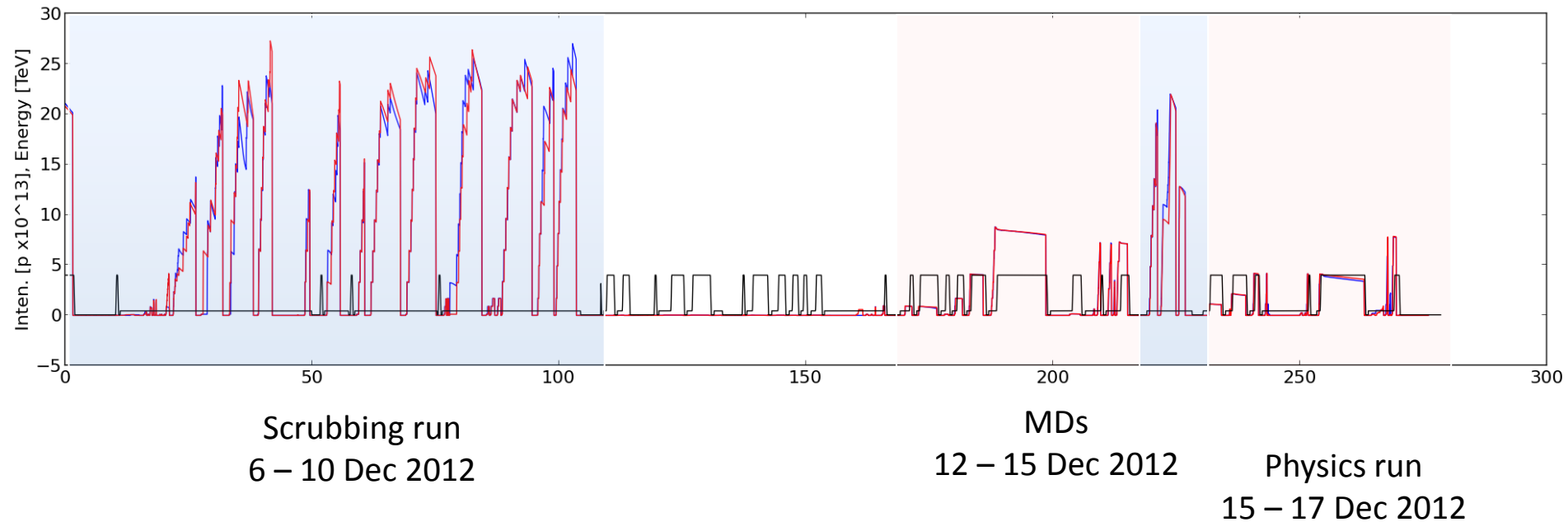


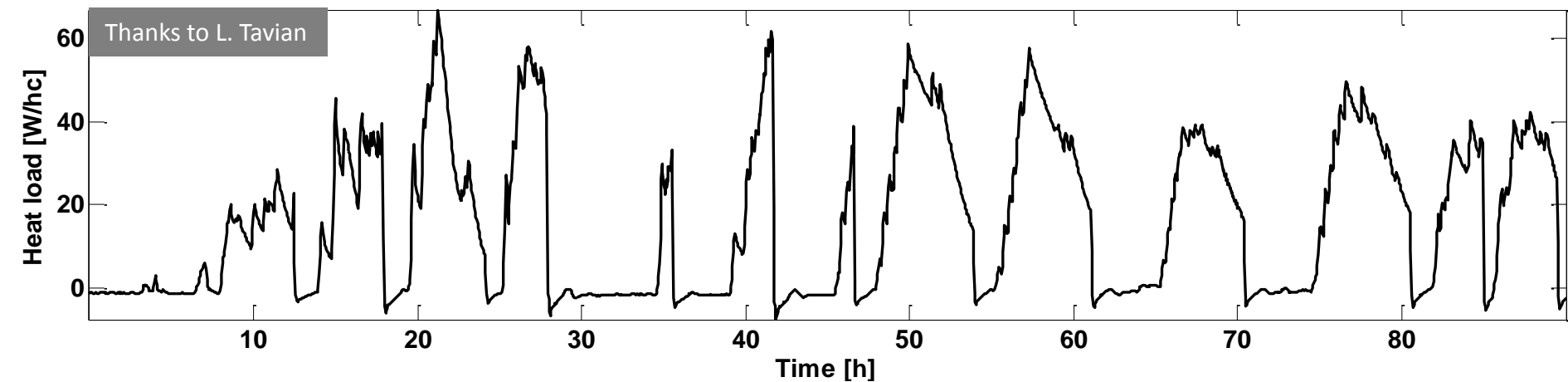
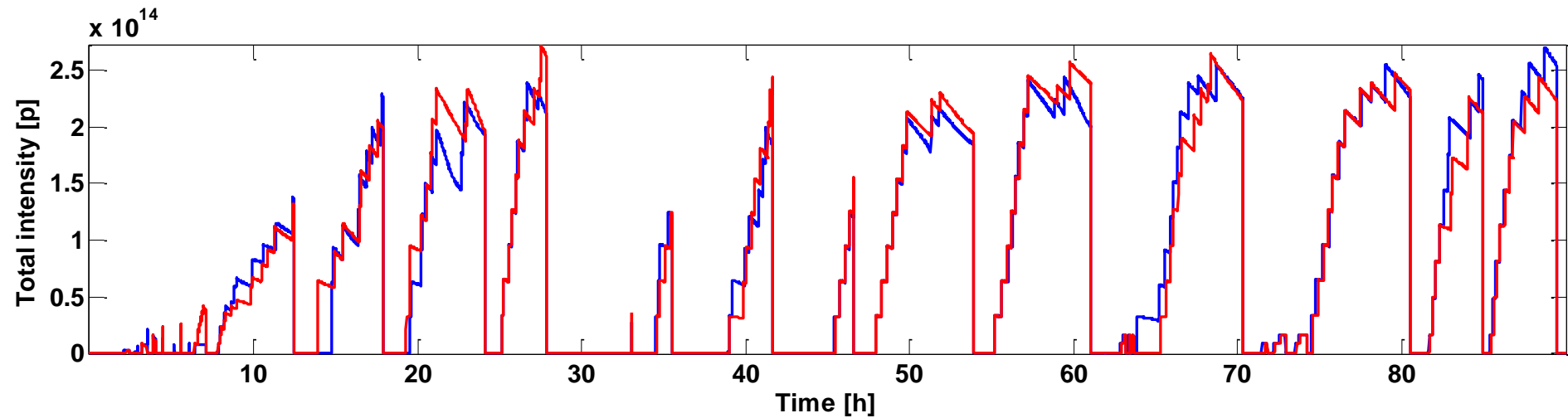
25 ns in the LHC in 2012 Overview



- 1) **Scrubbing speed**: why has the scrubbing process seemingly stopped in the LHC ?
- 2) Behavior of the heat load/stable phase shift with the **beam energy**

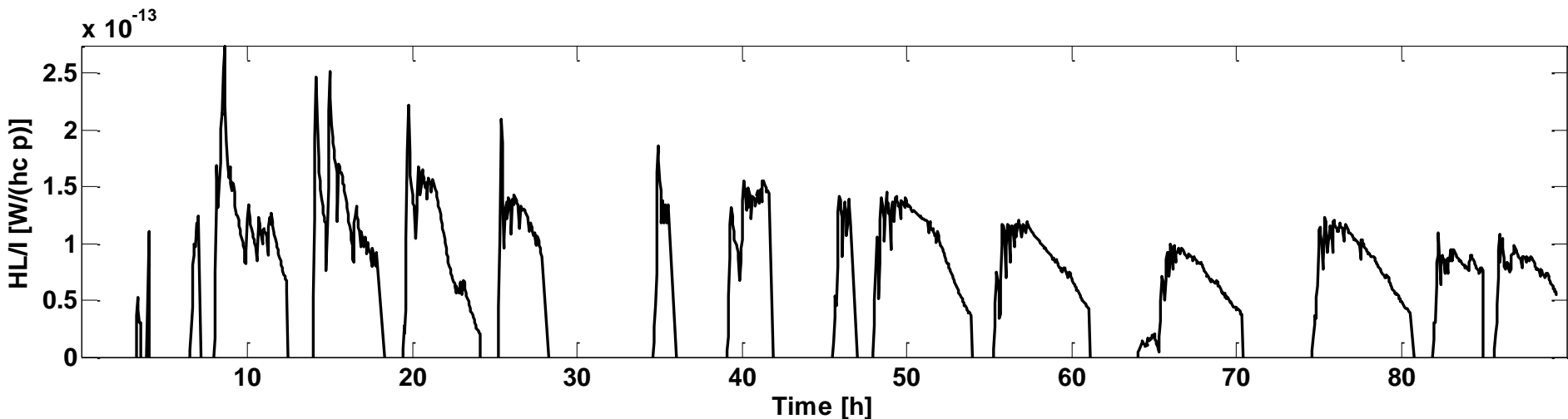
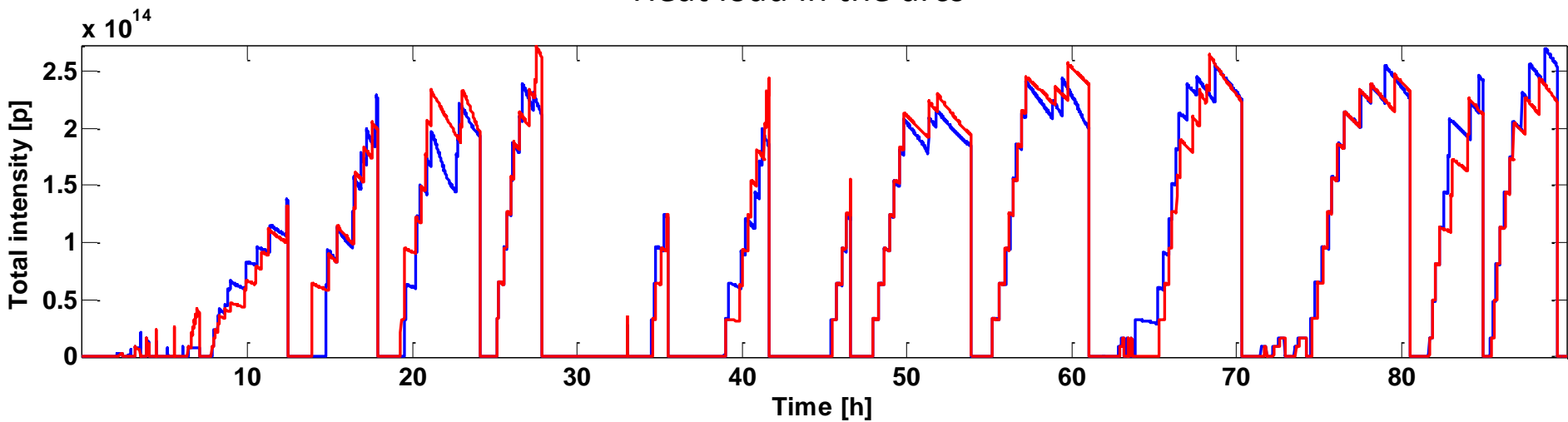
Scrubbing Run

Heat load in the arcs



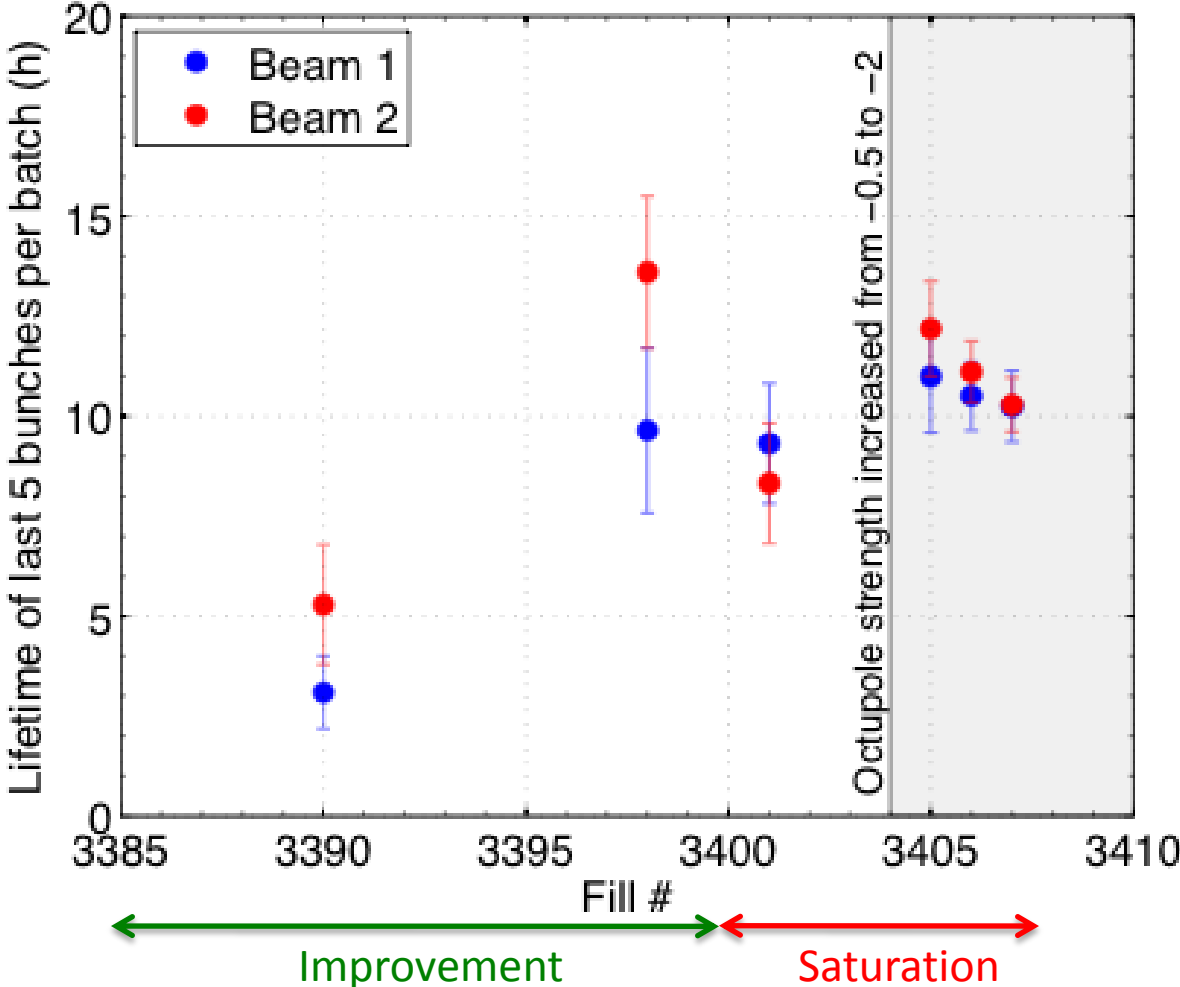
Scrubbing Run

Heat load in the arcs



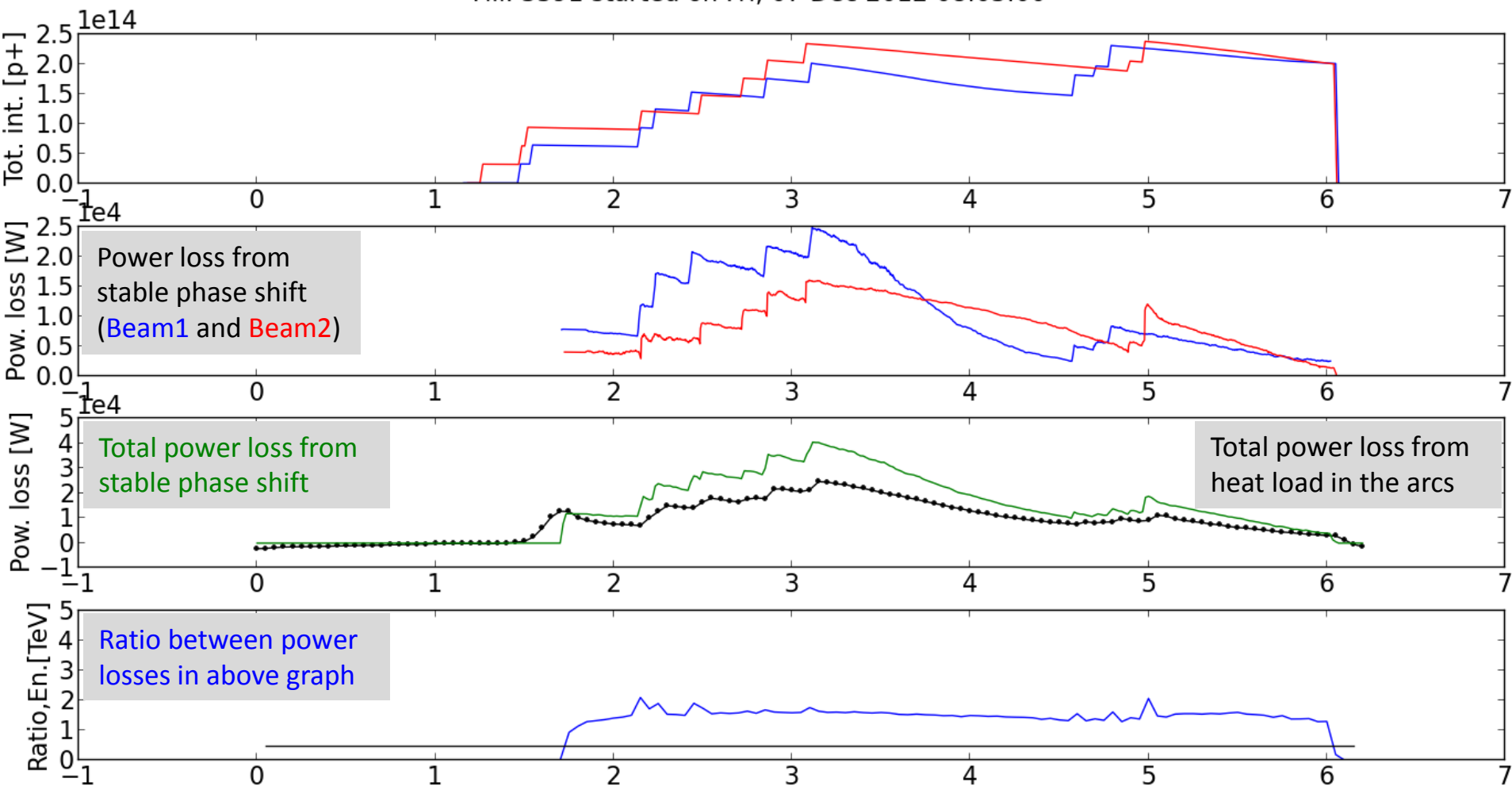
← Improvement → Saturation →

Scrubbing Run
Beam lifetimes



Scrubbing Run Stable phase shifts

Fill. 3391 started on Fri, 07 Dec 2012 08:03:00



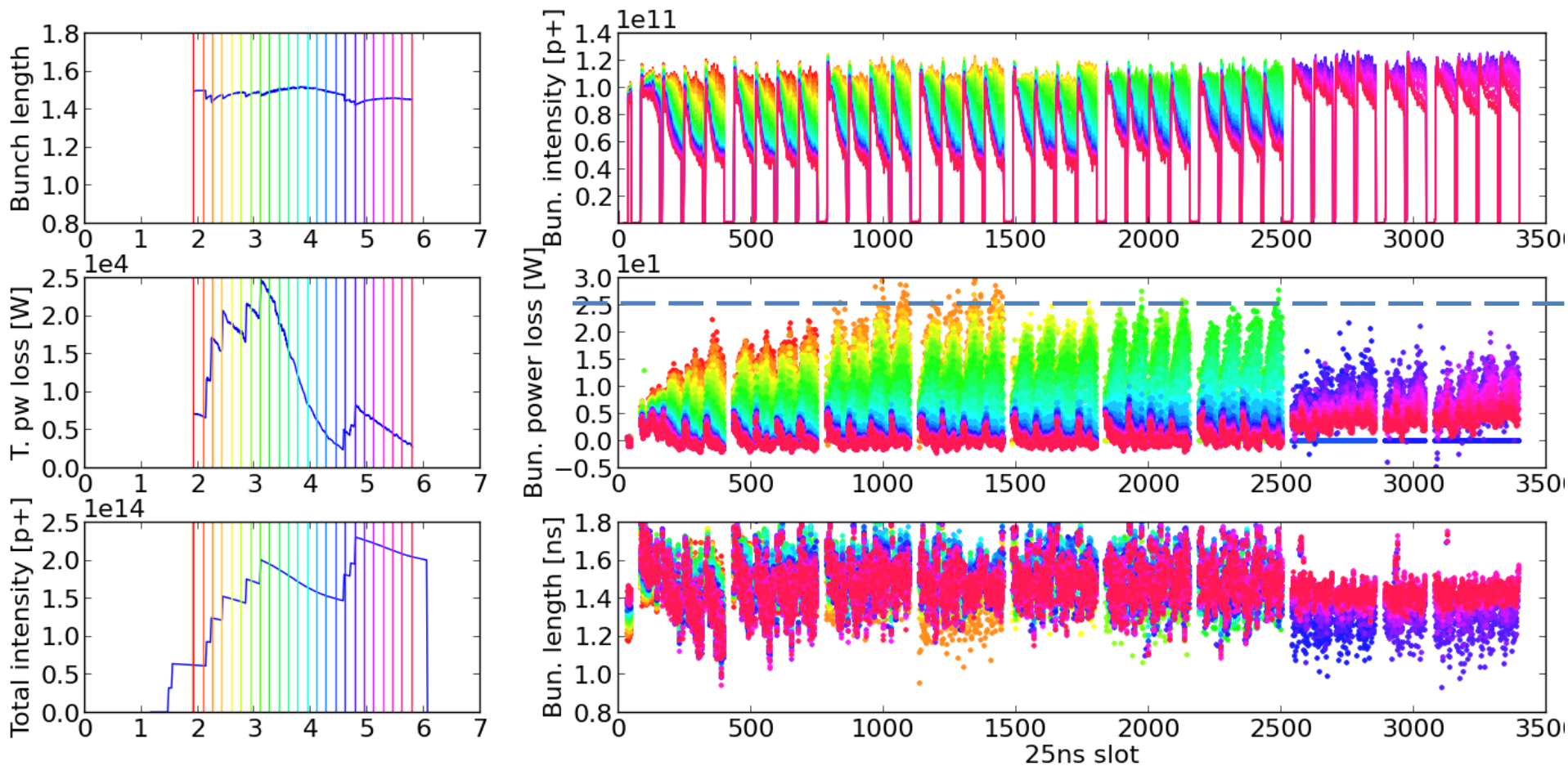
Beam 1 loses more power than Beam 2 →
consistent with worse lifetime

Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B1 Fill. 3391 started on Fri, 07 Dec 2012 08:03:00
First Acq. 115, Fri, 07 Dec 2012 09:58:54



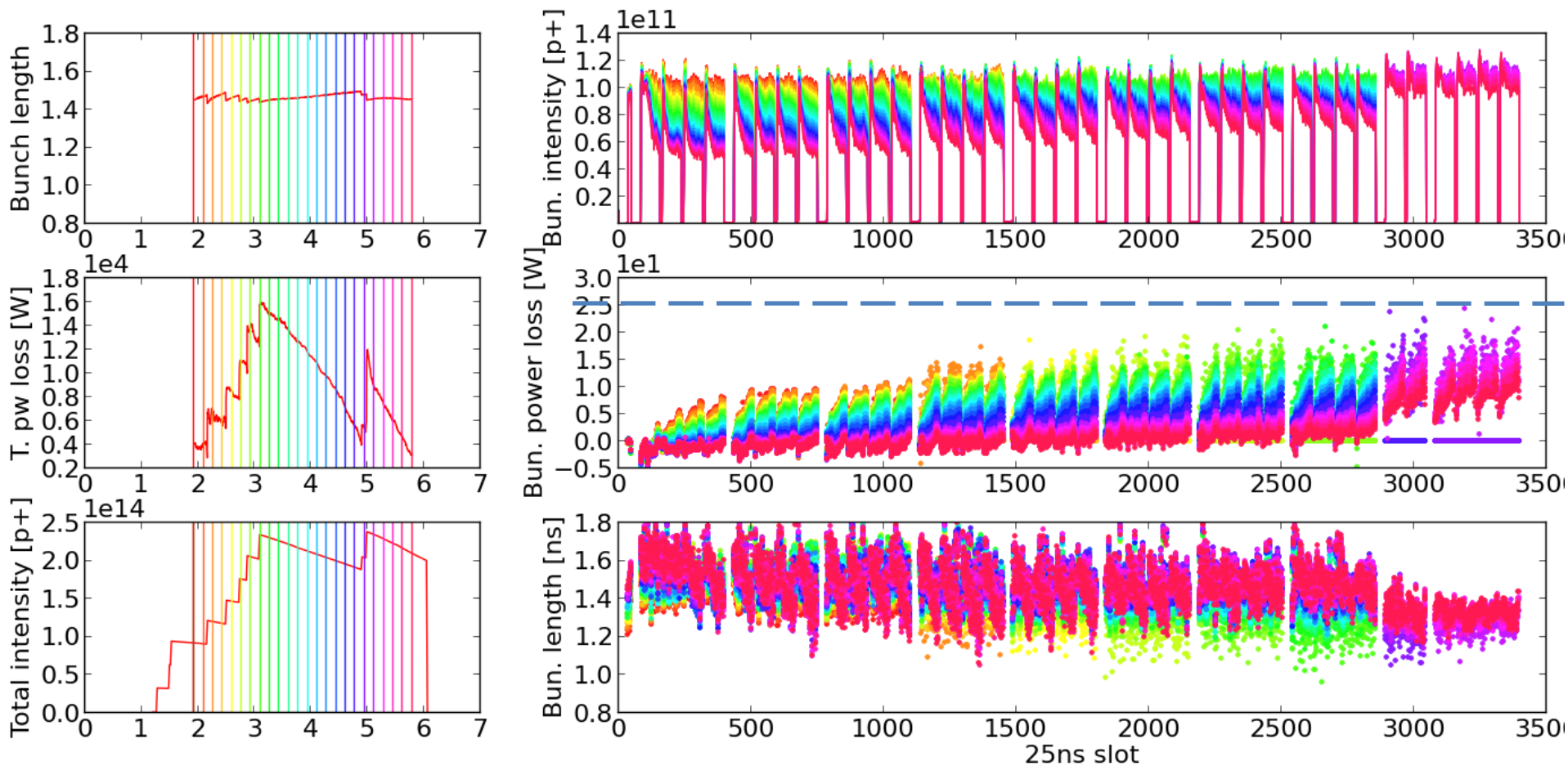
Information on the build up of the e-cloud from the bunch-by-bunch measurements: **saturated within the first four batches**
Could explain better lifetime of last injected batches

Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

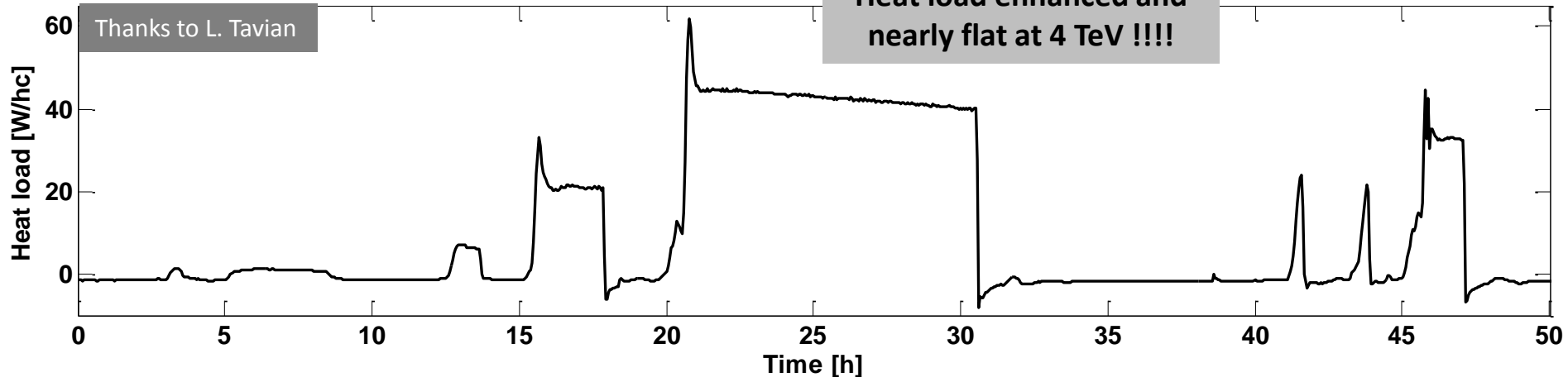
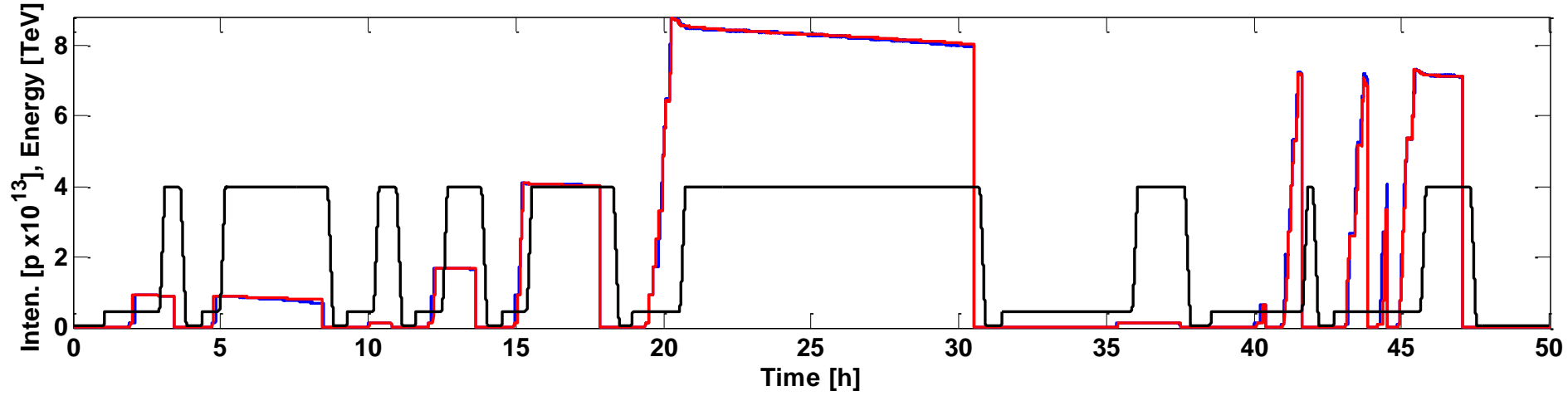
B2 Fill. 3391 started on Fri, 07 Dec 2012 08:02:30
First Acq. 115, Fri, 07 Dec 2012 09:58:21



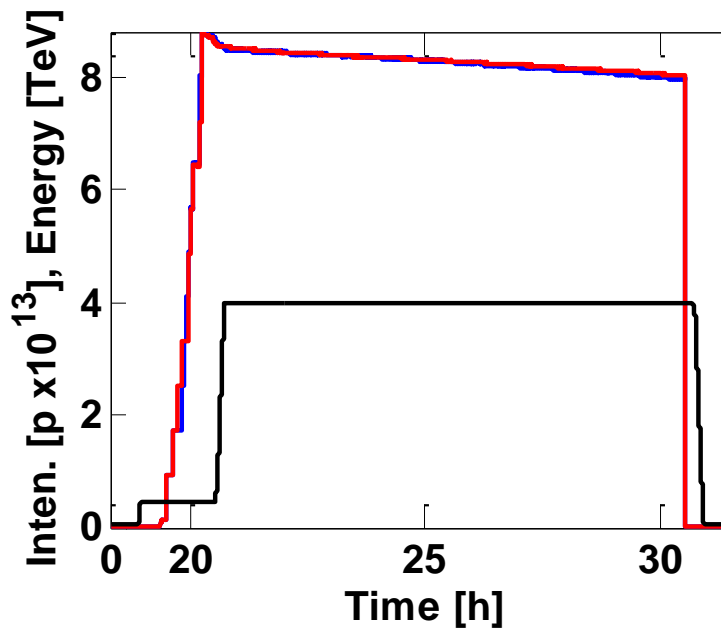
Information on the build up of the e-cloud from the bunch-by-bunch measurements: **still building up, not yet in saturation**
Could explain worse lifetime of last injected batches

Thanks to J. Esteban-Müller,
E. Shaposhnikova

MDs at 4 TeV Heat load



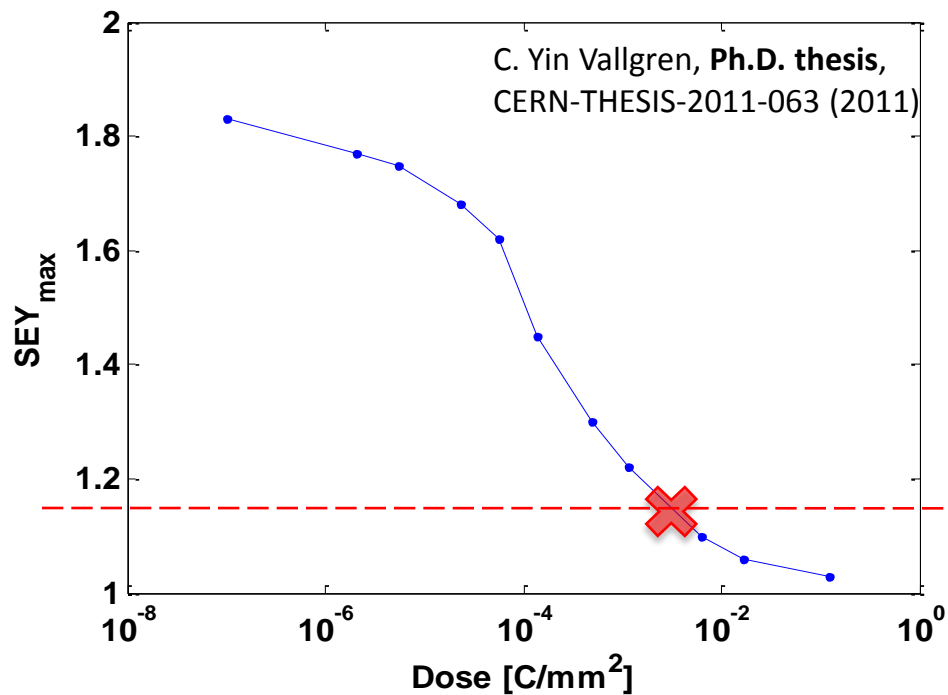
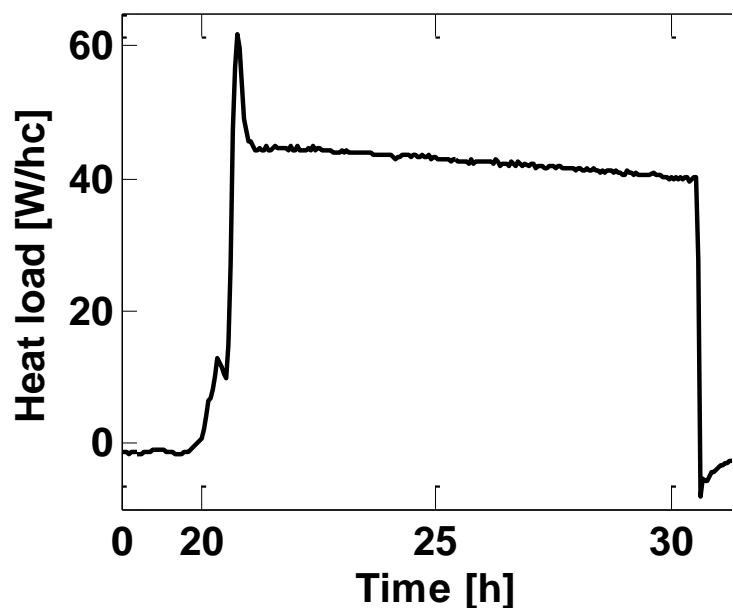
Fill 3429



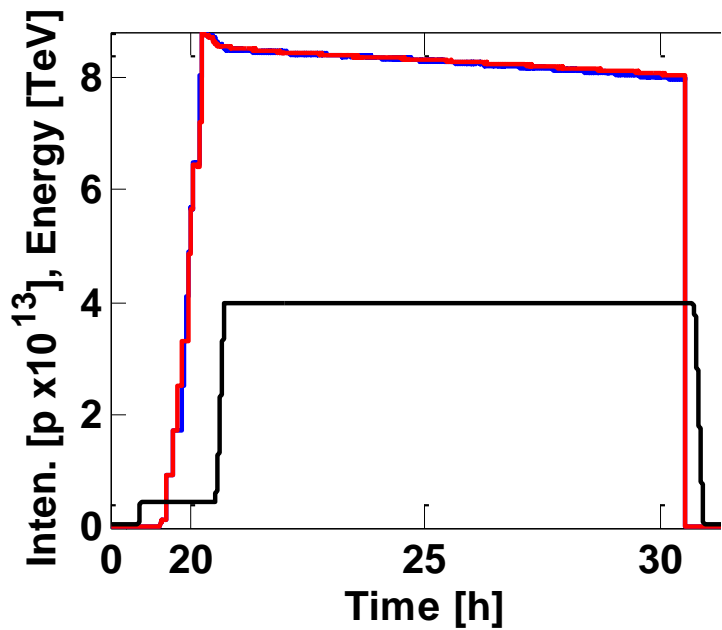
800 bunches@4 TeV for 8h



Electron dose of about
 $2.4 \times 10^{-3} \text{ C/mm}^2$
(estimated by simulations)



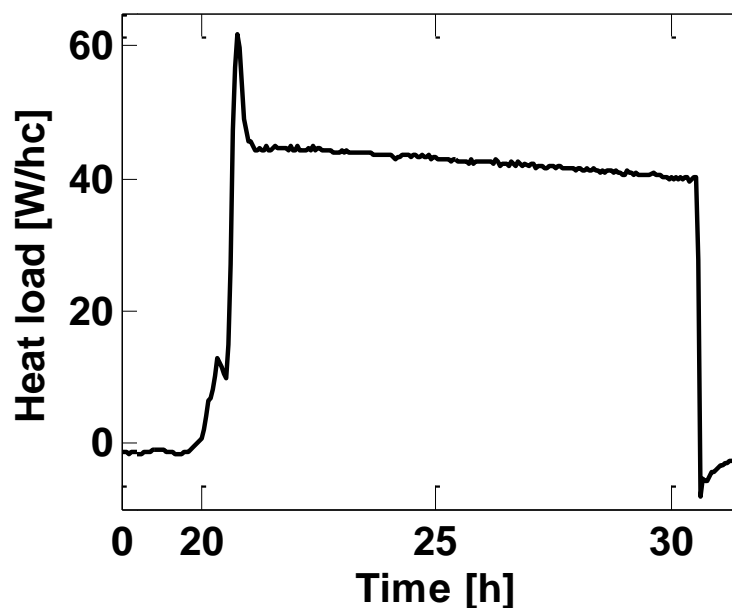
Fill 3429



800 bunches@4 TeV for 8h

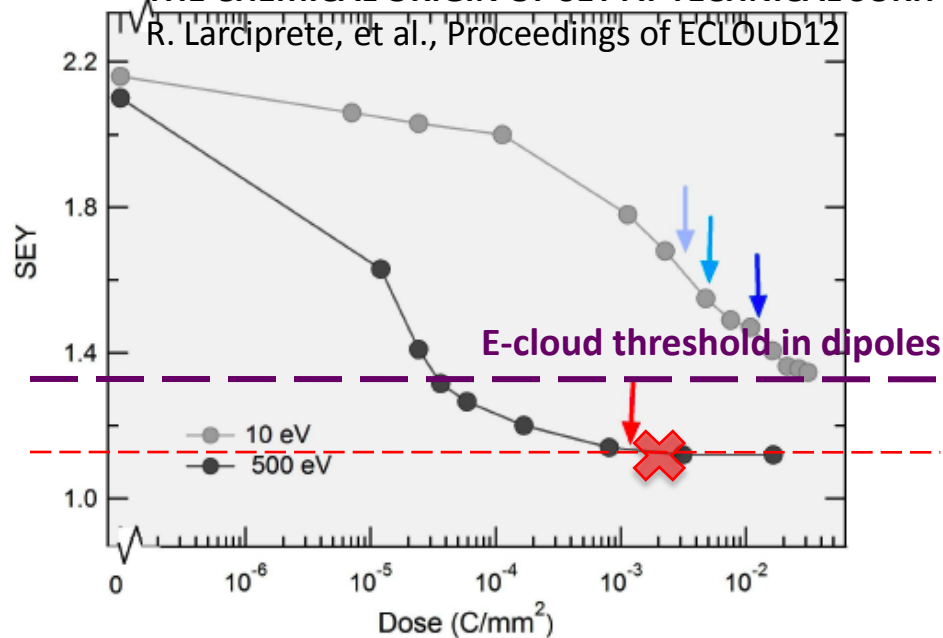


Electron dose of about
 $2.4 \times 10^{-3} \text{ C/mm}^2$
(estimated by simulations)



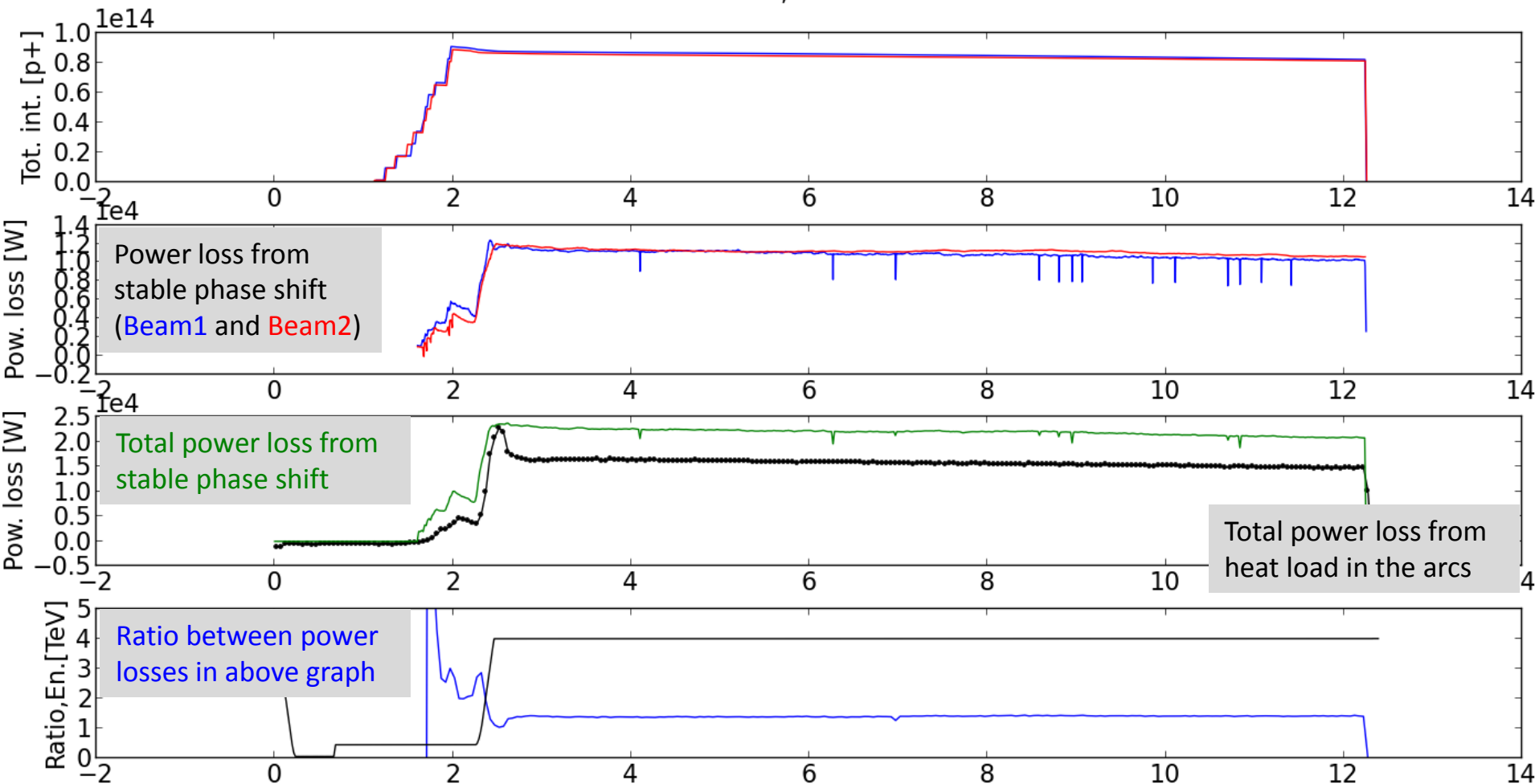
THE CHEMICAL ORIGIN OF SEY AT TECHNICAL SURFACES

R. Larciprete, et al., Proceedings of ELOUD12



Scrubbing Run Stable phase shifts

Fill. 3429 started on Thu, 13 Dec 2012 18:16:50



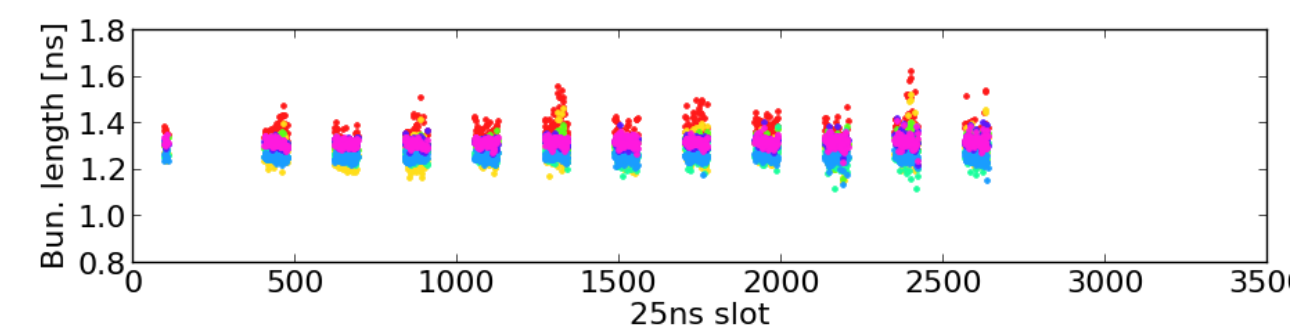
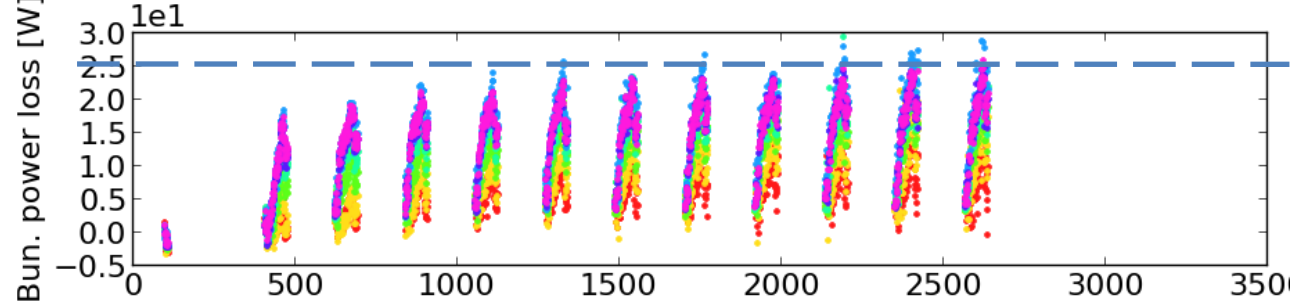
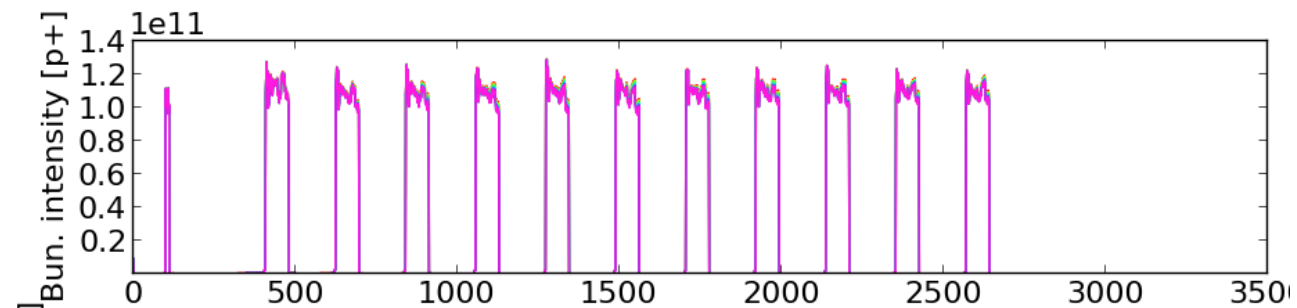
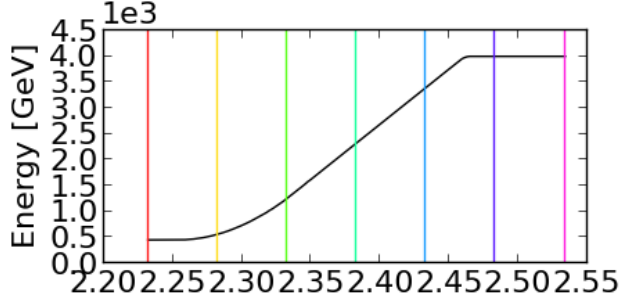
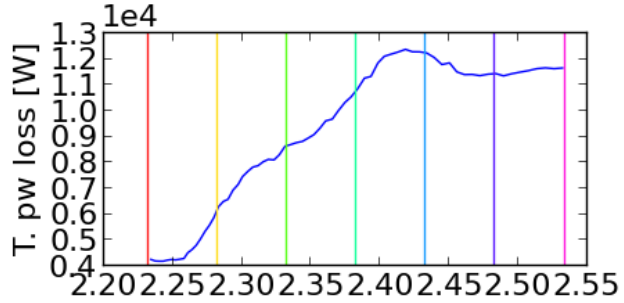
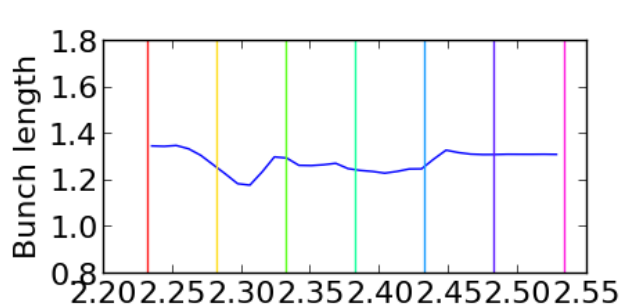
Transverse emittances (from BSRT) were not much degraded for this fill

Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B1 Fill. 3429 started on Thu, 13 Dec 2012 18:16:50
First Acq. 133, Thu, 13 Dec 2012 20:30:44

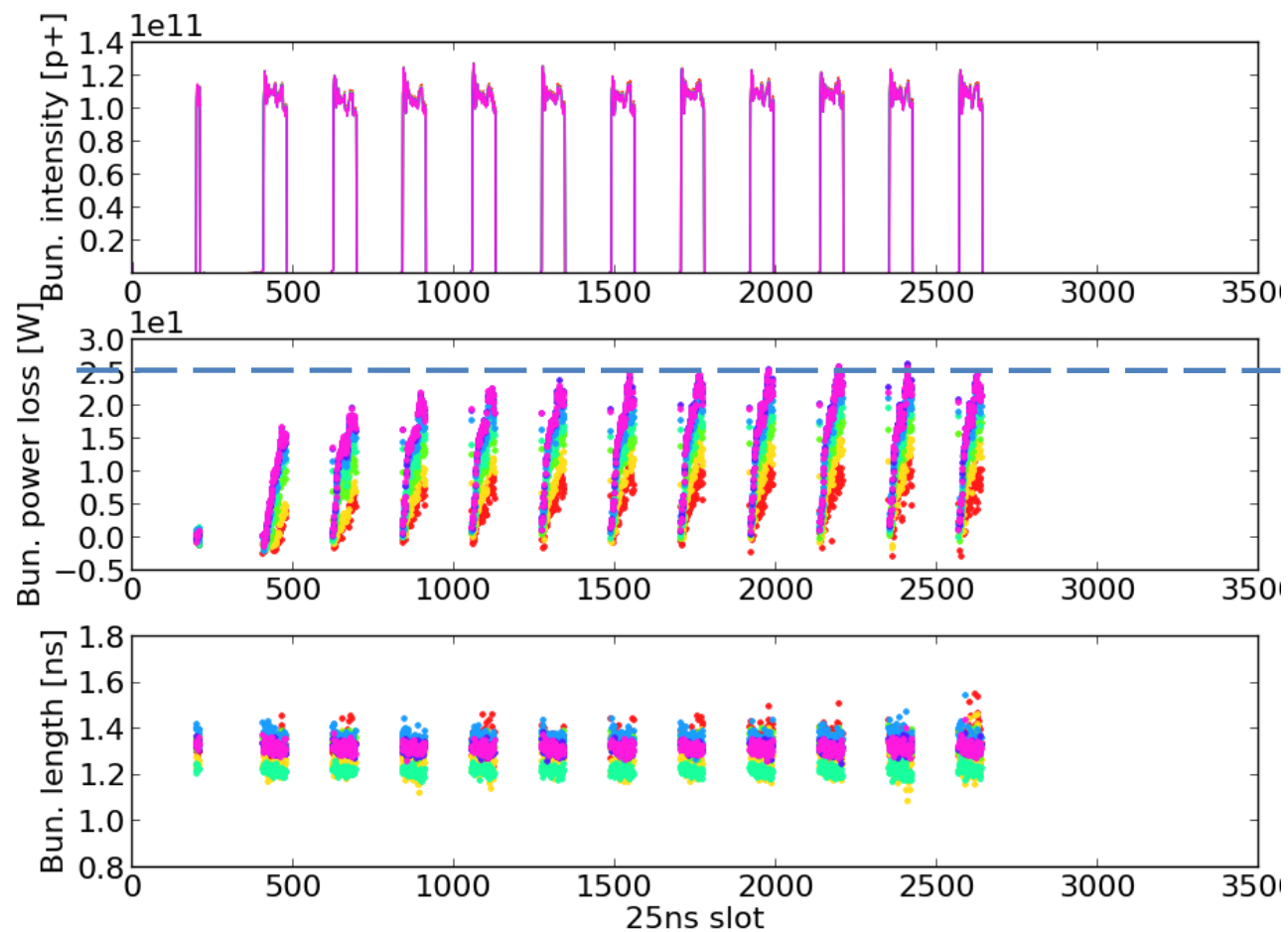
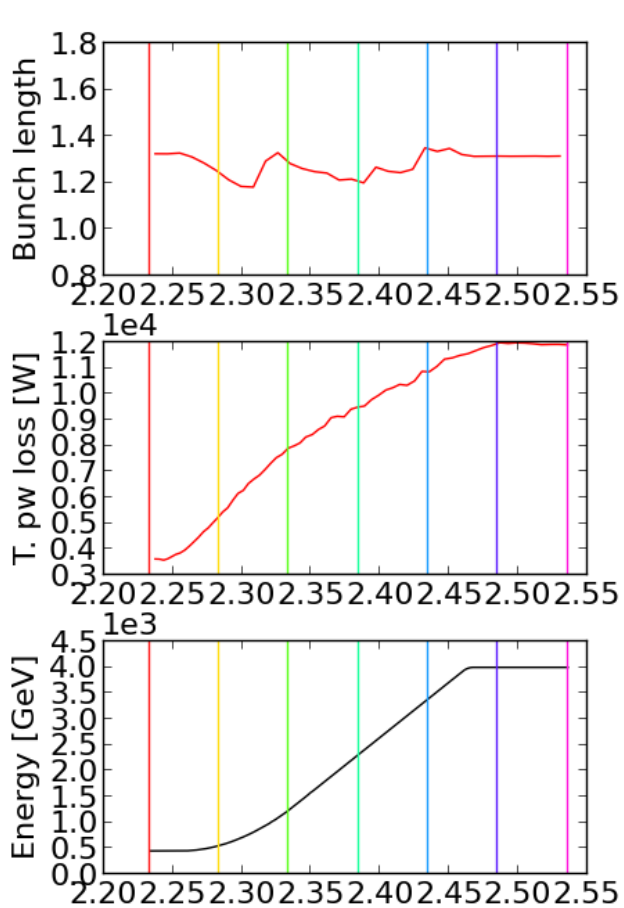


Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B2 Fill. 3429 started on Thu, 13 Dec 2012 18:16:43
First Acq. 133, Thu, 13 Dec 2012 20:30:44



Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run Stable phase shifts

Fill. 3453 started on Sun, 16 Dec 2012 11:58:37



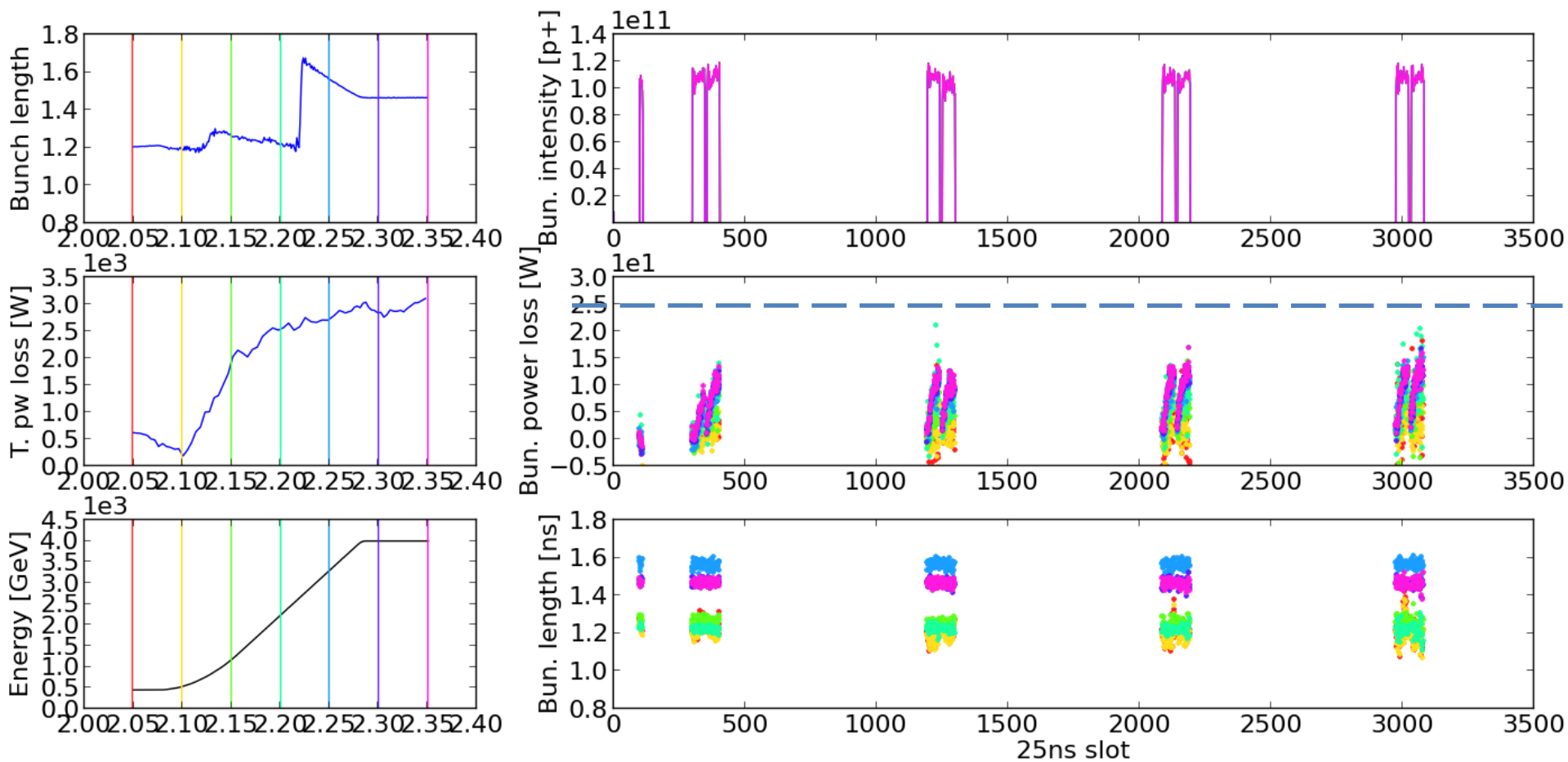
Transverse emittances (from luminosity)
were degraded for this fill

Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B1 Fill. 3453 started on Sun, 16 Dec 2012 11:58:37
First Acq. 122, Sun, 16 Dec 2012 14:01:34



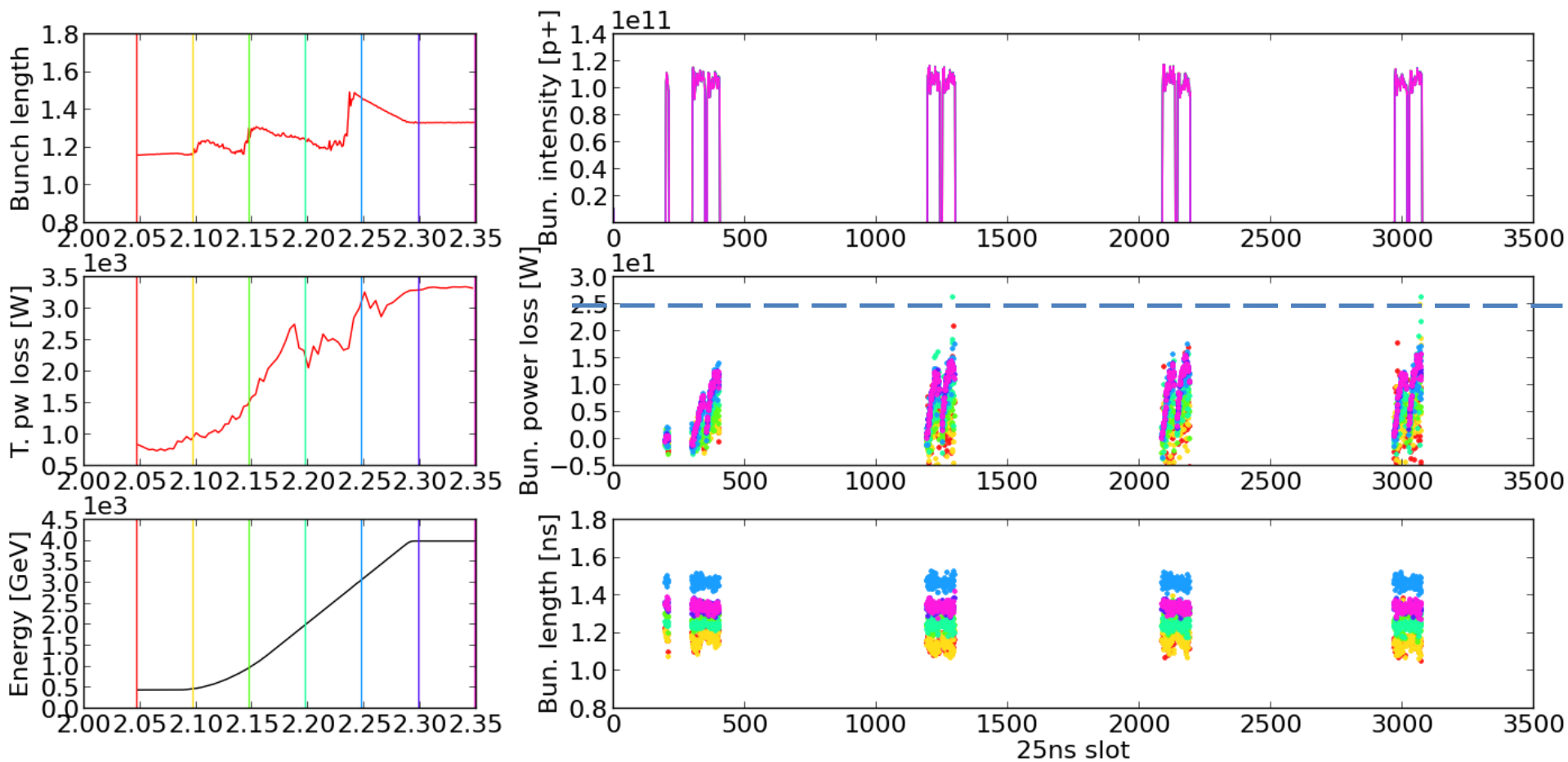
Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B2 Fill. 3453 started on Sun, 16 Dec 2012 11:58:09

First Acq. 122, Sun, 16 Dec 2012 14:00:58

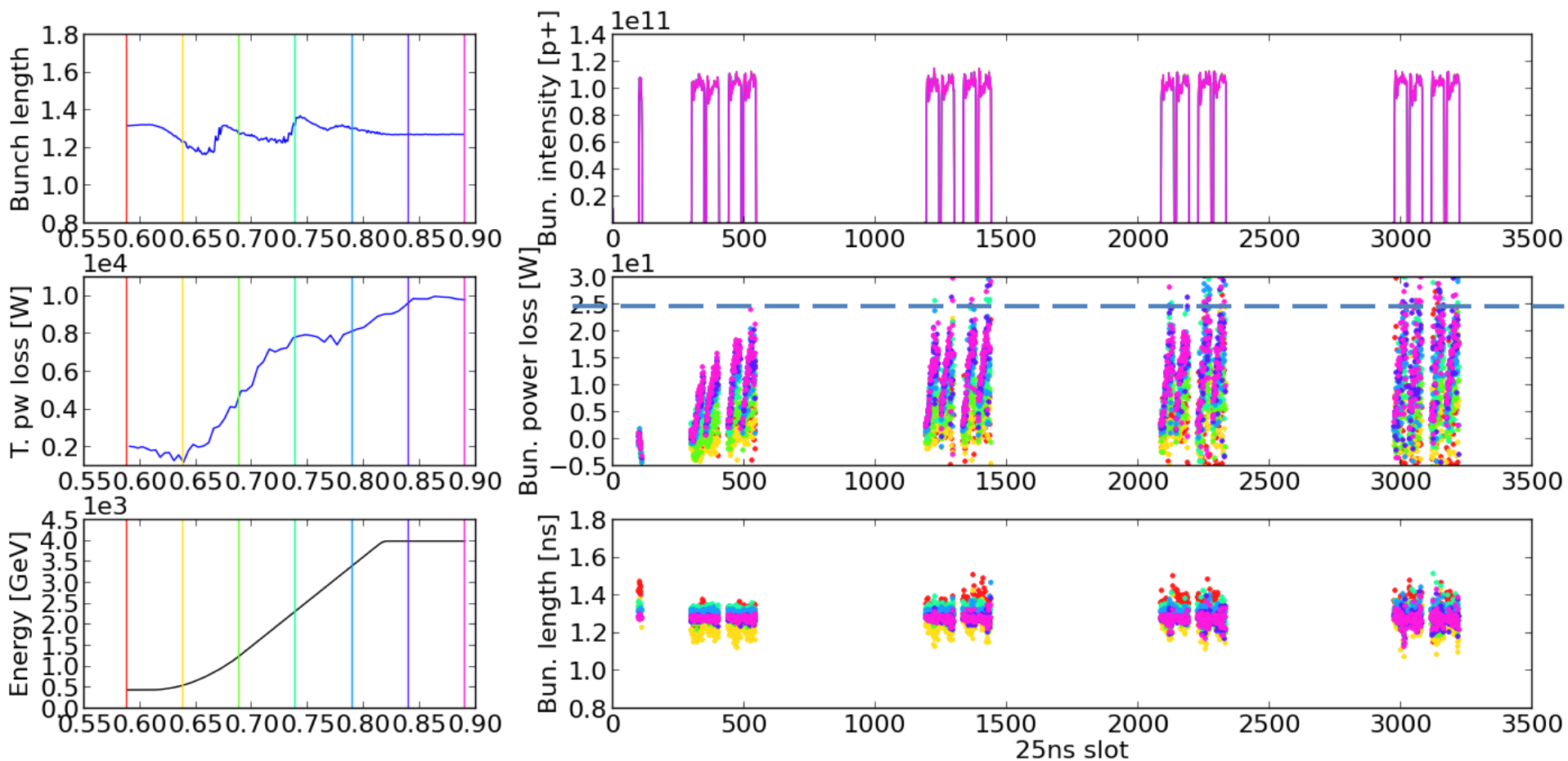


Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

B1 Fill. 3457 started on Mon, 17 Dec 2012 04:22:03
First Acq. 35, Mon, 17 Dec 2012 04:57:20



Fill 3457 has about the same number of bunches as Fill 3429 (but BCMS)

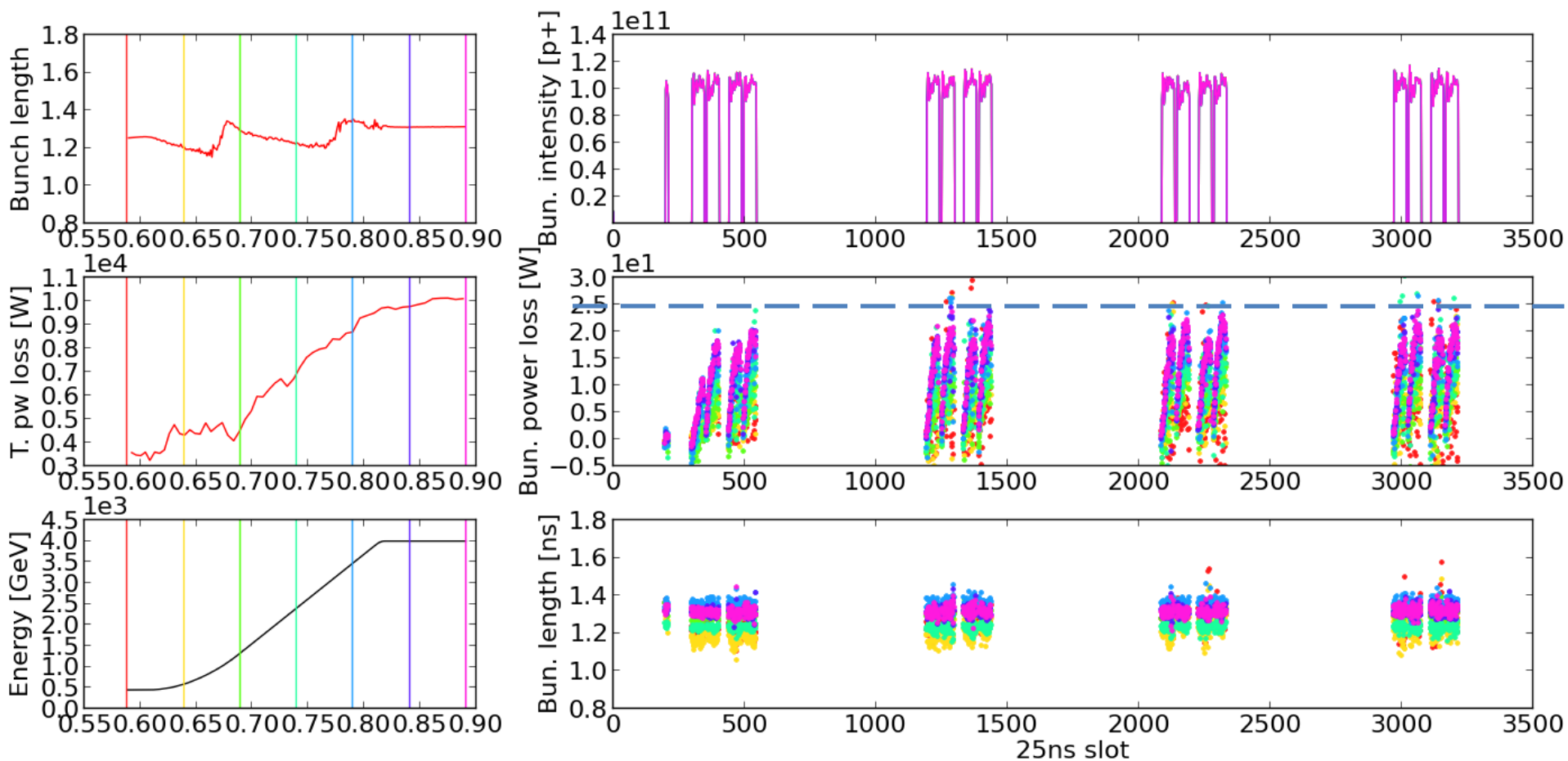
Thanks to J. Esteban-Müller,
E. Shaposhnikova

Scrubbing Run

Stable phase shifts

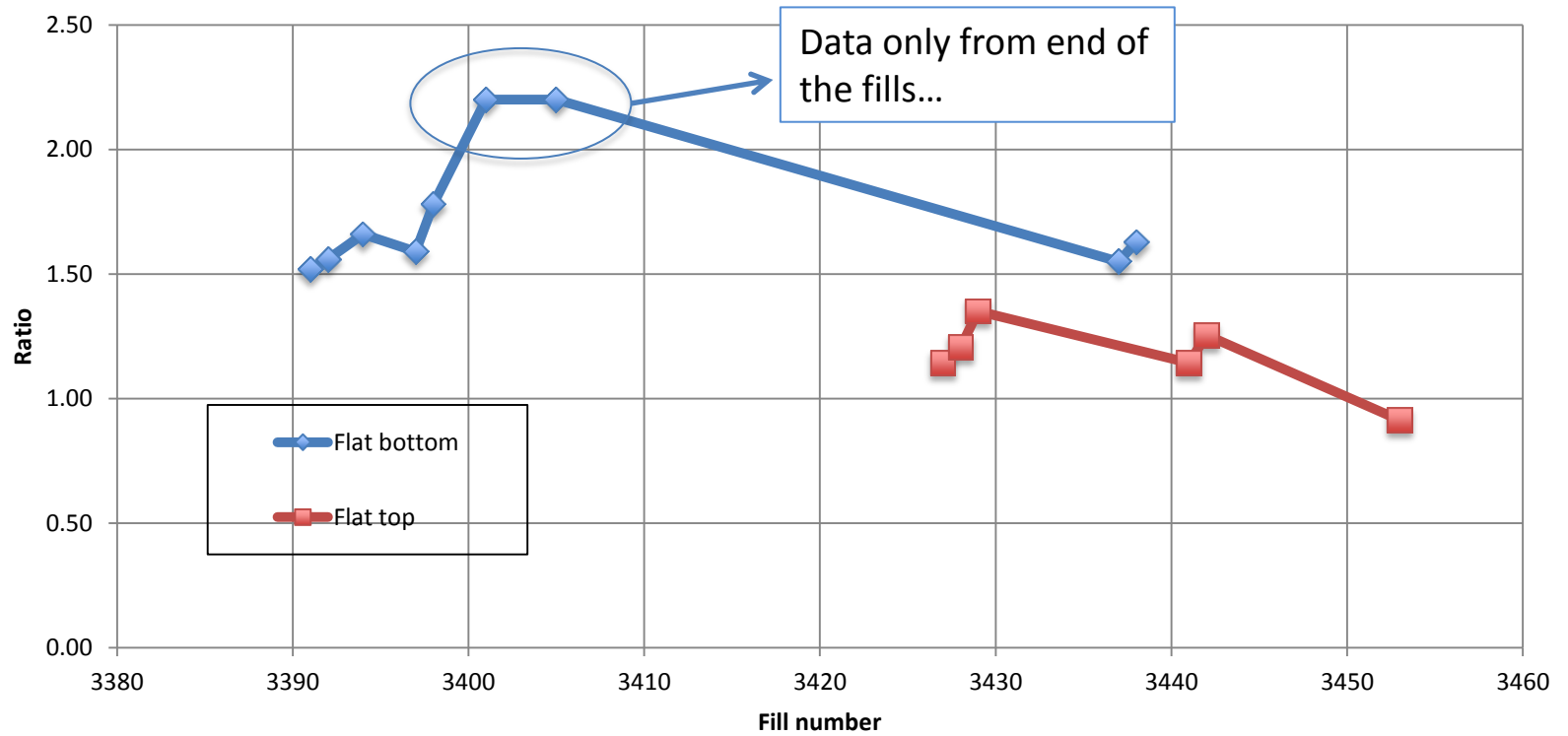
B2 Fill. 3457 started on Mon, 17 Dec 2012 04:22:12

First Acq. 35, Mon, 17 Dec 2012 04:57:31



Thanks to J. Esteban-Müller,
E. Shaposhnikova

(Power loss from phase shift)/(Heat load)

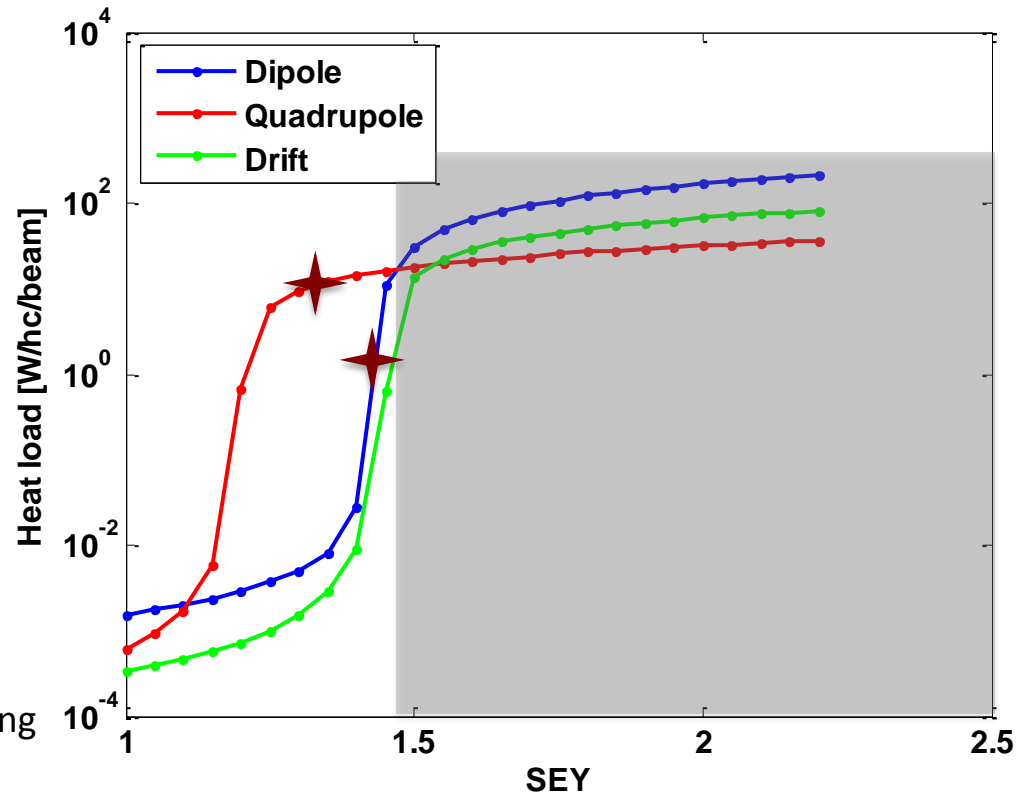
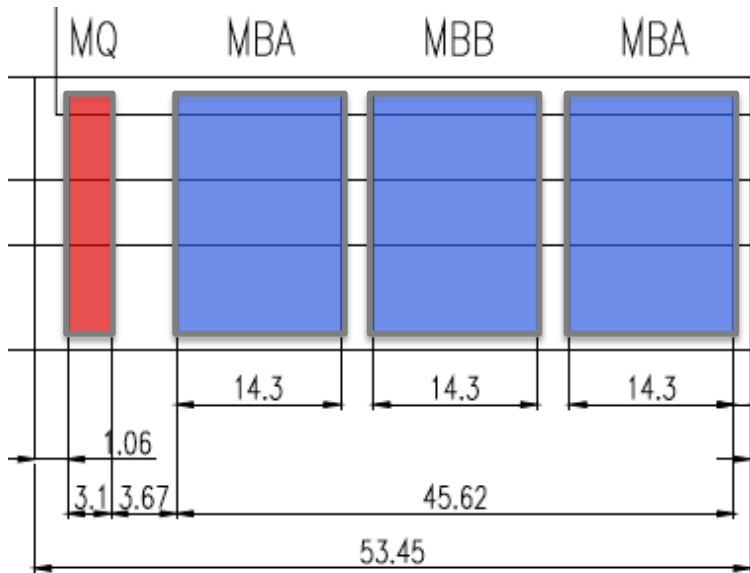


Why scrubbing stops

- Electron cloud in the arcs elsewhere than in the dipoles?
 - Quadrupoles, multipoles
- Modeling of the Secondary Emission process
 - What happens at low energies?
 - Re-diffused electrons
- Scrubbing behaviour
 - Cold surfaces?
 - ✓ Lab measurements suggest similar scrubbing curves
 - ✓ The COLDEX experience → slow decay of heat load ...
 - Scrubbing relies on the presence of C
 - ✓ Do we have formation of a C layer in the LHC BS ?

→ Contribution from quads?

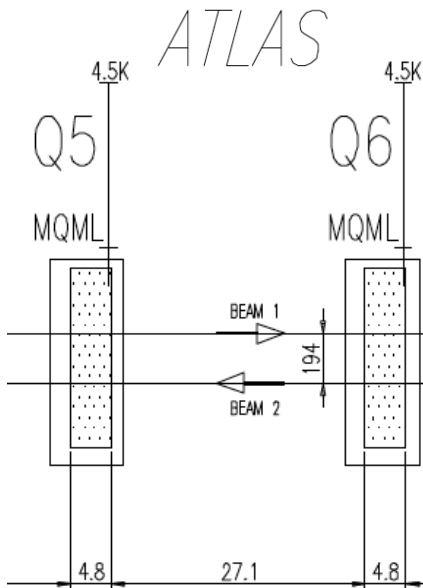
- ✓ Cells composed of 80% dipoles, but also 6% quadrupole + 14% drift & multipoles
- ✓ SEY thresholds are different in dipole/drift (1.45) or quadrupole (1.2)
- ✓ Electron cloud in dipoles is dominant (1-2 orders of magnitude) as long as $\delta_{\max} > 1.5$ in dipole chambers
- ✓ But now quadrupoles (and multipoles?) could be dominant ...



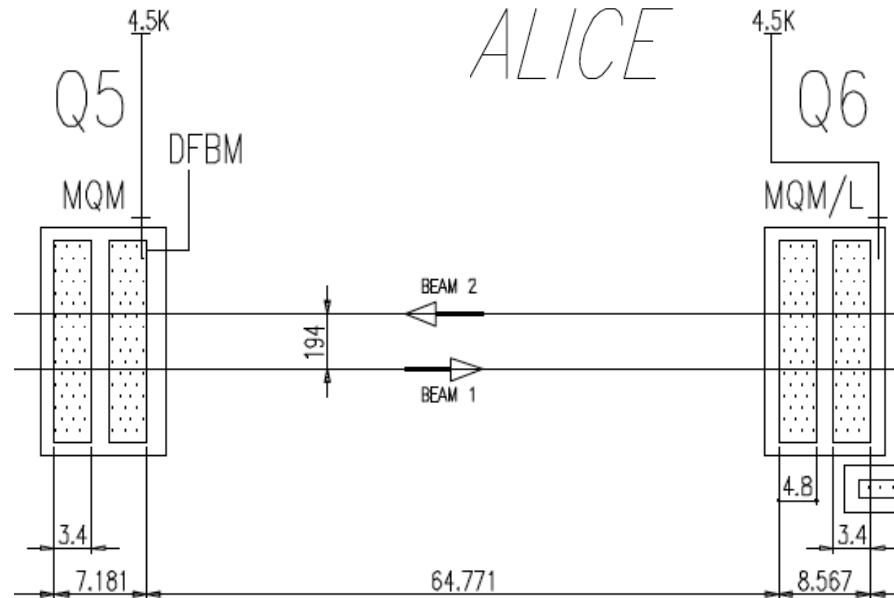
→ Consistent with

- ✓ Saturation of scrubbing process (scrubbing curve becomes flat for SEY below 1.3)
- ✓ Long memory between trains
- ✓ Stand-alones

Standalones (SAM) – examples

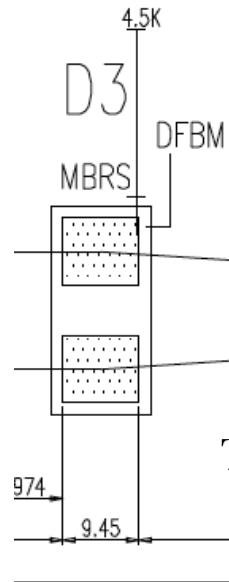


right side of IR1



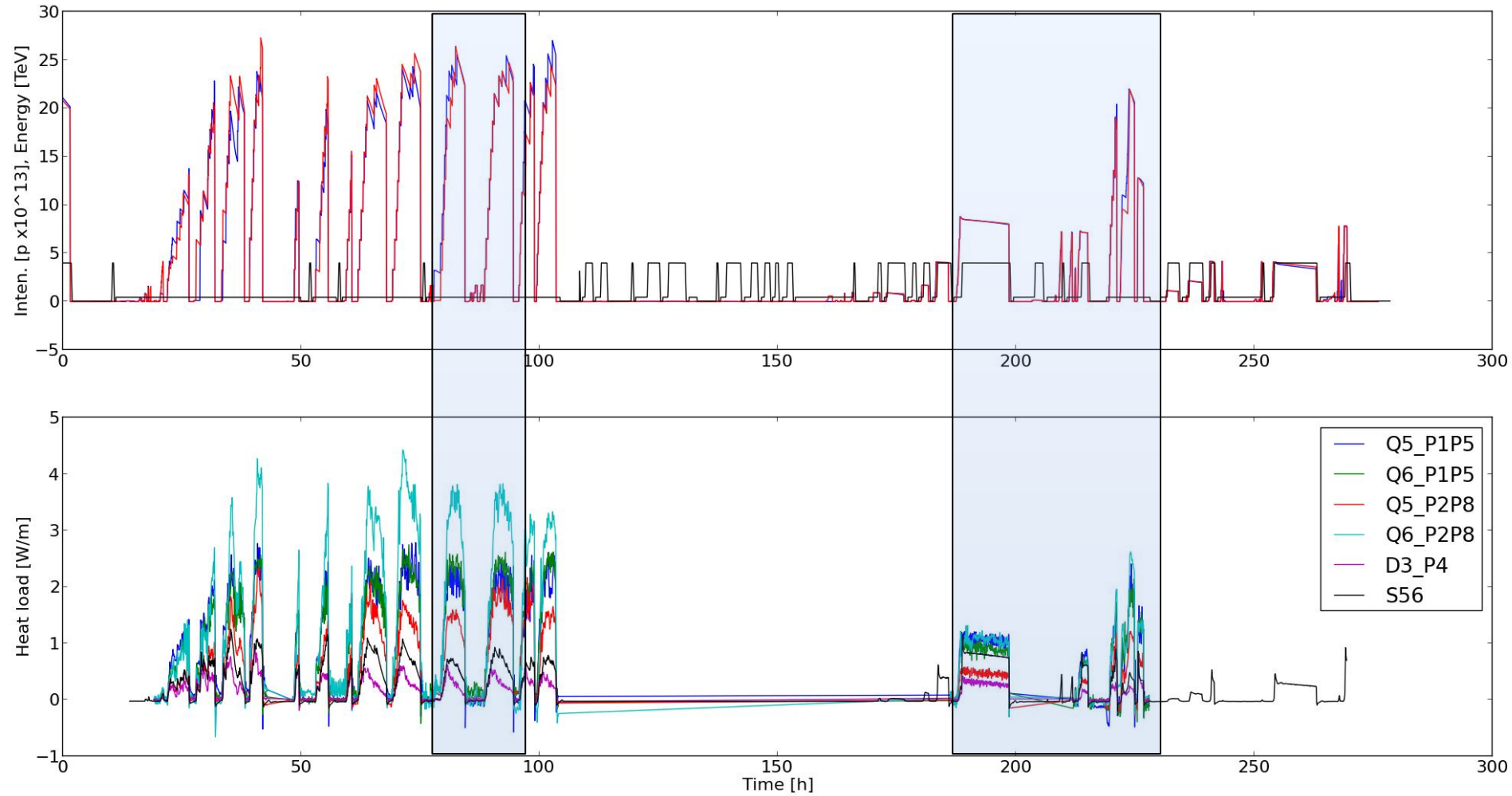
The right side of the matching section in IR2

RF INSERTION

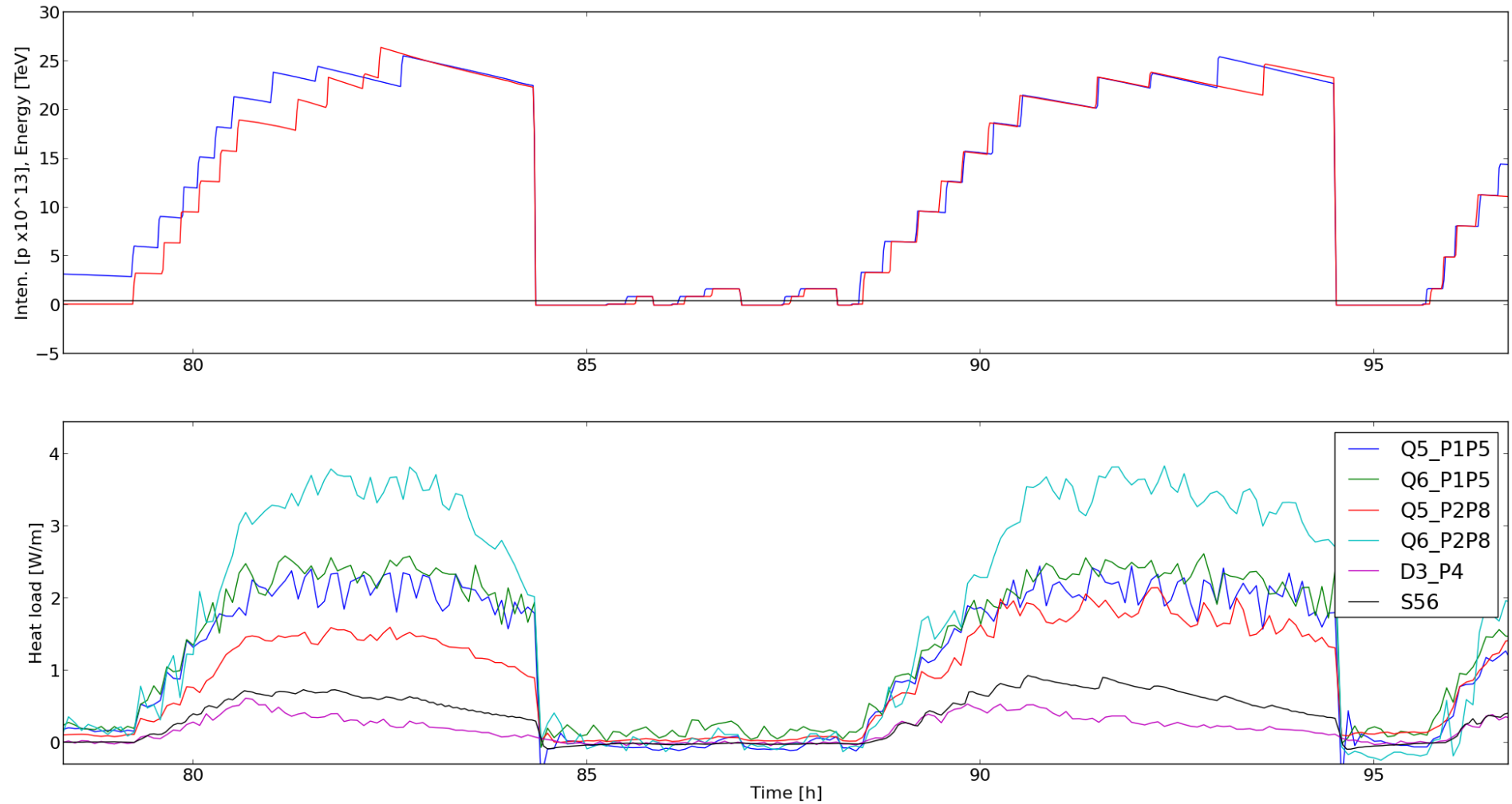


The right-hand side of the matching section in IR4

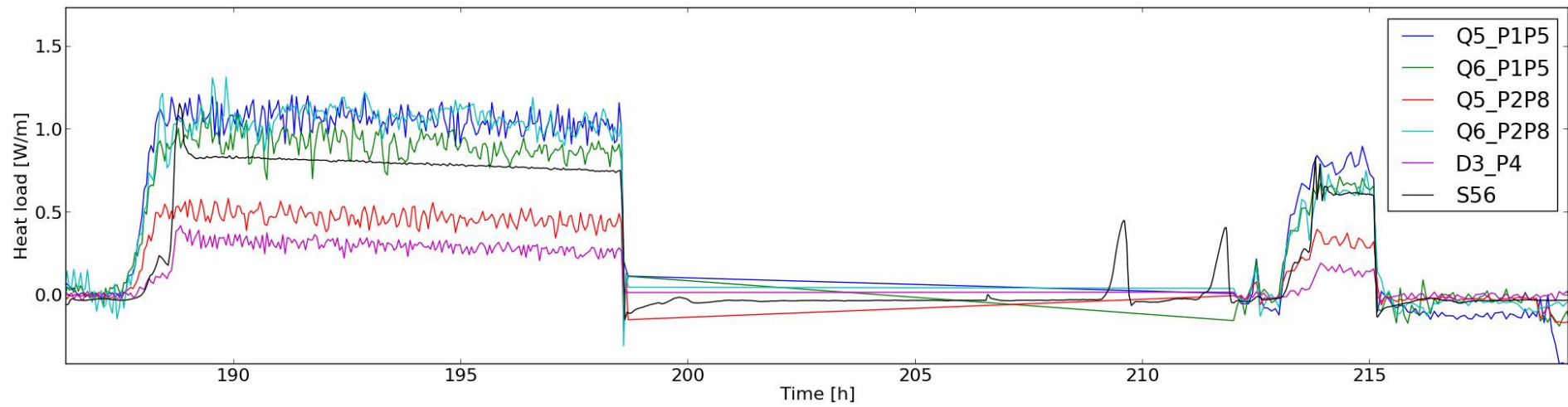
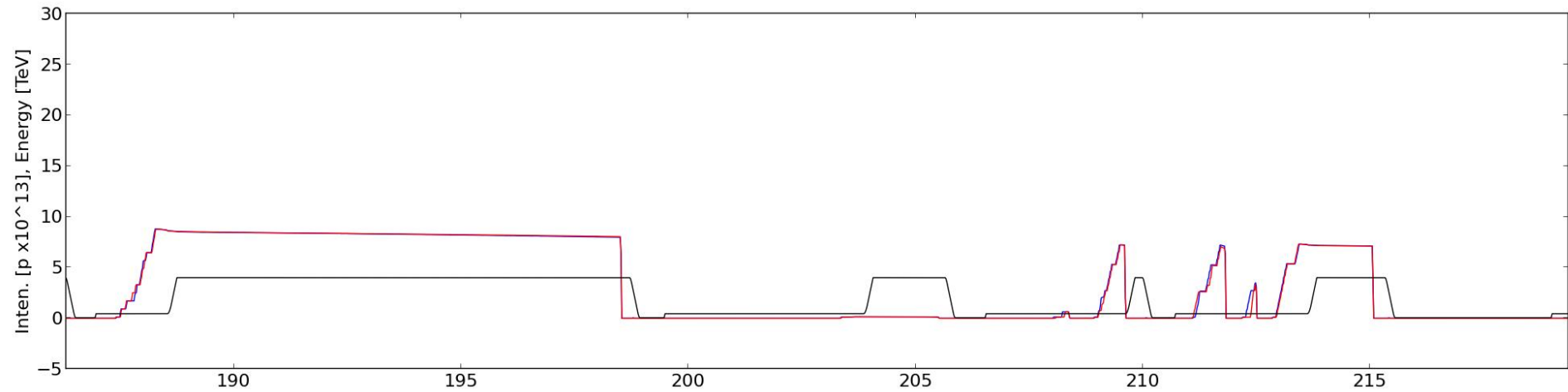
Standalones (SAM)



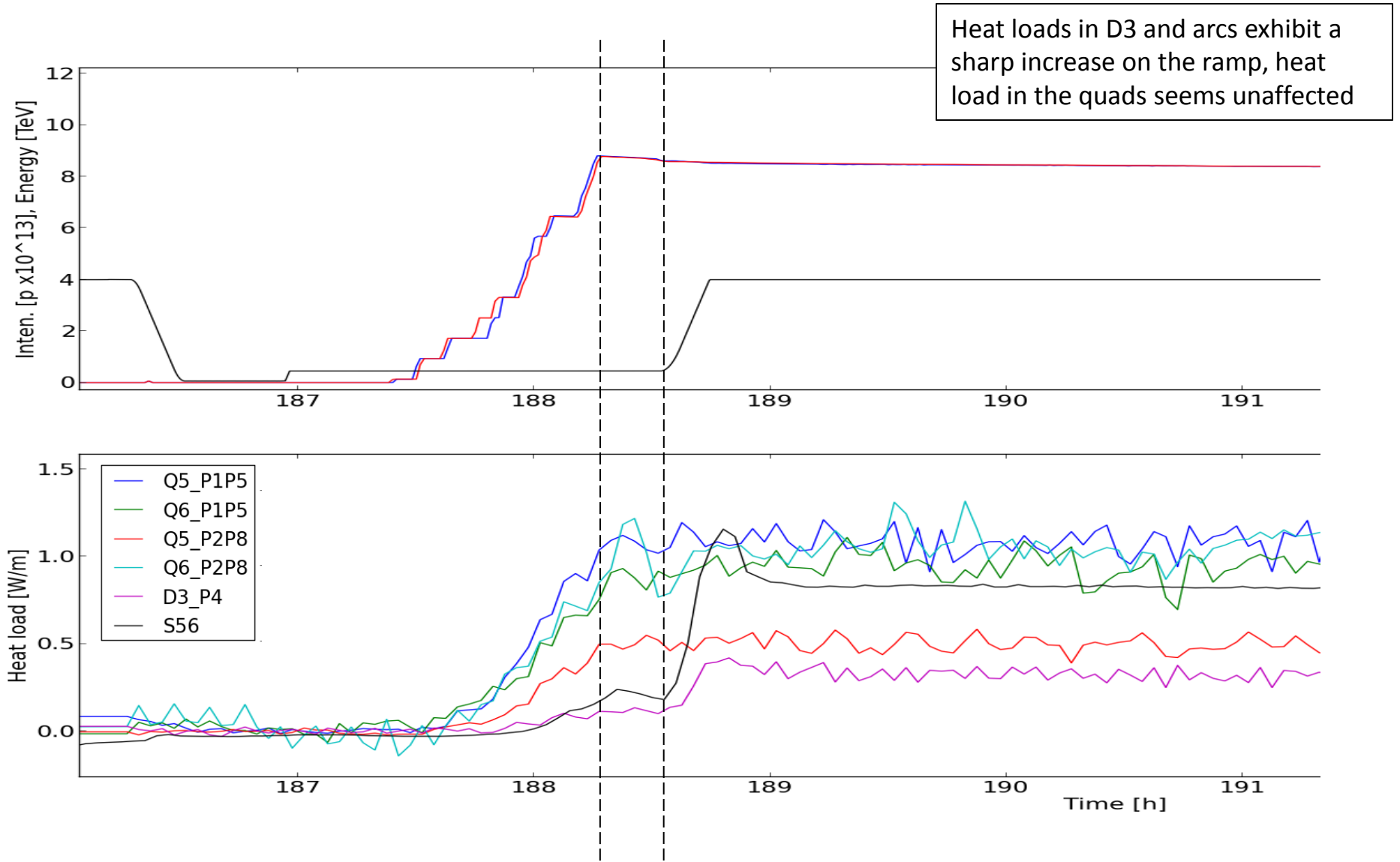
Standalones (SAM)



Standalones (SAM)



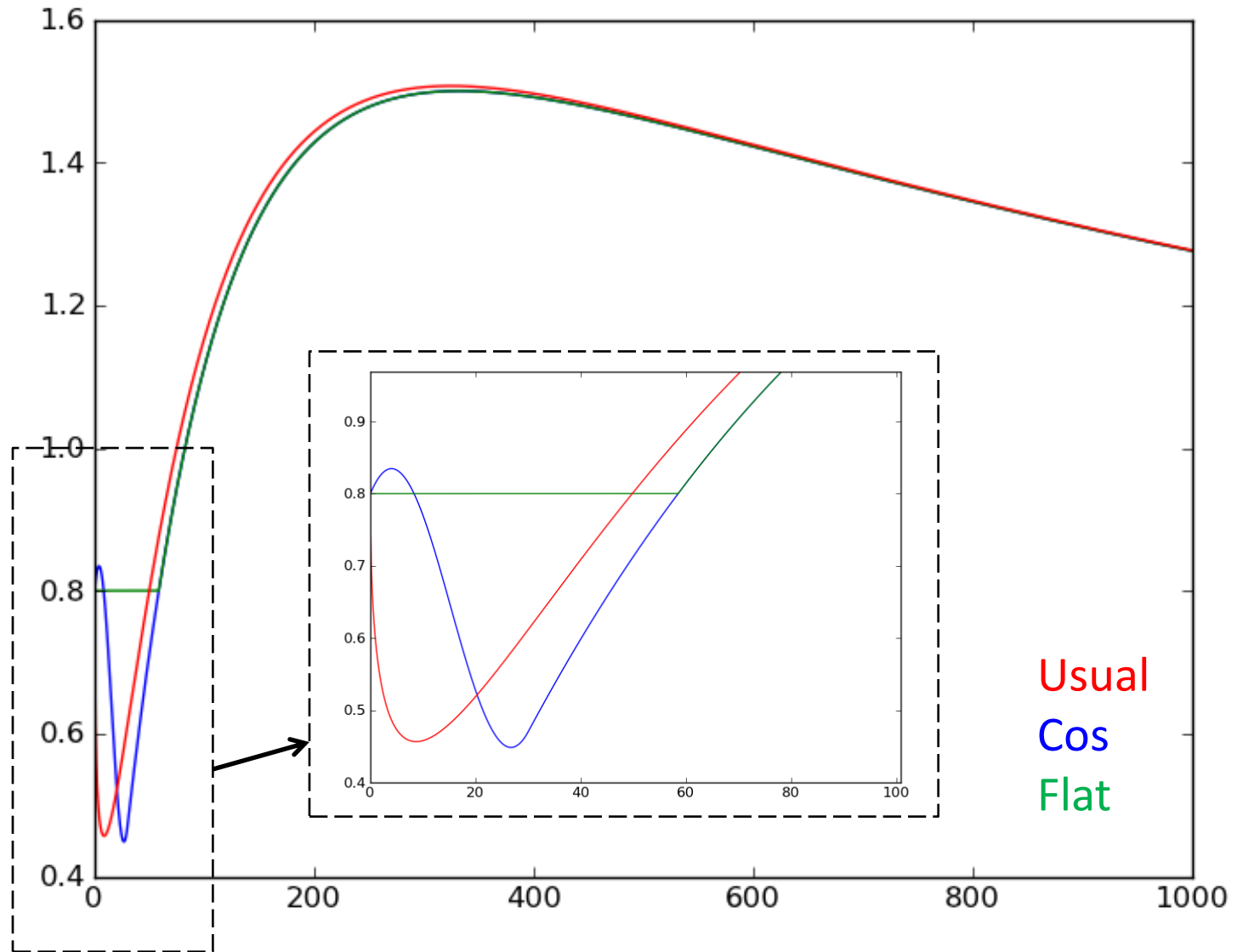
Standalones (SAM)

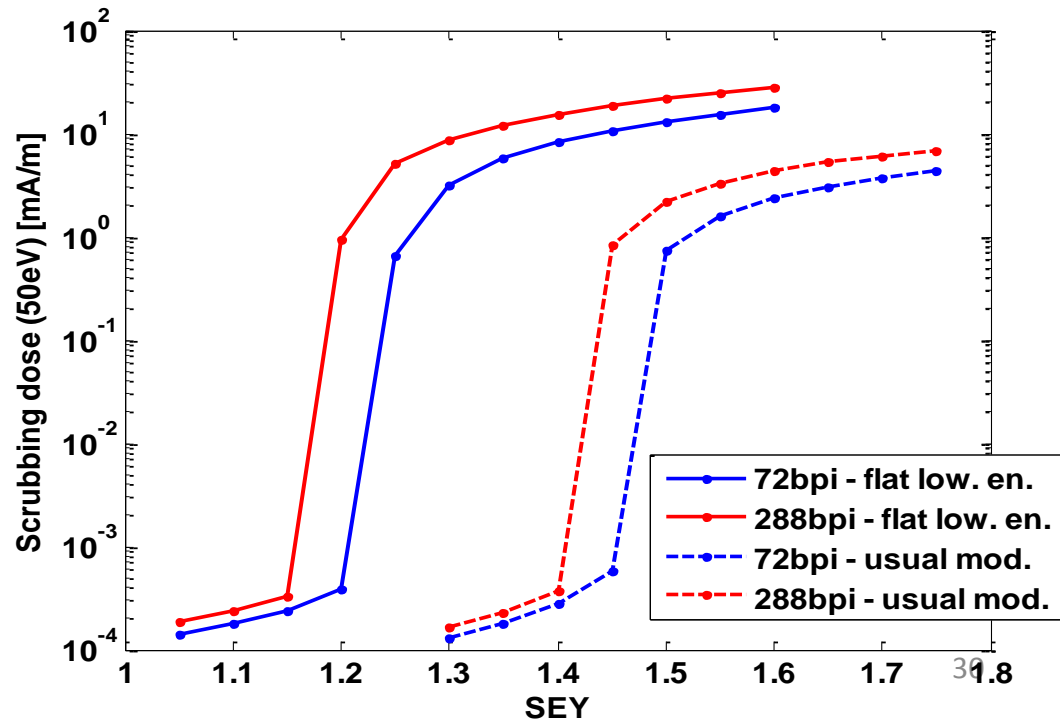
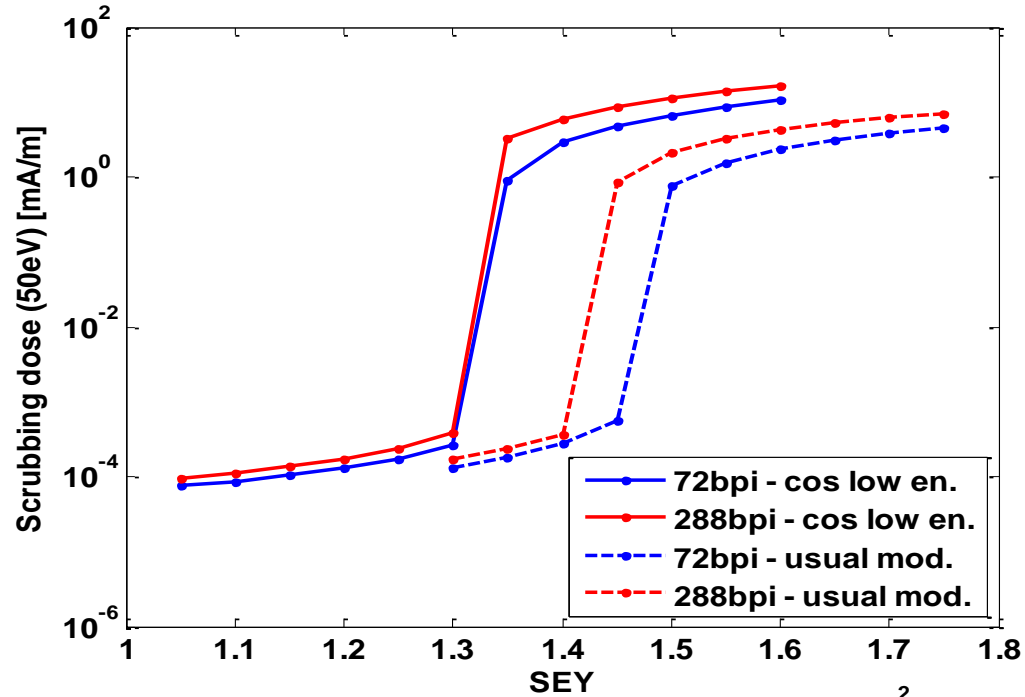


Energy dependence

- Effect of the beam size?
 - Bunch length is about constant, transverse sizes decrease
 - Simulations seem not to confirm effect of transverse size
- Dependence of surface properties on magnetic field
 - SEY would affect multipacting
- Photoelectrons
 - Would only affect seed electrons and the time to reach saturation
 - No threshold effect observed at around 2 TeV
 - Dipole edge effects cause photoelectrons already at 450 GeV?
- Probably seen only close to threshold (also based on SPS experience, though with shortening bunches)

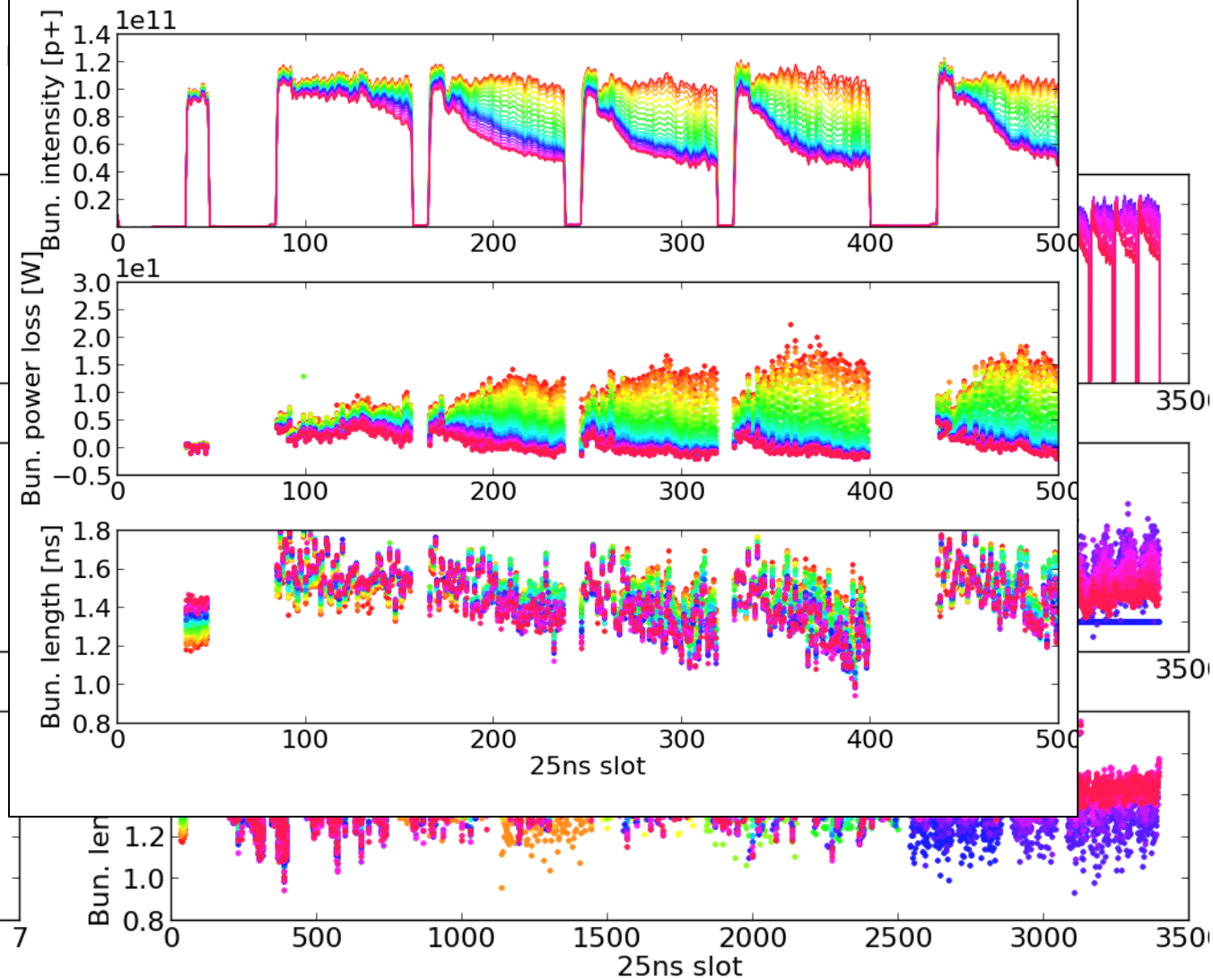
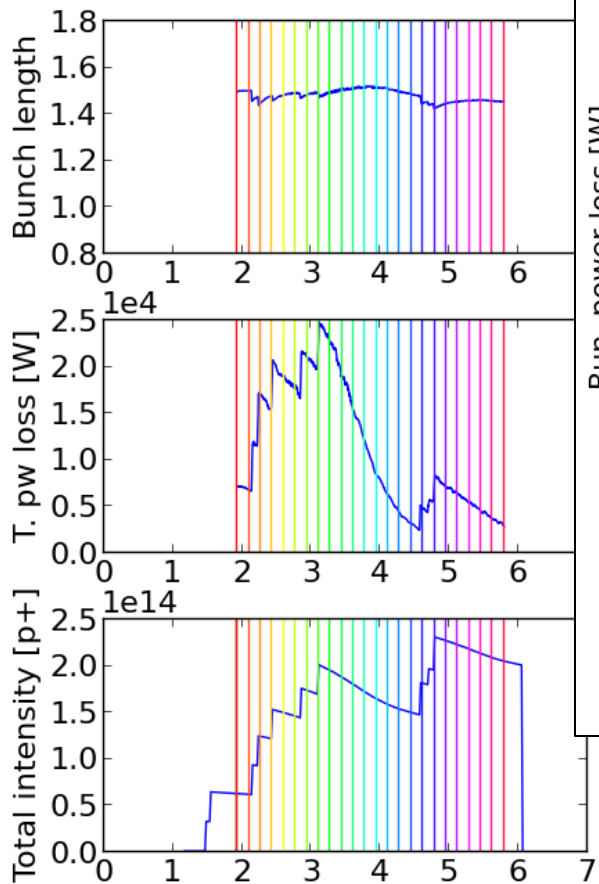
Influence of low energy electrons





Fill. 3391 started on Fri, 07 Dec 2012 08:03:00

First Acq. 115, Fri, 07 Dec 2012 09:58:54



Thanks to J. Esteban-Müller,
E. Shaposhnikova