Results from e-cloud MDs: Negative octupole polarity at injection and 1000 bunches with 2.3e11 ppb

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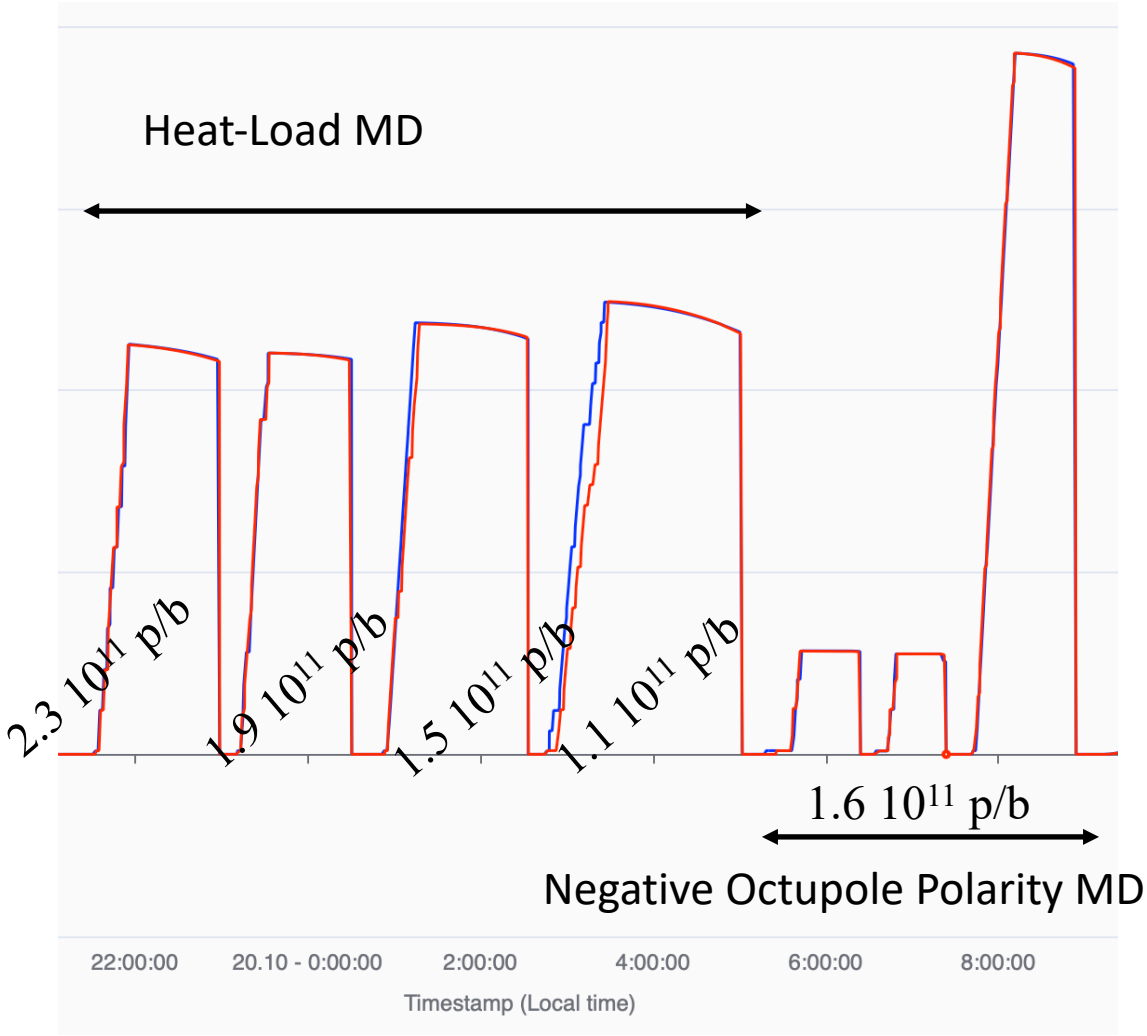
MDs Overview



Heat-load at injection

Short fills (**trains of 2x48b**) at:

1. 2.3 10^{11} p/b (972 bunches)
2. 1.9 10^{11} p/b (1164 bunches)
3. 1.5 10^{11} p/b (1548 bunches)
4. 1.1 10^{11} p/b (2124 bunches)

Negative octupole polarity

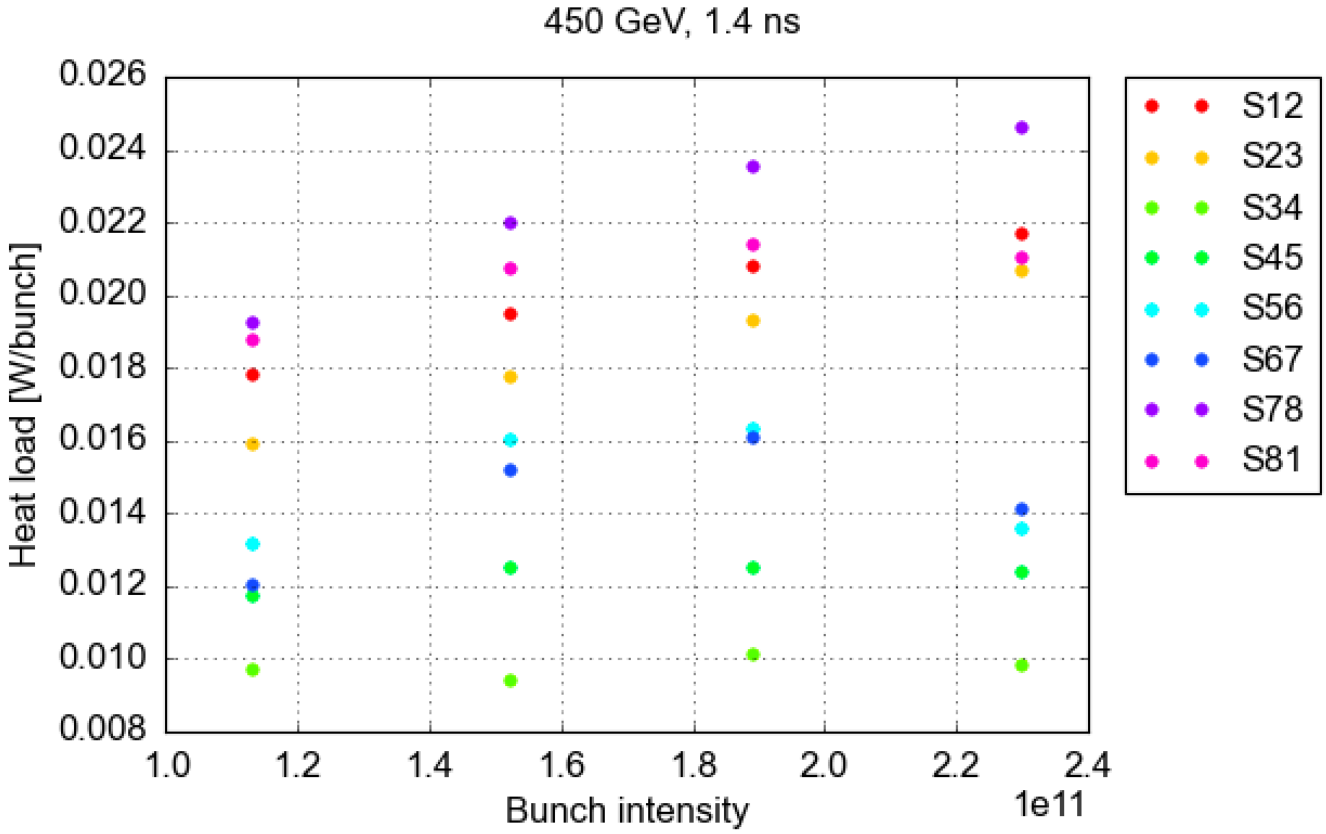
Find optimal tune and stability threshold with:

1. Negative oct. polarity
2. Positive oct. polarity

and

3. Test LHC filling with negative octupole polarity

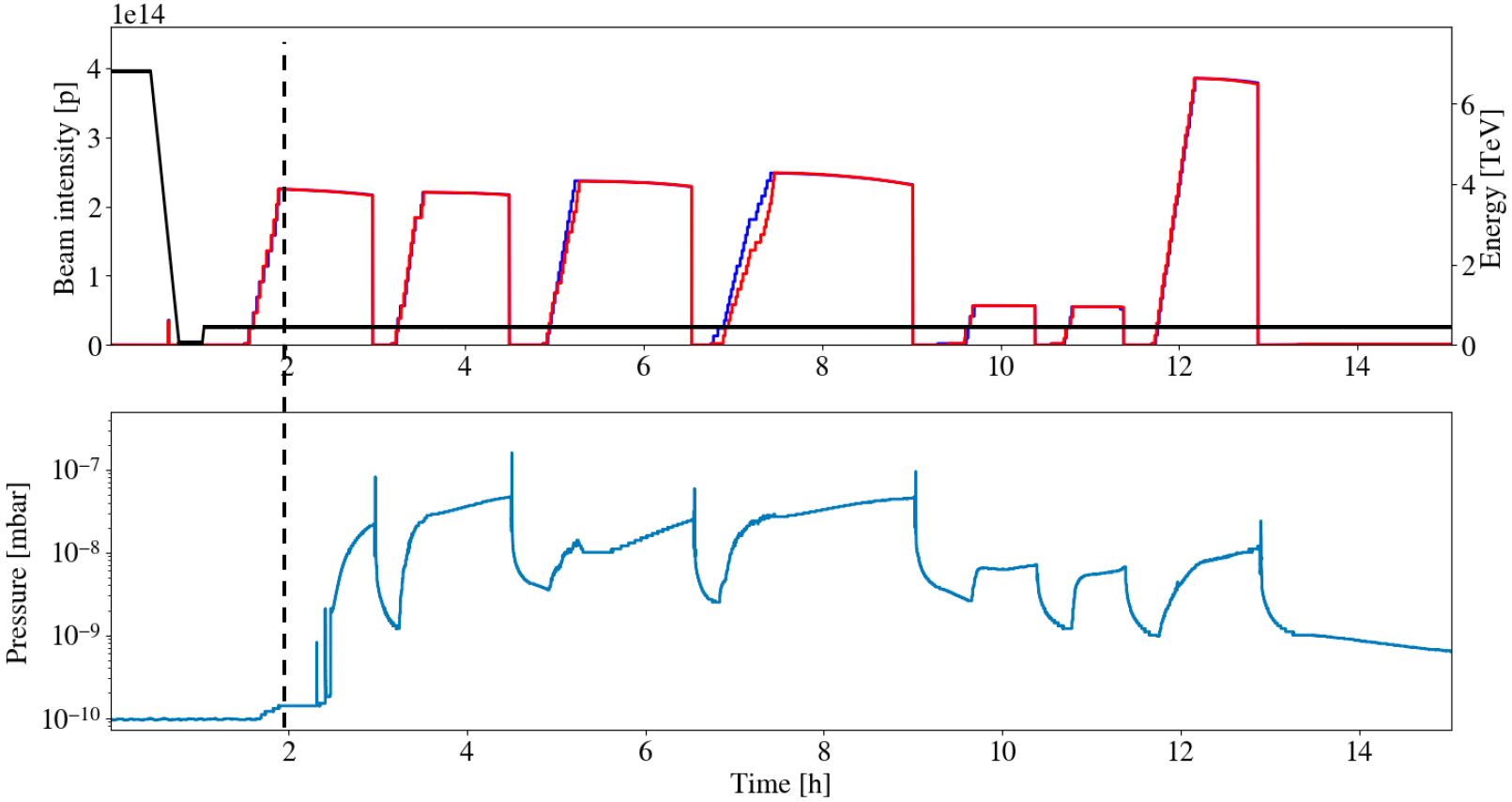
Heat load



- High heat-load sectors (78, 81, 12, 23) show a trend that is increasing with bunch intensity.
- Medium heat-load sectors (56, 67) have lower heat load at 2.3 10^{11} p/b compared to 1.8 10^{11} p/b.
- Low heat-load sectors (34, 45) are rather constant at low heat loads (also larger uncertainty due to low absolute heat-load)

Compatible with expectations!

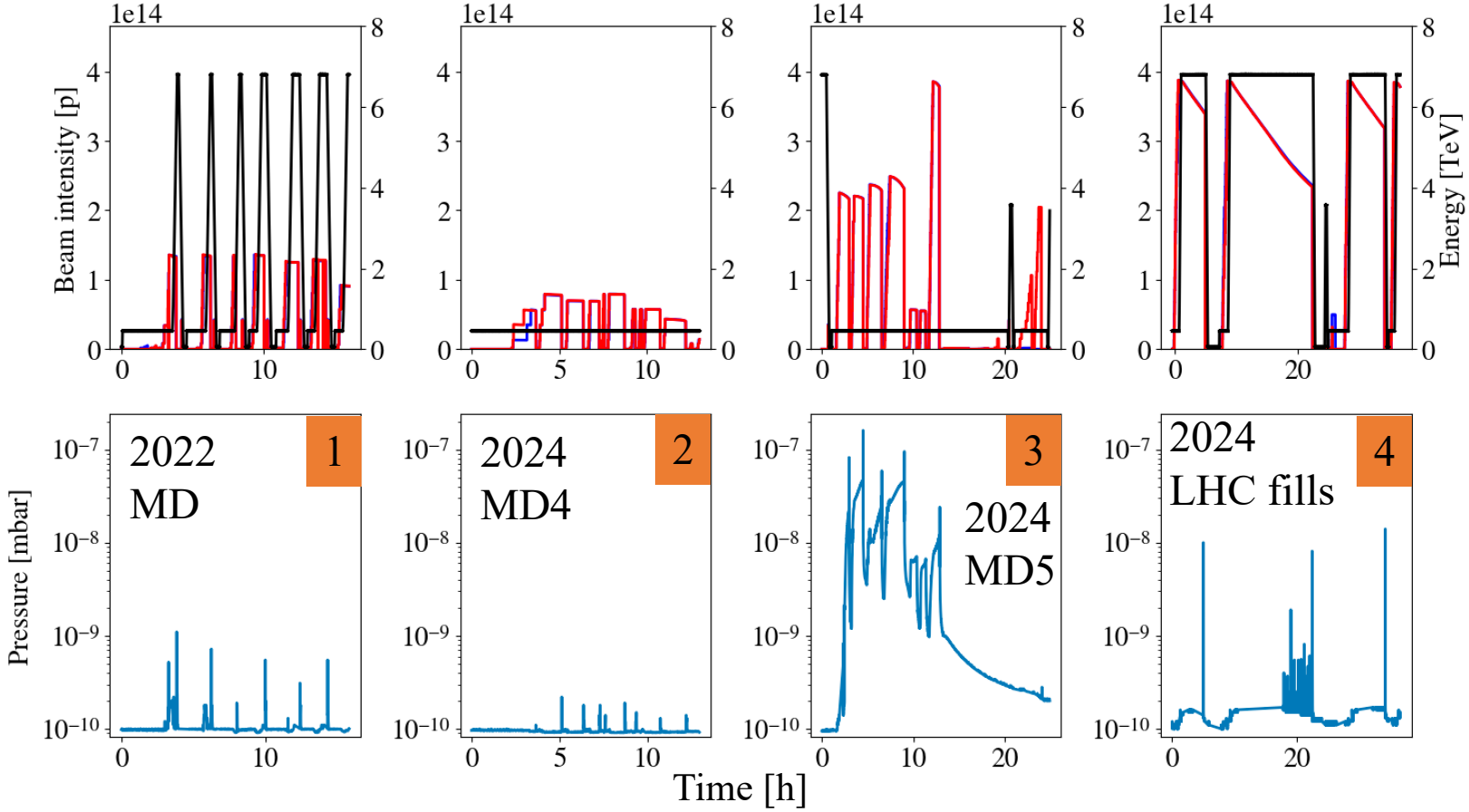
Pressure in VGPB.222.1L5.X.PR



Stronger than usual outgassing was observed left and right of IP5 in common chambers (VGPB.222.1L5.X.PR, VGPB.222.1R5.X.PR).

- Small pressure spikes followed by
- inrease of dynamic pressure, significantly delayed with respect to the injection of bunches.
- Dynamic pressure remained in later fills even with lower bunch intensities

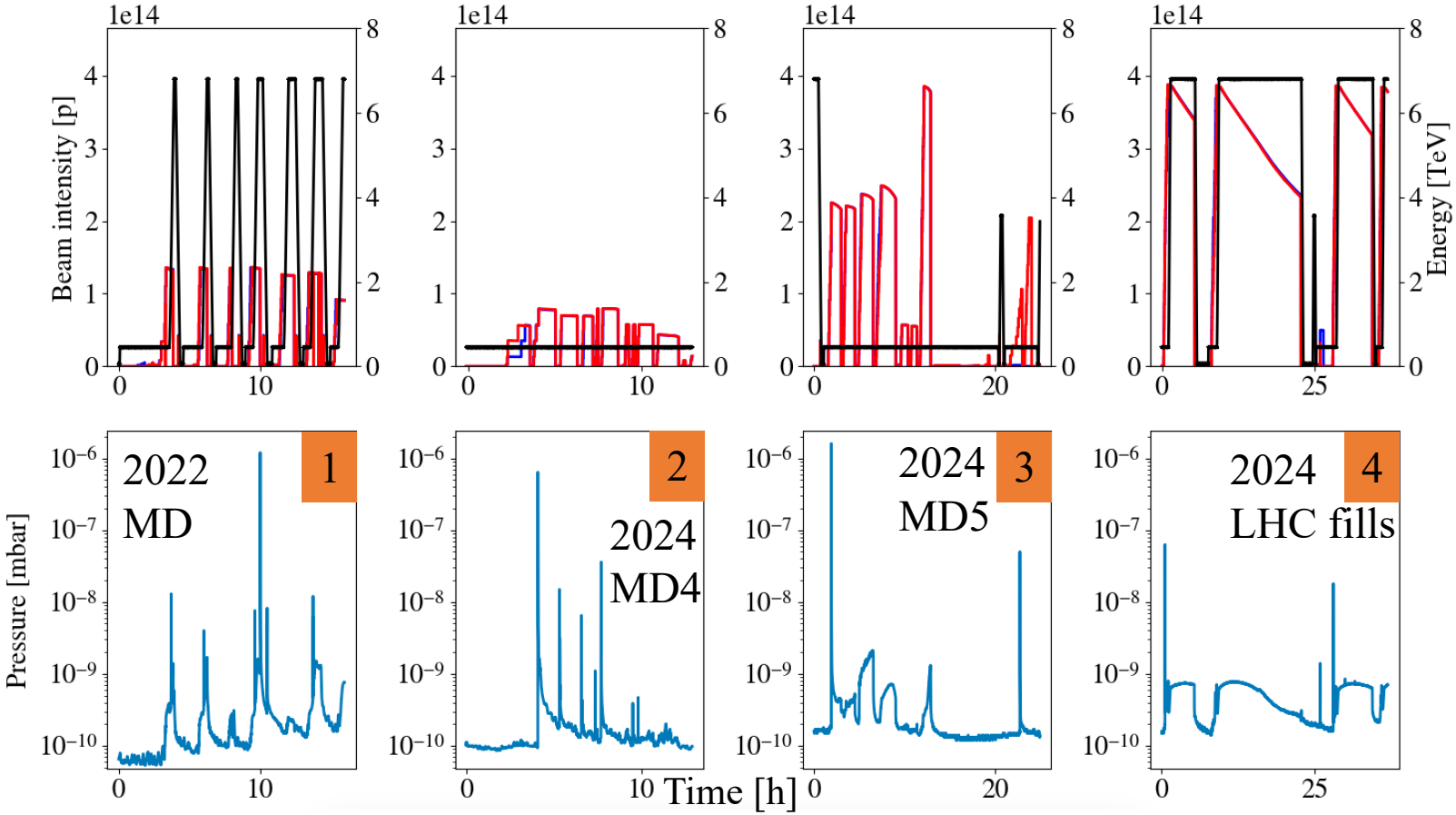
Pressure in VGPB.222.1L5.X.PR



Small spikes during:

1. Small spikes during MD with 1.8 10^{11} p/b at top energy (in 2022),
2. Tiny spikes during MD with 2.3 10^{11} p/b at injection (350 bunches)
3. Larger spikes and dyn. pressure during MD with 2.3 10^{11} p/b at injection (972 bunches)
4. Small dyn. pressure rise during latest LHC fills in 2024.
5. Larger dynamic pressure rise **has not re-appeared in the 2024 pp reference run.**

Pressure in VGPB.1175.5R4.R.PR



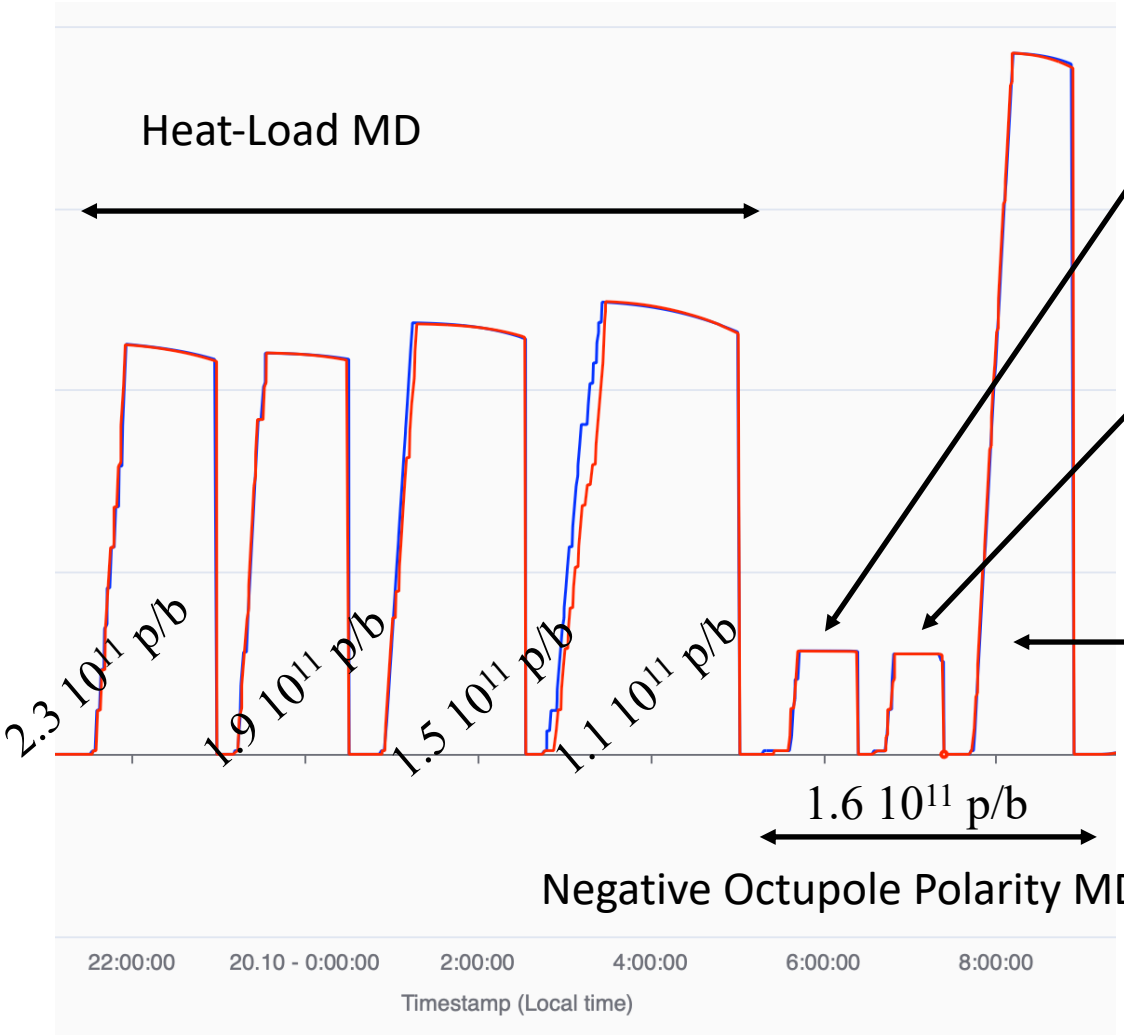
Location in cell 5R4, B2 show large pressure spikes (~10^{-6} mbar) during all MDs and frequently during LHC fillings.

Summary (1/2)

Heat load MD – experience with 2.3 10^{11} p/b:

- Very succesful MD, no major issues encountered.
- Heat load data confirm qualitative behaviours expected from e-cloud simulations. To be compared quantitatively in more detail.
- Suspicious behaviour of pressure spikes and dynamic pressure rise in the common beam chambers left and right of IP5:
  - Has not re-appeared in the pp reference run. Unlikely to have caused damage.
  - Possibly related to high bunch intensity + large number of bunches.
  - Possibly related to event during MD block, where loss of communication caused all vacuum valves to close around IP5.
- Pressure spikes in 5R4 - B2. Is being followed up.

MDs Overview



Negative octupole polarity:

1. Find optimal tune.
2. Decrease octupole slowly to find instability threshold.

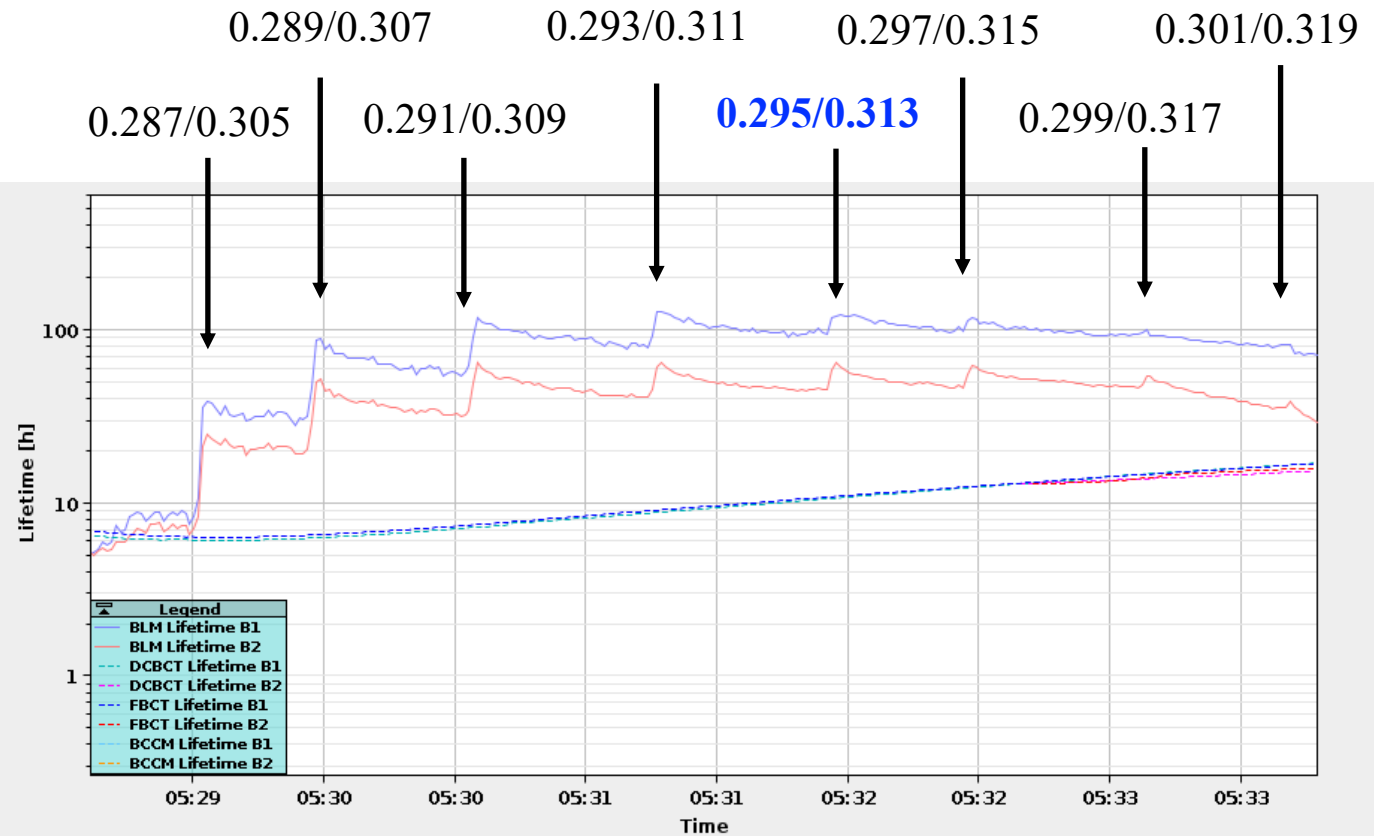
Positive octupole polarity:

1. Find optimal tune.
2. Decrease octupole slowly to find instability threshold.

Test LHC injection with negative polarity.

Negative octupole polarity

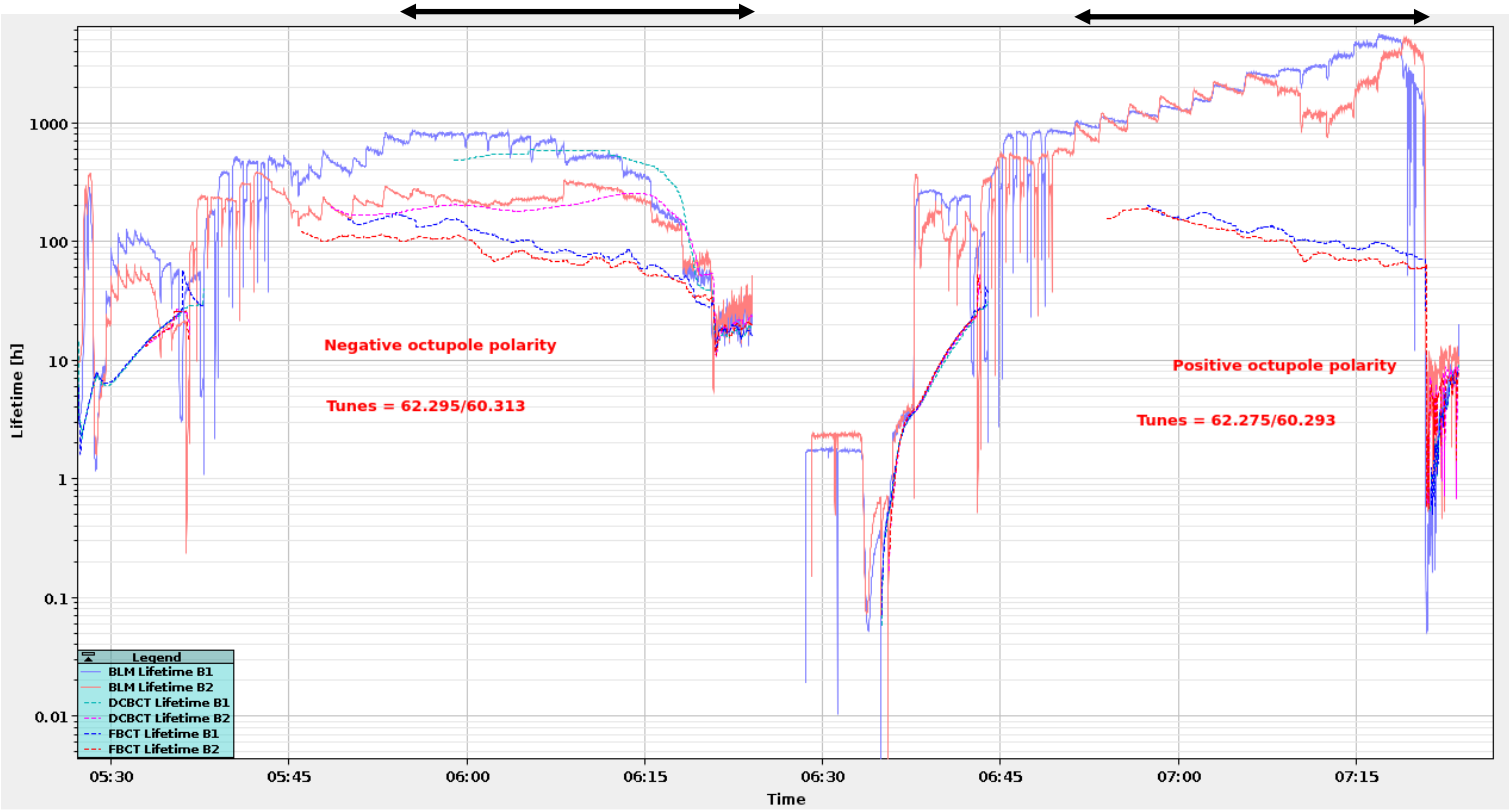
- 12 bunches
- Smaller scan repeated around optimal tune after injecting trains
- Optimal tune with trains was always equal to optimal tune with 12 bunches.



- Process was repeated with positive octupole polarity to find that current tune (0.275/0.293) is optimal.

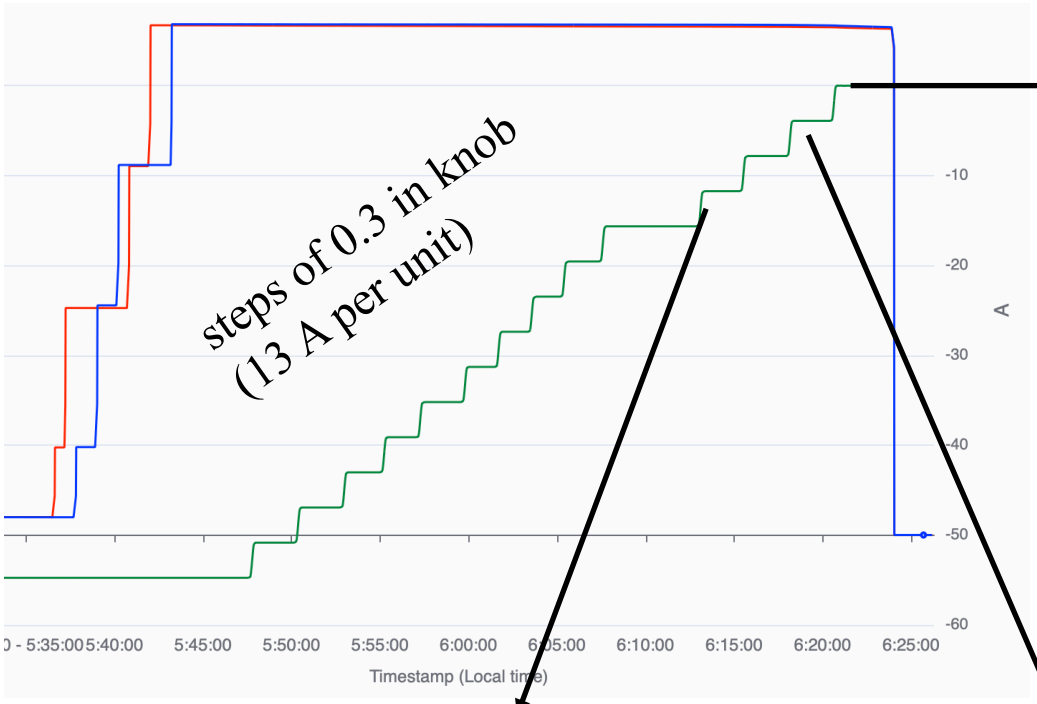
Lifetime comparing negative and positive octupole polarity

Scanning octupole current (starting from $|I_{MO}|$ ~50 amps down to 0)

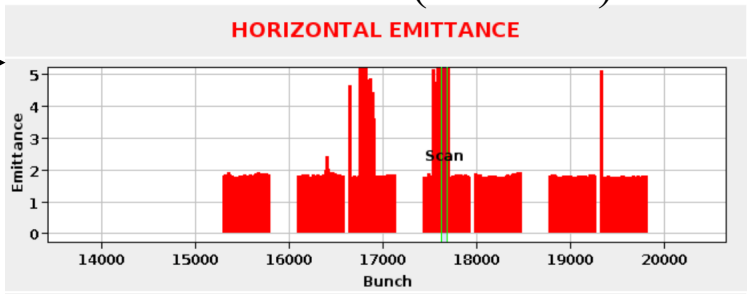


- Lifetime with positive octupole polarity is almost always much better.

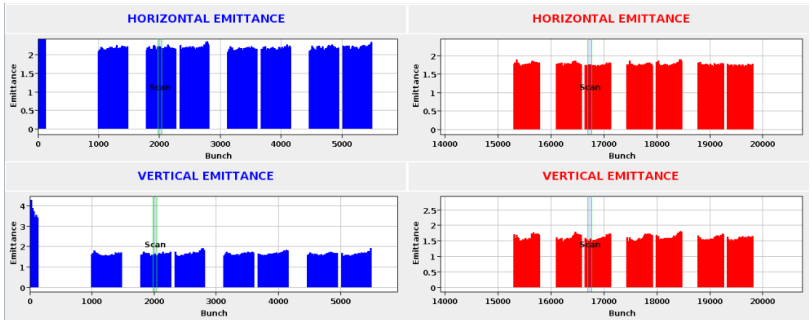
Negative octupole polarity – octupole scan



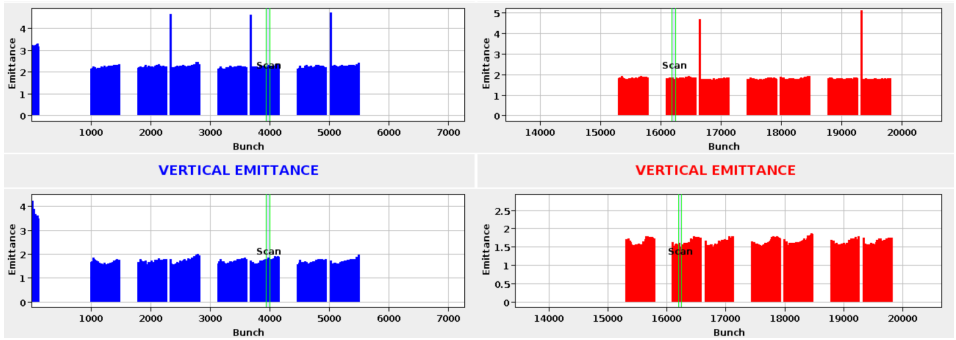
Violent instabilities (knob = 0)



Lifetime started dropping (knob = 0.9)

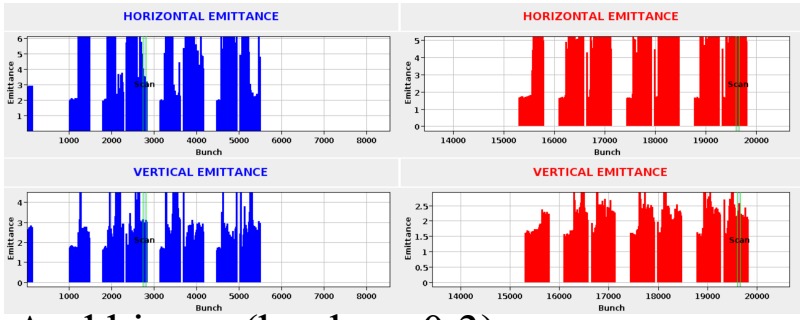


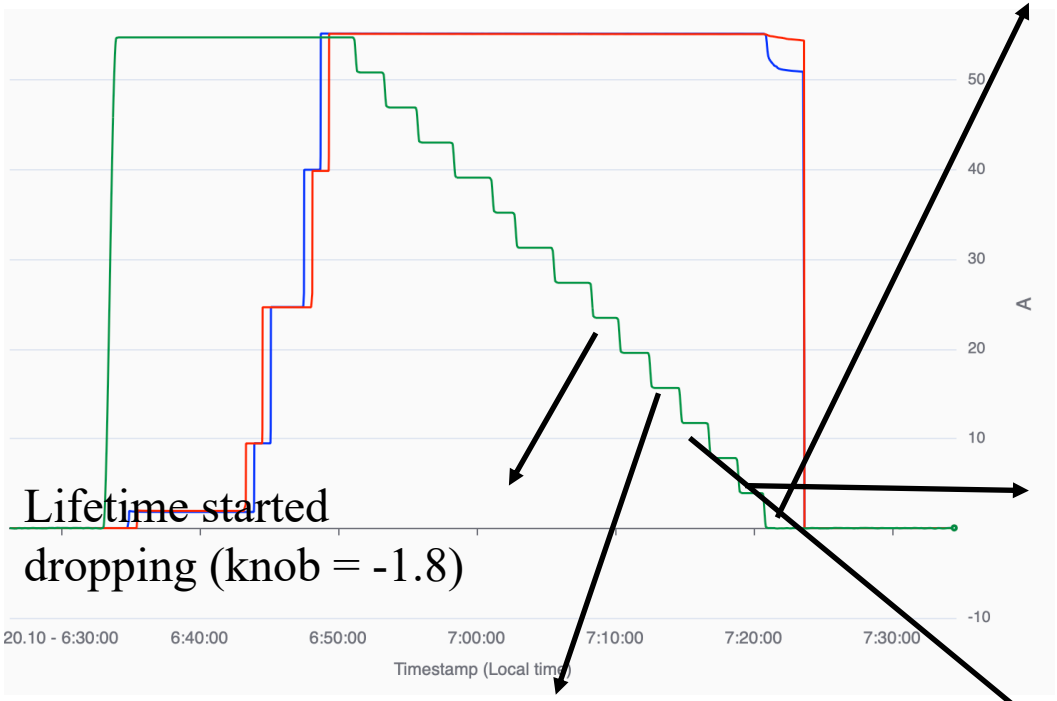
Middle bunches instability (knob = 0.3)



Positive octupole polarity – octupole scan

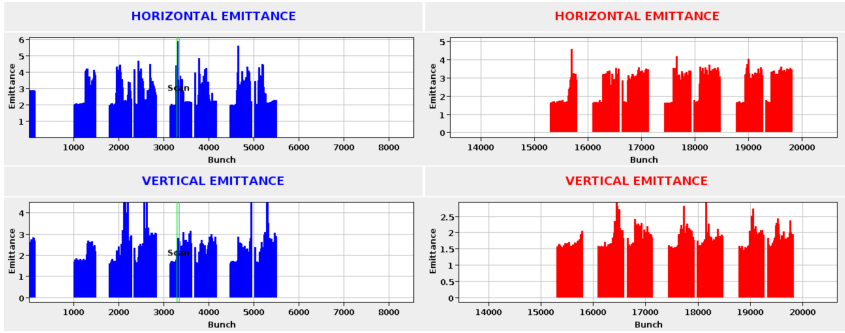
Violent instabilities (knob = 0)



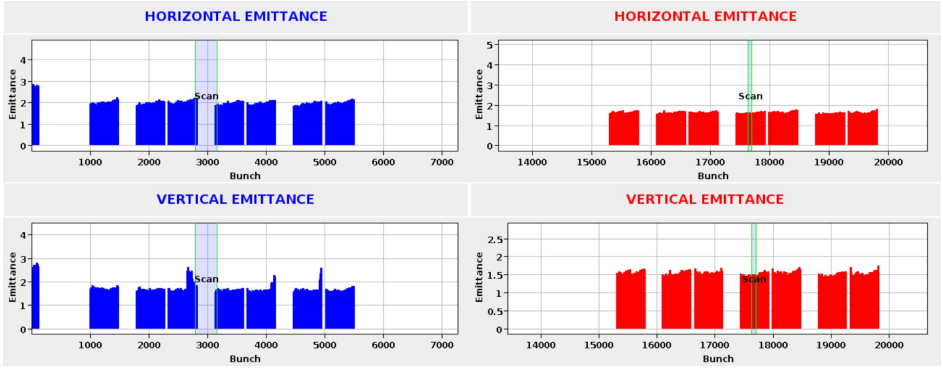


Lifetime started dropping (knob = -1.8)

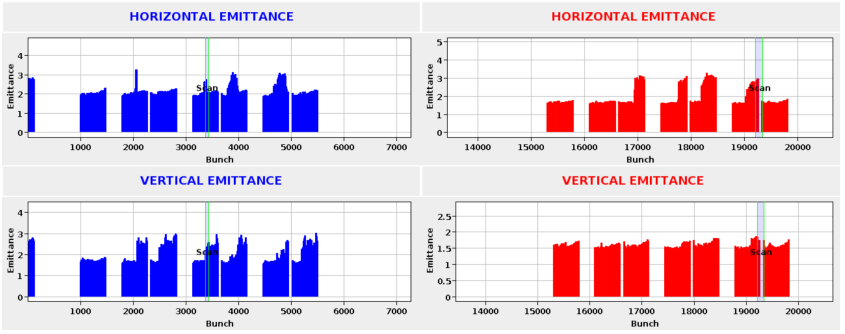
And bigger (knob = -0.3)



Mini instabilities (knob = -1.2)



Bigger instabilities (knob = -0.9)

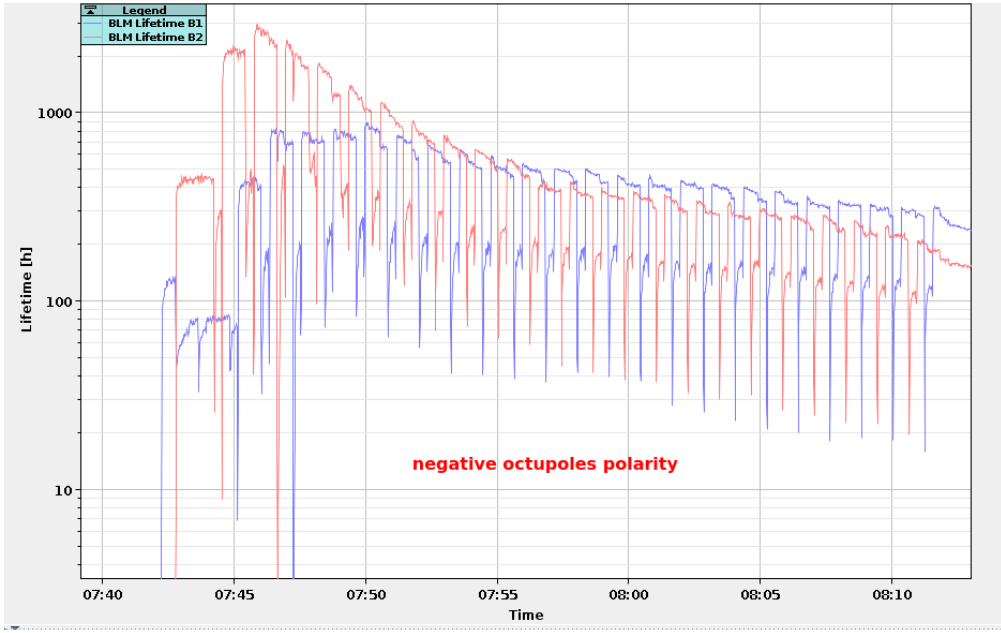


Test injection fill with negative octupole polarity

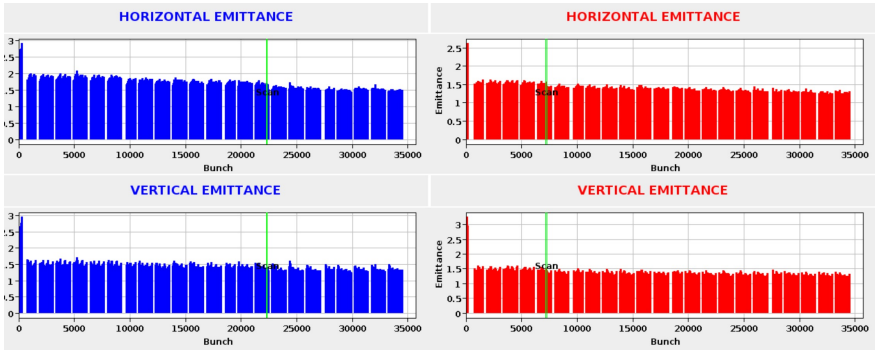
Operational octupole settings were:
B1 knob: -4.2
B2 knob: -3.5
Tunes at 62.275/60.293

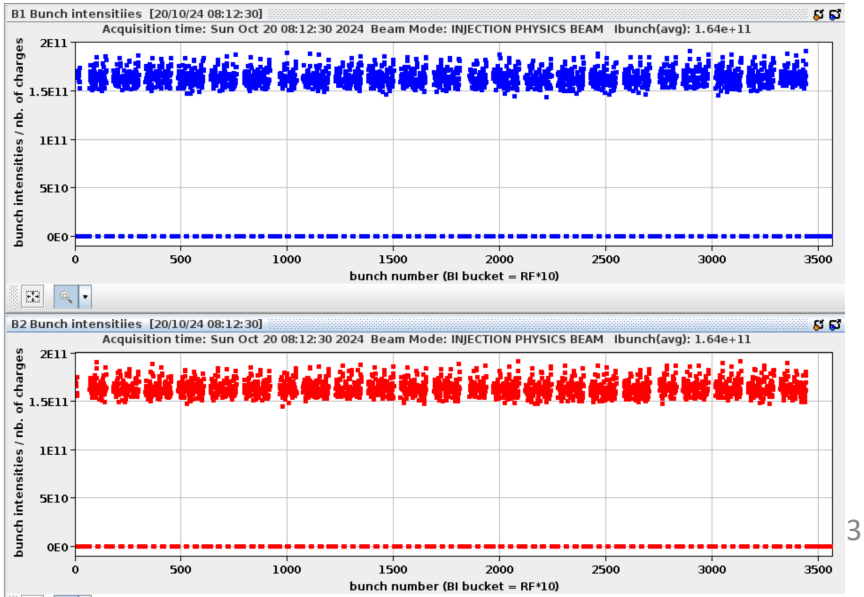
Different from threshold that was found.
Possibly due to injection process being:

- With constant injections
- Magnetic decays changing coupling and chromaticity
- Scrubbing?



Tested with octupole settings:
B1 knob: 3.2
B2 knob: 2.5
Tunes at 62.295/60.313





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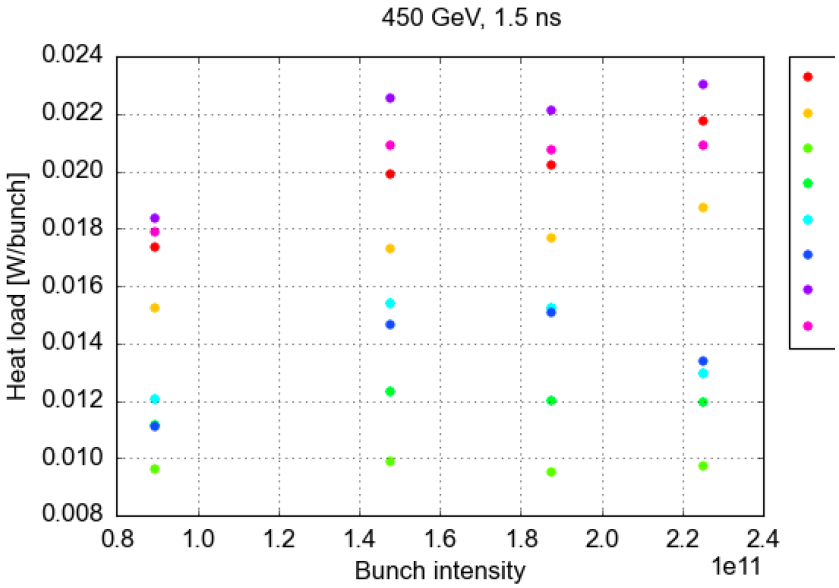
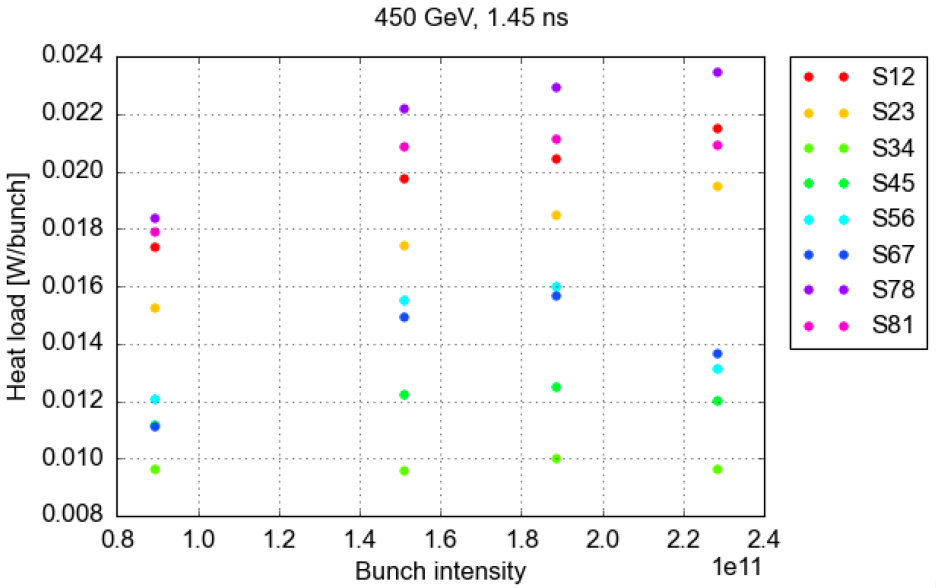
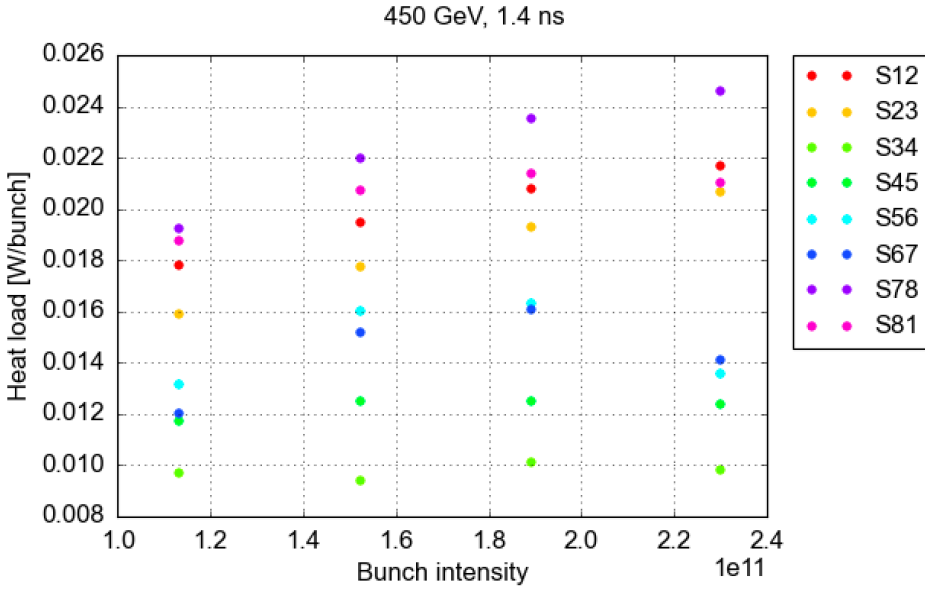
Negative octupole polarity at injection energy:

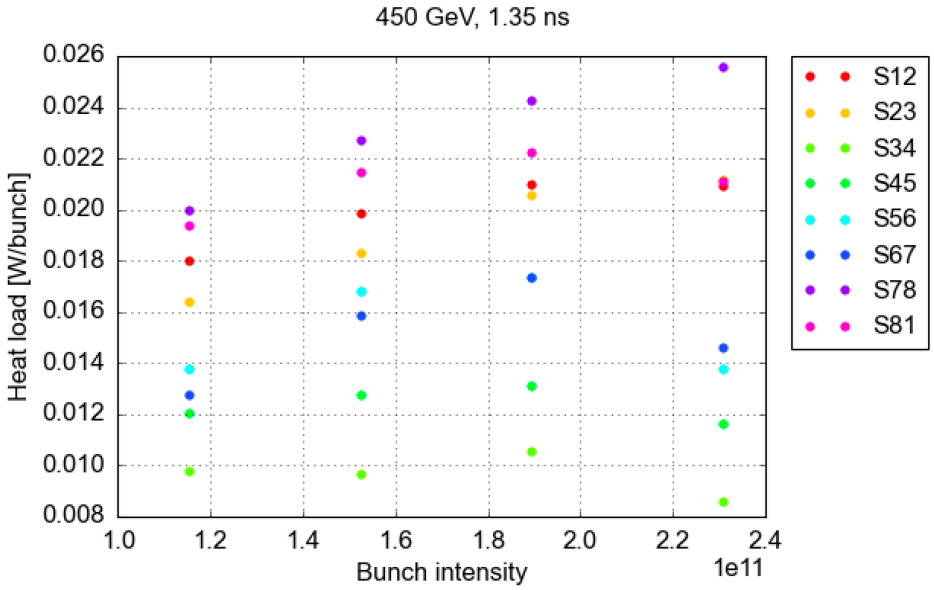
- Optimal tune was found with negative octupole polarity: **62.295/60.313**
- Instabilities appear at lower strength of octupoles with negative polarity.
- Lifetime is worse with negative octupoles compared to positive octupoles – but still acceptable (> 100h).
- **LHC can run comfortably with negative octupole polarity at injection energy.**

Thank you for your attention!
Konstantinos Paraschou


450 GeV, 1.5 ns
Heat load [W/bunch]
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Bunch intensity
1e11


450 GeV, 1.45 ns
Heat load [W/bunch]
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Bunch intensity
1e11
S12
S23
S34
S45
S56
S67
S78
S81


450 GeV, 1.4 ns
Heat load [W/bunch]
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Bunch intensity
1e11
S12
S23
S34
S45
S56
S67
S78
S81


450 GeV, 1.35 ns
Heat load [W/bunch]
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Bunch intensity
1e11
S12
S23
S34
S45
S56
S67
S78
S81