ATF2 Commissioning Progress

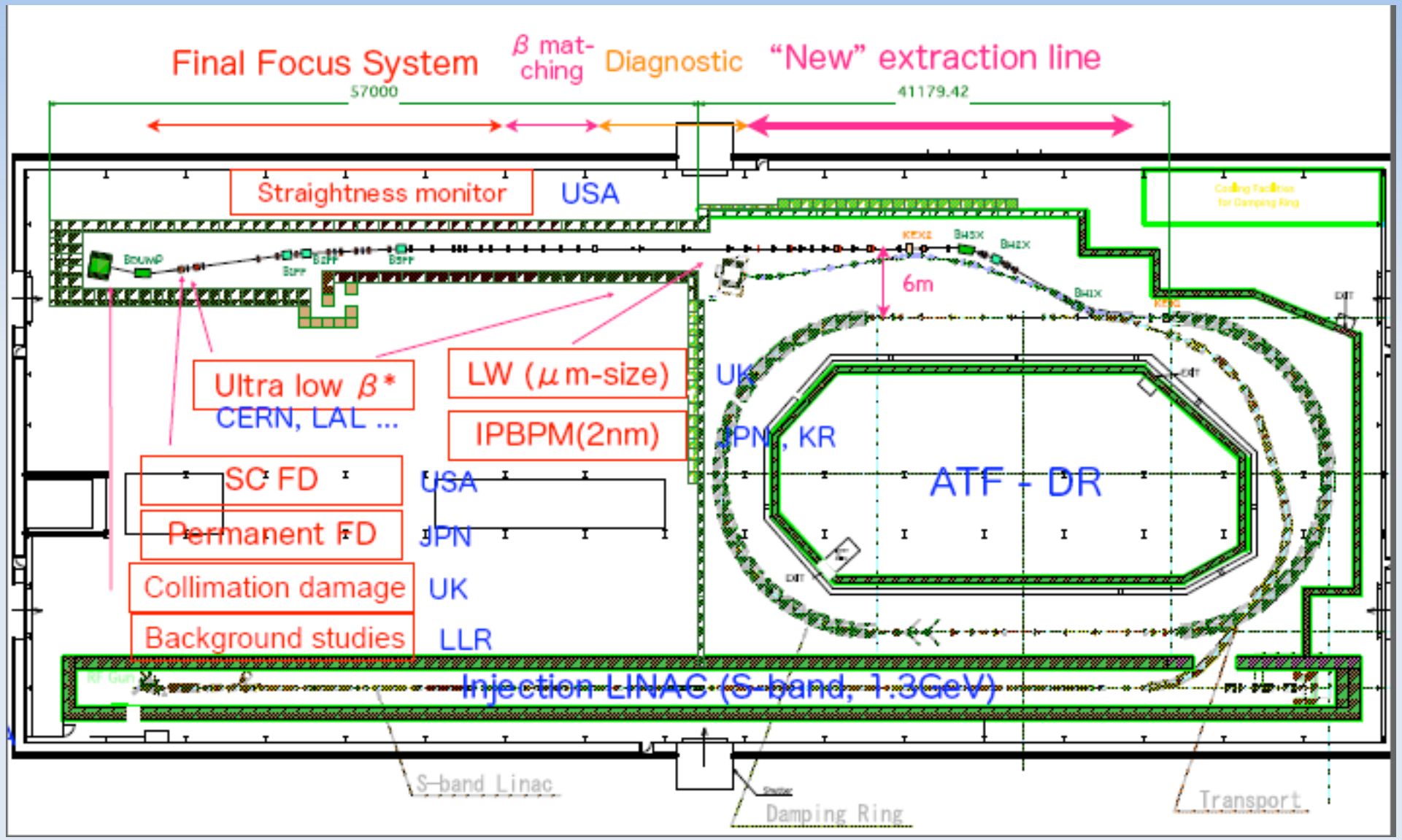
G. White, on behalf of ATF2 collaboration commissioning team

- Reminder of ATF2 commissioning goals and requirements.
- Instrumentation.
- Software and beam tuning.
- Summary of commissioning progress.
- Highlight on current commissiong (April run).
    - Summary of outstanding issues
    - Presentation of selection of beam tuning tools in use.

ATF2

- The idea of a new test facility at ATF, to prototype the **advanced final focus, for linear collider**, was conceived in **2002** at Nanobeam workshop
- Comissioning started Dec 2008, further commissioning runs in Feb/March and April 2009.
- Expect ~21 weeks of running 2009 and 2010, 50% operation time for ATF2 commissioning.
- ATF2 primary goals
  - Prototype ILC Final Focus system
  - Develop FF tuning methods, instrumentation
  - Learn about achieving ~35nm size & ~nm stability reliably
- ATF2 final goal – help to ensure collisions of nanometer beams, i.e. luminosity of ILC

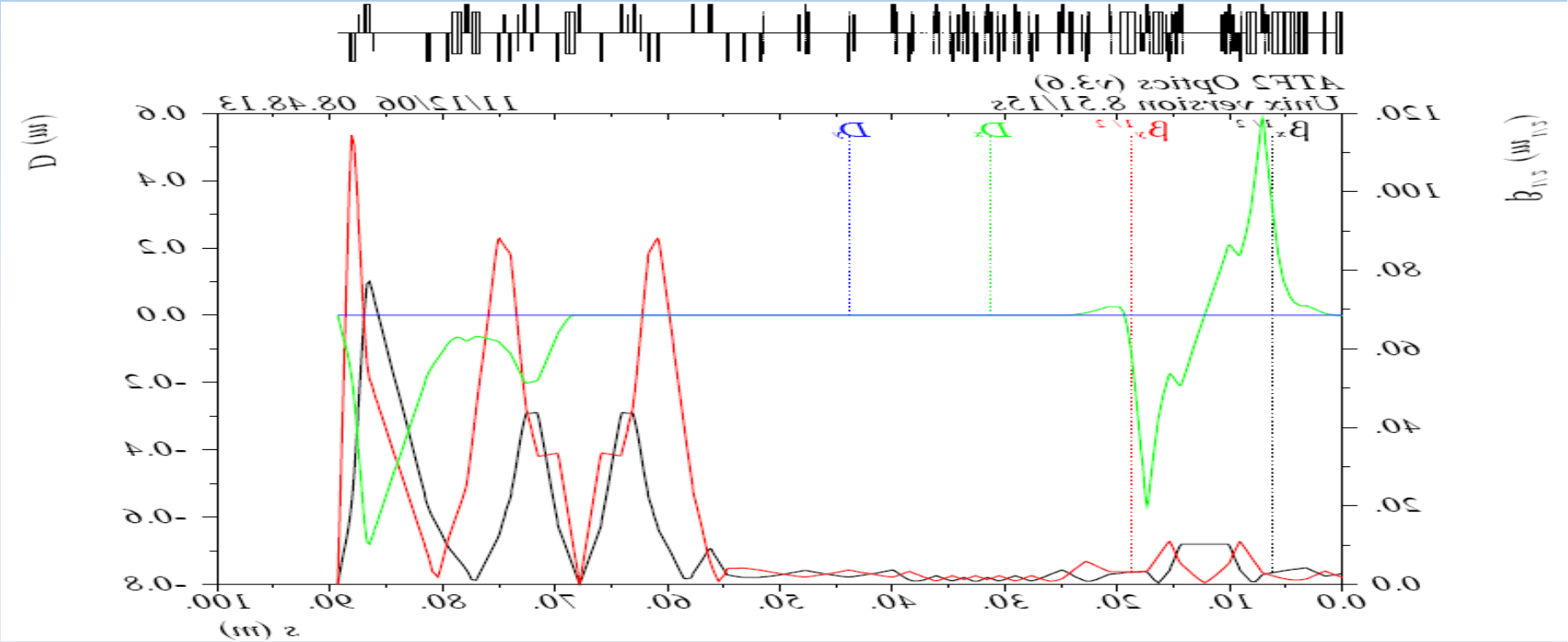
ATF2 Layout and Proposed R&D



The ATF international collaboration include more than 200 researchers and the ATF MOU is signed by 20 institutions from all over the world

Scaled model of ILC final focus (local chromatic correction)

ATF2 – model of ILC BDS



ATF2 goals

(A) Small beam size

Obtain σ_y ~ 35nm

Maintain for long time

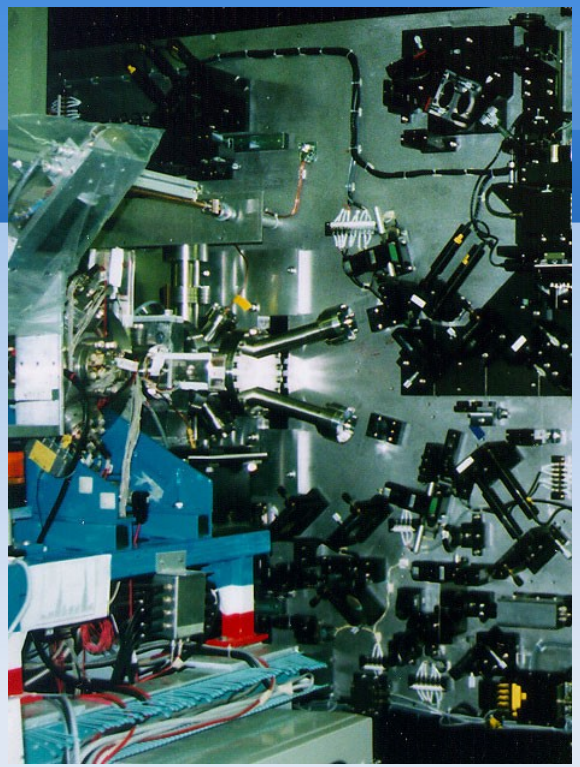
(B) Stabilization of beam center

Down to < 2nm by nano-BPM

Bunch-to-bunch feedback of ILC-like train

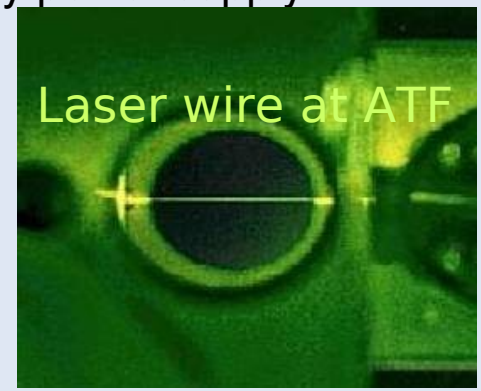
Advanced beam instrumentation at ATF2

- IPBSM to confirm 35nm beam size
- nano-BPM at IP to see the nm stability
- Movers, stabilization, alignment system
- ILC spec high-availability power supplies
- Laser-wire to tune the beam
- Cavity BPMs to measure the orbit
- Fast-pulse Kickers to produce ILC-like train, intra-train feedback.
- PLIC fibre loss monitor
- Post-IP tungsten/carbon wire installation

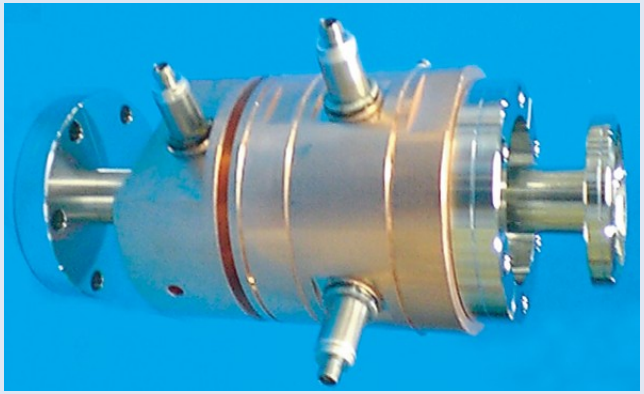


IP Beam-size monitor (BSM) (Tokyo U./KEK, SLAC, UK)

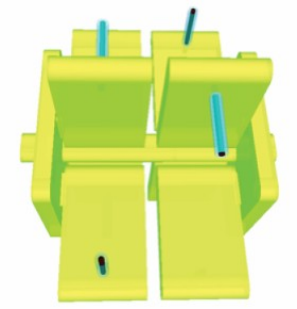
ILC-style high availability power supply (SLAC)



EXT laserwire diagnostics (JAI, UK)

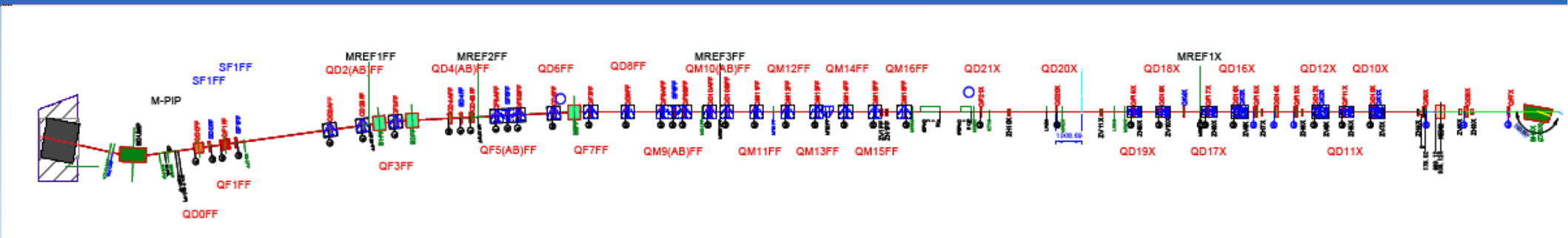


41 C and S-band Cavity BPMs, for use with Quad/Sext magnets with 100nm resolution (PAL, SLAC, KEK)



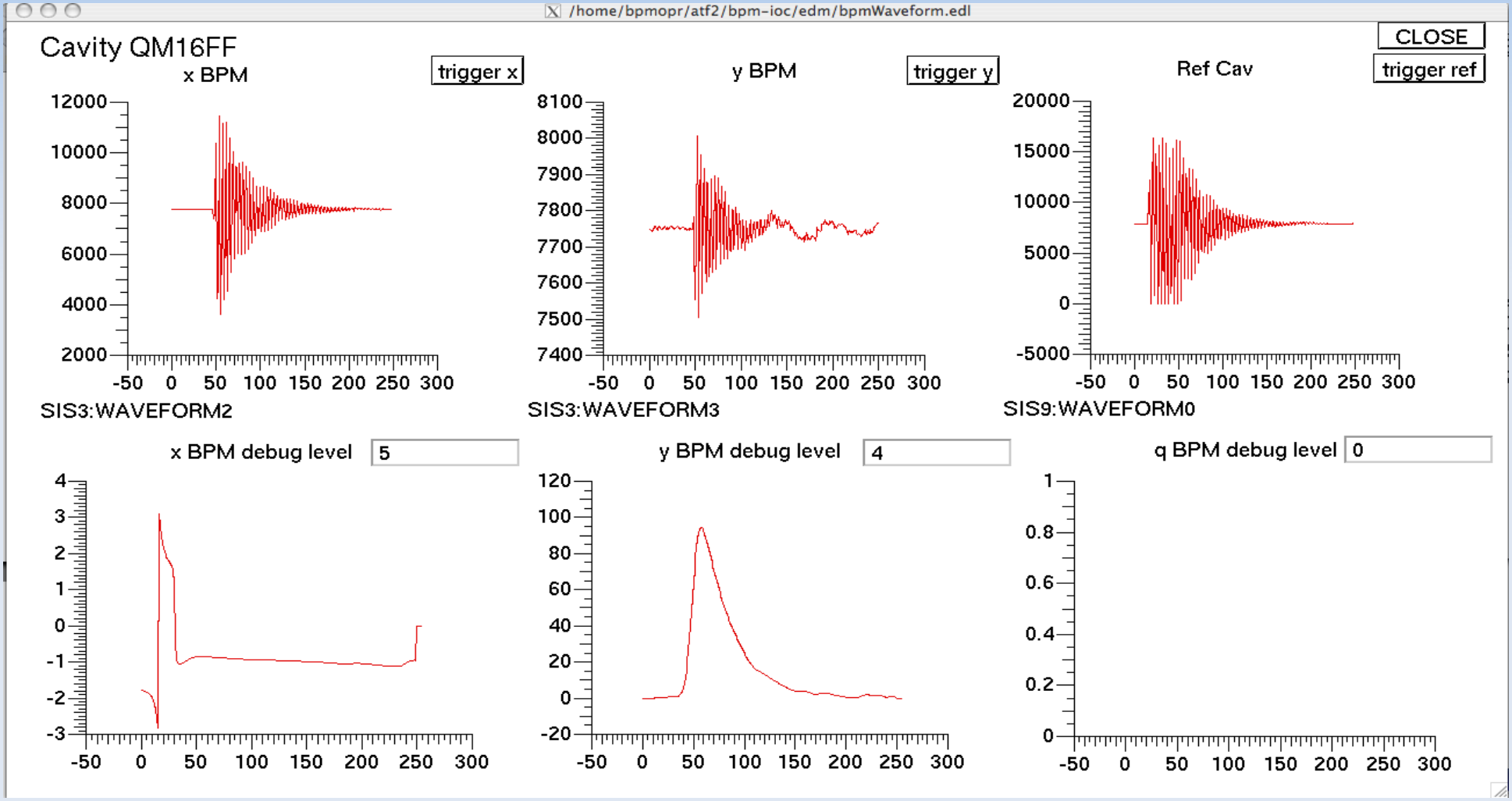
Cavity BPMs with 2nm resolution, for use at the IP (KEK)

Cavity BPM System

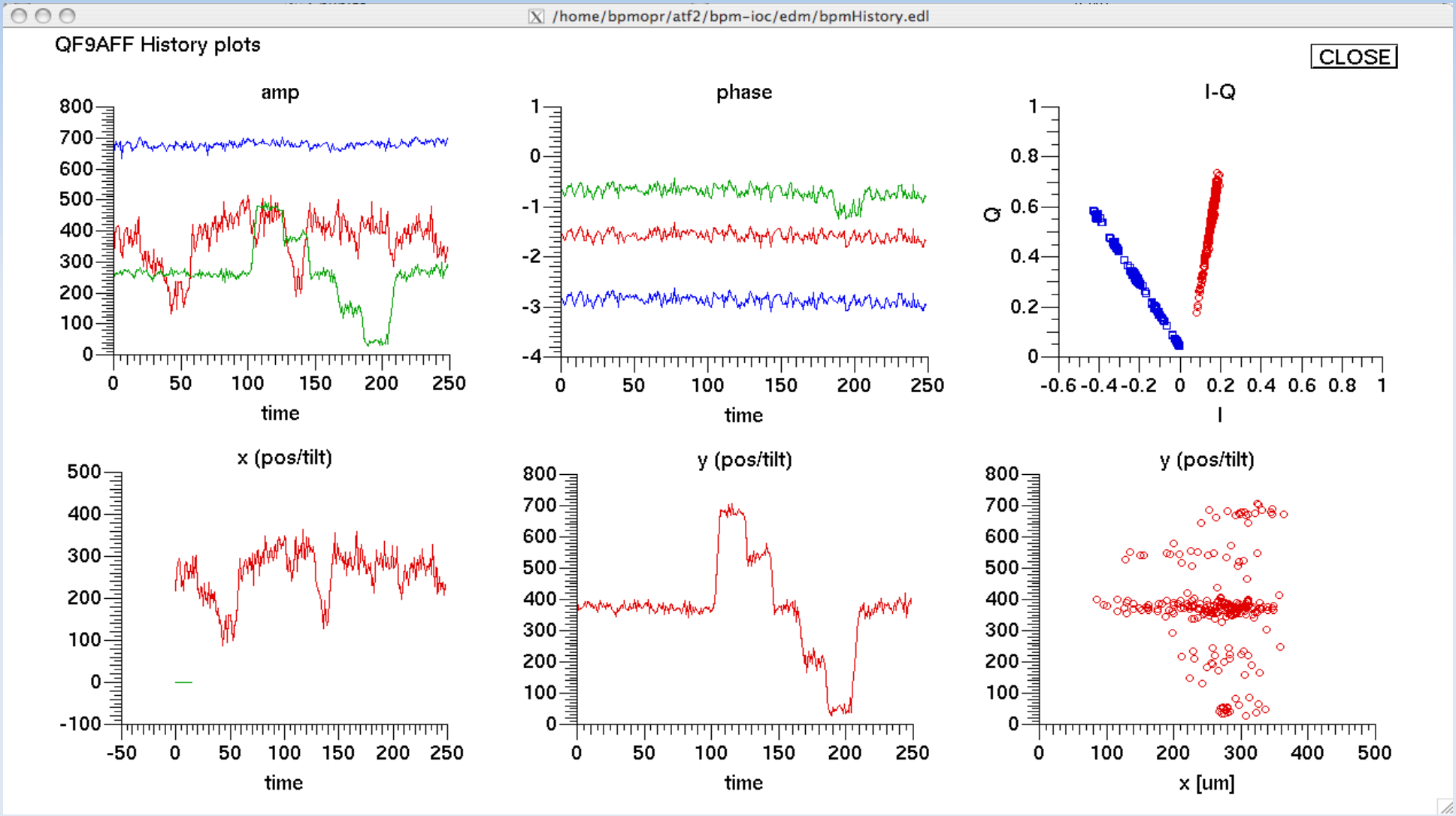


- 41 C- and S-band cavity BPMs, ~<100nm resolution expected.
- All c-band system operational, s-band system for final doublet quads and sexts electronics being installed this run.
- VME/EPICS based readout with EDM high-level user interface.
- Automated s/w based calibration and monitoring system put in place this run.
- h/w cal-tone and temperature monitoring also being installed.

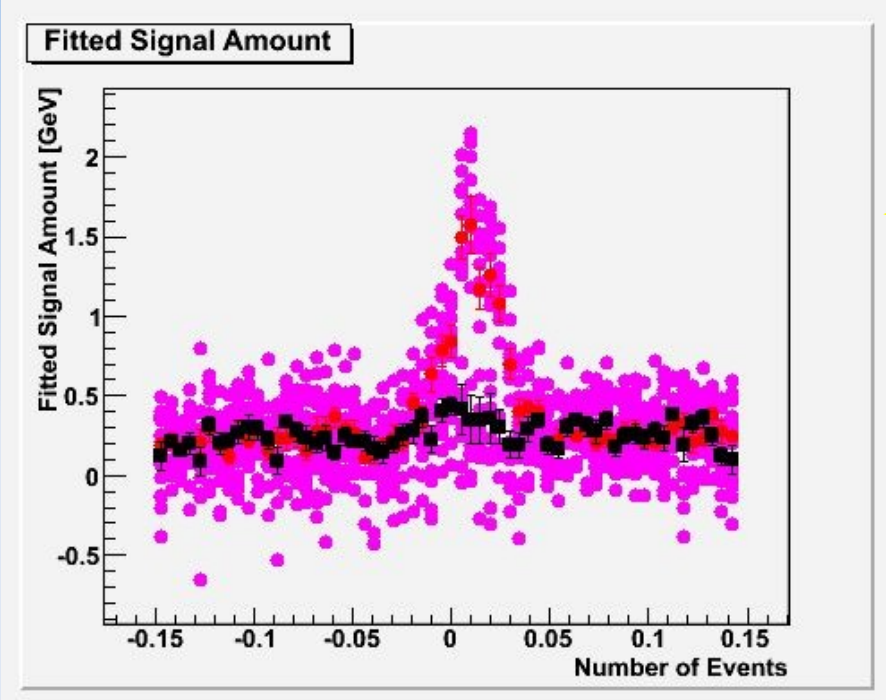
EDM Calibration and Monitoring User Interface



Mover and Corrector-based Automated Calibration

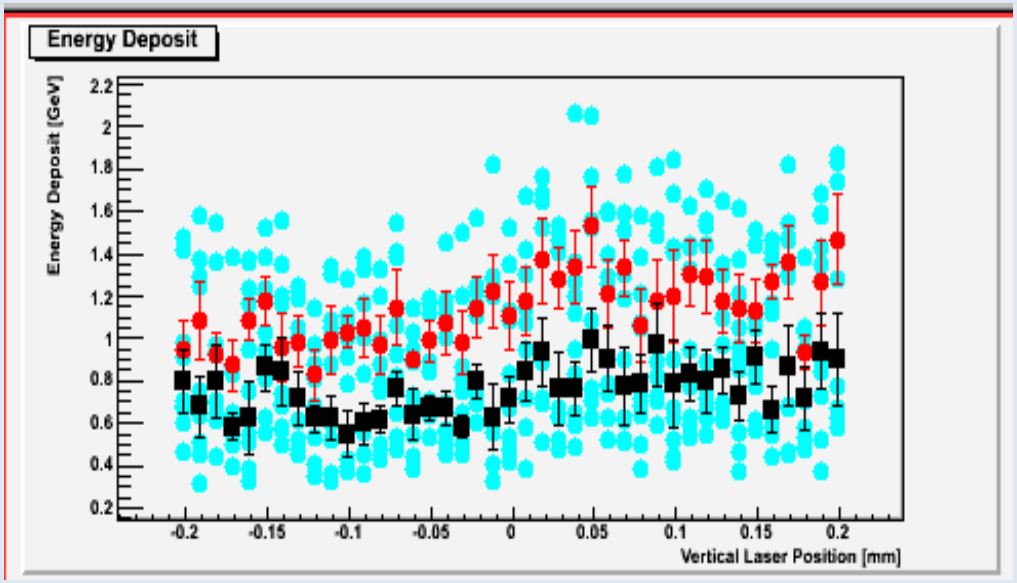


IPBSM - ”Shintake” Interference Fringe Laser Beamsize Monitor

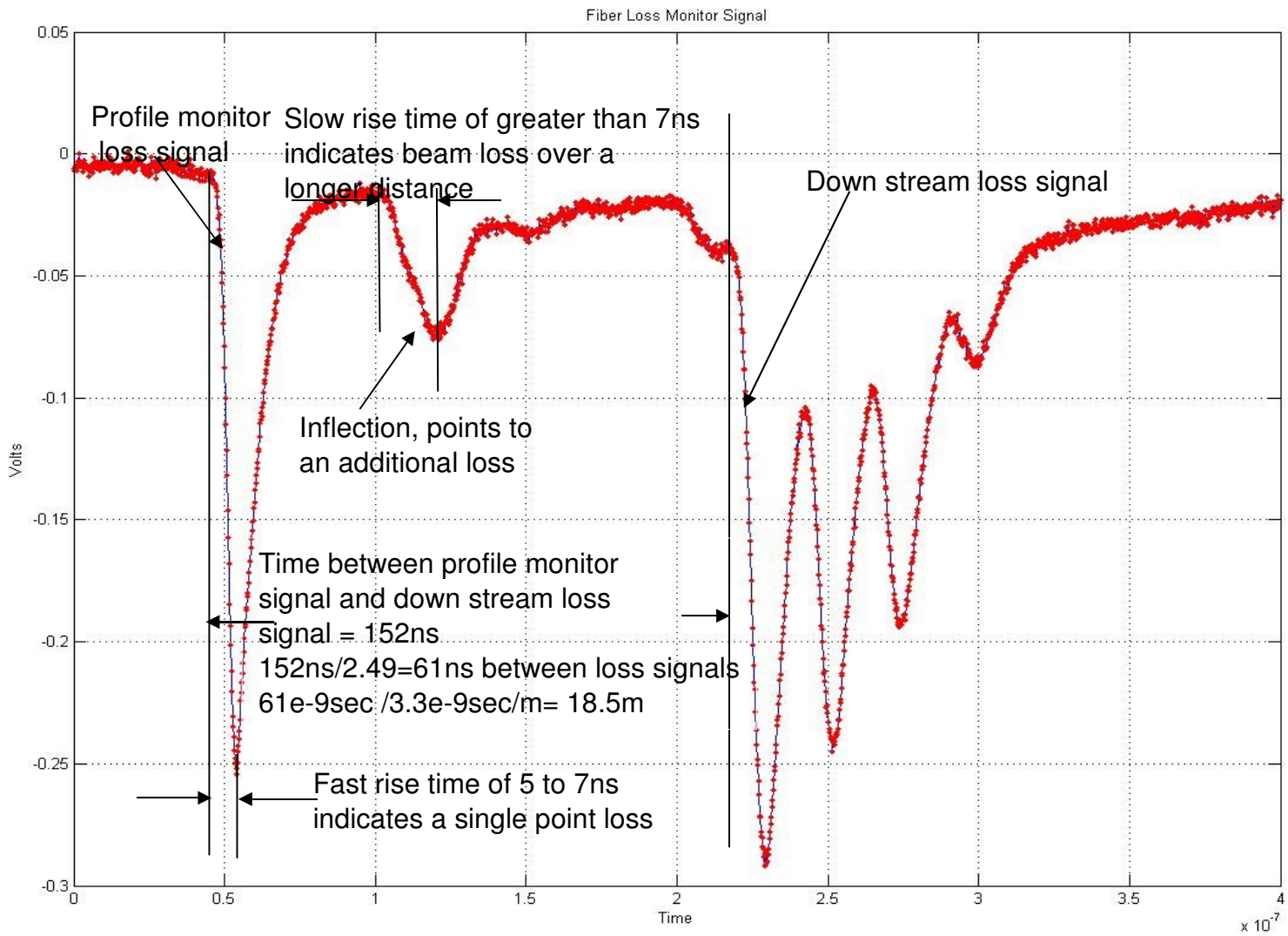


March, measurement of IP horizontal beamsize in 'laserwire' mode

April, first interference mode tests, compton signal seen over background levels, working on reducing backgound levels and ~1um vertical IP beamsize.

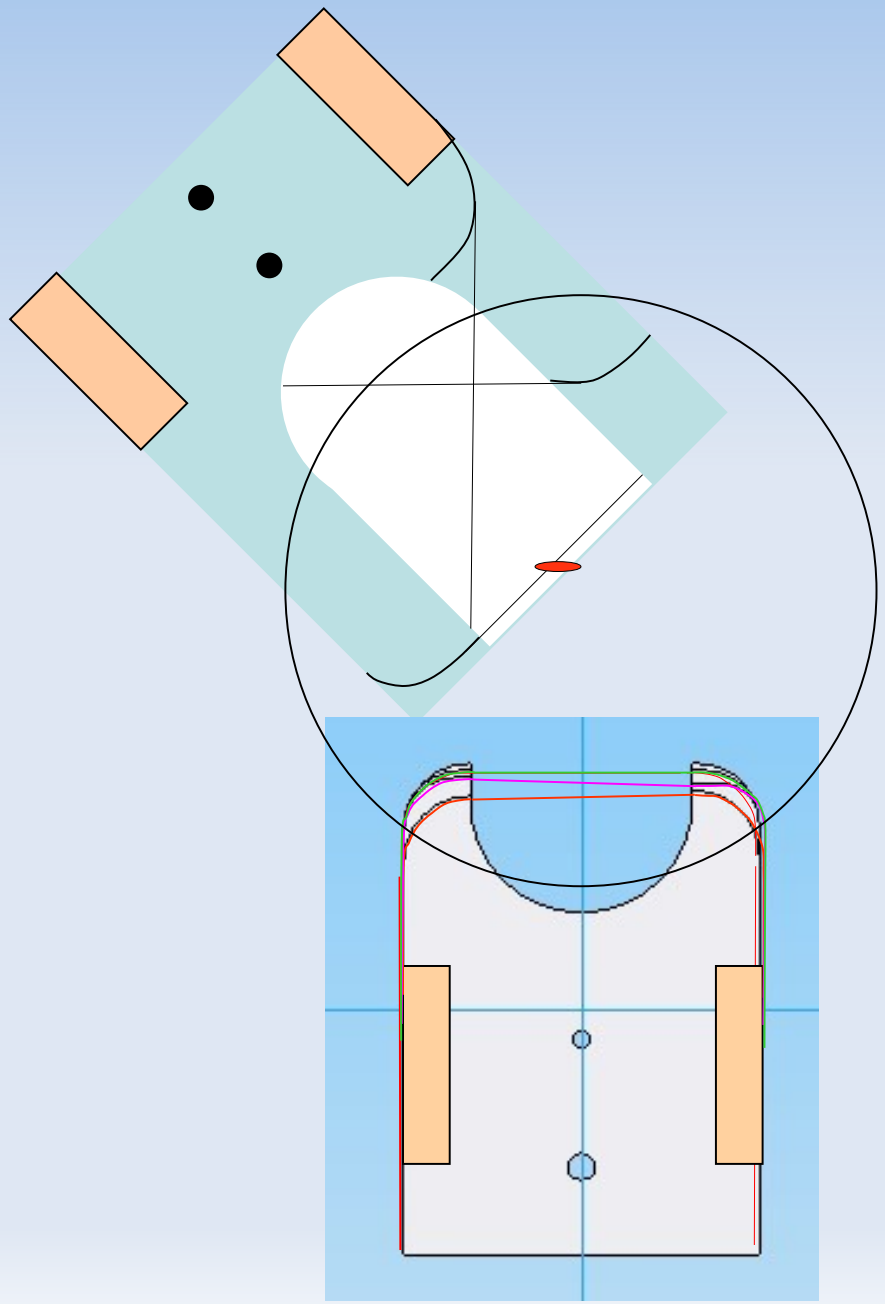


PLIC Fibre Loss Monitor

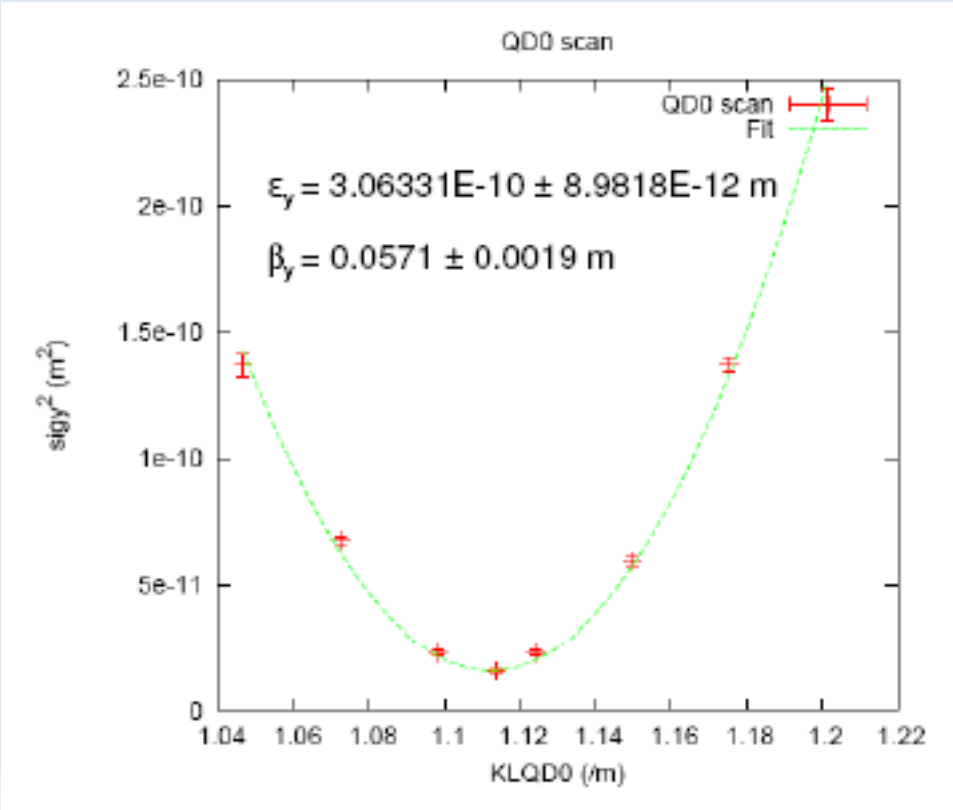


- Has been very useful this run for initial tuning and fast detection of mis-steering etc

MSPIP Tungsten & Carbon Wirescanner



- Initial IP beamsize tuning reliant on post-ip wirescanners to achieve ~um scale vertical beamsize for IPBSM detection
- 10um tungsten wires for ~3um detection
- 5um carbon wires for ~1.5um detection



ATF2 Tuning Software

- 2 high-level software frameworks for developing beam tuning tools and algorithms
  - V-system with SAD interface
  - Flight-simulator (portable control system development and application framework)- Includes Lucretia and MAD modeling codes and provides plugins to others.
  - Goals same for each: provide intuitive non-expert graphical based interface for each tuning task.
- Low-level controls exist in V-System and EPICS, effort underway to provide V-System functionality in EPICS.
- Design and production of tuning software by multiple groups worldwide.
- Software planning started with meeting at LAL, march 2008 with monthly status meetings since by webex.

Principal Software Tuning Tasks

Project Title	Contributing Institutes	Priority	Leader
Coupling Mea.&Corr. in EXT	KEK,SLAC,LAL,CI	VH	C.Rimbault
Dispersion Mea.&Corr. In EXT	KEK,SLAC,CI	VH	J.Jones
EXT Beta-Matching	SLAC, KEK,CI,LAL	VH	K.Kubo
EXT Orbit Corr./FB	SLAC,KEK,LAL,CI, JAI	VH	Y.Renier
FFS Orbit Corr./FB	SLAC,KEK,LAL,CI, JAI	VH	A.Scarfe
Beam Line Modeling Tools	SLAC,CI	M	S.Molloy
IP FB(Pulse-Pulse)	LAL, JAI	H+L	Y.Renier
FB Integration	SLAC, JAI	H	J.R.Lopez
IP Waist&Beta adjustment	LAL(IHEP),CI	H	S.Bai
Non-Mover-Based BBA(EXT)	KEK,LAPP	H	T.Okugi
Mover-Based BBA(FFS)	SLAC,KEK,LAPP	H	J.Nelson
Final IP Spot-Size Tuning	SLAC,KEK,LAL,Tokyo,CERN,CI	M/H	G.White
Bunch-Bunch IP FB(Intra-Pulse)	JAI	M	J.R.Lopez
FS Core Software Dev.	SLAC	M(Ongoir	G.White
EXT Bunch-Bunch FB	JAI,Oxford	L/M	J.R.Lopez
Integrated Automated Tuning	SLAC	L	G.White

- Each tuning software task managed by appointed leader, responsible for task completion and reporting at monthly meetings.
- Where non-KEK led task, software developed and tested offsite using flight-simulator simulated ATF2 environment to test performance.

Commissioning Strategy

- 3 Principal commissioning branches
  - DR emittance goal
  - H/W commissioning (Acquire IPBSM signal + BPM)
  - Achieve low IP beam sizes.
- Presently, these often involve different optics configurations, moving towards integratation.
- Start with larger IP beta configuration, incrementally move to more agressive optics as IPBSM configurations proven and successful tuning of corresponding optics.

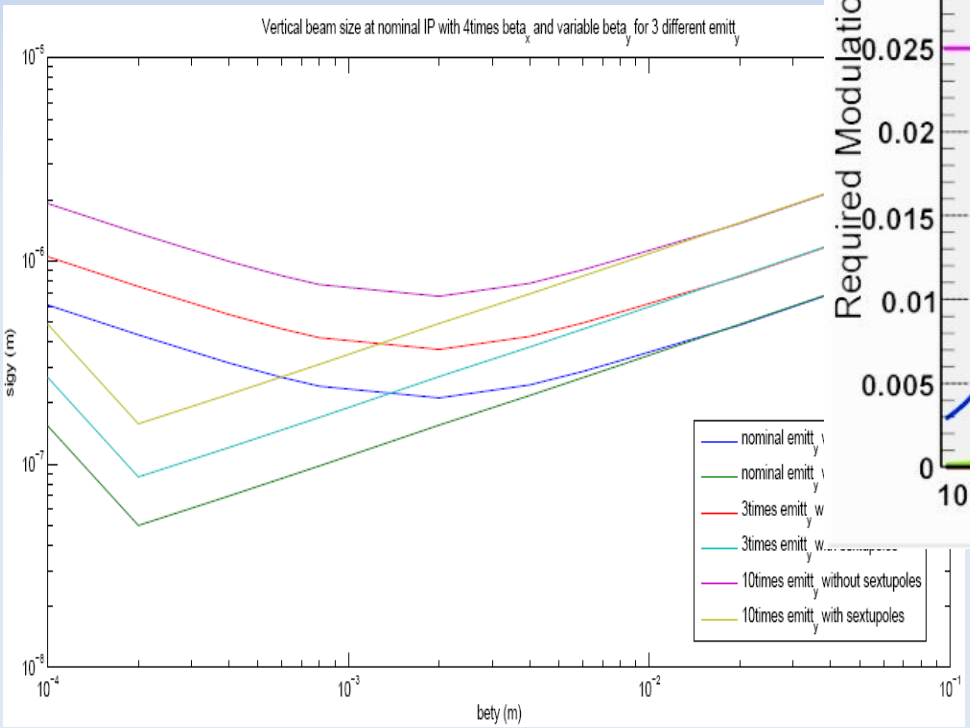
Summary of Run Periods to date

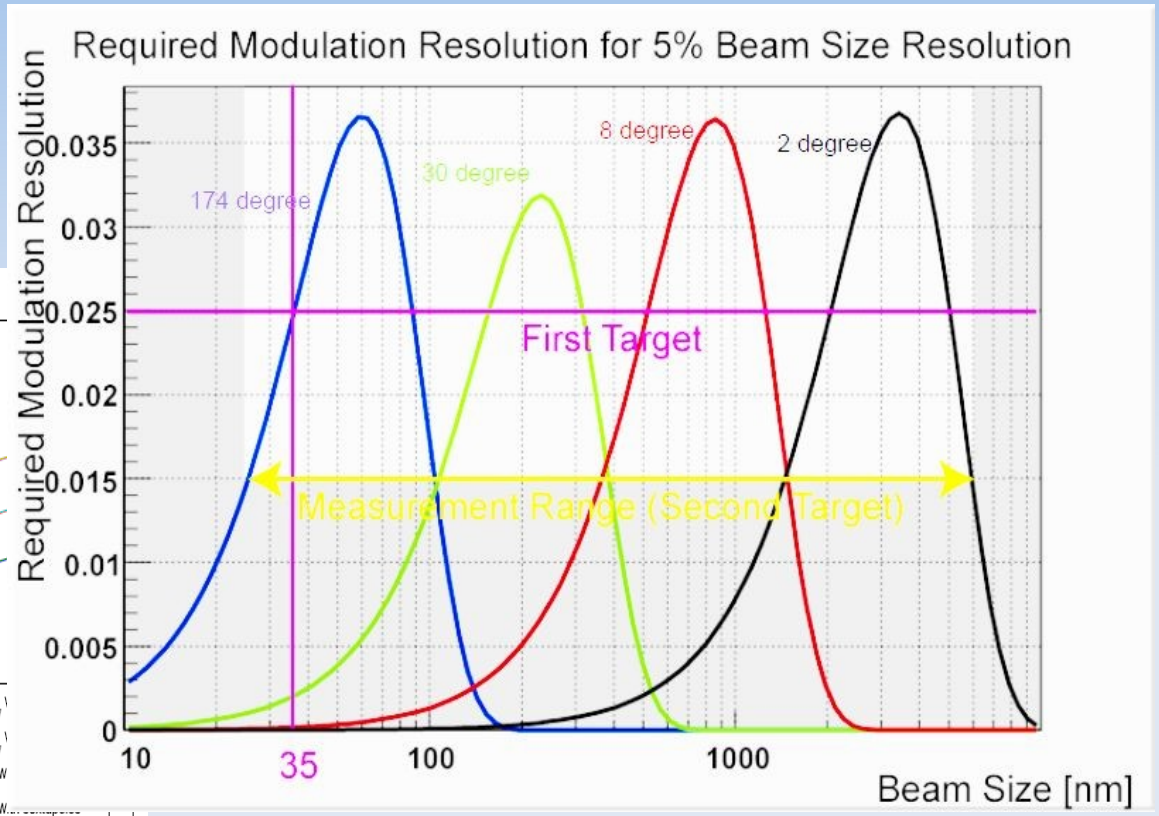
- December (2 weeks)- large IP beta optics, semi-ballistic trajectory
  - Pass radiation inspection, establish beam to dump and begin h/w and software tools checkout
- Feb/March (3 weeks), 100*beta_y optics
  - Switch on all magnets for first time
  - Laserwire mode IPBSM checkout
  - Start using tuning tools (EXT disp./coupling correction, IP scans, twiss and emittance determination)
- April (3 weeks), 20*beta_y optics
  - Attempt ~1um IP beam size
  - Further tests of tuning tools (BBA, steering, optics verification, acquition of IP carbon wire signal)
  - Attempt stable emittance and orbit injection from EXT → Final Focus system

Current Status

- Attempt to attain IPBSM interference-mode signal with 1um IP beam size and low backgrounds.
- Currently running optics without sextupoles switched on, hope to be able to switch on, align and use later- should see small beamsize improvement and be able to use for IP aberation tuning tests.
- Understanding of emittance growth in EXT injection.
  - EXT vertical emittance unstable, varies 20-80pm after correction.
  - Seems very sensitive to extracted orbit especially around second EXT kicker aperture.
  - IP backgrounds also sensitive to kicker currents and orbit here.
- Need good performance from stripline BPMs in this section- working on improving calibration and reliability. Ability to monitor and restore good beam trajectory in this region, BBA also important.
- BBA of all magnets, ability to steer to good orbit throughout beamline.

Target Beam Size for this run

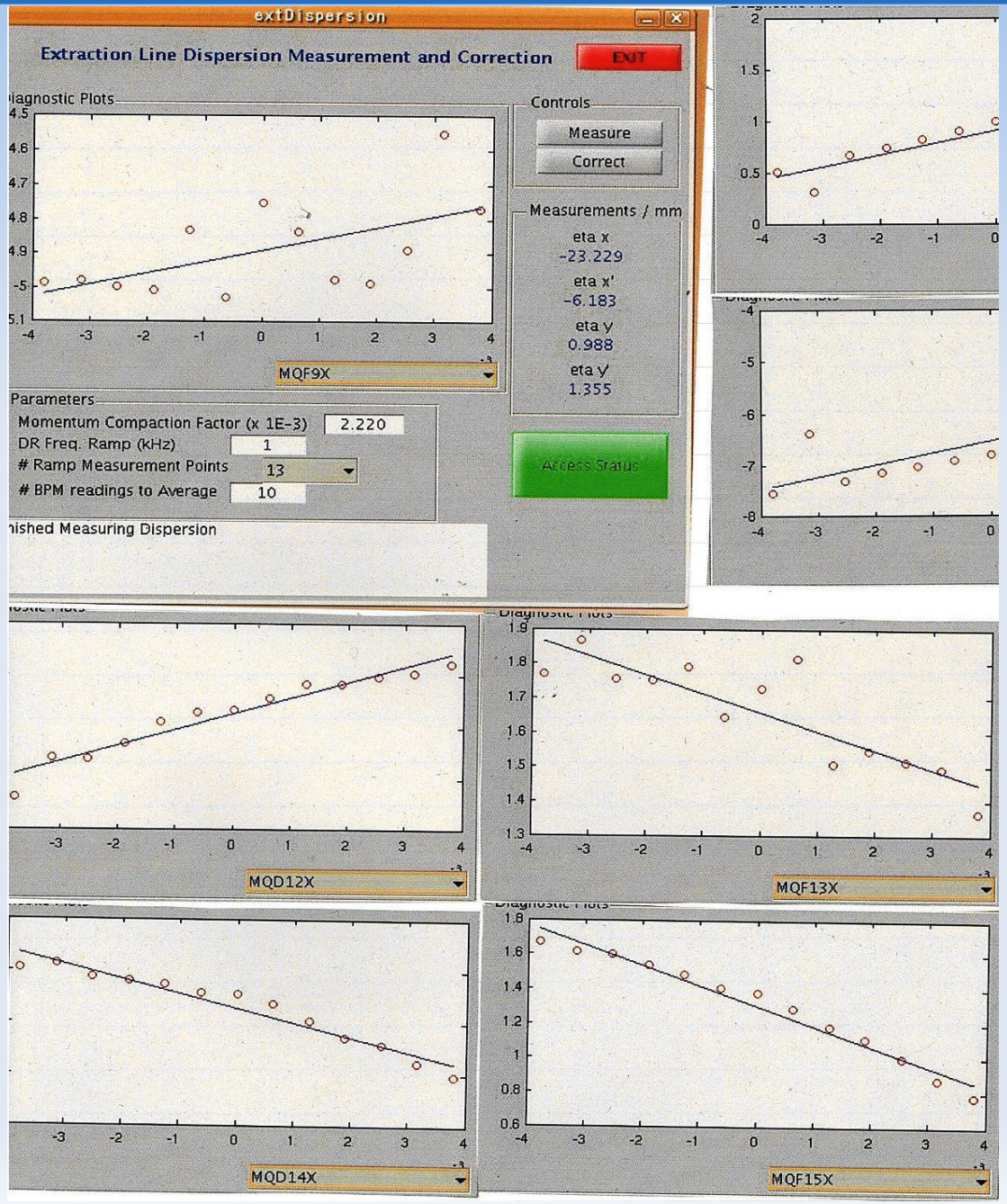




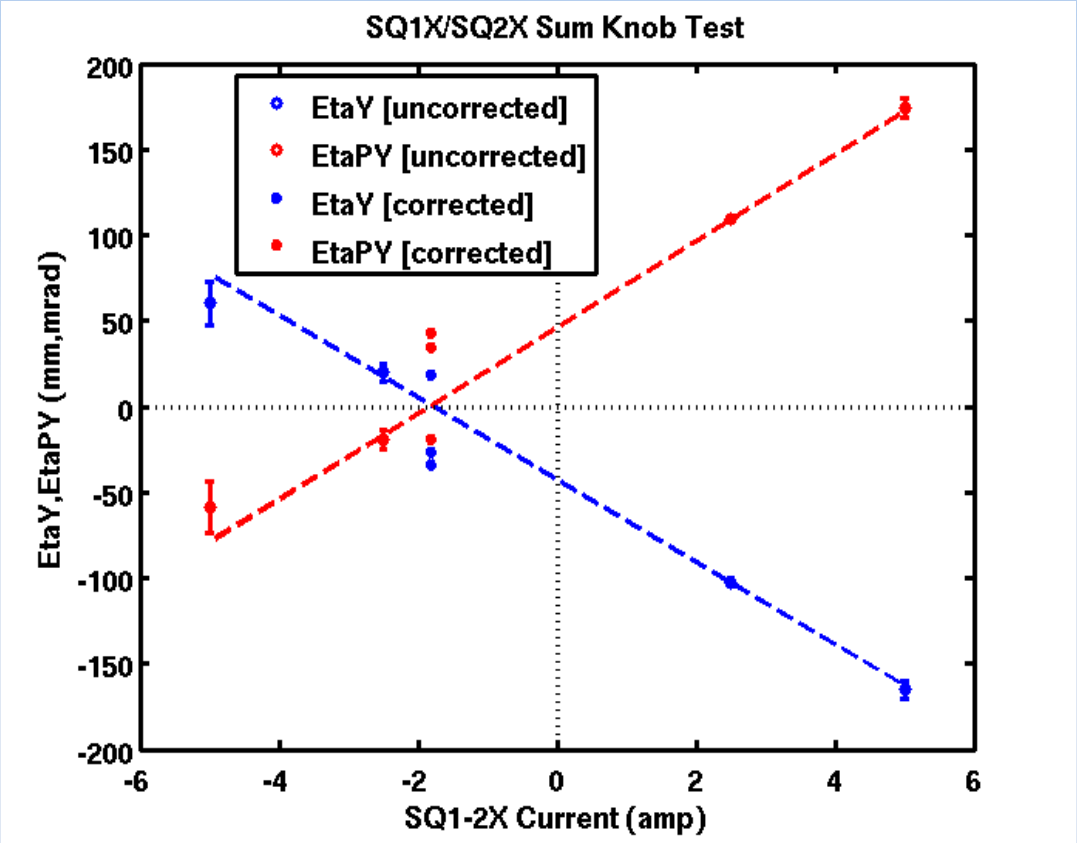
- Need around 1um for IPBSM measurements
- Minimise with PIP carbon wirescanner, and scan waist, can adjust IP beta functions with final doublet scans.

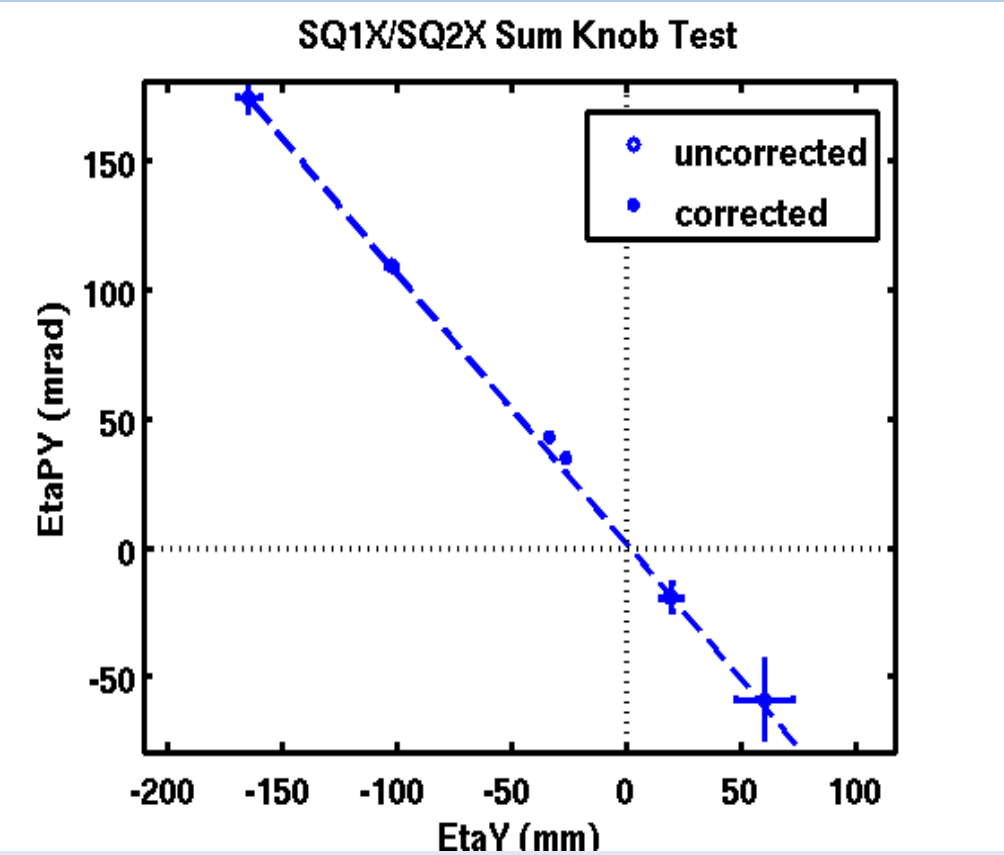
EXT Dispersion Correction

- x+x' correction by orthogonal quad knobs. y+y' simultaneously corrected with skew quad sum knob in dispersive part of extraction line.
- Dispersion measurement using DR frequency ramp.



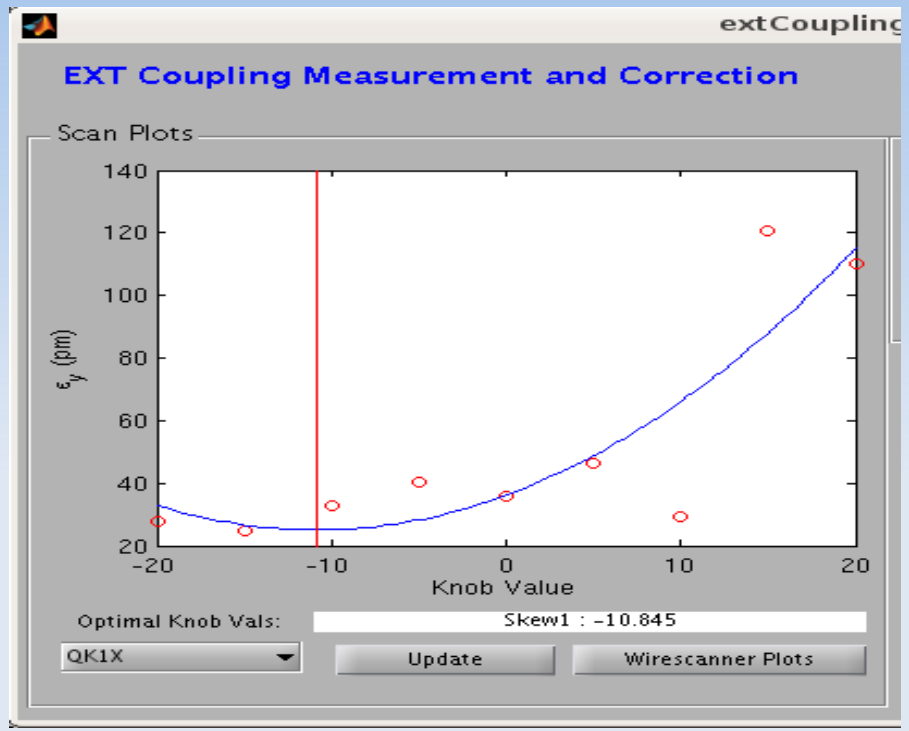
Eta-y Correction

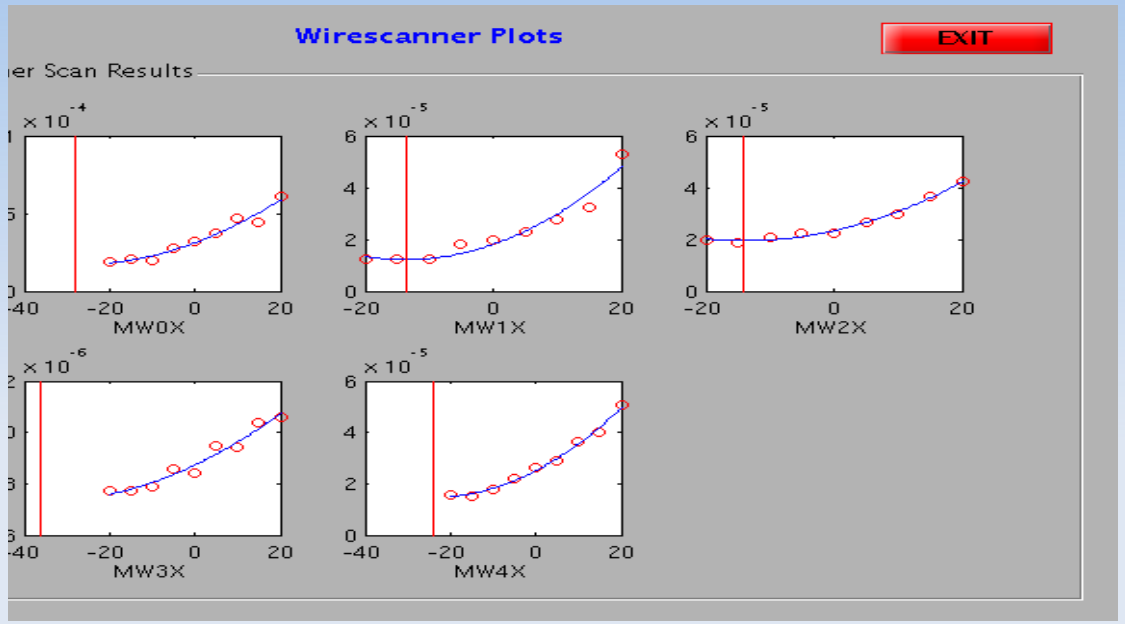




- Sum knob behaves as designed- corrects eta & eta' together- indication of well matched optics.

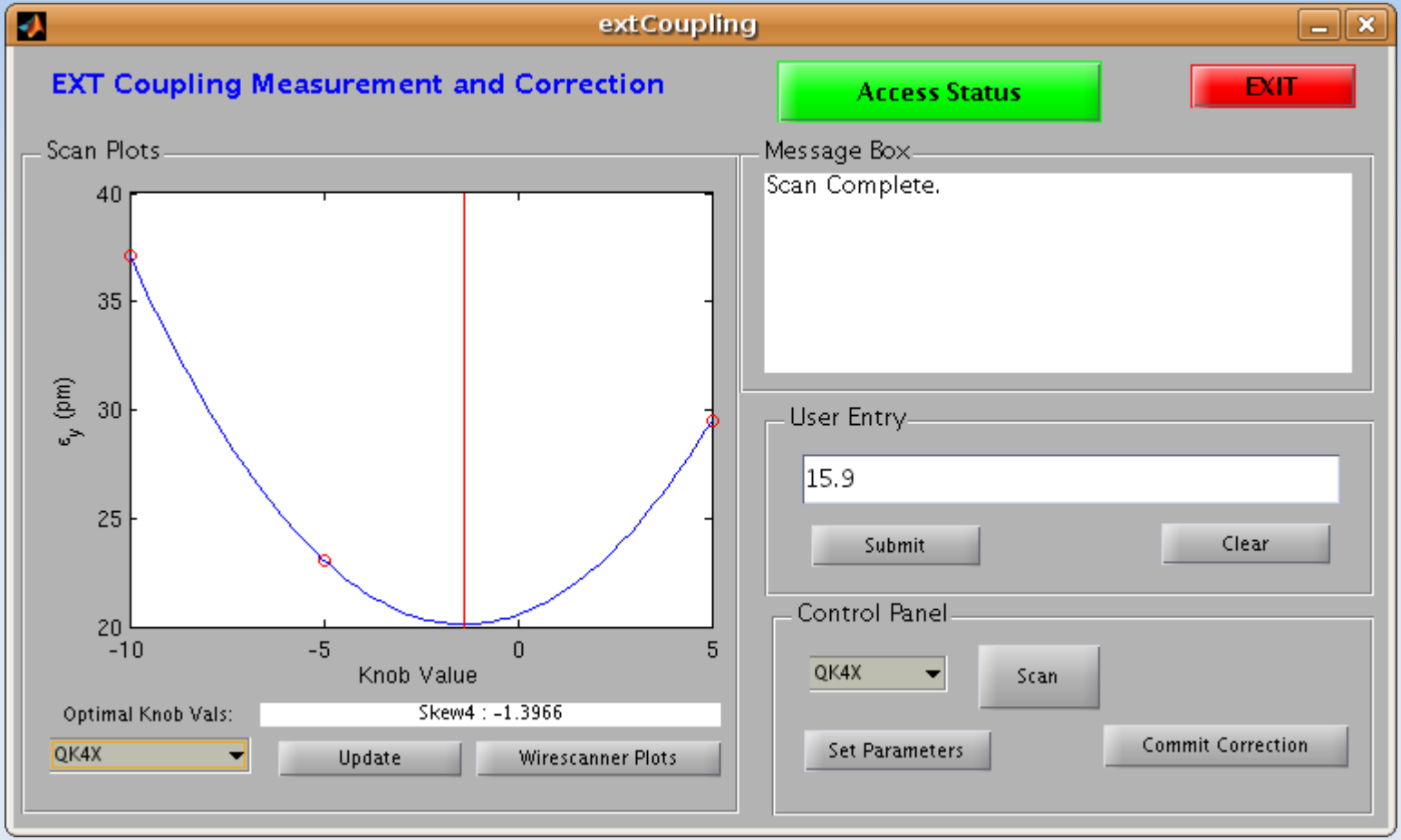
EXT Coupling Correction – QK1X, QK4X Scans





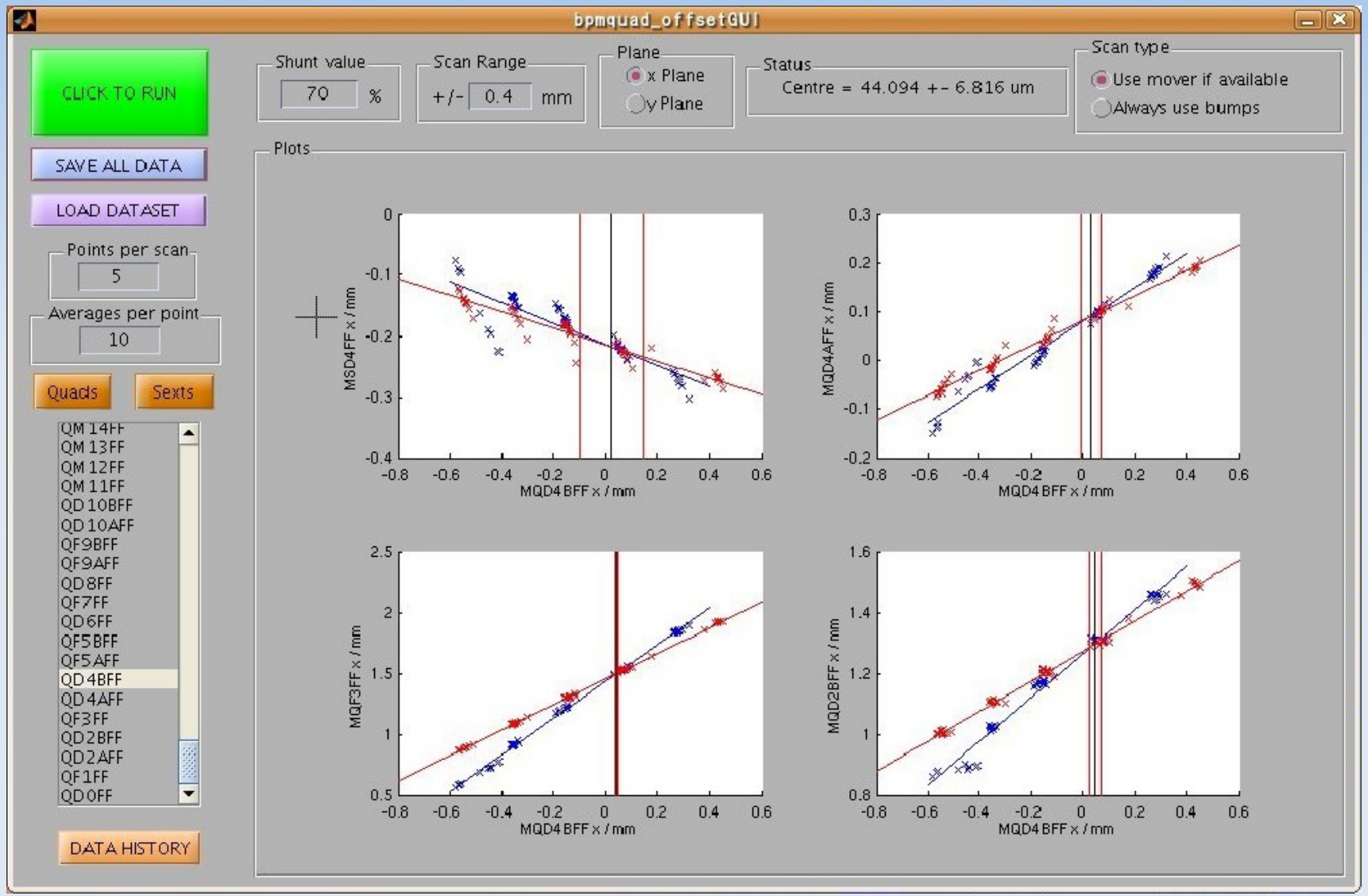
- Vertical emittance scans using 2 available skew quads (QK1X,QK4X).
- Emittance measurement using 5 vertical wire scanners (slow – full scan takes nearly whole shift).
- Remaining 2 skew quads expected later this year.

EXT Emittance after Dispersion and Coupling Correction



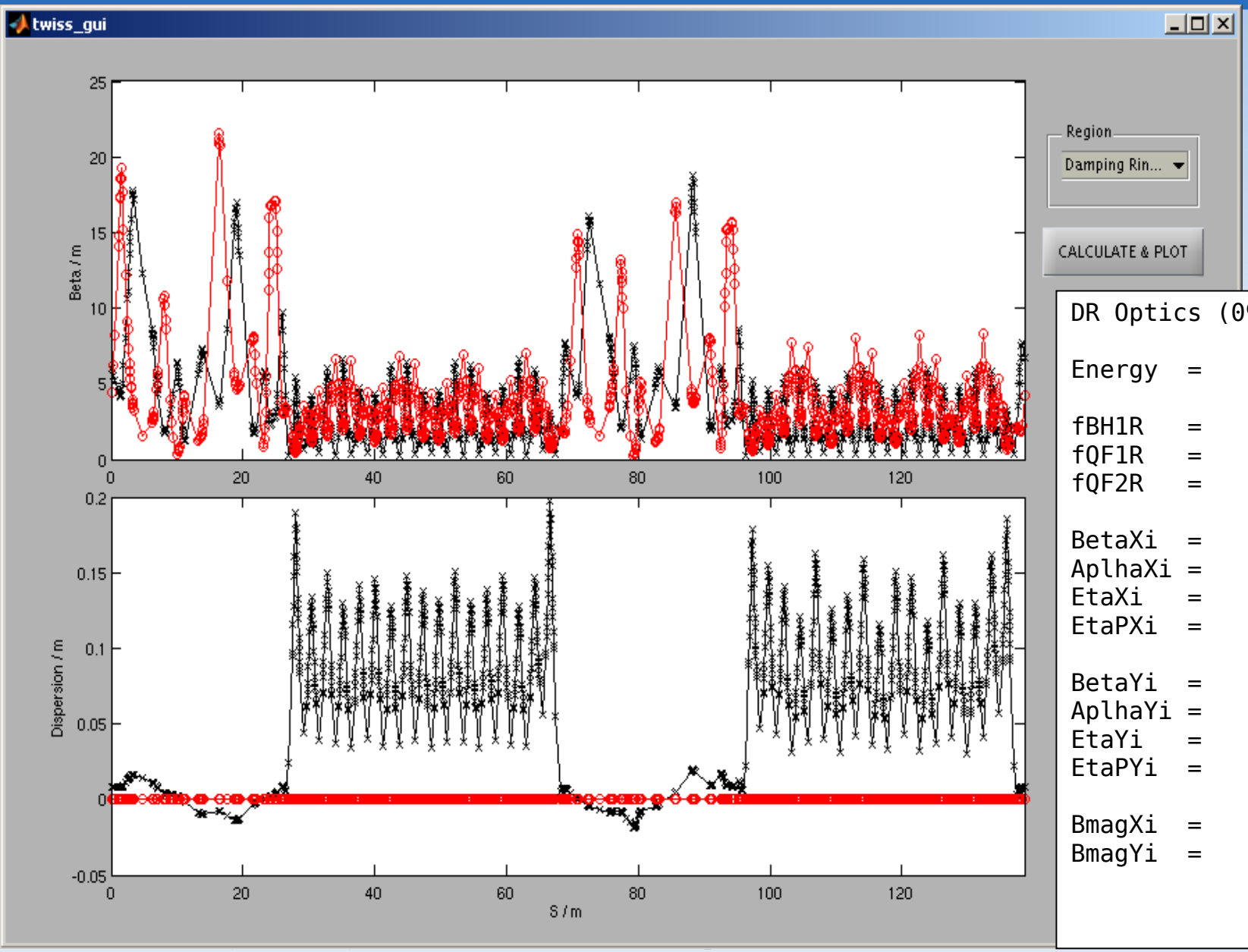
- Best achieved extracted emittance to date ~20pm (DR emittance ~12pm).

BPM-Quad BBA (Quad Shunting)



- Automated BBA tool for Quad and Sext BPM alignment.

Optics verification - DR

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DR Optics (09apr15 02:00)

Energy   =     1.2857 (    1.3000)

fBH1R    =     1.0055 (    1.0    )
fQF1R    =     1.0000 (    1.0    )
fQF2R    =     1.0086 (    1.0    )

BetaXi   =     5.9827 (    6.8534)
AplhaXi  =     0.8468 (    1.1123)
EtaXi    =     0.0083 (    0.0000)
EtaPXi   =    -0.0003 (    0.0000)

BetaYi   =     4.4538 (    2.9413)
AplhaYi  =    -3.1844 (   -1.9111)
EtaYi    =     0.0000 (    0.0000)
EtaPYi   =     0.0000 (    0.0000)

BmagXi   =     1.0181 (    1.0    )
BmagYi   =     1.1152 (    1.0    )
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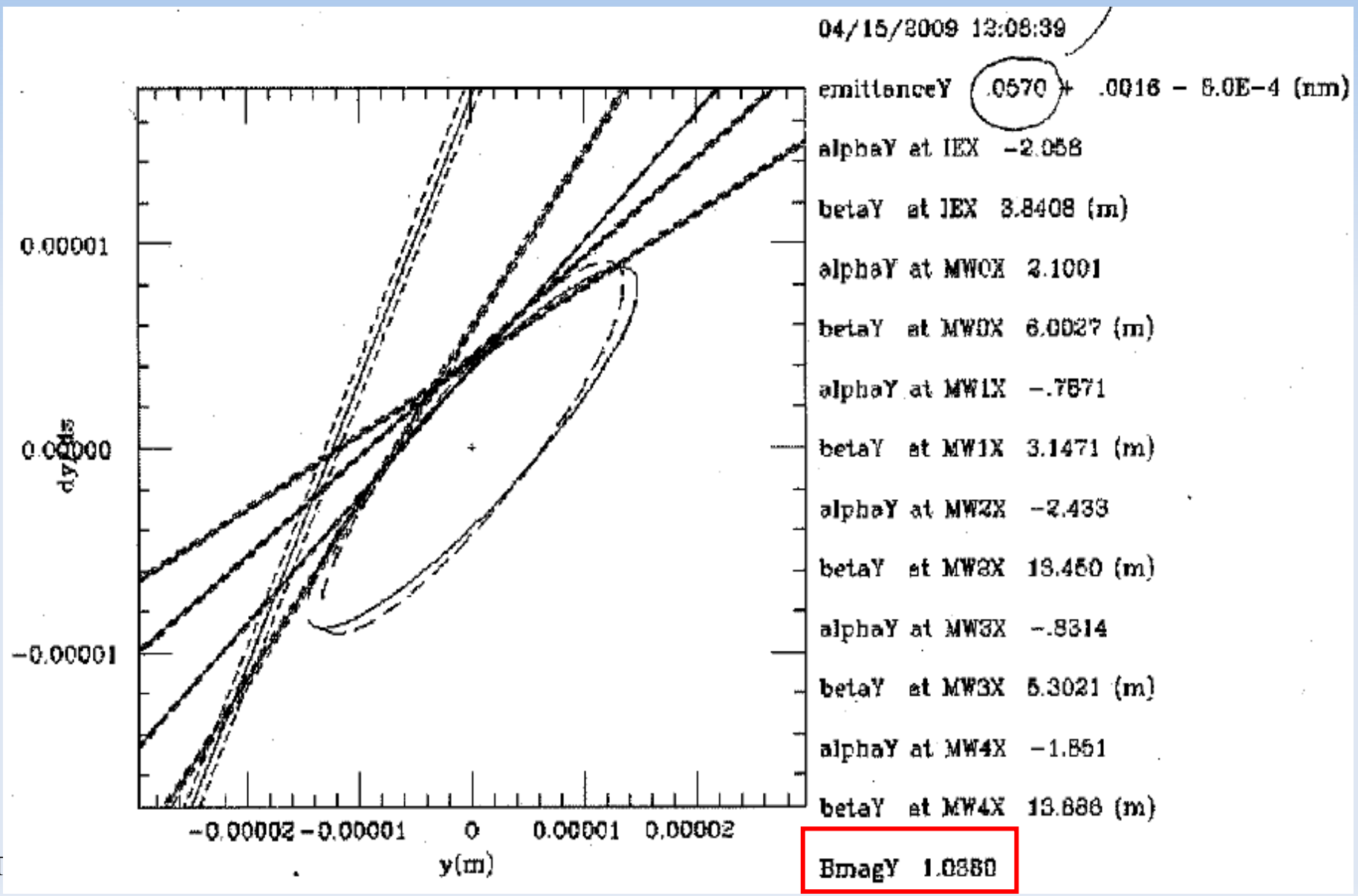
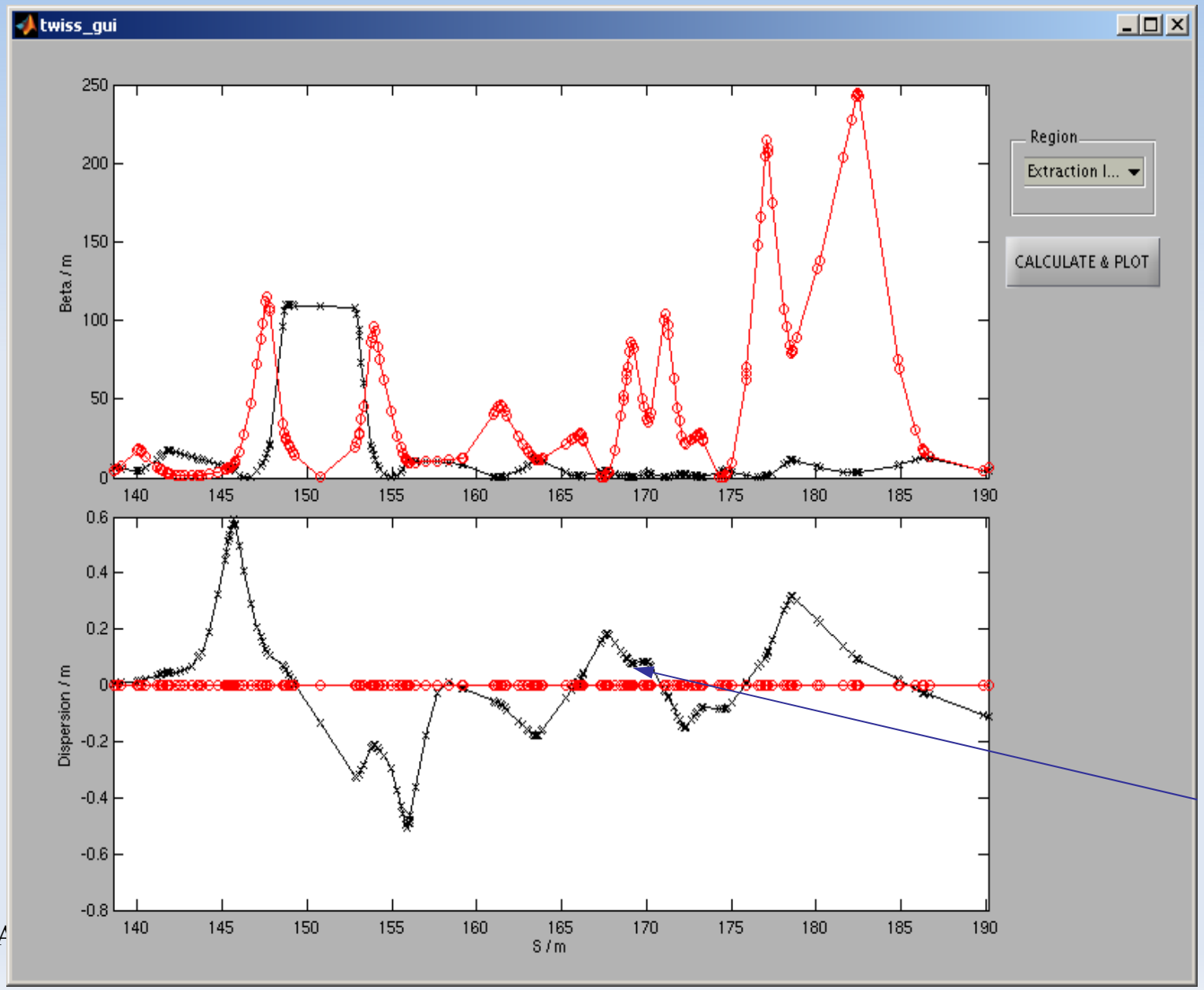
SAD Optics verification – well matched in EXT

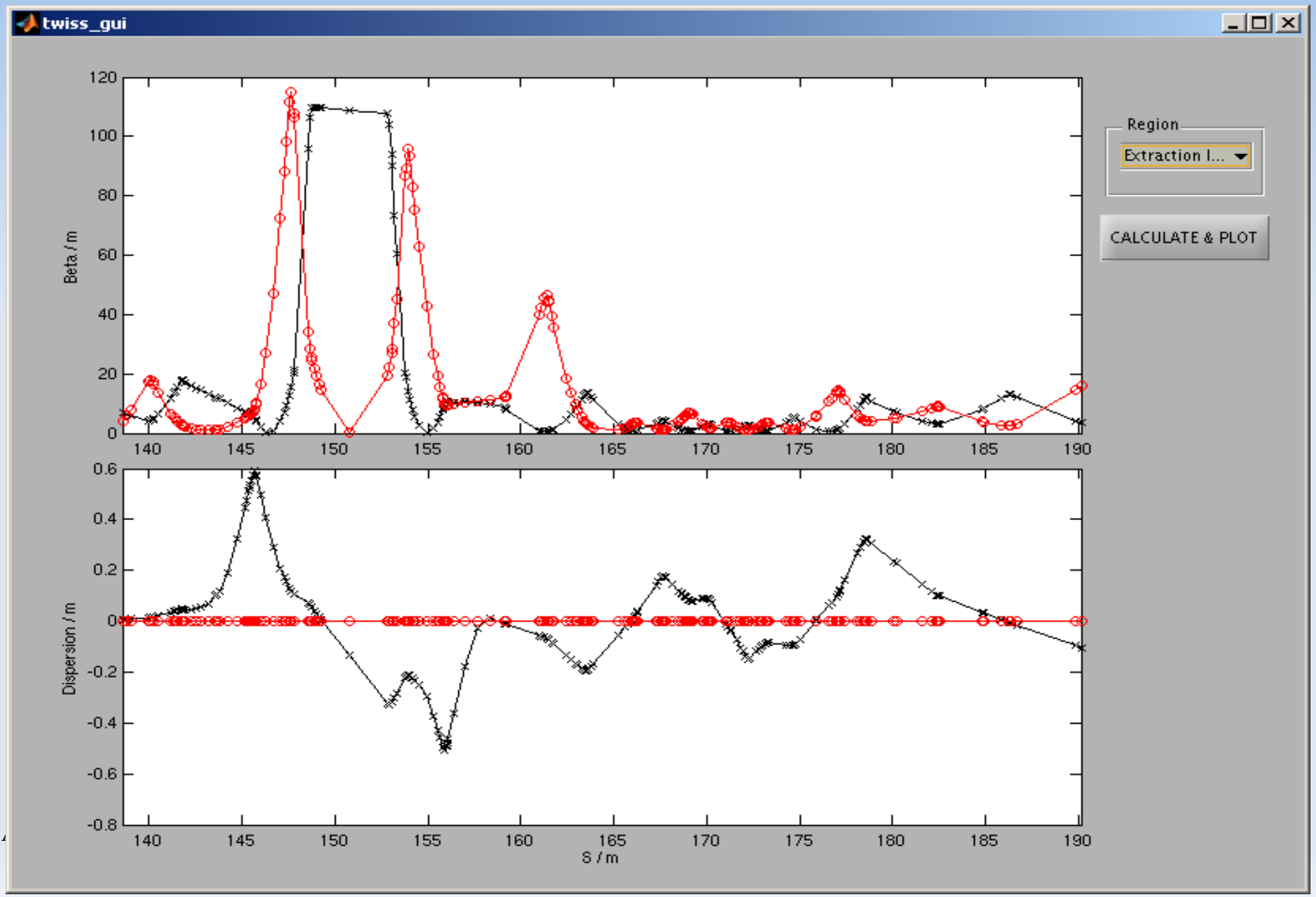


Optics Verification – EXT (discovery of badly set magnet)

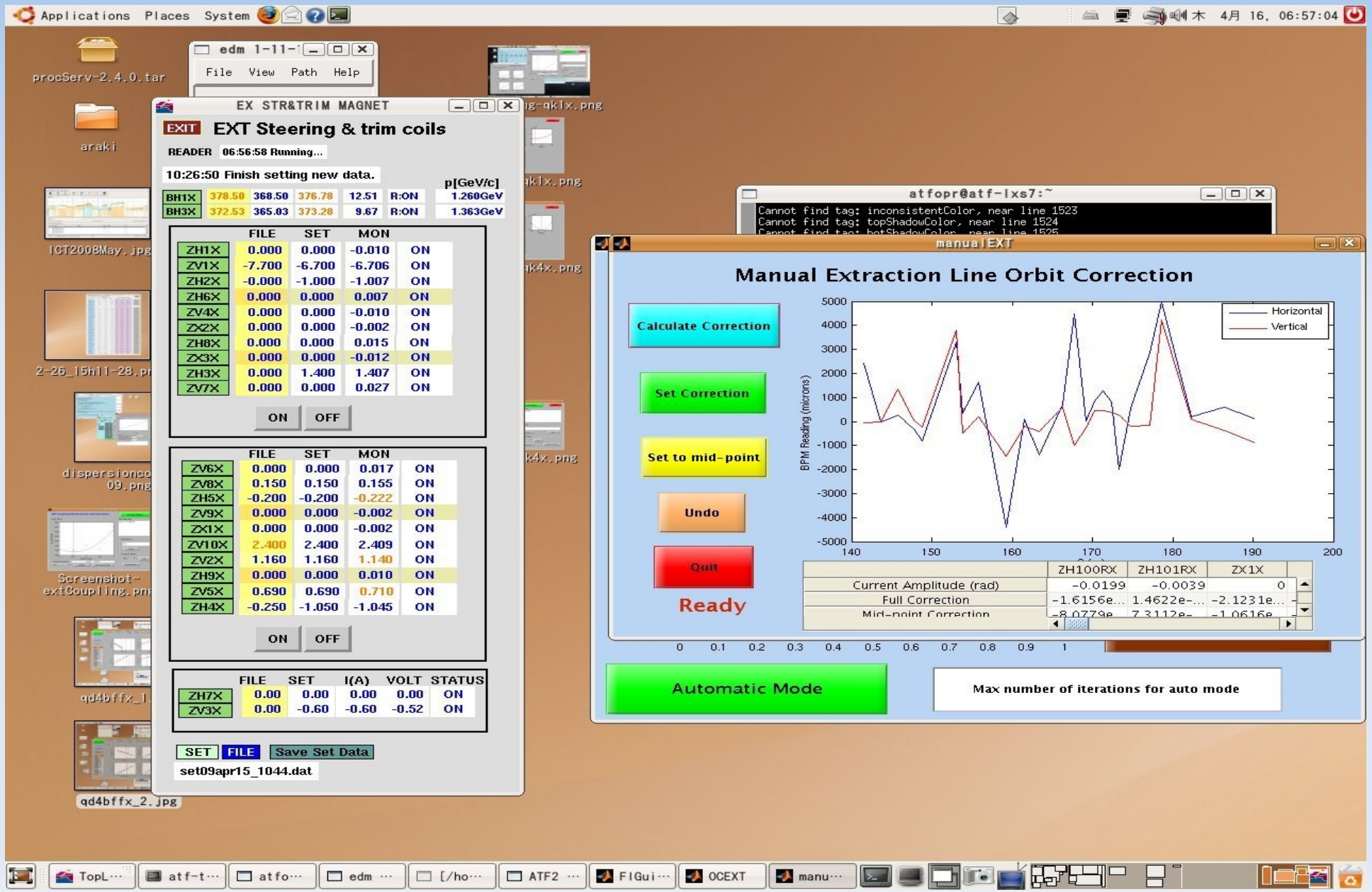


QF1X/QF6X dispersion correction

Optics Verification – Correct optics in EXT



Steering Software



Summary

- Huge amount of effort invested in ATF2 hardware and software by KEK and worldwide groups. Not all covered here, and much more to come.
- Very exciting to see efforts starting to come together and to be working together on the unified goal of achiving the goals of ATF2. Great example of multinational co-operation on combined project.
- Lots more hard work required to get to ATF2 goals, state-of-the-art hardware and unique tuning requirements to work.
- We are up for the task and look forward to reporting on many successful milestones to come.

The Heavy collide
With the Light -- what
happens now? Physics shall
guide us.
- Will (physics haiku)