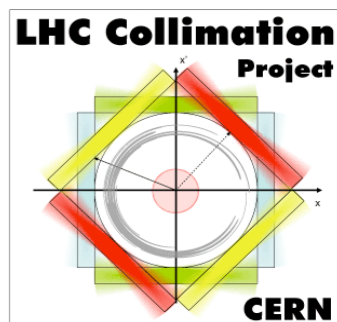


Overview of collimator MD's and beam measurement data

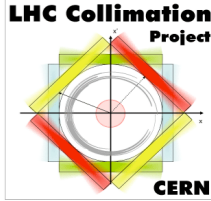
Stefano Redaelli, AB-OP

on behalf of the LHC collimation team





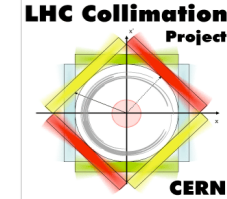
Agenda of this meeting



- | | |
|-------------|---|
| S. Redaelli | Overview of collimator MD's and beam measurements data |
| M. Jonker | Performance of collimator controls |
| S. Redaelli | Precision of collimator positioning and gap values |
| C. Bracco | Beam-based alignment and tail re-population |
| T. Weiler | Beam scraping studies |
| E. Métral | First results of the 2006 collimator impedance measurements |



Agenda of this meeting



S. Redaelli

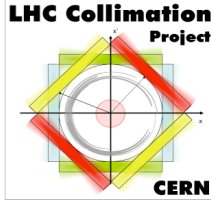
Overview of collimator MD's and
beam measurements data



- 1. Introduction - MD goals*
- 2. Overview of the performed MD s*
- 3. Available measurement data*



Agenda of this meeting



S. Redaelli

Overview of collimator MD's and beam measurements data



- 1. Introduction - MD goals*
- 2. Overview of the performed MD s*
- 3. Available measurement data*

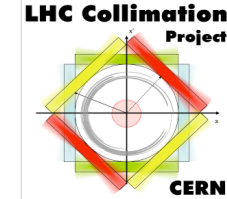
*Presented on behalf of: **Collimation team** (R. Assmann, C. Bracco, T. Weiler, G. Robert-Demolaize, M. Jonker, M. Sobczak, A. Masi, R. Losito), **BLM team**, **FLUKA team**, **TS team**, ...*

Acknowledgments: OP crew (G.Arduini, J.Wenninger, M. Lamont, V. Kain, F. Follin), CO LSA team (G. Kruk, ...), ...



Goals of the 2006 collimator MD's

(Ralph's talk at LCWG, 02/10/2006 + Chiara's at APC, 13/10/2006)



LSS5

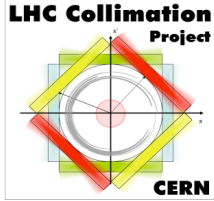
1. Check and test as much of the **LHC collimator controls infrastructure** as possible (low level, medium level, top level with HW, FESA, logging, ... interfaces).
2. Assess limitations in applied controls approach and understand **areas to be improved** (calibration, reaction speed, refresh rates, safety related info, failures, ...).
3. **Beam loss observations** with collimators and BLM's (see list): time response, repopulation, loss maps, collimator jaw BB calibration, ...
4. **Impedance measurements** of jaws. Higher priority if **by-pass effect** can be measured.

TT40

1. **Repeat 2004 robustness tests** (essentially 5-6 full intensity shots at depths from 0-5 mm. Plus each 1 shot for 1, 2, 3 batches at 5 mm depth plus set-up shots at lower intensity).
2. Measure **jaw vibrations** during and after beam impact (at jaw support point and jaw middle point → doubles number of shots) as a basic cross-check of predictions (not possible in the LHC).
3. Investigate usage of accelerometers and microphones for **impact detection in the LHC** (iteration on 2004 results).

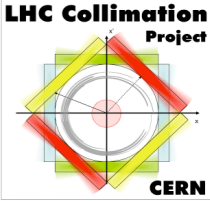


2006 collimator MD's





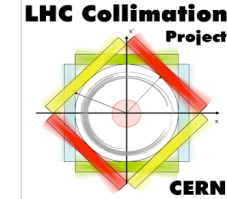
2006 collimator MD's



- SPS-SS5 MD1** - 31/10/2006 (24h)
Low intensities (1-4 bunches x $1.1 \cdot 10^{11}$ p)



2006 collimator MD's

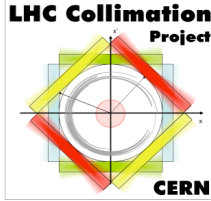


- SPS-SS5 MD1** - 31/10/2006 (24h)
Low intensities (1-4 bunches x $1.1 \cdot 10^{11}$ p)

- SPS-SS5 MD2** - 07/11/2006 (24h)
High intensities ([1-4] x 72 bunches)



2006 collimator MD's



- SPS-SS5 MD1** - 31/10/2006 (24h)
Low intensities (1-4 bunches x $1.1 \cdot 10^{11}$ p)
- SPS-SS5 MD2** - 07/11/2006 (24h)
High intensities ([1-4] x 72 bunches)
- TT40 test** - 09/11/2006 (16h)
Robustness test with LHC injection batch

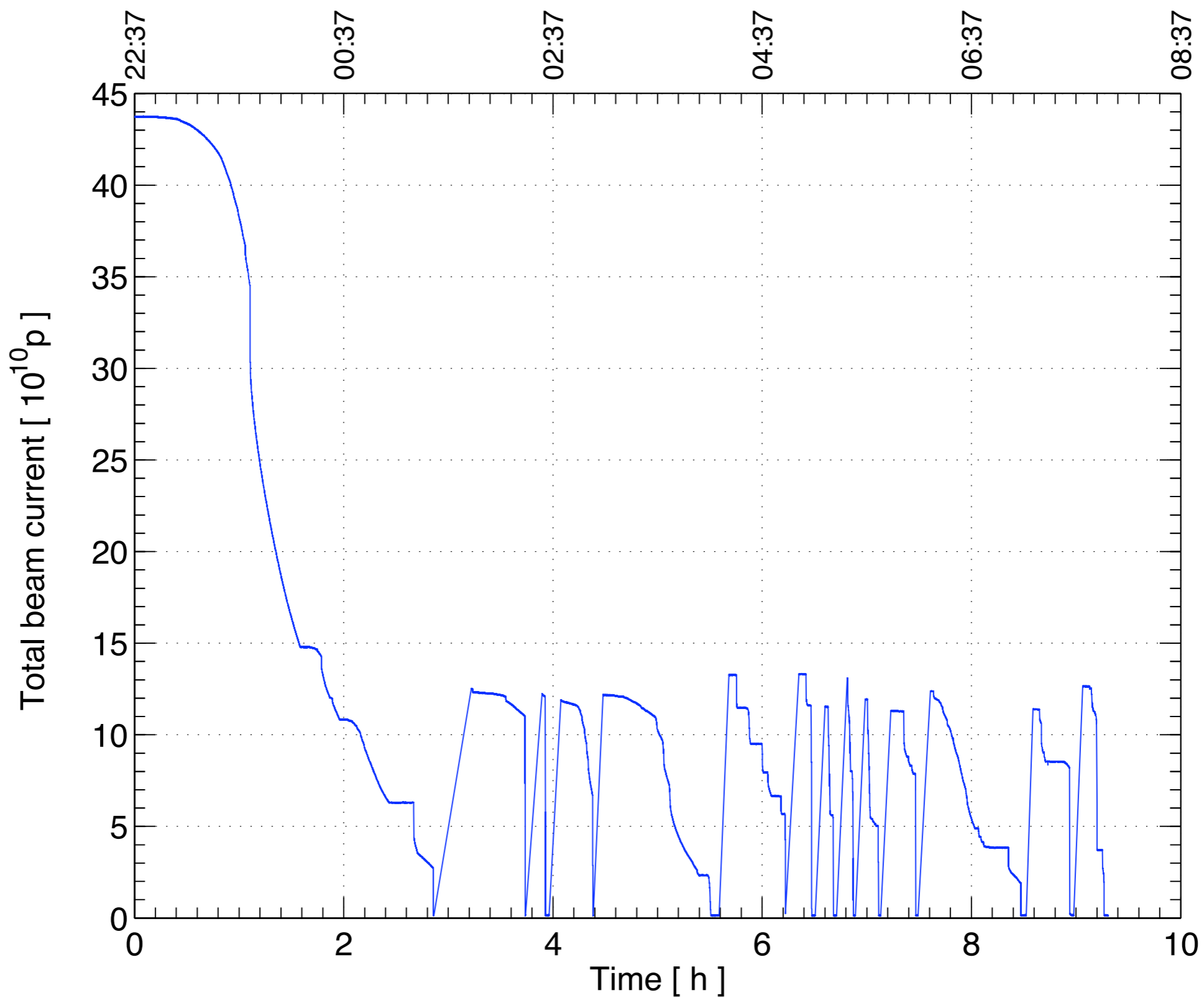
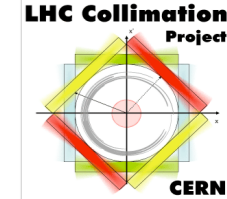
- SPS-SS5 MD1** - 31/10/2006 (24h)
Low intensities (1-4 bunches x $1.1 \cdot 10^{11}$ p)
- SPS-SS5 MD2** - 07/11/2006 (24h)
High intensities ([1-4] x 72 bunches)
- TT40 test** - 09/11/2006 (16h)
Robustness test with LHC injection batch
- SPS-SS5** - 15/11/2006 (~4h, parasitic)
Tests of fast BLM acquisitions, 12 bunches

- ☑ **SPS-SS5 MD1** - 31/10/2006 (24h)
Low intensities (1-4 bunches x $1.1 \cdot 10^{11}$ p)
- ☑ **SPS-SS5 MD2** - 07/11/2006 (24h)
High intensities ([1-4] x 72 bunches)
- ☑ **TT40 test** - 09/11/2006 (16h)
Robustness test with LHC injection batch
- ☑ **SPS-SS5** - 15/11/2006 (~4h, parasitic)
Tests of fast BLM acquisitions, 12 bunches

This meeting: Focus on MD1 and MD2 with circulating beams.
Other topics discussed in later meetings.

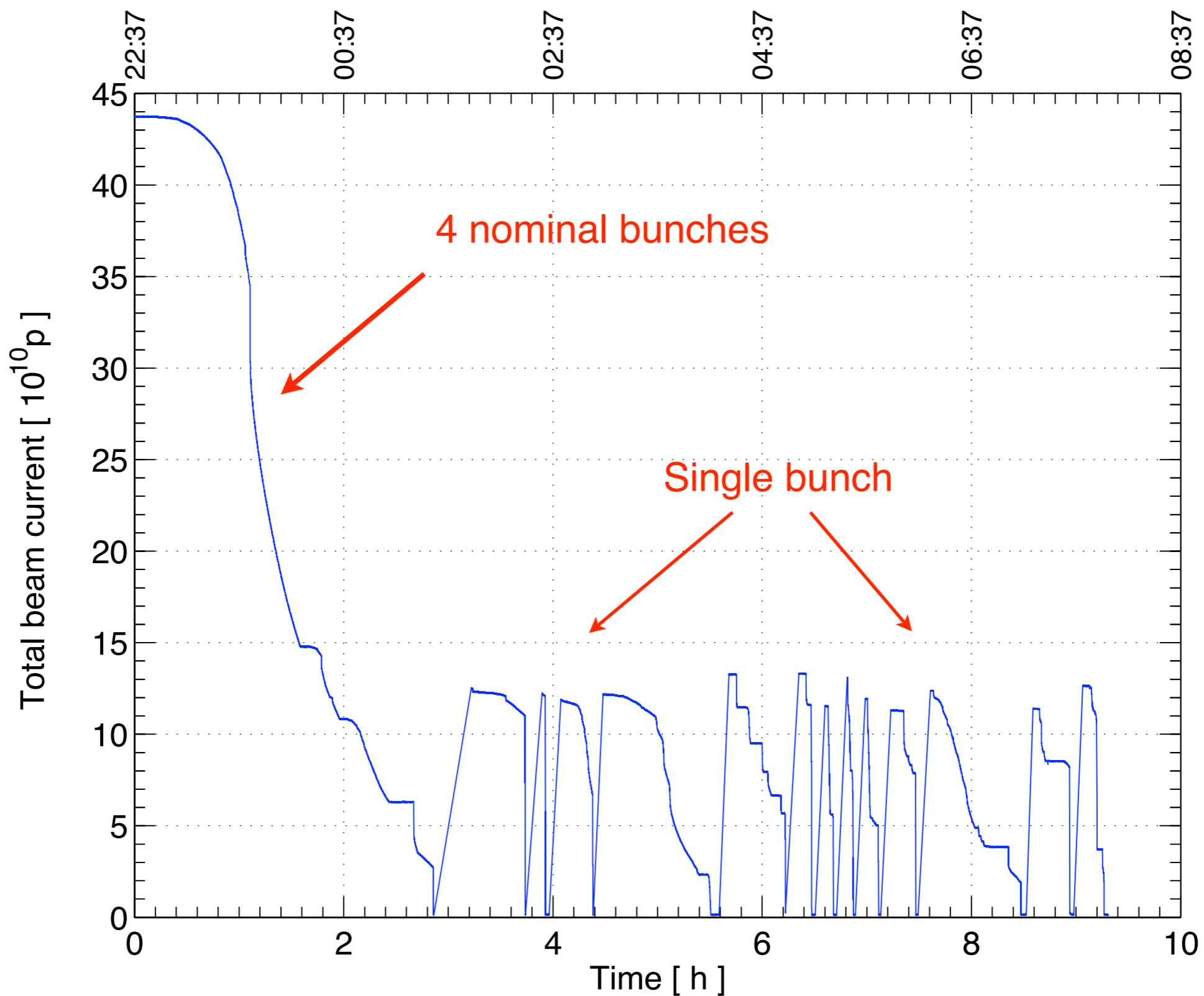
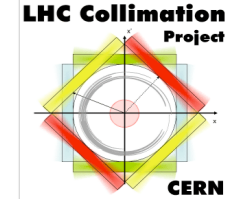


SPS-SS5 MD1 - 31/10/2006



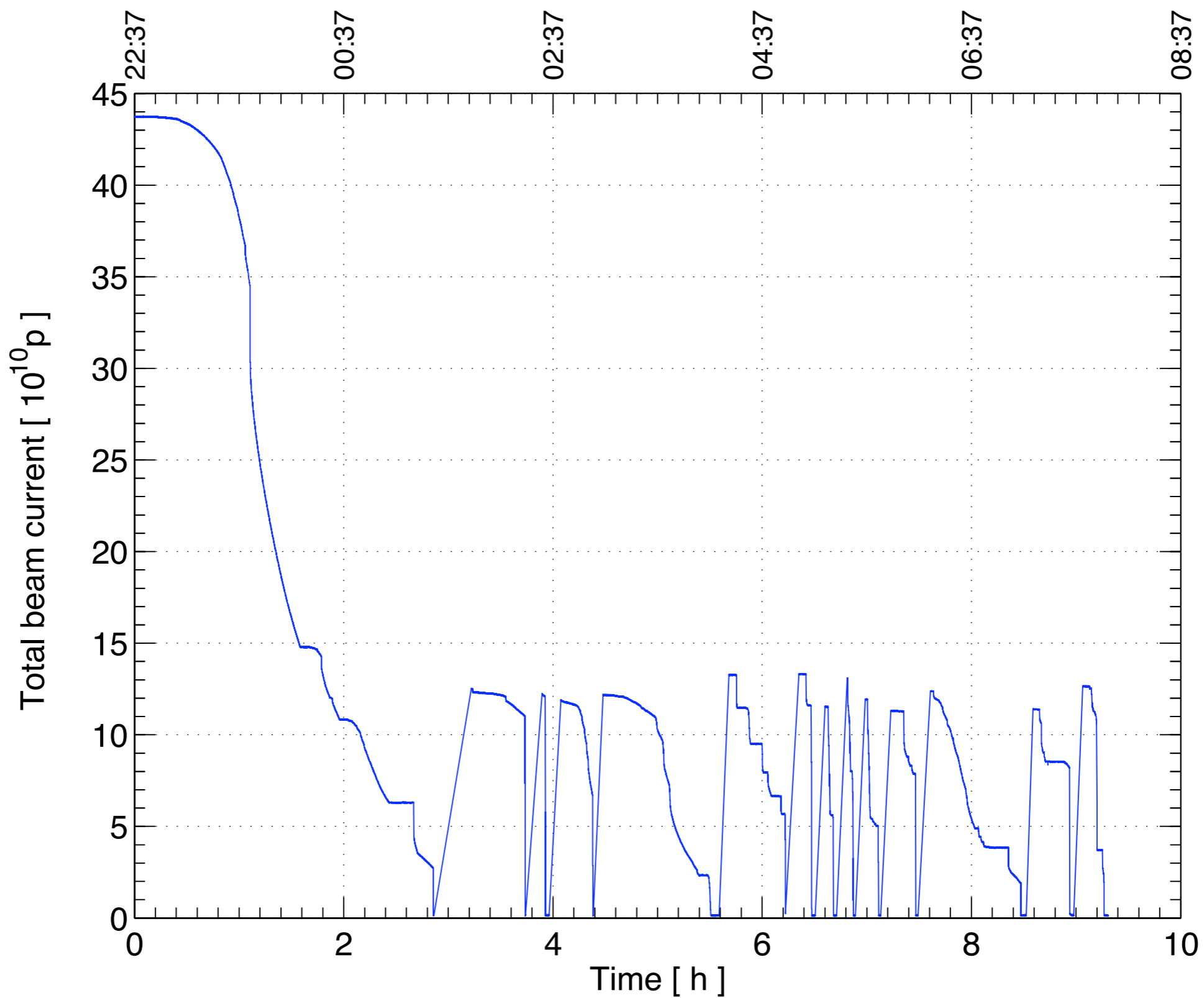
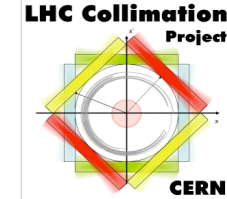


SPS-SS5 MD1 - 31/10/2006



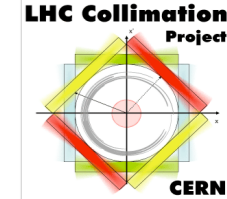


SPS-SS5 MD1 - 31/10/2006

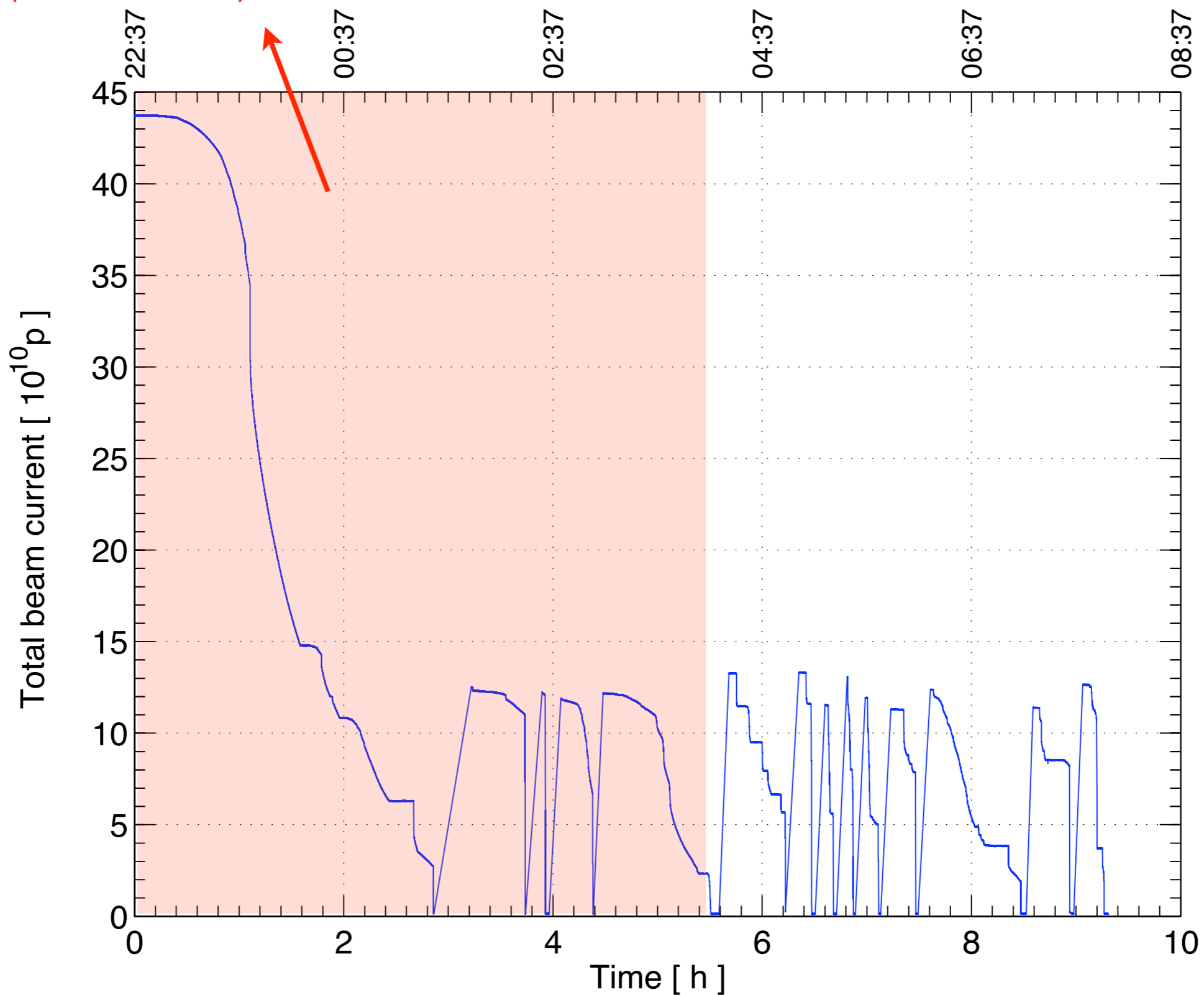




SPS-SS5 MD1 - 31/10/2006

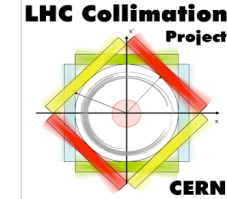


Beam-based alignment; beam tail studies
(Chiara's talk)



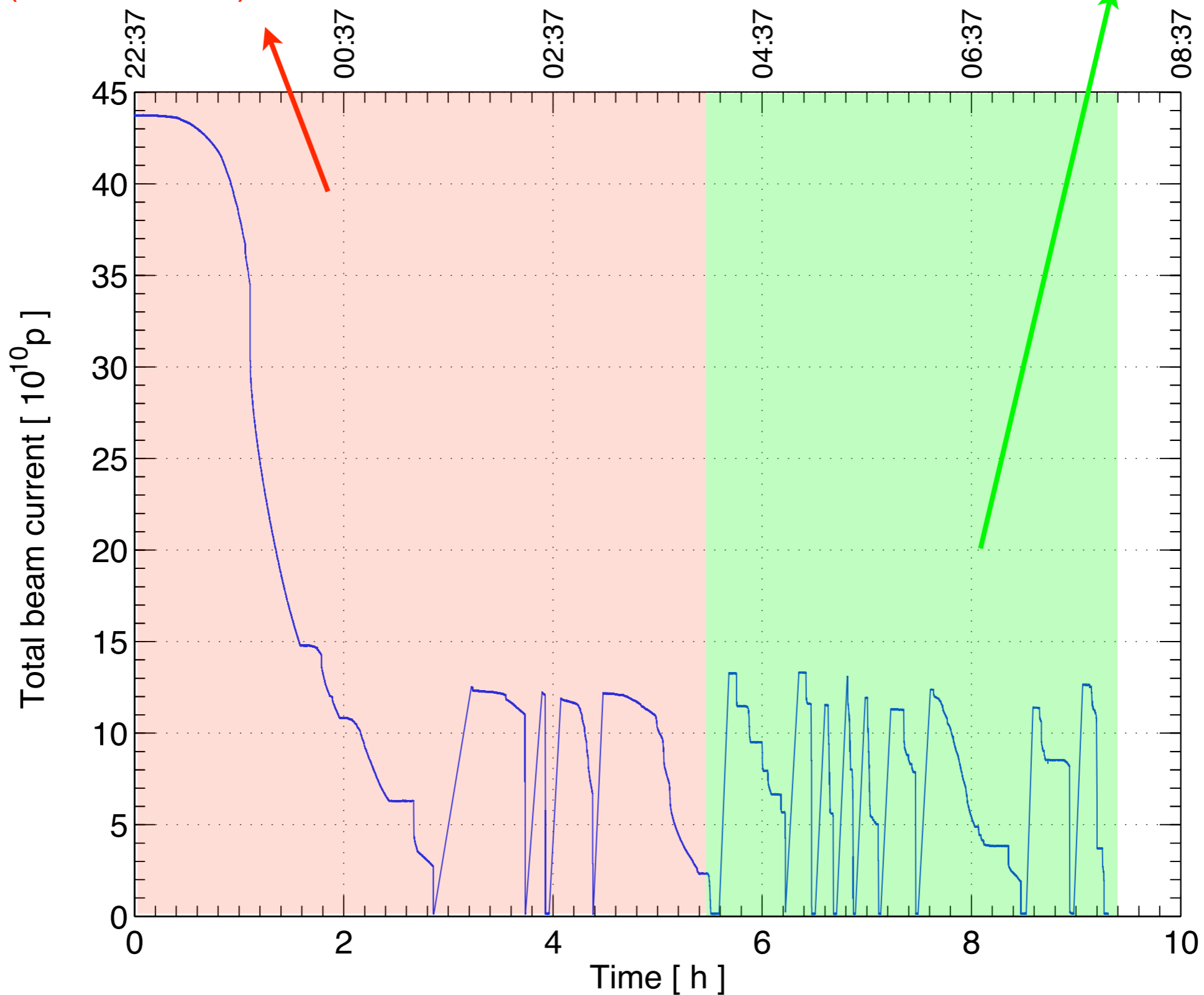


SPS-SS5 MD1 - 31/10/2006



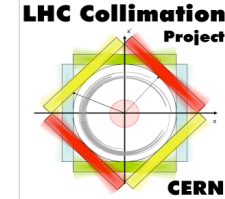
Beam-based alignment; beam tail studies
(Chiara's talk)

Tune shift from collimator impedance (imag. part)
(Elias' talk)



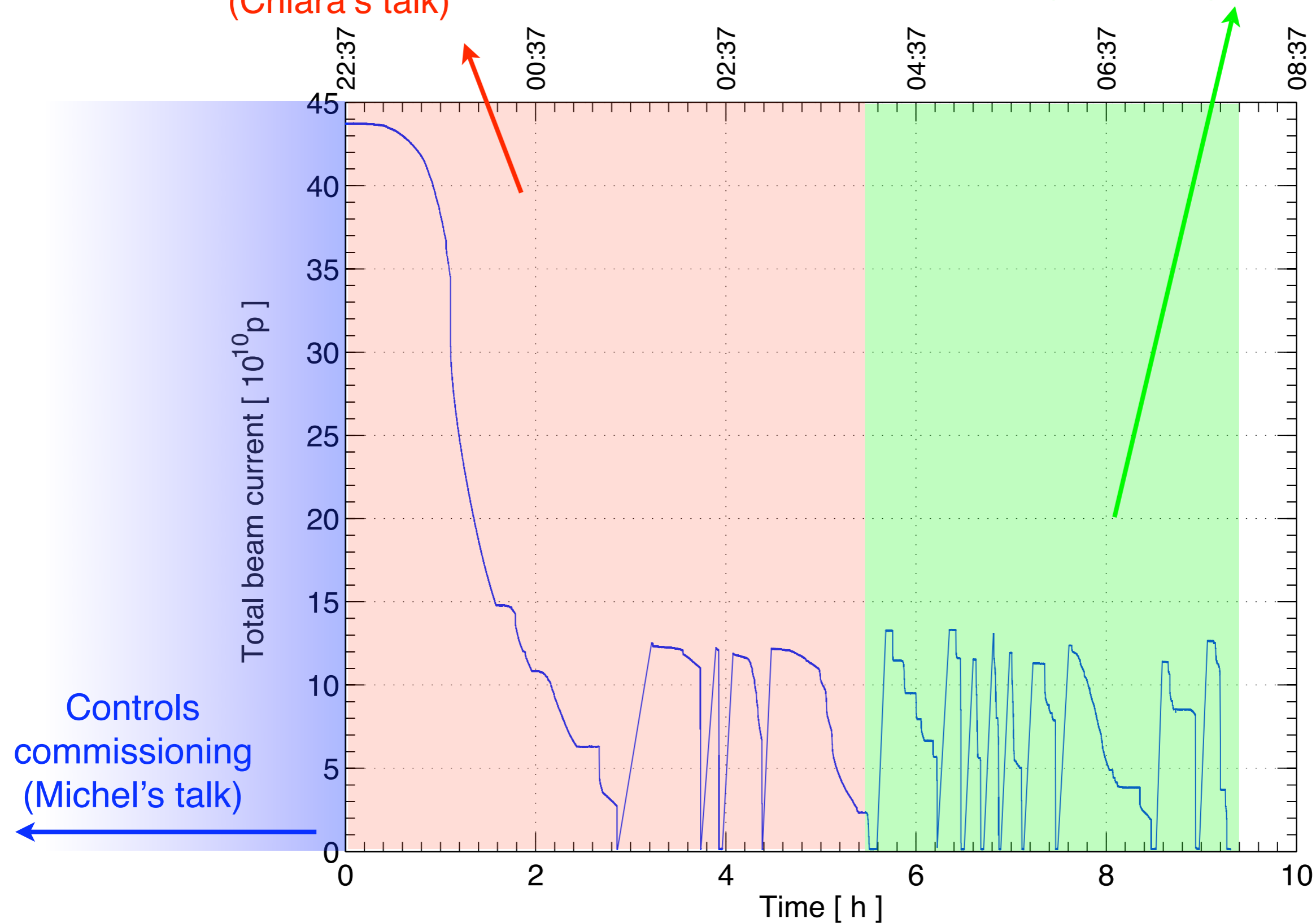


SPS-SS5 MD1 - 31/10/2006



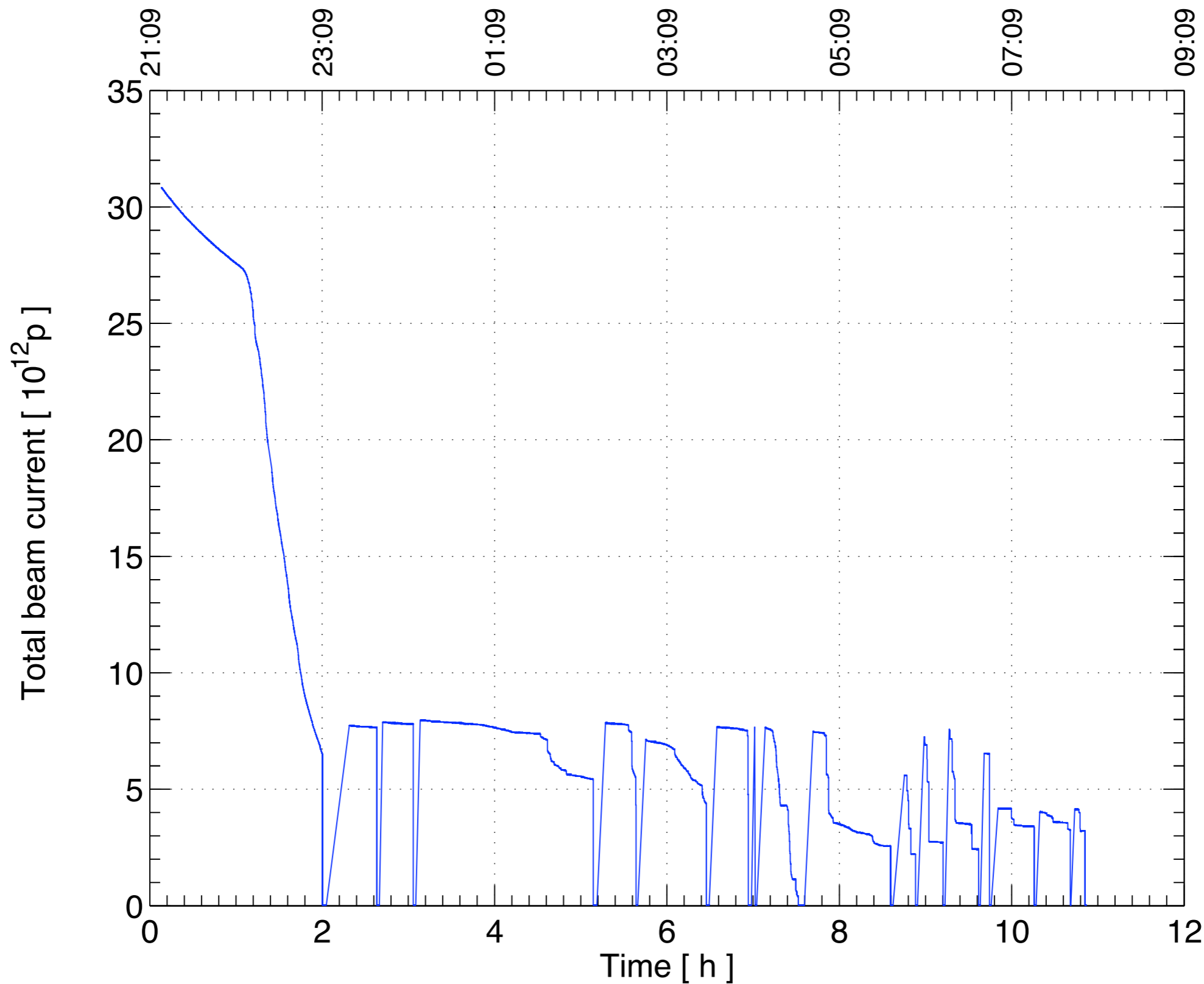
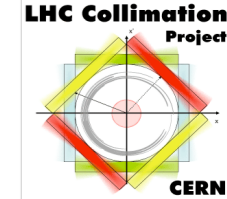
Beam-based alignment; beam tail studies
(Chiara's talk)

Tune shift from collimator impedance (imag. part)
(Elias' talk)

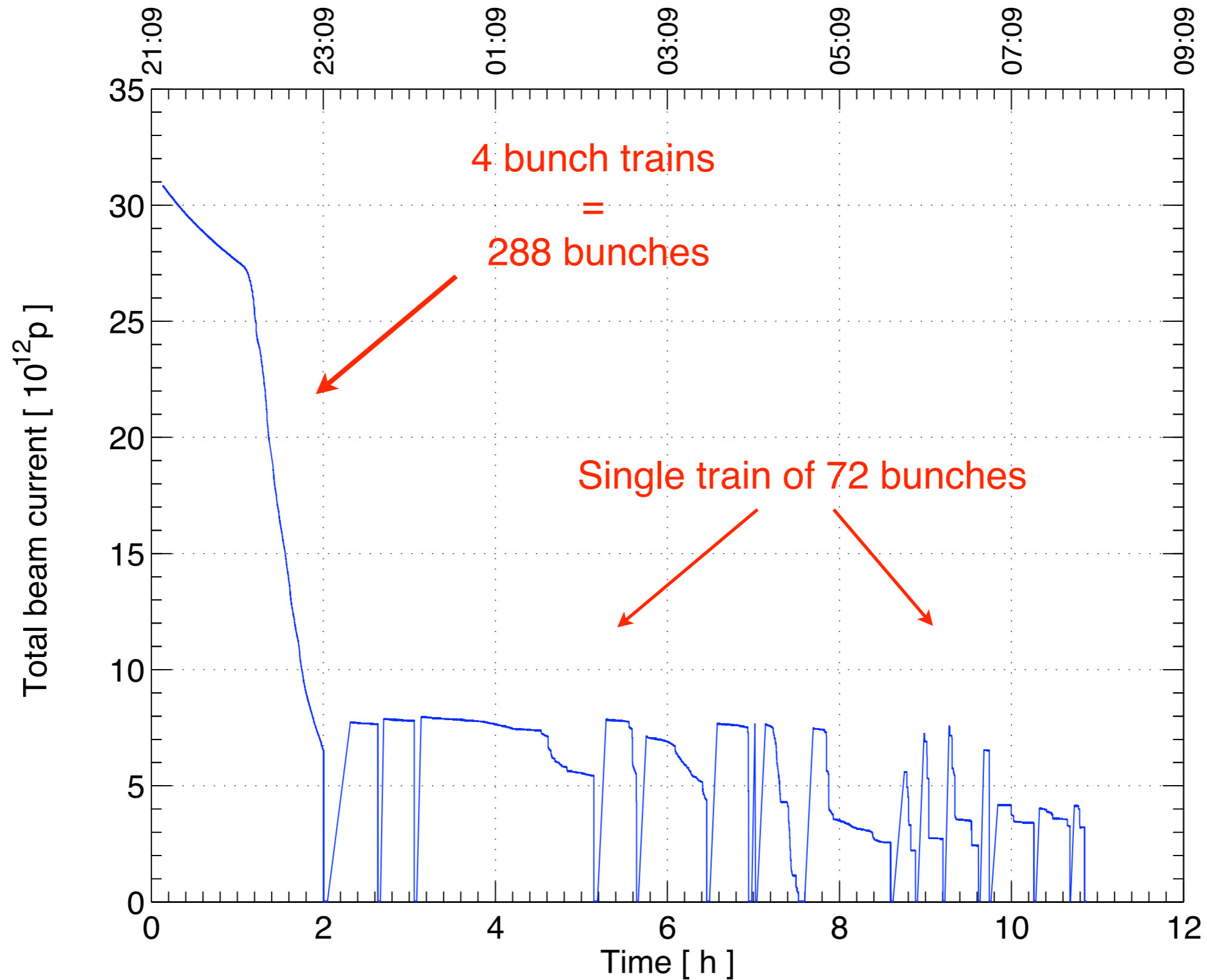




SPS-SS5 MD2 (07/11/2006)

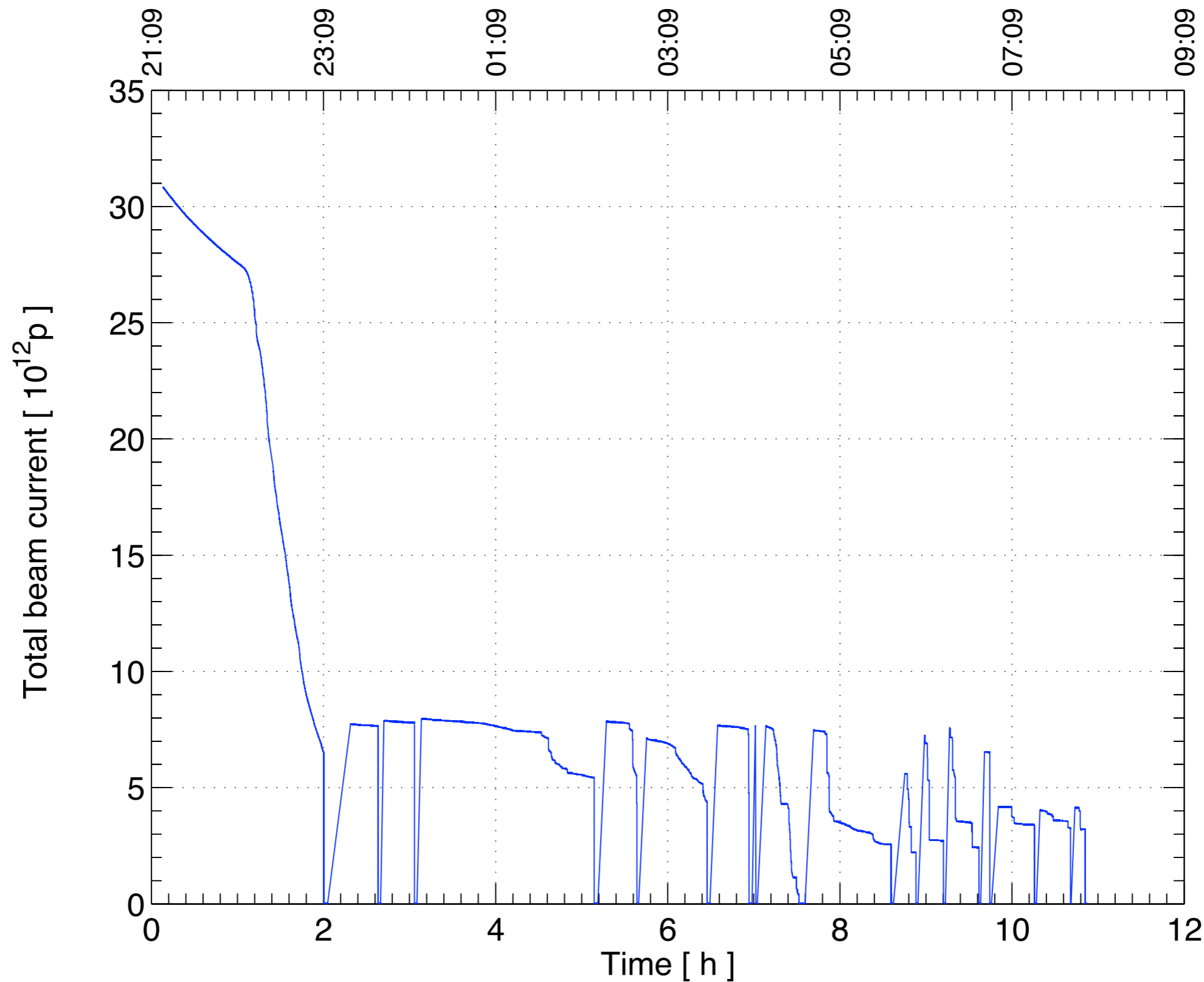
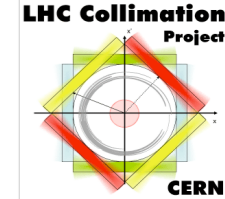


SPS-SS5 MD2 (07/11/2006)



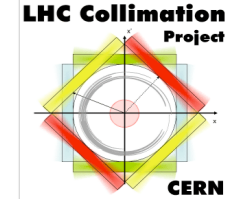


SPS-SS5 MD2 (07/11/2006)

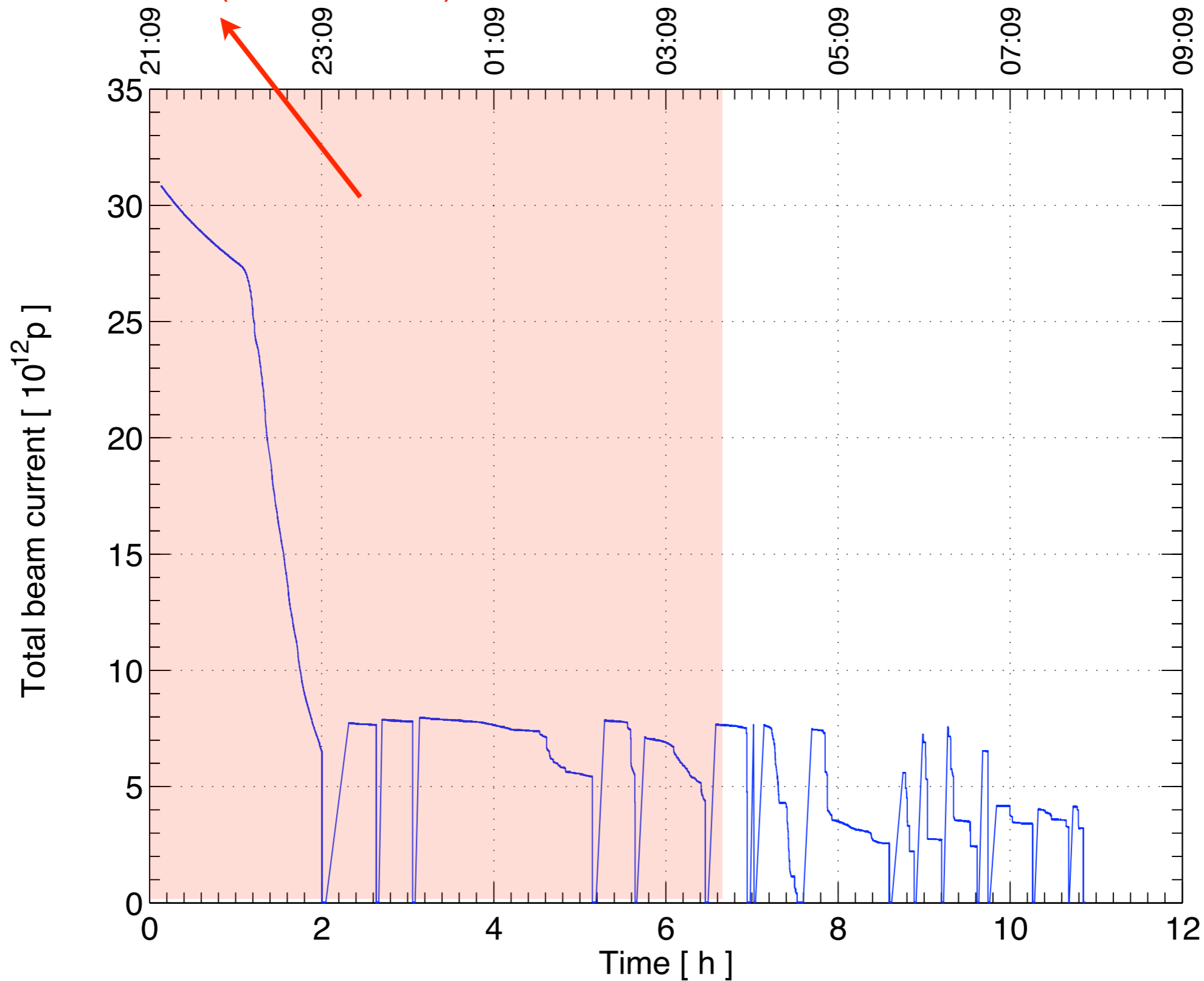




SPS-SS5 MD2 (07/11/2006)

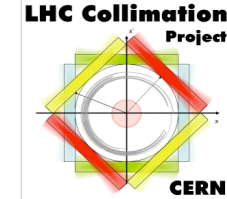


Beam-based alignment; BL studies; tail re-population vs. tune (Chiara's talk)



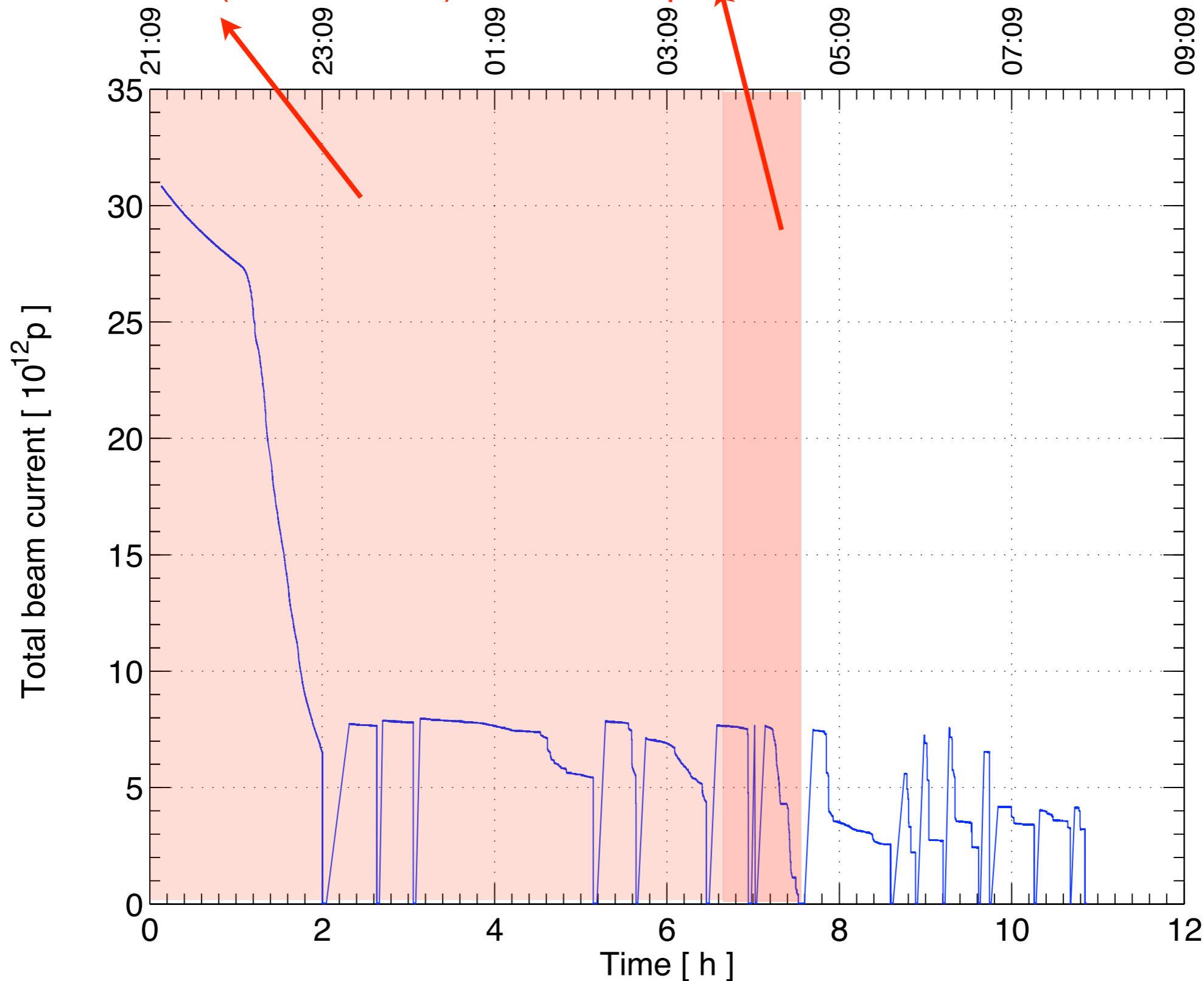


SPS-SS5 MD2 (07/11/2006)



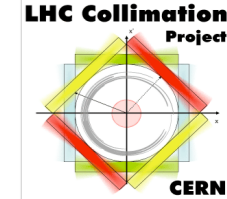
Beam-based alignment; BL studies; tail re-population vs. tune (Chiara's talk)

Non-linear bumps





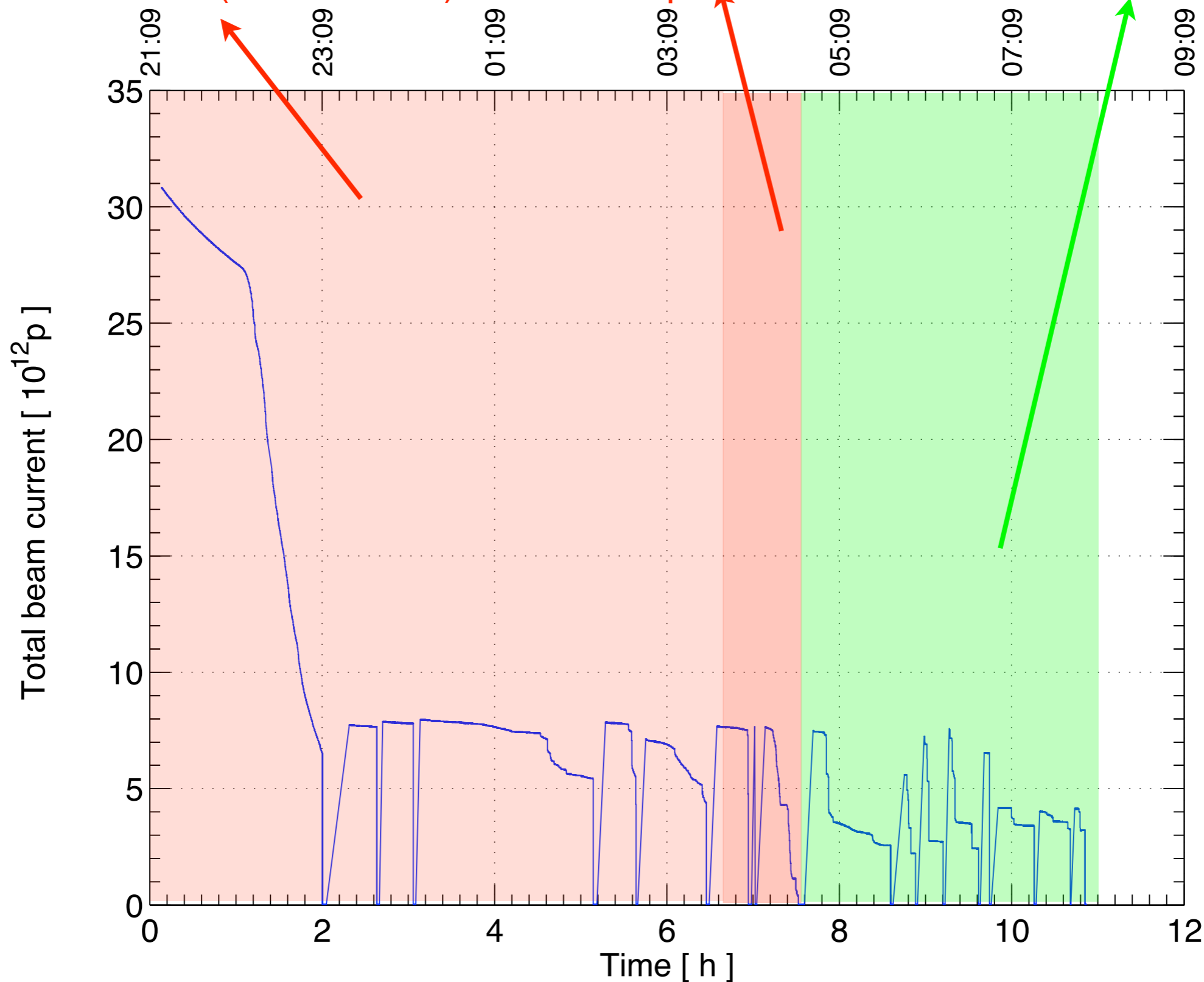
SPS-SS5 MD2 (07/11/2006)



Beam-based alignment; BL studies; tail re-population vs. tune (Chiara's talk)

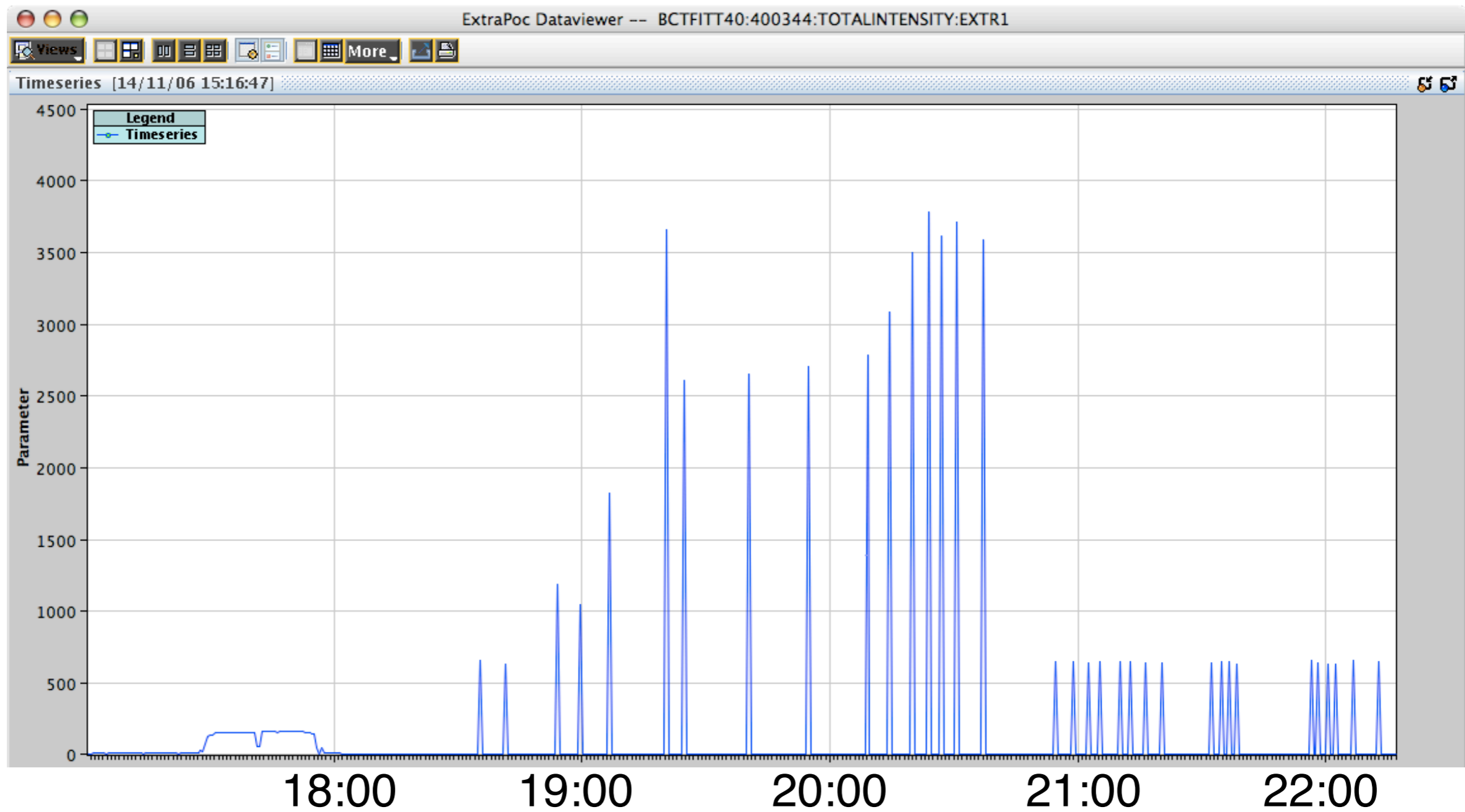
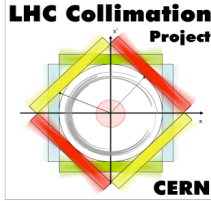
Non-linear bumps

Growth of instabilities from collimator impedance - real part (Elias' talk)



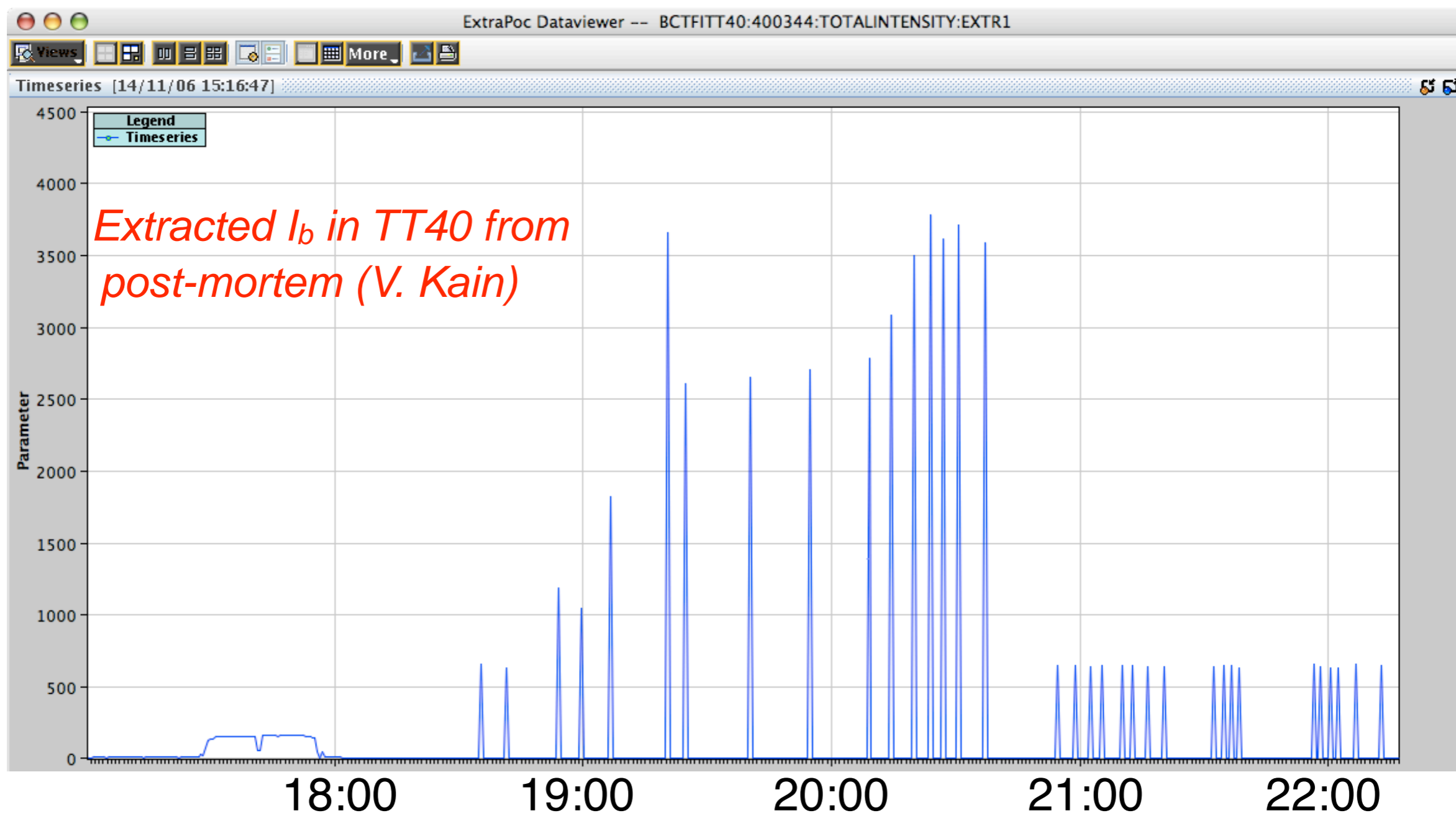
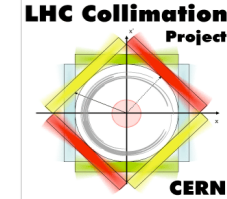


TT40 robustness test



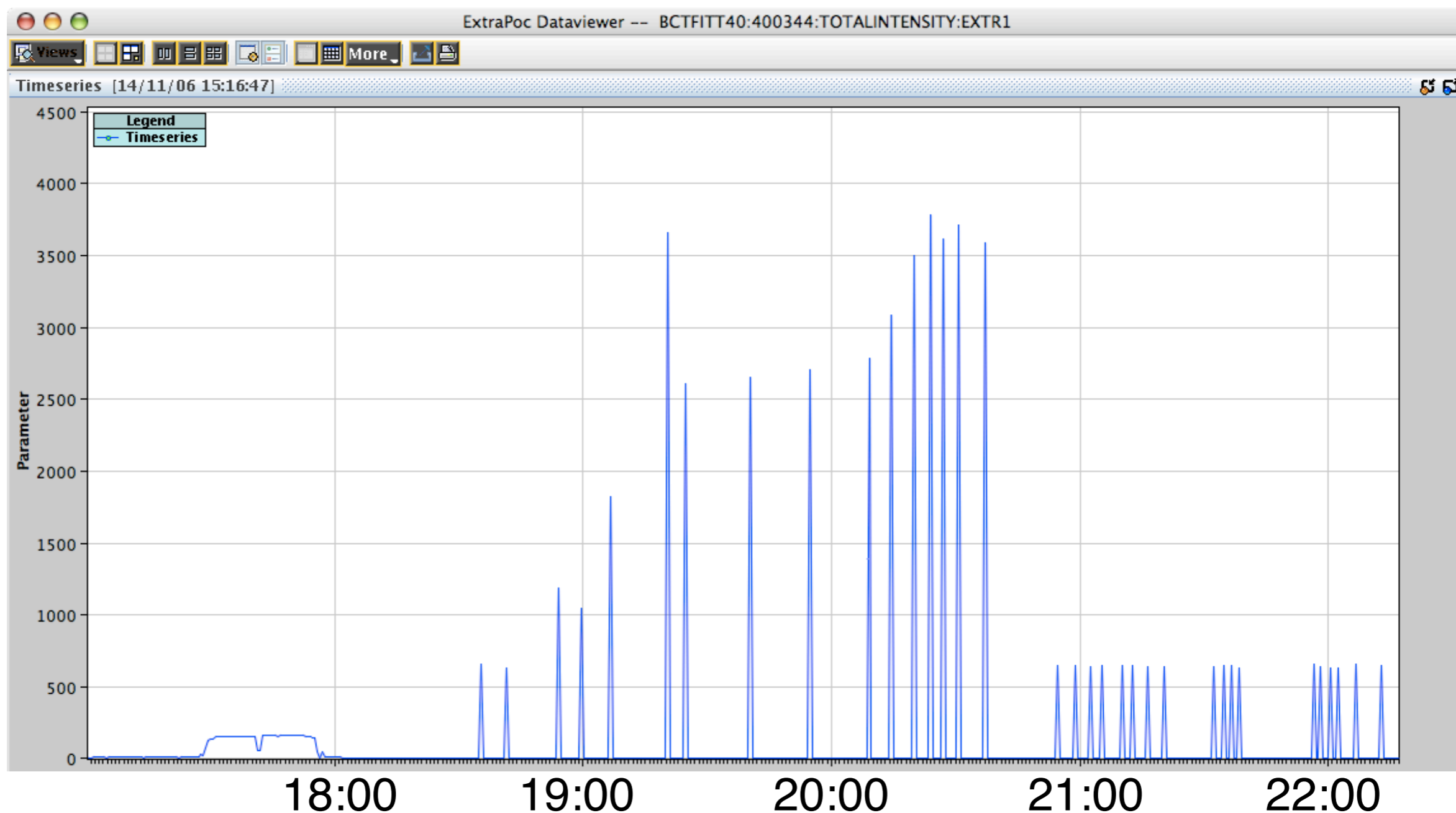
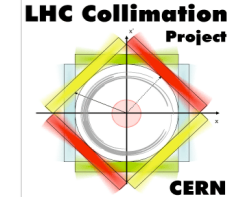


TT40 robustness test



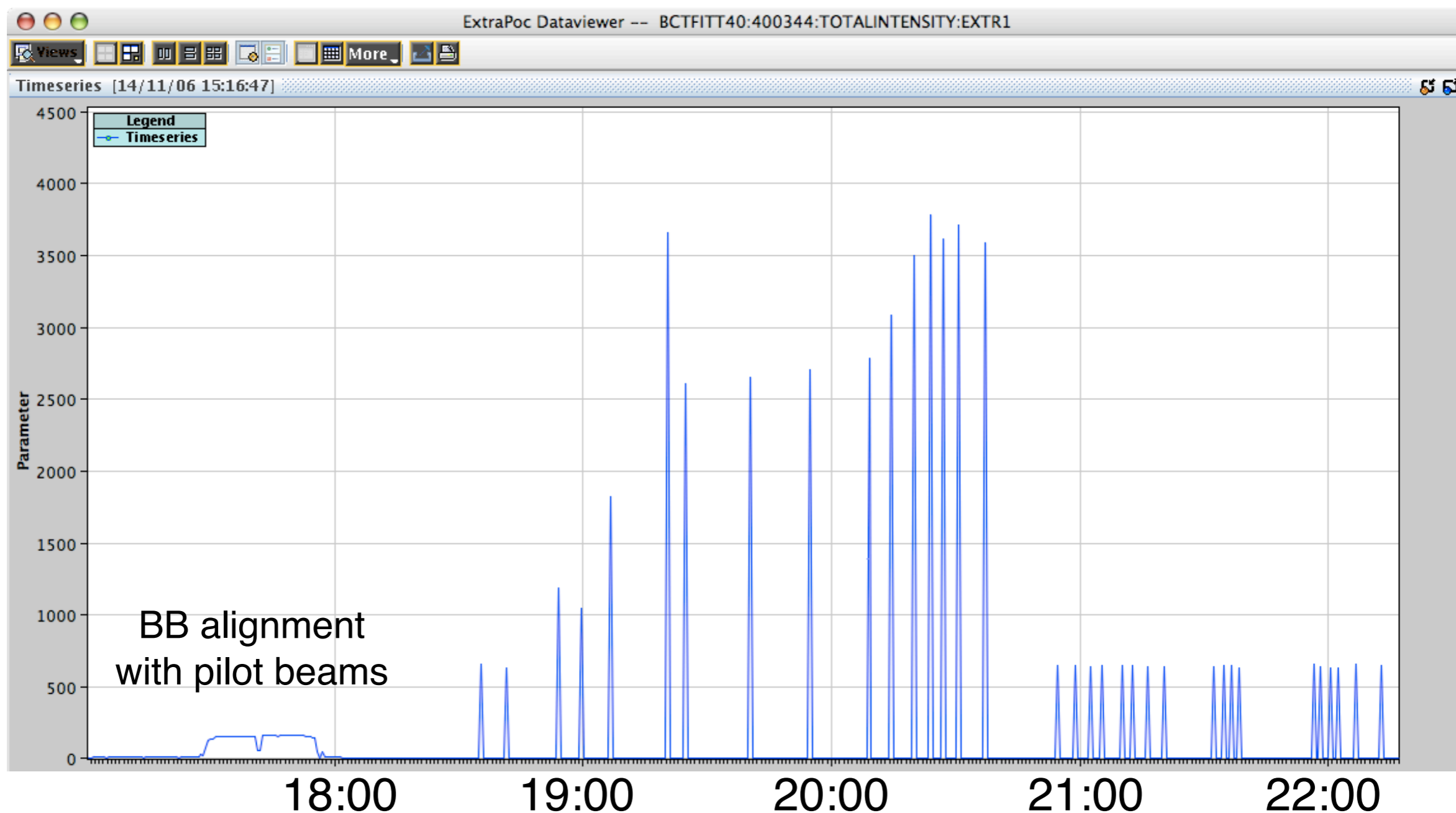
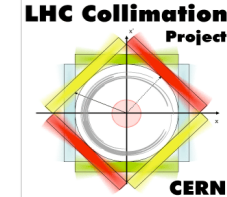


TT40 robustness test



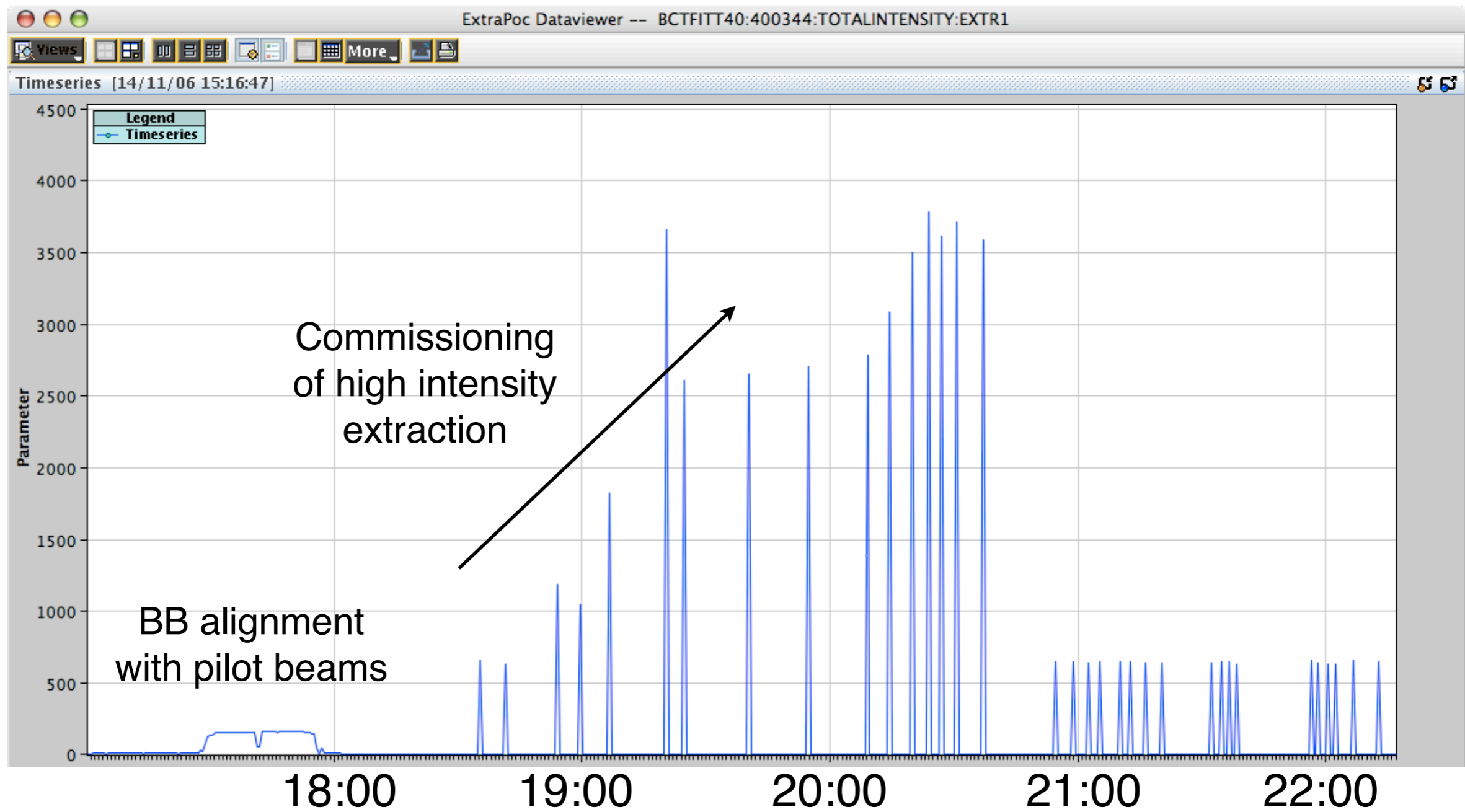
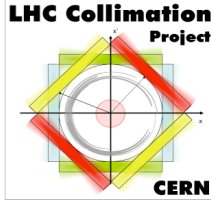


TT40 robustness test

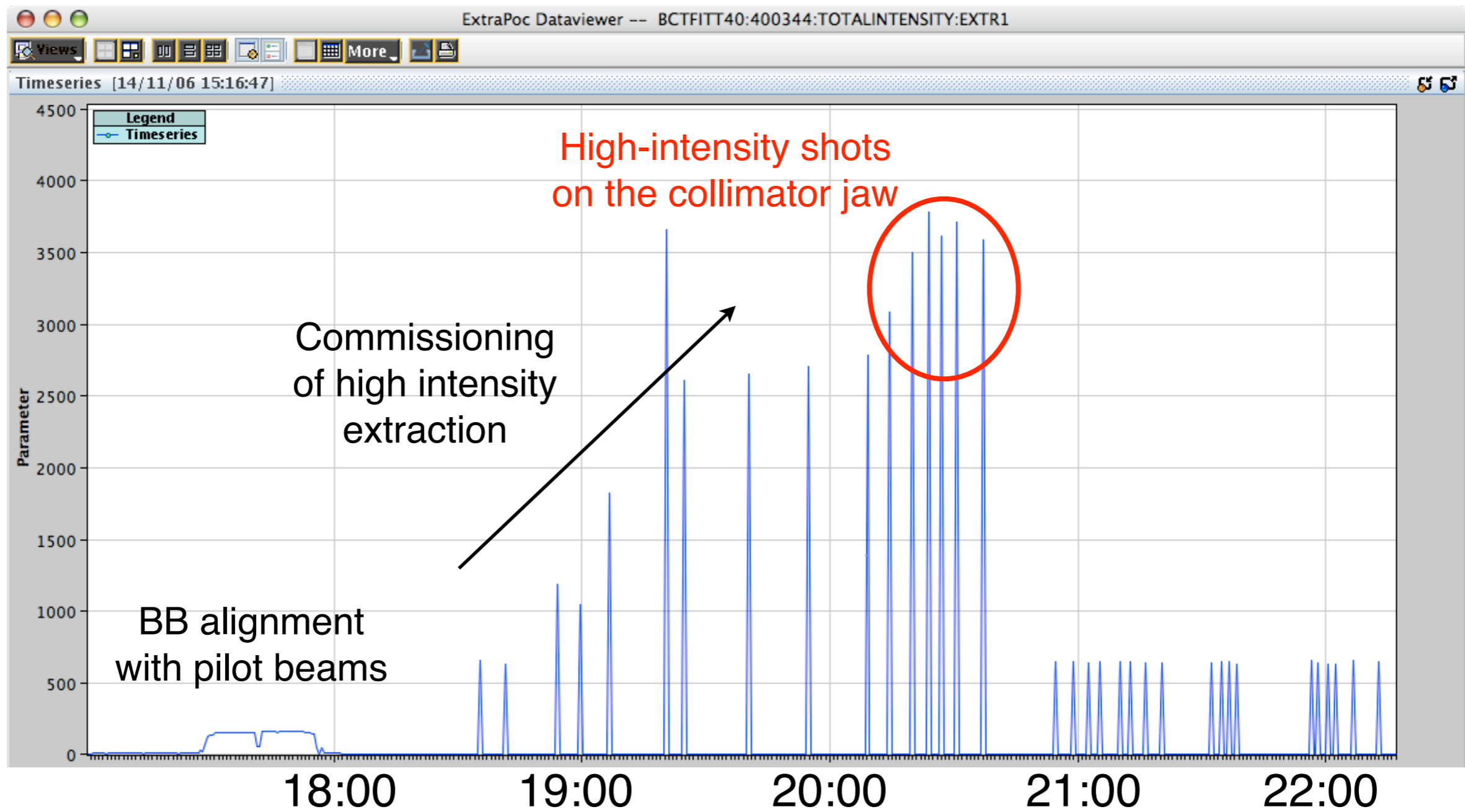




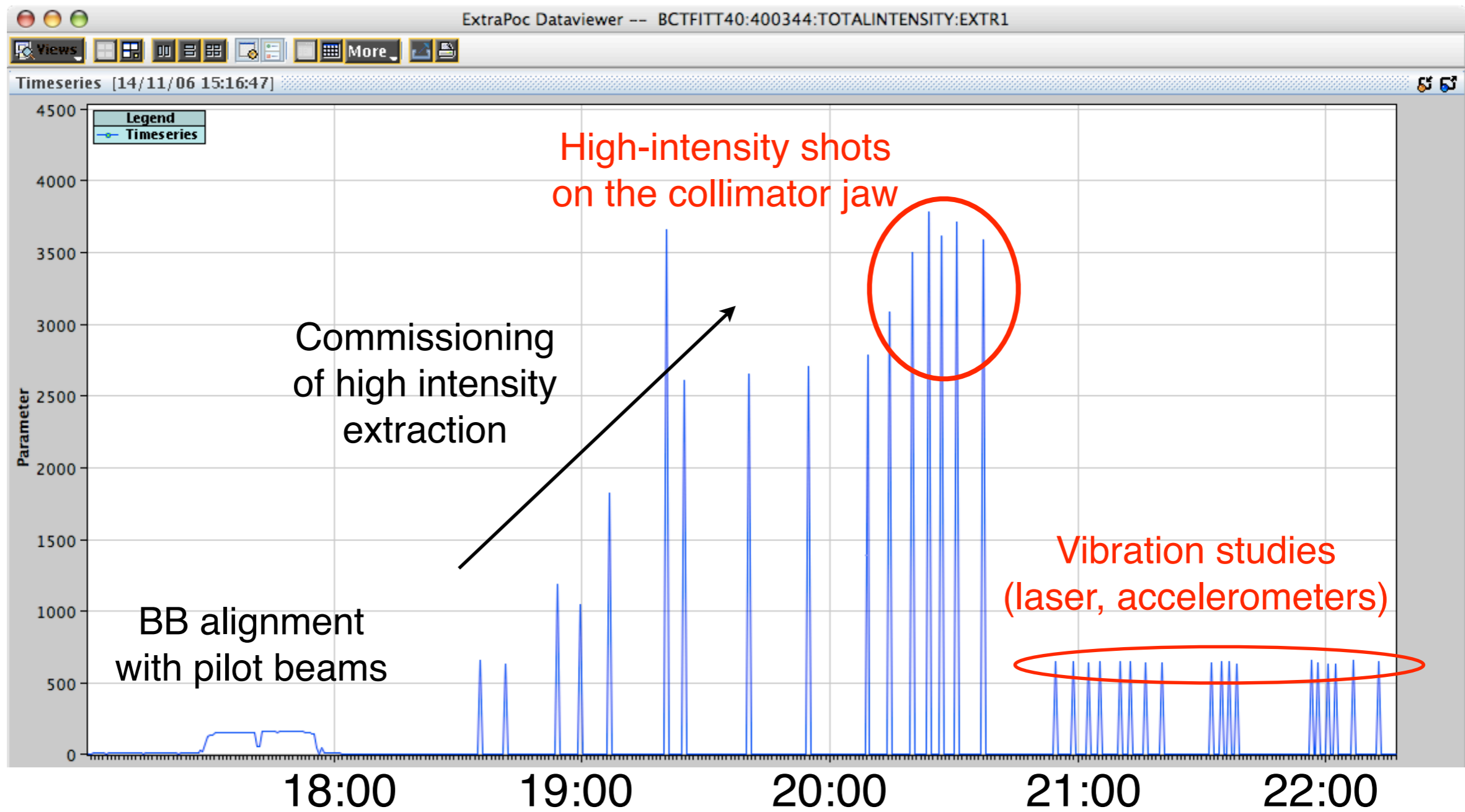
TT40 robustness test

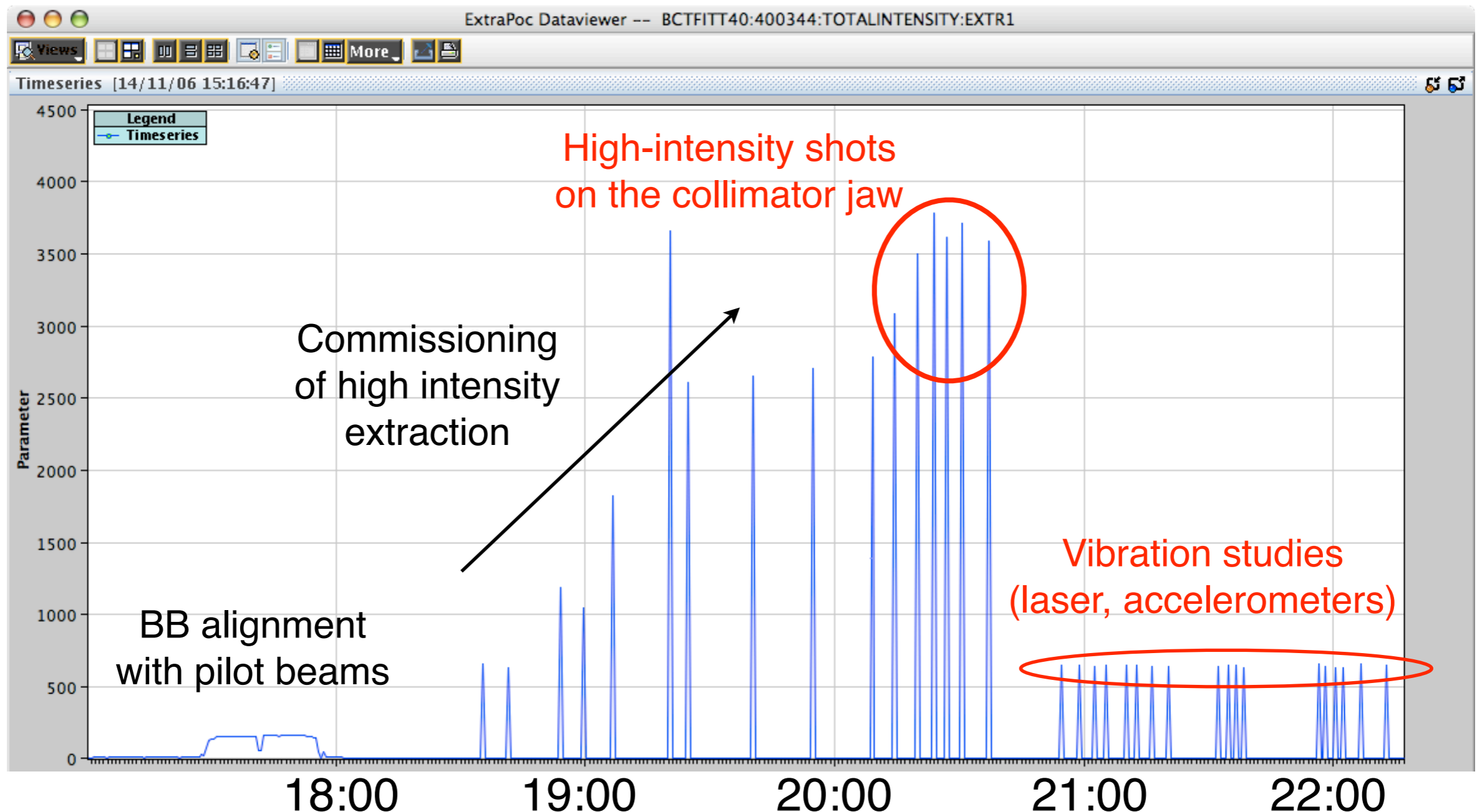


TT40 robustness test



TT40 robustness test

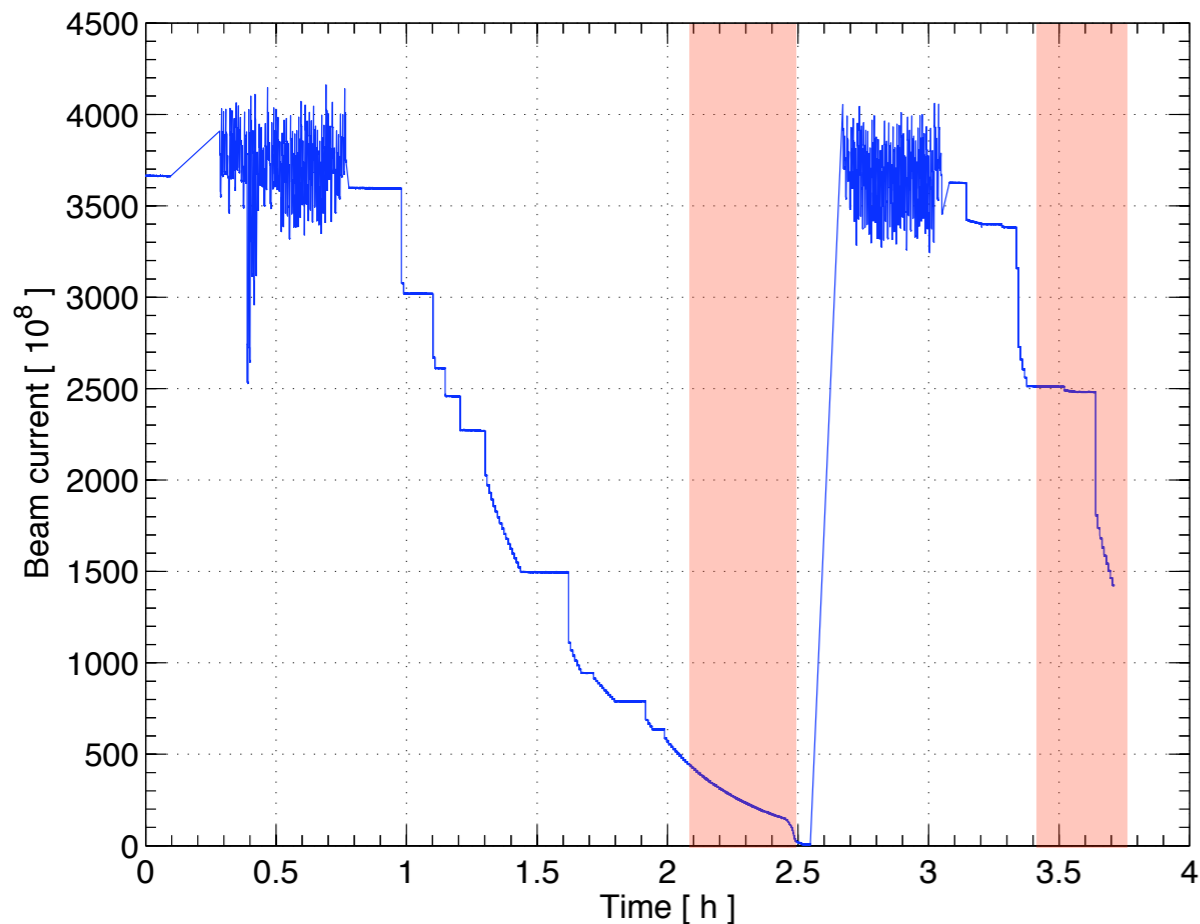




Robustness test carried out **successfully**: No indications of damage; detailed inspections after Jan. 2007 to measure permanent jaw deformation.

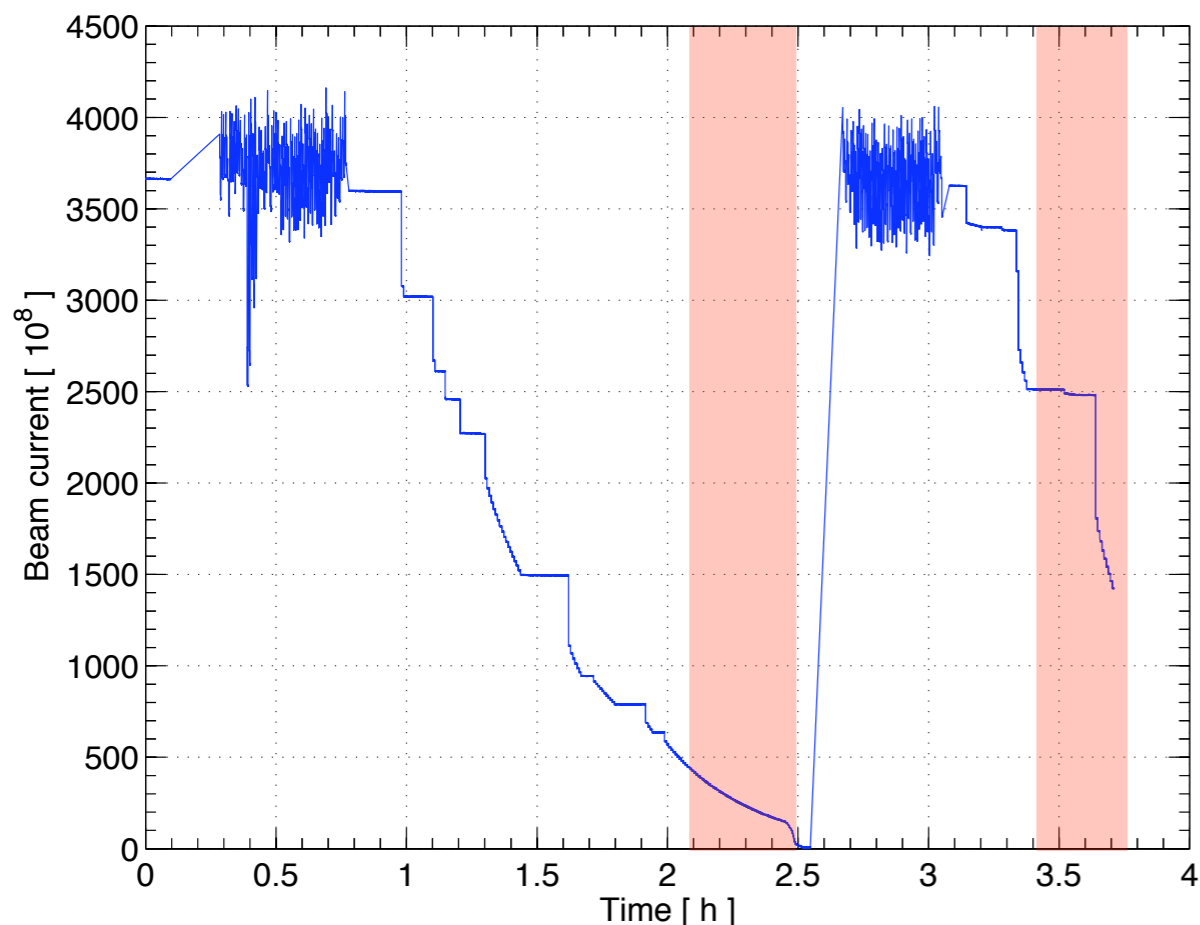
Systematic studies of **jaw vibrations** induced by impacting beams: laser vibrometer [R. Wilfinger], accelerometers and microphones [S. Redaelli] → dedicated LCWG later on

*Parasitic measurements during
H. Burkhardt scraper MD (15/11/2006)*

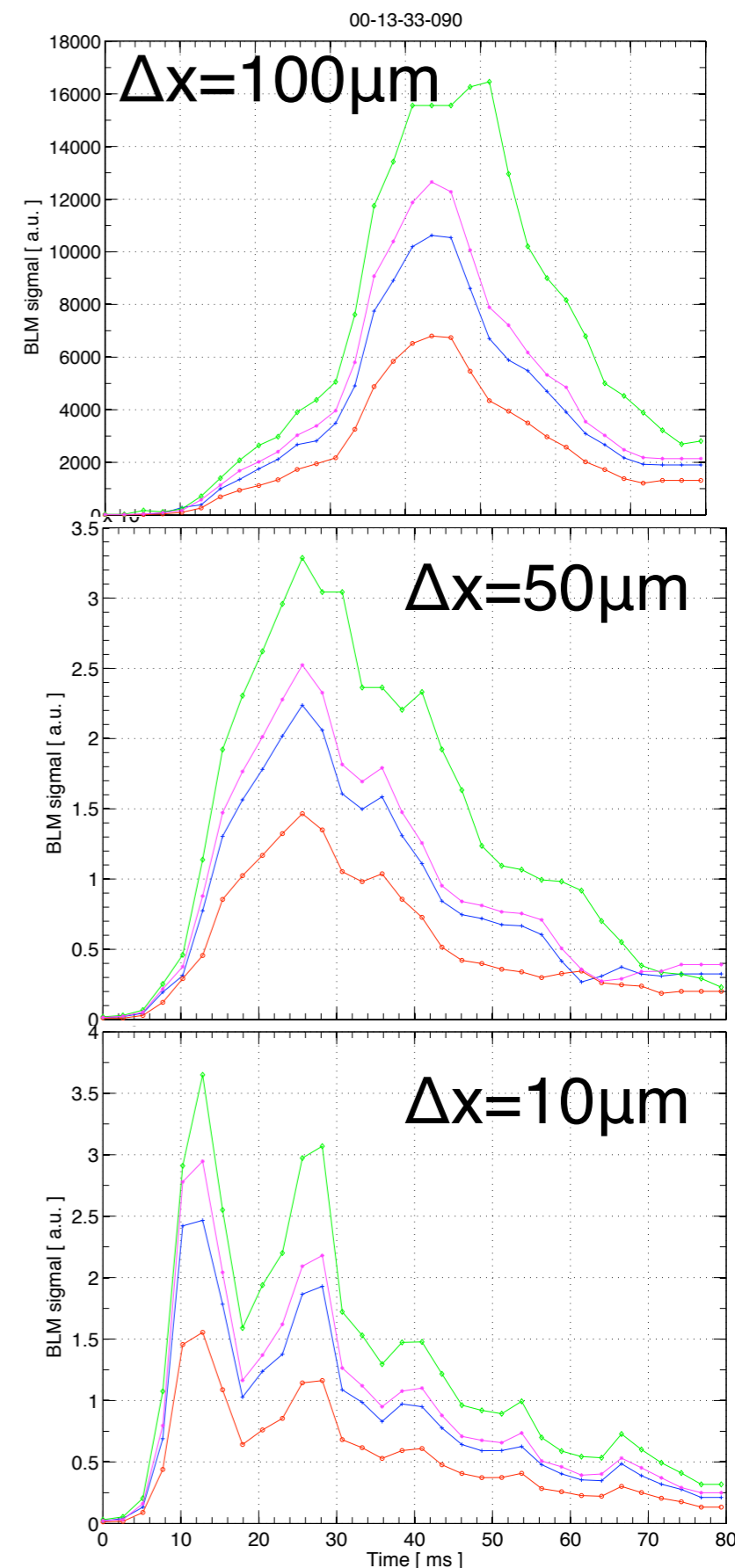


- **Transient BLM** data from *post-mortem* buffer:
T=32x2.56ms~80ms, triggered by jaw movements
- Acquisition successfully set-up!
(It did not work during MD1 and MD2)
- Detailed results to be presented D. Kramer
and C. Zamantzas

*Parasitic measurements during
H. Burkhardt scraper MD (15/11/2006)*

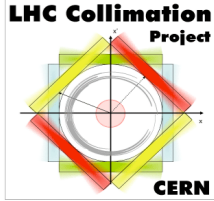


- **Transient BLM** data from *post-mortem* buffer:
T=32x2.56ms~80ms, triggered by jaw movements
- Acquisition successfully set-up!
(It did not work during MD1 and MD2)
- Detailed results to be presented D. Kramer
and C. Zamantzas



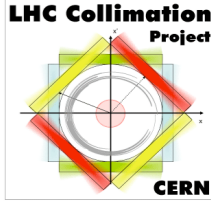


Beam measurements





Beam measurements

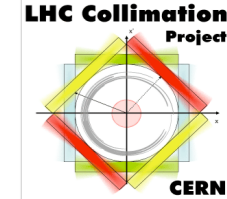


Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)



Beam measurements



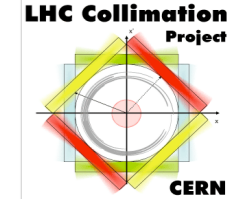
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey



Beam measurements



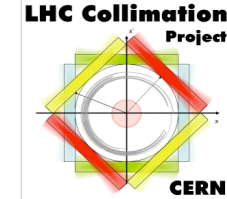
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)



Beam measurements



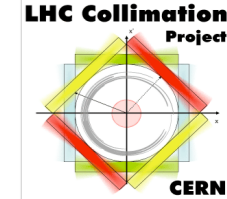
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements



Beam measurements



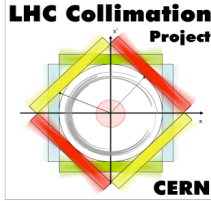
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)



Beam measurements



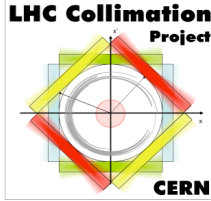
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)
- Measurement of closed-orbit. Local 3C-bumps for aperture scans



Beam measurements



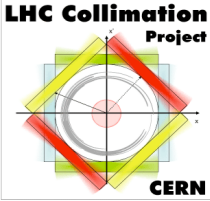
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)
- Measurement of closed-orbit. Local 3C-bumps for aperture scans
- Collimator impedance: BBQ, 1000-turn BPM, LHC BPM



Beam measurements



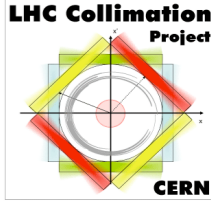
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)
- Measurement of closed-orbit. Local 3C-bumps for aperture scans
- Collimator impedance: BBQ, 1000-turn BPM, LHC BPM
- + bunch length measurements by T. Bohl (*report in future meetings*)



Beam measurements



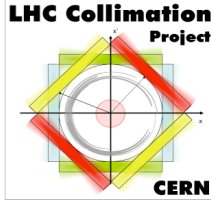
Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)
- Measurement of closed-orbit. ~~Local 3C-bumps for aperture scans~~
- Collimator impedance: BBQ, 1000-turn BPM, LHC BPM
- + bunch length measurements by T. Bohl (*report in future meetings*)



Beam measurements



Requirements for the SPS test with circulating beams

(S.R., APC of 13/10/2006)

- Dedicated BLM's close to the collimator. Position and temperature survey
- Fast monitoring (20 ms) of losses around the ring (BLRING)
- Beam current measurements (slow + fast). Beam lifetime measurements
- Emittance measurements (wires)
- Measurement of closed-orbit. ~~Local 3C-bumps for aperture scans~~
- Collimator impedance: BBQ, 1000-turn BPM, LHC BPM → *See Elias talk*
- + bunch length measurements by T. Bohl (*report in future meetings*)

File Settings Display info

Jaw corners Positions/Angles Increment

Set increments of jaw positions/angles

Left POSIT [mm]:

Right POSIT [mm]:

Left ANGLE [mrad]:

Right ANGLE [mrad]:

Repeat times every sec.

Repeat option finished - 12/12 executed.

Left Jaw UP-IN UP-OUT DW-IN DW-OUT

Right jaw UP-IN UP-OUT DW-IN DW-OUT

Anti COLL UP DOWN

Positions readout from the low-level

Motor st... Left UP 1.395 Gap UP 2.39

Jaw edges Left DW 1.395 Gap DW 2.39

Right UP -0.995 Centre UP 0.2

Right DW -0.995 Centre DW 0.2

Display jaw: Left Jaw (dashed) Right jaw (solid)

Positions: Settings LVDT's Resolvers Motor steps

BLM: BLM 1 BLM 2 BLM 3 BLM 4 LogY

Views More

Beam loss data [01/11/06 03:44:06]

Beam loss signal [a.u.]

Jaw positions [01/11/06 03:44:06]

Jaw positions [mm]

time [hh:mm:ss]

Setting panel

Setting panel

File Settings Display info

Jaw corners Positions/Angles Increment

Set increments of jaw positions/angles

Left POSIT [mm]:

Right POSIT [mm]:

Left ANGLE [mrad]:

Right ANGLE [mrad]:

Repeat times every sec.

Repeat option finished - 12/12 executed.

Left Jaw UP-IN UP-OUT DW-IN DW-OUT

Right jaw UP-IN UP-OUT DW-IN DW-OUT

Anti COLL UP DOWN

Positions readout from the low-level

Motor st...

Jaw edges

Left UP	1.395	Gap UP	2.39
Left DW	1.395	Gap DW	2.39
Right UP	-0.995	Centre UP	0.2
Right DW	-0.995	Centre DW	0.2

Display jaw: Left Jaw (dashed) Right jaw (solid)

Positions: Settings LVDT's Resolvers Motor steps

BLM: BLM 1 BLM 2 BLM 3 BLM 4 LogY

Beam loss data [01/11/06 03:44:06]

LHC-type BLM at SS5

Beam loss signal [a.u.]

03:40:30 03:41:00 03:41:30 03:42:00 03:42:30 03:43:00 03:43:30 03:44:00

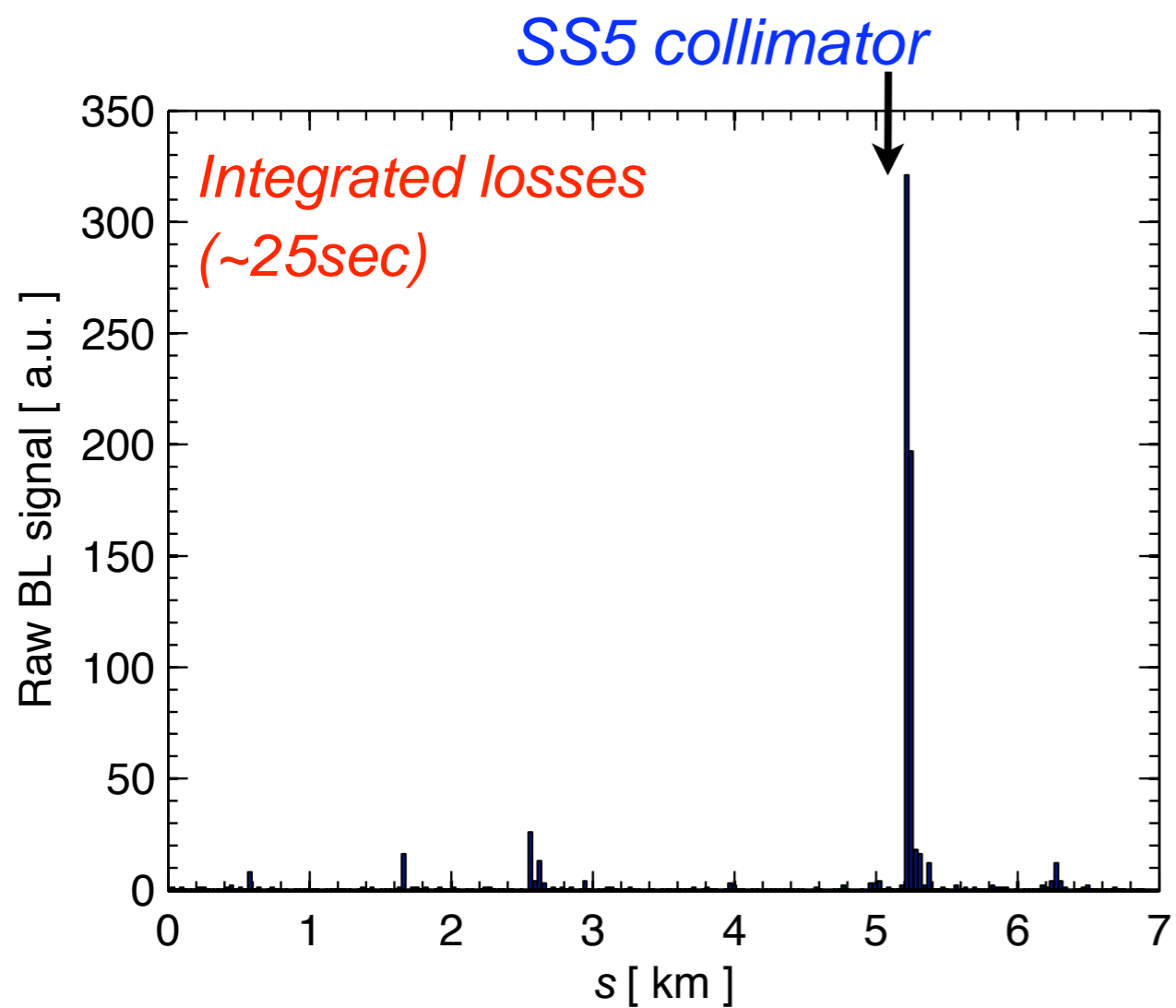
Jaw positions [01/11/06 03:44:06]

Jaw positions [mm]

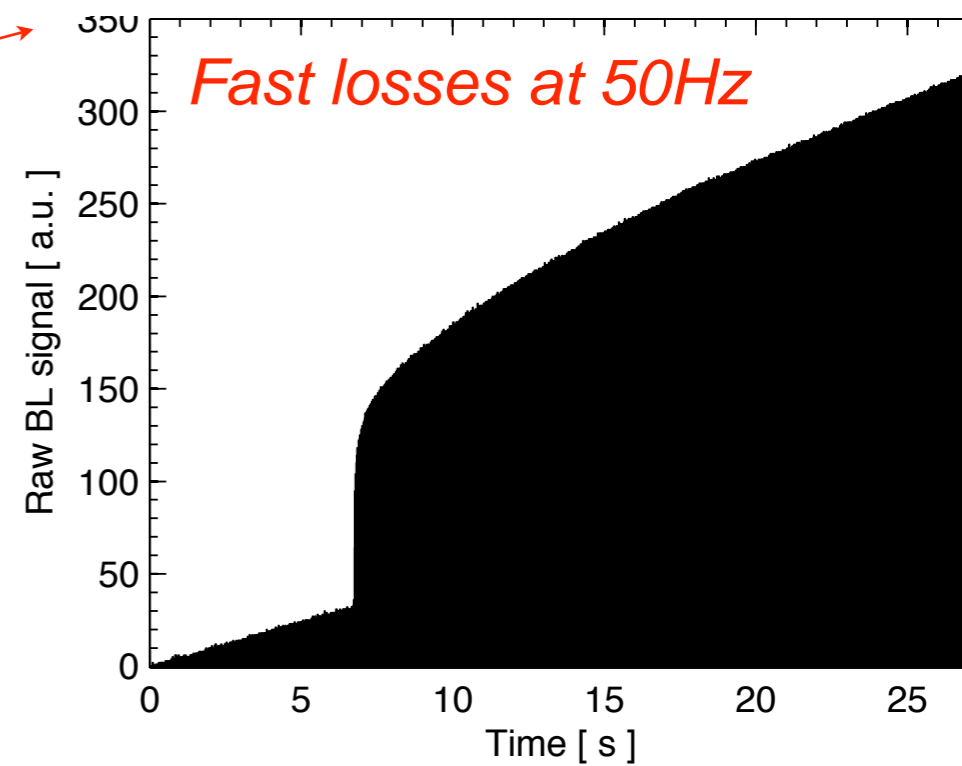
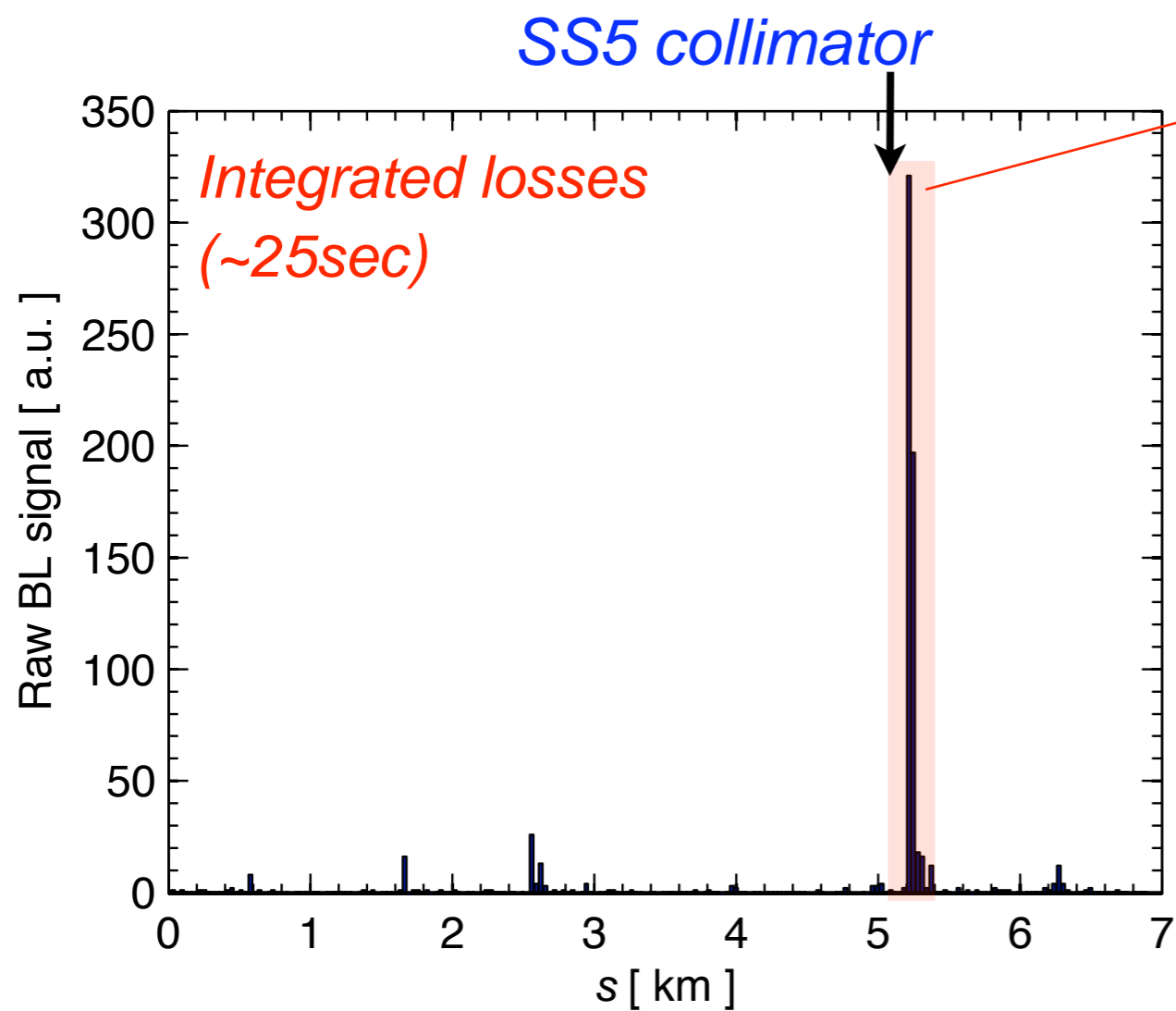
time [hh:mm:ss]

On-line monitoring of jaw positions

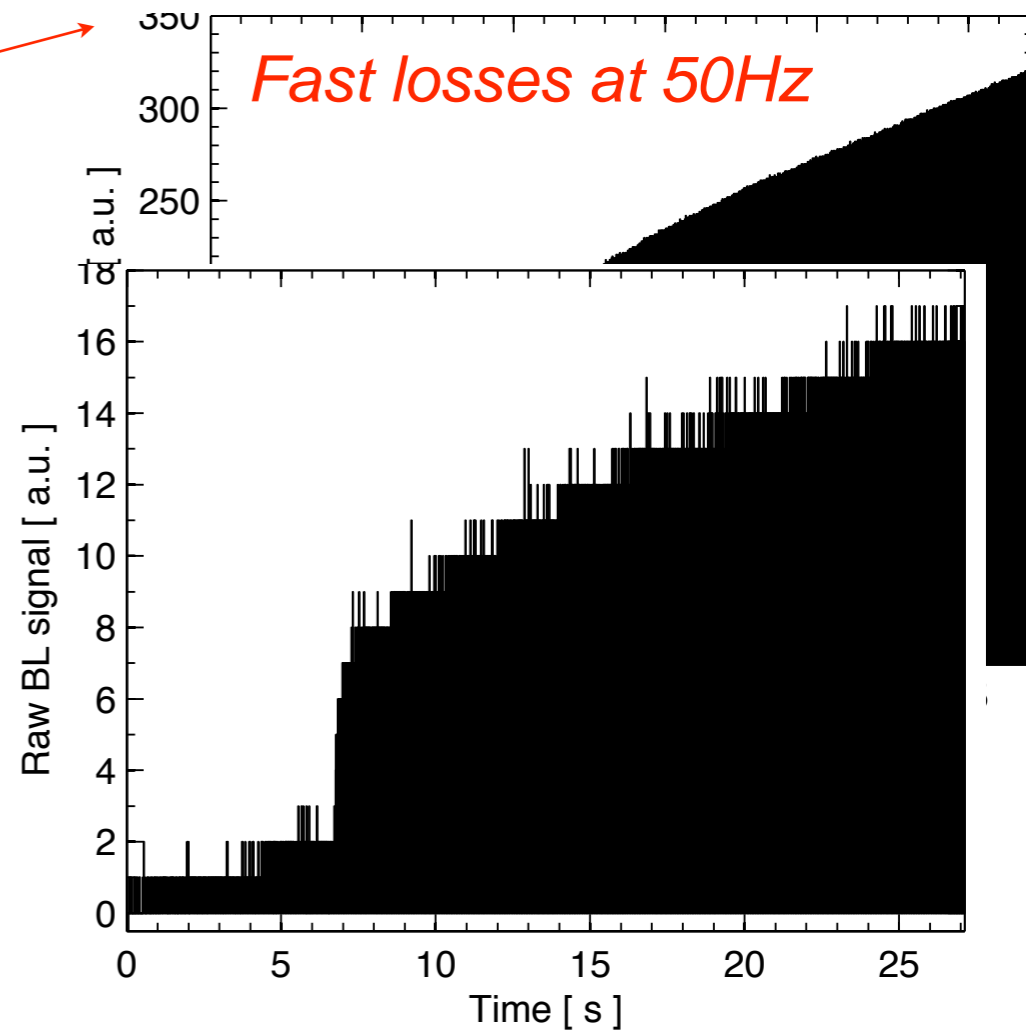
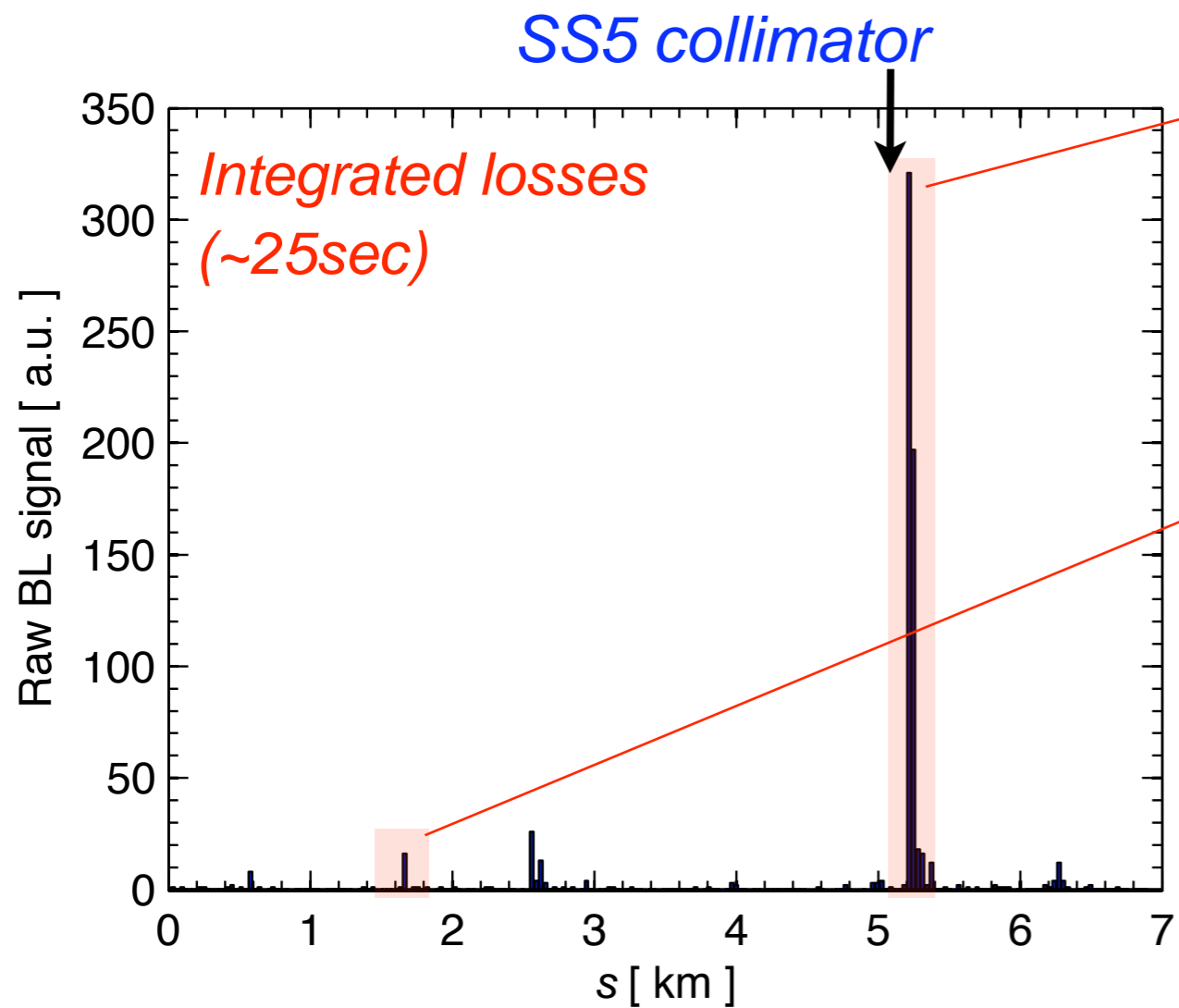
Beam loss monitoring around the ring



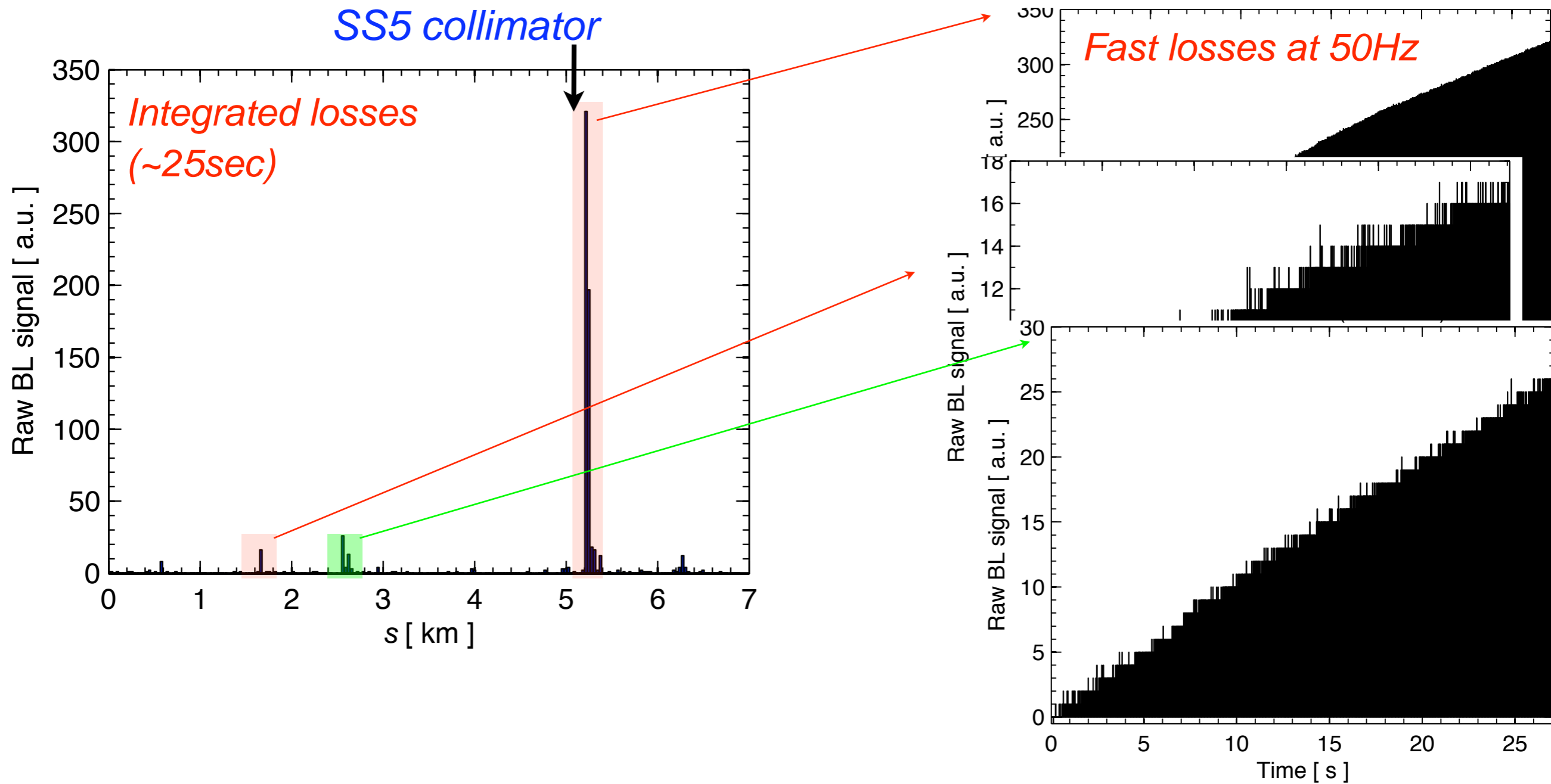
Beam loss monitoring around the ring



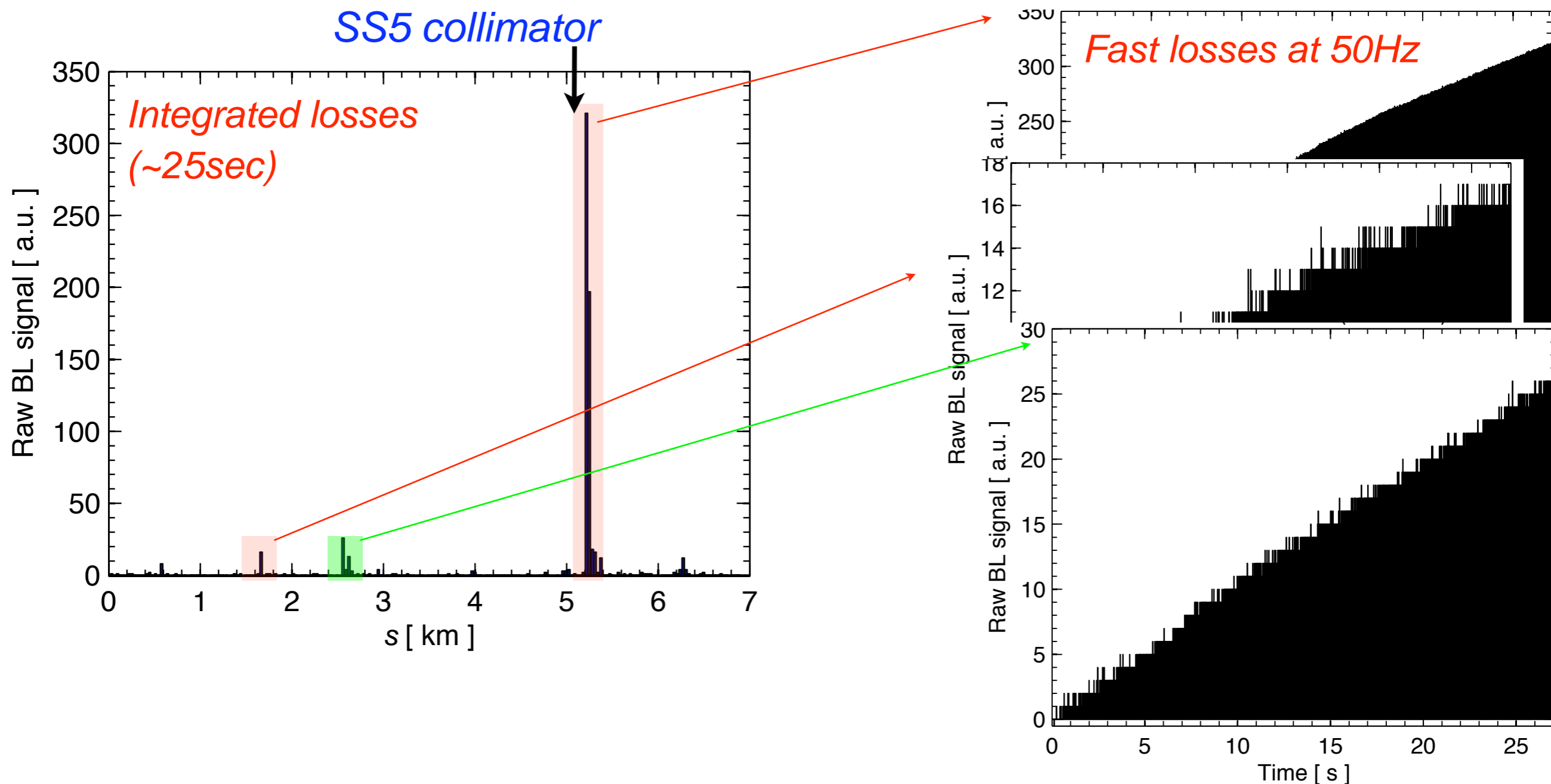
Beam loss monitoring around the ring



Beam loss monitoring around the ring

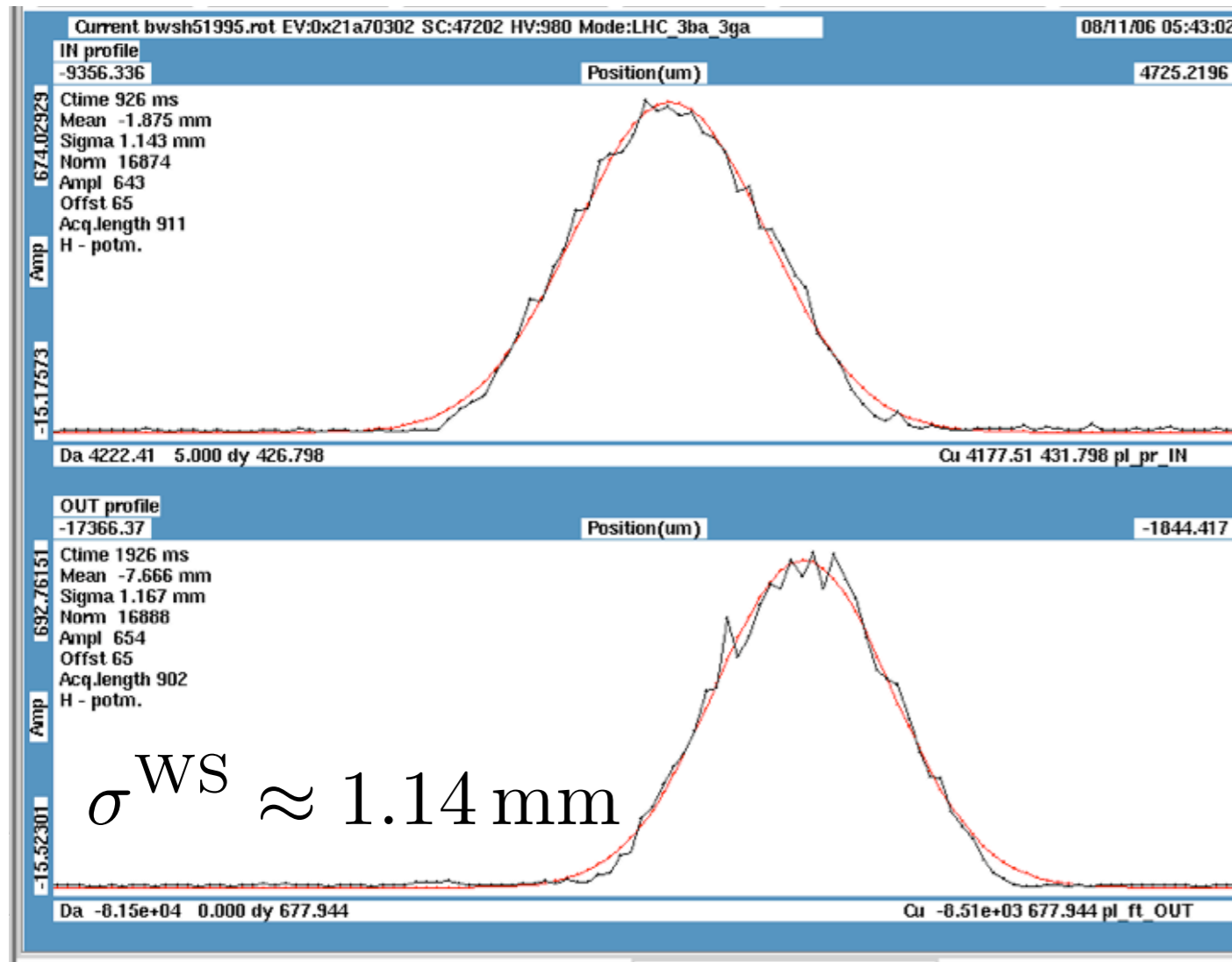


Beam loss monitoring around the ring



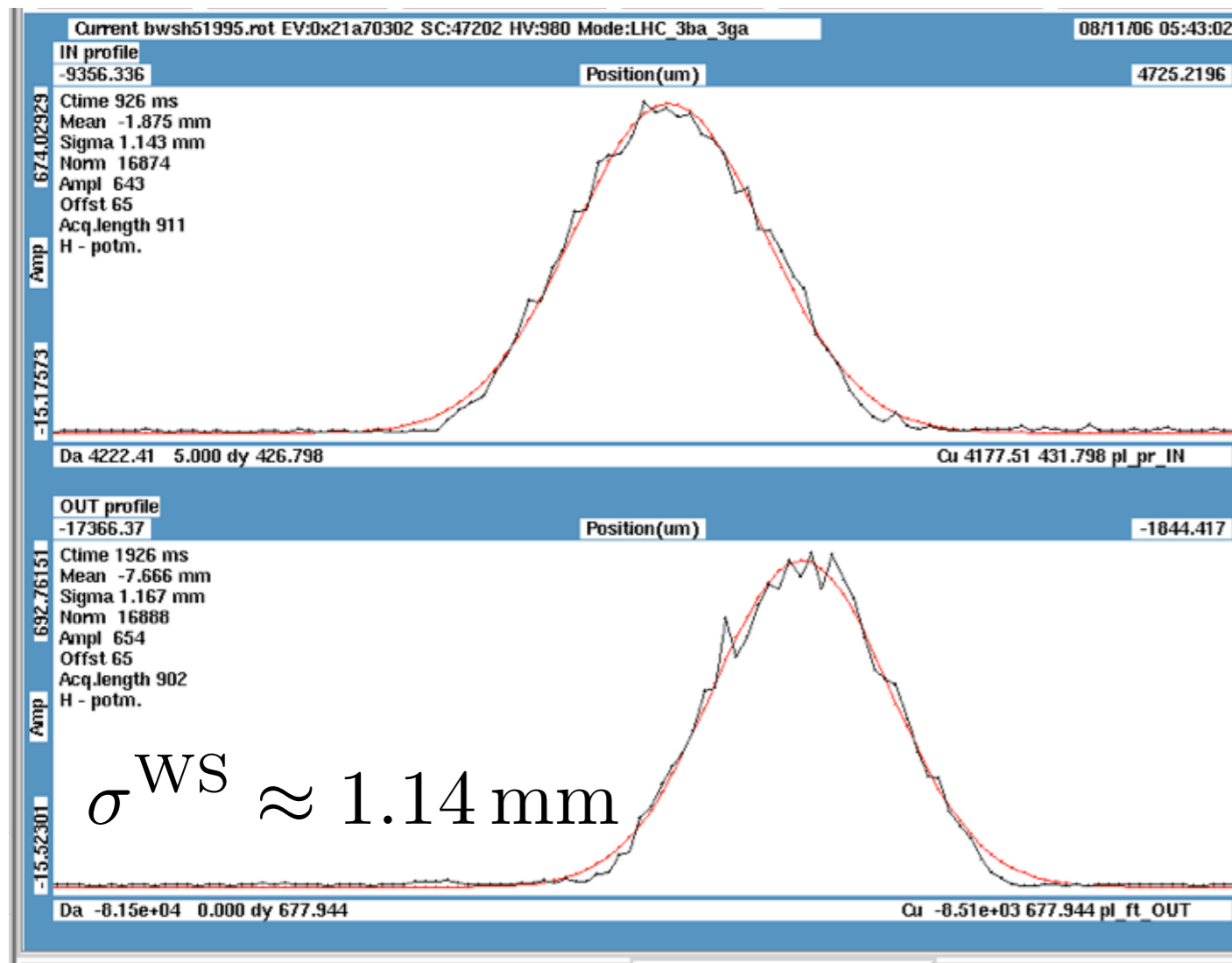
- **Faster acquisition** will allow **more detailed comparisons with simulations**
- Collaboration with LHC-ion team for benchmarking of ICOSIM (R. Bruce)
- More studies for losses with **non-linear bumps** (with R. Tomás, J. Resta Lopez)

Beam profile measurements

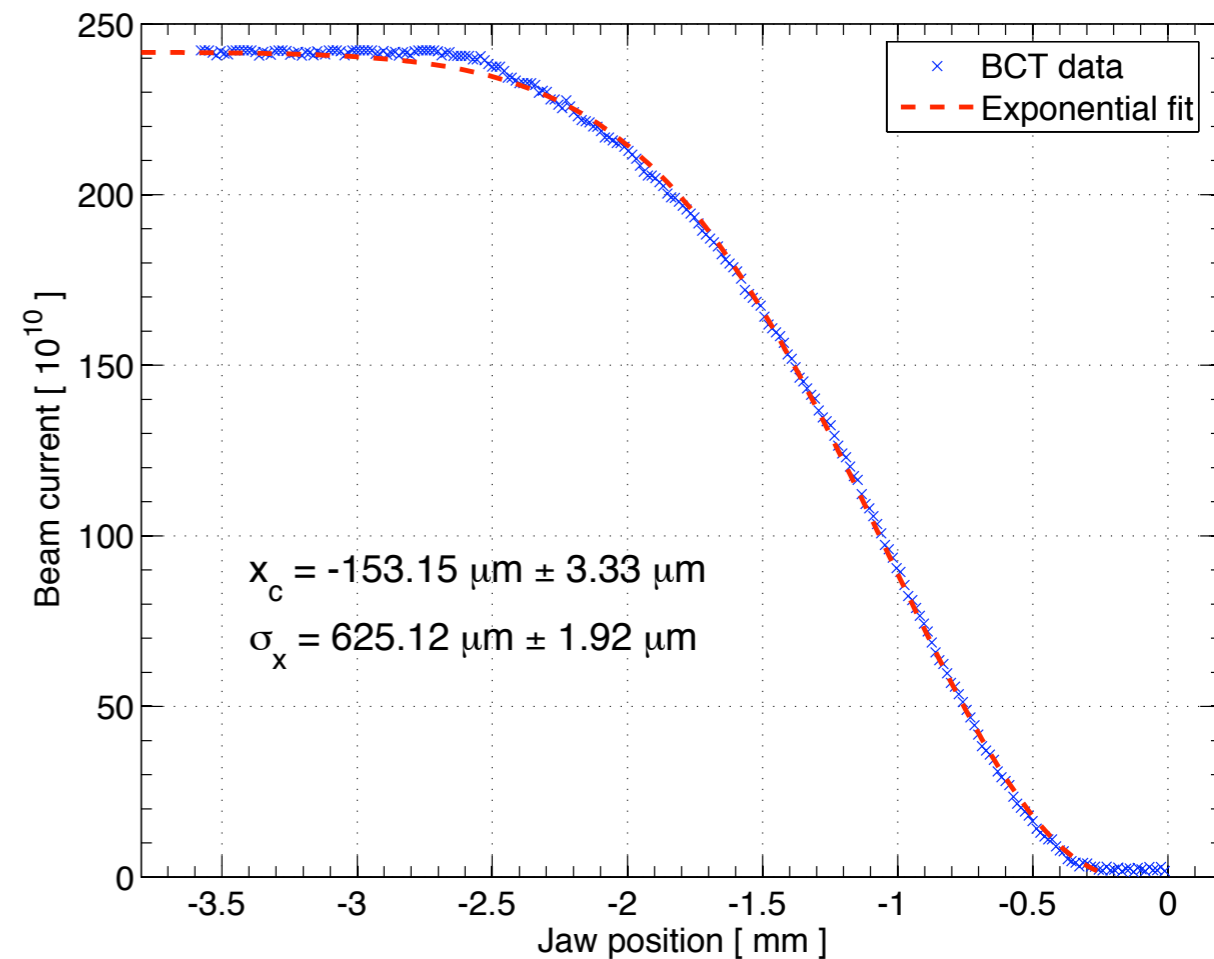


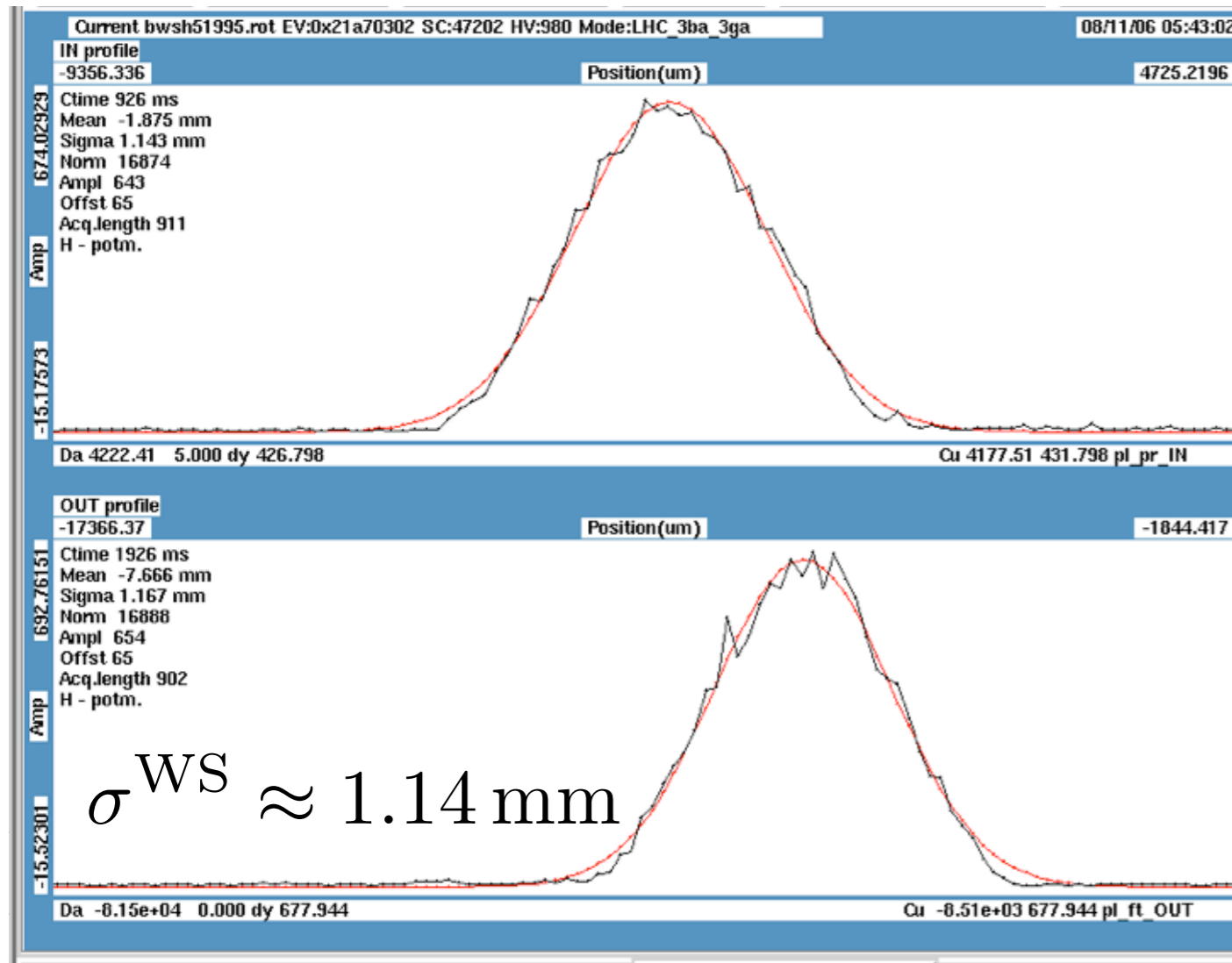
$$\sigma^{\text{Coll}} = \sqrt{\frac{24.9}{85.5}} \times \sigma^{\text{WS}} = 617 \mu\text{m}$$

Beam profile measurements

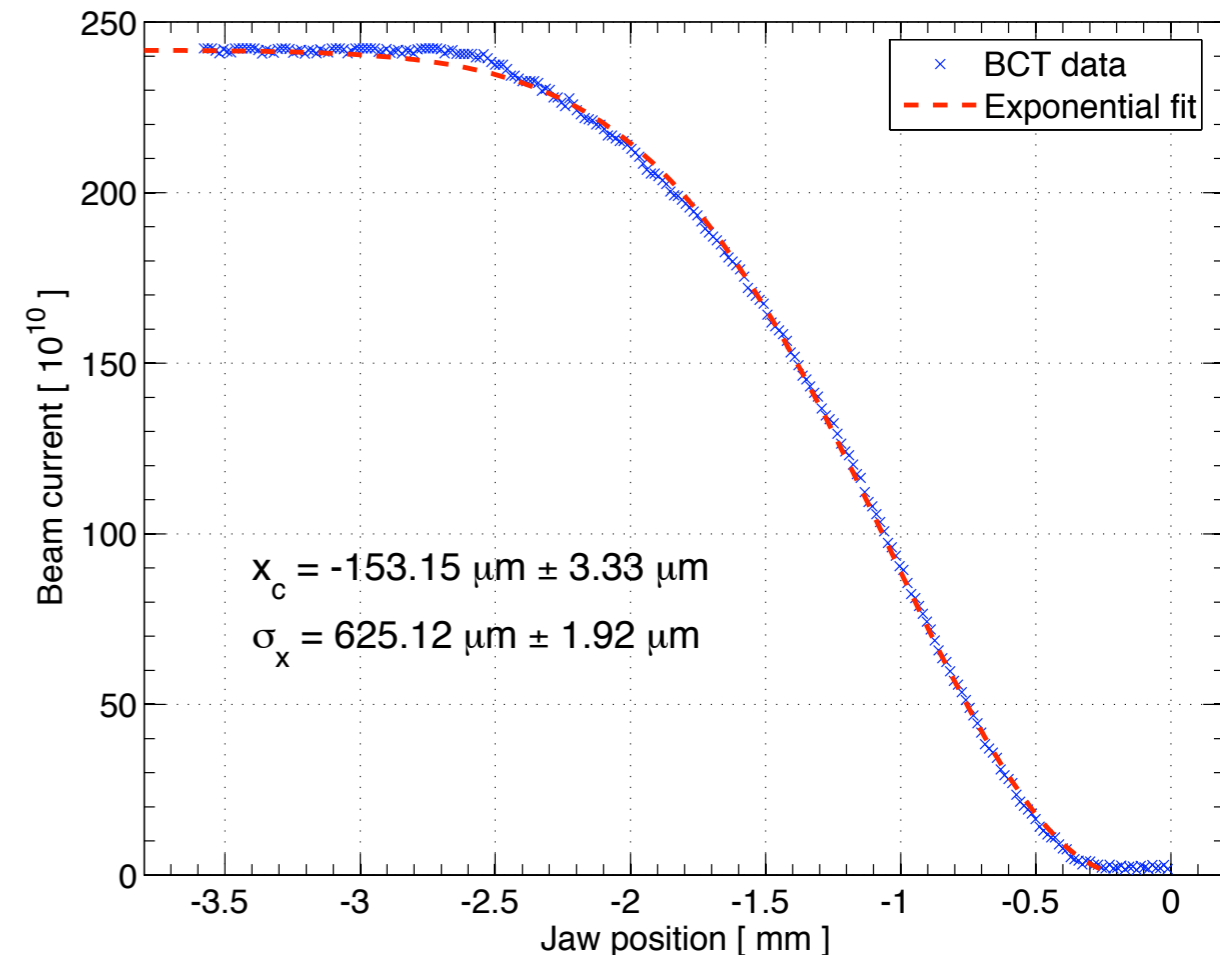


$$\sigma^{Coll} = \sqrt{\frac{24.9}{85.5}} \times \sigma^{WS} = 617 \mu\text{m}$$



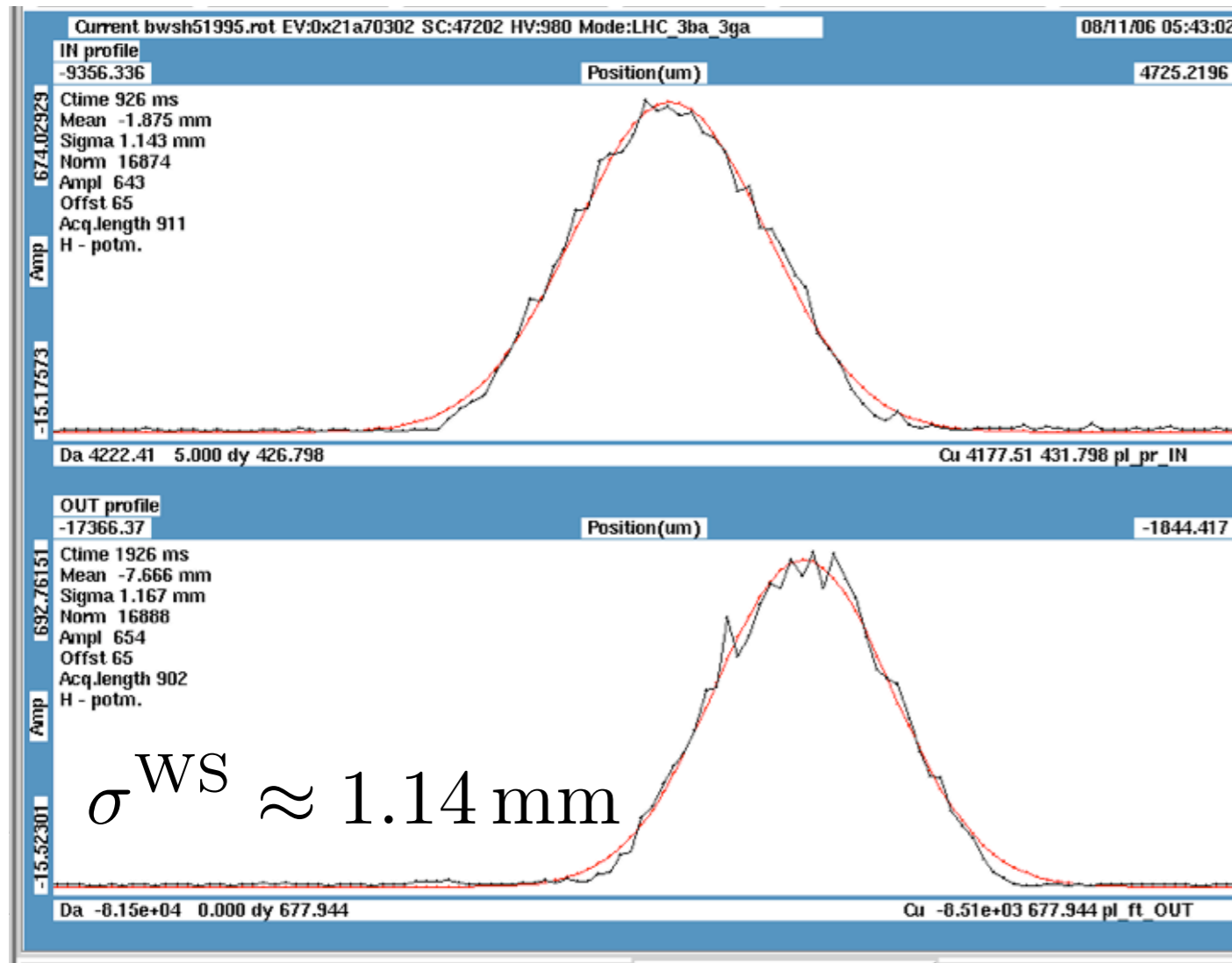


$$\sigma^{\text{Coll}} = \sqrt{\frac{24.9}{85.5}} \times \sigma^{\text{WS}} = 617 \mu\text{m}$$

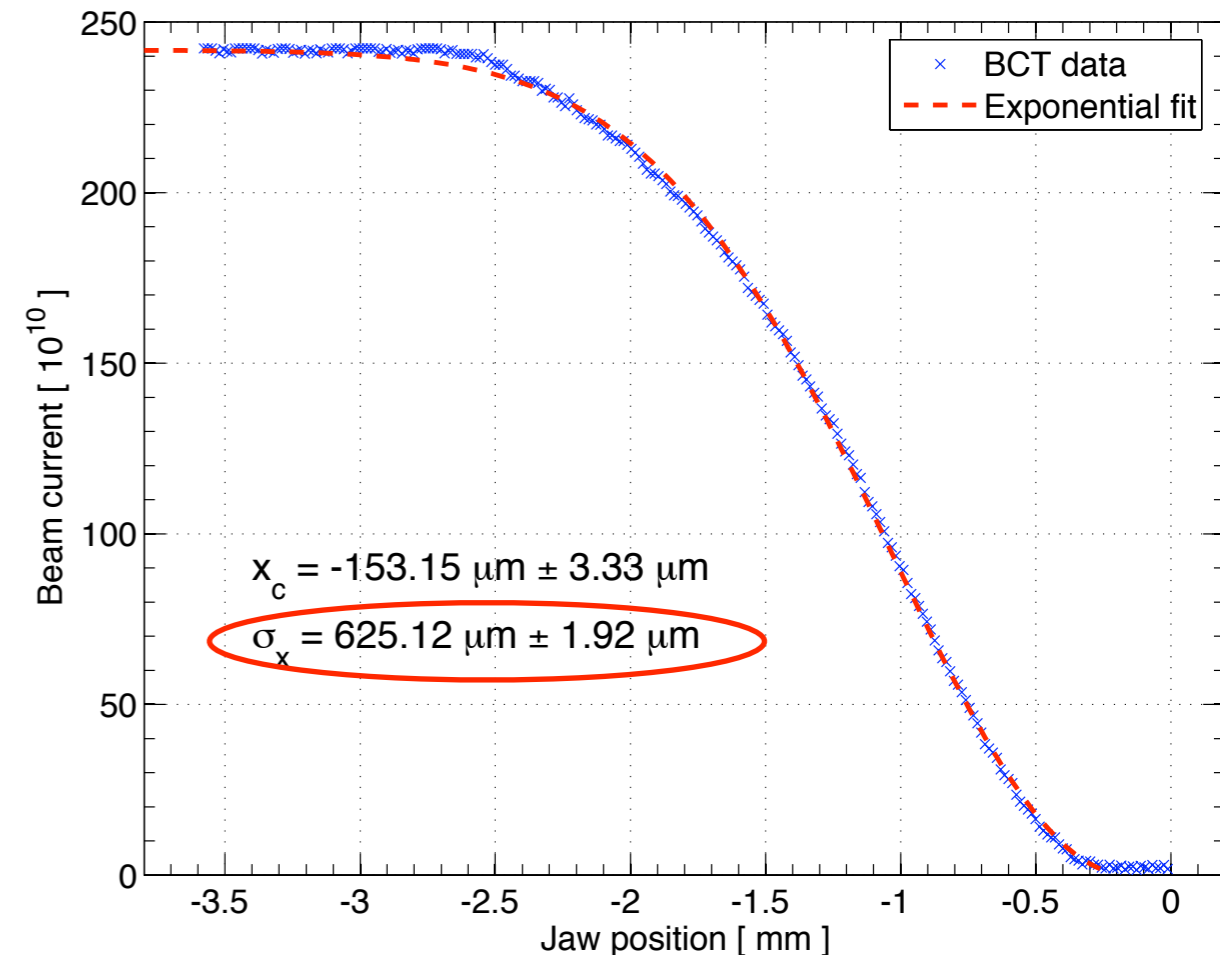


- **Fast** beam current measurements (100 Hz) **compared to wire measurements**
- Get beam size and centre \Rightarrow **Assessment of beam based alignment!**

(see talk by T. Weiler + SR at LCWG of Jan. 2005)



$$\sigma^{Coll} = \sqrt{\frac{24.9}{85.5}} \times \sigma^{WS} = 617 \mu\text{m}$$

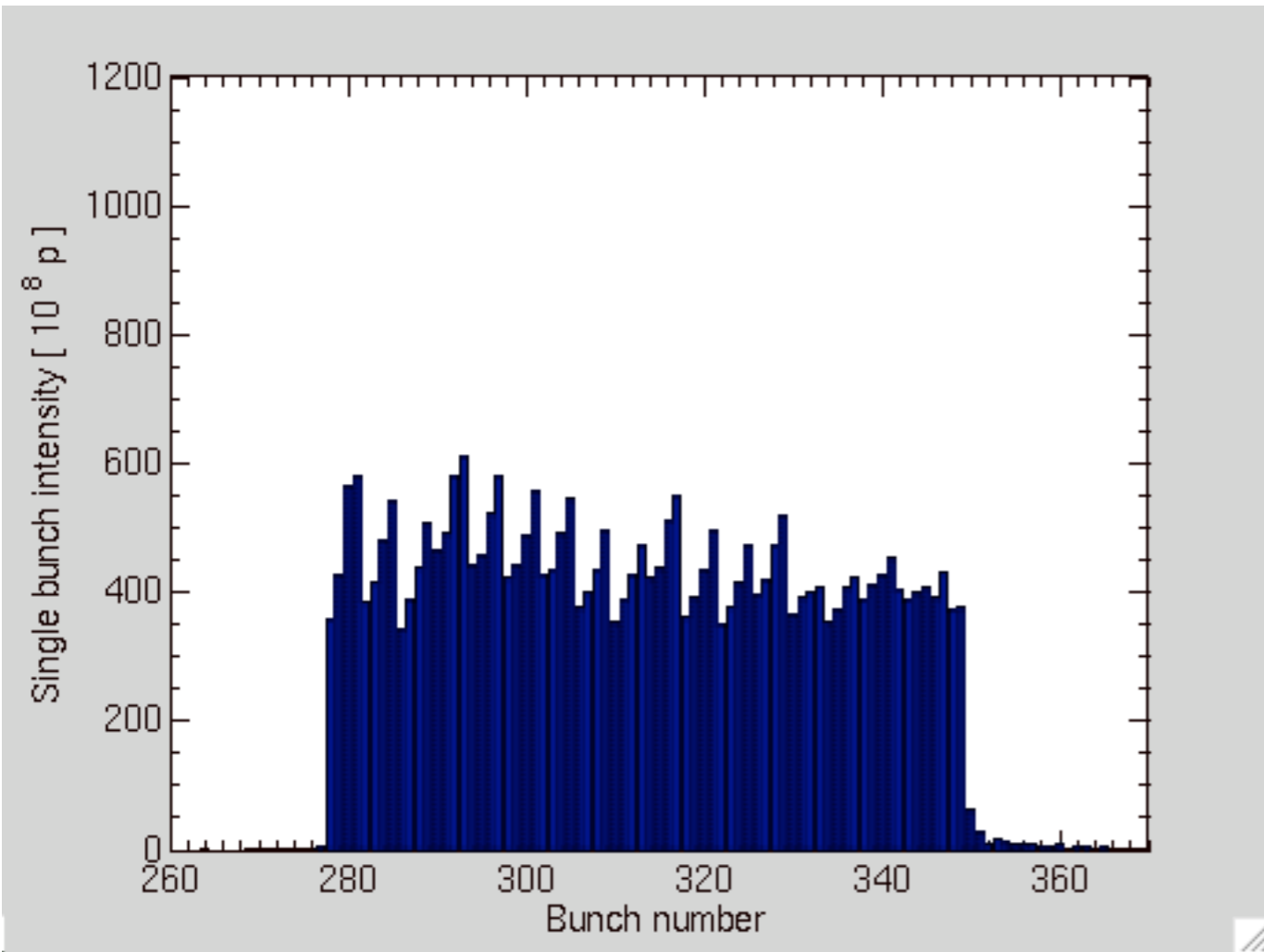
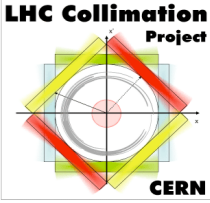


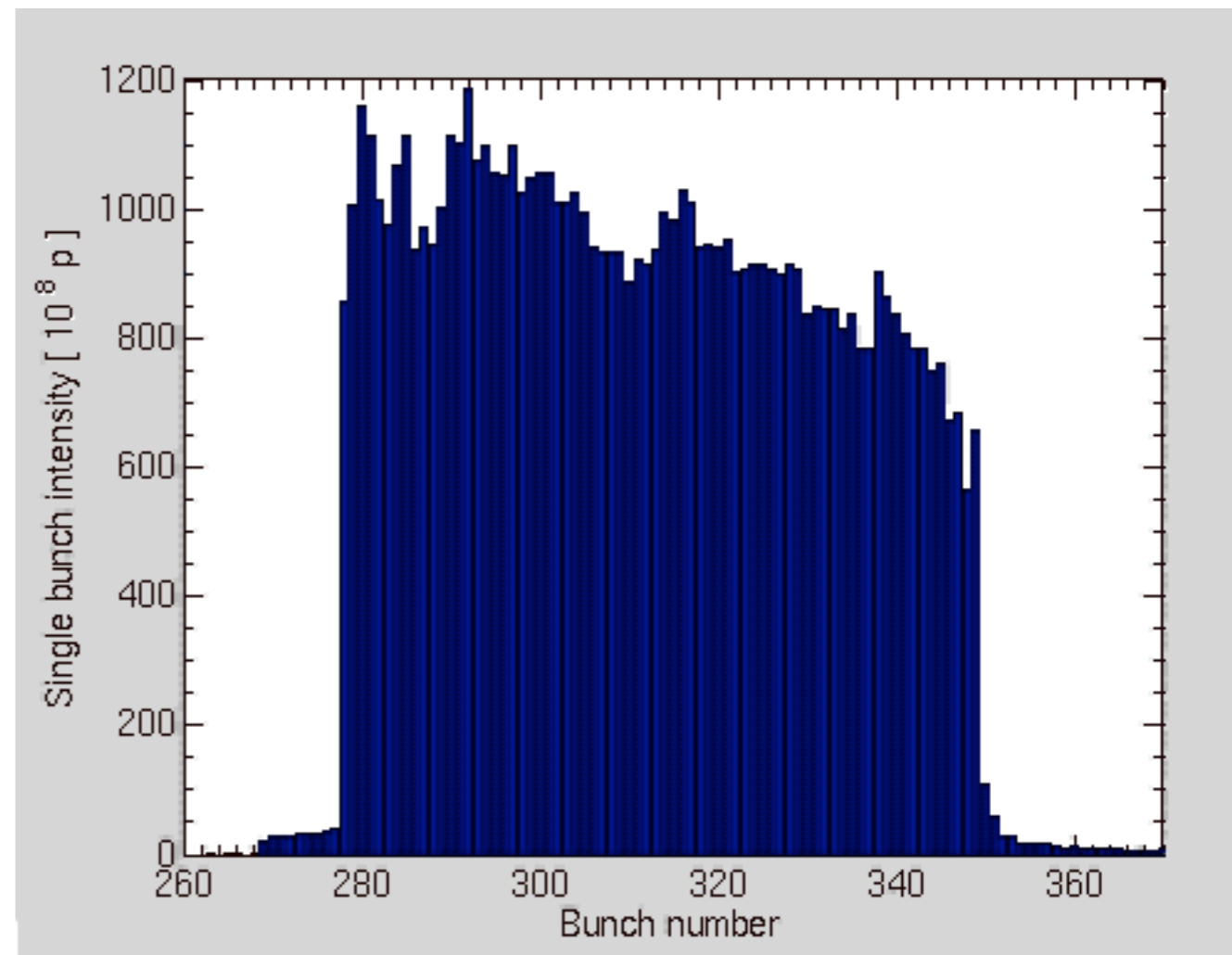
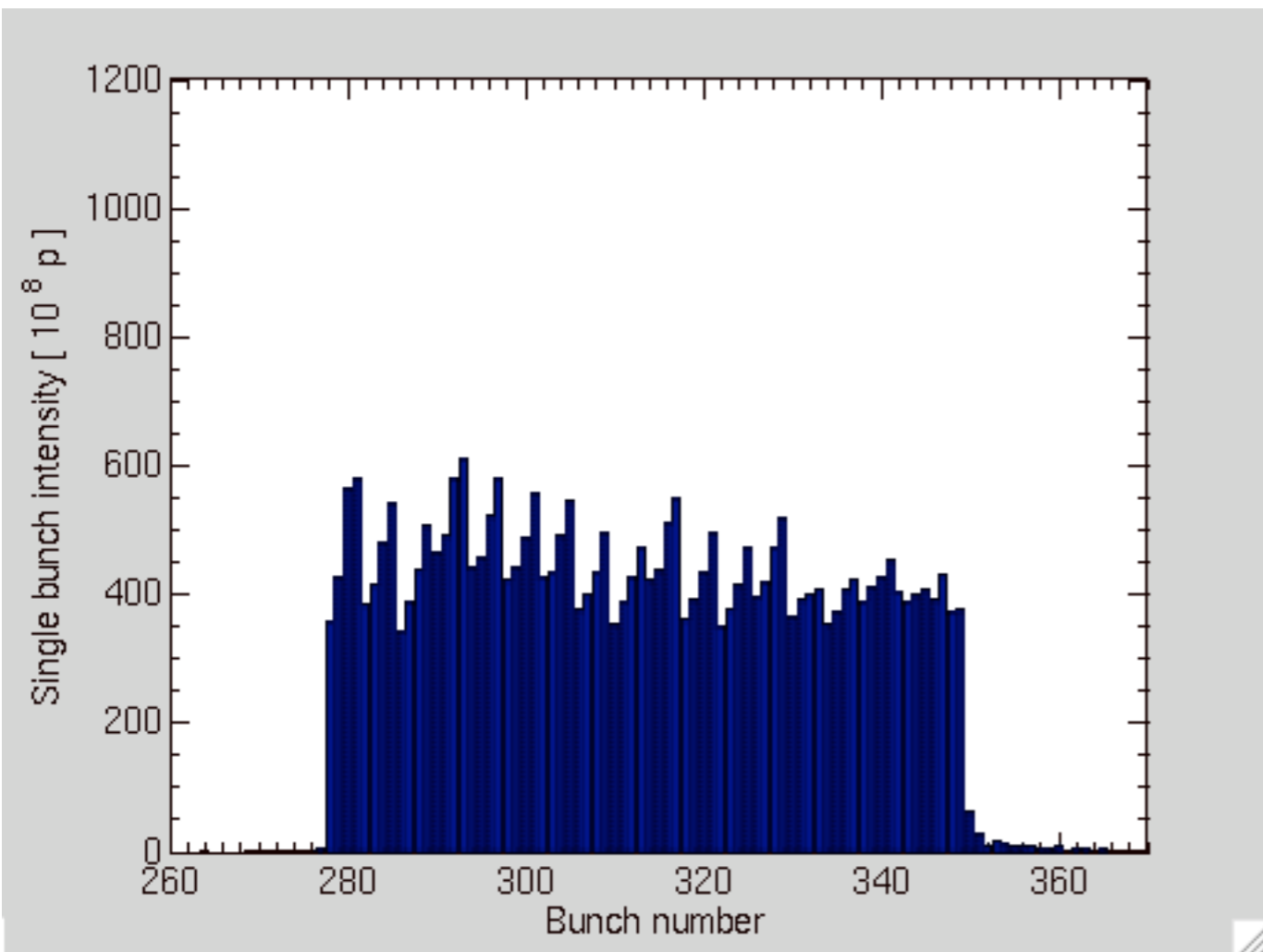
- **Fast** beam current measurements (100 Hz) **compared to wire measurements**
- Get beam size and centre \Rightarrow **Assessment of beam based alignment!**

(see talk by T. Weiler + SR at LCWG of Jan. 2005)



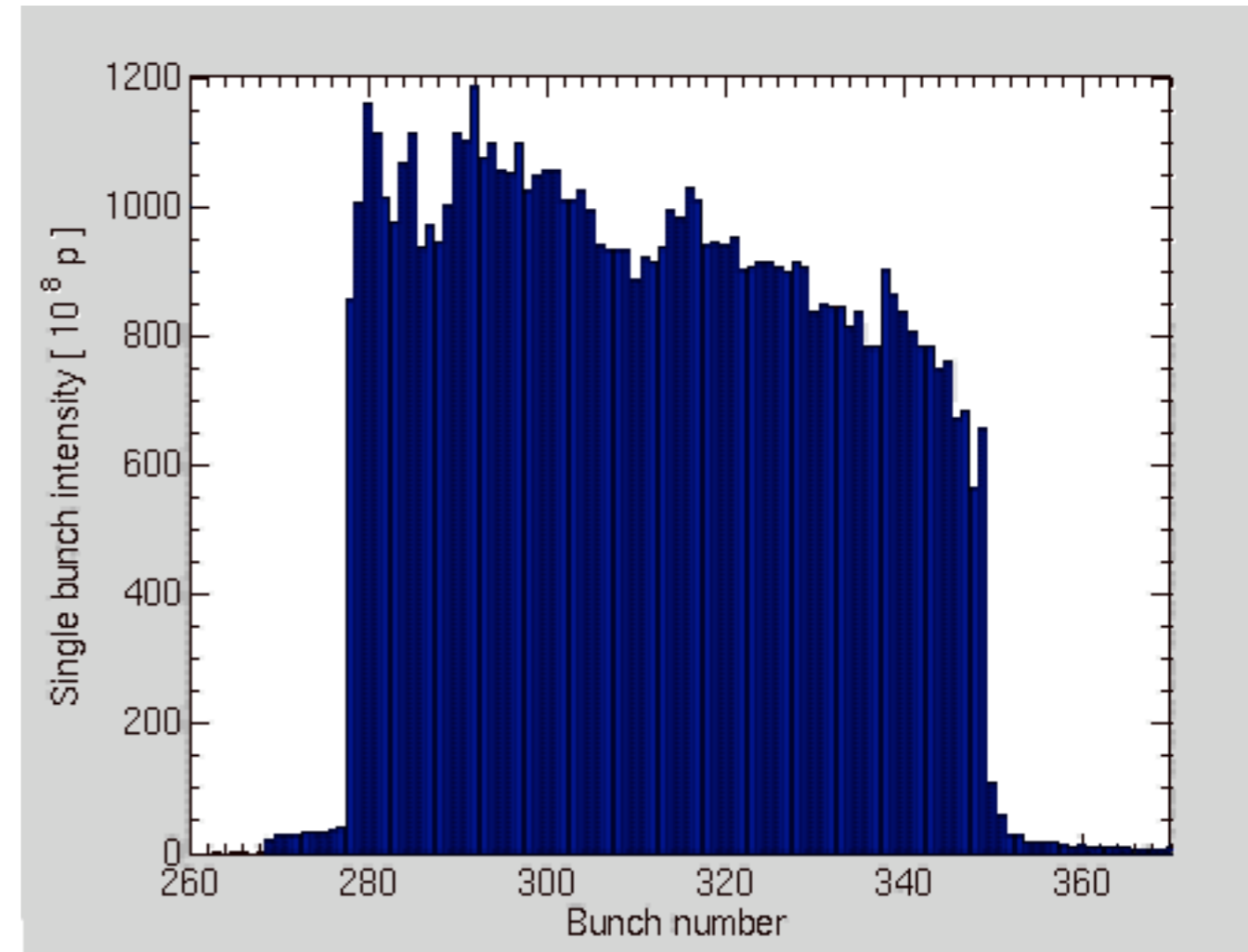
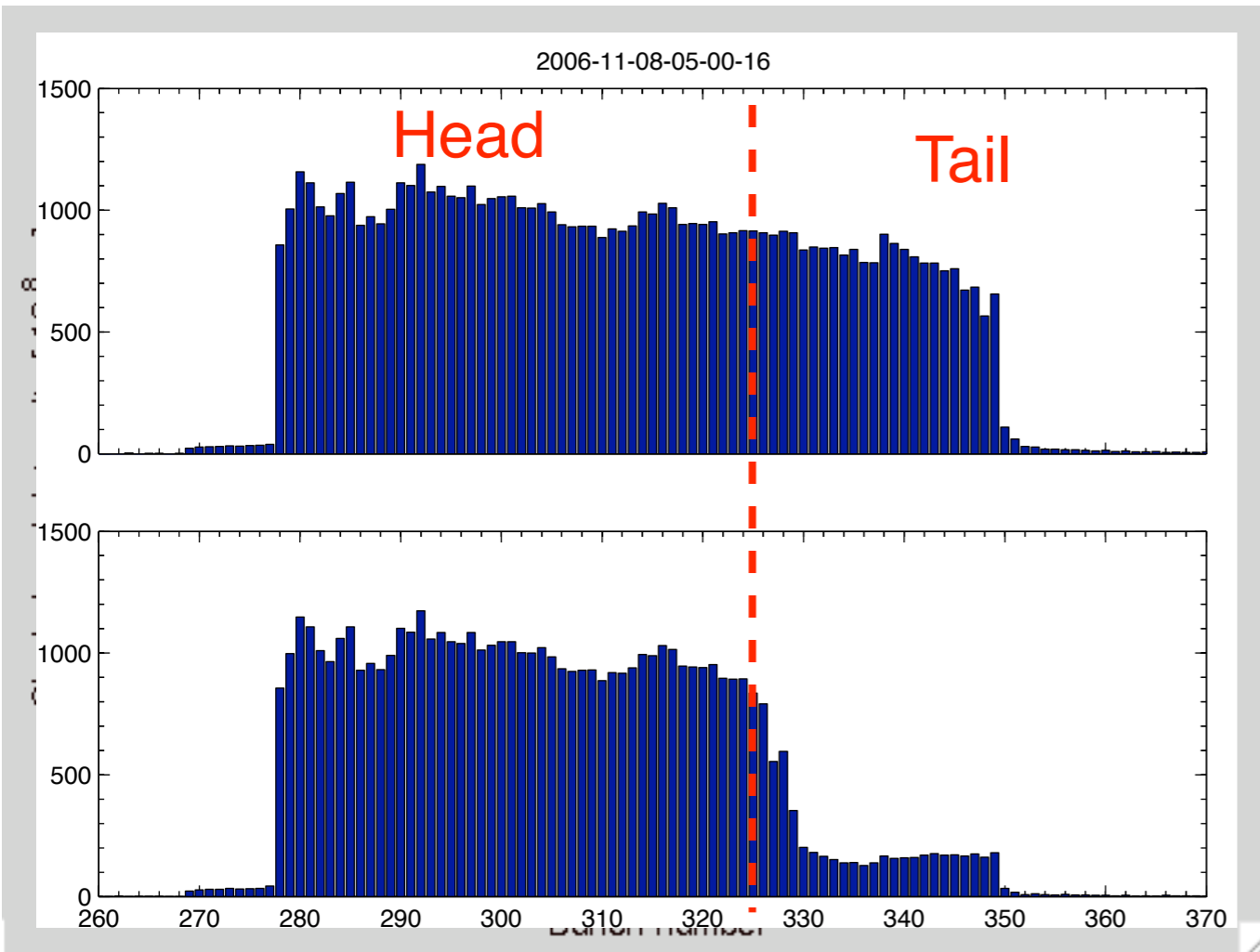
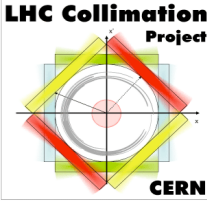
Bunch-by-bunch current measurements

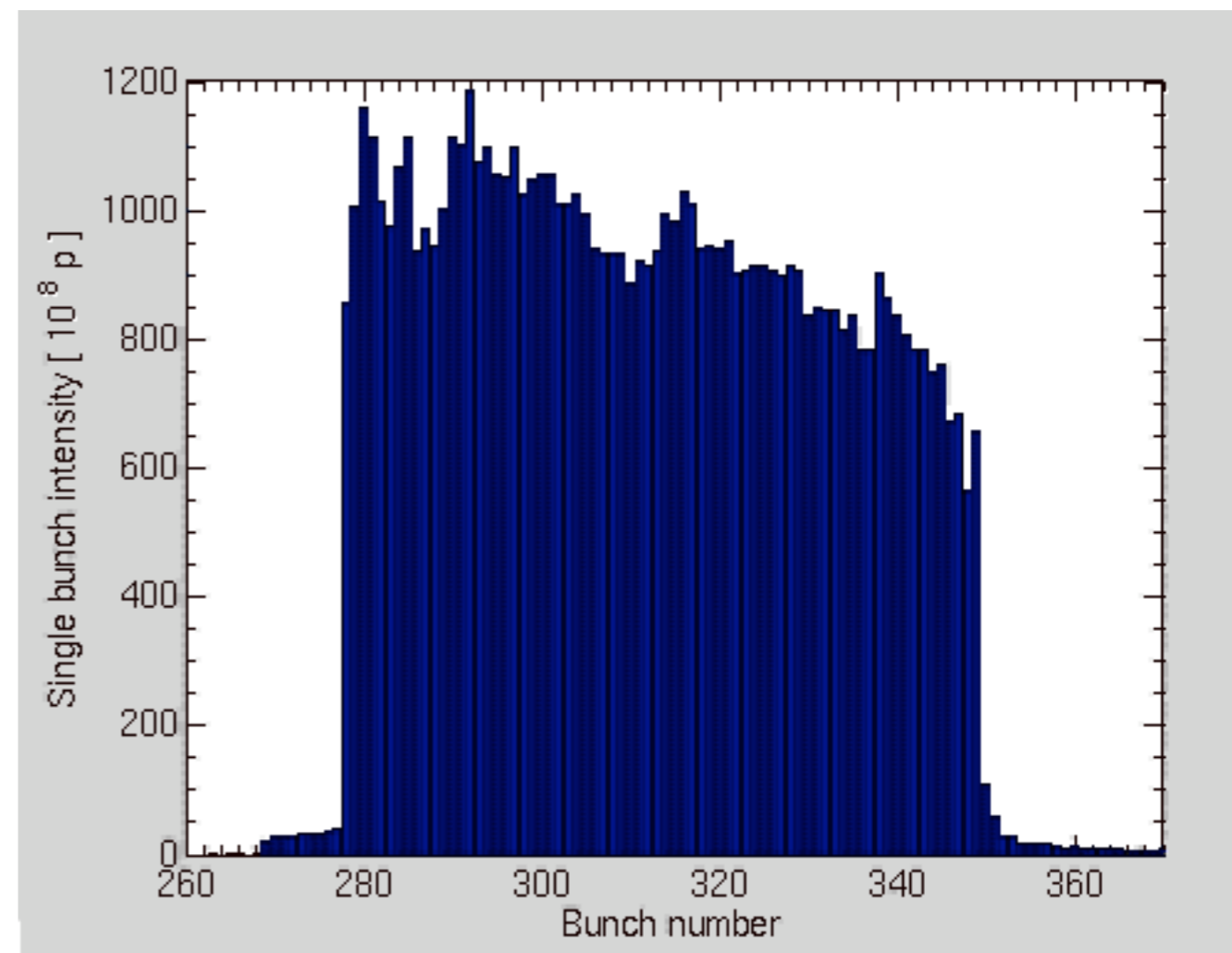
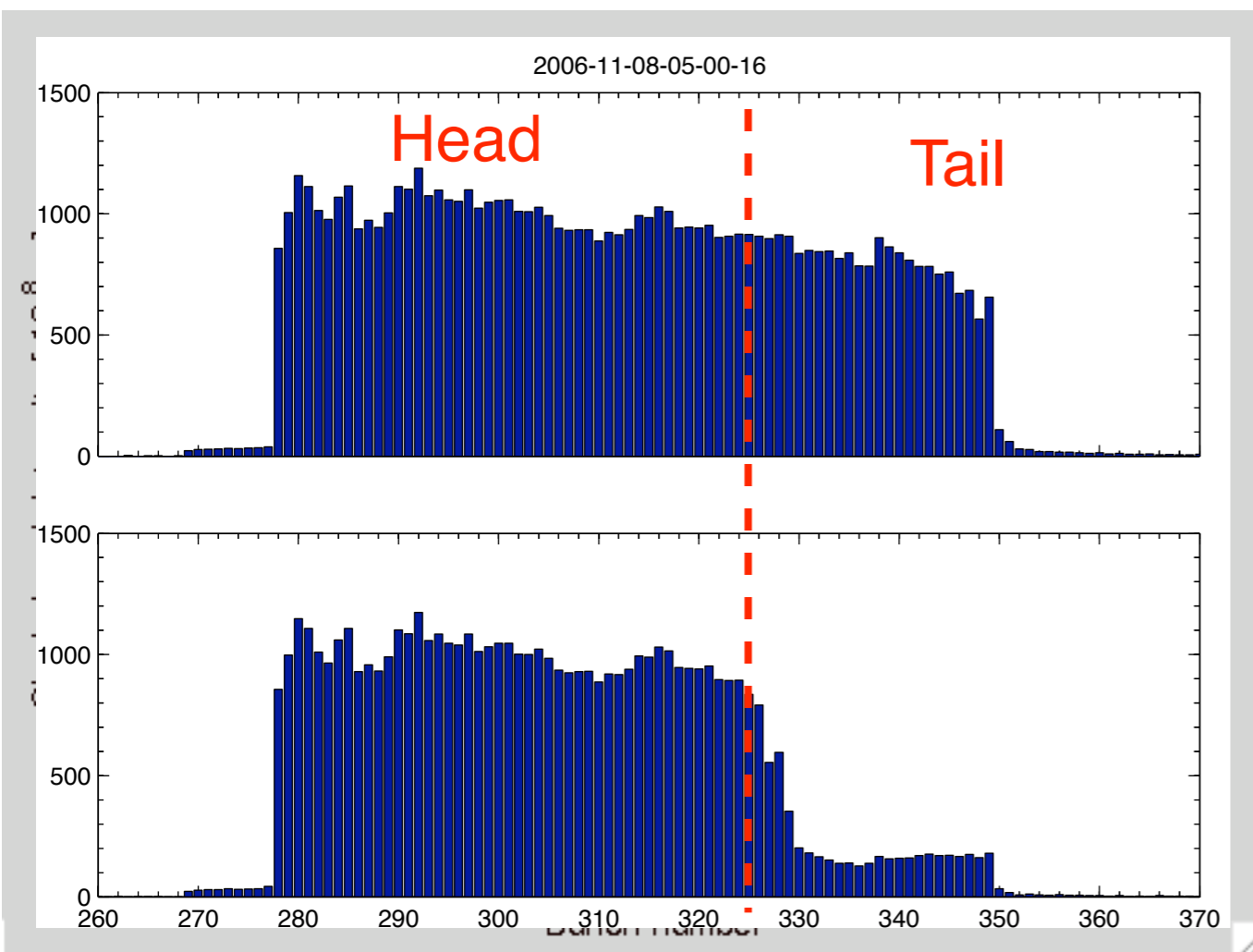






Bunch-by-bunch current measurements





- **PRELIMINARY** results from studies of beam instability from chromaticity + gap changes. Bunch tail **ONLY** is affected by collimator jaws!?
- **Require more detailed studies** (synchronization to collimator movement, value of chromaticity, ...)
- Fast current data available for both MD!

- ☑ Collimator tests with beam were very **successful!**
 - Basic goals have been achieved!
 - More details in the next presentations...

- ☑ **Beam measurements** significantly improved w. r. to 2004!
 - Main beam parameters systematically monitored
(Beam size (WS), beam current, beam centre during scraping, ...)

Slow and **fast** beam loss monitoring around the ring!

Fast beam current measurements, potentially interesting
for impedance studies?

- ☑ A lot of data is available to have fun during the shutdown!