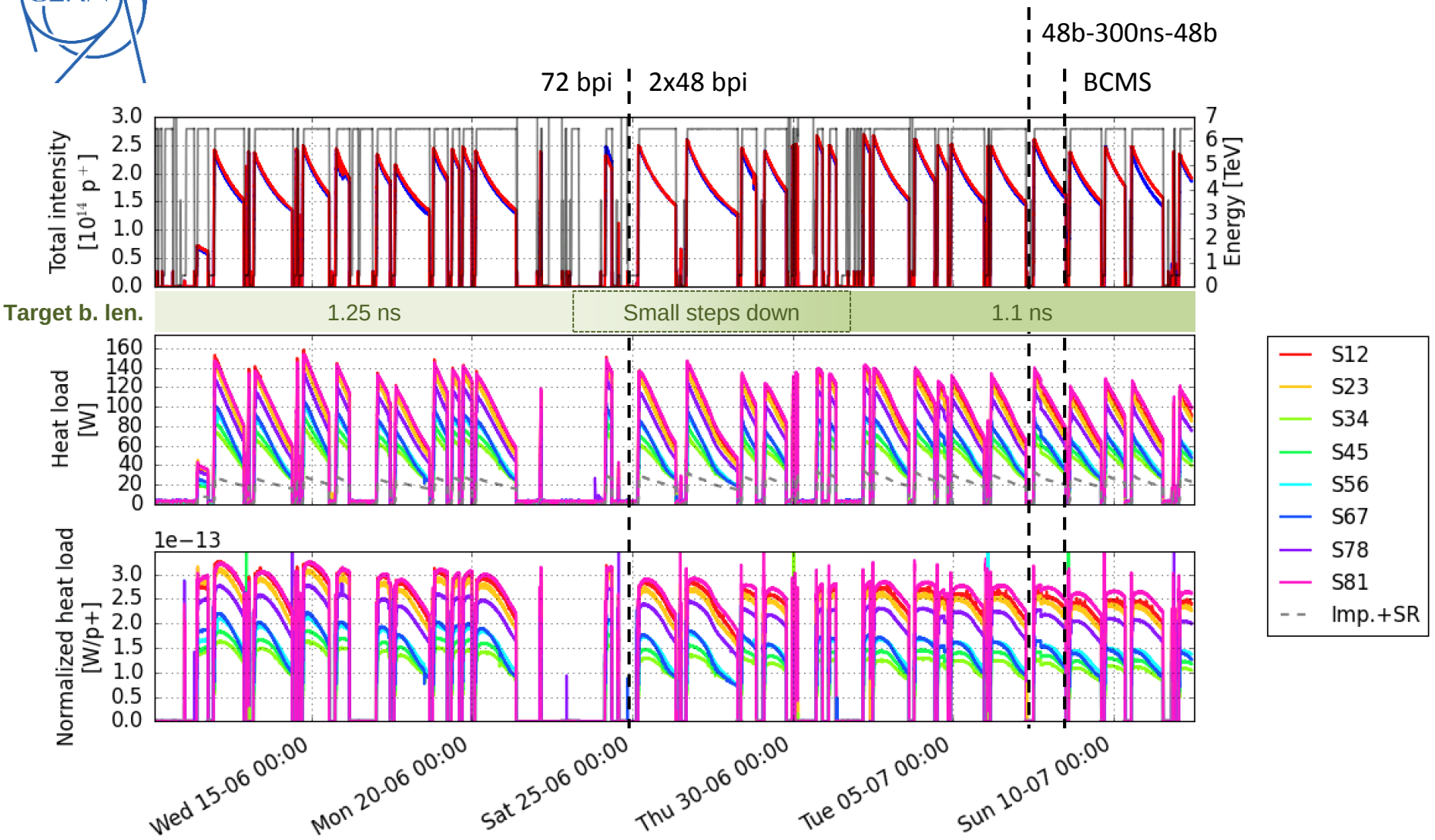
Follow-up on LHC observations

G. Iadarola, L. Mether, G. Rumolo

e-cloud meeting – 3 June 2015

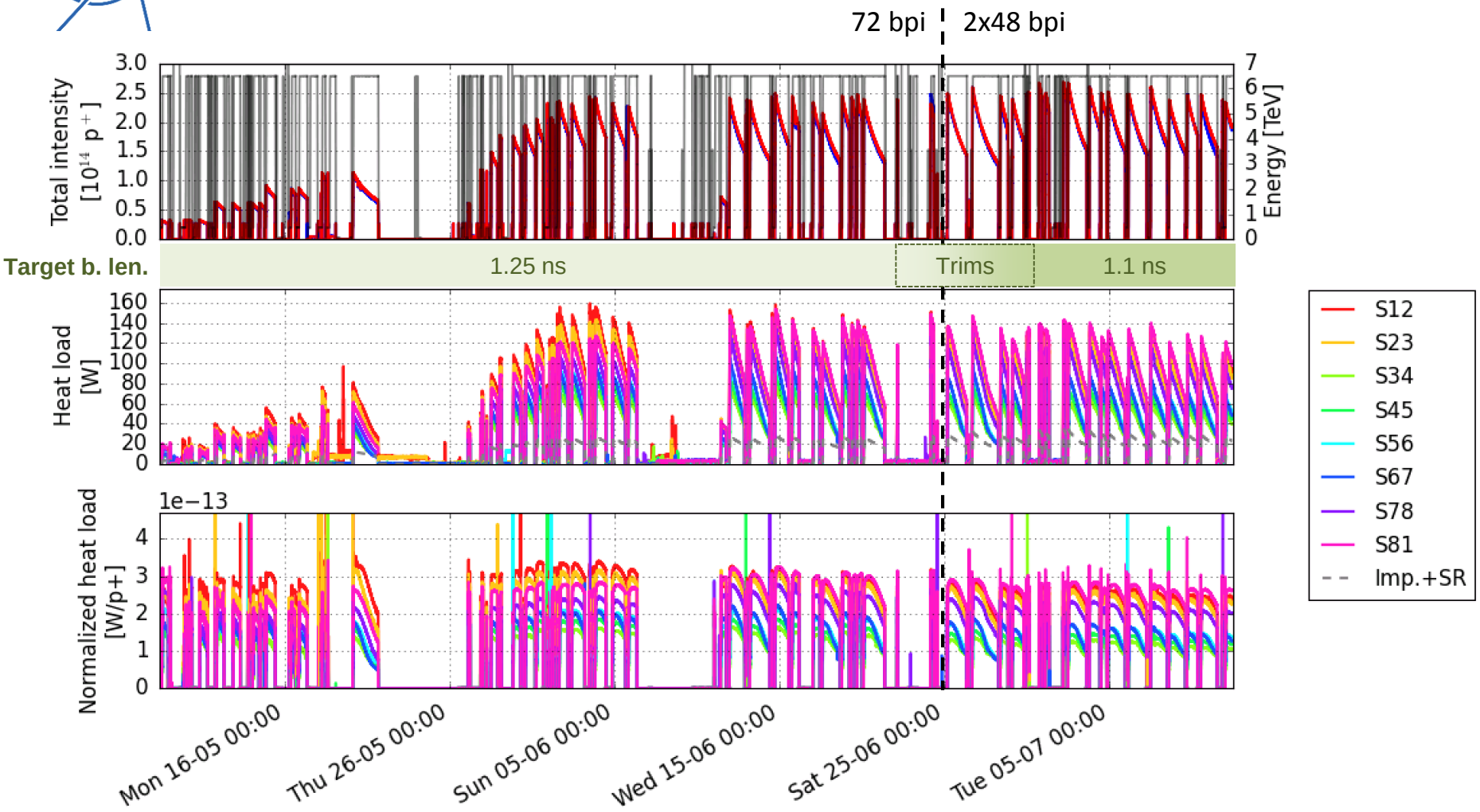
Heat load evolutions

Heat load evolution

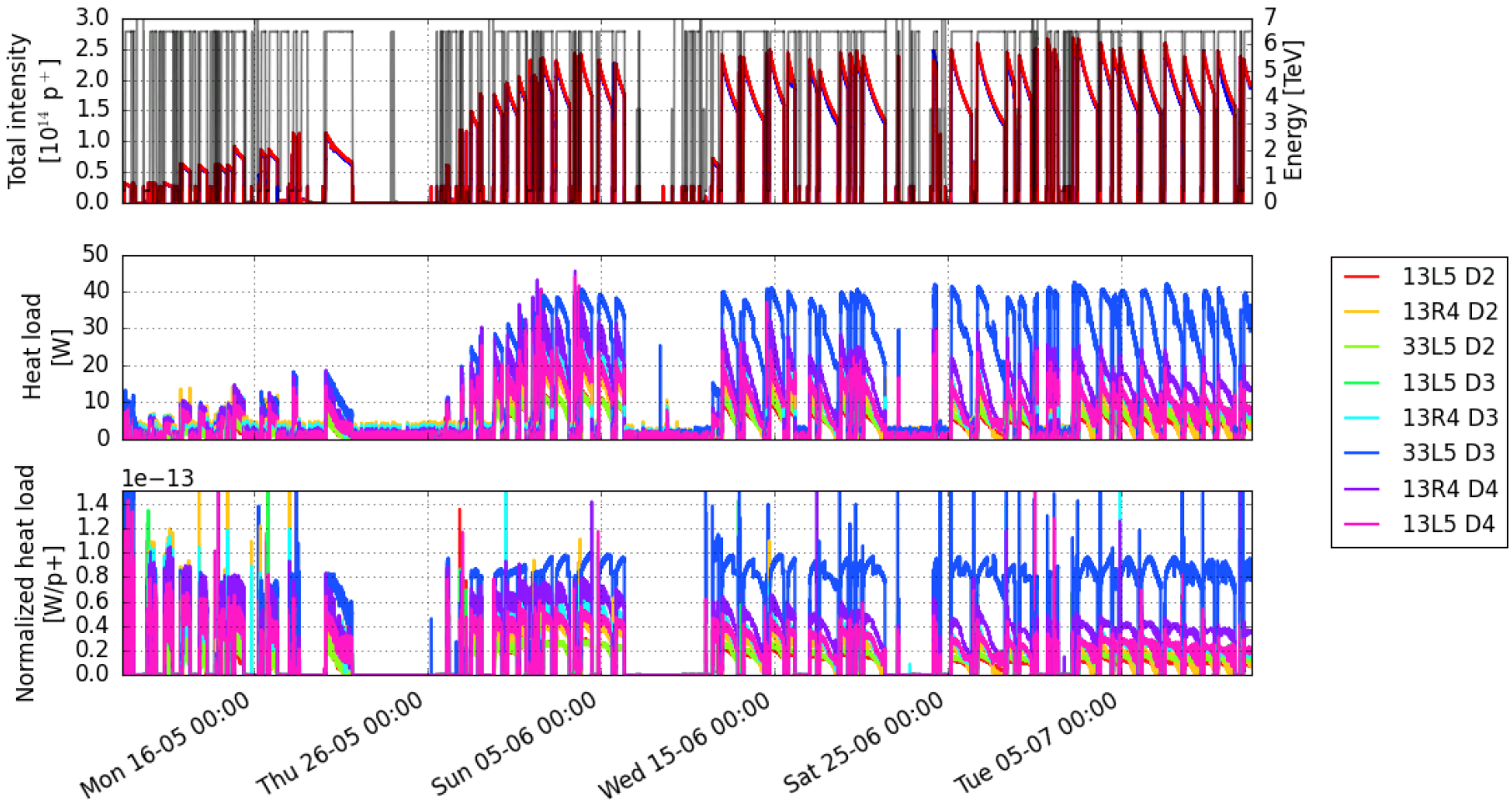


- **~10% heat load decrease** when moving from injections of 72b. to **injections of 2x48b.**
- No strong effect observed when slightly increasing the gap between the trains of 48b. (250 ns → 300 ns)
- No strong effect observed when moving to BCMS production scheme (with controlled blow-up in the injectors)

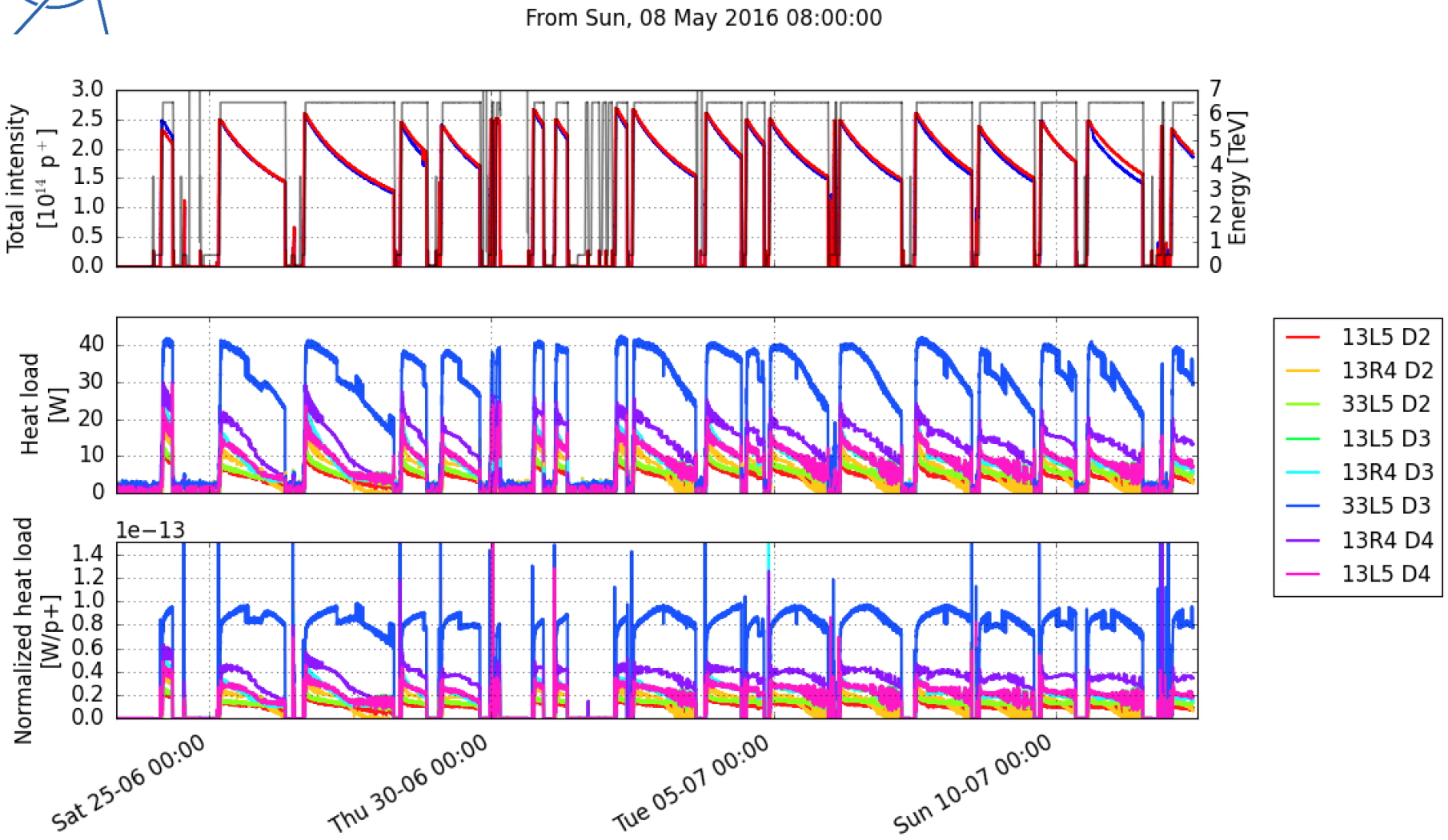
Heat load evolution



Heat load evolution



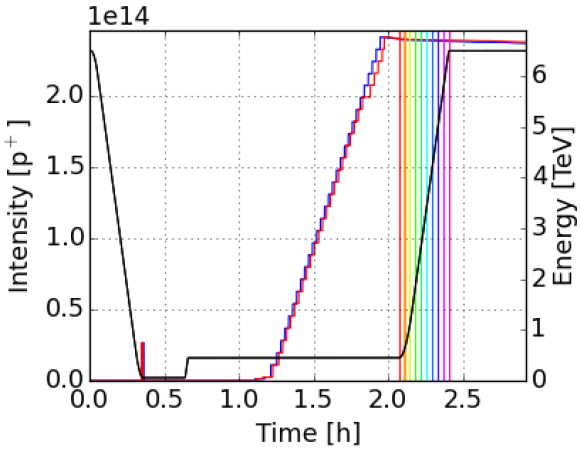
Heat load evolution

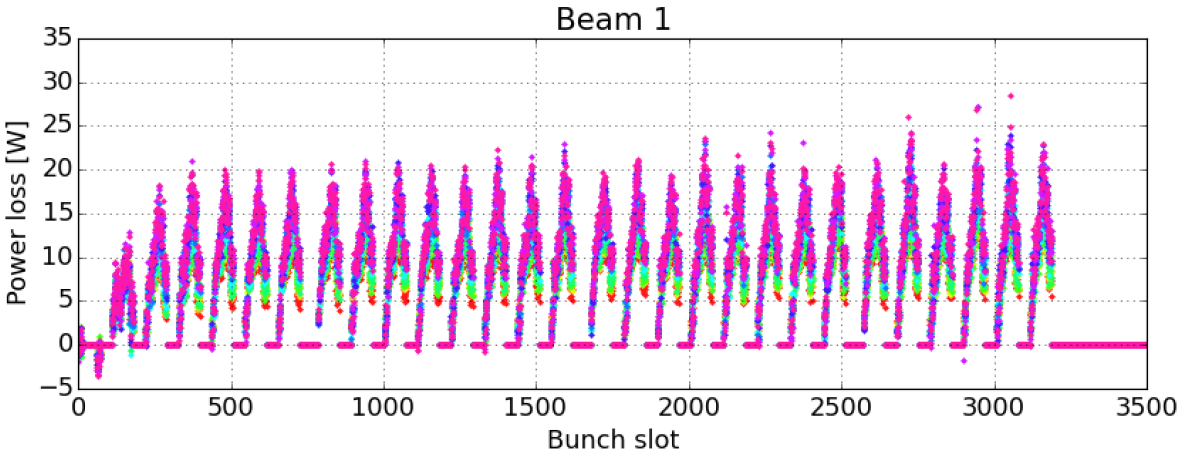


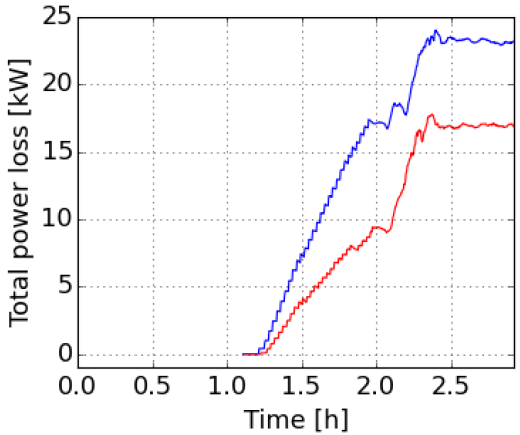
Heat load vs stable phase

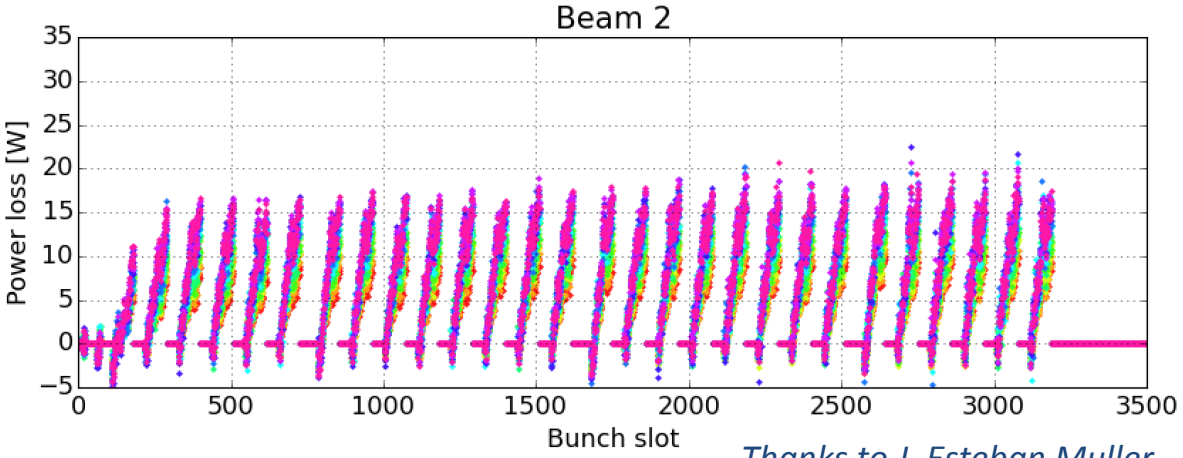
Bunch by bunch power loss

Fill 4985: started on Fri, 03 Jun 2016 18:08:04









Thanks to J. Esteban Muller

Bunch by bunch power loss

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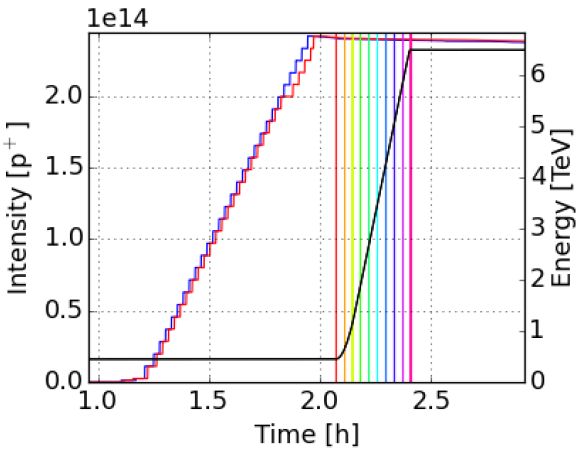
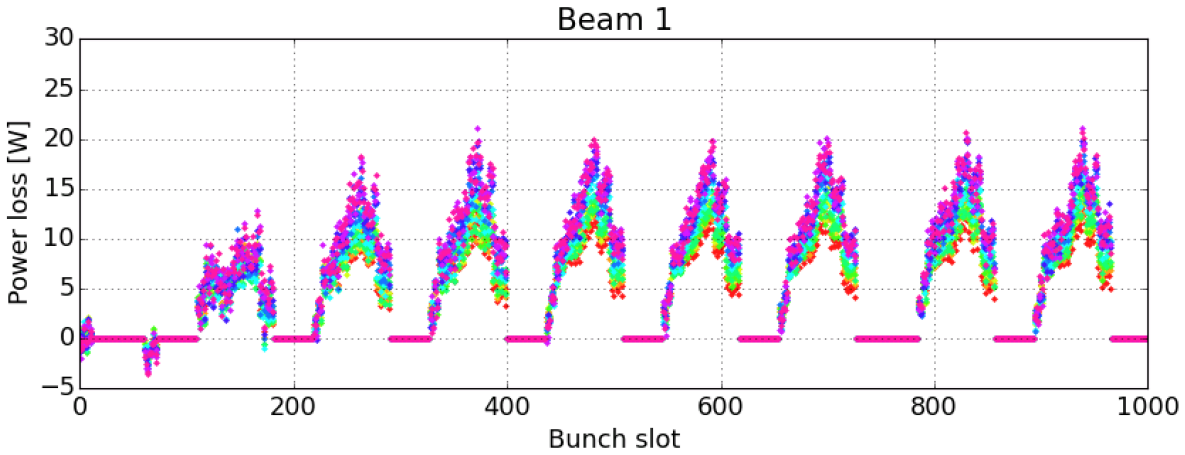
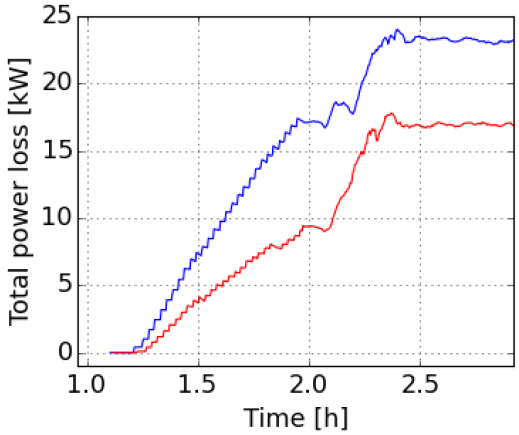
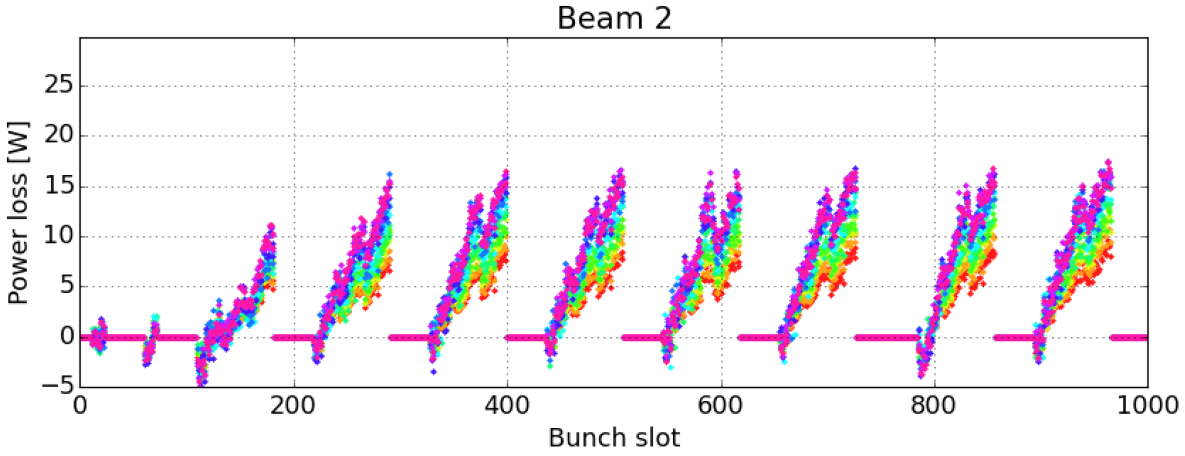


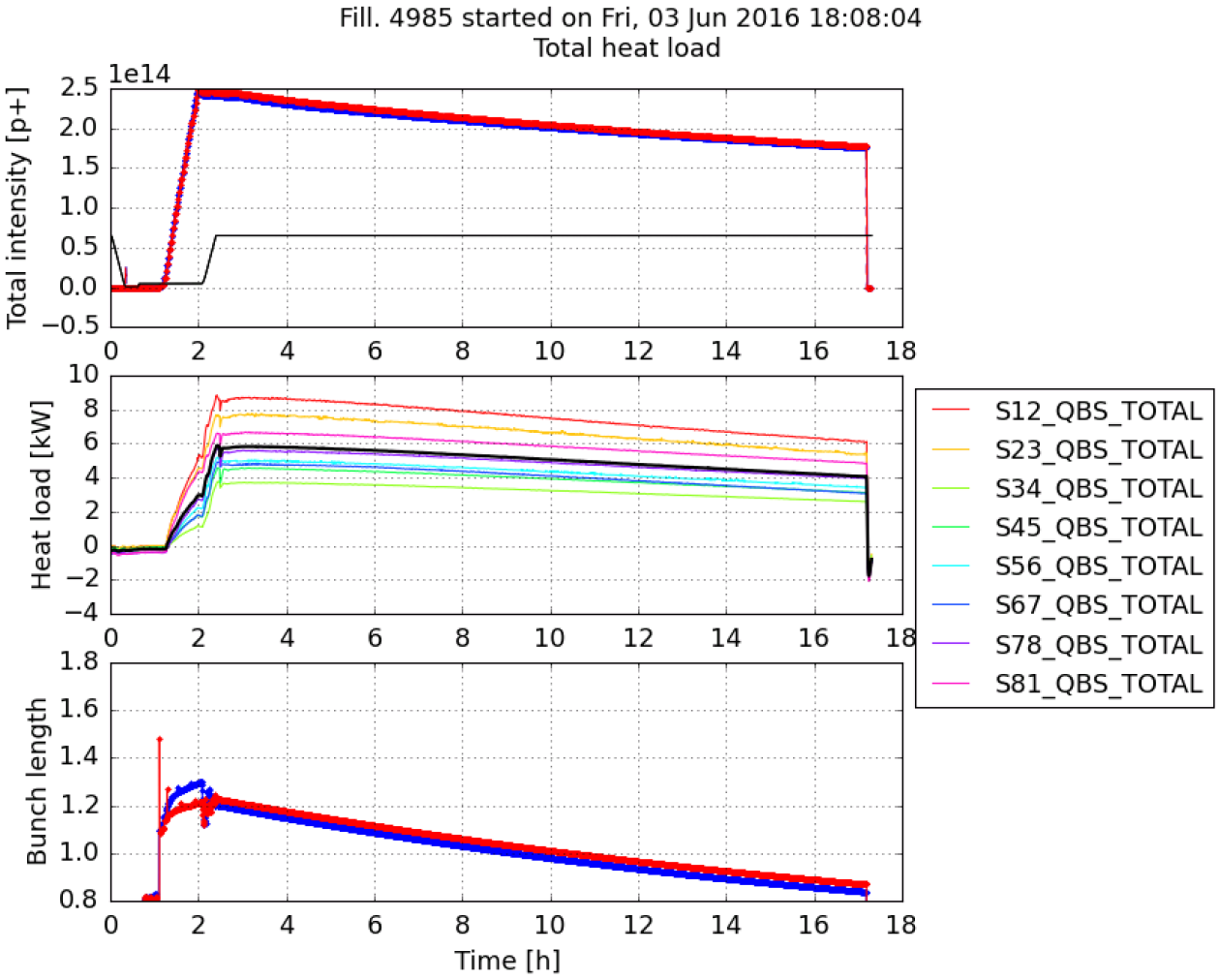






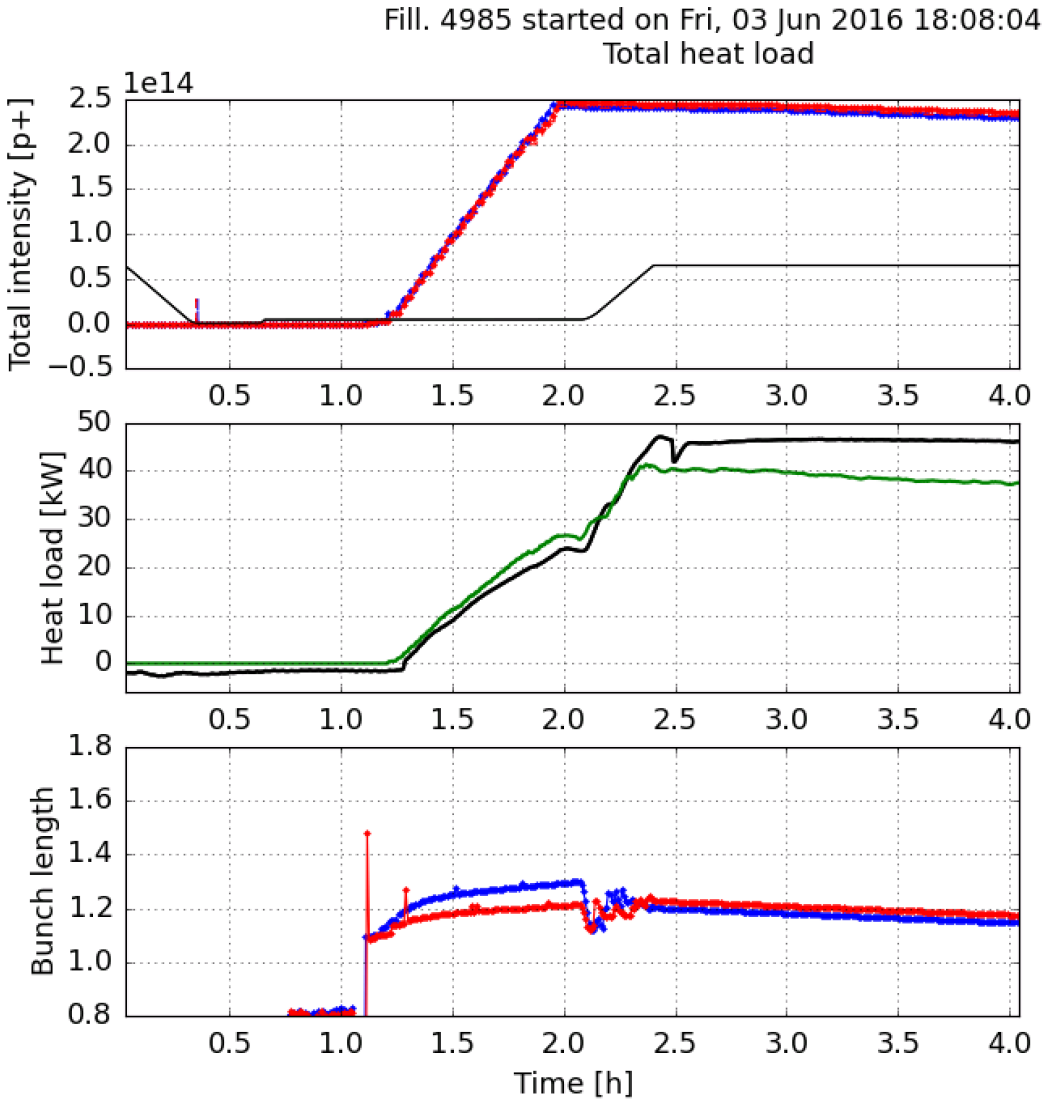
Total heat load per sector

Total heat load per sector as downloaded from the logging database



Total heat load per sector

- **Reasonable agreement**

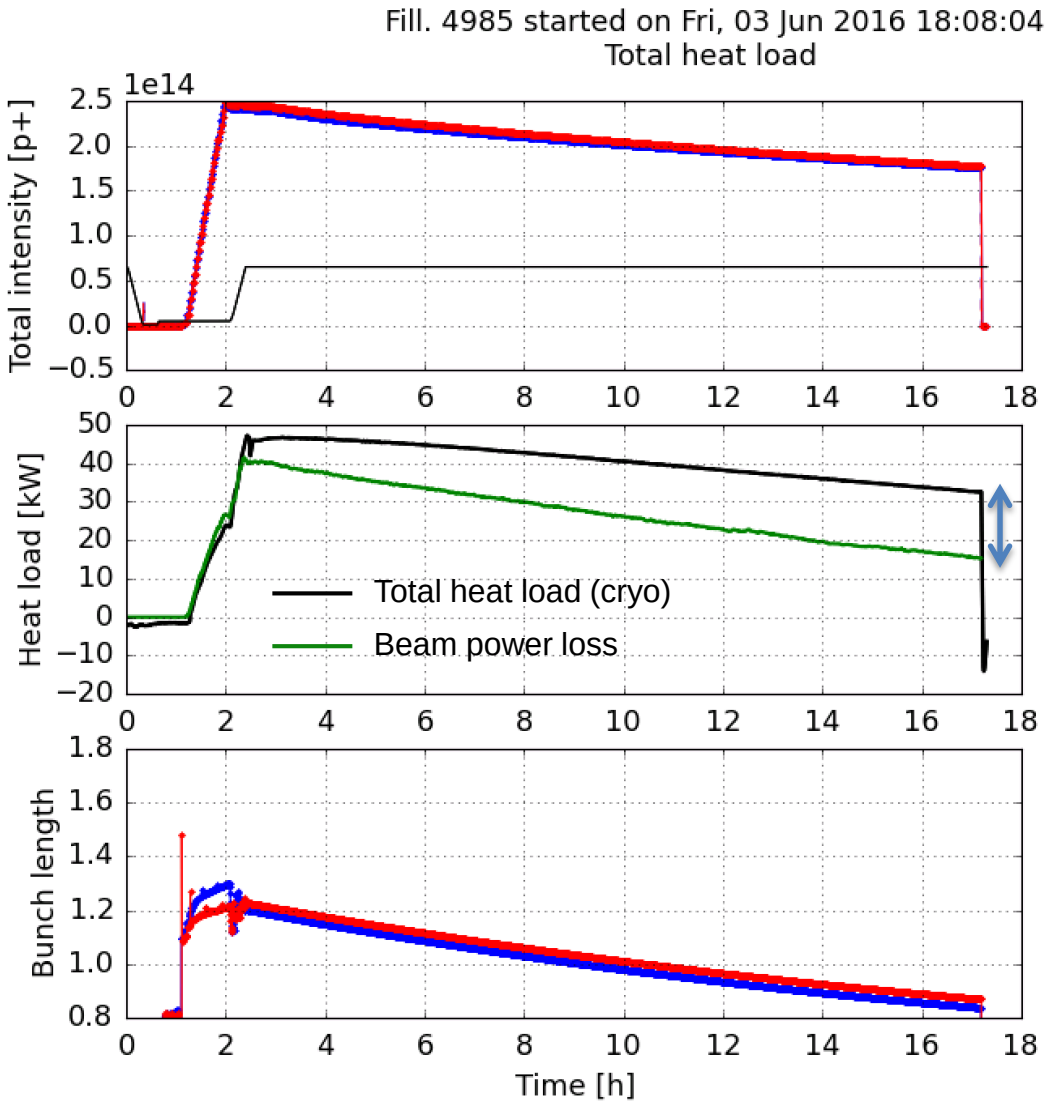


Total heat load (cryo)

Beam power loss

Total heat load per sector

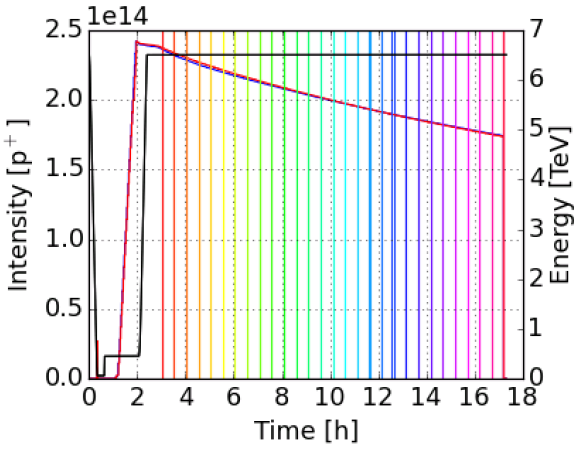
- **Difference increases during physics fills**

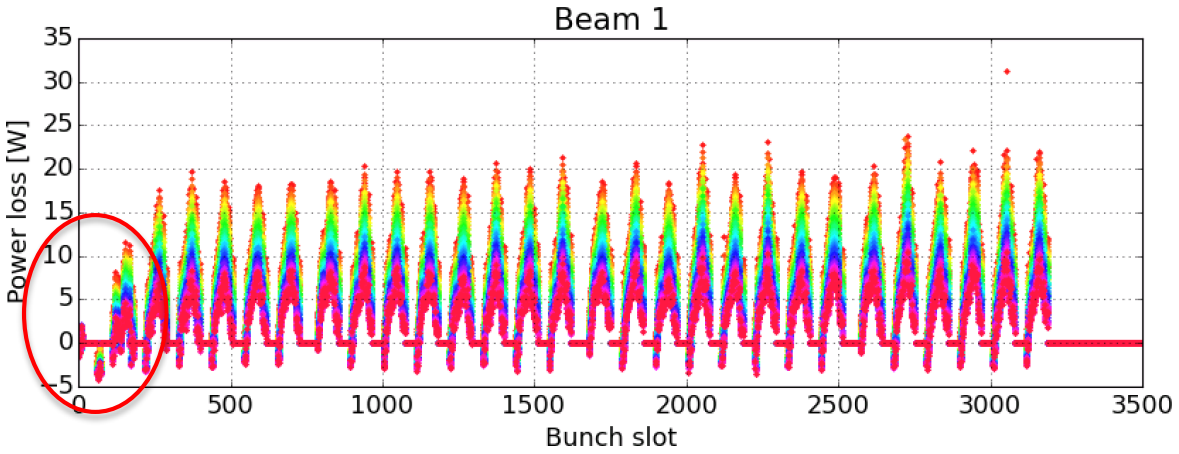


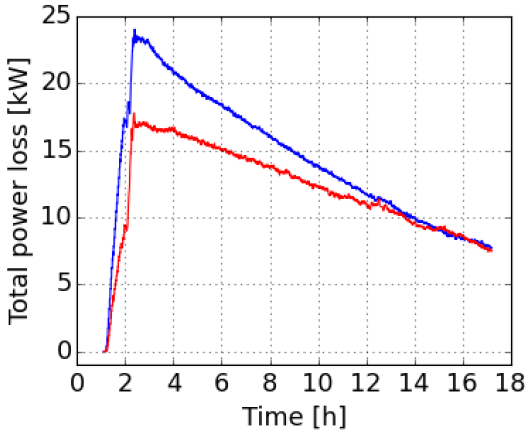
Consistent with error of ~3 W/bunch expected from more intense reference bunches (see next slide)

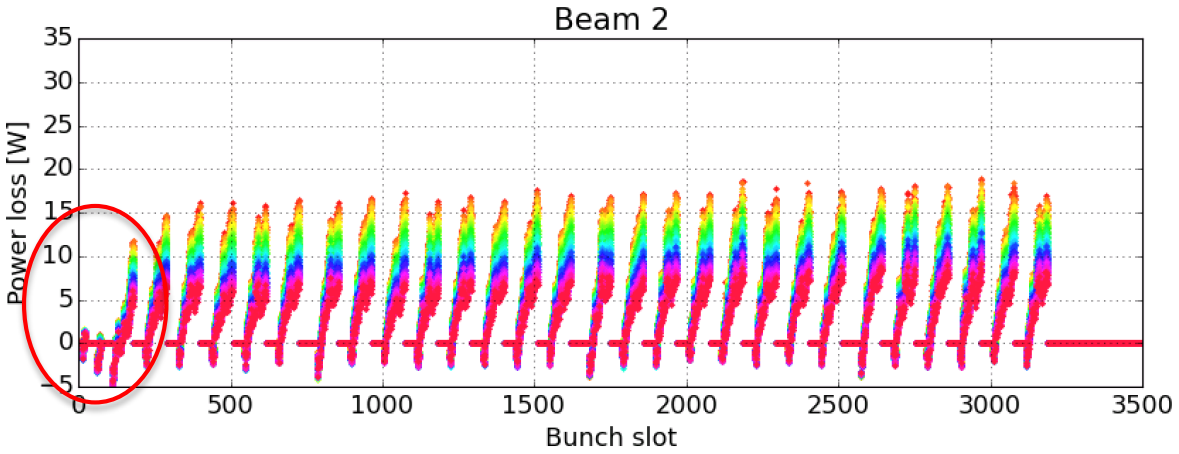
Total heat load per sector

Fill 4985: started on Fri, 03 Jun 2016 18:08:04









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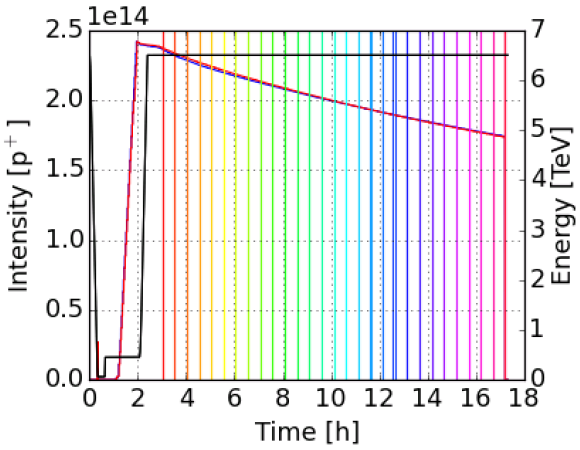

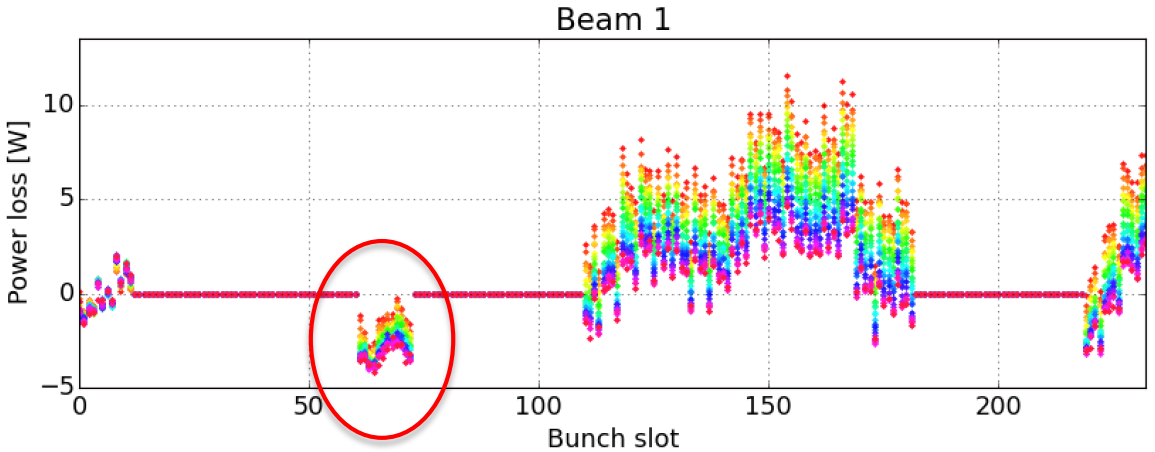

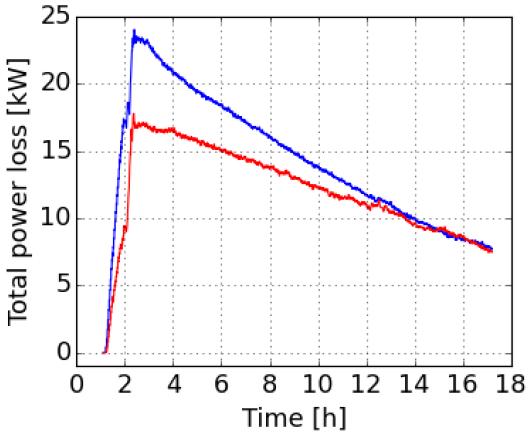

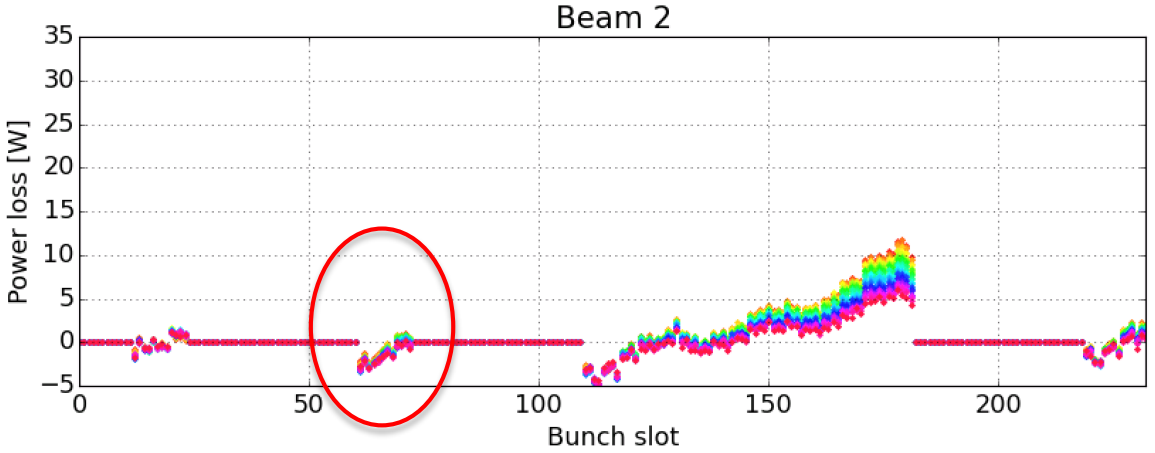

Losses in collision

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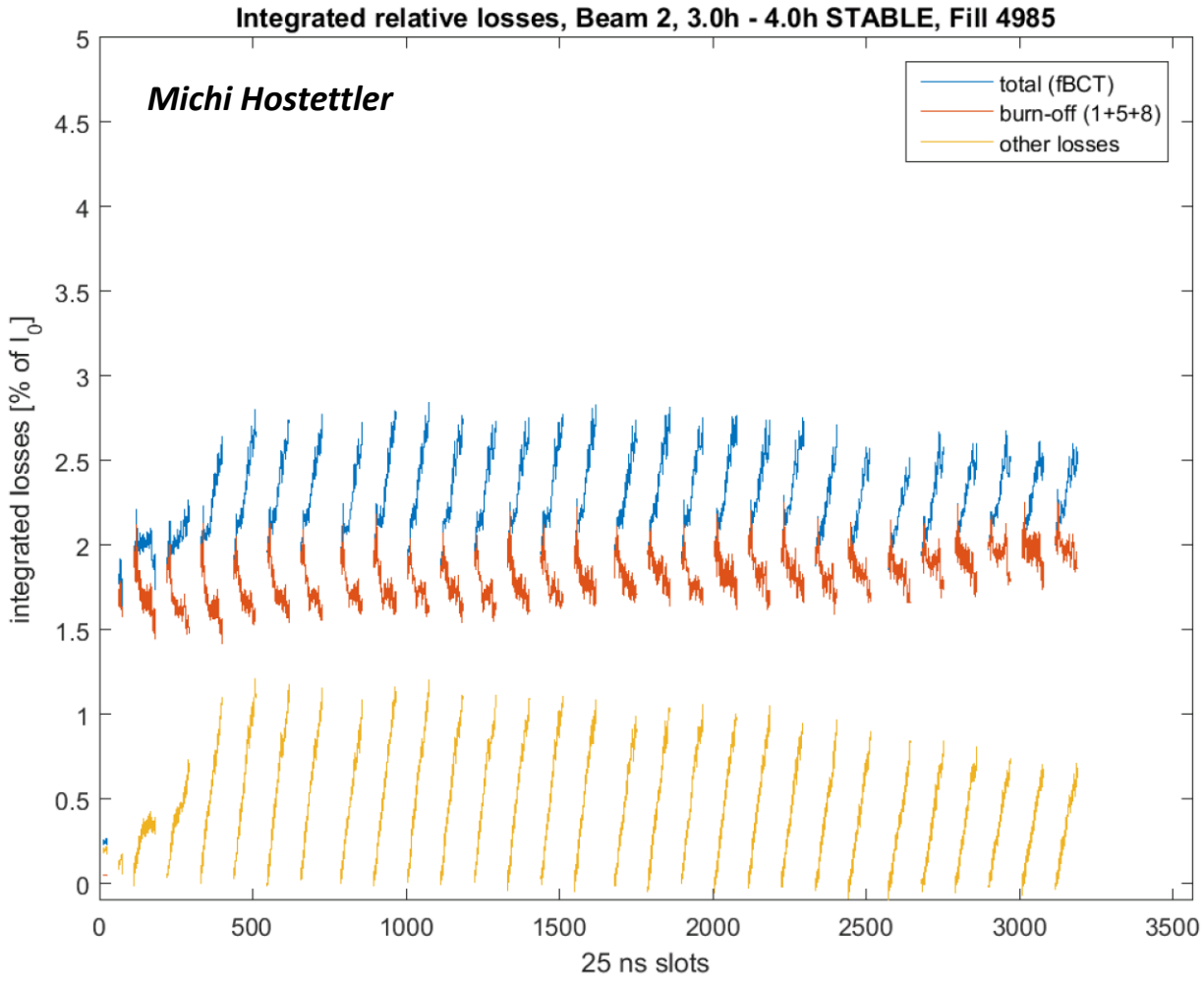

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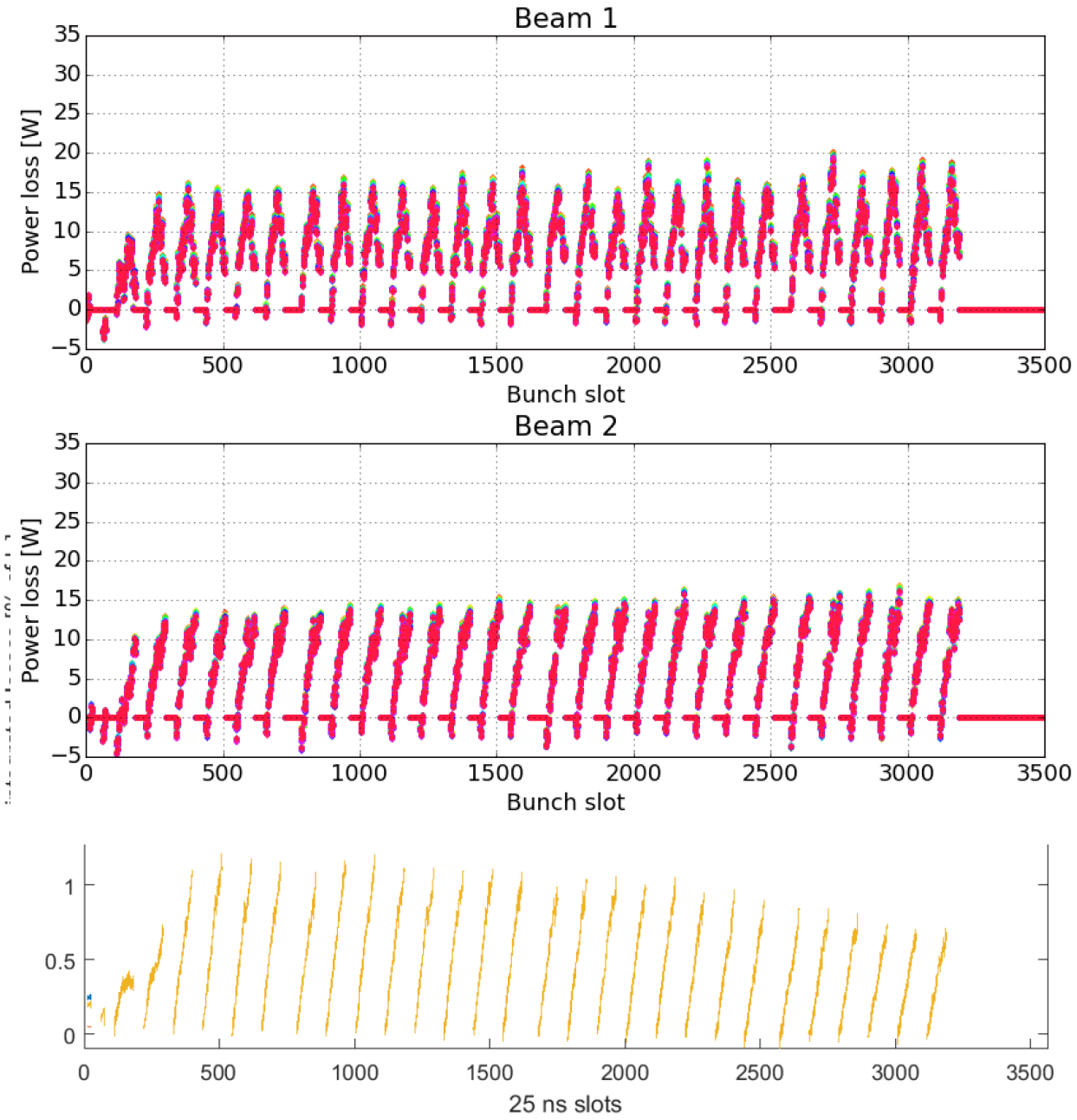
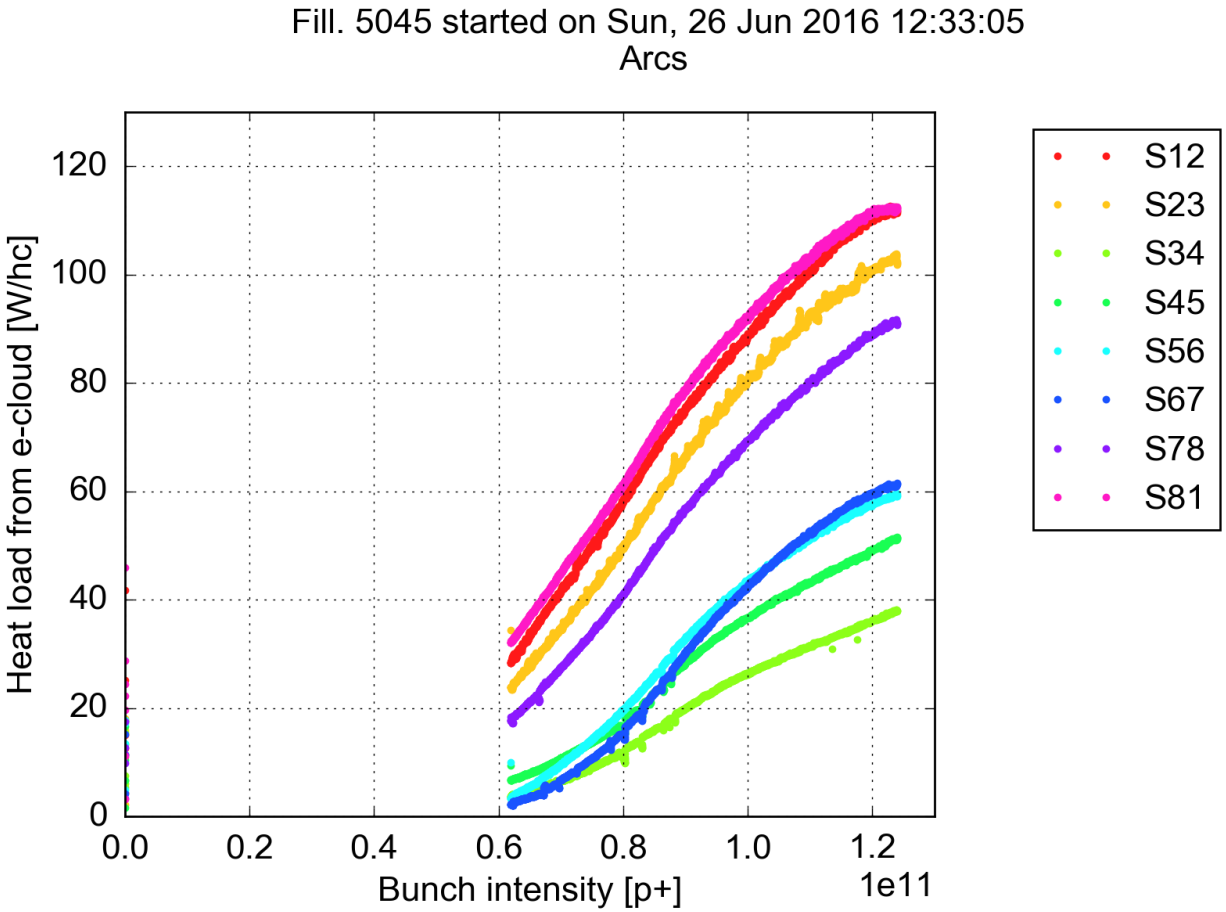


Heat load vs bunch intensity during long physics fills

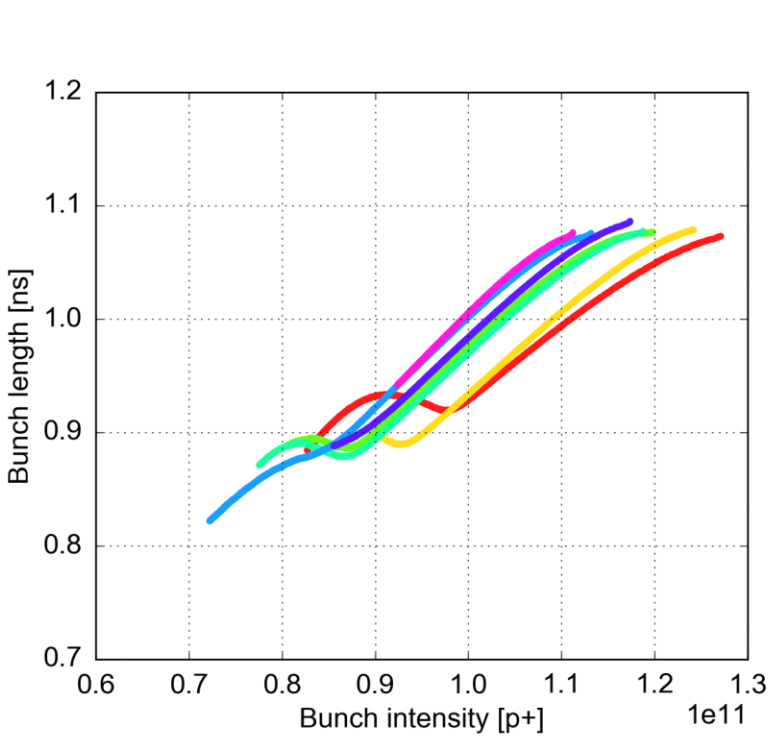
Dependence on beam intensity

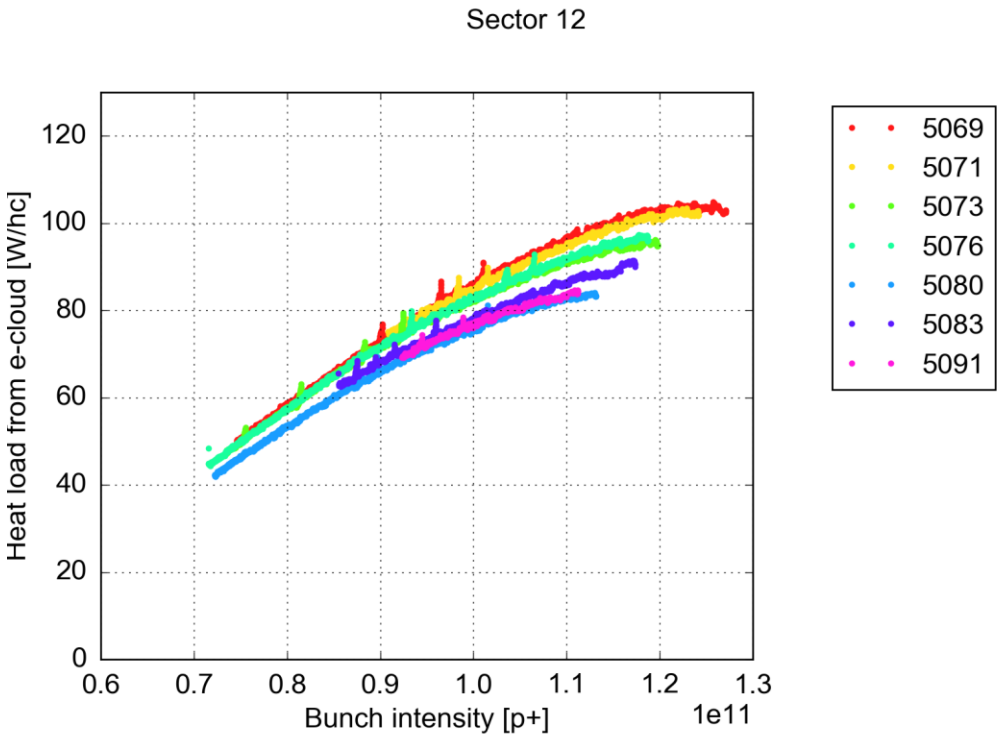
- **Synchrotron radiation** and **impedance** components **subtracted** from measured values
- **Intensity threshold behavior** clearly visible in the measurements
  - → **Modification was required in the cryo feed-forward** to avoid overcooling at the end of long fills
- **High heat load sectors** show a **lower intensity threshold** → compatible with **higher SEY**



Dependence on beam intensity

- **Limited fill-to-fill variations** for fills with **the same controlled longitudinal blow-up in the ramp** are correlated with differences in **bunch length**





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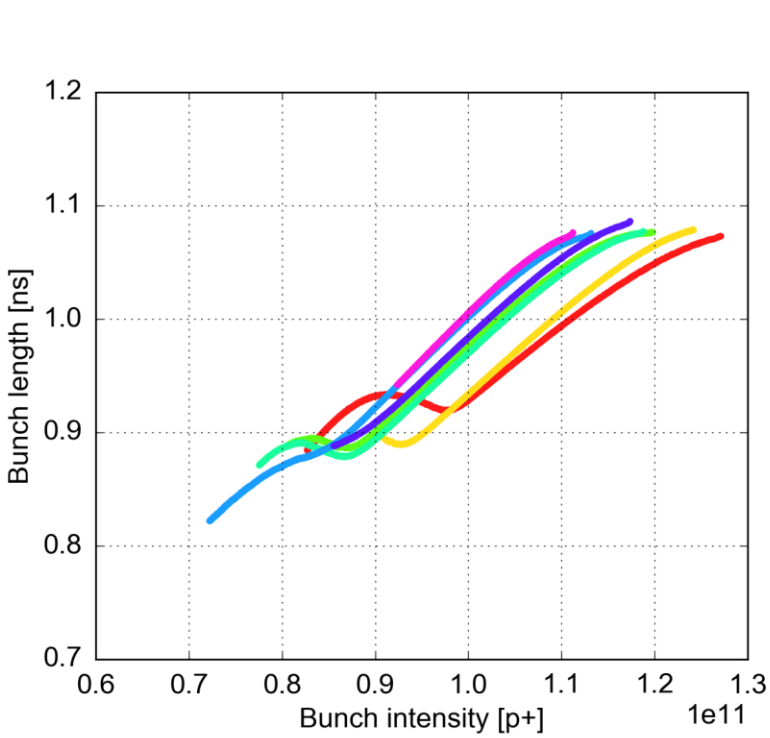

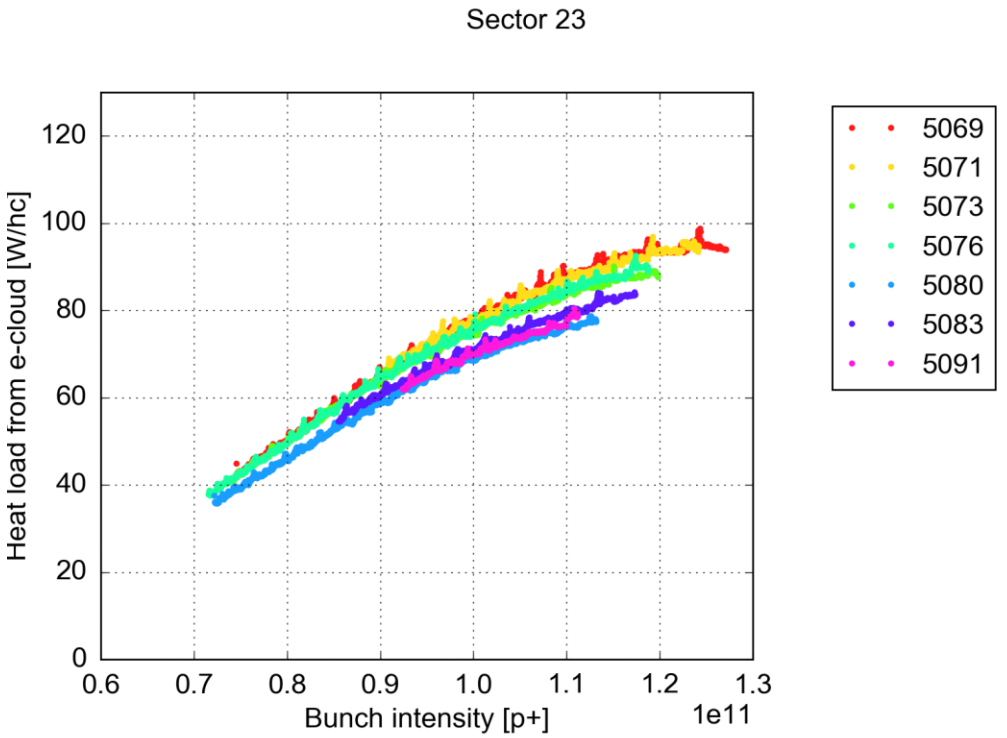

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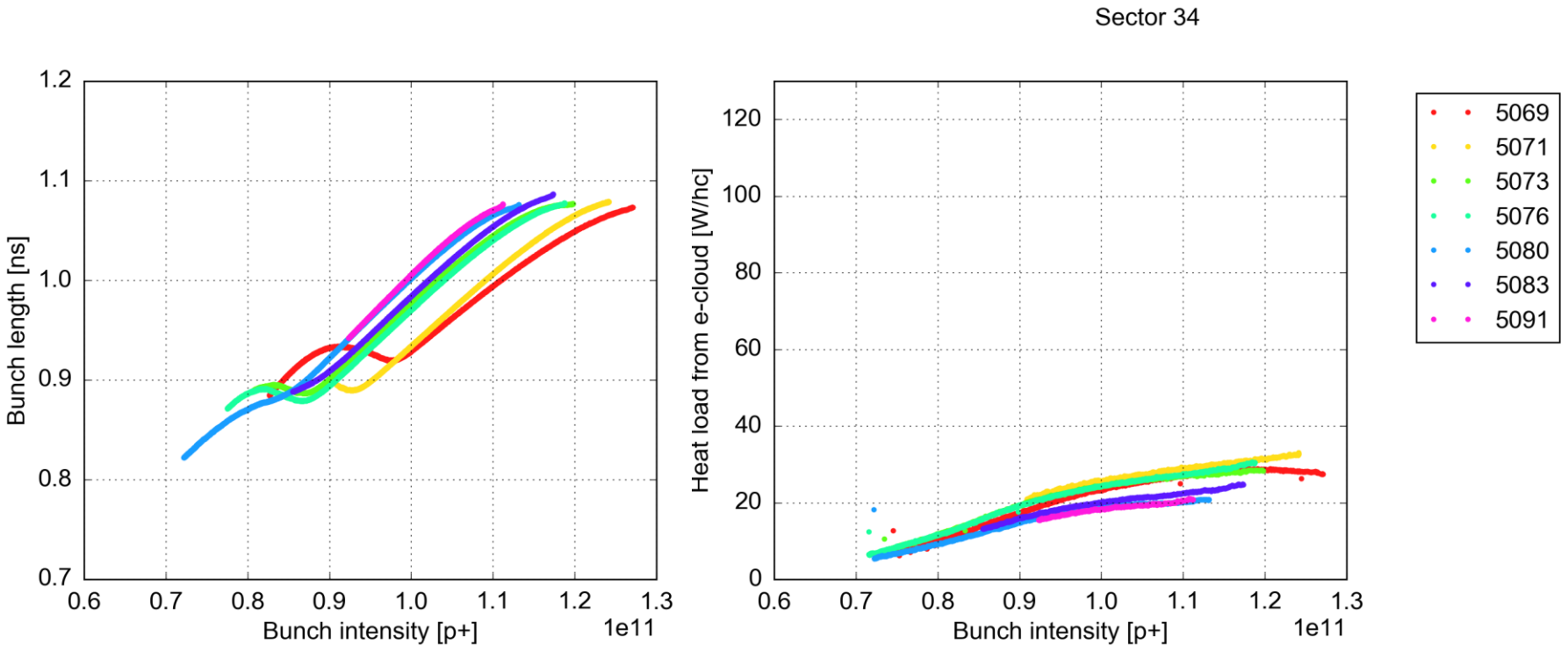

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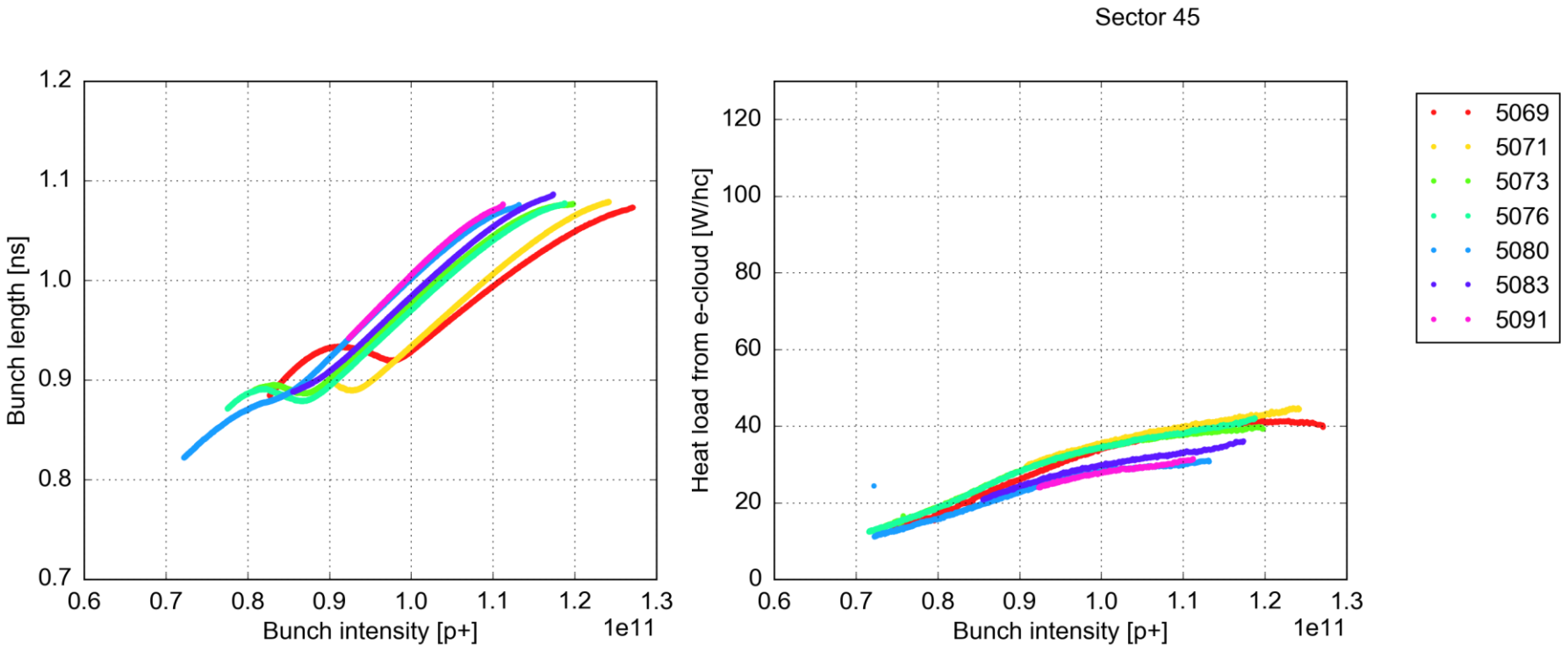

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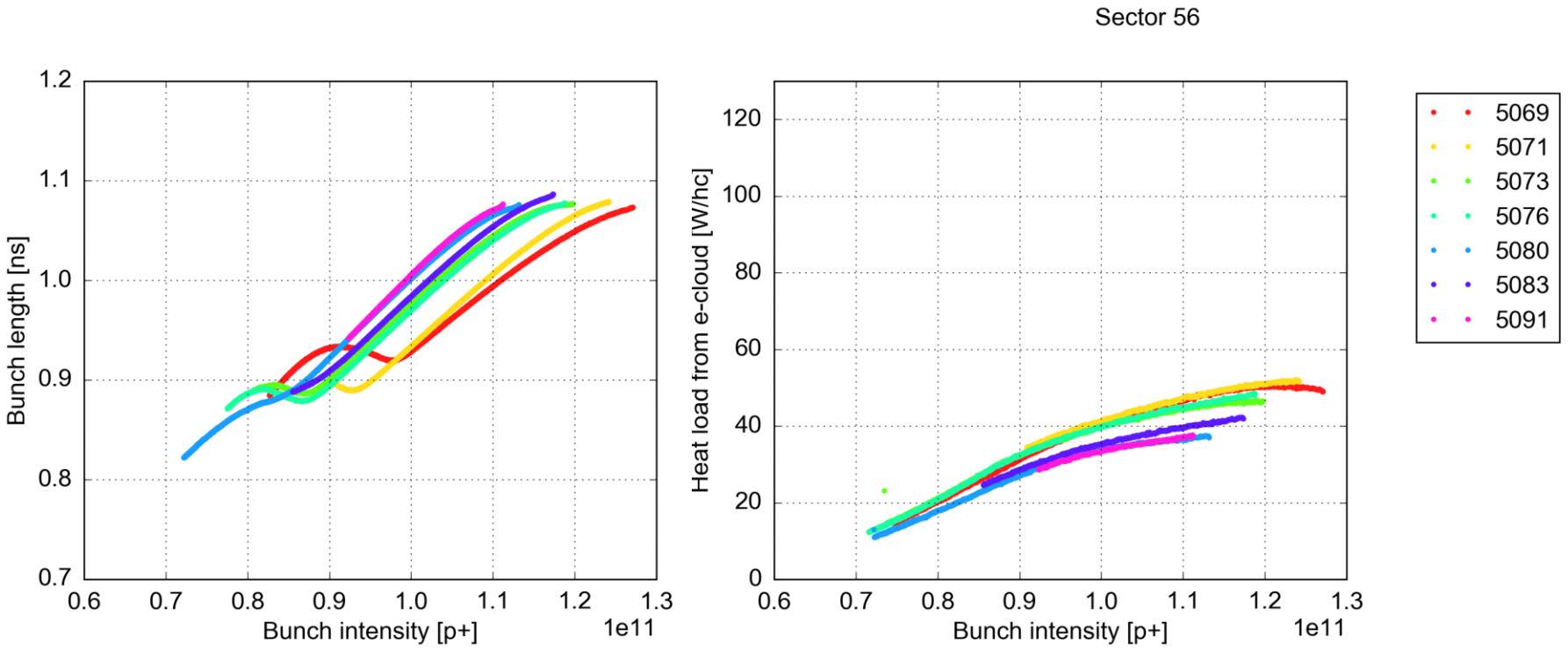

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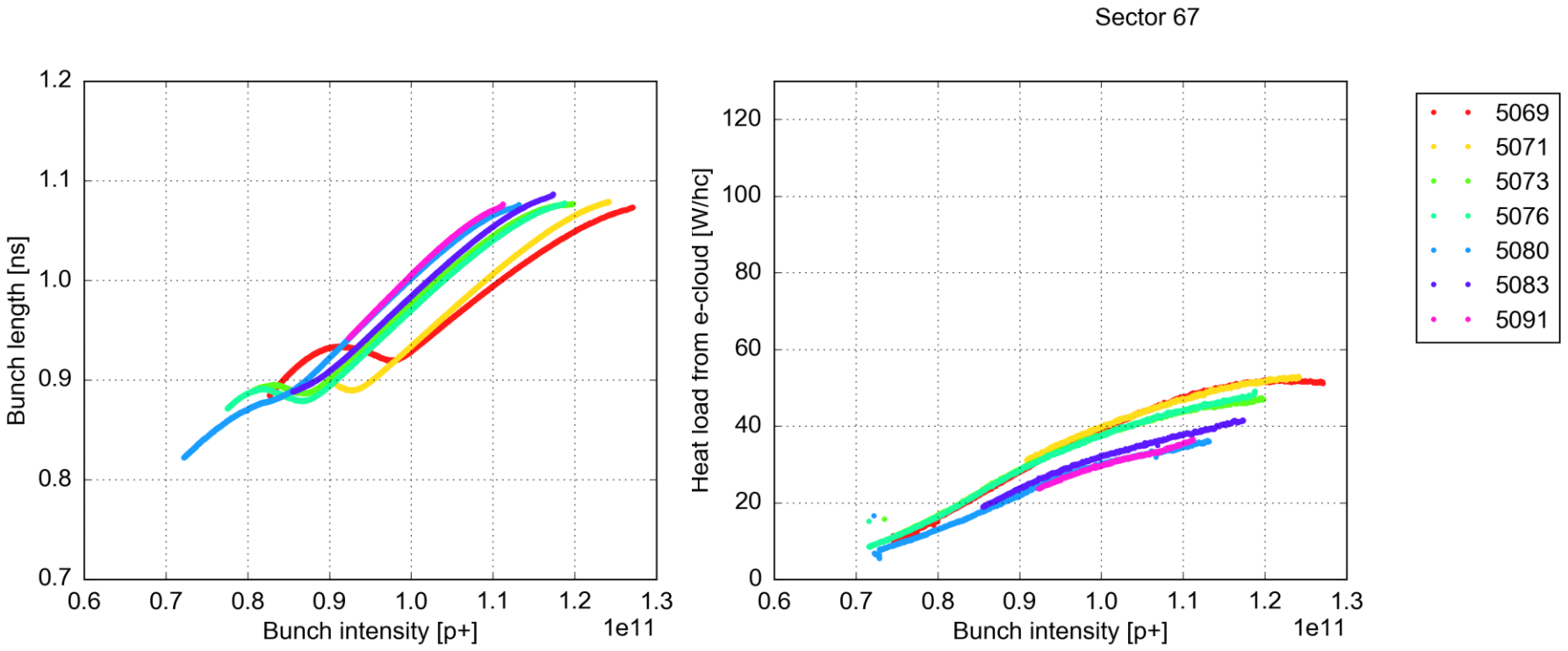

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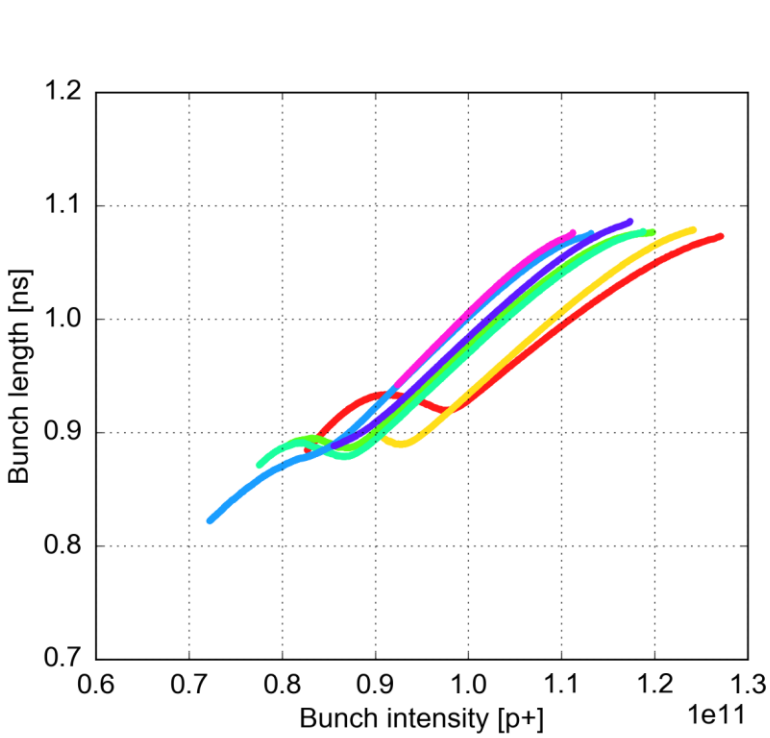

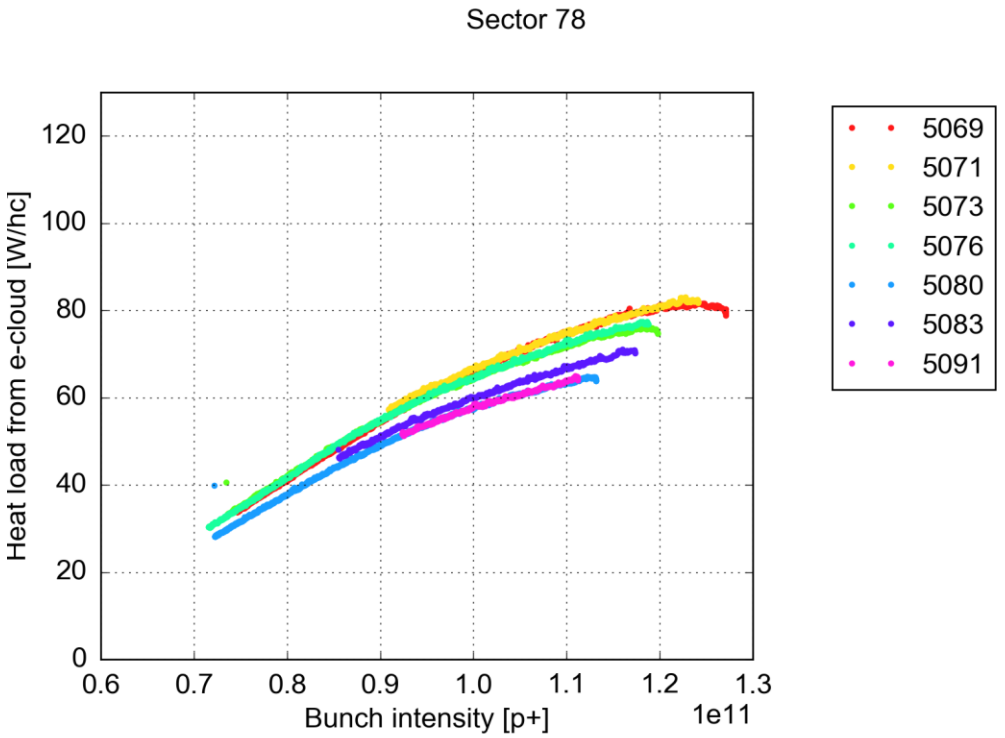

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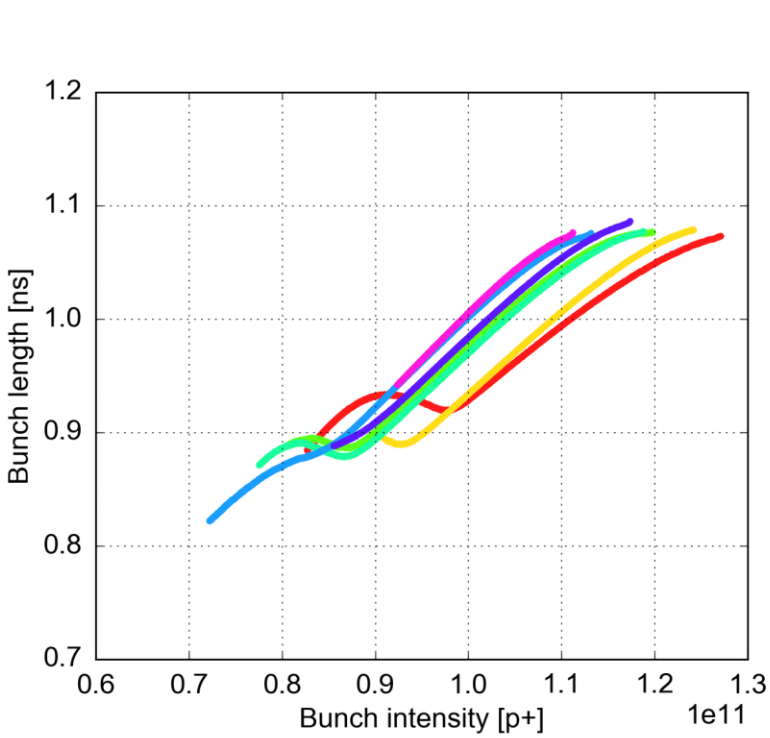
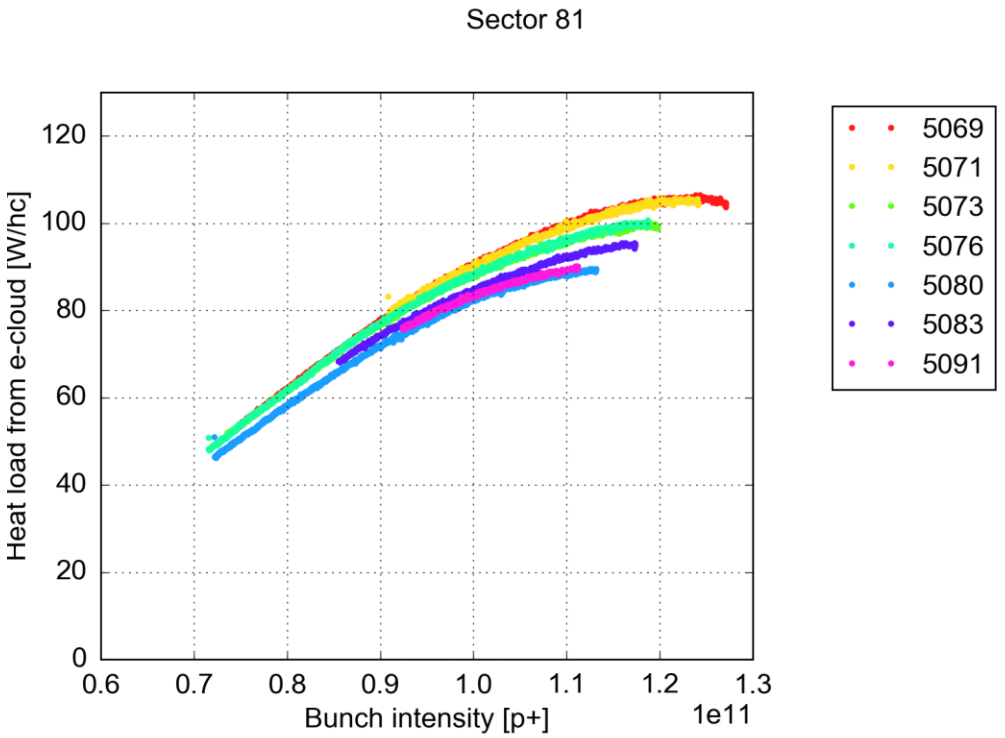
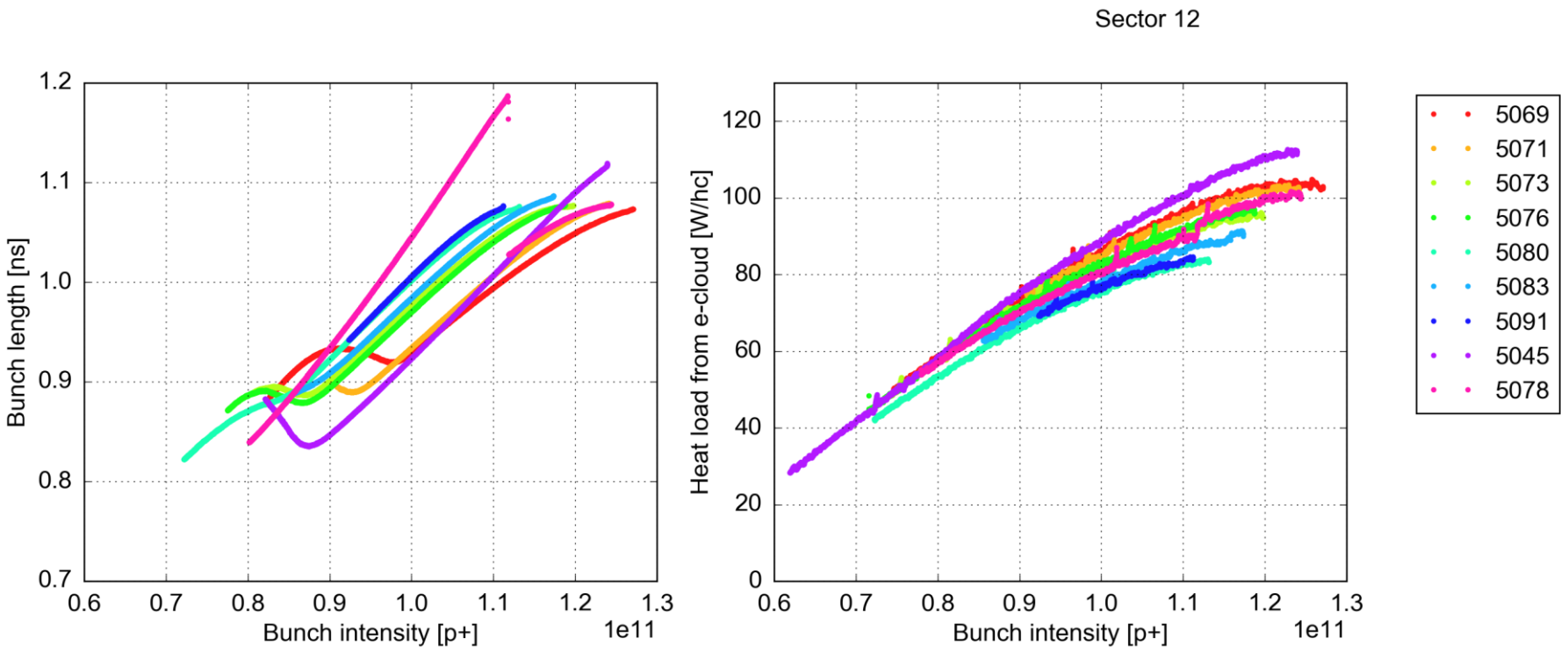




Dependence on beam intensity

- Fills with **different target bunch length** (e.g. fill 5045) or with **controlled profile flattening** in stable beams (e.g. fill 5078) **behave very differently**
  - → **The BQM measures** the FWHM of the profile and rescaled to the r.m.s. bunch length assuming a **Gaussian profile** → but **profiles can be very different**



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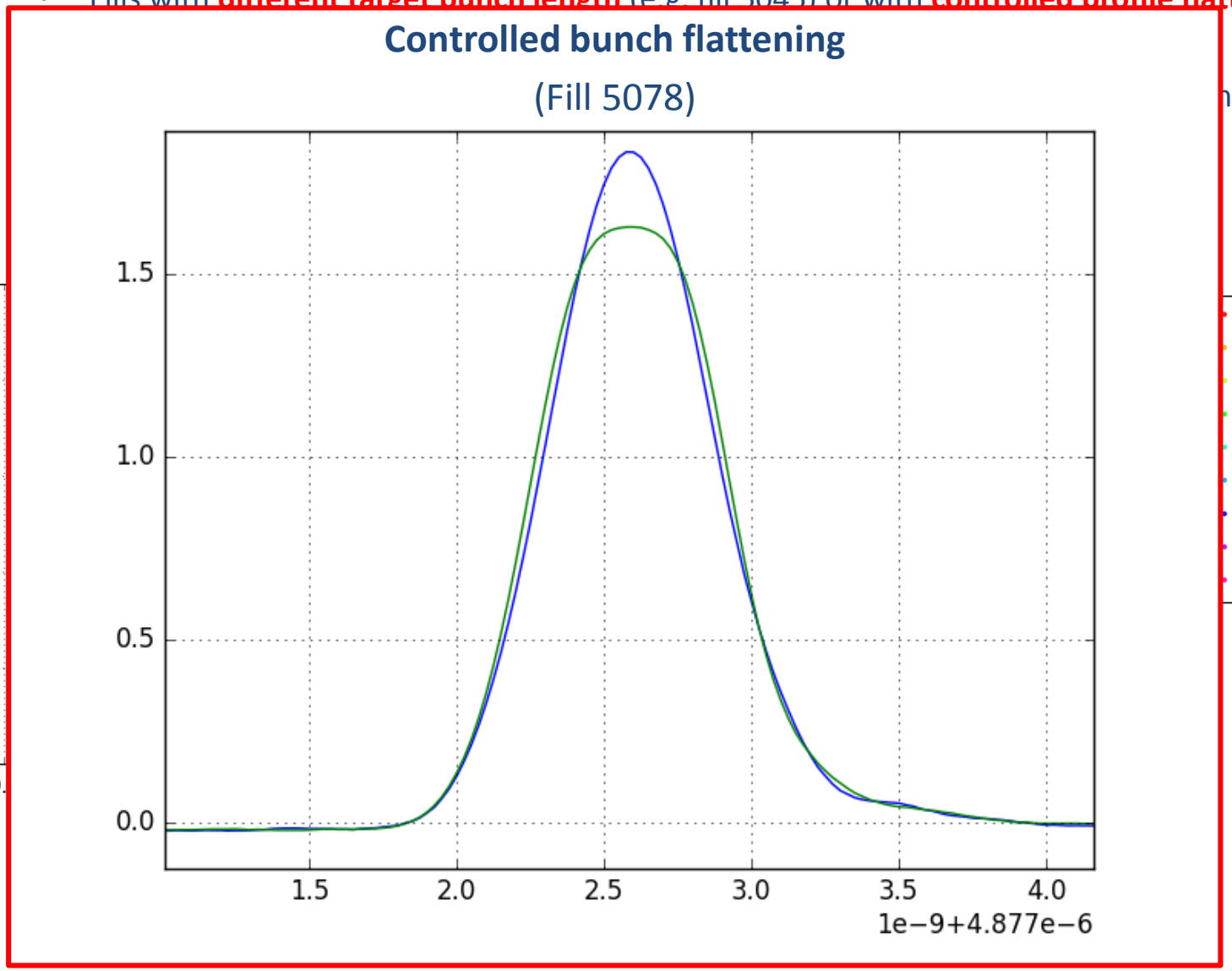
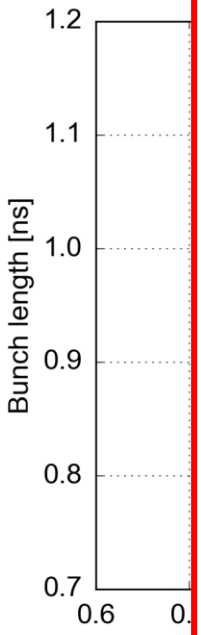
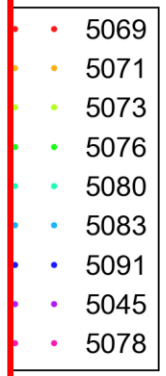


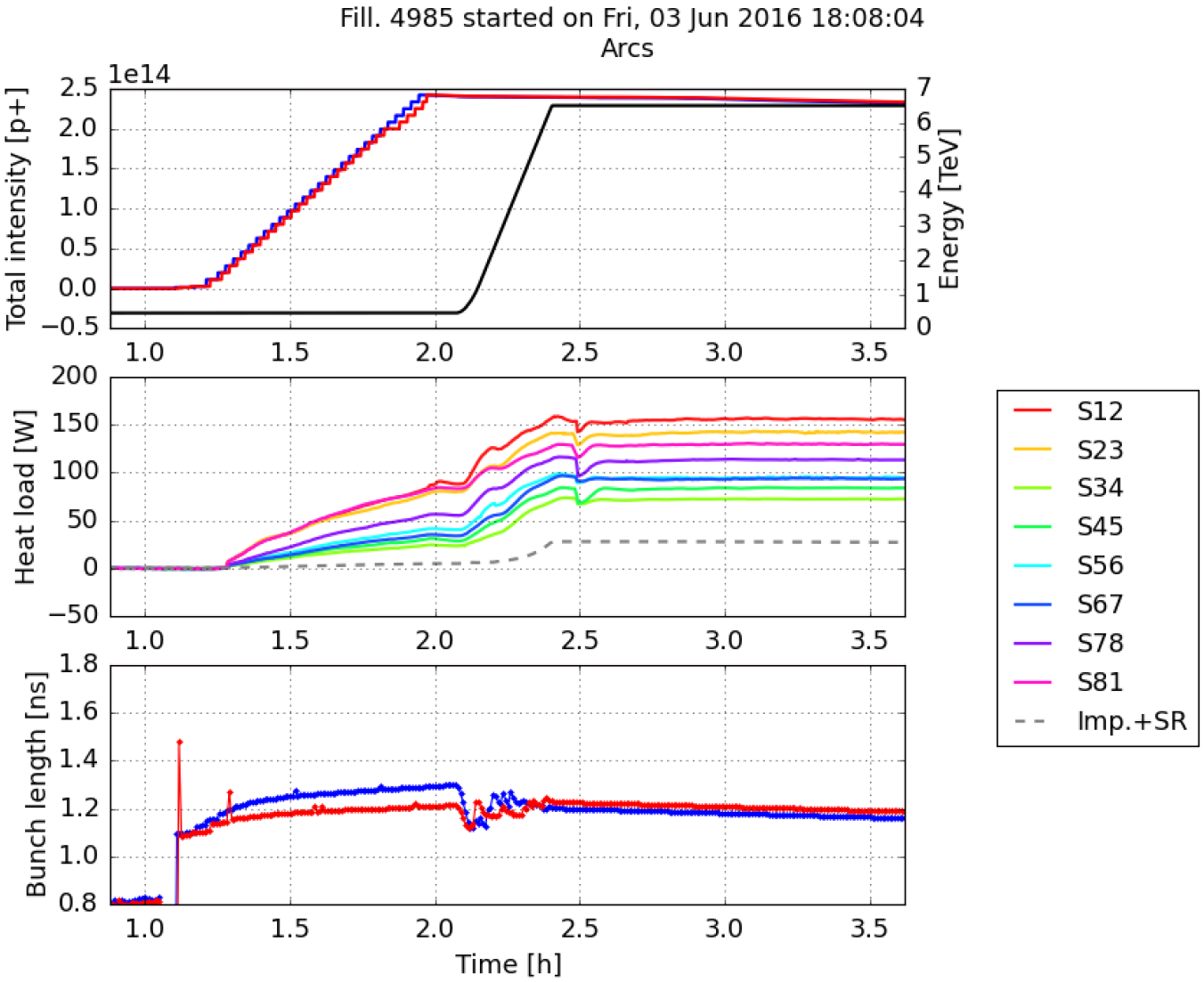
length





Heat load during the energy ramp

Heat load evolution during the energy ramp



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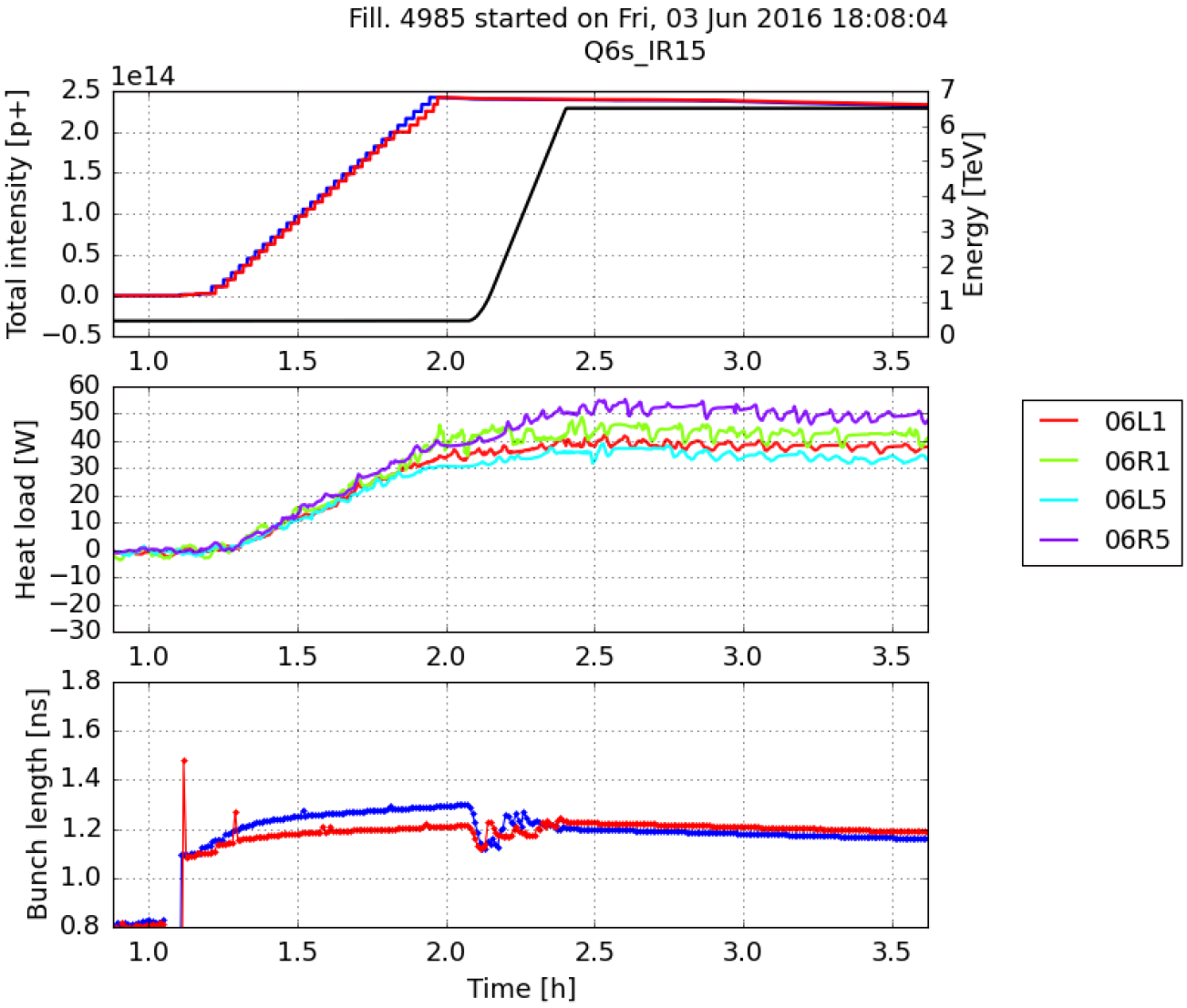

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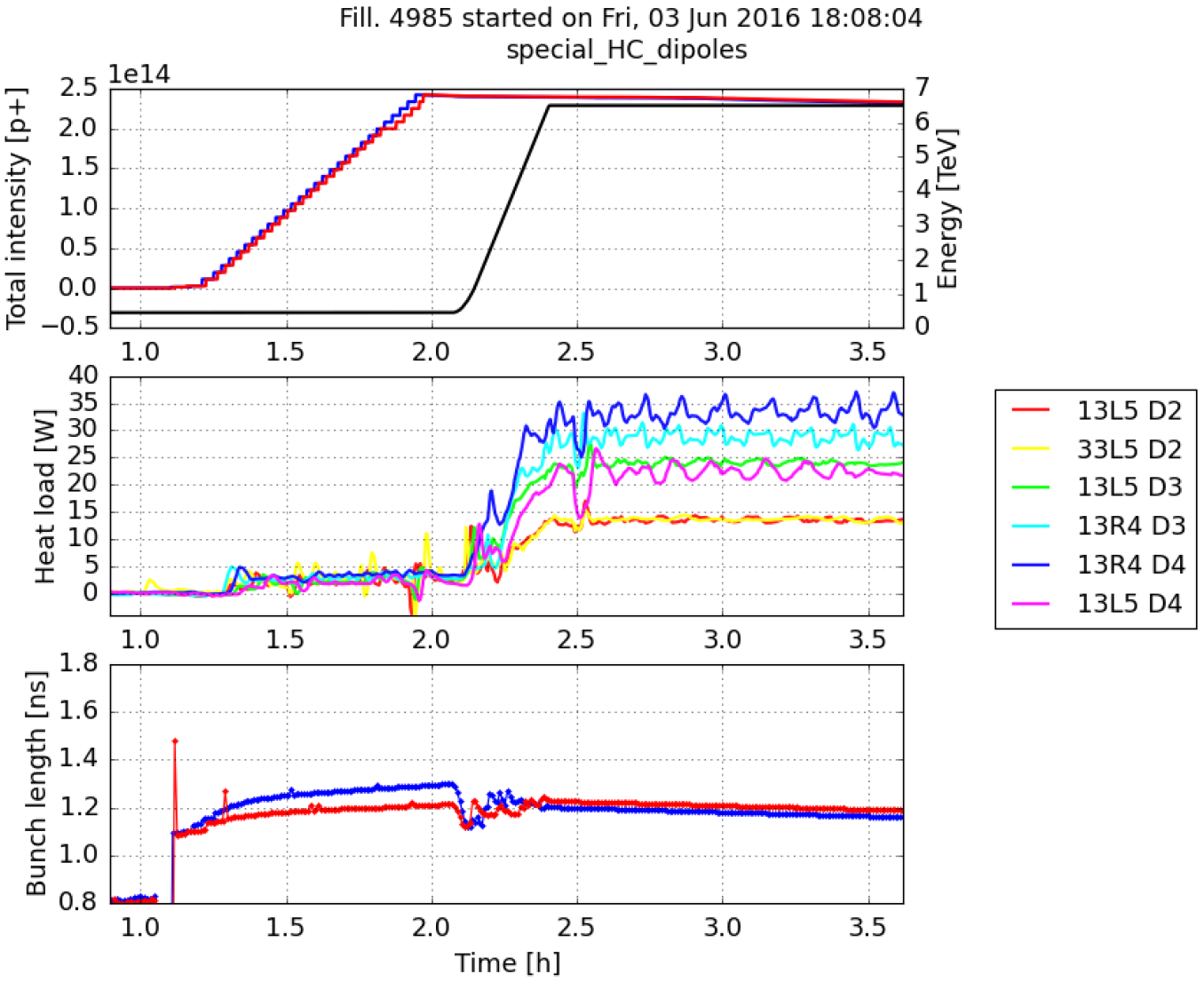
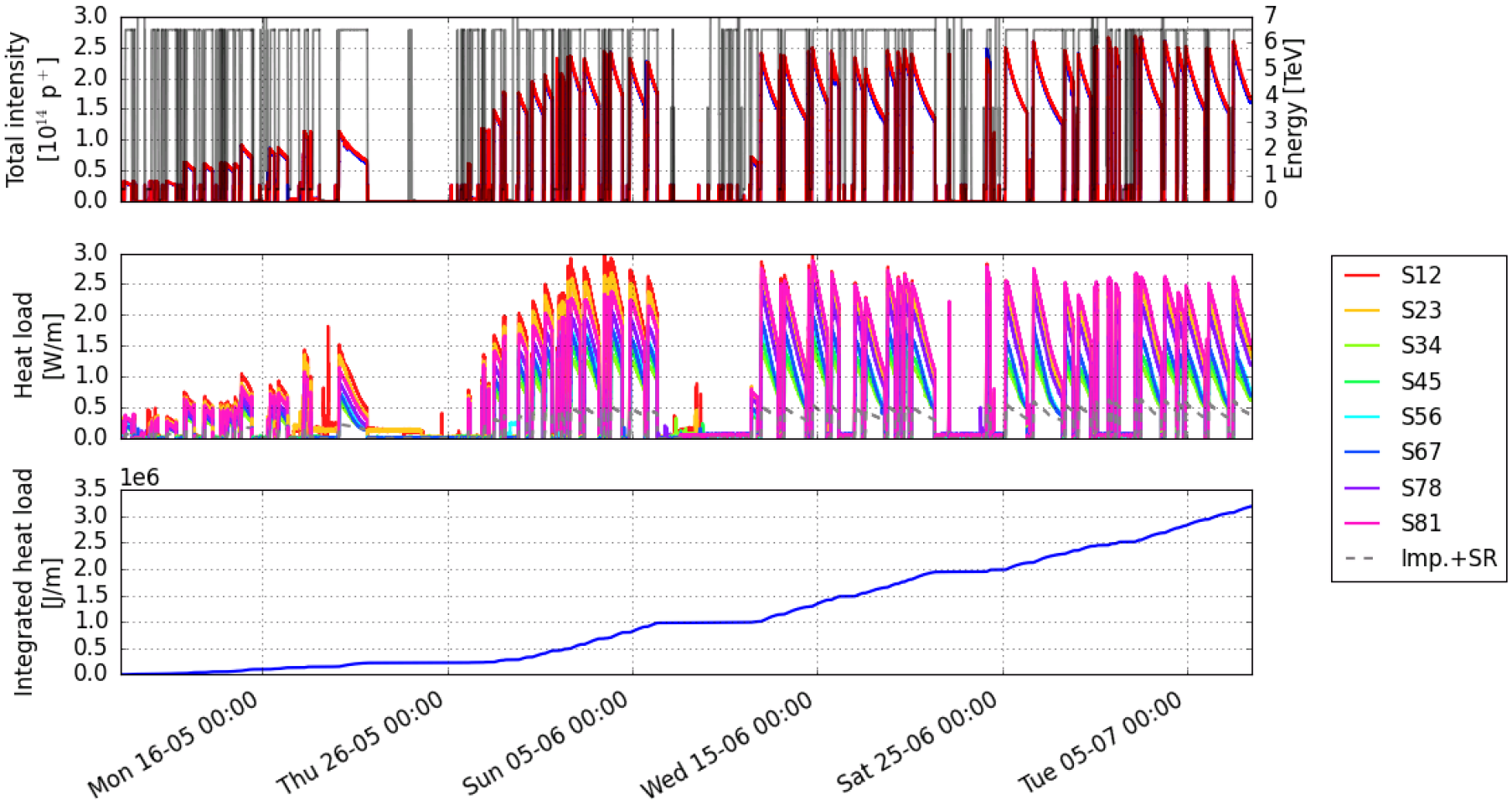


Accumulated electron dose

Computation of the integrated electron dose

- The dose is computed from the **integrated heat load** (cryo measurements)

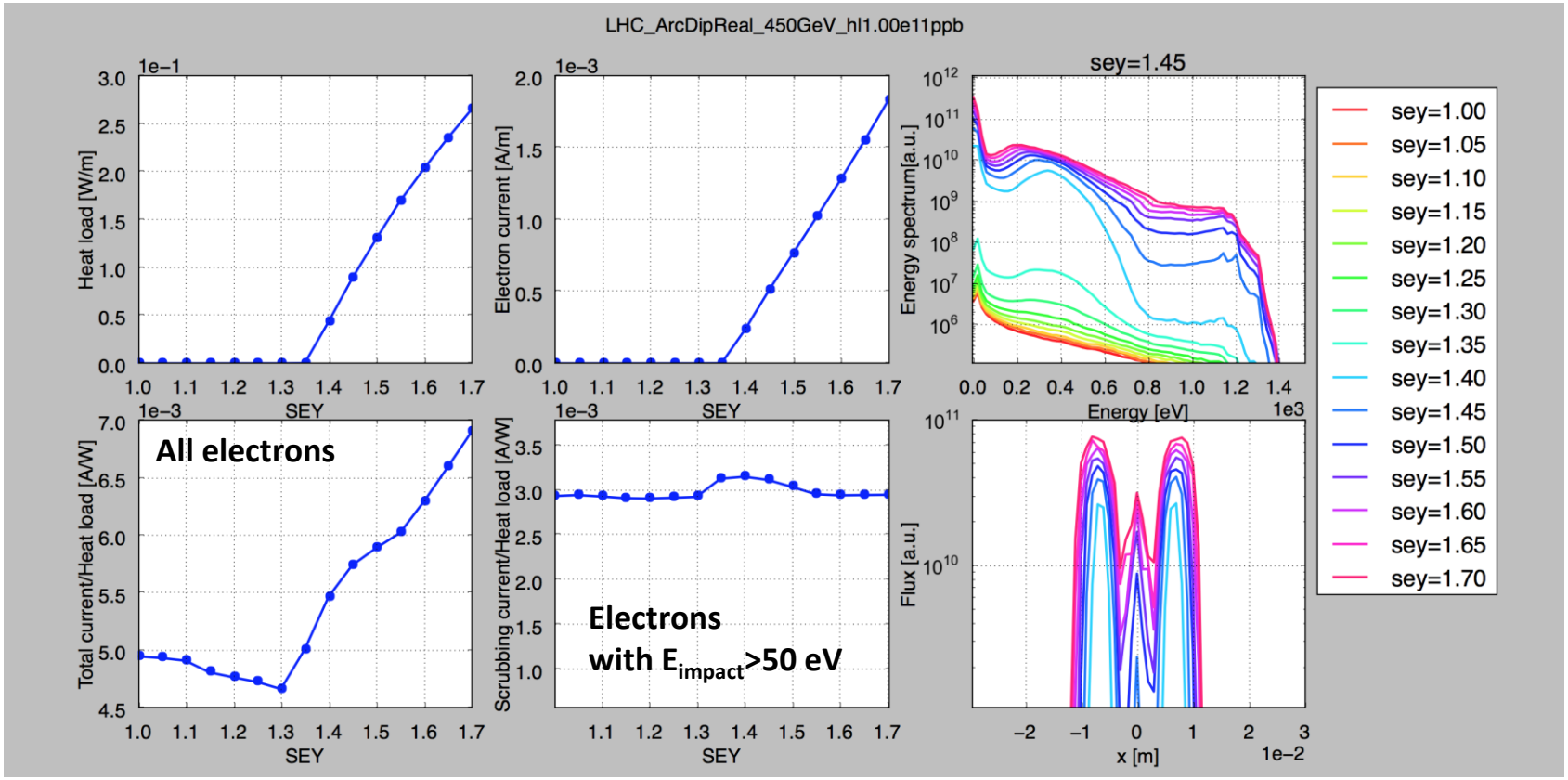


Computation of the integrated electron dose

From **PyECLOUD simulations** we obtain a **conversion factor** of **3 mA/W**

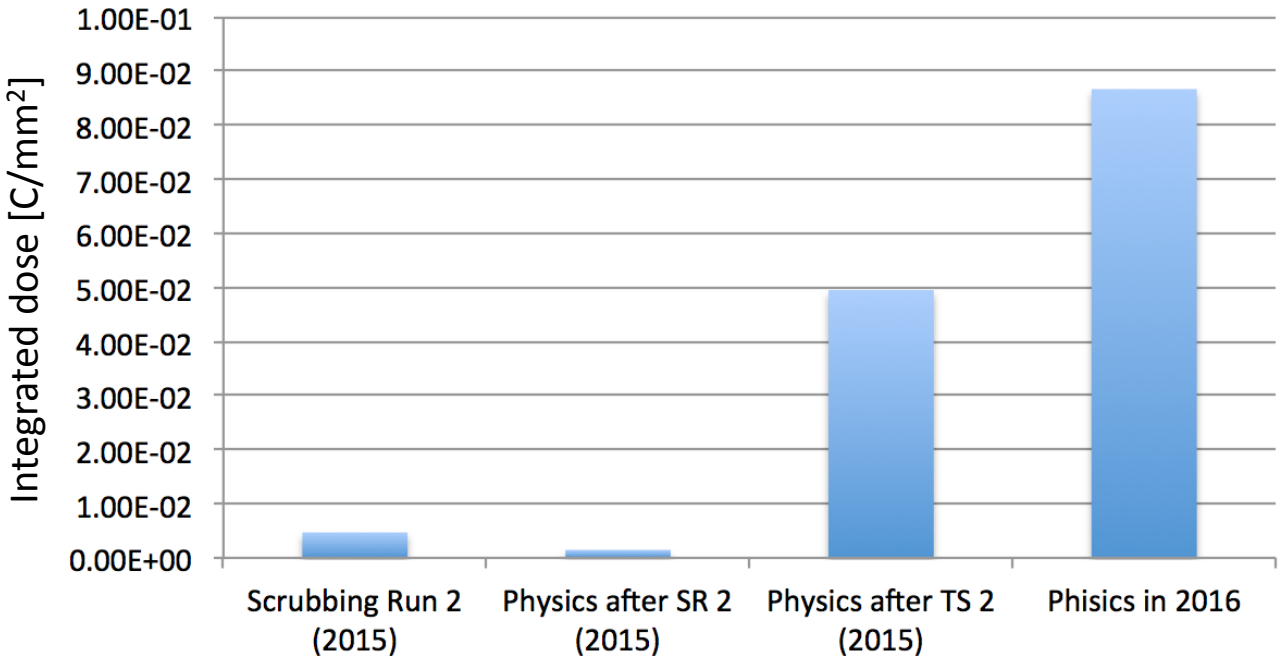
→ Equivalent to an **average energy** of the impacting electron of **333 eV**

We count only "good" scrubbing electrons **E_{impact}>50 eV**



Computation of the integrated electron dose

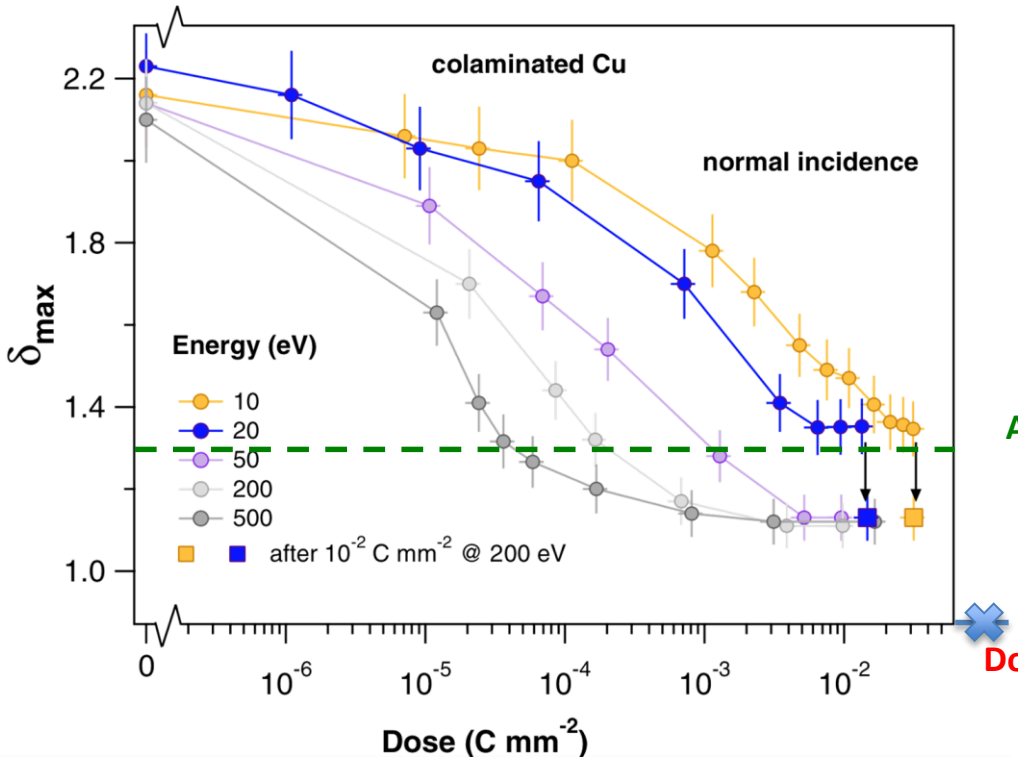
Calibration I/HL	3.00E-03	[A/W]	
Area	0.08	2 cm *2 (top bottom) *2 beam pipes	
Reduction factor (remove quad, imped, SynRad)	0.66		
Period	**Integrated heat load [J/m] (2 beams)**	**Integrated dose [C/m] (2 beams)**	**Integrated dose [C/mm2]**
Scrubbing Run 2 (2015)	1.90E+05	3.76E+02	4.70E-03
Physics after SR 2 (2015)	6.00E+04	1.19E+02	1.49E-03
Physics after TS 2 (2015)	2.00E+06	3.96E+03	4.95E-02
Phisics in 2016	3.50E+06	6.93E+03	8.66E-02



Computation of the integrated electron dose

According to **lab measurements (300 K)** the **dose accumulated in 2016** should be **largely sufficient to achieve full e-cloud suppression** in the dipoles…

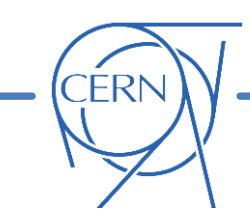
… but the machine seems to behave very differently



Arc dipoles SEY threshold

Dose accumulated in 2016

R. Cimino, V. Baglin et al., " Phys. Rev. Lett., vol. 109, p. 064801, Aug 2012



Thanks for your attention!