Status of LHC Collimation

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LMC, 2.12.2009

HWC: **EN/STI, BE/OP, BE/ABP** → not reported here in detail

Collimation beam commissioning team:
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plus common activities with **TE/ABT (Brennan et al), BE/BI (Bernd et al), …**

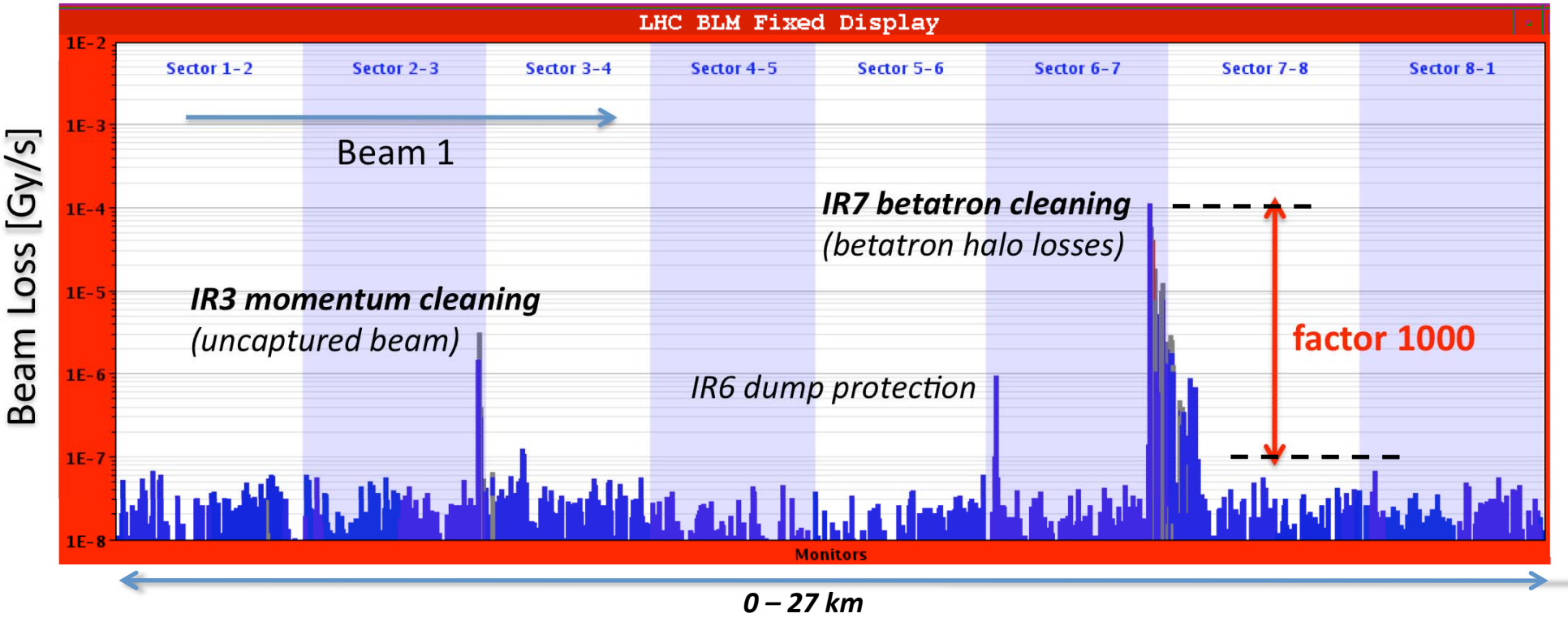
Hardware Status

- System frozen since start of September (only required improvements agreed).
- All **100 LHC collimators fully operational.**
- No problems so far: not a single access required since start of beam operation. Good sign for collimator reliability.
- Collimators moved as required for splash events and then for collimation setup.

First Multi-Stage Betatron and Momentum Collimation

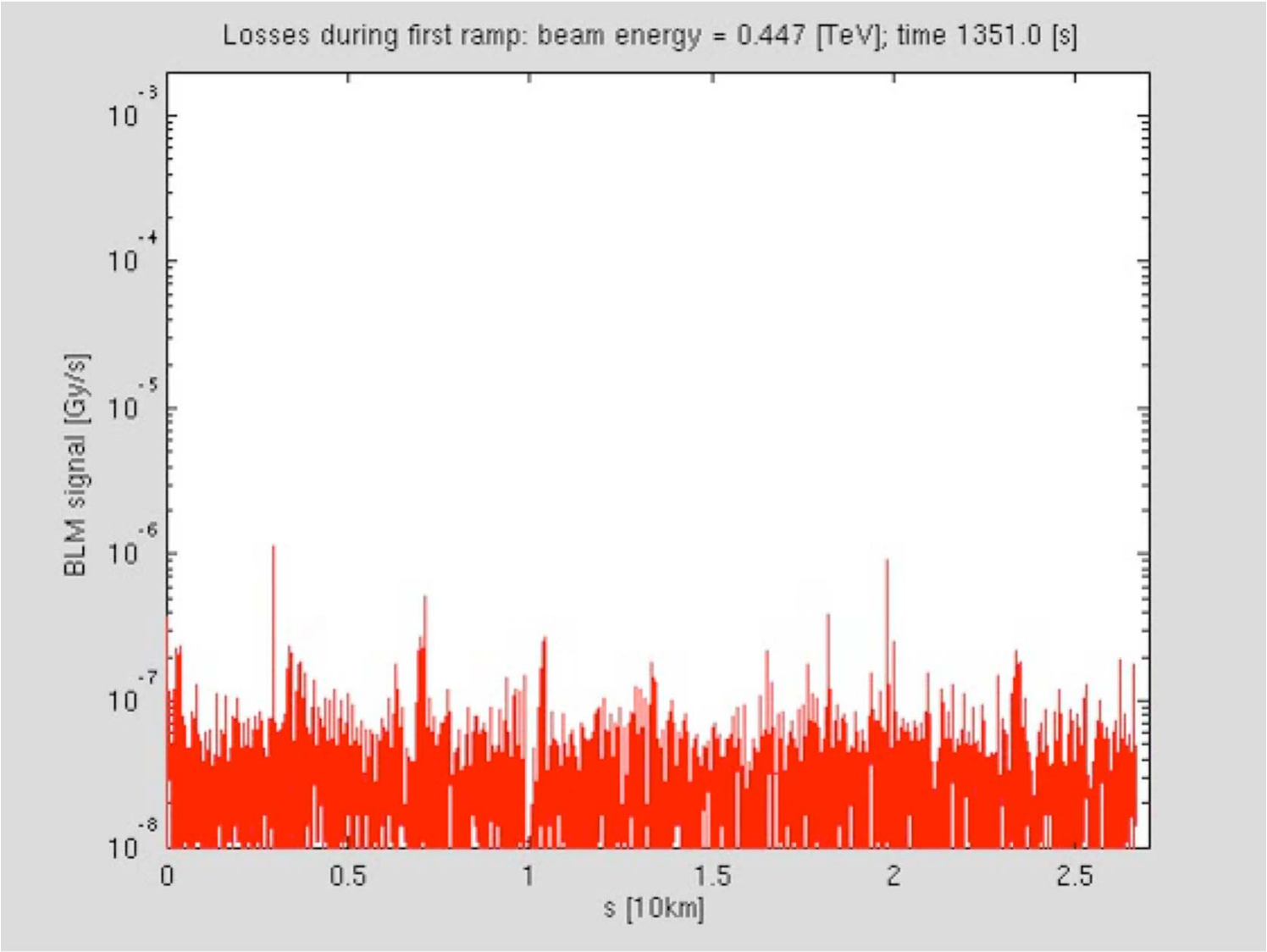
21/100 coll. beam-based aligned to nominal settings for trial ramp 24.11.2009 (others coarse).

IR7	*Primary:*	***5.7 σ***	*Secondary:*	*~10 σ*	*Tungsten absorber:*	*10 σ*
IR3	*Primary:*	***8.0 σ***	*Secondary:*	*~10 σ*	*Tungsten absorber:*	*10 σ*
IR6	*TCS:*	*~7.0 σ*	*TCDQ:*	*~8.0 σ*		



- No unexpected losses in arcs, experimental insertions, …
- Initial cleaning efficiency: **> 99 %**

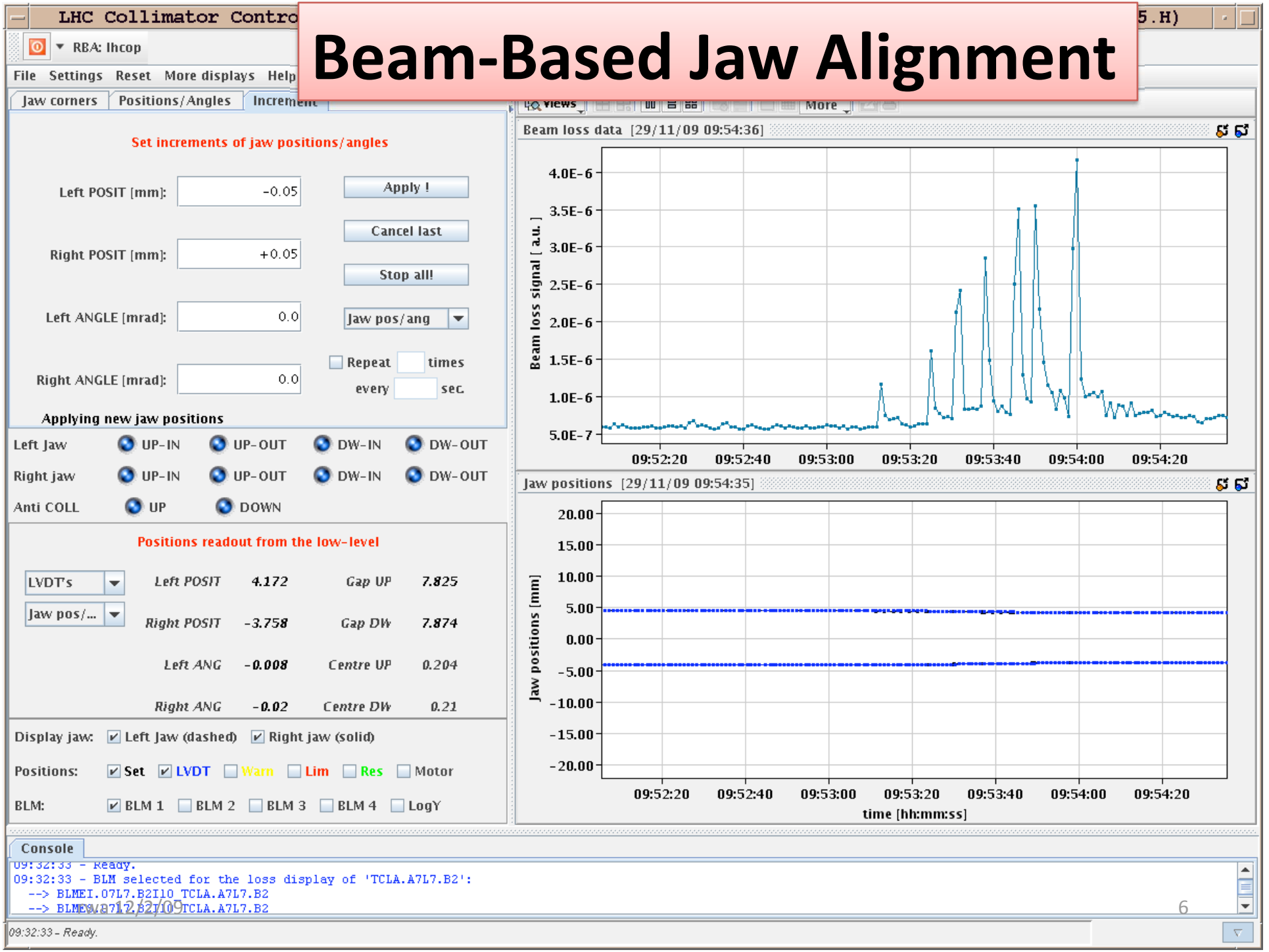
First Ramp with Rough Collimator Settings

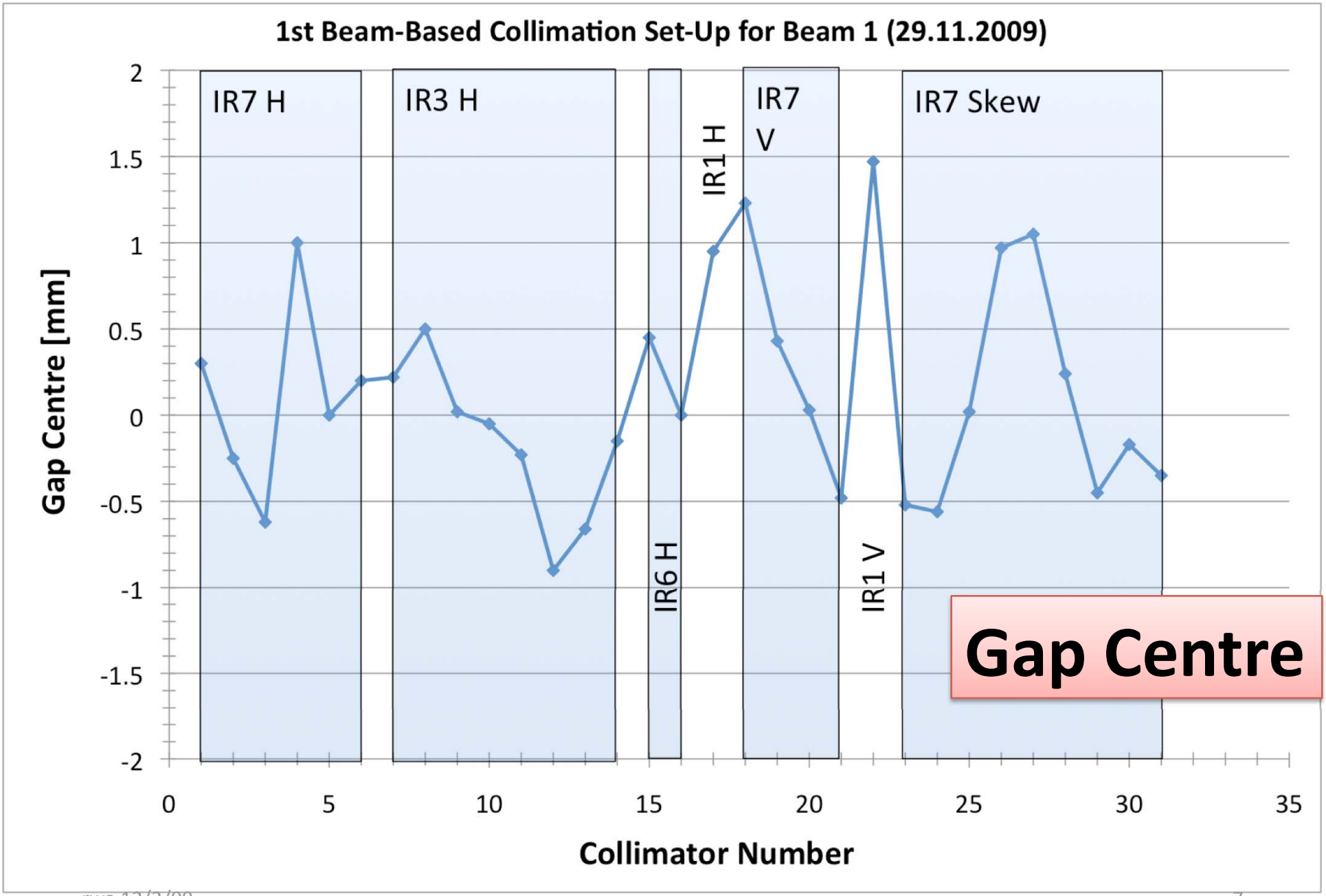


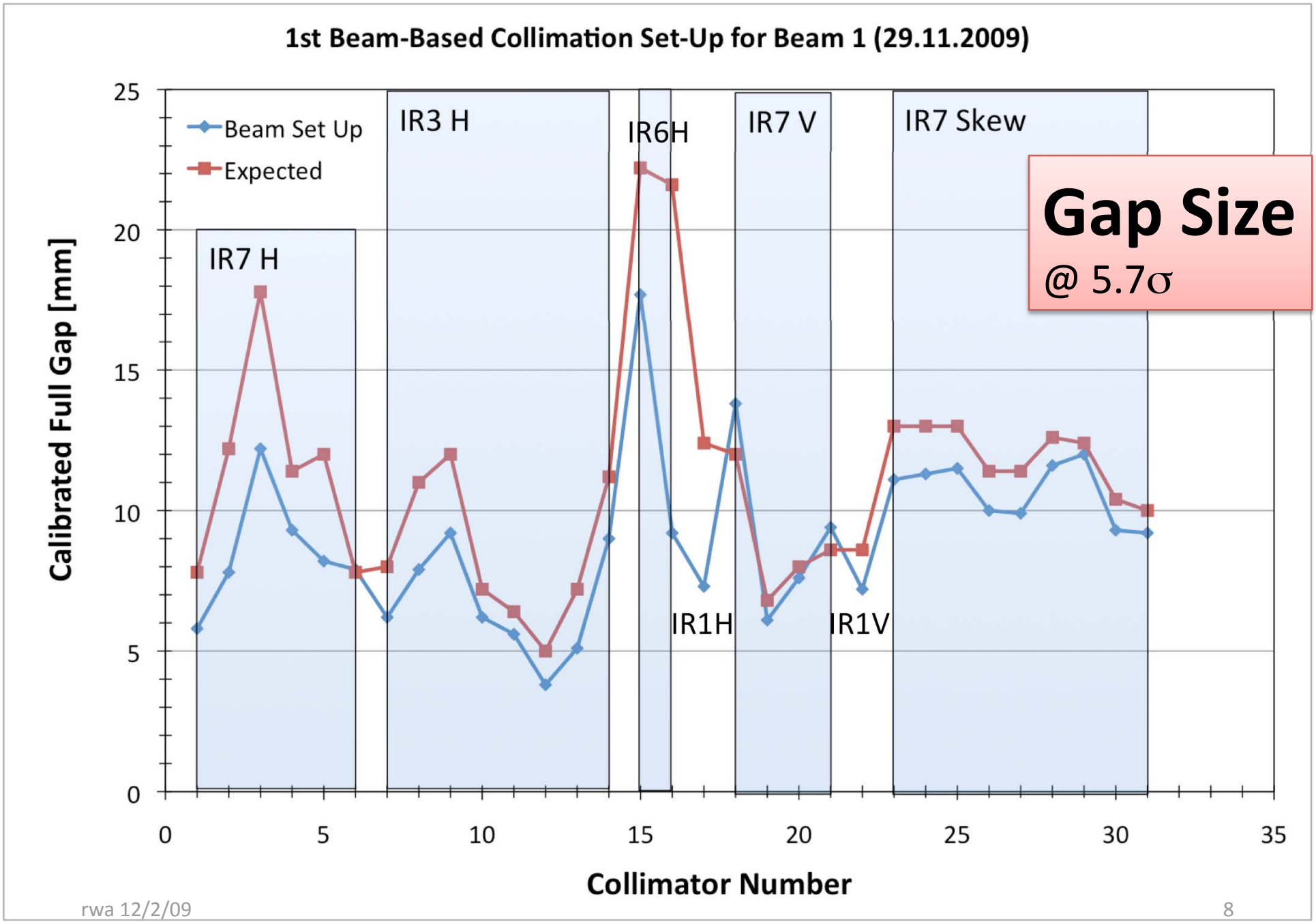
Then Full Collimation Set-Up Last Sunday

- **Both beams in parallel (2 teams of 2 persons each) for 1 shift.** Carefully prepared by the team…
- Setting up to injection settings (expressed in nominal emittance):
  - Primary betatron collimators: 5.7 σ
  - Primary momentum collimators: 8.0 σ
  - and the full multi-stage hierarchy (see our papers)
- Achieved 60 collimators (120 jaws) in ~7 hours: ~10 min per collimator.
- Principle: **Created halo edge at assumed 5.7 σ and move all jaws to the edge.** Accuracy: 200-300 μm

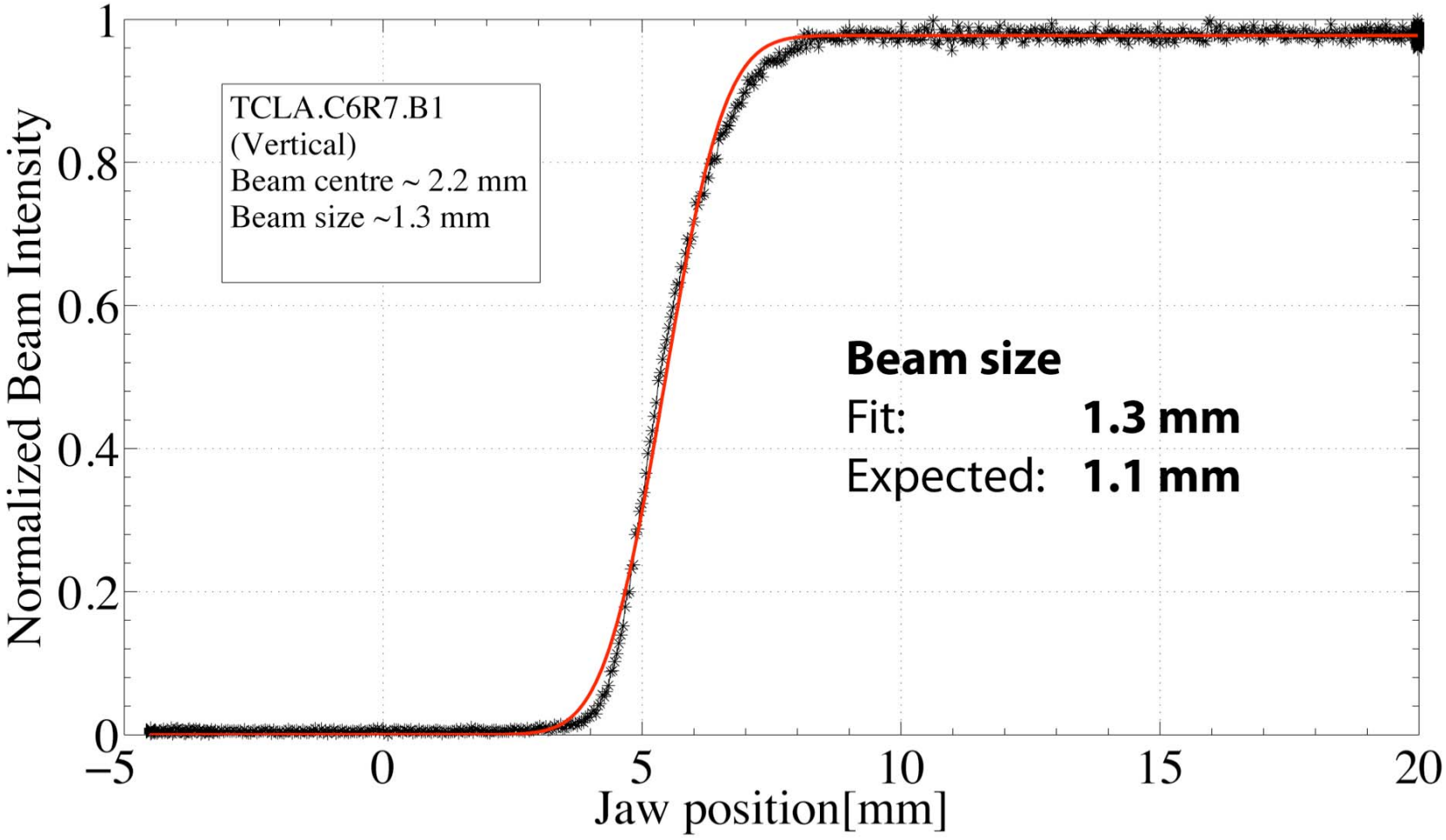
Beam-Based Jaw Alignment




1st Beam-Based Collimation Set-Up for Beam 1 (29.11.2009)
IR7 H
IR3 H
IR6 H
IR1 H
IR7 V
IR1 V
IR7 Skew
Gap Centre [mm]
Collimator Number
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
30
35
Gap Centre


1st Beam-Based Collimation Set-Up for Beam 1 (29.11.2009)
Beam Set Up
Expected
IR7 H
IR3 H
IR6H
IR1H
IR7 V
IR1V
IR7 Skew
Gap Size
@ 5.7σ
Calibrated Full Gap [mm]
Collimator Number
0
5
10
15
20
25
30
35

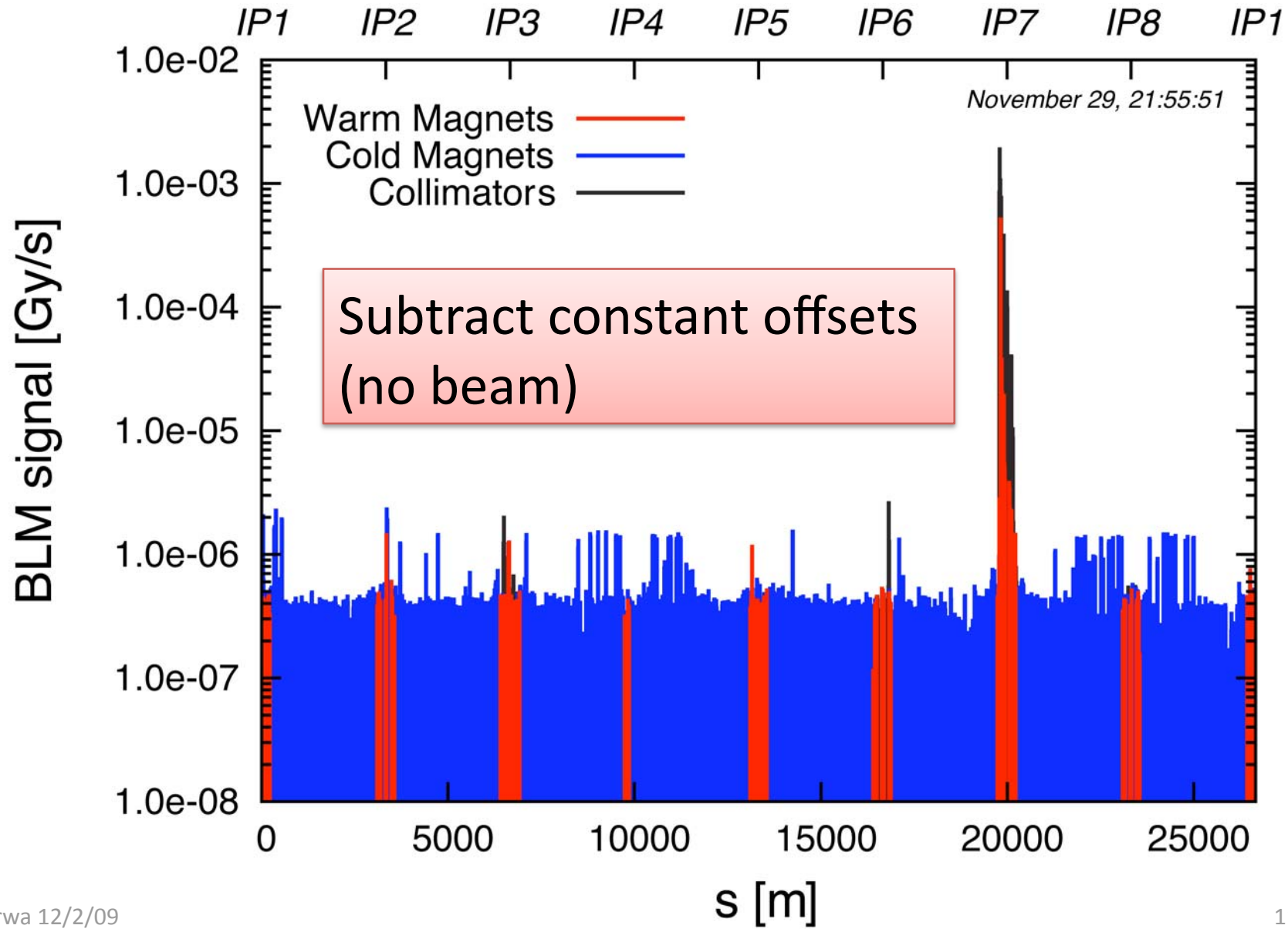
Collimator Scans (beam size and centre)

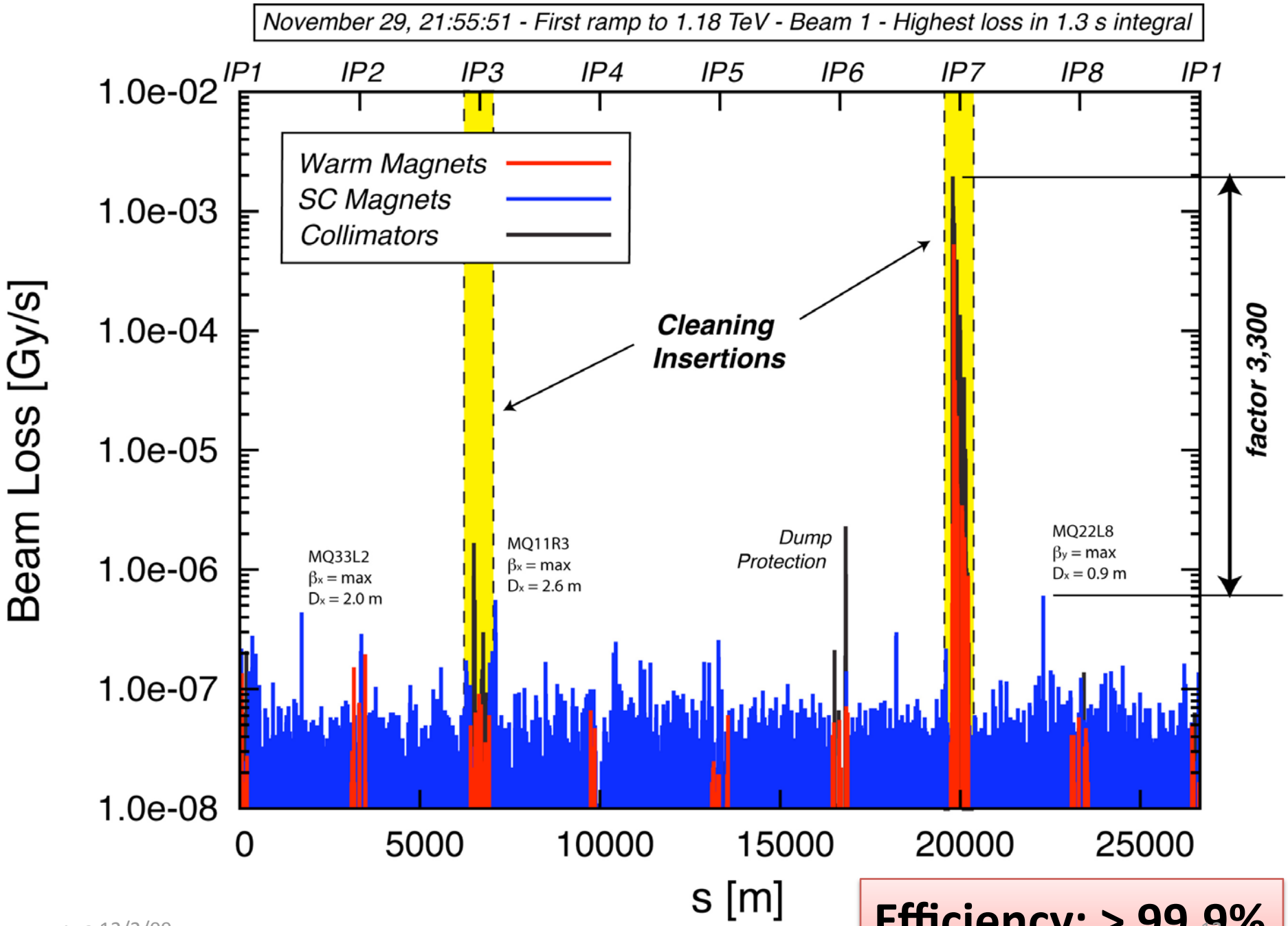


Observations

- Worked very well. Accuracy: ~0.2 mm
- Gap centre offsets between **-1.0mm and +1.5mm**.
- Most results nicely compatible with expected gaps. We follow the expected variation!
- Some larger deviations in IR6 (high beta) and IR1 (experimental area) to be followed.
- Collimator jaws were then retracted from their calibrated 5.7σ settings to nominal gap values to establish multi-stage collimation (secondaries to 6.7 σ, absorbers to 10σ, …).

Peak loss first ramp to 1.18 TeV





Efficiency: > 99.9%

LHC Operation with Collimation

- Cleaning and collimation so far looking highly efficient, no hole (loss at unexpected location) shown yet.
- Price to pay? Reduction of beam lifetime **~50h → ~3h** with collimators in place.
- Not a total surprise: Lifetime and background issues for collimation below 5σ observed at many places!
- Reason: Likely slow diffusion process much more visible with tight aperture than loose aperture. Too early for predicted impedance issues!?
- Needs beam optimization (diffusion), collimator experiments and/or higher intensity to analyze.
- Risk: OK for pilot injection but what happens for higher intensities? When do we need transverse damper?

Collimation Machine Protection Aspects

- Collimator position and gap interlocks passed full qualification (except TDI). Fully documented in MTF collimator database. MPP can check…
- Thresholds only active for tertiary collimators (TCT's). Can be put elsewhere, once decided.
- Issues for BLM thresholds at tungsten resolved with BLM team. Created known beam loss at collimators and calibrated BLM signal in power loss at collimators. Can relax collimator thresholds (factor 100?) and unmask. ➔ BLM team.
- System can be declared safe (except TDI issue).

Conclusion

- Very **happy to see the system working with beam** after 7 very busy years.
- Already **>99.9%** of cleaning efficiency is visible after 10 hours of beam time for optimization. Thanks to the very efficient young collimation team members (C. Bracco, D. Wollmann) and BE/BI for excellent diagnostics (BLM's).
- See first signs of interesting halo dynamics (lifetime). Must follow up, especially for higher intensity! We need low diffusion beam.
- System is safe (documented), with triple redundancy. Not a single failure yet (HW and beam).
- Next steps: **Put thresholds active, better accuracy setup, injection protection, closing jaws during ramp (intermediate).**
- From collimation, we feel so far confident for increasing beam intensity (2010 goal is 40 MJ stored energy). Looks like simulated.