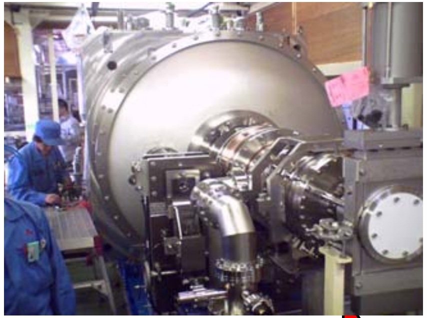
Status of
the accelerator upgrade

2nd Open meeting for the proto-collaboration
July 3, 2008
Haruyo Koiso

SuperKEKB

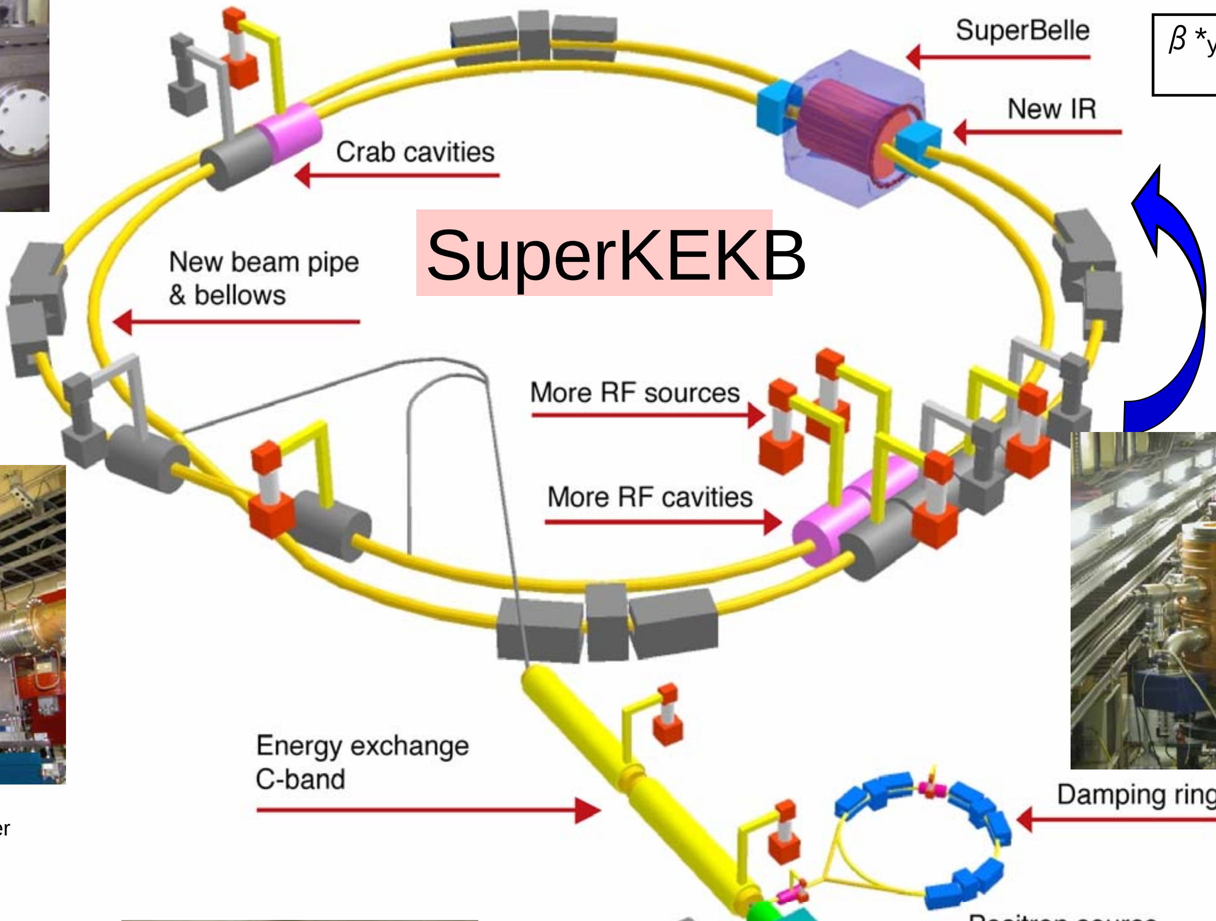
$\beta^*_y = \sigma_z = 3$ mm



Crab cavities will be installed and tested with beam in 2006.

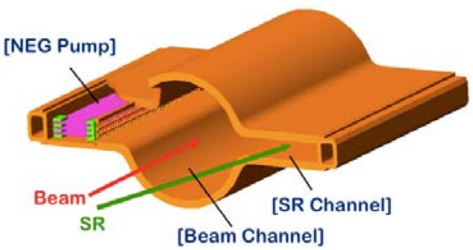
e+ 4.1 A

e- 9.4 A



The superconducting cavities will be upgraded to absorb more higher-order mode power up to 50 kW.

The state-of-art ARES copper cavities will be upgraded with higher ener storage ratio to support higher current.



The beam pipes and all vacuum components will be replaced with higher-current-proof design.

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\right)\left(\frac{R_L}{R_y}\right)$$

will reach 8×10^{35} cm^{-2}s^{-1}.

Costs & Effects

Preliminary

Item	Object	Oku-yen = 1.0 M$	Luminosity
New beam pipes	Enable high current Reduce e-cloud	178 (incl. BPM, magnets, etc.)	x1.5
New IR	Small $\beta*$	31	x2
e+ Damping Ring	Allow injection with small increase e+ capture	40 incl. linac upgrade	if not, x0.75
More RF and cooling systems	High current	179 (incl. facilities)	x3
Crab Cavities	Higher beam-beam param.	15	x2 - x4

Items are interrelated.

K. Oide

KEKB Upgrade Meeting

Nov. 2	Parameters, Vacuum system
Nov. 28	Lattice, Interaction region
Dec. 21	RF, Facility
Jan. 18	Linac, Beam transport, Damping ring
Feb. 22	Beam instrumentation, Magnet
Mar. 13	Control, Crab cavity
Apr. 9	Vacuum
May 15	Interaction region
Jun. 18	Detector background

Subgroup meeting

- Collective effects and impedance
- IR
- Magnet & lattice

RF parameters

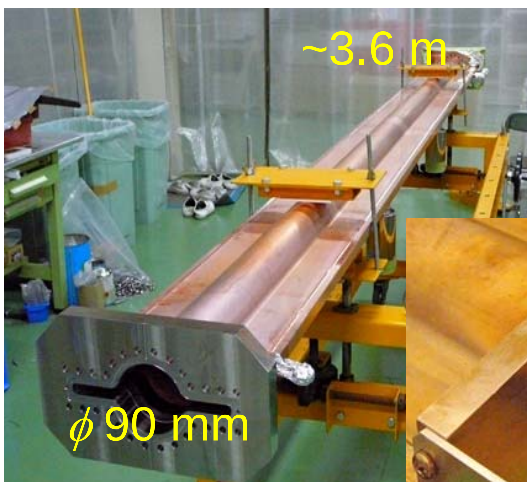
Ring	LER	HER		unit
Beam energy	3.5	8.0		GeV
Beam current	9.4	4.1		A
Energy loss /turn	0.84	3.42		MV
Radiation loss	7.91	14.02		MW
Total loss factor, assumed	40 ± 5	45 ± 10		V/pC
Parasitic loss	7.09 ± 0.89	1.52 ± 0.34		MW
Total beam power	15.0 ± 0.9	15.5 ± 0.3		MW
Cavity type	ARES (modified)	ARES	SCC	
Number of cavities (= klystrons)	22〜24	18〜16	8	
Voltage /cavity	0.5	0.5	1.3	MV
Beam power /cavity	650	720	460	kW
Wall loss /cavity	233	150	-	kW
Detuning frequency	44	31	75	kHz
Klystron power	940	930	490	kW
Total RF voltage	〜11	〜18		MV
Total AC plug power	35	33		MW

K. Akai

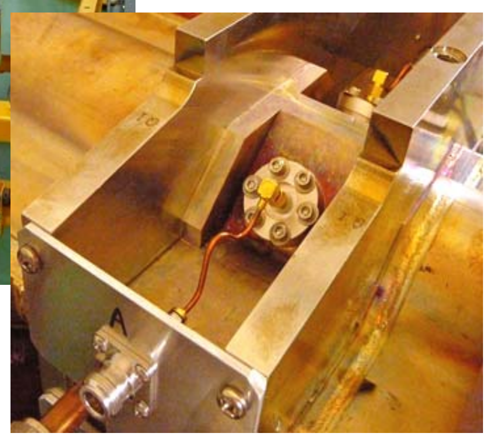
Beam pipe with antechamber

- Copper beam pipe with antechamber to reduce SR power density, photon density, photoelectron density, impedance.
- Straight ducts were Installed in KEKB LER.
- No serious problem up to 1.7A.
- Photoelectron density was decreased.

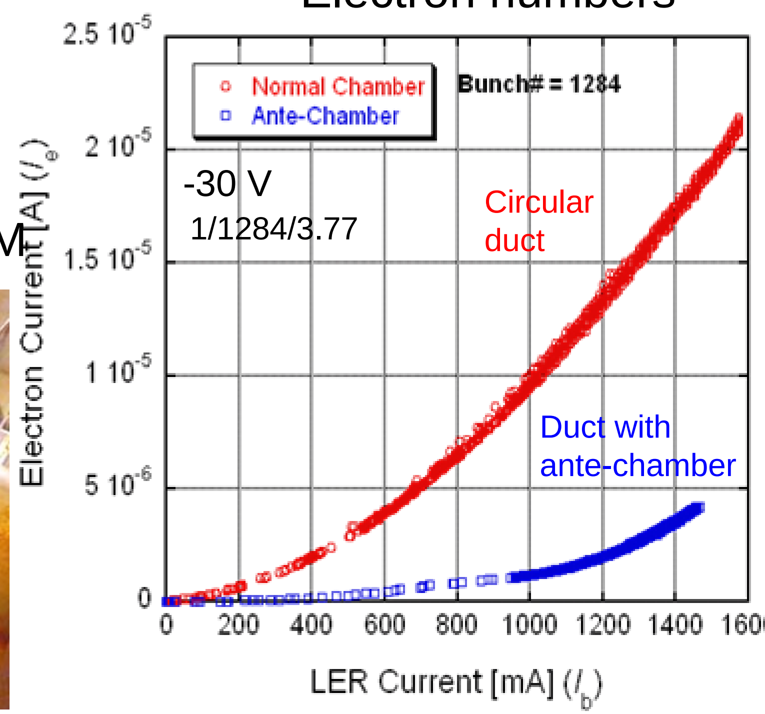
Straight duct



Q-duct with BPM



Electron numbers



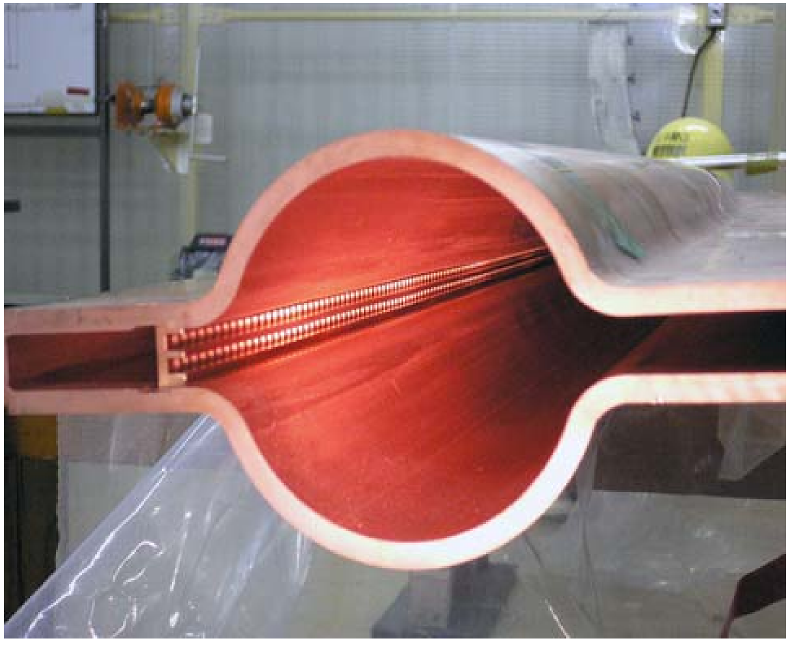
Y. Suetsugu, et. al.

Beam pipe with antechamber

- Duct for a bending magnet with a curvature of 16 m using a cold drawn pipe.

Bent duct for LER (ϕ 90 mm)

Slit for pump channel

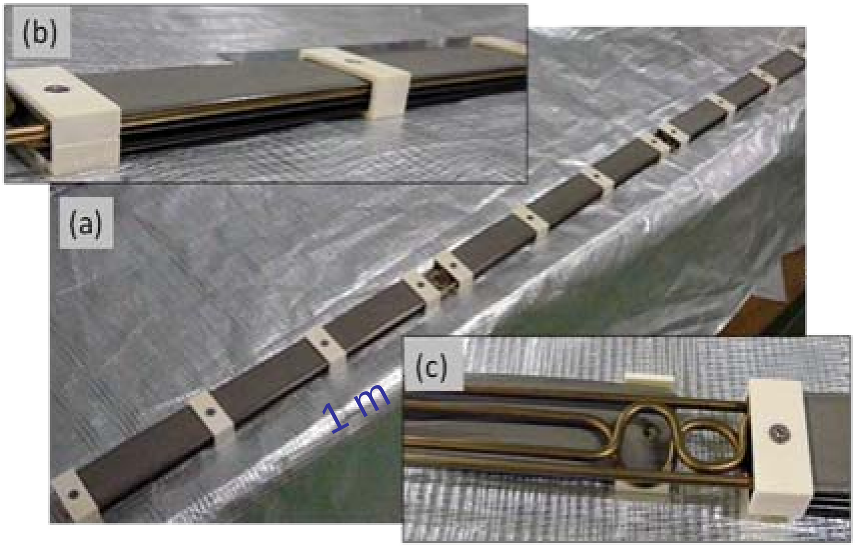


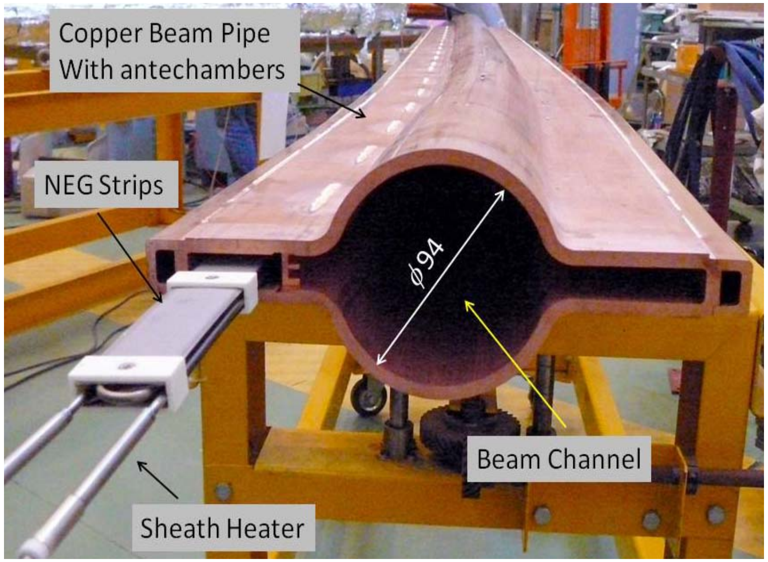
Y. Suetsugu, et. al.

Beam pipe with antechamber

- Pomp system installed in antechamber.

Multilayer NEG strips for test (three layers)



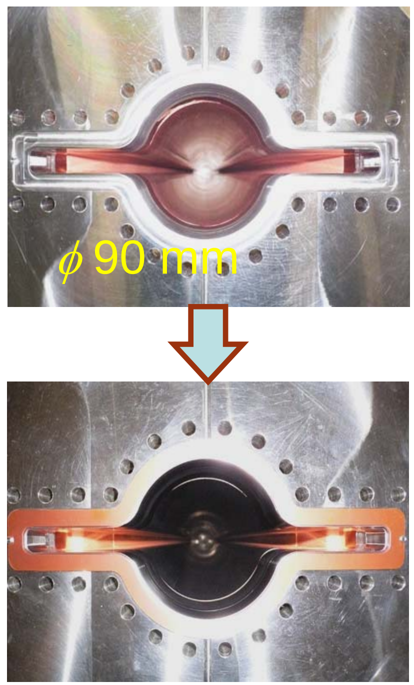


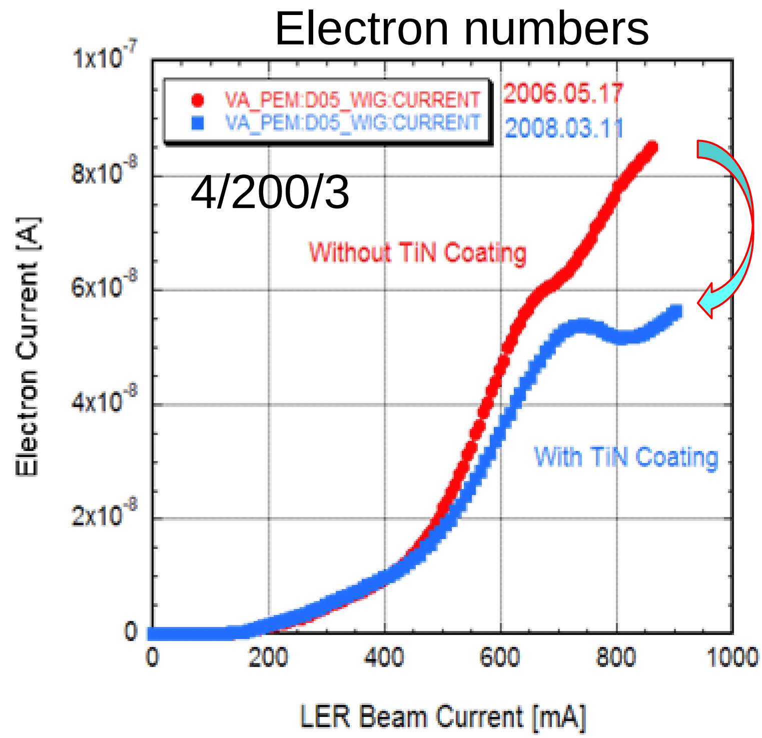
Prot-type:
ST-707 strip
Three layers
Indirect heating

Y. Suetsugu, et. al.

Beam pipe with antechamber

- TiN coating to cure ECI (electron cloud instability)
  - Decrease SEY: Max. SEY ~0.8
  - Coating system available for ~4 m pipe was set up in Oho area.
  - Electron density was decreased at high beam currents.



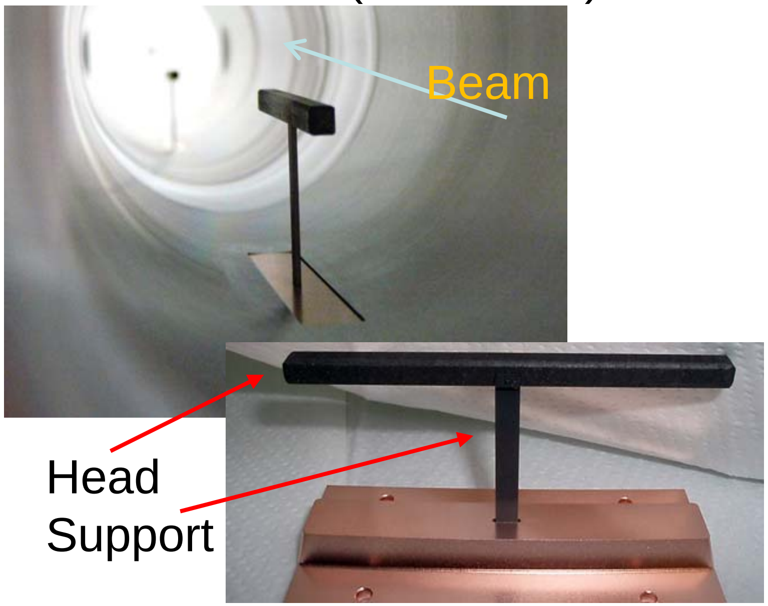


Y. Suetsugu, et. al.

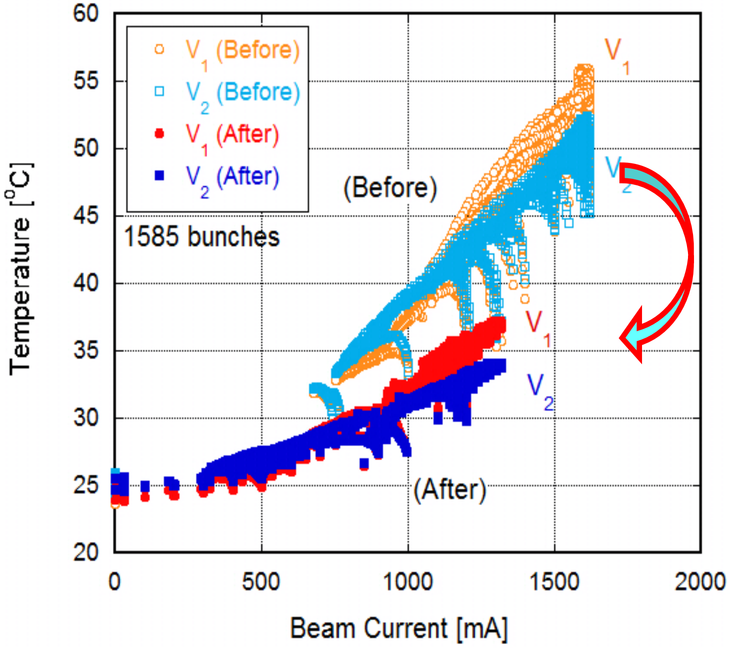
Movable Mask Ver.6

- Installed in KEKB LER
  - Worked at lower beam currents.
  - Lower temperature at bellows and HOM dampers.
  - Damaged at higher currents.

Head of Ver.6 (trial model)

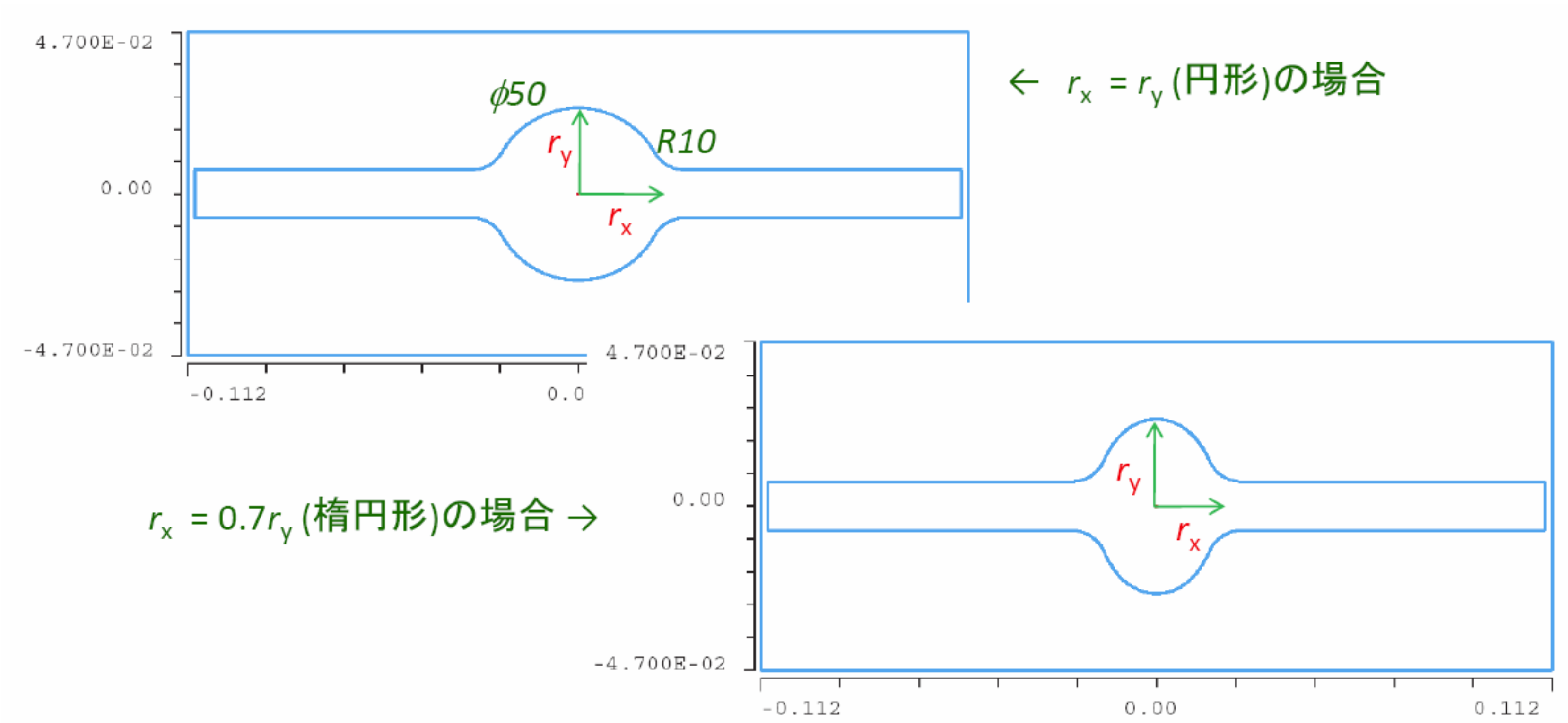


Temperature of bellows near masks



Optimization of cross-section shape of vacuum chamber

- Estimation by MAFIA 2D
- Calculate quadrupole component dEq/dr, changing the ellipticity rx/ry = 0.7 ~ 1.0



K. Shibata

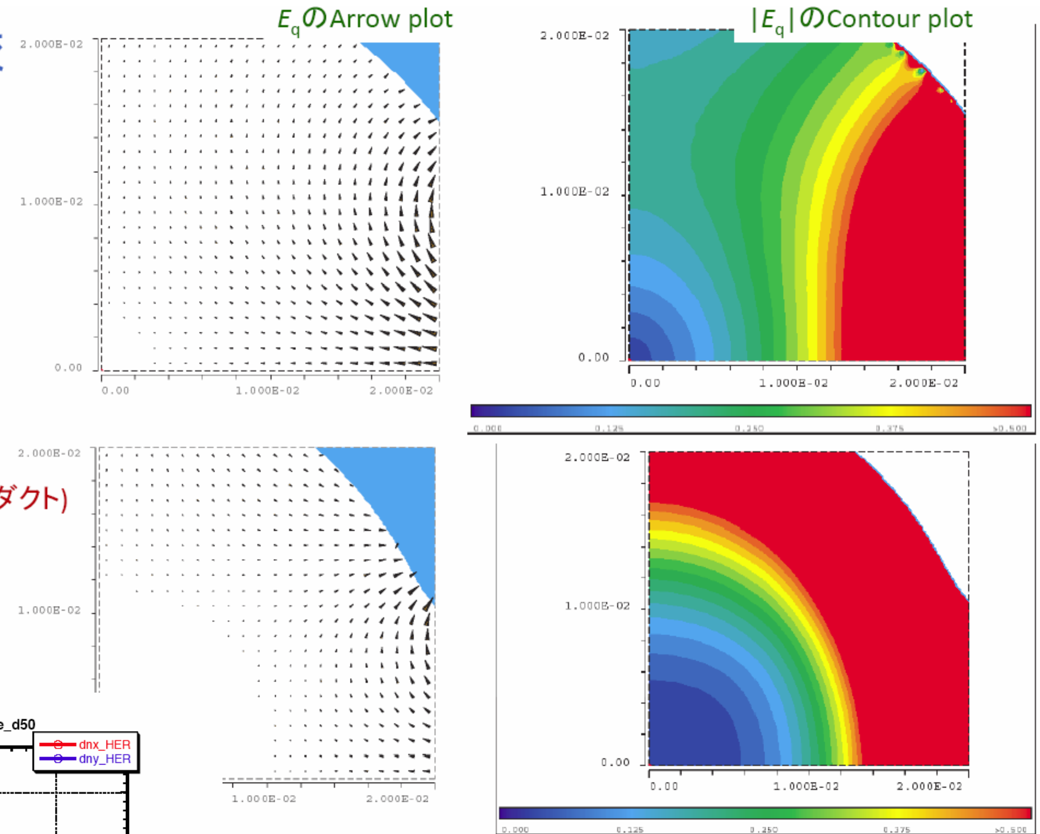
Optimization of cross-section shape of vacuum chamber

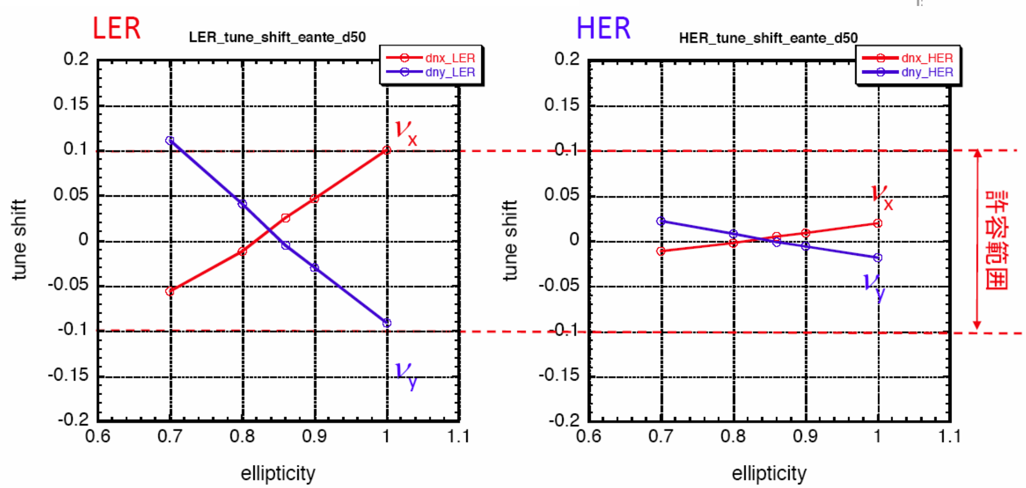
- E_q比較

α = 1 (円形ダクト)

- Tune shift can be adjusted < 0.1 in case of diameter of 50 mm.

α = 0.85 (楕円形ダクト)





acceptable range

K. Shibata

Crab cavity

- Present type of cavity is usable in HER (4.1A) with modification
  - 2 or more cavities are necessary.
  - New HOM damper system (ferrite + SiC) is necessary against 71 kW
    - HOM power ~400 kW in LER

- New type cavity is necessary for LER to reduce both HOM power and impedance.

- New cavity
  - Coaxial coupler / Wave guide,
  - Super (LER 1, HER 2 cavities)/Normal
  - 1 GHz option

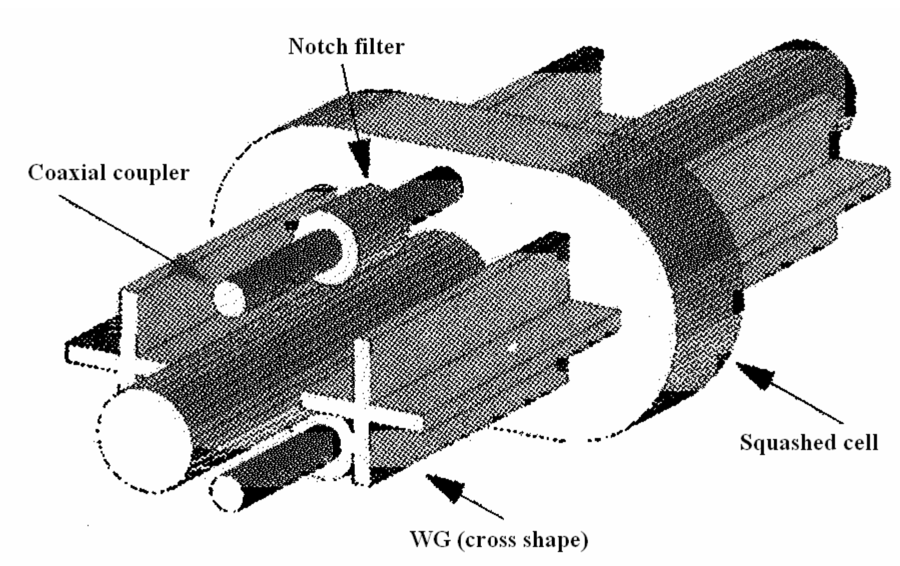
Y. Morita, K. Akai

Crab cavity

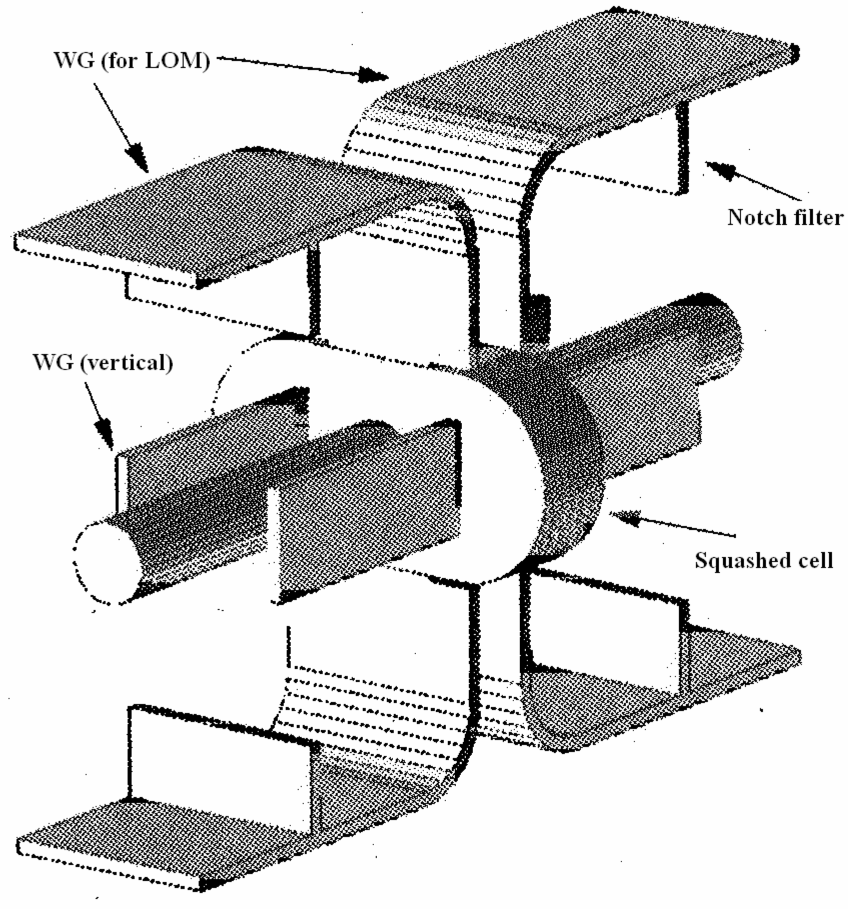
PAC2005

目的：十分なMode dampingとHOM powerの軽減を得る

Coaxial type



Wave guide type



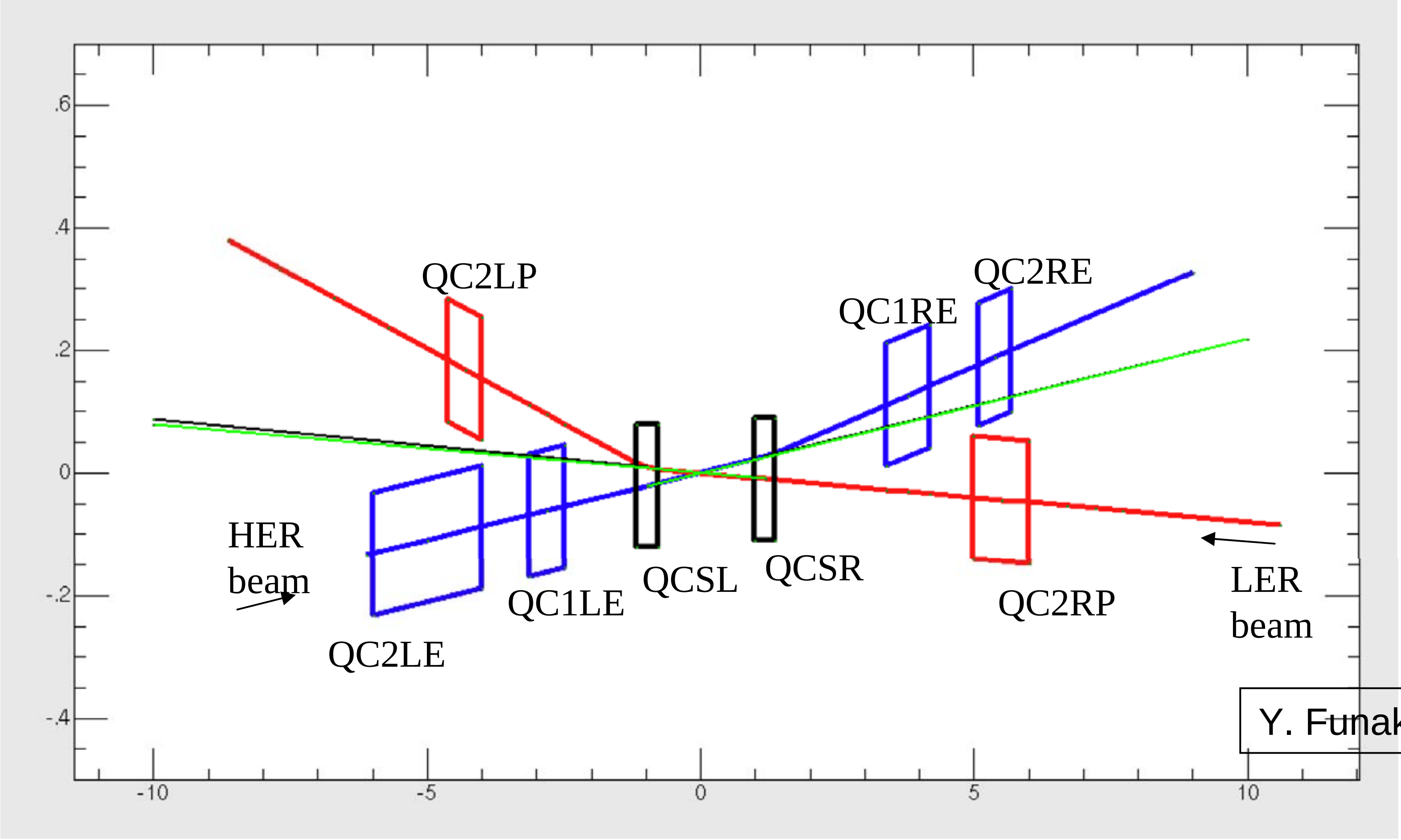
LOM damping: Coaxial coupler

LOM damping: Wave guide

Y. Morita, K. Akai

Interaction Region

- Physical aperture is very tight at IR quadrupoles.
- New layout : Moved QC2LE & QC2RP closer to IP
- Larger βx^*(20→40 cm), higher νx(.503 →.505)

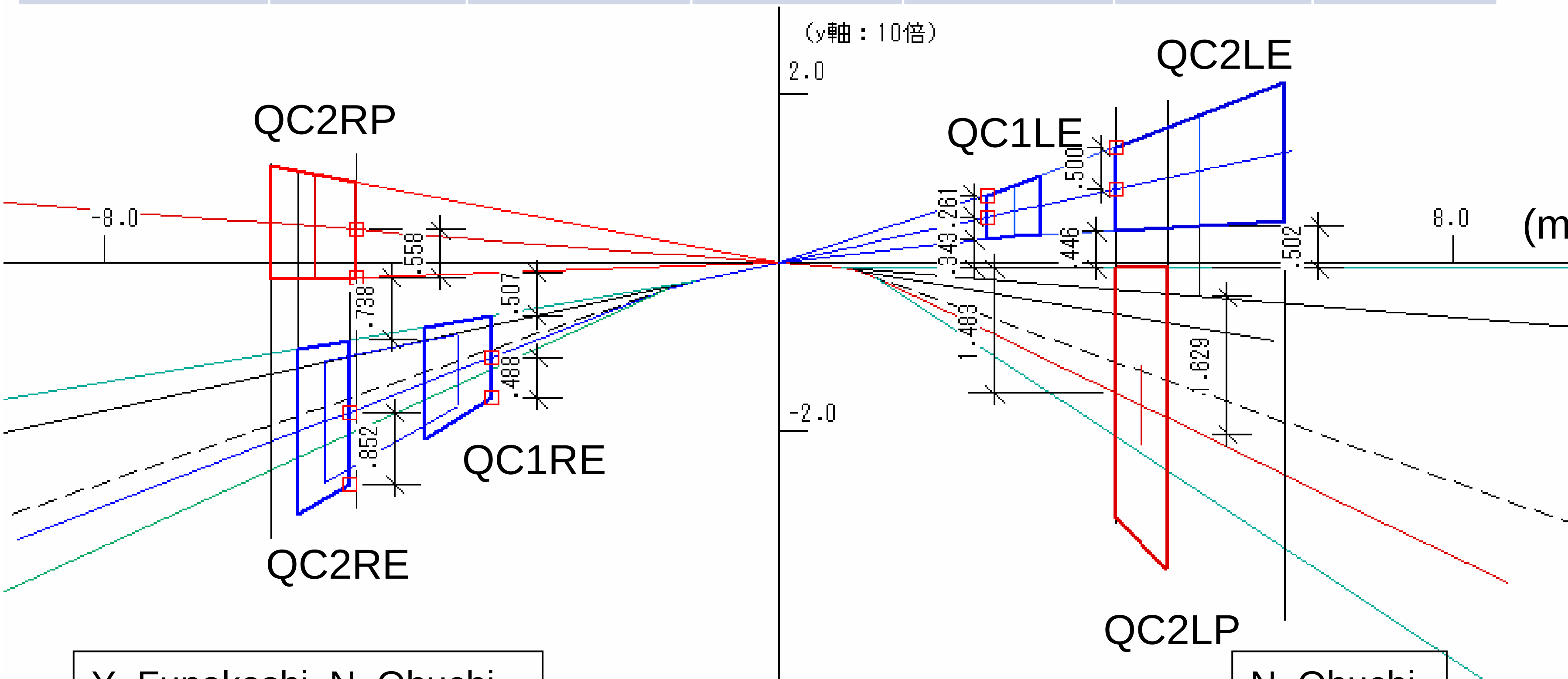


Y. Funakoshi

Interaction Region

	QC1LE	QC2LE	QC1RE	QC2RE	QC2LP	QC2RP
β_x^*=20cm QC2RE:元	8.2 (41)	26.9 (134.5)	11.6 (58)	28.8 (144)	14.7 (73.5)	18.6 (93)
β_x^*=20cm QC2RE->IP	8.4 (42)	19.0 (95)	12.0 (60)	20.7 (103.5)		
β_x^*=40cm QC2RE->IP	5.9 (29.5)	13.4 (67)	8.5 (42.5)	14.6 (73)	9.8 (49)	12.3 (61.5)

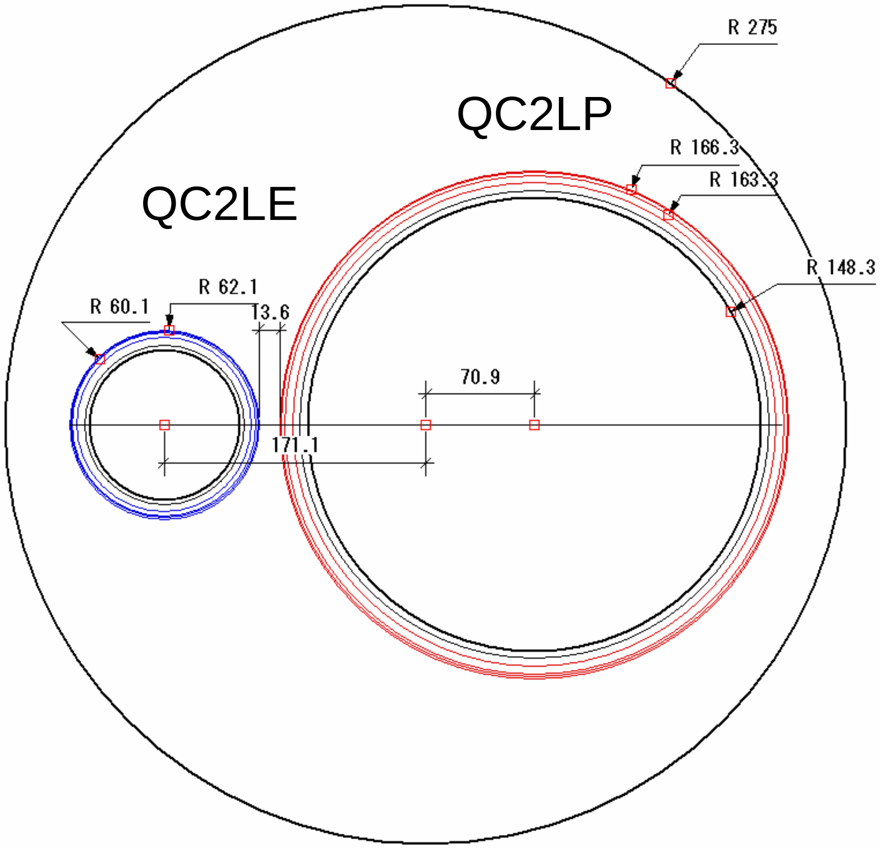
ν_x =.505
(): 5 σ_x



Y. Funakoshi, N. Ohuchi

N. Ohuchi

QC2LE & QC2LP
(super)



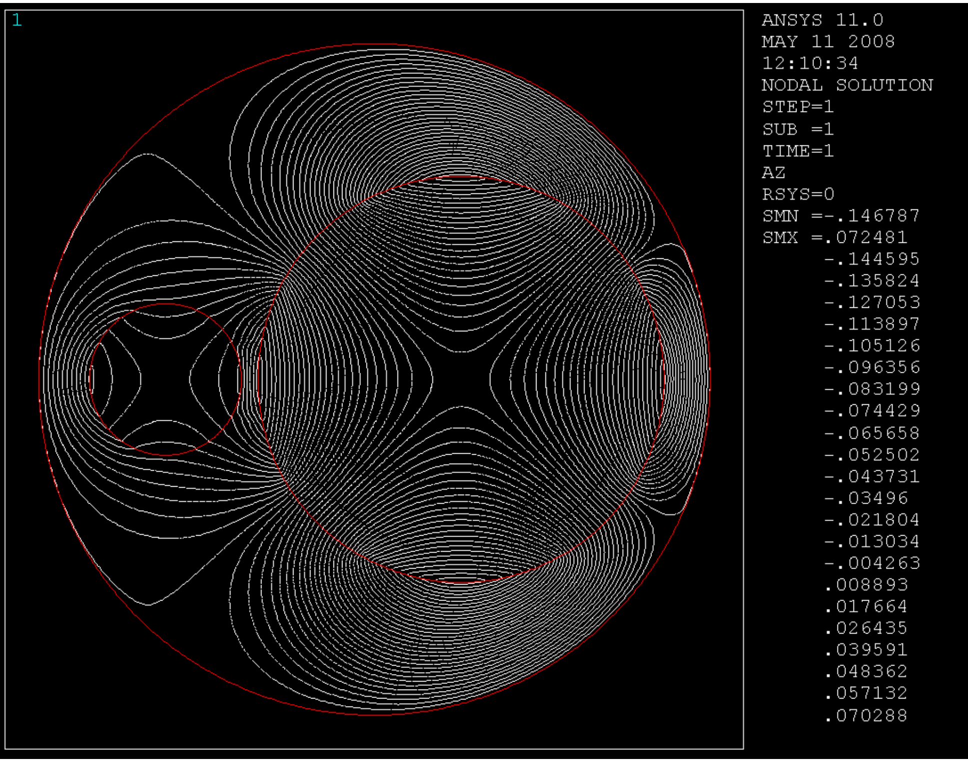
QC2LE

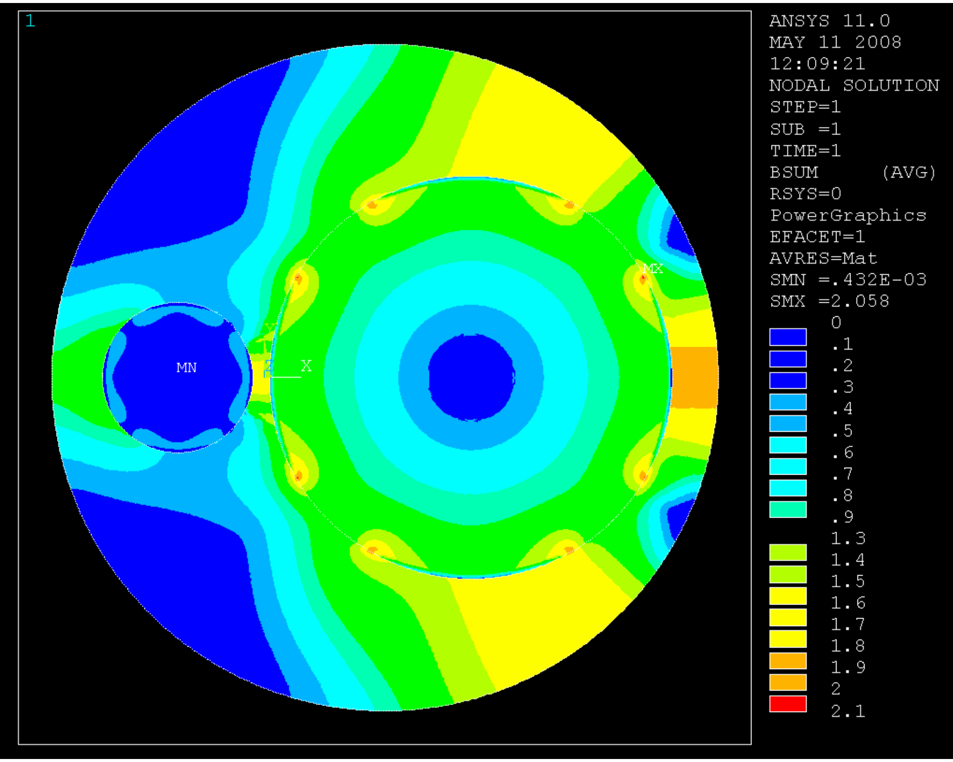
1. 平均磁場勾配＝3.4 T/m
2. 実効磁場長＝2.0 m
3. ビームパイプボアー内半径＝49.1 mm（T=80K）
4. クライオスタットボアー内半径＝57.1 mm
5. コイル形状（円錐台形）
   - 超伝導ワイヤー1層コイル
   - コイル内半径＝60.1 mm（IP側）
   - コイル内半径＝77.75 mm（中心部）
   - ターン数＝31
6. 鉄ヨーク外半径＝275 mm
7. IP側必要磁場勾配（概算）
   G_{IP}= 3.4×（77.75/60.1）^{2}＝5.69 T/m

QC2LP

1. 平均磁場勾配＝6.7 T/m
2. 実効磁場長＝0.6 m
3. ビームパイプボアー内半径＝148.3 mm（T=80K）
4. クライオスタットボアー内半径＝158.3 mm
5. コイル形状（円錐台形）
   - 超伝導ワイヤー2層コイル
   - コイル内半径＝163.3 mm（IP側）
   - コイル内半径＝178.15 mm（中心部）
   - ターン数＝86 × 2
6. IP側必要磁場勾配（概算）
   G_{IP}= 6.7×（178.15/163.3）^{2}＝7.97 T/m

QC2LE & QC2LP Magnetic Field





QC2LE
- 超伝導ワイヤー電流値＝272.7 A
- 磁場勾配＝5.68 T/m
- 超伝導ワイヤー部電流密度 = 520.2 A/mm^2
  Cu/NbTi=1.4の場合のNbTi部の電流密度＝1248.4 A/mm^2
- コイル部最大磁場＝0.5 T

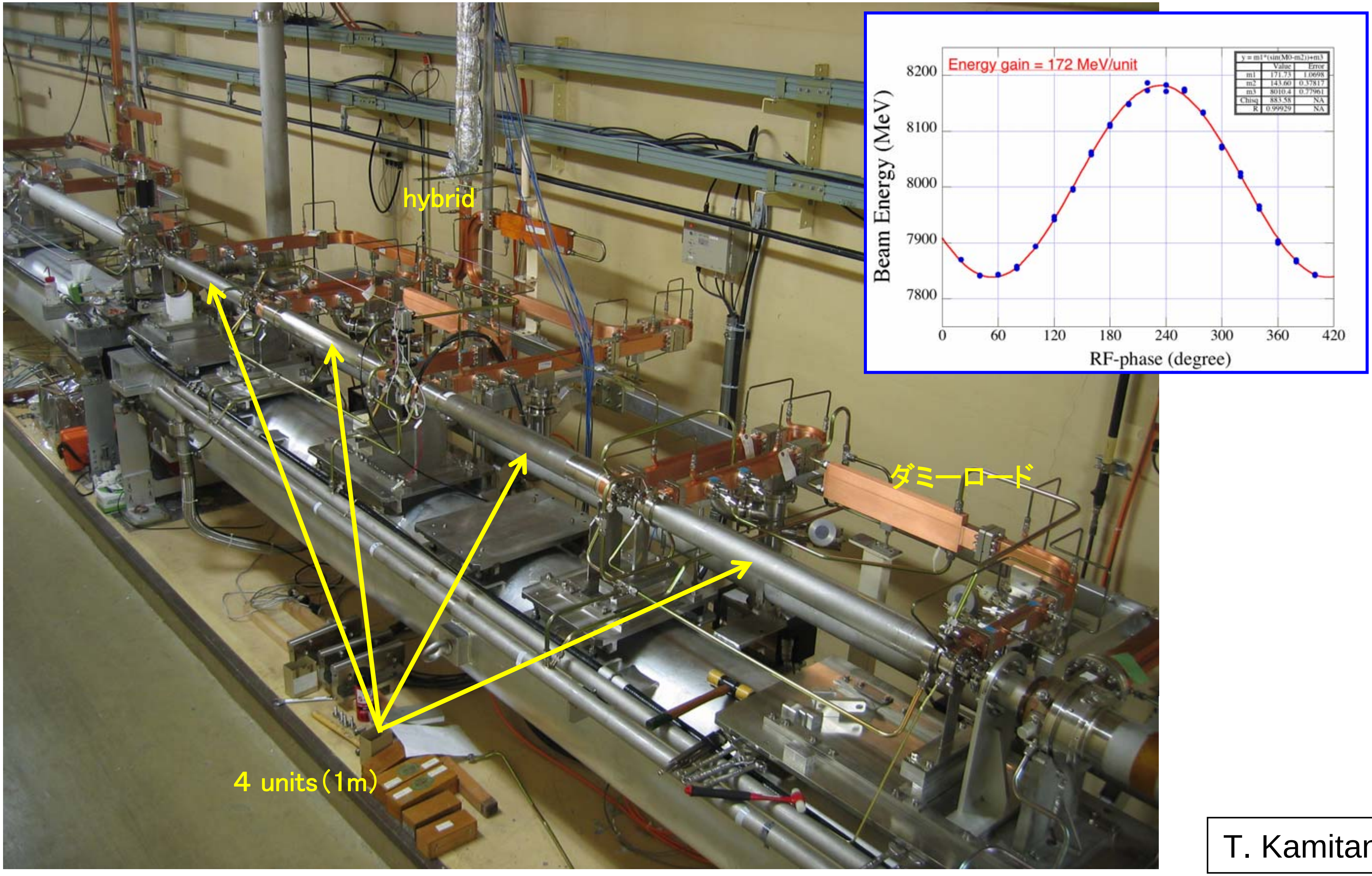
QC2LP
- 超伝導ワイヤー電流値＝505.0 A
- 磁場勾配＝7.96 T/m
- 超伝導ワイヤー部電流密度 = 963.3 A/mm^2
  Cu/NbTi=1.4の場合のNbTi部の電流密度＝2311.9 A/mm^2
- コイル部最大磁場＝2.058 T

QC2LEとQC2LP間の磁場＝1.8T
QC2LPからQC2LEへの磁場の侵入が大きい

⇨

鉄の量が少ない
前方に光マスク必要（QC2LPの内径を小さくする）

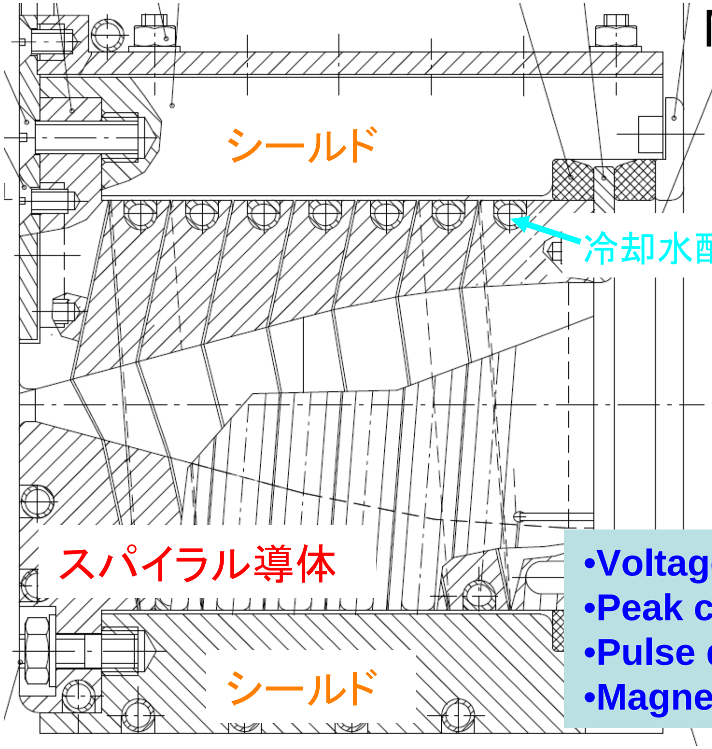
Linac C-band unit



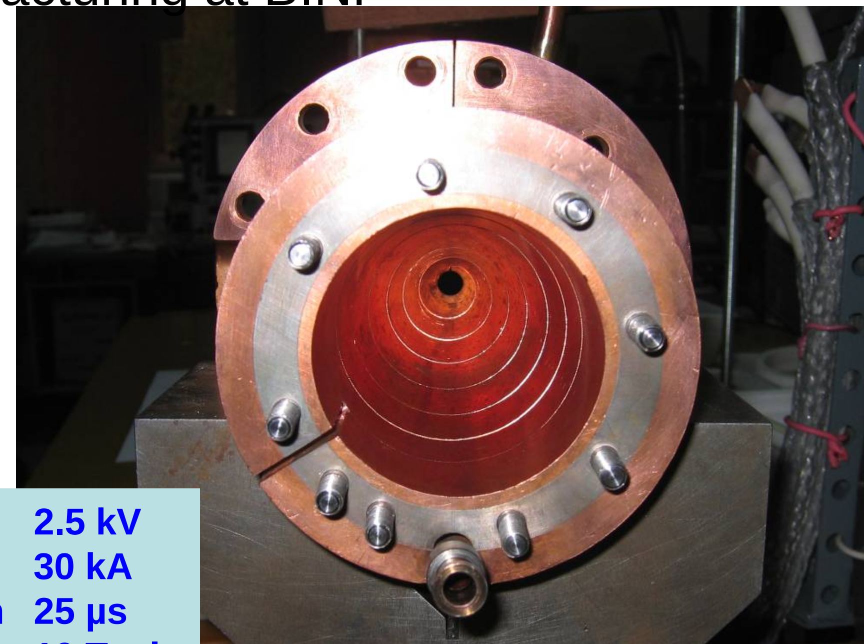
T. Kamitani

average accelerating field = 45 MV/m @ klystron output power = 53 MW

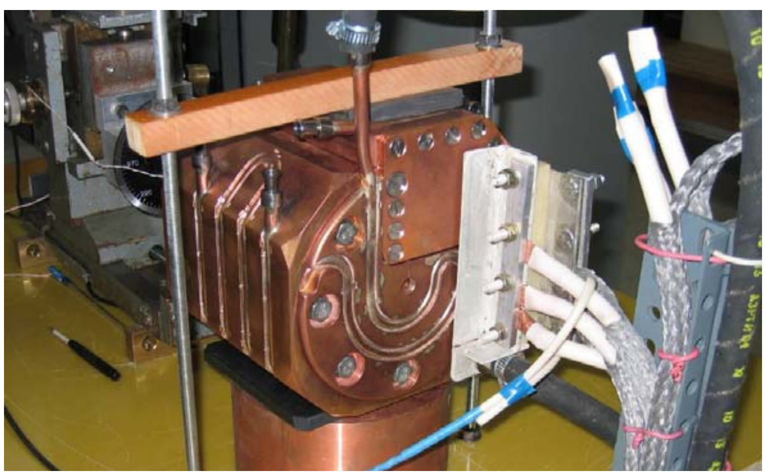
e+ Flux Concentrator Prototype

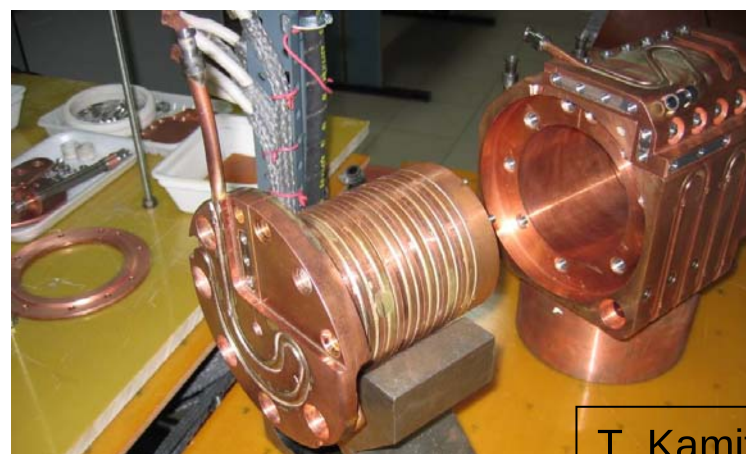


Manufacturing at BINP

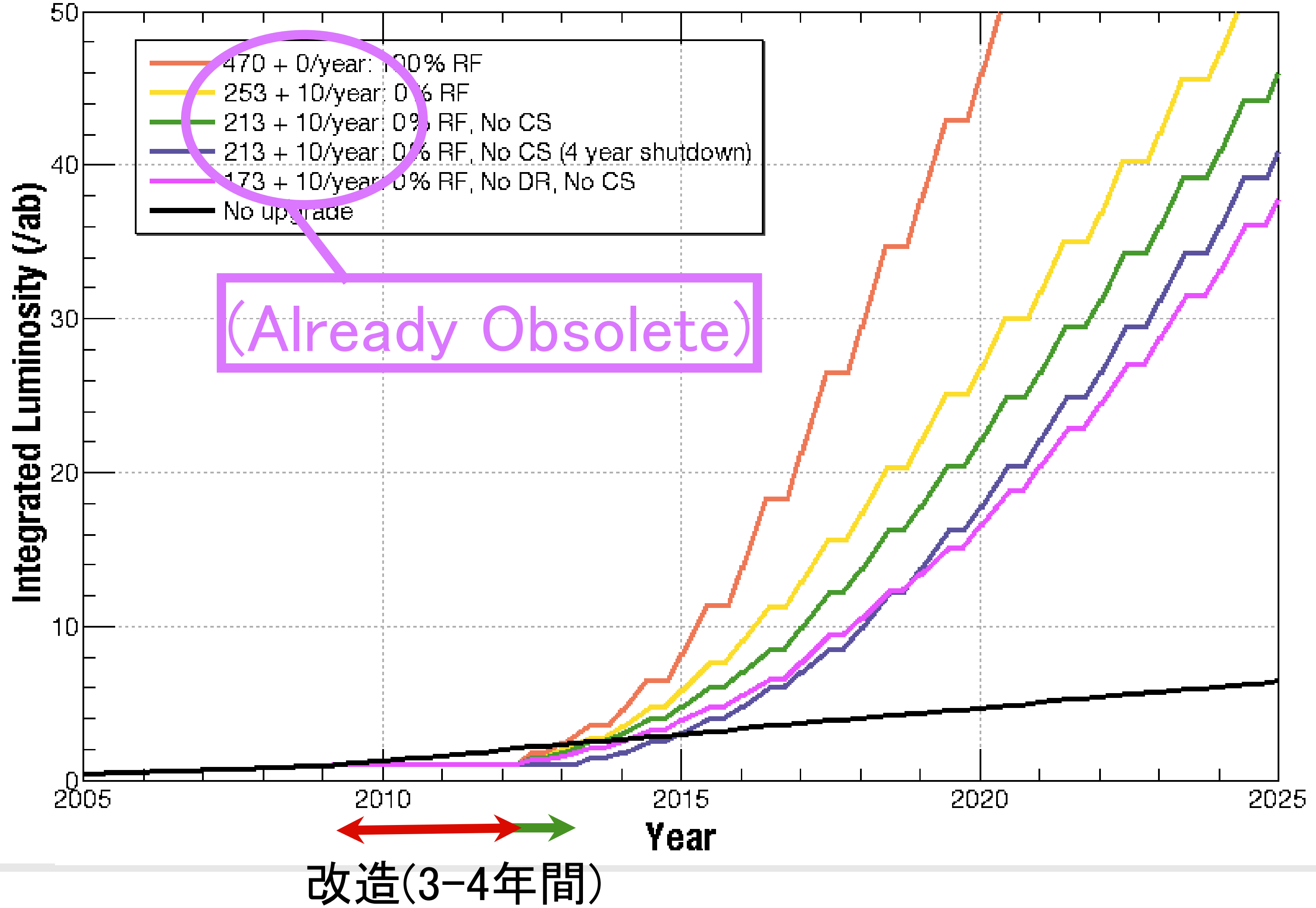


- Voltage 2.5 kV
- Peak current 30 kA
- Pulse duration 25 μs
- Magnetic field 10 Tesla





T. Kamitani



470 + 0/year: 100% RF
253 + 10/year: 0% RF
213 + 10/year: 0% RF, No CS
213 + 10/year: 0% RF, No CS (4 year shutdown)
173 + 10/year: 0% RF, No DR, No CS
No upgrade
(Already Obsolete)
Integrated Luminosity (/ab)
Year
0
10
20
30
40
50
2005
2010
2015
2020
2025
改造(3-4年間)

K. Oide

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Jul. 16	Issues

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- IR
- Magnet & lattice