LHC Beam Operation Committee meeting

March 27th, 2012

CERN, Geneva, Switzerland

2012 LHC aperture measurements
Preliminary results

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Introduction

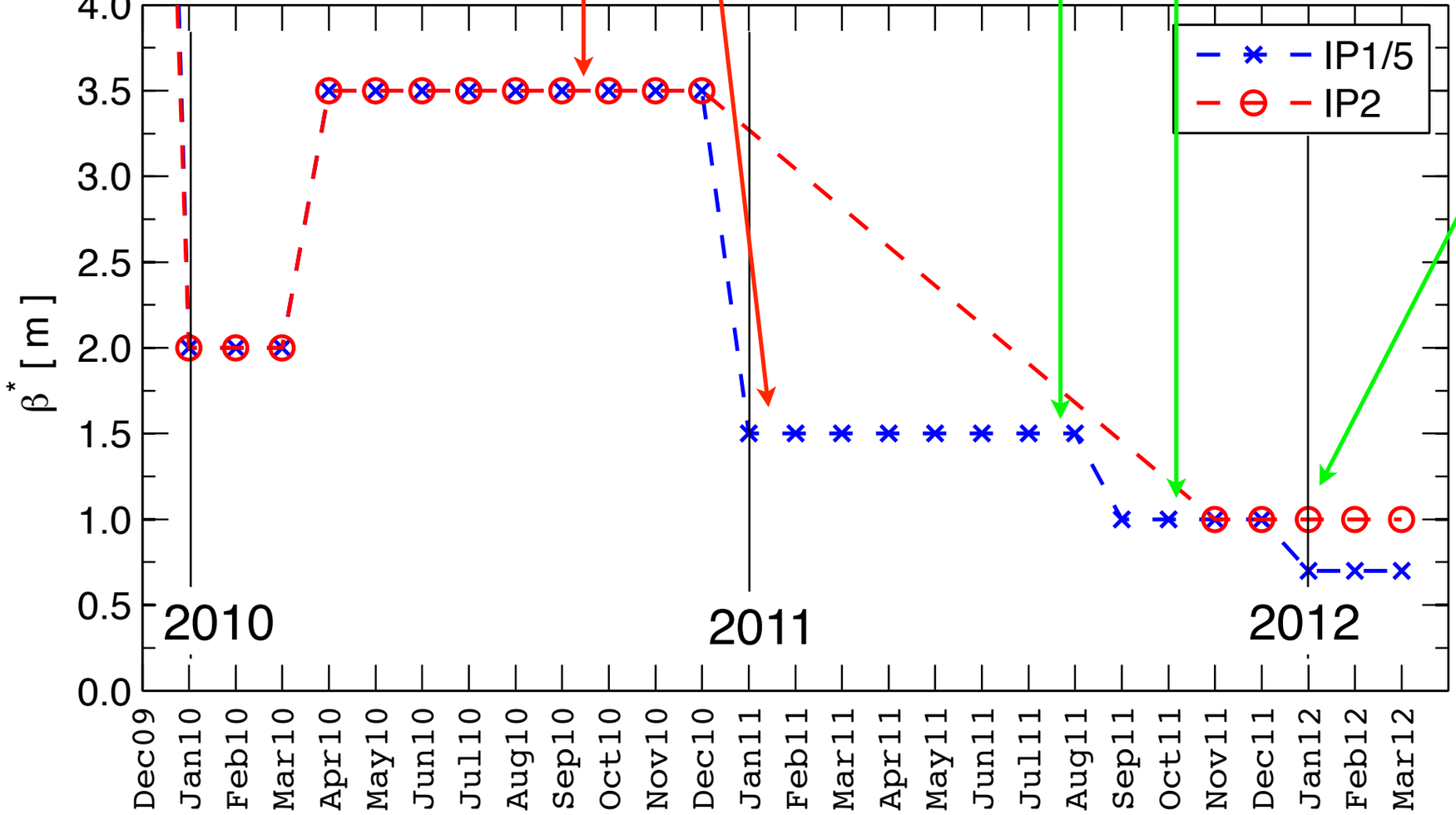
Initial 450 GeV measurements

MQX aperture at 450 GeV

IR1/5 aperture at 3.5 TeV

IR2 aperture at 3.5 TeV

2012 β* must also rely on aperture measurements!

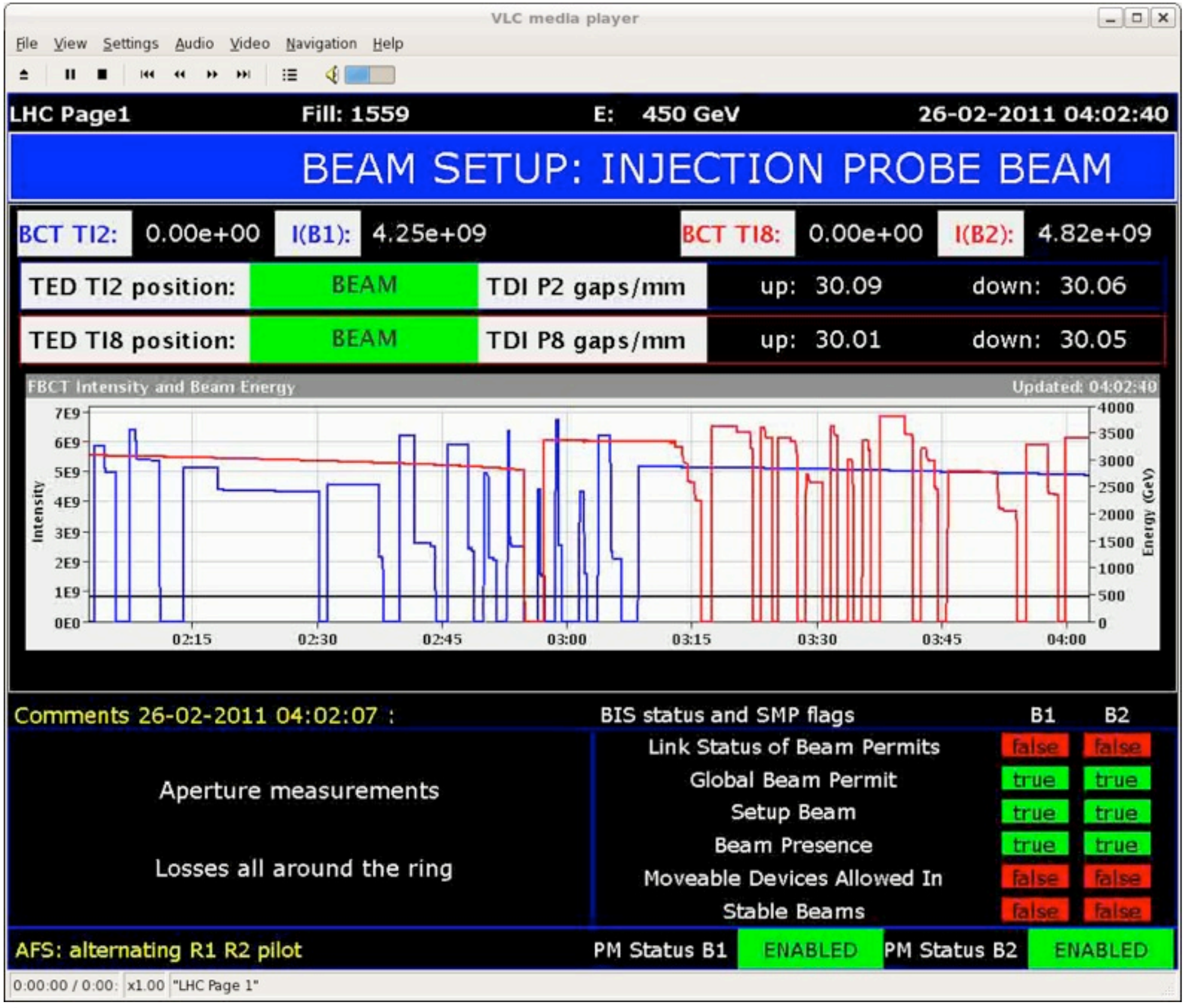


Aperture measurements crucial for the determination of beam-based performance reach! High pressure in 2012 to address the feasibility of 60 β.*

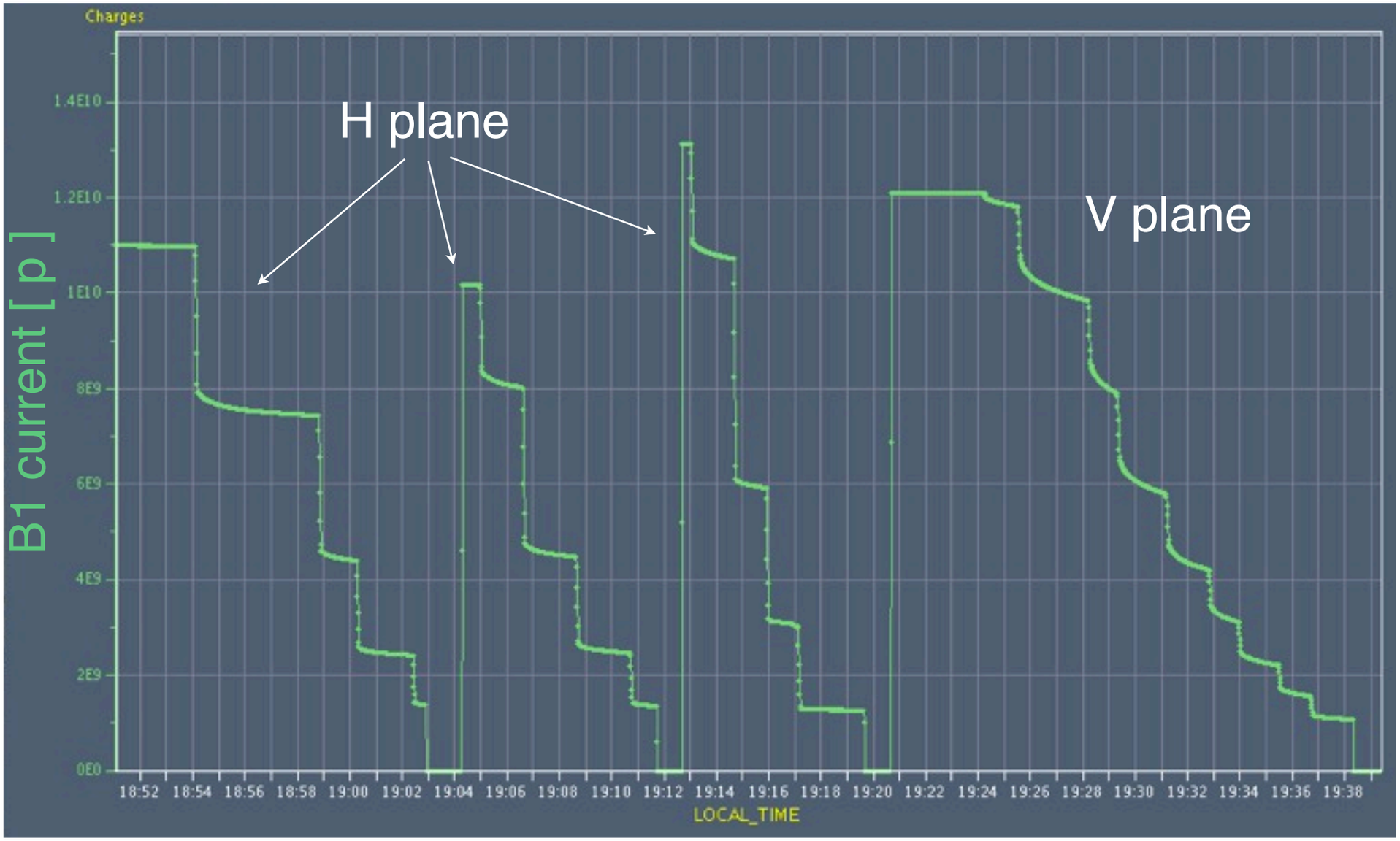
Outline

- ☑ Introduction
- ☑ Aperture at injection
- ☑ Aperture at 4 TeV, 60 cm
- ☑ Conclusions

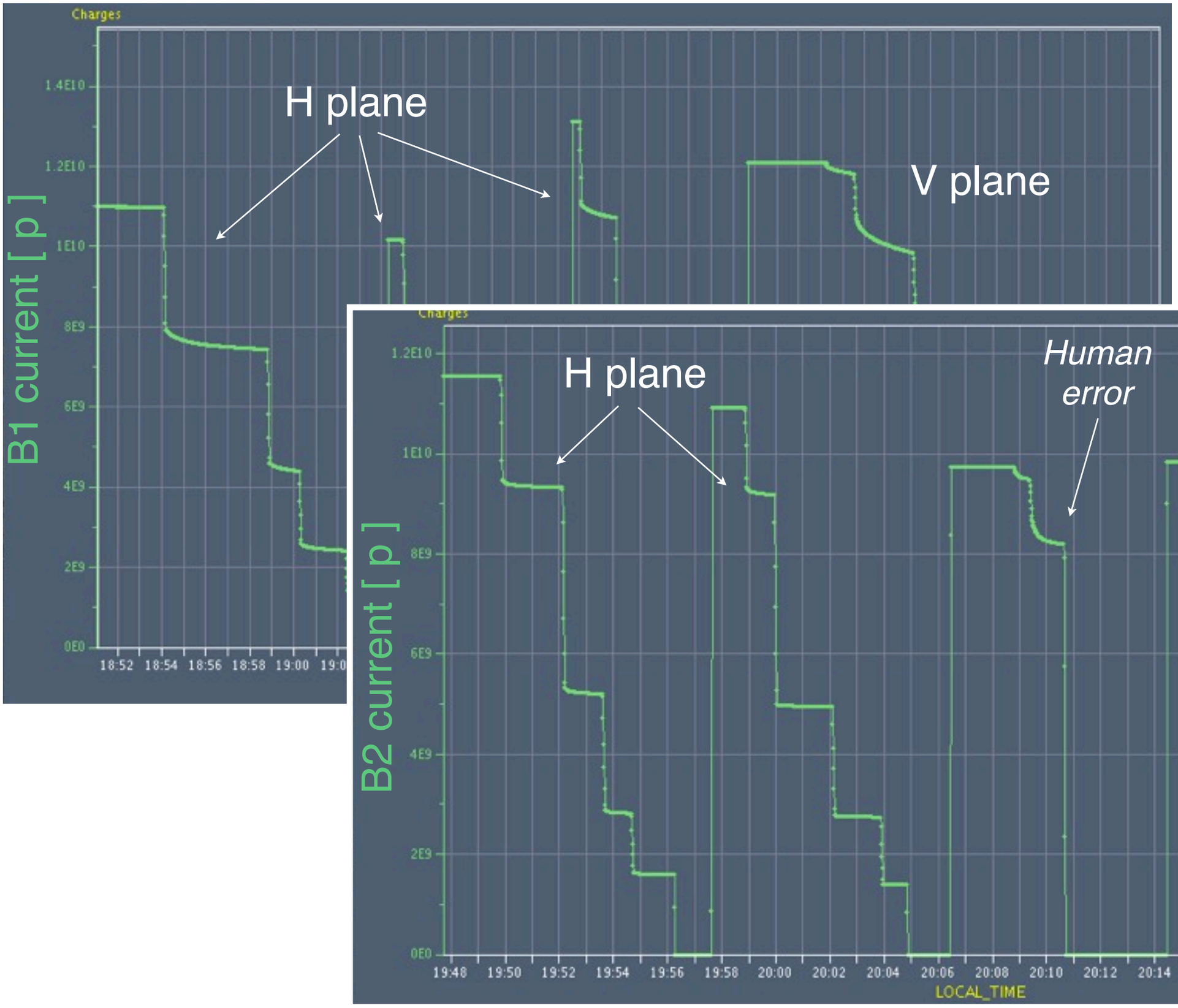
2011 aperture measurements



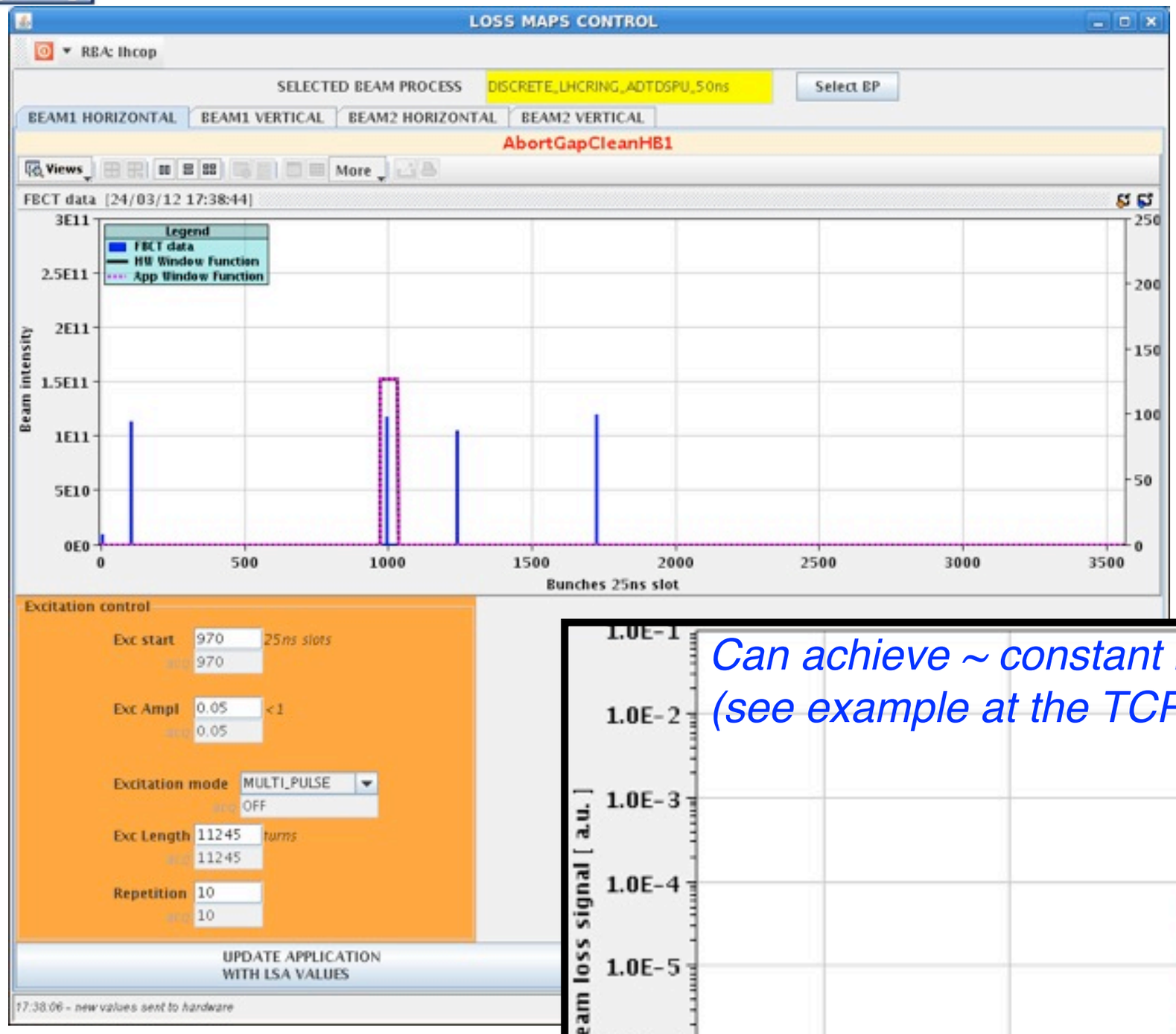
2012 aperture measurements



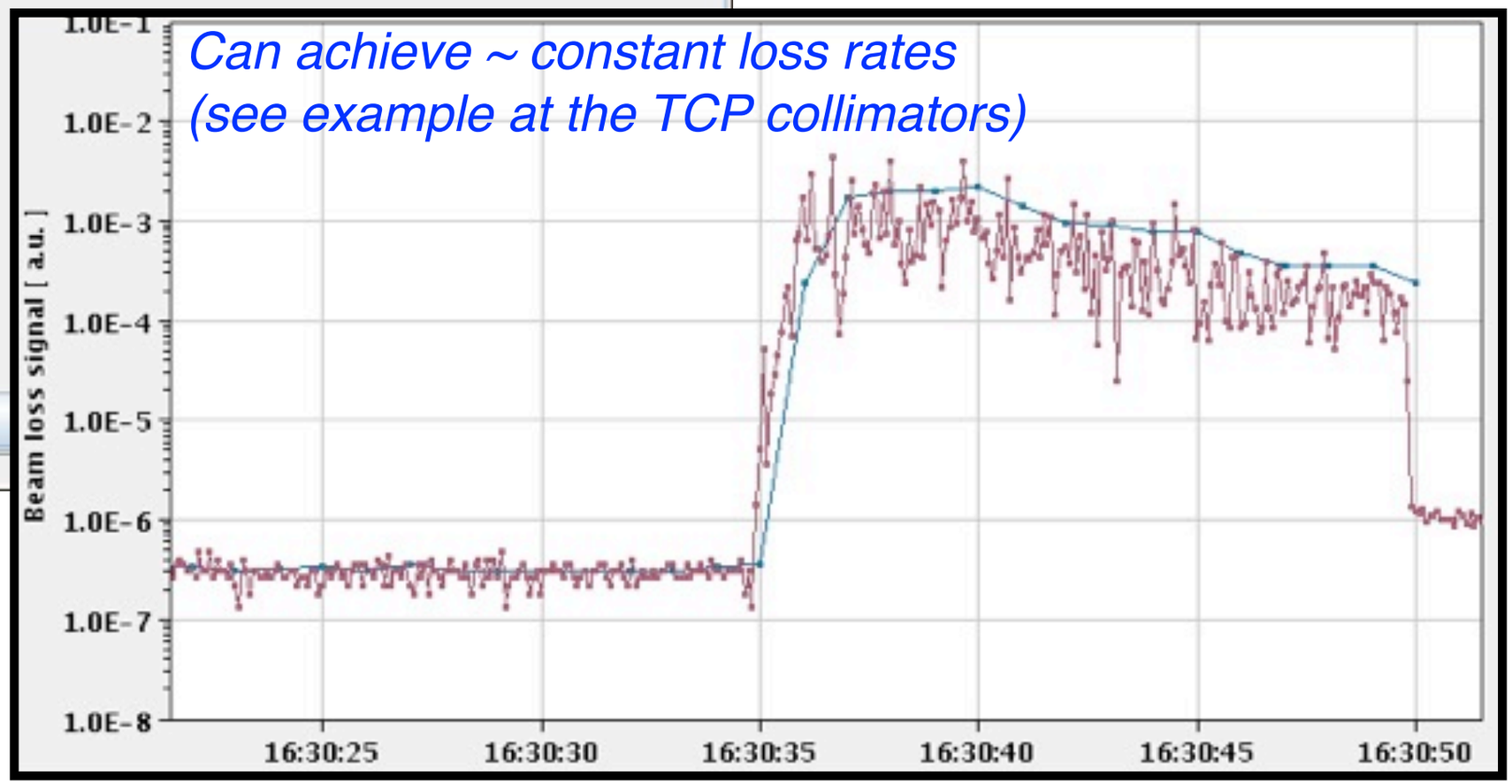
2012 aperture measurements



ADT-driven controlled blow-up



Application by D. Jacquet



Smoothly commissioned in 2012 after preliminary MD tests in 2011.

Used so far with well-separated individual bunches.

Method for global measurements

Basic idea:

0. Beam based alignment of TCP collimators

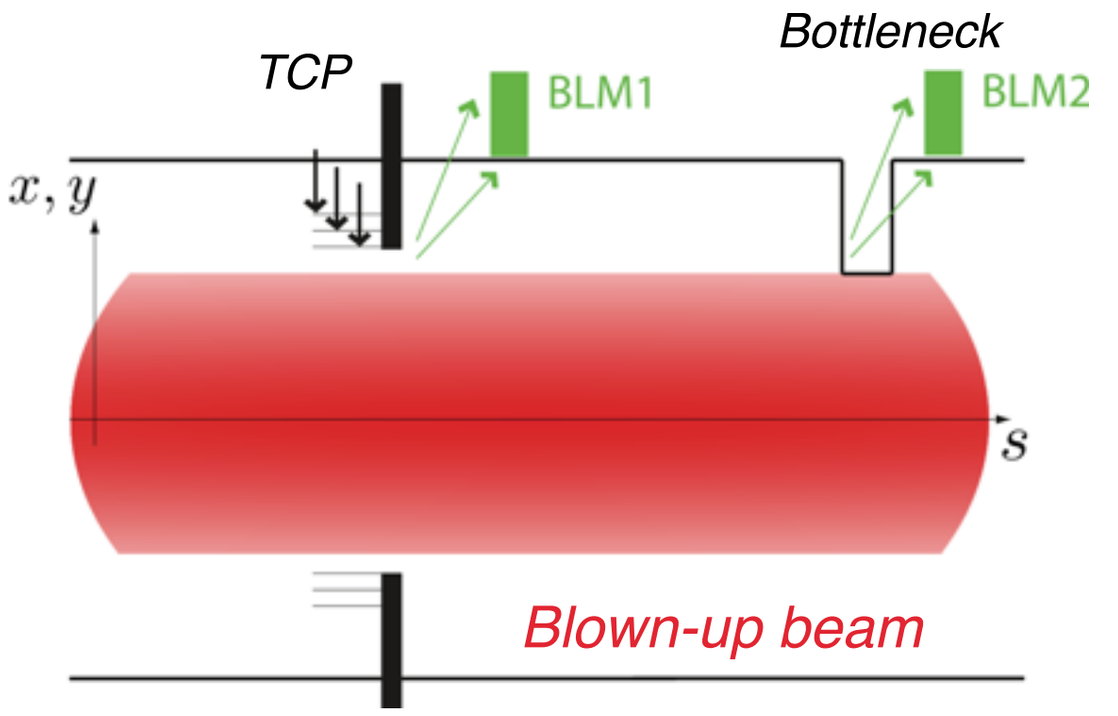
1. Emittance blow-up to find bottleneck (coll. open)

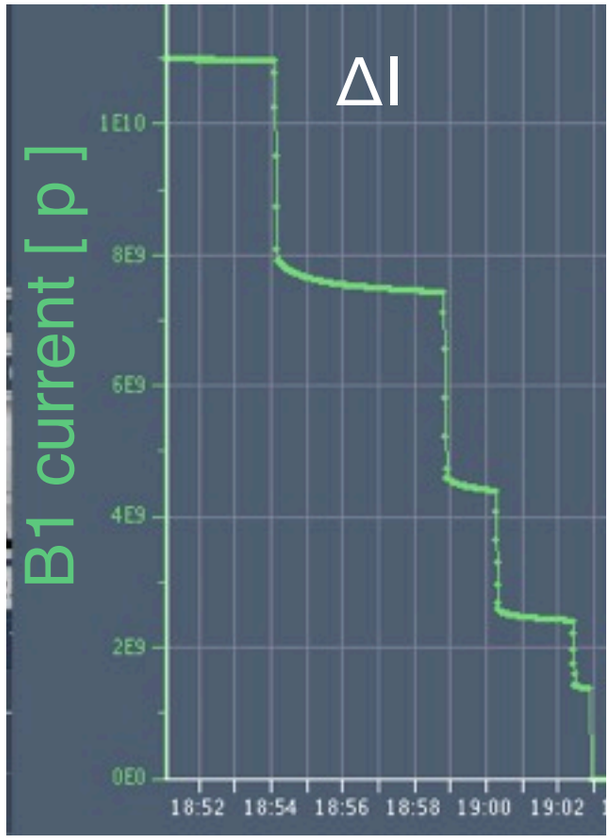
2. Perform a collimator scan and repeat blow-up

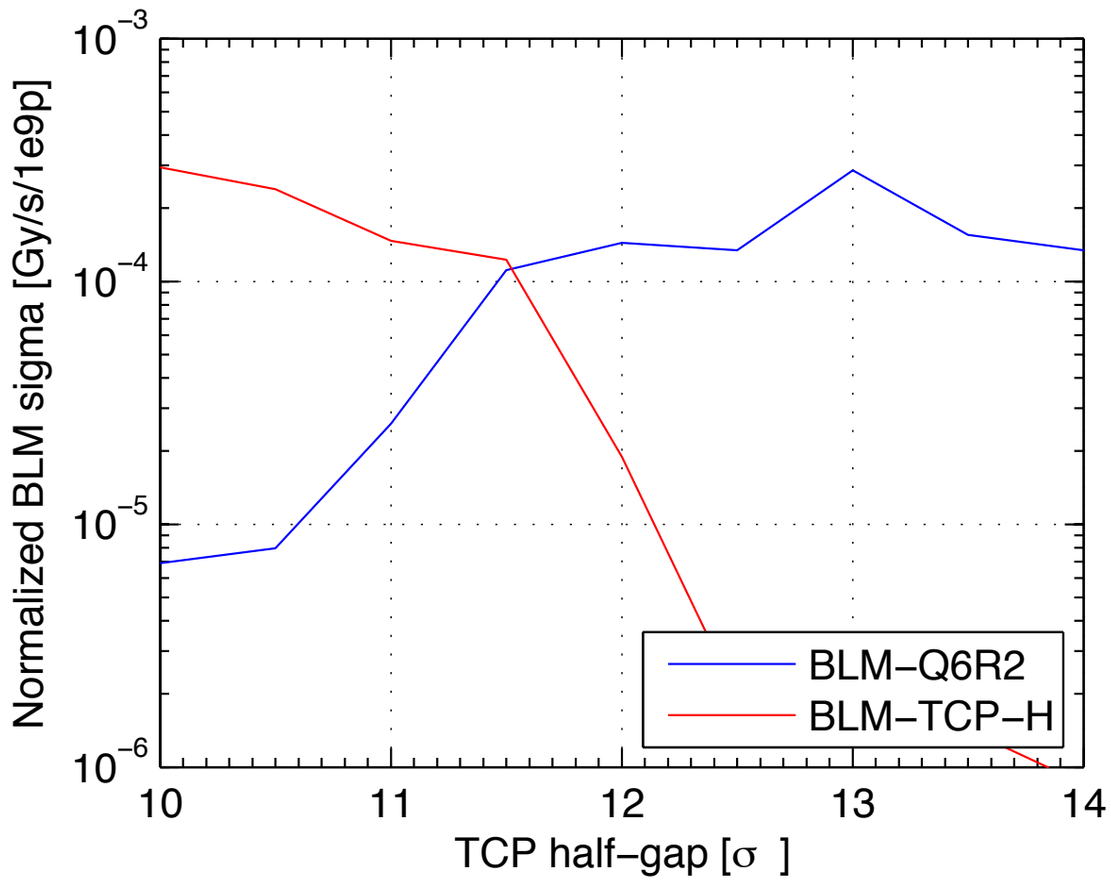
*3. When losses move to the TCP, the **precise** knowledge of **collimator gap** gives the **N_σ***

4. Can be used for approximated LOCAL measurements with orbit bumps

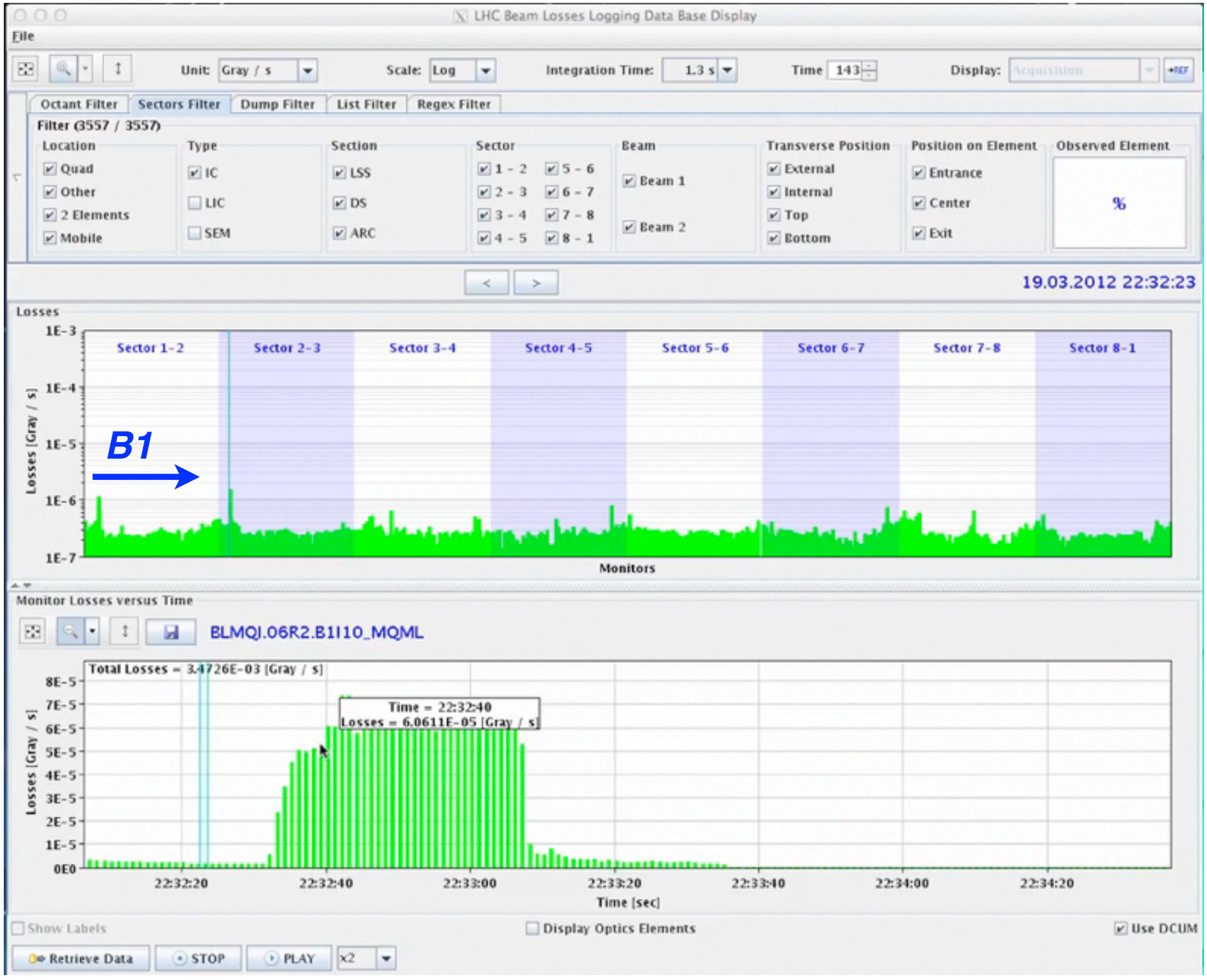
Refined calculations use normalized BLM



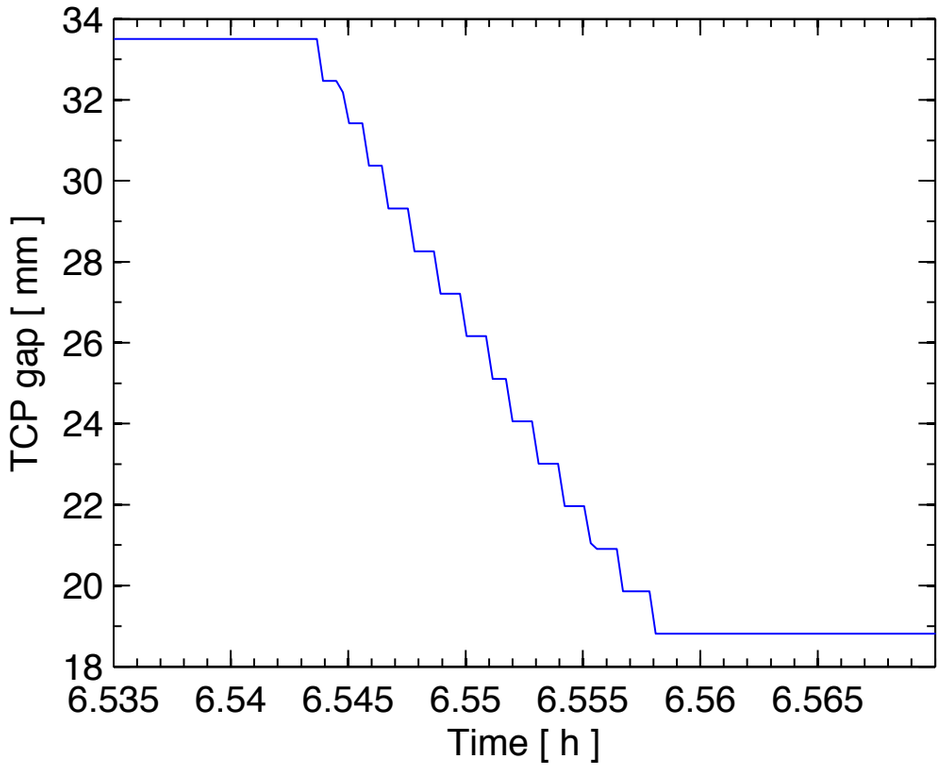


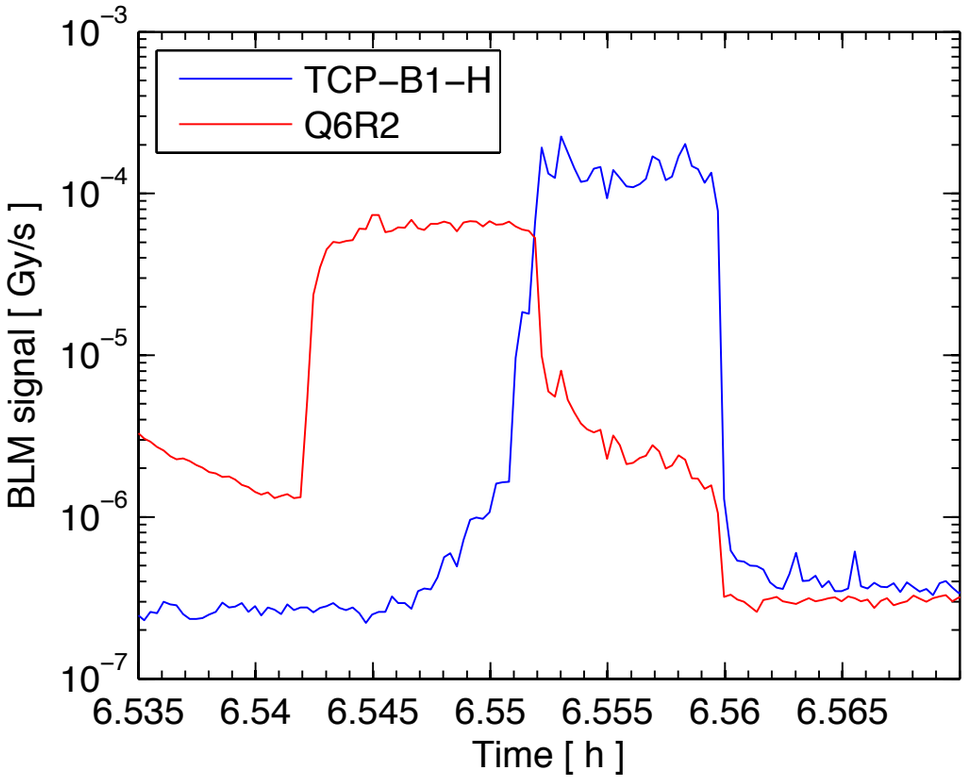


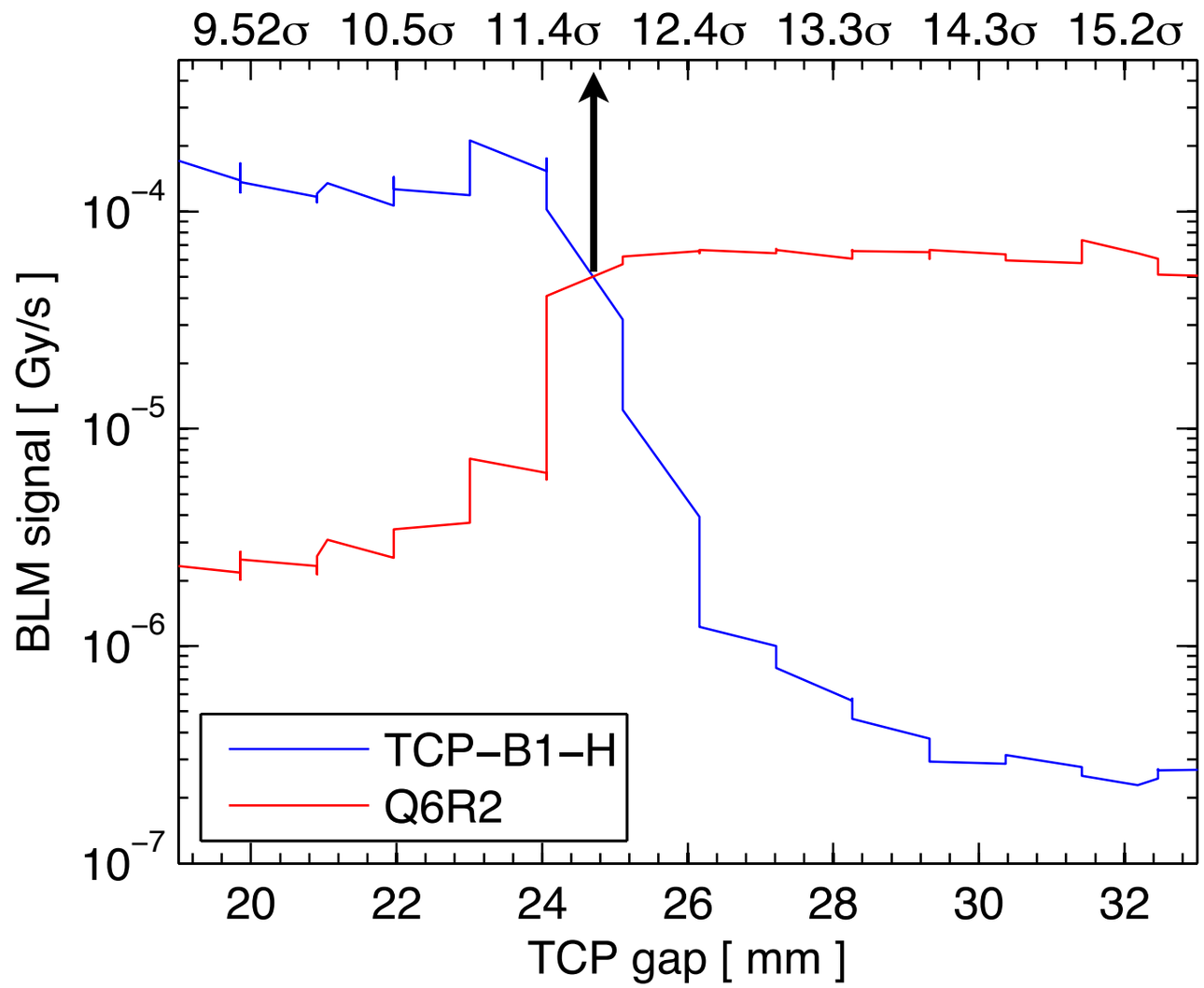
Example of one fast scan



Data processing

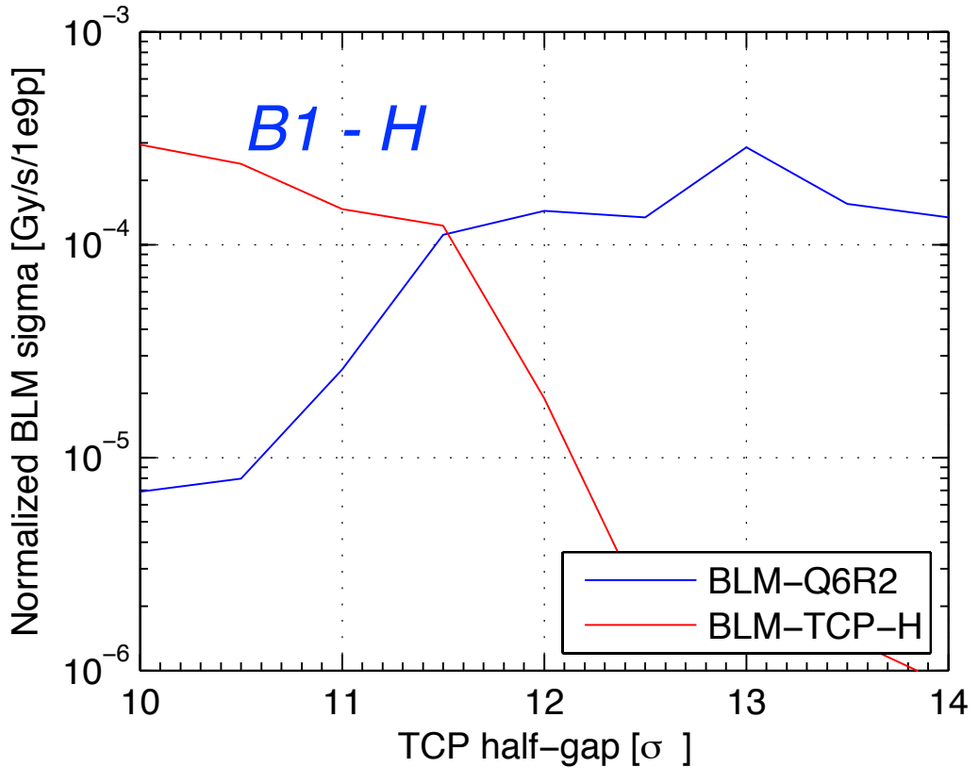


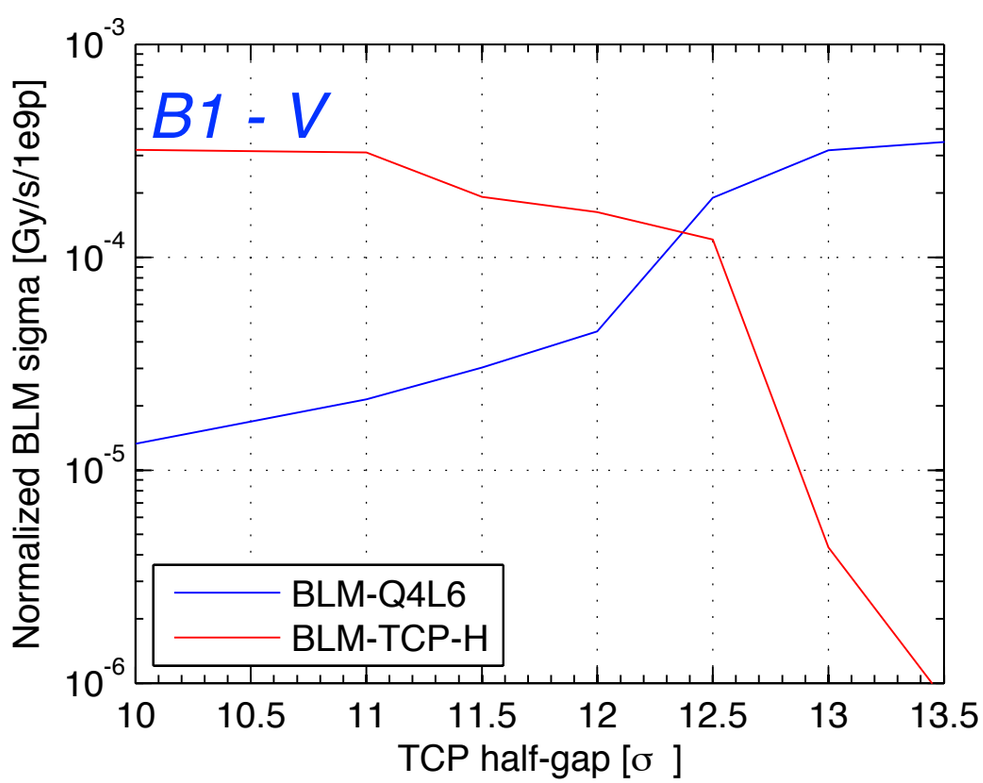


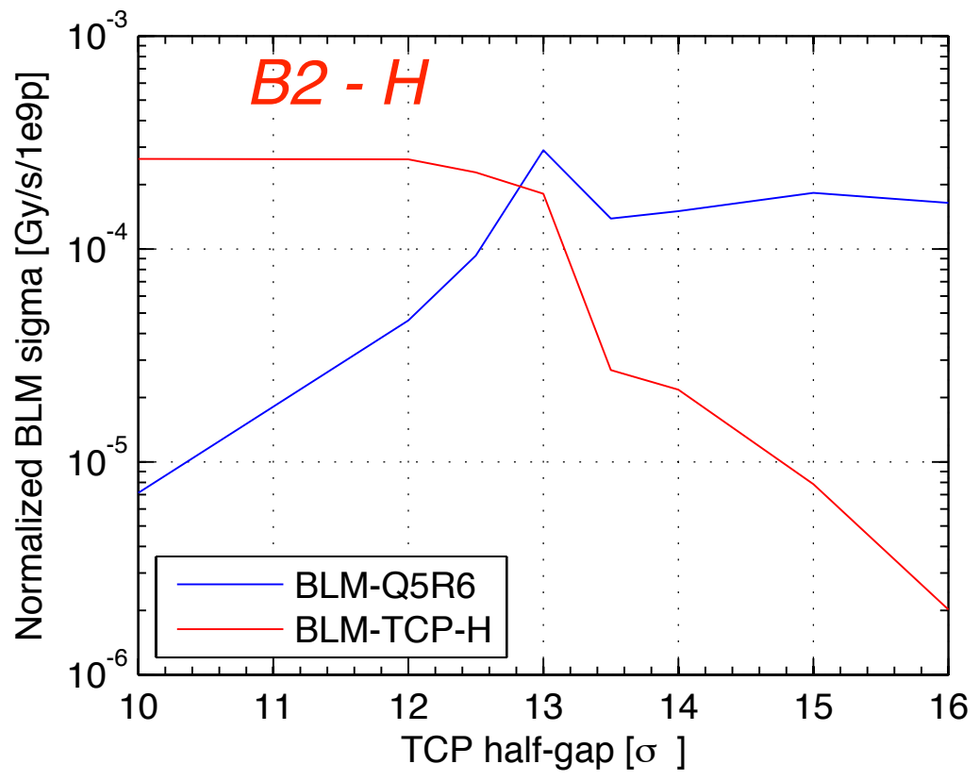


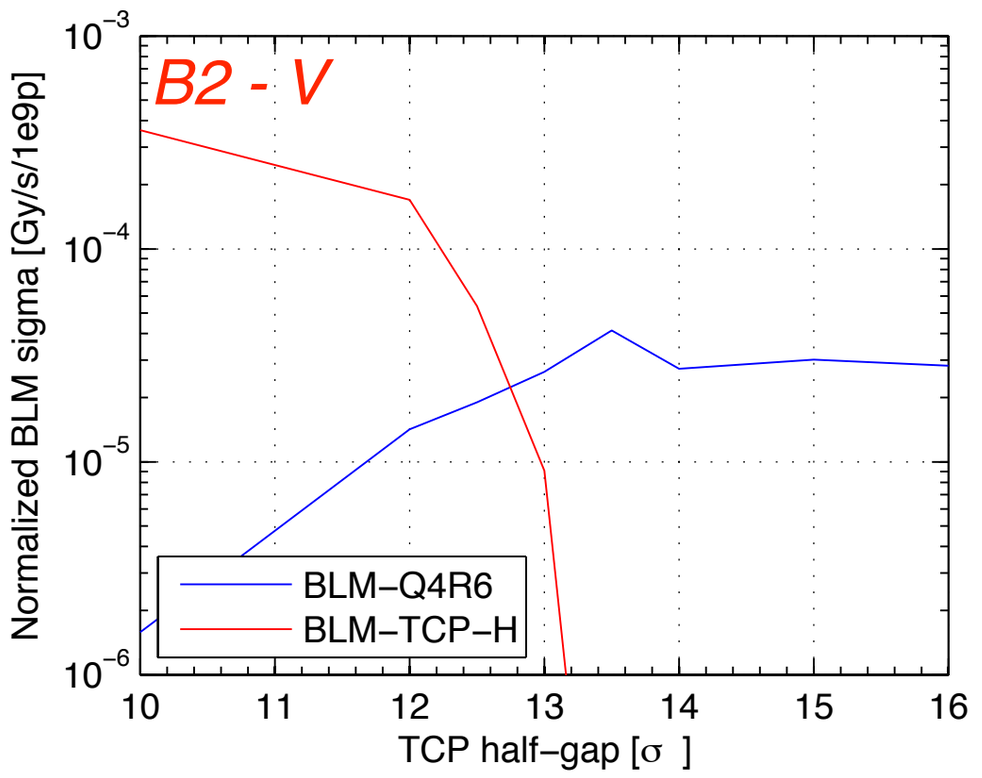
Fast scans only used for comparison for 2 planes, after we gained good confidence with the blow-up parameters

Results for all planes









Summary of injection aperture

Global aperture 2012

	H [σ]	V [σ]
B1	11.5 (Q6R2)	12.5 (Q4L6)
B2	12.5 (Q5R6)	13.0 (Q4R6)

Beam-based centre shifts

	H [mm]	V [mm]
B1	**0.00** (Q6R2)	**-0.80** (Q4L6)
B2	**0.50** (Q5R6)	**0.25** (Q4R6)

Global aperture 2010

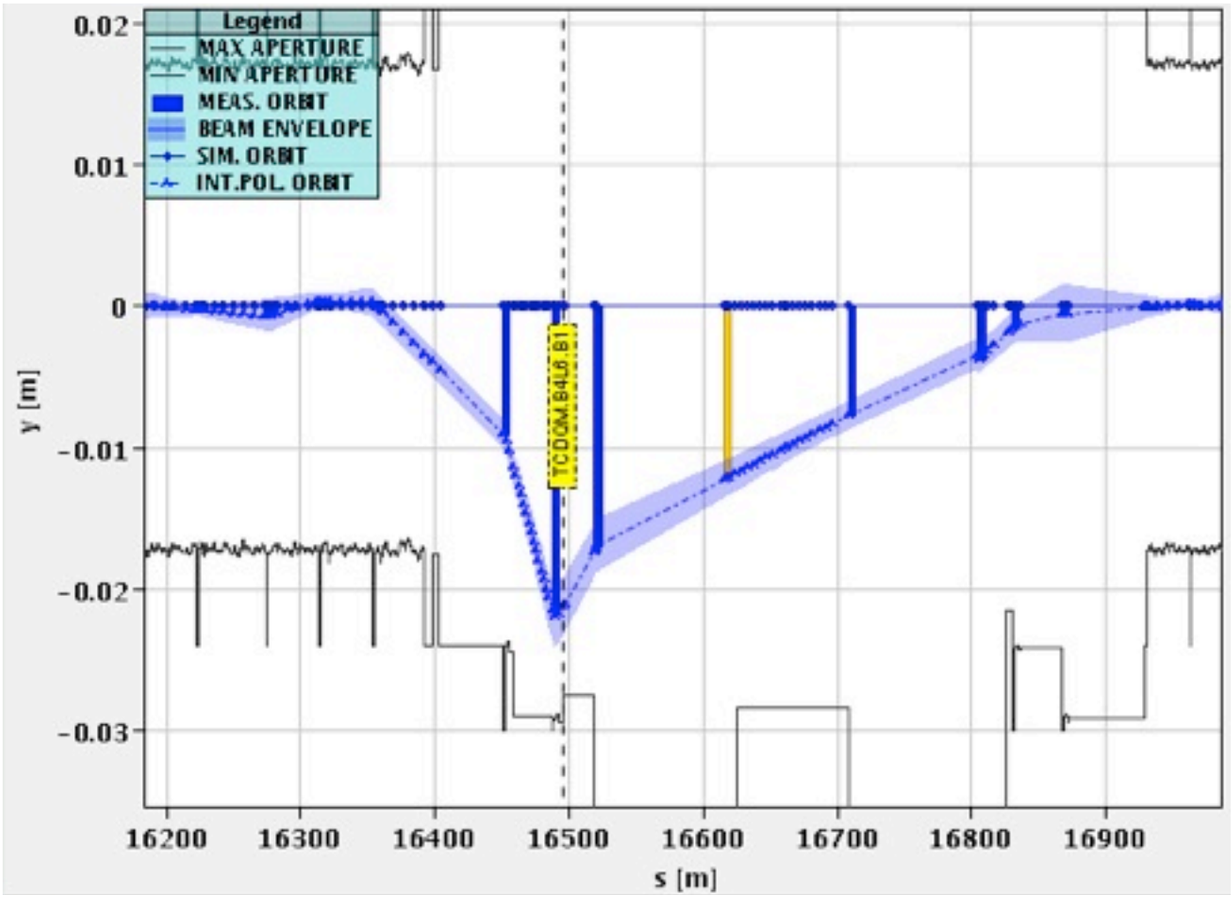
	H [σ]	V [σ]
B1	12.5 (Q6R2)	13.5 (Q4L6)
B2	14.0 (Q5R6)	13.0 (Q4R6)

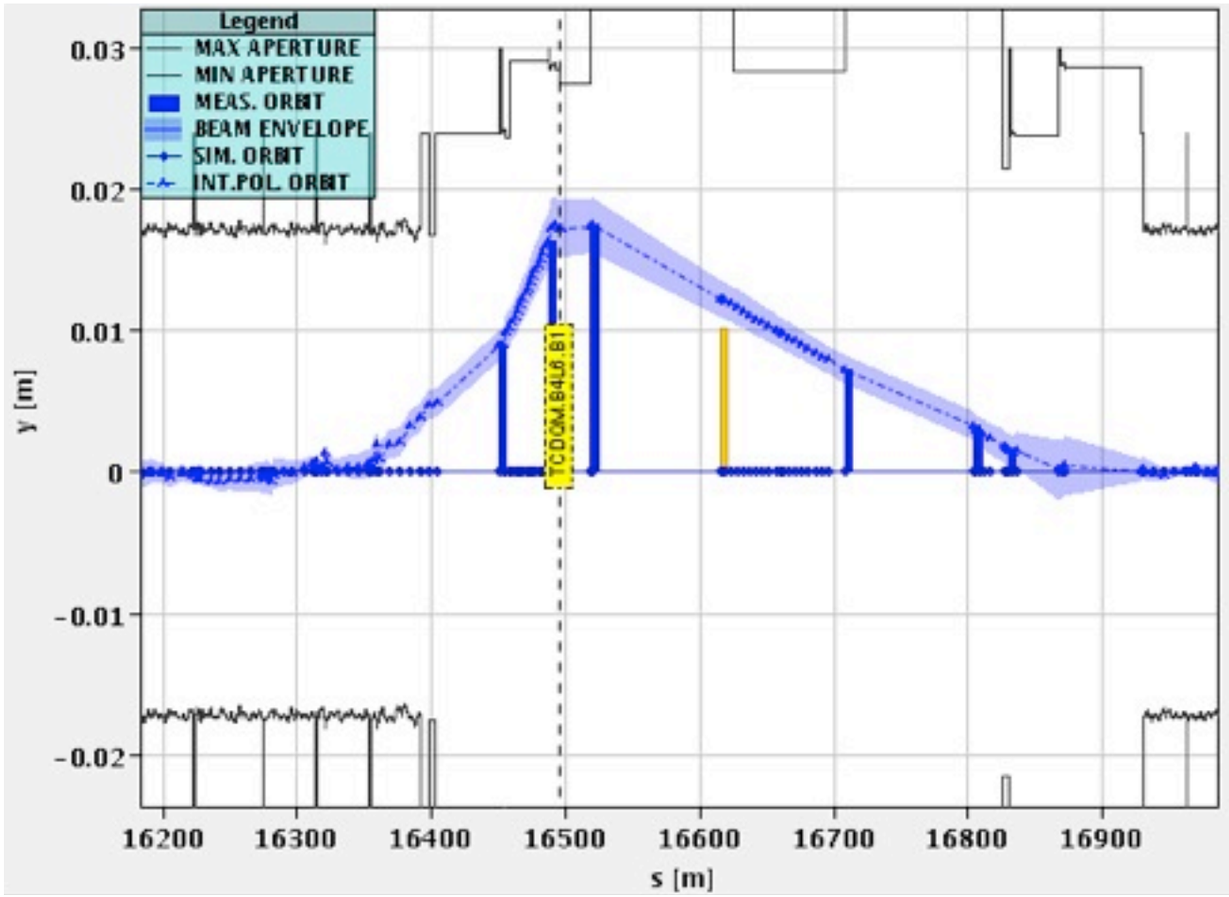
Global aperture 2011

	H [σ]	V [σ]
B1	12.0 (Q6R2)	13.0 (Q4L6)
B2	12.5 (Q5R6)	13.0 (Q4R6)

Same locations found in the last years for the bottlenecks.
We are loosing 0.5-1.0 sigmas per year. Check with the SU team?

Centring the orbit at the bottlenecks

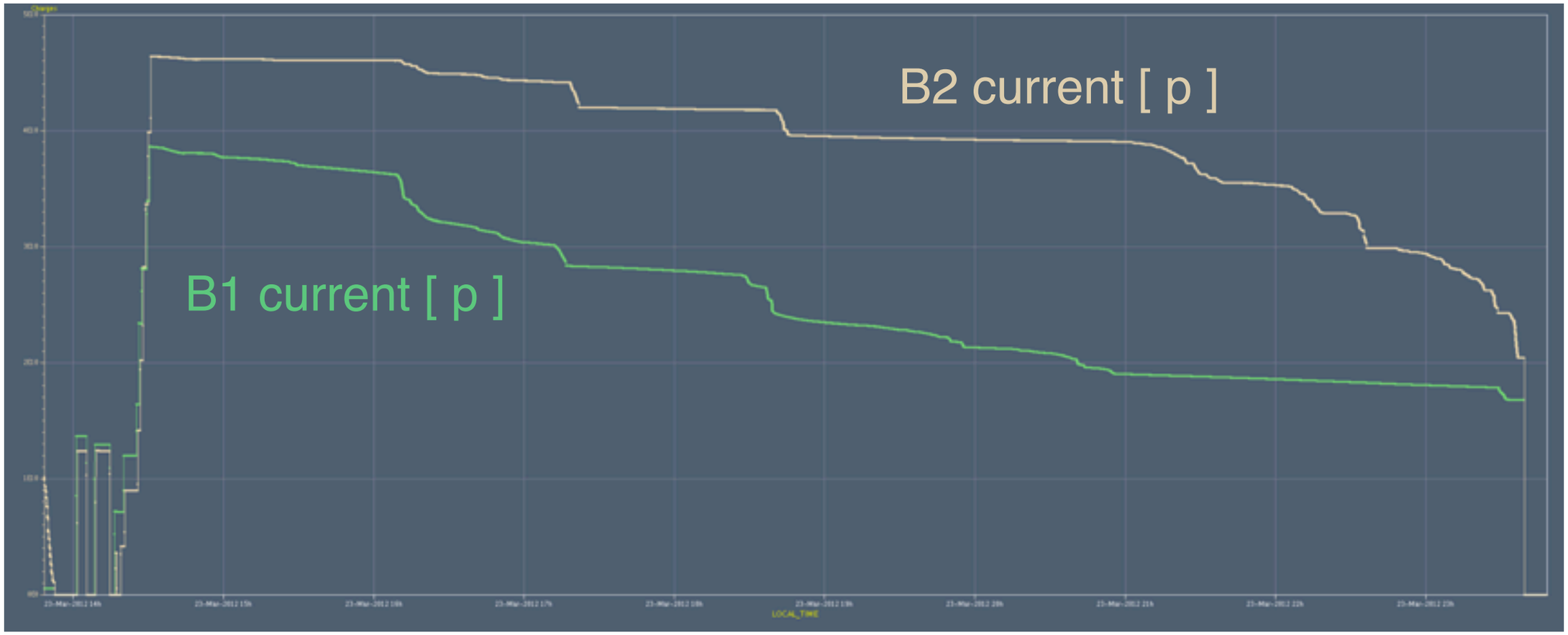




Local 3- or 4-corrector local bumps at the global bottlenecks

Beam-based alignment of TCP collimators to determine precise the width of the beam halo (for detailed off-line analysis): $A = \Delta_{co} + N_{env}\,\sigma$

Global aperture at 4 TeV



Injected 7-8 "small" probe bunches of ~5e9 protons, emittance > 3-4 microns

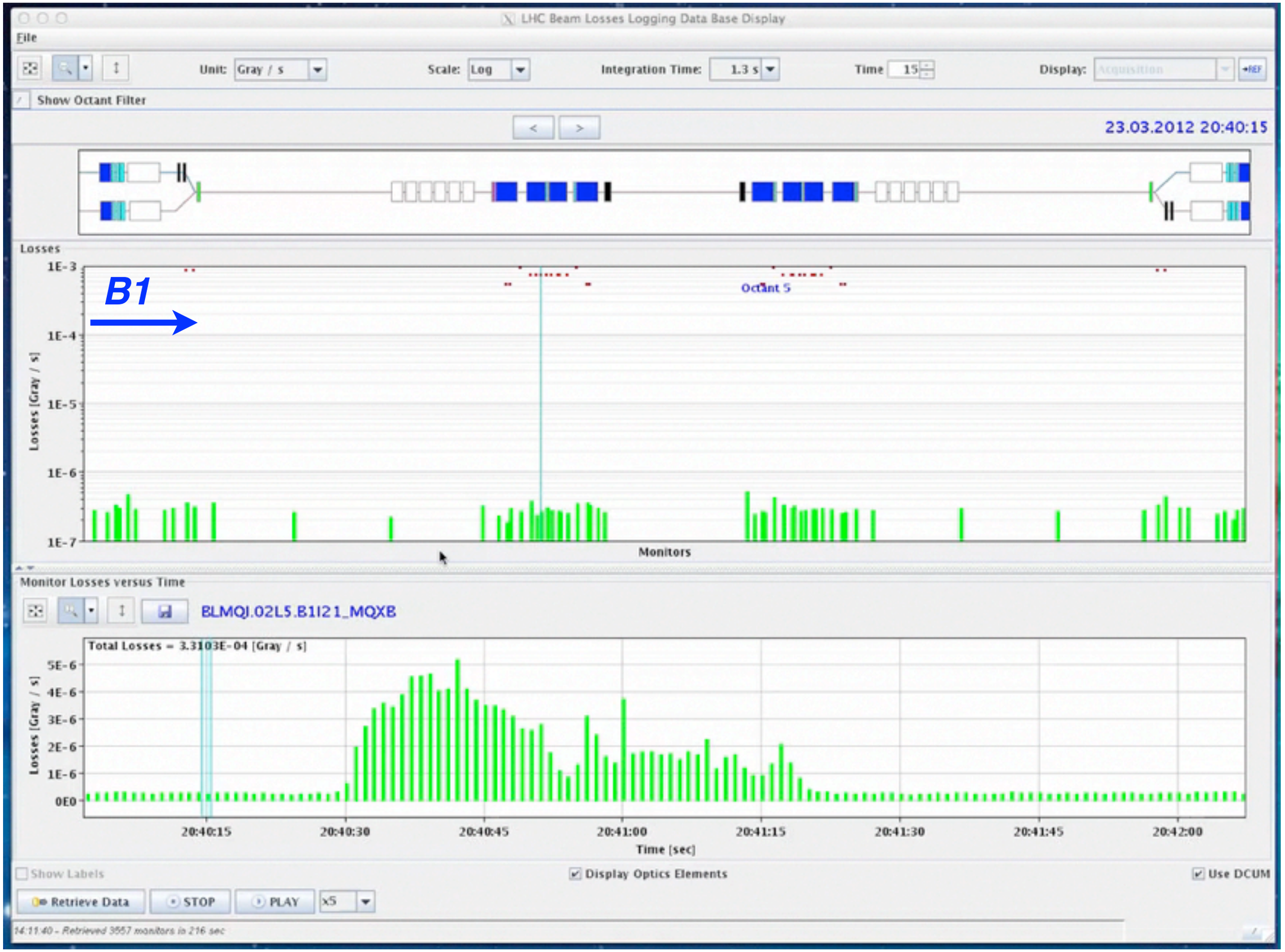
Selective blow-up of individual bunches

Collimator settings:

- *End-of-ramp coarse settings in IR3/6/7 → global bottlenecks at the MQX's*
- *Align TCP and TCT collimators for precise, nominal optics for TCT gaps*
- *TCT scans to determine settings that expose the triplet: ADT driven loss rates*

Orbit for probe intensity

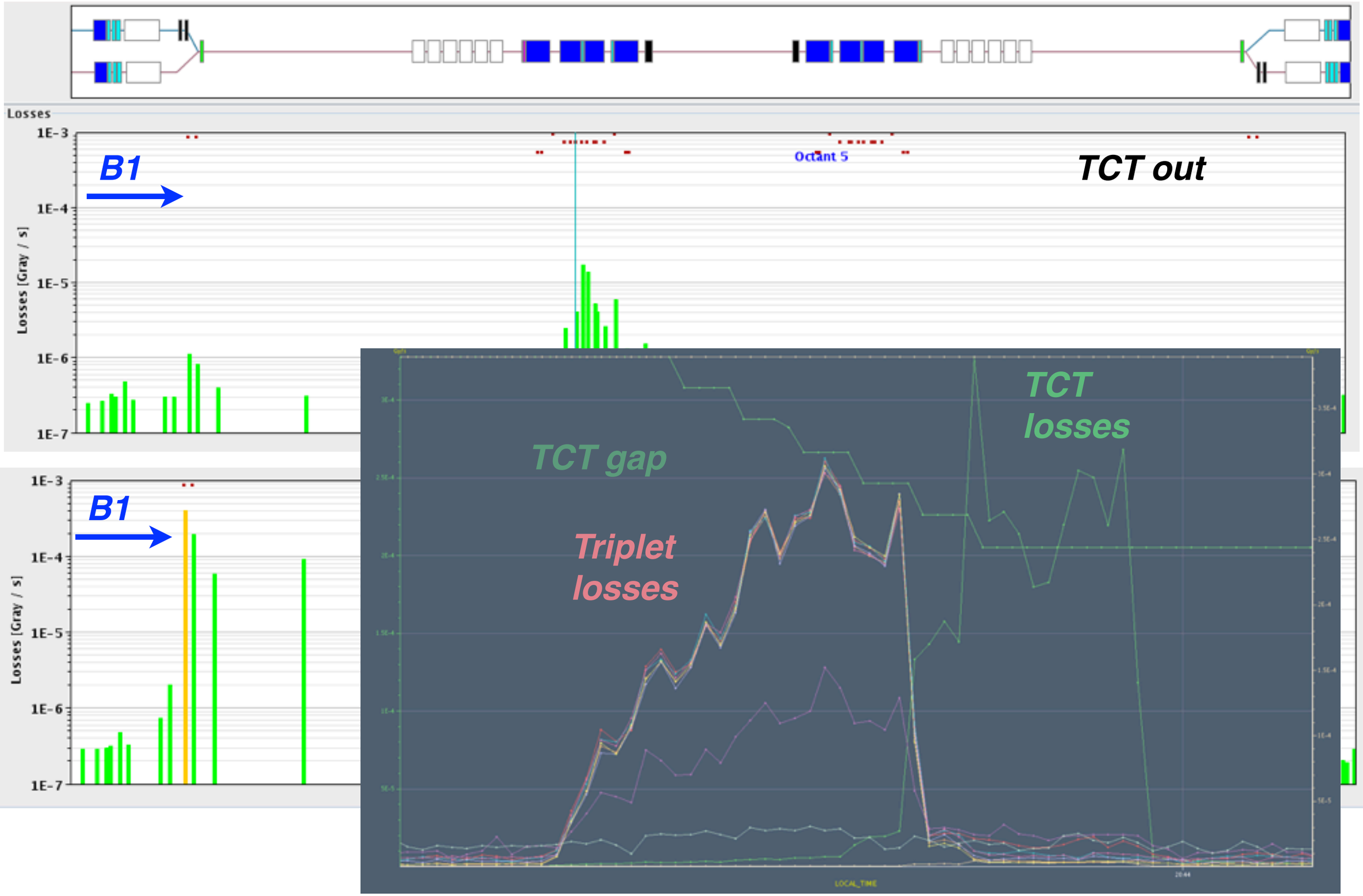
Example: B1-IR5-H (i)



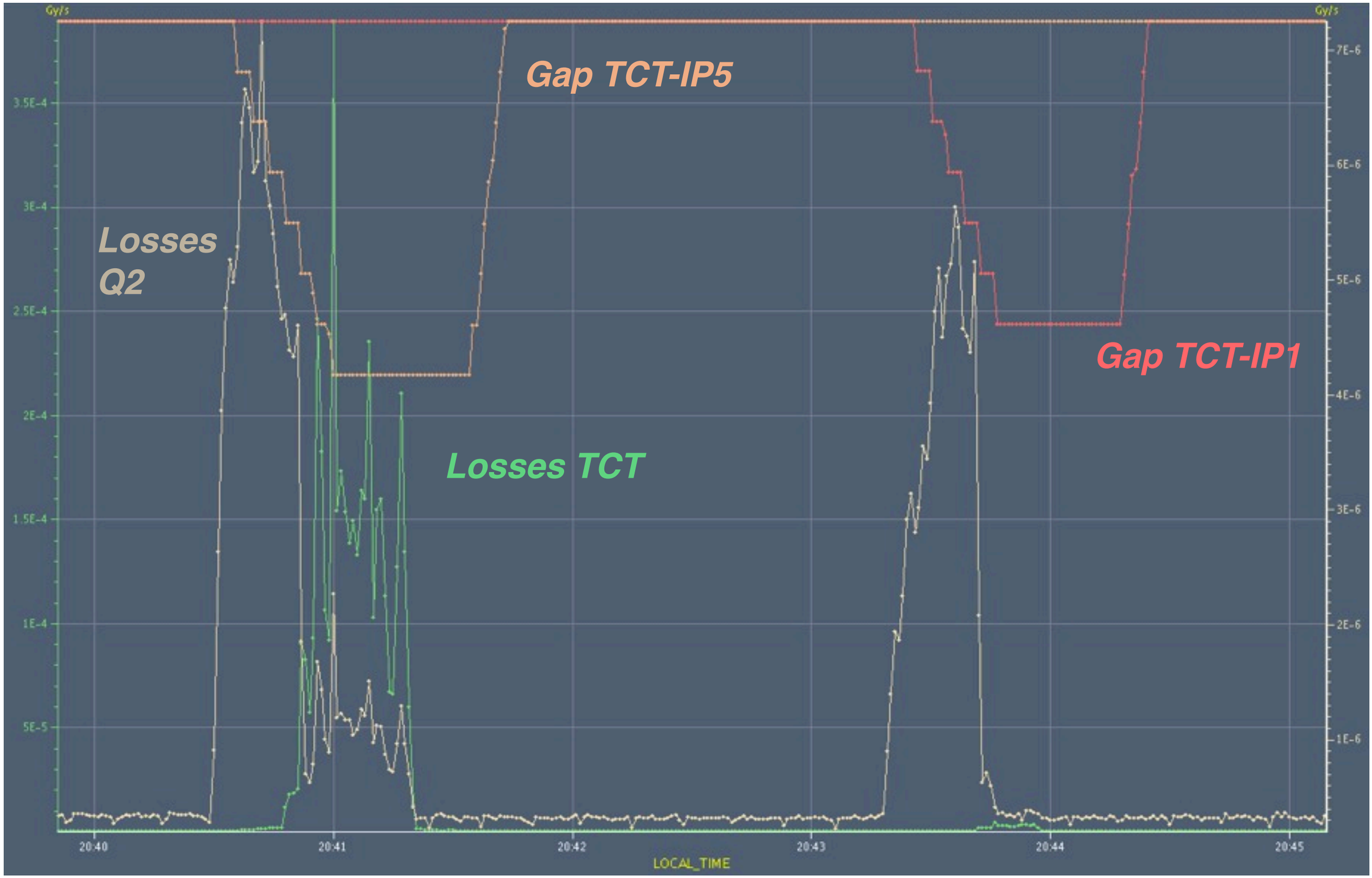
Example: B1-IR5-H (ii)

Example: B1-IR5-H (ii)

Example: B1-IR5-H (ii)



Scans with TCTs in both IRs



Summary of 4 TeV, β* = 60 cm

(Separation = 650 μm, crossing = 145 μrad)

	H [σ]	V [σ]
B1	11.5 - 12.0 (Q2-L5)	11.0 - 11.5 (Q3-L1)
B2	11.5 - 12.0 (Q3-R1)	11.0 - 11.5 (Q3-R1)

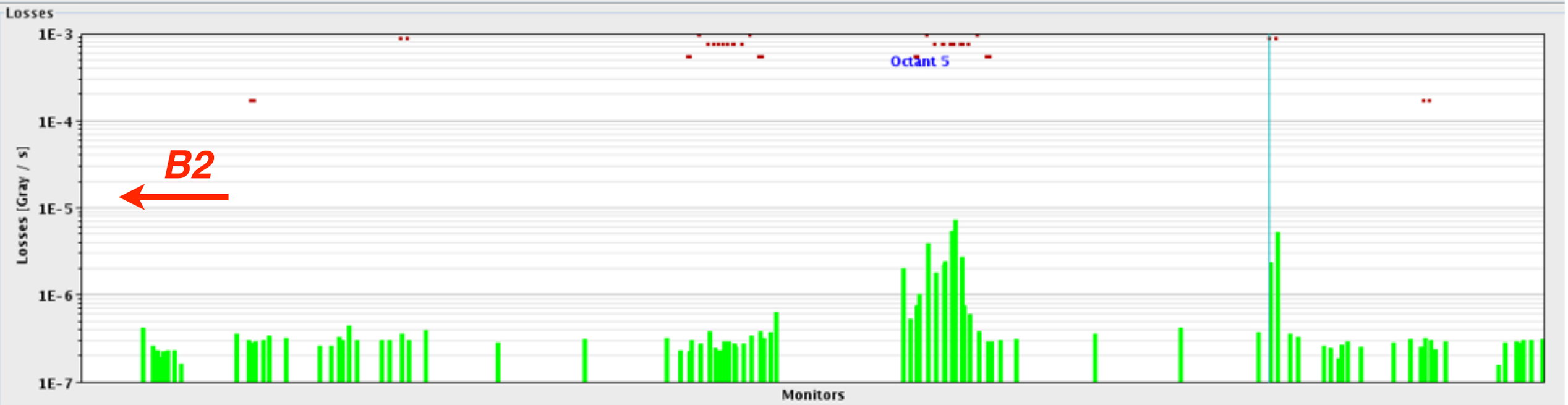
Assumptions to achieve 60 cm: ***10.8 sigma***

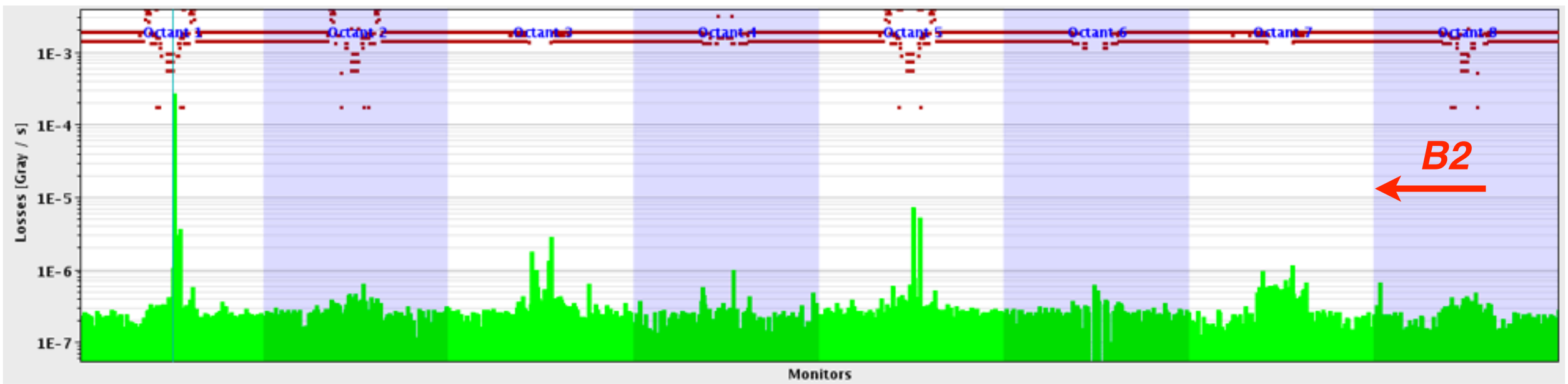
→ ***Preliminary conclusions: OK***

Reminder / caveats:

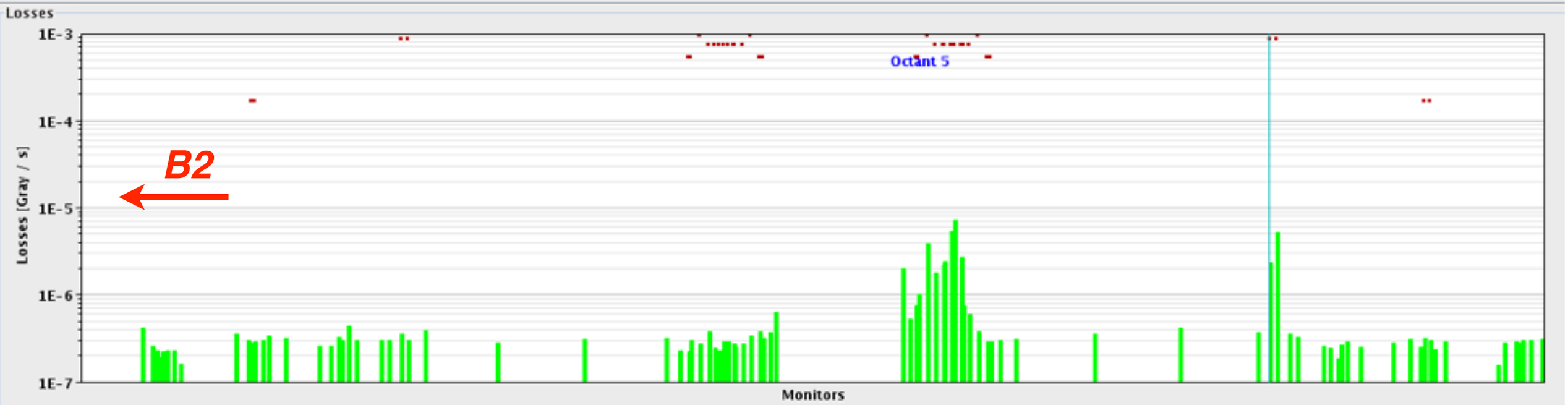
- *Measurements performed with probe orbit reference: to be repeated after nominal bunch reference is established, with final TCT settings!*
- *Unexpected loss location in IR1 for B2-h (separation plane)*

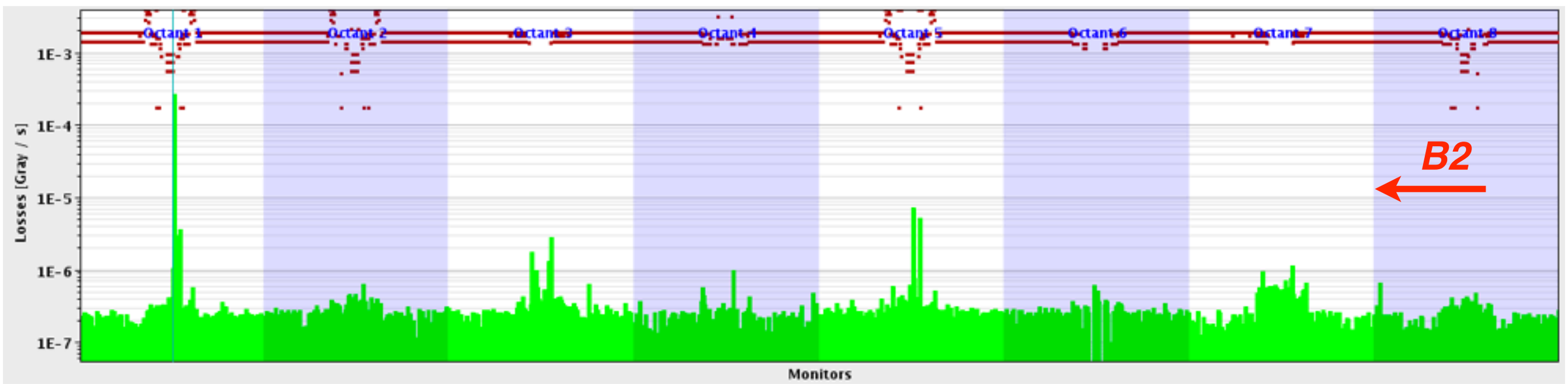
Case B2 - H


Losses
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
B2
Octant 5
Monitors

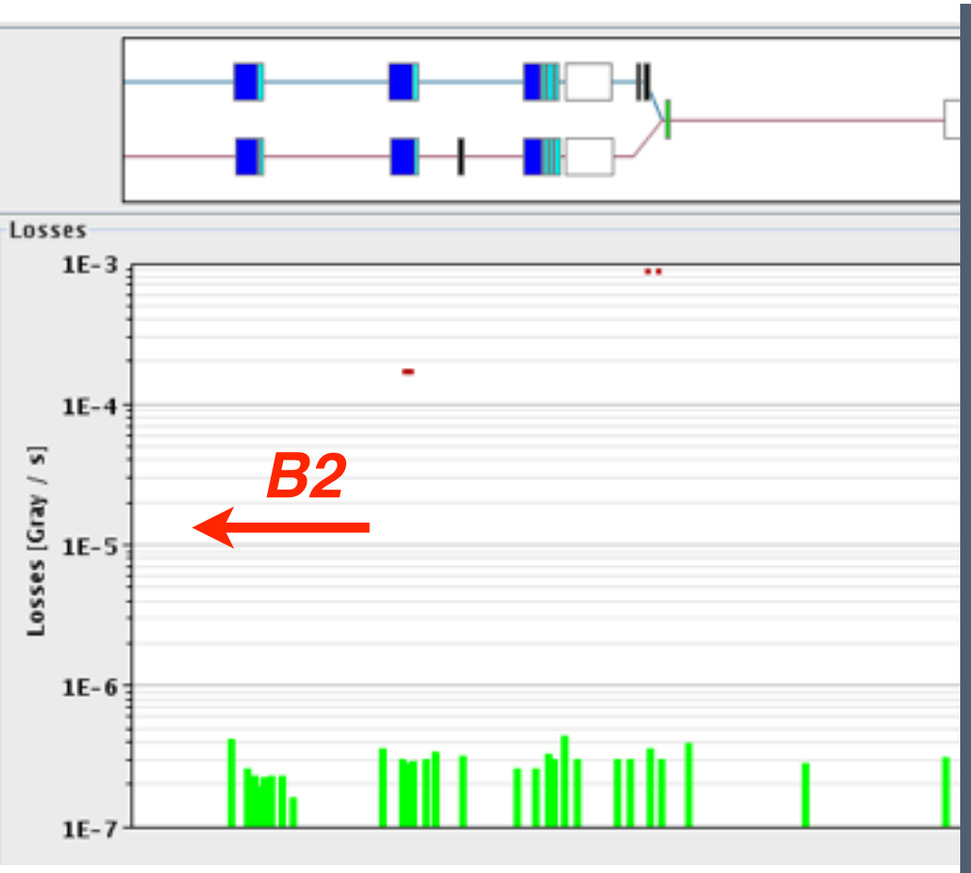

Octant 1
Octant 2
Octant 3
Octant 4
Octant 5
Octant 6
Octant 7
Octant 8
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
B2
Monitors

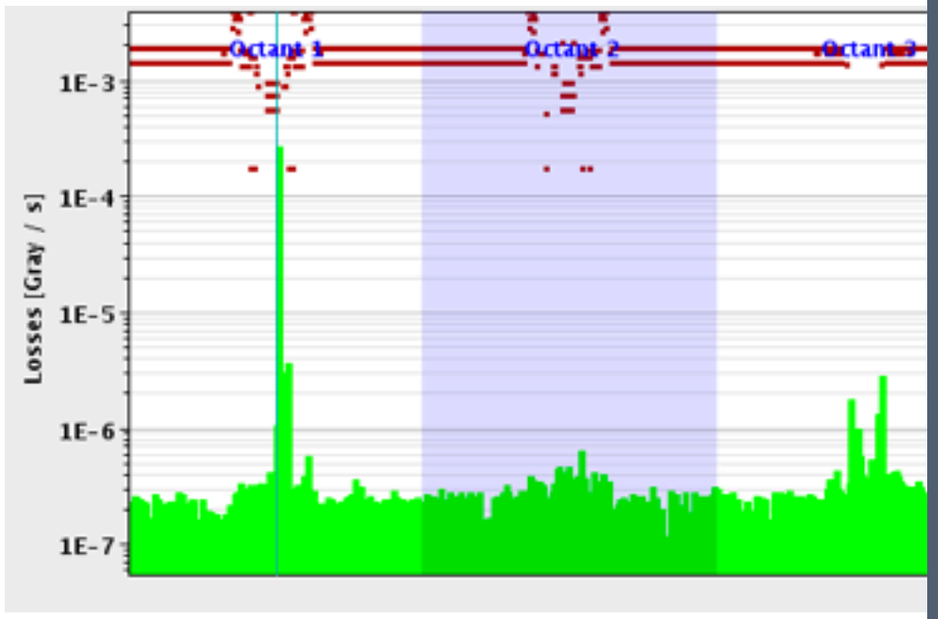
Case B2 - H

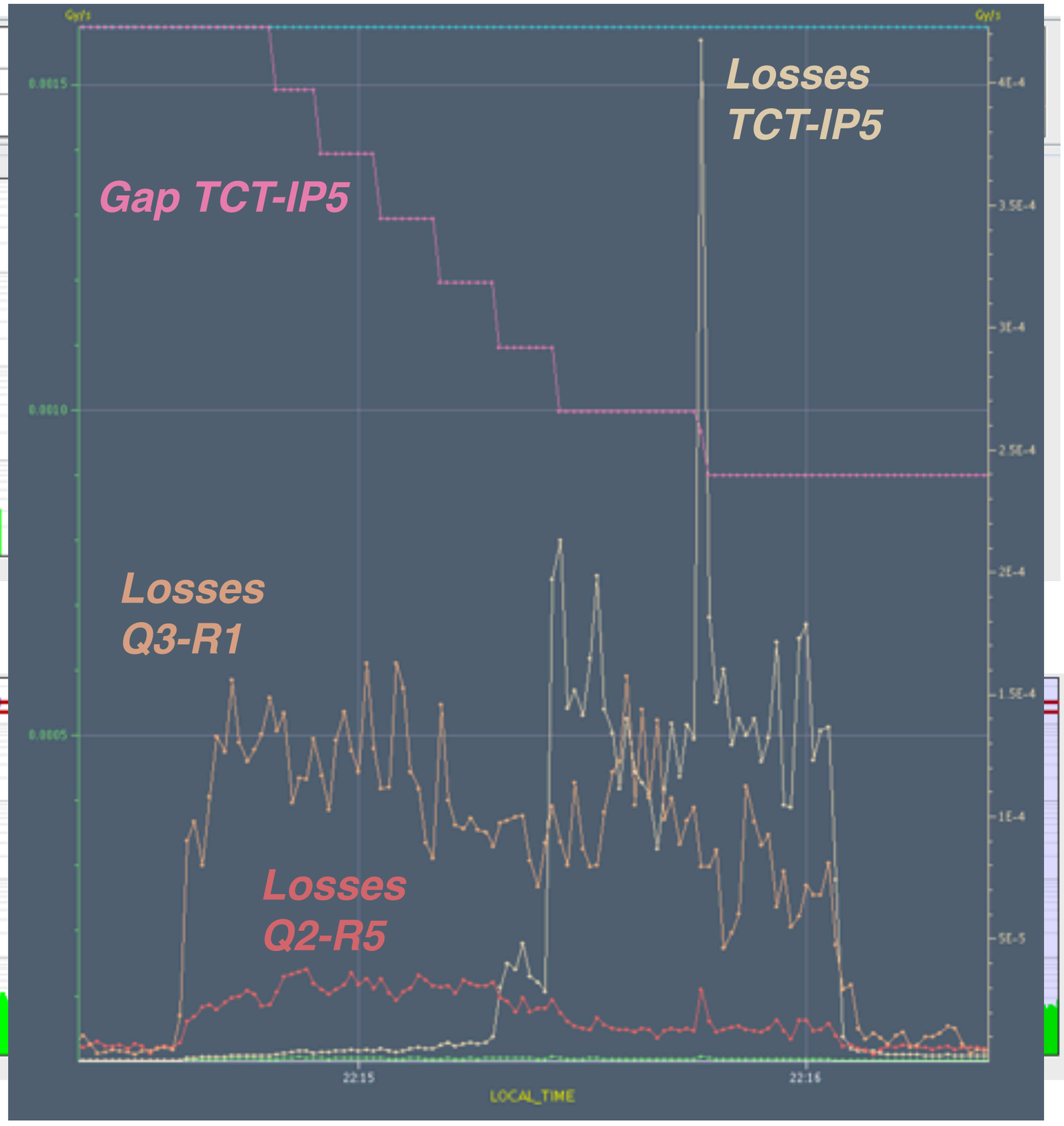

Losses
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
B2
Octant 5
Monitors


Octant 1
Octant 2
Octant 3
Octant 4
Octant 5
Octant 6
Octant 7
Octant 8
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
B2
Monitors

Case B2 - H


Losses
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
B2


Octant 1
Octant 2
Octant 3
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]


Losses
TCT-IP5
Gap TCT-IP5
Losses
Q3-R1
Losses
Q2-R5
22:15
22:16
LOCAL_TIME

Conclusions

- ☑ **We performed global aperture measurements at injection and with squeeze/separated beams**
- ☑ **The ADT blow-up works great!**
  - *Faster measurements at injection*
  - *Global measurements possible at 4 TeV for the first time*
- ☑ **The LHC aperture looks still good!**
  - *No limits at injection, even if we loose ~ 0.5 σ / year*
  - *We can continue with the commissioning at 60 cm*
- ☑ **Outlook:**
  - *Repeat 4 TeV measurements with nominal reference*
  - *Investigate further B2-H case. Symmetric scans of the triplet?*
  - *Off-momentum aperture measurements*
  - *Local scans: TDI and BTV regions. IR2 for ion squeeze.*
  - *IR8 injection aperture for vertical crossing studies?*
- ☑ **Standard commissioning or MD?**