LHC beam screens: Cryo status for 2018

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E-cloud meeting
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Summary

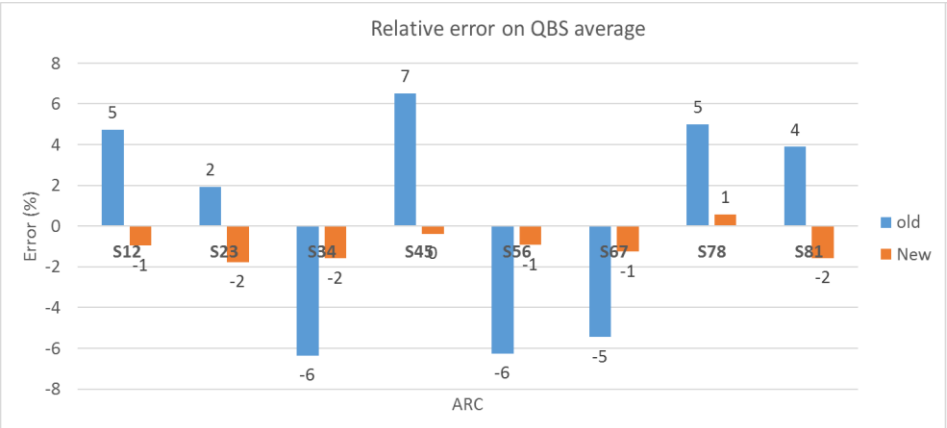
- Cryo valve calibration
- Electrical Heater survey
- Online QBS calculations
- Individual FF control

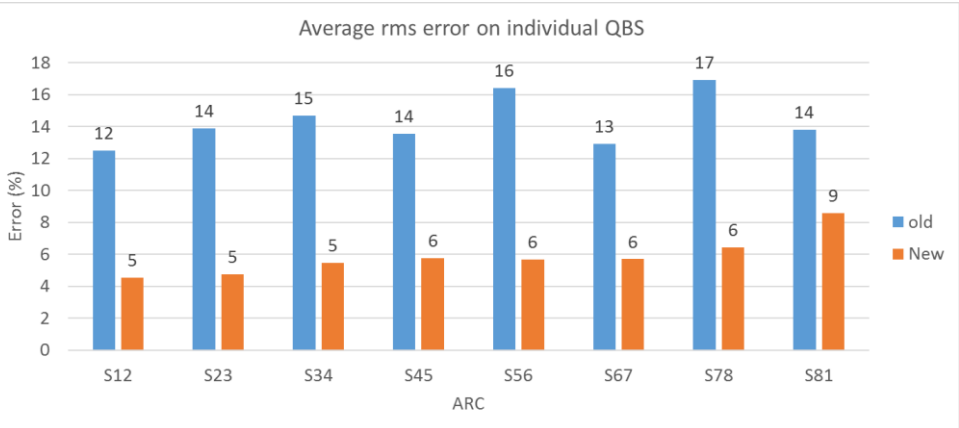
Cryo valve calibration

- All beam screen valves have been calibrated to estimate the valve rangeabilities
  - ARC12, ARC23, ARC78: September 2016
  - ARC34, ARC81: March 2017
  - ARC45, ARC56, ARC67: March 2018
  - LSS: different periods between May 2016 and March 2018

- 11 beam screen valves in LSS cannot be estimated properly
  - **4xQ5**: Q5R2, Q5L8, Q5R8, Q5L1
  - **7xQ6**: Q6R2, Q6L3, Q6R3, Q6L4, Q6R4, Q6L8, Q6R8
  - Valves installed seems to not be the ones specified in the database.
  - All valves have been inspected/recalibrated in EYETS 2016 or YETS 2017: nothing found.
  - To be checked/replaced in LS2.

- All results will be communicated to be able to re-process data between LS1 and now.

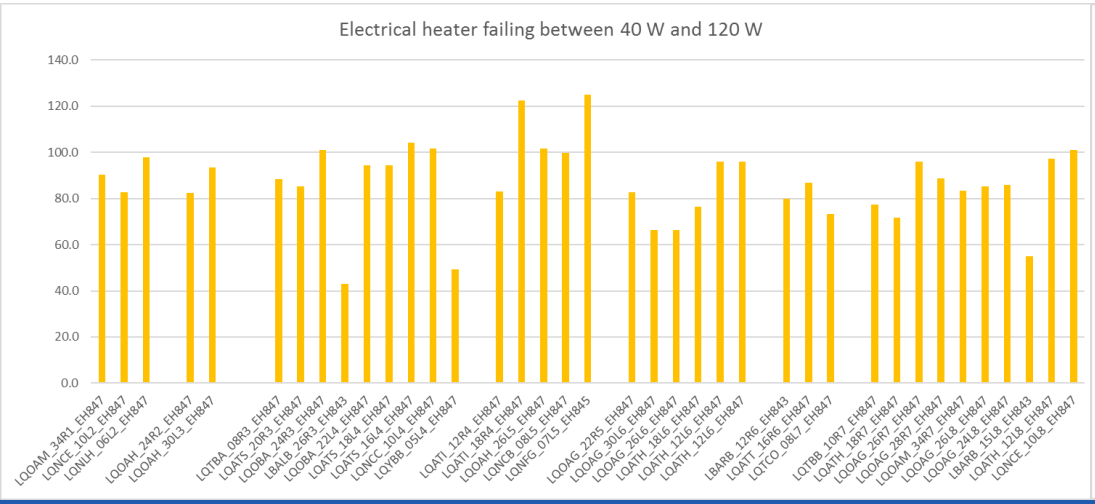


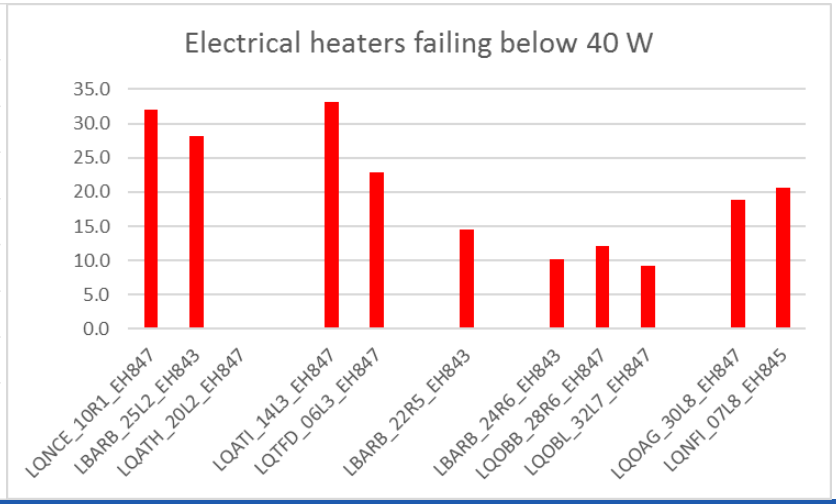


Electrical Heater survey

- During March 2018: Beam screen regeneration at 50 K for beam vacuum

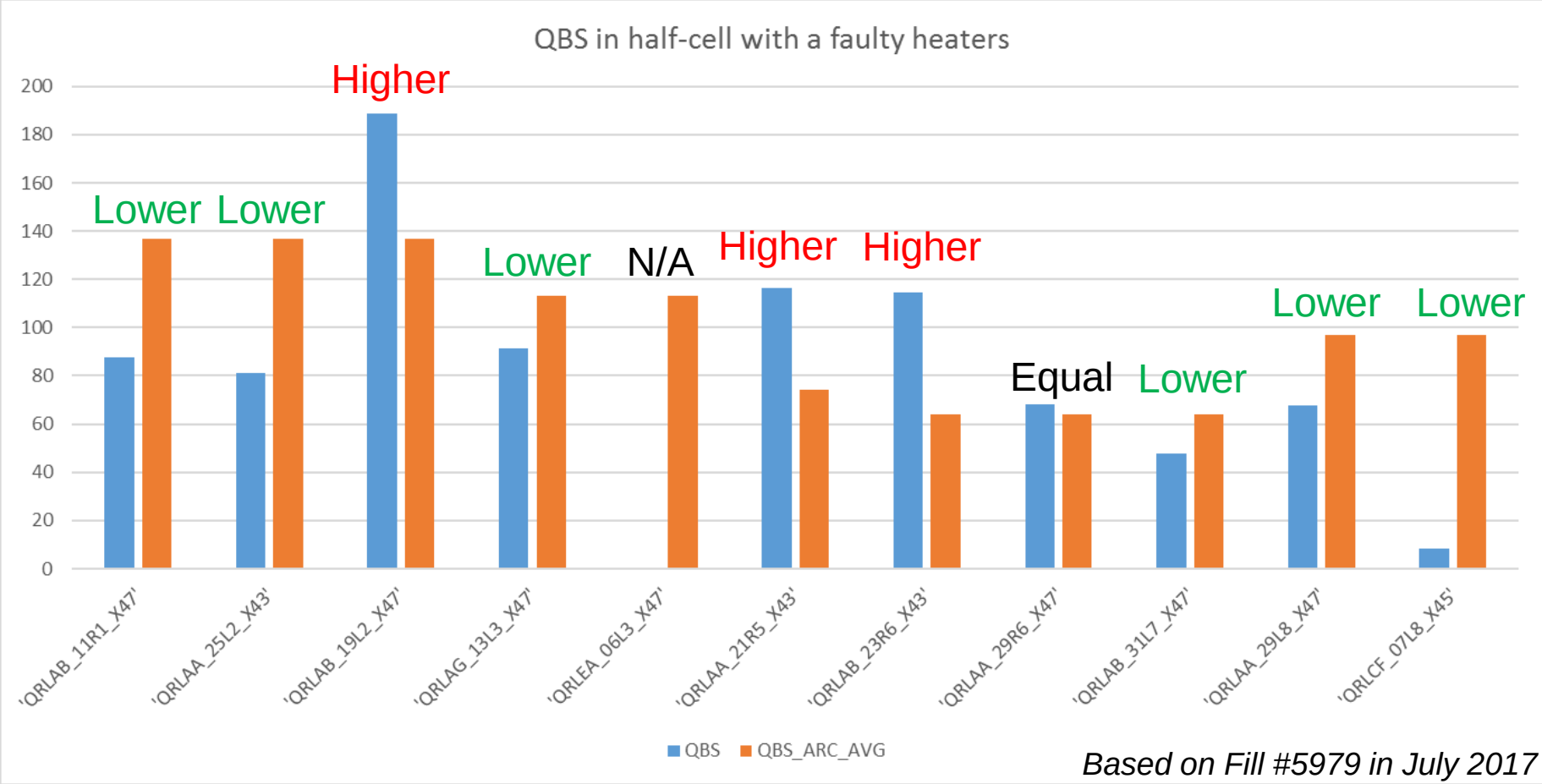
- Several electrical heaters are demonstrating limitations
  - Thermal switch protection issue on electronic card
  - 38 electrical heaters are failing between 40 W and 120 W
    - Regeneration is still possible but can be disturbed
  - 11 electrical heaters are not able to go over 40 W
    - Regeneration is impossible
    - Will be corrected/replaced in LS2





Faulty heaters and heat loads correlation ?

- Plot QBS for the faulty heaters compared with the respective ARC average…
  - No correlation between faulty heaters and large heat load cells



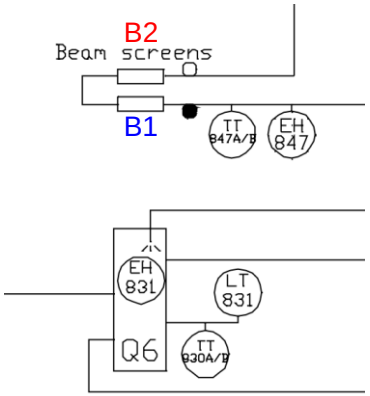
Based on Fill #5979 in July 2017

Online QBS calculation: modifications

- All calibration results have been inserted in the online QBS calculations

- For the 11xQ5/Q6 suspicious beam screen valves:
  - Valve rangeability is setup to 0.0 as we cannot fit any realistic data on these valves.
  - QBS = 0.0 W to avoid any misunderstanding on these loops.

- For the beam screens in D2Q4, Q5, Q6, D4Q5, D3
  - The beam screen cooling loop is passing first in B1 and then in B2
  - The number of cooling pipes nc=2 (was 4 before)
  - The Beam screen length = 2*L (was L before)



- Instrumented cells (4x in ARC45 + 1 x ARC12)
  - Heat load distinction between B1 and B2 apertures
    - Beam 1 example: QRLAA_13R4_QBS947_D3**B1**
    - Beam 2 example: QRLAA_13R4_QBS947_D3**B2**
  - Massflow asymmetry between B1/B2 is estimated
    based on density difference on each circuit (not yet deployed, under validation)

Beam screen FF control

- Summary of beam screen cryo control loops:
  - **Run 1 before LS1**
    - Individual Feed-Back on valves
    - Individual Feed-Back on heaters
  - **Run2 / 2015**
    - Individual Feed-Back **+ common Feed-Forward on ARC+IT valves**
    - Individual Feed-Back on heaters
  - **Run2 / 2016, 2017**
    - Individual Feed-Back + common Feed-Forward on ARC **+ individual FF in LSS valves**
    - Individual Feed-Back **+ common Feed-Forward on ARC + individual FF in LSS heaters**
  - **Run2 / 2018**
    - Individual Feed-Back **+ individual Feed-Forward on ARC/LSS valves**
    - Individual Feed-Back **+ individual Feed-Forward on ARC/LSS heaters**

Individual FF control

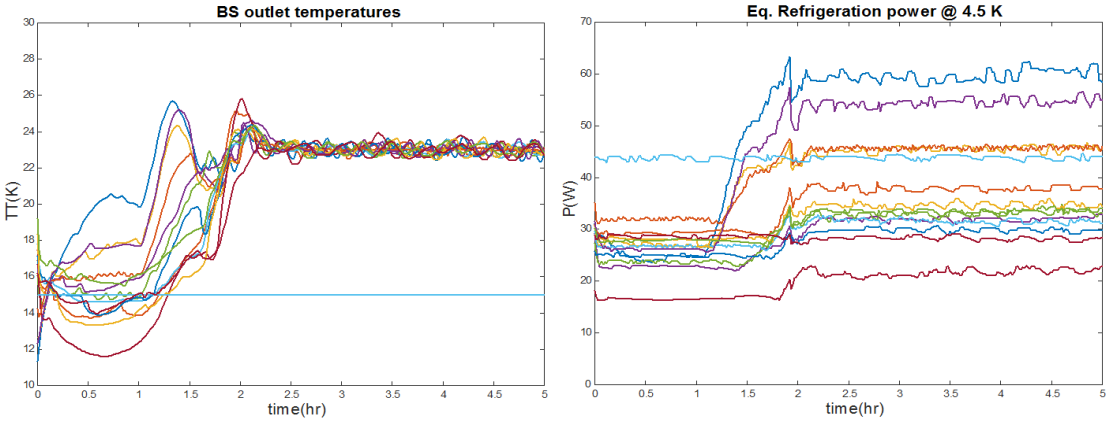
- 2018: Individual FF on the 585 beam screen cryogenics loops
  - About 3 000 parameters to tune and adjust
  - Allow to estimate heat loads in each beam screen independently along the LHC
  - Allow to save refrigeration power on the less heating half-cells
  - Cannot be manually setup anymore

- Automatic script have been developed
  - Offline computation of all FF parameters based on a reference fill
  - Apply all parameters in the cryo control systems by a simple click per sector (recipe)

- Operator actions
  - A global gain for each sector can be adjusted
    - Adjust the estimated load with the cleaning effect
    - Adjust massively the FF action when the injection scheme is changed
  - Each individual parameters can be still adjusted cell by cell if necessary

Individual FF control

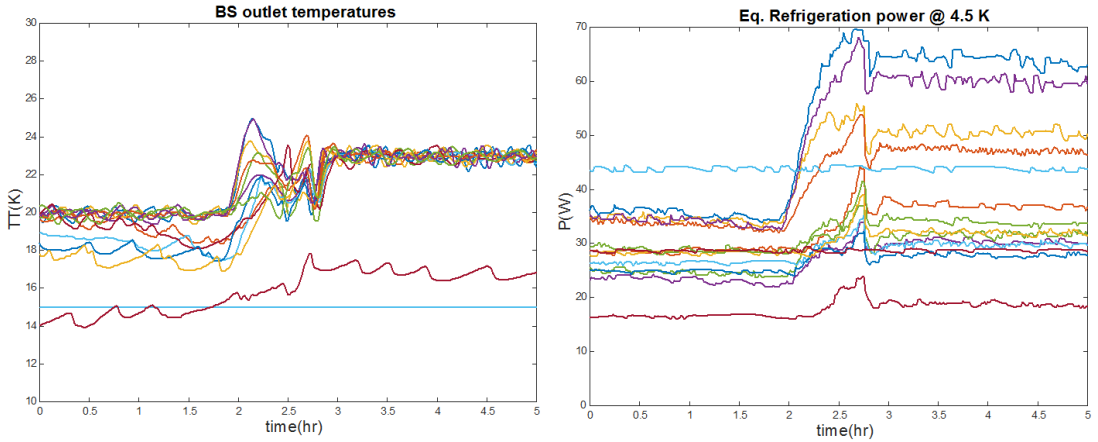
Comparison over 3 almost identical fills in S81 during 2017



Fill 6240 (1916 bunches in 8b4e)

No FF applied

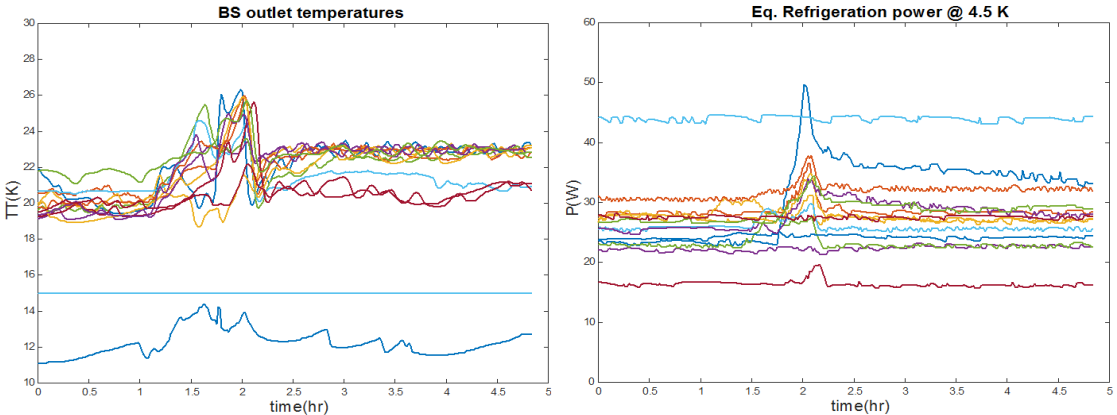
(control applied before LS1)



Fill 6245 (1916 bunches in 8b4e)

Common FF for entire sector

(control applied in 2017).



Fill 6276 (1868 bunches in 8b4e)

Individual FF
(control tested in 2017 and deployed for 2018).

NB: this comparison is not really representative for 2018 because it was done during the 8b4e scheme with small heat loads

Conclusion

- All LHC beam screen valves have been calibrated
  (but still 11 valves in some Q5/Q6 cannot be explained)

- Problematic beam screen heaters have been identified for LS2
  - And they show no correlation with large heat load half-cells

- Online QBS computations have been improved
  - Reduced uncertainties
  - LSS particularities taken into account
  - B1/B2 distinction in Instrumented half-cells

- Individual Feed-Forward deployed and setup in all the machine
  - Cryo is ready to handle dynamic heat loads in beam screens