Commissioning Status of ATF2 beam line

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8th ATF2 project meeting

2009 / 6 / 8

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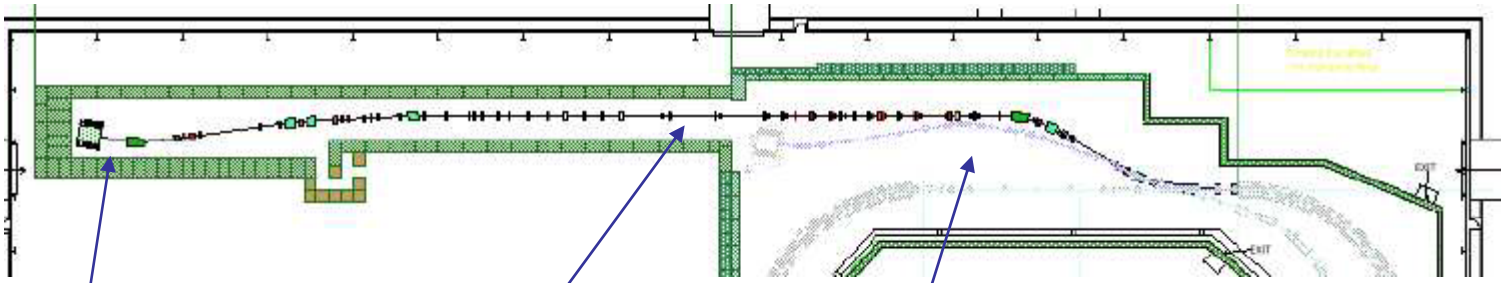
We operate the ATF2 beam line with high beta optics (β_x=0.08m, β_y=0.01m) in 2009 spring run.



Extraction line tuning
(dispersion and coupling correction)

Emittance measurement in extraction line

Matching and beam size tuning at post-IP wire scanner

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.

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

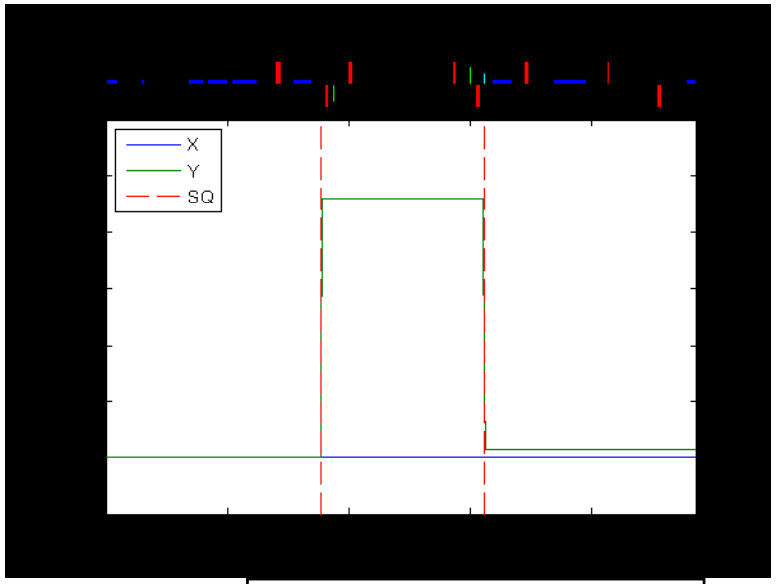
$$\mathrm{Q}_{x,y} \equiv \frac{1}{\sqrt{\beta_{x,y}}} \begin{bmatrix} \beta_{x,y} & 0 \\ -\alpha_{x,y} & 1 \end{bmatrix}$$

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

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

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

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



	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

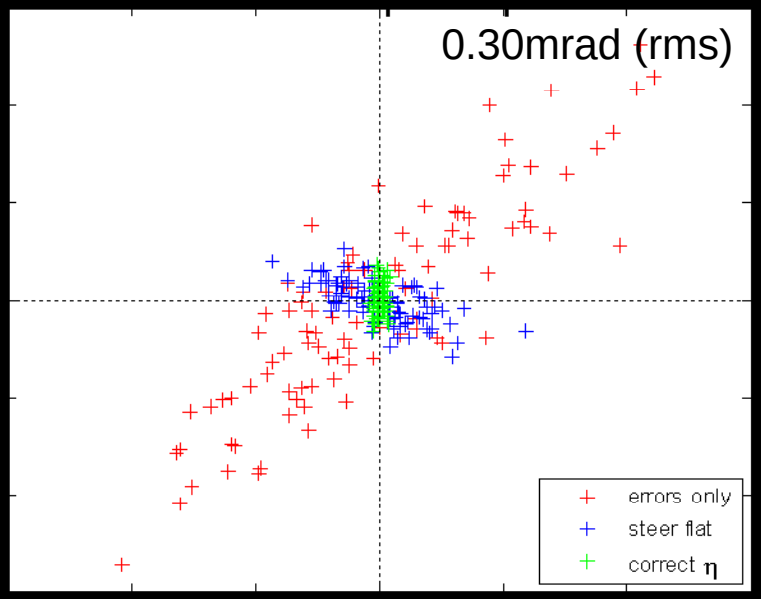
Errors;

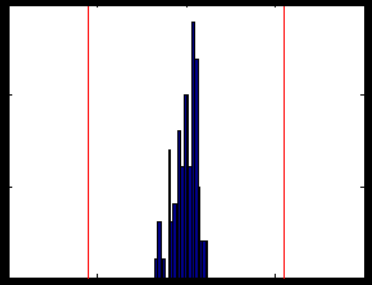
vertical dipole misalignments: 0.10mm (rms)

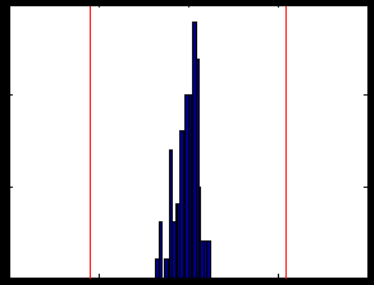
horizontal quadrupole misalignments:
0.05mm (rms)

vertical quadrupole misalignments:
0.03mm (rms)

0.30mrad (rms)







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

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

Example of the 1-by-1 correction

Coupling can be corrected with 1-by-1 correction

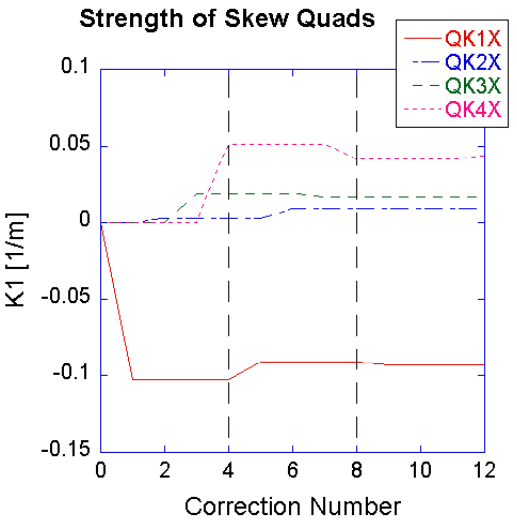
Errors;

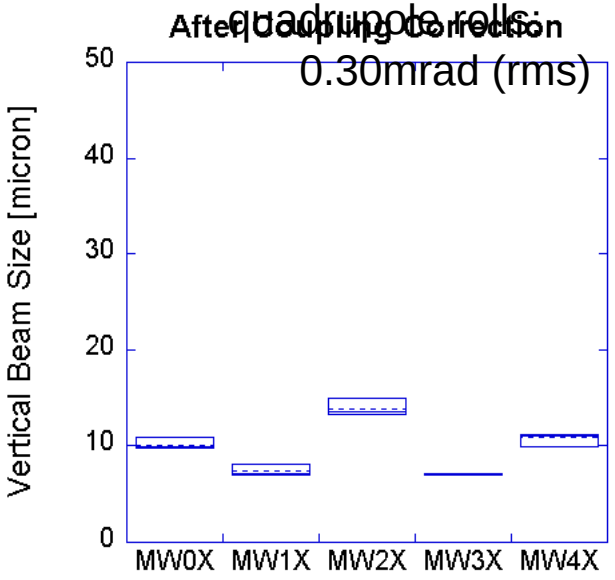
vertical dipole misalignments: 0.10mm (rms)

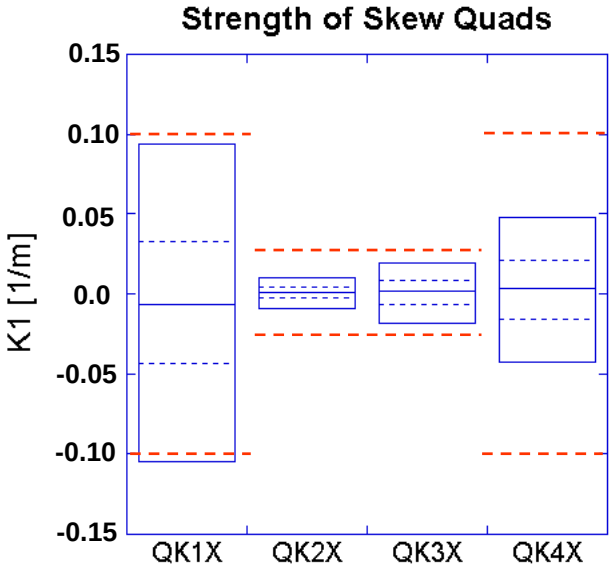
horizontal quadrupole misalignments:
0.05mm (rms)

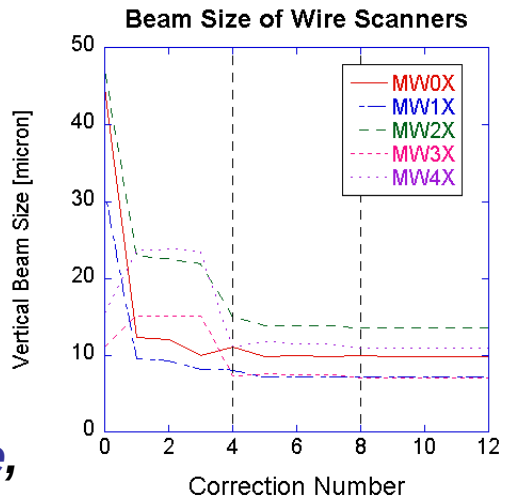
vertical quadrupole misalignments:
0.03mm (rms)

quadrupole rolls:
0.30mrad (rms)





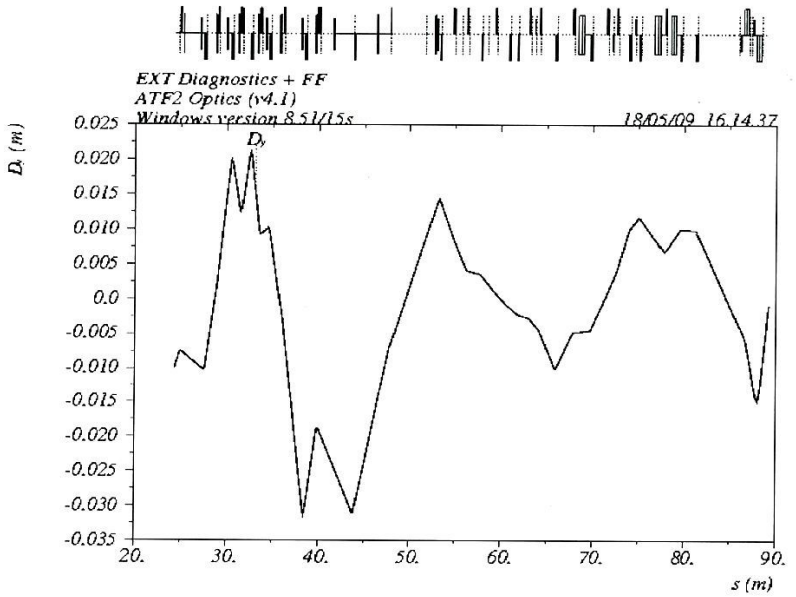




When the coupling sources are only in the extraction line, we can correct the coupling with the present QKs.

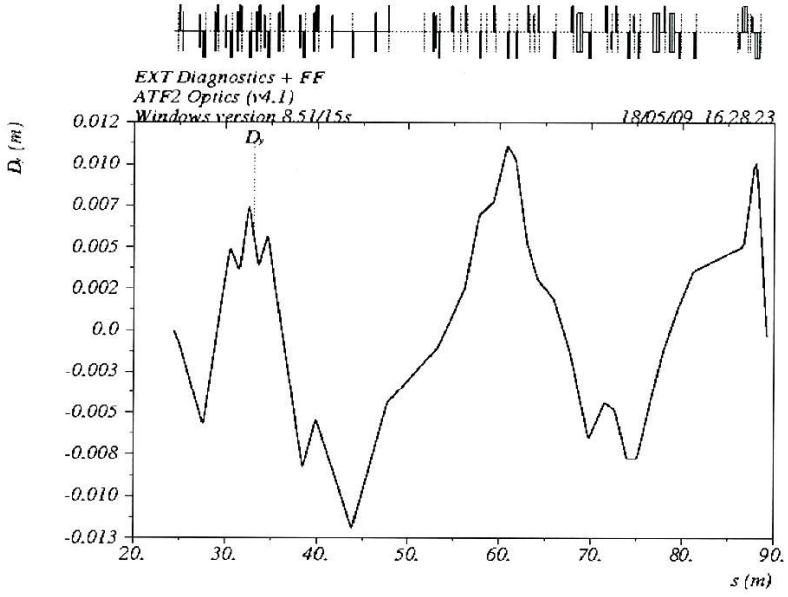
Vertical Dispersion Measurement (05/14)

Before Dispersion Correction



Dispersion Correction with sum-knob

QS1X = +0.455A
QS2X = +0.455 A

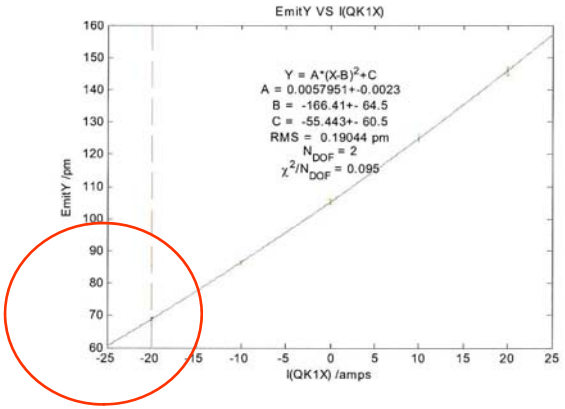


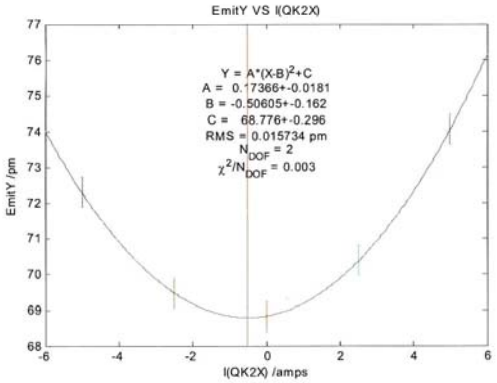
The measured dispersion cannot be corrected with only sum-knobs, it means the incoming vertical dispersion is large and the phase of incoming dispersion is not on phase to sum-knob.

Simulation for the coupling correction with independent QSs

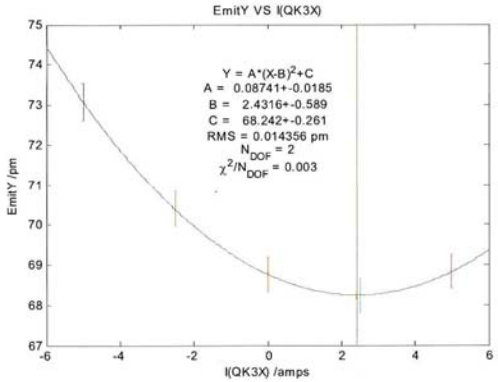
Calculated by M.Woodley

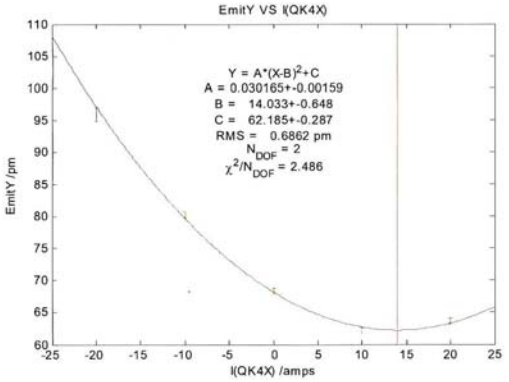
In order to correct the dispersion with QSs, we must apply large opposite fields to QSs, and it make large betatron coupling.





QS1X = - 6.295 A
QS2X = +6.359 A



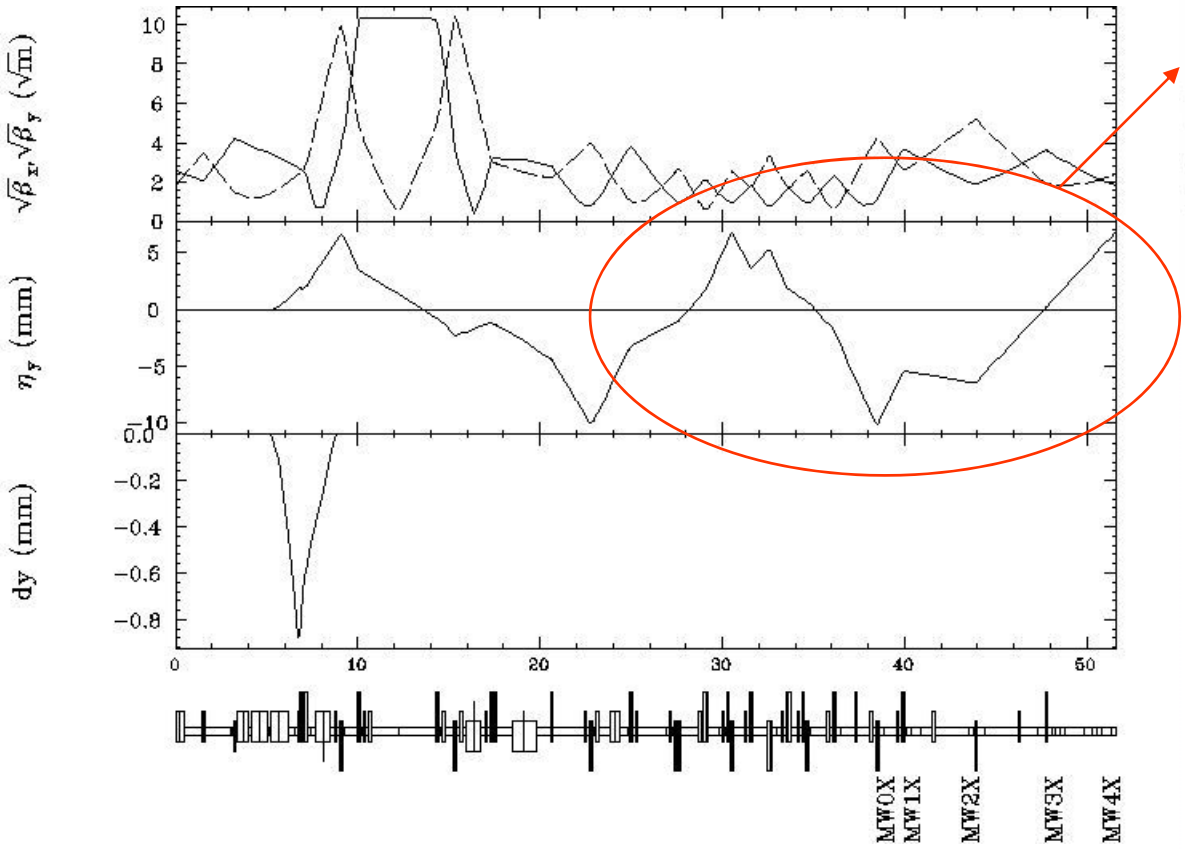


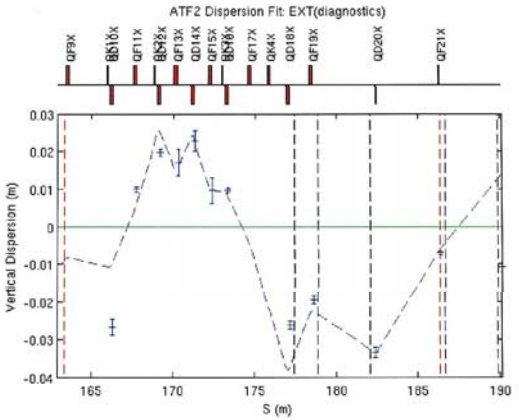
In order to correct the coupling, generated by the QSs with QKs, the maximum field of QK1X was too weak

Candidate of the incoming dispersion source

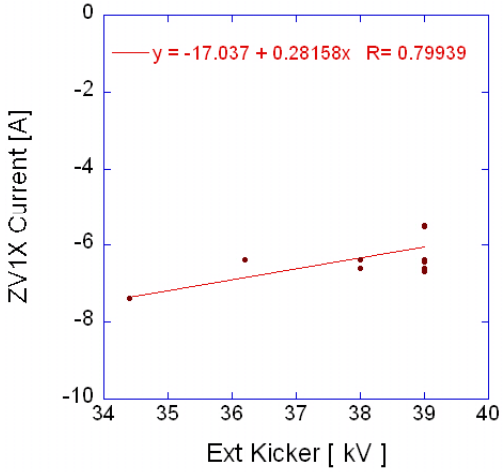
-*ZV1X must be apply huge field to pass the beam.*

-*When we assumed the vertical kick at septum and ZV1X and ZV2X, we can simulate the residulal vertical dispersion.*





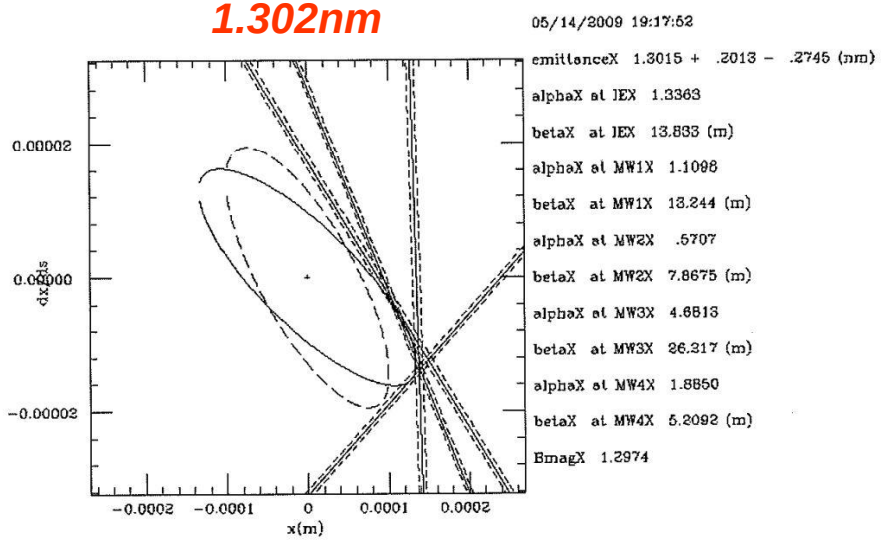
Measured dispersion



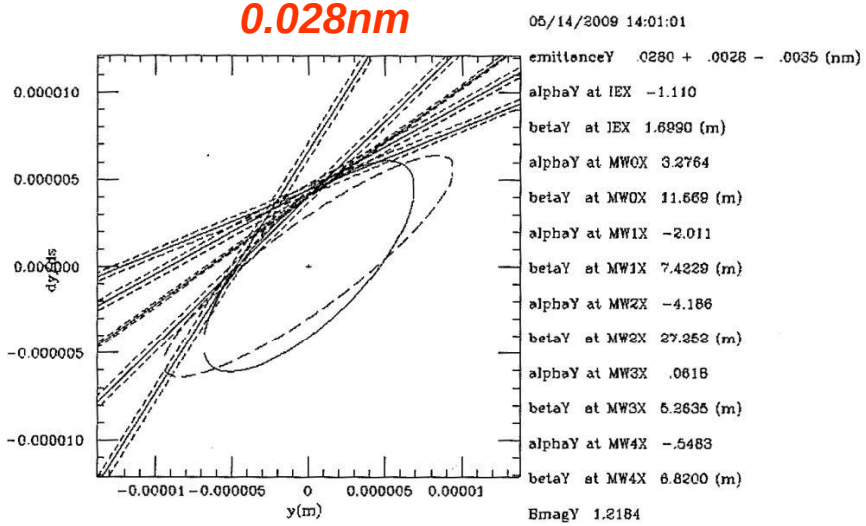
Vertical kick at septum was smaller for higher kicker voltage

Emittance Measurement in Extraction Line (05/14)

Horizontal Emittance
1.302nm



Vertical Emittance
0.028nm



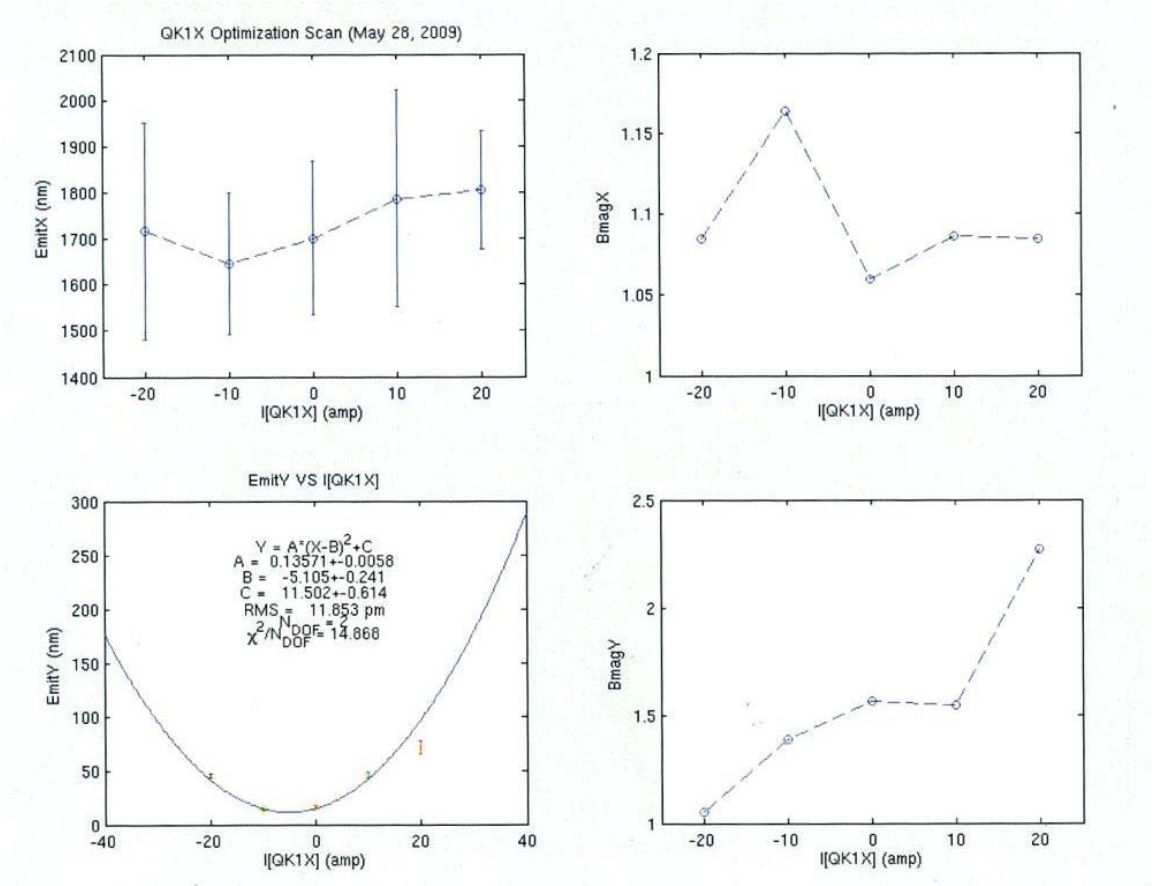
Opposite Current

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

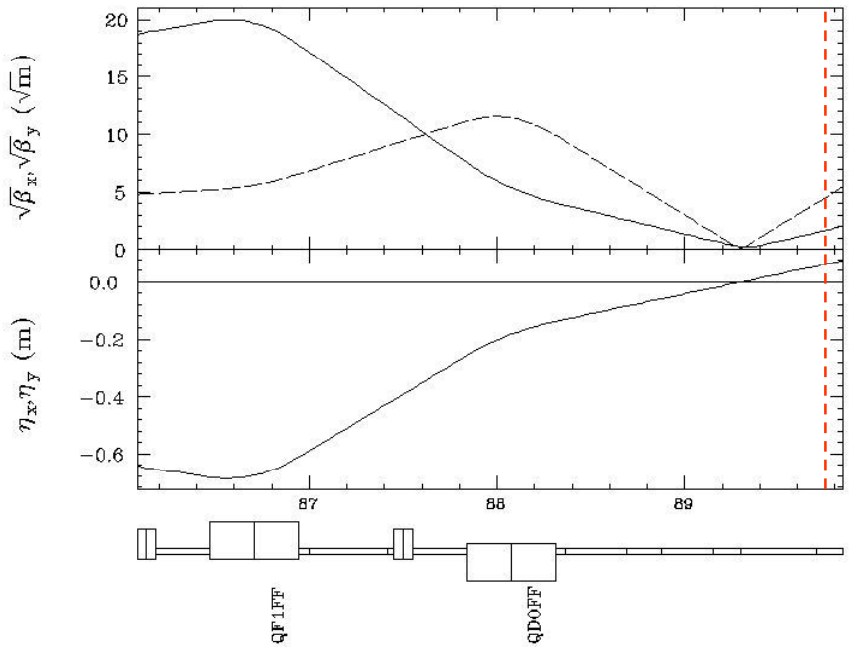
QS1X	**-**	**0.42A**
QS2X	**-**	**0.42A**
QK1X	**-**	**5.11A**
QK2X		**0.00A**
QK3X		**0.00A**
QK4X		**0.00A**

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

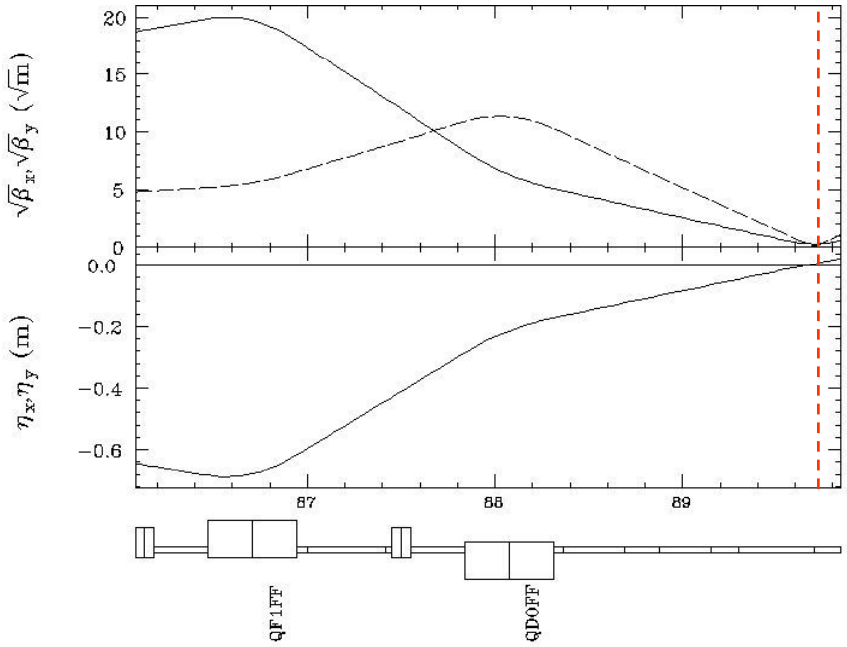
σ_y = 20.4μm -> σ_y^* = 0.5μm

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

beam waist at MW1IP

QF1FF = 66.87A

QD0FF = 105.24A



σ_x^* = 11.4μm

σ_y^* = 4.1μm

Horizontal beam size was consistent with the design.

Design Beam Size at IP

σ_x^* = 10.1μm

σ_y^* = 0.53μm

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)

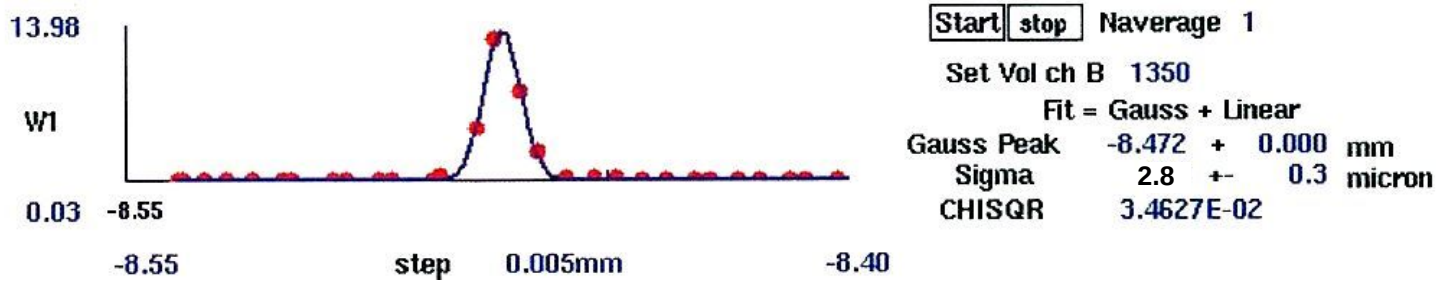
-***Residual vertical dispersion was dominant for the vertical beam size***

- 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 10μm diameter wire



Summary

-*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 10mm diameter wire,
but not the nominal beam size tuning with sextupole mover)