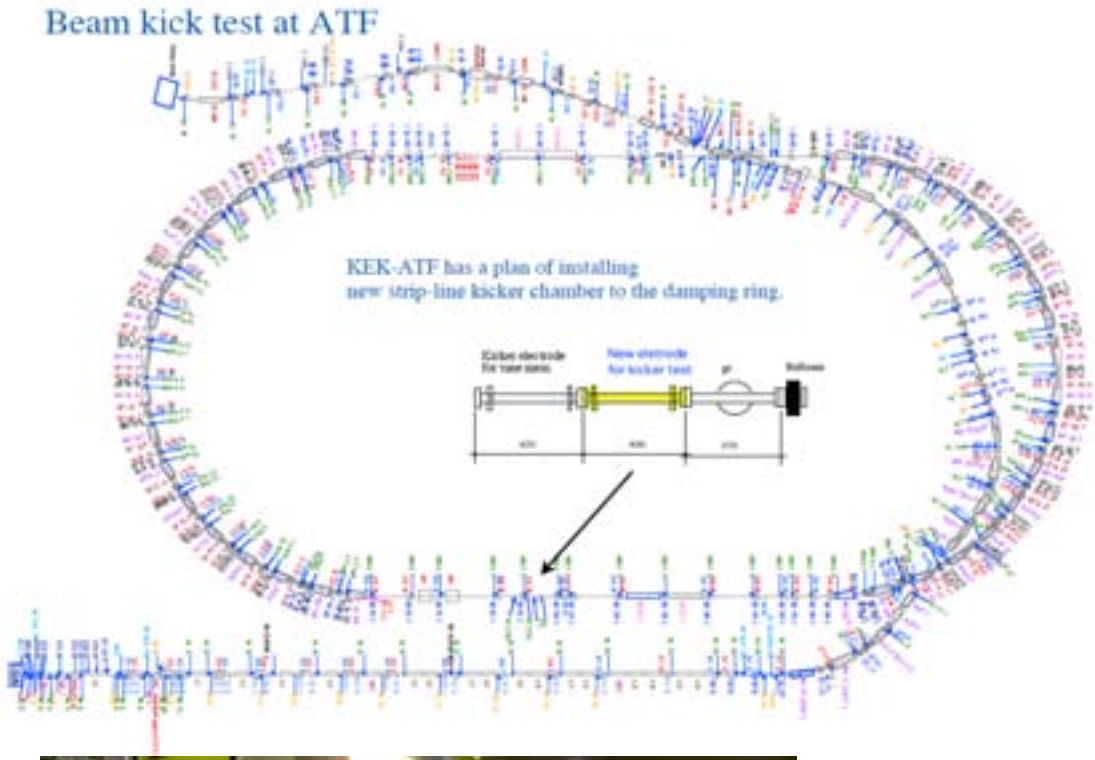
2nd ILC Workshop 2005 8/17/2005
At Snowmass, Wed. 10-12,15+5

Instrumentation R&D at KEK-ATF

J.Urakawa

1. *Introduction of ATF*
2. *Mutibunch Emittance Study*
3. *BPM Improvement*
4. *Laser wire results*
5. *Pulsed laser wire development*
6. *ODR monitor results*
7. *New device for nm beam control*
8. *Beam dynamics study with wigglers*

ATF Introduction



Emittance status

E=1.28GeV, N_e*=2x10*^{10} *e-/bunch*

1 ~ 20 bunches, *Rep=3.125Hz*

X emit=2.5E-6 **(at 0 intensity)**

Y emit=1.25E-8 **(at 0 intensity)**

Multibunch emittance study

Monitors of MB emittance

MB (or projected) Laser-wire,

Projected SR interference monitor,

X-ray SR monitor,

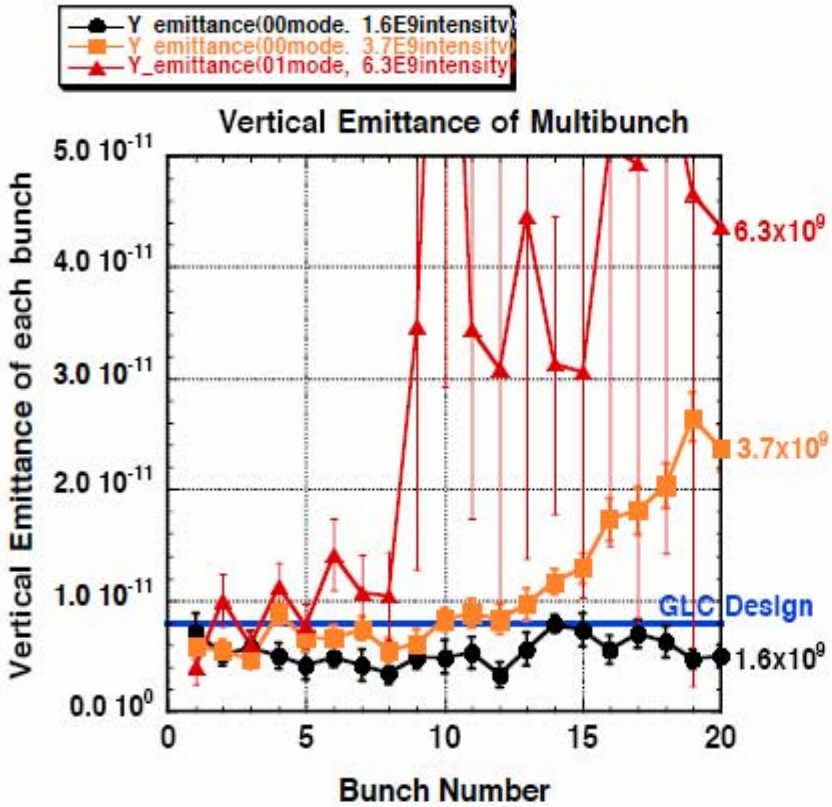
MB (or projected) wire scanner:

(EXT-line coupling problem?)

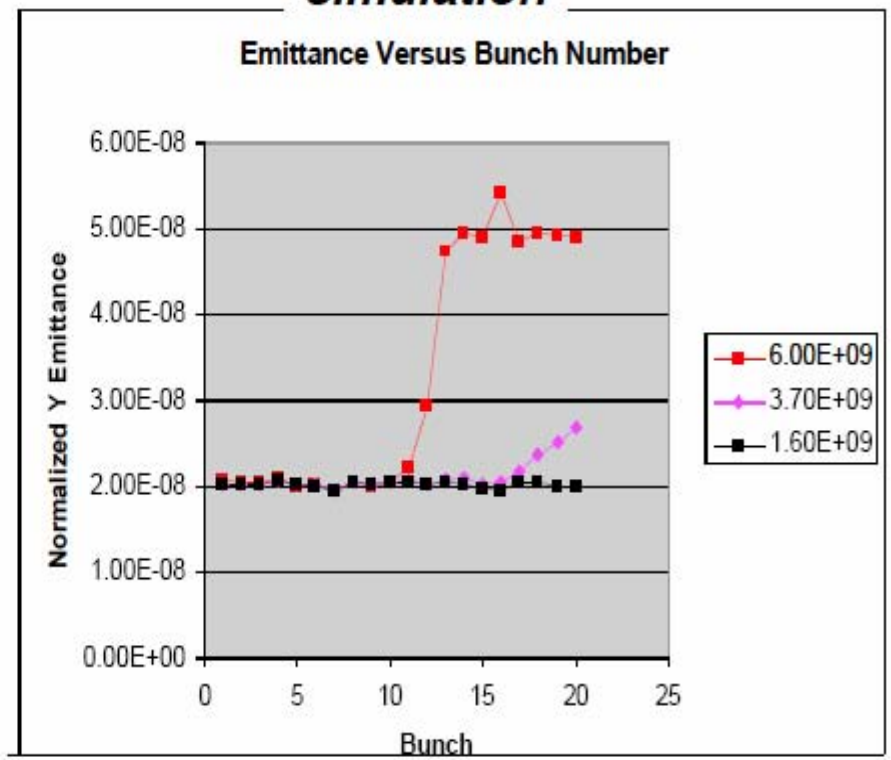
Problem of MB emittance

Fast Ion Instability ?

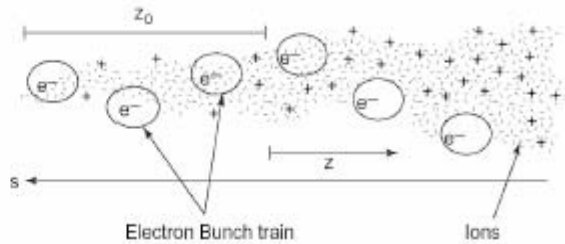
Preliminary result of Fast Ion Instability simulation



simulation

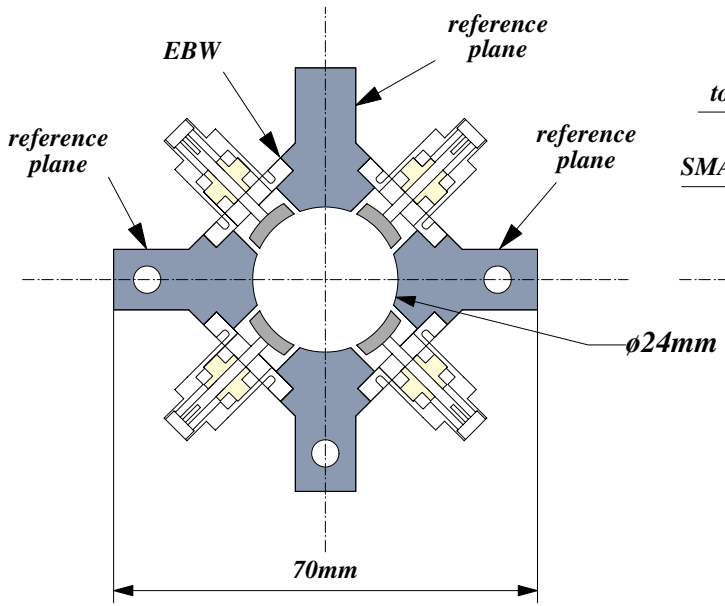


Behavior of Y emittance is very similar.

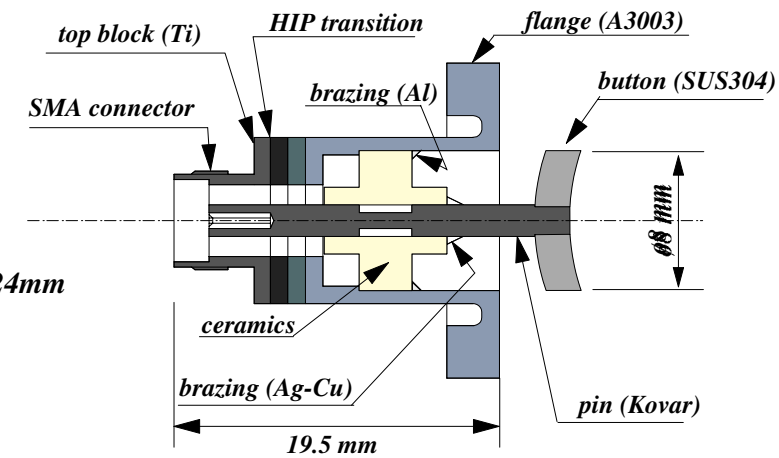


Schematic of the Fast-Beam Ion Instability

ATF Damping Ring BPM



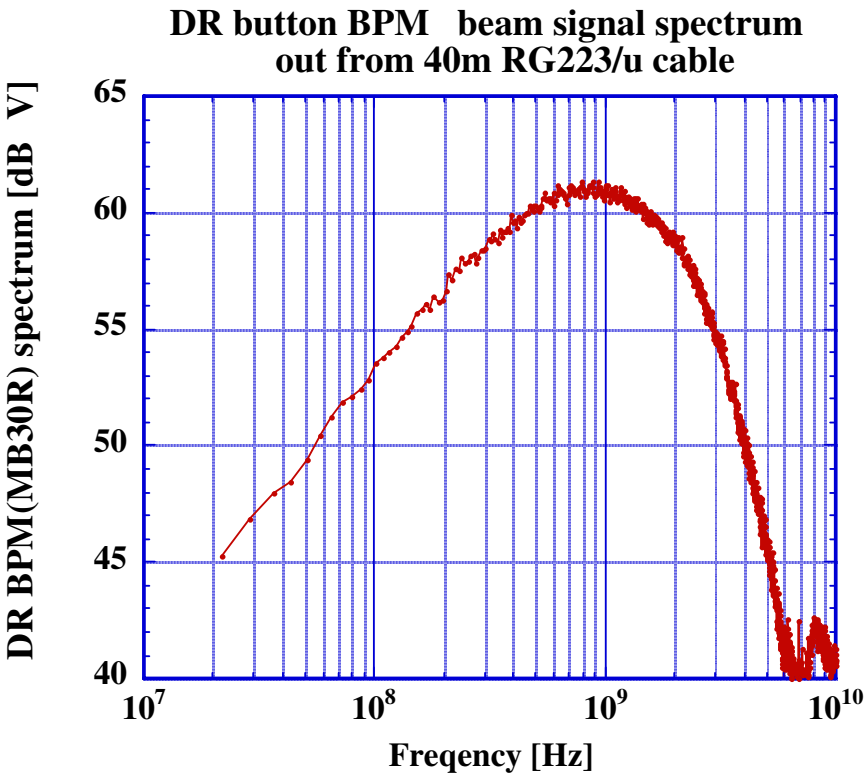
cross section of BPM camber



Button electrode assembly

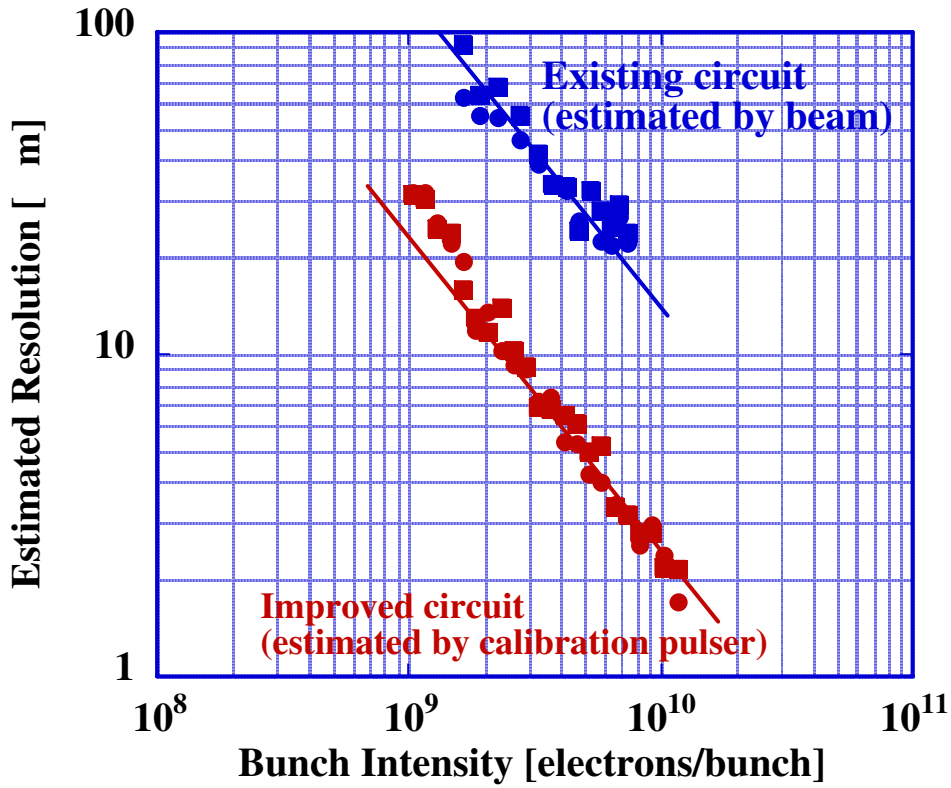
Electronics: single pass detection for 96 BPMs
DC-50MHz BW,
base line clip & charge ADC,
min. resolution ~20μm

Spectrum of DR BPM



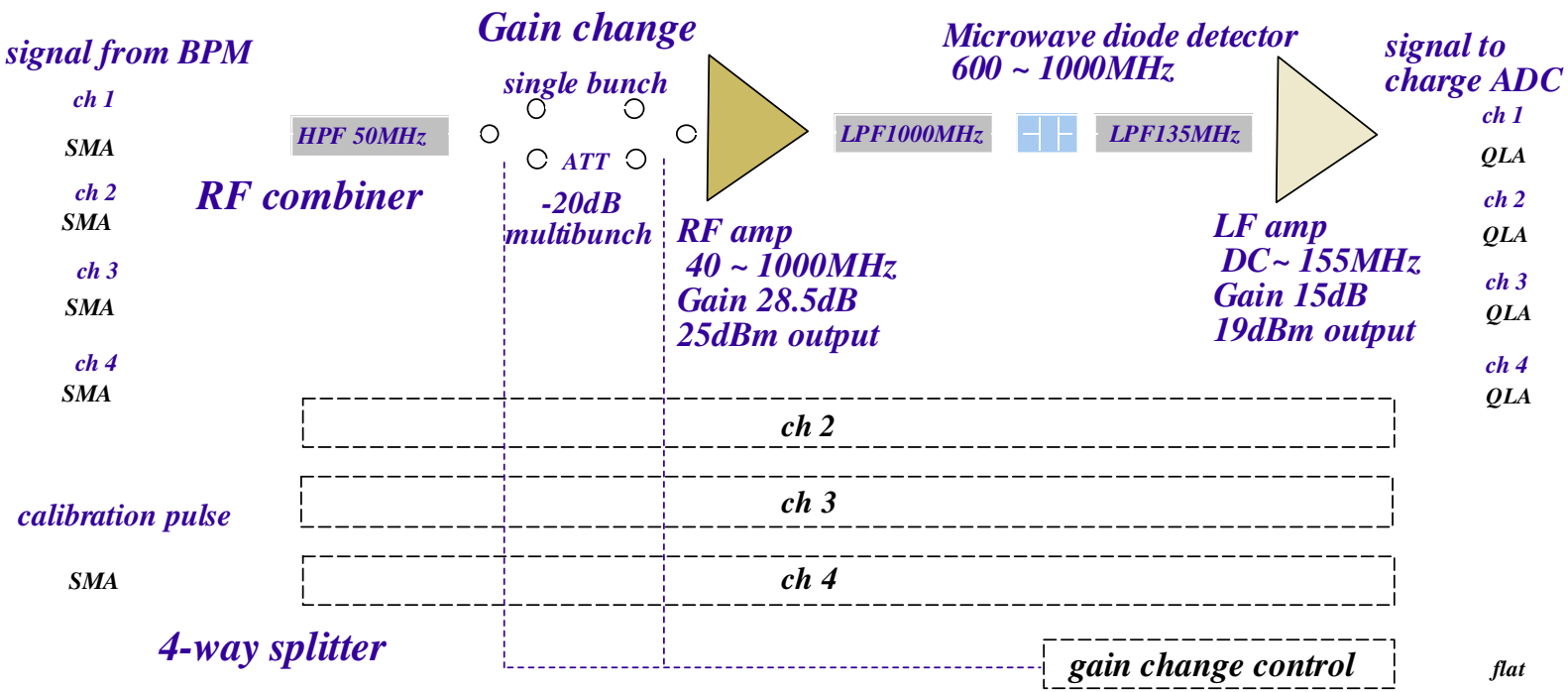
Signal peak at ~ 1GHz

Resolution Improvement



Min. resolution ~ 2μm

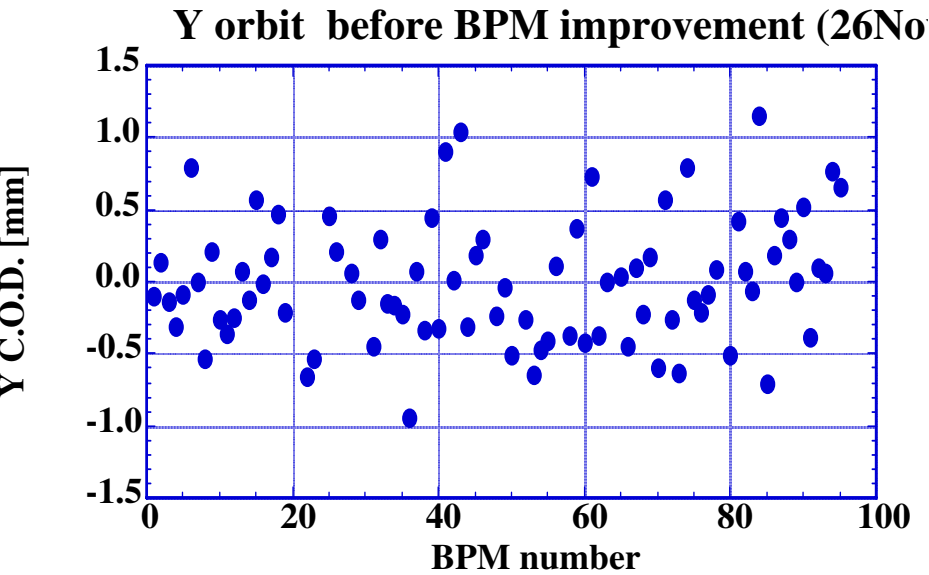
BPM electronics improvement

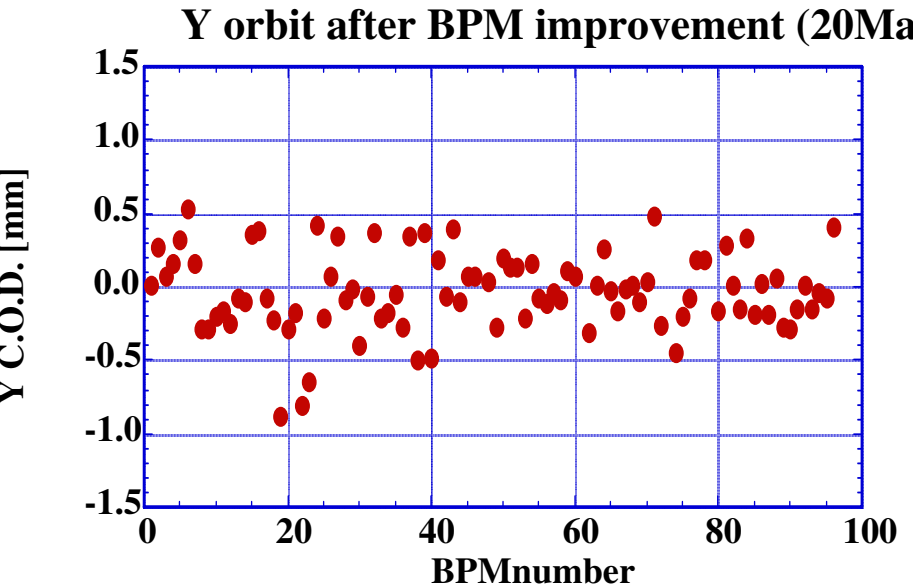


Improved BPM Circuit (simplified diagram)

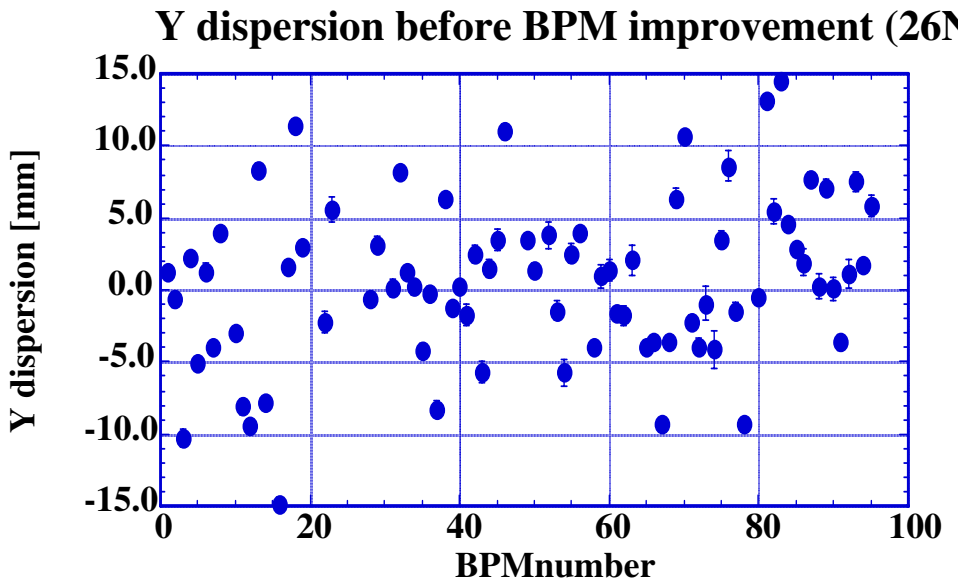
Electronics: 40MHz - 1GHz BW,
base line clip & low noise LF amp
min. resolution ~2μm

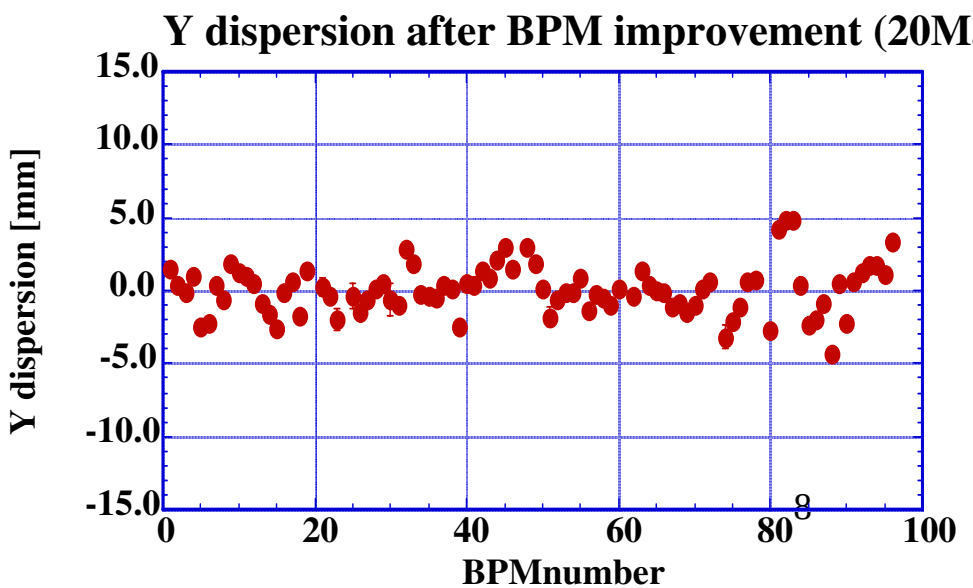
Vertical orbit Improvement



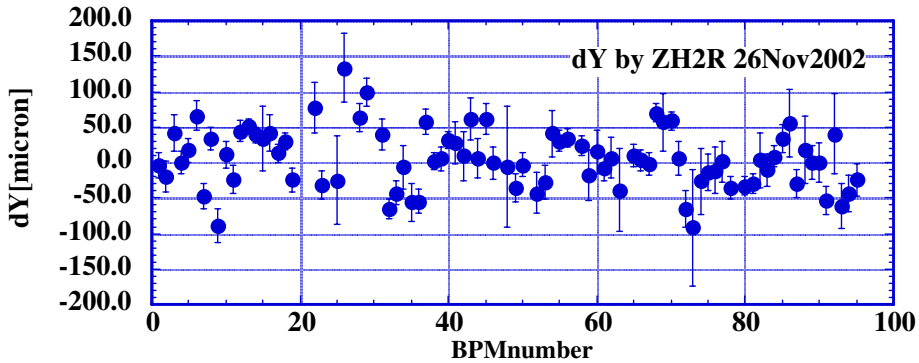


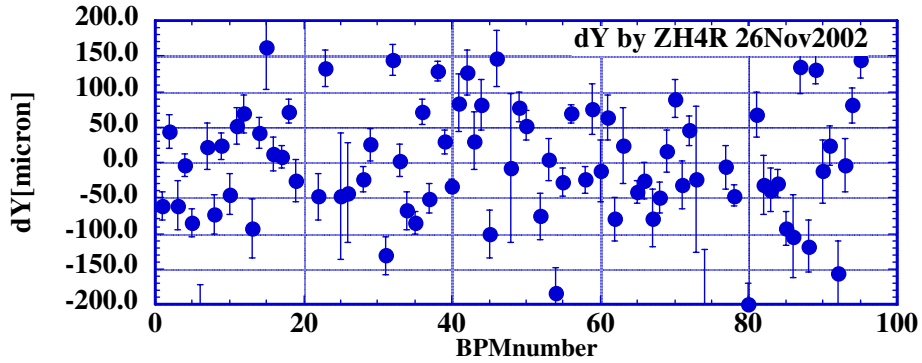
Vertical dispersion Improvement

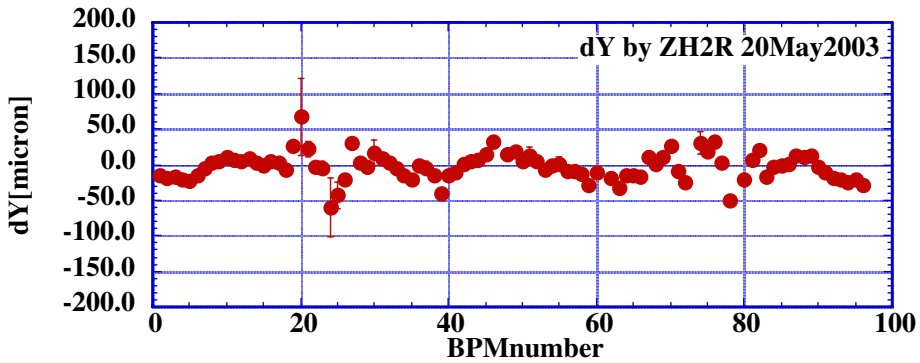


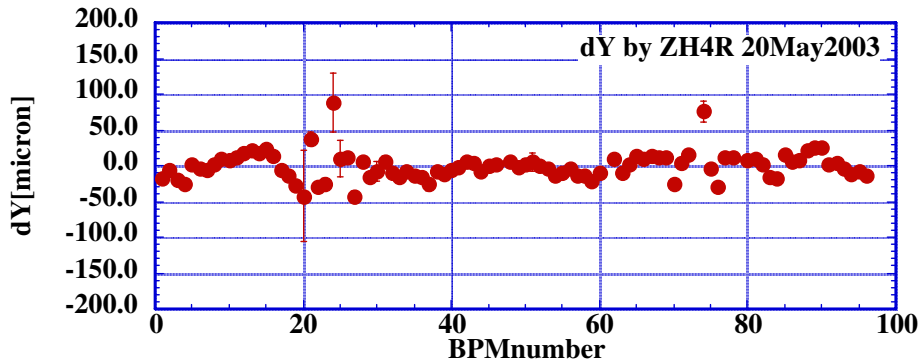


X to Y coupling Improvement

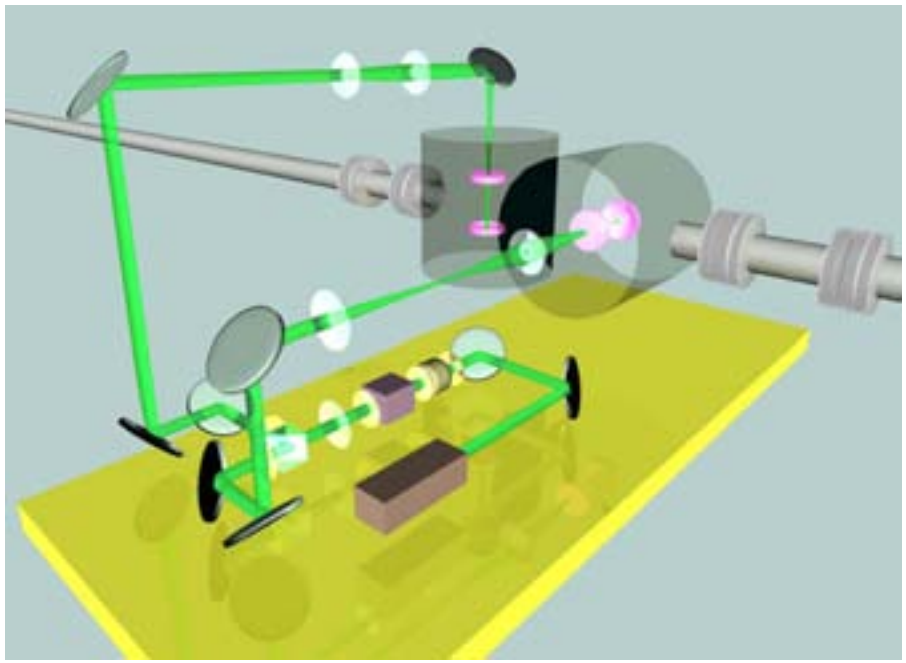








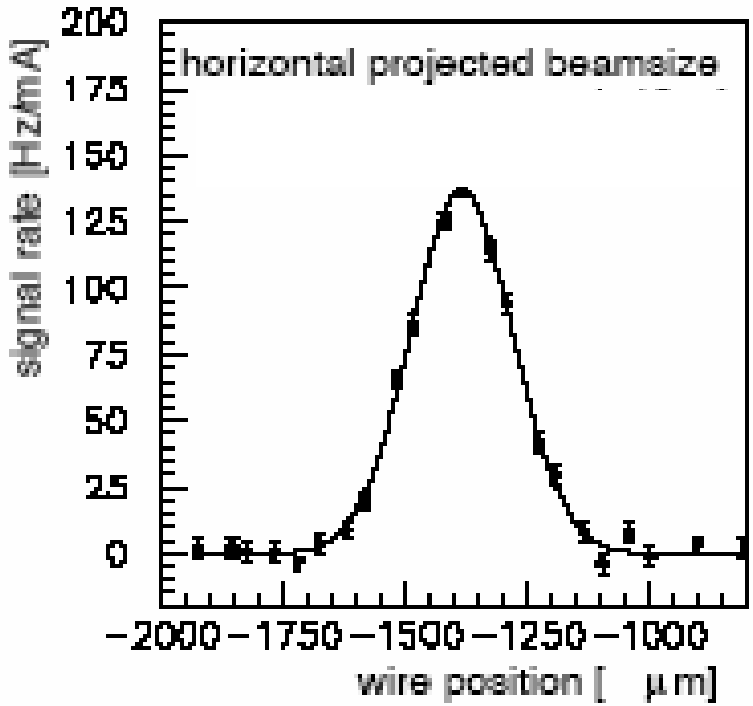
Laser wire beam size monitor in DR

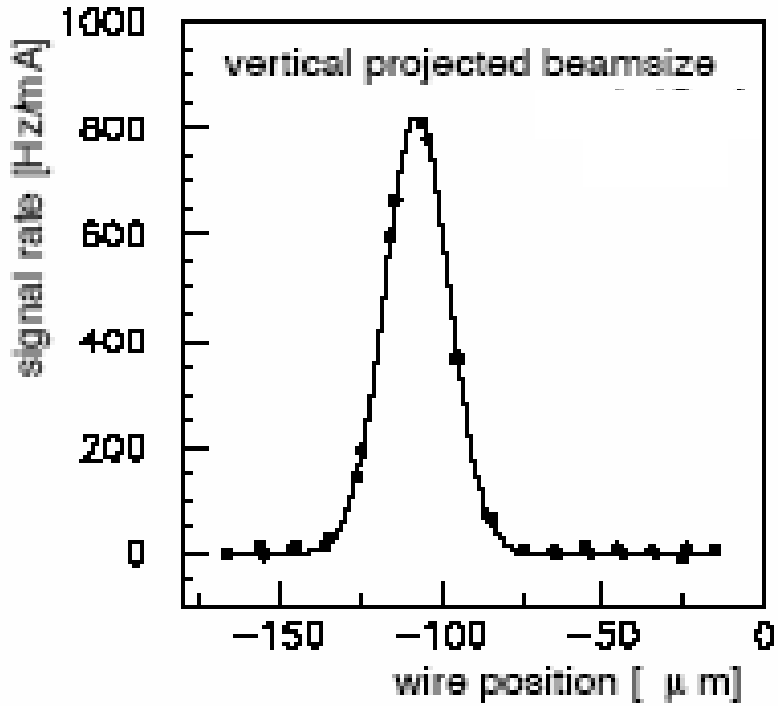


300mW 532nm Solid-state Laser Fed into optical cavity

14.7μm laser wire for X scan 5.7μm for Y scan (whole scan: 15min for X, 6min for Y)

Beam profile by Laser wire



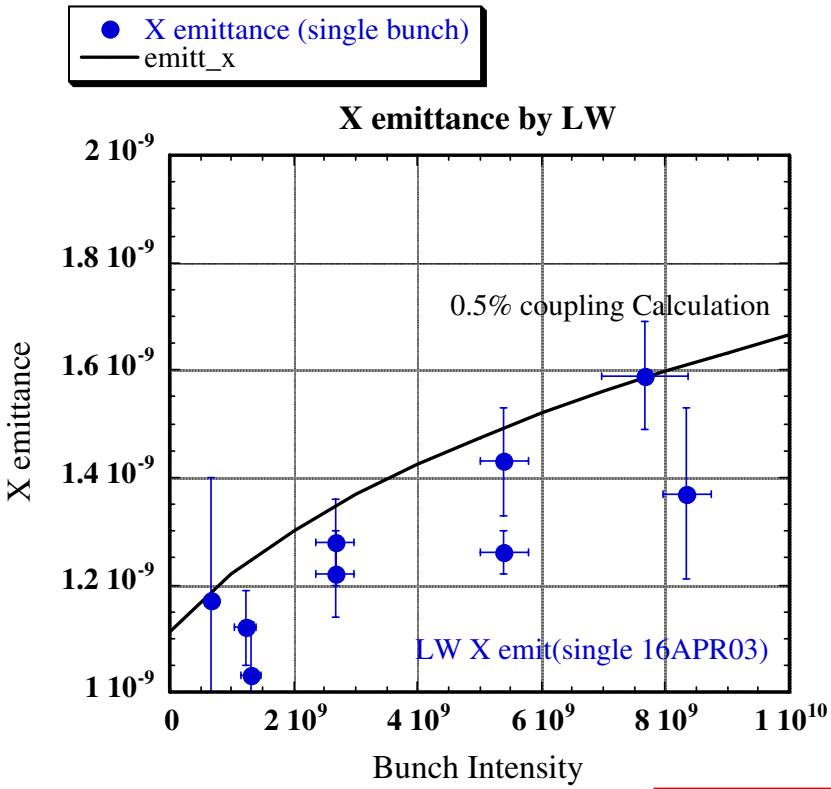


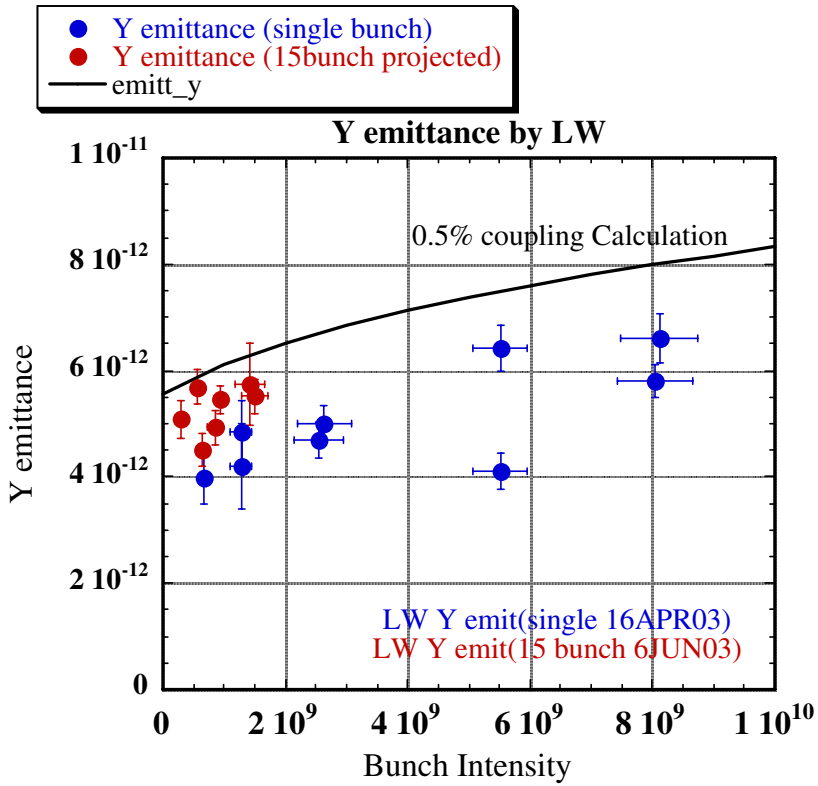
$$\sigma_e^2 = \sigma_{\mathrm{meas}}^2 - \sigma_{lw}^2$$

$$\varepsilon\beta = \sigma_e^2 - [\eta(\Delta p/p)]^2$$

β:*measured by Q-trim excitation*

Emittance by Laser wire





< 0.5% y/x emittance ratio

Y emittance =4pm at small intensity

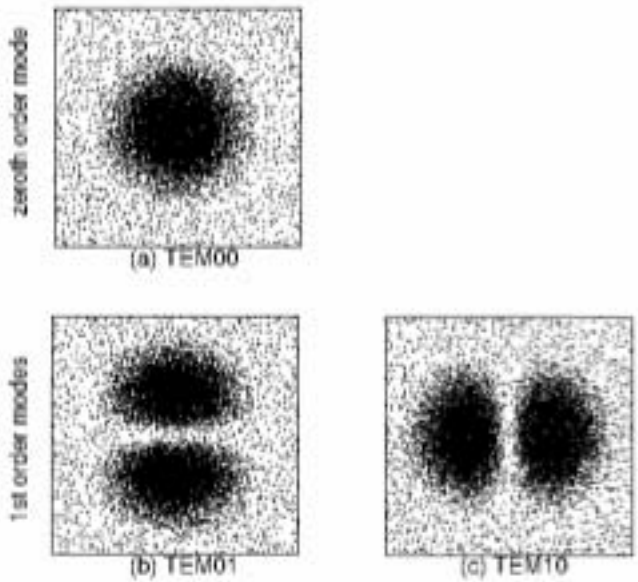
VOLUME 92, NUMBER 5 PHYSICAL REVIEW LETTERS week ending 6 FEBRUARY 2004

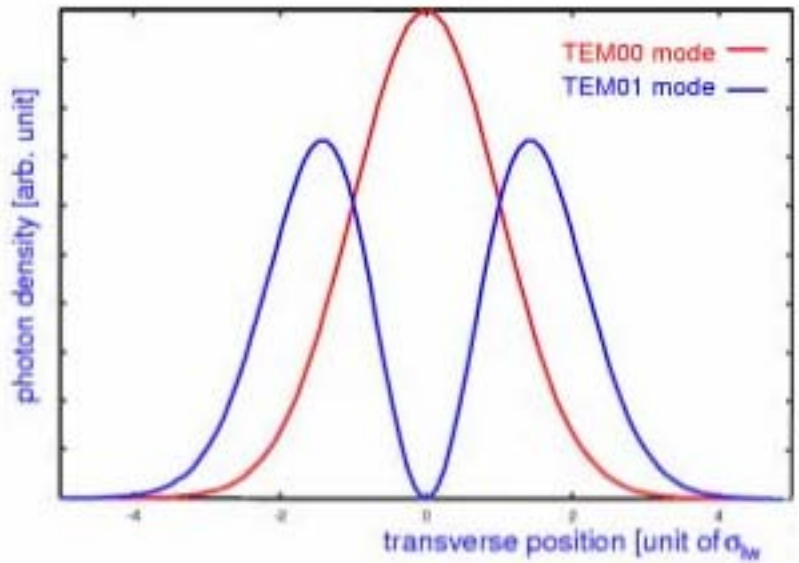
Achievement of Ultralow Emittance Beam in the Accelerator Test Facility Damping Ring

Y. Honda,[1] K. Kubo,[2] S. Anderson,[3] S. Araki,[2] K. Bane,[3] A. Brachmann,[3] J. Frisch,[3] M. Fukuda,[6] K. Hasegawa,[14] H. Hayano,[2] L. Hendrickson,[3] Y. Higashi,[2] T. Higo,[2] K. Hirano,[13] T. Hirose,[15] K. Iida,[12] T. Imai,[9] Y. Inoue,[7] P. Karataev,[6] M. Kuriki,[2] R. Kuroda,[8] S. Kuroda,[2] X. Luo,[11] D. McCormick,[3] M. Matsuda,[10] T. Muto,[2] K. Nakajima,[2] Takashi Naito,[2] J. Nelson,[3] M. Nomura,[13] A. Ohashi,[6] T. Omori,[2] T. Okugi,[2] M. Ross,[3] H. Sakai,[12] I. Sakai,[13] N. Sasao,[1] S. Smith,[3] Toshikazu Suzuki,[2] M. Takano,[13] T. Taniguchi,[2] N. Terunuma,[2] J. Turner,[3] N. Toge,[2] J. Urakawa,[2] V. Vogel,[2] M. Woodley,[3] A. Wolski,[4] I. Yamazaki,[8] Yoshio Yamazaki,[2] G. Yocky,[3] A. Young,[3] and F. Zimmermann[5]

higher mode laserwire

- use TEM01 resonance mode in an optical cavity as a laserwire

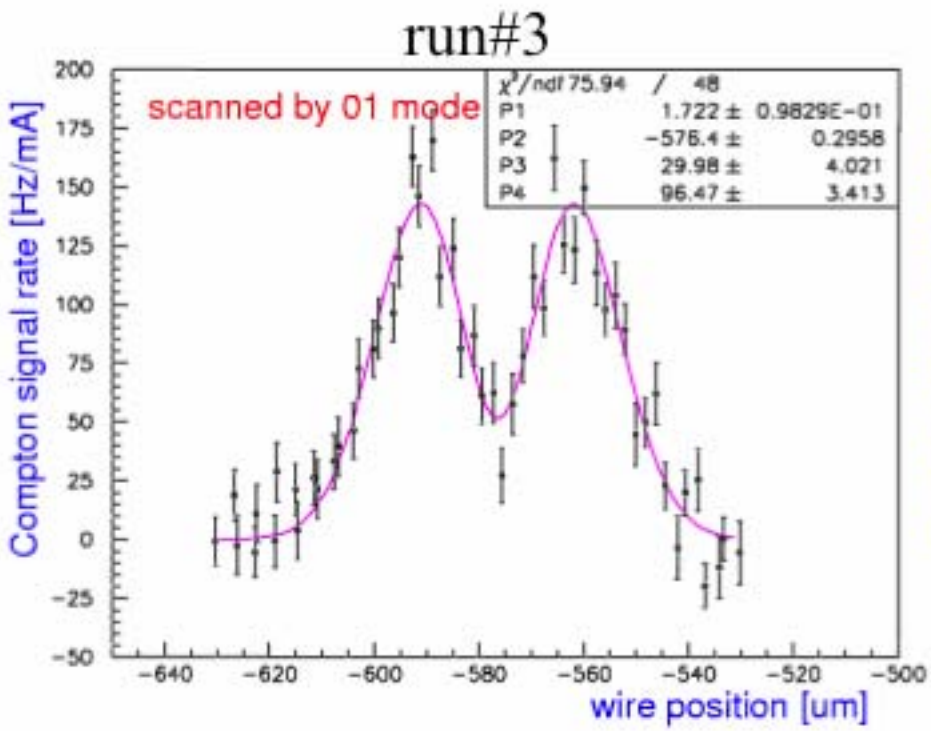


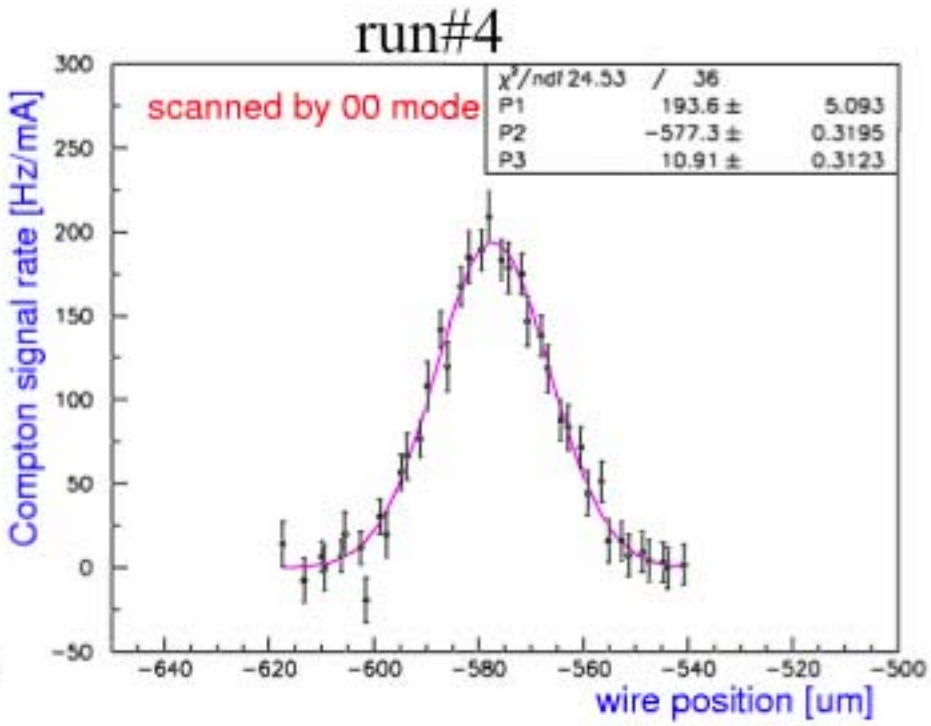


TEM01 mode has two lobe and a node

beam experiment

- normal beam

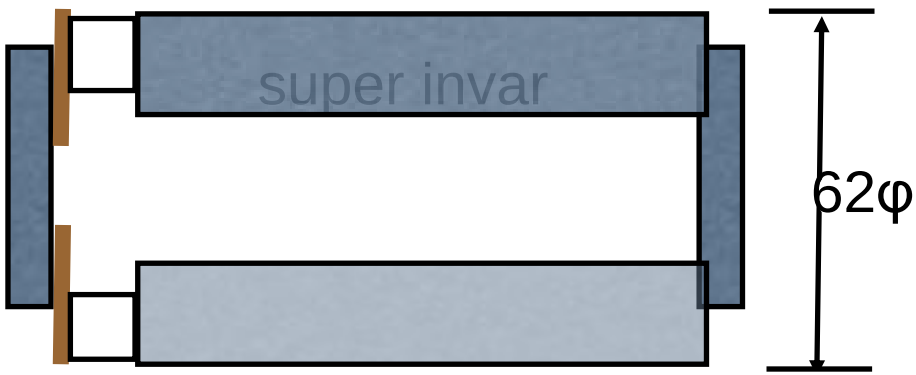


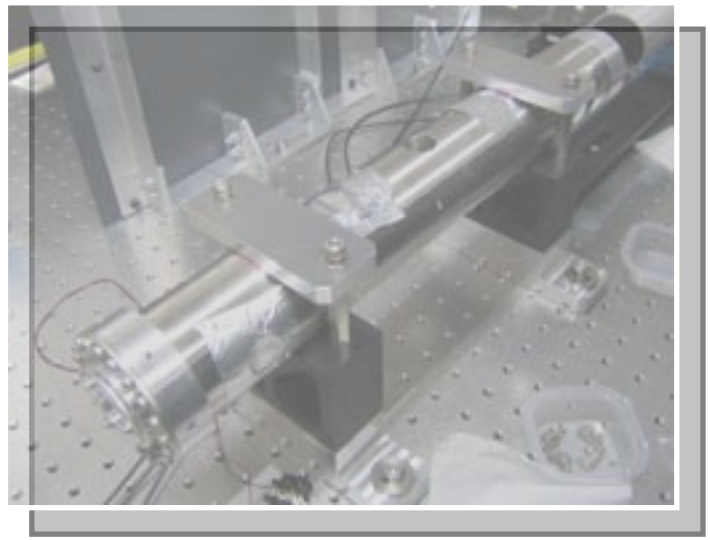


Pulse Laser Storage

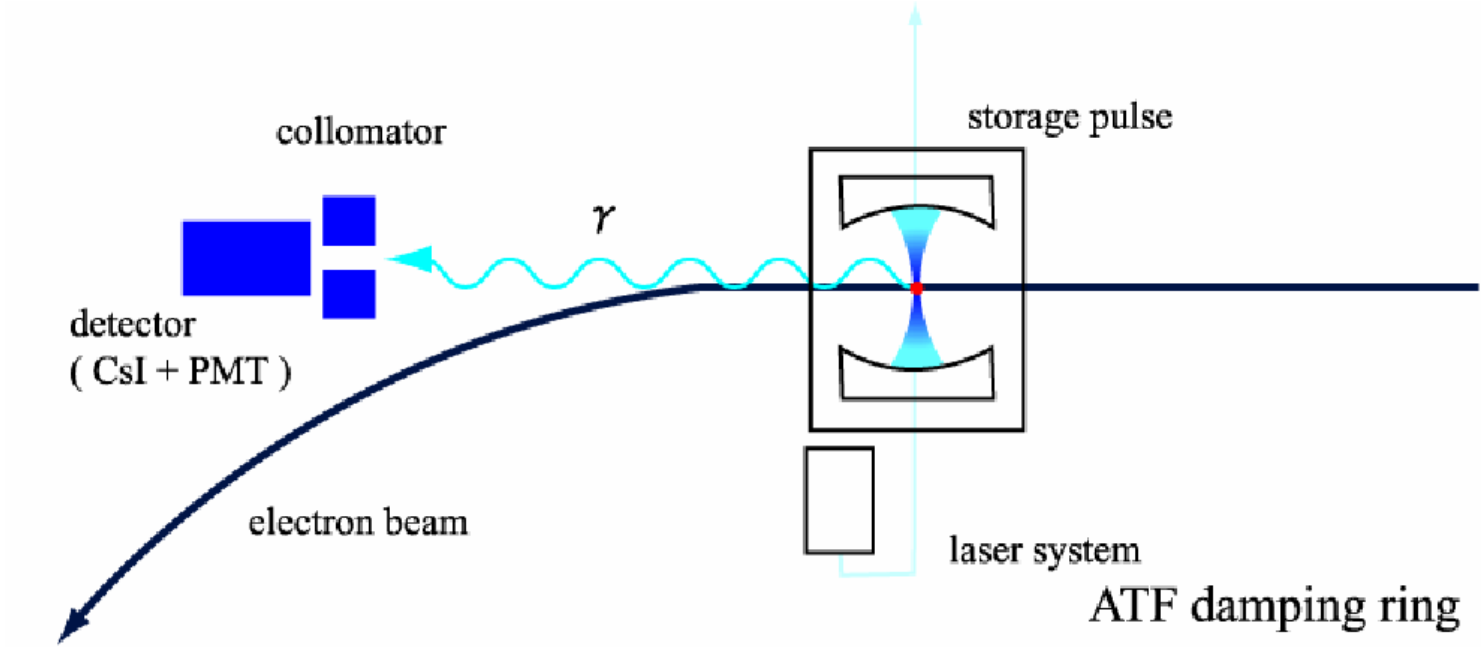
Ext. Cavity:

Cavity:	Super Invar
Cavity length:	0.42 m
Mirrors:	
Reflectivity:	99.7%, 99.9%
Curvature:	250 mm (ω_0 = 180μm)





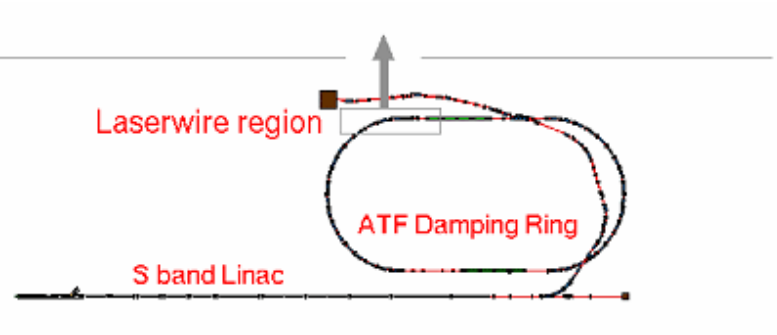
Plused Laser and Electron Beam Collision to measure bunch length



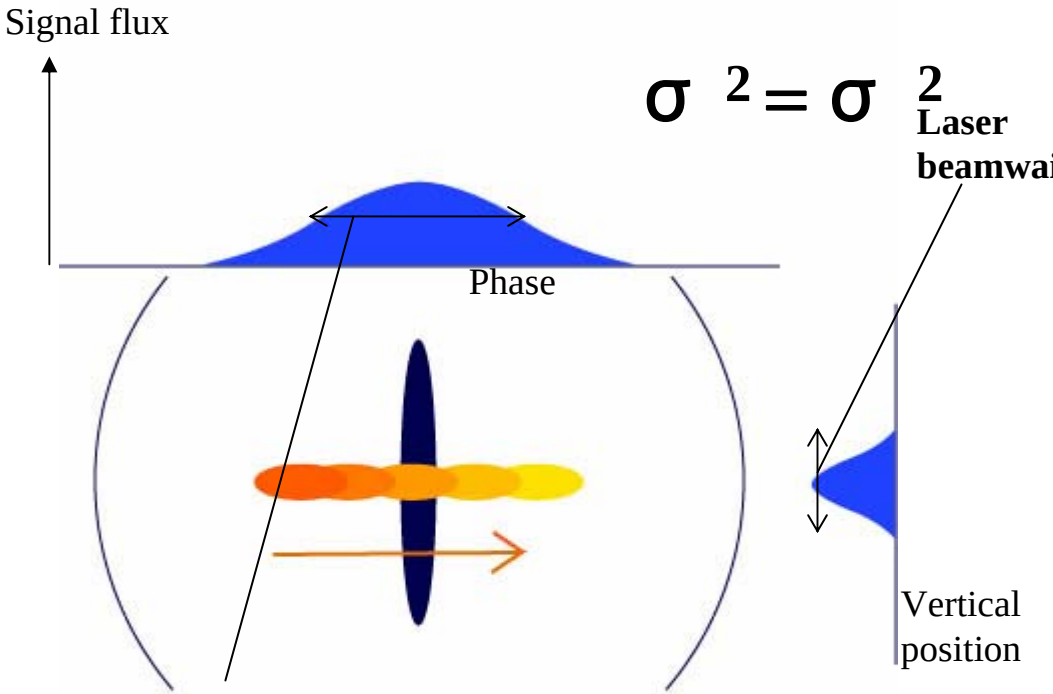
Pulse Laser Wire

(Storage laser pulses in optical cavity):

The systems for New X-ray source & New bunch length monitor at a storage ring



Count rate & Measurement



$$\sigma^2 = \sigma^2_{\text{Laser beamwaist}} + \sigma^2_{\text{e- v-beamwaist}}$$

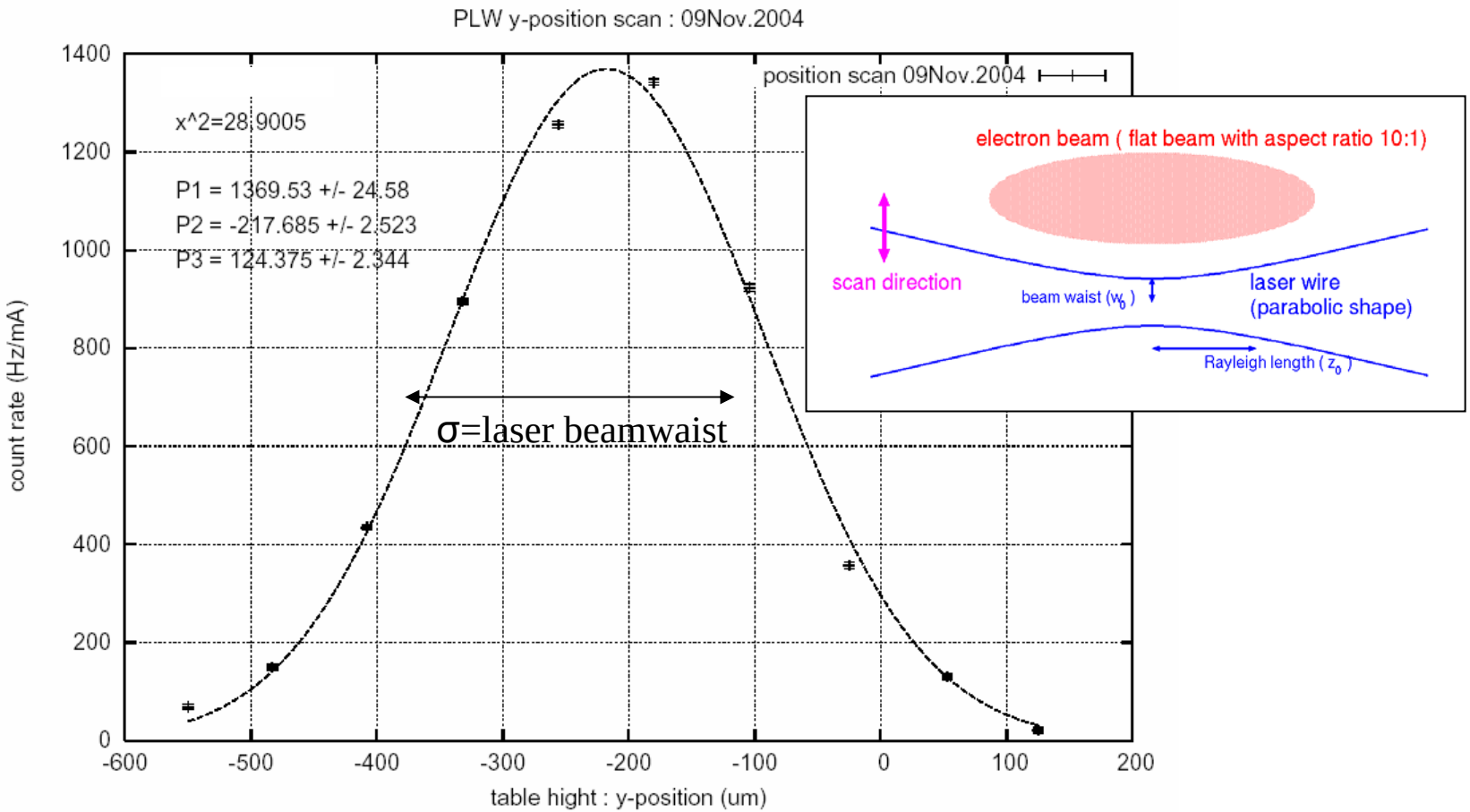
Suppose both electron bunch and laser pulses have a Gaussian intensity distribution, the measured profile is also a Gaussian shape.

$$\sigma^2 = \sigma^2_{\text{Laser pulse width}} + \sigma^2_{\text{e- bunch length}} + \sigma^2_{\text{Laser beamwaist}} + \sigma^2_{\text{e- h-beamsize}}$$

$$\sim \sigma^2_{\text{e- bunch length}}$$

The electron bunch length is 20 ~ 40 psec (10mm)
Laser pulse width (FWHM =7 psec ; 1 mm)
Laserwire beamwaist(120μm), electron's horizontal beamsize (100μm)

Count rate

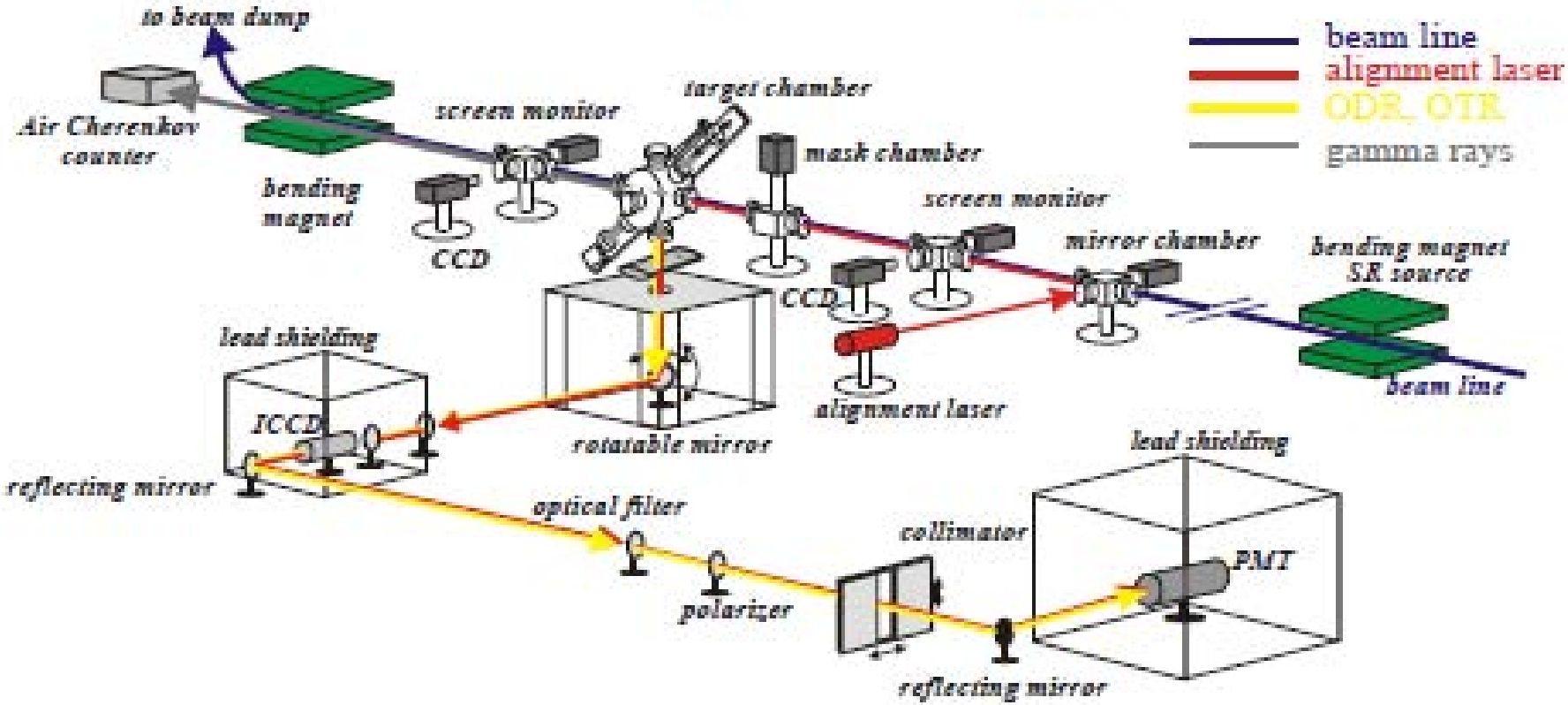


Calculated maximum count rate is ~ 2500 [Hz/mA] .

Actual count rate is ~ 1500 because of imperfectly adjustment cavity length with shoulder feedback system.

ODR Beam Size Monitor

Modified experimental layout



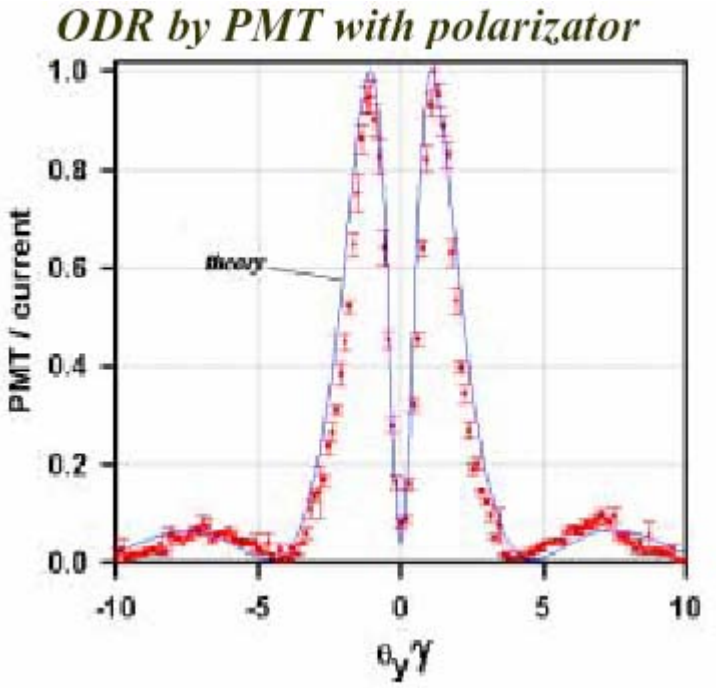
Target to ICCD distance = 1.9m
Lens f = 150mm

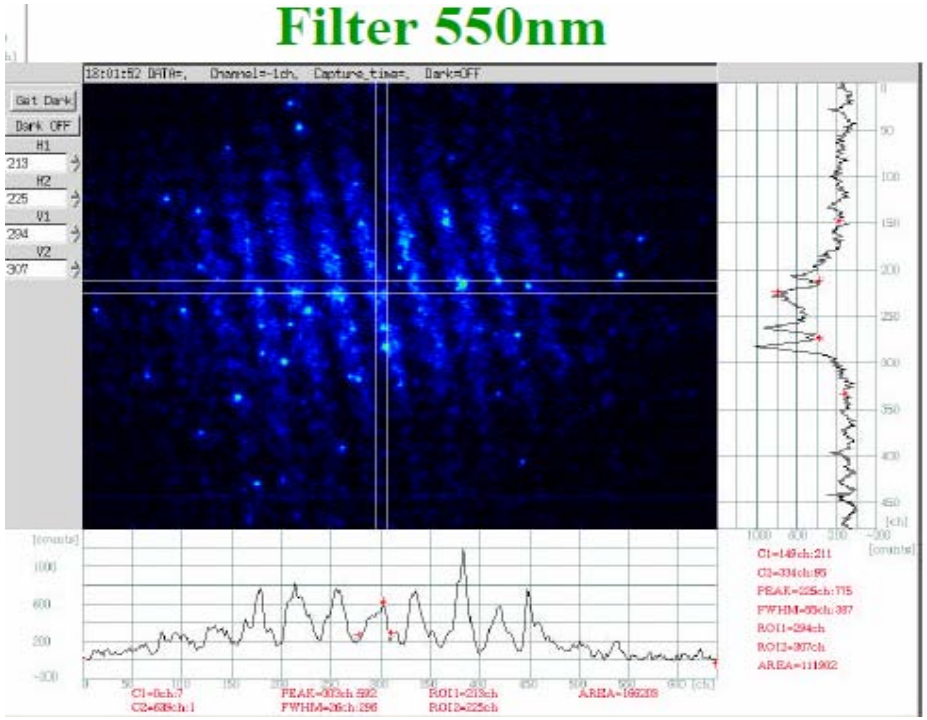
Target parameters: $2\alpha = 6.2\text{mrad}$

$a_{in} = 420\mu\text{m}$

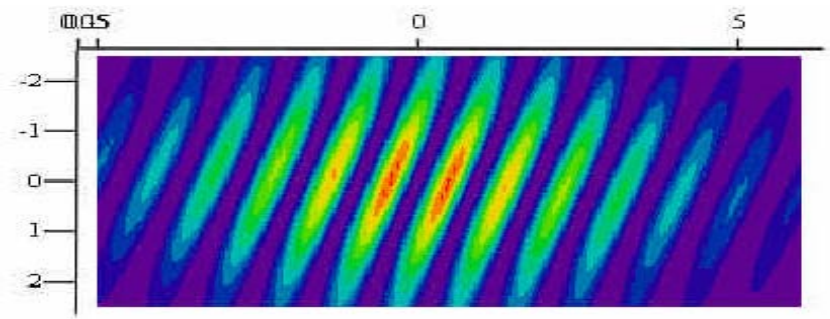
Multi-shots Measurement

Single-shot Measurement



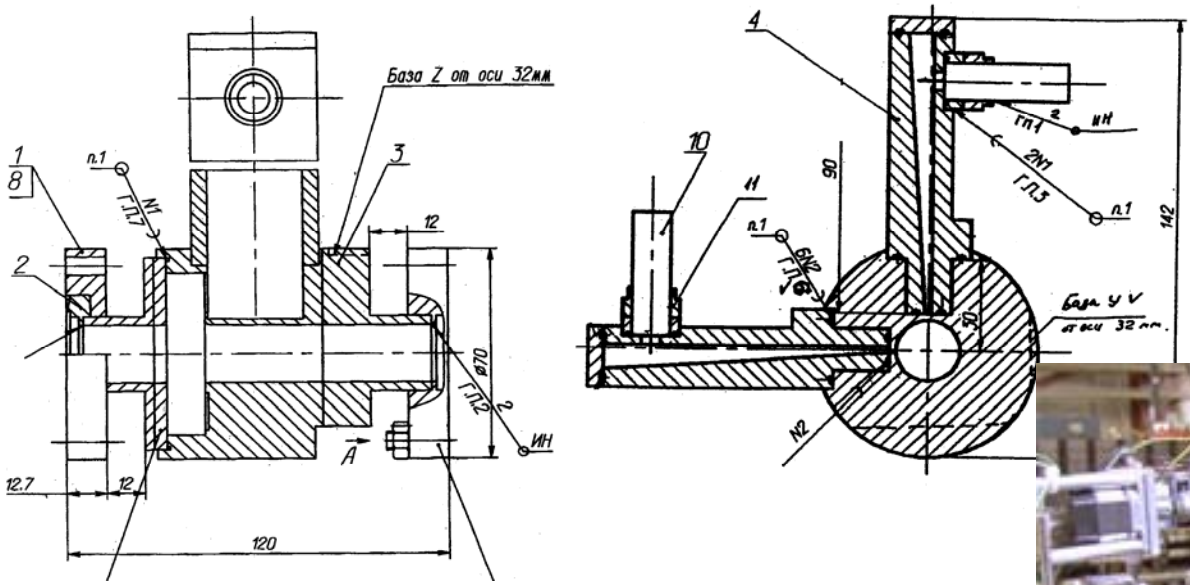


We are planning to finish this study until mid. of next year successfully.



Example of Calculation

3 BPM setup for nm resolution study



June 2003

f = 6.426GHz

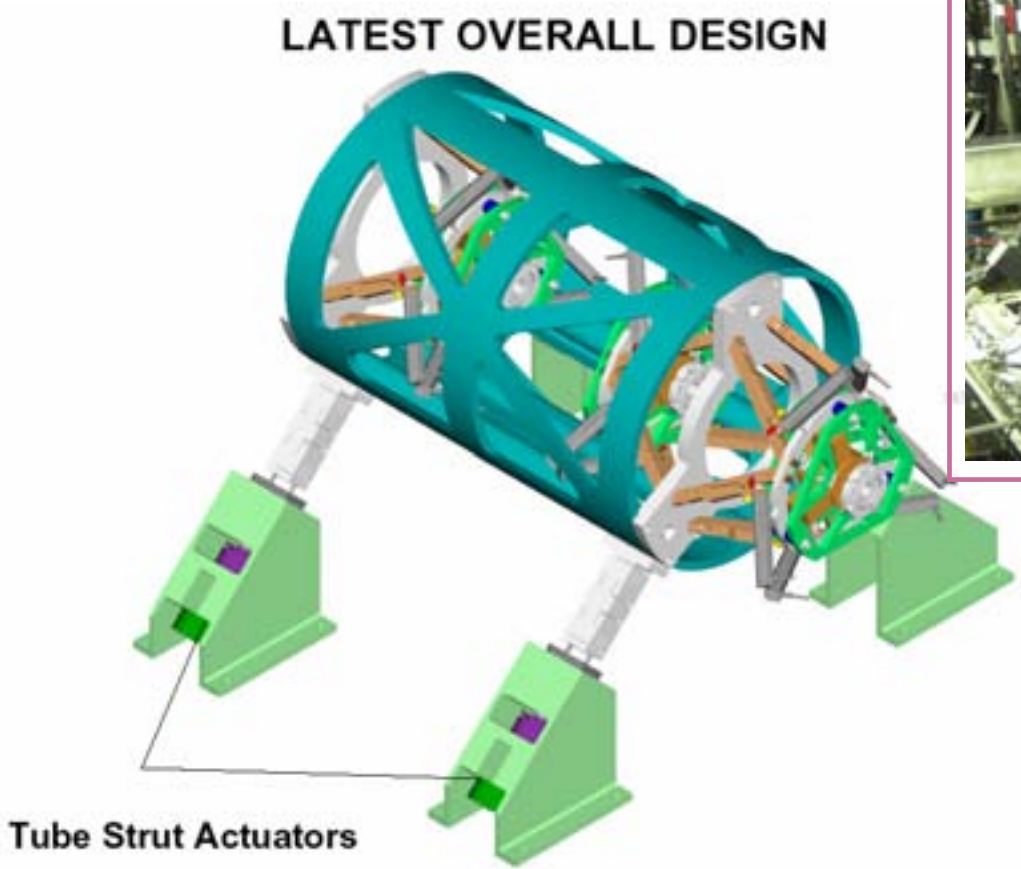
TM110 mode, single port coupling

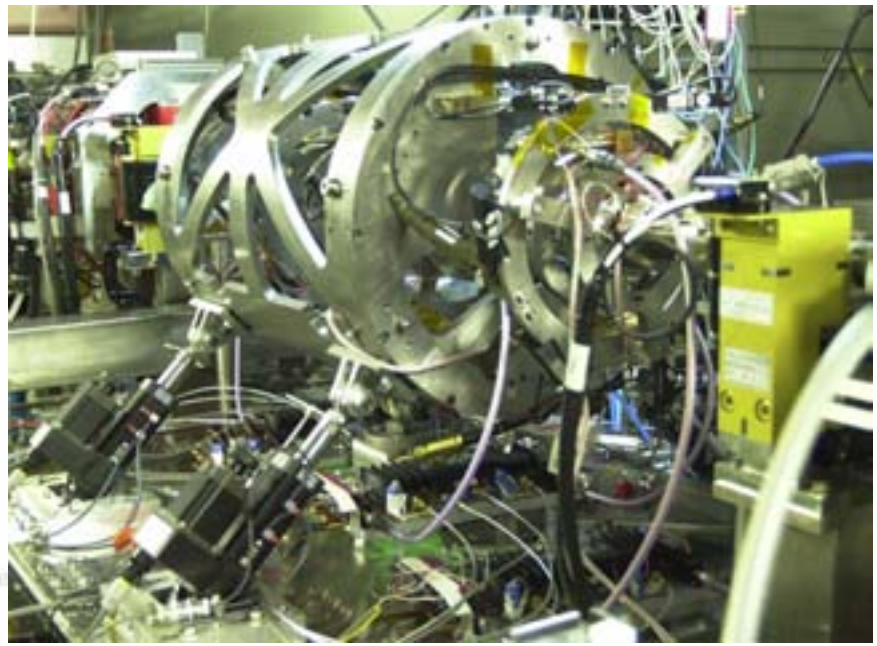
Achieved highest resolution 20 nm

Mover stage step 0.25μm(X) 0.37μm(Y)

With cavity tilt-mover

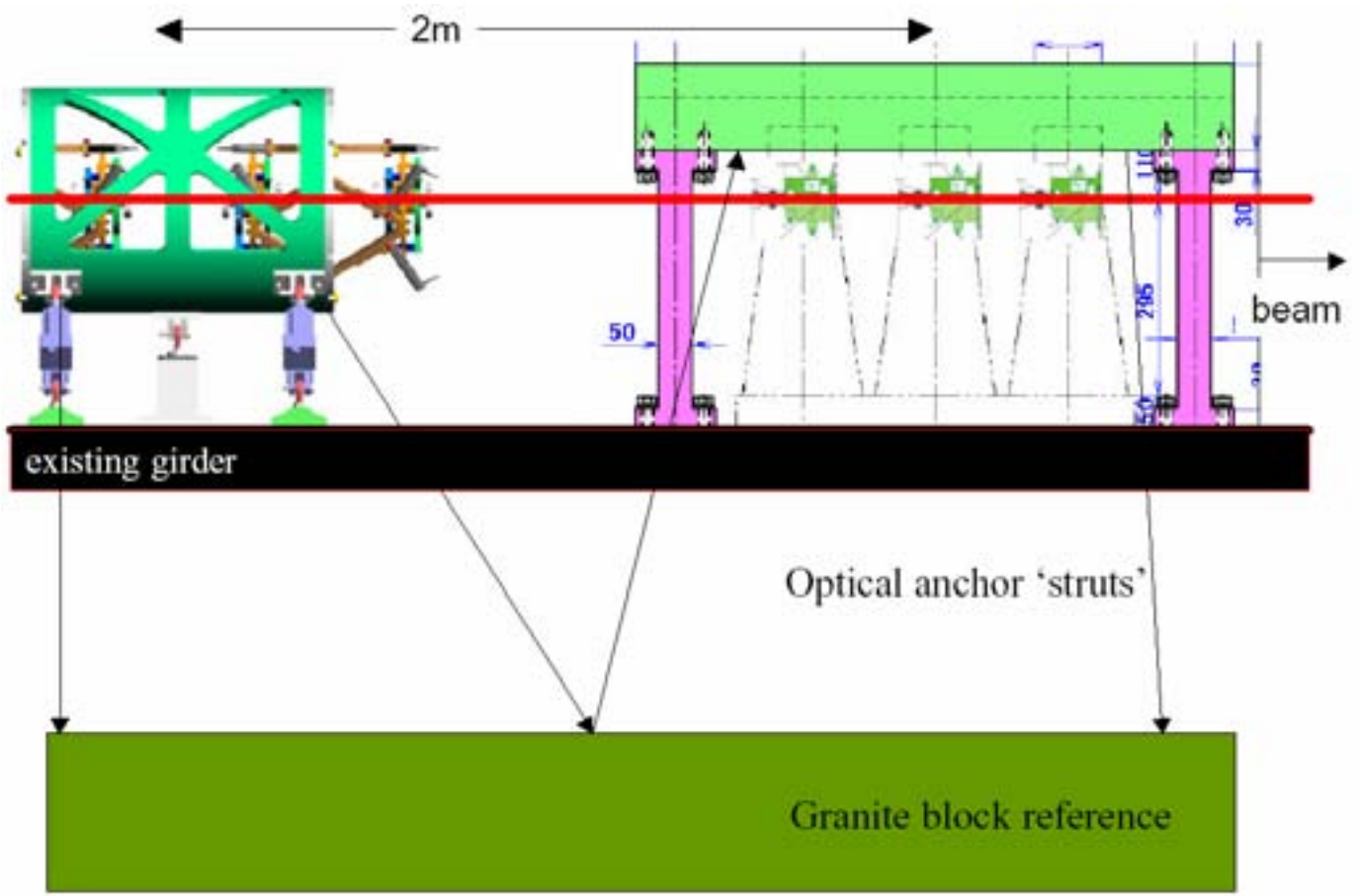
New precise Mover for nm resolution study





LLNL Design mover, Improved electronics, installed Mar. 2004

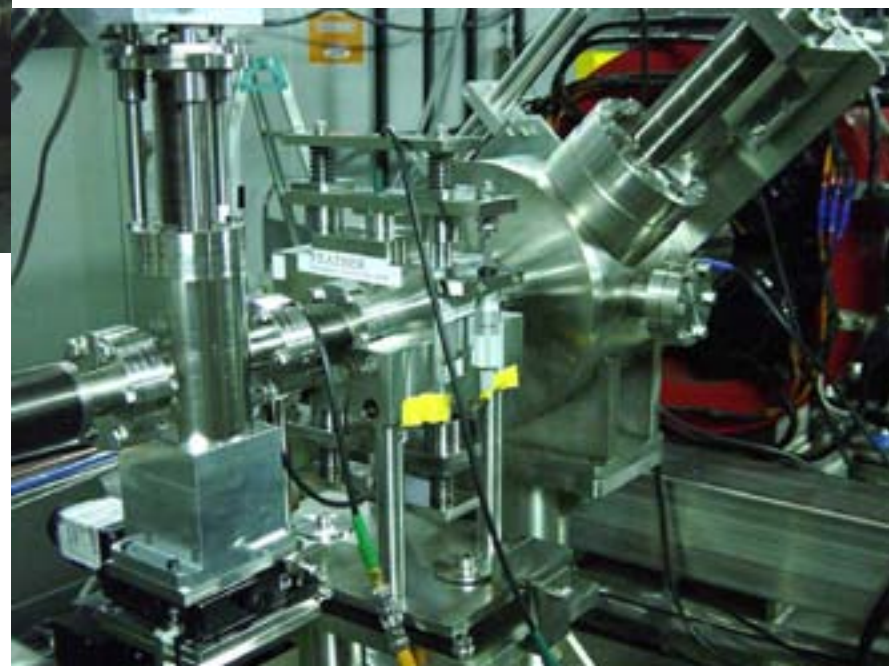
Nano-BPM project is on going in the frame of International Collaboration at ATF-EXT.



Beam orbit stabilization is necessary within 1μm.

New precise kicker & BPM for nm position feedback control study

FEATHER stripline Kicker



FEATHER BPM

Beam dynamics Study with wigglers

- Four wigglers(2m long) are turned on and 600A supplied to main coil with correction electric loads.
- The damping times and emittances were measured. We confirmed the consistency with calculation values.
- **Beam dynamics study with wigglers using fast kicker and turn-by-turn BPM.**