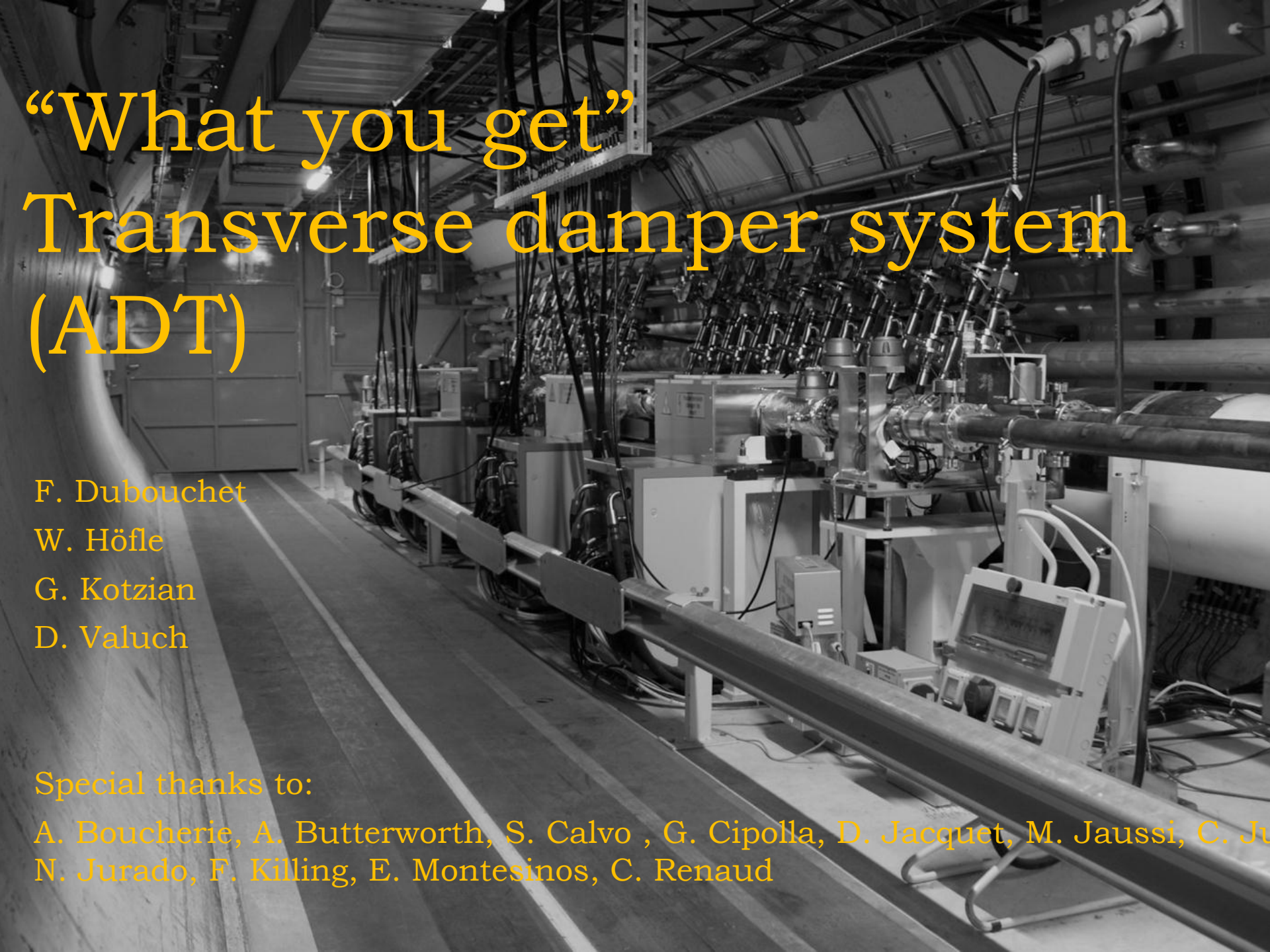


“What you get” Transverse damper system (ADT)

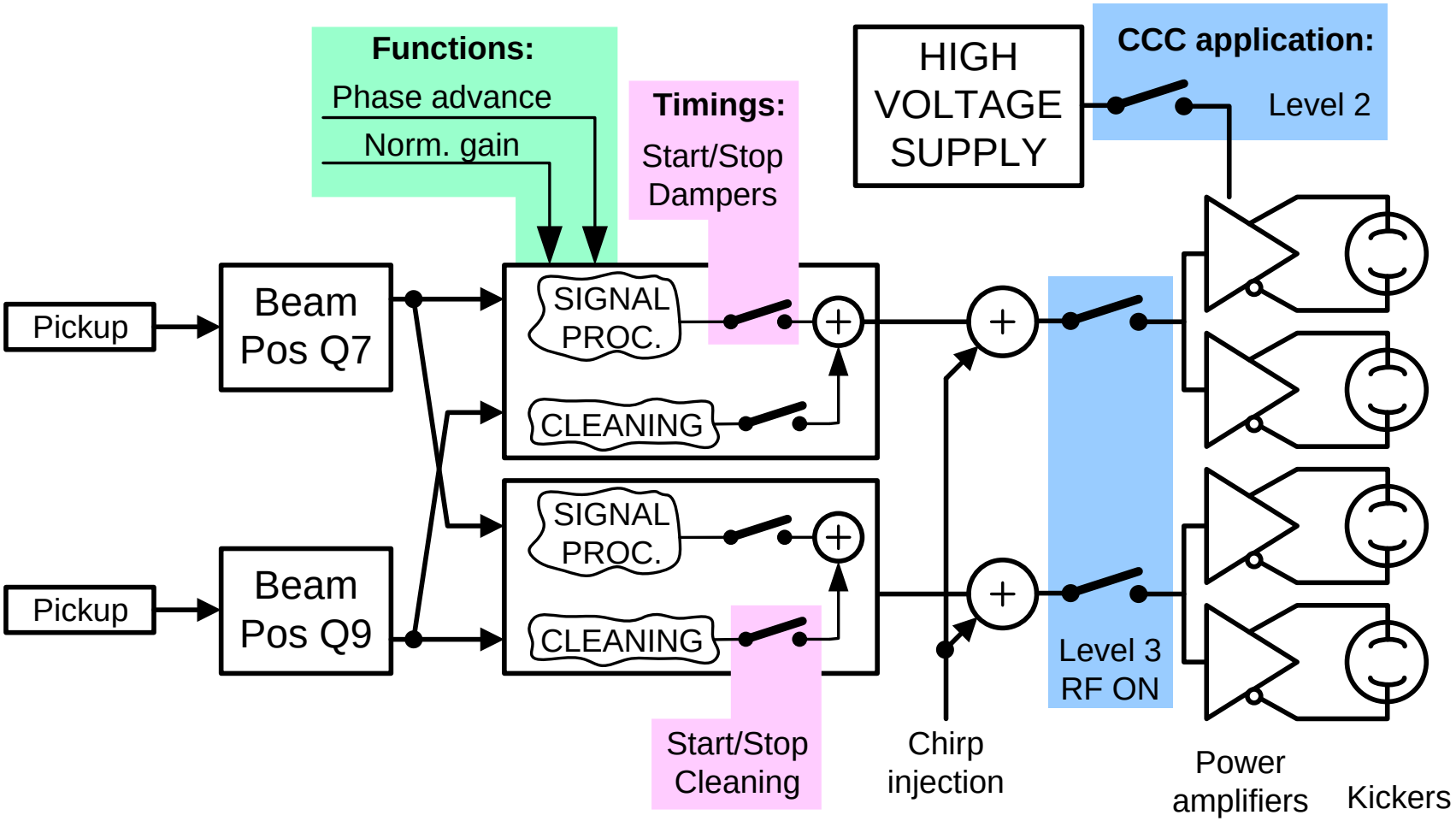
F. Dubouchet
W. Höfle
G. Kotzian
D. Valuch

Special thanks to:
A. Boucherie, A. Butterworth, S. Calvo , G. Cipolla, D. Jacquet, M. Jaussi, C. Ju
N. Jurado, F. Killing, E. Montesinos, C. Renaud

The transverse damper system

- Operation in 2012 was very smooth, routinely switching between different modes and operating the feedback during the entire LHC cycle.
- Not much downtime, total 18 hours in fault
- Several MDs
  - ADT vs. BBQ cohabitation
  - Noise vs. emittance conservation
  - Fast controlled losses
  - Increased bandwidth operation
- New features
  - Selective blow-up
  - Tune observation "infrastructure"
  - High bandwidth

ADT as seen from the CCC



Faults summary in 2012

- Total downtime 18 hours in 2012

Tetrode exchange	Amplifier faults	HV Power supply faults	PLC & Server faults	Kicker Faults	Low-level RF
#9 #12 #16	#3 PT100 (exchange amplifier)	#15-16 HV cables burnt	#11-12 FESA server crashed	RB46 TPG 300 exchange	40MHz clock havoc after TS
#3 #15 #6	#8 PT100 (exchange amplifier)	#9-10 Gate control failure	#9-10 FESA server crashed		Gigabit link connector bad soldering
#14 #1 #4 #2	#2 attenuator (exchange amplifier)		#11-12 Beckhoff module exchange		
Total 20 tetrodes out of 32 replaced	#9 HV load (exchange amplifier)				
	#10 water flow meter				

ADT Settings management

- Frequently asked question: *"Why do we always need to call the ADT experts to load settings?"*

- Beam position part is sensitive to per-bunch intensity
  - Wrong settings could lead to a damage of expensive equipment resulting in a very long downtime
  - Injection inhibit interlock implemented in 2012

- Signal processing part is sensitive to bunch spacing
  - Wrong settings will lead to unstable beam

ADT Settings management

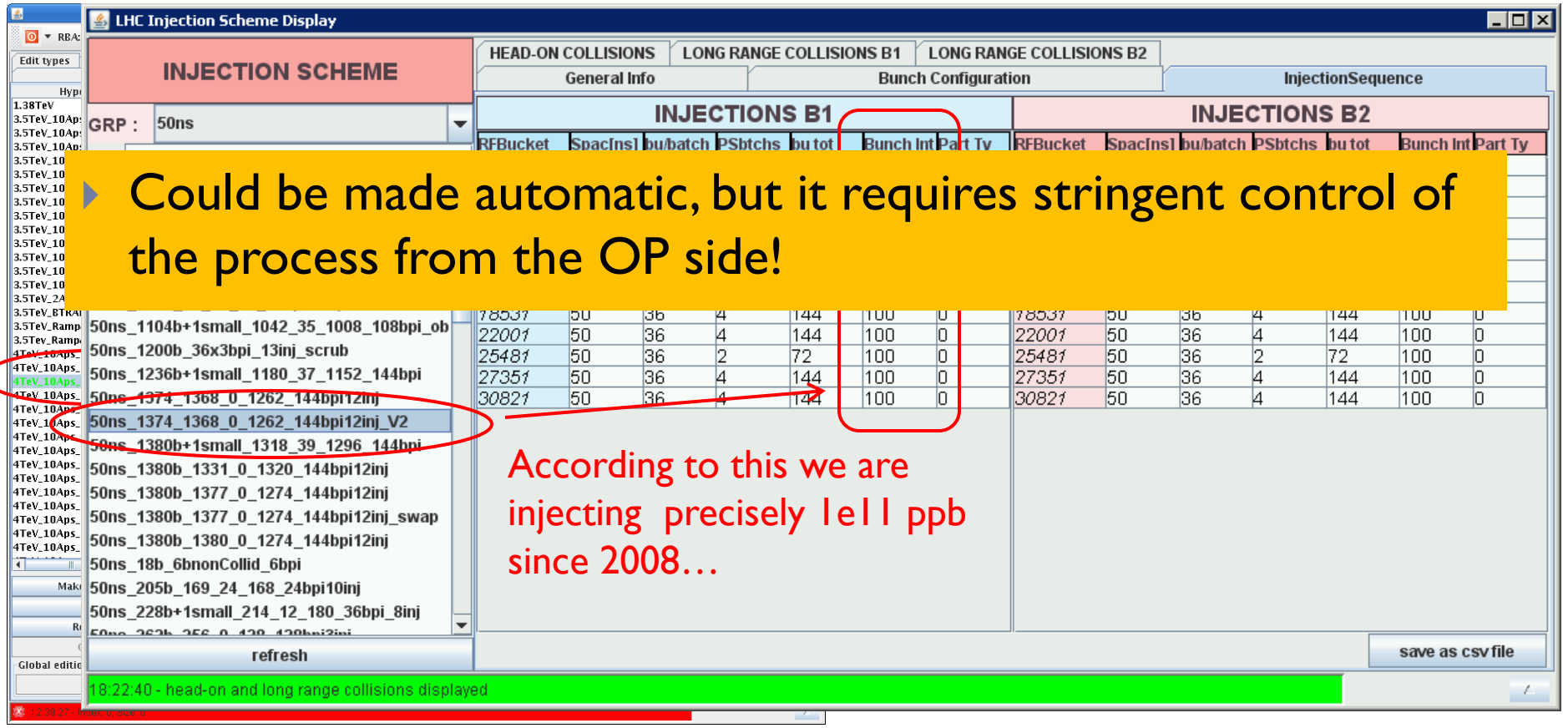
- Most settings stored in LSA:
  - Beam processes e.g. DISCRETE_LHCRING_ADTDSPU_50ns with parameters relevant to bunch spacing
  - Beam processes e.g. DISCRETE_LHCRING_ADTDSPU_SQUEEZE relevant to the cycle phase

- Several operational sequences e.g.
  - LOAD ADT DSPU INJECTION SETTINGS
  - LOAD ADT DSPU BUNCH MASK FOR PHYSICS
  - ADT LOAD WIDEBAND SETTINGS

- Bunch intensity + interlock is controlled manually

ADT Settings management

- Why not yet automatic?



Controlled blow-up (new in 2012)

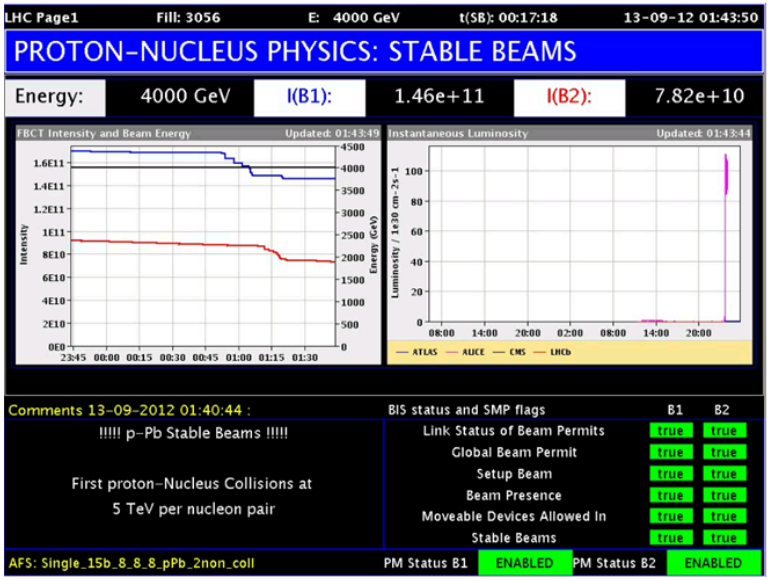
- A portion of the beam (up to 11.5 μs long) could be excited by a white noise – fully controlled blow-up
- Made loss maps extremely efficient. *All "transverse" loss maps could be done in one single ramp*
- The excitation could be done at any phase of the cycle
  - Loss maps during the ramp, squeeze, physics…

Controlled blow-up (new in 2012)

- Example of controlled excitation
  - 14 bunches injected and ramped
  - When in collision two bunches used for loss maps
  - Remaining 12 used for several hours of physics!

Second pPb ramp

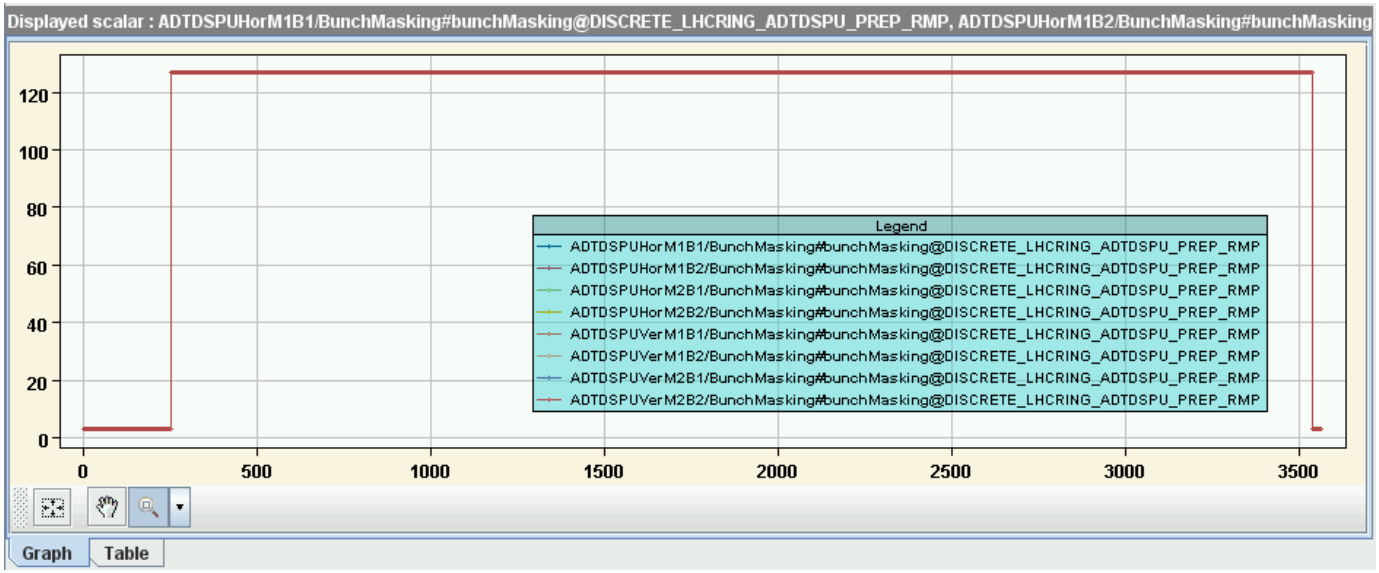
- 22:42 @ 4 TeV
- 23:00 Re-phasing – found collisions
- 00:50 Start of loss maps
- 01:26 Stable beams, first time pPb
  - Lumi's approaching 10^26 cm-2s-1



13/09/2012 LHC 8:30 meeting

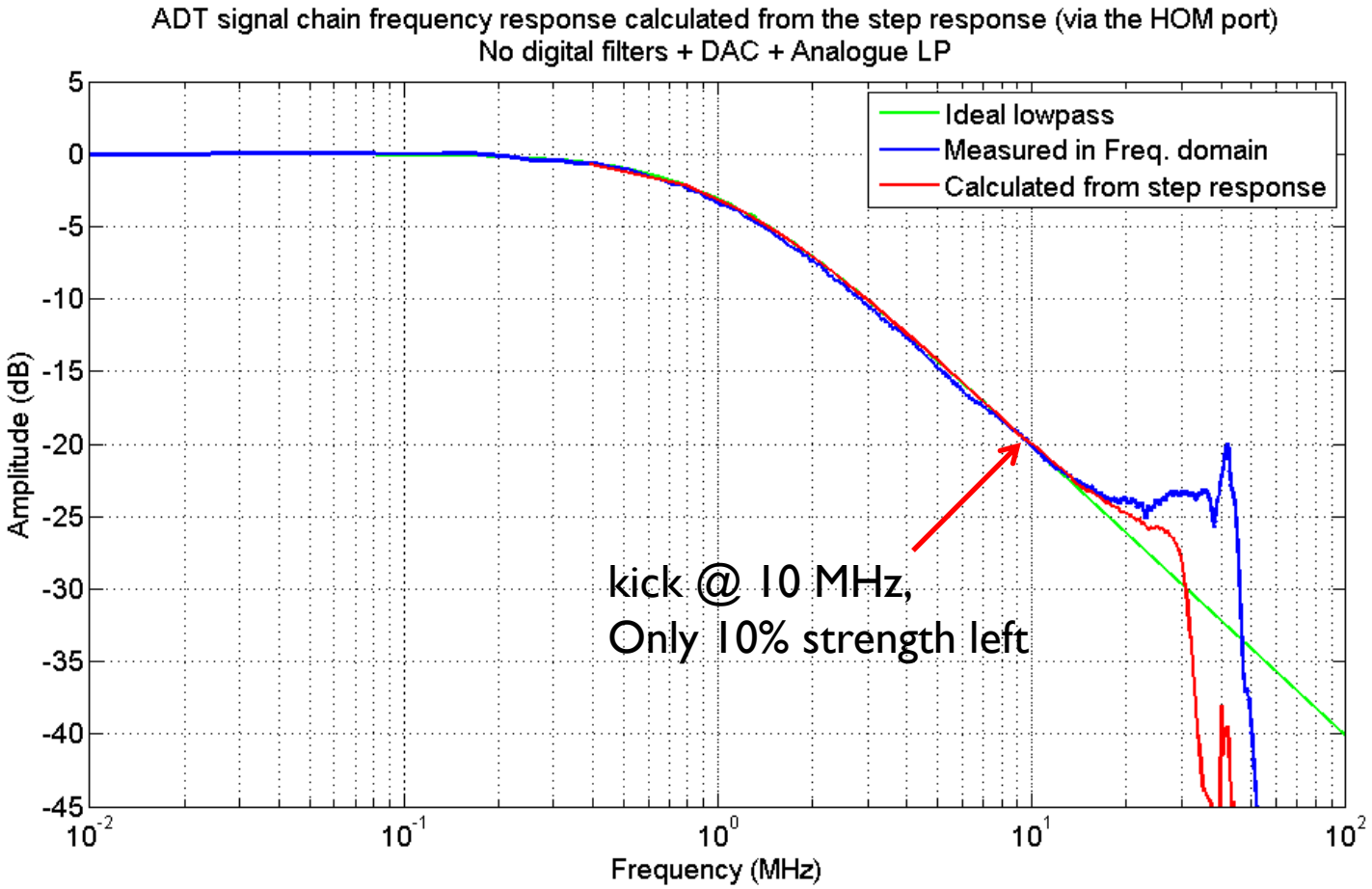
Gain modulation (new in 2012)

- Gain modulation within turn
  - Commissioned early 2012, aim to help BBQ to get cleaner signal
  - Not helping with standard BBQ and many bunches
  - *Fully exploited late 2012 with the gated BBQ made operational*



High bandwidth (new in 2012)

- Power amplifiers, 1st order low pass, -3 dB @ 1 MHz
- Power amplifier phase response compensated by digital filter



Frequency domain measurements February 2012 B. Lojko.

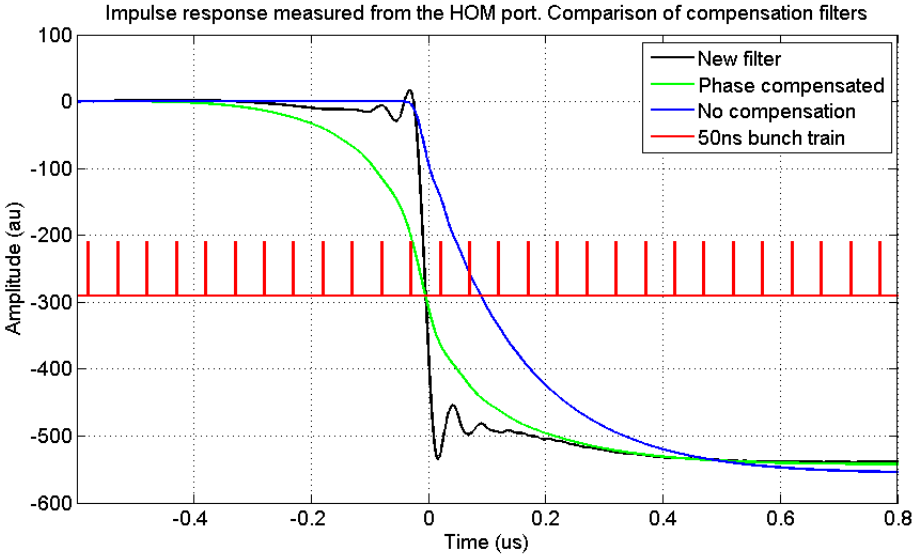
Step response measurements 19.9.2012 D.Valuch, G.Kotzian

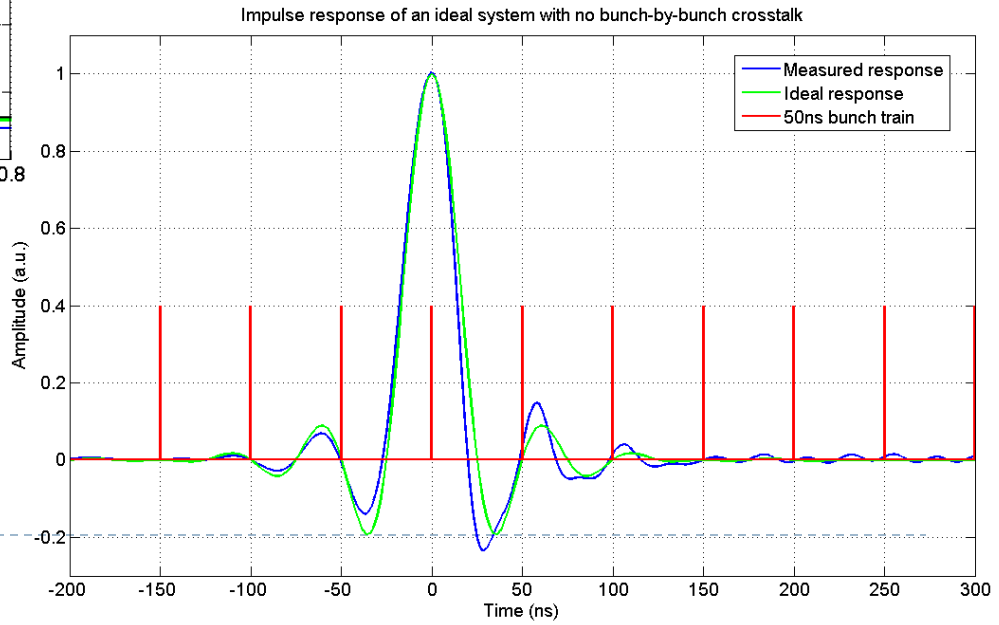
High bandwidth (new in 2012)

- The full power is needed only for efficient injection oscillation damping, damper uses <1% of its strength otherwise
- Small signal response could be enhanced by drive signal pre-distortion
- Enhanced bandwidth provides faster damping of high frequency modes
  - "Ideal damper" – treats each bunch individually
  - Drawback – increase of noise injected through the damper, mitigations for noise reduction foreseen for after LS1
- *Commissioned end September 2012*

High bandwidth (new in 2012)

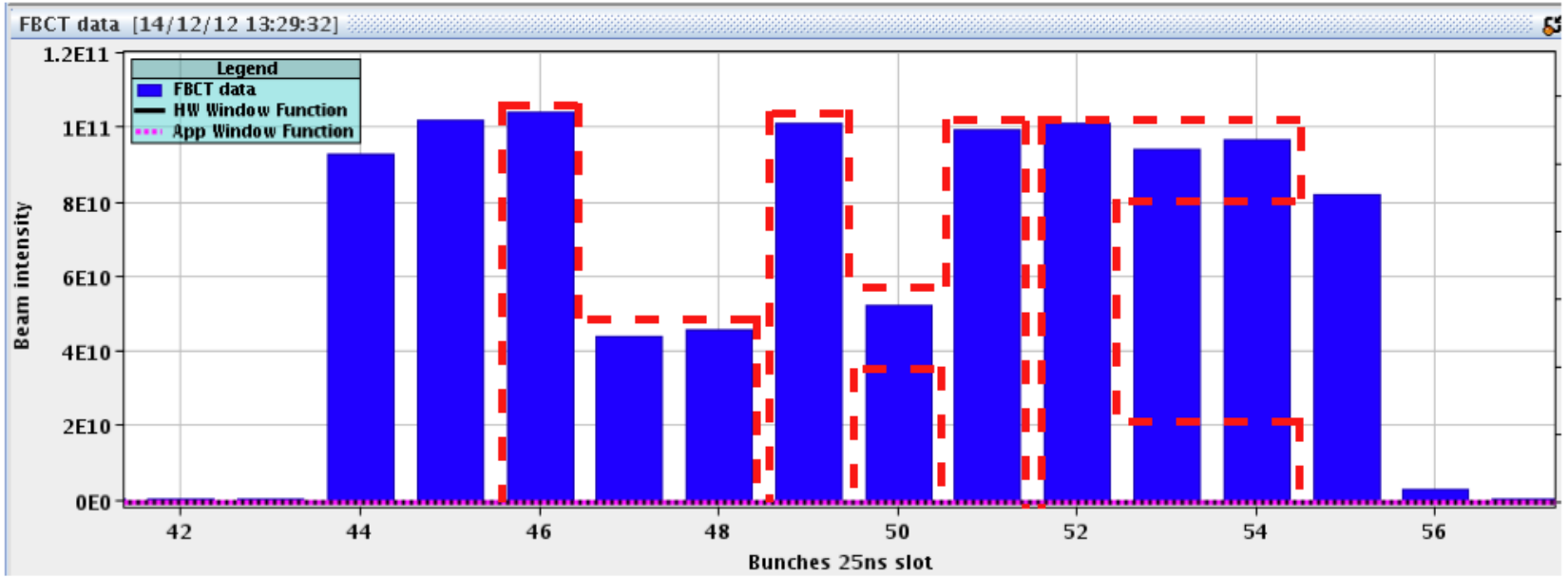
- Measured enhanced frequency response reaches beyond 20 MHz → *Bunch by bunch damper!*





High bandwidth (new in 2012)

- Increased bandwidth has interesting consequences → also the cleaning and excitation becomes feasible bunch-by-bunch



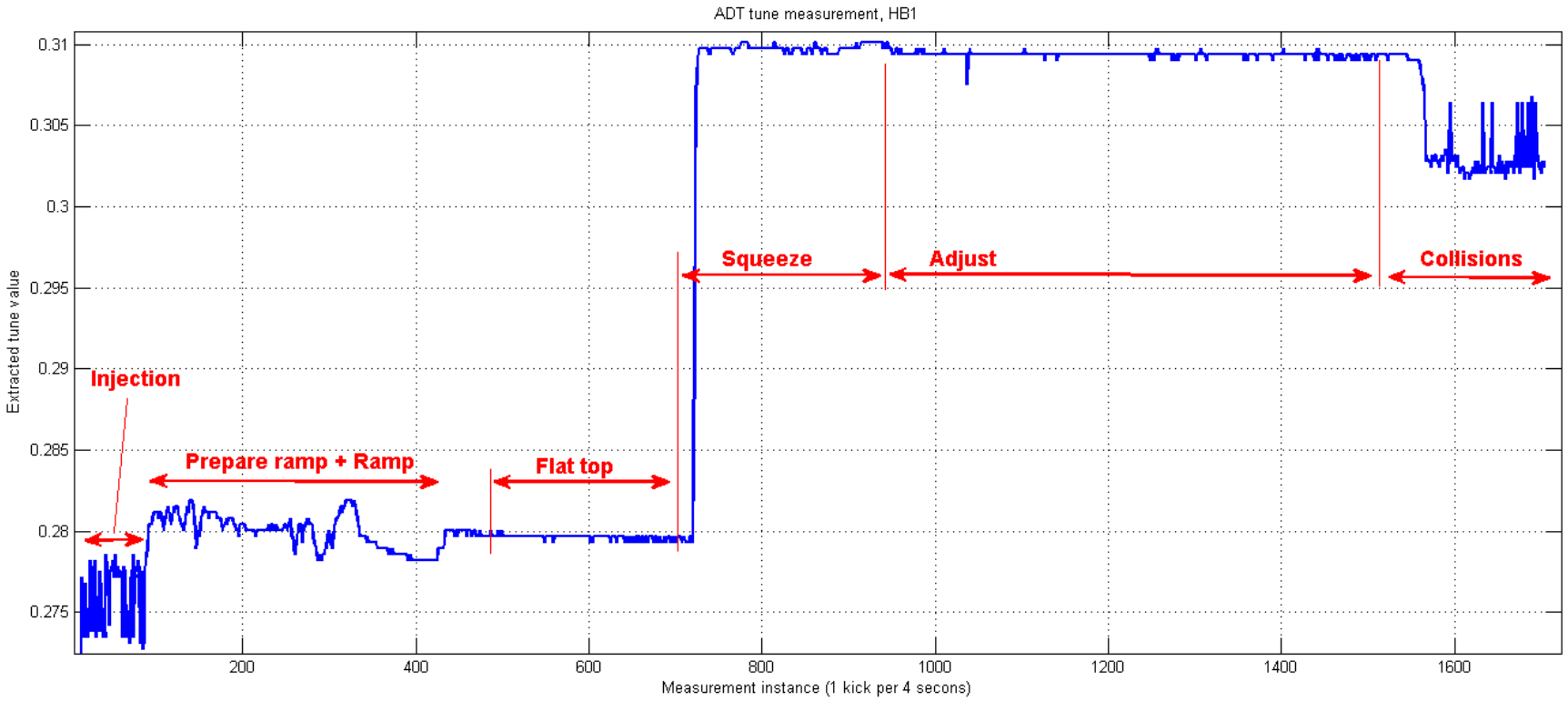
Loss maps 14.12.2012. A train of 12 bunches with 25ns spacing + 2 indivs injected. Bunches in slots #44 and #56 used for loss maps. Bunches in slots #47, #48, #50 were consecutively blown up without significant effect on the neighbour bunches.

Tune measurement tests

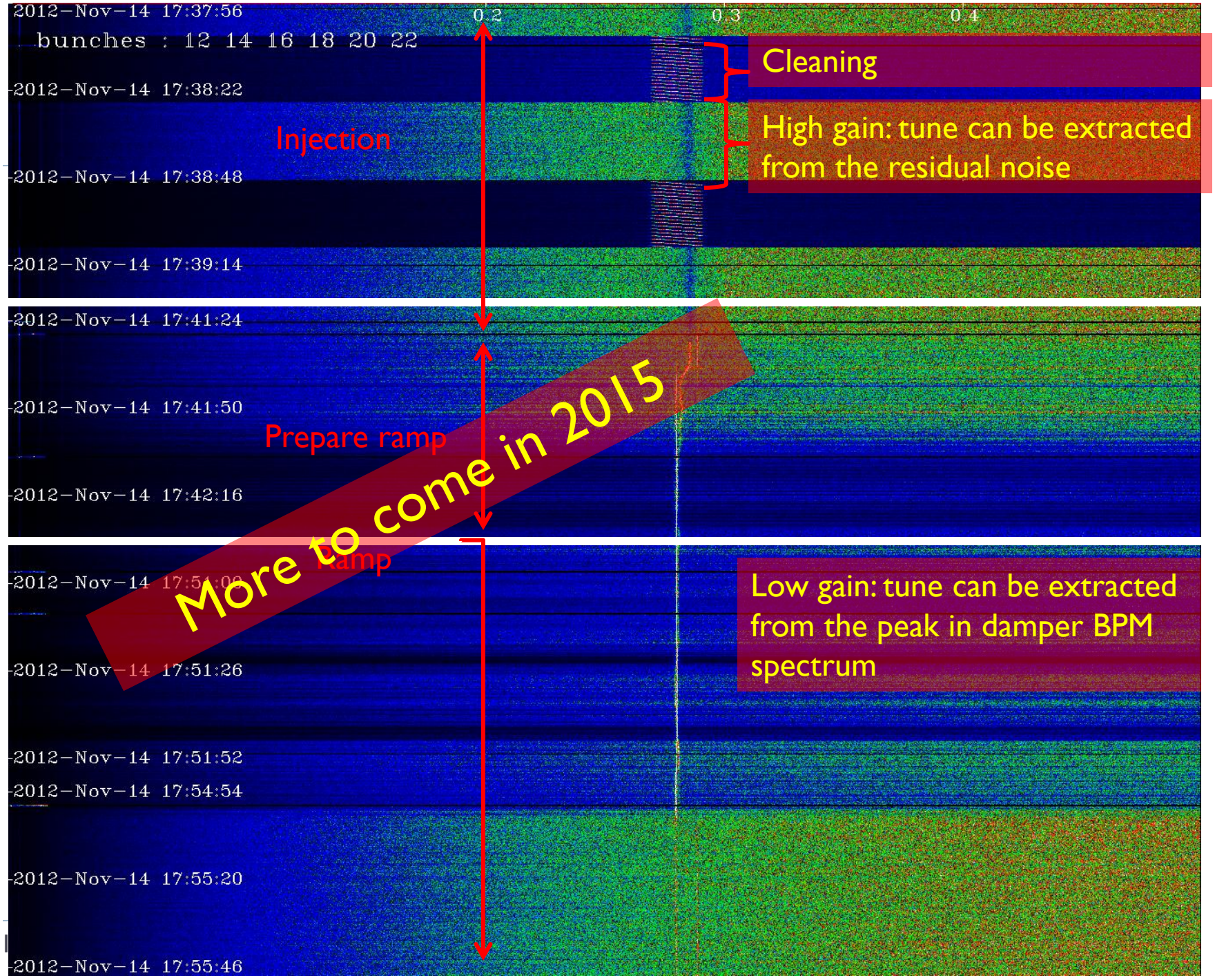
- ADT vs. BBQ cohabitation
  - Several tests and operational developments done on tune extraction from ADT
  - Witness bunch method: active kicking by 10's μm
  - Extraction of tune from the residual noise
  - Passive observation of bunches with lowered gain

Tune measurement tests

Tune measurement with active kicking of the first 6 (witness) bunches with full ADT gain. Horizontal plane, Beam 1, 12.8.2012.



Passive observation of the first 6 bunches with reduced gain. Hor. B2



Performance scaling for 6.5 TeV

- Damping time in order of 50 turns feasible at 6.5 TeV, needs redistribution of gain within the system (LS1)
- Enhanced bandwidth operation in stable beams
  - Potential issue with noise
- Noise – mitigation measures during LS1
  - Double number of pickups
  - New pickup cabling
  - New beam position and signal processing electronics
  - Optimized signal processing

Plans for the LS1

- Complete recabling – replacement of the damaged coaxial cables
  - >25 km of 7/8" smooth-wall coaxial cable
- Increasing number of pickups from 2 to 4 per beam per plane
- New beam position module (16x)
  - lower noise, better observation
- New digital signal processing unit (8x)
  - handling of 4 pickups, sophisticated excitation schemes, gain modulation, better observation, automatic setting up

Plans for the LS1

- Tune extraction
  - Decide on optimum after careful analysis of collected data
  - Witness bunches proved very promising, *can we have a decision to keep them?*

- Internal instability observation trigger

Re-commissioning after LS1

- ADT will undergo significant upgrade during the LS1

- Restart and re-commissioning with beam will need time…

Summary

- ADT operation in 2012 was very smooth, very few hardware problems
- ADT is routinely switching between different modes and operating the feedback during the entire LHC cycle
- 2012 was devoted mainly to development of new features, modes of operation, studies and MDs
- New features like selective blow-up significantly reduced duration of certain repetitive tasks (like loss maps) and made many other tests possible (e.g. fast losses)

Summary

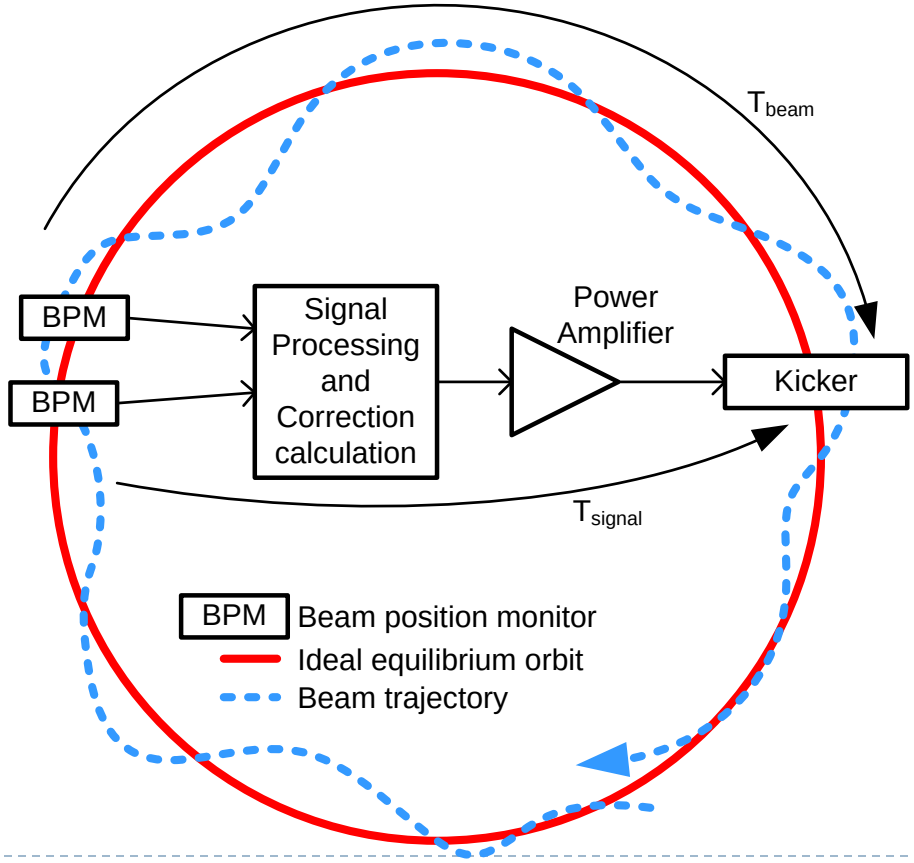
- LS1 will be very busy for the ADT team
  - New cables, new electronics, new firmware
  - Implementation and proper integration of all new features and operational modes experienced during the 2010-2012 run
  - New automatic setting up procedures required

- Outstanding:
  - Settings management and switching between different operational modes and intensities

Thank you…

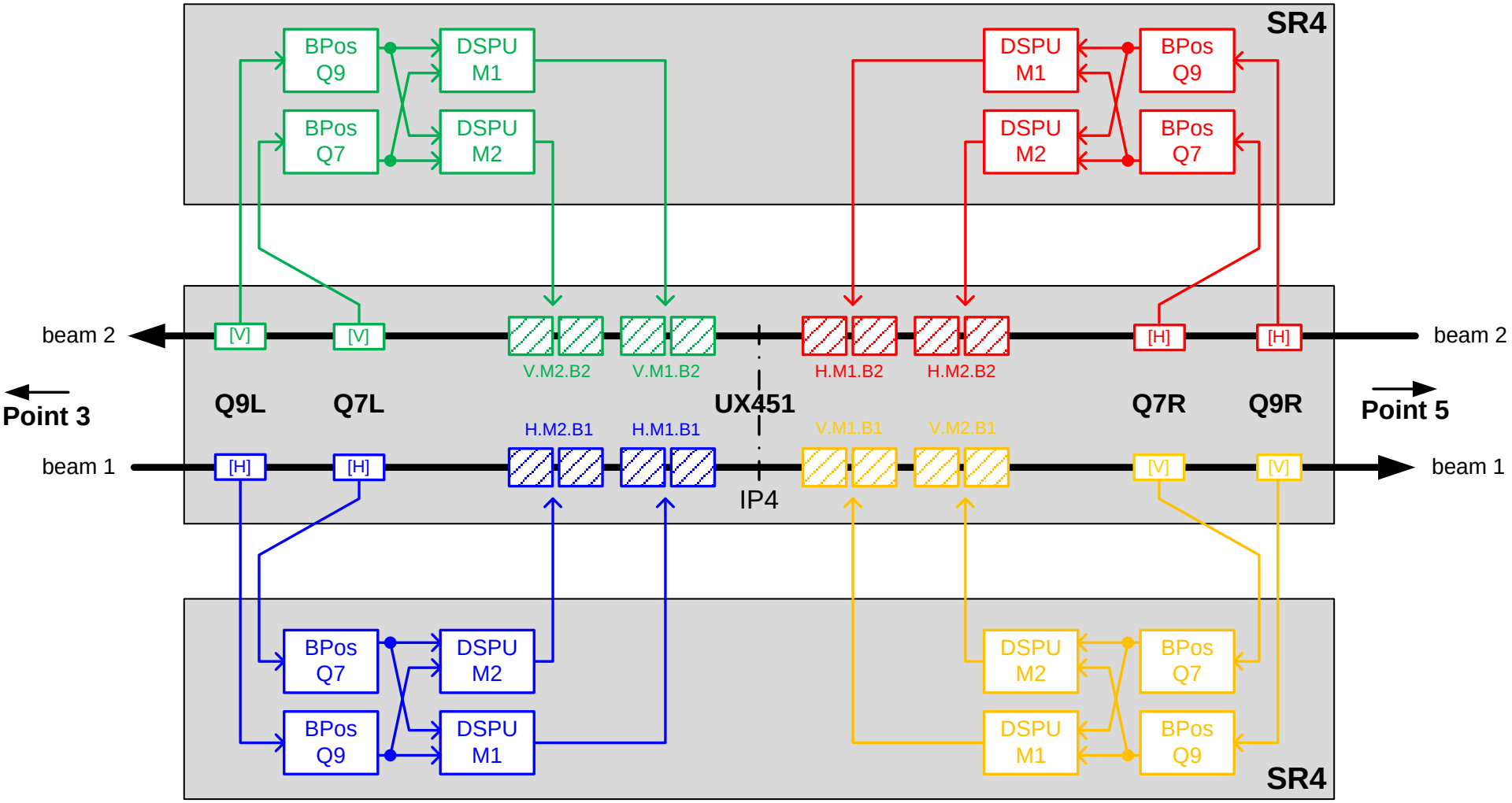
The transverse damper in general

- The transverse damper is a feedback system: it measures the bunch oscillations and damps them by fast electrostatic kickers



- Key elements:
  - Beam position monitor(s)
  - Signal processing system
  - Power amplifiers
  - Electrostatic kickers
- Key parameters:
  - Feedback loop gain, phase and total delay
  - Kick strength
  - System bandwidth
  - The one visible from the CCC: **damping time**

LHC transverse damper (ADT)



Bpos – Beam Position Module
DSPU – Digital Signal Processing Unit

ADT through the cycle