Summary of Accelerator Physics

(and Technology)

M. Biagini, INFN-LNF

E. Levichev, BINP

eeFact2018, IAS, HK, Sep. 27th 2018

Workshop outlook, Accelerator part

- 11 WG, 1 plenary + 8 parallel sessions
- Total 85 talks
- Accelerator talks “due” in this summary → 68
- All talks very good, but…
- …due to lack of time I clearly cannot cover all presentations

I apologize to the speakers
for the talks which could not be summarized here

FCCee, CEPC, ILC, CLIC

The BIG ones for the future…

Beam-beam

Main Limitations Associated with Beam-Beam

- Beamstrahlung leads to an increase in the energy spread (several times at low energies) and creates long non-Gaussian tails (mainly at high energies).

  This requires obtaining a large momentum acceptance (especially at high energies) to ensure the necessary beam lifetime.

- Two new phenomena were recently discovered in simulations:

  1) 3D flip-flop (occurs only in the presence of beamstrahlung, when $\sigma_z >> \sigma_{z0}$)
  2) Coherent X-Z instability

  Both instabilities are bound with LPA and horizontal synchro-betatron resonances – satellites of half-integer. Most strongly manifested at low energies.

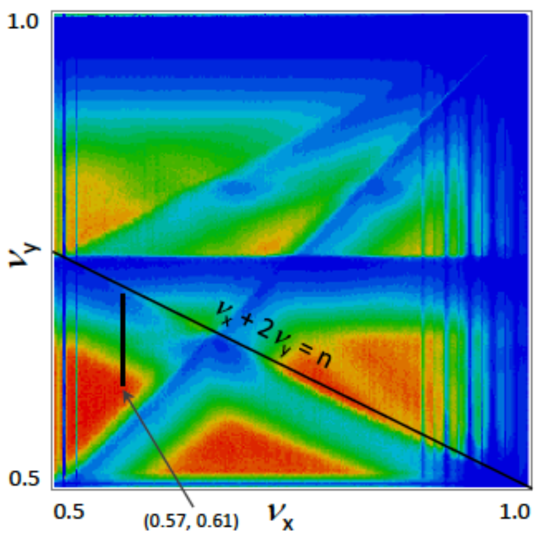
- For high luminosity, an allowable asymmetry in the population of colliding bunches should be small (because of beamstrahlung).

  This imposes strict requirements on the injector and the scheme of its operation.

D. Shatilov

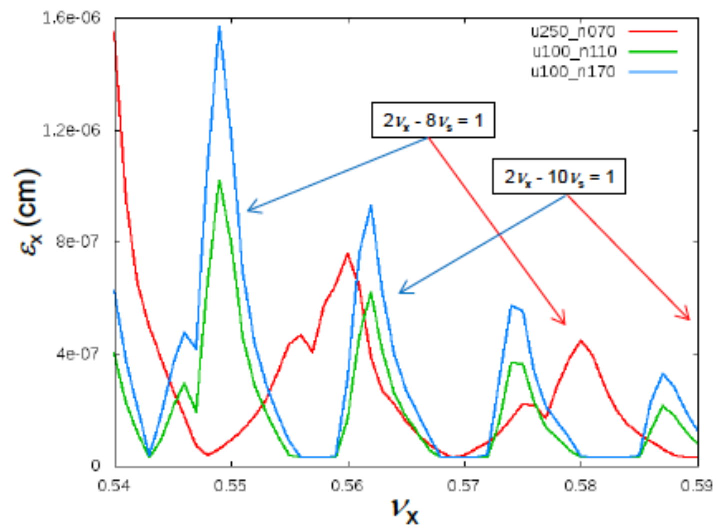
FCC-ee at Z (45.6 GeV)

Luminosity vs. betatron tunes, simplified model, weak-strong simulations. Colors from zero (blue) to $2.3 \cdot 10^{36}$ cm^{-2}c^{-1} (red).



The range of permissible ν_x for large ξ_y is bounded on the right by 0.57÷0.58.

Coherent instability: ε_x dependence on ν_x and ν_s. Quasi-strong-strong simulations. U_{RF} = 250 MV (red) and 100 MV (green, blue).



The distance between resonances is ν_s. The width depends on ξ_x and the order of resonances.

We need to reduce ξ_x / ν_s ratio and increase the order of resonances near the working point.

- Decrease β_x^* (and thus ξ_x).

  This leads to a decrease in the energy acceptance. Eventually it can be reduced to 15 cm.

- Increase the momentum compaction factor: ν_s and σ_z grow, ξ_x decreases.

  This is done by changing FODO arc cell (K. Oide), which also leads to an increase in ε_x. However, ε_y = 1 pm can be achieved. Besides, the threshold of microwave instability is raised.

- Reduce the RF voltage.

  This decreases ν_s and ξ_x in the same proportion, but increases the order of resonances near the w.p.

- Neat choice of ν_x between synchro-betatron resonances.

D. Shatilov

Bootstrapping

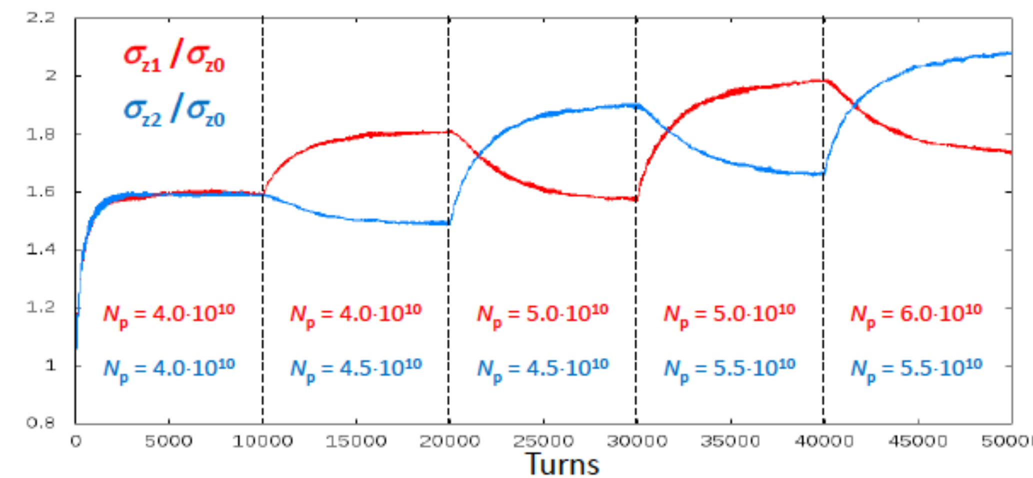
- When the energy spread is defined mainly by beamstrahlung, the dependence on N_p (bunch population) becomes:

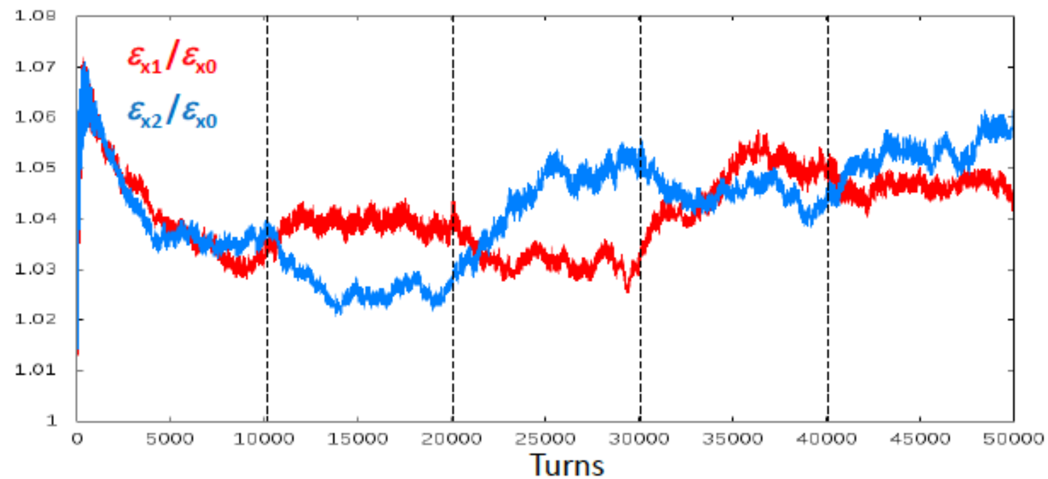
$$\xi_x = \text{const}, \quad \sigma_E, \sigma_z, \xi_y, L \propto \sqrt{N_p}$$

- With the nominal $N_p = 1.7 \cdot 10^{11}$ required for high luminosity, σ_z increases ~3.5 times.
- If we bring into collision such bunches with the "initial" σ_z (energy spread created only by SR), the beam-beam parameters will be far above the limits.

⇩

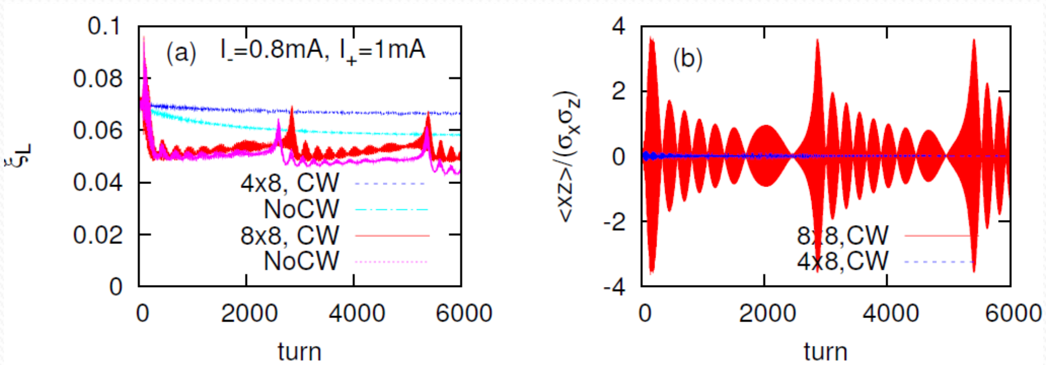
- The beams will be blown up and killed on the transverse aperture, before they are stabilized by the beamstrahlung.
- To avoid this, we have to gradually increase the bunch population during collision, so we come to *bootstrapping*.





D. Shatilov

Coherent beam-beam Instability seen in strong-strong simulation @SuperKEKB

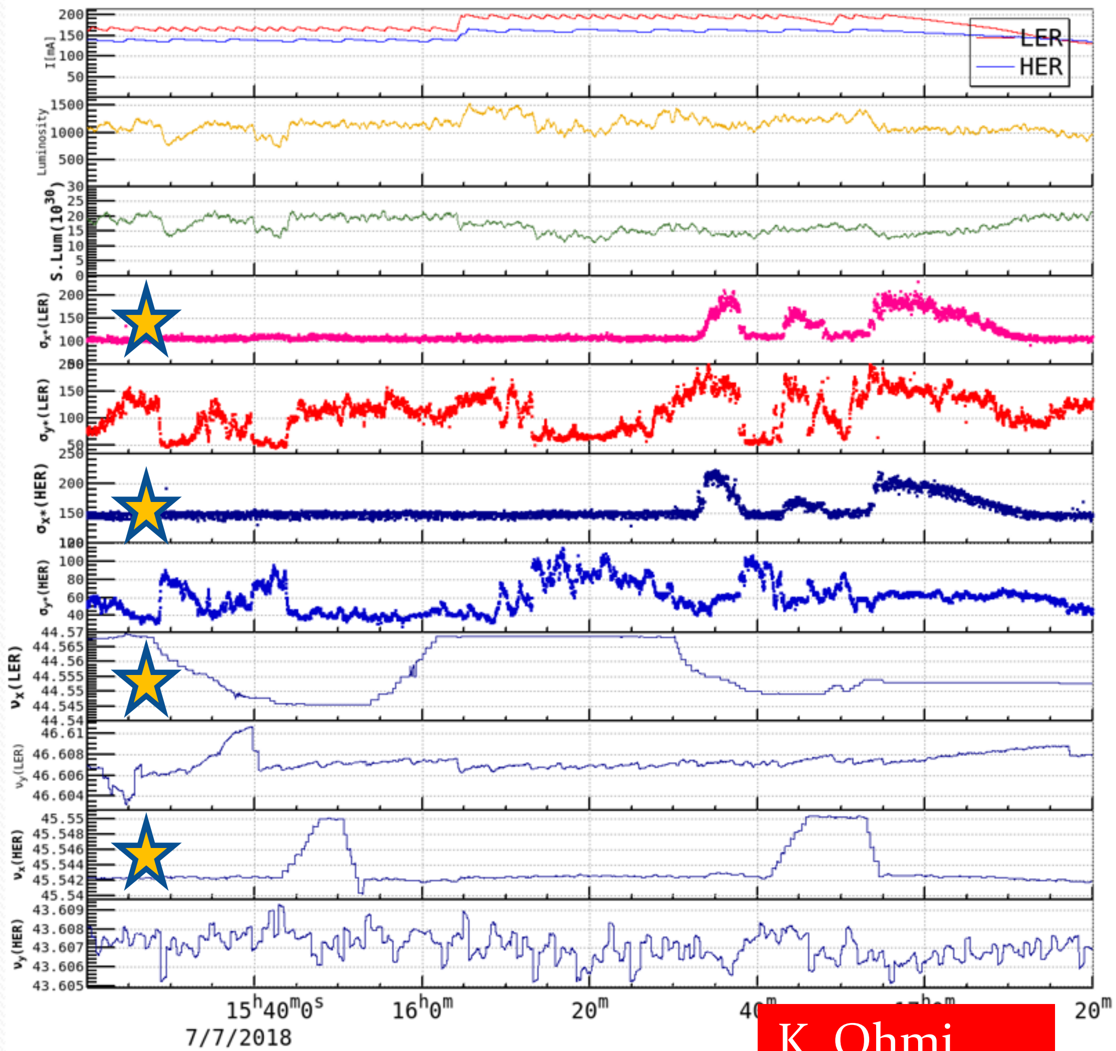


- Design parameters of SuperKEKB was stable
- We squeeze β* step-by-step
- Instability was seen in detuned β* (8x,8x)
- Coherent instability in head-tail mode due to large crossing angle
- Plan to study this instability in Phase II commissioning
- This instability is serious for FCC-ee design

K. Ohmi

Measurements of threshold of the instability

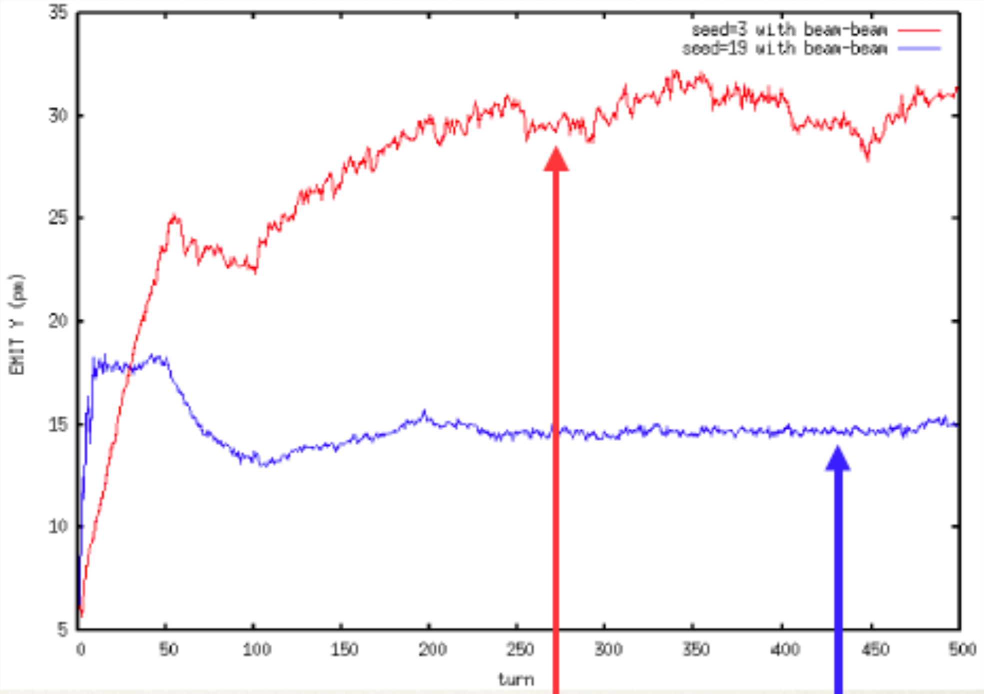
- 170mAx142mA, No σ_x blowup
- 200mAx160mA, blowup is seen.
- No blow-up in single beam tune scan.



K. Ohmi

Unexpected beam blowup

- D. El Khechen has observed an unexpected vertical beam blowup in tracking simulations with beam-beam and lattice at FCC-ee ttbar.
- The vertical (on closed orbit) emittance of the lattice is generated by random misalignments of sextpoles and set to the design (2.9 pm = 0.2%).
- In early simulation with beam beam and lattice without misalignment did not show such blowups (D. Zhou).
- The blowup strongly depends on the random number for strength of skew quads or misalignment of sextupoles to produce the vertical emittance.
- See D. El Khechen's presentation on Tuesday (WG4, 17:10).



Coupling (%)	0.2	0.2
RMS of sext. Offset ()	11	15
Seed	3	19
η_y @ (IP.1, IP.2) ()	(-5.3, 4.24)	(-8.9,8)
η_{py} X β_y^* @ (IP.1, IP.2) ()	(6.8, 1.04)	(35.4,23)
R2 parameter	$(1.8\times10^{-3},1.8\times10^{-3})$	$(-5.1\times10^{-5},-1.8\times10^{-4})$

lattice emittance on closed orbit = 2.9 pm

D. El Khechen

- This unexpected blowup occurs even when the residual dispersion at the IP is below the criteria given by D. Shatilov with beam-beam simulation with beamstrahlung but without the lattice.

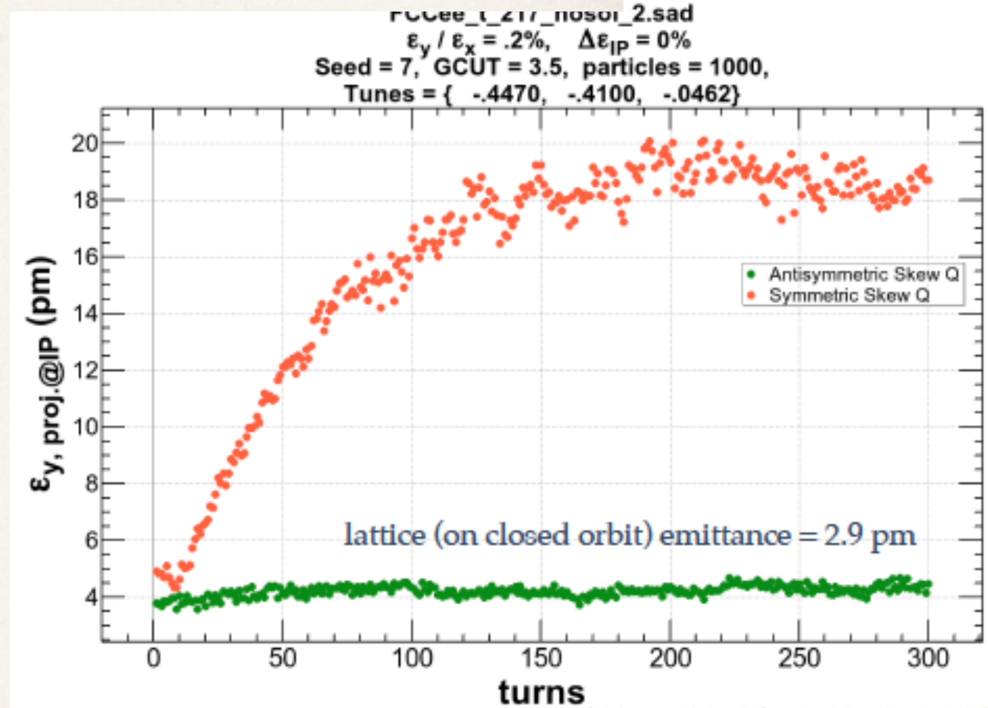
- Then it was found that such a blowup could occur even ***without beam-beam***.

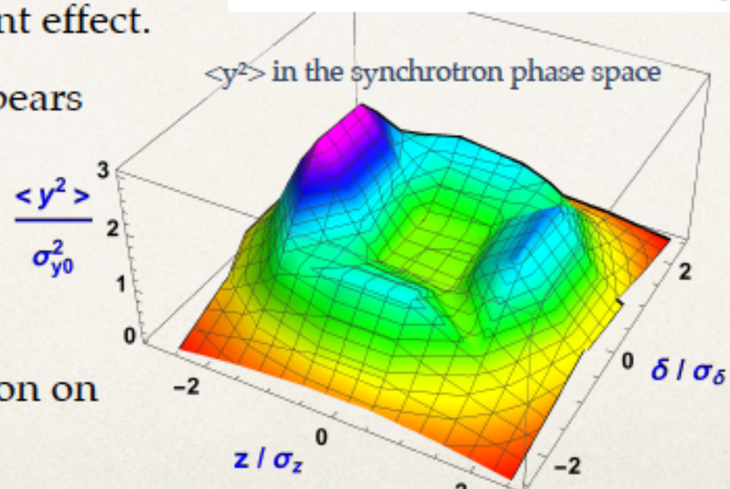
- The blowup depends on how the vertical emittance is generated (between symmetric skew = *x-y* coupling dominated and antisymmetric skew = vertical dispersion dominated).

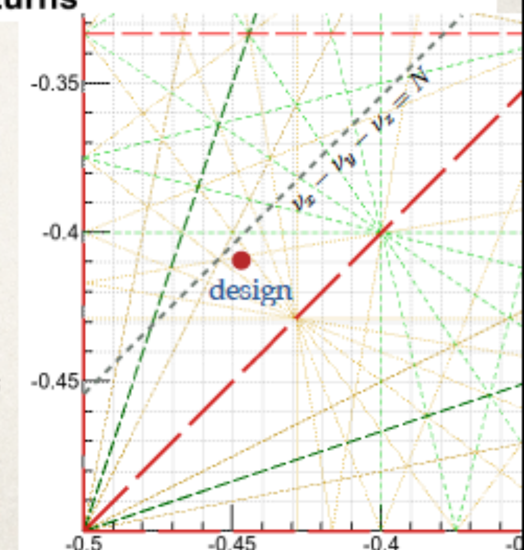
- The blowup is explained by a Vlasov model for "anomalous emittance" in Ref. [2].

- The first sideband of the main coupling resonance has the most dominant effect.

- With beam-beam, this effect appears differently.







- Please visit K. Oide's presentation on Wednesday (WG2a, 11:00).

[2] K. Oide, H. Koiso, ``Anomalous equilibrium emittance due to chromaticity in electron storage rings", Phys.Rev. E49 (1994) 4474-4479.

DA limitations due to SR from FF quads @ FCCee

Vertical plane @ 45 GeV

1. Observed and studied a new effect limiting dynamic aperture.
2. Radiation from FF quadrupoles modulates p_σ at double betatron frequency.
3. Parametric resonance in vertical motion changes damping. It is observed in tracking and obtained by equations.
4. Estimations with some assumptions predict dynamic aperture limit $J_{y,limit} \approx 51\sigma_y$, tracking gives $58\sigma_y$.
5. $\pi/2$ phase advance between quadrupoles will decrease p_σ modulation at double betatron frequency and eliminate parametric resonance.

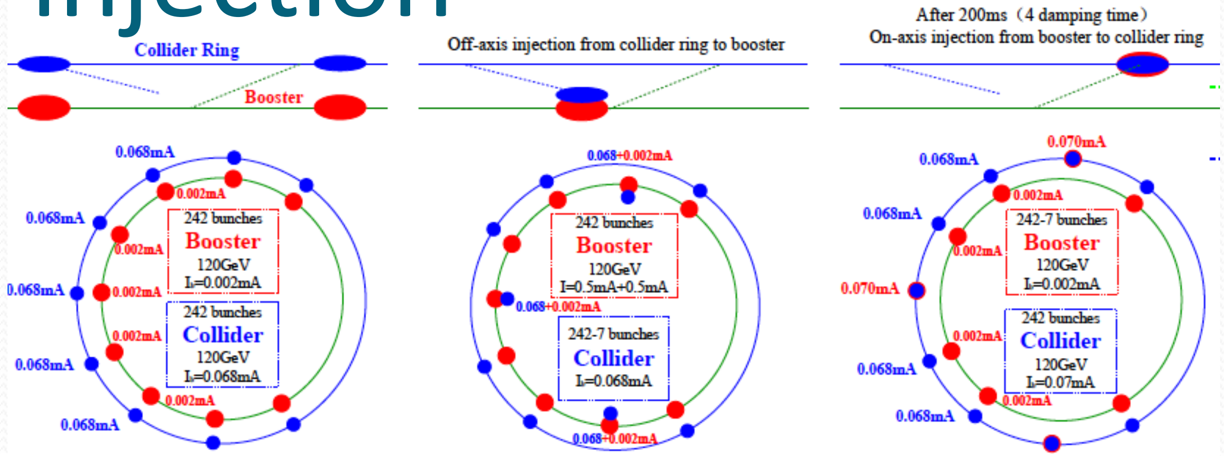
A. Bogovmiakov

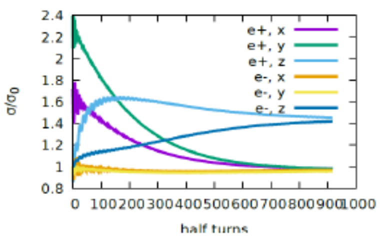
Horizontal plane @ 45 GeV

1. Radiation from quadrupoles shifts the synchronous phase and energy proportional to the horizontal action,
2. therefore synchrotron oscillations arise.
3. Horizontal tune dependence on action and energy of the particle shifts the tune to integer resonance.
4. Minimization of beta function chromaticity will reduce $\frac{\partial^2 \nu_x}{\partial J_x \partial p_\sigma}$ and enhance horizontal dynamic aperture.

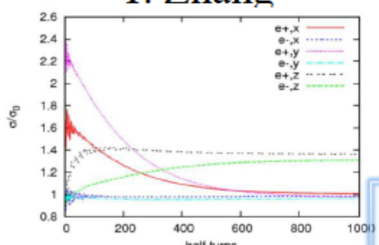
CEPC on-axis injection

X. Cui

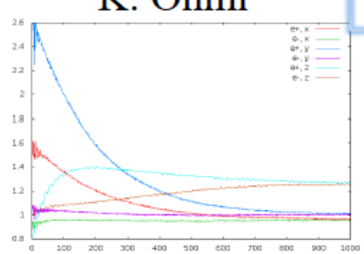




Y. Zhang



K. Ohmi



D. Shatilov

The on-axis injection

Even with the conditions:

Horizontal offset 9% sigma_X

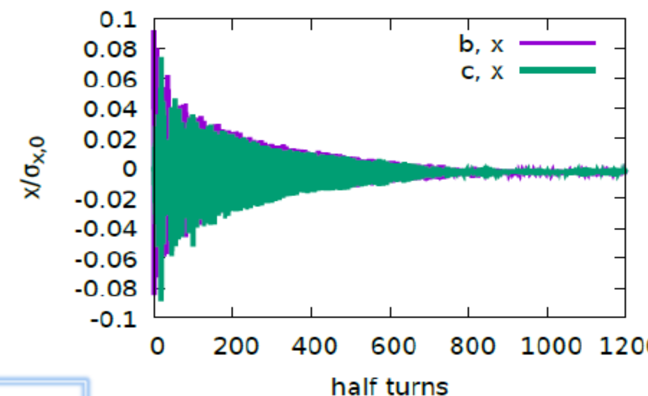
Vertical offset 50 % sigma_Y

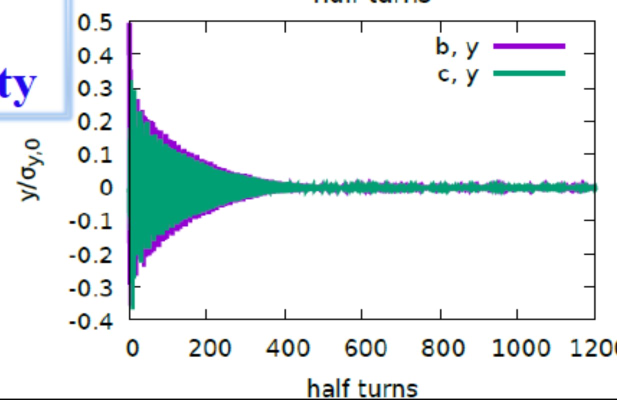
Intensity difference 3%

- **Different codes agree well**
- **There is no flip-flop instability**

Collision is stable

Only 8 σ_x DA needed





CEPC Booster challenge

D. Wang

Low field dipole magnets

➢ Challenges:

- Field error <29Gs*0.1%=0.029Gs
- Field reproducibility <29Gs*0.05%=0.015Gs
- The Earth field ~0.2-0.5 Gs, the remnant field of silicon steel lamination ~ 4-6 Gs.

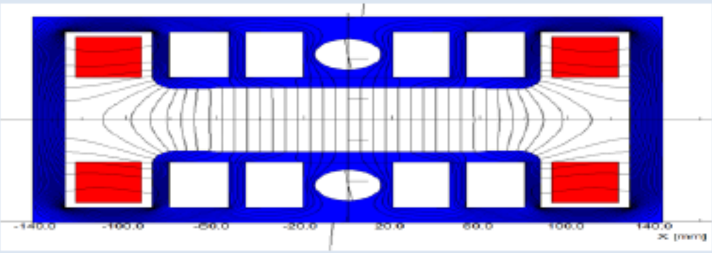
➢ Thinking beyond CDR

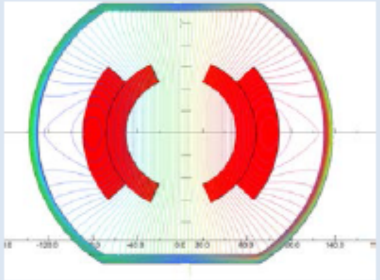
- Wiggler dipole scheme
- Combine the magnets with core and without core
- Combine CCT dipole with sextupole coils
- …

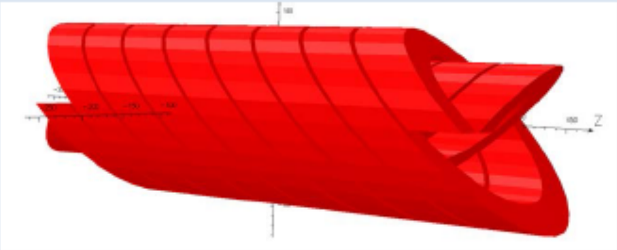
➢ Solutions by technical way

- With magnetic core - dilution (better material)
- Without magnetic core (higher power)

a) CT b) CCT







New CLIC Staged Scenario

Plenty of physics at low ce
energies

Energy and luminosity tar
Physics Study Group

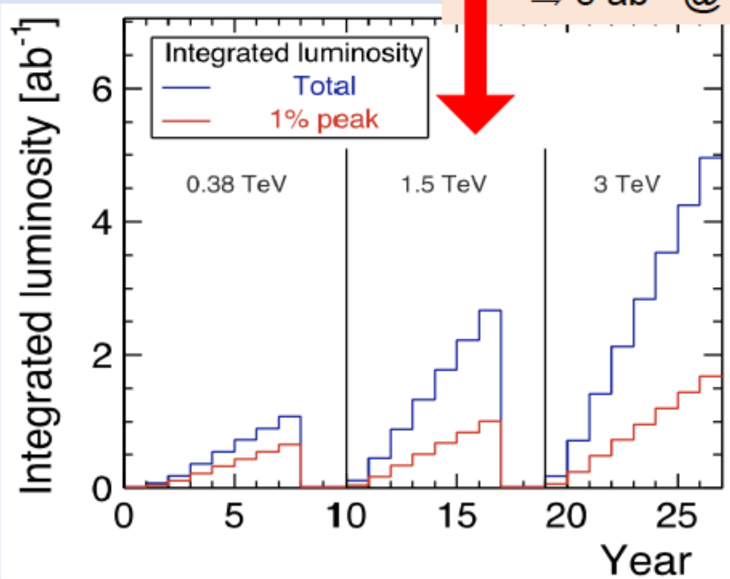
- Review of effective operation time for luminosity per year showed increase from 1.08 x 10^7 s to 1.2 x 10^7
- Consider total of 5 extra years at full luminosity
  - ⇒ 1 ab^{-1} @ 380 GeV
  - ⇒ 2.5 ab^{-1} @ 1.5 TeV
  - ⇒ 5 ab^{-1} @ 3 TeV

e threshold
Zh and WW

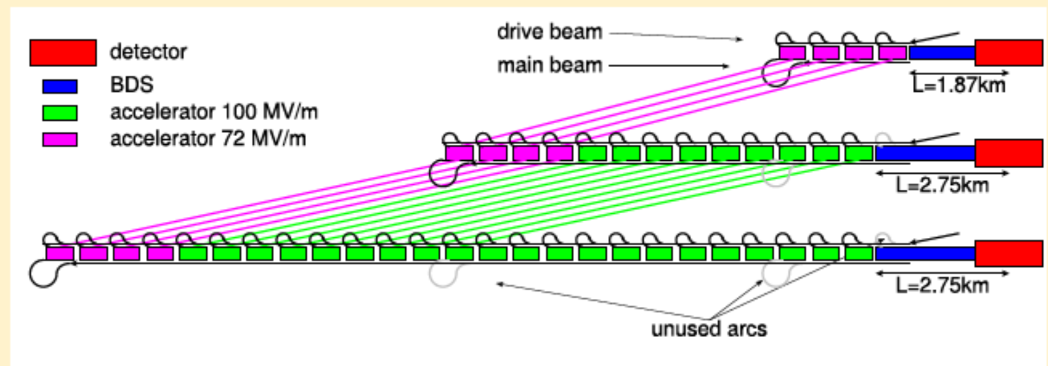
top at
old

pdated with more input from LHC and stage 1

3 3000 3000



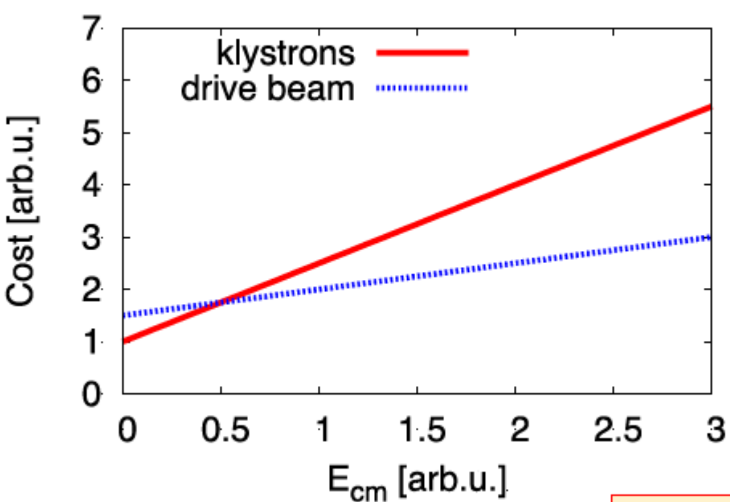
Implementation in stages

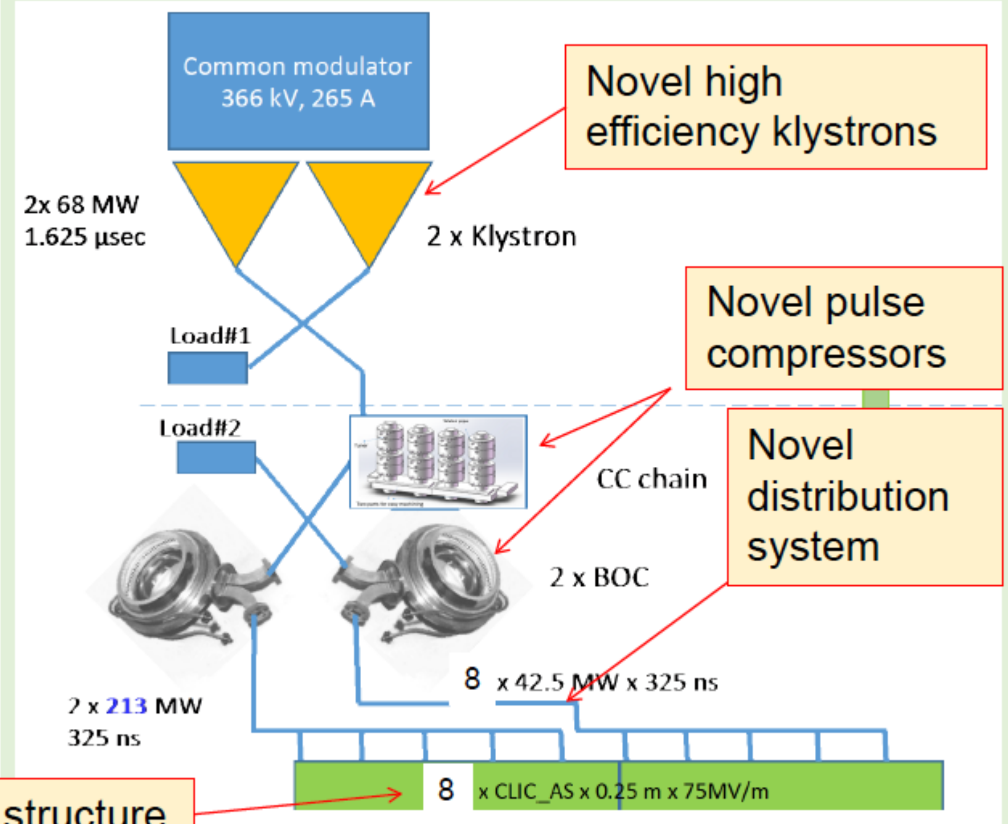


D. Schulte

Klystron-based Alternative

Develop klystron-based alternative
Expect comparable cost for first energy stage
But increases faster for high energies





Optimised structure

D. Schulte

K. Yokoya

We are preparing documents for the last meetings!

- List of possible risks
  - including those raised by Nomura report
- Plan for the preparation period (assumed to be 4 years)
- Answers to many questions

Unfortunately, all these are in Japanese

The Final decision to be made by MEXT and Government, not by SCJ.

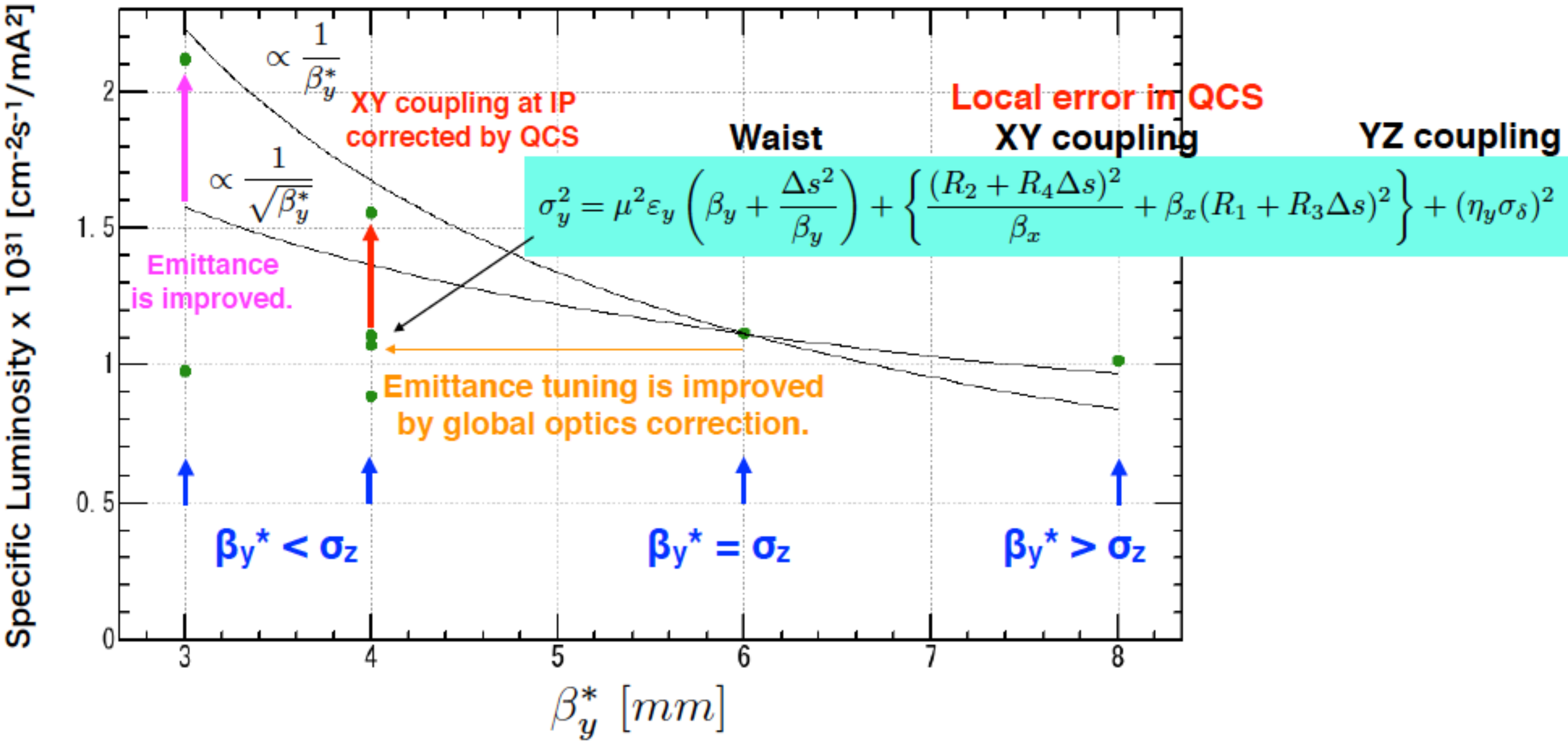
Only a few more months to approval/disapproval !!

SuperKEKB

From simulations to real life…

Squeezing β_y*

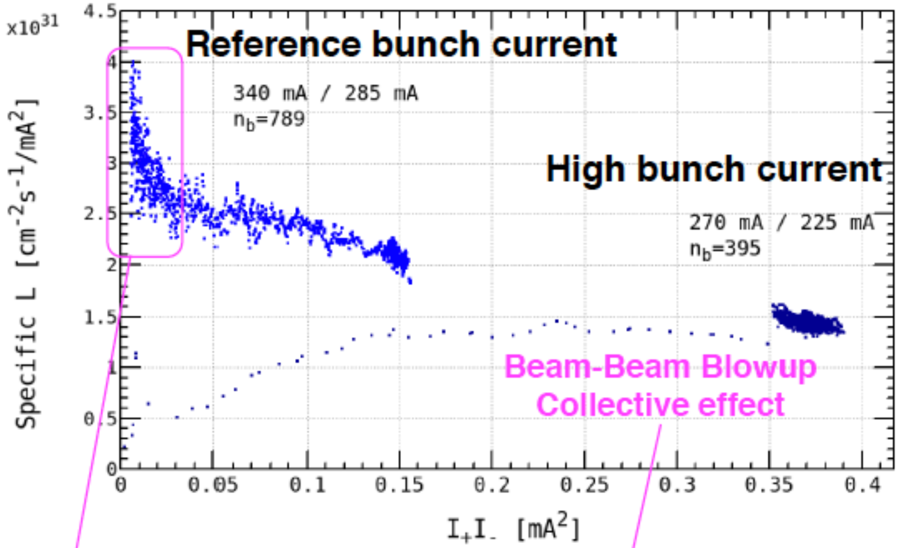
$$L \propto \frac{1}{\sqrt{\varepsilon_y \beta_y^*}} \quad \text{or} \quad L \propto \frac{\xi_y}{\beta_y^*} \qquad \xi_y \propto \sqrt{\frac{\beta_y^*}{\varepsilon_y}}$$

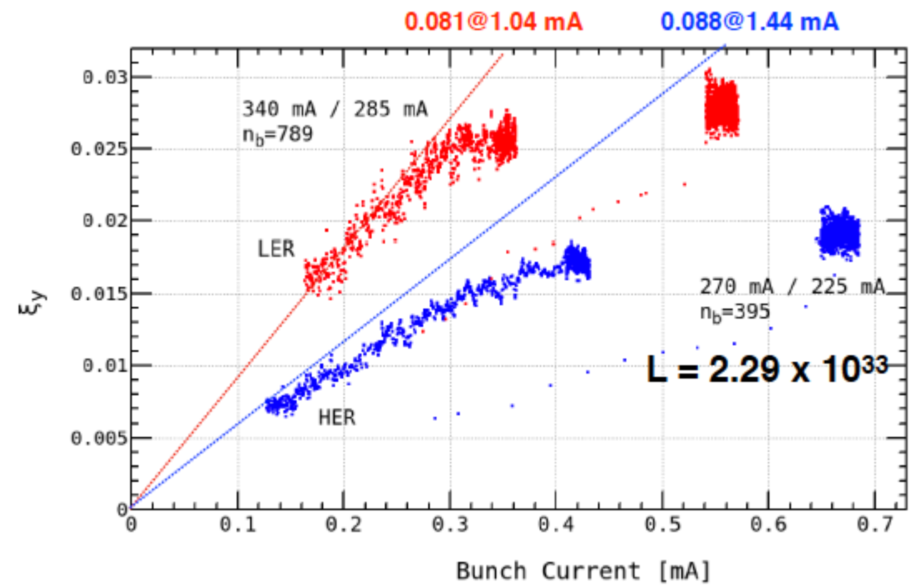


Squeezing β* is not enough if XY-YZ coupling is not locally corrected!

Y. Ohnishi

Specific L and bb tune shifts





Luminosity drop at low current. ☞ issue in Phase 3

$$L_{sp} = \frac{L}{n_b I_+ I_-} = \frac{1}{4\pi(\sigma_z \phi_x)e^2 f_0 \sigma_y^*} = \frac{1.25 \times 10^{25}}{\sigma_y^*} \; [cm^{-2}s^{-1}/mA^2]$$

The beam size from L_{sp} is consistent with that of no beam-beam.

$L_{sp} = 4\text{x}10^{31} \rightarrow \sigma_y^* = 300$ nm ($\varepsilon_y = 30$ pm)

$\leftrightarrow \varepsilon_y = 23$ pm for single beam in LER

The beam-beam parameter is 0.02.

The beam-beam parameter is saturated at high bunch current. ☞ issue in Phase 3

Interference of bb and lattice non-linearities degrades Luminosity

Y. Ohnishi

Importance of local correcting coils

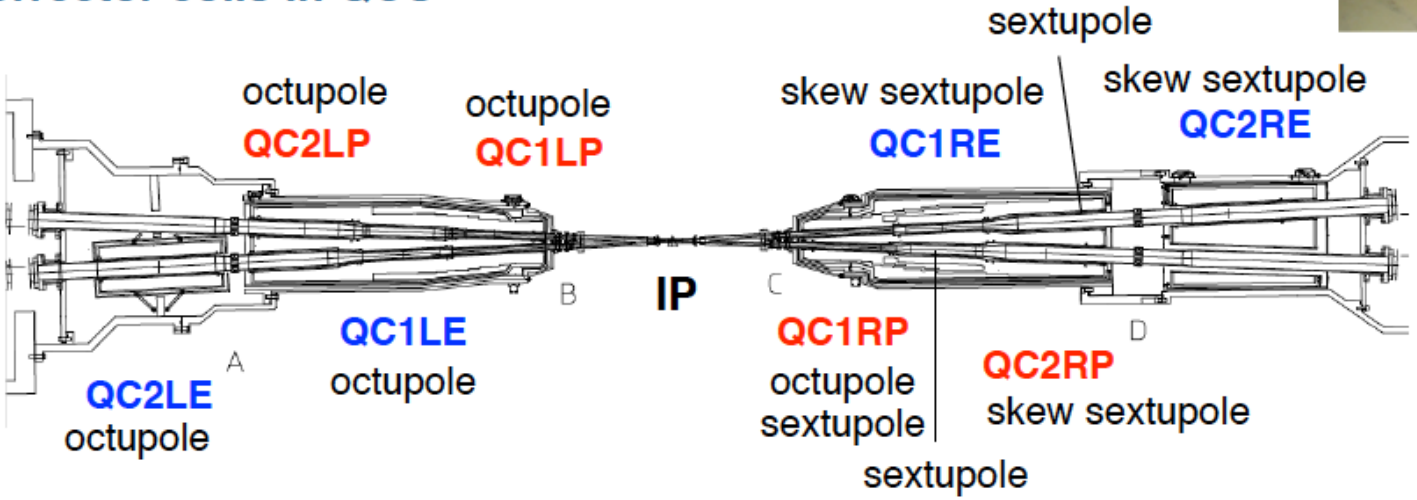
Skew quadrupole corrector coils in QCS (for each main quads.)

Rotatable sextupoles in LER

Sextupole corrector coils in QCS

Skew sextupole corrector coils in QCS

Octupole corrector coils in QCS



XY coupling via QC1 skew quads

$$\beta_x^* = 200\ mm \quad \beta_y^* = 4\ mm$$

Extremely low bunch current
15.8 mA/1576 bunches
to avoid beam-beam blowup as much as possible and to get geometrical luminosity.

0.1 mA/bunch

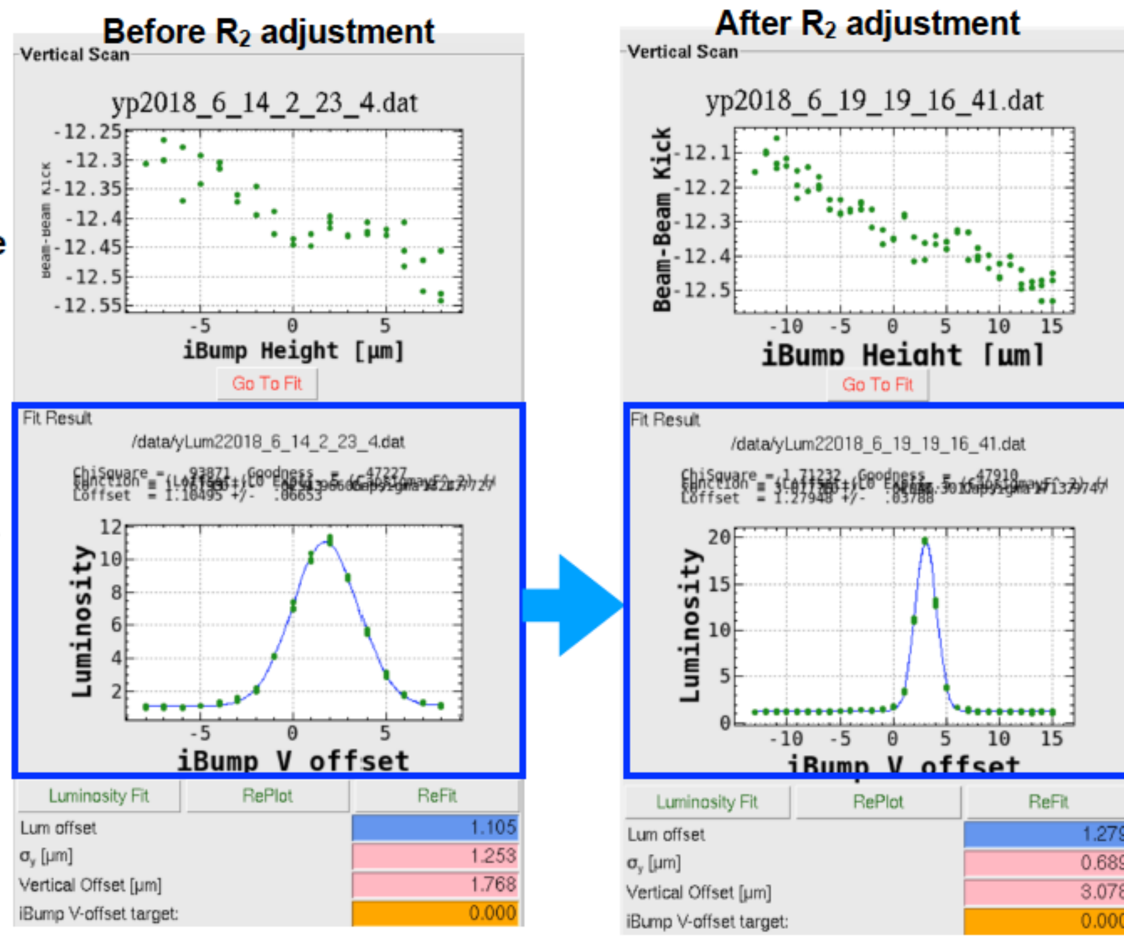
$$\Sigma_y = \sqrt{\sigma_{y-}^{*2} + \sigma_{y+}^{*2}} \qquad \sigma_y^* = \Sigma_y/\sqrt{2}$$

LumiBelle2 is good performance !

Very large beam size ! →

Estimation from X-Ray Monitor:
σ_y^* = 0.4 μm (LER), 0.5 μm (HER)
No change after adjustment of X-Y coupling(R_2) at IP

Measurement by beam-beam scan:
σ_y^* = 1.253 μm → 0.689 μm
Very small !

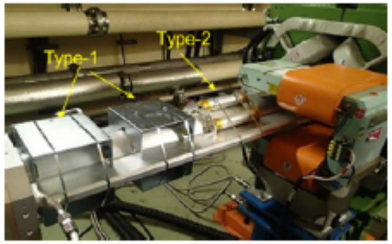


Y. Funakoshi

e-cloud… good news

Additional permanent magnets

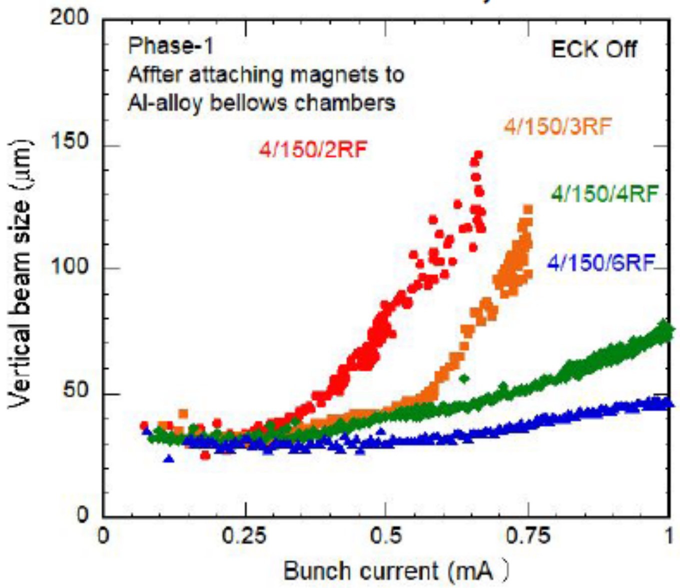
Y. Suetsugu et al.



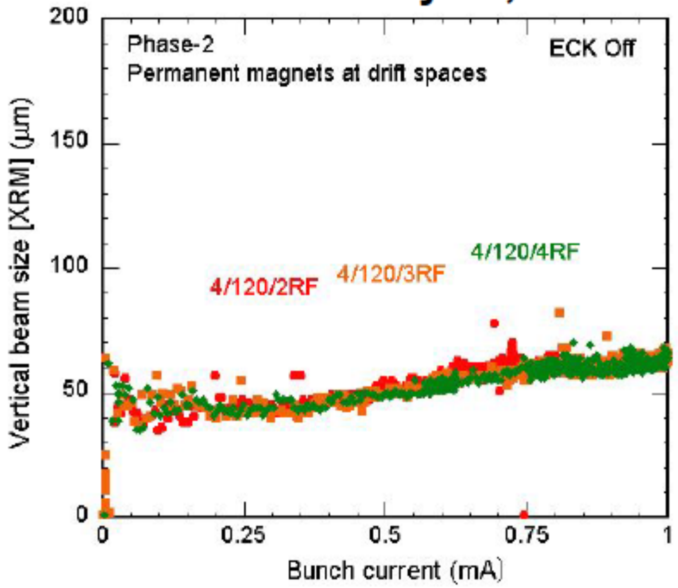
Threshold is much improved.
more than twice of 0.2 mA/bunch/RF bucket

Mode of CBI changes and the growth rate is reduced.

Phase 1: June 9, 2016

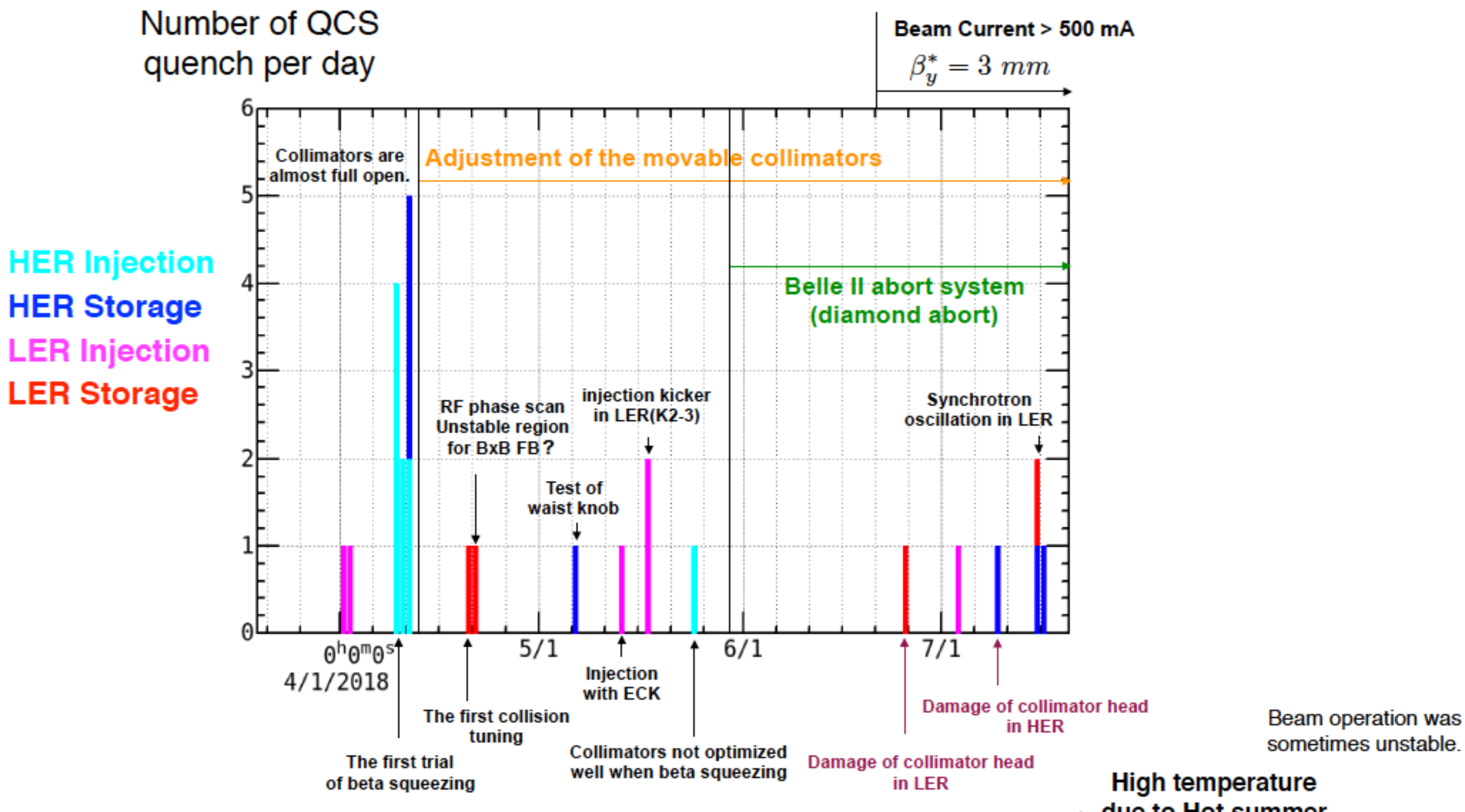


Phase 2: July 12, 2019



no blowup

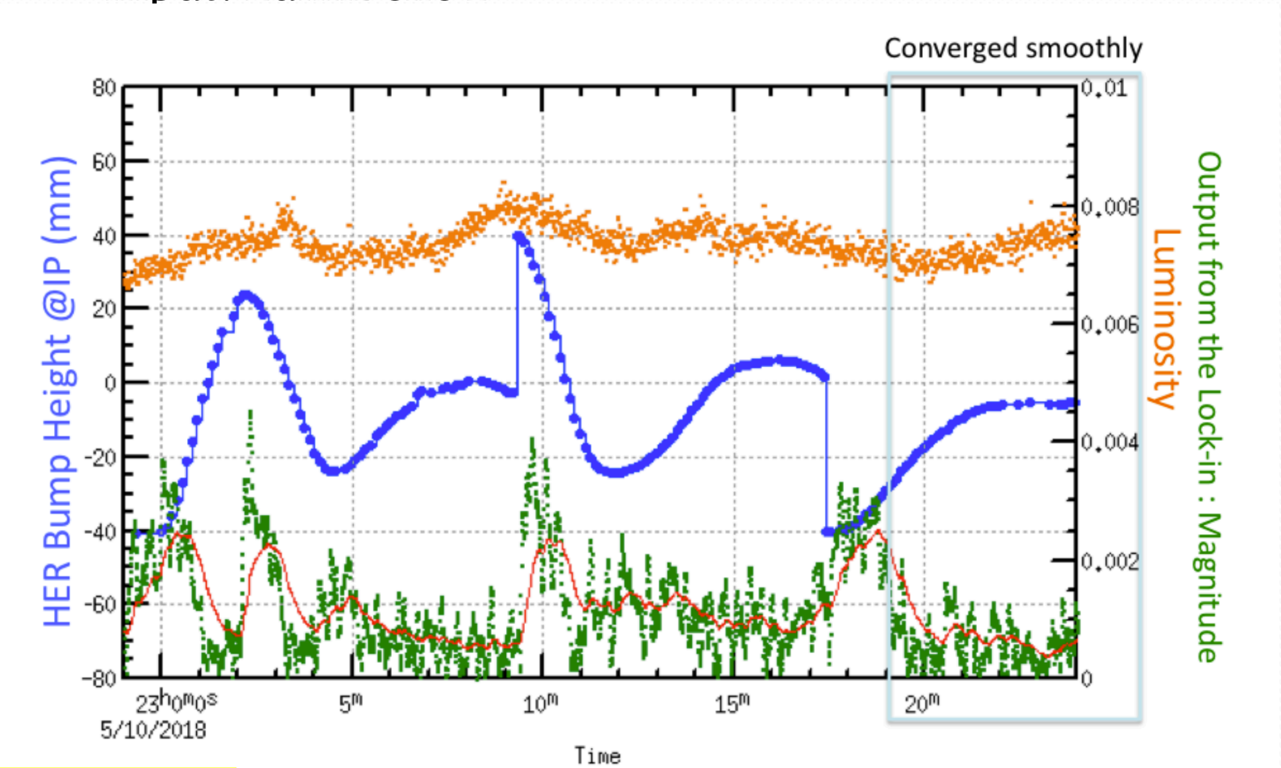
QCS quenches… bad news



Dither feedback @ SuperKEKB

Due to very small bb parameters in horizontal (**0.0028/0.0012**) the orbit feedback based on the beam-beam deflection cannot be used

Input: LumiBelle 2



SLAC collaboration

Feedback cycle ~ 7 sec

Dither feedback worked well. But luminosity was not sensitive to the horizontal offset and fluctuated for other reasons. No vertical orbit feedback has been used yet.

Y. Funakoshi

MDI

MDI issues (conclusions)

Summary (2)

- A good IR design should try to be as **"flexible"** as possible in order to **"bend"** and not **"break"** when slightly different running conditions or circumstances turn out to produce better machine and/or detector performance

- One needs to study around the large multi-parameter space near the design choices in order to find out where the **"breaking points"** are located

M. Sullivan

FCCee HOM in IR

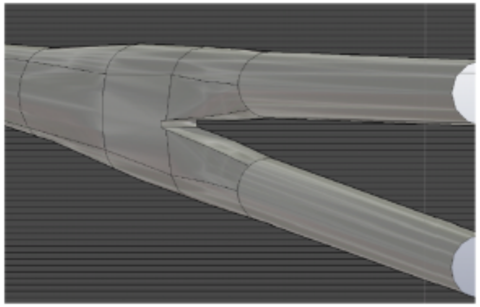
IR trapped modes and HOM absorbers

The two beam pipes combine into one in the interaction point,
here they can generate e.m. waves, depending on their frequency there can be trapped modes in the IR, that might heat the IR .

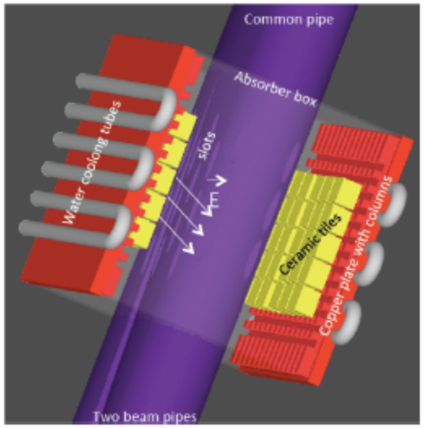
The best design is model No. III with a smooth beam pipe:

TABLE I. RF parameters of a trapped mode in the model 1 and model 3.

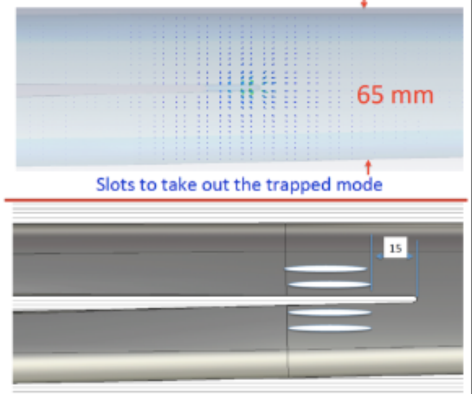
Model No.	Trapped mode frequency [GHz]	Near revolution harmonic numbers	Mode loss factor [V/pC]	Mode decay time [ns]	Power of a trapped mode [kW]	Propagating modes power: Bunch 5 mm [kW]	Propagating modes power: Bunch 2.5 mm [kW]
I	5.774	14 and15	0.38	5.51	8.71	2.42	10.77
III	3.459	8 and 9	0.08	9.2	2.91	0.45	2.10



CAD design using CATIA



A trapped mode near the beam pipe connections.



- The trapped modes analysis was completed*
- The HOM absorbers have been designed for the FCC-ee IR

*A. Novokhatski et al.,PR-AB **20** 111005 (2017)

M. Boscolo, eeFact18, Hong Kong

M. Boscolo

FCCee synchrotron radiation

SR photon rates

	Energy (GeV)	Critical energy (keV)	number of bunches	Current (mA)	Incident γ/xing (500μm from tip)	Incoming on central pipe/xing	γ rate on central pipe (Hz)
tt+	**182.5**	113.4	33	5.41	3.32E+09	1195	1.18E+08
tt	**175**	100	40	6.4	3.06E+09	1040	1.25E+08
h	**125**	36.4	328	29	1.05E+09	10.3	1.01E+07
W	**80**	9.56	1300	147	6.11E+08	0.18	7.02E+05
Z	**45.6**	1.77	16640	1390	9.62E+07	1.92E-04	9.58E+03

rate of photons that strike the central pipe that come from the mask tip

- No SR from dipoles or from quads hits directly the central beam pipe (cylinder +/- 12.5 cm in Z with a 1.5 cm radius)
- Non-Gaussian beam tails, considered out to +/-20 σ_x and +/-60σ_y
- On-axis beam
- Quadrupole radiation that may strike mask surfaces included

- Photons tracked into CLD and IDEA detector showing the effectiveness of masking system

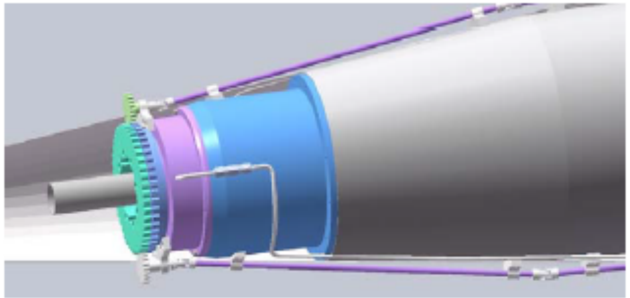
M. Boscolo

CEPC IR

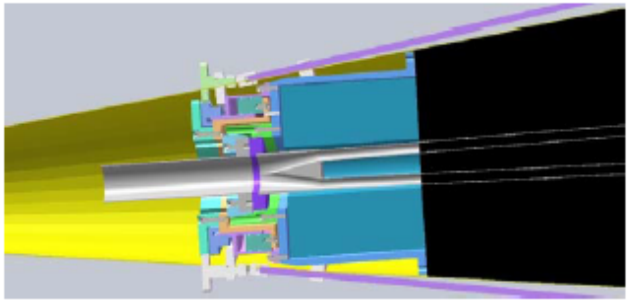
IR Mechanics Assembly

- 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.

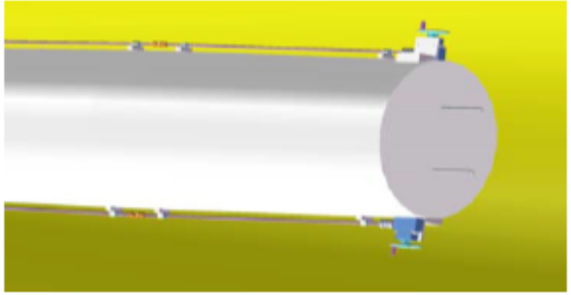
RVC head and drive gear



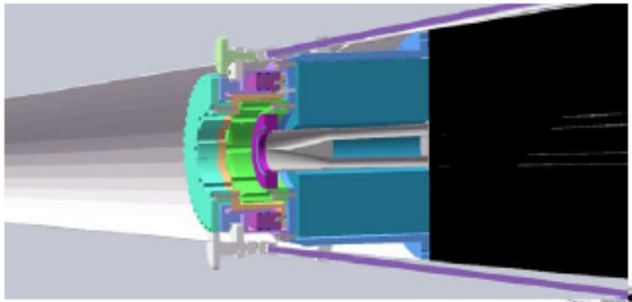
cutaway view of RVC head



RVC tail/handwheel structure



Cutaway view of moving part



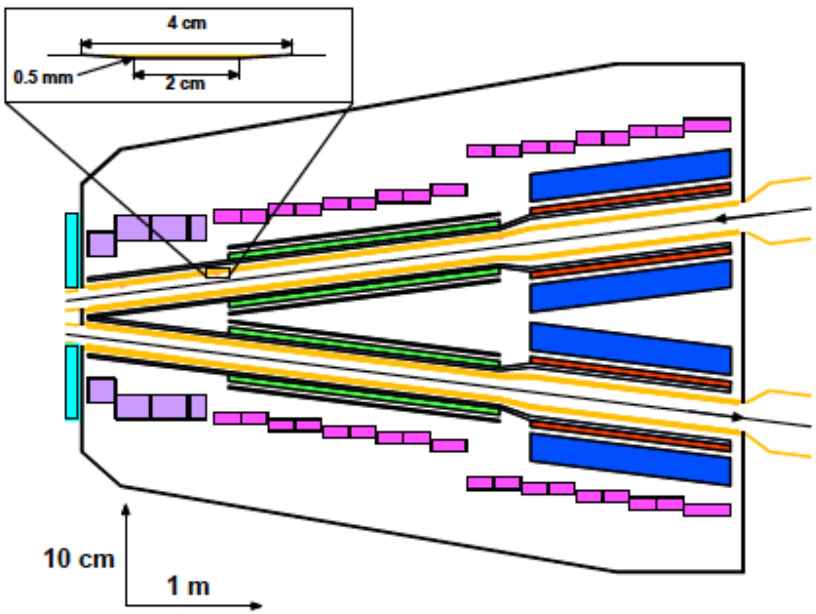
RVC is under development

中国科学院高能物理研究所
Institute of High Energy Physics, Chinese Academy of Sciences

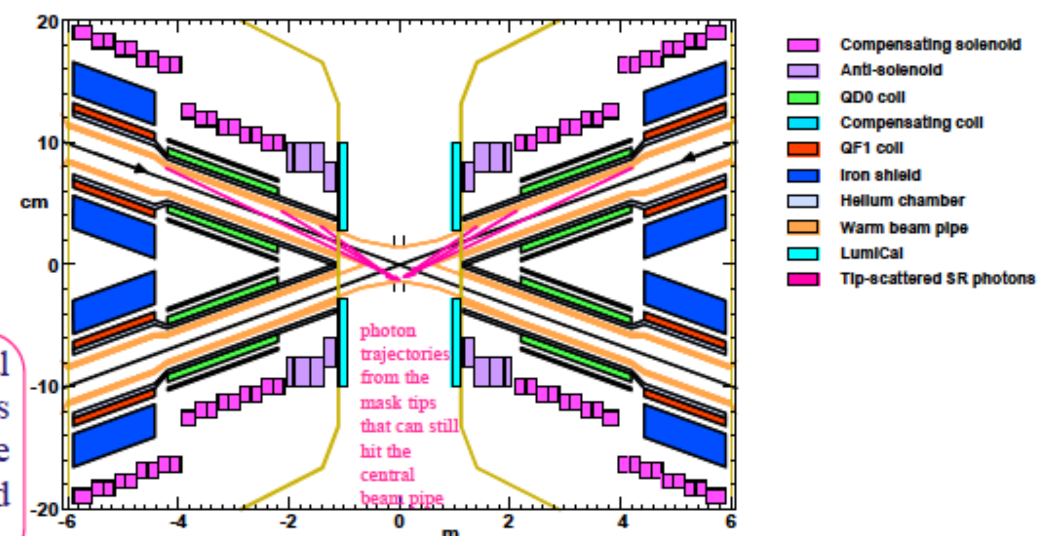
S. Bai

CEPC IR Masks

Mask design of IR



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).



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.

中国科学院高能物理研究所
Institute of High Energy Physics, Chinese Academy of Sciences

S. Bai

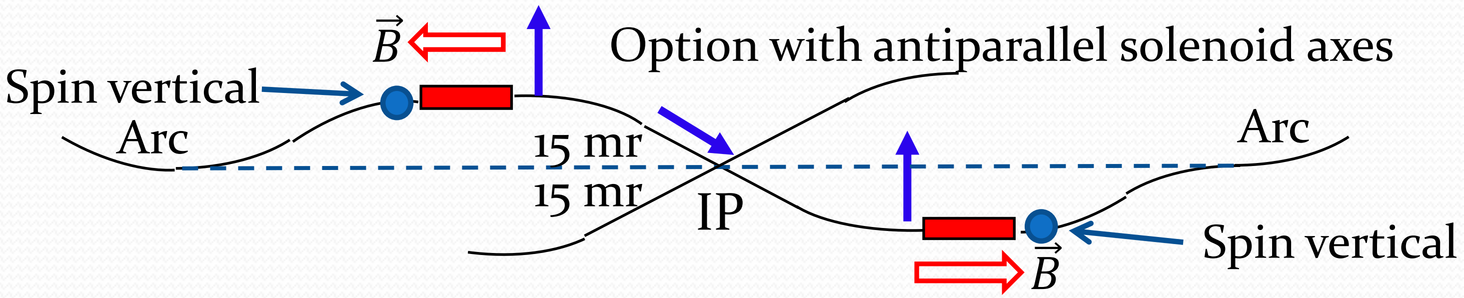
Polarization

Ideas for longitudinal polarization

- At Z the longitudinal polarization can be obtained by installing two 90° spin rotators, which are spaced by antisymmetric chicane with ±15 mrad bend from the IP point
- Such scheme with zero bend between spin rotators has minimal depolarization effects on spin motion due to SR
- Pre-polarized electron and positron beams can be achieved in a damping ring with strong SC bends or wigglers
- Acceleration in the main booster can be done using static solenoid field Partial Siberian Snake. Same in pre-booster
- At W all this becomes much more difficult

I. Koop

Optimal option for LP @ Z



- Antisymmetric chicane plus two 90° solenoid type spin rotators. Opposite polarities of left-right from IP magnetic fields cancel spin direction chromaticity outside of the insertion. Spin tune unchanged!

Spin rotation ϕ by the half-chicane (angle α):

$$\phi = \frac{\pi}{2} \quad \rightarrow \quad \alpha = \frac{\phi}{\nu_0} = 15 \text{ mr (at Z } \nu_0 = 103.5)$$

Tolerance: $\Delta\alpha = \pm 5$ mr

- In this option only the chicane magnets contribute to the radiative depolarization, therefore the spin depolarization time at Z exceeds 24 hours! But beamsstrahlung will decrease it, say to 1-2 hours. Still OK!

I. Koop

CEPC polarization

Depolarization effect of quantum fluctuations in presence of ver
orbit distortions at CEPC has been estimated taking into accou
modulation of spin tune by synchrotron oscillations.

Spin harmonic amplitude of vertical closed orbit distortion sourc
should be corrected to level $\leq 10^{-3}$ at Z-pole to ensure 50% equ
polarization degree.

If this is done it is possible to reach polarization in range (6-10)
GeV CEPC in time of (2-4) hours using e.g. ten shifter magnets
moderate characteristics.

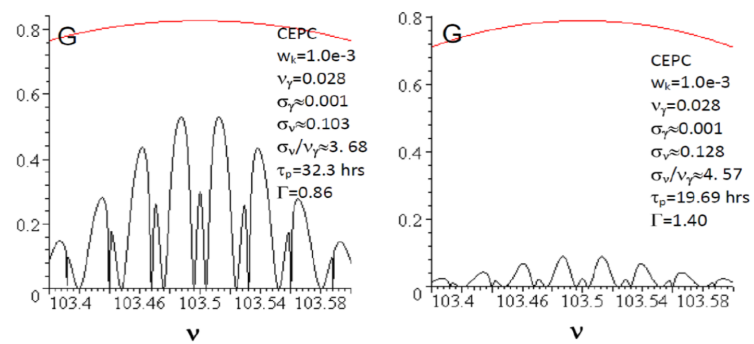
Spin Response Function has been calculated for CEPC at 4
(in two ways for self-cross-checking). It allows us to determir
of machine field errors with respect to depolarization process

At 45 GeV, expected harmonic amplitude of closest integer s
(quad offset of 50 μm, tilts of b. magnets and quads of $3\cdot10^{-4}$
times larger than desirable one. Correction of resonance har
103 and *k*= 104) is needed as it was done at LEP in past.

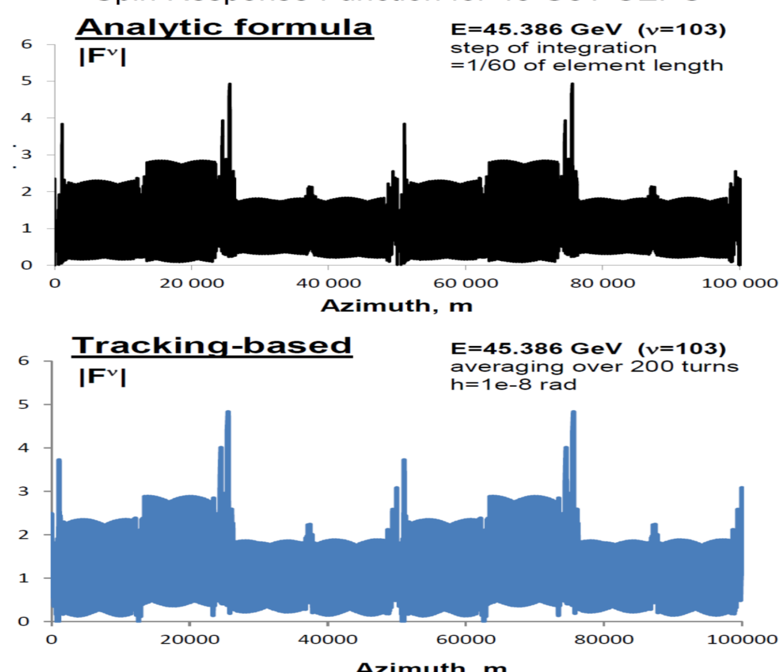
As can be seen from results of calculation of depolarizing infl
random tilts of quads, betatron contribution to spin-orbit coup
neglected in working range of energy.

It is shown that there is alternative possibility of obtaining pol
accelerating polarized particles in CEPC booster and then ir
into main ring. As Partial Siberian Snake one can use weak I
This option saves time spent on the polarization process, an
crucial for obtaining longitudinal polarization.

Depolarization factor $G=P/P_0$ vs spin tune for two variants of shifter magnet system for speeding up polarization: with field of 0.5 Tesla (left) and 0.6 Tesla (right)



Spin Response Function for 45 GeV CEPC



S. Nikitin

Performance of the FCC-ee polarimeter

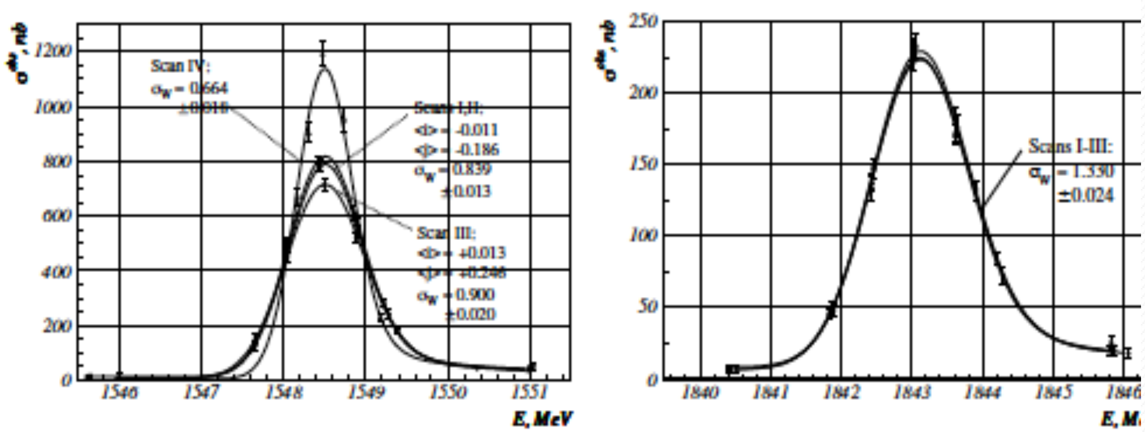
- Detecting both scattered photons & electrons increases the reliability of beam polarization measurement
- Polarimeter provides ≃ 1 % / s accuracy
- The beam energy spectrometer option does not require mandatory neither the B-field measurement nor the BPMs data:
  - Statistical precision $\Delta E/E \simeq 100$ ppm / 10 sec
  - Systematic effects estimation requires further studies: yet no limitations were founded
  - Test of the approach does not require high beam energy and should be performed with low emittance beam at low energy
- Allows to measure beam sizes & positions

N. Muchnoi

High precision experiments @ τ and J/Ψ

- High precision experiments in charmonium sector require beam energy calibration
- VEPP-4M storage ring with energy measurement by resonant depolarization method provided high precision mass measurement of J/Ψ- and Ψ(2S)- mesons with KEDR detector with accuracy 2×10^{-6}
- This narrow resonances can be used for calibration of energy scale of other accelerators such as BEPC-II or future SCTF equipped with Compton backscattering energy measurement system

J/ψ ($0.7, pb^{-1}$), $\psi(2S)$ ($1.0\, pb^{-1}$) mass measurement with KEDR detector



$M_{J/\psi} = 3096.900 \pm 0.002 \pm 0.006$ MeV

$M_{\psi(2S)} = 3686.099 \pm 0.004 \pm 0.009$ MeV

KEDR Collaboration / Physics Letters B 573 (2003) 63

V.V. Anashin et al. / Physics Letters B 749 (2015) 50

I. Nikolaev

Technology (some)

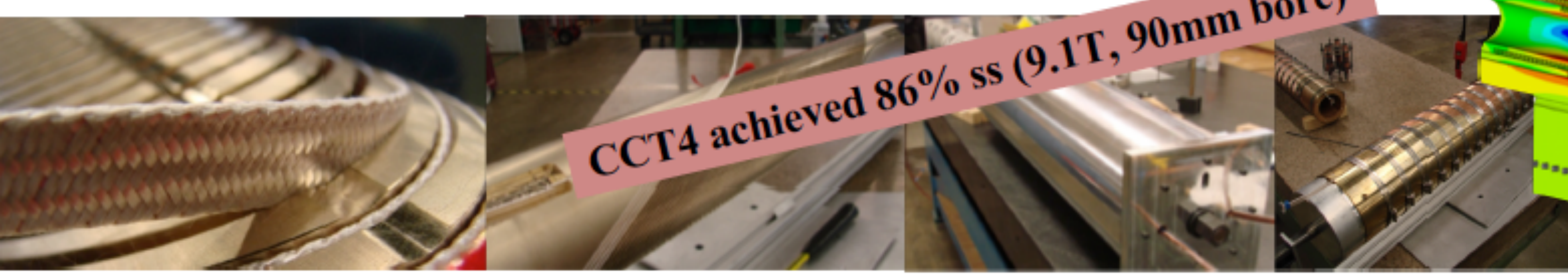
U.S. MAGNET DEVELOPMENT PROGRAM

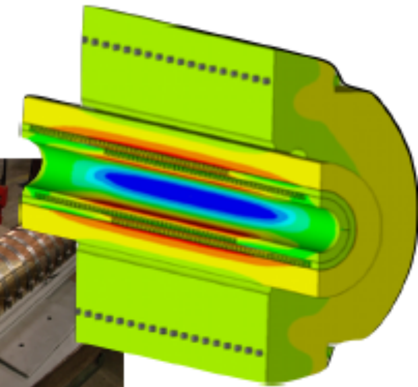
Progress on high-field magnet concepts

- Block Cosine-theta magnet fabrication is progressing well, with coil fabrication complete and mechanical structure tested

Expect test in ~January 2019

- Canted Cosine-theta:
  - Subscale CCT currently being pursued for fast turn-around technology development
  - CCT4 (the second Nb_3Sn CCT 2-layer magnet) was tested, and thermally cycled
  - CCT5 is in design, incorporating feedback from CCT4





CCT4 achieved 86% ss (9.1T, 90mm bore)

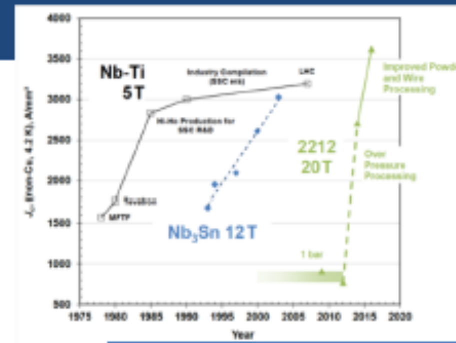
CCT5, designed to address training, will be tested in October 2018

S. Prestemon

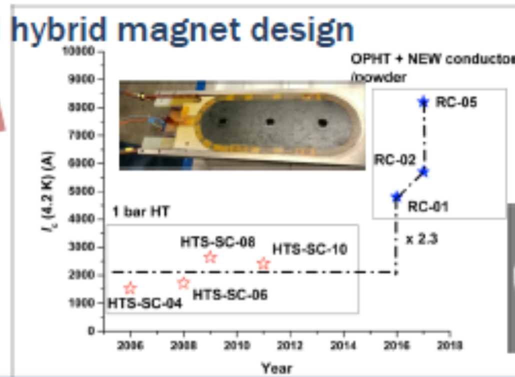
U.S. MAGNET DEVELOPMENT PROGRAM

Significant progress on the HTS magnet front

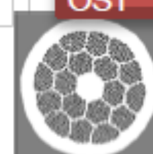
- Bi2212 has made dramatic strides in J_c over last 3 years –ready for magnets
  - Wire has been cabled and tested in racetrack configuration (RC5)
  - First Bi2212 CCT dipole has been wound; reaction and testing soon
  - Roadmap integrates Bi2212 CCT in a high-field hybrid magnet design

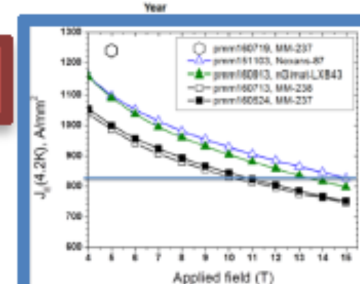


Bi2212 is now a magnet-ready conductor

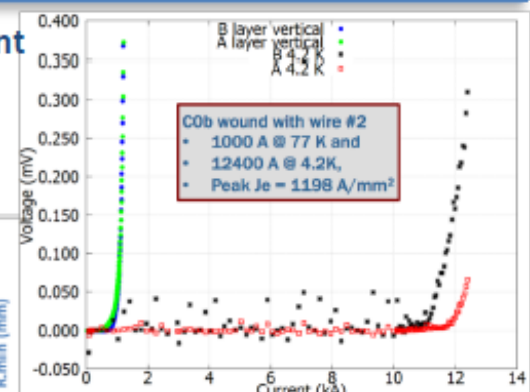


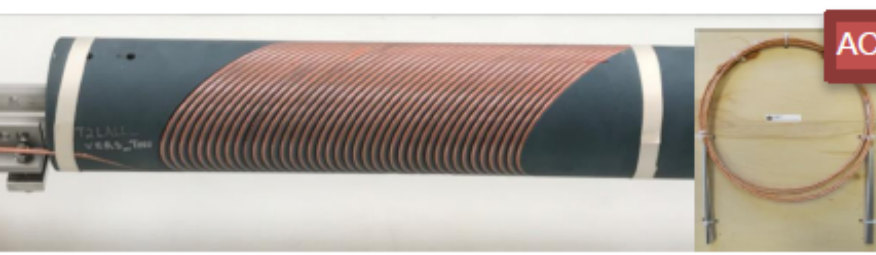
Bruker/OST



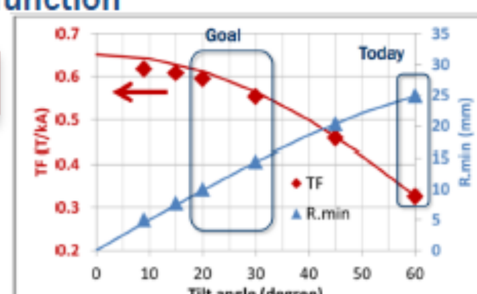


- REBCO development focused on CORC® cables and magnet technology development
  - 3-turn C0 “dipole” was used to develop winding tooling, fabrication processes
  - 40-turn C1 dipole was then fabricated and tested
  - Anticipate >x3 improvement in tape J_E and transfer function





ACT



S. Prestemon

Summary on magnets technology

- Magnet technology is evolving actively on all fronts
  - Permanent magnets may see a renaissance
  - Superconducting magnets have tremendous potential
    - But need better understanding and control of technology

- Impact of magnet technology on accelerators depends on improvements on multiple fronts:
  - Material properties – performance and measured data
  - Advances in modeling – faster processors, improved physics, improved feedback on design
  - Advances in diagnostics: key for understanding and feedback to design

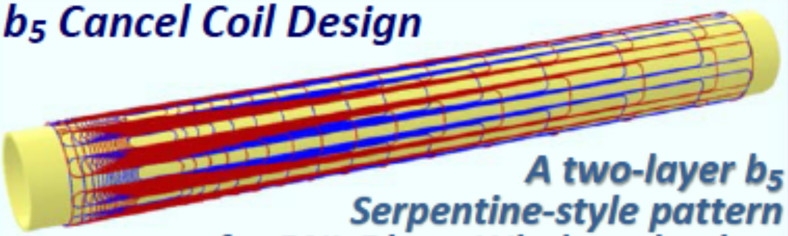
S. Prestemon

Few IR magnets designed @ BNL

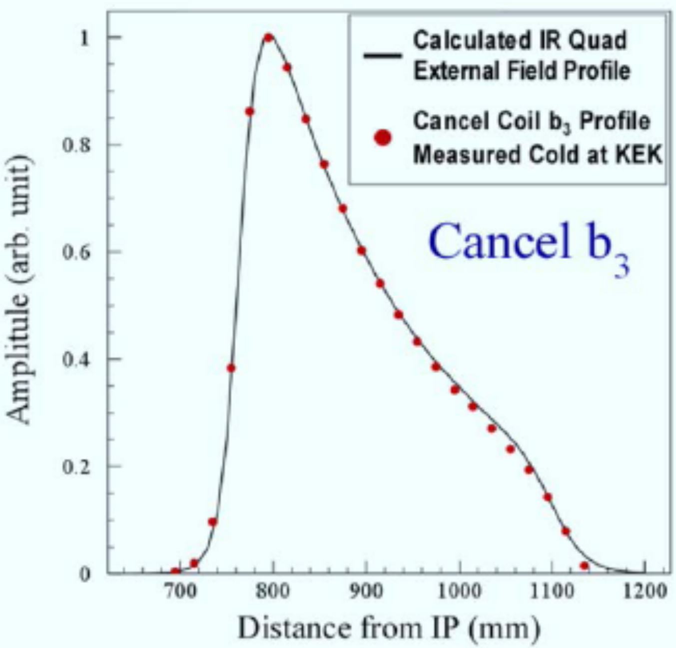
SuperKEKB Cancel Coil Experience

B. Parker

b_5 Cancel Coil Design

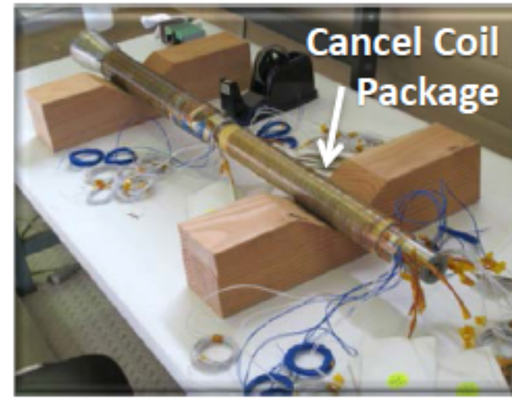


A two-layer b_5 Serpentine-style pattern for BNL Direct Wind production.



Compare Measured b_3 to Target Goal

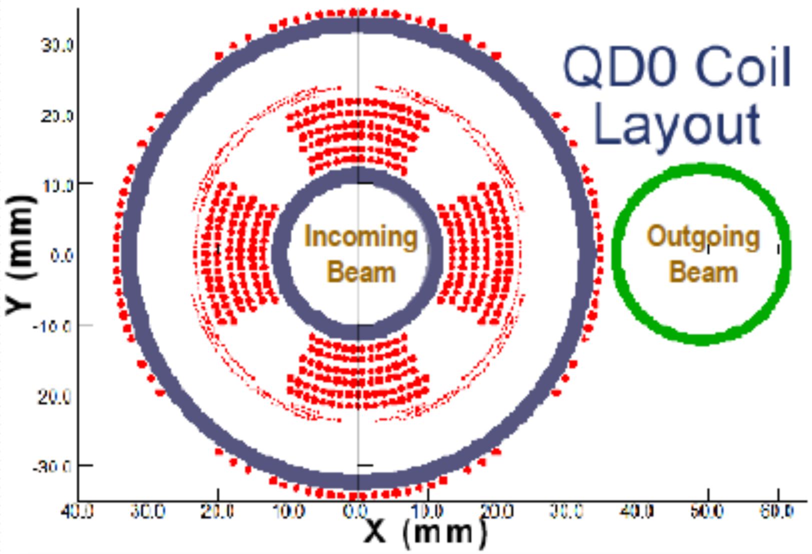
The b_4, b_5 and b_6 Cancel Coils also match their target profiles very well.*



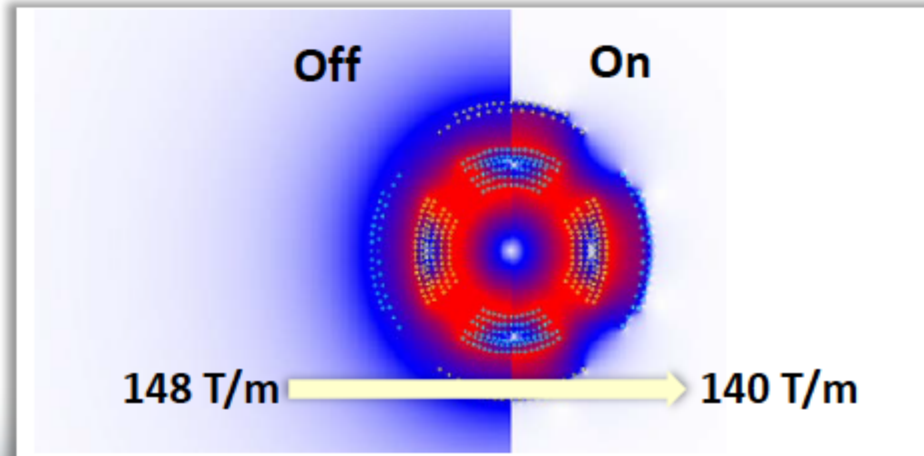
- SuperKEKB uses b_3, b_4, b_5 & b_6 Cancel Coils to buck non-linear fields from a neighboring quad coil.
- The linear, b_1 and b_2, components are not cancelled but instead included into the IR optics design.
- Strong b_1, b_2 cancel coils would themselves generate external fields and spoil main field quality.
- When both beam energies can be simultaneously scaled it is conceivable to design field corrections in both coils to maintain acceptable field; however, this is not practical in an EIC where the beam

B. Parker

Design for Compact Superconducting Magnet Used in the ILC 14 mr Layout.



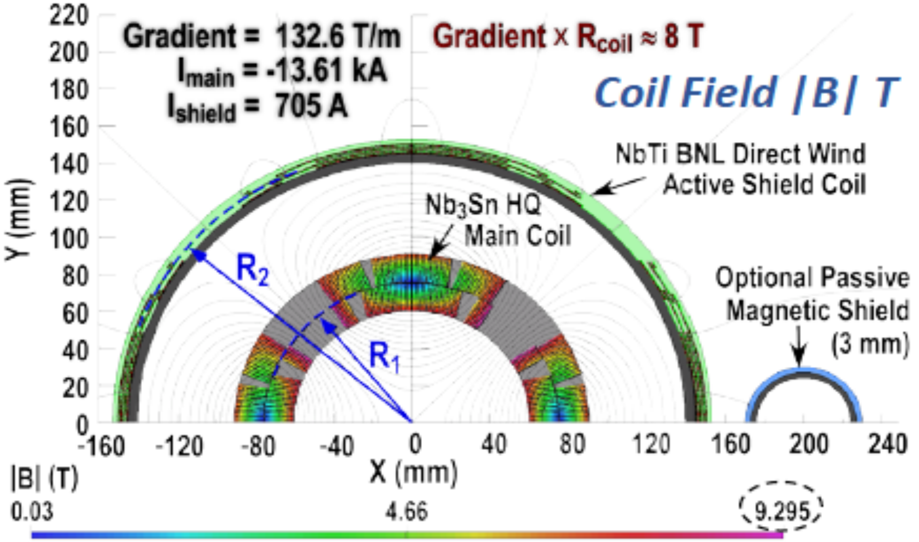
- 14 mr crossing angle via compact self-shielded QD0 coil windings.
- Extracted beam passes just outside coil into separate focusing channel.
- Cryostat to fit within limited space inside detector at L* = 4.1 m.



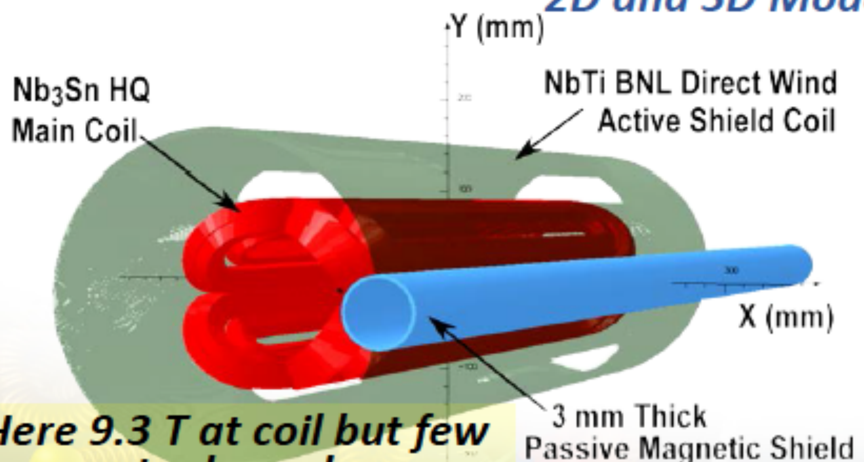
QD0 with active shield off/on

B. Parker

Active Shielding for EIC IR Quadrupoles



2D and 3D Models



Here 9.3 T at coil but few gauss at e-beam!

Actively Shielded Coil Designs

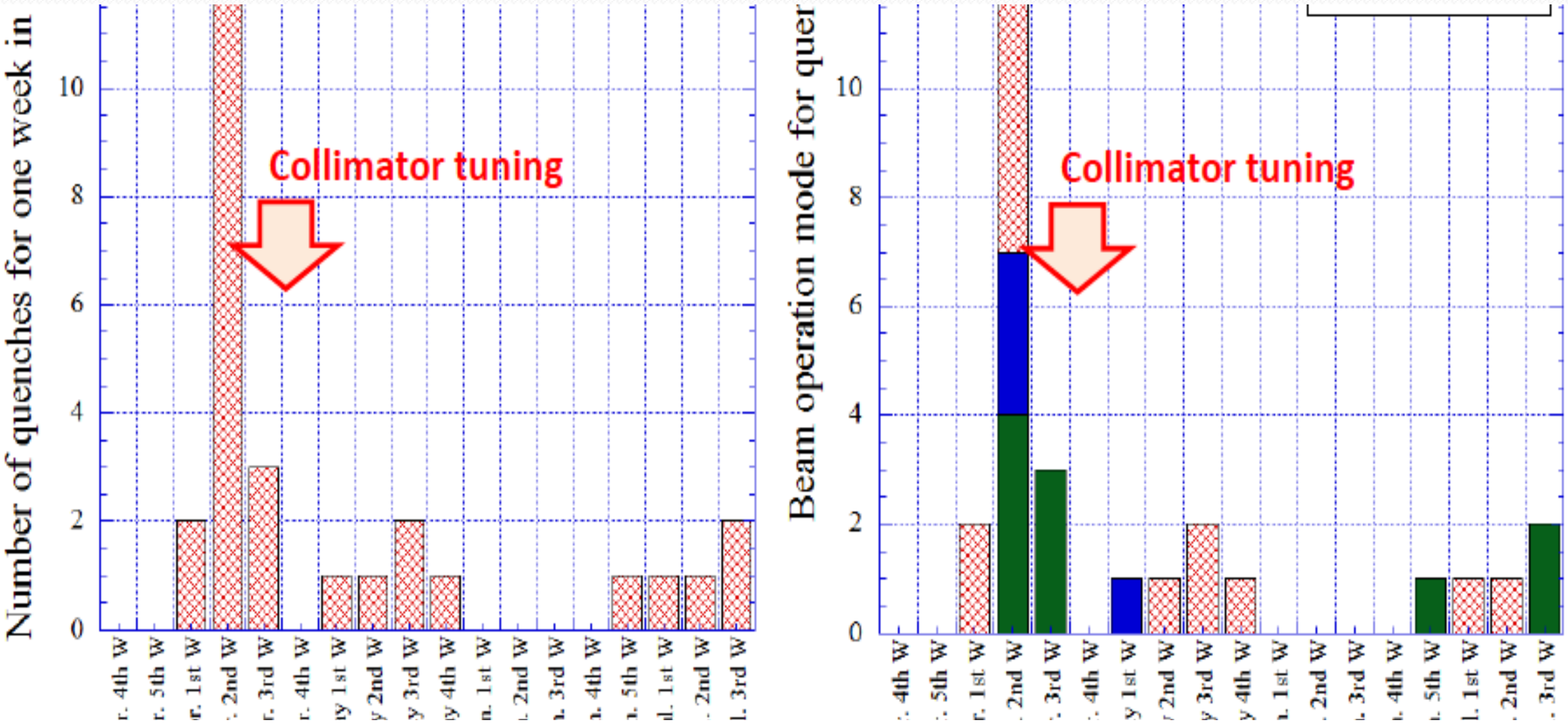
- As with the ILC QD0 we can use an Active Shield (here an anti-quad) to eliminate the external field.
- An Active Shield is useful for large crossing angles, since one can null the external field over a large region.
- Field cancellation leads to gradient loss

$$G_{Final} = [1 - (R_1/R_2)^4]\, G_{Main}$$

- Active Shield magnets are of interest for both the BNL and JLAB EIC IR designs and thus represent an area of common R&D interest.

Models correspond to the "Fast Track" R&D actively shielded quad now in production.

Operation of SuperKEKB IP quadrupoles (QCS)



- **Magnet quenches by beams were serious problem.**
  - Enhancement of beam diagnosis system and magnet quench detection system is planed for Phase-3 beam operation.
- Data of the magnetic field measurements on the beam lines are still being studied.
  - With the field measurement data, the precise and complete 3D field calculation model will be constructed for the Phase-3 operation.

N. Ohuchi

CEPC SRF

CEPC SRF Technology R&D Plan

- **SRF Key Technology R&D (2016-2020)**
  - High Q cavity
  - Very high power (300 kW) variable input coupler with low heat load
  - High power coaxial HOM coupler (1 kW) and wideband HOM absorber (5 kW)
- **Cryomodule Prototyping (2019-2022)**
  - **Collider cryomodules**: 650 MHz 2 x 2-cell and full scale 6 x 2-cell (11 m)
  - **Booster cryomodules**: 1.3 GHz full scale 8 x 9-cell (12 m)
  - High Q operation (clean assembly, magnetic hygiene and flux expulsion)
  - Beam test with DC-photocathode gun
- **Prepare for Mass-Production (2021-2023)**
  - Supported by PAPS large SRF infrastructure (start operation in early 2020)
  - In the frame of CEPC Industrial Promotion Consortium (CIPC)
  - In synergy with other SRF accelerator projects

J. Zhai

High efficiency klystrons @ IHEP

3 design schemes on-going simultaneously (plan → 2021)

- Scheme 1: Optimize cavity chain by using the same gun as 1st tube
- Scheme 2: With high voltage gun (110kV/9.1A), low perveance
- Scheme 3: MBK, 54kV/20A electron gun

Parameter	Scheme1	Scheme2	Scheme3
Freq. (MHz)	650	650	650
Voltage (kV)	81.5	110	54
Current (A)	15.1	9.1	20(2.5×8)
Beam No.	1	1	8
Perveance (μP)	0.65	0.25	1.6(0.2×8)
Efficiency (%)	>70	~80	>80
Power(kW)	800	800	800(100×8)

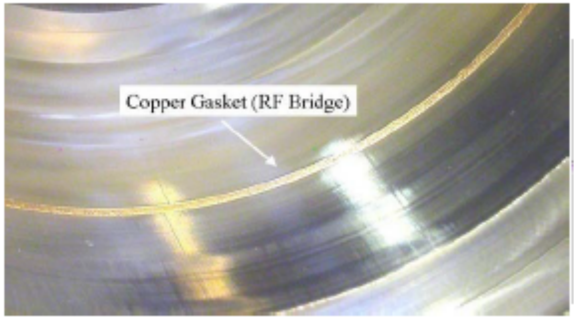
- Manufacture of the 1st prototype will be completed next April because of months of delays on construction of baking furnace
- Manufacture of the 2nd prototype will be started based on the most mature scheme as soon as possible

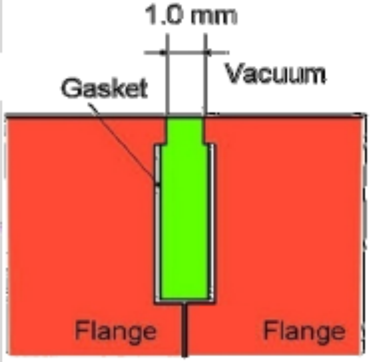
Z. Zhou

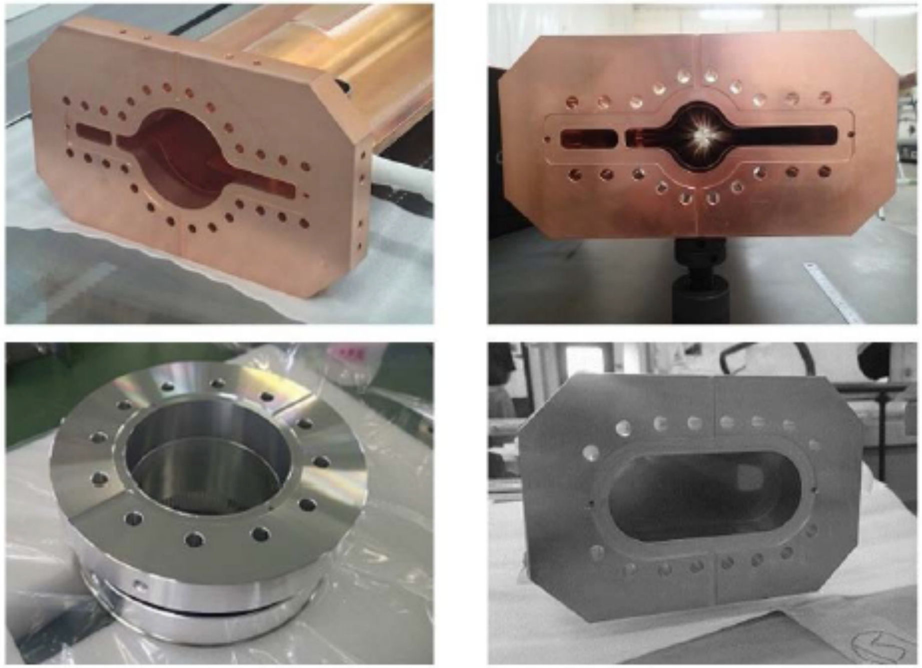
Vacuum@ SuperKEKB

Step-less MO-type flange

- High bunch currents (1.4 mA/bunch) and short bunch length (~6 mm) of SuperKEKB is likely to excite HOM.
- Step-less MO-type flange is adopted.
  - Vacuum-tight seal at the inner surface
  - Maintaining smooth flow of the wall current across a gasket.







Various types of the step-less MO-type flanges for SuperKEKB

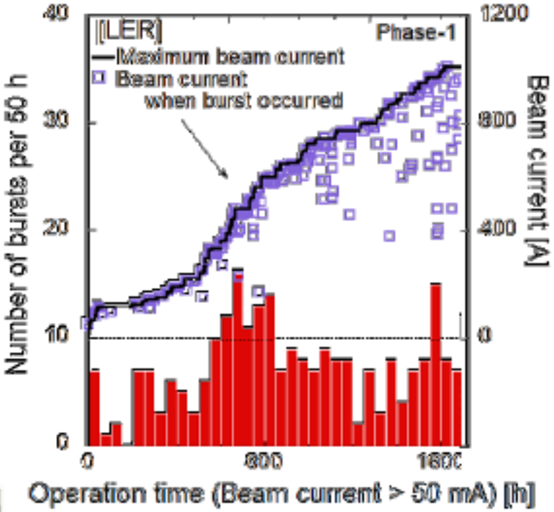
- SuperKEKB is the first machine to adopt the step-less MO-type flanges and comb-type rf-shield on the large scale.

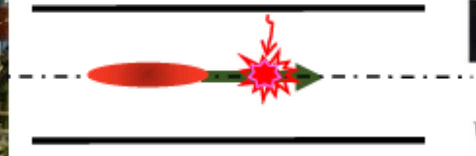
K. Shibata

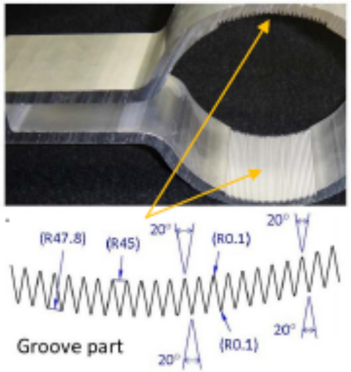
Dust particles

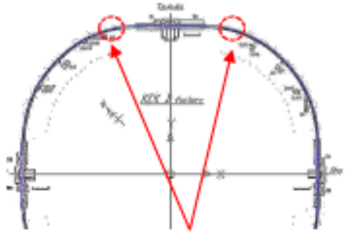
Phase-1 commissioning 3

- Major problem 1 : Localized pressure burst accompanied with beam loss in the LER
  - Became obstacle to beam commissioning.
  - More frequent near or inside Al-alloy beam pipes with grooved surfaces in dipole mag. in the Tsukuba straight section.
  - Seems likely to occur when the maximum beam current is increased.
  - Was reproduced by a knocker which impacts the beam pipe to drop dust particles from their ceilings.
  - ➡ Most probable cause is collisions between the circulating beams and dust particles falling from grooved structure on top surface.









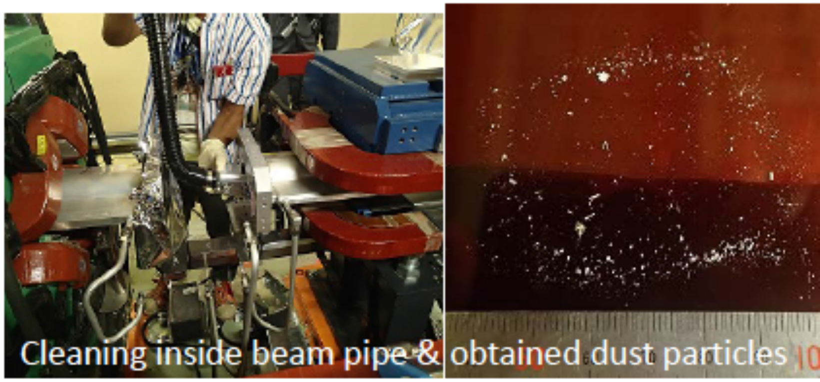
Locations where the pressure bursts occurred most frequently

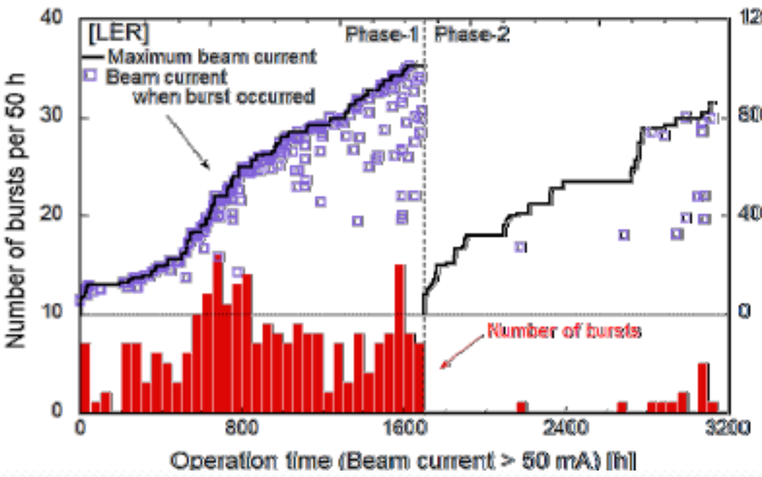
K. Shibata

Countermeasures

Phase-2 commissioning 3

- Effect of countermeasures against problems 1 : Localized pressure burst accompanied with beam loss in LER
  - ➢ Countermeasures during the shutdown before Phase-2
    - Gathering of dust particles from the beam pipes where the bursts were frequently observed by special tool & vacuum cleaner (2 beam pipes.)
    - ➡ Many dust particles were obtained!!
    - Knocking the beam pipes by the knocker to drop dust particle in advance. (24 beam pipes)
    - ➡ Frequency of pressure burst was greatly reduced in Phase-2.
      - But, not only at the location where the beam pipes were knocked but also at other locations.
      - Operation time with high beam currents was much shorter than that during the Phase-1.
      - Knocking is effective? The study will be continued.


Cleaning inside beam pipe & obtained dust particles



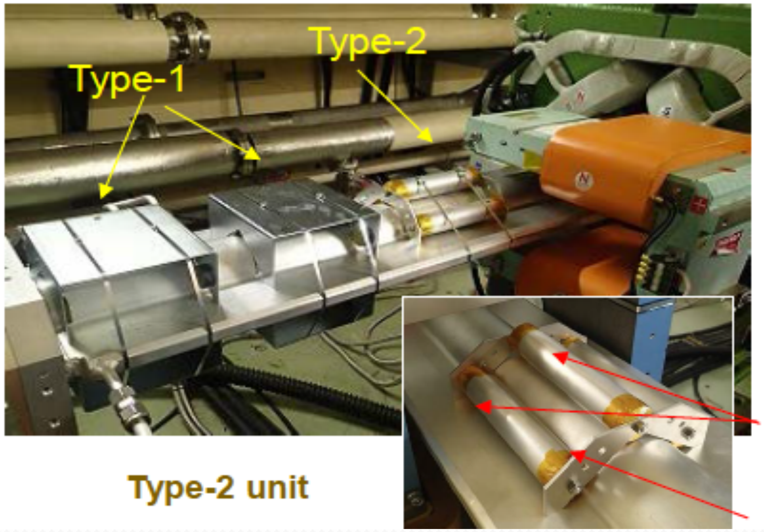
K. Shibata

e-cloud @ SuperKEKB (Phase 1)

Countermeasures for Phase-2

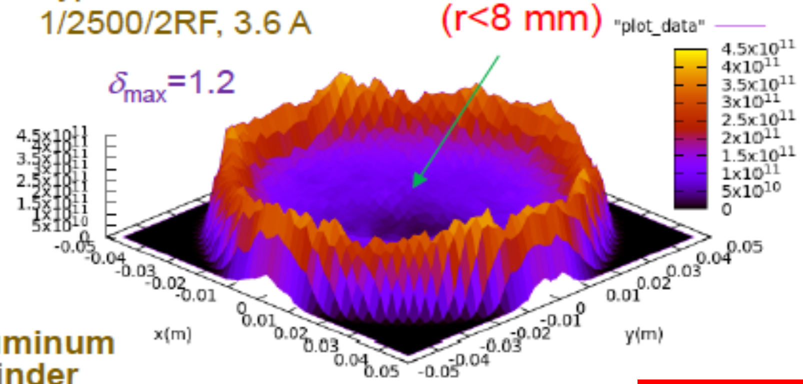
- Permanent magnets were attached to beam pipes at drift space.
  - Type-1 unit: PM units with iron yokes; eight ferrite magnets (ϕ30) + one iron plate (L160 mm), aligned with 40 mm gap.
  - Type-2 unit: PM units in Al cylinders; 21 ferrite magnets (ϕ30) in each Al cylinder (L180 mm). No ferromagnetic materials. → placed close to electromagnets
  - Approximately 86 %of the drift space of the ring (~2 km) was covered by B_z with a strength higher than 20 G before Phase-2 commissioning.

Type-1 and Type-2 units near Q magnet



Type-2 unit

Calculated n_e in Type-1 units for the designed beam parameters

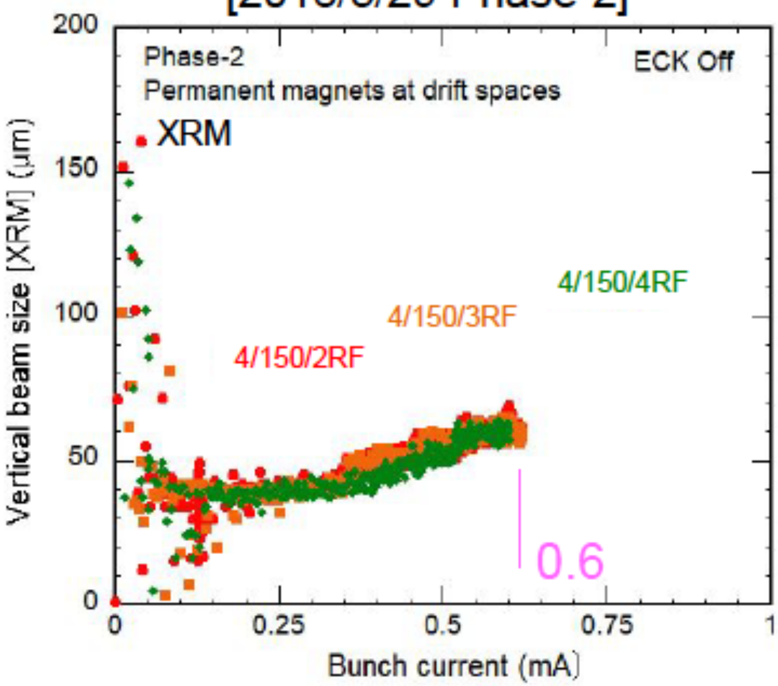


Y. Suetsugu

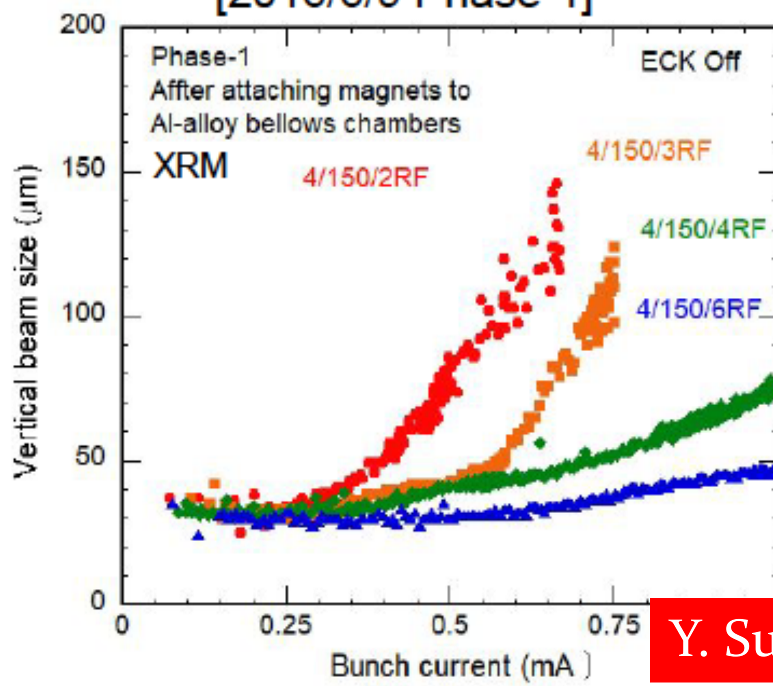
ECE in Phase-2

- The stored beam current was still low at present, but a preliminary study was performed on 29th, May.
- The blow up of beam sizes were measured for 2, 3, and 4 RF-bucket spacings, although the bunch currents were not so enough.
    - Bunch fill pattern = 8 trains with 60 bunches per train. In total 480 bunches.
- No blow-up was observed until ~0.6 mA/bunch for at least 2RF-bucket spacing.

[2018/5/29 Phase-2]



[2016/6/9 Phase-1]



Y. Suetsugu

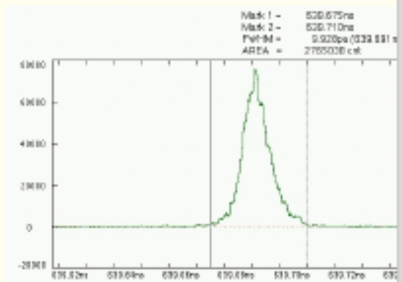
SuperKEKB injection

K. Furukawa

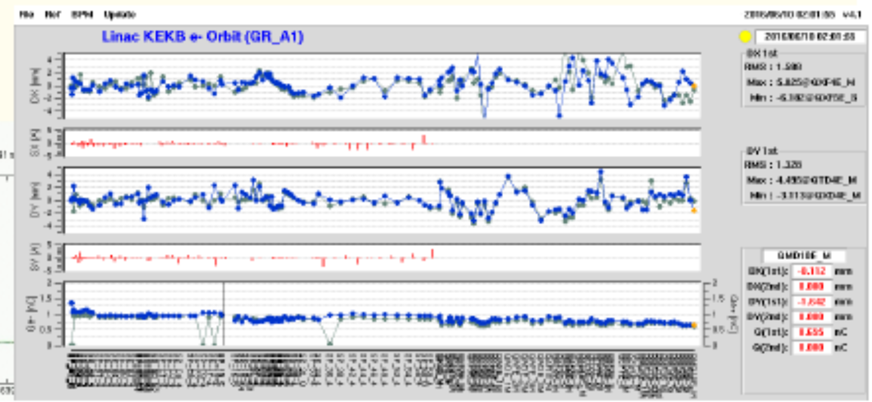
Development of Photo-cathode RF Gun

M. Yoshida et al.

- Succeeded in injection during SuperKEKB Phase 1 and 2 commissioning
- Employs Yb-doped-fiber and Nd/Yb:YAG laser, Ir5Ce cathode, QTWSC or cut disk cavities
- Stability improving
- Beam instrumentation improvements and comparison with simulation codes underway

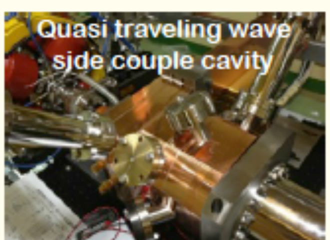


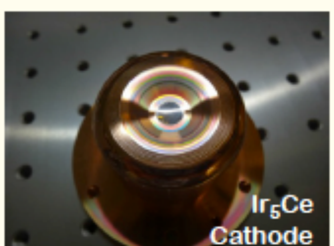
Bunch width

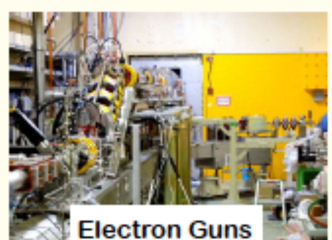


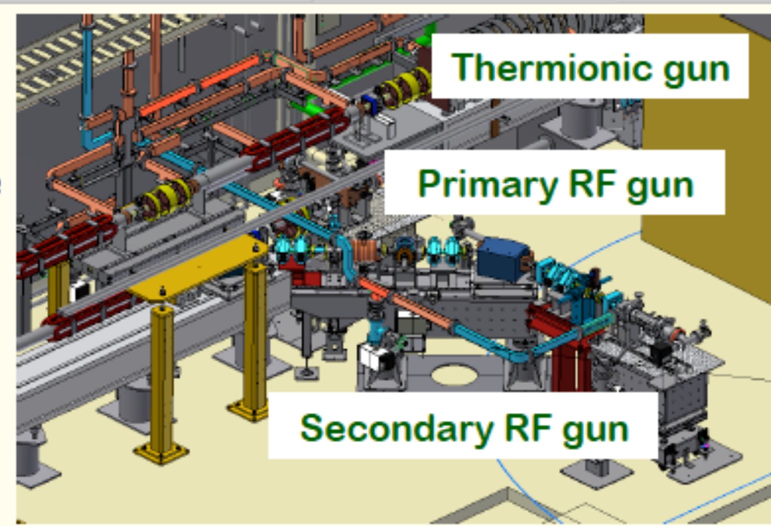
Beam orbit measurement

- Secondary RF gun was constructed as a backup
- Incorporate suggestions by review committee for availability and so on









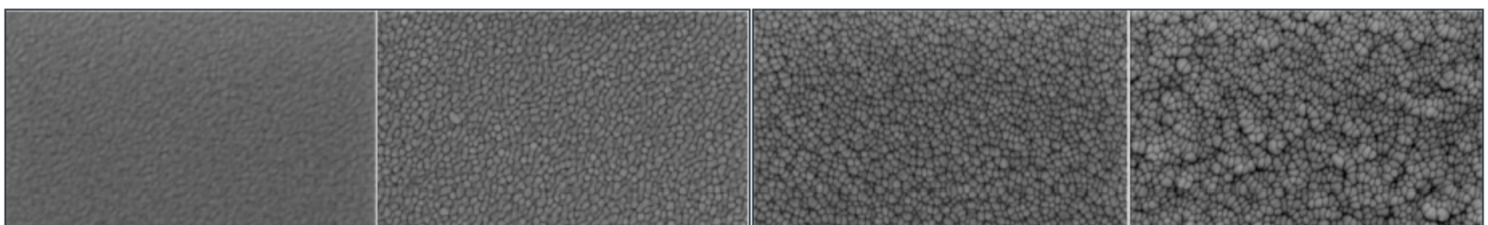
NEG coating @ FCCee

NEG deposition

- NEG deposition on chemically polished Cu samples by DC magnetron sputtering in a cylindrical system
- Kr as working gas
- Intertwisted 3mm diameter Ti-Zr-V wires as cathode
- Stainless steel vacuum chamber positioned in the centre of a solenoid providing a 200 G magnetic field
- Samples at 46 mm from the cathode
- Movable mask to allow coatings at different thickness in the same run
- 28 at.% Ti, 29 at.% Zr, 43% V film composition, measured by energy dispersive X-ray spectroscopy (EDS)

Surface morphology and thickness

- Real thickness determined by Scanning Electron Microscopy (SEM)



Δ_{real}= 30*nm* (Δ_{target}= 50*nm*) | Δ_{real}= 87*nm* (Δ_{target}= 100*nm*) | Δ_{real}= 203*nm* (Δ_{target}= 200*nm*) | Δ_{real}= 1100*nm* (Δ_{target}= 1000*nm*)

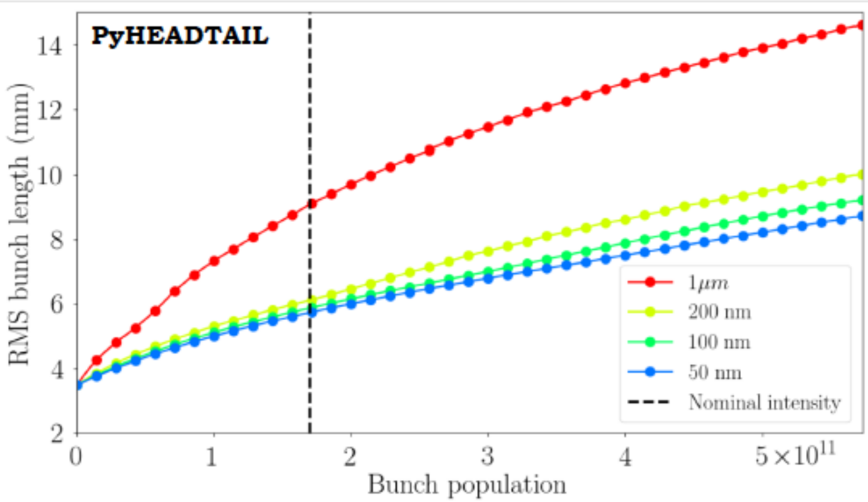
- Full surface coverage
- Uniform thickness
- Changes in the coating roughness with increased thickness

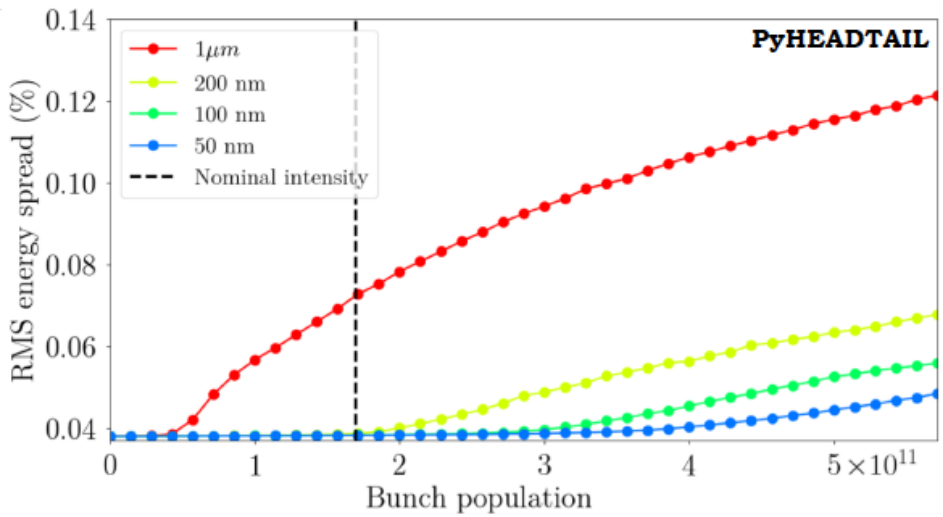
E. Belli

NEG impact on longitudinal dynamics @ FCCee

NEG thin films: single bunch longitudinal dynamics

- NEG thin films with 1μm, 200nm, 100nm, 50nm thicknesses
- **Microwave instability (MI)**
  - Instability threshold defined as the value of the bunch population corresponding to an increase of the energy spread of about 10% w.r.t. its nominal value



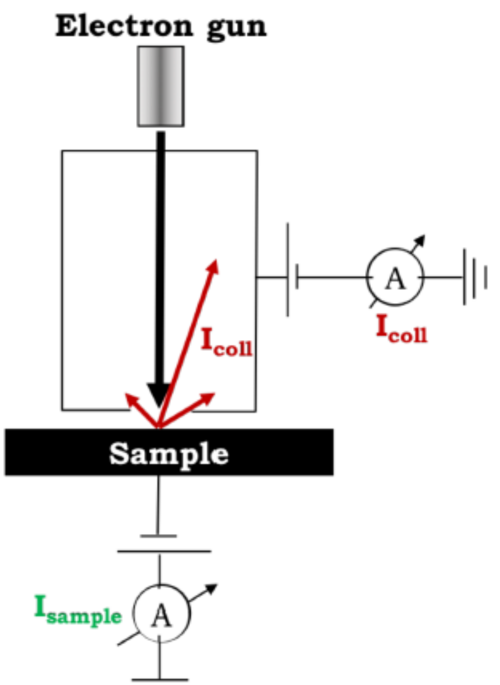


- 1μm thickness makes the bunch unstable
- Thinner films allow to increase the MI threshold
- For 100 nm film, MI threshold ≈ 2x higher than nominal bunch population

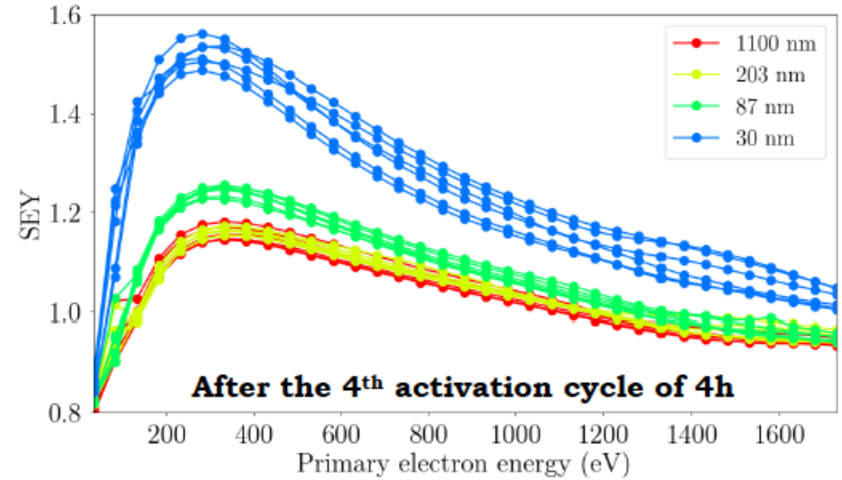
E. Belli

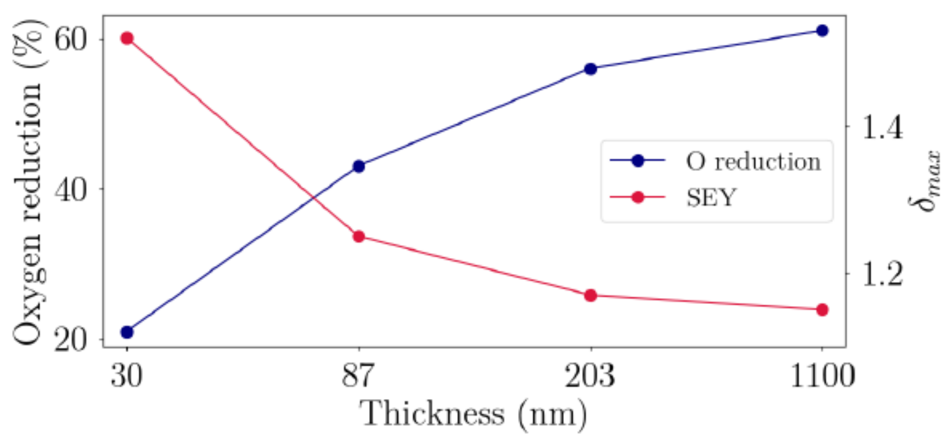
SEY measurements@ FCCee

SEY measurements



$$\delta = \frac{I_{coll}}{I_{coll} + I_{sample}}$$





SEY decreases for thicker layers

The presence of O on the surface is responsible for higher SEY

E. Belli

DAΦNE as a Beam Test Facility

- Workshop to be held at Frascati on December 17th 2018
- Web page in preparation

Scientific Committee:

L. Rivkin (EPFL and PSI, chair)
C. Bloise (INFN-LNF)
A. Ghigo (INFN-LNF)
M. Giovannozzi (CERN)
C. Milardi (INFN-LNF),
N. Pastrone (INFN-Torino)
A. Variola (INFN-LNF)

Local Organizing Committee

A. Drago (INFN-LNF, chair)
A. De Santis (INFN-LNF)
O. R. Blanco Garcia (INFN-LNF)


DAFNE-TF Workshop 2018

17 December 2018 *INFN - Laboratori Nazionali di Frascati*

HOME LNF HOME PROGRAM REGISTRATION HOW TO REACH US CONTACT

ICFA Mini-Workshop on
DAFNE as Open Accelerator Test Facility in year 2020

The workshop will take place on December 17th, 2018 at the Touschek Auditorium, Frascati Laboratory of INFN, Italy.

The workshop is intended to discuss the interest from scientists to access the DAFNE e^+e^- complex, which will conclude its physics program as collider by the end of 2020. An infrastructure almost unique, that could open as Test Facility (DAFNE-TF) to the international community for studies of accelerator technologies and beam physics, for small experiments, and to be used as a test bed for enterprises active in the sector of components for accelerators.

Scientific Committee
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Organizing Committe
O. R. Blanco Garcia (INFN-LNF), A. De Santis (INFN-LNF), A. Drago (INFN-LNF, chair)

Secretariat
D. Ferrucci (INFN-LNF), M. Luciani (INFN-LNF)

Dates: 17 December 2018 (09:00-17:00)
Timezone: Europe/Rome

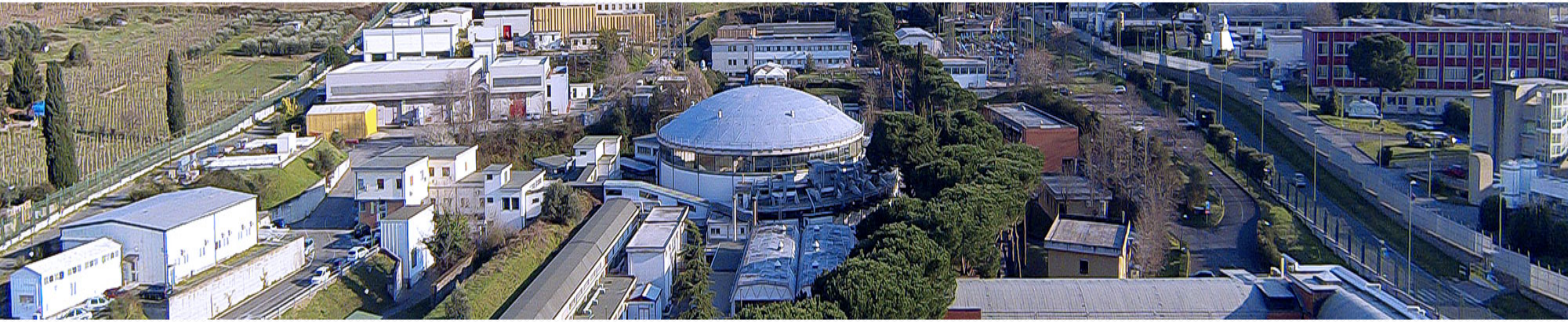
https://agenda.infn.it/conferenceDisplay.py?confId=16334

Summary of summary

- e^+e^- colliders are still a very active field
- “Big” machines are the future if high energy, high luminosity are needed for New Physics
- Smaller colliders should still be built to
  - **perform precision measurements**
  - **keep the field alive and train new generations while waiting for the big leap forward**
- New phenomena (instabilities…) are being discovered
- Damages due to high currents are still an issue
- Technology is advancing (maybe not as fast as we would like) and in the time span of the future projects we can **be bold and think BIG**

Next ICFA eeFact2020

- To be held at Frascati National Laboratories INFN
- Autumn 2020, dates to be confirmed
- See you there!



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