CLIC Cavity Beam Position Monitors

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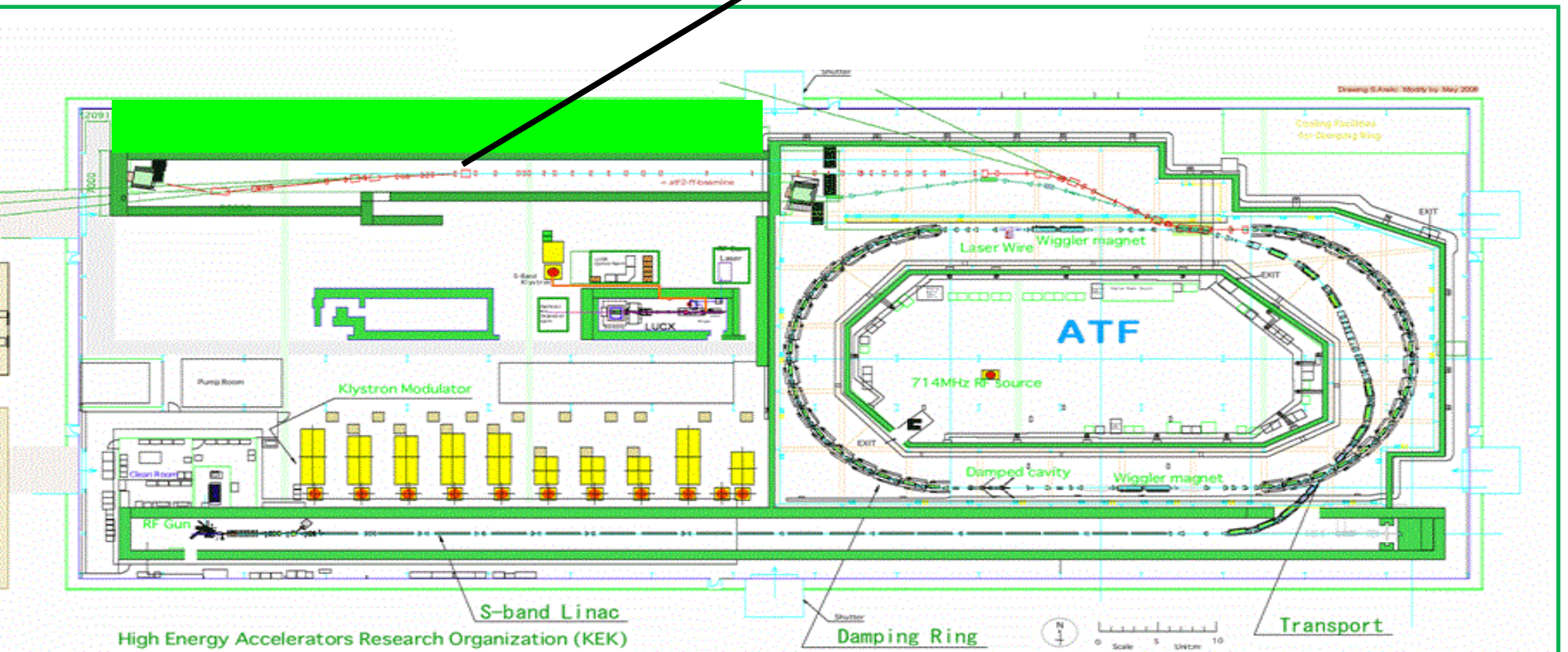
https://www.pp.rhul.ac.uk/twiki/bin/view/JAI/BeamPosition

Introduction

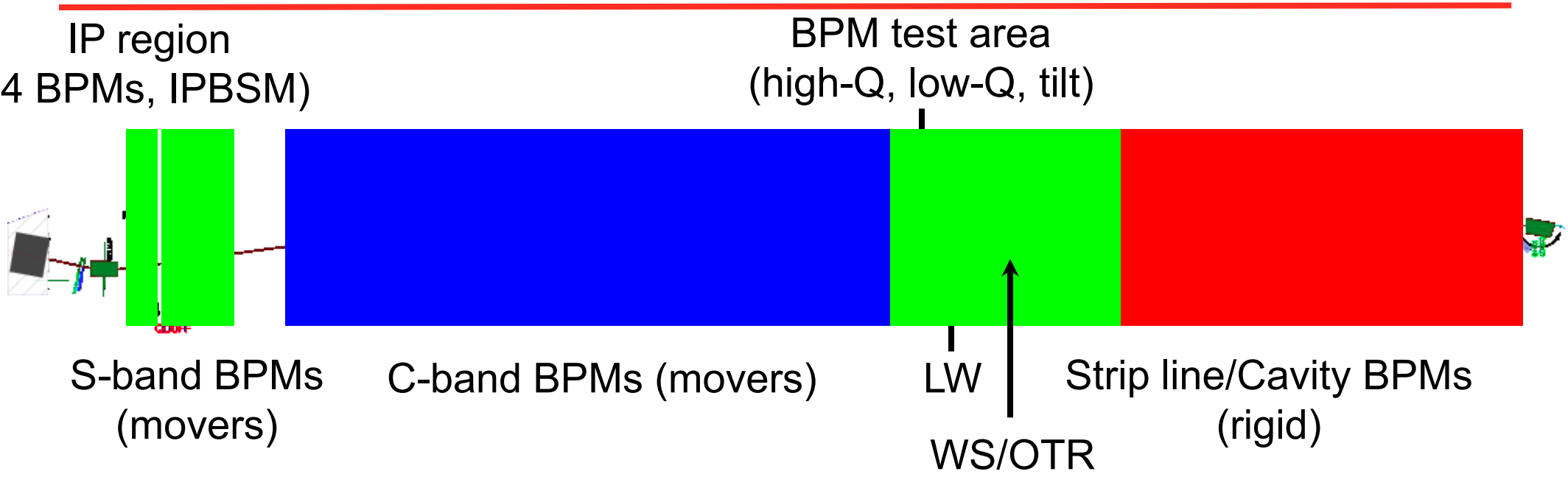
- ATF2 Cavity BPM system (C-band, ILC-like)
  - System performance
  - Multi-bunch studies with High-Q cavity
    - Bunch subtraction
- Low-Q CLIC BPM (FNAL) simulations
  - Wake-fields (GdfidL, ACE3P)
- Quadrupole stabilisation studies
  - Idea from Steve Smith
  - Extreme resolution BPMs (<1 nm)

Accelerator test facility

- Test system for 35 nm focus size



ATF2 Overview (instrumentation)



- Very dense with instrumentation
  - 2 independent emittance diagnostic systems (3 axis wires, OTR)
  - 2 independent IP systems (BPMs, IPBSM)

Cavity position monitor system

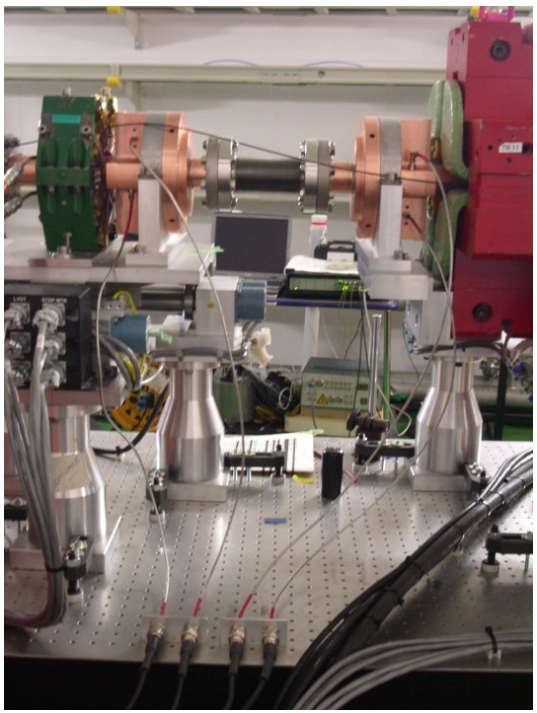
IP region
(4 BPMs)

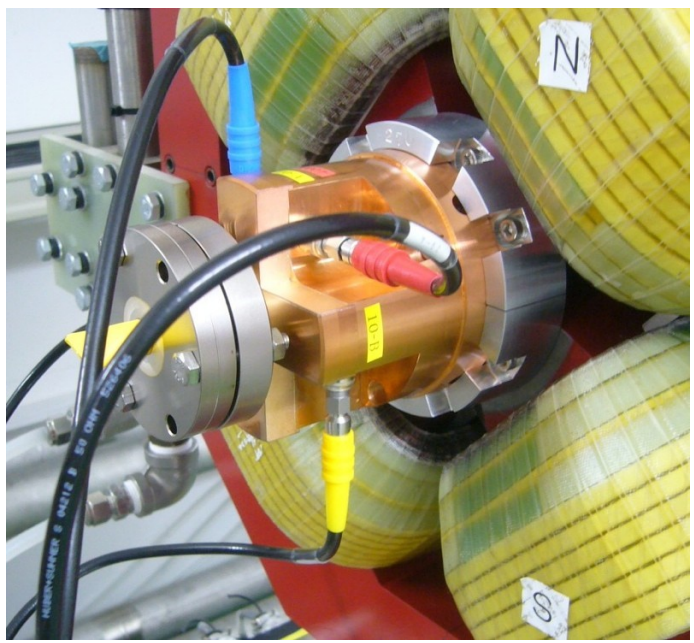
BPM test area
(high-Q, low-Q, tilt)

S-band BPMs
(movers)

C-band BPMs (movers)

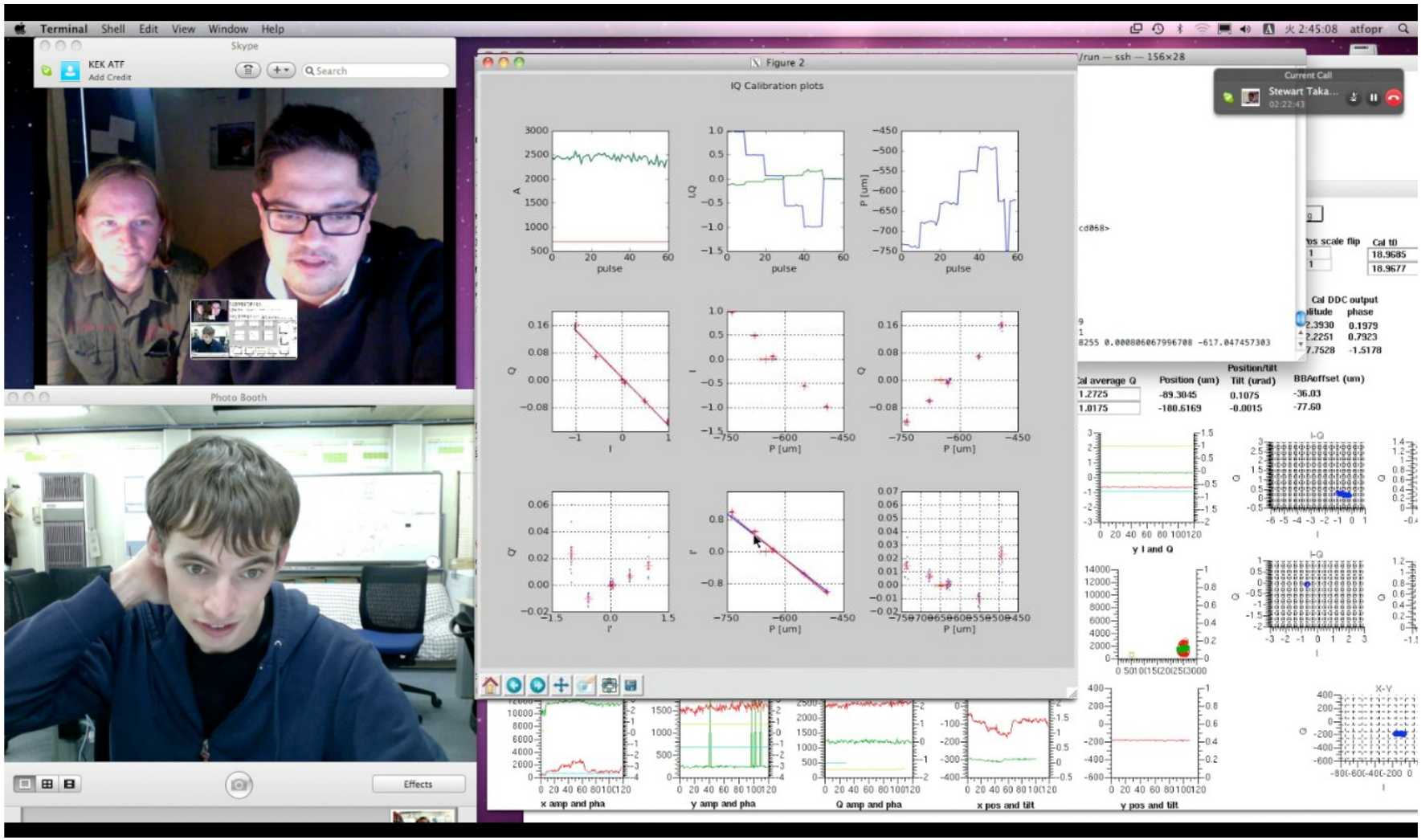
Strip line/Cavity BPMs
(rigid)





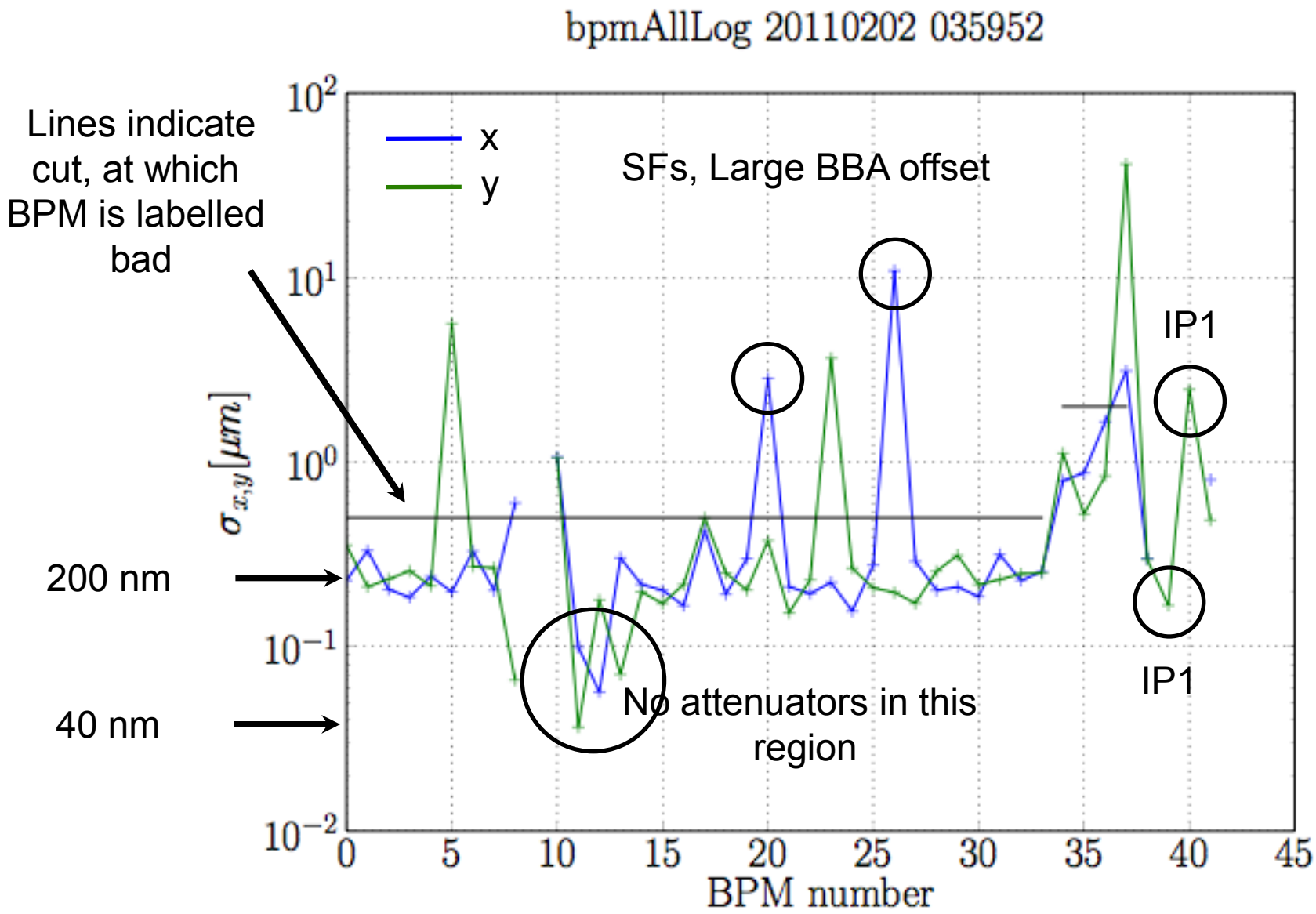
Jitter subtracted calibration

- Use MIA/SVD to measure beam jitter subtracted calibration constants (remote operation)



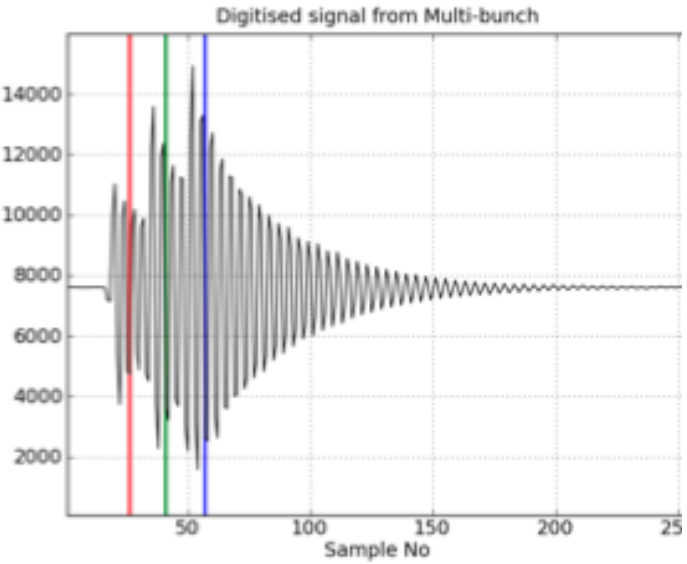
IP calibration 20110202 (035952)

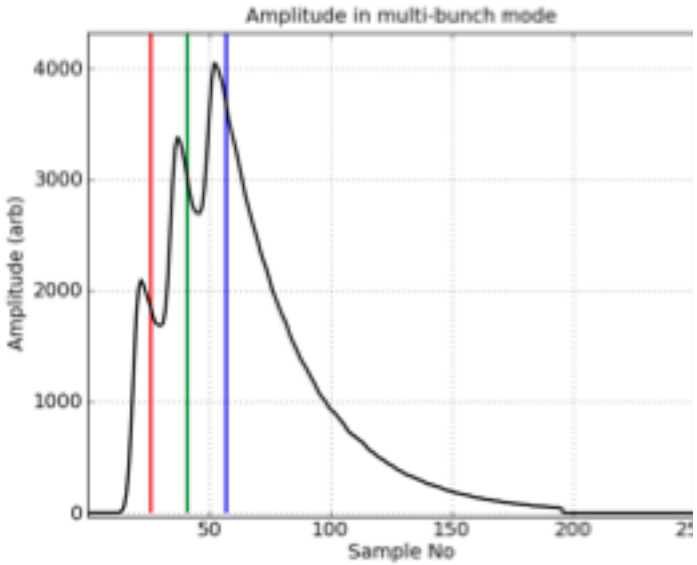
SB

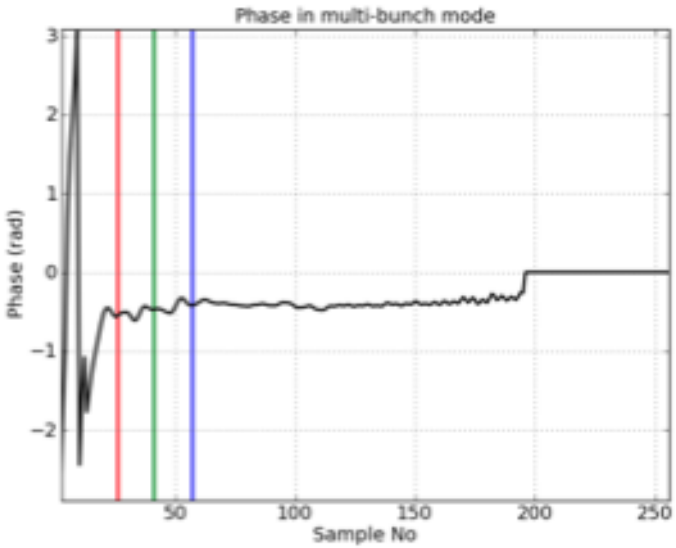


Multi-bunch studies

- ATF2 cavities designed for single bunch operation
  - 3 Bunches overlapping within cavity
  - Attempt to extract amplitude and phase from each bunch transit



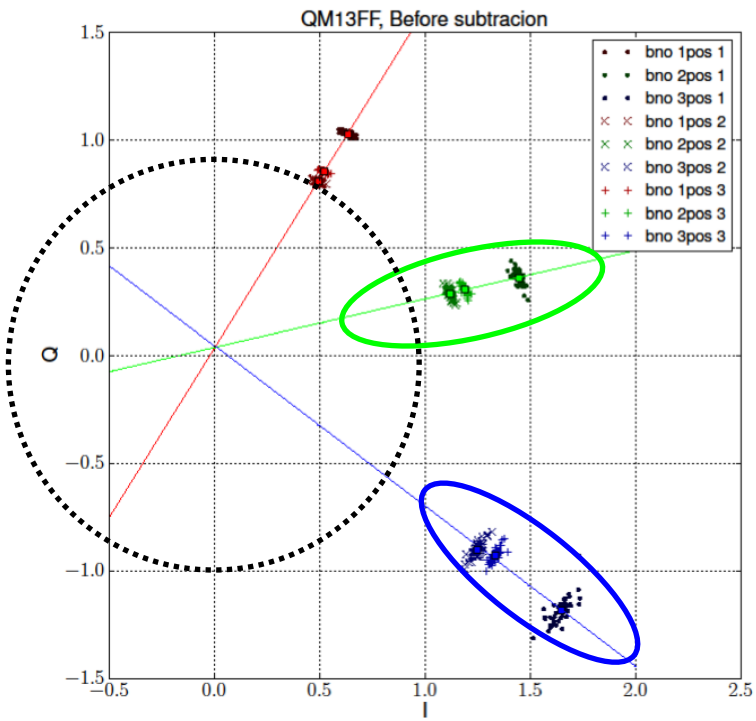


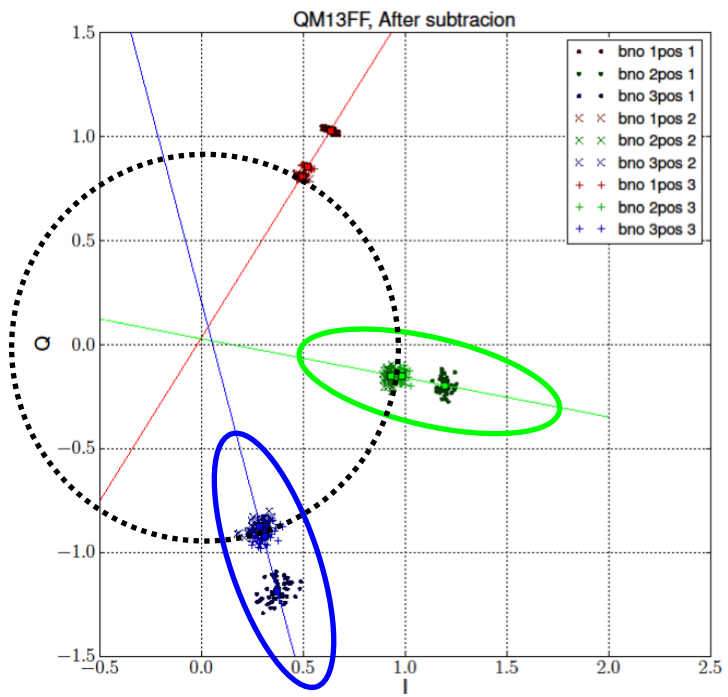


Multi-bunch studies

N. Joshi

- 3 bunches with separation of 150 ns.
  - Signal decay time ~300 ns. (ILC bunch separation)
  - Correction seems appropriate
    - Large increase in jitter

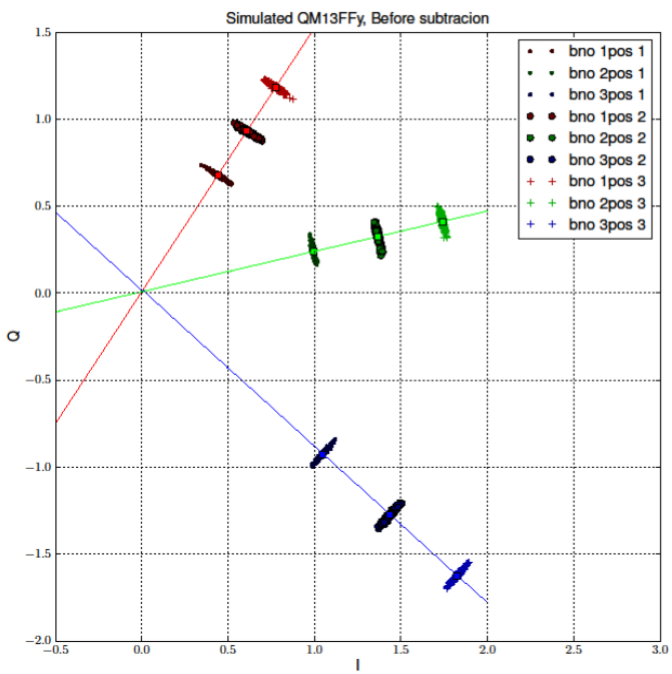


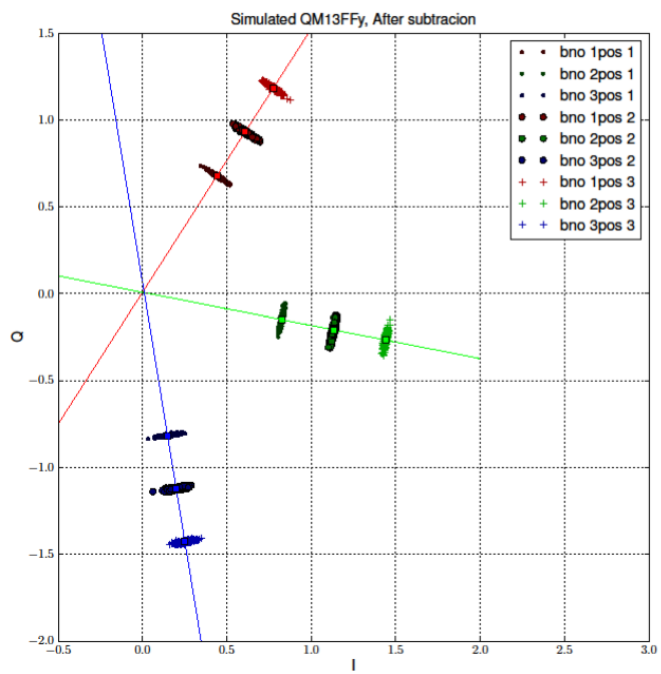


Multi-bunch studies (simulated)

N. Joshi

- Apply subtraction technique on simulated data
  - Initial cavity and beam parameters similar to measurement
  - Correction does not increase signal jitter

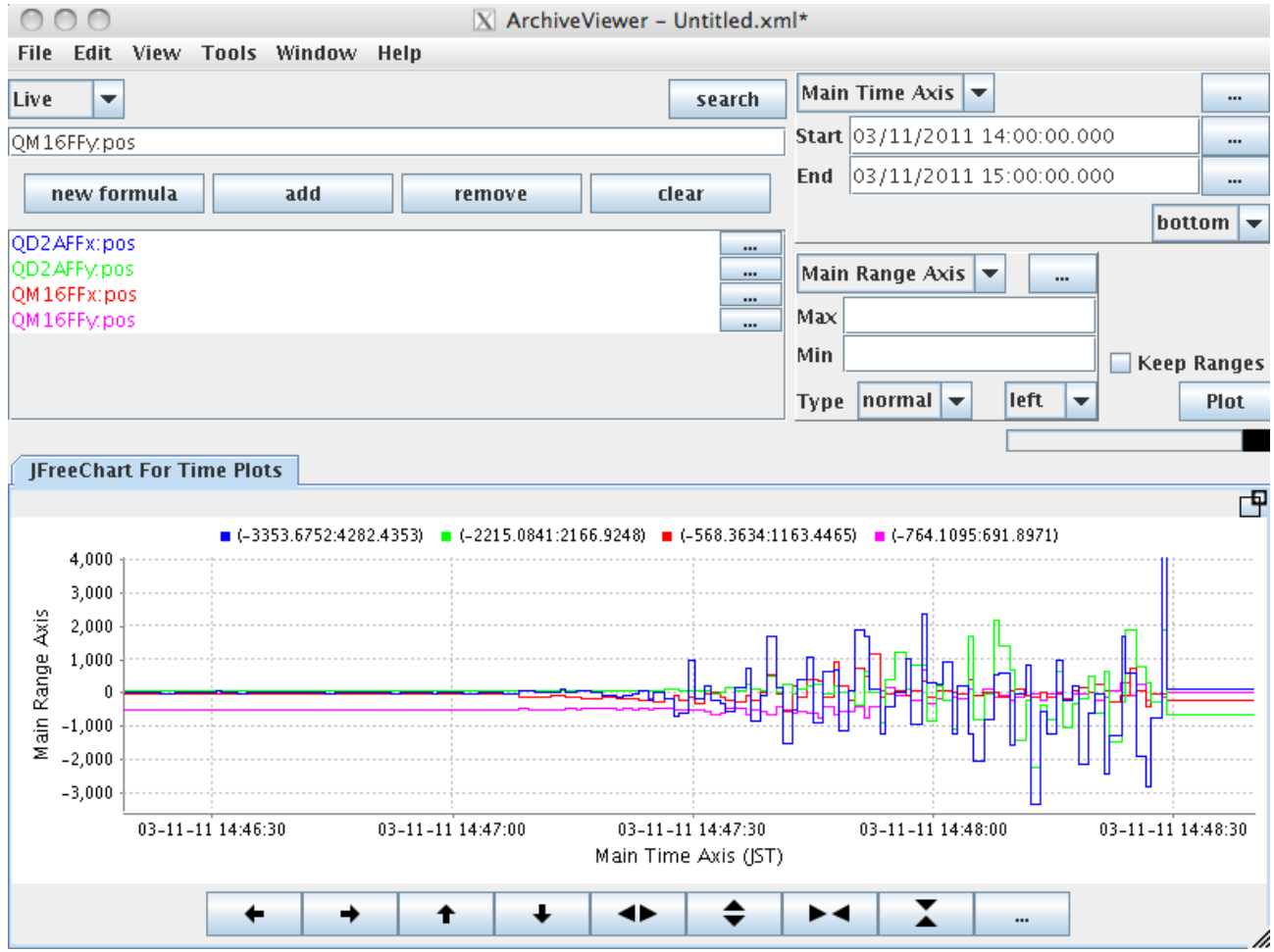




Japan earth quake

ATF2 group

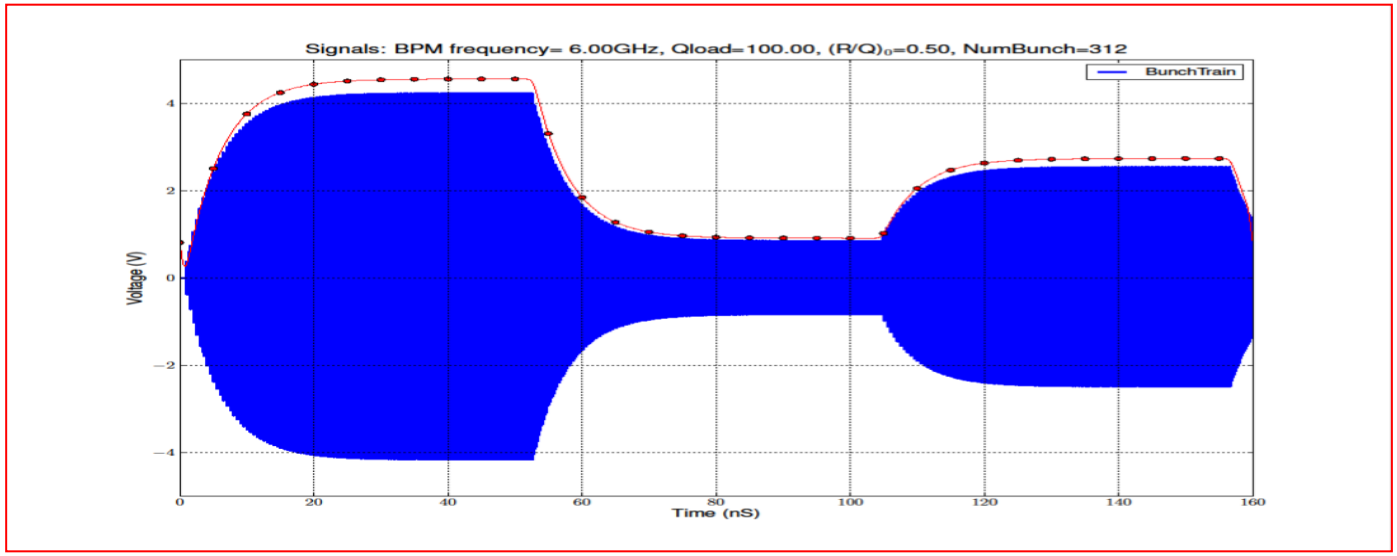
- 11th March 2011, 2:46:23
- 320 km, 8 km/s gives 46 s propagation time
- Beam manually aborted
- ATF damage comparatively light.

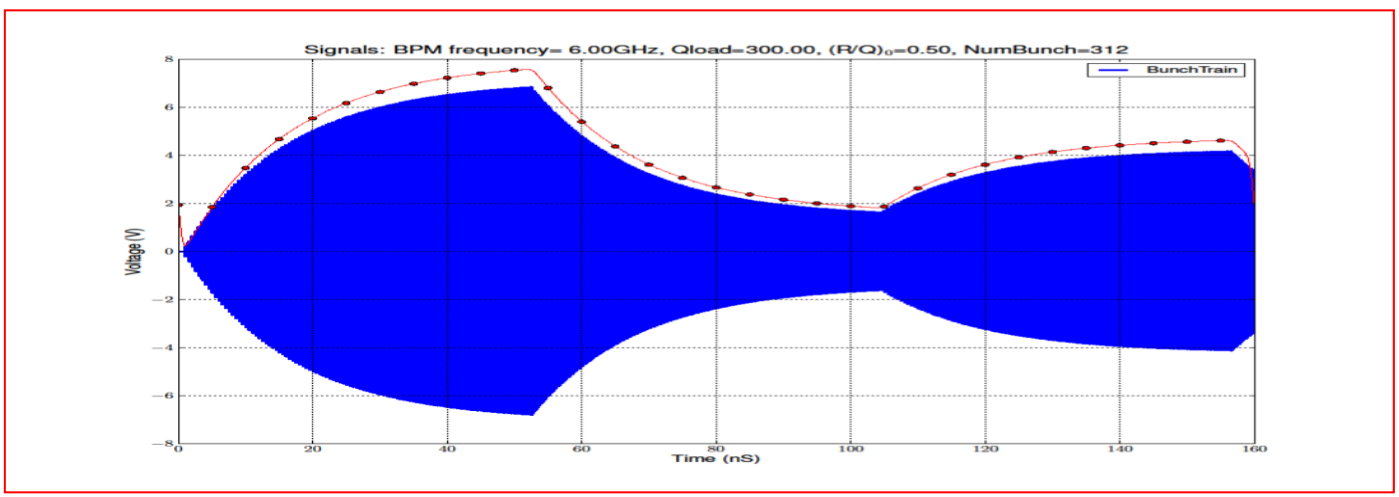


BPM Q-factor?

N. Joshi

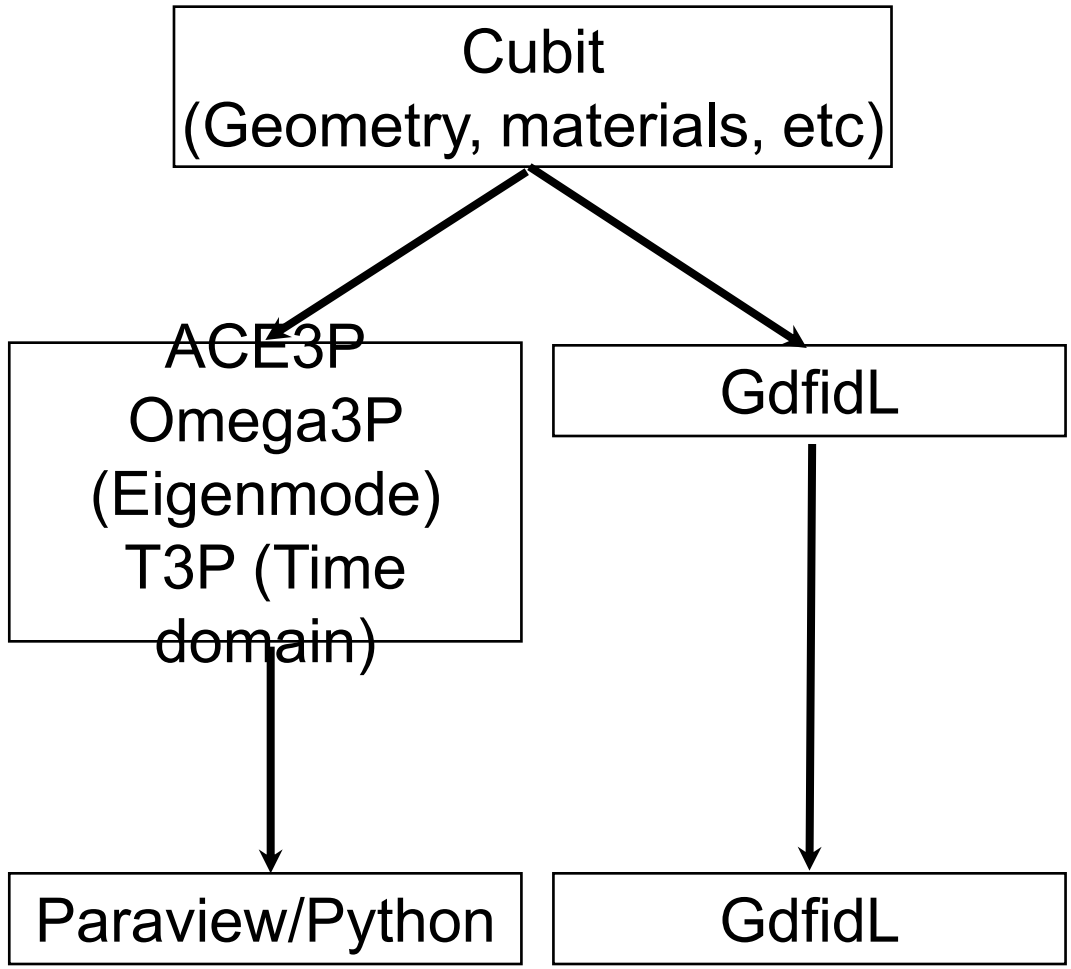
- Beam loading of BPM
- How to treat data with significant bunch overlap
- Simulate CLIC beam train through cavity and representative electronics





RF simulation work flow

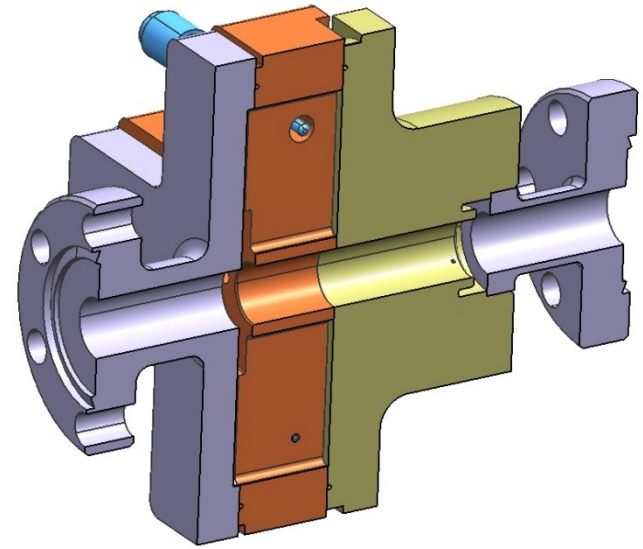
- Use two different simulation codes
  - GdfidL (A. Lyapin)
  - ACE3P (N. Joshi)
- Merge work flow with single model
  - Developed in Qubit
  - Exported via standard files

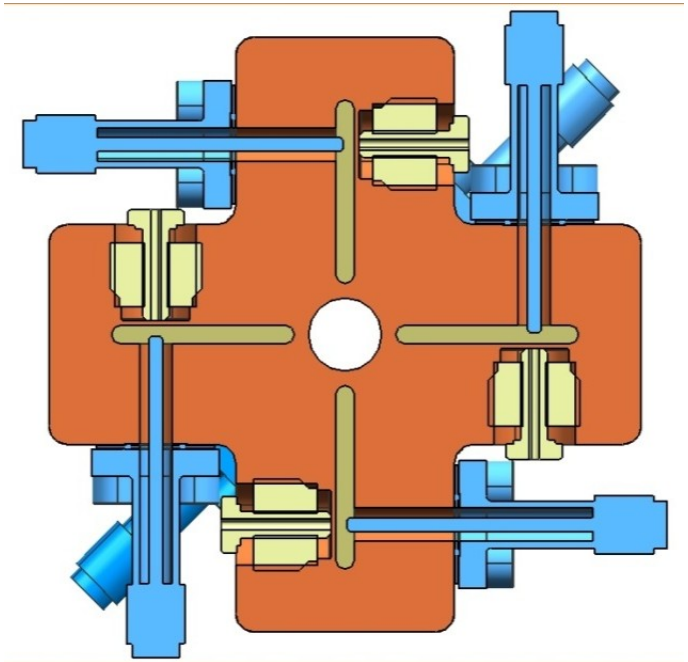


CLIC BPM design

M. Wendt (FNAL)

- FNAL conceptual design and prototype being fabricated
- Low-Q, fabricated from stainless steel
- Standard cavity, magnetically coupled monopole suppressing
- Start with simulation of this cavity

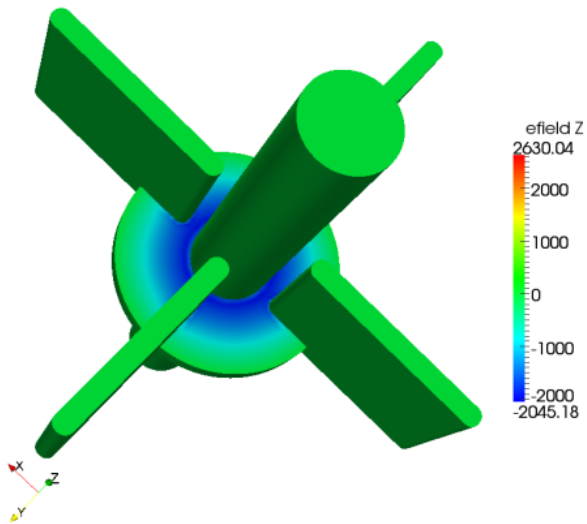




Low-Q simulations

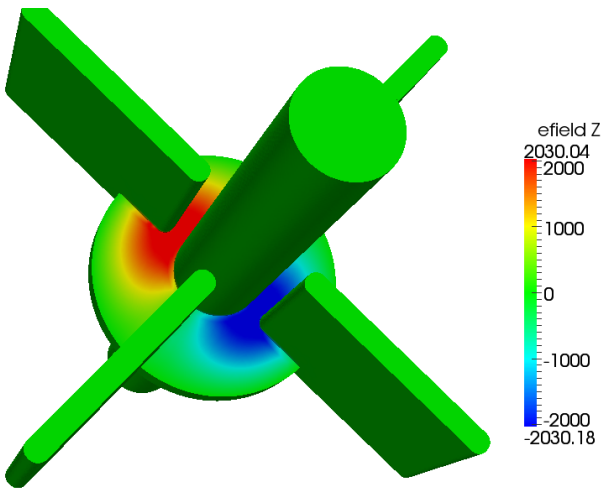
N. Joshi

- FNAL-CERN design, geometry in Cubit, eigenmode solution in Omega3P.
  - Adding feedthroughs now



Monopole:

- Frequency : 11.14 GHz
- Q_0 : 421.96
- R/Q_{1mm} : 46.41 Λ



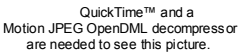
Dipole:

- Frequency : 14.988 GHz
- Q_0 : 517.89
- R/Q_{1mm} : 3.4 Λ

Low-Q simulations

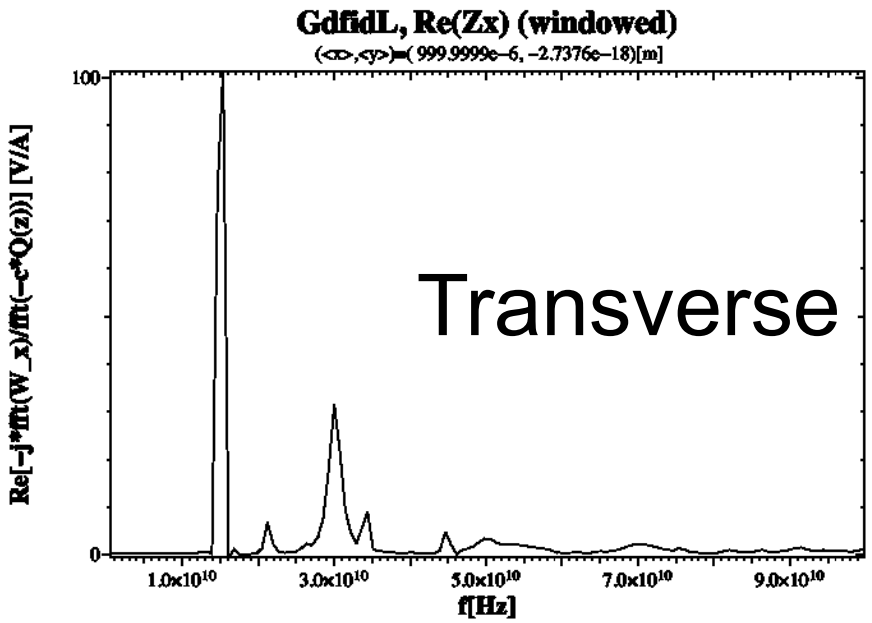
N. Joshi

- Started time-domain simulations for wake field
  - Need to compare with GdfidL
  - Pass information onto beam dynamics people

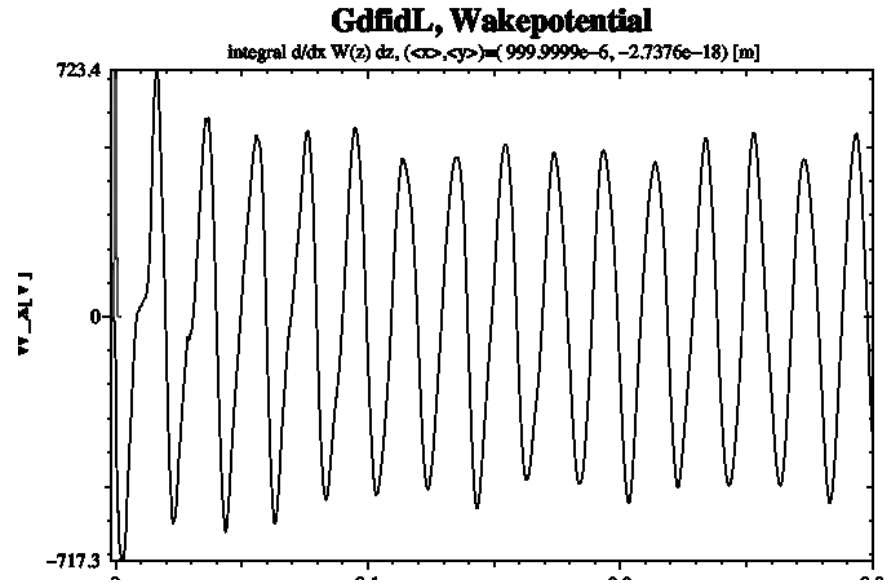


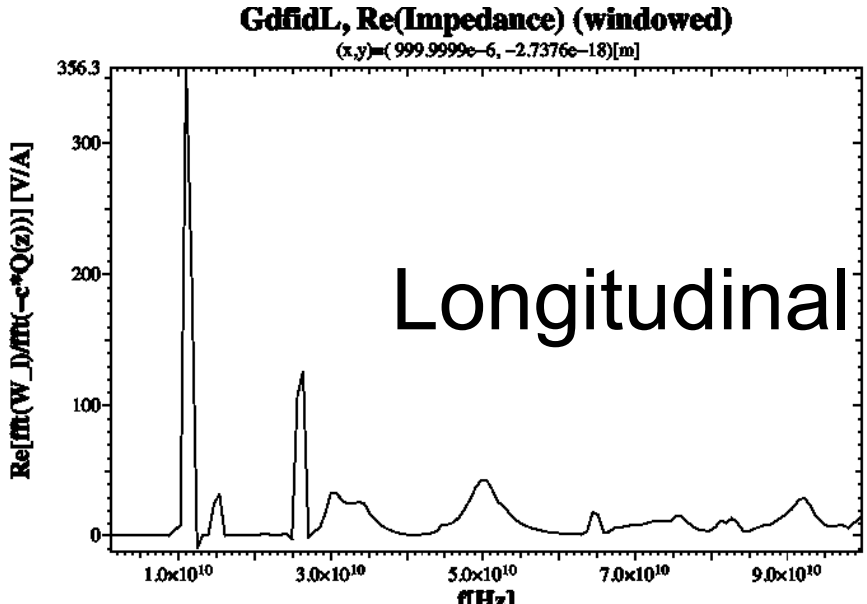
GdfidL Wake-fields

A. Lyapin

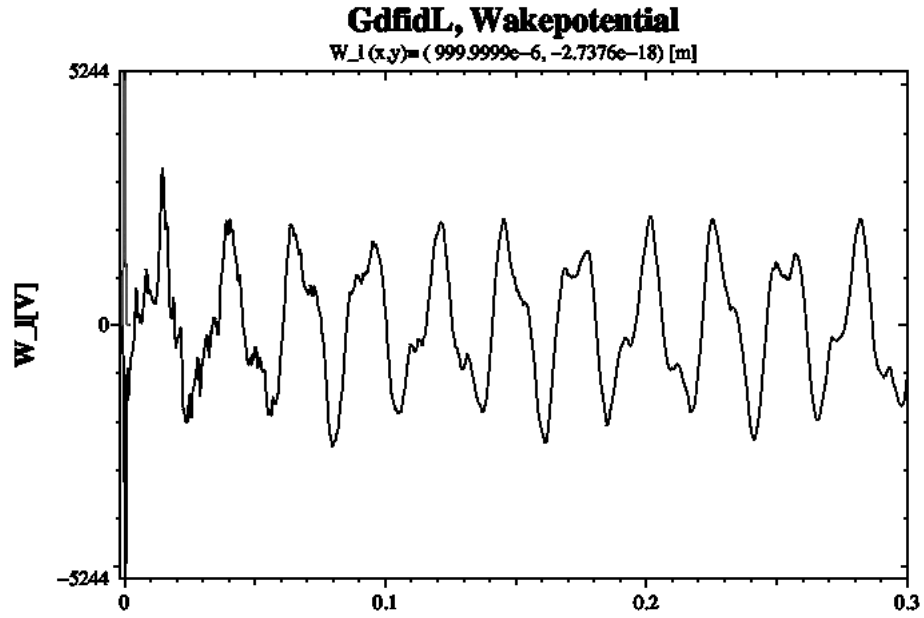


Transverse





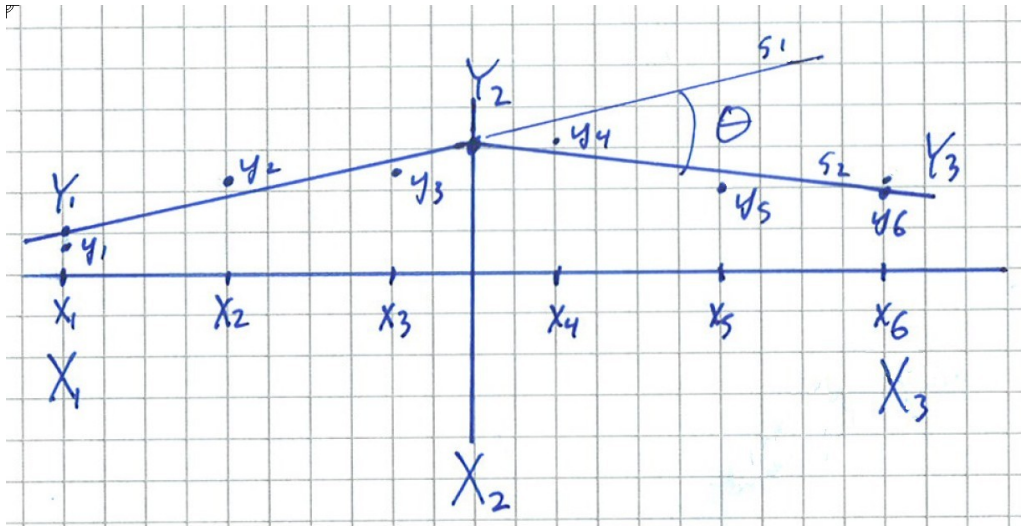
Longitudinal

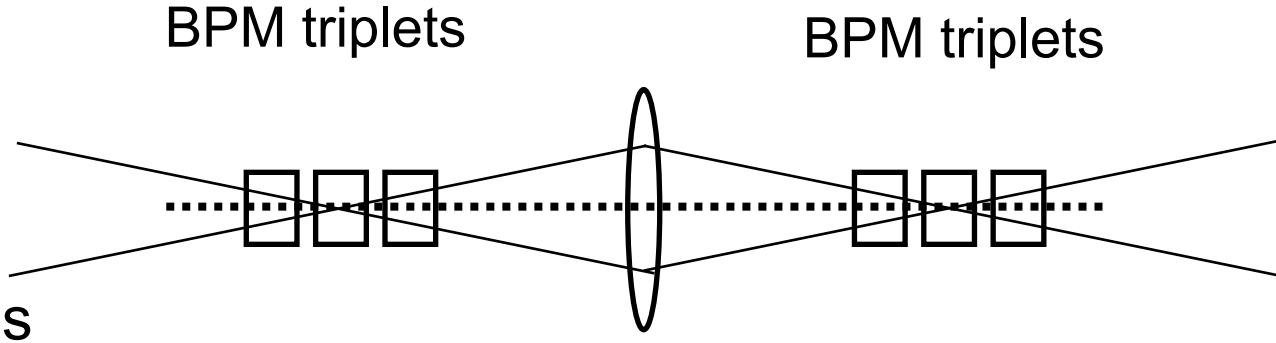


Quadrupole stabilisation

F. Cullinan

- Monitor beam after passage through quadrupole (< 1nm RMS, down to ~ 1 Hz)
  - Determine jitter introduced by quad
  - BPM resolution ~1 nm
- Consider quasi-CW beam test (JLAB)
- Interest in
  - BPM
  - Readout and analysis
  - Measurement scheme





Issues... Geometry, inter BPM calibration, beam jitter (position, angle & energy),

Quadrupole stabilisation

- Strong similarities with ATF2 project/problems
  - Quad alignment
  - Jitter constant 20% of beam size
  - Effect of quad-fields on each BPM
- Also strong similarities with ESA programme
  - BPM resolution significantly worse (~500 nm)
  - ~20 m length systems
- Is such a test desirable?

Near term work

- Based on discussions last month
  - Evaluate performance of FNAL-CERN prototype
  - Analyse possible improvements based on ATF2/Diamond BPMs
  - Assess the ambient temperature change effect (20 degrees is a lot)
  - Modified/alternative design
    - Higher-Q
  - Investigate stabilisation studies with high resolution BPMs
  - Test beam electronics

Longer term work

- Involvement in BPM triplet tests in CERN
  - Single bunch resolution is easily achieved
  - Critical test is 3 BPMs with CLIC like bunch structure
- Alternative processing schemes
  - Hardware subtraction of previous signal
  - FFT based analysis, statistical, ensemble approach
- Electronics processing scheme
- Requirements for CLIC, integrated diagnostics-beam dynamics studies

Summary

- Started already defining focus and work plan
  - Will evolve strongly over next year
- Propose to
  - Check existing (FNAL) design
  - Concrete processing scheme (proper treatment of signals)
  - Involvement in test beam validation of prototypes
  - Alternative design, higher Q, combined with processing scheme (RF and digital)
  - Optimisation of performance, location, usage (calibration etc)