Present Status of R&D for the warm linacs-2

K. Kubo (KEK)

Prepared with H. Hayano, T. Higo,

M. Yamamoto, H. Matsumoto, et al.

GLCTA (Global LC Test Acclelrator) (X-band)

C-band Linac

Polarized electron source

ATF (Accelerator Test Facility):

Low emittance beam

Other R&D

ACFA LC Symposium (February, 2003)
GLC Project Report (Road Map Report)

ACFA, JHEPC, KEK

Contributors are from120 institutes.

Australia, China, France, Filipinos, Germany,
India, Japan, Korea, Russia, Singapore,
Taiwan, Thailand, UK, USA and Vietnam

JLC -> G(Global)LC

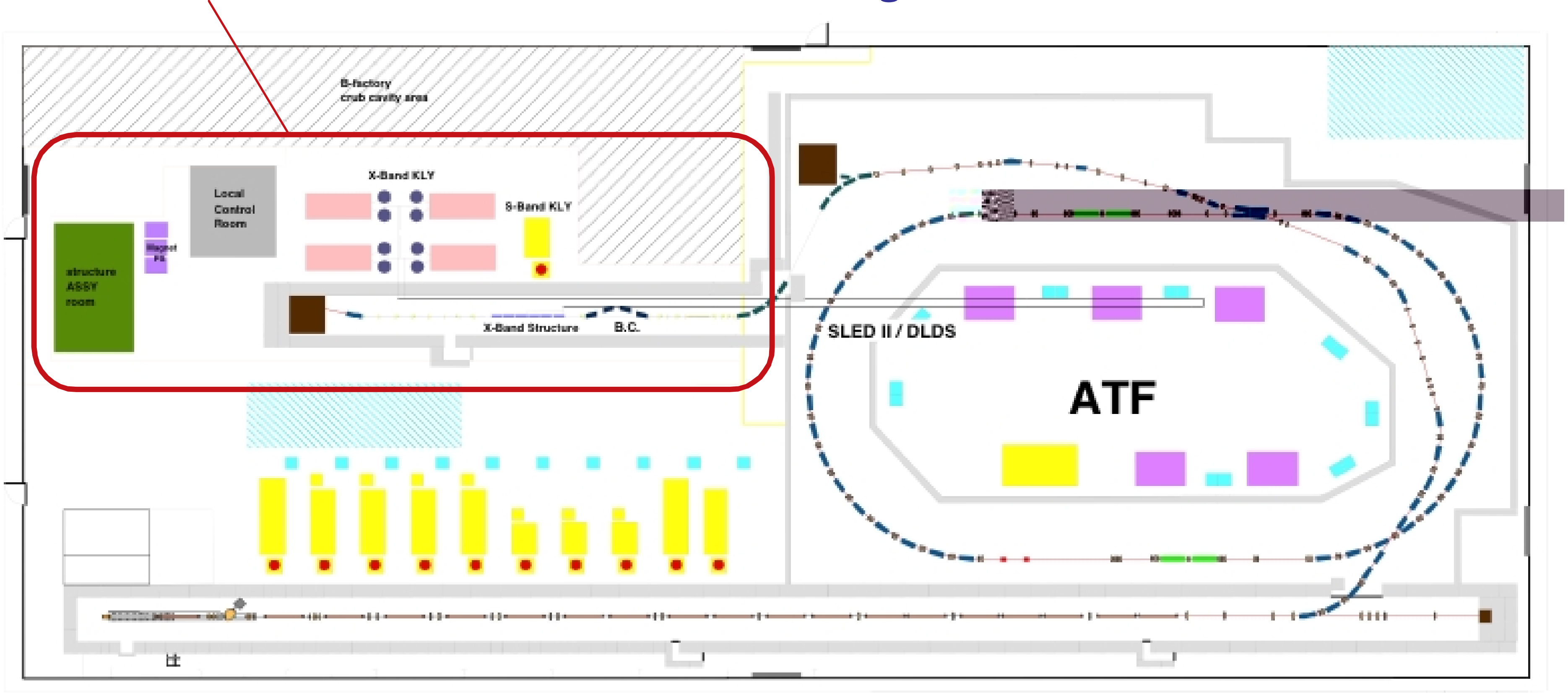
GLCTA: GLC Test Accelerator (X-band)

Purpose:

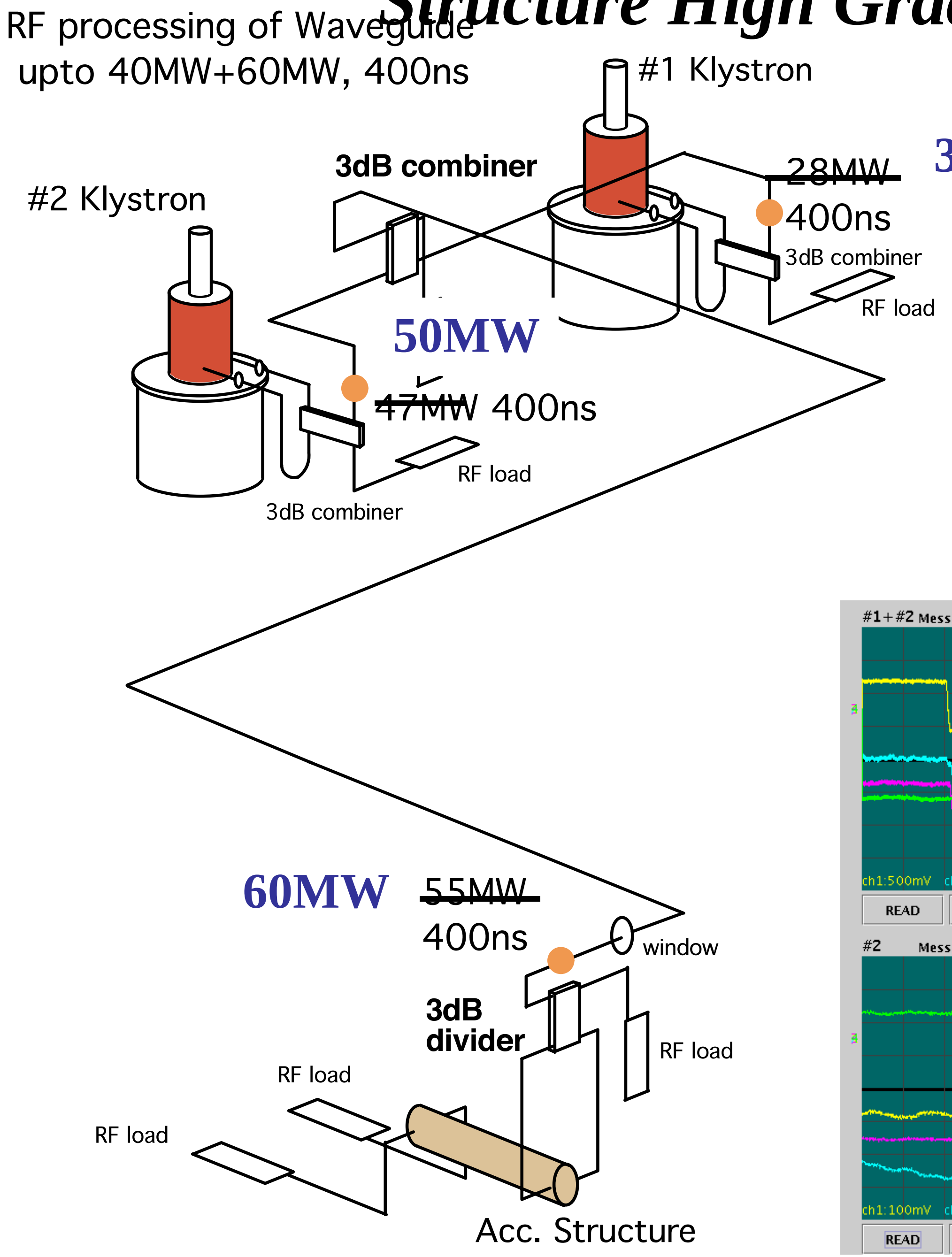
1. ***Structure High Gradient Test Stand***
2. ***High Power Generation Demonstration***
3. ***Main Linac Unit Demonstration***

Technology establishment and demonstration
by KEK, universities, companies.
Training, experience of people, students, companies.
Will be one of R&D center for LC community.

GLCTA Located in the same building of ATF



Structure High Gradient Test



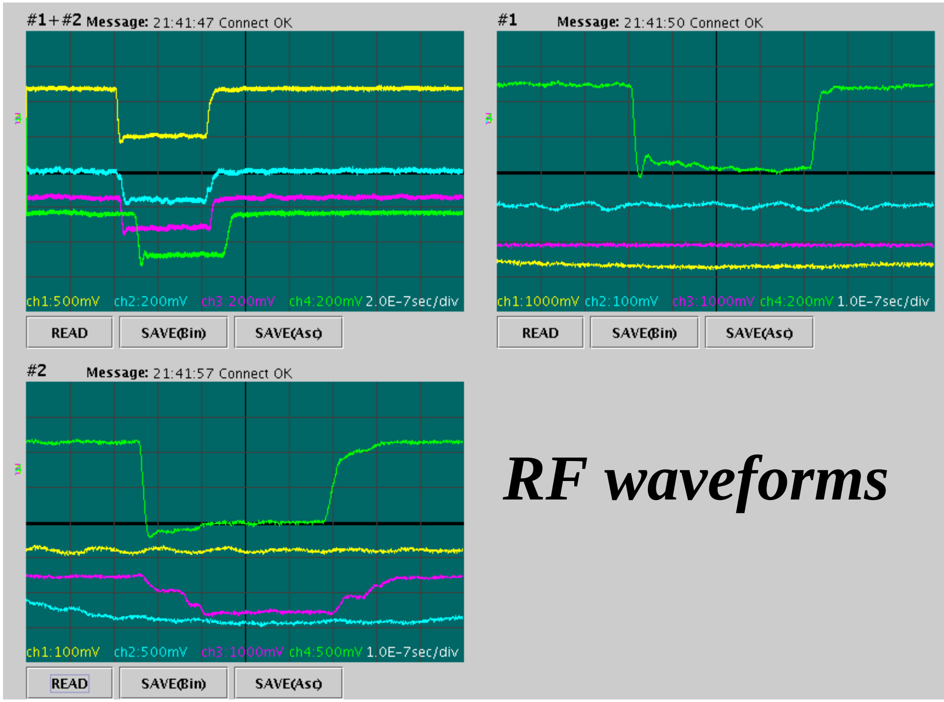
System check was done.

Problem:

waveguide Breakdown

-> Replace

New structure test started.

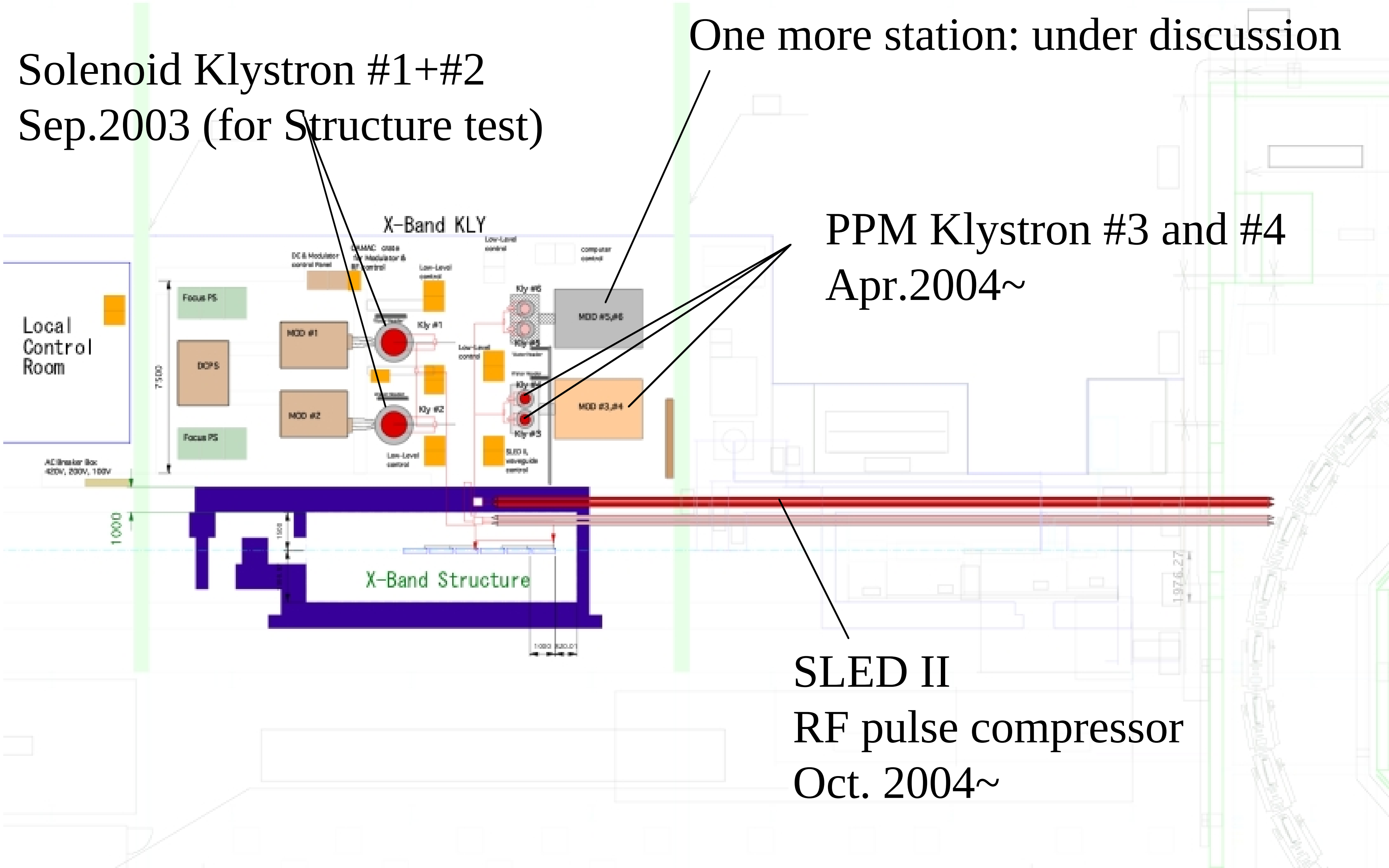


RF waveforms

H60VG3K1

High Gradient Test started in Apr. 2004
Will be tested up to 65MV/m (Limited by input power ~63 MW)

High Power Generation



High Power Generation plan

Staging Plan:

2004. 3: New Modulator start-up

2004. 5~8: 3 PPM Klys processing

2004. 9: Putting more Inverter PS for 2 Klys drive

2004. 10: 75MW Kly + SLED II (WR-90) start-up

2005. 1: 50MW Kly +50MW Kly + SLED II (WR-90)

2005. 1: 1 more Modulator start-up

2005. 4: 75MW Kly +75MW Kly + SLED II (over height WG)

2005. 4~8: power distribution system to structure build-up

Main Linac Unit Demonstration Plan

6m Linac Unit : Dec. 2005 commissioning

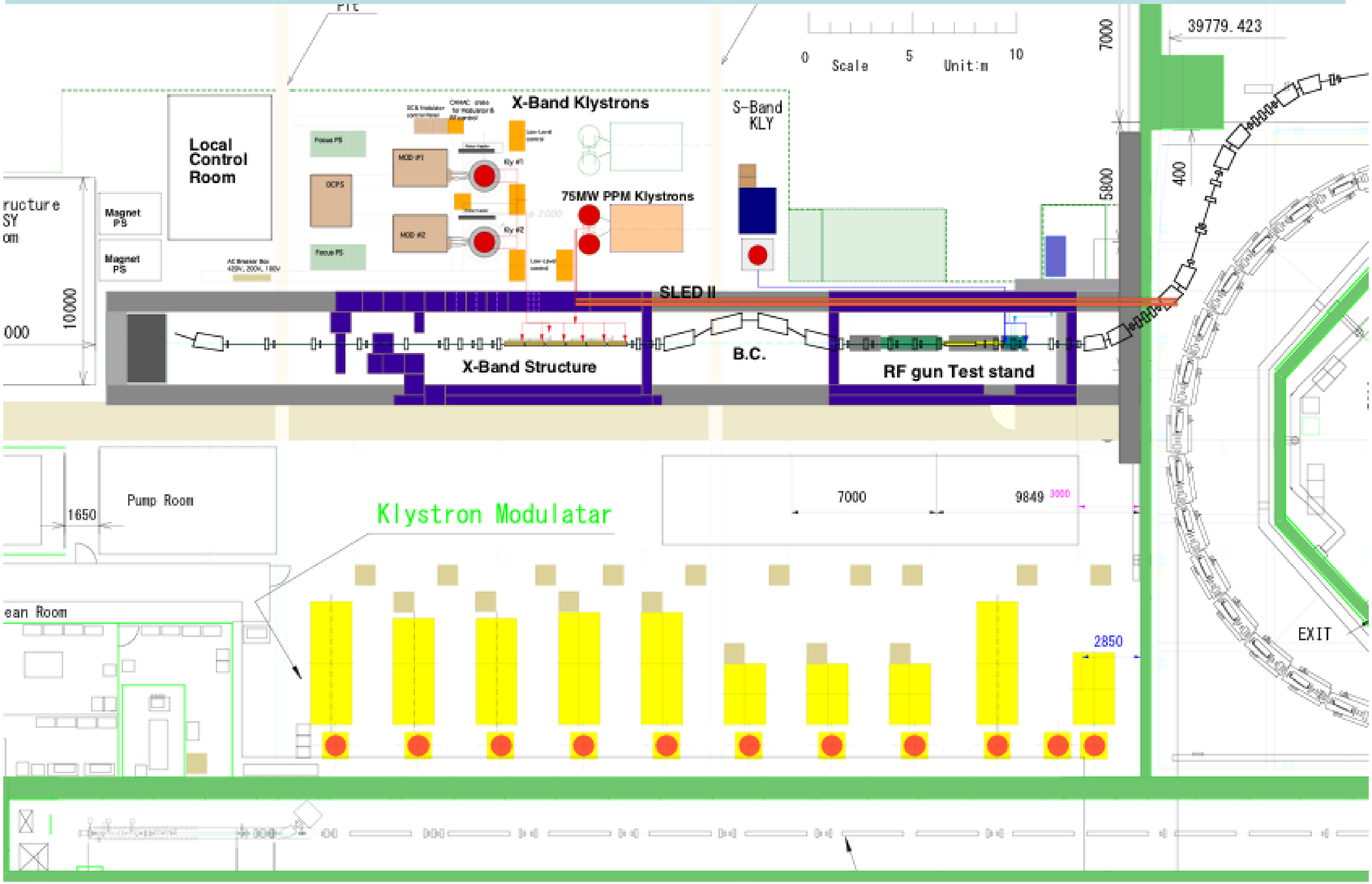
1. **75MW + 75MW + SLED II power source**
2. **power distribution to structures**
3. **8 of 0.6m Structure with active mover stage**
4. **LC spec. Quadrupole with cavity BPM and active mover stage**
5. **Possibility of beam supply:**

from ATF+B.C. (2.8ns, 20 bunch with LC spec. emittance)

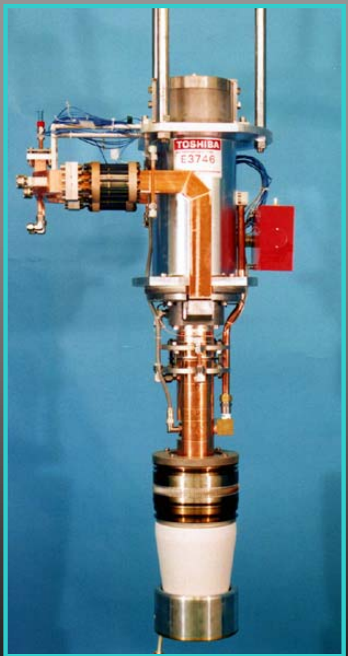
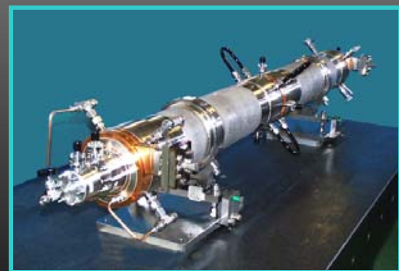
or

from RF gun test stand (1.4ns, 192 bunch with 5μm emittance)

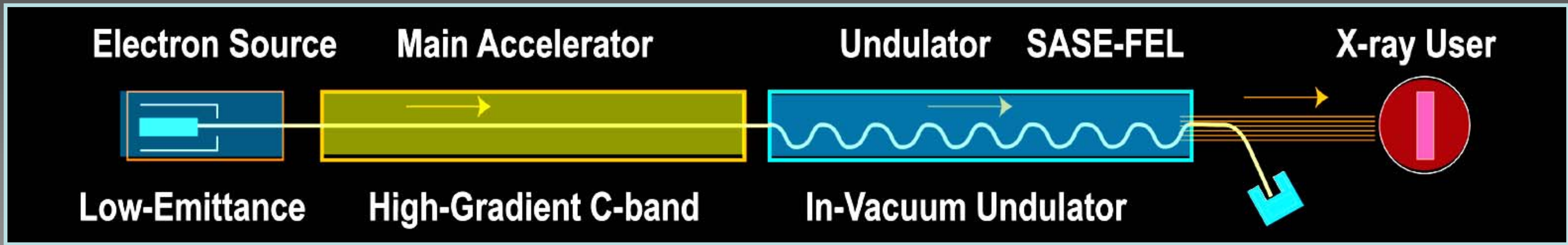
GLCTA Beam Line details



Phase-I R&D Summary

C-band Klystron	Klystron Modulator	RF Pulse Compressor	Accelerating Structure
50 MW, 2.5 μsec, 47 % OK	110 MW 100 pps OK	Flat Pulse Gain 3 (3.5) OK	1.8 m Choke-Mode OK
Life test >8000 hours, OK. 	Smart modulator-I using inverter HV charger. Running for klystron life test. 	Three-cell cavity.  1 m long cold model.  Tested up to 135 MW @KEK	Beam acceleration at 50 MV/m was done at ATF-KEK, with S-band model. HOM damping performance was proved by ASSET-SLAC test, 1998. 

SCSS : SPring-8 Compact SASE Source



- Low Emittance Injector → **Short Saturation Length**
- High Gradient Accelerator → **Short Accelerator Length**

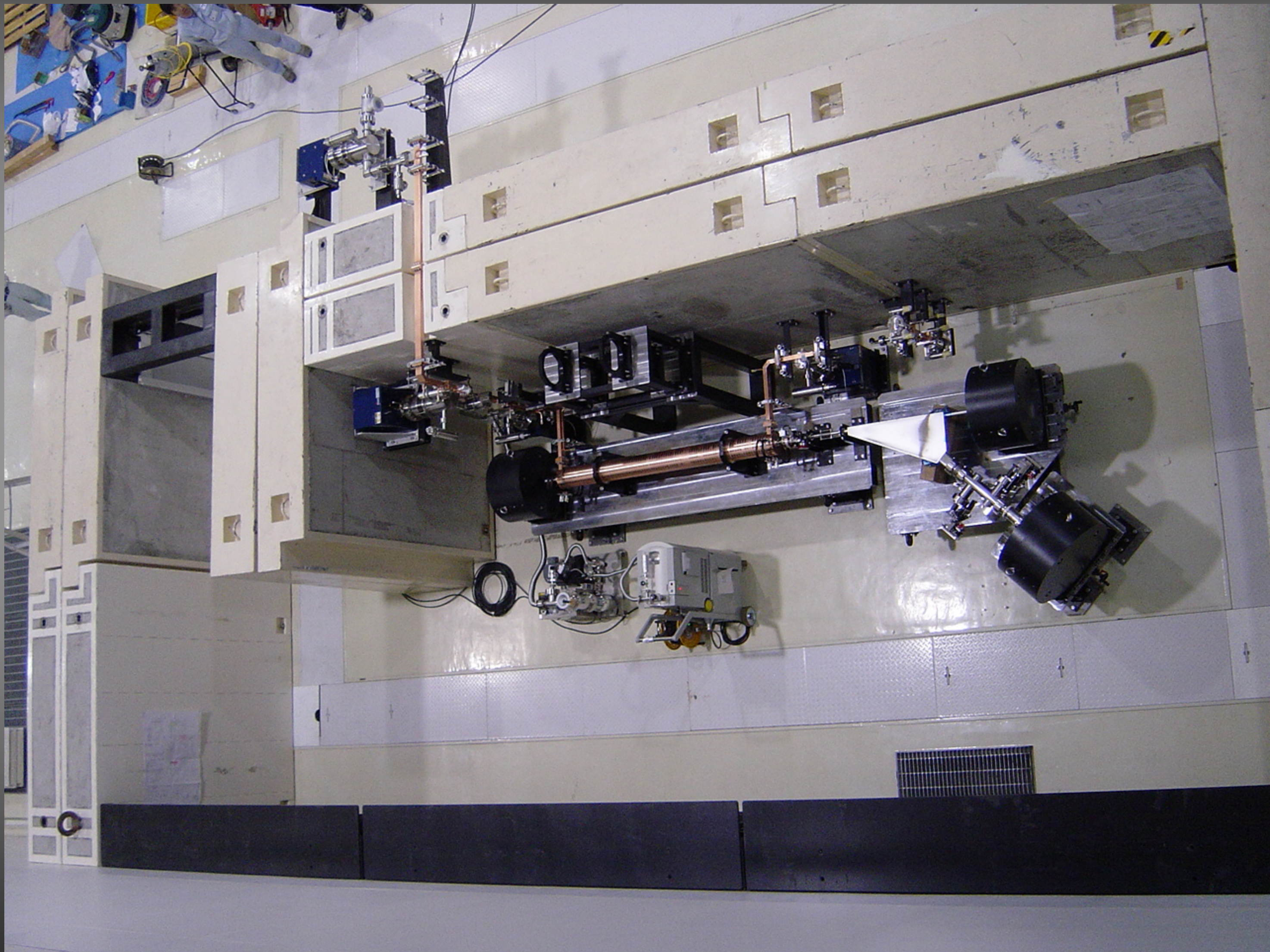
  KEK C-band 35 MV/m x 30 m = 1 GeV (4 units)

  35 MV/m x 180 m = 6 GeV (24 units)
- Short Period Undulator → **Lower Beam Energy and Short Saturation Length**

with Kitamura's In-Vacuum Undulator : E = 6GeV, lu = 15 mm, lx = 0.1 nm

PAL/POSTECH KEK/SCSS-RIKEN

High Gradient Test



STRUCTURE LENGTH:

1.8 m LONG

ACCELERATING GRADIENT:

56 MV/m

DARK CURRENT ENERY:

100 MeV (MAX.)

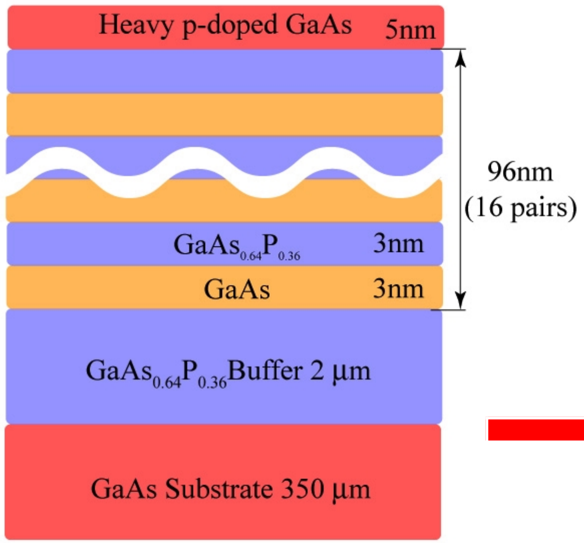
MONITORS:

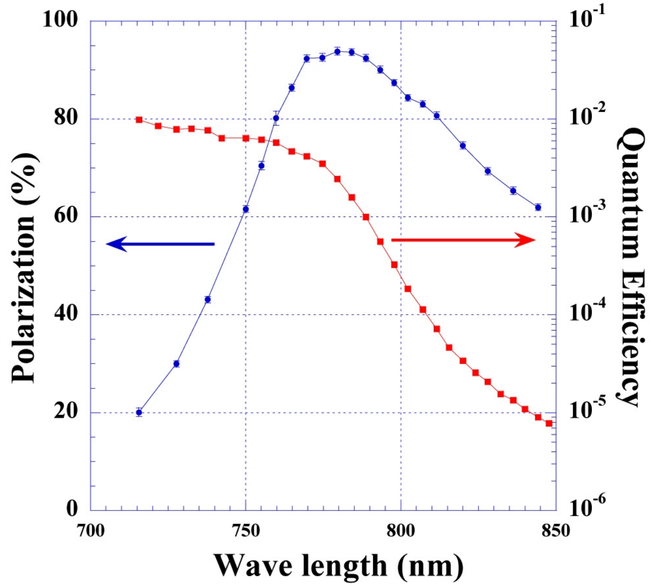
- FARADAY CUP &
- PICO-AMPERE-METER
- CURRENT MONITOR
- X-RAY SURVEY METER
- SCINTILATOR &
- PHOTO-MULTIPLIER
- PROFILE MONITOR &
- VIDEO-CAMERA

We will start on March, 2004

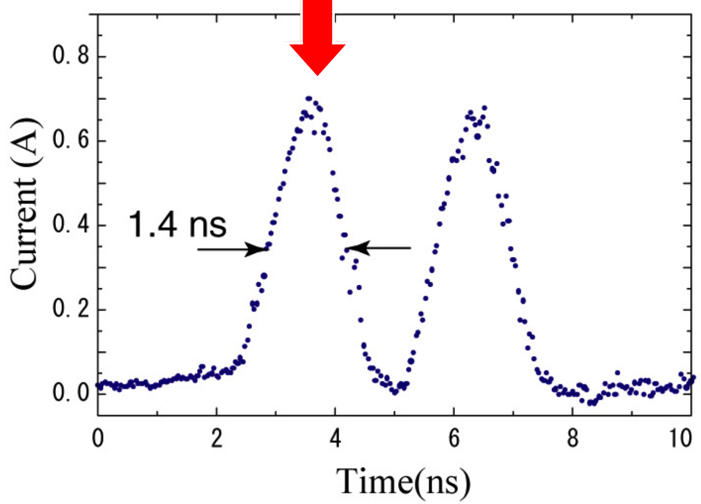
Polarized Electron Source (Nagoya Univ.)

GaAs-GaAsP superlattice Photocathode



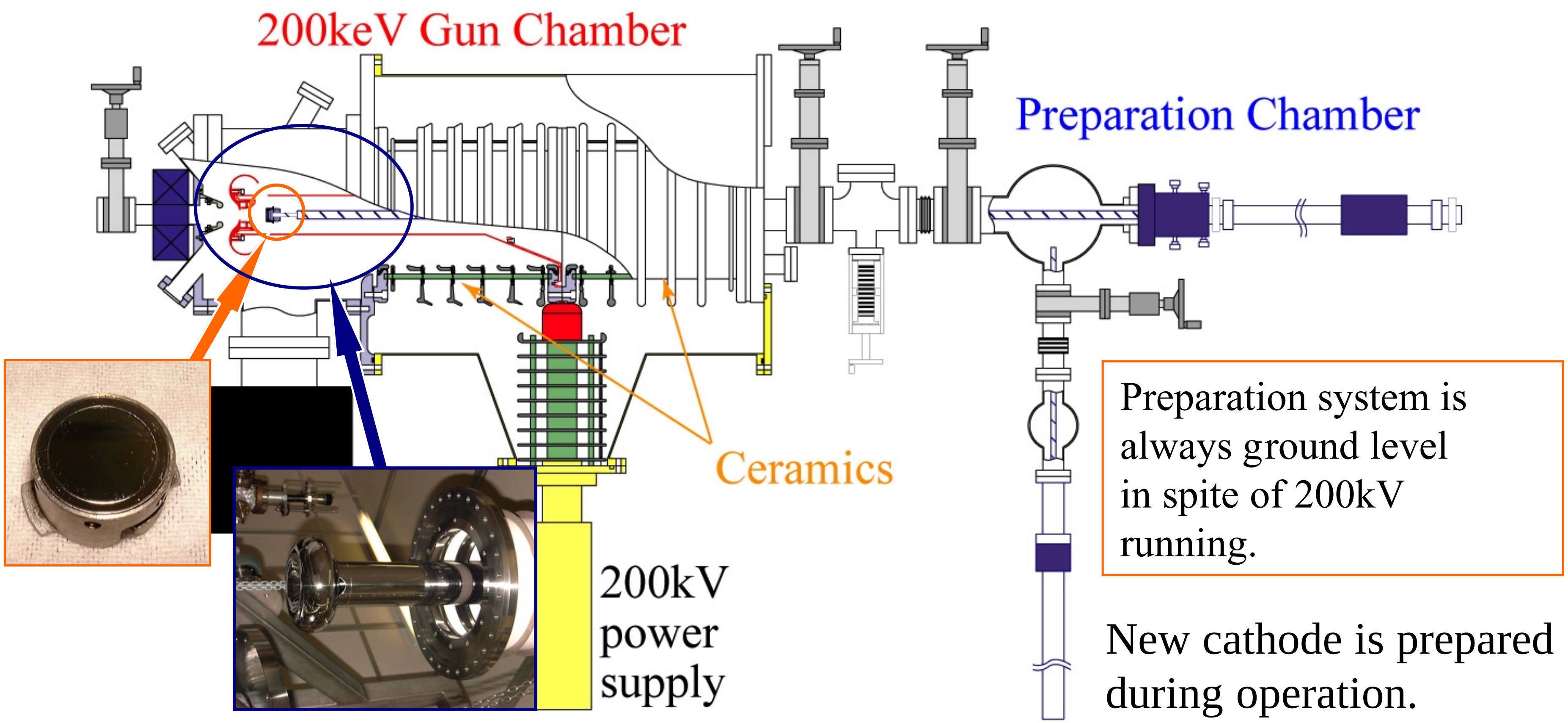


Polarization 92%
Q.E. 0.5%
(Satisfy LC sepc.)



Nanosecond multi-bunch beam production is possible.
1.4 ns spacing, higher peak current will be tested.

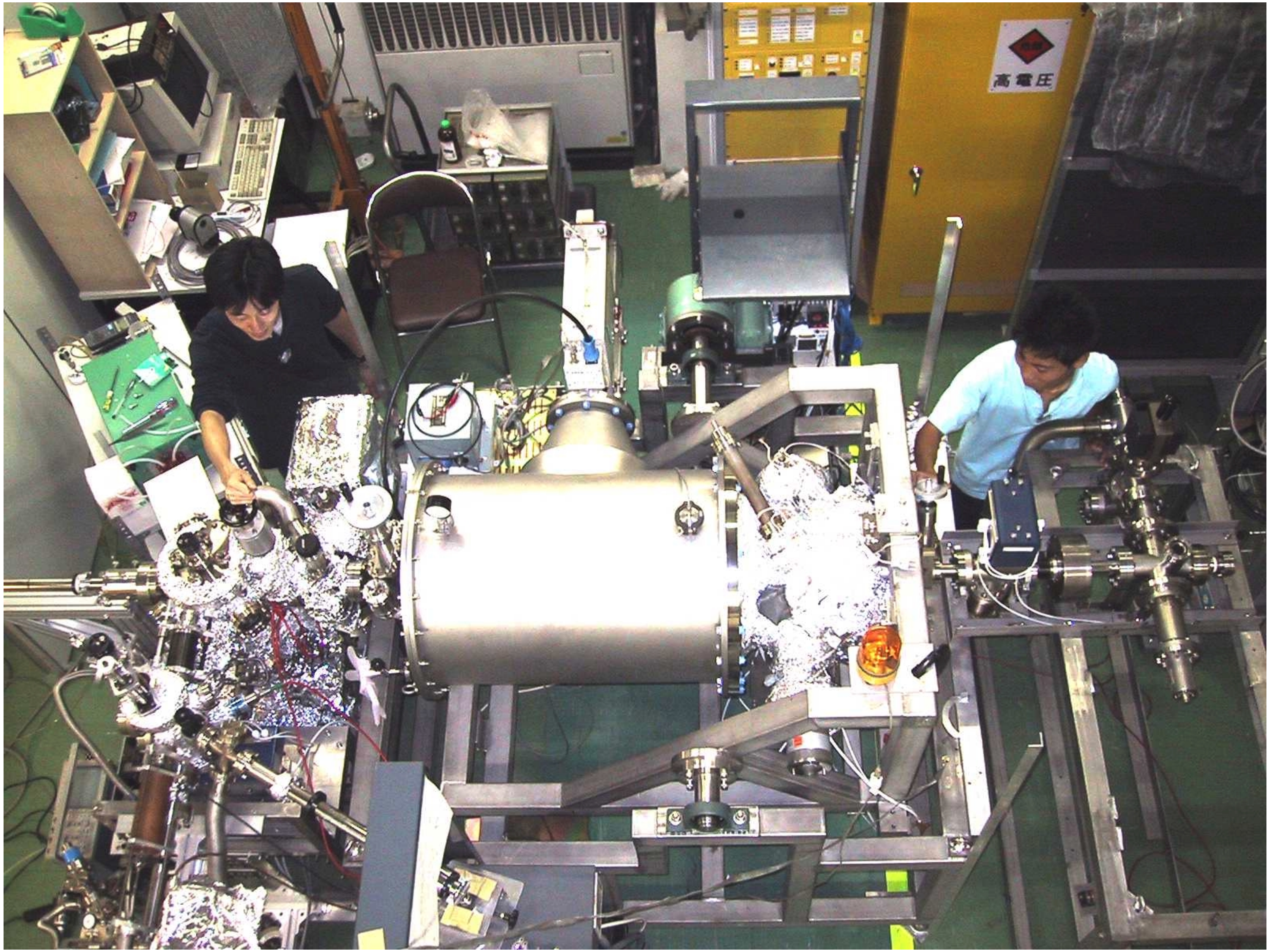
200keV Polarized Electron Source



Features of 200keV PES

- Load lock system
- Ultra high vacuum (~ 10^{-10}Pa)
- Dark current < 1nA (@200kV)
- 3MV/m (@photocathode surface)
- Two ceramics insulation
- Atomic hydrogen cleaning

200keV Polarized Electron Source



Polarized electron source

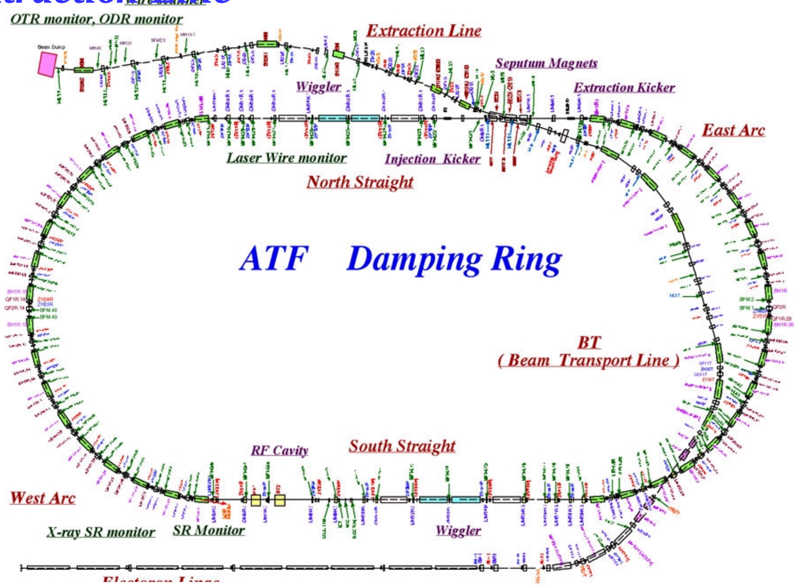
Acieved: Polarization 92%, Q.E. 0.5%,
high current multi-bunch of 2.8 ns spacing using
200 KV Gun and GaAs-GaAsP superlattice Photocathode.
(1.4 ns spacing will be tested.)

Next target is ultra low emittance pol. e- source;
Higher voltage/field Gun
NEA(Negative Electron Affinity)-GaAs Cathode.
Reduction of dark current is the key.
(if not, the surface will be damaged.)
Material and polishing of the electrodeshas been studied.

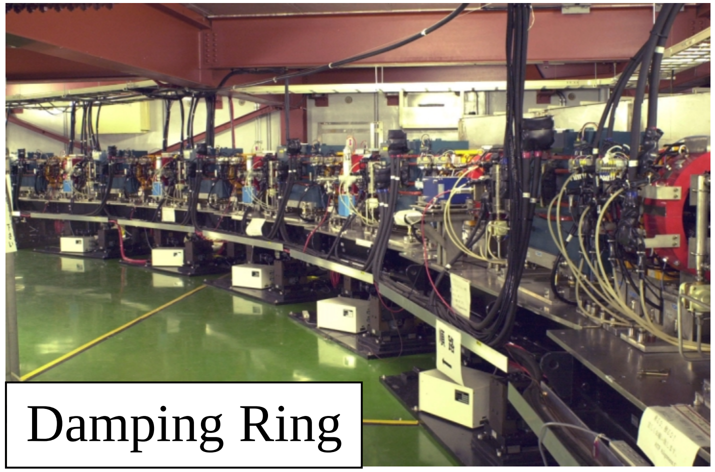
Detail will be reported in WG (Polarization Session).

ATF: Accelerator Test Facility (at KEK)
For testing Injector part of LC

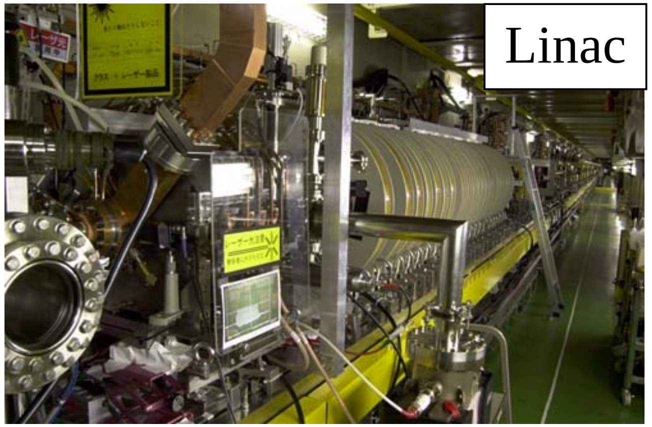
Extraction Line



Electron Linac



Damping Ring



Linac

E=1.28GeV (GLC: 1.98)
Ne=1x10^{10} e-/bunch (0.75x10^{10})
1 ~ 20 bunches/pulse (192)
Rep rate=1.5Hz (100 ~150 Hz)

Low emittance in ATF Damping Ring

Low vertical emittance is essentially important
for small beam size at IP. --> high luminosity

Emittance in Damping Ring (DR) [GLC/NLC design]

Injected to DR : $\gamma\varepsilon_{x,y} = 1 \times 10^{-4}$ m

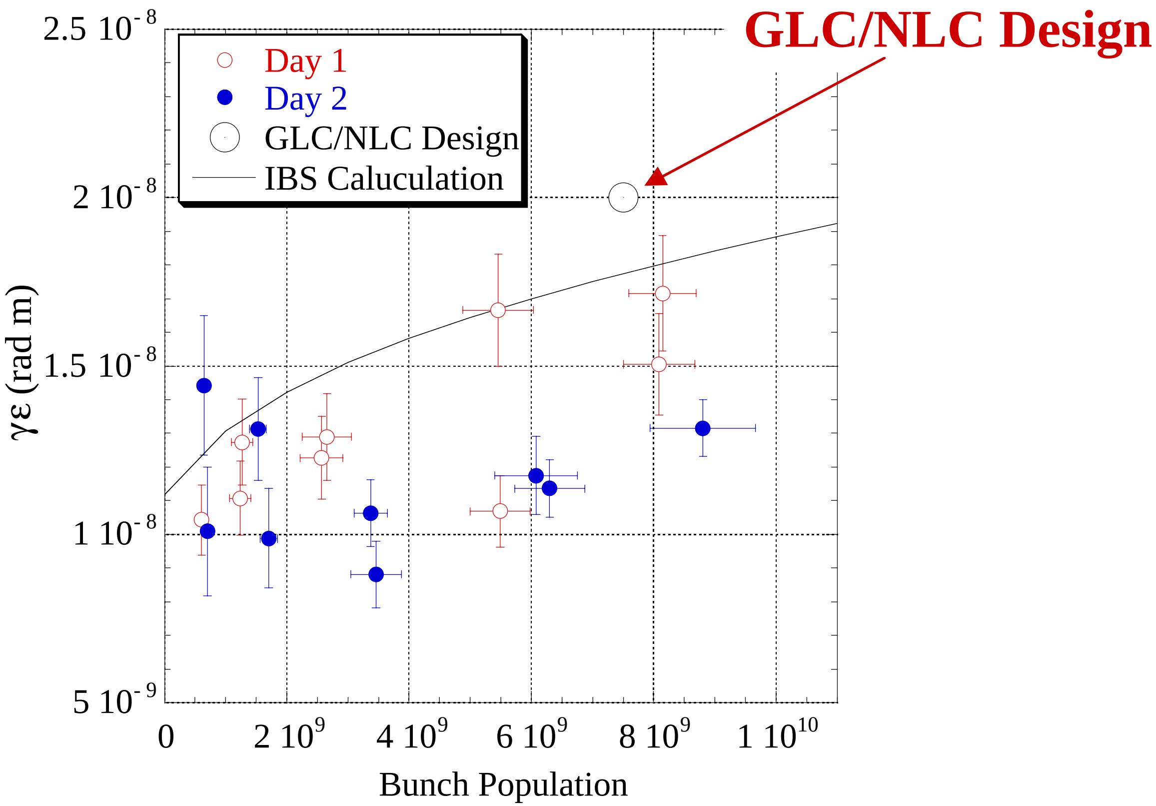
Extracted from DR : $\gamma\varepsilon_{x} = 3 \times 10^{-6}$ m, $\gamma\varepsilon_{y} = 2 \times 10^{-8}$ m

Dominant source of the vertical emittance in DR are

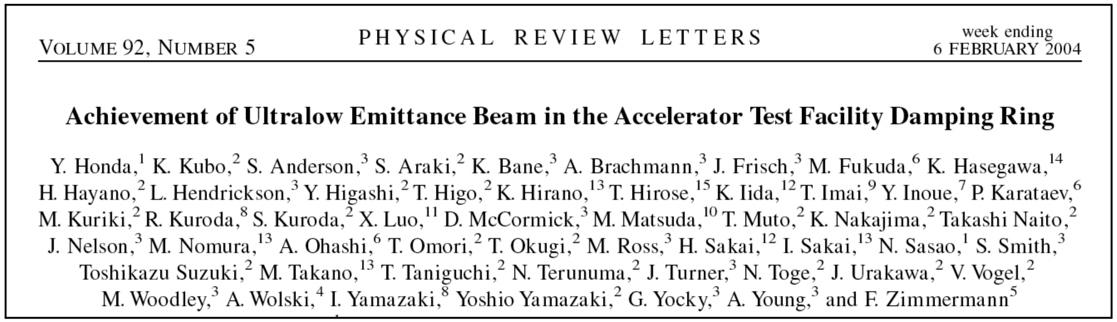
Vertical dispersion

X-y coupling

Vertical emittance vs. bunch population



(We achieved low emittance well below the GLC/NLC design)

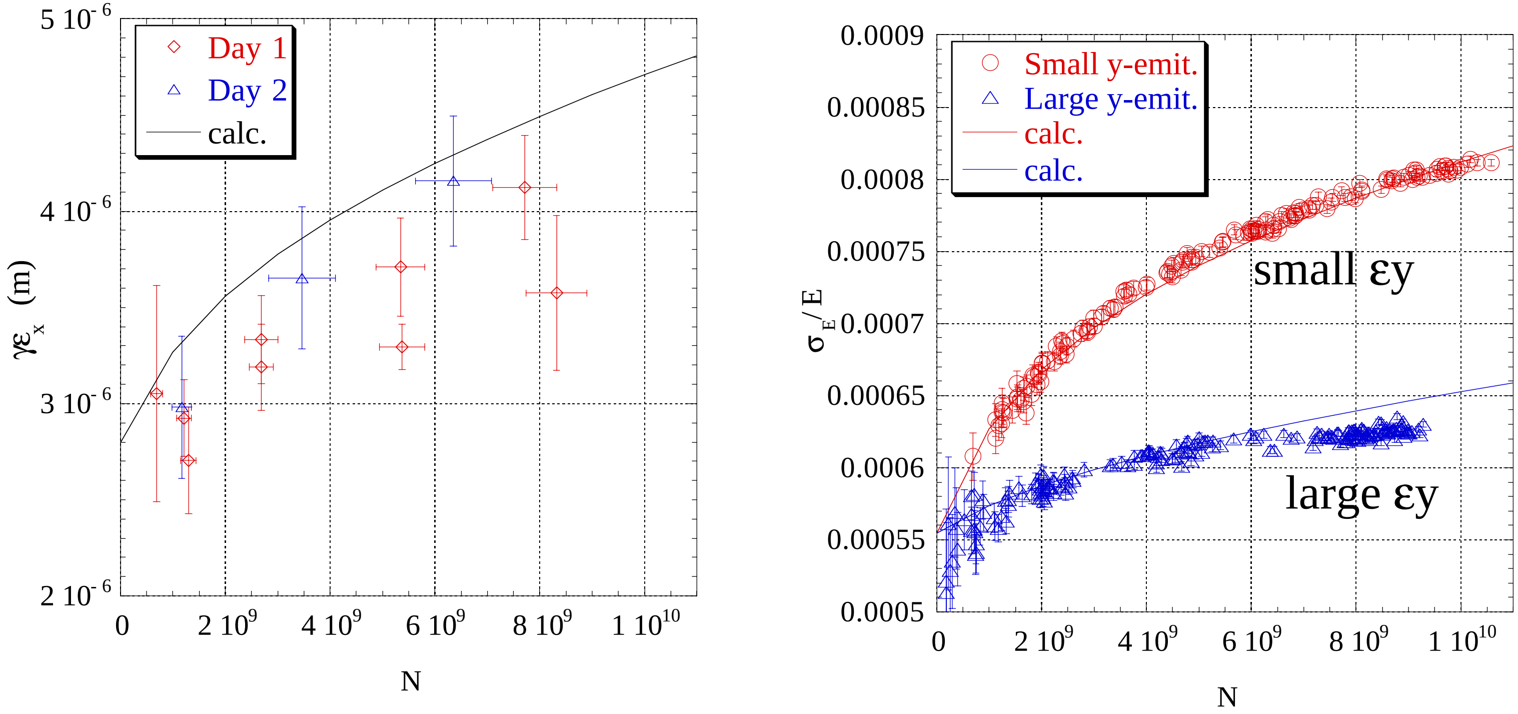


VOLUME 92, NUMBER 5 PHYSICAL REVIEW LETTERS week ending 6 FEBRUARY 2004

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

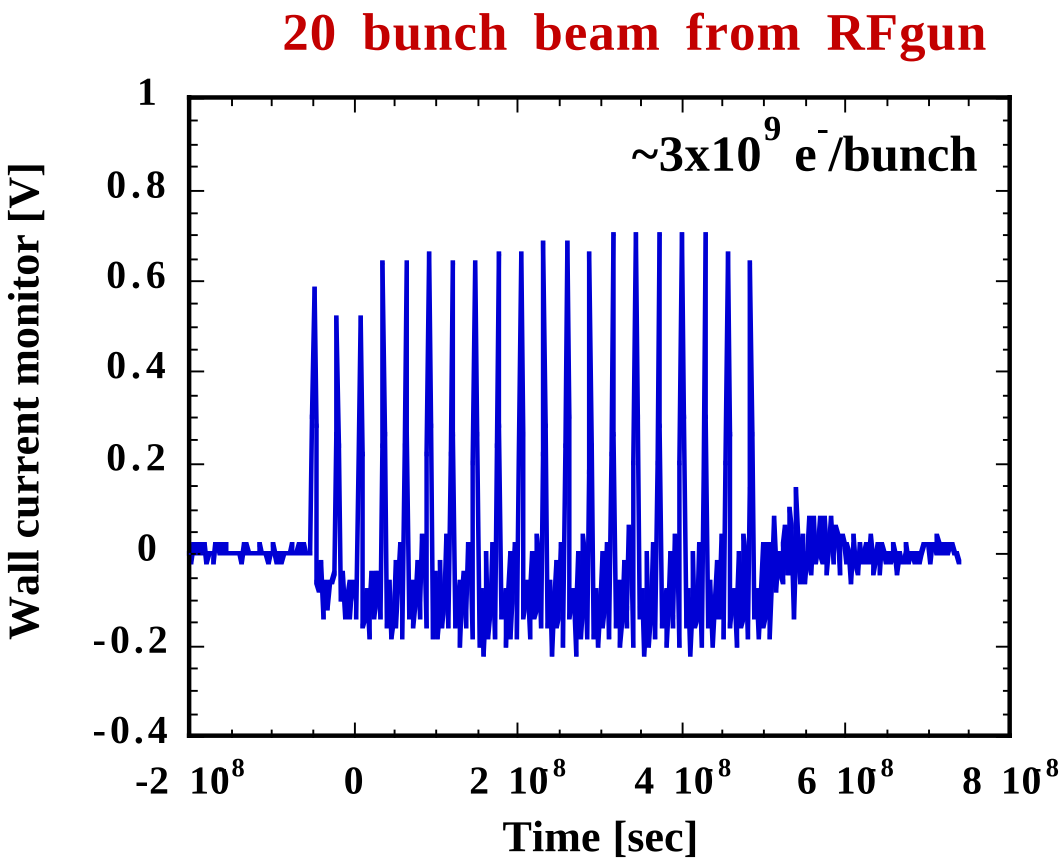
Y. Honda,[1] K. Kubo,[2] S. Anderson,[3] S. Araki,[2] K. Bane,[3] A. Brachmann,[3] J. Frisch,[3] M. Fukuda,[6] K. Hasegawa,[14] H. Hayano,[2] L. Hendrickson,[3] Y. Higashi,[2] T. Higo,[2] K. Hirano,[13] T. Hirose,[15] K. Iida,[12] T. Imai,[9] Y. Inoue,[7] P. Karataev,[6] M. Kuriki,[2] R. Kuroda,[8] S. 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]

Horizontal emittance and momentum spread vs. bunch population



Intensity dependence is explained by intra-beam scattering, consistent with calculation.

High quality multibunch beam from RF-gun



- Beam Intensity

  ~1x10^{10}/bunch

- Normalized Emittance

  εy= 4 ~ 7 x10^{-6} rad.m

- Bunch length

  σz= 3 ~ 6 ps

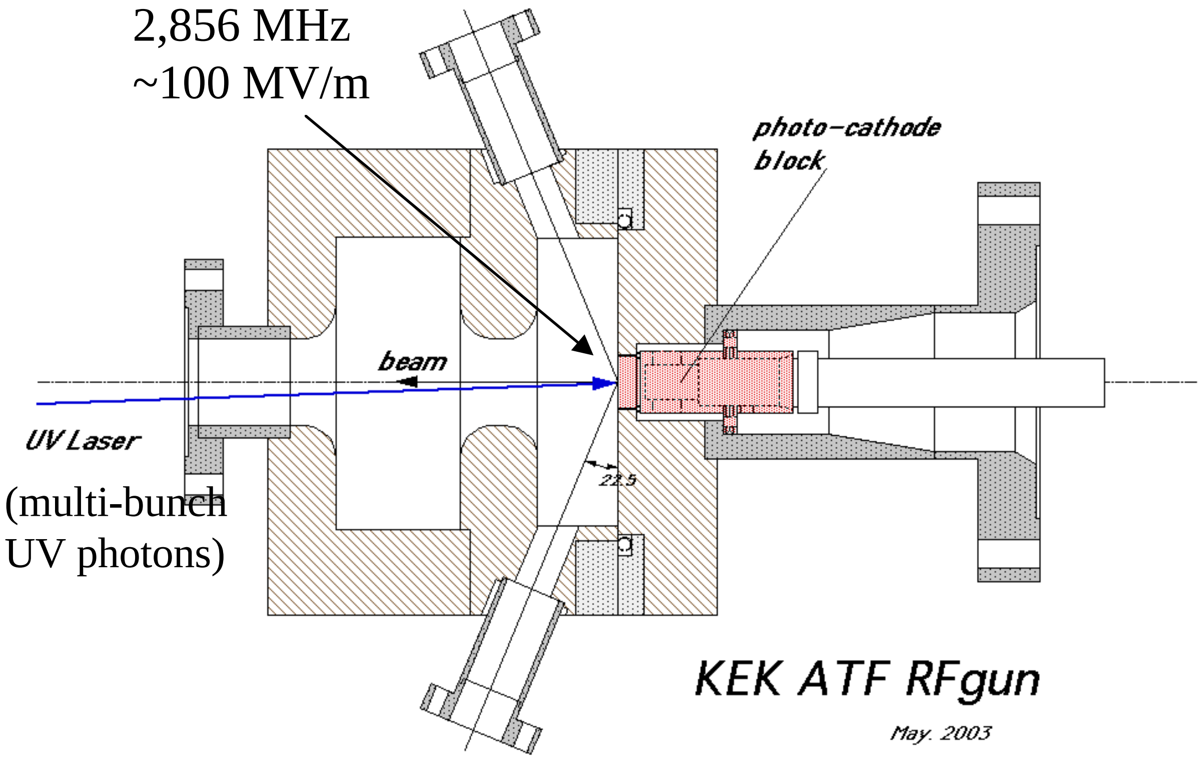
- Energy spread

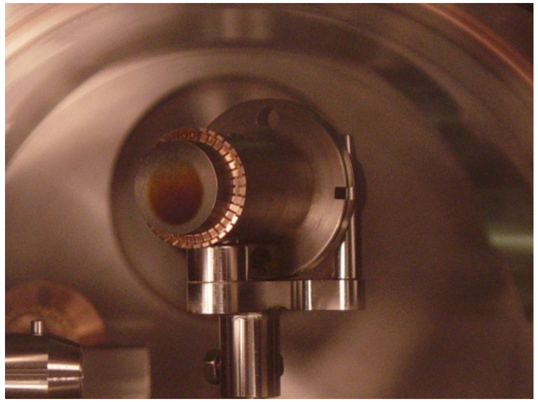
  dE/E = 2 ~ 3 % full-width

- Q.E. of CsTe cathode

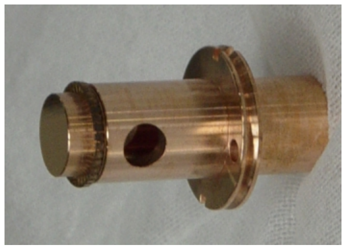
  16% initial, ~ 1% with RF ON & keep constant over few weeks

Photo-cathode RF-gun

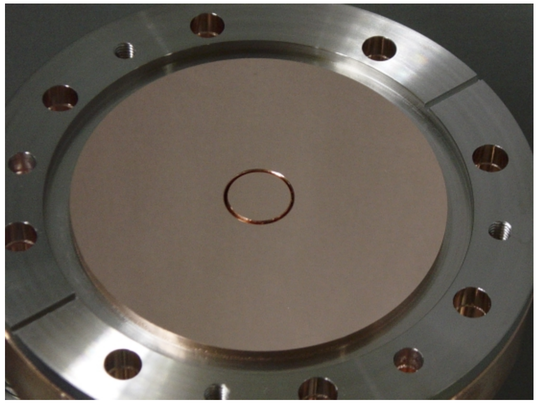




Cathode block with CsTe coating



Cathode block



End plate with cathode block

Multibunch emittance in ATF DR

Monitors of MB (bunch-by-bunch) emittance

In DR : Laser-wire

Extracted beam: wire scanner

Problem of MB emittance

Vacuum level in DR: High intensity beam -> SR light ->

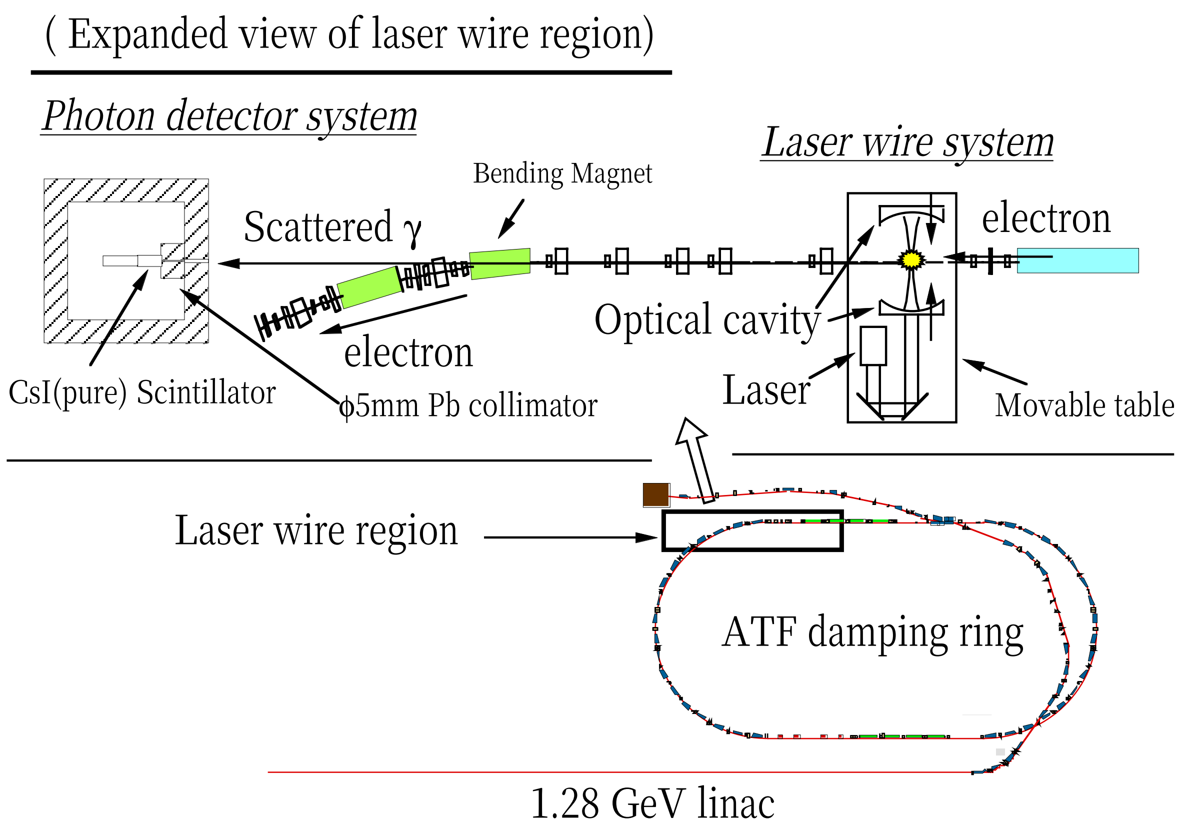
Gas from chamber wall

‘Scrubbing’ is going on for better vacuum

Big energy fluctuation

Coupled bunch longitudinal oscillation.

To be cured by feedback.

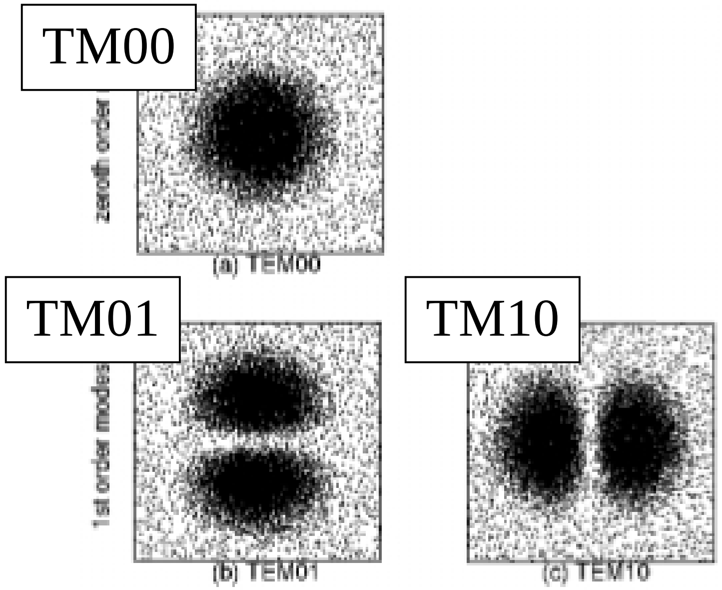


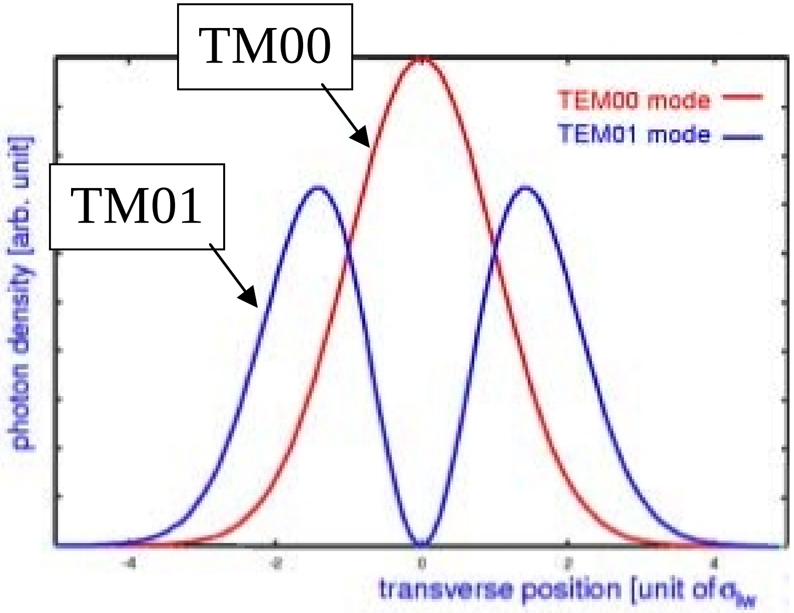
A thin wire' of light is created in an optical cavity, consists of two mirrors.
When the electron beam hits the wire, γ-rays are produced by Compton scattering.
A scintillation detector detects gamma rays.
The whole optical system is placed on a movable table.
The beam size is measured in a manner similar to conventional wire scanners.

higher mode laserwire

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

Transverse profile in optical cavity





TEM01 mode has two lobe and a node

TM01 mode laser wire:

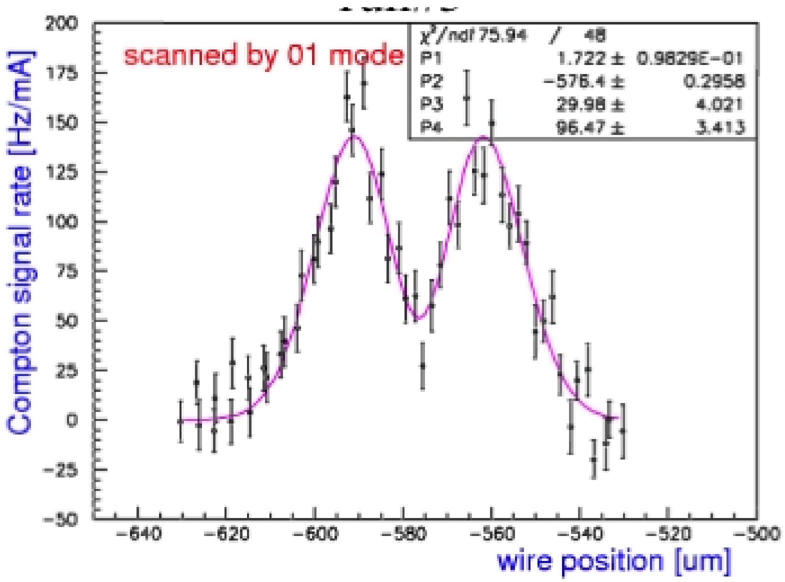
Bottom-peak ratio is sensitive to the beam size.

Better accuracy for small beam (beam size ~ laser size of TM00).

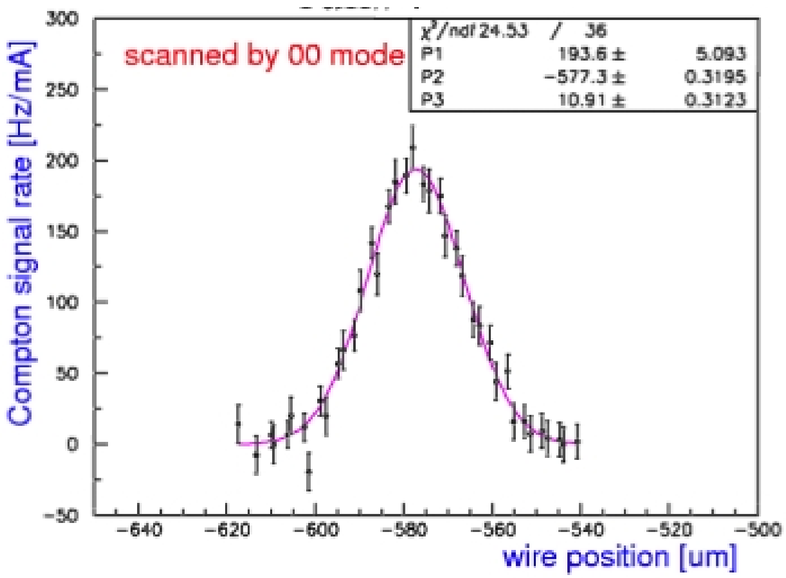
beam experiment

Signal rate vs. laser wire position

TM01



TM00



Diffraction Radiation(DR) experiment for non-invasive beam diagnostics

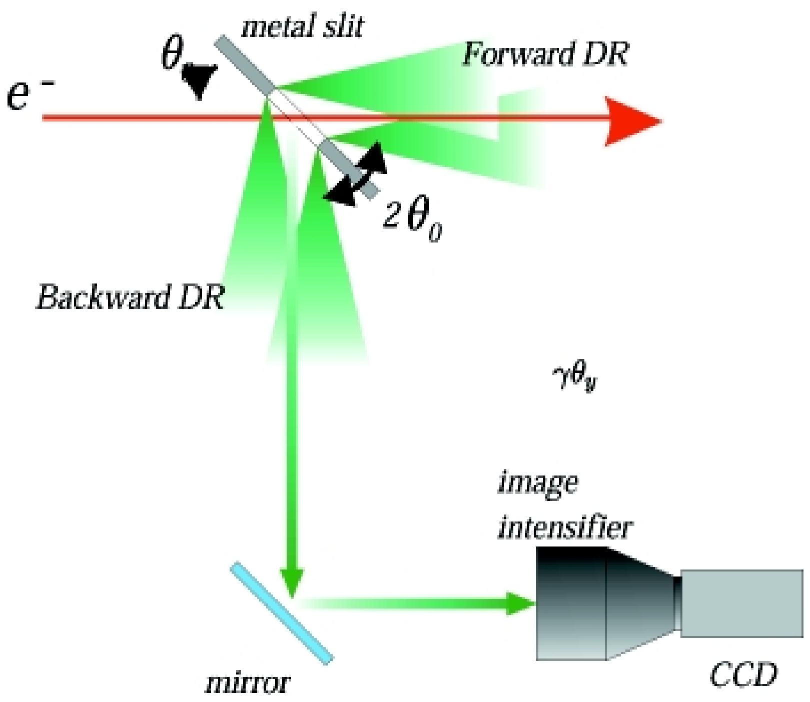
DR is emitted when a charged particle passes through the vicinity of a conducting target

(When a charged particle go through the metal surface: Transition radiation (TR))

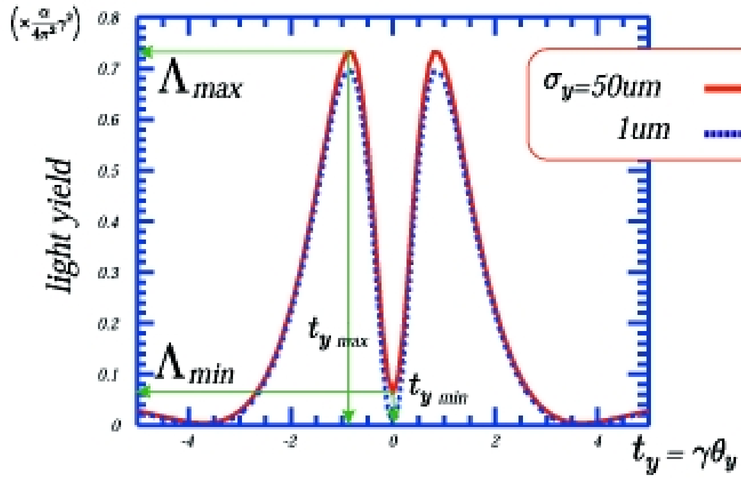
beam diagnostics using DR

- *non-invasive*
- *single path measurement*
- *large radiation angle*

measurement set up



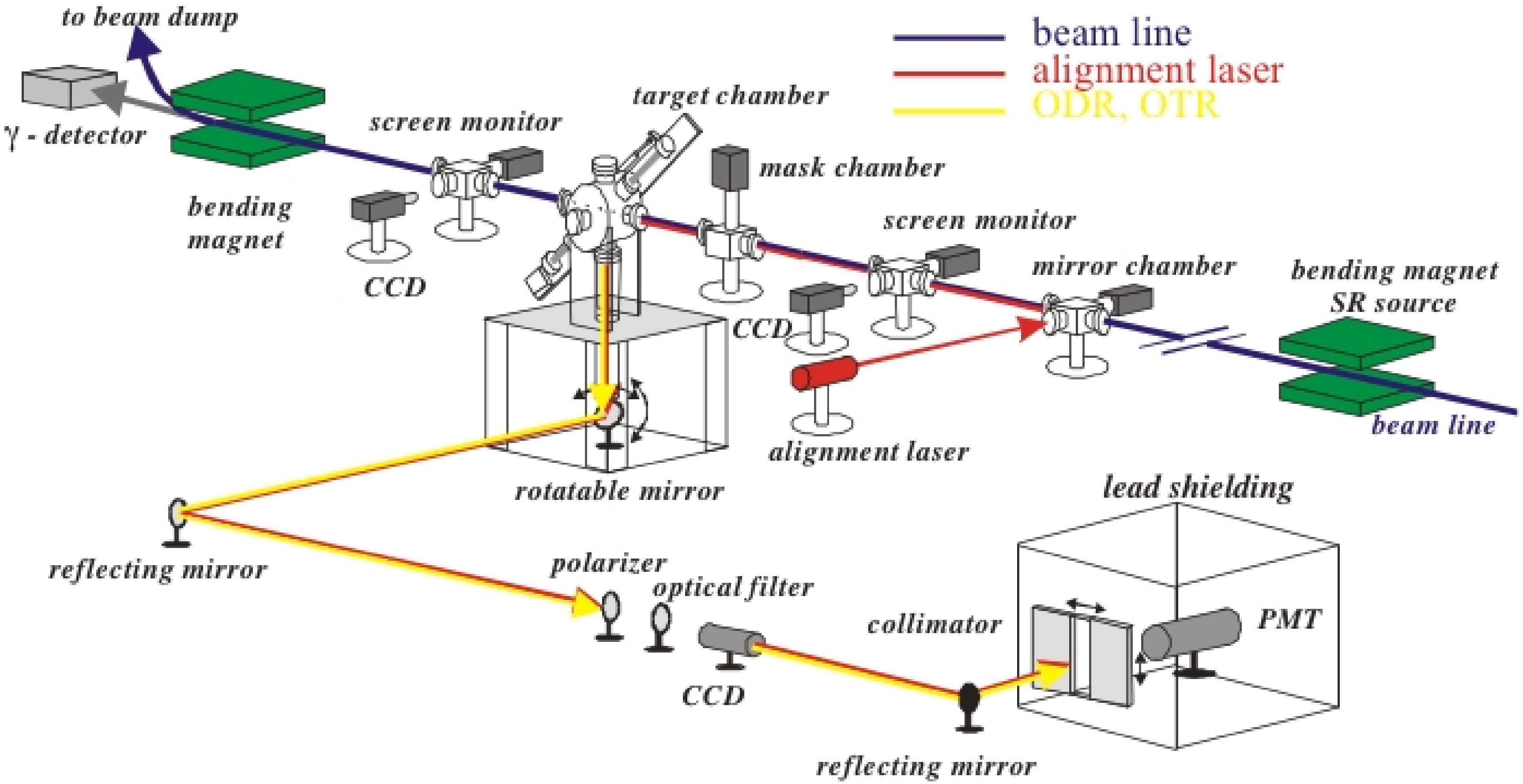
Angular distribution of DR from slit



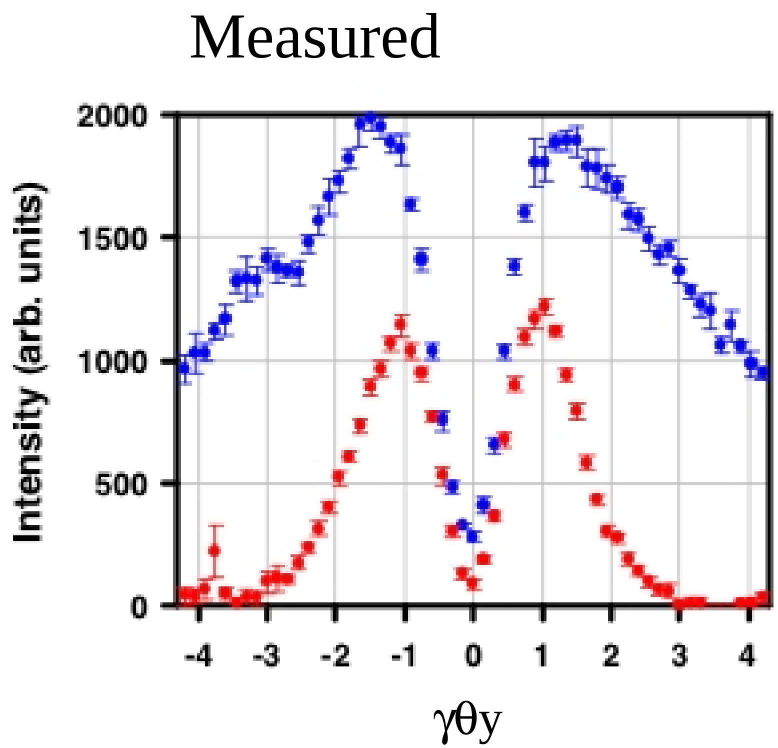
Beam size

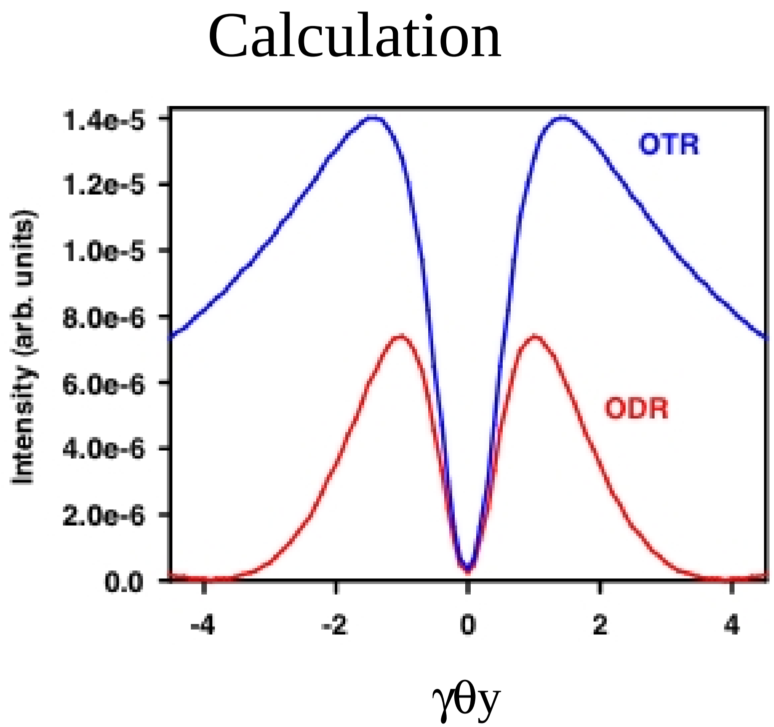
$$\sigma_y = \frac{\gamma\lambda}{2\pi}\sqrt{\frac{(1+t_{y\,min}^2)\Lambda_{min}}{(1+t_{y\,max}^2)\Lambda_{max}}}$$

Experimental Setup



Measurements and calculation (458 nm wavelength)



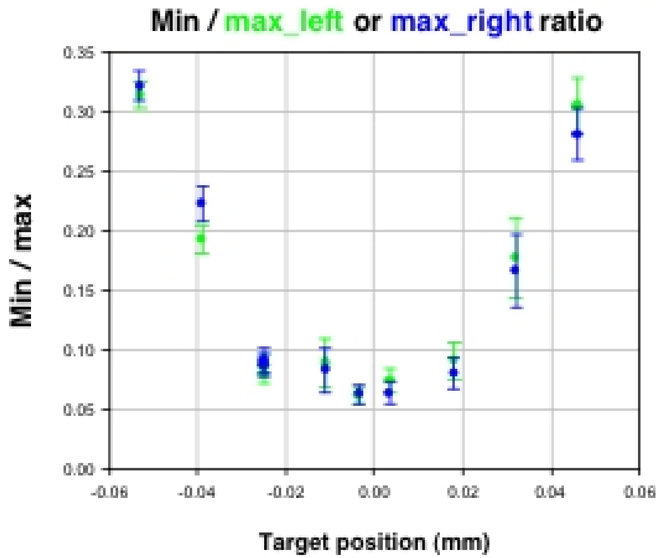


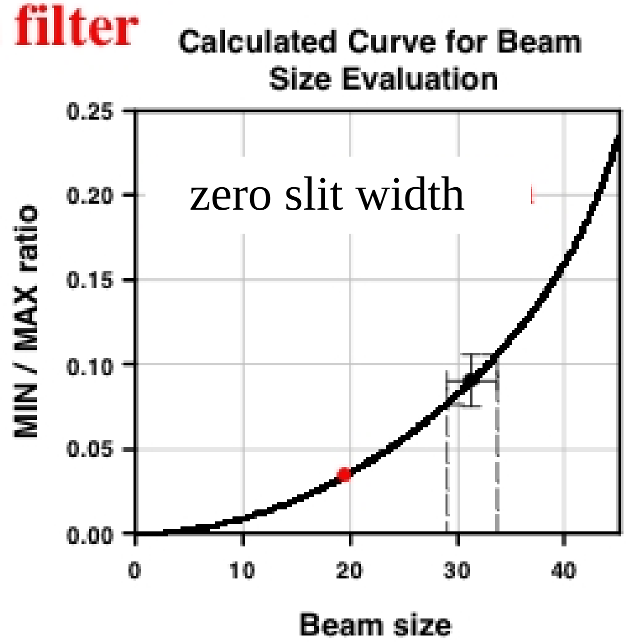
Anguler distribution of

Transition radiation (beam hit the thin metal) and

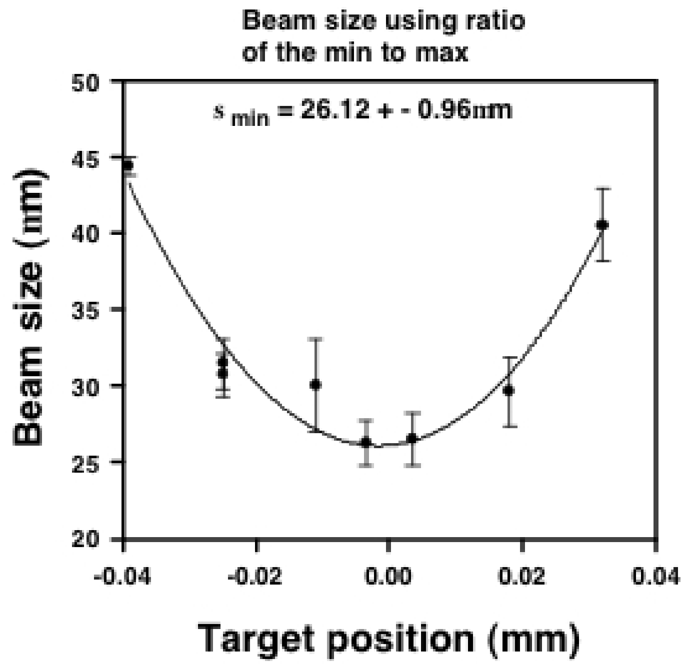
Diffraction radiation (beam thorough the slit of the thin metal

Beam size with 550nm filter

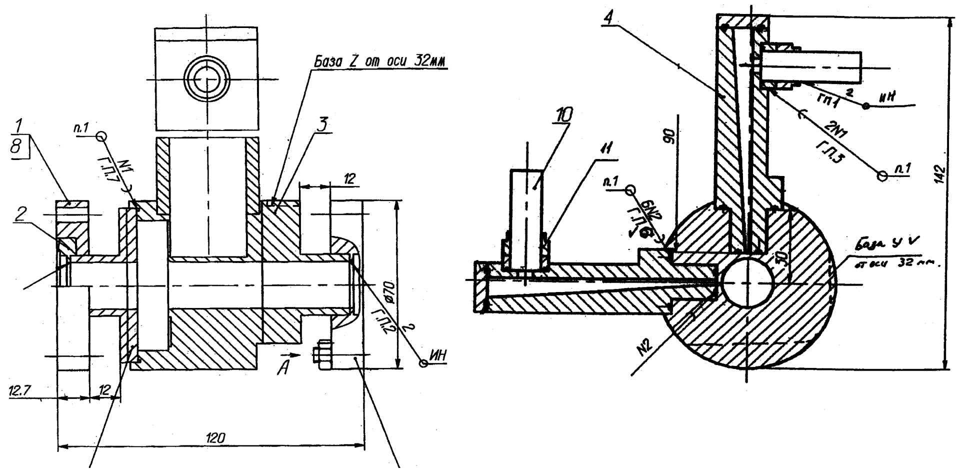




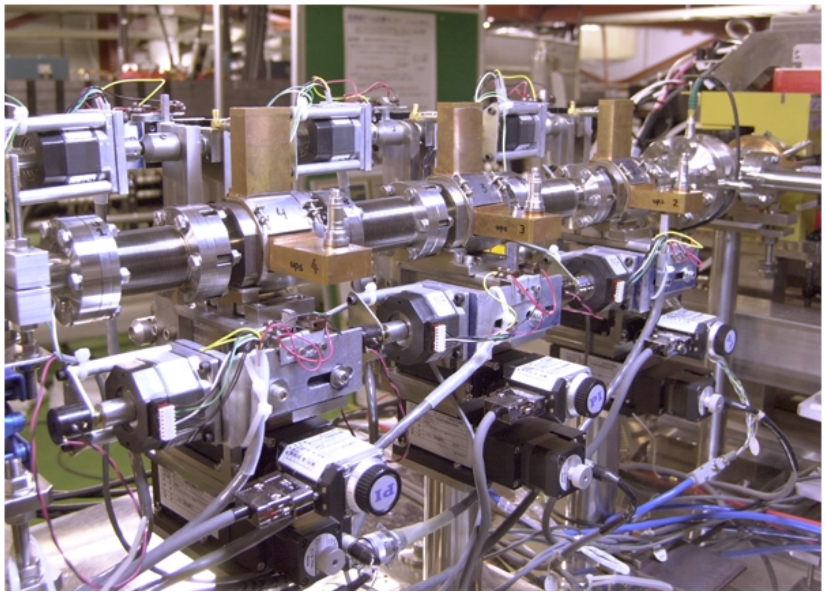
Principle was demonstrated.
Excellent result as first trial.
Need to reduce background for practical use.



nm resolution Cavity BPM study
SLAC-LLNL-KEK



June 2003



f = 6.426GHz

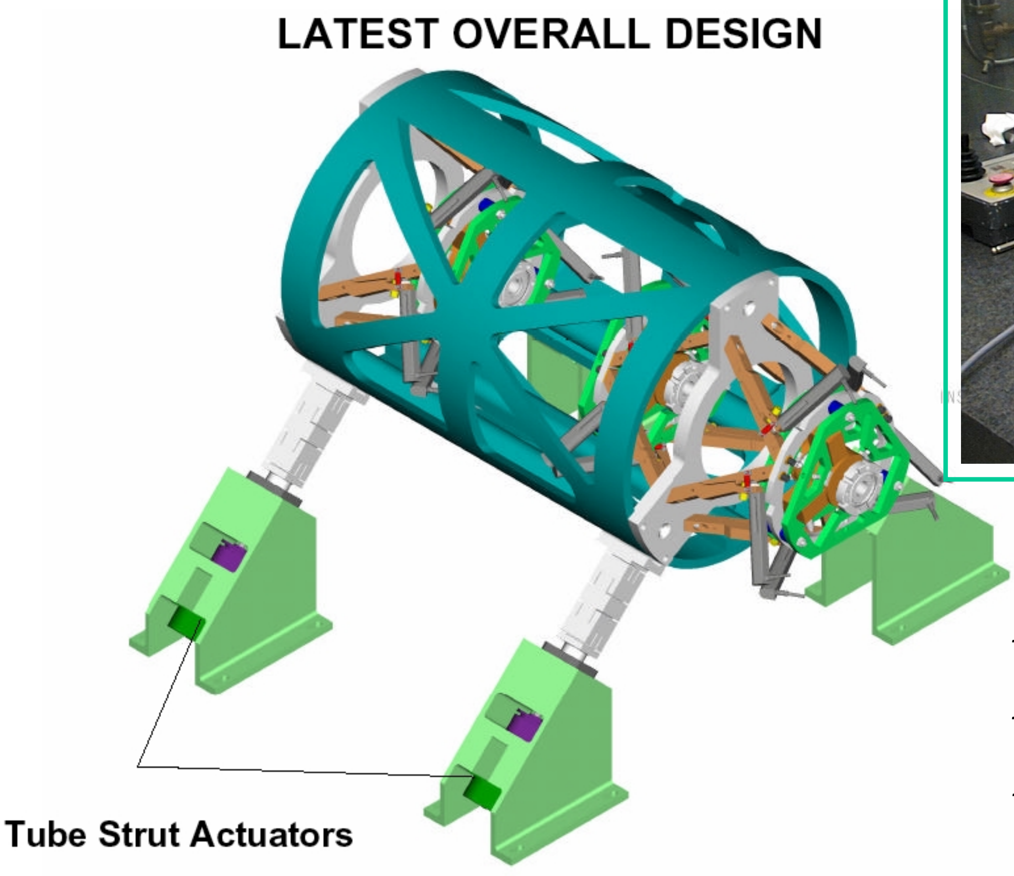
TM110 mode, single port coupling

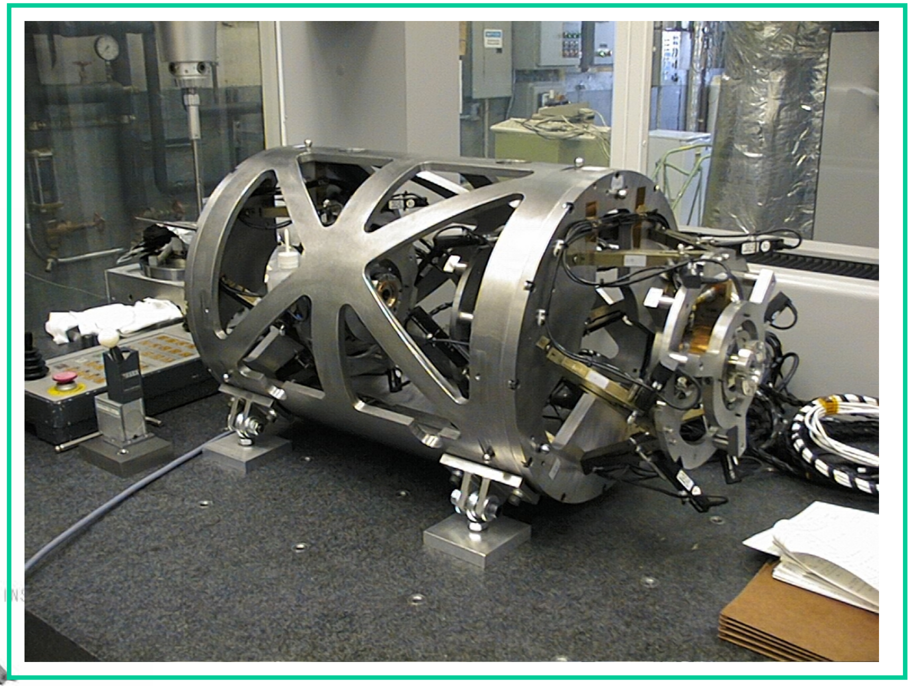
Highest resolution so far is 91 nm:

suspected to be from mechanical vibration

New BPM support/mover for nm resolution study

Very small internal vibration.
Relative movement of 3 BPMs ~nm.
--> Confirm nm resolution





LLNL Design
Installed in ATF bema line
First test in March 2004

ATF Plans for 2004

- ***Multibunch emittance study***

  High current injection is started.

  Low Y emittance will be confirmed by Laser Wire.
- ***nm resolution BPM test & demonstration***

  Development of new precise mover &

  new cavity-BPM electronics.
- ***intra-pulse Fast feedback test & demonstration Polarized positron production***
- ***Other instrumentation developments***

  LW, XSR monitor, ODR monitor, cavity-BPM, multibunch BPM, etc.