

# ATF2 commissioning in Autumn 2009

*for discussion*

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LAL & KEK

*on behalf of the commissioning team*

# Background material used :

1. Personal strategy for ATF2 beam operation in 2009

T. Okugi, July 22, 2009 ATF2 weekly meeting

<http://ilcagenda.linearcollider.org/getFile.py/access?resId=1&materialId=slides&contribId=2&sessionId=1&subContId=0&confId=3654>

2. Schedule plan of machine studies in October to December

P. Bambade, Y. Kamiya et al., P. Burrows, August 12, 2009 ATF2 weekly meeting

<http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=3657>

3. Presentations at June 2009 ATF2 project meeting

<http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=3511>

# Commissioning periods

December 2008

→ 3 weeks

January – June 2009

→ 14 weeks (=1+2+4+3+3+1)

October – December 2009

→ 7 weeks (=2+2+3) *planned*

2010...

~ *idem*

Now...

## Beam time scheduling

→ 70% fraction for ATF2 & 4 + days per week operation <sup>+ few</sup> add. days

## Individual R&D tasks → common goal

Groups: **KEK**, Tokyo, Sendai, **SLAC**, IHEP, UK, France, Spain, **CERN**,...

## → ATF2 educational function

Several PhD & young post-doc researchers in accelerator science

# New hardware systems for ATF2

22 **Q**uadrupoles, 5 **S**extupoles, 3 **B**ends in downstream of QM16  
 (IHEP, China) (SLAC) (SLAC, IHEP)

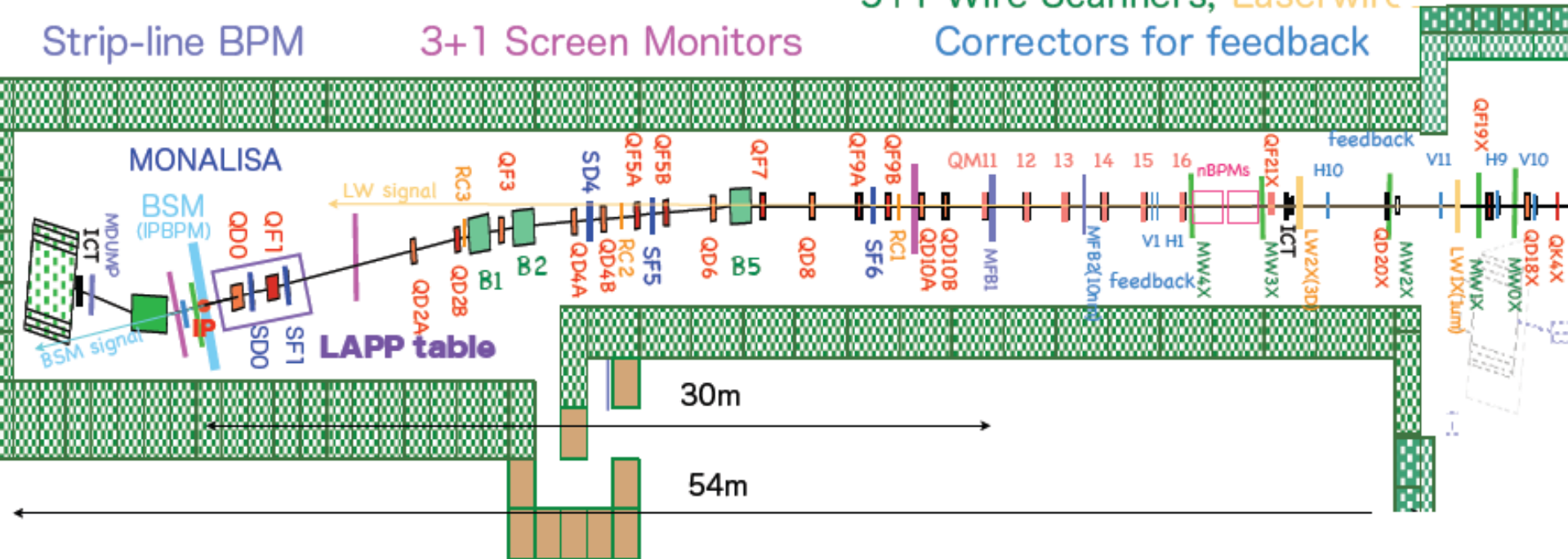
All Q- and S-magnets have cavity-type beam position monitors (QBPM, 100nm)  
 (PAL, KNU, Korea, and SLAC, RHUL for electronics)

5+1 Wire Scanners, Laserwire

Strip-line BPM

3+1 Screen Monitors

Correctors for feedback



- Shintake Monitor ( beam size monitor, BSM with laser interferometer ):Tokyo univ.
- MONALISA ( nanometer alignment monitor with laser interferometer ):Oxford univ.
- Laserwire ( beam size monitor with laser beam for 1  $\mu$ m beam size, 3 axes):RHUL
- IP intra-train feedback system with latency of less than 150ns (FONT):Oxford univ.
- Magnet movers for Beam Based Alignment (BBA):SLAC
- High Available Power Supply (HA-PS) system for magnets:SLAC

# Priorities for December 2008 – June 2009

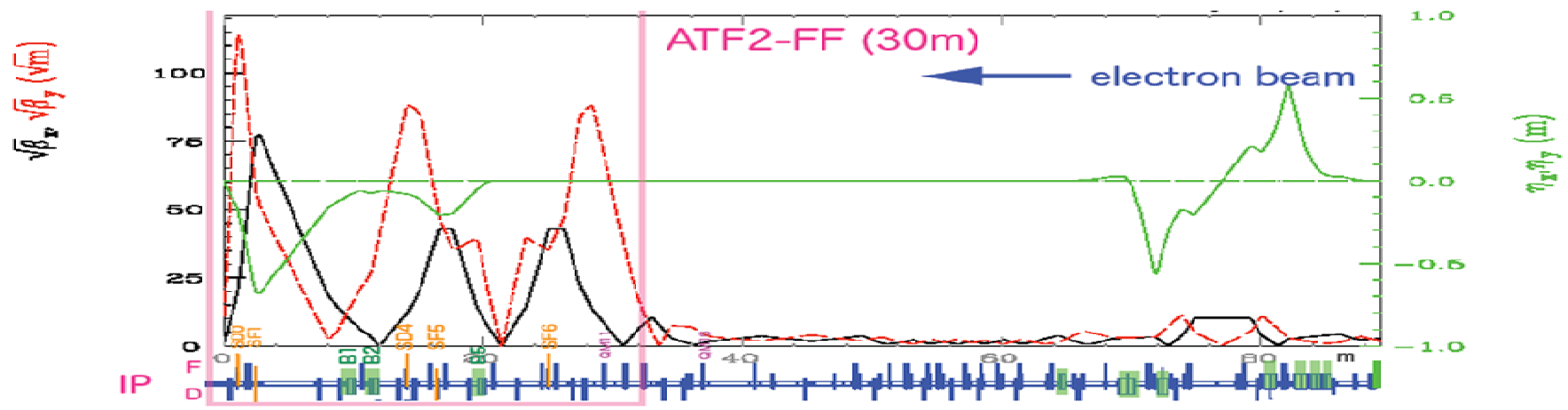
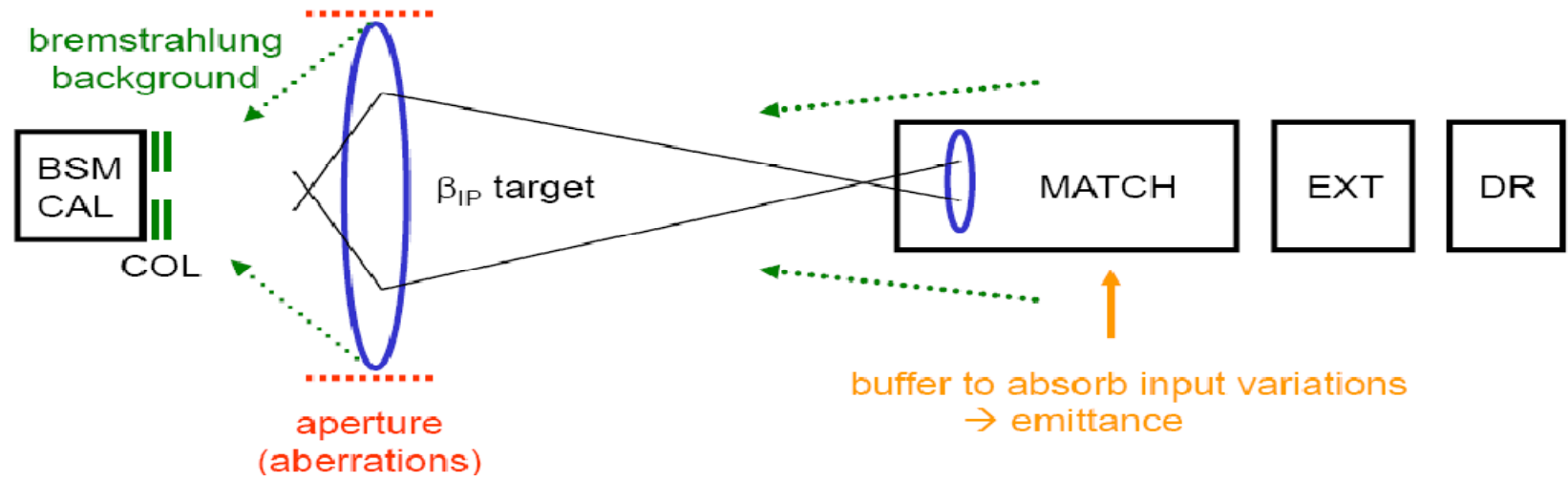
- Radiation inspection @ KEK → get authorization
- Fast extraction kicker R&D in Damping Ring
- ATF2 hardware commissioning (magnets & instruments)
- Shintake monitor (BSM) commissioning & study
- Initial 1<sup>st</sup> order optics measurements (methods, software)

# Commissioning $\rightarrow$ gradual $\beta_{x,y}^*$ (demagnification) reduction paced by

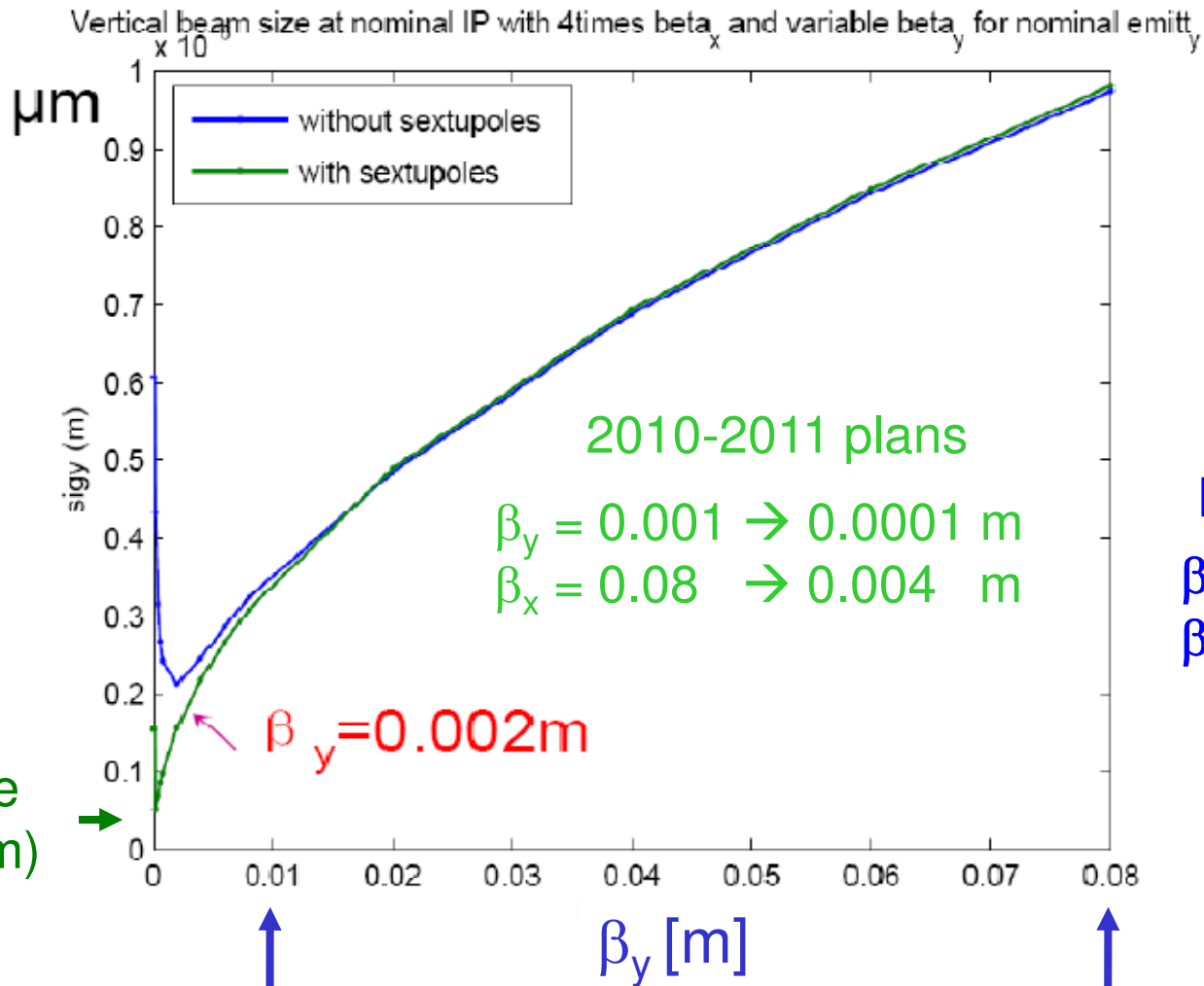
beam tuning

instrumentation (BSM / other)

background study



# Variable $\beta_{IP}$ at ATF2



2010-2011 plans

$\beta_y = 0.001 \rightarrow 0.0001 \text{ m}$

$\beta_x = 0.08 \rightarrow 0.004 \text{ m}$

presently

$\beta_y = 0.01 \text{ m}$

$\beta_x = 0.08 \text{ m}$

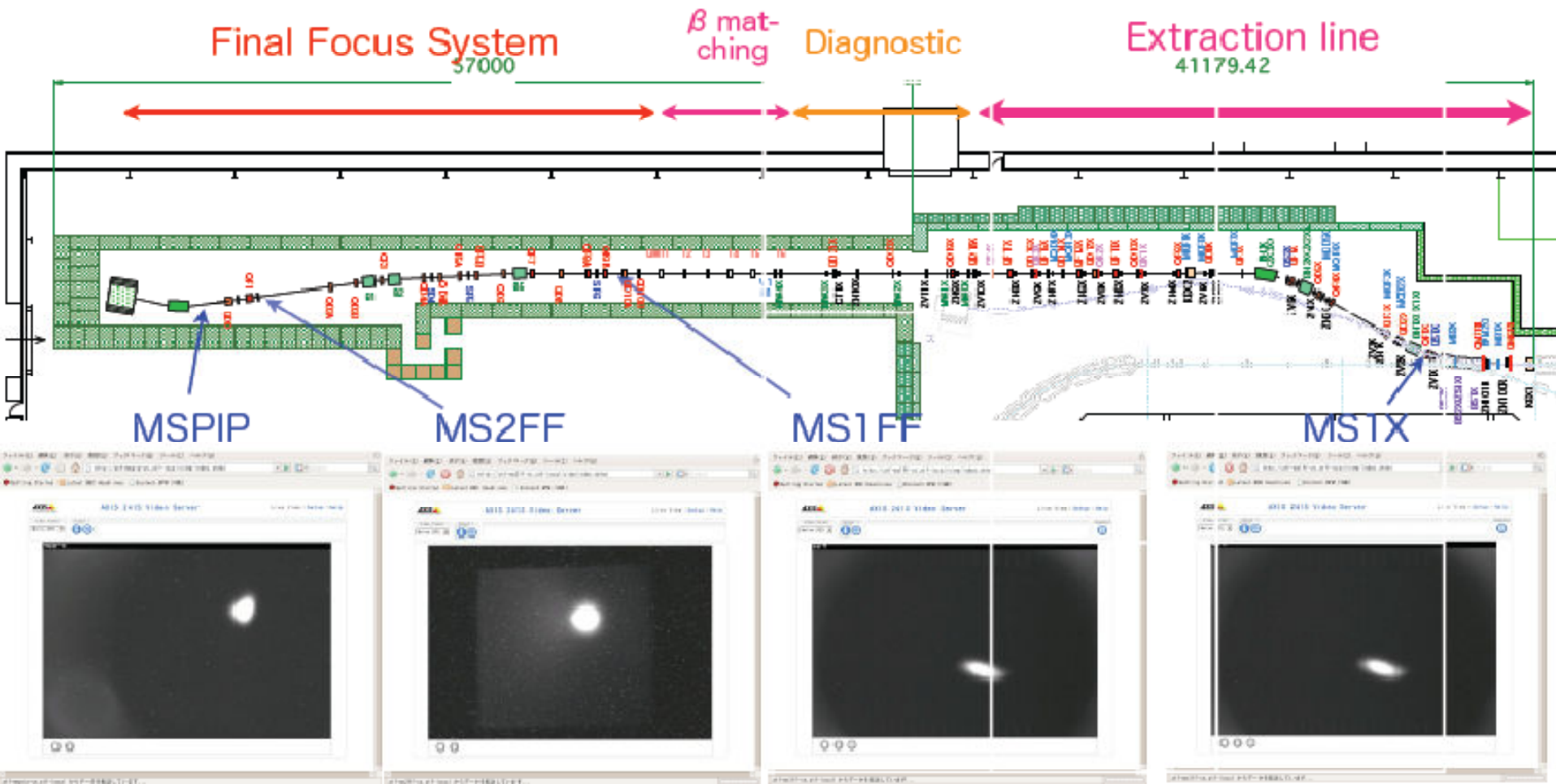
nominal value  
( $\beta_y = 0.0001 \text{ m}$ )

April - December 2009

March 2009

# ATF2 Commissioning

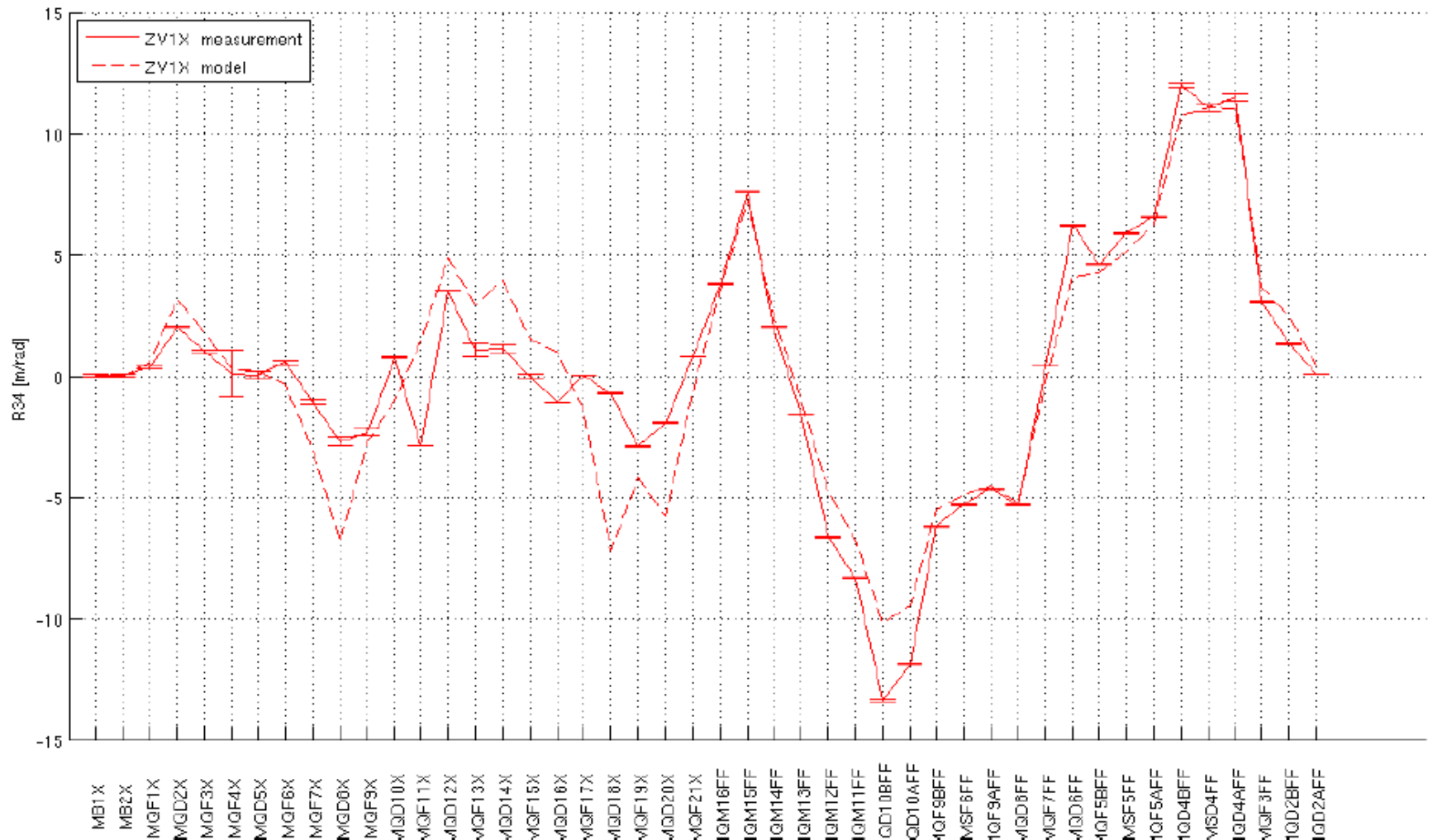
First commissioning by screen monitors and raw signals of BPMs



December 2008

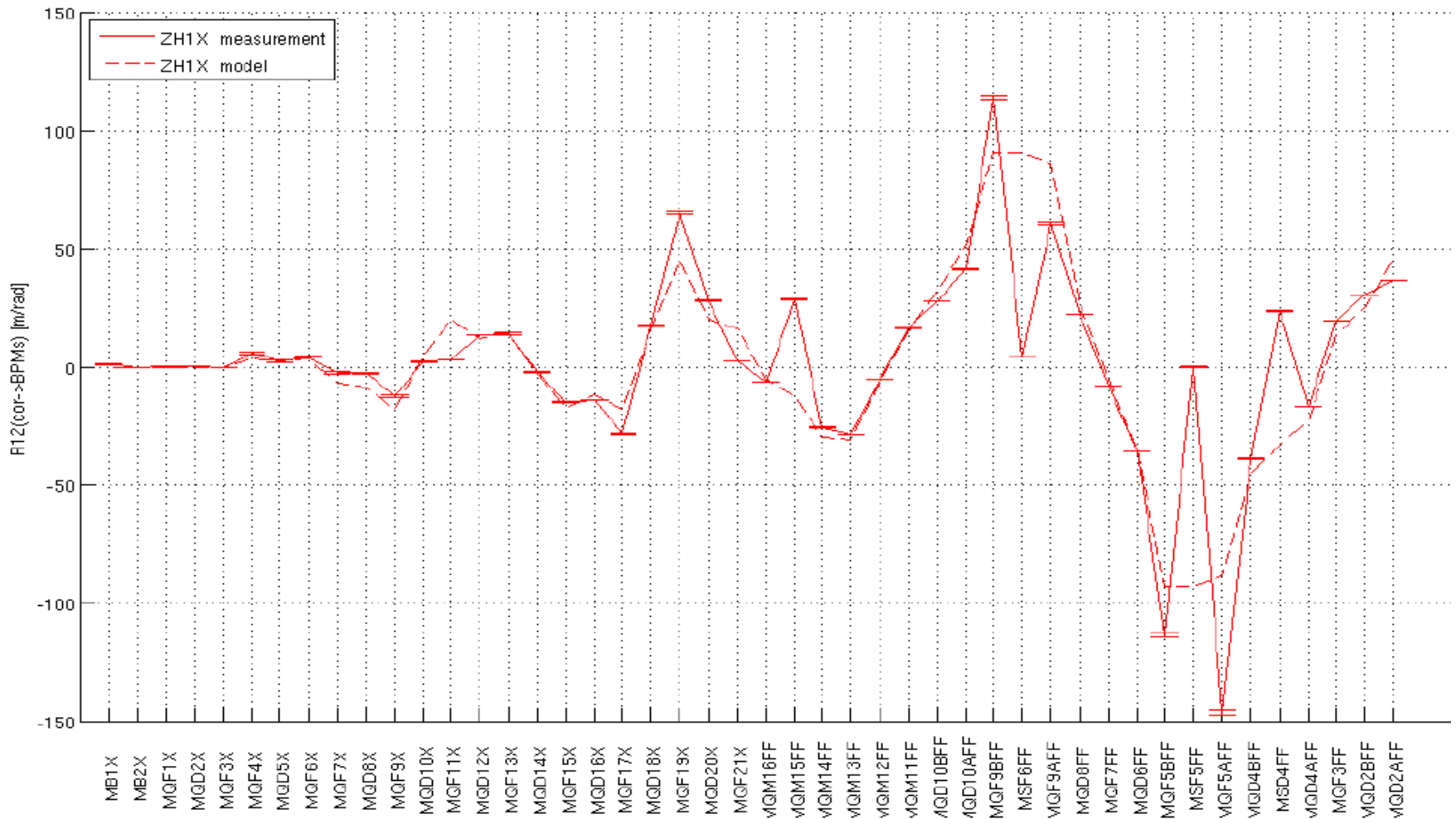


# Vertical transfer matrix (ZV1X → QD2A)



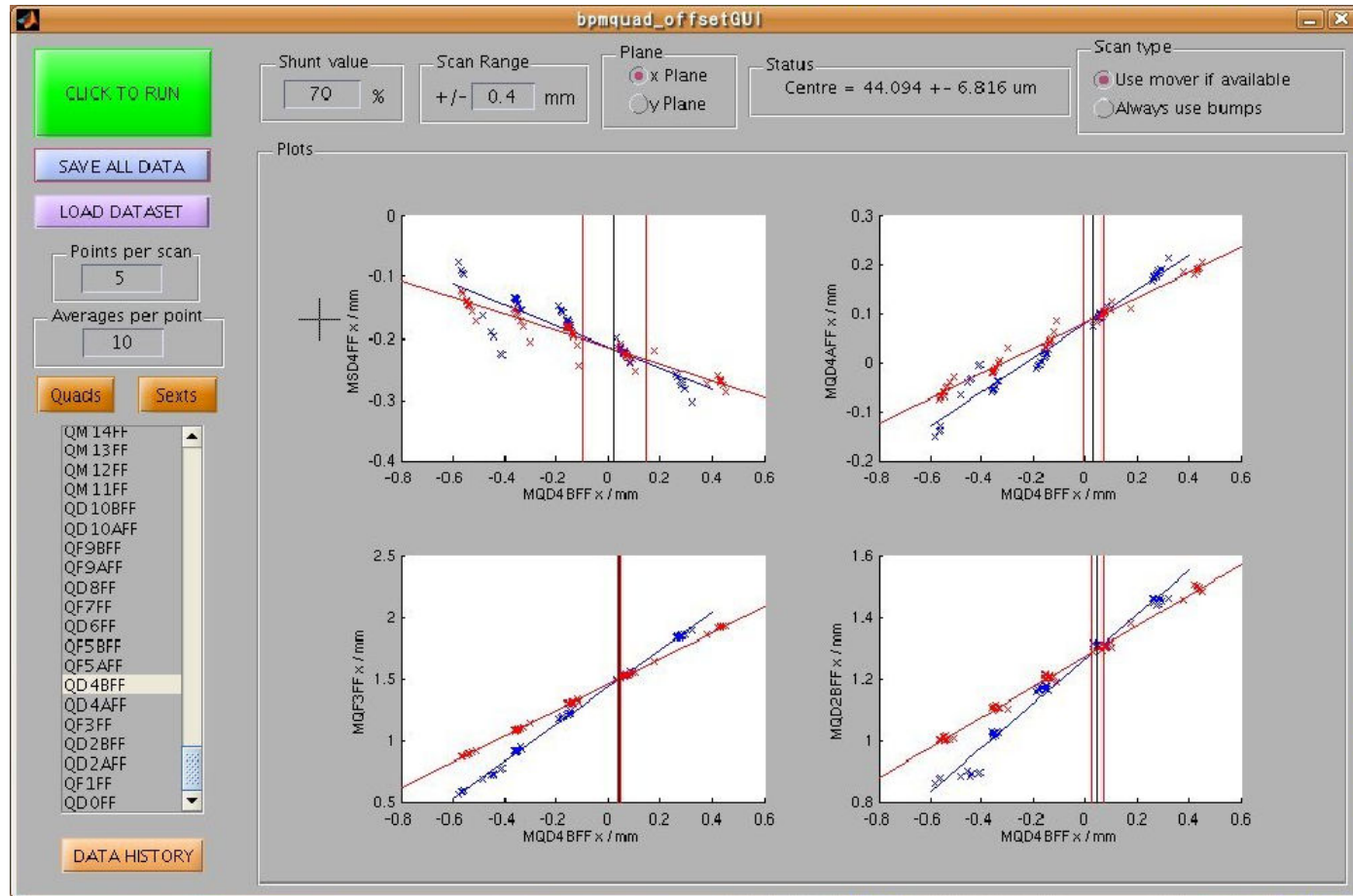
On-going : separate beam / instrumental variations & noise

# Horizontal transfer matrix (ZH1X → QD2A)



non trivial check ! Final Doublet → not yet “Flight Simulator”

# Test of beam based alignment automated software tool in “Flight Simulator”



cavity BPM fixed on F.F. quad mounted on mover

BPMs on sextupoles and quads not on movers → in progress

# Phase space in extraction line

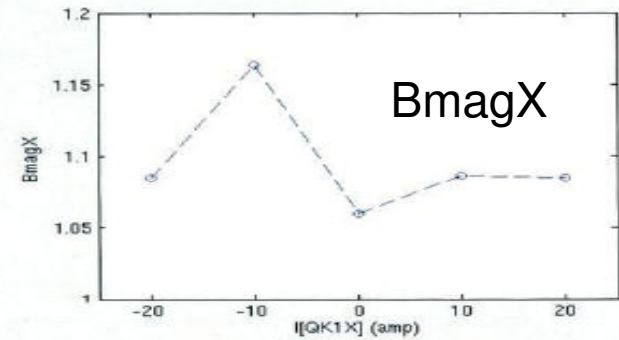
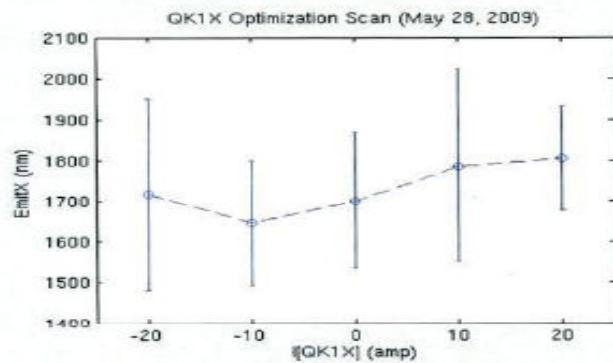
- April & May
- systematic “manual” BBA on selected quads
  - careful dispersion + coupling measurement & correction

“Flight Simulator”  
and V-system tools

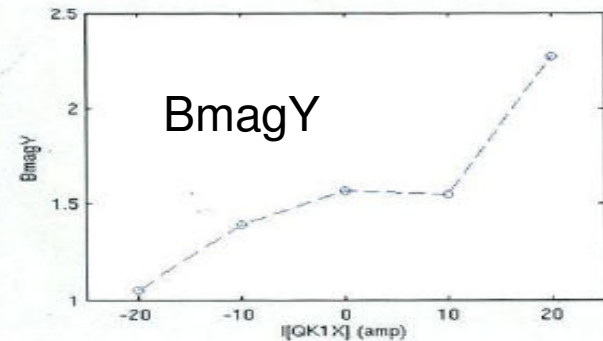
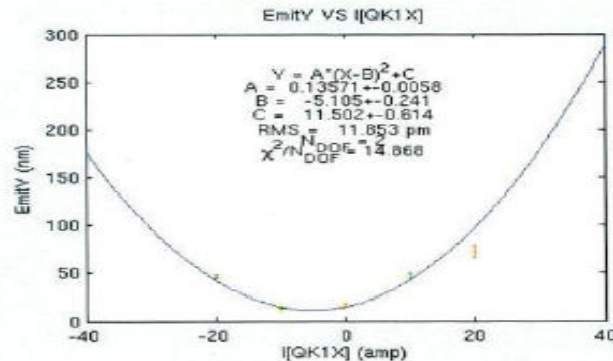
→  $\epsilon_y \sim 10\text{-}30$  pm reproducibly !

DR measures  $\sim 6$  pm  
ATF2 nominal = 12 pm

$\epsilon_x \sim 1.7$  nm



$\epsilon_y \sim 11$  pm  
(at minimum)

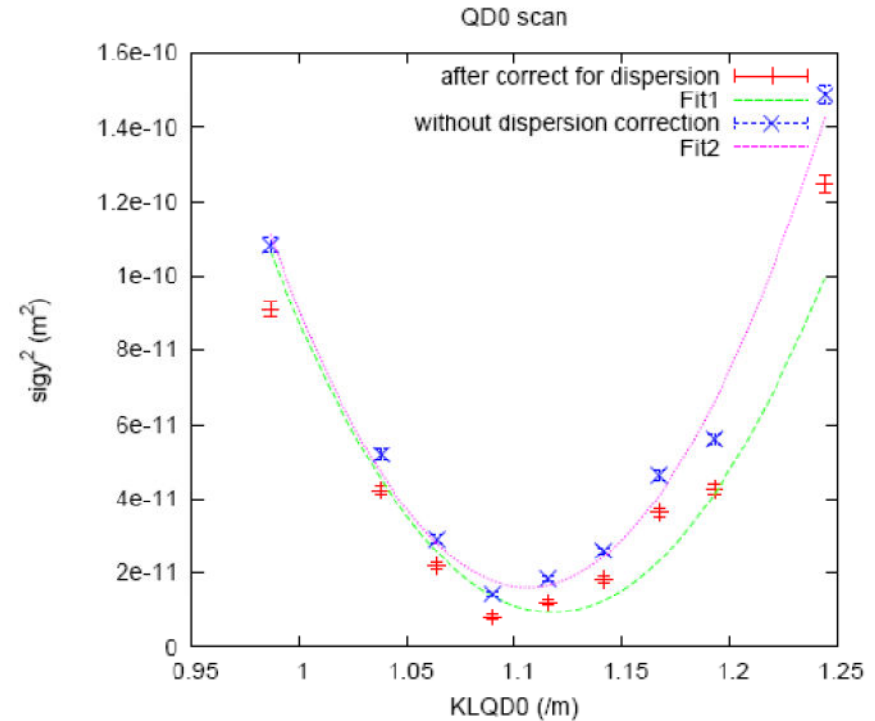
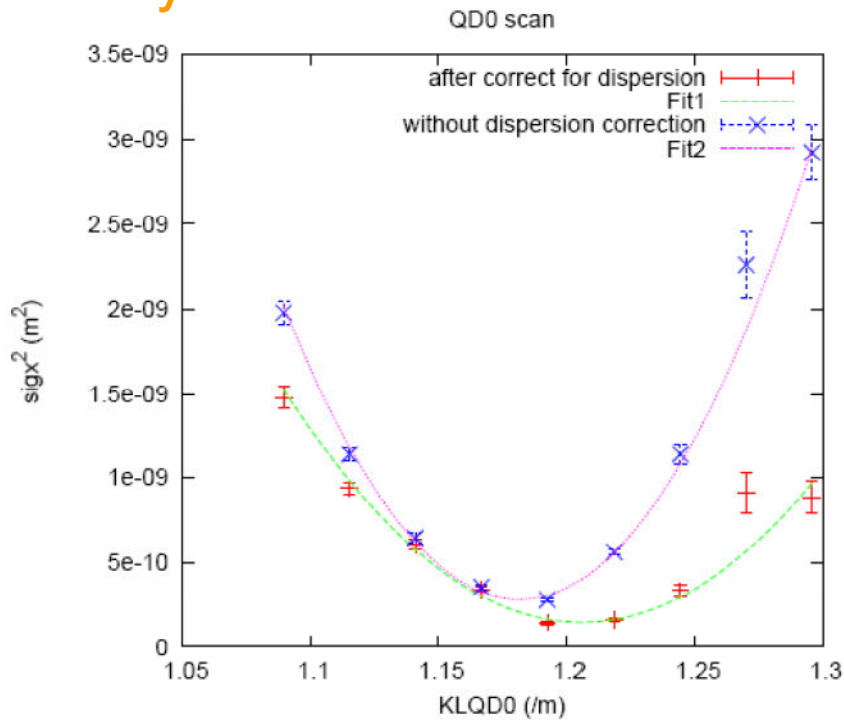


Emittance and  $\beta$  mismatch during coupling reduction

# Phase space at post-IP wire-scanner

28 May 2009

Tungsten, 10  $\mu\text{m}$  diameter, 40 cm behind IP



- Minimum beam size  $\sim 10 \mu\text{m}$  is resolved
- Must subtract measured dispersion (nominal + anomalous)

$$\begin{aligned}\varepsilon_x &= 1.13 \pm 0.06 \text{ nm} \quad (\text{design} = 1.2 \text{ nm}) \\ \beta_x &= 13 \pm 1 \text{ cm} \quad (\text{design} = 10 \text{ cm})\end{aligned}$$

- cannot resolve  $\sigma_y \sim 0.35 \mu\text{m}$
- subtract (anomalous) dispersion

$$\begin{aligned}\text{use } \varepsilon_y \text{ measured in extraction line} \\ \rightarrow \beta_y \sim 1.4 \text{ cm} \quad (\text{design} = 1.8 \text{ cm})\end{aligned}$$

**→ Basic check of optical transfer from DR → IP**

# IP $\sigma_y$ minimization at post-IP wire-scanner

( 5 /20 ) by using FF multi-knobs ( sextupole movers )

5.8 $\mu\text{m}$  ( 5.8 ,6.1 ,5.5 ) -> 4.1 $\mu\text{m}$  ( 3.9, 4.2, 4.1 )

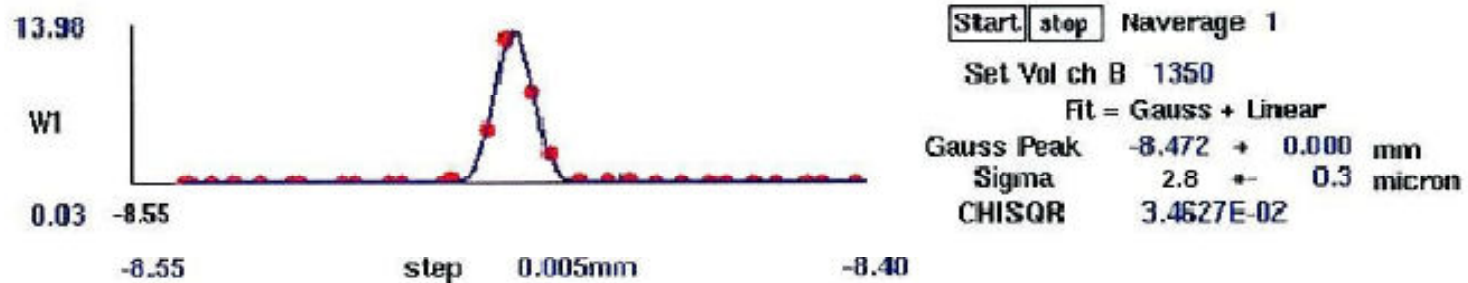
- Residual vertical dispersion was dominant for the vertical beam size
- Vertical dispersion was larger than correctable range for multi-knobs

( 5 /26 ) - All sextupoles off

- Qs scan (skew-Q for vertical dispersion correction )
- QKs scan (skew-Q for coupling correction )
- QF6X scan (normal-Q for horizontal dispersion correction )

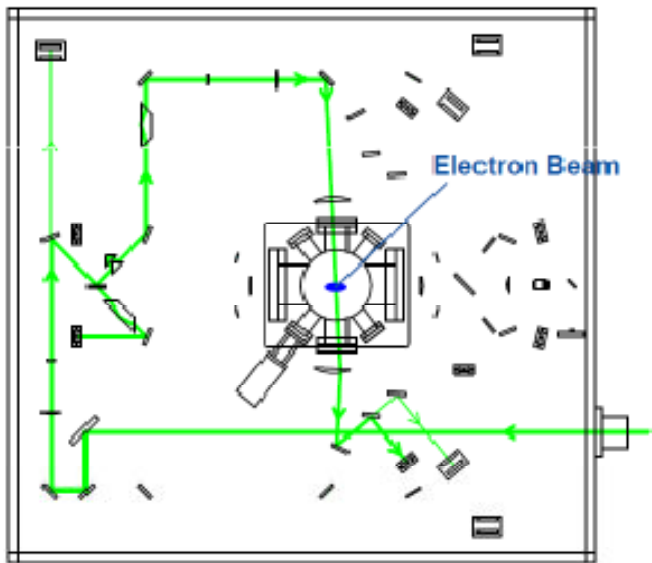
5.0 $\mu\text{m}$  ( 4,7 ,5.2, 5.2 ) -> 2.9 $\mu\text{m}$  ( 3.0, 2.8, 2.9 )

*Effect of wire size (10 $\mu\text{m}$  diameter) is dominant*

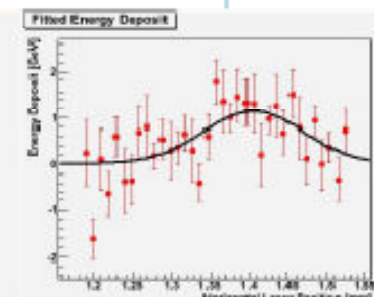
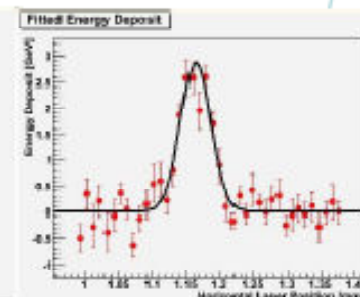
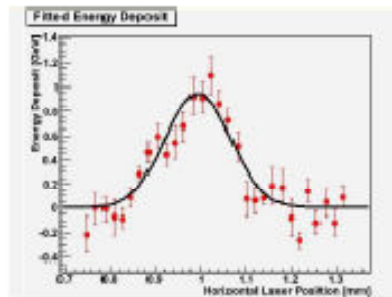
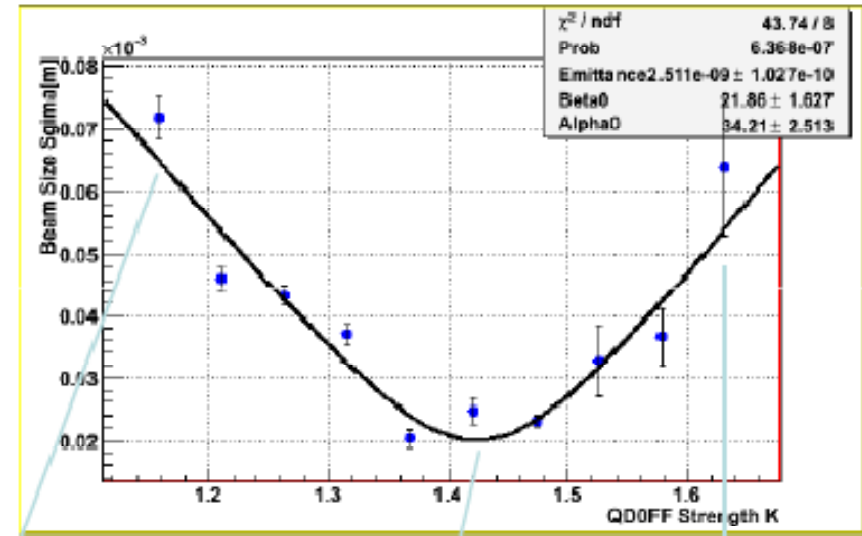


# IP $\sigma_x$ with BSM “laser wire” mode established

- First Compton signal was observed in February.
- Beam size and emittance measurement was done in May.
  - horizontal beam size at MW1IP was 20 $\mu\text{m}$ .
  - laser beam size 10 $\mu\text{m}$  assumed.
  - fitted horizontal emittance was 2.5nm.



laser wire mode optics  
(horizontal measurement)



$\sigma_y$  in interference mode  $\rightarrow$  not yet a convincing signal but good progress made

# Goals for October - December 2009

- Continue fast extraction kicker R&D in Damping Ring
- Confirm large  $\beta^*$  optics ( $\beta_{x,y}=8,1\text{cm}$ )  $\rightarrow$  towards sub- $\mu\text{m}$   $\sigma_y$
- First signal evidence in interference mode  $\rightarrow$  BSM  $\sigma_y$  measurement

## Sub-goals

- New BSM hardware
- Carbon wire scanner at IP with 5  $\mu\text{m}$  diameter
- Cavity BPM stability and reproducible calibrations
- Strip-line BPM improved calibration & reproducibility
- Efficient optical tuning strategy in extraction line  $\rightarrow$  IP spot

## Additional goals preparing for 2010-2011

- New strip-line BPM electronics
- Multi-OTR fast extraction line 4D phase space diagnostics
- Tilt monitor & IP-BPM R&D
- FONT
- Background study at and near IP as function of  $\beta^*$  and FD alignment



# Priority tasks & responsibilities for Autumn commissioning

1) Team up by interest to conduct shifts, prepare software, do simulations & data analyses 2) Open and flexible

- Cavity BPM : calibration, stability, incl. S-band Boogert, Aryshev, Lyapin, Okugi, Naito, Molloy...
- Stripline BPM : better calib., add ADCs, high pass filter Renier, Naito, Okugi,...
- BSM : new diagnostics & other hardware, LW & interference modes, beam setup Kamiya + Tokyo group + local KEK team,...
- Post IP C-wire : commissioning, IP waist & knob scans incl.  $\beta^*$  determination Bolzon, Bai, Zhou, McCormick, Kuroda, Terunuma, Tokyo group...
- Orbit reconstruction, on-line BPM & lattice diagnostics Renier, Boogert, Okamoto, White...
- Dispersion correction : EXT & IP, different knobs & methods incl. sextupoles Jones, Kubo, Kuroda, Marin-Lacoma, Okugi, White, Woodley,...
- Coupling correction : EXT & IP, different knobs & methods incl. sextupoles Bolzon, Kubo, Kuroda, Okugi, Rimbault, White, Woodley,...
- Background study : BSM + near IP, dependence with FD alignment &  $\beta^*$  Guler + Verderi, Okugi + Tokyo group,...

→ not listed here : Fast Kicker, DR, FONT, LW, new EXT-BPM electronics + multi-OTR + tilt monitor

# Collect important questions for each priority task

1) Below are only a few examples...

2) The whole group should add & improve !

TASK	QUESTIONS	STATUS
Cavity BPM	<ul style="list-style-type: none"> <li>• Can the stability of calibrations for a given BPM be monitored daily / weekly ?</li> </ul>	
Strip line BPM	<ul style="list-style-type: none"> <li>• High-pass filters and separate ADCs sufficient for calibrations → precision &lt; 5 μm ?</li> </ul>	
BSM	<ul style="list-style-type: none"> <li>• Can scanning be automated in ATF control system (V-system, Flight Simulator) ?</li> </ul>	
C wire & β match	<ul style="list-style-type: none"> <li>• What is expected signal strength from C wire and visibility in BSM reference layer ?</li> <li>• Would automatic waist scans incorporating dispersion measurement be feasible ?</li> <li>• How Twiss par. measured at IP compare with propagated ones from EXT meas. ?</li> </ul>	
Traj.rec.&latt. diag.	<ul style="list-style-type: none"> <li>• Stability of BPM scale coefficients ?</li> <li>• Precision of strip line and cavity BPMs ?</li> <li>• Magnitude of reconstructed injected beam fluctuations ?</li> </ul>	
Dispersion	<ul style="list-style-type: none"> <li>• Can IP <math>D_y</math> be corrected to &lt; 1 mm with EXT line “sum-knob” in <math>\beta_y = 1</math> cm optics ?</li> <li>• Can vertical bumps help to fully correct <math>D_y</math> (i.e. both phases) in EXT ?</li> </ul>	
Coupling	<ul style="list-style-type: none"> <li>• How can we automate EXT coupling corrector + wire scanning ?</li> <li>• Matching of FF horizontal dispersion for sextupole mover knobs to be orthogonal ?</li> </ul>	
Background	<ul style="list-style-type: none"> <li>• Max. flux of bremsstrahlung gammas in BSM detector for Compton signal detection ?</li> <li>• Flux prediction from FD region GEANT4 simulation for given input halo distribution ?</li> </ul>	

→ not listed here : Fast Kicker, DR, FONT, LW, new EXT-BPM electronics + multi-OTR + tilt monitor

# Propose successive realistic goals for each task

1) Start with end goals for 2009... are listed ones OK ? 2) Each group asked to formulate appropriate sequence

TASK	October	November	December	End 2009
Cavity BPM				<ul style="list-style-type: none"> <li>• Calibration stability on day &amp; week timescales</li> <li>• S-band BPM</li> <li>• Non-mover calibrations</li> </ul>
Strip line BPM				<ul style="list-style-type: none"> <li>• Offset stability &amp; acceptable intensity dependence</li> </ul>
BSM				<ul style="list-style-type: none"> <li>• Signal evidence in 4.5 degree mode with <math>\sim 1 \mu\text{m}</math> vertical spot</li> </ul>
C wire & $\beta$ match				<ul style="list-style-type: none"> <li>• Reach <math>\sim 1 \mu\text{m}</math> C wire resolution limit</li> <li>• Waist + disp. autoscan</li> </ul>
Traj.rec.&latt. diag.				<ul style="list-style-type: none"> <li>• Sub-<math>\mu\text{m}</math> resolution in cavity BPMs</li> <li>• Running traj.rec.&amp;latt.diag. spy program</li> </ul>
Dispersion				<ul style="list-style-type: none"> <li>• <math>D_y &lt; 1 \text{ mm}</math> @ <math>\beta_y</math> waist</li> <li>• Consistency of IP and EXT propagated results</li> </ul>
Coupling				<ul style="list-style-type: none"> <li>• <math>\epsilon_y^{\text{IP}} / \epsilon_y^{\text{EXTLINE}} &lt; 3</math></li> </ul>
Background				<ul style="list-style-type: none"> <li>• First indication of "background-aperture" in Final Doublet region</li> </ul>

→ not listed here : Fast Kicker, DR, FONT, LW, new EXT-BPM electronics + multi-OTR + tilt monitor

# External presence at KEK for ATF2 during Fall 2009

known as of 1 October 2009

	Oct 12	Oct 19	Oct 26	Nov 2	Nov 9	Nov 16	Nov 23	Nov 30	Dec 7	Dec 14
White		X	X	31/10				X	X	X
Woodley			X	X	X	X		X	X	X
Zhou					X	X				
McCormick				4/11	X	X				
Nelson				X	X	X				
Angal-Kalinin										X
Jones					X	X				
Renier	X	X	X	X	X	X	X	X	X	X
Rimbault										
Jeremie									X	X
Bolzon			X	X	X	X	X	X	X	X
Verderi				4/11	X	X				X
Guler				4/11	X	X			X	X
Bai		X	X	X	X	X	X	X	X	X
Marin-Lacoma						19/11	X	X	X	X
Okamoto	X	X	X	X	X	X	X	X	X	X
Faus-Golfe						X				X
Alabau (J)	X		X	X	X	X				X
FONI-team										
LW & cav-BPM										

+ permanently @ KEK : Aryshev, Bambade, Kubo, Kuroda, Naito, Okugi, Oroku, Tauchi, Terunuma, Yamanaka,...

# Tentative overall beam time scheduling during Fall 2009



topics / weeks	Oct 12	Oct 19	Oct 26	Nov 2	Nov 9	Nov 16	Nov 23	Nov 30	Dec 7	Dec 14
Start-up & injection tuning										
DR low emittance tuning										
Other non-ATF2 activities										
Fast kicker										
Cavity BPM calibration stabil. Study										
S-band cavity BPMs → establish										
Strip-line BPM calibration & tests										
Test new strip-line BPM readout										
Multi-OTR preparation										
Establish post-IP C wire										
Test of new tilt cavity monitor										
BBA → EXT & FFS										
Lattice diag. + rec. / cor. Trajectory										
Dispersion FXT										
Coupling CXT										
Emittance & Iwiss EXI										
IP waist scan + measure $\beta^*$										
IP spot min. with optics knobs										
BSM beam & setup preparation										
BSM laser wire > interference										
Background study BSM / near IP										
Laser Wire										
FONT										
Total number of shift to schedule	(8)	12	12		13	13		13	13	9

confirmation of participant availability @ KEK    feedback / suggestions on tasks & goals

# Concluding remarks → discussion

- The progress made may be slow but is solid and can be built upon:
  - very successful installation, and performing hardware
  - BSM LW mode established and has carefully evaluated and implemented many improvements for this run
  - other instrumentation is working though needs improving
  - check of large  $\beta$  optics basic soundness
  - first optics correction experience
  - invaluable experience for small international team learning to work together
- Clear & agreed end-of-2009 goals + group mostly same from start
- But many different ATF2 and ATF activities: richness, though a focus and scheduling of main tasks is important given commissioning interdependencies
- A few software improvements in V-system & Flight Simulator are critical to automate and speed up tuning tasks
- Weekly Friday scheduling can consider overall scheduling, goals, progress made
- Mechanism needed to prepare, discuss + communicate weekly task schedules
- Such task schedules are in the hands of each group, but should ideally be presented & reviewed each at Friday meeting, and at least posted on the ATF web at the beginning of each week (through a button directly on the main schedule)