Joint Workshop
4th Beam Physics Seminar &
9th ATF International Collaboration Meeting

Kamogawa, Chiba ken, Sotobo “outside of Bozo Peninsula”, March 19-21, 2003

Joint Workshop

- 55 participants: 31 Japan, 8 China, 3 SLAC, 3 Russia, 3 UK, 2 India, 2 Jordan, 1 UCLA, 1 Orsay,1 CERN

- sponsored by JSPS Core University Program – Beam Physics ('Japanese Society for the Promotion of Science')

- JSPS Subprogram: Linear Collider Accelerator R&D (responsible J. Urakawa)

- Beam Physics Seminar (1st at IHEP, 2nd at IHEP, 3rd at Nasu (Joint), 4th Kamogawa); China-Japan Collaboration

- ATF Int'l Collaboration Meeting (1st at KEK 1996, 2nd at SLAC, …, 7th at Nikkou (2001), 8th Nasu (2002), 9th Kamogawa 2004

Agenda of Joint Workshop:

- Review of ATF R&D
- Hardware
- Chief Director of JSPS Asian Program – JSPS R&D
- Extraction Line Diagnostics & Experiments
- Instrumentation and Beam Physics
- Future Plan

detailed schedule

Agenda for Joint Workshop for 4th Beam Physics Seminar and 9th ATF International Collboration Meeting (JSPS Core university program＆KEK-ATF)

March 19(Fri.)

17:30 Chartered Bus will leave at KEK (near ATF Control room).
The Bus is going through Tsukuba Center to Kamogawa Universe Hotel .

22:00 Check In (Several peoples will arrive hotel later by car).

March 20(Sat.)

Overview talks and recent results (session chair : K.Kubo)

9:00	Opening Remarks	Junji Urakawa
9:05	ATF Status	Hitoshi Hayano
9:30	Laser Wire Development	Y.Honda & M.Takano
10:00	Future plans for ATF Instrumentation	Marc Ross
10:20	Discussion on Emittance Measurement (20min.)	All
10:40	Coffee Break	

Hardware reviews (session chair : H.Hayano)

10:45	X-ray SR	H.Sakai & T.Muto
11:10	Laser Wire Beam Size Monitor R&D in the future	K.Takezawa & M.Nomura
11:35	Laser Wire R&D+Plans in the extraction line	Grahame Blair
12:00	Lunch Break	

Collaboration Issues under Core University Program of JSPS (session chair : J.Urakawa)

13:30	Welcome talk	Tsuyoshi Enomoto
13:55	Outline of Core-University program	Shin-ichi Kurokawa
14:05	Present Status of Accelerator Projects in China	Fang ShouXian
14:25	Collaboration between IHEP and KEK: results and future	Qin Qing
14:50	ACFA activities	Satish Joshi
15:05	Future Prospect of Asian Collaboration: Indian View	Atul Gurtu
15:20	SESAME project	Sami Mahmood
15:35	Accelerator Science Activities in the Middle East	Mahmoud Al-Kofahi
15:50	Study on photo-cathode RF gun in IHEP	Jianping Dai
16:10	Coffee Break	

Research & Development at the extraction line (session chair : T.Omori)

16:30	Noninvasive diagnostic development	Alexander P. Potylitsin & Y.Fukui
16:40	ODR study	P.Karataev & T. Muto
17:00	Nano-BPM project at the extraction line	Mrac Ross
17:20	Feather project	Nicolas Delerue
17:40	Experimental Results for Pol. Positron generetion	I.Yamazaki & A.Ohashi
18:00	Dinner (reception)	

March 21(Sun.)

Instrumentation and Beam Physics (session chair:N.Terunuma)

9:00	Comments about ATF instrument and future plan	Mrac Ross
9:05	Feedback on Nanosecond Time scales(FONT) at NLCTA and ATF	Steve Molloy
9:20	Intrabeam scattering analysis of low emittance data	Kiyoshi Kubo
9:35	RF damping at ATF	Frank Zimmermann
10:00	Discussion (20min.)	All
10:20	Coffee Break	

Future Plan (session chair : T.Naito)

10:30	Plans for 2004-2005 runs	Junji Urakawa
10:35	Highlighting Development Works	Hitoshi Hayano
11:00	Future Plan for Multi-bunch beam generation	K.Hirano & Y.Yamazaki
11:30	Discussion (30min.)	All
12:00	Chartered Bus will leave and Go to Narita Airport and KEK.	

I will present my impression from all talks & slides from:

"Opening Remarks"

- Junji Urakawa

"ATF Status"

- Hitoshi Hayano

"Future Plans for ATF Instrumentation"

– Marc Ross

"Laser Wire R&D and Plans in the Extraction Line"

– Grahame Blair

"Welcome Talk JSPS"

– Tsyuyoshi Enomoto

"Comments about ATF Instruments & Future Plan"

– Marc Ross

"Plans for 2004-2005 ATF Run"

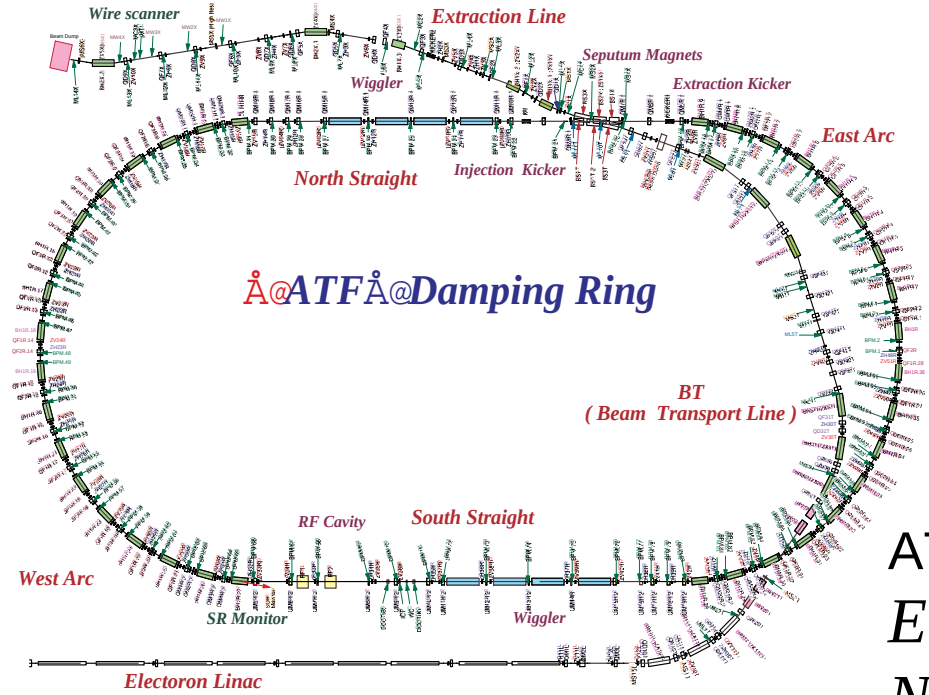
– Junji Urakawa

"Developments at 2004 ATF Run"

- Hitoshi Hayano

Accelerator Test Facility

this and many following slides from H. Hayano!



Damping ring

ATF is the **largest LC Test Facility**

$E=1.28GeV$

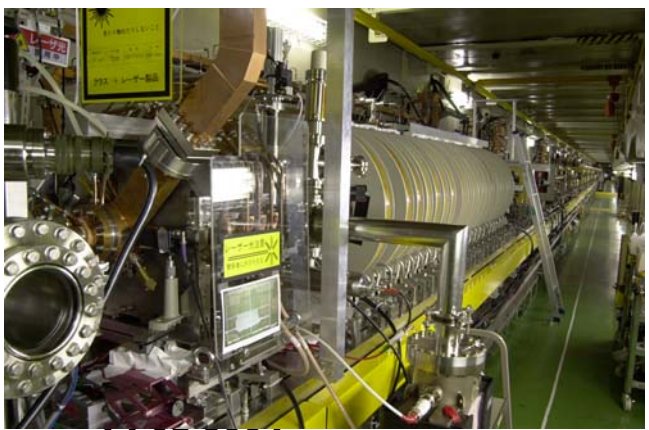
$Ne=1x10^{10}\ e^{-}/bunch$

1 ~ 20 bunches

$Rep=1.5Hz$

$X\ emit=2.5E\text{-}6\ \mu m$ **(at 0 intensity)**

$Y\ emit=2.5E\text{-}8\ \mu m$ **(at 0 intensity)**



Linac

Low Emittance Tuning

- ***Beam-based optics modeling***

  Q-magnet strength correction in model

- ***Beam based BPM offset measurement***

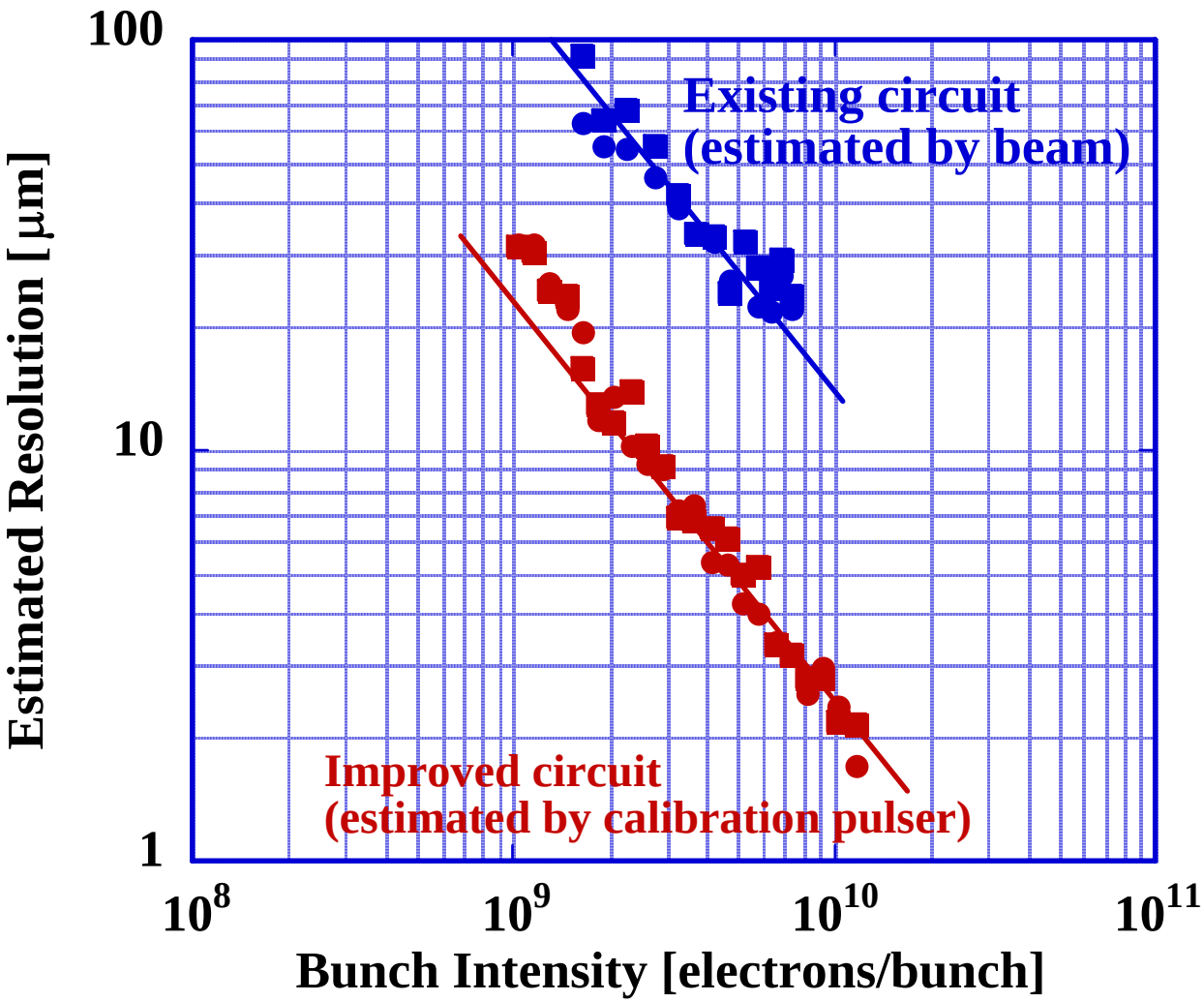
  Q, SX trim excitation & bump orbit to orbit response

- ***COD correction***
- ***Dispersion correction***
- ***Coupling correction***

  horizontal kick to vertical response, then skew corrector

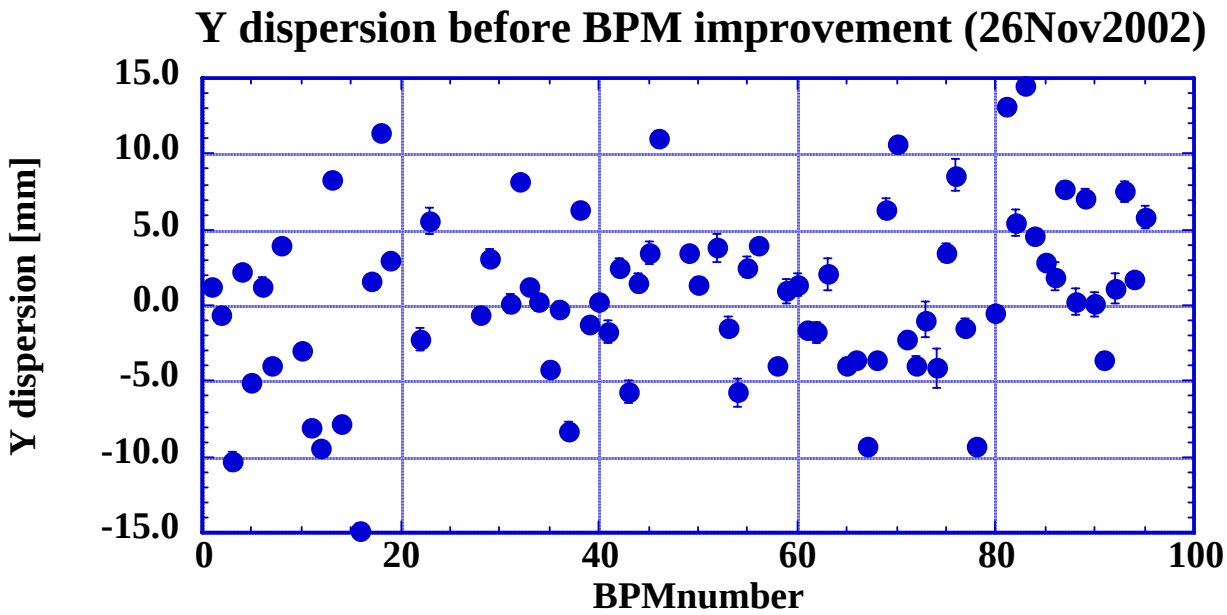
H. Hayano

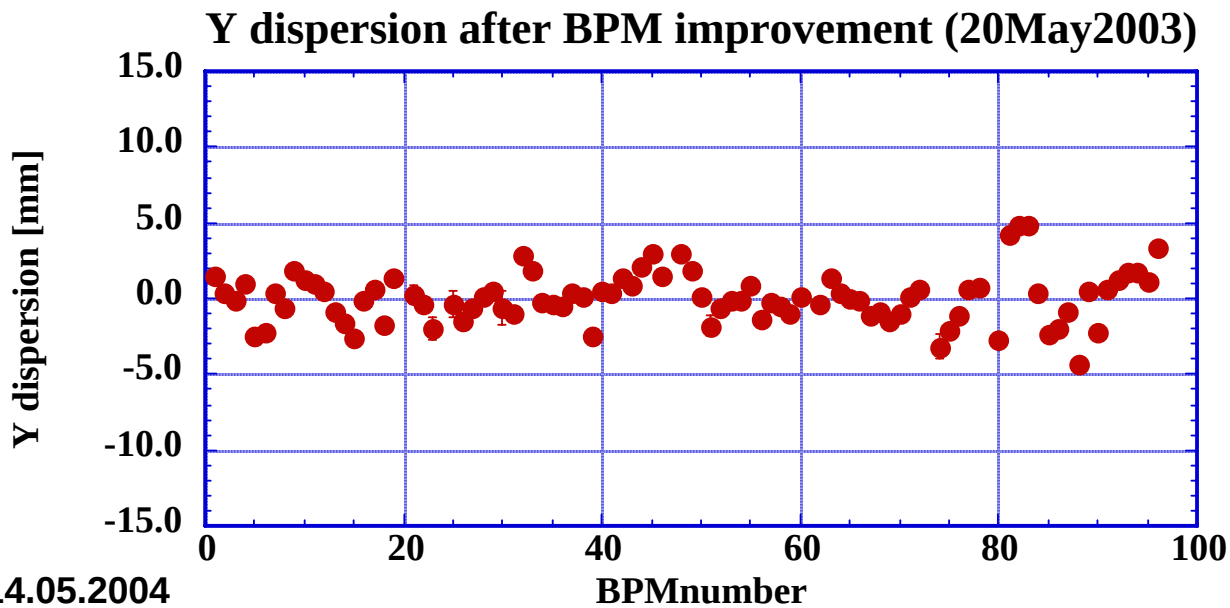
BPM Resolution Improvement



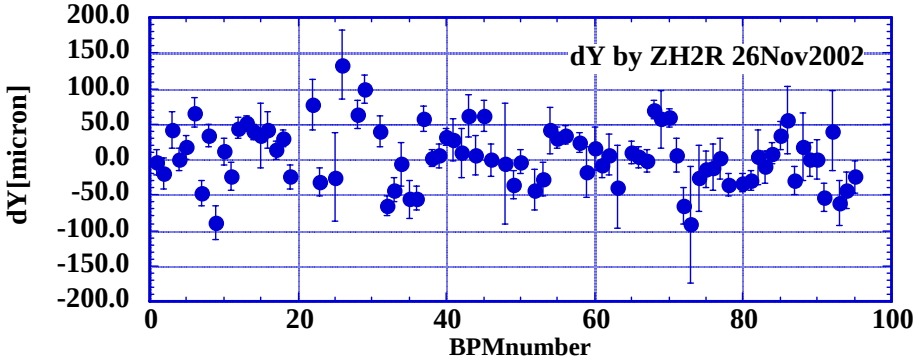
Min. resolution ~ 2μm

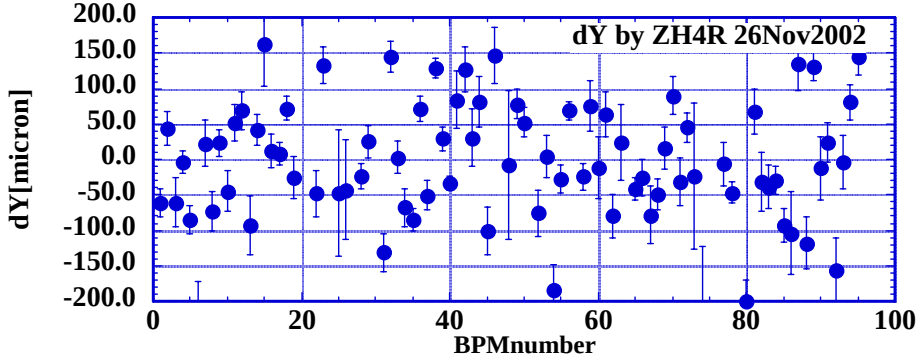
Vertical dispersion Improvement

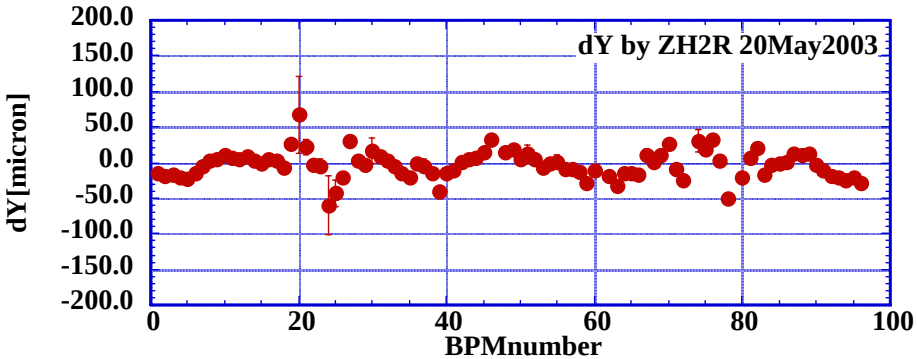


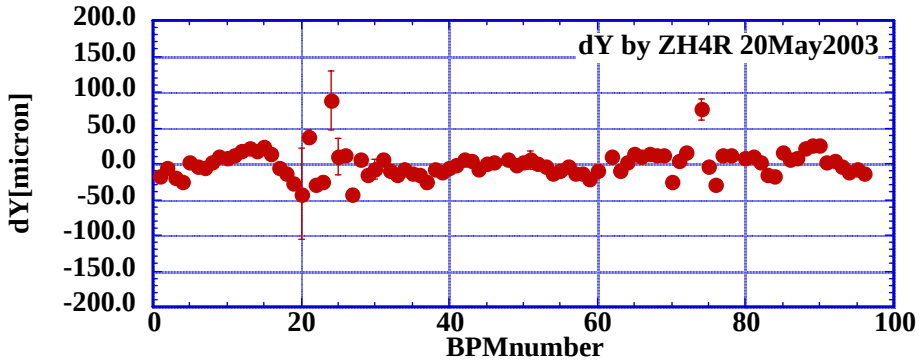


X to Y coupling Improvement

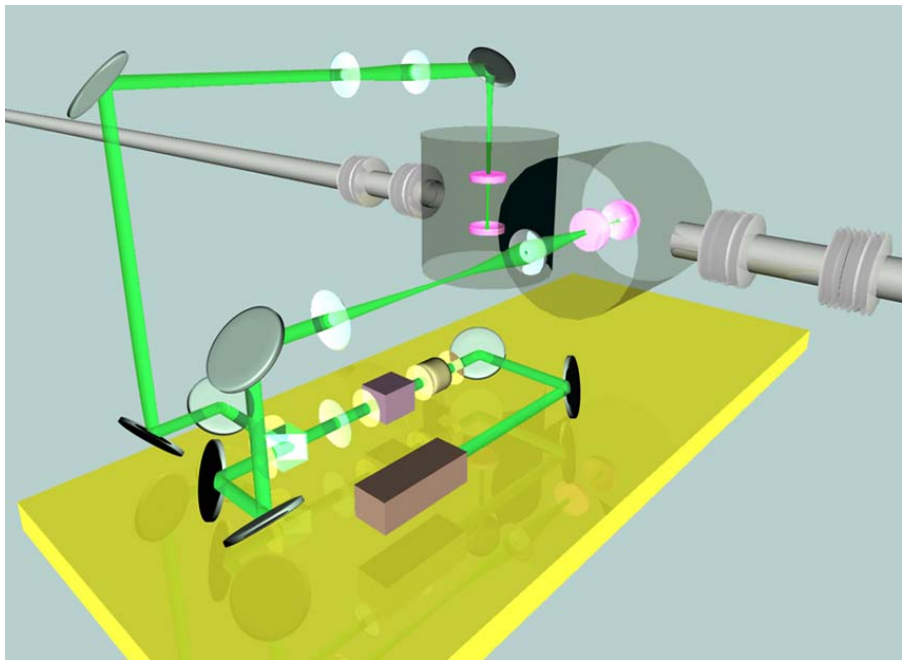


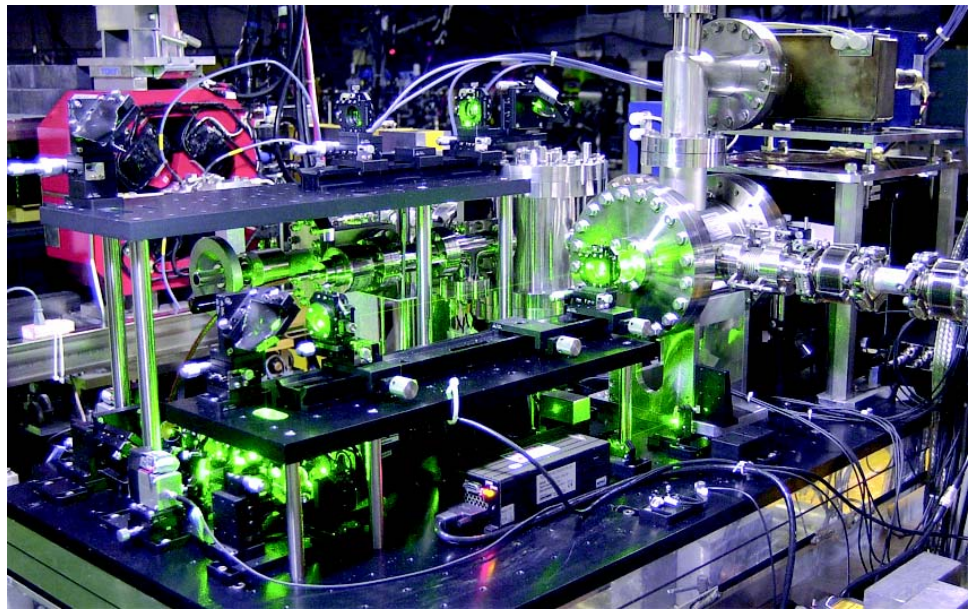






Laser wire beam size monitor in DR

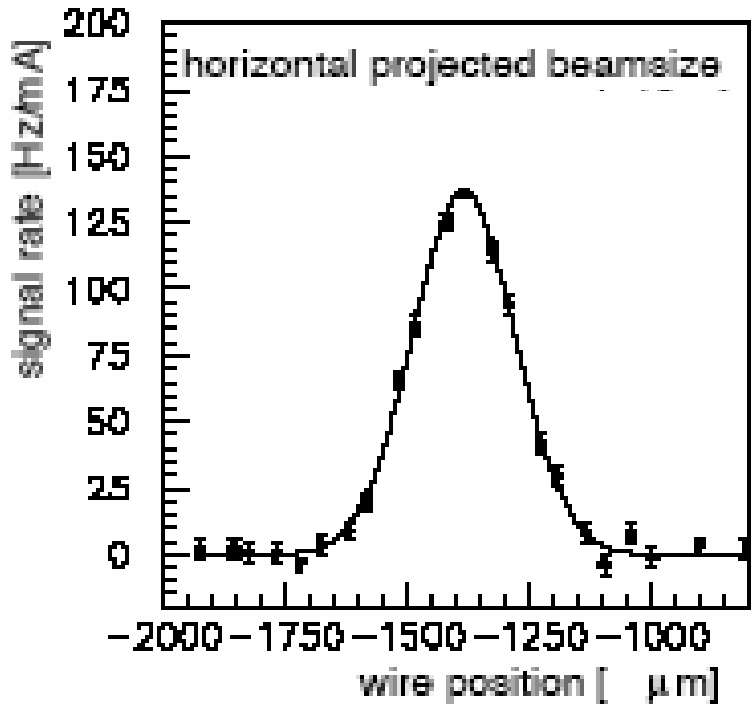


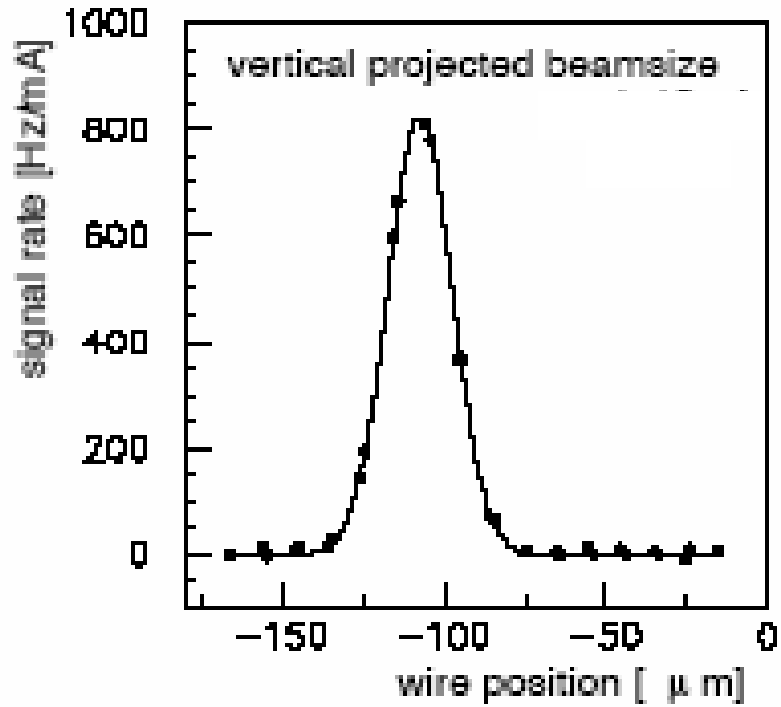


300mW 532nm Solid-state Laser
Fed into optical cavity

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

Beam profile by Laser wire





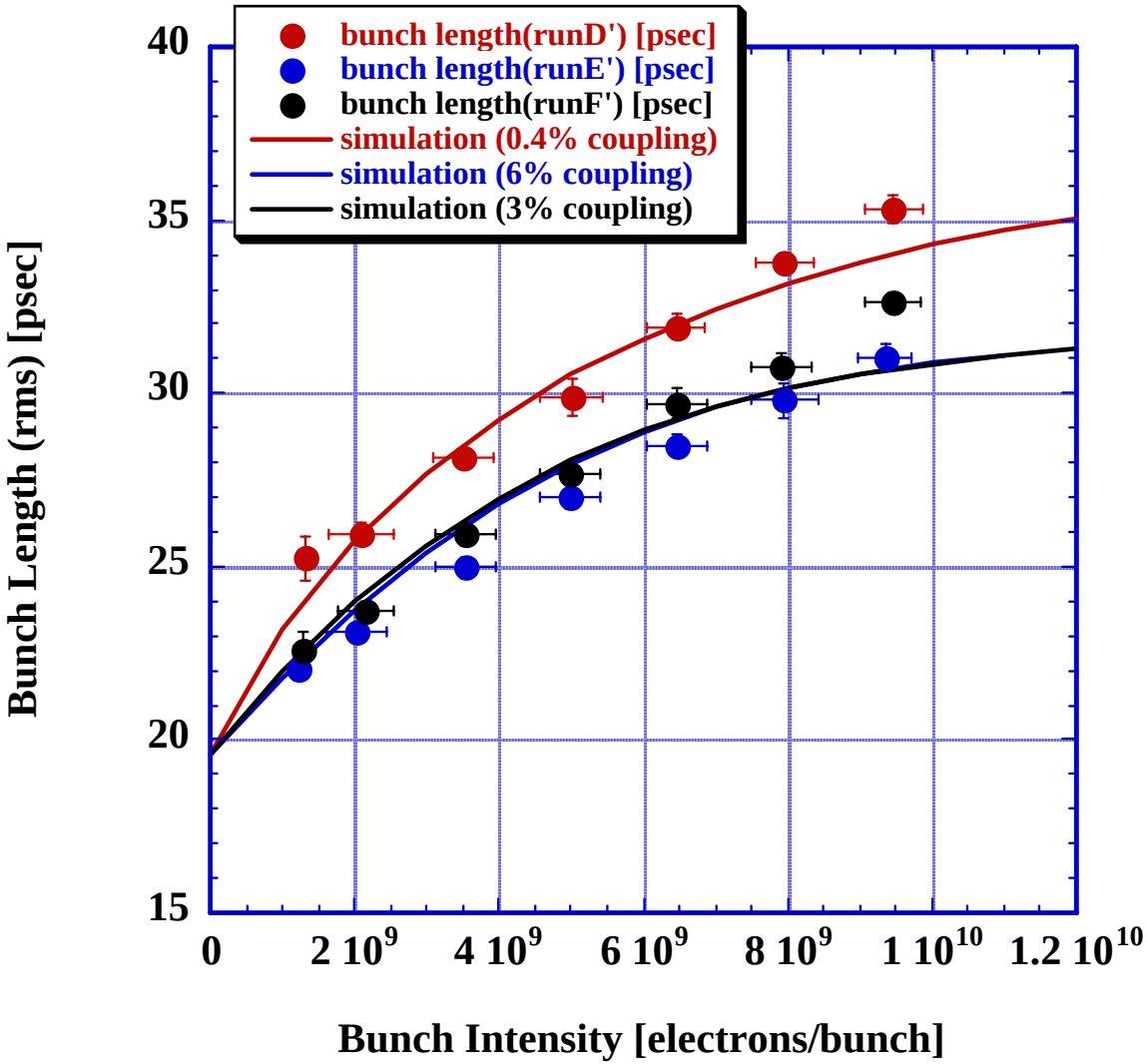
$$\sigma_e^2 = \sigma_{\mathrm{meas}}^2 - \sigma_{lw}^2$$

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

β:*measured by Q-trim excitation*

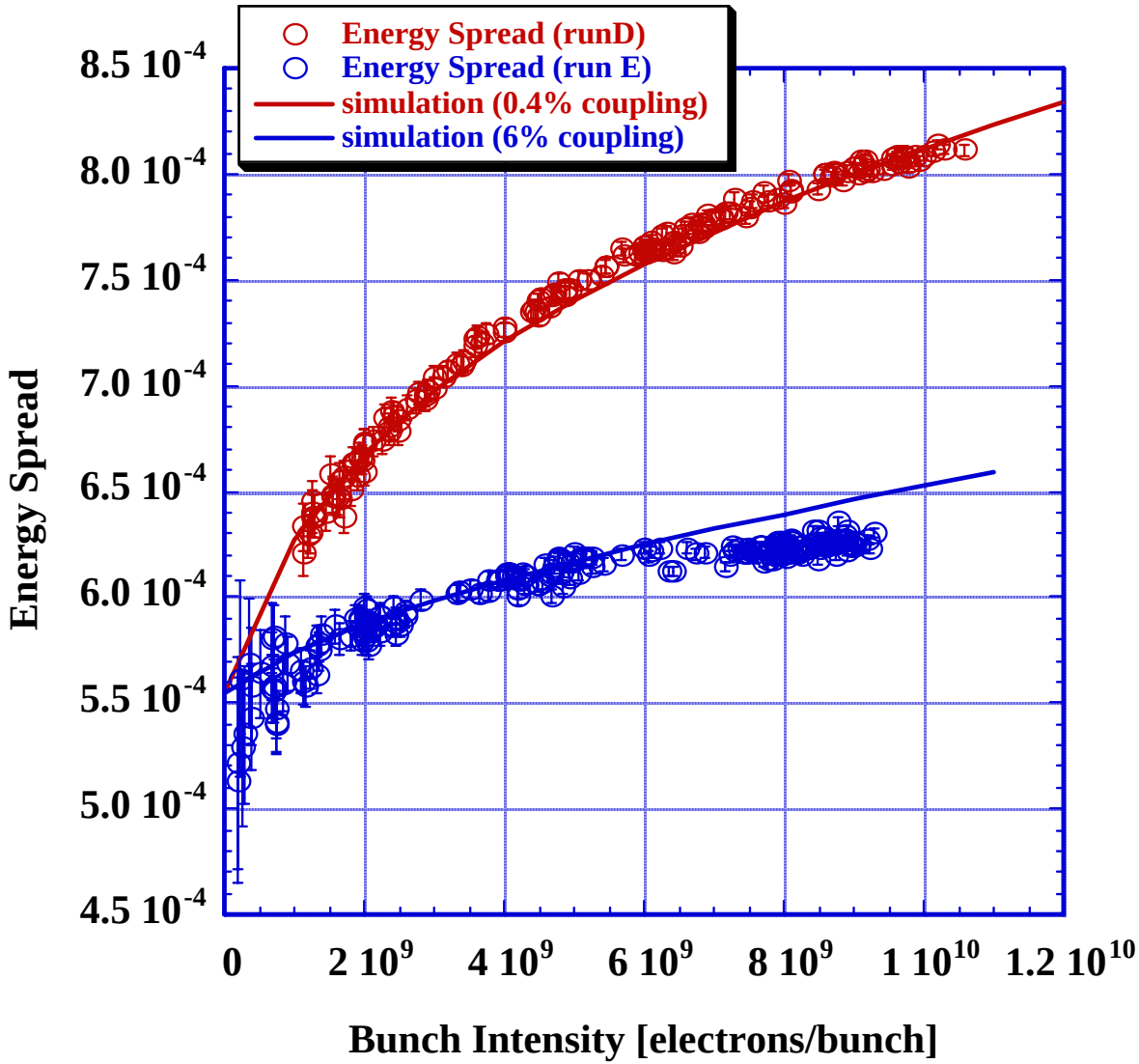
Bunch Length

by SR monitor streak camera



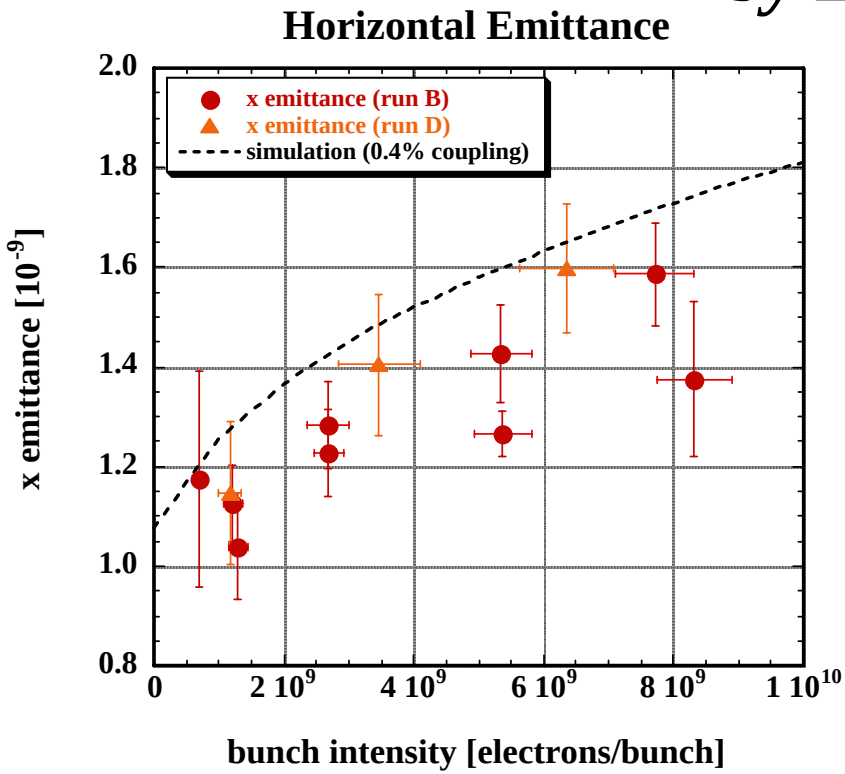
Energy Spread

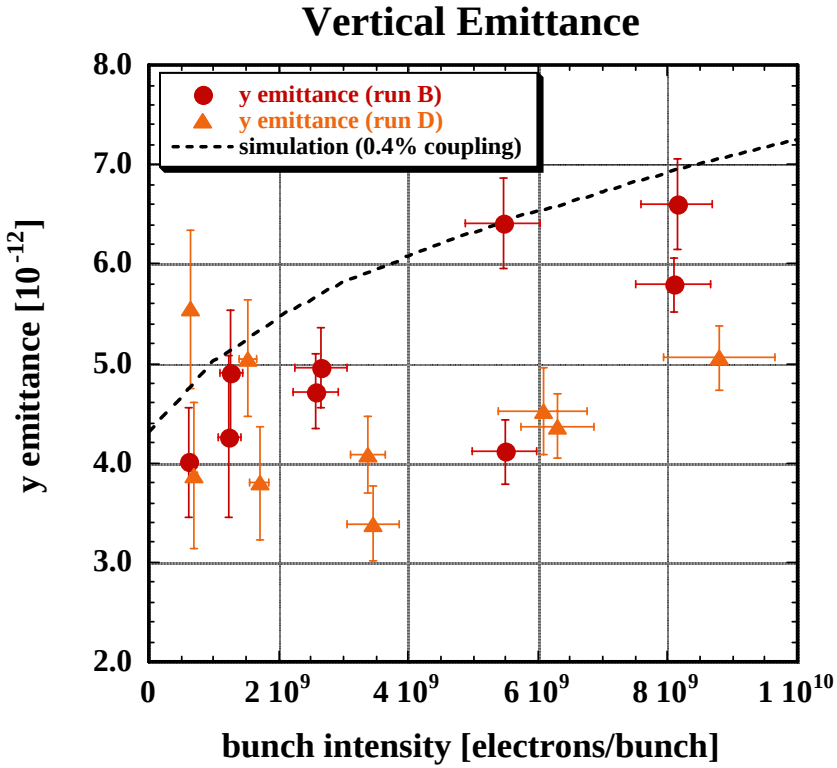
by beam size monitor at EXT dispersive point



Transverse Emittance

by Laser wire





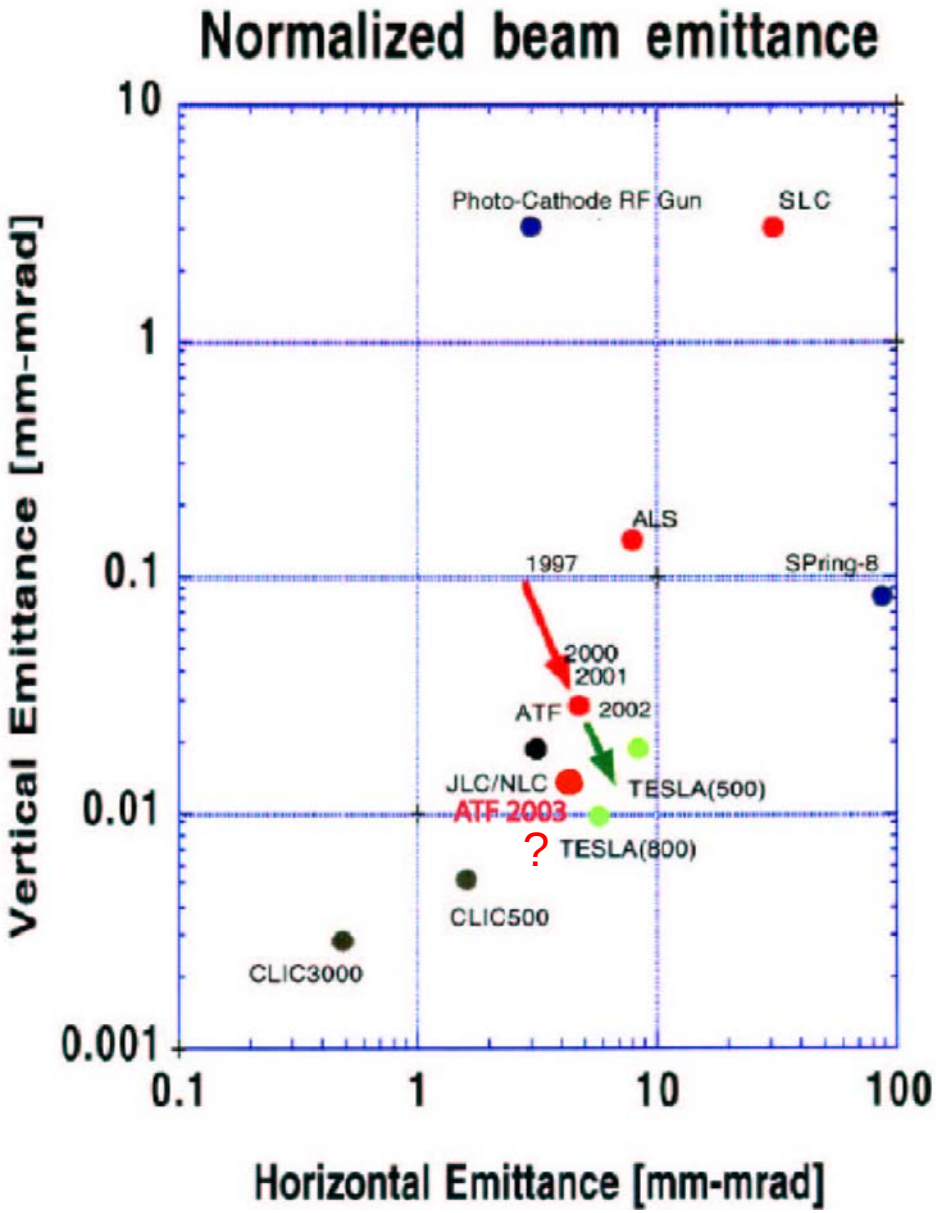
< 0.4% y/x emittance ratio

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]



demonstrated single bunch emittance

$\gamma\varepsilon_x$~3.5-4.3 μm

(1.4-1.7 nm)

$\gamma\varepsilon_y$~13-18 nm

(5-7 pm)

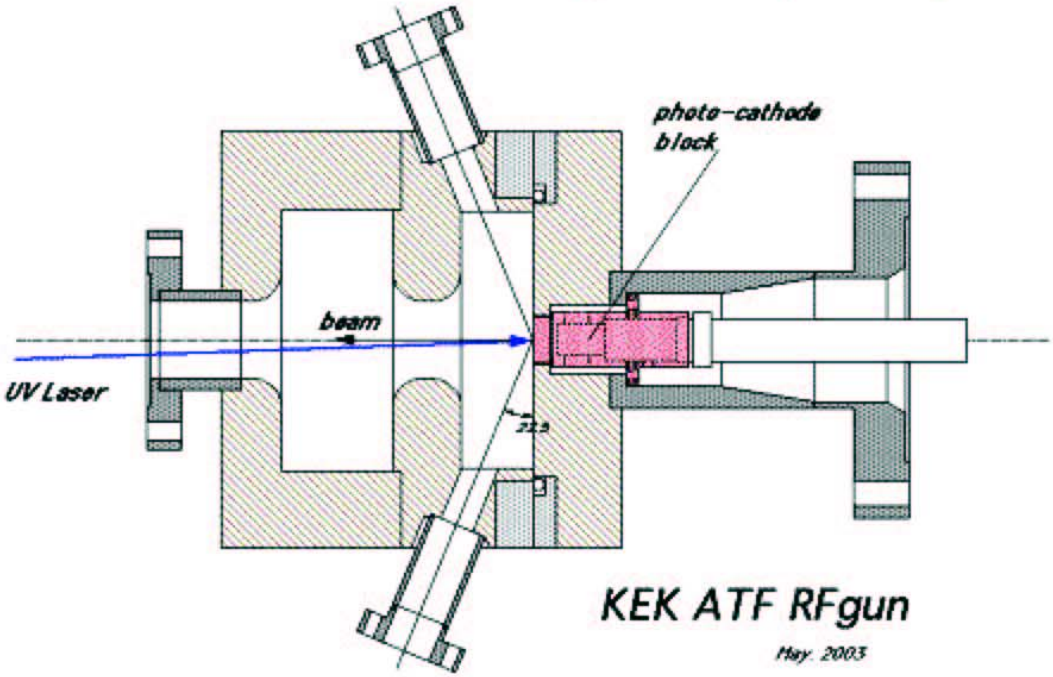
CLIC target values

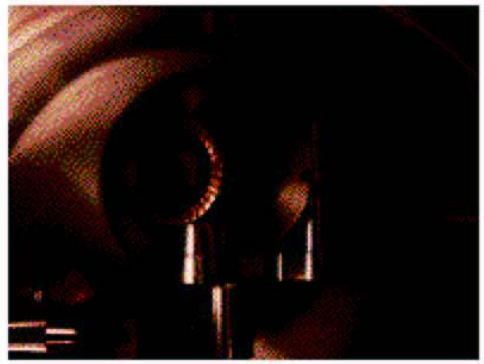
$\gamma\varepsilon_x$~0.45 μm

$\gamma\varepsilon_y$~3 nm

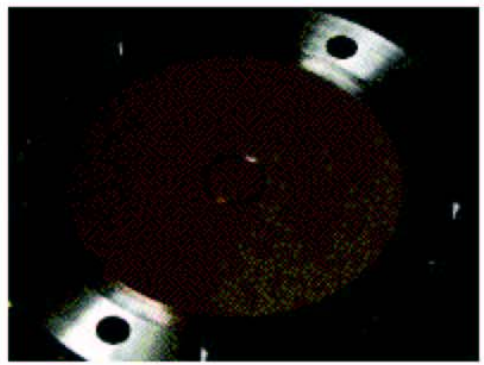
Photo-cathode RF-gun

2 years operation experience from Oct.2002

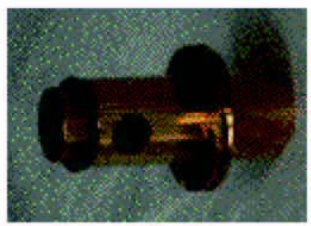




Cathode block with CsTe coating

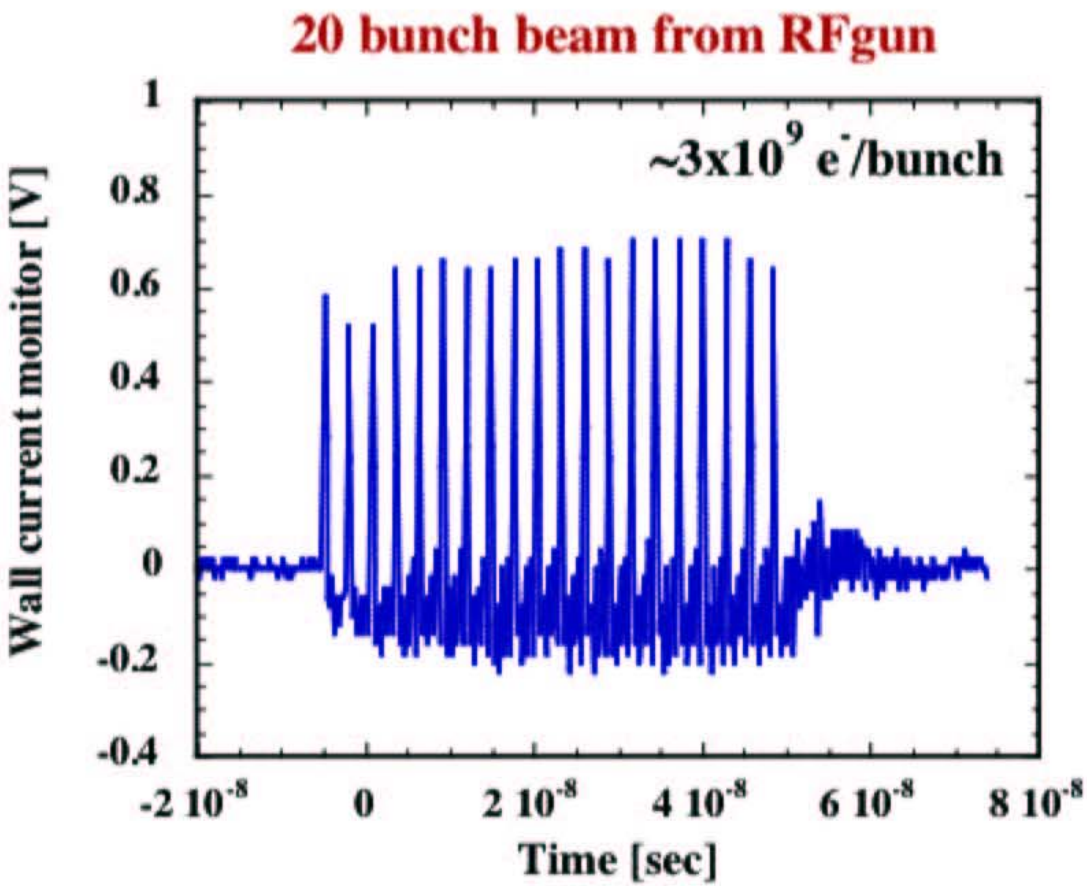


End plate with cathode block



Cathode block

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

Multibunch emittance study

- ***Scrubbing of DR was started***

  DR pressure should be < 7 x10^{-7} Pa for 1% emittance ratio
  (<5 ntorr)

  for 1.0 x10^{10} e^{-}, 20 bunch, (=67mA) 0.78Hz repetition

  so far, >1 x10^{-6} Pa **(>7.6 ntorr)**

- ***Monitors of MB emittance***

  MB (or projected) Laser-wire *ODR monitor?*

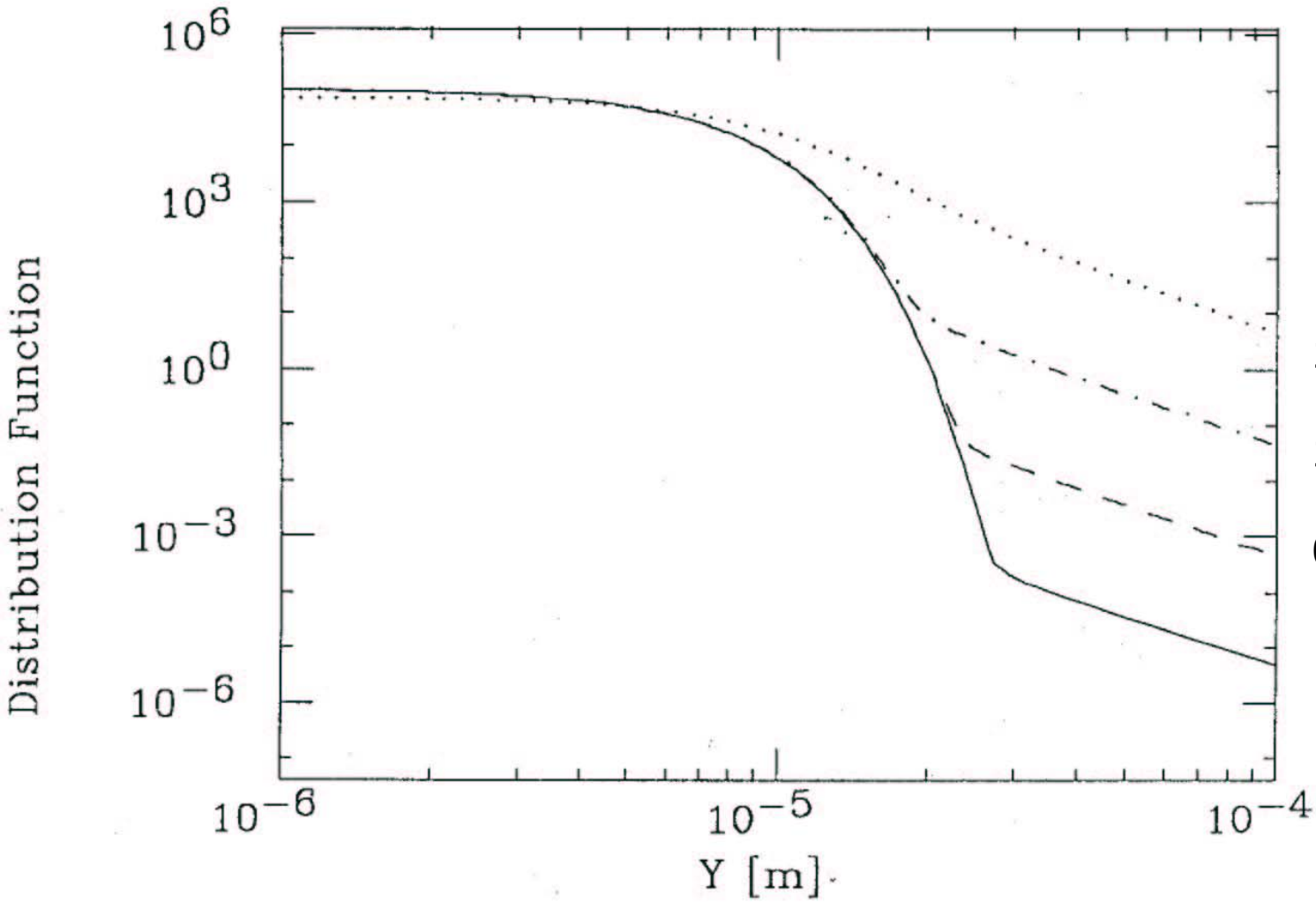
  Projected SR interference monitor, X-ray SR monitor

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

- ***Problem of MB emittance***

  big energy fluctuation (coupled bunch longitudinal oscillation)

observed pressure sensitivity in striking contrast to prediction



Tor Rauben-heimer, KEK-92-7, 1992

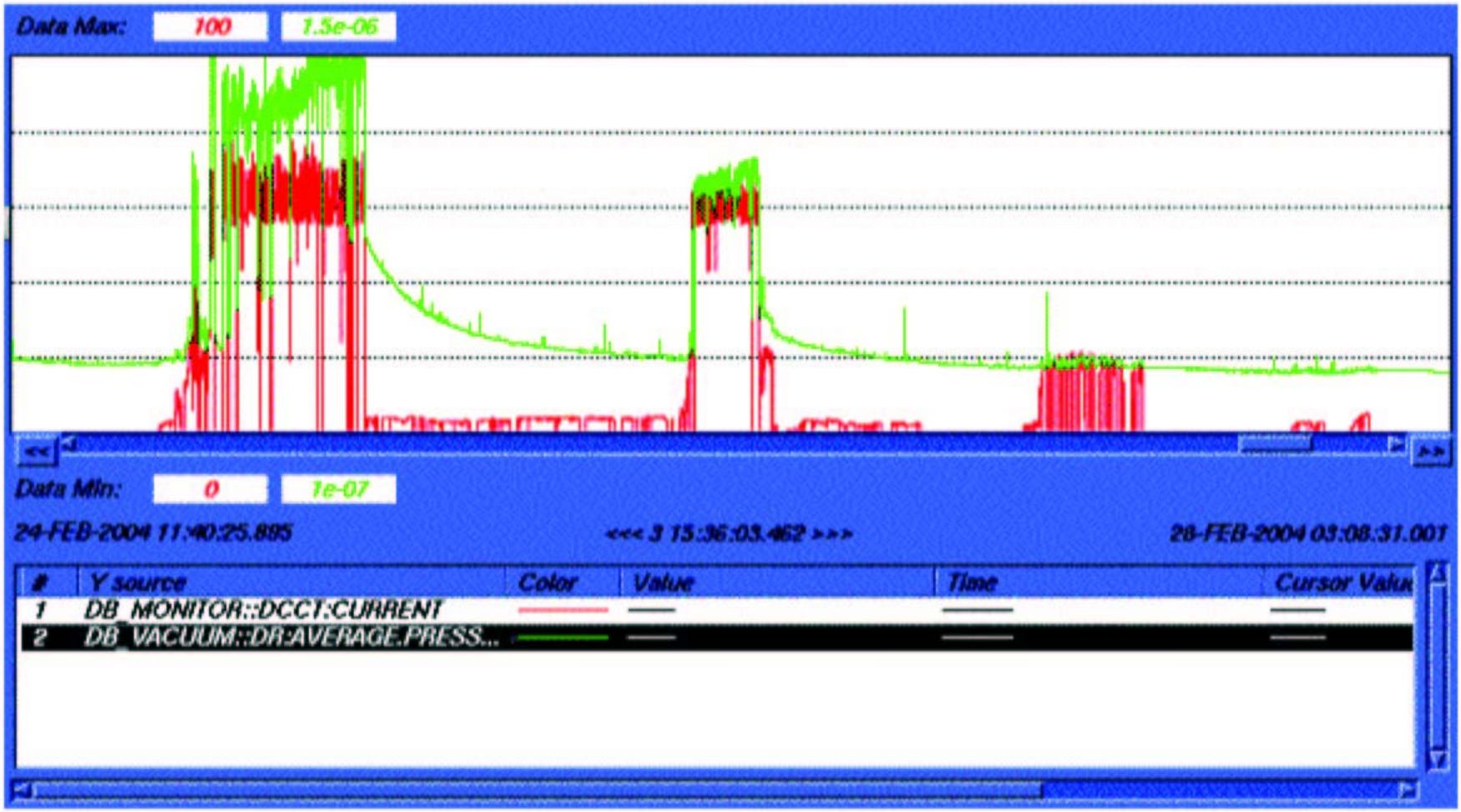
1000 ntorr

10 ntorr

0.1 ntorr

Fig. 1 Beam distribution in the NLC damping ring with CO gas pressures of 10^{-12} Torr (solid), 10^{-10} Torr (dashed), 10^{-8} Torr (dot-dash), and 10^{-6} Torr (dotted). "at large amplitudes tail from elastic gas scattering like ~$1/y^3$"?

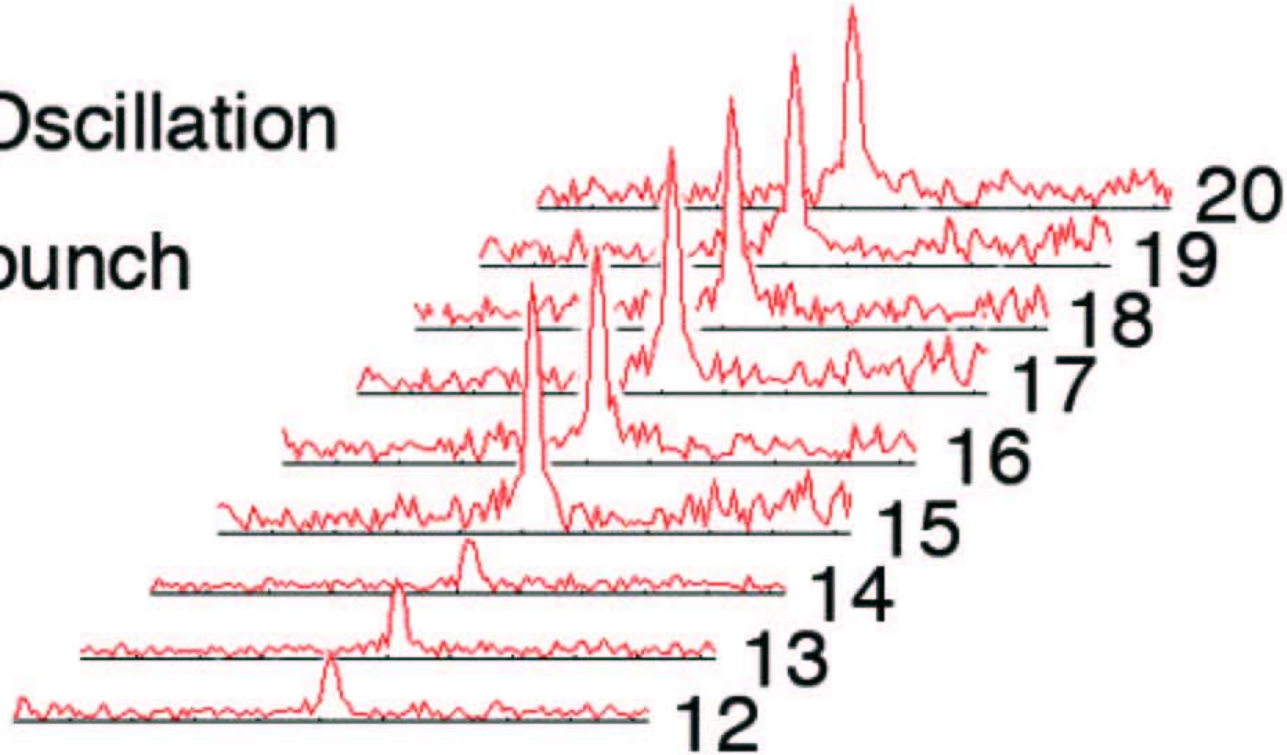
Scrubbing of DR example

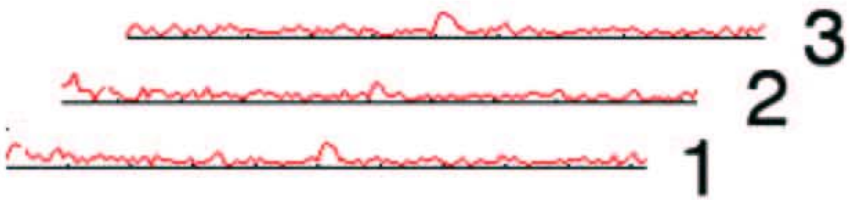


60~70mA (20bunch, 3train);

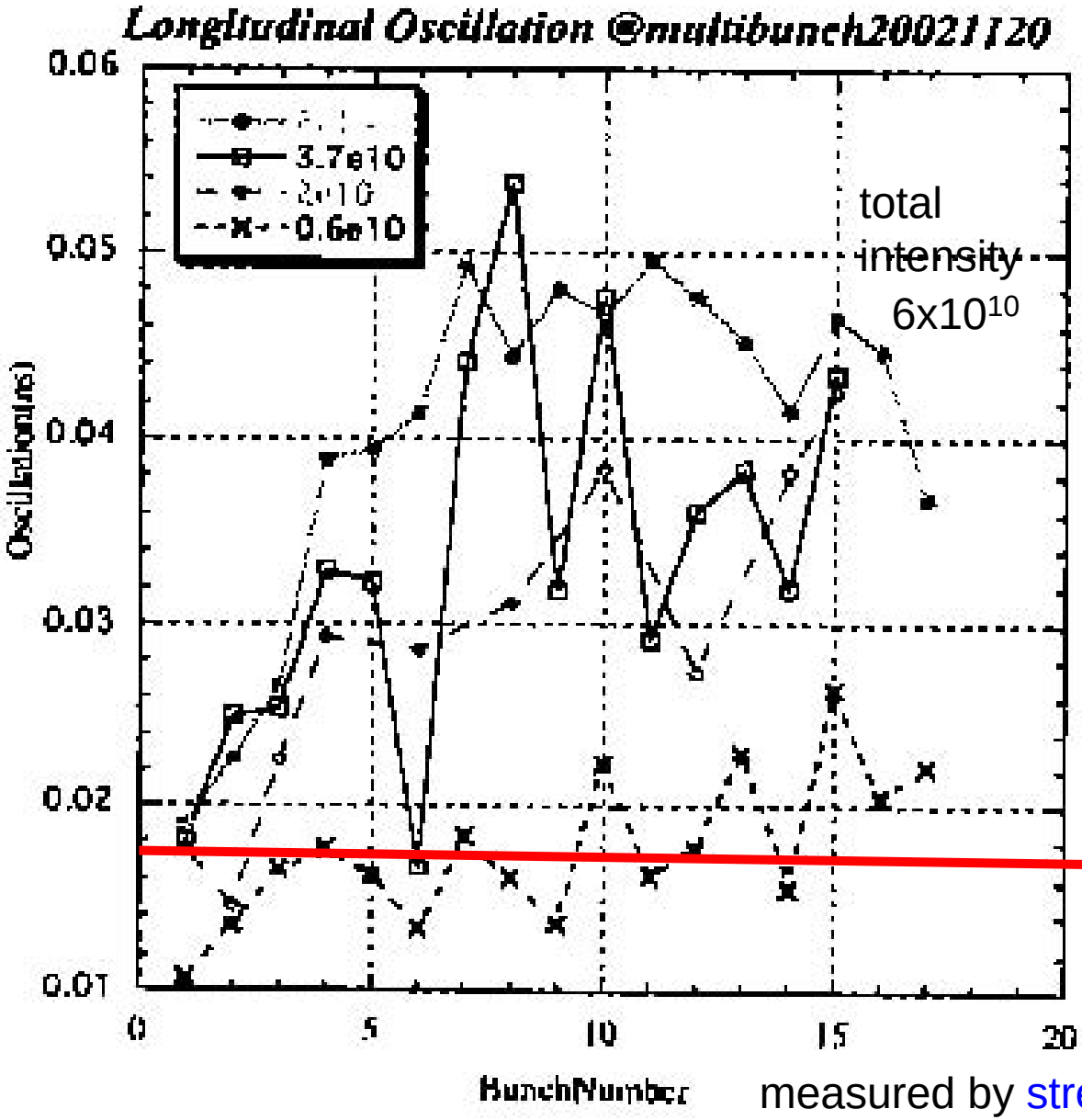
$1.3\sim1.5\times10^{-6}$ pa --> $1.0\sim1.1\times10^{-6}$ pa

Synchrotron Oscillation growth in 20 bunch





FFT spectrum of Multi-bunch BPM data



T. Naito et al.,
"Observation of the Longitudinal Beam Oscillation at ATF-DR"
KEK Preprint 2003-73
October 2003
A

the amplitude of the longitudinal oscillation at each bunch (1σ)

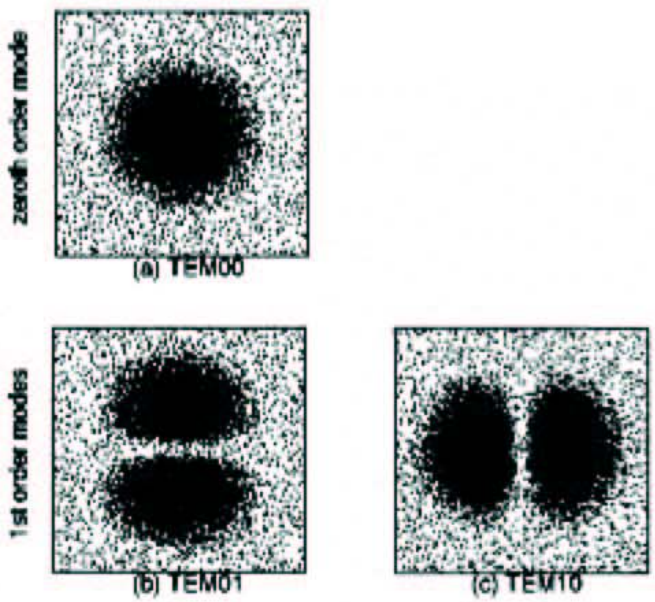
<u>for comparison</u>

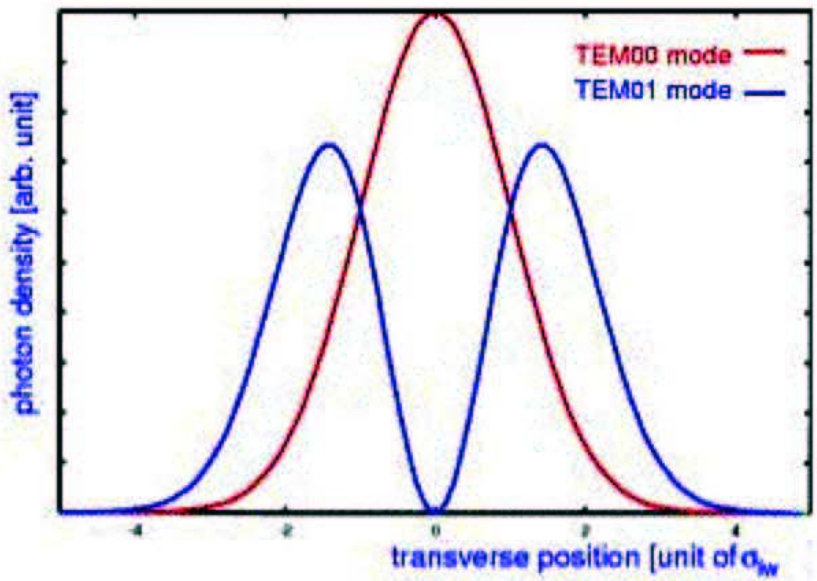
full bucket size: 1.4 ns
rms bunch length: 0.017 ns

measured by streak camera
similar scatter seen in energy profiles
sensitive to rf temperature, suspect HOM

higher mode laserwire

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

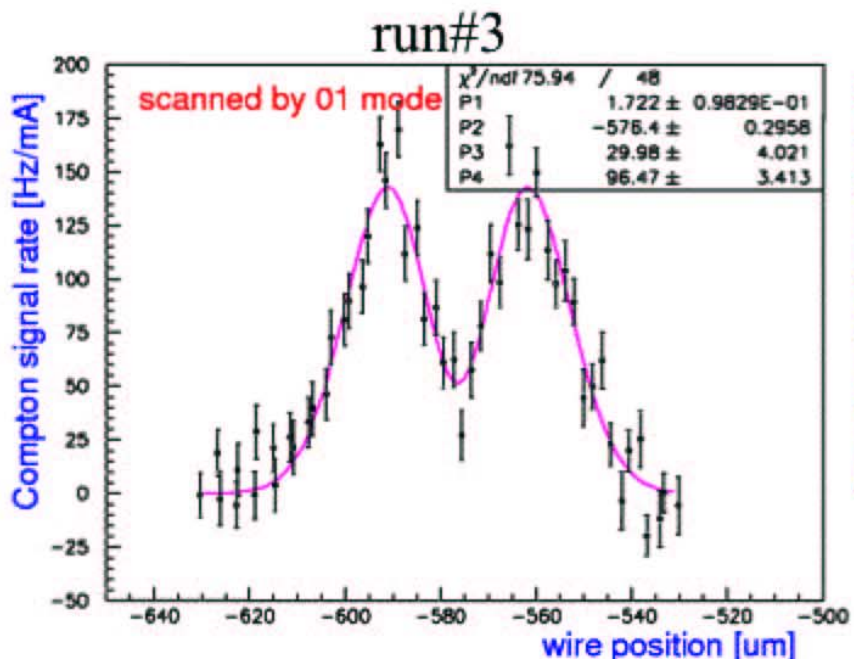


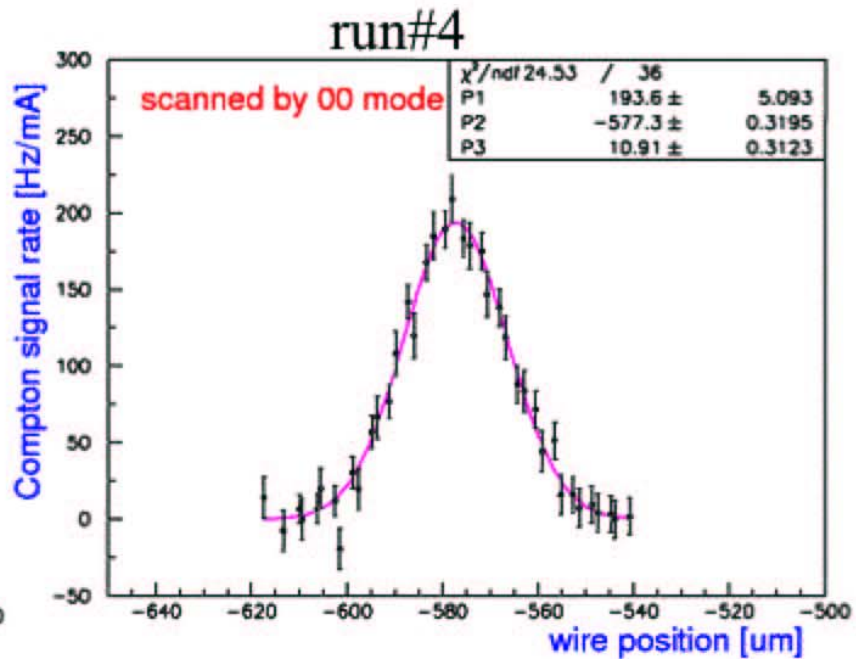


TEM01 mode has two lobe and a node

beam experiment

- normal beam

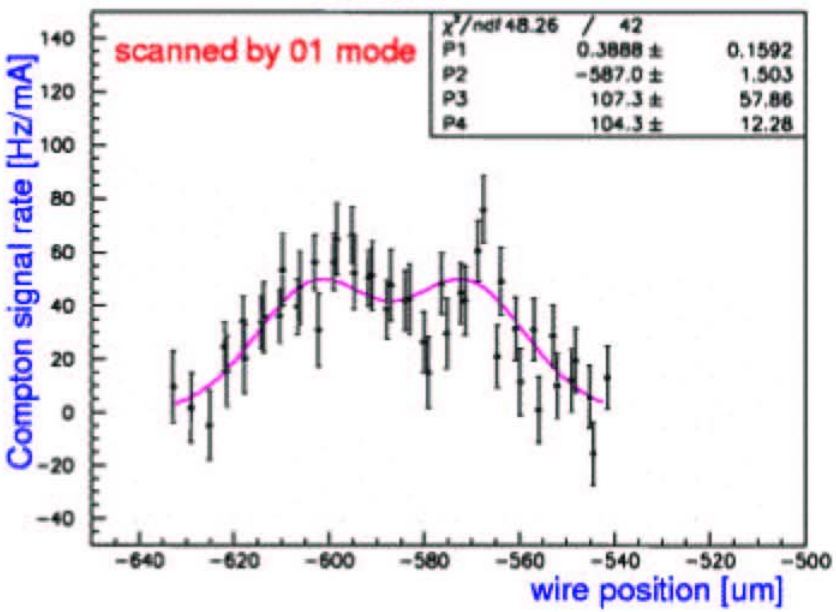




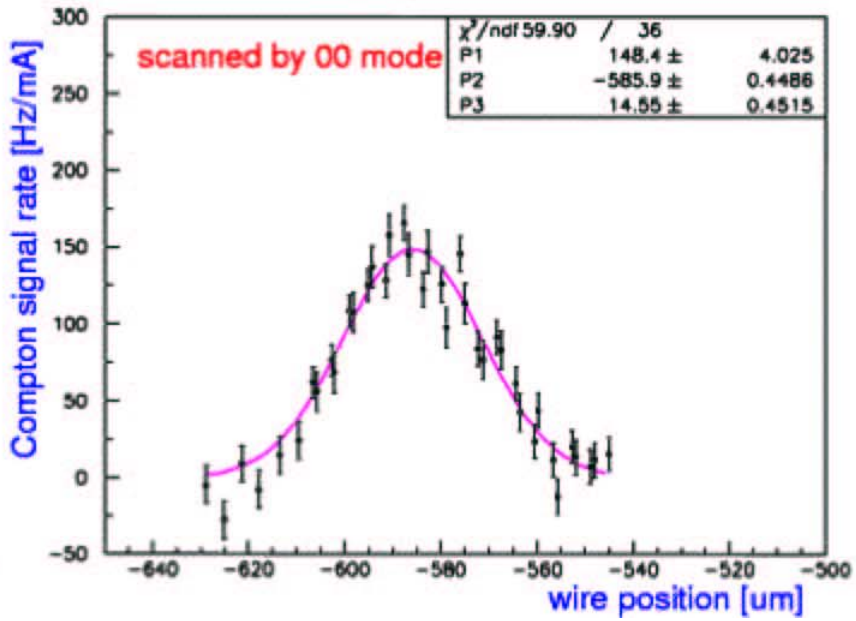
beam experiment

- bigger beam (skew corr. turned off)

run#6



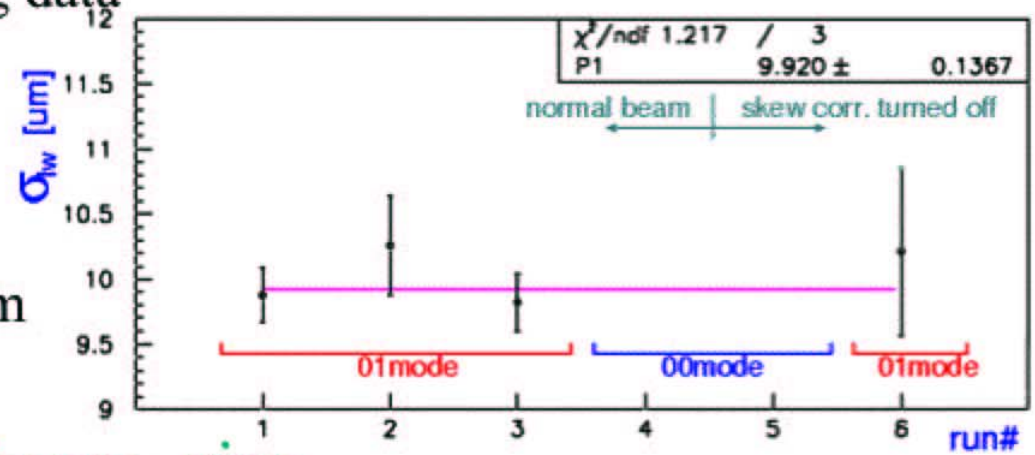
run#5



fitted result

- estimation of the laserwire size

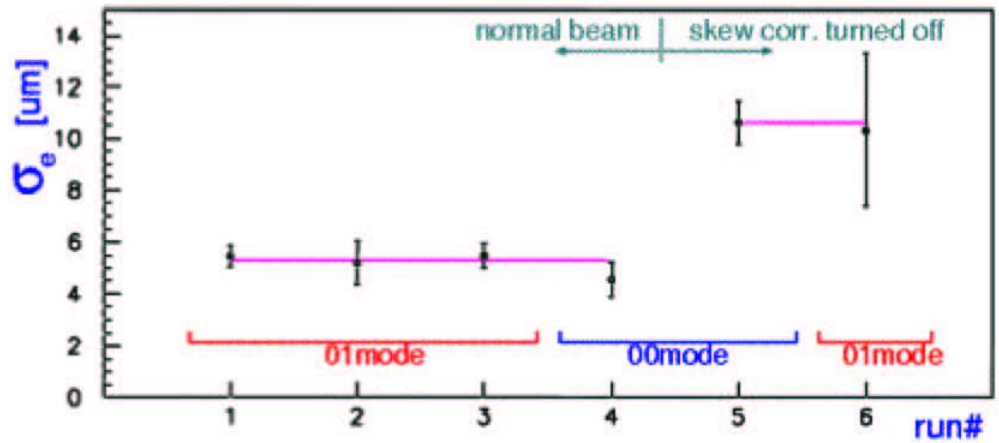
  from 01mode scanning data



combined result for the laser size : 9.92 ±0.14um

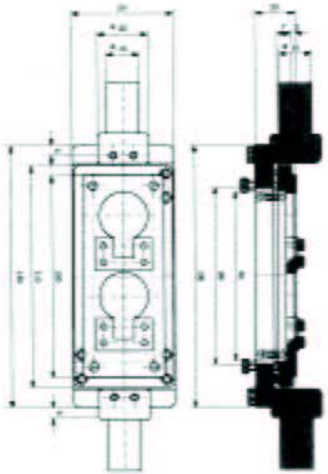
- estimation of the beam size

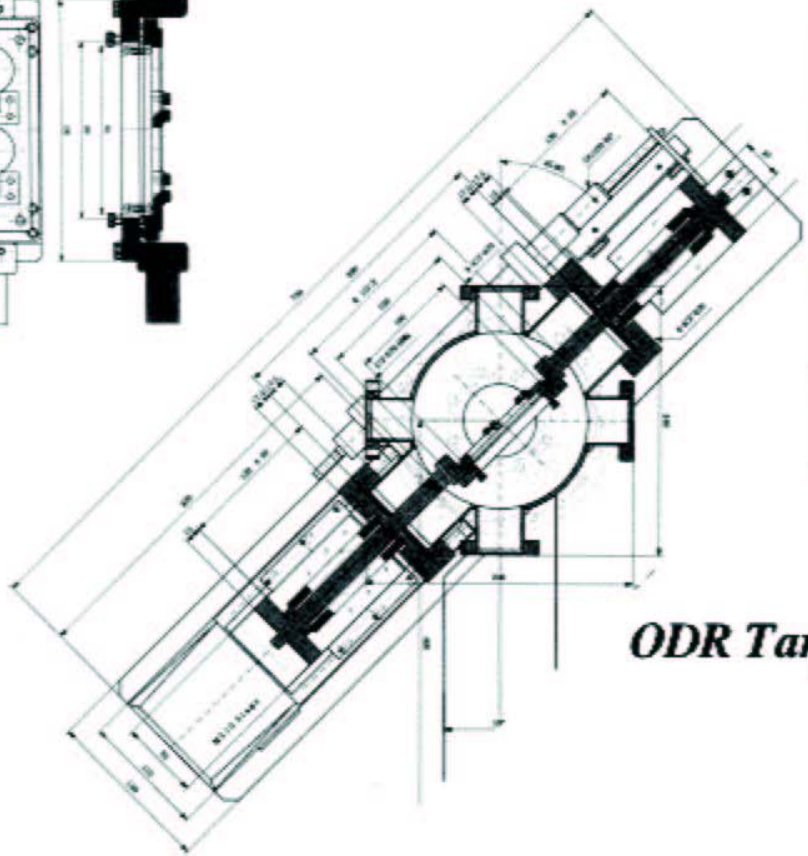
  the result above was used to subtract laser size from 00mode results

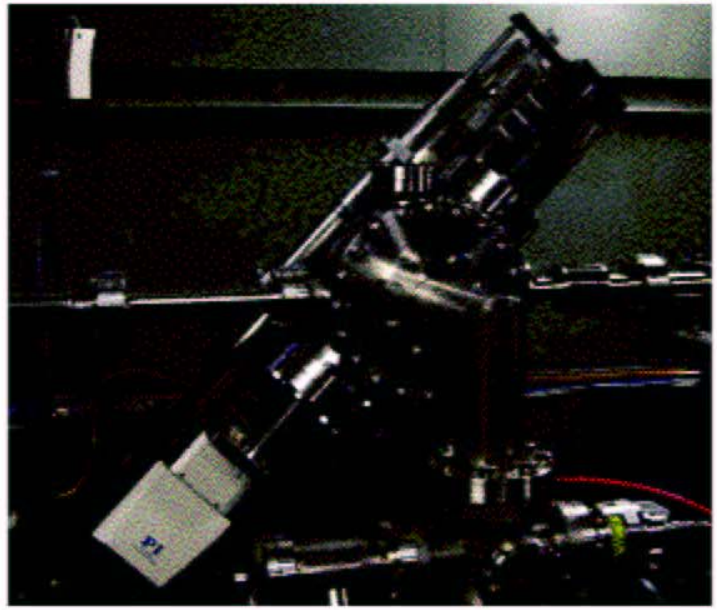


ODR Monitor

ODR Target Holder







ODR Target chamber

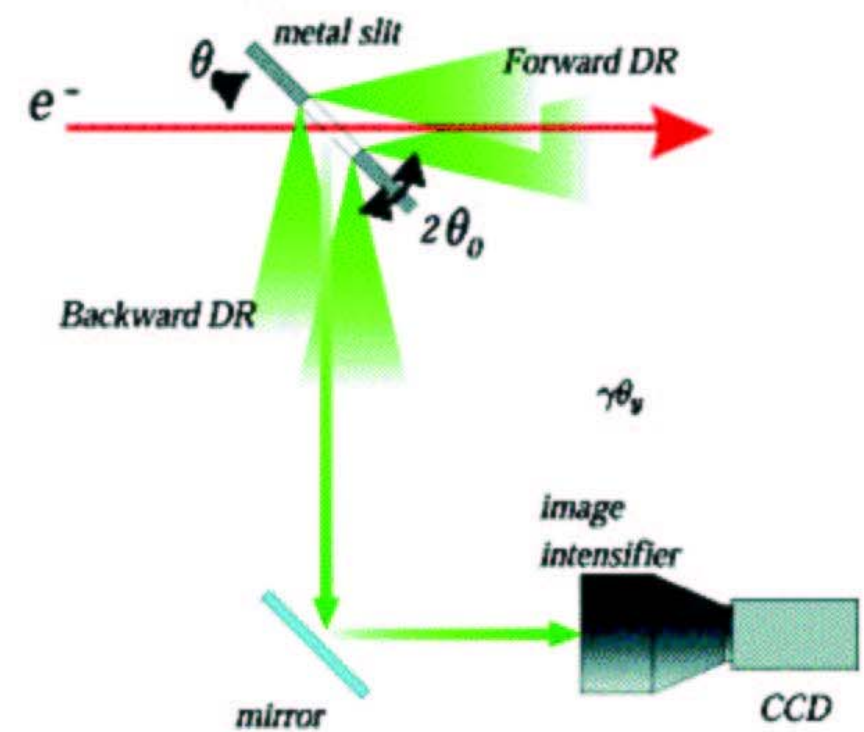
Diffraction Radiation(DR) experiment for non-invasive beam diagnostics

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

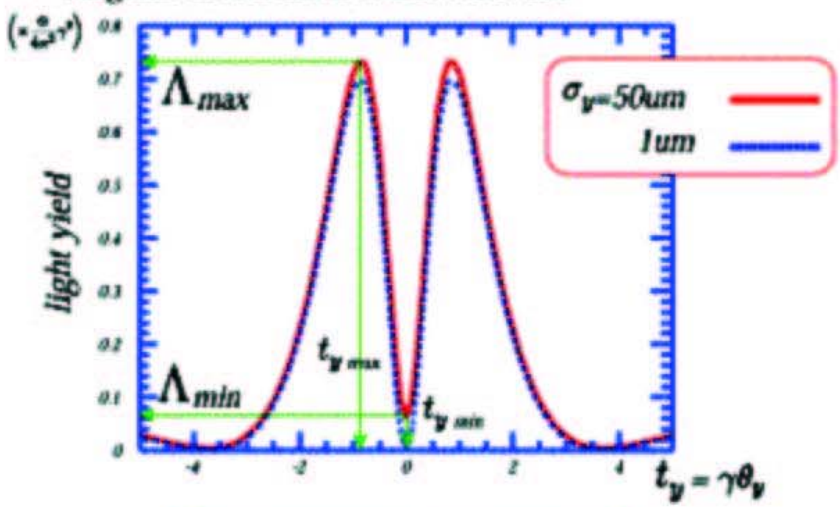
beam diagnostics using DR

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

measurement set up



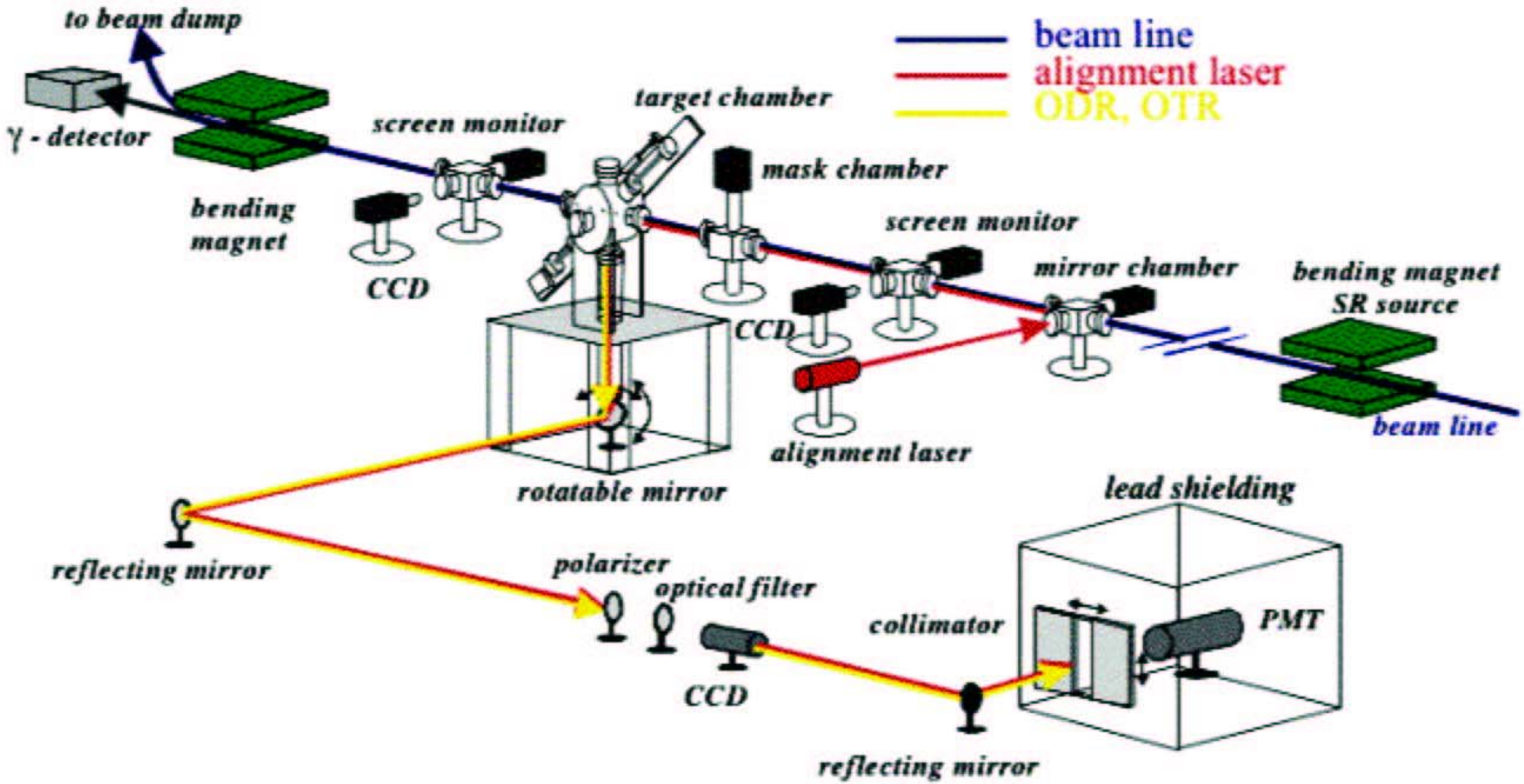
Angular distribution of DR from slit



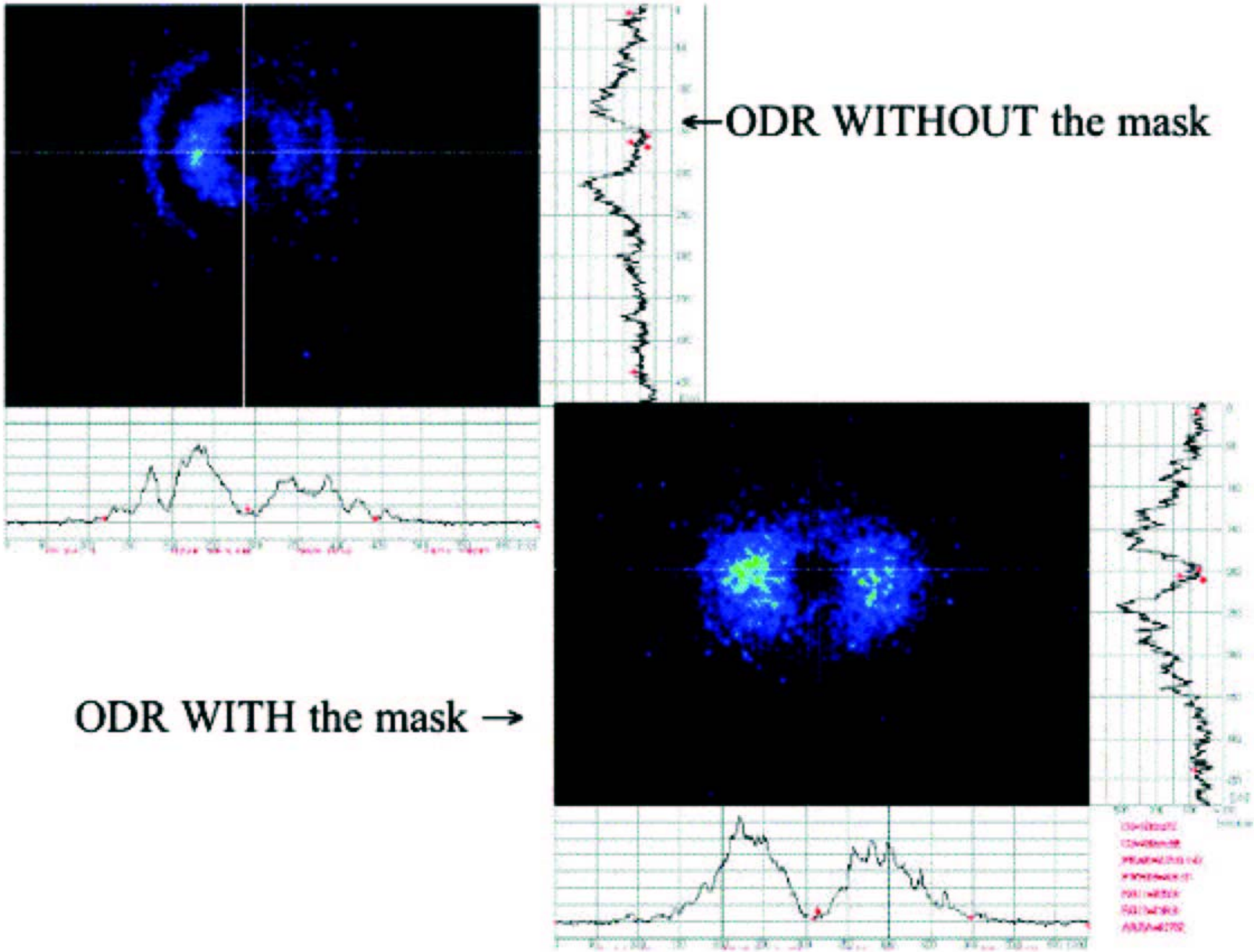
Beam size

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

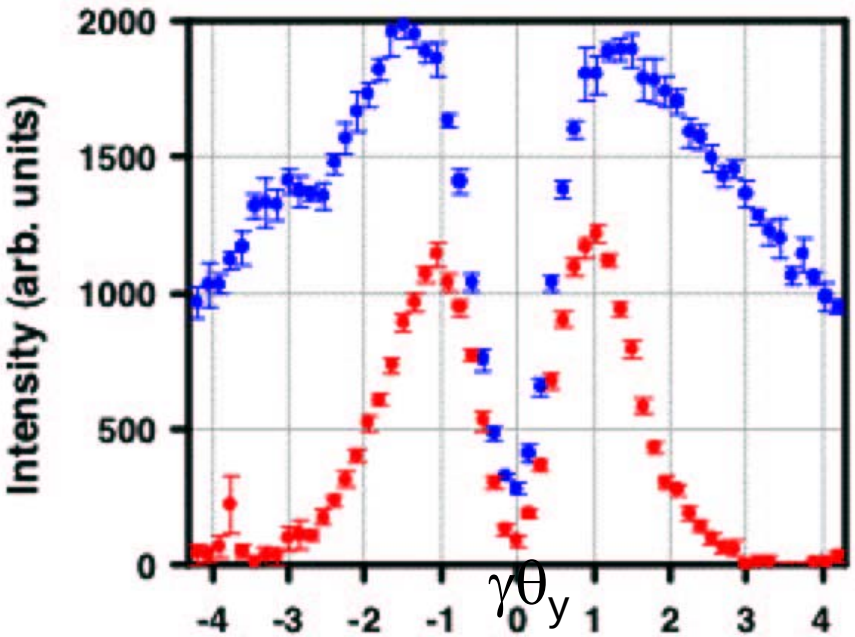
Experimental Setup

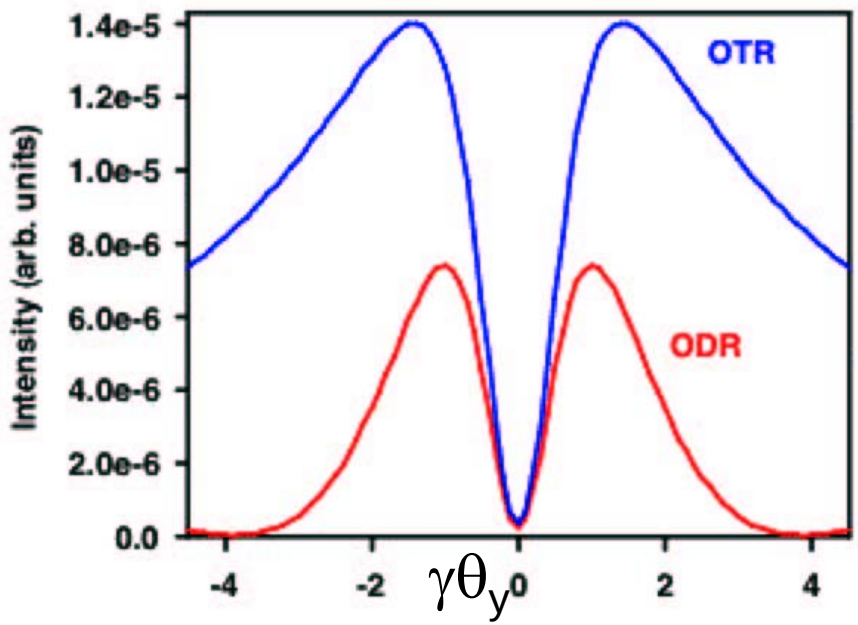


ODR measurements with 550nm filter

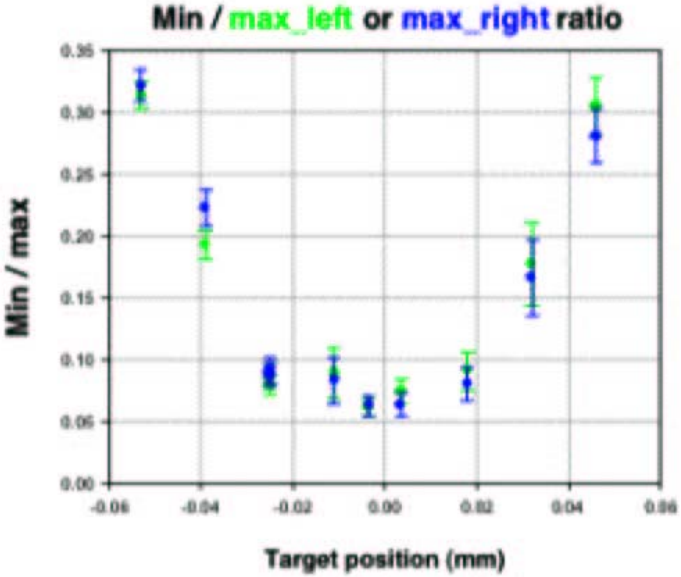


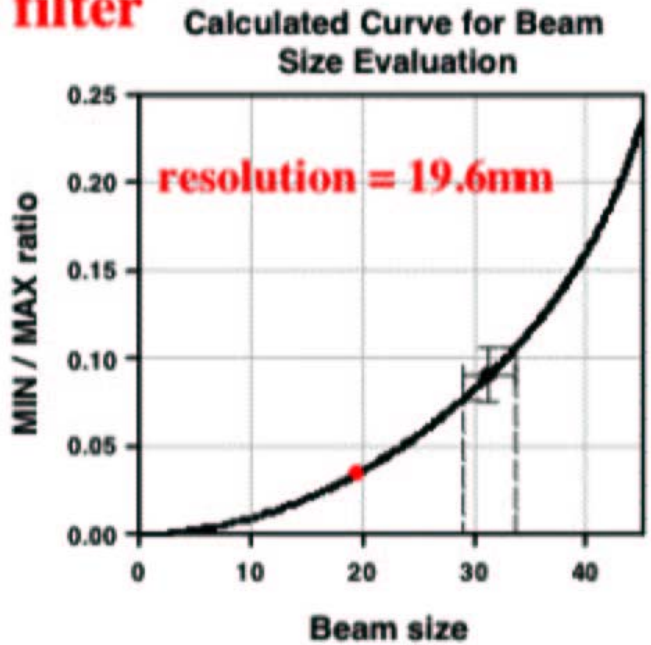
Measurements and calculation (458 nm wavelength)

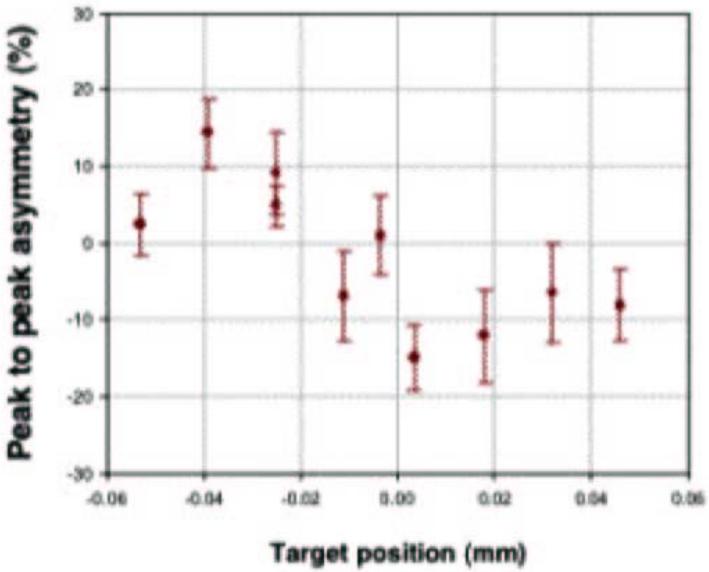


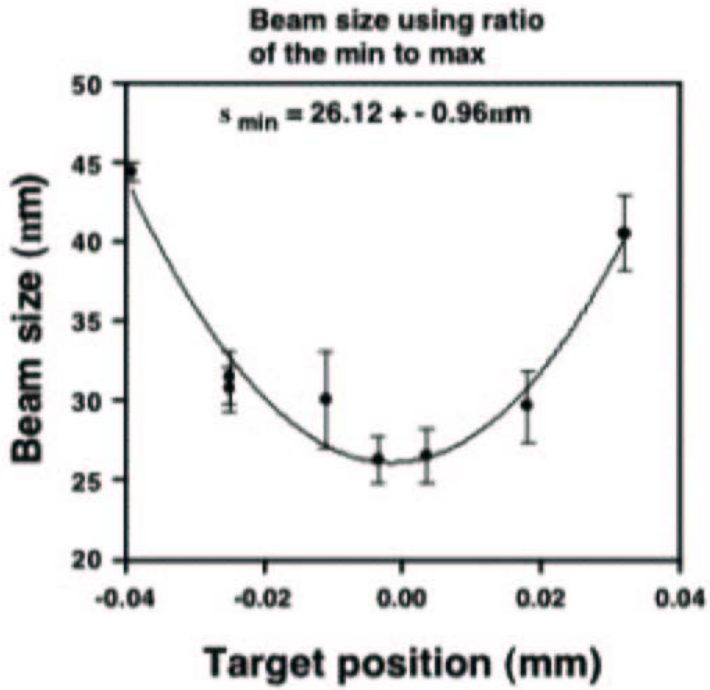


Beam size with 550nm filter



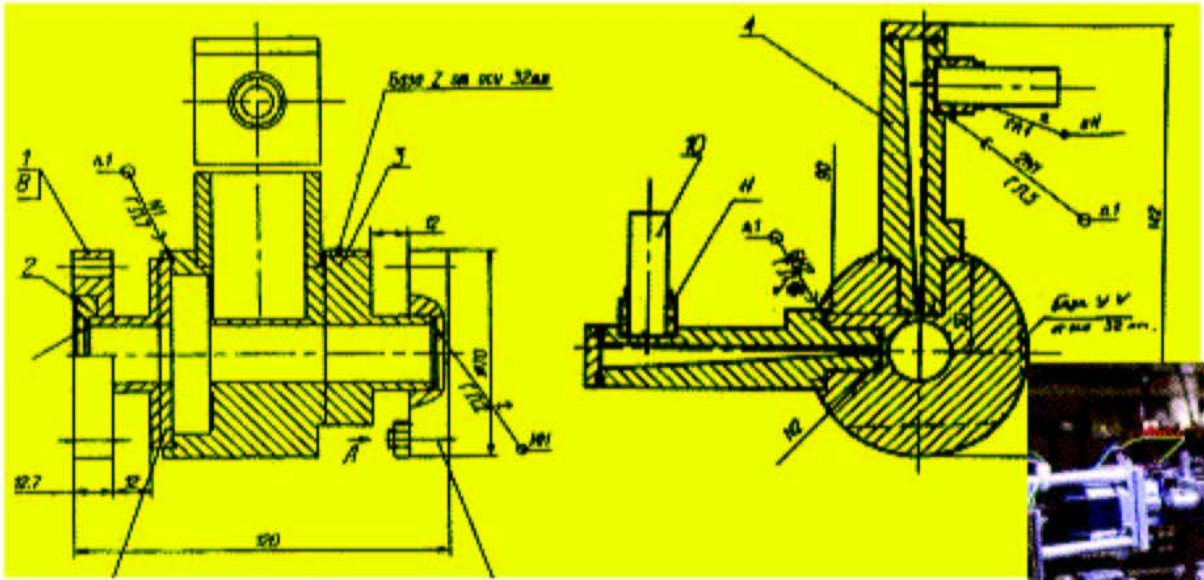




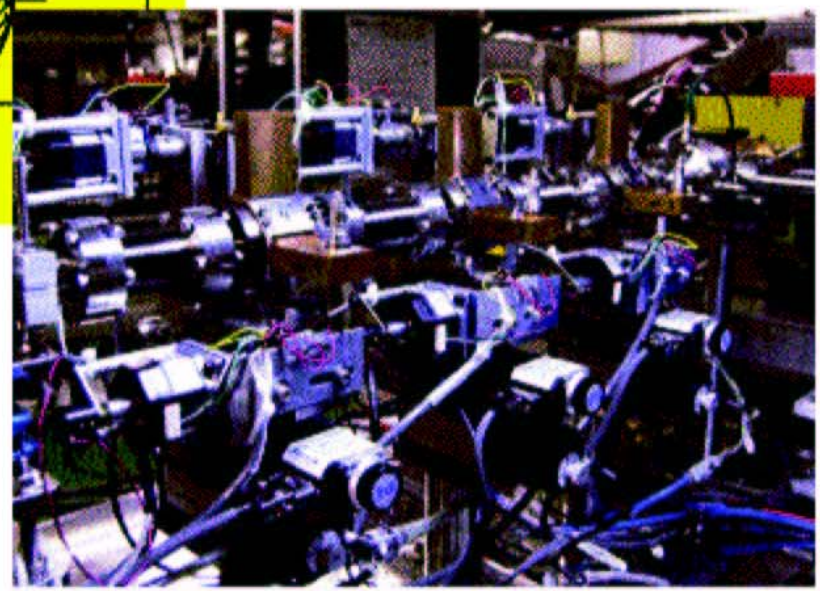


BINP-SLAC-LLNL-KEK collaboration on nanometre BPM; thermal noise level 1 nm, measures position and angle

3 BPM setup for nm resolution study



June 2003



f = 6.426GHz

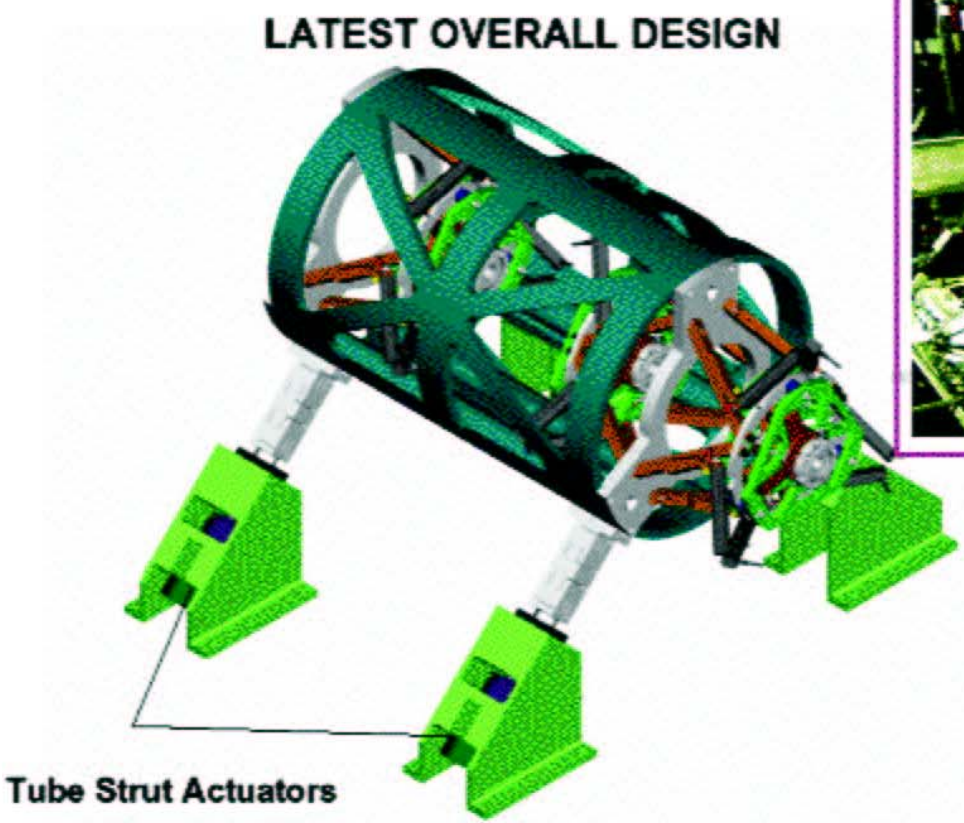
TM110 mode, single port coupling

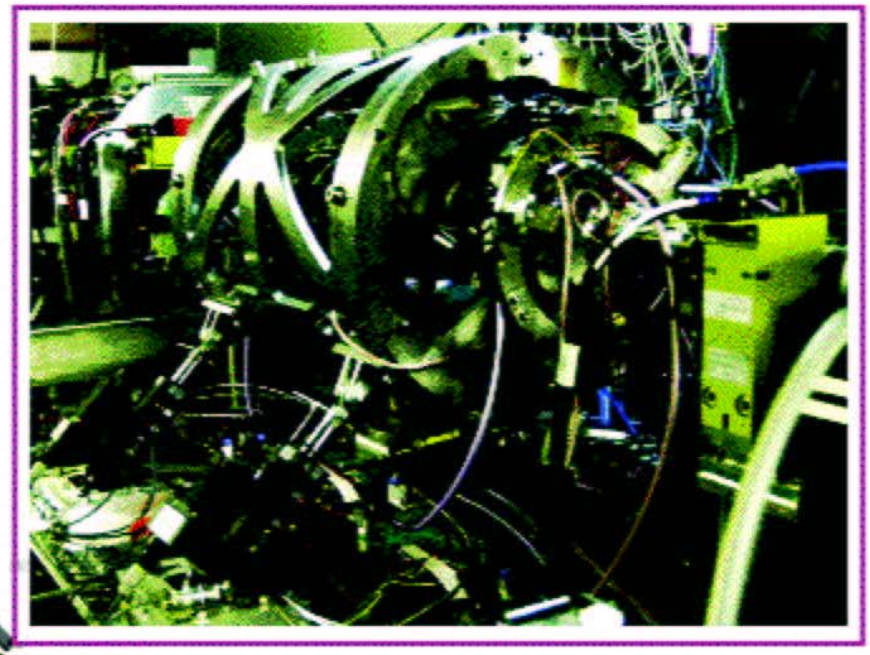
Highest resolution 91 nm

Mover stage step 0.25μm(X) 0.37μm(Y)

With cavity tilt-mover

New precise Mover for nm resolution study

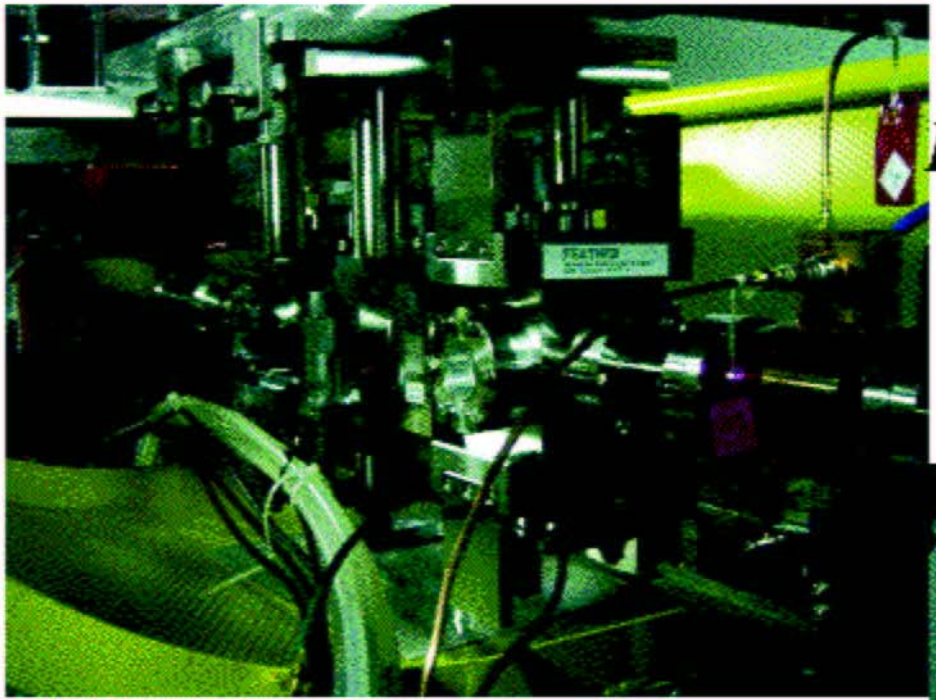




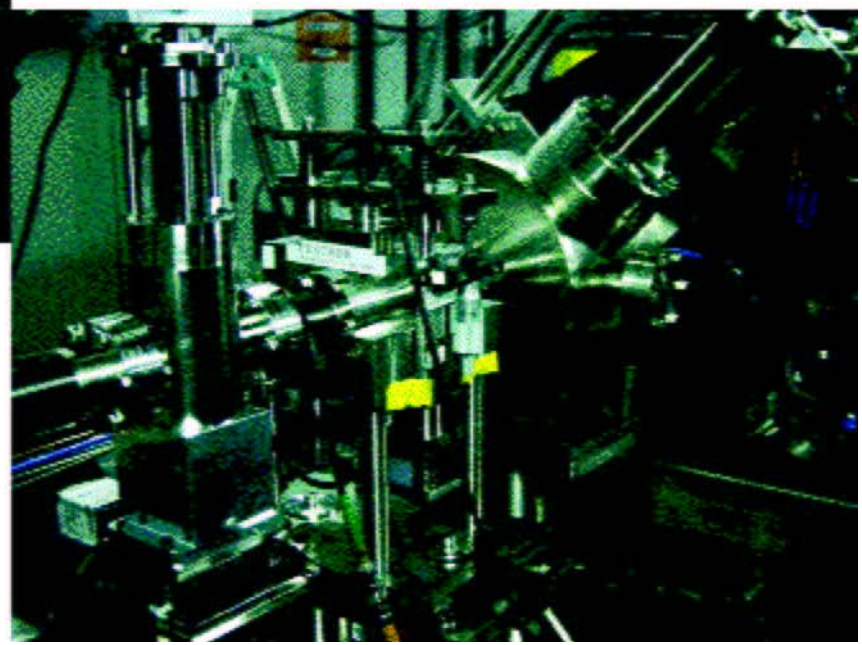
LLNL Design mover, Improved electronics, installed Mar. 2004

21

New precise kicker & BPM for nm position feedback control study



FEATHER stripline Kicker



FEATHER BPM

X-ray SR monitor

real time measurement <20 ms

avoids diffraction limit

FZP as lens on CCD

Measured 6.5-7 micron

Expected 5 micron

Why? magnification (checked!), vibration, alignment

ODR monitor

first observation of ODR from slit target

SR suppressed by mask

20 micron sensitivity achieved

measured beam size too large

both ODR & XSR give 20% larger σ than laser wire

outstanding questions

- **multibunch emittance increases about 2x faster with intensity than single bunch emittance**

- **gas pressure effect not consistent with Tor's prediction (sensitivity to vacuum much higher than expected, direct correlation)**

- **performance with wigglers (planned)**

- **e-cloud coating tests in the ATF (M. Ross' proposal) what should be measured?**

ATF Plans for 2004

20 weeks operation JFY 2004 and 2005

April-June: high current multibunch

MB emittance study: vacuum scrubbing, high current,
x/y emittance by laser wire, longitudinal oscillations

nm resolution BPM test: new mover & new cavity electronics
compare with nm BPMs from KEK

fast feedback test & demonstration: basic test BPM &
kicker first, test for 1-3 train extraction, FEATHER -> FONT

instrumentation developments
ODR, laser wire, X-ray monitor, fast sweep laser (UK)

October-December: performance of wiggler magnets

From 2005: “ATF R&D 2nd phase”

unique studies as determined by GDO

Meeting Plans (J. Urakawa)

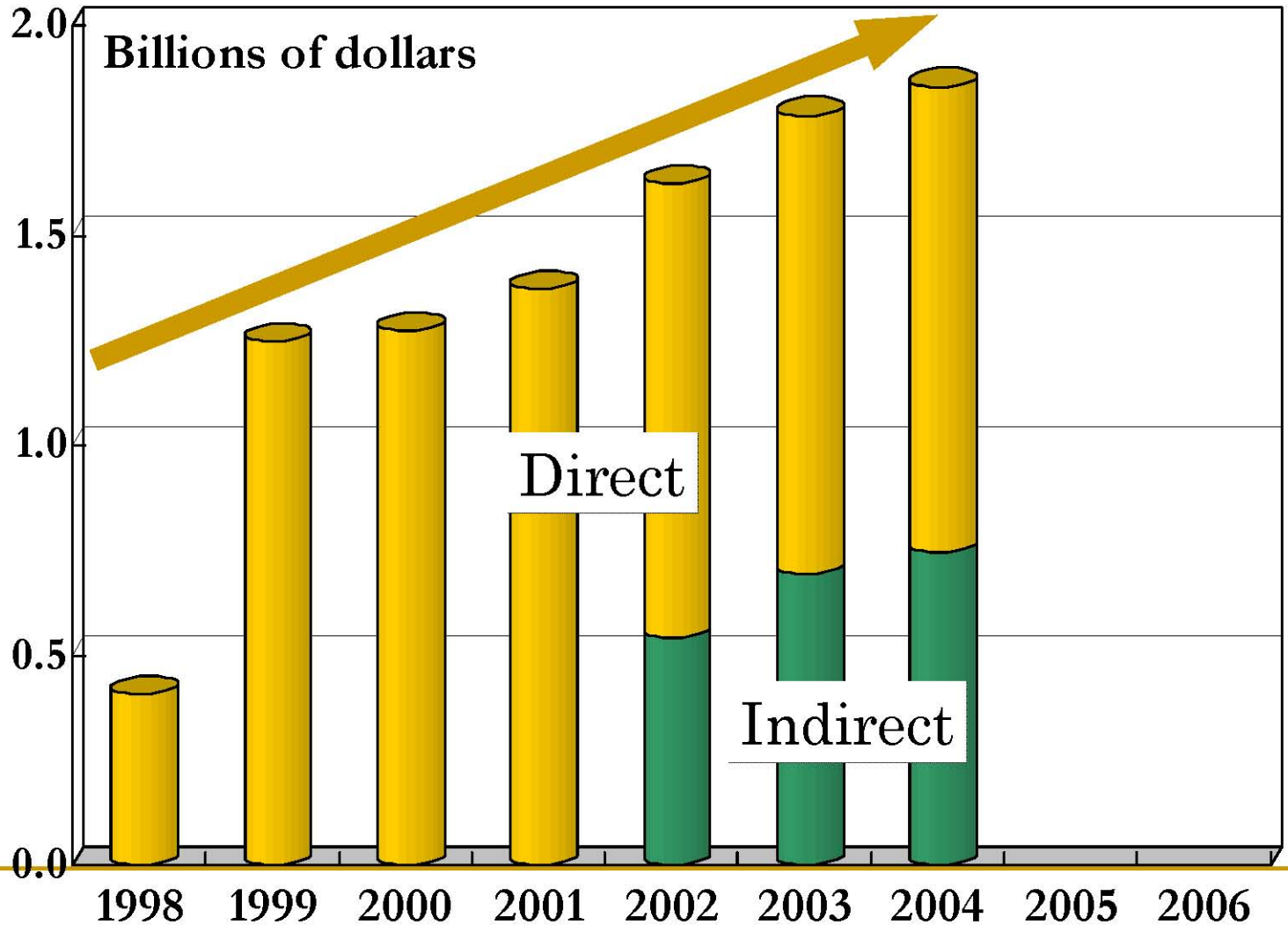
9th ATF International Collaboration meeting is final meeting for ATF. Because we already started/planned second phase of ATF R&D which consists of Nano-BPM, FONT, Laser-wire in linac/BDS, GLCTA and so on. Beam Physics Seminar will continue until 2009. Also, we already organize Laser-wire mini-workshop and Nano-BPM and Feedback mini-workshop per year.
I asked 5th beam physics seminar in Beijing around October to JSPS. Also, we are considering joint workshop on Nano-BPM and Laser-wire in July.

JSPS and Core University Programme

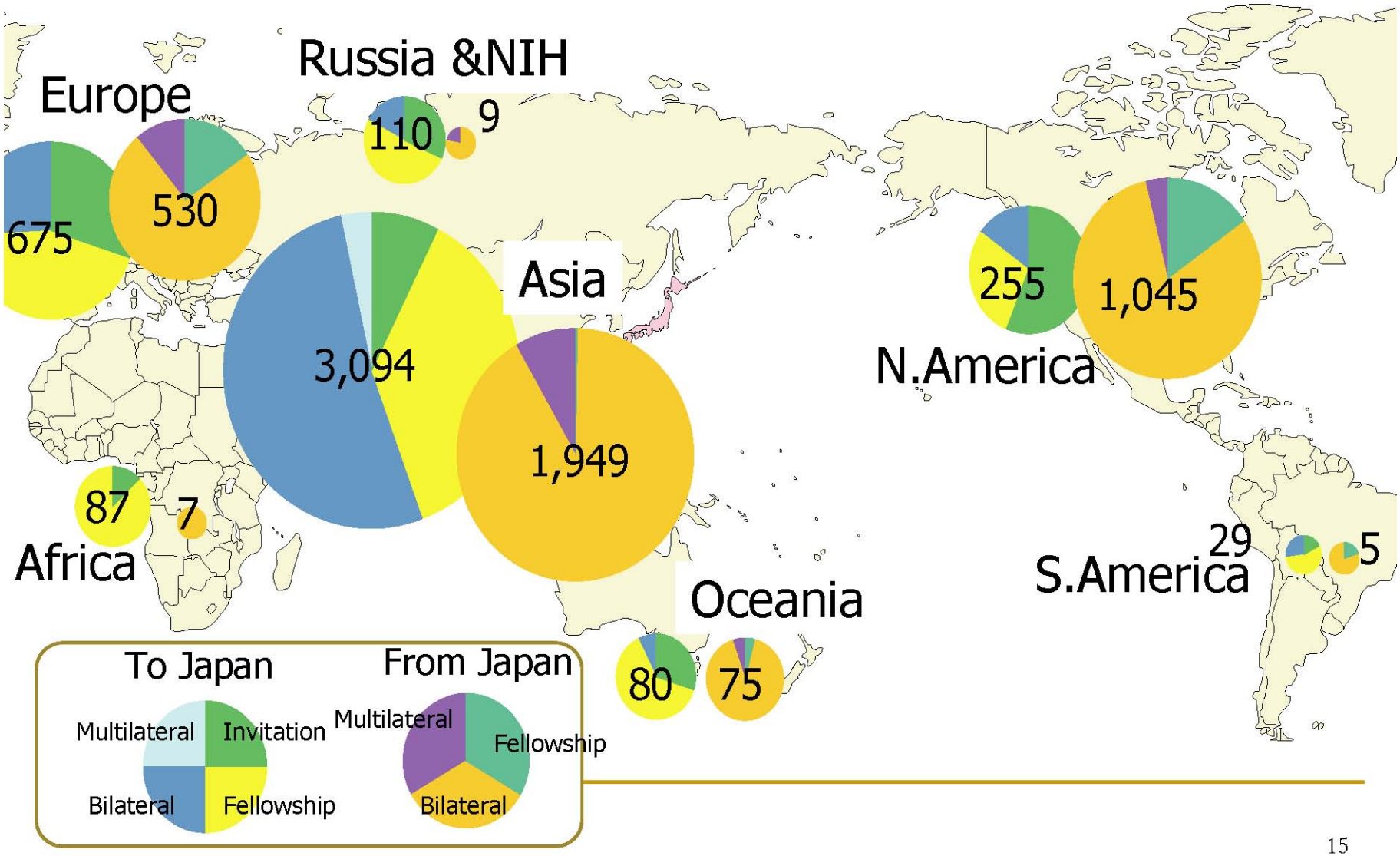
Kamogawa, 20 March 2004

Tsuyoshi ENOMOTO
Asian Programme Div. & Overseas Fellowship Div.
JSPS
enomoto@jsps.go.jp

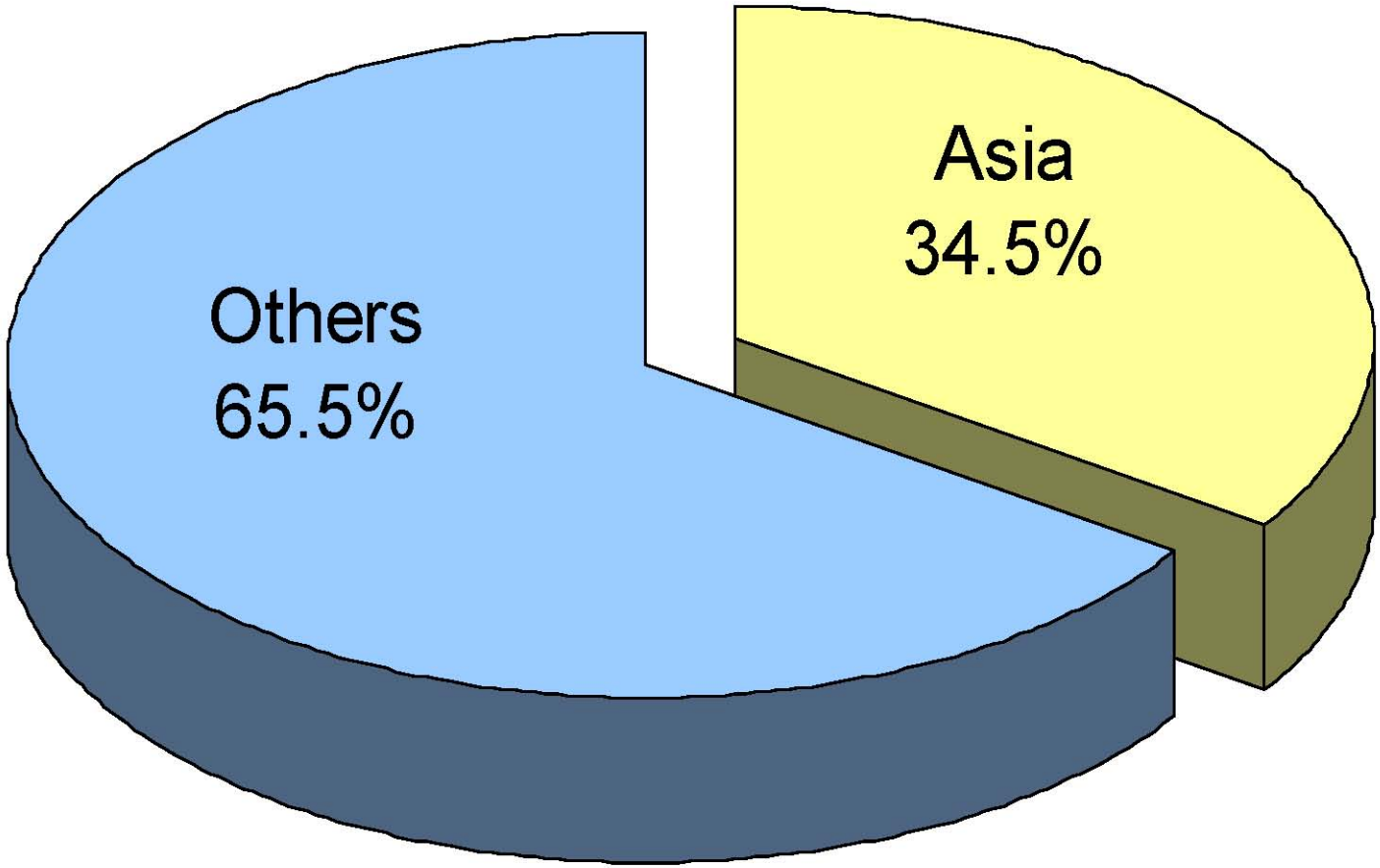
JSPS Budget 1998-2006



No. of scientists exchanged in 2002



Why Asia? -Researcher Population-



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朴房

Marc Ross

Future Plans for ATF Instrumentation

- Measurement of emittance – verification that ATF meets Linear Collider performance requirements
- Operation of ATF for instrumentation and beam physics RD during LC development

20.03.2004

Joint Workshop Beam Physics & ATF International Collaboration

鳥川ユニバースホテル

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ATF and the ITRP

- International Technology Review Panel (ITRP) will recommend (decide) the LC technology in 2004
- Demonstrated performance Warm(NLC/GLC)/Cold (T) successfully at design values
- Cold DR has not been demonstrated
  - an acknowledged risk
- Warm DR has been demonstrated
  - ATF Single bunch
  - Multi-bunch almost demonstrated
  - If the multi-bunch is demonstrated soon, this result will affect the decision

頑張りが利く

ATF and the ITRP

- Measurement of goal single bunch parameters show that alignment, tuning and diagnostic requirements have been met.
  - confident that multi-bunch performance can be met- *technology demonstration*
- What needs to be done for multi-bunch tests?
  - coherent instabilities → multi-bunch feedback
  - vacuum → contribution of individual sources
  - instrumentation (back up for laserwire…)→
    - XSR
    - extraction line

Digital BPM's for ATF

- Uses waveform digitization and fast signal processing
- Stretch the fast, bipolar signal into a short 'tone' burst
  - Match:
    1. the ring clock,
    2. the sampling rate of the electronics and
    3. the frequency content of the bunch
- Fermilab:
  - 53 MHz bunch frequency content
  - 8/7 ring clock used for sampling rate

鳥川ユニバースホテル

朴房

Fermilab Damping Ring Meeting (last week)

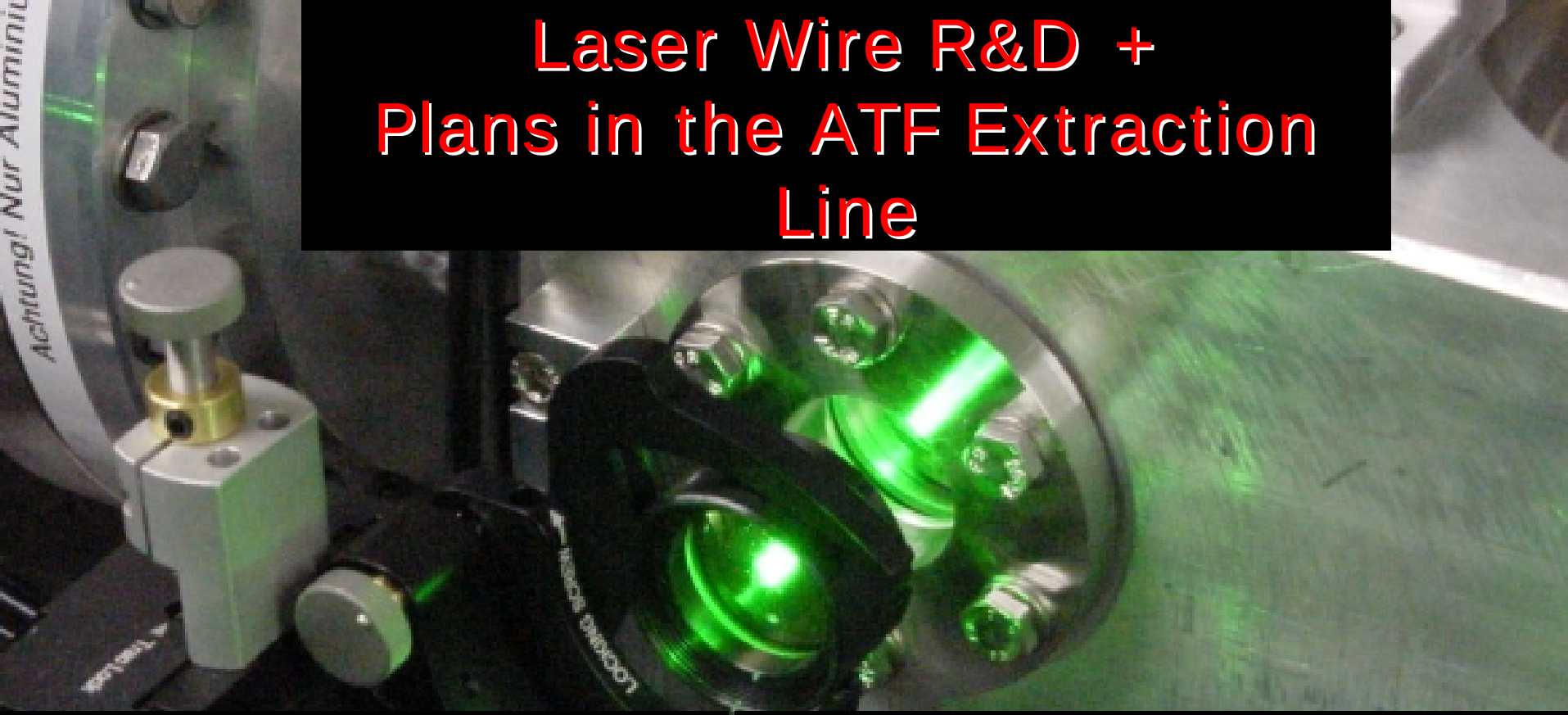
- I. Kickers
  - A. Two-ring scheme (Joe Rogers)
  - B. Fourier series kicker (George Gollin)
  - C. RF kicker with dispersive section (this is Dave Rubin's idea)

II. Lattice dynamics
- A. Operating point (Nick Solyak & George)
  1. tune
  2. chromatic effects
- B. Dynamic aperture
  1. multiples (Shekhar & George)
  2. sextupoles (Francois)
  3. wigglers (Francois, Shekhar, Aimin, George)
- C. Higher order correction schemes

III. Instabilities (Bill Ng, Dave Neuffer, Joe Rogers)
- A. Electron cloud
- B. Space charge
- C. Coupled bunch instabilities

IV. Infrastructure setup: have MAD installed on various FNAL fast computers

Laser Wire R&D + Plans in the ATF Extraction Line



Laser-wire at PETRA

- Environment at PETRA
- Installation of Hardware
- First measurements

UK R&D Plans

Extraction Line

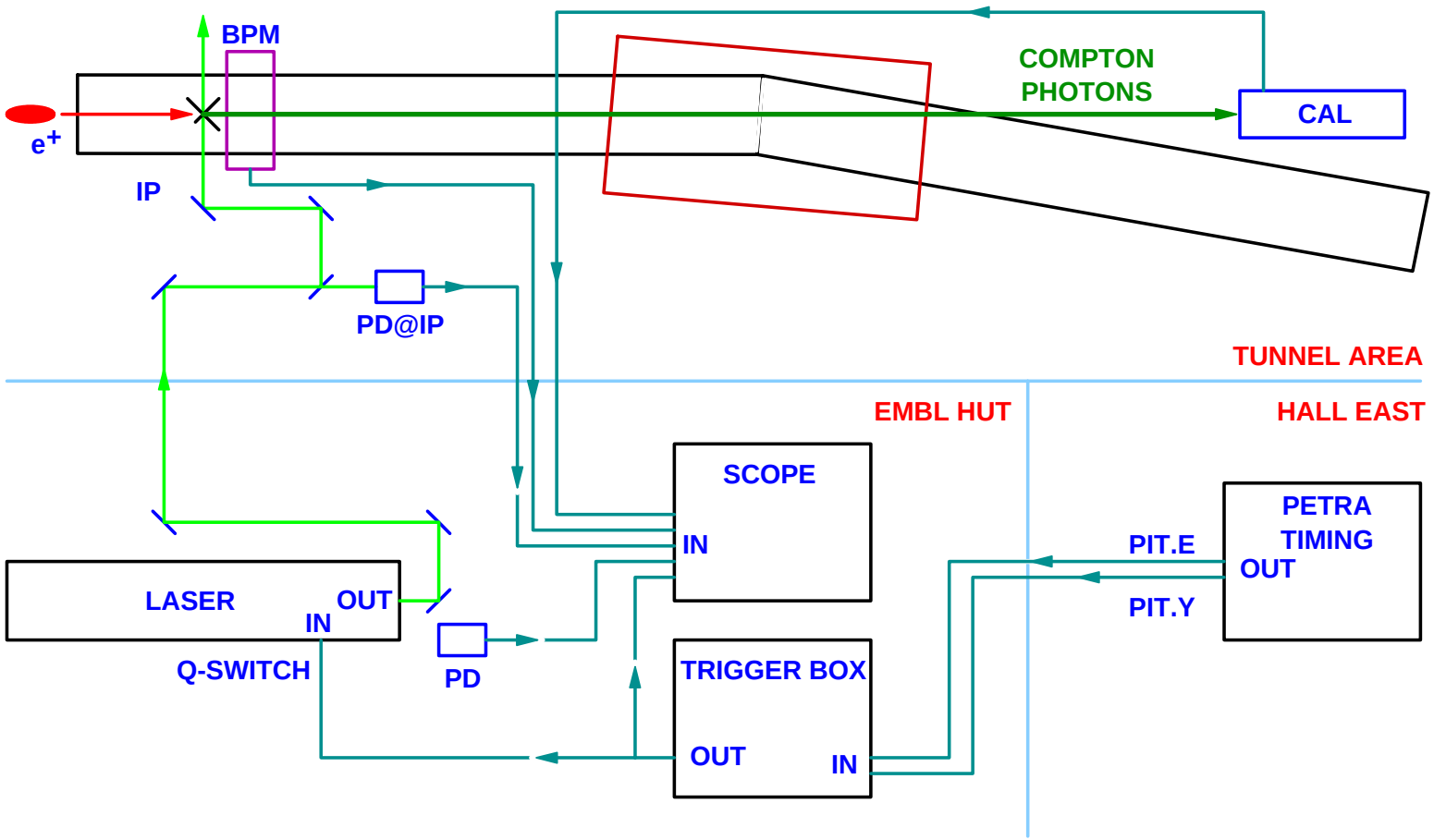
Conclusions and Outlook

G. A. Blair
Royal Holloway Univ. London

Joint Workshop for
4th Beam Physics Seminar and
9th ATF International Collaboration Meeting
20th March 2004

this and the following slides from G. Blair!

Setup at PETRA

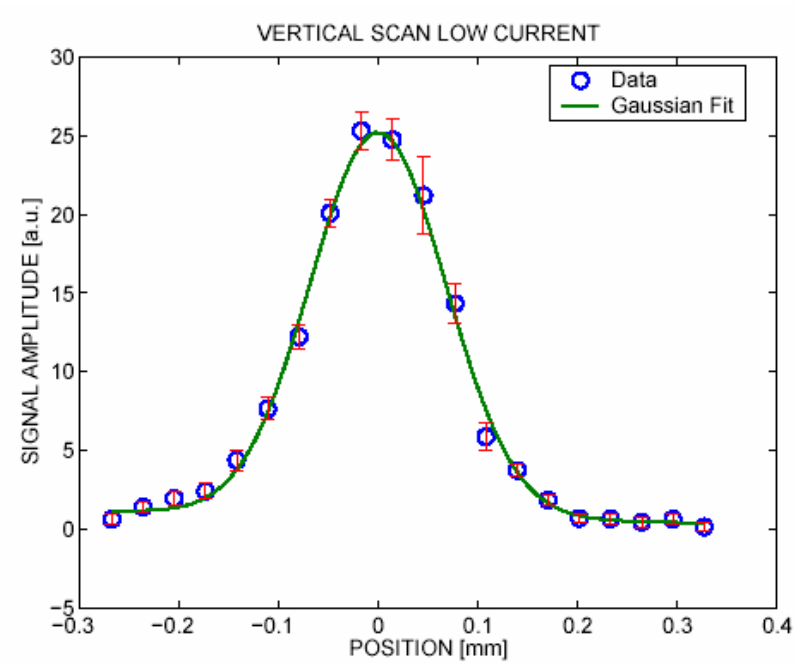


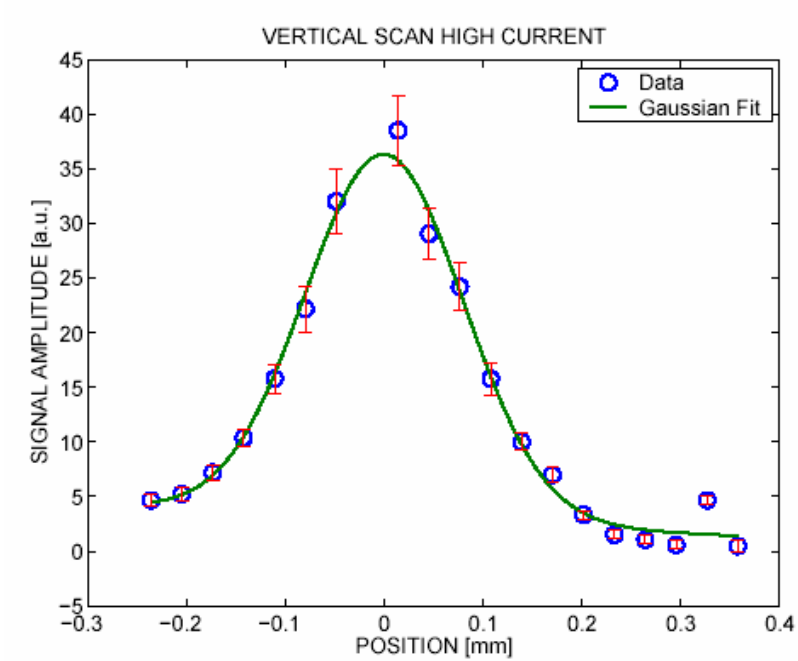
Results 04.12.03 Data

Gaussian approximation of beam shape

σ_m =(68 ± 3 ± 20) µm at low current

σ_m =(80 ± 6 ± 20) µm at high current





Next steps

Laserwire at PETRA produced first compton photons and measure vertical beam size Next steps:

- Full characterisation of laser: beam size, divergence, and power (stability) with slot scans and imaging techniques
- Update all readout software, merge BPM and PMT software
- Do more systematic scans with the fast scanner
- Go to smaller spot sizes and reduce errors
- Build second dimension (x) scanner.

- **Start designing a complete laser-wire emittance measurement system for the LC BDS.**
- **Look to ATF for micron-scale laserwire system**

UK funding for accelerator science for particle physics 2004 - 2007

UK funding agency, PPARC, secured from Govt. £11M for 'accelerator science' for particle physics, spend period April 04 – March 07

Called for bids from universities and national labs; large consortia were explicitly encouraged

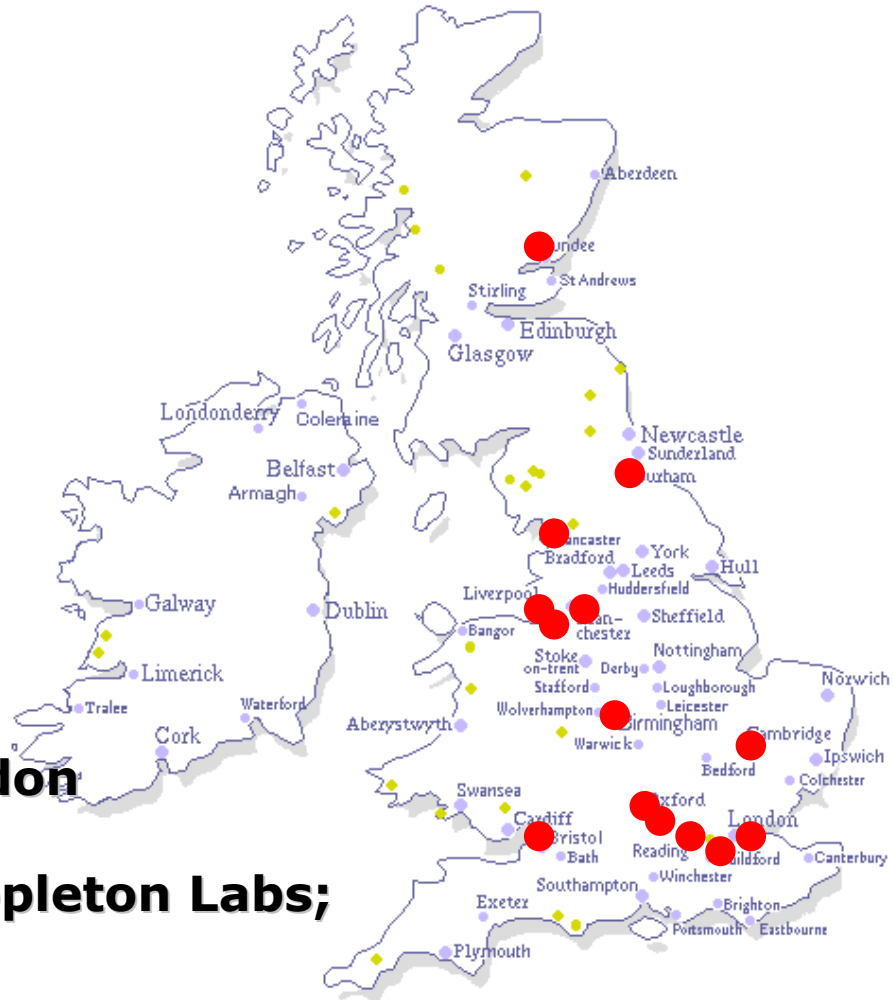
Bids peer-reviewed and preliminary new allocations made Oct 21 2003:

Funding (http://www.pparc.ac.uk/Nw/accelerators.asp):

- LC-Beam Delivery £9.1M
- UKNF £1.9M
- 2 university-based accelerator institutes:
  - Oxford/RHUL
    - Cockroft: Liverpool, Manchester, Lancaster, NW dev. agency

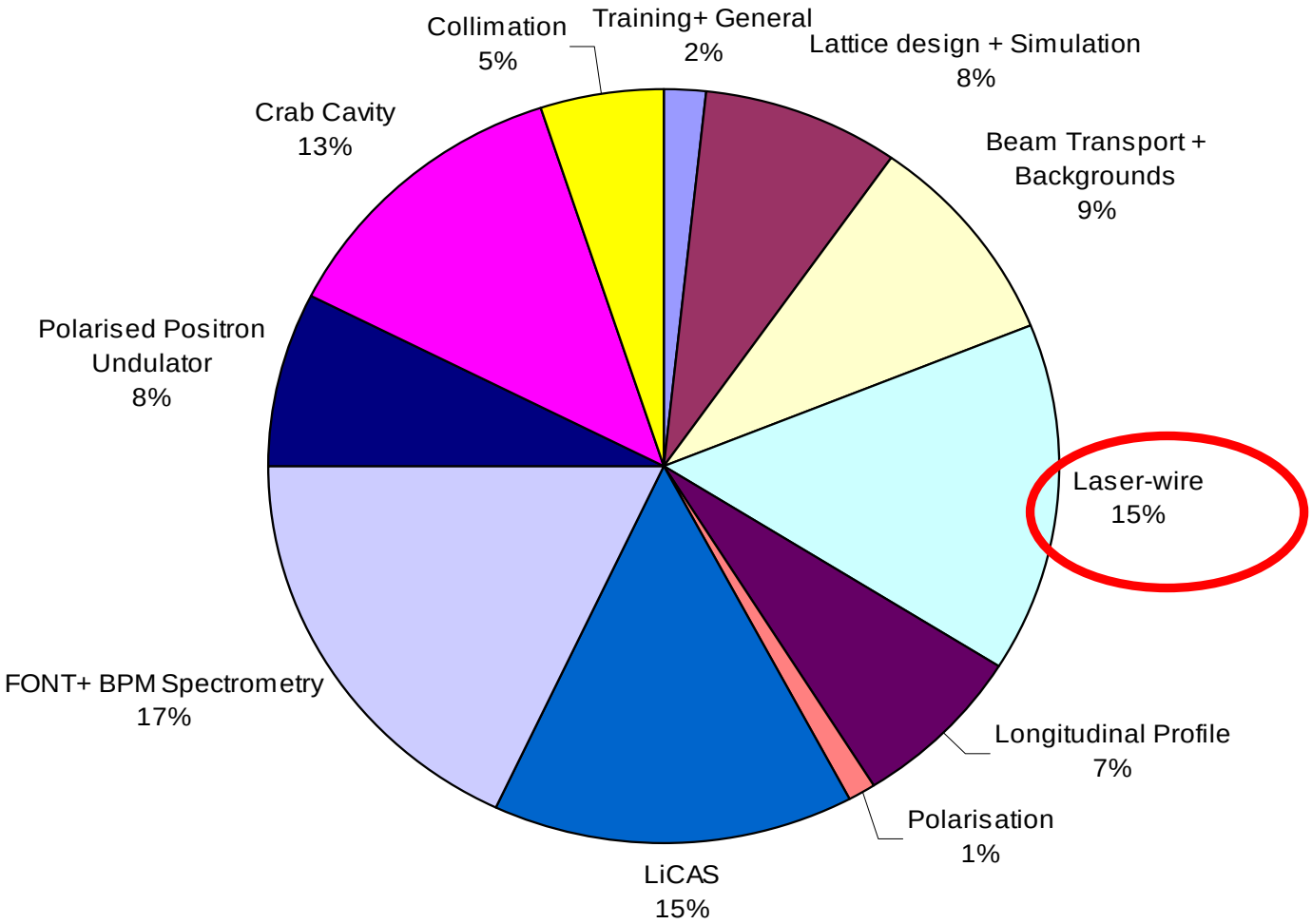
LC-ABD Collaboration

- **Abertay**
- **Bristol**
- **Birmingham**
- **Cambridge**
- **Durham**
- **Lancaster**
- **Liverpool**
- **Manchester**
- **Oxford**
- **Queen Mary, Univ. London**
- **Royal Holloway, Univ. Of London**
- **University College, London**
- **Daresbury and Rutherford-Appleton Labs;**



41 post-doctoral physicists (faculty, staff, research associates) + technical staff + graduate students

Overview of LC Projects



Essentially independent of Linac-technology

International ATF Laser-wire Project

Extraction line: **sigma_y ~ 5 μm, intra-train fast scanning**

Clear additional technical challenges to PETRA experiment

UK funding introduces the possibility to collaborate on an **international ATF laser-wire**

SLAC expertise will bolster the project

Very constructive discussions this week

We will explore the technical details and start preliminary designs

Exciting opportunity to establish a nucleus within a future GDO.

Looking forward to making this happen.
Thank you to our ATF hosts.

THE ROYAL SOCIETY

鳥川ユニバースホテル

外房

KEK ATF – report to EuroTeV meeting by Marc Ross

- International collaboration with MoU etc
  - (DESY/CERN included – however minimally involved in last 5yrs)
- Operations funding entirely from KEK
  - ~ 3M$/year
  - ongoing involvement SLAC/LBNL (~200K/year including labor)
  - SLAC workers visit in teams, for a few weeks at a time
    - like a user-facility

- KEK management welcomes Luminosity – related RD and *will support* beam tests at ATF
- We (SLAC/LBNL/KEK) strongly encourage testing at ATF
  - UK funded work in 2004/05:
    - FONT (QMUL/Oxford)
    - Laserwire (RHUL/Bessy)

20.03.2004

Joint Workshop Beam Physics & ATF International Collaboration

other topics:

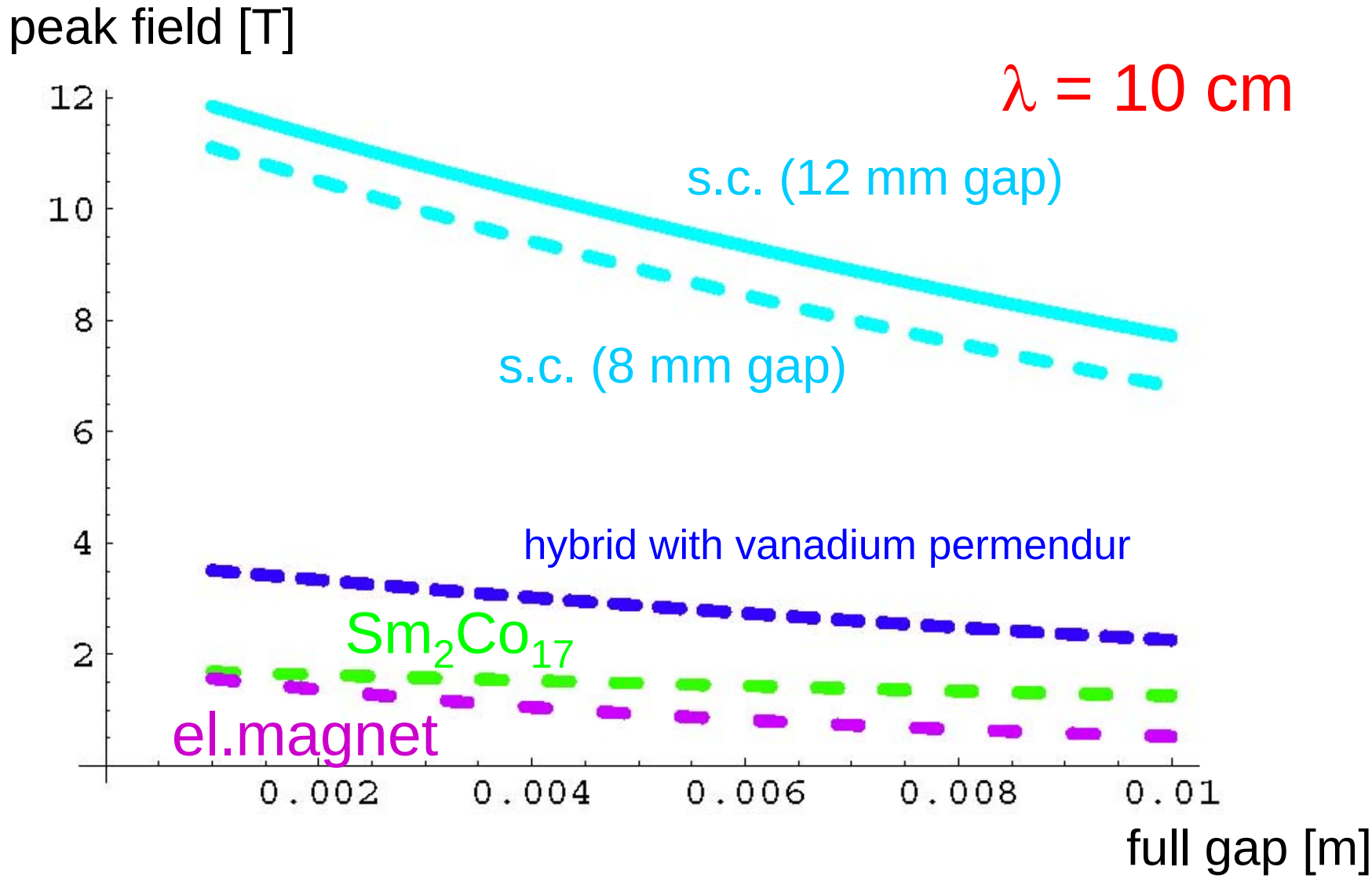
- highlights from APAC’04
- wiggler for CLIC DR
- electron cloud in LCs (ECLOUD’04 etc.)

APAC'04 Highlights:

- many participants from Asia & Russia (unlike in US!)
- push to build LC in Asia/Japan; endorsed by ACFA
- T. Shintake: 6-GeV SASE FEL at SPring-8, novel gun design achieves 1 micron emittance in both planes
- BEPC & Shanghai Light Source approved
- BEPC e-cloud study: octupoles, solenoids, BPM bias, all reduce vertical blow up
- CSR calculations by Yokoya and Angoh
- Compact SASE FEL at PAL (3rd largest e- linac) by 2008
- V. Parkhomchuk: beam-beam, e-cloud and heating, longitudinal effect of e-cloud plasma waves?
- KEKB will install 1st crab cavity in 2005, new target luminosity is 3e34 in 2006
- W. Chou: proton driver for superneutrino beam (high flux, long baseline), FNAL-Beijing – 9400 km under study
- K. Yokoya: ERL project at KEK

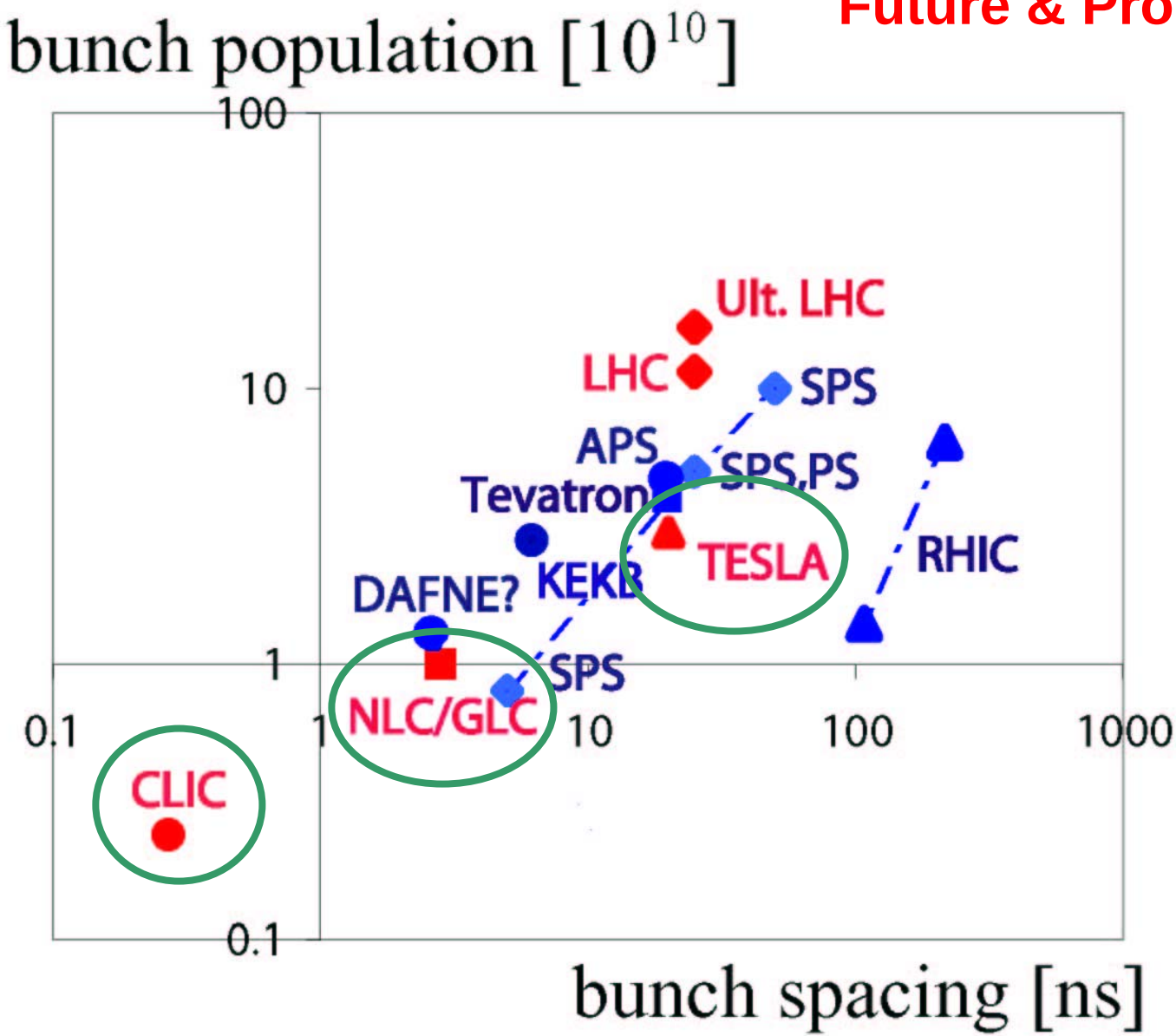
which wiggler for CLIC DR?

P. Elleaume et al., NIM A 455, 503 (2000)



Observed Electron Cloud Threshold vs. Bunch Spacing

Future & Proposed Machines



SPS, PS, Tevatron, APS thresholds are all similar

DAFNE and KEKB look better, RHIC worse

extrapolation to shorter spacings?

DR e-cloud simulations and estimates at ECLOUD04

http://icfa-ecloud04.web.cern.ch/icfa-ecloud04/agenda.html

- M. Pivi (SLAC) for NLC & TESLA

  >> disaster for TESLA, NLC 30% above threshold
- K. Ohmi (KEK) for JLC/GLC

  >> threshold ~10^{12} m^{-3} but scaling is broken
- A. Ghalam (USC) for TESLA

  >> disaster for TESLA
- R. Wanzenberg (DESY) & F. Zimmermann (CERN) for TESLA & CLIC

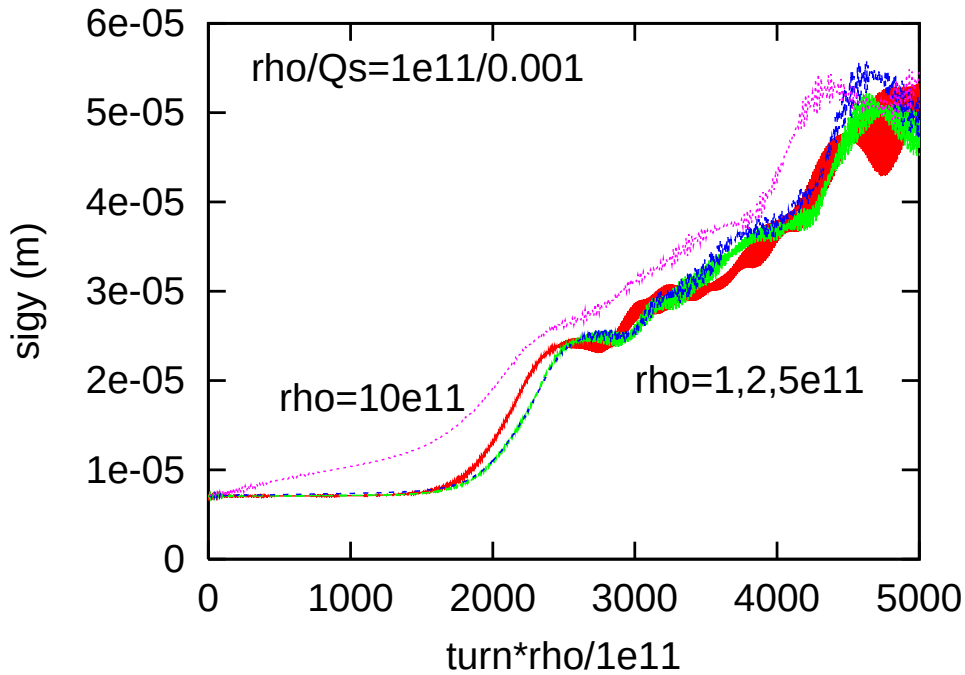
  >> pessimistic? BBR model suggests TESLA a factor 2 below threshold, CLIC near threshold

huge controversy

Scaling of ν_s and cloud density

- In the theory of the strong head-tail instability, the instability should be scaled by the ratio of the wake strength (cloud density) and the synchrotron tune.

K. Ohmi



e^- cloud effects in single-pass system (LC beam delivery)

- e- can build up along bunch train and reach densities up to 10^{14} m^{-3}
- blow up of IP spot size for densities above threshold of 10^{11} m^{-3}
- two effects: breakdown of –I in CCS and direct focusing effect at IP

$$\Delta\nu \approx \frac{r_e \rho_e \langle\beta\rangle C}{\gamma}$$

phase advance change

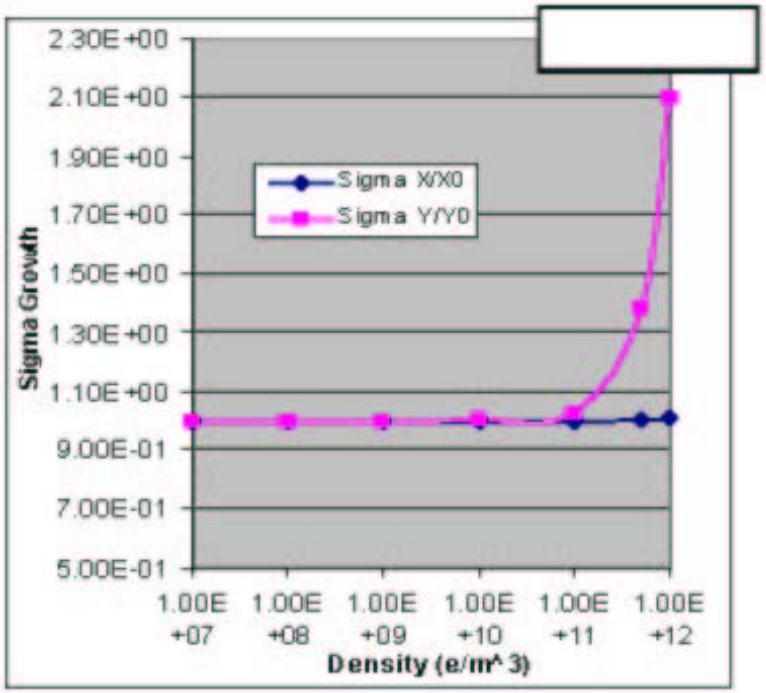
$$\frac{\Delta\sigma_y^*}{\sigma_y^*} \approx \frac{4\pi}{\gamma}\int_0^C \rho_e \beta_y \sin^2\left[\phi^* - \phi(s)\right] ds$$

direct focusing effect

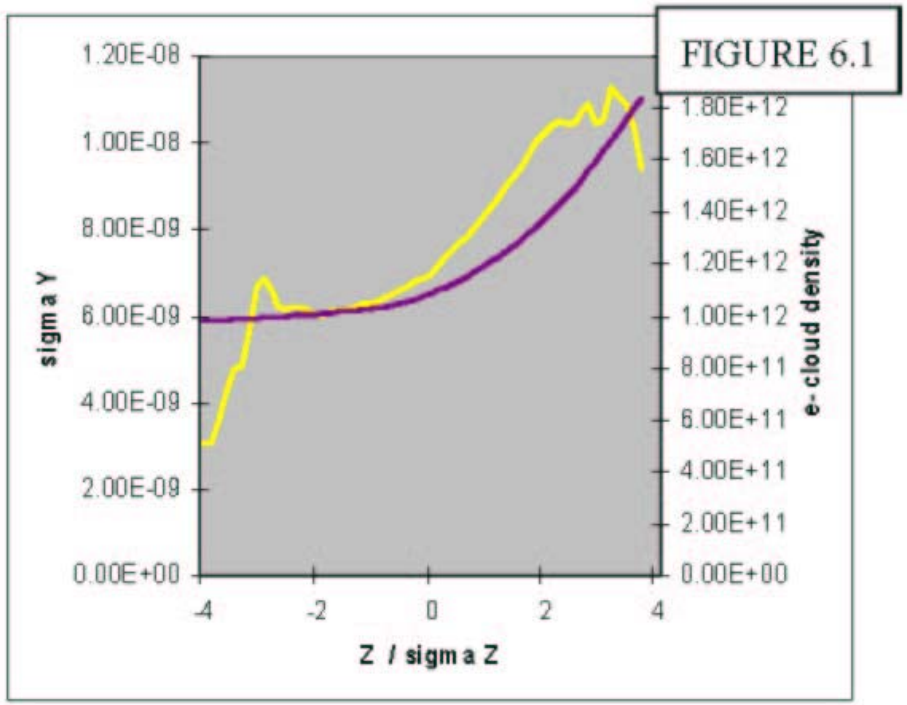
(D. Chen, et al., 2003)

e- cloud effect in NLC beam delivery

IP beam size vs electron density, revealing threshold at 10^{11} m^{-3}



IP beam size and central electron density 100 m upstream of IP, vs. position along the bunch

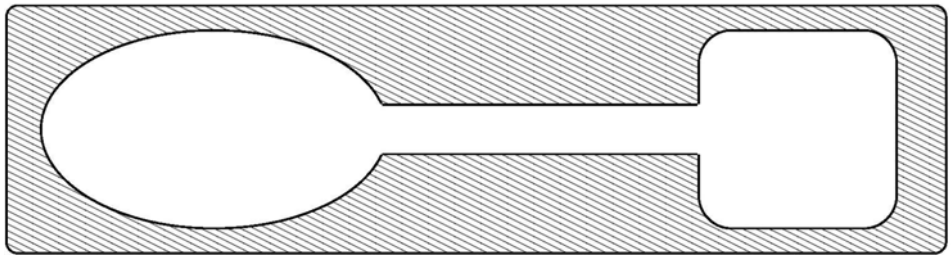


(D. Chen, A. Chang, M. Pivi, T. Raubenheimer, 2003)

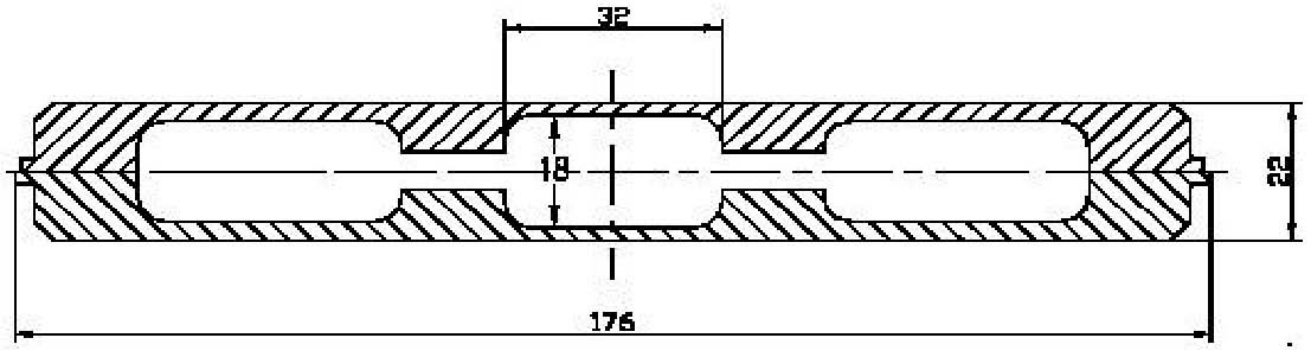
recent e-cloud studies for CLIC damping ring (design by Maxim Korostelev)

collaboration with R. Wanzenberg and D. Schulte

no design of CLIC DR vacuum system yet;
for the moment we assume vacuum chambers
similar to those of the TESLA DR



arc chamber
h_x=22 mm, h_y=18 mm
(half axes)

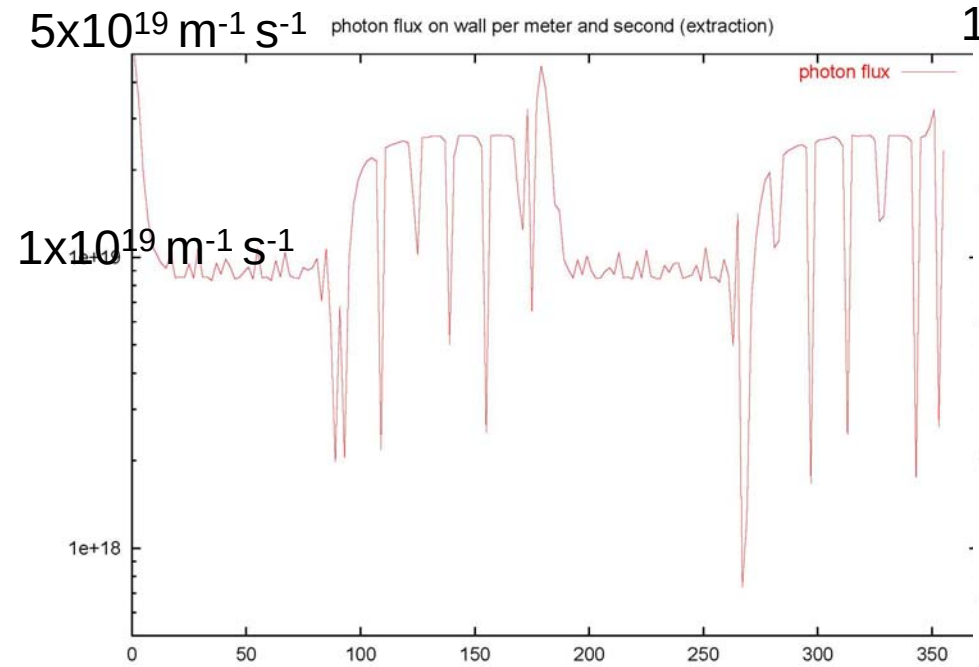


wiggler chamber
h_x=16 mm, h_y=9 mm (half axes)
half height of a.c. slot 3 mm

photon flux around the CLIC DR

without any antechamber

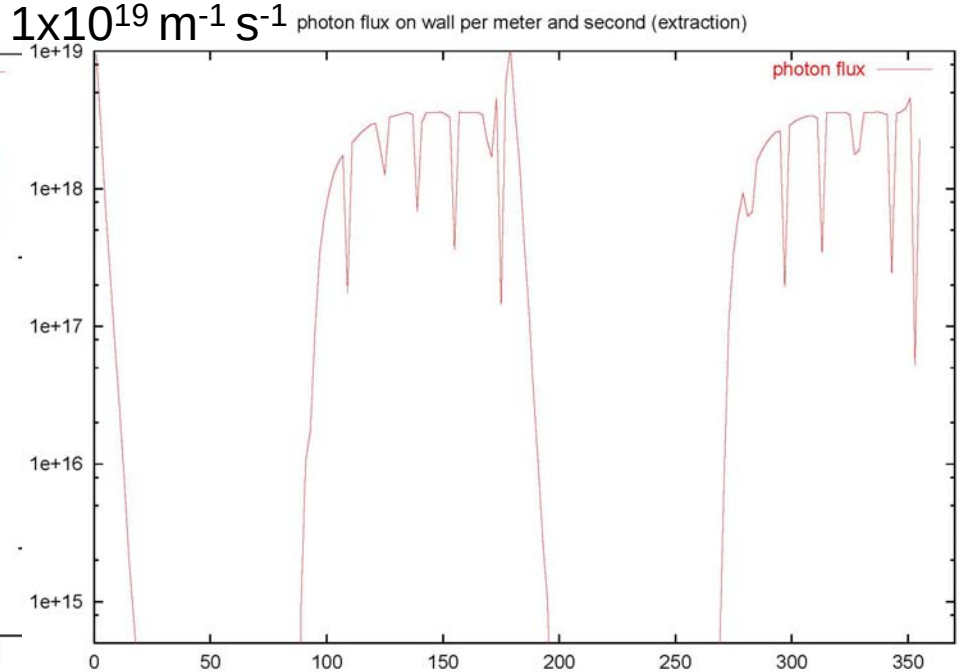
5×10^{19} m^{-1} s^{-1}



1×10^{19} m^{-1} s^{-1}

with continuous antechamber

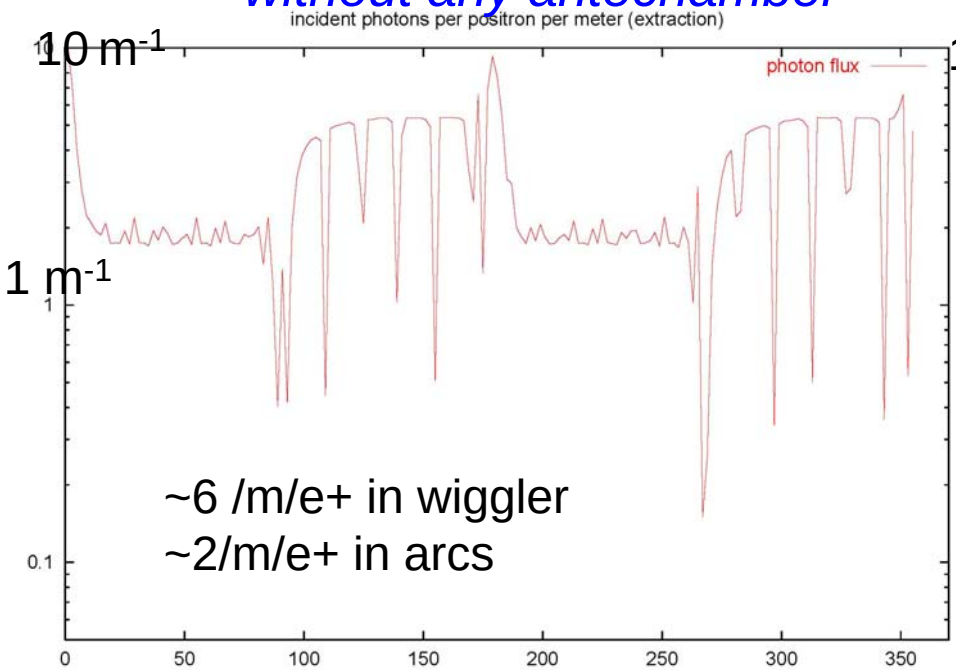
1×10^{19} m^{-1} s^{-1}



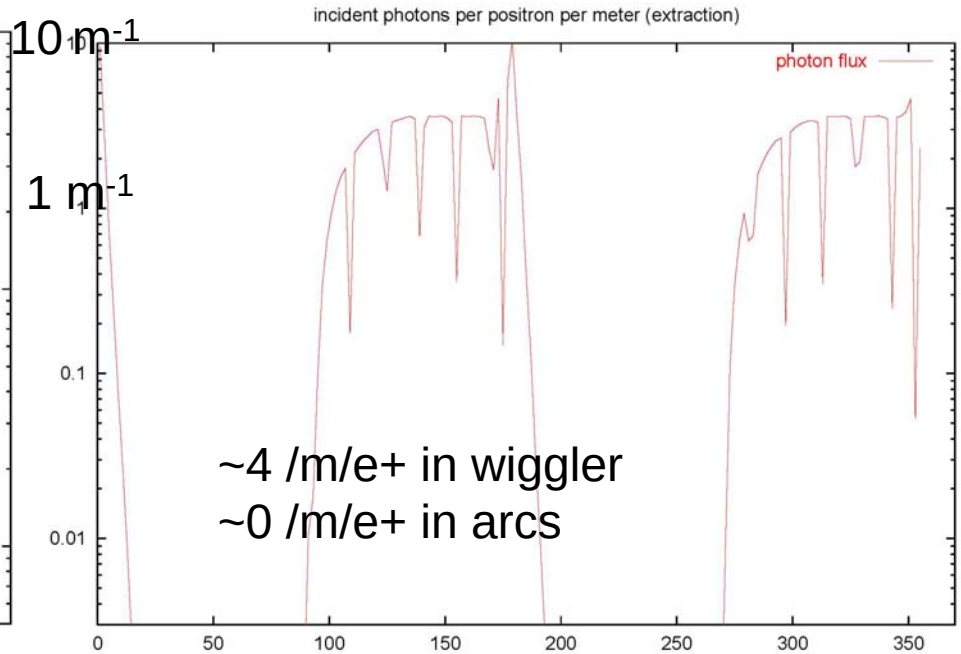
(simulated by PHOTON code)

photons per meter per e+ around CLIC DR

without any antechamber



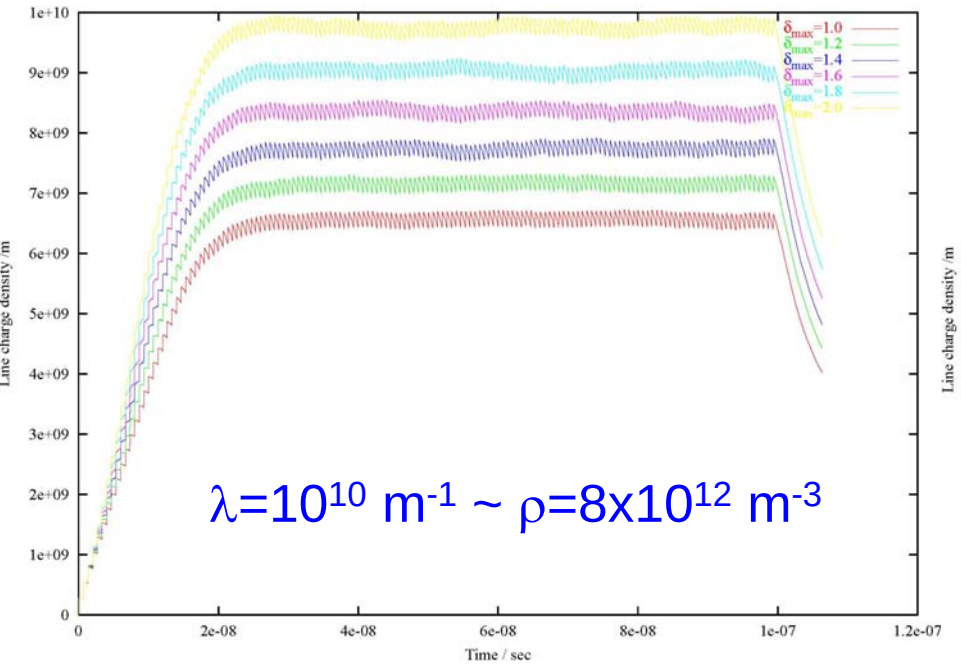
with continuous antechamber



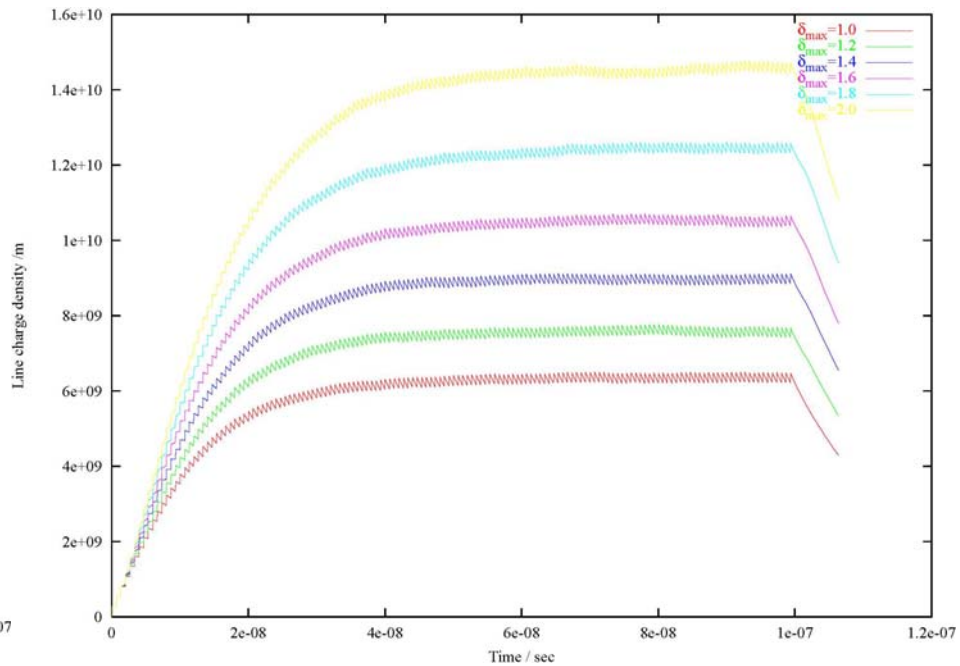
(simulated by PHOTON code)

e- build up in CLIC DR arcs

$1x10^{10}$ m^{-1} dipole field in arcs



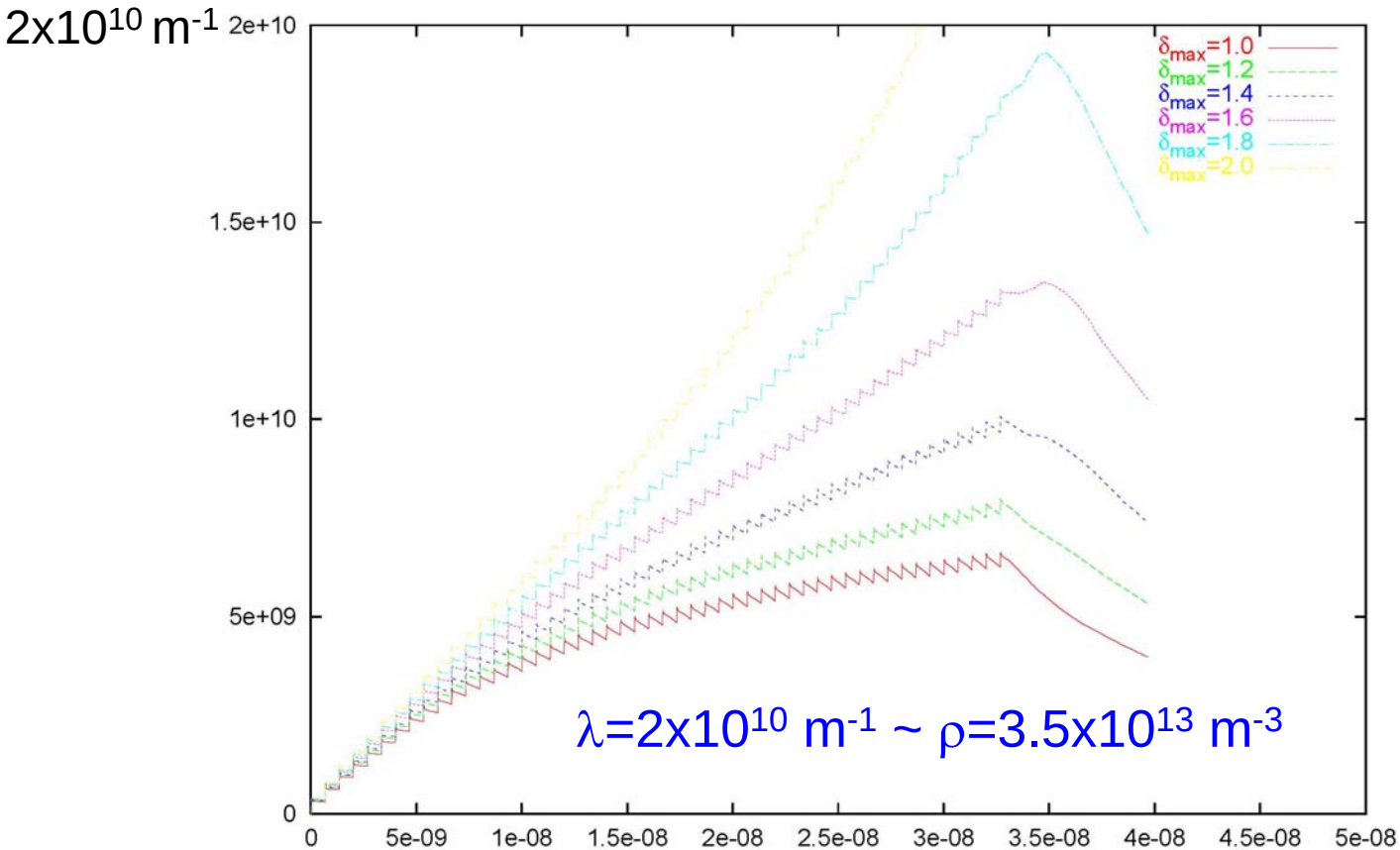
$1.6x10^{10}$ m^{-1} field-free region in arcs



(simulated by ECLOUD code)

assuming 0.06 e- /m/e+
(which relates to Yeff=0.01% w/o antechamber)
typical high density is reached, not very sensitive to δ_{max}

e- build up in CLIC DR wiggler

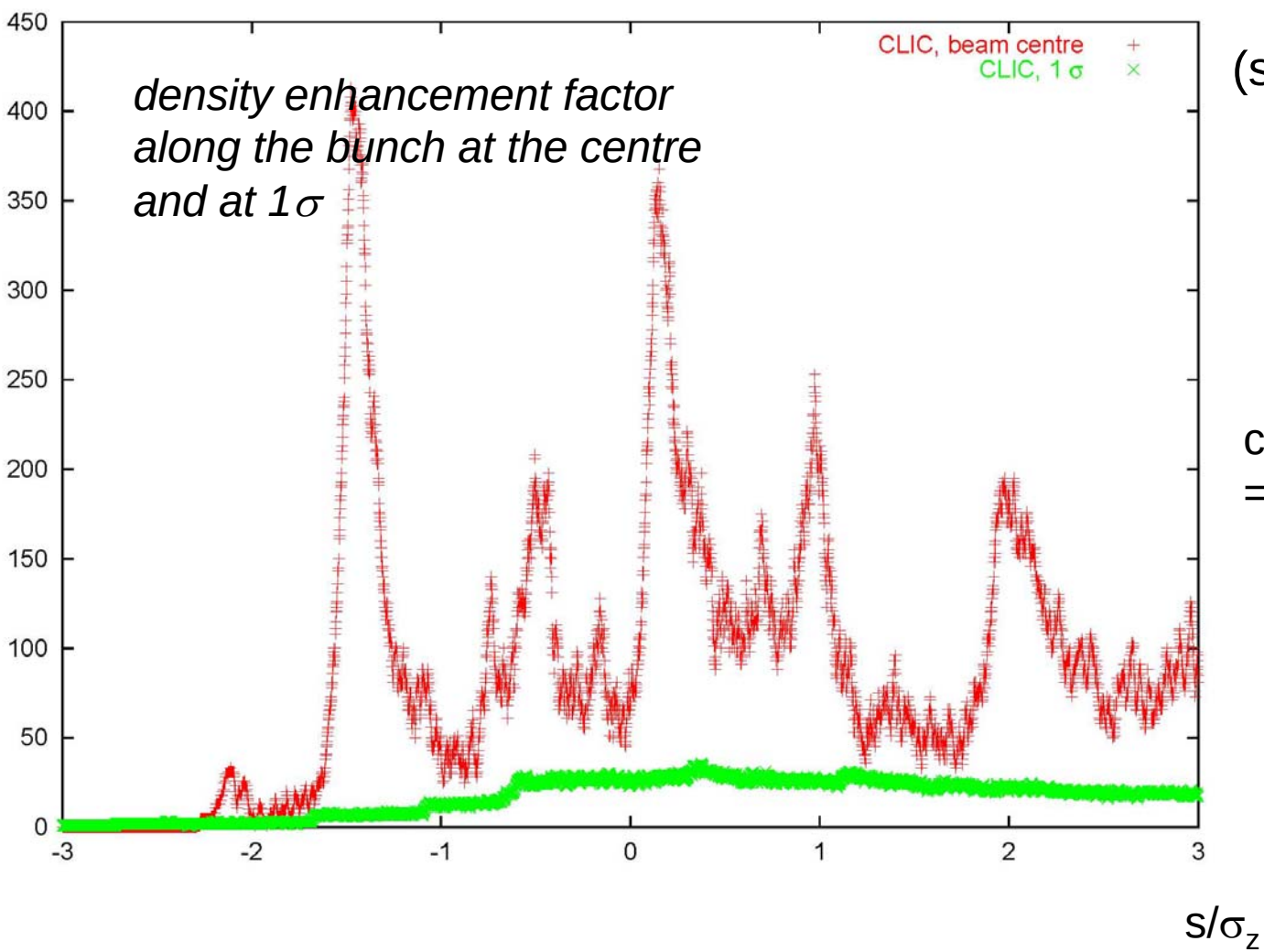


(simulated by ECLOUD code)

assuming 0.11 e- /m/e+
(which relates to Yeff=0.01% w/o antechamber)
1-2x higher density than arc, more sensitive to δ_{max}

e- pinch during bunch passage in CLIC wiggler

450

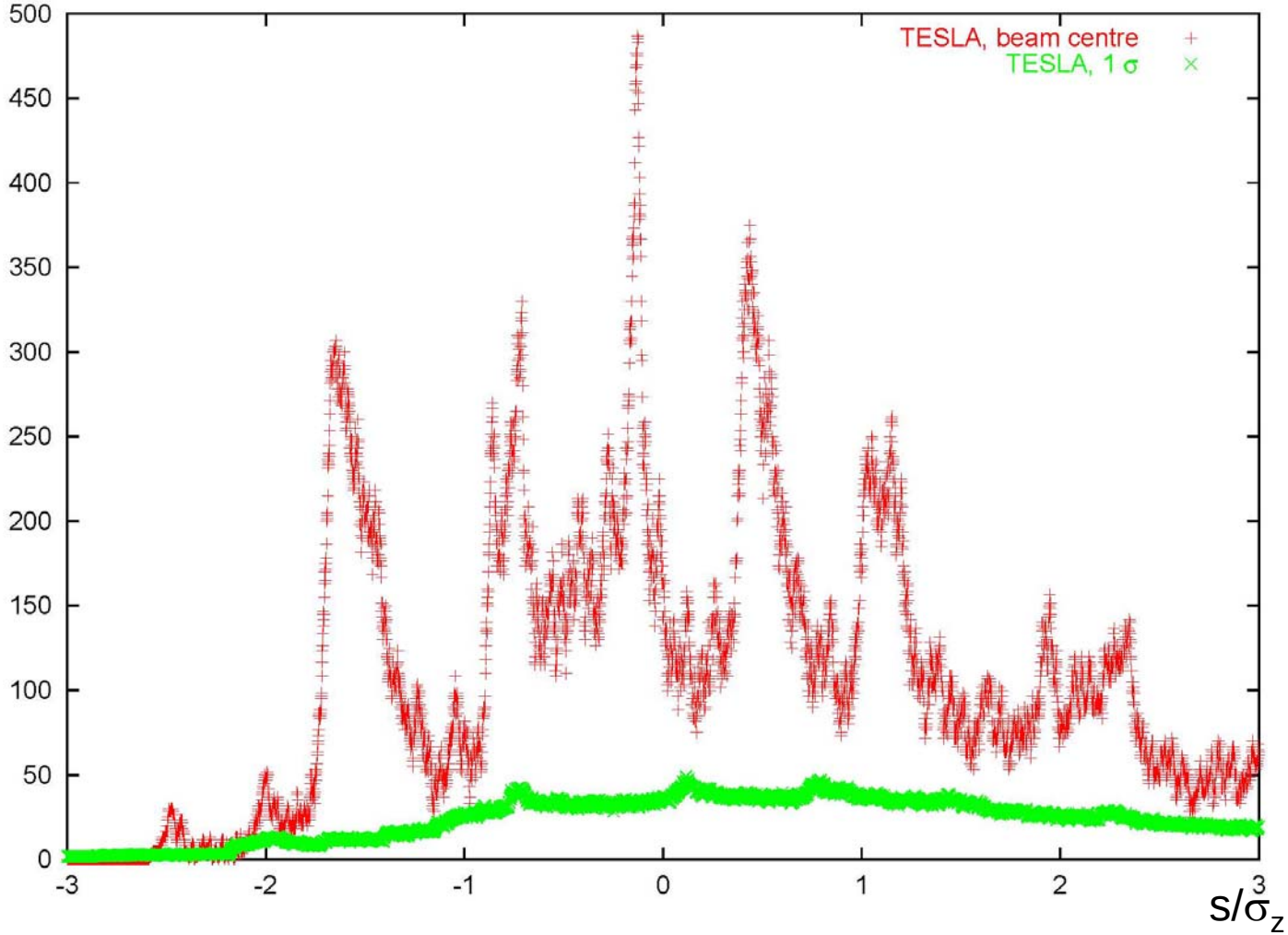


(simulated by PINCH code)

cloud rms =30 σ

e- pinch during bunch passage in TESLA wiggler

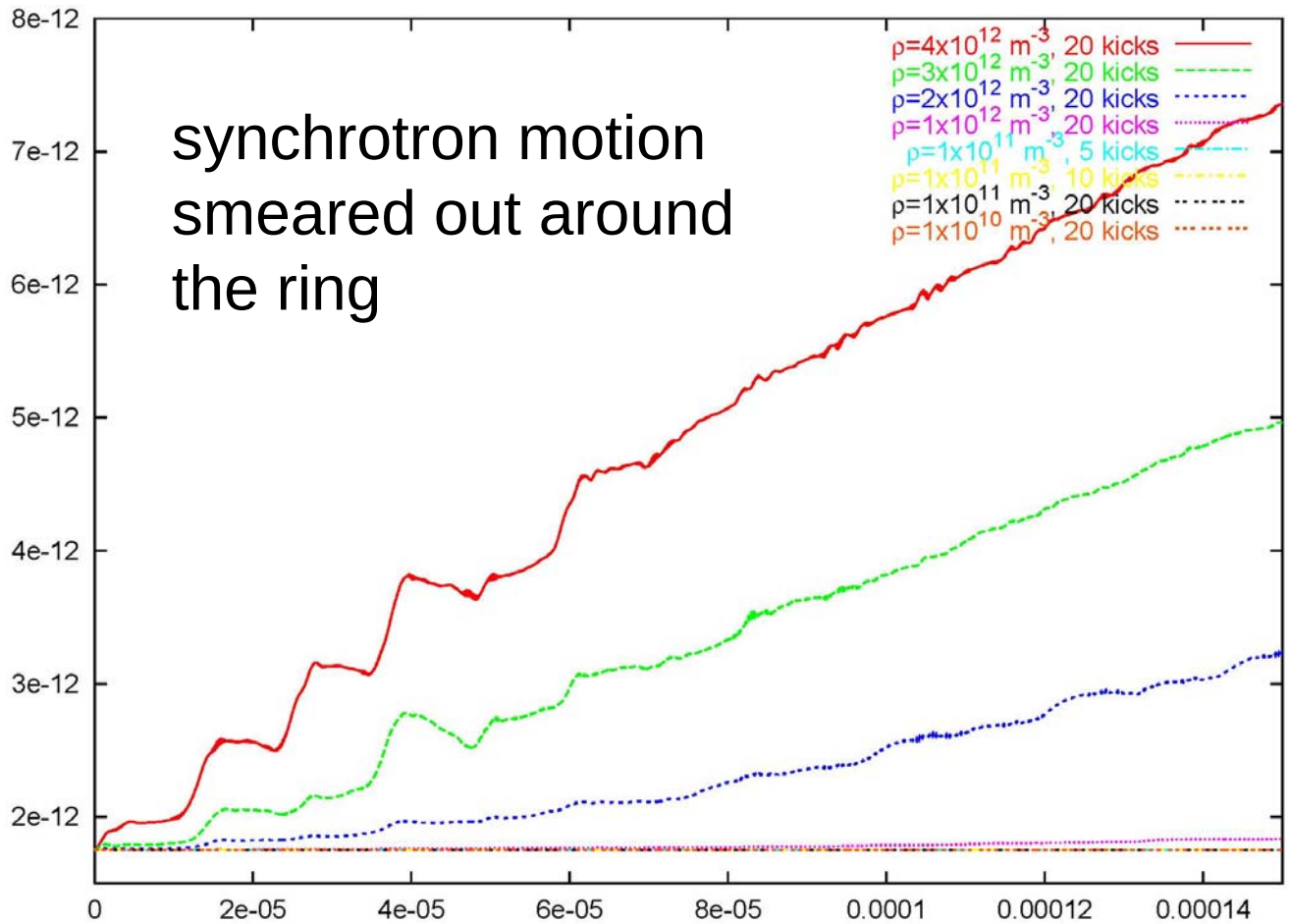
500



(simulated by PINCH code)

cloud rms =30 σ

e- driven TMCI instability in CLIC DR

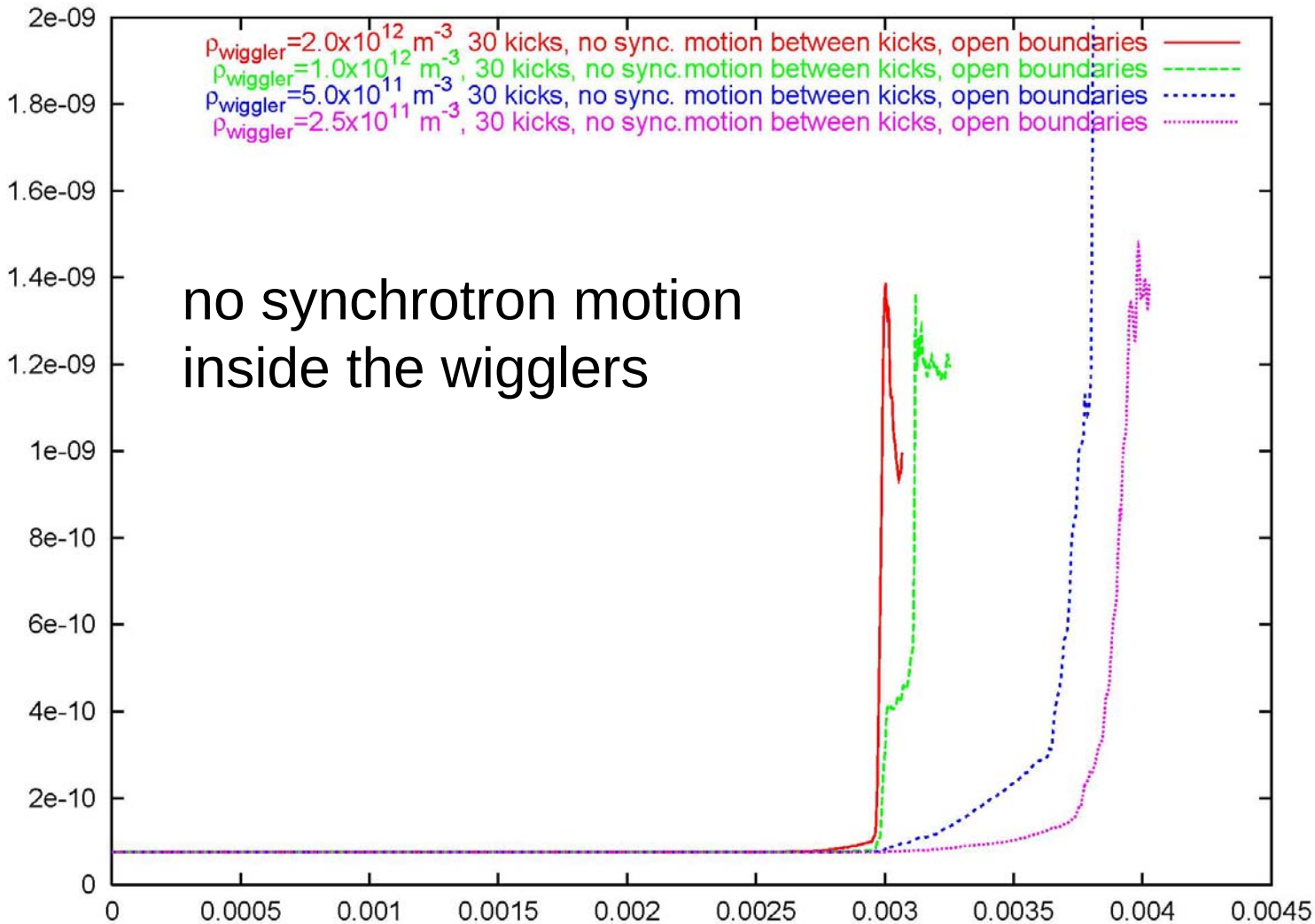


synchrotron motion smeared out around the ring

(simulated by `HEADTAIL` code)

threshold e- volume density ~1x10^{12} m^{-3} all around the ring

e- driven TMCI instability in TESLA DR



(simulated by HEADTAIL code)

threshold e- volume density <2.5x10^{11} m^{-3} in the wiggler

thank you for attention!