Micron electron beam optics at ATF extraction line for laser wire experiment

R&D group of the Laser Wire at KEK-ATF extraction line:

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The purpose of the laser wire experiment is to demonstrate a possibility to measure ~1mm electron beam size

Required optics parameters

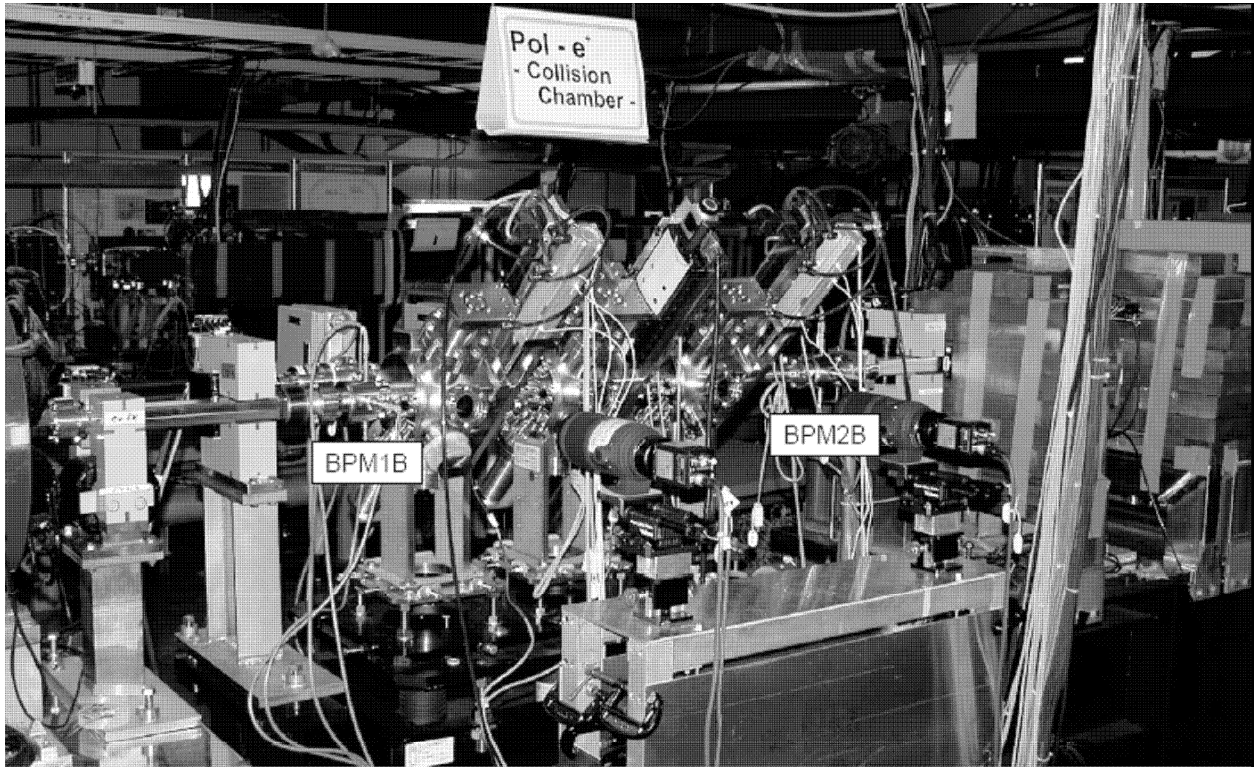
- 1㎜ vertical beam size;

- horizontal beam size from 10 – 100㎜;

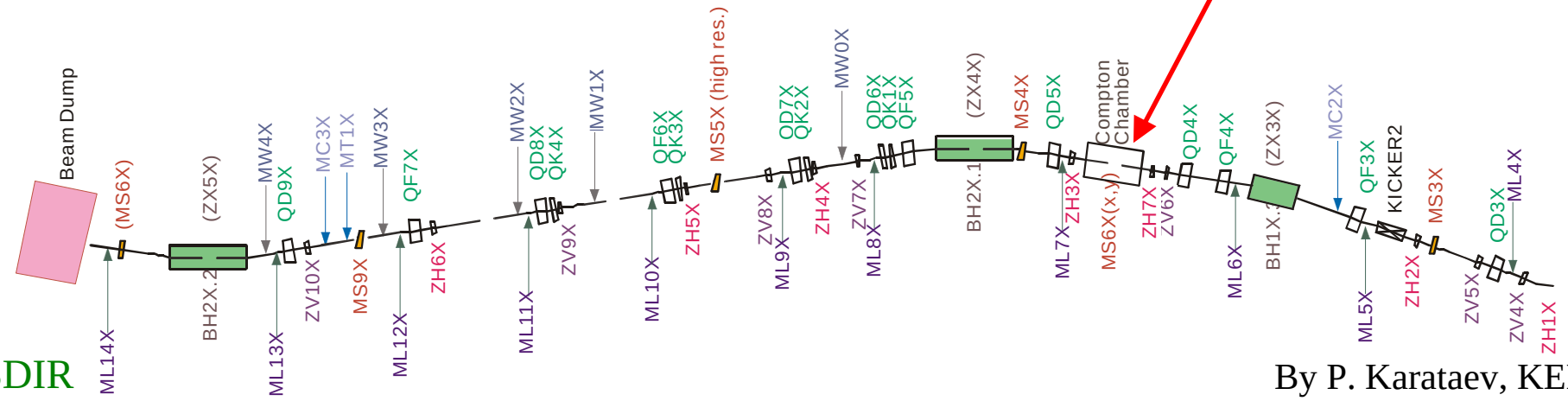
- Both vertical and horizontal beam sizes in the entire extraction line < 1mm;

- Stable beam at the laser wire interaction point.

The ATF extraction line layout



MS6X
e^+ collision point



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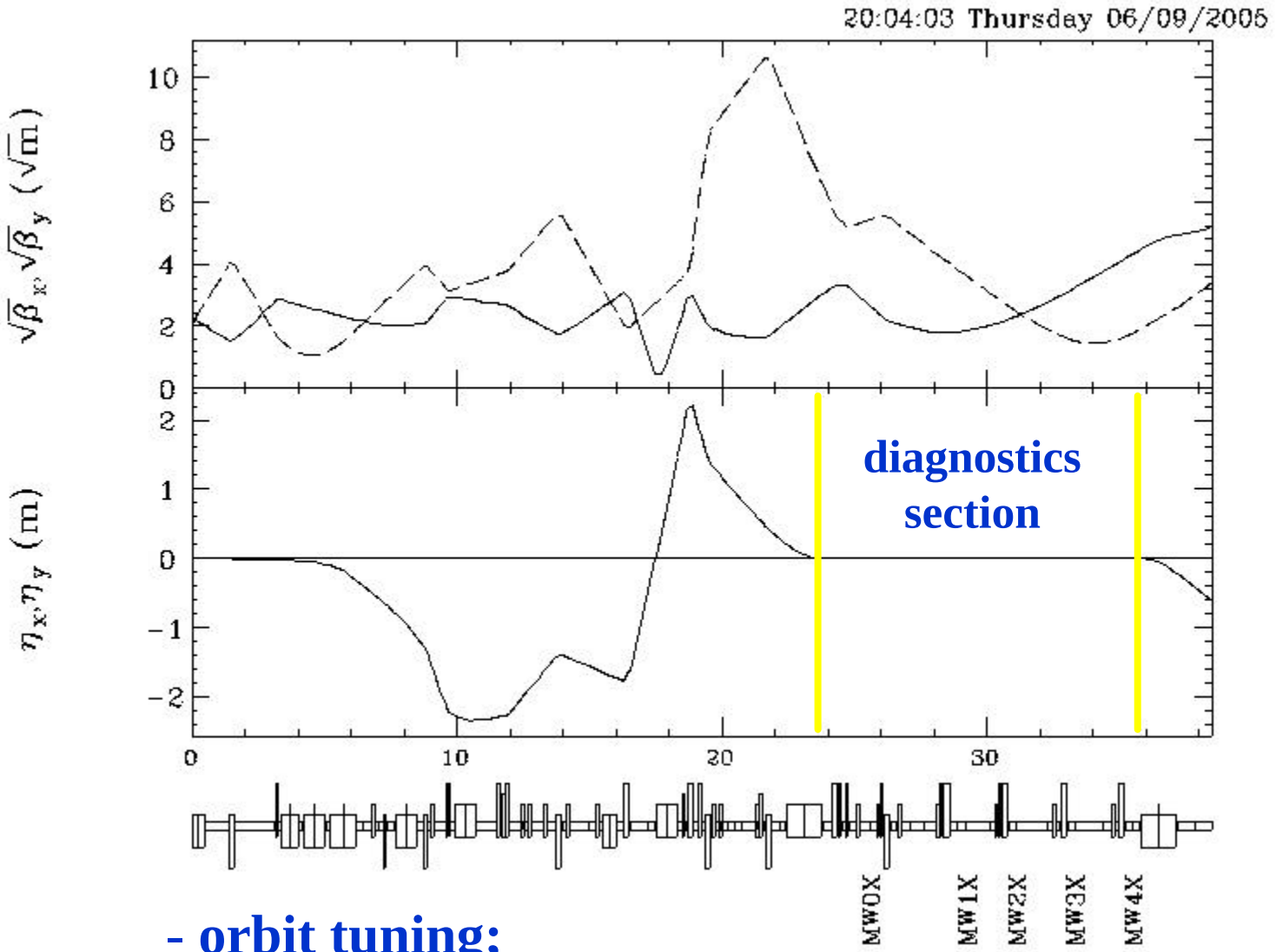
Normal beam optics tuning



- orbit tuning;
- dispersion correction;
- emittance measurement.

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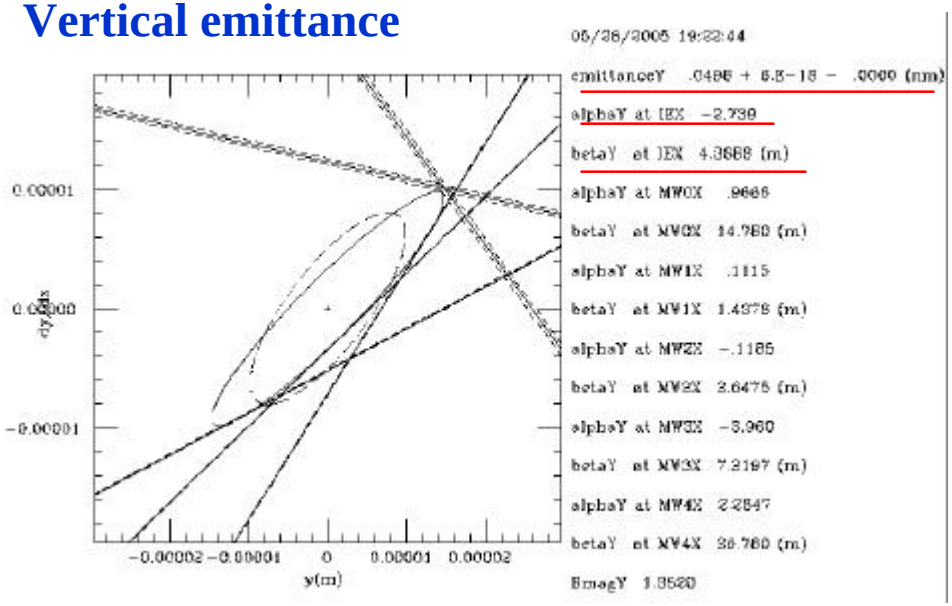
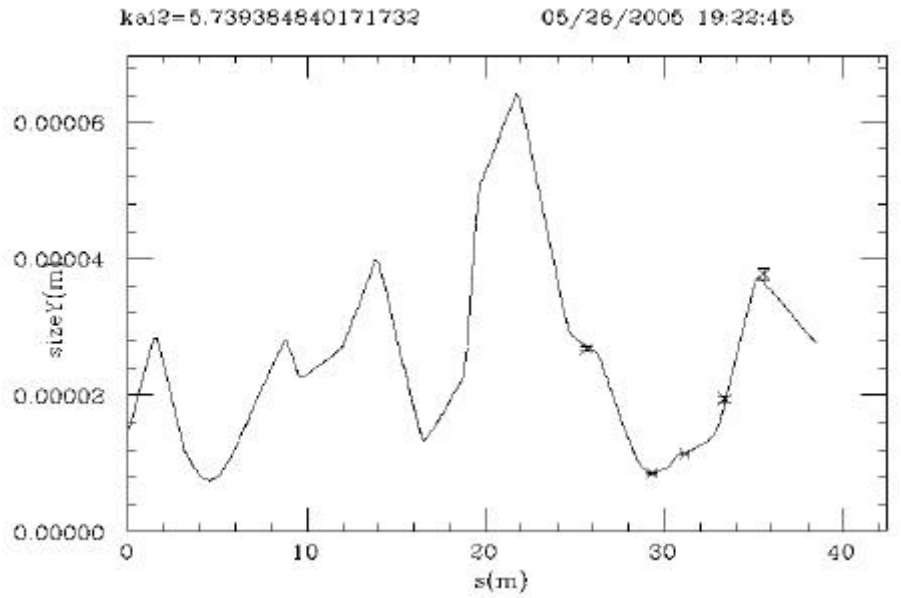
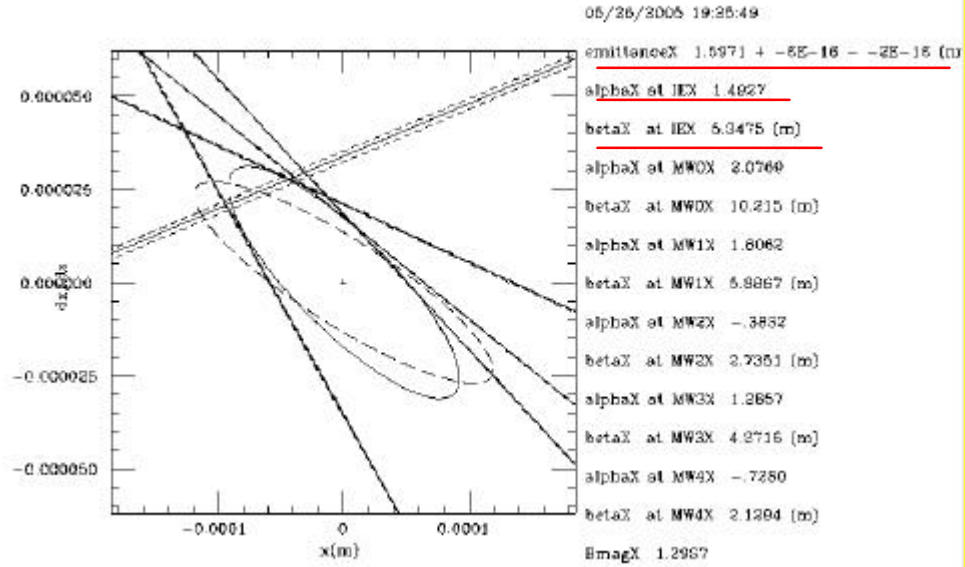
Emittance measurement on May 26.

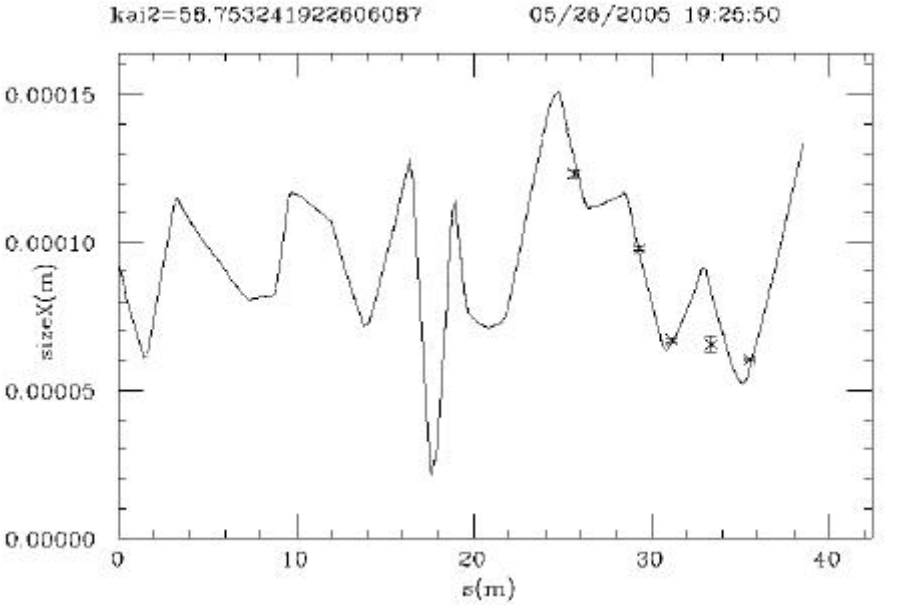
Vertical emittance





Horizontal emittance





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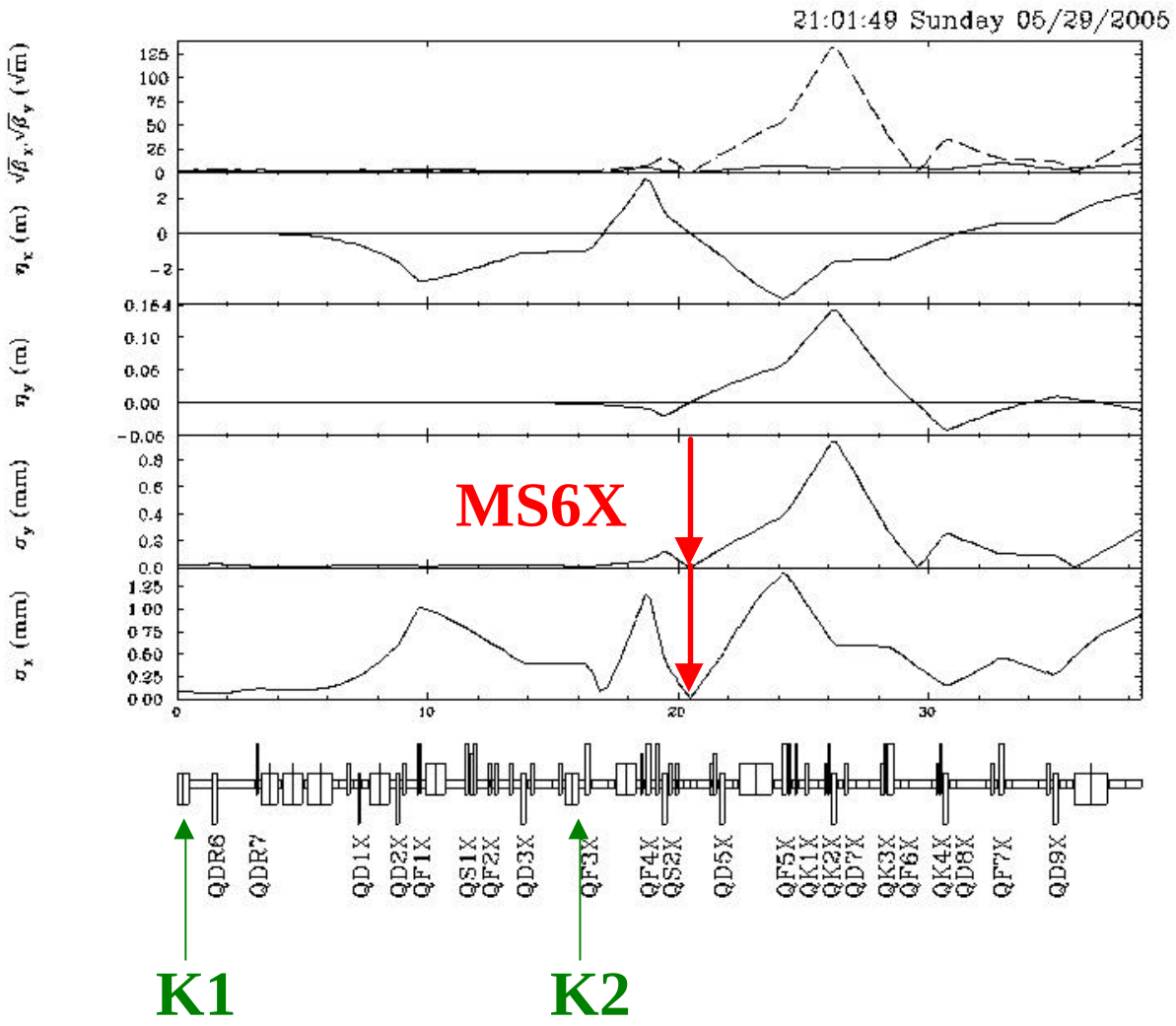
SAD calculation of the optics



MS6X is the current IP of the polarized positron setup and possible IP for the laser wire

Emittance:

$\varepsilon_y = 4.98\ 10^{-11}$ m rad

$\varepsilon_x = 1.6\ 10^{-9}$ m rad

IEX parameters:

Alpha Y = -2.74 Beta Y = 4.37m

Alpha X = 1.49 Beta X = 5.35m

$$R_{K1\to K2} = \begin{bmatrix} -1.0 & 0 \\ -0.5 & -1.0 \end{bmatrix}$$

$\sigma_x = 20.26\mu m$

$\sigma_y = 1.02\mu m$

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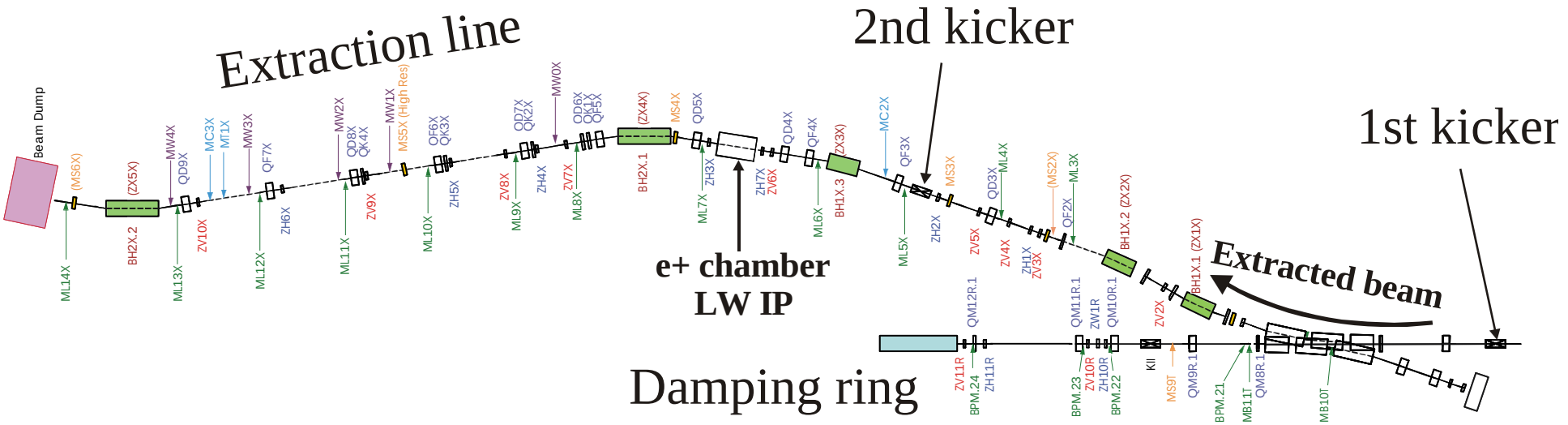
Kicker jitter compensation



T. Imai, et al., Highly stable beam extraction by double kicker system, KEK Preprint 2002-16, May 2002, A

$$\begin{pmatrix}\Delta x\\ \Delta x'\end{pmatrix} = R_{K_1\to K_2}\begin{pmatrix}0\\ \Delta\theta_1\end{pmatrix} + \begin{pmatrix}0\\ \Delta\theta_2\end{pmatrix}$$

$$\Delta x = m_{12}\Delta\theta_1$$

$$\Delta x' = m_{22}\Delta\theta_1 + \Delta\theta_2$$

$$m_{12} = 0 \text{ and } m_{22} = -1$$

$R_{K1®K2}$ – transfer matrix between two kickers

m_{ij} – transfer matrix elements

Dx and Dx' are the horizontal displacement and angular deviation

Dq_1 and Dq_2 are the kick angle variations of the first and second kickers respectively

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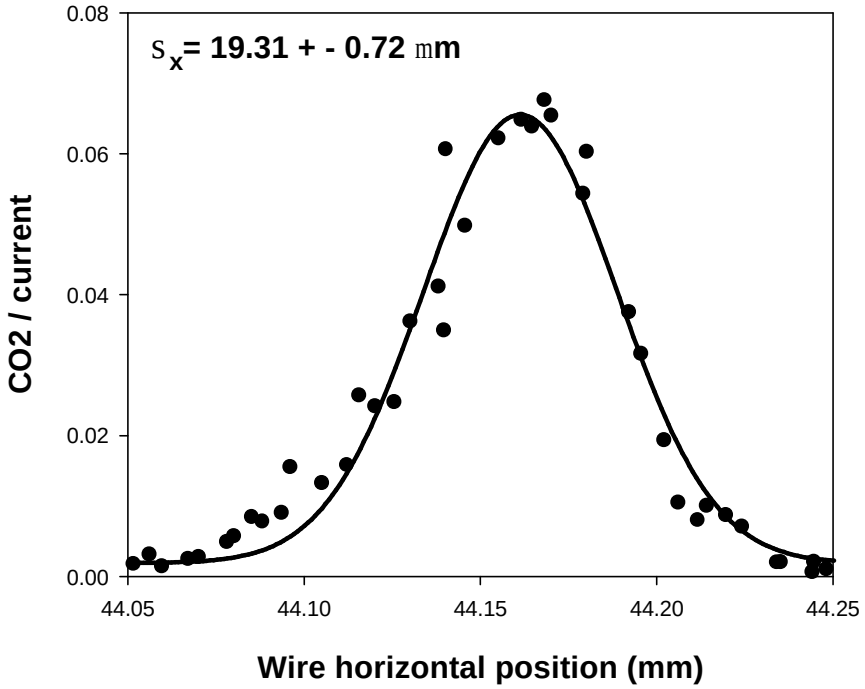
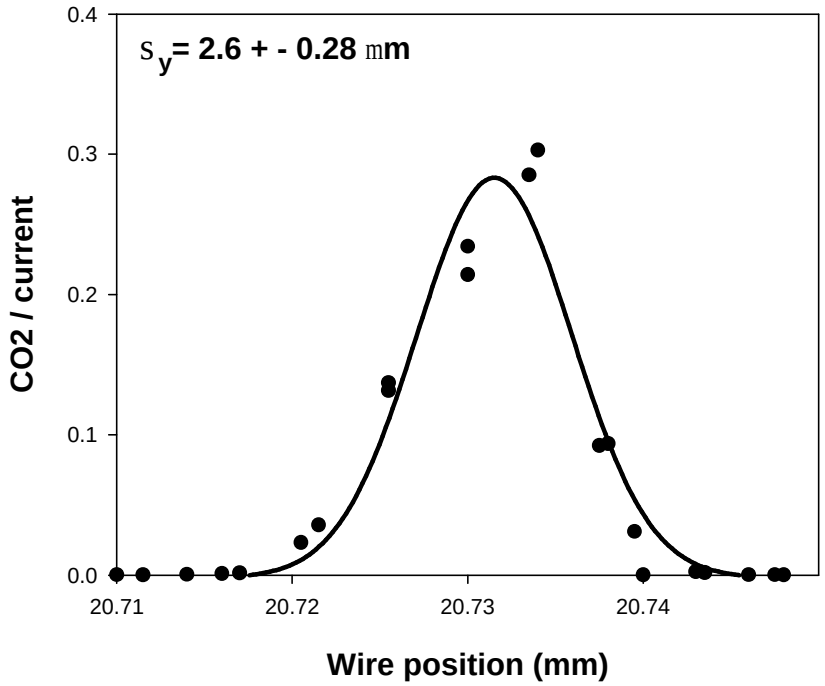
Optics test

Beam size measurement with 10mm tungsten wire





Optics loading and tuning

- **Normal electron beam optics:**

  a) tune the beam orbit

  b) correct dispersion

  c) measure beam emittance

  d) calculate IEX parameters

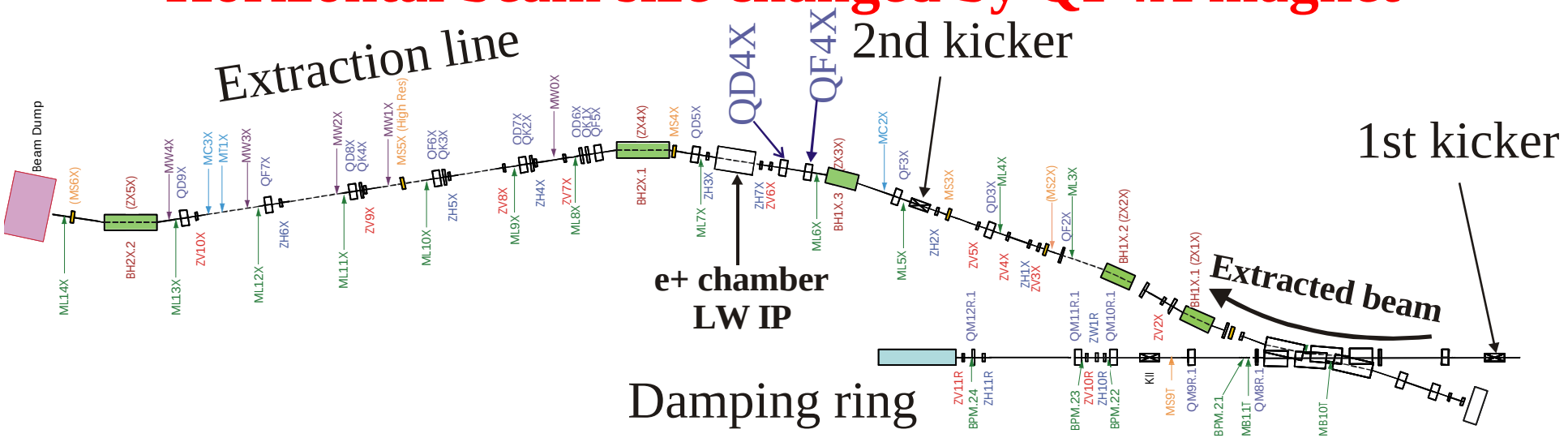
  e) calculate and load the optics

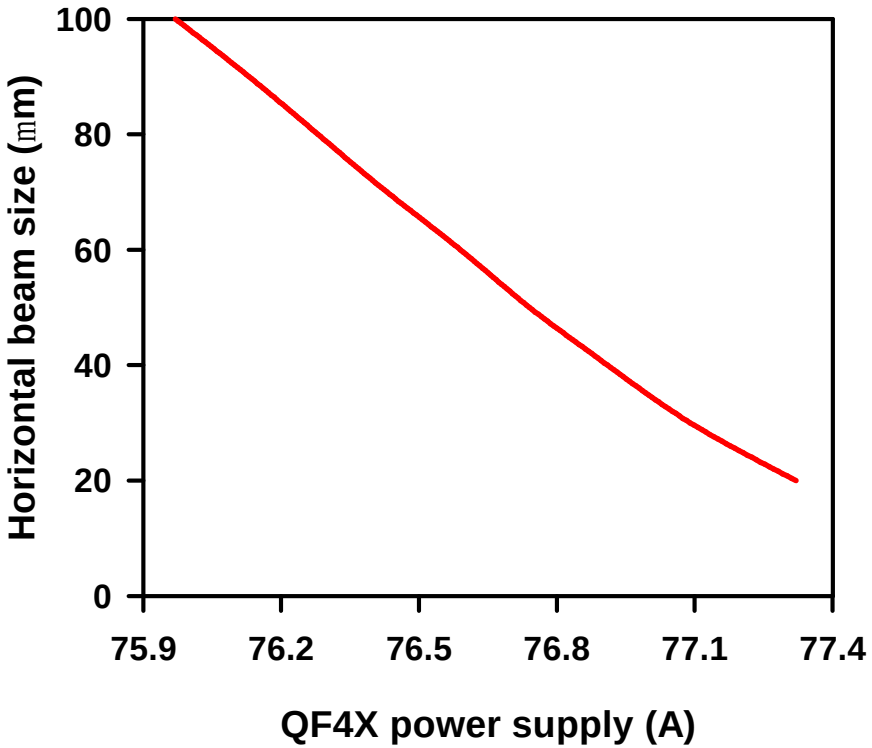
- **New optics:**

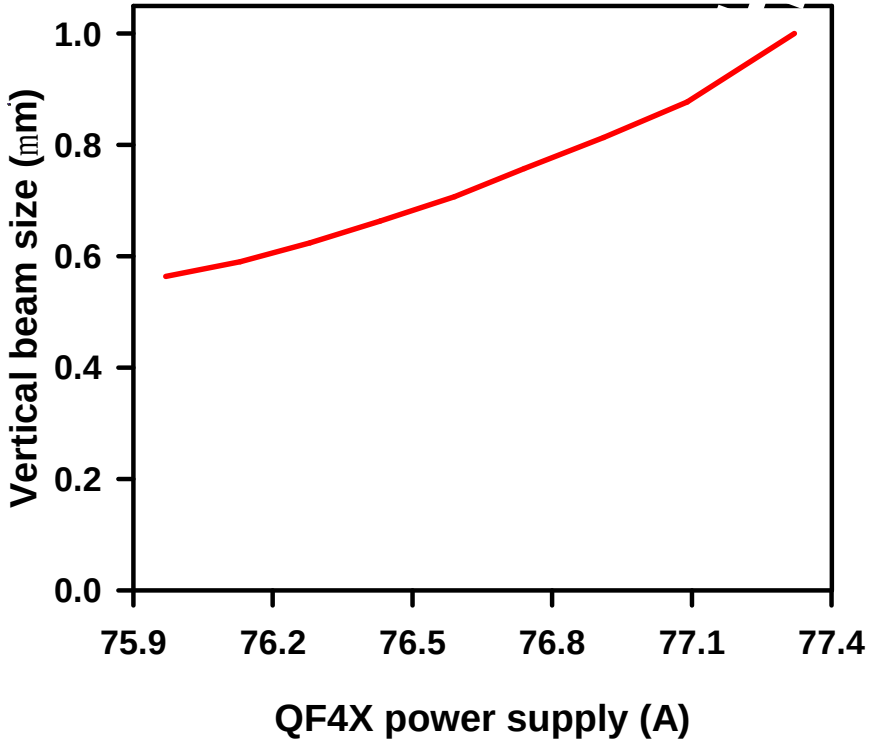
  a) correct the orbit

  b) recalculate the optics including the steering magnet settings

Horizontal beam size changed by QF4X magnet







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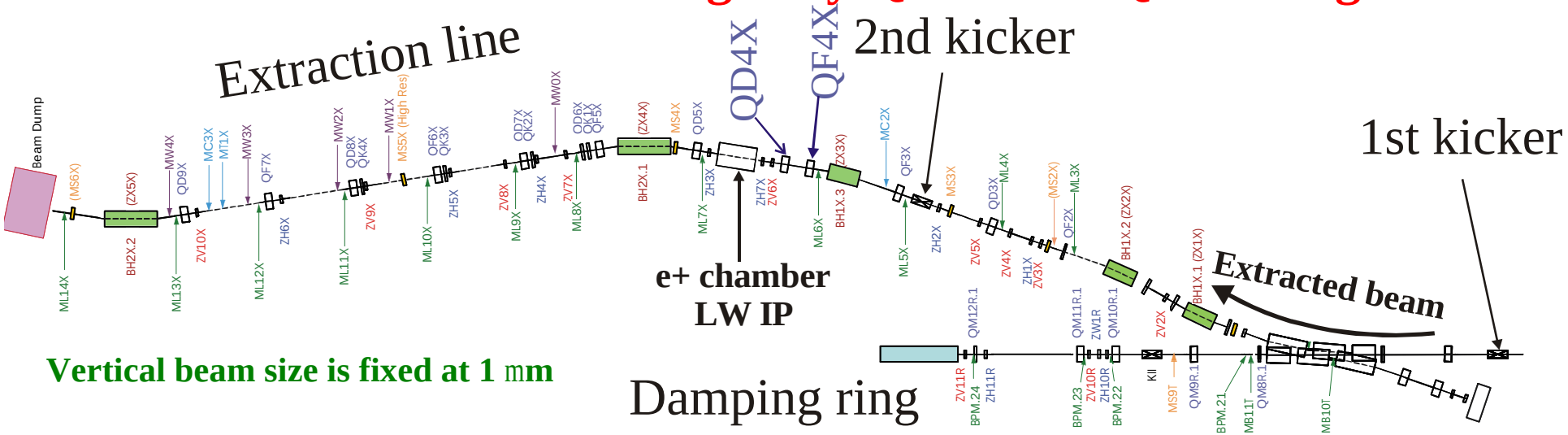
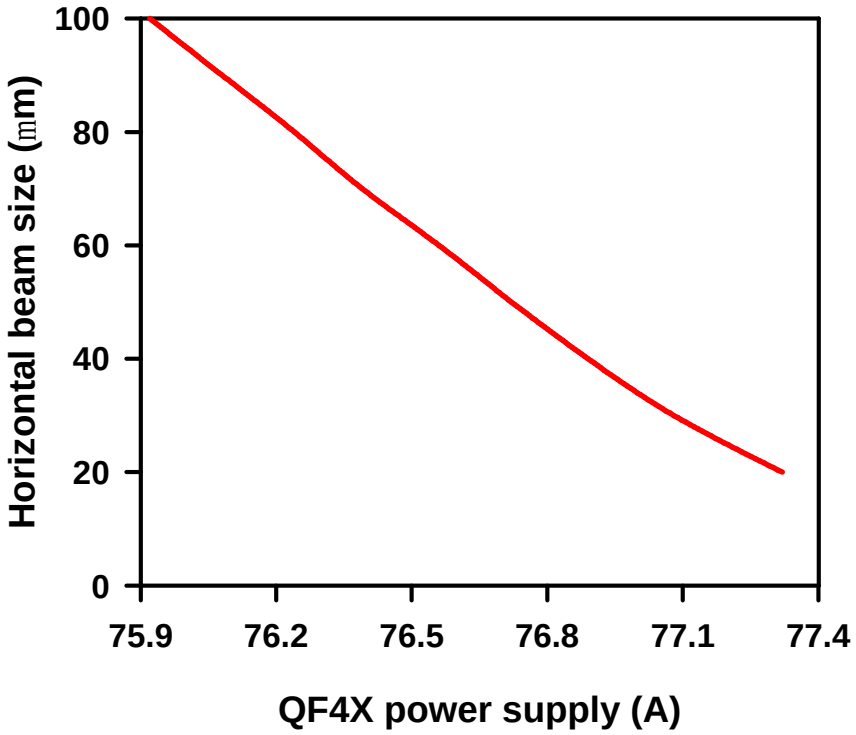
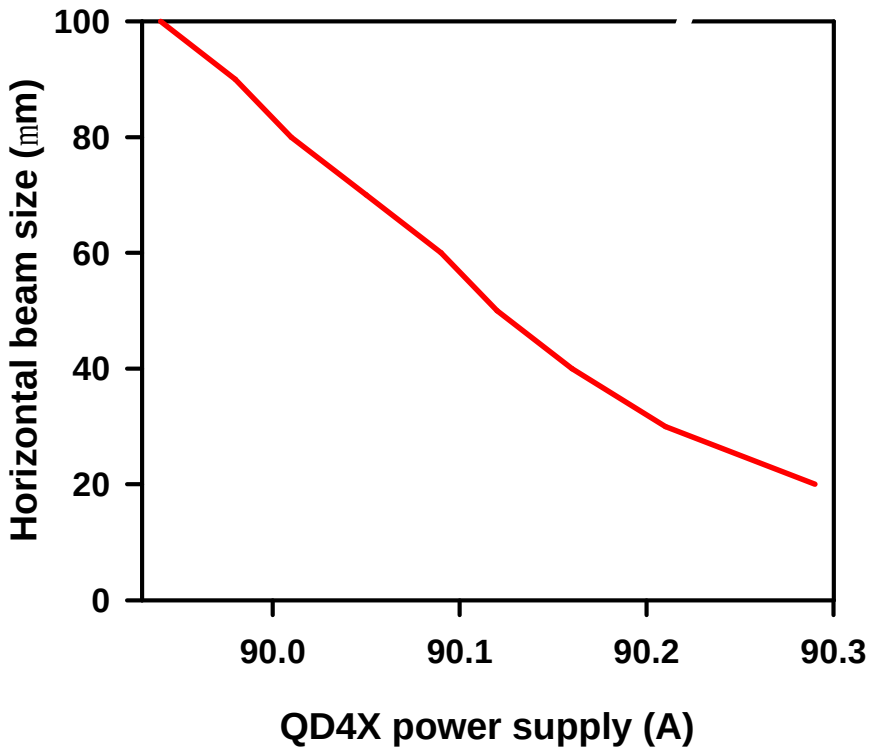
Horizontal beam size changed by QF4X and QD4X magnets



Vertical beam size is fixed at 1 mm





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Summary

- ~20μm measured horizontal beam size

- ~2.6μm measured vertical beam size

- it takes 1 shift (~8 hours) to achieve this optics

- It is better to use a 7 μm carbon wire for beam size measurement

- The beam current should be > 0.5 10^{10}

- a method for correcting dispersion in the IP is necessary (it may speed up the optics tuning time)