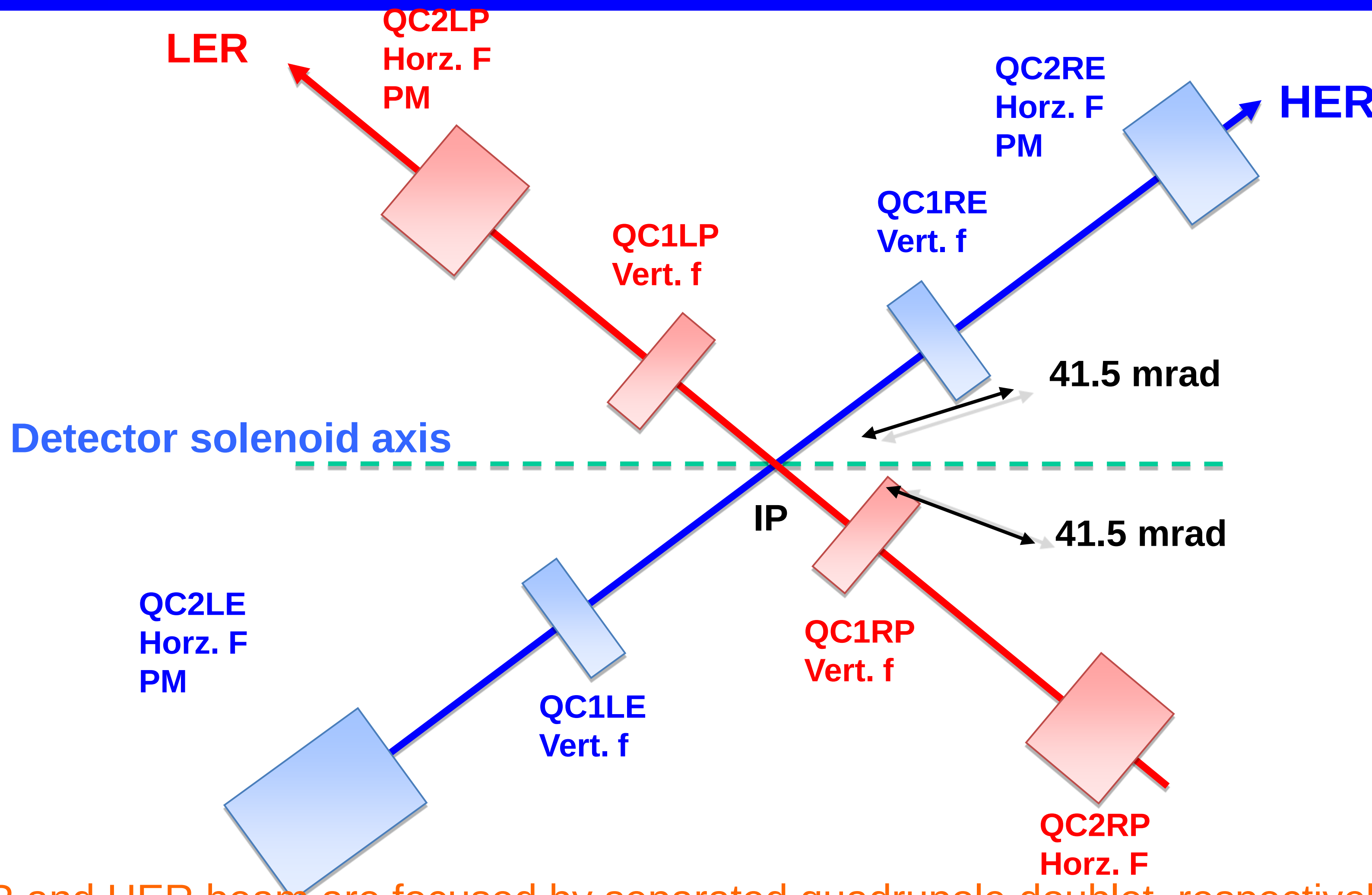
Belle II IR design

Shuji Tanaka
KEK
Joint Belle II & superB Background meeting
2012//Feb/8-9th

Requested to discuss about IR

- **IR magnets**
  - **magnetic filed calculation, canceling coils,canceling solenoid, leak filed, fabrication status,cryostat (Ohuchi-san'talk)**
- **IR mechanical design**
  - **beam pipe design, fabrication process, cooling, heavy metal shield,installation procedure, assembly, cabling space),**
  - **Movable collimator(shape, material, instability, impedance, secondary particles)**
  - **Vertex detectors**
  - **Beast II(Belle II commissioning)**

SuperKEKBIR magnet design



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

Belle rotation is decided to satisfy above setting

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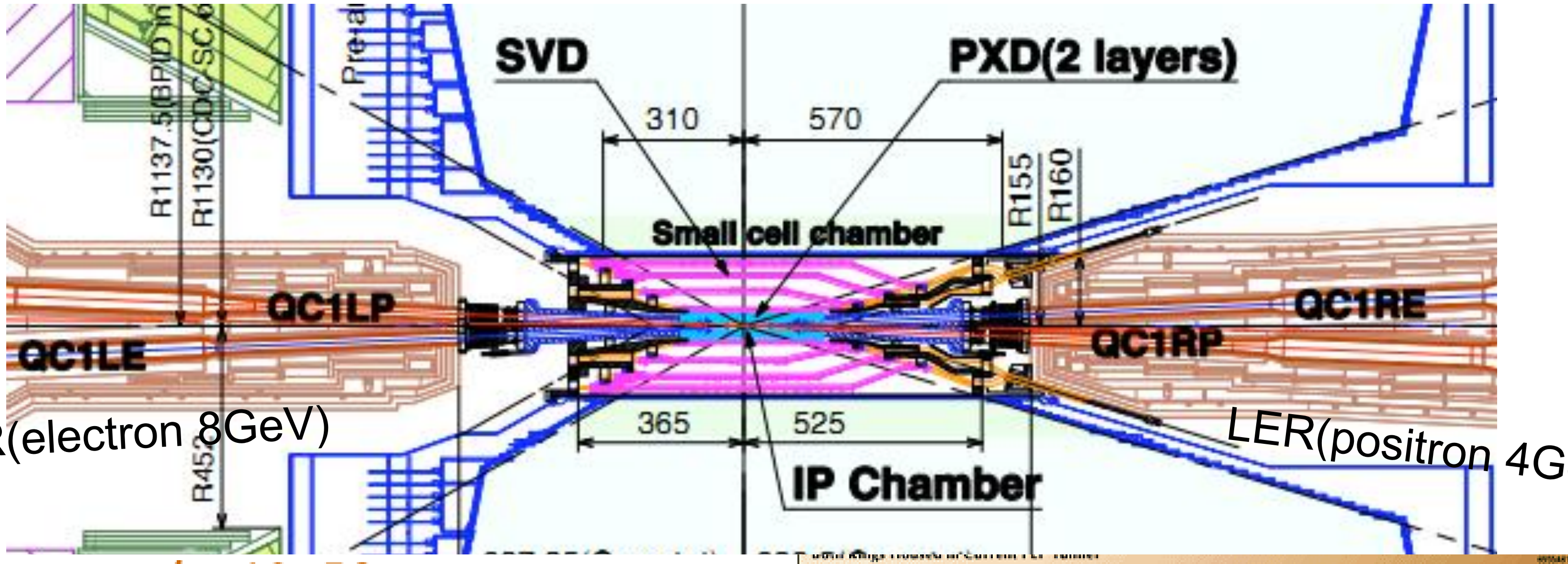
Detector setup around IP



$\sqrt{s}$=10.58 GeV

$e^+ \rightarrow$ Υ(4s) $\leftarrow e^-$

Υ(4s) → B, $\overline{B}$ $\Delta z \sim c\beta\gamma\tau_B \sim 200\mu m$

BaBar	$p(e^-)$=9 GeV	$p(e^+)$=3.1 GeV	$\beta\gamma$=0.56
Belle	$p(e^-)$=8 GeV	$p(e^+)$=3.5 GeV	$\beta\gamma$=0.42
Belle II	$p(e^-)$=7 GeV	$p(e^+)$=4 GeV	$\beta\gamma$=0.28

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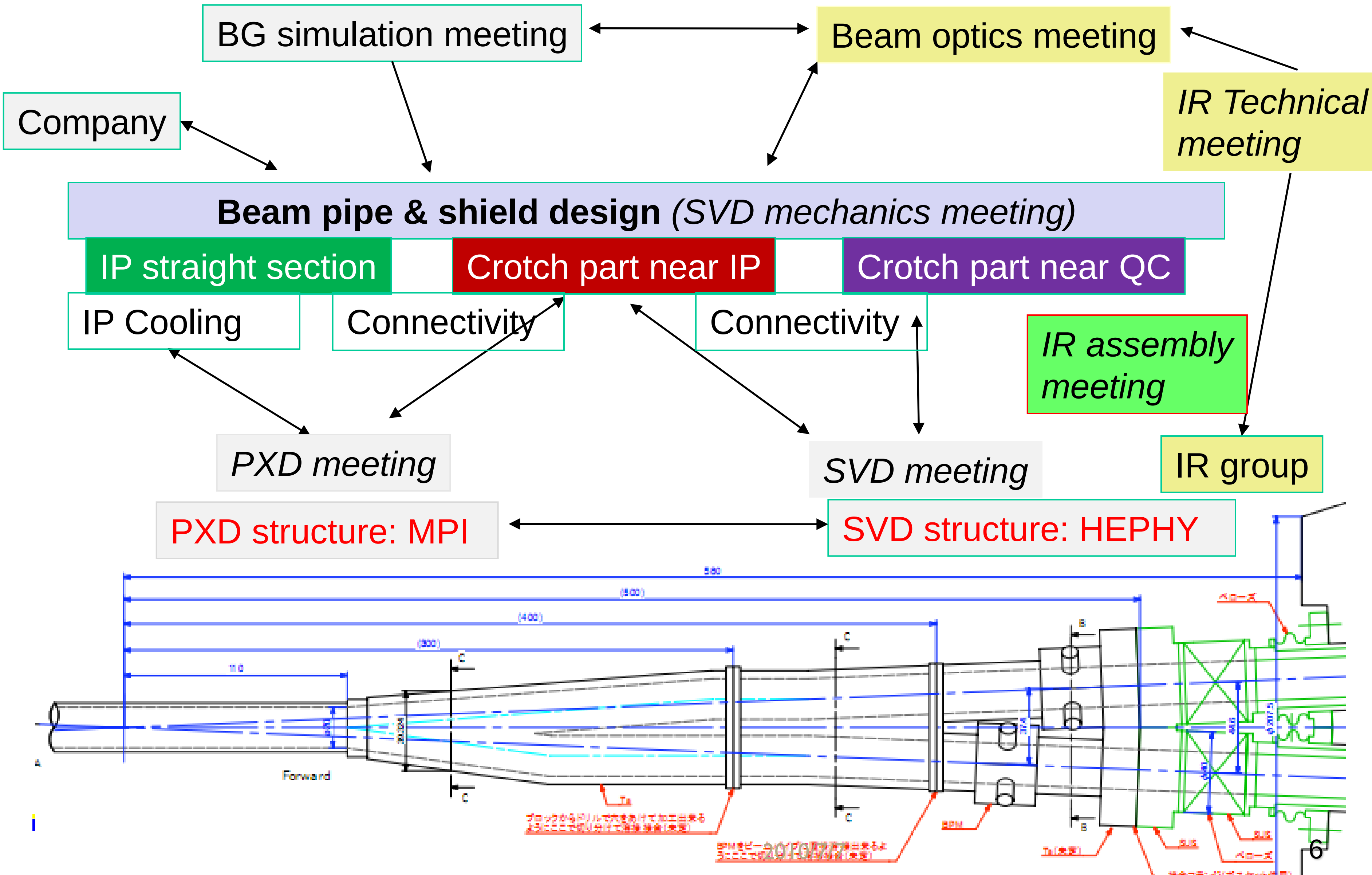
Beam Pipe at IP

Interaction Region Correlation



How to optimize the IR mechanics design?

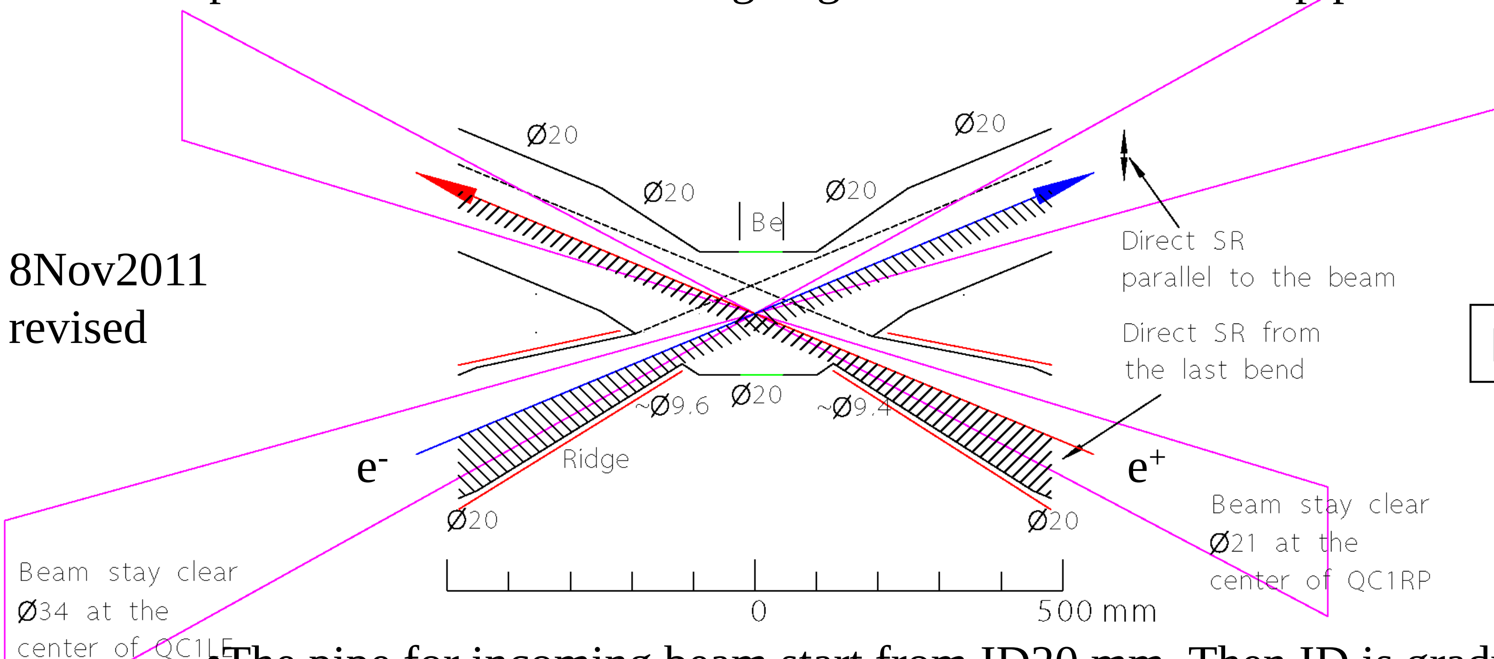
Subpart		Requirement to optimize
IP chamber	Be part	lowest atomic number metal
	Ti part	coefficient of linear thermal expansion difference with Be (similar number is better)
	Au coating	Protect SR into VXD from final focus magnet
Crotch part	Material (Tantalum)	Cost, heavy material as shield , experience using as vacuum chamber, BG simulation
	Outer shape	Production procedure, Space requirement from PXD,SVD
	Inner shape	Beam optics, SR shielding, HOM power
	Au coating (QCS region)	To achieving more better vacuum level by avoiding oxygen emitting by SR hits
Shield	Heavy metal shield	Cost, upper limit from CDC weight request, BG simulation, Space request from PXD, SVD

IP Chamber Design Features

•Minimize the creation and the trap of HOM.

•The central part and the branch for out going beam constitute a bent pipe of ID20mm.

8Nov2011
revised

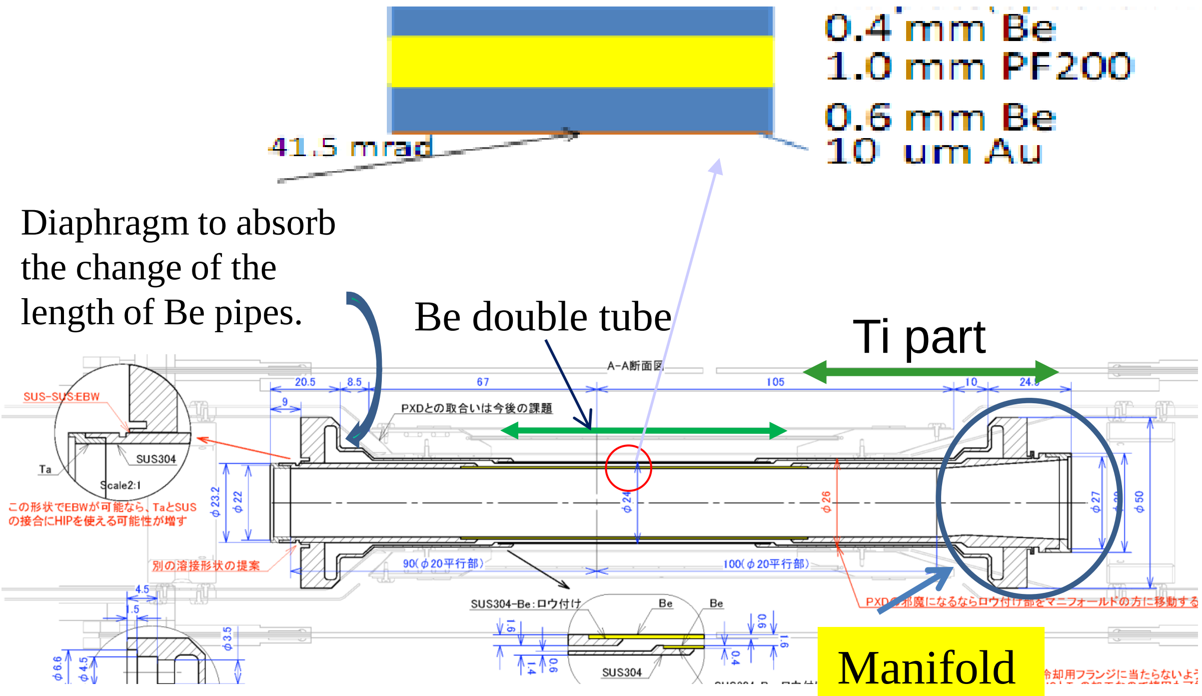


Kanazawa

•The pipe for incoming beam start from ID20 mm. Then ID is gradually reduced to about 9 mm to stop direct SR.

•The inner surface of a pipe for incoming beam has ridges to prevent scattered light from hitting the central part.

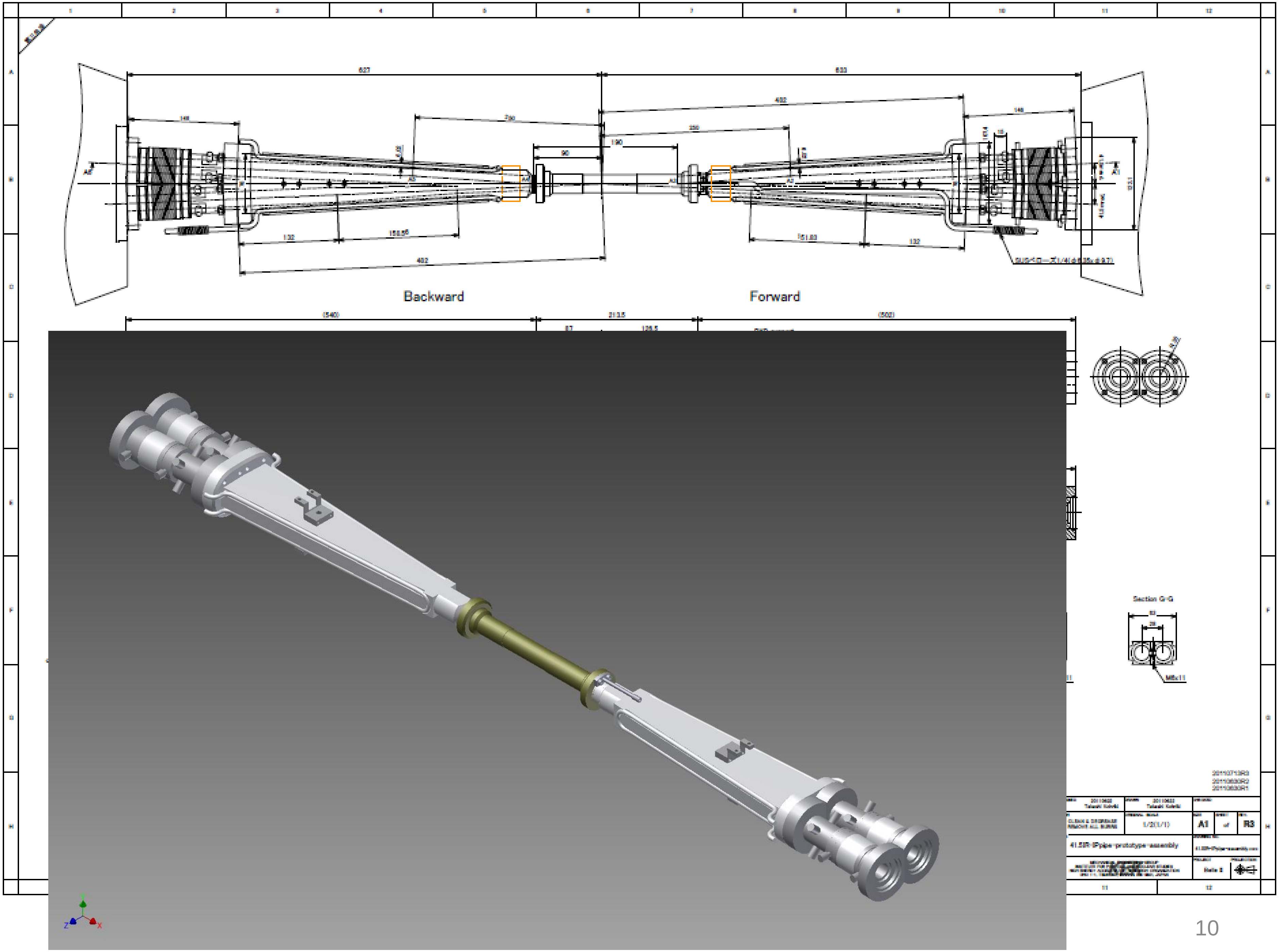
IP Chamber design



(Kohriki)

- The central part of the central part is a Be double tube. The gap is a space for a coolant.
- The coolant is paraffin. The flow of paraffin can absorb a heat of ~270W for a temperature rise of 10℃. (Estimated heat load from the beam is less than 100W.)
- In this design, it is permitted to put a weld seam between paraffin and vacuum.
- At first, the manifolds at the end of a Be pipe is designed to be made of stainless steel. The material is changed to Ti according to the result of stress analysis.

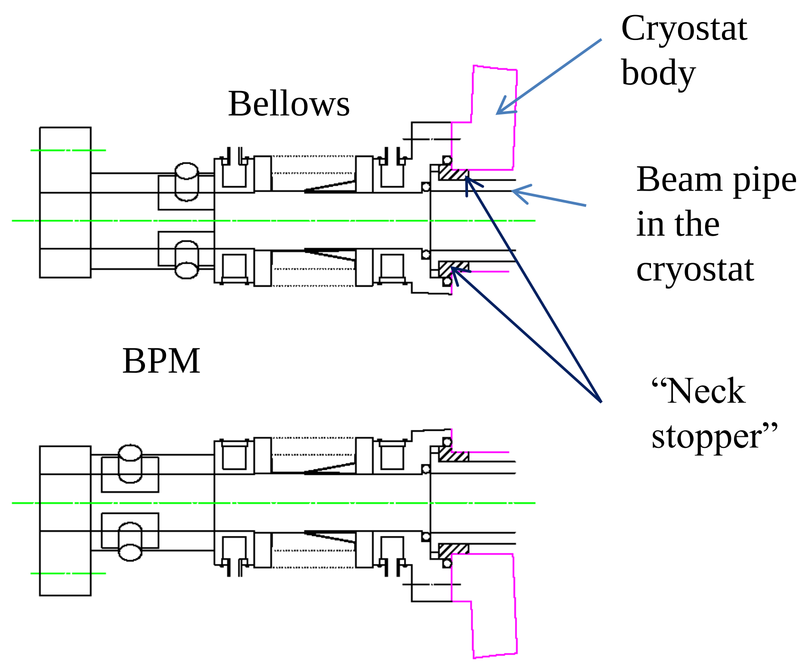
Mock-up model for cooling test


Backward
Forward
Section G-G

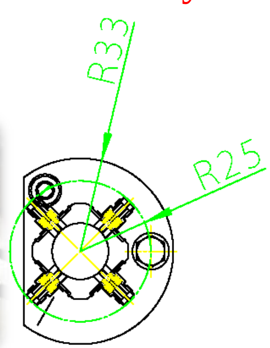
Connection to the QCS Cryostat

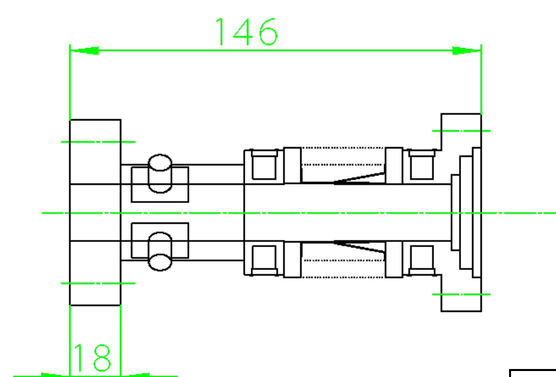
- IP chamber and the cryostat is connected with bellows chamber to absorb a possible motion of the cryostat after exciting magnetic fields.
- The bellows has a finger type rf-bridge to ensure flexibility.
- The bellows is water-cooled on both ends.
- The bellows and BPM is integrated into a short pipe. This makes it easy to replace them.
- The position of bellows is fixed to IP chamber.

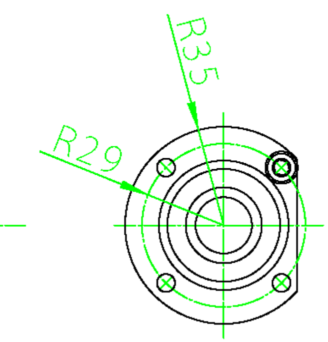
The sealing mechanism on both ends of the pipe is designed using reduced number of screws. A model test of the sealing mechanism was successfully done.



(Photo by Tanaka)







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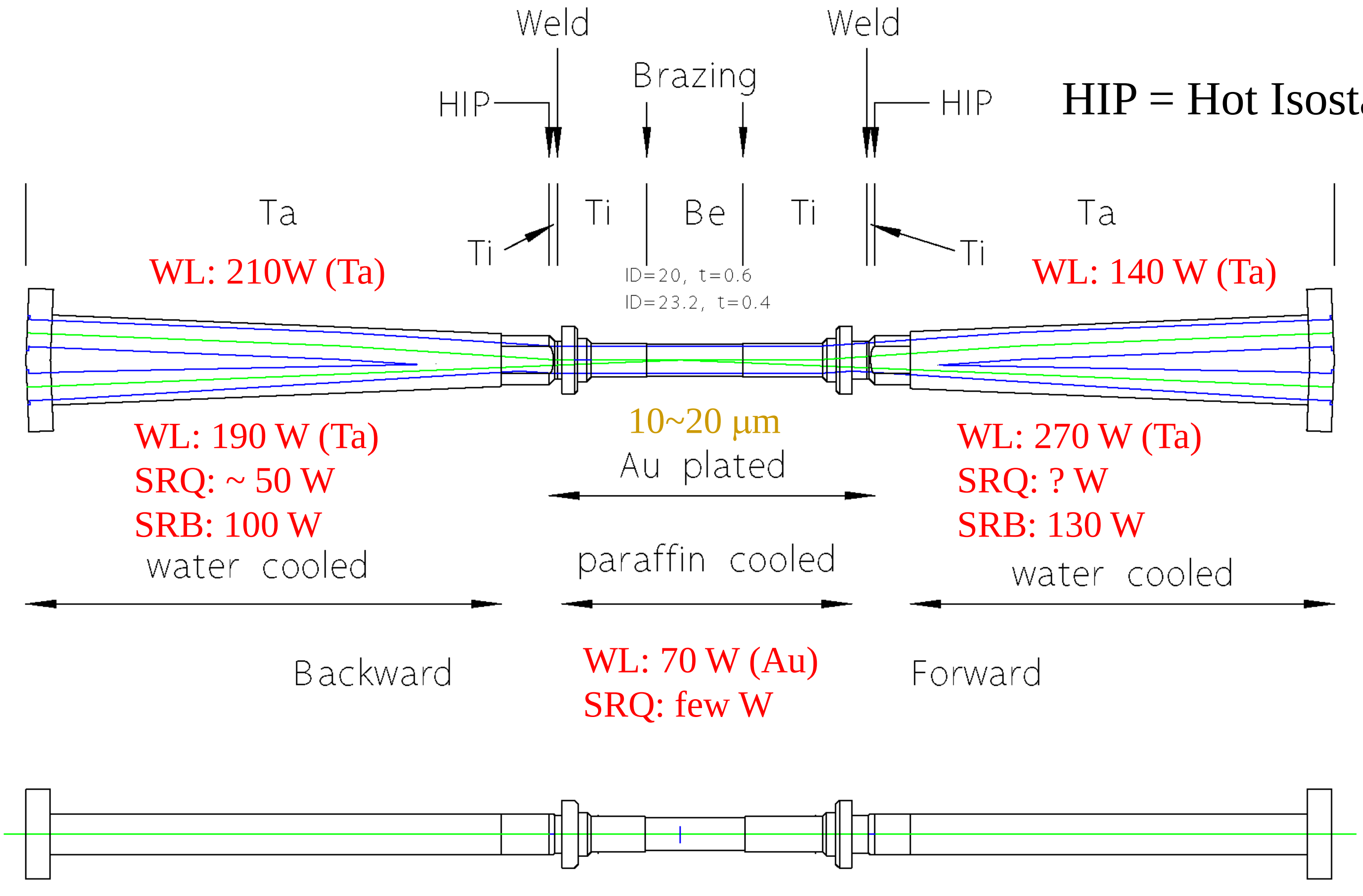
IP Chamber Fabrication

HIP = Hot Isostatic Pressing



- A test for Be-Ti brazing and Ti-Ta HIP is now undergoing.
- They are not special technologies.
- Ti is adopted instead of stainless steel to reduce the stress

Kanazawa

Shielding and how to reduce each BG effect for sub-detector

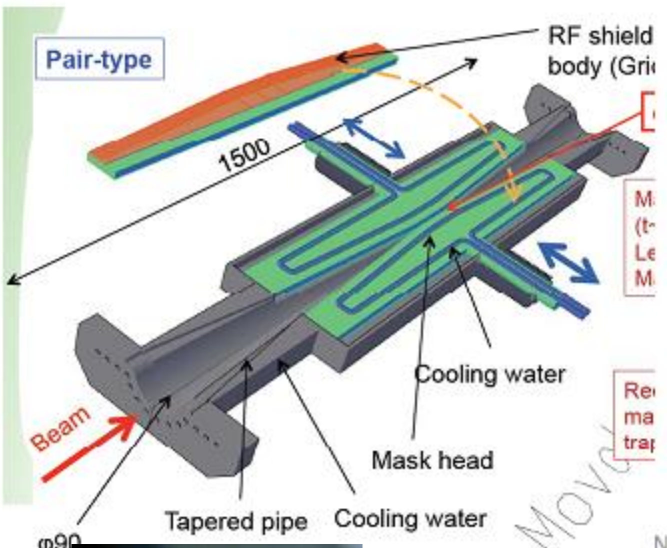
Background shielding

Collimators in the ring

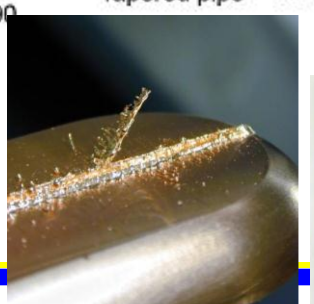
- Horizontal collimation from both inner/outer sides
- Stop off-momentum e+/e- before reaching interaction region

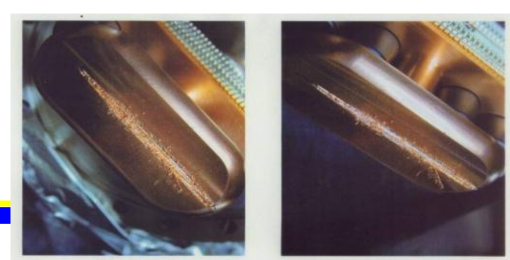
Heavy-metal shield

- Placed outside IR beam pipe
- Protect inner detector from EM shower created by loss particle

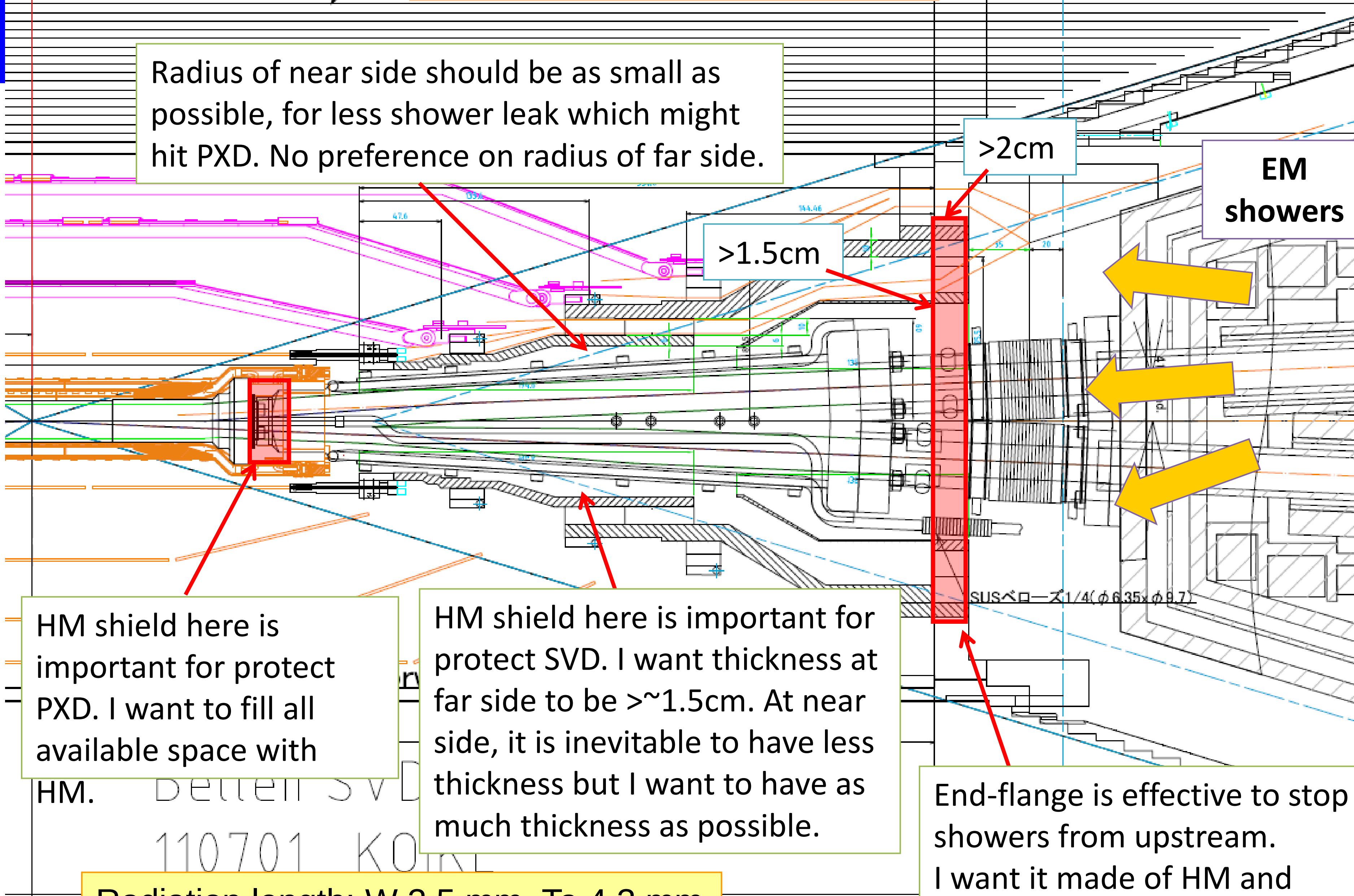


Nakayama (KEK) 5





Requirement from BG simulation



Radius of near side should be as small as possible, for less shower leak which might hit PXD. No preference on radius of far side.

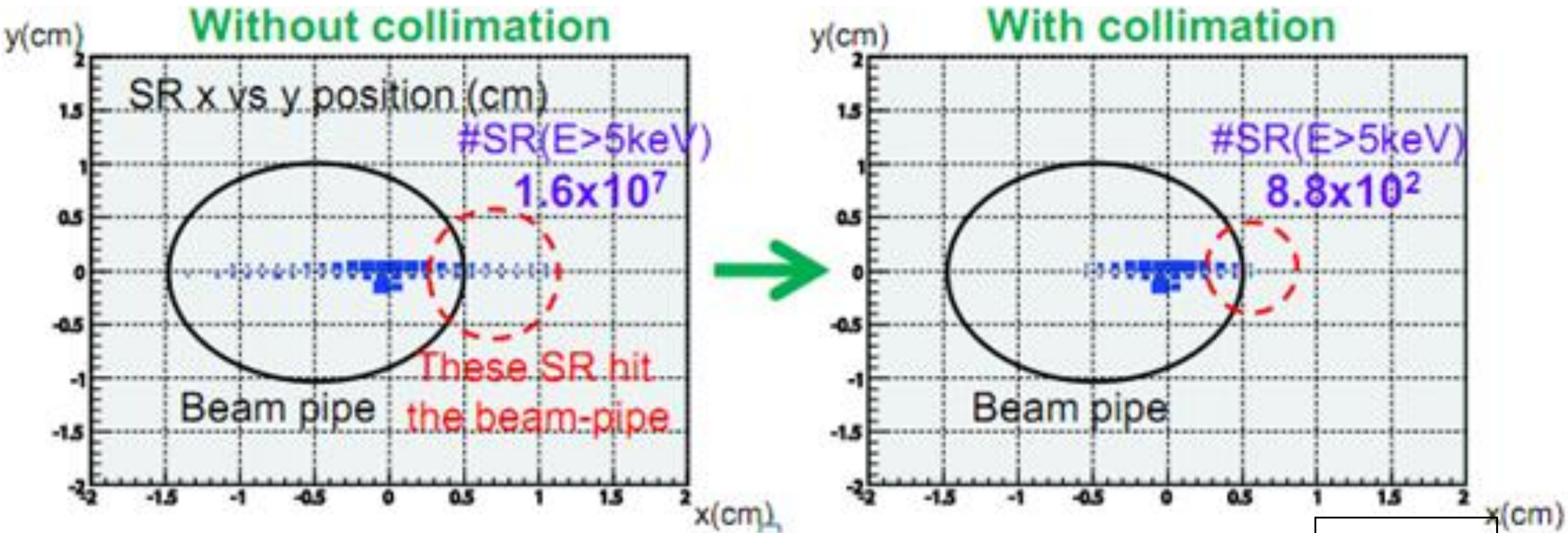
HM shield here is important for protect PXD. I want to fill all available space with HM.

HM shield here is important for protect SVD. I want thickness at far side to be >~1.5cm. At near side, it is inevitable to have less thickness but I want to have as much thickness as possible.

End-flange is effective to stop showers from upstream.
I want it made of HM and thickness of >~2cm.

Radiation length: W 3.5 mm, Ta 4.3 mm

Requirements from simulation



Iwasaki

- **SR by QC magnet is unavoidable because of focusing the beam**
- **Should care of direct SR hit on IP.**
  - **PXD acceptable occupancy**

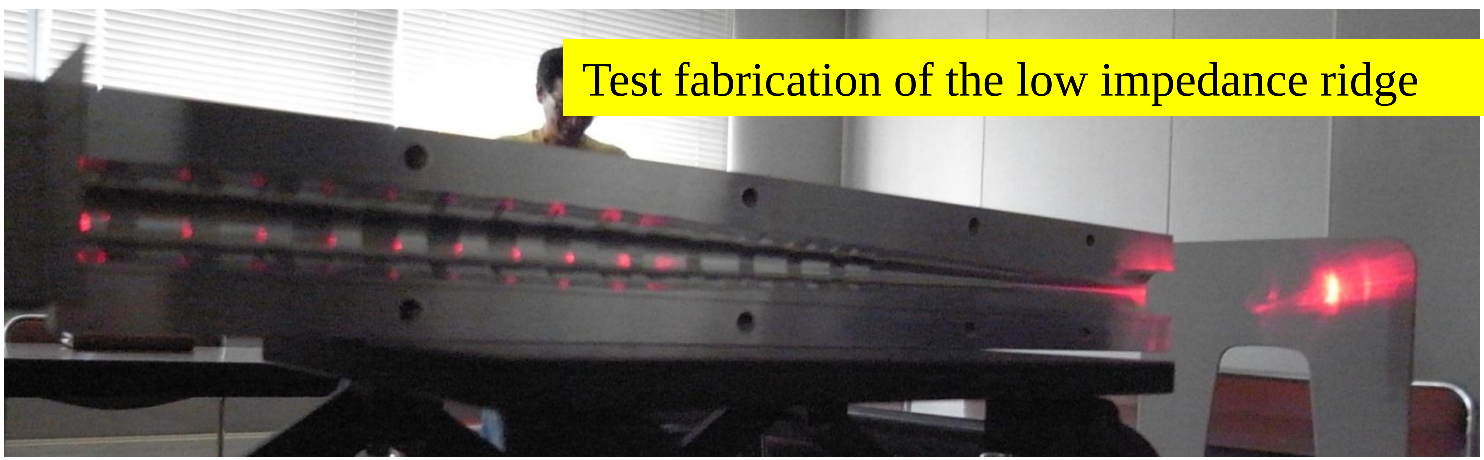
This data is very old, it will be updated soon with 3D magnetic field.

Ridge structure (Crotch part)

Shielding for SR from final focus magnet

Low risk for multiply scattered photon to escape forward

Risk for multiply scattered photon to escape forward



Test fabrication of the low impedance ridge

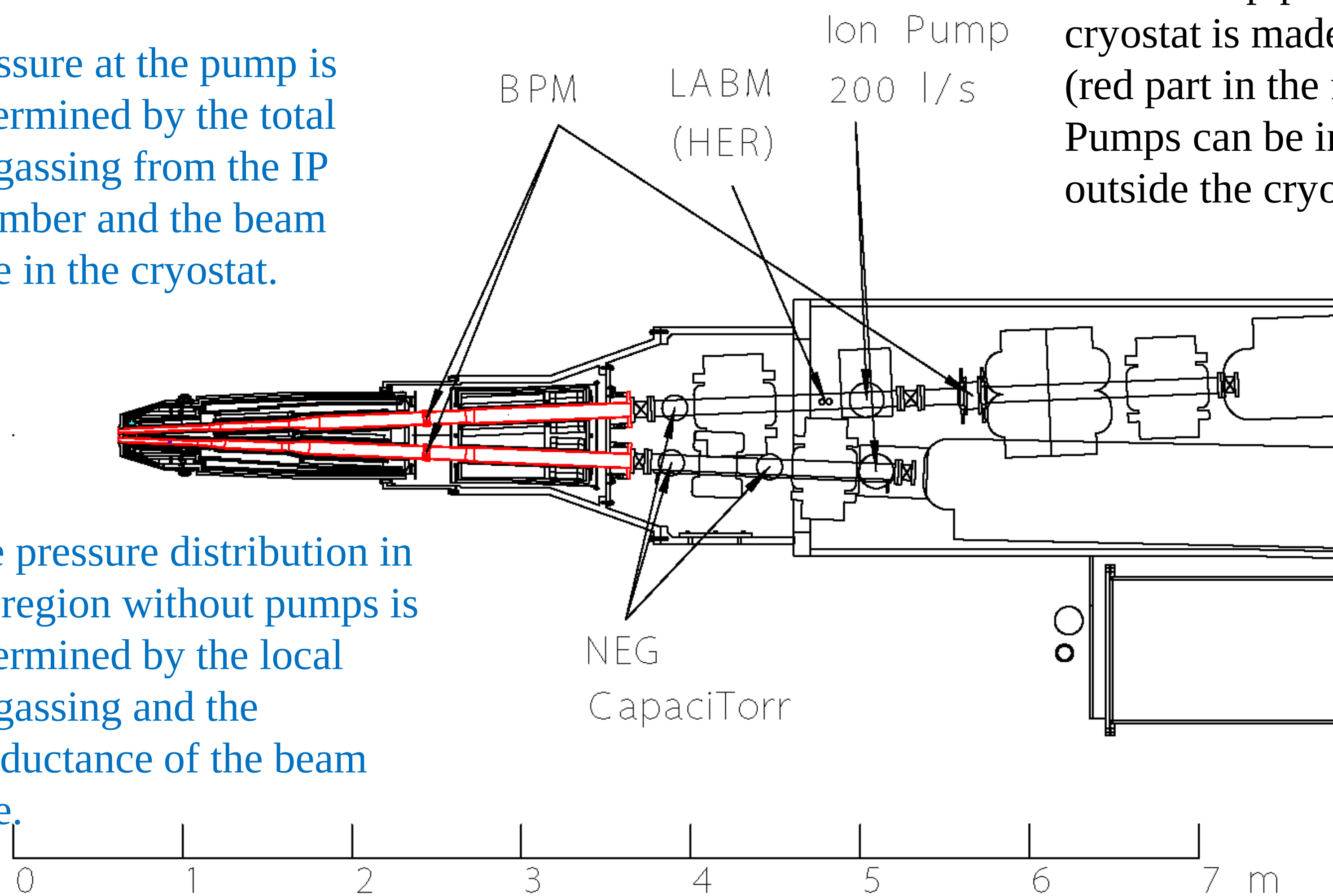
Final decision on the shape of the ridge depends on the estimated impedance (loss factor).

Pressure around IR
Layout of vacuum components in the R side

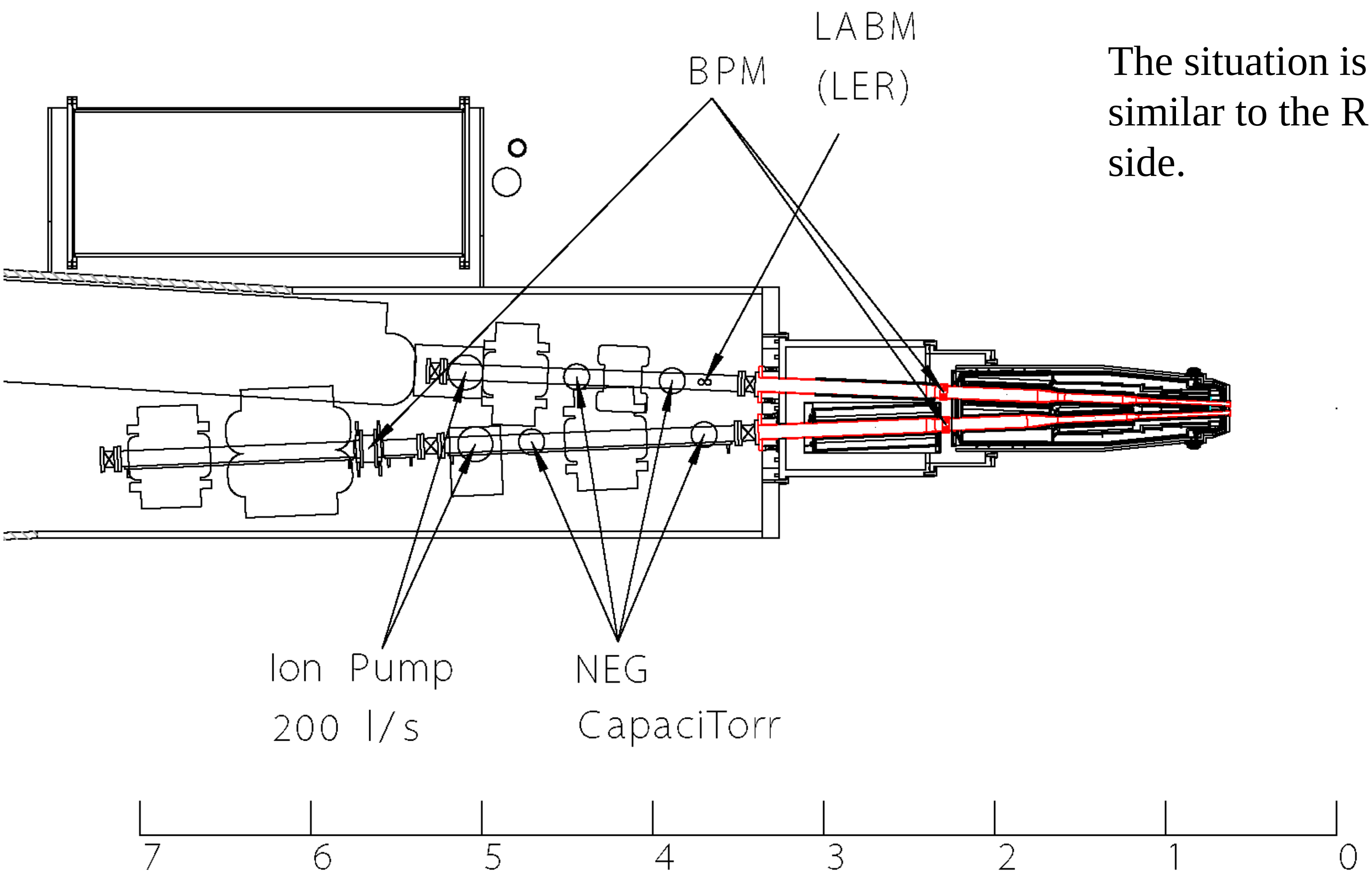
Pressure at the pump is determined by the total outgassing from the IP chamber and the beam pipe in the cryostat.

The pressure distribution in the region without pumps is determined by the local outgassing and the conductance of the beam pipe.

The beam pipe in the cryostat is made of Ta (red part in the figure). Pumps can be installed outside the cryostat.



Pressure around IR
Layout of vacuum components in the L side



The situation is similar to the R side.

Pressure around IR
Consideration on IR Pressure

•The pressure around the IP (±5m) must not affect the overall average design pressure of the ring (1×10^{-7} Pa). Otherwise an already short beam lifetime will be much shorter. Therefore the target pressure in this region must be less than $1 \times 10^{-7} \times 3000/10 = 3 \times 10^{-5}$ Pa.

• The main gas source in this region is photon-desorbed gas due to the direct SR from the last bend. If a photo-desorption coefficient η is assumed to be 1×10^{-5} molecules/photon, The average pressure of this region will be a few $\times 10^{-5}$ Pa.

•To realize a lower pressure it is proposed to coat Ta beam pipe in the cryostat with Au that is expected to show a lower photo-desorption coefficient compared to other metals with a surface oxide layer.

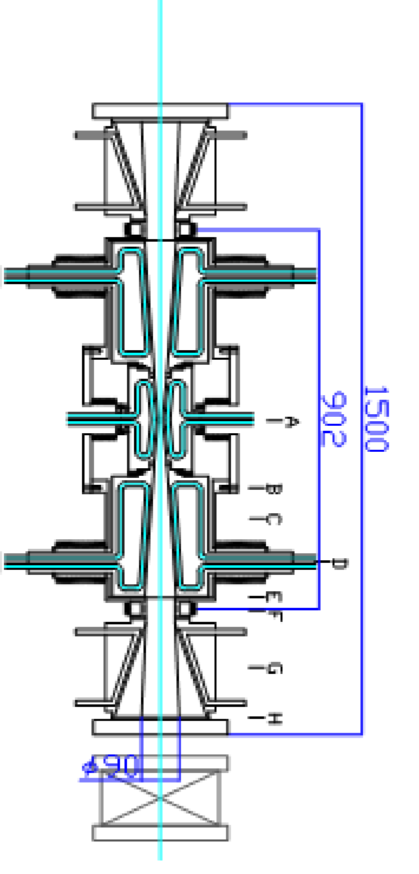
•To check this idea, the photo-desorption coefficient of Au coating and Ta will be measured at PF (Photon Factory) of KEKin this month.

Kanazawa

Movable collimator

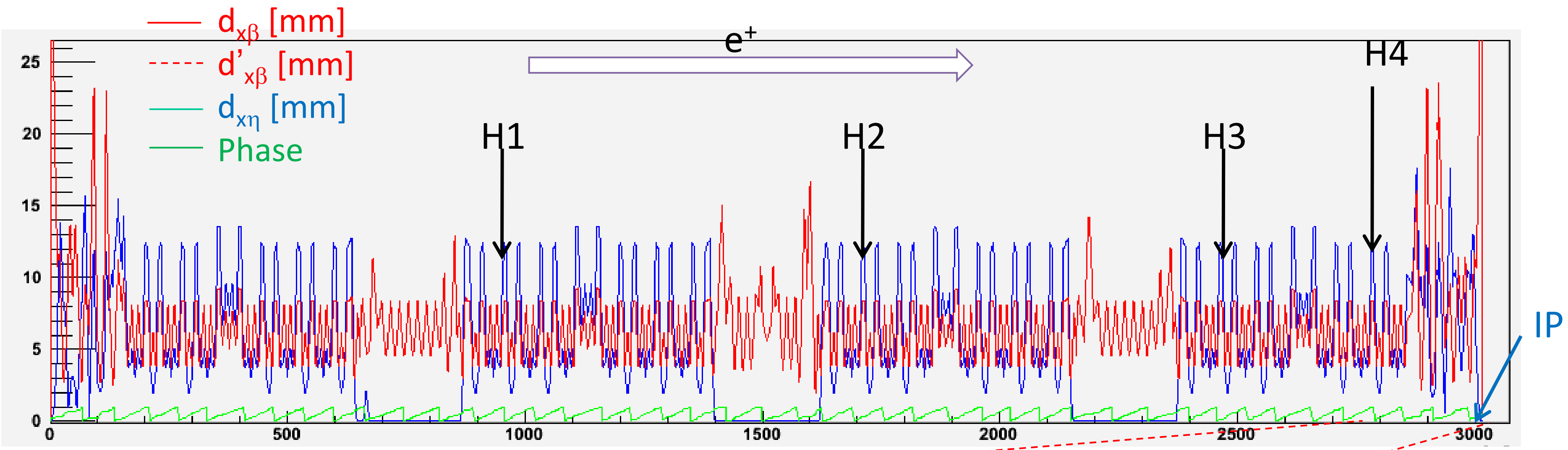
How to use movable collimators to reduce BG

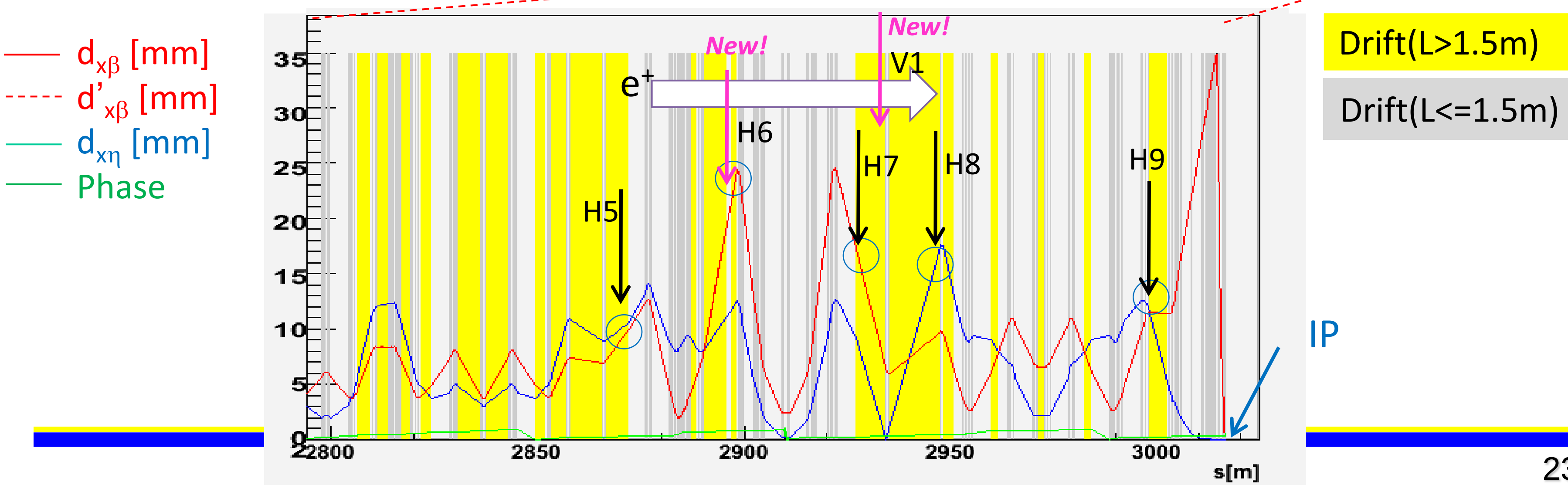
- **There are two options to select collimator material.**
  - **use light material (like carbon) to kick out off-orbit particles on large beta**
    - **should take care secondary particle**
  - **use heavy material (Tungsten) to absorb BG source particle (Touschek or beam gas)**
    - **need to effective cooling for collimator material**
    - **need to fine control to avoid melting material**
- On superKEKB we choose heavy material



Based on lerfqlc_1604

LER horizontal collimators



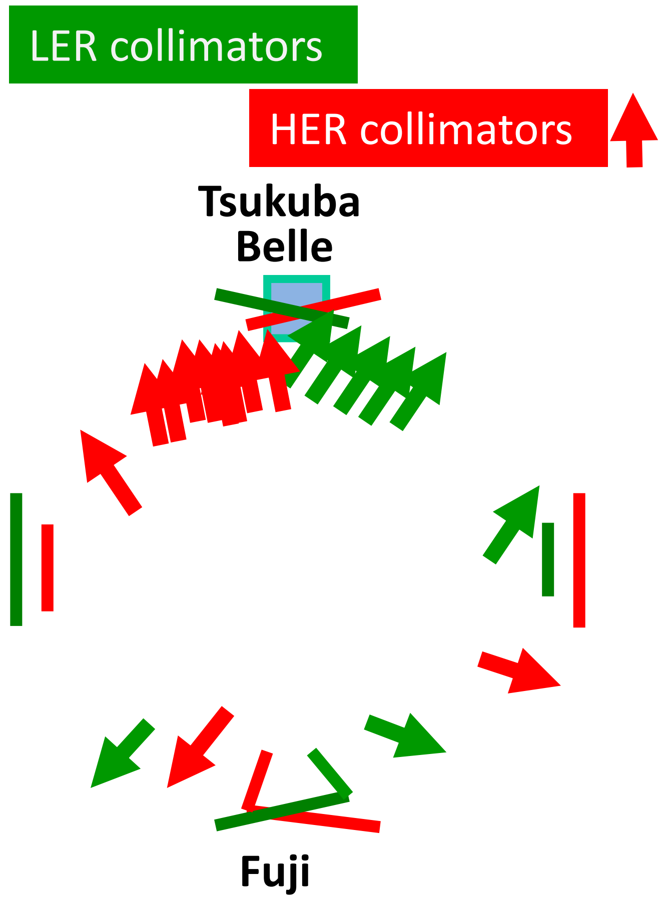


Updated on 20111219

Collimator settings

lerfqlc_1604

		s[m]	Depth [mm]	Touschek SAD[GHz]
H1	*L8P.13*	*956.17*	*12.34*	73.9
H2	*L8PM H1.1*	*1710.94*	*12.31*	52.3
H3	*L8P.32*	*2463.71*	*12.34*	38.7
H4	*-L8PM HD3.3*	*2783.89*	*12.28*	76.2
H5	*LLA8R*	*2872.03*	*10.54*	22.0
new **H6**	*LLA4R*	*2895.88*	*19.65*	11.8
H7	*LLB3R*	*2926.89*	*17.36*	0.7
H8	*LLB2R*	*2947.36*	*17.39*	8.0
H9	*LLC2R*	*2998.22*	*11.52*	18.2
	LLB3R		*2.6*	
			Touschek IR loss	0.16
V1	*LLB3R*	**2934.18**	*2.6*	127.4



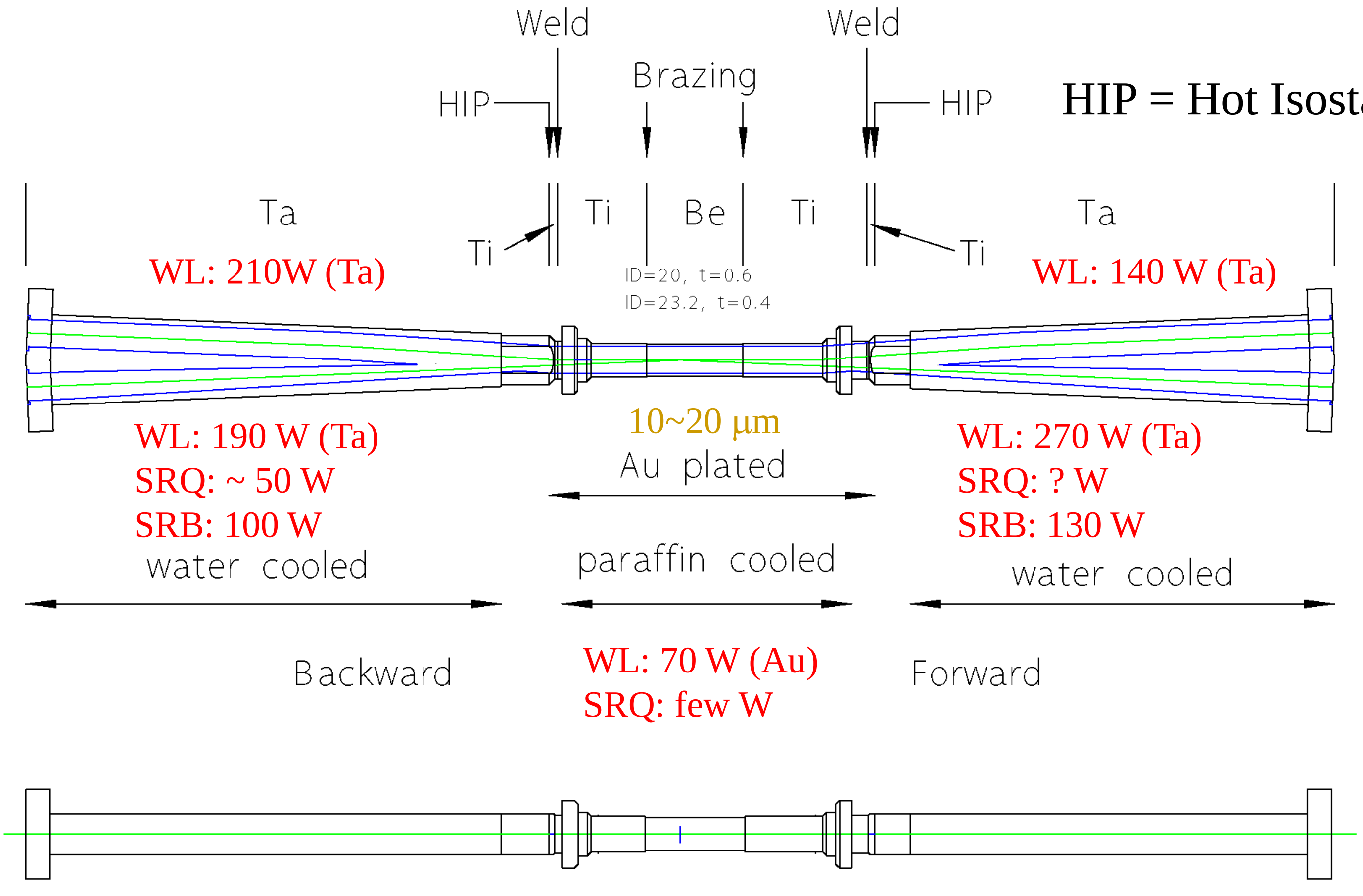
herfqlc5605

		s[m]	Depth [mm]	Touschek SAD[GHz]
H1	*L8EE.34*	*2057.52*	*8.94*	0.0006
H2	*L8EE.22*	*1302.95*	*8.94*	0.0058
H3	*L8EE.10*	*549.85*	*8.94*	0.0006
H4	*L8EE.3*	*202.3*	*8.94*	0.0000
H5	*L8EE.2*	*156.6*	*8.94*	0.0000
H6	*L8EE.1*	*128.16*	*16.1*	0.0000
H7	*LTLA1*	*99.84*	*17.46*	0.0000
H8	*LTLB4*	*75.75*	*16.66*	0.0000
H9	LTLY1.2	**48.38**	5.83	0.0000
H10	LTLY1.1	**34.11**	5.83	0.0000
H11	*LTLC6*	*17.7*	*10.58*	0.0023
V1	*LTLB2*	*60.95*	*2.2*	0.0000
	LTLB2	*60.95*	*2.2*	

Element name means collimator should be placed downstream of that element

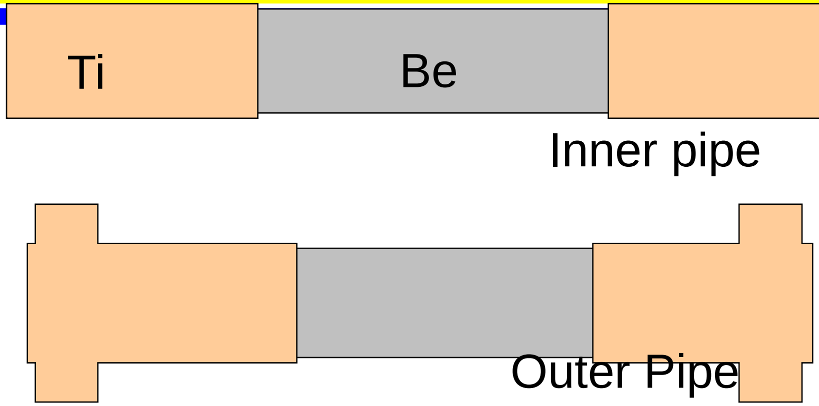
IP Chamber Fabrication

HIP = Hot Isostatic Pressing

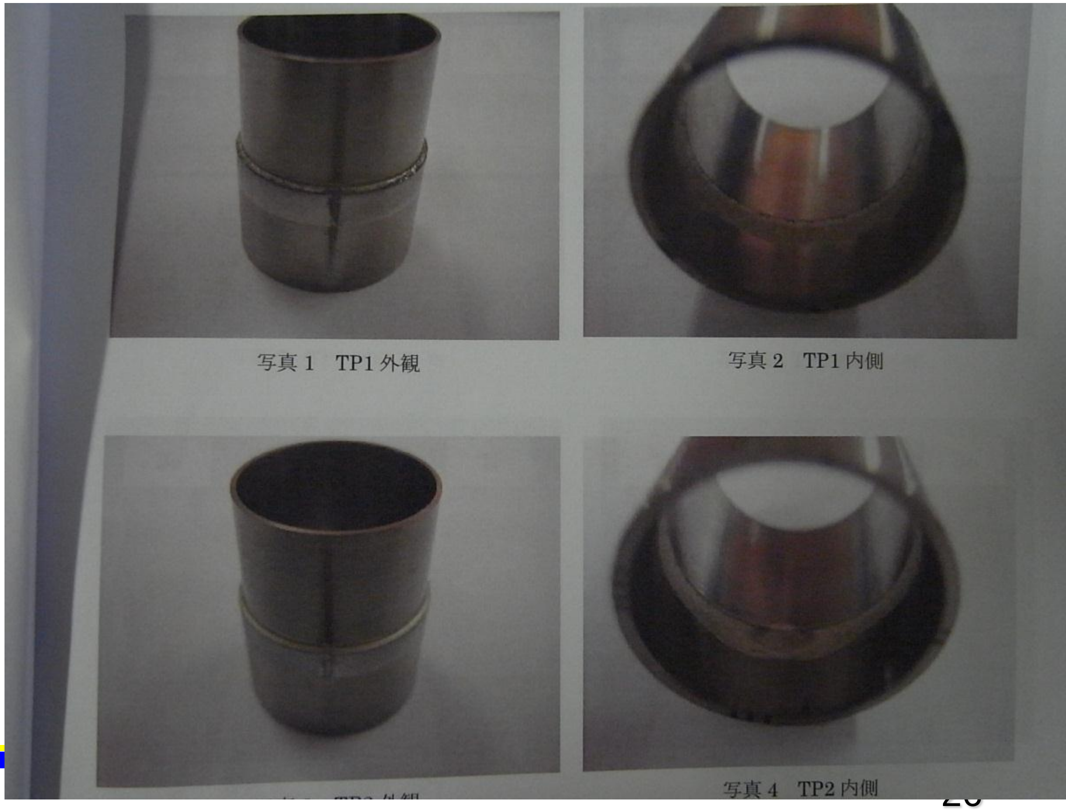


- A test for Be-Ti brazing and Ti-Ta HIP is now undergoing.
- They are not special technologies.
- Ti is adopted instead of stainless steel to reduce the stress.

IP chamber production(Be-Ti)



- **The Brazing test between Titanium part and Beryllium part has been doing (leak test was OK).**
- **The mechanical stress test will be finished soon (before Mar).**



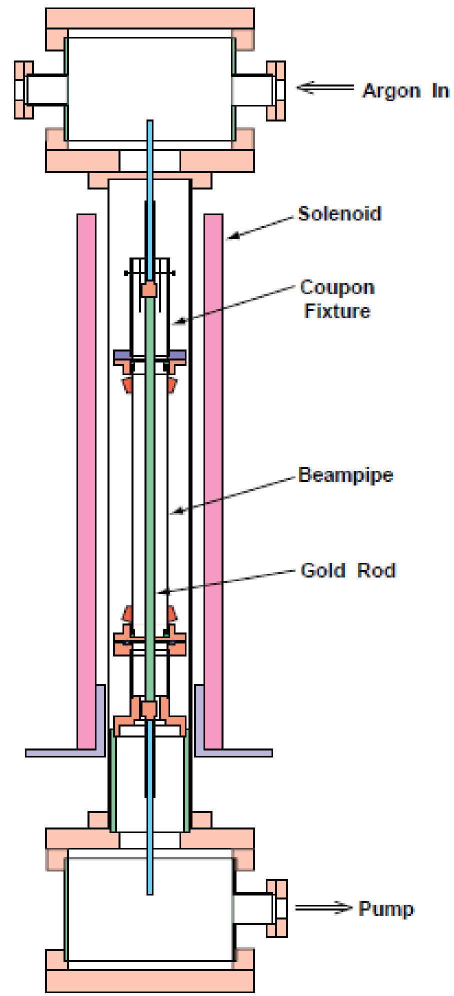
Au coating inside of IP chamber

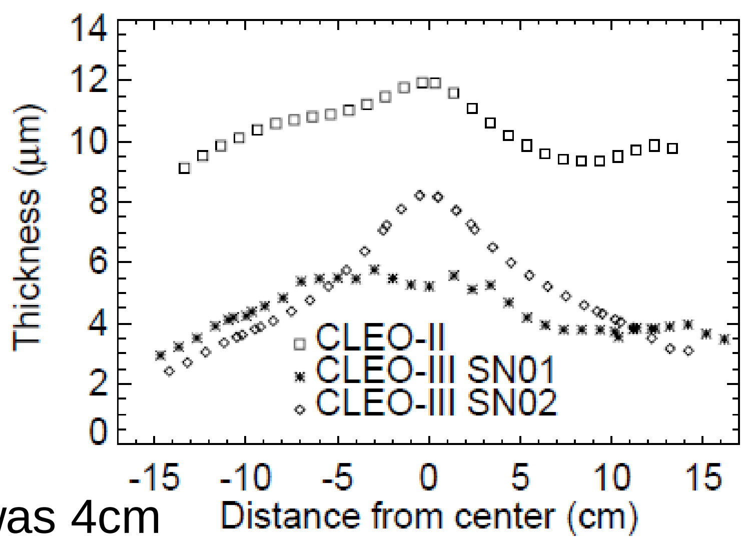
- **The company, which performed Au coating, changed their policy not to use Be. Then we ask another company to produce dedicated sputtering system.**
- **Next fiscal year, we will try Au sputtering study using SUS pipe with CLEOII data.**

Proceedings of the 1999 Particle Accelerator Conference, New York, 1999

A METHOD FOR GOLD COATING EXPERIMENTAL DETECTOR BEAMPIPES*

S. Henderson†, S. Roberts, Cornell University, Ithaca, NY

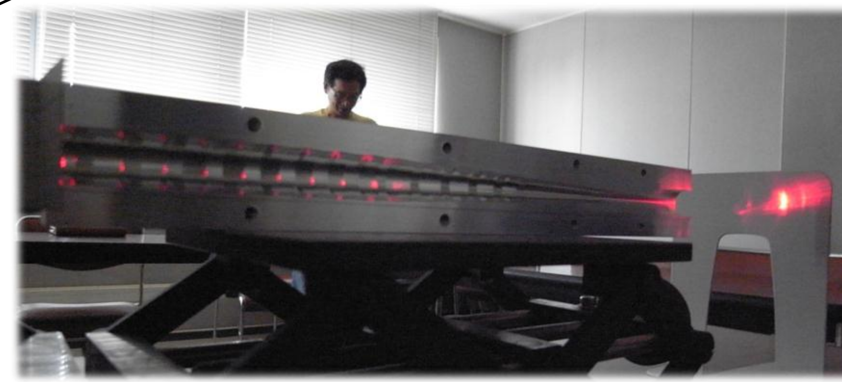


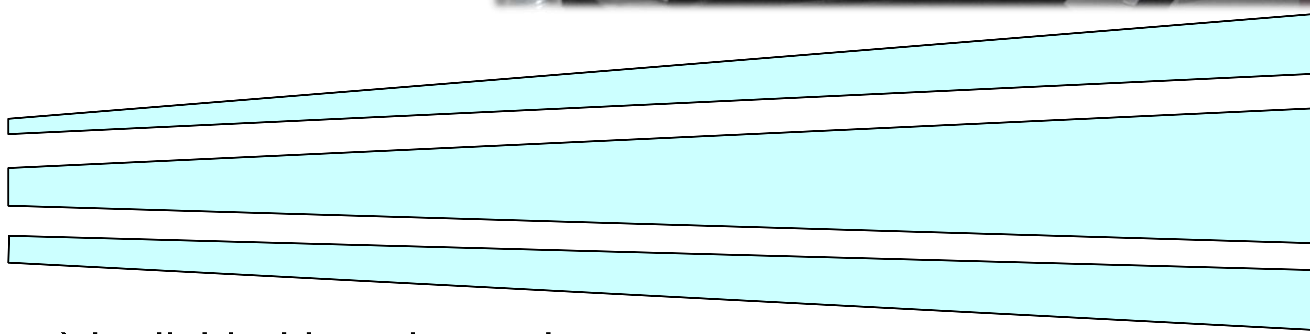


Pipe diameter was 4cm

Beam pipe (Crotch part)

Ridge shape to protect SR(x-ray) from final focus magnet





The crotch part (Tantalum) is divided into three pieces.
The inner pipe structure has made by drilling with 5-axis stage.
After then, those three pieces are joined by welding.

- Drilling test : finished
- Material for 1st version has ordered

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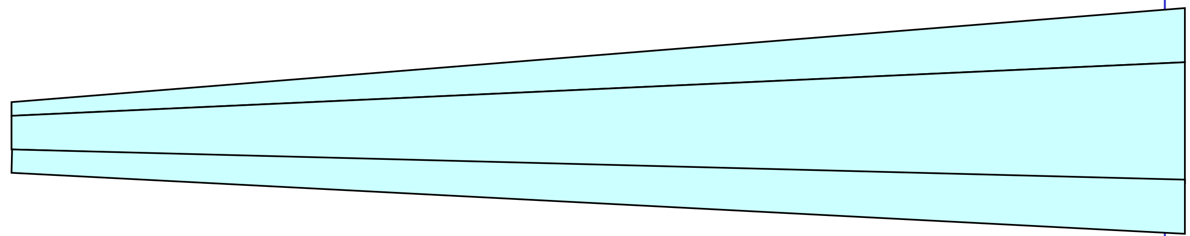
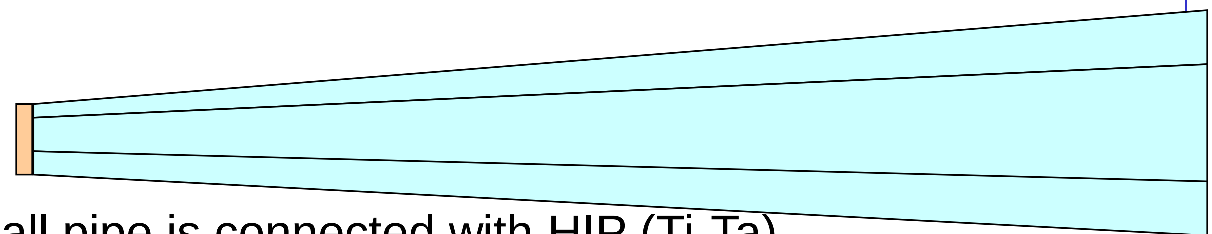
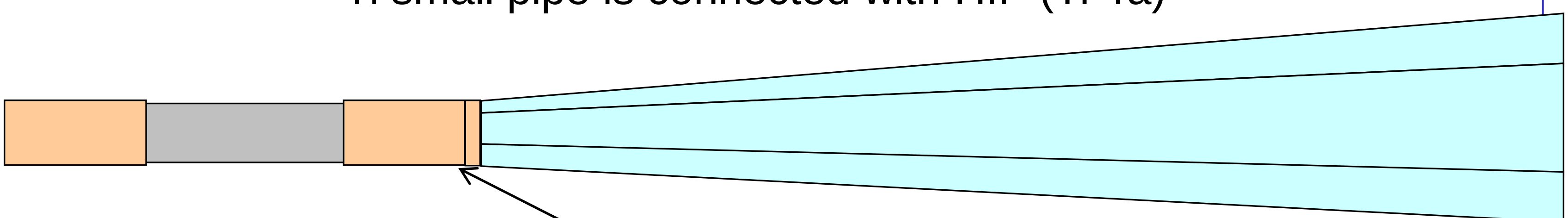
Beam pipe production

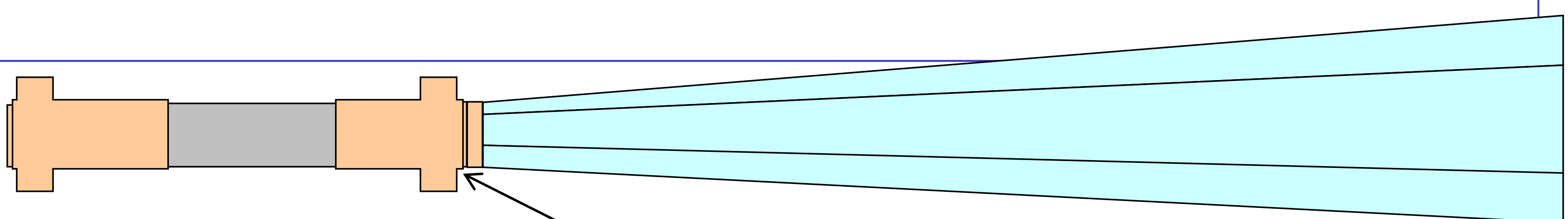




Ti small pipe is connected with HIP (Ti-Ta)



IP chamber(inner) is connected with welding (Ti-Ti)



Outer pipe of IP chamber and inner pipe are connected by EBW

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BEAST II
SuperKEKB comissioning

30

BEAST II Motivation

universität bonn

Beam Exorcism for A STable experiment II

A background detector for the commissioning of the Belle II experiment

- Synchrotron and neutron backgrounds were unexpectedly problematic in Belle.

1. The main purpose of BEAST II is to determine whether is it safe to roll-in the detector

   → Measure instantaneous and integrated radiation dose at position of Belle II subdetectors and test the beam abort systems

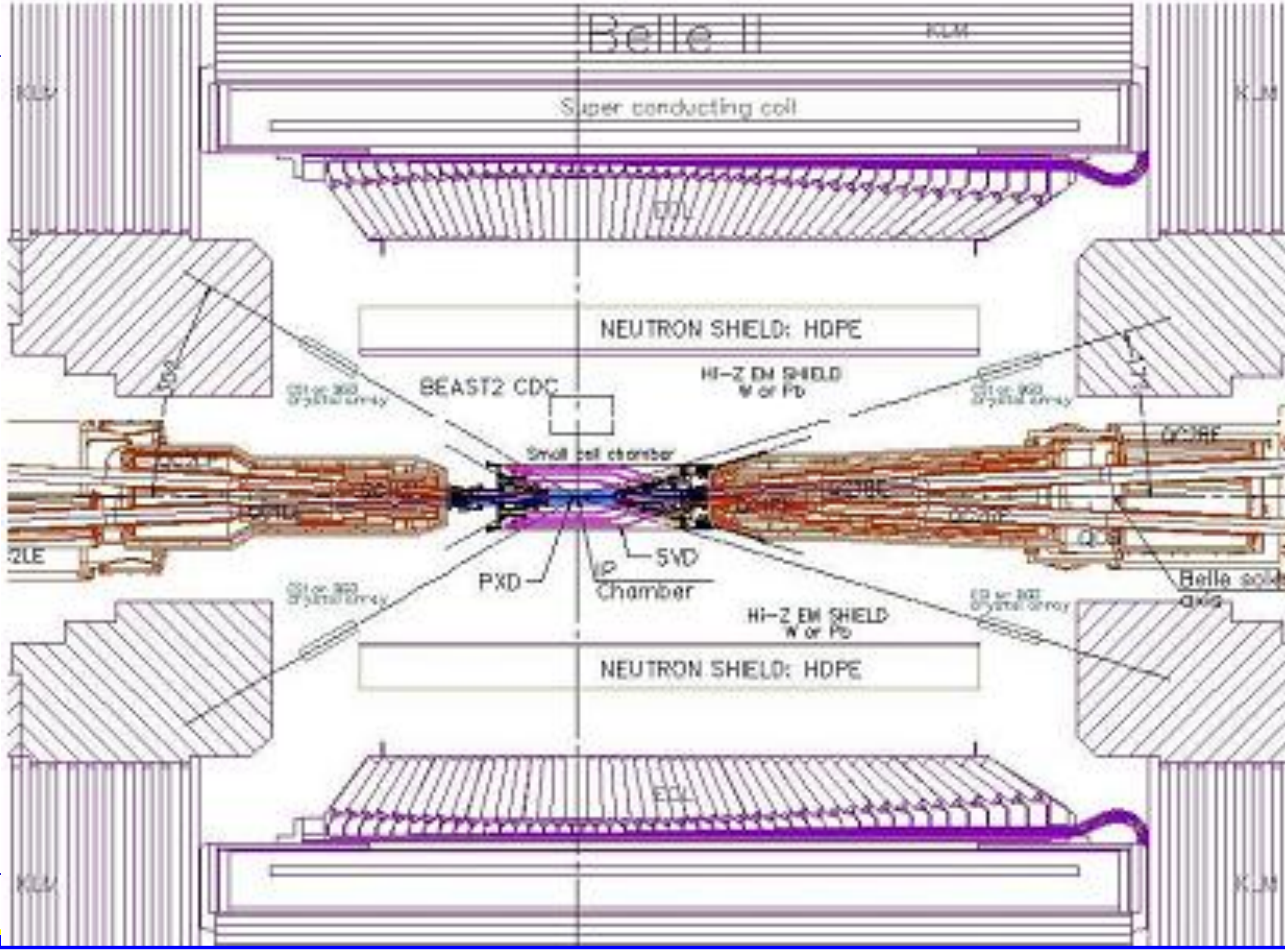
2. SuperKEKB machine needs real time measurements of luminosity and background levels during beam commissioning (tuning of beam optics and moveable mask positions)

3. Detailed understanding of beam background sources needed to validate the simulations

   → Touschek, Radiative Bhabha, Beam gas, Synchrotron Radiation, Beam Injection Noise

cmarinas@uni-bonn.de

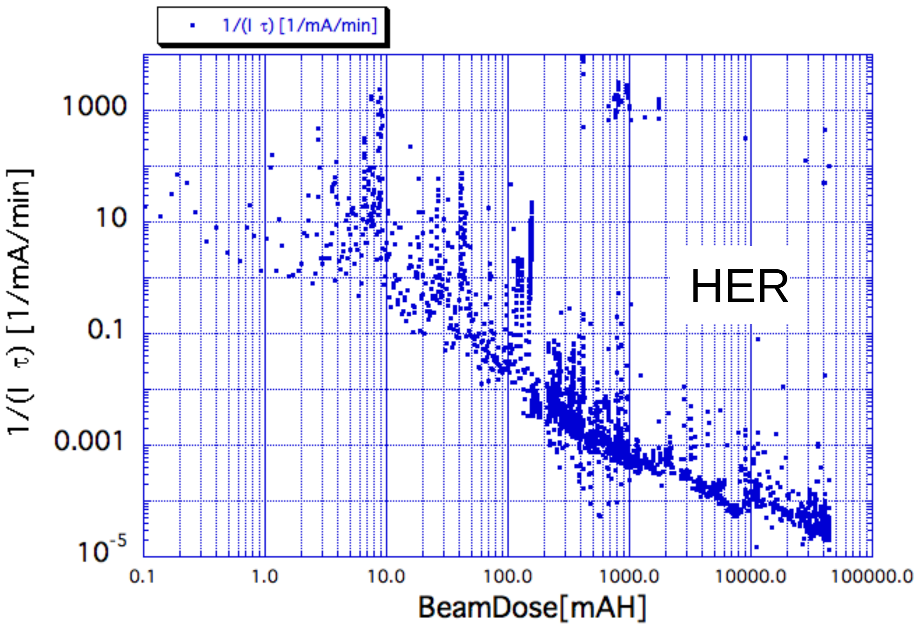
BEASTII setup

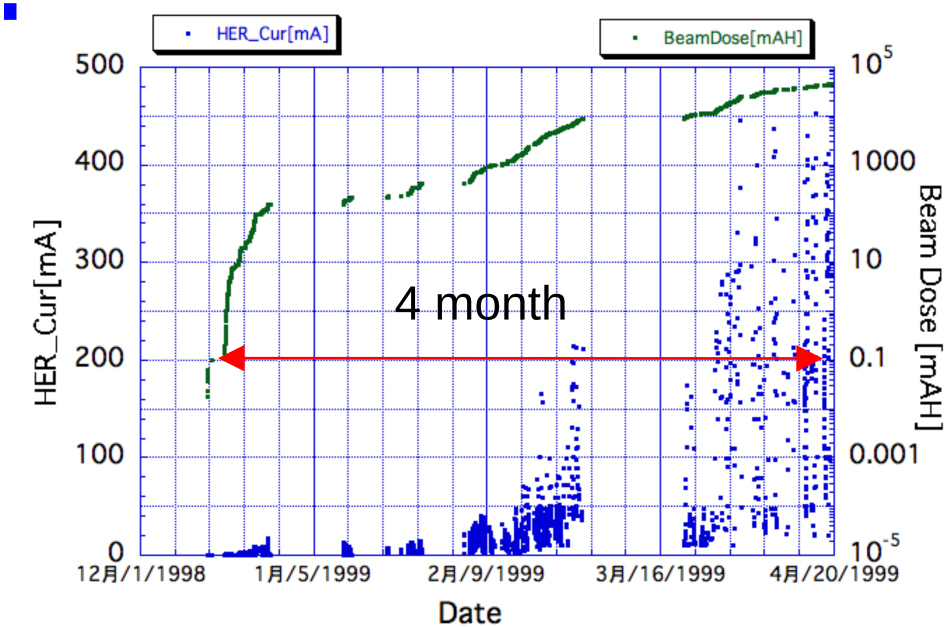


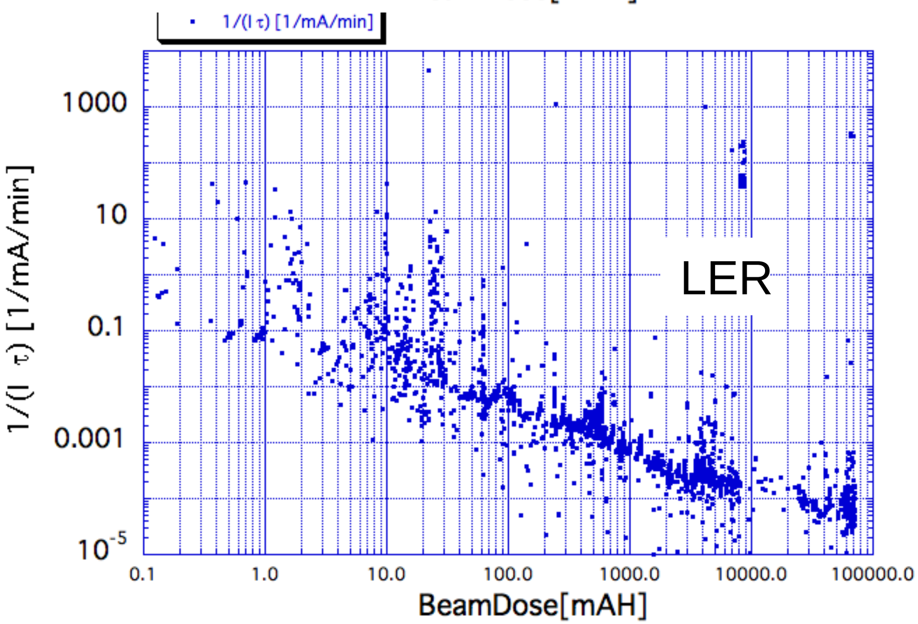
SuperKEKB(Machine study list)

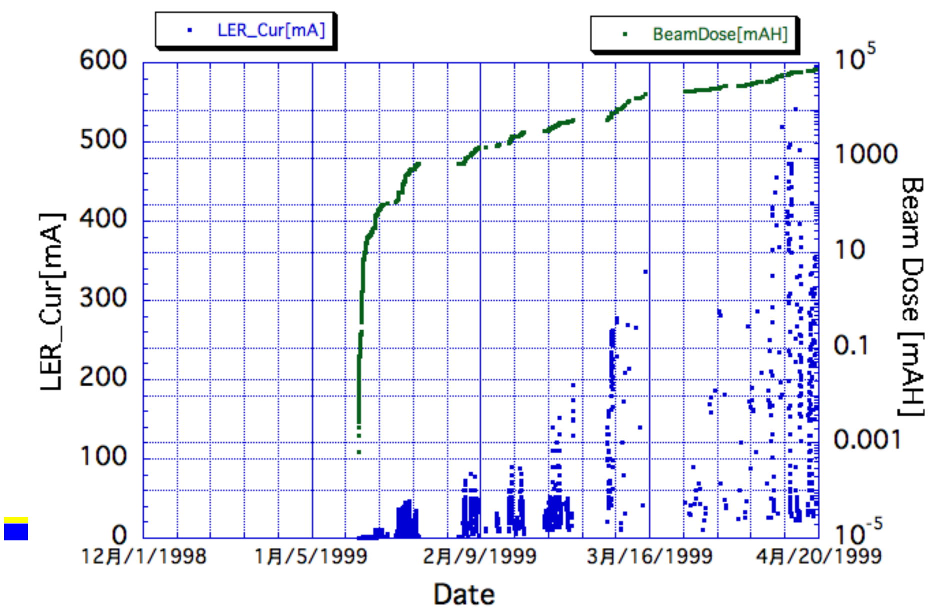
- Commissioning I (1.5 Month)
  - Linac tuning（Need check Beam Transfer(BT) from linac to KEKB ring）
  - Damping Ring tuning（no experience in KEKB(at least 10 day will be taken)
  - BT tuning
  - Injection tuning (with synchronous injection with PF)
  - COD correction、Optics correction（Roughly)）
  - Abort system tuning
  - Monitor tuning（incluing Beam feedback）
  - Hardware tuning
  - Radation monitor
  - Debugging each software
- Vacuum scrubbling（Commissioning II)（~3 Month)
- Belle II background study and their tuning (movable masks or adding material?)
- More high precision beam tuning（Commissioning III)
  - Optics Measurement、Optics correction, Beta function tuning
  - Collision and luminosity tuning
  - Applying higher curentWe should also take into account on time consuming by machine trouble or bad repeatability of beam condition

KEKB vacuum scrubbing (HER/LER)









BEASTII(Belle II detector side)

- 1 Just studying BG level and checking sensor response(like BEAST).
  - ex.: SR, Touschek and beam gas BG, Beam injection noise, Luminosity monitor (output to BG simulation) On this stage, each sub-part may study individually.
- 2 Pre-commissioning stage:
  - a, Trigger(ECL,KLM will be ready),
  - b, Luminosity feedback to optimize beam orbit control,
  - c, Beam injection veto(sending veto signal to trigger system on beam injection, which is critical subject on PXD system.)
  - d, Movable beam mask optimization to reduce BG
  - e, KEKB beam abort setting by each sub-detector As a result, all sub-detector(+machine) should join to BEASTII operation. (Therefore BEASTII is assigned to common session on next B2GM.)

Thank you!

Tomorrow's subjects:

VXD assembly procedure

Beam pipe fabrication

Belle II comissioning

etc.