50 ns test and e-cloud considerations

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with input from LHC and Injectors operation crews,
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LMC meeting, 26 Jul 2017

- **Test with 50 ns beams:**
  - e-cloud observations
- **Electron cloud effects in dipole correctors**
  - Simulations
  - Cell-by-cell observations
- **Update on coherent motion observations**
  - Considerations on Fast Beam-Ion Instability

Outline

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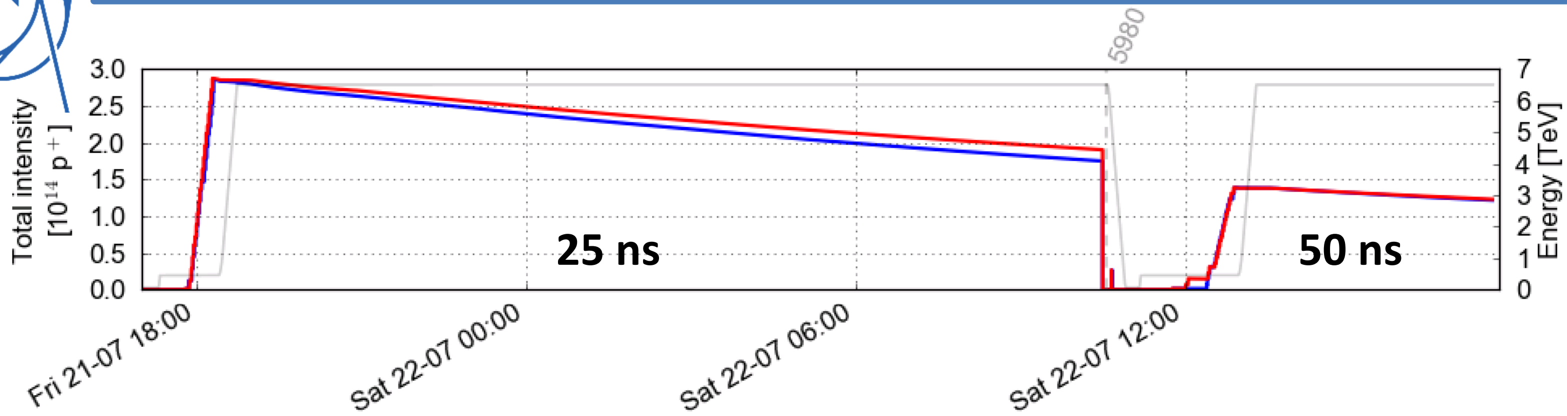
Test fill with 50 ns



A **fill with 50 ns bunch spacing** was performed on Saturday afternoon in order to probe the impact of the bunch spacing on losses and other observations in 16L2

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**

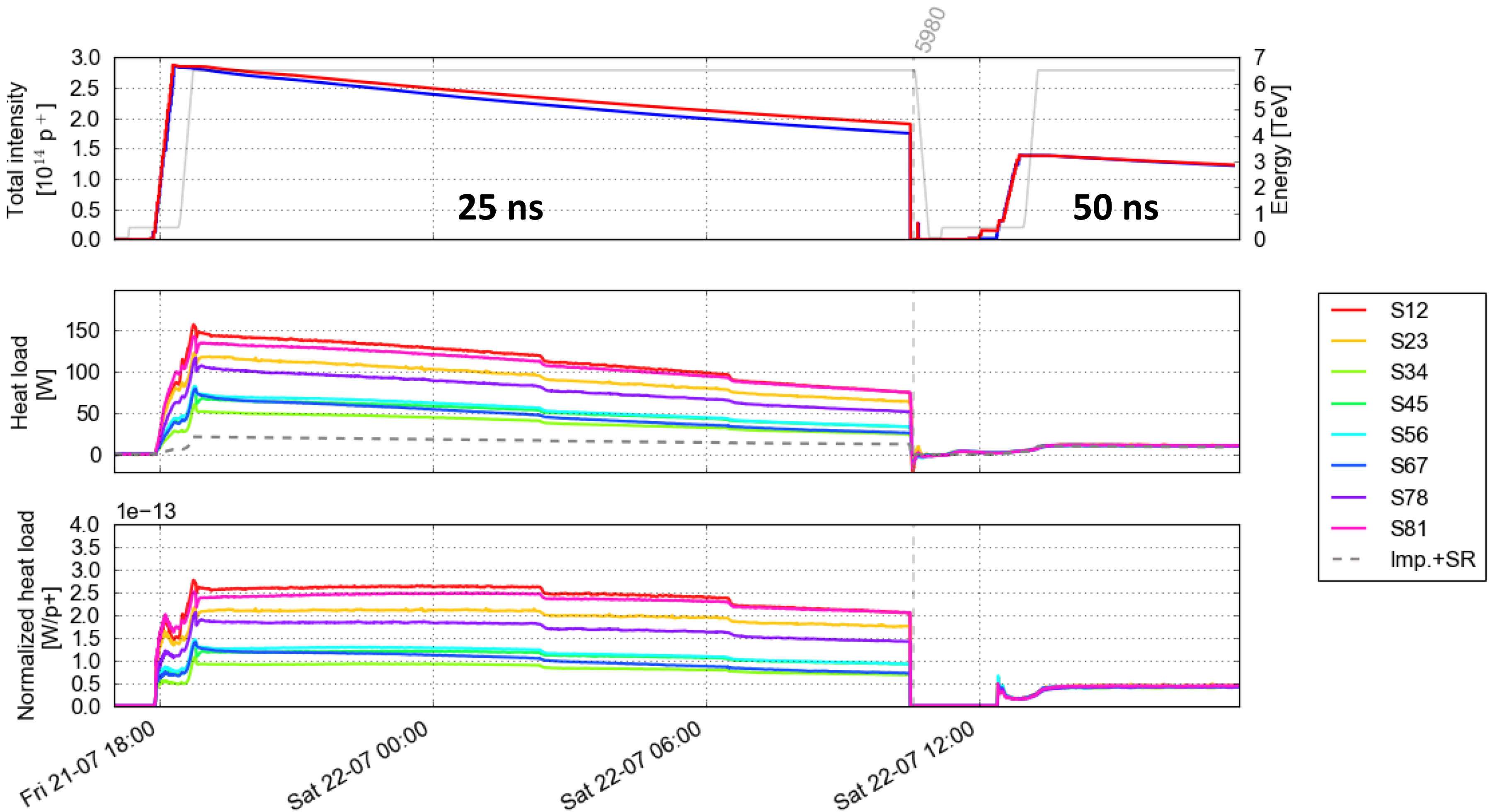
The planned set of measurements was performed rather quickly, still the fill was kept **6.7 h in Stable Beams** as beam from the injectors was not available for refill with 25 ns

Test fill with 50 ns

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**



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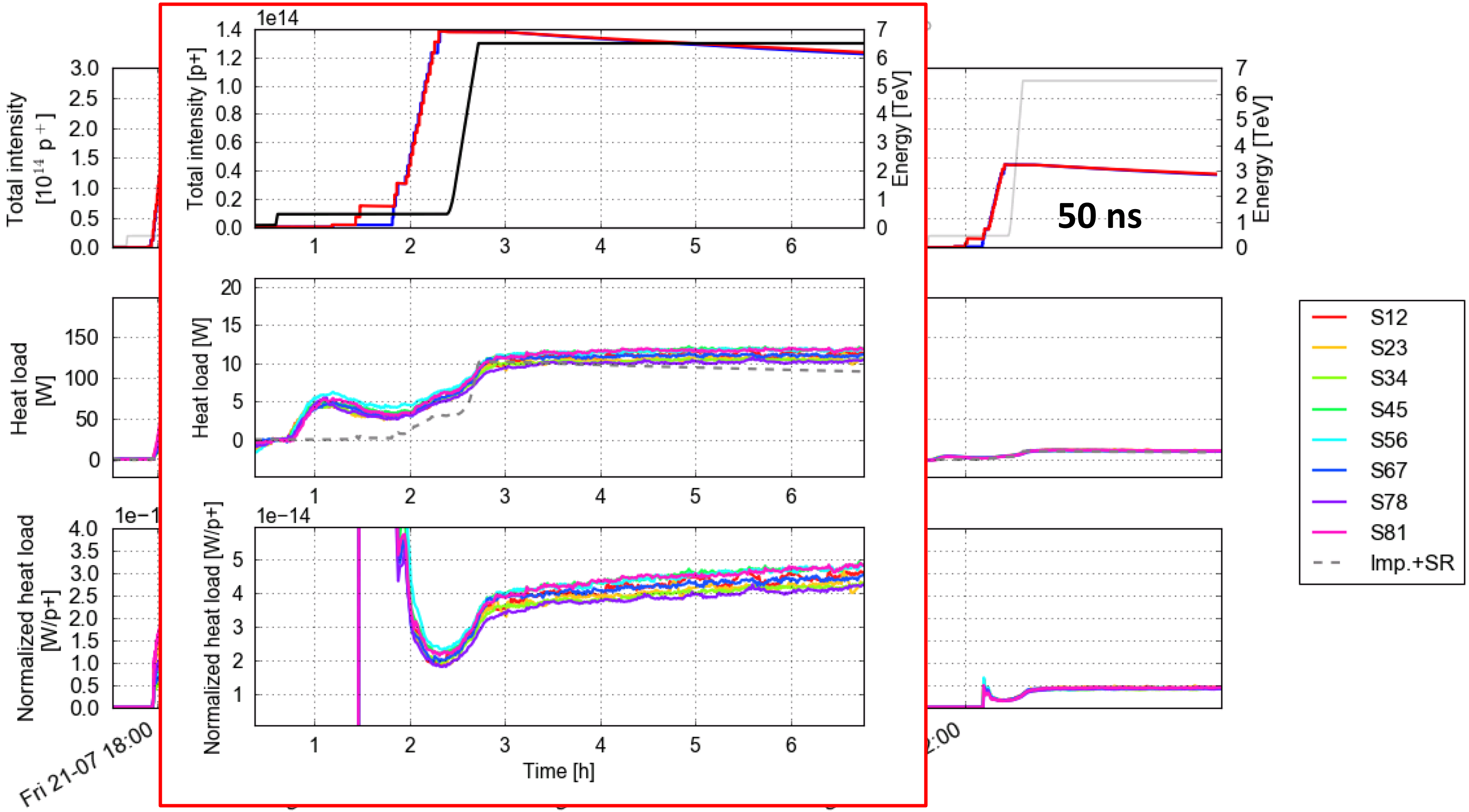
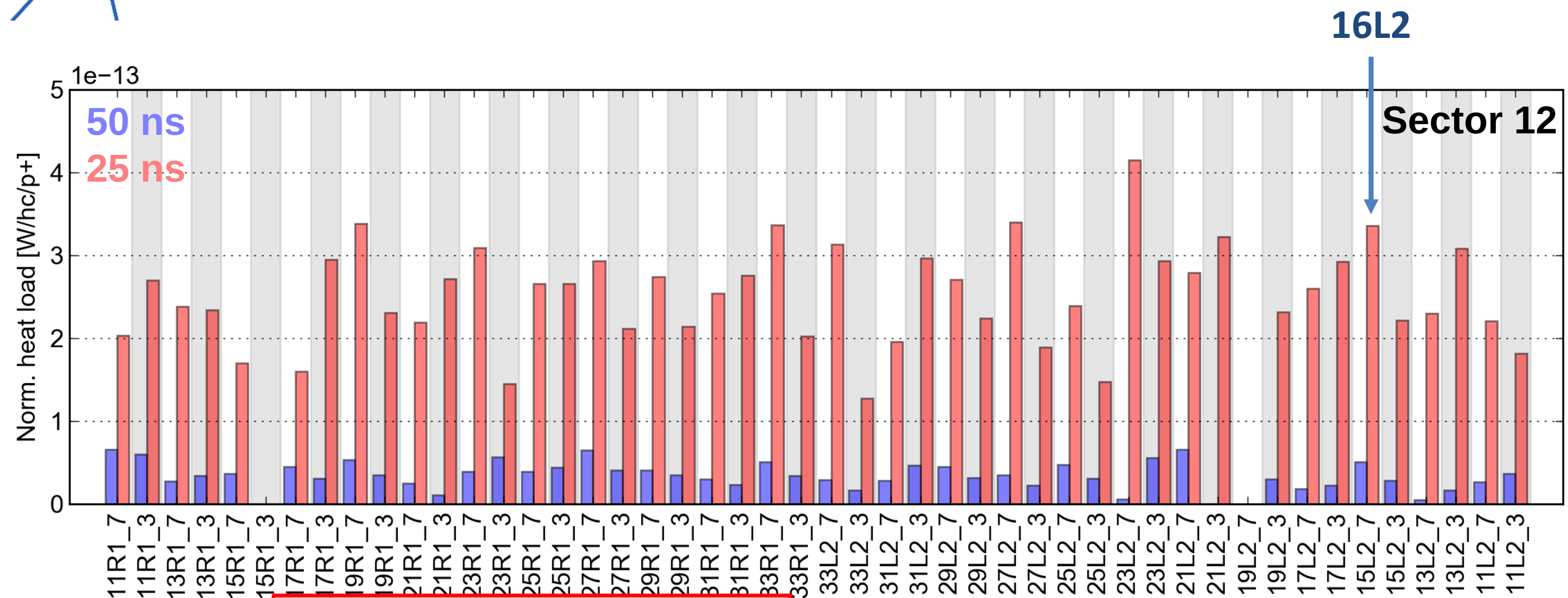
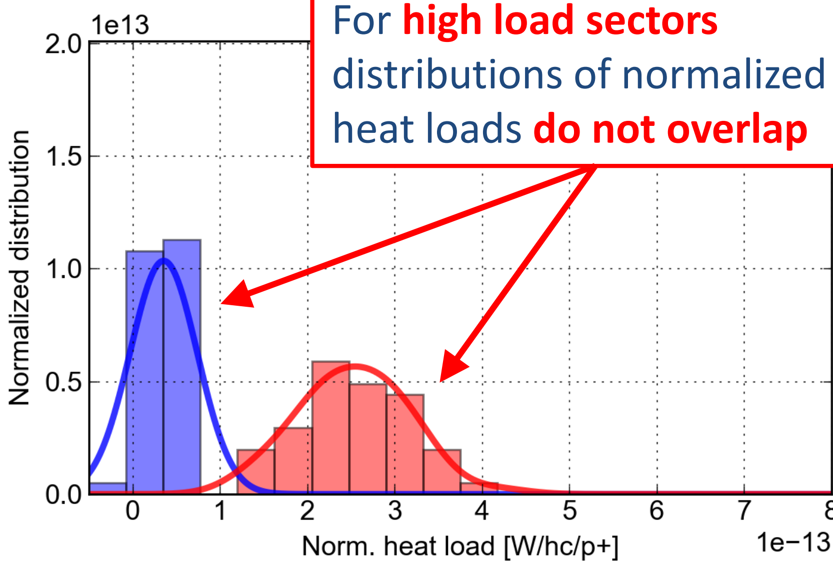


Cell-by-cell comparison

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

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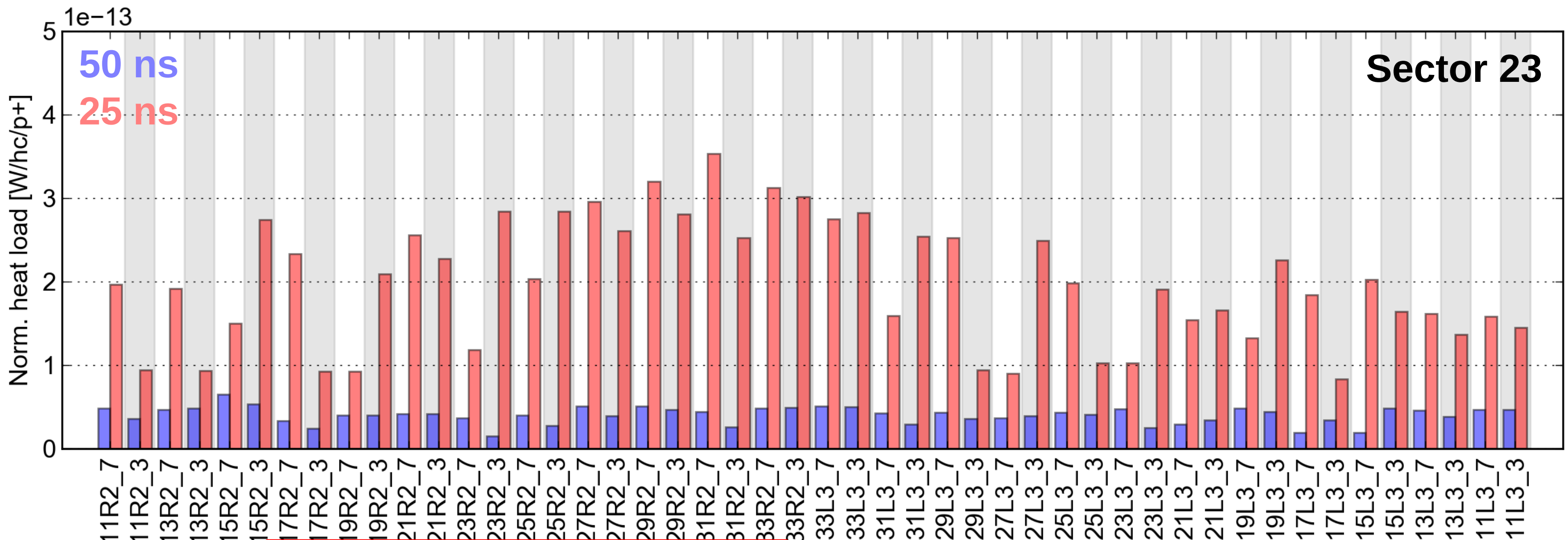

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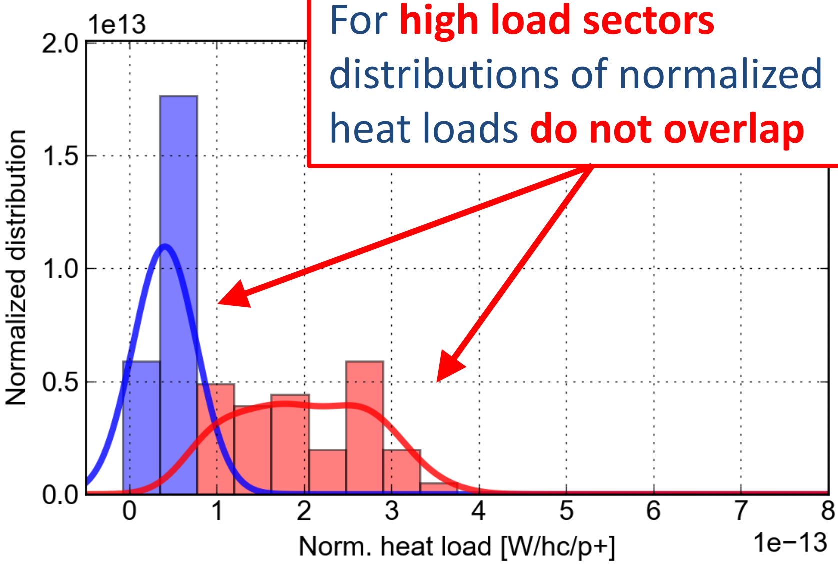

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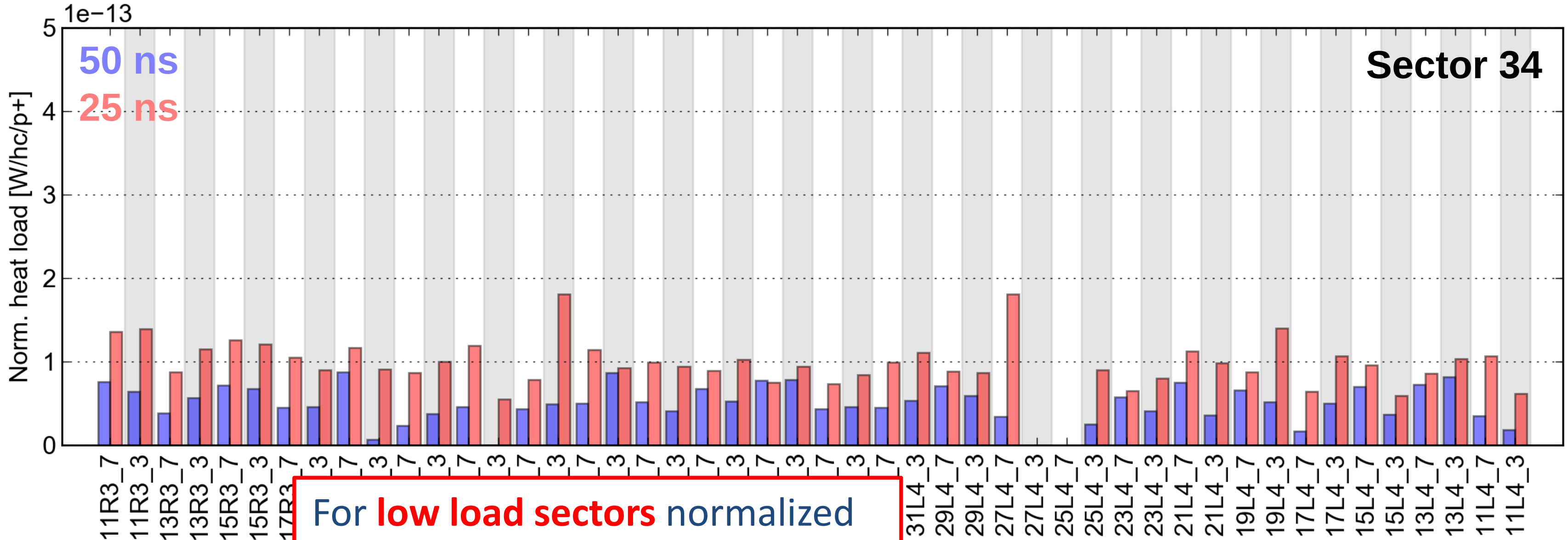
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S23 (avg) [W]	11.19	112.27
H.L. S23 (std) [W]	2.76	41.57
H.L. exp. imped. [W]	4.33	9.20
H.L. exp. synrad [W]	5.87	12.01
T_nobeam [h]	0.63	2.00

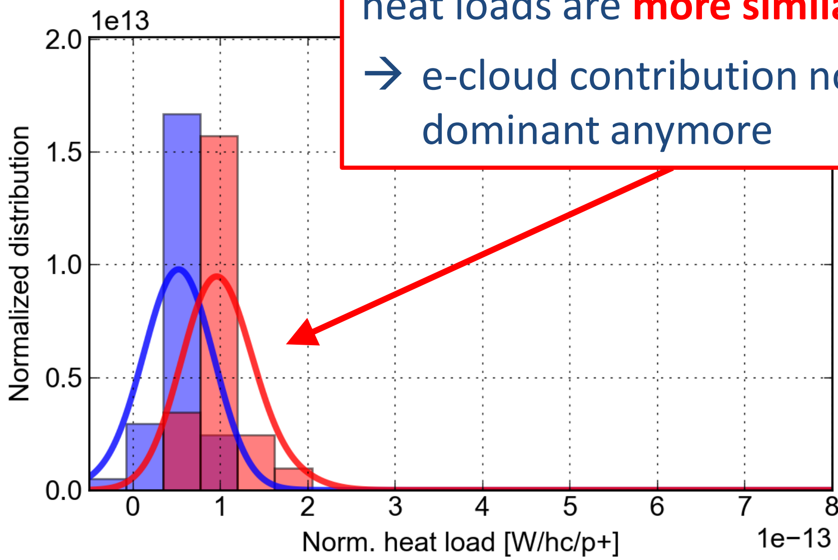
Cell-by-cell comparison

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

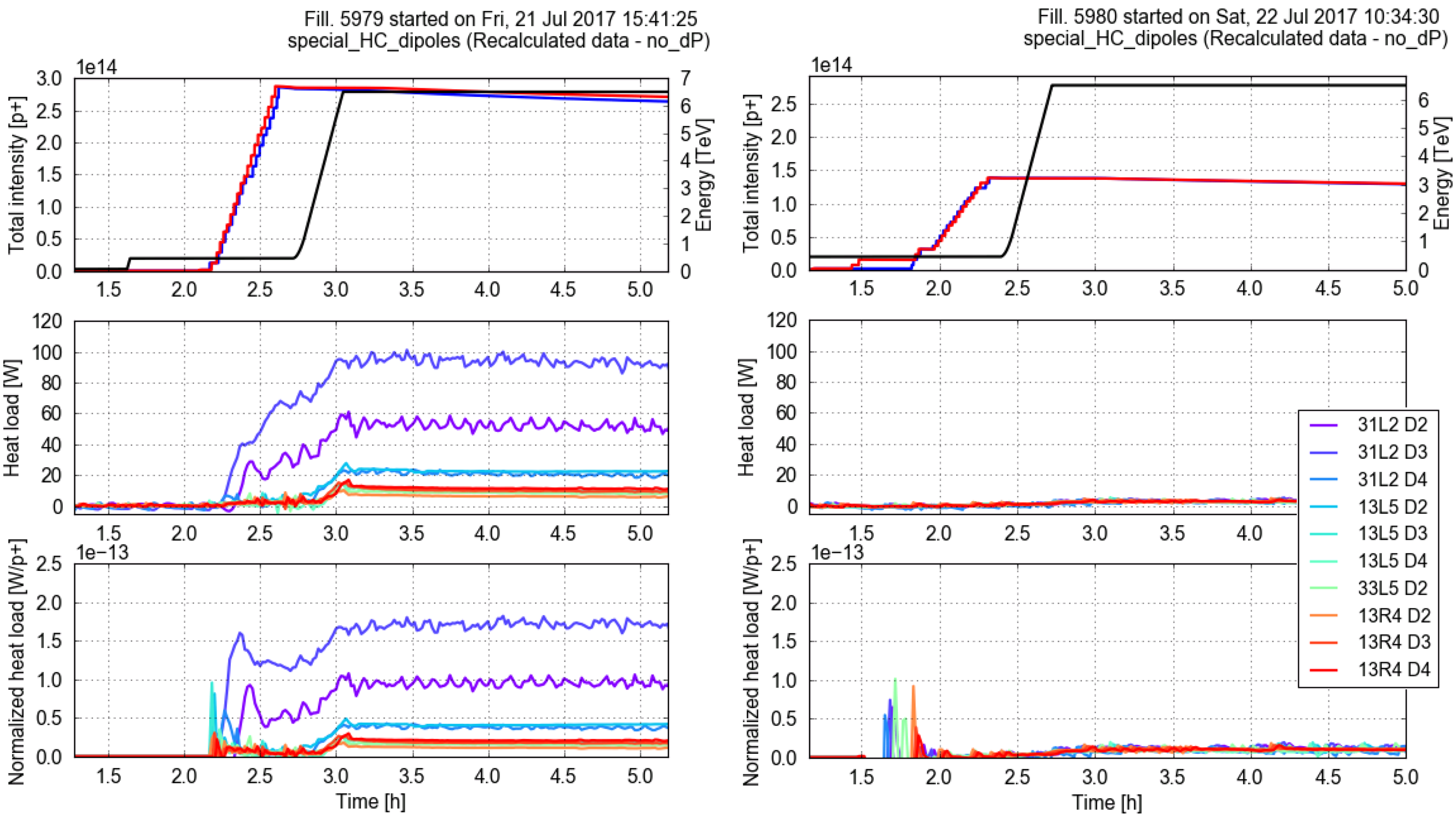


	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S34 (avg) [W]	13.98	56.41
H.L. S34 (std) [W]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

Instrumented magnets

Observation on **instrumented magnets and LSS matching quadrupoles** are consistent with observations on the arc averages:

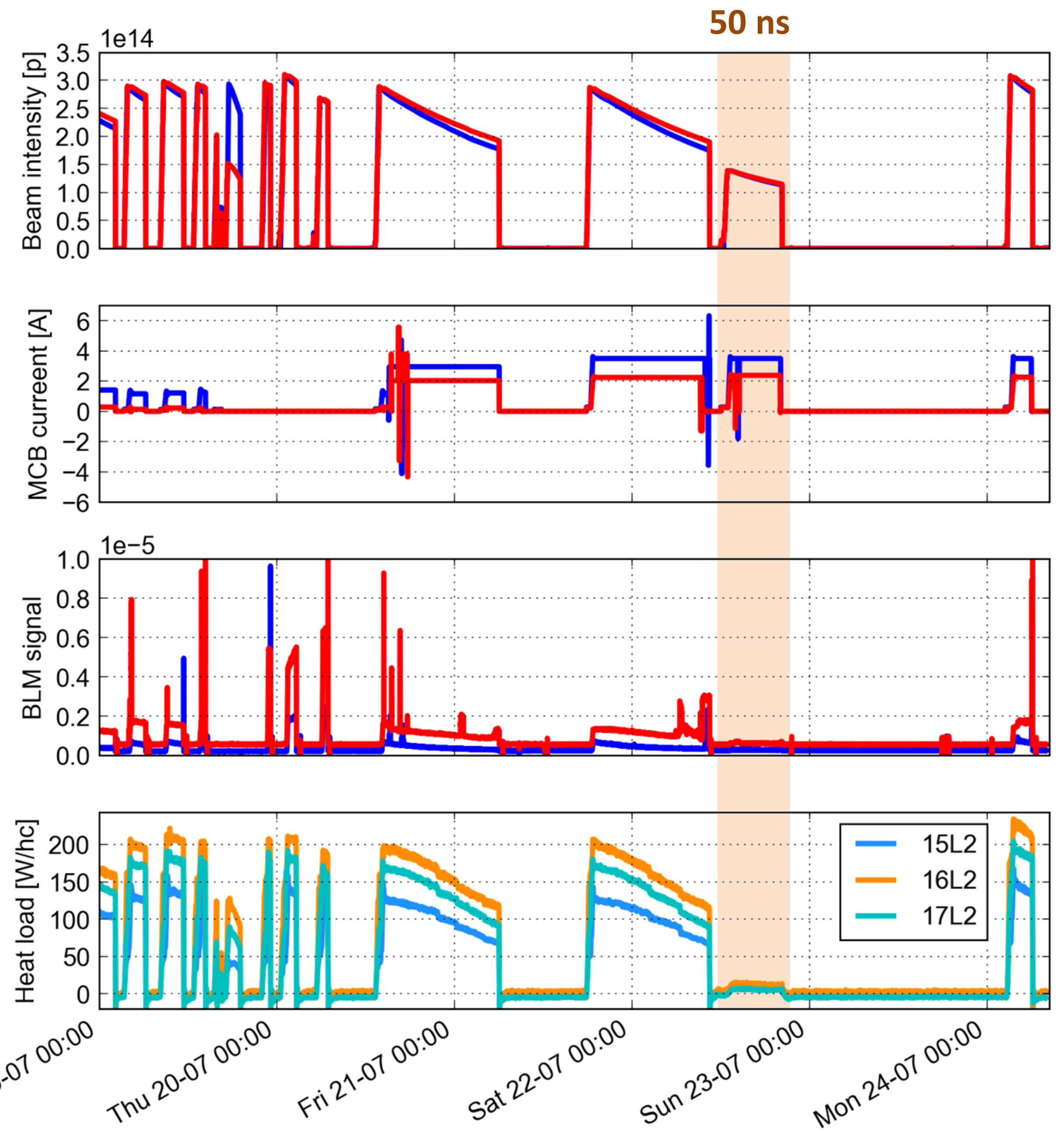
- **Heat loads are reduced** and **large differences are suppressed**



Heat loads on the beam-screens at 16L2 and close-by

No anomalous behavior compared to the other arc half-cells

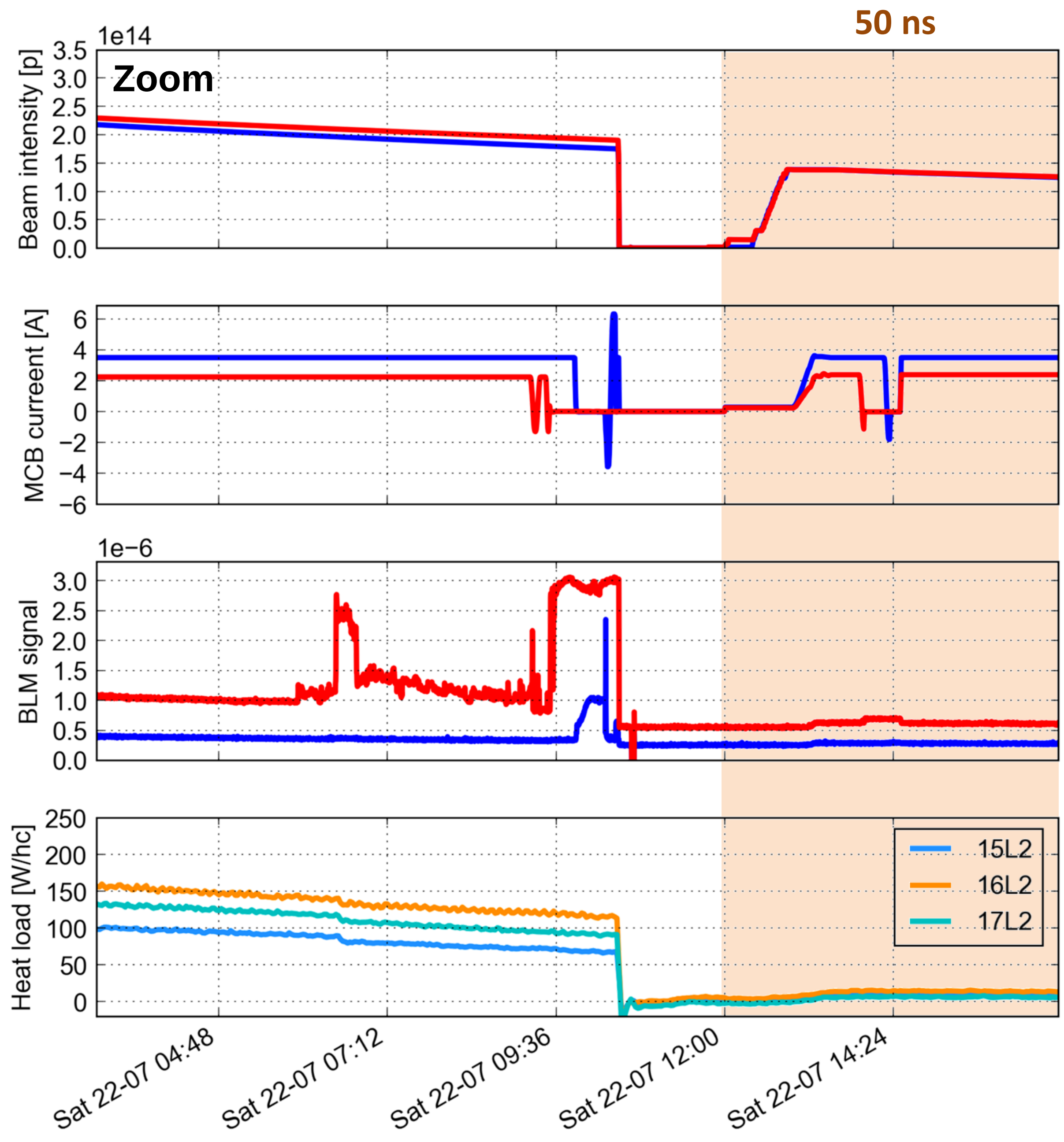
- **No changes** in heat loads observed **when changing the current in dipole correctors**



Heat loads on the beam-screens at 16L2 and close-by

No anomalous behavior compared to the other arc half-cells

- **No changes** in heat loads observed **when changing the current in dipole correctors**
- **No correlation with** measured steady state **losses**
- Heat load **reduction with 50 ns similar to other half-cells**



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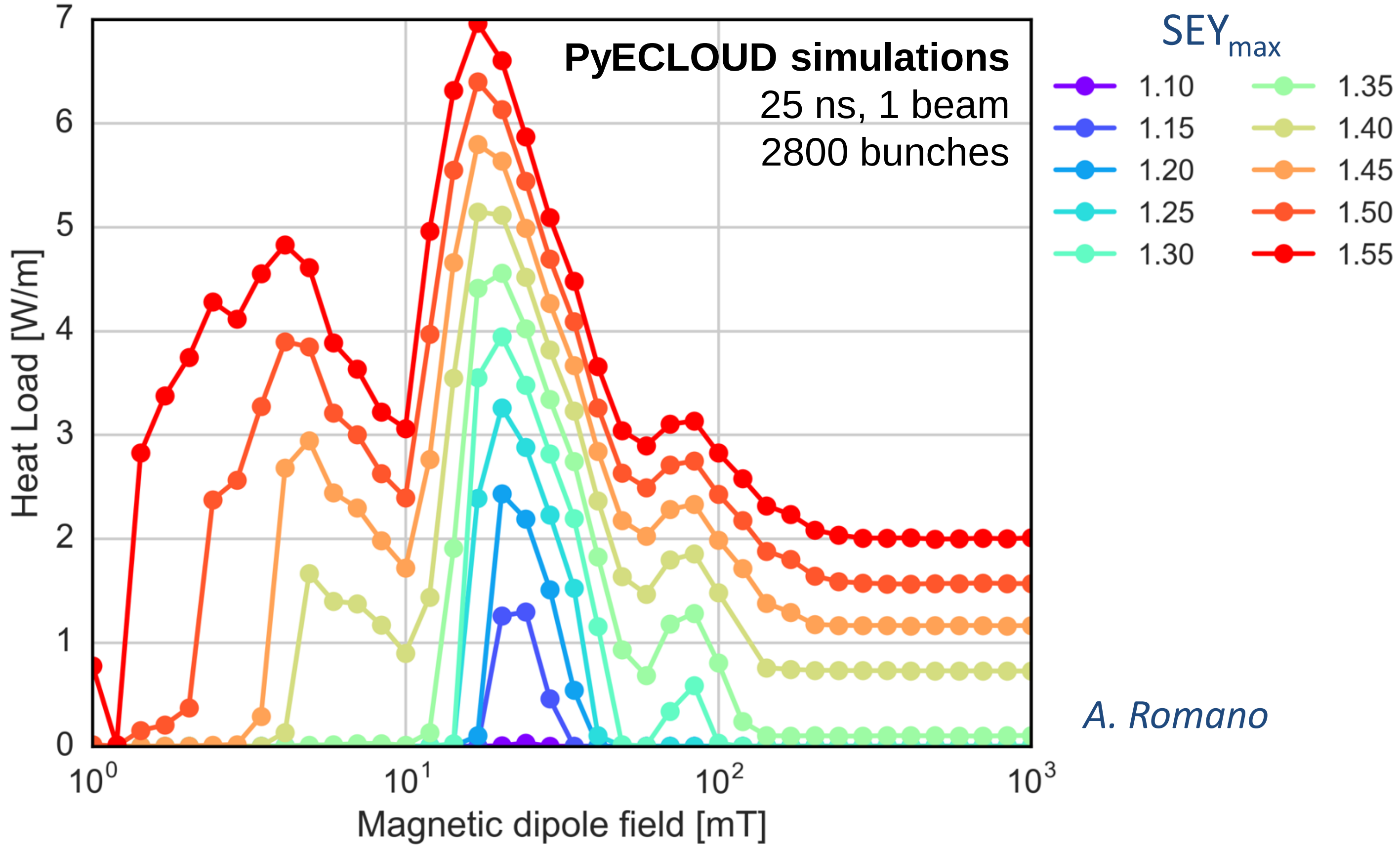
Effect of the dipole correctors on the cell heat load

Do we expect an effect on the heat load when changing the corrector setting?

→ **Not really:** there is a dependence on the magnetic field, but heat **load values quite low** (L_{corr} = 68 cm over 50 meter cell length)

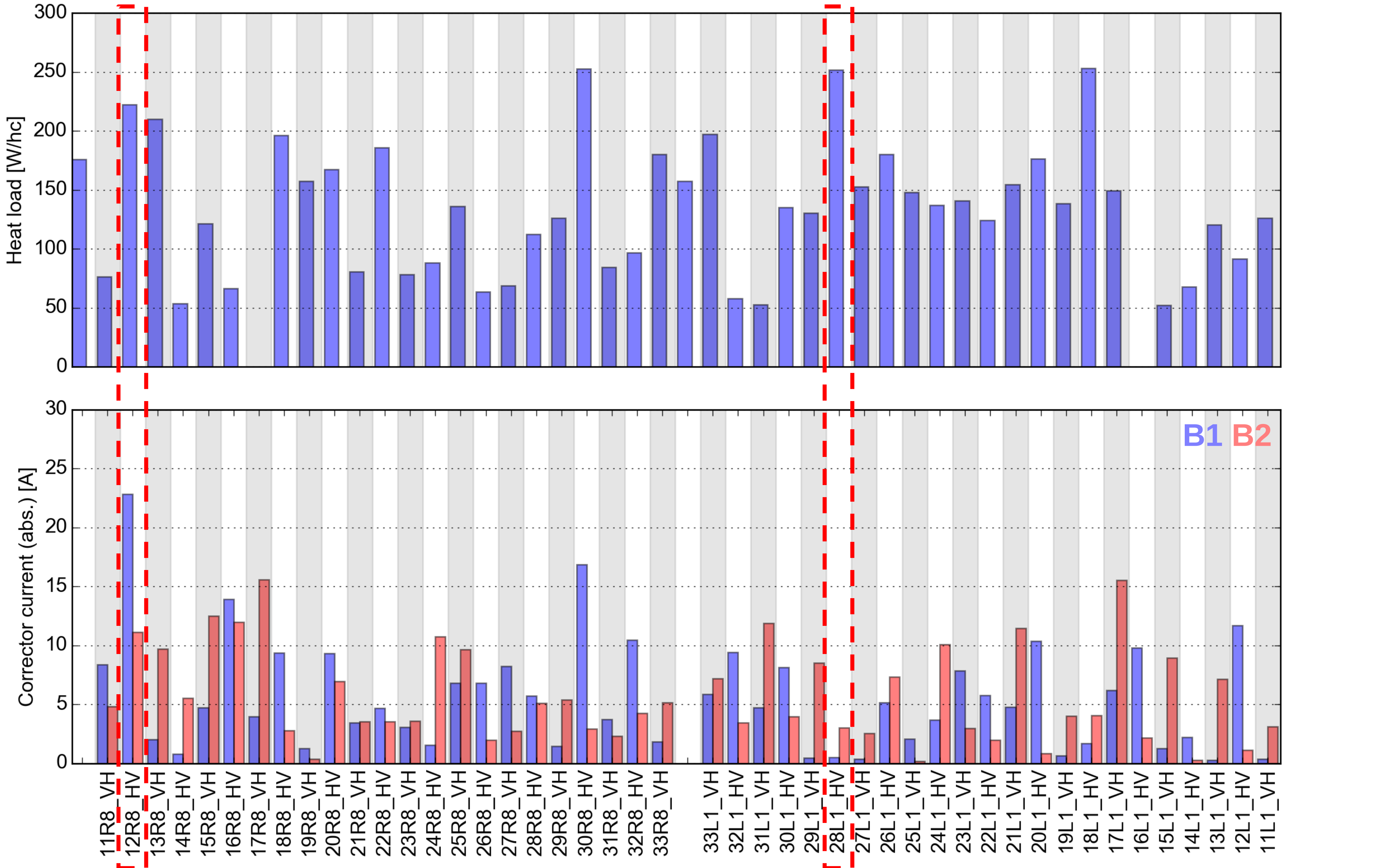


A. Romano

Impact of correctors on cell-by-cell heat loads

Any correlation between corrector settings and cell heat load?

→ Nothing evident when looking at the cell-by-cell patterns…

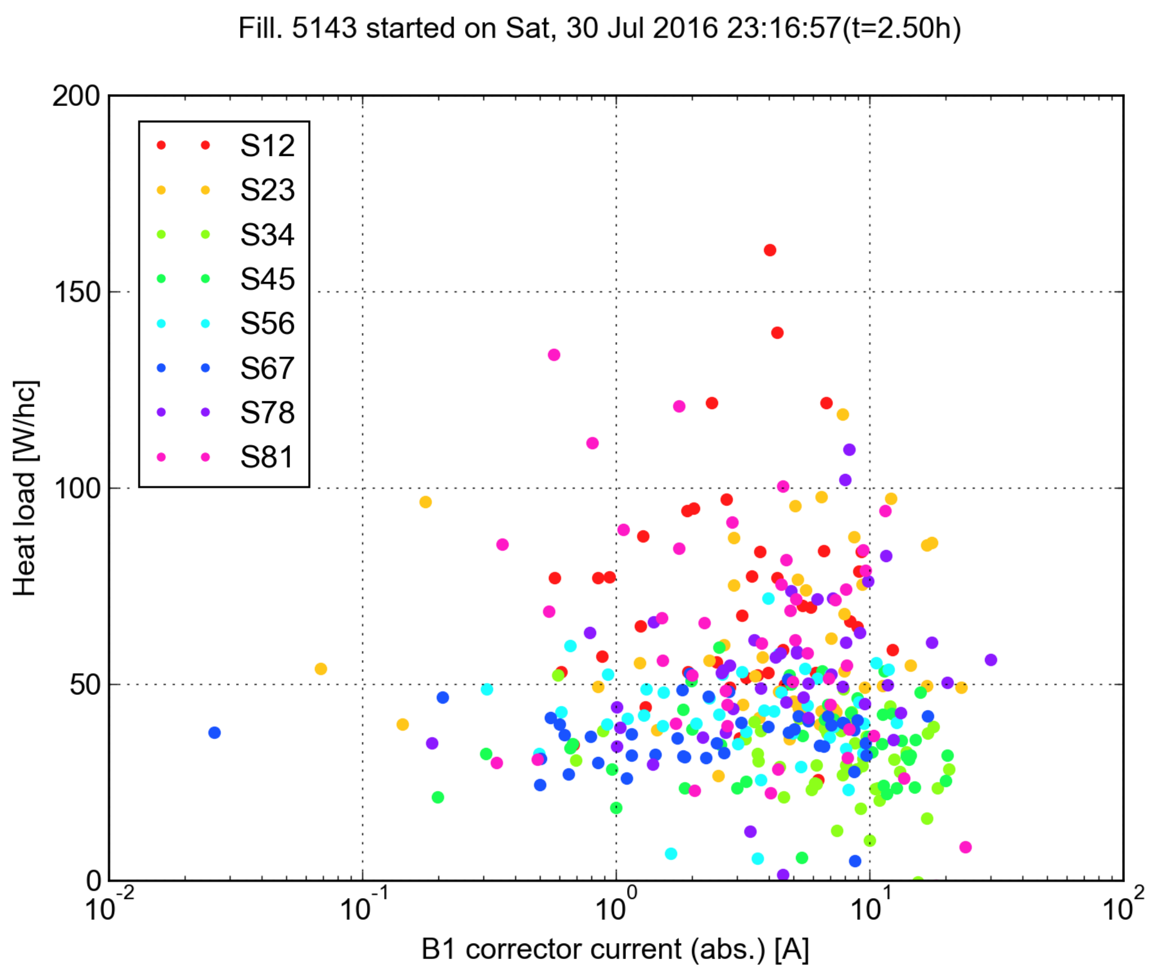


Impact of correctors on cell-by-cell heat loads

Correlation plot produced for a **fill with only B1 in the machine** (~2000b), to avoid arbitrary assumptions in combining the effect of the two correctors in the same half cells
→ **no dependence could be identified**

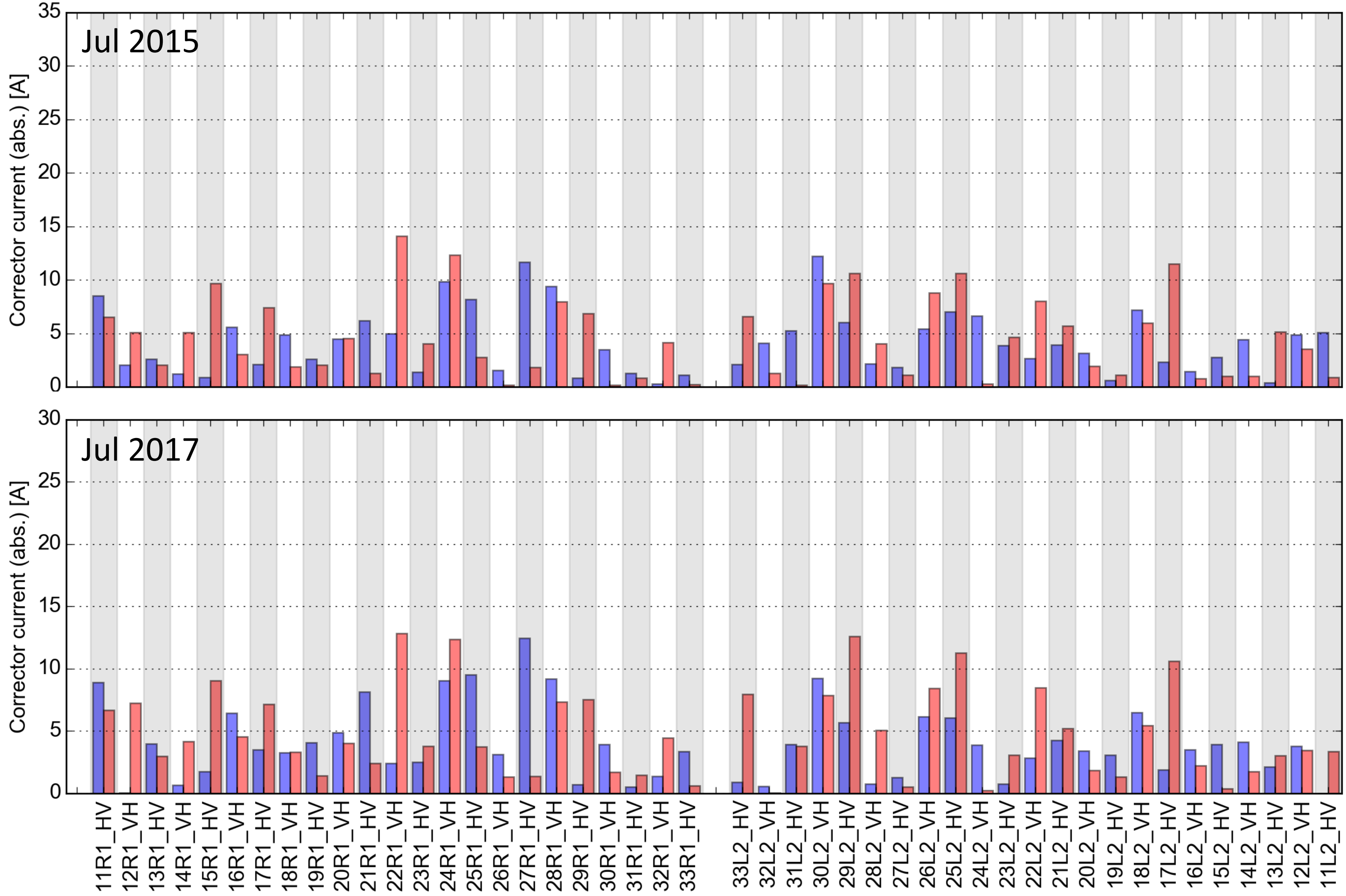
Correctors settings at high energy did not change much during Run 2 (see next slide)

→ this plot practically also shows the dependence on the integrated current in the MCBs



Corrector settings 2016 vs 2017

Correctors settings at high energy did not change much during Run 2



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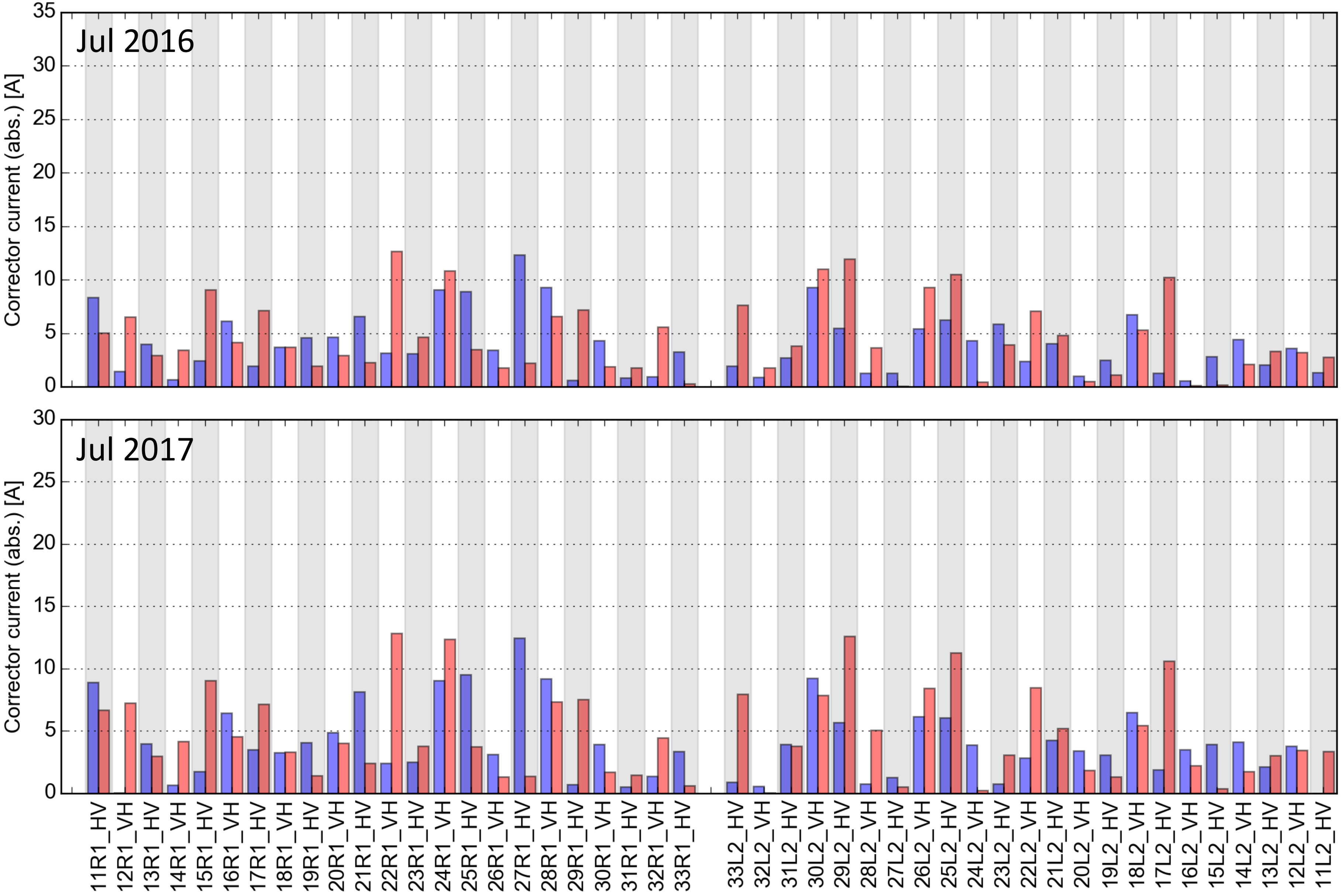

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Coherent motion observations: update

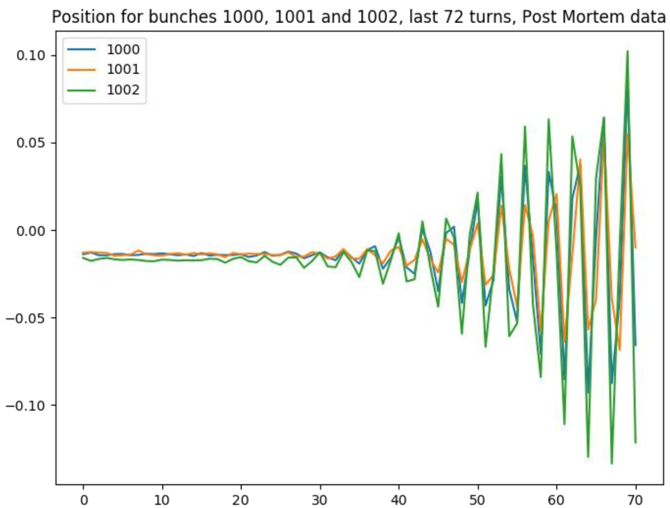
All dumps in the last week has features similar to those described by Elias and Xavier in the last two LMC meetings:

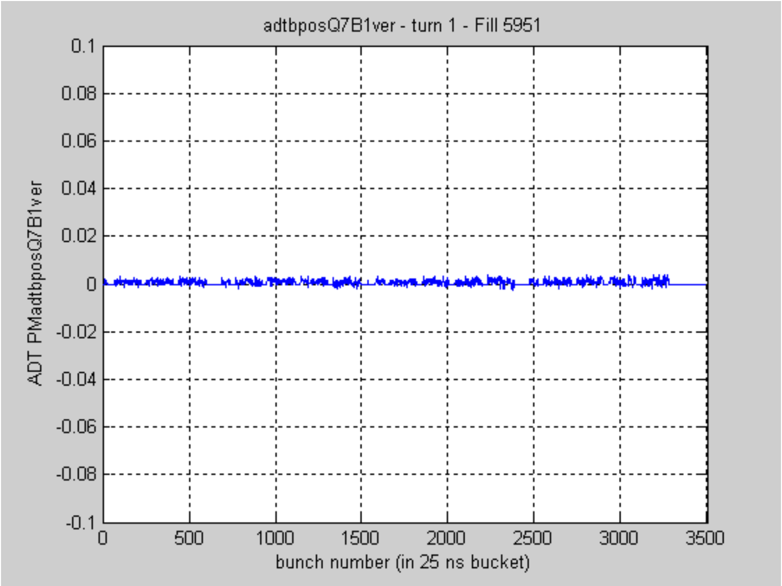
- **Coherent motion is observed** after the sharp increase of beam losses in 16L2 right before the dump
- At high energy the dynamics is too fast (10-20 turns) to perform spectral analysis on the beam motion

We had **one dump at injection** on Sat 15 July. In that case the beam stayed longer, allowing to get a better insight on the instability:

→ Clear indication of **coupled bunch motion**

→ Large **positive tune shift** of the unstable mode





D. Amorim
X. Buffat
L. Carver
B. Salvant

Coherent motion observations: update

Summary table with main observations:

Fill #	Date	Cycle phase	Beam loss	Plane of losses	Most unstable plane	Motion type	# bunches	Beam intensity [10^13]	bunch intensity [10^11]
5725	29/05/17	Injection (scrubbing)	B1	V	V	-	1236	13.4	01.08
5749	05/06/2017	Stable beam	B1	V	V	Single bunch, beginning of trains	601	6.18	01.03
5825	13/06/2017	Stable beam	B1	V	V	Single bunch, beginning of trains	985	11.73	1.19
5848	20/06/2017	EOF scraping test	B1	H and V	V	Single bunch, beginning of trains	1741	11.05	0.63
5860	23/06/2017	Squeeze (~ 53 cm)	B2	H	H	Coupled bunch	2317	27.32	1.18
5861	23/06/2017	Squeeze (~ 53 cm)	B1	V	H	Coupled bunch	2317	26.47	1.14
5864	23/06/2017	Stable beam	B2	H	H	Coupled bunch and beginning of trains	2317	20.54	0.89
5870	25/06/2017	Stable beam	B1	V	H	Coupled bunch	2460	27.13	1.10
5871	25/06/2017	After End Of Squeeze	B1	V	H	Coupled bunch	2460	27.48	1.12
5946	14/07/2017	Stable beam	B2	H	H	Single bunch, beginning of trains	1357	15.12	1.14
5951	15/07/2017	Injection physics beam	B1	V	V	Coupled bunch	2317	26.25	1.13
5954	16/07/2017	Stable beam	B2	H	H	Coupled bunch	2317	24.24	01.05
5960	18/07/2017	Stable beam	B2	H	H	Single bunch, beginning of trains	2317	22.87	0.99
5965	19/07/2017	Stable beam	B1	V	-	Only BBQ signal	2556	27.7	01.08
5966	19/07/17	Stable beam	B2	H	H	Single bunch, beginning of trains	2556	28.6	1.12
5970	19/07/17	Adjust	B1	V	-	Only BBQ signal	2556	29.1	1.14
5971	20/07/17	Stable beam	B2	H	-	Only BBQ signal	2556	29.7	1.16
5974	20/07/17	Stable beam	B1	V	-	Only BBQ signal	2556	26.2	01.02
5984	24/07/17	EOF 16L2 corrector current test	B2	H	H	Single bunch, beginning of trains	2556	28.2	1.10

Fast beam-ion instability?

The presence of localized losses and coherent beam motion suggests that the underlying mechanism for the beam oscillation could be a **Fast Beam-Ion Instability (FBII)**

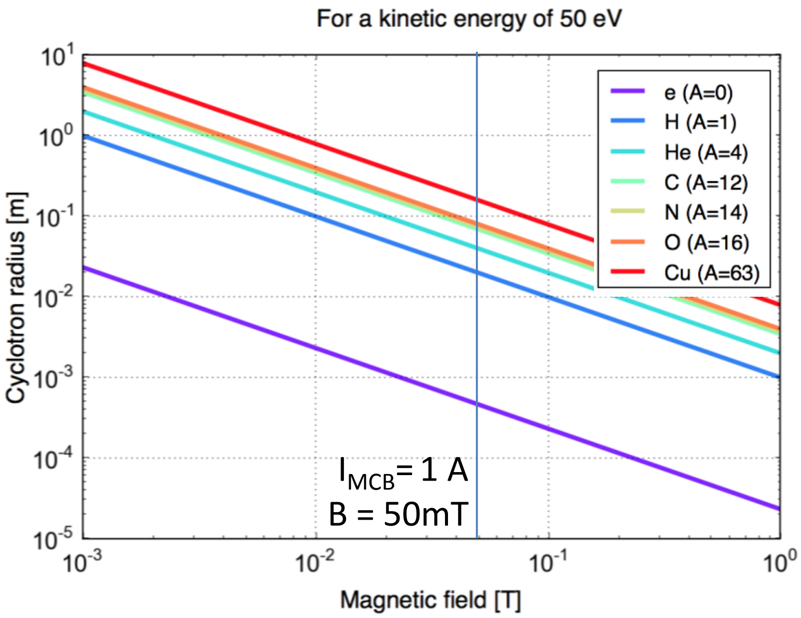
Coupled-bunch (FBII), typically encountered in **electron machines** due to **ion trapping**

→ Not expected with positively charged beams due to the repulsion of the ions

However (first calculations by L. Mether and G. Rumolo presented at LBOC 82):

- **Simulations** show that for high enough density (1e13 ion/m^3) **ions can drive an instability** even with protons
- The **presence of electron cloud** in the chamber **could enhance** the ionization mechanism and change the dynamics (trapping?)
  - This can be quantitatively assessed only with simulations of the full three-stream system (beam-electrons-ions) → requires some development work…
- Involved ions and electrons have **energies in the order of 10^1-10^2 eV**

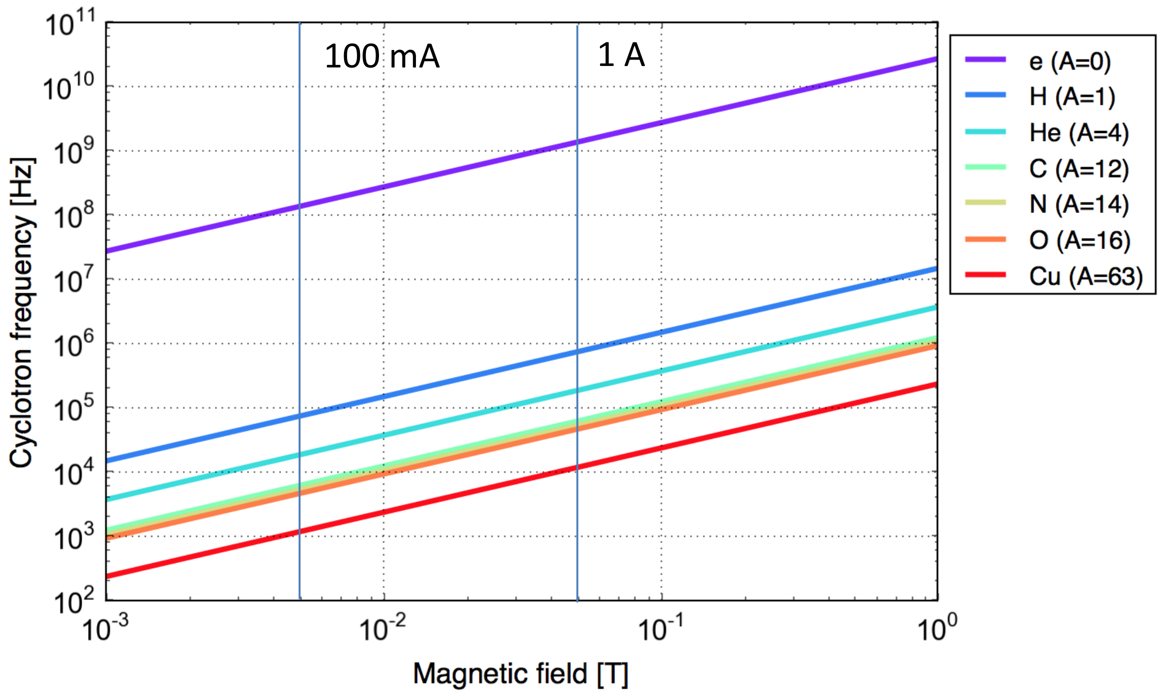
  → their **motion can be strongly influenced by "weak" magnetic fields** (as those introduced by the MCBs)

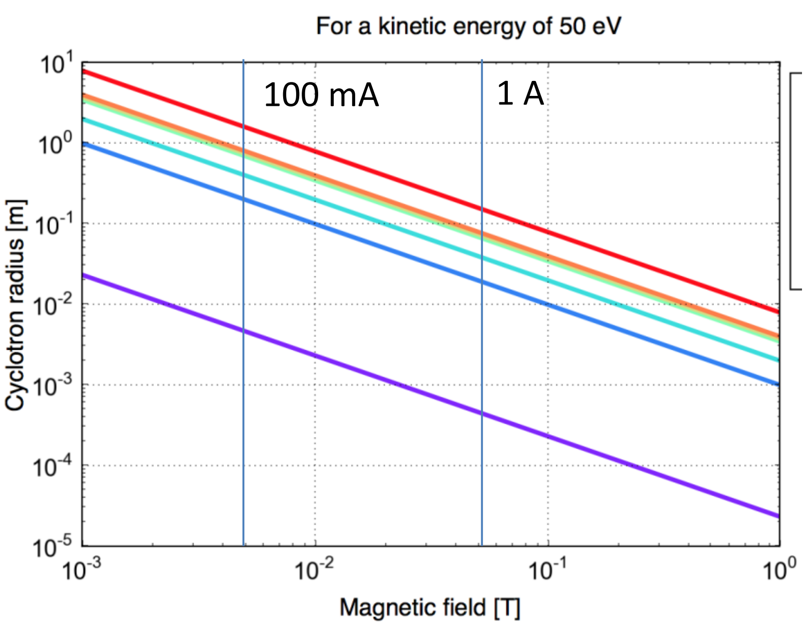


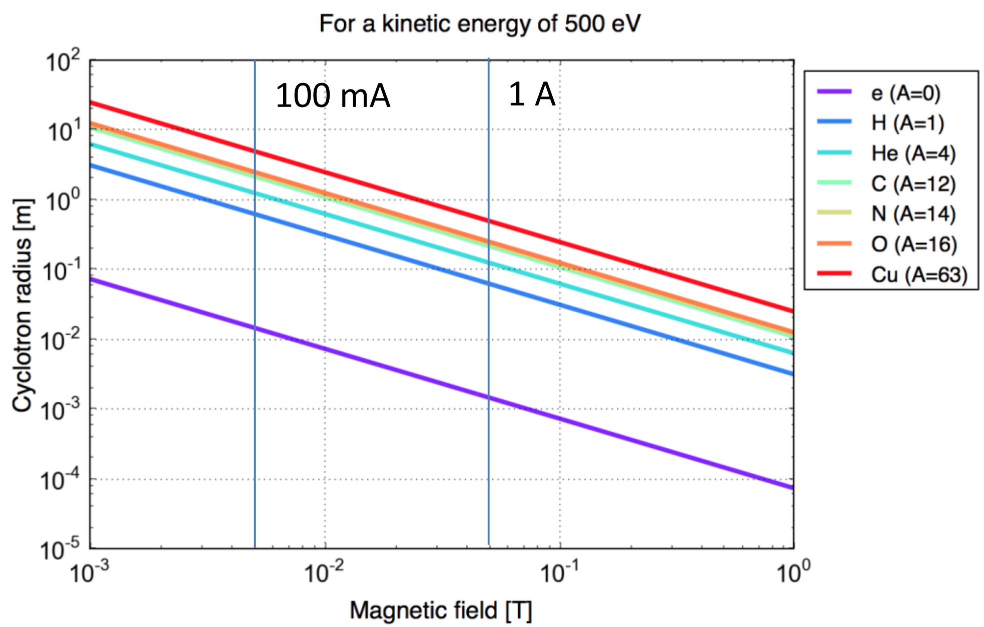
Summary and conclusions

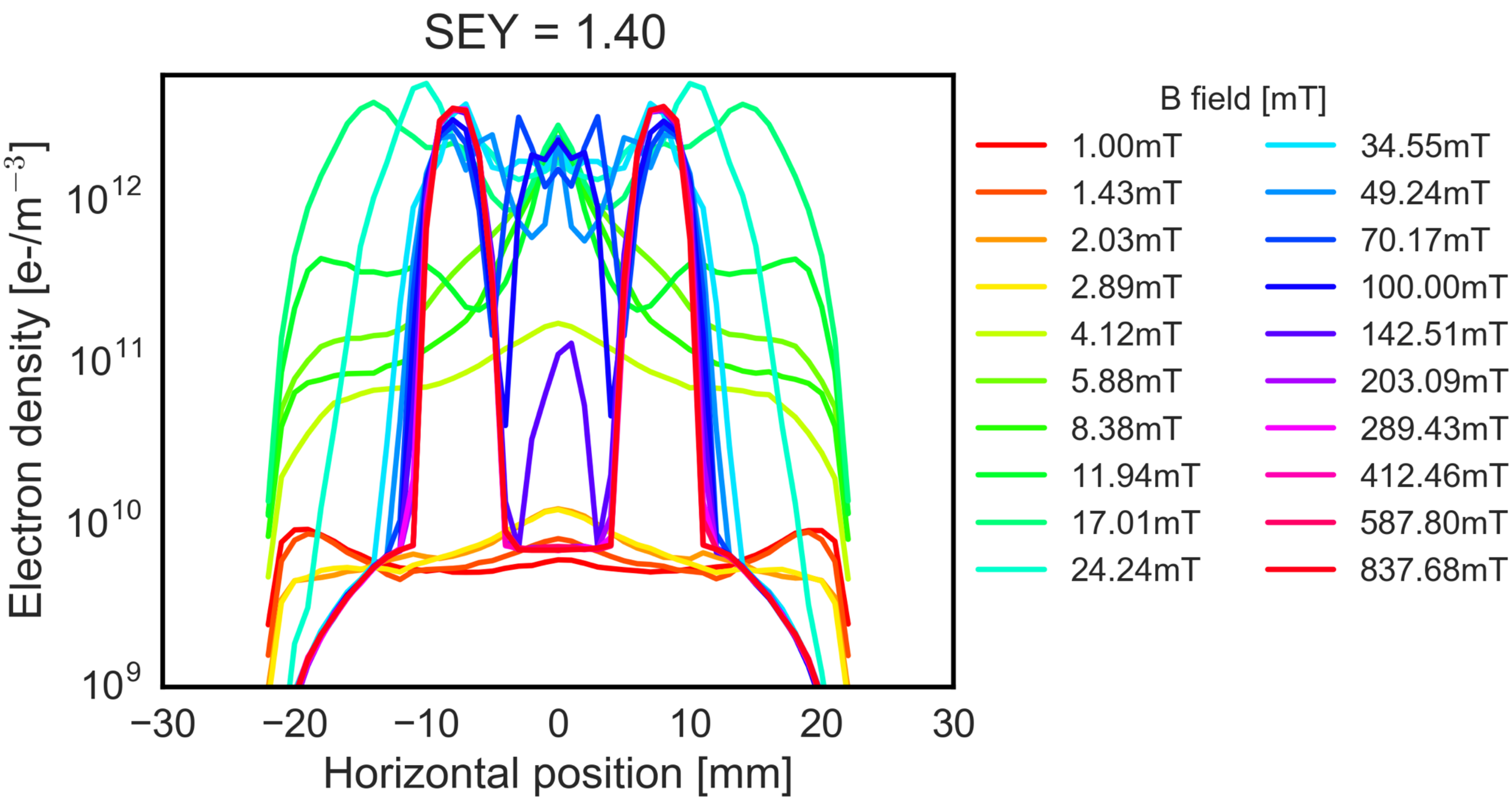
- In the **50 ns fill** performed on Sat 22 Jul, the expected **e-cloud suppression was clearly visible on the heat loads** in all twin-bore magnets in the machine
  - **No particular behavior is observed at 16L2** and neighboring cells
  - In particular there is **no correlation of heat load with beam losses when changing the current in the MCBs**
  - It would be desirable to perform a scan during a **25 ns fill with same number of bunches and bunch intensity** to have a clear comparison (e.g. if at some we need an intermediate intensity fill for MP reasons)
- The **contribution of the corrector magnets** to the heat load per half cell is **expected to be small**
  - **No evident correlation** is found between cell-by-cell heat loads and corrector settings
- As observed before, **coherent beam motion** was present right before all dumps
  - Too fast at high energy to allow for a meaningful spectral analysis
  - In the case of the **dump at 450 GeV** the beam stayed for a longer time after becoming unstable → observed **clear coupled bunch motion**, large **positive tune shift**
  - First simulations show that a **Fast Beam Ion Instability (FBII)** could be a possible driving mechanism for the coherent motion (for large enough ion density) → some development work needed to make quantitative estimates

Thanks for your attention!


100 mA
1 A
e (A=0)
H (A=1)
He (A=4)
C (A=12)
N (A=14)
O (A=16)
Cu (A=63)
Cyclotron frequency [Hz]
Magnetic field [T]

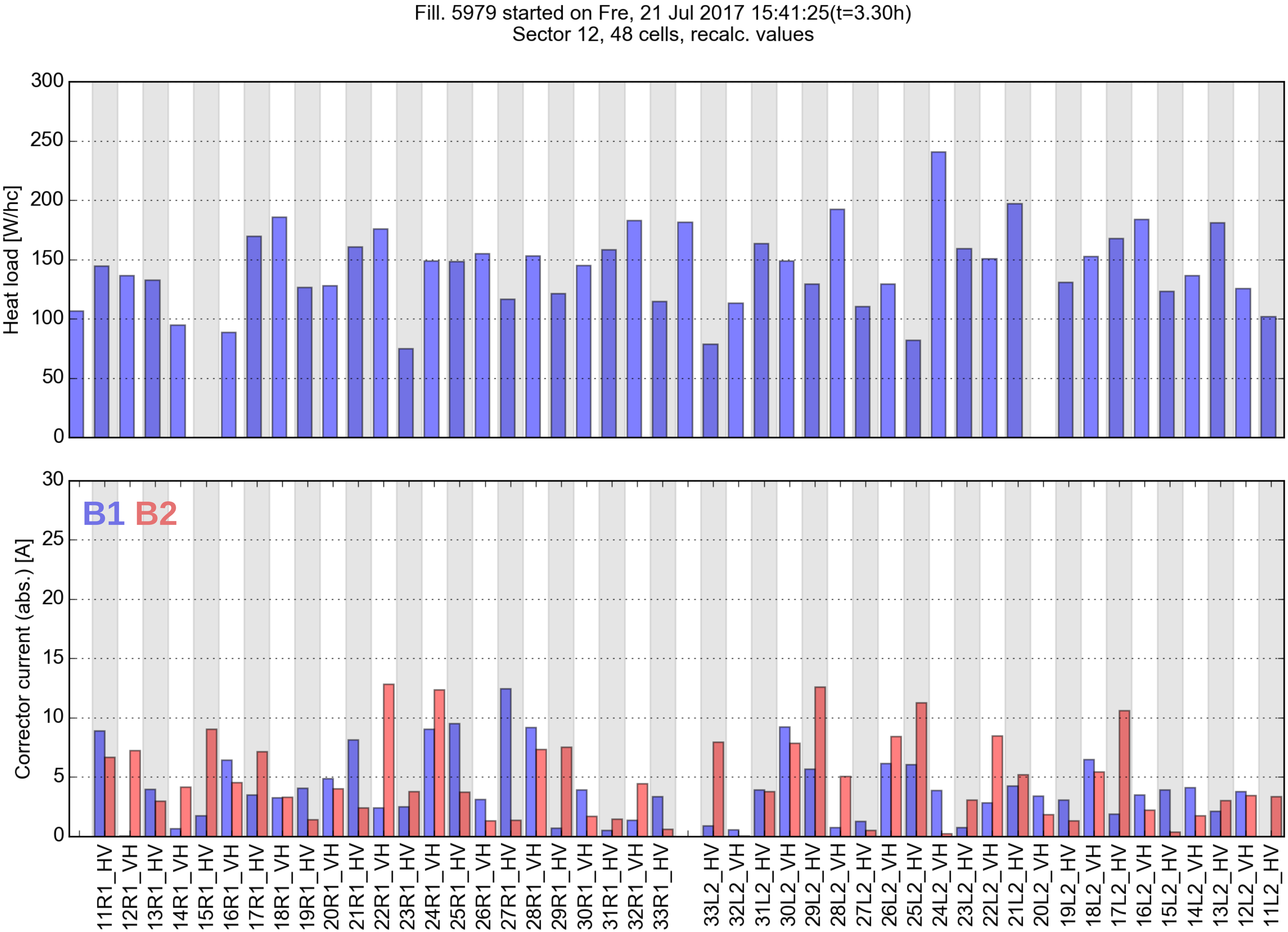

For a kinetic energy of 50 eV
100 mA
1 A
Cyclotron radius [m]
Magnetic field [T]


For a kinetic energy of 500 eV
100 mA
1 A
e (A=0)
H (A=1)
He (A=4)
C (A=12)
N (A=14)
O (A=16)
Cu (A=63)
Cyclotron radius [m]
Magnetic field [T]


SEY = 1.40
Electron density [e-/m^{-3}]
10^{12}
10^{11}
10^{10}
10^{9}
−30
−20
−10
0
10
20
30
Horizontal position [mm]
B field [mT]
1.00mT
1.43mT
2.03mT
2.89mT
4.12mT
5.88mT
8.38mT
11.94mT
17.01mT
24.24mT
34.55mT
49.24mT
70.17mT
100.00mT
142.51mT
203.09mT
289.43mT
412.46mT
587.80mT
837.68mT

Fill 5979
(21 Jul 2017)

25 ns, 2556b/beam, 6.5 TeV



Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 12, 48 cells, recalc. values
Heat load [W/hc]
Corrector current (abs.) [A]
B1 B2
11R1_HV
12R1_VH
13R1_HV
14R1_VH
15R1_HV
16R1_VH
17R1_HV
18R1_VH
19R1_HV
20R1_VH
21R1_HV
22R1_VH
23R1_HV
24R1_VH
25R1_HV
26R1_VH
27R1_HV
28R1_VH
29R1_HV
30R1_VH
31R1_HV
32R1_VH
33R1_HV
33L2_HV
32L2_VH
31L2_HV
30L2_VH
29L2_HV
28L2_VH
27L2_HV
26L2_VH
25L2_HV
24L2_VH
23L2_HV
22L2_VH
21L2_HV
20L2_VH
19L2_HV
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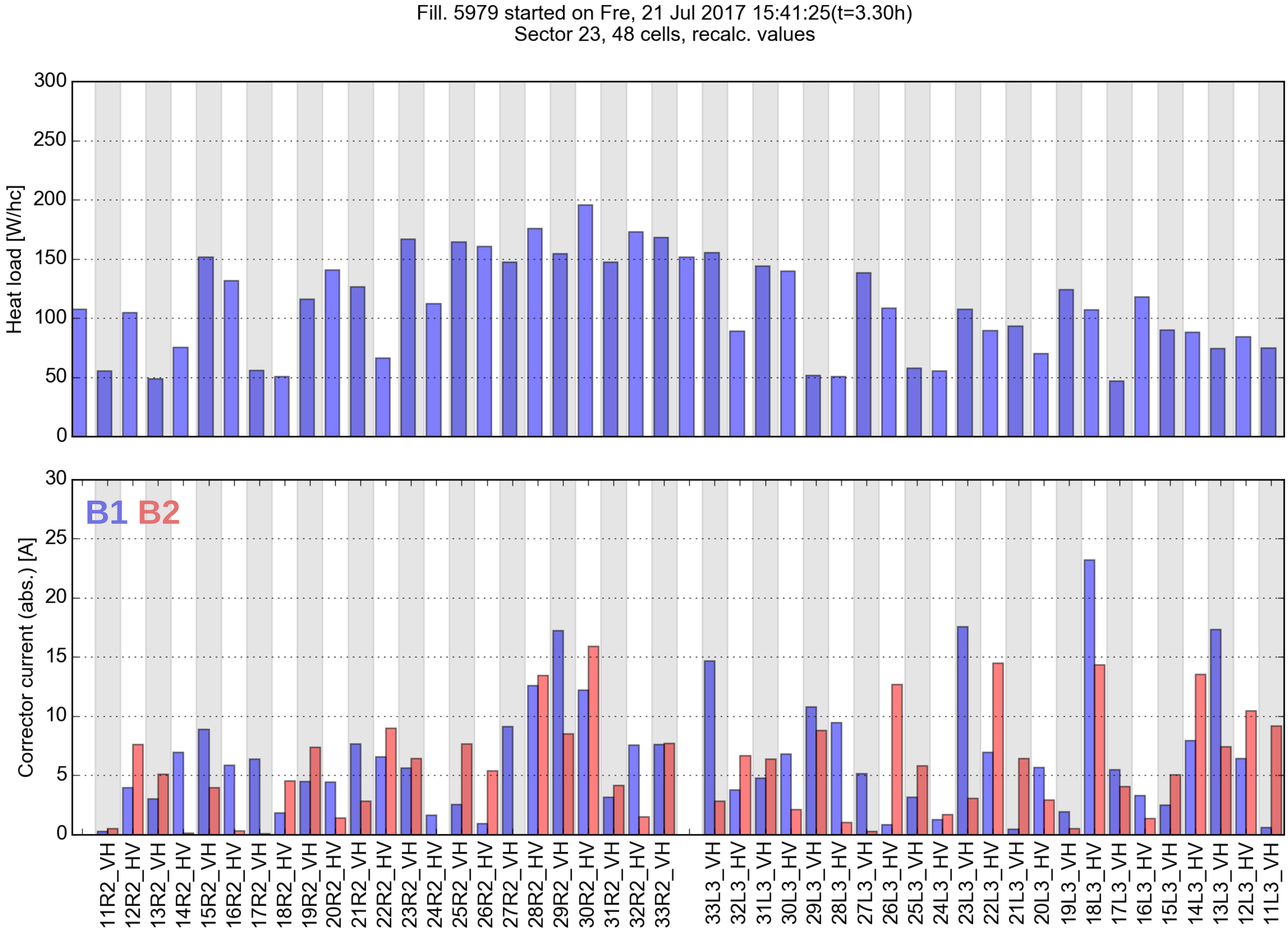
14L2_VH
13L2_HV
12L2_VH
11L2_HV


Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 23, 48 cells, recalc. values
Heat load [W/hc]
Corrector current (abs.) [A]
B1 B2
11R2_VH
12R2_HV
13R2_VH
14R2_HV
15R2_VH
16R2_HV
17R2_VH
18R2_HV
19R2_VH
20R2_HV
21R2_VH
22R2_HV
23R2_VH
24R2_HV
25R2_VH
26R2_HV
27R2_VH
28R2_HV
29R2_VH
30R2_HV
31R2_VH
32R2_HV
33R2_VH
33L3_VH
32L3_HV
31L3_VH
30L3_HV
29L3_VH
28L3_HV
27L3_VH
26L3_HV
25L3_VH
24L3_HV
23L3_VH
22L3_HV
21L3_VH
20L3_HV
19L3_VH
18L3_HV
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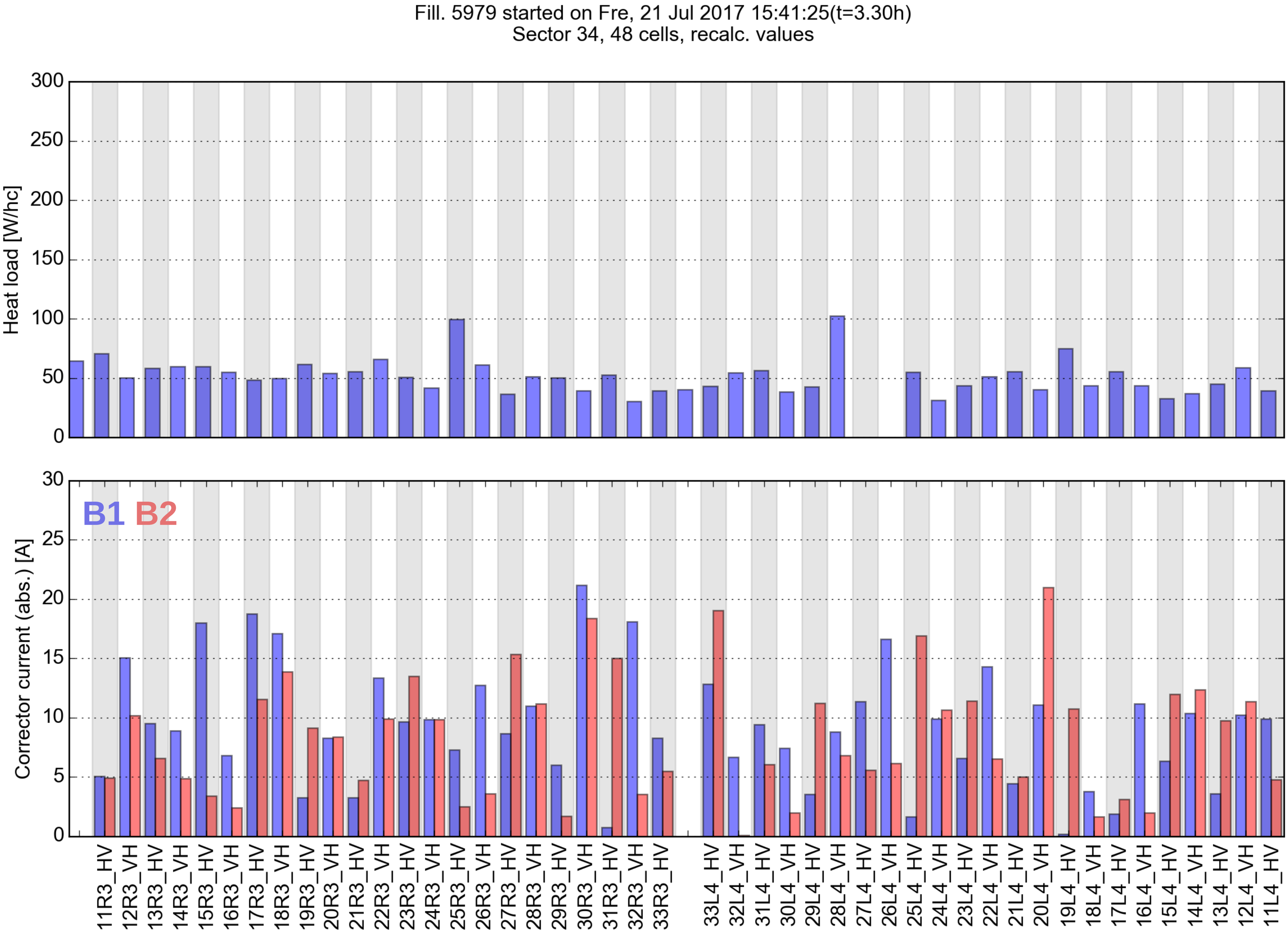
15L3_VH
14L3_HV
13L3_VH
12L3_HV
11L3_VH



Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 34, 48 cells, recalc. values
Heat load [W/hc]
Corrector current (abs.) [A]
B1 B2
11R3_HV
12R3_VH
13R3_HV
14R3_VH
15R3_HV
16R3_VH
17R3_HV
18R3_VH
19R3_HV
20R3_VH
21R3_HV
22R3_VH
23R3_HV
24R3_VH
25R3_HV
26R3_VH
27R3_HV
28R3_VH
29R3_HV
30R3_VH
31R3_HV
32R3_VH
33R3_HV
33L4_HV
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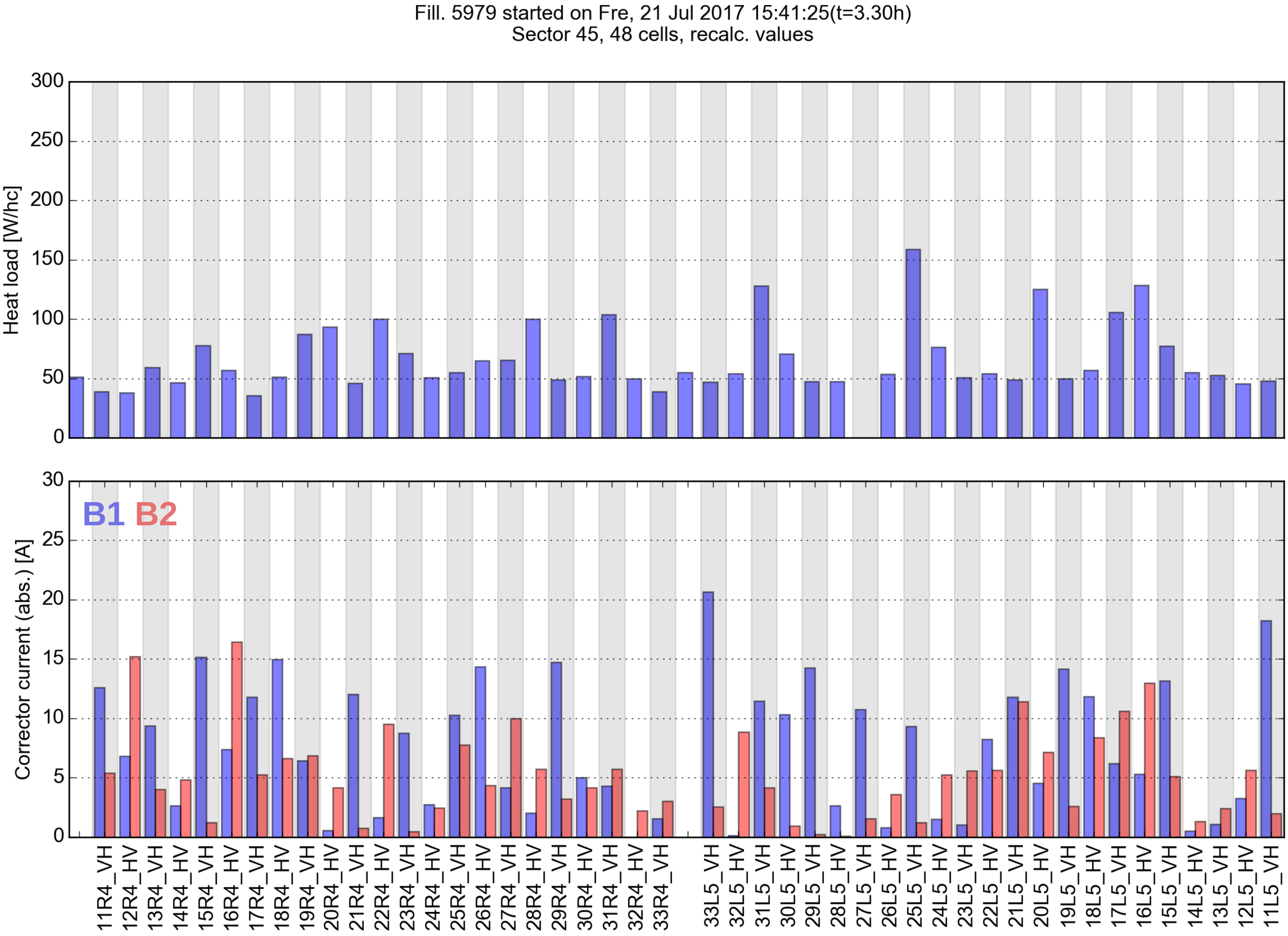
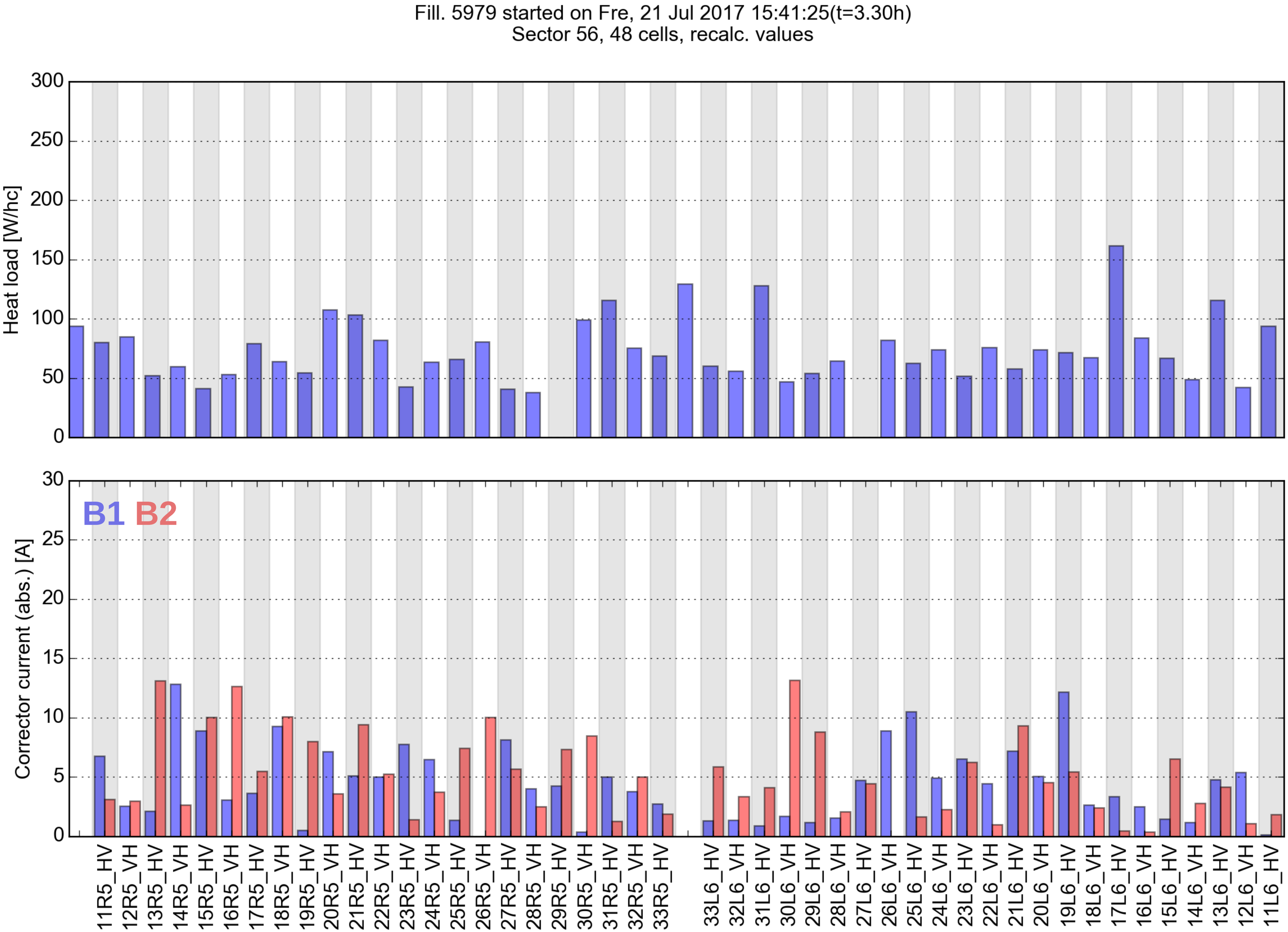
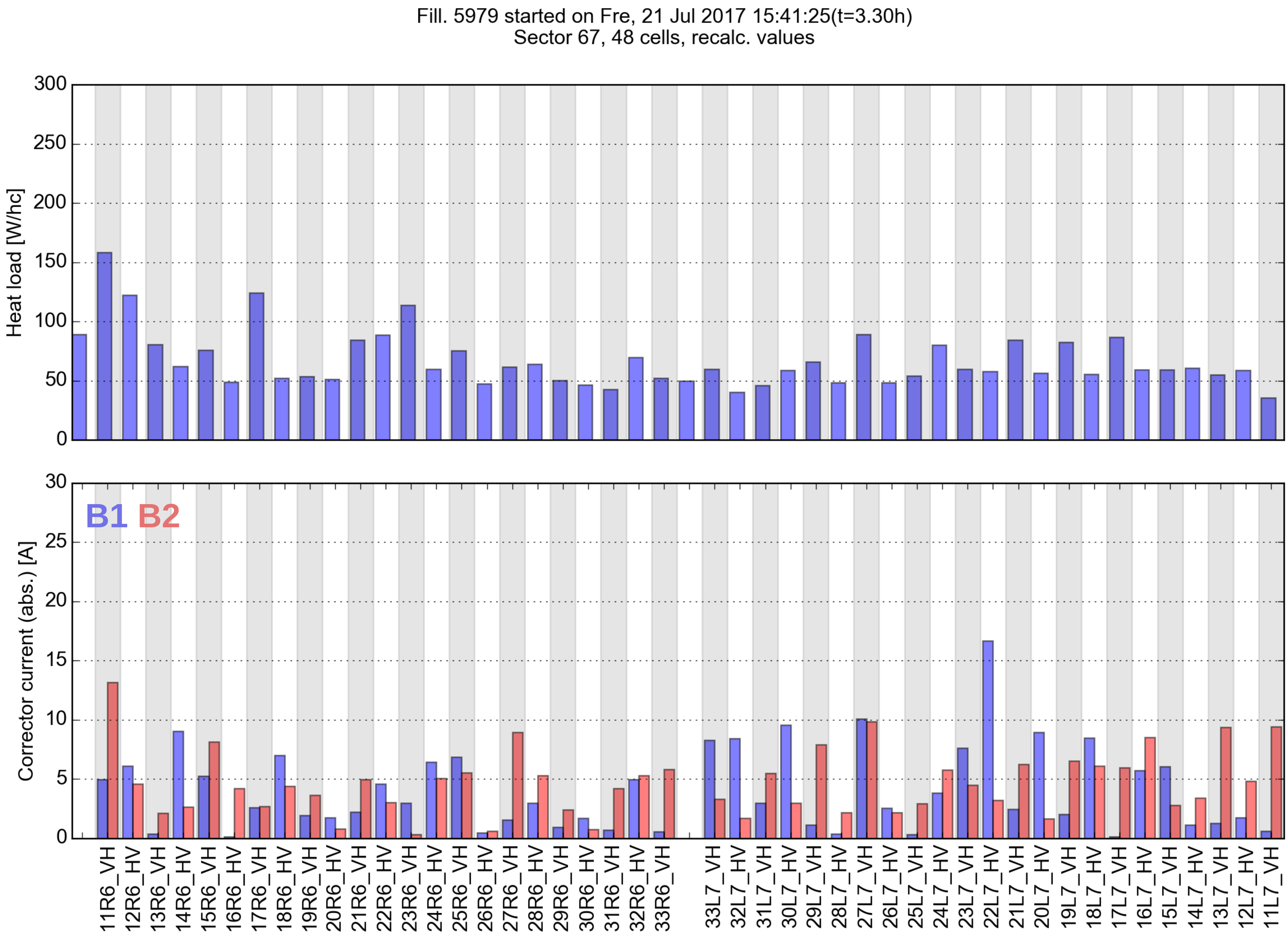
31L4_HV
30L4_VH
29L4_HV
28L4_VH
27L4_HV
26L4_VH
25L4_HV
24L4_VH
23L4_HV
22L4_VH
21L4_HV
20L4_VH
19L4_HV
18L4_VH
17L4_HV
16L4_VH
15L4_HV
14L4_VH
13L4_HV
12L4_VH
11L4_HV

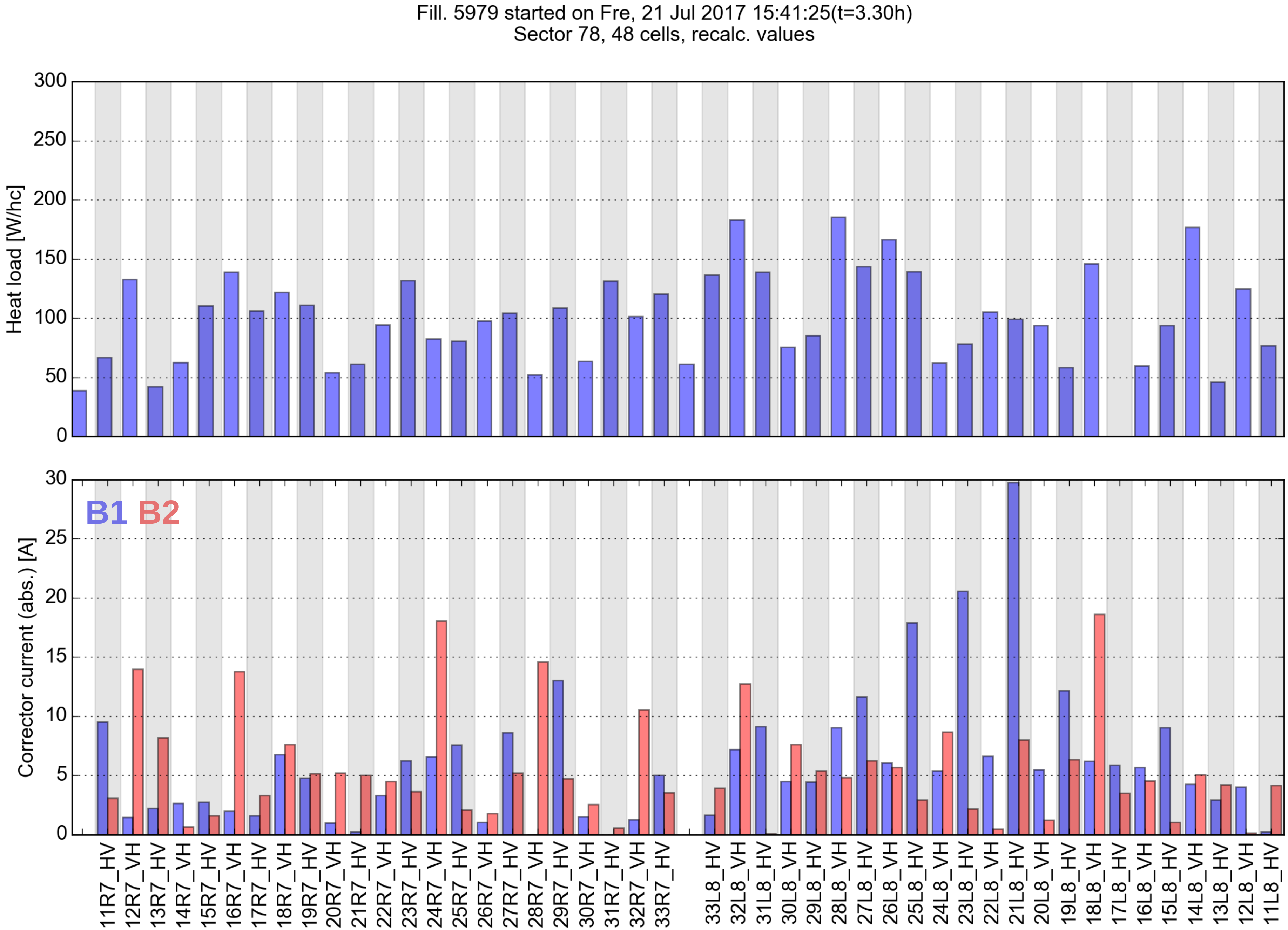


Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 45, 48 cells, recalc. values
Heat load [W/hc]
Corrector current (abs.) [A]
B1 B2
11R4_VH
12R4_HV
13R4_VH
14R4_HV
15R4_VH
16R4_HV
17R4_VH
18R4_HV
19R4_VH
20R4_HV
21R4_VH
22R4_HV
23R4_VH
24R4_HV
25R4_VH
26R4_HV
27R4_VH
28R4_HV
29R4_VH
30R4_HV
31R4_VH
32R4_HV
33R4_VH
33L5_VH
32L5_HV
31L5_VH
30L5_HV
29L5_VH
28L5_HV
27L5_VH
26L5_HV
25L5_VH
24L5_HV
23L5_VH
22L5_HV
21L5_VH
20L5_HV
19L5_VH
18L5_HV
17L5_VH
16L5_HV
15L5_VH
14L5_HV
13L5_VH
12L5_HV
11L5_VH

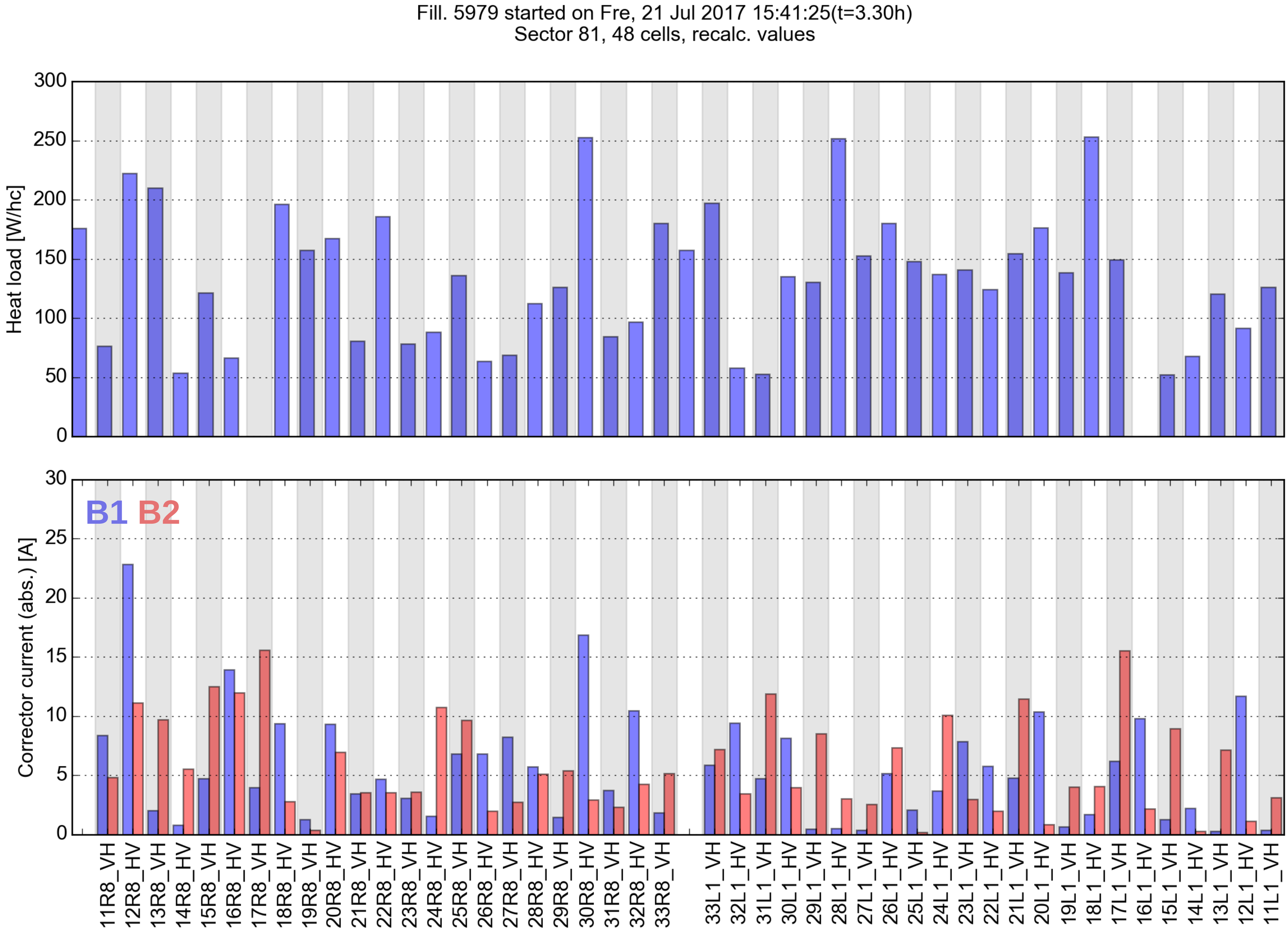


Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 56, 48 cells, recalc. values
Heat load [W/hc]
300
250
200
150
100
50
0
Corrector current (abs.) [A]
30
25
20
15
10
5
0
B1 B2
11R5_HV
12R5_VH
13R5_HV
14R5_VH
15R5_HV
16R5_VH
17R5_HV
18R5_VH
19R5_HV
20R5_VH
21R5_HV
22R5_VH
23R5_HV
24R5_VH
25R5_HV
26R5_VH
27R5_HV
28R5_VH
29R5_HV
30R5_VH
31R5_HV
32R5_VH
33R5_HV
33L6_HV
32L6_VH
31L6_HV
30L6_VH
29L6_HV
28L6_VH
27L6_HV
26L6_VH
25L6_HV
24L6_VH
23L6_HV
22L6_VH
21L6_HV
20L6_VH
19L6_HV
18L6_VH
17L6_HV
16L6_VH
15L6_HV
14L6_VH
13L6_HV
12L6_VH
11L6_HV


Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 67, 48 cells, recalc. values
Heat load [W/hc]
300
250
200
150
100
50
0
Corrector current (abs.) [A]
30
25
20
15
10
5
0
B1 B2
11R6_VH
12R6_HV
13R6_VH
14R6_HV
15R6_VH
16R6_HV
17R6_VH
18R6_HV
19R6_VH
20R6_HV
21R6_VH
22R6_HV
23R6_VH
24R6_HV
25R6_VH
26R6_HV
27R6_VH
28R6_HV
29R6_VH
30R6_HV
31R6_VH
32R6_HV
33R6_VH
33L7_VH
32L7_HV
31L7_VH
30L7_HV
29L7_VH
28L7_HV
27L7_VH
26L7_HV
25L7_VH
24L7_HV
23L7_VH
22L7_HV
21L7_VH
20L7_HV
19L7_VH
18L7_HV
17L7_VH
16L7_HV
15L7_VH
14L7_HV
13L7_VH
12L7_HV
11L7_VH



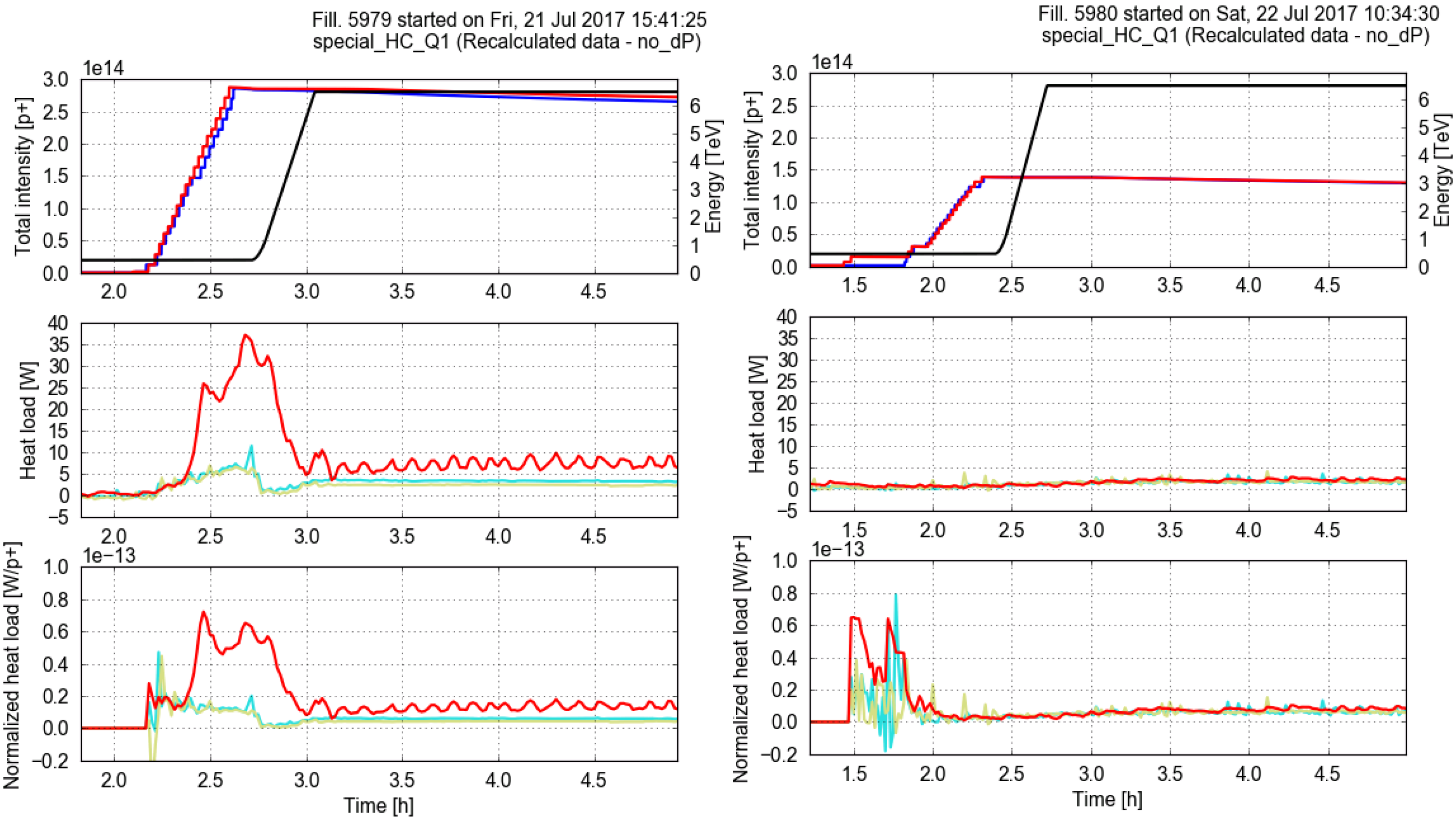
Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 78, 48 cells, recalc. values
Heat load [W/hc]
Corrector current (abs.) [A]
B1 B2
11R7_HV
12R7_VH
13R7_HV
14R7_VH
15R7_HV
16R7_VH
17R7_HV
18R7_VH
19R7_HV
20R7_VH
21R7_HV
22R7_VH
23R7_HV
24R7_VH
25R7_HV
26R7_VH
27R7_HV
28R7_VH
29R7_HV
30R7_VH
31R7_HV
32R7_VH
33R7_HV
33L8_HV
32L8_VH
31L8_HV
30L8_VH
29L8_HV
28L8_VH
27L8_HV
26L8_VH
25L8_HV
24L8_VH
23L8_HV
22L8_VH
21L8_HV
20L8_VH
19L8_HV
18L8_VH
17L8_HV
16L8_VH
15L8_HV
14L8_VH
13L8_HV
12L8_VH
11L8_HV


Fill. 5979 started on Fre, 21 Jul 2017 15:41:25(t=3.30h)
Sector 81, 48 cells, recalc. values
Heat load [W/hc]
0
50
100
150
200
250
300
Corrector current (abs.) [A]
0
5
10
15
20
25
30
B1 B2
11R8_VH
12R8_HV
13R8_VH
14R8_HV
15R8_VH
16R8_HV
17R8_VH
18R8_HV
19R8_VH
20R8_HV
21R8_VH
22R8_HV
23R8_VH
24R8_HV
25R8_VH
26R8_HV
27R8_VH
28R8_HV
29R8_VH
30R8_HV
31R8_VH
32R8_HV
33R8_VH
33L1_VH
32L1_HV
31L1_VH
30L1_HV
29L1_VH
28L1_HV
27L1_VH
26L1_HV
25L1_VH
24L1_HV
23L1_VH
22L1_HV
21L1_VH
20L1_HV
19L1_VH
18L1_HV
17L1_VH
16L1_HV
15L1_VH
14L1_HV
13L1_VH
12L1_HV
11L1_VH

Instrumented quadrupoles

Consistent with observations on the arc averages:

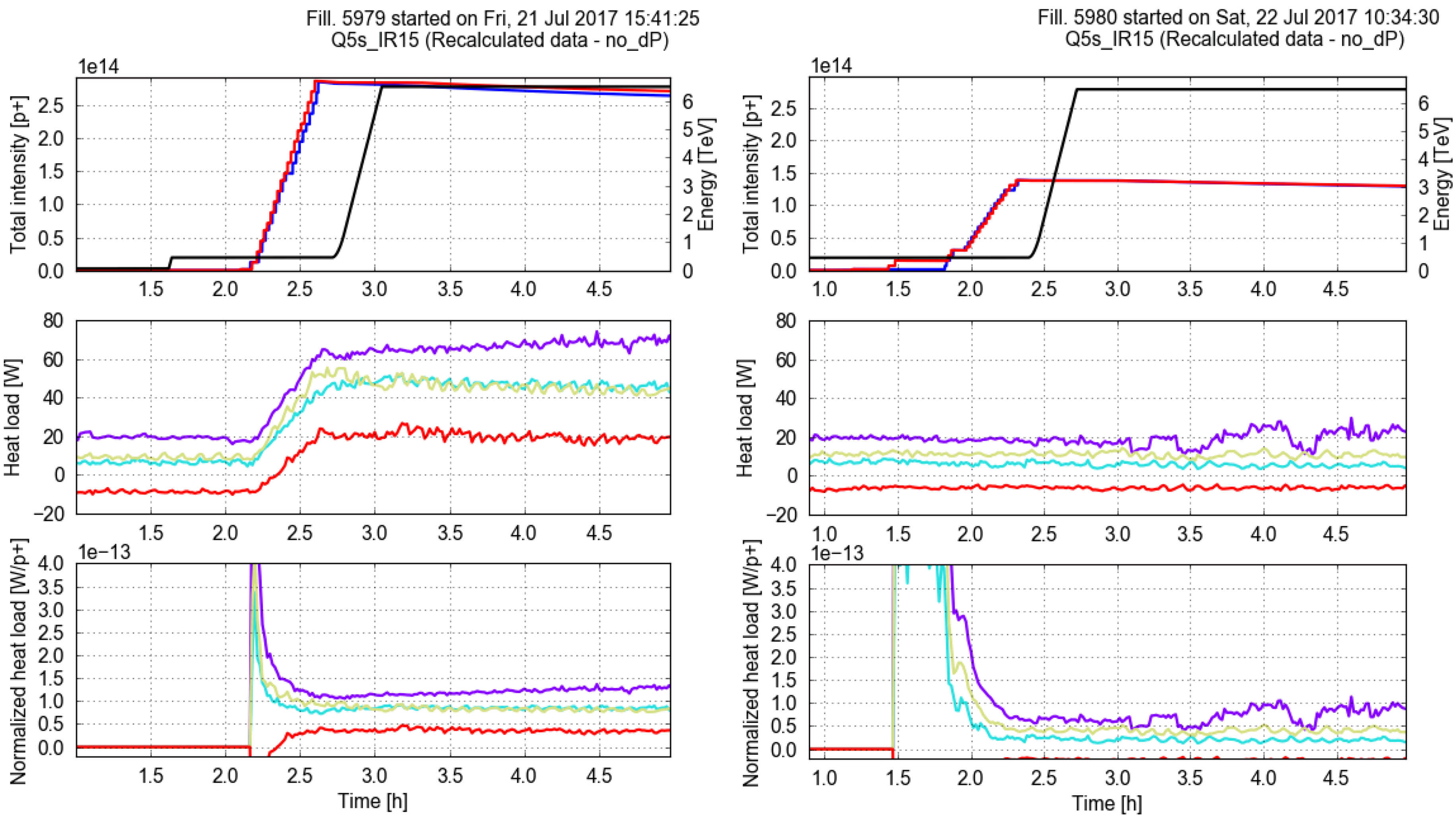
- **Heat loads are reduced** and **large differences are suppressed**



Stand alone quadrupoles: Q5s

Consistent with observations on the arc averages:

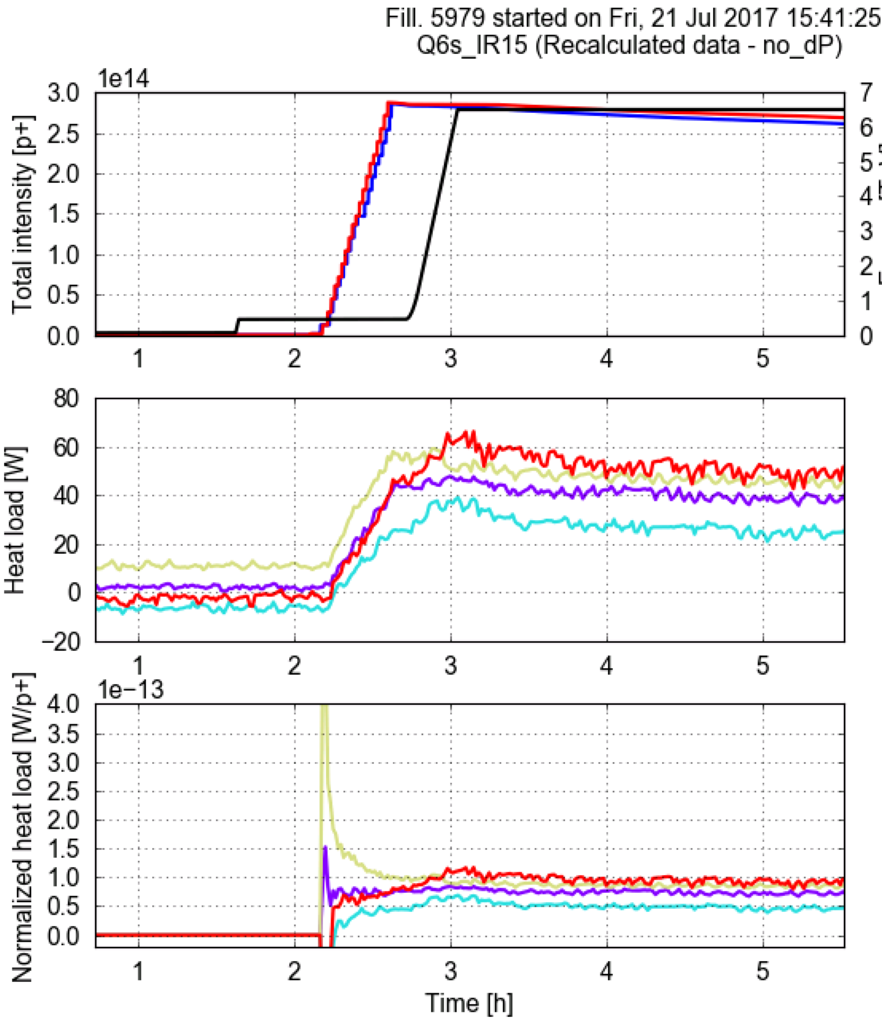
- **Heat loads are reduced** and **large differences are suppressed**

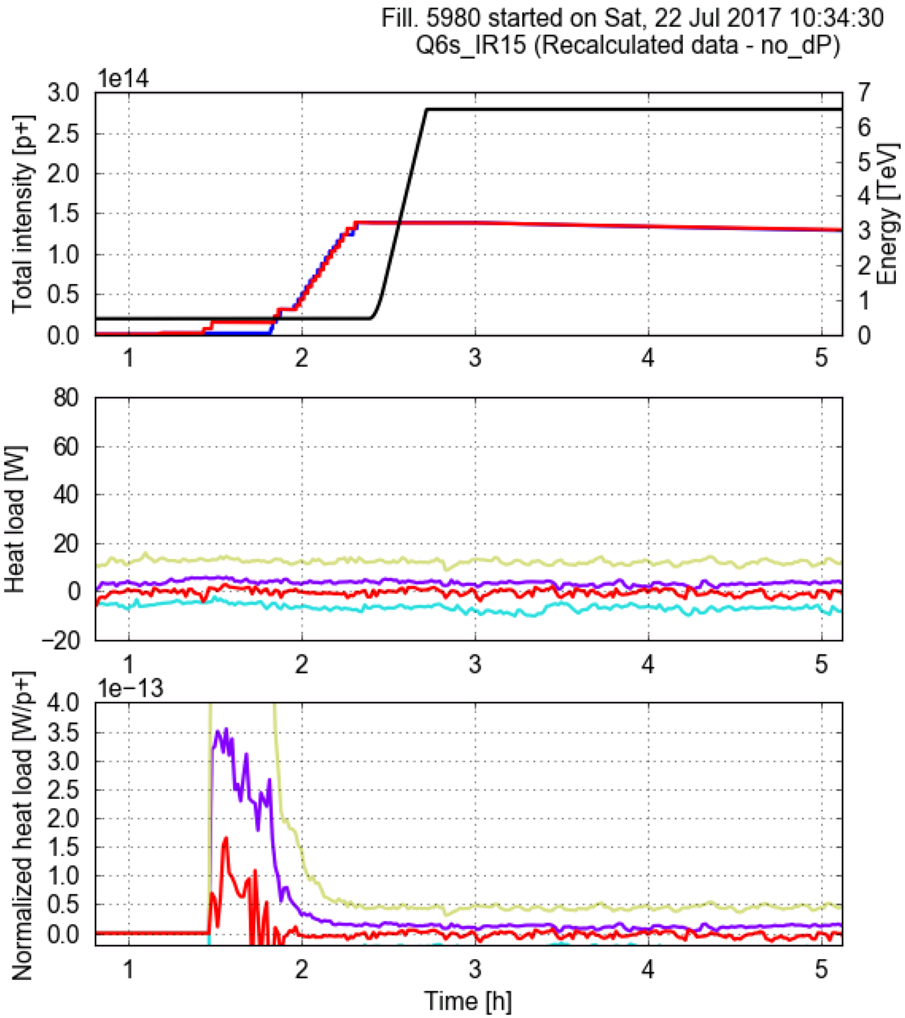


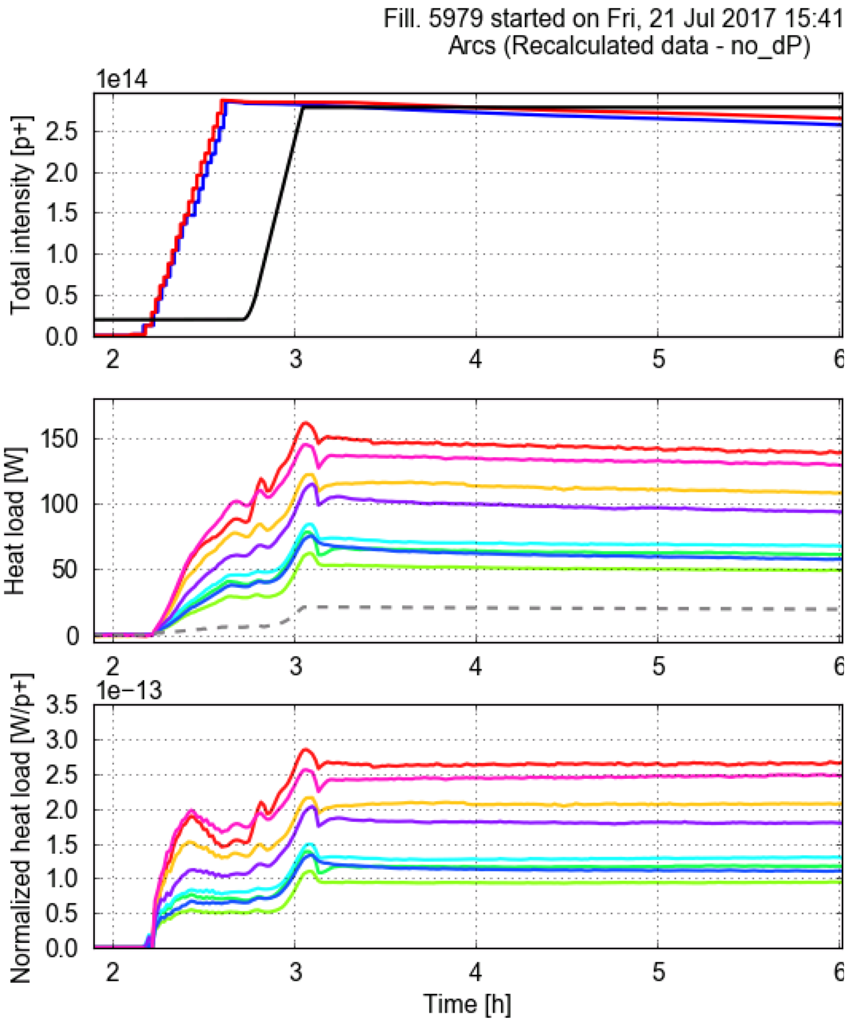
Stand alone quadrupoles: Q6s

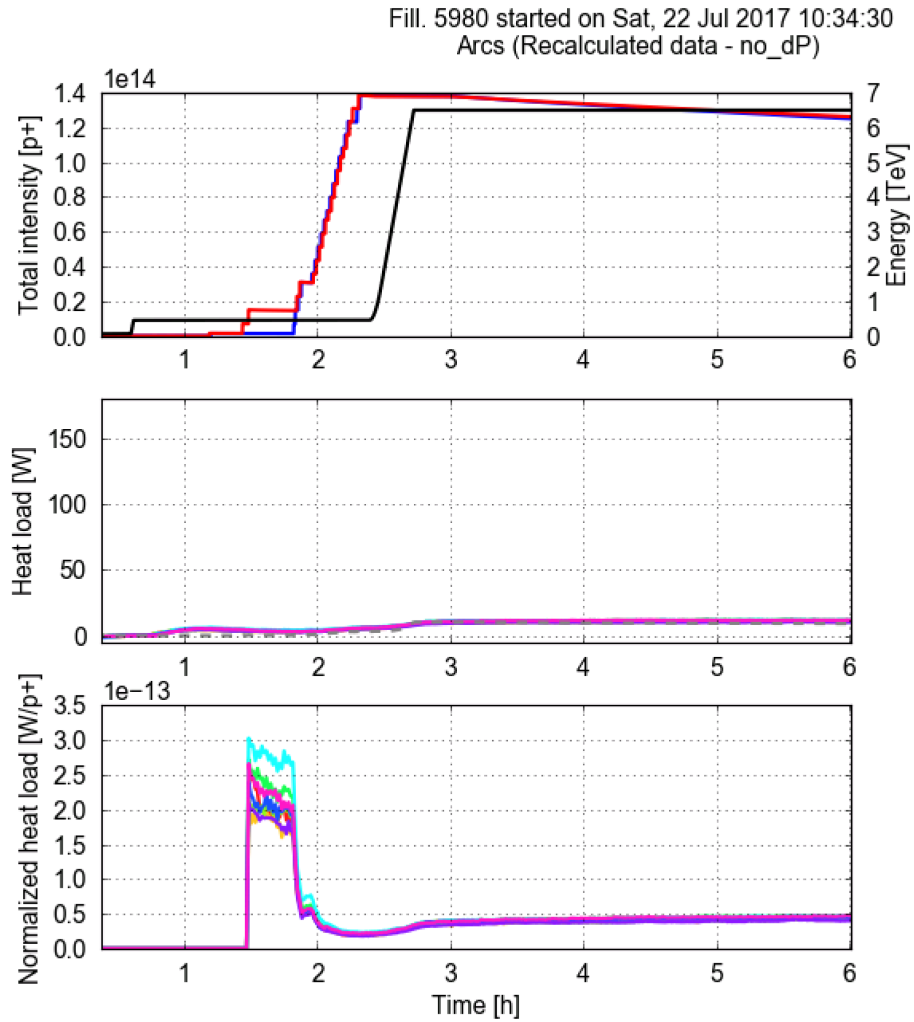
Consistent with observations on the arc averages:

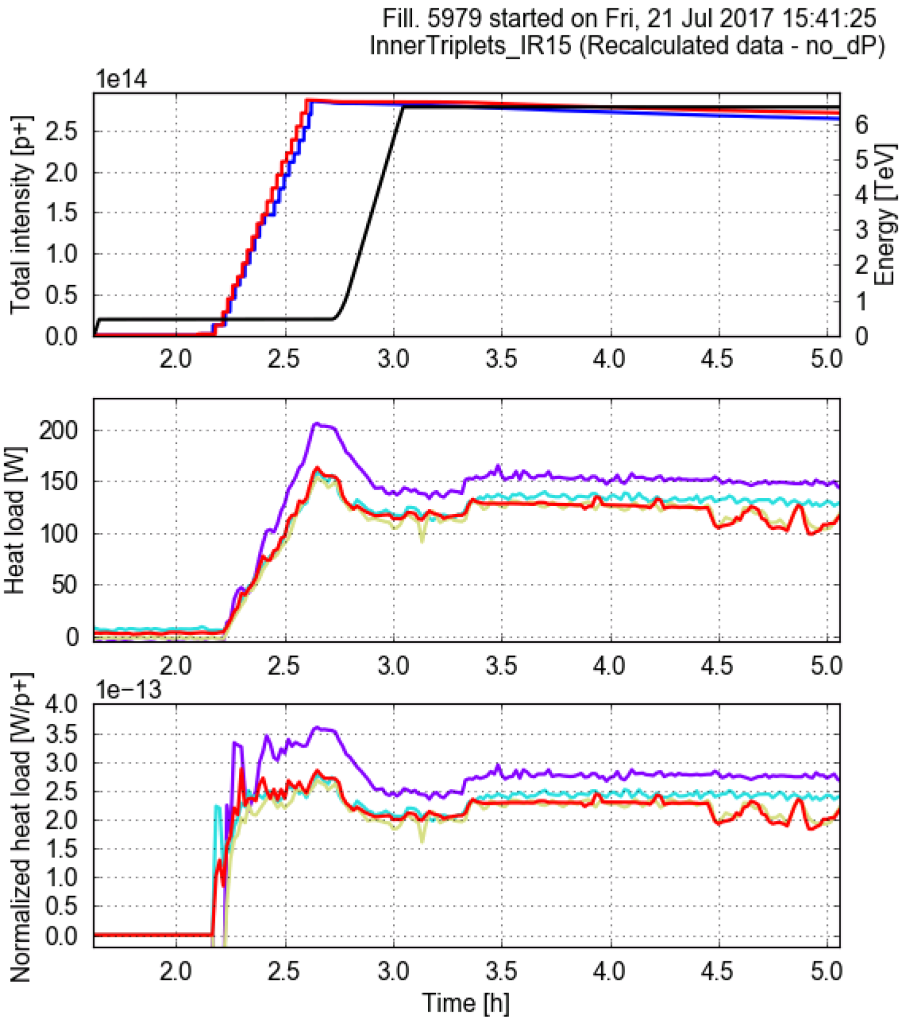
- **Heat loads are reduced** and **large differences are suppressed**

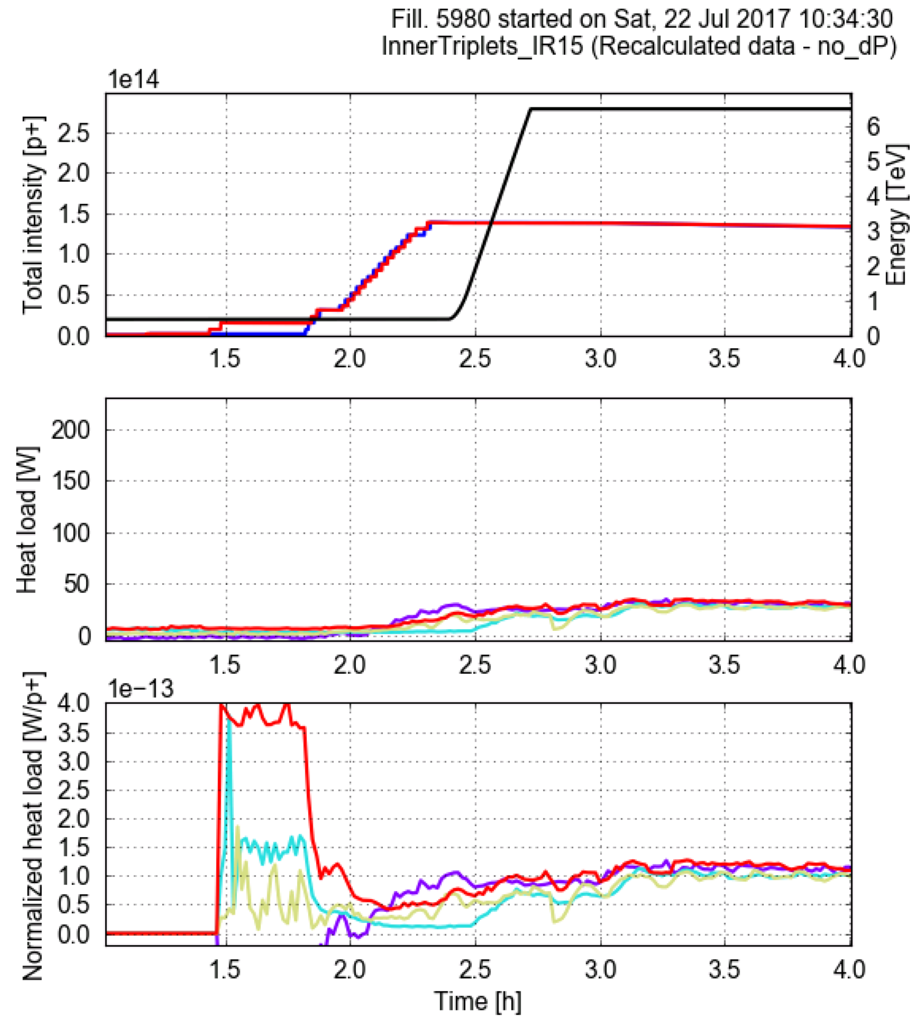


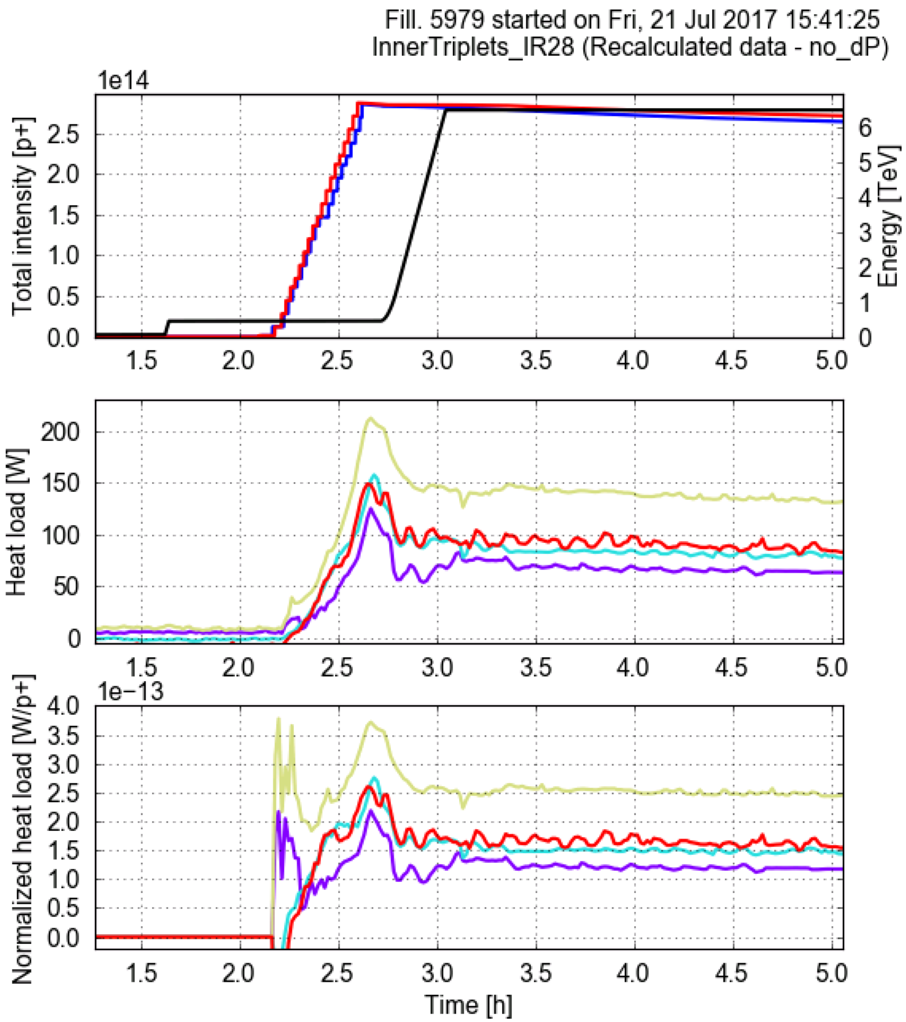



Fill. 5979 started on Fri, 21 Jul 2017 15:41
Arcs (Recalculated data - no_dP)
1e14
Total intensity [p+]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]

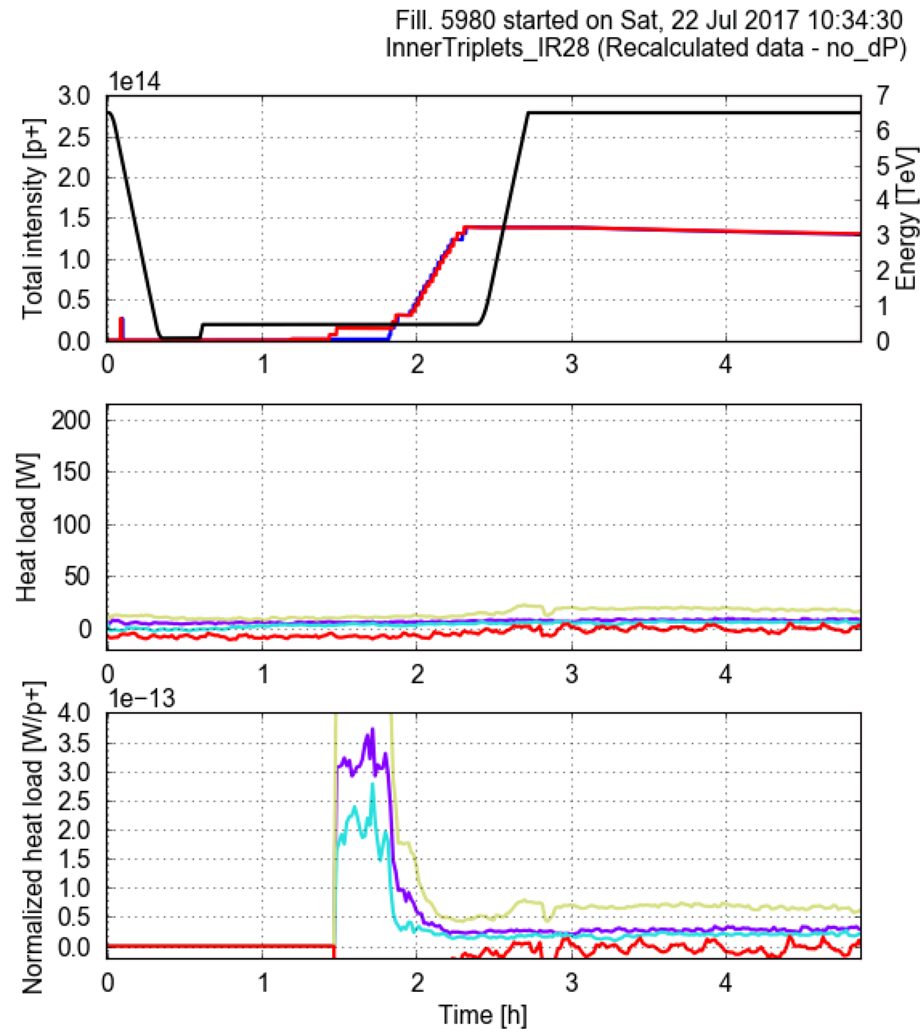

Fill. 5980 started on Sat, 22 Jul 2017 10:34:30
Arcs (Recalculated data - no_dP)
1e14
Total intensity [p+]
Energy [TeV]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]


Fill. 5979 started on Fri, 21 Jul 2017 15:41:25
InnerTriplets_IR15 (Recalculated data - no_dP)
1e14
Total intensity [p+]
Energy [TeV]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]

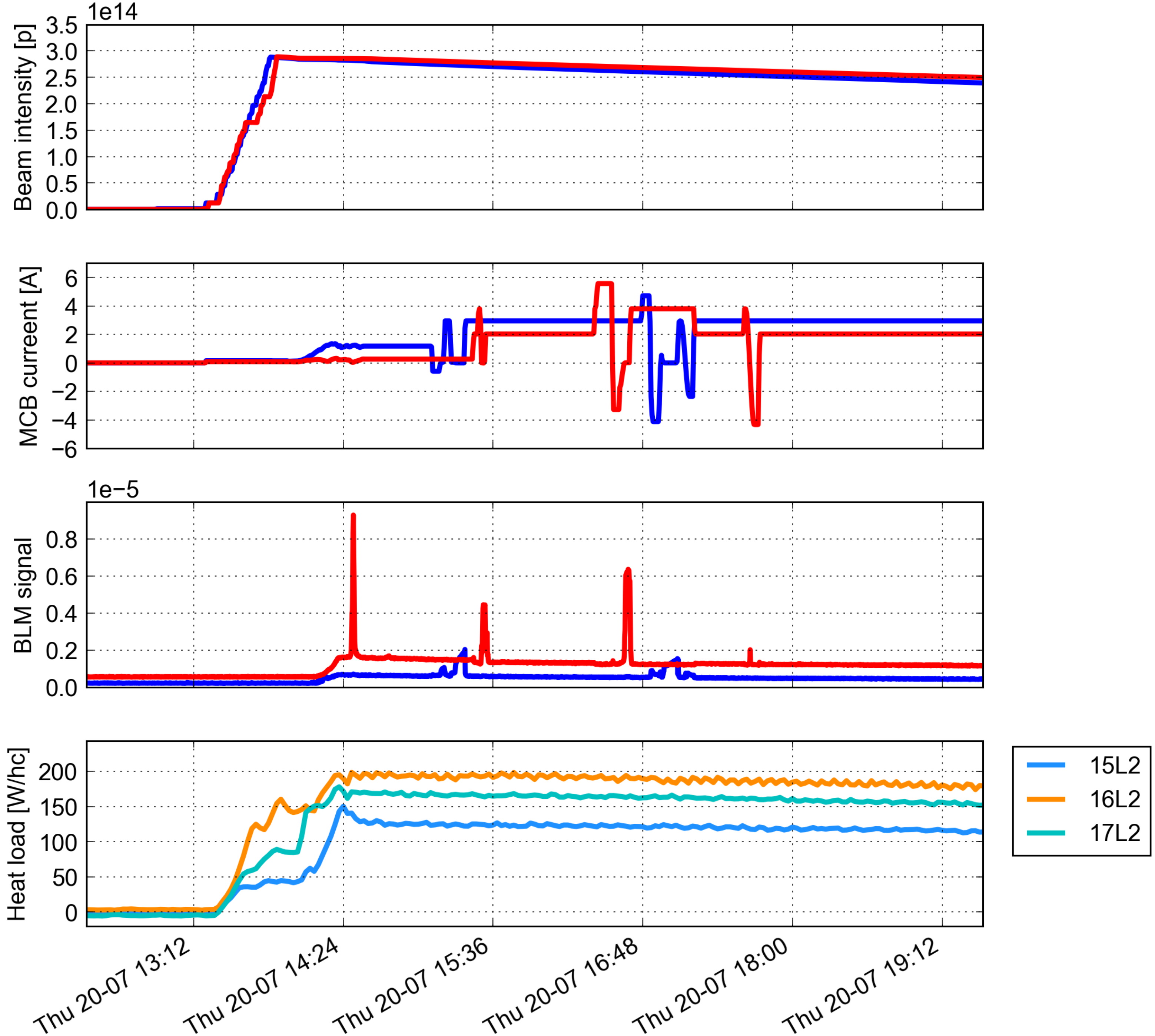

Fill. 5980 started on Sat, 22 Jul 2017 10:34:30
InnerTriplets_IR15 (Recalculated data - no_dP)
1e14
Total intensity [p+]
Energy [TeV]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]

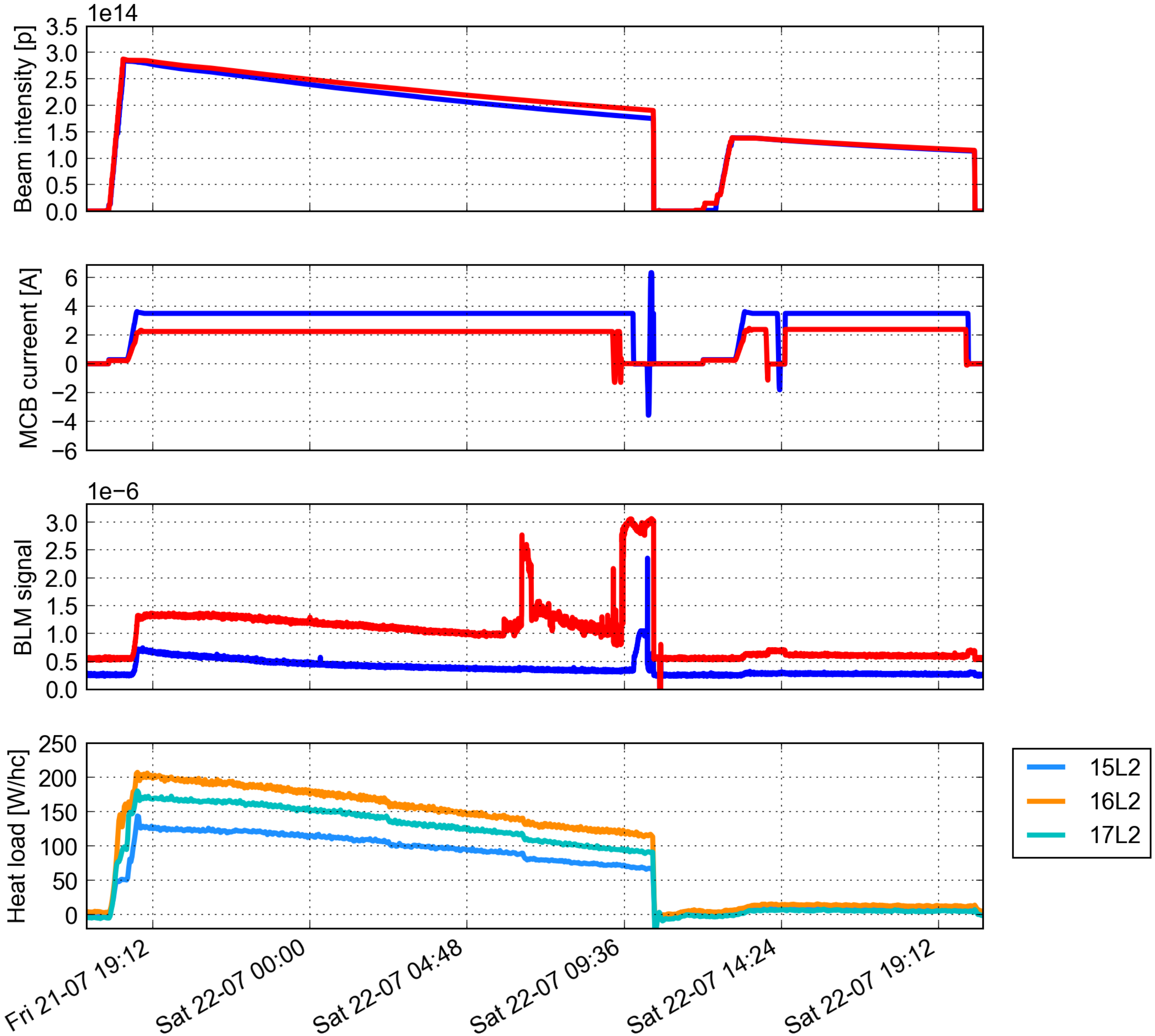


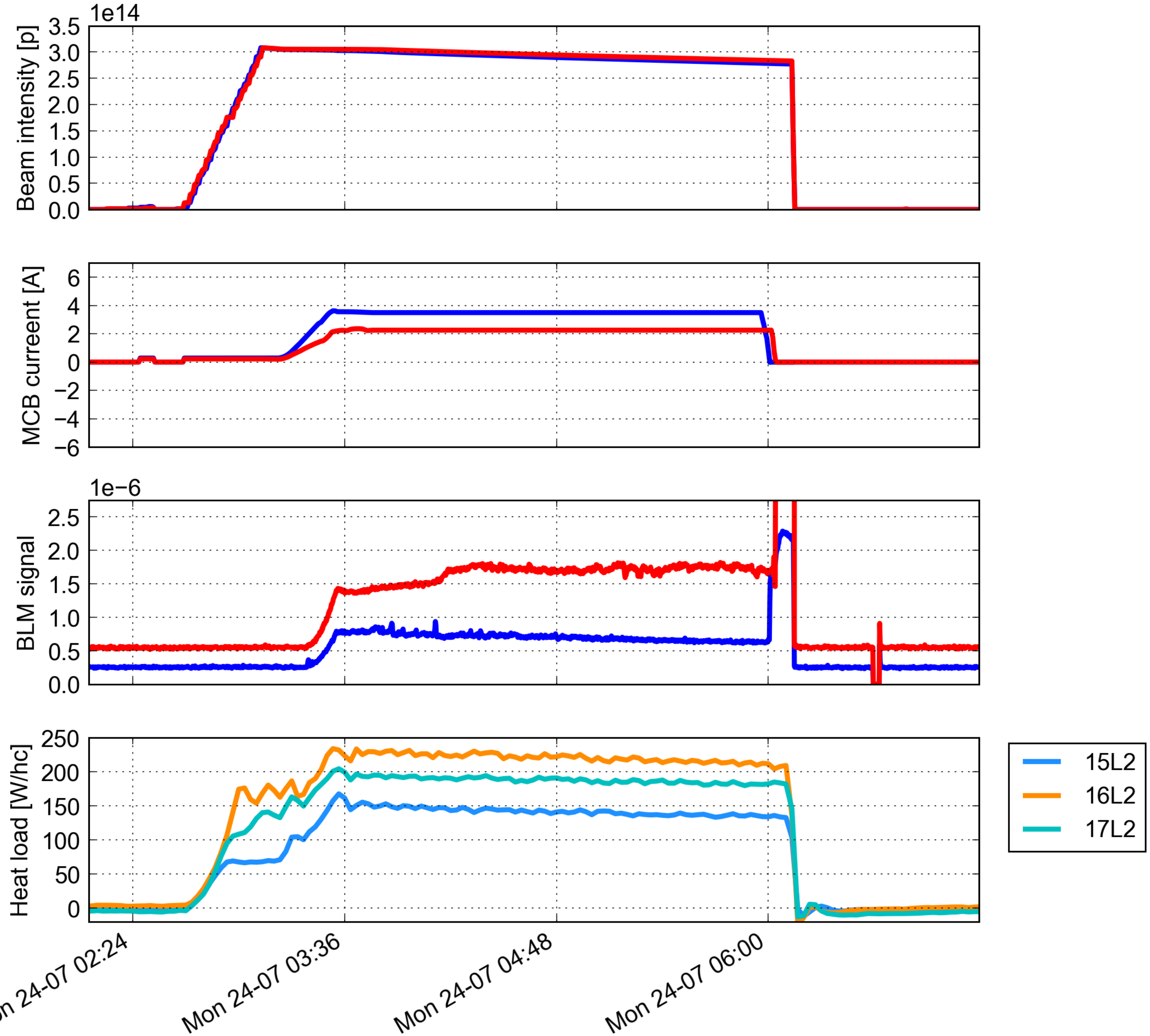
Fill. 5979 started on Fri, 21 Jul 2017 15:41:25
InnerTriplets_IR28 (Recalculated data - no_dP)
1e14
Total intensity [p+]
Energy [TeV]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]



Fill. 5980 started on Sat, 22 Jul 2017 10:34:30
InnerTriplets_IR28 (Recalculated data - no_dP)
1e14
Total intensity [p+]
Energy [TeV]
Heat load [W]
1e−13
Normalized heat load [W/p+]
Time [h]


1e14
Beam intensity [p]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
MCB curreent [A]
6
4
2
0
−2
−4
−6
1e−5
BLM signal
0.8
0.6
0.4
0.2
0.0
Heat load [W/hc]
200
150
100
50
0
15L2
16L2
17L2
Thu 20-07 13:12
Thu 20-07 14:24
Thu 20-07 15:36
Thu 20-07 16:48
Thu 20-07 18:00
Thu 20-07 19:12

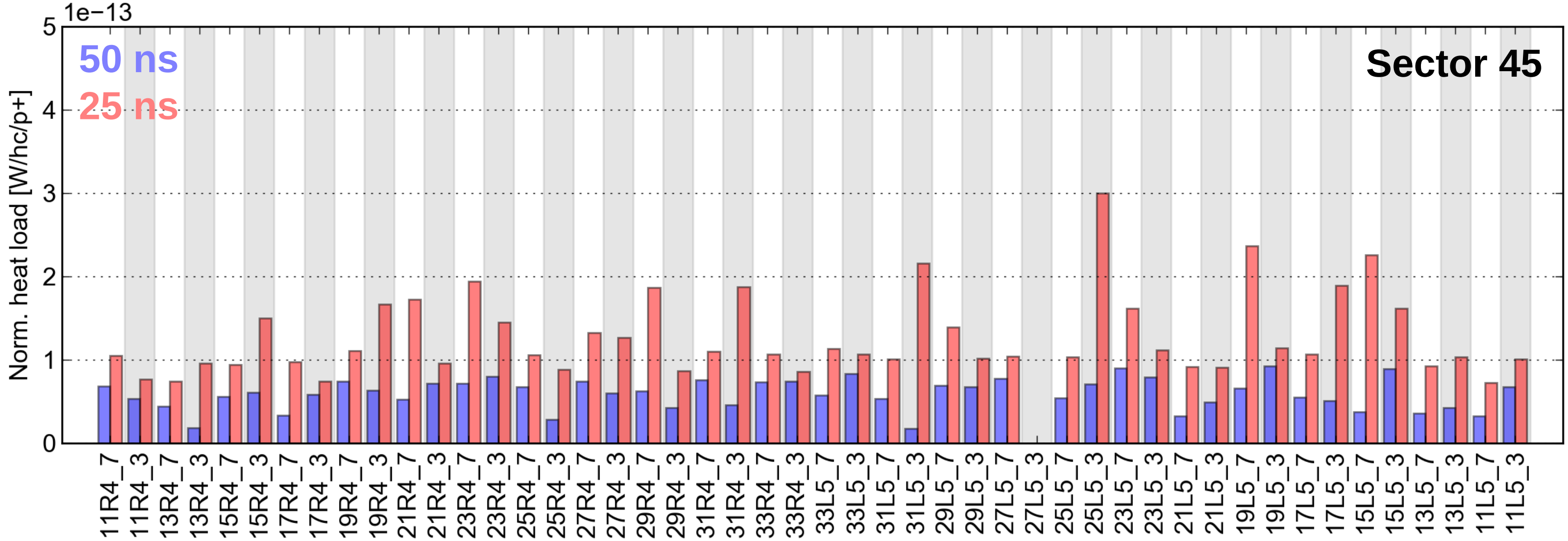

1e14
Beam intensity [p]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
MCB curreent [A]
6
4
2
0
−2
−4
−6
1e−6
BLM signal
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Heat load [W/hc]
250
200
150
100
50
0
15L2
16L2
17L2
Fri 21-07 19:12
Sat 22-07 00:00
Sat 22-07 04:48
Sat 22-07 09:36
Sat 22-07 14:24
Sat 22-07 19:12

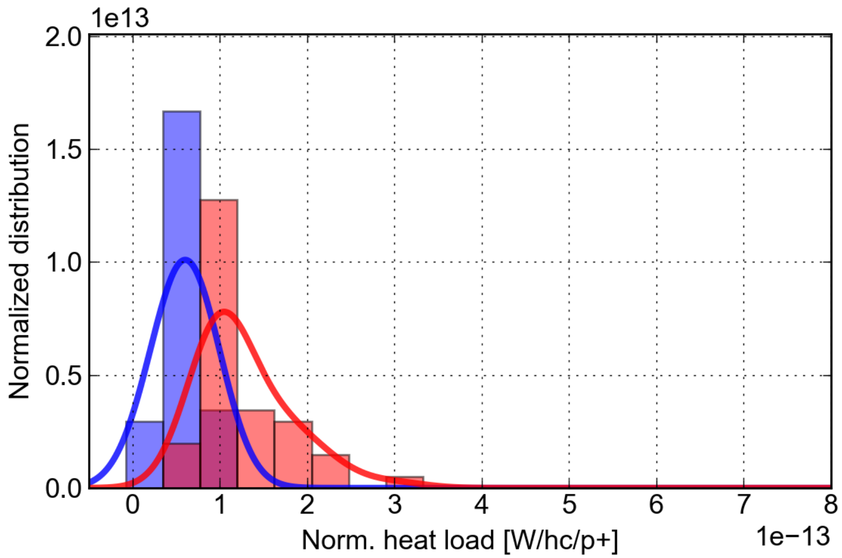


1e14
Beam intensity [p]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
MCB curreent [A]
6
4
2
0
−2
−4
−6
1e−6
BLM signal
2.5
2.0
1.5
1.0
0.5
0.0
Heat load [W/hc]
250
200
150
100
50
0
Mon 24-07 02:24
Mon 24-07 03:36
Mon 24-07 04:48
Mon 24-07 06:00
15L2
16L2
17L2

Cell-by-cell comparison

Reduction of normalized heat load is observed in all cells

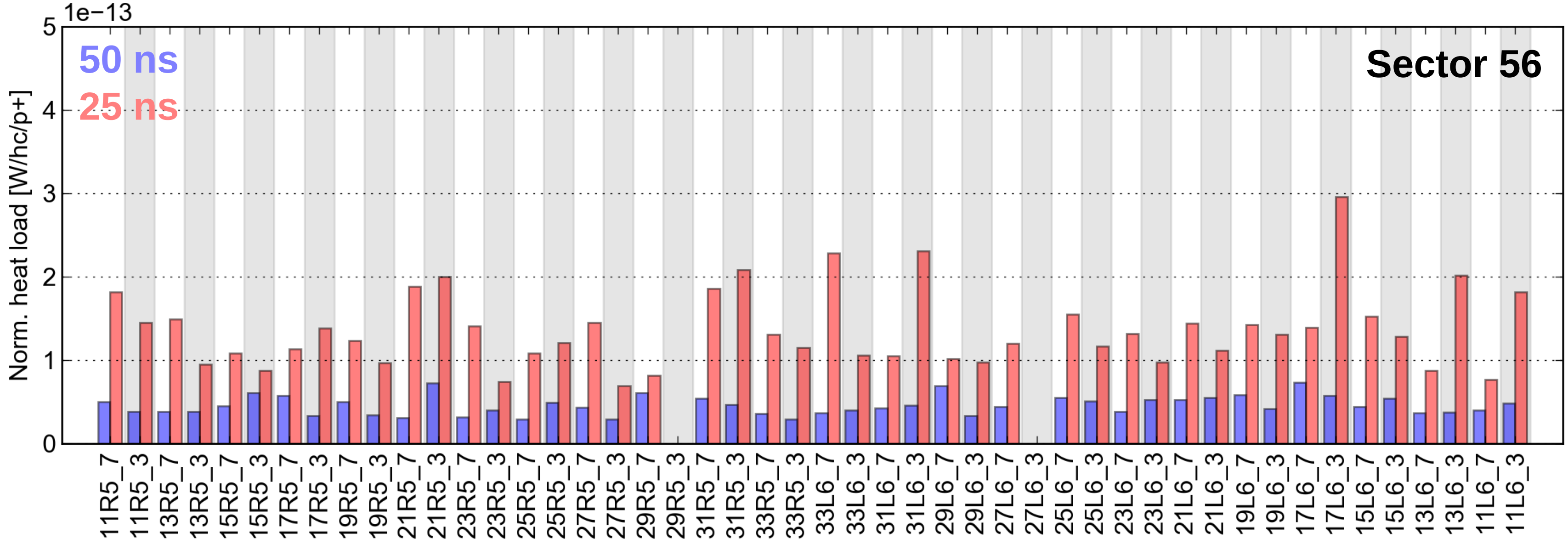


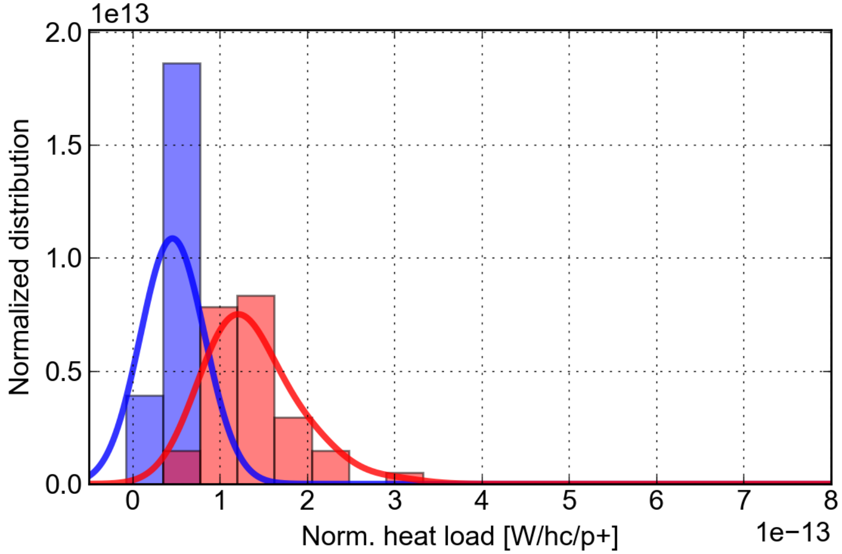


	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S45 (avg) [W]	16.41	72.33
H.L. S45 (std) [W]	5.02	27.61
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

Cell-by-cell comparison

Reduction of normalized heat load is observed in all cells

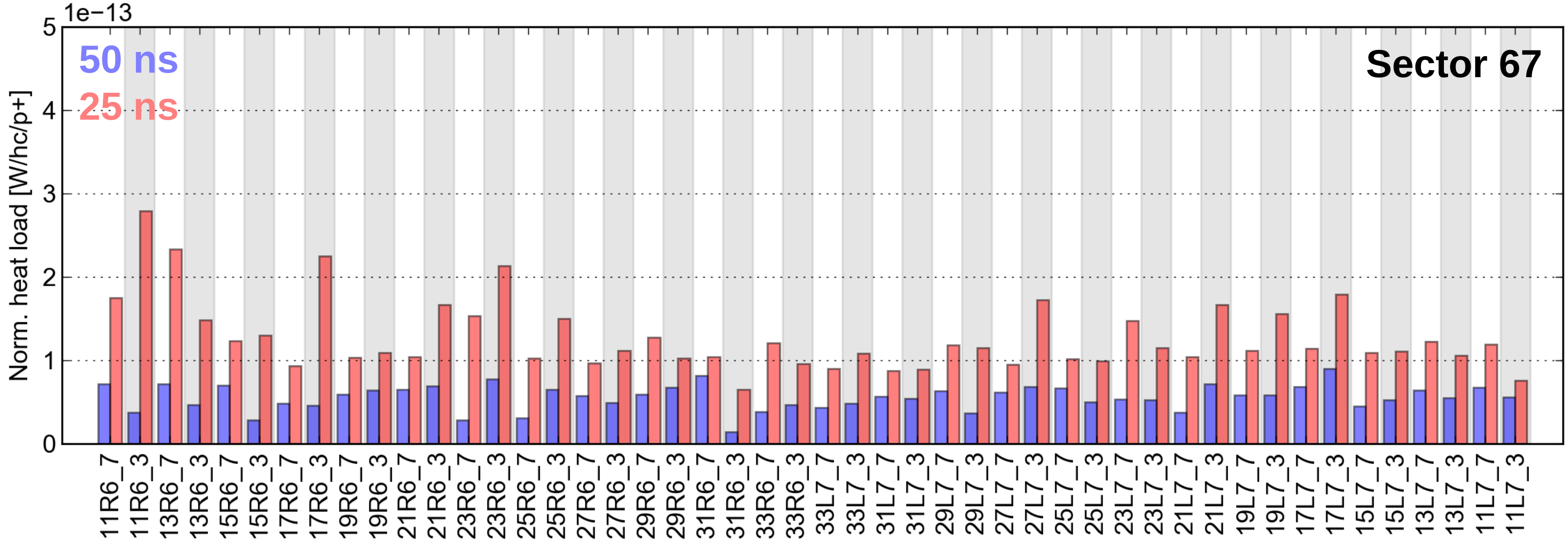


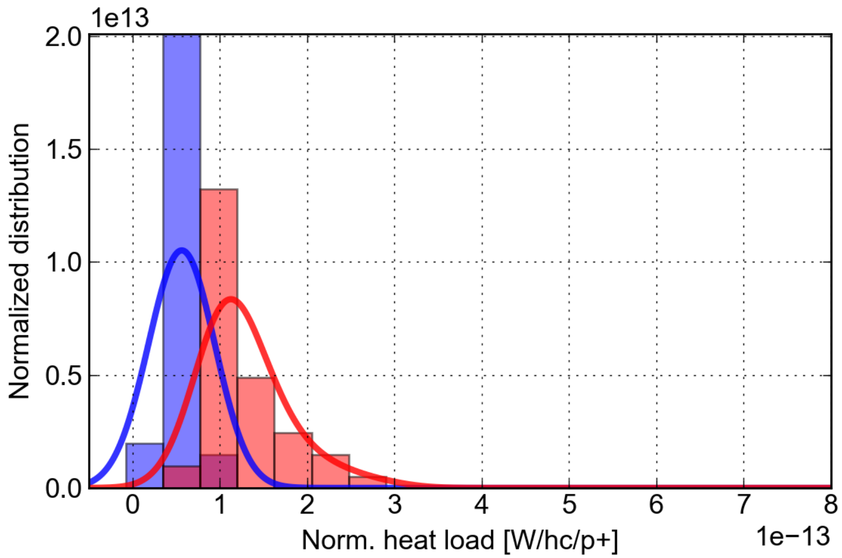


	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S56 (avg) [W]	12.72	77.28
H.L. S56 (std) [W]	3.09	26.28
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

Cell-by-cell comparison

Reduction of normalized heat load is observed in all cells

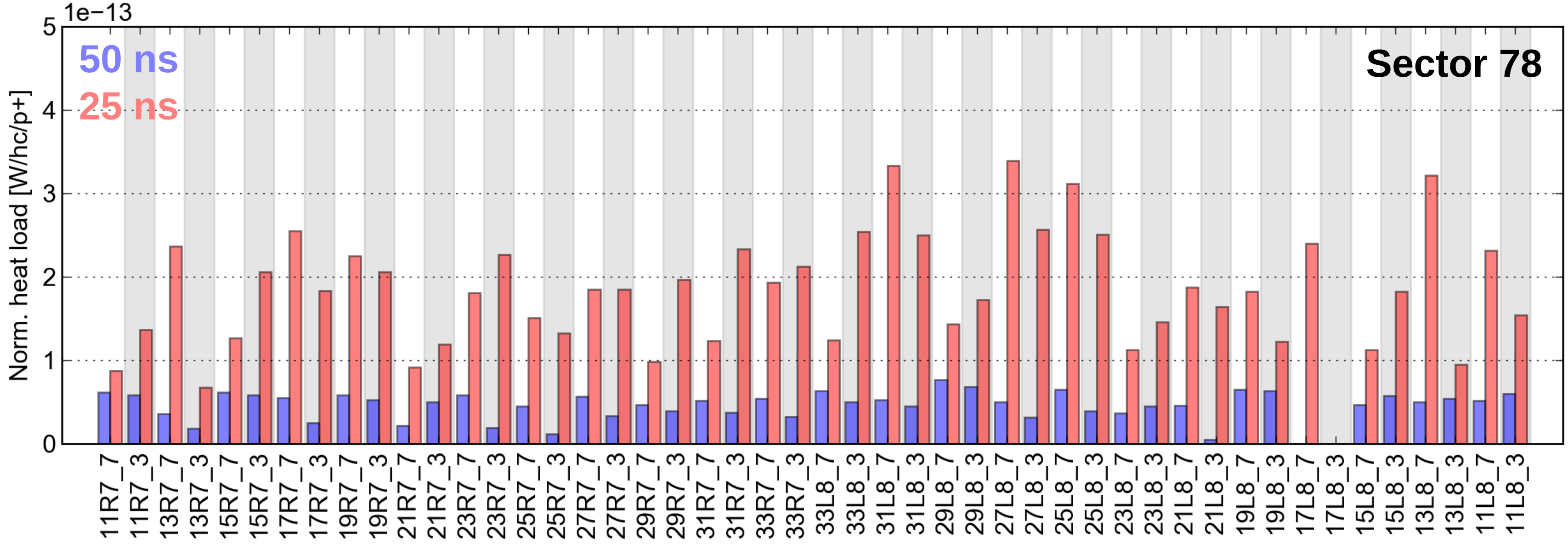


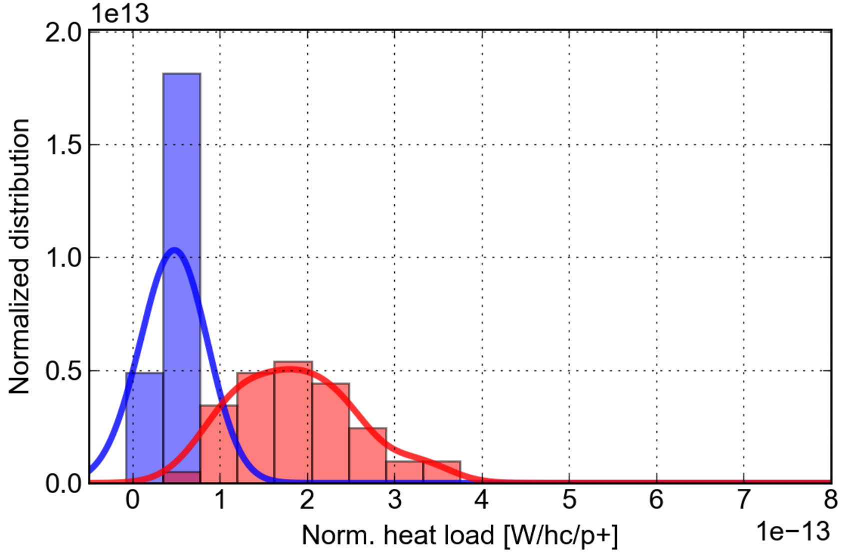


	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S67 (avg) [W]	15.45	72.41
H.L. S67 (std) [W]	4.08	24.02
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

Cell-by-cell comparison

Reduction of normalized heat load is observed in all cells

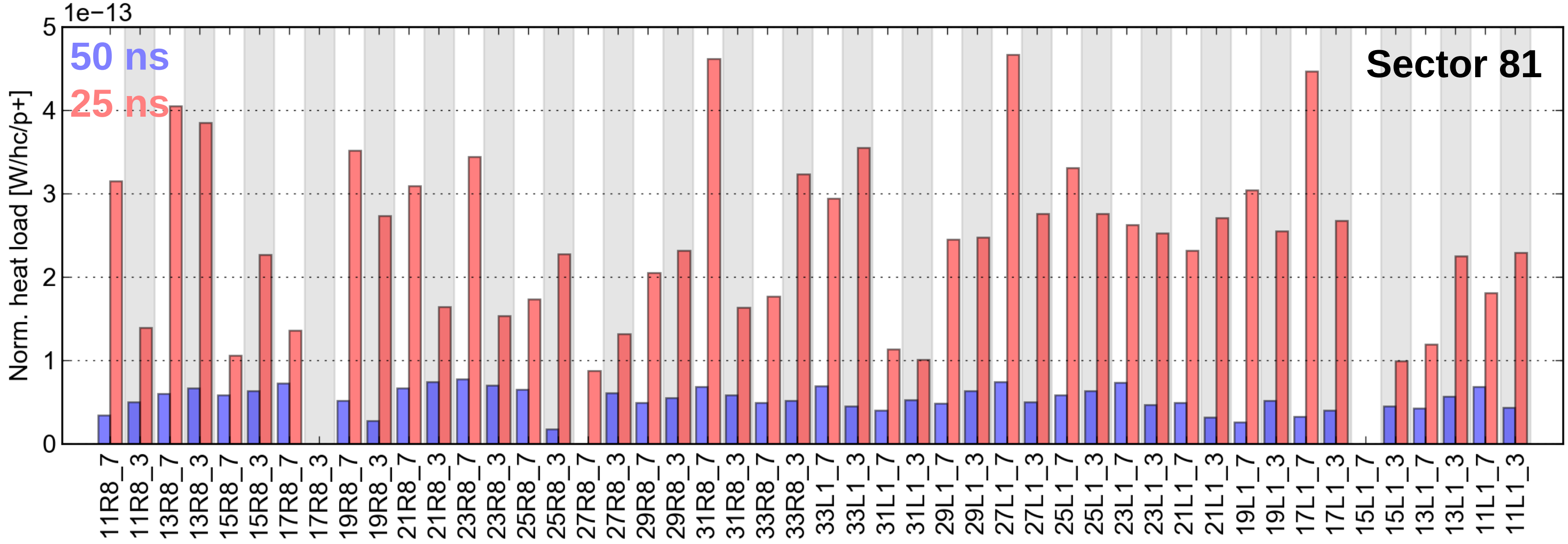


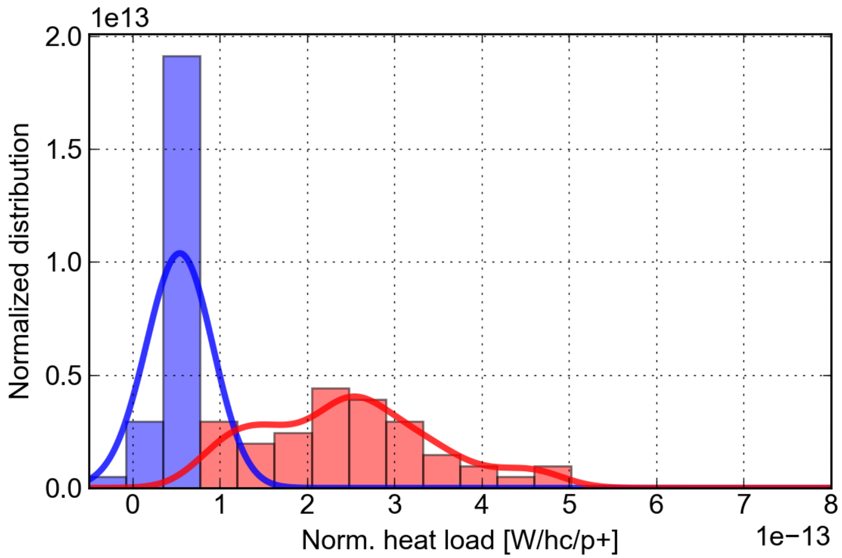


	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S78 (avg) [W]	12.78	105.10
H.L. S78 (std) [W]	4.66	37.44
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

Cell-by-cell comparison

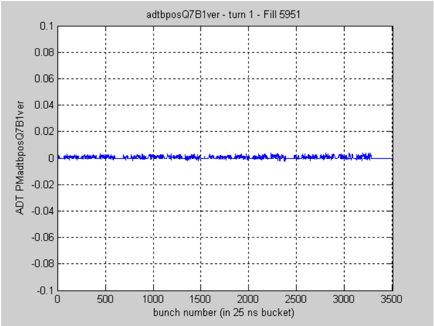
Reduction of normalized heat load is observed in all cells



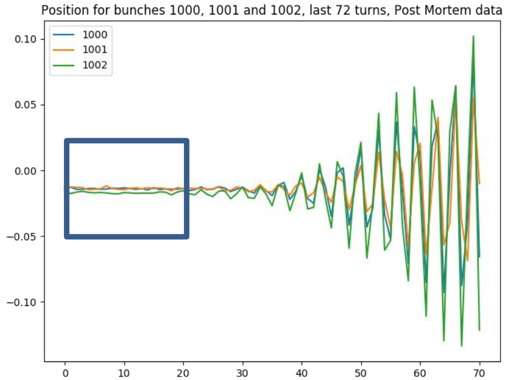


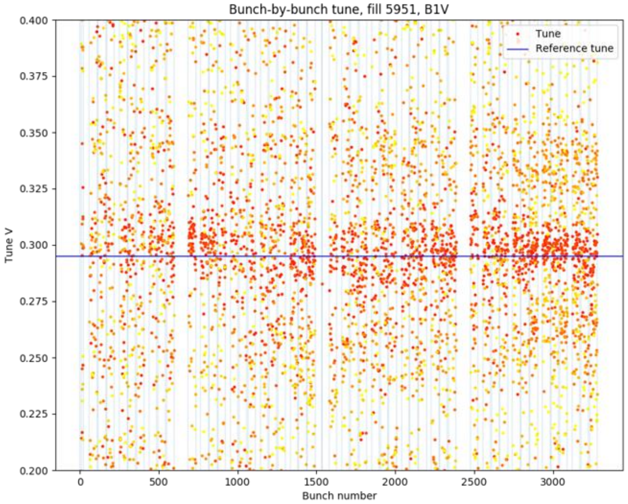
	50 ns	25 ns
Fill	5980	5979
Started on	22 Jul 2017 10:34	21 Jul 2017 15:41
T_sample [h]	3.00	3.30
Energy [GeV]	6499	6499
N_bunches (B1/B2)	1284/1284	2556/2556
Intensity (B1/B2) [p]	1.38e14/1.38e14	2.80e14/2.84e14
Bun.len. (B1/B2) [ns]	1.08/1.09	1.07/1.07
H.L. S81 (avg) [W]	14.55	139.15
H.L. S81 (std) [W]	4.60	55.26
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

Observations of Coherent Motion



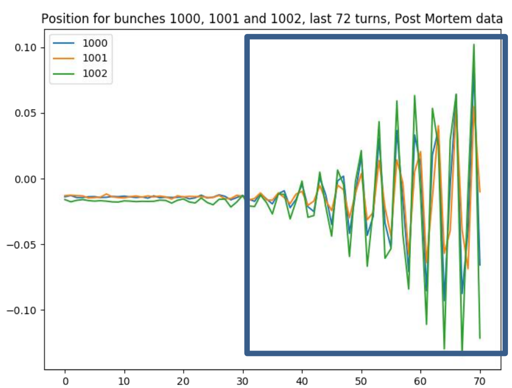
- Clear coupled bunch coherent motion in B1V was observed for fill 5951 at injection energy on Saturday July 15th from ADT Post Mortem.
- 30-40 turns of large signal amplitude allows basic tune analysis to be performed.
- Tune shift is seen when comparing bunch by bunch tunes before and after the instability.

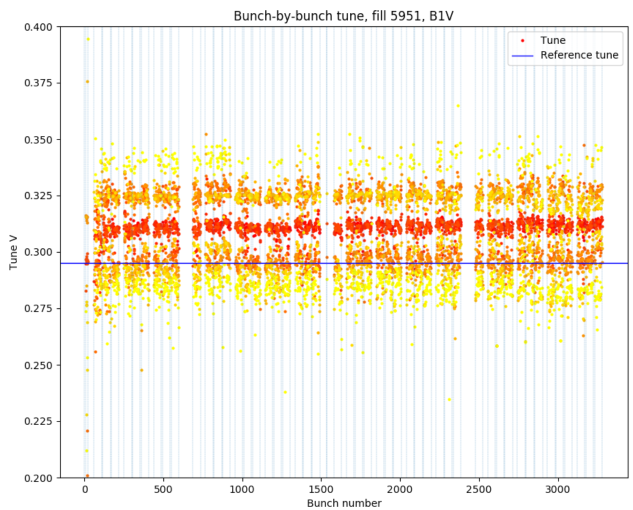




Observations of Coherent Motion

- Clear coupled bunch coherent motion in B1V was observed for fill 5951 at injection energy on Saturday July 15th from ADT Post Mortem.
- 30-40 turns of large signal amplitude allows basic tune analysis to be performed.
- Tune shift is seen when comparing bunch by bunch tunes before and after the instability.





Clear tune shift is seen which is on the order of 3Qs. To be understood.

Observations of Coherent Motion

- Weak coherent motion observed in dumps at flat top for both beams, with usually a single bunch pattern (head of trains). Coupled bunch motion observed in some cases.
- Data from the ADTObsBox show few turns (~20) with increasing oscillation amplitude → Spectral analysis is more difficult
- This behaviour is typical among most high energy dumps.
- **→ We could try to probe the instability mechanism with dedicated studies at injection energy (assuming that an instability can be triggered within a reasonable time).**