

# Research and Development Status and Programs for ILC at KEK-ATF

We are going to research and develop on advanced accelerator technology under International Collaboration (ATF-MoU) for ILC at KEK-ATF. I will report the highlight of present research programs and prospect the future, especially the results of ATF2 project in 2008.

Junji Urakawa (KEK)  
at Oxford, 10/27

# *ATF Status and Prospect*

*Emittance status,*

*BPM Improvement,*

*Laser wire results,*

*Pulsed laser wire development,*

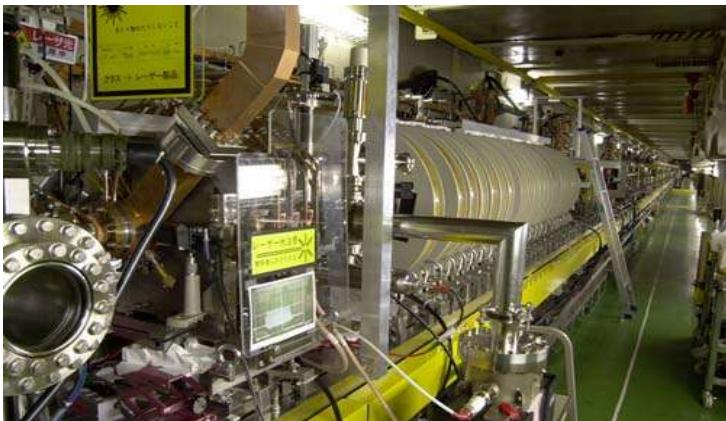
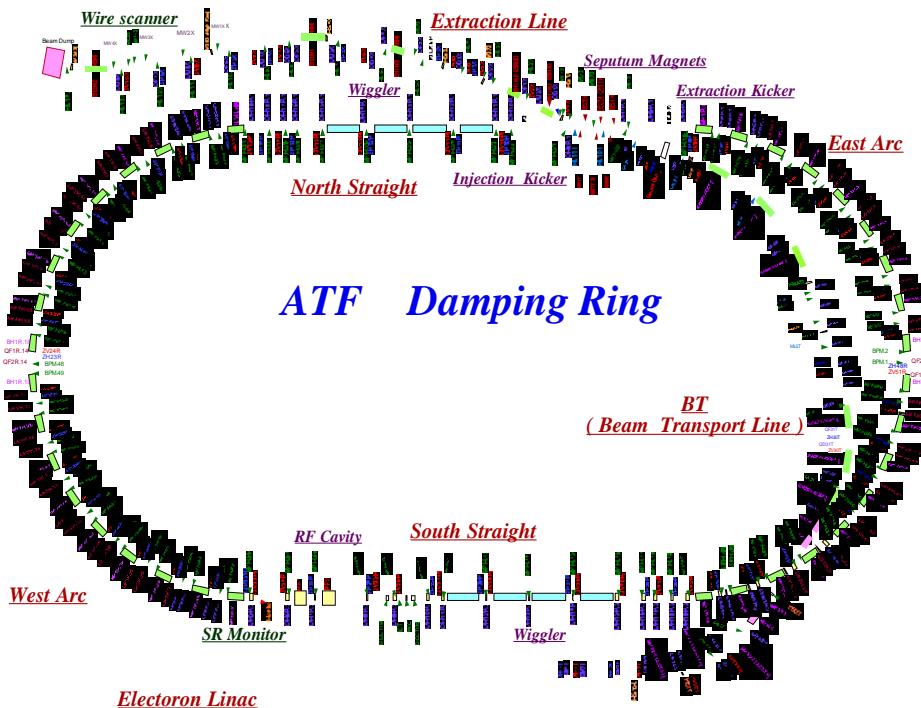
*ODR monitor results,*

*Fast kicker R&D,*

*Laser Interferometer in an Optical Cavity*

*New device for nm beam control.*

# ATF Introduction



$E=1.28\text{GeV}$   
 $N_e=1 \times 10^{10} e^-/\text{bunch}$

$1 \sim 20 \text{ bunches}$   
 $Rep=3.125\text{Hz}$   
 $X \text{ emit}=2.5 \times 10^{-6}$   
 $Y \text{ emit}=1.25 \times 10^{-8}$   
as normalized emittance<sup>3</sup>

# *Multibunch emittance study*

- *Scrubbing of DR was started*

*DR pressure should be  $< 7 \times 10^{-7}$  Pa for 1% emittance ratio for  $1.0 \times 10^{10}$  e<sup>-</sup>, 20 bunches, (=67mA, beam scrubbing with 210mA is necessary.) 0.78Hz repetition*

*so far,  $> 1 \times 10^{-6}$  Pa -  $\rightarrow < 5 \times 10^{-7}$  Pa*

- *Monitors of MB emittance*

*MB (or projected) Laser-wire*

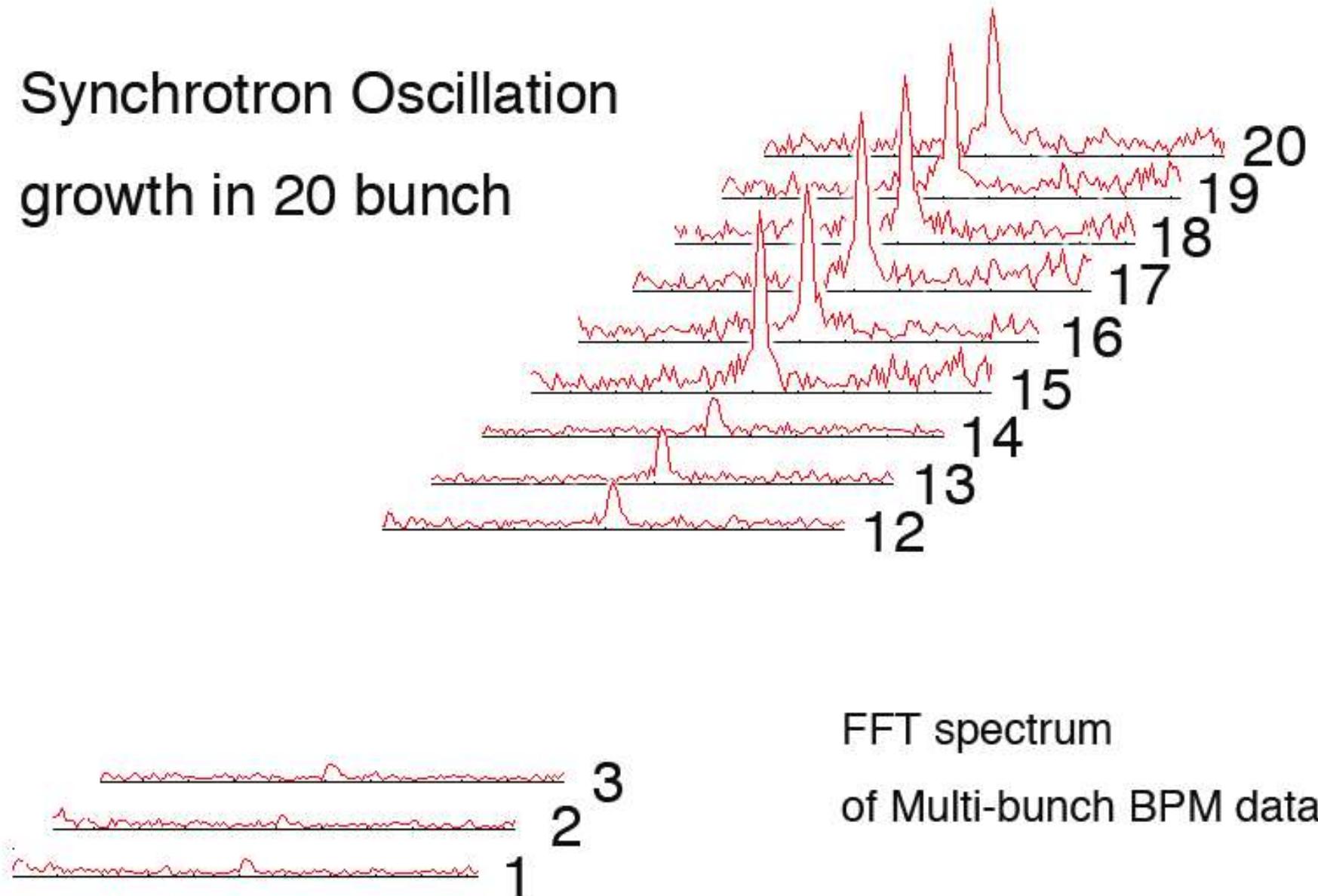
*Projected SR interference monitor, X-ray SR monitor*

*MB (or projected) wire scanner: (**EXT-line coupling problem?**)*

- *Problem of MB emittance*

*Fast Ion Instability ?*

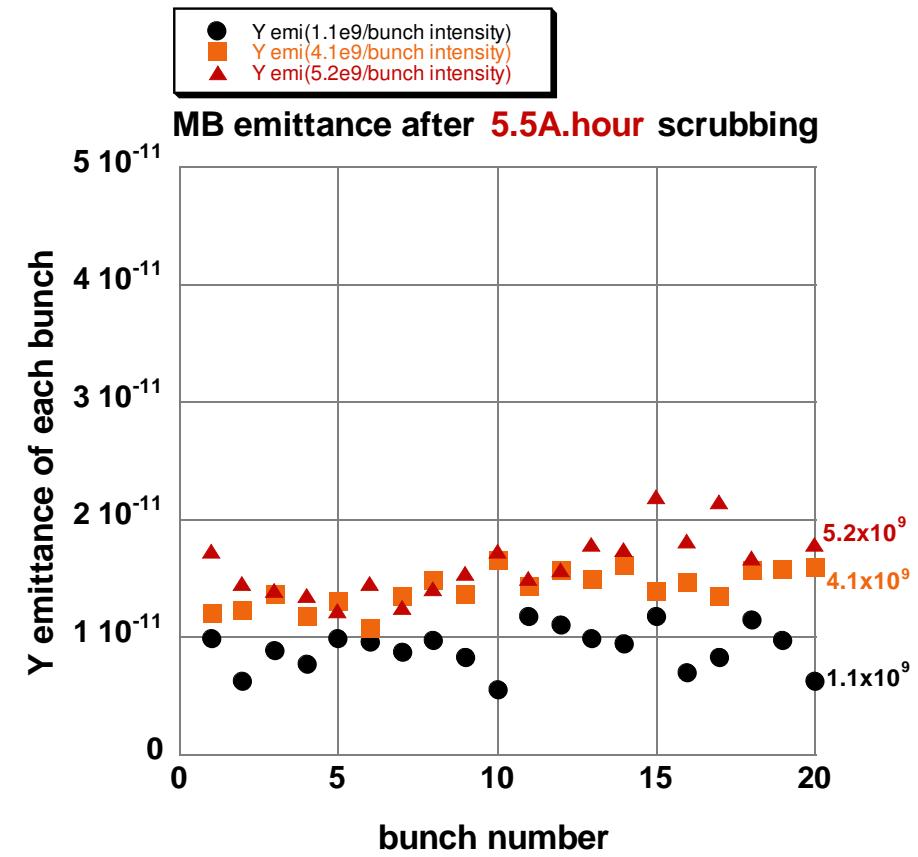
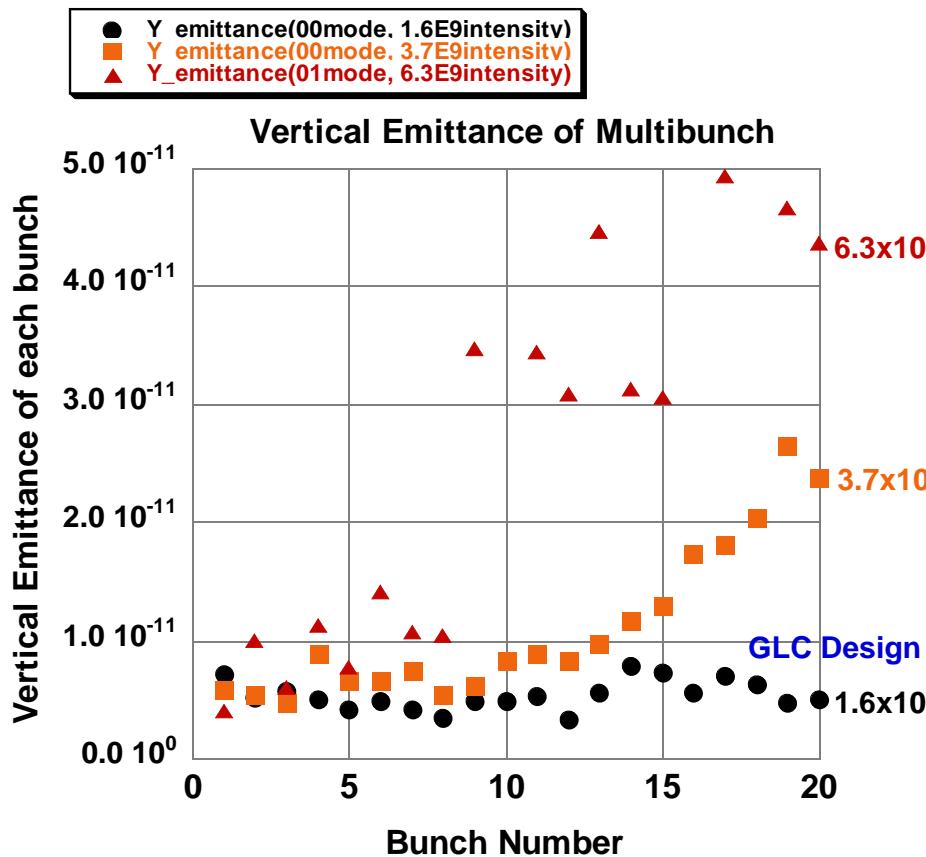
# Synchrotron Oscillation growth in 20 bunch



FFT spectrum  
of Multi-bunch BPM data

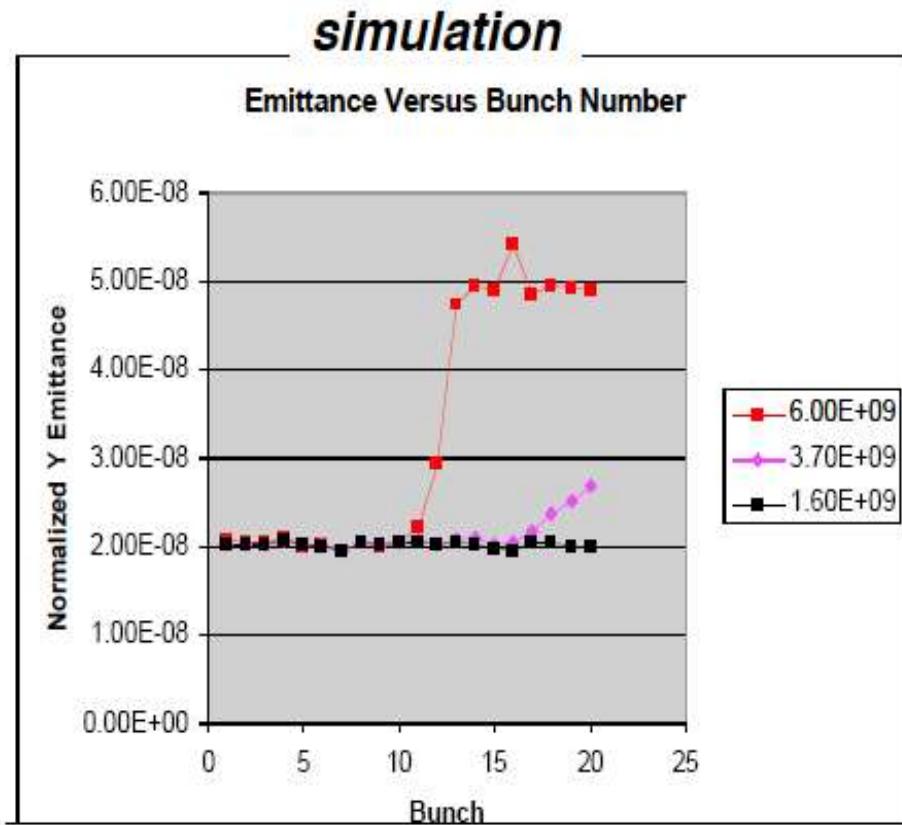
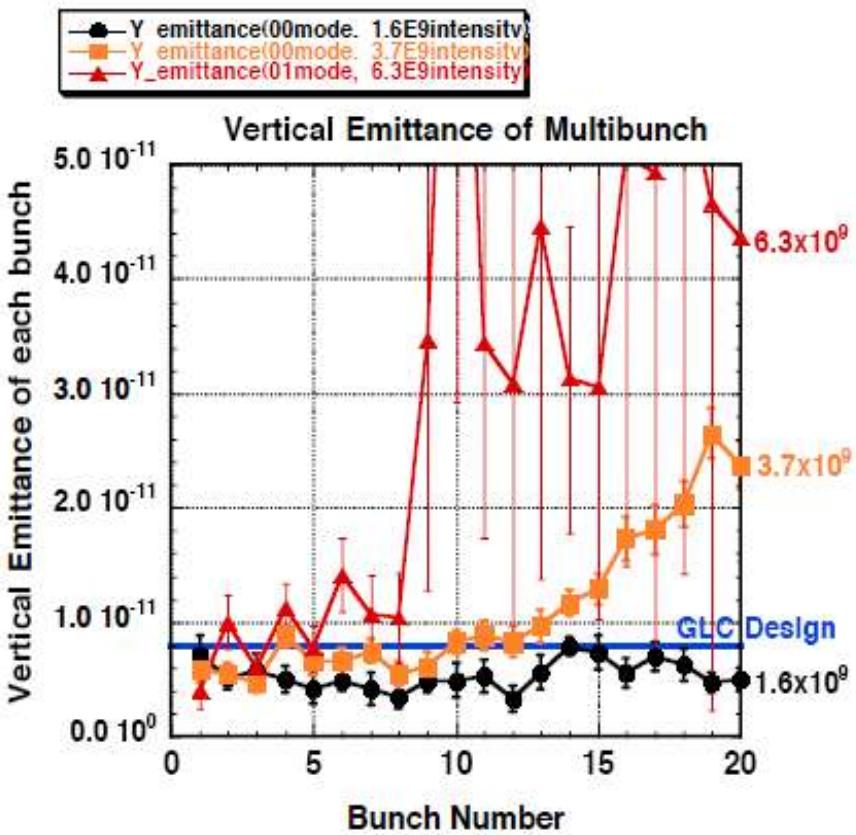
# Fast Ion Instability: Experimental Results at ATF

Required vertical emittance : 2pm rad for ILC

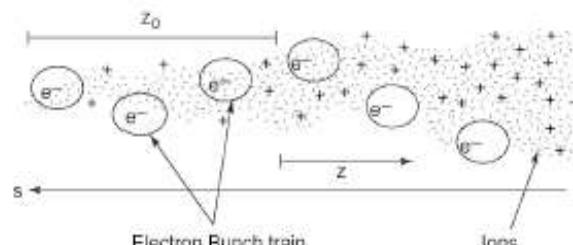


Vacuum Pressure  $< 10^{-8} \text{ Pa}$  (0.1nTorr) in ILC 6

# Preliminary result of Fast Ion Instability simulation

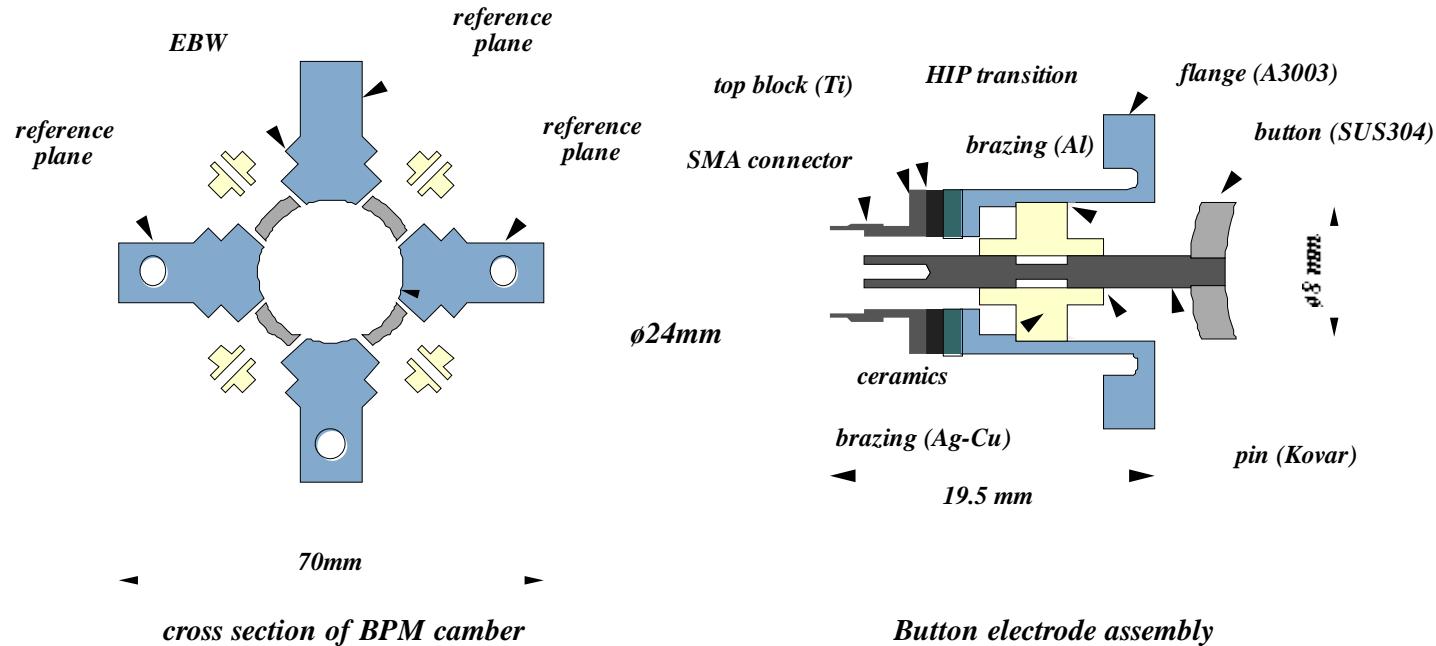


Behavior of Y emittance is very similar.



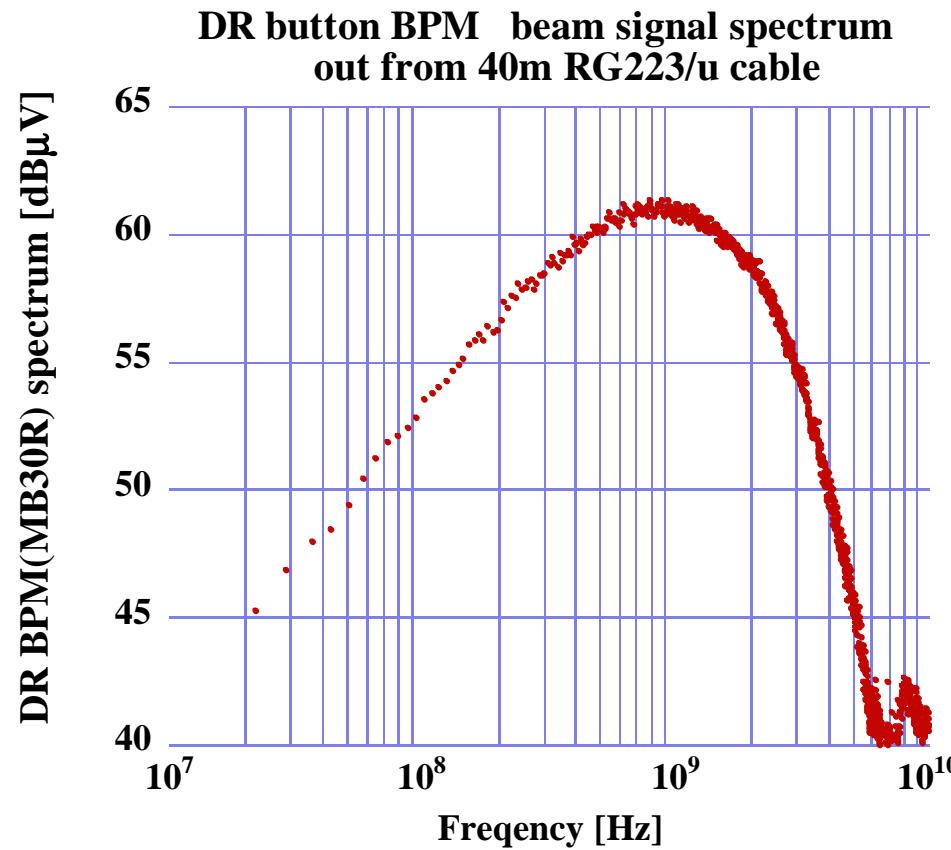
Schematic of the Fast-Beam Ion Instability

# *ATF Damping Ring BPM*



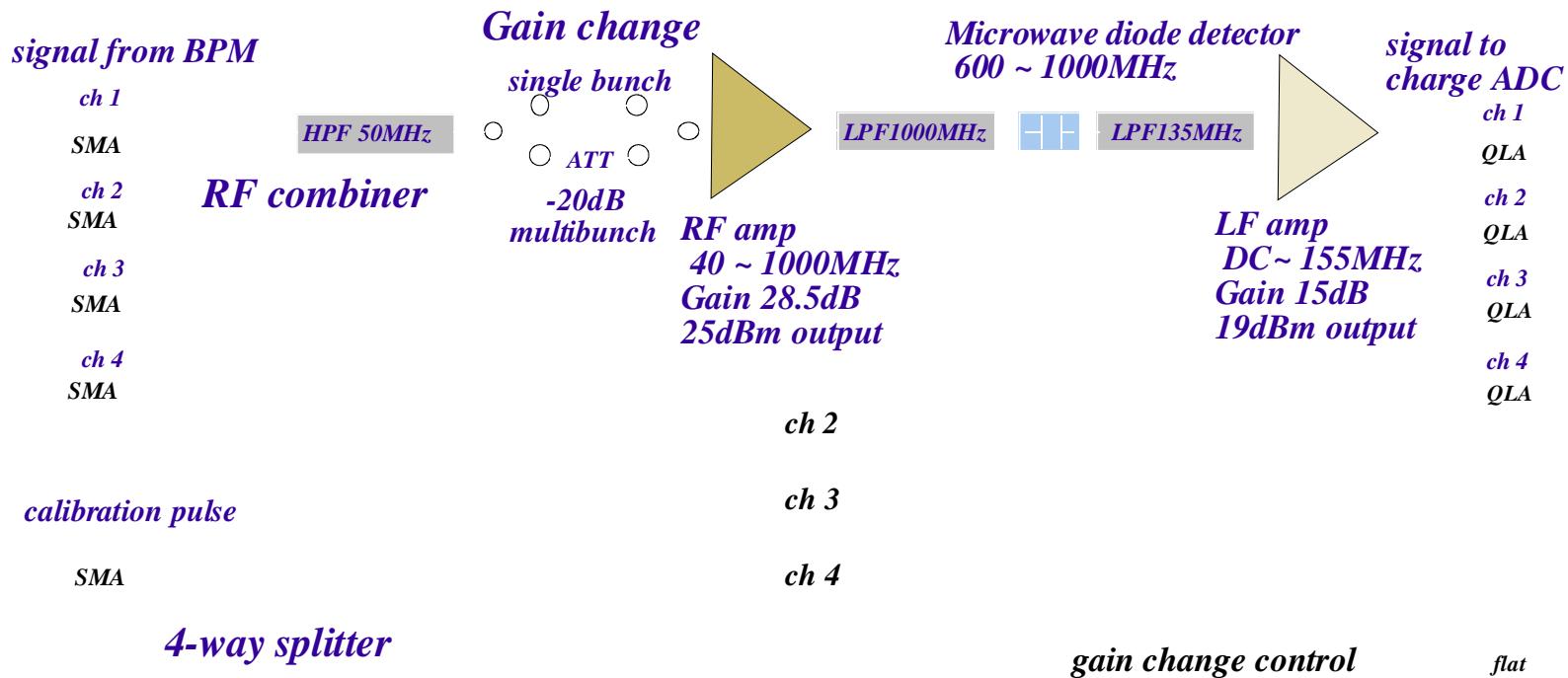
*Electronics: single pass detection for 96 BPMs  
DC-50MHz BW,  
base line clip & charge ADC,  
min. resolution  $\sim 20\mu\text{m}$*

# *Spectrum of DR BPM*



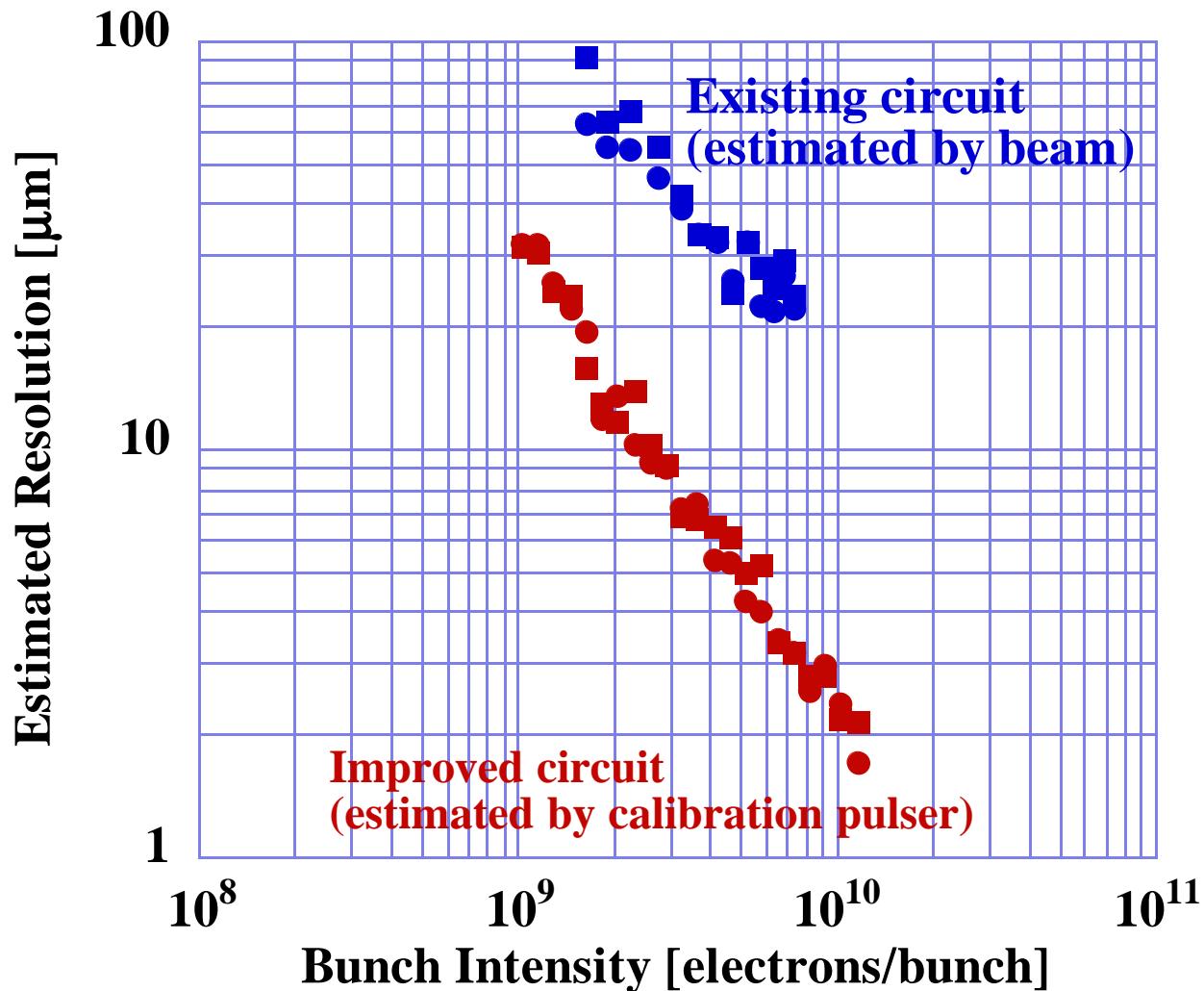
*Signal peak at  $\sim 1GHz$*

# BPM electronics improvement



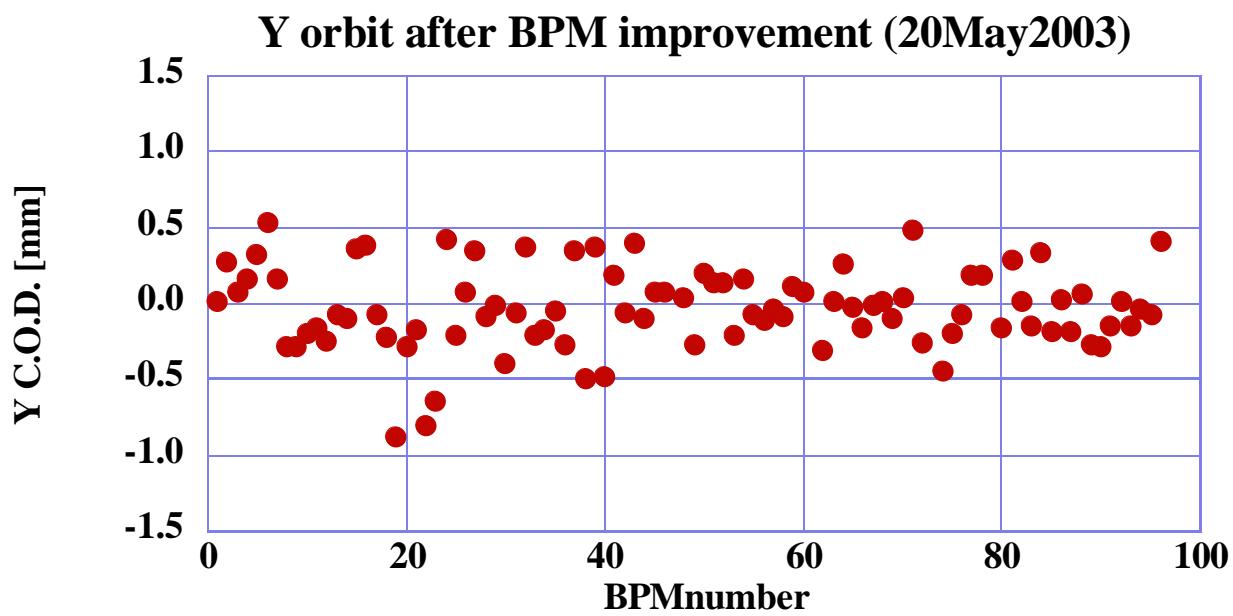
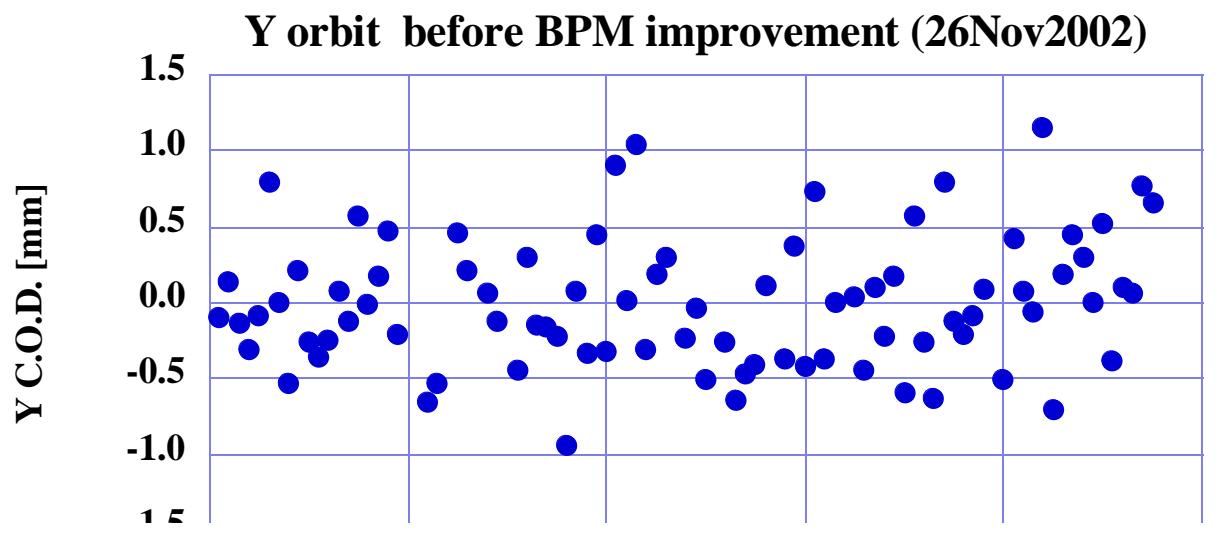
*Improved BPM Circuit ( simplified diagram )*

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

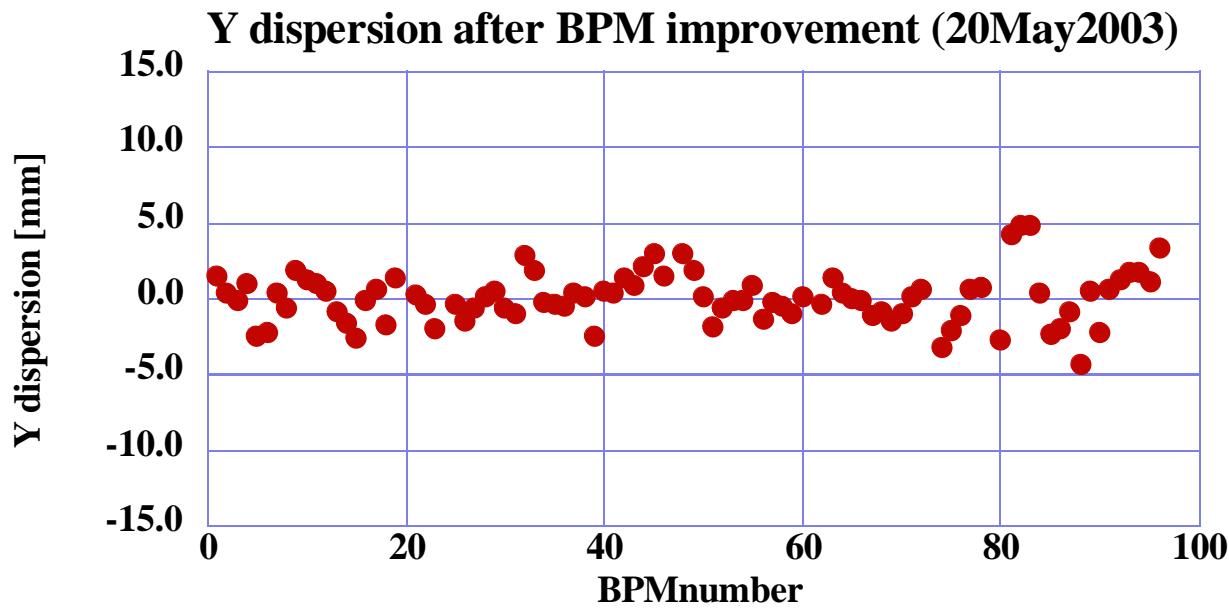
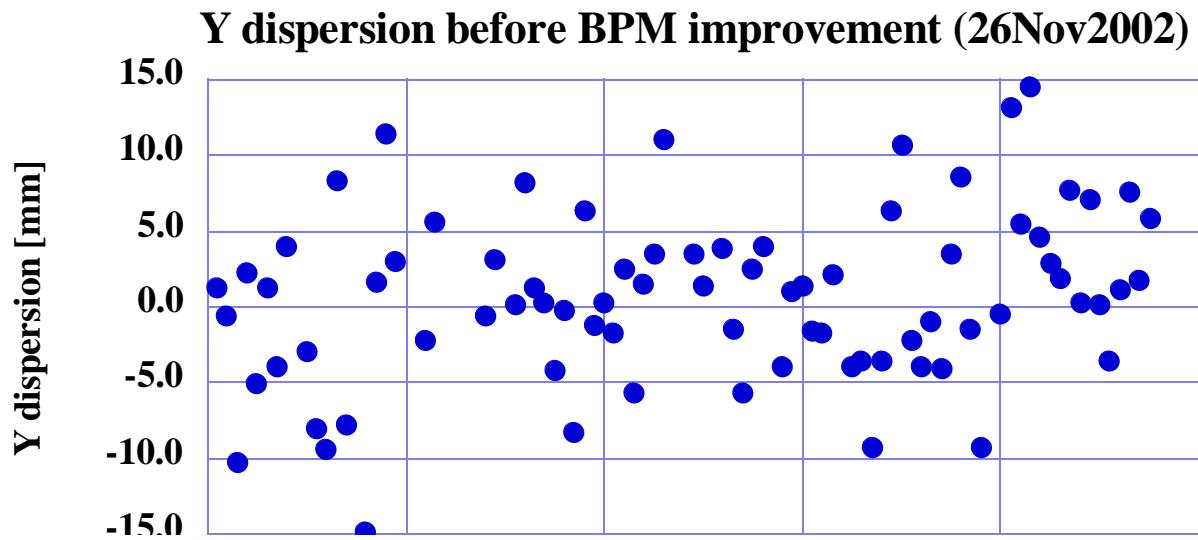


*Min. resolution ~ 2μm*

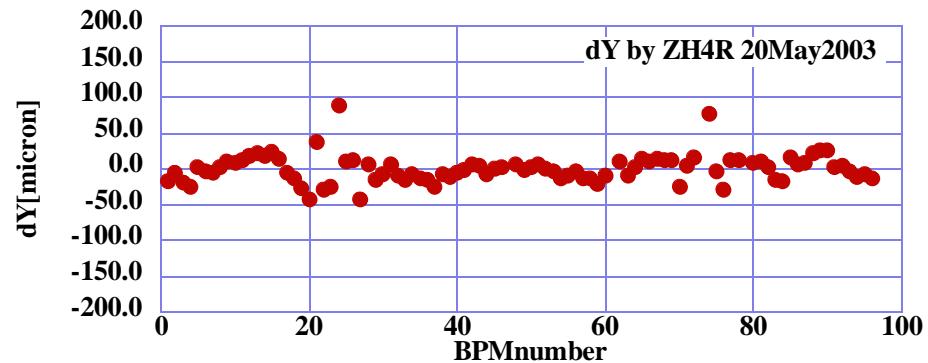
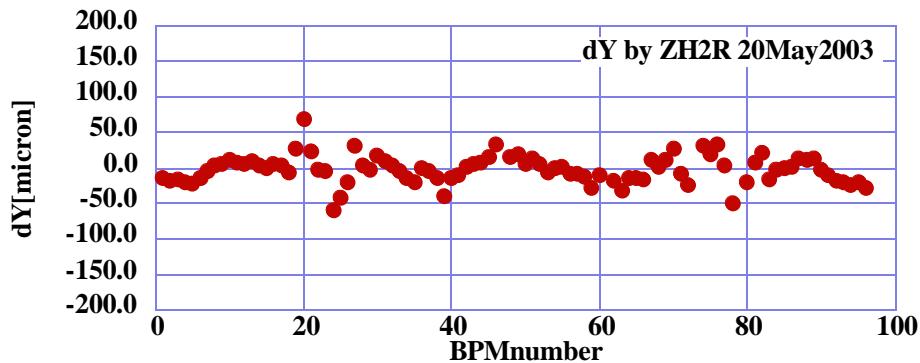
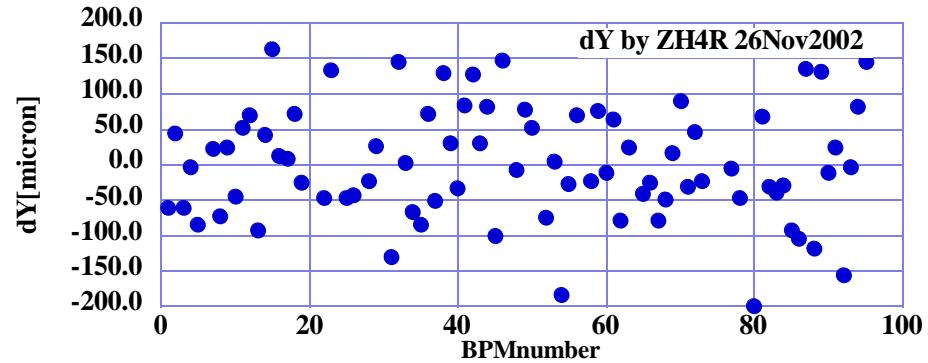
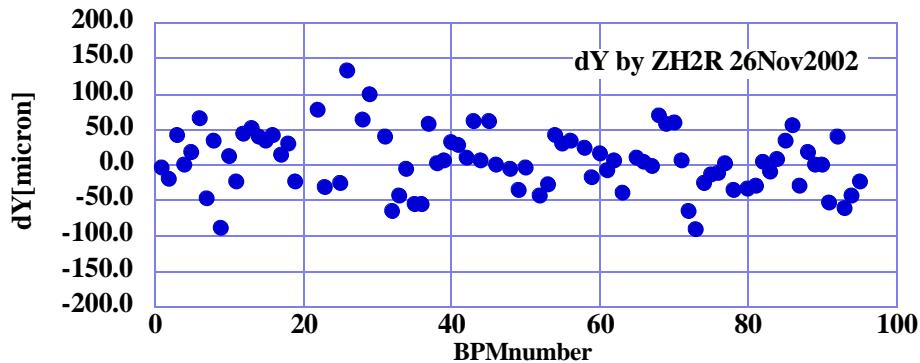
# *Vertical orbit Improvement*



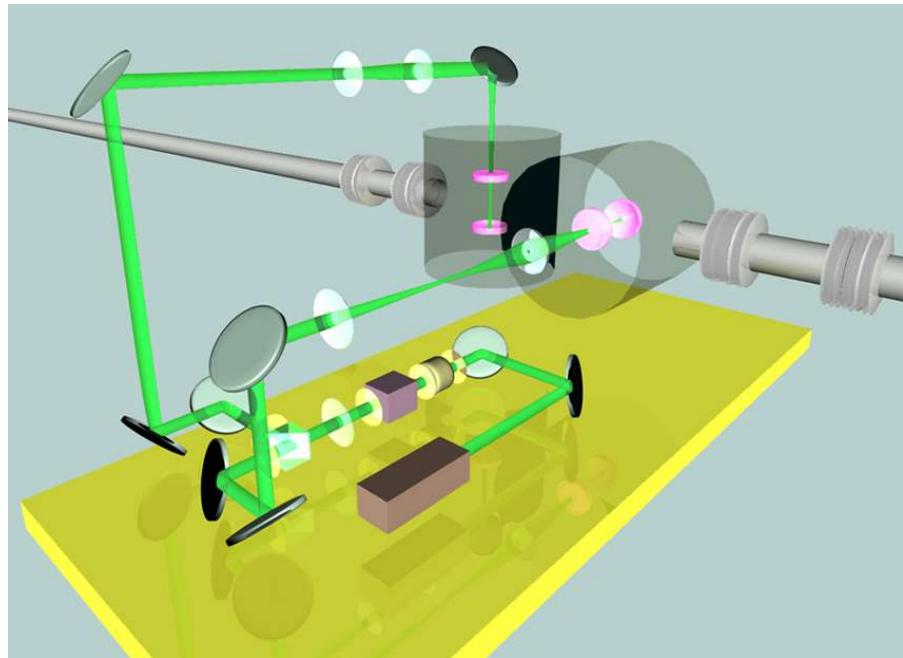
# *Vertical dispersion Improvement*



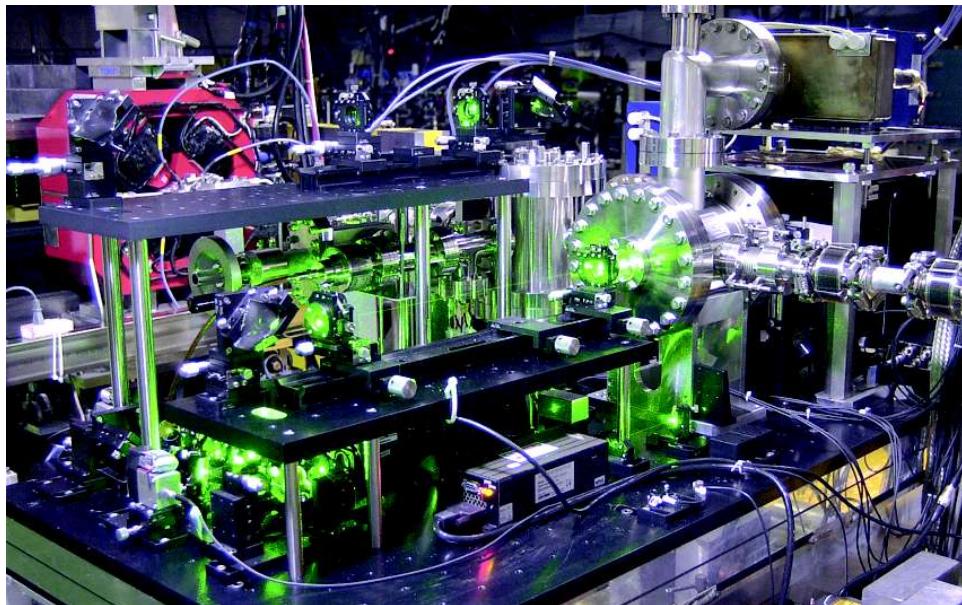
# *X to Y coupling Improvement*



# *Laser wire beam size monitor in DR*

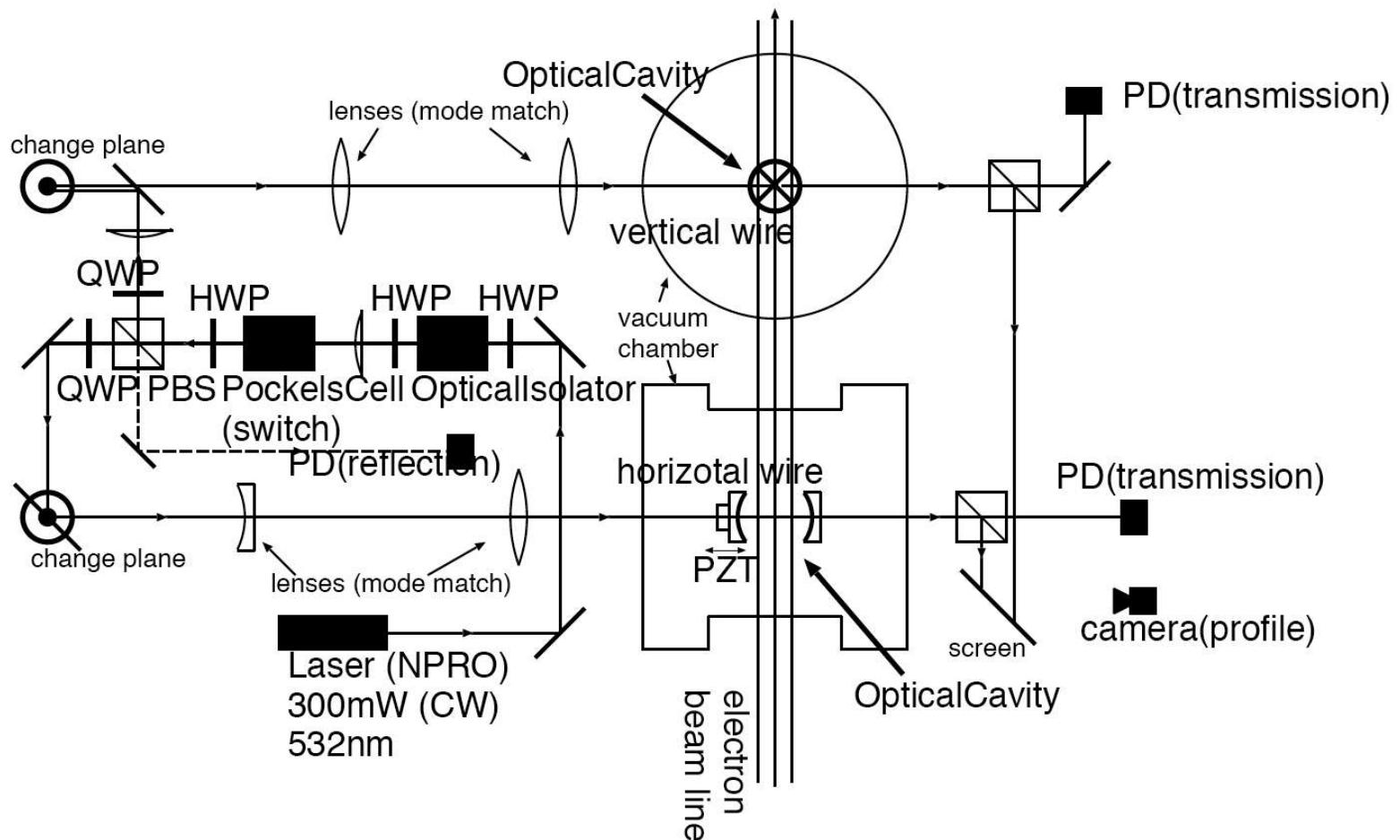


*300mW 532nm Solid-state Laser  
Fed into optical cavity*



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

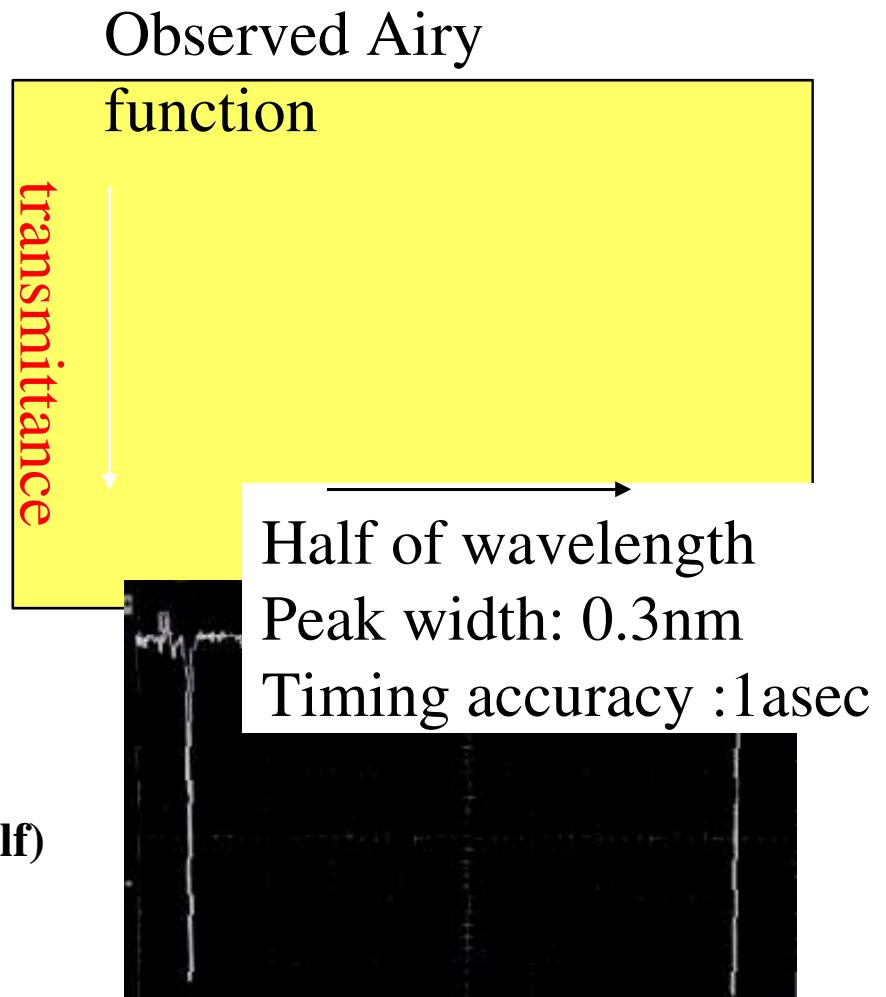
# *Laser wire block diagram*



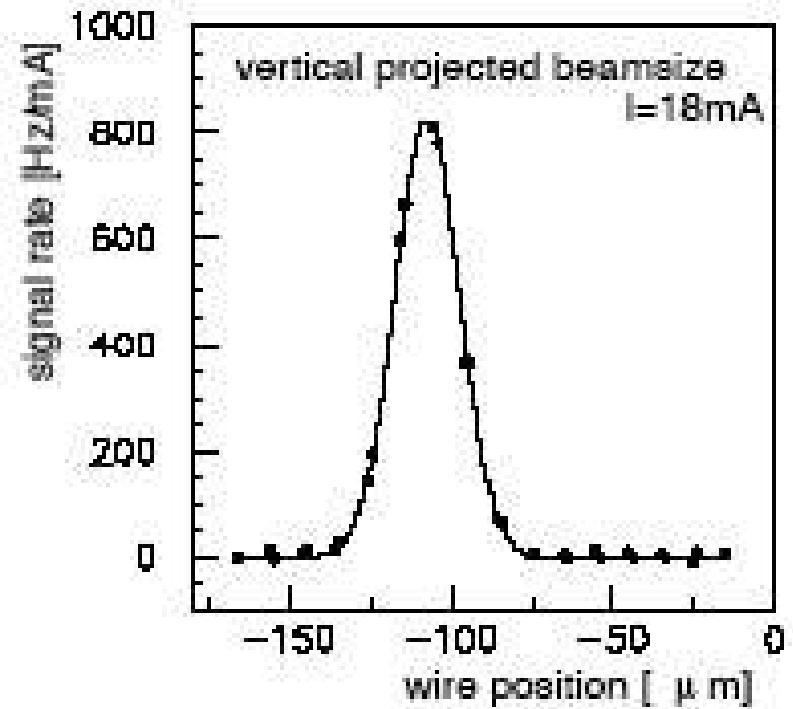
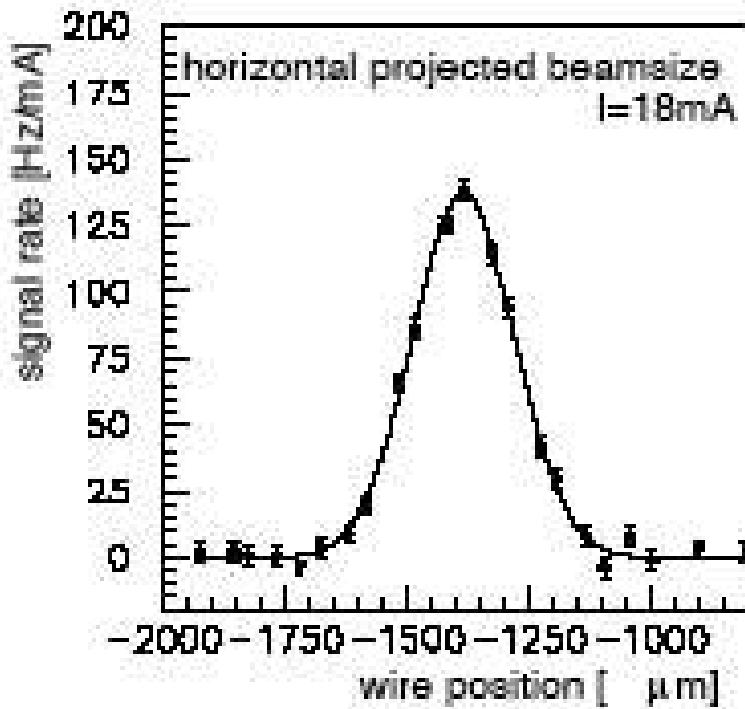
*optical cavity resonance is kept by piezo actuator*

# Two important cavity parameters

- There are two important parameters which characterize the cavity.
  - Finess (F): sharpness of resonance
    - proportional to power gain (G)
    - determined by mirror reflectivity
    - measured by its transmitted light.
  - Waist ( $w_0$ ): thinness of the beam
    - measure of spatial resolution or luminosity
    - determined by cavity geometry
    - measured by phase difference between two modes (or e<sup>-</sup> beam itself)
  - F.o.m:  $G/(w_0)^n$  ( $n=1\sim 2$ )



# *Beam profile by Laser wire*



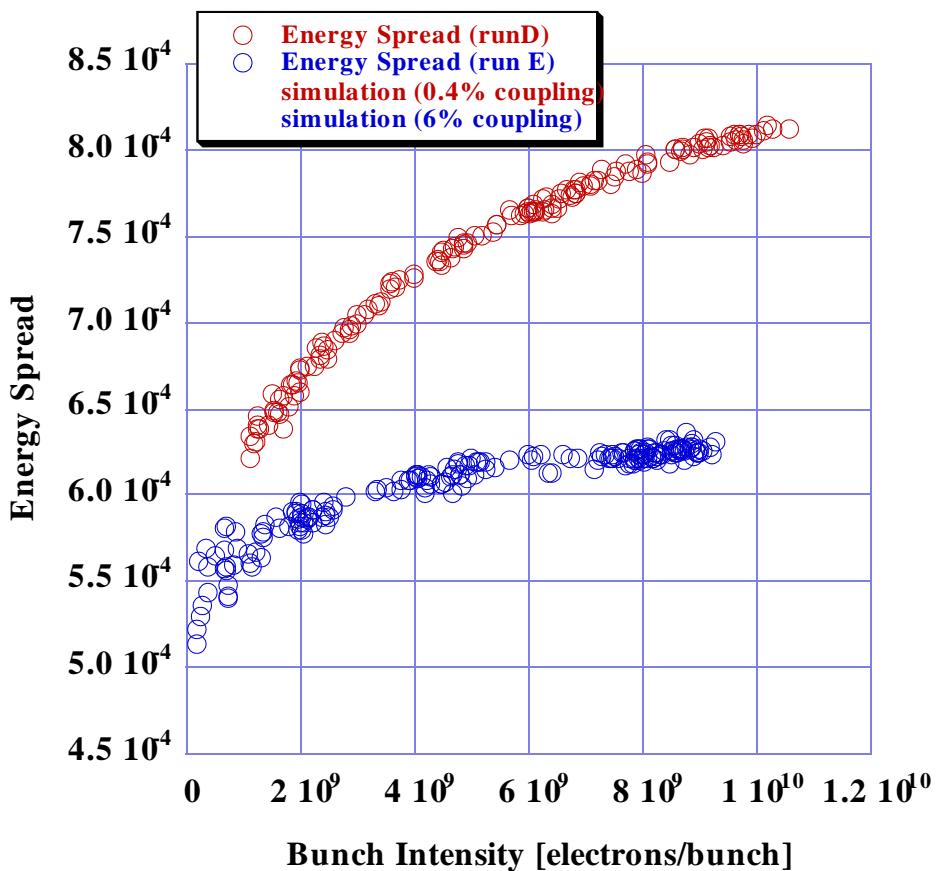
$$\sigma_e^2 = \sigma_{\text{meas}}^2 - \sigma_{lw}^2$$

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

$\beta$ : measured by *Q-trim excitation*

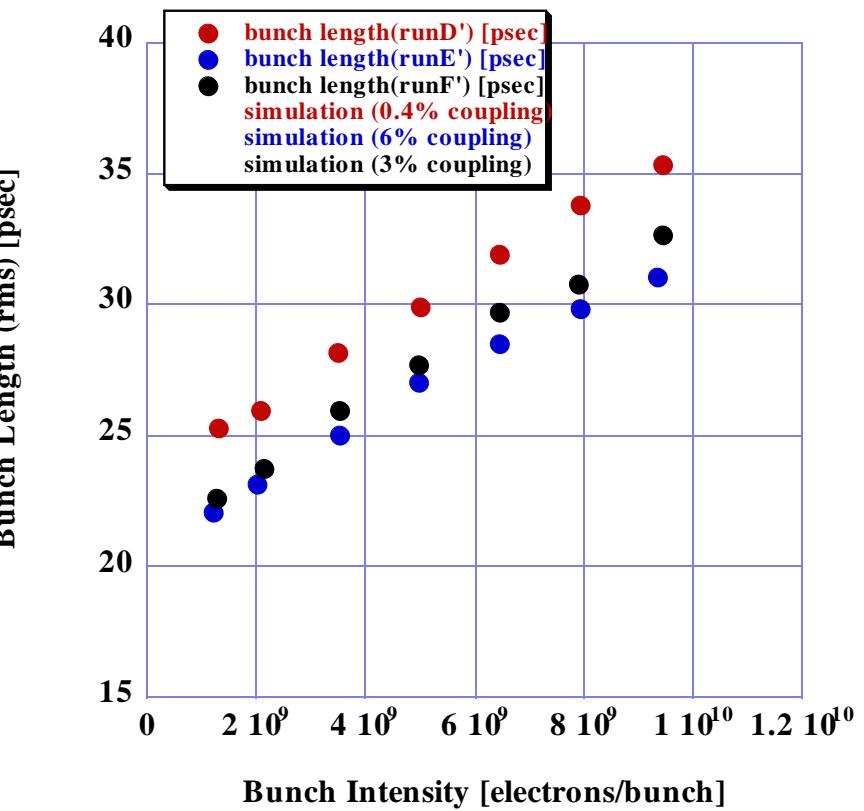
# *Energy Spread*

*by beam size monitor at EXT dispersive point*

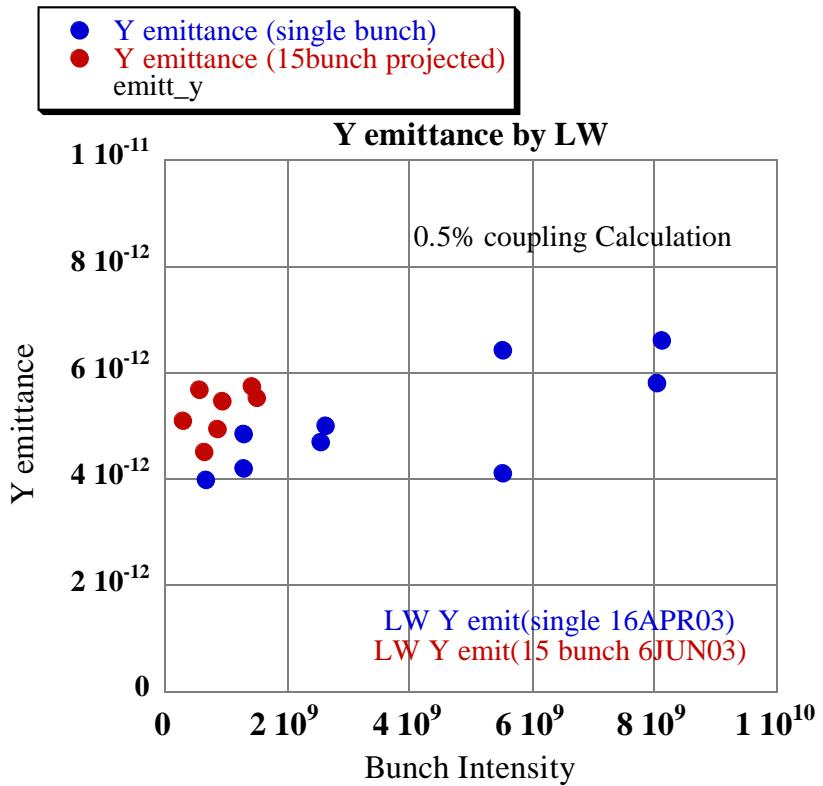
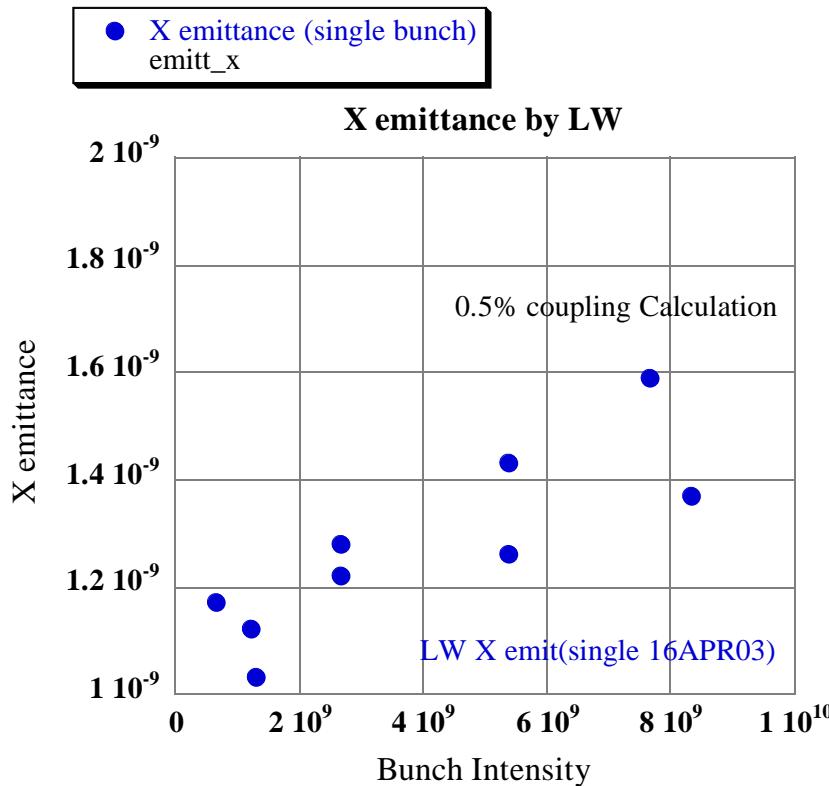


# *Bunch Length*

*by SR monitor with streak camera*



# Emittance by Laser wire



< 0.5% y/x emittance ratio

Y emittance = 4pm at small intensity

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PHYSICAL REVIEW LETTERS

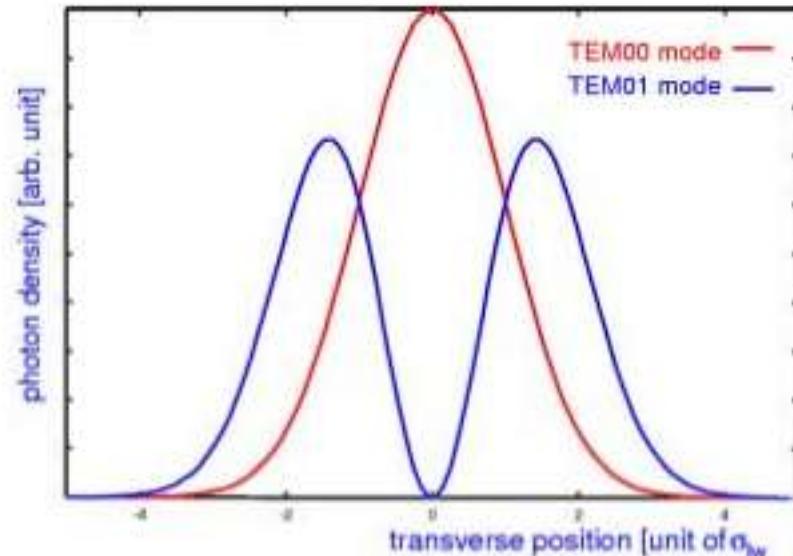
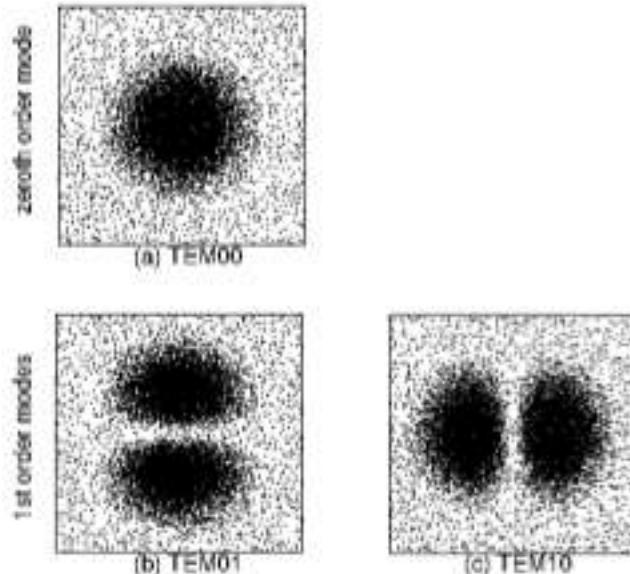
week ending  
6 FEBRUARY 2004

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

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

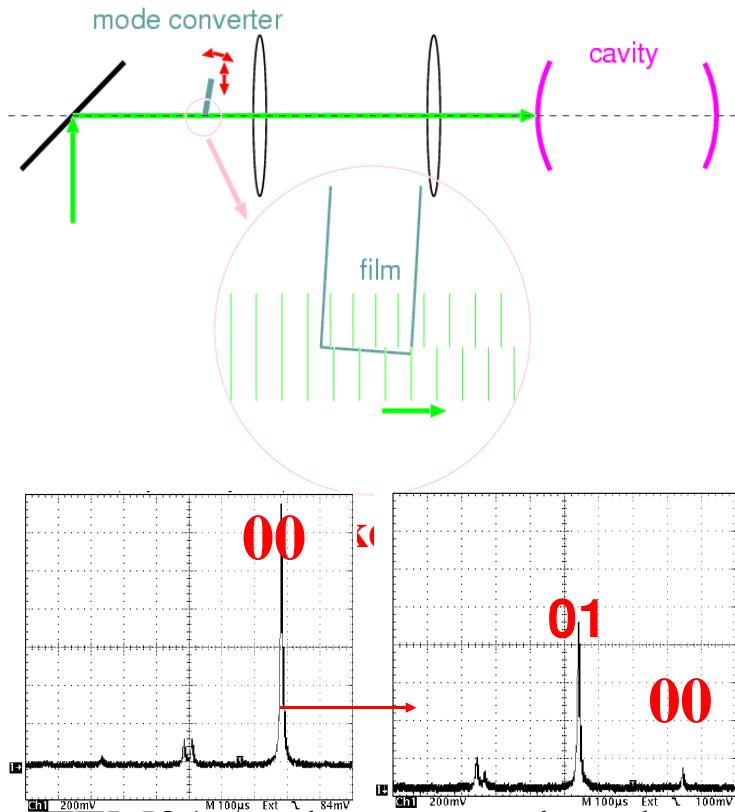
# higher mode laserwire

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

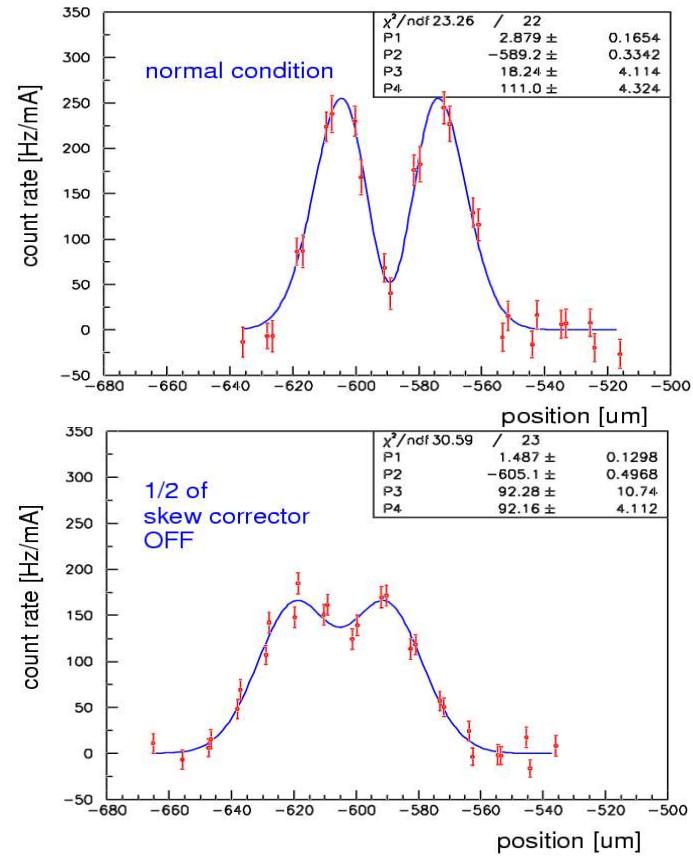


TEM01 mode has two lobe and a node

# Results with higher transverse mode



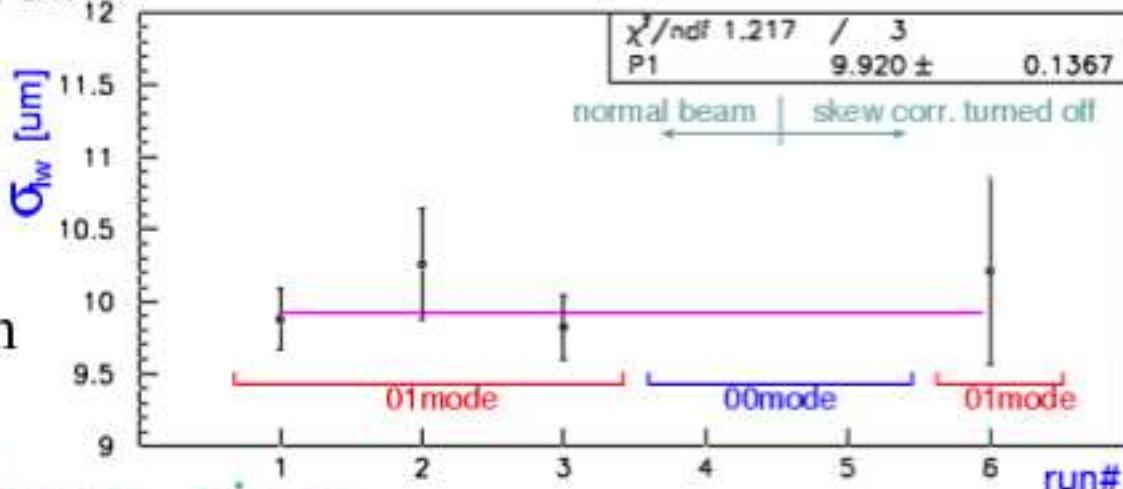
TEM01 mode was produced with efficiency of 60% by inserting phase converter.



- Resolution may be improved by  $\sim x3$  with the same  $w_0$ .

# fitted result

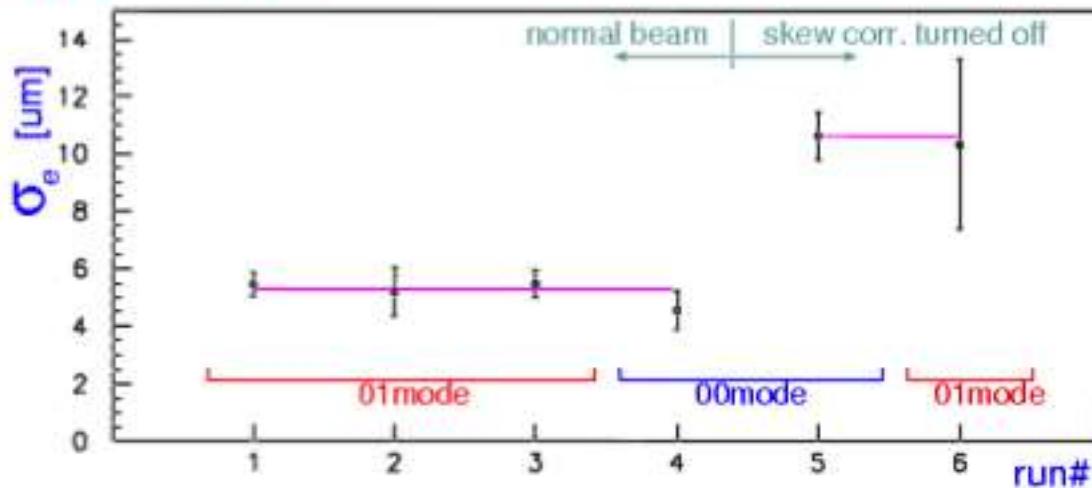
- estimation of the laserwire size  
from 01mode scanning data



combined result for the  
laser size :  $9.92 \pm 0.14$ um

- estimation of the beam size

the result above was  
used to subtract laser  
size from 00mode  
results





# Experimental results ( Pulse Laser Storage )

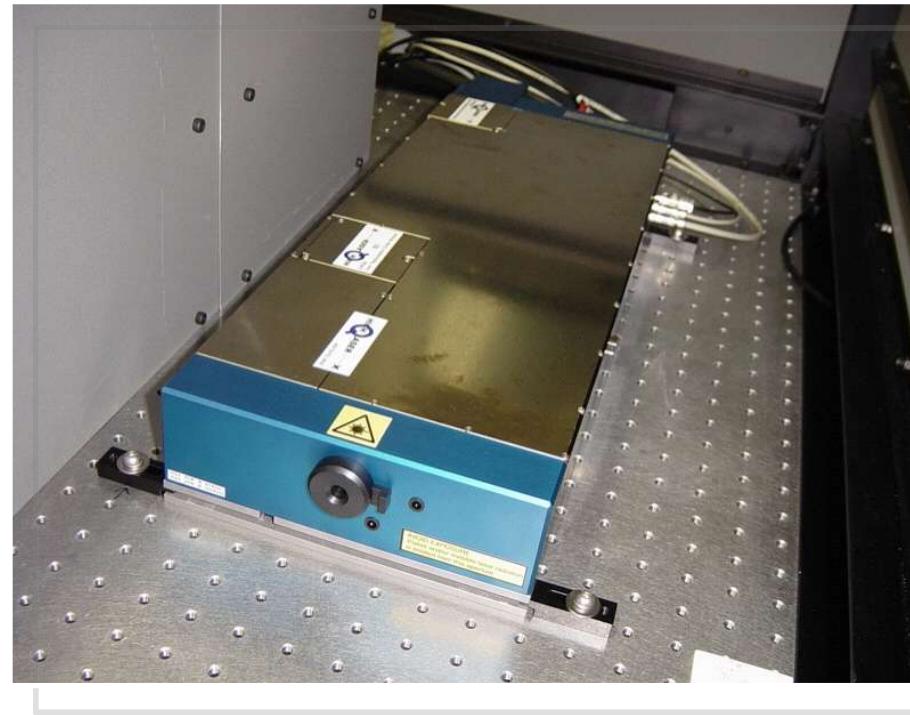
Laser:

Mode Lock: Passive  
SESAM

Frequency:  
357MHz

Cavity length: 0.42 m  
Pulse width: 7.3 p sec  
(FWHM)

Wave Length: 1064 nm  
SESAM: Semi-conductor Saturable Absorber Mirrors  
Power:  $\sim 6W$



# Ext. Cavity:

Cavity:

Super Invar

Cavity length:

0.42 m

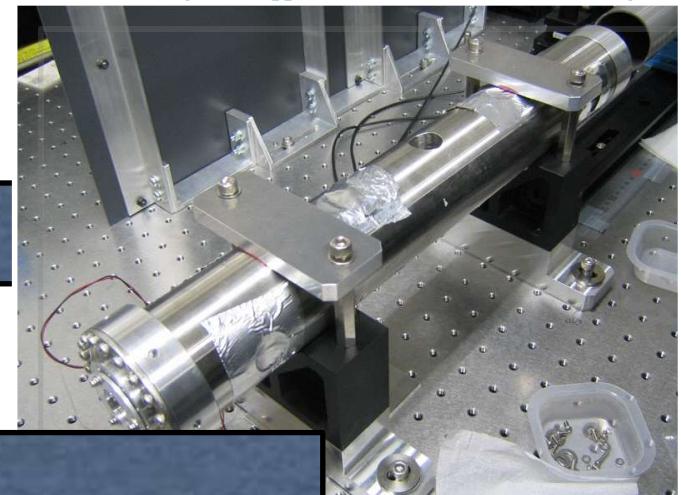
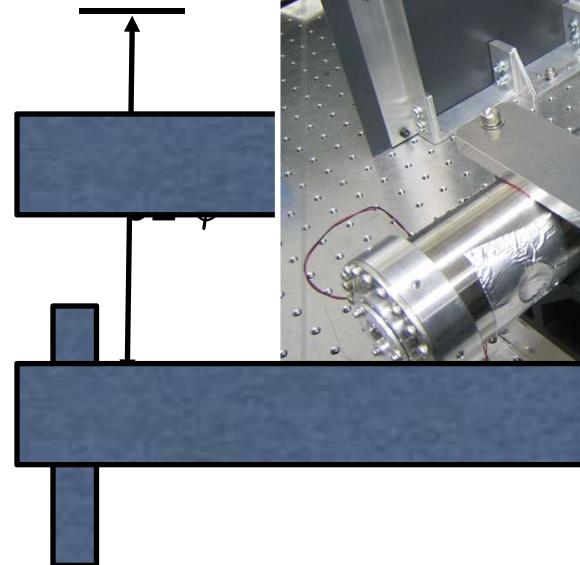
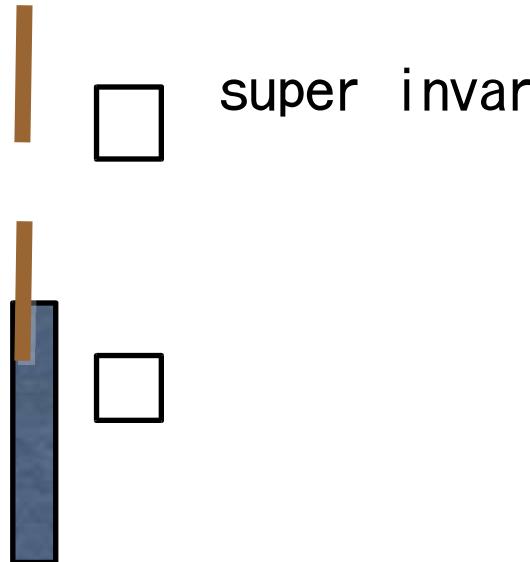
Mirrors:

Reflectivity:

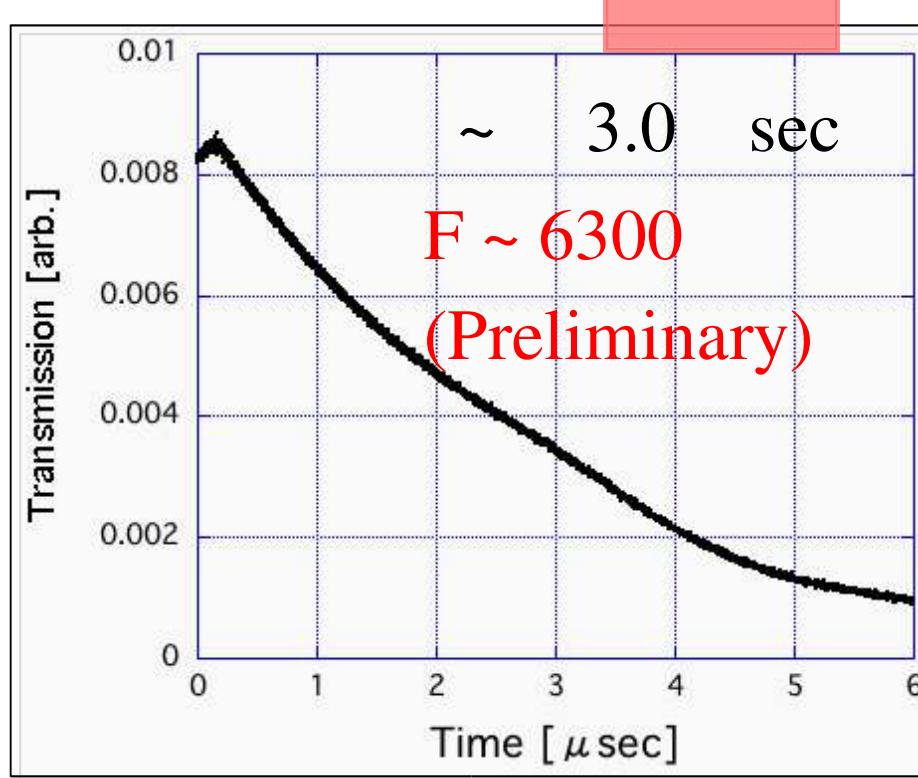
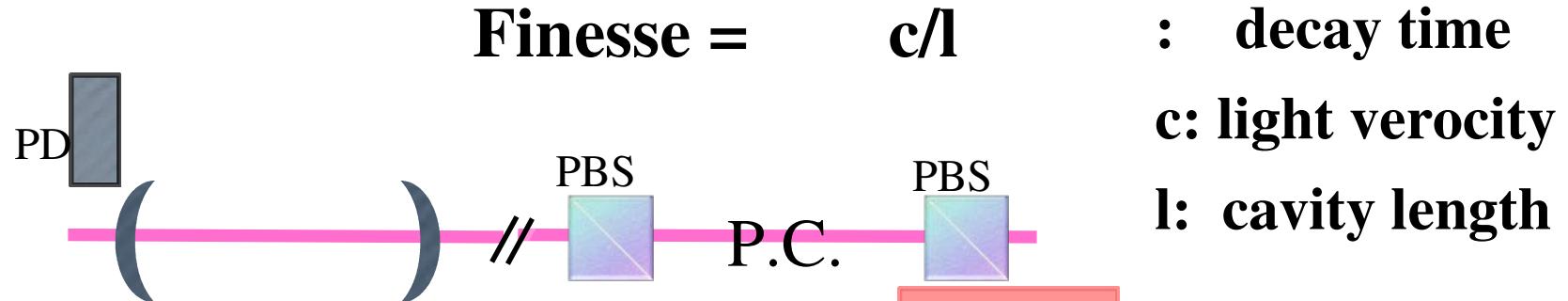
99.7%, 99.9%

Curvature:

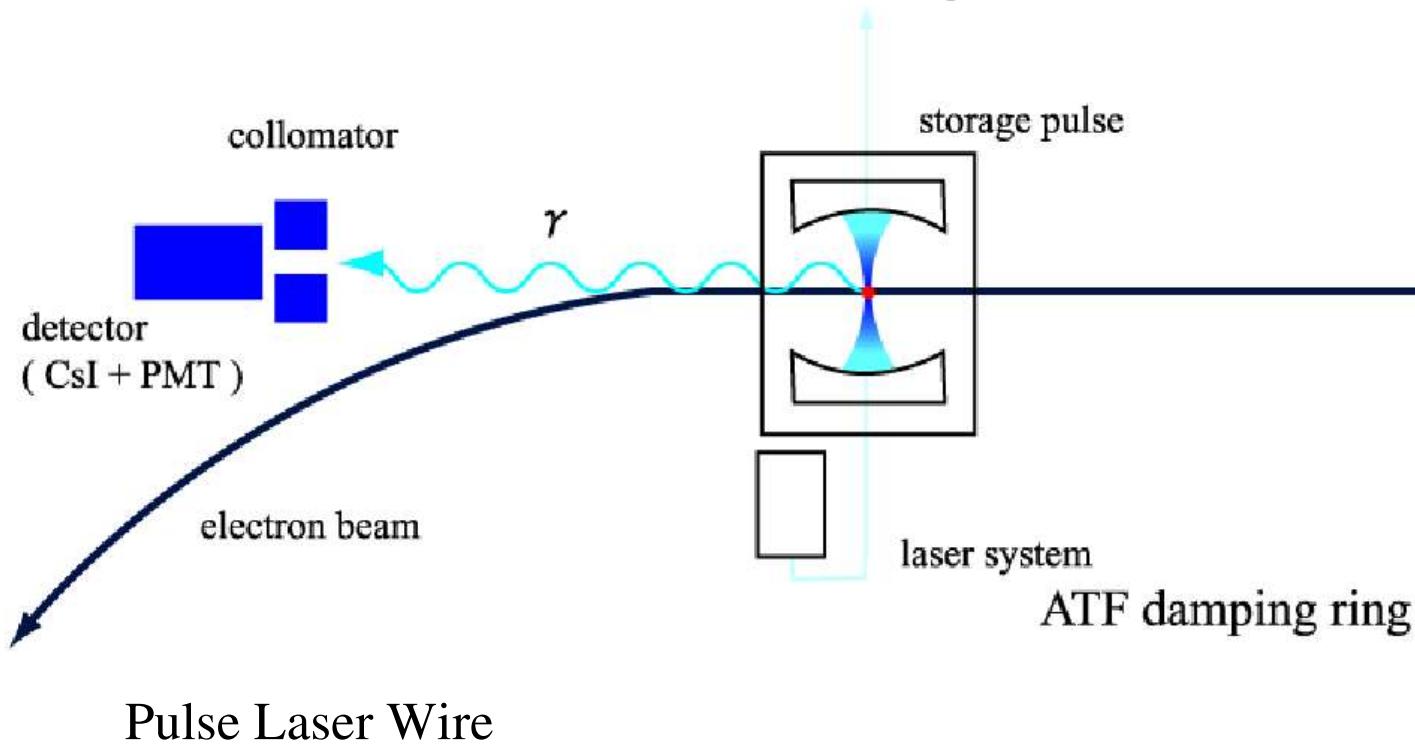
250 mm ( $\lambda_0 = 180 \text{ nm}$ )



Finesse: **R = 99.9 %**

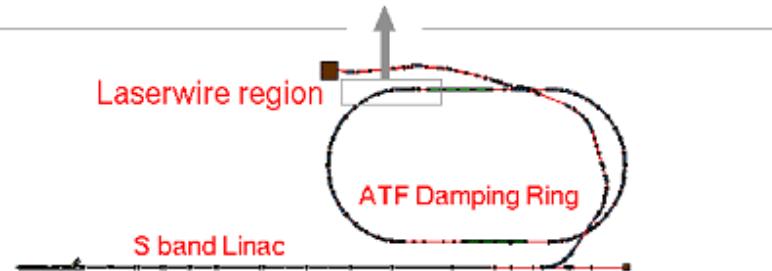


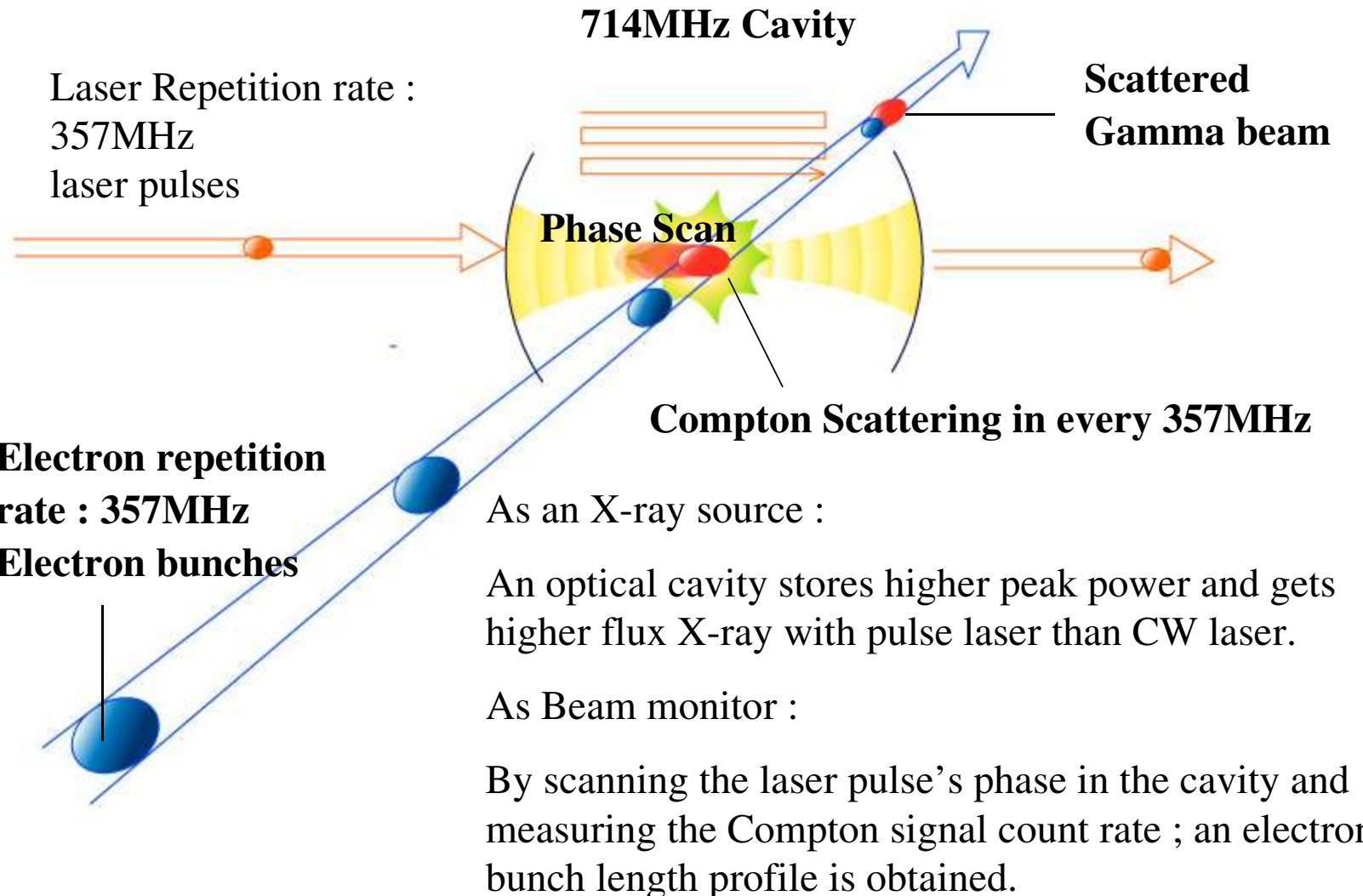
# Plused Laser and Electron Beam Collision to measure bunch length



(Storage laser pulses in optical cavity):

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





# Storage of laser pulse

Resonance condition :

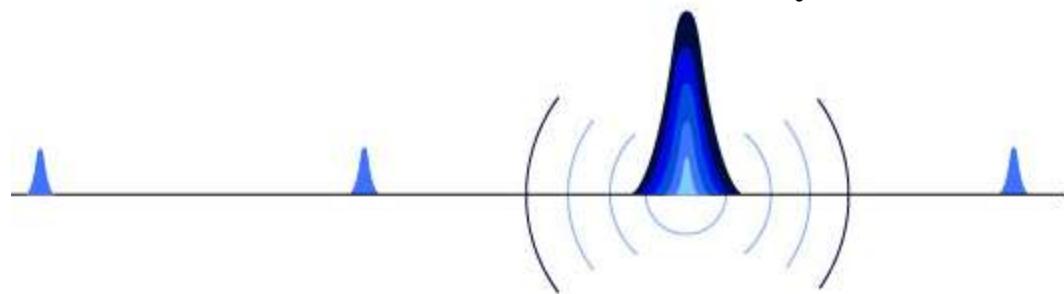
The relationship with  
laser and cavity :

$$L_{cav} = n \cdot \frac{\lambda}{2},$$

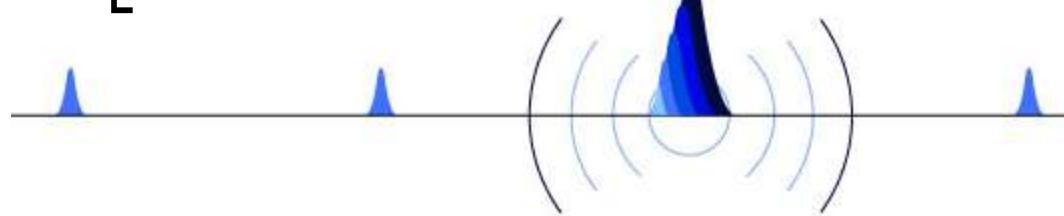
$$\Delta l = L_{laser} - L_{cav}, \quad \Delta l = 0.$$

The enhancement factor  
is the function of  
reflectivity,  $l$  and laser  
pulse width.

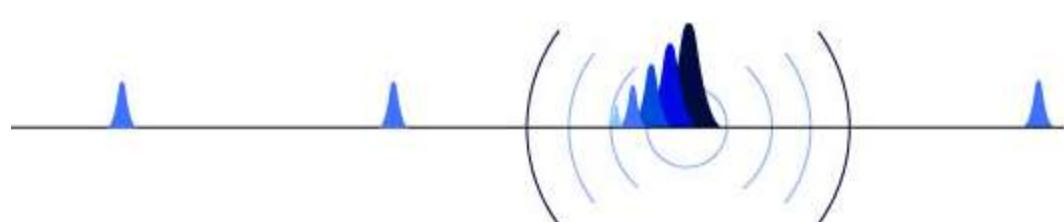
Perfect resonance :  $L_{laser} = L_{cavity}$



Imperfect Resonance :  $L_{laser} \approx L_{cavity}$

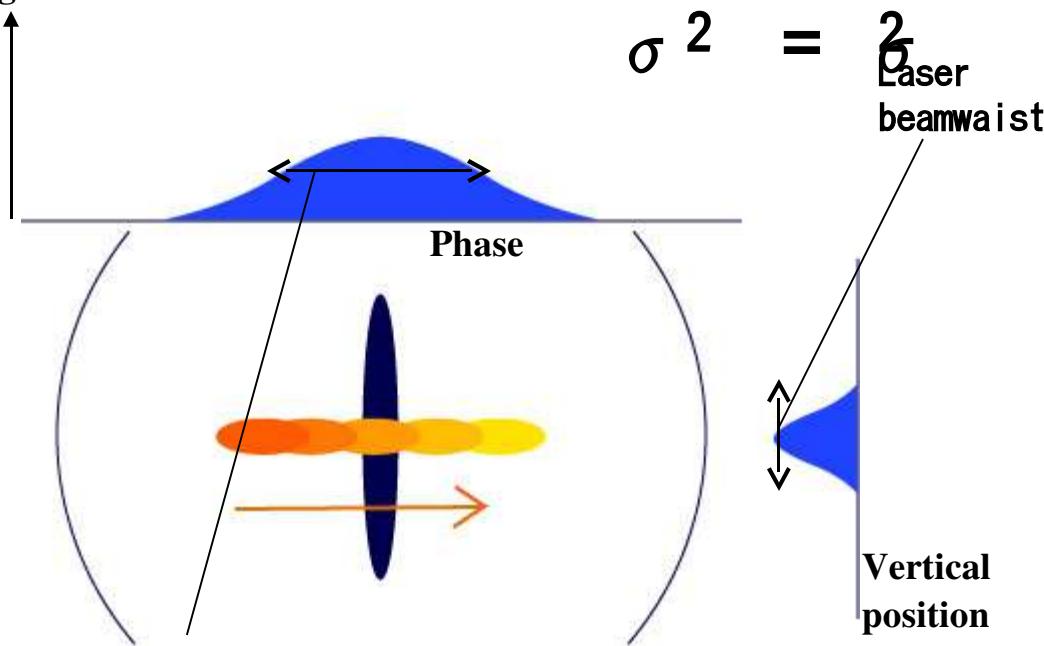


Not resonance :  $L_{laser} \neq L_{cavity}$



# Count rate & Measurement

Signal flux



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

$$\frac{2}{e}$$

$$\frac{2}{e}$$

Laser pulse width

$$\frac{2}{e}$$

$e^{-\frac{1}{2}}$  bunch length

$$\frac{2}{e}$$

Laser beamwaist

$$\frac{2}{e}$$

$e^{-\frac{1}{2}}$  h-beamsize

$e^{-\frac{1}{2}}$  bunch length  $\sim$

The electron bunch length is  $20 \sim 40$  psec (10mm)  
Laser pulse width ( FWHM = 7 psec ; 1 mm)

Laserwire beamwaist( 120um ), electron's horizontal beamsize ( 100um )

# OPTICAL CAVITY

Cavity length : 714 MHz +/- 2 kHz ( from PZT dynamic range )

Cavity length is 210mm. It is easy to adjust cavity length with short cavity.

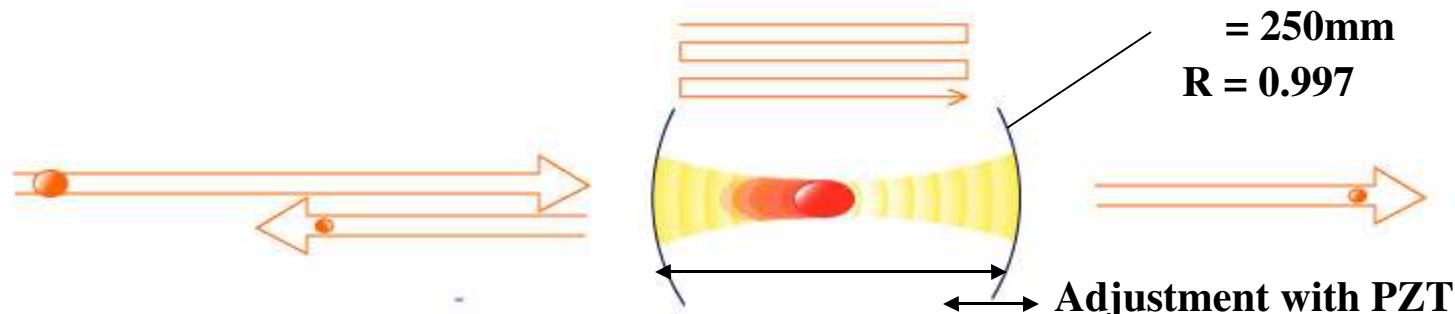
For cavity's dynamic range , long PZT is used ( 10um ).

## Mirrors

- The radius of curvature : 250 mm
- The reflectivity : 0.997 +/- 0.001

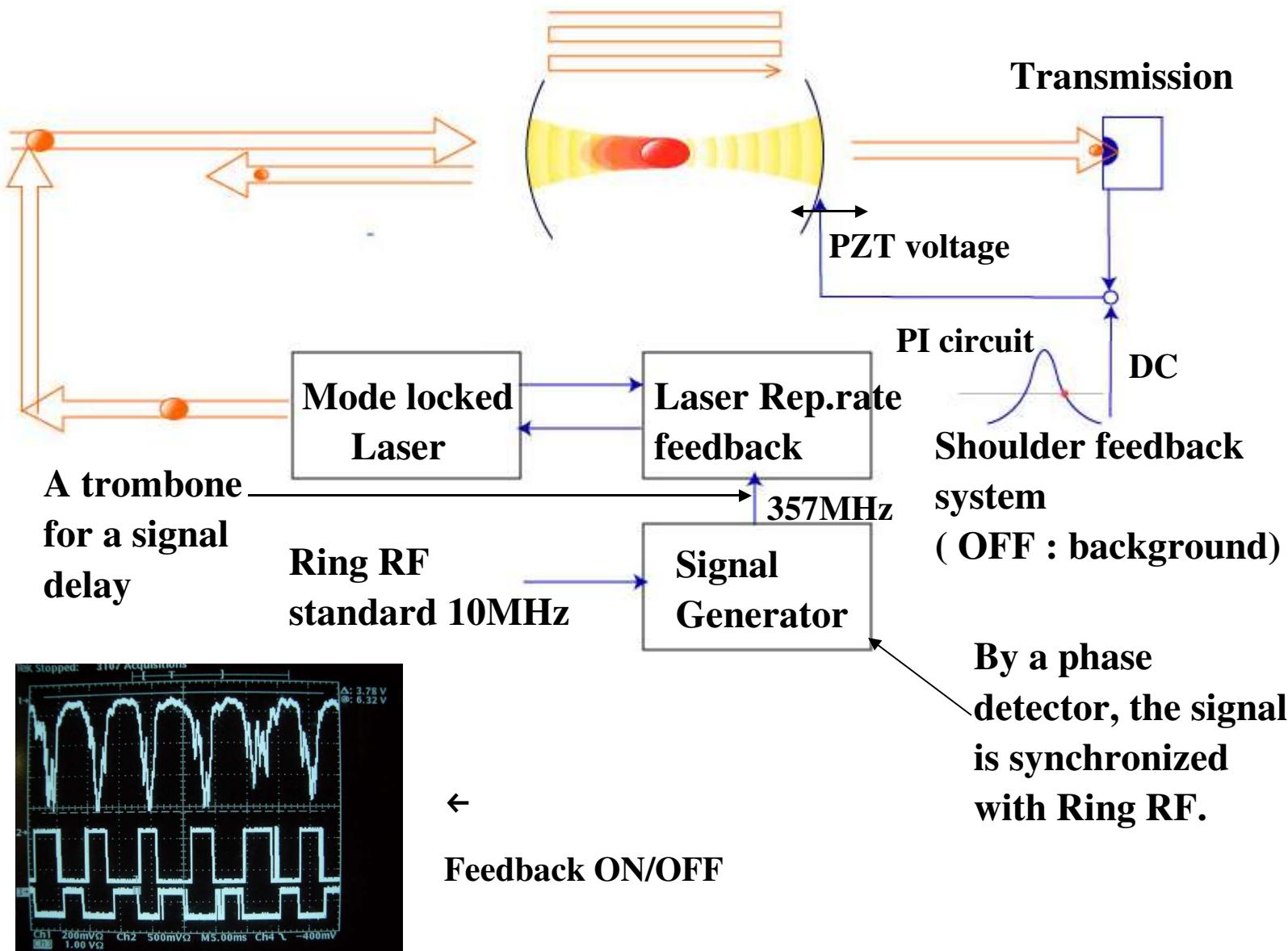
Finesse is  $\sim 1000$ . But effective finesse is  $\sim 500$ , when the length of cavity is 21cm. 4 times reflections occur during each laser pulse injection.

It is difficult to make thin laserwires at long cavity length.  
**Beamwaist > 200 um**

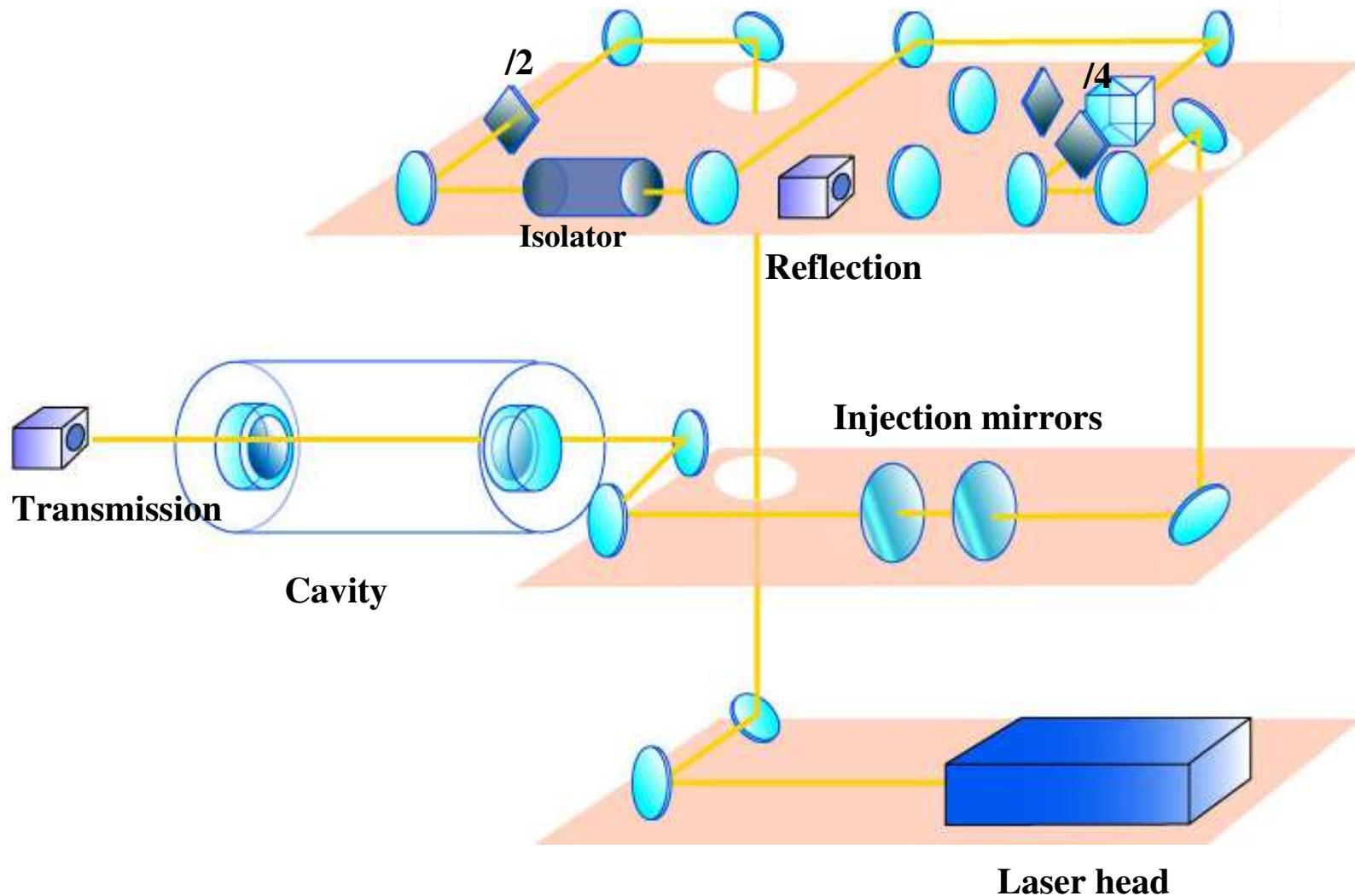


714MHz corresponds 21cm.

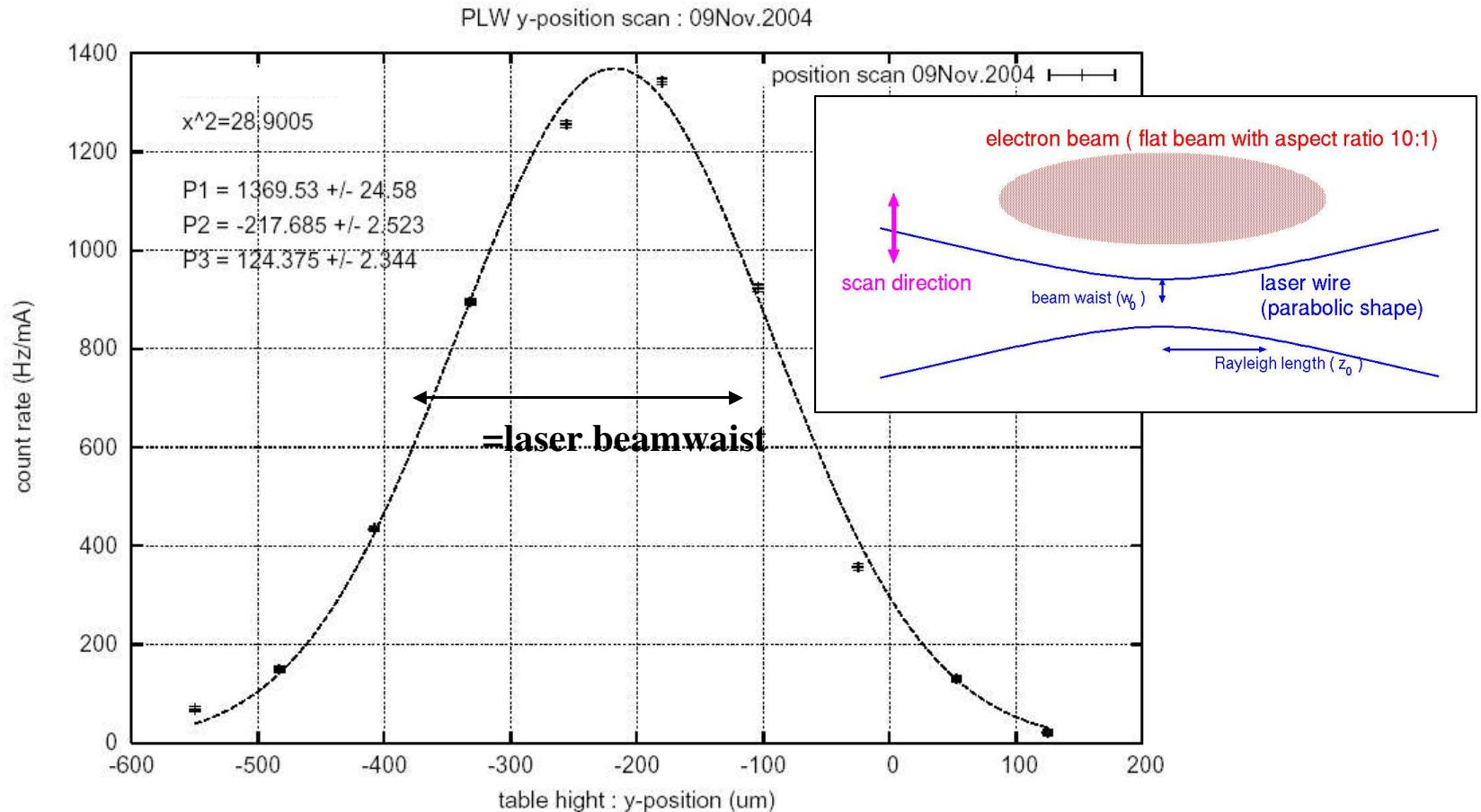
# OPTICAL CAVITY : feedback circuit



# EXPERIMENTAL SETUP : Optics



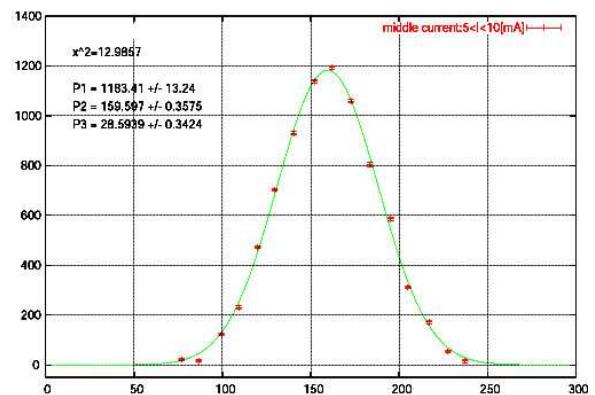
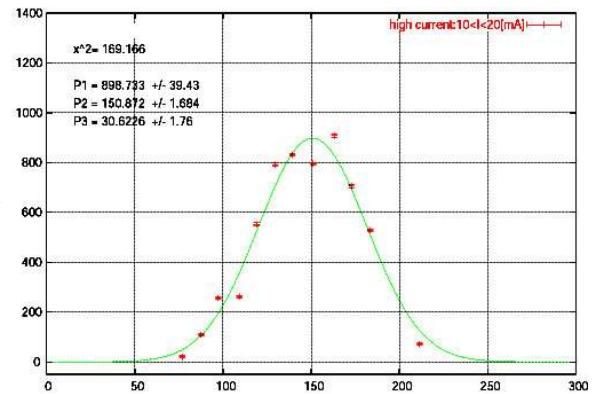
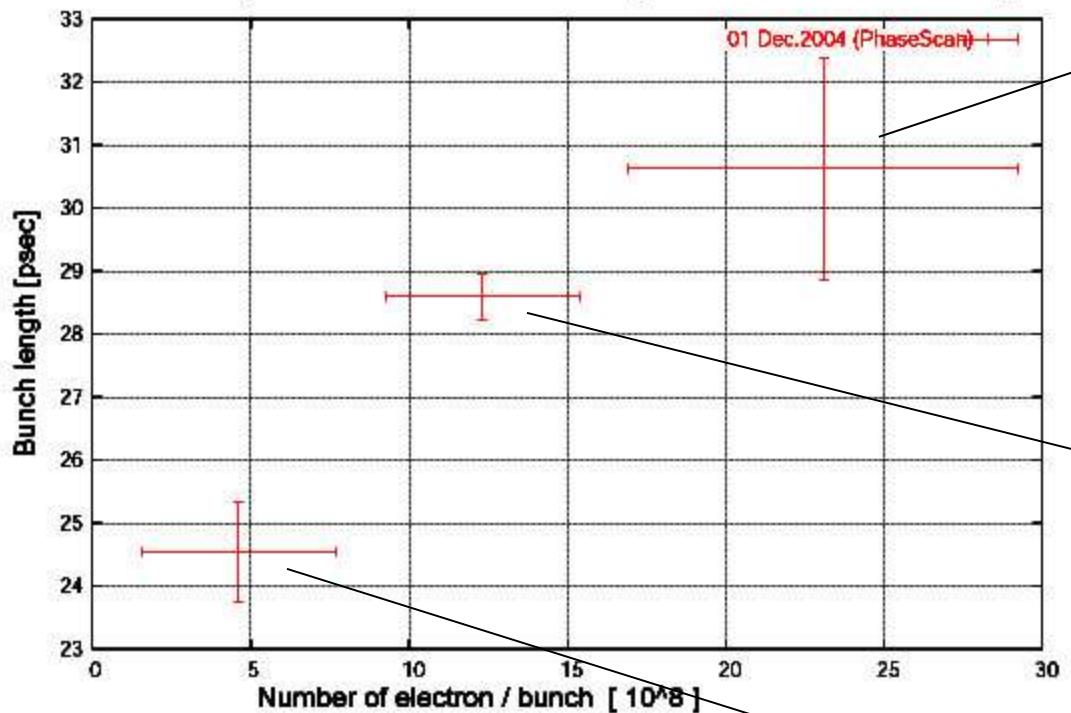
# Count rate



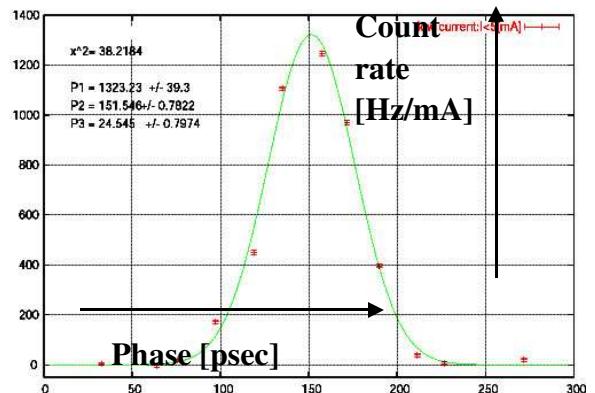
Calculated maximum count rate is  $\sim 2500$  [Hz/mA].

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

Bunch length measurement : Low current ( multibunch 1 train : < 10 mA )



When bunch current is increased , the Gaussian shape of photons count rate changes.



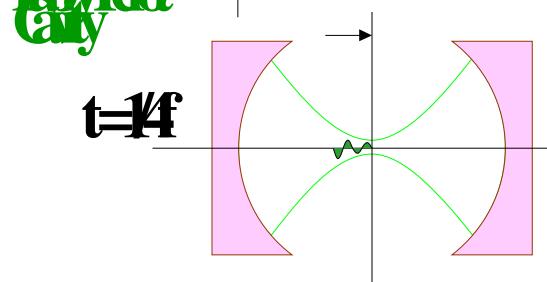
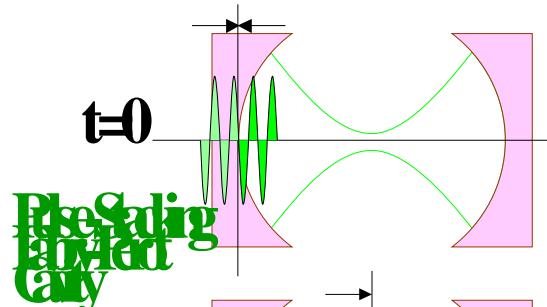
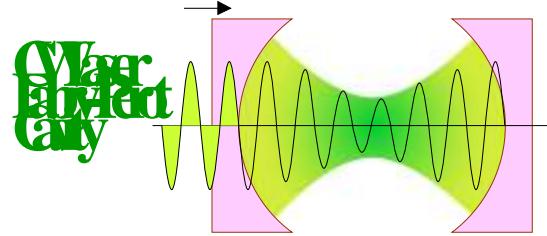
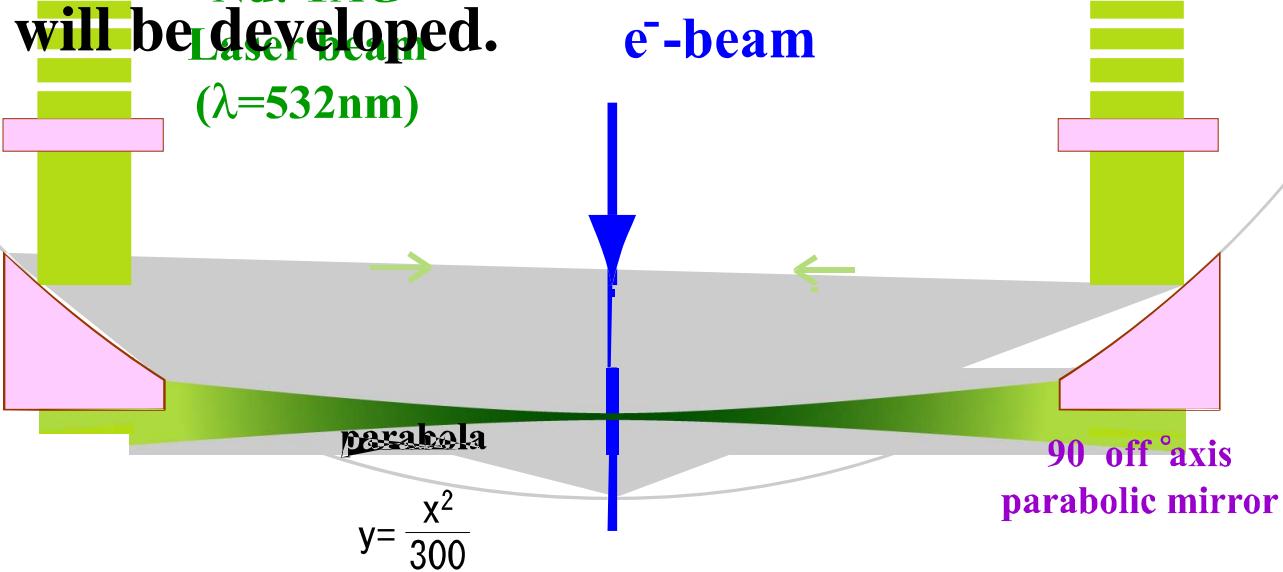
**For more  $\gamma$  generation :**

**Storage of short pulse laser and  
Crossing angle less than 5 degrees  
to make near head-on.**

**Large optical cavity (Super-Cavity)  
will be developed.**

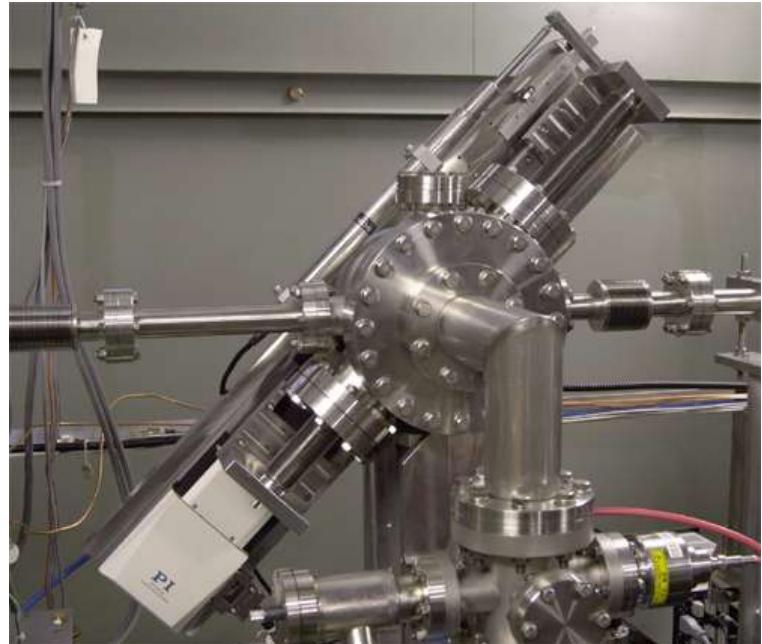
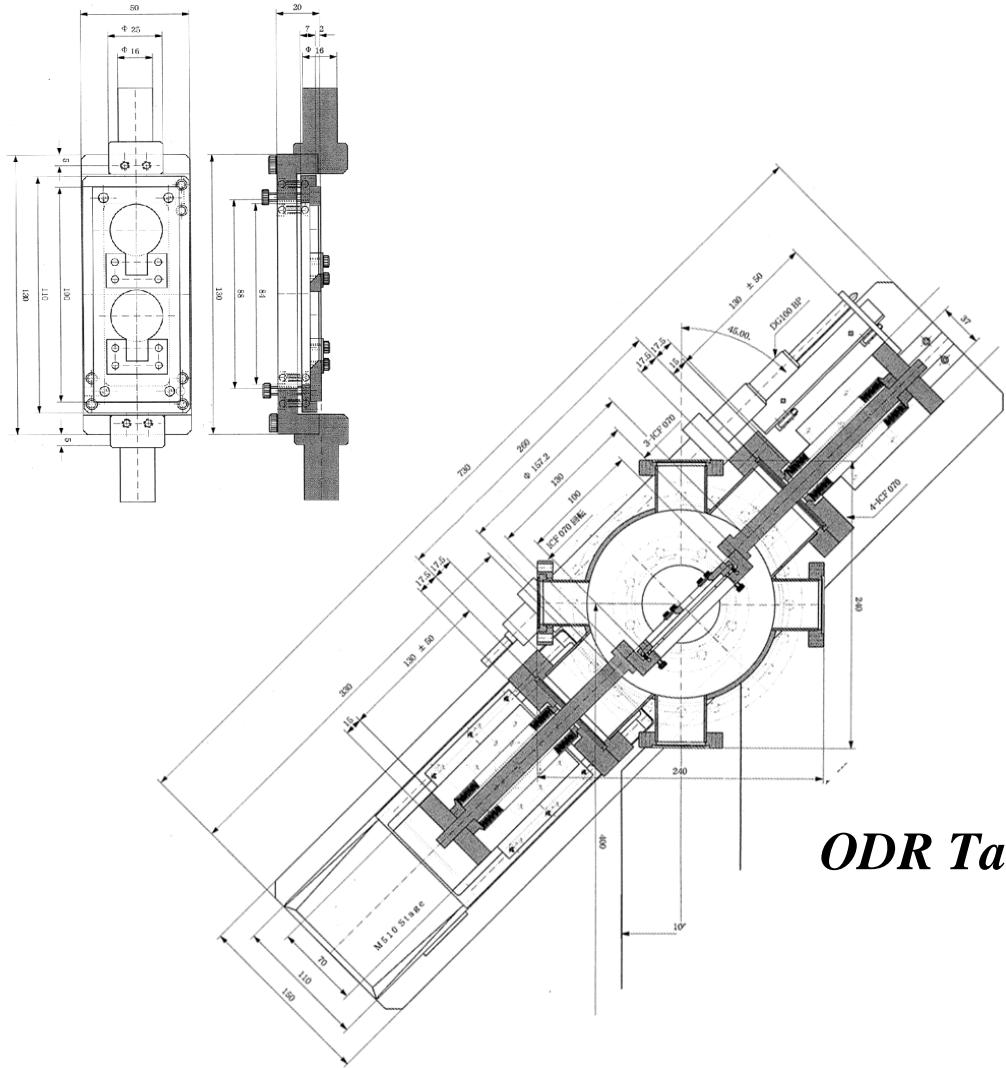
**Off axis parabolic mirror is  
necessary.**

**Then, new cavity like below type  
 $\text{Nd: YAG}$   
will be developed.**



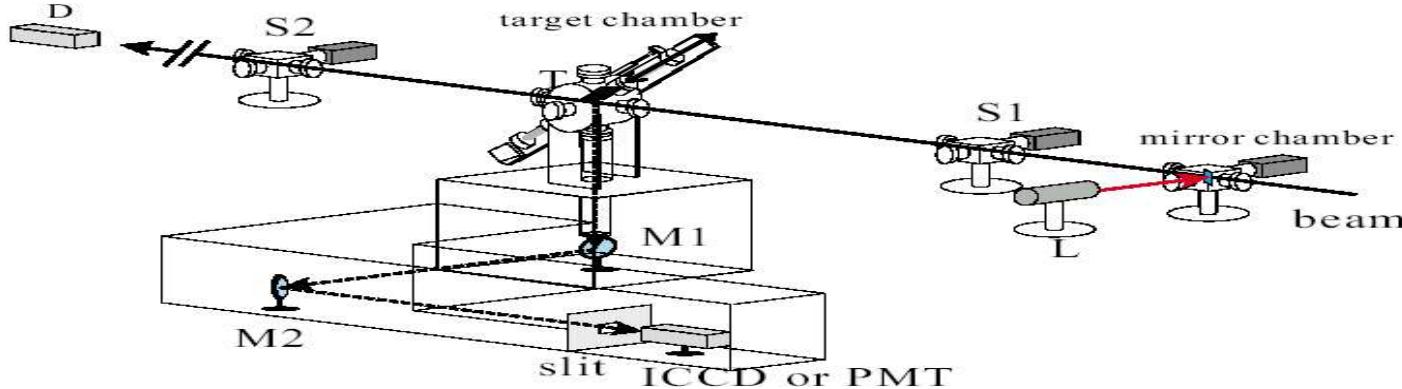
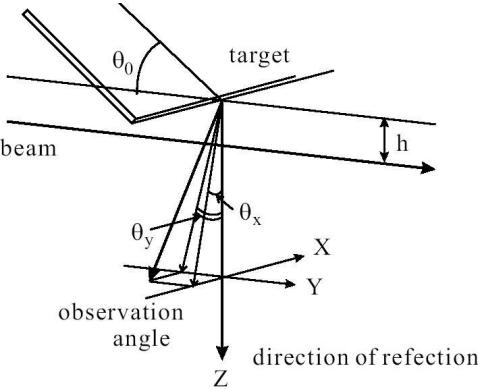
# *ODR Monitor*

## *ODR Target Holder*



*ODR Target chamber*

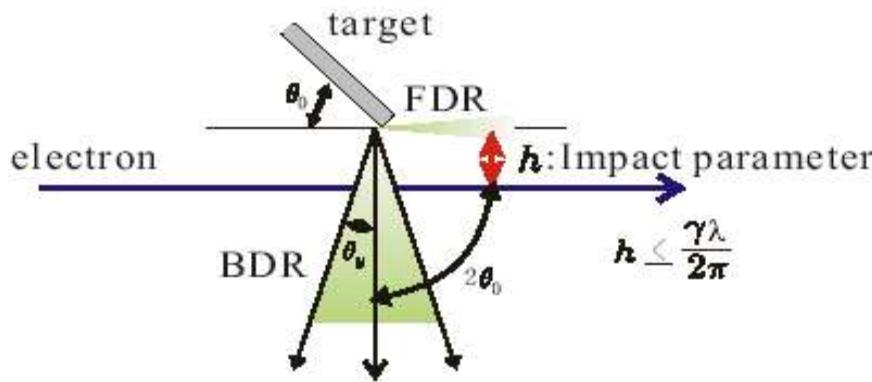
# Experimental study on optical diffraction radiation



## Diffraction Radiation(DR)

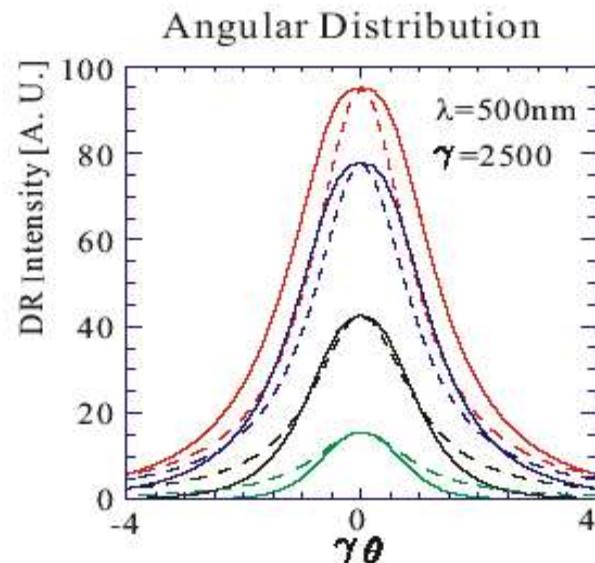
DR is emitted when a charged particle passes through the vicinity of a conducting target

ODR  
by single  
edge



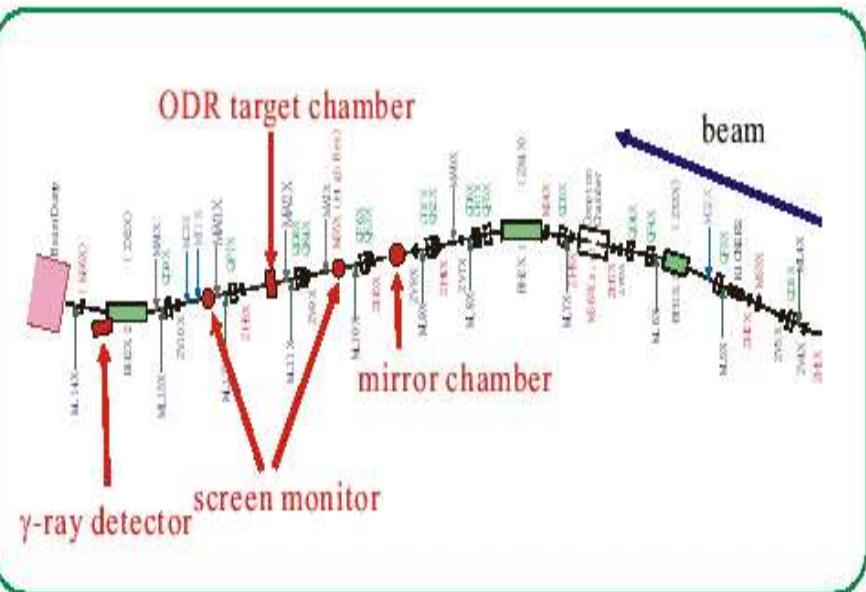
$$\frac{d^2W_{DR}}{d\Omega d\omega} = \frac{\alpha}{4\pi^2} \exp\left(-\frac{4\pi h}{\lambda\gamma}\sqrt{1+\gamma^2\theta_x^2}\right) \frac{\gamma^{-2} + 2\theta_x^2}{(\gamma^{-2} + \theta_x^2 + \theta_y^2)(\gamma^{-2} + \theta_x^2)}$$

$$\theta_x, \theta_y \sim \frac{1}{\gamma} \ll 1$$

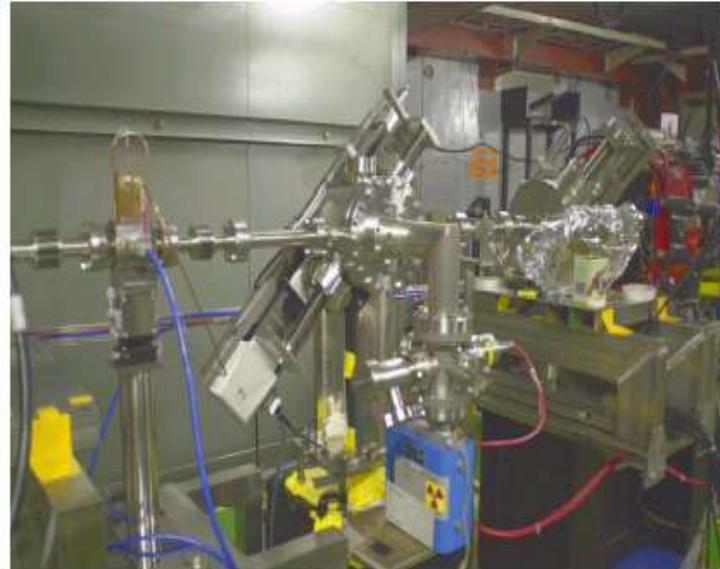


$h=20\mu\text{m}$	$\theta_x$ ( $\theta_y=0$ )
	$\theta_y$ ( $\theta_x=0$ )
$h=40\mu\text{m}$	$\theta_x$ ( $\theta_y=0$ )
	$\theta_y$ ( $\theta_x=0$ )
$h=100\mu\text{m}$	$\theta_x$ ( $\theta_y=0$ )
	$\theta_y$ ( $\theta_x=0$ )
$h=200\mu\text{m}$	$\theta_x$ ( $\theta_y=0$ )
	$\theta_y$ ( $\theta_x=0$ )

## KEK-ATF Extraction Line



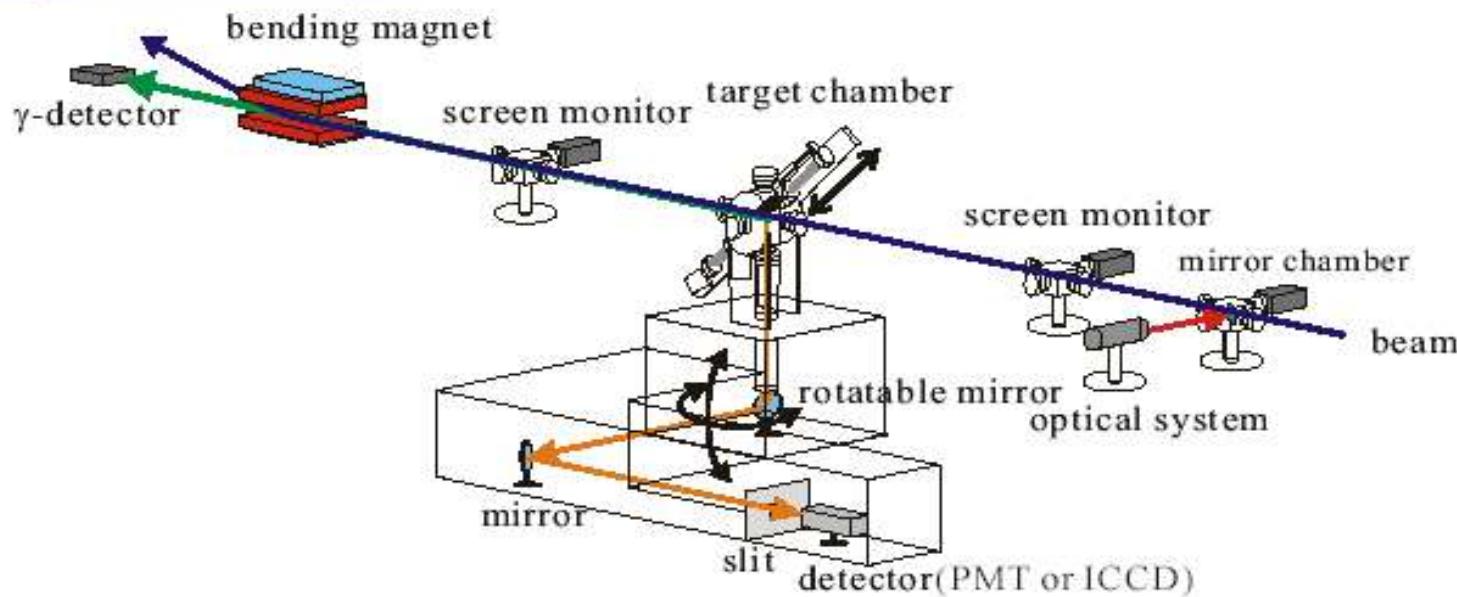
## Target Chamber



## Target

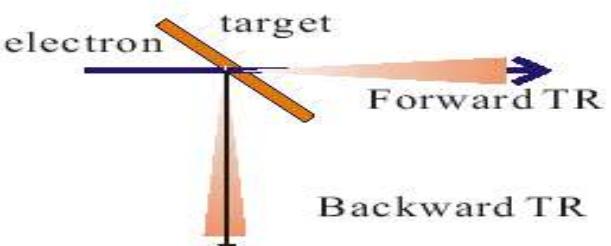
Si wafer( $\sim 300\mu\text{m}$ ) coated with Al or Au( $\sim 0.5\mu\text{m}$ )

## Experimental Layout



## Transition Radiation(TR)

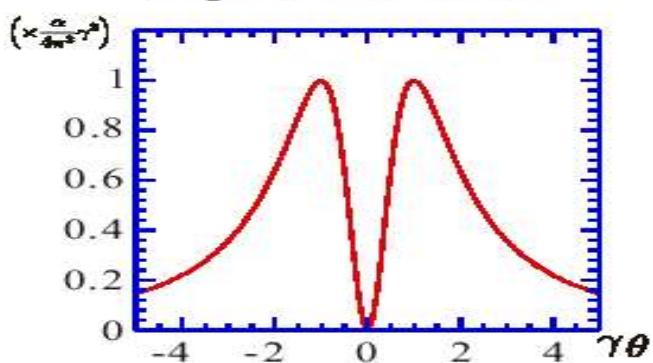
OTR



$$\frac{d^2W_{TR}}{d\Omega d\omega} = \frac{\alpha}{\pi^2} \frac{\theta_x^2 + \theta_y^2}{(\gamma^2 + \theta_x^2 + \theta_y^2)^2}$$

$\alpha$  : fine structure constant

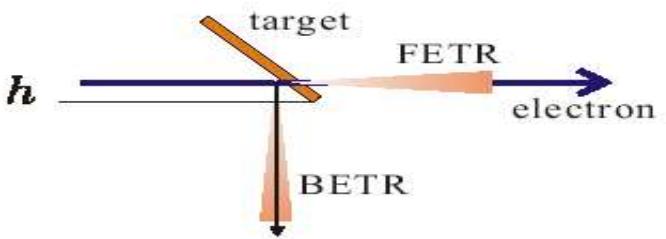
### Angular Distribution



Angular distribution has no wave length dependence, two maxima ( $\theta = \pm 1/\gamma$ ) and one bottom ( $\theta = 0$ )

## Edge Transition Radiation(ETR)

ETR

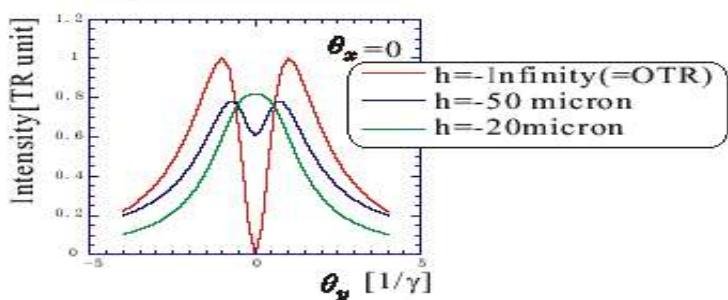


$$E_{ETR(x,y)}(-h) = E_{TR(x,y)} - E_{DR(x,y)} \exp(i\varphi)$$

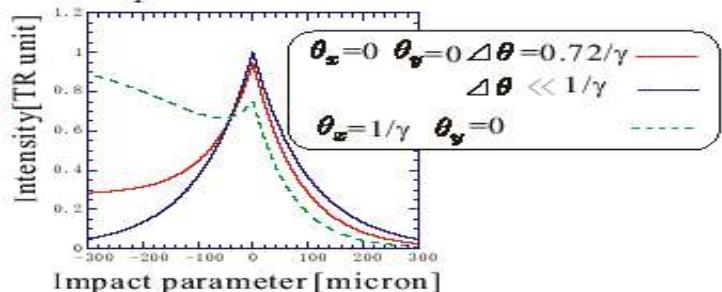
$$\frac{d^2W_{ETR}(-h)}{d\omega d\Omega} = 4\pi^2 (|E_{ETR,x}|^2 + |E_{ETR,y}|^2)$$

$$\varphi = \frac{2\pi h}{\lambda} \theta_y$$

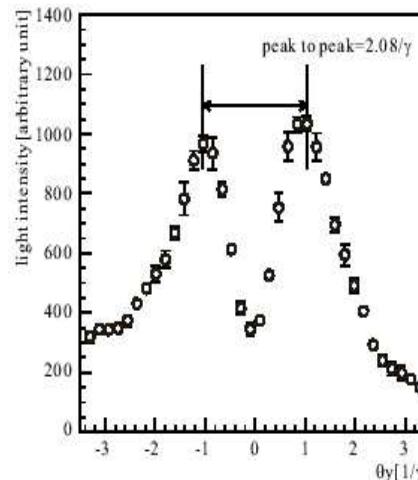
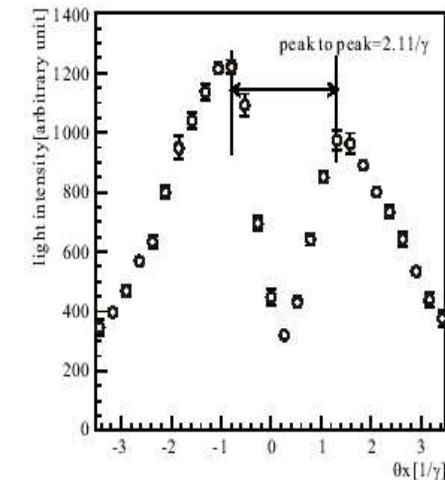
### Angular Distribution



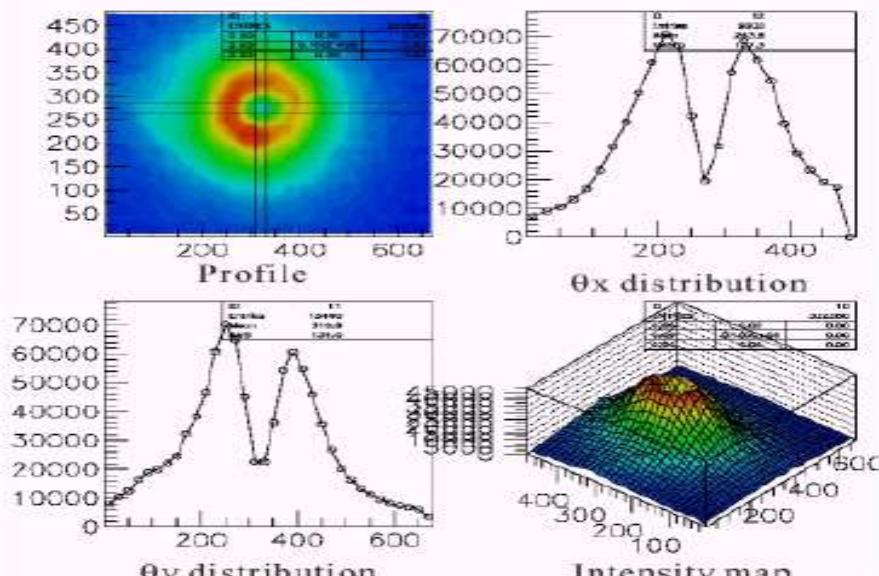
Impact parameter dependence



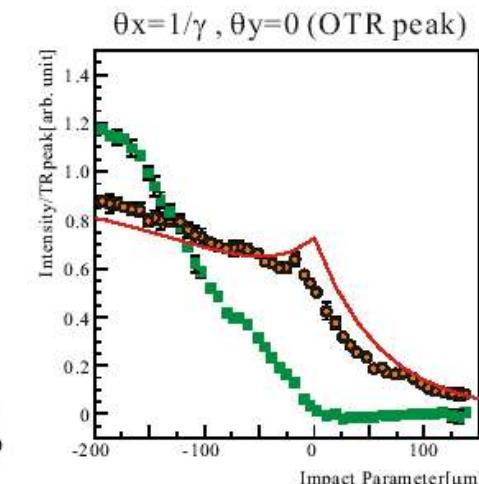
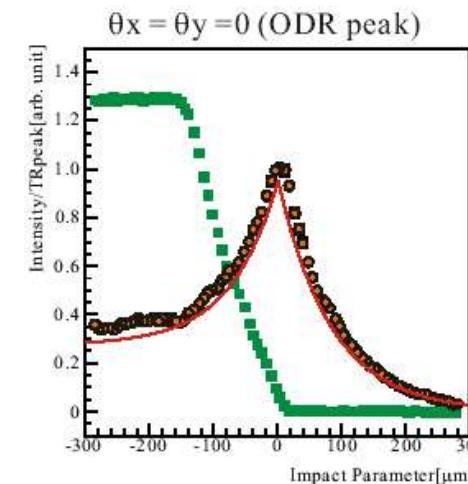
## Transition Radiation Angular Distribution



OTR measurement by ICCD

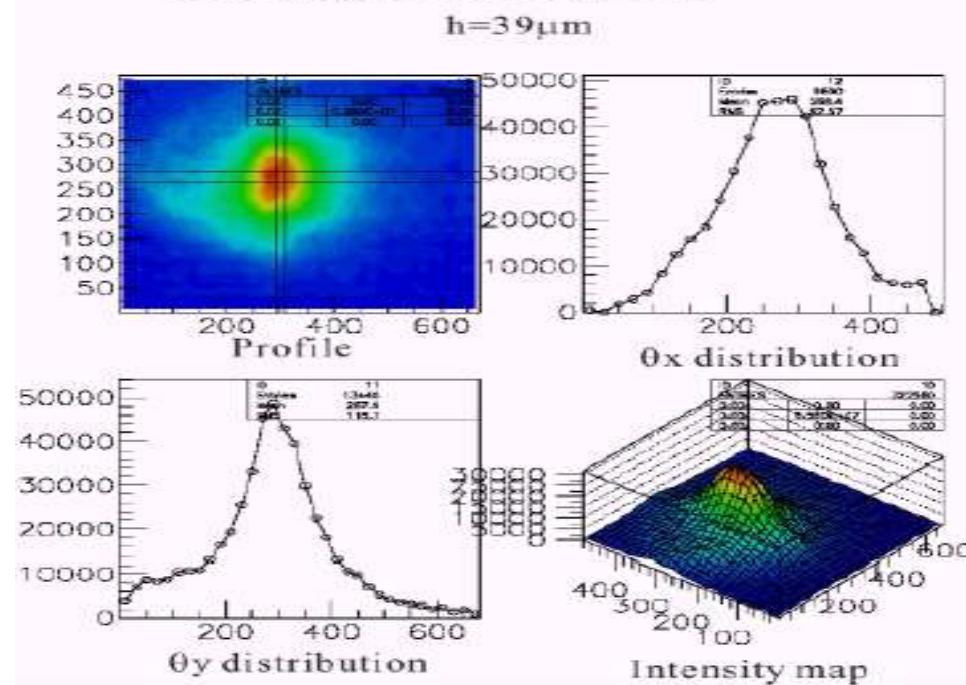


## Impact parameter dependence



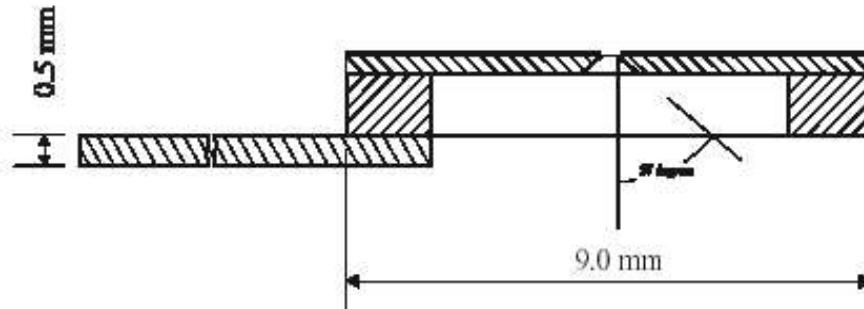
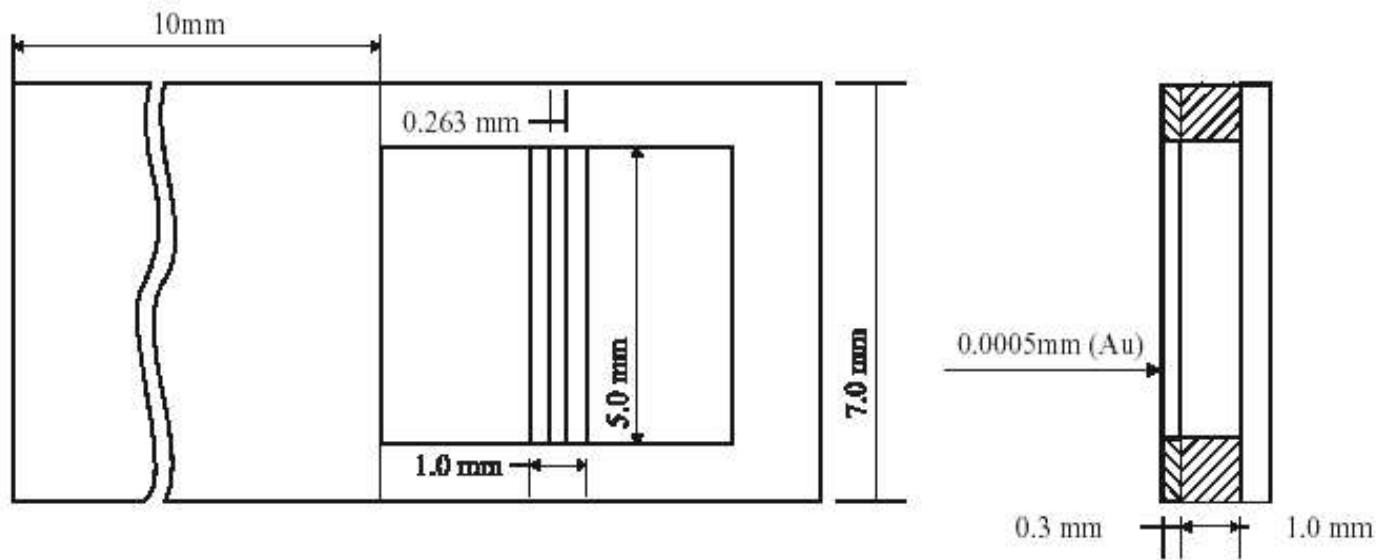
- Relative light yield
- Calculation
- gamma-ray intensity

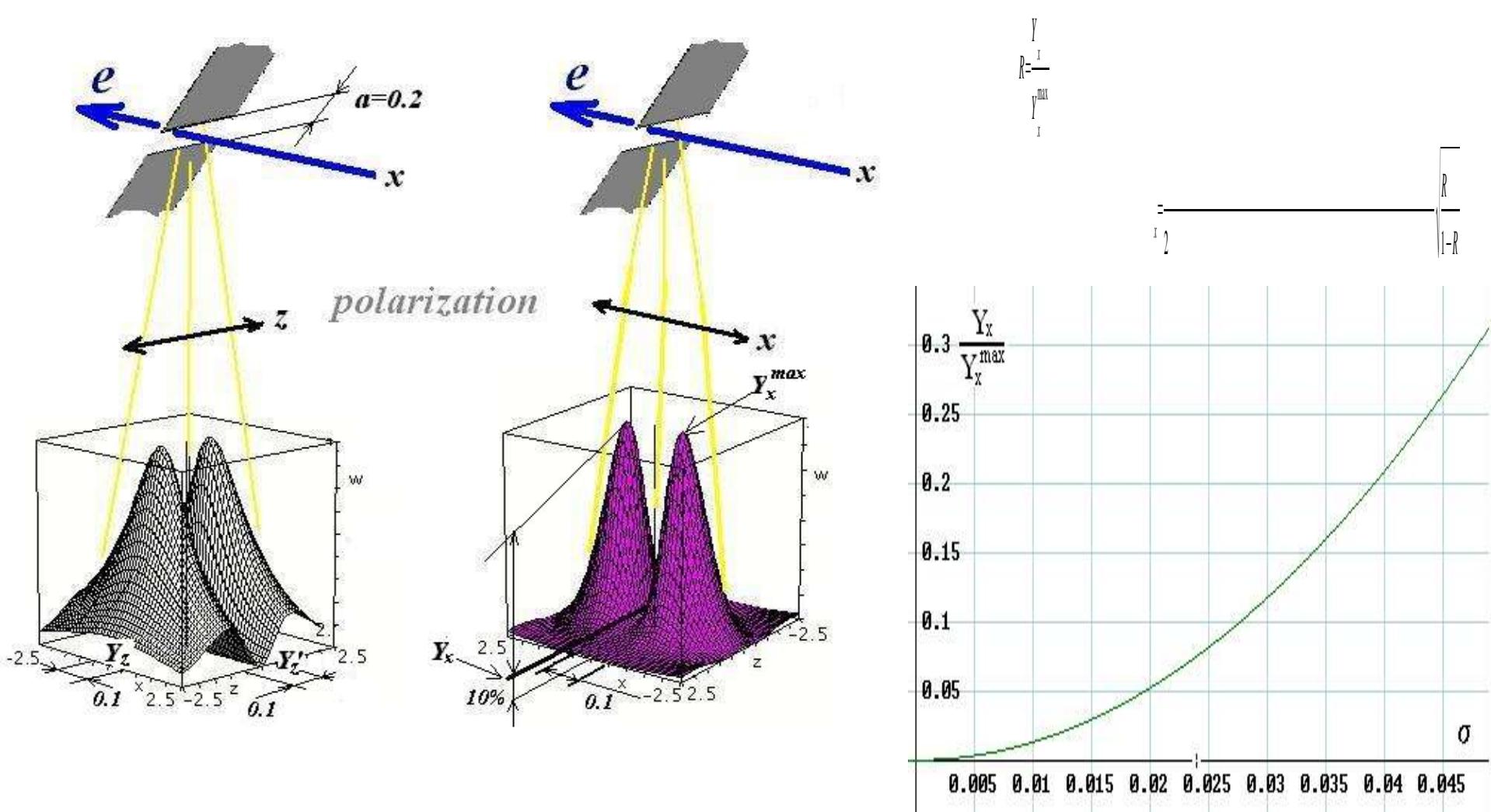
ODR measurement by ICCD



How to measure beam size from ODR angular distribution.  
We have to use slit target and measure the interference from both edges.

Slit Target

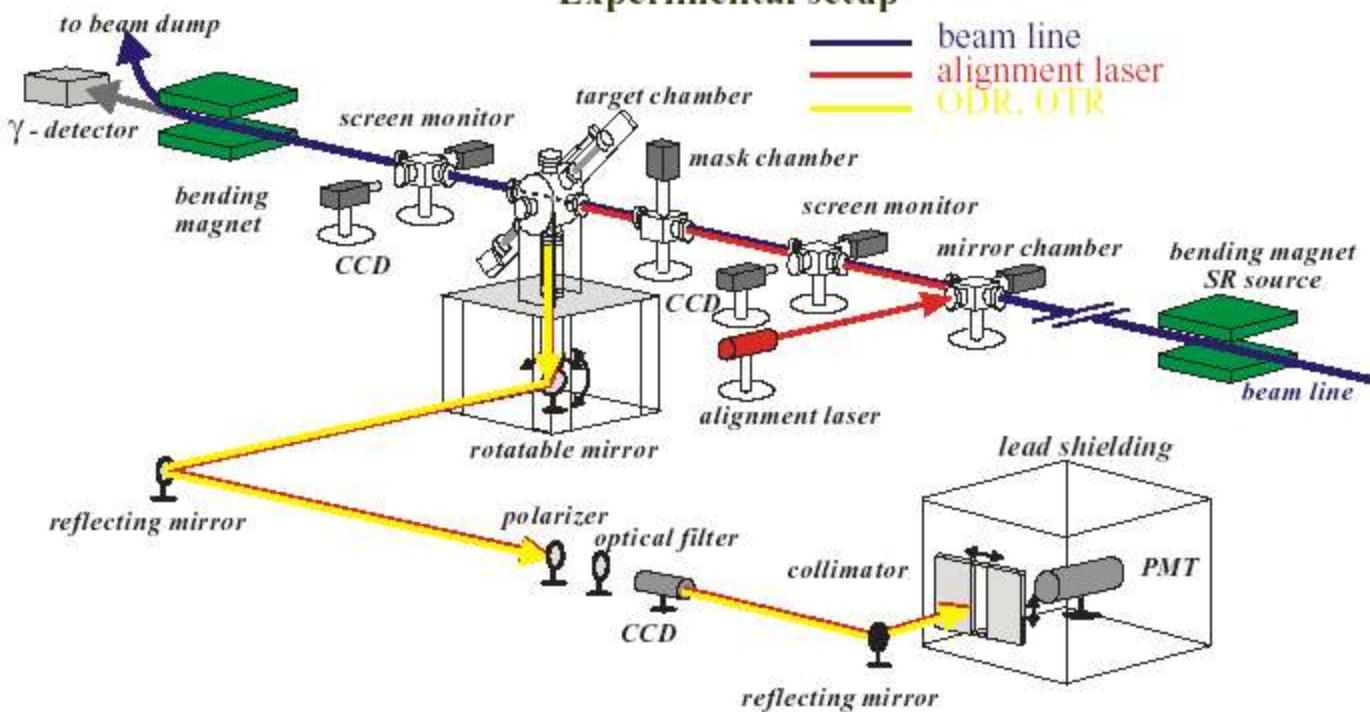




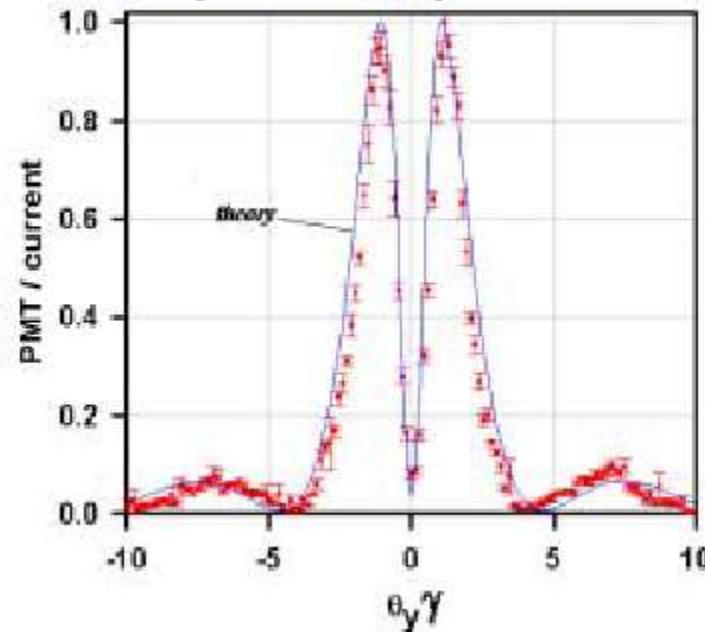
$Y_x$  is much more sensitive to the beam size.

We already measured interference of ODR from both edges and found fine interference structure due to synchrotron radiation from a near bending magnet.

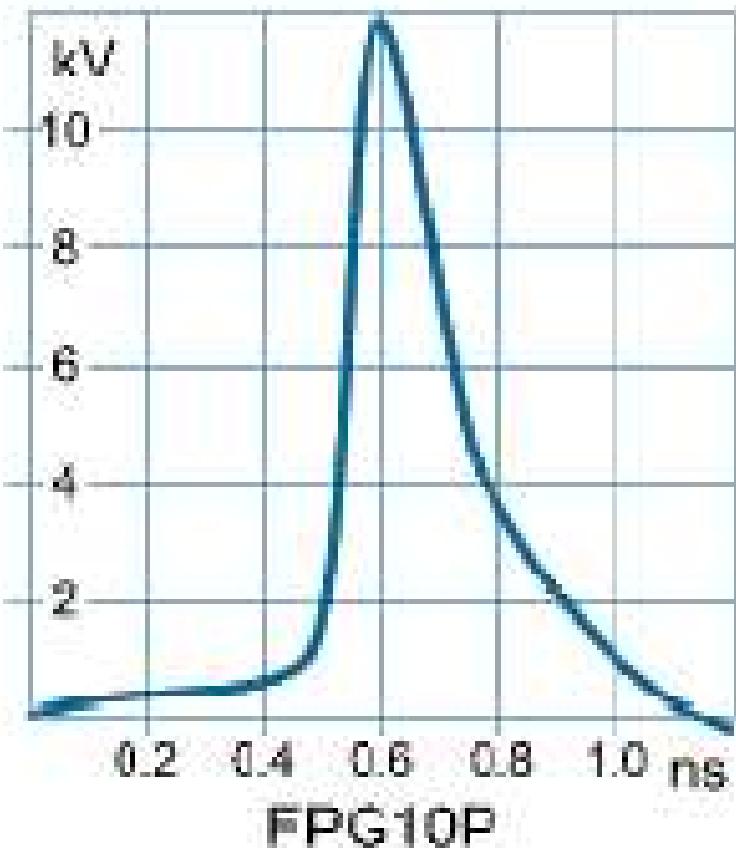
# Experimental setup



## ODR by PMT with polarizer



# Fast Kicker R&D : Present Technology on Pulse PS



FPG10 & FPG 20

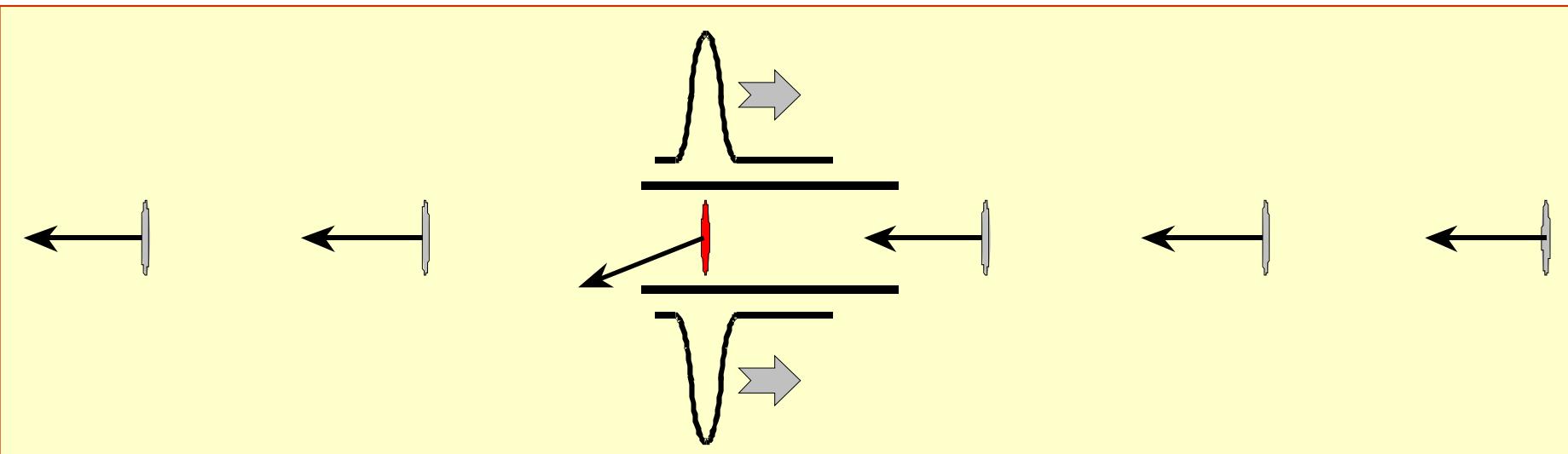
VMOS Technology by FID GmbH

# Strip line kicker modules

Fast switches dump high voltage pulses into a series of strip line structures.

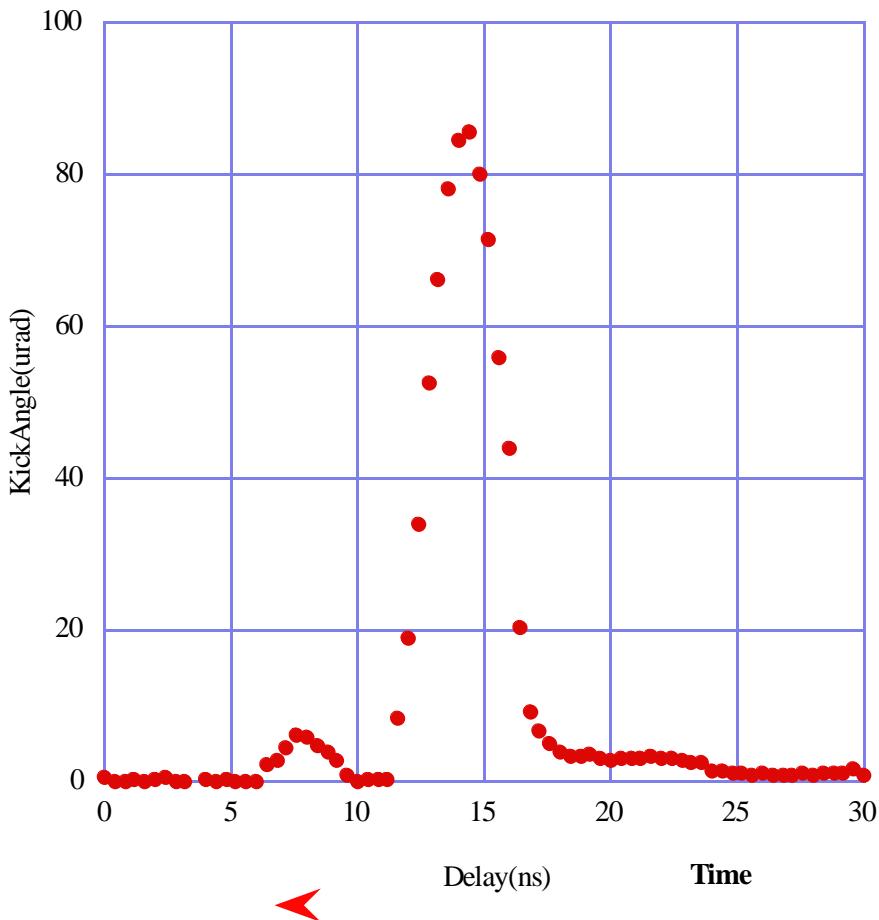
Electromagnetic pulse applies transverse kick to one bunch, but is absorbed in a load in each strip line module before next bunch arrives.

- switch speed, on-resistance, and stability are concerns
- adequate precision of strip line termination is challenging

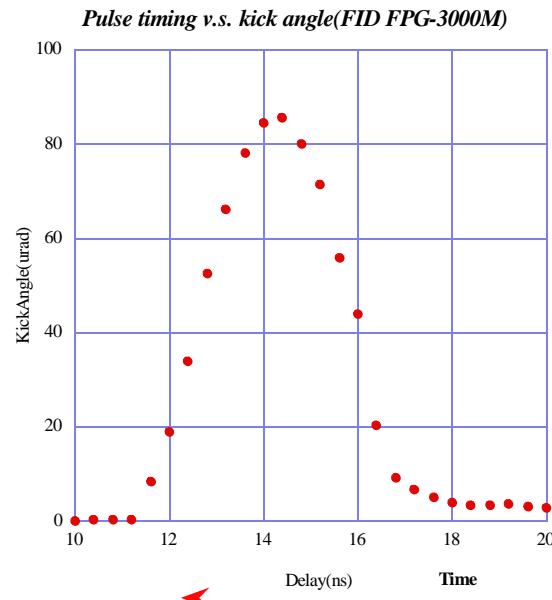


# Measurement result of FPG5-3000M

Pulse timing v.s. kick angle(FID FPG-3000M)

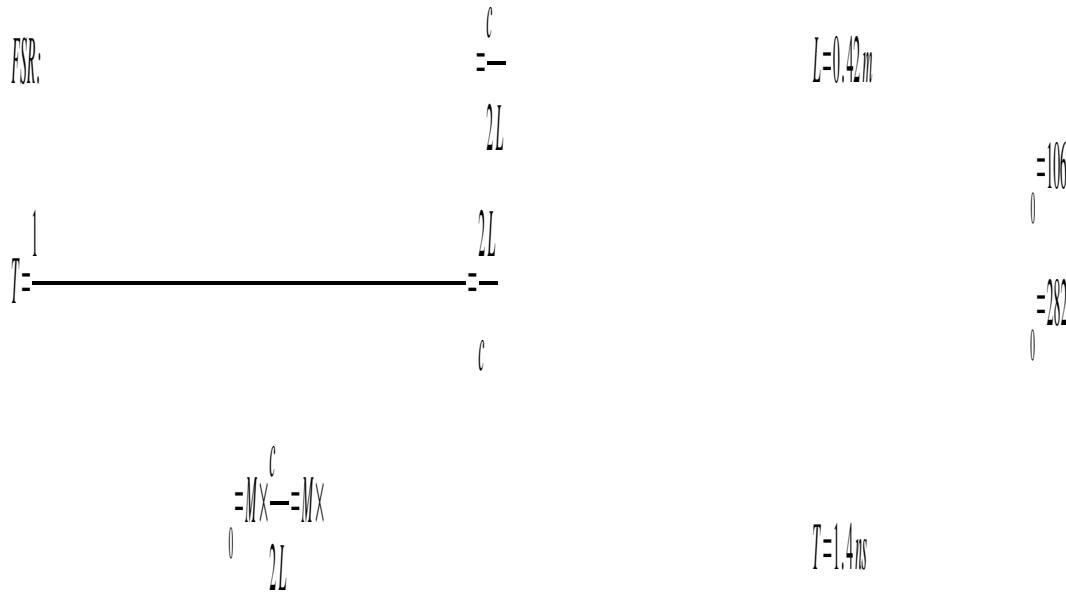


Rise time~3.2ns  
Kick angle ~85μrad  
(calc. 94.7μrad)



Expanded horizontal scale

# *Principle of Laser Interferometer in an Optical Cavity for **nm resolution***



\*This is frequency consideration.  
\*Two modulation methods for optical cavity are space of the cavity and frequency of mode-locking.

**Short laser pulse can be generated by many longitudinal waves which are completely mode-locked.**

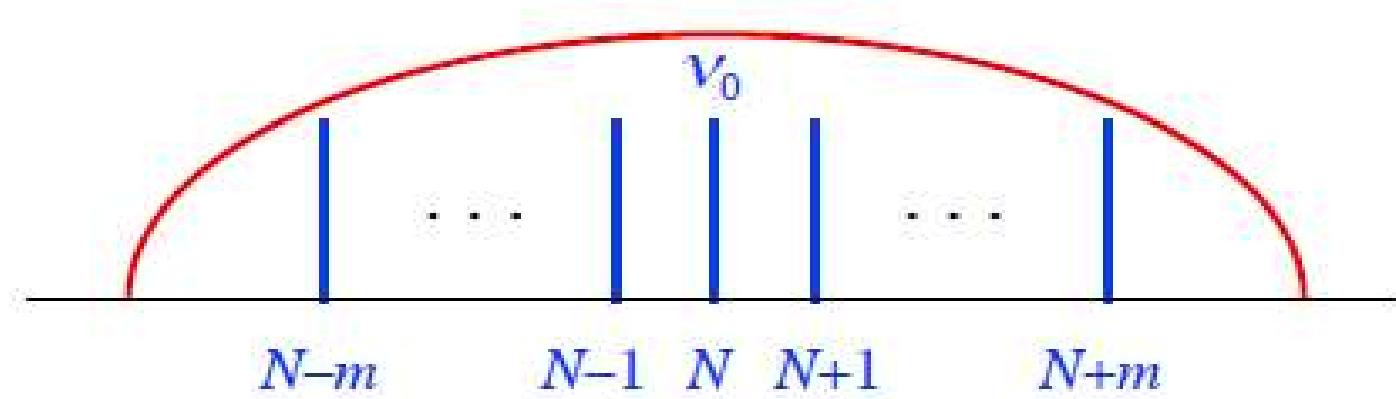
**7psec pulse width requires 200 longitudinal modes in the case of 714MHz repetition rate.**

$(|k| \leq m, M=2m+1)$

$$E(t) = \sum_{k=-m}^{+m} E_k e^{ik\omega t}$$

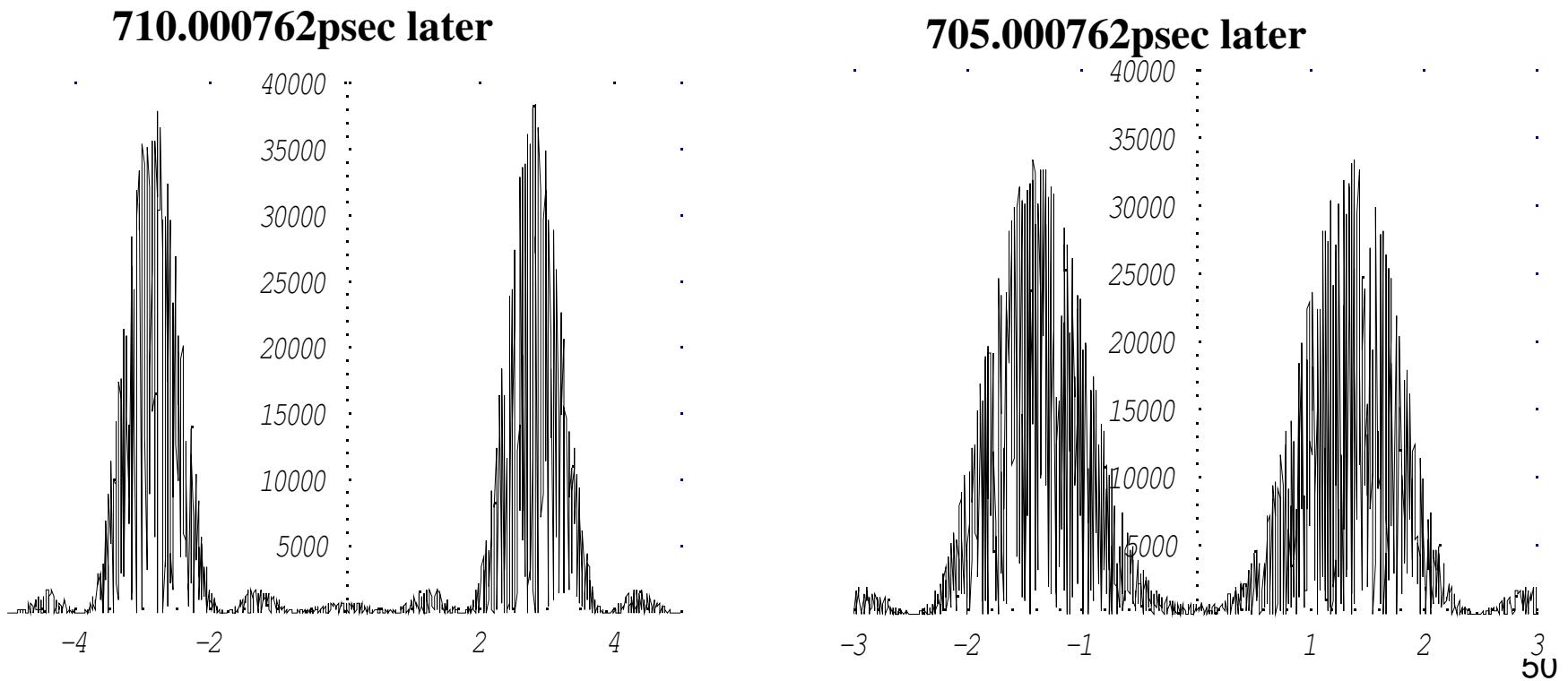
$$iE_0 e^{ik\omega t} = iE_0 \sum_{k=-m}^{+m} e^{ik2\pi f t}$$

$$iE_0 e^{ik\omega t} = \frac{i \sin(M\pi f t)}{\sin(\pi f t)}$$



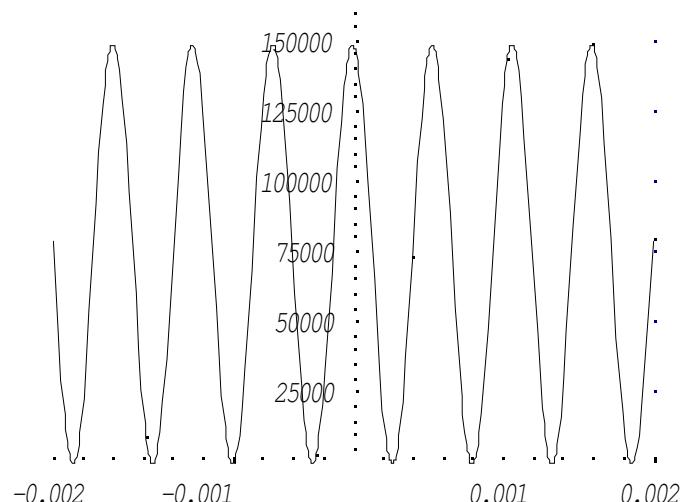
# Check by Mathematica in my laptop computer

Cavity Length =420mm, Center of the Cavity is z=0. Two 7psec laser pulses are moving upward and downward from high reflective Mirrors at t=0.

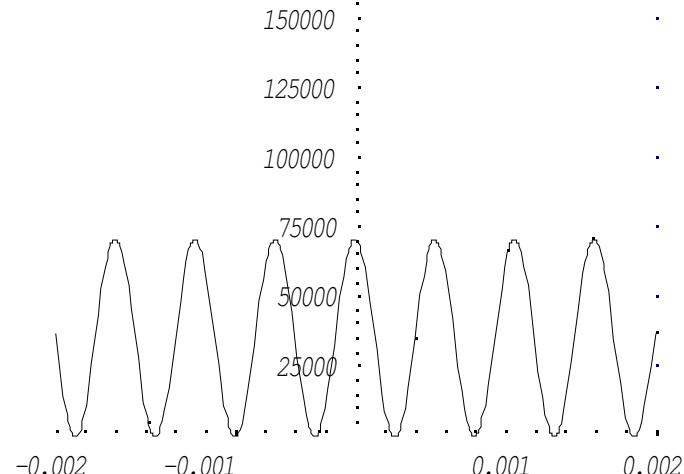


# Interference

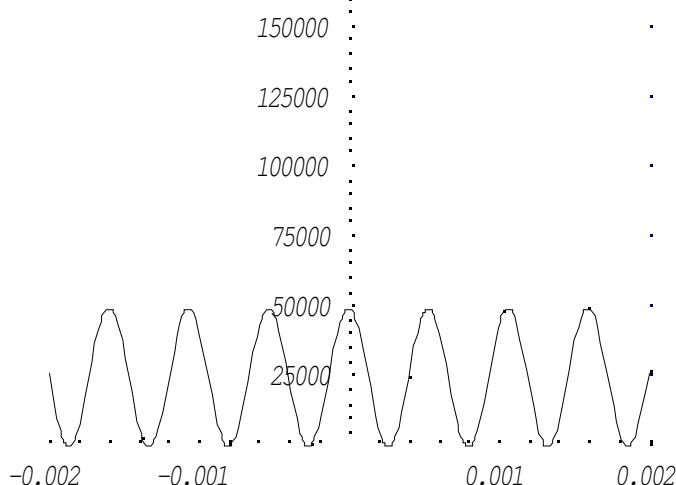
700.00076psec later



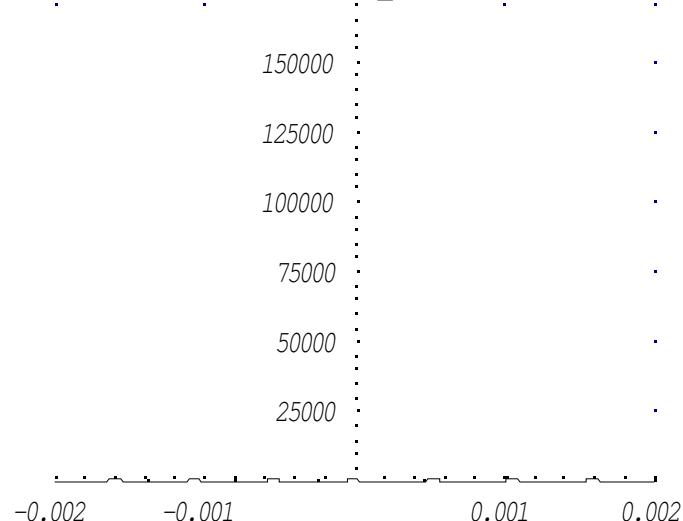
700.002psec later



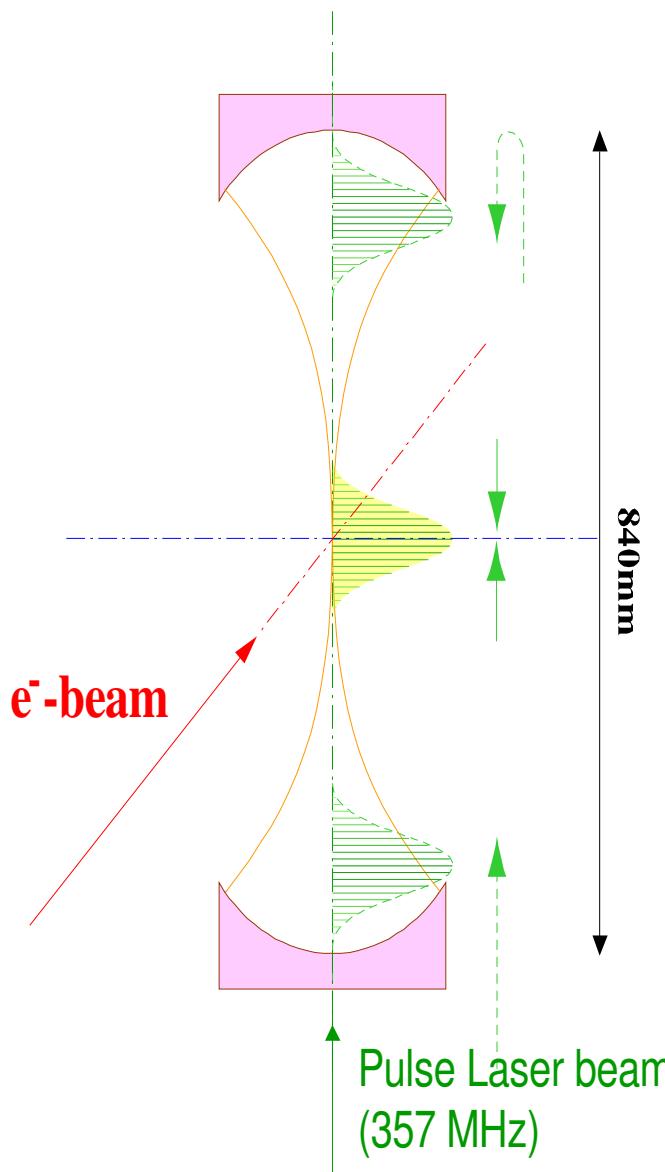
700.003psec later



700.0033psec later



# *Plan of Test Experiment*



We changed the length of the optical cavity from 840mm to 420mm since we could order 741MHz mode-lock laser.

**Specification of the 714MHz mode-lock laser**

800mW, 7psec pulse width(FWHM)

0.4psec(rms) timing jitter

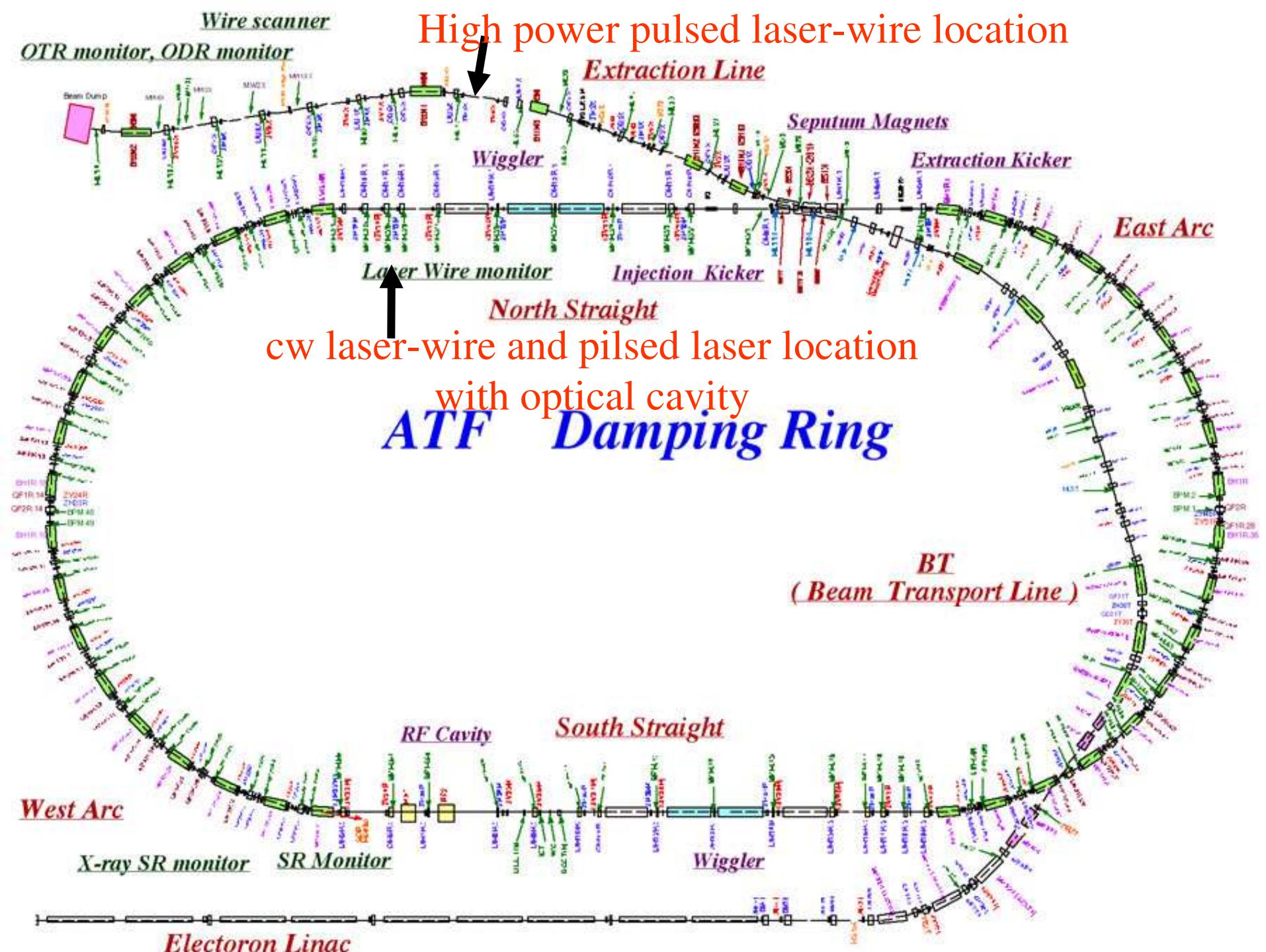
**First step : Confirmation of Interference**

**Second step : Movement of the Interference by phase shift or move Table**

**Third step : Installation into  $A_{52}^{TF}$  Damping ring**

# *Future plan for reliable nano beam size monitor*

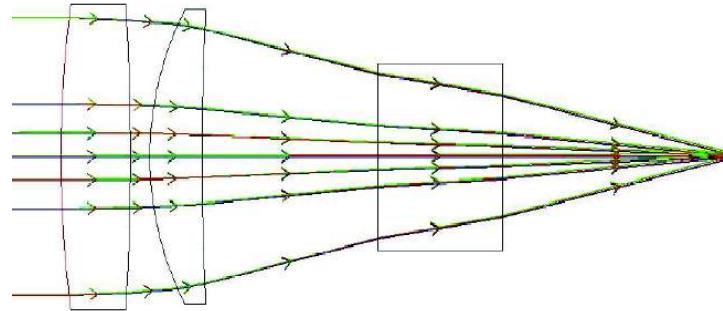
- We will design the chamber which includes vertical 42cm optical cavity and is attached with upstream cavity BPM and downstream cavity BPM. Two BPMs can measure the beam orbit within the accuracy of a few nano-meter.
- We will change the laser wavelength from **1064nm** to **532nm(Green)**.
- This is a backup system for Shintake monitor.



# ATF Extraction line laser-wire



Vacuum vessel + lens  
Designed and built at Oxford

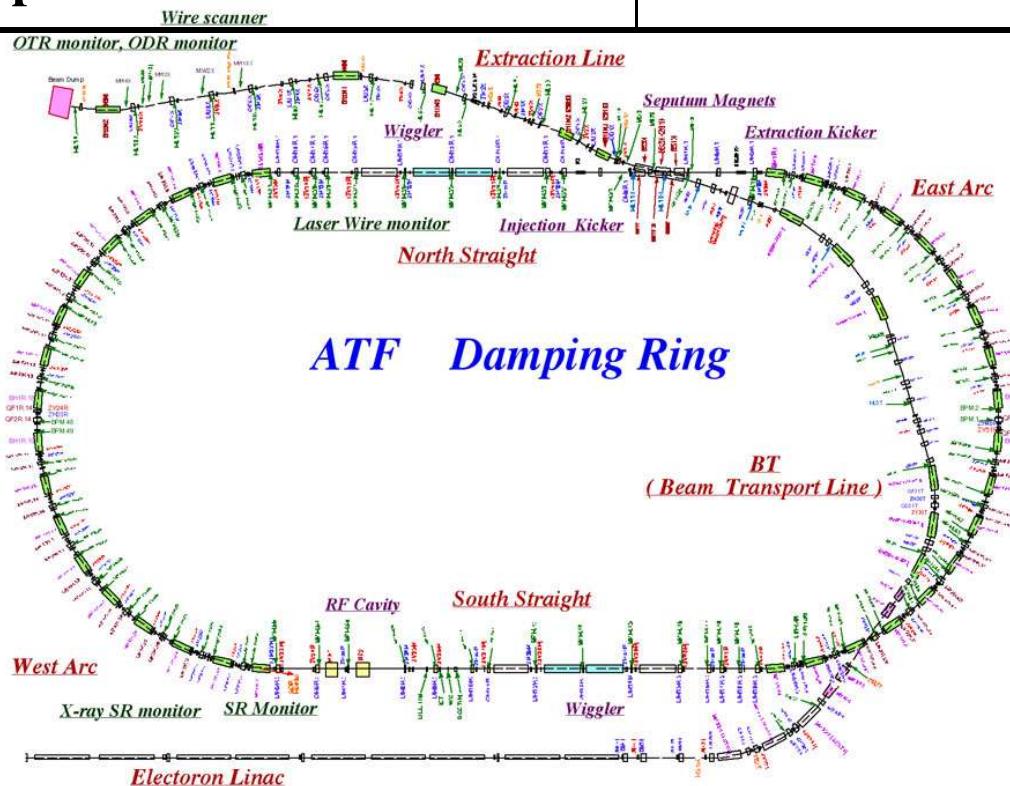


Vacuum vessel installed in ATF Oct 05  
Data taking planned for Dec 05

# Mission of ATF/ATF2

- ATF, to establish the technologies associated with producing the electron beams with the quality required for ILC and provide such beams to ATF2 in a stable and reliable manner.
- ATF2, to use the beams extracted from ATF at a test final focus beam-line which is similar to what is envisaged at ILC. The goal is to demonstrate the beam focusing technologies that are consistent with ILC requirements. For this purpose, ATF2 aims to focus the beam down to a few tens of nm (rms) with a beam centroid stability within a few nm for a prolonged period of time.
- Both the ATF and ATF2, to serve the mission of providing the young scientists and engineers with training opportunities of participating in R&D programs for advanced accelerator technologies.

<b>Maximum energy</b>	<b>1.28 GeV (<math>\gamma = 2500</math>)</b>
<b>Beam emittance</b>	<b>Vertical</b> $(1.5 \pm 0.25) \times 10^{-11} \text{ m rad}$
	<b>Horizontal</b> $(1.4 \pm 0.3) \times 10^{-9} \text{ m rad}$
<b>Bunch Length</b>	<b>~8mm (26 ps)</b>
<b>Single bunch population</b>	<b><math>1.2 \times 10^{10}</math></b>
<b>Energy Spread</b>	<b>0.08%</b>

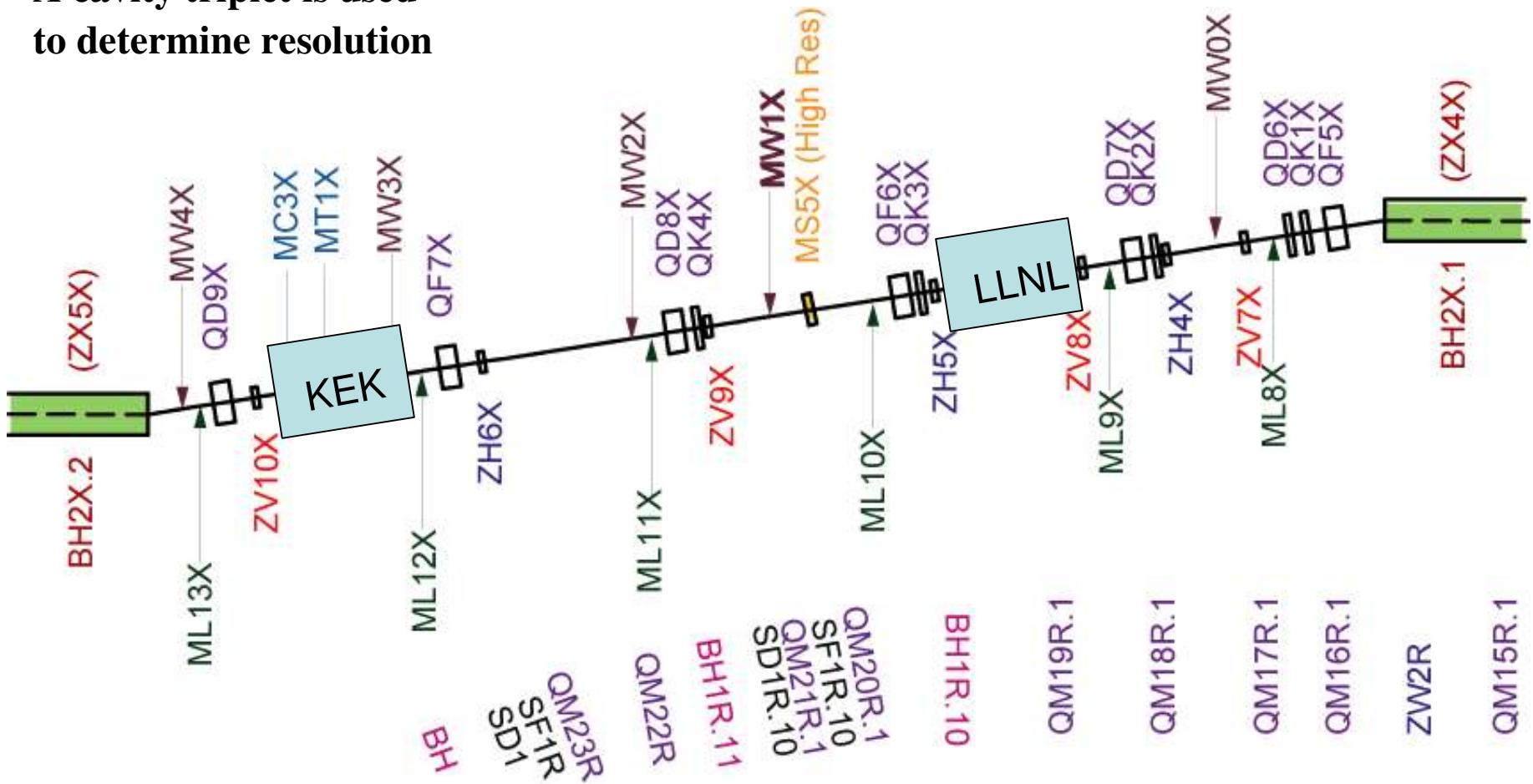


# **Present Research Programmes at ATF**

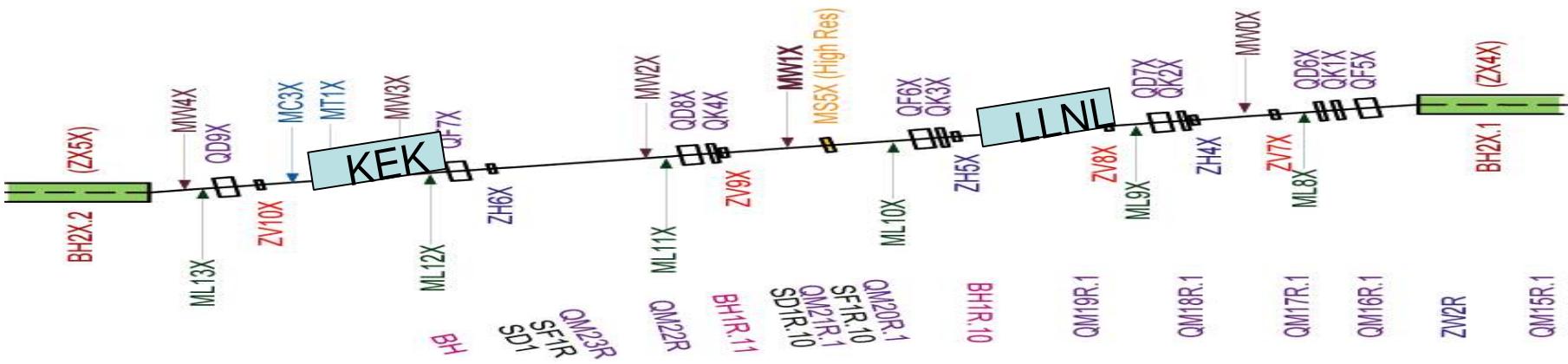
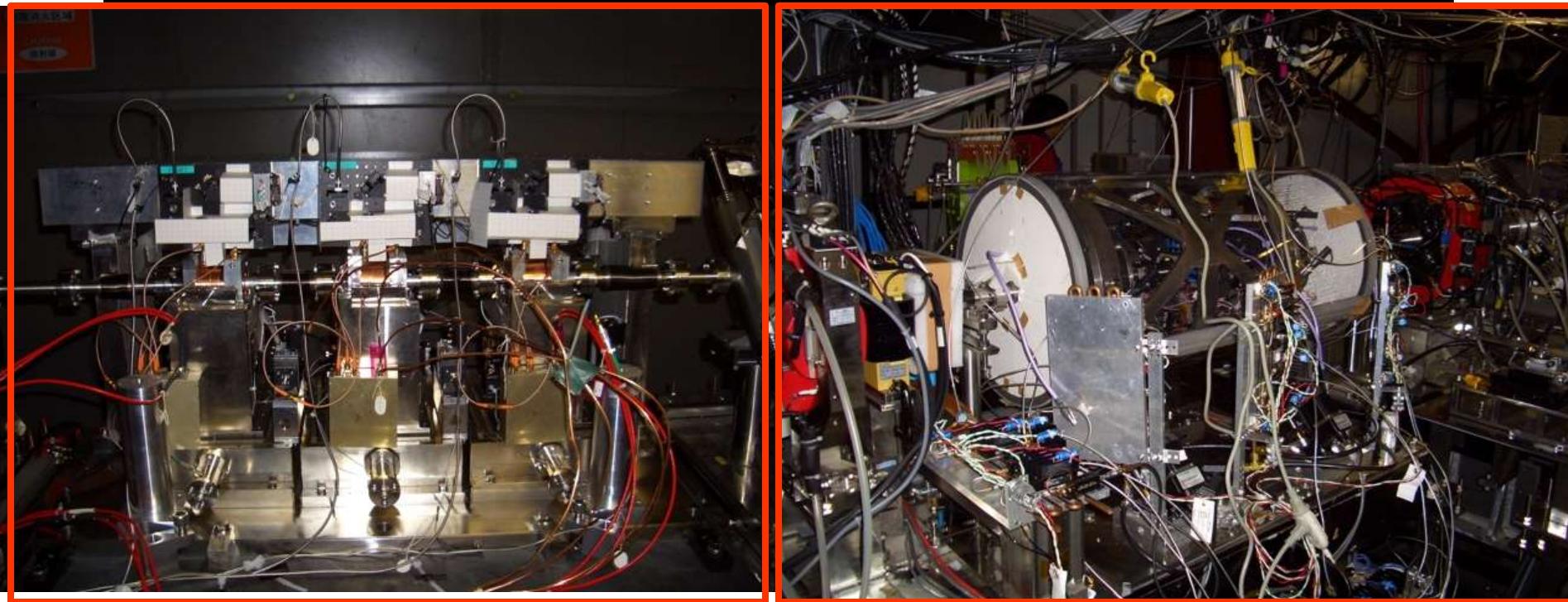
- 1. Pol. Positron generation R&D at EXT (ended June 2005)**
- 2. Laser wire R&D in Damping Ring (Kyoto University)**
- 3. High quality electron beam generation by photo-cathode RF Gun (Waseda University)**
- 4. X-SR Monitor R&D (University of Tokyo)**
- 5. ODR R&D (Tomsk University)**
- 6. Beam Based Alignment R&D**
- 7. Nano-BPM project of SLAC, LLNL and LBNL**
- 8. Nano-BPM project of KEK**
- 9. FONT project (UK Institutes)**
- 10. Laser Wire project at EXT (UK Institutes)**
- 11. Fast Kicker Development project (DESY, SLAC, LLNL)**
- 12. Fast Ion Instability Research**

# 2 Cavity BPM triplets in ATF Extraction Line

A cavity triplet is used  
to determine resolution

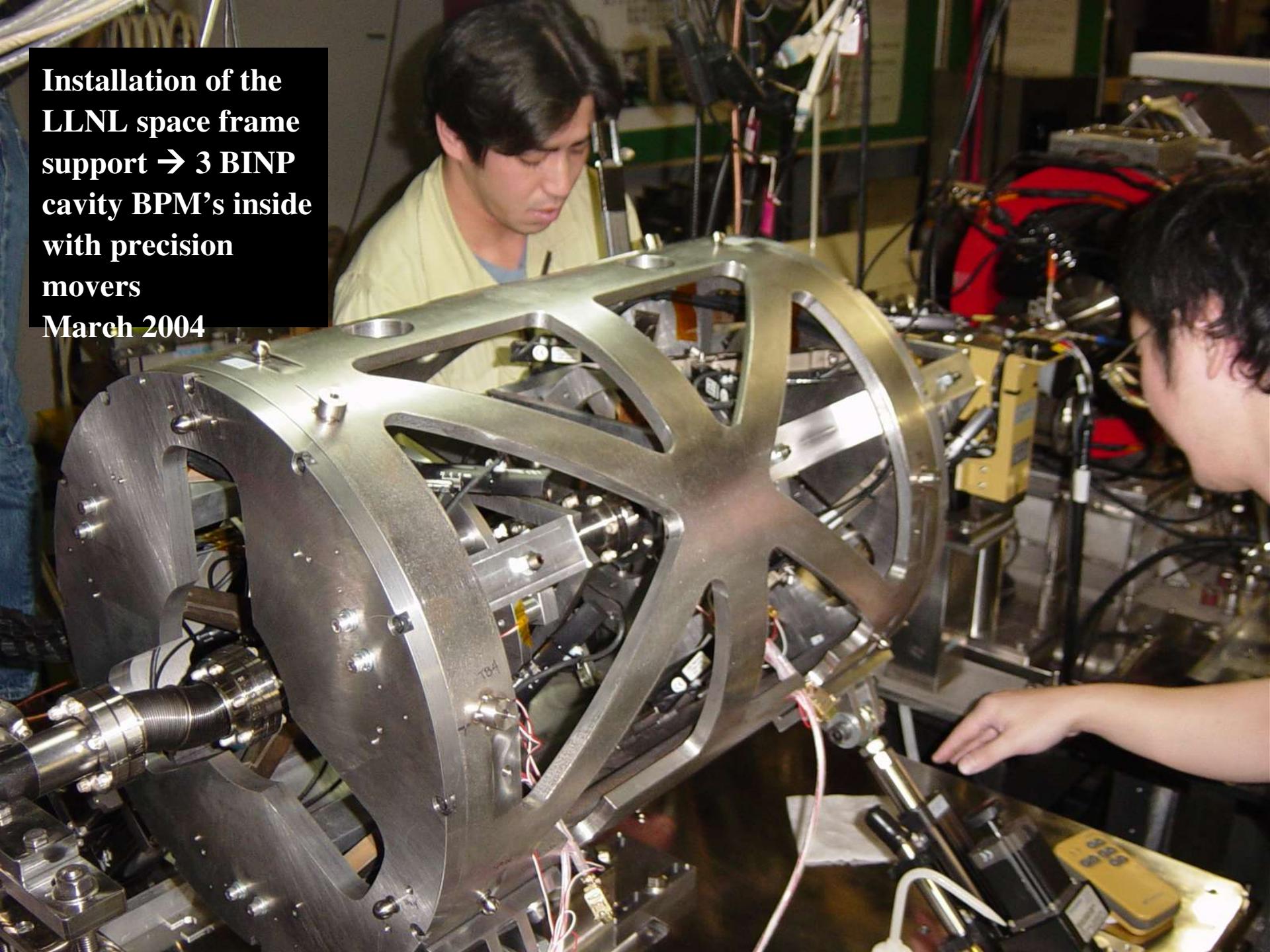


# ATF Nano BPM



**Installation of the  
LLNL space frame  
support → 3 BINP  
cavity BPM's inside  
with precision  
movers**

**March 2004**



# BINP Cavities (Vogel, *et al.*) ~ 2cm aperture Dipole-mode selective couplers

Incoming beam params:

Charge Q ~ 1.5 nC

Spot size:

x ~ 80  $\mu\text{m}$

y ~ 8  $\mu\text{m}$

z ~ 8mm (!)

Energy

dispersion ~  $10^{-3}$

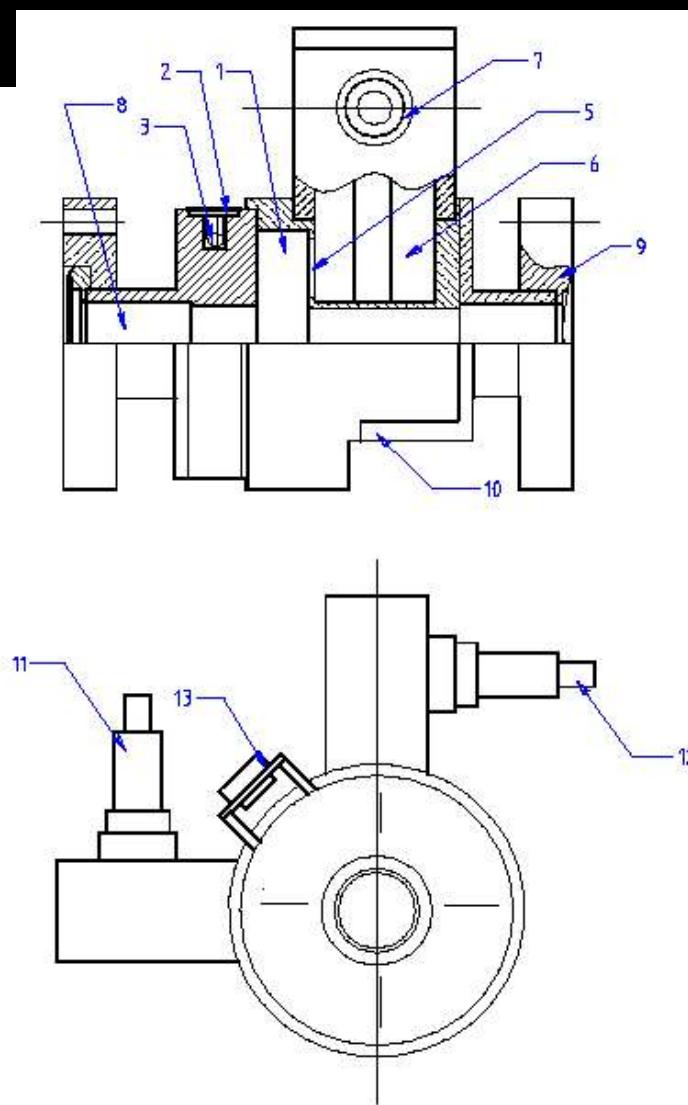
E/E ~  $5 \cdot 10^{-4}$

Position & angle jitter:

x 20  $\mu\text{m}$

y 3.5  $\mu\text{m}$

, 1000  $\mu\text{rad}$



Cross-sectional view of BINP cavity BPM 6426 MHz, (5p. in KEK ATF + 1p.). 2000.

1.- Cavity sensor .

2- Heater.

3 – Temperature sensor.

5 – Coupling slot.

6 – Output waveguide.

7 – Output feedthrough.

8 – Beam pipe.

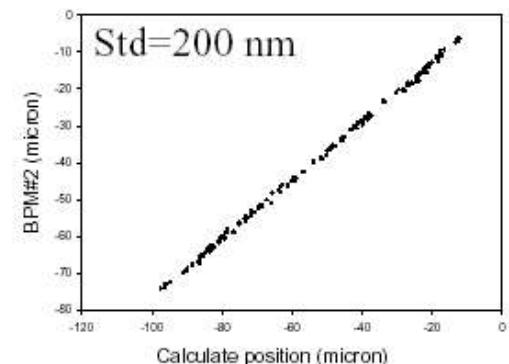
9 – Vacuum flange.

10 – Support plate.

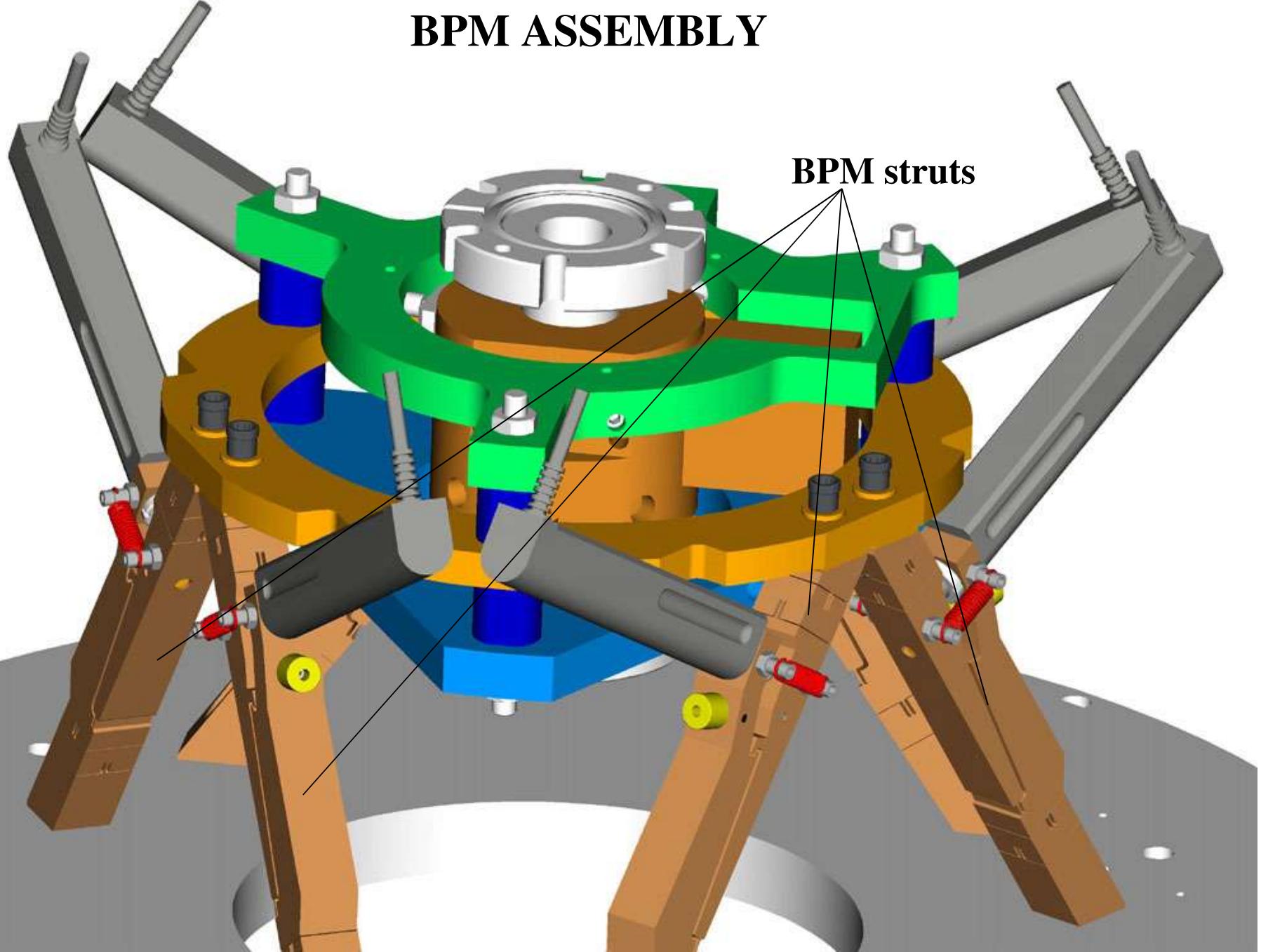
11 – Y position output.

12 - X position output.

13 – Heater control connector.

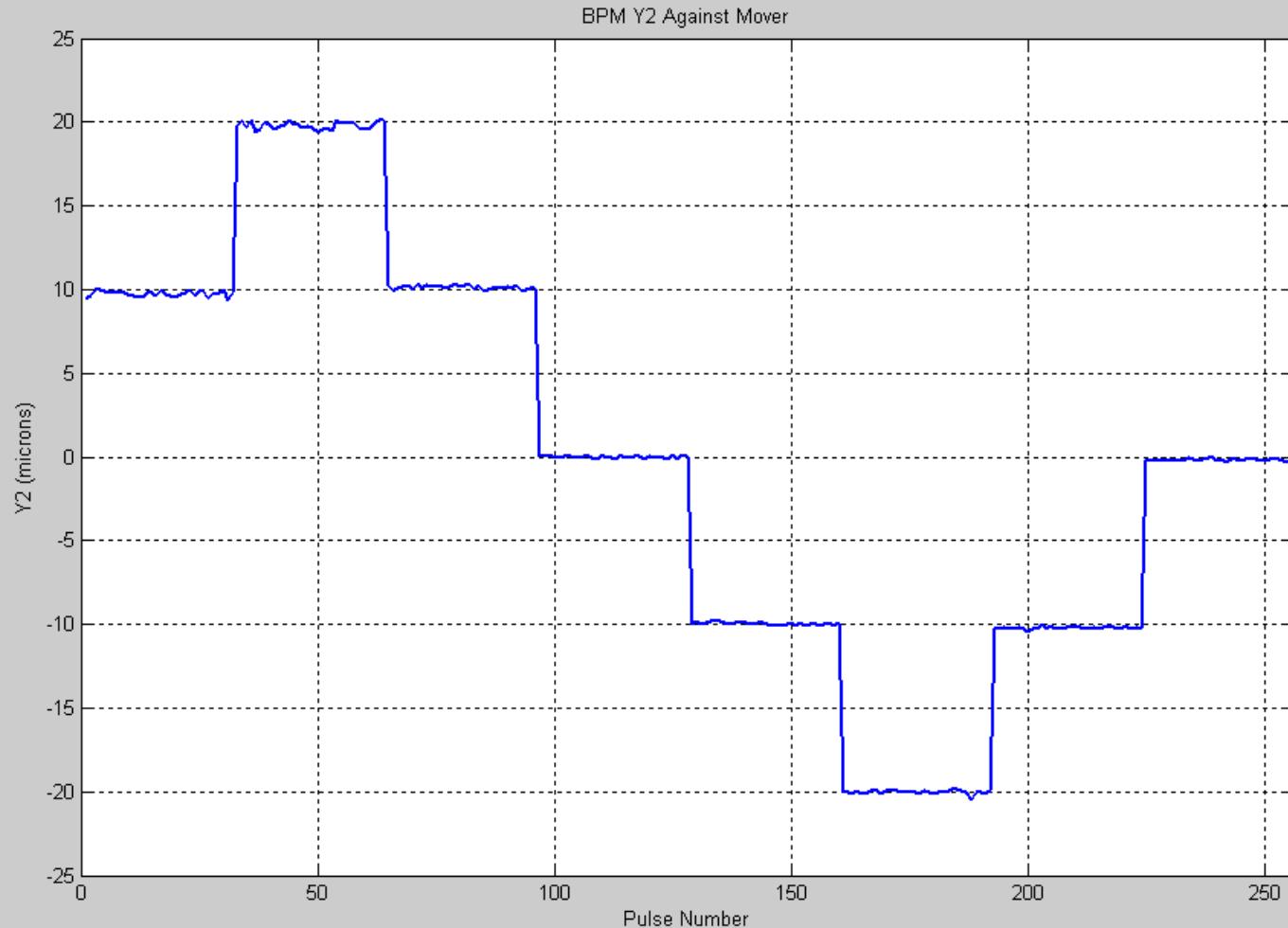


# BPM ASSEMBLY

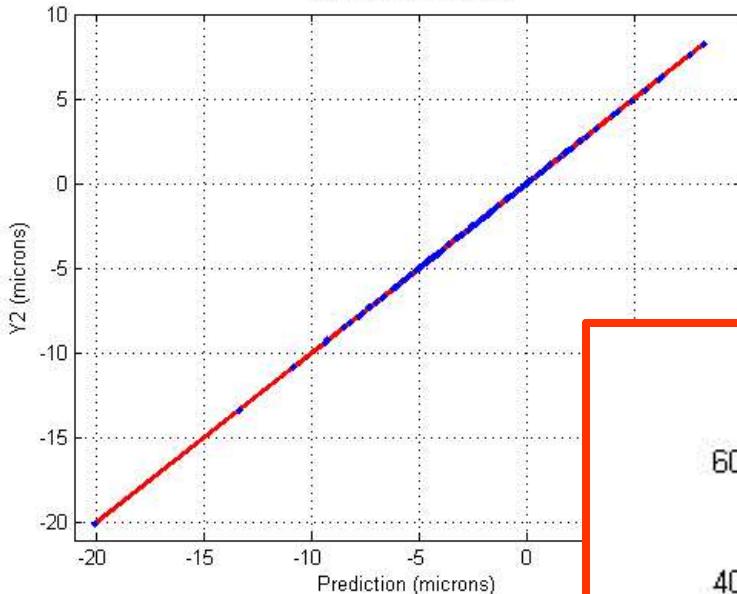


# Calibration

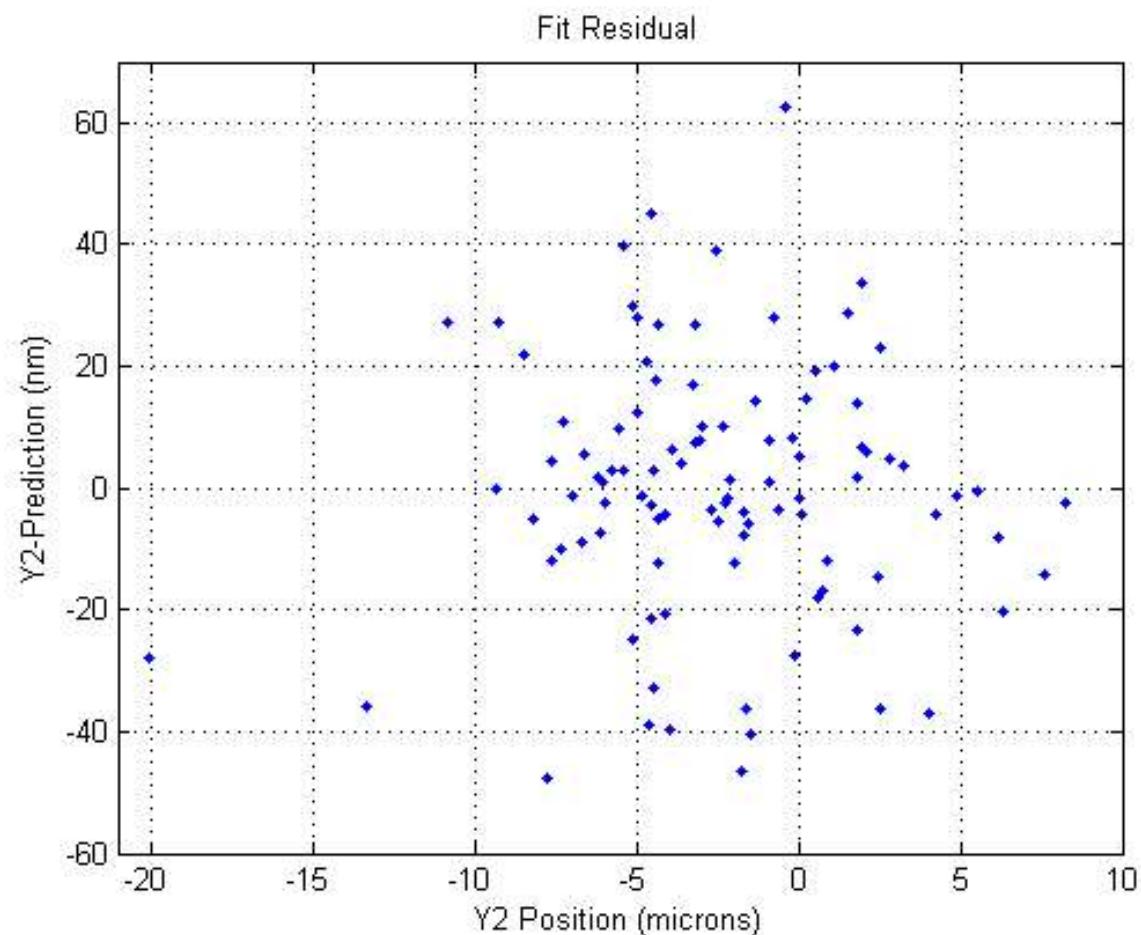
- Move one BPM at a time with movers
- Extract BPM phase, scale, offset as well as beam motion by linear regression of BPM reading against mover + all other BPM readings.



# Short Term Resolution



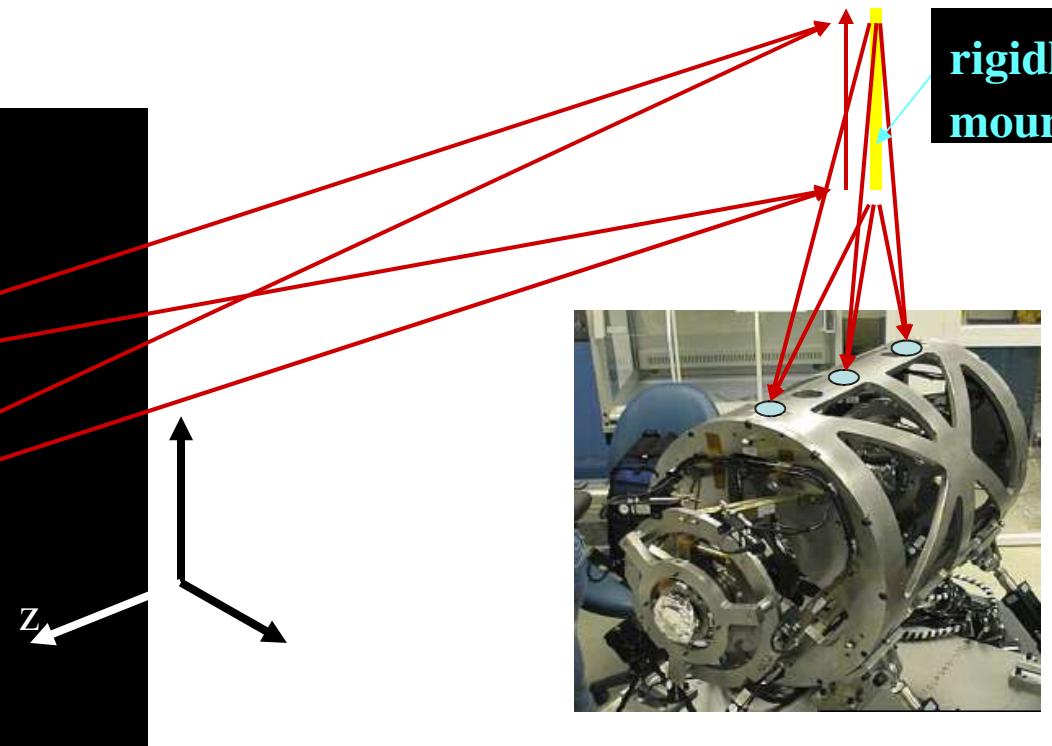
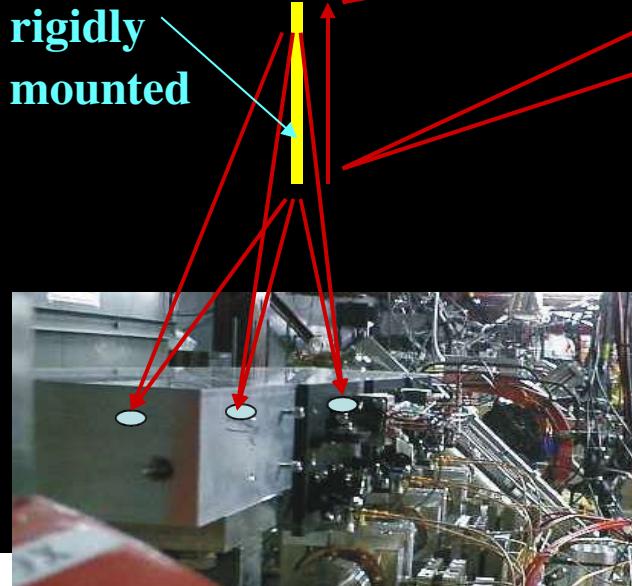
Predict Y2 from other BPMs  
Linear least-squares fit to (x, y, x',  
y') at BPMs 1&3



- 1 minute
- 100 pulses
- $s = 17 \text{ nm}$
- Is it real ?

# Optical Geodetic structure

- Considering two different setups:



Cartoon for Setup 1:  
2-dimensional Grid of  
distance meters (Michelson  
Interferometers)

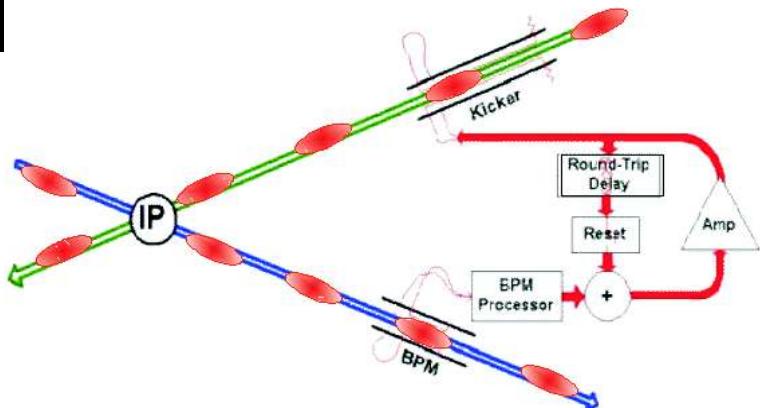
# Beam-based Feedback Systems:

- **FONT UK:**

Queen Mary: Philip Burrows, Glen White, Glenn Christian,  
Hamid Dabiri Khah, Tony Hartin, Stephen Molloy,  
Christine Clarke, Christina Swinson

Daresbury Lab: Alexander Kalinin, Roy Barlow, Mike Dufau

Oxford: Colin Perry, Gerald Myatt

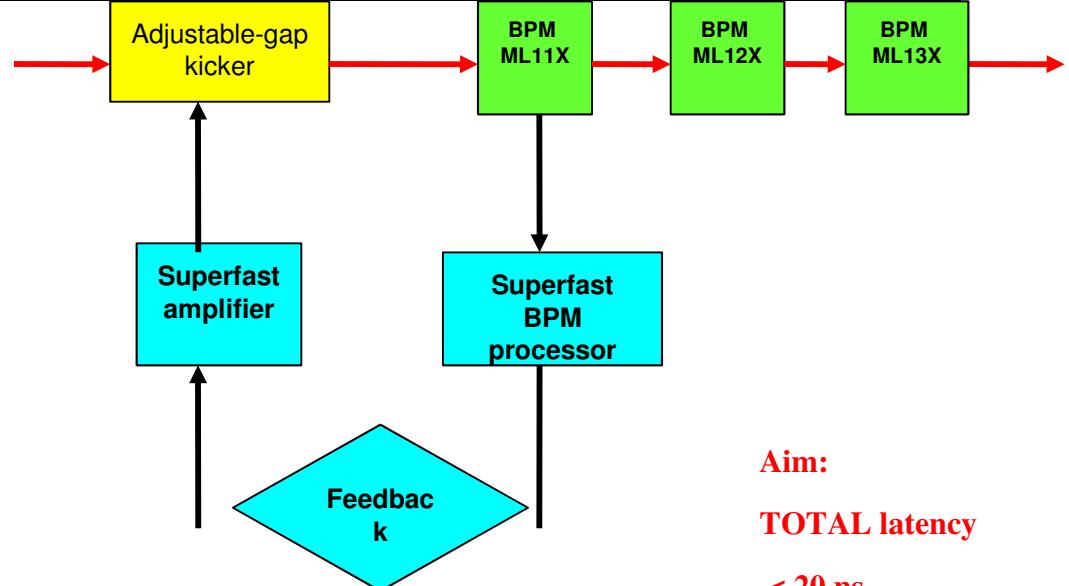
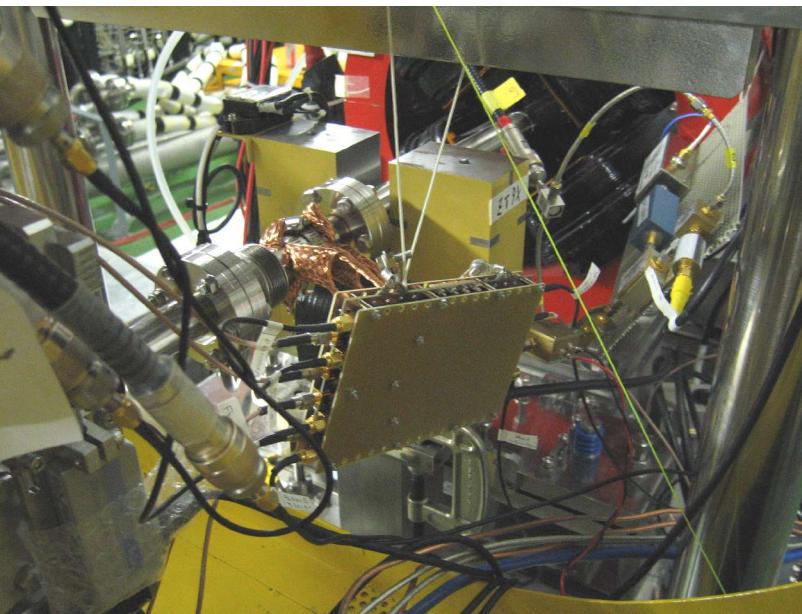


**FONT3 PCB  
amplifier + FB**



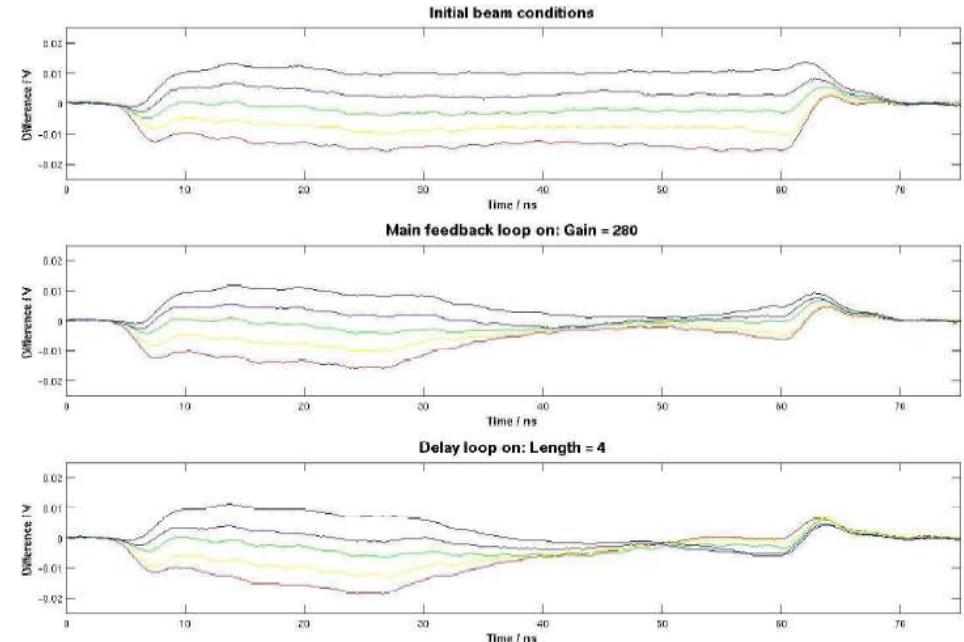
**Same drive power  
as needed for ILC**

# FONT3 Installation in ATF extraction line



Aim:  
**TOTAL latency**  
**< 20 ns**

- Demonstrated feedback with delay loop
- Ultra-fast system: total latency 23 ns
- Varied main gain, delay loop length, delay loop gain
- system behaves as



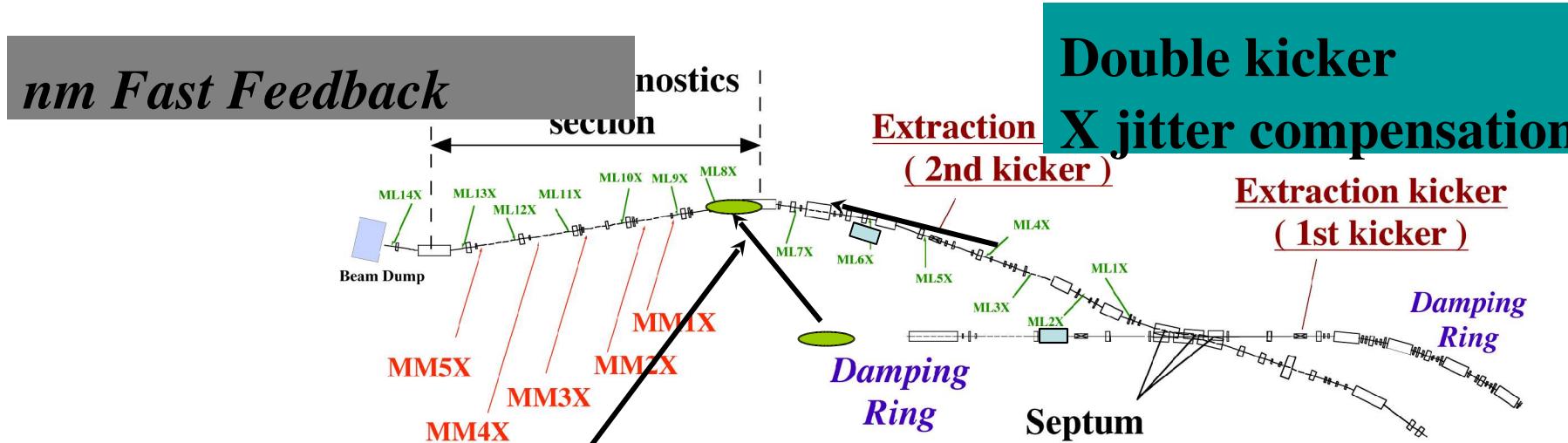
# **FONT4: Prototype Digital Feedback System**

- ATF/(ATF2): 1.3 GeV beam, 3 bunches with spacing c. 150ns
- FONT4 (2005-6):
  - modified FONT3 BPM front-end signal processor
  - digital FB system
  - FEATHER adjustable-gap kicker
- Aiming for first demonstration of FB w. ILC-like bunches:
  - latency 100ns (electronics)
  - stabilisation of 3<sup>rd</sup> bunch at um level
- Possible first component tests at ATF December 2005/March 2006

# FONT project (UK Institutes)

## Feedforward to Extraction Line

### Layout of KEK-ATF Extraction Line



μm Feedforward ( DR BPM -> EXT Line new strip line kicker)

Cavity BPM (MM1X-MM5X)  
sensor cavity

# ATF2

## Technology Challenge of ILC

- High Gradient Acceleration

Several test facilities: TTF(DESY), STF(KEK), SMTF(FNAL)

- High Luminosity Issues

- Equally important

- ATF achieved a small emittance a few pm radian

- FFTB reached a small beamsize  $\sim 70\text{nm}$ ,  
with position jitter 20-40nm

- Need one more step to nano-meter

- ★ Smaller size by the optics with local chromaticity compensation

- ★ Stabilization

- ★ Learn commissioning/tuning process (recall SLC)

⇒ Make use of ATF beam

# ATF2

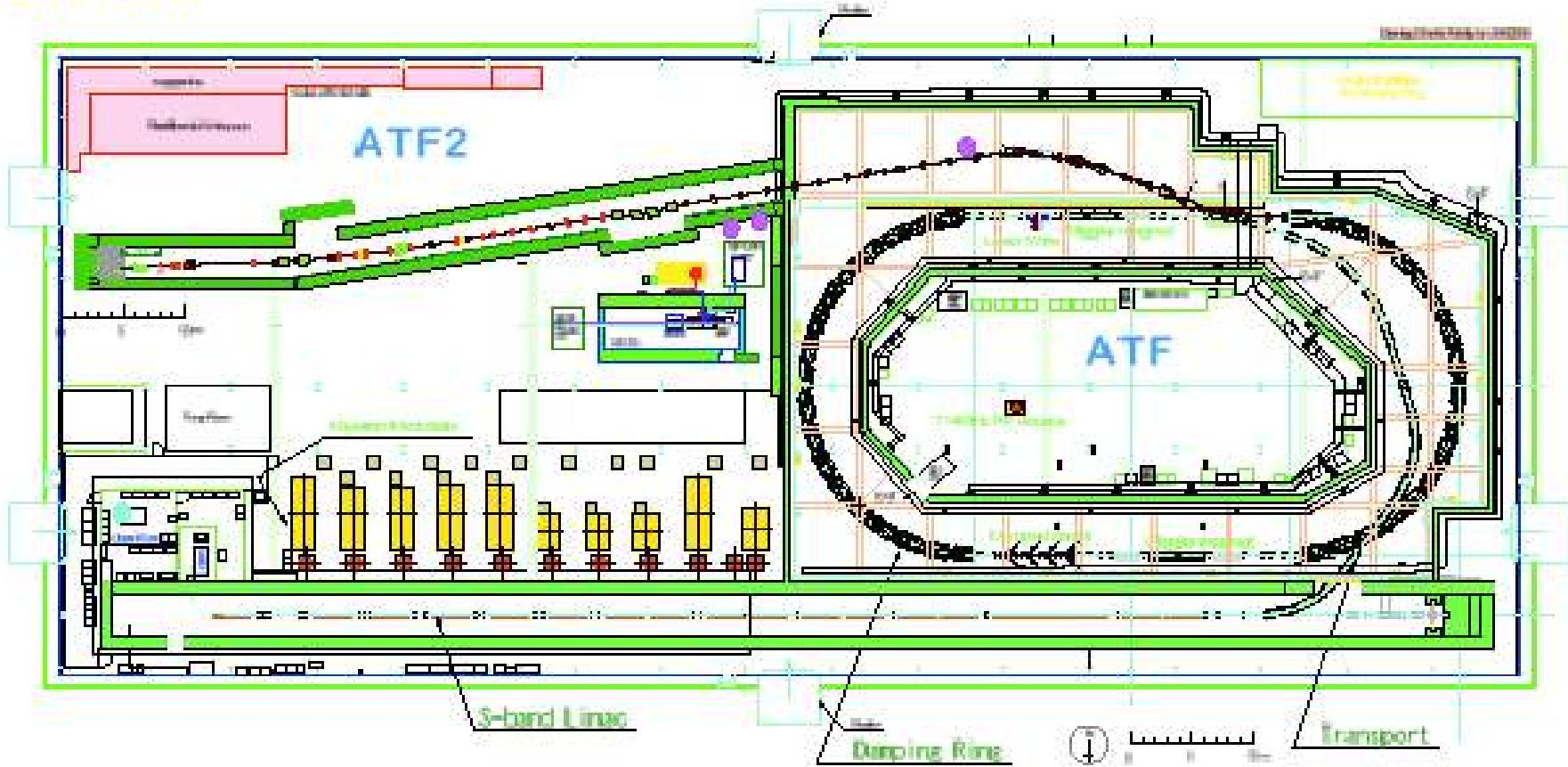
## ATF2 Proposal

- Vol.1
  - Scientific issues
  - Completed yesterday  
<http://lcdev.kek.jp/ILC-AsiaWG/WG4notes/atf2/>
- Vol.2
  - Collaboration, budget, timeline
  - To be completed by around nanoBeam workshop at Kyoto

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Masao Kuriki, Shigeru Kuroda, Mika Masuzawa,  
Toshiyuki Okugi, Ryuhei Sugahara, Takeshi Takahashi,  
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# ATF2

## Layout



- So-called optimal layout: Total length of FFS  $\approx 36\text{m}$
- Plus diagnostics section and beam-dump

# ATF2

## Goals of ATF2

(A) Achievement of beam size  $\sim 37\text{nm}$

(A1) Demonstration of a compact final focus system based on local chromaticity correction scheme

(A2) Maintenance of the small beam size

(B) Control of beam position

(B1) Demonstration of beam orbit stabilization with nano-meter precision at IP.

(B2) Establishment of beam jitter controlling technique at nano-meter level with ILC-like beam

# ATF2

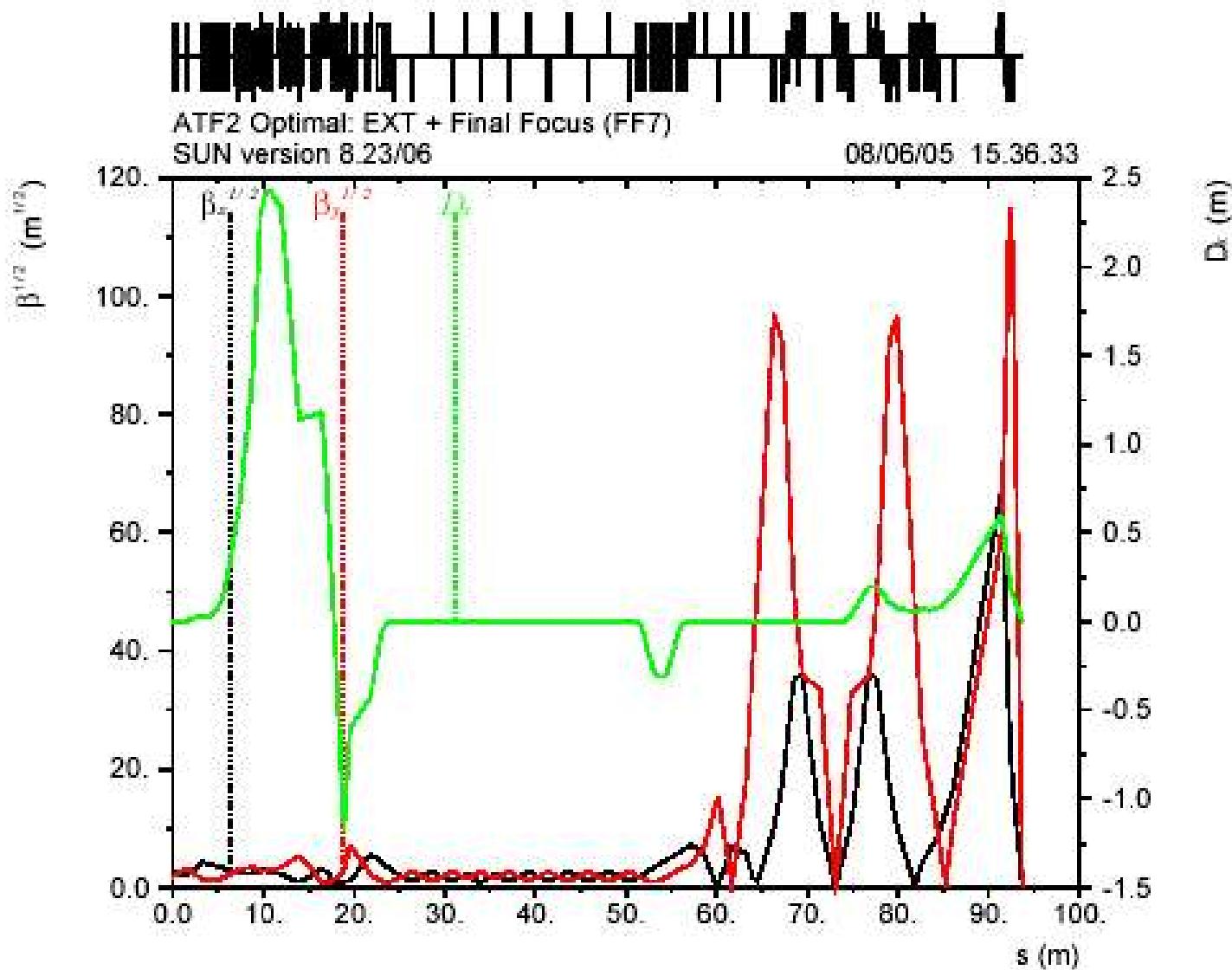
## Optics

- Local chromaticity correction
- Similar to ILC-FFS in
  - Chromaticity
  - Energy spread similar
  - Aspect ratio
- But different in
  - Geometric emittance
  - Bunch length

ATF2 proposed optics IP parameters  
in comparison with ILC

	ATF2	ILC
Beam Energy [GeV]	1.3	250
$L^*$ [m]	1	3.5 – 4.2
$\gamma \epsilon_x$ [m-rad]	3e-6	1e-5
$\gamma \epsilon_y$ [m-rad]	3e-8	4e-8
$\beta_x^*$ [mm]	4.0	21
$\beta_y^*$ [mm]	0.1	0.4
$\eta'$ (DDX) [rad]	0.14	0.094
$\sigma_E$ [%]	~0.1	~0.1
Chromaticity $W_y$	~ $10^4$	~ $10^4$
$\sigma_z$	8mm	0.3mm

# ATF2



## Optics

- Scale down from the ILC-FFS (NLC-type)

# ATF2

## Requirements on the ATF Beam

- Position jitter of ATF extracted beam
  - $\lesssim 1/3 \sigma_y$  for **A** (Present best value almost satisfies this)
  - $\lesssim 1/20 \sigma_y$  for **B**
- Extracted emittance
  - Nominal value for ATF2 :  $\gamma \epsilon_y = 3 \times 10^{-8}$  rad·m
  - Present best value :  $1.5 \times 10^{-8}$  (ring),  $4.5 \times 10^{-8}$  (extracted)
- Bunch structure
  - 3 bunches with  $\sim 150\text{ns}$  interval for the 2nd step in **B1**
  - Many bunches with a few nsec interval for **B2**

# Prospect of ATF and ATF2

- ATF International R&D will generate necessary results for ILC, especially how to control high quality beam, develop many kinds of advanced instrumentation, educate young accelerator physicists and engineers.
- ILC like beam which means 20 bunches with bunch spacing about 300nsec.
- Realization of about 35nm beam for long period.