Operational Tools from 2017 to 2018

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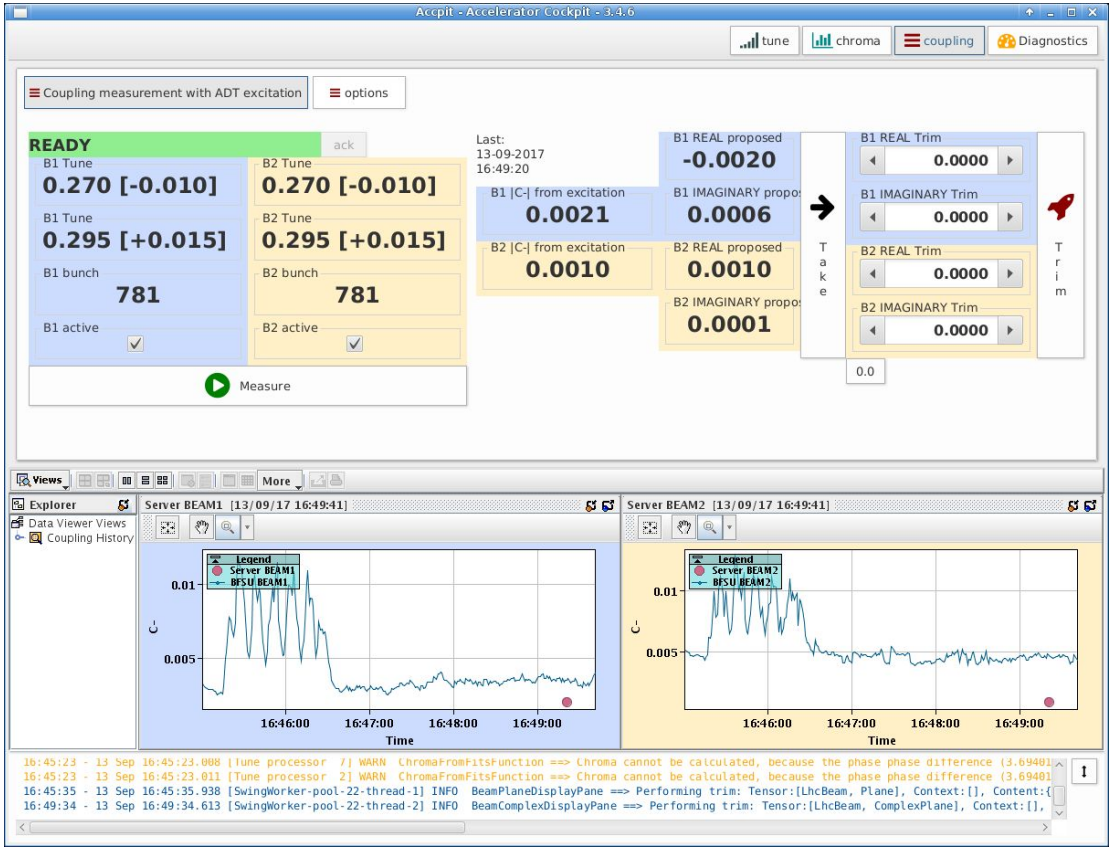
Outline

- Coupling measurement
- Luminosity Levelling
- Collaboration
- Summary

Coupling measurement and correction

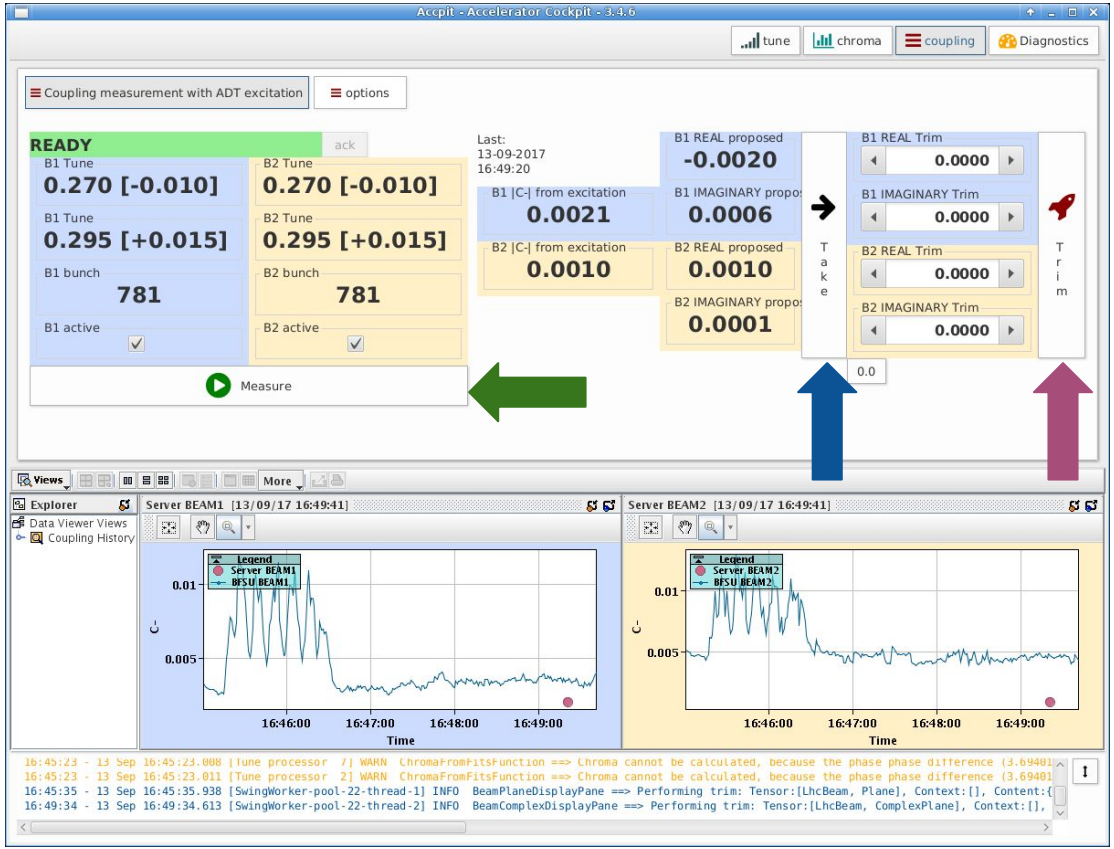
Coupling measurement and correction

- Precise coupling measurement
  → ADT excitation as AC-dipole
- Integrated into *Accpit* app
  → Small Framework, easy to add other perspectives (measurements) in the future



Challenge: make it simple (to use)

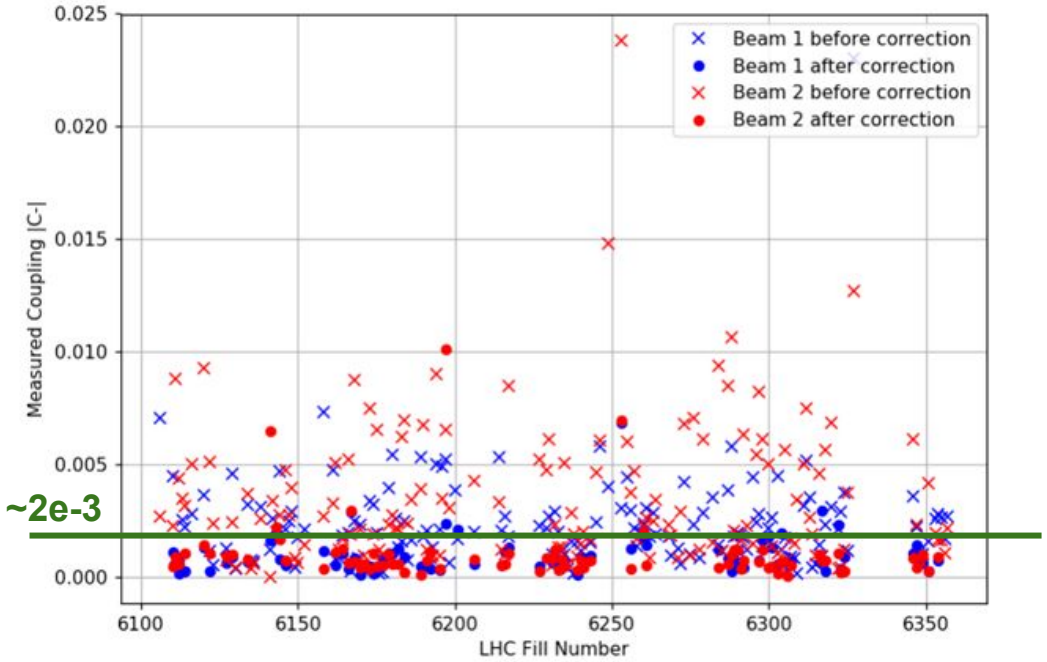
1. Arm ADT-AC Dipole
2. Arm BPM concentrator
3. Timing Event trigger
4. Analysis
5. Propose correction
6. Apply correction



Coupling corrections in operations

- Used systematically in operations at injection (but not limited to that mode)

  → Down to 2e-3



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Coupling measurement observations

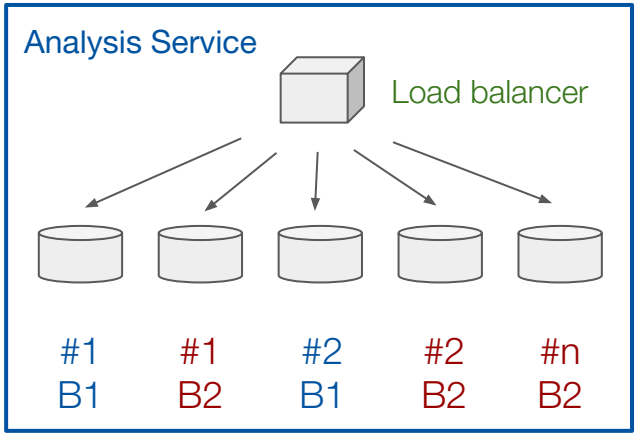
- Measurement and correction campaign for the squeeze in August and September
- A sensitivity of the results to the filling scheme was observed in collisions
  - → Shifts of ~0.002 in C-
  - → The shift seems to be related to long range beam-beam effects
  - → Analysis of an MD session in progress

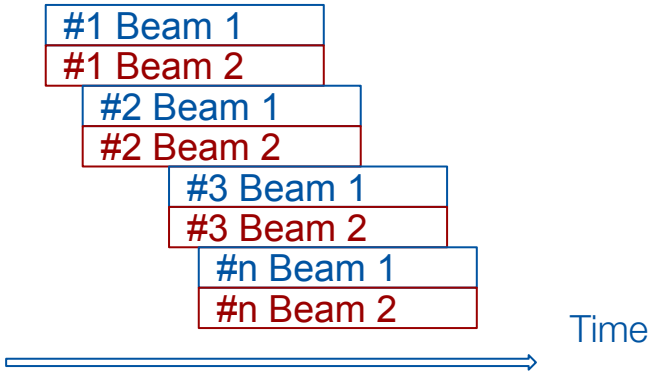
Slide from "New optics correction approaches in 2017" presentation from Ewen Hamish Maclean

2018 Ideas

Coupling analysis performance

- Current analysis takes ~ 5 min
- Algorithm improvements
  - → ~ x2 performance boost
- Horizontal scaling
  - → Cluster
- Coupling measurement queue
  - → Multiple measurements in parallel
  - → Gives more statistics to the operator





Bunch-by-bunch tune measurement

- Interest for bunch by bunch tune measurement for MDs and operation
  - → The measurement could be used to improve the coupling correction analysis
  - → Measure tune before going to collisions
- ADT team plans to implement this feature mid 2018
- This is a next step to be taken
  - → … but not yet clear who and when

See “Systems Performance: RF” presentation from Helga Timko
and “Instrumentation: What to expect next year” presentation from Tom Levens for more details

Luminosity levelling

Luminosity levelling

- *LHC Luminosity Scan* app
- Controls the LHC luminosity
- Feature-rich
  - → Luminosity levelling
  - → Luminosity calibration
  - → IP optimization
  - → IP steering
- Easy to use

Luminosity levelling plan

- LBOC and Chamonix

• **EYETS project**: implement luminosity in the luminosity server

principle demonstrated

1. simple separation levelling
   - no DIP communication
   - parameters set by direct input by OP
   - baseline for IP 1/5 in 2017 ?

planned

2. separation levelling for IP 2/8
   - re-implement the current DIP protocol
     - nothing will change for ALICE & LHCb
   - decommission the old application

uncertain

3. novel levelling schemes
   - levelling by beta*, crossing angle, ...?
   - requires further studies

M. Hostettler LBOC 01/11/2016

Luminosity levelling plan

- LBOC and Chamonix

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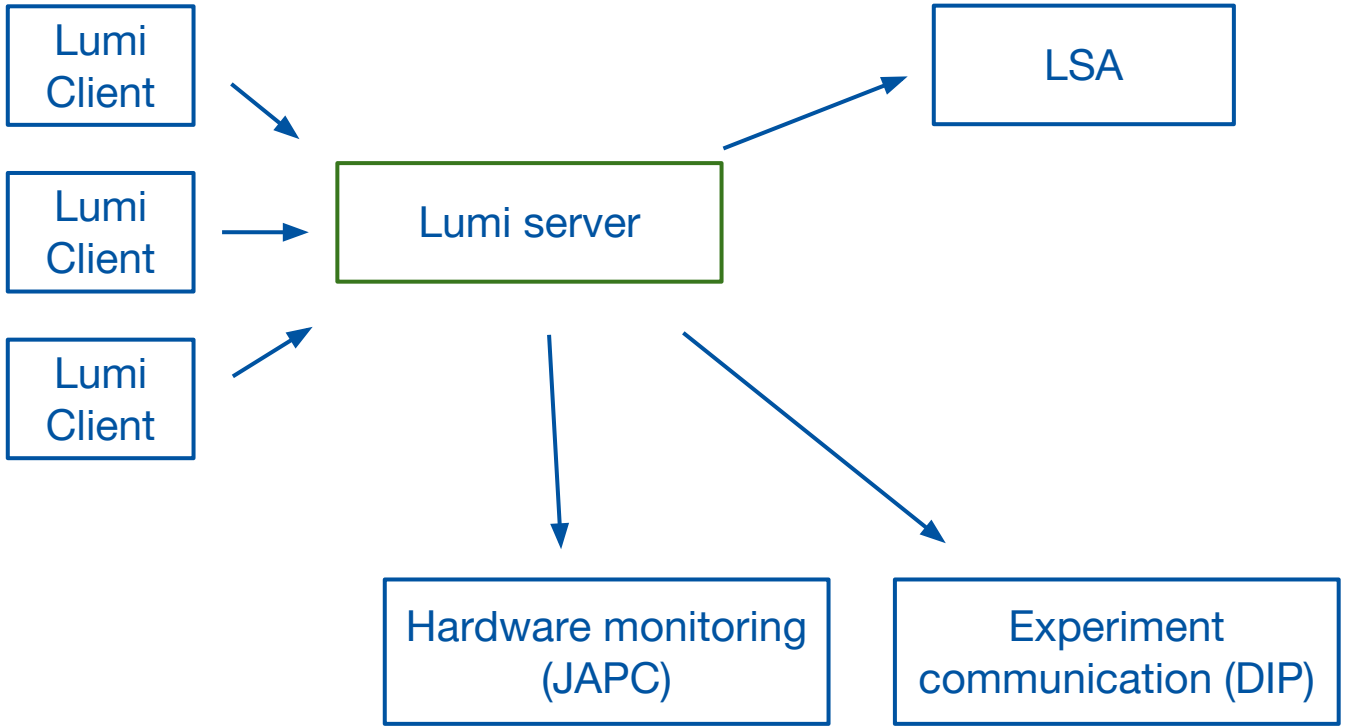
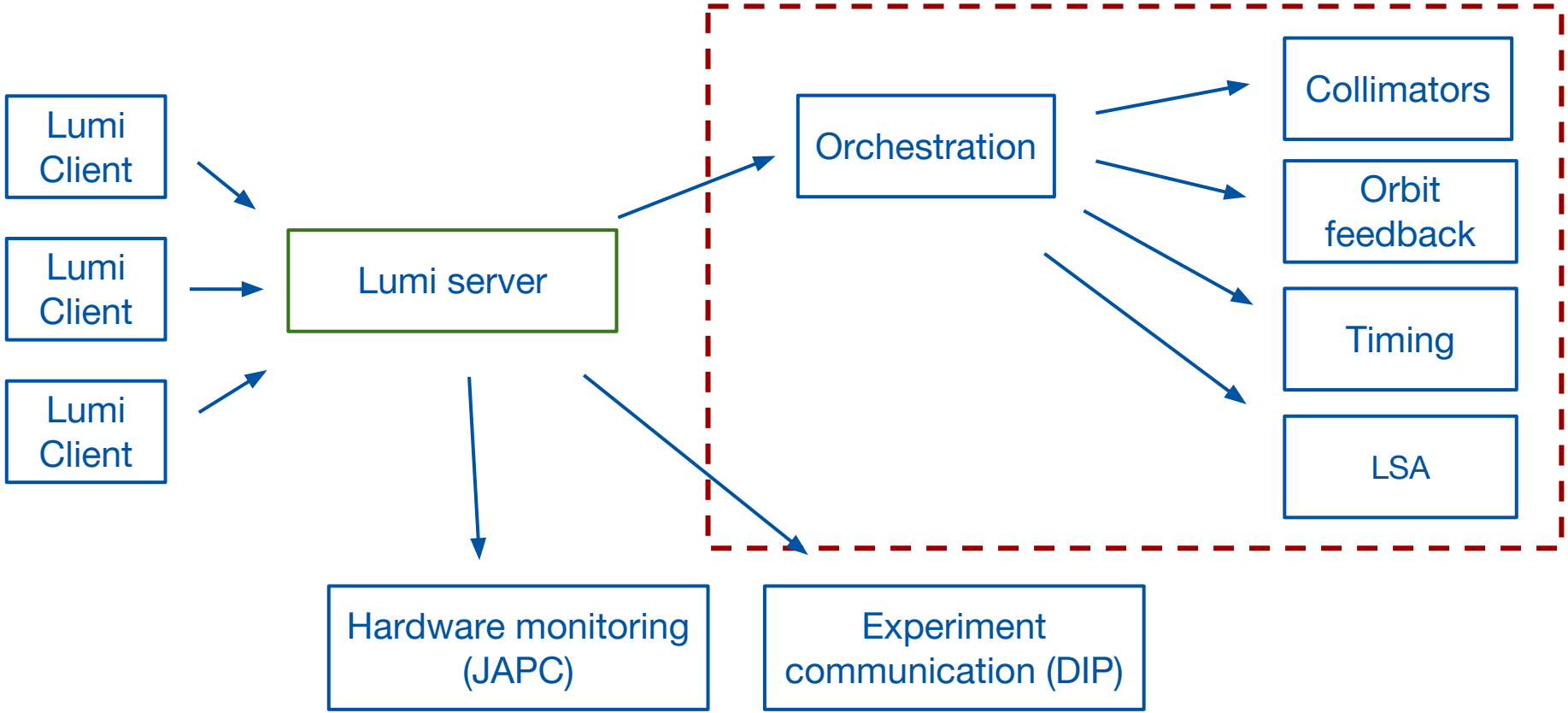
Lumi Server challenges



See extra slides for more details

Lumi Server challenges



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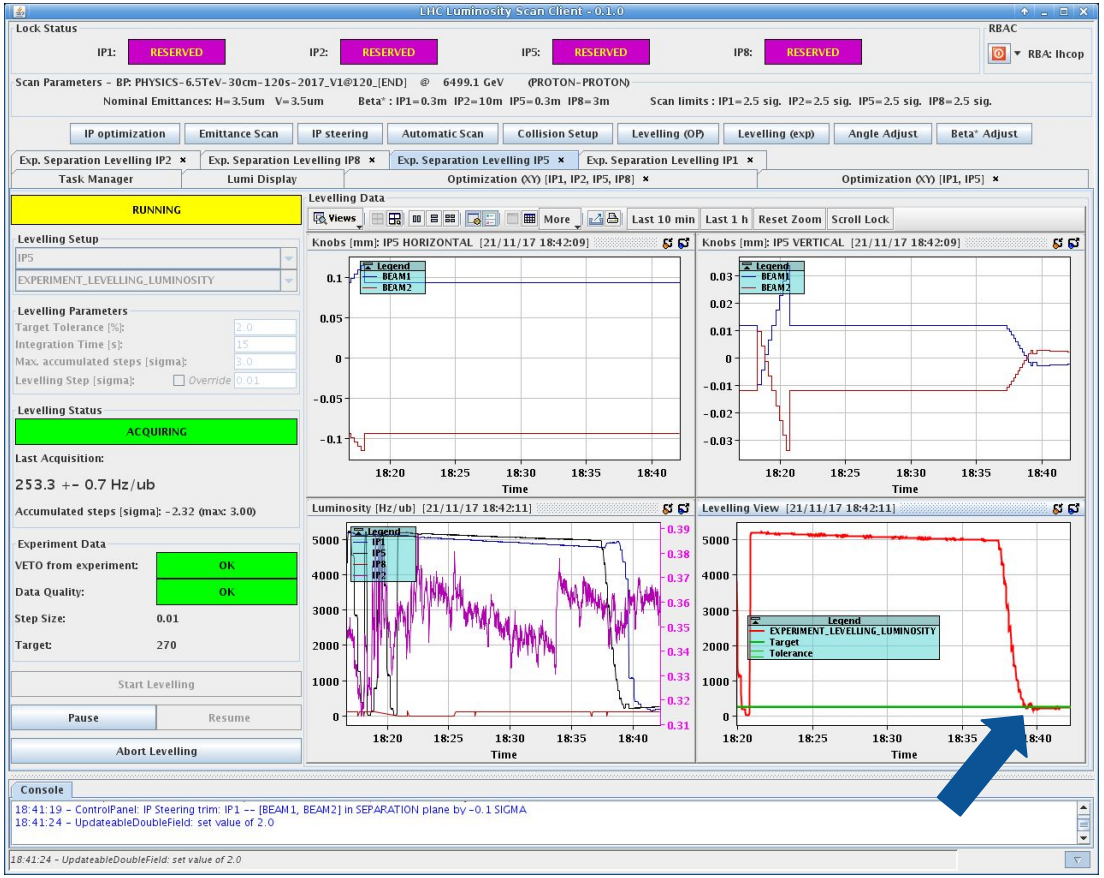
2017 Operational features

Automatic Separation levelling

- Separation levelling on all IPs
  - → First time for IP1 and IP5
- Luminosity target specified by
  - → Experiments (DIP)
  - → Operator manual override
- Crucial for 2017 run
  - → Pile-up constraints



See "Feedback from the Experiments on the 2017 run" presentation from Jamie Boyd for more details

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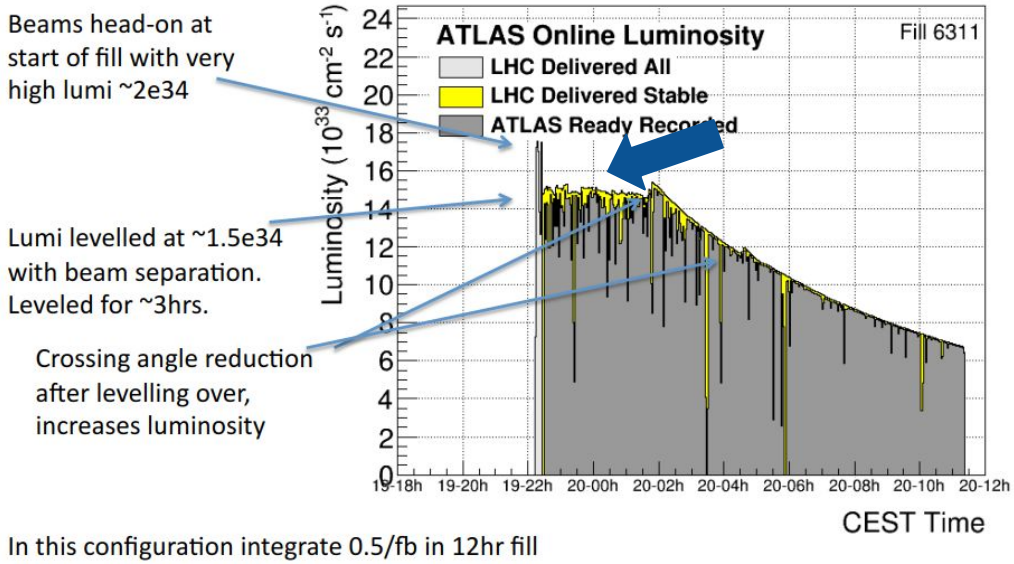
High luminosity data taking

A typical 8b4e, BCS, β*=30cm fill in ATLAS (same for CMS)

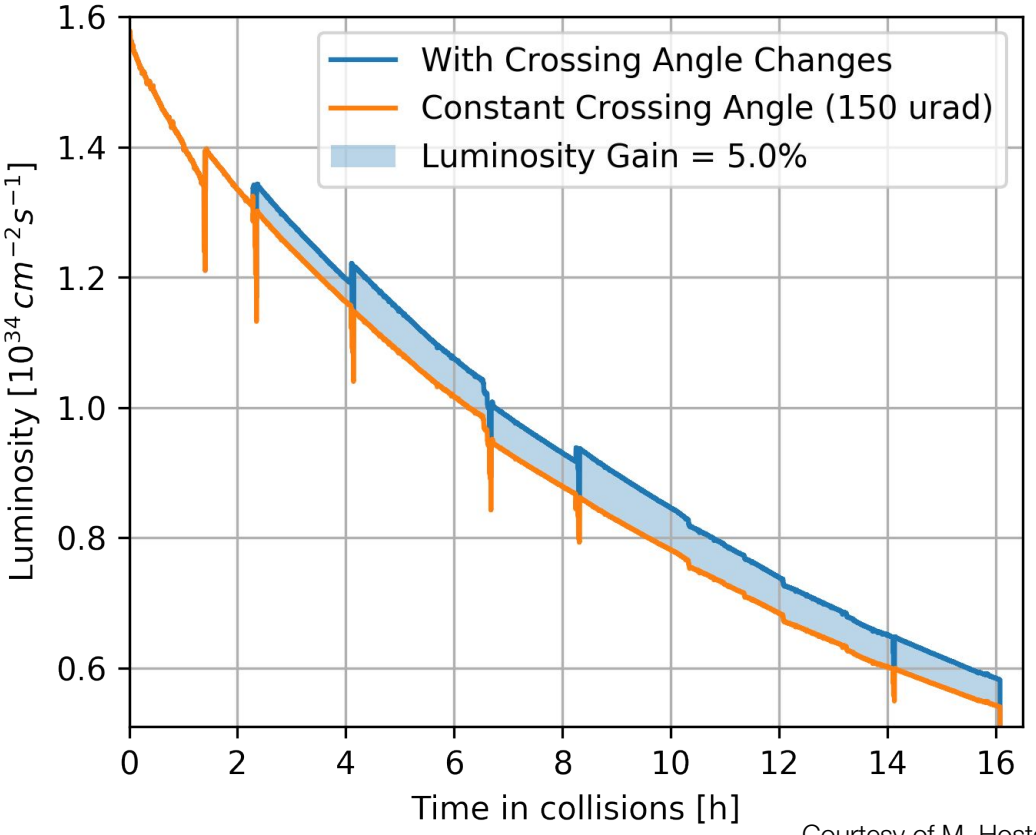


In this configuration integrate 0.5/fb in 12hr fill

Slide from "Feedback from the Experiments on the 2017 run" presentation from Jamie Boyd

Crossing Angle changes

- Crossing Angle changes
  - → Operational in 2017
  - → 150 to 120 murad
  - → Technically possible in all IPs
- Commissioned during intensity ramp-up
- Gain in luminosity over 16h
  - → **~ 5%**

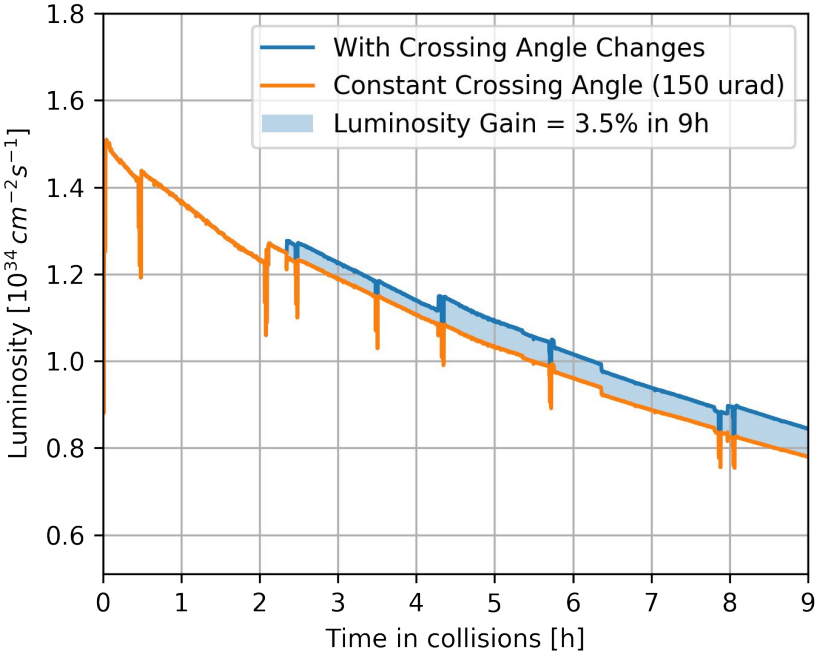


Courtesy of M. Hostettler

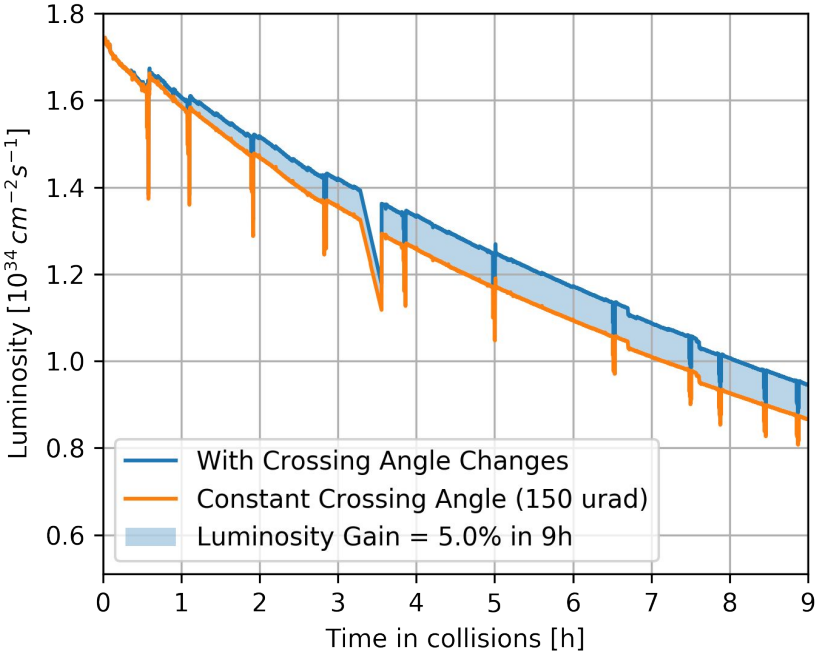
2018 Options

#1 Continuous Crossing Angle levelling

Crossing Angle from 150 to 120 murad in 9 h



10 murad steps

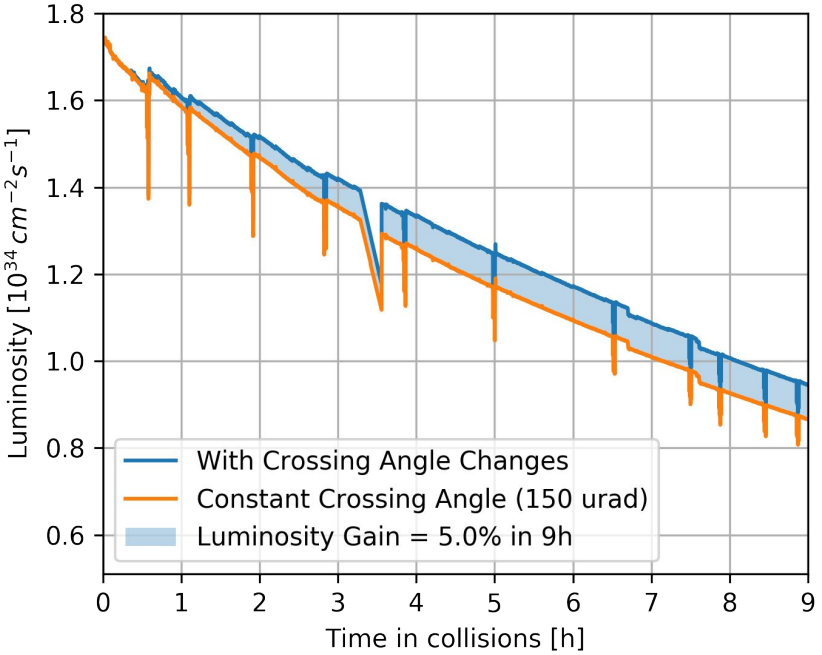


1 murad steps

Courtesy of M. Hostettler

#1 Continuous Crossing Angle levelling

- Small steps towards target
  → 1 murad?
- More “gentle” approach
- Ok for the experiments
- Currently done manually
  → Some more work for automation
- Gain in luminosity over 9h
  → **~ +1.5%**

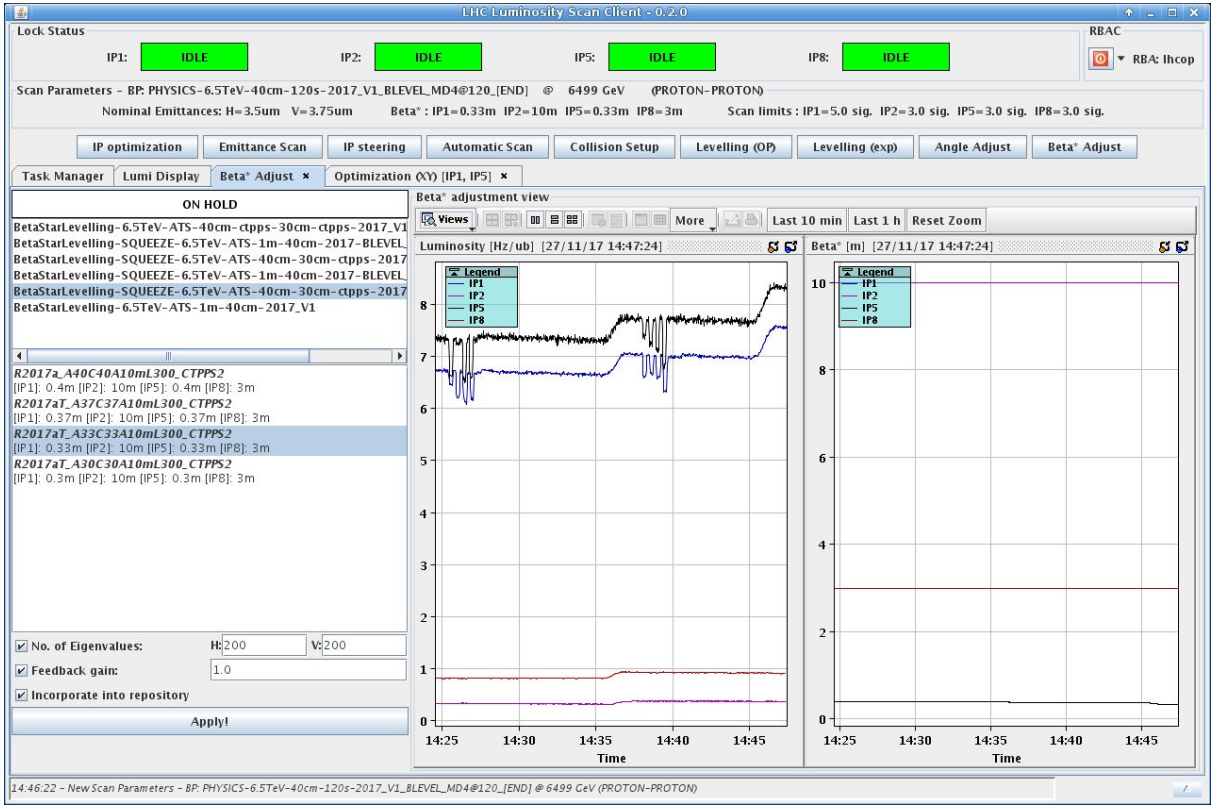


See “Feedback from the Experiments on the 2017 run” presentation from Jamie Boyd for more details

Courtesy of M. Hostettler

#2 Beta* levelling

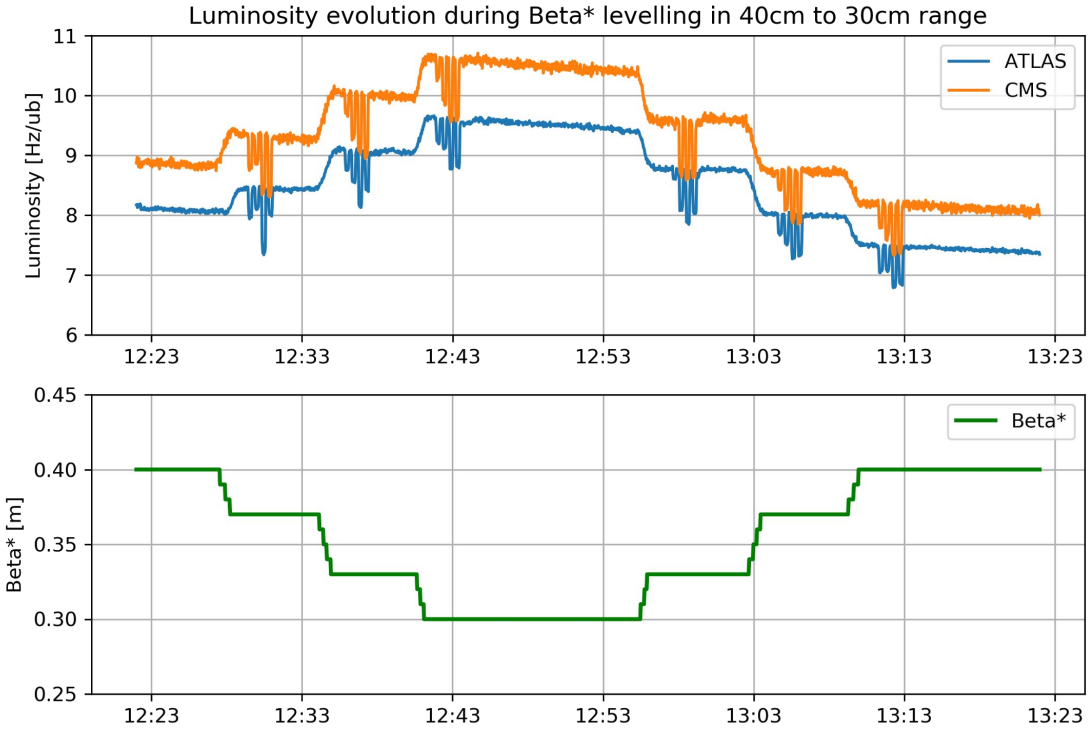
- First prototype of the operational Beta* levelling
- Optic matchpoints
- Easy to use
- Complexity
  - → Non local changes
  - → Collimators
  - → Settings incorporation
  - → Orbit feedback
  - → ...



First Beta* levelling in collisions

MD4 Beta* levelling: 40cm to 30cm

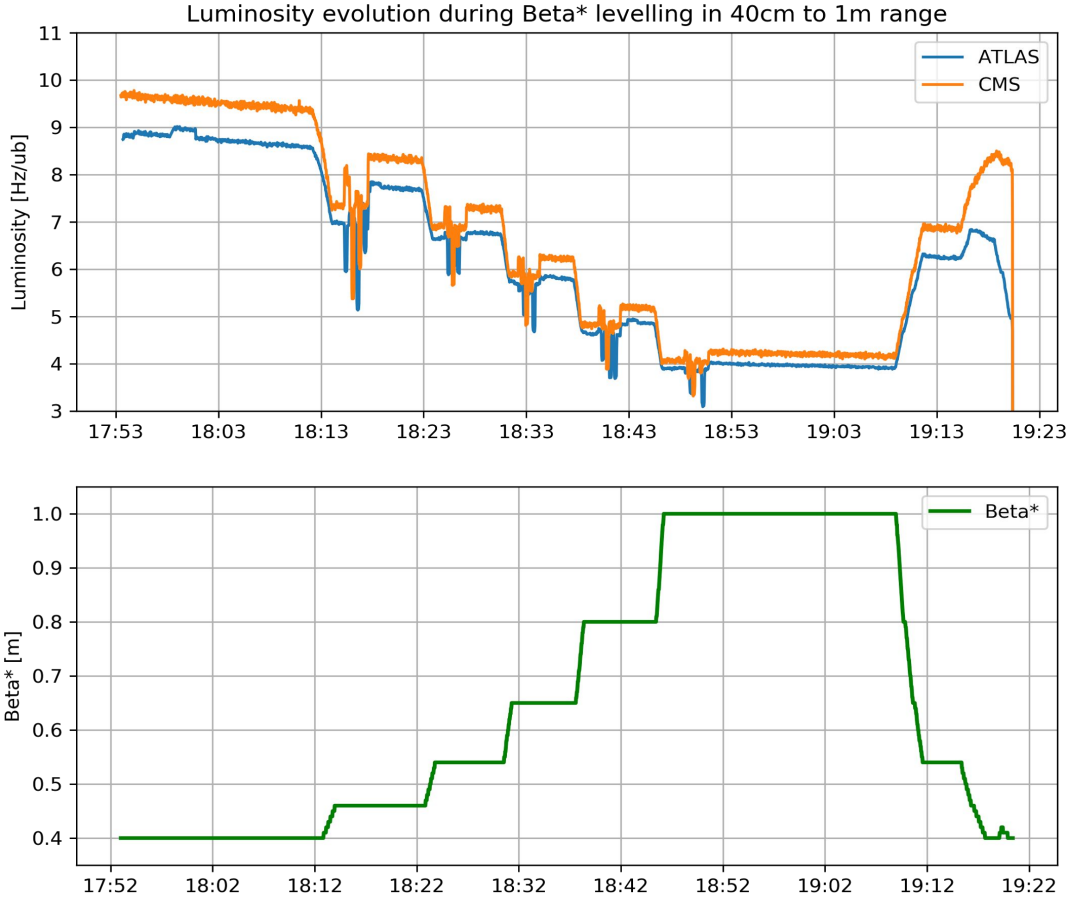
- Close to a possible operational scenario...
- Started at end of Squeeze 40cm
- Going to 30cm in steps during collisions
  → Luminosity follows as expected
- Optimized at each step
  → Not much to optimize! :)
- Orbit ok
  → Eigenvalue cut = 200 Gain = 1.0



See extra slides for more details

MD4 Beta* levelling: 40cm to 1m

- De-squeeze from 40cm to 1m during collisions
  - → Technically possible
  - → Luminosity as expected
- Optimization needed
  - → Never commissioned with collisions
  - → It still worked :)



MD4 Beta* levelling: collimator movement

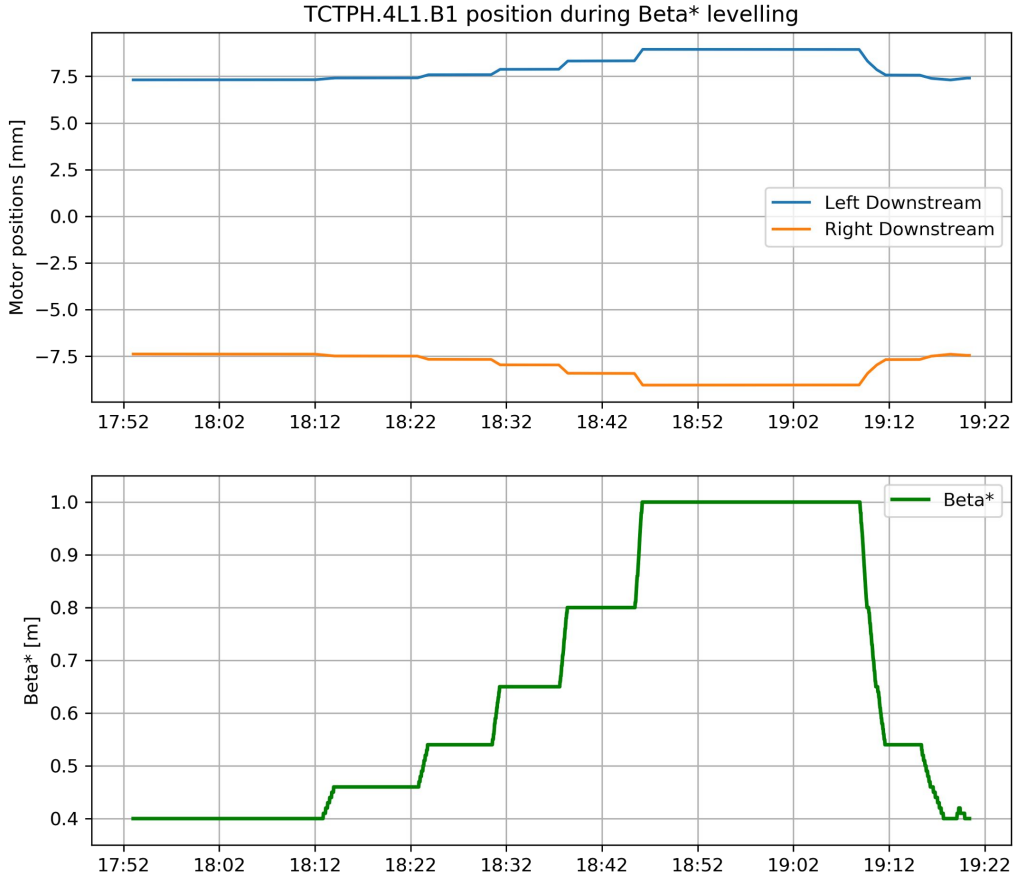
- Relevant movement in the range

  1m to 40cm Beta*

  → ~ 2 mm
- Collimator center

  → According to orbit position
- Collimator Half-gap

  → According to Squeeze function



Beta* levelling: road to operations...

- PcInterlock limits (phase advance and orbit corrections protection)
  → Need to be adjusted dynamically
- Collimator limits need to be kept constant or changed on the fly
  → Discussion ongoing
- No “automagic” levelling foreseen yet
  → Levelling (separation, crossing angle, …) must be performed manually
- Confident to be ready at end of YETS
- To be commissioned during intensity ramp-up
  → Proved to be a very useful approach as seen from Crossing Angle changes
  → Gain confidence

Getting things done as a Team

- Efficient way of achieving a common goal
- No requirements ping-pong…
- Knowledge sharing
- Quick feedback loop
- Collaboration across Beams Department

→ BE Beams Department | Operation

→ BE Beams Department | Controls

→ BE Beams Department | Accelerators and Beam Physics

→ BE Beams Department | Radio-Frequency

Summary

- Luminosity levelling
  - → Separation
    - First time operational for IP1 and 5. Essential for 8b4e running
  - → Crossing Angle
    - Commissioned during intensity ramp-up and used operationally since then
  - → ~ Beta*
    - Still some work to do. Confident to be ready for commissioning for 2018
- Precise online coupling measurement and correction
- Some ideas for 2018
  - → Better LHC injections statistics
  - → More automation for the LHC

Summary

Luminosity levelling à la carte

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  - → Separation
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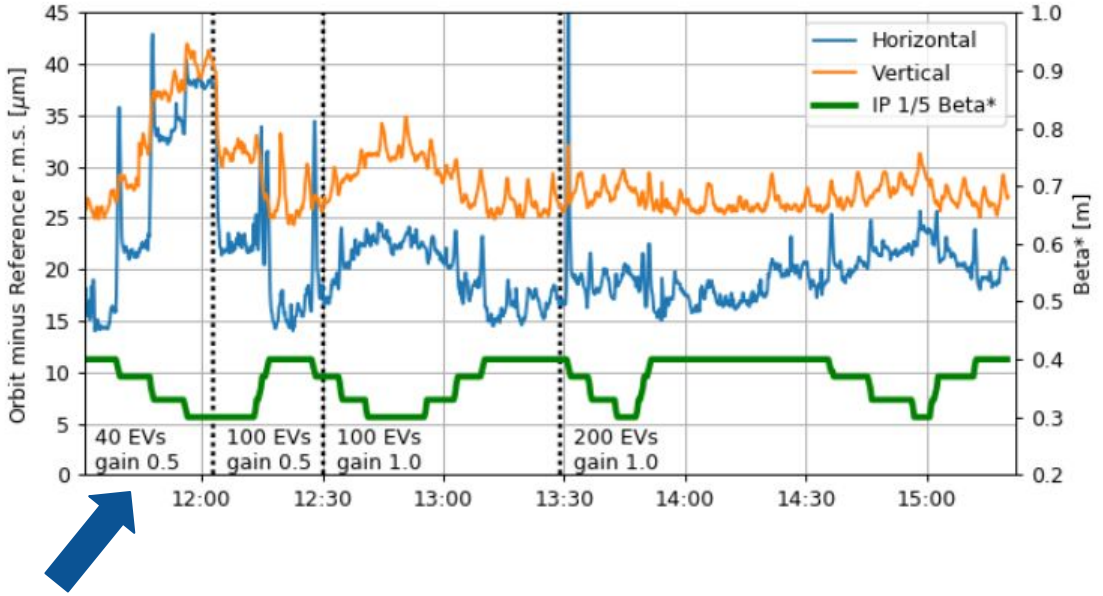
Happy holidays!

Extras

Orbit evolution during Beta* 40cm to 30cm

- Was reasonably OK
  - → ~ 20 um r.m.s.
- Good results with
  - → Eigenvalue cut = 200
  - → Gain = 1.0
- Changes applied during levelling step and reverted afterwards



Stable beams settings

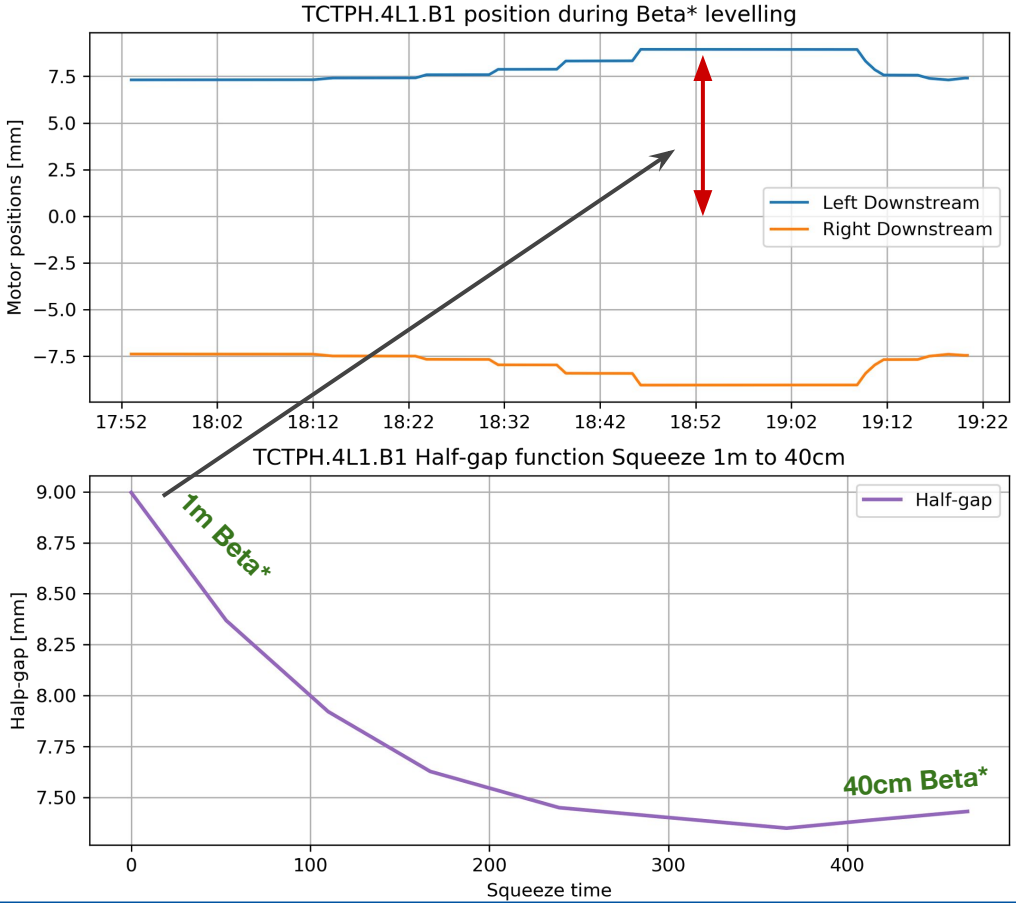
Courtesy of M. Hostettler

Other 2018 ideas...

- LHC Filling Diagnostic
  - → Essential for injection statistics
  - → Analysis improvements (Kickers, BIC inputs, …)
  - → See “Time spent at injection” by Georges-Henry Hemelsoet
- Consider automation improvements
  - → Run LHC sequences in parallel
  - → Scenarios to e.g. conditionally skip certain actions
  - → Good opportunity to team up with CO again
  - → See “LHC Operation” by Mirko Pojer

MD4 Beta* levelling: collimator movement

- Collimator center
  - → According to orbit
- Collimator Half-gap
  - → <u>According to Squeeze function</u>

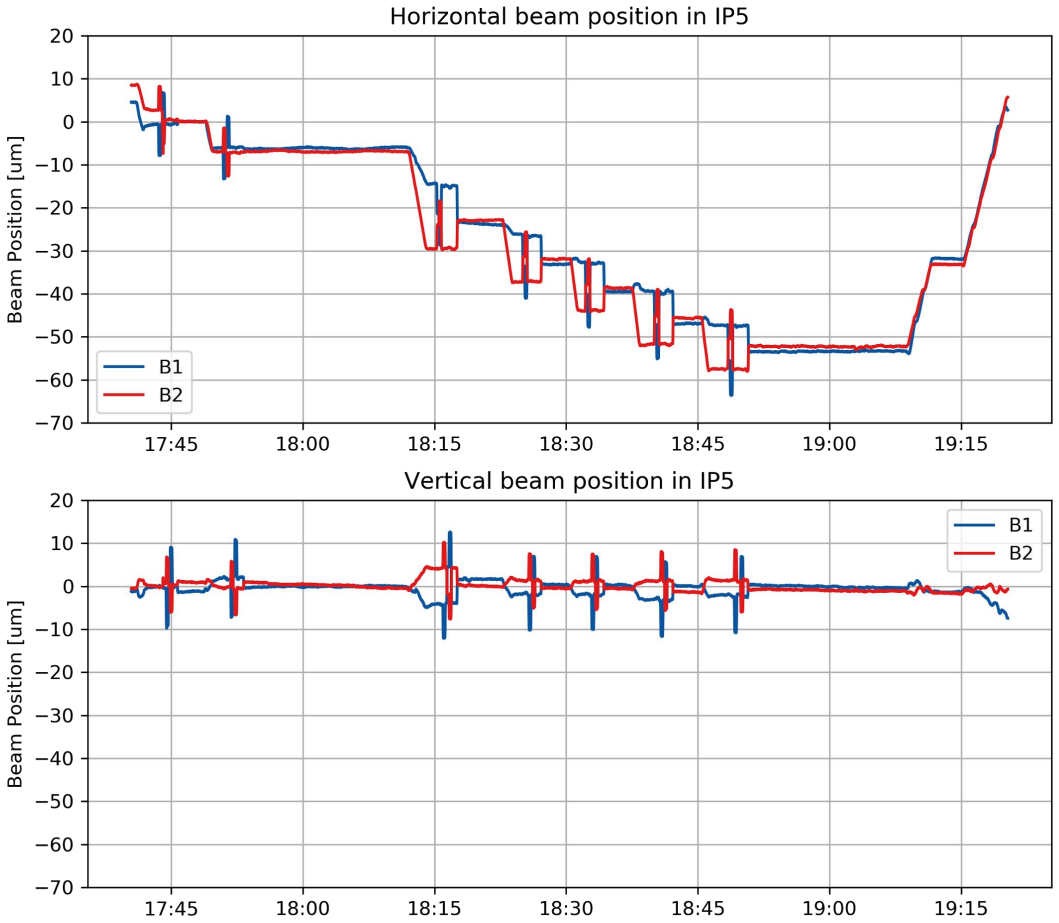


MD4 Beta* levelling

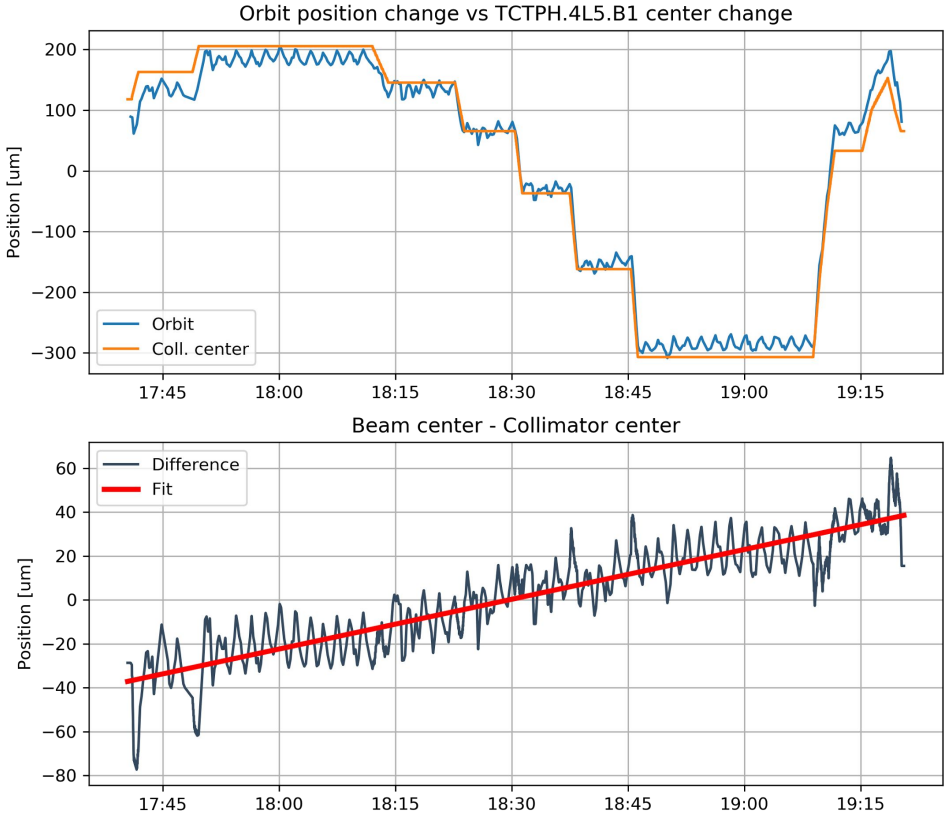
- During de-squeezing to 1m
- Estimated beam position IP 5

  → Optimization kept head-on
- B1 V experienced some instrumental drifts

  → 3rd order polynomial fit



MD4 Beta* levelling: orbit at collimators



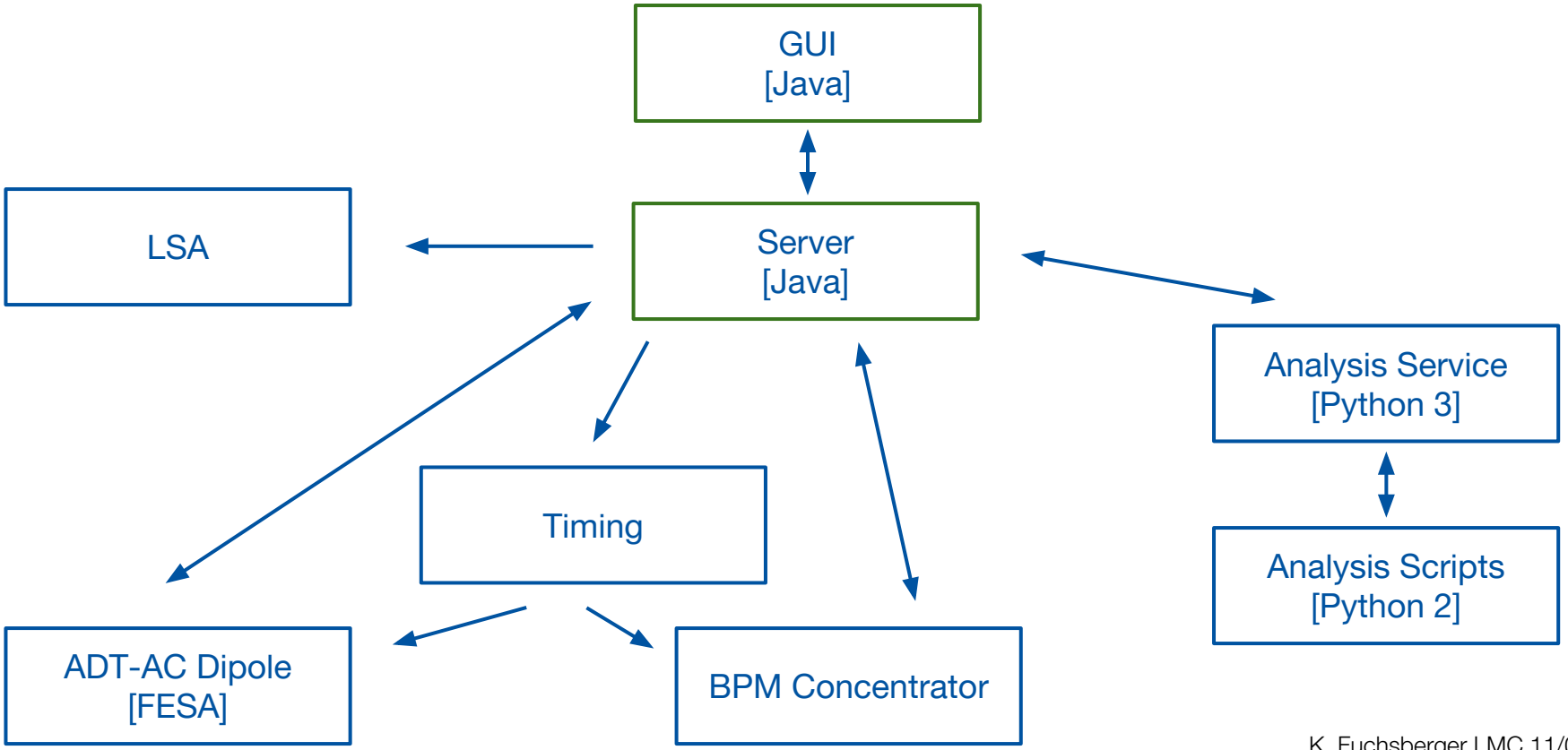
Orchestration

- Trims on Crossing Angle or Beta* knobs (may) affect the orbit
  - → Non local “bumps”
- Orbit Feedback must “follow” the changes
  - → Reference orbit updates
  - → Settings for Eigenvalue cut and Gain
- A step in Beta* involves changing the LHC optic
  - → LSA optic update (future trims must be consistent)
  - → Orbit Feedback optic update

Orchestration

- Collimators (may) need to follow orbit and optics matchpoint
  - → Center displaced according to orbit shape (TCTs and TCLs)
  - → Gap moved according to the function stored in LSA (TCTs)
- Orchestration synchronized using Timing Events
  - → Power Converters
  - → Collimators
  - → Orbit Feedback

Coupling application architecture



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