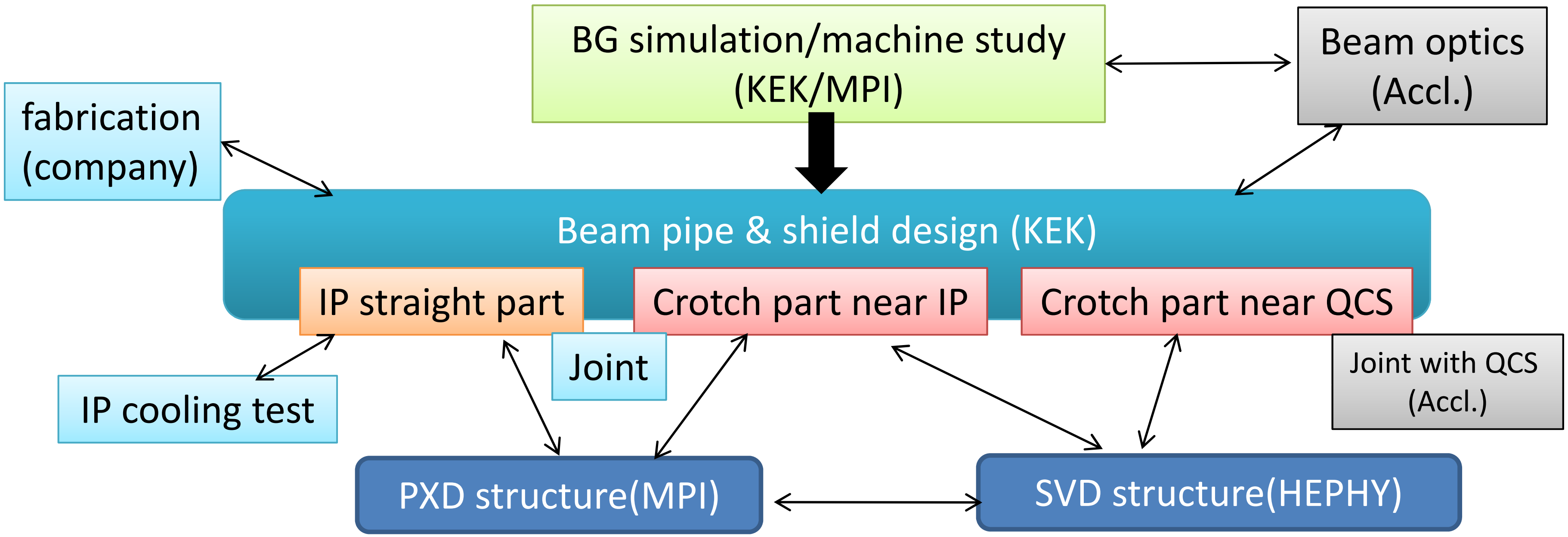
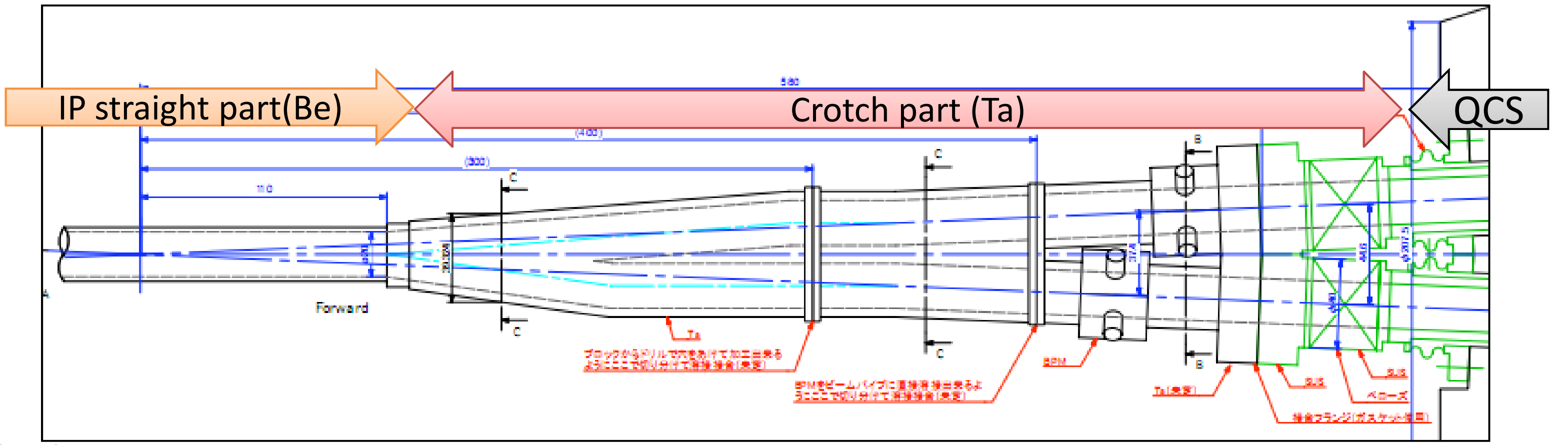
Beam pipe and background at Belle-II

H. Nakayama (KEK)

XIV SuperB General Meeting

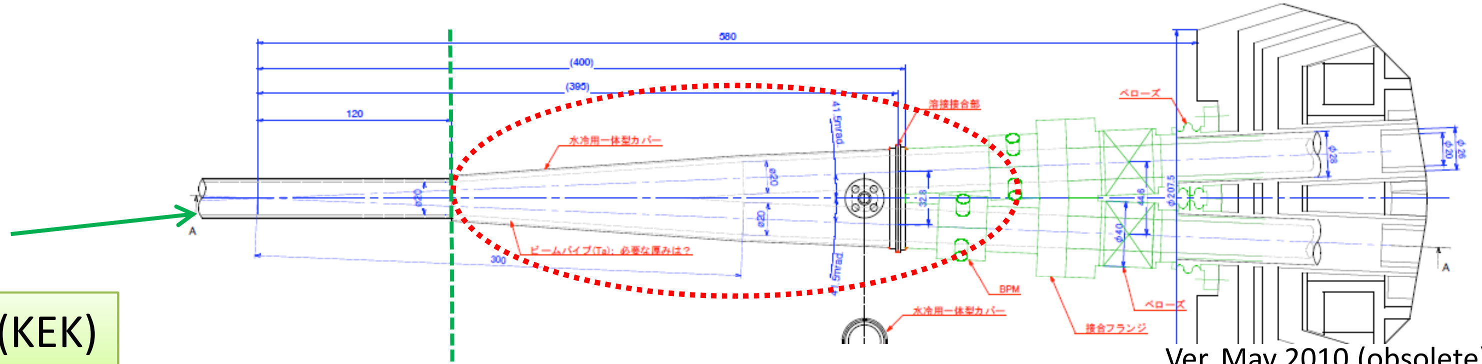
Beam pipe design & BG estimation





Crotch part (Ta)

- We found serious SR hits on Be part, if we use the crotch design at that time (thanks to M. Sullivan).

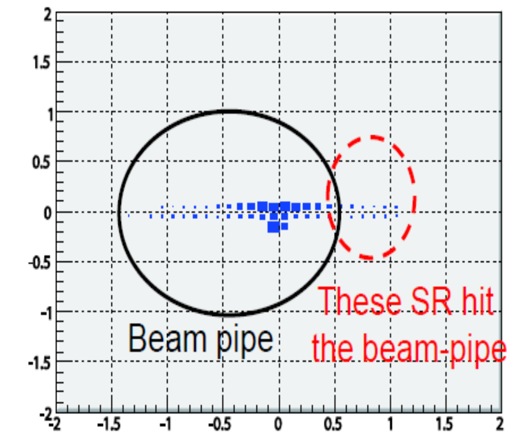


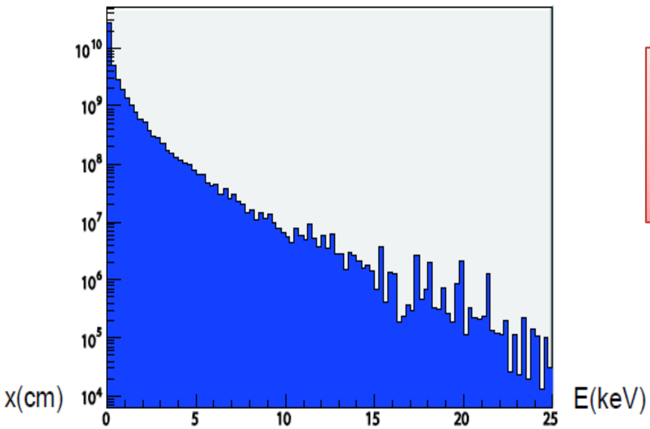
Ver. May 2010 (obsolete)

M. Iwasaki(KEK)

Scaled for 1 bunch

HER





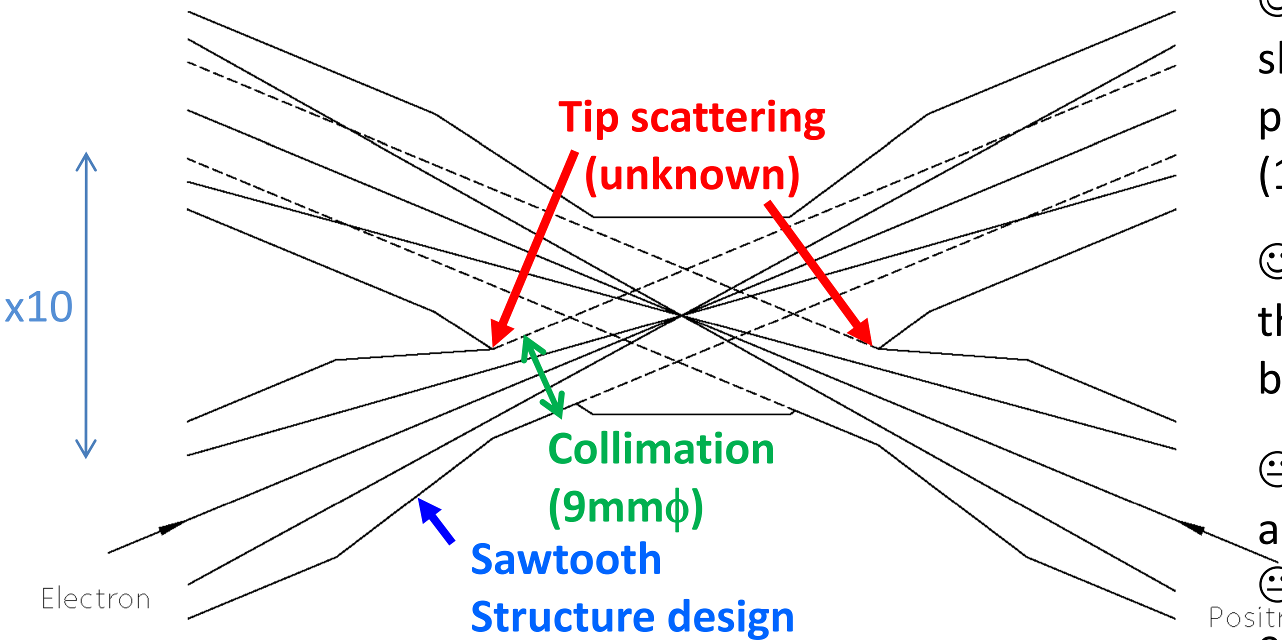
Geant4-based simulation

SR/bunch(E>5keV) : <u>$1.6x10^7$</u>

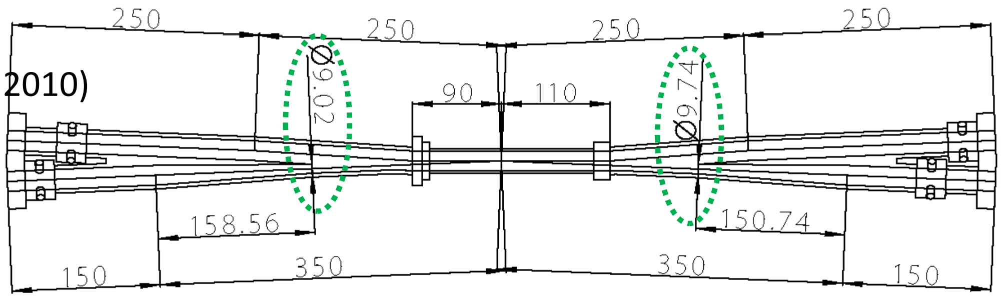
PXD requirement:
SR/bunch (E >5-6keV) < ~10^2-10^3/ bunch

New crotch part design

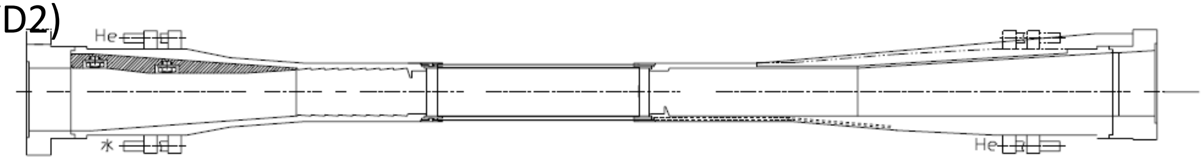
K. Kanazawa



Belle-II
(Ver. July 2010)



cf.
Belle(SVD2)



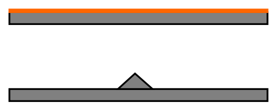
☺ Incoming pipes are cone-shaped, collimating SRs to prevent direct hits on Be part. ($1.6x10^7$→$8.8x10^2$/bunch)

☺ HOM can escape through the pipes for the outgoing beam.

😐 Still suffers from SRs which are not parallel to beam.

😐 Quite sensitive to alignment error

• Tip-scattering or refection on saw-tooth structure is hard to simulate. We are planning a beam test.



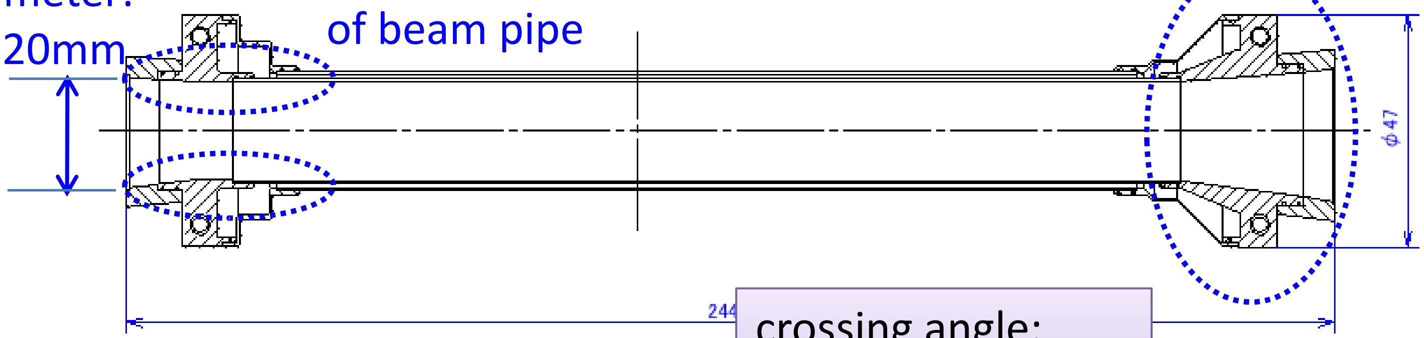
IP straight part (Be)

Belle-II current design

Inner diameter:
30mm→20mm

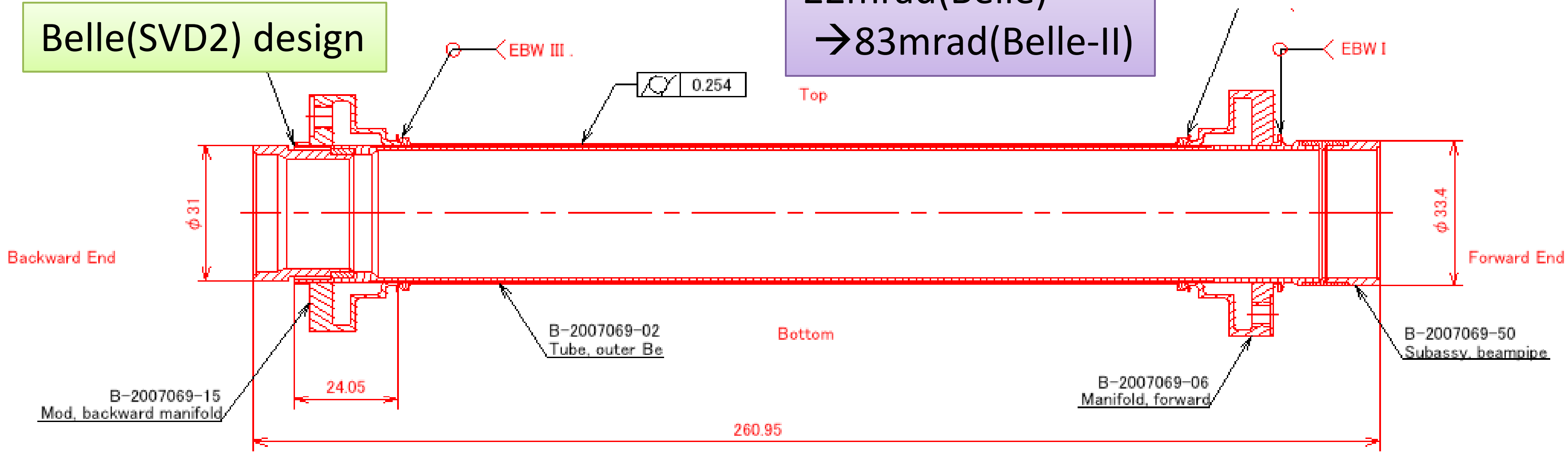
Flat inner wall
of beam pipe

Coooling manifold
sits on crotch part



crossing angle:
22mrad(Belle)
→83mrad(Belle-II)

Belle(SVD2) design



Beam pipe design summary

- Current Belle-II beam pipe design is presented
- Company for Be part: BW, or other candidate?
- Direct SR hits is collimated by cone-shaped design of crotch part
- Simulation study using current beam-pipe design has started

Introduction: background sources

- **Touschek effect ($\propto I \times E^{-3}$)**
  - Intra-bunch scattering → energy increase & decrease
  - Significant in low energy ring (LER)
- **Beam-gas scattering ($\propto P \times I$)**
  - Collision with remaining gas
  - Type 1: Coulomb scattering → direction change
  - Type 2: Bremsstrahlung → energy decrease
- **Synchrotron Radiation ($\propto E^2 \times B^2$)**
  - Type 1: Upstream (SR hit Be beam pipe directly)
  - Type 2: Backscatter (SR hit downward beam pipe, then reflected back to IP)
- **Radiative Bhabha, other QED process ($\propto L$)**
  - Type 1: radiated gamma + magnet Fe → neutron, main bkg source for KLM
  - Type 2: e+,e- lose energy→off-trajectry→ hit downward beam pipe → shower
- **Beam-beam effect**
  - Injected particles with a large horizontal oscillation (due to injection error) may be lost

Upgrade from KEKB to SuperKEKB

- smaller beam size, more current
  → x40 higher luminosity

Machine parameter	HER (KEKB)	LER (KEKB)	HER (SuperKEKB)	LER (SuperKEKB)
Vertical beam size	0.94μm	0.94μm	59nm	59nm
Beam current(mA)	1188	1637	2600	3600
luminosity($cm^{-2}s^{-1}$)	$2.1x10^{34}$		$8x10^{35}$	

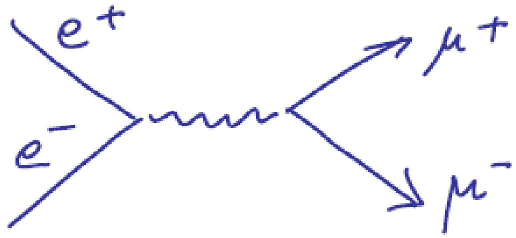
Two topics covered in this talk

1. QED BG
   – Machine study at KEKB in June 2010
   – Might give an answer to "Which QED MC is correct, SuperB's or ours?"
2. Touschek/Beam-gas BG
   – Machine study at KEKB in June 2010
   – Gives latest estimation (extrapolation) for SuperKEKB BG level.

C. Kiesling

1. QED process

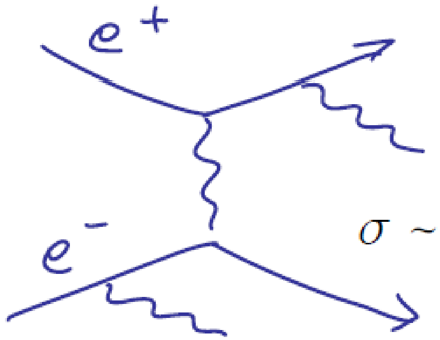
Cross sections for s-channel processes fall like 1/s



Rate ~ 600 ev/s

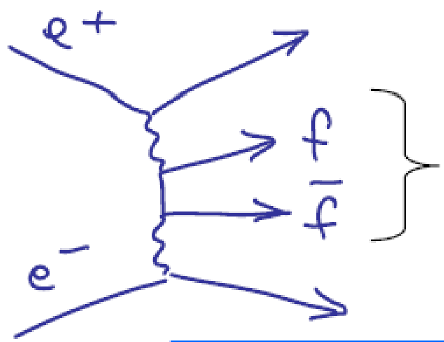
@10^3 / nb s

Cross sections for t-channel processes are largely independent of s



$\sigma \sim 50\ \mathrm{nb}$

Bhabha scattering



e^+e^- :

$\sigma \sim O(10^7\,\mathrm{nb})$

2-photon-processes

C. Kiesling, VI Open Meeting of the Belle II Collaboration Meeting, July 5-7, 2010 3

C. Kiesling

QED BG estimation

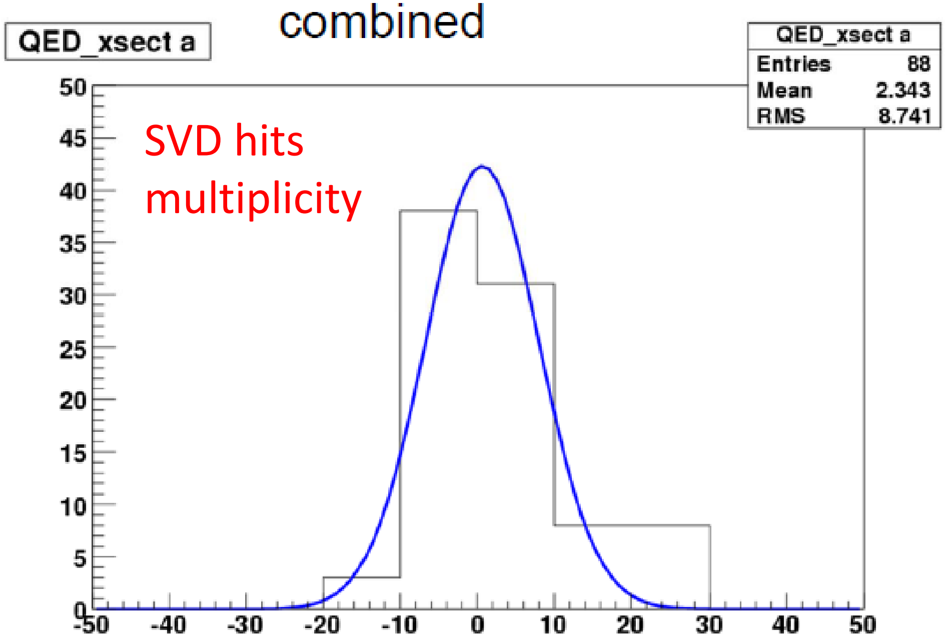
- SuperB QED simulations : 10MHz/cm2
  → ~1.5 % occupancy for PXD, which is close to our limit (2%)
- However, our simulation shows ~0.1% occupancy
  - Our generators (BDK/KW/Grace) show consistent results

- Find out the correct answer by KEKB machine study .
  - Collide two beams (LER and HER)
  - Vary luminosity by varying beam separation, beam size, or beam current.

C. Kiesling

Machine study results

all layers (z and phi) combined



Gauß-Fit including all layers:

$$N_{hits} = 0.7 \pm 7.3$$

Expected hits from KoralW (averaged over the layers):

$$< N_{hits} >= 0.65$$

Cross check analysis:

$$N_{hits} = -5.8 \pm 9.9$$

$$< N_{hits} >= 10.4$$

(SuperB MC)

C. Kiesling, VI Open Meeting

Further analysis is on-going using CDC information

2. Touschek/Beam-gas BG

I: beam current, τ: life time
k: proportional constant

$$BG = I \cdot \left(k_{Touschek} \cdot \frac{1}{\tau_{Touschek}} + k_{beam-gas} \cdot \frac{1}{\tau_{beam-gas}} + \ldots\right)$$

- KEKB machine study results can be extrapolated for SuperKEKB
- Extrapolation strategy
  - Measure k and τ at KEKB by machine study
  - Assume same $k_{Touschek}$, $k_{beam\text{-}gas}$, $\tau_{beam\text{-}gas}$ at SuperKEKB
  - For $\tau_{Touschek}$ at SuperKEKB, use optics simulation result
  - SR, Rad.Bhabha, beam-beam BG are not included

KEKB machine study (Jun. 2010)

- Single beam(HER/LER only), random trigger
- Vary vertical beam size to see Touschek effect
- Measure SVD,CDC,ECL background level

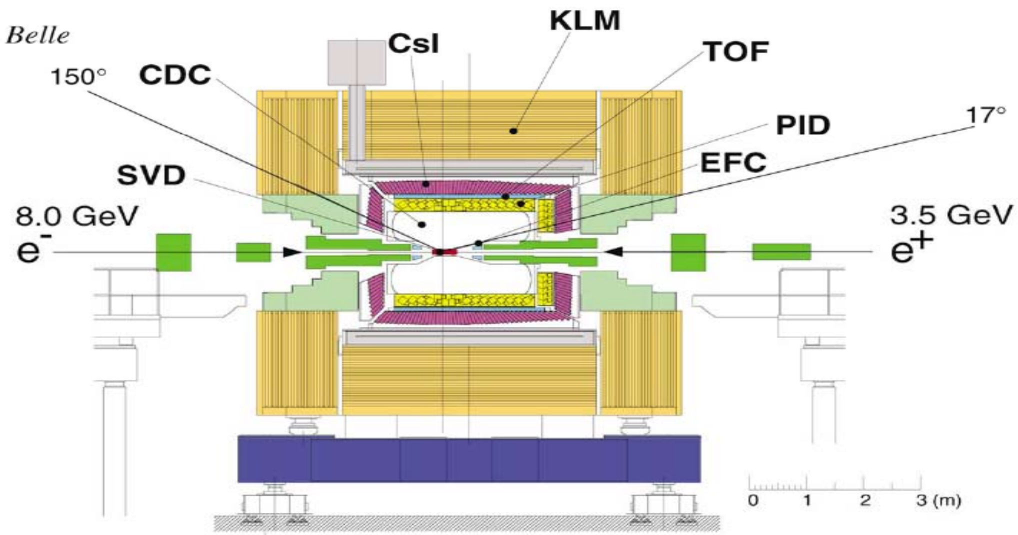


Fig. 1. Side view of the Belle detector.

Belle detector

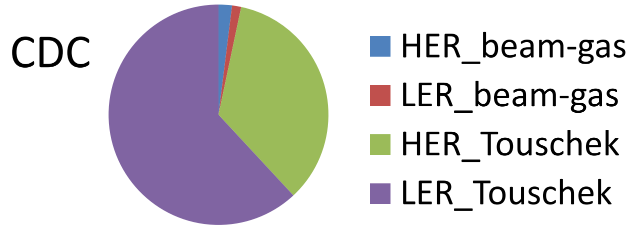
BG estimation at SuperKEKB

Assumptions:
- Use $\tau_{Touschek}$ from optics simulation: 8.7min(LER), 15.3min(HER)
- Use same $\tau_{beam\text{-}gas}$ from KEKB machine study: 800min(LER), 3400min(HER)
- Use same $k_{Touchek}$, $k_{beam\text{-}gas}$ from KEKB machine study

CDC

400+-40 uA (cf. ~20uA@2003)

→ ~120 kHz/wire or less at layer 6 or outer



LER/total: 60~70%,
Touschek/total: >90%

SVD

6000+-600 event/trigger

→ shorter shaping time (800ns→50ns)

→ ~400 event/trigger, occupancy: 2.7%+-0.3% <10%(SVD2)

ECL

60+-5 GeV/event

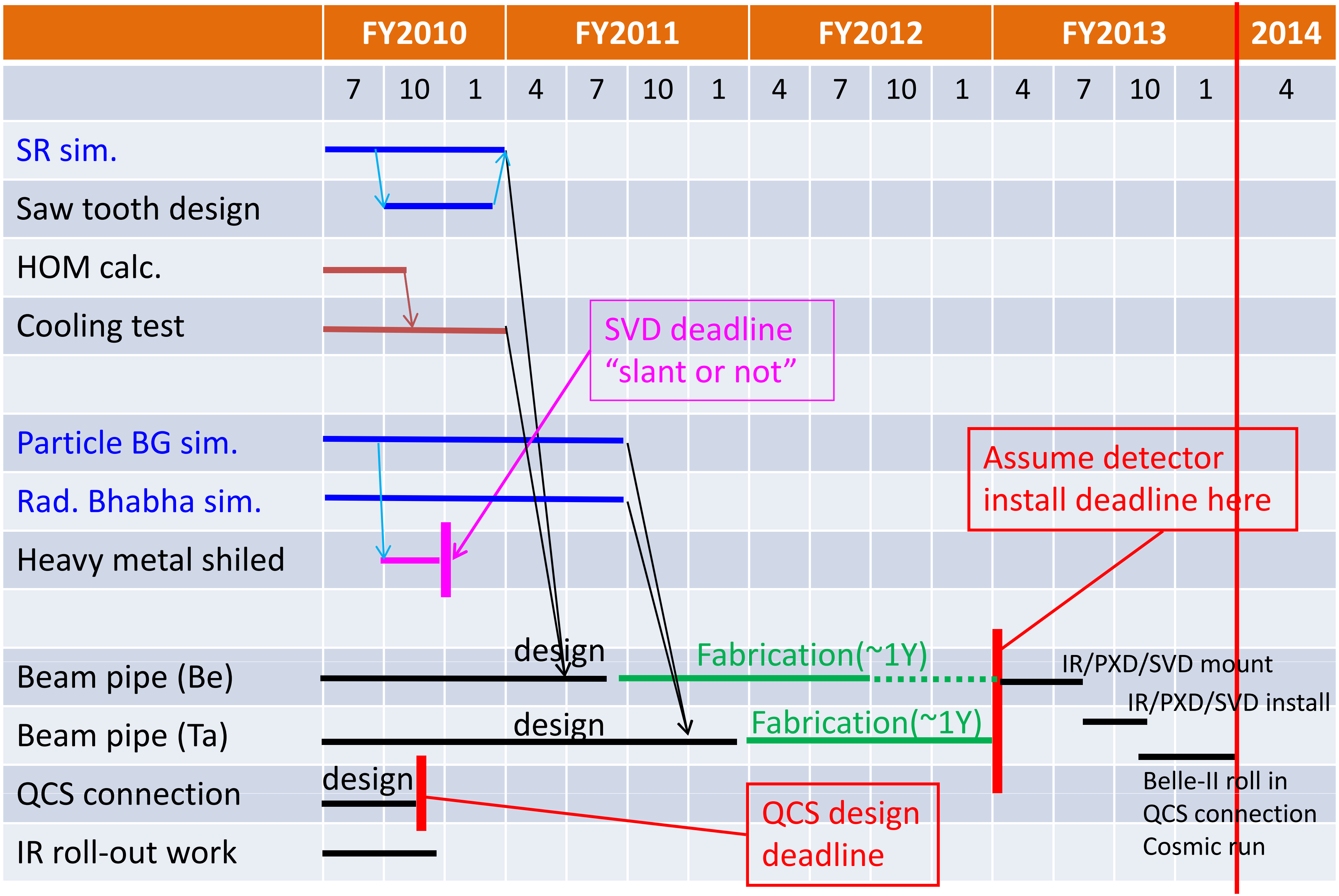
→ wave form fitting (x1/7) → ~9 GeV/event

These detectors can be operated at these BG level
Try further BG reduction for better analysis performance

SR, Rad.Bhabha, beam-beam BG are not included

H.Naka

Schedule (draft)



backup

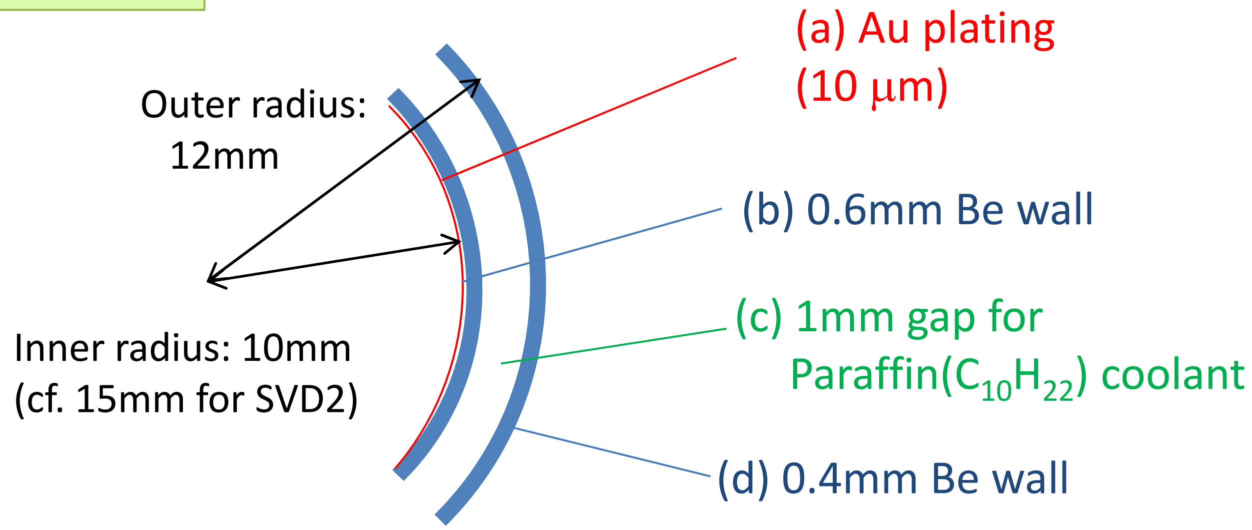
IR tasks not covered in talk

- Touschek/beam-gas simulation
  - TURTLE+Geant4
- Rad. Bhabha simulation
  - Dedicated generators: BHLUMI/BHWIDE/BBbrem
- IP beam-pipe cooling test
- HOM calculation
- Heavy-metal shield design
- Mirror current heating estimation
- Vibration

Beam pipe design

Beam pipe parameters

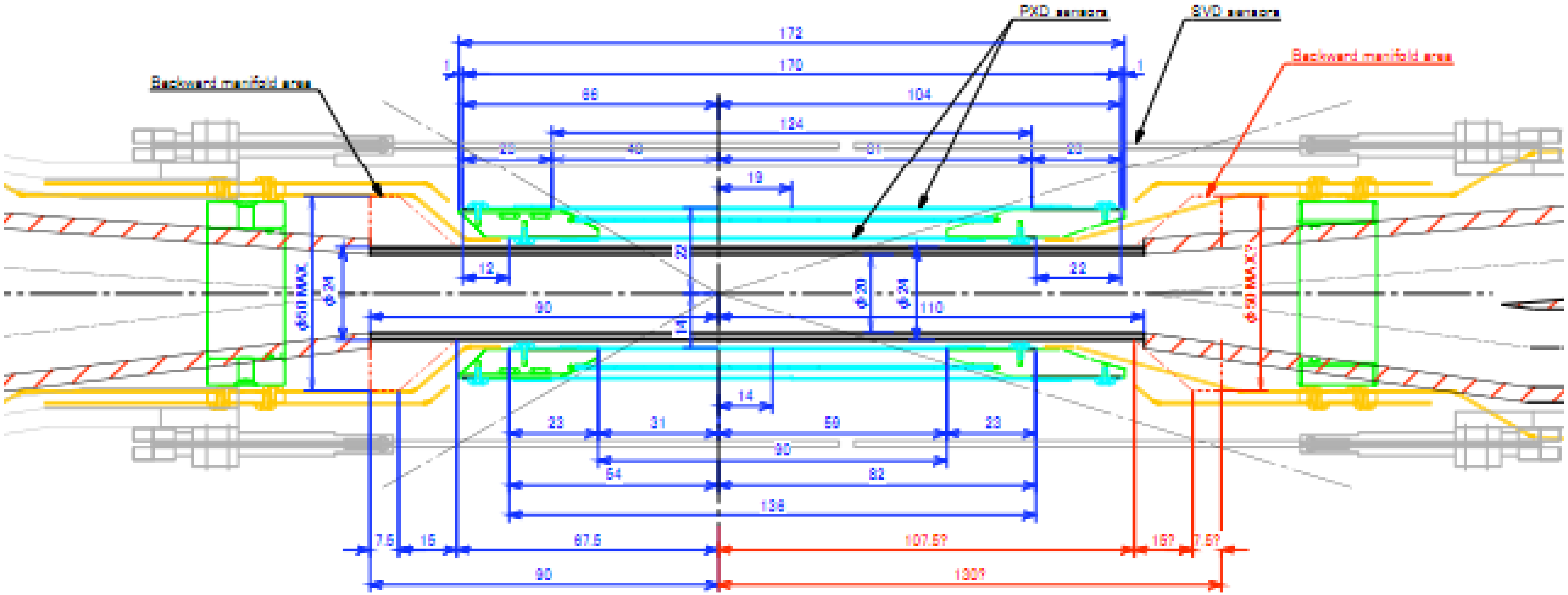
Be center part



Ta crotch part

Inner radius: 10mm
Ta thickness: 4mm
Au plating on inner surface
Dig drains on outer surface to put water cooling pipes
Saw tooth structure to prevent reflected SR lights to hit Be part

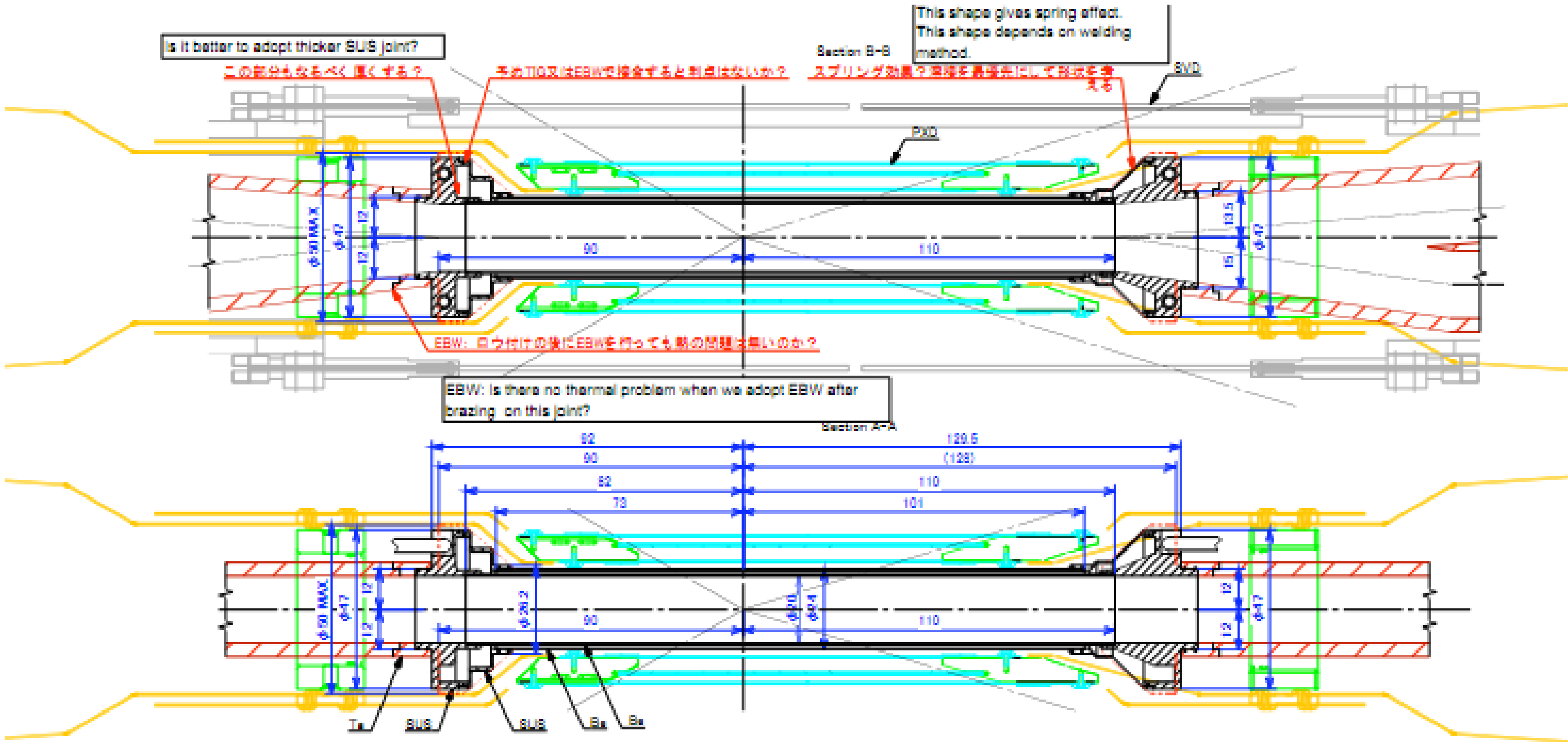
Current Space assignment near IP



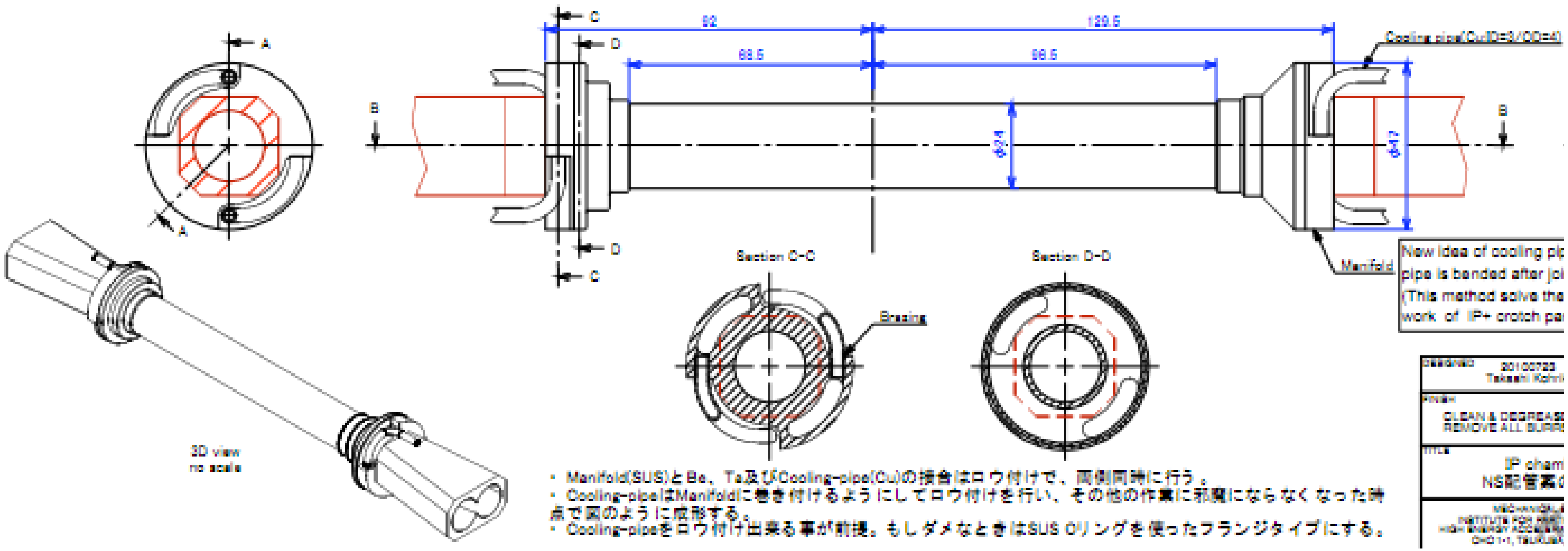
The manifold of left side (backward) shows acceptable space by PXD group requirement.
Red line region is not fixed yet.

- PXD左側（ Backward）の台形はIP chamber manifoldに当てられるスペースを示す。
- PXD右側（ Forward）の台形もIP chamber manifoldに当てられるスペースを示すが、確定ではない。
- 赤字は未定を示す

Current Space assignment near IP

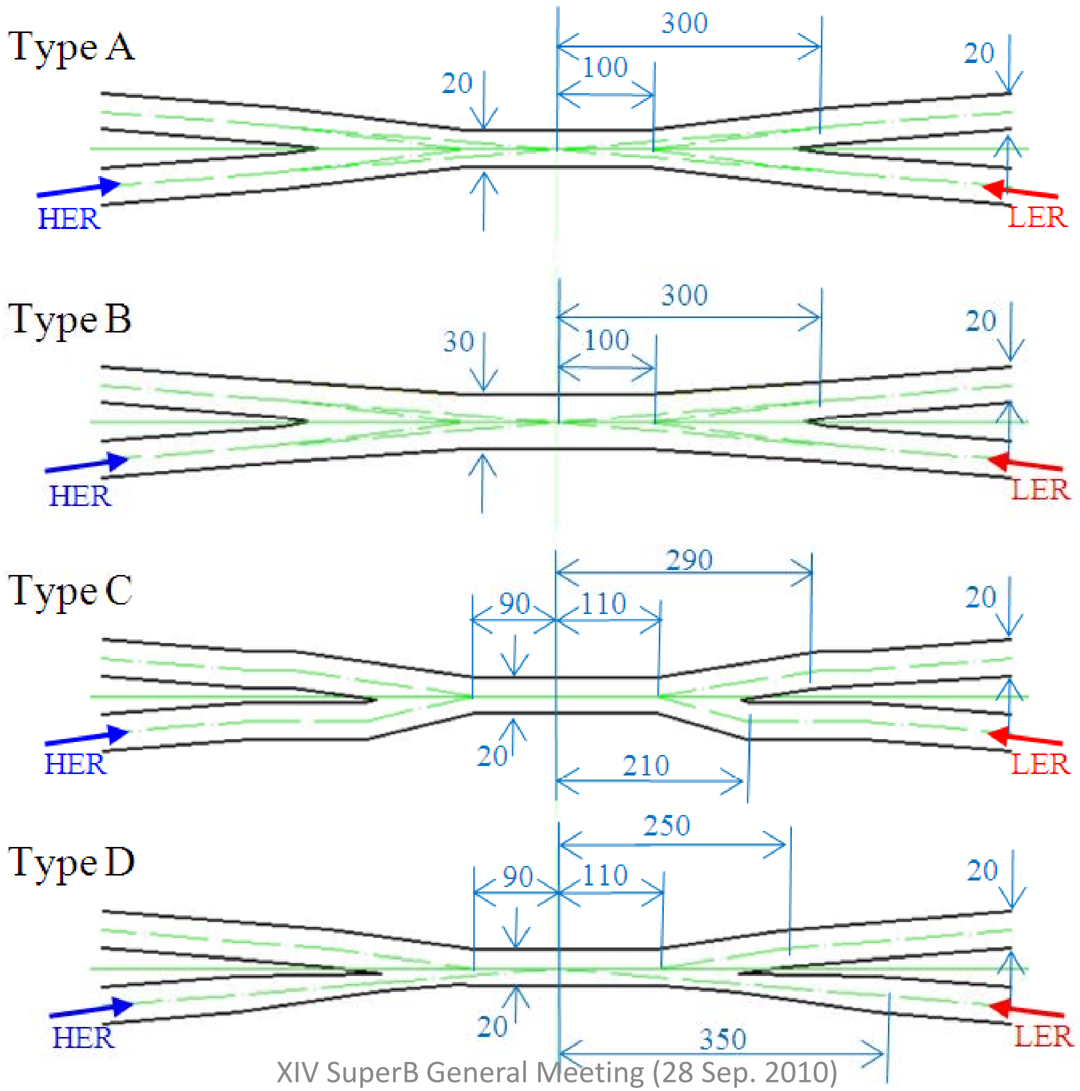


Cooling pipe connection on IP chamber

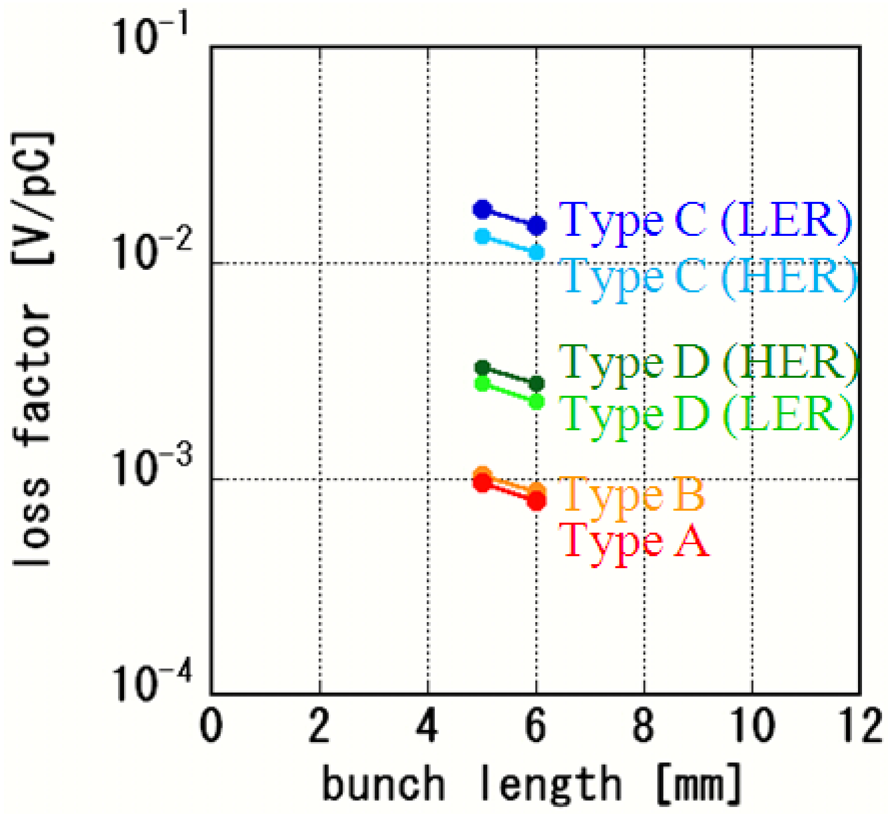


HOM simulation

チェンバーの種類


Type A
300
100
20
20
HER
LER
Type B
300
100
30
20
HER
LER
Type C
290
90
110
20
20
210
HER
LER
Type D
250
90
110
20
20
350
HER
LER

ロスファクター

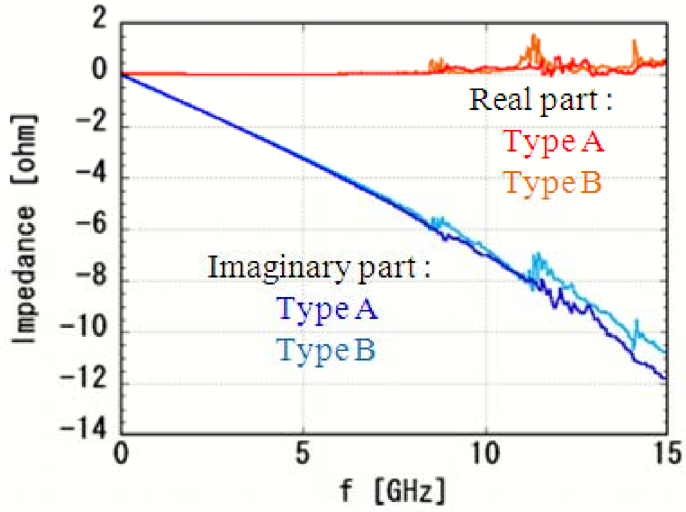


•Type A、Type Bと比べると、Type C、Type Dではロスファクターが大きくなっているが、これはダクトの折れ曲がりの影響だと考えられる。

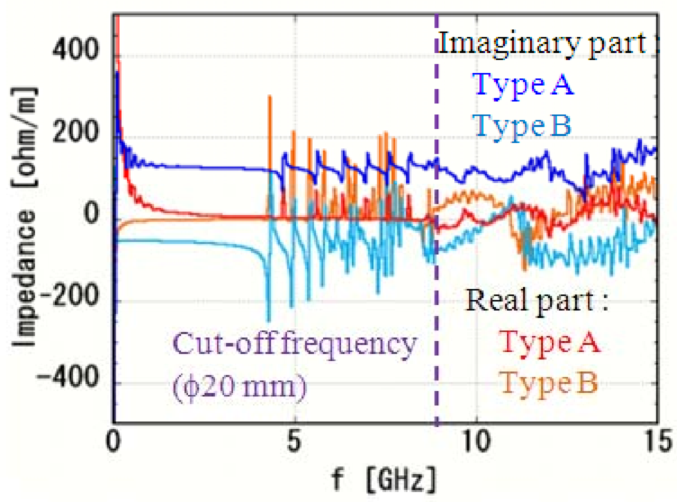
•Type CのロスファクターはType Dよりも大きくなっているが、これはType Dではダクト交差部で入射側のダクト径が小さくなっているため、発生するウェイク場が抑えられるためだと考えられる。

Impedance (Type A and Type B)

(a) 進行方向



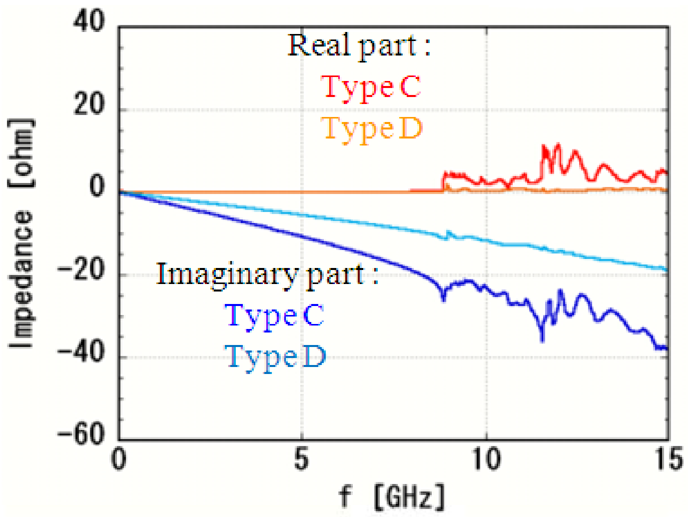
(b) 垂直方向



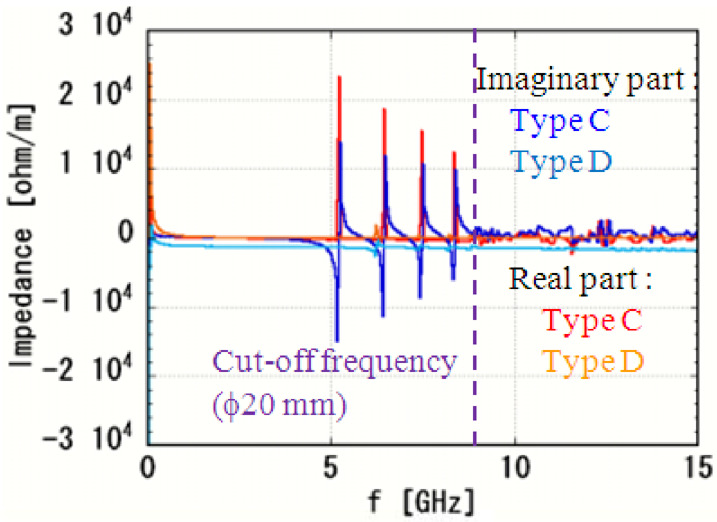
進行方向インピーダンスでは目立った捕捉モードは確認されなかったが、ビームを垂直方向に1~2 mmずらして計算した垂直方向インピーダンスでは、いくつかの捕捉モードが存在していることが分かった。これらのモードがどこに捕捉されているのかを調べるために、GdfidLでIPダクトの固有モード計算を行った。その結果、二股部に各ピークに対応する固有モード（TEモード）が存在していることが分かった。一方、ビームを水平方向にずらして得た水平方向インピーダンスのグラフには、目立ったピークは確認されなかった。

Impedance (Type C and Type D)

(a) 進行方向



(b) 垂直方向

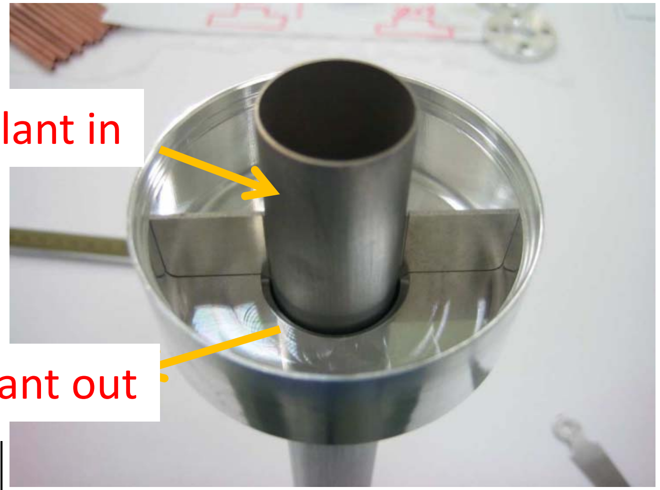


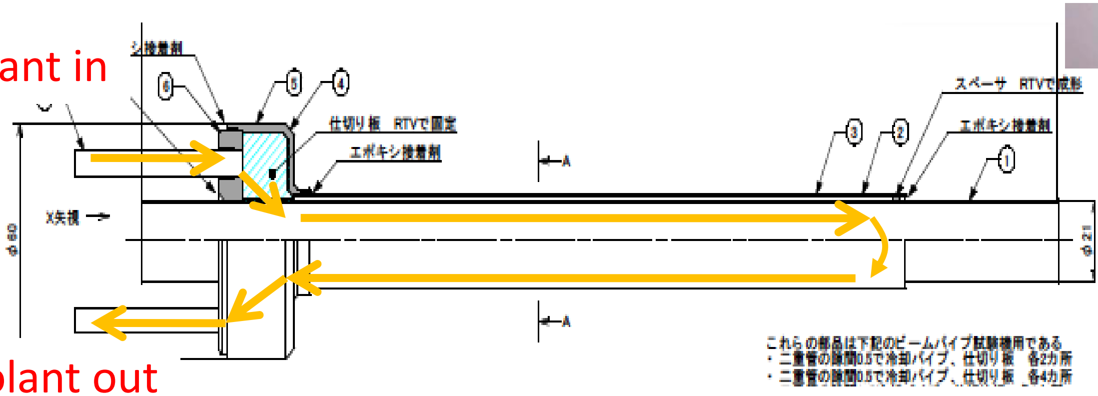
ビームはLERにのみ走らせている。進行方向には目立った捕捉モードは確認されなかった。垂直方向インピーダンスでは、特にType Cでいくつかのモードが捕捉されているのが確認された。これらのモードがダクトのどの部分に捕捉されているかは、これから確認する予定である。なお、こちらの場合も水平方向インピーダンスのグラフには、目立ったピークは存在していなかった。

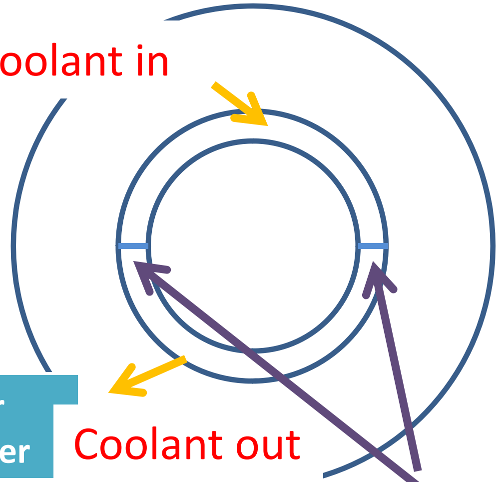
Cooling test

Mock-up for cooling test

- Material: Al, not Be
- Geometry: design value
- Coolant: water



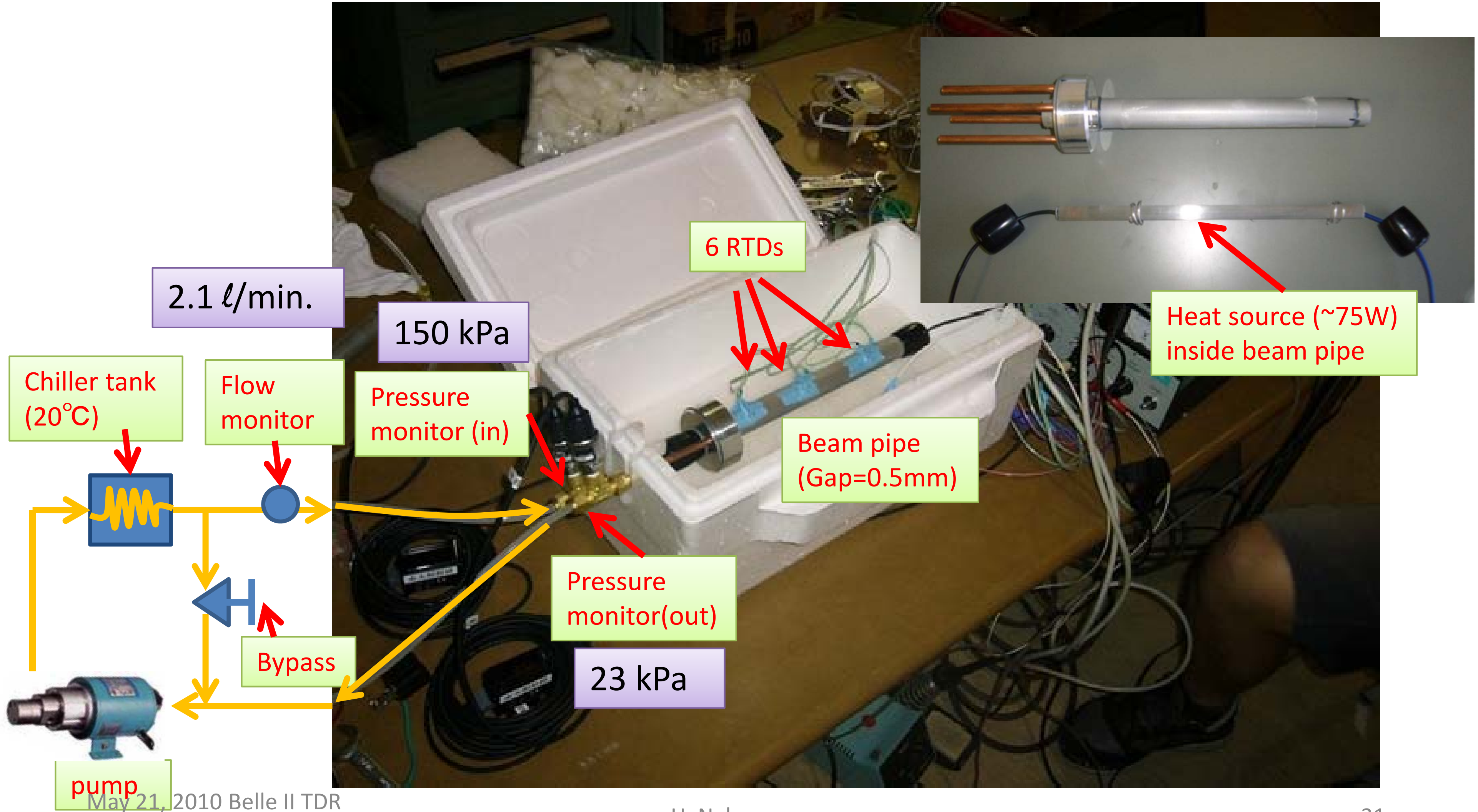




	Inner diameter	Inner pipe wall	Gap for coolant	Outer Pipe wall	Outer diameter
Cooling test mockup	20mm	Al 0.5mm	0.5mm/ 1.0mm	Al 0.5mm	23mm/ 24mm

Coolant gap is separated by 2 walls

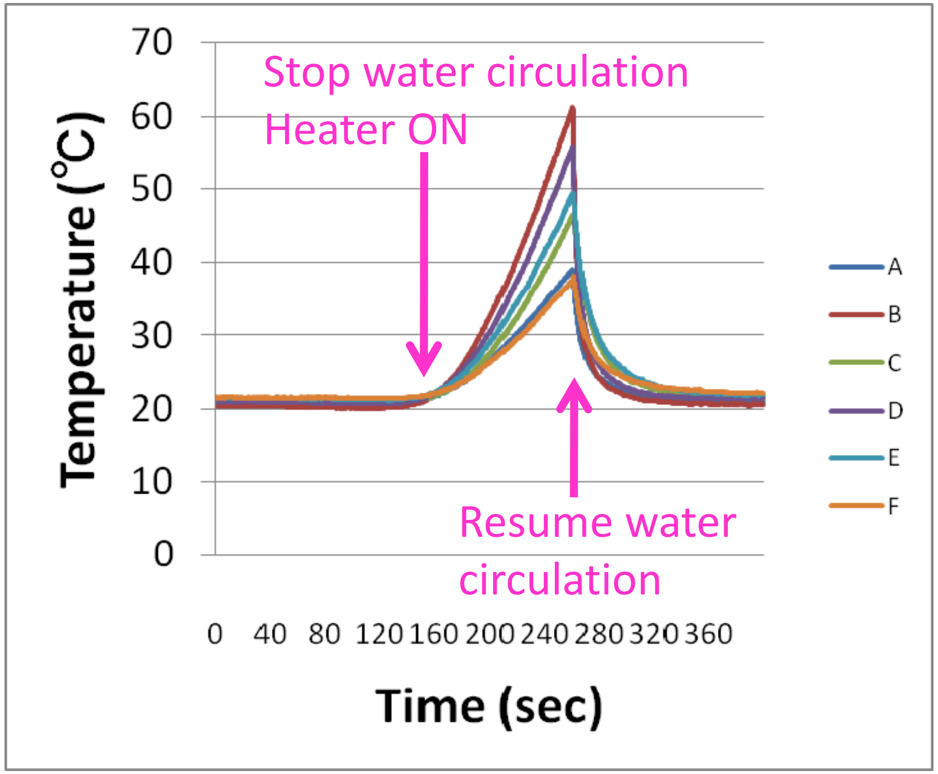
Cooling test setup

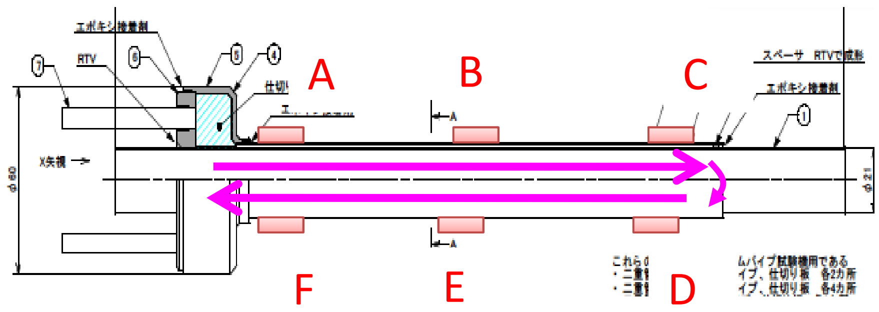


Results

21, May 2010

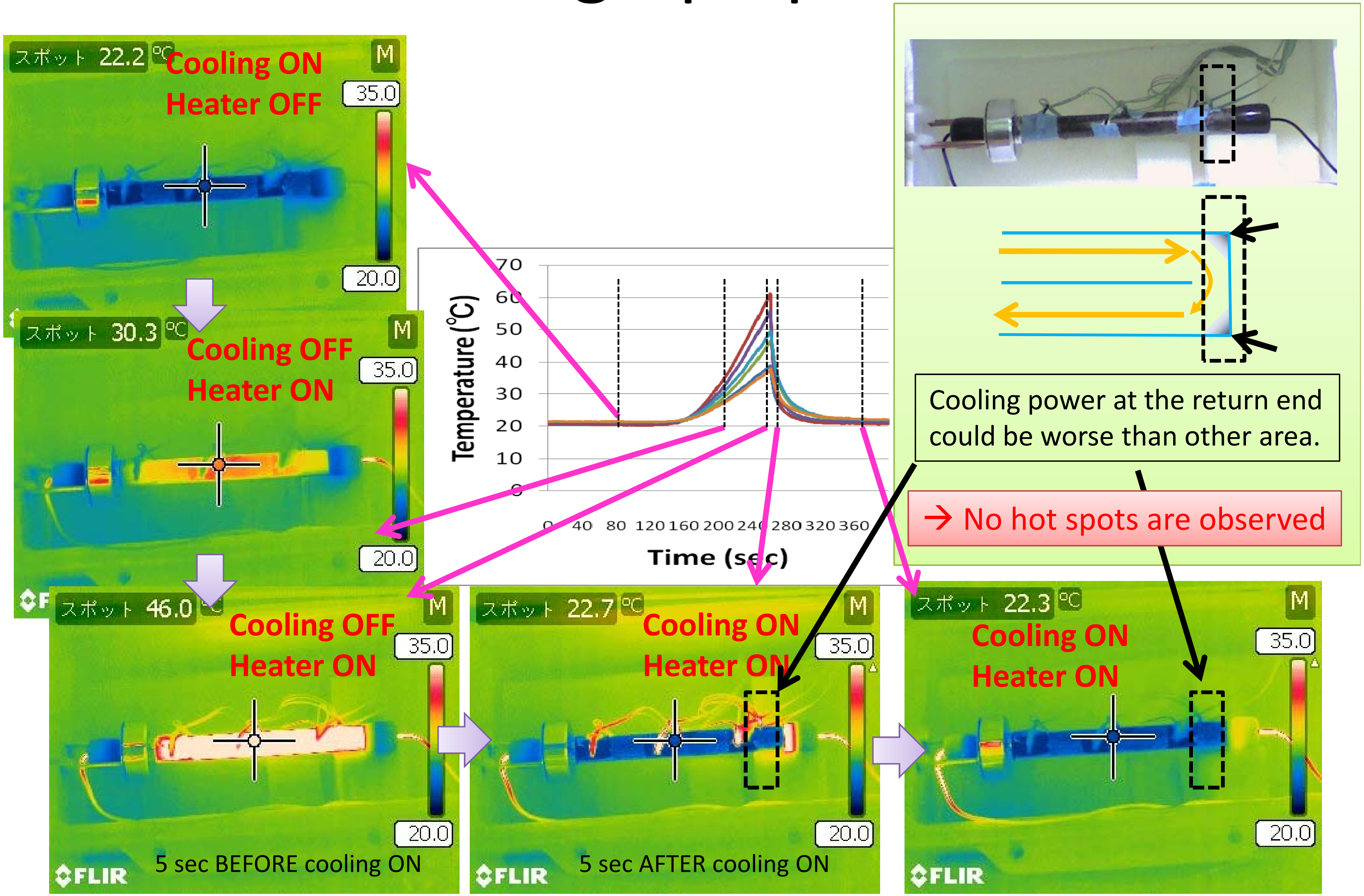
Temperature of beam-pipe is measured by 6 RTDs attached to beam-pipe surface.
RTD name: "A" to "F", from upstream to downstream.





Good cooling performance against ~75W heating

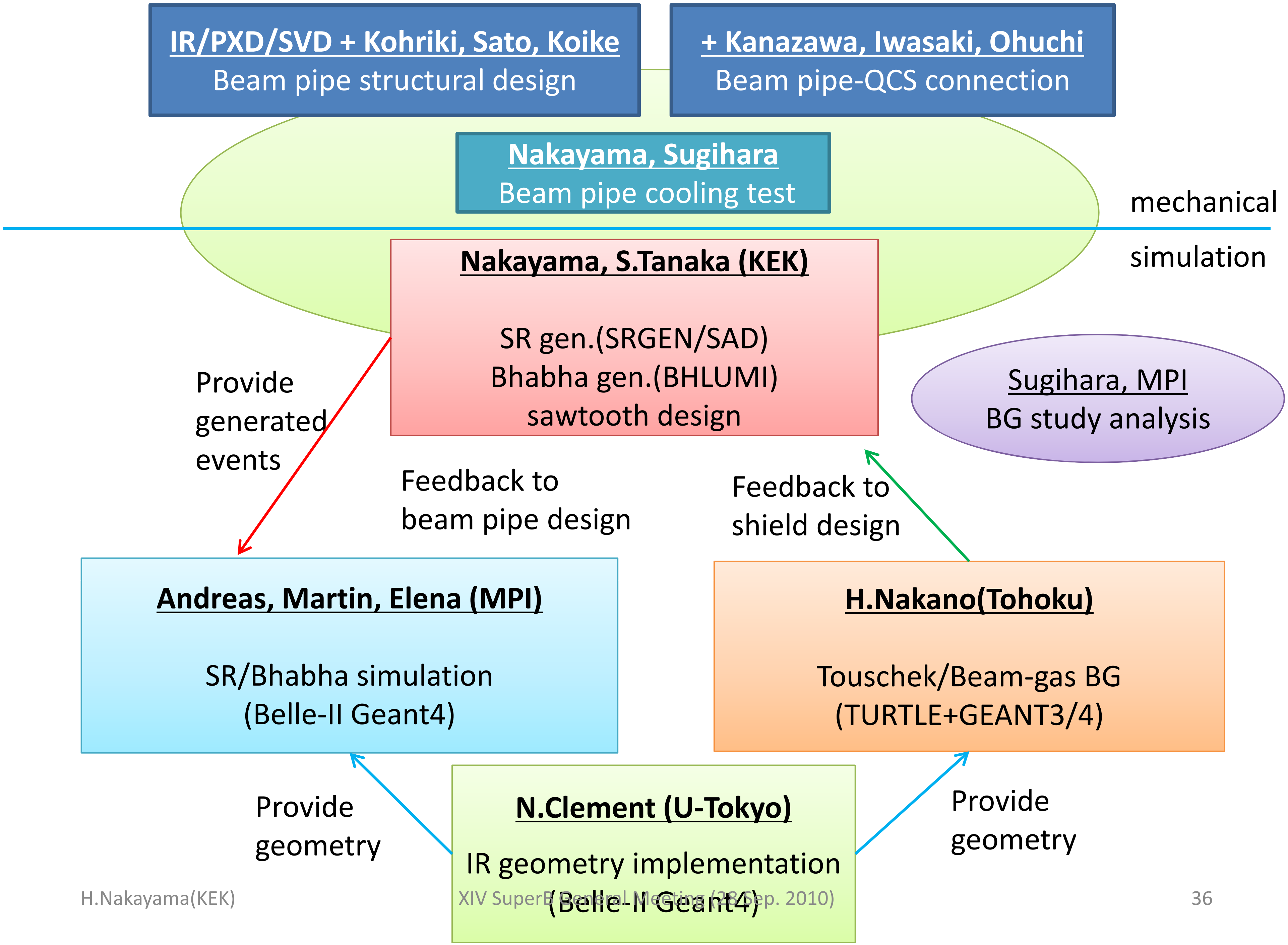
Thermograph pictures



BG simulation

IR tasks

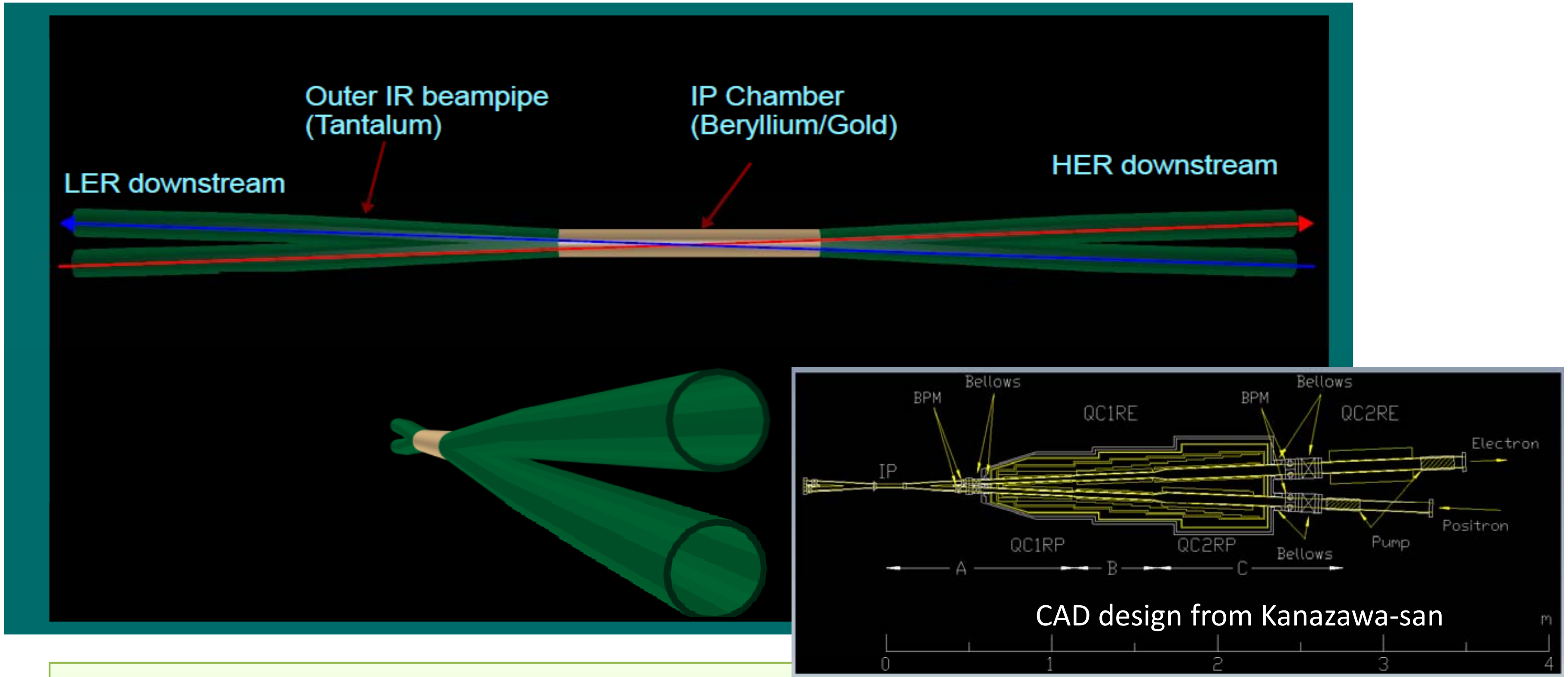
- **BG simulation**
  - Particle BG (Touschek, Beam-gas)
  - Radiative BhaBha
  - SR (upstream, back-scatter)
  - IR geometry implementation
- **BG study**
  - Touschek, Beam-gas study
  - QED study
- **Beam-pipe structural design**
  - Be center part (strength, cooling, fabrication method)
  - Ta crotched part (SR stopping, cooling, fabrication method)
  - QCS connection (BPMs, flanges, bellows, fastening method)
- **Other beam-pipe design**
  - Al mockup test for return cooling
  - Saw tooth design
  - HOM calculation
  - Heavy-metal shield design
  - Mirror current heating estimation
  - Vibration


IR/PXD/SVD + Kohriki, Sato, Koike
Beam pipe structural design
+ Kanazawa, Iwasaki, Ohuchi
Beam pipe-QCS connection
Nakayama, Sugihara
Beam pipe cooling test
mechanical
simulation
Nakayama, S.Tanaka (KEK)
SR gen.(SRGEN/SAD)
Bhabha gen.(BHLUMI)
sawtooth design
Sugihara, MPI
BG study analysis
Provide generated events
Feedback to beam pipe design
Feedback to shield design
Andreas, Martin, Elena (MPI)
SR/Bhabha simulation
(Belle-II Geant4)
H.Nakano(Tohoku)
Touschek/Beam-gas BG
(TURTLE+GEANT3/4)
Provide geometry
N.Clement (U-Tokyo)
IR geometry implementation
(Belle-II Geant4)
Provide geometry

BG simulation group

- Japan
  - KEK: H.Nakayama, (S.Tanaka, T.Hara)
  - Tokyo: N.Clement, S.Sugihara
  - Tohoku: H.Nakano (supervised by Prof.Yamamoto)
- MPI
  - C.Kiesling, A.Moll, M.Ritter, H.G.Moser, E.

0. Geometry implementation to Belle-II Geant4 (Clement)



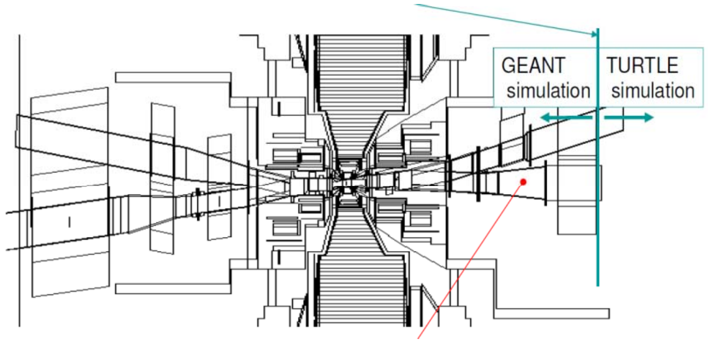
CAD design from Kanazawa-san

Status

- So far, Be/Ta part is implemented with symmetric design
- June design is coming, then July design (including taper part)
- Shield, magnet, etc.. will be coming

Simulation method:
1,2. Touschek/Beam-gas

- Simulation framework (Nakano)
  - **TURTLE** + **Belle-II Geant4** (at first, Geant3)
    - Ring part: matrix calculation by TURTLE
    - IR-nearby: step-by-step tracking by Geant4
- Generator (Nakano)
  - No specific generator used
  - Change direction/energy according to theoretical equation

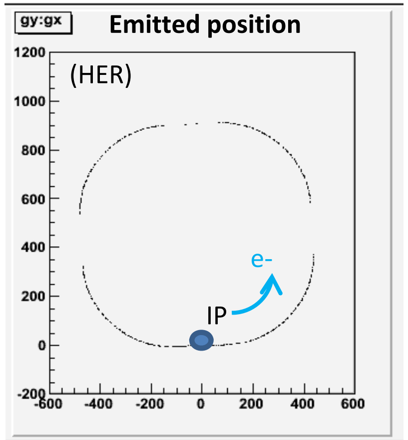


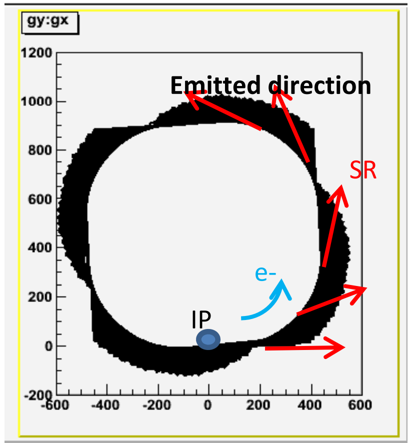
Status

- Still working on KEKB simulation. Need more time for SuperKEKB.
- Heavy metal shield study is urgent.
  SVD group should decide "slant" or "straight" by this autumn.
  "Slant" means less heavy-metal shield than "straight".
- Run Geant4 simulation with reasonable energy assumption?
  Or, use SAD simulation output (by Ohnishi) for Geant4 input?
  These can be done within Belle-II Geant4 framework, without TURTLE.

Simulation method
3. SR Background

- Simulation framework (MPI)
  - **Belle-II Geant4**
    - simulate SR absorption/reflection by Geant4
      (Geant4 can take care of interaction of very low-energy photon)
    - Surface effect is very difficult to simulate. (EGS?)
- Generator (KEK)
  - A) **SADtoSR** or B) **SRGEN** or C) LCBDS
  - So far, use A. (No need for optics conversion)

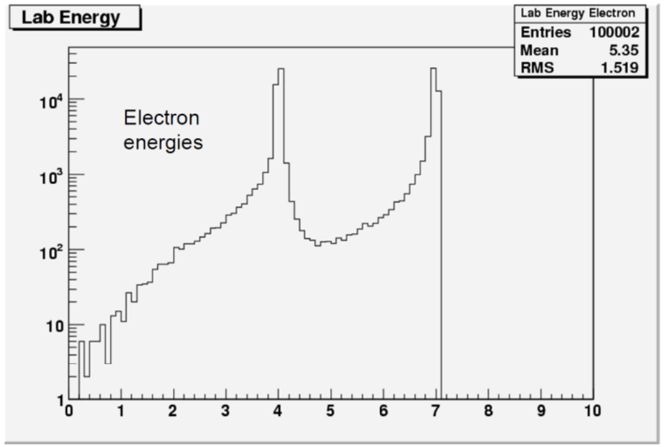


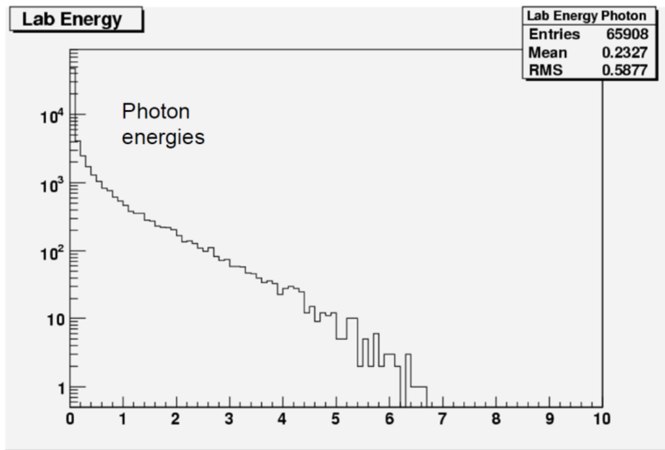


Status
- Start SADtoSR.
- Need to validate SADtoSR function using simple model.
- Need cross-check with Iwasaki-san's LCBDS results.

Simulation method
4. Rad. Bhabha

- <u>Simulation framework (MPI)</u>
  - **Belle-II Geant4**
    - simulate interaction of $\gamma/e^{+/-}$ with matter by Geant4
- <u>Generator(KEK,MPI)</u>
  - A) **BHLUMI** or B) **BHWIDE** or c) **BBbrem**

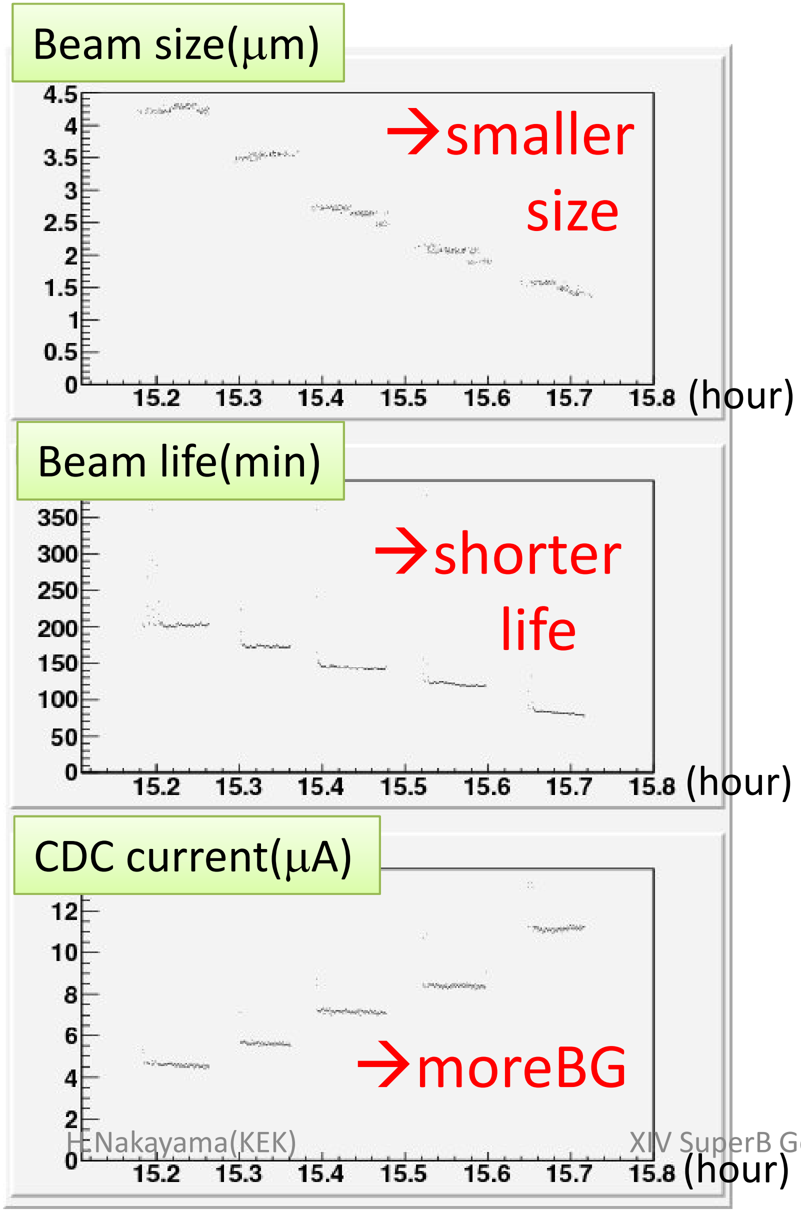


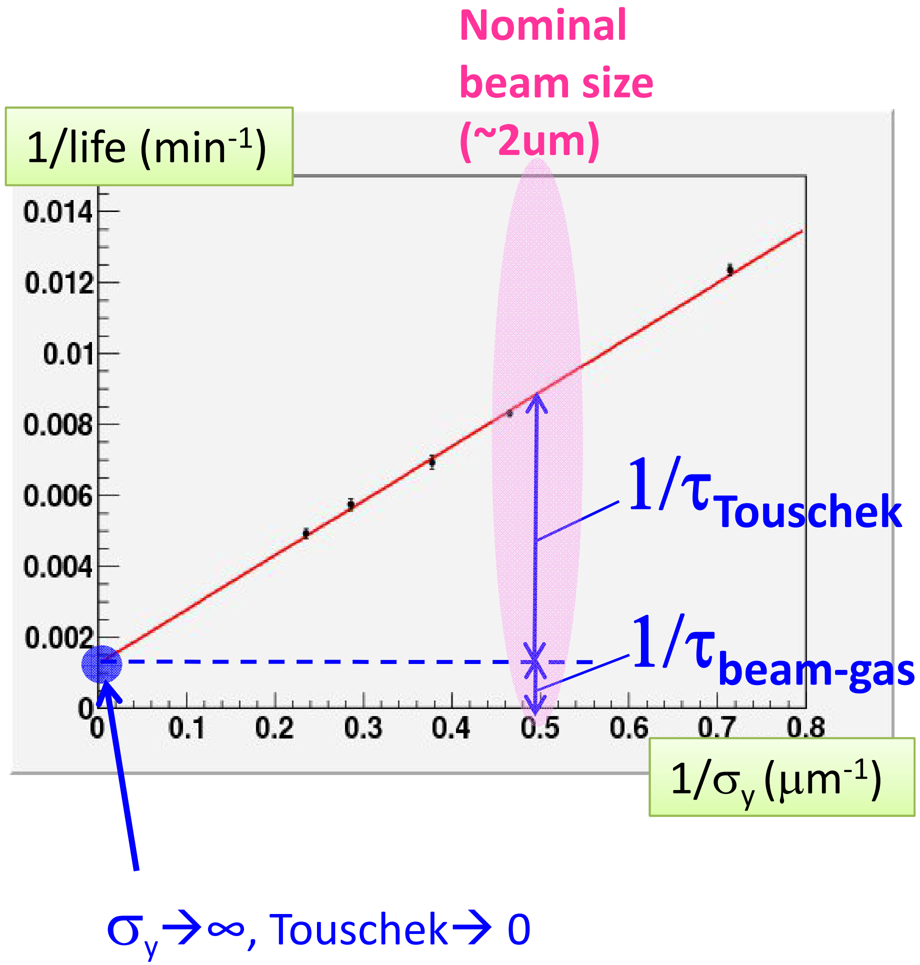


Status
- Start running generator
- Need cross-check with Funakoshi-san's results.

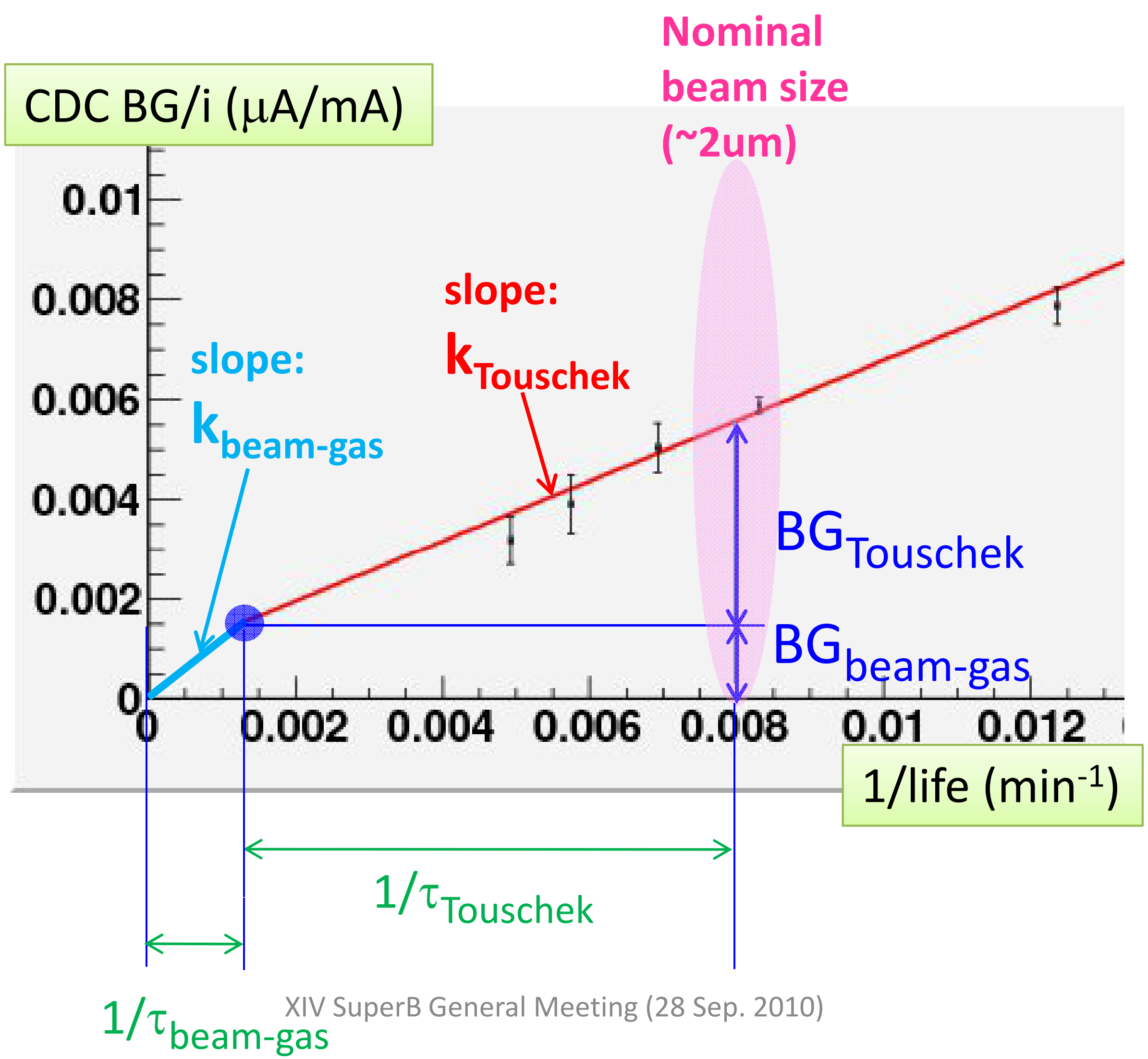
Touschek/Beam-gas machine study

How to measure $\tau_{Touschek}$, $\tau_{beam\text{-}gas}$



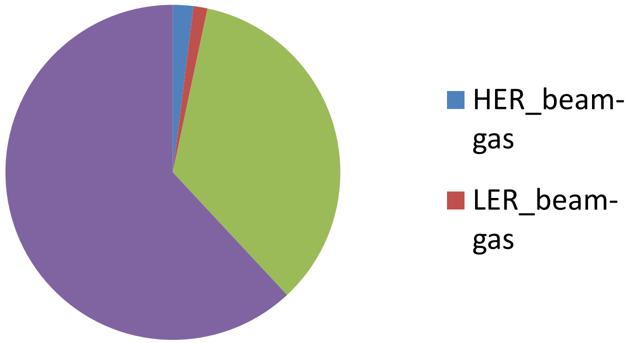


How to measure $k_{Touschek}$, $k_{beam\text{-}gas}$

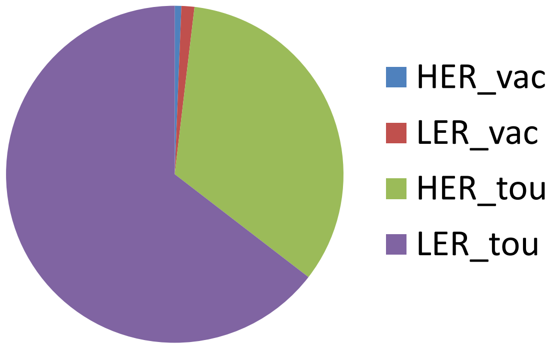


Estimated BG fraction at SuperKEKB

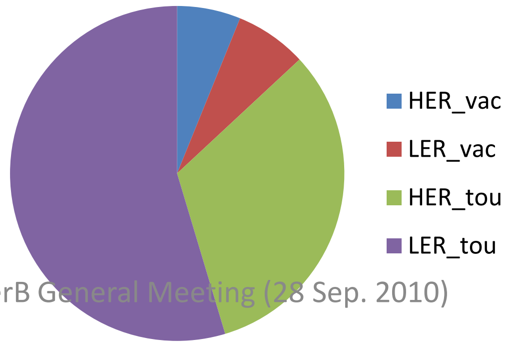
CDC



SVD



ECL



QED

QED Background at Belle experiment

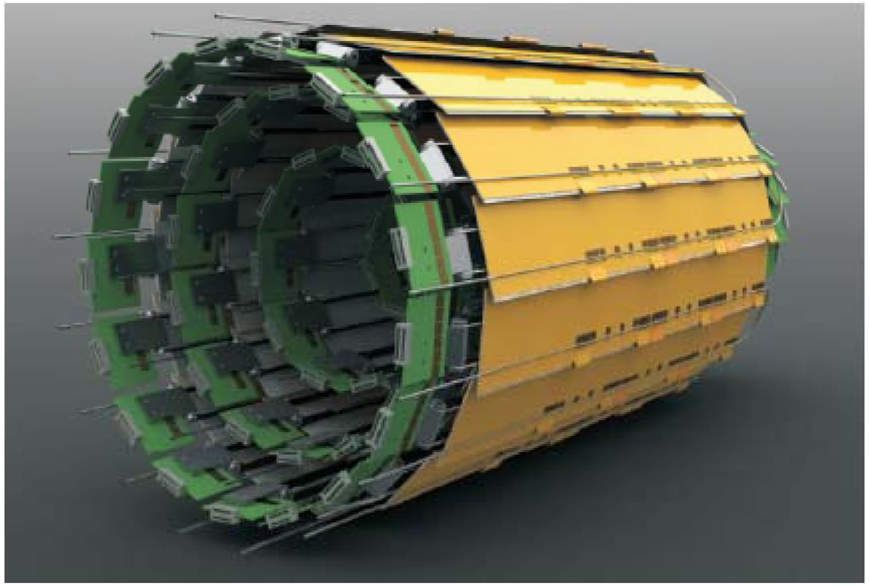
Elena Nedelkovska
Max – Planck Institute for physics, Munich

- Expected background at BELLE II
- QED Background Experiments
- Background analysis
- Next steps
- Conclusions

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Si - Detectors

Strips vs Pixels

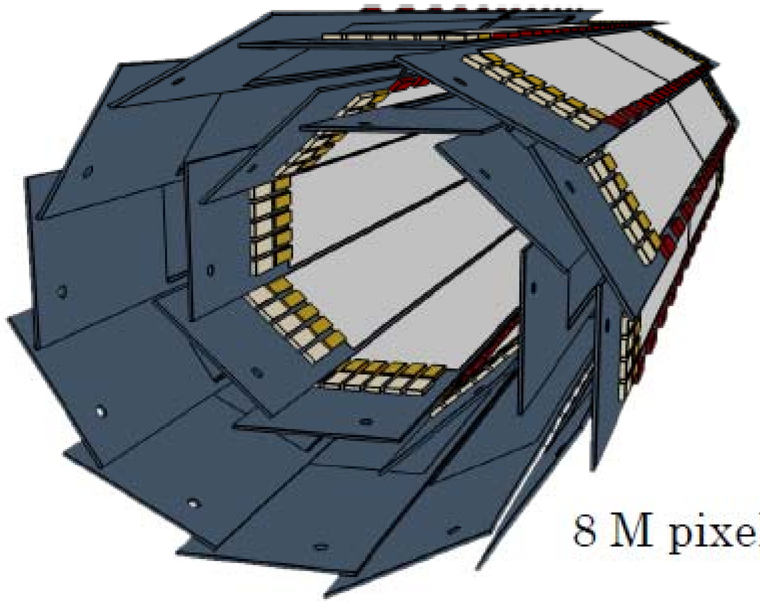


Silicon Vertex Detector at Belle II

- **4 layers**
- **DSSDs**
  - **z strips**
  - **phi strips**

4 cm

Pixel Vertex Detector (PXD)



8 M pixels

has to handle harsh background at Belle II

2 layers

- **1.4 cm**
- **2.2 cm**

Expected Background at Belle II

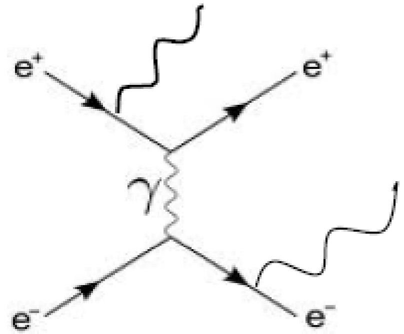
Machine background

expected increase by a factor of 2 (due to current)

- Beam – gas scattering (bremstrahlung and Coulomb scattering)
- Touschek effect (intra – bunch scattering)
- Synchrotron Radiation

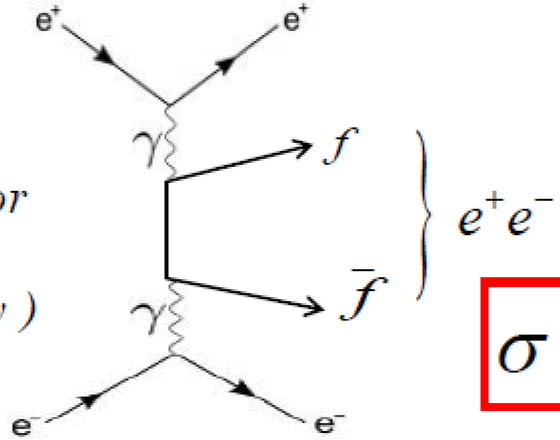
Luminosity – related background

- Radiative Bhabha scattering
- $\gamma\gamma$ reactions



$$\sigma \sim 50nb$$

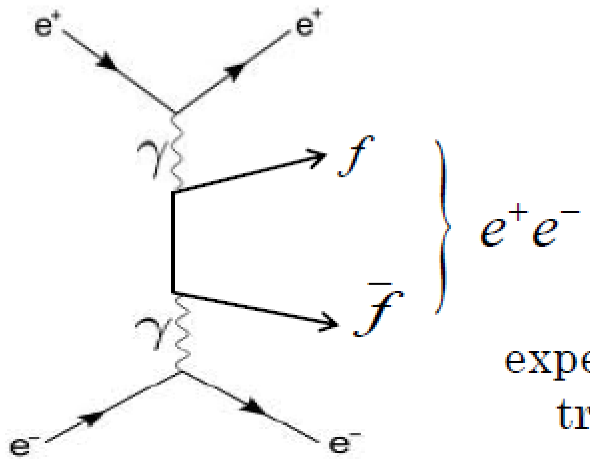
increase by a factor of 40 (due to luminosity)



$$\sigma \sim O(10^7 nb)$$

QED Processes – 2 photon processes

t – channel processes



- Berends – Daverfeldt – Kleiss (BDK)
- S.Jadach et al. (KW)
- J.Fujimoto et al. (Grace)

expected background tracks per event → ***Occupancy (inner layer):***

BDK: 0.07%
KW: 0.1%

in strong disagreement with the number form SuperB (a factor of 15 difference)

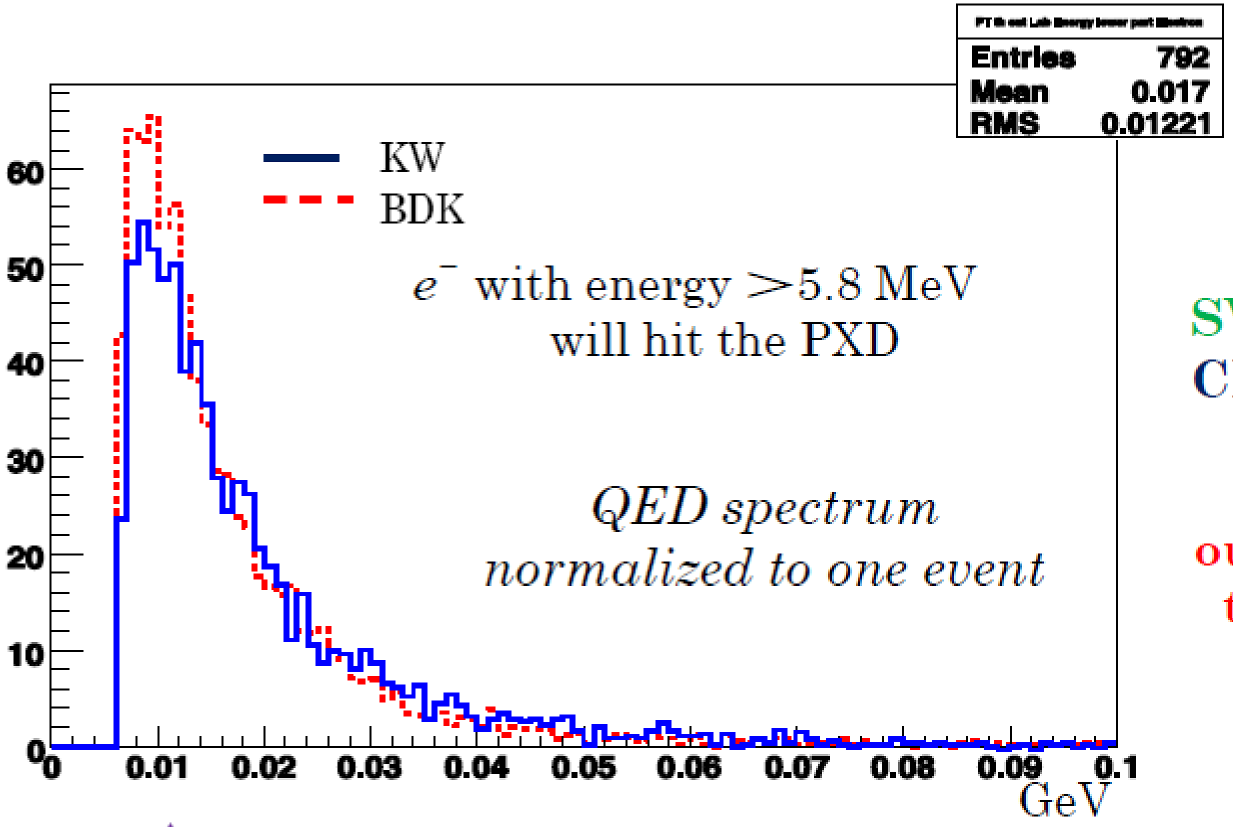
our three MCs are consistent

SuperB, Italy
$rate \rightarrow 10MHz/cm^2$

PXD:

$tracks \rightarrow 13800$ ← per event
$occupancy \rightarrow 1.3\%$ ← would be a problem

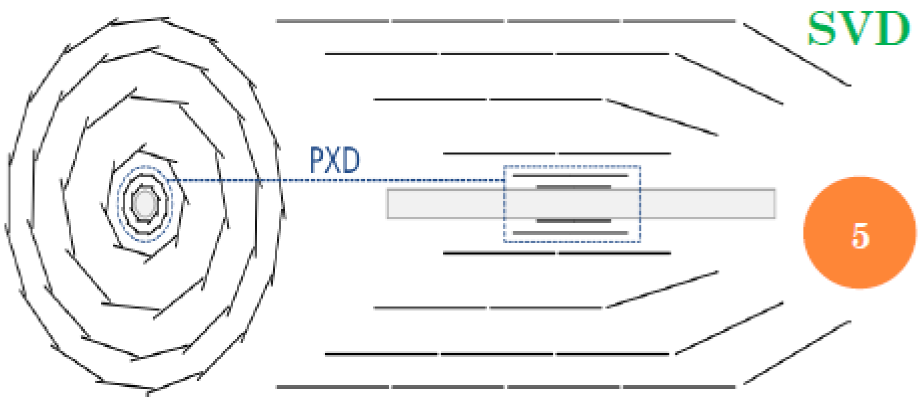
QED Processes – 2 photon processes



SVD : > 40 MeV
CDC : > 100 MeV

our MC gives ~ 800 tracks per event

high rate at very low momentum
(~ 5 – 20 MeV)



→ Look at real data from Belle to decide between MC's

➢ A few MeV cannot be triggered at Belle

↓

Therefore:

Random Triggers (unbiased background)

Assumption : the "non – physics" hits in the SVD

- beam background (expected to be ~ beam current)
- QED processes (~ luminosity)

Idea:

separation of the two components and thus determine the QED cross section

QED Expectations

SuperKEKB Simulation: ~ 800 tracks per PXD frame
(~ 13 000 tracks, SuperB Simulation)

- L ~ 1000 /nbs
- Integration time = 20 μs **(PXD)**

Scale to **KEKB**:

Factor 1000 less: 0.8 tracks per SVD frame

- L ~ 10 /nbs ($10^{32} cm^{-2} s^{-1}$)
- Integration time = 2 μs **(SVD)**

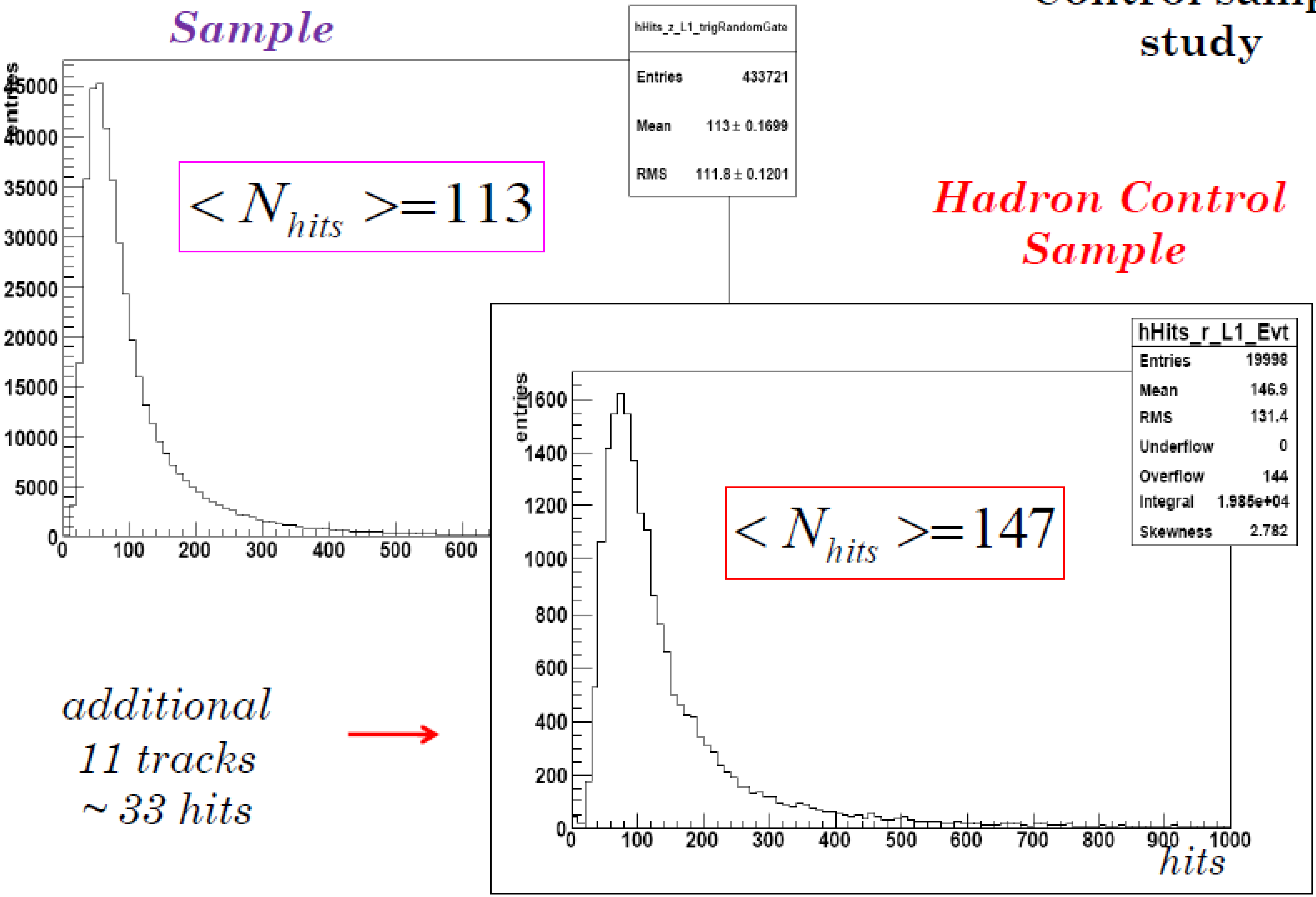
Belle		**Belle II**
SuperB MC :	3 hits/track	
22 hits	←	expected hits in layer 1 SVD
Our MC :		
1.5 hits	←	expected hits in layer 1 SVD

SVD Hit Multiplicity

Random Trigger Sample

Control sample study

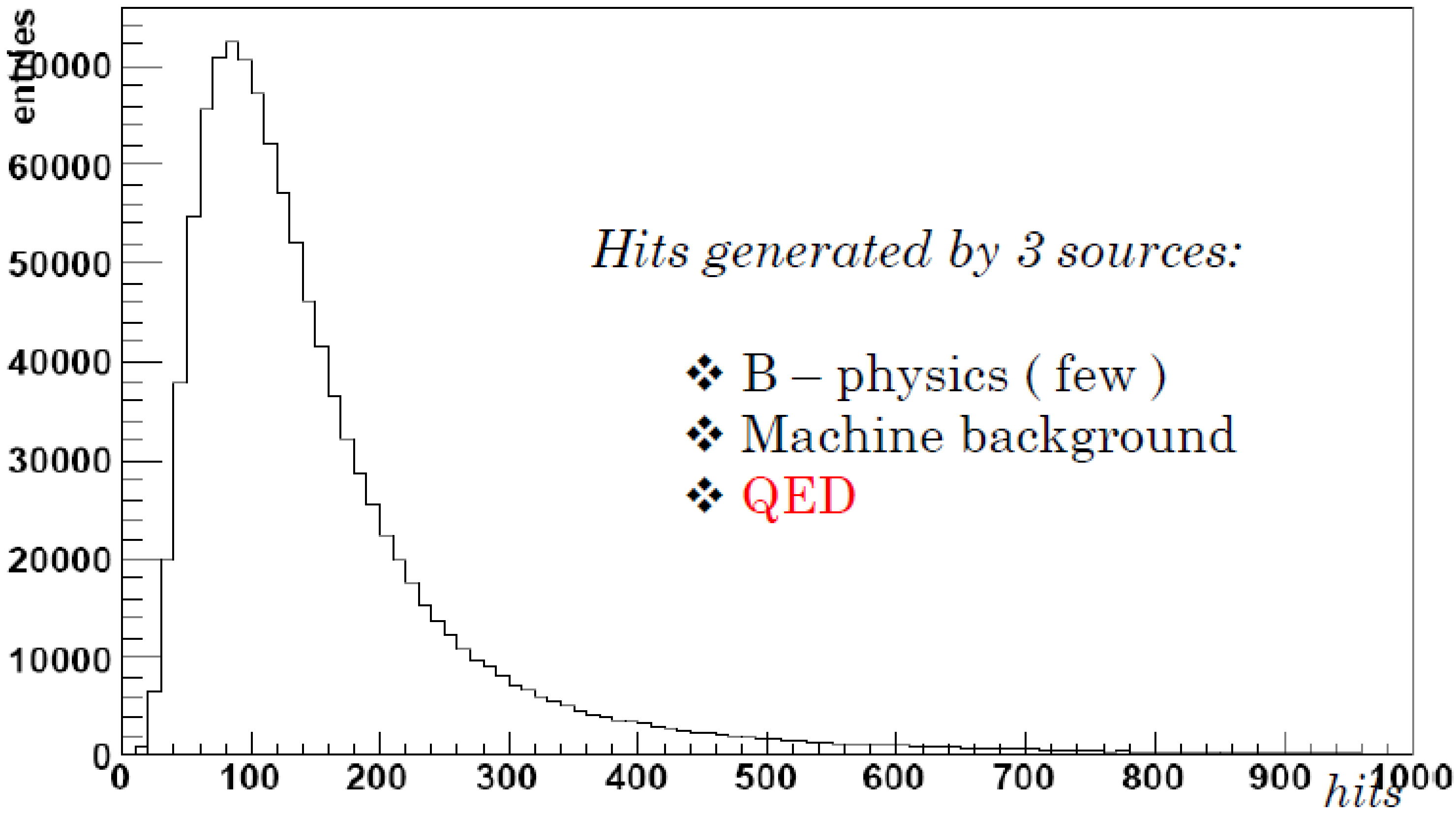
Hadron Control Sample



additional 11 tracks ~ 33 hits →

QED “Measurement”

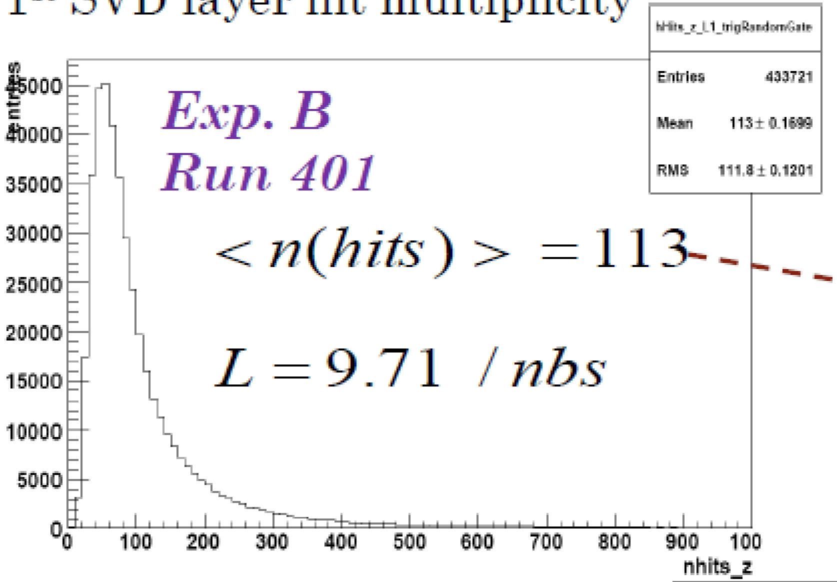
Hit multiplicity in the SVD per **randomly triggered** event

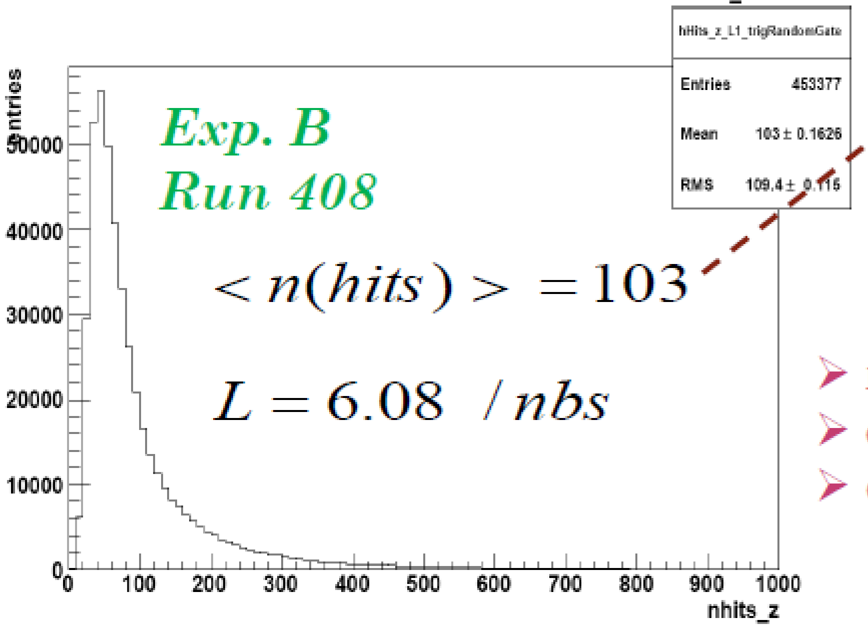


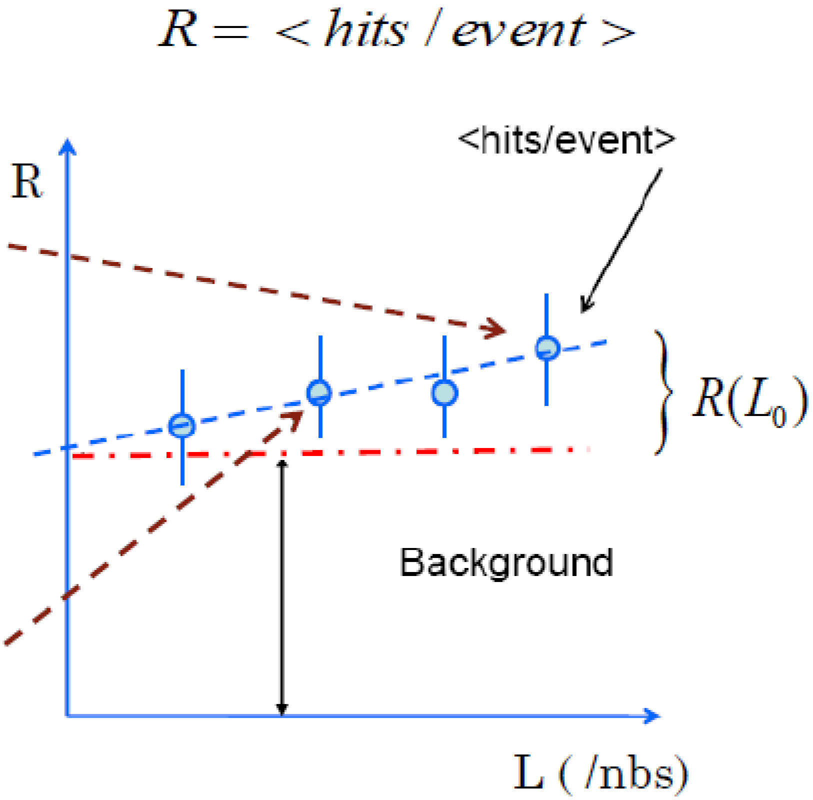
To do: Try to separate the three sources by measuring < hit/event > as function of luminosity

QED "Measurement"

1st SVD layer hit multiplicity







- measure R as function of L
- extrapolate to L = 0 ("non – QED" BG)
- difference → QED rate

Random Trigger Runs and Data Sample

Exp. A (**separate the beams vertically**)
Run (415 – 420) each run 500 k triggers

Exp. B (**increase vertical beam size in HER**)
Run (401 – 411) each run 500 k trigger

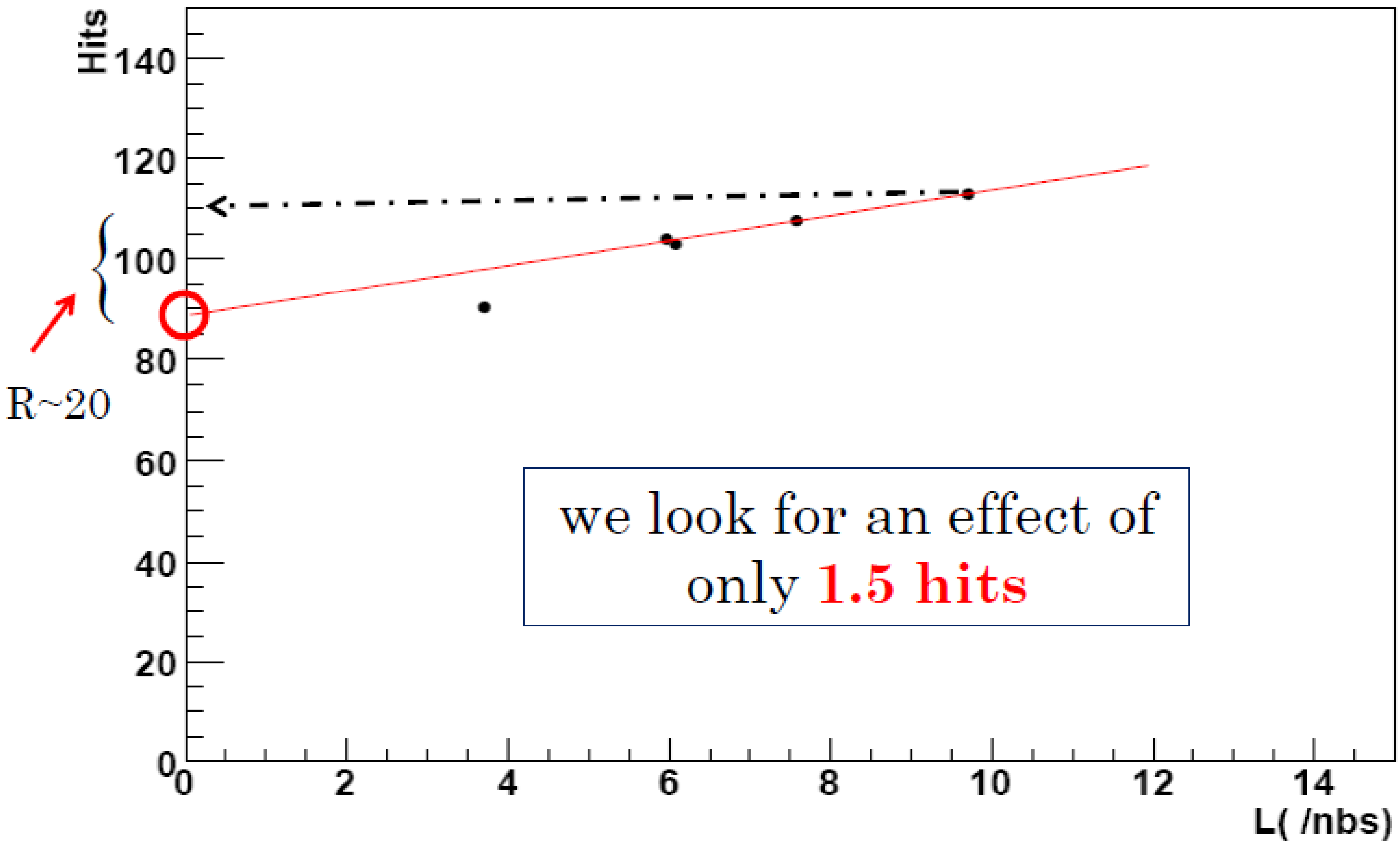
Exp. C (**change beam currents by stopping injection**)
Run (421 – 427) each run 10 min

Random trigger rate: 400Hz
Bhabha trigger rate: 50Hz moderate start luminosity (~ 10/nbs)

Each experiment started with a run ~ 10 /nbs (" default ")
500 k triggers at 400Hz = 30 min (including beam setup)
vary luminosity steps of 2 /nbs
10, 8, 6, 4 /nbs

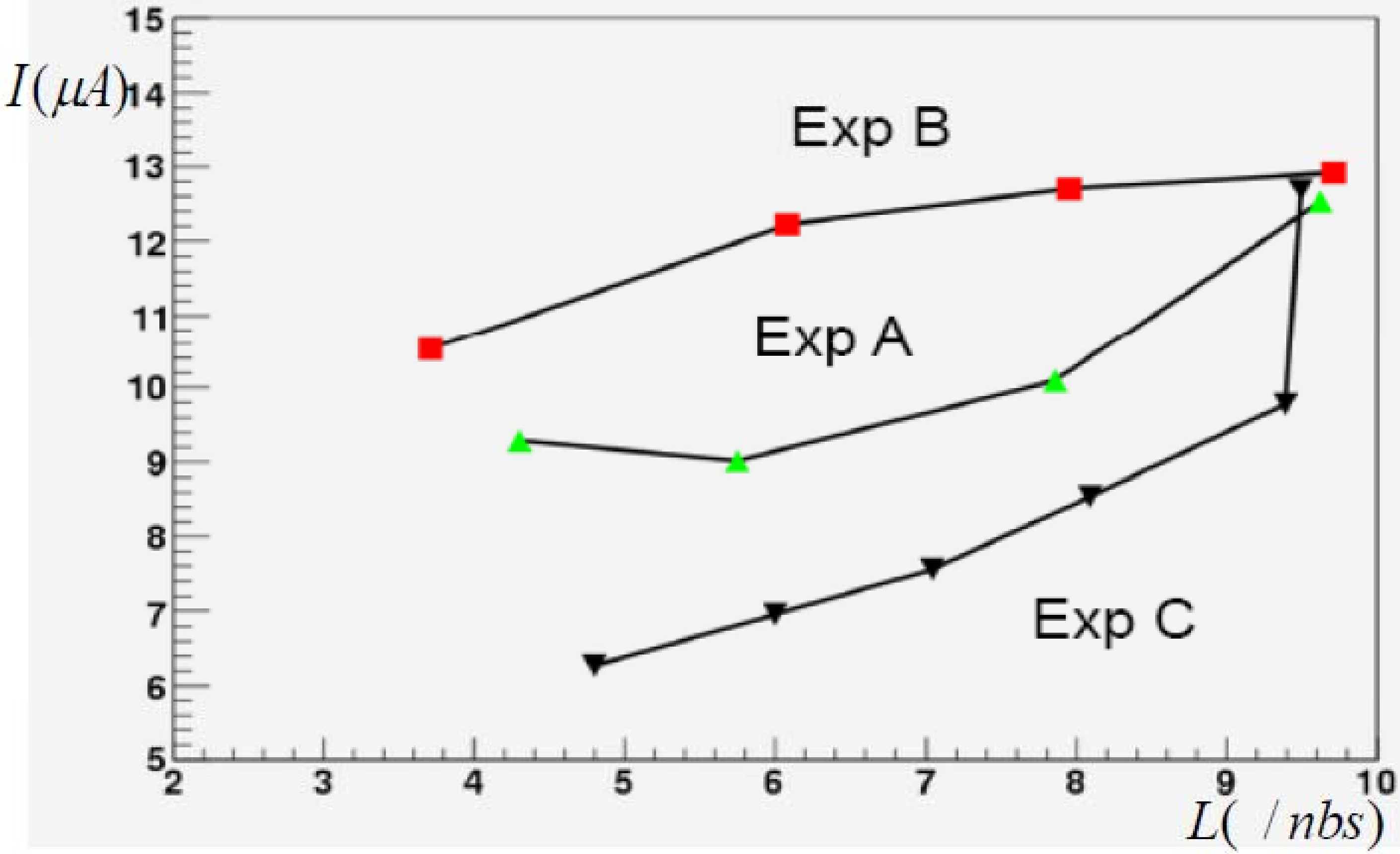
Exp. B

Hit multiplicity in the 1st layer of the SVD for Z strips as function of luminosity



Beam Background Monitoring

CDC (Central Drift Chamber) currents as function of luminosity



Exp. A and Exp. B - **no current change**

Only for Exp. C - **current change**

The different behavior of A, B (and C) is unexpected and unexplained

Development of analysis strategies

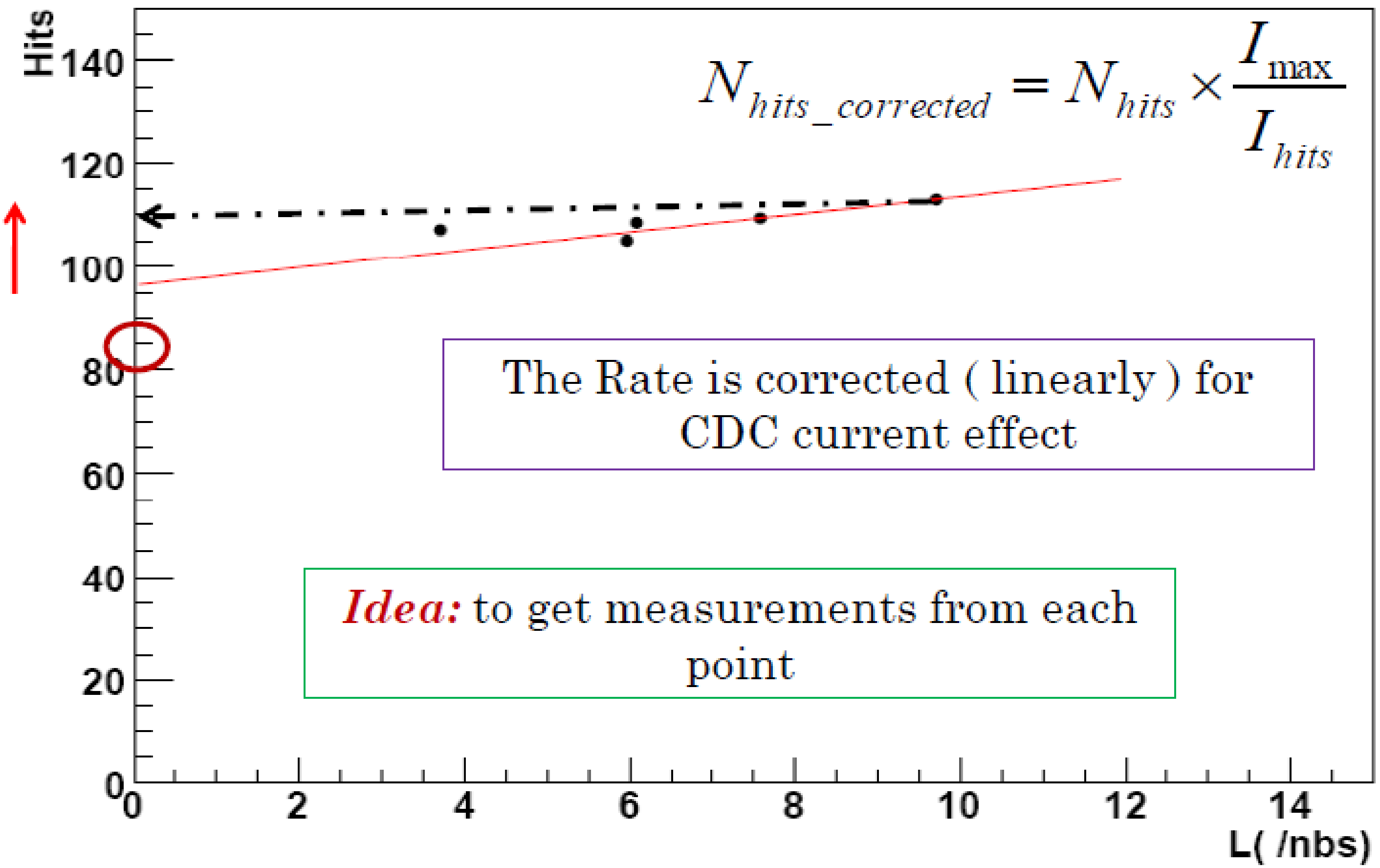
- Background is not independent of luminosity (in all exp.)
- More refined strategies are needed to limit QED
- CDC current varies with Luminosity

→ ***There is luminosity – related background other than 2 photon QED***

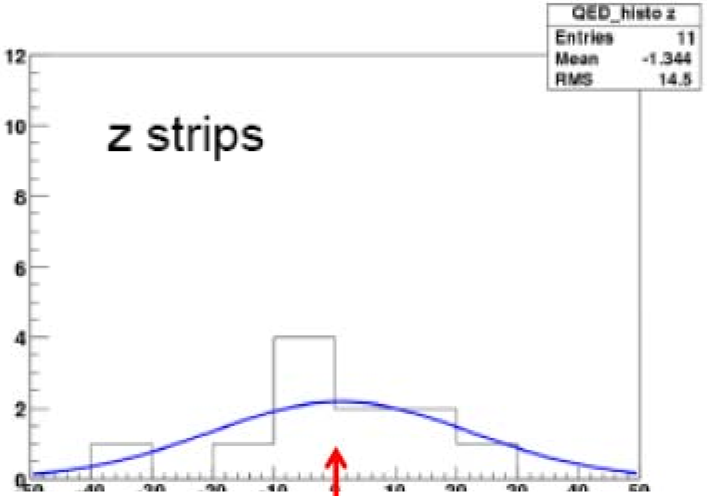
- This luminosity – related variation must be interpreted as background
- Correction due to CDC current variation will " flatten " the background

CDC correction analysis strategy

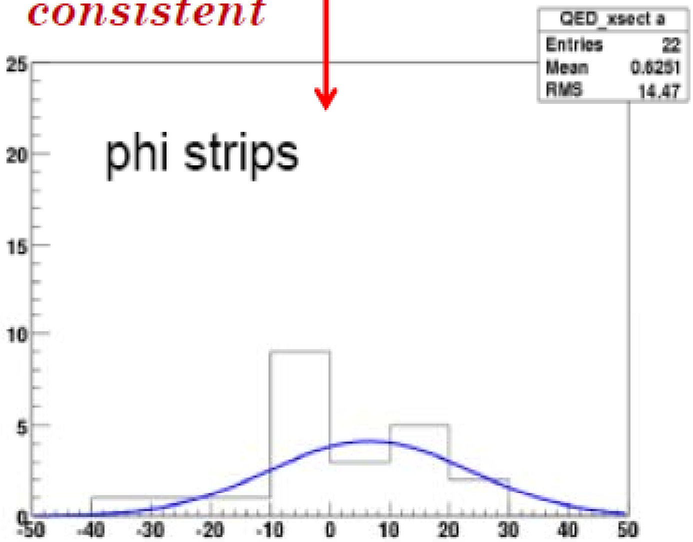
Hit multiplicity in the 1st layer of the SVD for Z strips with CDC correction included



Analysis strategy outcome



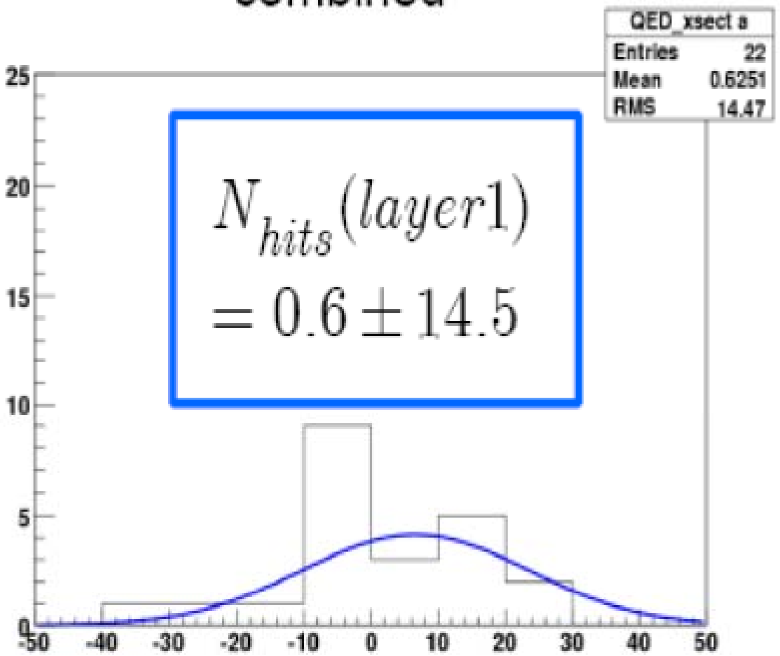
consistent



1[st] layer:

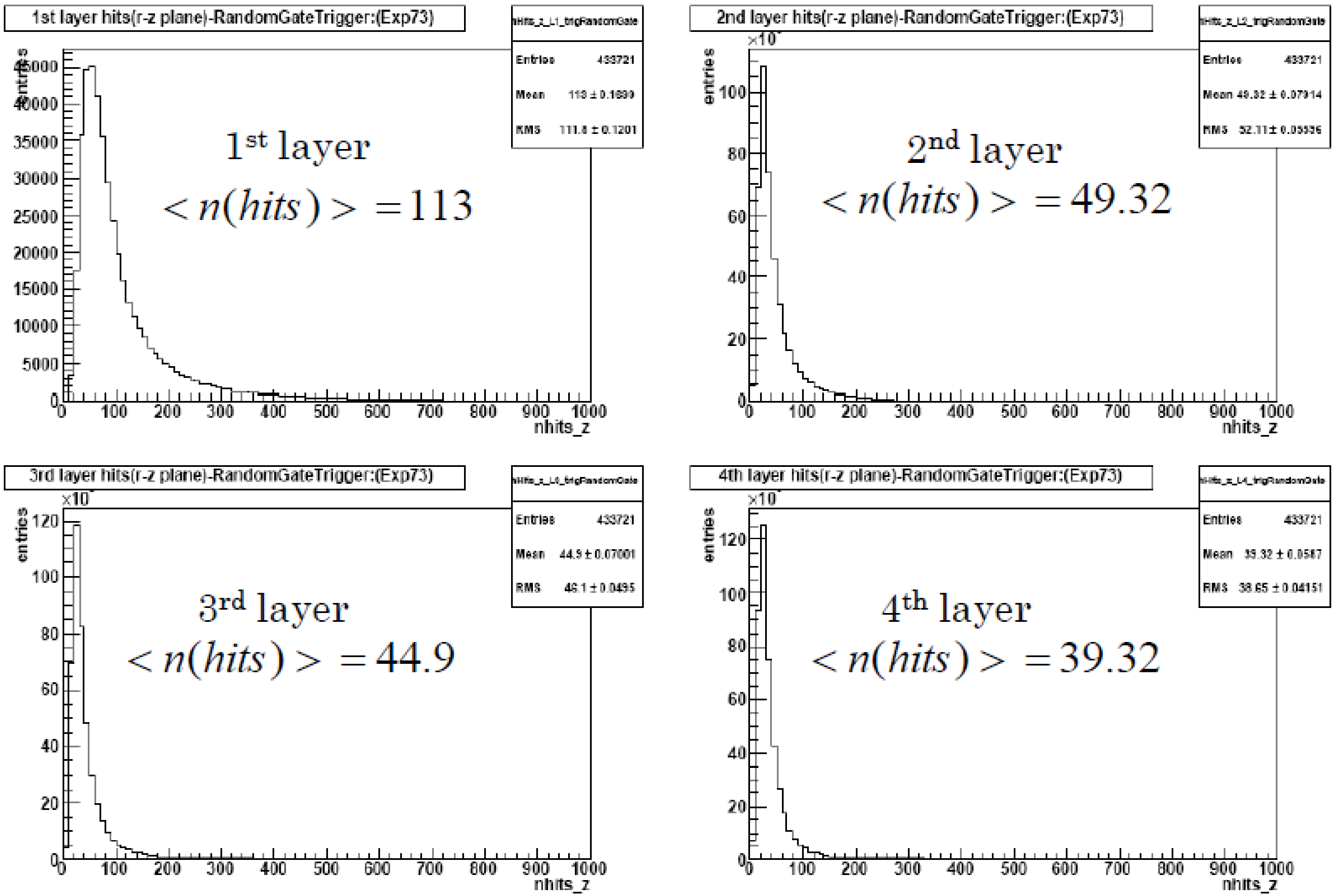
$$N_{KW}(Layer1) = 1.49$$

combined



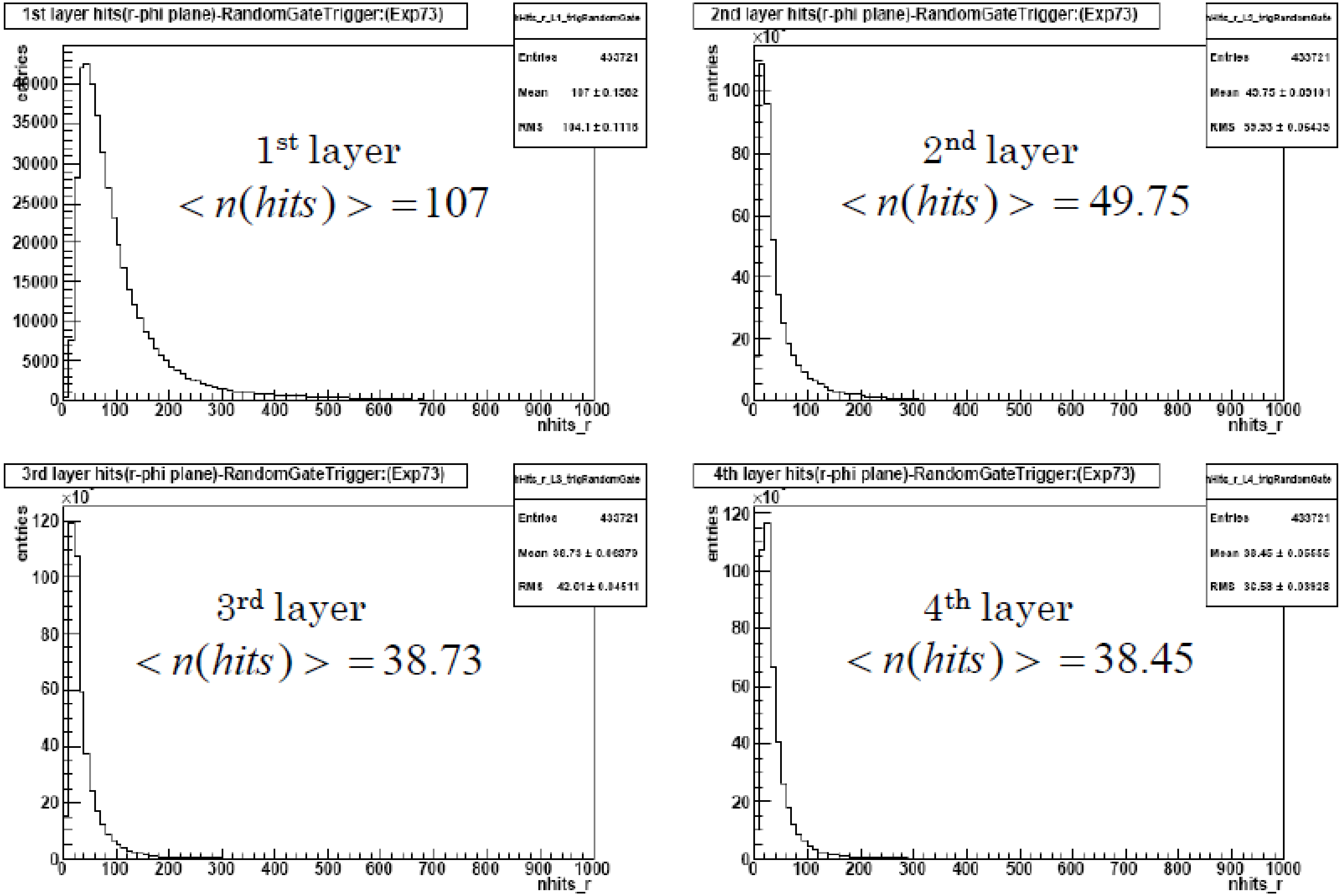
Use also the higher layers

Z strips



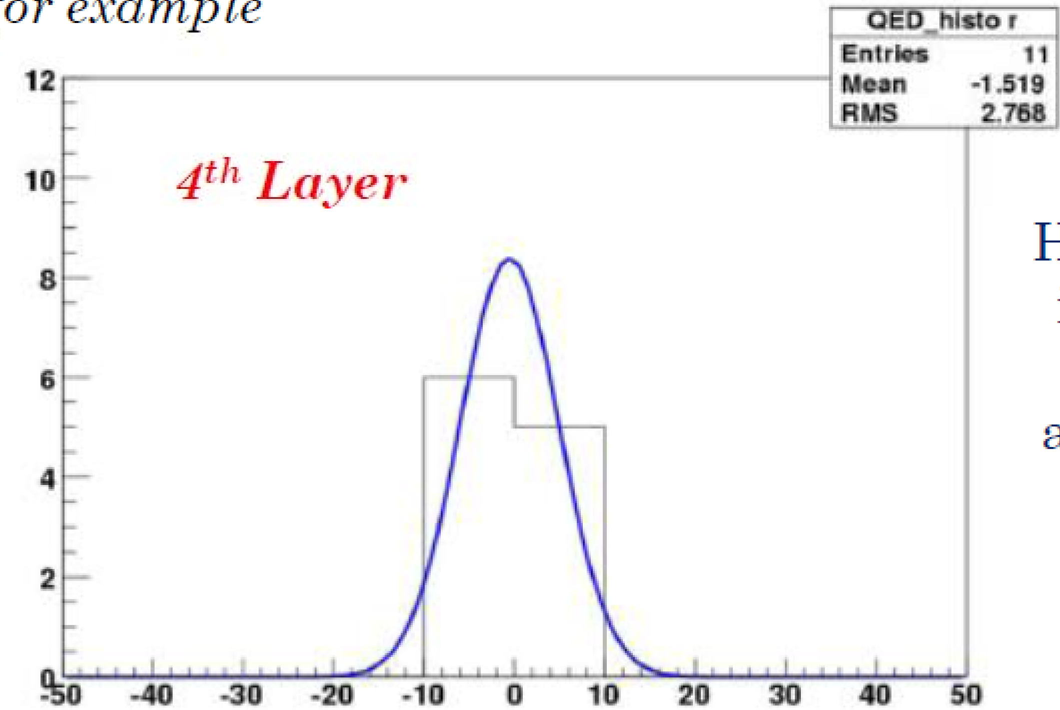
And the phi strips

Phi strips



Analysis strategy outcome – Higher Layers

for example



Higher layers can also be included but then QED expectation has to be averaged over the layers

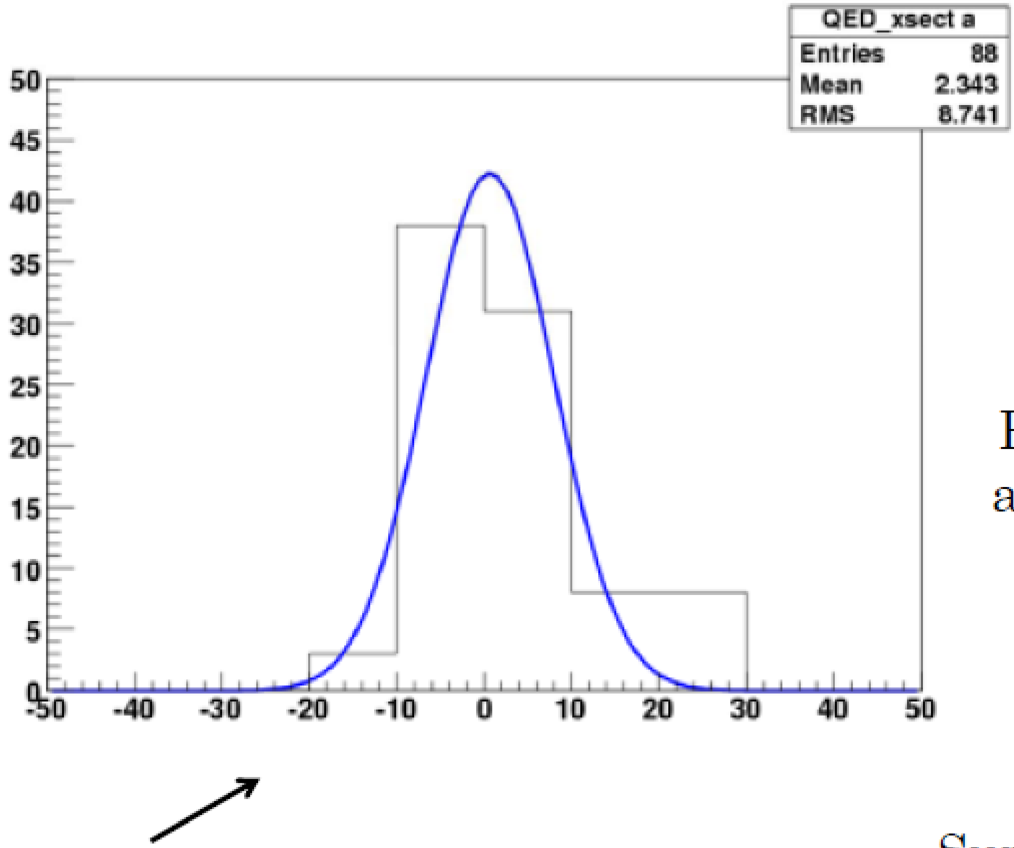
From KW MC

expected number of hits

SVD

- Layer 1: 1.49
- Layer 2: 0.52
- Layer 3: 0.33
- Layer 4: 0.26

All Layers Combined



Combined all layers for both phi and z strips

Gauss – Fit including all layers:

$$N_{hits} = 0.7 \pm 7.3$$

Expected hits from KW averaged over all layers in the SVD

$$< N_{hits} >= 0.65$$

SuperB MC:

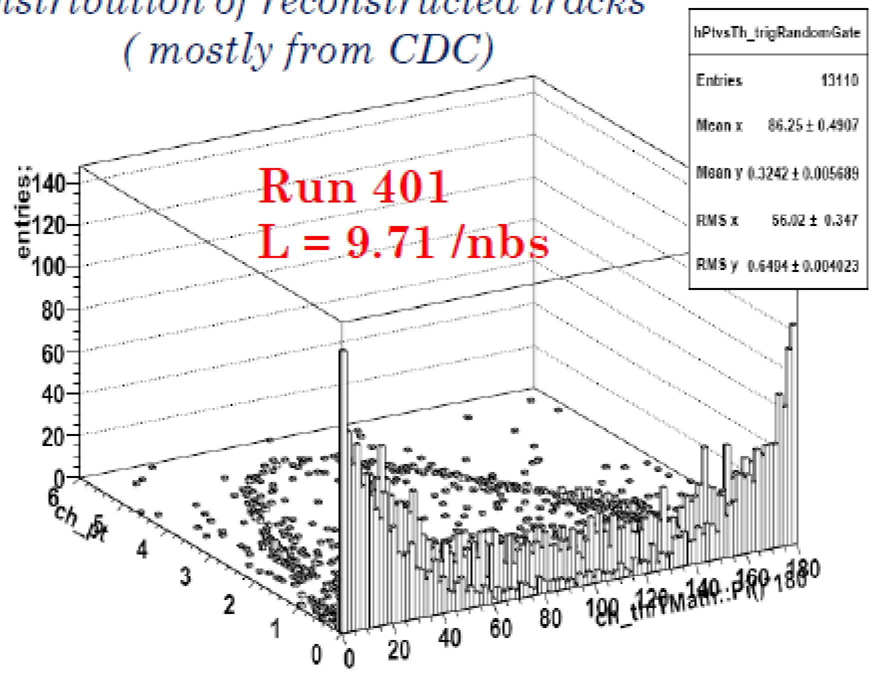
$$< N_{hits} >= 10.4$$

Next Steps

Try to improve CDC correction:

- ➢ exclude regions with unstable CDC current
- ➢ look at hit maps per wire layer
- ➢ improve the radial dependence to extrapolate into SVD region

Polar angle vs Pt
Distribution of reconstructed tracks
(mostly from CDC)



Later:

- ➢ use the track information to explicitly reconstruct QED events
- ➢ use full reconstruction:
  (analyze 2 – track events with vertex in random triggers)

Conclusions

• MCs give us very different answer for the QED background
• Three QED experiments were done at KEK to resolve the MC puzzle

> ➢ Exp. B – increase vertical beam size in HER
> ➢ Exp. A – separate the beams vertically
> ➢ Exp. C – change bunch currents

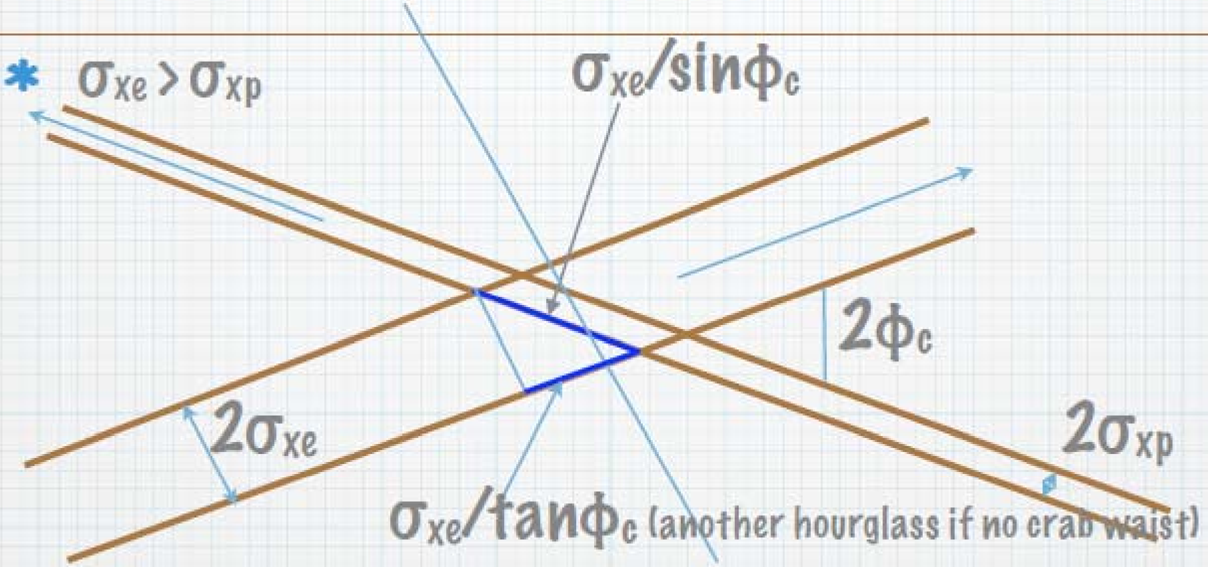
• Background variation much more complicated
• Special correction in CDC current was applied
• Preliminary results points to a small contribution of QED consistent with our calculation
• Next steps are defined (we hope to exclude the SuperB's number better than 80%)

Beam-beam bkg

Beam-beam effect on the beam injection

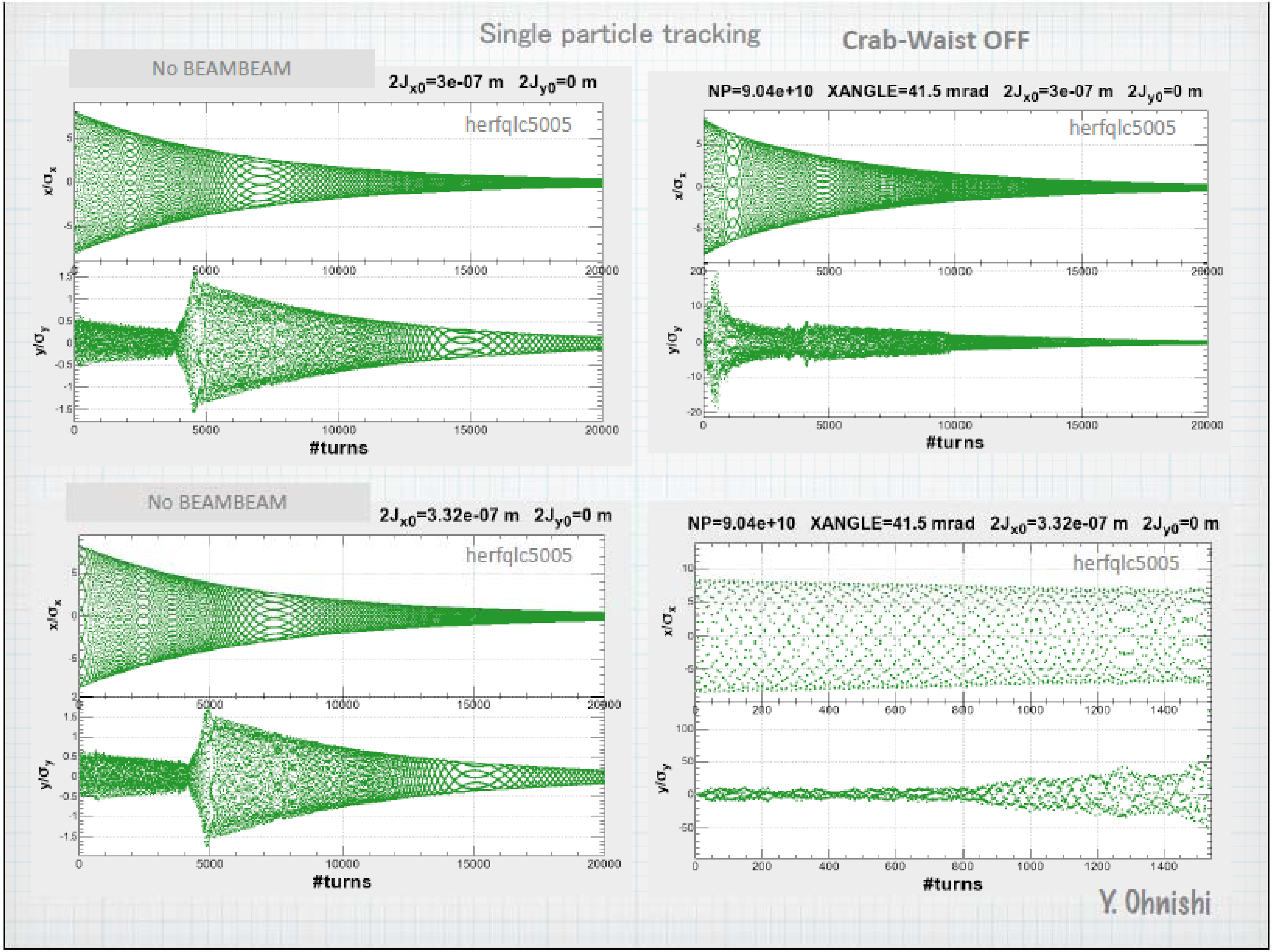
* Phenomena (found by the simulation)
  * In the Nano-Beam scheme, a particle with the horizontal displacement at the IP collides with the other beam at the position where the vertical beta function is larger than its minimum value.
  * Due to this effect, an injected particle with a large horizontal oscillation (due to injection error) may be lost.
  * This effect is serious in HER (due to smaller physical acceptance)
* Counter-measures
  * Crab waist scheme
  * Synchrotron injection

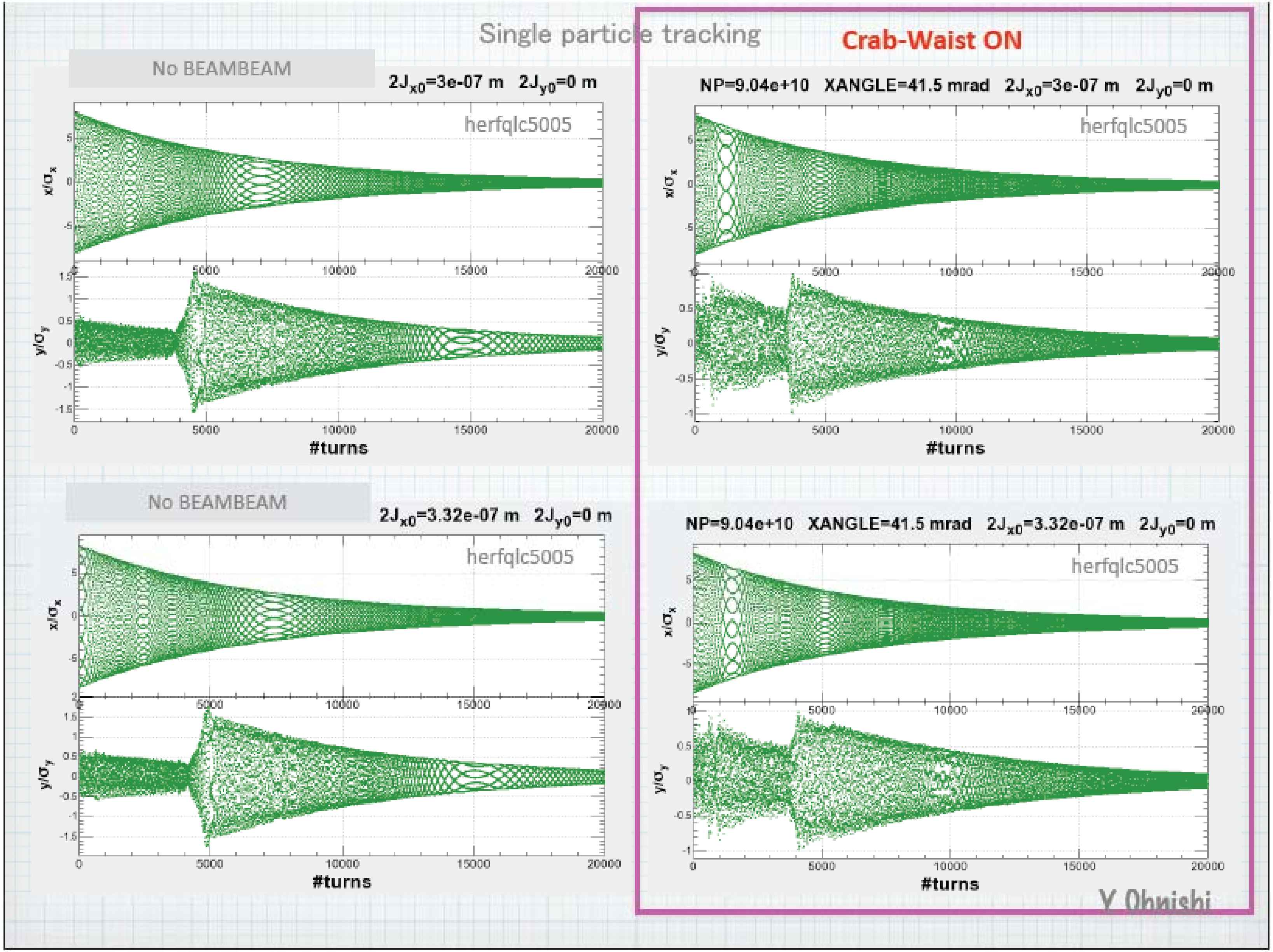
Hourglass condition for the NanoBeam scheme



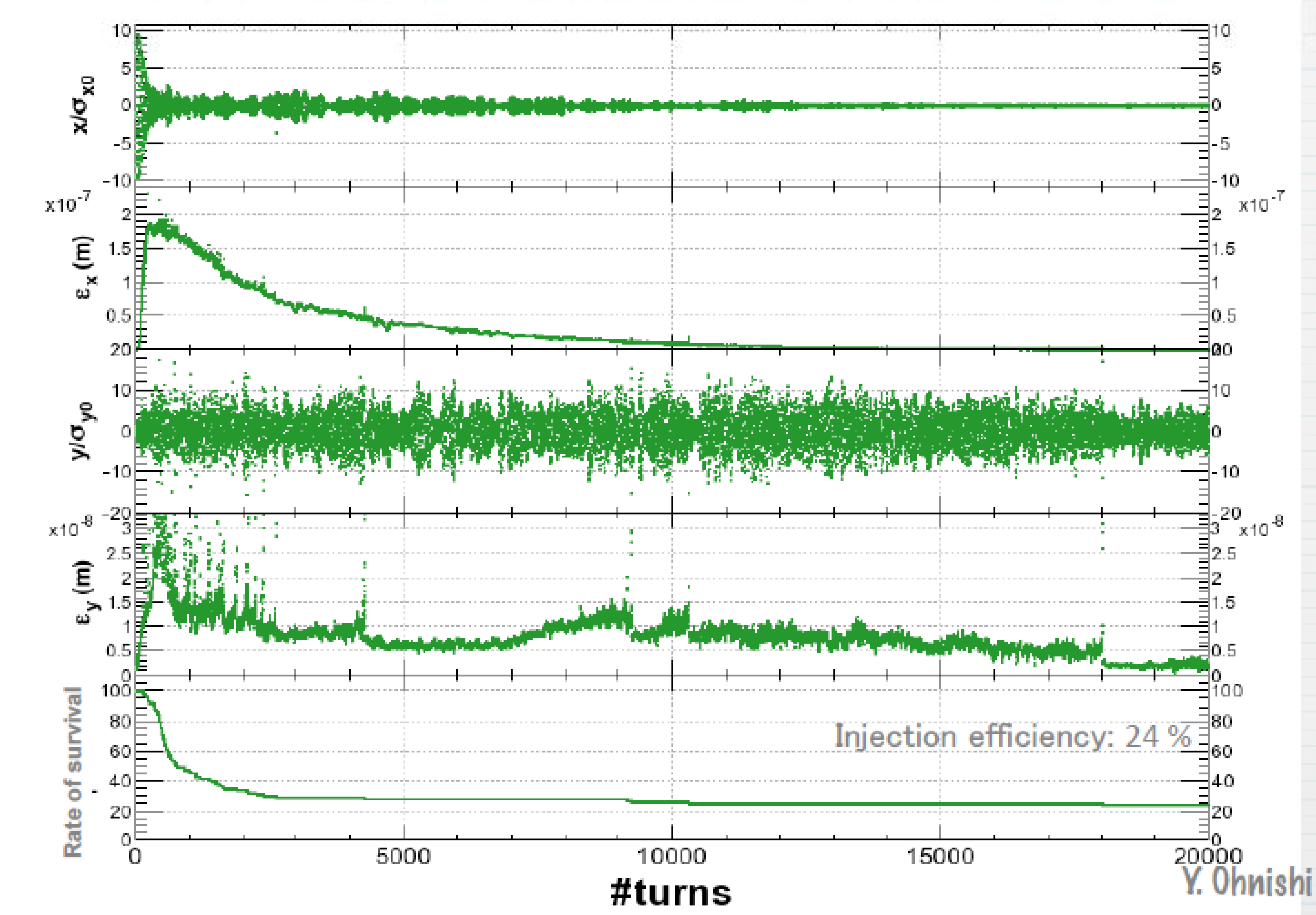
$\beta_{yp}^* \gtrsim \sigma_{xe}/\sin\phi_c = 2\sigma_{ze}^{effective} = 2(\sigma_{xe}/\sin2\phi_c)$

$\beta_{ye}^* \gtrsim \sigma_{xp}/\sin\phi_c = 2\sigma_{zp}^{effective} = 2(\sigma_{xp}/\sin2\phi_c)$

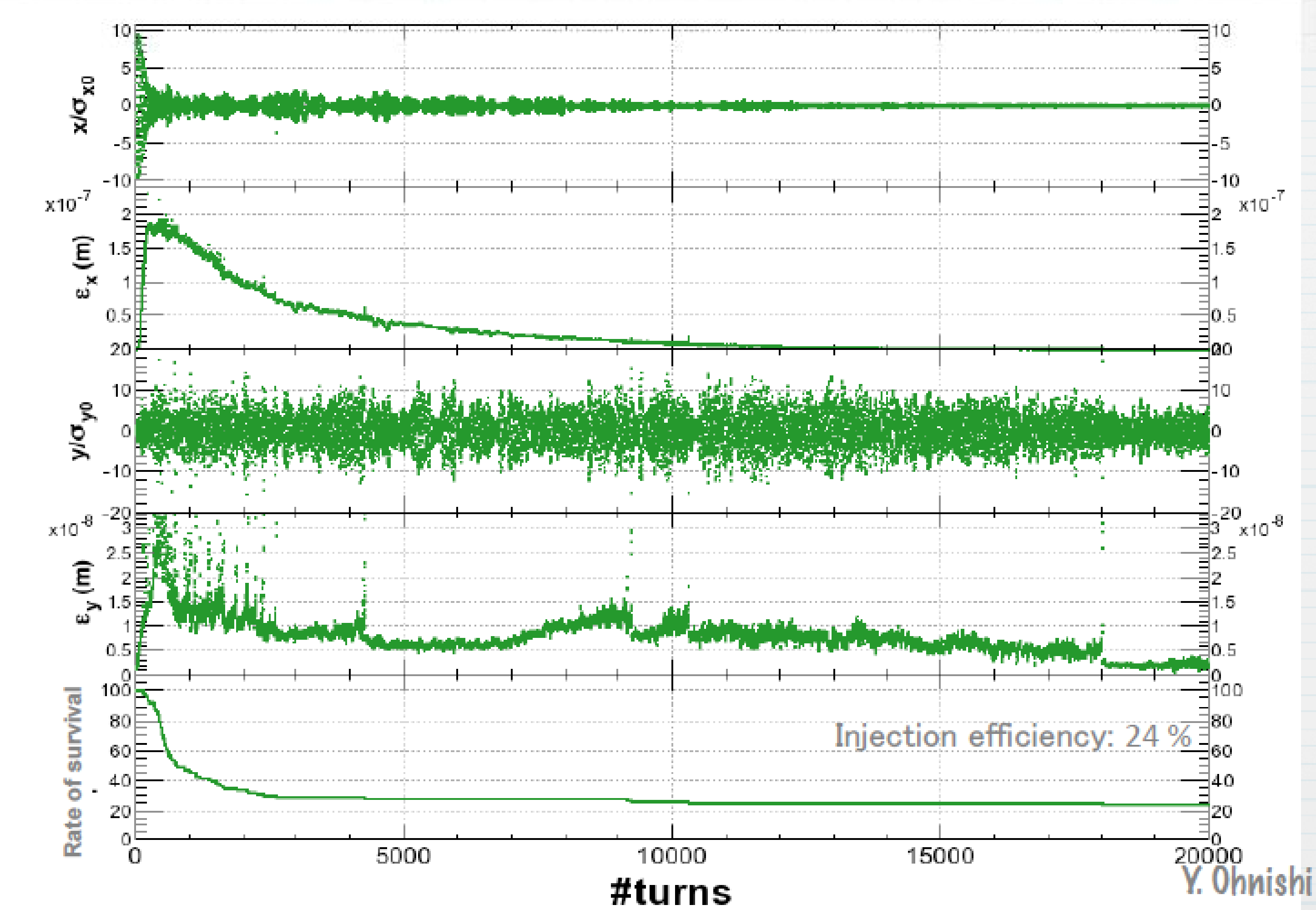

Single particle tracking
Crab-Waist OFF
No BEAMBEAM
2Jx0=3e-07 m 2Jy0=0 m
herfqlc5005
#turns
NP=9.04e+10 XANGLE=41.5 mrad 2Jx0=3e-07 m 2Jy0=0 m
herfqlc5005
#turns
No BEAMBEAM
2Jx0=3.32e-07 m 2Jy0=0 m
herfqlc5005
#turns
NP=9.04e+10 XANGLE=41.5 mrad 2Jx0=3.32e-07 m 2Jy0=0 m
herfqlc5005
#turns
Y. Ohnishi


Single particle tracking
Crab-Waist ON
No BEAMBEAM
2Jx0=3e-07 m 2Jy0=0 m
herfqlc5005
x/σx
y/σy
#turns
NP=9.04e+10 XANGLE=41.5 mrad 2Jx0=3e-07 m 2Jy0=0 m
No BEAMBEAM
2Jx0=3.32e-07 m 2Jy0=0 m
NP=9.04e+10 XANGLE=41.5 mrad 2Jx0=3.32e-07 m 2Jy0=0 m
Y.Ohnishi

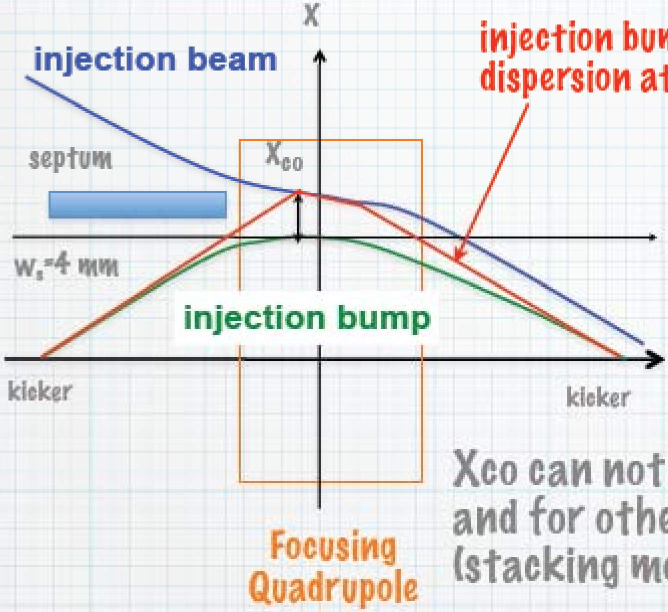
With Beam-Beam (No Crab-Waist)



With Beam-Beam (No Crab-Waist)



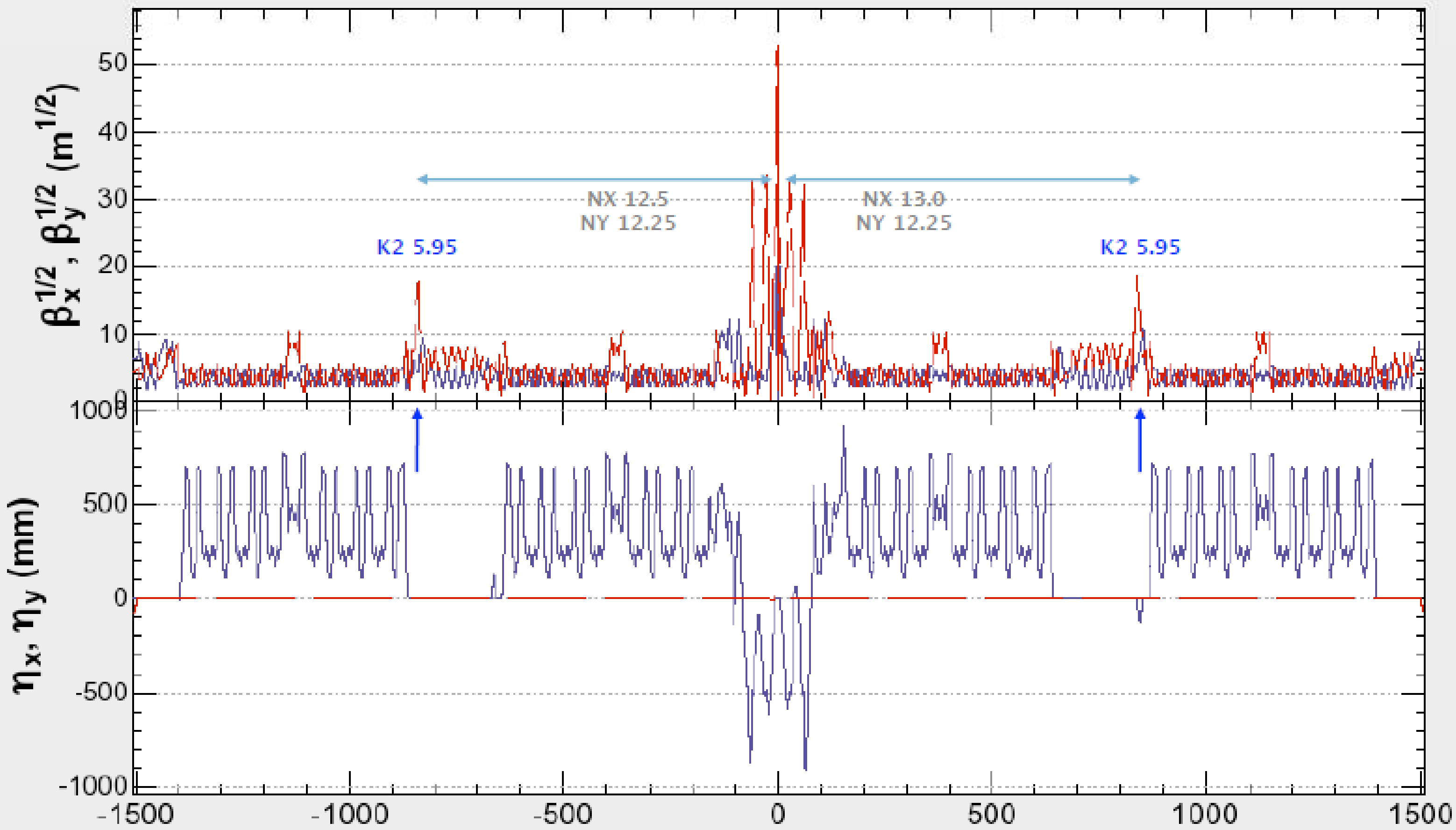
Beam injection scheme



Xco can not be set zero due to thickness of the septum magnet and for other reasons in case of the usual betatron injection (stacking mode).

In case of synchrotron injection, Xco can be zero but the synchrotron oscillation is induced, since the energy of the injected beam should be different from that of the stored beam.

SuperKEKB LER Crab waist



IR: lerfqlc_Oide_1137.sad

H. Koiso