LHC beam screens: cryogenic observations and analysis

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TE-CRG

E-cloud meeting
*14th July 2017*

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ARC Heat loads 2016 Vs 2017

- *Fill #5416 = 14th October 2016: 25ns_2220b_2208_1940_2036_96bpi_24inj*
- *Fill #5882 = 28th June 2017: 25ns_2556b_2544_2215_2332_144bpi_20inj*
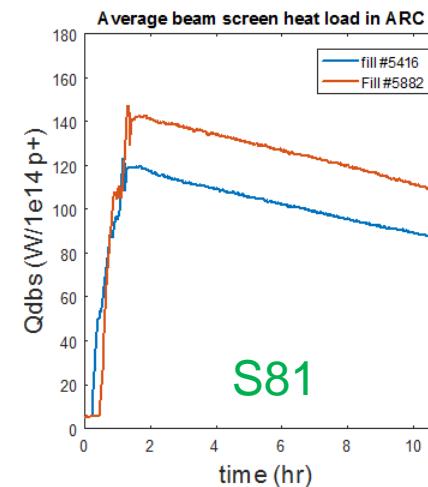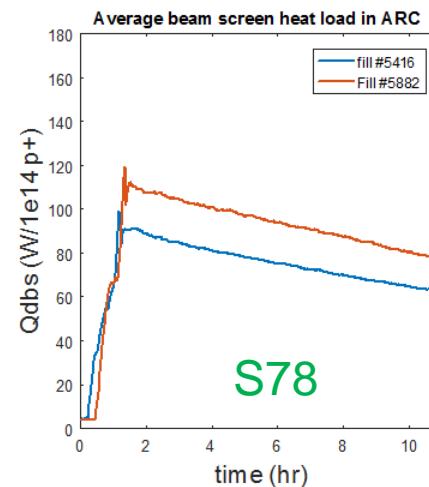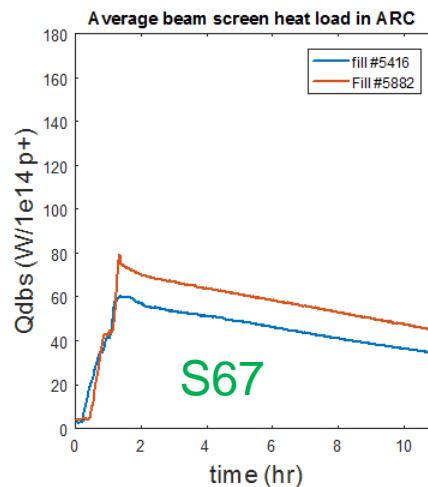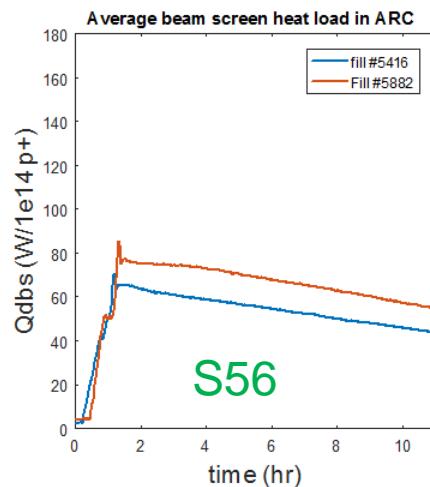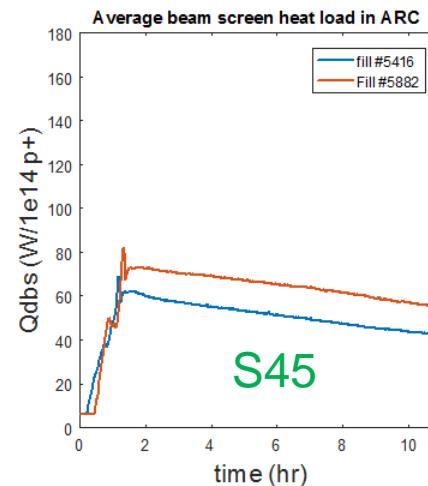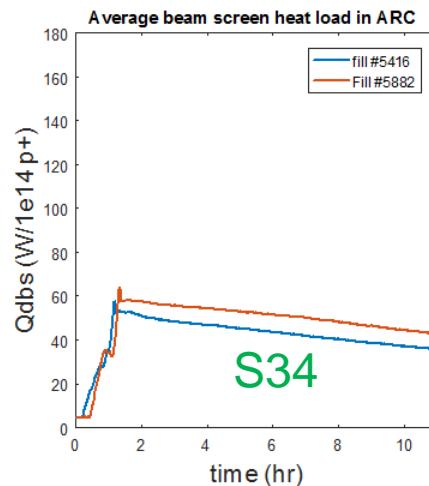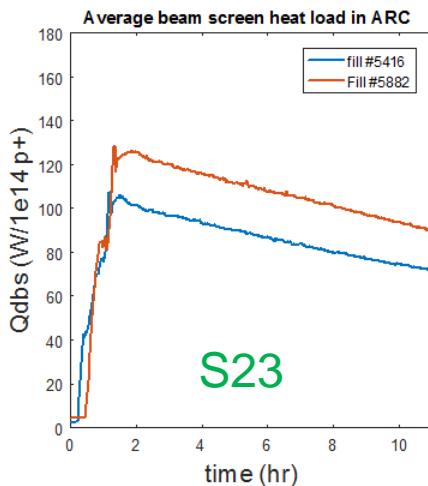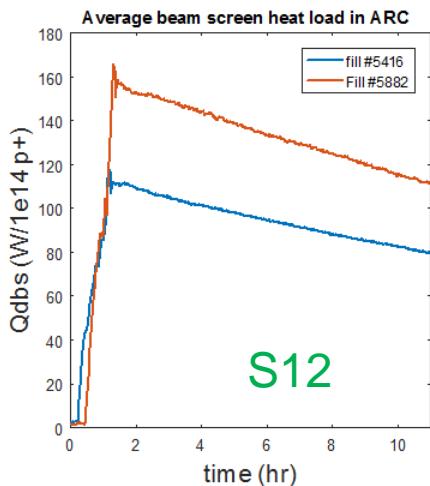
ARC Normalized Heat loads 2016 Vs 2017

- *Fill #5416 = 14th October 2016: 25ns_2220b_2208_1940_2036_96bpi_24inj*
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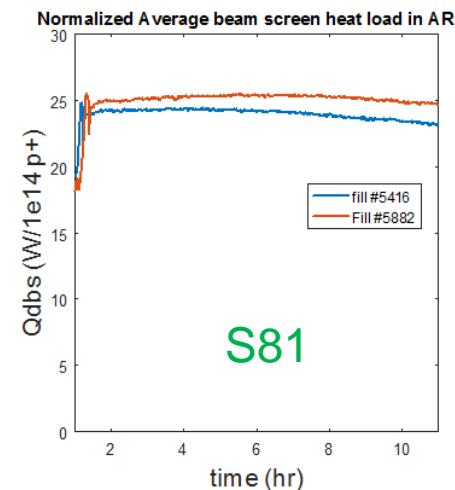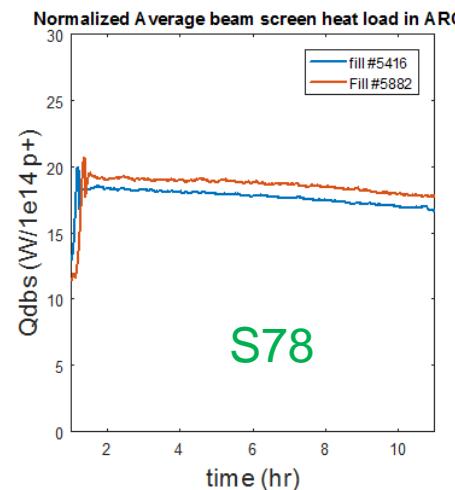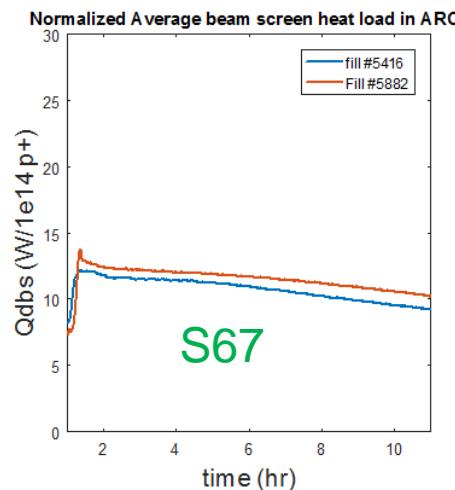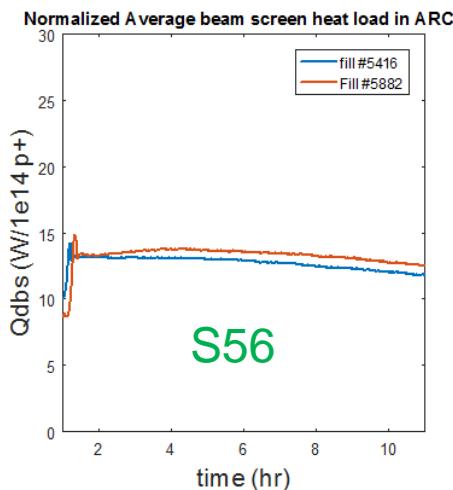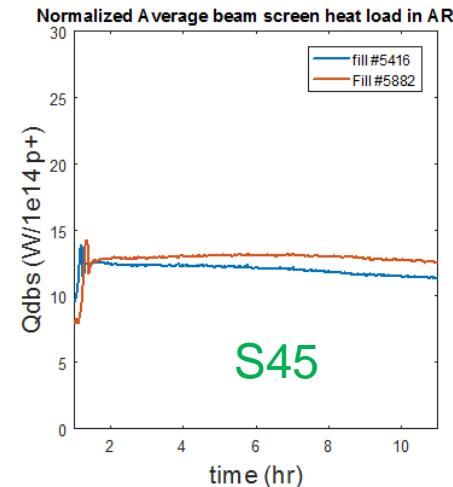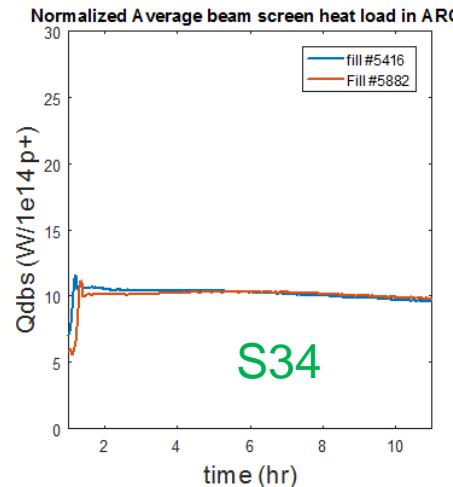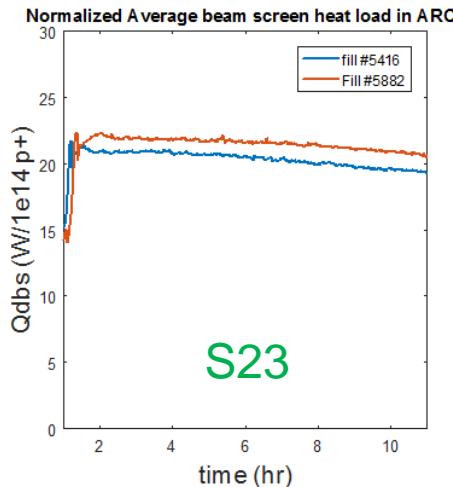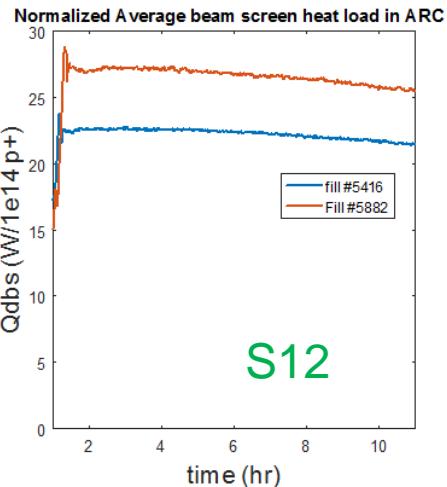
Feed-Forward: Reminder

- Feed-forward action on cryo valves + heaters to anticipate heat loads
- Beam induced heat load calculated from online beam parameters
- 3 tuning parameters are used to compute the e-cloud contribution :
  - **Qeci**: heat load per half-cell per bunch at injection (450 GeV)
  - **Qecr**: heat load per half-cell per bunch after ramp (6.5 TeV)
  - **Nb0**: proton per bunch threshold to activate e-cloud process

$$Q_{dbs} = Q_{sr} + Q_{ic} + Q_{ec}$$

$$Q_{sr} = Q_{srnom} \cdot L \cdot \left(\frac{E}{E_{nom}}\right)^4 \cdot \left(\frac{Nb}{Nb_{nom}}\right) \cdot \left(\frac{nb}{nb_{nom}}\right)$$

$$Q_{ic} = Q_{icnom} \cdot L \cdot \left(\frac{0.6 \cdot E + 2800}{E_{nom}}\right)^{0.5} \cdot \left(\frac{Nb}{Nb_{nom}}\right)^2 \cdot \left(\frac{nb}{nb_{nom}}\right) \cdot \left(\frac{\sigma}{\sigma_{nom}}\right)^p$$

$$Q_{ec} = \left[K_{eci} \cdot \frac{q_{eci}}{2} \cdot \left(1 - \frac{E - E_{inj}}{E_{ramp} - E_{inj}}\right) + K_{ecr} \cdot \frac{q_{ecr}}{2} \cdot \left(\frac{E - E_{inj}}{E_{ramp} - E_{inj}}\right) \right] \cdot n_b \cdot \frac{Nb - Nb_0}{Nb_{nom} - Nb_0}$$

Heat Load observations in ARC

- Evolution of FF parameters
  - Qeci: heat load per half-cell per bunch at injection (450 GeV)
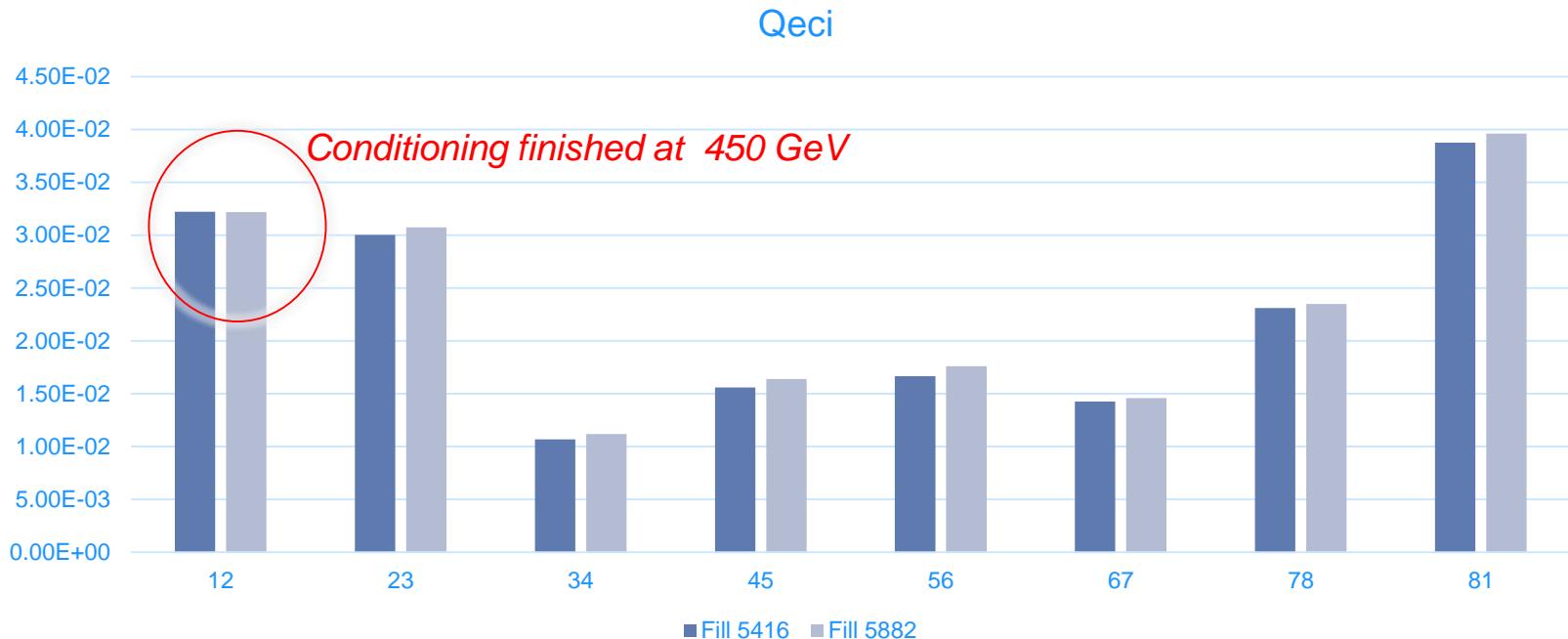
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- *Fill #5882 = 28th June 2017: 25ns_2556b_2544_2215_2332_144bpi_20inj*

Heat Load observations in ARC

- Evolution of FF parameters
  - ➢ Qecr: heat load per half-cell per bunch after ramp (6.5 TeV)
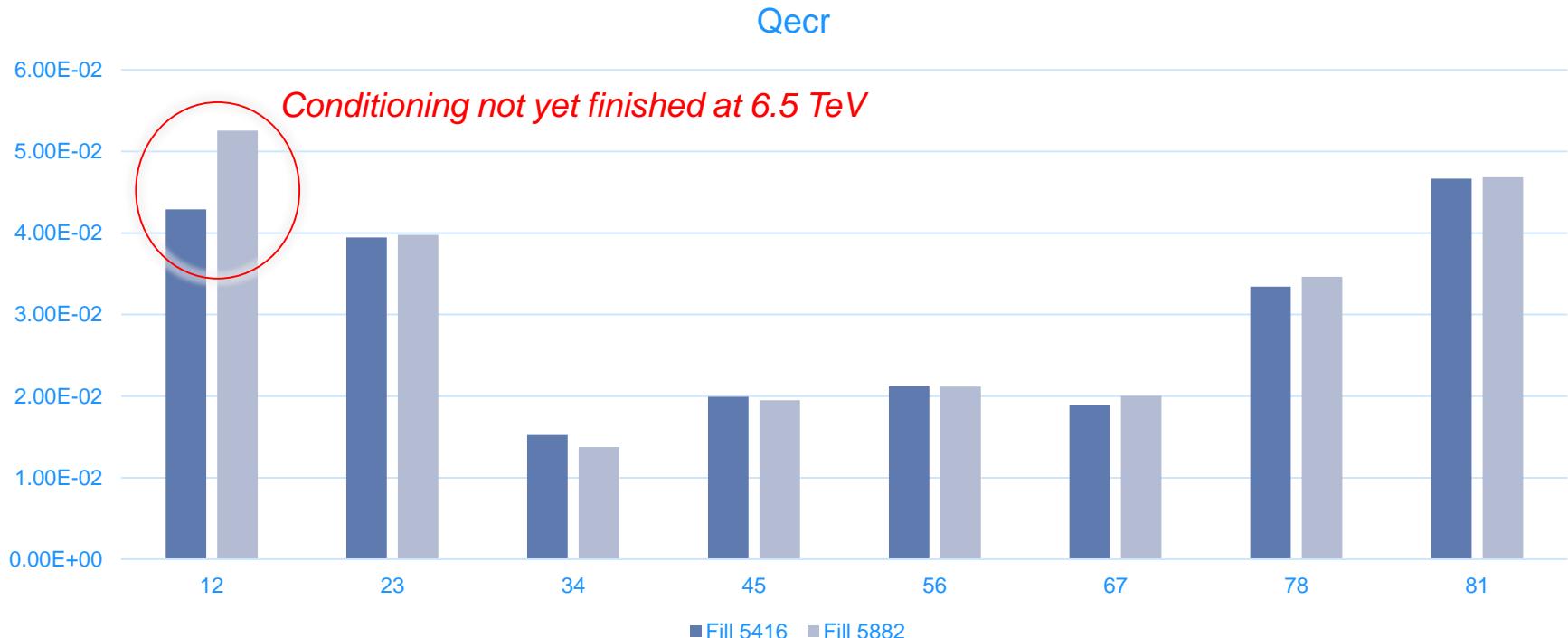
Qecr

Conditioning not yet finished at 6.5 TeV

Legend: ■ Fill 5416 ■ Fill 5882

- *Fill #5416 = 14th October 2016: 25ns_2220b_2208_1940_2036_96bpi_24inj*
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Heat Load observations in ARC

- Evolution of FF parameters
  - Nb0: proton per bunch threshold to activate e-cloud process

*E-cloud threshold slightly lower after EYETS in high load sectors (12,23,78,81)*
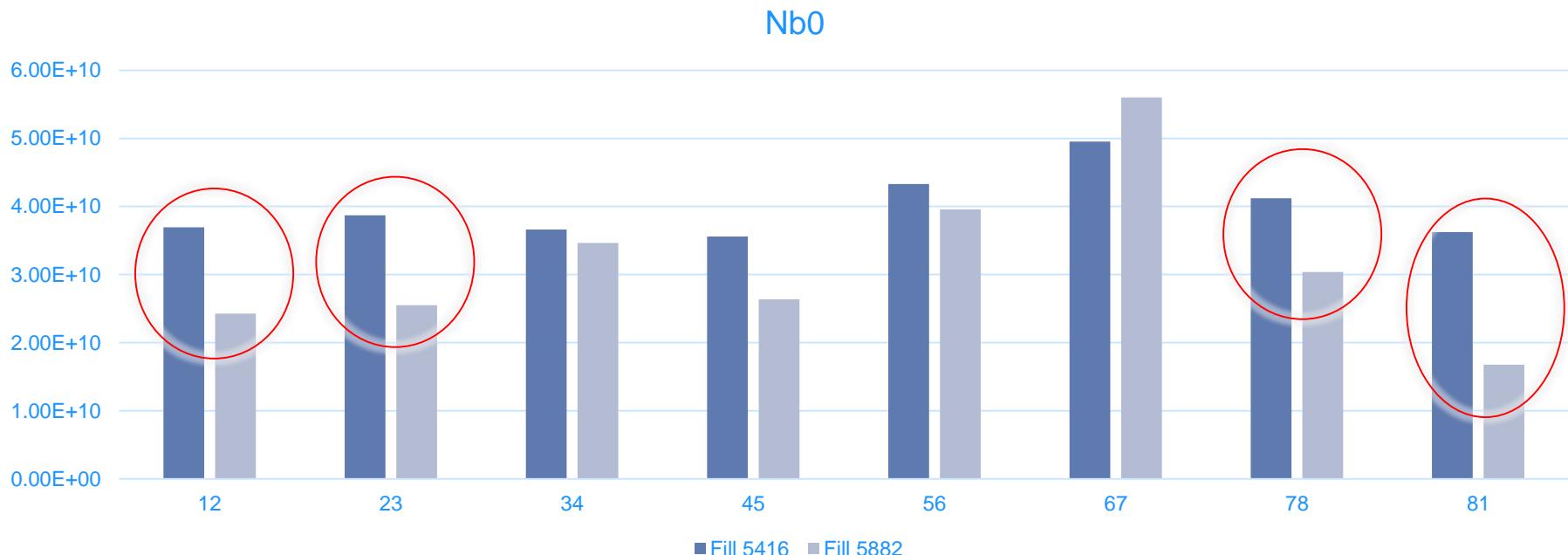
Nb0

- *Fill #5416 = 14th October 2016: 25ns_2220b_2208_1940_2036_96bpi_24inj*
- *Fill #5882 = 28th June 2017: 25ns_2556b_2544_2215_2332_144bpi_20inj*

E-cloud threshold in ARC12

Qec = Qdbs (meas) - Qsr (theo) – Qic (theo)
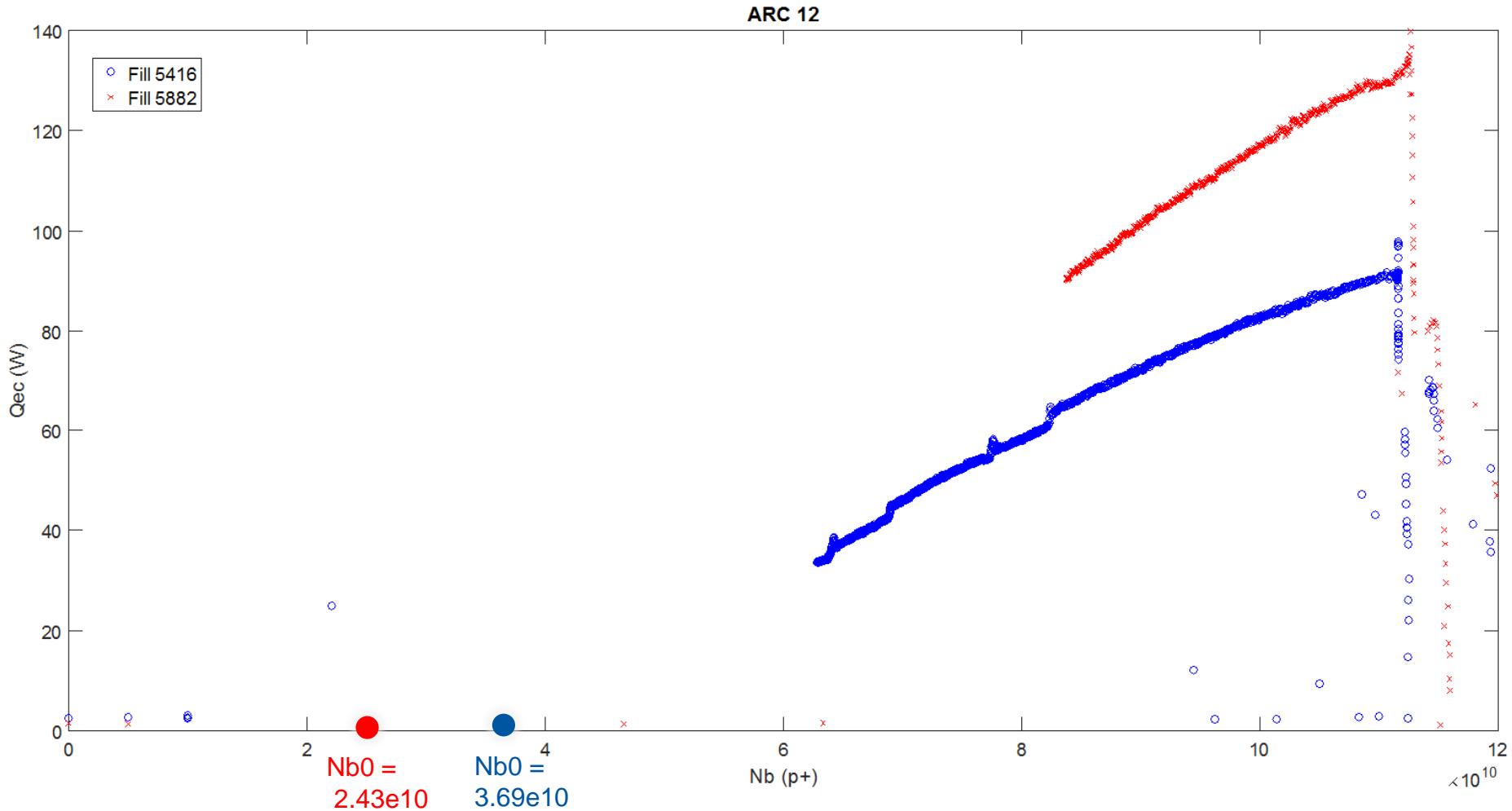
E-cloud threshold in ARC81

$Qec = Qdbs (meas) - Qsr (theo) - Qic (theo)$

ARC 81

Nb0 =
1.68e10

Nb0 =
3.63e10
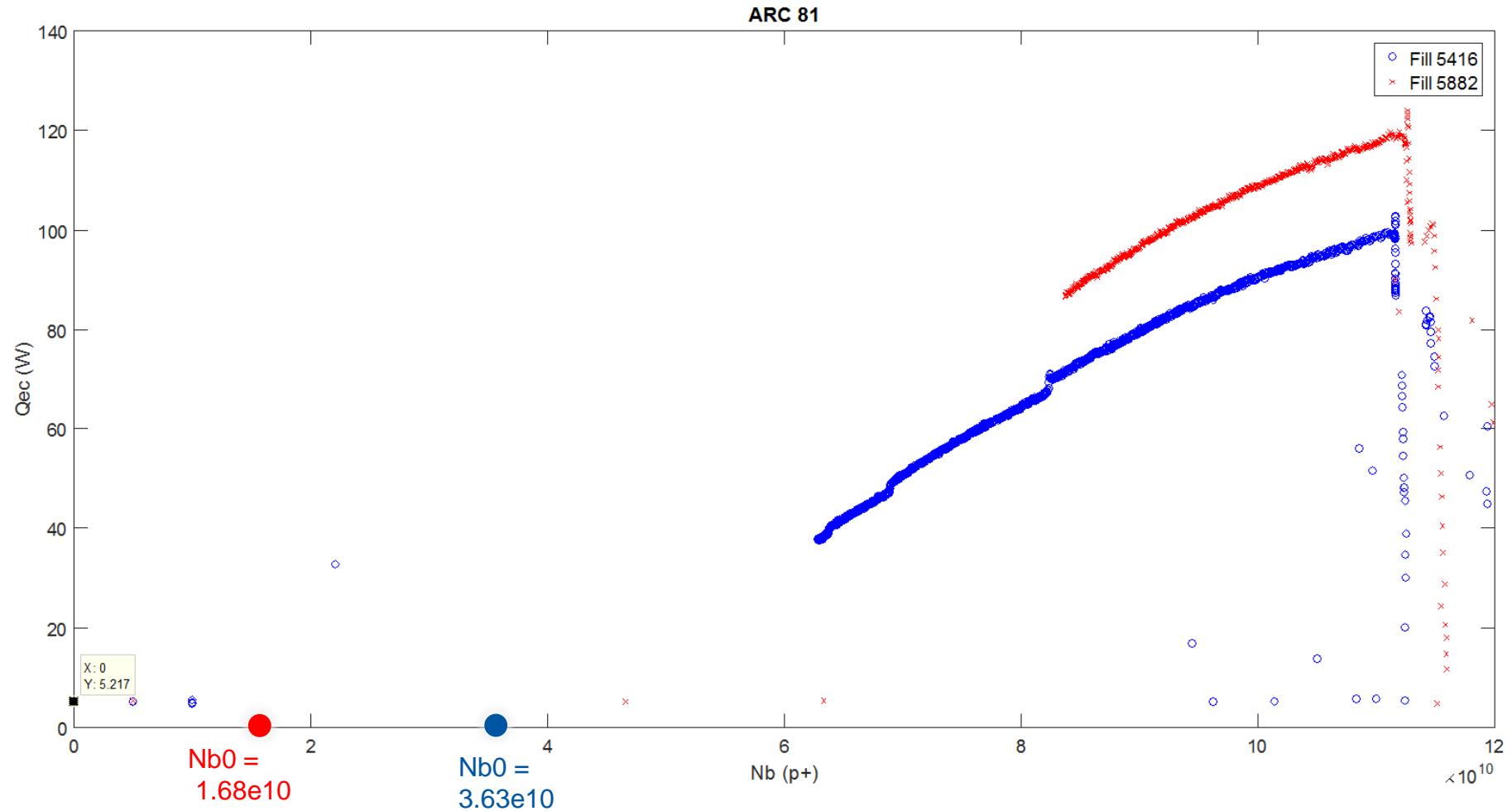
Instrumented cells

- 3 cells in S45 since LS1

- 1 cell in S12 since EYETS 2016

- Total = 4 quadrupoles and 12 dipoles

- Before EYETS 2016:
  - 34R4: one sensor not working (QBBI_A34L5_TT826)
  - 34R4: suspicious sensor (QBBI_A34L5_TT824) ➔ Error on 2 dipoles
  - 13L5: sensor calibration issues ➔ Errors on 1 quadrupole

- After EYETS 2016
  - All sensors have been re-calibrated
  - 34R4: Previous issues solved except QBBI_A34L5_TT824 still suspicious
  - 13L5: One sensor not working (QBBI_B13L5_TT824)
  - ➔ all magnet heat loads can be correctly calculated in 2017

Instrumented cells in S45

➔ very good temperature matching between B1/B2 between 6 K/30 K : no sensor deviation

Instrumented Quadrupoles
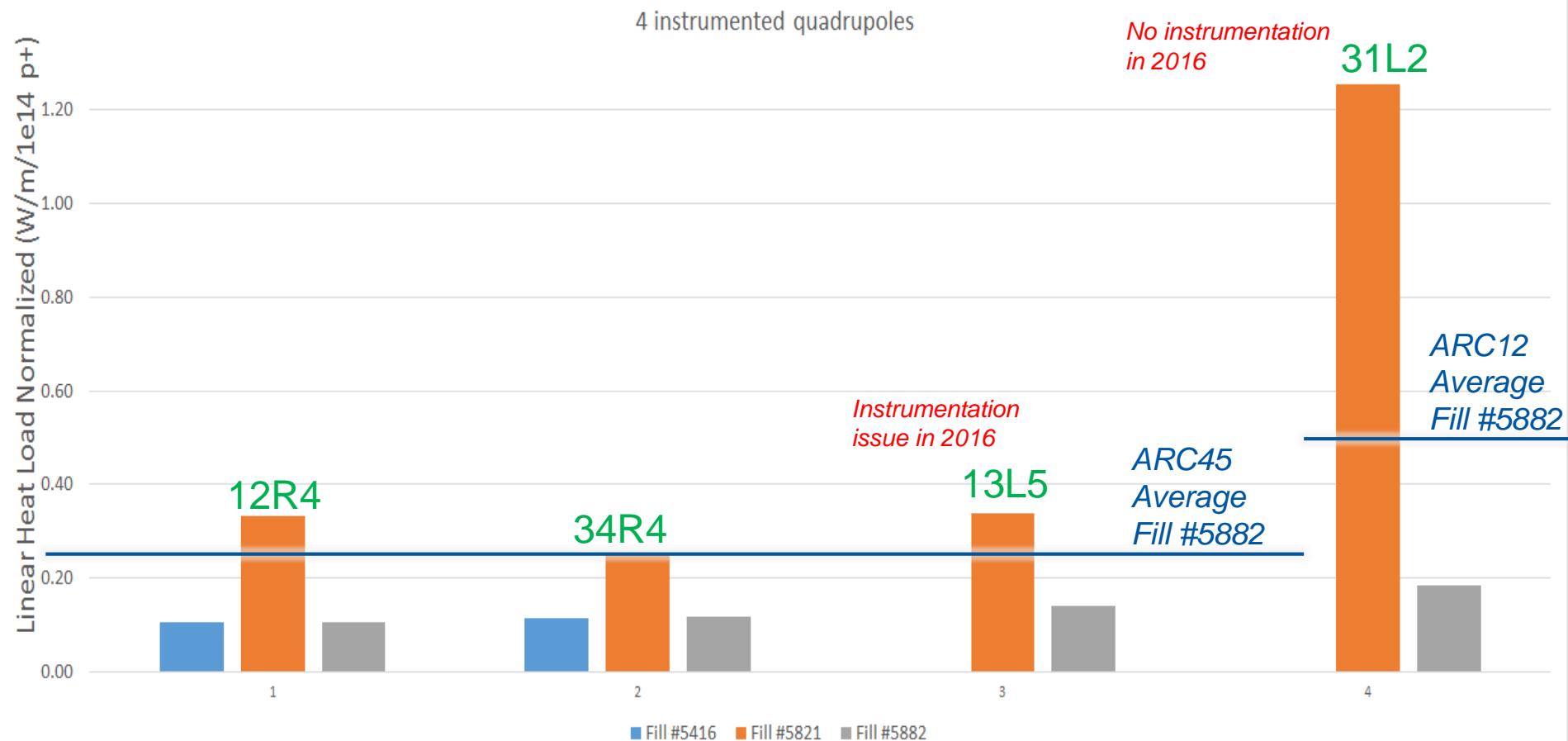
4 instrumented quadrupoles

- *Fill #5416 @ 6.5 TeV   (14th October 2016) 25ns_2220b_2208_1940_2036_96bpi_24inj*
- *Fill #5821 @ 450 GeV   (12th June 2017)   25ns_2820b_288bpi_scrub2017*
- *Fill #5882 @ 6.5 TeV   (28th June 2017)   25ns_2556b_2544_2215_2332_144bpi_20inj*

Instrumented Dipoles
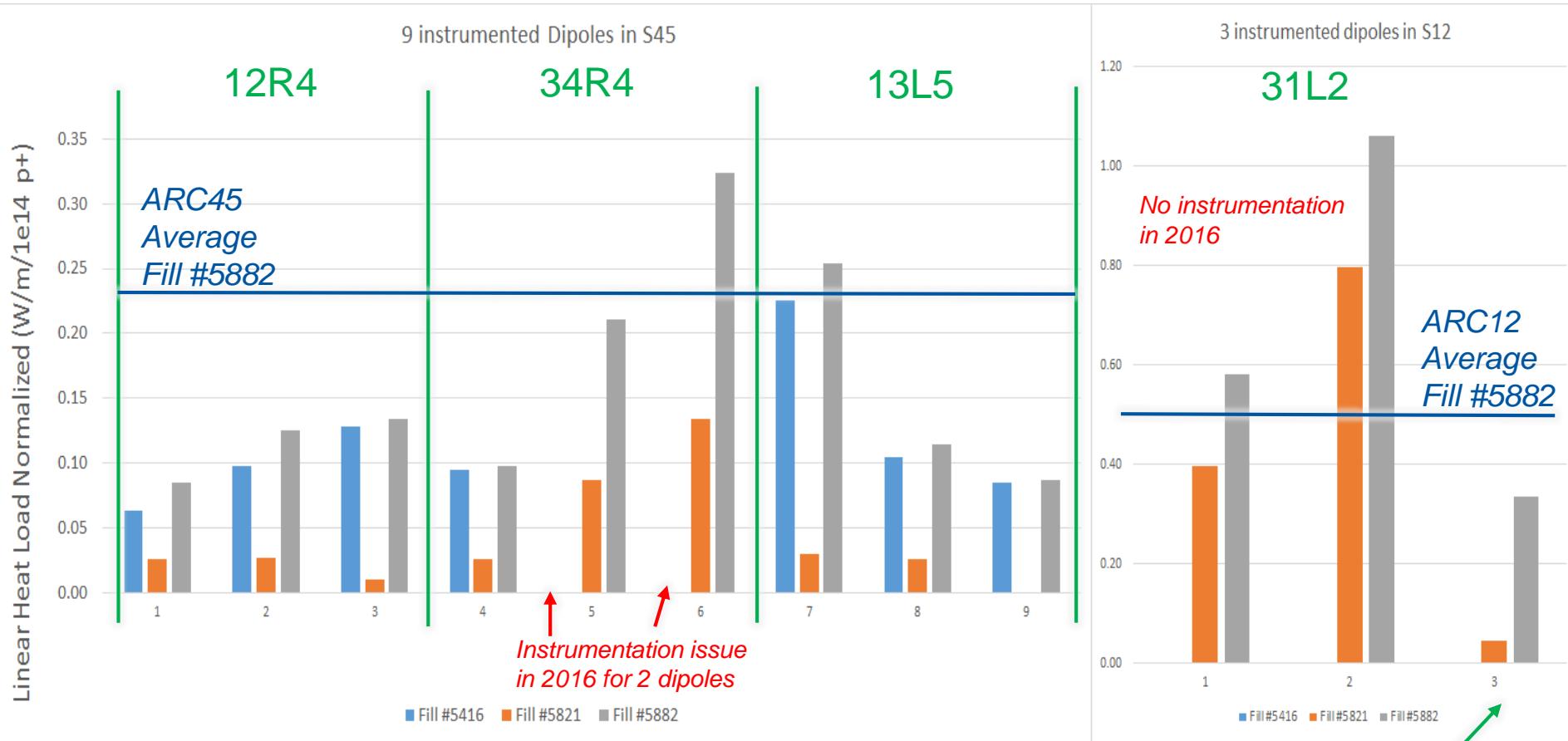
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- *Fill #5882 @ 6.5 TeV (28th June 2017) 25ns_2556b_2544_2215_2332_144bpi_20inj*

Conclusion

- **Heat loads in ARC**
  - 2017 similar to 2016
  - S12 conditioning done @ 450 GeV, not yet @ 6.5 TeV

- **FF parameters**
  - 2017 similar to 2016 except for e-cloud threshold (small impact)

- **Instrumented cells**
  - Quadrupoles
    - "heating" at injection (450 GeV)
    - Small dispersion of quadrupole heat loads at 6.5 TeV (but only 4 quad)

  - Dipoles
    - "heating" after the ramp (6.5 TeV)
    - Important dispersion of dipoles at 6.5 TeV (on 12 dipoles)

  - Replaced Dipole in 31L2 shows lower heat loads than the rest of S12