MDI status

2010/2/15 M. Iwasaki

For SuperKEKB MDI group

U. Tokyo, Tohoku U., and KEK

MDI group home page

http://hep.phys.s.u-tokyo.ac.jp/superKEKBMDI/

Introduction

SuperKEKB : To increase the luminosity,

machine parameters will drastically change

Machine-Detector-Interface design is very important

To assure the stable detector operation

In this talk we show

1. Beam background

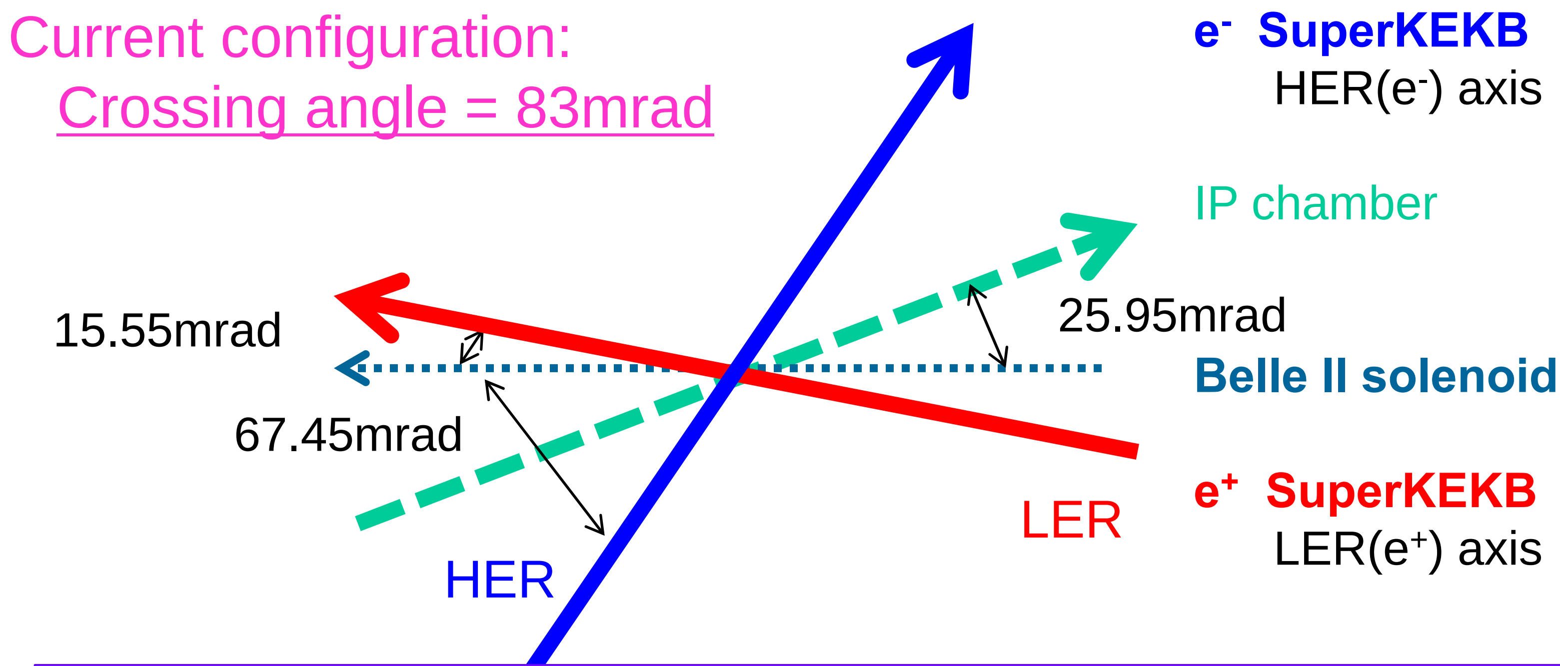
High beam current / Small beam-size / Strong Q-magnets

2. Space around IR

Two final-Q magnets in both L and R sides

Large crossing angle (83 mrad)

Relationship btw Belle II and SuperKEKB

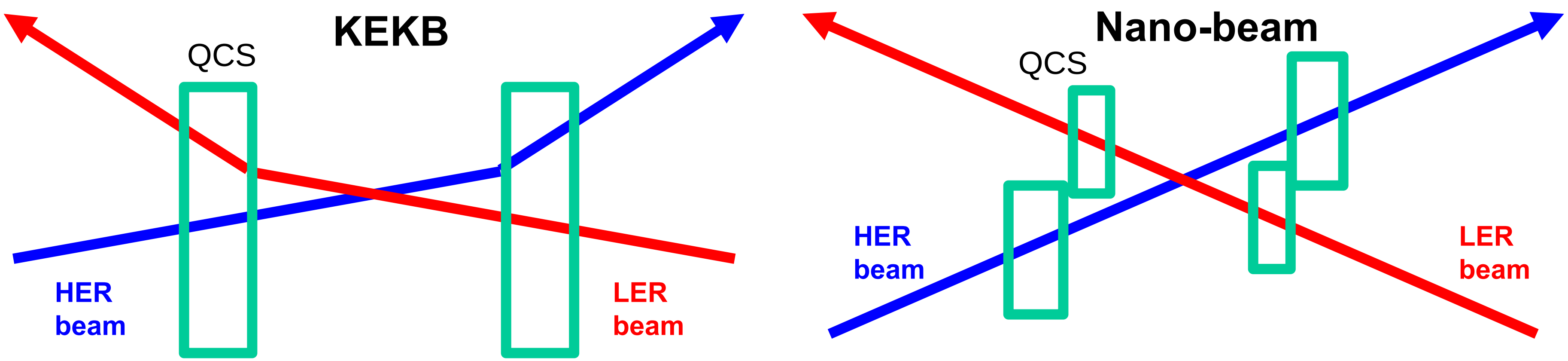


IP chamber : center direction of the LER and HER

Angle btw beam direction and Belle solenoid		Angle btw Belle solenoid and IP-chamber (mrad)
HER (mrad)	LER(mrad)	
41.50	41.50	0
52.82	30.18	11.32
67.45	15.55	25.95

Detector BG

	Nano-beam option
SR (upstream)	**Lower? But affects to the IP-chamber design** Small beam size at final Q Bending magnets effect? Detector solenoid?
SR (back-scatter)	**Much lower** little QCS bending
Radiative-BhaBha	**Much lower** Large crossing angle, but little QCS bending
Touschek	**Much higher?** Very small beam size
Beam-gas	**Higher?** High current



Detector BG status

1. Upstream SR

- GEANT4 simulation by Tokyo (with detector solenoid)

2. Touschek

- Rough estimation based on life-time (LER)

  x20 - 30 higher than the current Belle
- TURTLE+GEANT3 simulation by Tohoku

3. Beam-gas

- Vacuum around IP (+- 2m) will be worse (x10-100) than KEKB
- Simulation by Tokyo and Tohoku

4. We did BG run during the last fall Belle run

To get the real data related to the Touschek and beam-gas.

5. Rough BG estimations based on the optics (without solenoid)

- Radiative Bha-Bha 1/40
- Backscattering SR 1/800 of the current Belle

  (it may change with the new optics with detector solenoid)

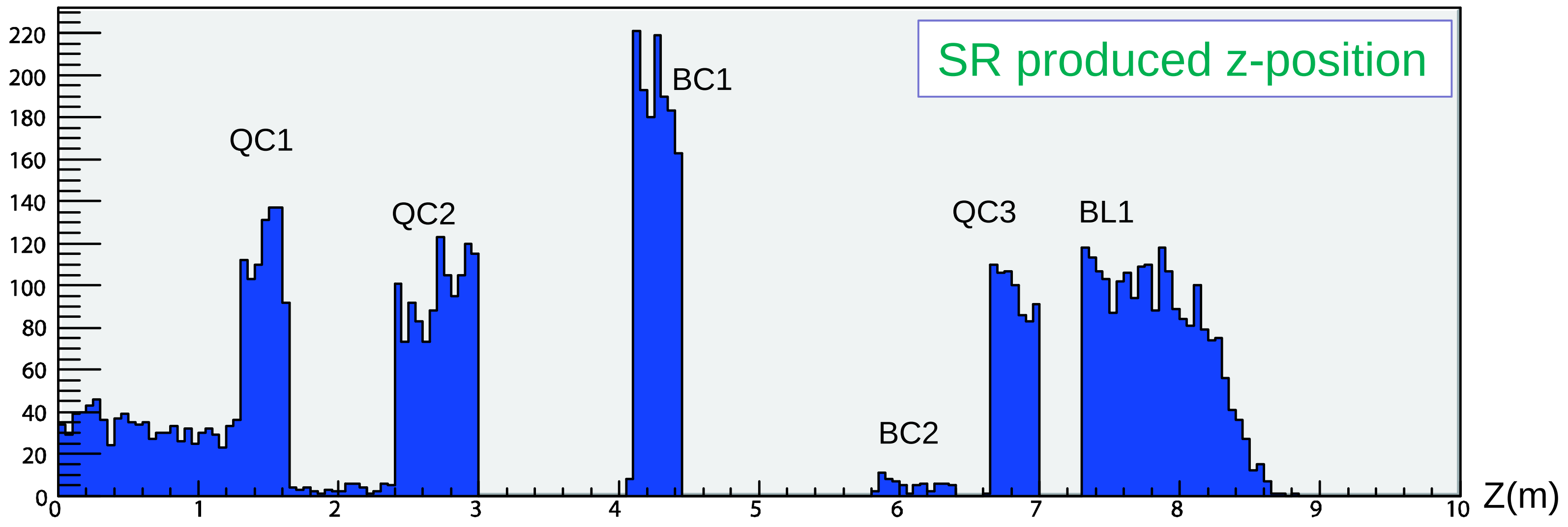
1. Detector BG

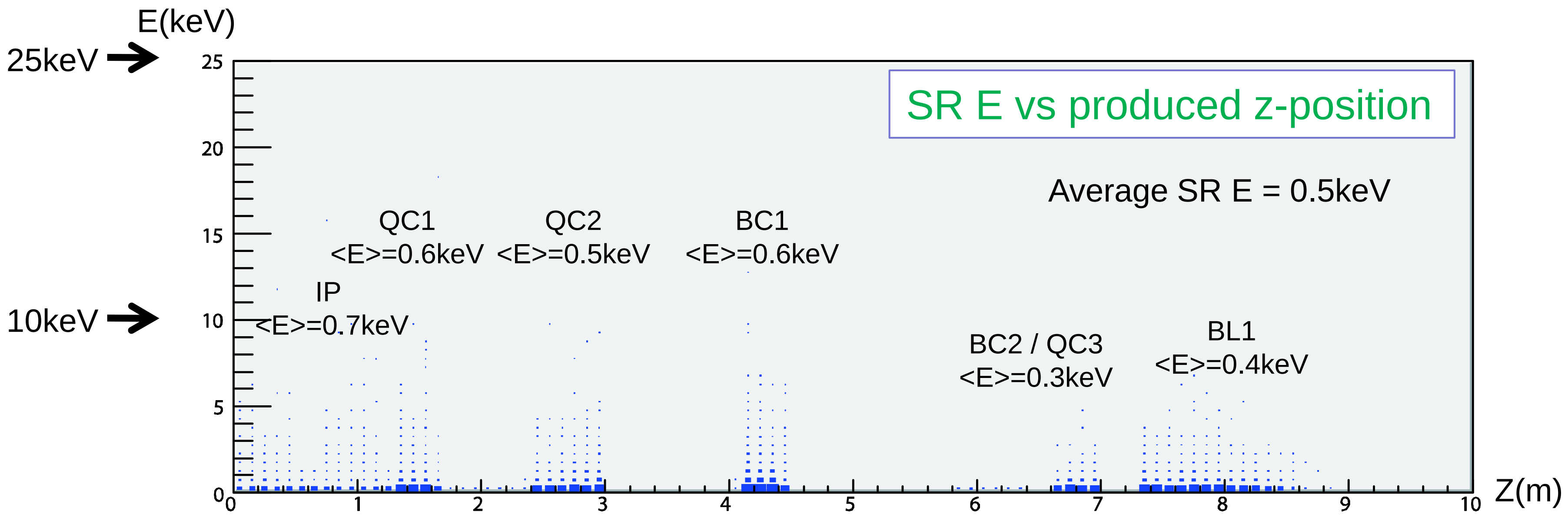
1-1 Upstream SR

HER beam-line simulation

New optics without the QC1/QC2 steering magnets (herfqlc4051)

41.5 / 41.5 mrad



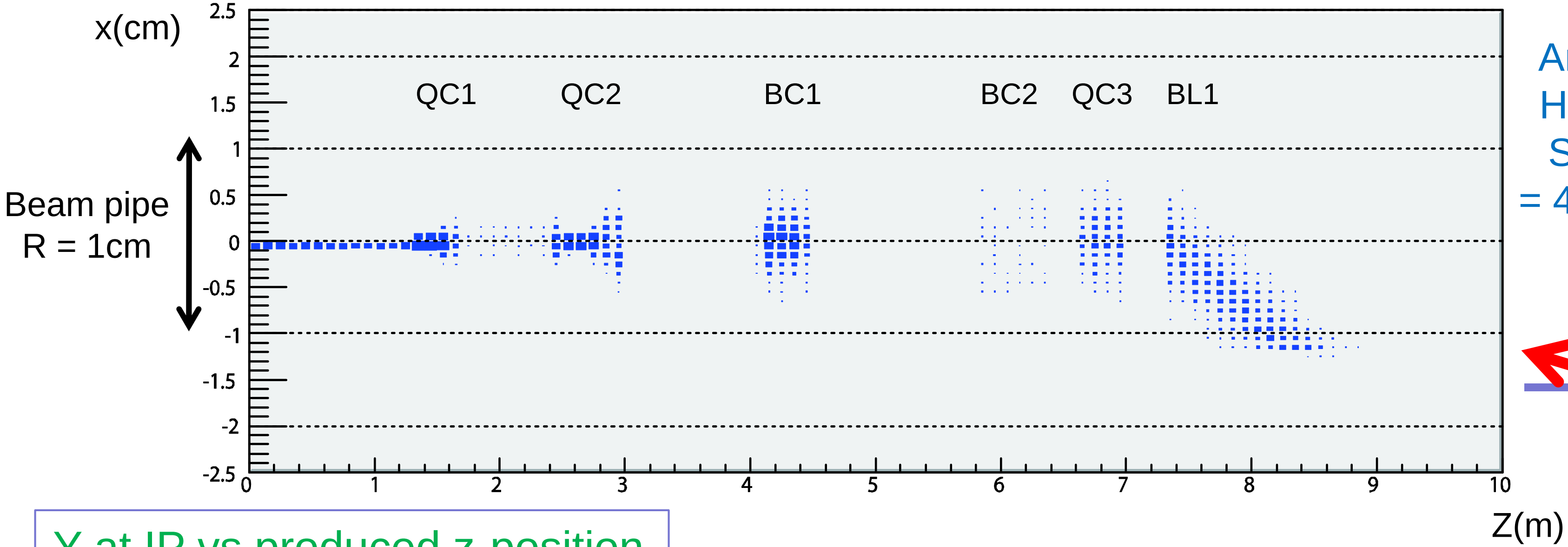


HER beam-line simulation

X at IP vs produced z-position

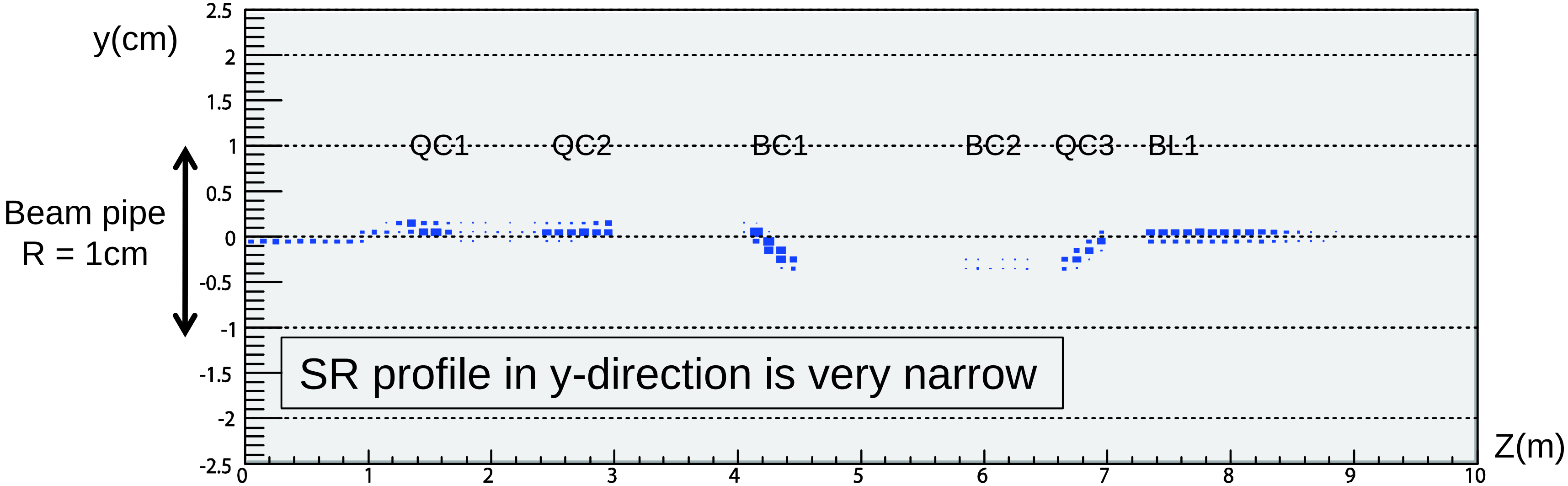
herfqlc4051

HER41.5 / LER 41.5 mrad



Angle btw HER and Solenoid = 41.5 mrad

Y at IP vs produced z-position

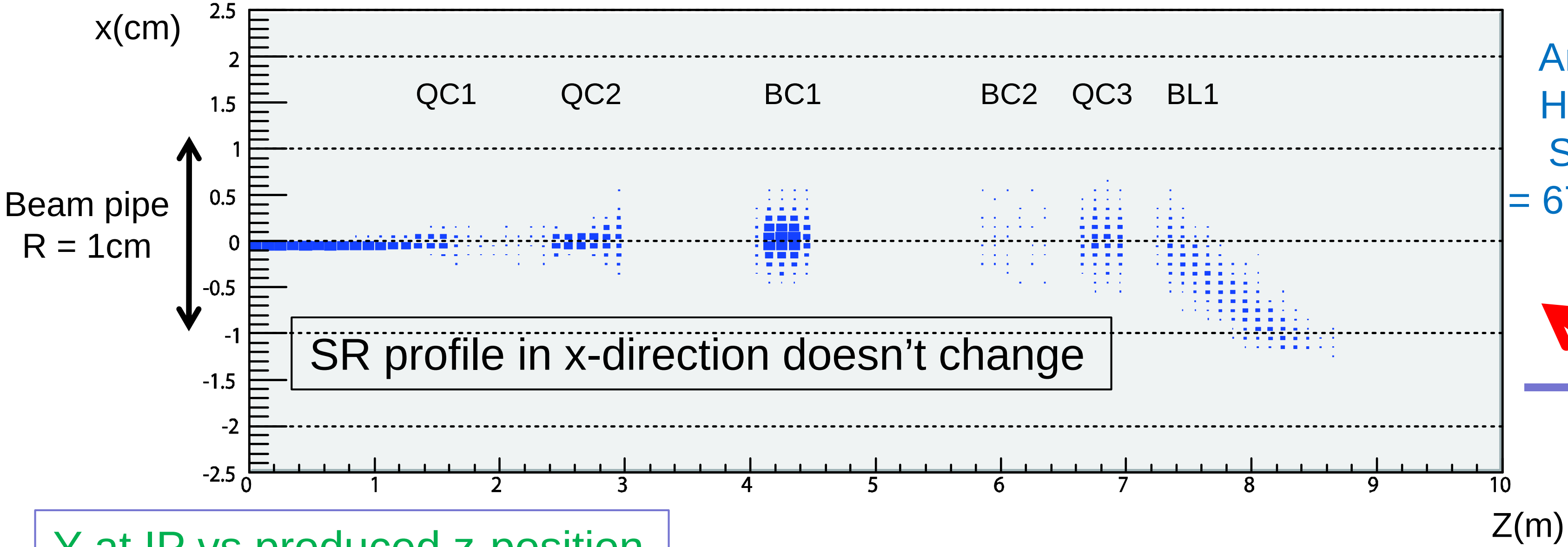


HER beam-line simulation

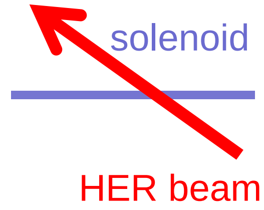
X at IP vs produced z-position

herfqlc4038

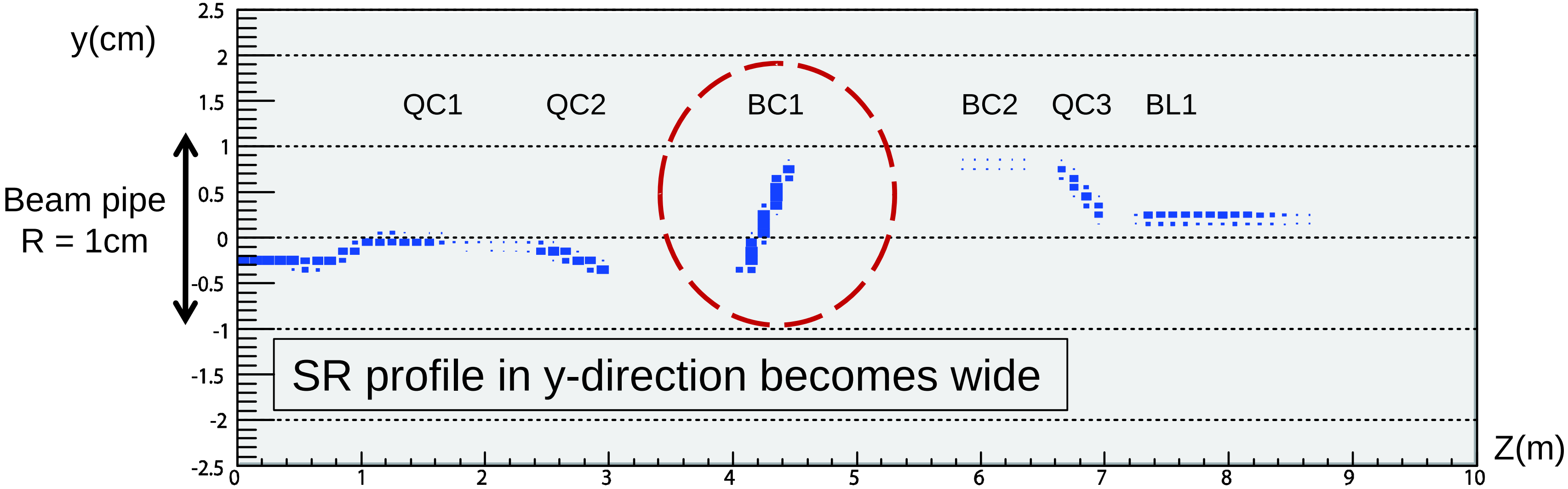
HER 67.45 / LER 15.55 mrad



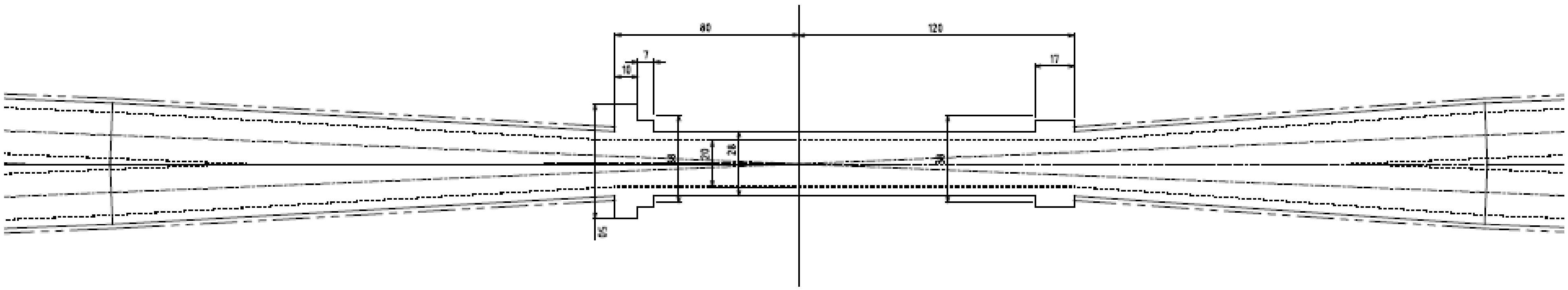
Angle btw HER and Solenoid = 67.45 mrad

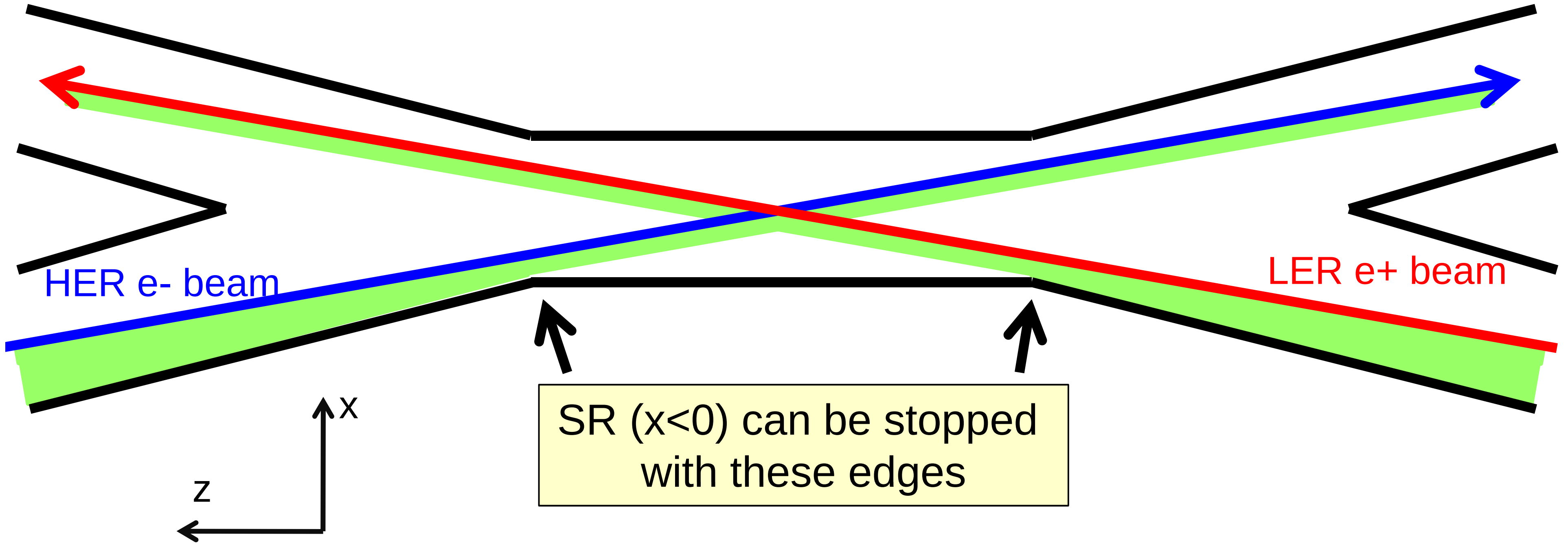


Y at IP vs produced z-position



IP chamber and SR





Summary of SR BG

- Average SR energy is low enough (< 1keV)

- No direct SR hits to the IP-chamber Be-part from HER

- If we choose the previous design of 67.45 /15.55 mrad angles, SR from vertical bending magnet (BC1) may hit the beam pipe (spread in the y direction)

To Do

1. Implement the IP-beam pipe / PXD in the simulation
2. Estimate the energy deposit to the IP-chamber crotched parts
3. LER simulation

1. Detector BG

1-2. Particle BG

KEKB BG study
KEKB beam-gas simulation
SuperKEKB beam-gas simulation

Particle BG studies

1. BG study with single e+ or e- beam

To get the real data related to the Touschek and beam-gas.
we did BG studies during the last fall Belle run

1-1 To see the Touschek effect we change the beam-size

1-2 To see the Beam-gas effect, we change the Vacuum level

1-3 We also change the Vacuum level around IP
(The vacuum level at SuperKEKB will be
x10-100 worse than current KEKB)

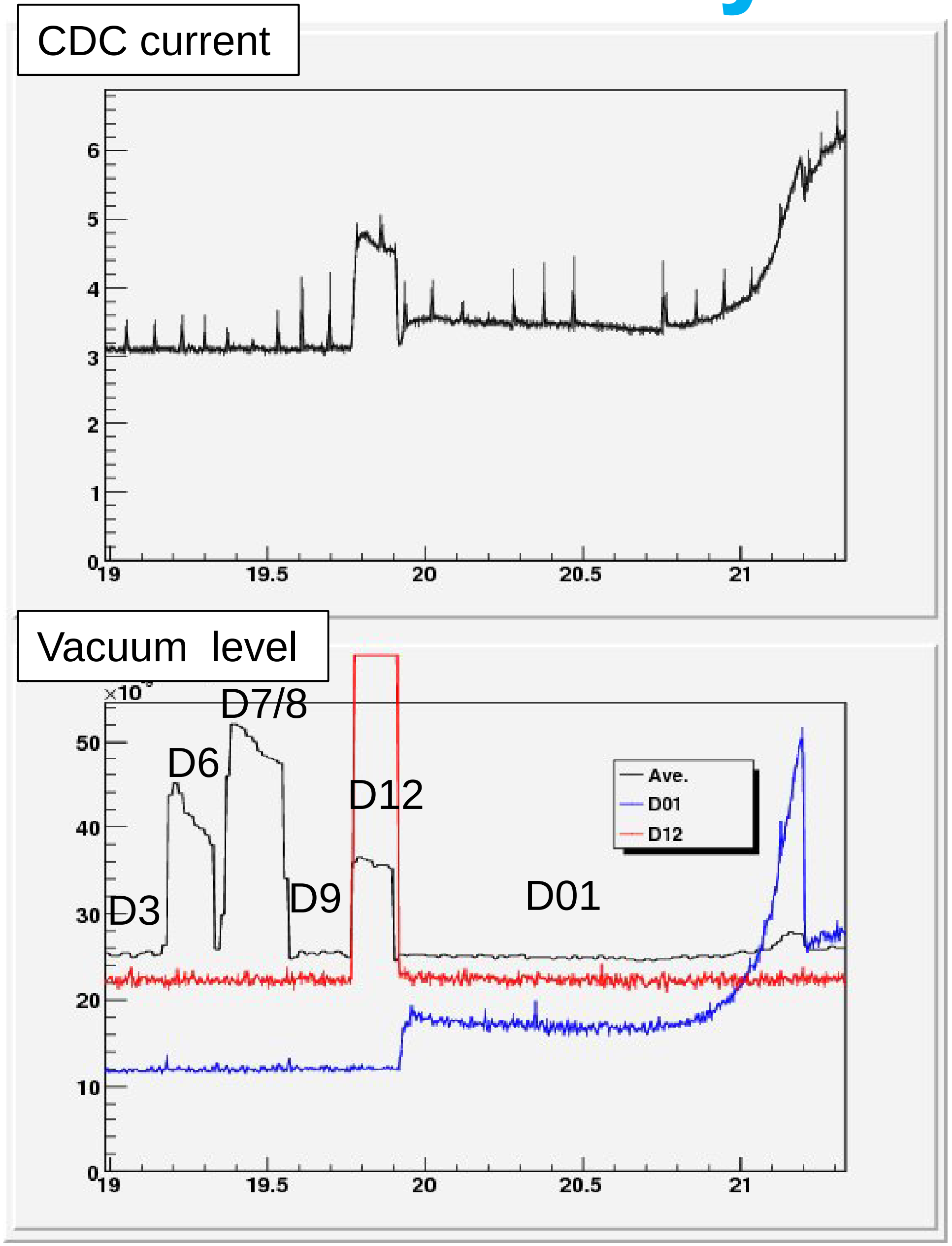
2. MC simulations

2-1 To estimate the BG level at SuperKEKB, we prepare the
Beam-gas and Touschek simulations
→ Important information to design the maks

2-2 To evaluate the MC simulation, we prepare the
Beam-gas and Touschek simulations for KEKB
→ Compare the real data

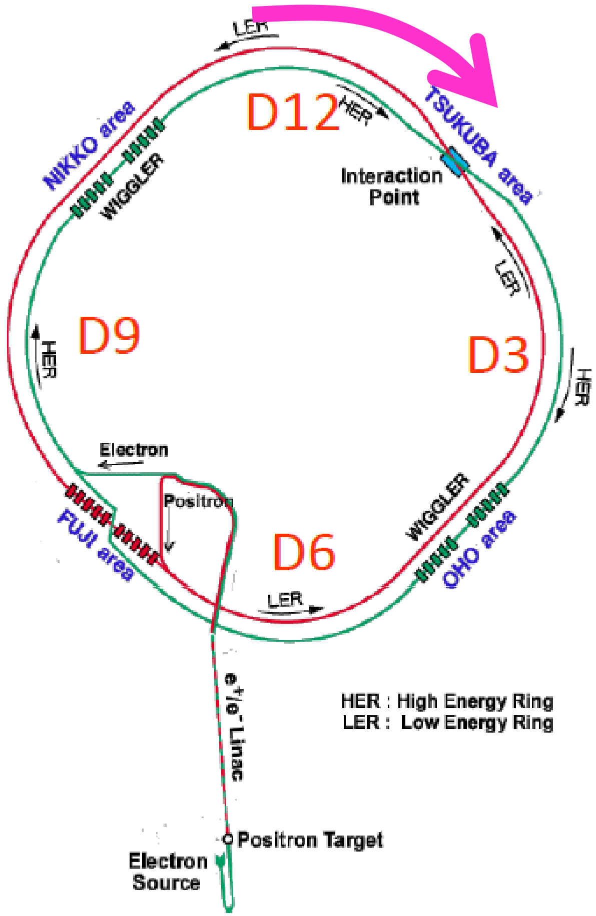
BG-study : Vacuum bump

S.Sugihara

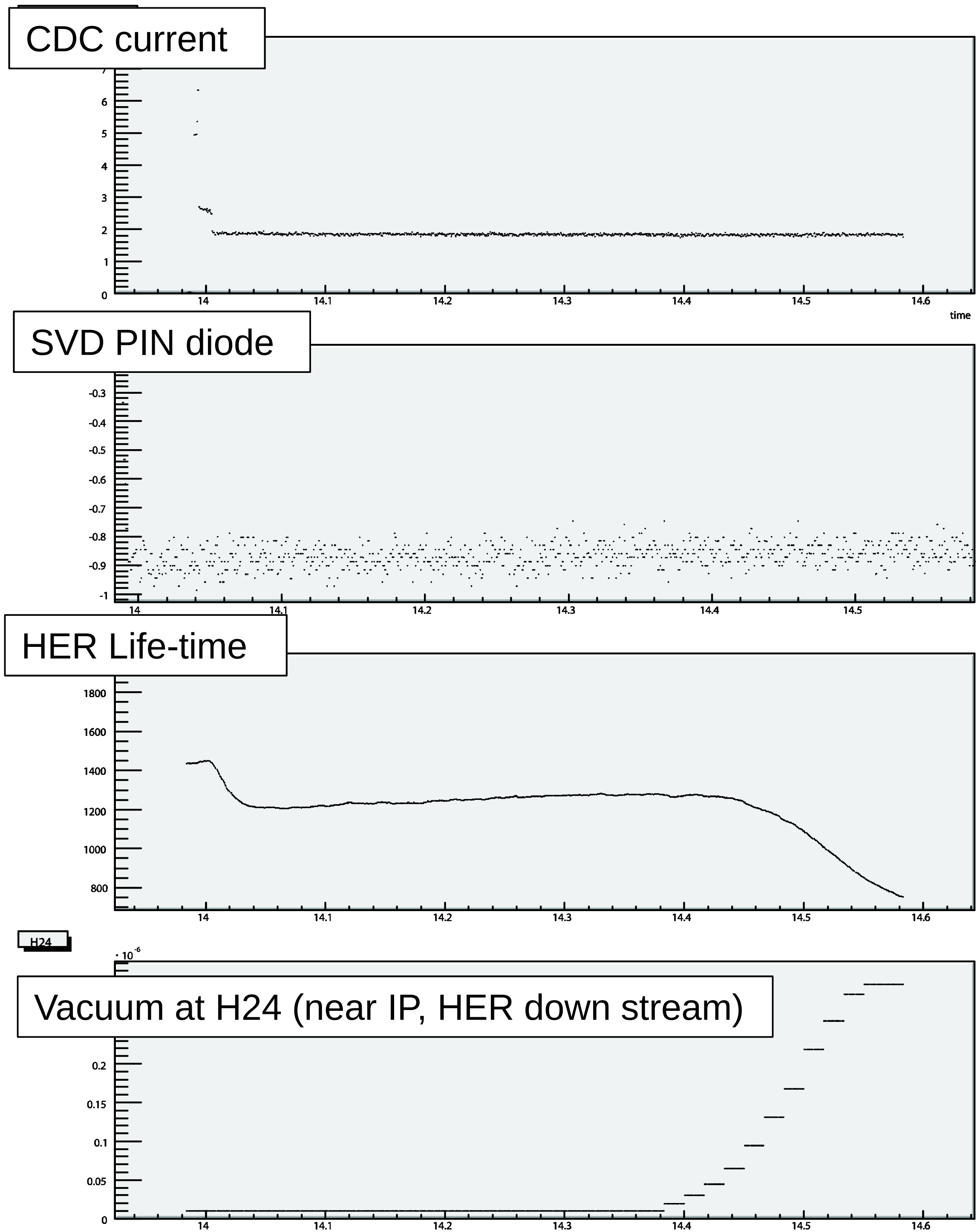


2009.12.7 19:00-21:20(HER)

Vacuum level at D12 and D1 (arc and upstream IP sections) affects to the detector BG level



BG-study : Change IP Vacuum



2009.12.17 HER (IP)

Change the IP vacuum level
with NEGs near the IP
(HER downstream)

Bad IP vacuum level affects
to the beam life time, but
not affects to the detector BG

S.Sugihara

KEKB Beam-gas simulation

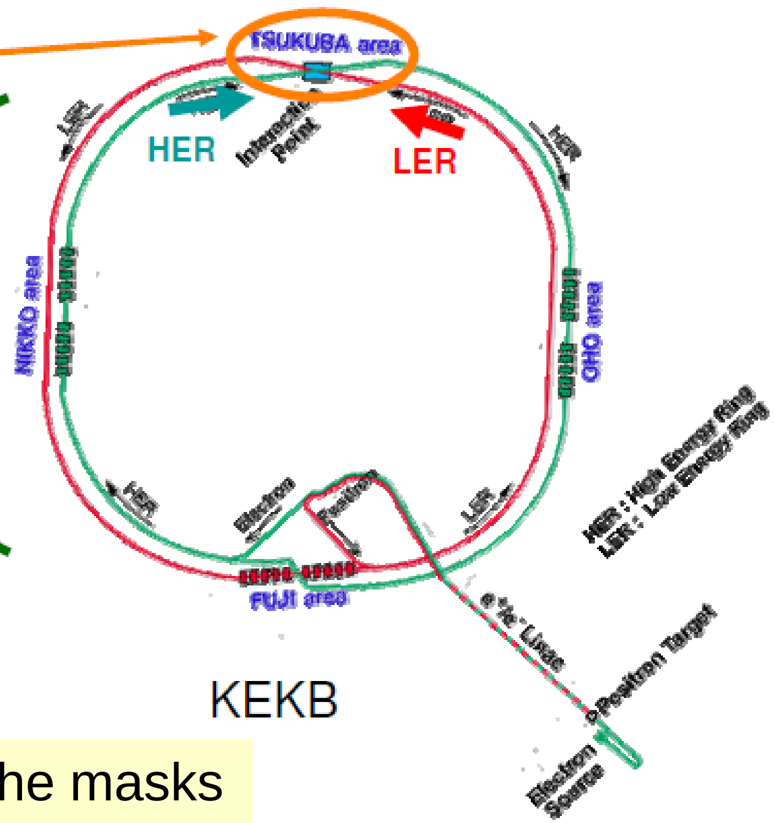
Simulation tools

H.Nakano (Tohoku)

Detector part
- GEANT

Other part of the rings
- TURTLE

These two simulation software were used



KEKB

In this simulation, we implement the masks

LER beam

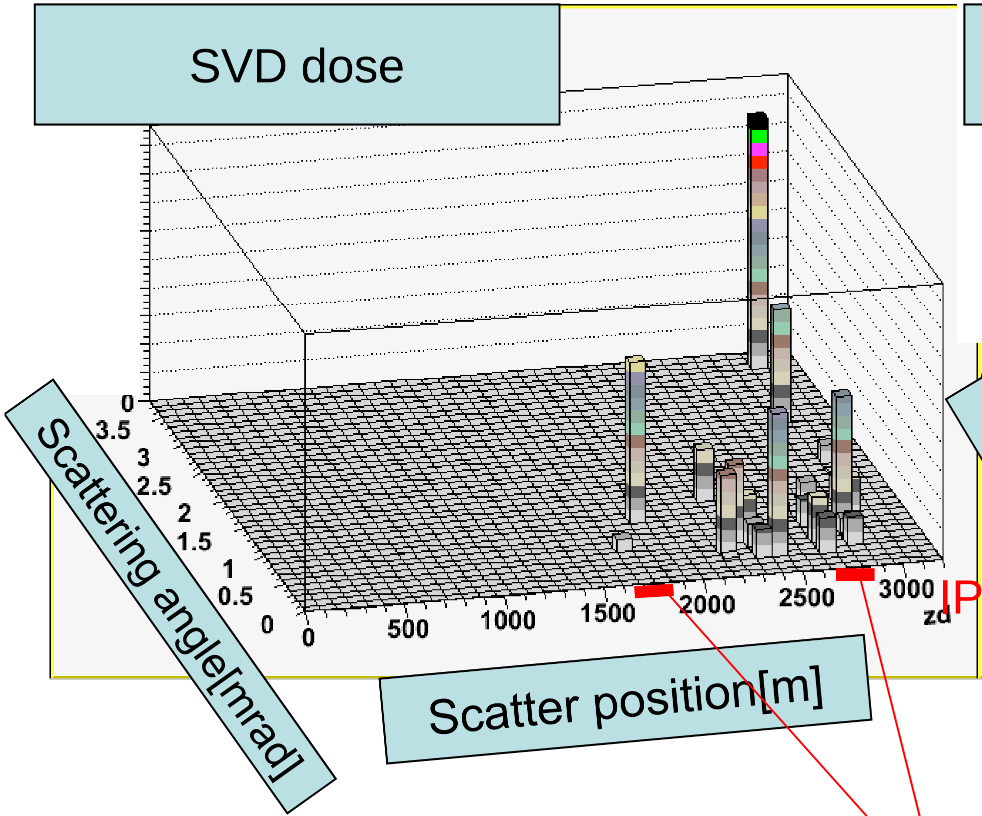
0 1700 1800 2700 2800 3007

4 masks at each places

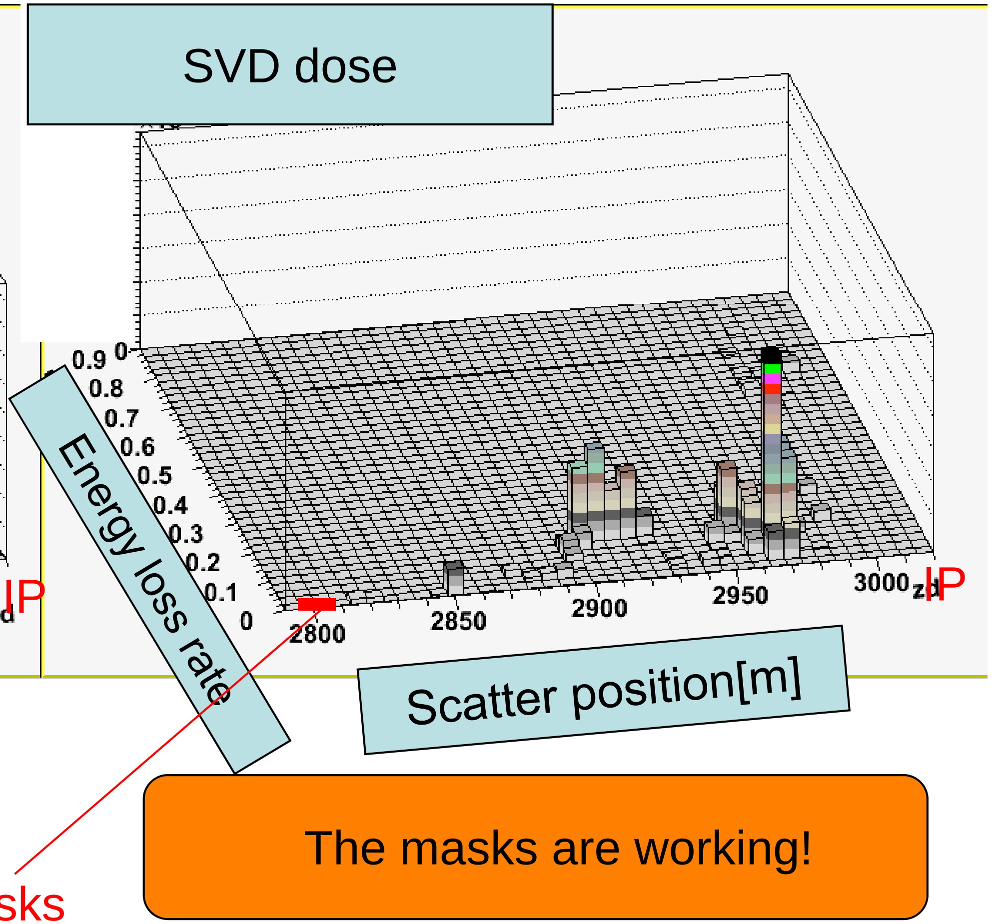
SVD dose and Beam-gas scattering location

H.Nakano

Coulomb (change direction)



Bremsstrahlung (change energy)



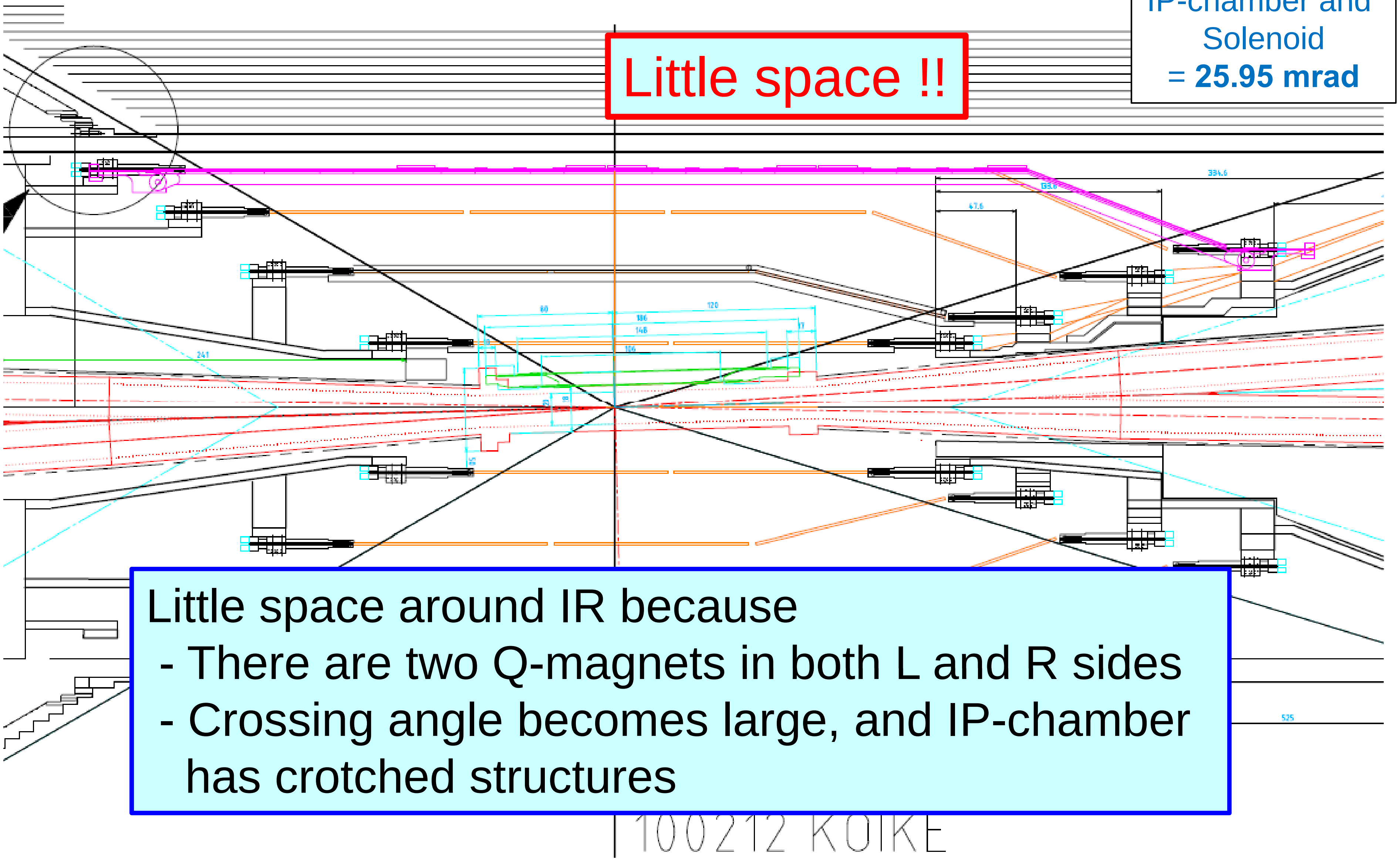
The masks are working!

ToDo
1. Start KEKB Touschek simulations
2. Compare BG-study data and simulations
3. Start SuperKEKB simulations

2. Space for IR

Space for IP region

Angle btw IP-chamber and Solenoid = **25.95 mrad**

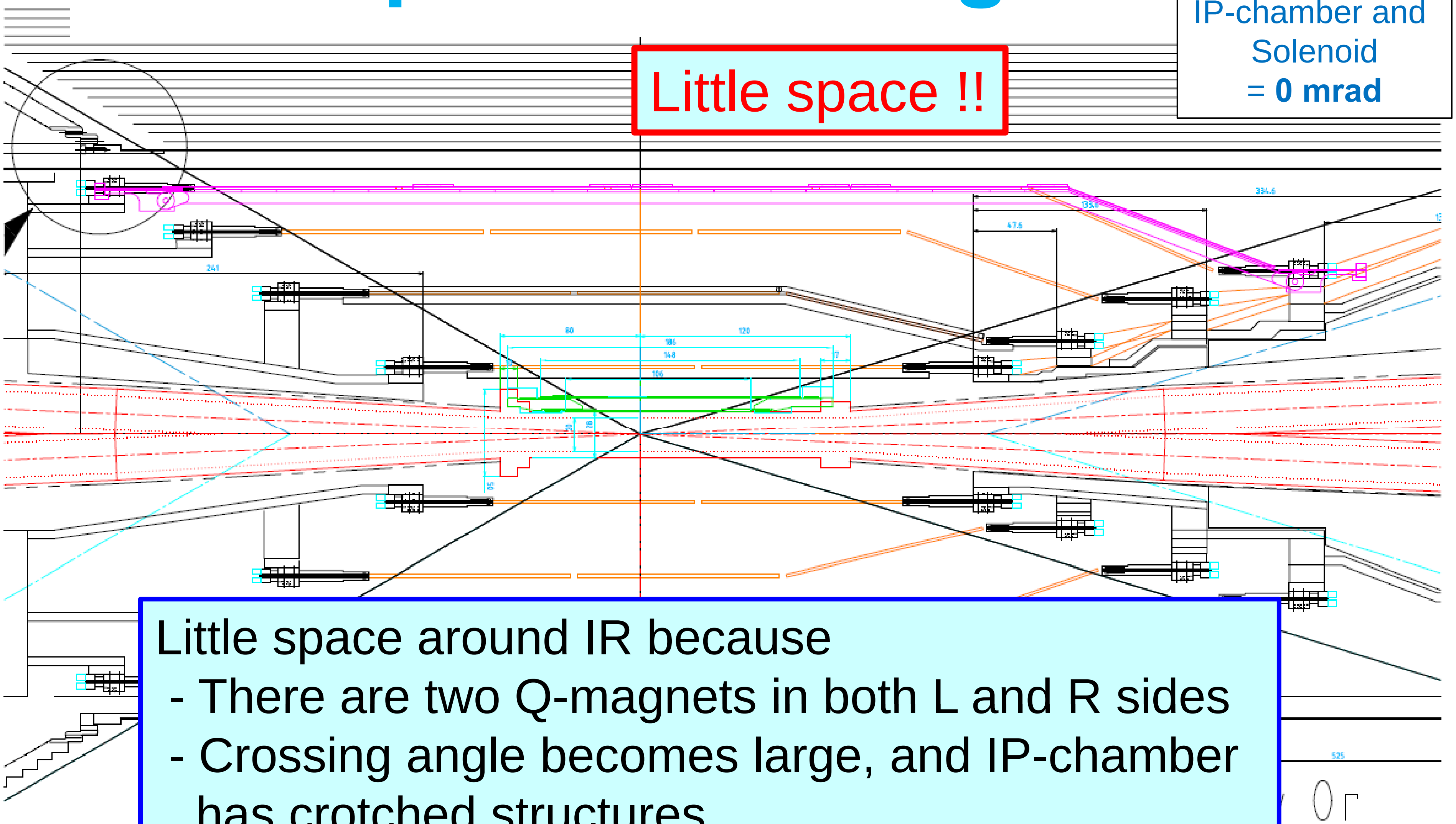


Little space !!

Little space around IR because
- There are two Q-magnets in both L and R sides
- Crossing angle becomes large, and IP-chamber has crotched structures

Space for IP region

Angle btw IP-chamber and Solenoid = **0 mrad**



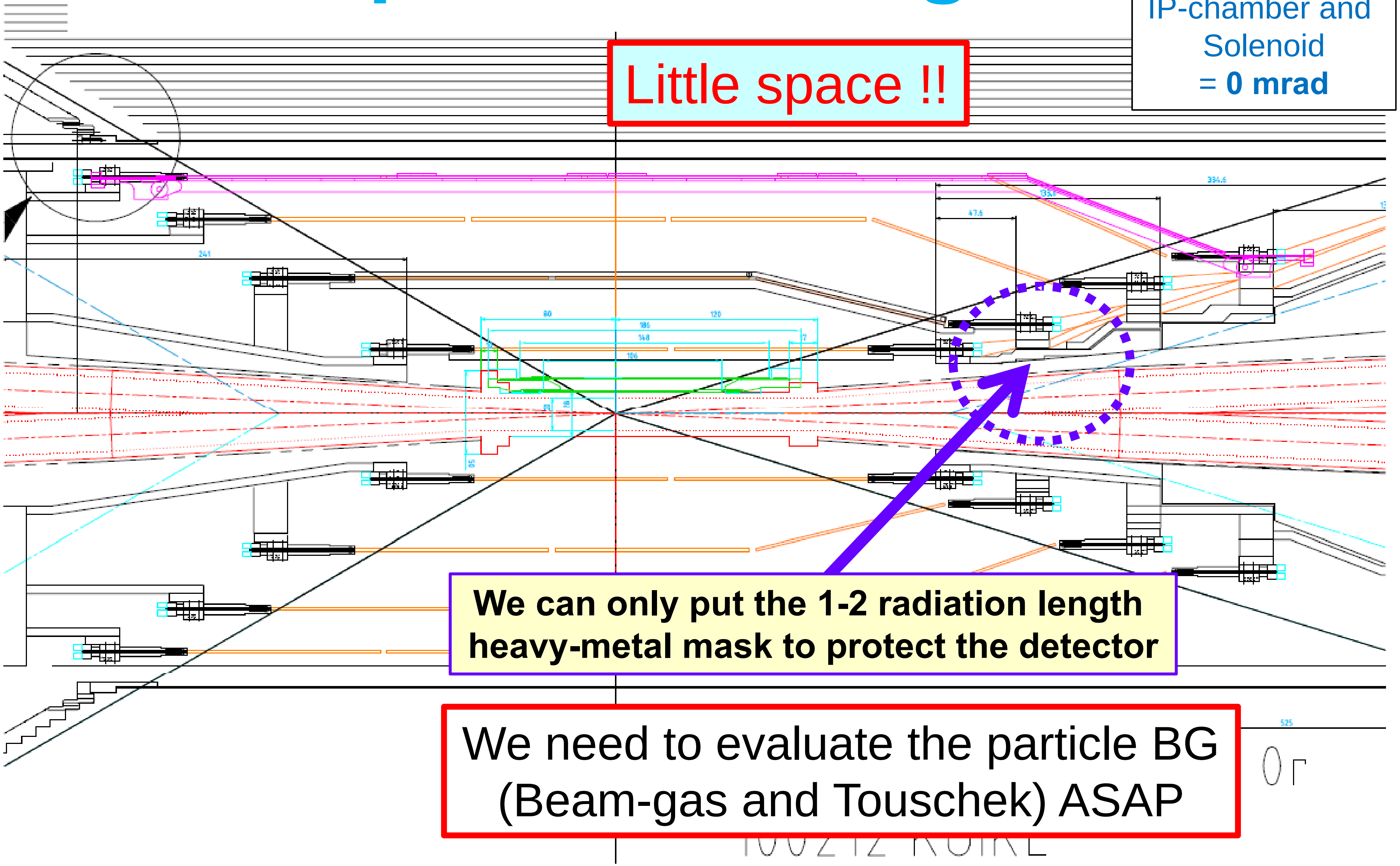
Little space around IR because
- There are two Q-magnets in both L and R sides
- Crossing angle becomes large, and IP-chamber has crotched structures

→ IR assembly / design of IR components

See K.Kanazawa's talk

Space for IP region

Angle btw
IP-chamber and
Solenoid
= **0 mrad**



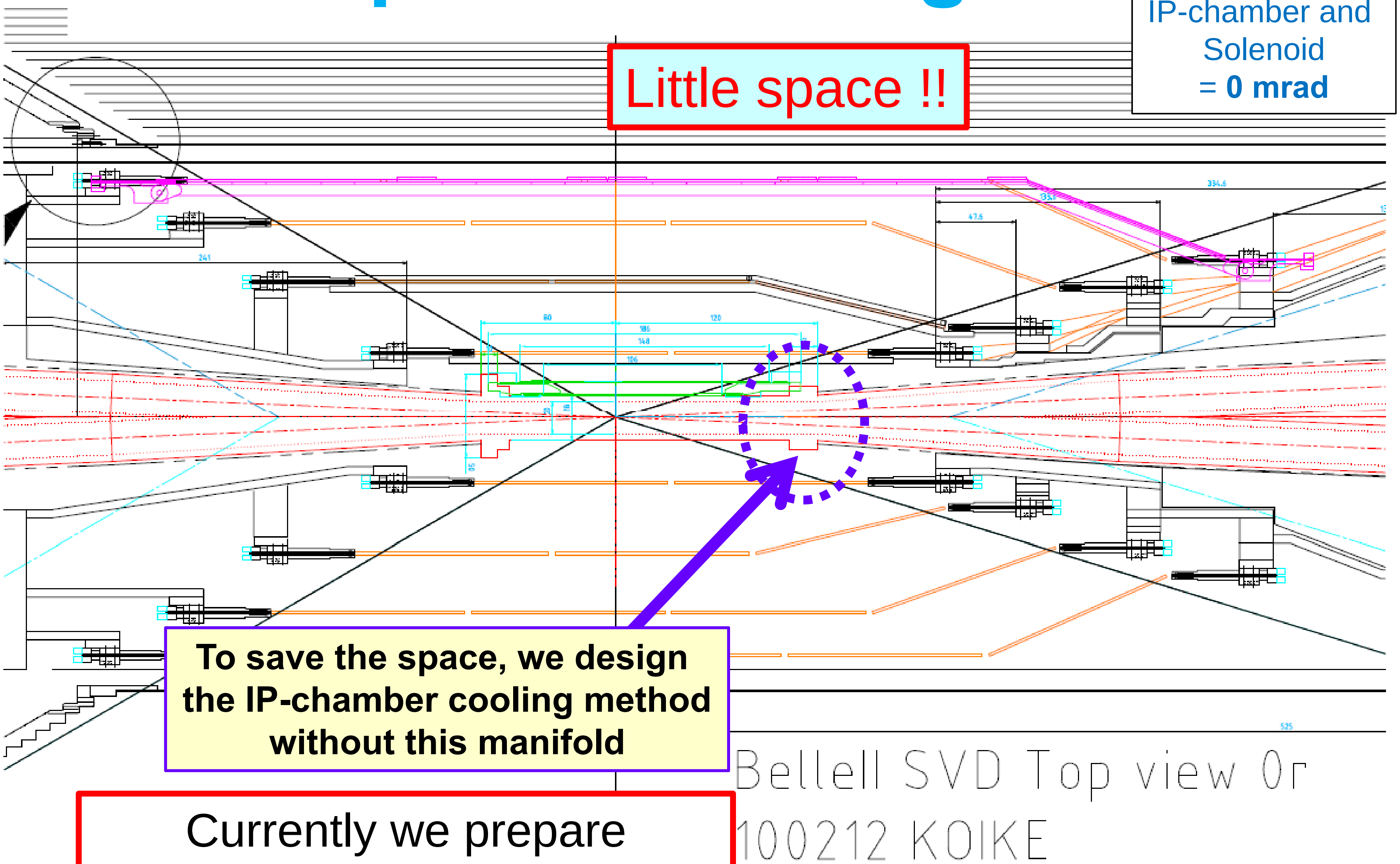
Little space !!

We can only put the 1-2 radiation length heavy-metal mask to protect the detector

We need to evaluate the particle BG (Beam-gas and Touschek) ASAP

Space for IP region

Angle btw IP-chamber and Solenoid = **0 mrad**



To save the space, we design the IP-chamber cooling method without this manifold

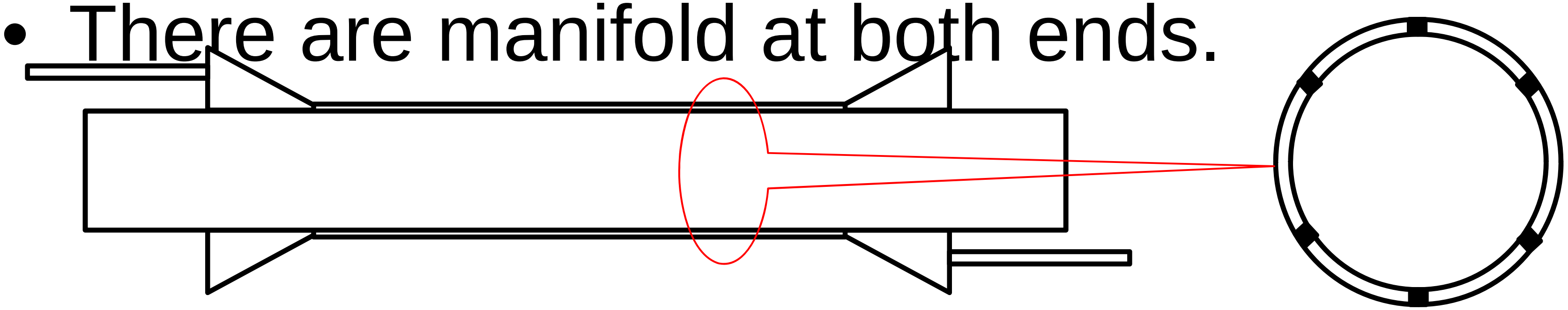
Currently we prepare prototypes for the cooling test

2010 Feb. Koike

T.Tsuboyama

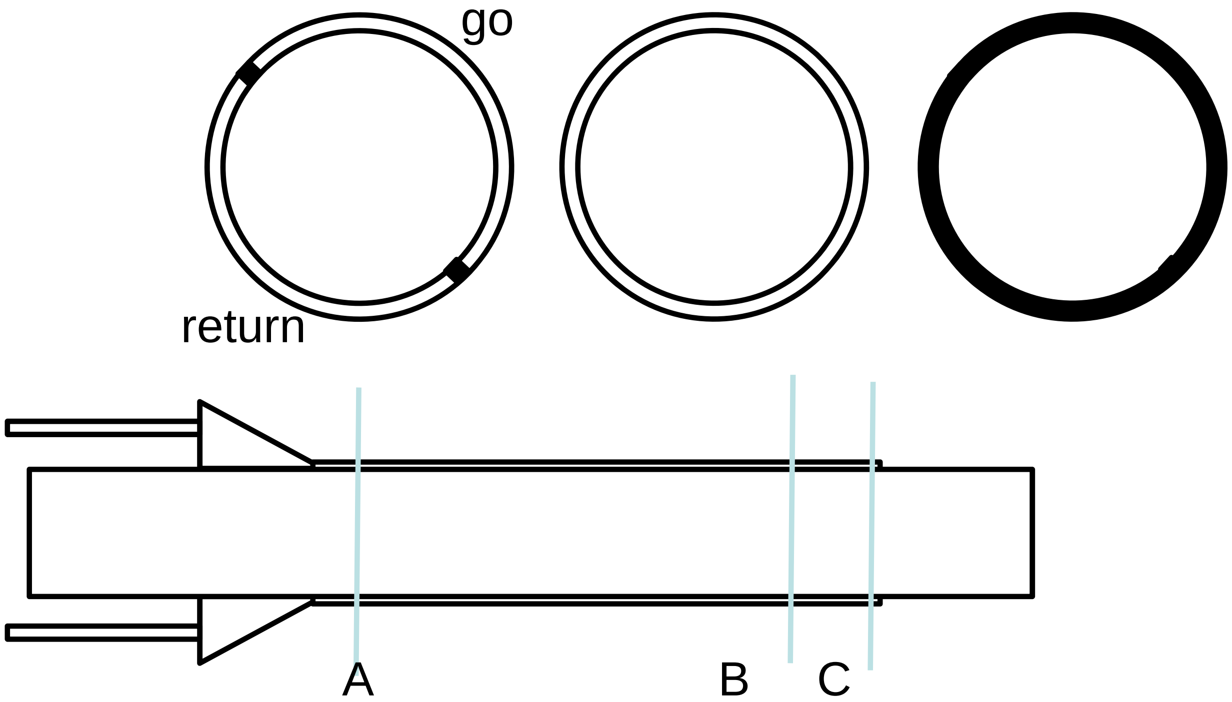
The beryllium chamber

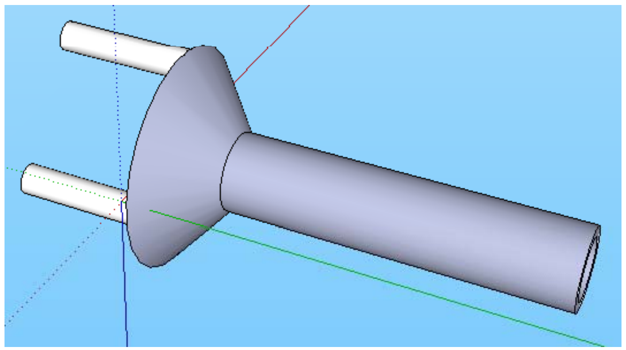
- The central part of the IP chamber is a double-wall beryllium tube
- Two tubes are supported by ribs
  - Keep the two tubes with uniform gap.
  - Control the liquid flow (?)
- There are manifold at both ends.



Example 1

T.Tsuboyama





- The coolant from the inlet go to in one slot to the end. It returns through another slot to the exit.
- Two tubes in the manifold.
- A fear of non-uniformity of the flow.

Summary

1. Detector BG

1-1 SR

- To design the IP-chamber we start SR simulations

1-2 Particle BG

- We did BG-study related to the particle BG
- Currently we try to do the KEKB particle BG simulation to compare the MC and data
- We are constructing the SuperKEKB particle BG simulation

  → Important to design the mask

2. We have little space around IP

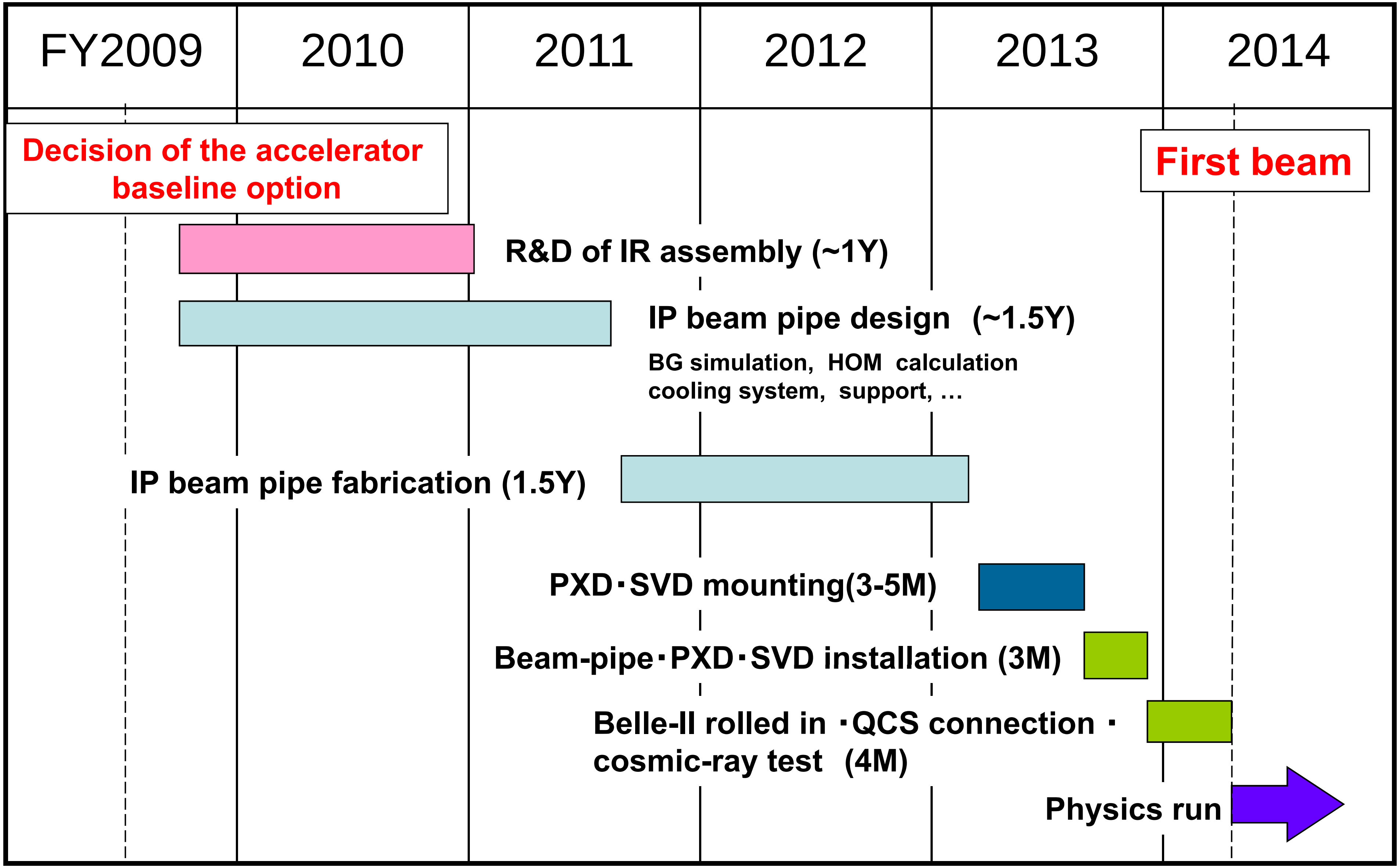
2-1 New cooling design to reduce the IP-chamber size

- We make prototypes for the cooling test
- Will start the thermal calculation soon

2-2 We cannot put the large mask (only 1-2 radiation length)

- Need particle BG simulations as soon as possible

Schedule


FY2009
2010
2011
2012
2013
2014
Decision of the accelerator baseline option
First beam
R&D of IR assembly (~1Y)
IP beam pipe design (~1.5Y)
BG simulation, HOM calculation
cooling system, support, …
IP beam pipe fabrication (1.5Y)
PXD･SVD mounting(3-5M)
Beam-pipe･PXD･SVD installation (3M)
Belle-II rolled in ･QCS connection ･
cosmic-ray test (4M)
Physics run

Back up

Introduction

SuperKEKB : To increase the luminosity,

machine parameters will drastically change

Issues of the MDI :

1. Beam background

   High beam current / High power SR emission

2. Heating of IR components

   High current / HOM / SR

3. Structure design and assembly of inner detectors, beam pipe, and final magnets

   Place final Q magnets closer to IP / vibration

MDI design is very important in SuperKEKB

In this talk, we'll show

Detector BG and 2. Space around IP

SuperKEKB Accelerator design

- The base design is Nano-beam option
  → There are two final-Q magnets in both L / R sides

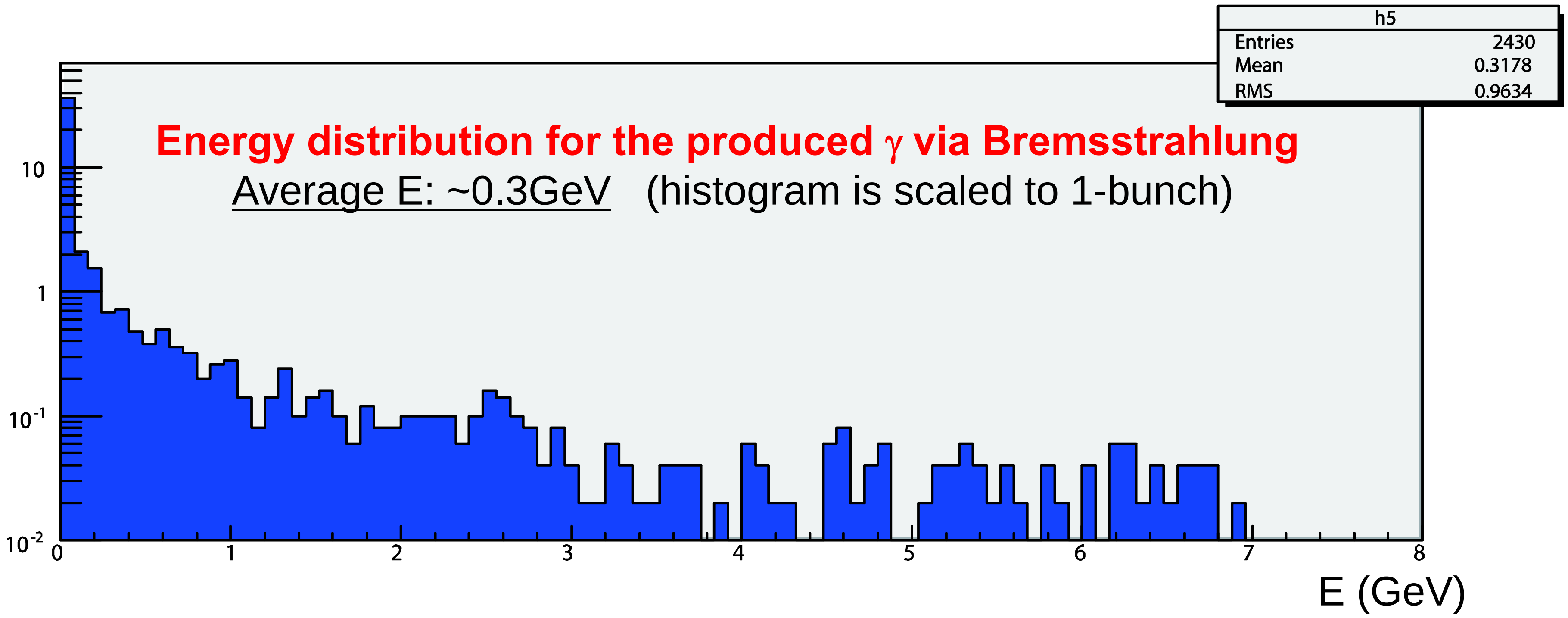
- 7x4GeV beam energies
  (To solve the problem on dynamic aperture.)

- Crossing angle is 83 mrad
  to put the final-Q magnets closer to the IP

- The QCS chamber radius is 1cm
  → to avoid the resonant cavity structure,
  our IP beam-pipe radius should be 1cm

SuperKEKB HER beam-line simulation

-Construct ¼ of the whole electron ring (~700m) for the Beam-gas simulation
-Vacuum level = 10^7 worse than the nominal value
(average # beam-gas scattering is 0.002 / ~700m / particle)
Assumed uniform pressure
-Input beam-pipe: r=4.5 (ring) 3.5 (QC2) 1.7 (QC1), and 1cm (IP),
Thickness=4(IR) or 6mm(ring), material = SUS (← will change later)
-# Generate = 5×10^5 event
→ 10^7(scale factor for vacuum) x 5×10^5 (event) corresponds to ~50 bunches
- Process : Bremsstrahlung only (will include Coulomb later)

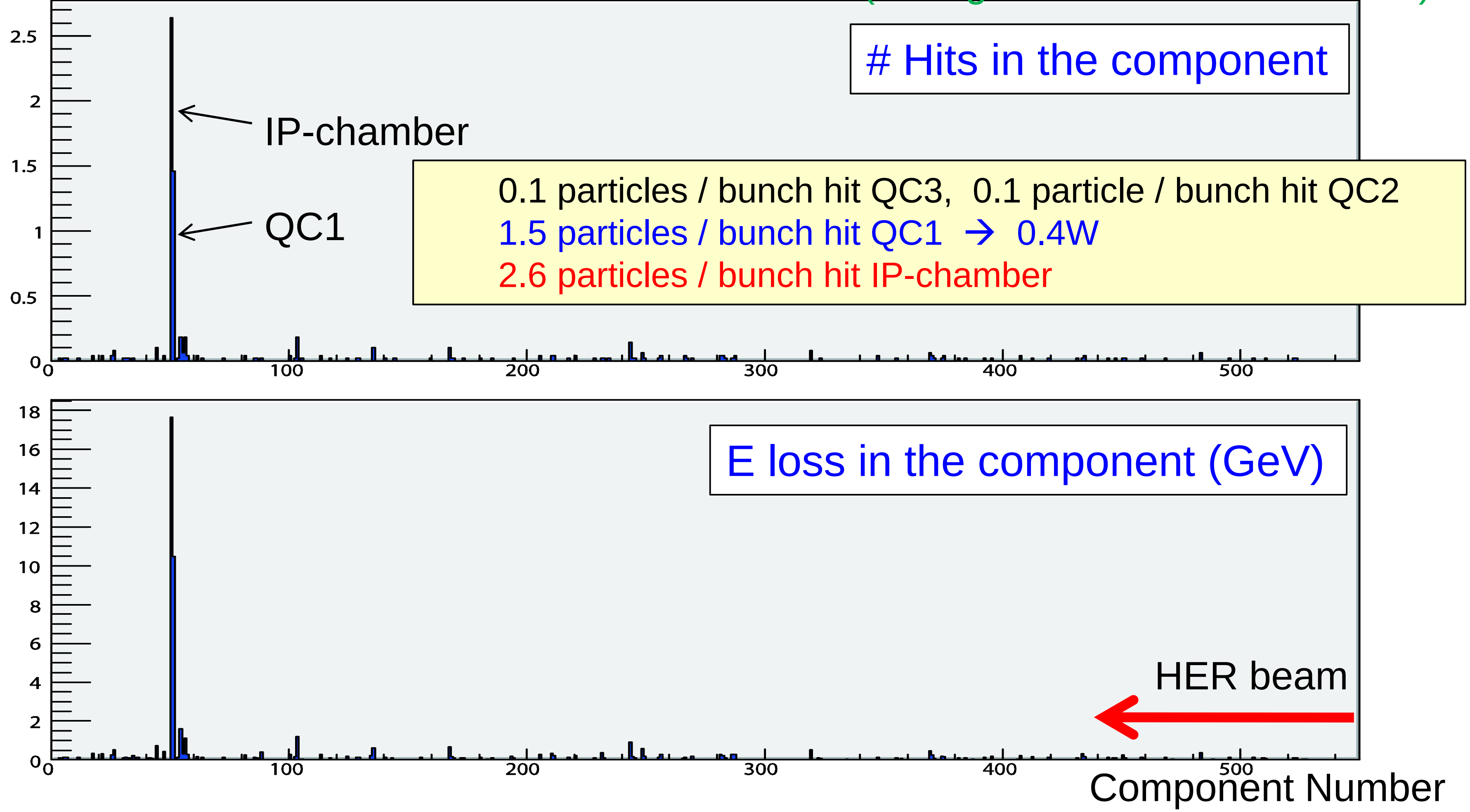


HER beam-line simulation

At first, we study where (what component) we have beam particle hits

(We turn off the showering process)

(Histogram is scaled to 1-bunch)



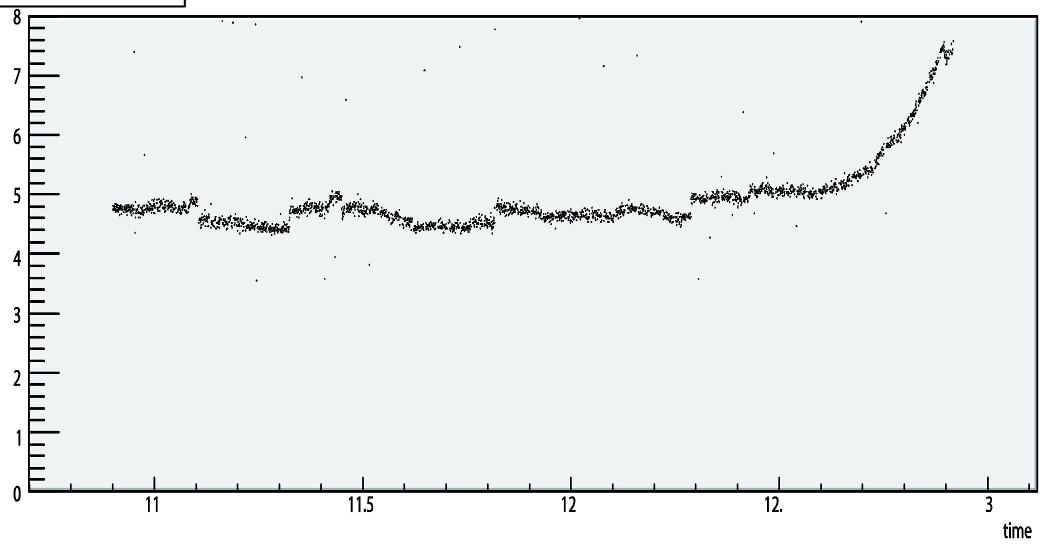
To Do : Implement the IP-chamber and masks.
Estimate the particle BG effect to the detector

BG-study : Vacuum bump

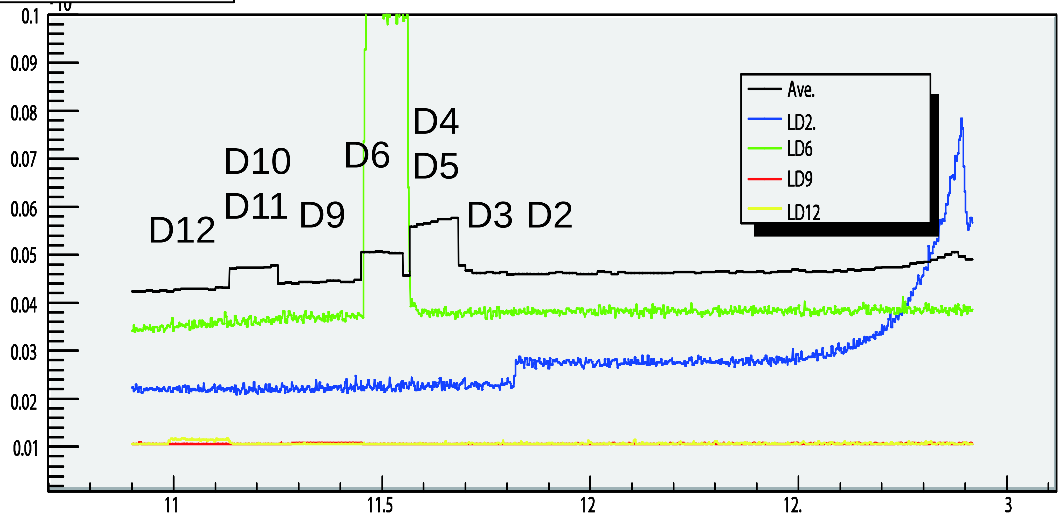
S.Sugihara

CDC current

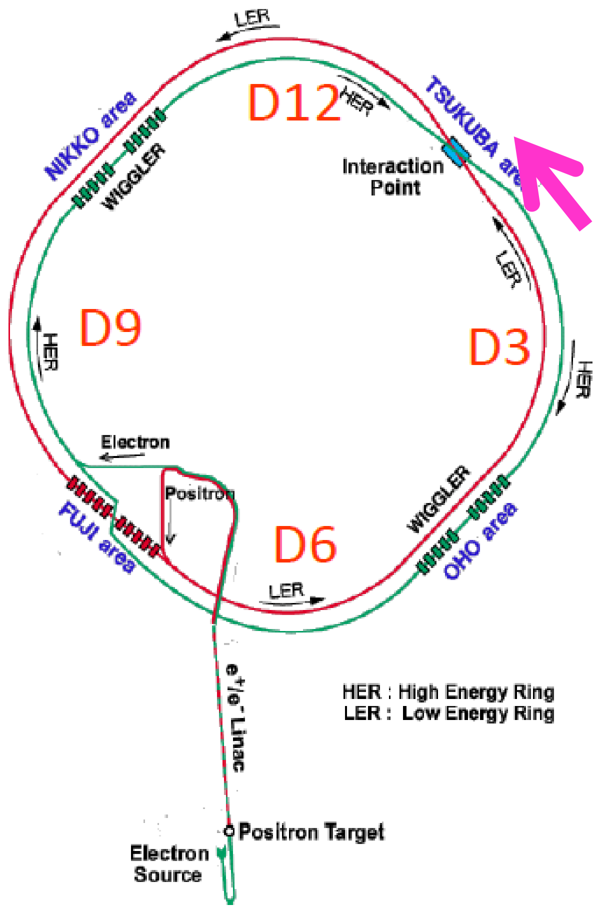
2009.12.17 LER



Vacuum level

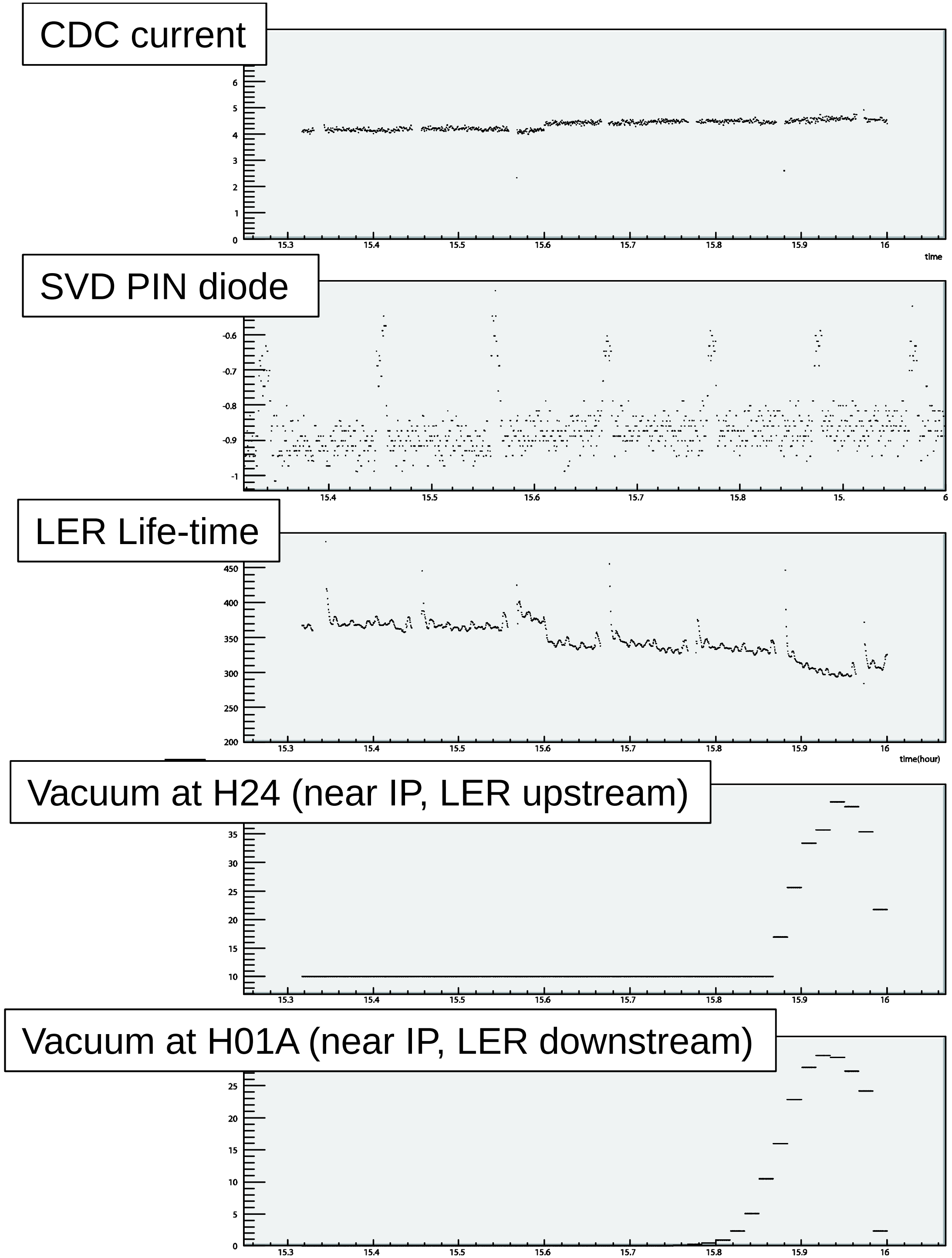


Vacuum level at D2
(upstream IP sections)
affects to the detector BG level



BG-study : Change IP Vacuum

2009.12.17 LER (IP)



Change the IP vacuum level with NEGs near the IP (LER downstream)

Vacuum level at LER upstream also becomes worse

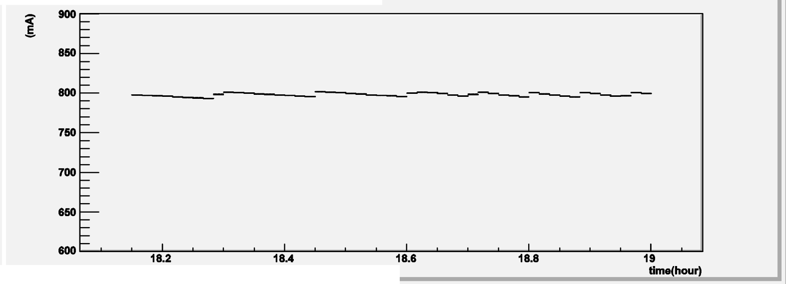
Bad IP vacuum level not affects to the detector BG

S.Sugihara

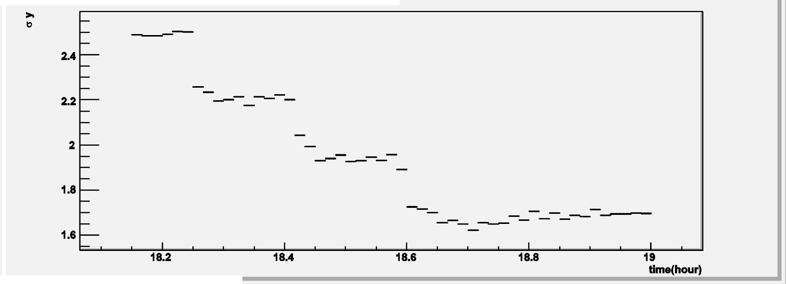
Touschek effect

2009.12.7 18:10-19:00 (HER)

HER Beam current

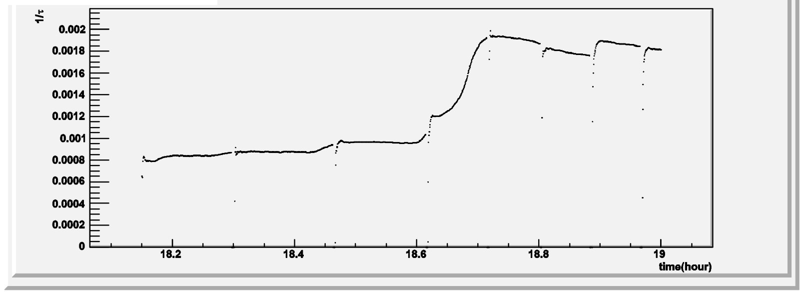


Vertical Beam size



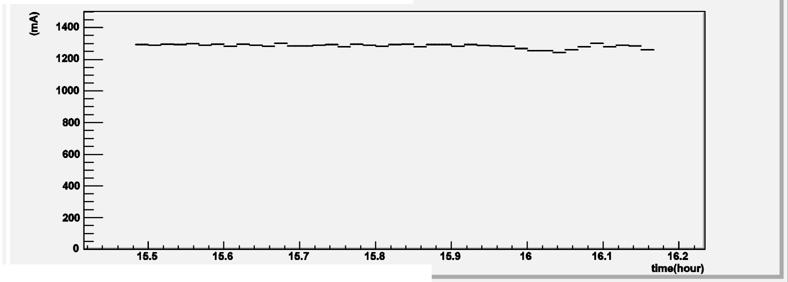
Beam life τ

1/τ

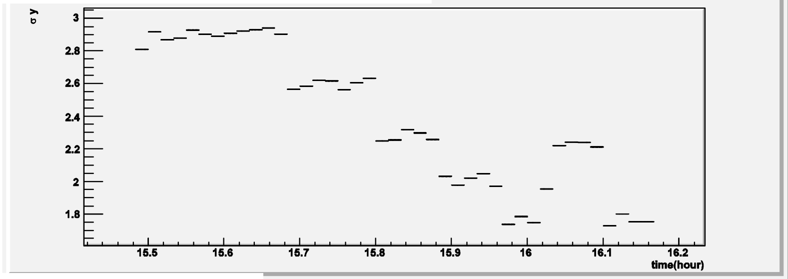


2009.12.8 15:30-16:10 (LER)

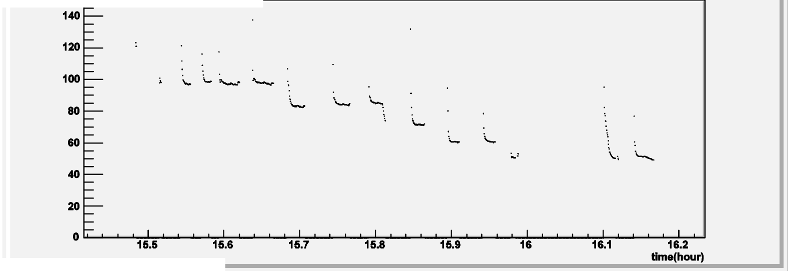
LER Beam current



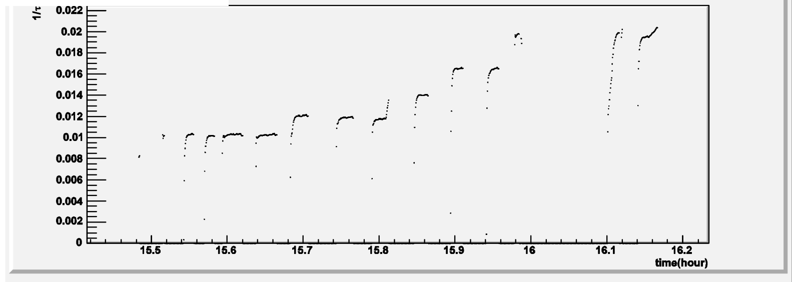
Vertical Beam size



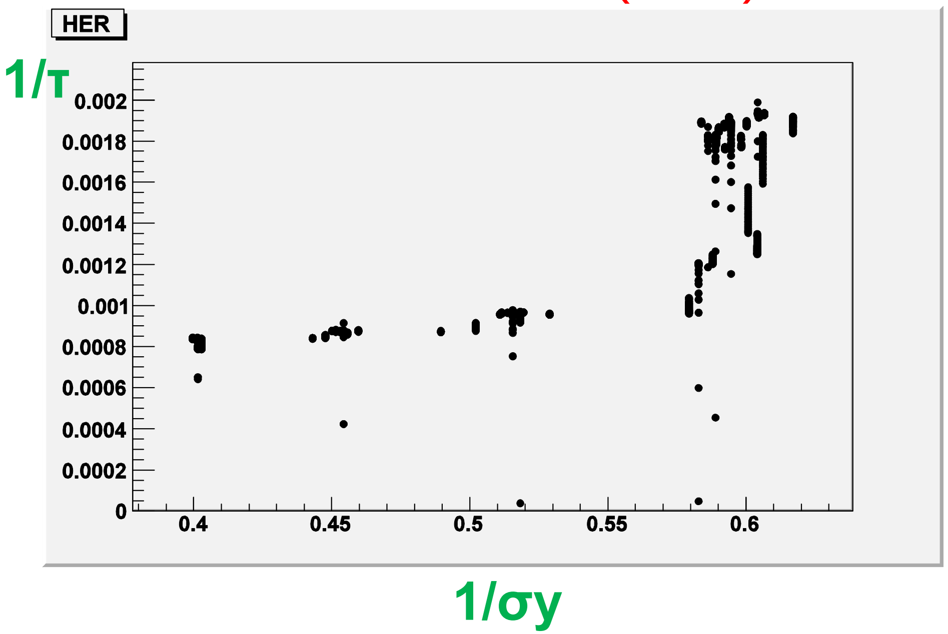
Beam life τ



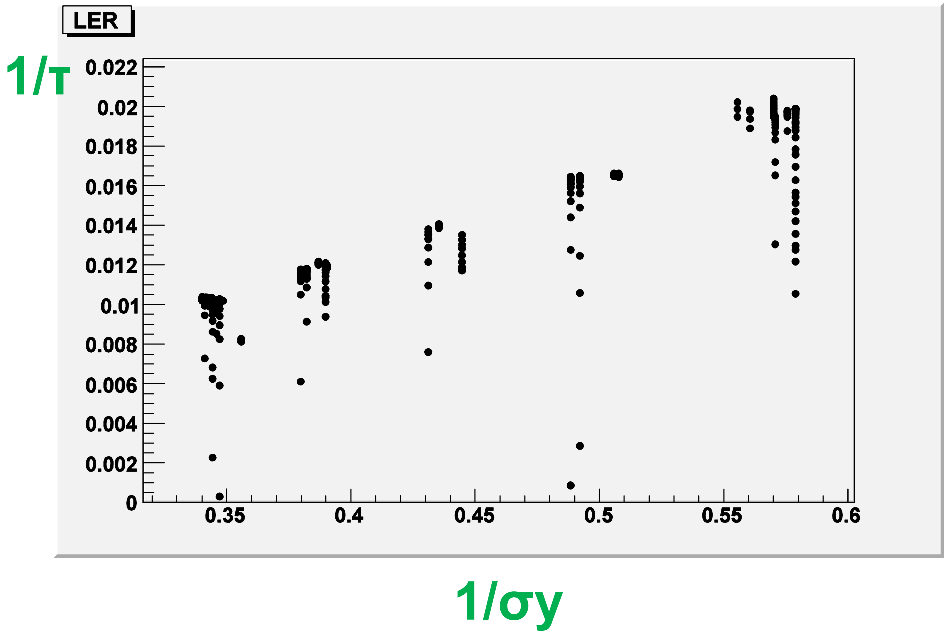
1/τ



2009.12.7 18:10-19:00 (HER)

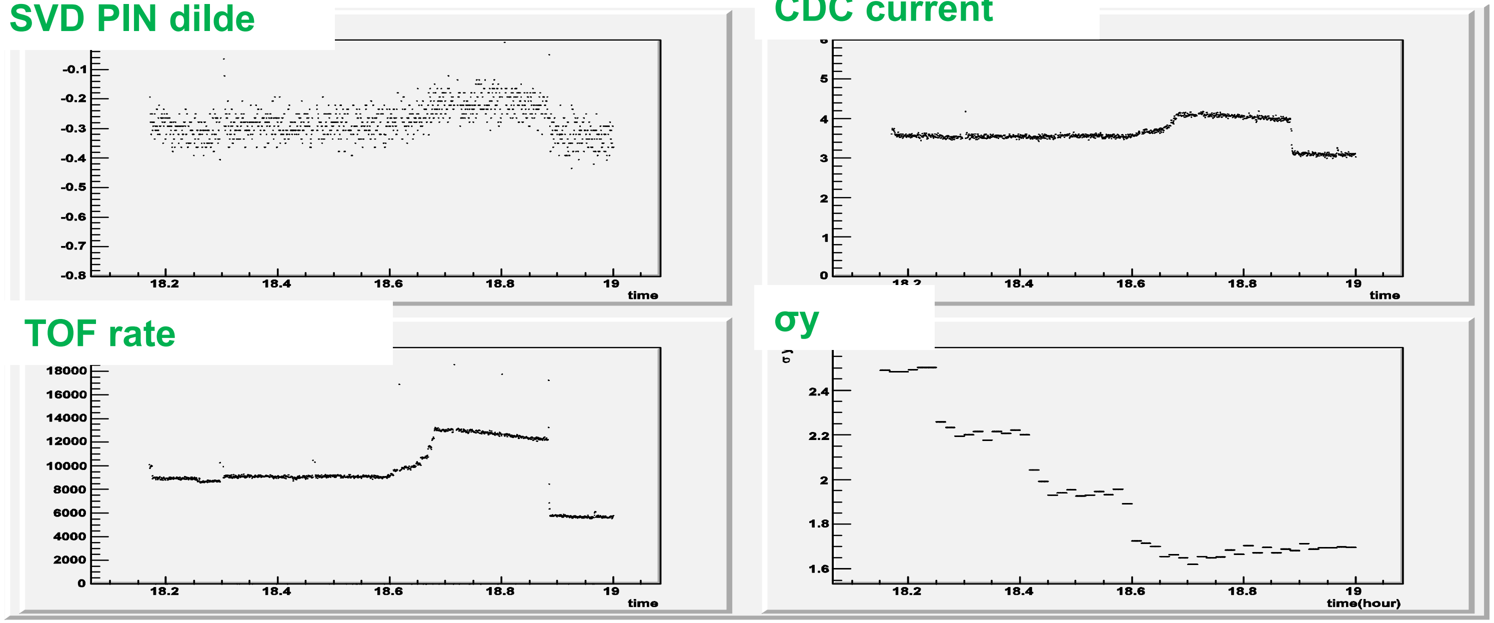


2009.12.8 15:30-16:10 (LER)

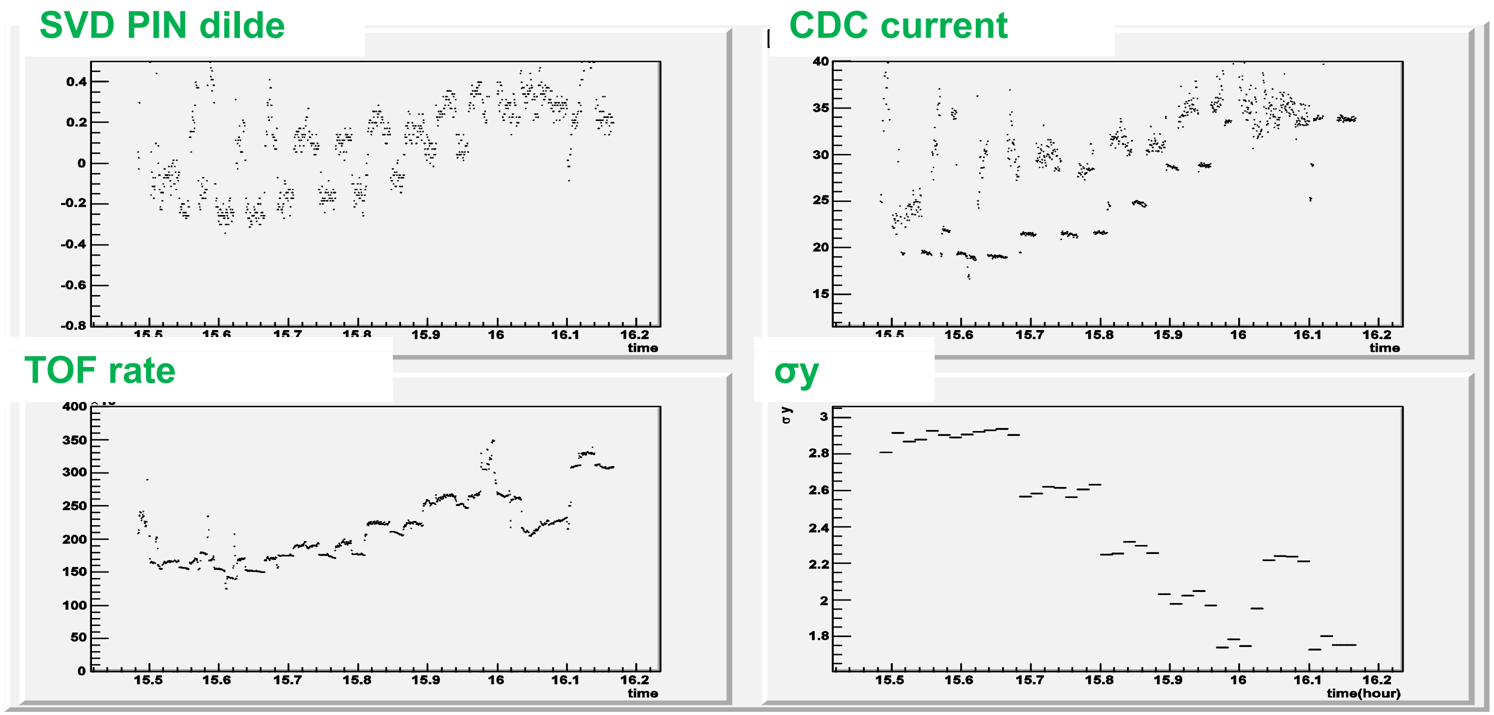


Beam life time supposed to follow $\frac{1}{\tau} \propto \frac{i_{bunch}}{\sigma_y}$

2009.12.7 18:10-19:00(HER)



2009.12.78 15:30-16:10 (LER)



Space for PXD and SVD

18 Nov. 2009

Toru Tsuboyama (KEK)

T. Tsuboyama

Number of cables and tubes

Tubes and cables from each side. For the most narrow part, heat shield will not be minimized.

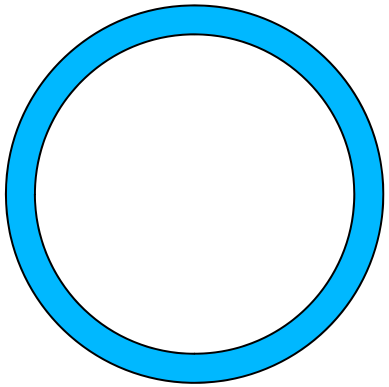
	Cables (cm^2)	Tubes (cm^2)
IP chamber	4 (8 BPM cables)	2 (3 tubes)
PXD	30(power) 5 (signal)	2 (minimum heat shield)
SVD	94 (hybrid)	2 (4 tubes)
Total	133 cm^2	6 cm^2

The outer radius of the SVD support will be 14 cm. If we use 1/3 of the circumference for mechanical support, 2/3 can be used for cables and tubes.

The thickness, T, of cables and tubes is, then,

$$T = 133/(14*3.14*2*(2/3))=2.2 \text{ cm}$$

This is not impossible to design.



Beam pipe mock up

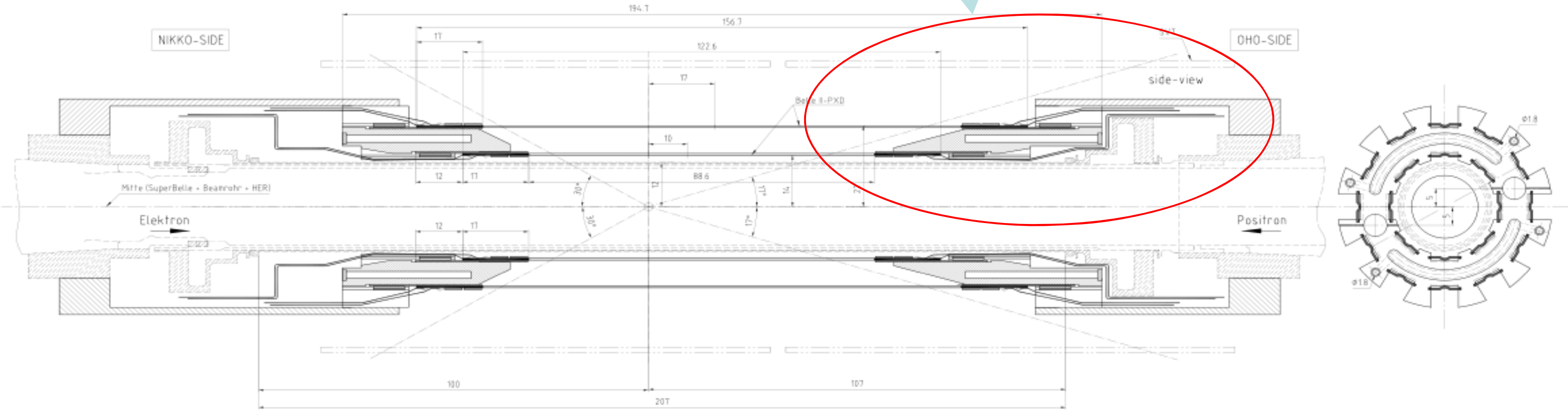
18 Dec. 2009

T. Tsuboyama (KEK)

T.Tsuboyama

The PXD issue

- In the present IP region, PXD does NOT have enough space in the forward region.
- The forward manifold is an obstacle.
- I propose to get rid of the forward manifold.
- Instead, the coolant should enter and exit from the backward manifold.



T.Tsuboyama

The beryllium chamber

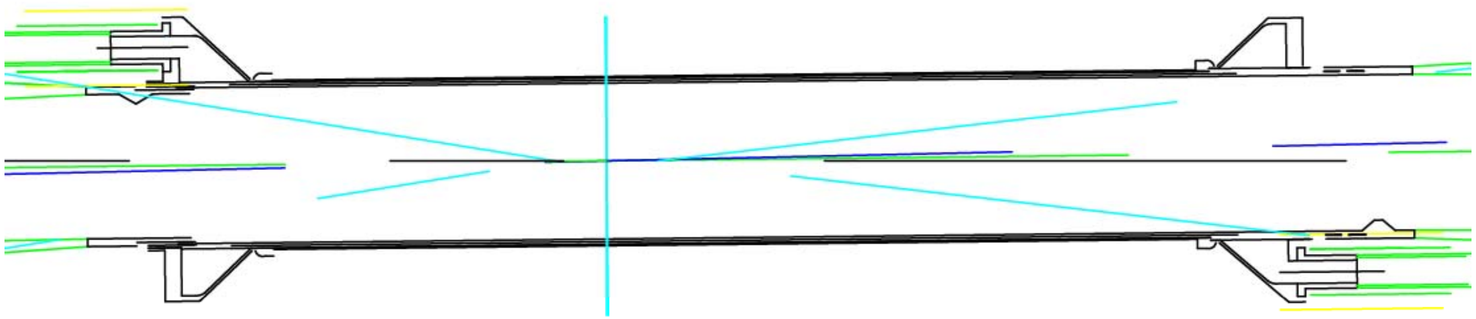
- The central part of the IP chamber will be very similar to that of SVD2.
  - Double wall of thin beryllium pipes.
  - Paraffin will be used as the coolant for safety.
  - I assume 200 W is the maximum heat to be removed.
    - HOM power is very limited by design.
    - Main contribution: Mirror current (No calculation yet).
    - With 2 liter/min paraffin flow the temperature increase is
      $\Delta T=200/((2000/60)*0.78*2.0)=4^{o}C$

Viscosity	$2.4*10^{-3}$ kg/ms
Heat capacity	2 J/gK
Density	0.78 g/cm^3

T.Tsuboyama

The SVD2 chamber mockup

- The structure is (almost) same as the final one.
- Made of aluminum.
- Tests were done
  - Flow rate (pressure drop) measurement
  -



T.Tsuboyama

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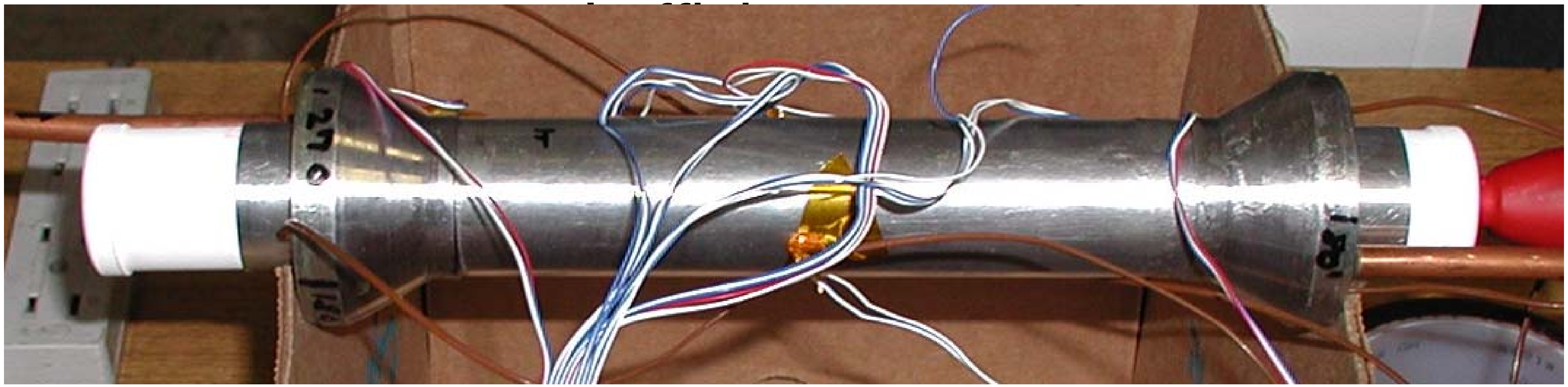
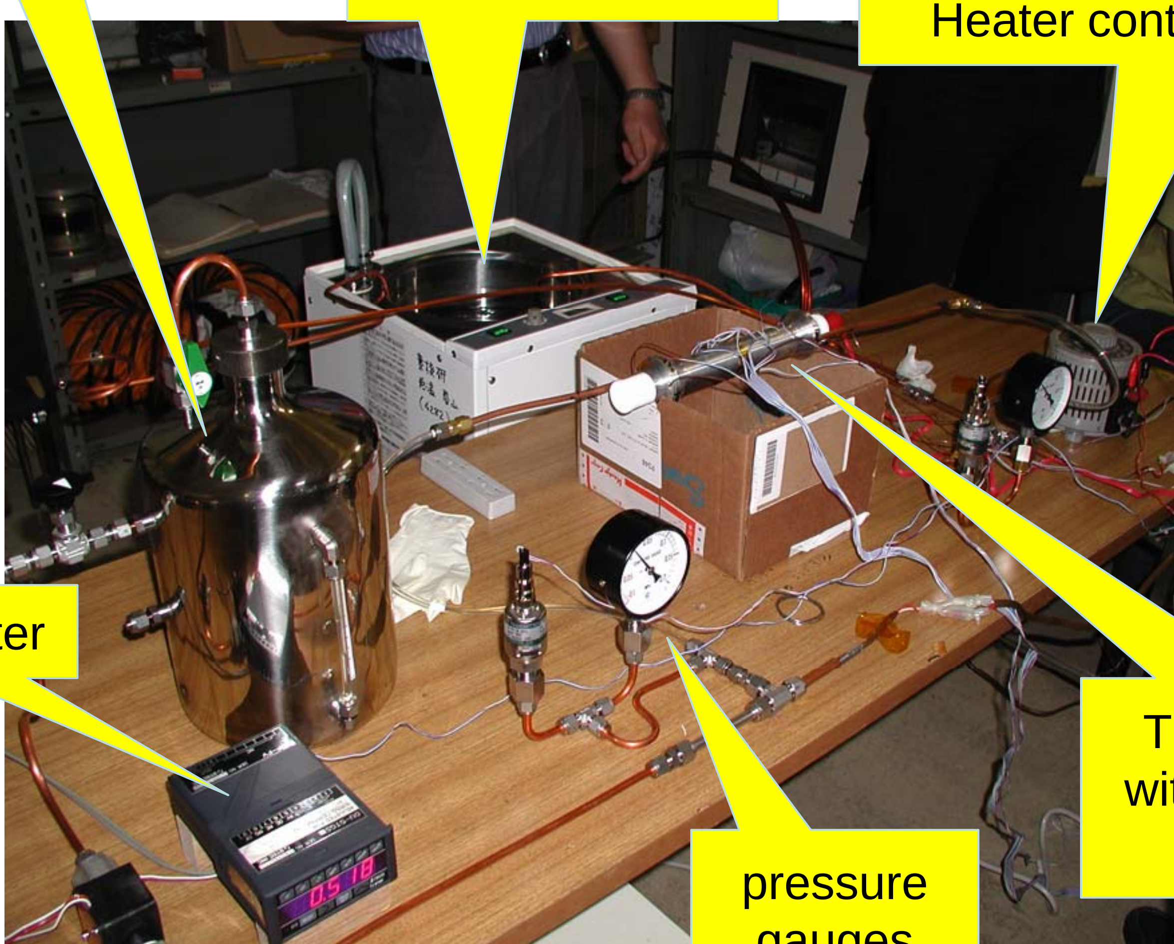


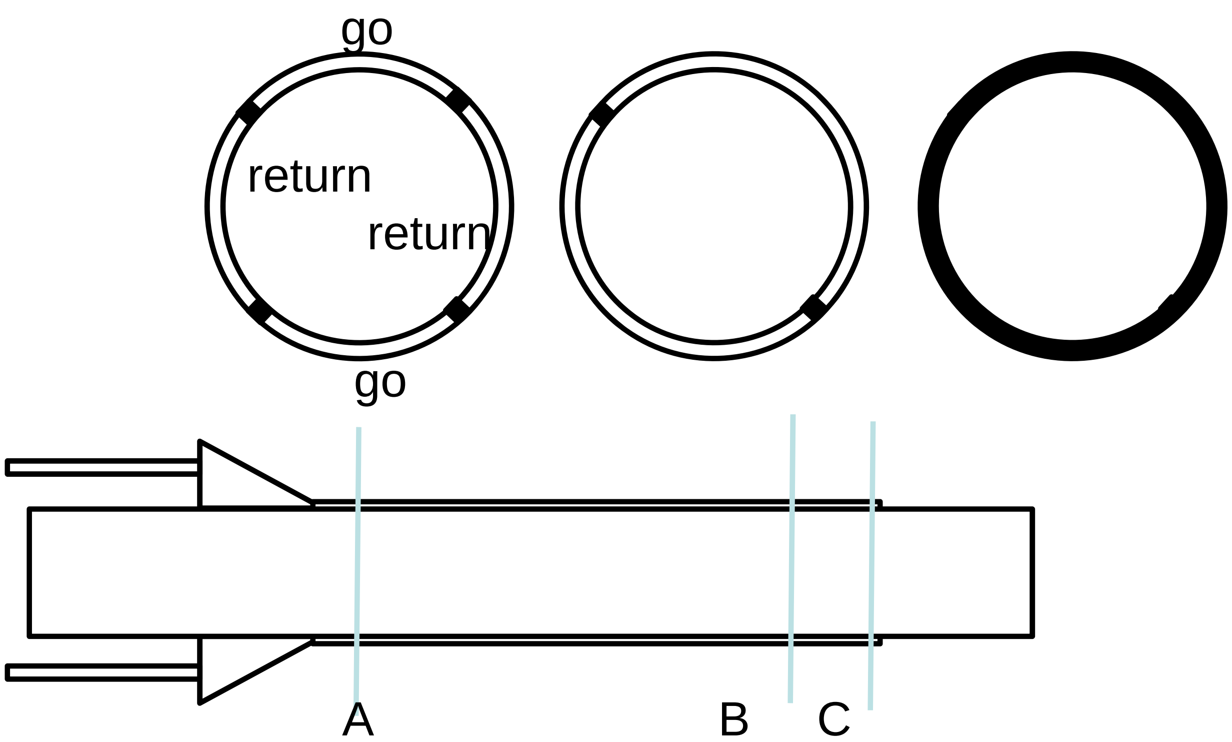
T.Tsuboyama

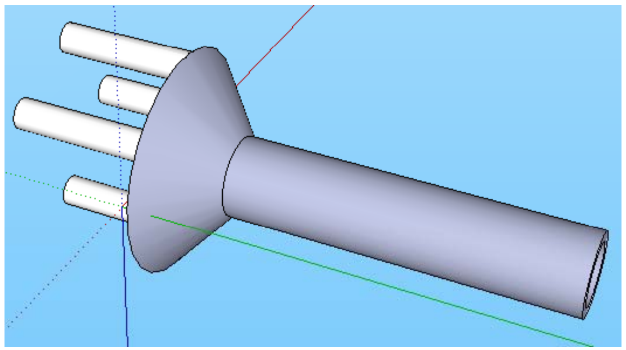
1999 test setup



T.Tsuboyama

Example 2





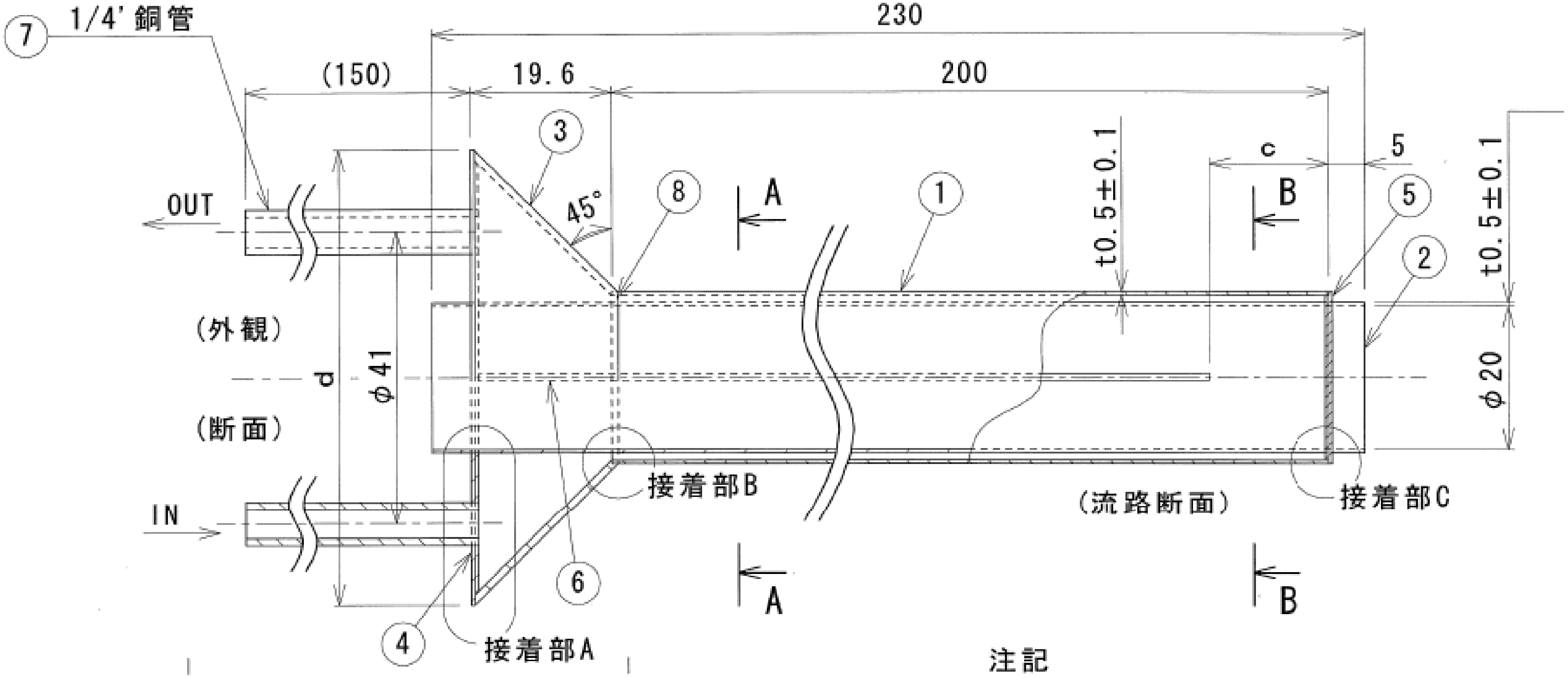
- To improve the flow uniformity, we may need to have two channels.
- Two tubes at the manifold. Two are for inlet and two for exit.
- The coolant should be separated at the no-manifold end.

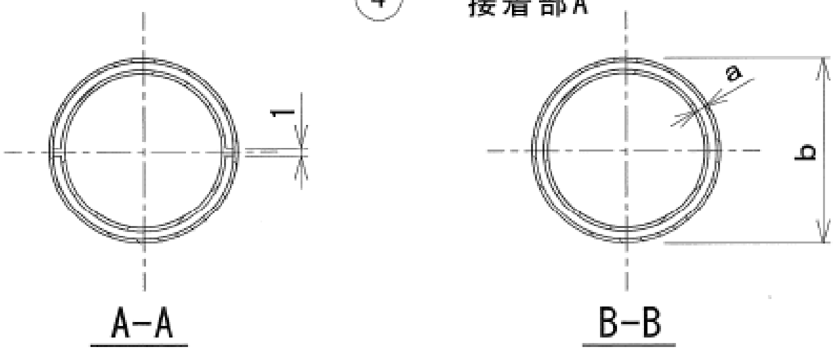
T.Tsuboyama

Summary

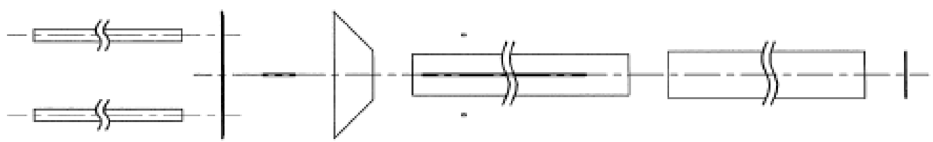
- I prefer Example 1 for its simplicity.
  – Let us make a mock up and test.
- Some worry in the temperature uniformity.
  – Can the pipe and manifold stand for 4^{o}C temperature variation: Mechanics simulation necessary.
  – If Example 1 fails, we should go to Example 2.
  – Should we go to Example 2, are there better idea to keep the number of tubes 2?
- If the calculated heat is much larger than 200 W, we must make the gap wider to have more paraffin flow. (Otherwise, the IP chamber will be broken by mechanical or heat stress.)

流　路	a	b	c
2	0.5	23	16
(IN-OUT1系統)	1	24	17





注記
1. 外筒および内筒は、ｱﾙﾐ角棒からﾜｲﾔｰｶ
2. 部品単体で納入するものとします。



部品図 (S=1:4)

No	品　番	品　名	材質
8		ｽﾍﾟｰｻ	A5052
7		銅管	C1220
6		仕切り板	A5052
5		端板2	A5052
4		端板1	A5052
3		ﾏﾆﾎｰﾙﾄﾞ	A5052
2		内筒	A6063
1		外筒	A6063

発行年月日

SR simulation

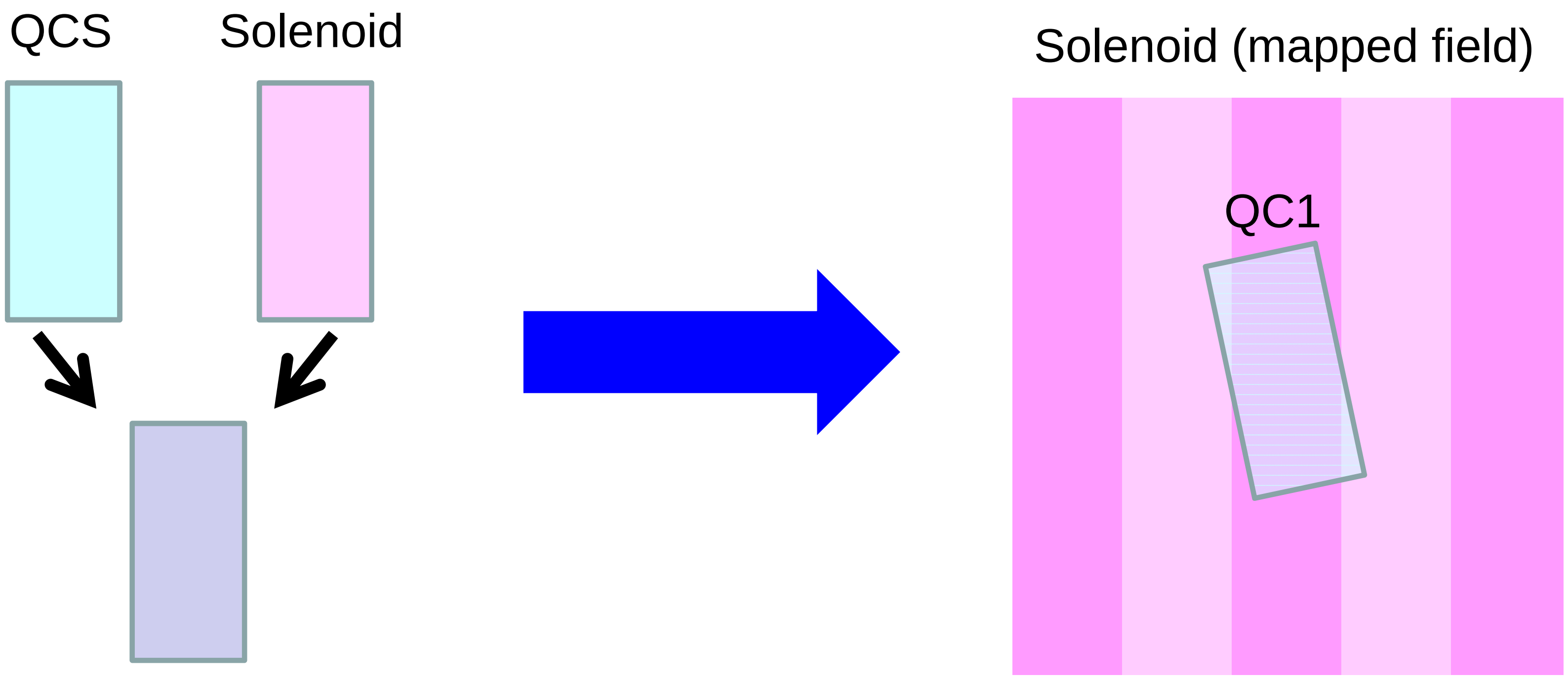
- Detector solenoid affect to produce the SR

  → We need to check this effect

- Current status

  Constructing the nano-beam option beam-line simulation

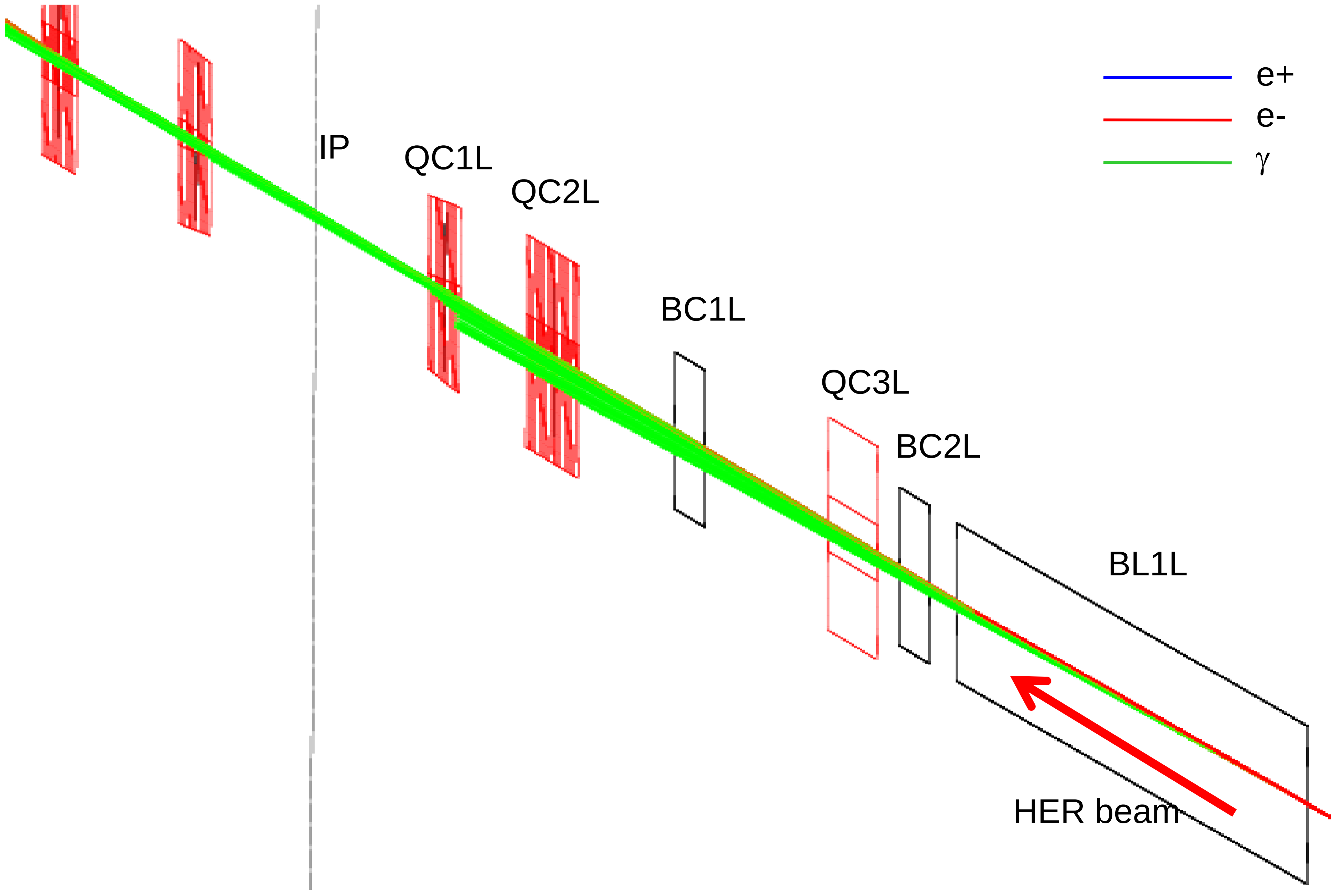
We modify our simulation to implement the solenoid field



At first we used the high-current option optics to check this modification.

→ We obtain the exactly same results from both two methods.

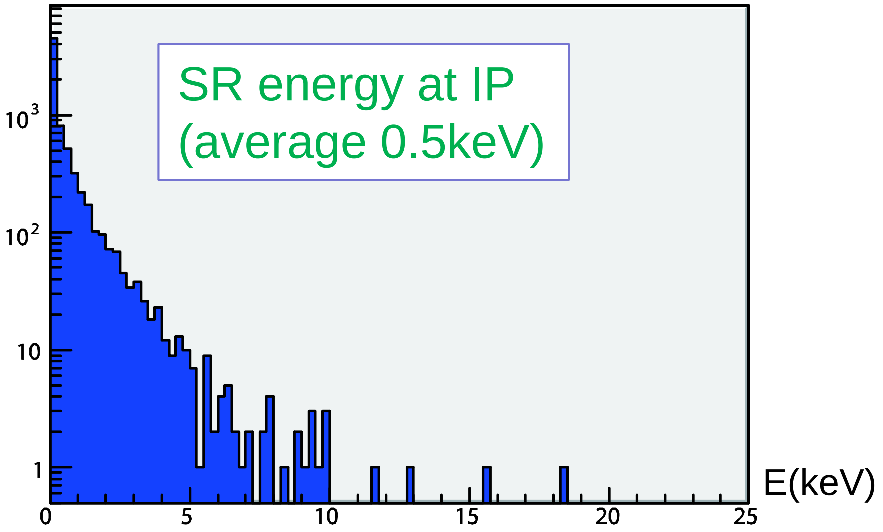
HER beam-line simulation

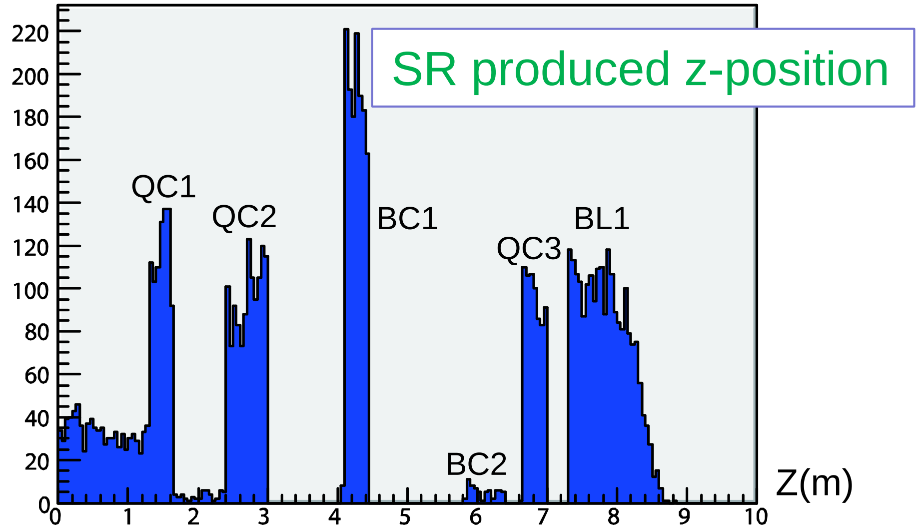


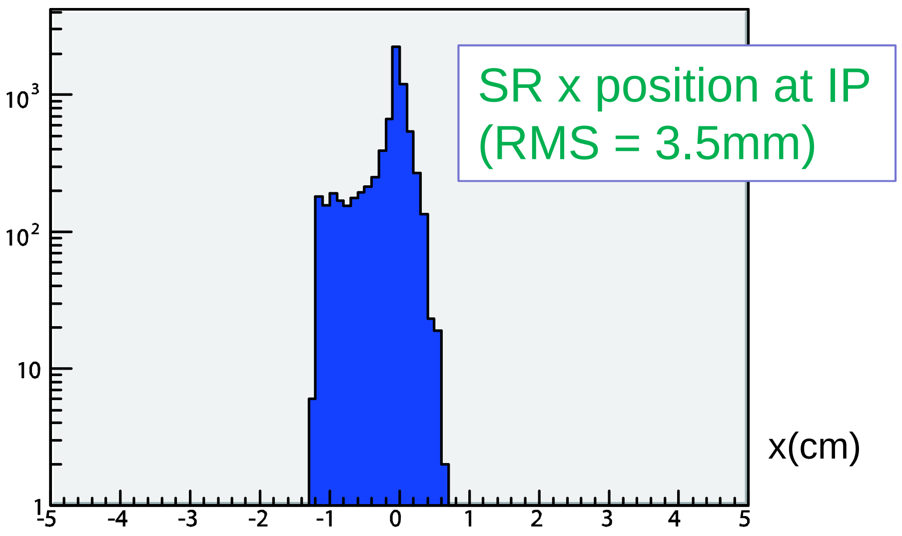
HER beam-line simulation

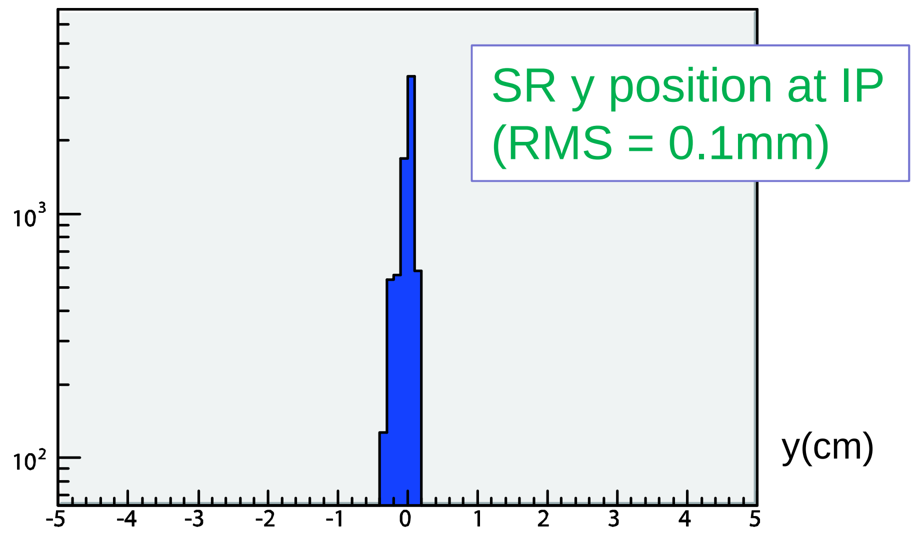
New optics without the QC1/QC2 steering magnets (herfqlc4051)

41.5 / 41.5 mrad







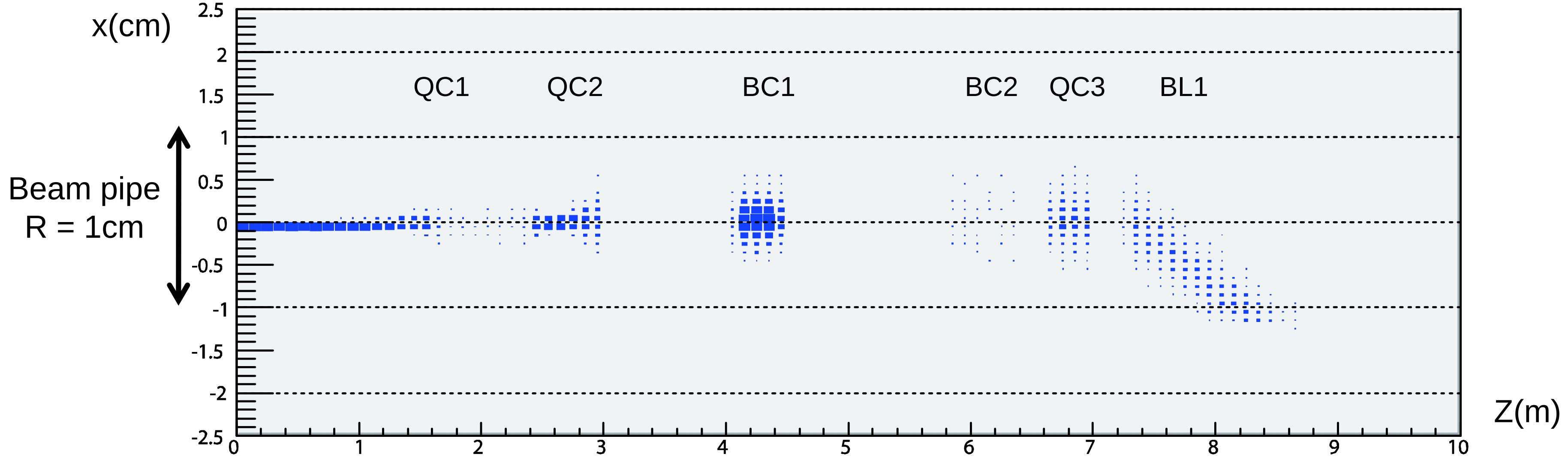


HER beam-line simulation

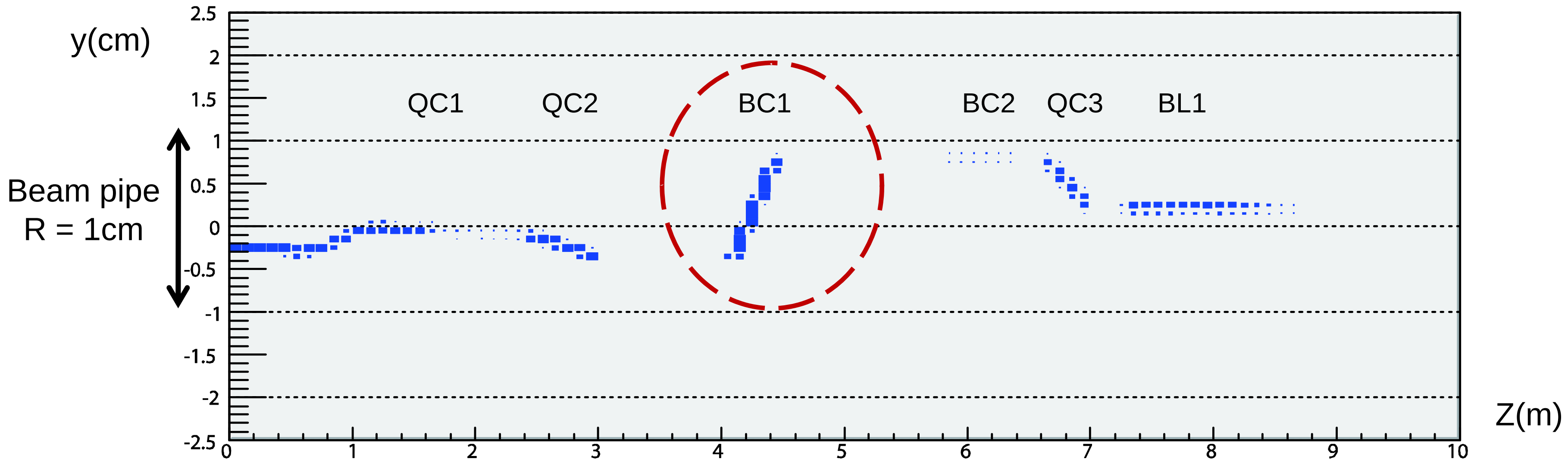
herfqlc4038

HER 67.45 / LER 15.55 mrad

X at IP vs produced z-position



Y at IP vs produced z-position

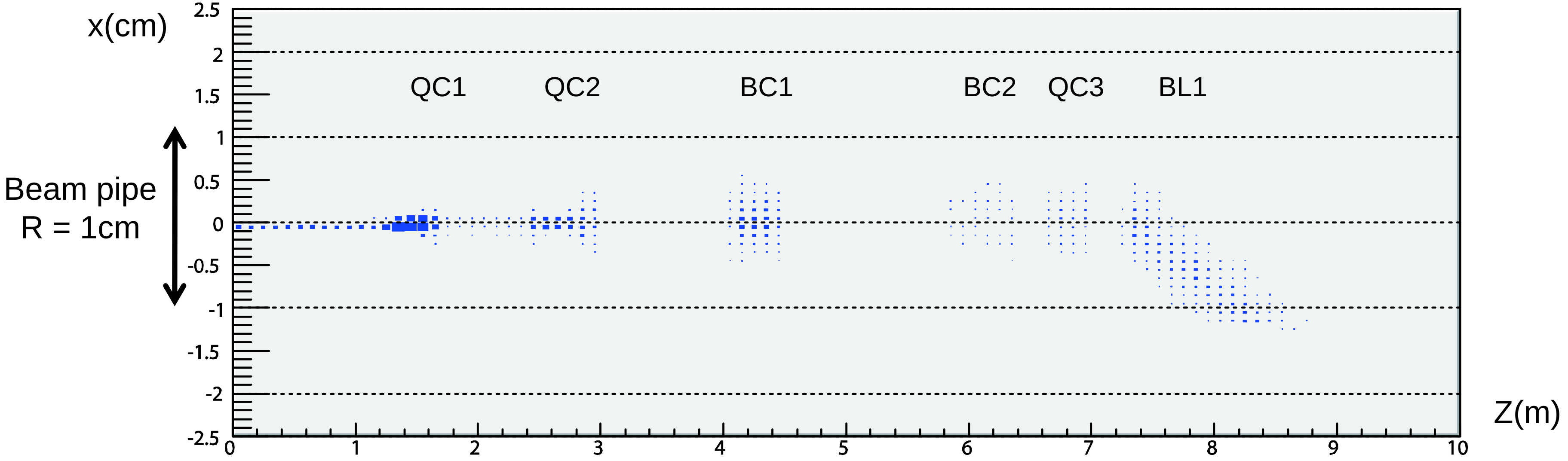


HER beam-line simulation

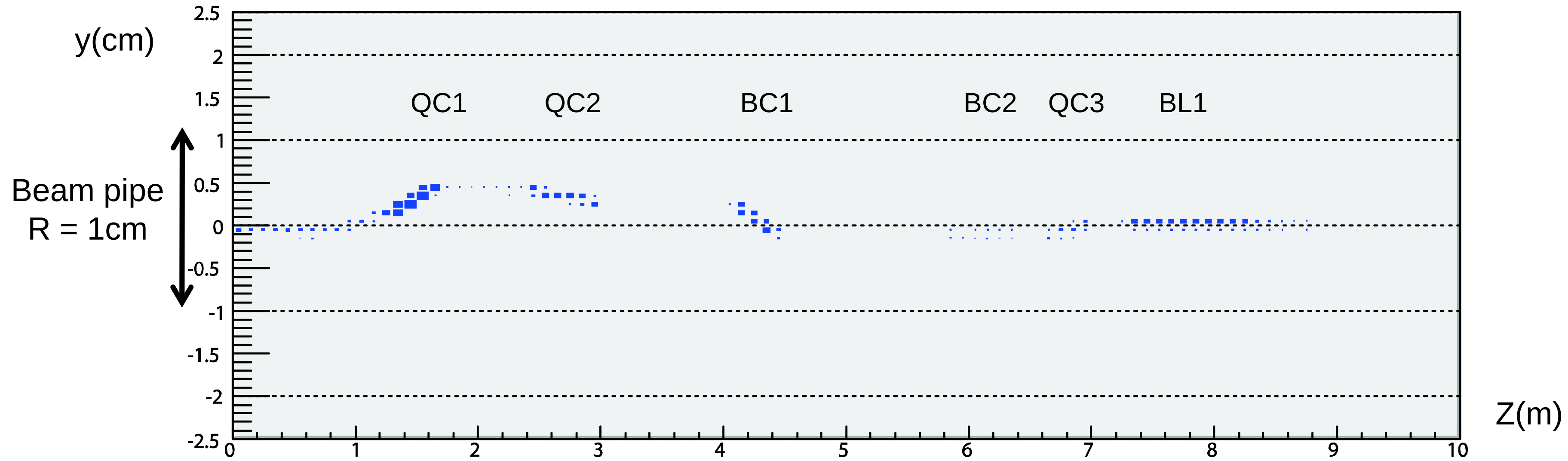
herfqlc4039

HER 52.82 / LER 30.18 mrad

X at IP vs produced z-position



Y at IP vs produced z-position

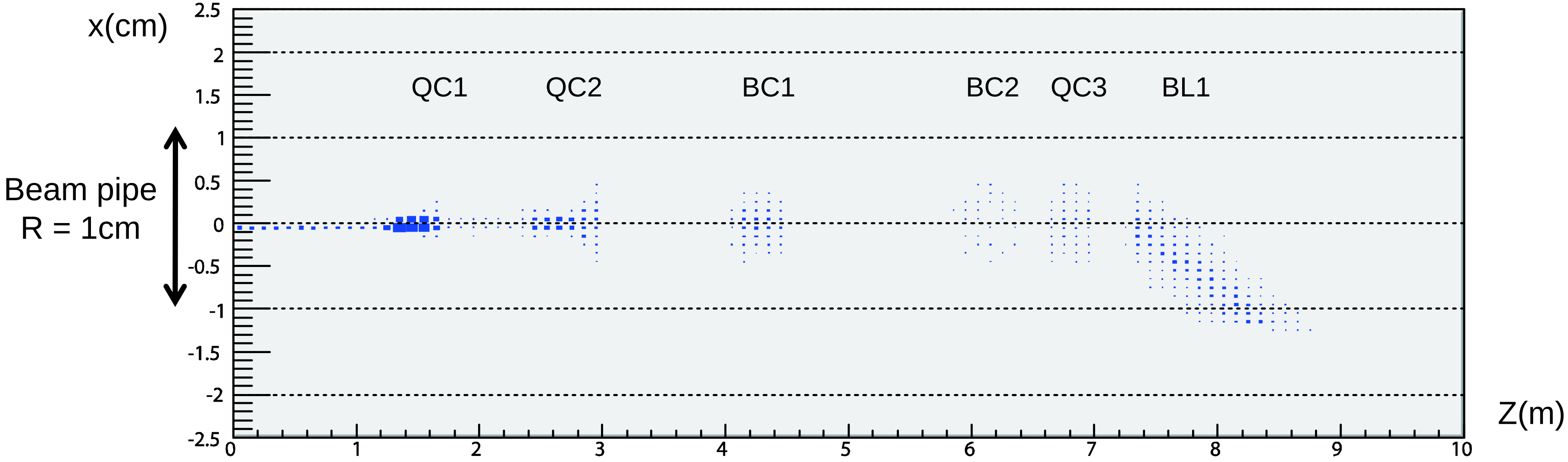


HER beam-line simulation

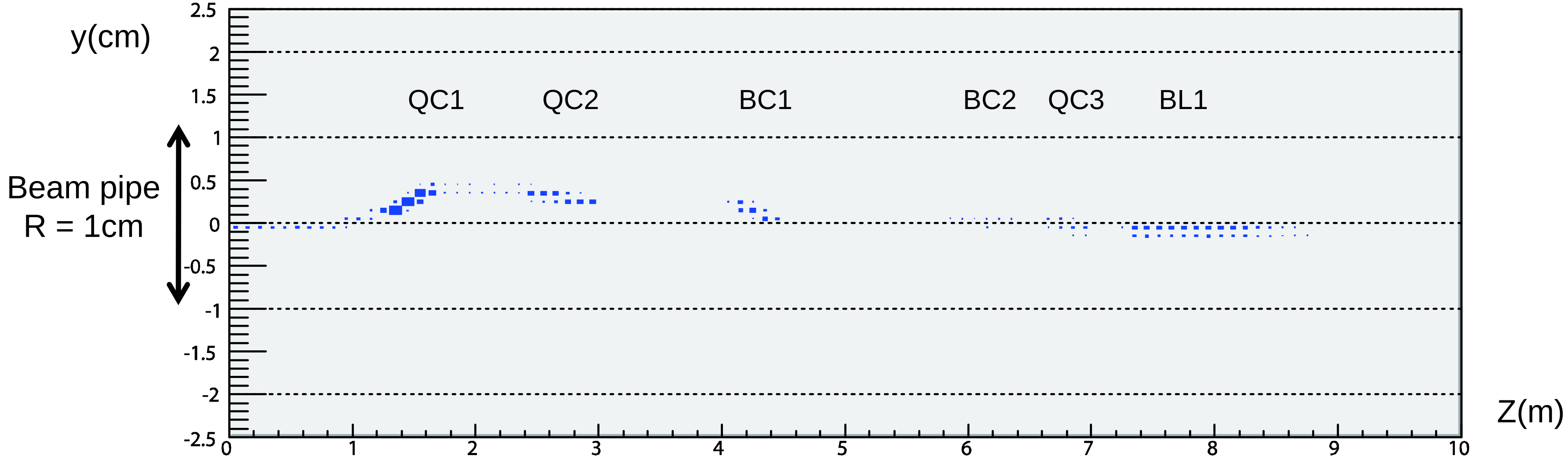
X at IP vs produced z-position

herfqlc4039

HER 41.5 / LER 41.5 mrad



Y at IP vs produced z-position



K.Kanazawa

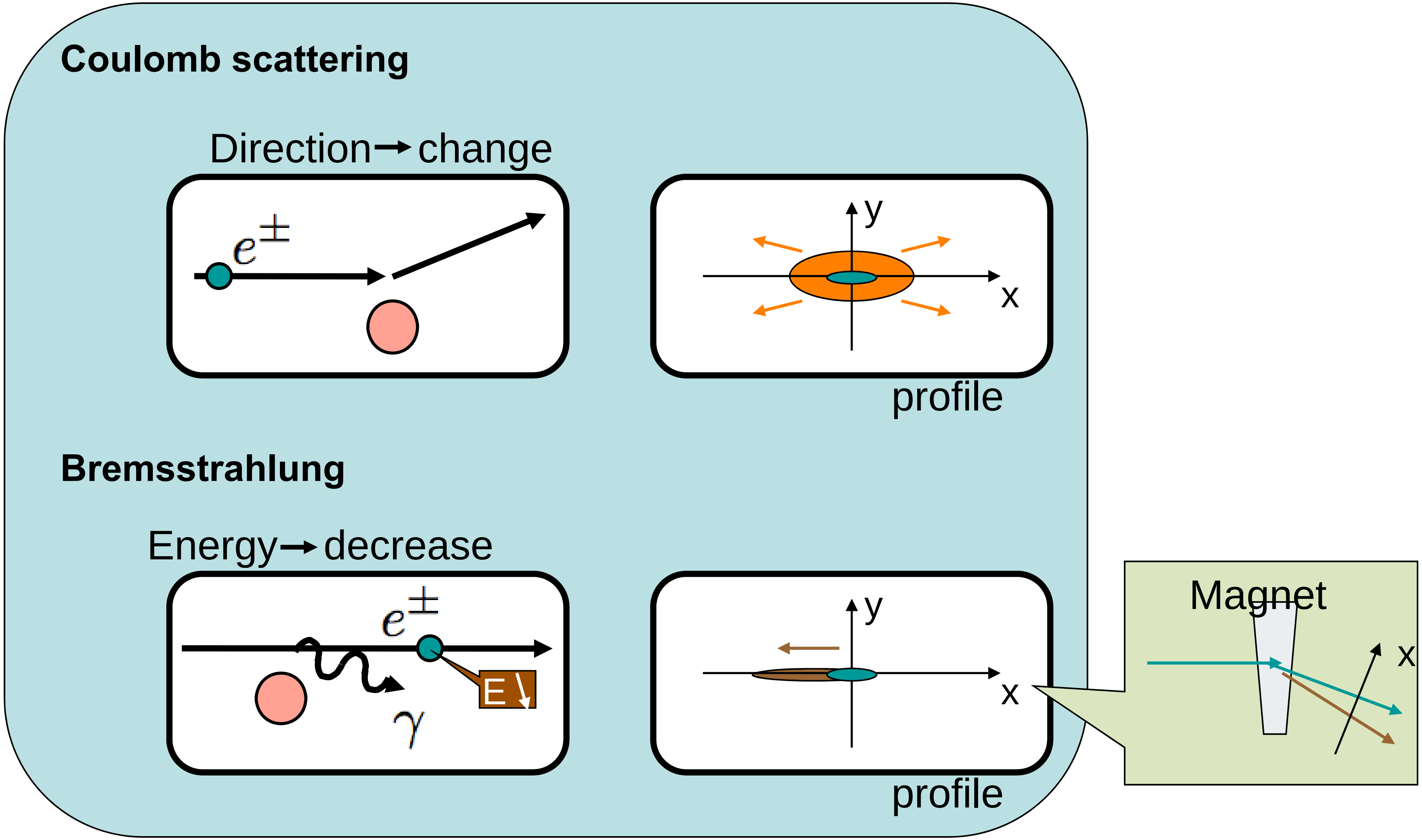
Pressure around IP-Summary

- Pressure within 2m from the IP is of the order of 10^{-5} Pa after 12 days of full current run.
- The final pressure will be around 10^{-6} Pa.
- The thermal desorption rate and the photo-desorption coefficient of a gold plated surface is not reported. (This perhaps means the gold surface has no superior vacuum property than other metals).

x10-100 higher vacuum pressure than current KEKB

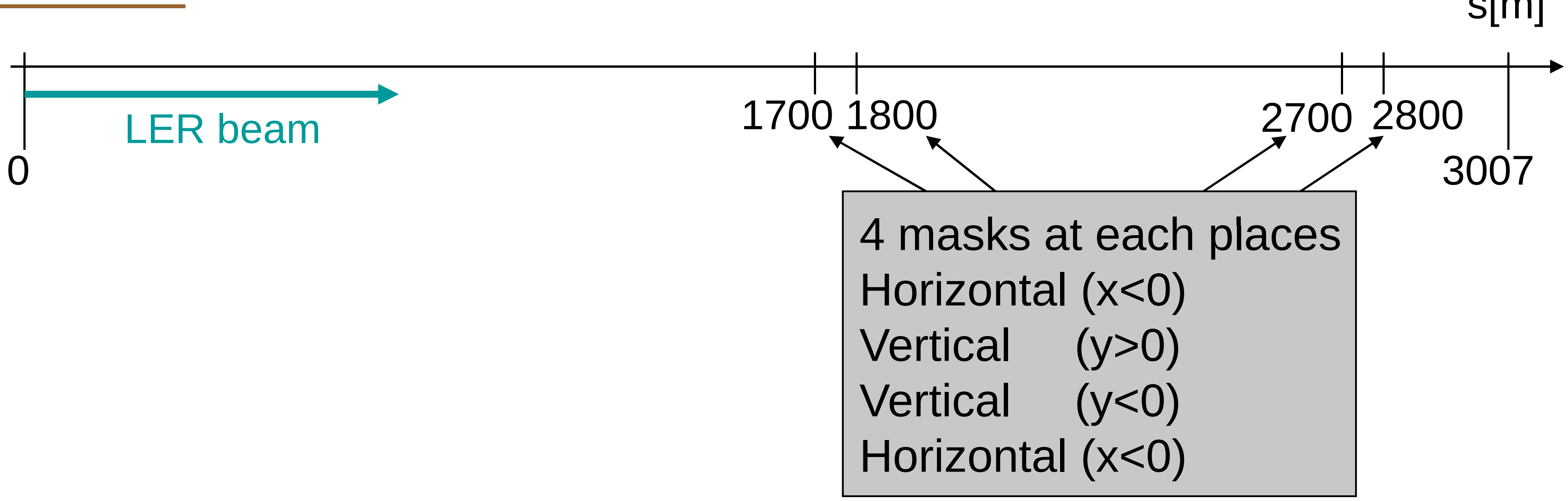
Beam-gas scattering

H.Nakano

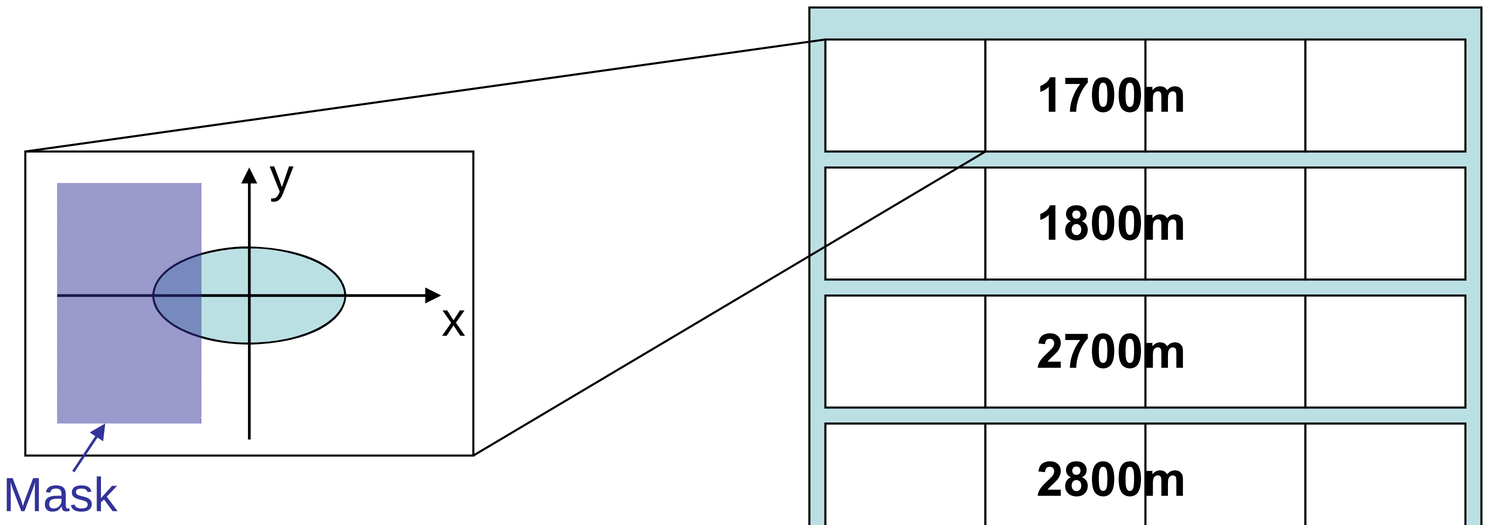


Masks

H.Nakano



Next pages: beam profiles at each masks

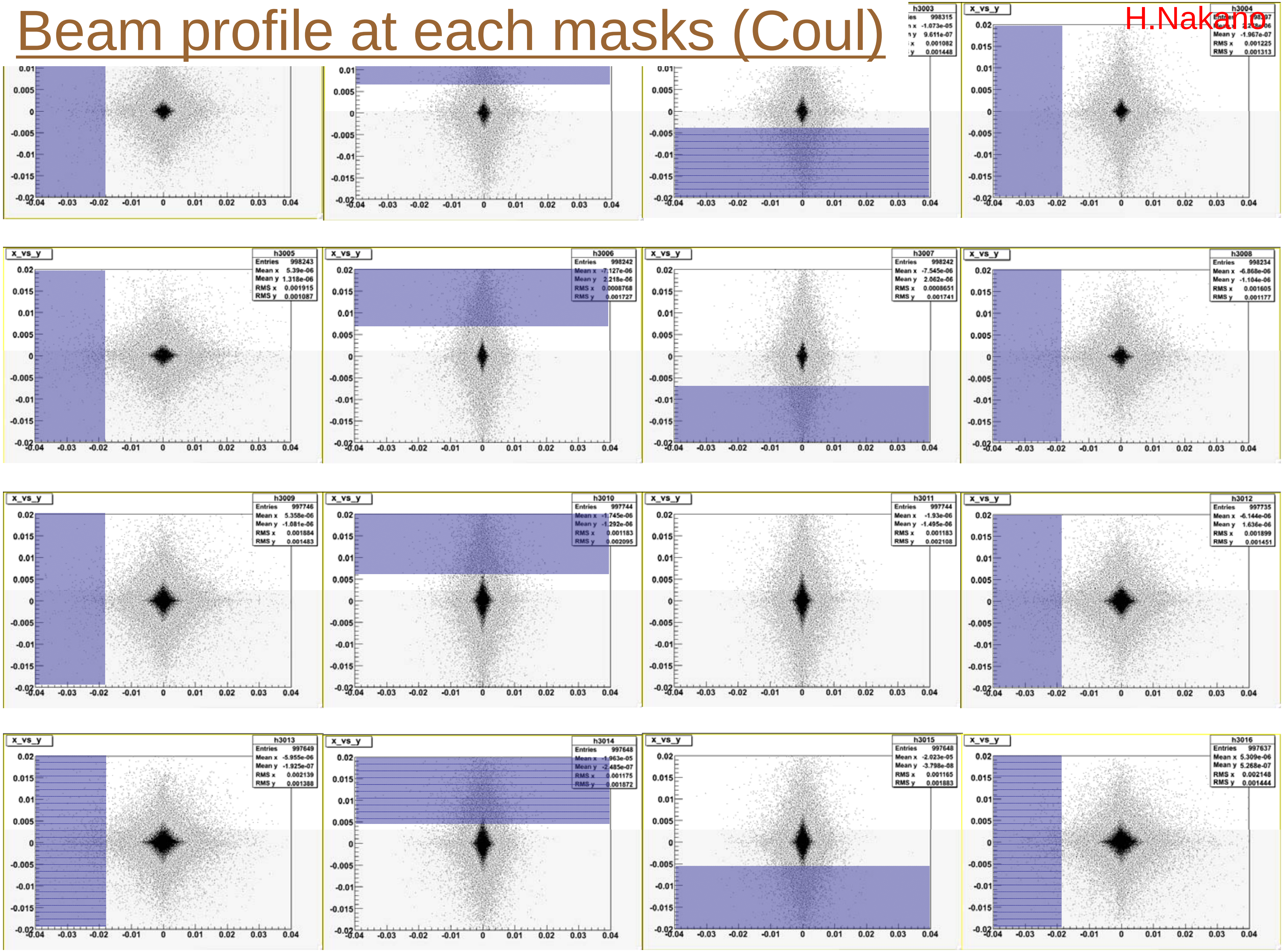


H.Nakano

Beam profile at each masks (without physics process)

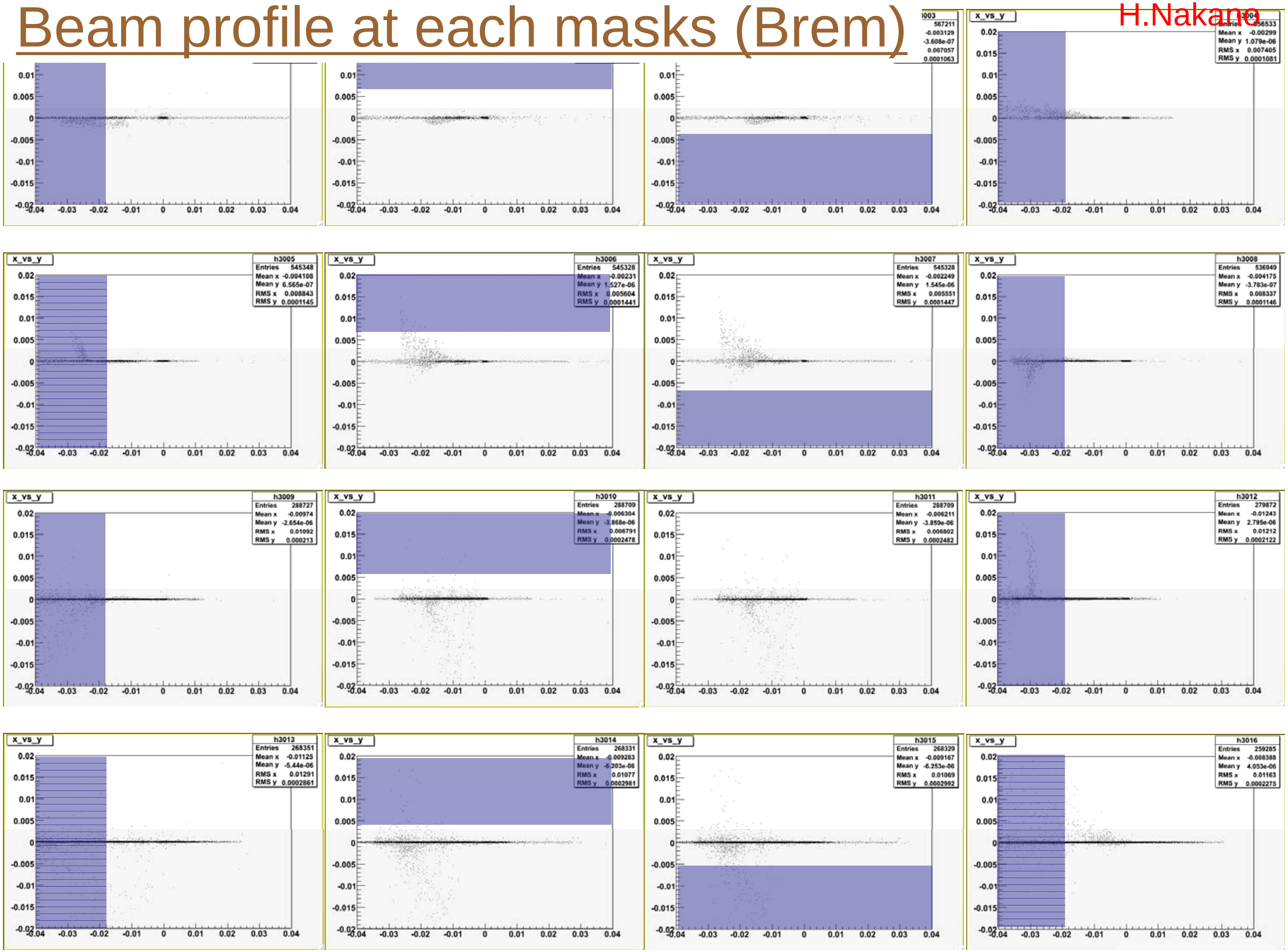
Beam profile at each masks (Coul)

H.Nakano



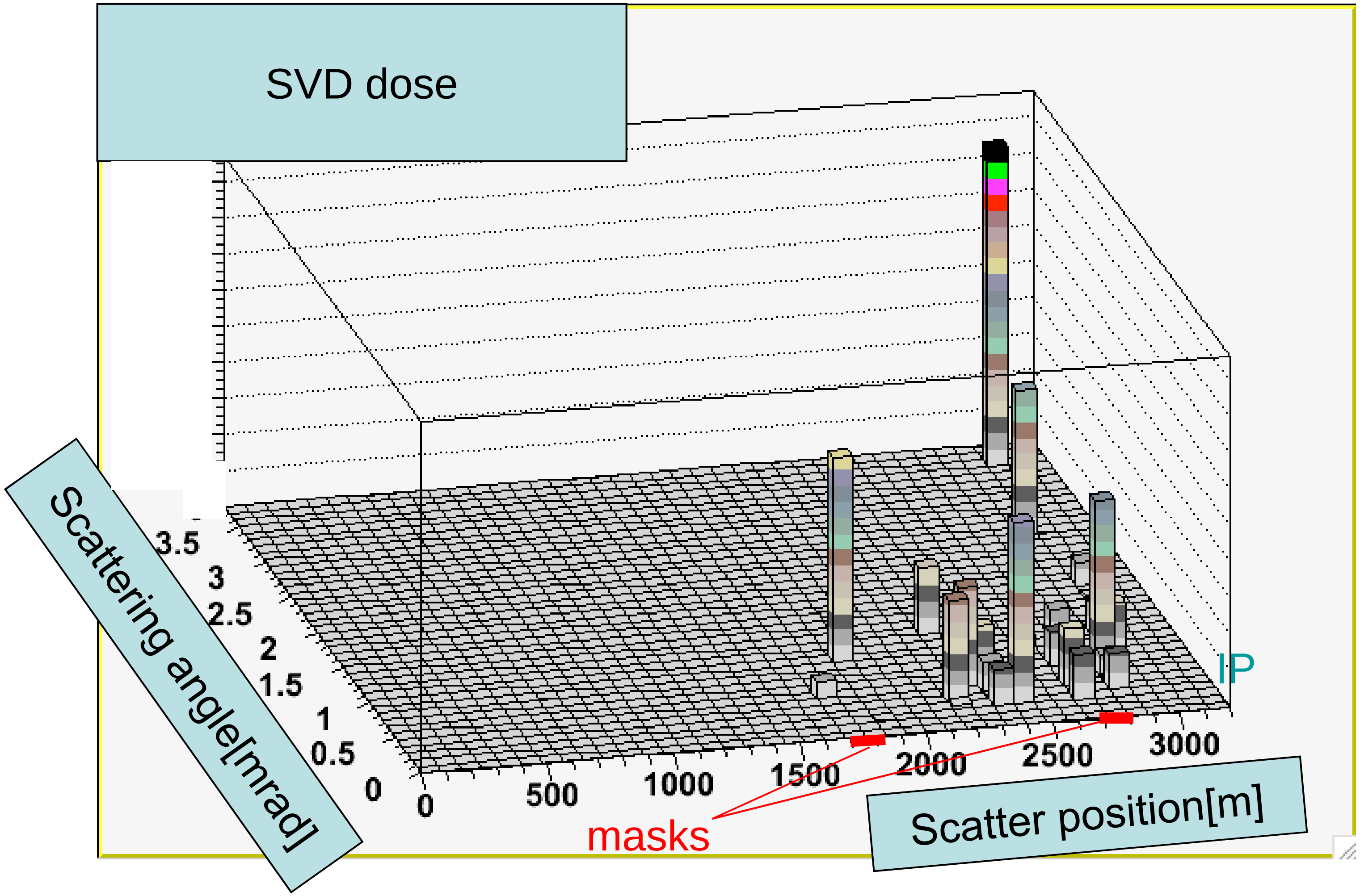
Beam profile at each masks (Brem)

H.Nakano



Scatter position and parameter (Coul)

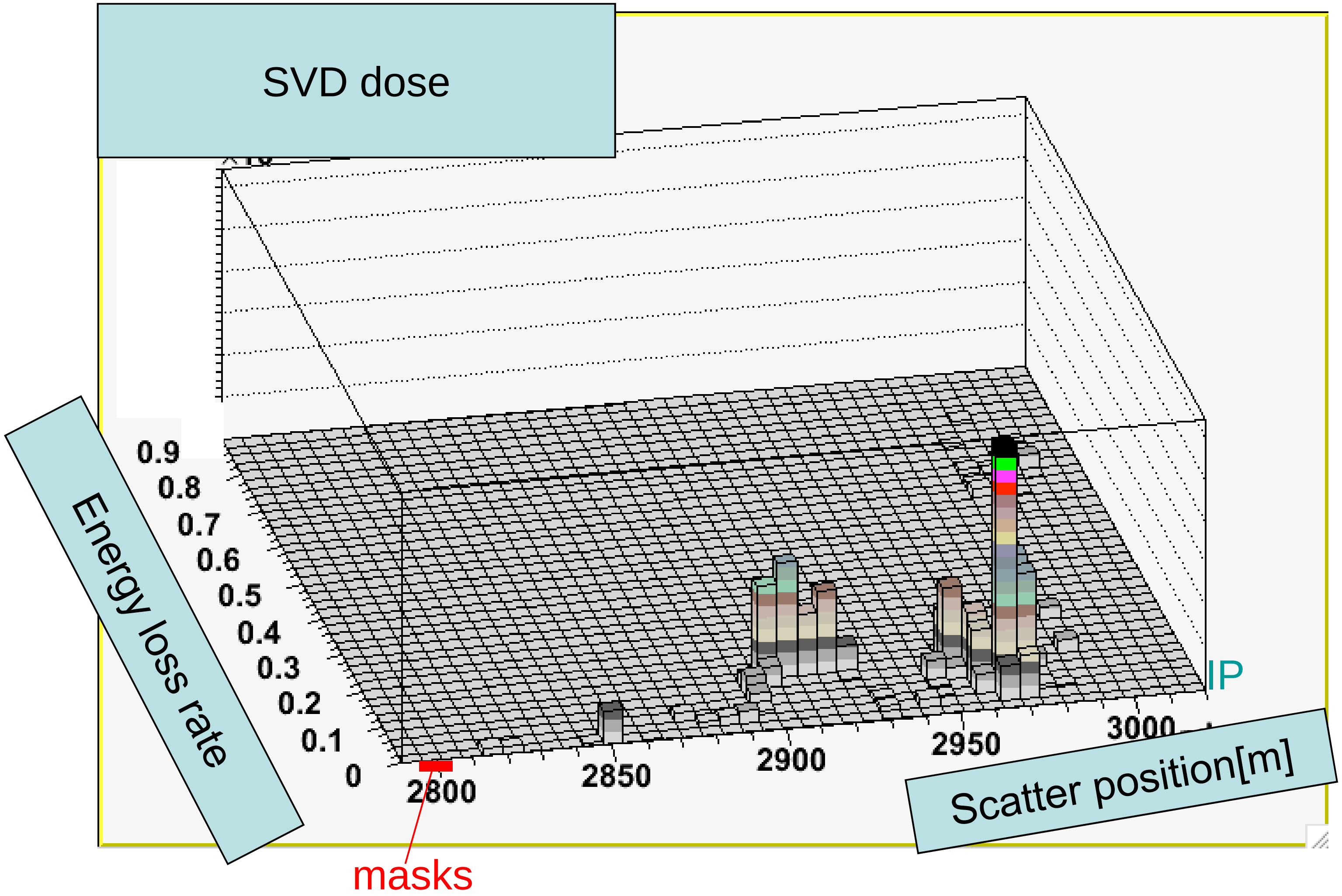
H.Nakano



The masks are working!

Scatter position and parameter (Brem)

H.Nakano



The masks are working!

まとめ、今後の予定

H.Nakano

「まとめ」
・Coulomb散乱、bremsstrahlungともに
可動マスクによって止められている。

・SVDに当たるものは可動マスク以降で
散乱されたものである。

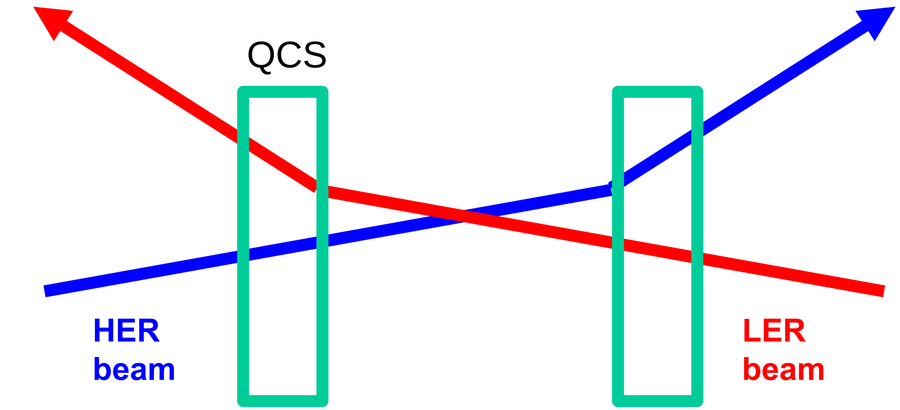
「予定」
・TouschekのBG量を見積もる。

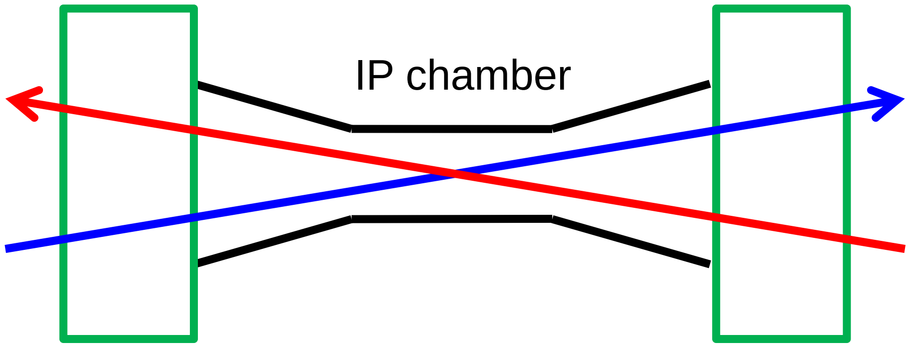
・実際のdose量、occupancyと比較し、
シミュレーションの妥当性を確認する。

Final Q layout & IP chamber

KEKB

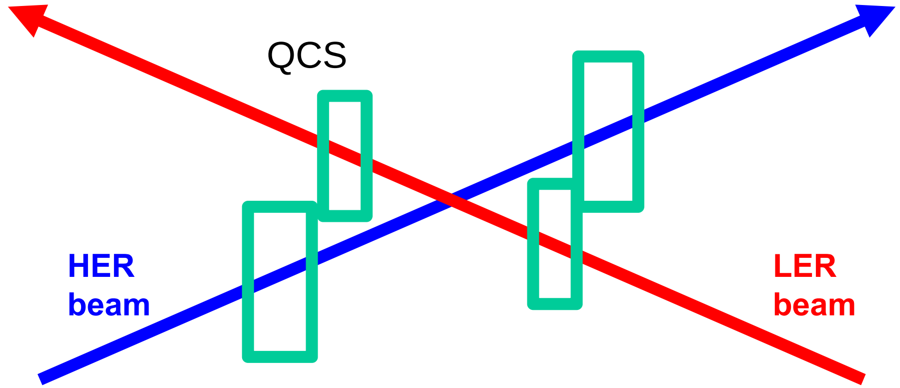
Common QCS for 2 beams

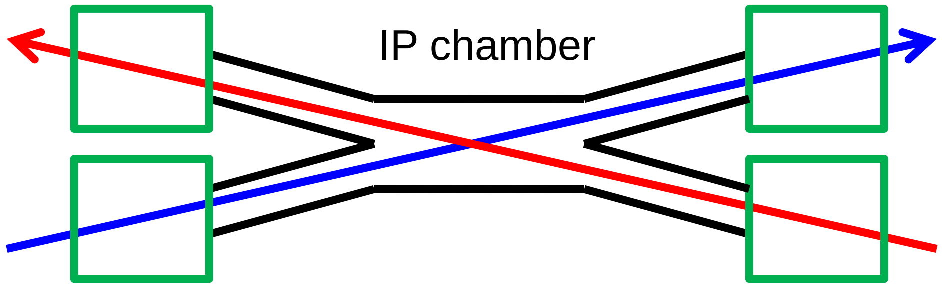




SuperKEKB Nano-beam option

Two-separate Q-magnets for each 2 beams

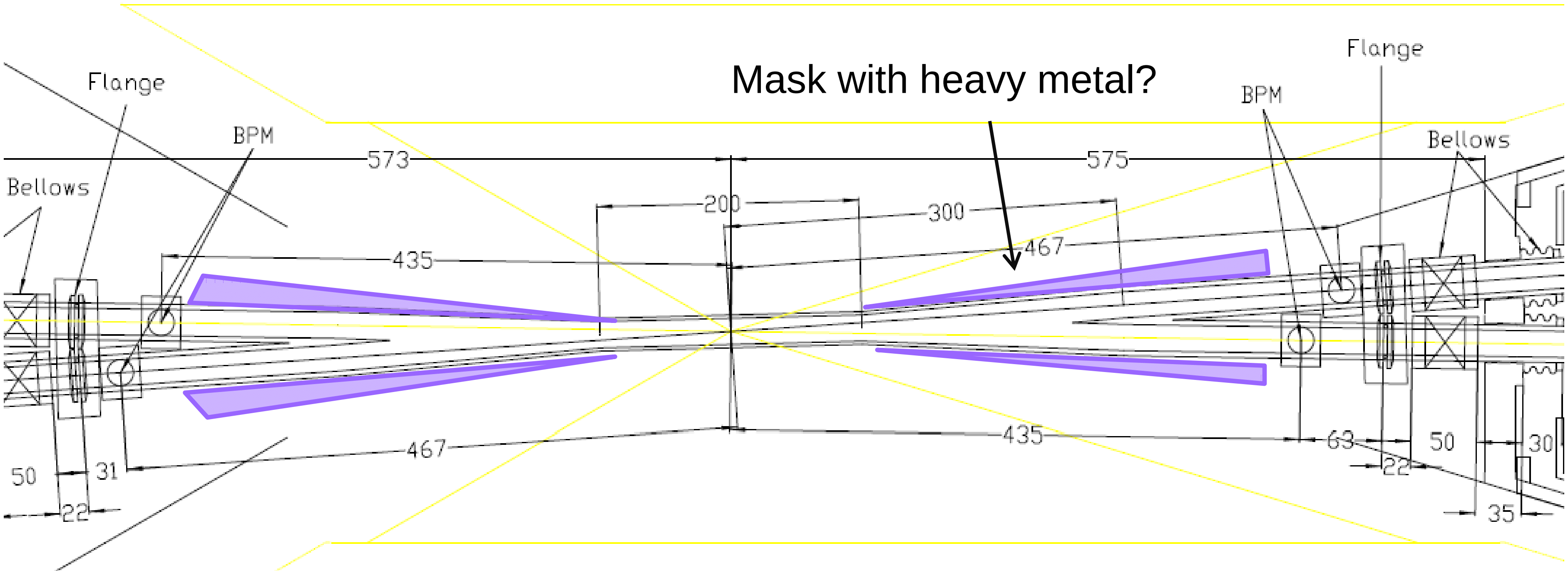




To connect with the separate Q magnets
the IP chamber has branch structures
(crotch structures)

→ Kanazawa-san’s talk

Belle-II IP chamber deign (2009,Aug)



- Size / shape : preliminary
- Assume 1cm radius to Be straight part beam pipe

→ We need to think about the support of the heavy metal masks (~20kg in one side)

They should be supported by SVD and CDC (otherwise, 1cm radius Be pipe will be broken)

From KEKB to Super-KEKB
Strategies for Increasing Luminosity

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

Lorentz factor

Beam current

Beam-beam parameter

Lumi. reduction factor (crossing angle)&
Tune shift reduction factor (hour glass effect)
0.8 ~ 1
(short bunch)

Classical electron radius

Beam size ratio@IP
1 ~ 2 % (flat beam)

Vertical beta function@IP

High-Current Option

(1) Smaller β_y^*

(2) Increase beam currents

(3) Increase ξ_y

Nano-Beam Option

Two machine parameter options

*Currently 2 machine options are considered: **High-current** and **Nano-beam***

	High current option (LER/HER)	Nano-beam option (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 - QCS magnets 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**

High-current option … Higher SR BG / HOM heating
Nano-beam option … IR assembly is difficult

Design Options

Comparison of parameters

	KEKB Design	KEKB Achieved (): with crab	SuperKEKB High-Current Option	SuperKEKB Nano-Beam Option
β_y^* (mm)(LER/HER)	10/10	6.5/5.9 (5.9/5.9)	3/6	0.22/0.22
ε_x (nm)	18/18	18(15)/24	24/18	1/1
σ_y(μm)	1.9	1.1	0.85/0.73	0.034/0.044
ξ_y	0.052	0.108/0.056 (0.101/0.096)	0.3/0.51	0.07/0.07
σ_z (mm)	4	~ 7	5(LER)/3(HER)	6
I_{beam} (A)	2.6/1.1	1.8/1.45 (1.62/0.95)	9.4/4.1	2.96/1.70
$N_{bunches}$	5000	~1500	5000	2500
Luminosity (10^{34} cm^{-2} s^{-1})	1	1.76 (1.68)	53	80

High Current Option includes crab crossing and travelling focus.
Nano-Beam Option does not include crab waist.