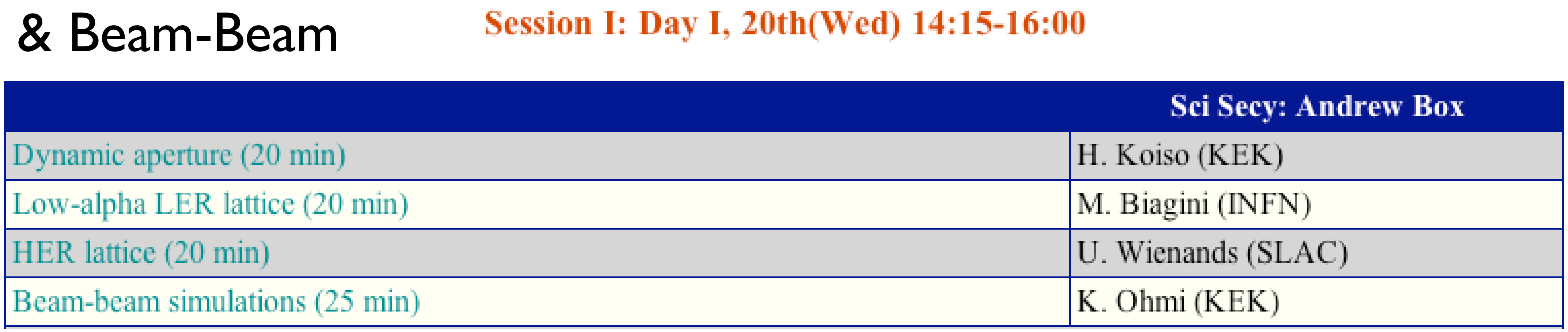
Accelerator Summary

Apr. 22, 2005
K. Oide(KEK) @ Hawai`i

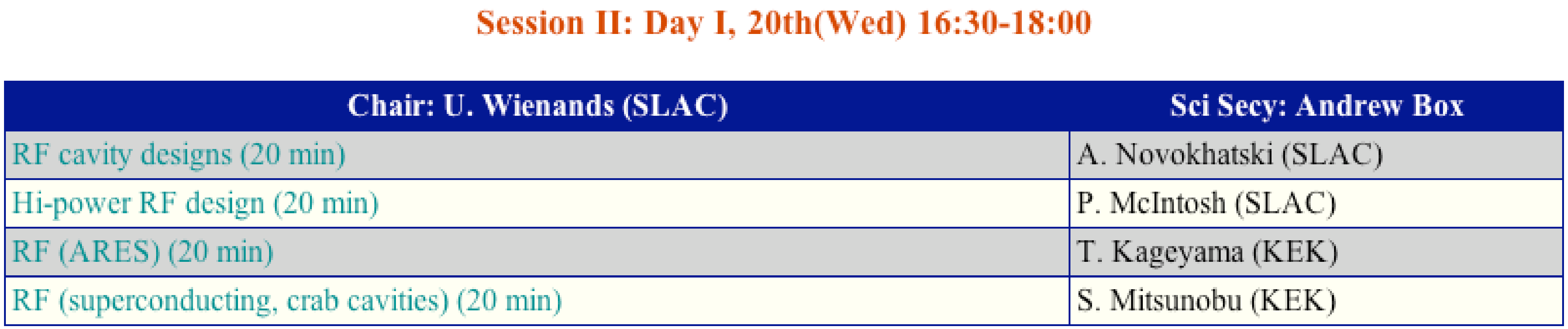
Optics & Beam-Beam



Session I: Day I, 20th(Wed) 14:15-16:00

	Sci Secy: Andrew Box
Dynamic aperture (20 min)	H. Koiso (KEK)
Low-alpha LER lattice (20 min)	M. Biagini (INFN)
HER lattice (20 min)	U. Wienands (SLAC)
Beam-beam simulations (25 min)	K. Ohmi (KEK)

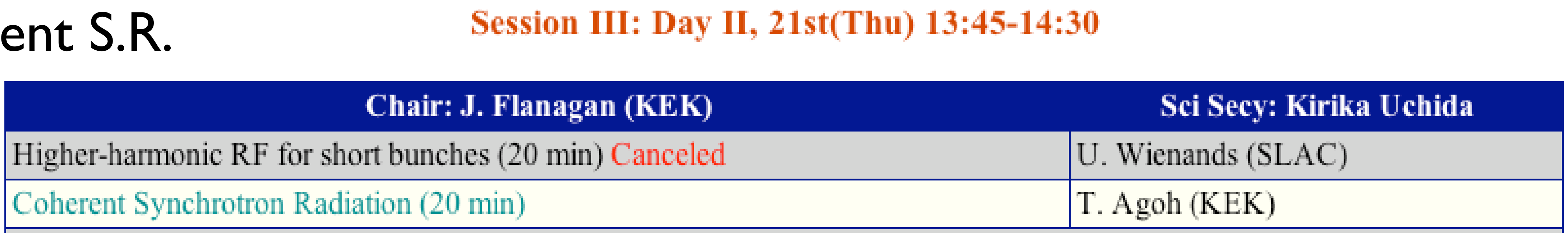
RF



Session II: Day I, 20th(Wed) 16:30-18:00

Chair: U. Wienands (SLAC)	**Sci Secy: Andrew Box**
RF cavity designs (20 min)	A. Novokhatski (SLAC)
Hi-power RF design (20 min)	P. McIntosh (SLAC)
RF (ARES) (20 min)	T. Kageyama (KEK)
RF (superconducting, crab cavities) (20 min)	S. Mitsunobu (KEK)

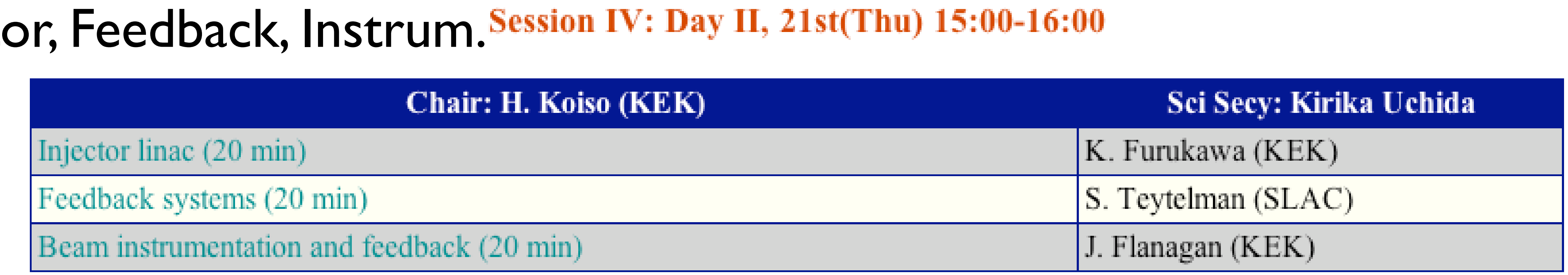
Coherent S.R.



Session III: Day II, 21st(Thu) 13:45-14:30

Chair: J. Flanagan (KEK)	**Sci Secy: Kirika Uchida**
Higher-harmonic RF for short bunches (20 min) Canceled	U. Wienands (SLAC)
Coherent Synchrotron Radiation (20 min)	T. Agoh (KEK)

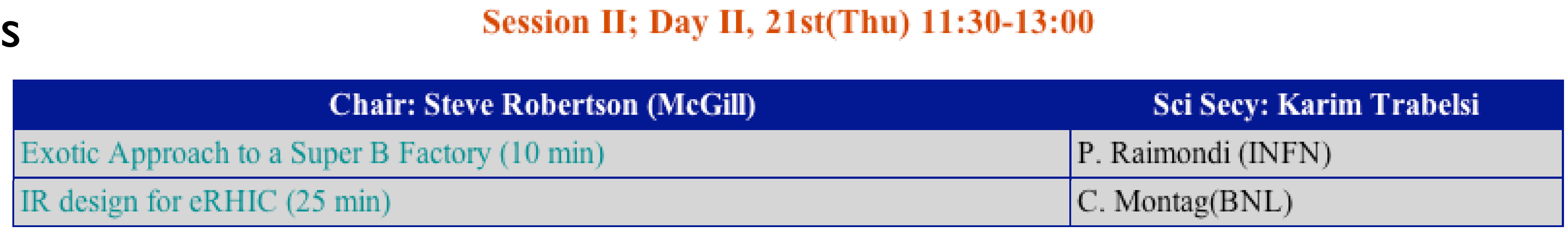
Injector, Feedback, Instrum.



Session IV: Day II, 21st(Thu) 15:00-16:00

Chair: H. Koiso (KEK)	**Sci Secy: Kirika Uchida**
Injector linac (20 min)	K. Furukawa (KEK)
Feedback systems (20 min)	S. Teytelman (SLAC)
Beam instrumentation and feedback (20 min)	J. Flanagan (KEK)

Others



Session II; Day II, 21st(Thu) 11:30-13:00

Chair: Steve Robertson (McGill)	**Sci Secy: Karim Trabelsi**
Exotic Approach to a Super B Factory (10 min)	P. Raimondi (INFN)
IR design for eRHIC (25 min)	C. Montag(BNL)

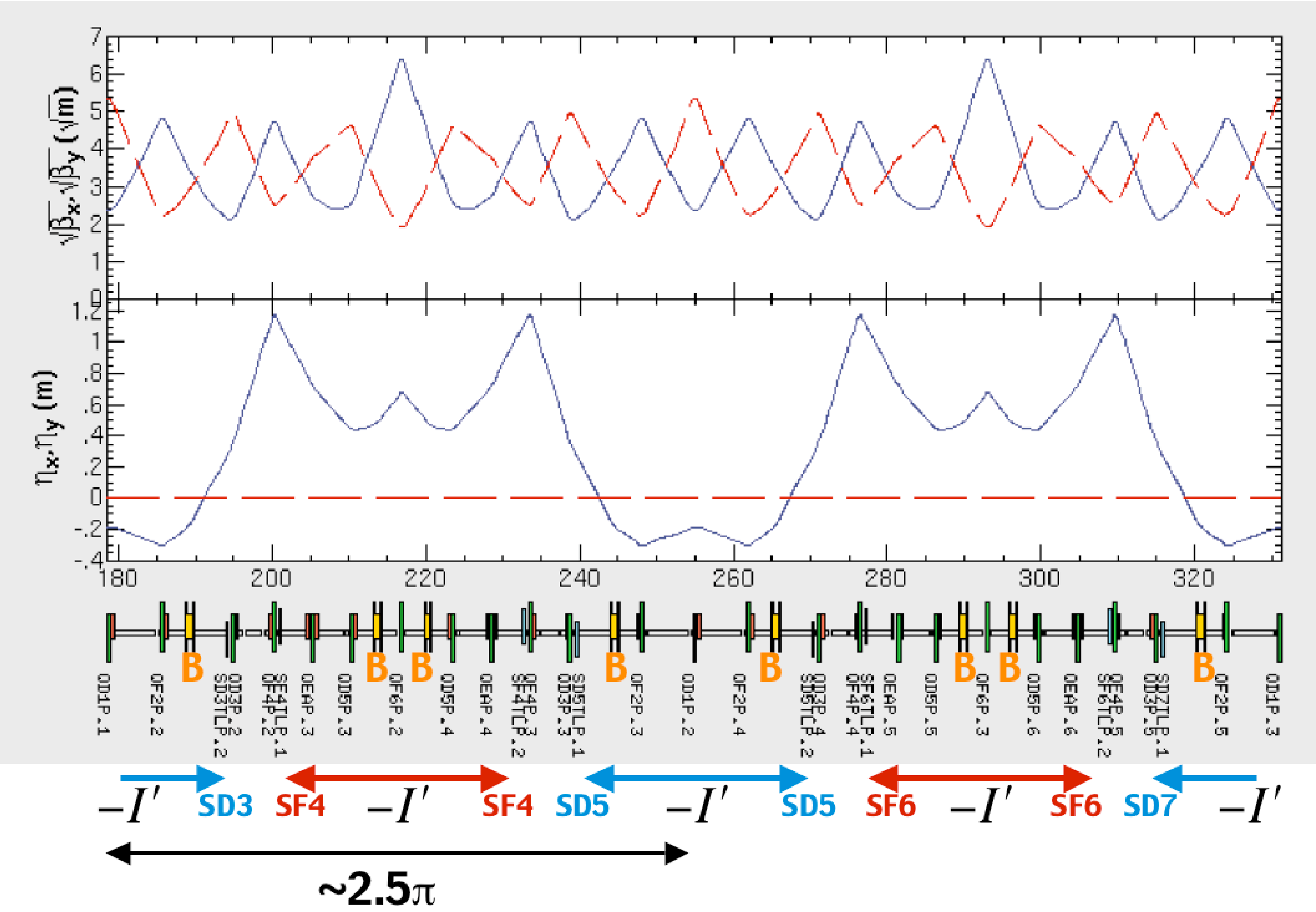
Summary

H. Koiso

- LER dynamic aperture satisfies the requirements for transverse acceptances at injection.
- Modeling method of QCS and solenoid fields (for example, the thickness of slices) affects the dynamic aperture.
  - Effect of the edge of quadrupole field? Need to check.
- QCS multipoles do not change the dynamic aperture significantly.
- HER aperture still needs improvement.
  - Local chromaticity correction may be necessary.
- Dynamic apertures are decreased by the beam-beam effect.
- Dynamic apertures of both rings will be improved by further optimization of sextupole strengths.
  - should be estimated at a working point ~(.503 ,530) .
- Correction methods for off-momentum optics should be developed.

2.5π cell structure

H. Koiso



εx and α are independently adjustable.

εx 10 ~ 36 nm , α −4 ~ 4×10^{-4}

Noninterleaved sextupoles (52HER/54LER pairs)

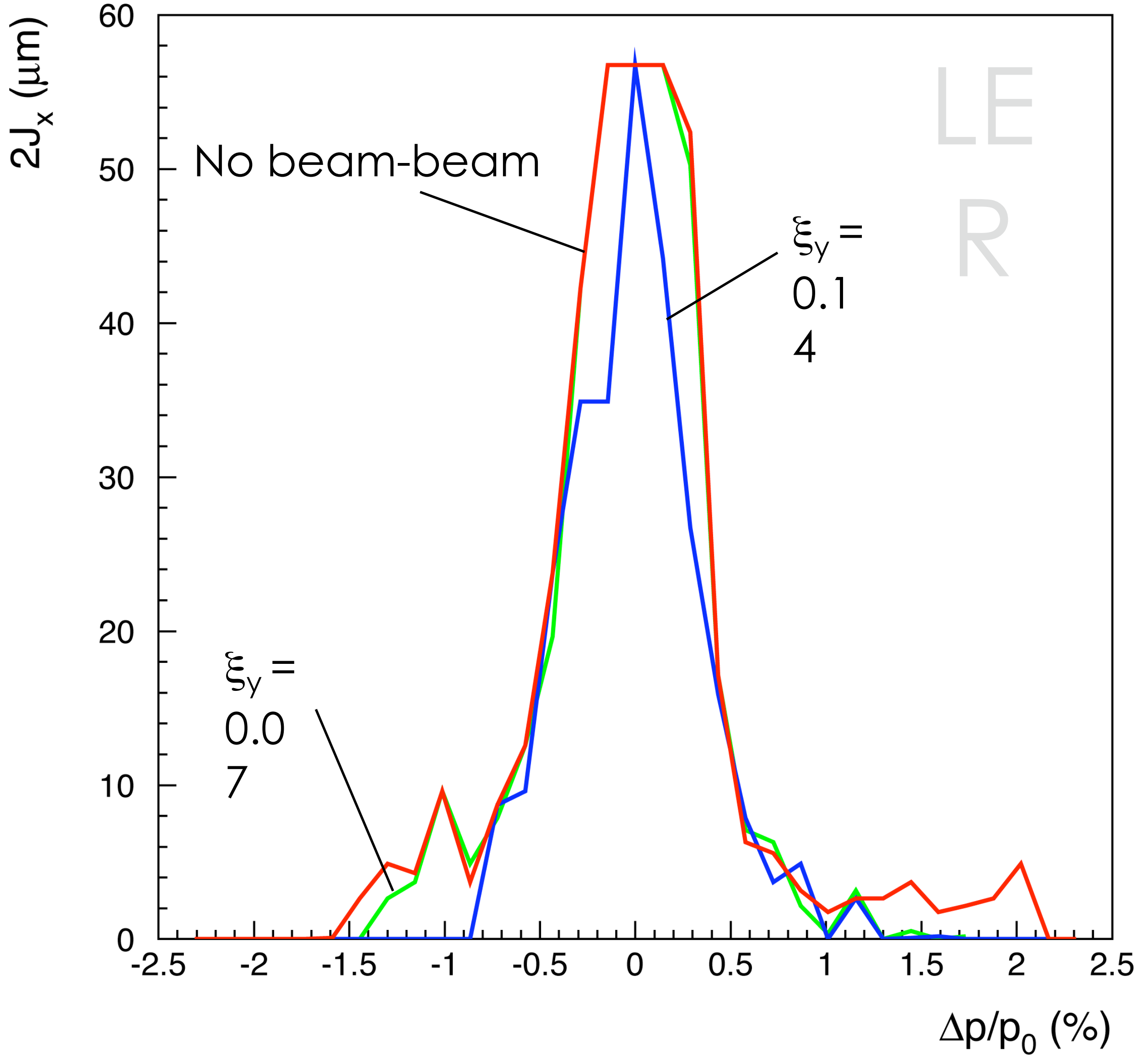
Dynamic Aperture with Beam-Beam Effect

H. Koiso

by Y.Onishi

Stored beam $J_y/J_x = 2$ %

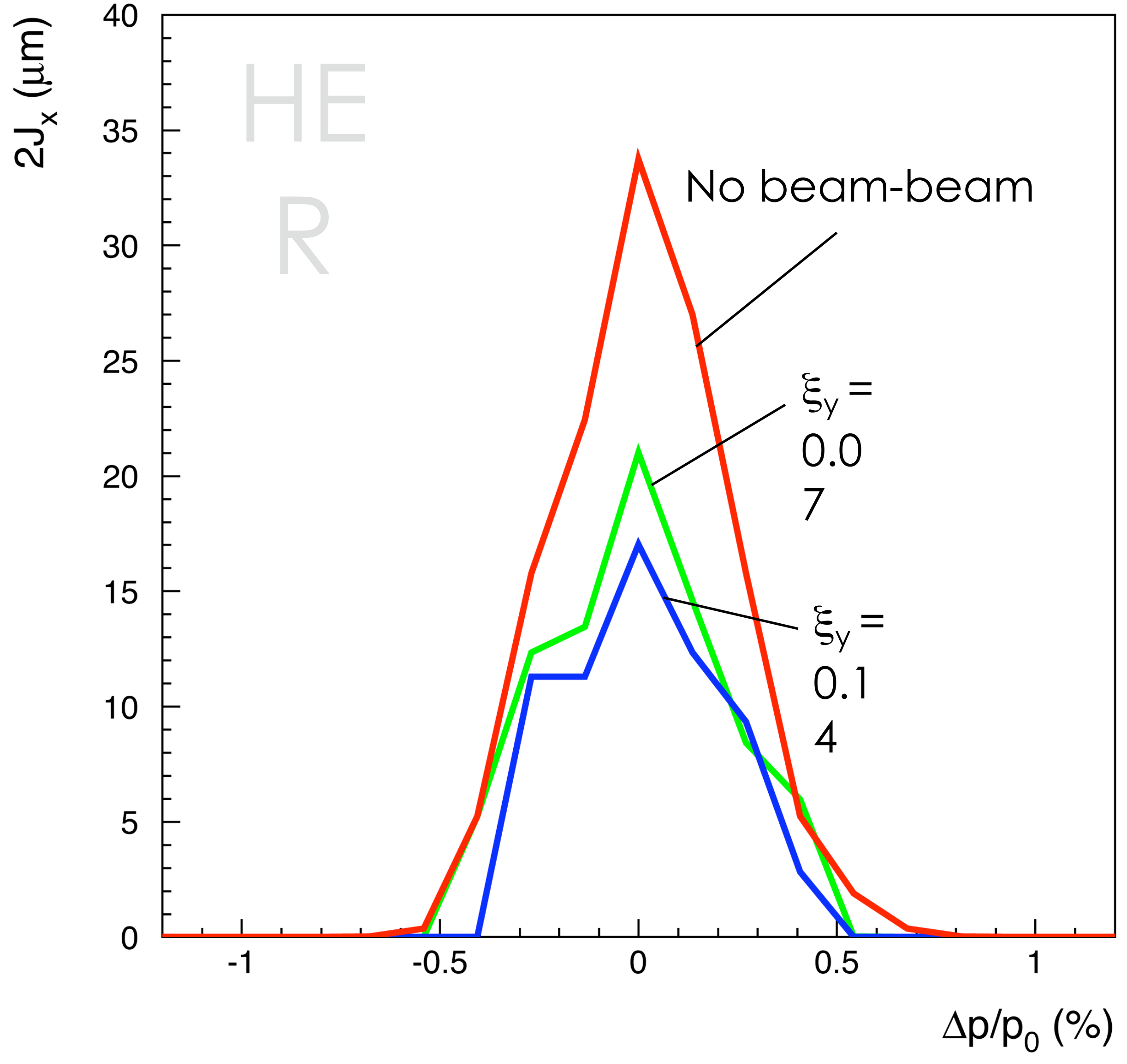
$\nu_x/\nu_y = 45.510/43.545$



* no machine error

Stored beam $J_y/J_x = 2$ %

$\nu_x/\nu_y = 45.510/43.570$



- Case $\xi_y = 0.14$, dynamic aperture shrinks in large momentum deviation for LER.
- Transverse aperture decreases in HER due to beam-beam effect.
- Touschek lifetime with beam-beam(x_y= 0.14): 50 min in LER / 180 min in HER

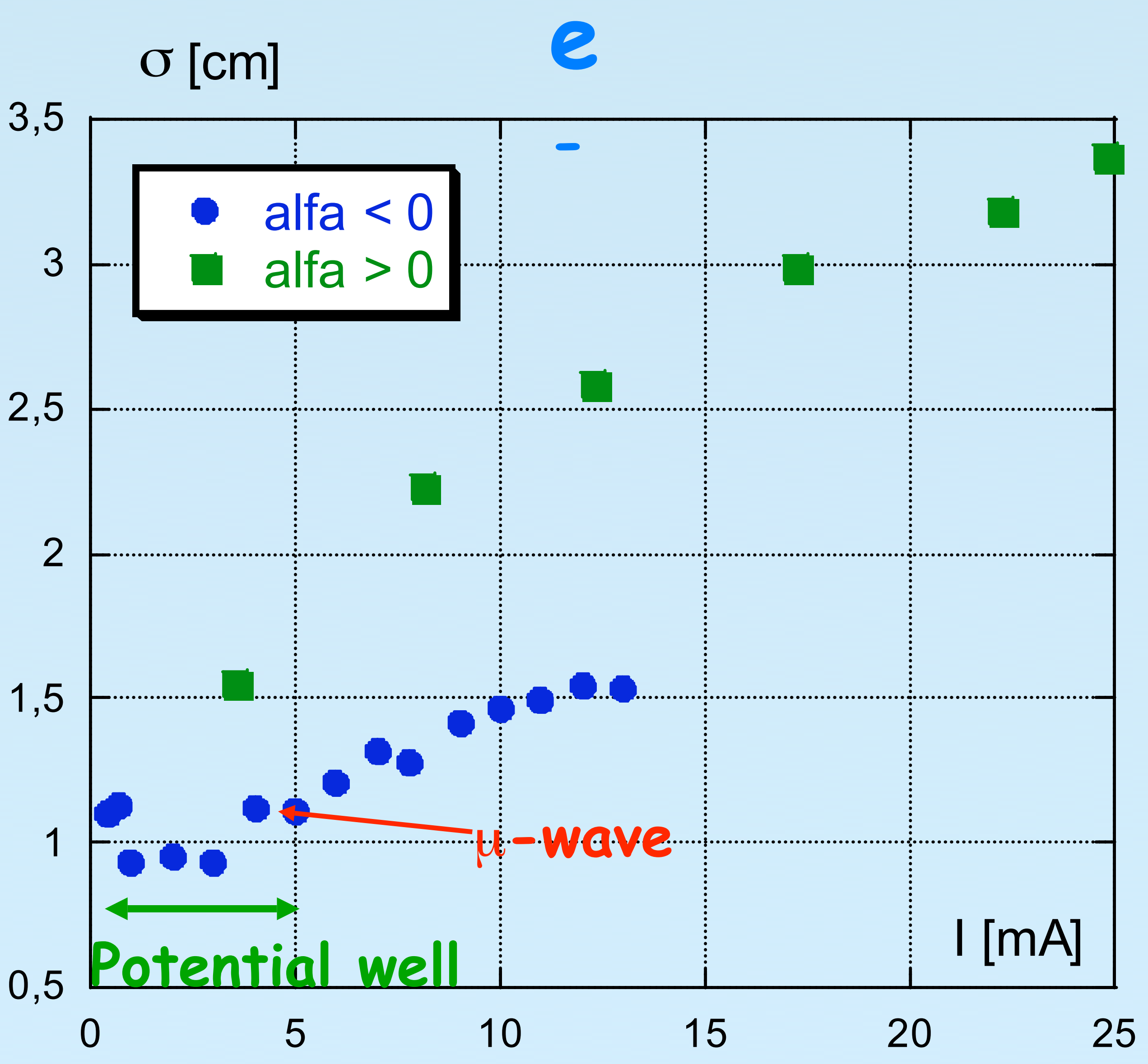
New SBF lattice

M. Biagini

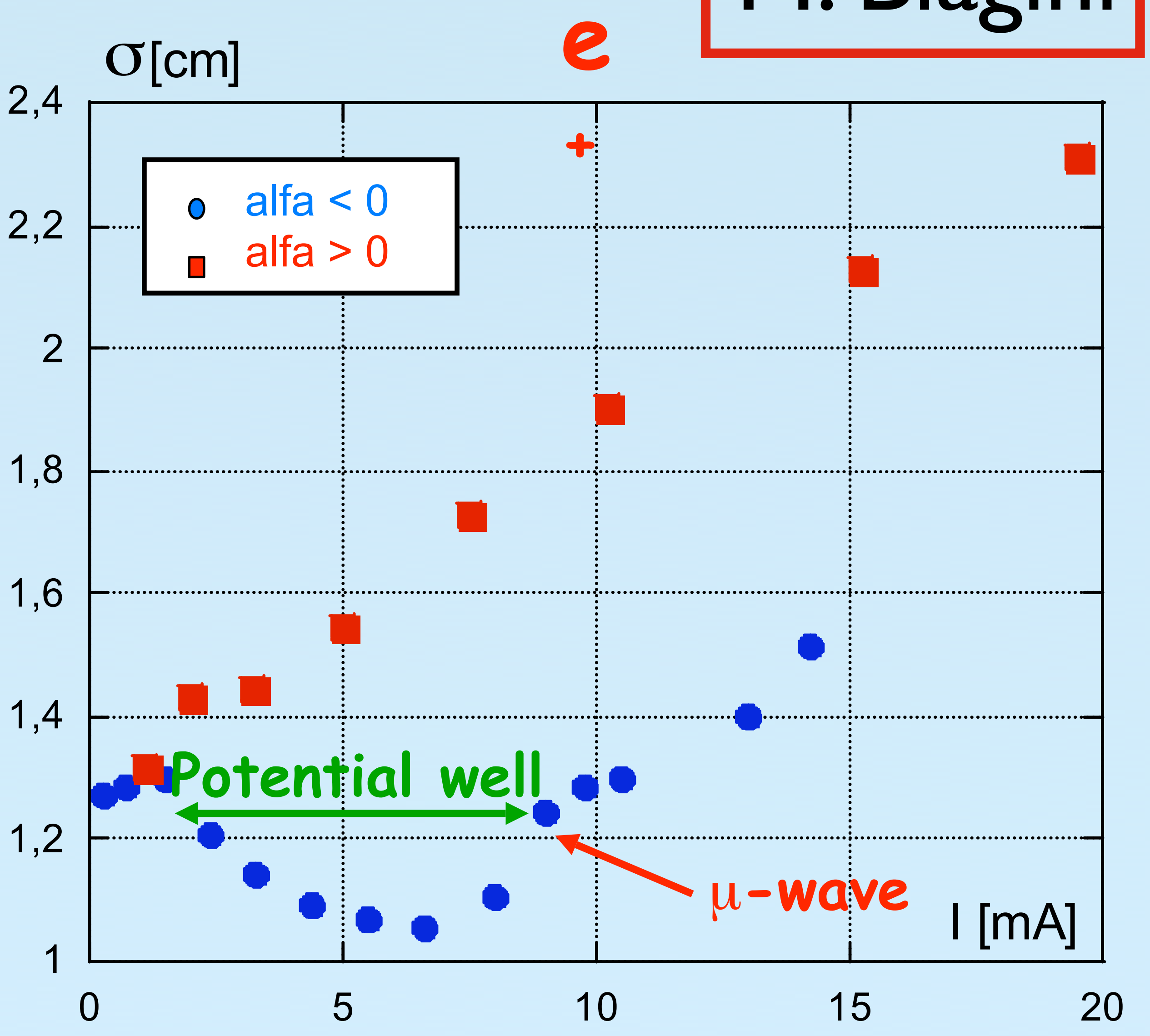
- For flexibility, easy chromaticity correction, and α_c tunability the "KEK-B like" 2.5 π lattice was suitable to our needs
- Preliminary lattice with no IR insertion
- Two lattices were studied:
  - Low negative α_c (-1.6×10^{-4})
  - Low positive α_c ($+7\times10^{-4}$)

Measured DAΦNE bunch length

M. Biagini



Bunch length vs bunch current for V_{RF} = 165 kV

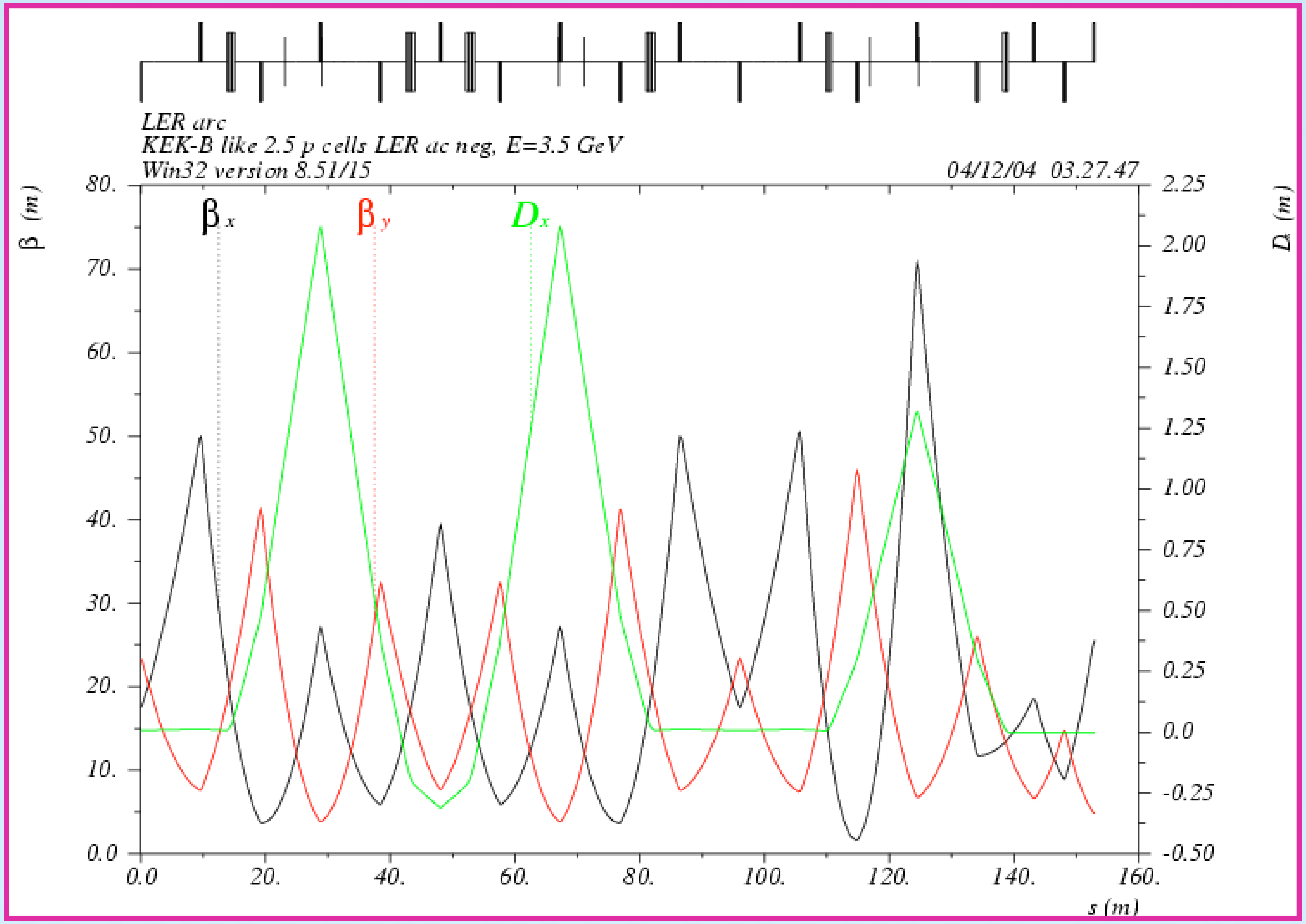


Bunch length vs bunch current for V_{RF} = 110 kV and 120 kV

Negative α_c lattice (-1.6×10^{-4})

Arc + Dispersion suppressor

M. Biagini



U.Wienands

Conclusion (for now)

- As expected, a low-α_p lattice for a Super-PEP HER is not easy to find.
- For 90°/cell, $\alpha_p \approx 0.0006$ seems to be about as low as it will go, in the PEP-II context (ε_x, tunnel, s.r.)
  - very preliminary tracking suggests chromaticity correction is feasible.
- For comparison, the 90° HER lattice for PEP-II will have $\alpha_p \approx 0.00167$.
- For 135°/cell, lower α_p is feasible to 1st order, but chromaticity correction will be a major challenge.

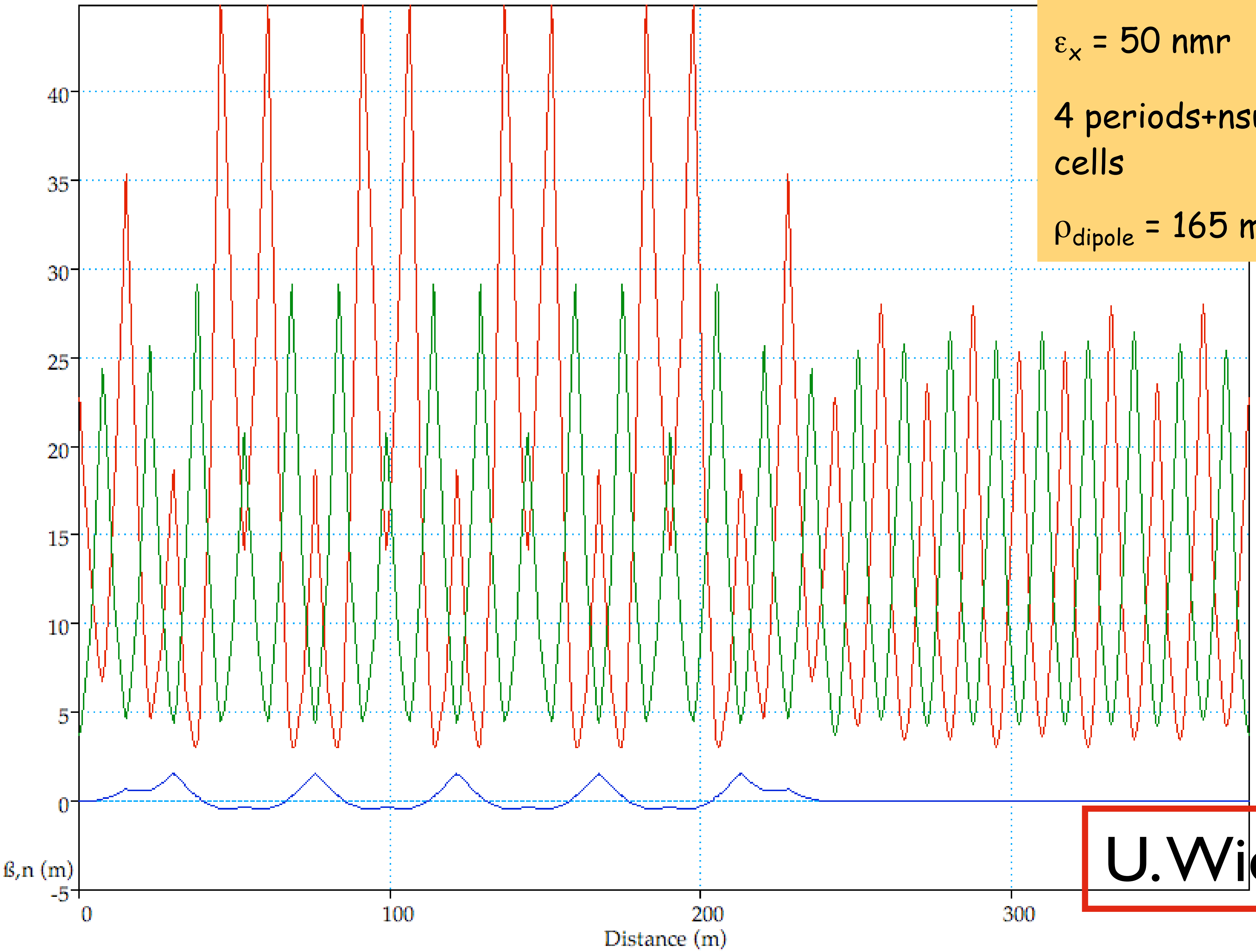
HER Sextant, 90° cell

α_p = 0.0006

ε_x = 50 nmr

4 periods+nsup=16 cells

ρ_{dipole} = 165 m



U.Wienands

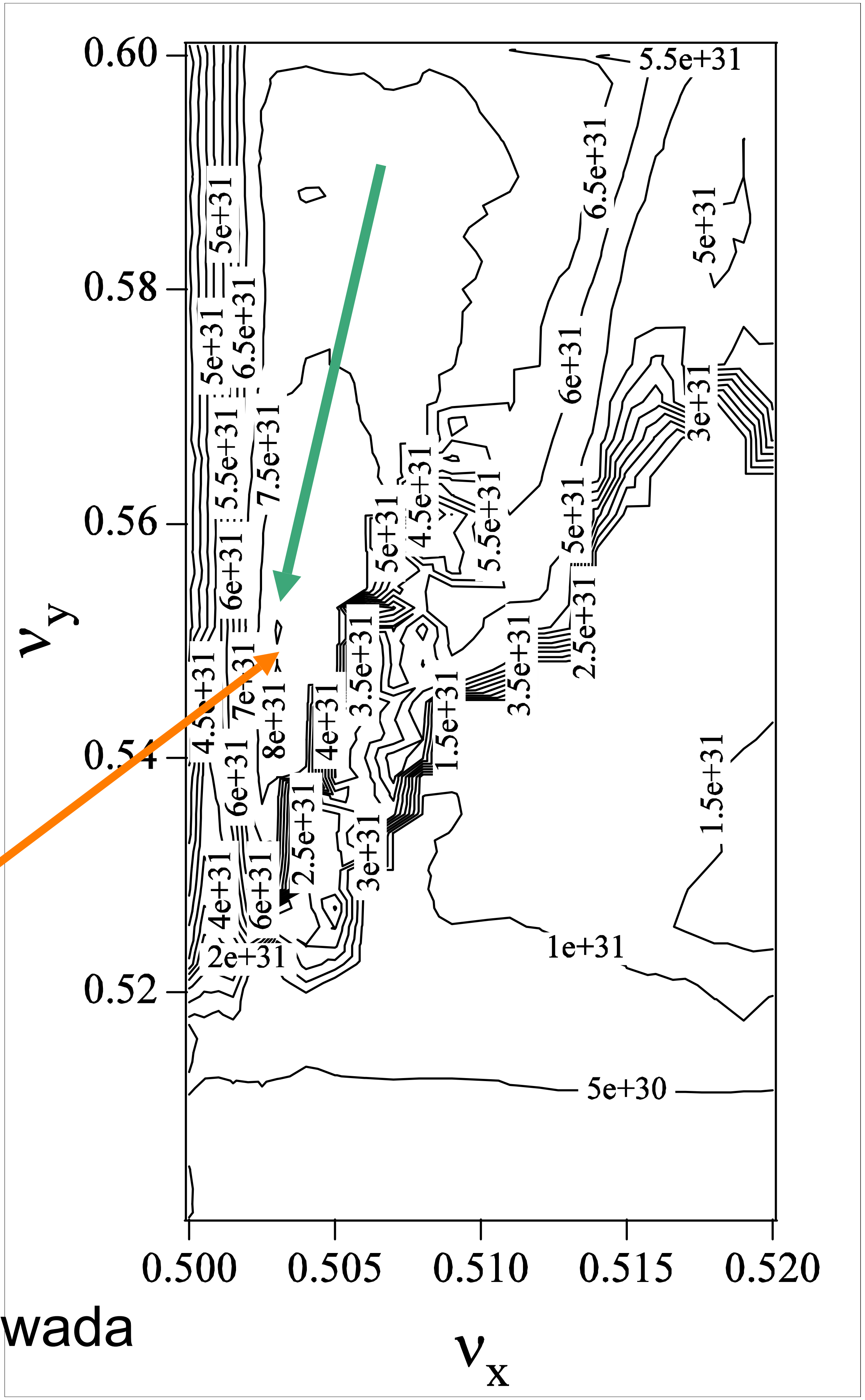
K. Ohmi

Summary

- Design and tolerance for $L_{tot} = 4x10^{35}\ cm^{-2}\ s^{-1}$ were studied.
- Reduce optics error at the collision point. Maybe acceptable.
- Reduce external diffusions especially those with fast frequency component.
- Arc nonlinearity and life time issues will be studied soon by collaboration with BINP (D. Shatilov).
- Efforts on higher luminosity are continued.

Tune scan

- Bunch luminosity v.s. tune
- Total luminosity = 5000x bunch luminosity
- Green line sketches progress of KEKB.



$L_{tot} = 4\mathrm{x}10^{35}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$

By M. Tawada

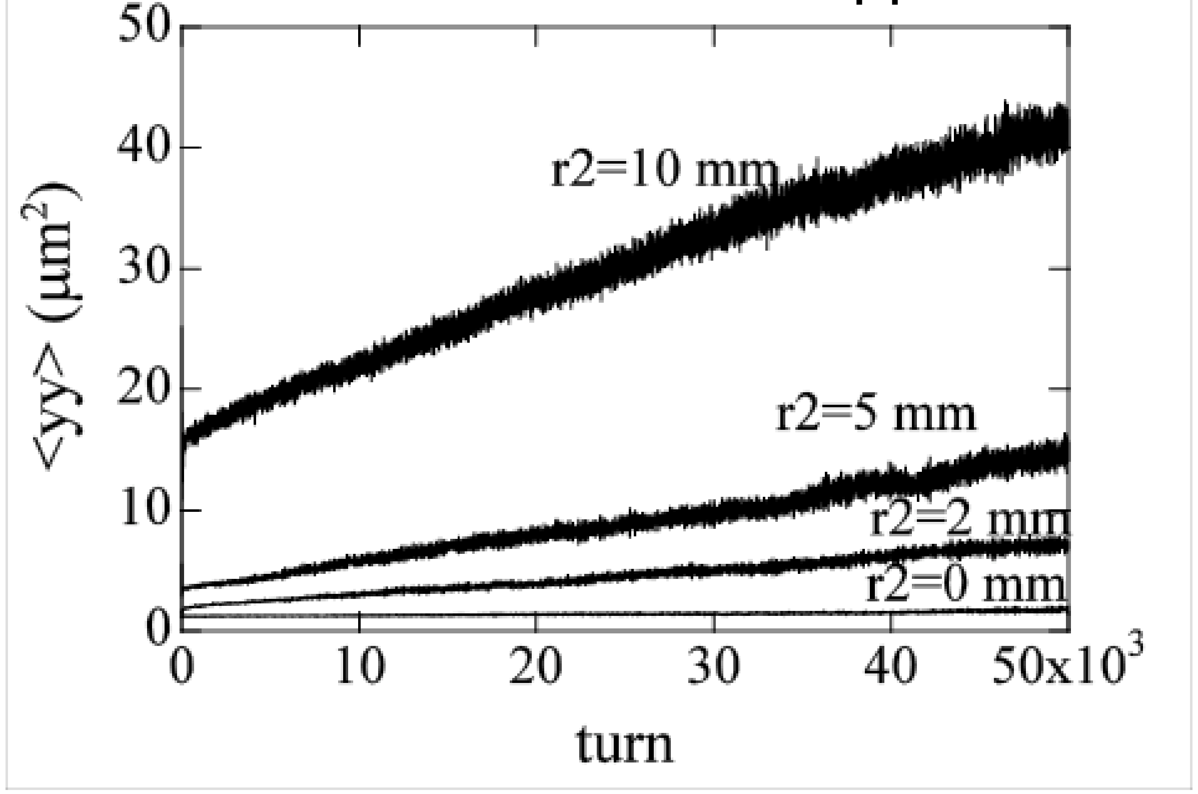
K. Ohmi

X-y coupling

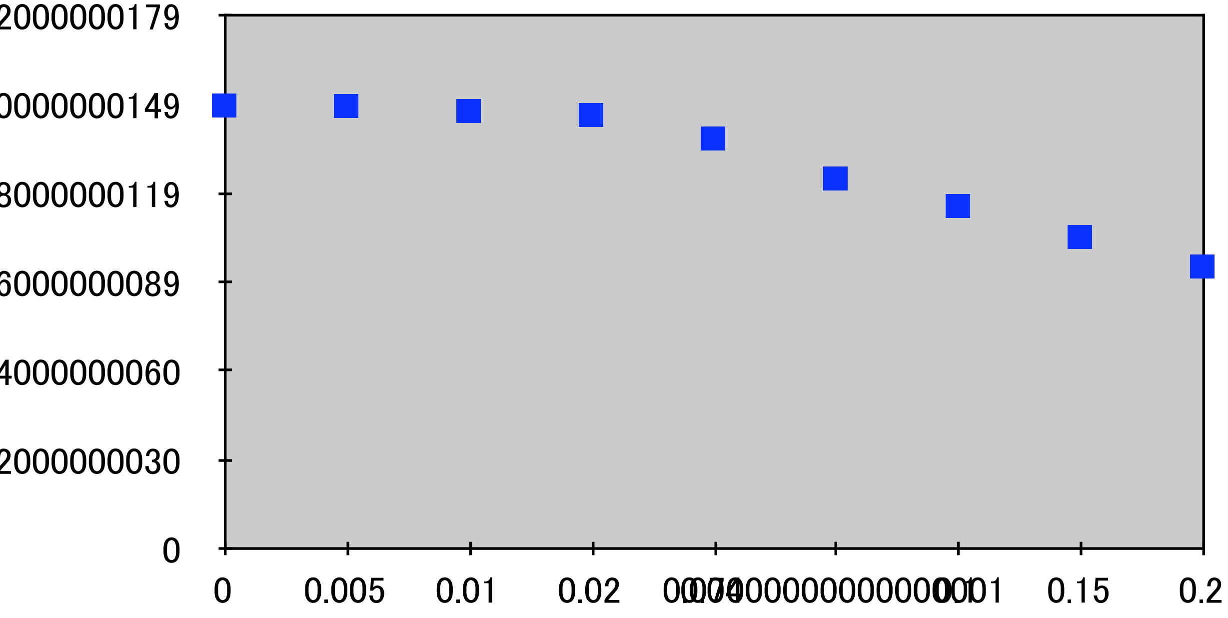
K. Ohmi

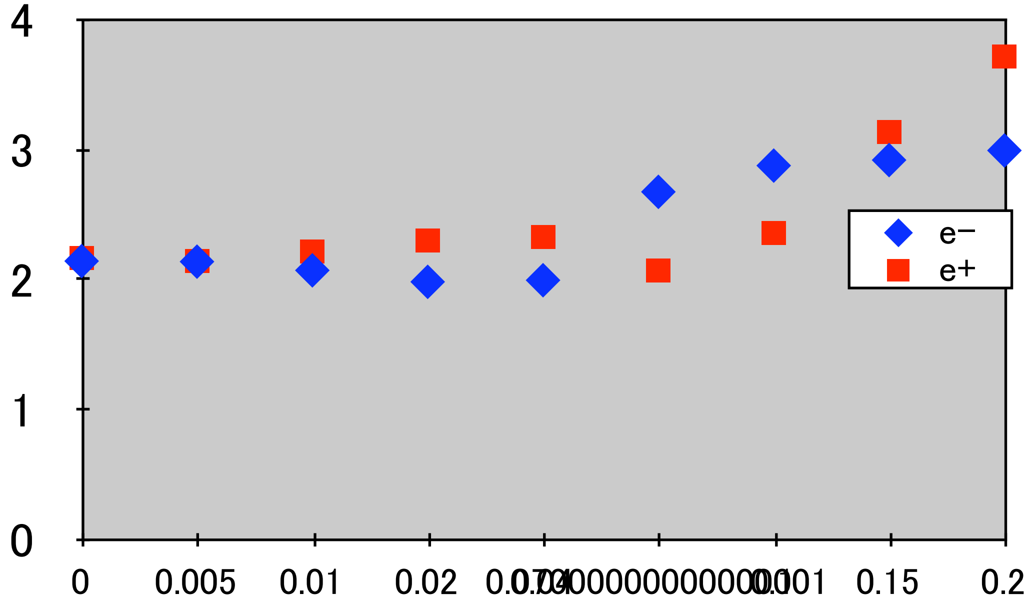
- Diffusion due to x-y coupling.
- Luminosity and beam size degradation.

Gaussian approx.



PIC simulation



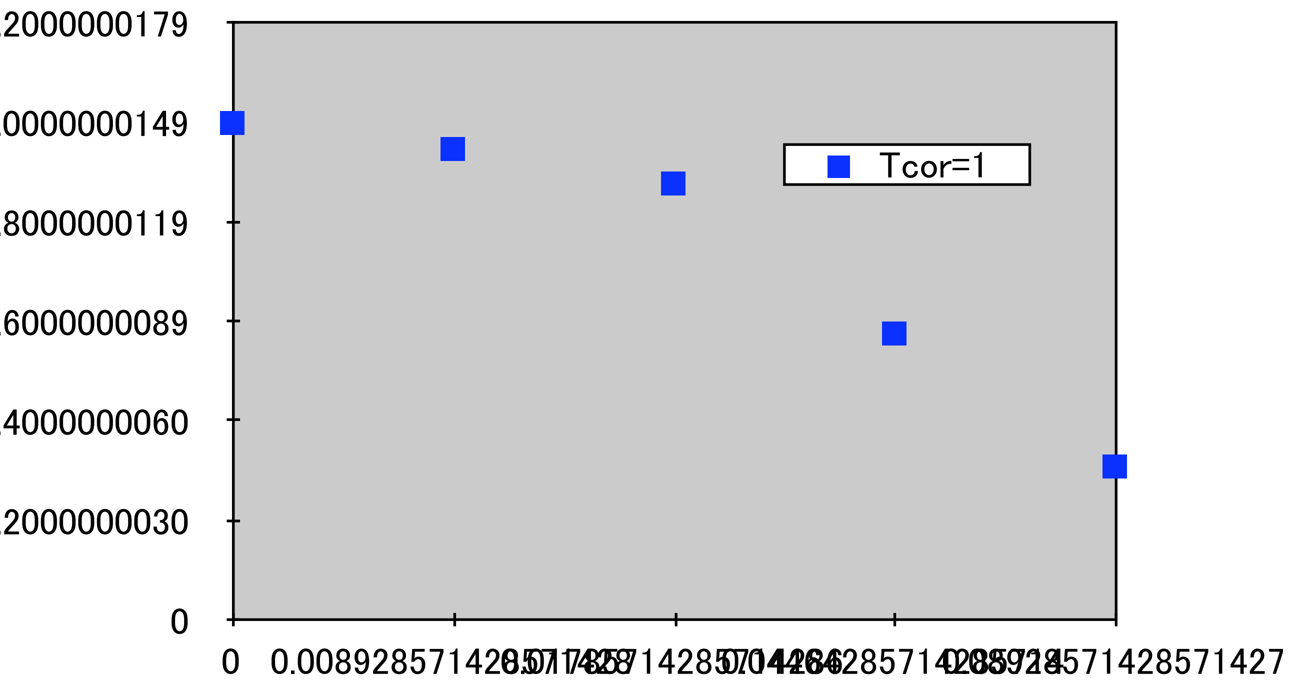


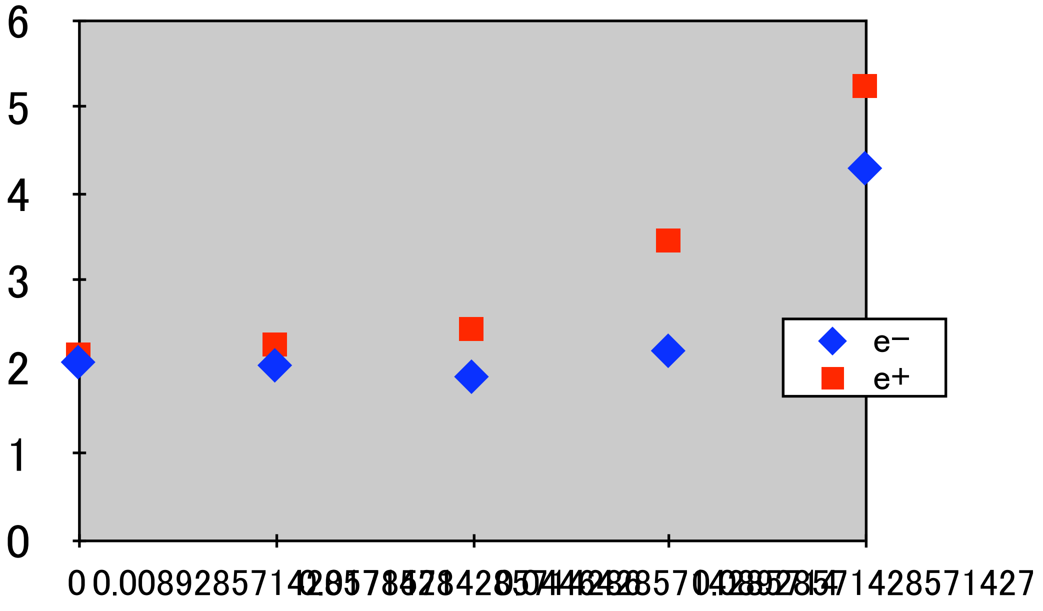
K. Ohmi

External diffusion: Vertical offset noise

- Since the beam-beam system is chaotic, such noise enhances the diffusion of the system.
- Luminosity degradation for the noise without correlation between turns.

$$\left\langle \Delta y(t)\Delta y(t')\right\rangle = \Delta y^2 \delta(t-t')$$





Conclusions

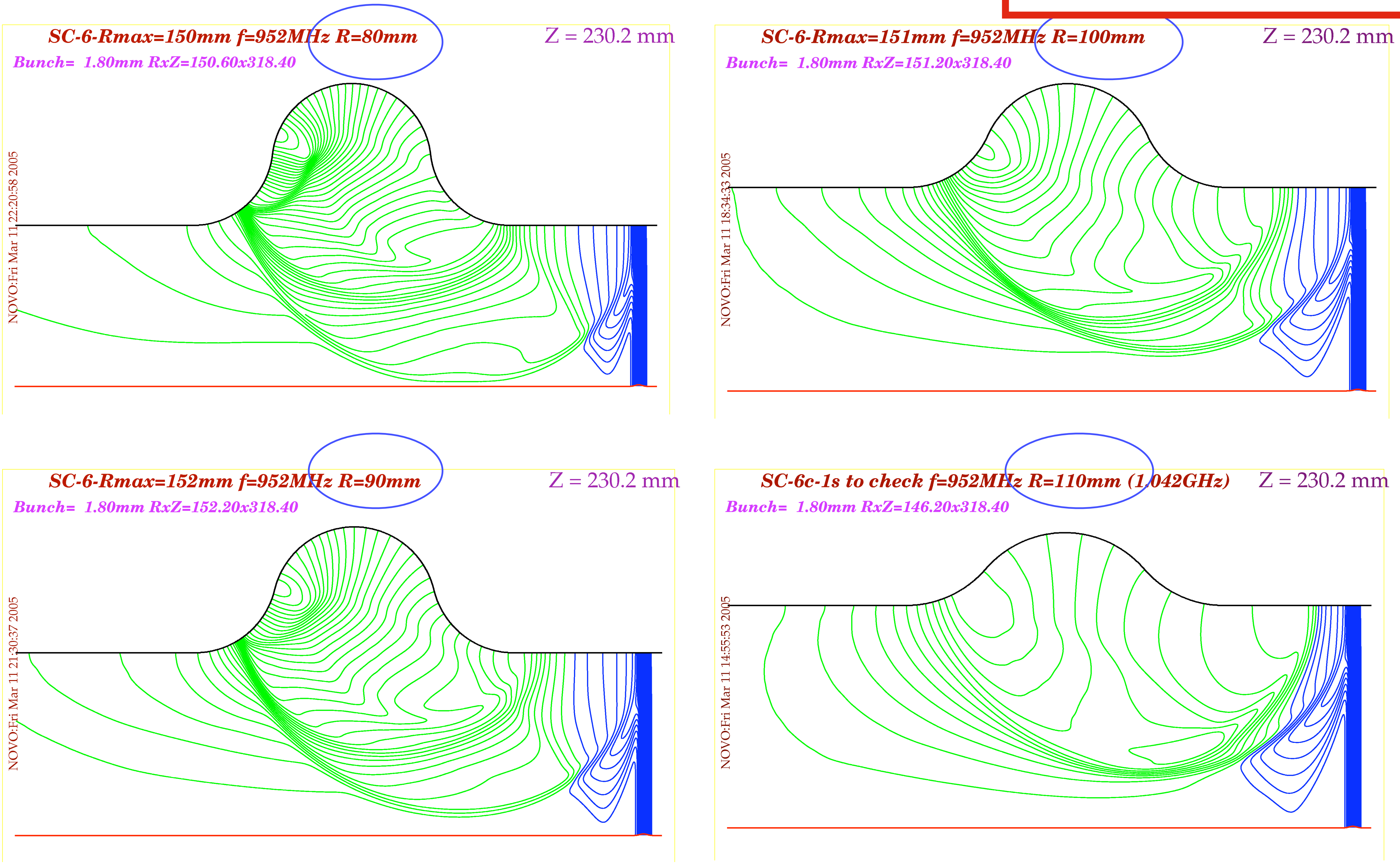
S. Novokhatski

- Low R/Q cavities are needed for super high luminosity factories. These cavities are superconducting cavities.
- Low R/Q is achieved by using large beam pipe. Cut-off frequency is very closer to the working frequency.
- Trapped transverse modes must be damped using external loads.
- High voltage and correspondent momentum compaction give additional bunch shortening at interaction point.

Varying beam pipe radius

S. Novokhatski

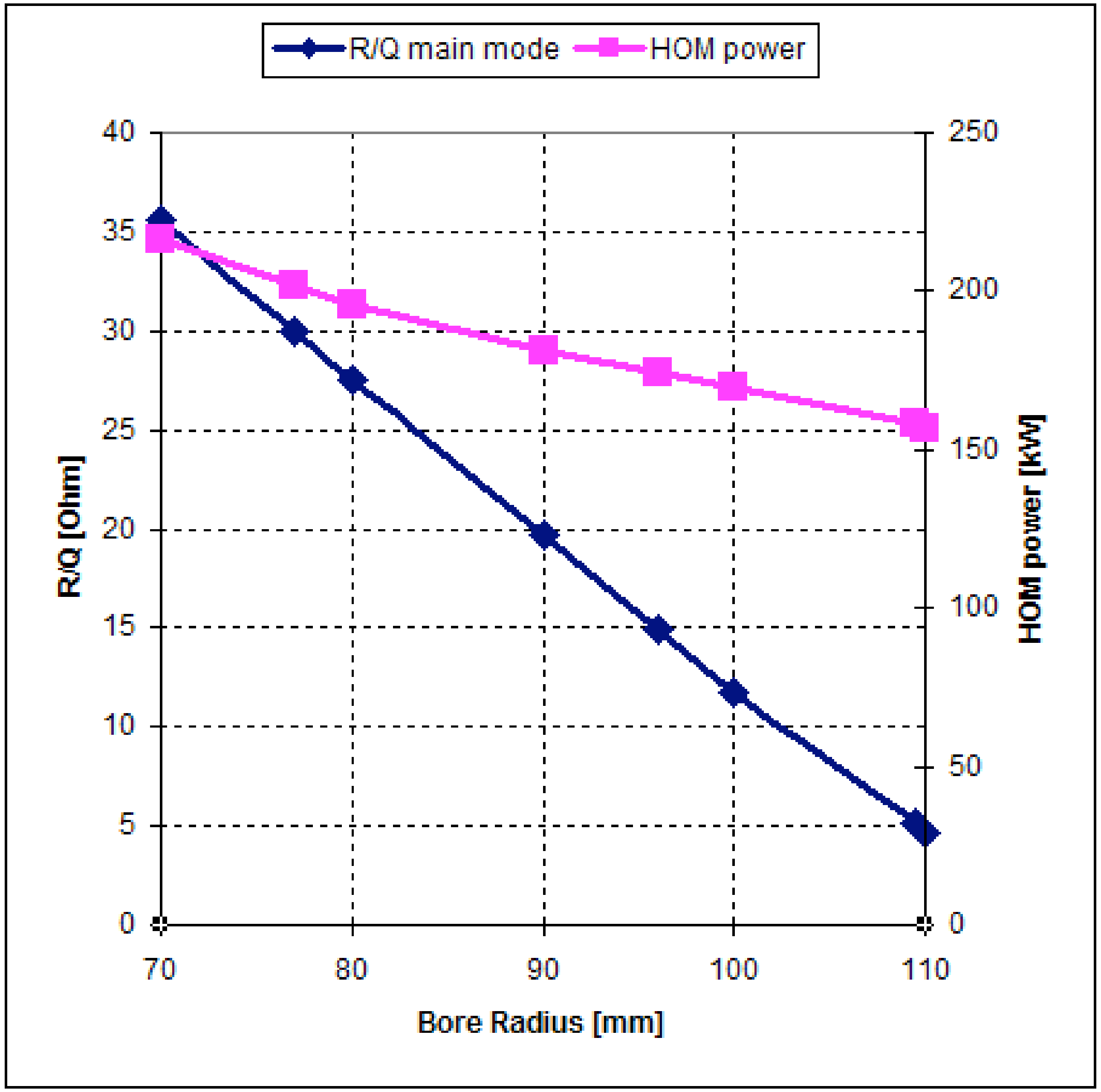
S. N. “ Cavities for Super B–Factory”



“Wakefield” calculations

R/Q and HOM Power

S. Novokhatski



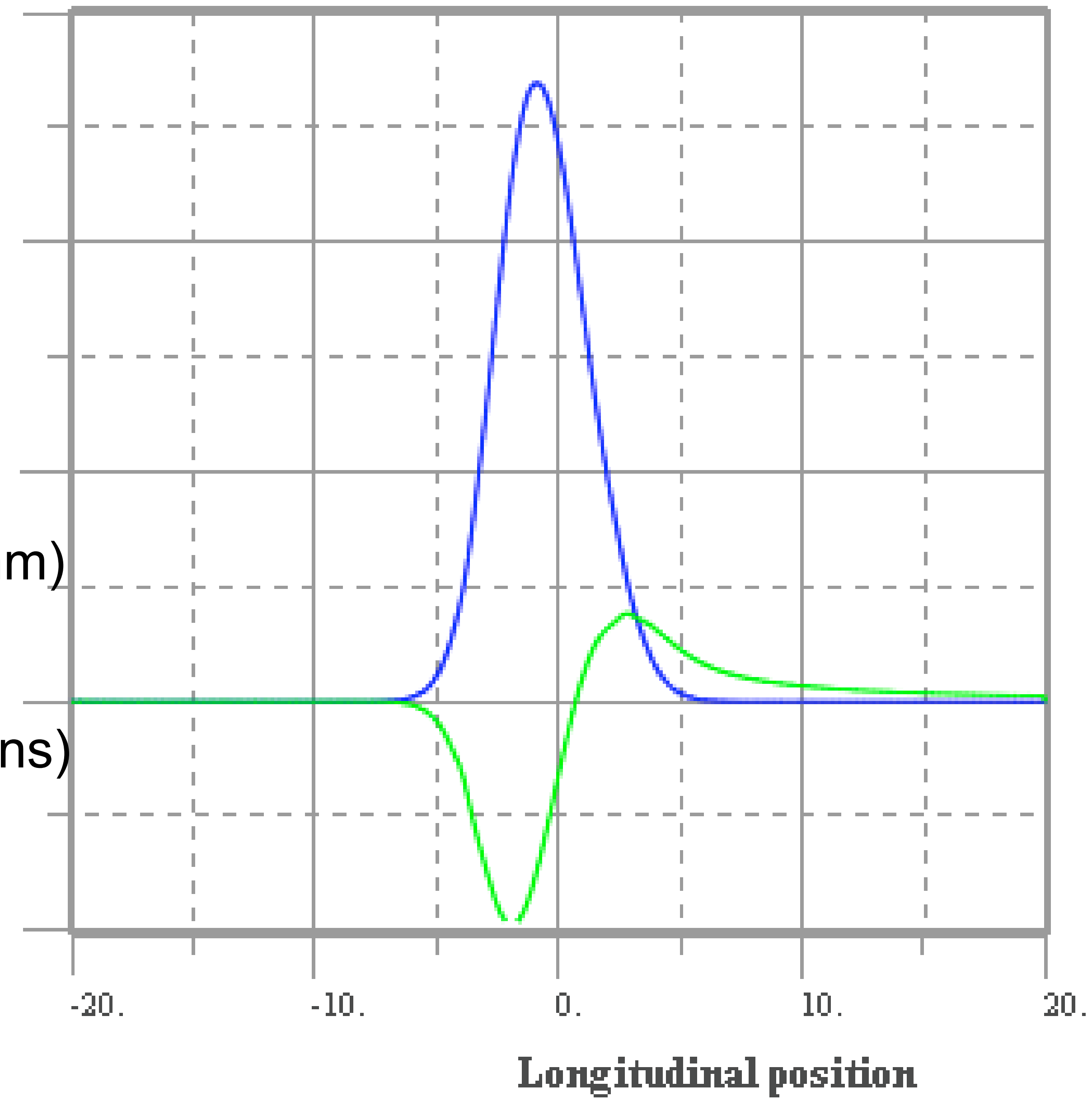
All wakes included

S. Novokhatski

S. N. “ Cavities for Super B-Factory”

Bunch Current	3.300	mA
Bunch Charge	24.21	nC
Zero bunchlength	1.80	mm
Moment. compact.	9.400E-04	
Ring Energy	3500.0	MeV
Energy Spread	2.400	MeV
SR Energy loss	0.970	MeV per turn
RF Voltage:	52.50	MV
Number of cavities	42	
Phase Angle	1.059	degree (0.926 mm)
Harmonic Number	6984	
Rev. frequency	136.2707	kHz
Synchrotron freq.	17.045 kHz	(7.995 Turns)
Damping turns	4100.000	

1.83 mm



Conclusions

P. McIntosh

- RF requirements for L=7e35 and L=1e36 identified ⇒ need up to 190 MW site AC power!
- Low R/Q cavities needed for stability control.
- Cavity voltage and RF power limits identified ⇒ how far can we push these?!?
- High power klystrons (> 1 MW) at 952 MHz look to be achievable.
- High power circulators appear to be available from industry.

Watch this space!

RF and AC Power (5Ω)

P. McIntosh

	Luminosity = 7.0 E+35			Luminosity = 1.0 E+36		
	LER	HER	Sum	LER	HER	Sum
Currents (A)	15.50	6.80		23.00	10.00	
Energy (GeV)	3.50	8.00		3.50	8.00	
HOM Losses						
Cavity loss (MW)	1.58	0.22	1.80	6.33	0.75	7.08
Number of cavities	22.00	16.00		40.00	25.00	
Resistive Wall (MW)	2.75	0.53	3.28	6.07	1.15	7.21
IP region (MW)	1.82	0.35	2.17	4.01	0.76	4.77
Other HOMs (MW)	0.50	0.10	0.60	1.11	0.21	1.32
Total HOM Losses (MW)	6.66	1.20	7.86	17.52	2.86	20.38
SR Losses						
SR power (MW)	15.04	14.96	30.00	22.31	22.00	44.31
Total RF Power (MW)	21.70	16.16	37.86	39.83	24.86	64.69
RF AC Power (MW)	43.39	32.32	75.71	79.66	49.73	129.38
Magnet AC Power (MW)	5.00	5.00	10.00	5.00	5.00	10.00
Cryogenics						
Loss per Cavity (W)	52.00	52.00		52.00	52.00	
Total Cavity Losses (kW)	1.14	0.83	1.98	2.08	1.30	3.38
Cryogenic AC Power (MW)	0.86	0.63	1.49	1.56	0.98	2.54
Injector, LCLS, SPEAR3 etc (MW)			40.00			40.00
TOTAL SITE AC POWER (MW)	49.25	37.94	127.20	86.22	55.70	181.92

P. McIntosh

RF and AC Power (30Ω)

Increased
🟥

Reduced
🟩

	Luminosity = 7.0 E+35			Luminosity = 1.0 E+36		
	LER	**HER**	**Sum**	**LER**	**HER**	**Sum**
Currents	15.50	6.80		23.00	10.00	
Energy (GeV)	3.50	8.00		3.50	8.00	
HOM Losses						
Cavity loss (MW)	2.02	0.28	2.30	8.48	0.95	9.43
Number of cavities	22.00	16.00		42.00	25.00	
Resistive Wall (MW)	2.75	0.53	3.28	6.07	1.15	7.21
IP region (MW)	1.82	0.35	2.17	4.01	0.76	4.77
Other HOMs (MW)	0.50	0.10	0.60	1.11	0.21	1.32
Total HOM Losses (MW)	7.10	1.26	8.36	19.66	3.07	22.73
SR Losses						
SR power (MW)	15.04	14.96	30.00	22.31	22.00	44.31
Total RF Power (MW)	22.13	16.22	38.35	41.97	25.07	67.04
RF AC Power (MW)	44.26	32.44	76.70	83.95	50.14	134.09
Magnet AC Power (MW)	5.00	5.00	10.00	5.00	5.00	10.00
Cryogenics						
Loss per Cavity (W)	26.00	26.00		26.00	26.00	
Total Cavity Losses (kW)	0.57	0.42	0.99	1.09	0.65	1.74
Cryogenic AC Power (MW)	0.43	0.31	0.74	0.82	0.49	1.31
Injector, LCLS, SPEAR3 etc (MW)			40.00			40.00
TOTAL SITE AC POWER (MW)	49.69	37.75	127.45	89.77	55.63	185.40

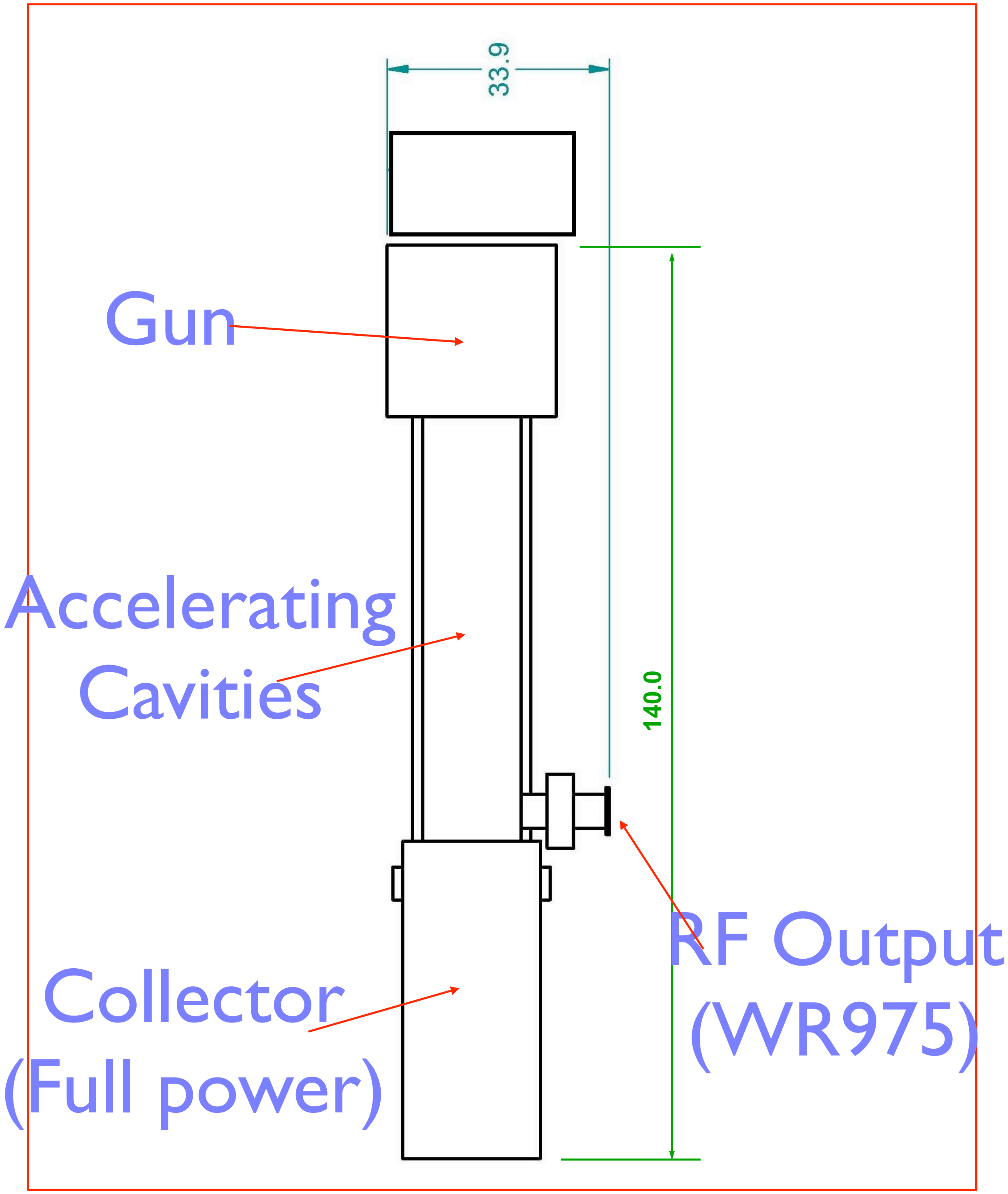
Super-B HVPS Options

P. McIntosh

- 1.2 MW Klystron:
  - Existing 2.5 MVA HVPS system compatible.
  - No development overhead.
- 2.4 MW Klystron:
  - Same 2.5 MVA HVPS design, with larger transformers to reach 4 MVA:
    - Applicable transformers are commercially available.
  - Higher voltage required (125 kV):

1.2 MW Klystron Specification

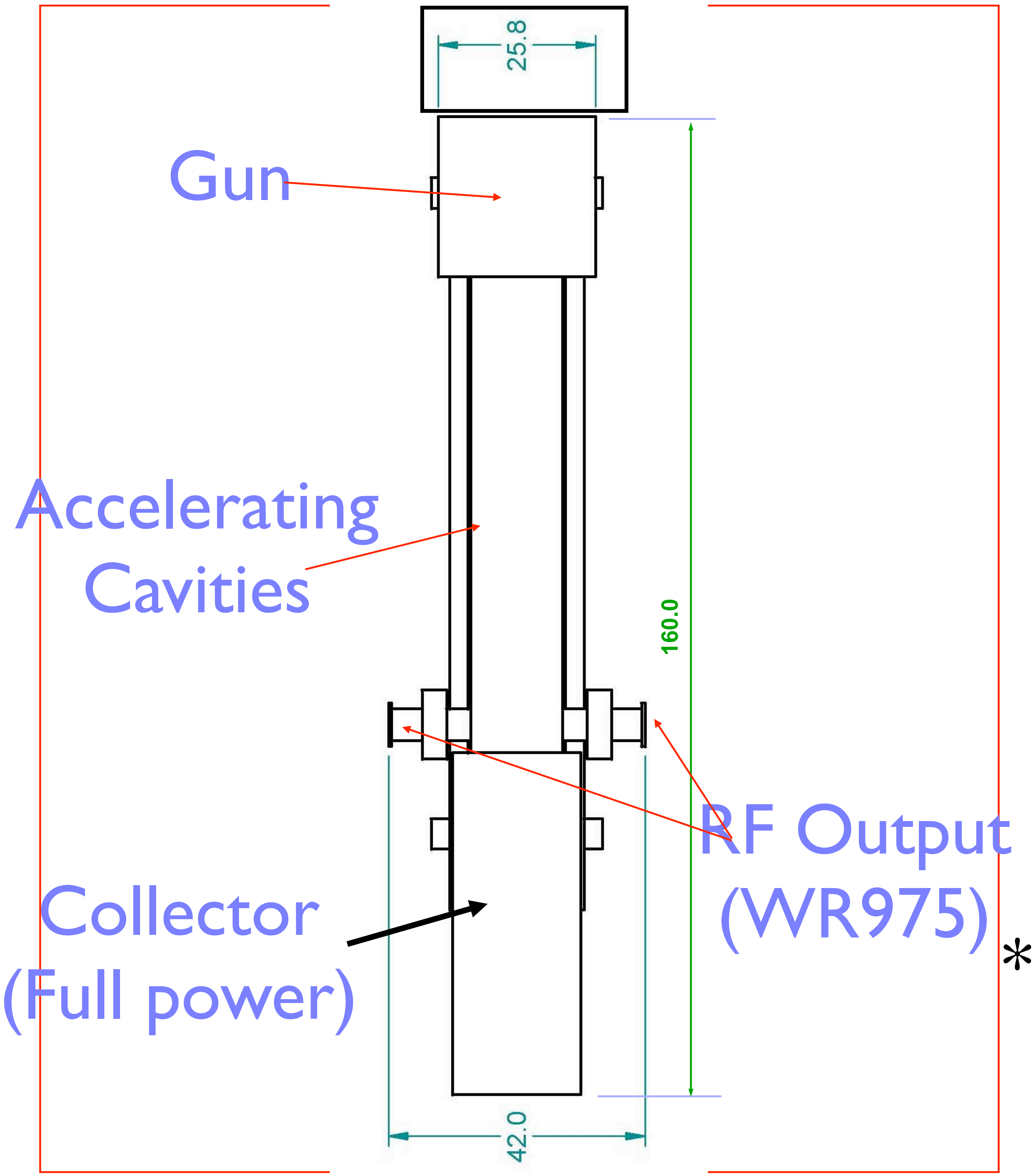
P. McIntosh



Parameter	Value
Frequency (MHz)	952
Beam Voltage (kV)	83
Beam Current (A)	24
Perveance	1.004
Bandwidth (MHz)	±10
Gain (dB)	47
Efficiency (%)	70

2.4 MW Klystron Specification

P. McIntosh



Parameter	Value
Frequency (MHz)	952
Beam Voltage (kV)	125
Beam Current (A)	29.2
Perveance ($A/V^{3/2}$)	0.6607
Bandwidth (MHz)	±8*
Gain (dB)	49.8
Efficiency (%)	70

* Needs further optimization

T. Kageyama

Summary
ARES Upgrade

- **ARES scheme is flexible to upgrade.** ← $\frac{U_s}{U_a} = \frac{k_a^2}{k_s^2}$

- **CBI due to the π/2 mode:**
  By increasing U_s/U_a from 9 to 15, the severest CBI (μ = -1) due to the π/2 accelerating mode can be eased by one order of magnitude and down to τ = 1.5 ms (manageable with an RF feedback system).

- **CBI due to the parasitic 0 and π modes:**
  The fastest growth time of CBI due to the impedance imbalance between the 0 and π modes is estimated as τ = 4 ms (manageable with longitudinal bunch-by-bunch FB system).

- **HOM loads:**
  The power capabilities of the WG and GBP HOM loads need to be increase up to ~20 kW and ~6 kW, respectively.
  The GBP with indirectly water-cooled SiC tiles should be replaced with a winged chamber loaded with directly water-cooled SiC bullets.

Summary (cont'd)

T. Kageyama

Ongoing R&D Programs

High-power testing of HOM loads

- Construction of a new test stand with a more powerful L-band klystron has been almost completed.
- RF power up to 30 kW has become available.

High-power testing of input couplers

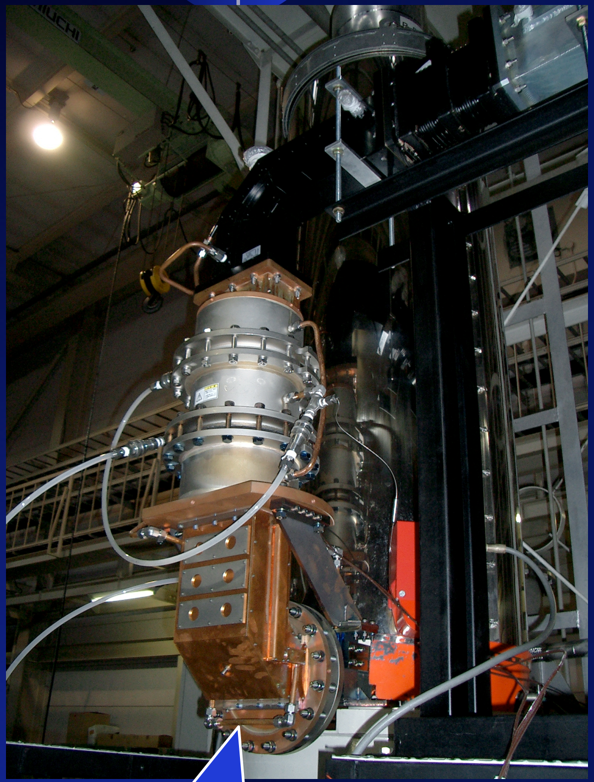
- A new test stand was constructed to simulate the operating condition as will be seen at SuperKEKB.
- We have demonstrated that the KEKB input coupler is capable of RF power over 800 kW.
- TiN coating or grooving might be necessary to completely suppress MP discharge at the coaxial line.

High-purity copper electroplating

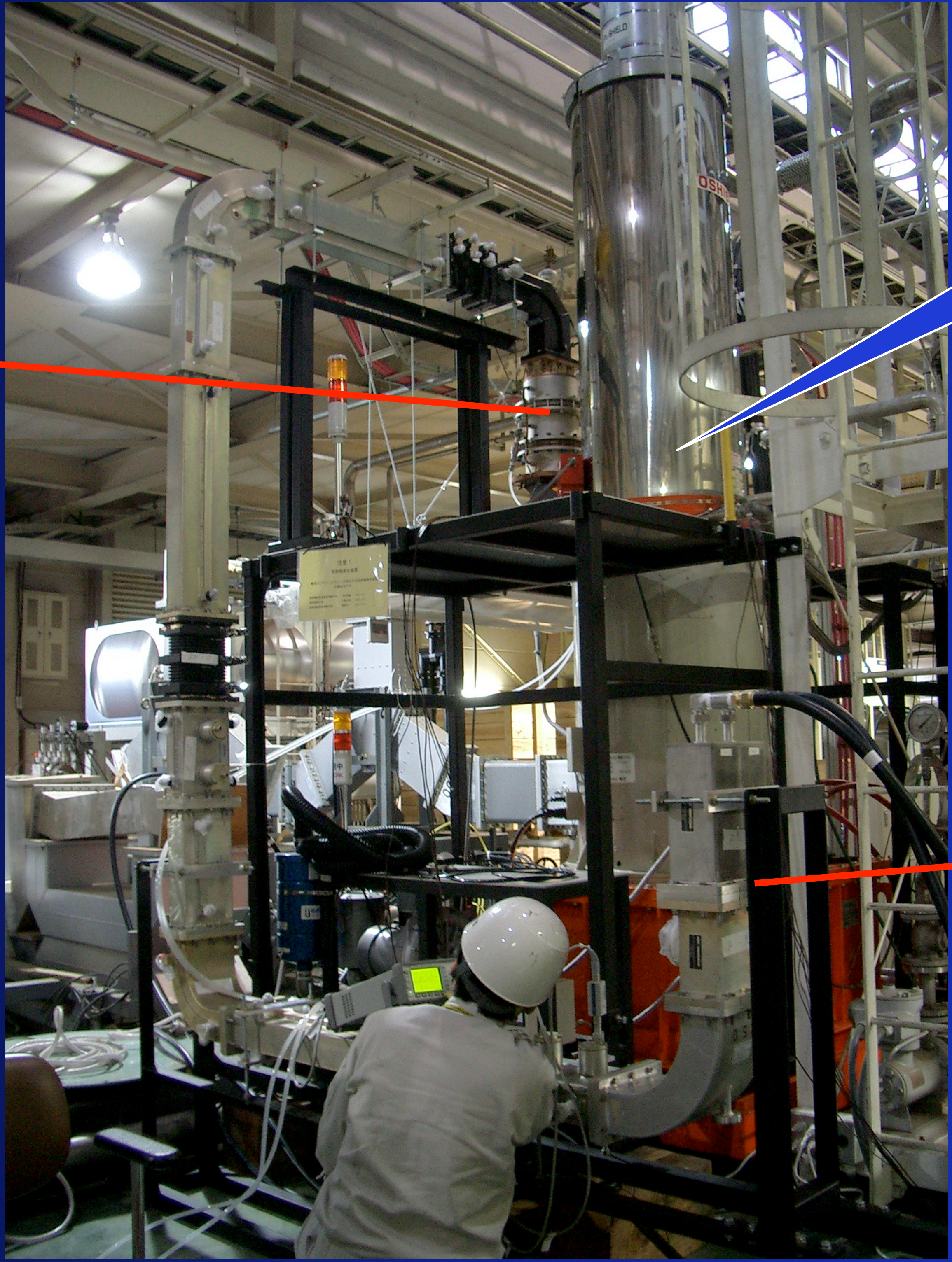
- To be applied to storage cavities newly built for SuperKEKB.
- The electric conductivity is almost the same as that of OFC.
- Electropolished copper surfaces are almost defect-free.
- A test cavity is under fabrication to study the vacuum performance.

T. Kageyama

New HOM-Load Test Stand

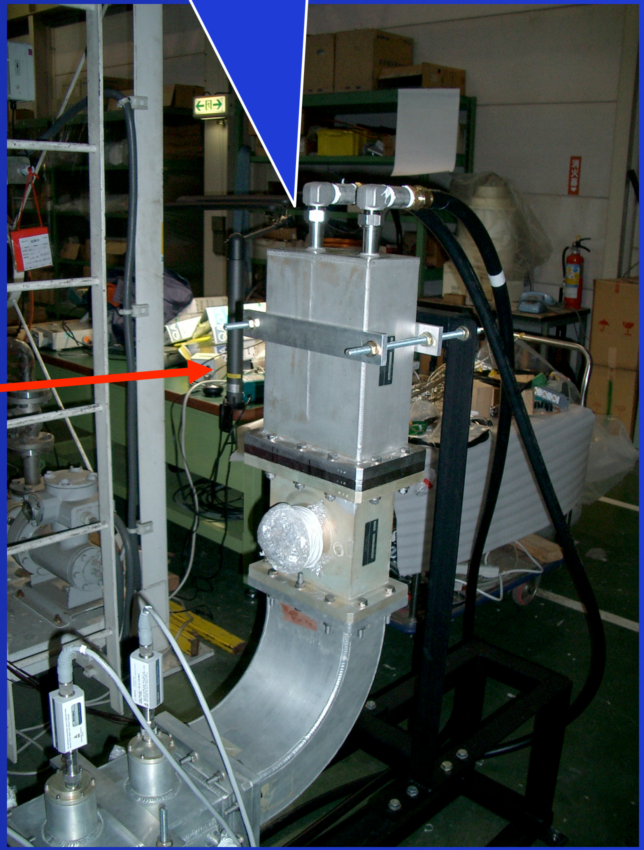


Klystron Output



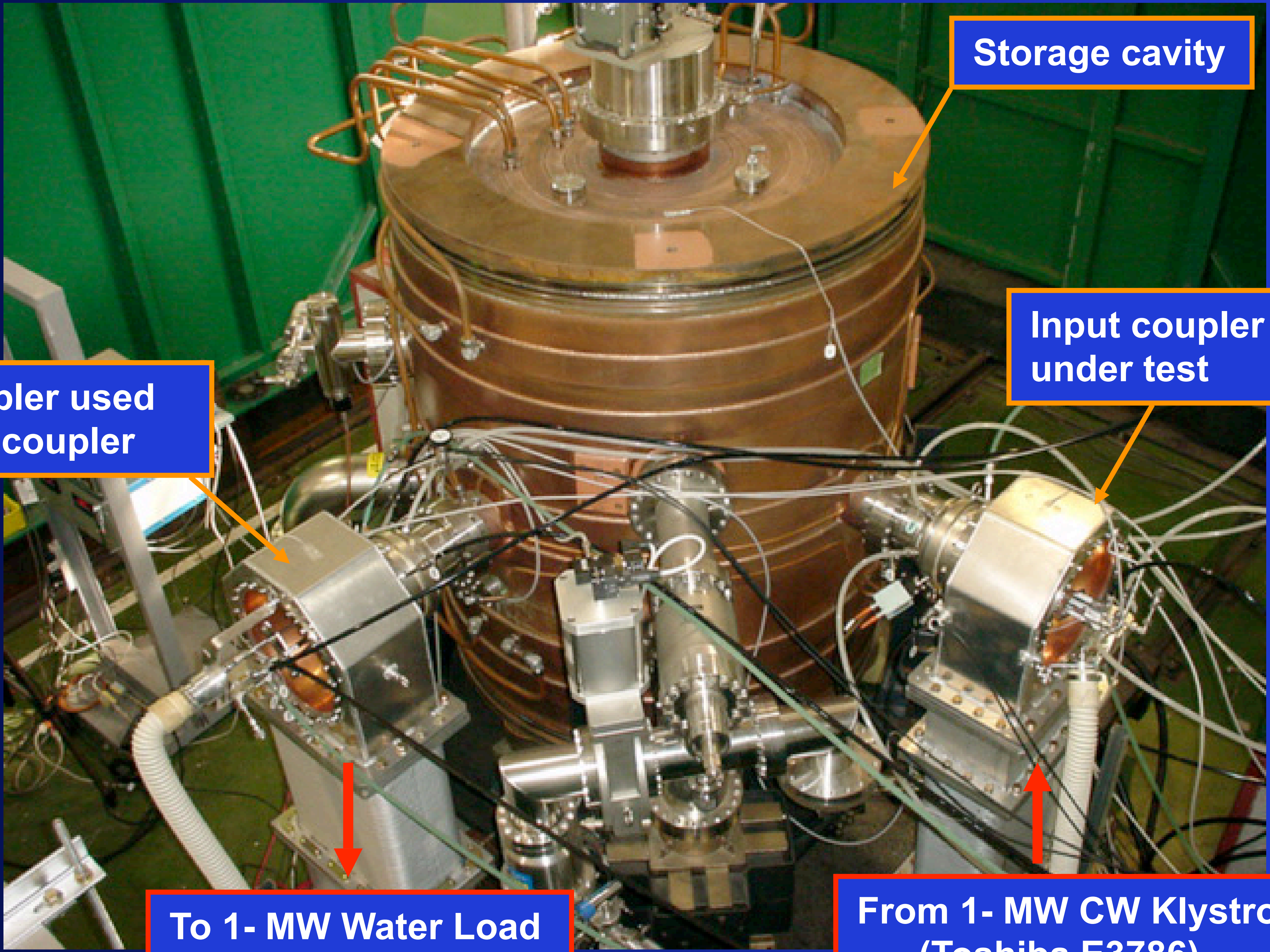
L-band Klystron

Water Dummy Load



KEKB Input Couplers tested with New Setup

T. Kageyama



Storage cavity

Input coupler under test

Input coupler used as output coupler

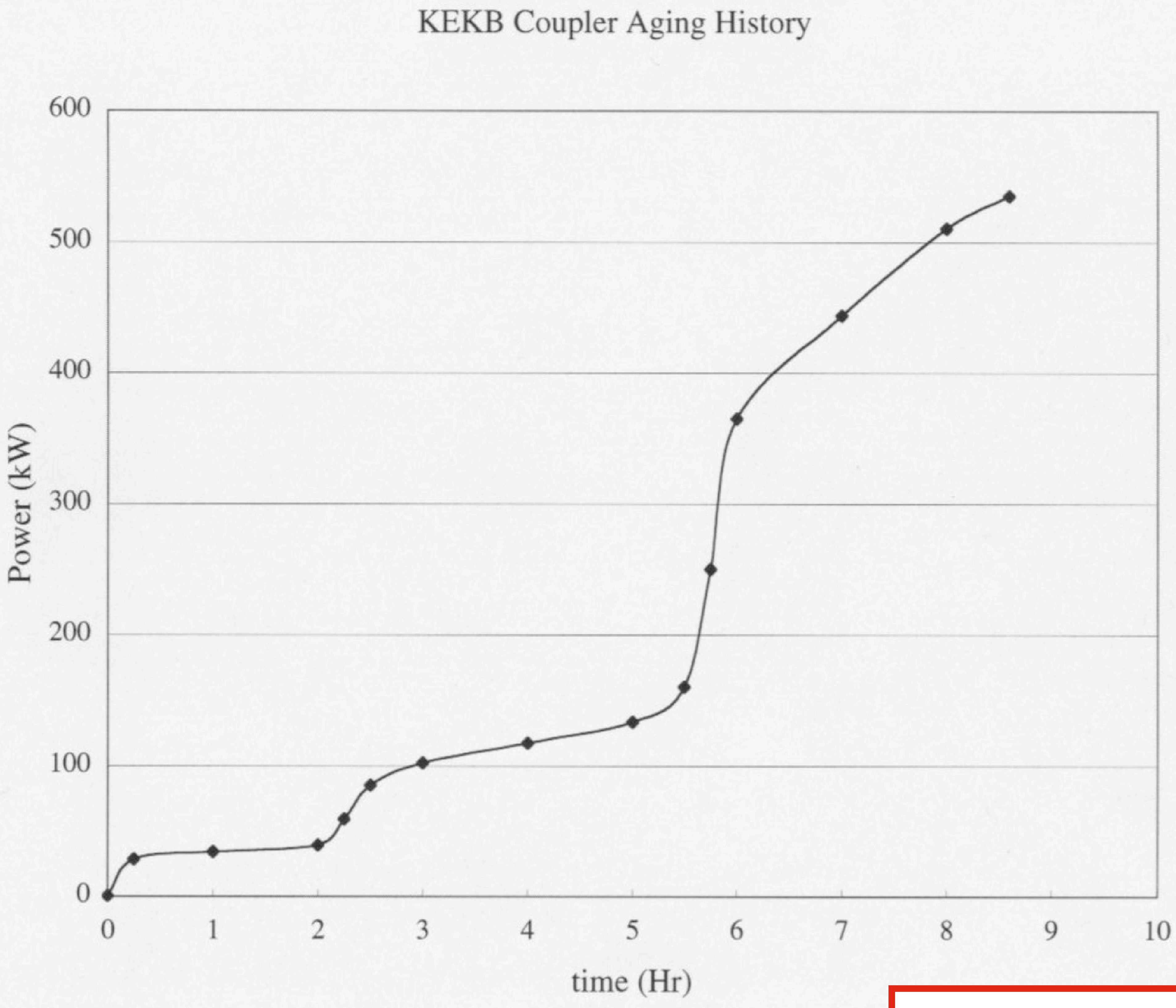
To 1- MW Water Load

From 1- MW CW Klystron (Toshiba E3786)

Summary

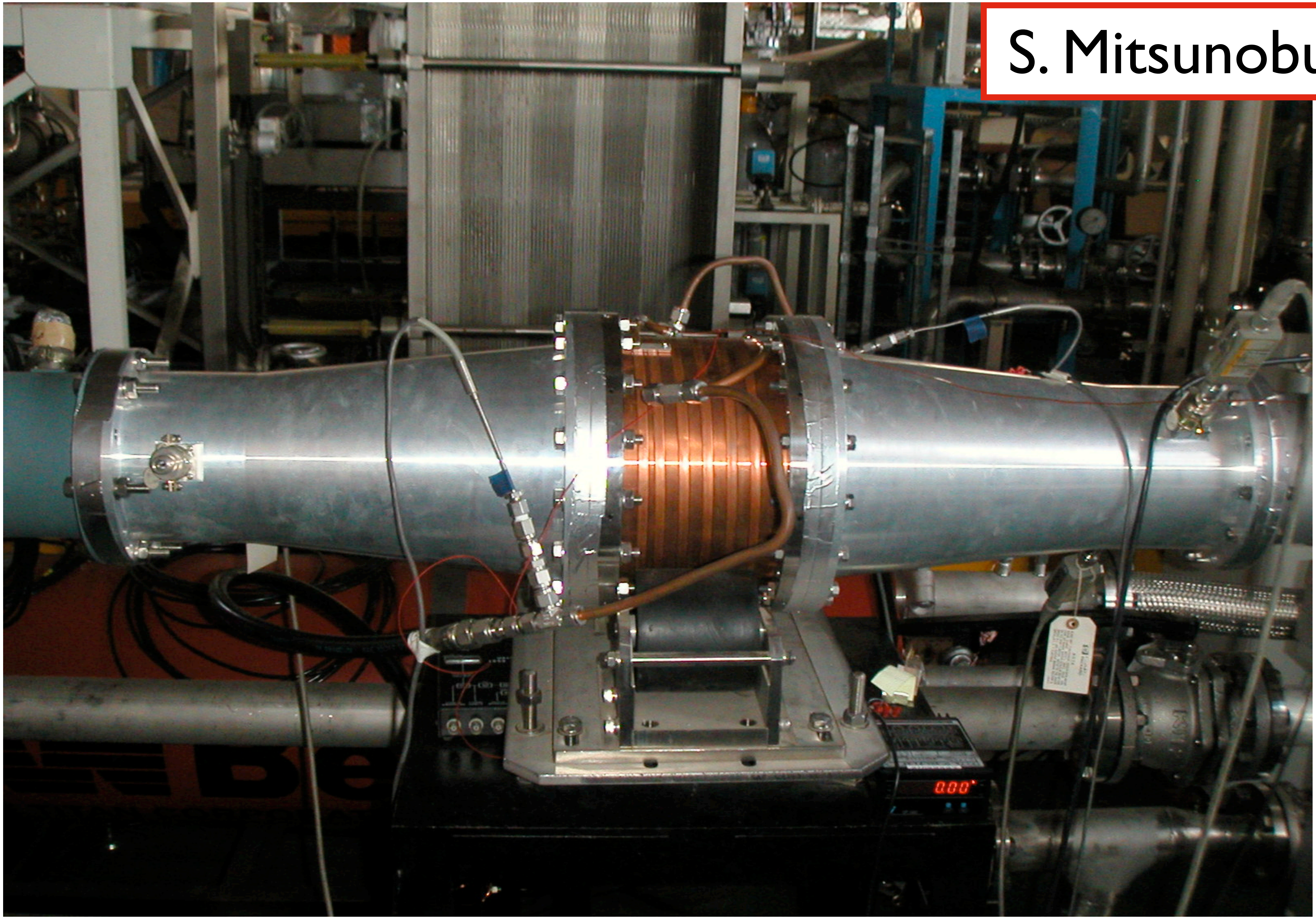
S. Mitsunobu

- KEKB SC will be used with small modification for Super-KEKB.
- Coupler already tested more than 500kW(800kW in short time),beam test will be done.
- HOM damper is most important issue for Super-KEKB SC. (43kW reached)
- Crab cavities going to be test soon.


KEKB Coupler Aging History
Power (kW)
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
time (Hr)

S. Mitsunobu

S. Mitsunobu



A SBP HOM damper have been tested up to 18 kW and 25 kW for LBP HOM damper.

5. Summary

T. Agoh

- SuperKEKB HER has no problem with CSR.

Design Ib=0.82mA   Limit 6.8mA (Ne 68 nC)

Only 5.6% bunch lengthening at design Ib

- LER is affected with CSR because of (1) short bunch length, (2) high bunch charge, (3) small bending radius.

The bunch of 3mm length and 2mA current is unstable due to CSR in the present chamber r = 47mm.

- Above a bunch current, the longitudinal instability occurs.

The threshold is Ib = 0.8mA (8nC) in the present chamber.

- Small vacuum chambers suppress CSR.

The threshold half height is r = 30mm for Ib = 2mA (20nC).

- Resistive wall wakefield moderates the sawtooth instability.

However, the instability threshold does not change so much.

- Loss factor by CSR+RW is k = 18.8V/pC for r=47mm.

It cannot be smaller than 12.3 V/pC for any vacuum chamber.

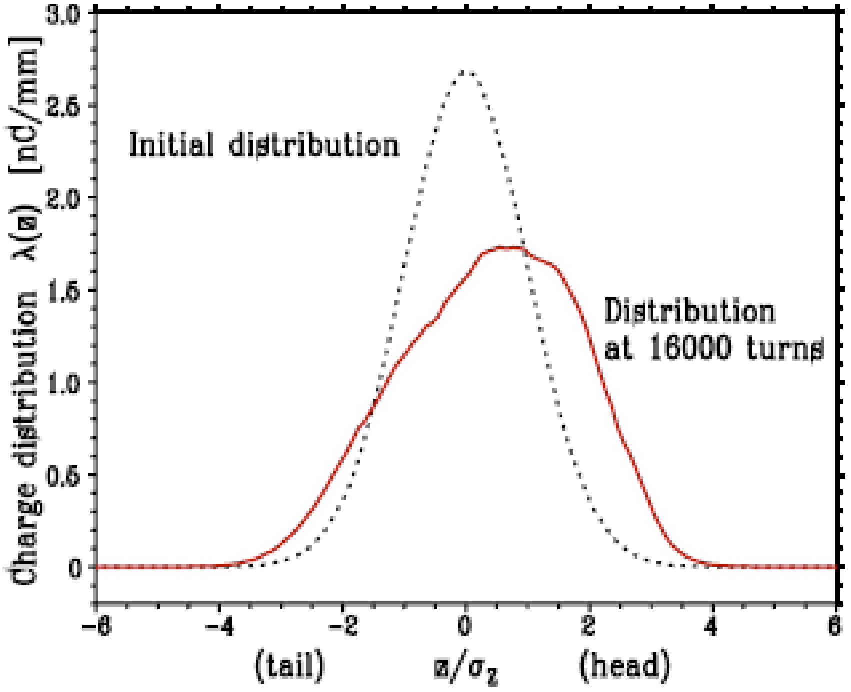
- Small vacuum components may have large impedances.

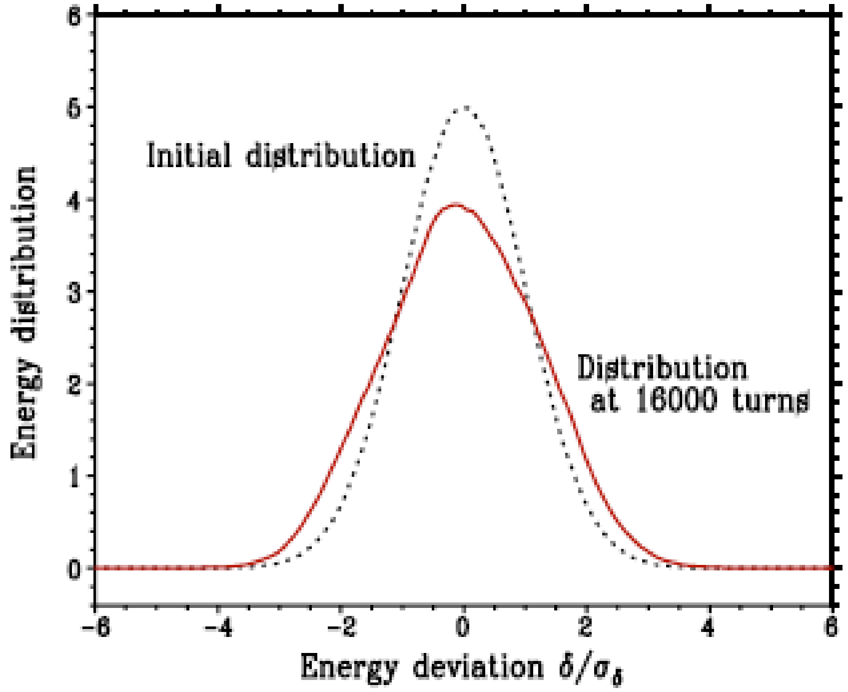
Bunch length in the SuperKEKB LER is limited by CSR.

T. Agoh

- Bunch distribution
- Energy spread

($r = 47$mm)





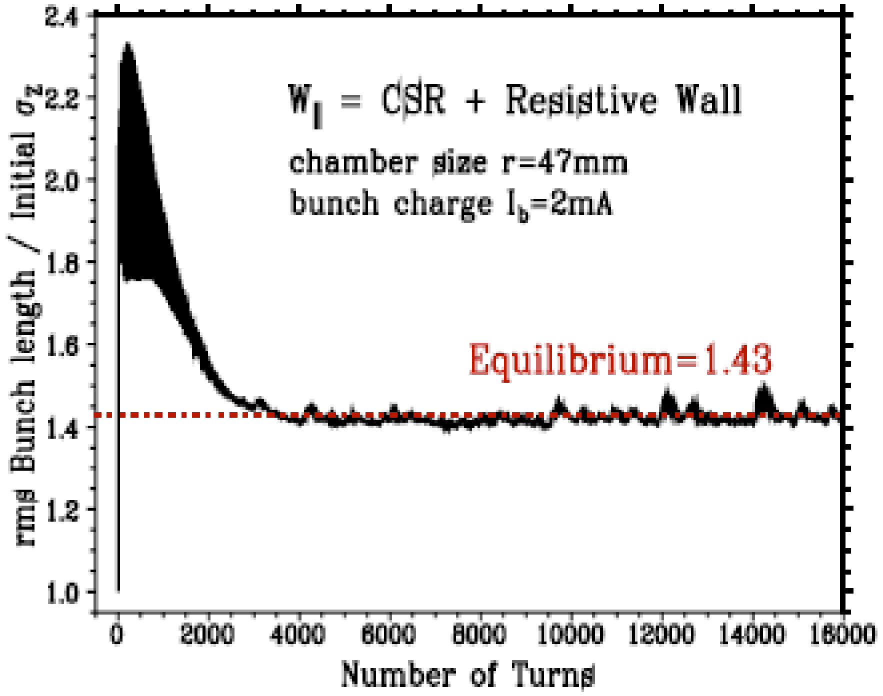
Initial

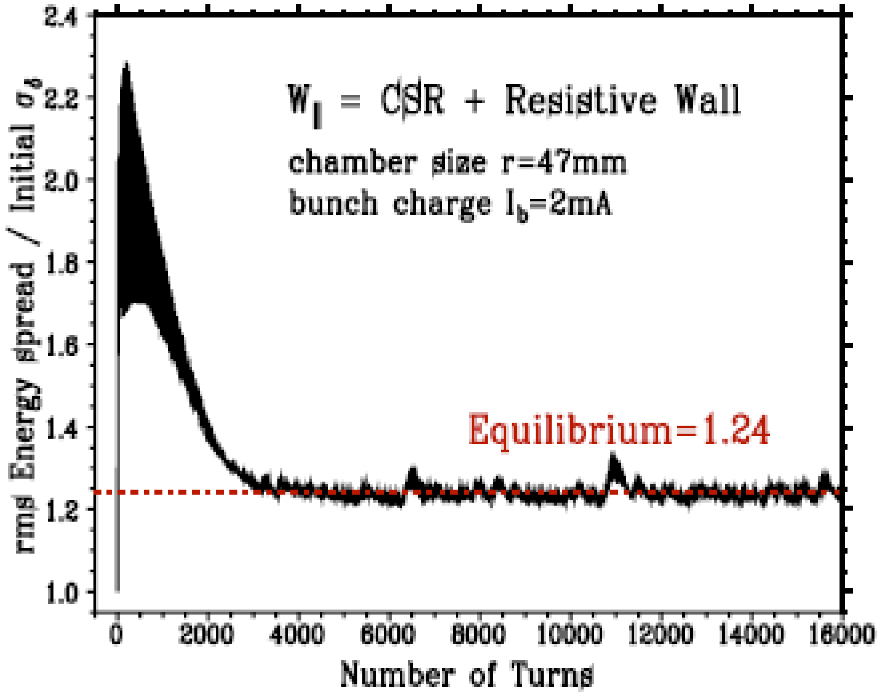
Bunch length

$\sigma_z = 3.0$mm

Energy spread

$\sigma_\delta = 7.1 \times 10^{-4}$





Equilibrium

Bunch length

$\sigma_z \sim 4.3$mm

Energy spread

$\sigma_\delta \sim 8.8 \times 10^{-4}$

UNSTABLE

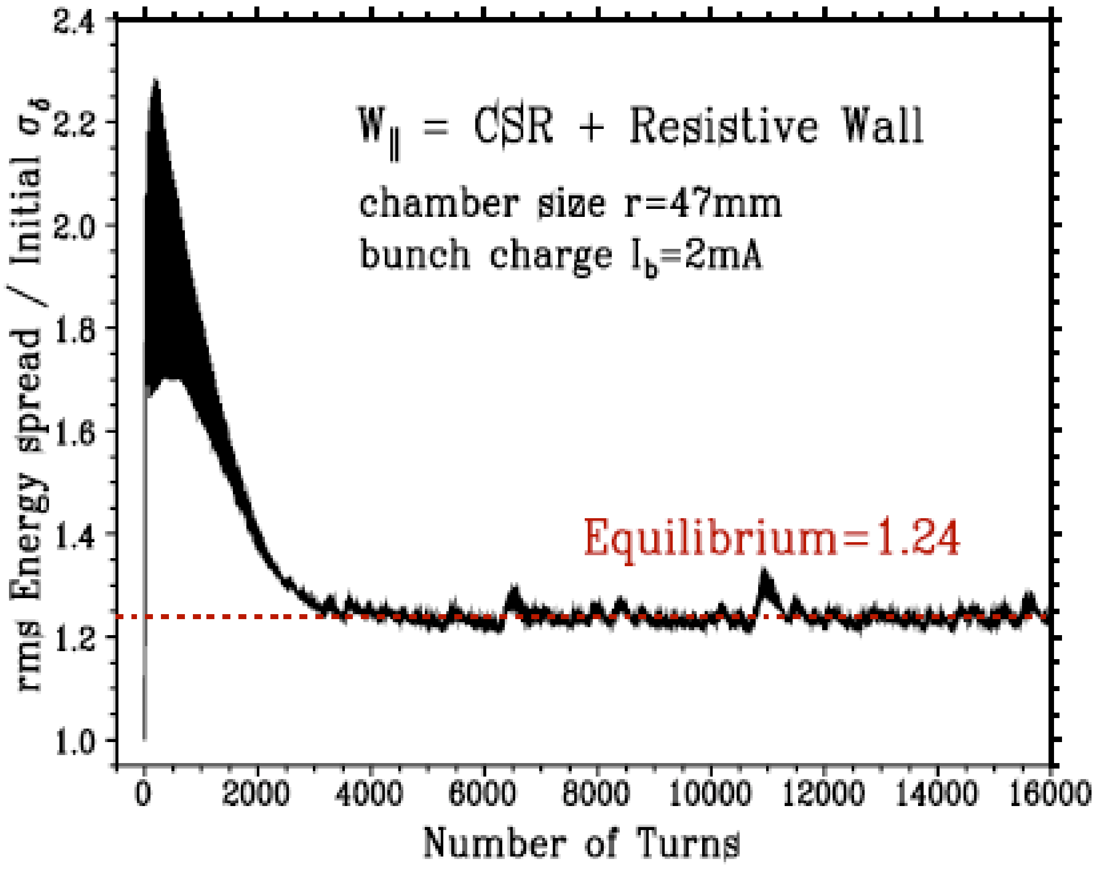
T. Agoh

Sawtooth Instability

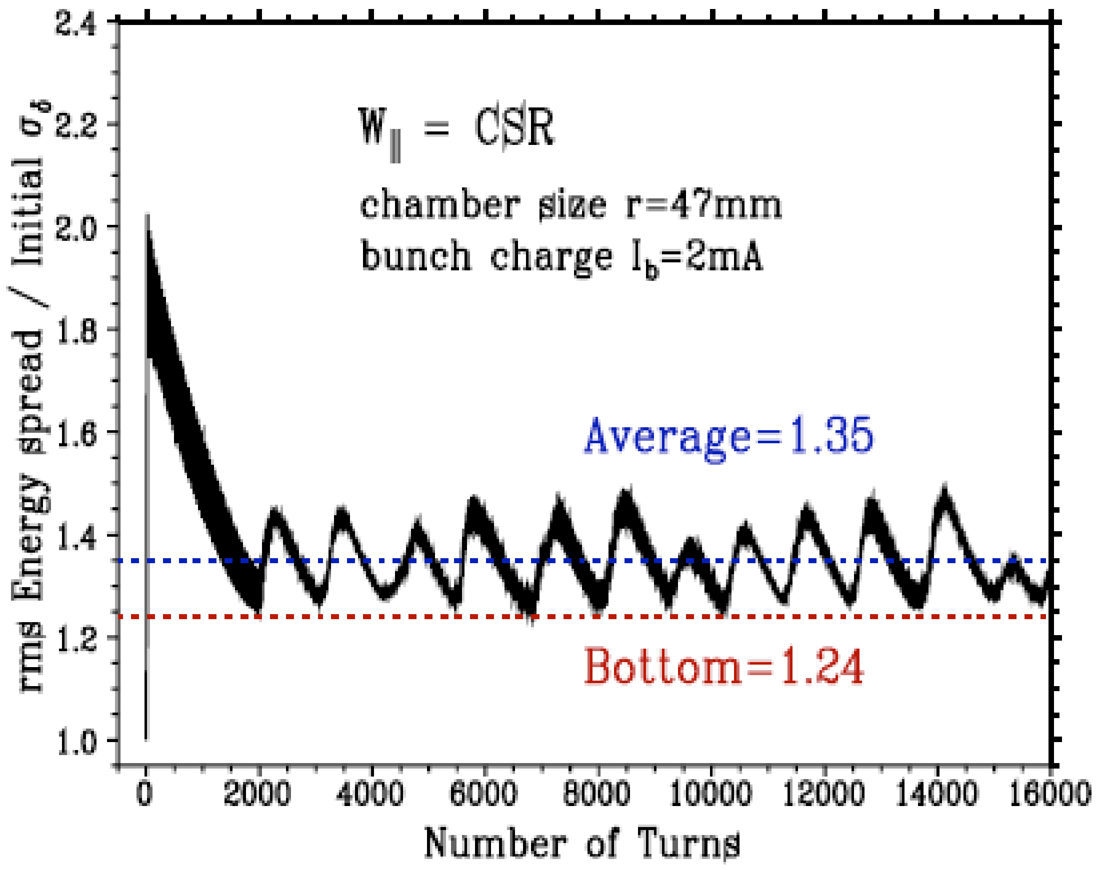
Resistive wall wakefield reduces the sawtooth amplitude.

But above a certain threshold, the energy spread is increased by CSR, the bunch is not stationary but unstable.

Oscillation: Radiation damping ⇔ CSR burst



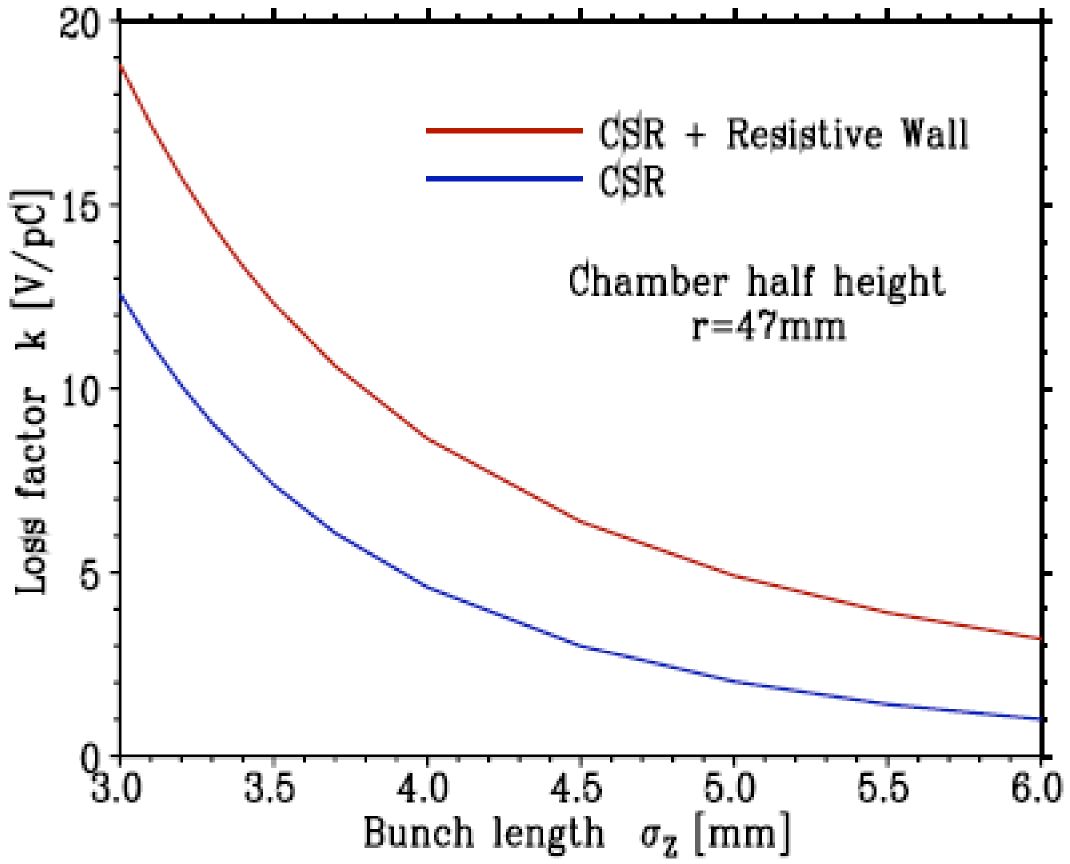
Equilibrium/ Initial $\sigma_\delta = 1.24$

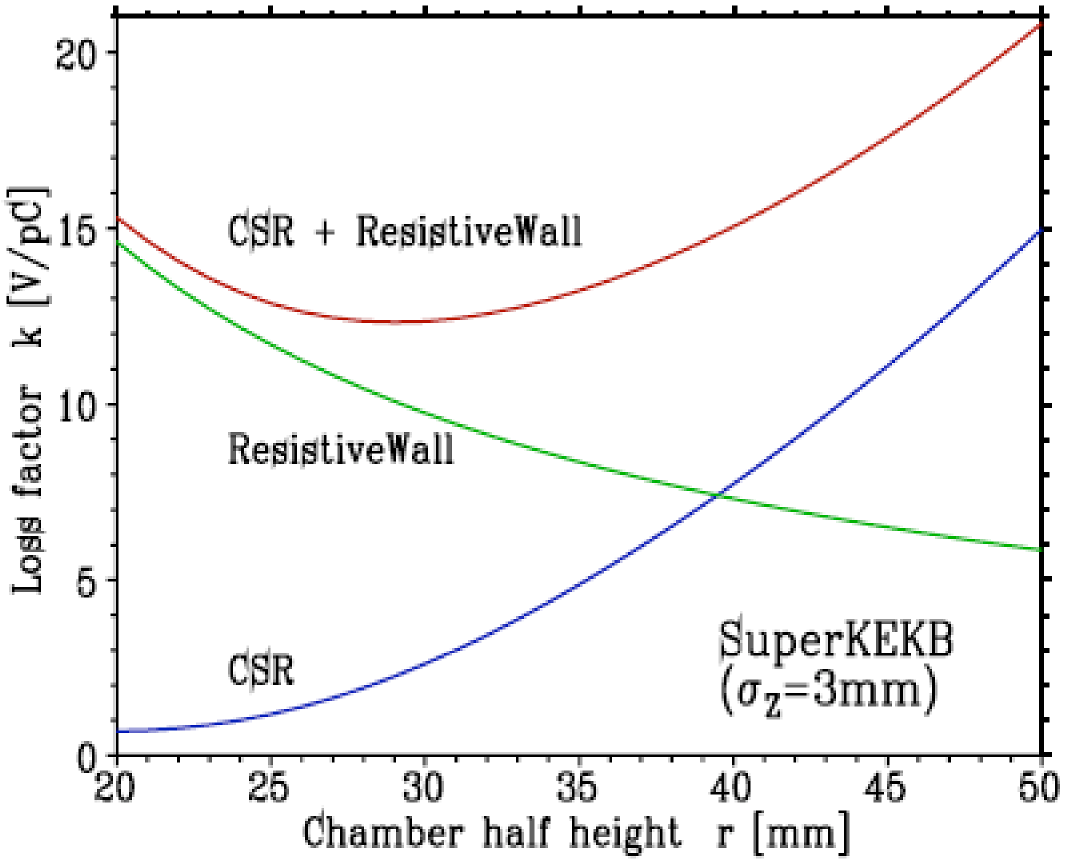


Equilibrium/ Initial $\sigma_\delta = 1.35$

T. Agoh

Loss factor due to CSR and Resistive Wall wakefield





$\boxed{\sigma_z = 3\text{mm}}$

CSR

$k = 12.6\,\text{V/pC}$

CSR + RW

$k = 18.8\,\text{V/pC}$

$\boxed{\sigma_z = 6\text{mm}}$

CSR

$k = 1.0\,\text{V/pC}$

CSR + RW

$k = 3.2\,\text{V/pC}$

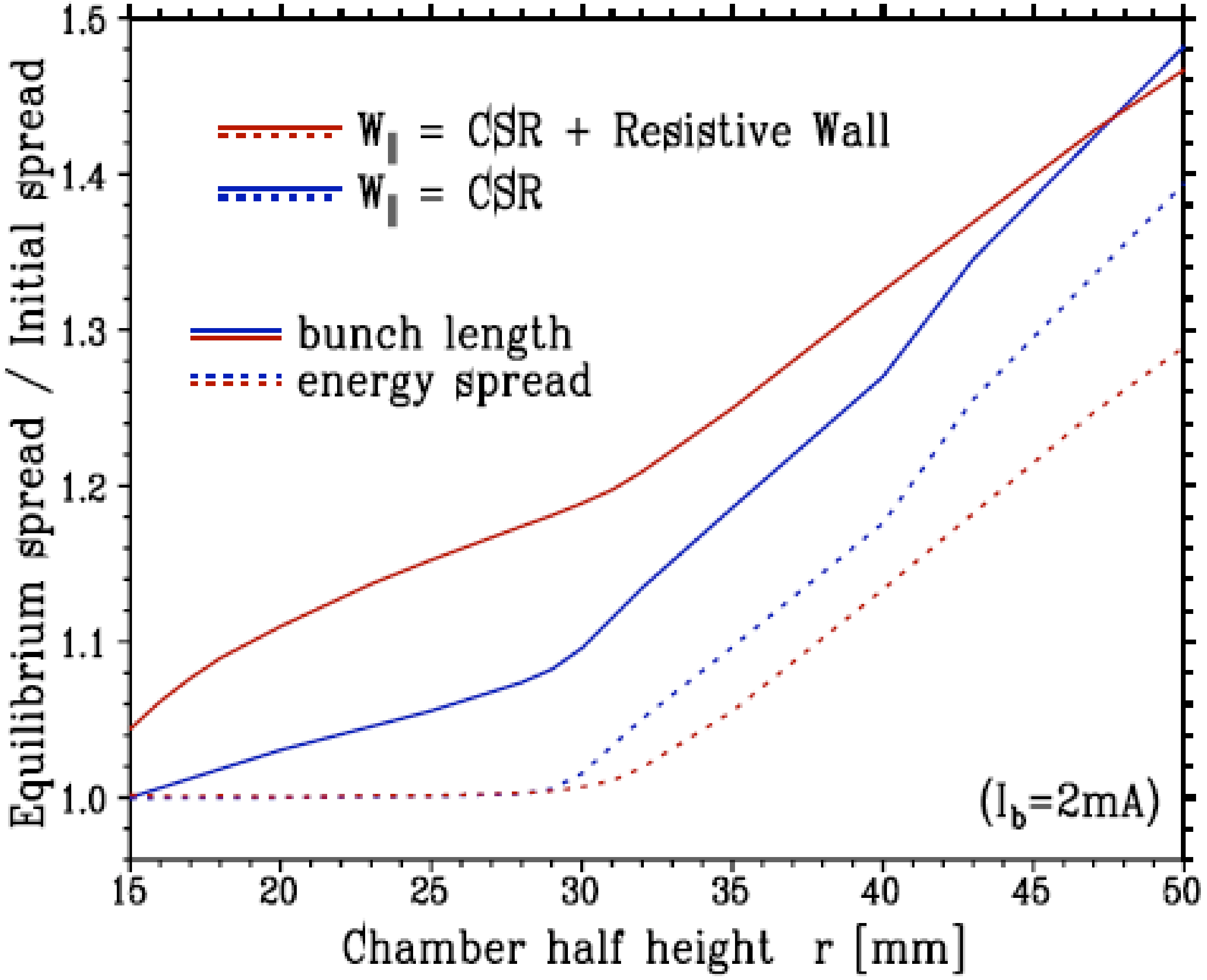
Loss factor due to CSR+RW is always larger than 12.3 V/pC.

The minimum value is determined by the dipole magnets (ρ, ℓ_m).

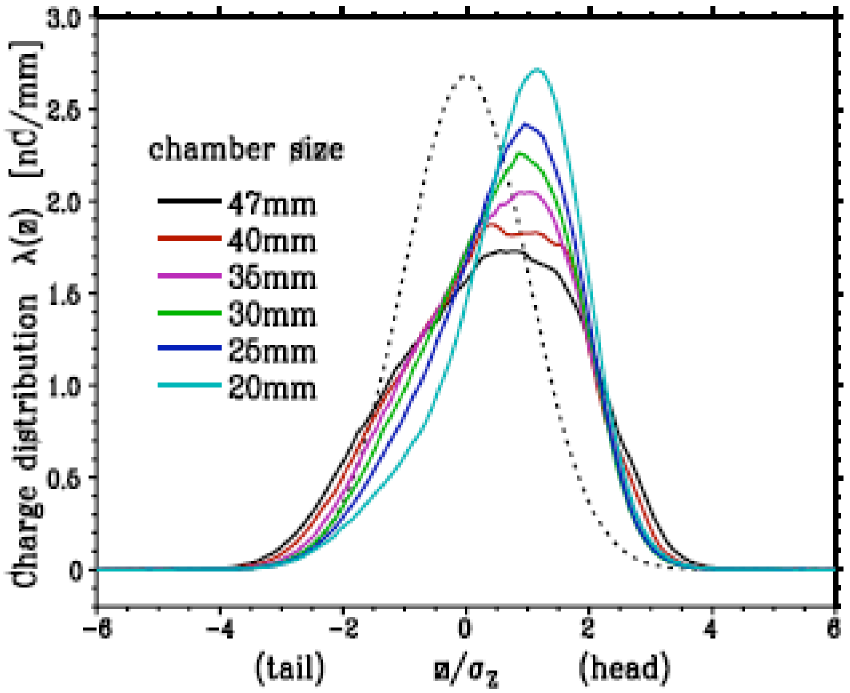
T. Agoh

Threshold for chamber size

- rms Bunch length and Energy spread



- Longitudinal bunch distribution



The bunch leans forward because of the energy loss due to the resistive wall.

Threshold for the chamber half height is $r_{\mathrm{th}} \sim 30$mm, when the bunch current is $I_b = 2$mA ($Ne \sim 20$ nC).

Summary

K. Furukawa

◆ Operational Improvements and Future Projects are Carried with Balancing between them

◆ Continuous Injection Surely Improved KEKB Luminosity

◆ Simultaneous Injection Project will Help both KEKB and PF Advanced Operation, and also Other Rings in Future

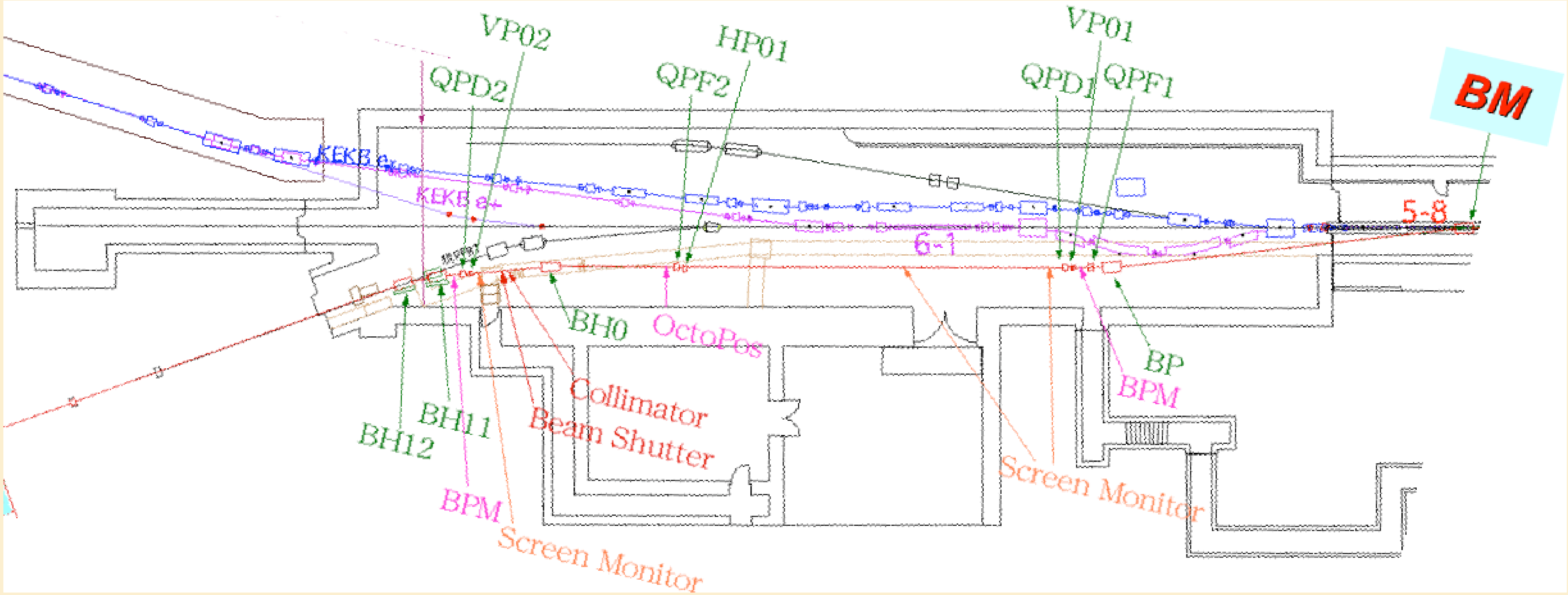
◆ Oriented Crystalline Positron Target may Enhance Positron Production

◆ C-band R&D for SuperKEKB Advances Steadily in relatively Short Term, and the Results seem to be Promising

Upgrade Overview

K. Furukawa

- It was decided to be Carried out as Soon as Possible.
- Upgrade would be Carried in 3 Phases
  - Phase-I: Construction of New PF-BT Line Summer 2005
  - Phase-II: Simultaneous Injection between KEKB e^- and PF e^-
  - Phase-III: Simultaneous Injection including KEKB e^+ (,PF-AR)
- Control / Timing Systems will be upgraded during Phases

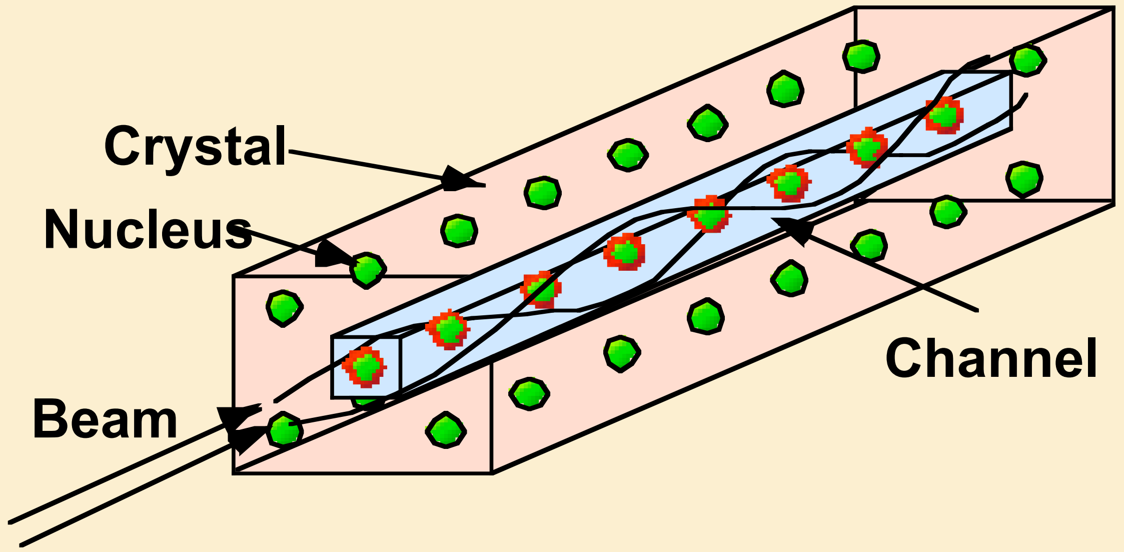


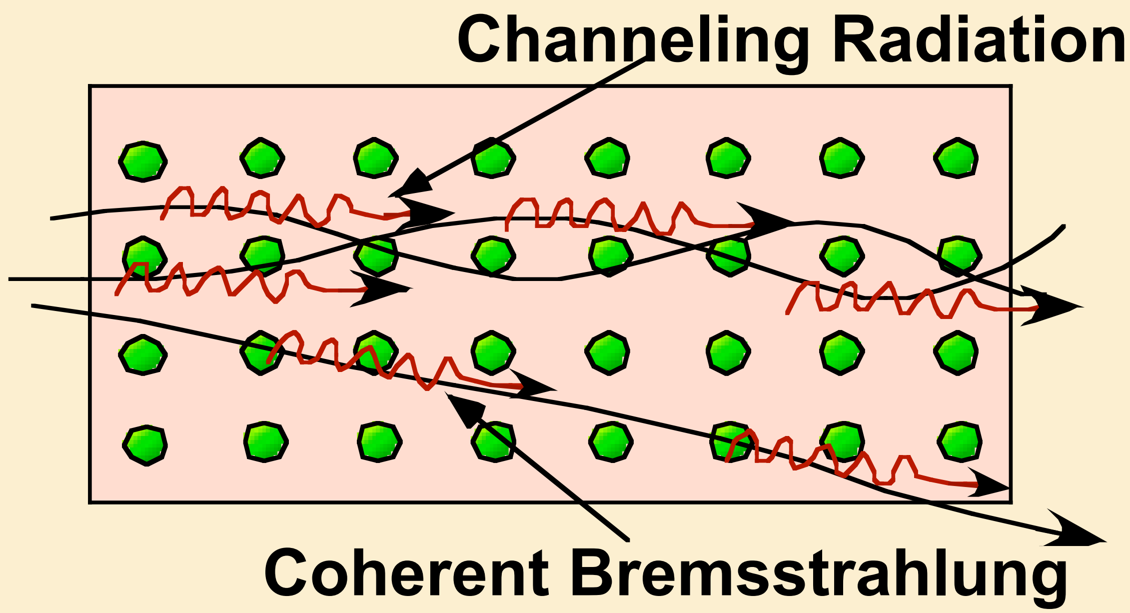
Positron Generation with Crystalline Tungsten

(Collaboration between KEK, Tokyo Metro. Univ., Hiroshima Univ., Tomsk Polytech., LAL-Orsay)

K. Furukawa

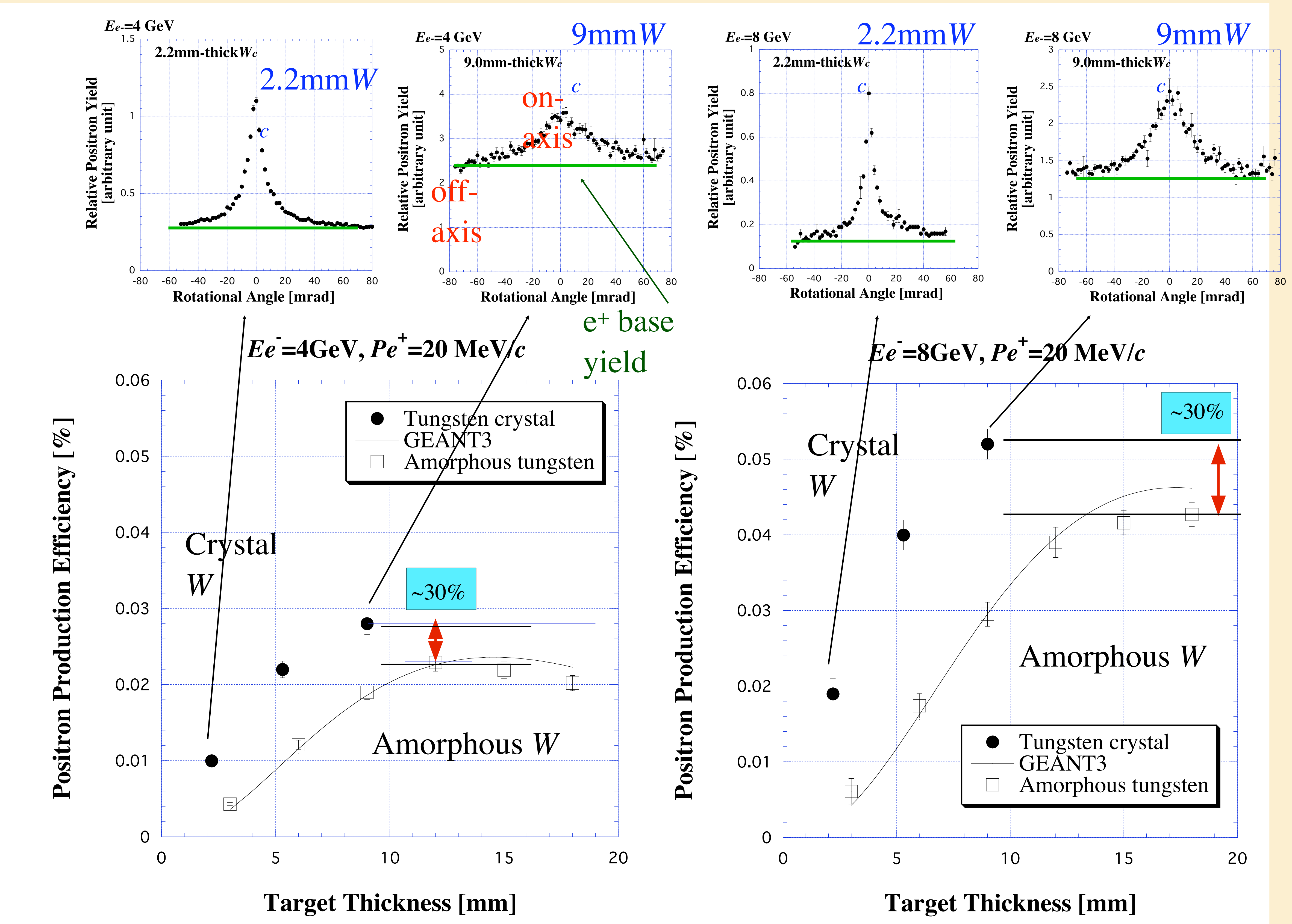
- High Intensity Positron is Always a Challenge in Electron-Positron Colliders
  - Positron Production Enhancement by Channeling Radiation in Single Crystal Target was Proposed by R. Chehab et. al (1989)
  - The Effect was Confirmed Experimentally in Japan (INS/Tokyo, KEK) and at CERN





Typical Experimental Measurements

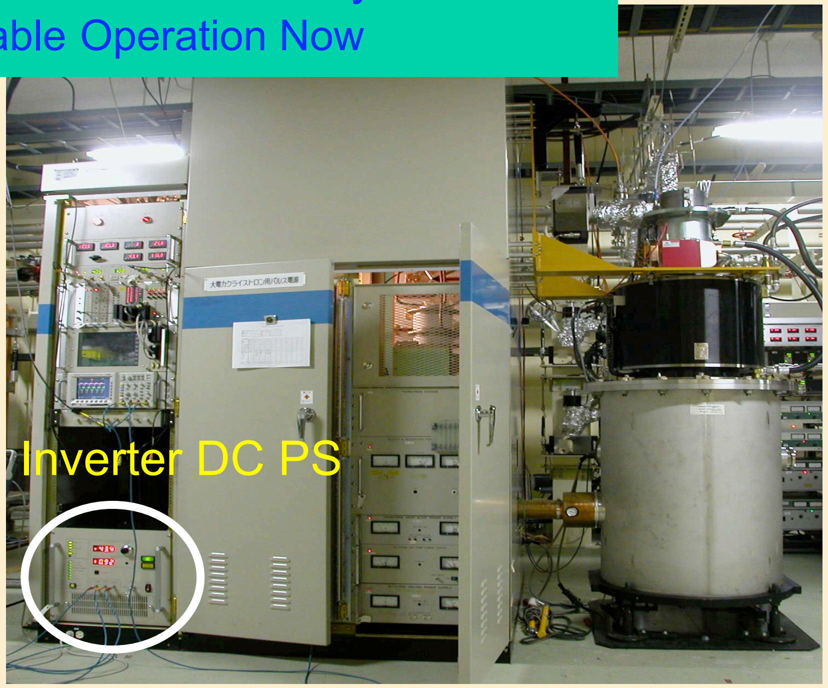
K. Furukawa



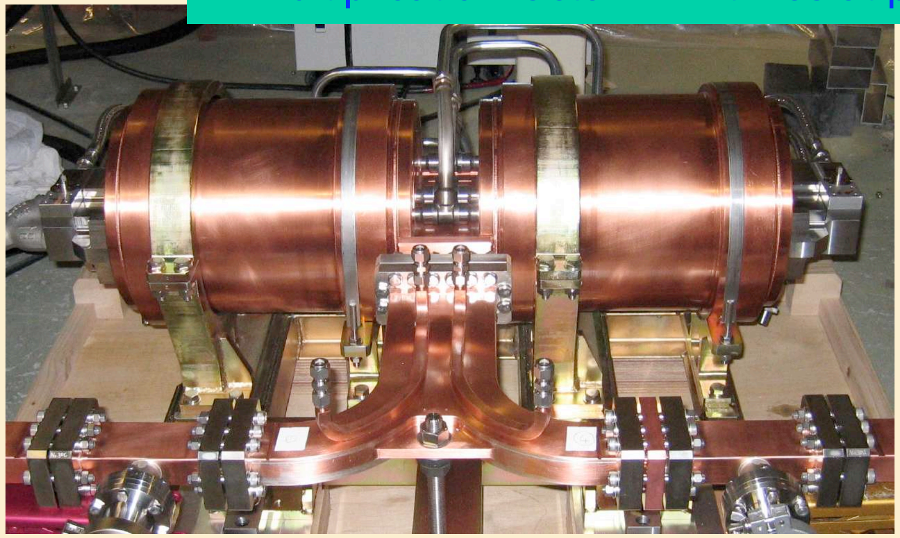
C-band Components

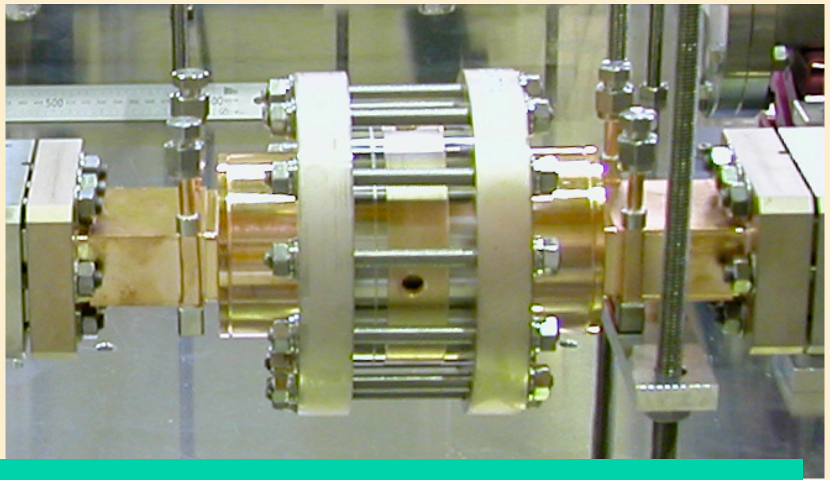
K. Furukawa

C-band modulator & klystron
- Reliable Operation Now

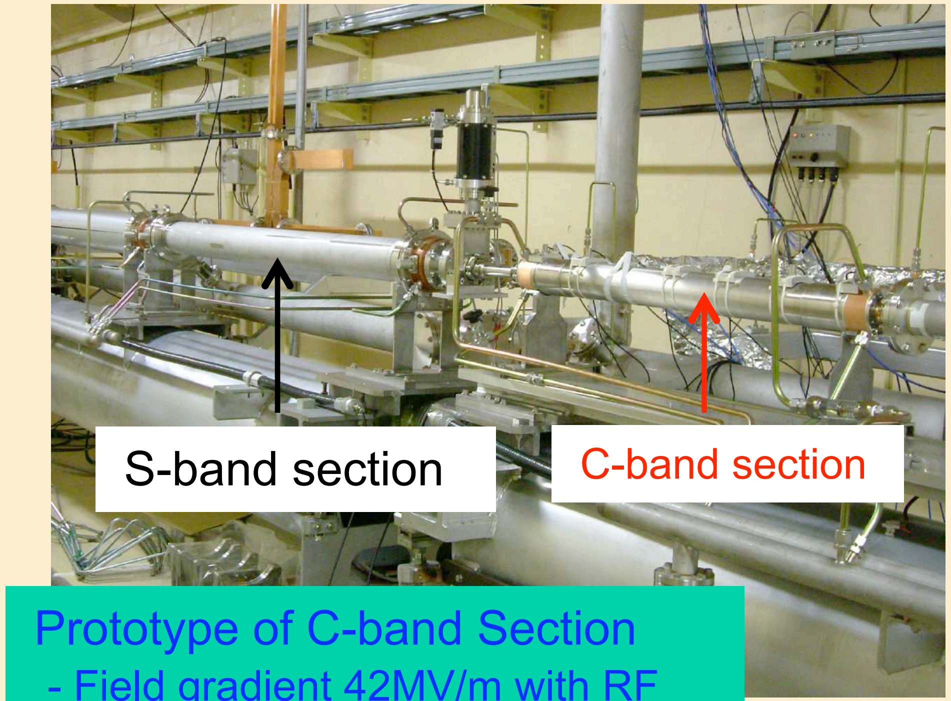


RF compressor
- TE038 type.
- 200 MW achieved at Test Stand.
- Multiplication factor: 4.7 times at peak.



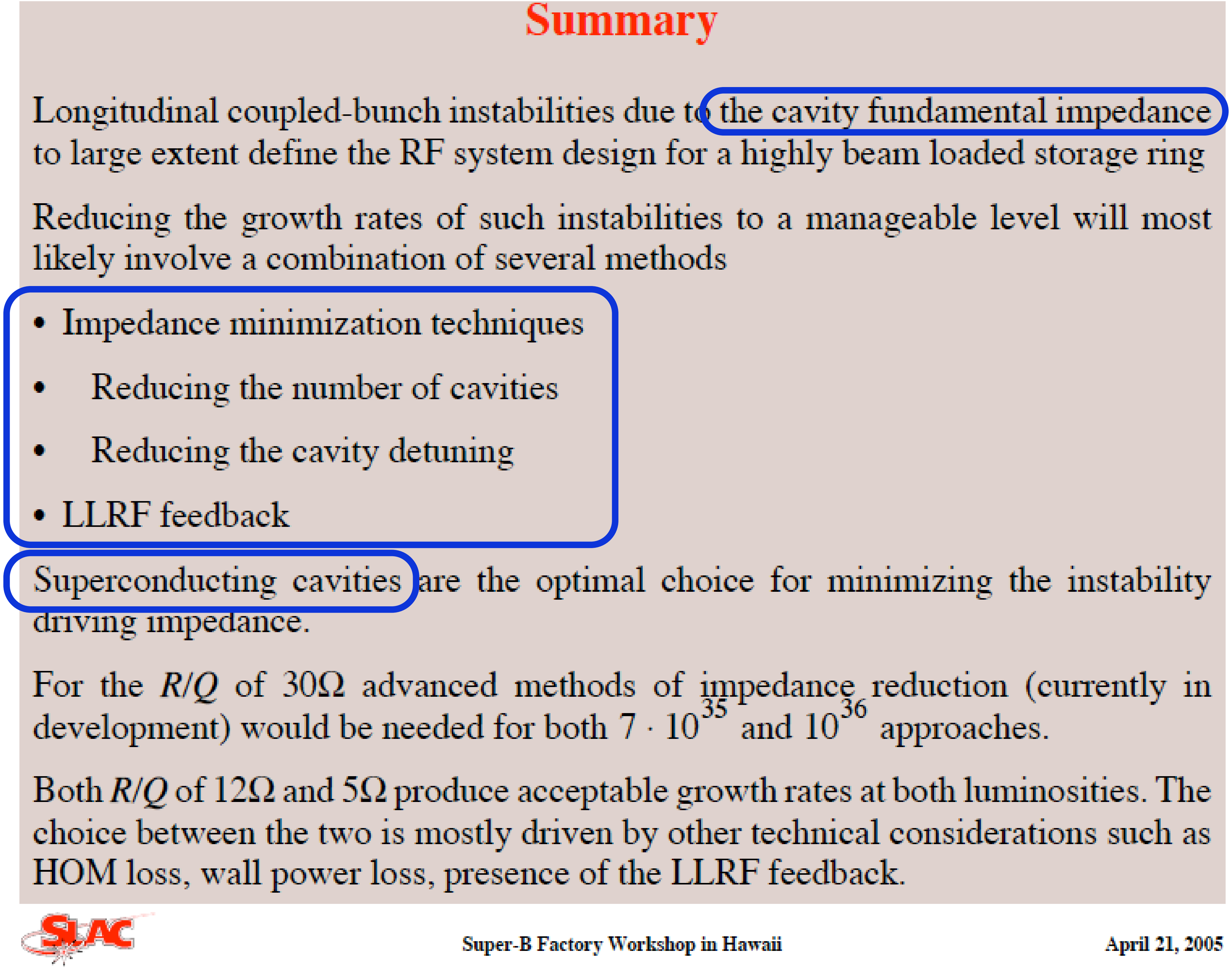


Mix-mode RF window
- TE11 +TM11
- 300MW transmission power is achieved.



Prototype of C-band Section
- Field gradient 42MV/m with RF compressor.

D. Teytelman



Summary

Longitudinal coupled-bunch instabilities due to the cavity fundamental impedance to large extent define the RF system design for a highly beam loaded storage ring

Reducing the growth rates of such instabilities to a manageable level will most likely involve a combination of several methods

- Impedance minimization techniques
  - Reducing the number of cavities
  - Reducing the cavity detuning
- LLRF feedback

Superconducting cavities are the optimal choice for minimizing the instability driving impedance.

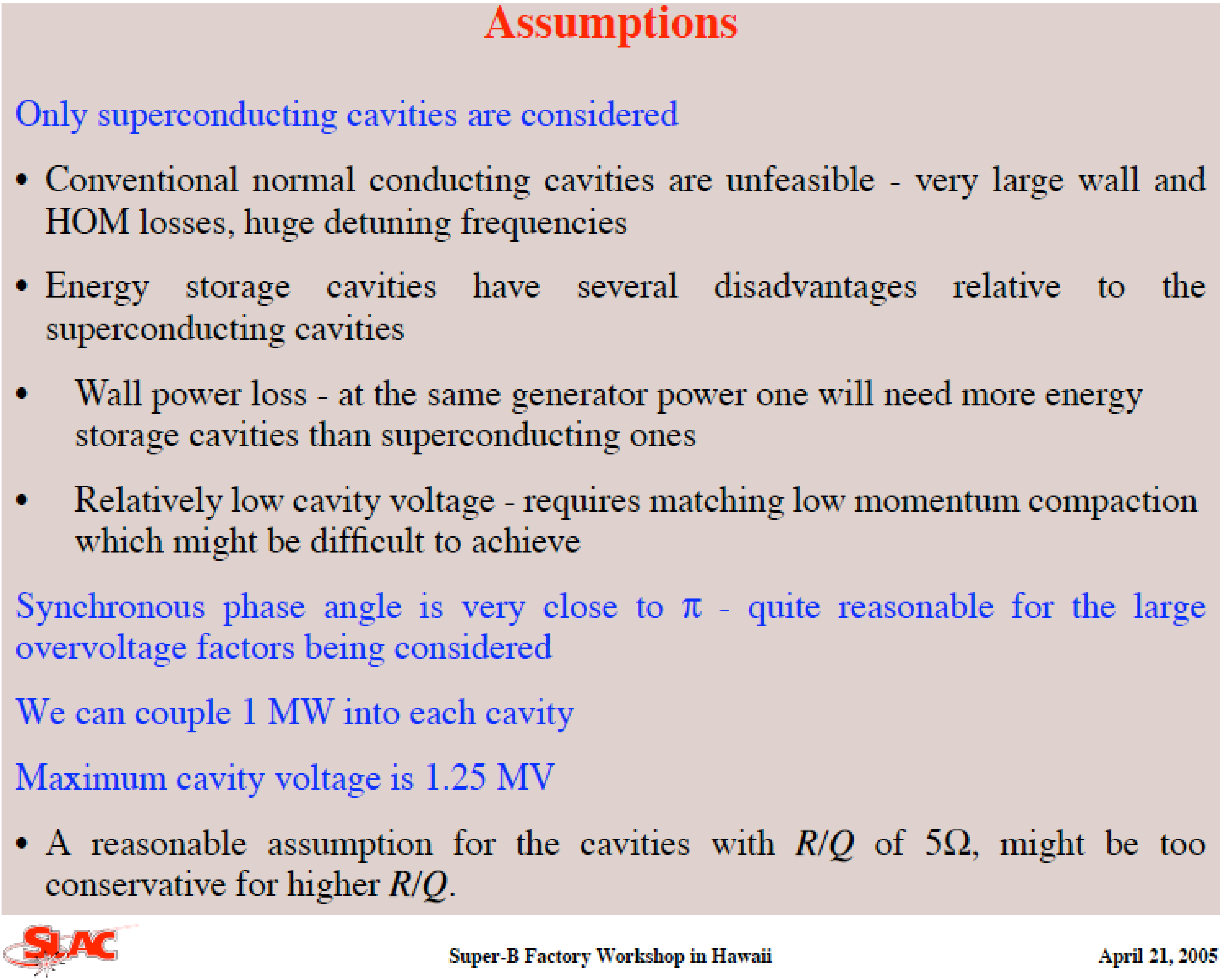
For the R/Q of 30Ω advanced methods of impedance reduction (currently in development) would be needed for both $7 \cdot 10^{35}$ and 10^{36} approaches.

Both R/Q of 12Ω and 5Ω produce acceptable growth rates at both luminosities. The choice between the two is mostly driven by other technical considerations such as HOM loss, wall power loss, presence of the LLRF feedback.

Super-B Factory Workshop in Hawaii

April 21, 2005

D. Teytelman



Assumptions

Only superconducting cavities are considered

- Conventional normal conducting cavities are unfeasible - very large wall and HOM losses, huge detuning frequencies
- Energy storage cavities have several disadvantages relative to the superconducting cavities
- Wall power loss - at the same generator power one will need more energy storage cavities than superconducting ones
- Relatively low cavity voltage - requires matching low momentum compaction which might be difficult to achieve

Synchronous phase angle is very close to π - quite reasonable for the large overvoltage factors being considered

We can couple 1 MW into each cavity

Maximum cavity voltage is 1.25 MV

- A reasonable assumption for the cavities with *R*/*Q* of 5Ω, might be too conservative for higher *R*/*Q*.

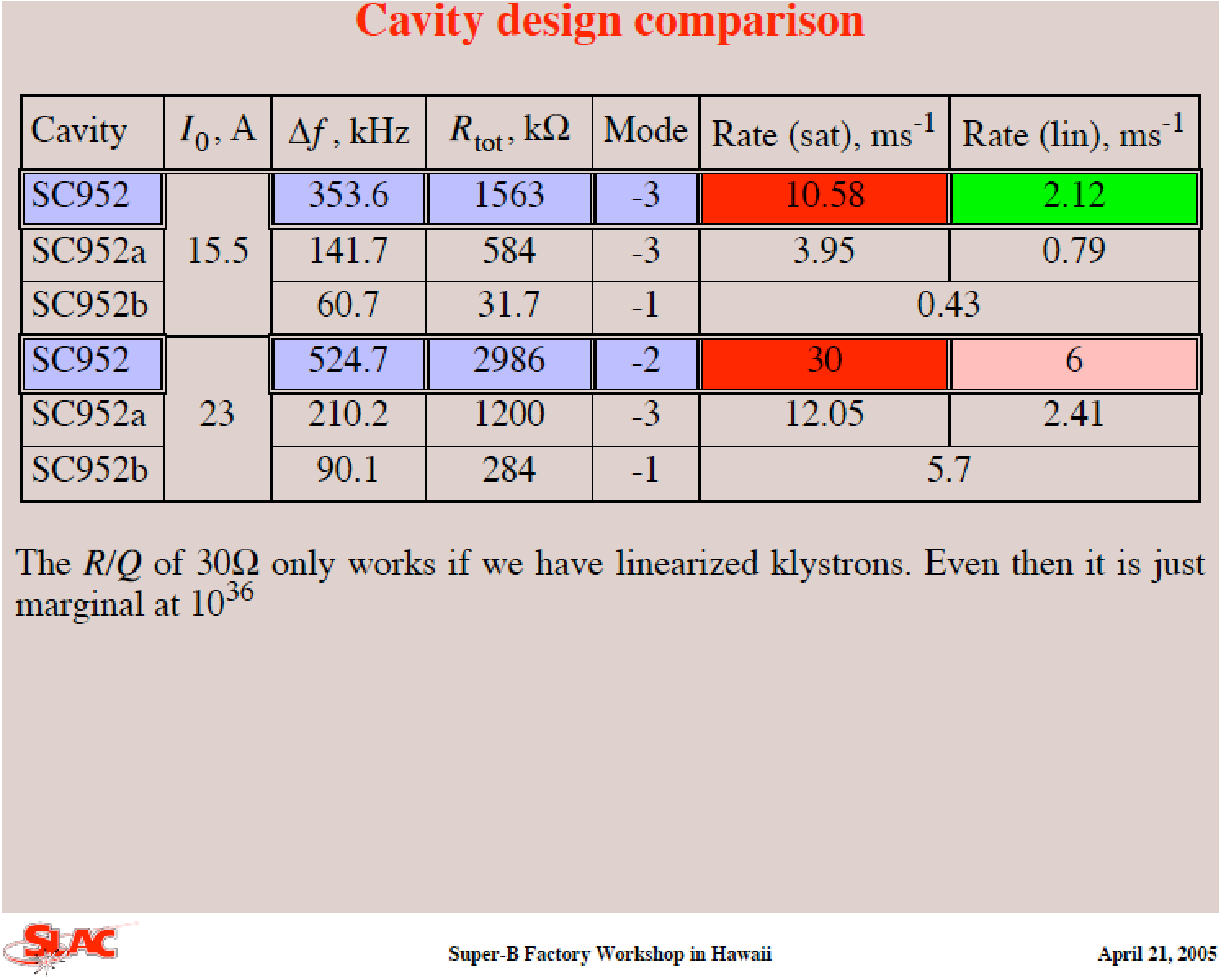
SLAC

Super-B Factory Workshop in Hawaii

April 21, 2005

R/Q = 30 Ohm

D. Teytelman



Cavity design comparison

Cavity	I_0, A	Δf, kHz	R_{tot}, kΩ	Mode	Rate (sat), ms^{-1}	Rate (lin), ms^{-1}
SC952	15.5	353.6	1563	-3	10.58	2.12
SC952a		141.7	584	-3	3.95	0.79
SC952b		60.7	31.7	-1	0.43	
SC952	23	524.7	2986	-2	30	6
SC952a		210.2	1200	-3	12.05	2.41
SC952b		90.1	284	-1	5.7	

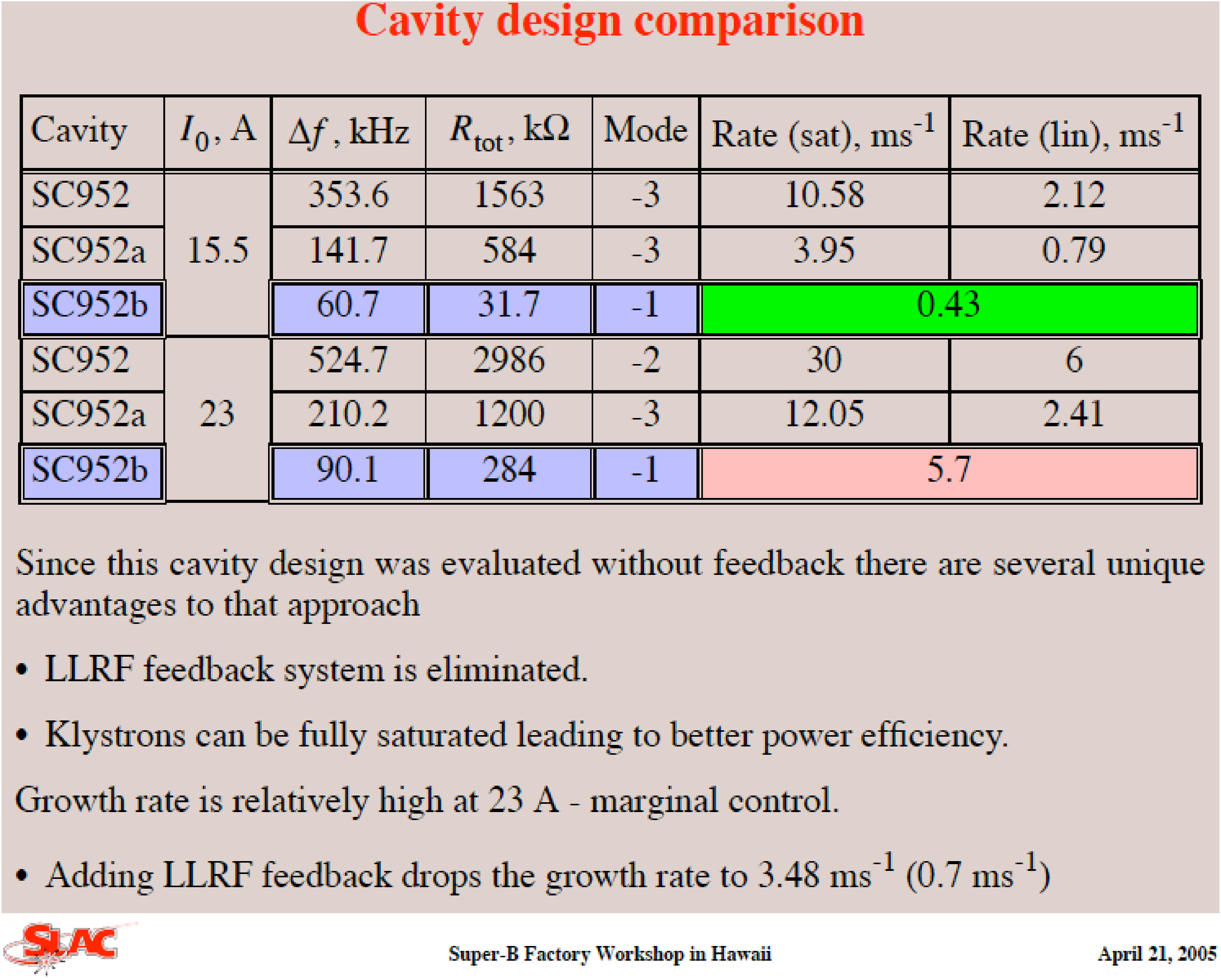
The R/Q of 30Ω only works if we have linearized klystrons. Even then it is just marginal at 10^{36}

Super-B Factory Workshop in Hawaii

April 21, 2005

R/Q = 5 Ohm

D. Teytelman



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SC952b		90.1	284	-1	5.7	

Since this cavity design was evaluated without feedback there are several unique advantages to that approach

- LLRF feedback system is eliminated.
- Klystrons can be fully saturated leading to better power efficiency.

Growth rate is relatively high at 23 A - marginal control.

- Adding LLRF feedback drops the growth rate to 3.48 ms^{-1} (0.7 ms^{-1})

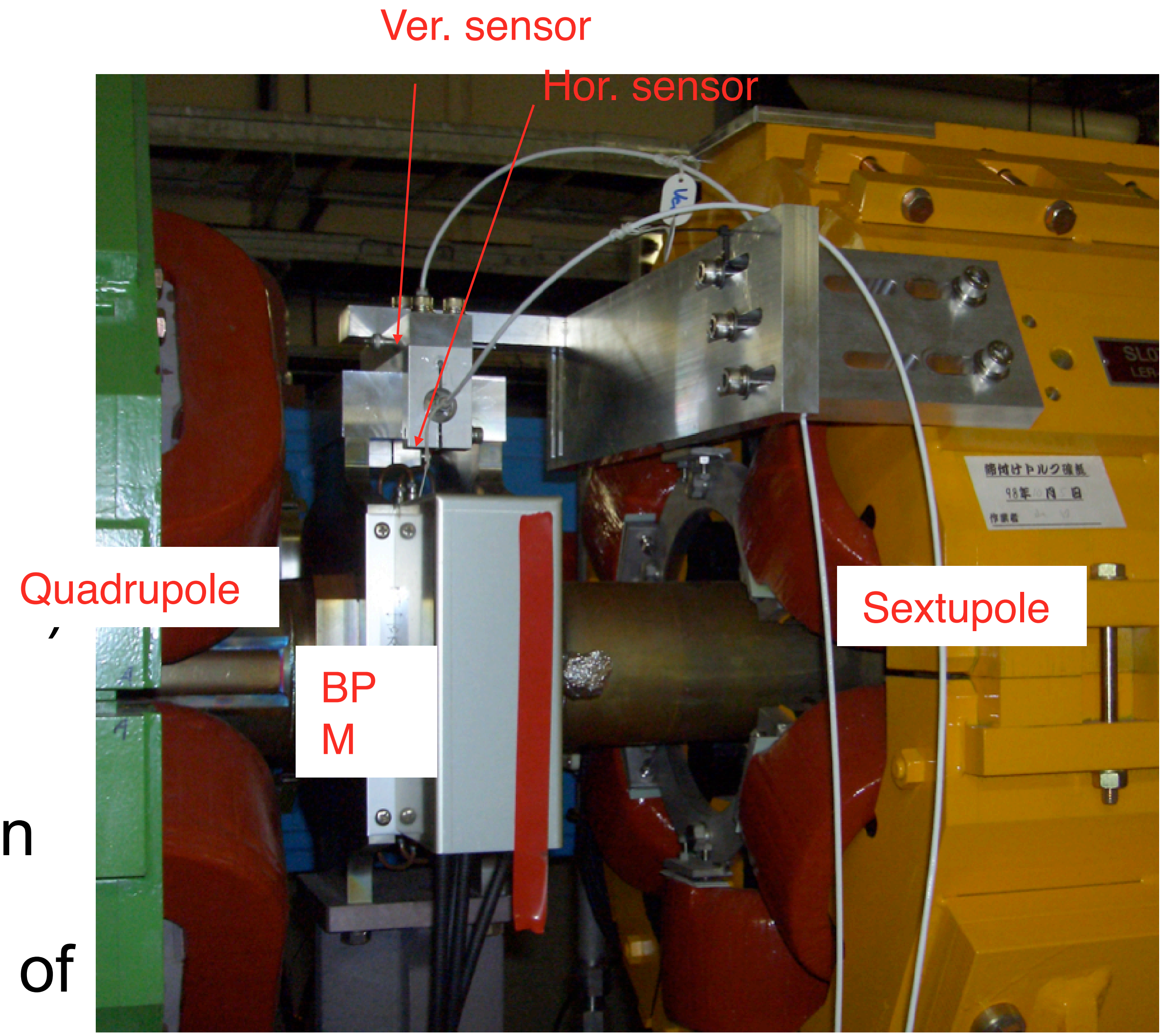
Super-B Factory Workshop in Hawaii **April 21, 2005**

BPM Summary

- Performance of current COD BPM system is expected to be sufficient for Super-KEKB.
- We will use as same front-end electronics as possible.
- Some modifications will be necessary to button electrodes to accommodate dynamic range of front-end at higher beam-currents.
- Expected performance
  - Similar to that in KEKB, but higher minimum measurable beam current. (not serious problem)
- Movement of BPM chamber due to thermal stress by high beam intensity as SuperKEKB will be a serious problem.

Development of displacement sensor for Super-KEKB

- Requirements
  - Impervious to magnetic field
  - Radiation resistance
  - Resolution less than 1μm
- Use capacitative sensors.
- Current commercial displacement sensor is too expense. ($5,000/ur
  - But newer options may be coming soon (in test).
- We also started development of an inexpensive displacement sensor, because Super-KEKB needs a lot of sensors.



Displacement sensor attached to sextupole magnet

Tejima, KEKB MAC, Feb.

Feedback Summary

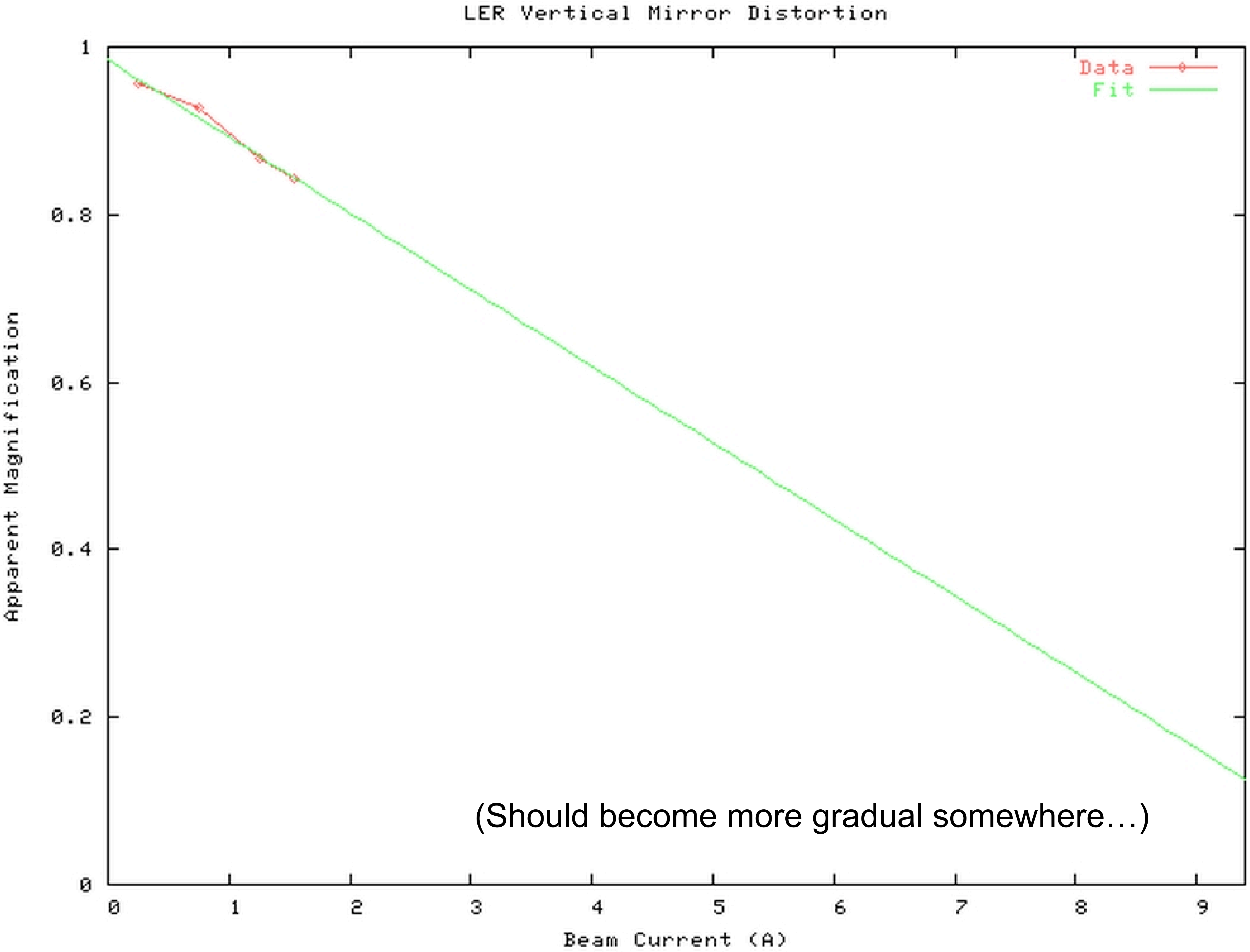
- FY2003
  - Gboard R&D project started officially.
- FY2004
  - Gboard: Production of 1st prototype board
  - R&D of glass-sealed BPM electrode and LER monitor chamber
  - Modified flexible feedthrough
- FY2005
  - Feedback experiment with Gboard prototype
  - R&D for new transverse feedback kicker
  - Longitudinal feedback MD

Summary

SR Monitors

- More cooling of extraction chamber, longer bending-radius source bends, reduce mirror heating.
- Second set of monitors for dynamic beta measurement.
- Gated camera, streak camera for damping ring

LER SR Monitor Mirror Heating at SuperKEKB



(Should become more gradual somewhere…)

Homework

- High Frequency RF (= high current)
  - We need a design, not a concept.
    - to evaluate the cost, time, FTE.
    - impact on vacuum, magnets, IR, injector, etc.
- High beam-beam
  - Crab crossing in 2006 @ KEKB
  - Why not at PEP-II (head-on) right now?
  - Consistent lattice, IR, etc.
- Coherent Synch. Radiation
  - More detailed estimation & optimization
- Details matter.