Beam induced heat load measured during Run2 in LSS

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Summary

- Introduction
- LSS BS heat load measurements method
- LSS BS heat load measurements in Run 2
- a-C coating in LSS : Cryo priorities

Introduction

- Cryogenic cooling power is limited for beam screens
  - Locally in each loop (hydraulic limitation ➔ ~120W/SAM)
  - On the global cryoplants (cooling power limitation ➔ ~10kW/sector)

- Beam Screen heat loads applied on the existing refrigerators will evolve for HL-LHC
  - Some magnets in LSS1&5 will be removed ☺
  - BS heat loads will increase in ARC and LSS from Run 3 ☹
    due to the intensity/energy increase (sync. rad + image current + e-cloud)

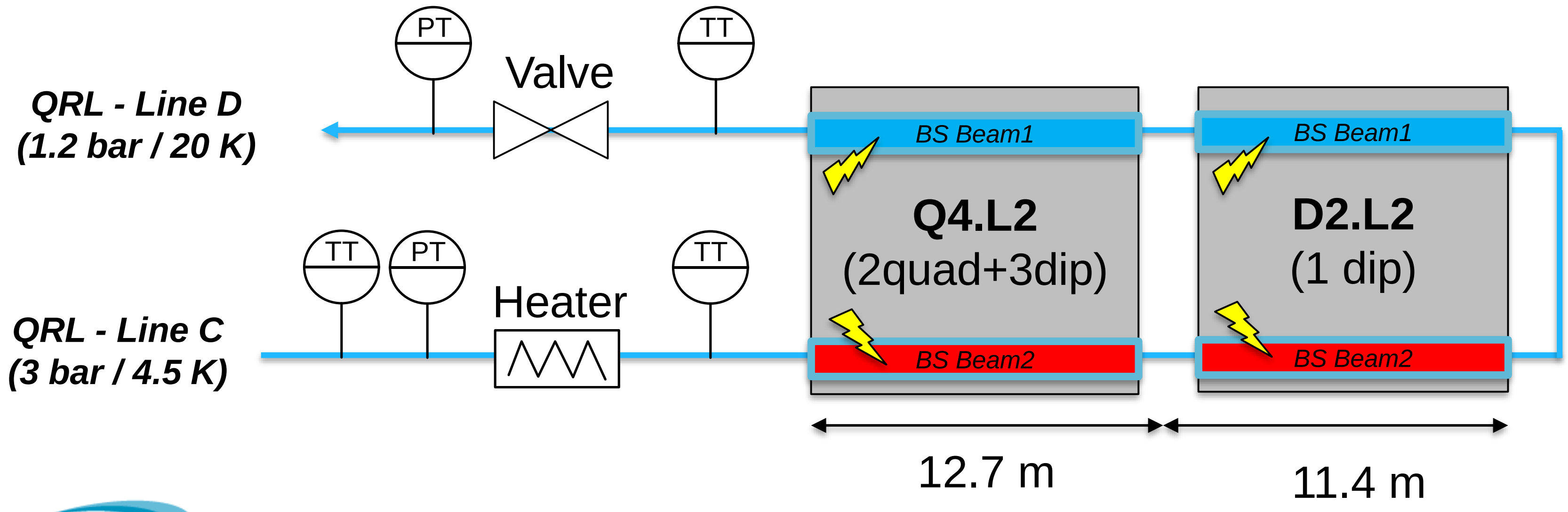
- One possible mitigation is the a-C coating in some LSS magnets to supress the e-cloud component

- Superconducting magnets concerned in LSS:
  - Inner Triplets (+D1)
  - SAM: D2,D3,Q4,Q5,Q6

LSS BS heat load measurement method

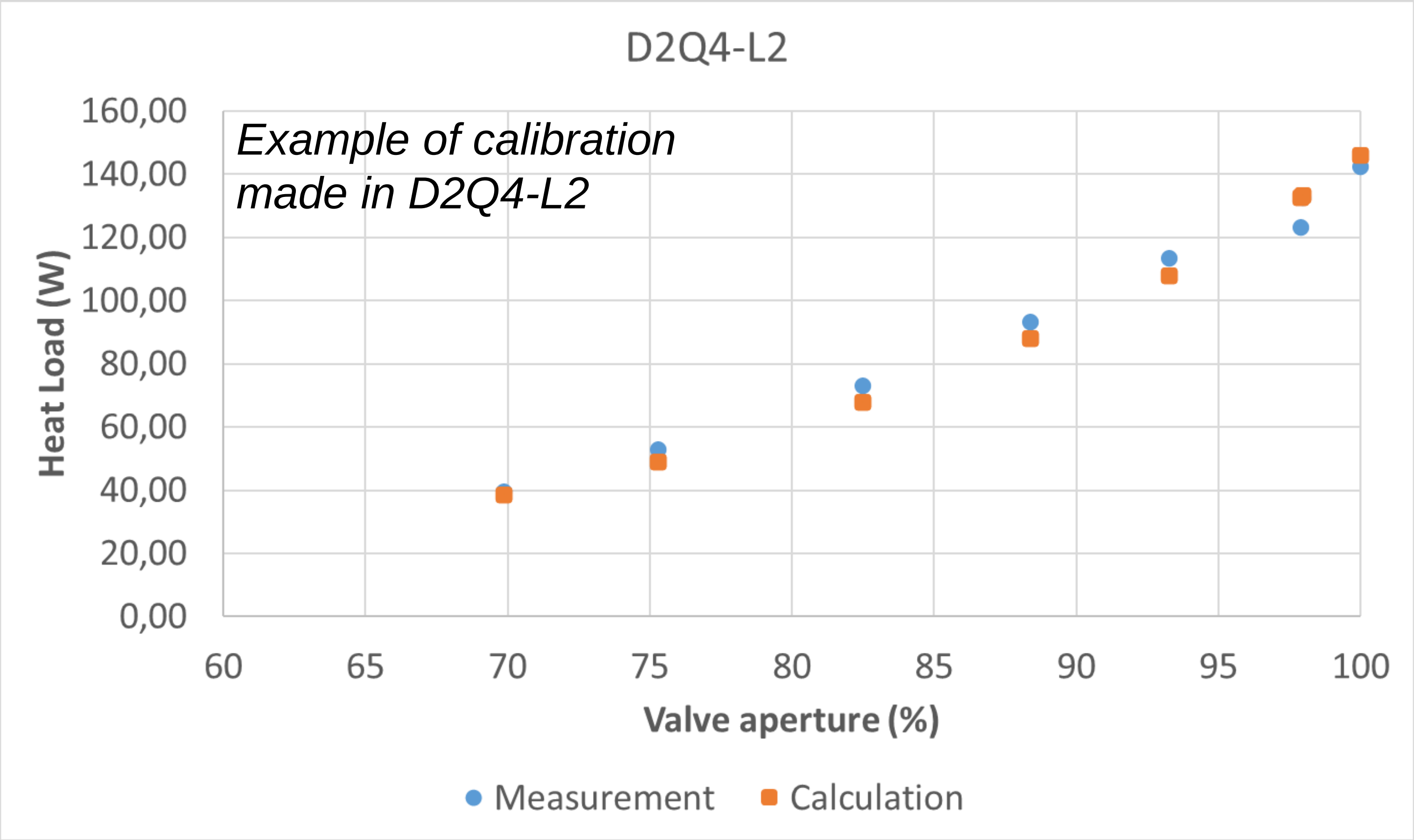
- BS Heat loads are measured over a cryo cooling loop
  - A cryo cooling loop embeds several magnets
  - It passes though one aperture and then by the other (for SAM)
  - Use the valve aperture, the ΔP and the ΔT over the loop to deduce the corresponding heat load

- Example of one SAM cooling loop (*D2Q4-L2*) :



Calibration of measurements

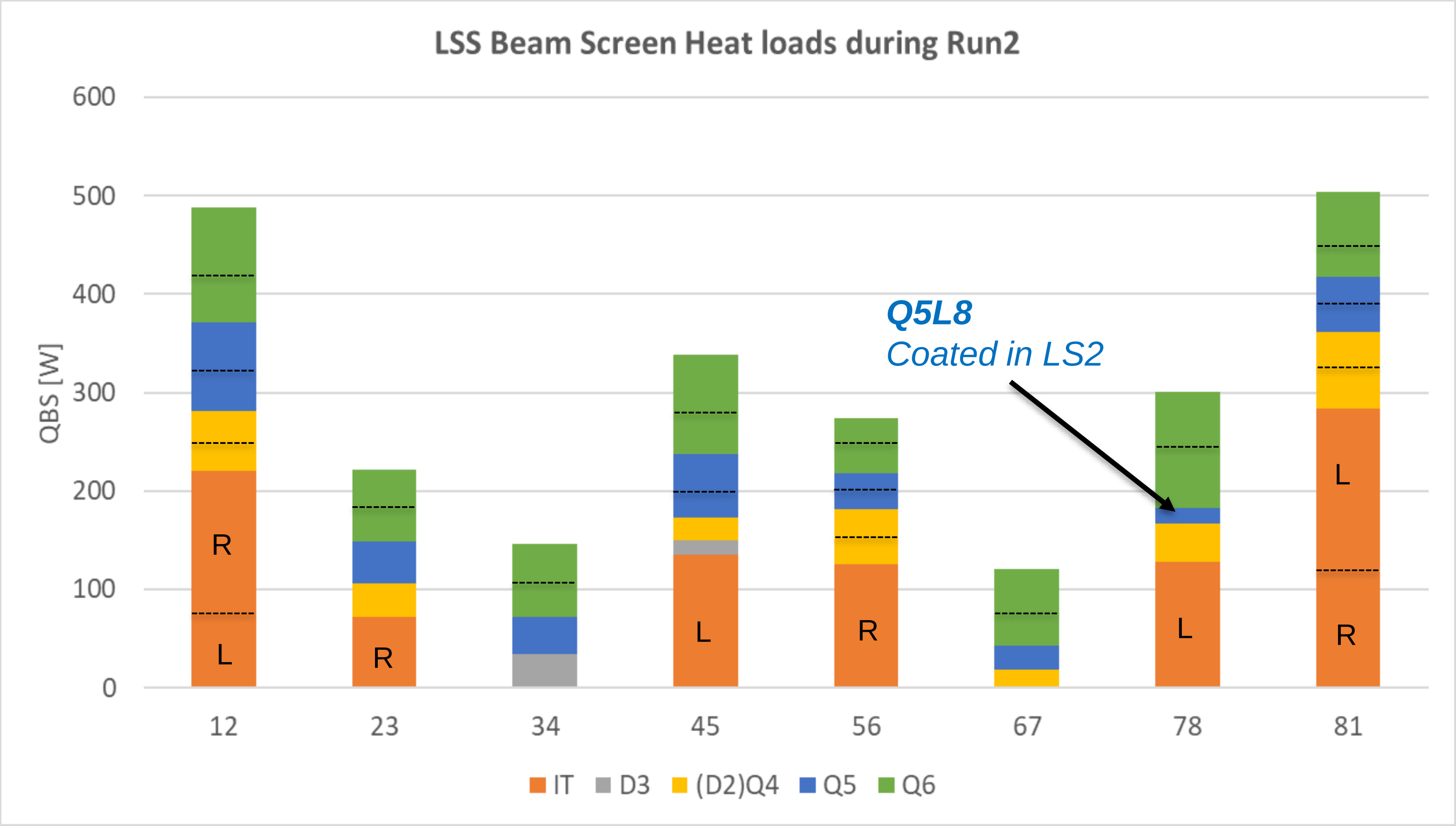
- One parameter was not well known (valve rangeability) to estimate the heat loads precisely
- In YETS 2017/2018, a calibration campaign was done to estimate this parameter precisely
- Following this calibration, an error <15% is assumed on the heat load calculations



LSS heat load measurements in Run 2

- Heat loads computed from fill #6675 (May 2018)
  - Inj. scheme: 25ns_2556b_2544_2215_2332_144bpi_20injV2 @ 6.5 TeV

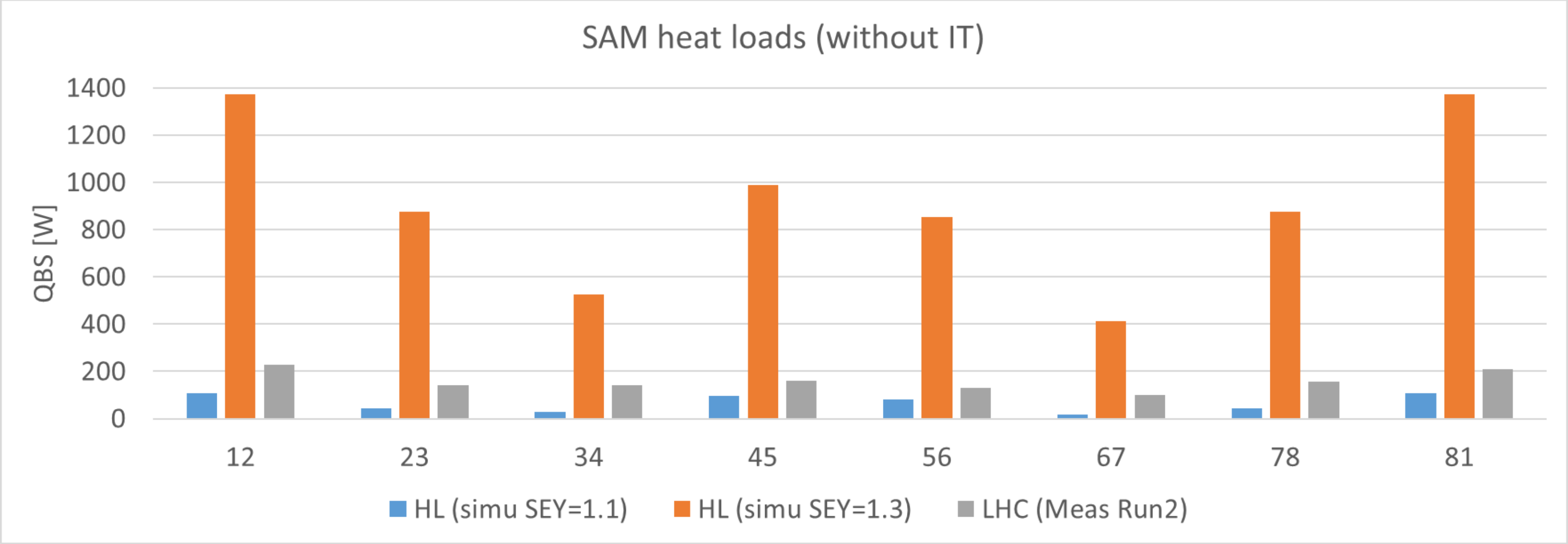
- Reminder: BS heat load in a sector is between 4 kW and 8 kW
  - LSS heat loads represent less than 10% of total beam screen heat load in a sector during Run2



SAM heat load estimation for HL-LHC

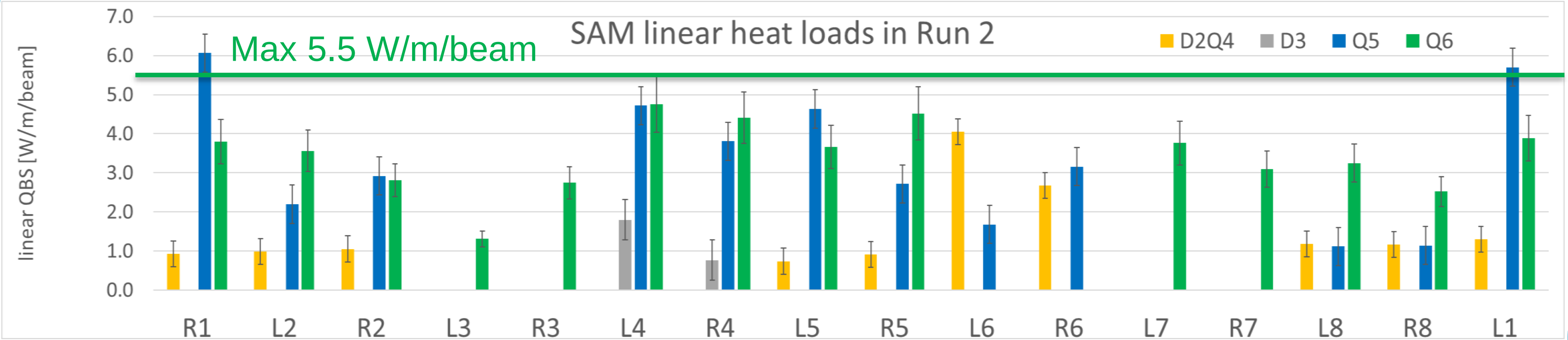
- **Very complicated to estimate the SAM heat loads for HL-LHC era**
  - Several magnets over a cooling loop
  - Large zoo of magnets/chambers
  - Large spread of SEY in each magnet/aperture can be imagined
  - SEY dependency is very different between quad, dip and drift (and non-linear)
  - Between SEY = 1.1 and 1.3, a factor 25 on heat loads is observed on simulations !

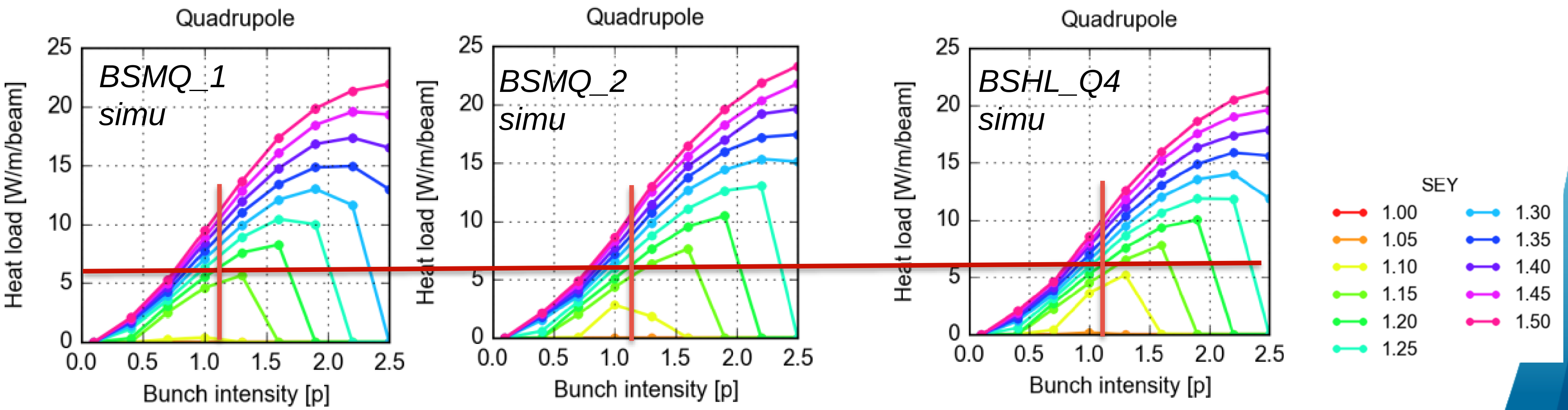
See CERN-ACC-2016-0112 *Beam induced heat loads on the beam-screens of the twin-bore magnets in the IRs of the HL-LHC.*



What we can learn from Run 2 ?

- Make some hypothesis / simplifications (worst case)
  - All heat loads are coming from e-cloud (sync. rad. + impedance neglected)
  - All the e-cloud are coming from the quad in Q4/Q5/Q6 and from the dip in D2&D3
- Estimate the average SEY from heat loads observed in Run 2
  - It seems that we have SEY < 1.2 in all SAM (even <1.15 for many of them)
- Replay e-cloud simulations with SEY=1.15 &1.2 to refine heat loads for HL-LHC





Cryo Priorities for a-C coatings

- **a-C coating is interesting for cryo**:
  - If the refrigeration capacity margin of the sector is limited
    (like in S23&S78)
  - If the beam screen heat loads are significant in a specific SAM
    (SAM valve apertures were doubled during LS2 to allow a max extraction of ~120 W)

- **Cryo priorities for LS3**:
  1. All new magnets around IP1&5: current baseline
  2. All IT around IP2&8: current baseline
  3. SAM in LSS 23 & 78 (weak sectors)
     - D2Q4R2 + D2Q4L8 + Q5R2 + Q6R2 + Q6L3 + Q6R7+ Q6L8 (Q5L8 already done)
  4. SAM with significant heat loads approaching the 120W in HL-LHC
     - To be checked with simulations at SEY=1.15 & 1.2

Conclusion

- LSS heat loads have been assessed during Run 2
  - SEY in SAM seems < 1.15 or < 1.2

- LSS heat loads estimations for HL-LHC should be re-assessed with appropriate SEY

- BS heat loads in SAM will be confirmed (or not) during Run3
  - Refinement of observed SEY at higher intensities
  - Final validation of needed coating during LS3

SAM heat loads during Run2 at a glance