

FIRST RESULTS FROM THE LHC BEAM INSTRUMENTATION SYSTEMS

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on behalf of the CERN BE-BI group and all our collaborators

PAC 09

May 4 – 8 2009

Vancouver, Canada

LHC START-UP

- 10 September 2008: first circulating beam in the large hadron collider (LHC)
- Both beams threaded around the ring in only a few hours
- Achievement possible thanks to thoroughly commissioning of the machine components and the availability of high quality beam instrumentation from day one

SEPTEMBER 10 2008



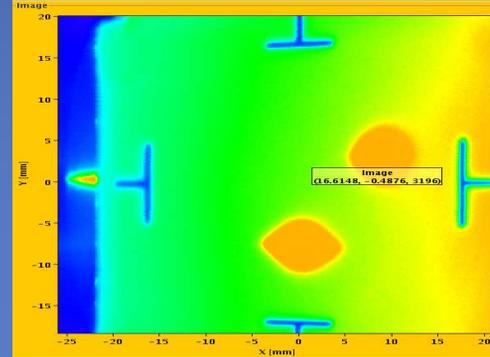
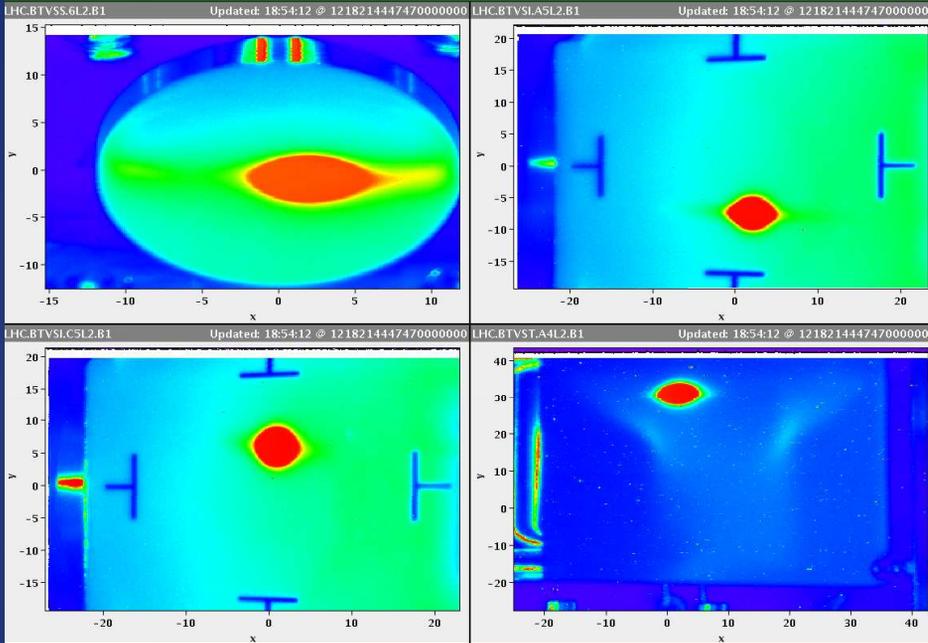
LHC beam instrumentation

- Scintillating and OTR screens
- Beam position monitors
- Tune and chromaticity monitors
- Beam loss monitors
- Current transformers
- Wire scanners
- Synchrotron light monitors
- Rest gas ionization monitors
- Schottky monitors
- Luminosity monitors
- Wall current monitors

LHC SCREENS SYSTEM (BTV)

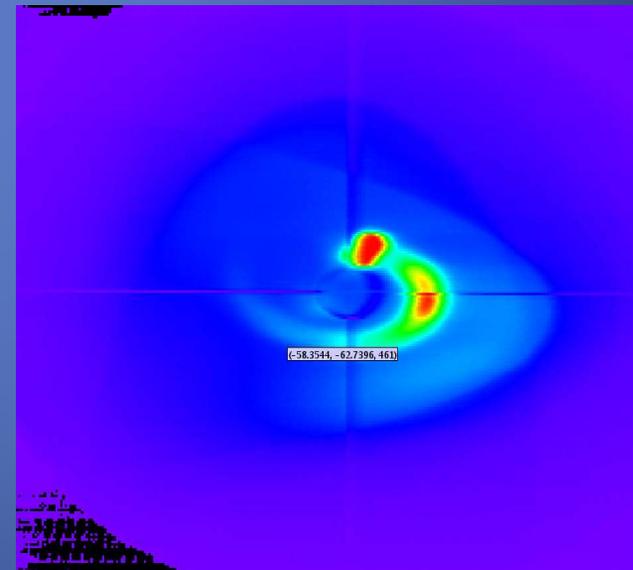
- 37 TV beam observation systems of 7 different types
- Each station equipped with a 1mm thick Al_2O_3 scintillator and a $12\mu\text{m}$ thick titanium OTR radiator
- Screens mainly used to match the optics in the transfer lines and steer the beam in the injection/extraction channels

LHC SCREENS SYSTEM (BTV)



First turn
in LHC

Steering of the beam through the injection channel using the Al_2O_3 screens



Sweep on the beam dump

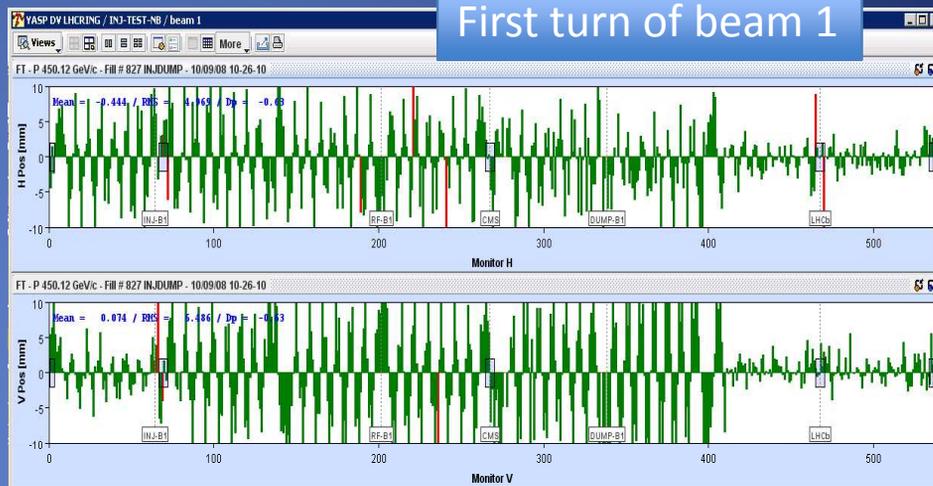
Beam position system (BPM)

- 1054 beam position monitors corresponding to 2156 electronics channels
 - Found only 24 channels with inversions or problems
- Read out system split in two parts
 - Analogue, auto-triggered, position to time normaliser in the tunnel
 - Acquisition and digital processing board in counting rooms on the surface
 - Signals transmitted via optical fibers

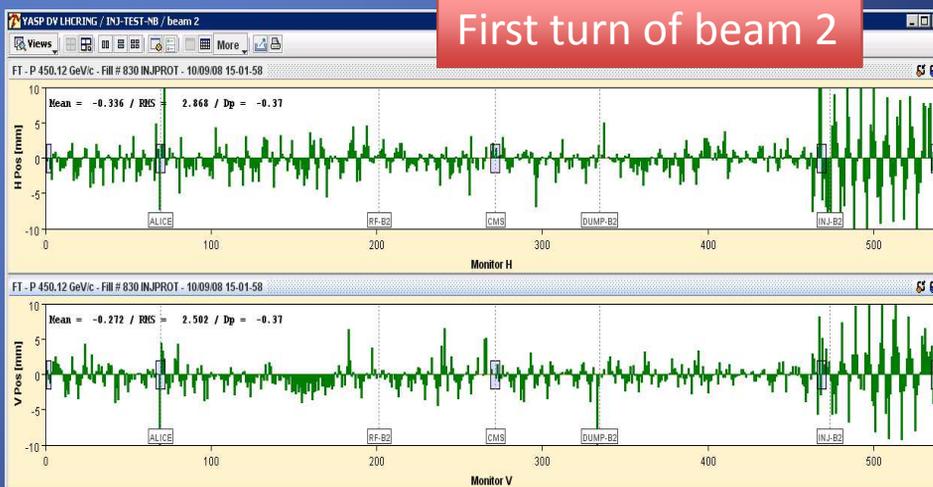
BPM acquisition

- Two acquisition modes available
 - Asynchronous FIFO mode, threading
 - ORBIT mode, 1 Hz filtered orbit information (IIR)

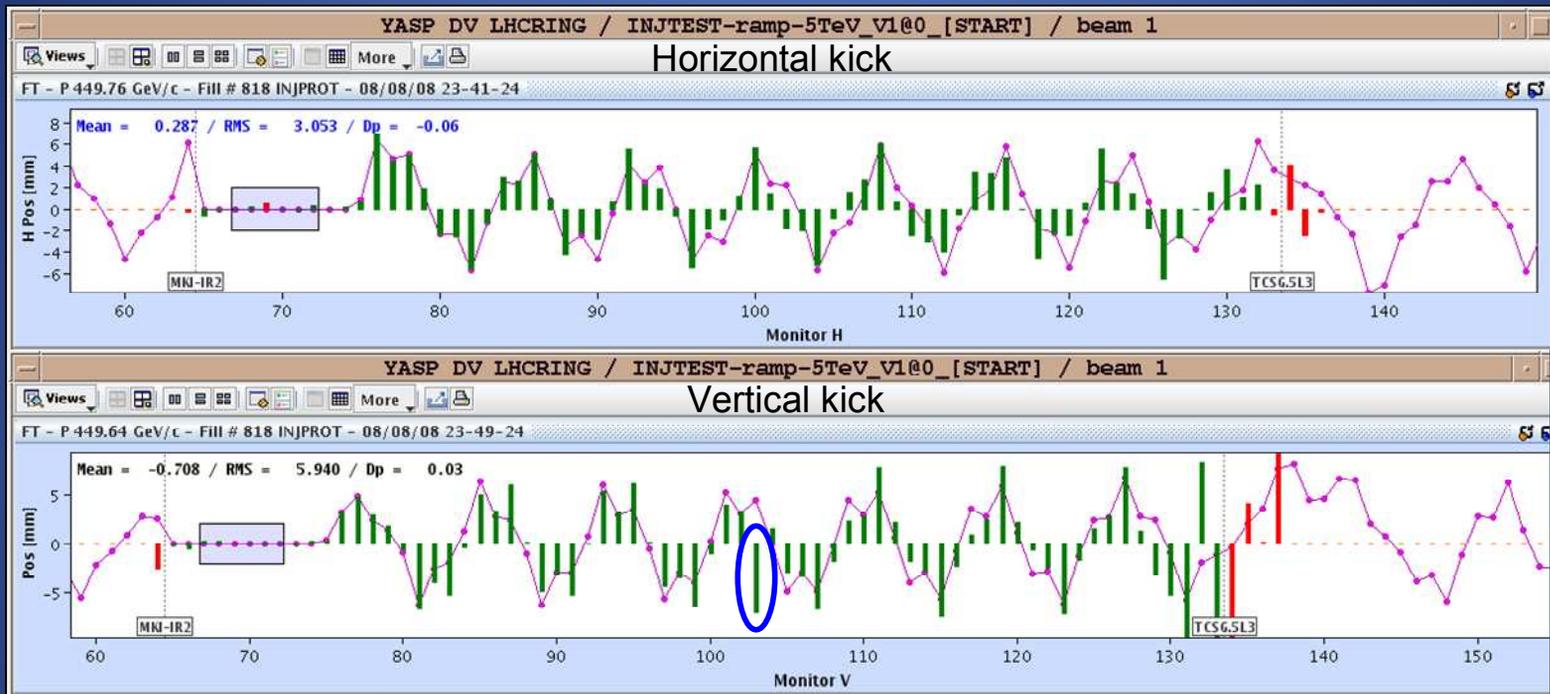
First turn of beam 1



First turn of beam 2

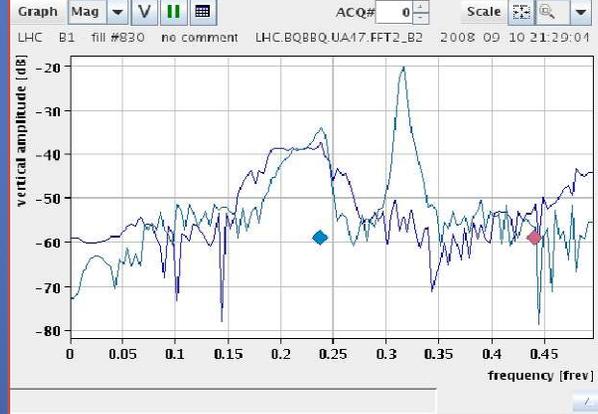
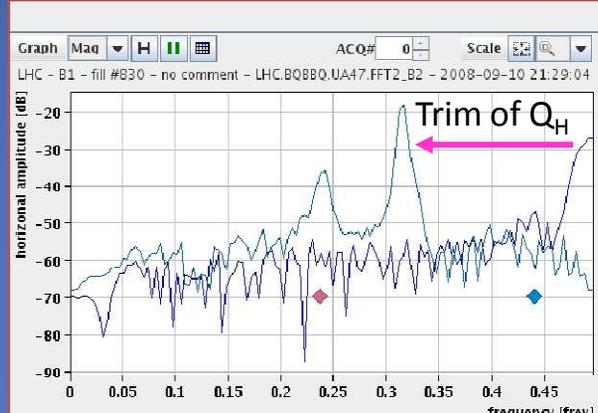
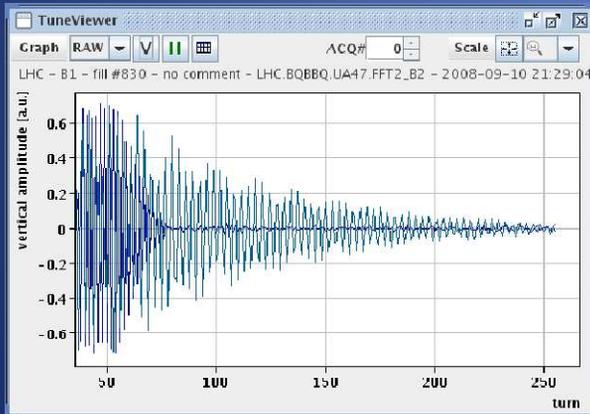
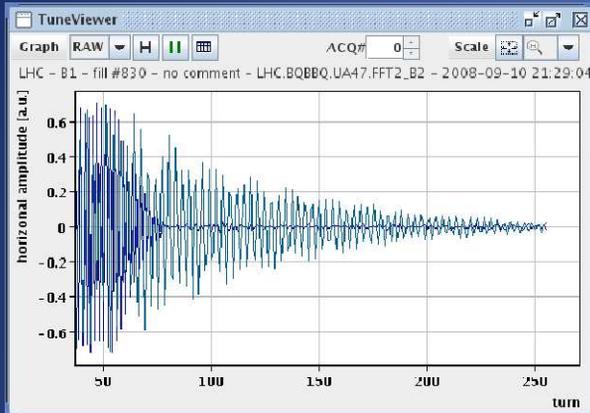


BPM optics analysis



- Powerful tools for online data analysis
- Easy to indentify BPM inversions or phase advance errors

Tune system



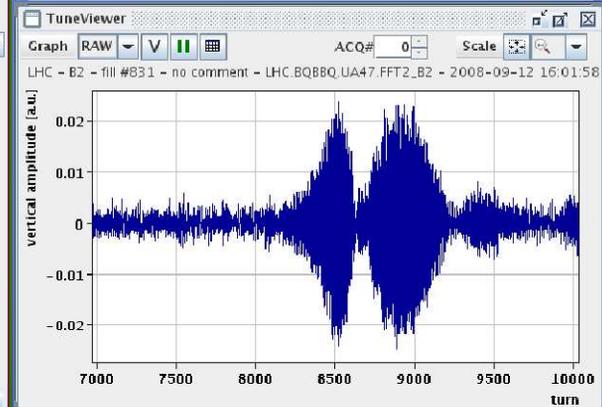
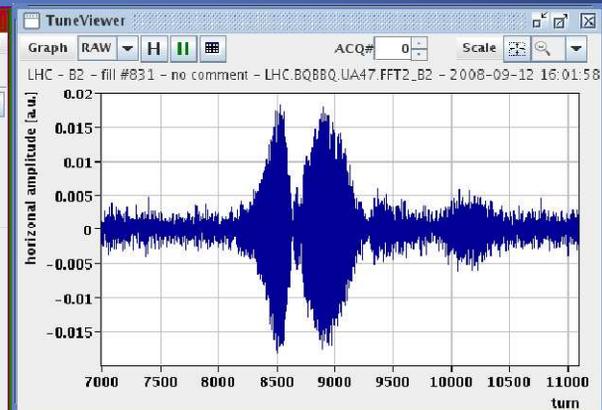
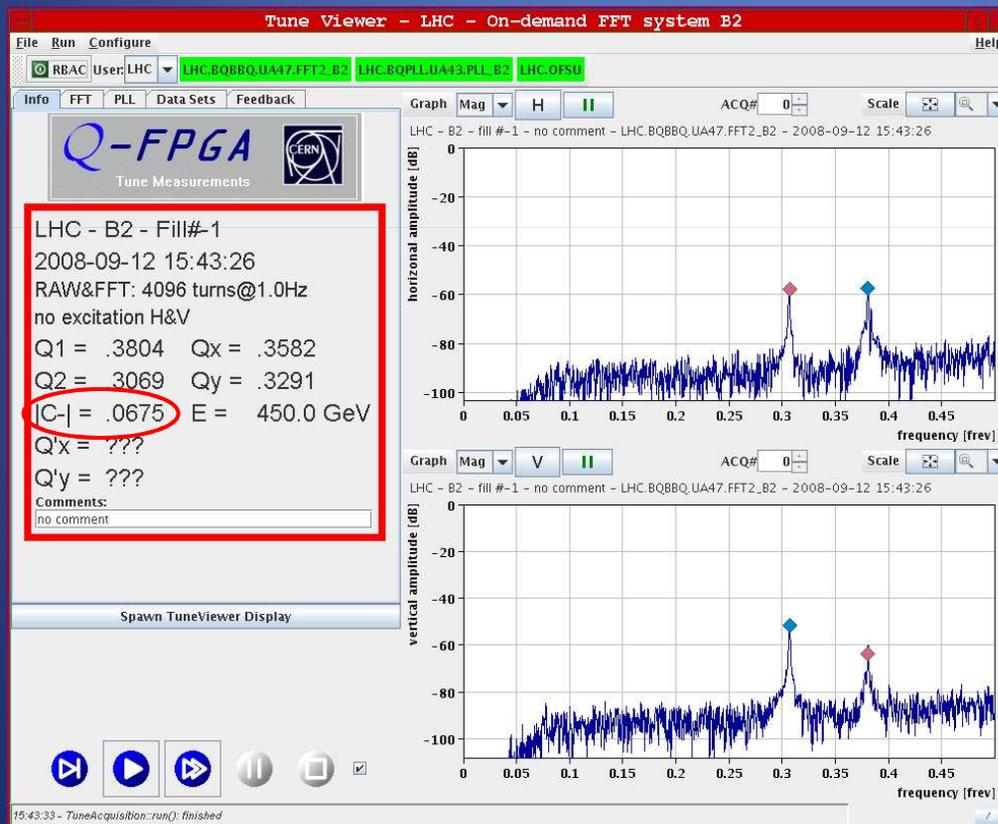
- BBQ system used with residual beam oscillations
- Allowed moving Q_H away from half integer

— Before correction
— After correction

RF OFF

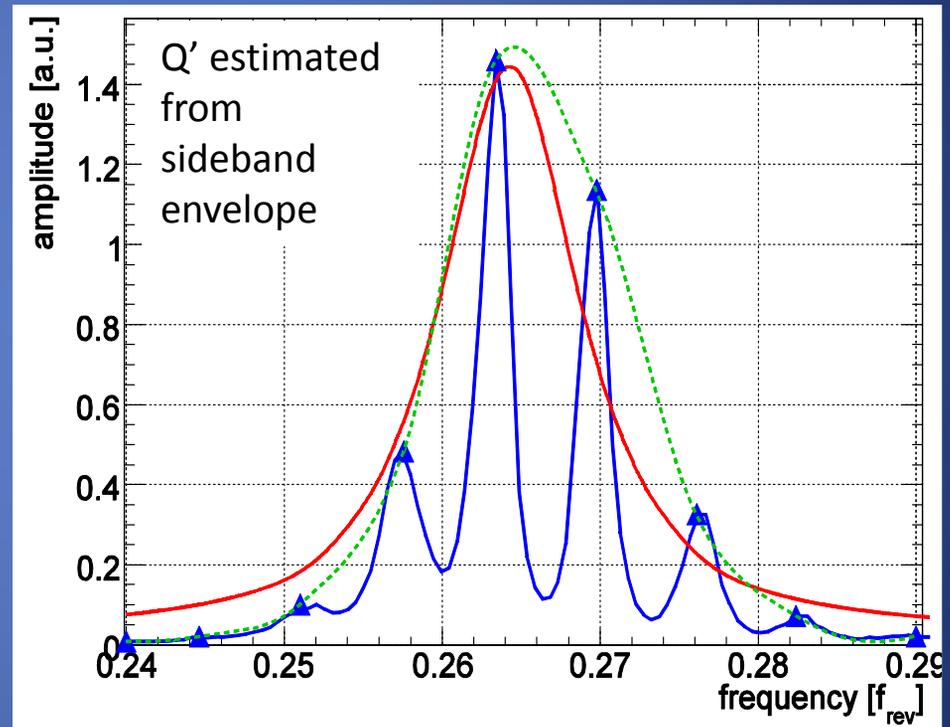
Tune with external excitation

- Chirp excitation using transverse damper
- Measured coupling $|C| \sim 0.07$



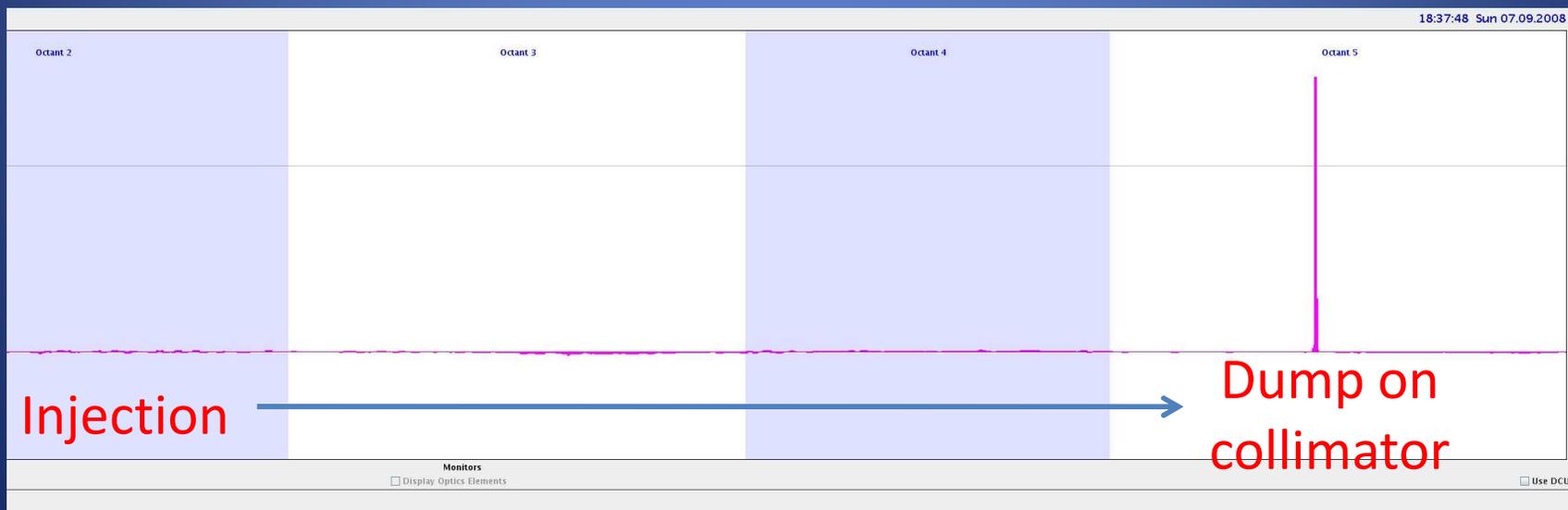
Chromaticity

- Estimated chromaticity from tune to synchrotron sideband amplitudes ratio
- $Q'_H \sim Q'_V \sim 32$



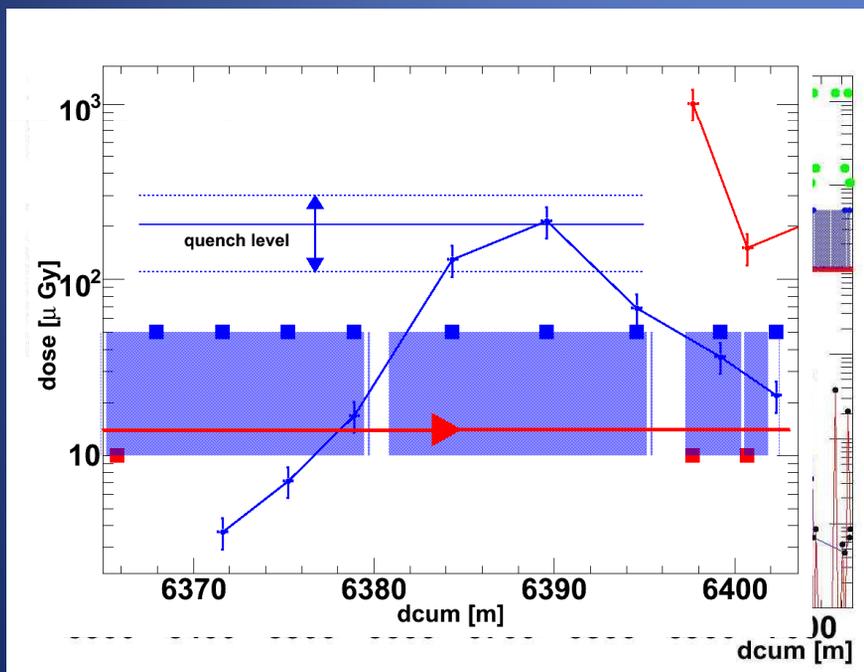
Beam loss system

- Over 4000 monitors, mainly ionization chambers
- BLM system used to protect and tune the machine
- Measured sensitivity $\sim 10^7$ protons

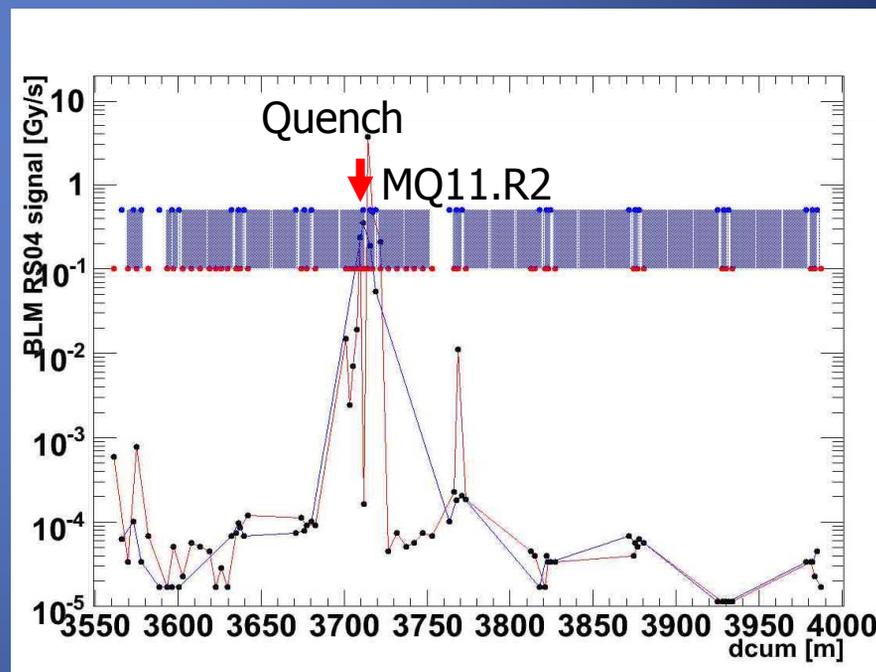


BLM, quench protection

- Two quenches observed with the BLM system
- Measurement and simulations agree well
- Quench levels: $\sim 15 \text{ mJ/cm}^3$ estimated from BLM measurements compared to 30 mJ/cm^3 expected

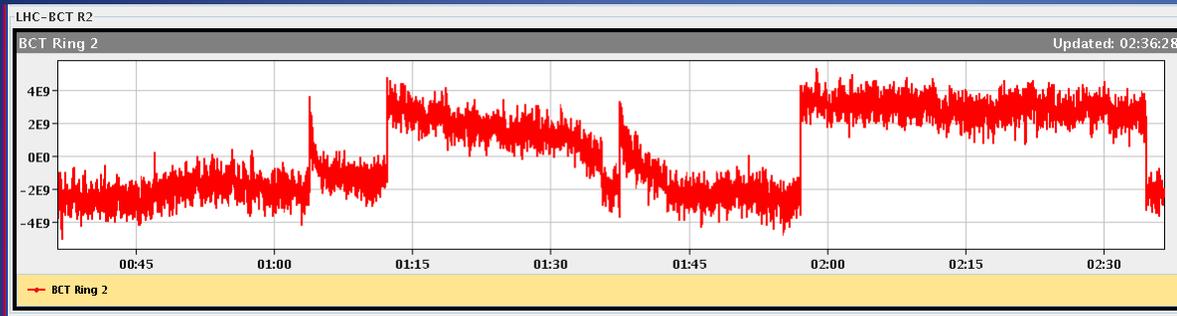


700m



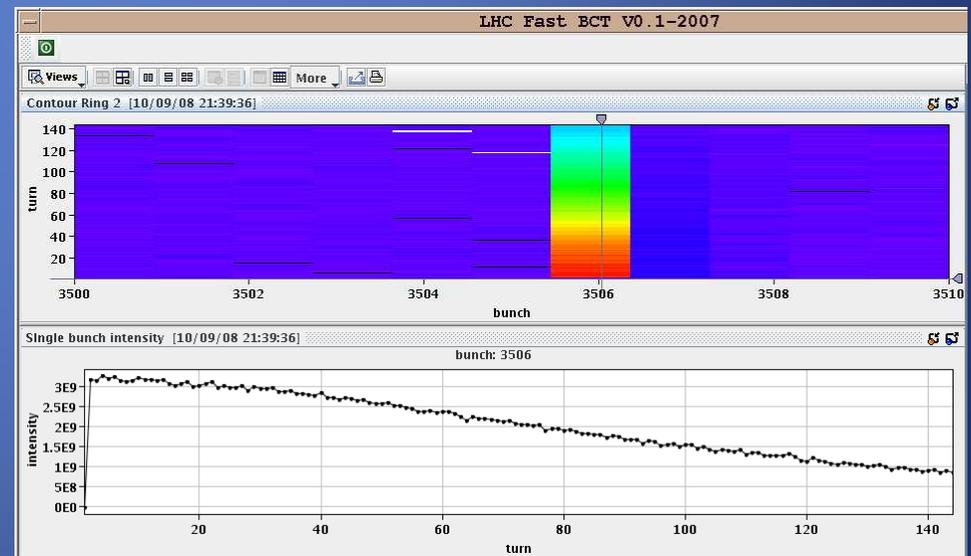
450m

Current transformers



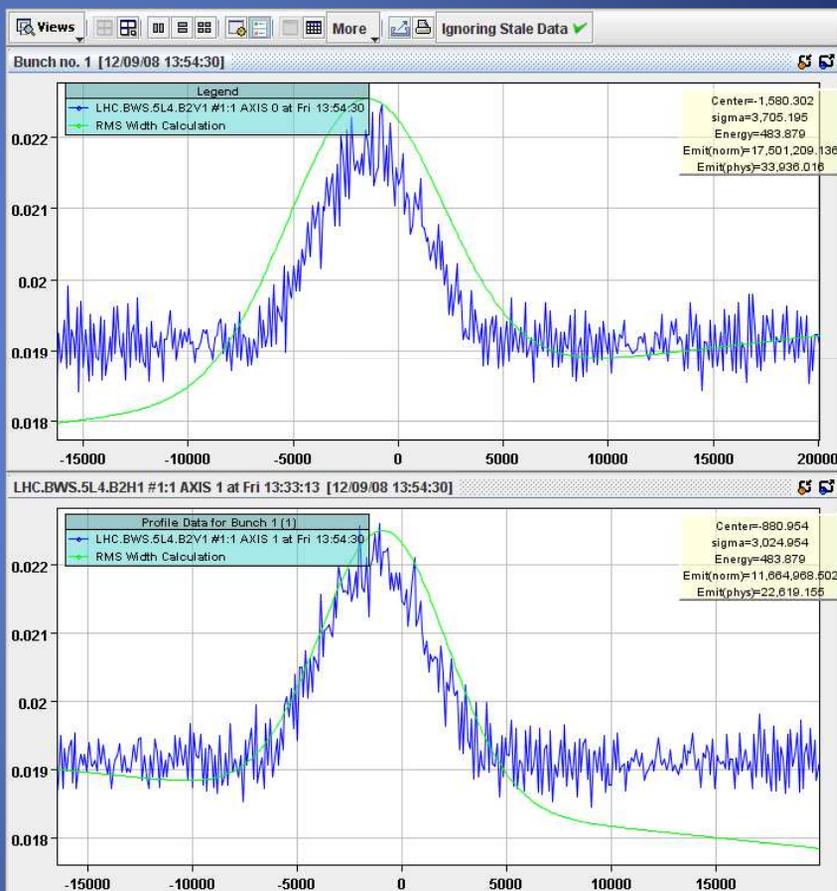
DC transformer
Sensitivity $\sim 1.5 \mu\text{A}$

- First beam observed with the fast transformer
- Signals and calibrations look good



Wire scanners

- Wire scanner system tested
- System works
- Measurements are encouraging although no detailed investigation due to limited beam time



Conclusions

- Beam instruments in LHC worked very well from the first injection test
- Circulating beam could be established rapidly
- Despite little beam time most instruments have been commissioned or at least tested
- A lot of work still to be done for the upcoming run

Acknowledgements

- This is the work of hundreds of people, CERN staff and collaborators, over many years
- Every one working on the B.I. can be proud of this achievement
- More posters on the subject: **TH5RFP032, TH5RFP034, TH5RFP035, TH5RFP037, TH5RFP073**. Plus many more on the LHC commissioning