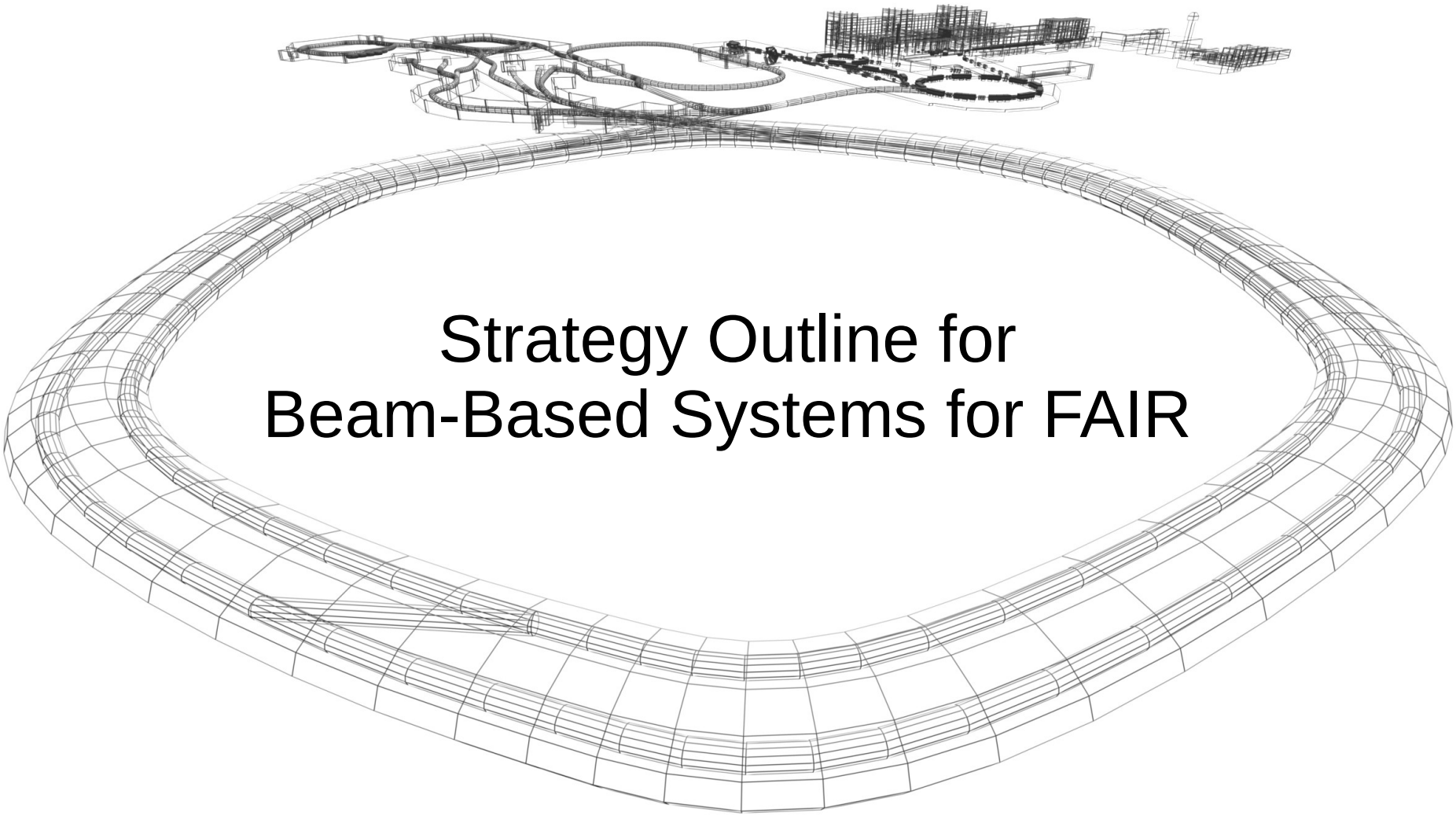
GSI Helmholtzzentrum für Schwerionenforschung GmbH



Strategy Outline for Beam-Based Systems for FAIR

What is Beam Instrumentation about...

- Beam Instrumentation provides the “eyes and ears” of the operators:
  - accelerator only as good as the instrumentation measuring its performance
  - without operators become “blindfolded F1 driver travelling at 300 km/h!”

- Two goals
  - Machine Performance – “to keep the beam in the pipe”
    - assess and maintain tight beam tolerances, intensity range and transmission required for collisions that are detected and analysed by the experiments
    - “every particle lost in the accelerator is a particle lost for physics”
  - Machine Protection
    – detect dangerous situations that require a safe beam extraction
    - protect multi-billion EUR investment for fundamental research
    - Impact of 'highly activated machine preventing hands-on maintenance' is on the same level as 'destroying accelerator equipment e.g. es. septum'

Lessons from LHC (& RHIC, Tevatron, J-PARC, ...) Priority of Beam-Based Systems

- Beam-Instrumentation (focus on HW)
  - Overview and strategy (M. Schwickert → done)
    - MP relevance, OP robustness/reliability, nice-to-have
  - Group I: Intensity monitoring across transfer lines & rings
  - Group II: Orbit/Trajectory & Q/Q'
  - Group III: Beam Loss & Vacuum
  - Group IV: longitudinal diagnostics (bunch shape/length, splitting/merging, abort gap monitoring, tomography, ...)
  - Group V: emittance diagnostics and preservation (after optics)
- Beam Control (focus on use-case):
  - Transmission Monitoring System (R. Steinhagen, next FC^{2}WG Meeting)
  - Trajectory and Orbit Control (R. Steinhagen & B. Schlei)
  - Tune and Chromaticity Diagnostics & Control (R. Steinhagen & ??)
  - RF capture and (later) RF gymnastics (??)
  - Transfer line & ring optics measurement & control (LOCO, AC-dipole techniques etc., ?)
  - Longitudinal emittance measurement (?)
  - Transverse emittance measurement (?)
  - Transverse and longitudinal feedbacks (RF: ???)

Some General Questions I/II

- What will be available for FAIR?
  - long-term vision?
  - medium-term plans for FAIR: 'Day-I' vs. 'Day-N' instruments
  - short-term strategy for SIS18 restart in 2017
  - prioritisation (beam operation vs. procurement)

- BI commissioning strategy:
  - How much can be done without beam (test-beds, dry-runs)?
  - How much can only done with beam?
  - How much needs to be repeated for re-commisioning/setup of new experiments and/or beams (day-to-day operation)?

- Integration of beam instrumentation into semi-automated systems
  - Transmission Monitoring (FCT) -> Interlock/Fast Abort System (question of robustness/redundancy)
  - BLMs and cryo-collimators -> slow or fast-beam-abort?
  - BPMs -> cycle-to-cycle injection/orbit/transfer-line steering (question of robustness/redundancy)
  - Q/Q' diagnostics -> cycle-to-cycle feedbacks, do we have an operational 'Q-meter'?

- Emittance diagnostics:
  - FCTs (longitudinal): can these be used continuously to monitor long. emittances and bunch profiles
  - IPMs, grids, MPWC: can these be used continuously to monitor trans. emittances and bunch profiles (question of "wear-out" of GEM foils? Grids OK?, MPWC?)
  - Can the grids be considered "transparent" for certain beams? Which one?

Some General Questions II/II

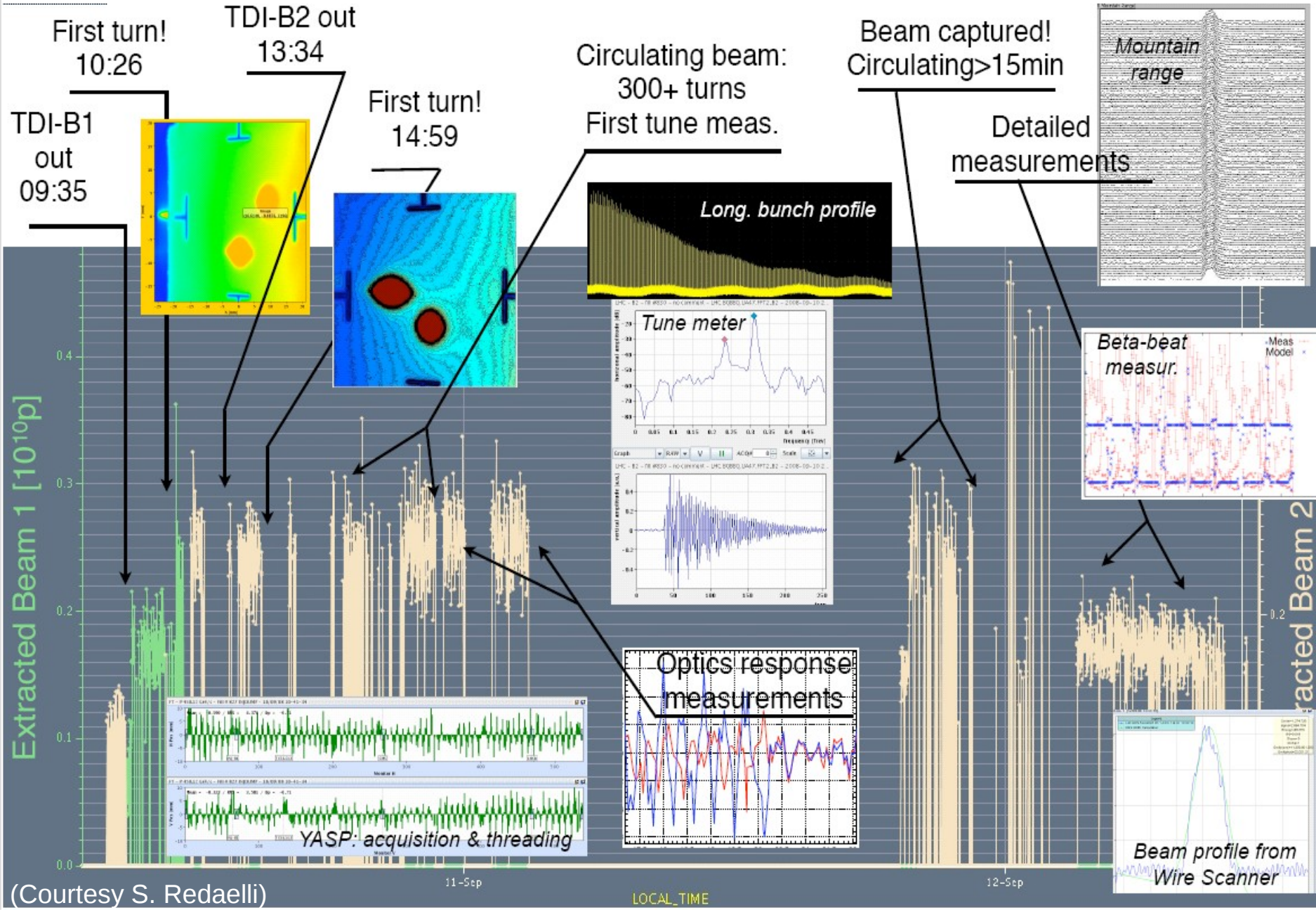
- Special diagnostics
  - the forgotten instruments & tools

- Miscellaneous
  - transition from expert tools to operational tools
  - paradigm that BI front-ends deliver already pre-processed "ready-to-use" beam parameter (ie. not only raw data)

- Open questions for commissioning, controls and beam operation from a BI perspective → MCs/MPLs
  - Are all beam parameters well defined?
  - Are the expected performance, interfaces, … well defined?
  - We need your input...

Some Examples
Beam-Based System Integration at CERN

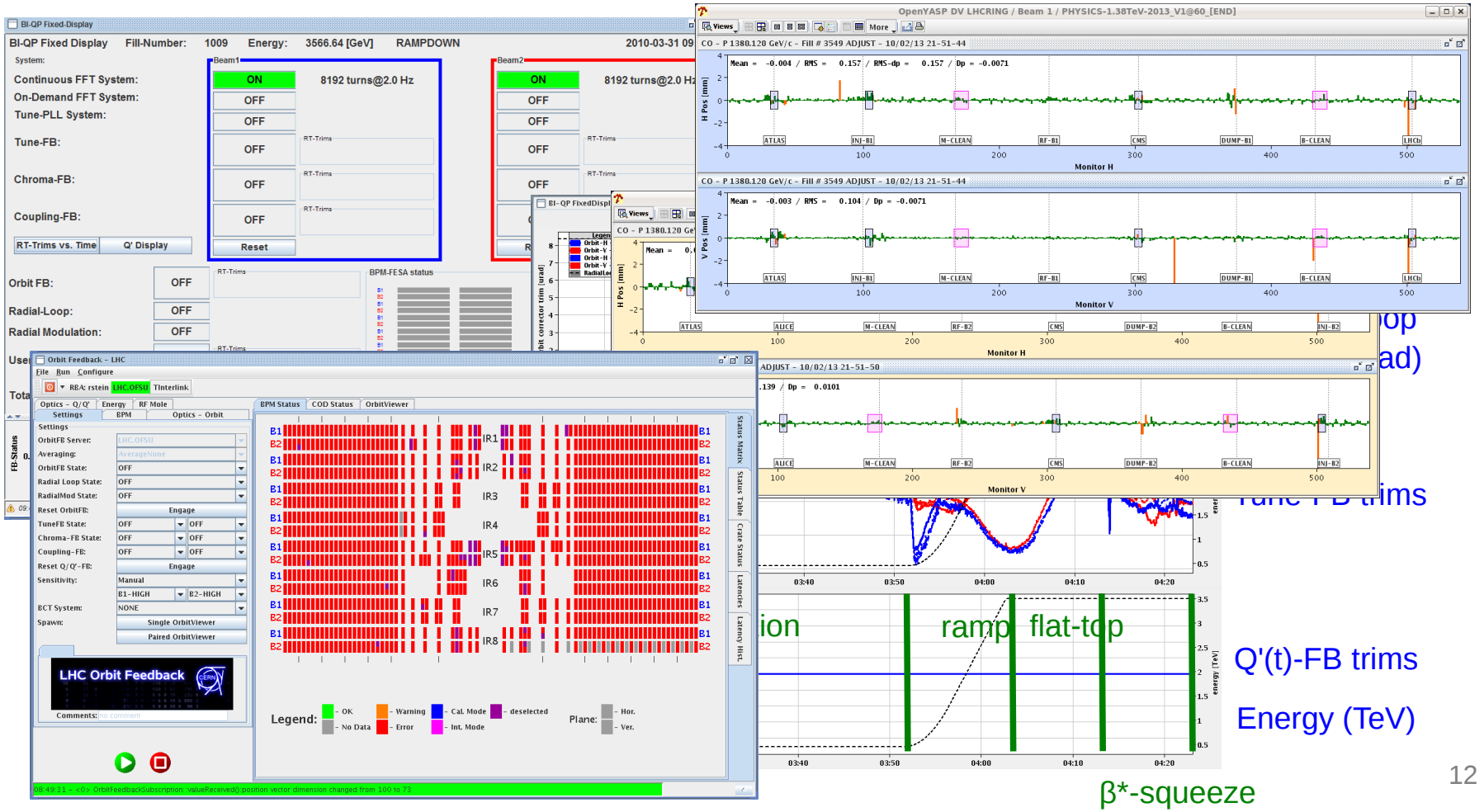
Example: 10th September 2008
Milestones of 50 Hours of LHC Beam Commissioning



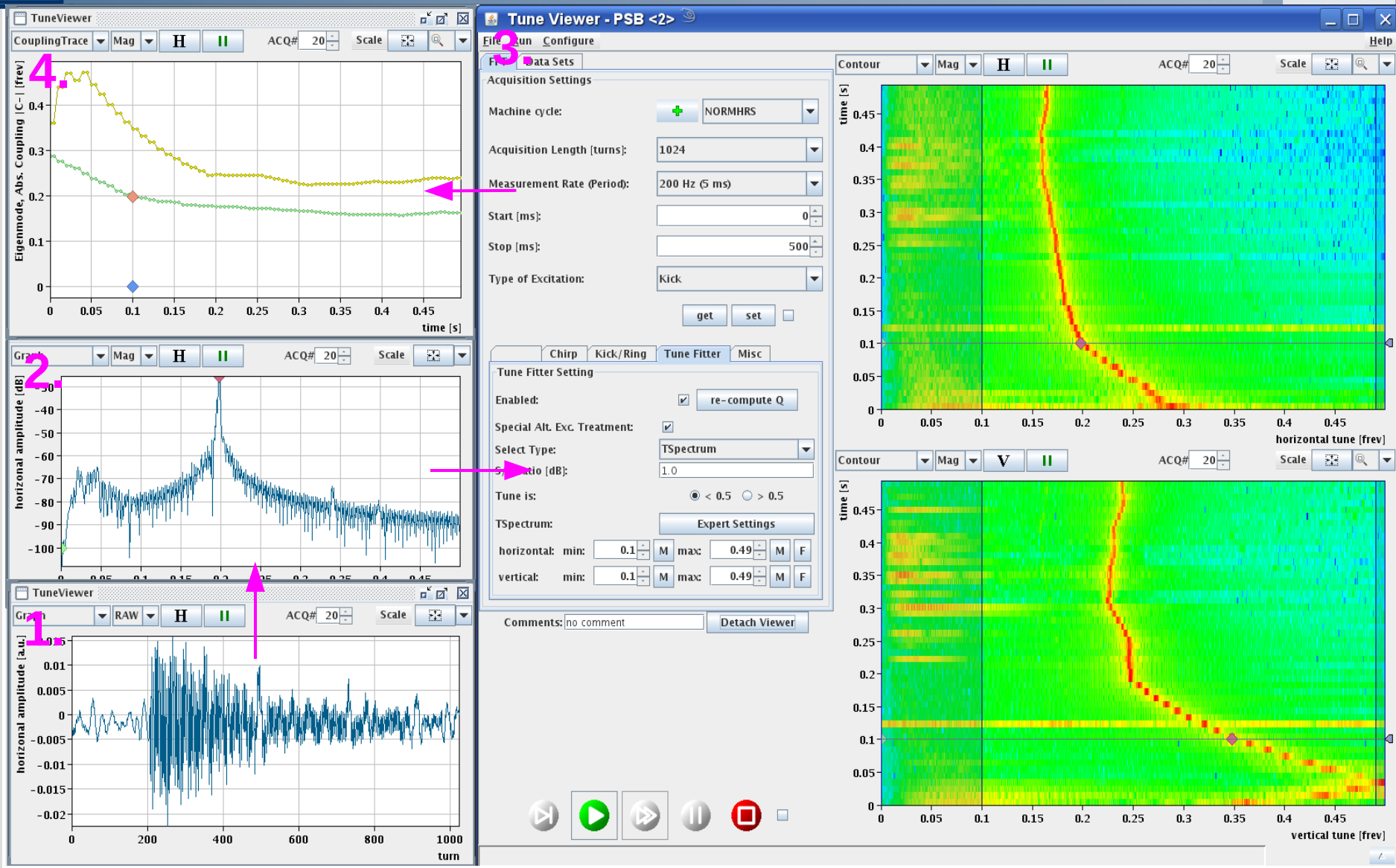
(Courtesy S. Redaelli)

LHC Feedback … one of the more visible systems in the CCC – Importance of Controls Integration and SW Usability

- Apple principle:
  "The best hardware is only as good as its software integration"
- Limited bandwidth of expert knowledge & most operators need to keep a wide focus to tackle many different tasks: KISS – Keep it Simple and Safe



BBQ Example Spectra
CERN-PSB, $f_{rev} \approx 2$ MHz



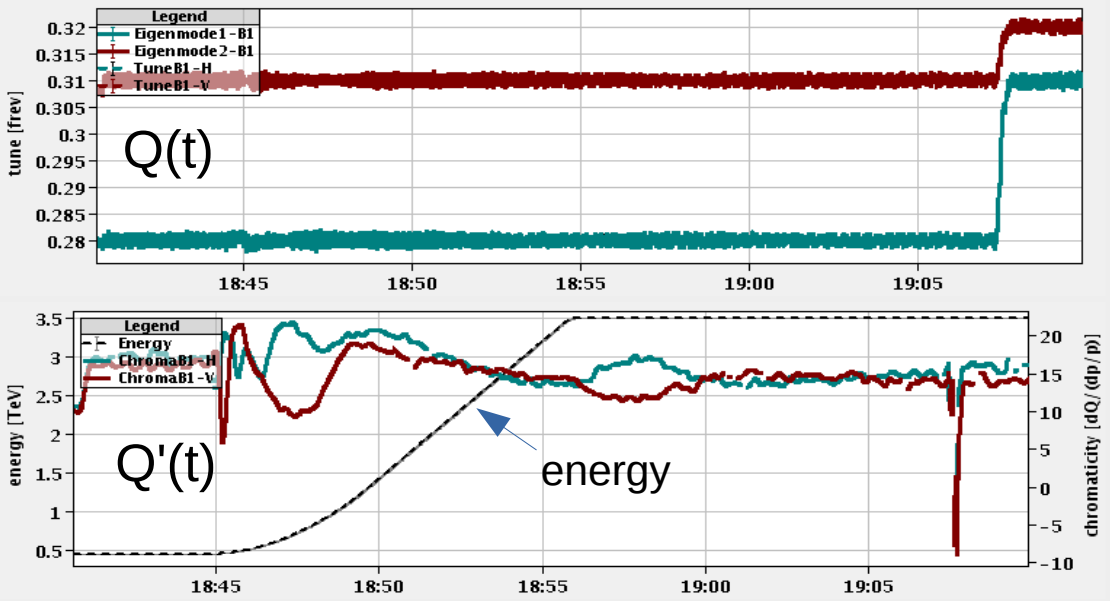
- BBQ → fast ADC → FPGA based digital signal processing chain, FFTs @ 500 – 1 kHz!
  - provides real-time Q diagnostics for operation

Typical Q/Q'(t) Control Room View (LHC)
2010 Statistics: Out of 191 Ramps...

LHC - Fill#1574
2011-03-03 19:09:51

Q1 = .309714 Qx = .310523
Q2 = .319568 Qy = .318759
|C-| = .005410 E = 3500.0 GeV
Q'x = +16.2 ± .1
Q'y = +14.0 ± .3

Beam 1



LHC - Fill#1574
2011-03-03 19:09:51

Q1 = .310105 Qx = .310434
Q2 = .320267 Qy = .319938
|C-| = .003598 E = 3500.0 GeV
Q'x = ???
Q'y = +11.9 ± .4

Beam 2