IR Overview

M. Tawada
for
IR design group

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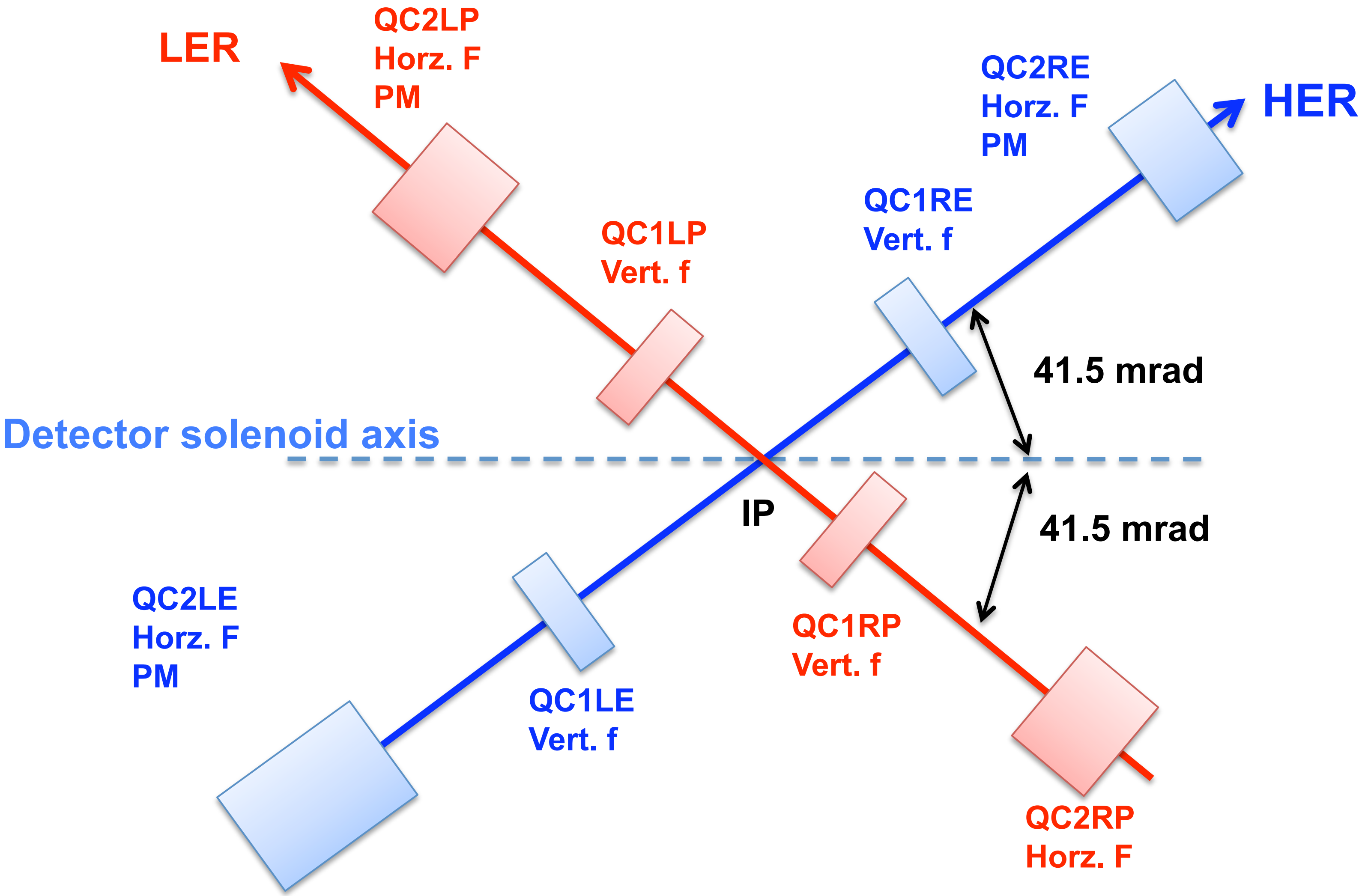
Design parameters

	KEKB Design	KEKB Achieved : with crab	SuperKEKB High-Current	SuperKEKB Nano-Beam
Energy (GeV) (LER/HER)	3.5/8.0	3.5/8.0	3.5/8.0	4.0/7.0
β_x^* (cm)	33/33	120/120	20/20	3.2/2.4
β_y^* (mm)	10/10	5.9/5.9	3/6	0.27/0.41
ε_x (nm)	18/18	18/24	24/18	3.2/2.4
Coupling (%)	2/2	1/1?	1/0.5	0.4/0.35
σ_y(μm)	1.9	0.94	0.85/0.73	0.060
ξ_y	0.052	0.129/0.090	0.3/0.51	0.09/0.09
σ_z (mm)	4	~ 6	5/3	6/5
I_{beam} (A)	2.6/1.1	1.64/1.19	9.4/4.1	3.6/2.6
$N_{bunches}$	5000	1584	5000	2503
Crossing angle (mrad)	22	0	0	83
Luminosity (10^{34} cm^{-2} s^{-1})	1	2.11	53	80

General IR design

- IR design based on Nano-beam scheme
- Beam energy was changed to 7x4 GeV
  - To save the short lifetime for LER
- Crossing angle 83 mrad
  - To make QC1 magnets closer to IP
  - Separated final quadrupole magnets
  - Use both of superconducting and permanent magnets
  - Boundary conditions between accelerator and detector are same as the present
- Angle of 41.5 mrad between HER orbit and Belle
  - To save vertical emittance increase by anti-solenoid fringe fields

IR design



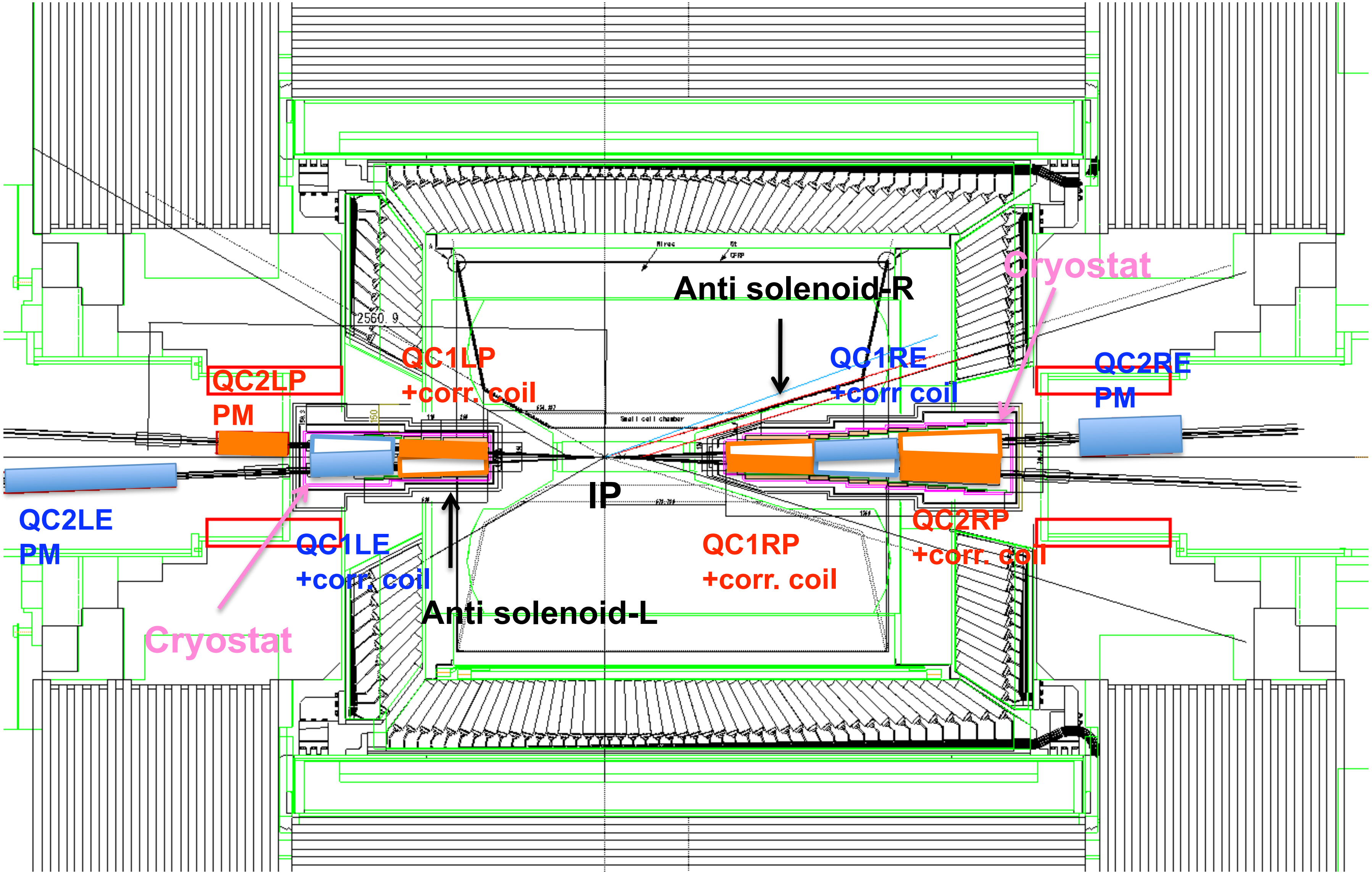
LER and HER beam are focused by separated quadrupole doublet, respectively

IR Magnets design

- Use both of superconducting magnets and permanent magnets
- Superconducting magnets
  - Leakage fields of superconducting magnets are canceled by correction windings on the other beam pipe
  - Warm bore
- Permanent magnets for QC2LE, QC2LP, QC2RE
  - Pros.
    - Cryostats are small
    - Assembly of vacuum chamber can be simple
    - Vacuum pump can be located near IP
  - Cons.
    - Need to develop a permanent magnet
    - Fine temperature control is required
    - Extra magnets are required to change beam energies

N. Ohuchi

IR design with PM version

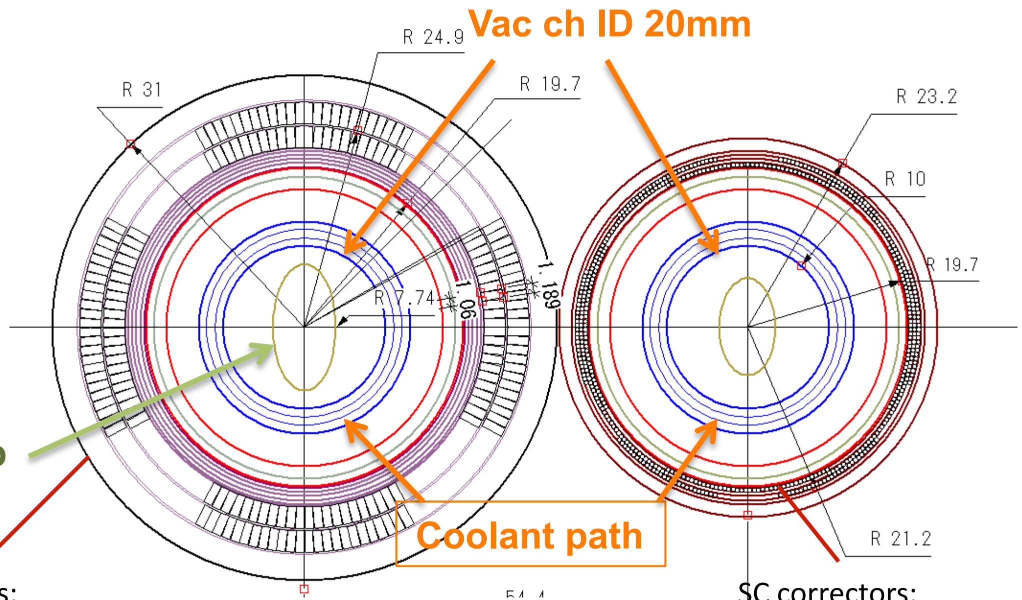


The magnet design of QC1R/L-P

N. Ohuchi

Magnet Parameters

- Magnet inner radius=22 mm, outer radius=27.55 mm
- Magnet current=1511 A
- Field gradient=75.61 T/m
- Current density, J_{SC}= 1615.8 A/mm^2
- Magnetic length L_{eff} = 0.2967 m
- Peak field w/o solenoids = 2.24 T
- Operation temperature = 4.4 K



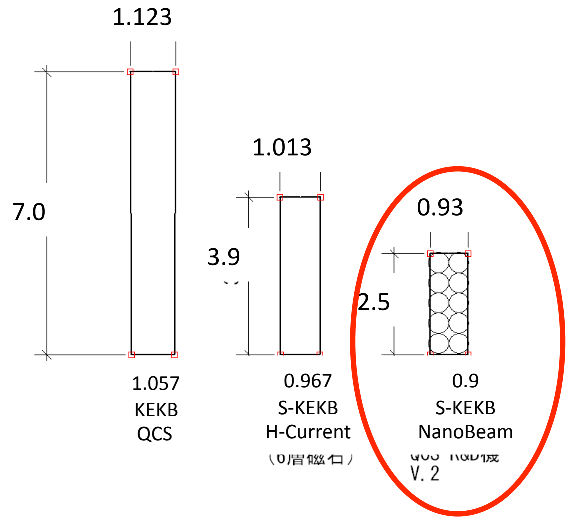
SC correctors:
Normal Octupole
Skew Quadrupole
Normal Dipole
Skew Dipole

Cross section of QC1 RP

SC correctors:
Normal Sextupole
Normal Quadrupole
Normal Dipole

Cable Parameters

- Size =2.5mm × 0.93mm
- Number of SC strand=10
- Diameter of the strand=0.5mm
- Cu ratio=1.8
- I_c= 2000 A @ 5T and 4.2 K

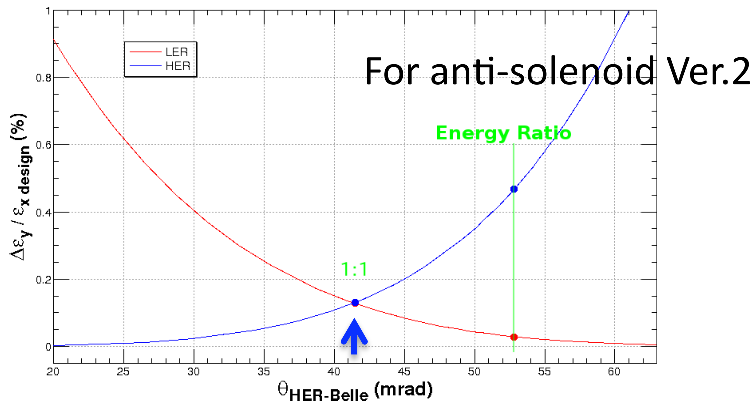


Designed new SC cable for main quadrupole

Leakage fields are canceled by the correction windings on the other beam pipe

Angle between HER and Belle

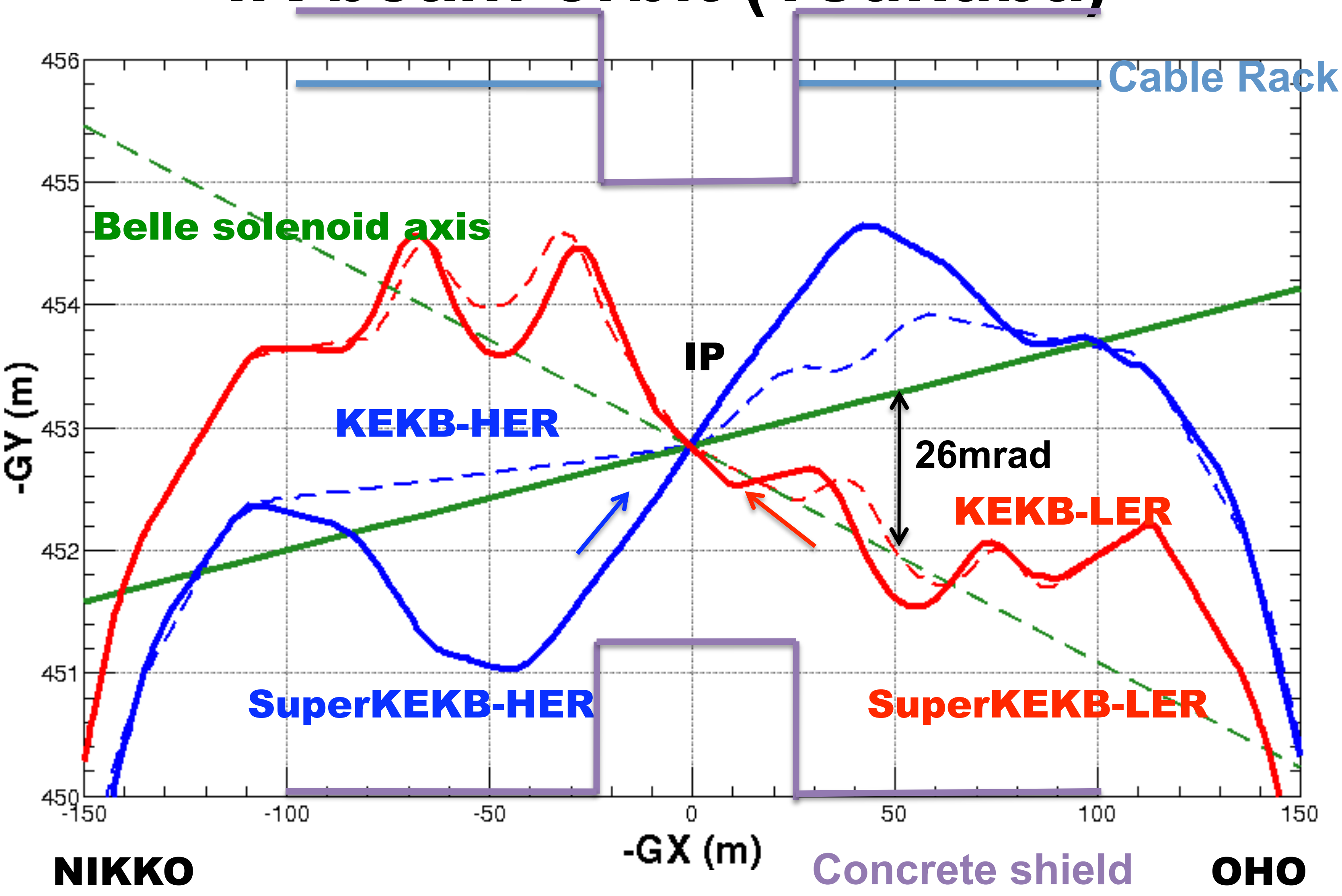
- Crossing angle of 83 mrad is determined by QC1
- Not easy to rotate HER orbit with large angle
  - Use existing tunnel
  - Small horizontal emittance
  - Large DA
- Angle between HER orbit and Belle solenoid axis
  - Determined by vertical emittance increase by the fringe field of anti-solenoid
  - Angle of 41.5 mrad is assumed for the current anti-solenoid field profile



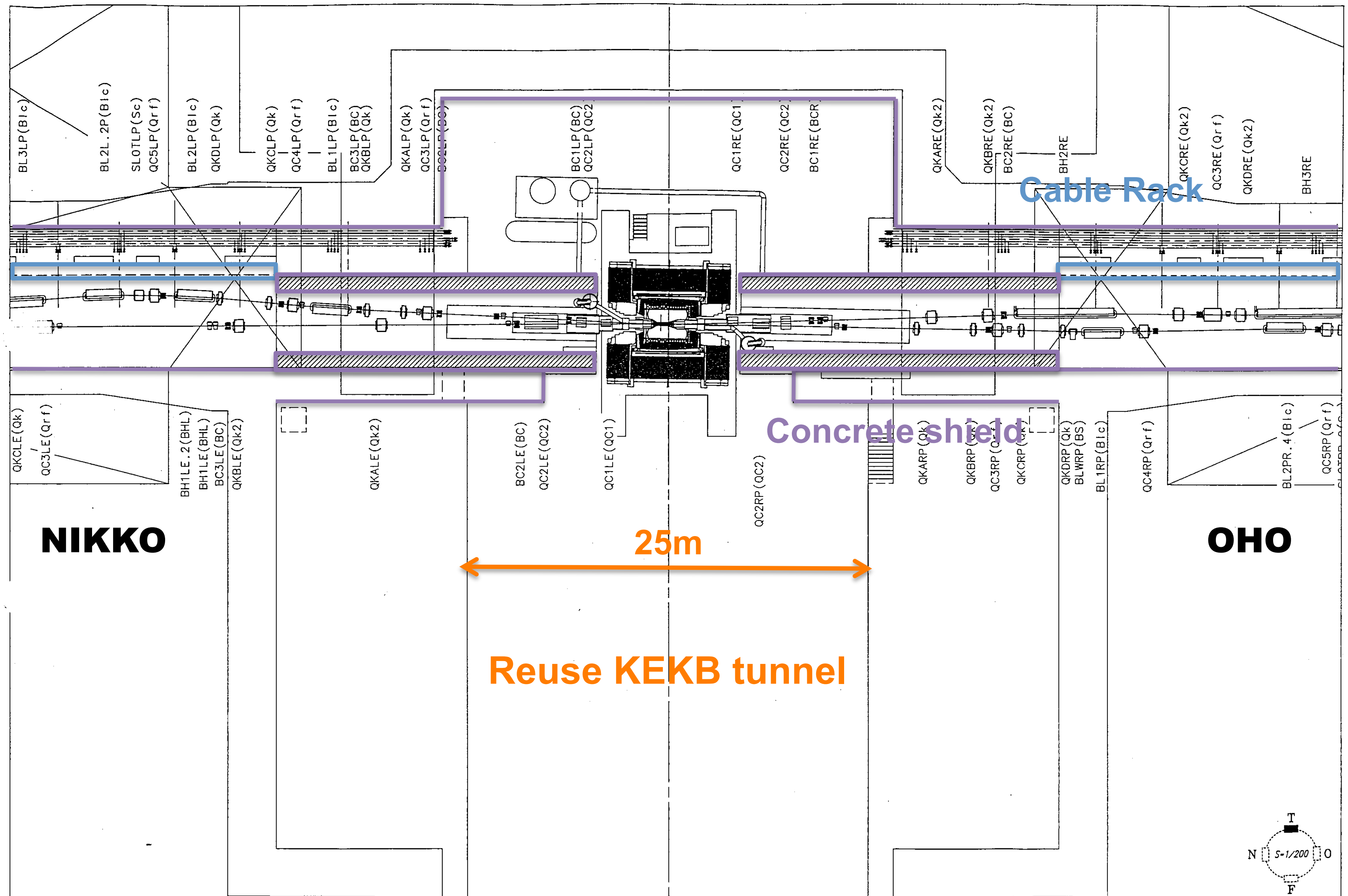
- We have to rotate Belle solenoid axis if HER orbit can not be rotated

IR beam orbit (Tsukuba)

A. Morita



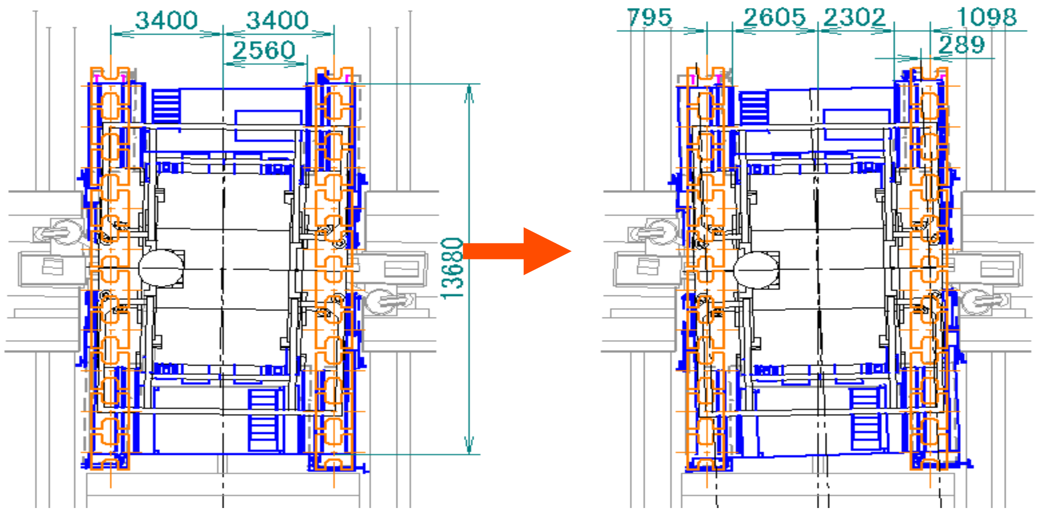
KEKB Tunnel (Tsukuba)



Belle rotation

It seems to be possible technically

- Pros.
  - We don't need to rotate HER orbit
  - Extra space for PXD/SVD cables and tubes will be available
  - EM force will be reduced if the radius of anti-solenoid would be smaller
- Cons.
  - Expensive (3 oku yen for belle rotation)
  - Need to modify the concrete bases and shields
  - Belle people worry about the damaging CsI calorimeter



We don't reach a consensus

○ Belle Detector

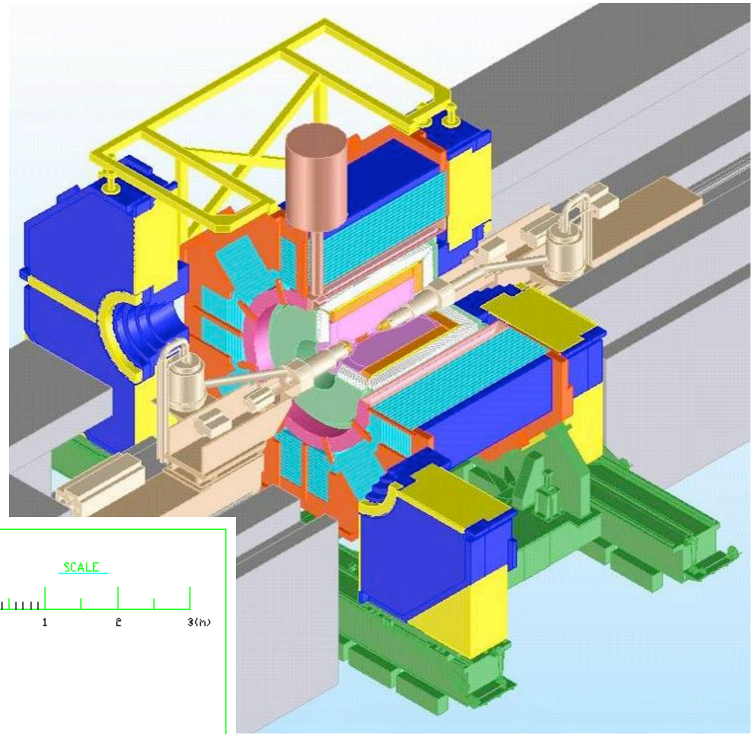
8m(W)×8m(L)×10m(H)

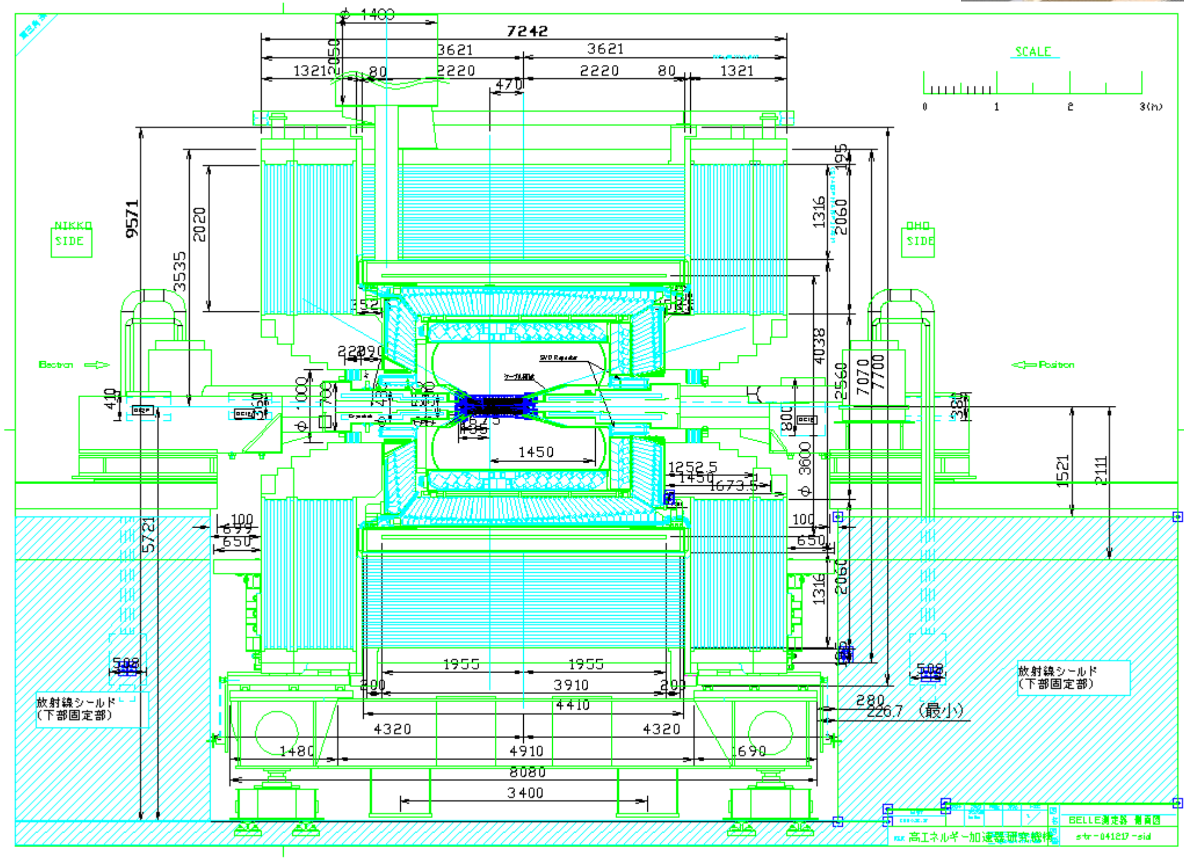
Total weight: 1300tons

650tons (Barrel Yoke)

600tons (End Yoke)

50tons (Others)





H. Yamaoka

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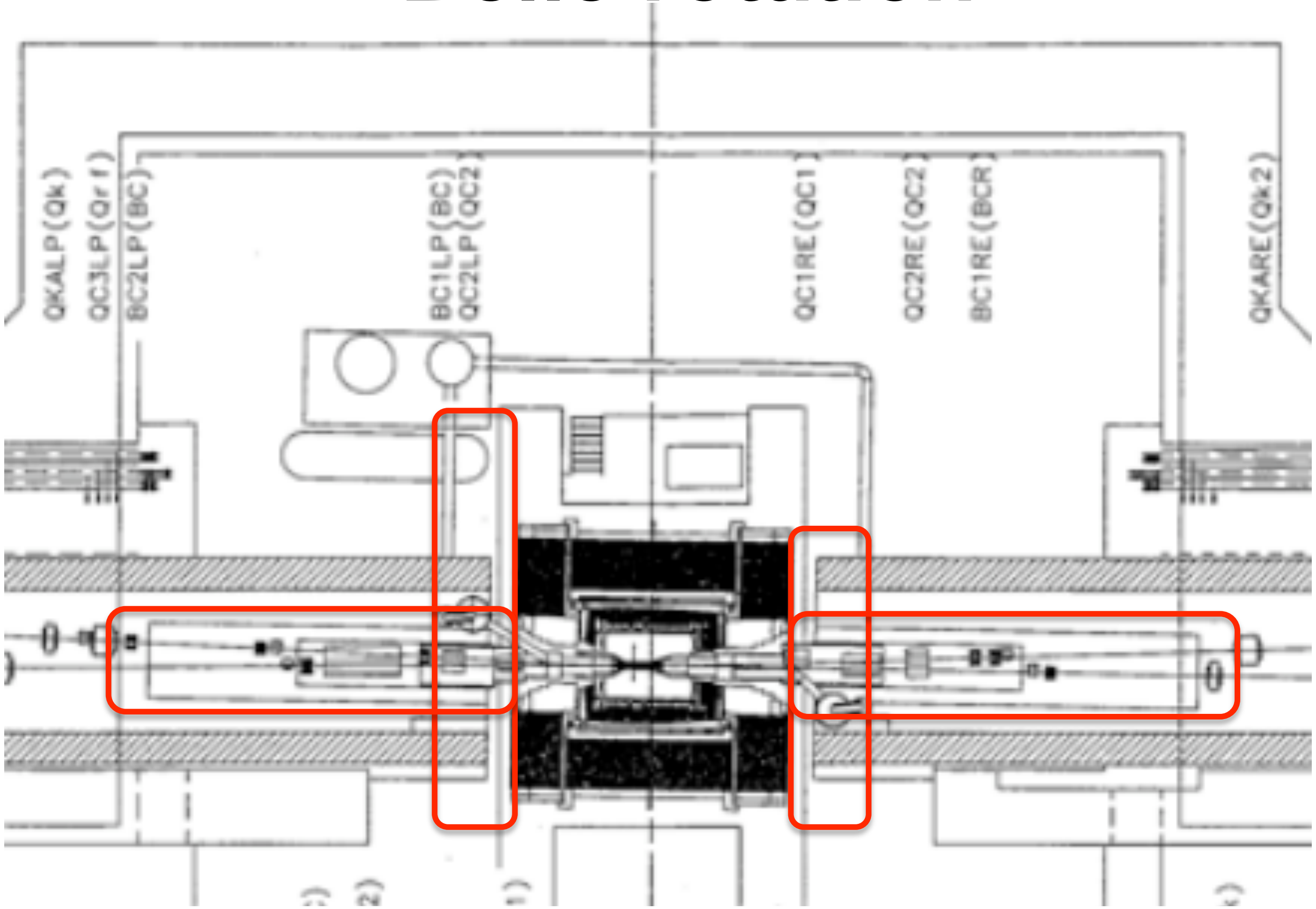
Belle rotation

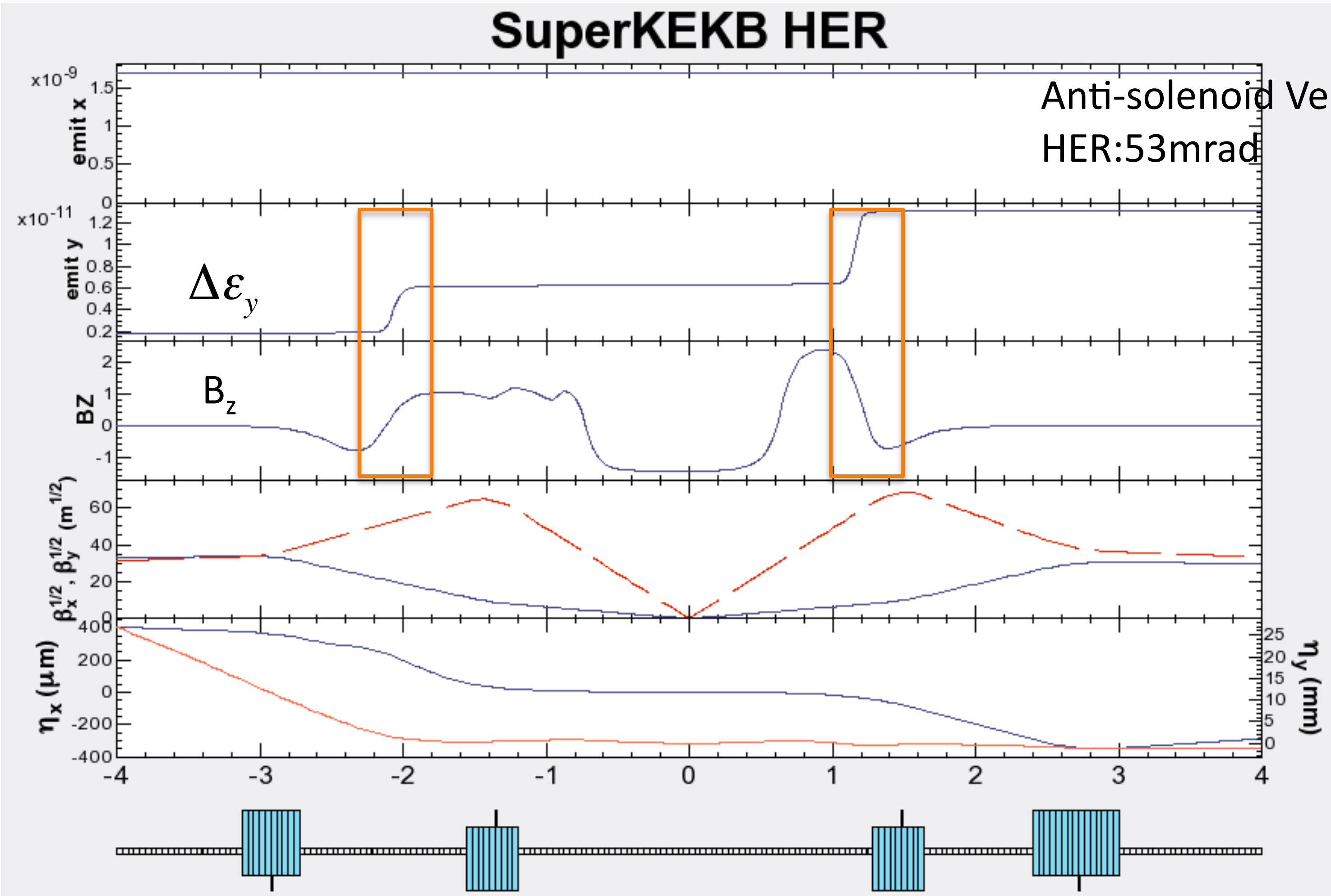


Need to modify the concrete base and shields in order to rotate Belle detector

Anti solenoid

H. Koiso

Vertical emittance degradation depends on the anti-solenoid fields profile

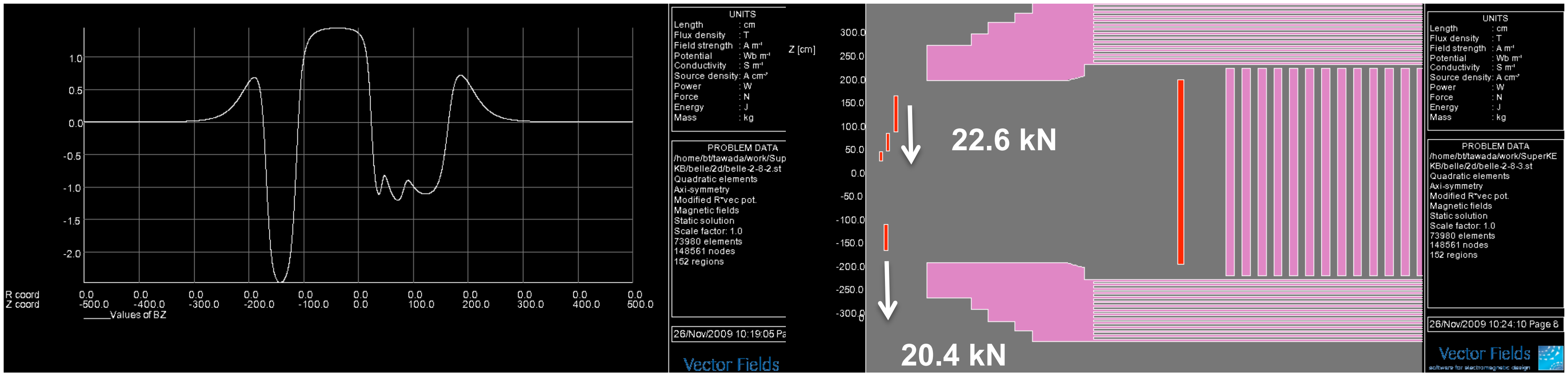


Anti solenoid

Issues for anti-solenoid

- B_x components degrade vertical emittance performance
  - LER $\Delta\varepsilon_y$=+5.8pm (+0.18% for 3.2 nm) for 41.5mrad
- EM force for anti-solenoids is better
  - SuperKEKB S-R= 20.4 kN, S-R= -22.6 kN
  - KEKB S-L= 22 .0 kN, S-R= 2.8 kN
- COD

We need to find a better solution for anti-solenoid



Anti-solenoid ver. 2

Anti Solenoid

EM forces are acceptable

< 40 kN

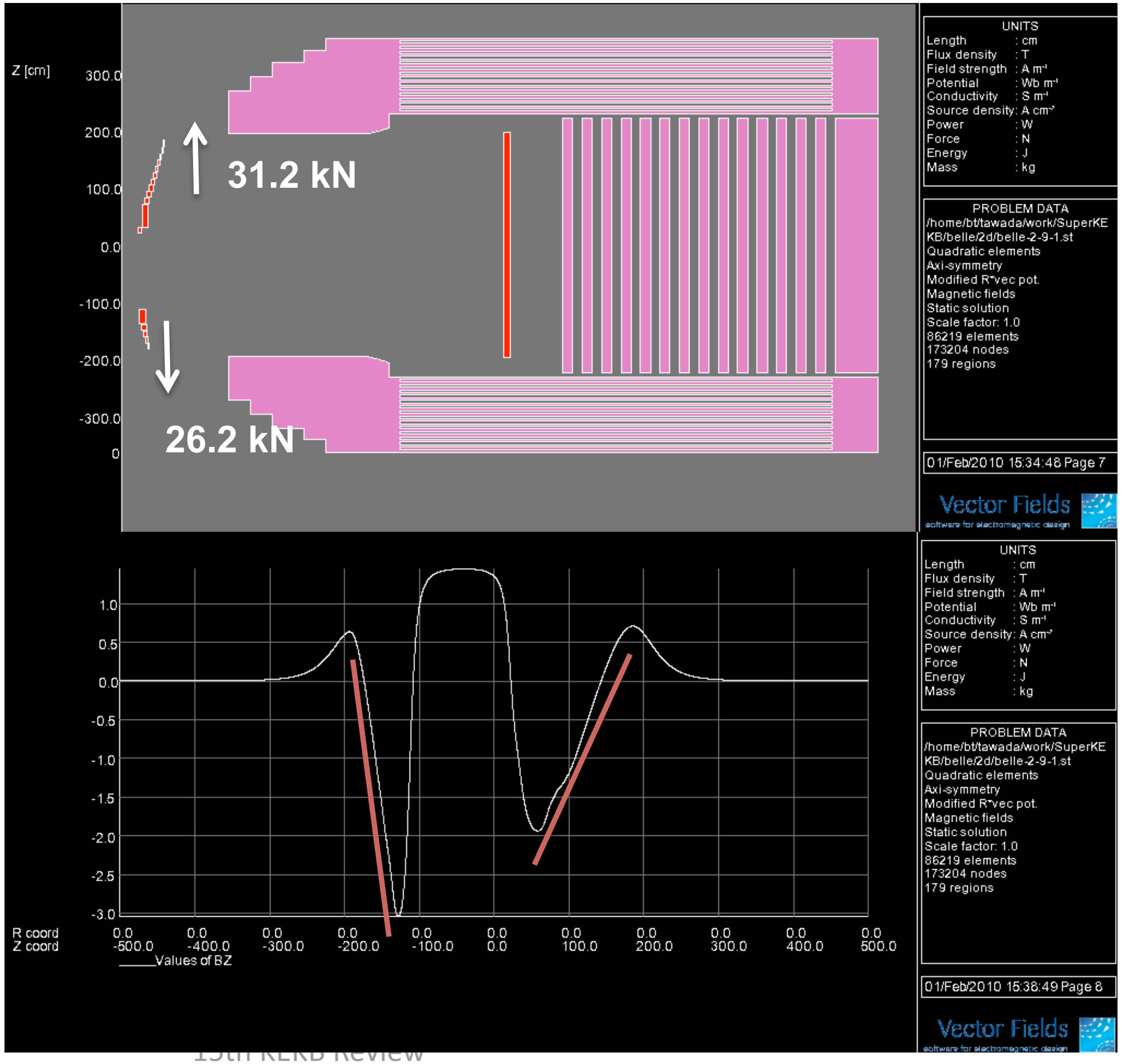
S-R=-22.6 kN → 31.2kN

S-L= 20.4 kN → 26.2kN

$$B_x = -\frac{1}{2}\frac{\partial B_z}{\partial z}x$$

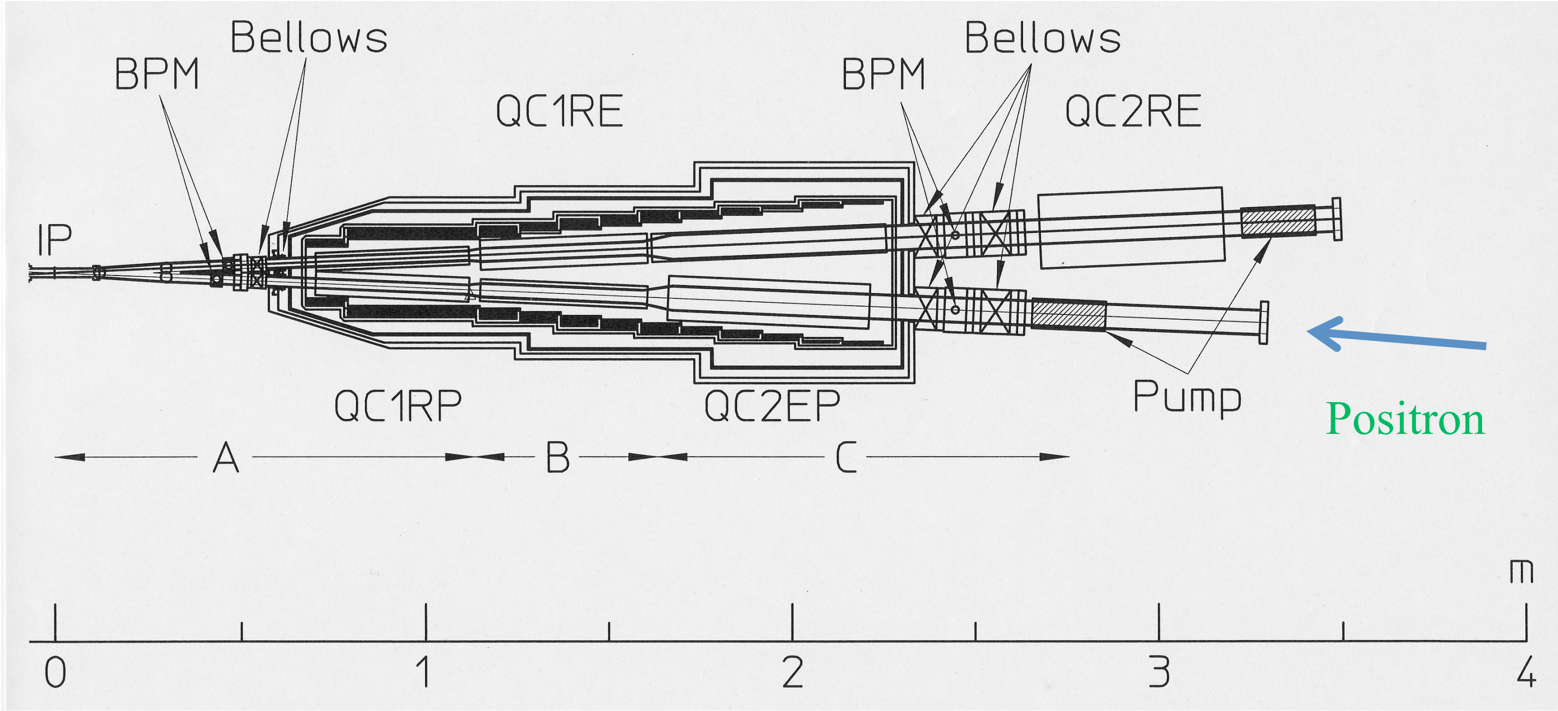
Gradients can be reduced

Anti-solenoid ver. 3



IR vacuum chamber

K. Kanazawa



- Vacuum level will be worse due to poor vacuum conductance.
- IR assembly is a big issue
- BPM can’t be fixed rigidly on the quadrupole magnet

Physical Aperture

- Required acceptance for injection
  - $2J_x$=5x10^{-7} (m), $2J_y$=2x10^{-8}(m), 4% coupling
  - Dynamic effects are ignored because nominal ν_x = 0.53
- Physical aperture is not enough for the design β-functions
  - COD is not taken into account
  - No margin for error

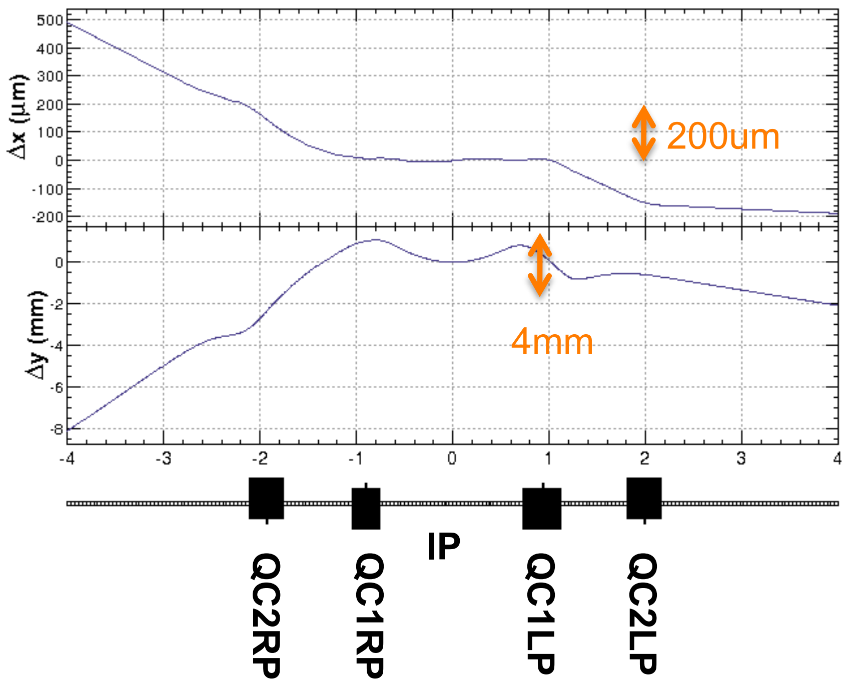
	QC1LP	QC1RP	QC1LE	QC1RE	QC2LP	QC2RP	QC2LE	QC2RE
Physical Aperture (mm)	20	20	30	30	60	60	70	70
Required Aperture (Horz.) (mm)	11.2	10.0	16.4	17.2	25.6	28.4	47.6	48.4
Vert. (mm)	15.8	14.8	18.2	18.2	9.4	9.6	15.4	10.6

COD (Belle)

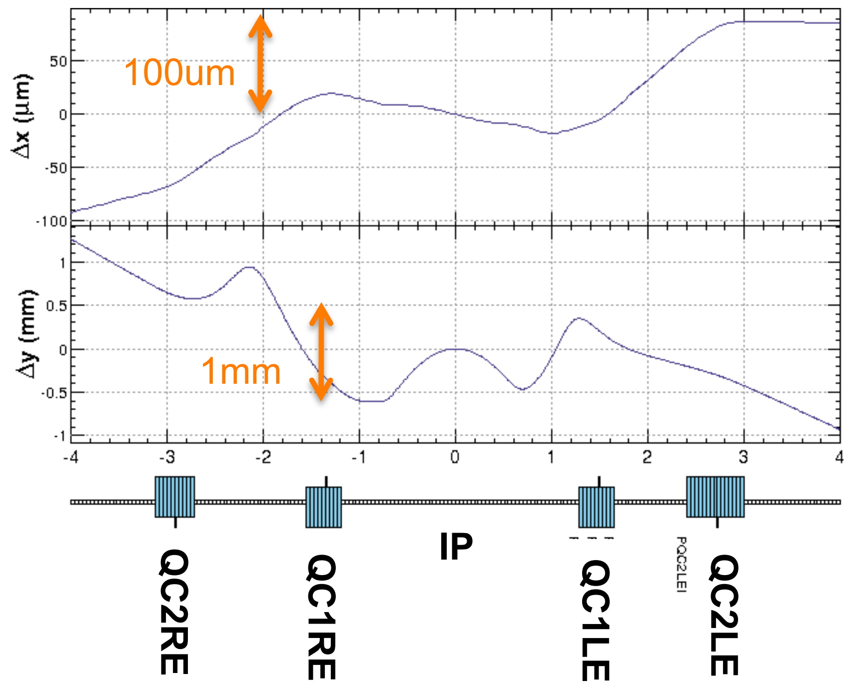
A. Morita

COD in Belle detector depends on the solenoid field profile

COD(LER 41.5 mrad)



COD(HER 41.5 mrad)

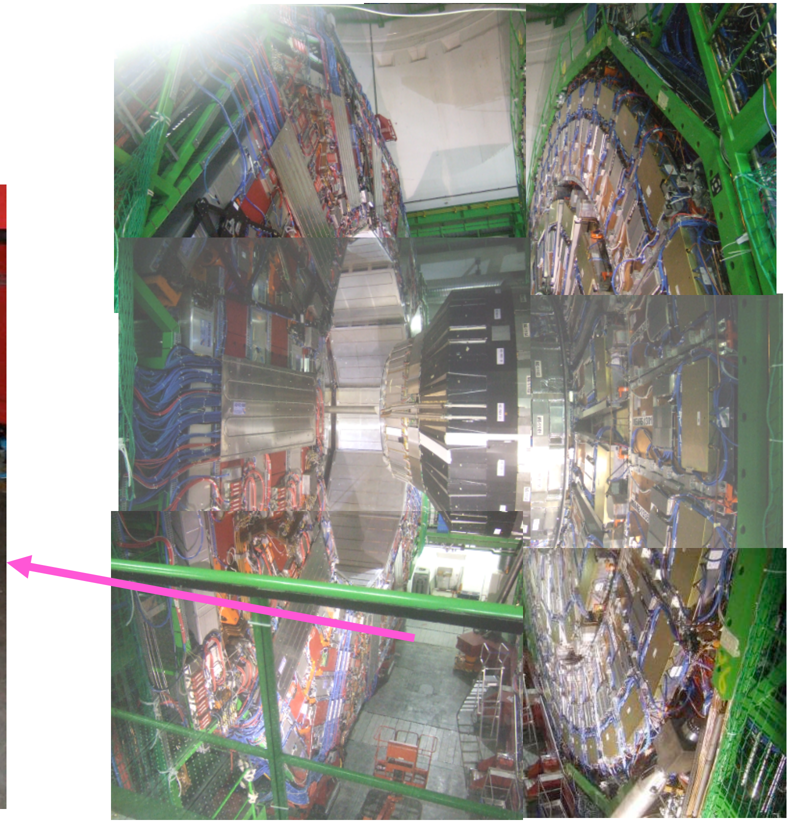


Summary

- IR design based on Nano-beam scheme
- Beam energy: 7x4 GeV and crossing angle: 83 mrad
- The design work is on-going
- Issues
  - IR magnets (N. Ohuchi)
  - Vacuum chamber and assembly (K. Kanazawa)
  - BG simulation for Belle (M. Iwasaki)
  - Vibration measurement (H. Yamaoka/M. Masuzawa)
  - Rotate HER orbit or Belle detector
  - Estimation of the beam loss rate at IR
  - Optics simulation with error

Spare slides

AirPad@CMS

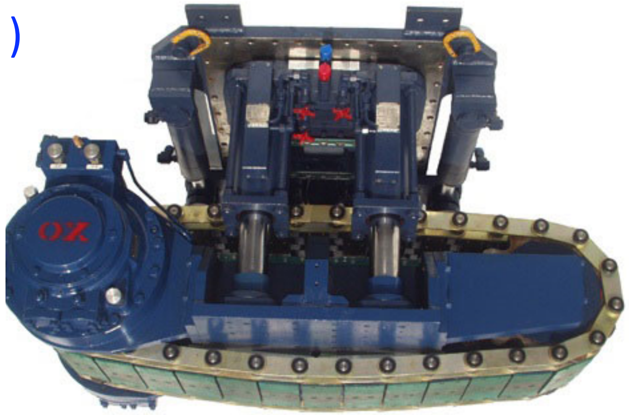


駆動式エンドレス滑り装置JES(オックスジャッキ(株))

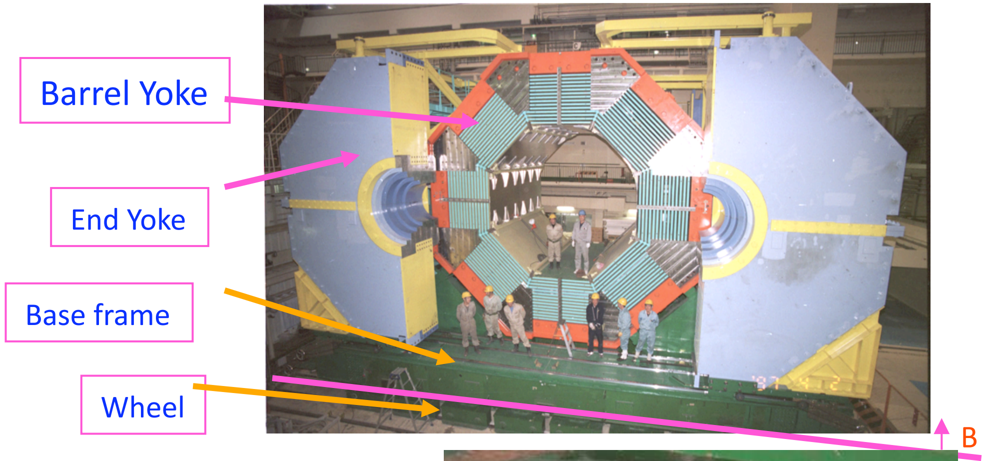
http://www.oxjack.co.jp/modules/general/index.php?action=view_product&product_id=66

仕　様

型　式	JES-25030
鉛直耐力	2,500 kN
鉛直方向調整量	300 mm
駆動力	150 kN
水平方向調整力	200 kN
水平方向調整量	±100 mm
送り出し方向調整角度	± 13°（最大）
橋軸縦断方向許容傾斜角	± 5°
橋軸横断方向許容傾斜角	± 3°
質　量	約 2,900 kg



Rotate Belle and base frame



How to:

1. Support Belle and base frame temporaly
2. Remove old wheel
3. Remove hydraulic machines
4. Rotate belle and base frame
5. Attach new support equipments
6. Put hydraulic machines
7. Put on the new wheel