Analysis of LHC arc heat loads

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Recap from 2016-17

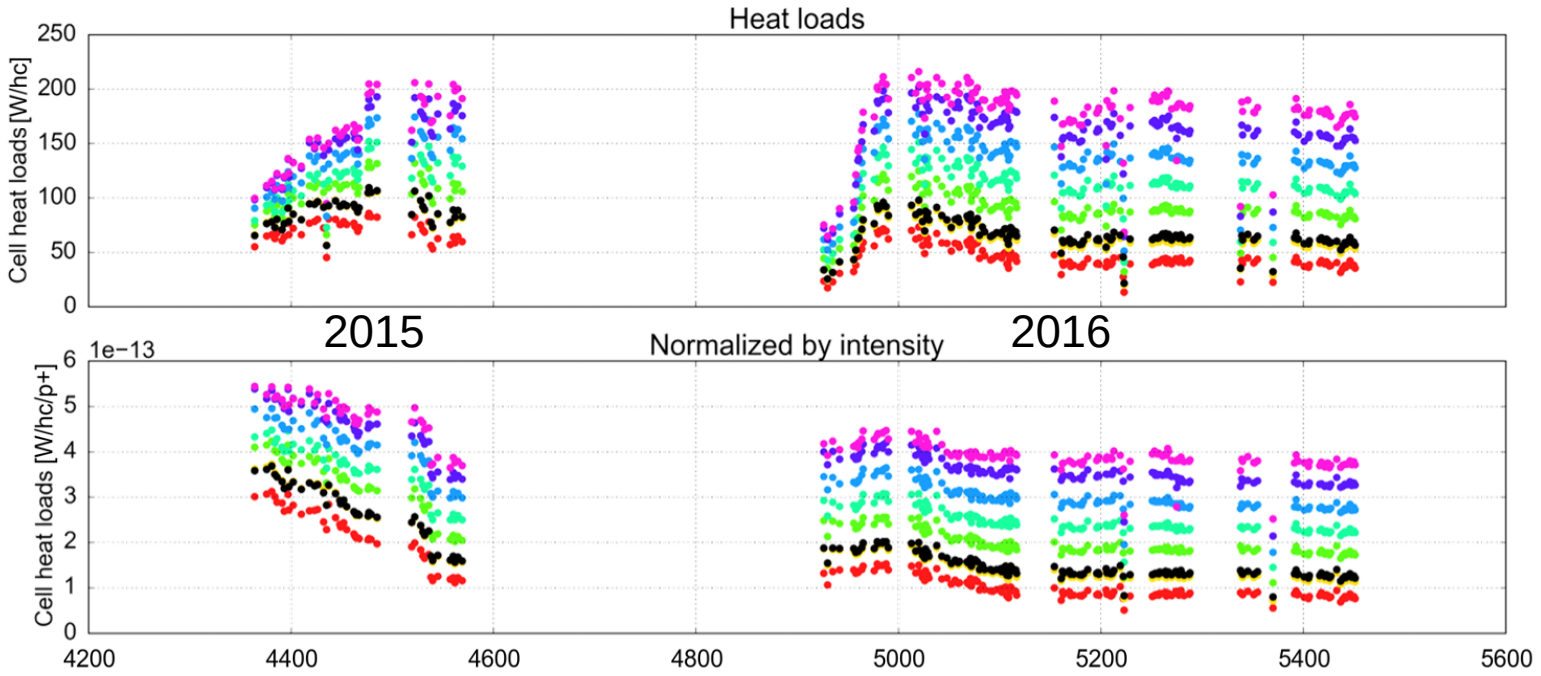
Recap from 2015-16

- During operation with 25 ns beams in Run 2 large beam-induced heat loads are measured on the arc beam screens
- Even after conditioning accumulated in the 2016-17 runs, the heat loads on the different arcs are largely uneven (up to a factor of three)
  - This is unexpected as the eight LHC arcs are on paper identical
- When normalizing heat loads to intensity we find out that the curves are strongly correlated and they practically differ only for a constant offset

Data are post processed to use the same calibration for all fills (in collaboration wit TE-CRG)

Recap from 2015-16

- A similar behavior is observed also at a cell-by-cell level: normalized heat loads differ only by a constant offset (scrubbing curves never cross!)
- Different cells are actually conditioning very similarly, but there seems to be an extra source of heat load, which is different from cell to cell, scales linearly with intensity and does not condition at all



Each color corresponds to **cells with similar heat** loads (within ~15 W)

- 73 cells
- 149 cells
- 70 cells
- 48 cells
- 28 cells
- 21 cells
- 7 cells
- Average

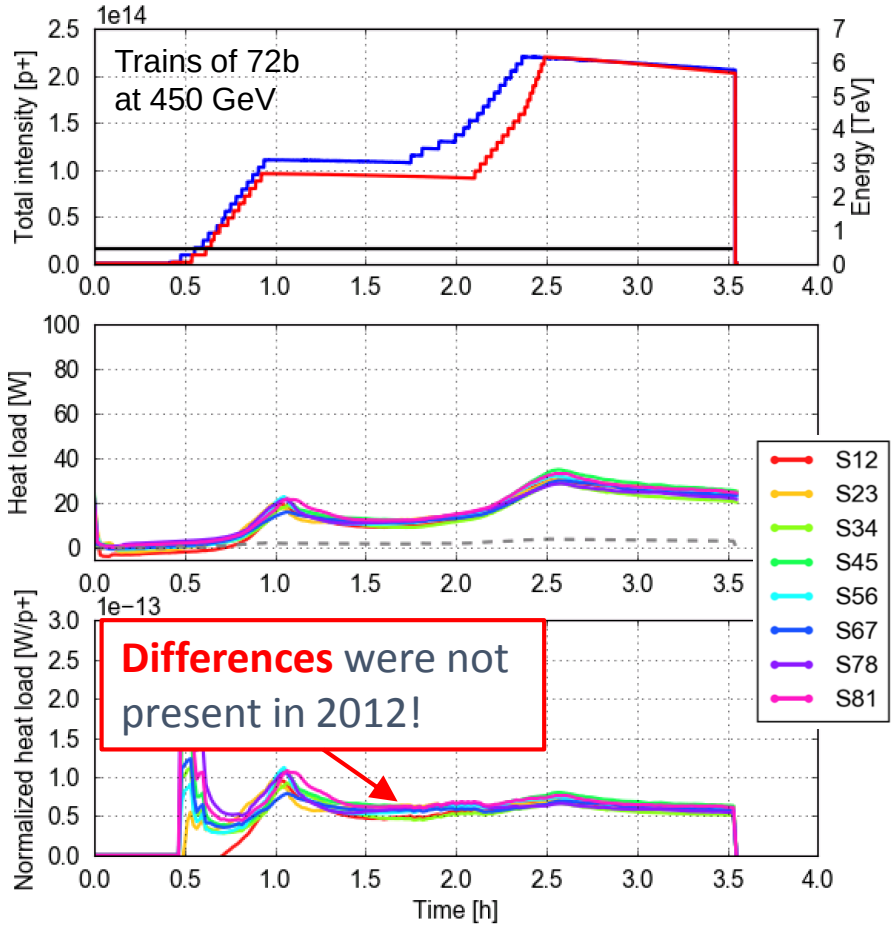
Data are post processed to use the same calibration for all fills (in collaboration wit TE-CRG)

Situation in Run 1

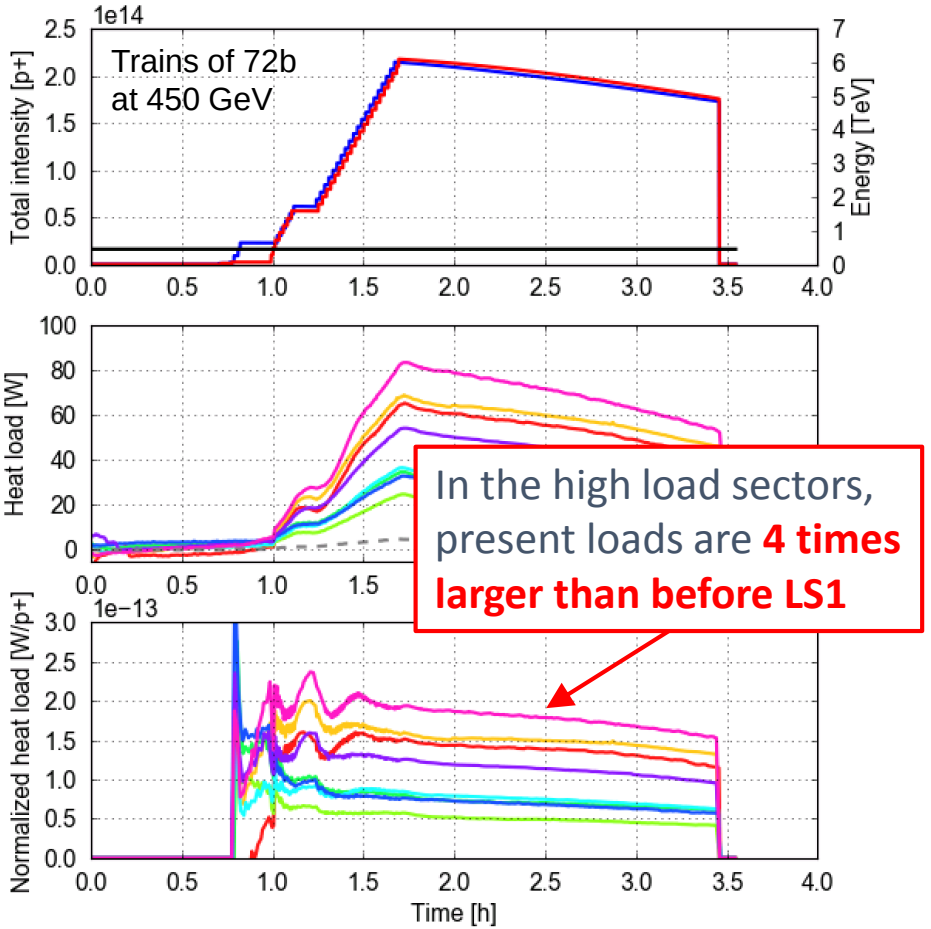
Was the difference always there? – situation before LS1

- A one-week test period with 25 beams took place in 2012
- In collaboration with TE-CRG we used the raw data recorded at that time to reconstruct the cell-cy-cell heat load, that can be directly compared with Run 2 data

2012 (after 3 d of scrubbing at 450 GeV)



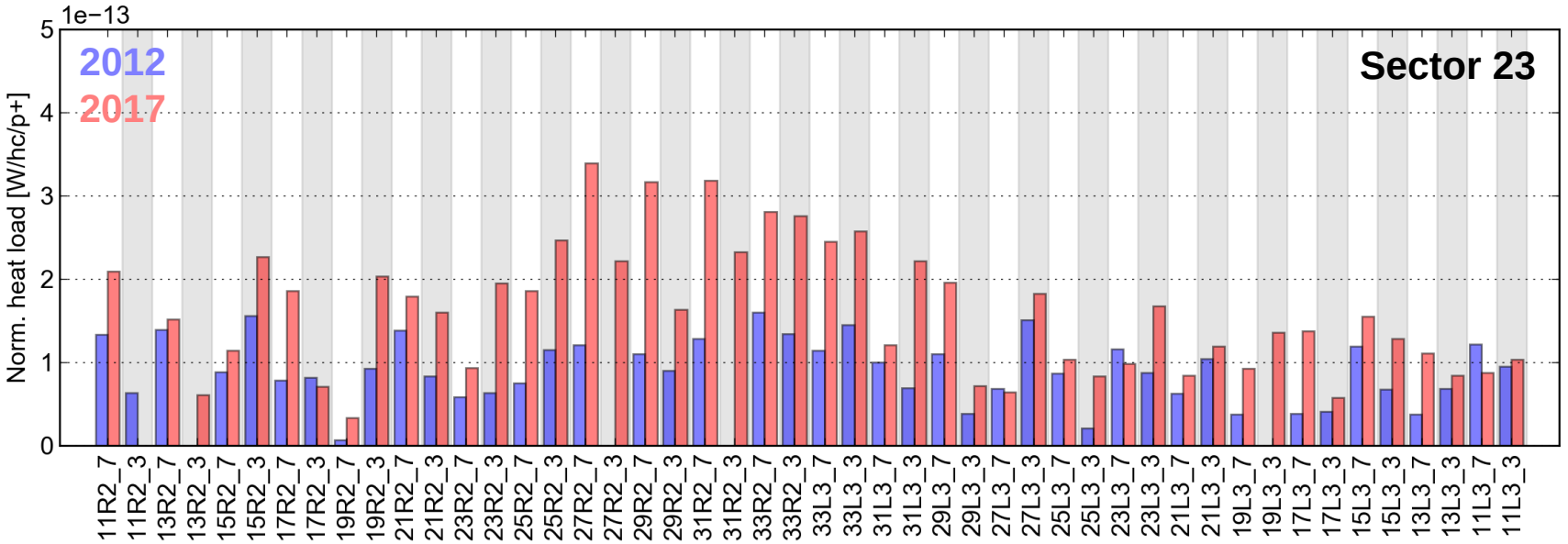
2017 (after 7 d of scrubbing at 450 GeV)

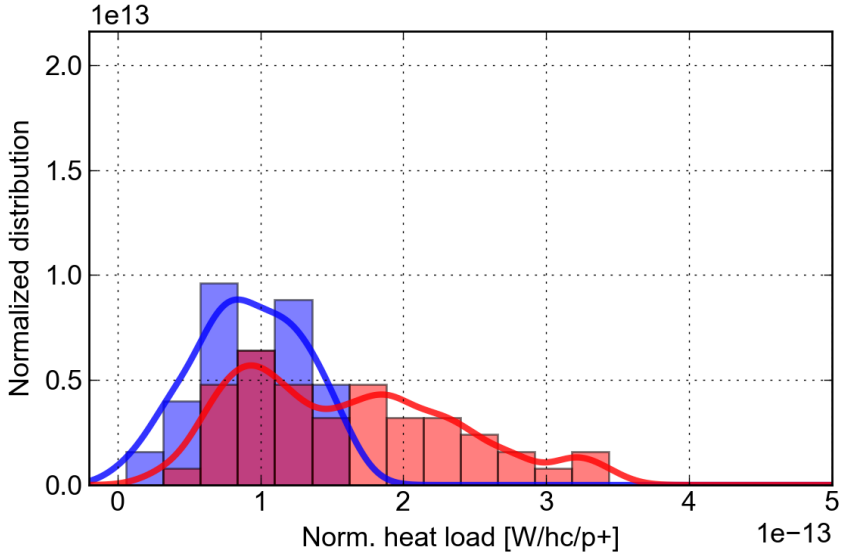


More information on 2012 vs Run 2 comparisons can be found here

Was the difference always there? – situation before LS1

- In a high load sector, a large increase (up to a factor of 3) is observed on many of the cells

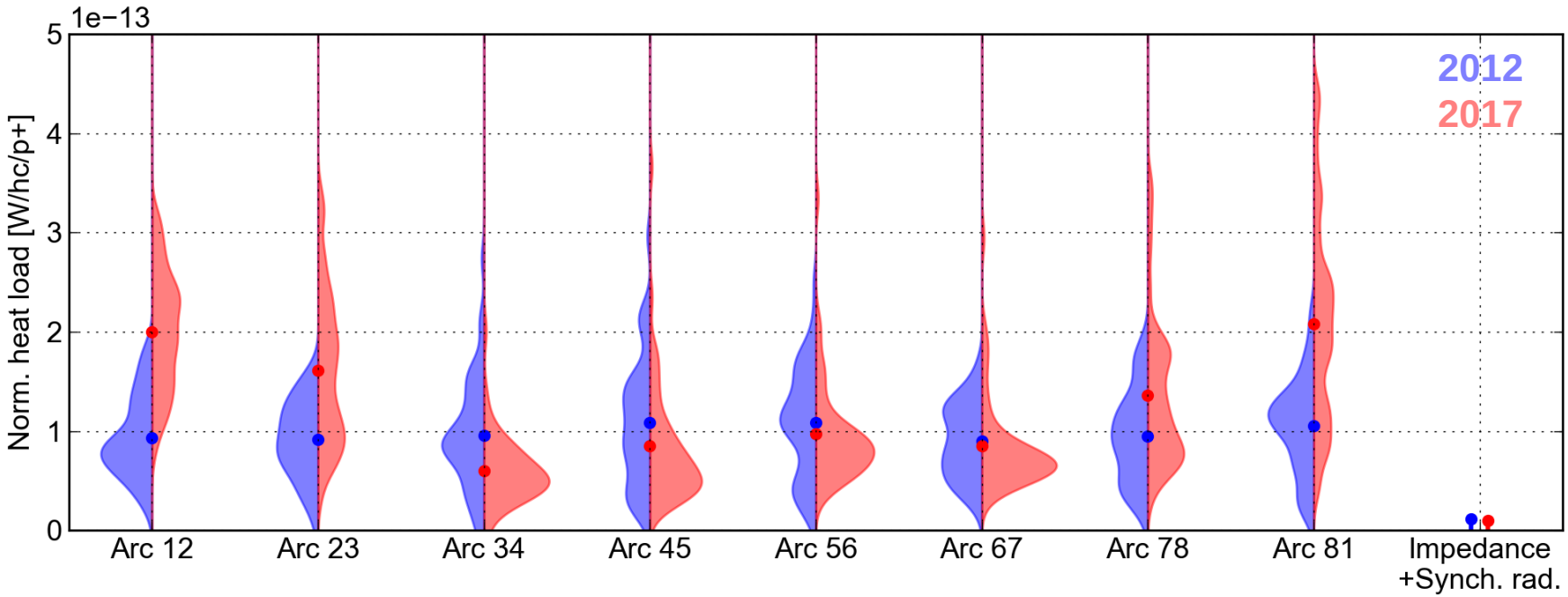




Fill	3439	5808
Started on	15 Dec 2012 08:53	11 Jun 2017 07:18
T_sample [h]	1.00	1.20
Energy [GeV]	450	450
N_bunches (B1/B2)	1164/1164	2820/2820
Intensity (B1/B2) [p]	1.27e14/1.27e14	2.86e14/2.93e14
Bun.len. (B1/B2) [ns]	1.26/1.23	1.18/1.26
H.L. S23 (avg) [W]	23.23	93.45
H.L. S23 (std) [W]	9.55	44.17
H.L. exp. imped. [W]	2.84	5.94
H.L. exp. synrad [W]	0.00	0.00
T_nobeam [h]	0.40	0.40

Has it always been there? – Situation before LS1

- Full overview with arc-by-arc averages and distributions

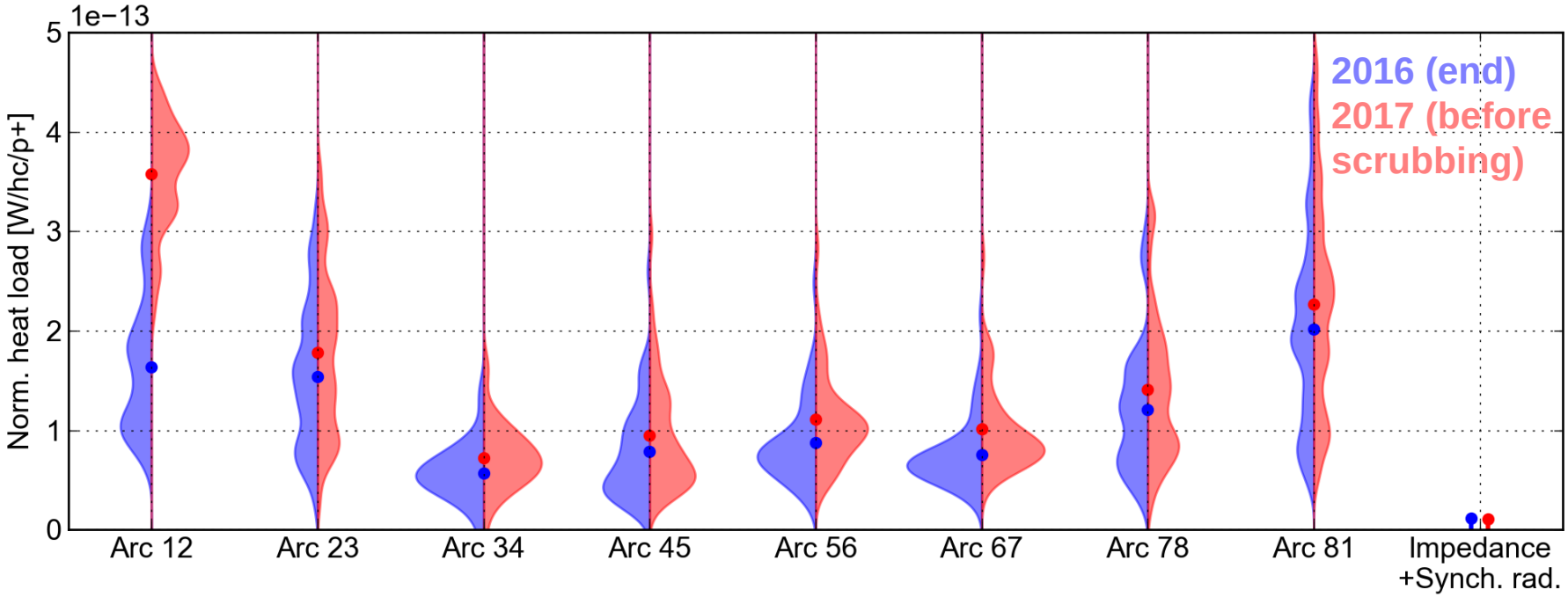


More information on 2012 vs Run 2 comparisons can be found here

Heat loads during the 2017 Scrubbing Run

Effect of the 2016-17 EYETS

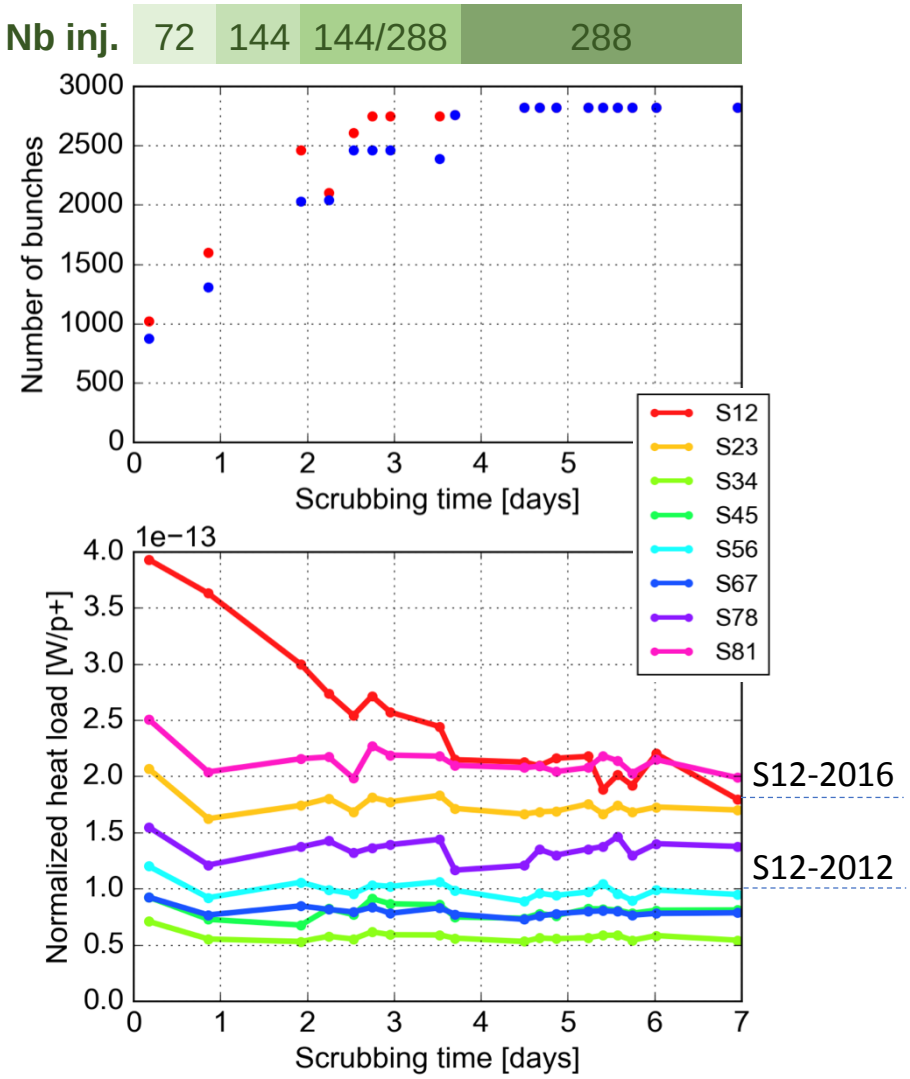
- Full overview with arc-by-arc averages and distributions



- Large deconditioning observed in S12 (warmed up and vented during EYETS)
- Very limited deconditioning observed in the other arcs

Arc heat loads during the 2017 scrubbing run

- The data at the selected samples is used to have an **indication of the heat load evolution** during the scrubbing run



Main observations:

Sectors which stayed cold during the EYETS:

- Conditioning observed only **over the first 24h** (recovery of the deconditioning from the EYETS)
- **Difference between sectors** very similar to end-2016 and un-affected by the scrubbing run

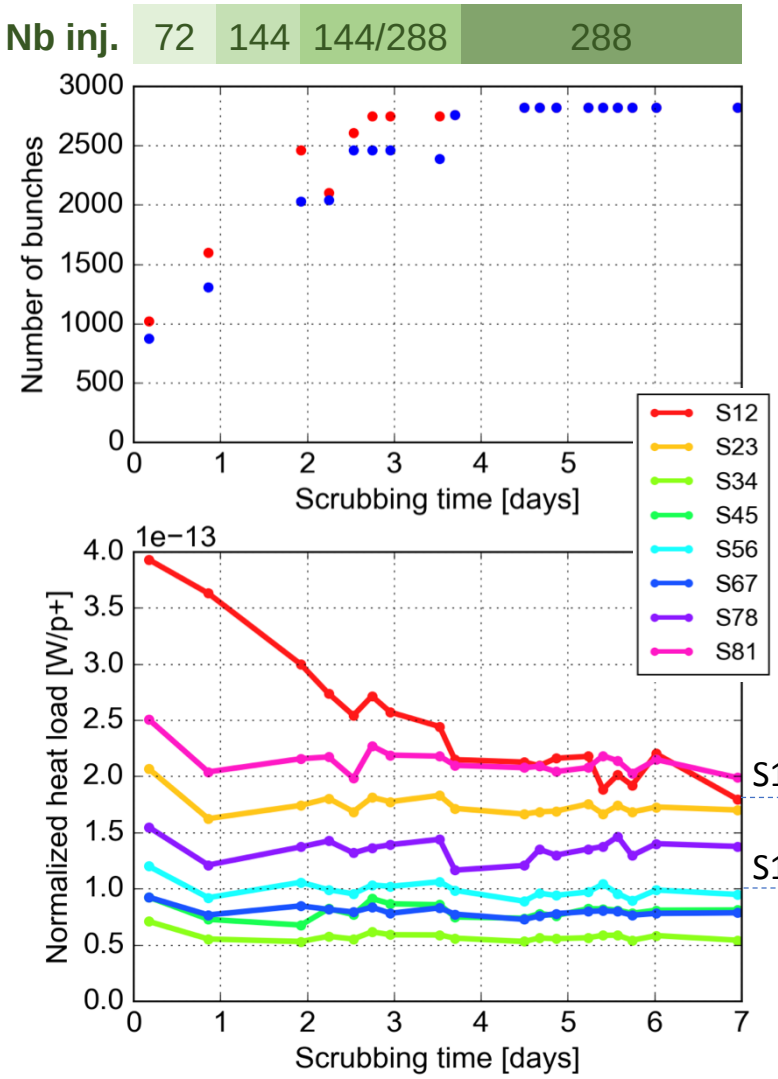
Sector 12 (opened during EYETS):

- Evident conditioning observed over **the first 4 d**
- **On day 4 heat load similar to end-2016** were reached
- **No evolution observed thereafter** (important info for planning future scrubbing runs)

Three days of scrubbing with **trains of 288b had no impact** on heat load levels nor on the difference between sectors (impossible to get back to 2012 levels)

Arc heat loads during the 2017 scrubbing run

- The data at the selected samples is used to have an **indication of the heat load evolution** during the scrubbing run



Proposed recipe
for future scrubbing runs 450 GeV

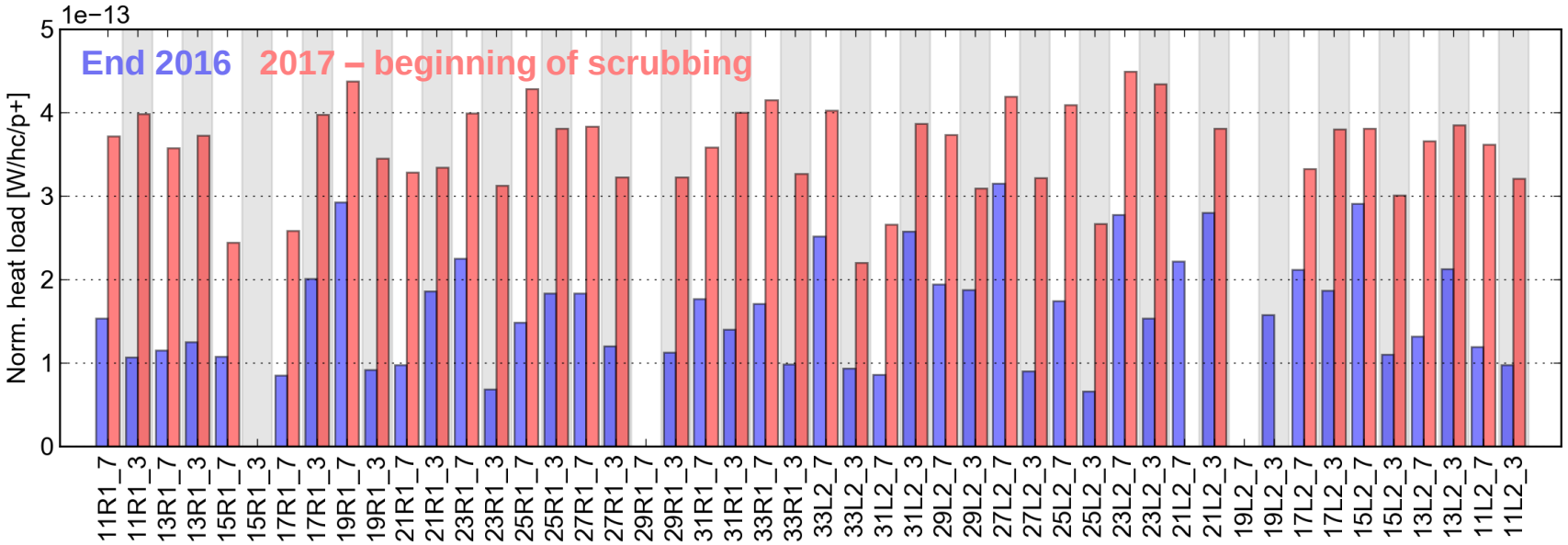
- **~12-24 h** required **after a Xmas stop** with no arc venting
- **~3-4 days** required to **recondition a single arc after venting**
- **~5-7 days** required in case the **full machine is exposed to air** (more difficult to ramp-up the intensity due to instabilities and poor beam quality)

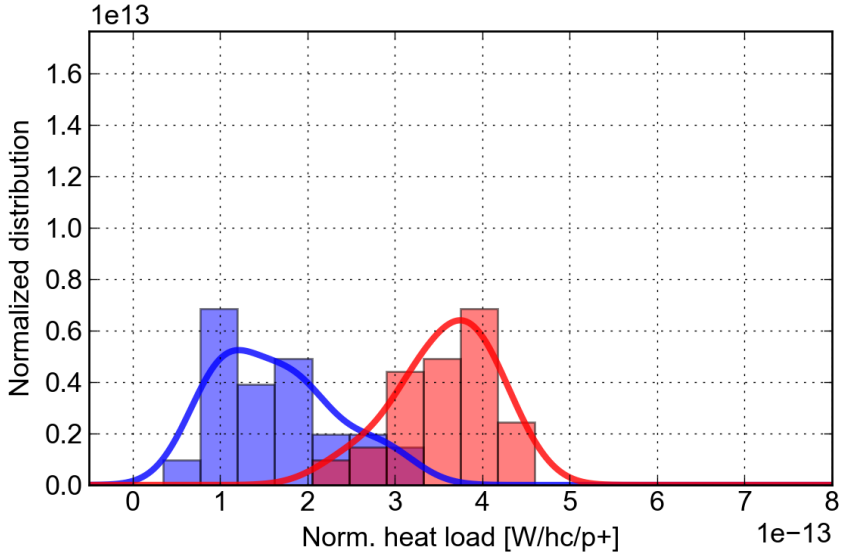
No evolution observed thereafter (important info for planning future scrubbing runs)

Three days of scrubbing with **trains of 288b had no impact** on heat load levels nor on the difference between sectors (impossible to get back to 2012 levels)

Cell-by-cell analysis at 450 GeV: S12

- Heat load **increase observed on all cells**
- **Deconditioning tends to equalize the heat loads**

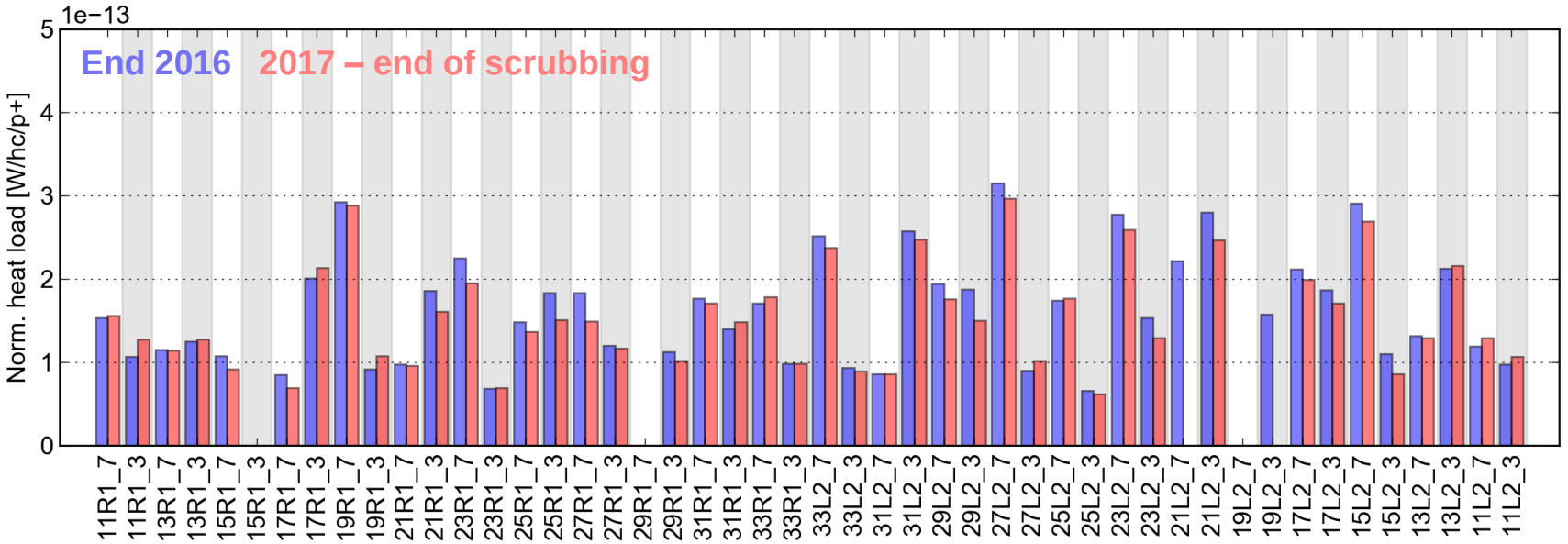


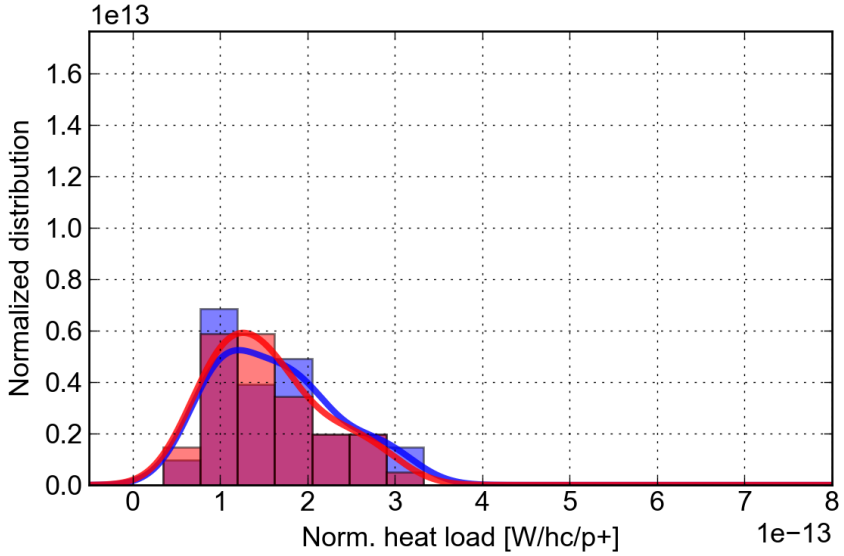


Fill	5433	5728
Started on	19 Oct 2016 22:26	30 May 2017 02:46
T_sample [h]	1.15	1.90
Energy [GeV]	450	450
N_bunches (B1/B2)	2040/2040	1308/1596
Intensity (B1/B2) [p]	2.14e14/2.20e14	1.37e14/1.77e14
Bun.len. (B1/B2) [ns]	1.17/1.18	1.22/1.26
H.L. S12 (avg) [W]	71.03	111.94
H.L. S12 (std) [W]	28.69	16.76
H.L. exp. imped. [W]	4.92	3.30
H.L. exp. synrad [W]	0.00	0.00
T_nobeam [h]	0.01	0.50

Cell-by-cell analysis at 450 GeV: S12

- Situation at the end of scrubbing run was practically **identical to end-2016**



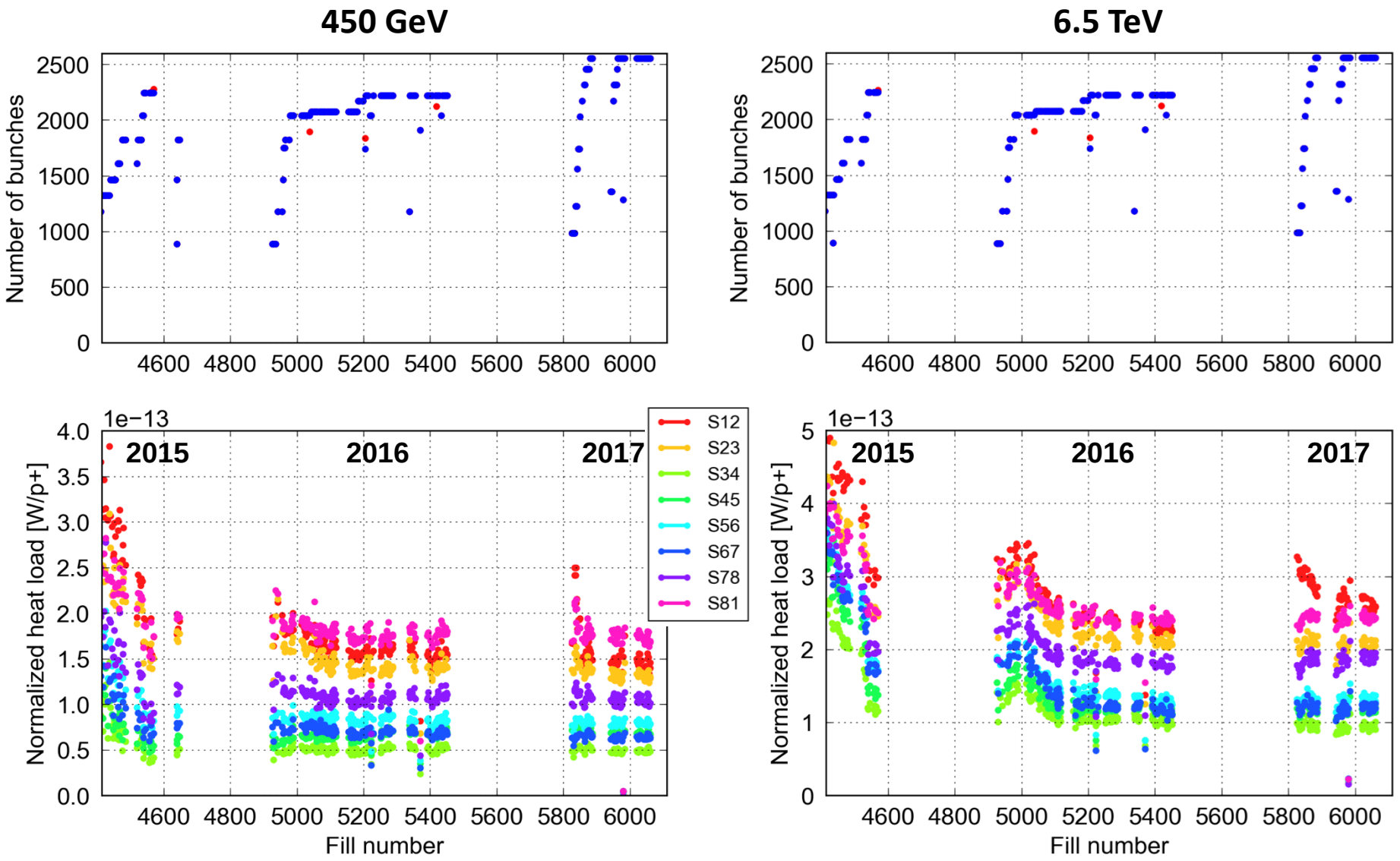


Fill	5433	5814
Started on	19 Oct 2016 22:26	11 Jun 2017 18:55
T_sample [h]	1.15	1.80
Energy [GeV]	450	450
N_bunches (B1/B2)	2040/2040	2040/2040
Intensity (B1/B2) [p]	2.14e14/2.20e14	2.13e14/2.16e14
Bun.len. (B1/B2) [ns]	1.17/1.18	1.15/1.28
H.L. S12 (avg) [W]	71.03	66.24
H.L. S12 (std) [W]	28.69	26.43
H.L. exp. imped. [W]	4.92	4.58
H.L. exp. synrad [W]	0.00	0.00
T_nobeam [h]	0.01	0.70

Data from physics fills

Heat load data from physics fills

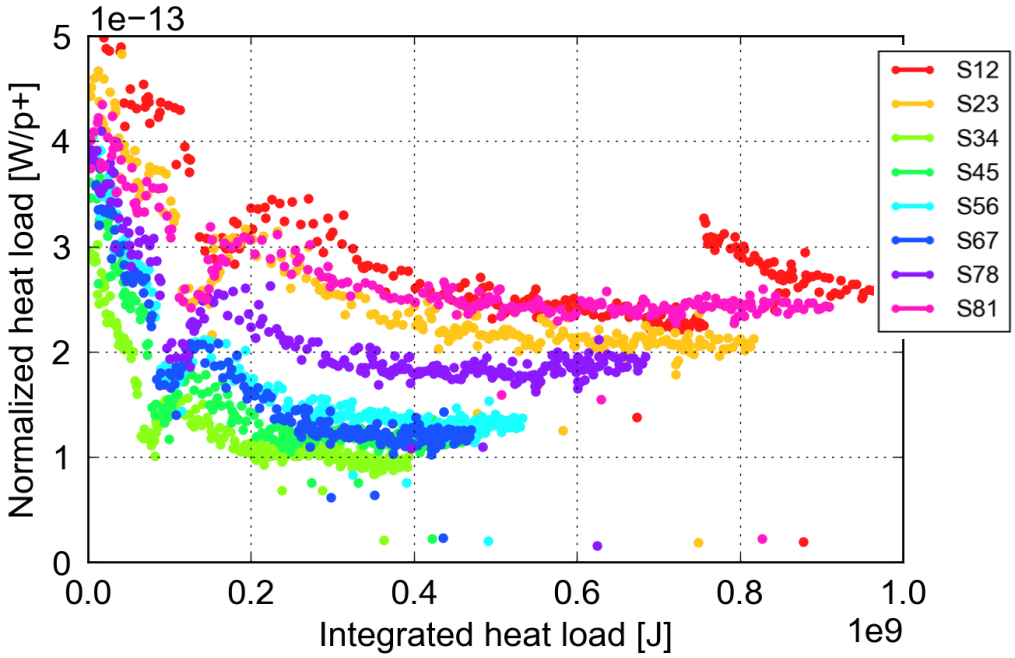
- Data from physics fills with more than 800b (scrubbing runs are not shown)

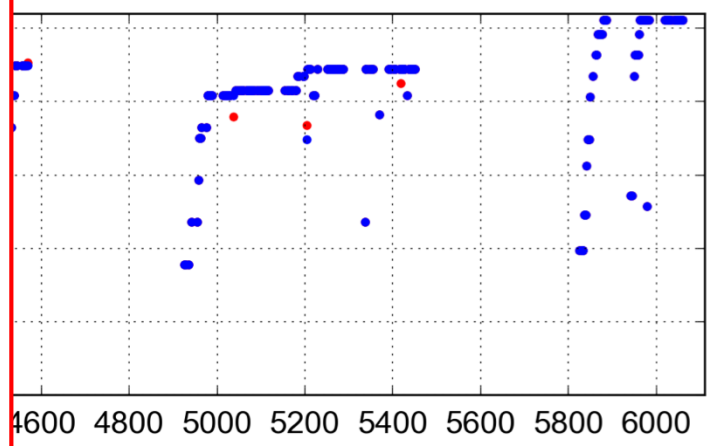


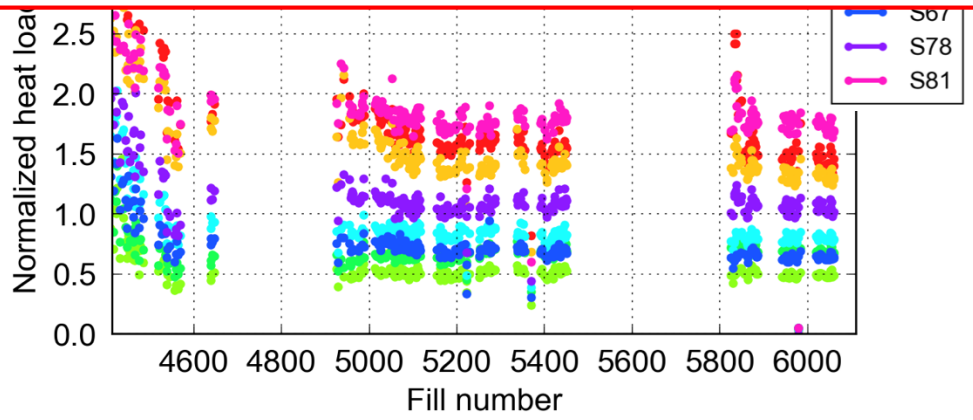
Heat load data from physics fills

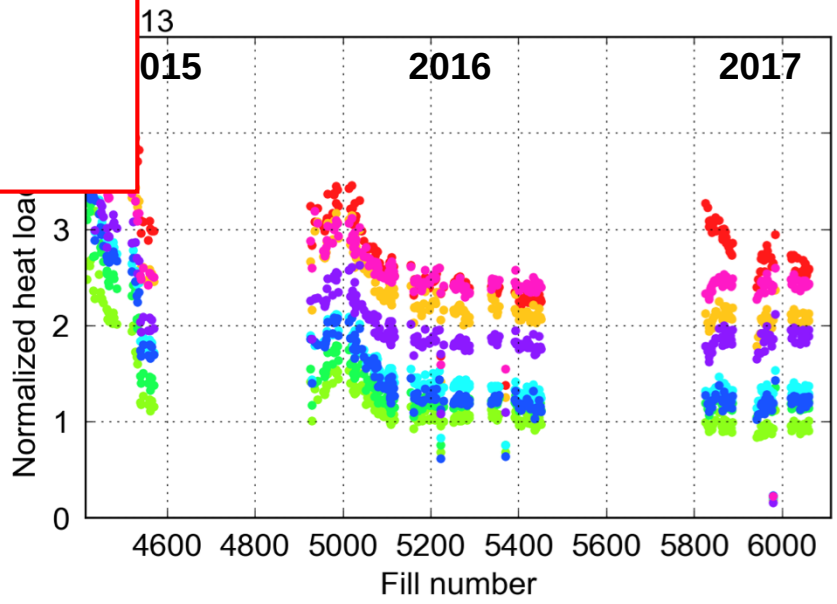
- Data from physics fills with more than 800b (scrubbing runs are not shown)

Experimental scrubbing curve at 6.5 TeV



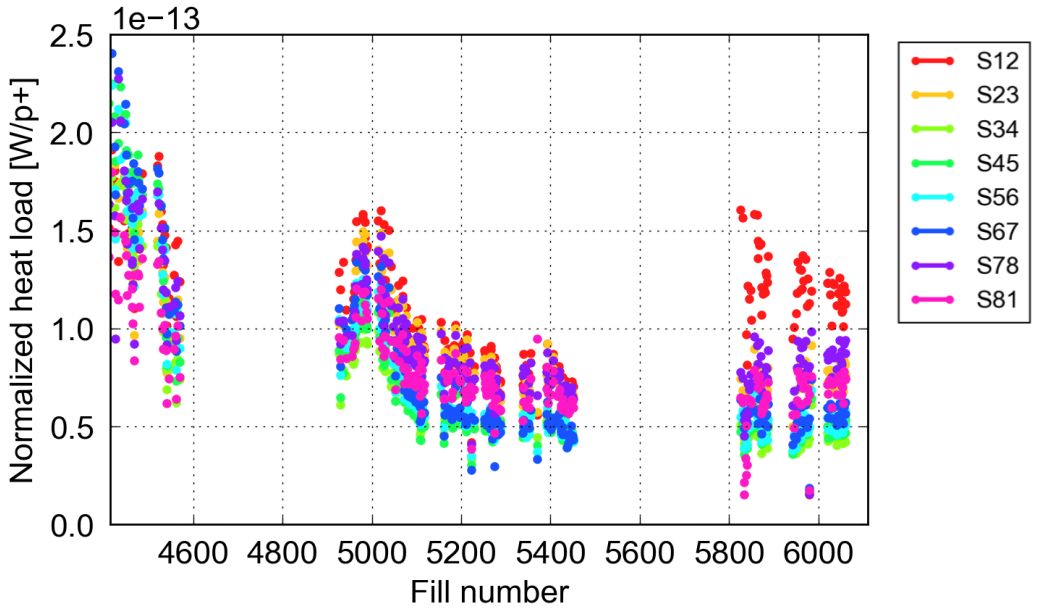






Heat load difference

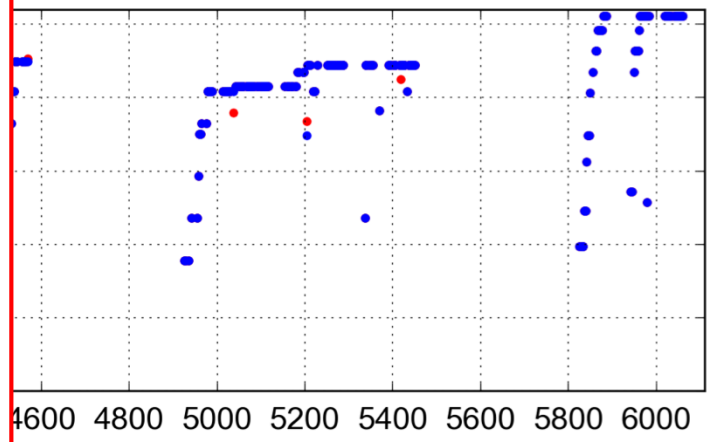
Heat load increase during the energy ramp



- No evident difference between sectors (apart from S12 re-conditioning)
- Differences between sectors appear at injection and stay constant as a function of energy

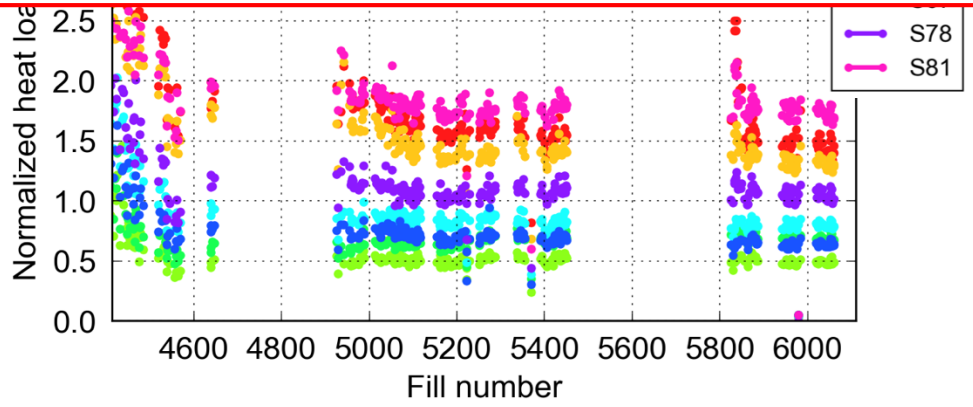
scrubbing runs are not shown)

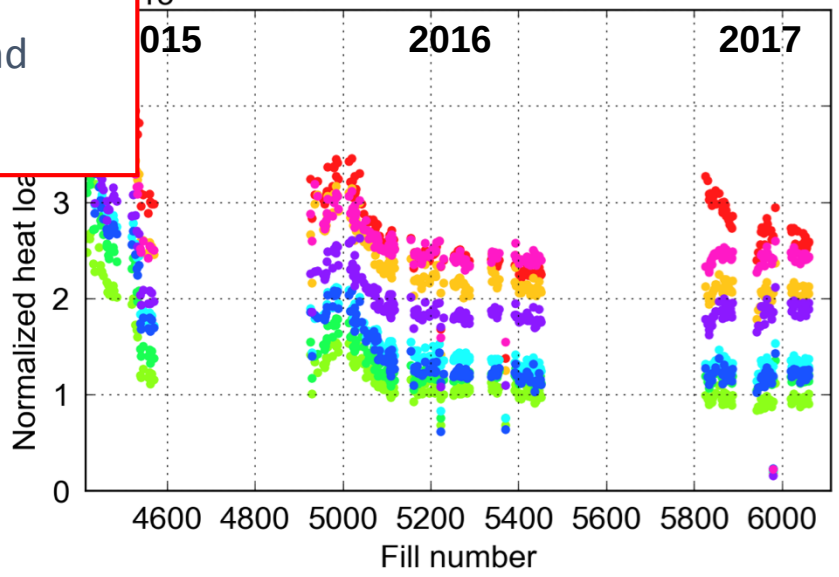
6.5 TeV



13

015 2016 2017

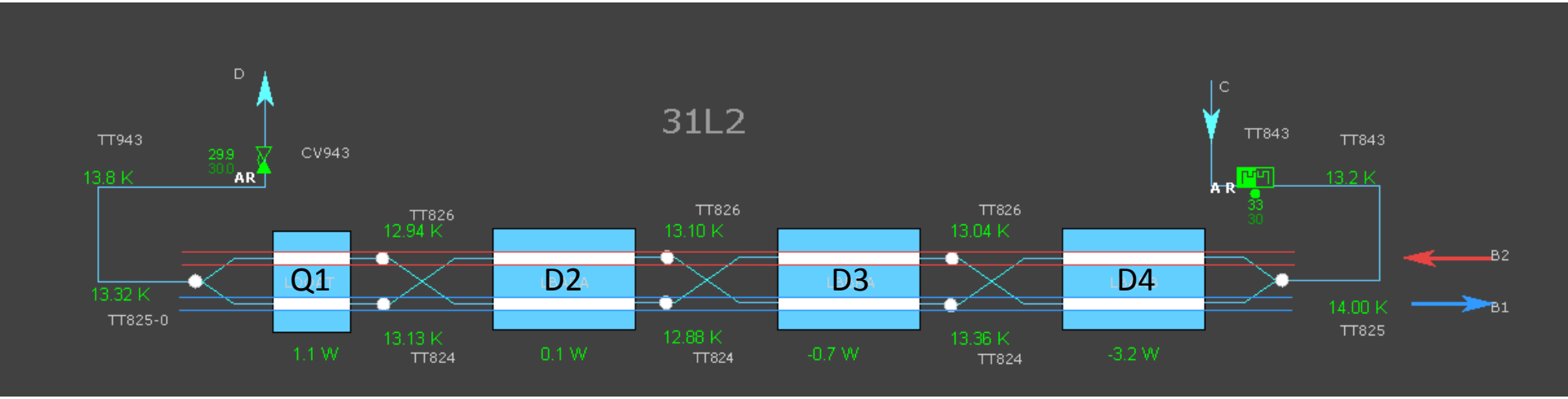




Additional information
from instrumented cells in S12 and S45

Heat loads in instrumented cells

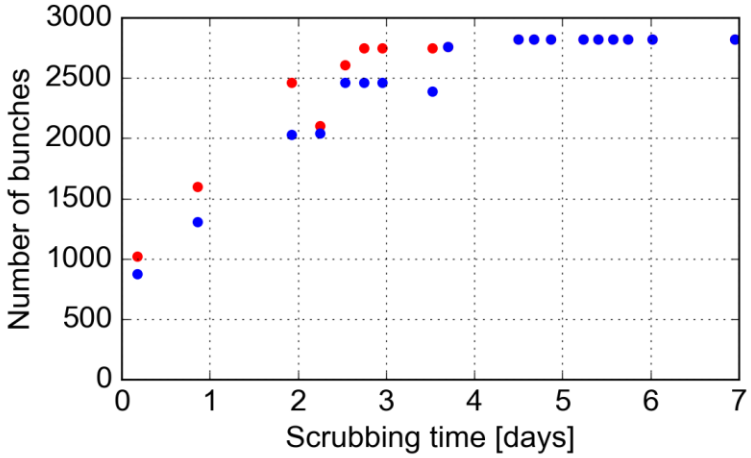
- Cells equipped with **extra thermometers to measure the heat loads magnet by magnet**
  - **3 cells in S45** were instrumented during LS1 (they always showed relatively low heat loads 2016-17)
  - **1 cell in S12** instrumented during the EYETS (it shows a large heat load)

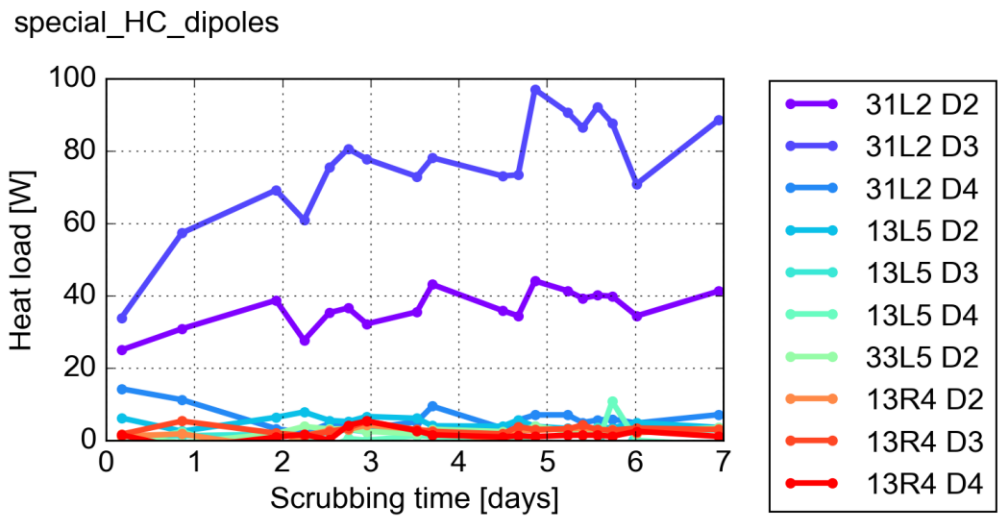


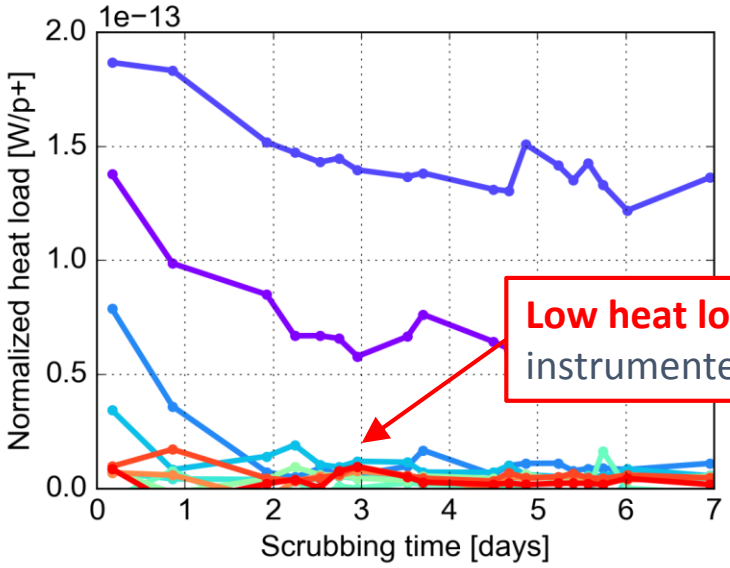
- TE-CRG provided us with the procedure to reconstruct the load in each magnet and the list of devices for which the measurement is reliable

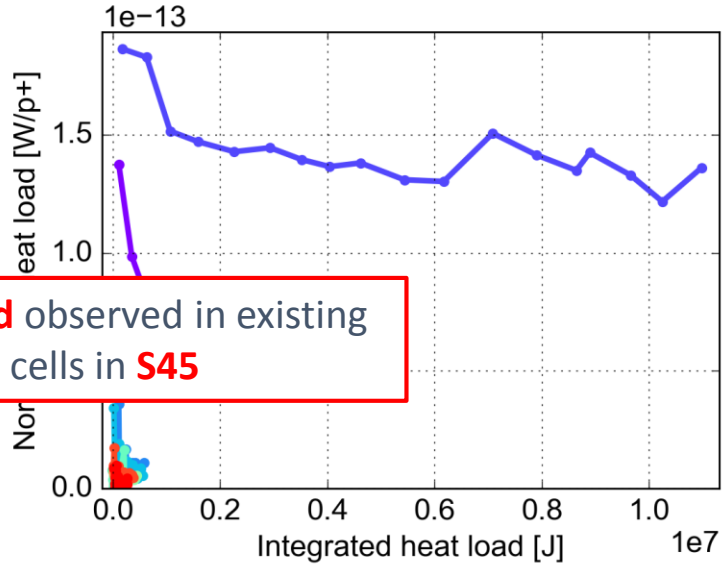
Dipole magnets: scrubbing run data

Nbun inj.	72	144	144/288	288





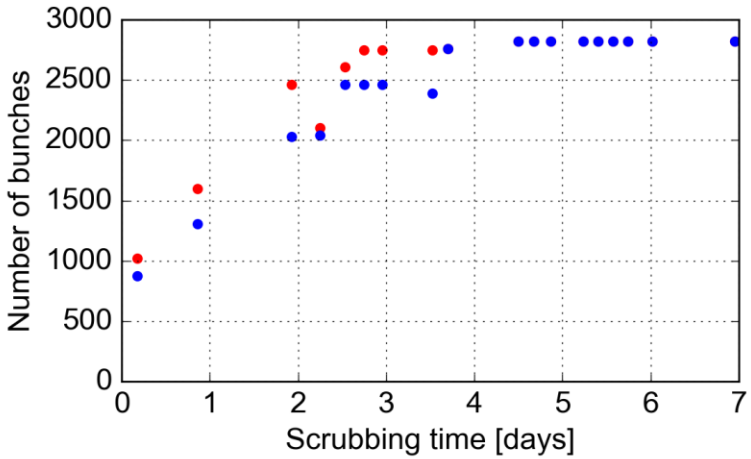


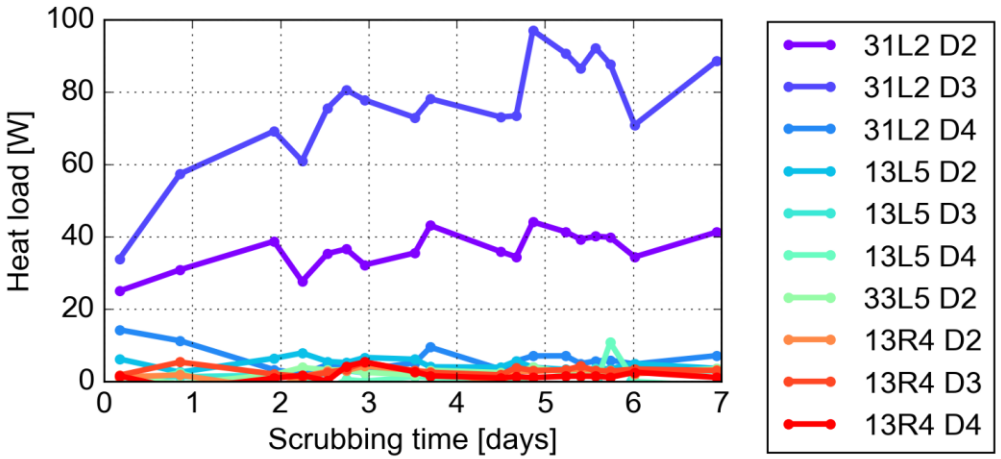


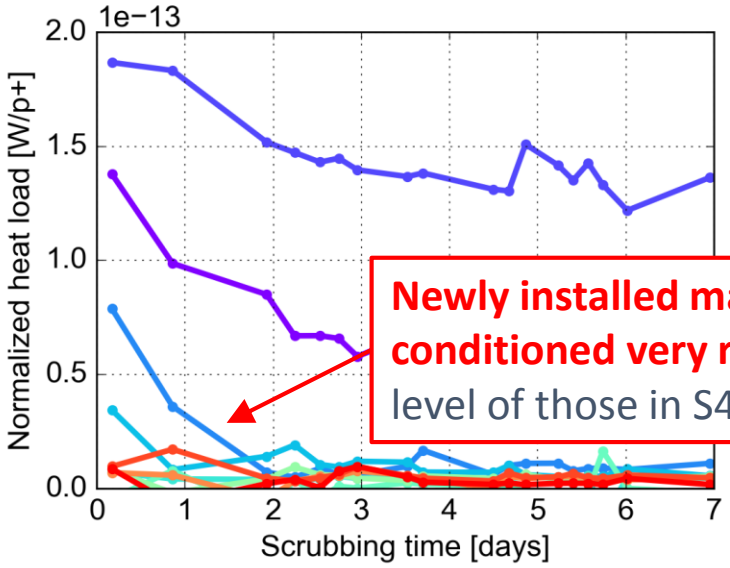
Low heat load observed in existing instrumented cells in **S45**

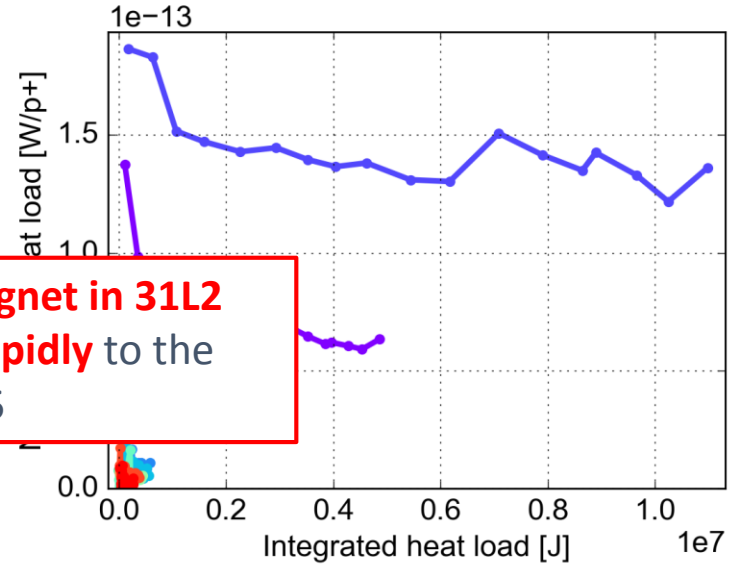
Dipole magnets: scrubbing run data

Nbun inj. 72 | 144 | 144/288 | 288





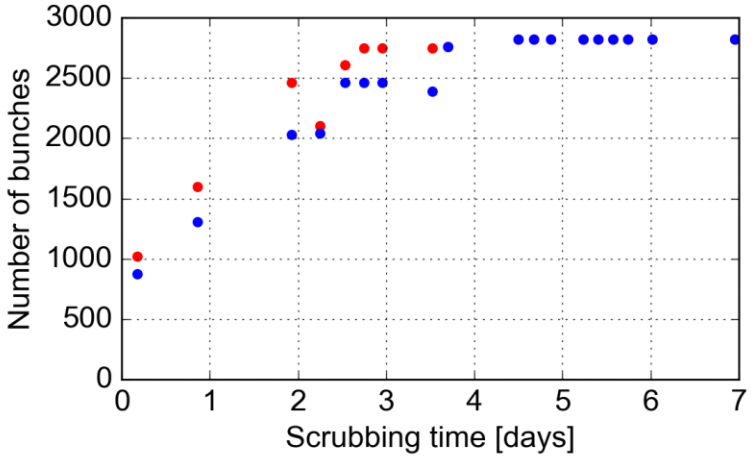


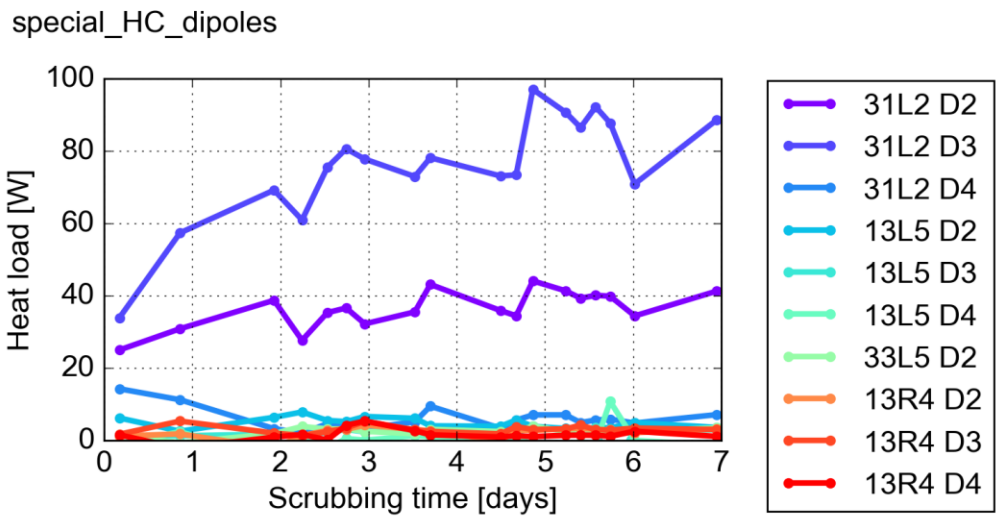


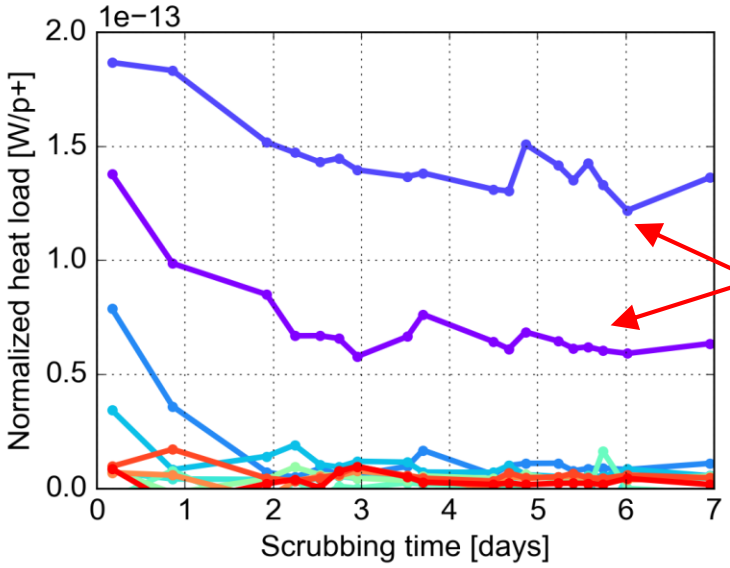
Newly installed magnet in 31L2 conditioned very rapidly to the level of those in S45

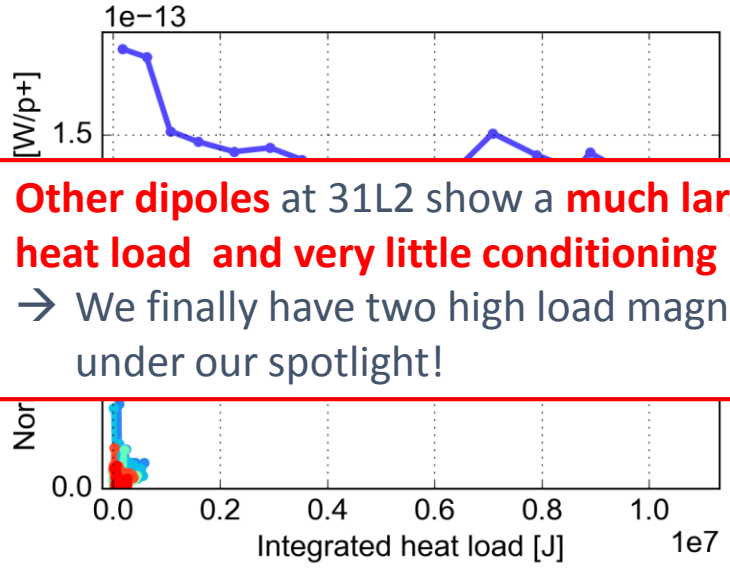
Dipole magnets: scrubbing run data

Nbun inj.	72	144	144/288	288







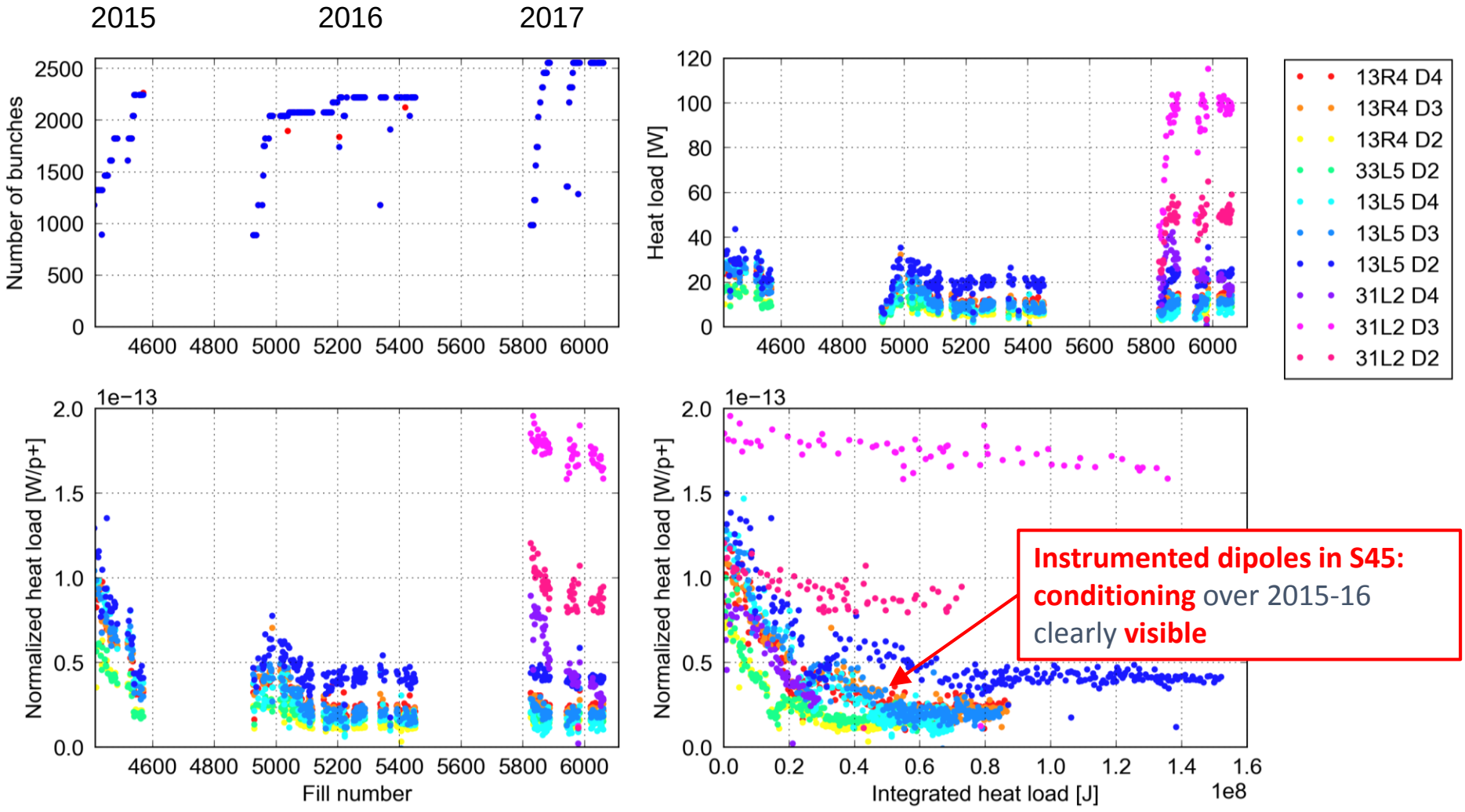


Other dipoles at 31L2 show a **much larger heat load and very little conditioning**

→ We finally have two high load magnets under our spotlight!

Dipole magnets: evolution at 6.5 TeV during run 2

- Complete evolution of the average arc **heat loads at 6.5 TeV over Run 2**
- Only **fills that reached stable beams** are included (→ fills from the scrubbing run are not shown)



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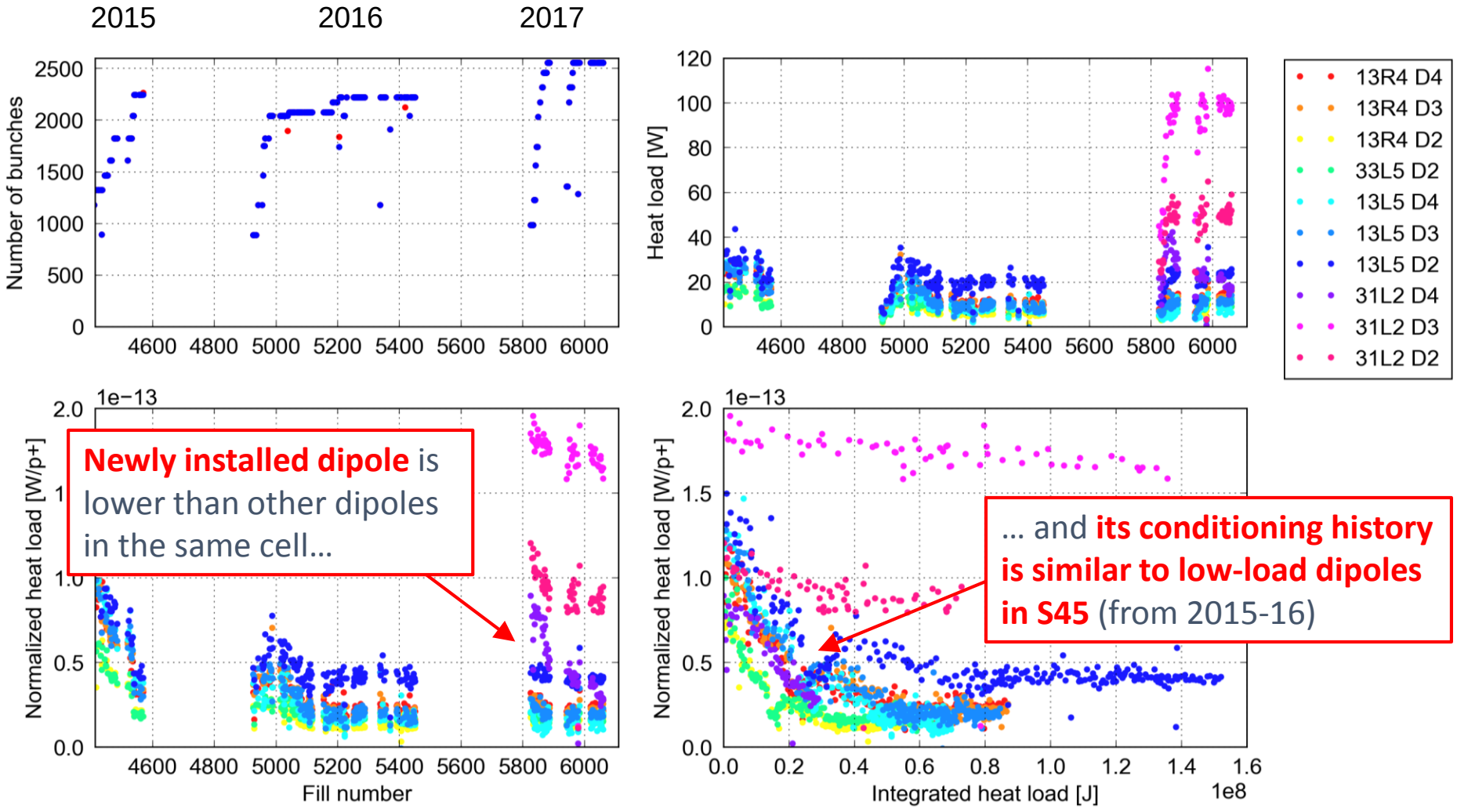

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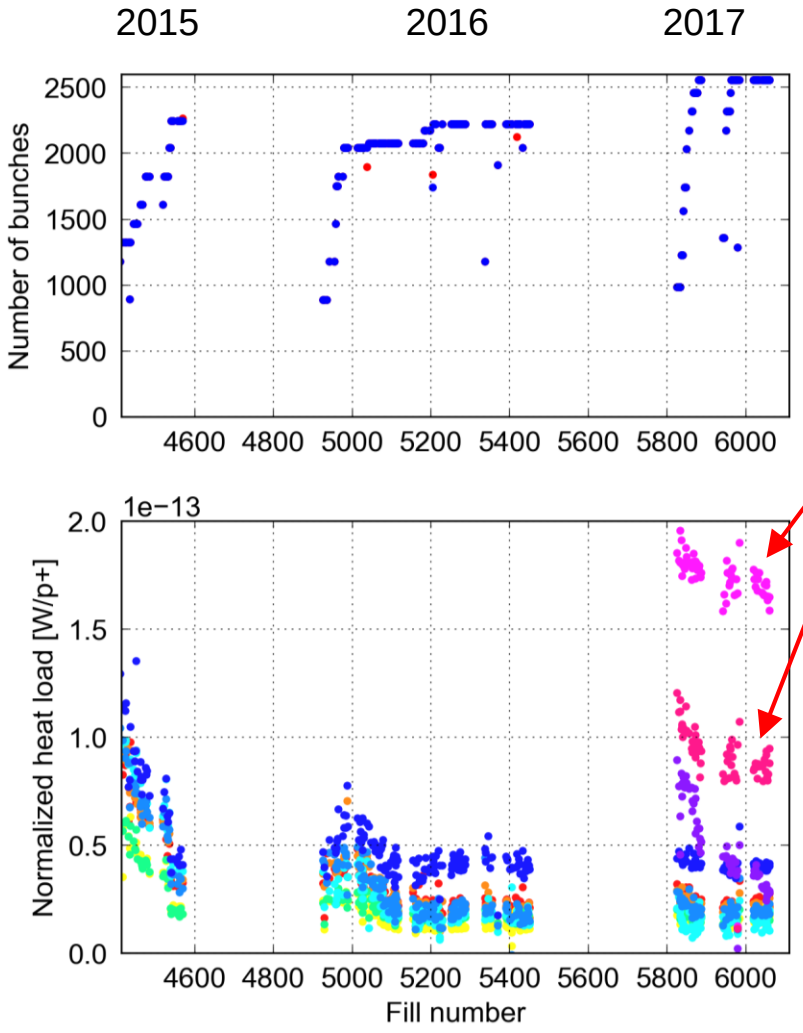
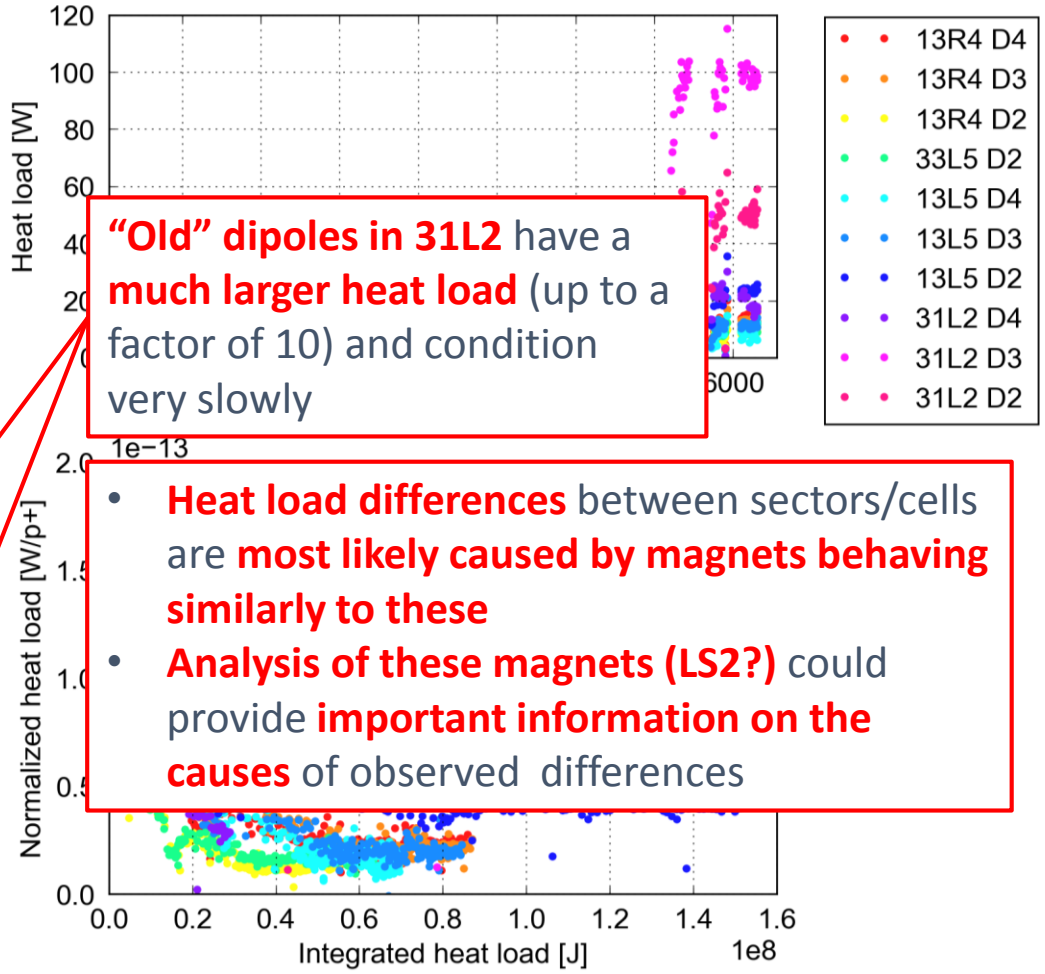


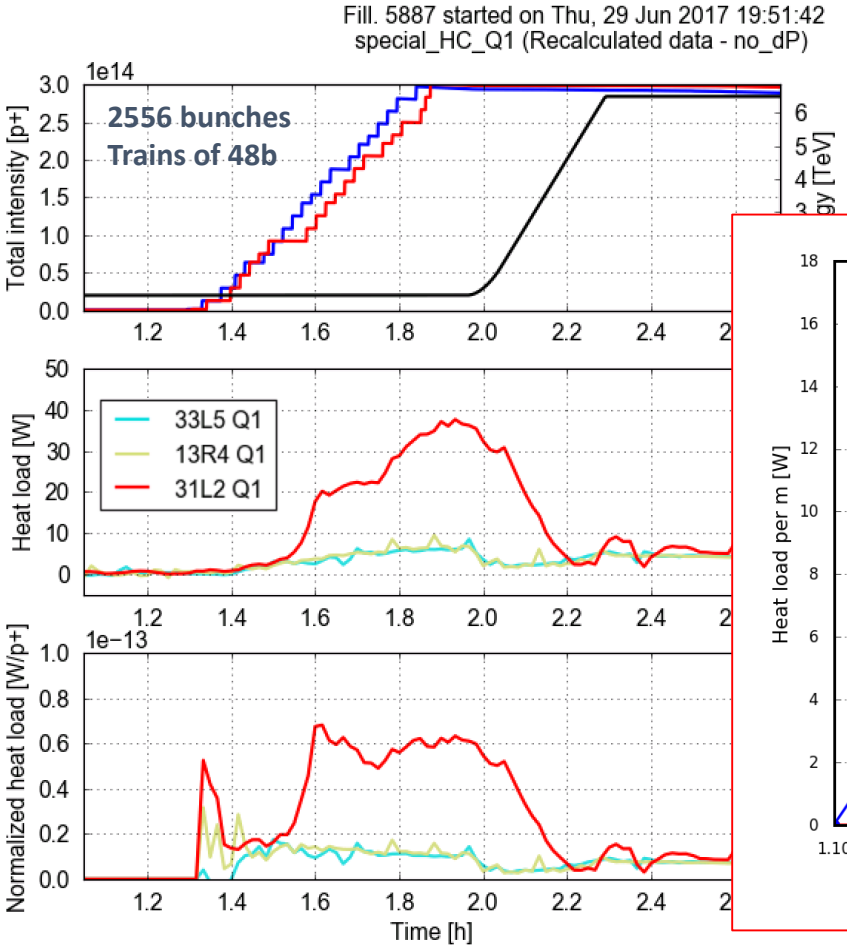


"Old" dipoles in 31L2 have a **much larger heat load** (up to a factor of 10) and condition very slowly

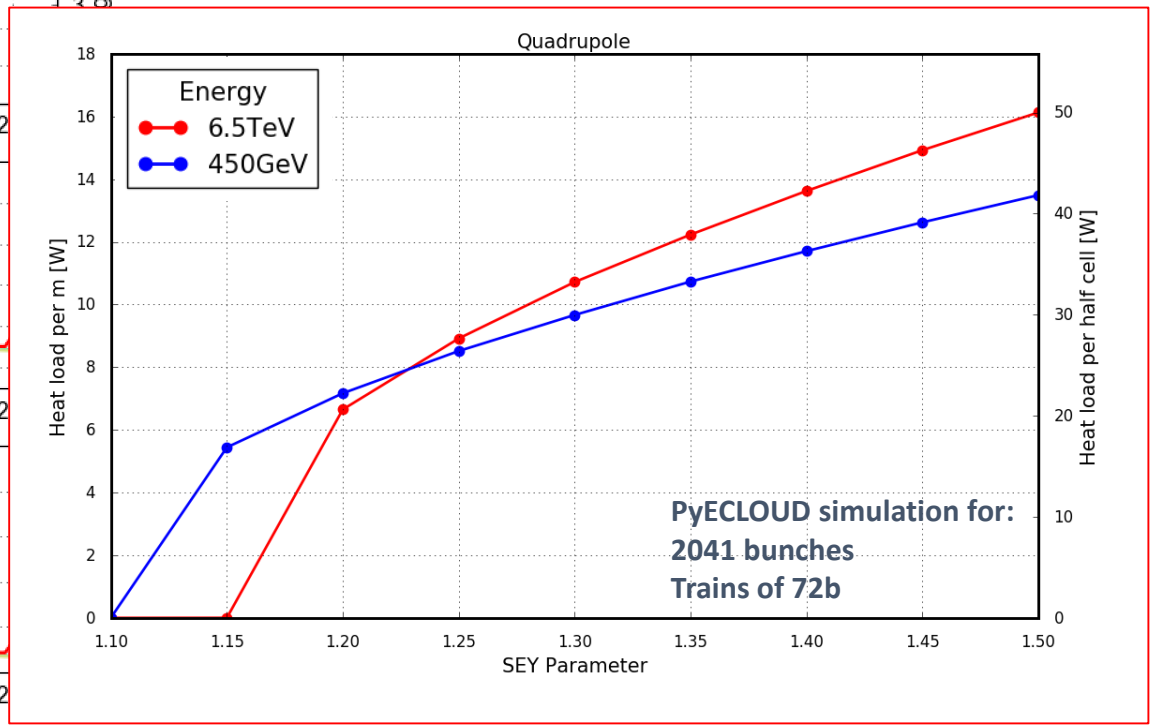
- **Heat load differences** between sectors/cells are **most likely caused by magnets behaving similarly to these**
- **Analysis of these magnets (LS2?)** could provide **important information on the causes** of observed differences

Quadrupole magnets: dependence on beam energy

- The instrumented quadrupole in 31L2 shows a peculiar behavior: **strong decrease of the heat load during the energy ramp**

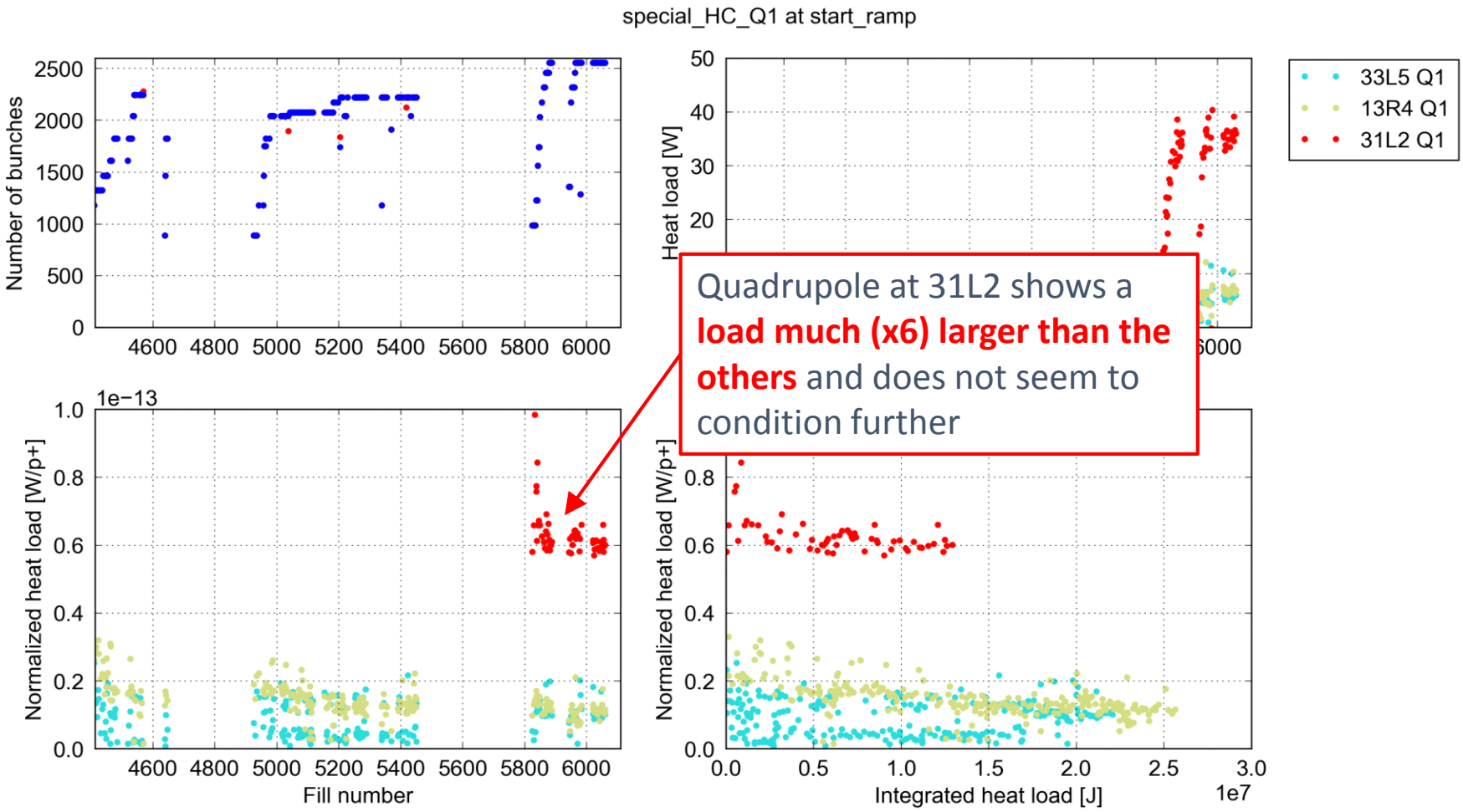


- Seems **consistent with (old) PyECLOUD simulations for low enough SEY**



- A similar behavior was observed in the other devices in 2015

Quadrupole magnets: conditioning

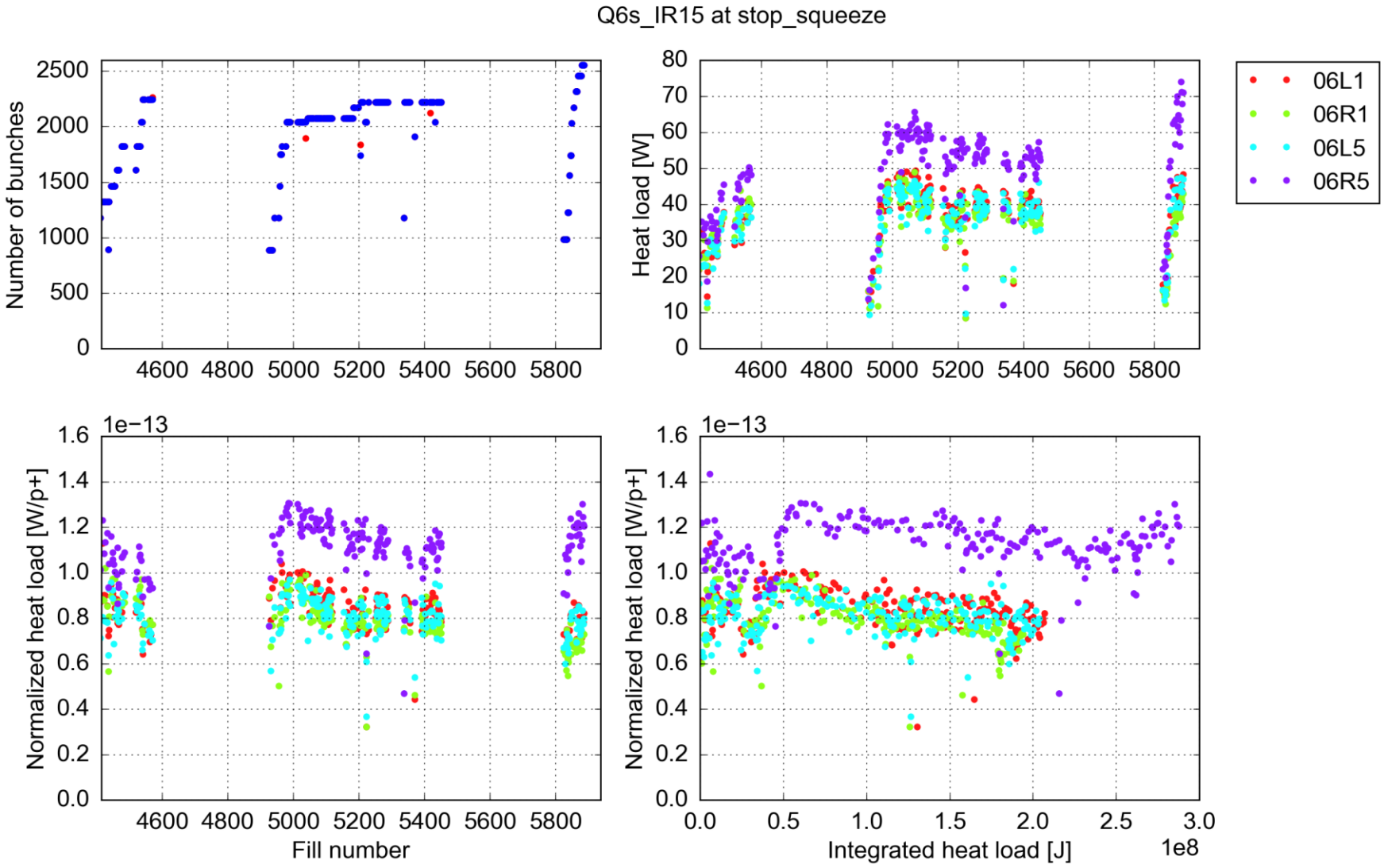


Quadrupole at 31L2 shows a **load much (x6) larger than the others** and does not seem to condition further

Stand-alone magnets

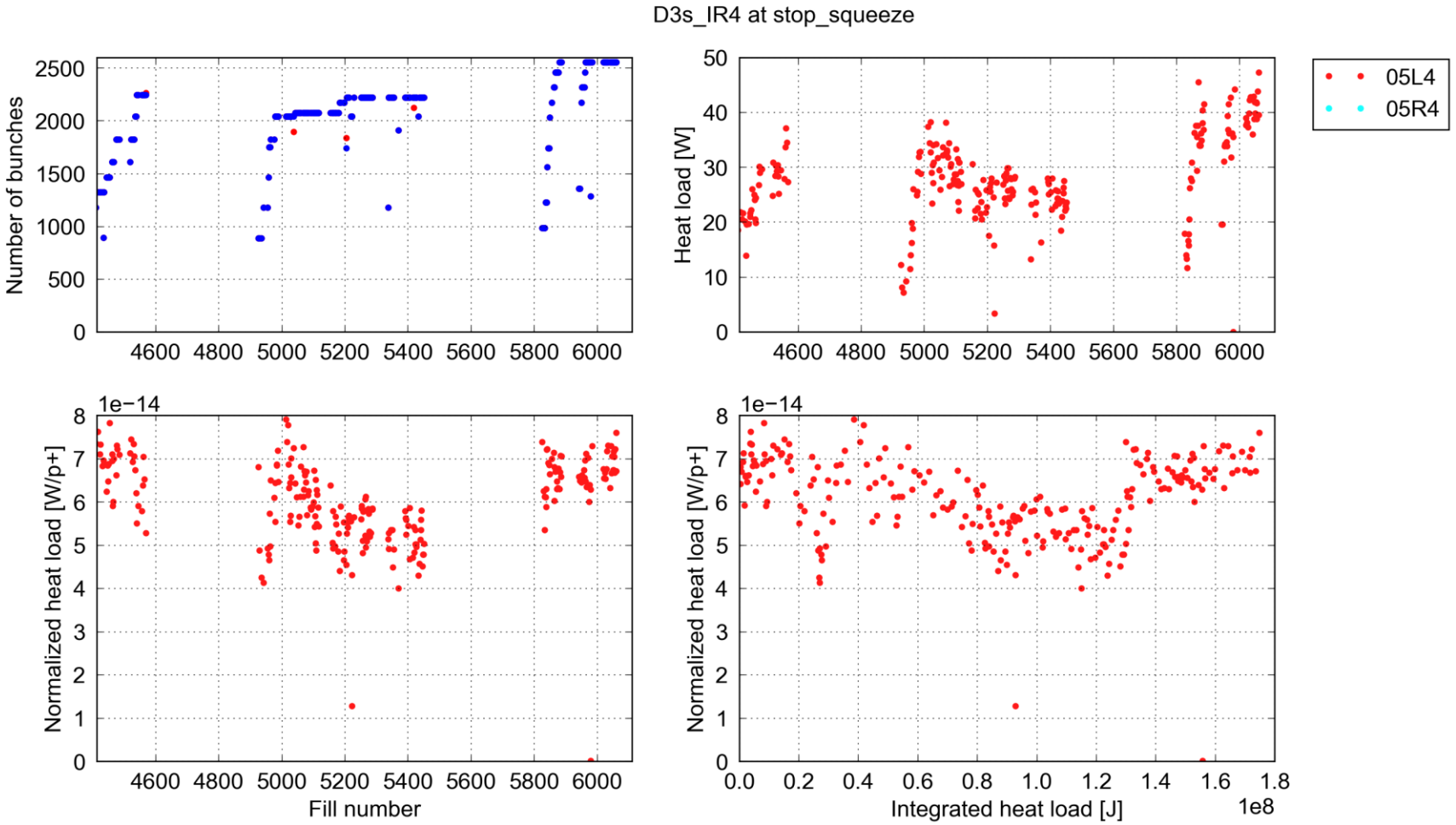
Stand alone quadrupoles: evolution at 6.5 TeV

- Quadrupoles (measurements crosschecked with cryo Q5 and Q6 in IR1&5)
- Heat loads are quite large and there is no clear observation of conditioning



Stand alone dipole in IR3: evolution at 6.5 TeV

- Heat loads are quite large and there is no clear observation of conditioning



Dependence on the bunch pattern

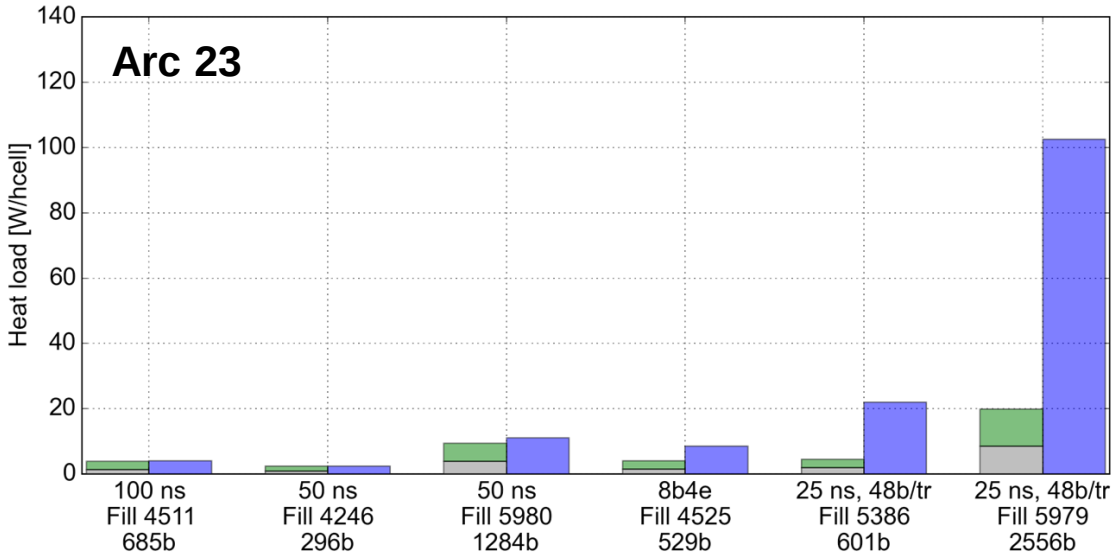
Heat loads with different filling patterns

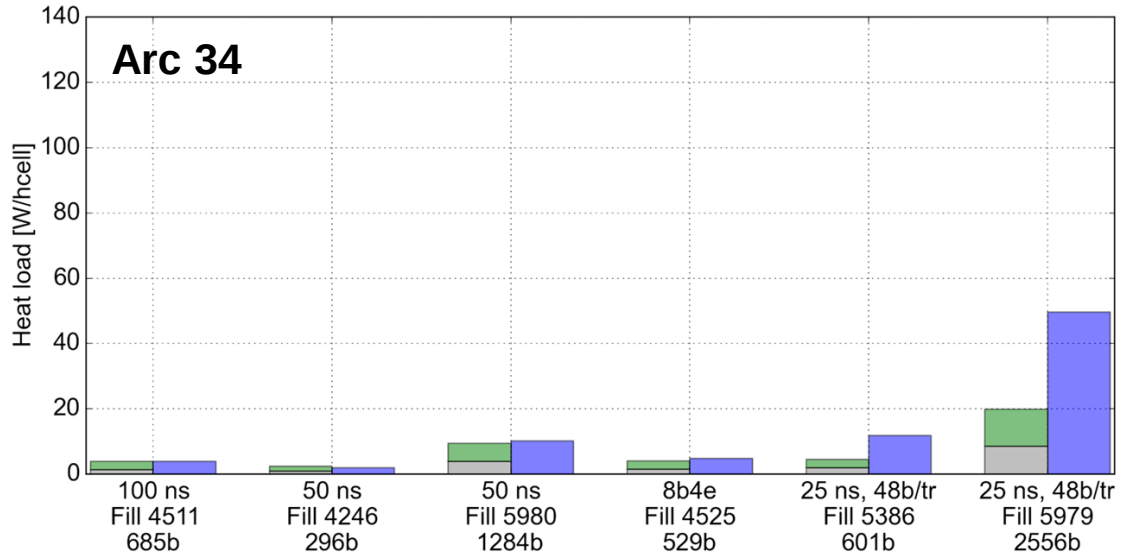
Main beam parameters (after 2h in Stable Beams)

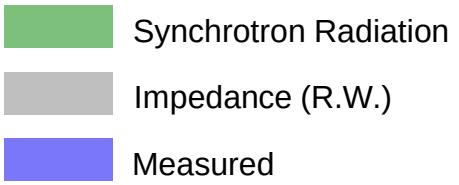
Beam type	Fill n.	N. bunches	Avg. bun. intensity	Avg. bun. length
100 ns	4511	685	0.85e11 p/b	1.11 ns
50 ns	4246	296	1.11e11 p/b	1.14 ns
50 ns	5980	1284	1.01e11 p/b	1.06 ns
8b4e	4525	529	1.11e11 p/b	1.24 ns
25 ns, 48b/tr	5386	601	1.01e11 p/b	1.03 ns
25 ns, 48b/tr	5979	2556	1.04e11 p/b	1.04 ns

Heat loads with different filling patterns

Measured data vs expectations from **synchrotron radiation** and **resistive wall impedance**



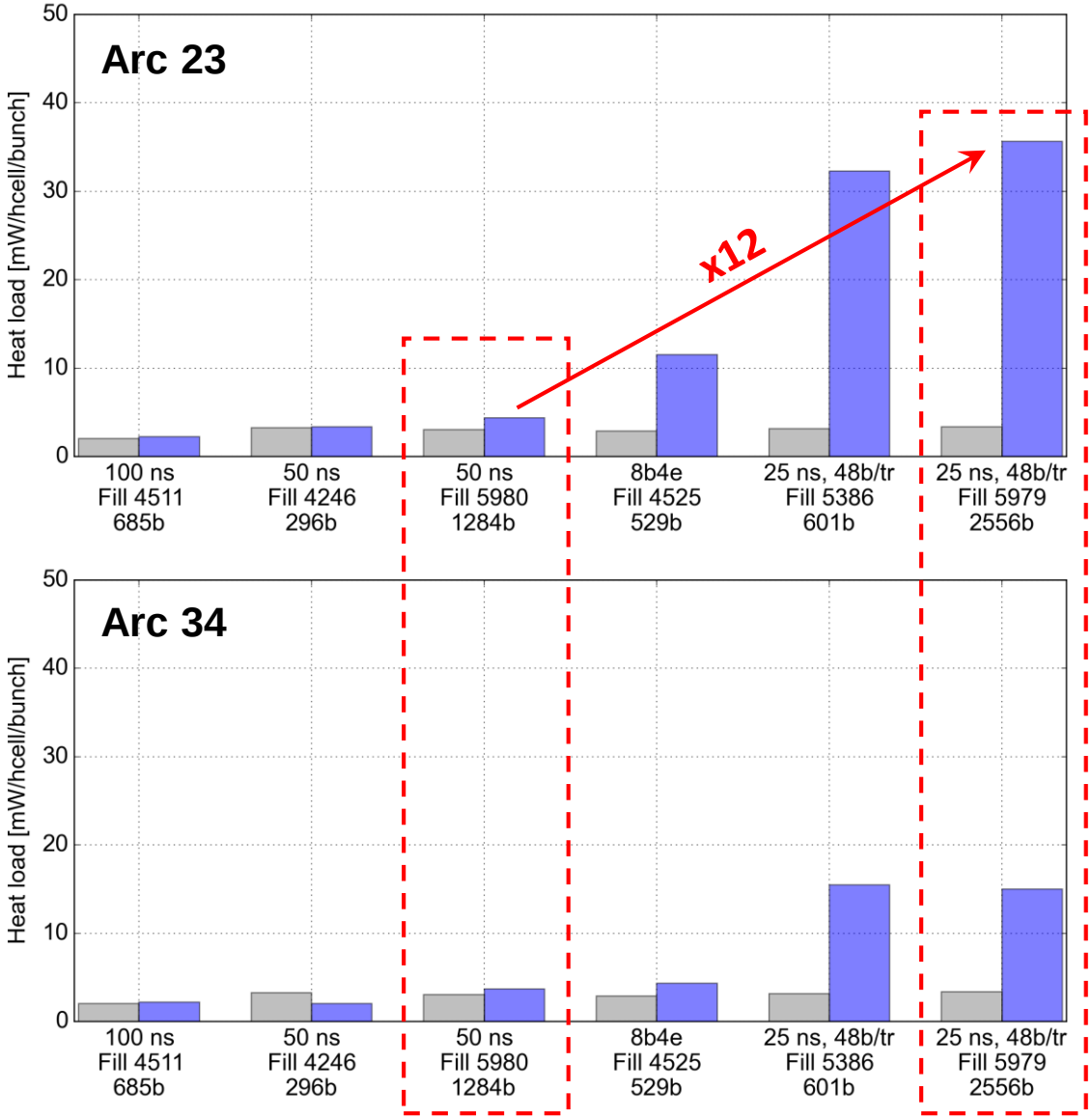




Comparison for the other sectors can be found here

Heat loads with different filling patterns

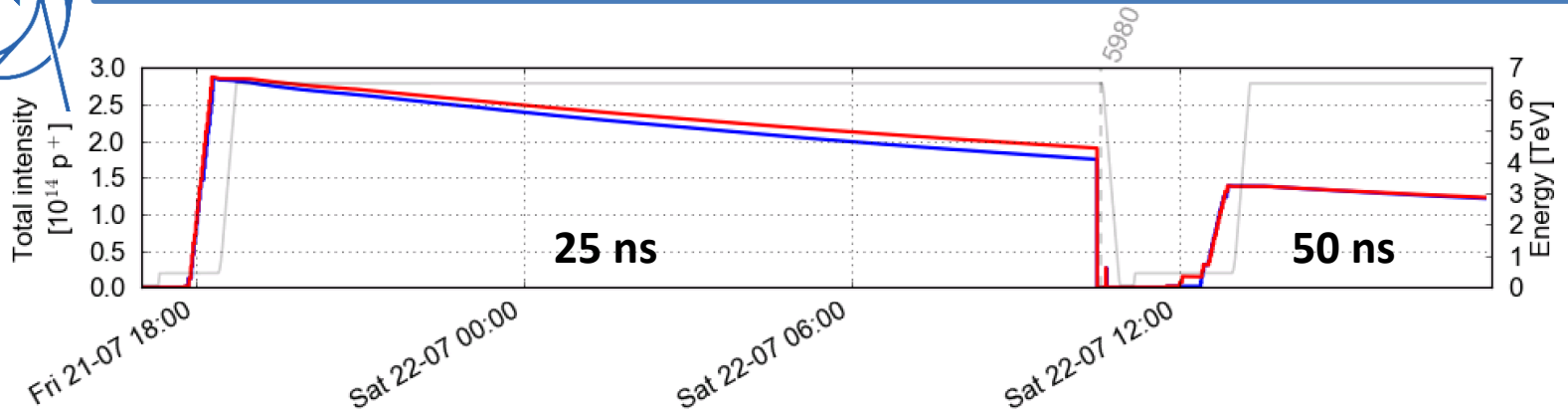
Normalize to the number of bunches and subtract contribution from synchrotron radiation



Observed increase between 50 ns and 25 ns (same train structure) → useful to exclude impedance heating as a possible source of the heat load differences (see talk by Benoit and Francesco)

Comparison for the other sectors can be found here

Test fill with 50 ns in 2017



We aimed at changing only the bunch spacing:

- Used **same filling pattern** as for production physics fills, replacing each 25-ns train of 48 bunches with a 50-ns train of 24 bunches
- **1284 b/beam**. Avg. bunch intensity at 6.5 TeV: **1.07e11 p/bunch**
- Used non-BCMS scheme in the PS → gave **transverse emittances similar to BCMS 25 ns**
- **No change in machine settings**

The planned set of measurements was performed rather quickly, still the fill was kept **6.7 h in Stable Beams** as beam from the injectors was not available for refill with 25 ns

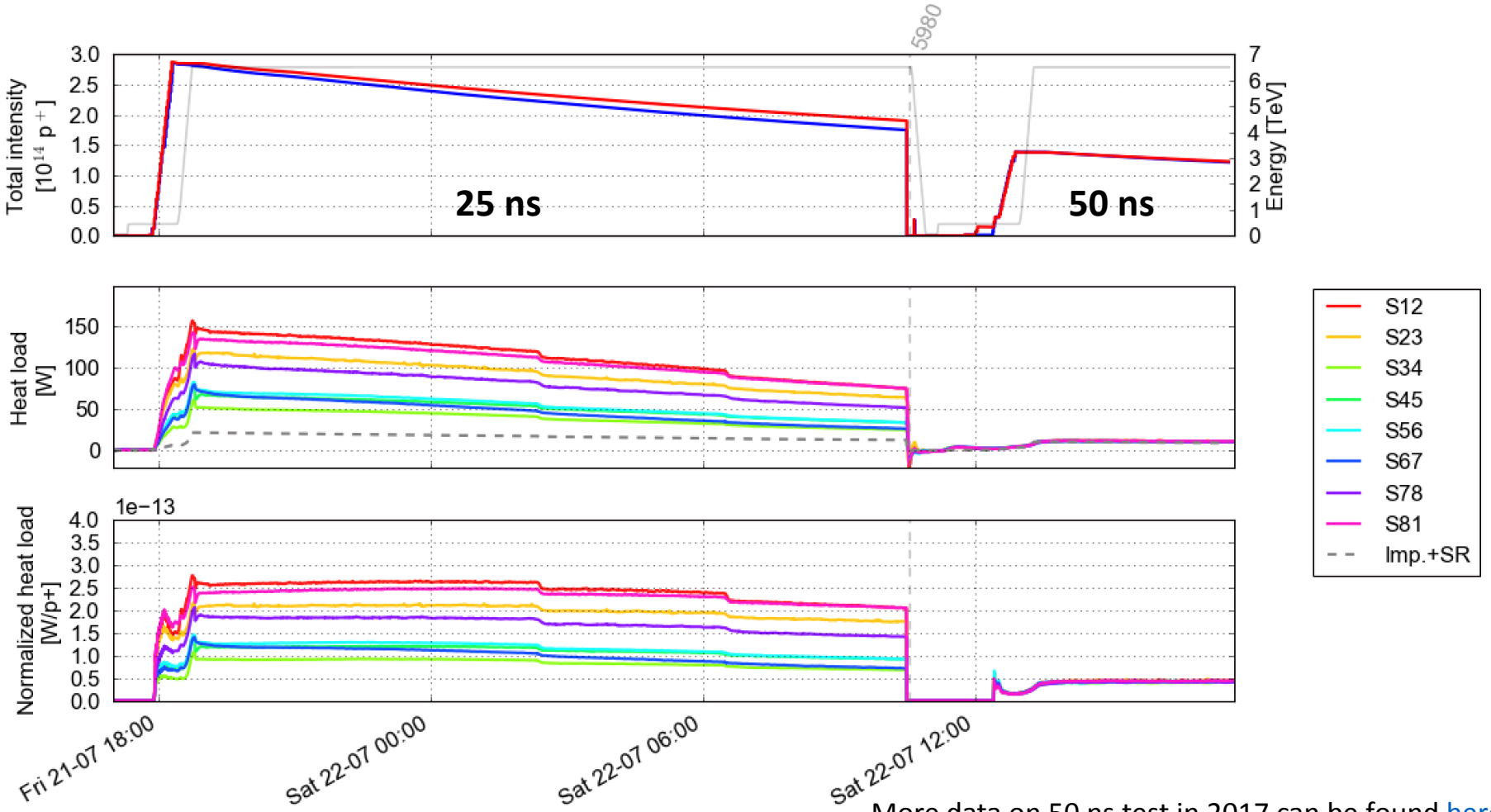
More data on 50 ns test in 2017 can be found here

Test fill with 50 ns in 2017

Electron cloud suppression with 50 ns confirmed by heat load measurements on the beams-screens

→ Consistent with expectations from impedance and synchrotron radiation

→ Large **differences between sectors** observed with 25 ns are not visible **with 50 ns**



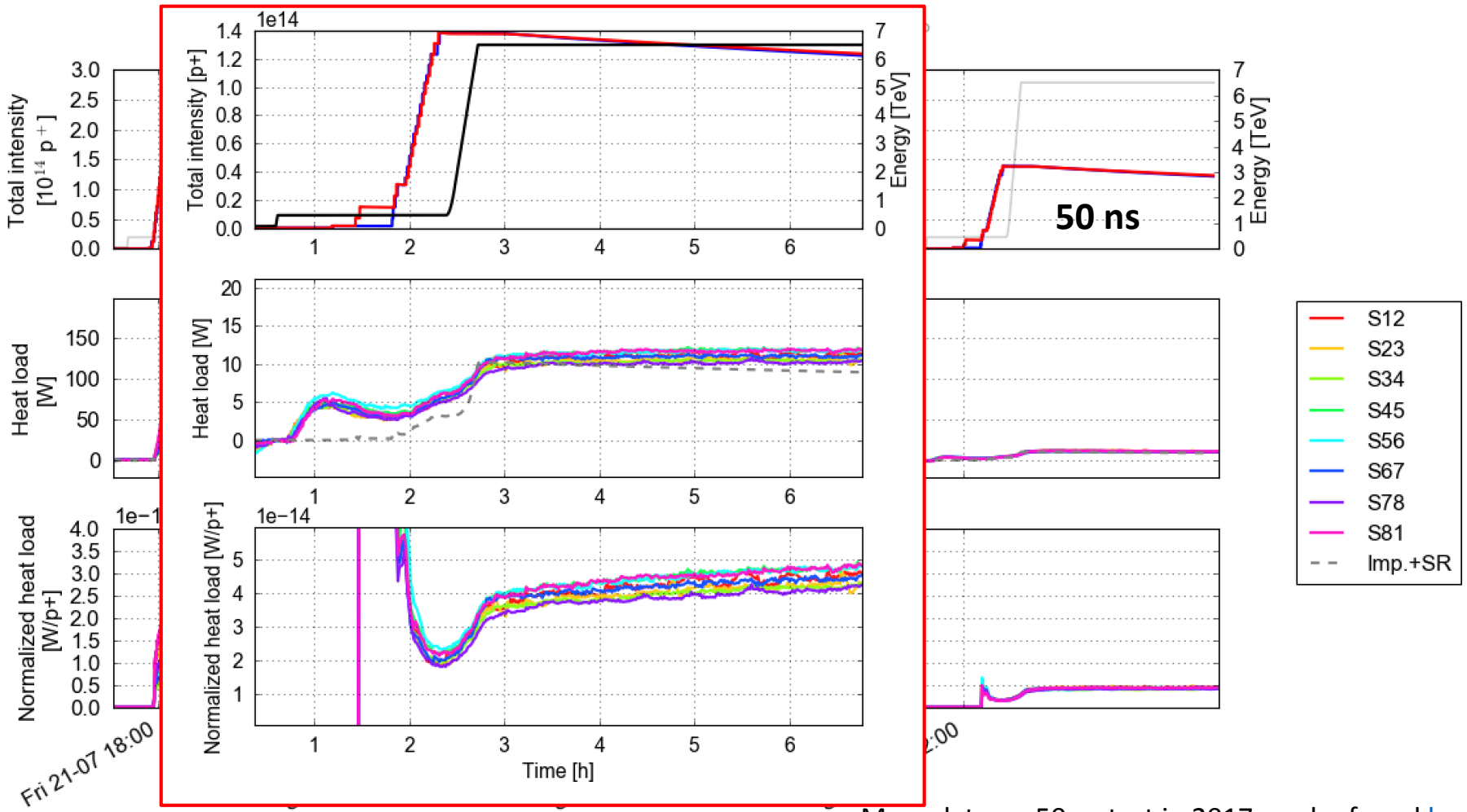
More data on 50 ns test in 2017 can be found here

Test fill with 50 ns in 2017

Electron cloud suppression with 50 ns confirmed by heat load measurements on the beams-screens

→ Consistent with expectations from impedance and synchrotron radiation

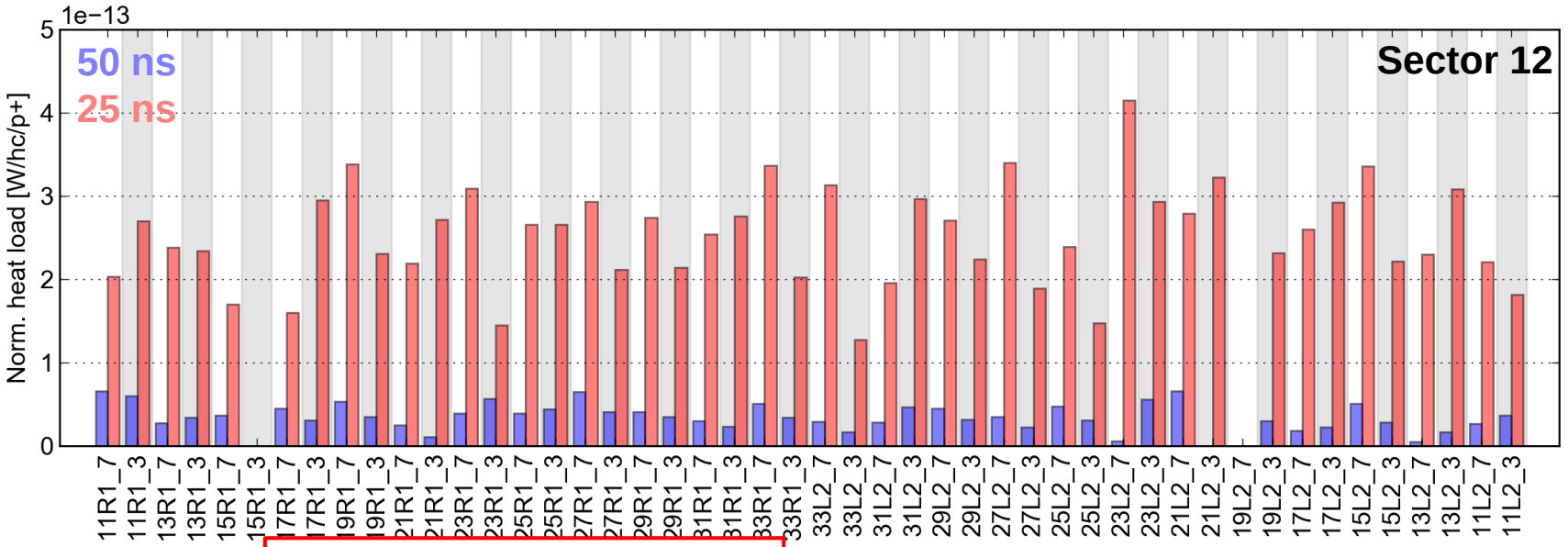
→ Large **differences between sectors** observed with 25 ns are not visible **with 50 ns**

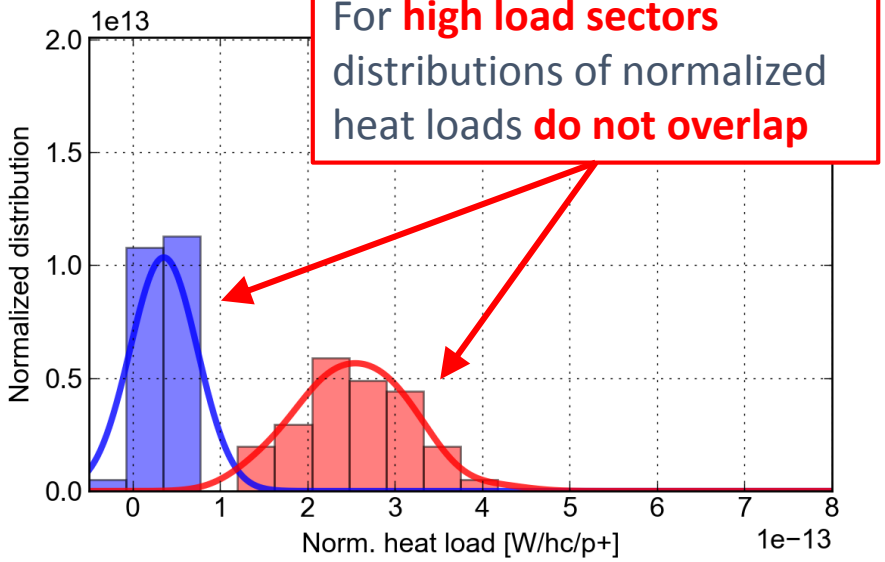


More data on 50 ns test in 2017 can be found here

Cell-by-cell comparison

Reduction of normalized heat load is **observed in all cells**





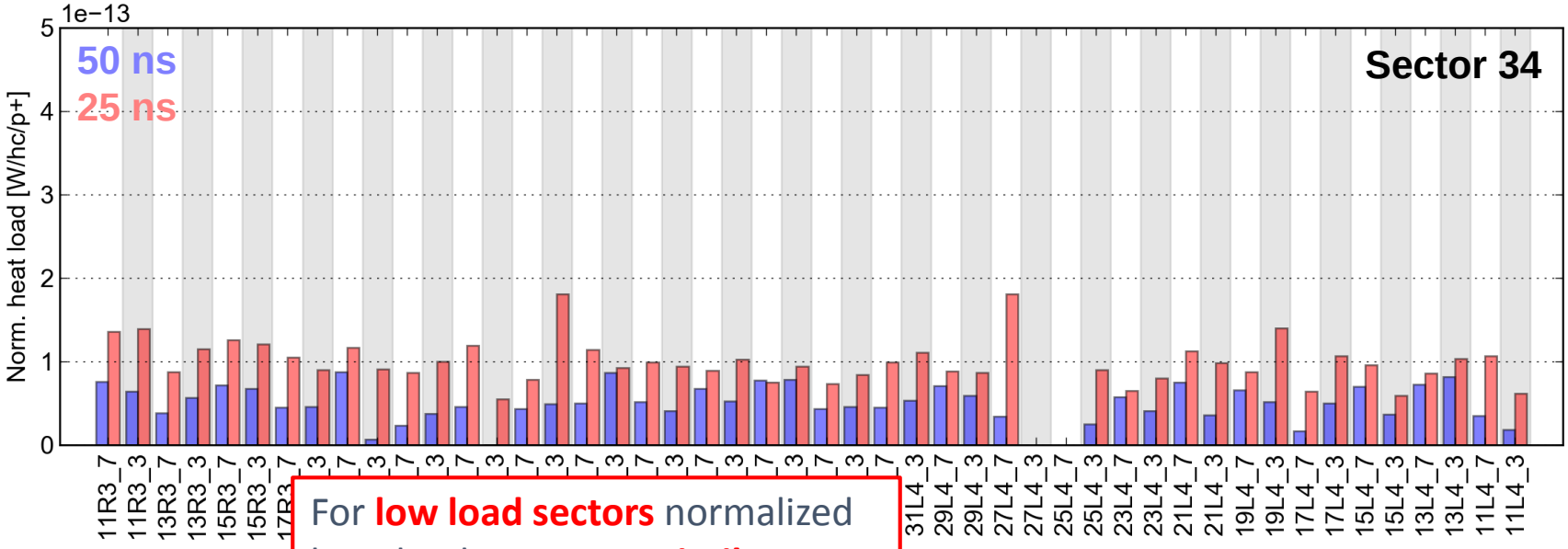
For **high load sectors** distributions of normalized heat loads **do not overlap**

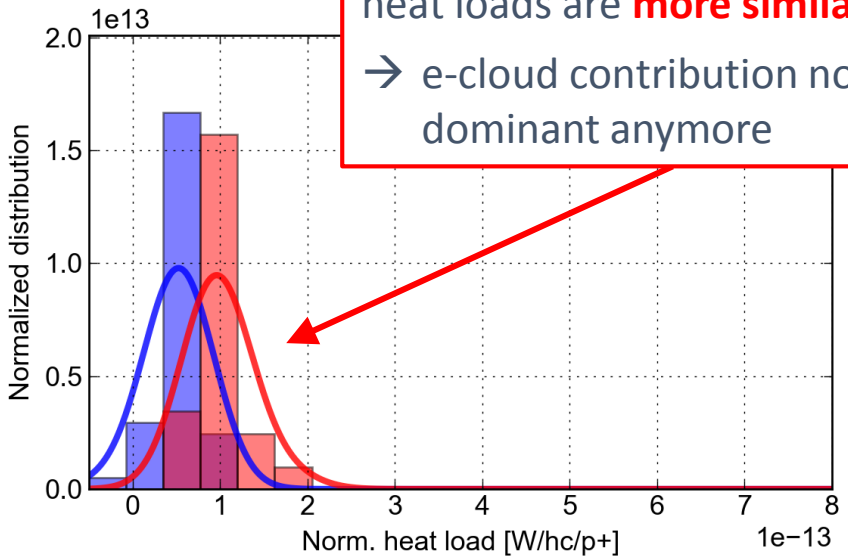
	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S12 (avg) [W]	9.72	142.57
H.L. S12 (std) [W]	4.55	33.44
H.L. exp. imped. [W]	4.33	9.20
H.L. exp. synrad [W]	5.87	12.01
T_nobeam [h]	0.63	2.00

More data on 50 ns test in 2017 can be found here

Cell-by-cell comparison

Reduction of normalized heat load is **observed in all cells**





For **low load sectors** normalized heat loads are **more similar**

→ e-cloud contribution not dominant anymore

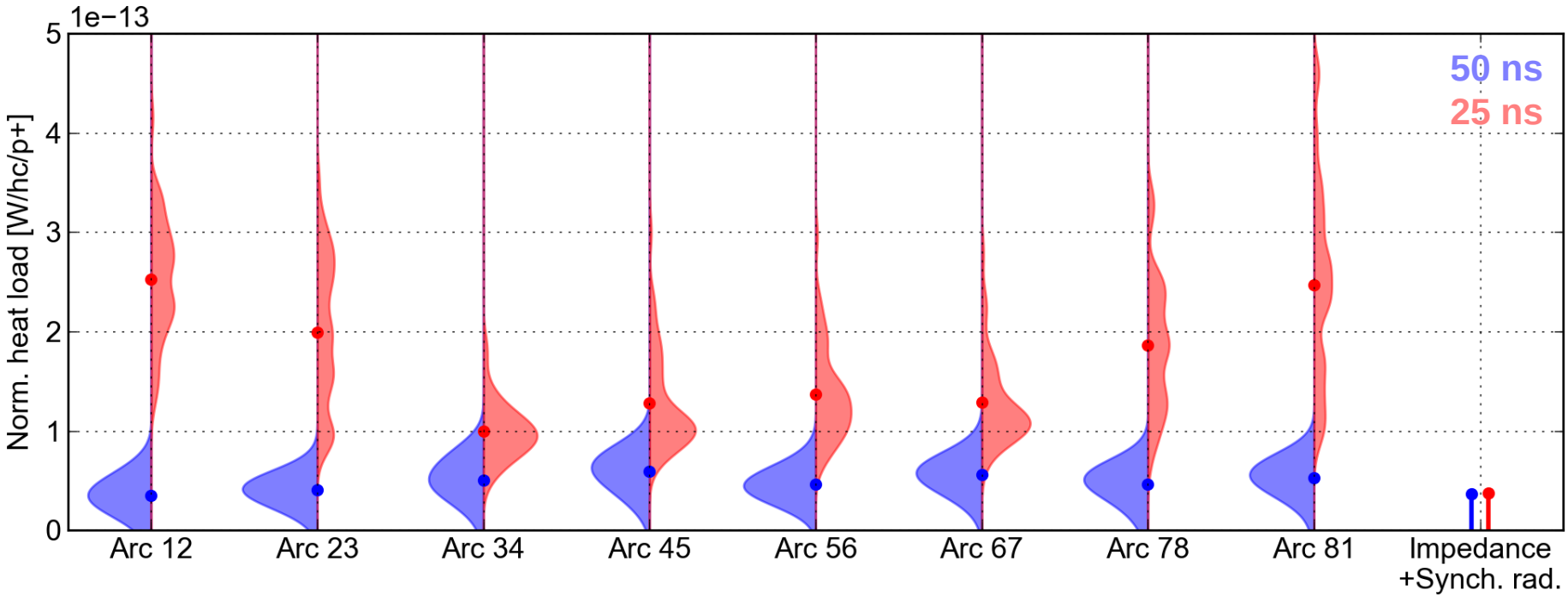
	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S34 (avg) [W]	13.98	56.41
H.L. S34 (std) [W]	6.18	14.79
H.L. exp. imped. [W]	4.33	9.20
H.L. exp. synrad [W]	5.87	12.01
T_nobeam [h]	0.63	2.00

More data on 50 ns test in 2017 can be found here

50 ns vs 25 ns

Looking at full overview with arc-by-arc averages and distributions

- With 50 ns beams averages and distributions are very similar
- Differences in averages and spreads become strong when moving to 25 ns beams



More data on 50 ns test in 2017 can be found here

Summary and conclusions

- In Run 2 large beam induced heat loads are measured in the LHC arcs when operating with 25 ns beams. In these conditions, large differences are observed among the arcs.

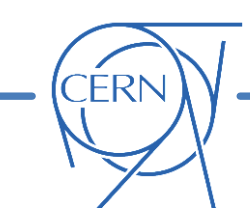
- Analysis of 2012 data collected with 25 ns beams showed that:
  - Difference between sectors was not present before LS1
  - At that time heat loads in sectors 12, 23, 78 and 81 were significantly lower compared to present values

- Deconditioning was observed after the thermal cycle of S12 in the EYETS (2016-17)
  - ~4 days of scrubbing were sufficient to recover the end-2016 conditions
  - No evolution observed thereafter (important info for planning future scrubbing runs)
  - Three days of scrubbing with trains of 288b had no impact on heat load levels nor on the difference between sectors (impossible to get back to 2012 levels)

Summary and conclusions

- Analysis of fills with different bunch pattern show that the difference in heat load is observed only in with 25 ns bunch spacing → useful to exclude impedance heating as a possible source of the heat load differences (see talk by Benoit and Francesco)

- Instrumentation installed in cell 31L2 during the EYETS is providing extremely interesting data:
  - The exchanged dipole conditioned extremely rapidly
  - Other dipoles in the cell (unchanged) show significantly larger heat loads (up to a factor of 10!) → we finally got a “bad magnet” under our spotlight
  - Heat load differences between sectors/cells are most likely caused by magnets behaving similarly to these → Analysis of these high load magnets (beam screens) could provide important information on the causes of observed differences (LS2?)



Thanks for your attention

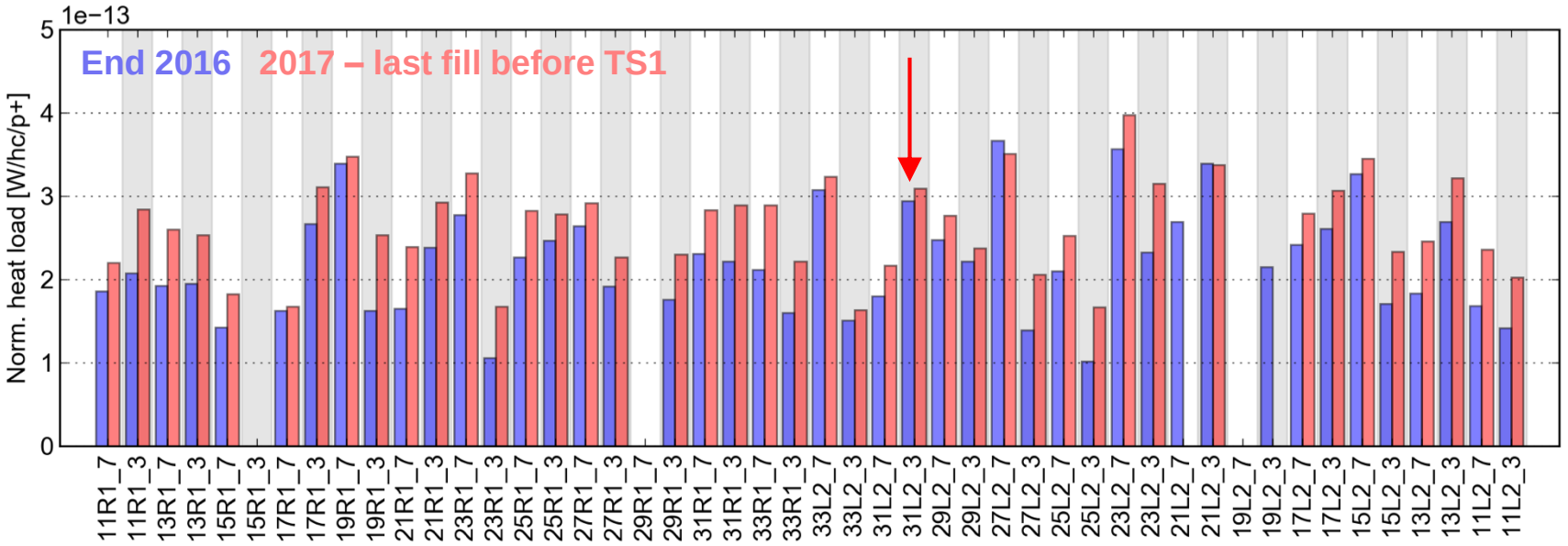
Additional material

What about the dipole that was taken out?

- No magnet-by-magnet diagnostics in 31L2 before the EYETS but:
  - **Total cell heat load** measured now is **extremely similar to end-2016 values**
  - Other cells show that **other magnets have practically recovered** the end-2016 conditioning state

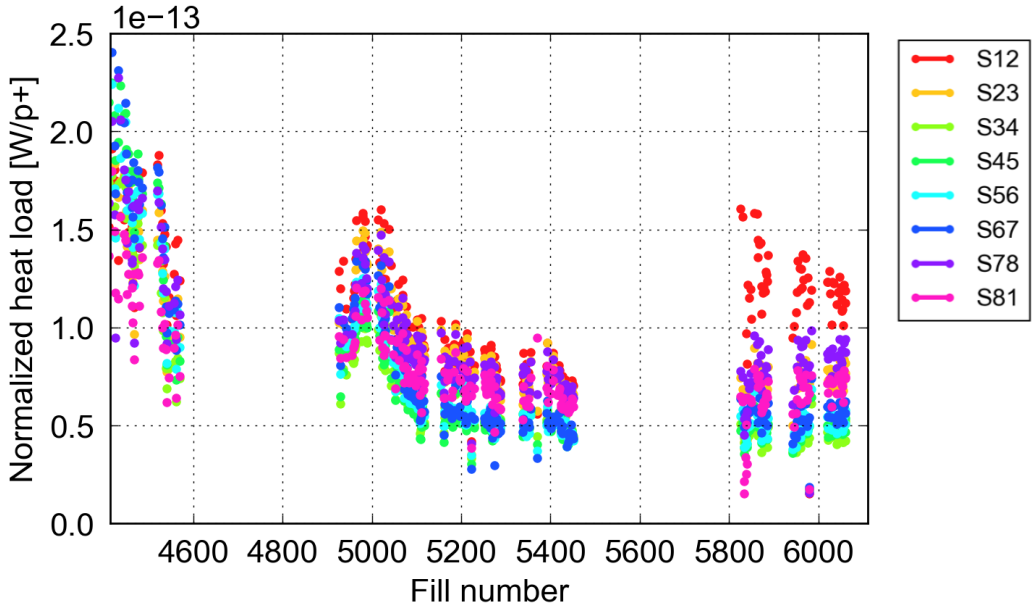
→ This means that the **old magnet was behaving similarly to the newly installed one**

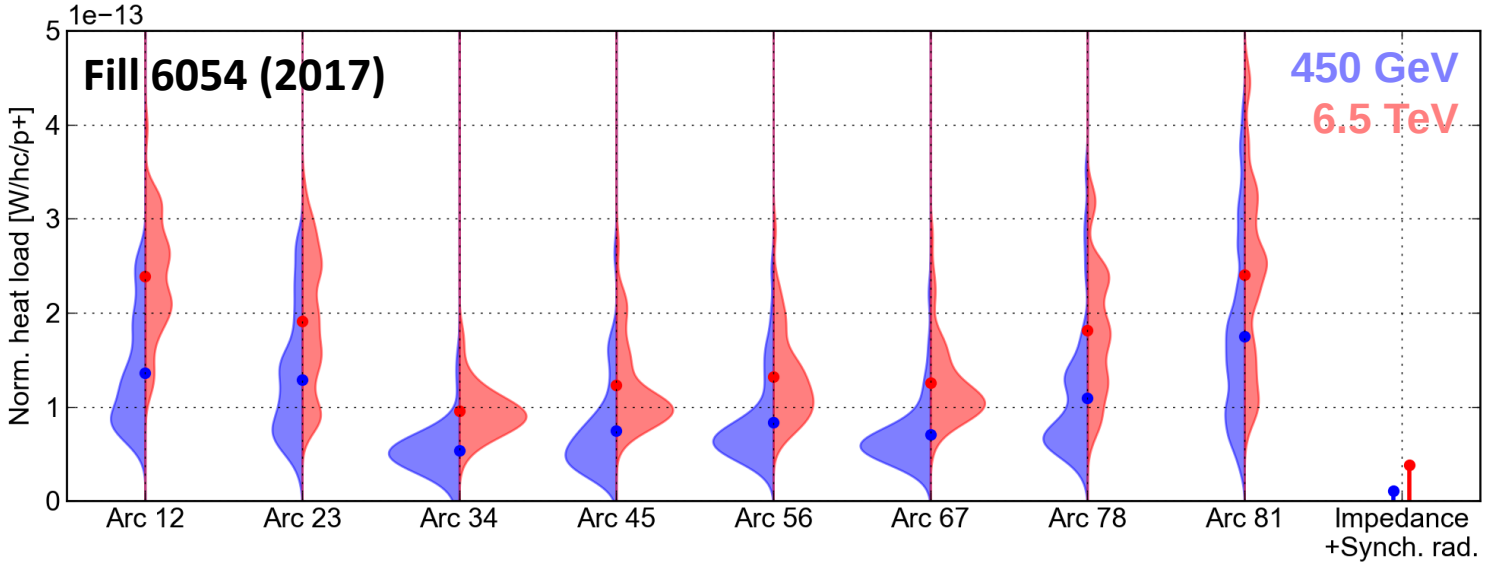
→ **The extracted magnet was a low-load magnet** (consistent with the fact that no issue was revealed by the lab analysis by TE-VSC)



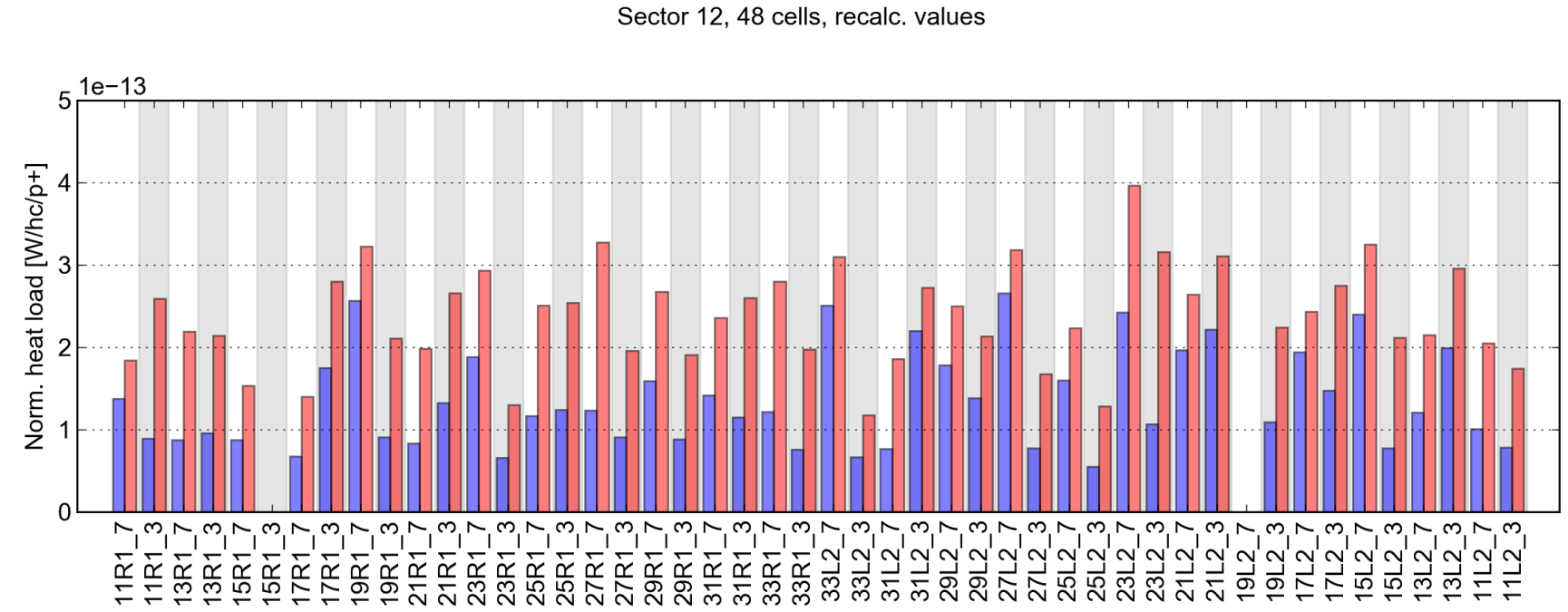
Detailed analysis of effect of energy

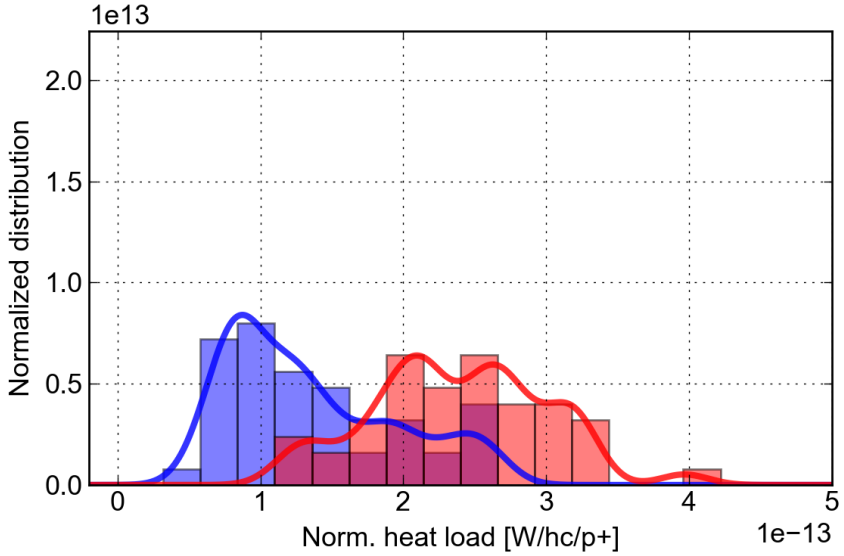
Heat load increase during the energy ramp





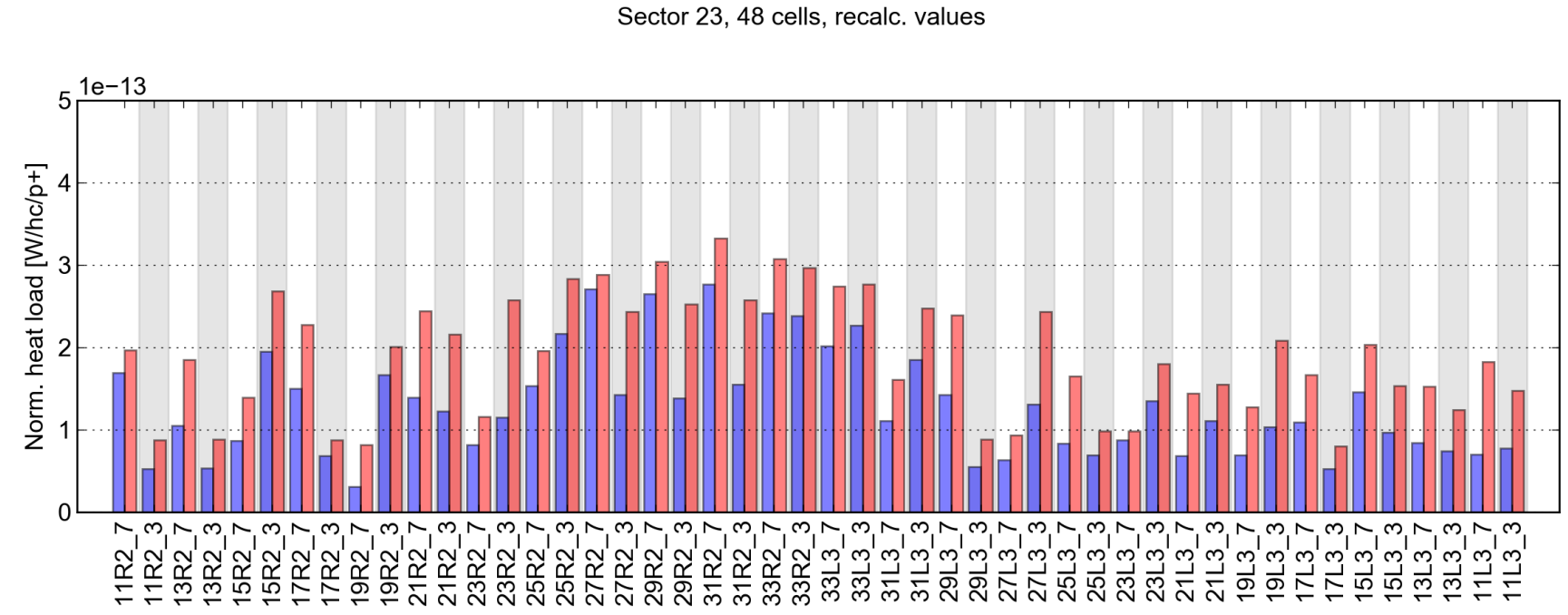
Detailed analysis of effect of energy

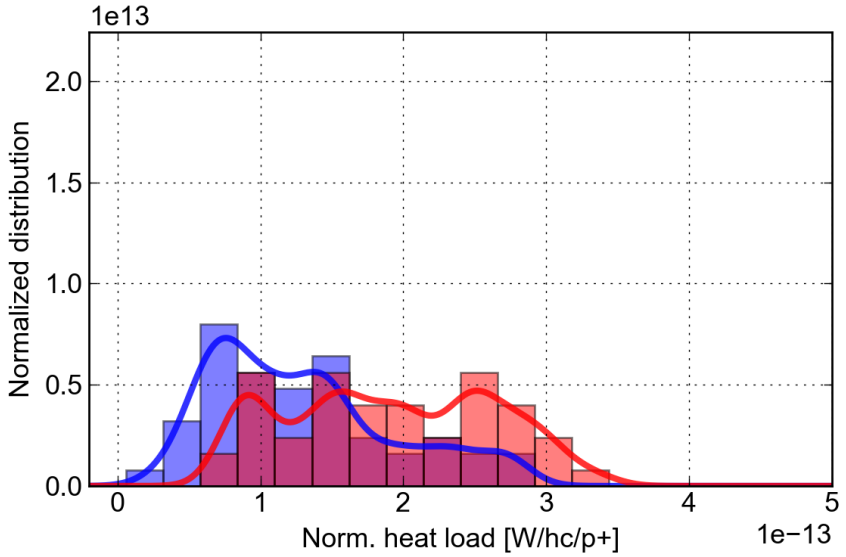




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S12 (avg) [W]	81.17	141.41
H.L. S12 (std) [W]	35.16	35.93
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

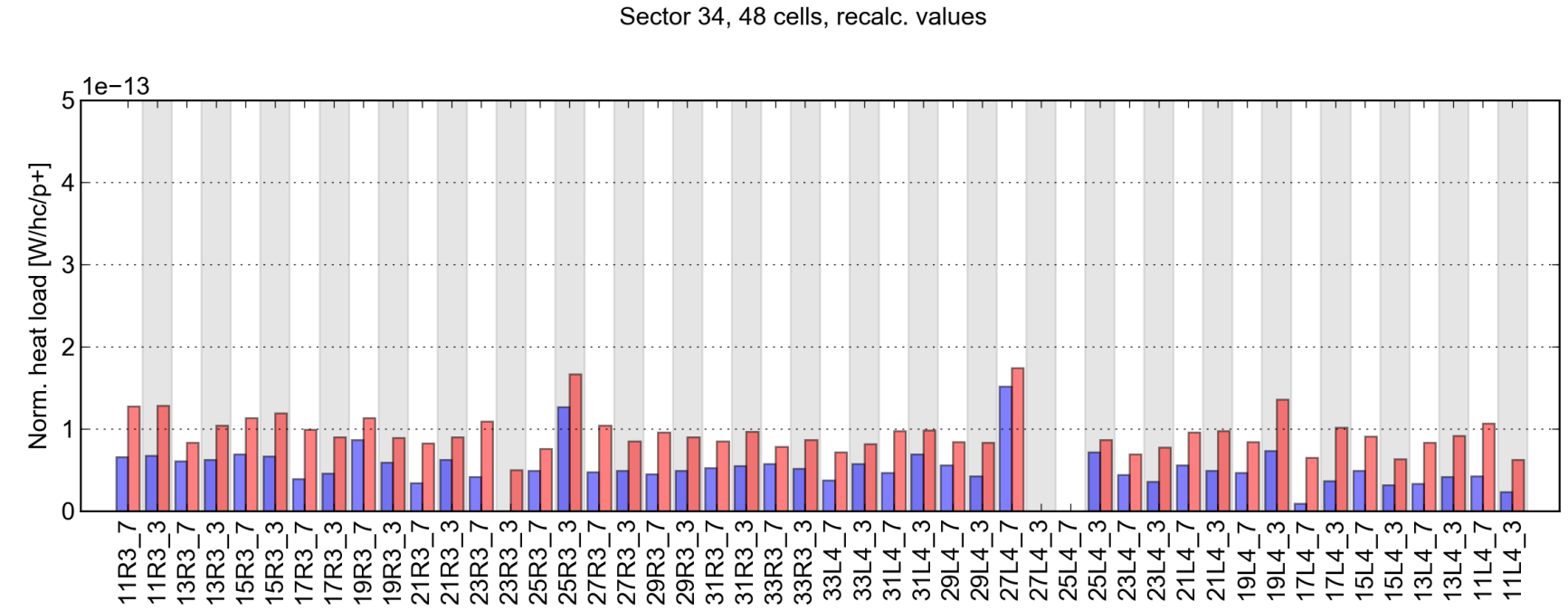
Detailed analysis of effect of energy

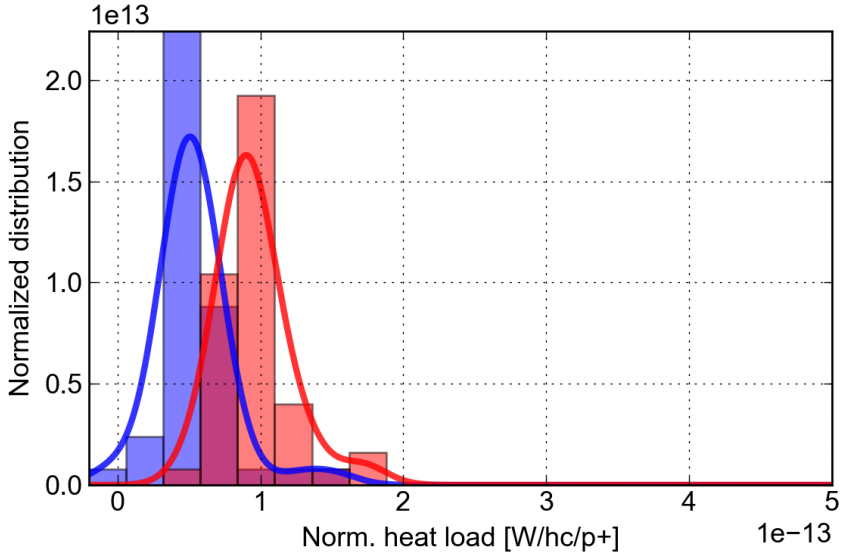




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S23 (avg) [W]	77.13	113.26
H.L. S23 (std) [W]	37.97	42.34
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

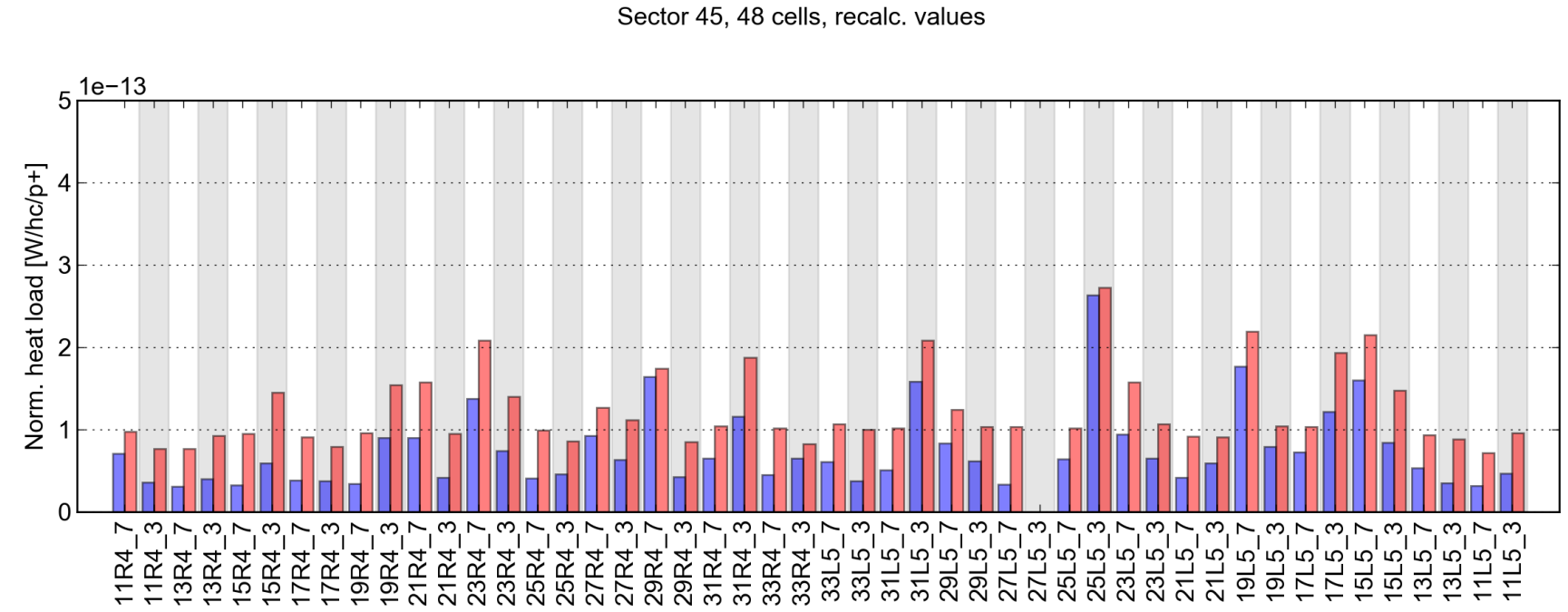
Detailed analysis of effect of energy

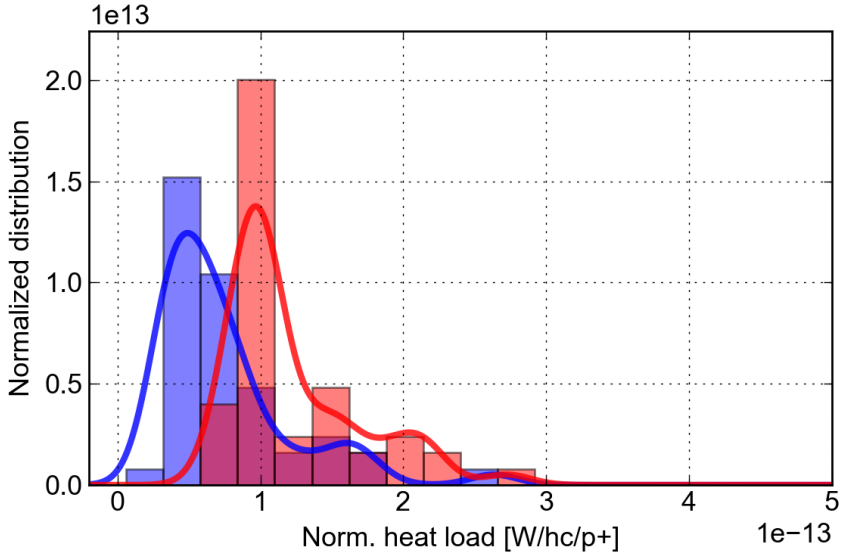




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S34 (avg) [W]	31.92	56.42
H.L. S34 (std) [W]	14.70	14.01
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

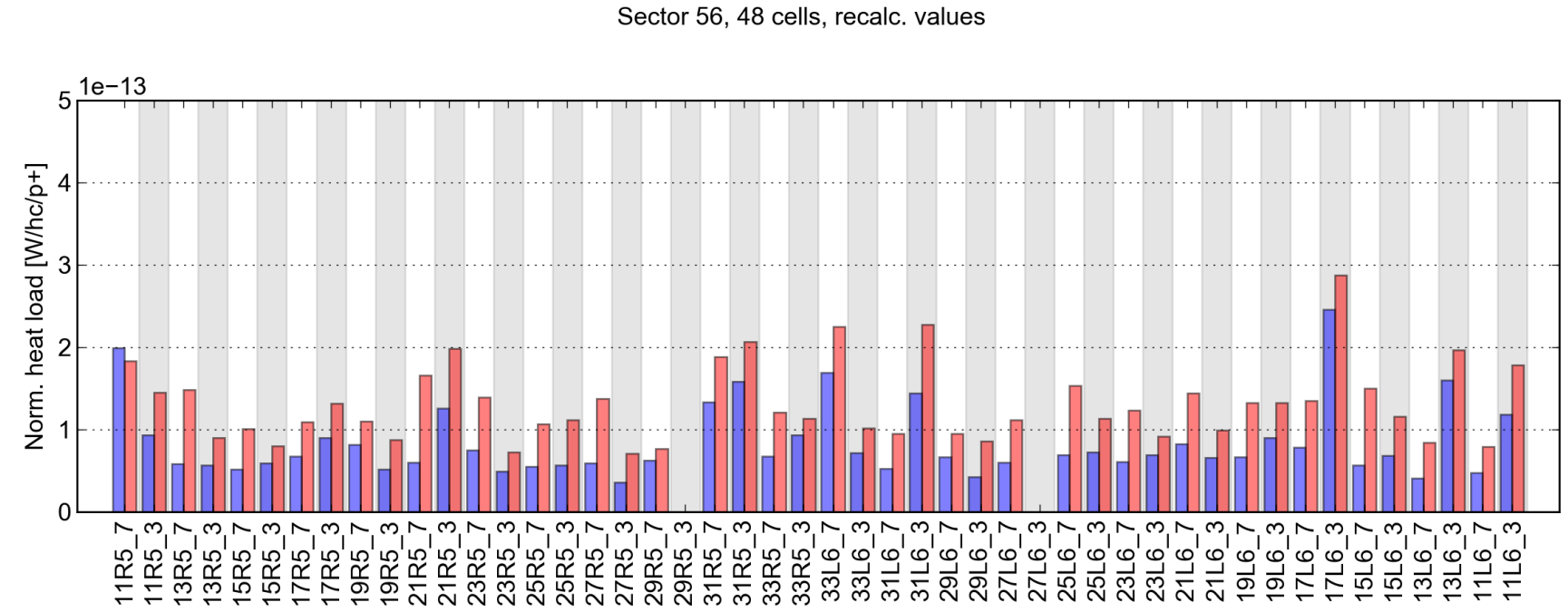
Detailed analysis of effect of energy

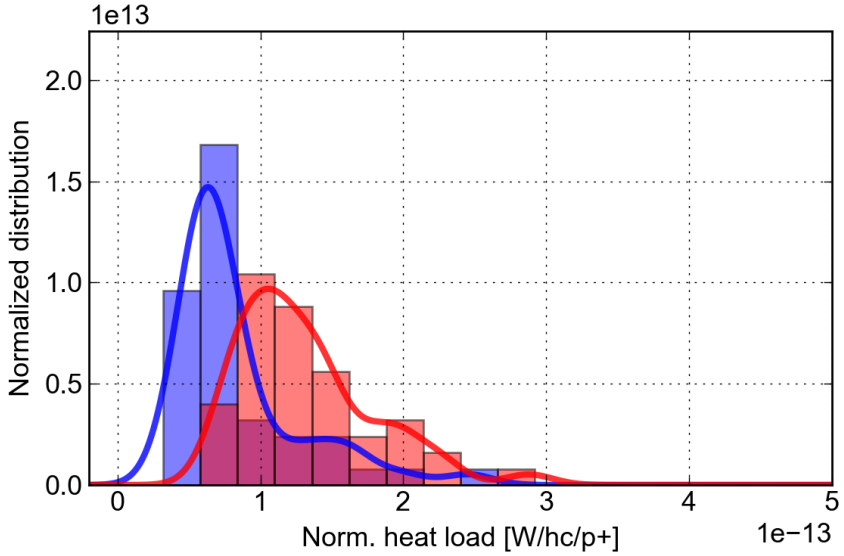




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S45 (avg) [W]	44.48	72.78
H.L. S45 (std) [W]	28.07	27.19
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

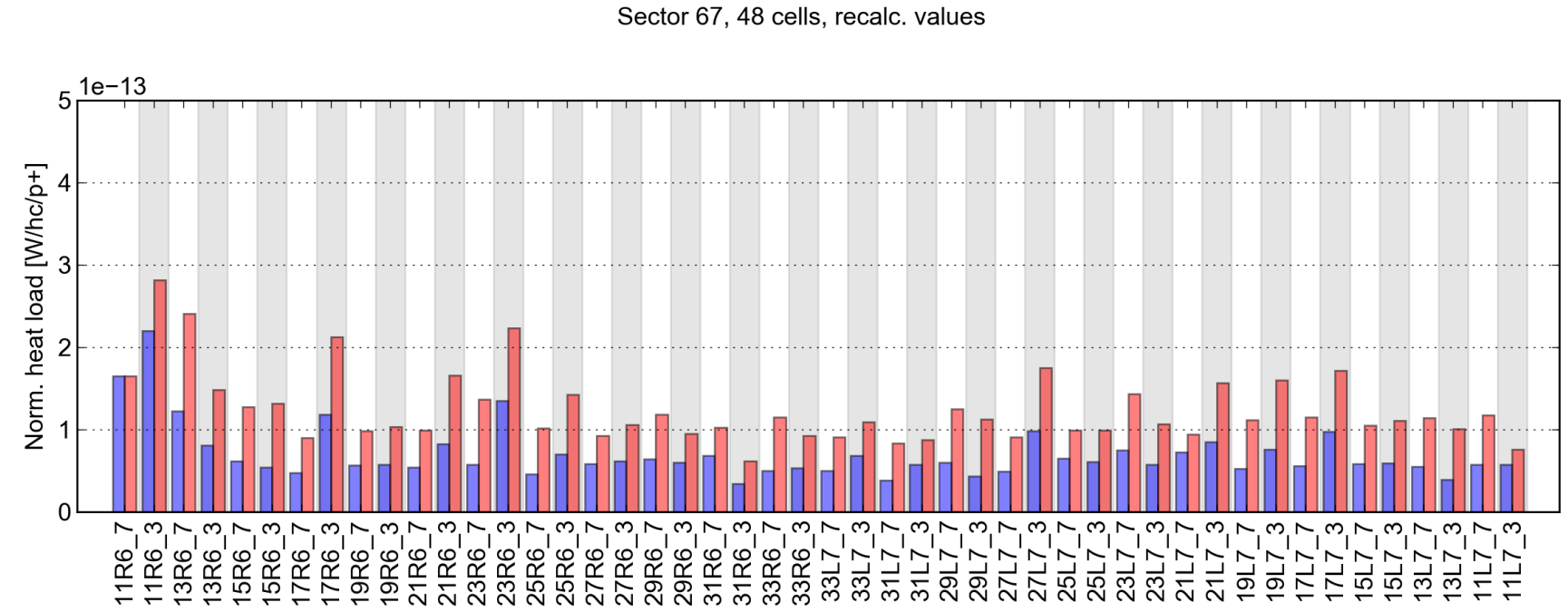
Detailed analysis of effect of energy

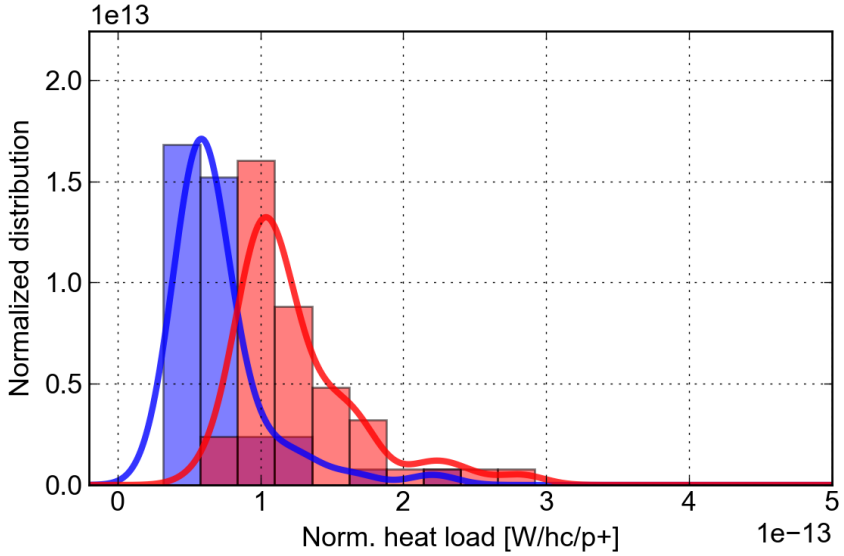




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S56 (avg) [W]	50.07	78.12
H.L. S56 (std) [W]	26.13	27.83
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

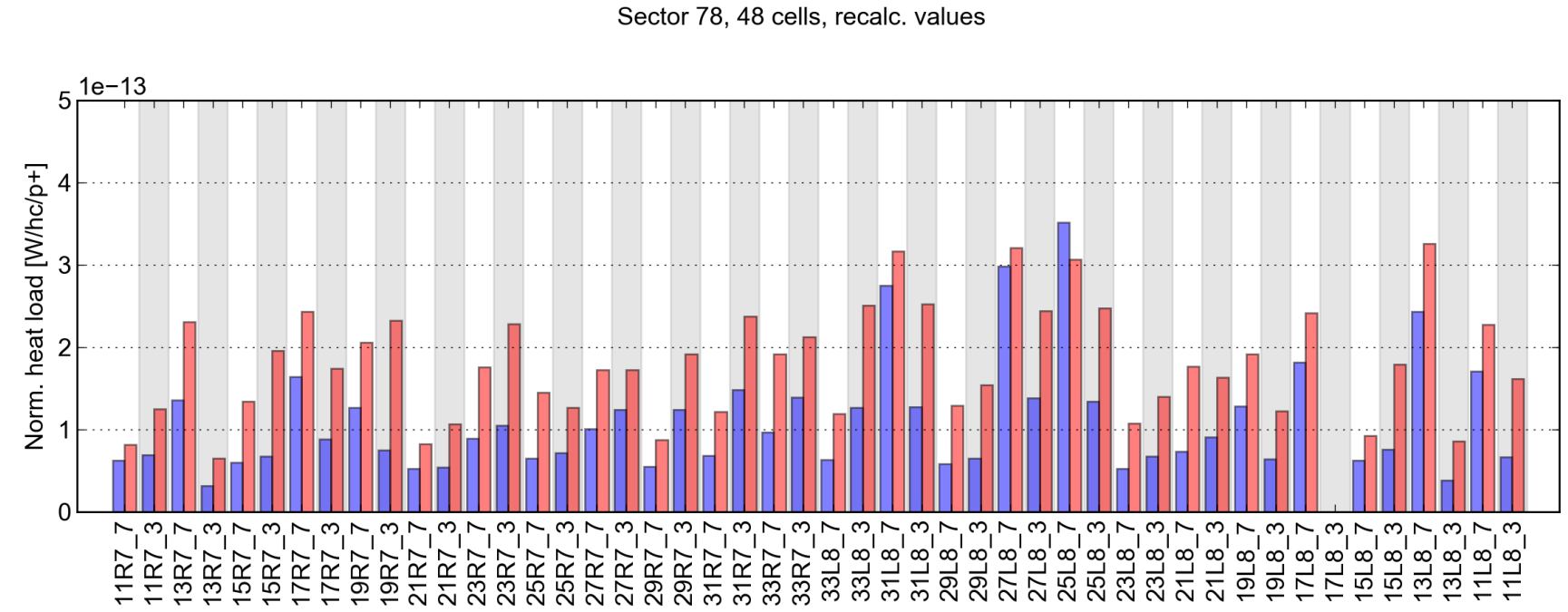
Detailed analysis of effect of energy

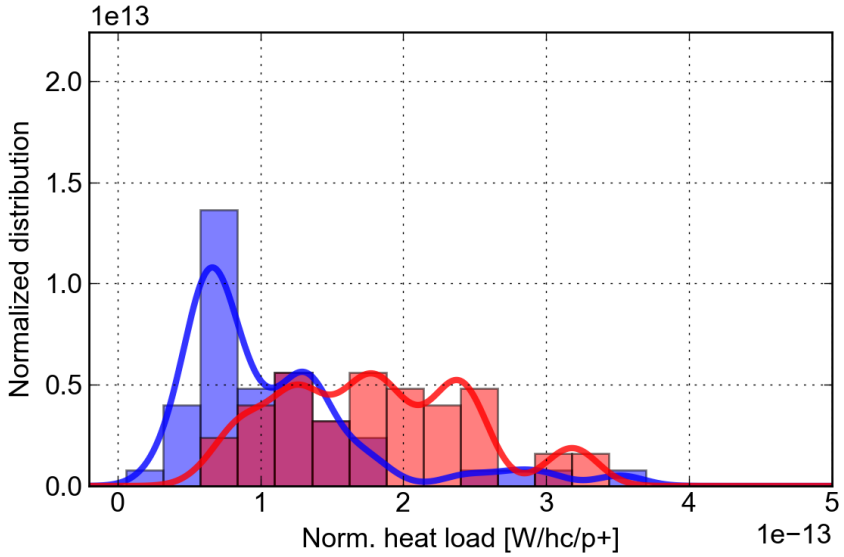




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S67 (avg) [W]	42.11	74.30
H.L. S67 (std) [W]	19.81	25.80
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

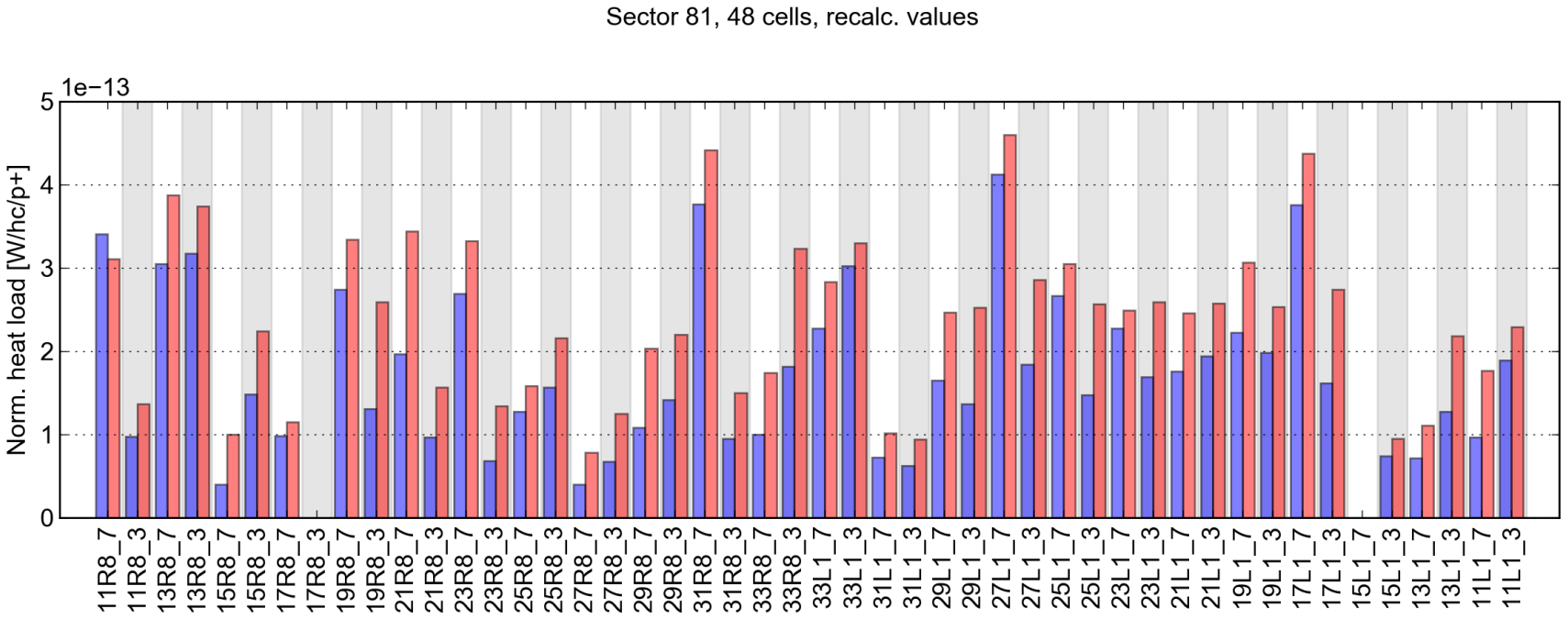
Detailed analysis of effect of energy

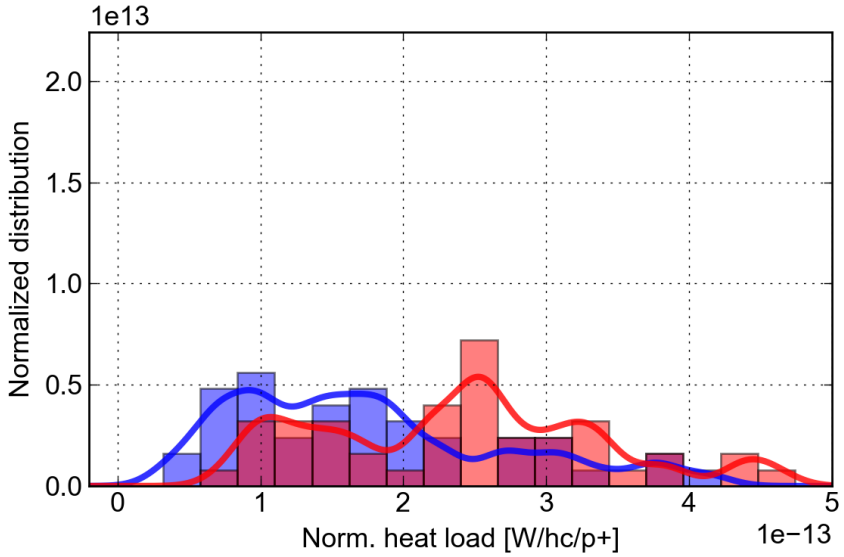




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S78 (avg) [W]	65.35	107.25
H.L. S78 (std) [W]	40.31	39.74
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

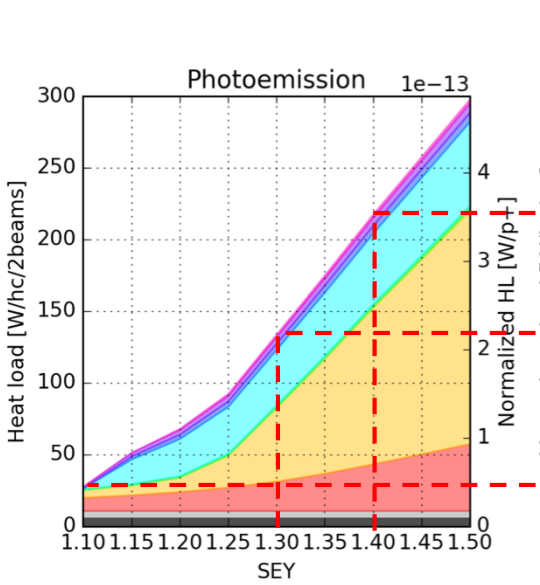
Detailed analysis of effect of energy

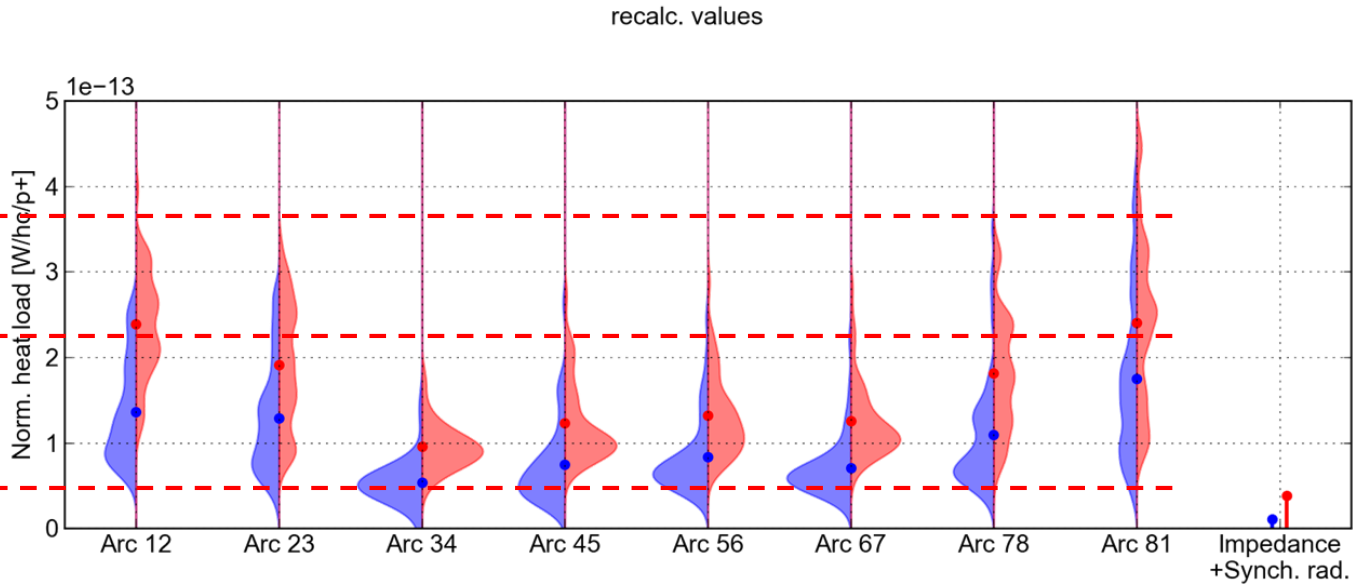


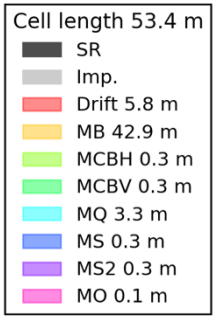


Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. S81 (avg) [W]	104.51	142.17
H.L. S81 (std) [W]	56.33	57.88
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
T_nobeam [h]	1.90	1.90

Comparison against simulations

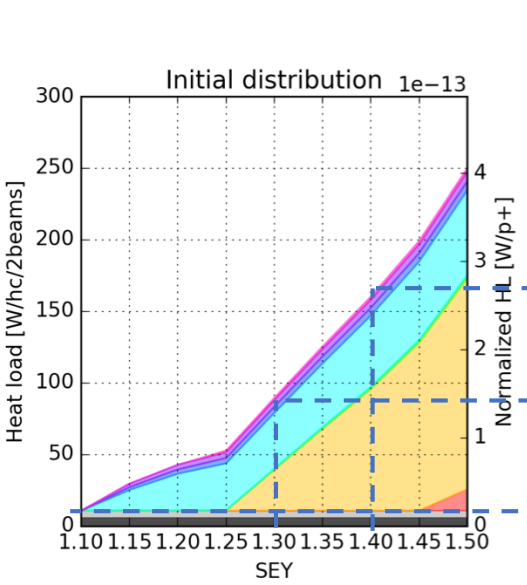


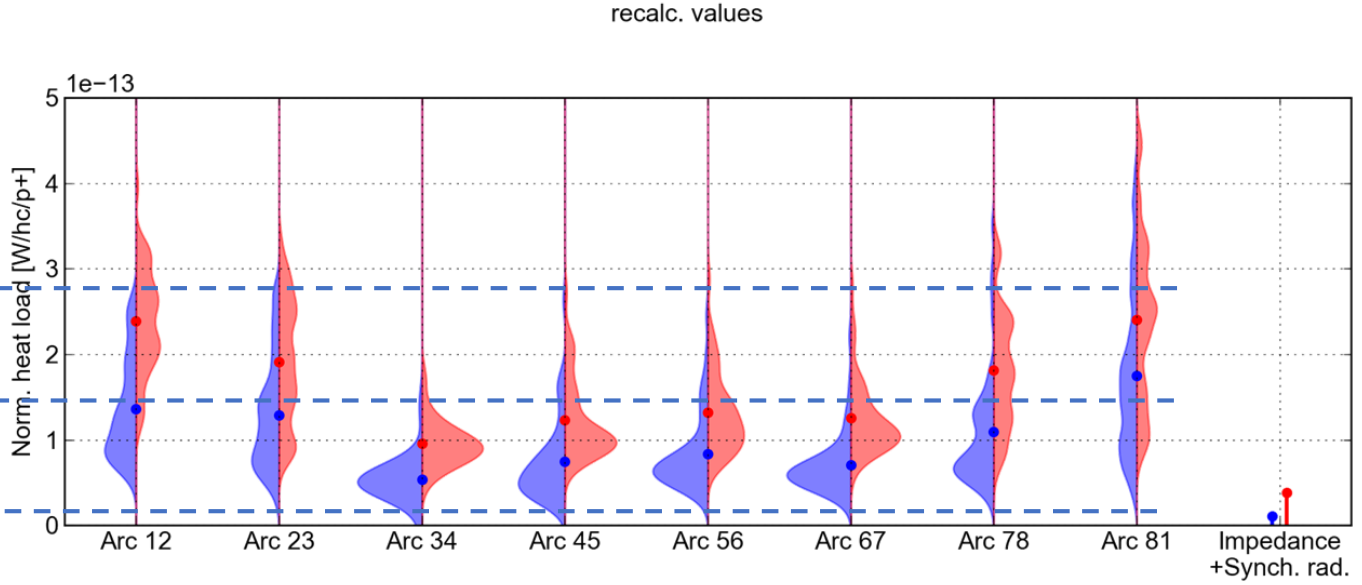


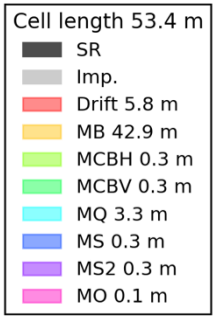


Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
H.L. exp. imp.+SR [W/p+]	1.08e-14	3.84e-14
T_nobeam [h]	1.90	1.90

Comparison against simulations



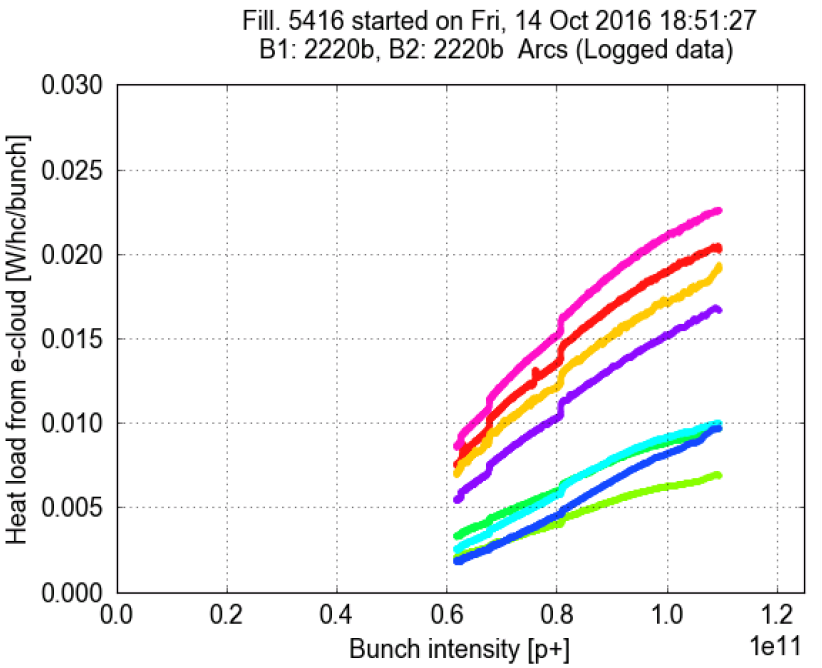




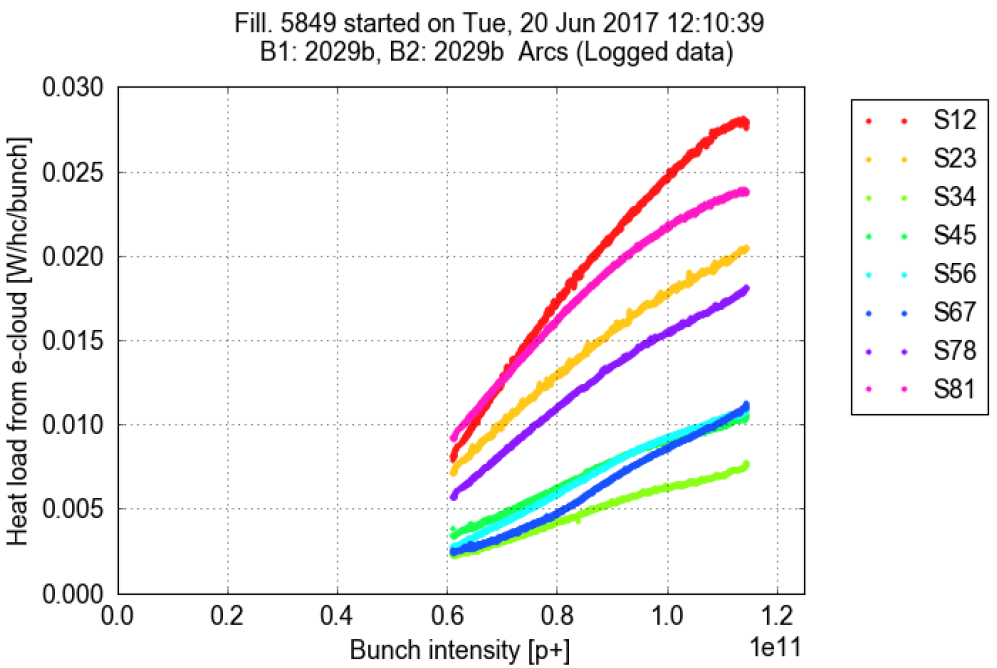
Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	2.58	3.10
Energy [GeV]	450	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.94e14/3.03e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.27/1.29	1.07/1.07
H.L. exp. imped. [W]	6.47	10.15
H.L. exp. synrad [W]	0.00	12.61
H.L. exp. imp.+SR [W/p+]	1.08e-14	3.84e-14
T_nobeam [h]	1.90	1.90

Dependence on bunch intensity from long fills

End 2016



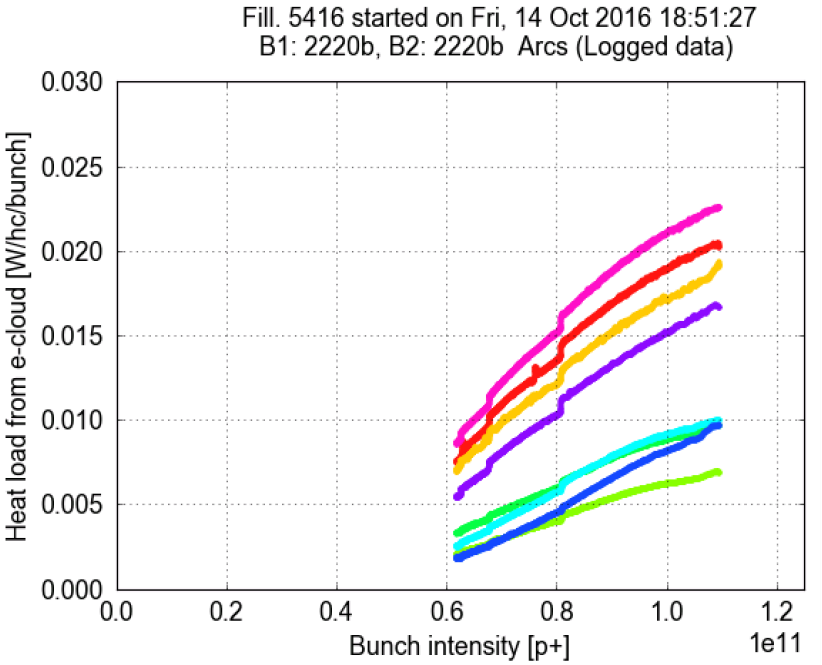
2017 (20/06)



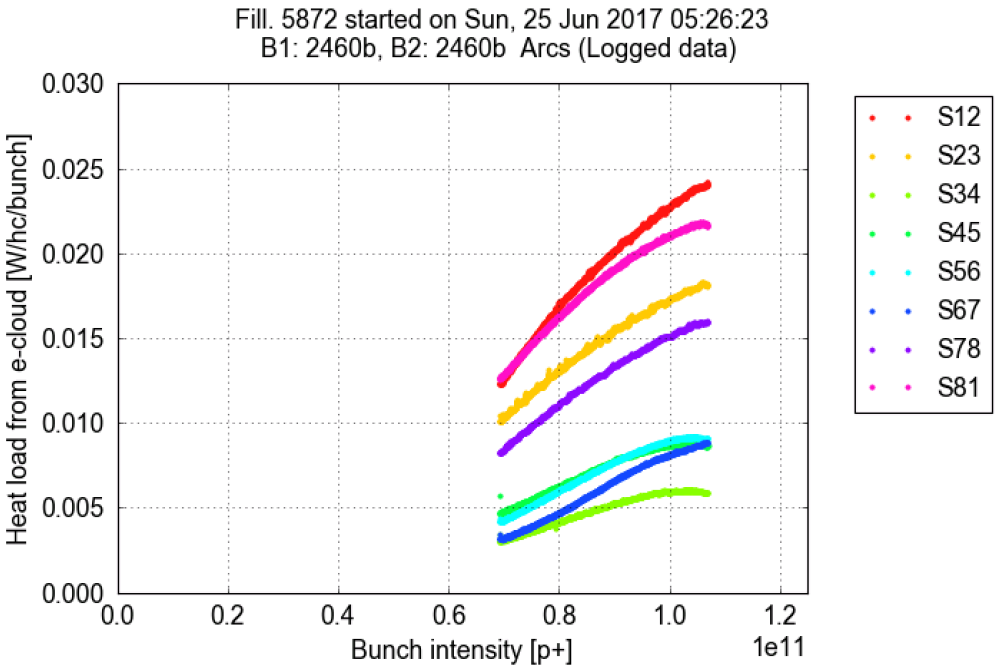
- Effect of **deconditioning visible mainly for high bunch intensity**

Dependence on bunch intensity from long fills

End 2016



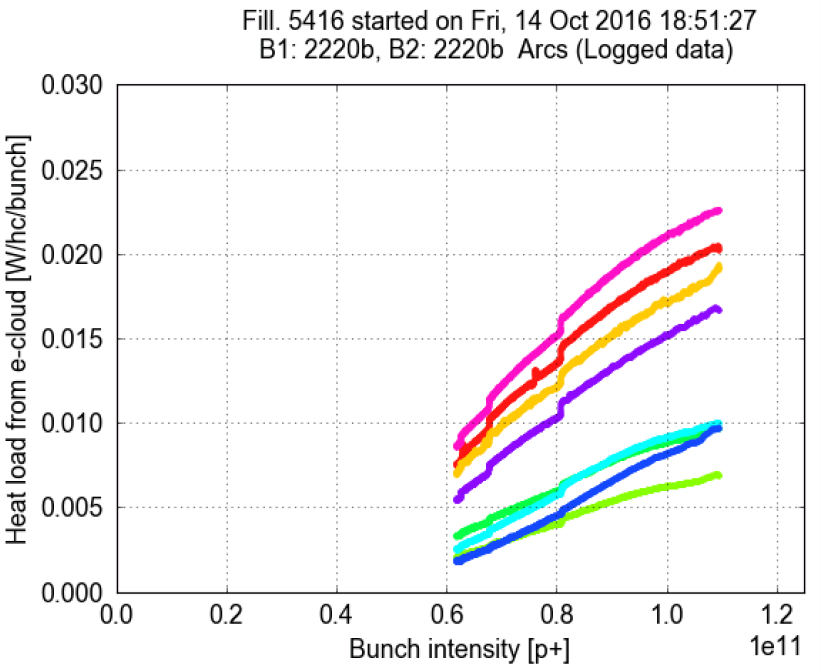
2017 (25/06)



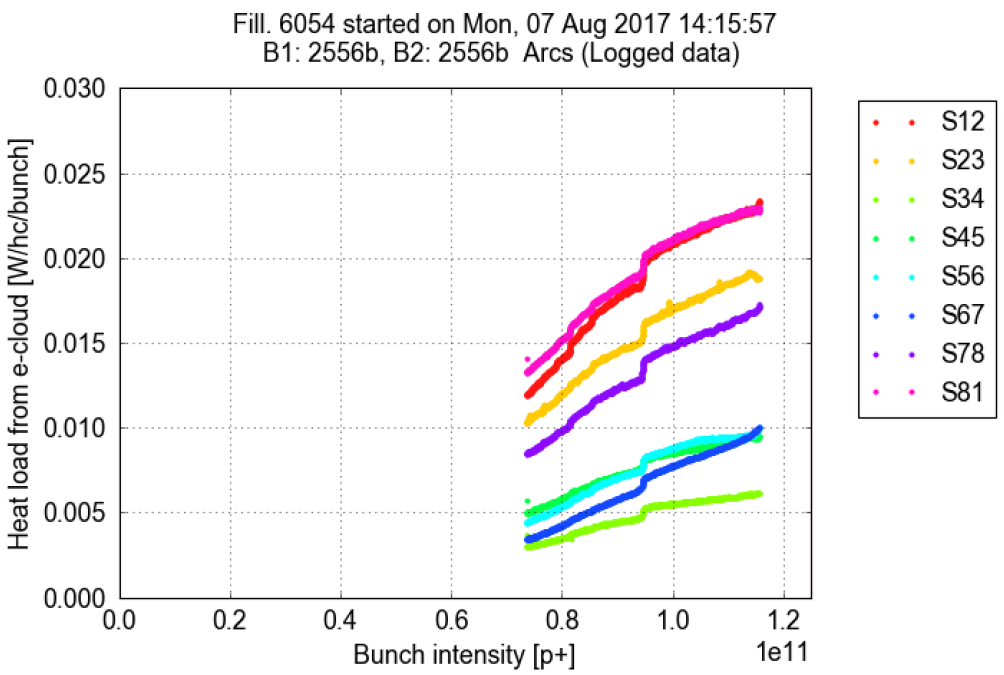
- Effect of **deconditioning visible mainly for high bunch intensity**

Dependence on bunch intensity from long fills

End 2016

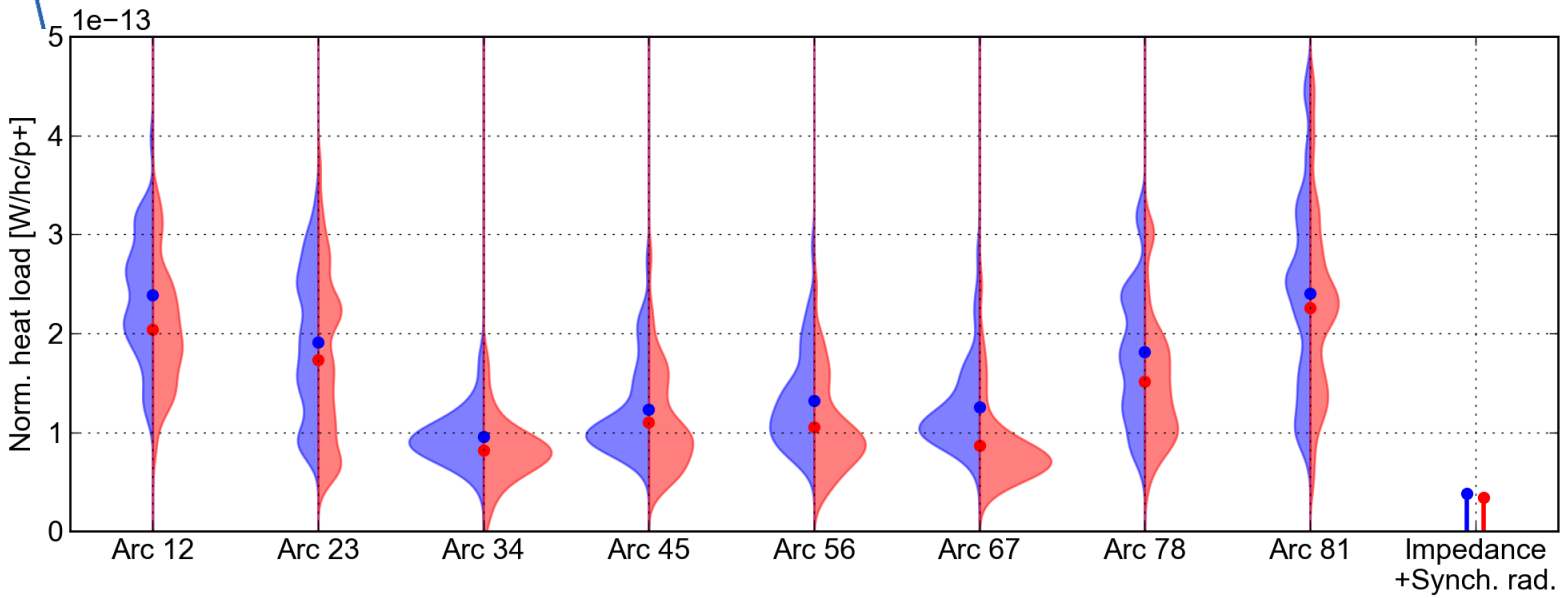


2017 (07/08)



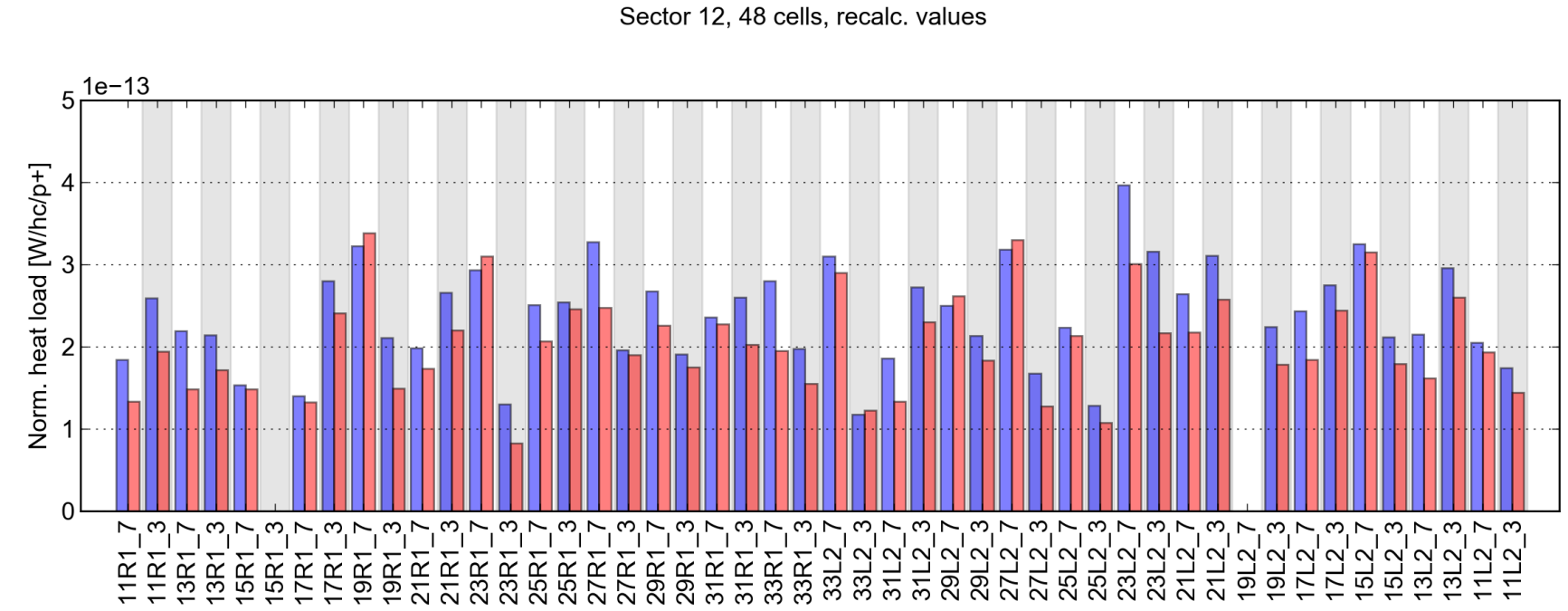
- Effect of **deconditioning visible mainly for high bunch intensity**

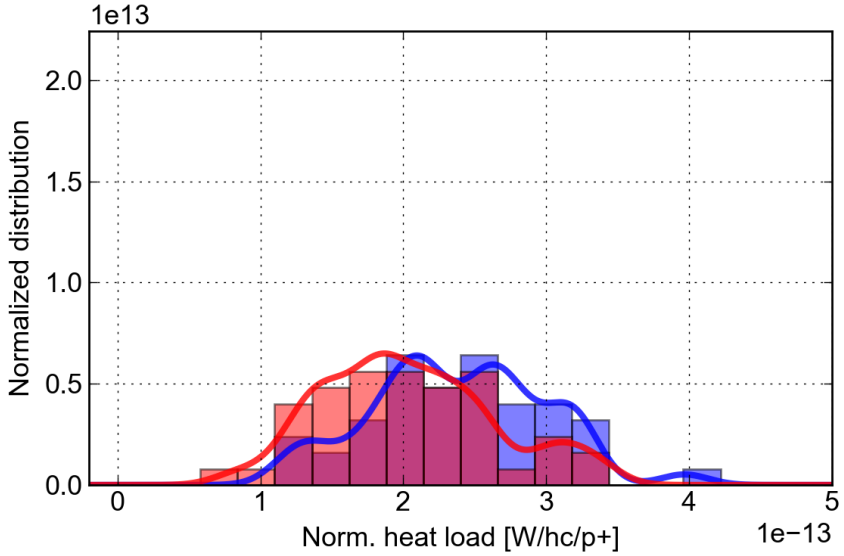
Detailed analysis of the effect of burn-off on heat loads



Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
H.L. exp. imp.+SR [W/p+]	3.84e-14	3.43e-14
T_nobeam [h]	1.90	1.90

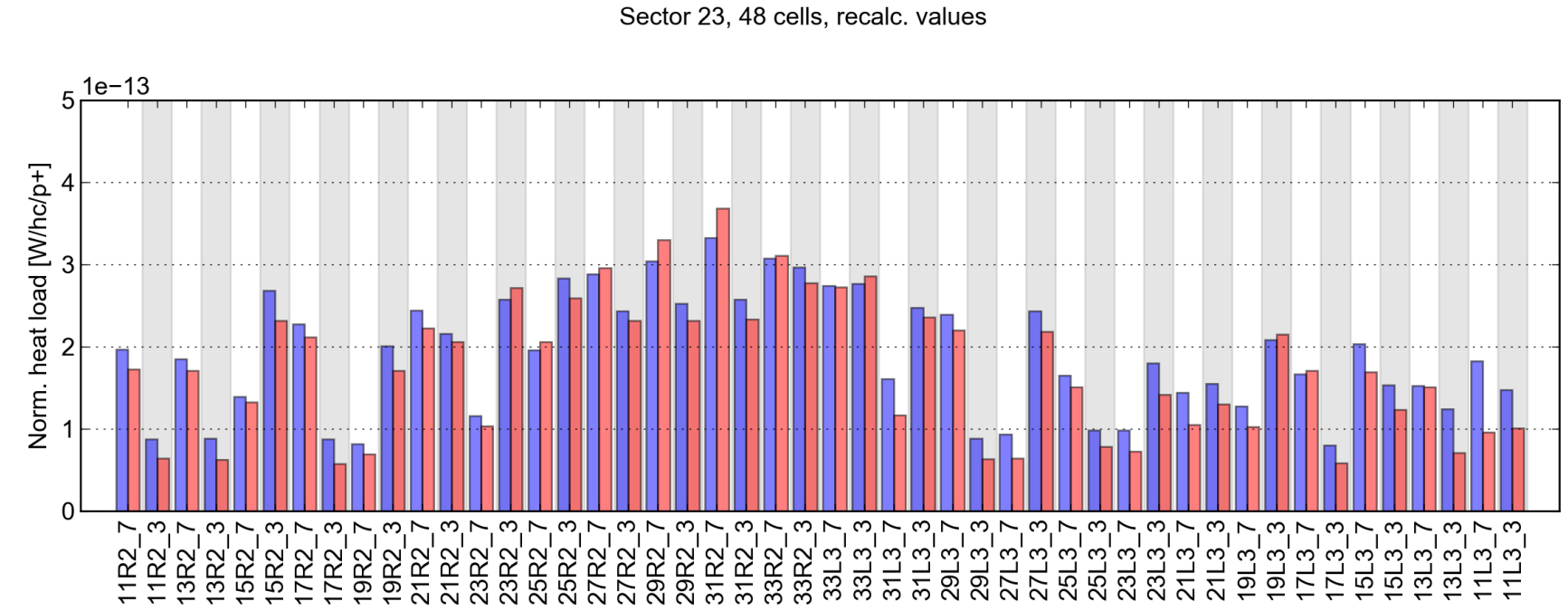
Detailed analysis of the effect of burn-off on heat loads

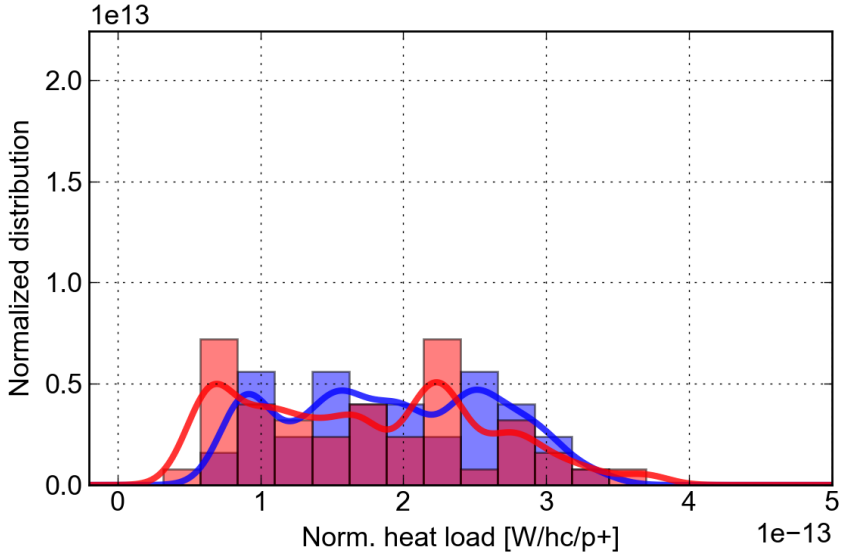




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S12 (avg) [W]	141.41	79.38
H.L. S12 (std) [W]	35.93	23.42
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

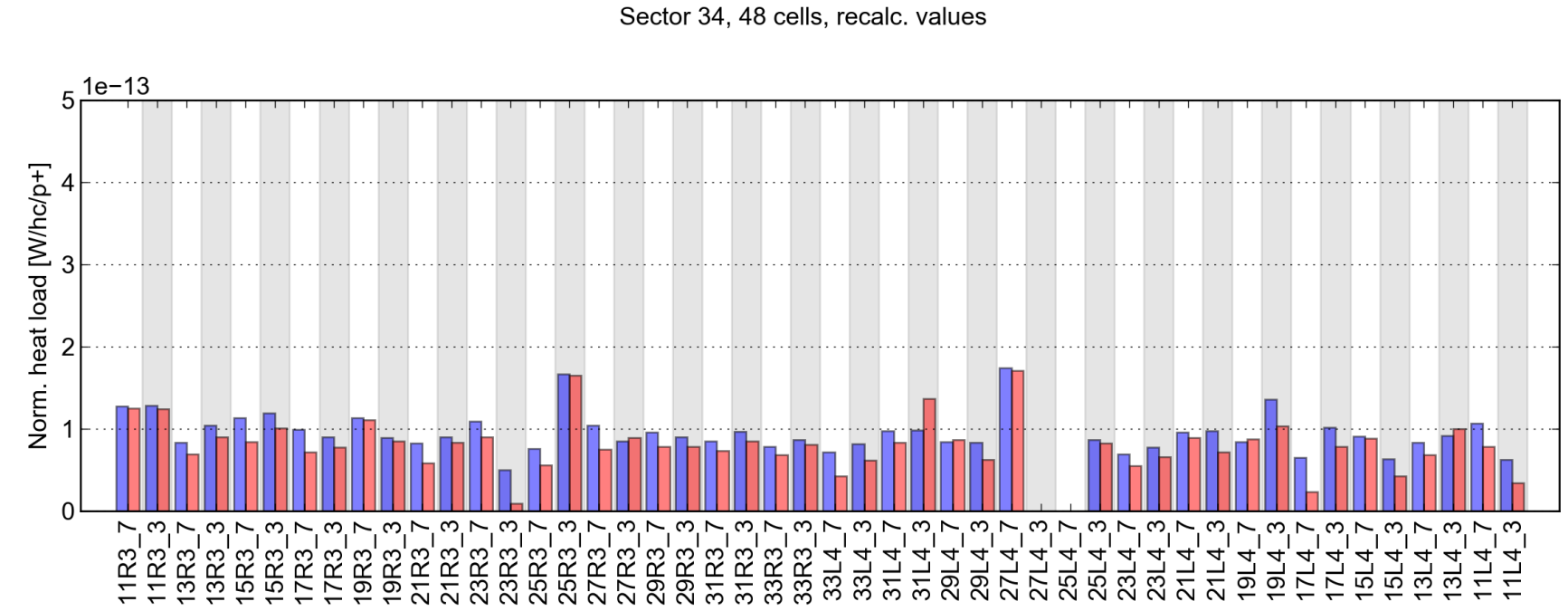
Detailed analysis of the effect of burn-off on heat loads

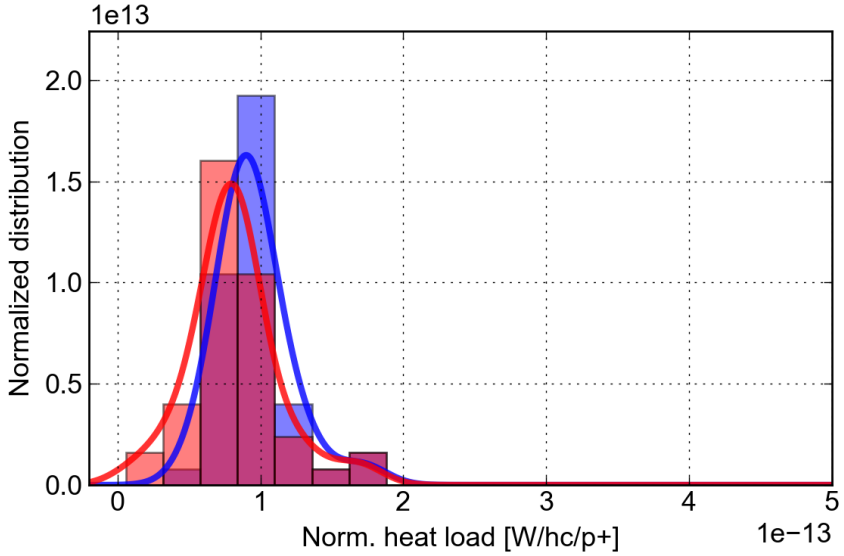




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S23 (avg) [W]	113.26	67.50
H.L. S23 (std) [W]	42.34	32.20
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

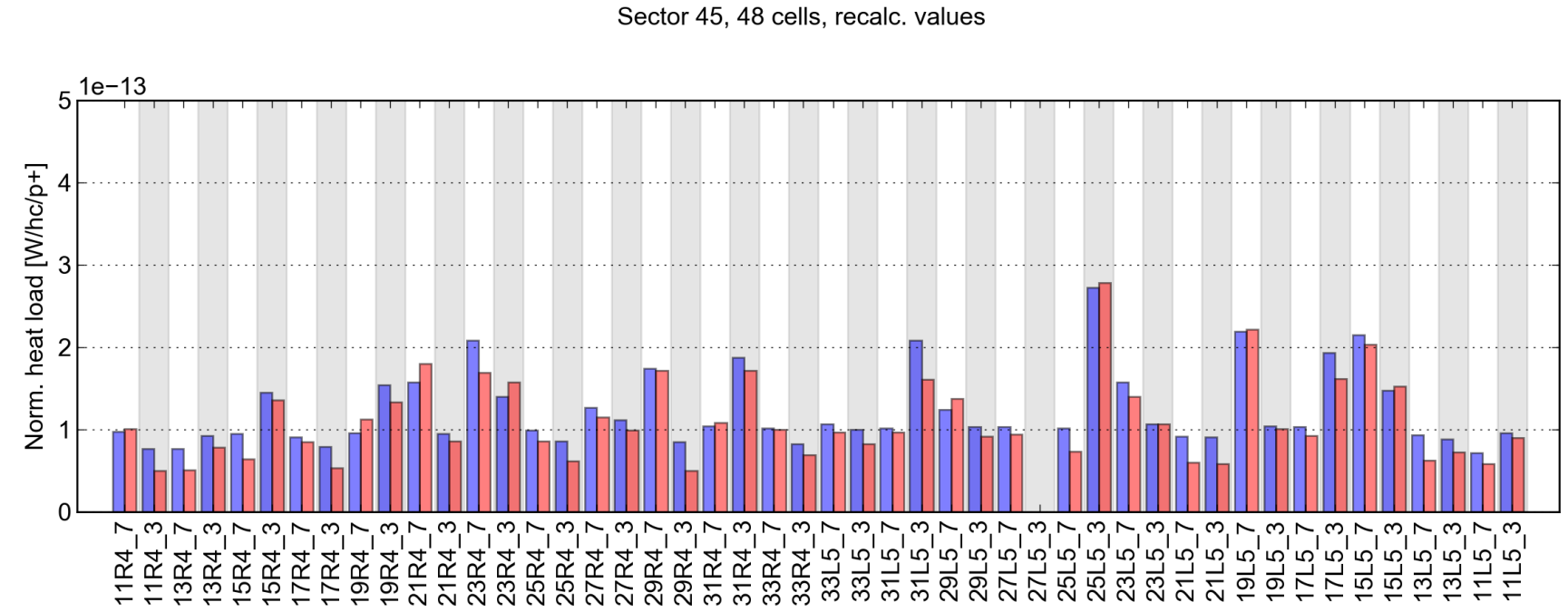
Detailed analysis of the effect of burn-off on heat loads

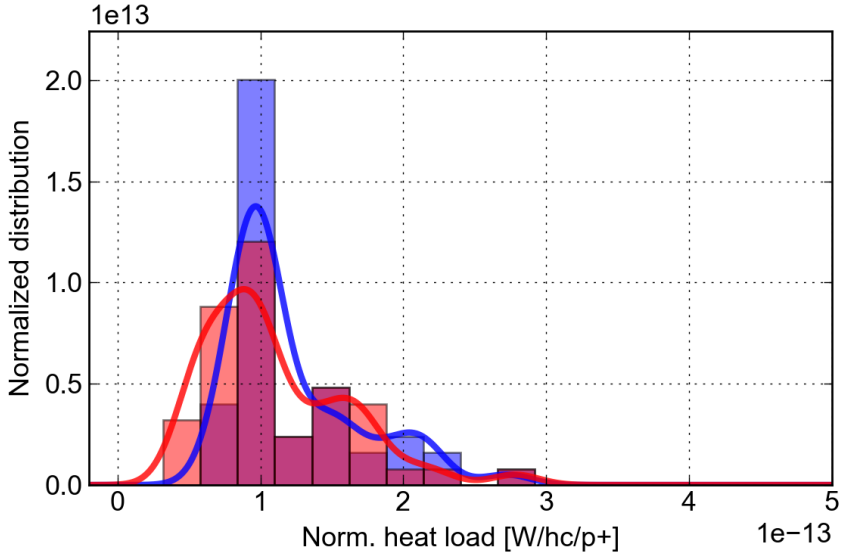




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S34 (avg) [W]	56.42	31.79
H.L. S34 (std) [W]	14.01	11.73
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

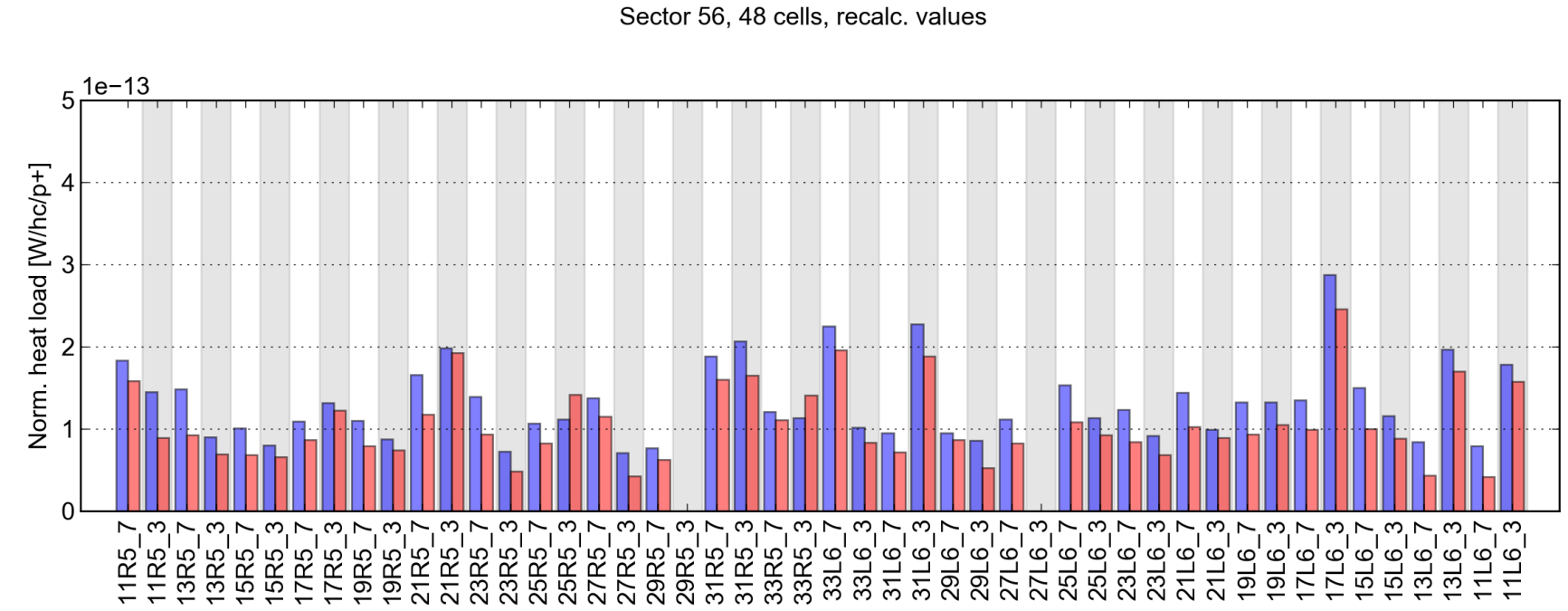
Detailed analysis of the effect of burn-off on heat loads

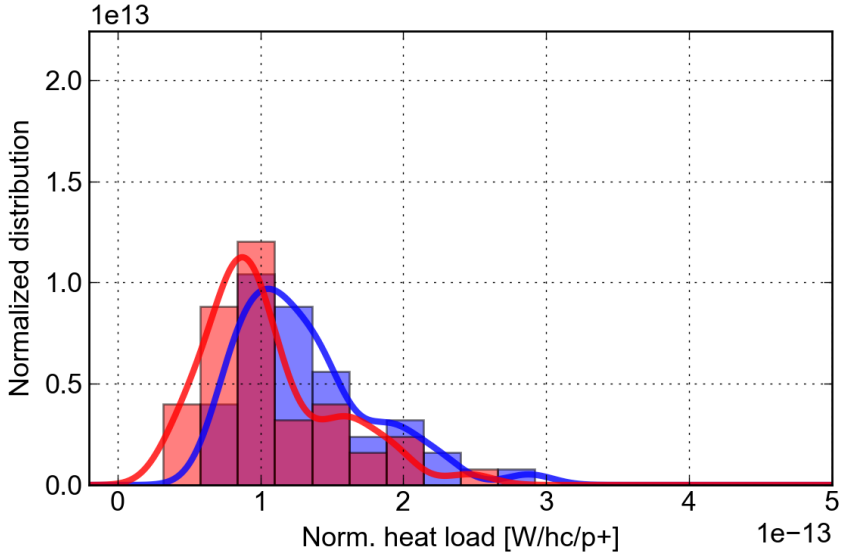




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S45 (avg) [W]	72.78	43.04
H.L. S45 (std) [W]	27.19	19.34
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

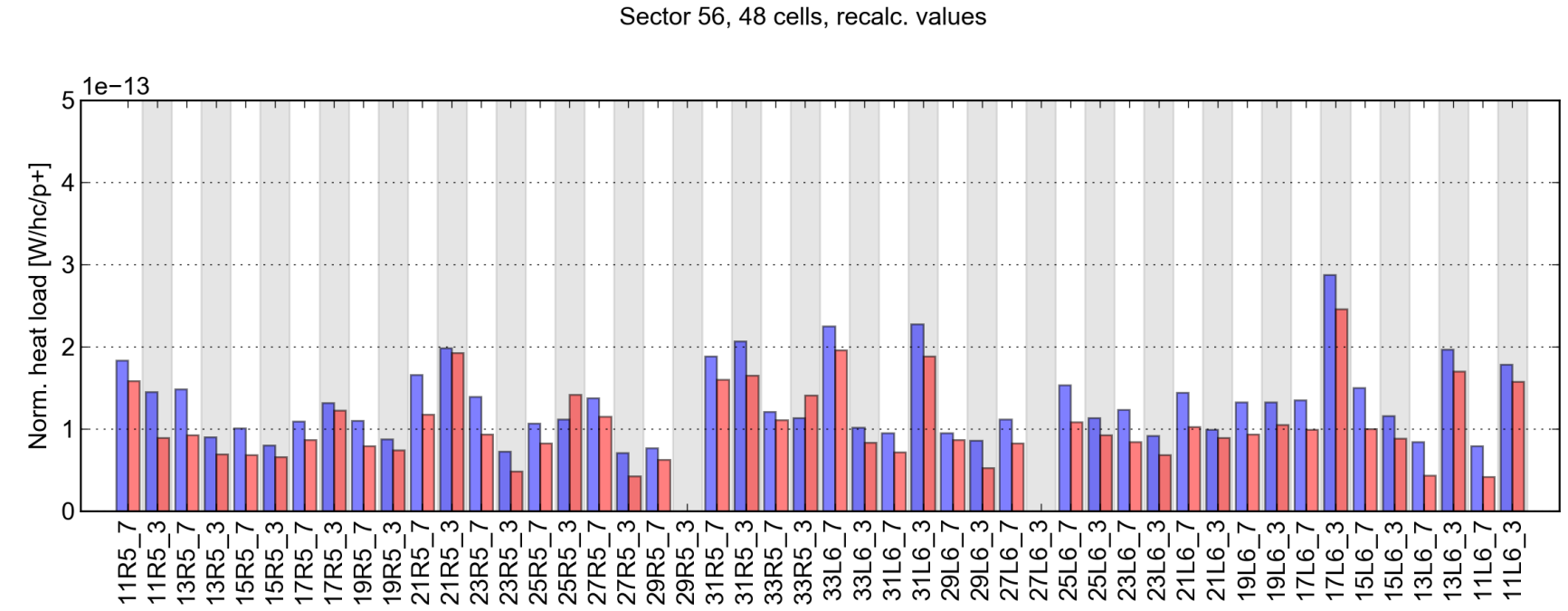
Detailed analysis of the effect of burn-off on heat loads

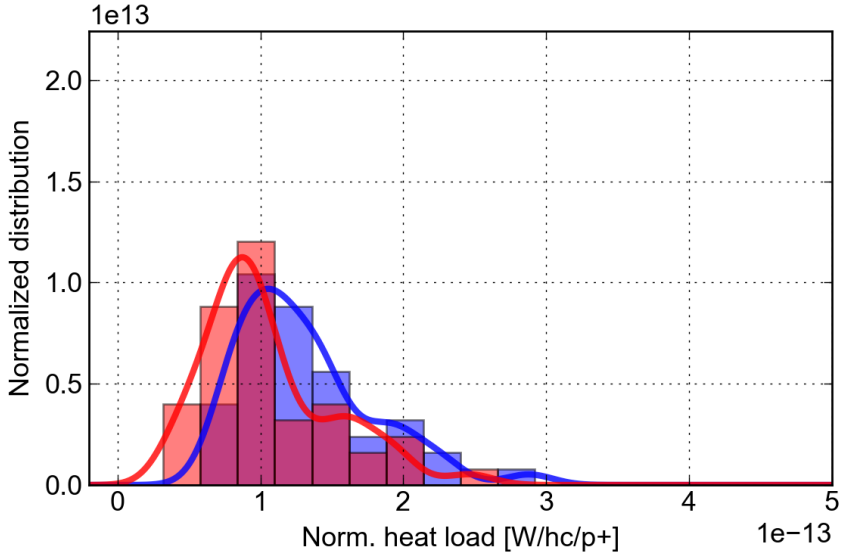




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S56 (avg) [W]	78.12	40.99
H.L. S56 (std) [W]	27.83	17.60
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

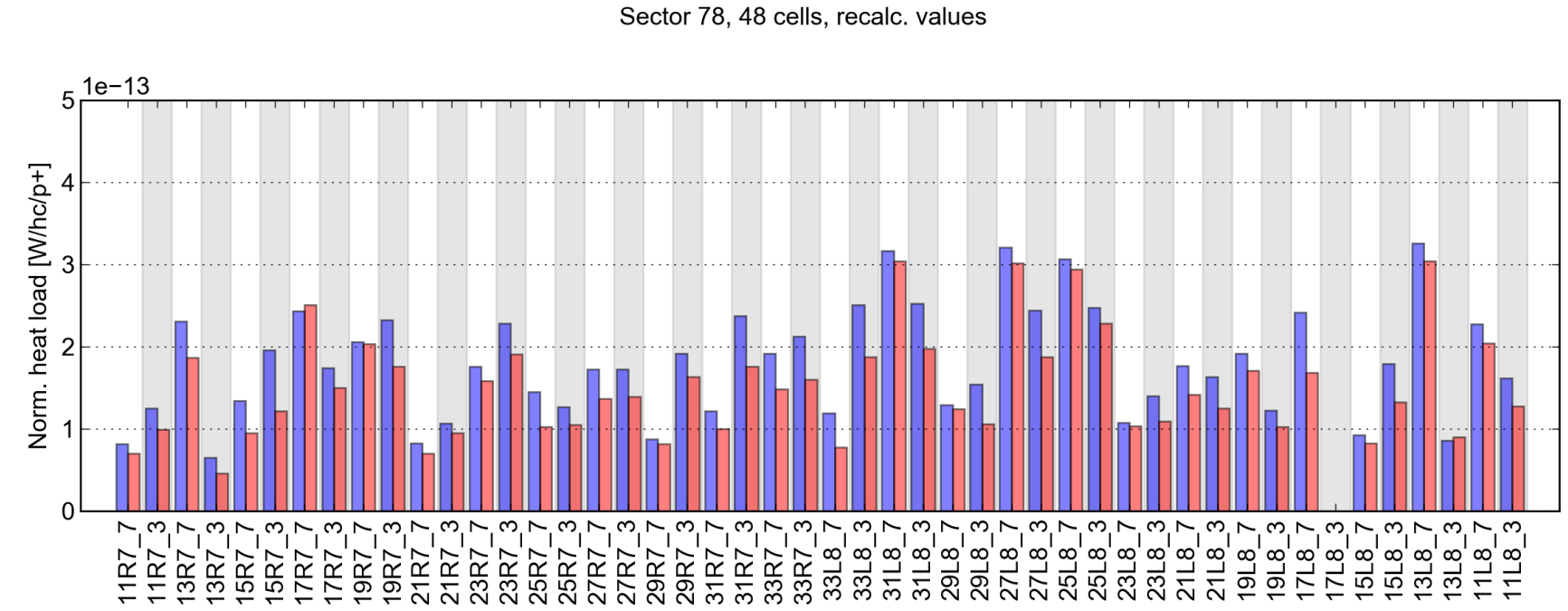
Detailed analysis of the effect of burn-off on heat loads

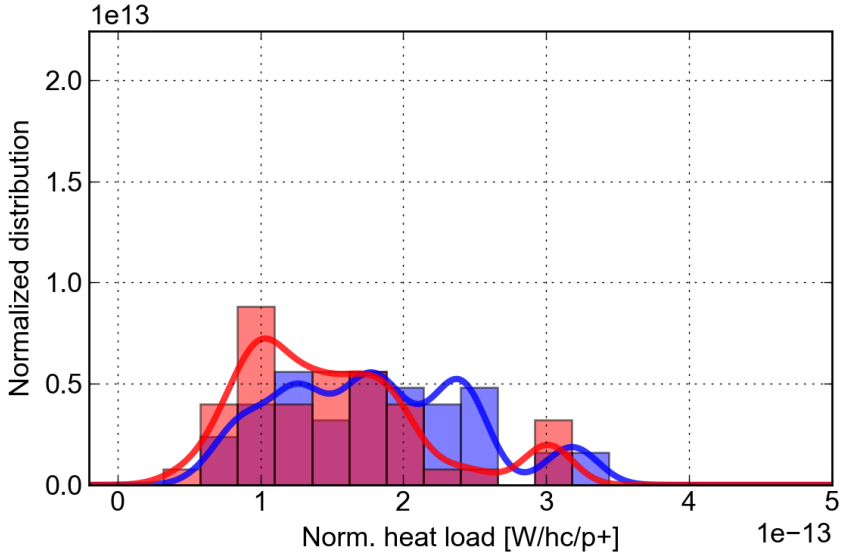




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S56 (avg) [W]	78.12	40.99
H.L. S56 (std) [W]	27.83	17.60
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

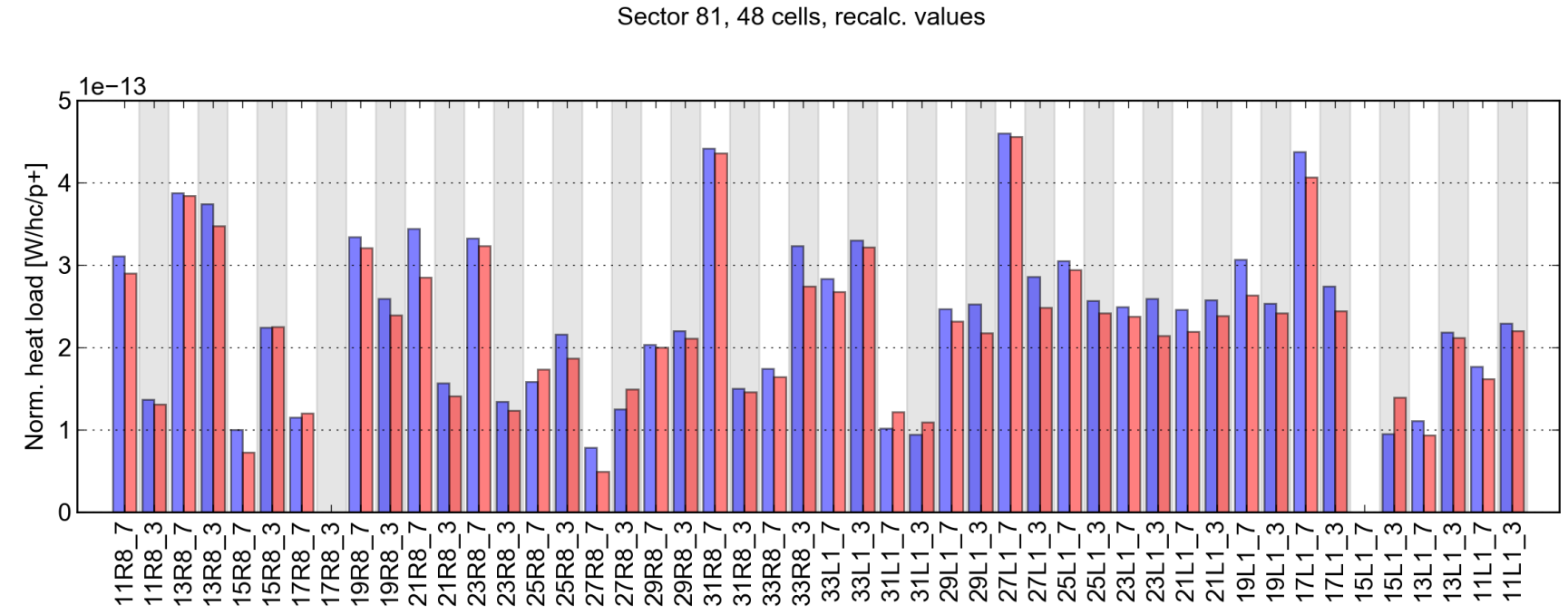
Detailed analysis of the effect of burn-off on heat loads

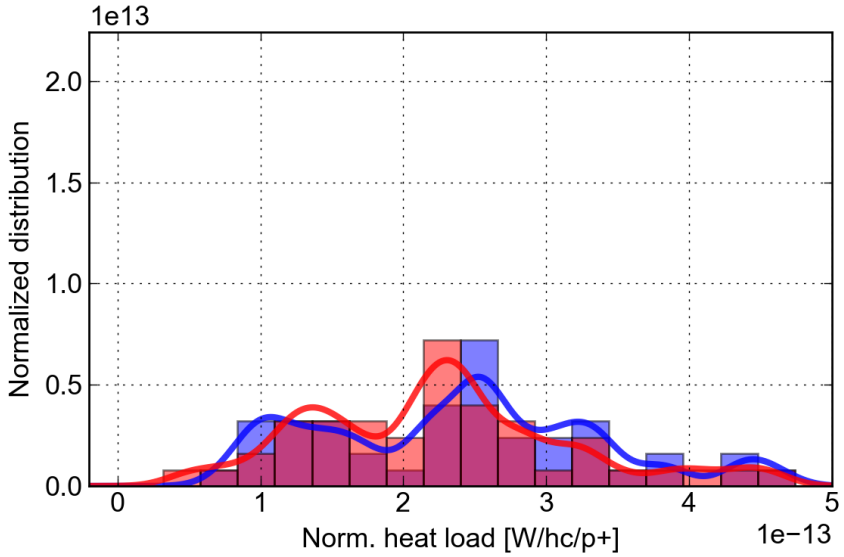




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S78 (avg) [W]	107.25	58.90
H.L. S78 (std) [W]	39.74	24.90
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

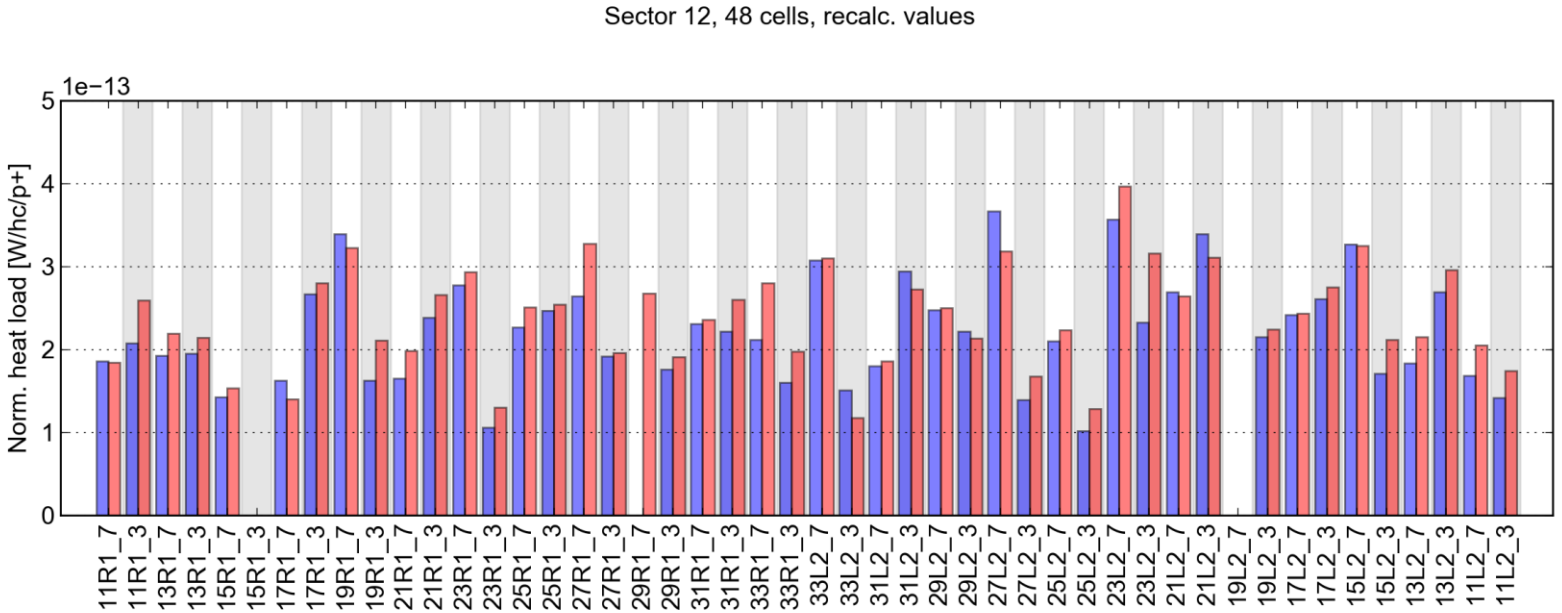
Detailed analysis of the effect of burn-off on heat loads

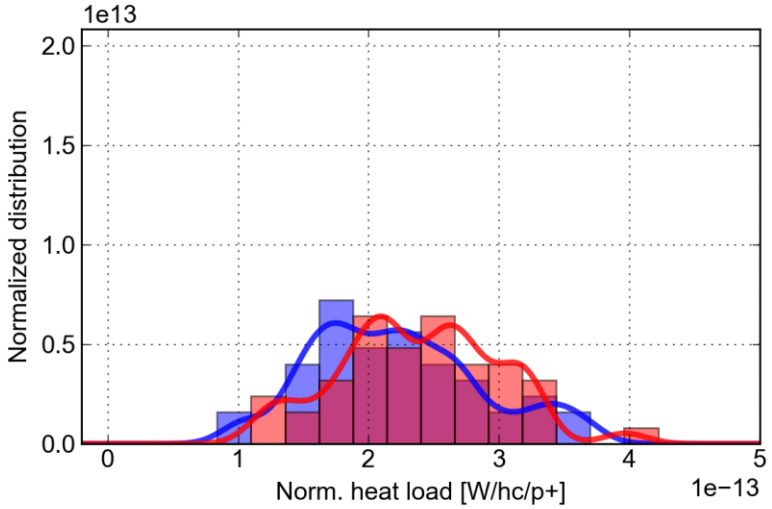




Fill	6054	6054
Started on	07 Aug 2017 14:15	07 Aug 2017 14:15
T_sample [h]	3.10	18.00
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2556/2556	2556/2556
Intensity (B1/B2) [p]	2.91e14/3.01e14	1.80e14/2.10e14
Bun.len. (B1/B2) [ns]	1.07/1.07	0.97/0.98
H.L. S81 (avg) [W]	142.17	88.07
H.L. S81 (std) [W]	57.88	35.62
H.L. exp. imped. [W]	10.15	5.07
H.L. exp. synrad [W]	12.61	8.29
T_nobeam [h]	1.90	1.90

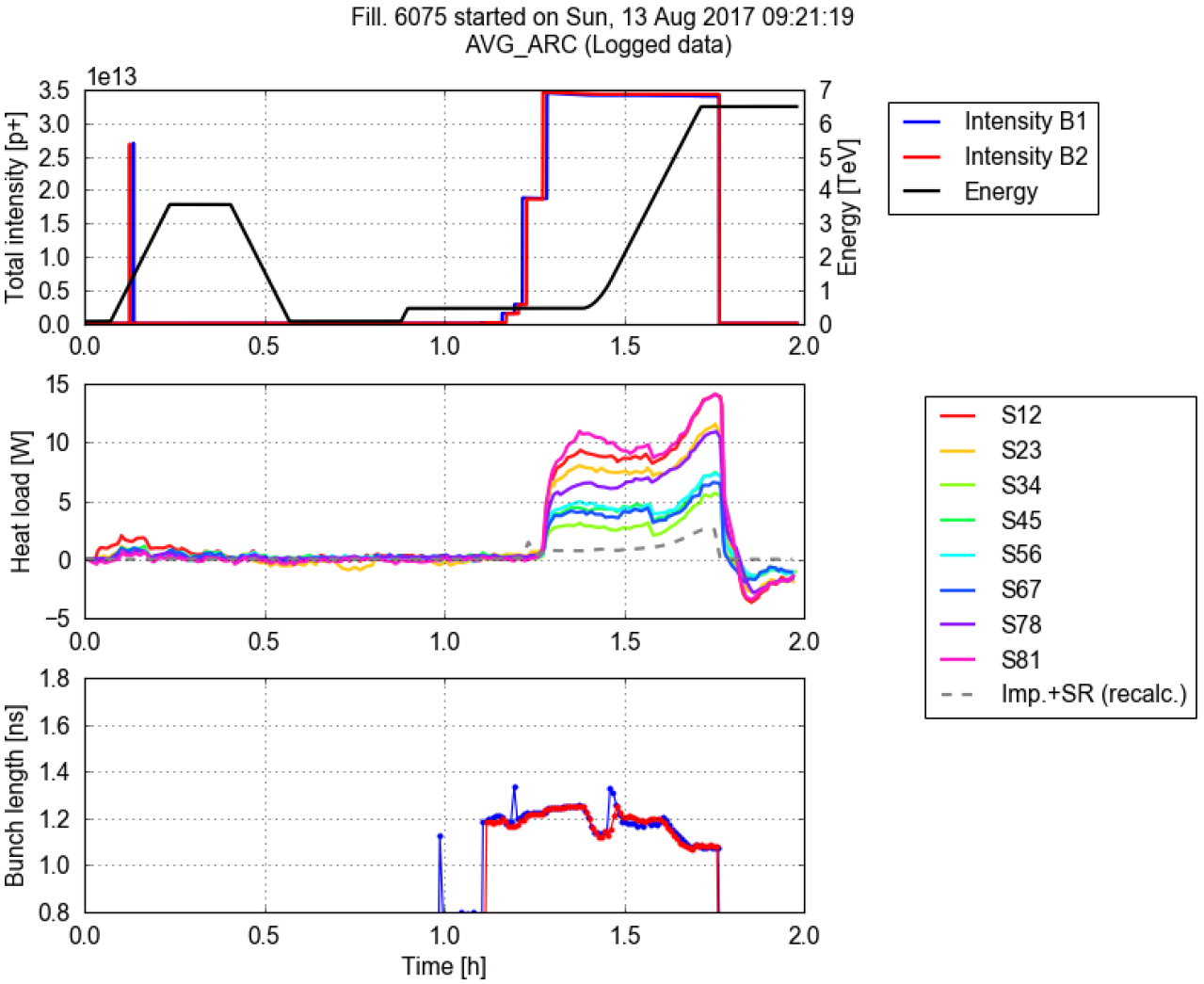
Present Status of S12 at high energy





Fill	5451	6054
Started on	26 Oct 2016 07:49	07 Aug 2017 14:15
T_sample [h]	3.00	3.10
Energy [GeV]	6499	6499
N_bunches (B1/B2)	2220/2220	2556/2556
Intensity (B1/B2) [p]	2.34e14/2.35e14	2.91e14/3.01e14
Bun.len. (B1/B2) [ns]	1.08/1.05	1.07/1.07
H.L. S12 (avg) [W]	103.88	141.41
H.L. S12 (std) [W]	30.21	35.93
H.L. exp. imped. [W]	7.37	10.15
H.L. exp. synrad [W]	9.97	12.61
T_nobeam [h]	1.25	1.90

A 25 ns fill with very low load



Arc heat loads during the 2017 scrubbing run

- The data at the selected samples is used to have an **indication of the heat load evolution** during the scrubbing run

Nbun inj.	72	144	144/288	288