http://eefact2018.ust.hk/index.php

Report from eeFact18 workshop

24-27 Sept. 2018, Hong Kong

Manuela Boscolo

4-days Workshop

- WG1- Physics
- WG2- Overview of ee Colliders
- WG3: Optics and Beam dynamics
- WG4: Beam-beam & instabilities
- WG5: **IR&MDI**
- WG6: Injector and Injection
- WG7: Polarization and energy calibration
- WG8: RF technology
- WG9: Magnet technology
- WG10: Vacuum
- WG11: Instrumentation
- WG12: Infrastructures, cryogenics, **Commissioning & operation**

Plenary

1. **The Future of High Energy Physics and China's Role,** Yifang Wang
2. **Highlights from SuperKEKB Phase 2 Commissioning**, Y. Onishi
3. **Challenges for Circular e+e- Colliders**, F. Zimmermann
4. **Physics at the FCCs,** P. Giacomelli
5. **Several Topics on Beam Dynamics in FCC-ee,** K. Oide
6. **DAFNE,** C. Milardi
7. **CLIC,** D. Schulte
8. **ILC,** K. Yokoya
9. **CEPC,** C. Yu
10. **Round Colliding Beams at VEPP-2000 with Extreme Tuneshifts,** D. Shwartz
11. **Low-Energy e+e- Collider to Search and Study ($\mu^+\mu^-$) Bound State,** A. Bogomyagkov
12. **A Project of Super Charm-tau Factory in Novosibirsk,** E. Levichev
13. **Report from ARIES Muon Collider Workshop Padua, 2-3 July 2018,** F. Zimmermann
14. **Status and Prospect of HIEPA/STCF in China,** Y. Zheng

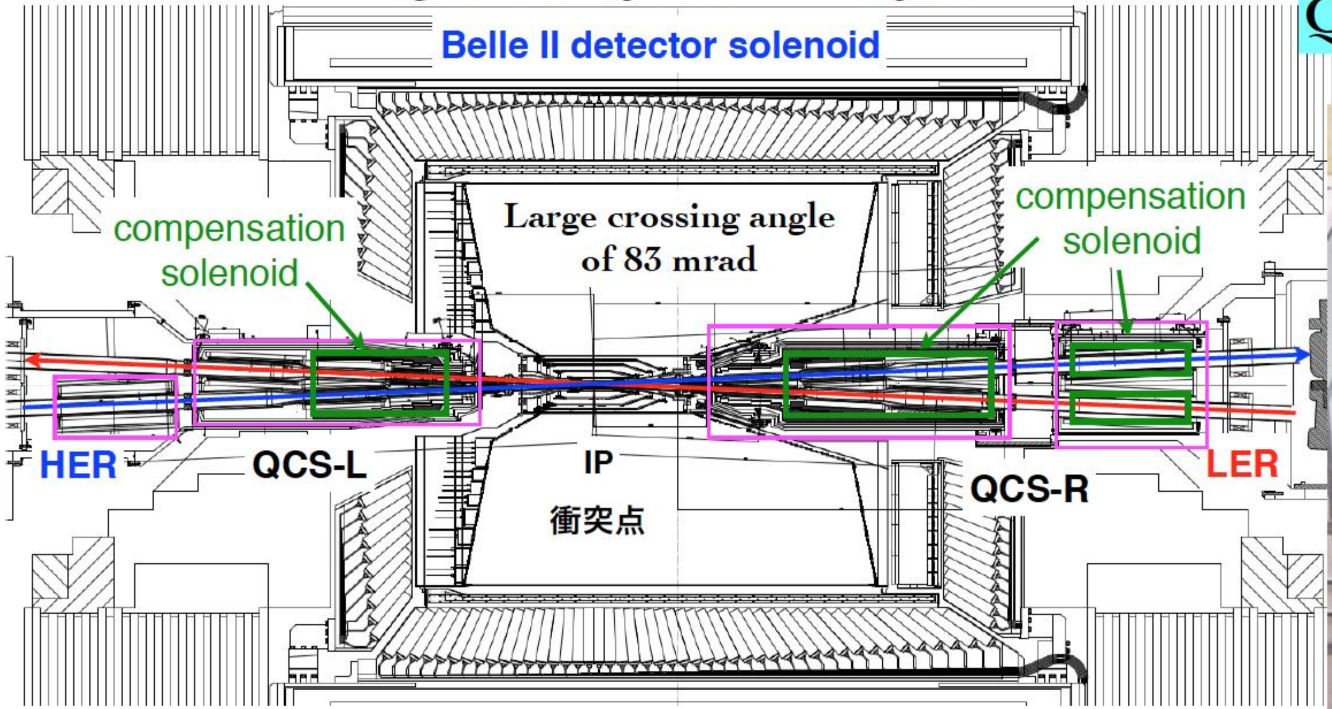
WG5: IR & MDI

1. IR design issues for high luminosity and low backgrounds, **M. Sullivan**
2. MDI for FCC-ee, **M.B.** http://eefact2018.ust.hk/files/20180926/20180926-LT-1040-Manuela-Boscolo.pdf
3. Beam blow-up due to synchro-beta resonance w & w/o beam-beam effects, **K. Oide**
4. Early commissioning of the luminosity dither system for SuperKEKB, **Y. Funakoshi**
5. MDI for CEPC, **Sha Bai**
6. Beam background at SuperKEKB during Phase 2 operations, **A. Paladino**

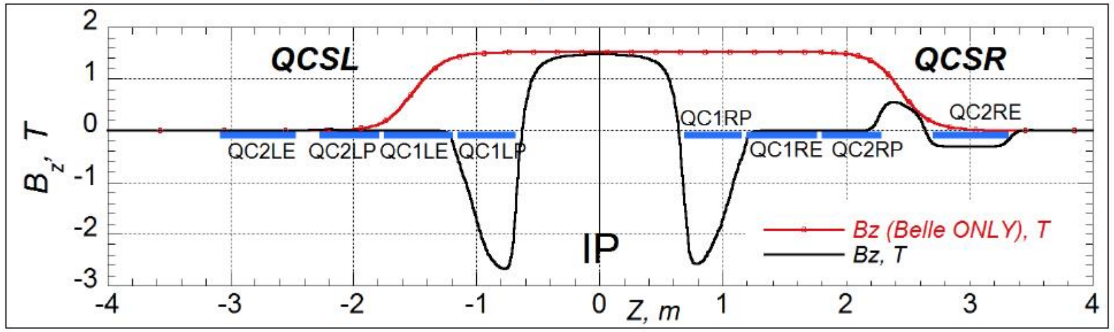
SuperKEKB

Final Focus Superconducting Magnets

Superconducting Final Focus Magnets

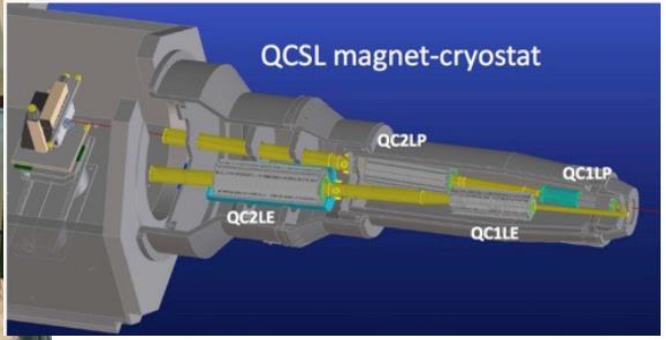


Belle II + compensation solenoid



Quadrupoles and Compensation Solenoids (QCS)

BROOKHAVEN NATIONAL LABORATORY



4 quadrupoles (QC1s, QC2s)
8 dipole corrector coils
4 skew quad. corrector coils
2 octupole coils
2 skew sextupole, etc for each ring.

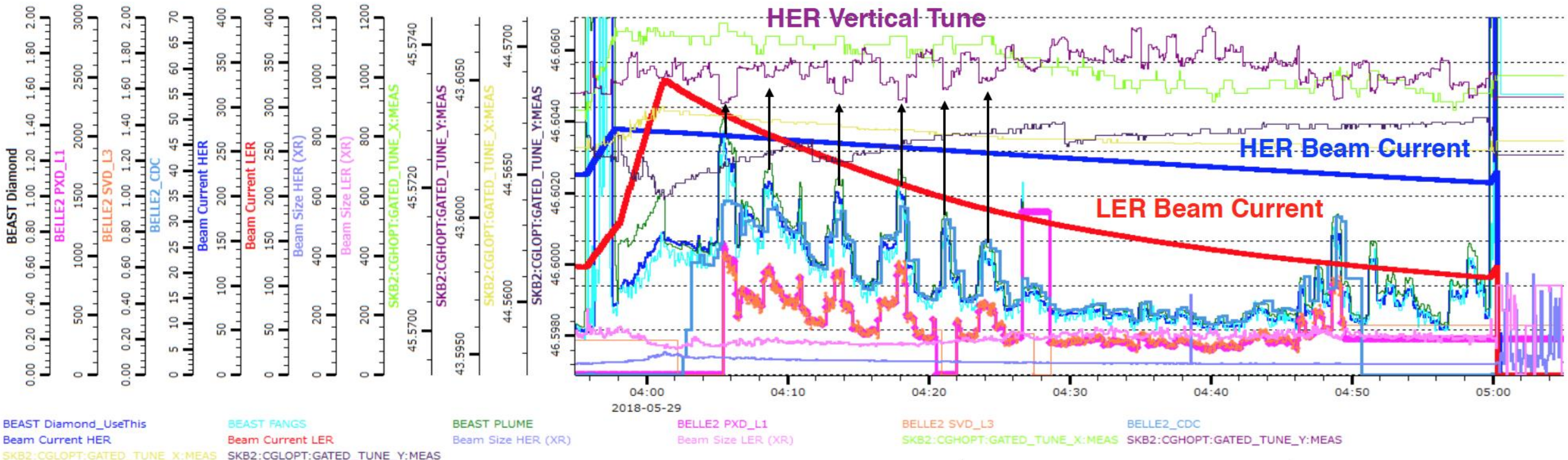
Number of coils is 55 !

No dispersions and XY couplings in the IP although there is the solenoid field.

HER Tune and Detector Background

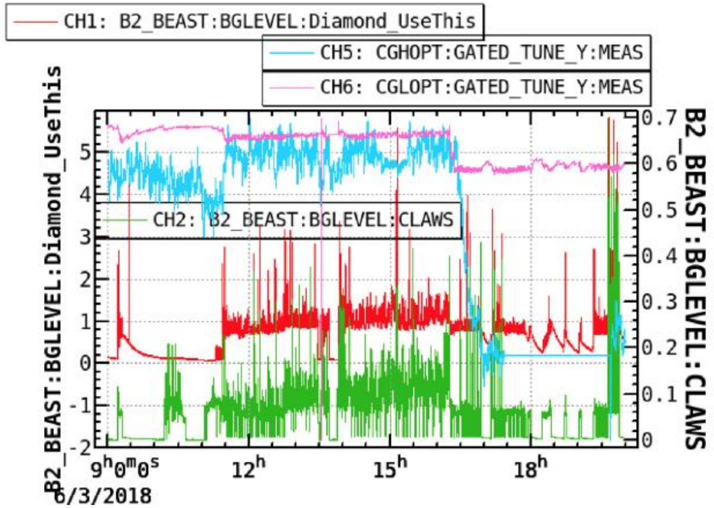
Luminosity run, May 29, 2018

H. Nakayama
slide from Phase 2 summary meeting

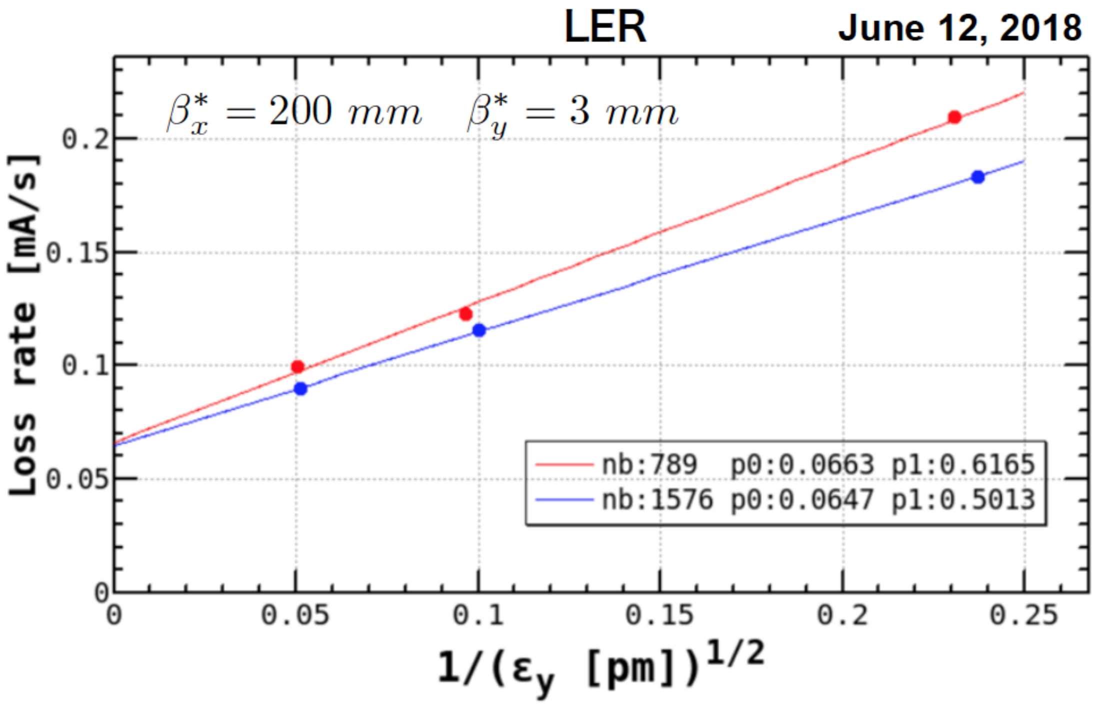


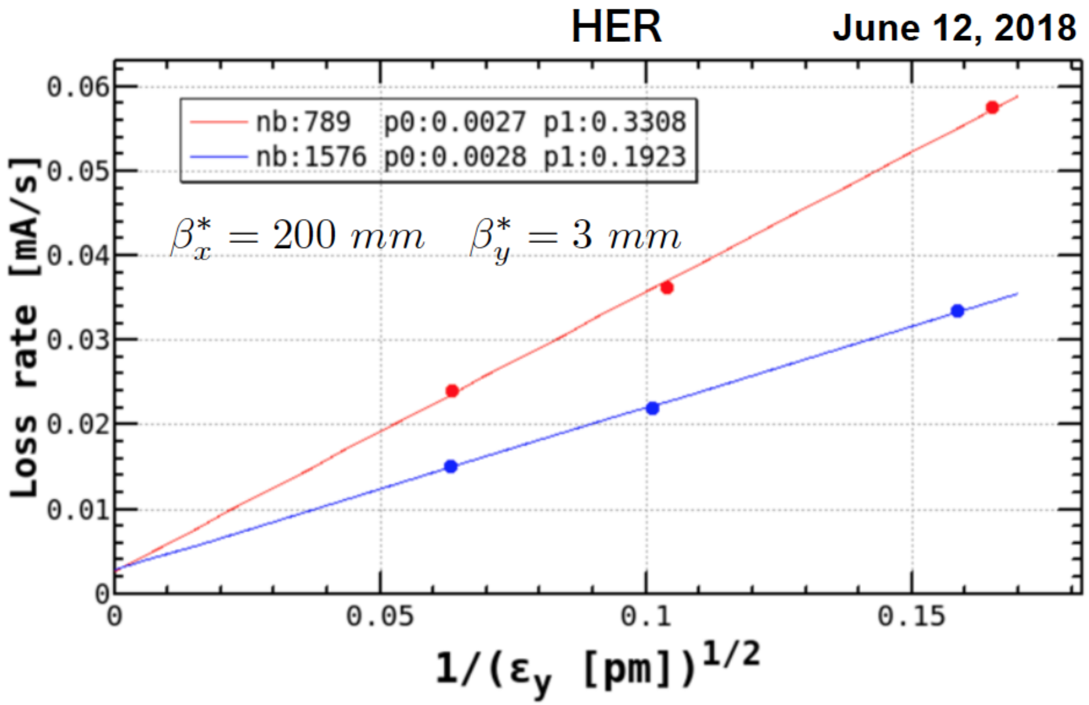
HER tune clearly affects the beam background.

We have to find better a working point and necessary to keep tunes.



Beam Lifetime





LER current: 320 mA
Touschek lifetime: 35 min (n_b: 789)
lifetime (others): 80 min

HER current: 285 mA
Touschek lifetime: 86 min (n_b: 789)
lifetime (others): 28 hours

Physical aperture limits the beam lifetime.

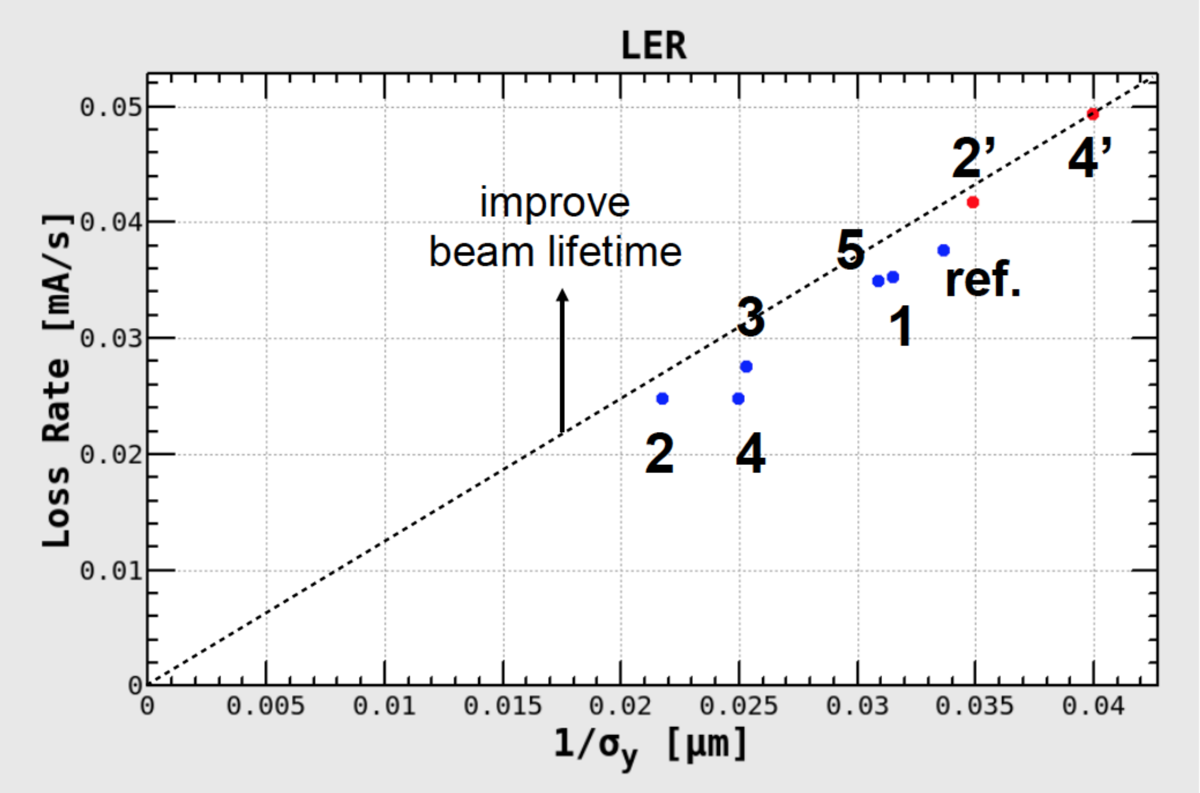
Movable collimators to reduce background and avoid QCS quench

ε_y is controlled by vertical dispersions.

Sextupole Tuning and Beam Lifetime

ID number specifies a different set of sextupole combination.

5 sets of sextupole settings



June 27, 2018

2' : with optics correction
4' : with optics correction

σy measured by XRM

← **Beam size larger** **Beam size smaller** →

Sextupole tuning could not improve the beam lifetime in the LER.

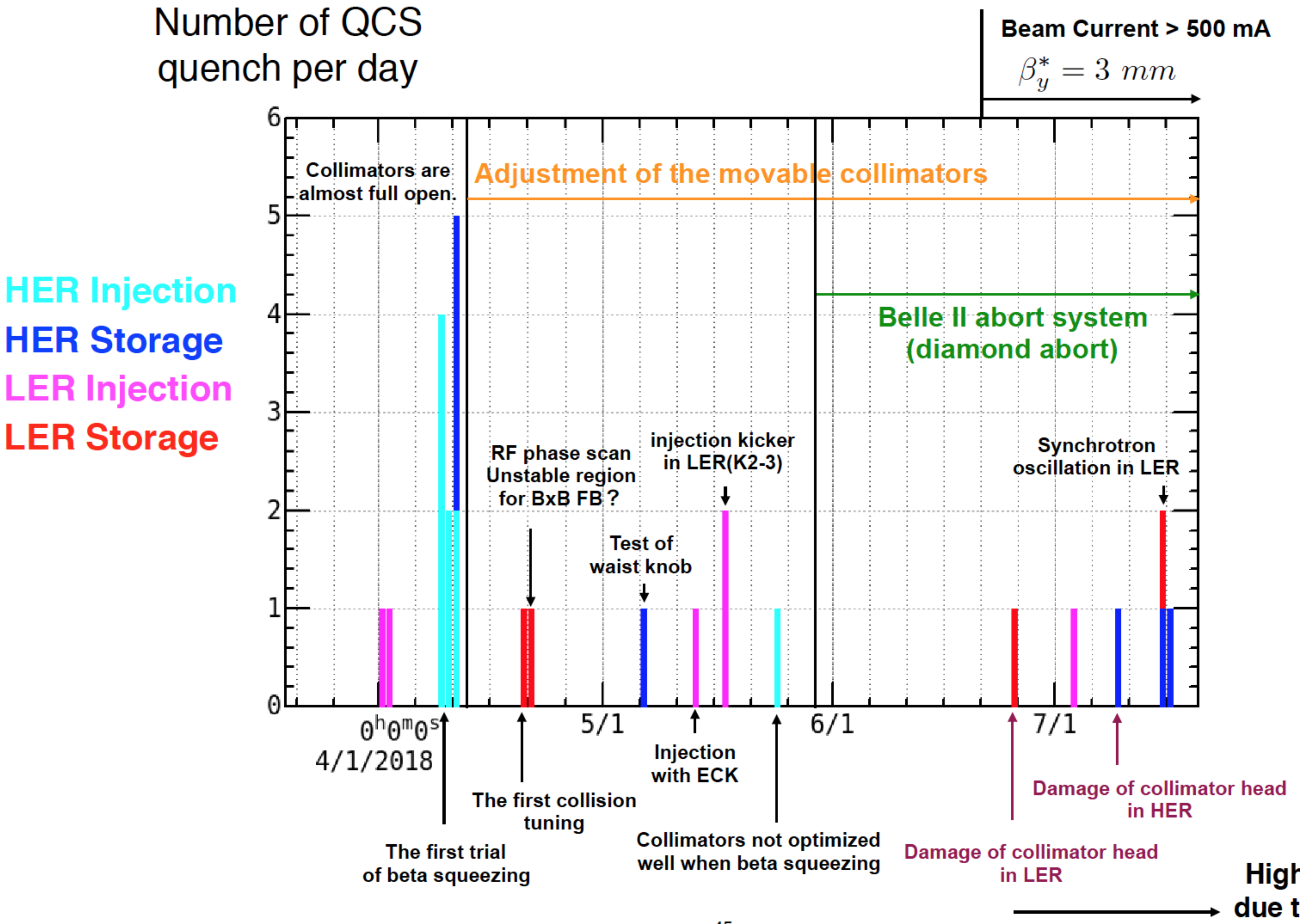
Physical aperture limits the beam lifetime. (Tracking simulation supports this.)

QCS Quench Issue

Highlights from SuperKEKB Phase 2 commissioning, Y. Ohnishi

- QCS quench
  - QCS quench during beam injection
    - Beam loss in the vertical direction due to XY coupling before optics corrections. QCS is the smallest physical aperture.
    - Movable collimators and Belle II fast diamond abort system could avoid QCS quenches.
  - QCS quench during beam storage
    - Movable collimators can avoid most of QCS quenches.
    - There are few unknown events.
      - Hit collimator head due to longitudinal instability, dust trapping, … ?
      - Large orbit change when the beam is aborted ?

QCS Quench



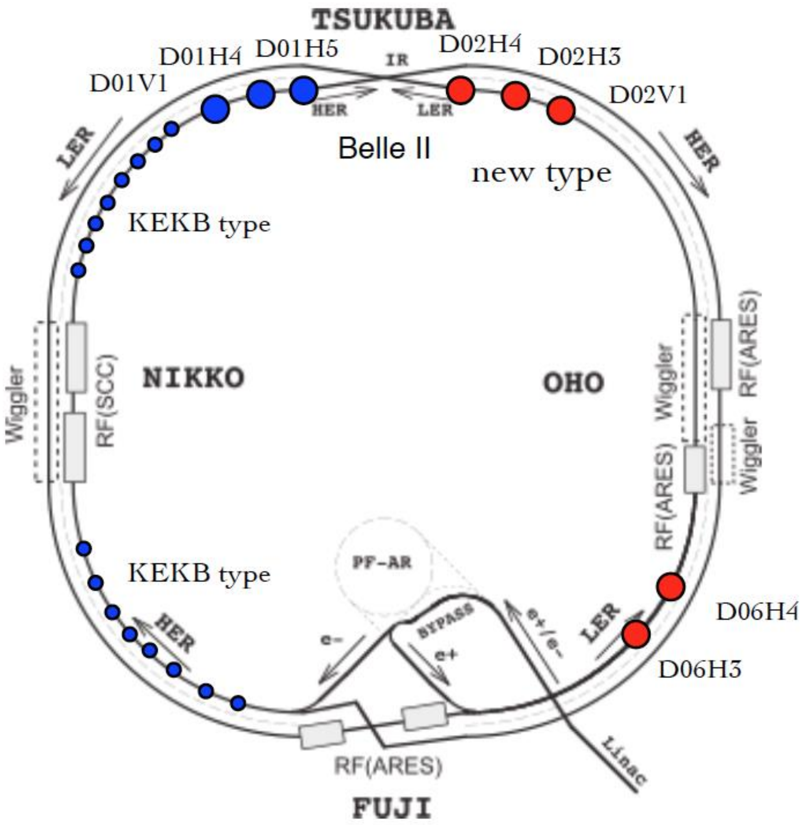
Beam operation was sometimes unstable.

High temperature due to Hot summer

Damage of Movable Collimator (Head)

Reduce beam background

Compromise lifetime, injection, and detector background.

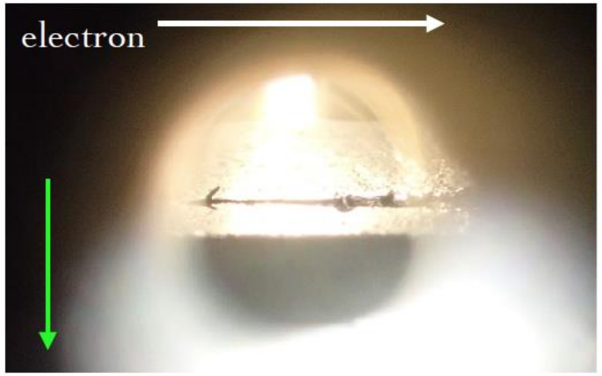


Number of movable collimators is small in LER. Especially, only one in the vertical.

Vertical Collimator

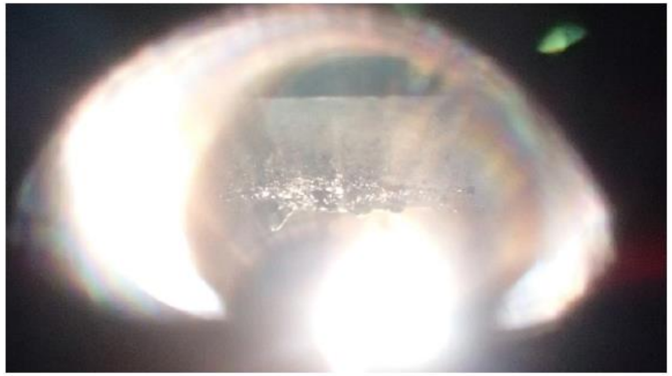
LER

Bottom

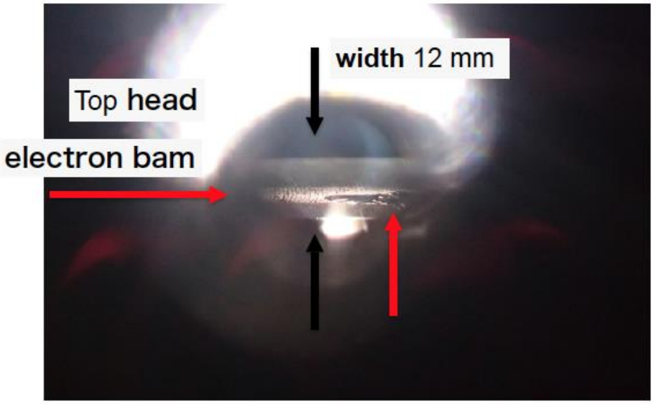


outer of the ring

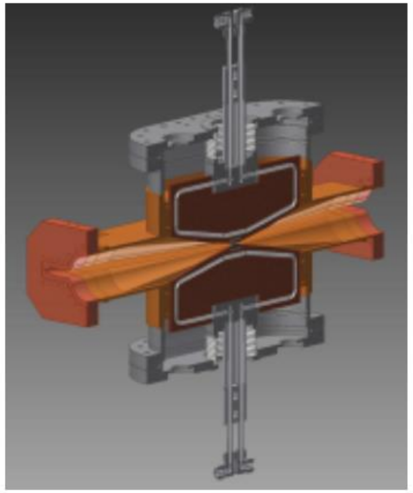
Top



HER



New collimator (SLAC type)



Y. Suetsugu, T. Ishibashi, S. Terui

Summary

- Verification of nano-beam scheme
  - luminosity tuning at β_y^*=3 mm (x10 final value)
  - 2.26 x 10^{33} $cm^{-2}s^{-1}$ at I_{LER} = 270 mA (n_b=395) → 10^{34} $cm^{-2}s^{-1}$ at I_{LER} = 1080 mA (n_b = 1576)
  - Beam-beam parameter reaches 0.02.
  - Peak luminosity is 5.55 x 10^{33} $cm^{-2}s^{-1}$ (LER: 790 mA).
- Max beam current is 860 mA, 800 mA in HER.

- QCS quench issue (unexpected). Movable collimators can avoid most of quenches.
- We will install additional collimators until Phase 3 operation to control beam loss and/or background.
- We will fight interference of beam-beam and lattice nonlinear to improve luminosity performance in Phase 3.

Verification of nano-beam
☺

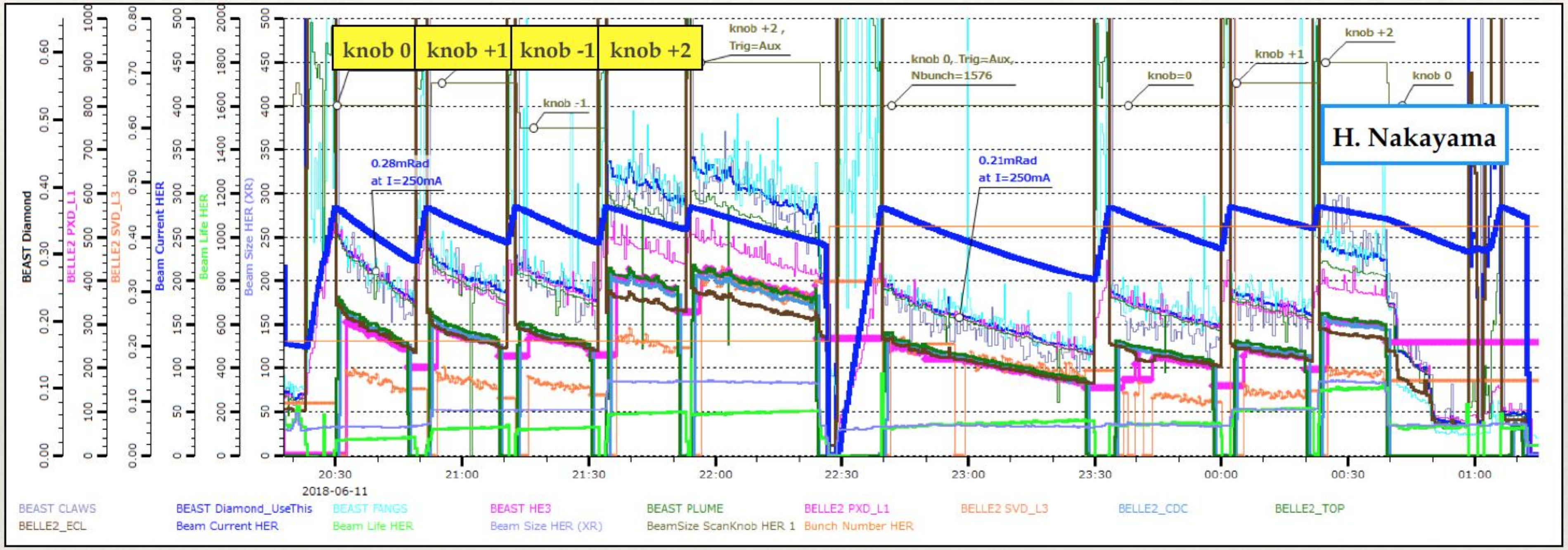
Beta squeezing
😀

Luminosity performance
🙁

I_{LER} < 1 [A]
🙁

Touschek background - beam size studies

- In a previous study done in June for the HER, same results obtained for knob ±1, but for even larger beam size an increase in background was observed, which is the opposite of the expectations for Touschek effect. Possible beam “scraping”, but not confirmed.



H. Nakayama

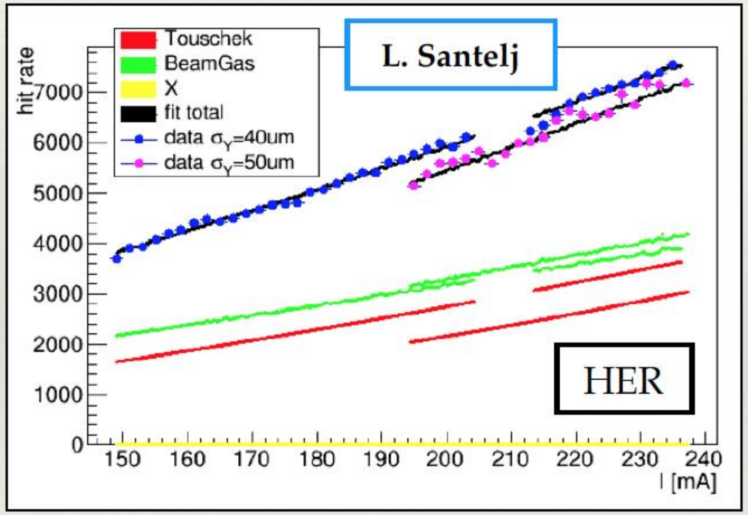
- For diamonds good agreement between data and simulation, for SVD there is discrepancy, other detectors are still performing analysis.

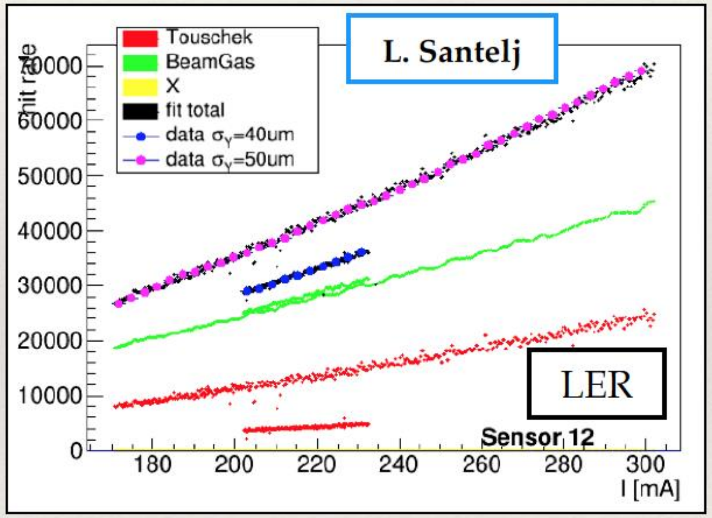
Beam-gas scattering

Interaction between beam particles and residual gas atoms in the beam pipe. Coulomb scattering changes particle trajectory, Bremsstrahlung decreases particle energy.

- In the IR, Touschek and beam-gas backgrounds have similar contributions. Fraction depends on the sensor, but background is of the same order.

Function used for the fit: $P = T\frac{I^2}{\sigma_y n_b} + BIp + XI^2\sigma_y^{n/2}$ → Only for HER and large beam size

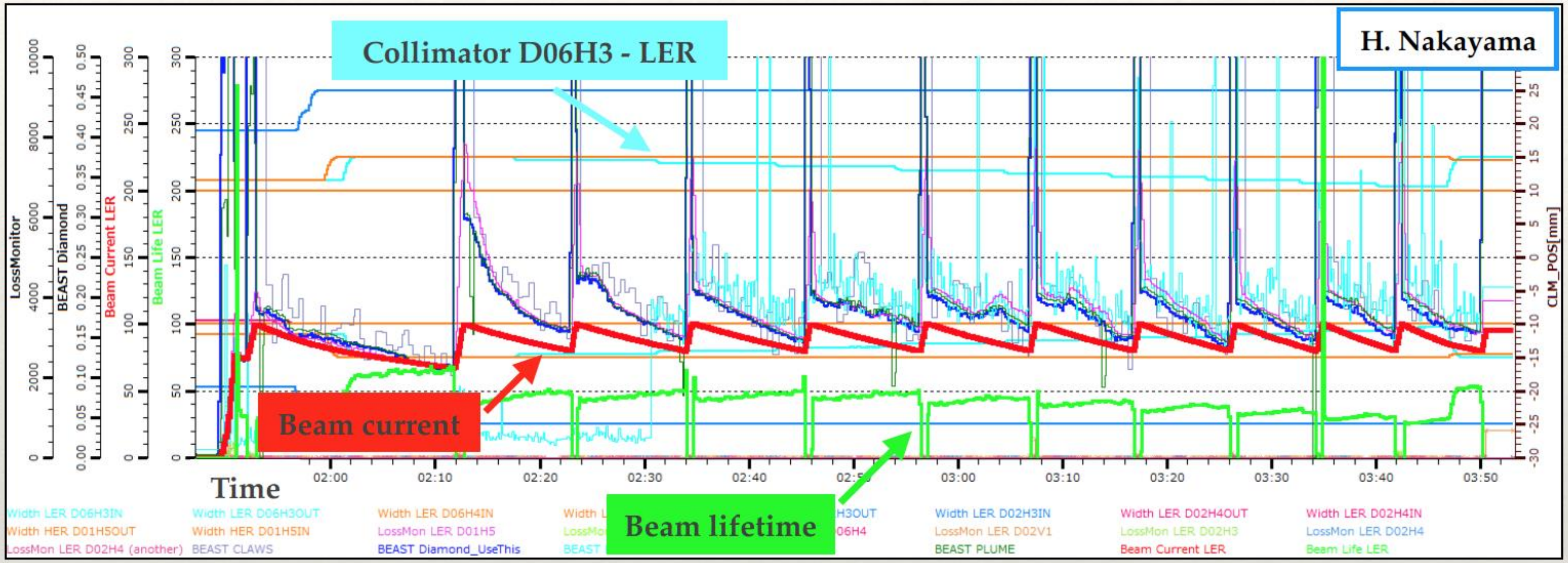




- In Phase 3 β_y inside the final focus system will be 10 times higher than the end of Phase 2. Therefore beam-gas Coulomb lifetime will be shorter and the background level will be very high without a proper vertical collimation.

Background reduction - collimators study

- Collimators studies performed with simulations and during Phase 2 operation.



- From an "open" collimators configuration, gradually close each collimator individually to find the best compromise between background level and beam lifetime.
- After closing collimators individually, all collimators were closed at the same time to their optimised aperture —> reduction in IR background clearly visible.
- Same study performed on HER with similar results.

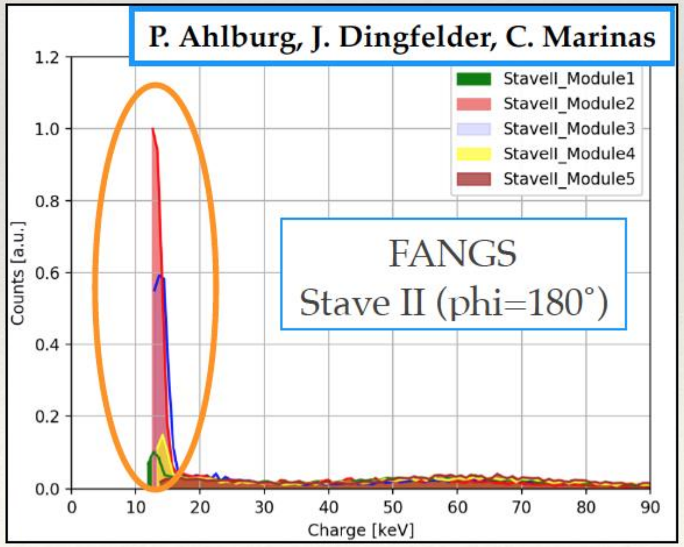
Synchrotron radiation

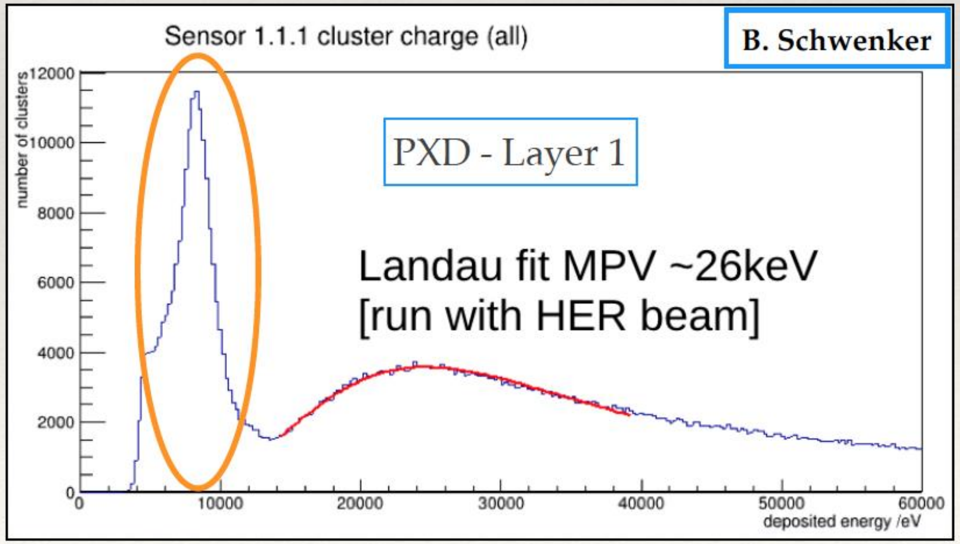
- $R_{SR} \propto E^2 B^2$ —> bigger contribution expected from HER.

- SR observation not expected in Phase 2.
- Energy of SR photon expected from a few keV to tens of keV.
- Inner surface of beryllium pipe coated with Au layer to absorb SR photons.
- Ridge structures of incoming pipes to avoid hits from forward reflected SR photons to IR beam pipe.
- Direct hits stopped by tapered shape of incoming beam pipes.


Aluminum mockup

- PXD (ring outer side) and FANGS (ring inner side) observed SR peaks around 8-10 keV.
- Longitudinal distributions for HER and LER suggest same mechanism of SR generation.

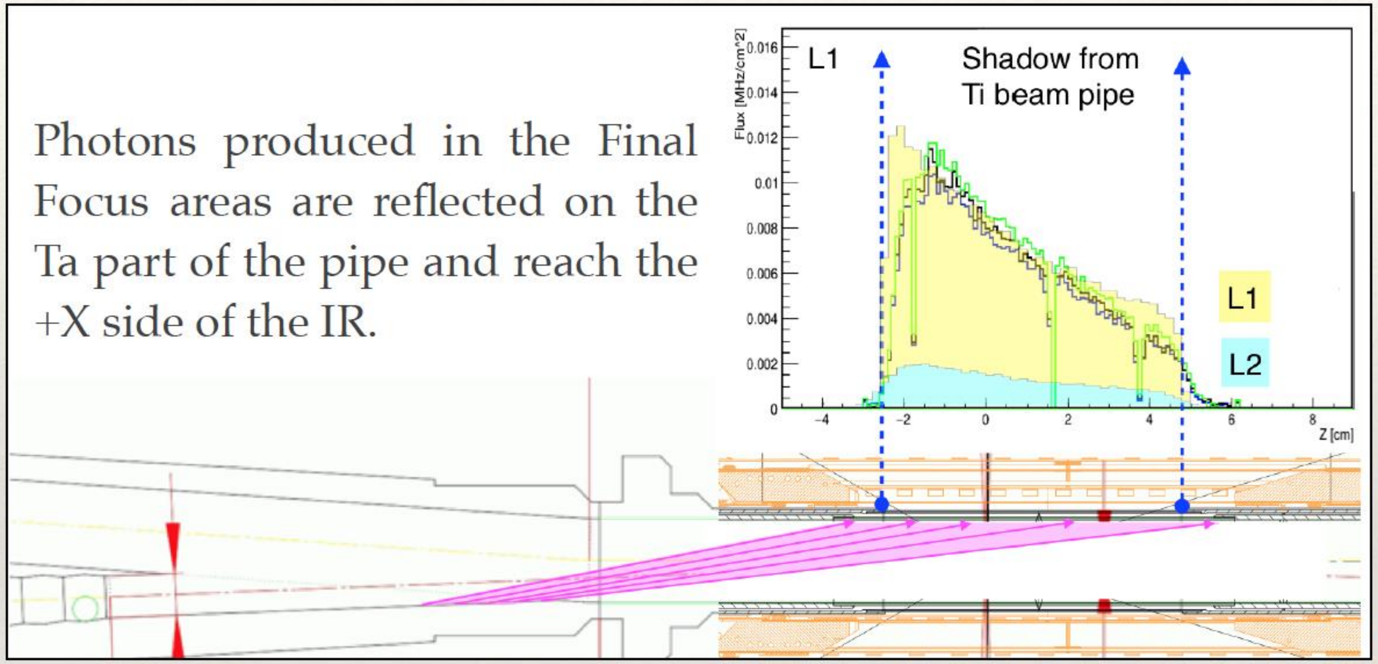

P. Ahlburg, J. Dingfelder, C. Marinas


B. Schwenker

Landau fit MPV ~26keV
[run with HER beam]

Synchrotron radiation

- It's unlikely to have direct hits from SR. The most probable mechanism is reflection of photons generated in the Final Focus sections.

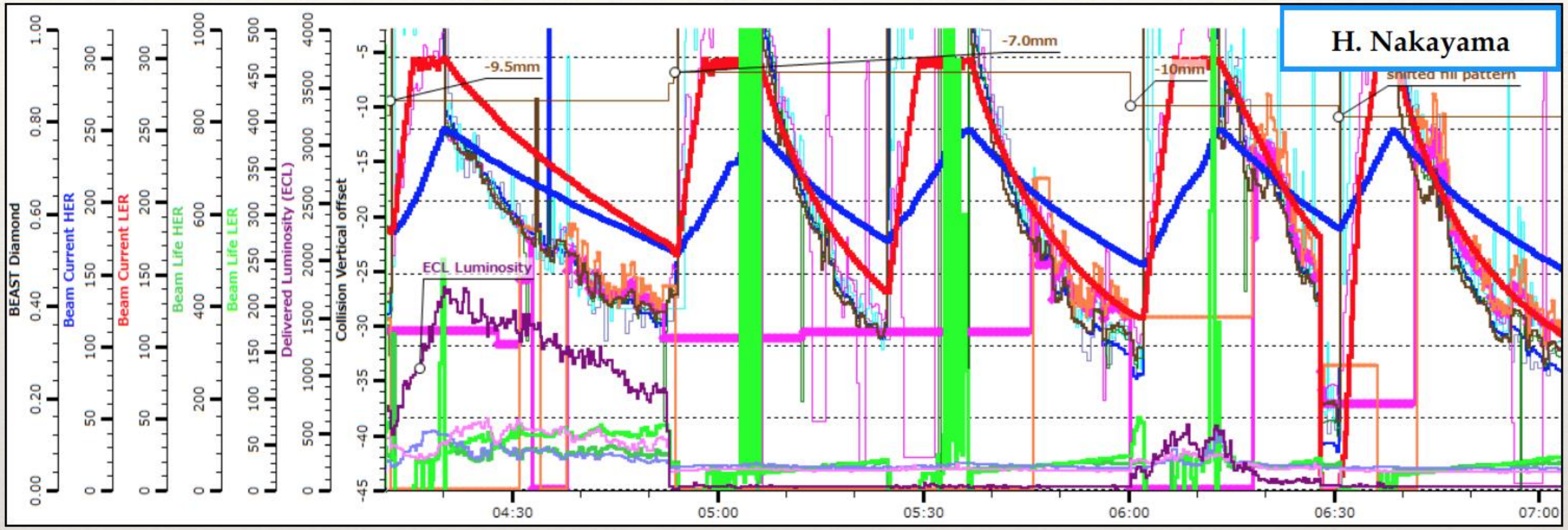


Photons produced in the Final Focus areas are reflected on the Ta part of the pipe and reach the +X side of the IR.

- Au layer in Phase 2: 6.6 μm
  Au layer in Phase 3: 10.0 μm
- The most recent simulations for SR can reproduce qualitatively the data, with still a few differences in the rate ratio between layer 1 and layer 2 of the PXD.

Luminosity background

The observation was that when luminosity goes to zero changing vertical offset, PXD and SVD background rates increase.



- We expect backgrounds to be smaller if luminosity background (two-photon process in particular) is the main source and no collisions occur.
- To be further investigated. Challenging analysis due to low luminosity and to changing BG conditions between single beam BG studies and luminosity studies: makes difficult to disentangle Touschek and beam-gas backgrounds and extract luminosity background component.

Conclusions

- BEAST II and Belle II detectors were successfully used to evaluate beam background components during Phase 2.
- Touschek and beam-gas BG components evaluated for Phase 2, revised projections for Phase 3 are under development.
- Synchrotron radiation was not expected in Phase 2, but was observed and the most recent simulation can predict it.
- More Luminosity BG results for Phase 2 yet to come from other sub-detectors; to be further studied at the beginning of Phase 3.
- Injection background can be kept under control and within the limits given by inner sub-detectors and QCS.
- Additional collimators will be installed for Phase 3 to allow better BG reduction in the IR.
- Overall, the background levels during Phase 2 look higher than expected, more time should be dedicated at the beginning of Phase 3 to improve background reduction.

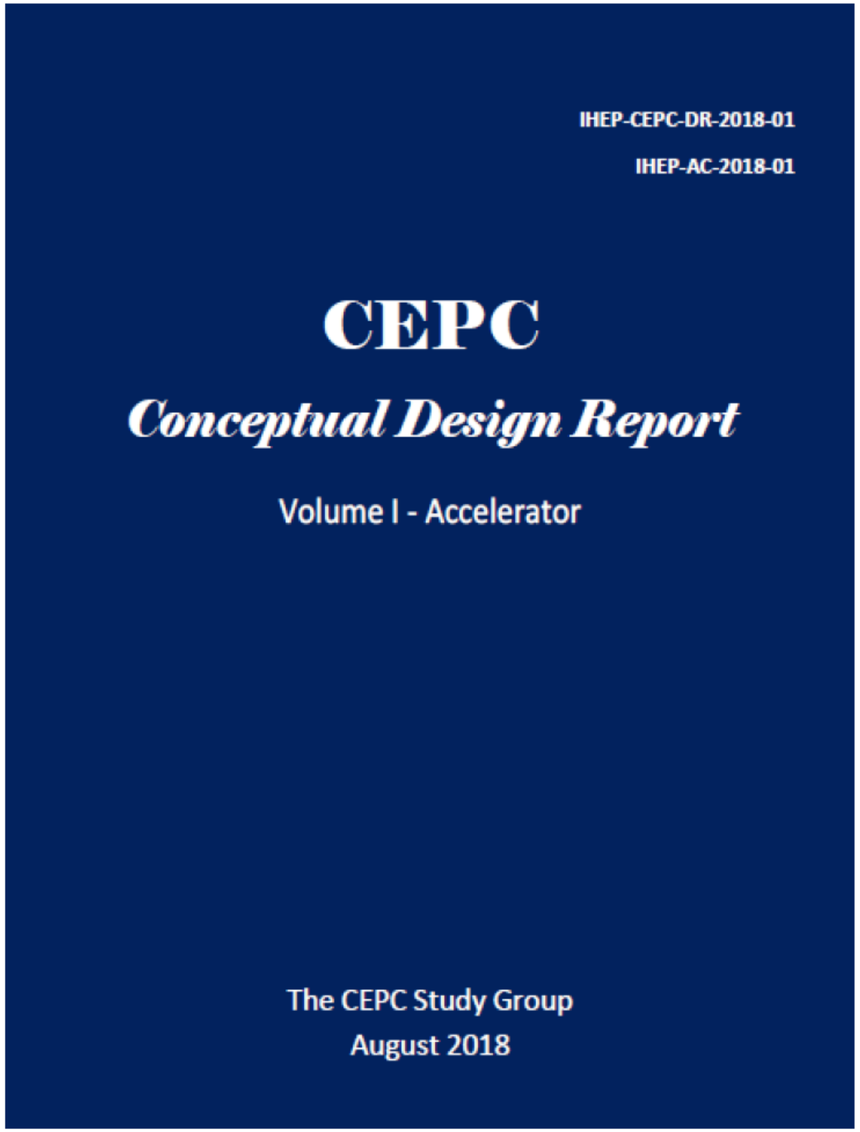
CEPC

Chenghui Yu

arXiv:1809.00285

CEPC accelerator CDR completed in June 2018

1. Introduction
2. Machine Layout and Performance
3. Operation Scenarios
4. CEPC Collider
5. CEPC Booster
6. CEPC Linac
7. Systems Common to the CEPC Linac, Booster and Collider
8. Super Proton Proton Collider
9. Conventional Facilities
10. Environment, Health and Safety
11. R&D Program
12. Project Plan, Cost and Schedule



IHEP-CEPC-DR-2018-01

IHEP-AC-2018-01

CEPC

Conceptual Design Report

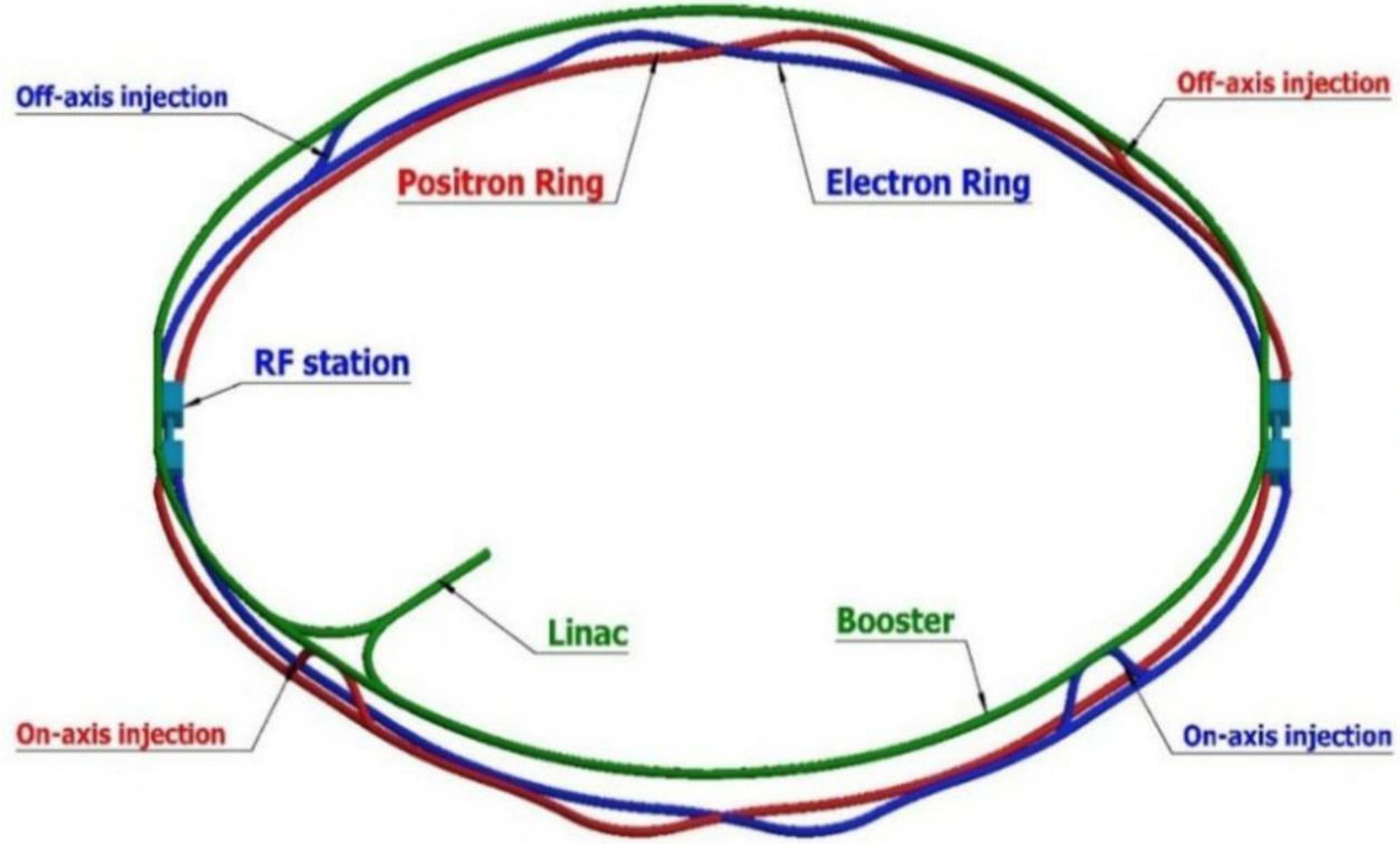
Volume I - Accelerator

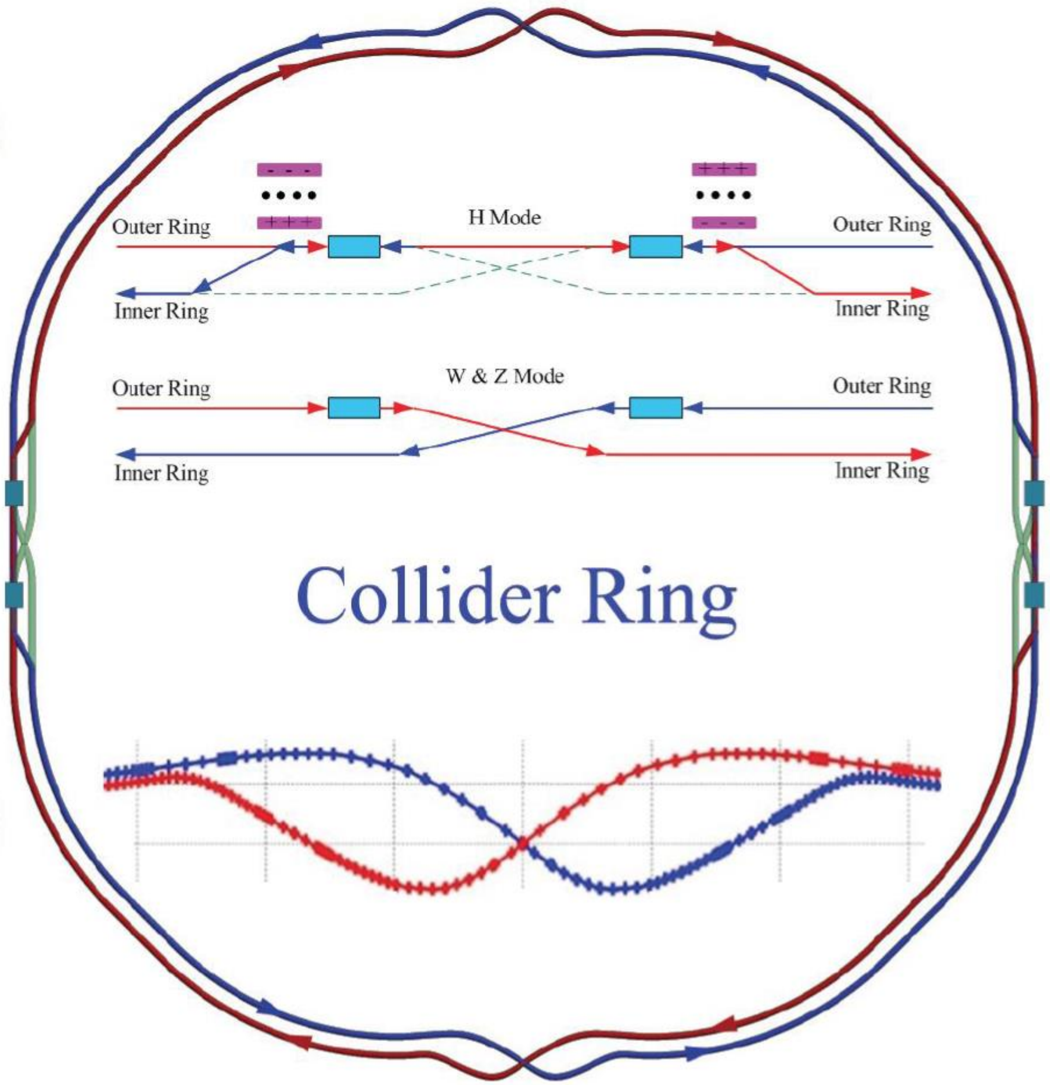
The CEPC Study Group
August 2018

CDR International Review June 28-30, 2018. Final CDR (accelerator) released on Sept. 2, 2018

Geometry design

Chenghui Yu





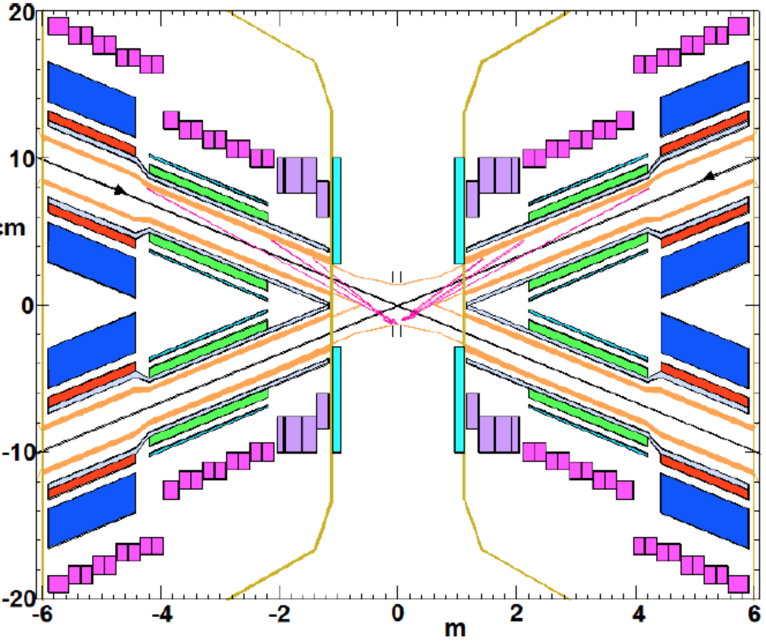
- Double ring collider with 2 IPs
- Compatible with the geometry of SPPC

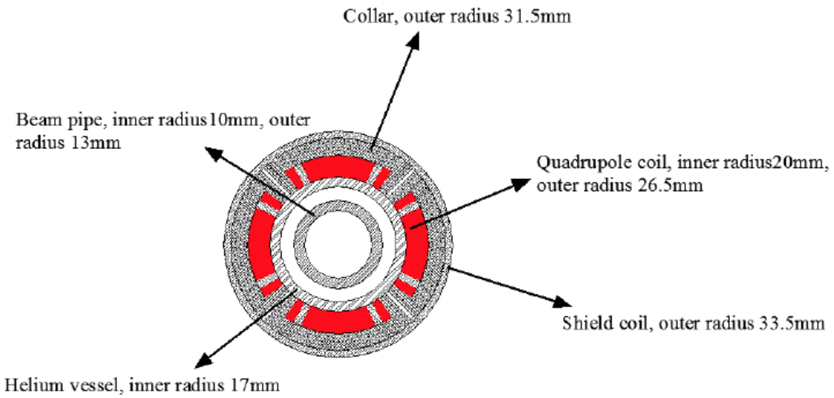
Beam performance of collider ring

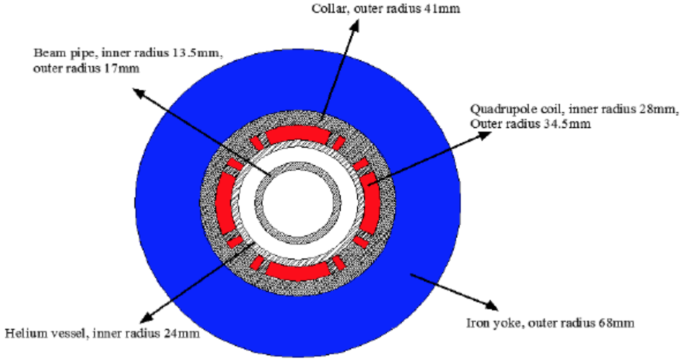
Interaction region

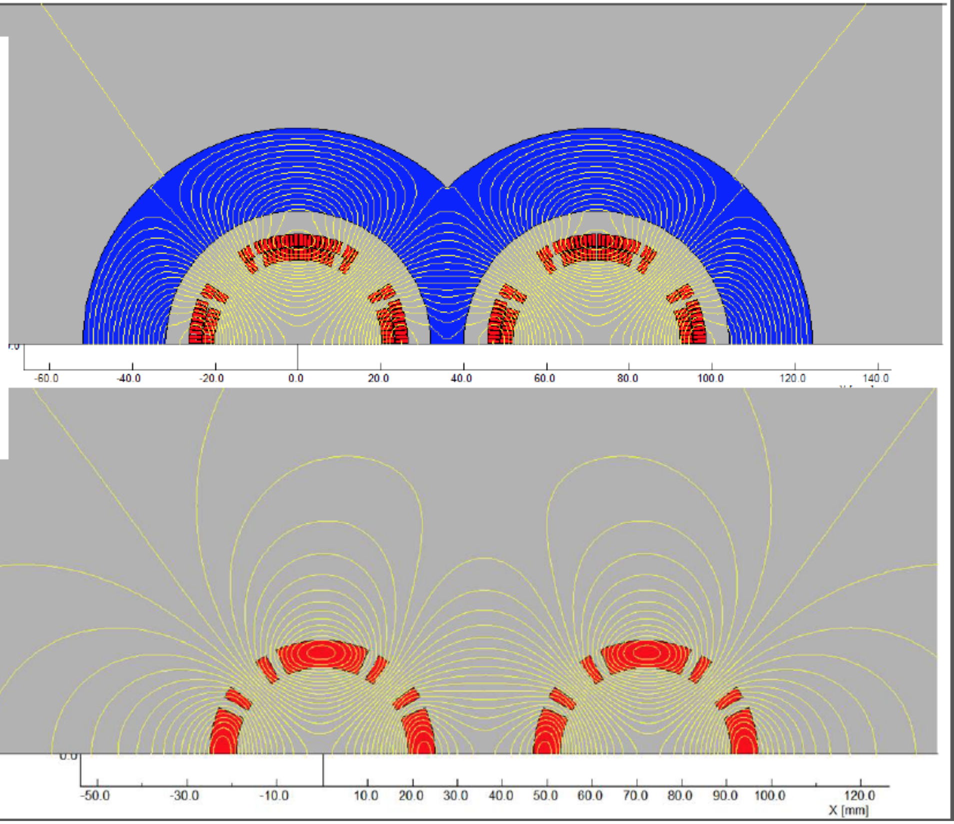
Chenghui Yu

- ✓ L*=2.2m, θc=33mrad, βx*=0.36m, βy*=1.5mm, Detector solenoid=3.0T
  - Lower strength requirements of anti-solenoids (B_z~7.2T)
  - Enough space for the SC quadrupole coils in two-in-one type (Peak field 3.8T & 136T/m) with room temperature vacuum chamber.



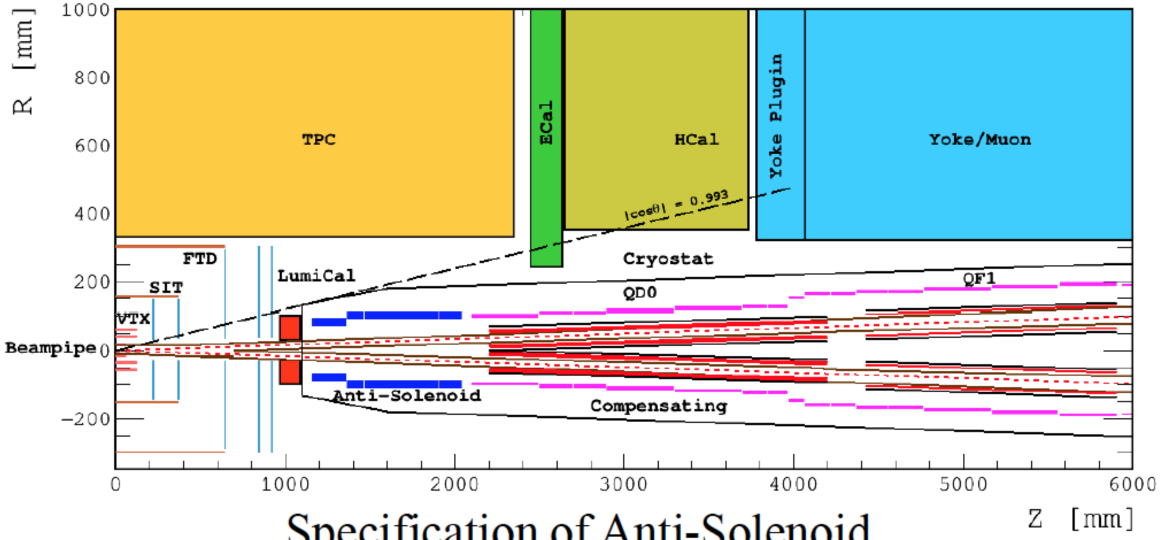


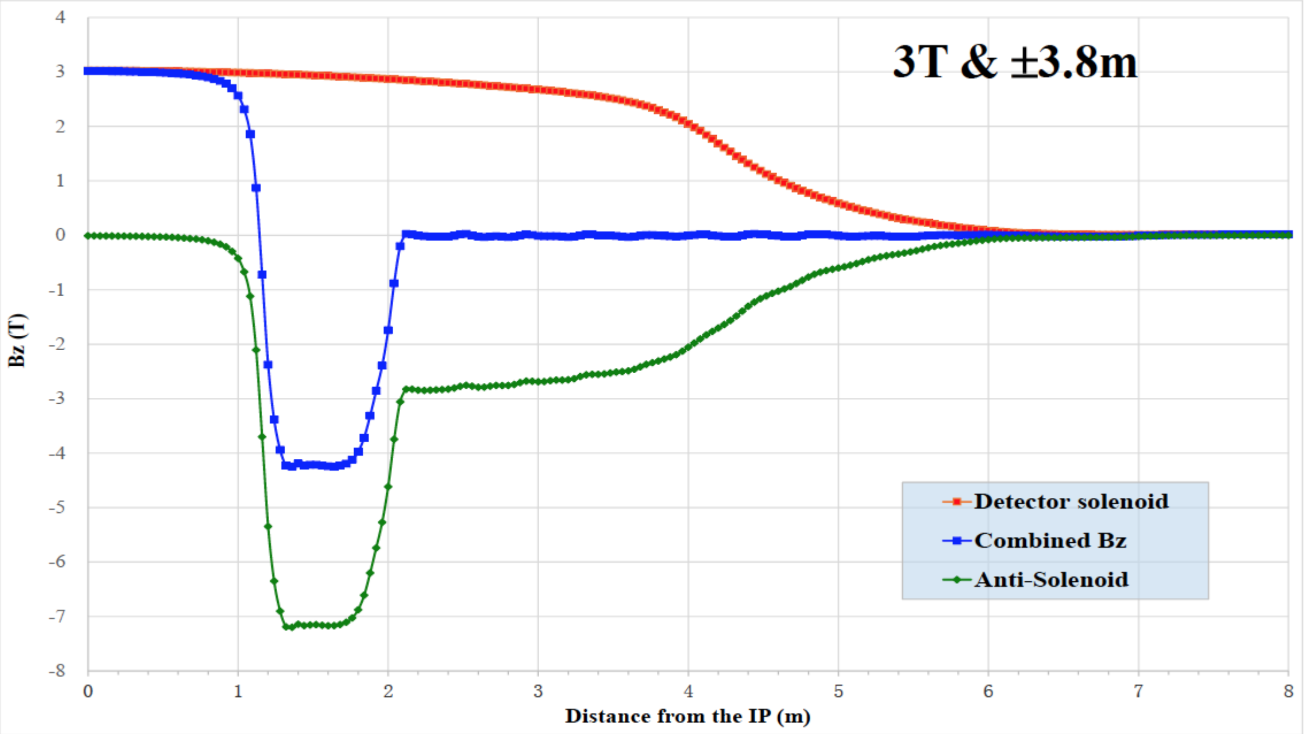




Beam performance of collider ring

Interaction region





Specification of Anti-Solenoid

Anti-solenoid	Before QD0	Within QD0	After QD0
Central field（T）	7.2	2.8	1.8
Magnetic length（m）	1.1	2.0	1.98
Conductor (NbTi-Cu, mm)	2.5×1.5		
Coil layers	16	8	4/2
Excitation current（kA）	1.0		
Inductance（H）	1.2		
Peak field in coil (T)	7.7	3.0	1.9
Number of sections	4	11	7
Solenoid coil inner diameter (mm)	120		
Solenoid coil outer diameter (mm)	390		
Total Lorentz force F_z (kN)	-75	-13	88
Cryostat diameter (mm)	500		

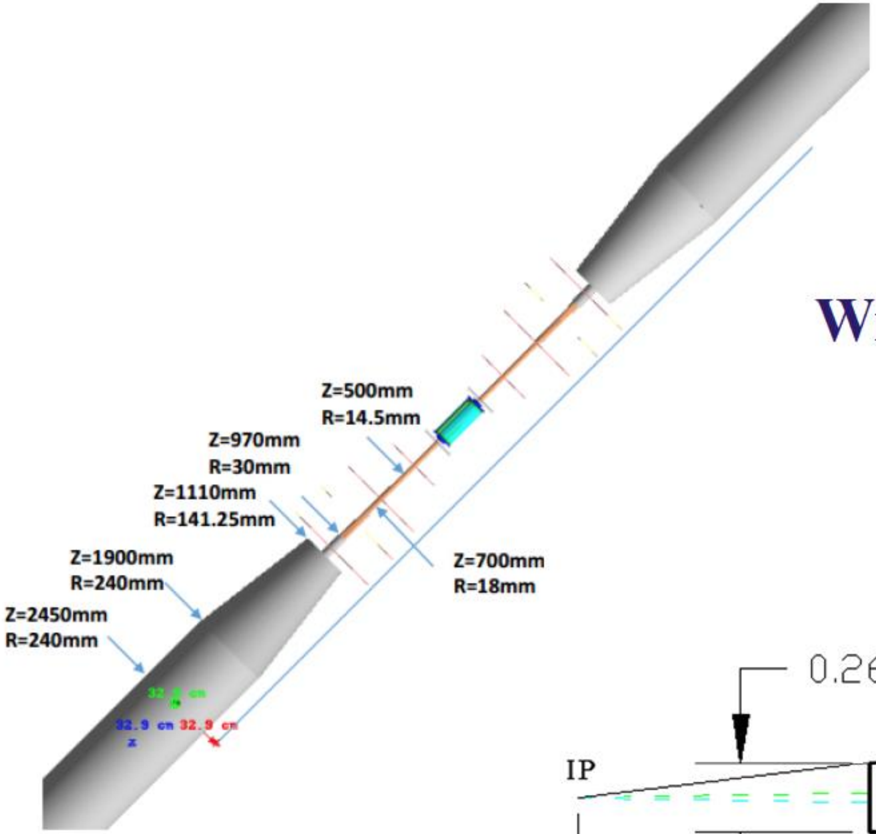
22 anti-Solenoid **sections with different inner coil diameters**

$\int B_z ds$ within 0~2.12m. Bz < 300Gauss away from 2.12m with local cancellation structure

The skew quadrupole coils are designed to make fine tuning of Bz over the QF&QD region instead of the mechanical rotation.

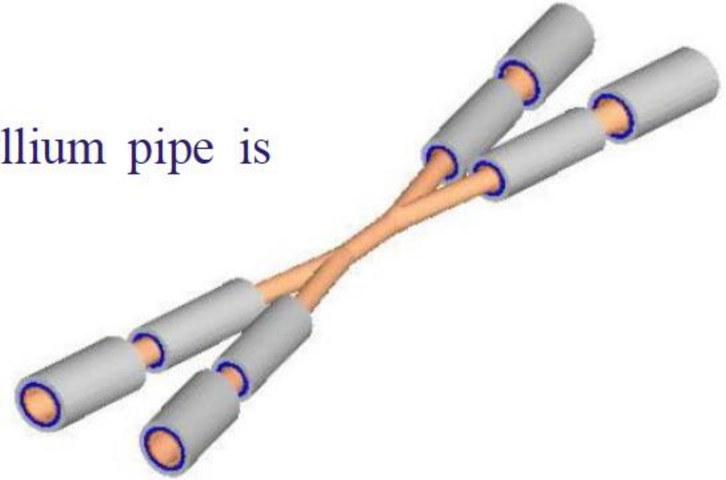
The design of interaction region

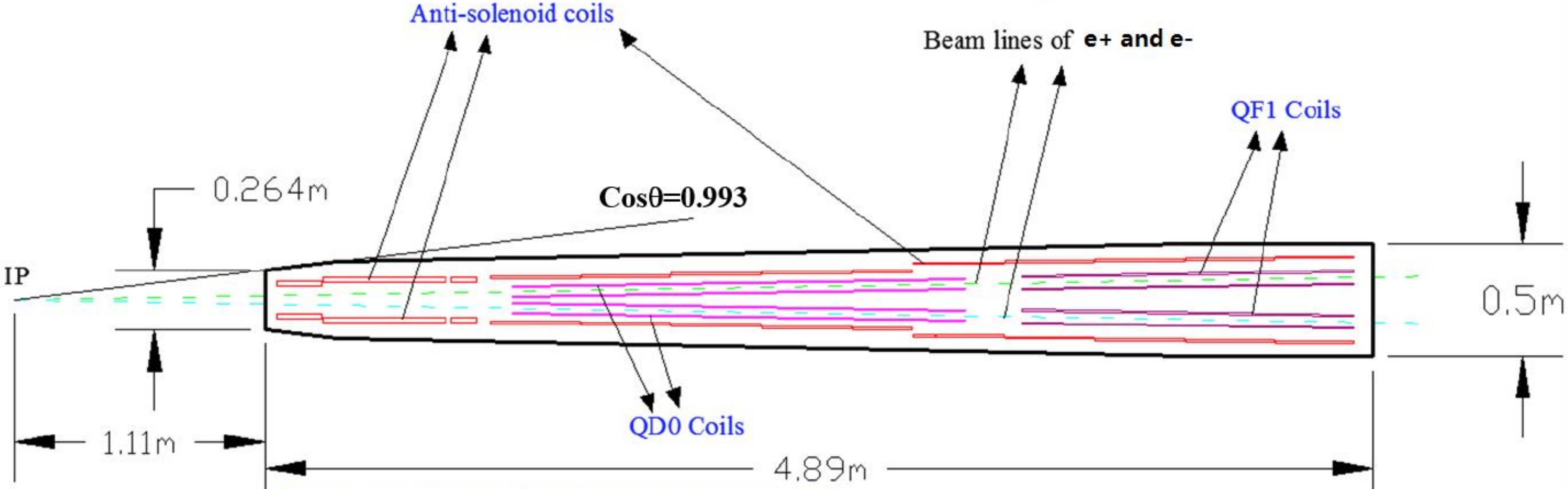
Sha Bai



The inner diameter of the beryllium pipe is 28mm with the length of ±7cm.

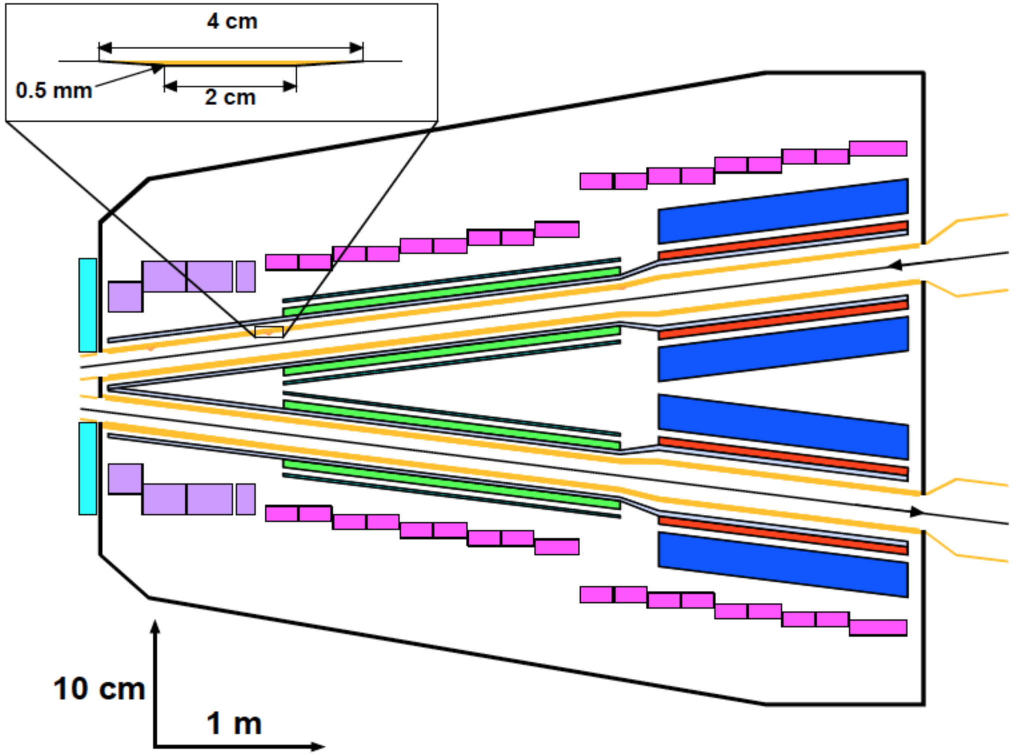
Without tungsten shield.





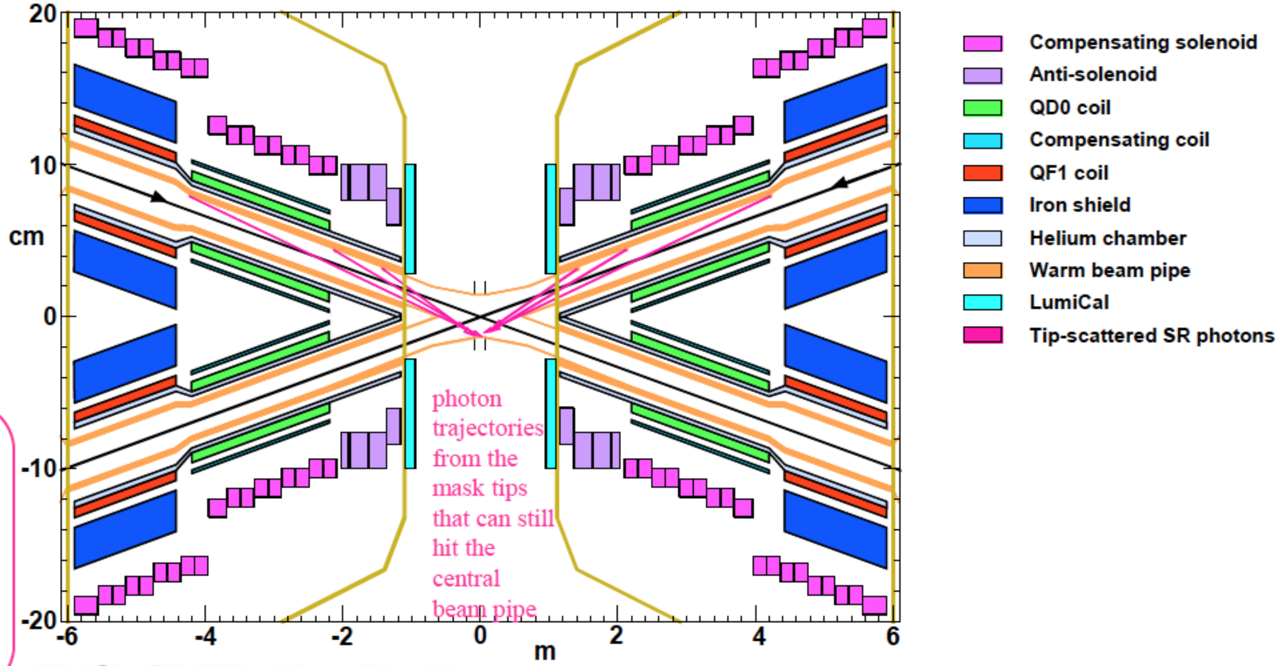
Mask design of IR

Sha Bai



The number of scattered photons that can hit the central beam pipe is greatly reduced to only those photons which forward scatter through the mask tips. The optimization of the mask tips (position, geometry and material) is presently under study.

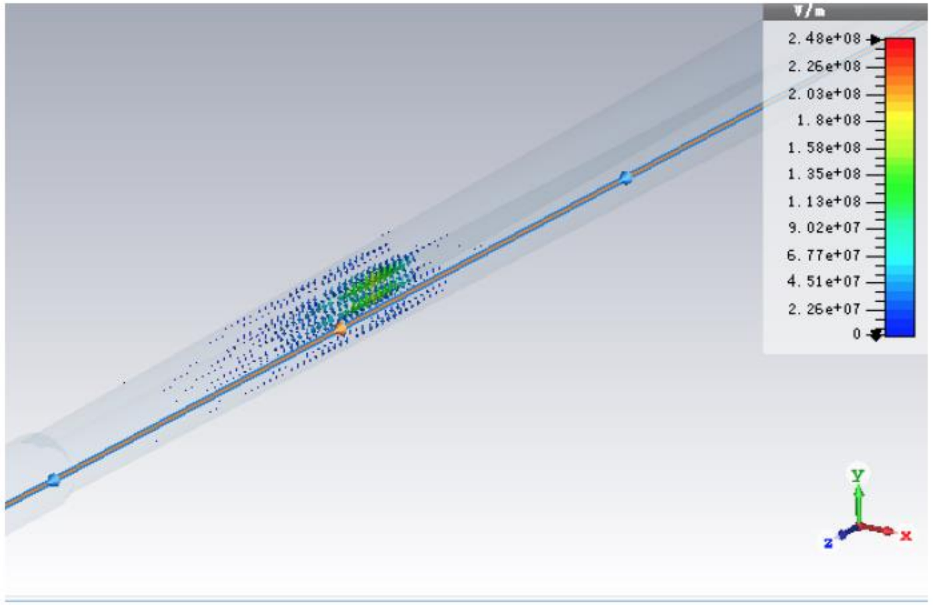
3 mask tips are added to shadow the beam pipe wall reduces the number of photons that hit the Be beam pipe from 2×10^4 to about 200 (100 times lower).

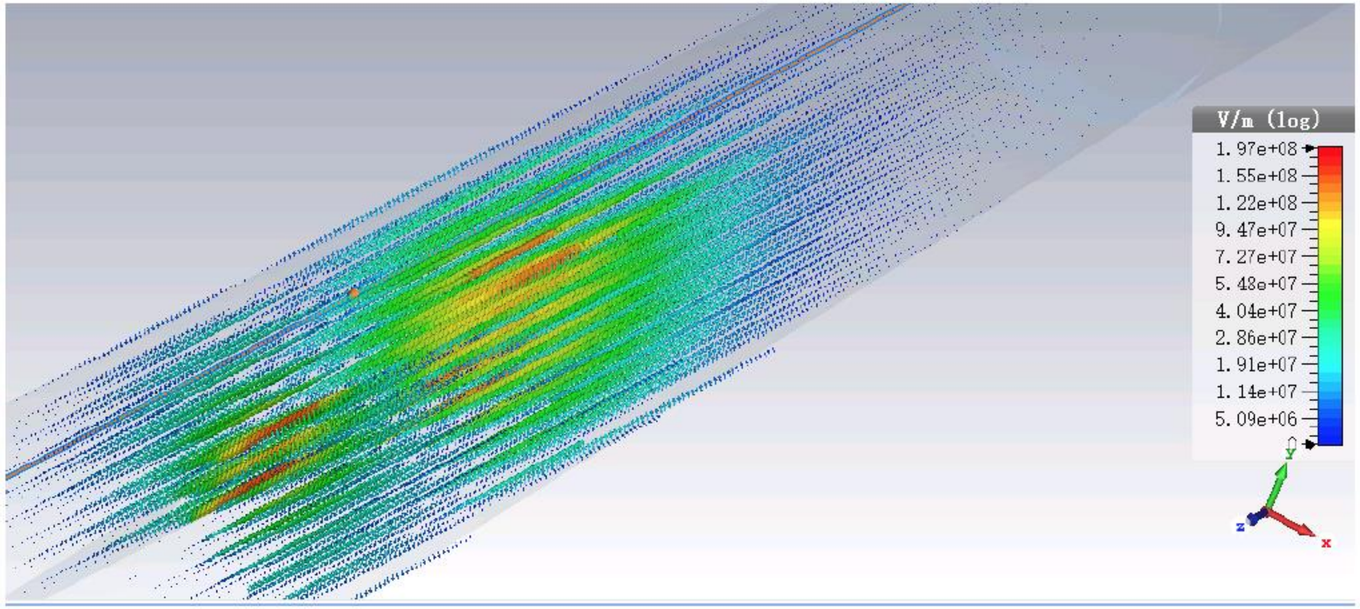


photon trajectories from the mask tips that can still hit the central beam pipe

HOM absorber

Sha Bai

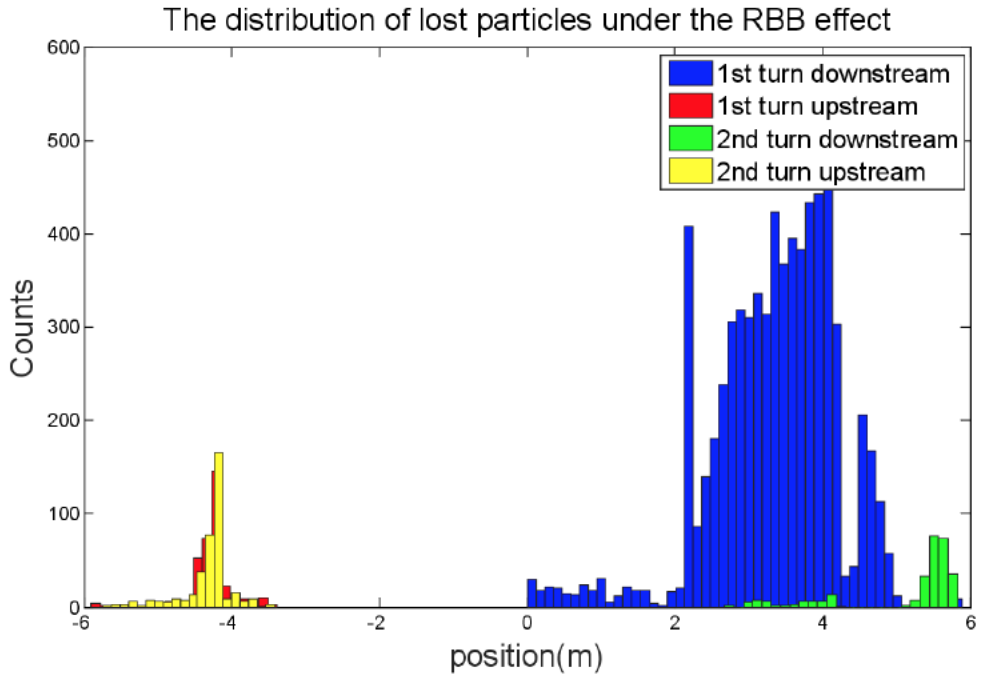


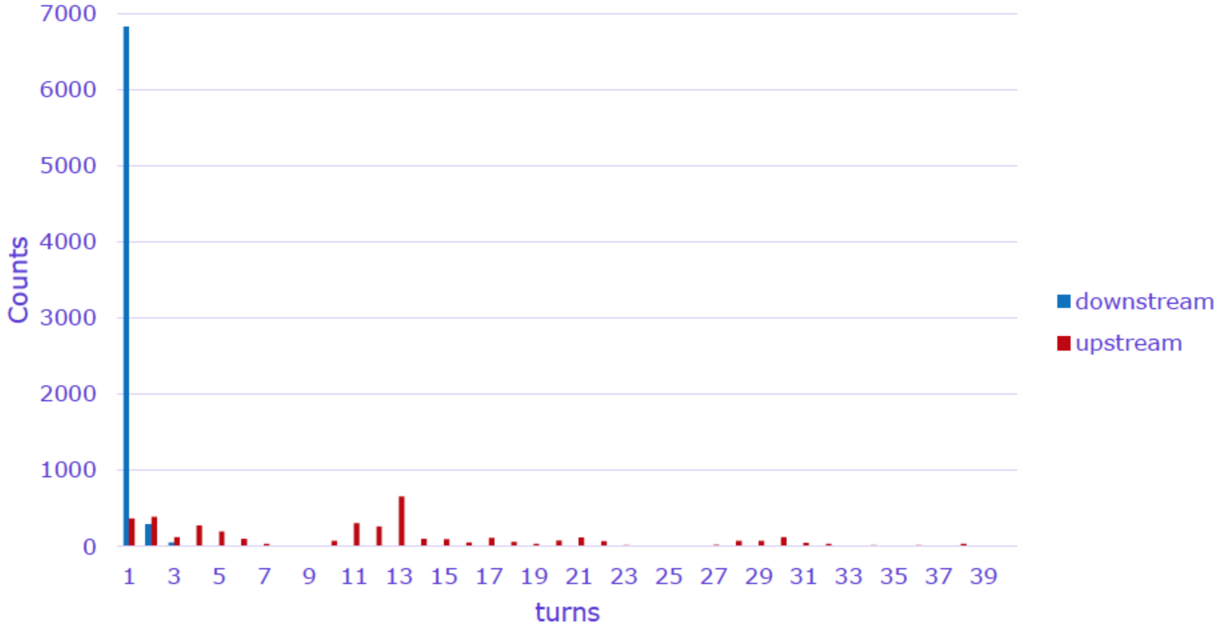


- TE mode, at crotch point（z~±700mm）
- Frenquency 3.2996GHz，Qe=1.42x10^{12}
- This mode is trapped mode.
- HOM absorber is needed，water cooling system considered.
- With the high order mode of this TE mode, eg. 3.715GHz.
- The boundary between accelerator and detector is still not clear. The design of HOM absorber can’t be confirmed in short period.

Loss particles due to RBB

Sha Bai

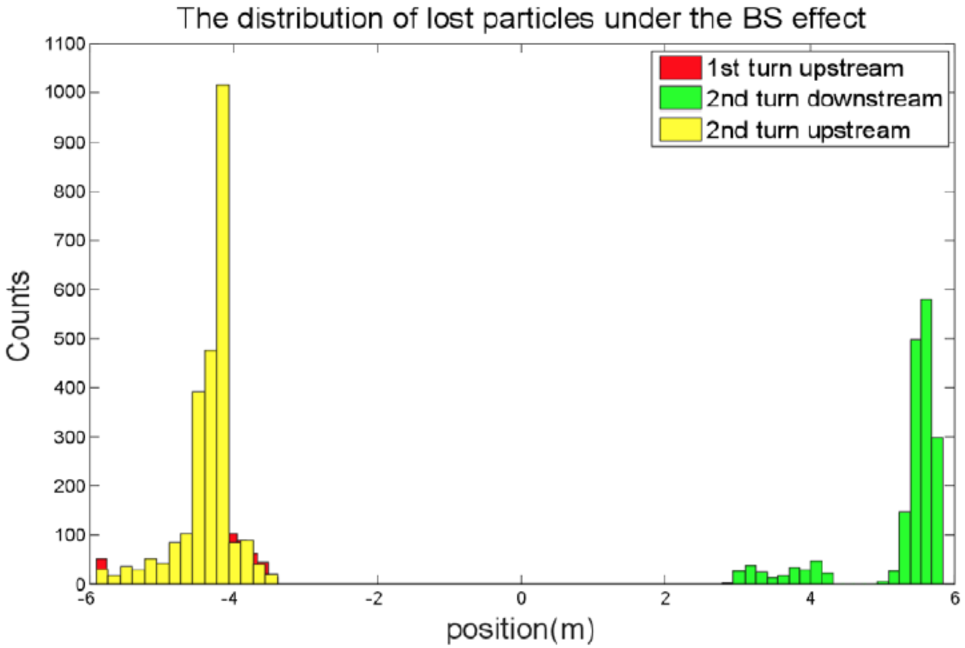

The distribution of lost particles under the RBB effect

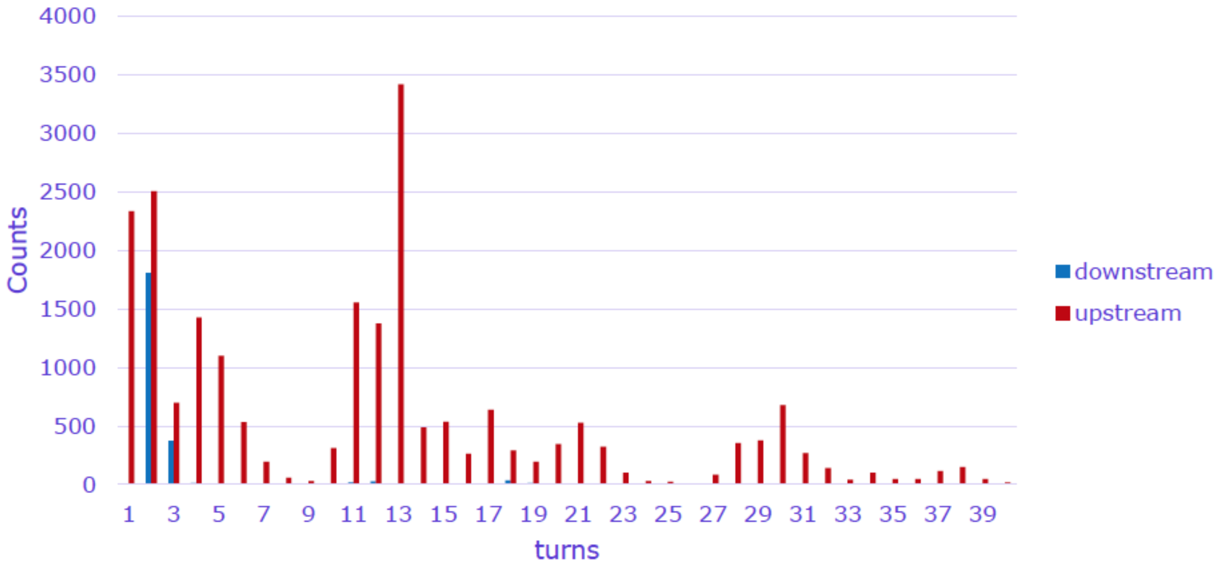


- Most the events lost in the detector immediately. A few particles with high energy will lost near the IP after one revolution for a small energy loss.
- Although pretty large fraction of events lost in the downstream region, the radiation damage for detector component is tolerable.
- Compared to the one turn's tracking, more particles get lost in the upstream region of the IR.
- The events lost in the upstream region are more dangerous for they are likely permeate into the detector components, even with the small flying angle respect to the longitudinal direction considered.
- Collimators are needed.

Loss particles due to BS

Sha Bai





- Energy spread distribution close to the energy acceptance, the beam loss particles not appeared in the downstream of first turn.
- Compared to the one turn's tracking, more particles get lost in the upstream region of the IR.
- The events lost in the upstream region are more dangerous for they are likely permeate into the detector components, even with the small flying angle respect to the longitudinal direction considered.
- Collimators are needed.

Collimator design in ARC for Higgs

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- Beam stay clear region: 18 σ_x+3mm, 22 σ_y+3mm
- Impedance requirement: slope angle of collimator < 0.1
- To shield big energy spread particles, phase between pair collimators: $\pi/2+n*\pi$
- Collimator design in large dispersion region: $\sigma=\sqrt{\varepsilon\beta + (D_x\sigma_e)^2}$

name	Position	Distance to IP/m	Beta function/m	Horizontal Dispersion/m	Phase	BSC/2/m	Range of half width allowed/mm
APTX1	D1I.1897	2139.06	113.83	0.24	356.87	0.00968	2.2~9.68
APTX2	D1I.1894	2207.63	113.83	0.24	356.62	0.00968	2.2~9.68
APTX3	D1O.10	1832.52	113.83	0.24	6.65	0.00968	2.2~9.68
APTX4	D1O.14	1901.09	113.83	0.24	6.90	0.00968	2.2~9.68

Beam-Gas bremsstrahlung loss particles

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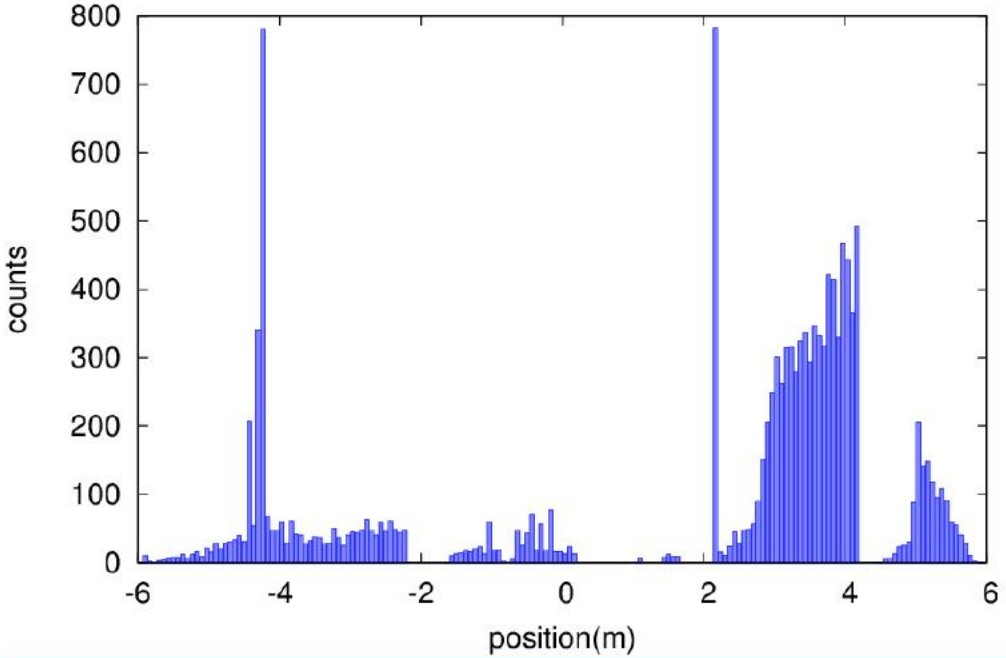
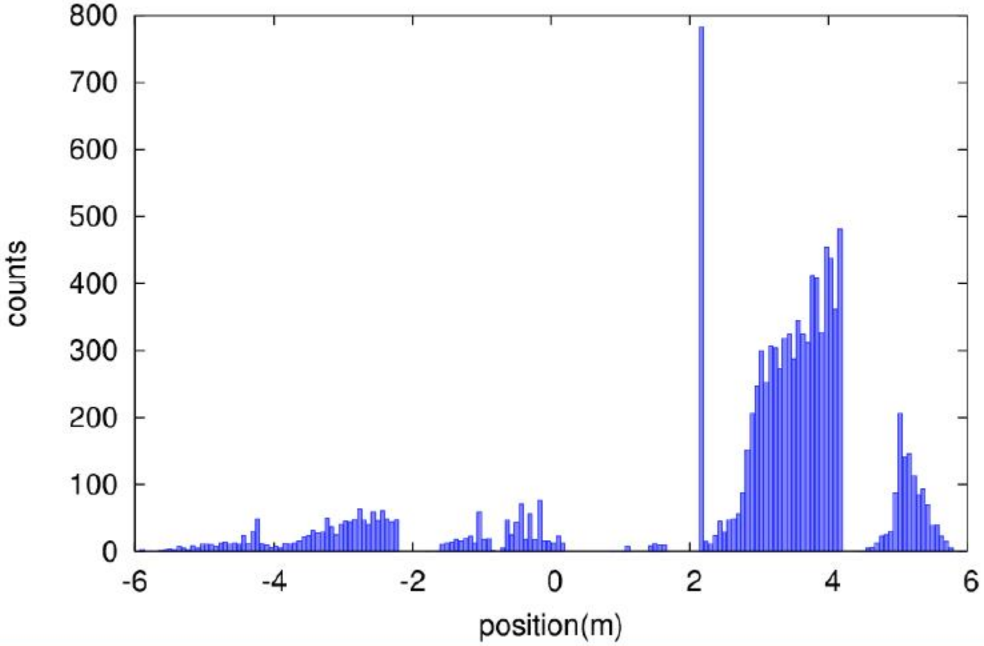
Without collimators



With collimators



- The lost particles has been reduced to a very low level with RBB collimators, especially in the upstream of the IP, can be accepted by the detector.
- Although the beam loss in the downstream of the IP is still remained, the radiation damage and the detector background are not serious, since the direction is leaving the detector.

Beam-Thermal photon scattering loss

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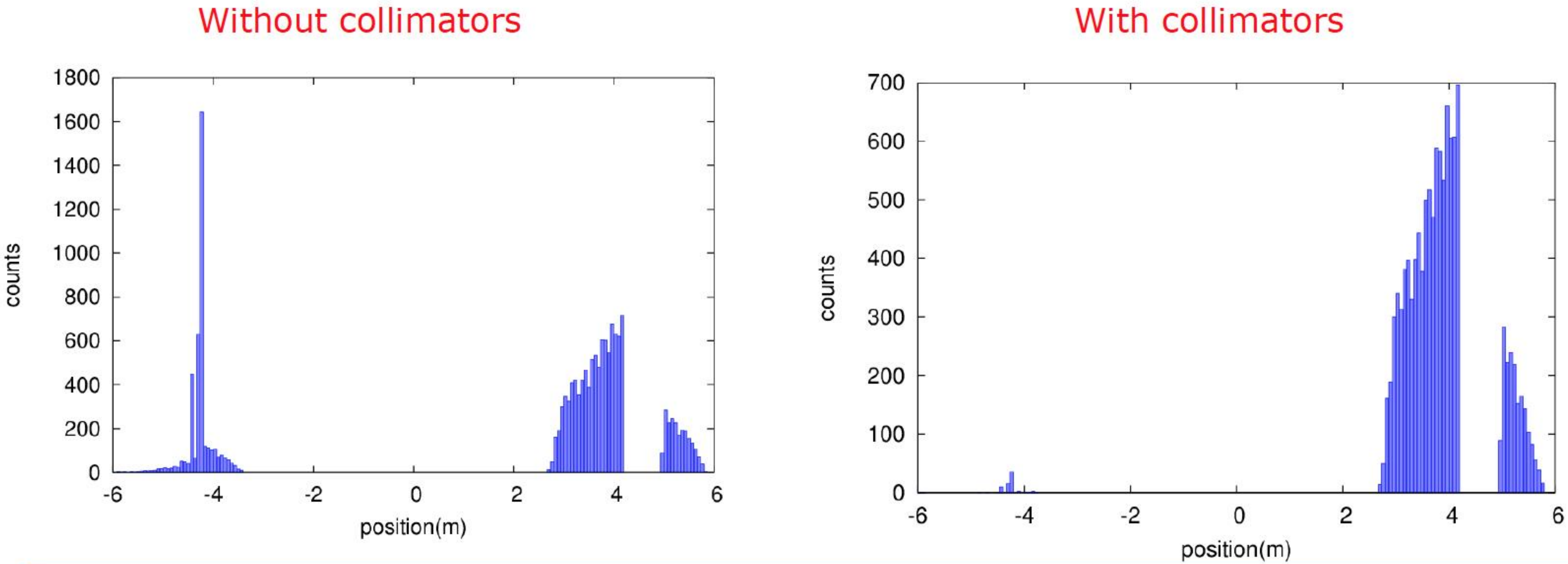

- The lost particles has gone with RBB collimators in the upstream of the IP, can be accepted by the detector.
- Although the beam loss in the downstream of the IP is still remained, the radiation damage and the detector background are not serious, since the direction is leaving the detector.

IR mechanics assembly

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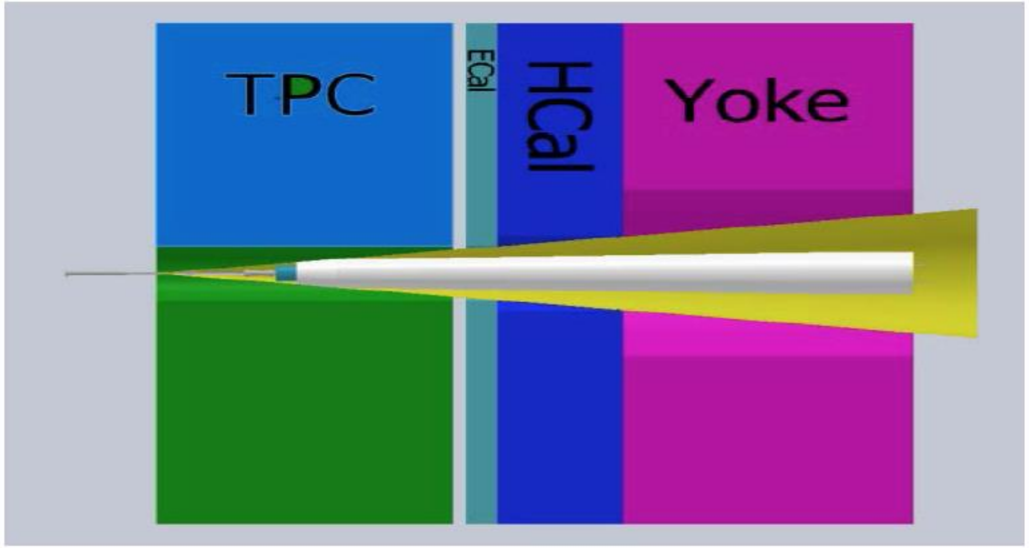

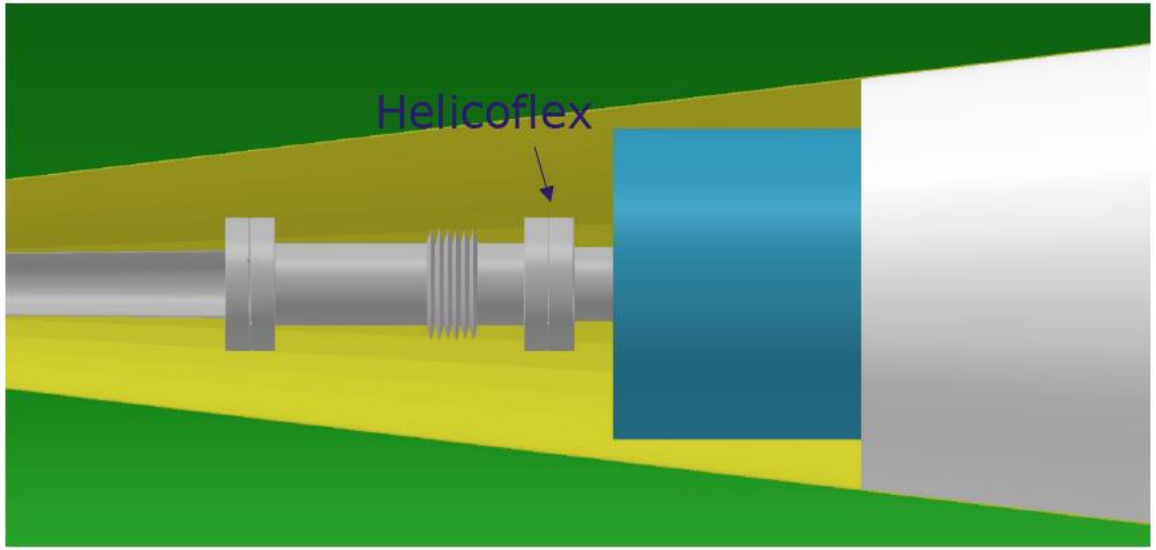

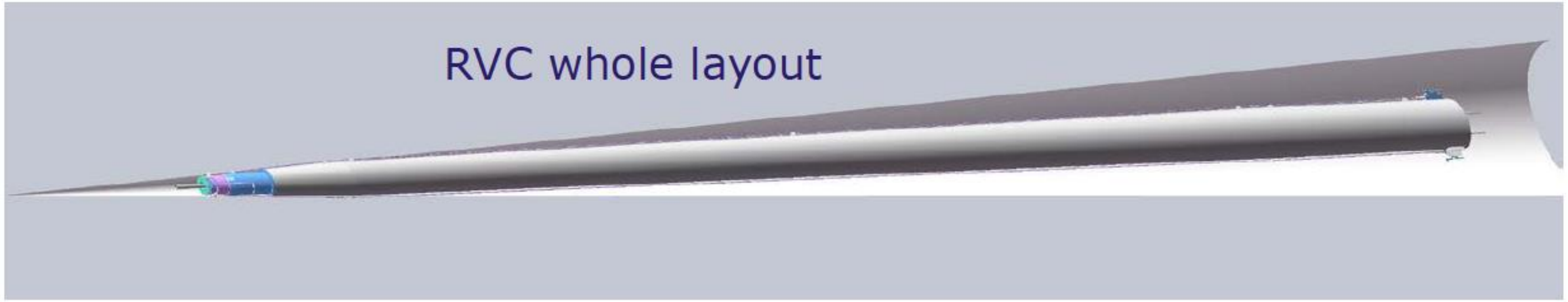

- IR mechanics assembly typical point is remote vacuum connection.
- The sealing point is 6m away from the operation point.
- Ultrahigh vacuum sealing, Helicoflex.

IR Mechanics Assembly

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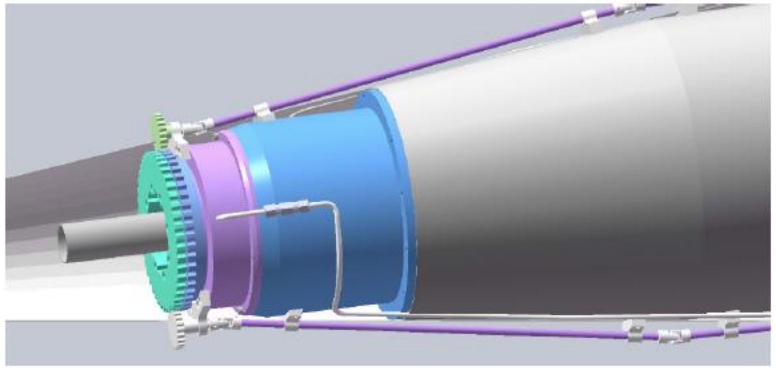
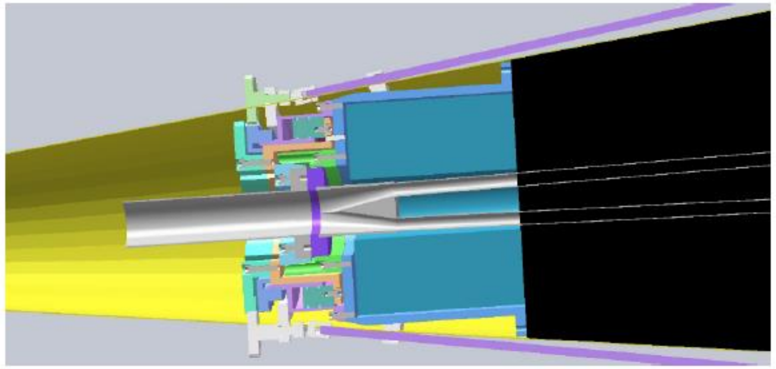
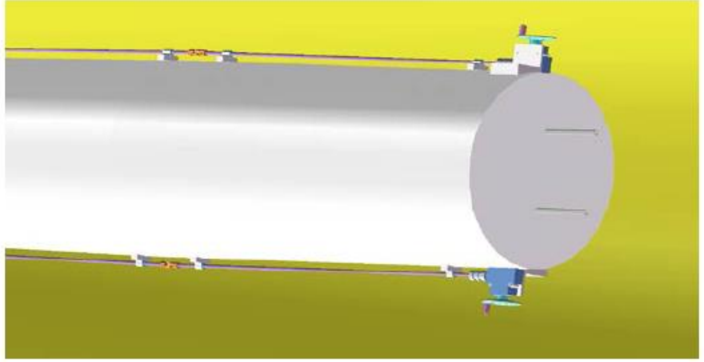
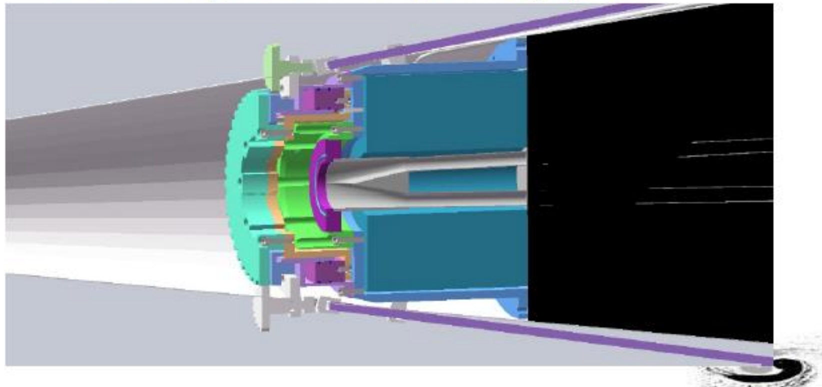
- No easy solution to install all the critical components in the IR with high precision; inspired by the Remote Vacuum Connection (RVC) developed by SuperKEKB
- We are studying the special installation tools for the remote connection of bellows.


RVC head and drive gear

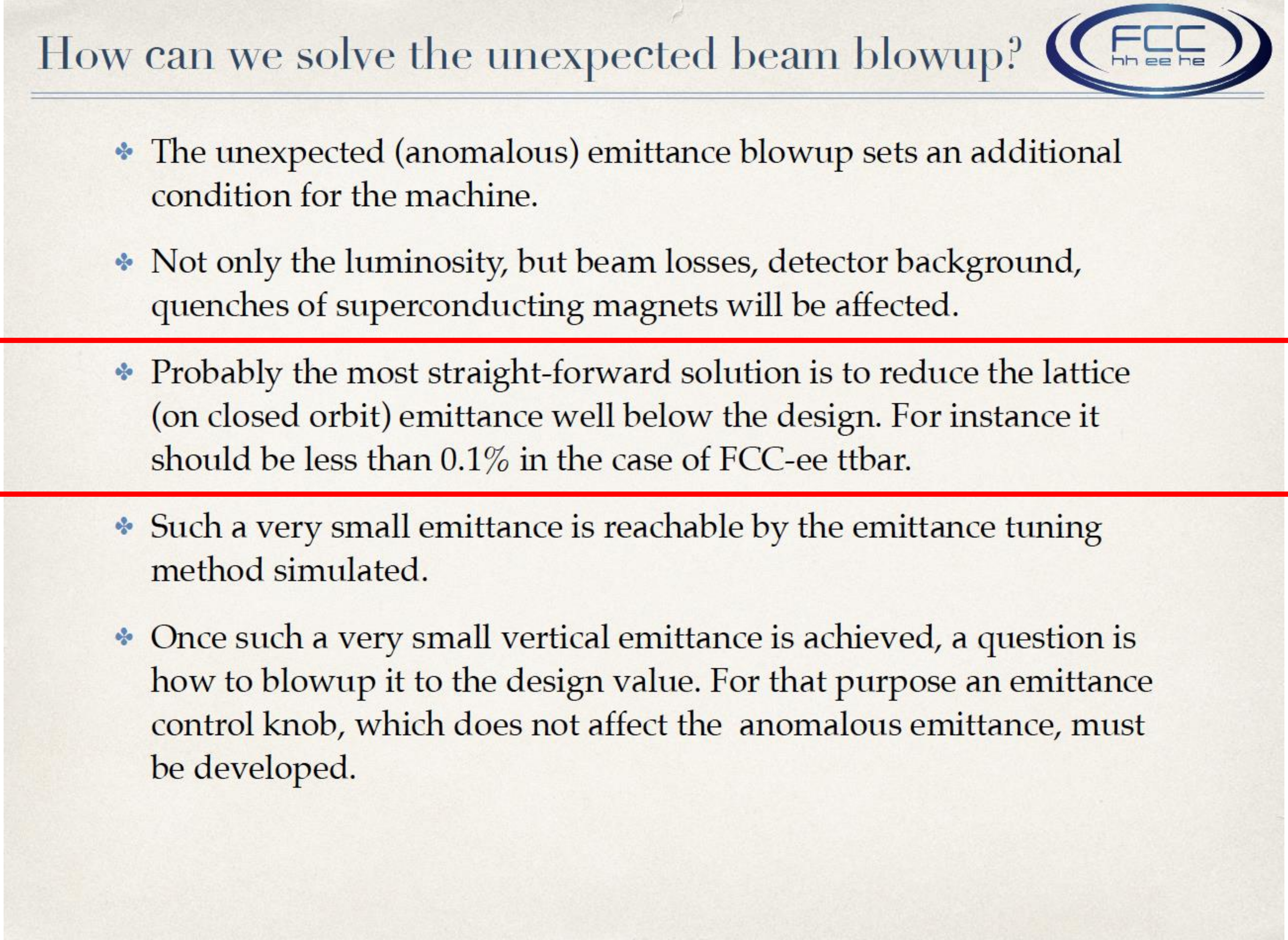

cutaway view of RVC head


RVC tail/handwheel structure


Cutaway view of moving part

RVC is under development

K. Oide



How can we solve the unexpected beam blowup?

- The unexpected (anomalous) emittance blowup sets an additional condition for the machine.
- Not only the luminosity, but beam losses, detector background, quenches of superconducting magnets will be affected.
- Probably the most straight-forward solution is to reduce the lattice (on closed orbit) emittance well below the design. For instance it should be less than 0.1% in the case of FCC-ee ttbar.
- Such a very small emittance is reachable by the emittance tuning method simulated.
- Once such a very small vertical emittance is achieved, a question is how to blowup it to the design value. For that purpose an emittance control knob, which does not affect the anomalous emittance, must be developed.

Next edition eeFact20 in Frascati !

Autumn 2020