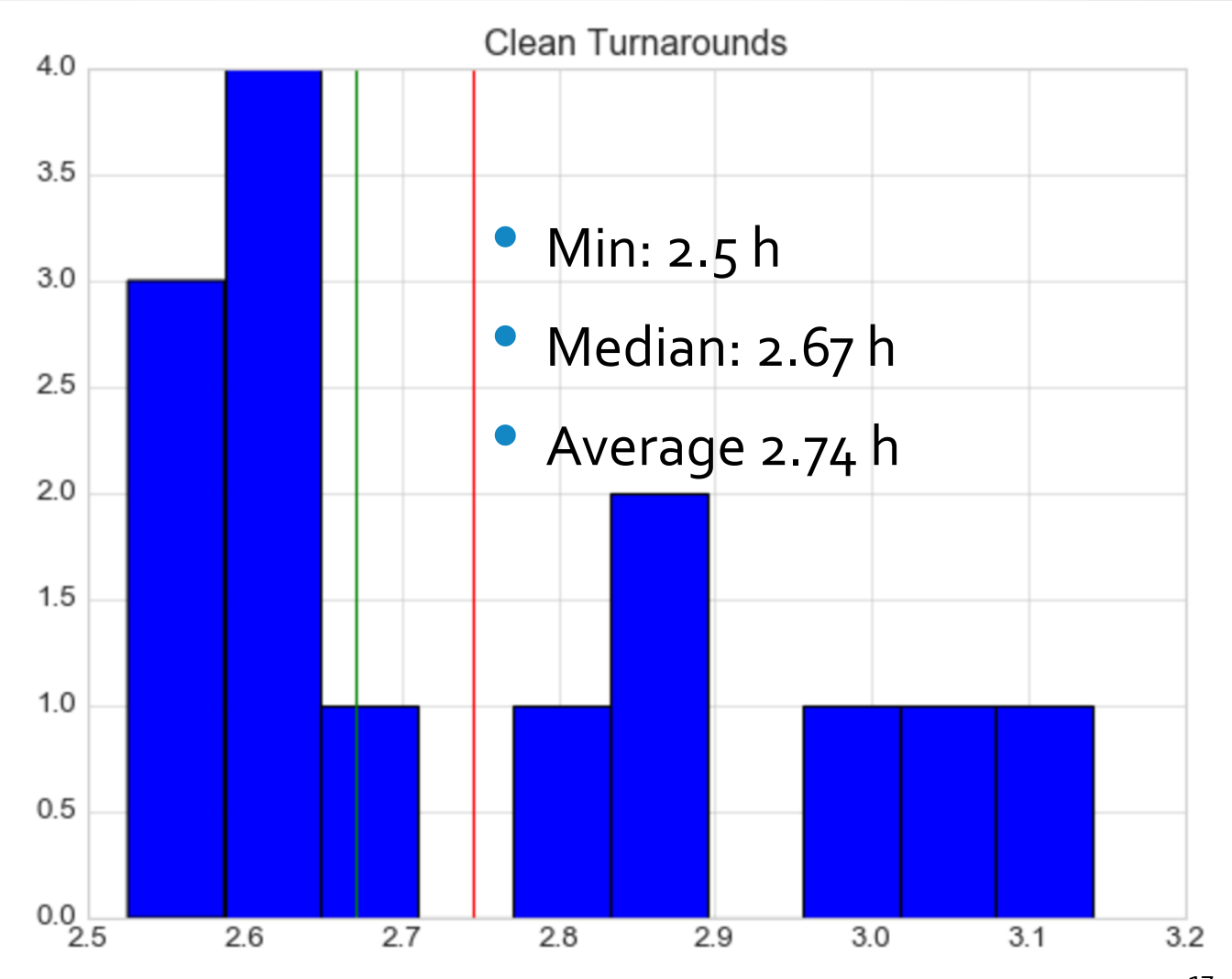
- Preinjection phase is completely fault dominated..
- Several tries to subtract faults from times ... No reliable results.

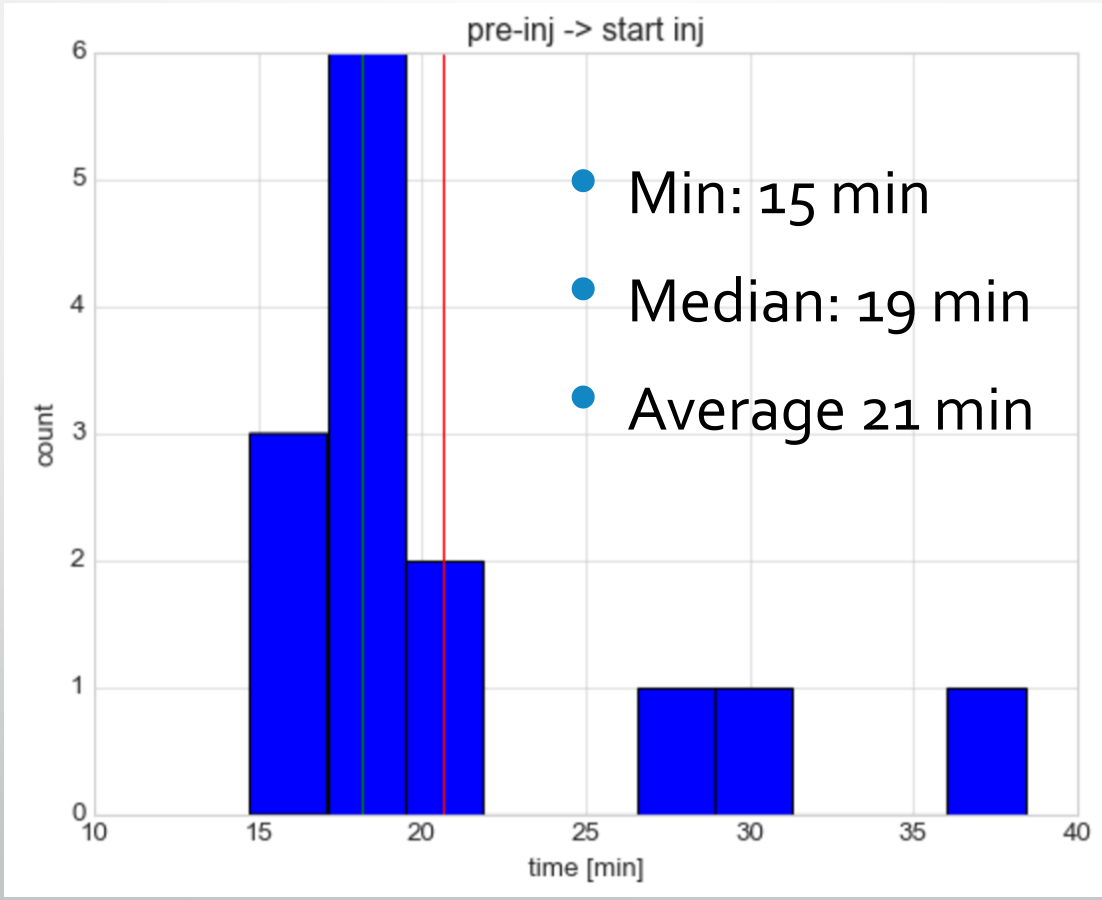
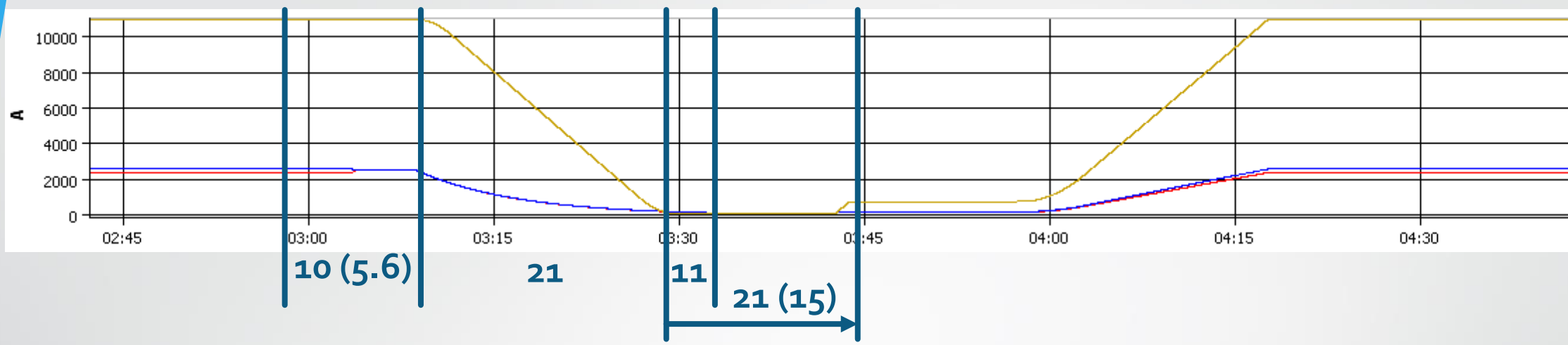
Clean turnarounds

- No gap in Fill-number
- No fault
- No Precycle
- No EOF MD

→ 14 Tas

All following a programmed dump!

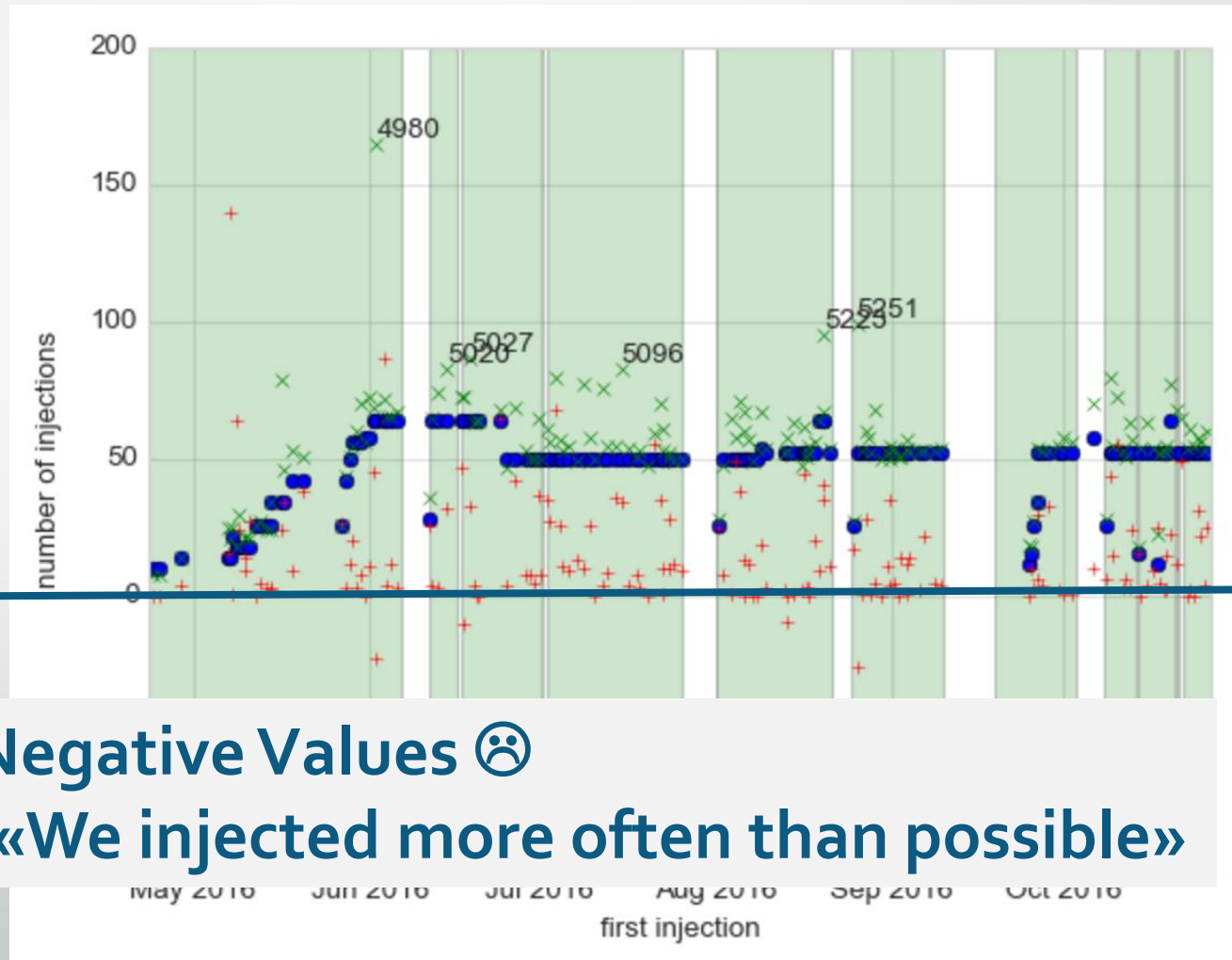




One of the tries...

Estimating, how many injections we miss per fill:

- Taking filling period
- Subtract fault time within this period
- Look at how many injections could have been done vs. Were done.

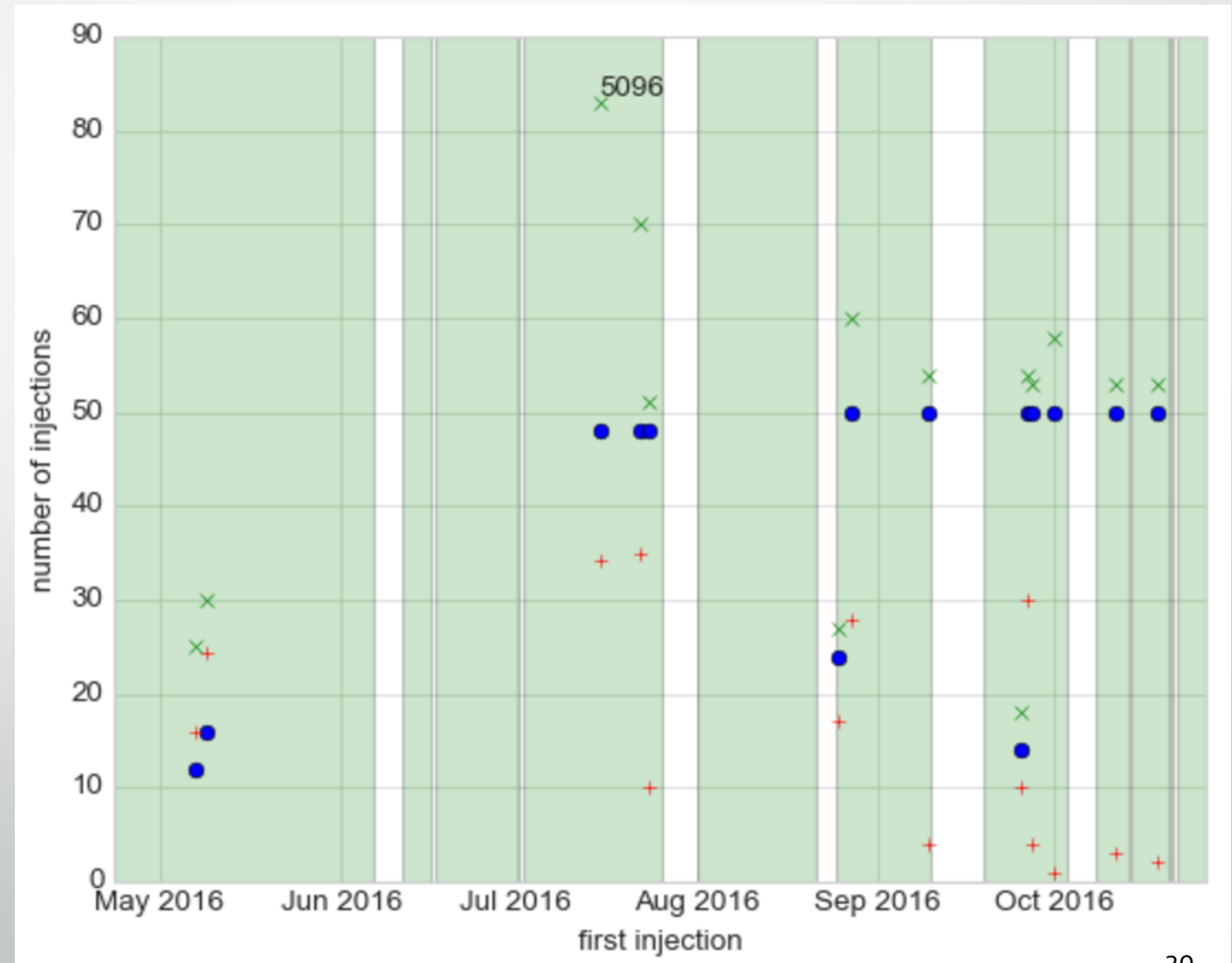


And here it looks consistent

Too many injections
(or equivalent time):

- Min: 5
- Median: 17
- Average: 25

→ Spend on average
50% more time while
filling than necessary!

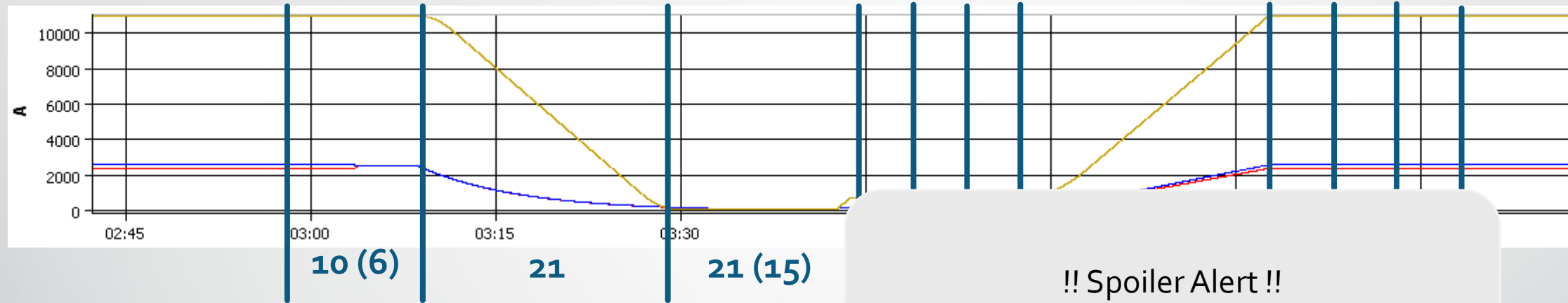


How to improve?

- Many different filling problems, which are not tracked (no 'faults'):
 - Rejected by CBCM
 - BQM (beam quality)
 - Interlocks
 - ...
- New diagnostics after EYETS
 - Have the relevant data logged to better understand what was going on
 - Online see at one glance what is wrong

The screenshot displays the 'LHC Injection Diagnostic' interface. It features two main panels for 'Injection analysis Ring 1' and 'Injection analysis Ring 2'. Both panels show a 'SUCCESSFUL' status for the injection analysis. The 'Ring 1' panel shows an evaluation time of '04-Dec-2016 09:38:26' and a time taken of '2 days 1 hour 16 minutes 18 seconds ago'. The 'Ring 2' panel shows an evaluation time of '04-Dec-2016 09:31:40' and a time taken of '2 days 0 hours 53 minutes 5 seconds ago'. Both panels list various assertions, such as 'Injection attempt completed', 'Number of PS batches matches requested in CBCM', and 'RING 1 requested in CBCM', all of which are marked as 'SUCCESSFUL'. The interface also includes a 'History' button and a 'Status' dropdown menu at the bottom of each panel.

To sum it up



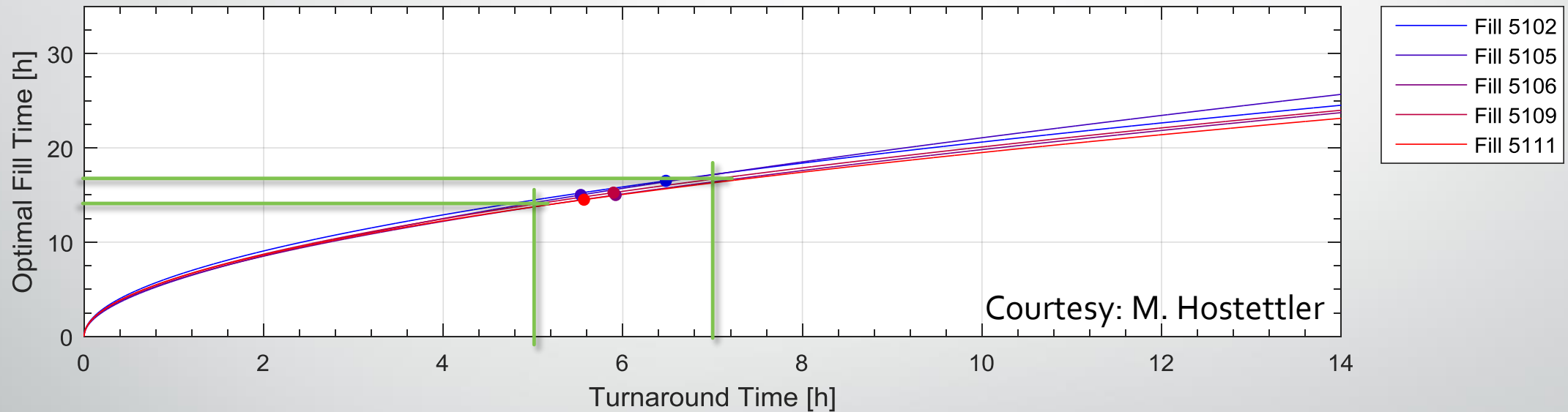
!! Spoiler Alert !!
See Davids presentation

- Sum of average: 3.0 h
- Sum of min: 2.2 h (Reminder: fastest TA: 2.5h)

Largest potential gains

- Injection Probe (~15 min):
 - Common 'principles' to correct just enough but not more: (e.g. Which coupling to correct and which better leave?)
- Injection Physics (~11 min):
 - Faster diagnostic when the beam does not come
 - Common 'principles': When correct Transferlines, when not?
- Adjust (~8 min):
 - Do we need to optimize before stable beams?

To dump or not to dump?



Reminder: Median=5.2 h; Average=7.1 h

-> Fill lengths ca. between 13h and 17h



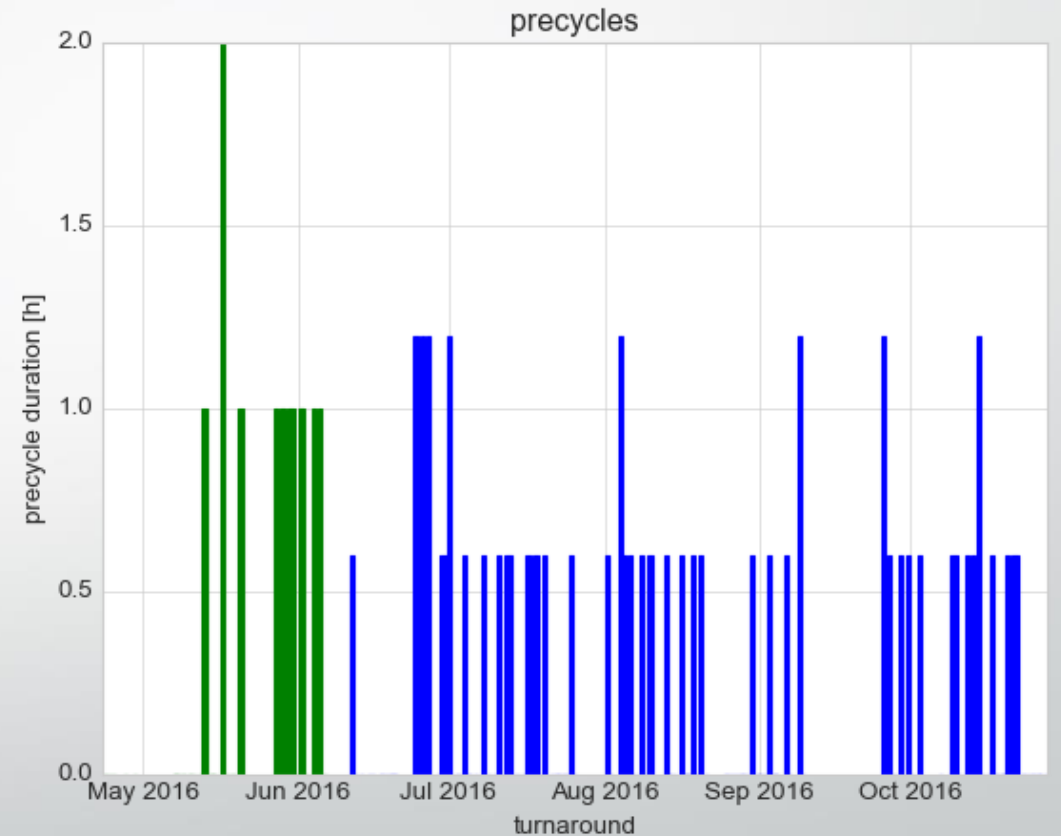
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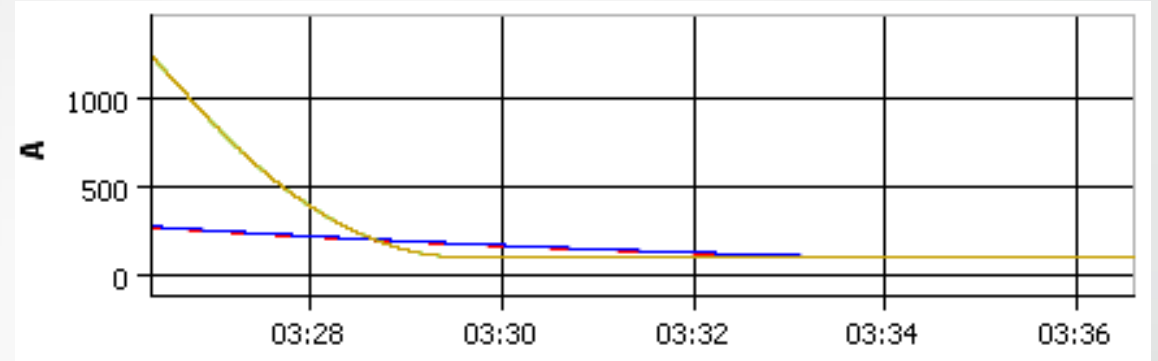
Summary

Precycle

- Precycle was changed in June (fill 5000 onwards) from 6.5 TeV to 3.5 TeV
- → duration changed from 1 h to 35 min.
- Total 64 precycles, 53 short ones
- → ~21 h gained (with the cost of ~8h commissioning)



Precycle – Can we do even better?



- Current Limitations: IPQs
(slowest: RQ₄.R₂ - about 5 min slower than RB)
- Option 1:
 - Not touching RBs, only IPQs.
 - Gain 5 min -> ~5 h per year
 - Practically no commissioning time (tune decay parasitically)
- Option 2: (To be discussed)
 - Also touching RBs. (Lowest possible ~2 TeV) -> gain of ~8.5 min -> ~9 h per year
 - Cost: ~2 shifts for recommissioning (requalifying field quality, chroma meas)



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- Biggest potential (operational) gain for turnaround: Injection
- Precycle: Two potential options available with moderate gains.
- It was a nightmare to compile this talk –without knowing exactly why 😞

