Status of ATF2

Toshiyuki OKUGI, KEK
10/ 15/ 2009
CLIC09 workshop, CERN

ATF2 Operation Status

2009 February – March

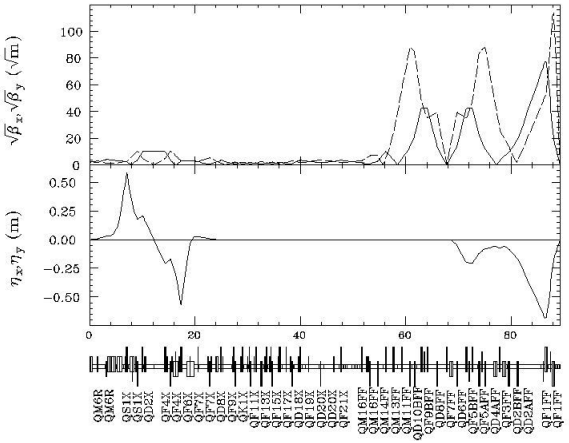
- *Operation of ATF2 beam line was started.*
- *IP-BSM was commissioned for the horizontal laser wire mode.*
- *Since IP-BSM group required the horizontal beam size of 10-20 μm, beam optics was the high beta optics (βx=0.08m, βy=0.04m).*
- *Beam size tuning was concentrate only for the horizontal direction.*
- *Most of the beam time was spent to hardware and software commissioning.*

2009 April – May

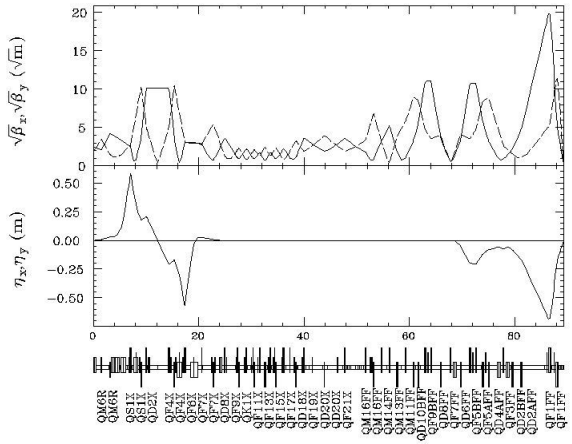
- *IP-BSM was commissioned for the vertical interference mode as well as the horizontal laser wire mode*
- *Since IP-BSM group also required the vertical beam size of 1 μm, beam optics was changed to new high beta optics (βx=0.08m, βy=0.01m).*
- *Both horizontal and vertical beam size tunings were applied.*

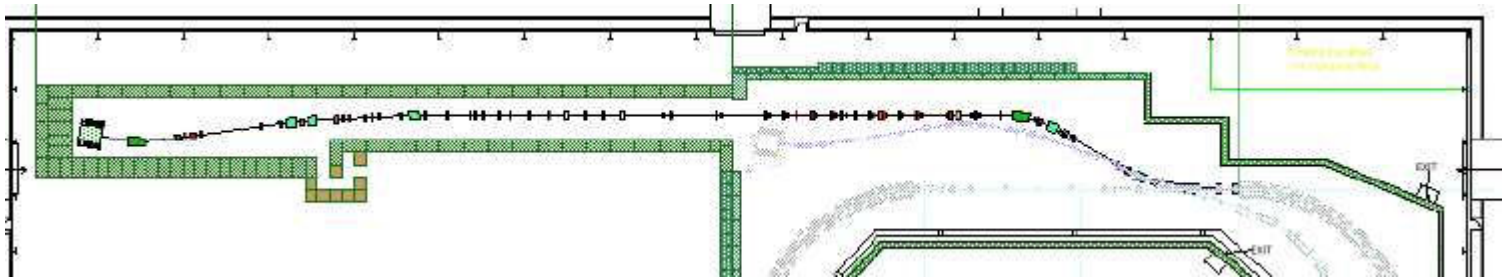
High Beta Optics of ATF2 Beamline

Normal Optics



High Beta Optics





Parameters	Normal Optics	High Beta
Energy	1.3GeV	
$\gamma\varepsilon_x$ / $\gamma\varepsilon_y$	5e-6m / 3e-8m	
ε_x / ε_y	1.97nm / 11.8pm	
β_x^* / β_y^*	4.0mm / 0.1mm	8.0cm / 1.0cm
σ_x^* / σ_y^*	2.8μm / 35nm	12.6μm / 0.34μm

Beam Tuning Sequence

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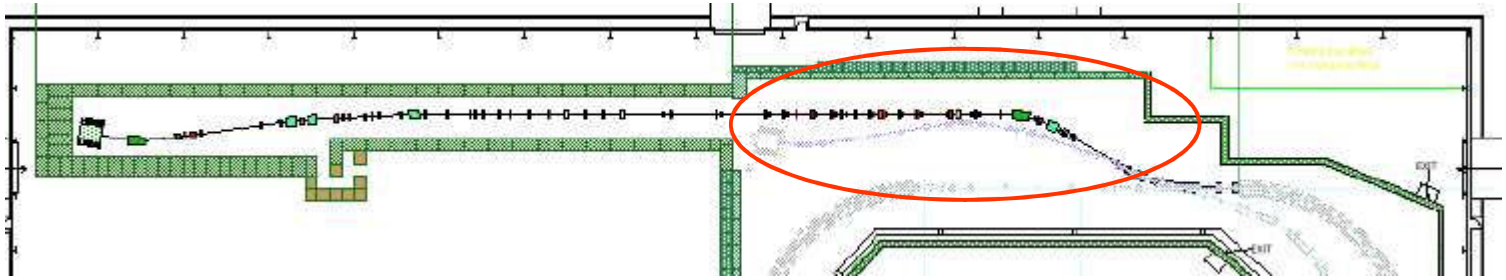
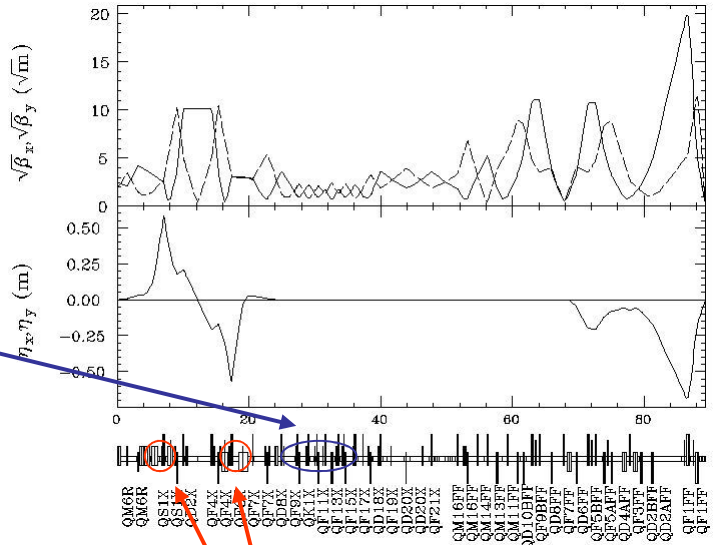


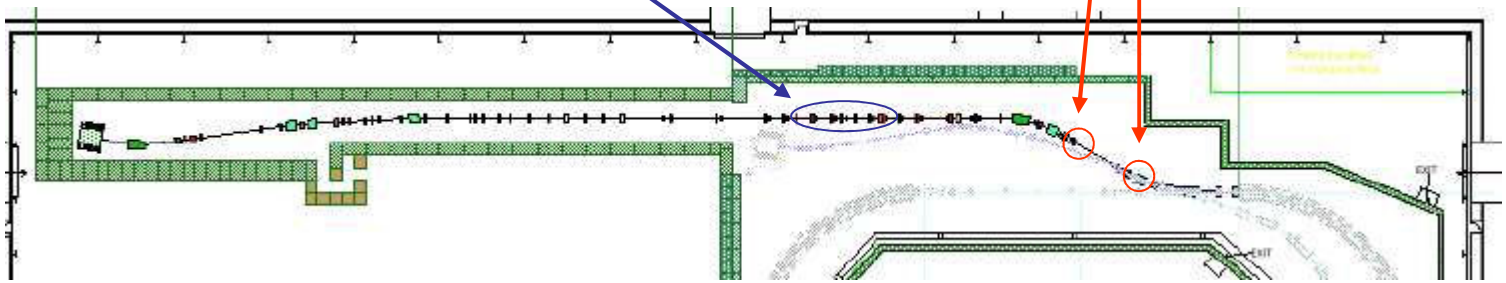
Skew quadrupoles for Correction

We have 6 skew quadrupoles in ATF2 beamline.



4 skew correctors for coupling correction at dispersion free region

2 skew quads for vertical dispersion correction (QS1X, QS2X) at high horizontal dispersion region



Vertical Dispersion Correction (Design)

3rd ATF2 project meeting (2007) M.Woodley

When we apply the sum-dispersion correction knob, only small betatron coupling is generated by the vertical dispersion correction with skews.

$$R = \begin{bmatrix} R_{11} & R_{12} & R_{13} & R_{14} \\ R_{21} & R_{22} & R_{23} & R_{24} \\ R_{31} & R_{32} & R_{33} & R_{34} \\ R_{41} & R_{42} & R_{43} & R_{44} \end{bmatrix} \equiv \begin{bmatrix} \mathrm{A} & \mathrm{B} \\ \mathrm{C} & \mathrm{D} \end{bmatrix}$$

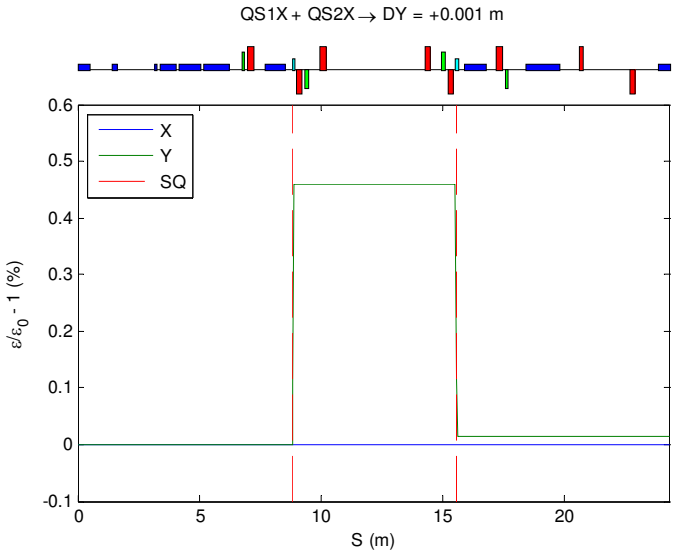
$$\mathrm{Q}_{x,y} \equiv \frac{1}{\sqrt{\beta_{x,y}}} \begin{bmatrix} \beta_{x,y} & 0 \\ -\alpha_{x,y} & 1 \end{bmatrix}$$

$$\mathrm{P} \equiv \mathrm{Q}_x^{-1} \mathrm{A}^{-1} \mathrm{B} \mathrm{Q}_y$$

$$\lambda = \mathrm{tr}\left(\mathrm{P}\mathrm{P}^{\mathrm{T}}\right)$$

$$\varepsilon_x^2 = |\mathrm{A}|^2 \varepsilon_{x0}^2 + |\mathrm{C}|^2 \varepsilon_{y0}^2 + |\mathrm{A}|^2 \varepsilon_{x0}\varepsilon_{y0}\lambda$$

$$\varepsilon_y^2 = |\mathrm{C}|^2 \varepsilon_{x0}^2 + |\mathrm{A}|^2 \varepsilon_{y0}^2 + |\mathrm{A}|^2 \varepsilon_{x0}\varepsilon_{y0}\lambda$$



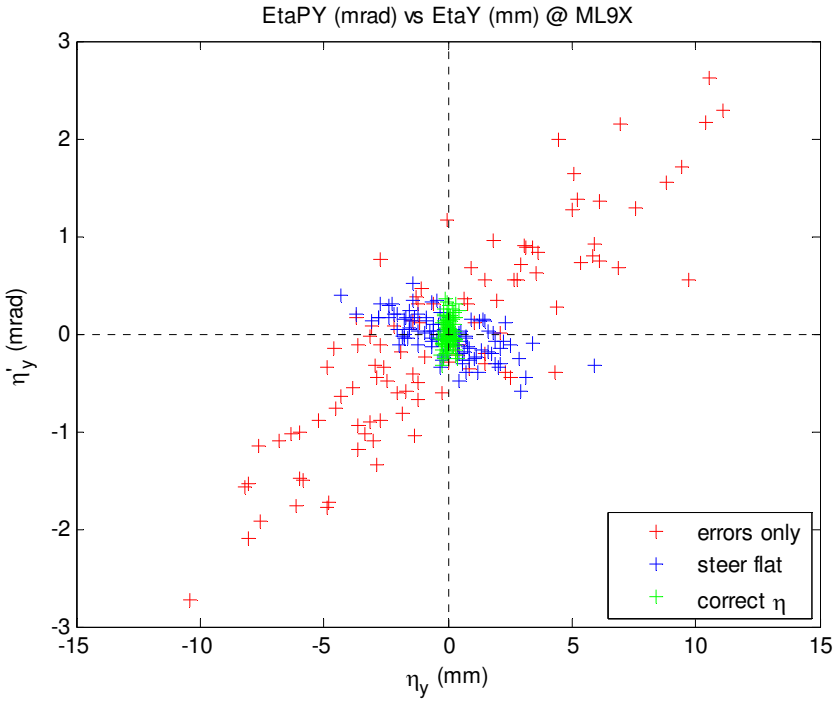
		QS1X	QS2X
βx	=	9.005	9.005
αx	=	-9.192	9.192
ηx	=	0.203	-0.203
βy	=	102.805	102.805
αy	=	-41.677	41.677
Δμx	=	-	7.710
Δμy	=	-	173.207
kl/klmax	=	0.121	0.121
residual	=	0.0001	

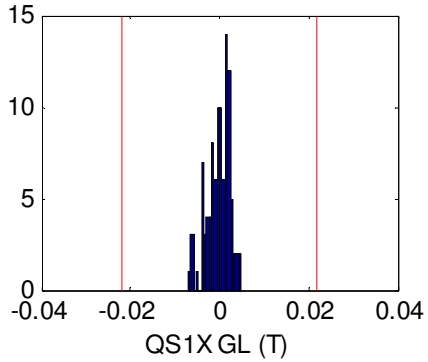
Vertical Dispersion Correction with sum-knob (Design)

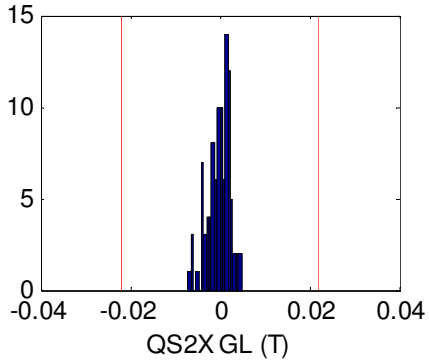
3rd ATF2 project meeting (2007) M.Woodley

Errors;

vertical dipole misalignments: 0.10mm (rms)
horizontal quadrupole misalignments: 0.05mm (rms)
vertical quadrupole misalignments: 0.03mm (rms)
quadrupole rolls: 0.30mrad (rms)







QS1X, QS2X
GLmax = 0.022 T
(20% IDX @ 5amp)

When the dispersion sources are only in the extraction line, we can correct the vertical dispersion with single sum-knob.

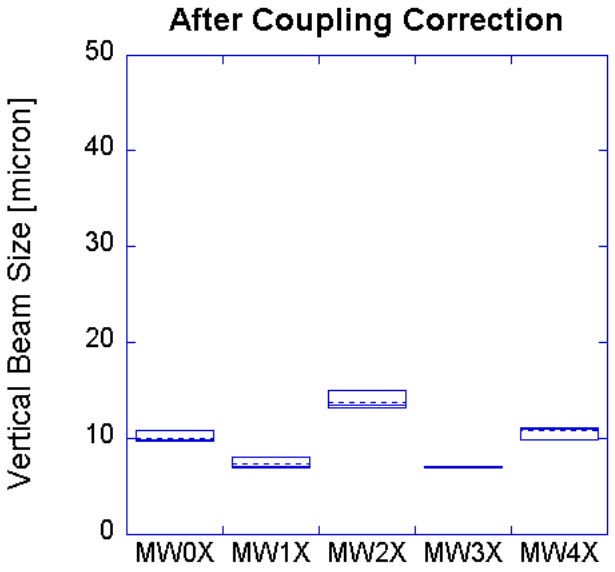
Coupling Correction (Design)

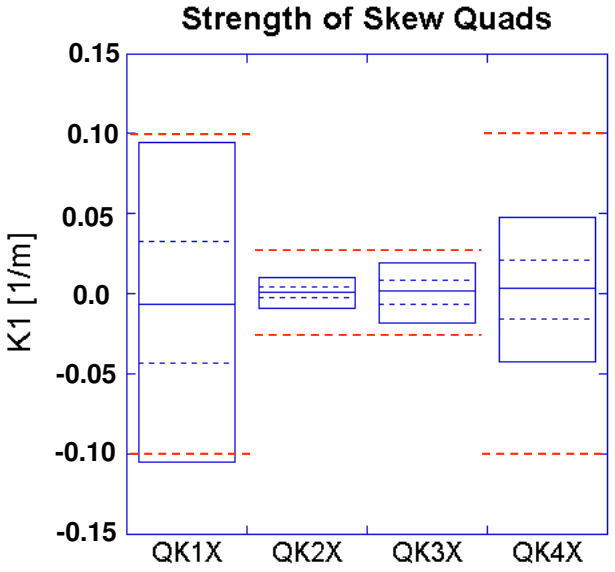
3rd ATF2 project meeting (2007) T.Okugi

Coupling can be corrected with 1-by-1 correction

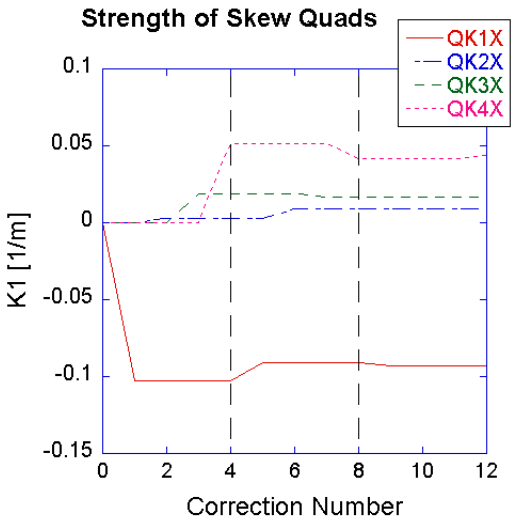
Errors;

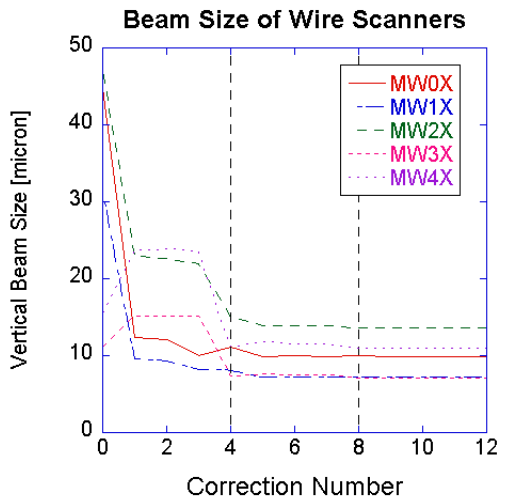
vertical dipole misalignments:	0.10mm (rms)
horizontal quadrupole misalignments:	0.05mm (rms)
vertical quadrupole misalignments:	0.03mm (rms)
quadrupole rolls:	0.30mrad (rms)





Example of the 1-by-1 correction

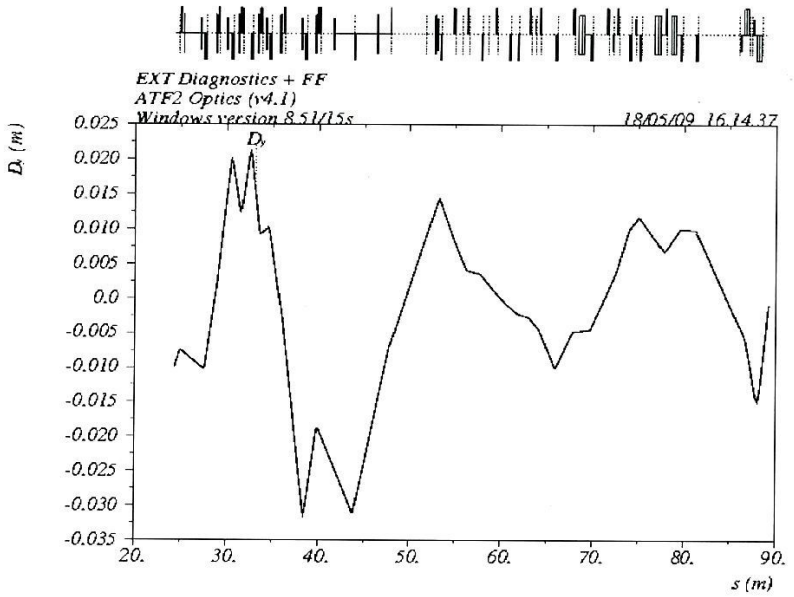




When the coupling sources are only in the extraction line, we can correct the coupling with the present QKs.

Vertical Dispersion Measurement (05/14)

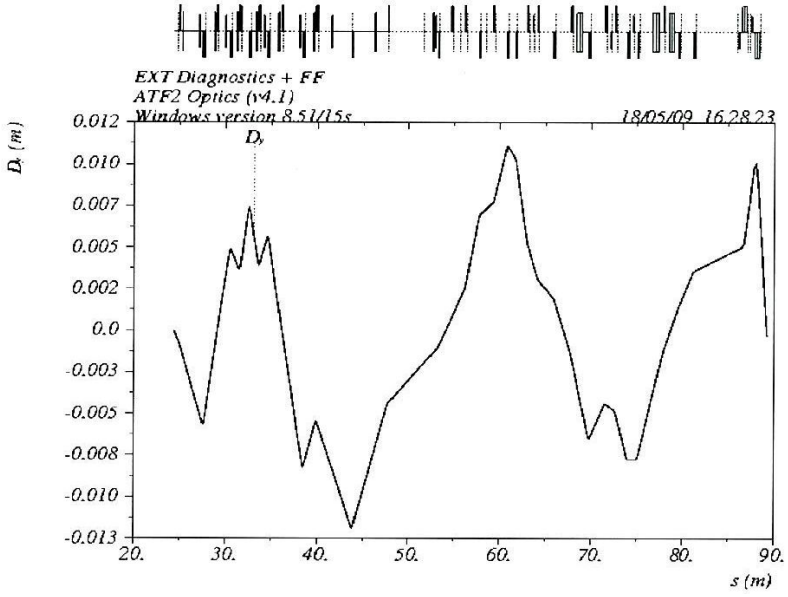
Before Dispersion Correction



Dispersion Correction with sum-knob

QS1X = +0.455A

QS2X = +0.455 A

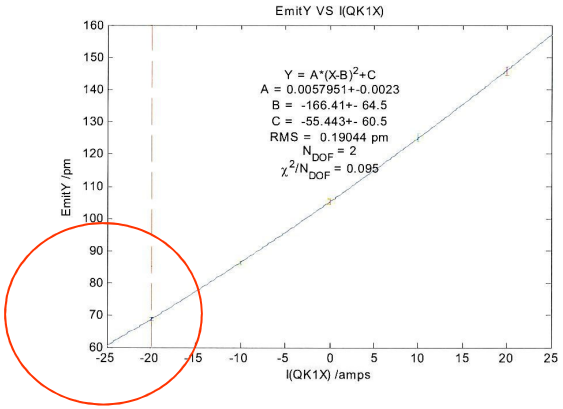


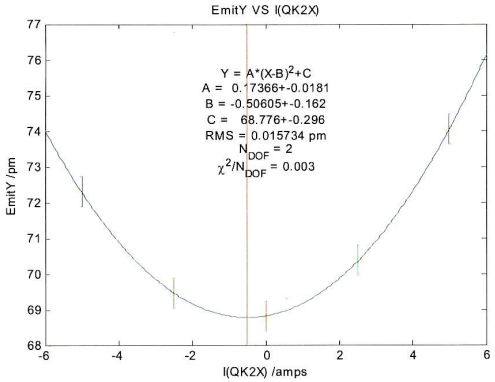
The measured dispersion cannot be corrected with only sum-knobs, it means the incoming vertical dispersion is large and the phase of incoming dispersion is not on phase to sum-knob.

Simulation for the coupling correction with independent QSs

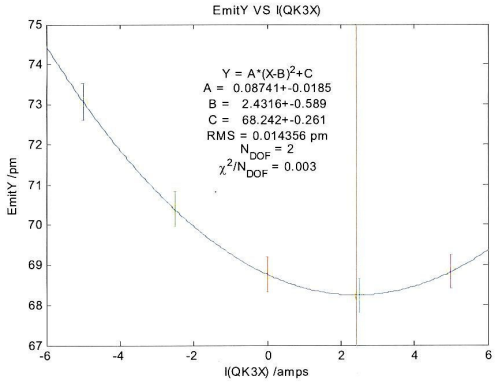
Calculated by M.Woodley

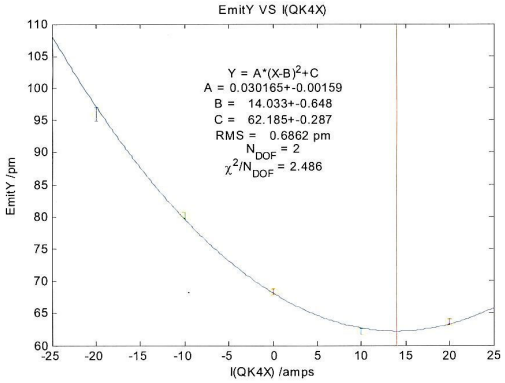
In order to correct the dispersion with QSs, we must apply large opposite fields to QSs, and it make large betatron coupling.





QS1X = - 6.295 A
QS2X = +6.359 A





In order to correct the coupling, generated by the QSs with QKs, the maximum field of QK1X was too weak

Beam Tuning Sequence

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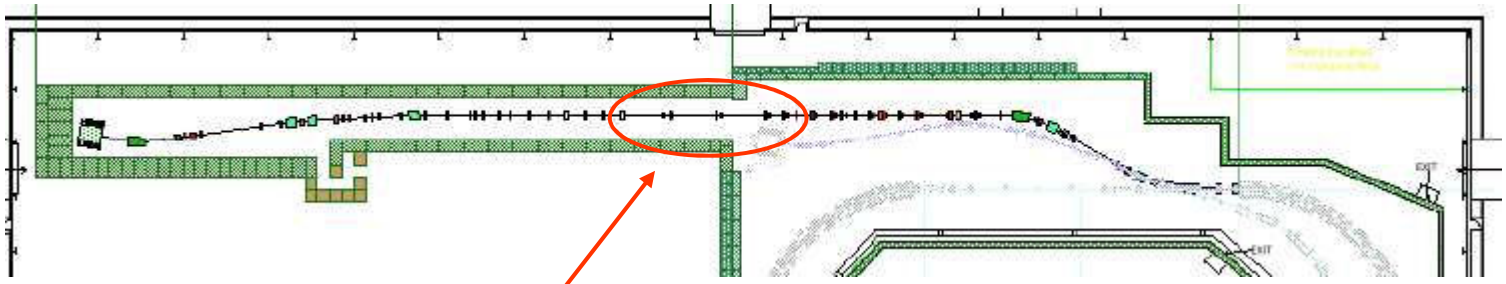
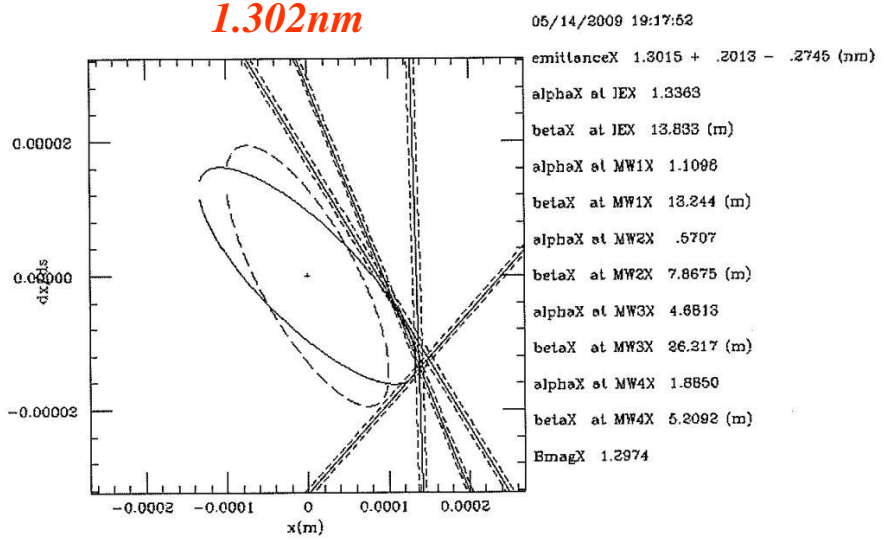


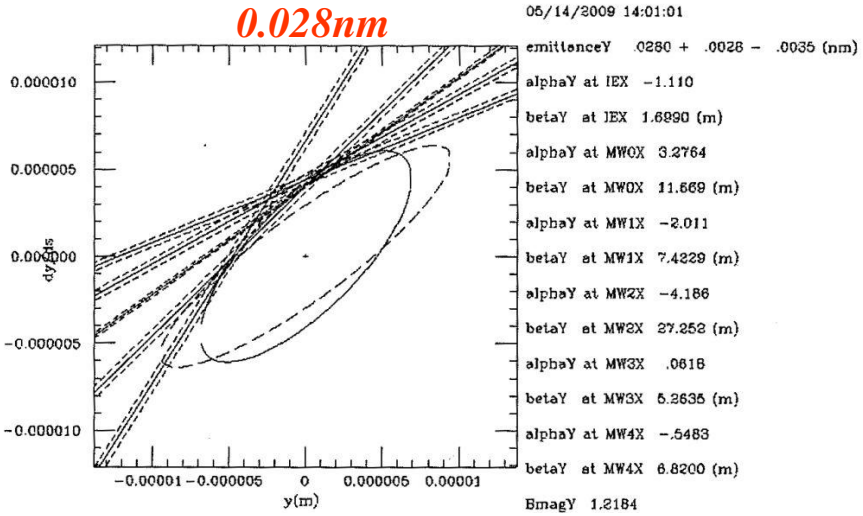
We have 5 wire scanners in matching section.

Emittance Measurement in Extraction Line (05/14)

Horizontal Emittance
1.302nm



Vertical Emittance
0.028nm



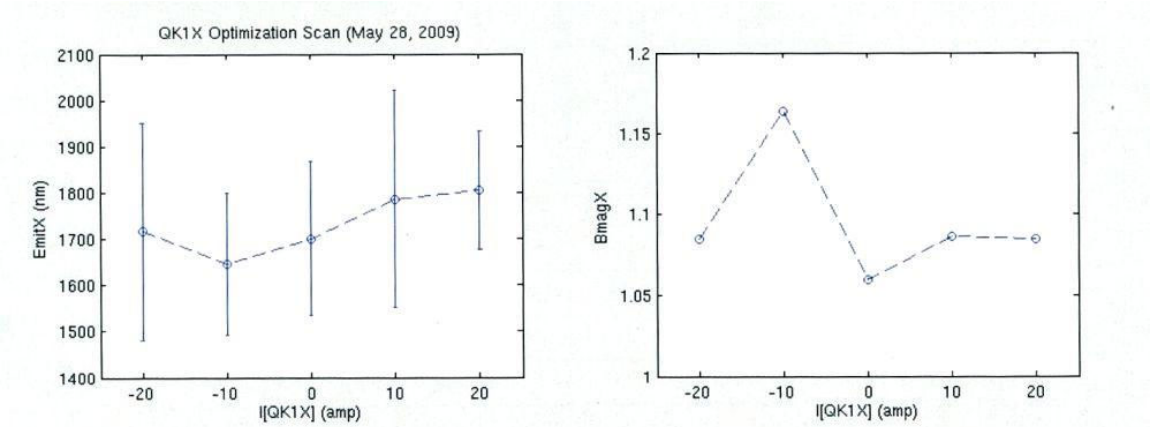
Opposite Current

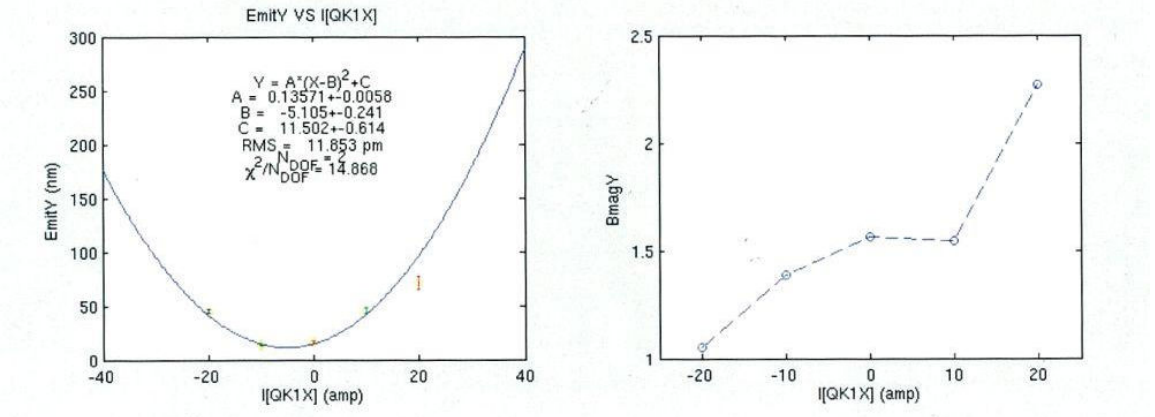
QS1X	**+ 4.38A**
QS2X	**- 4.38A**
QK1X	**- 19.50A**
QK2X	**+ 2.75A**
QK3X	**+ 1.21A**
QK4X	**+ 0.31A**

Limited by Hardware

Emittance Measurement in Extraction Line (05/28)

Horizontal Emittance
1.7nm





Vertical Emittance
0.011nm

Sum knobs

QS1X	**-**	**0.42A**
QS2X	**-**	**0.42A**
QK1X	**-**	**5.11A**
QK2X		**0.00A**
QK3X		**0.00A**
QK4X		**0.00A**

We could reduce the dispersion at WSs,
but still remain the dispersion to downstream.

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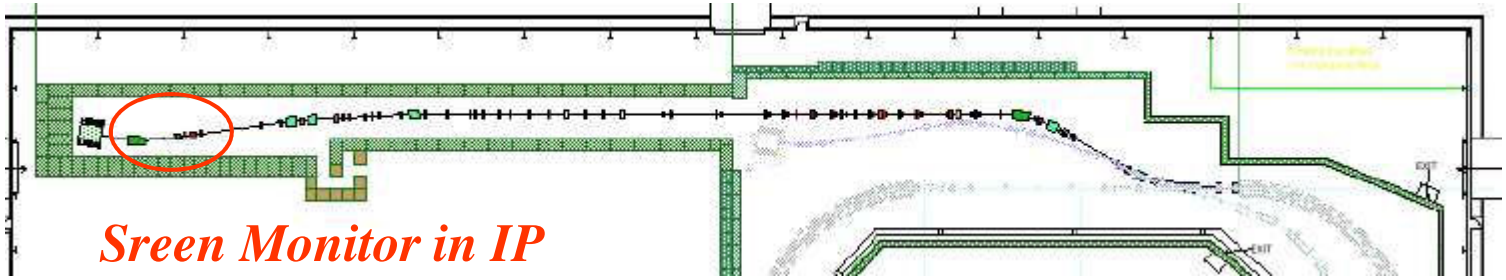


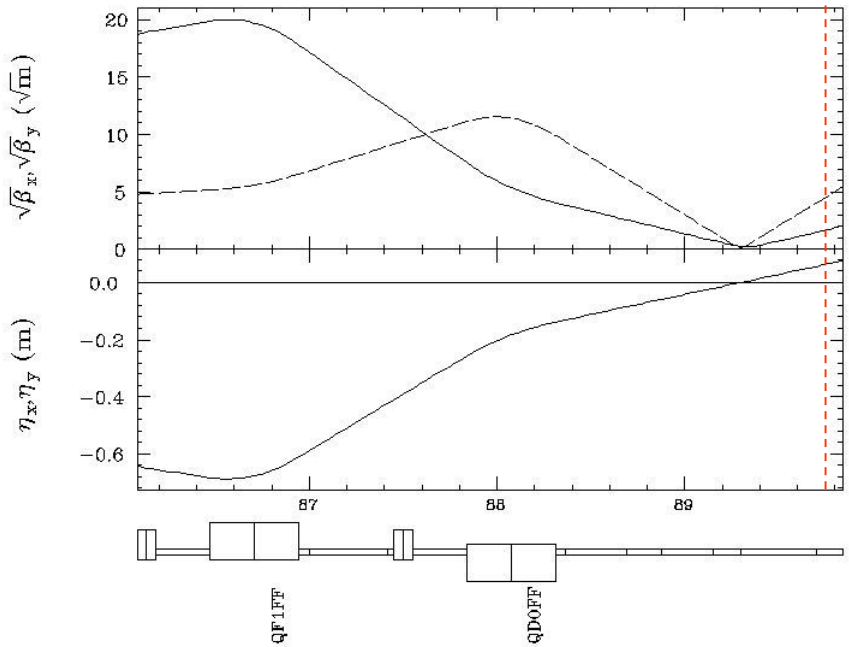
Wire Scanner is located to 40cm downstream of IP (MWPIP)

Beam Size Measurement at post-IP wire scanner (05/15)

beam waist at IP

QF1FF = 70.84A

QD0FF = 130.33A



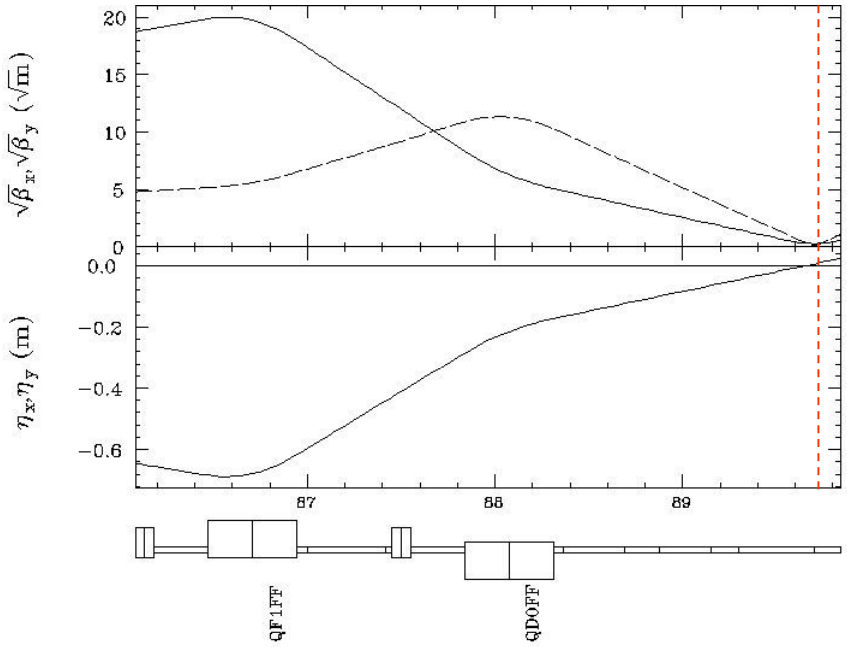
σ_x = 74.3μm -> σ_x^* = 7.0μm

σ_y = 20.4μm -> σ_y^* = 0.5μm

beam waist at MW1IP

QF1FF = 66.87A

QD0FF = 105.24A



σ_x^* = 11.4μm

σ_y^* = 4.1μm

(If α_x=0, α_y=0 at IP, ε_x=1.3nm, ε_y=28pm)

Design Beam Size at IP

σ_x^* = 10.1μm

σ_y^* = 0.53μm

Horizontal beam size was consistent with the design.

Vertical Beam Size Tuning at MW1IP

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

5.8μm (5.8 ,6.1 ,5.5) -> 4.1μm (3.9, 4.2, 4.1)

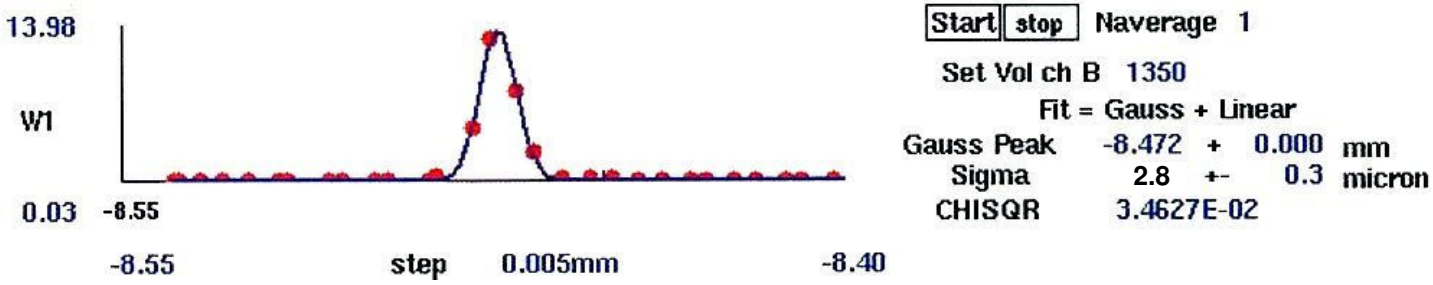
-Residual vertical dispersion was dominant for the vertical beam size

- Vertical dispersion was larger than correctable range for multi-knobs

(5 /26) - All sextupoles off
- QSs scan (vertical dispersion correction)
- QKs scan (coupling correction)
- QF6X scan (horizontal dispersion correction)

5.0μm (4,7 ,5.2, 5.2) -> 2.9μm (3.0, 2.8, 2.9)

Almost limit of the beam size measurenet with 10mm diameter wire



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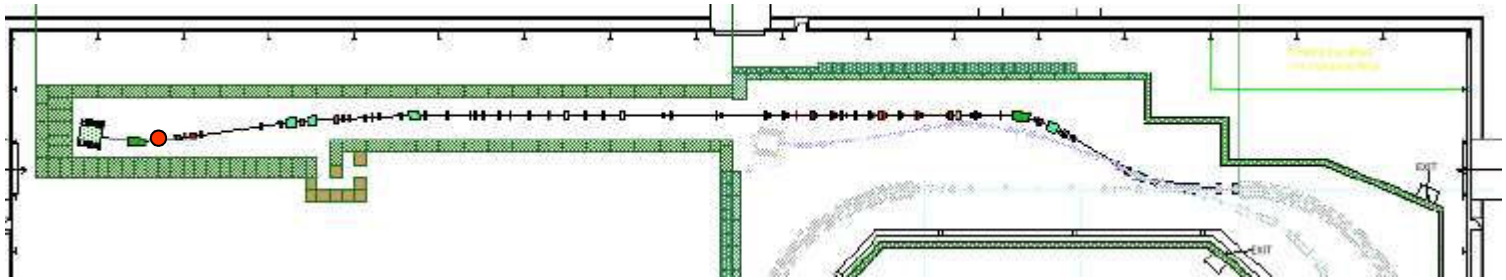
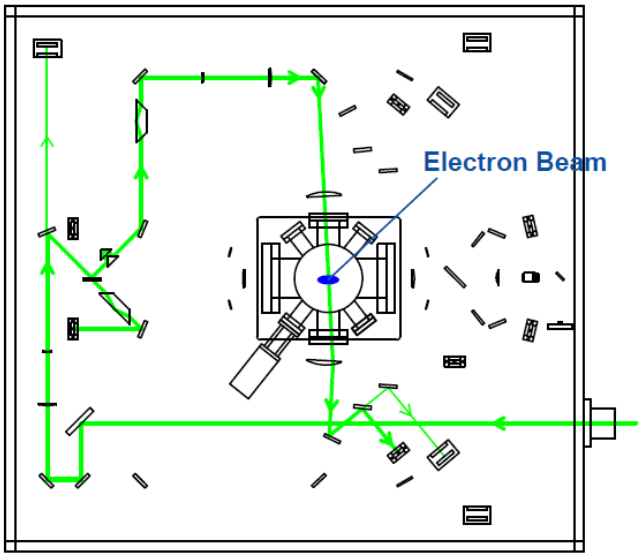


Horizontal Measurement (Laser Wire Mode)

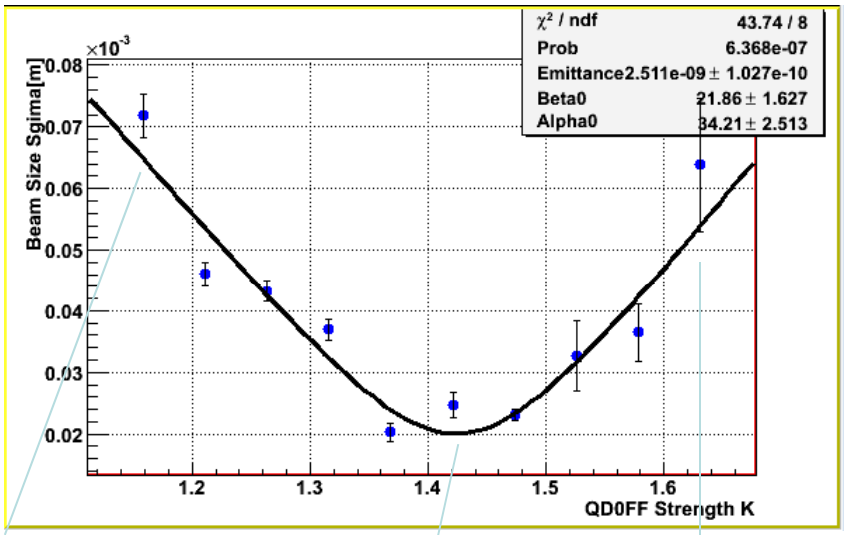
-*First Compton signal was observed at February.*

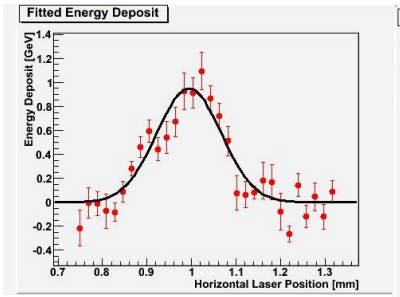
-*Beam size and emittance measurement was done at May.*

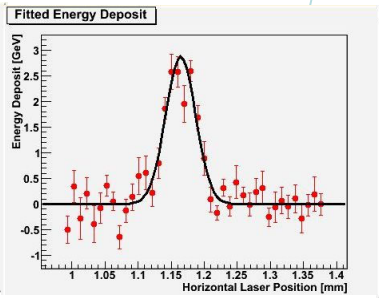
- *horizontal beam size at MW1IP was 20μm.*
- *laser beam size 10μm assumed.*
- *fitted horizontal emittance was 2.5nm.*

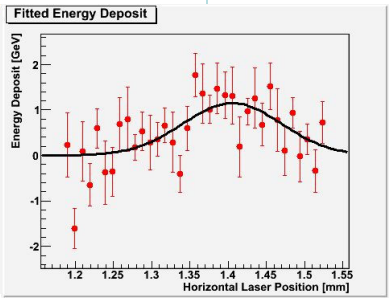


laserwire mode optics (horizontal measurement)







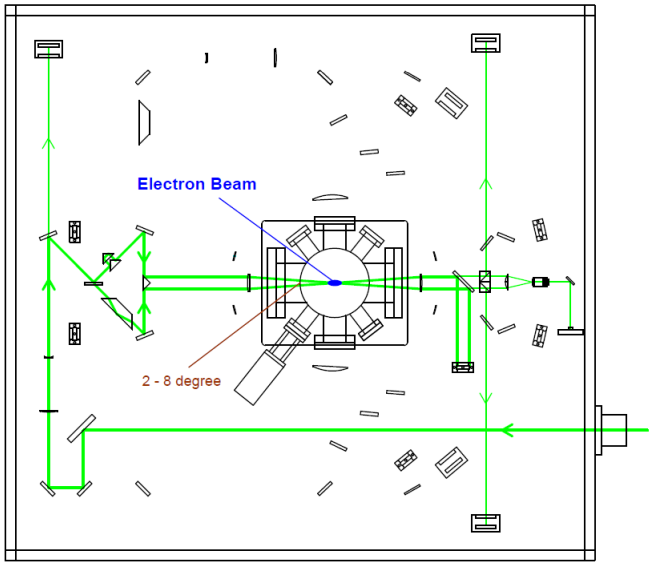


Vertical Measurement (Interference Mode)

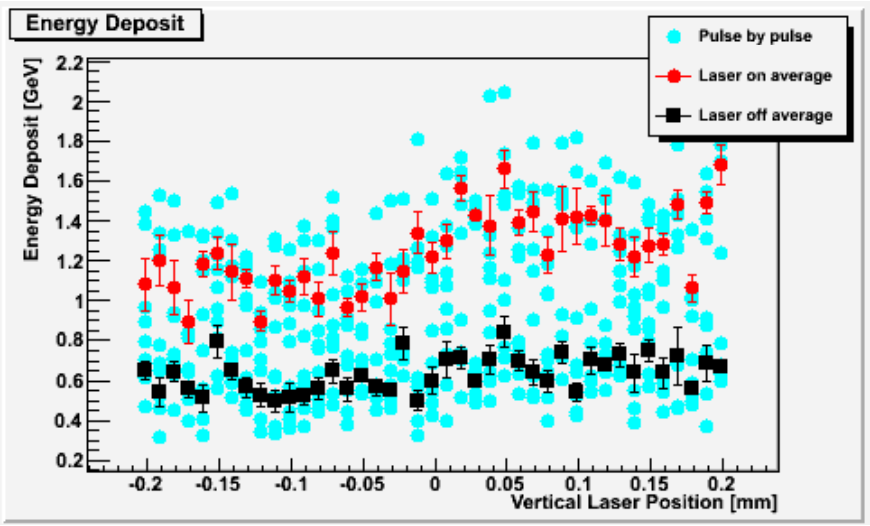
-2-8 degree crossing angle was used to measure several um vertical beam size.

-Signal was detected in the first week of April.
But, the clear peak was not observed and the signal was missed out at that time.

-We need more accurate laser-beam collision procedure



low crossing angle interferometer optics (vertical measurement)



measured on 9 April, 2009

For 2009 Autumn Beam Commissioning

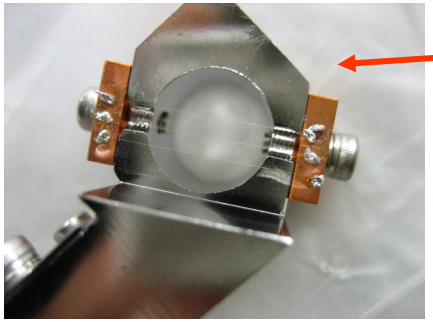
New IP target was installed

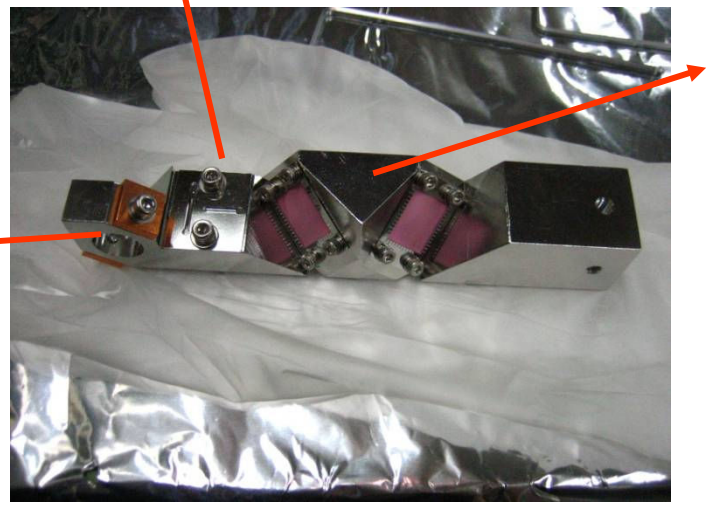
Laser beam size measurement

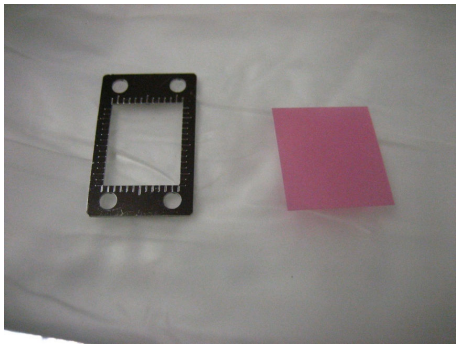
Prepare knife edge target
to make 10μm laser spot at IP

Electron beam size measurement

Attach10μm tungsten wire
at the tip of the holder
to make 1μm beam size at IP







- Laser-laser collision for all laser mode

- Electron-laser collition

Prepare 2 screen monitor

Summary of the ATF2 Beam Tuning in 2009 Spring Run

-Incoming vertical dispersion is large and difficult to correct with sum-knob.

-In order to correct vertical dispersion with independent QSs,
it makes large coupling and the coupling is difficult to correct with QKs.

-The measured minimum vertical emittance at extraction line was 11pm.
(vertical dispersion correction was only sum-knob)

-We could make a design horizontal beam size for high beta optics at MW1IP.

-We achieved the vertical beam size of 2.9μm at MW1IP.
(almost limit of the beam size measurenet with 10μm diameter wire,
but not the nominal beam size tuning with sextupole mover)

-We did horizontal beam size measurement by IP-BSM (laser wire mode).

-We did not yet measure the vertical beam size by IP-BSM (interference mode)
for poor laser-beam collision system.

Rough Schedules of ATF2 operation

We will start ATF&ATF2 Operation from end of this week.

2009 October

Fast kicker study in DR

Startup of the beamline and concentrate the hardware works for ATF2.

2009 November, December

Main Target of the ATF2 operation
is the measurement of the sub-micron beam size by Laser Interferometer

After the 2009 operation

- Decision of the beam optics for 2010 operation.

- mprovement of the IP-BSM DAQ to be used for beam operation

- Installation of the multi-OTR chambers.

Target by the end of 2010 spring run

Beam size measurement of < 100nm beam