IR summary

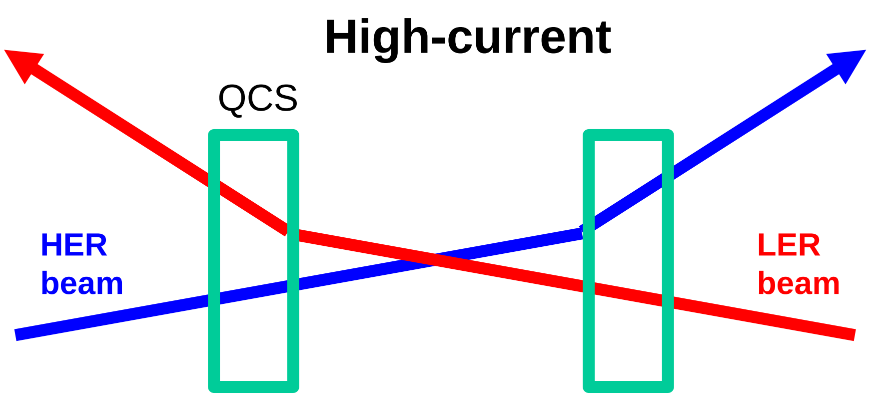
2009/7/9 M. Iwasaki (Tokyo)

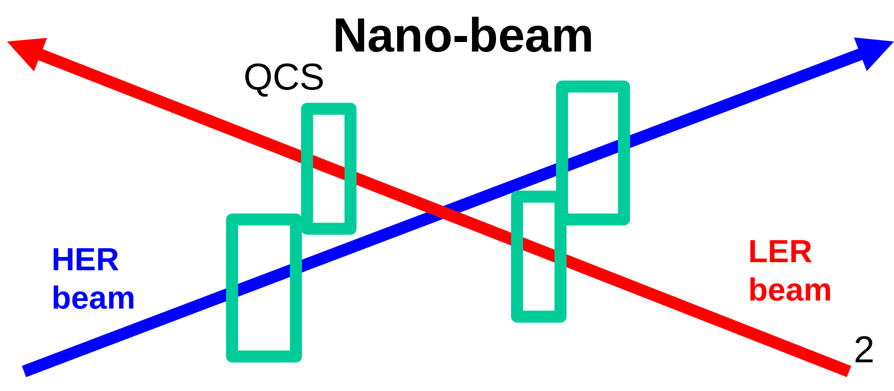
For Belle-II MDI Group
Tokyo / Tohoku / KEK

Two machine options

High-current option … SR BG & HOM heating
Nano-beam option … IR assembly & support

	High current (LER/HER)	Nano-beam(LER/HER)
Beam current I (A)	**High current** : 9.4/4.1	~3/~2
Bunch length σ_z (mm)	**Short bunch length** : 5/3	6/6
Emittance ε_x (nm)	24/18	Low emittance : 1/1
β_y (nm)	3/6	Small β : 0.22/0.22
Beam size σ_y	0.85/0.73 (μm)	**Small beam size** : 34/44 (nm)
Final Q-magnet layout	- Common QCS for 2 beams - location 40cm (L) / 65cm (R) Little space in L side	Two separate Q-magnets for each 2 beams **Little space in both L/R sides**





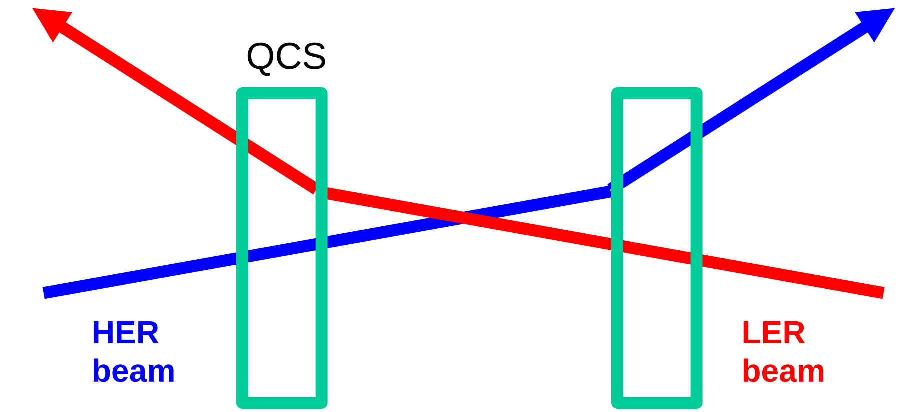
Final Q layout & beam-pipe

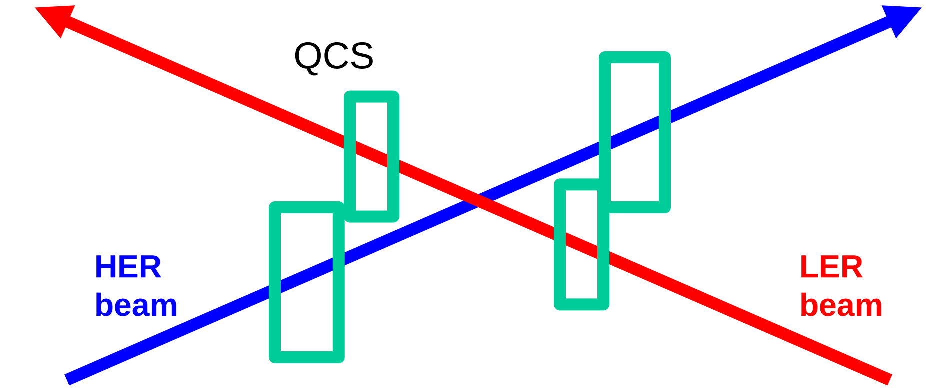
High-current option

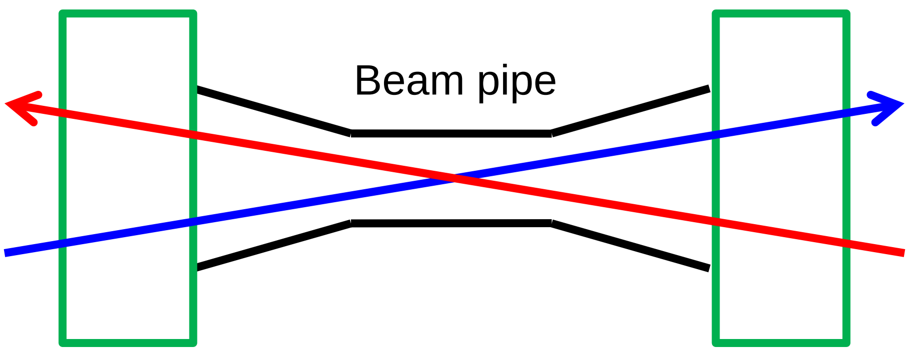
Common QCS for 2 beams

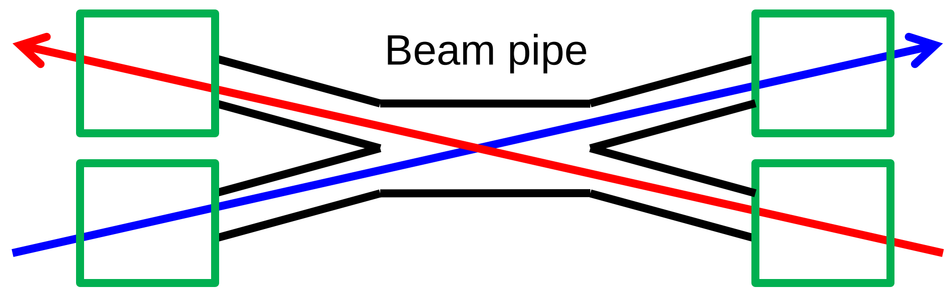
Nano-beam option

Two-separate Q-magnets for each 2 beams









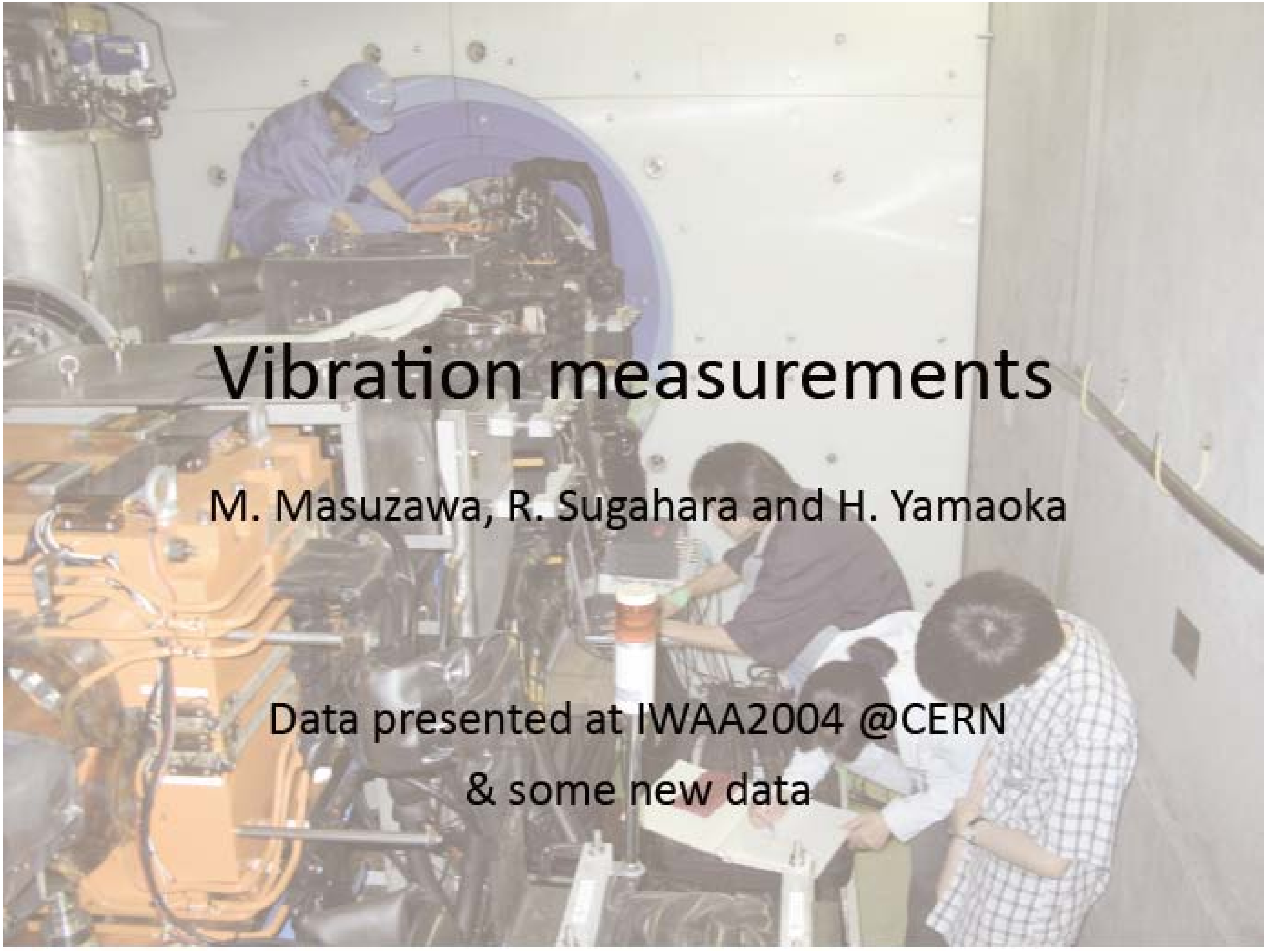
To connect with the separate Q magnets the IP beam pipe has branch structures (crotch structures)

IR session on 07/07

8 talks in the session

16:30->*19:30* **Parallel-A: IR** (3-go-kan seminar hall)

16:30	Introduction (schedule, etc) (15') (Slides)	Masako IWASAKI (*Tokyo Univ*
16:45	Vibration Measurements (15') (Slides)	Mika MASUZAWA (*KE*
17:00	Optics (15')	Akio MORITA (*KE*
17:15	QCS magnet (15') (Slides)	Norihito OHUCHI (*KE*
17:30	IP chamber design (15') (Slides)	Ken-ichi KANAZAWA (*KE*
17:45	HOM calculation (15') (Slides)	Hitoshi YAMAMOTO (*Tohoku U*
18:00	Assembly + BG simulation 1 (15') (Slides)	Masako IWASAKI (*Tokyo Univ*
18:15	BG simulation 2 (15') (Slides)	Clement NG (*U.Toky*
18:30	Discussion (30')	



Vibration measurements

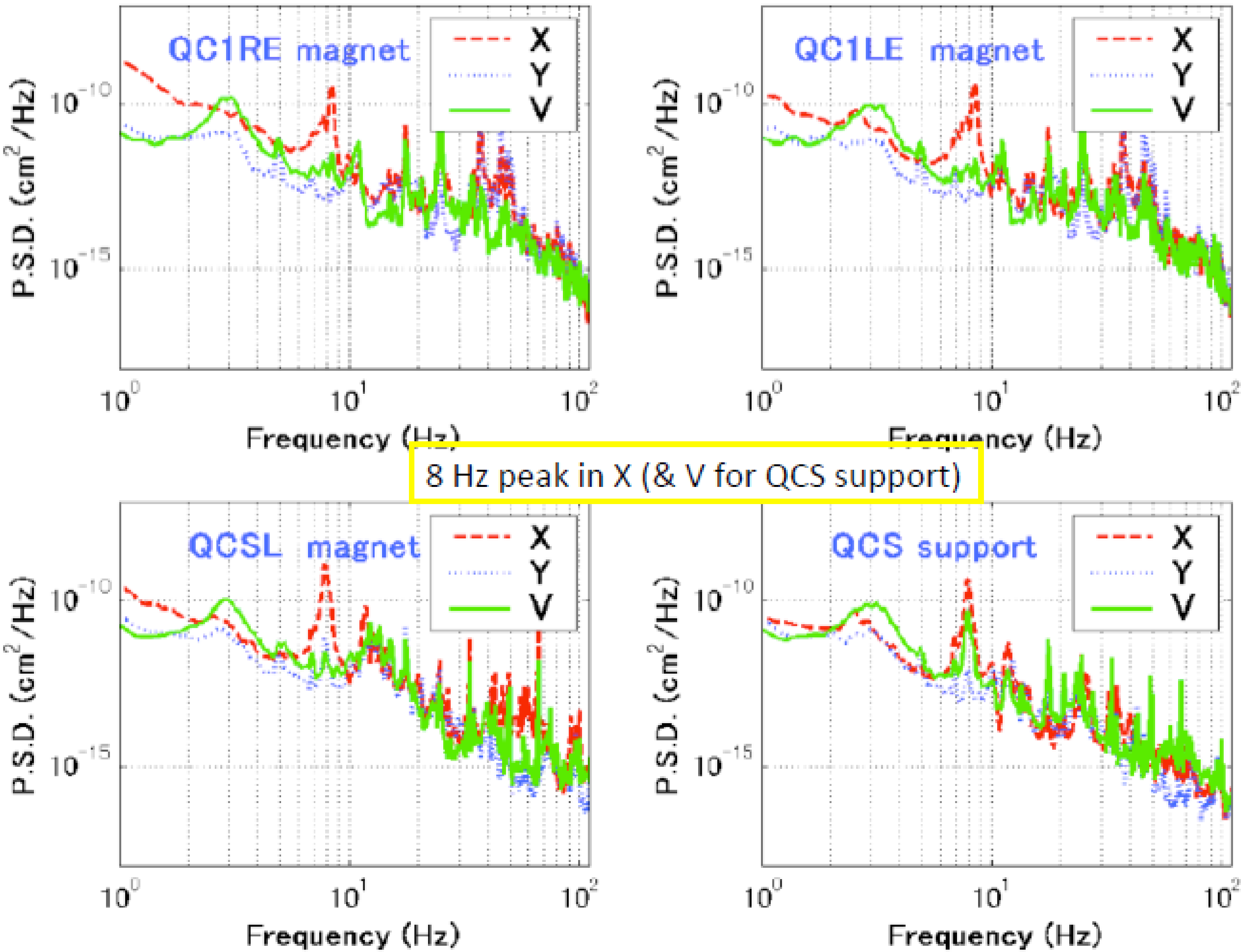
M. Masuzawa, R. Sugahara and H. Yamaoka

Data presented at IWAA2004 @CERN

& some new data

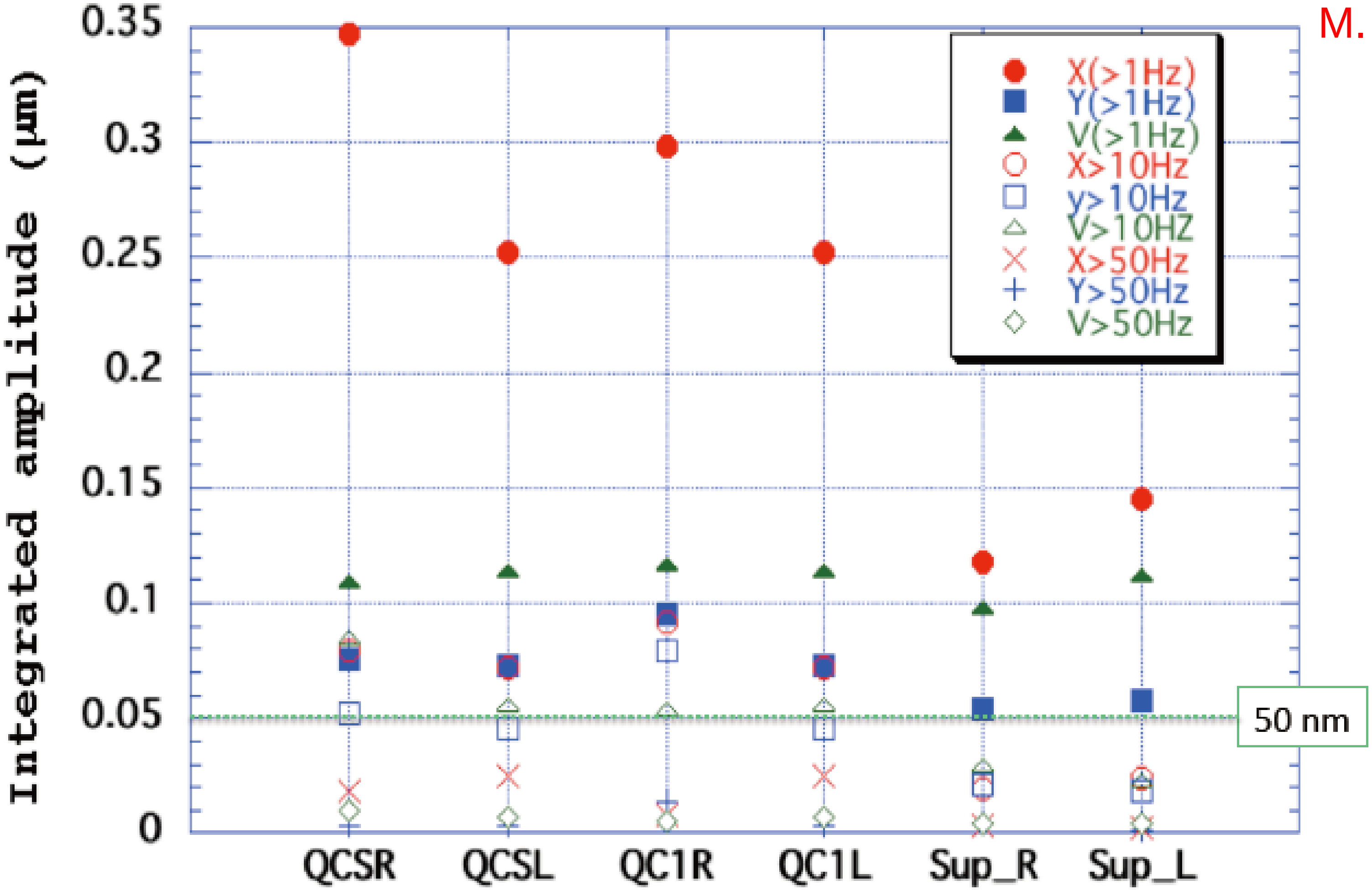
Vibration measurements (IP)

M. Masuzawa (KEK)



Vibration measurements

M. Masuzawa (KEK)



Amplitude of 8Hz peak ~0.3μm(X) ~0.1μm(V)

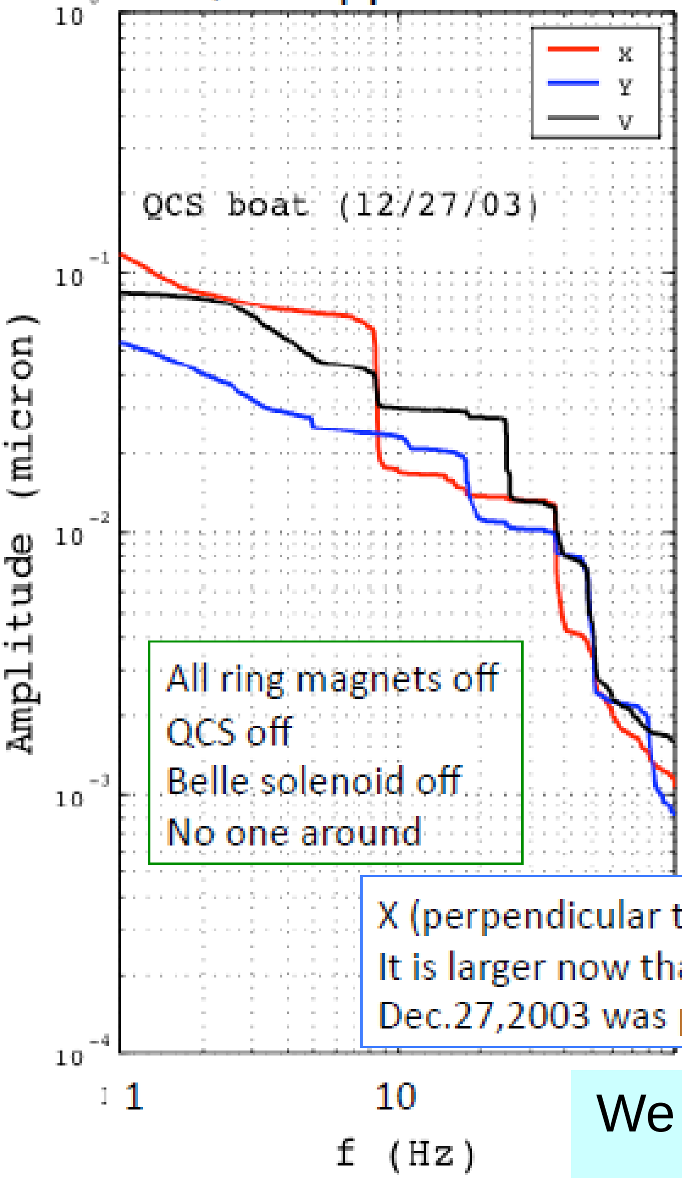
Comparing with the colliding beam sizes, these amplitudes are small (at KEKB)

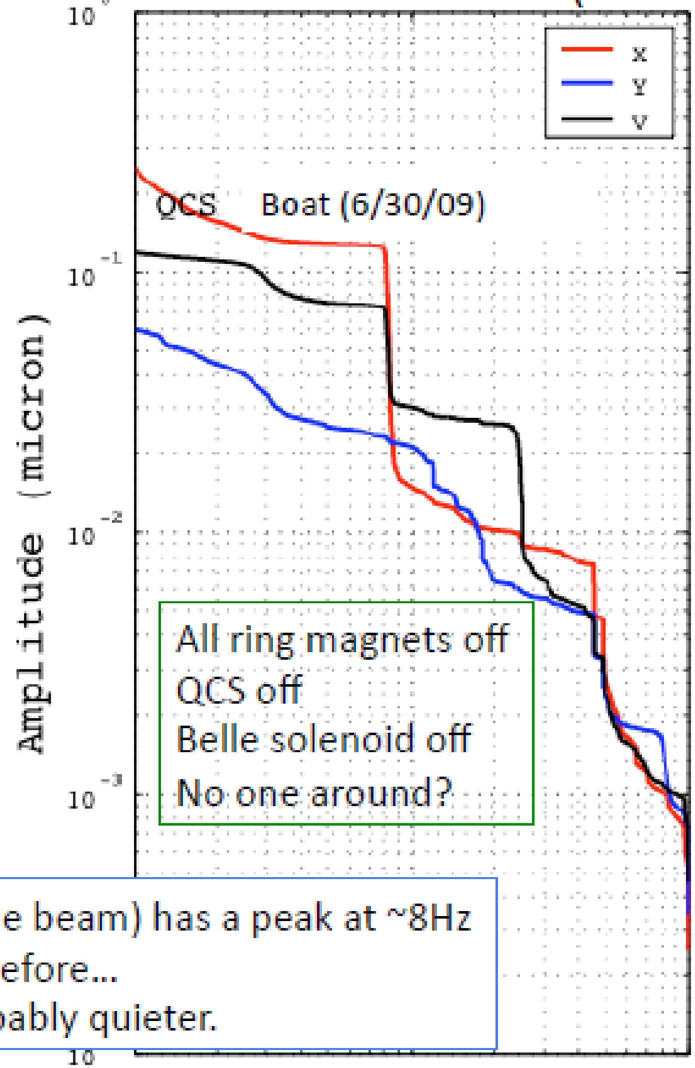
not small (at Super-KEKB)

Vibration measurements

IR R-side QCS support table "boat" vibration now and then (2003))

M. Masuzawa
(KEK)





X (perpendicular to the beam) has a peak at ~8Hz
It is larger now than before...
Dec.27,2003 was probably quieter.

We still have the ~8Hz peak around QCS magnets
Due to the support table boat vibration

Vibration measurements

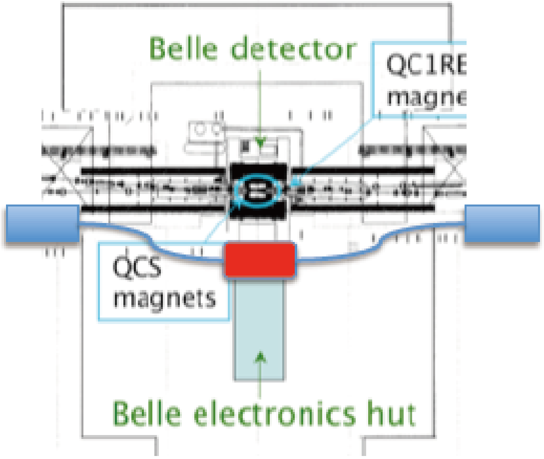
Plans for this summer

M. Masuzawa (KEK)

☆Environment has changed since the measurements in 2004. New data need to be taken again⇒Done on June 30 (with H.Yamaoka and et al)

☆Coherencey measurements between R-and L sides of the IP. Needs two sets of everything. ⇒Sometime this summer.

L側とR側の振動の違い。2台のロガーを用いてL側とR側同時測定を試みる。



☆New data on the effects of AC on/off

Plan for Super-KEKB

1) Feed-back system

(attach Beam Position Monitors to the IP-beam pipe)

2) R&D of the supporting structure / QCS boat

Current Status of SuperKEKB IR Design

2009-07-07

Akio Morita

Beam Optics design

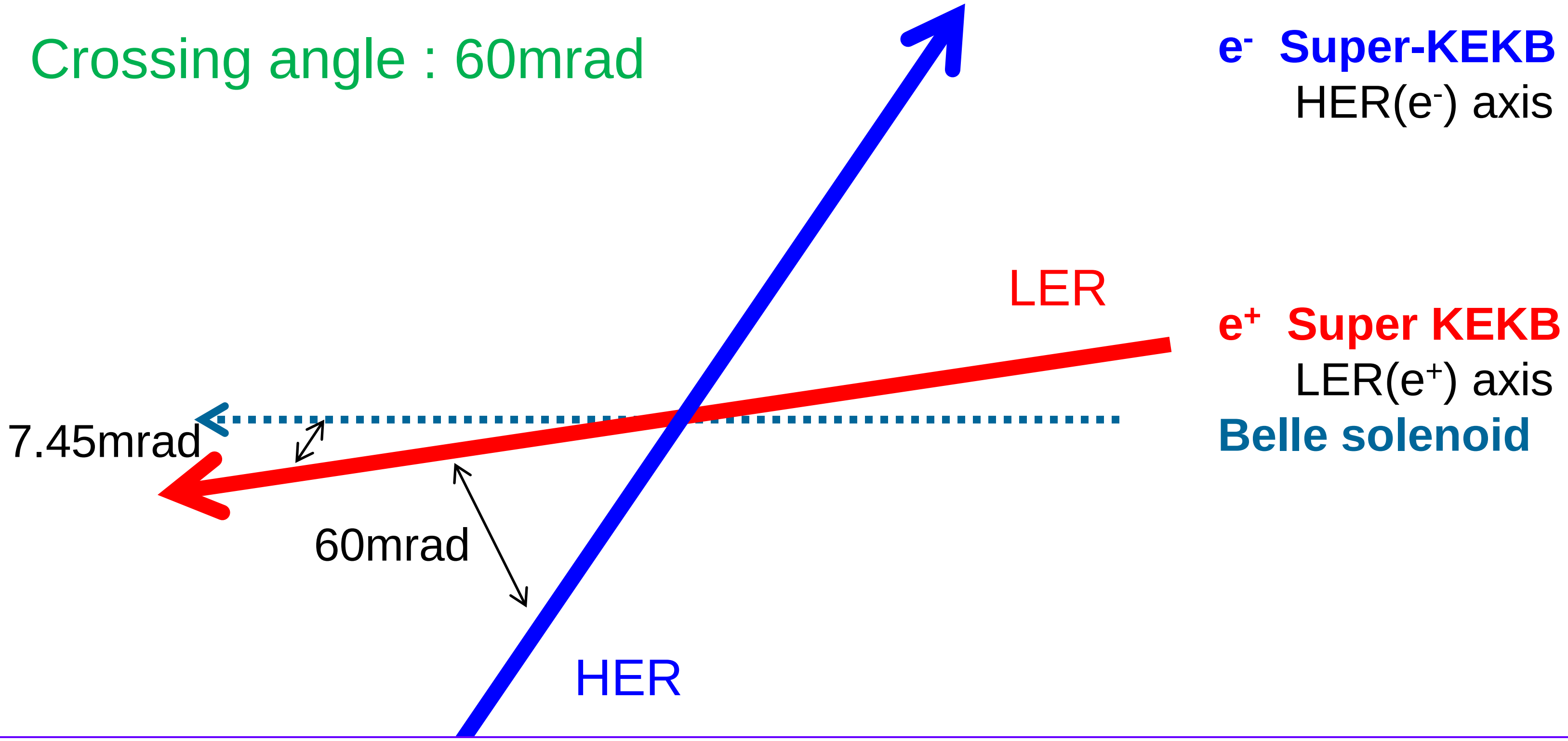
A.Morita (KEK)

Design Strategy & TODO

- **IR Design Constraint**
  - Current KEKB tunnel geometry
  - Separated final focusing quadrupole magnet geometry
  - Local chromaticity correction performance
  - Low emittance Local chromaticity correction
- **Current Critical Issue**
  - LER Touchek lifetime is too short.(< 200sec)
    - Limited by QC1's non-linear fringe feild(hard to cure)
  - Install SC QC1* quadrupole into current location is difficulty.
    - Switch to PMQ?
    - Increase crossing angle?
- **TODO**
  - Update QC* geometry/IP design parameter
  - Improve chromaticity correction/dynamic aperture
  - Implement QC* multipole/distribution and solenoid
  - etc...

Relationship between Belle-II and Super-KEKB: Nano-beam

Crossing angle : 60mrad



Beam pipe : parallel to HER? LER? Belle solenoid? Or??
→ depends on the SR BG → depends on the beam optics

Parameters are not fixed yet

- **Optics is updated every 1-2 weeks**
- **Rotate Belle-II?!**

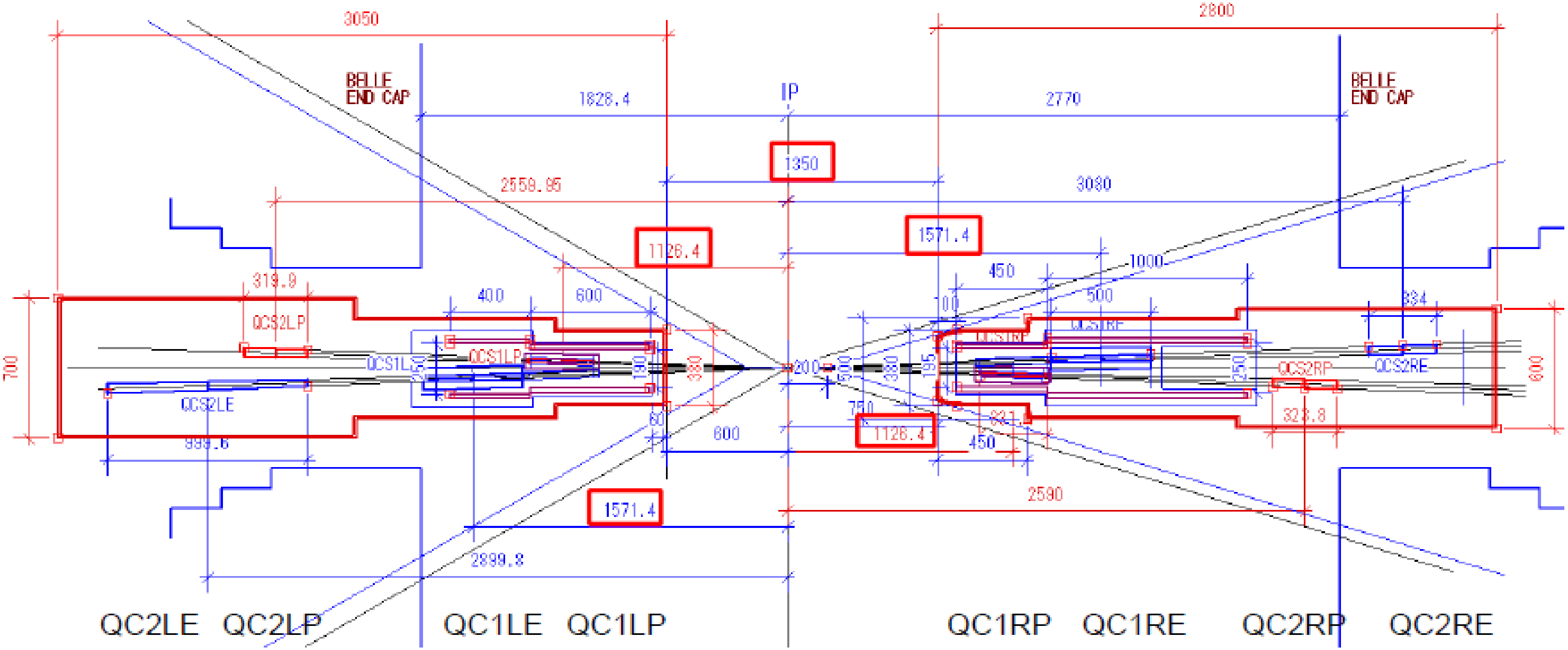
Final Focus Magnet System

N. Ohuchi, M. Tawada, Z. Zhanguo,
N. Higashi, K. Tsuchiya

QCS design

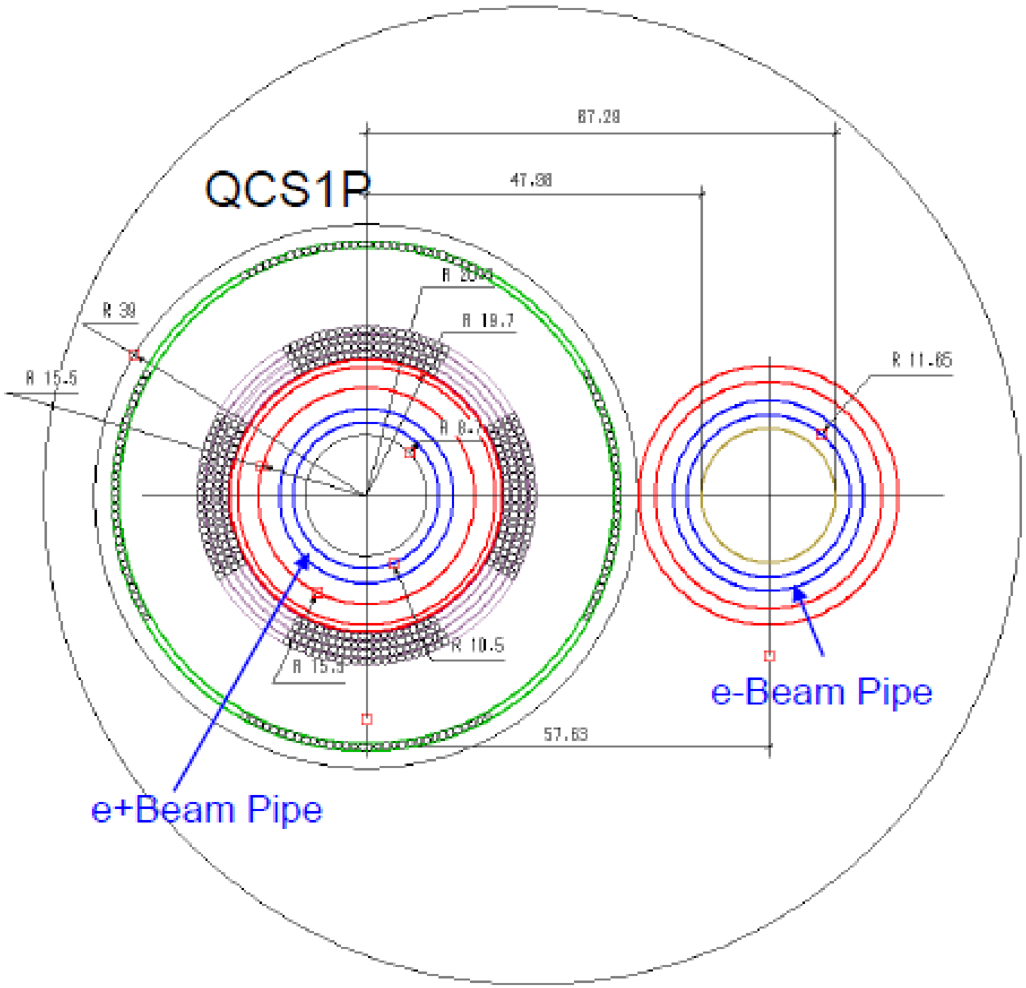
N. Ohuchi (KEK)

IR-magnet cryostat



QCS design QC1P(R/L)

N. Ohuchi (KEK)



QCS1P Cross Section

1. Design integral field
   - Int. G=17.683 T(R), 17.772 T (L)
2. Main quadrupole configuration
   - 4 layer coils (wire coil)
     - (1st layer/2/3/4=10 turns/10/11/11)
3. Active shield coil
   - 1 layer coil (16 turns)
4. Superconducting wire
   - Outer dia.=1 mm
   - Cu Ration=1.2
   - Current= 730.53 A(R), 734.21 A(L)
   - Current density (SC area)= 2900 A/mm^2 (R), 2915 A/mm^2(L)
   - Current density (wire)=1318 A/mm^2 (R), 1325 A/mm^2 (L)
5. Cryostat bore=Beam pipe (room temp.)
   - Inner radius=10.5mm
6. Helium vessel bore without LN_2 shield
   - Inner radius=15.5mm

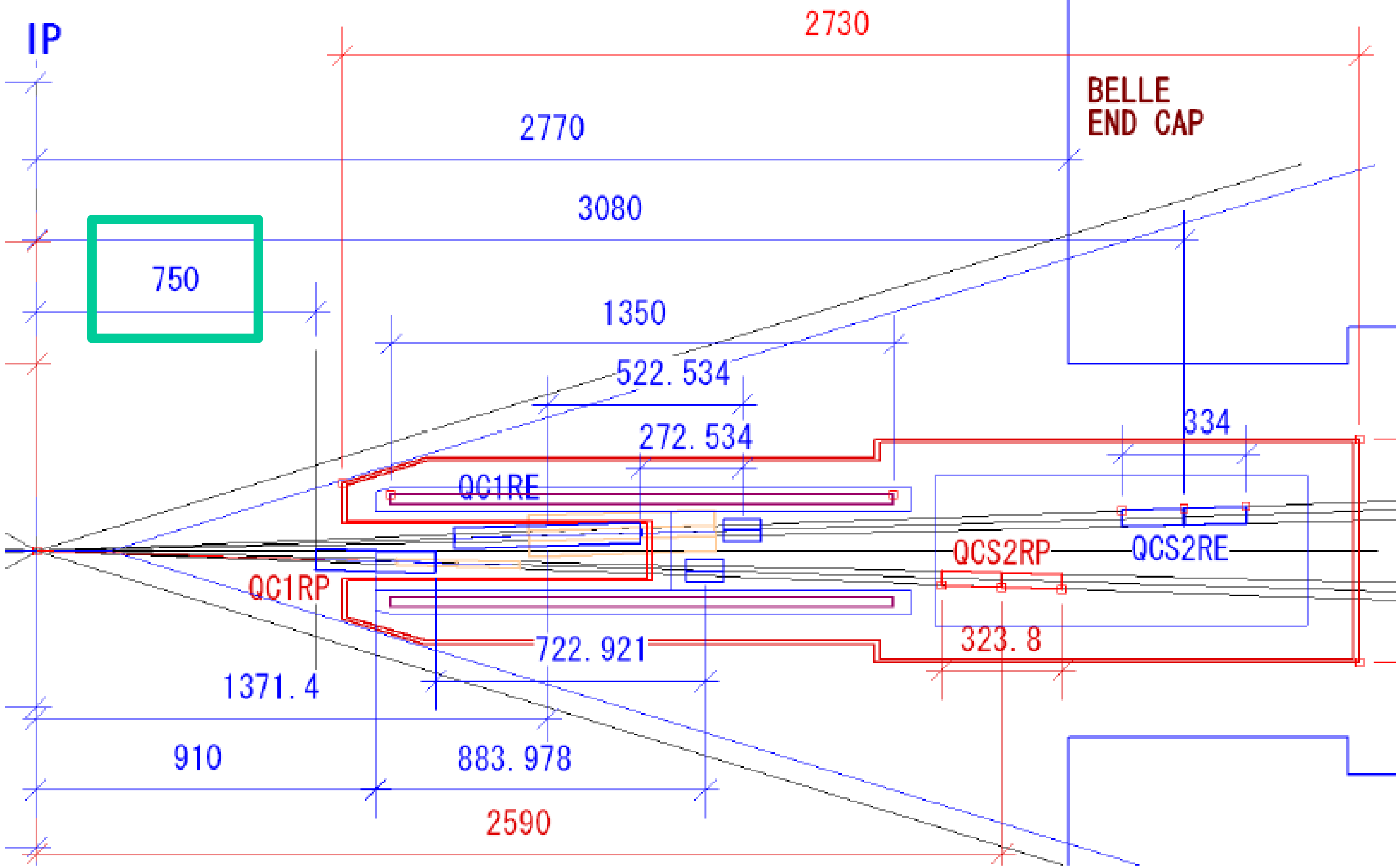
To avoid HOM trap, IP beam-pipe radius < QCS radius

→ **IP beam-pipe Inner radius = 10.5mm**

QCS design

N. Ohuchi (KEK)

QC1P/E(Permanent Magnet System)



Energy:4S ⇒ 1S~ 5S : Quadrupole strength -11% ~ +2.7%

QC1P: 18 (T/m)×m, QC1E:30 (T/m) × m

Preliminary IP Chamber Design

Ken-ichi Kanazawa
KEKB Vacuum Group
7 July 2009

IP-beam pipe design

K. Kanazawa (KEK)

Design Features

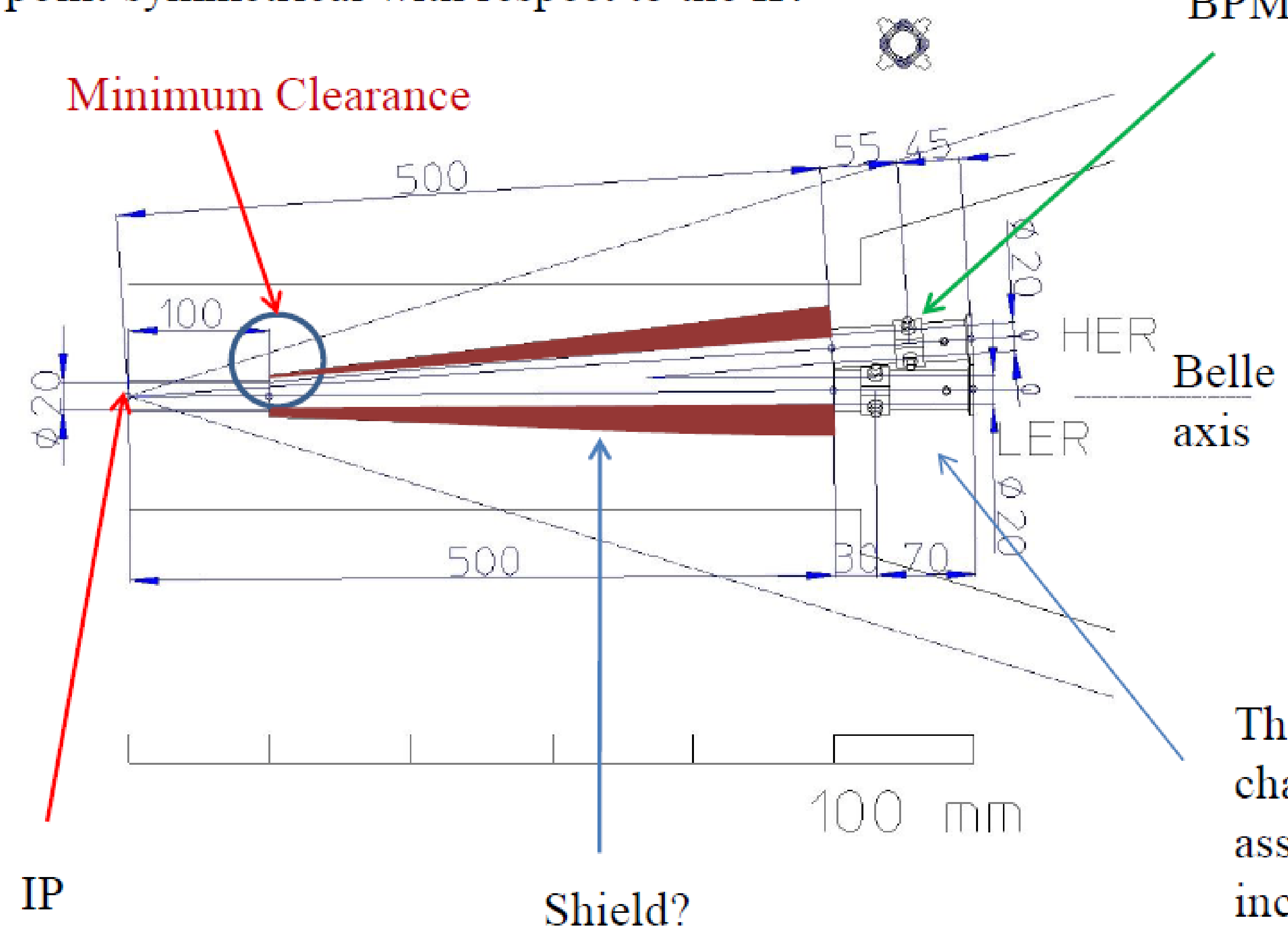
- LER beam (incoming): 7.46 mrad with respect to the Belle solenoid axis.
- HER beam (outgoing): 67.46 mrad with respect to the Belle solenoid axis.
- ϕ 20 mm x l 200 mm straight pipe parallel to the Belle solenoid axis at IP.
- With beam position monitors (BPM) For feed back
- ISO-KF-like flange.
- Avoid cavity-like structure at IP.

IP-beam pipe design

Preliminary Drawing

K. Kanazawa (KEK)

Half of the chamber. The other part is point-symmetrical with respect to the IP.

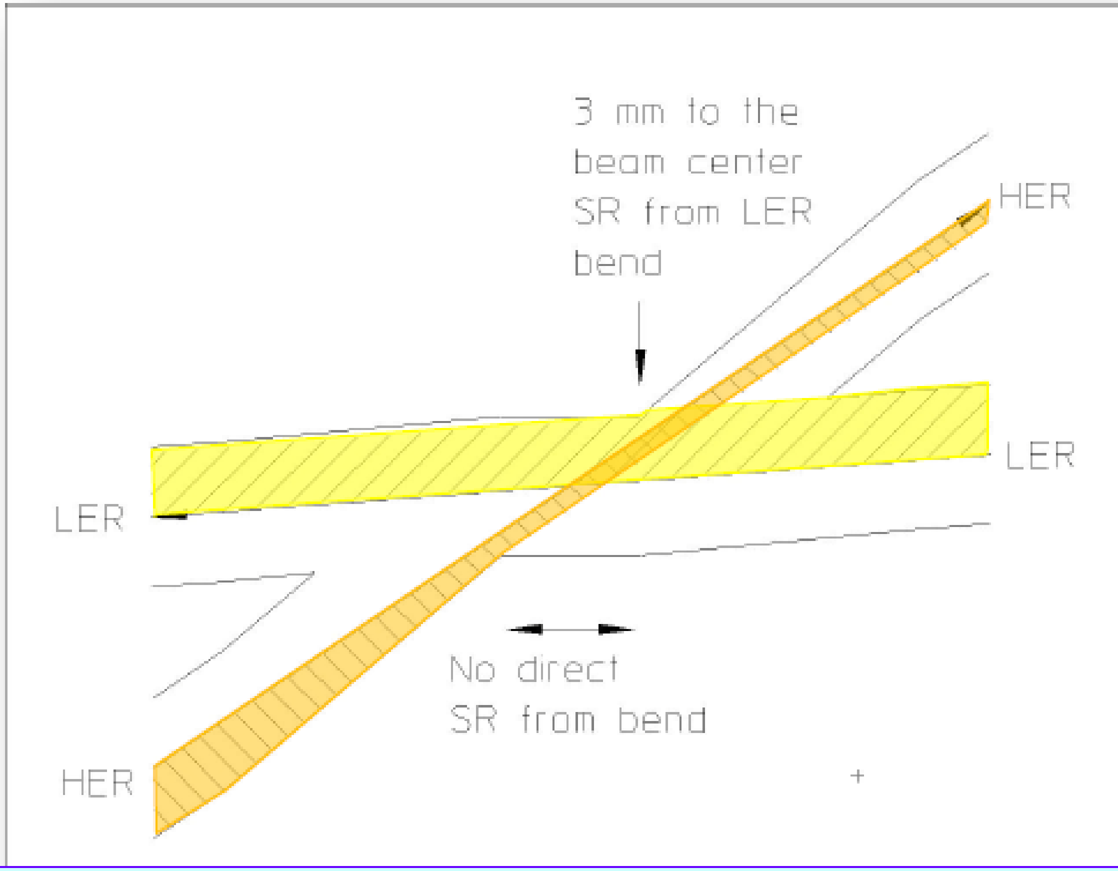


The minimum distance between the beam pipe wall and the high energy beam is ~3 mm (~5A_x).

The thickness of the chamber wall is assumed to be 4mm to incorporate a water channel.

IP-beam pipe design
SR from the last bend

K. Kanazawa (KEK)



No direct synchrotron radiation from the last bend on the central part.

Beam pipe parallel to Belle solenoid (~ LER axis) to avoid SR BG
→ But the optics assumed for this design is already obsolete…

HOM loss calculation of IP chamber

Nakano Hiroshi

7-Jul-2009

(presented by Hitoshi Yamamoto)

Thanks to Tetsuo Abe and other experts

H. Yamamoto (Tohoku)

HOM calculation

GdfidL: 3D field calculation tool

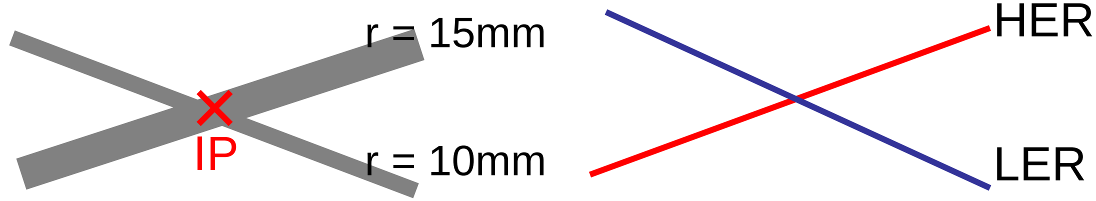
Options

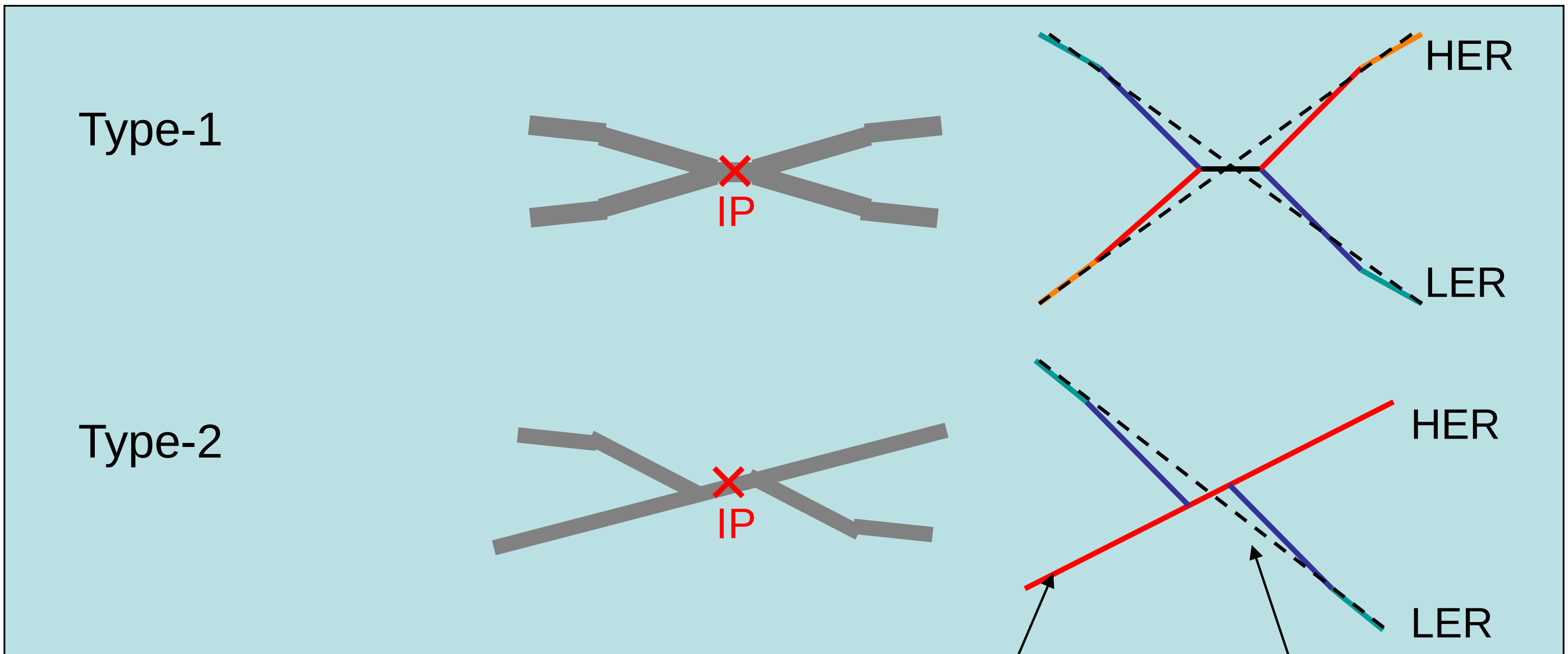
- Two modes
  - Grid moves with bunch (window wake = yes)
  - Grid fixed to lab (window wake = no)
- Symmtries
  - 1/2,1/4 etc.
- Mesh sizes

New geometries

H. Yamamoto (Tohoku)

before





color: center of pipe

dashed: beam trajectory

All pipes have 10mm radius.

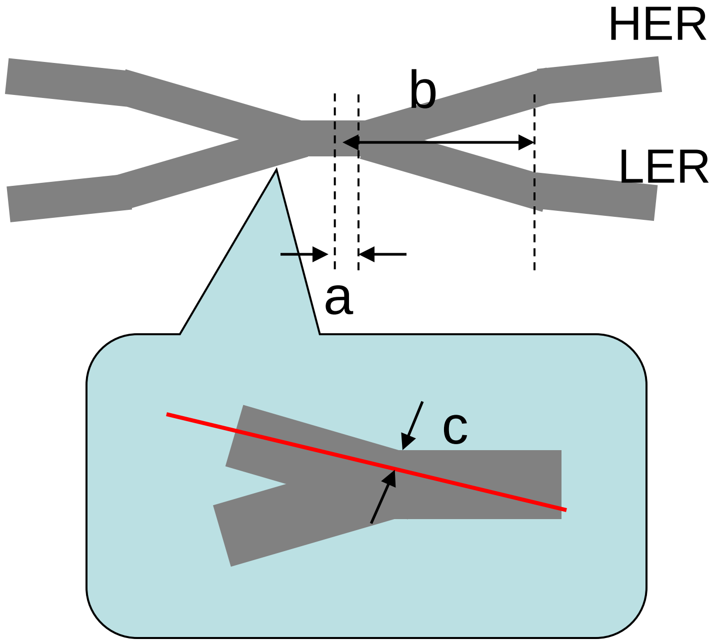
Crossing angle of the beams is 60mrad.

Type-1

H. Yamamoto (Tohoku)

*mesh size = 0.2mm, 1/2 model

a	b	c	loss factor $[10^{-3}V/pC]$
100	480	7.0	0.68
100	580	7.0	0.66
100	680	7.0	0.77
150	480	5.5	0.82
150	580	5.5	0.90
150	680	5.5	0.82



36~48W (HER+LER)

Check with finer mesh

Loss factor -> 1.2 * 10^-3[V/pC] (in case of mesh size = 0.08mm)

→ 64W

Type-2

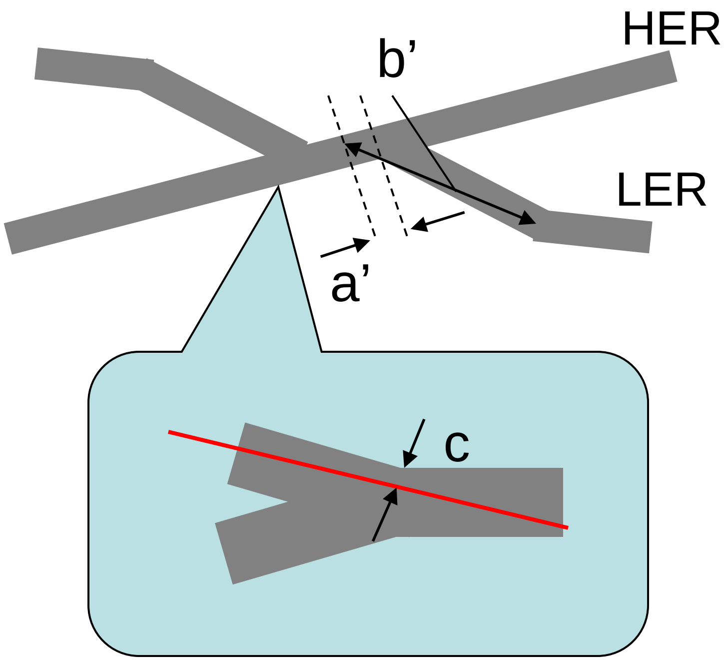
H. Yamamoto (Tohoku)

*mesh size = 0.13mm, 1/2 model

HER / LER

a'	b'	c	loss factor $[10^{-3}V/pC]$
86	480	7.3	1.9 / 2.3
165	480	5.0	2.4 / 2.1
84	680	7.5	1.8 / 2.4
165	680	5.0	2.1 / 2.2

115~119W (HER+LER)



Check with finer mesh

Loss factor -> 2.1 / 2.4 * 10^-3[V/pC] (in case of mesh size = 0.08mm)

→ 124W

H. Yamamoto (Tohoku)

Summary

- GdfidL gives stable(reliable) results
  - Within 10~20%
  - For different calculation modes, use of symmetries, length of wake calculation, mesh size, etc.

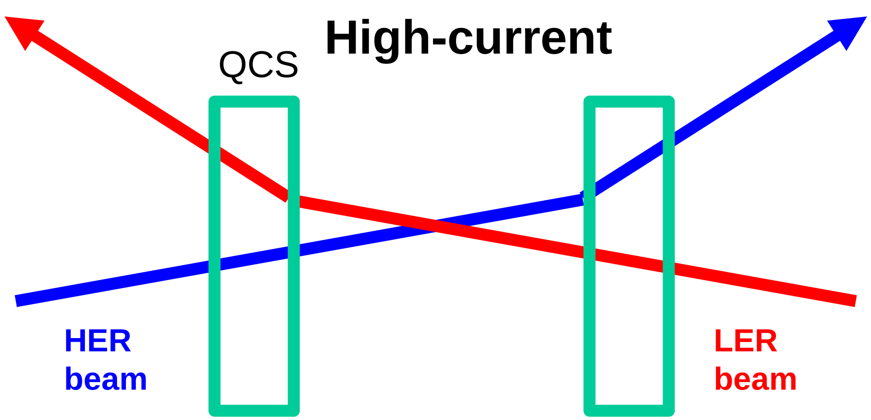
- Crossing beam pipe designs for nano beam option have been evaluated for HOM
  - HOM loss is of order 50W~100W
  - Larger for larger crossing angles

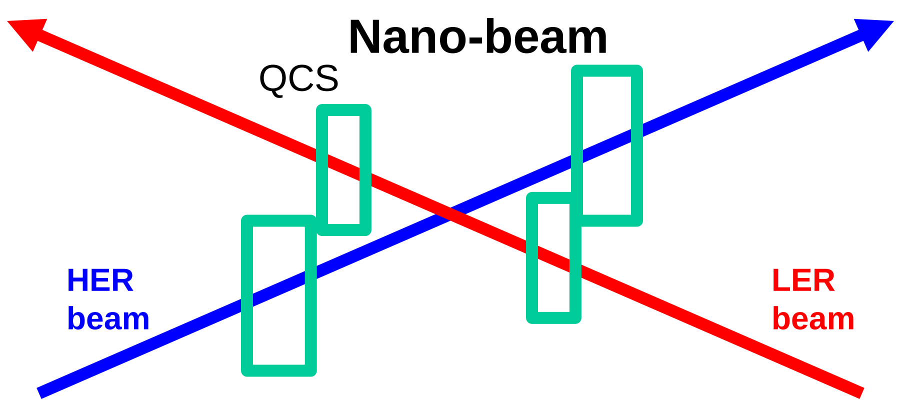
If the crossing angle is small enough,
no problem to use the crotch structure beam pipe

Detector BG

Detector BG

	High current option	Nano-beam option
SR (upstream)	**Much higher** Large beam size at Q Very high current	**Lower? Higher?** Small beam size at Q But large bending magnet
SR (back-scatter)	**Higher** Strong QCS B-field	**Much lower** No QCS bending
Radiative-BhaBha	**Higher** Larger crossing angle Strong QCS B-field	**Much lower** Large crossing angle, but no QCS bending
Touschek	**Higher?** Small beam size	**Much higher?** Very small beam size
Beam-gas	**Higher** Very high current	**Higher?** High current





Detector BG study

-To design the beam pipe, SR BG estimation is important

SR mask / beam-pipe geometry design

→ We estimate the SR BG first

-Other BG sources will be studied later

Touschek, Beam-gas, radiative BhaBha, …

-For the BG studies, we construct
the beam-line simulation based GEANT4
developed by K.Tanabe and T.Abe of U.Tokyo

B-field of magnets + (Simple beam pipe + 1st layer SVD)

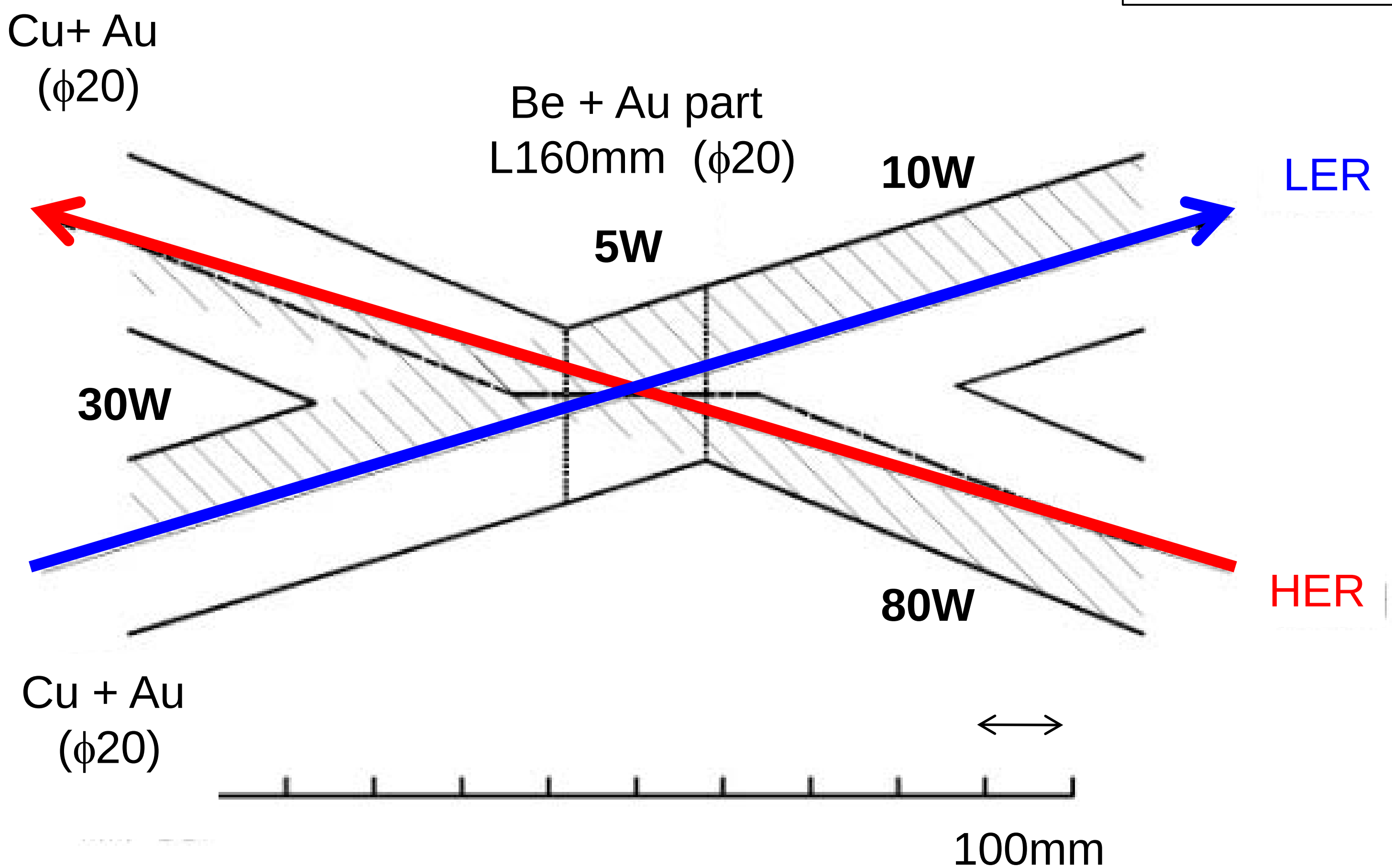
The number of particles in a bunch (Nano-beam option)

HER : 2.7A / ($1.6*10^{-19}$)/(100kHz)/3450 = $0.5*10^{11}$

LER : 4.6A / ($1.6*10^{-19}$)/(100kHz)/3450 = $1.0*10^{11}$

SR E deposit to the beam pipe

Nano-beam option



Preliminary

E deposit strongly depends on the beam-pipe geometry & optics

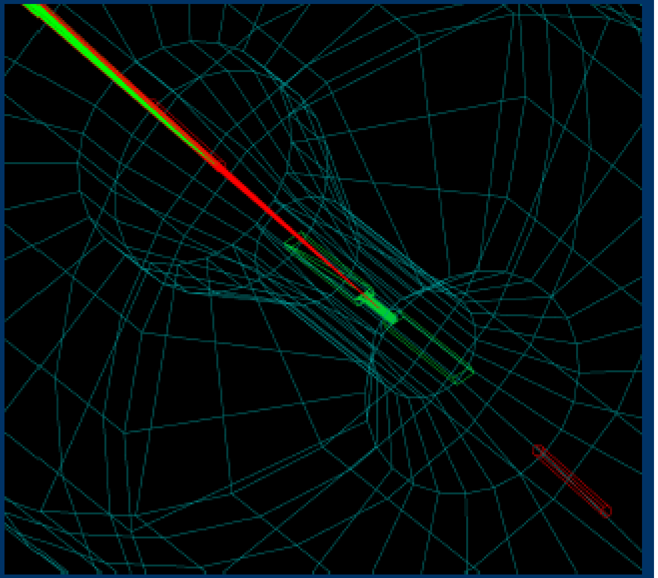
The optics assumed for this design is already obsolete…

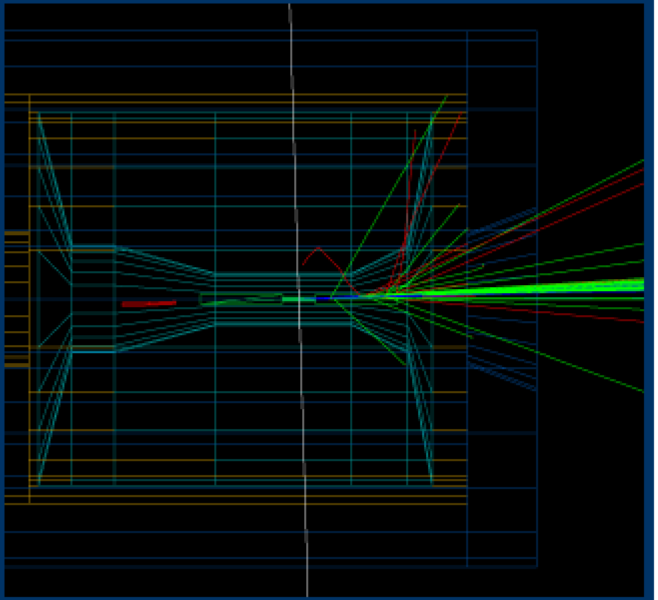
Radiative-BhaBha simulation

C. Ng (Tokyo)

Simulation outline

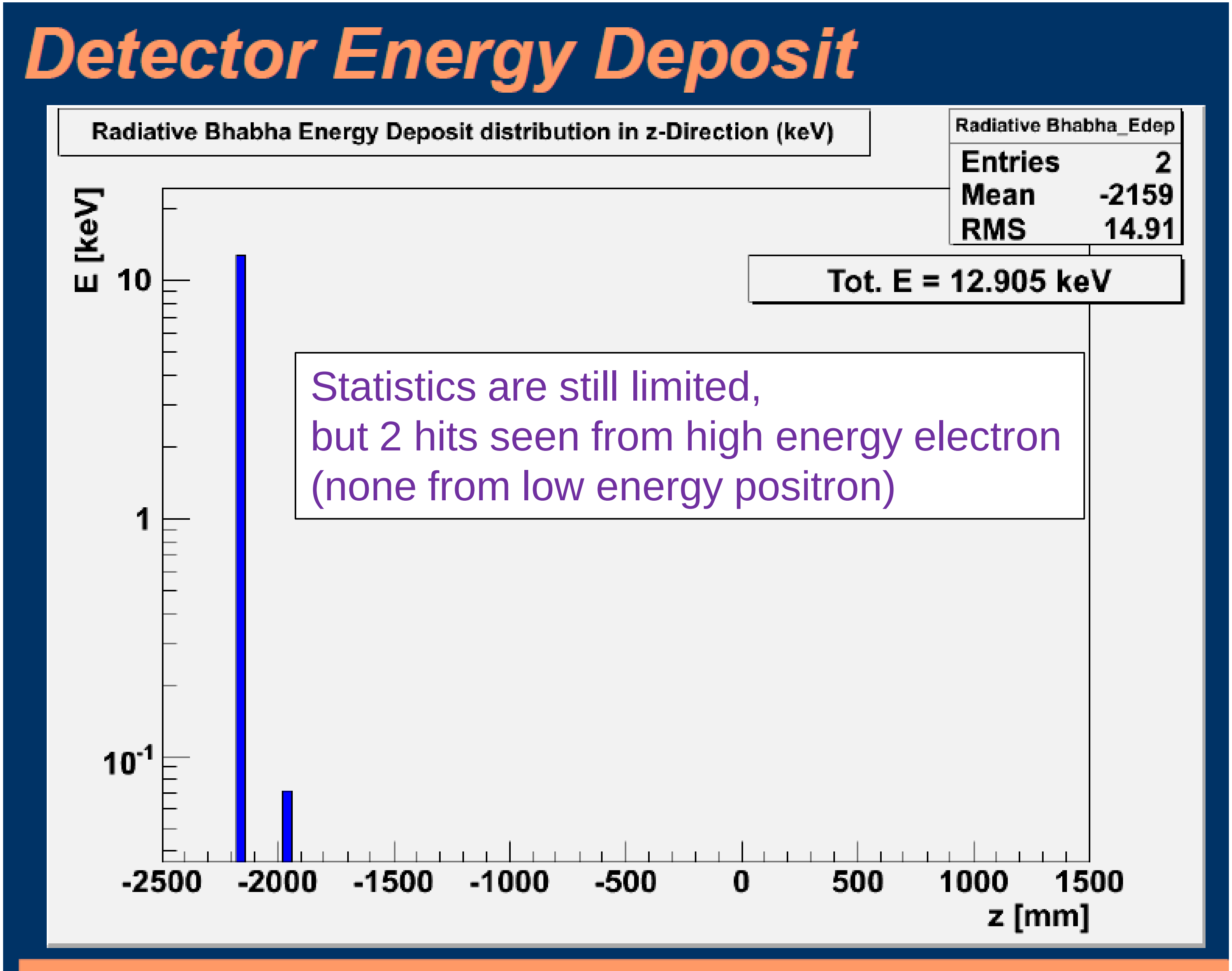
- Bhabha events generated through Bhlumi
- Bhlumi data is transformed from CMS frame to lab frame, and read into the LCBDS Geant4 framework
- Basic components implemented in Geant4:
    - Nano beam IP chamber (symmetrical)
    - Belle II detector (ECL, PID, CDC)
    - No magnet material
    - Nano optics field only (no solenoid field)
- Analysis peformed in ROOT





Radiative-BhaBha simulation

C. Ng (Tokyo)



Detector BG summary

1. We just start Nano-beam option SR simulation

- Nano-beam SR energy(HER) ~ 1/10 SR energy(High-current)
- Nano-beam SR energy(LER) ~ SR energy(High-current)
- Need to design and implement beam-pipe structure
- If we place beam-pipe parallel to LER

E deposit (to the Be part) ~ 5W ← very low

(but the optics we used was already obsolete..)

- We need further SR BG study

2. We also start the radiative BhaBha simulation

So far only high energy hits to the ECL (No hits from low energy positron)

Need further study (We don’t have enough statistics yet)

2. We need to start Touschek / beam-gas BG study

IR assembly R&D

Problem

QCS beam pipe and QCS cryostat will be integrated

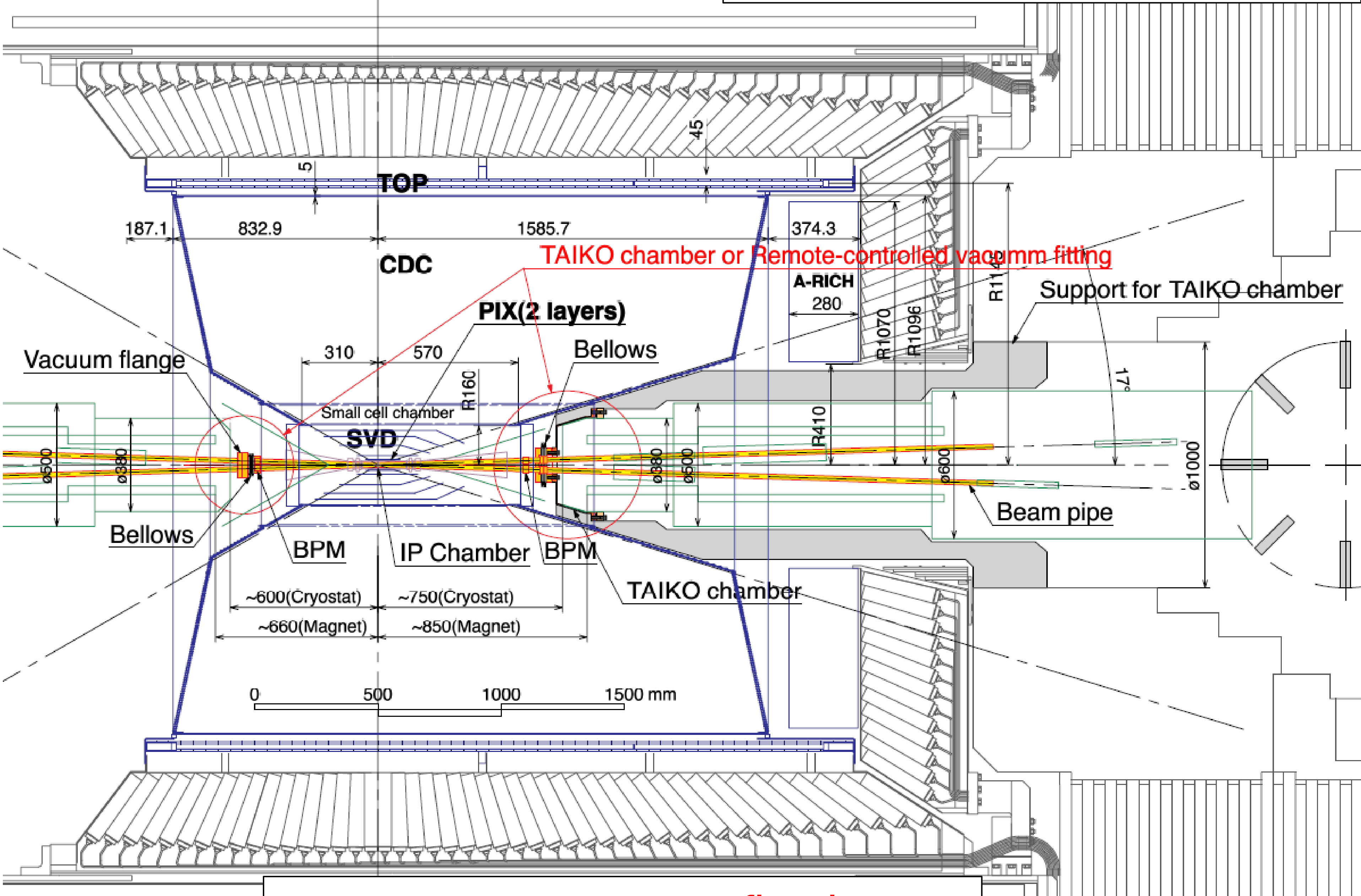
→ SVD/PXD/IP-beampipe
should be directly connected with QCS cryostat

How to connect

1. Remote-controlled vacuum fitting
2. "TAIKO" chamber

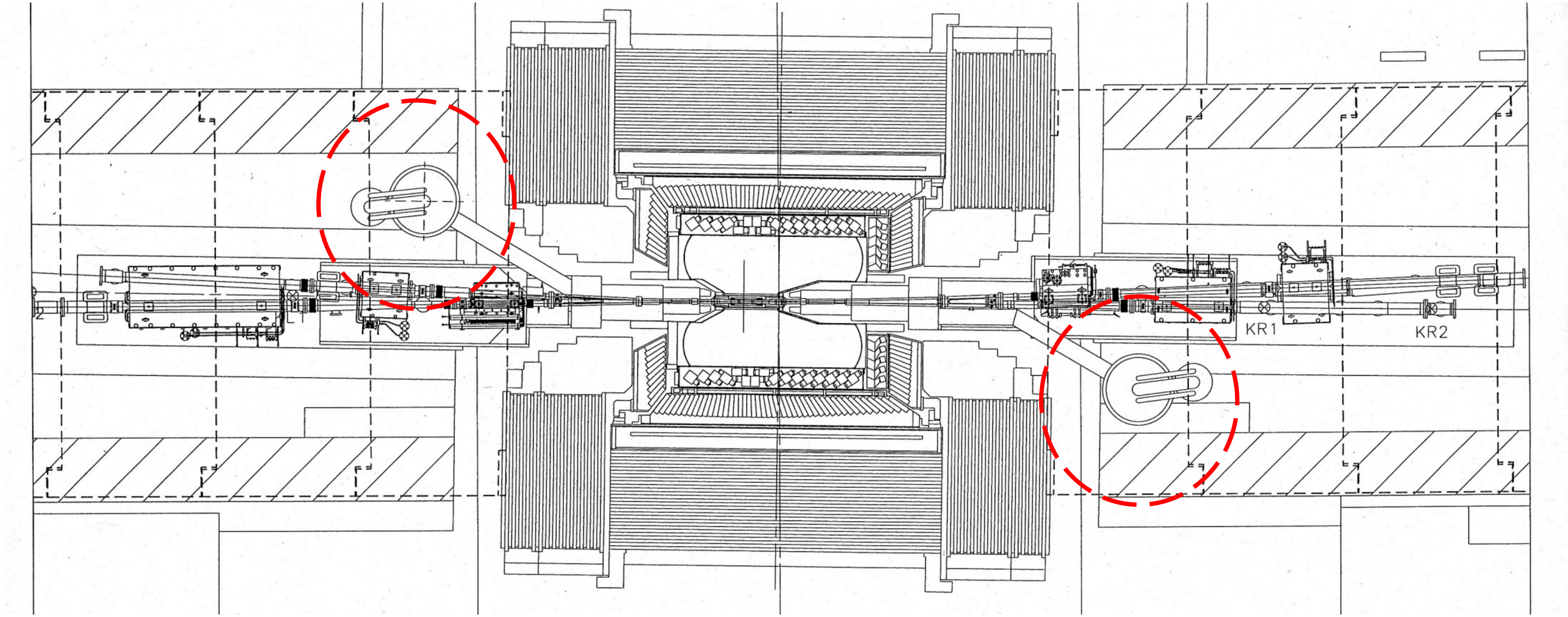
~~3. All components (SVD/PXD/beampipe/QCS) are integrated~~

T.Kohriki (2009/07/07 version)



Parameters are not fixed yet

All integrated??



There are huge components related to the superconducting magnets..

Original drawing: R. Sugahara

IR assembly : current status

Members:

KEK T.Kohriki + Machine shop

Strategy:

1. **R&D of remote-controlled vacuum fitting** (~ 0.5 year)
   If this method seems technically impossible

   ↓

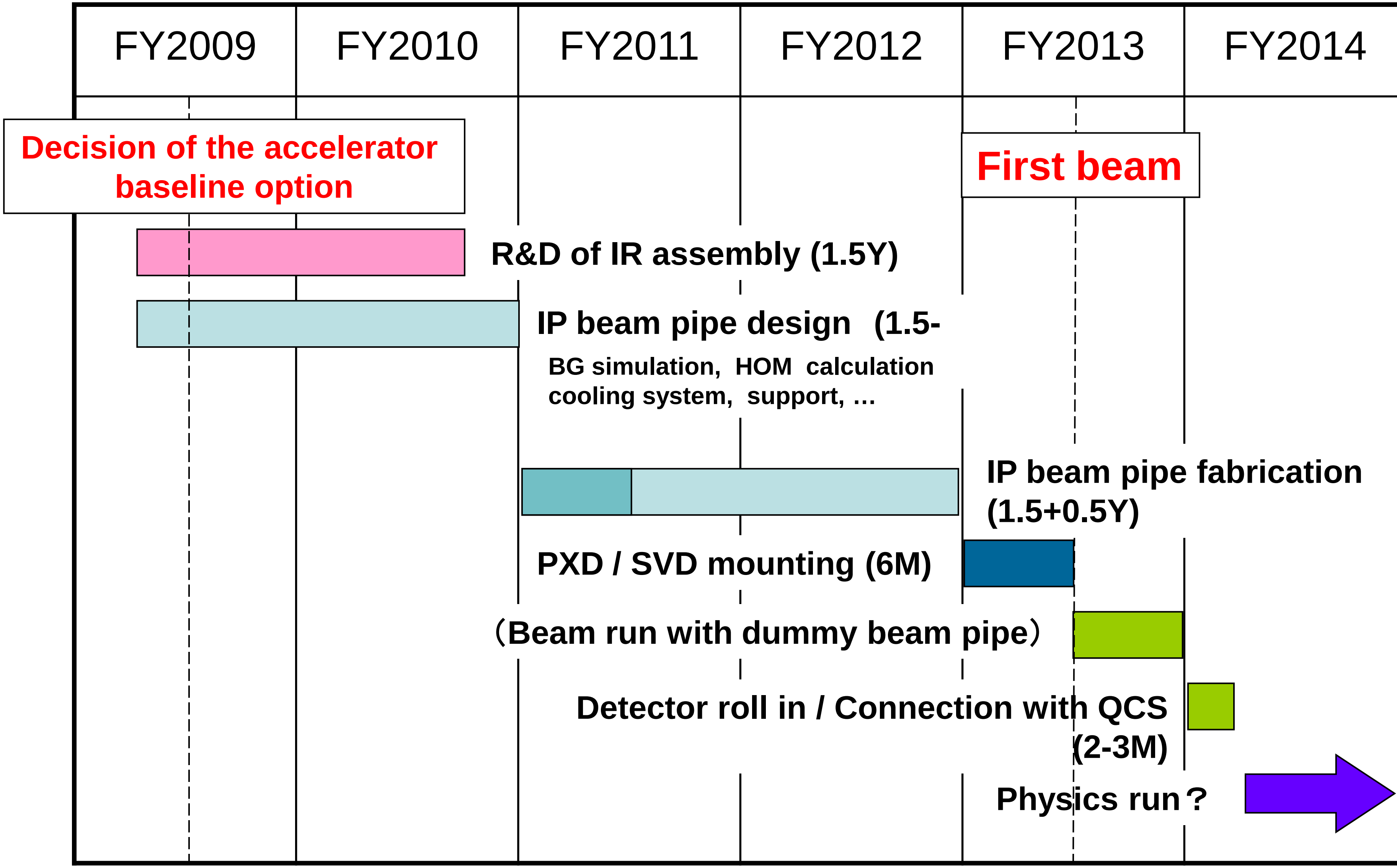
2. **"TAIKO" chamber** (~0.5 year)
   If this method seems technically impossible

   ↓

3. ~~**All components are integrated**~~

- In case, Belle should support QCS near the IP, TAIKO chamber might be the good candidate

Schedule


FY2009
FY2010
FY2011
FY2012
FY2013
FY2014
Decision of the accelerator baseline option
First beam
R&D of IR assembly (1.5Y)
IP beam pipe design (1.5-
BG simulation, HOM calculation
cooling system, support, …
IP beam pipe fabrication
(1.5+0.5Y)
PXD / SVD mounting (6M)
(Beam run with dummy beam pipe)
Detector roll in / Connection with QCS
(2-3M)
Physics run？

Summary

1. Vibration around IP ~8Hz ~0.4μm amplitude due to the QCS boat vibration

→ Feed back system / R&D of the supporting structure

2. Beam-line design

→ Relation btw Belle-II and Super-KEKB? (Rotate Belle-II?)

3. Beam-pipe geometry

- Inner radius = 10.5mm (= QCS inner radius)
- beam-pipe direction to prevent the direct SR hits
  → Depends on the beam optics (not yet decided)
- BPM will be attached to the beam pipe

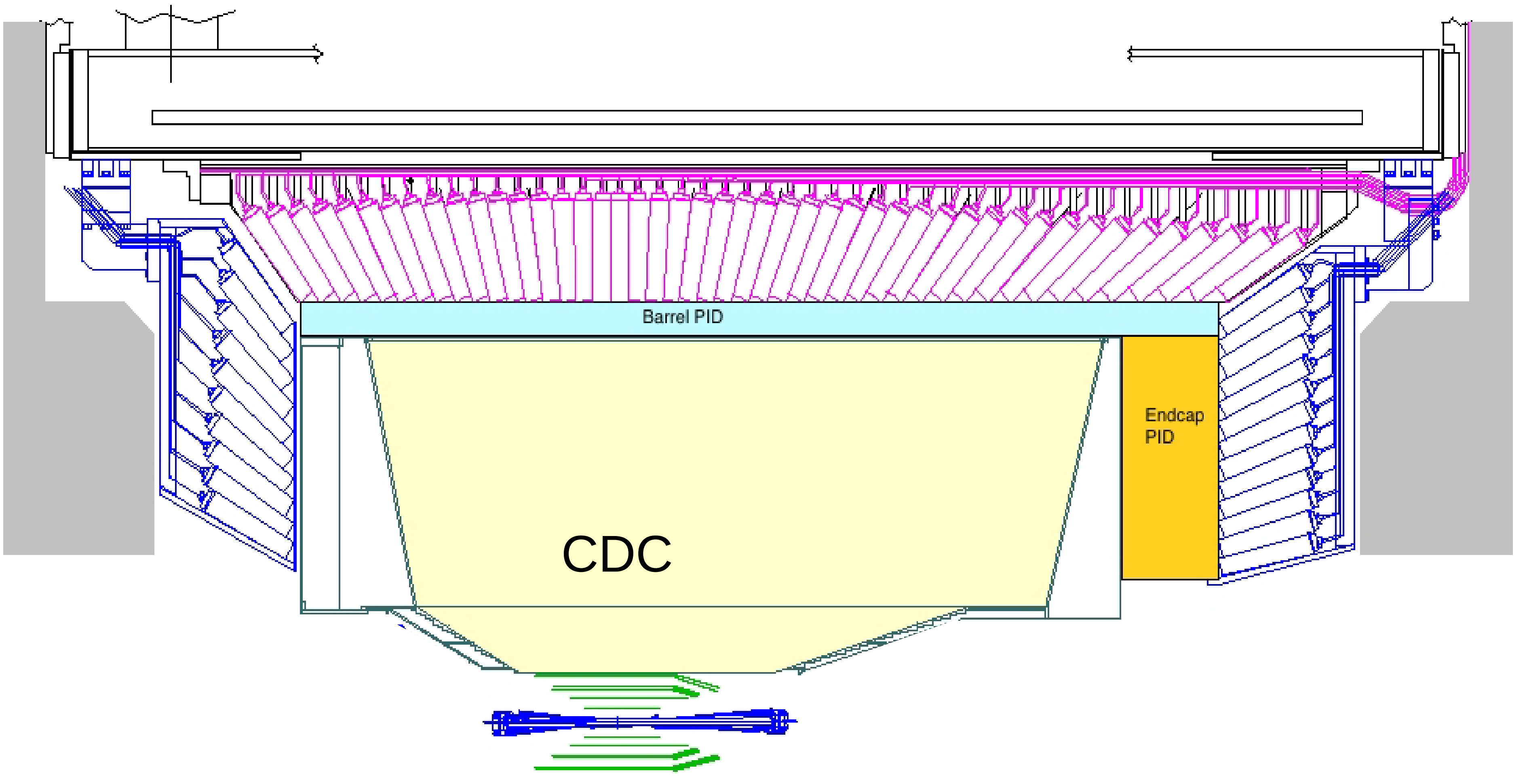
4. Further BG simulations are needed

5. We just start the IP assembly R&D

Backup

TAIKO chamber

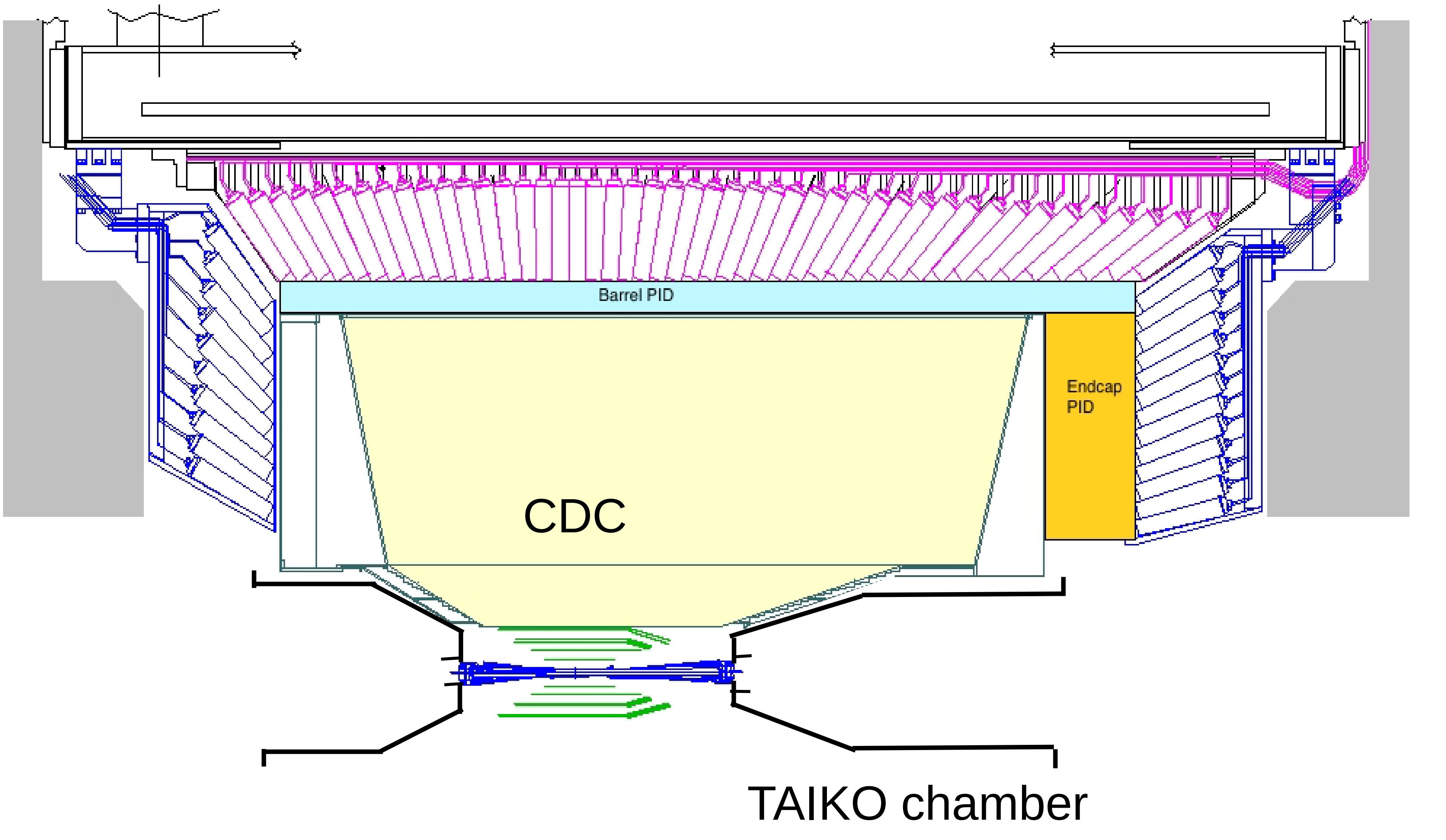
S.Uno / T.Kohriki



PXD/SVD + IP beam pipe

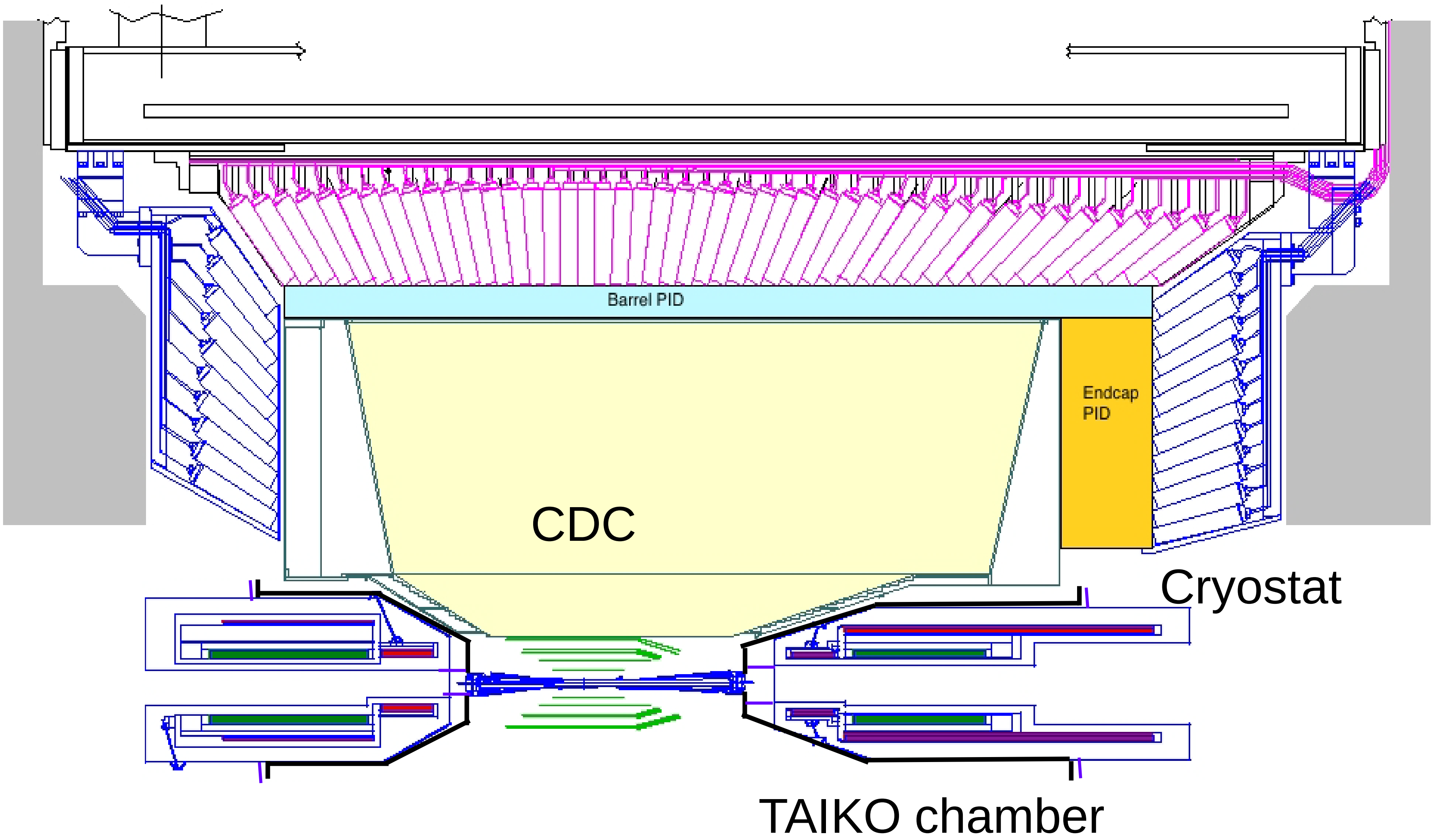
TAIKO chamber

S.Uno / T.Kohriki



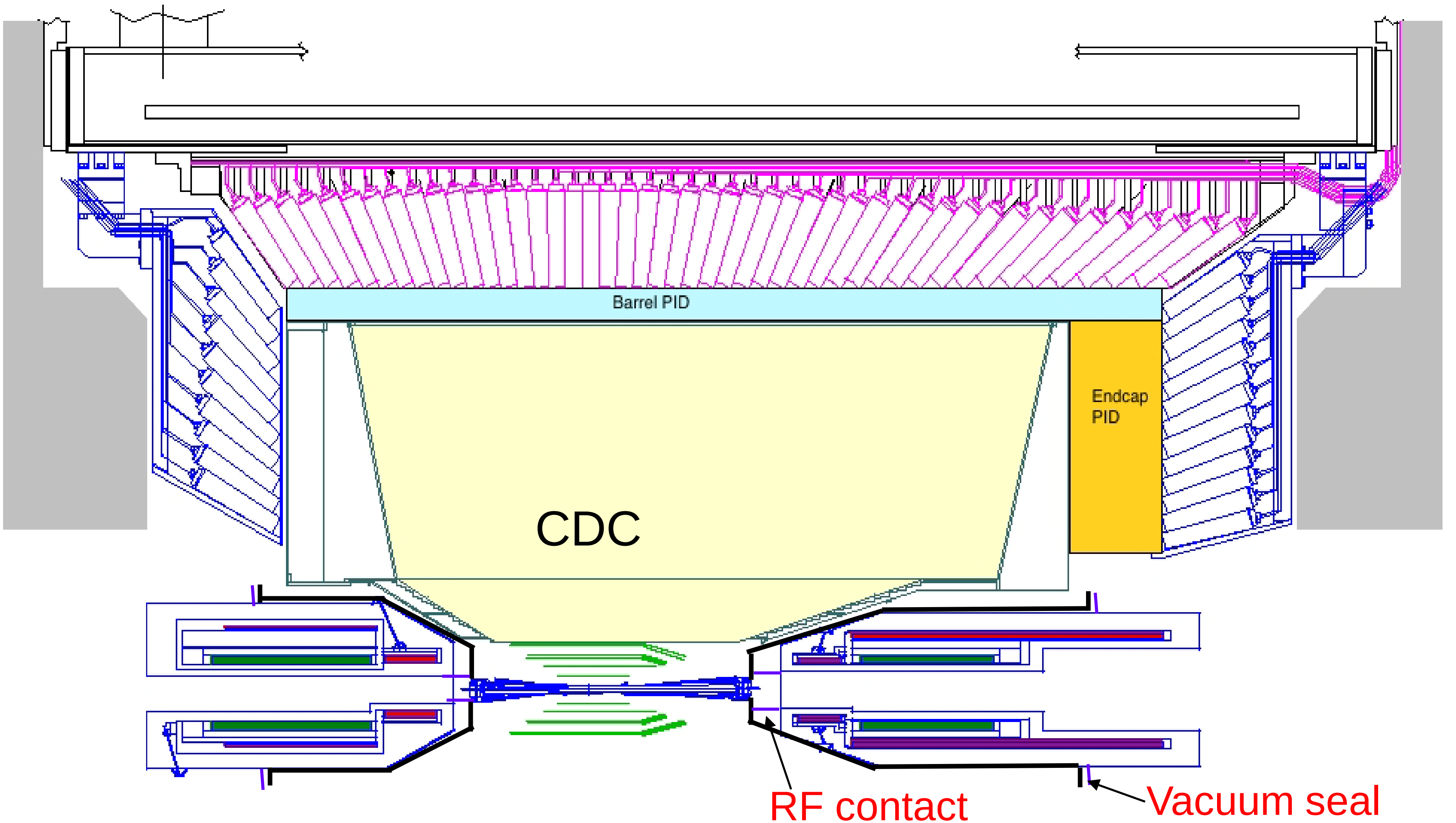
TAIKO chamber

S.Uno / T.Kohriki



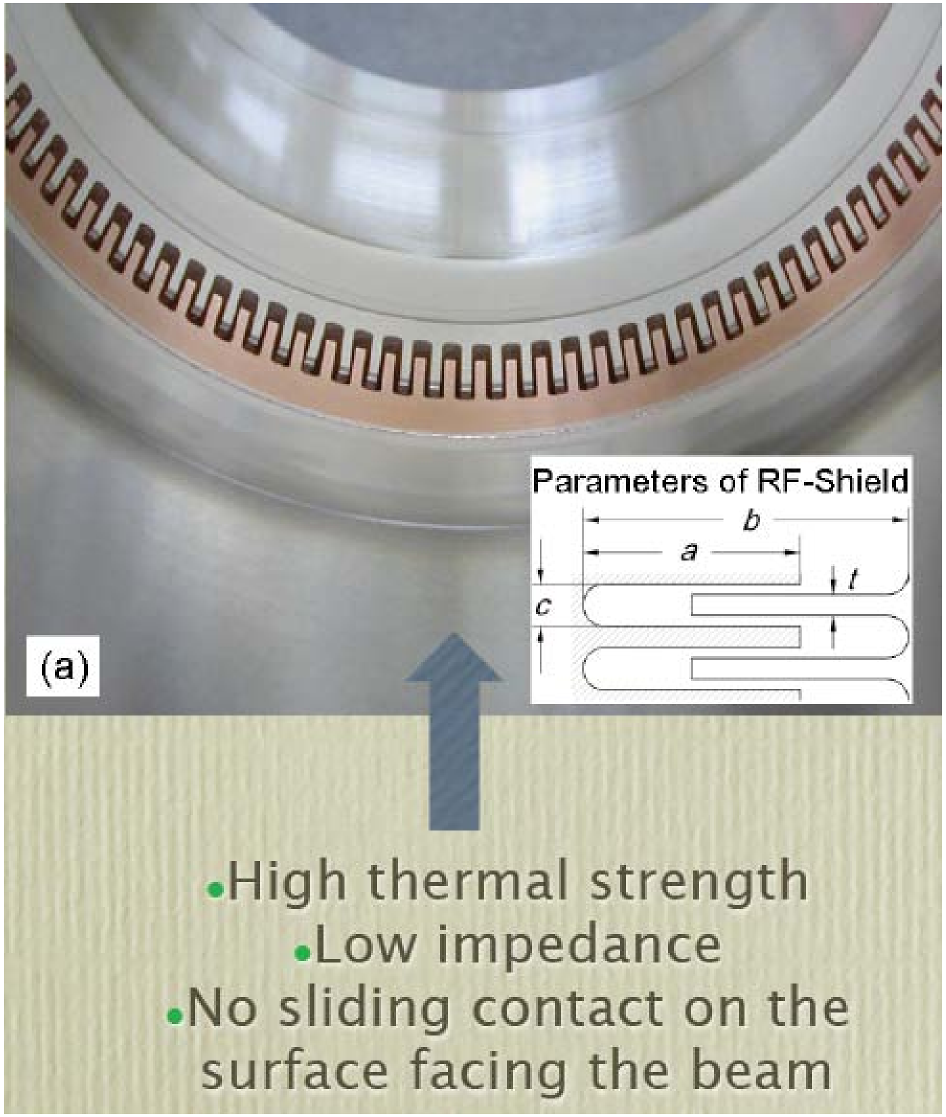
TAIKO chamber

S.Uno / T.Kohriki

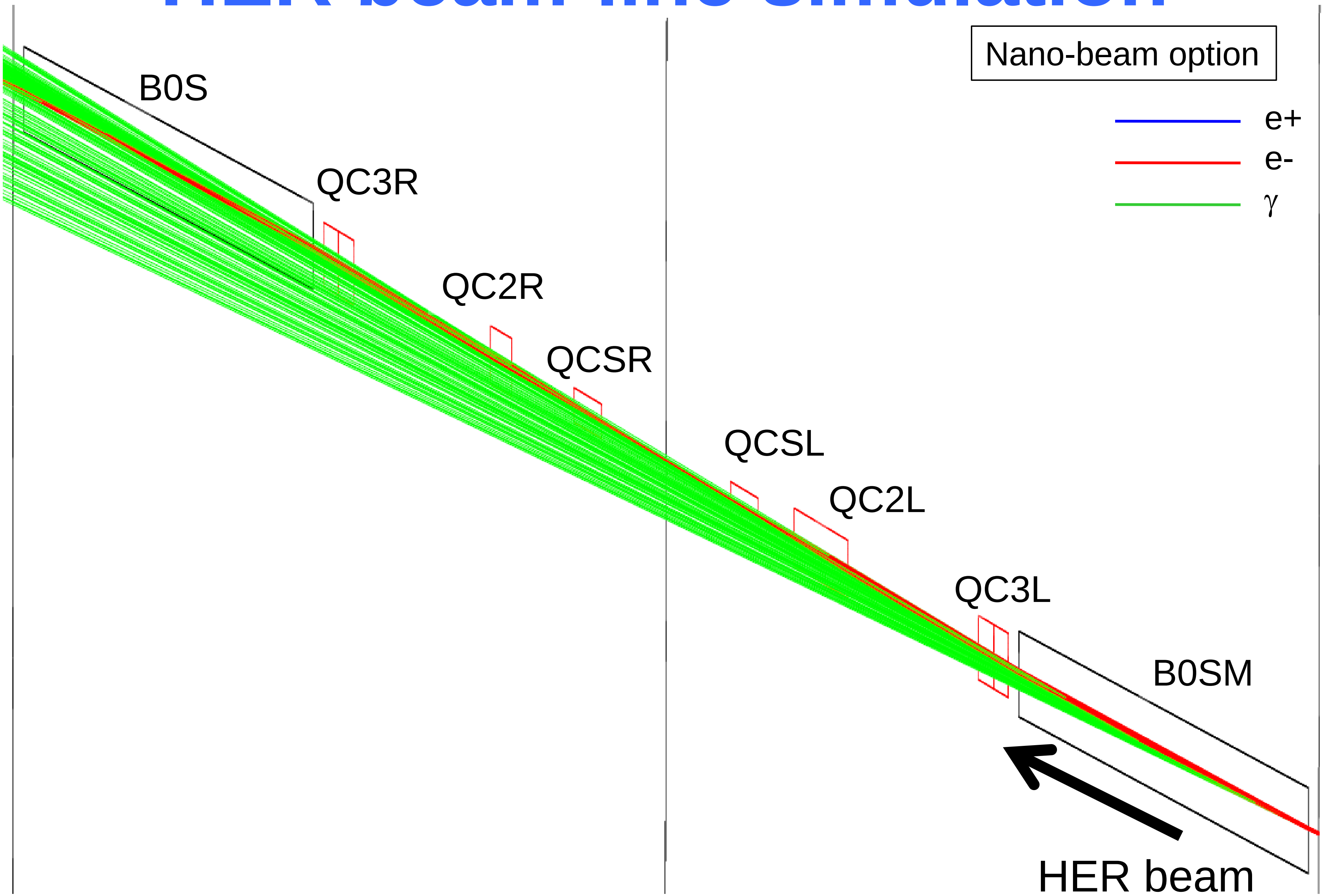


RF contact

By Y. Suetsugu



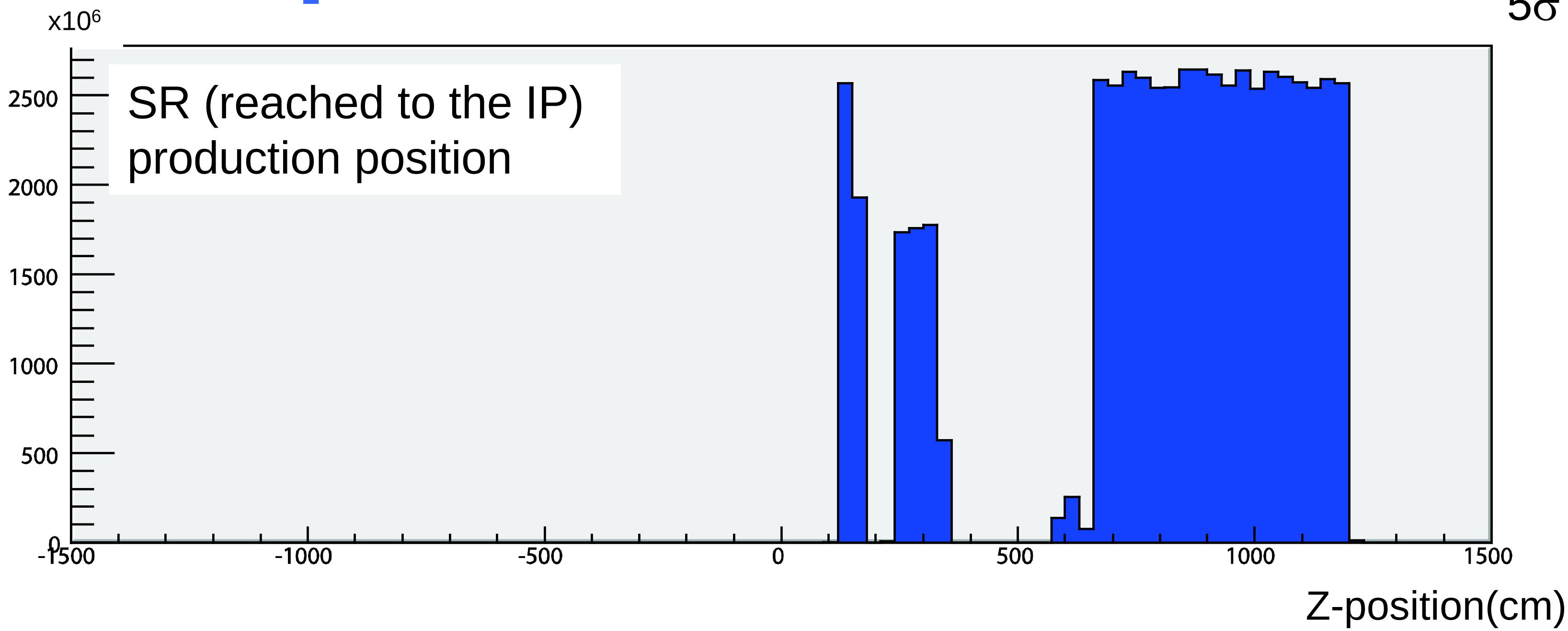
HER beam-line simulation

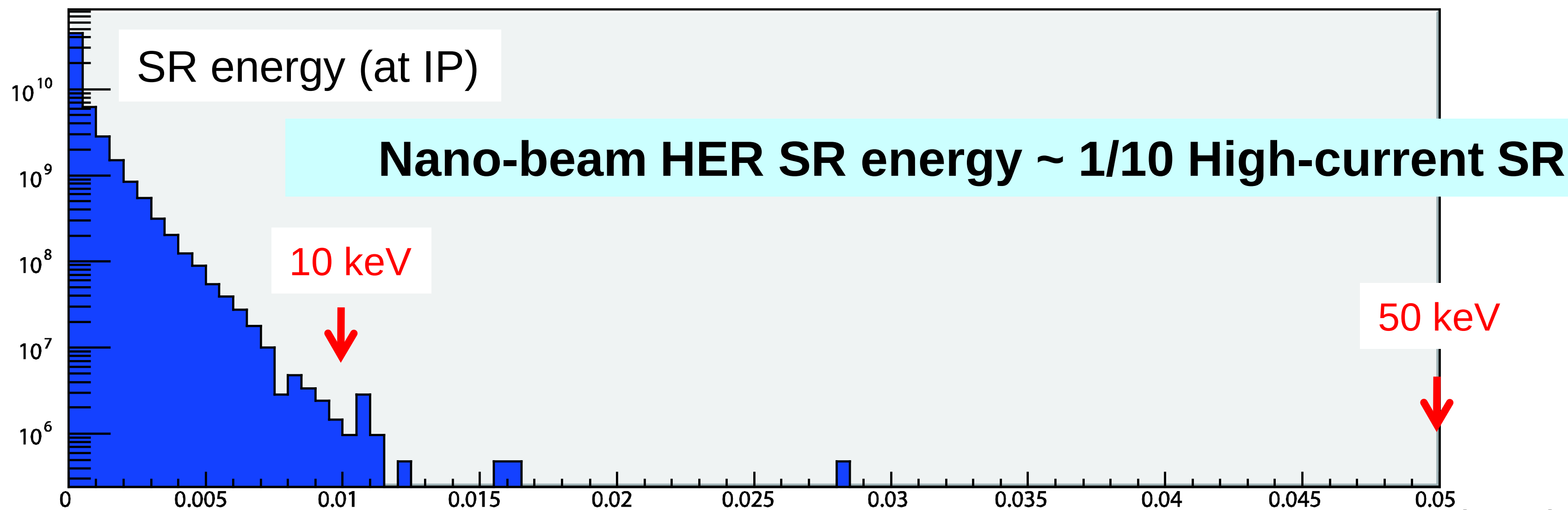


HER upstream SR @IP

Nano-beam option

5σ beam

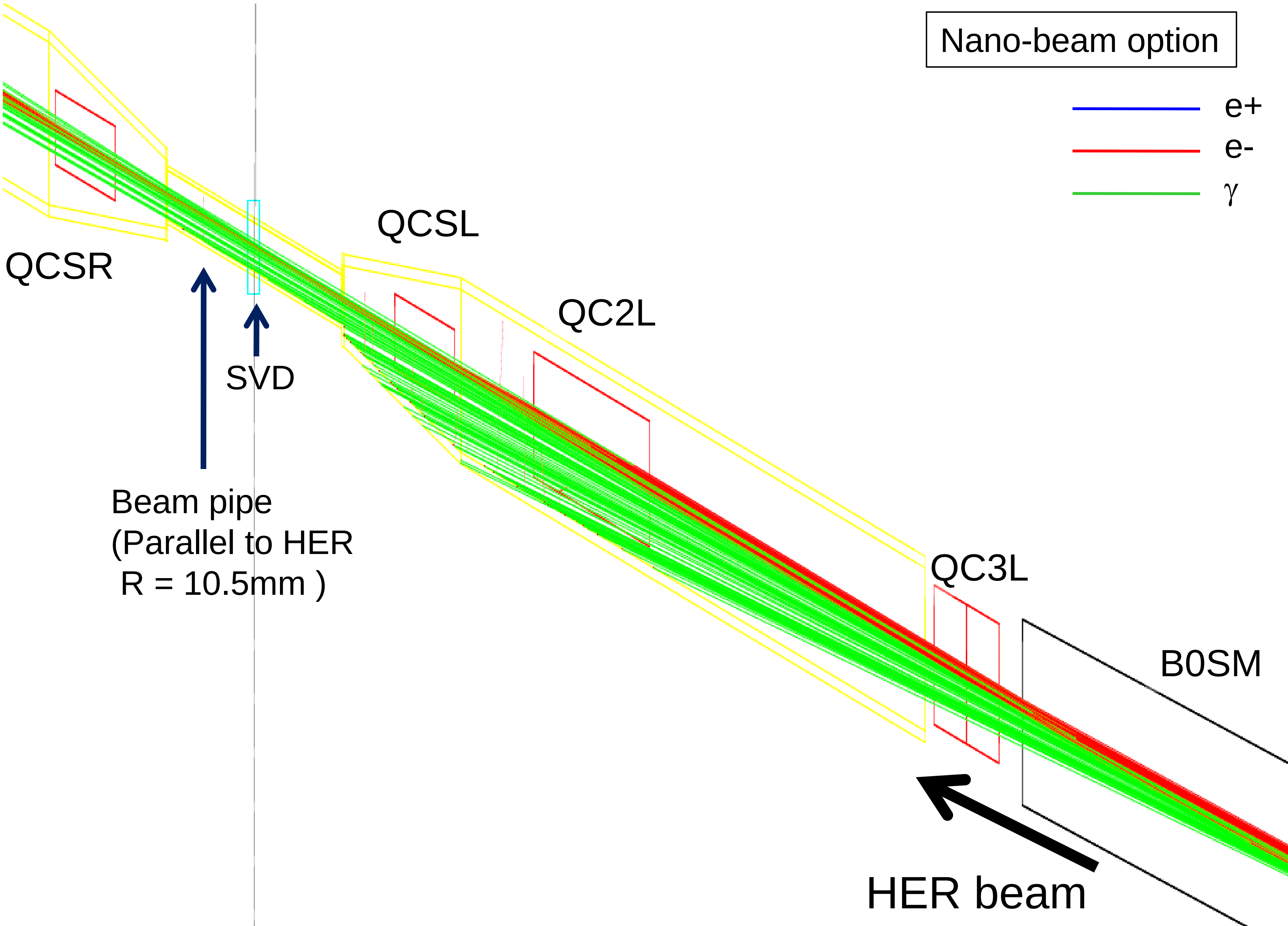




Nano-beam HER SR energy ~ 1/10 High-current SR

(Vertical scale: Scaled for 1-bunch beam)

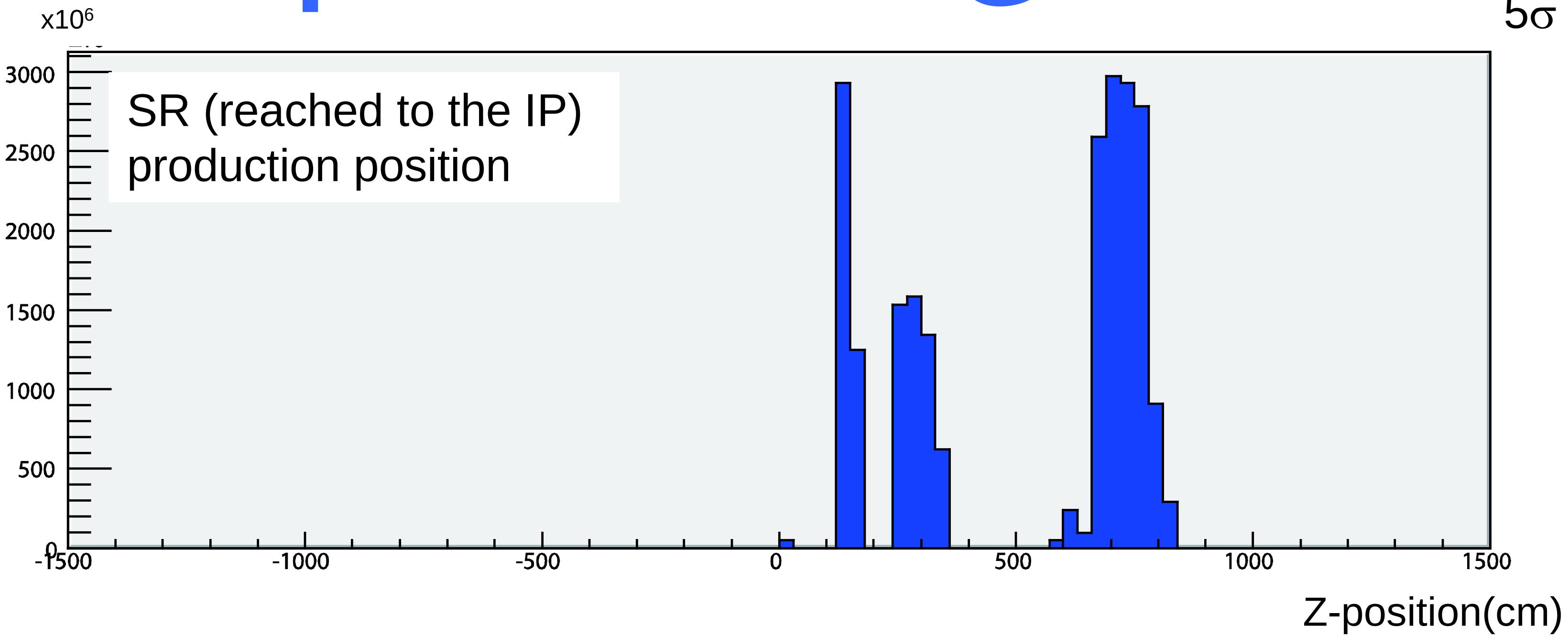
HER beam-line simulation

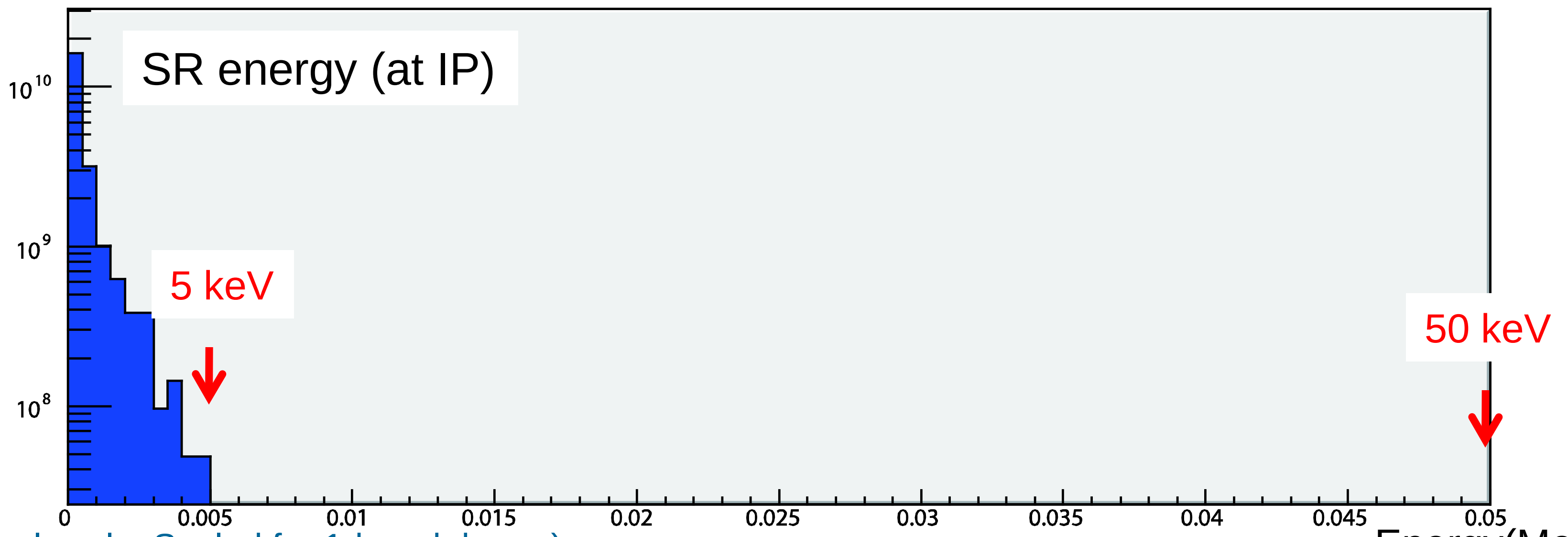


HER upstream SR @IP

Nano-beam option

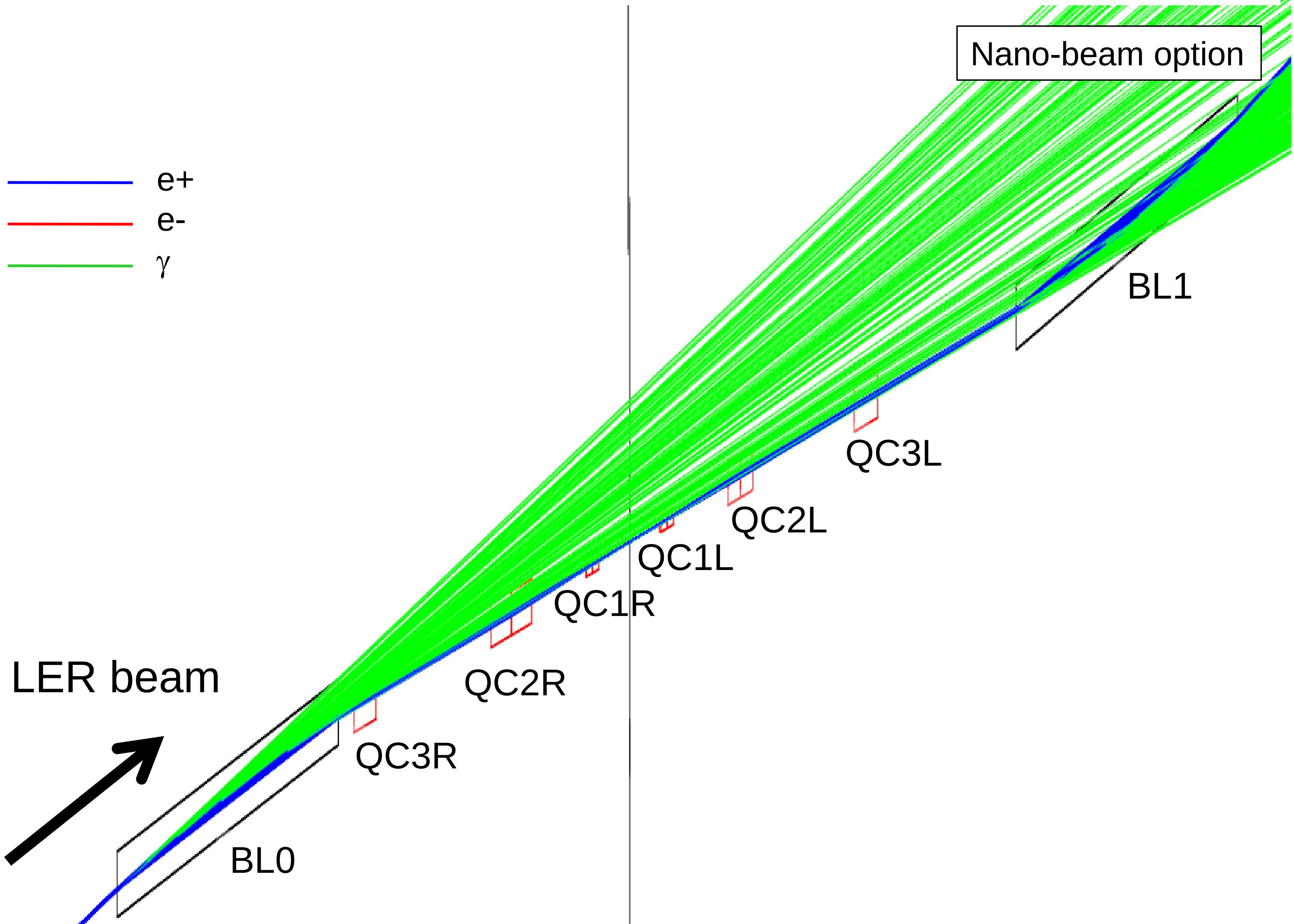
5σ beam





(Vertical scale: Scaled for 1-bunch beam)

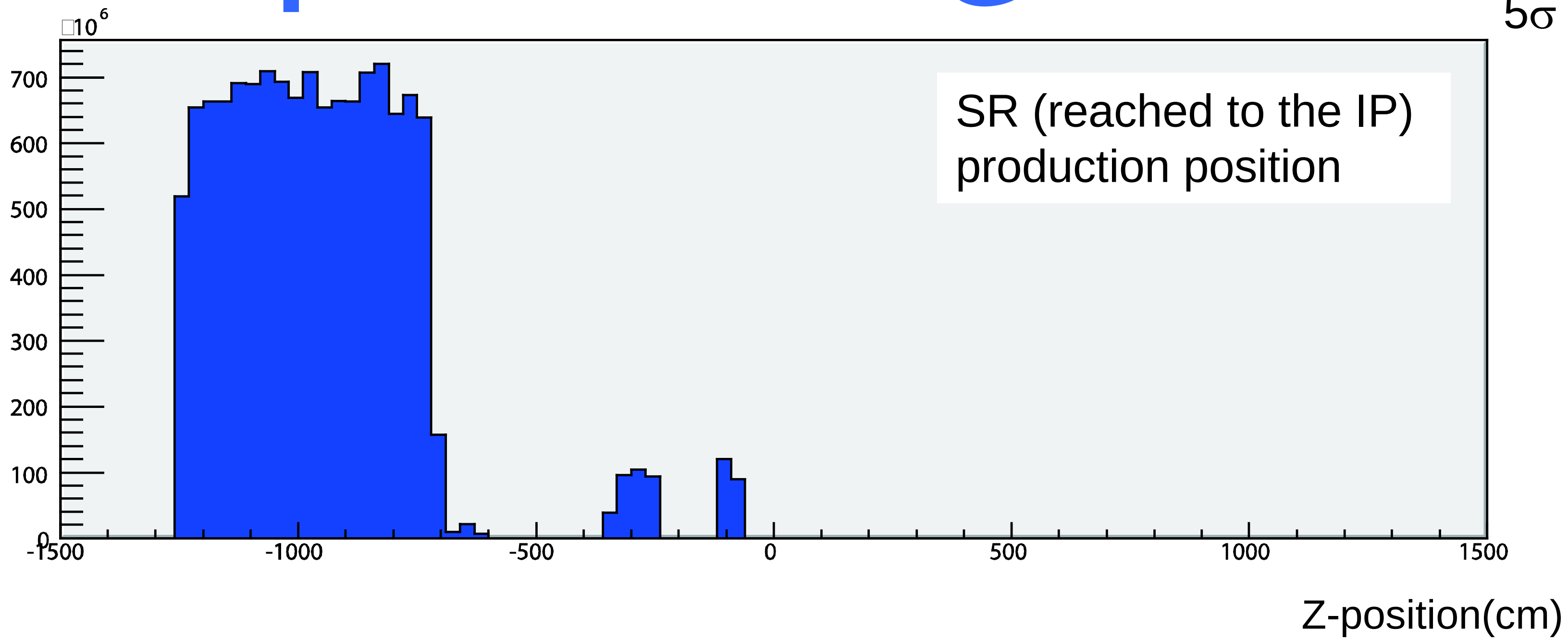
LER beam-line simulation

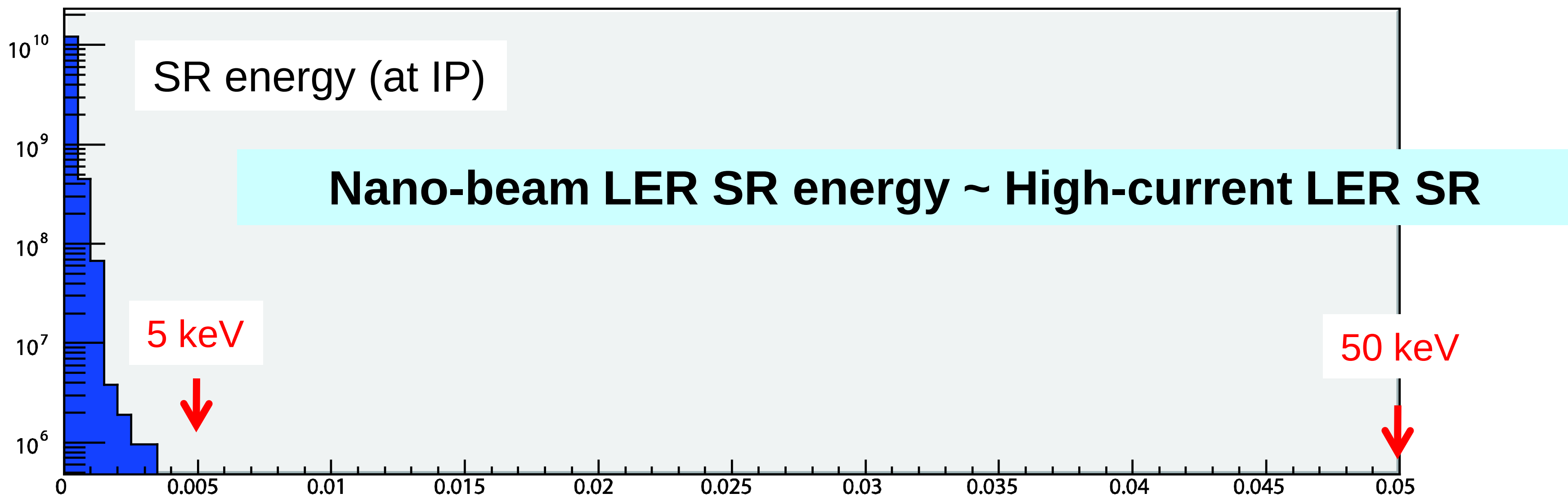


LER upstream SR @IP

Nano-beam option

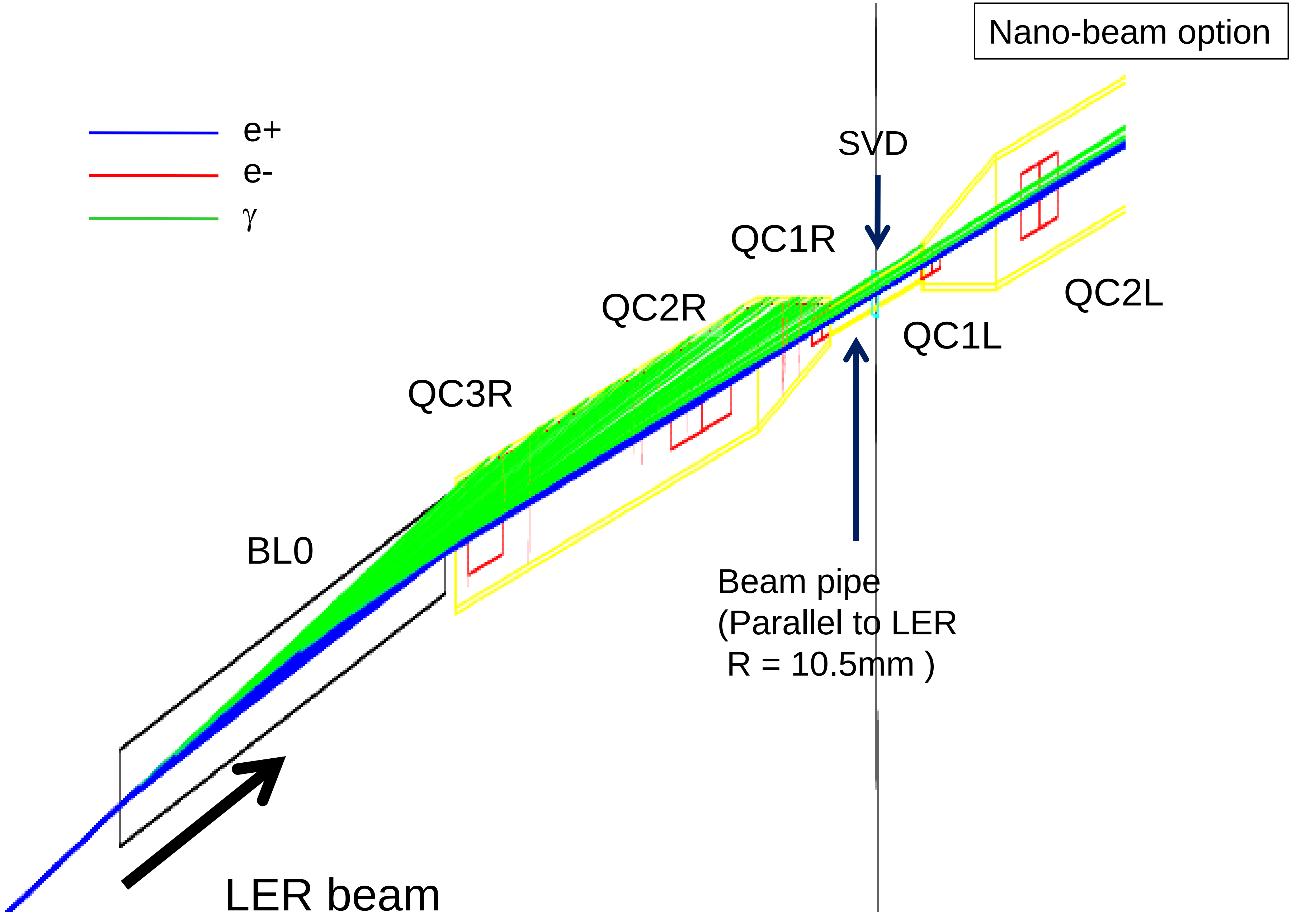
5σ beam





(Vertical scale: Scaled for 1-bunch beam)

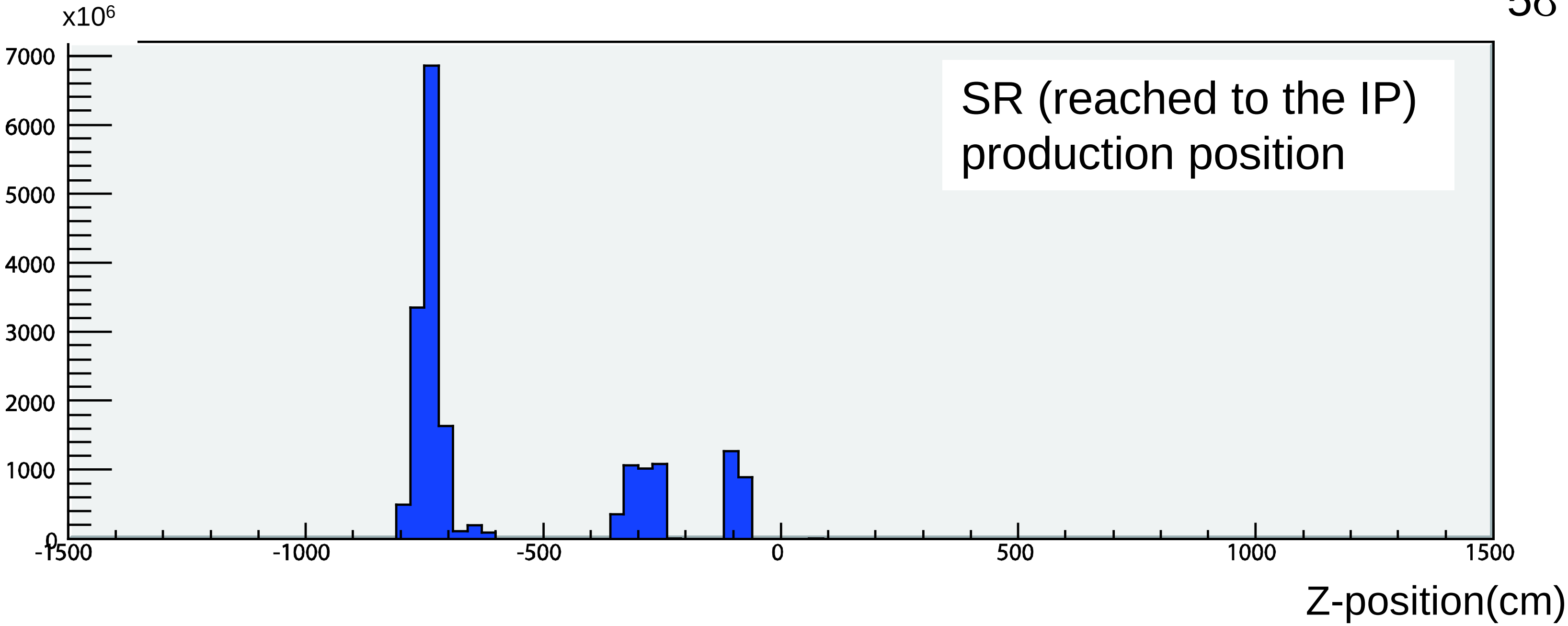
LER beam-line simulation

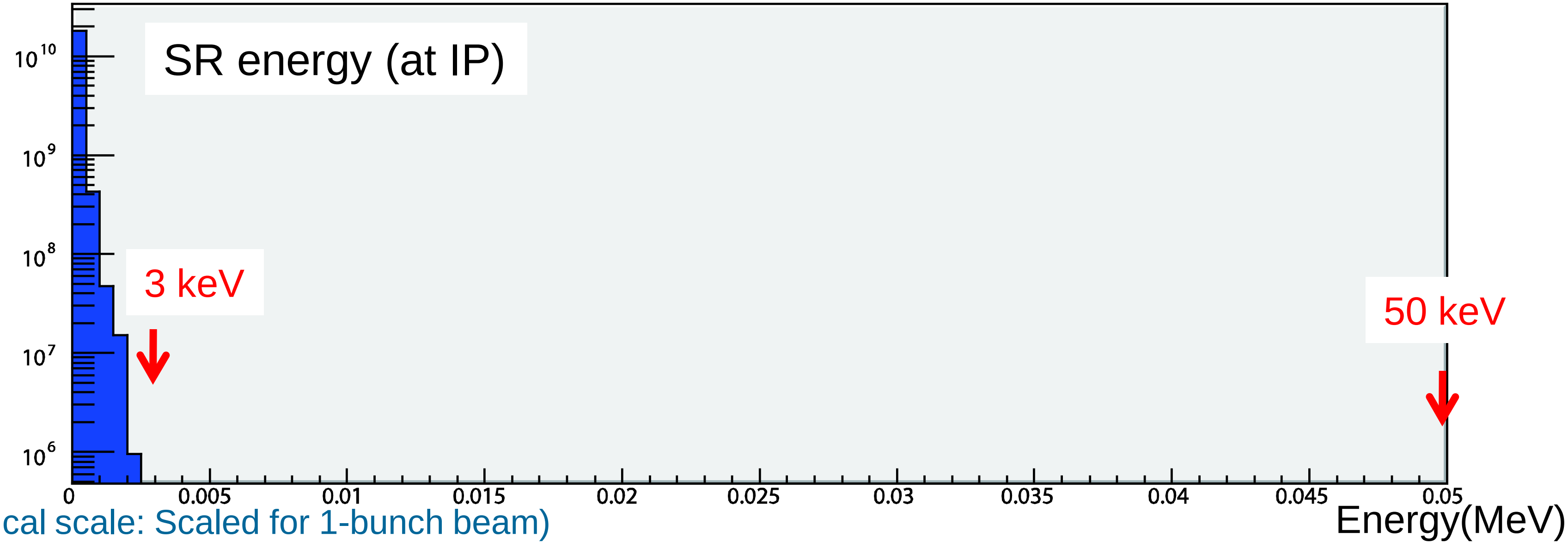


LER upstream SR @IP

Nano-beam option

5σ beam





(Vertical scale: Scaled for 1-bunch beam)

Super-KEKB beam line design

One of constraints is tunnel geometry.

TSUKUBA IR