KEK contributions to the FCC study

Yasuhiro Okada

Executive Director, KEK

Preparation Meeting for the FCC International Collaboration Board, September 10, 2014, CERN

- KEK shares the view with major HEP laboratories worldwide that global cooperation is more and more important to make future HEP programs to proceed.
- KEK has been cooperated with CERN and intends to continue to do so in various HEP projects; LHC, the LHC upgrade, CLIC and ILC.
- Our current priority is to carry out on-going projects like J-PARC and SuperKEKB and to lead preparatory works for realization of ILC hosted in Japan as a global project (KEK Roadmap 2013).
- We have discussed with CERN contacts and among ourselves which are areas where KEK can contribute to the FCC study effectively, and have agreed on work units. In these areas, experience/expertise at the KEK is useful for the study and/or there are common interests on planned technical developments.

Agreed areas of cooperation up to now

1. Electron-cloud and beam-beam simulations for arcs and key elements of FCC hadron and lepton colliders

2. Coordination of FCC-hh electron-cloud studies

3. Design of an FCC-ee injector complex based on the SuperKEKB design

4. Contributions to SC magnet developments (Nb_3Al and *HTS*)

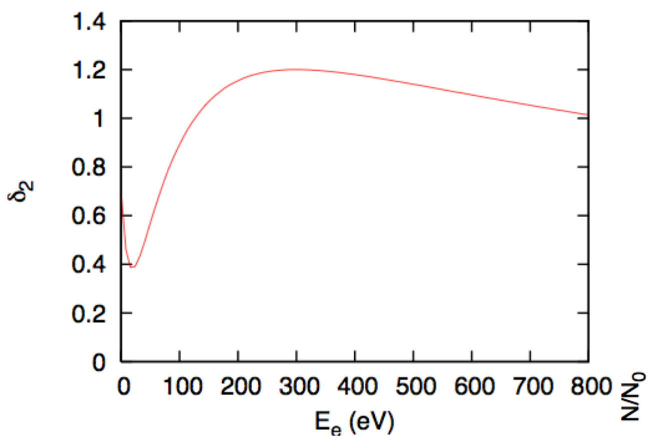
5. Contributions to SRF developments

6. Contributions to FCC-ee vacuum system design

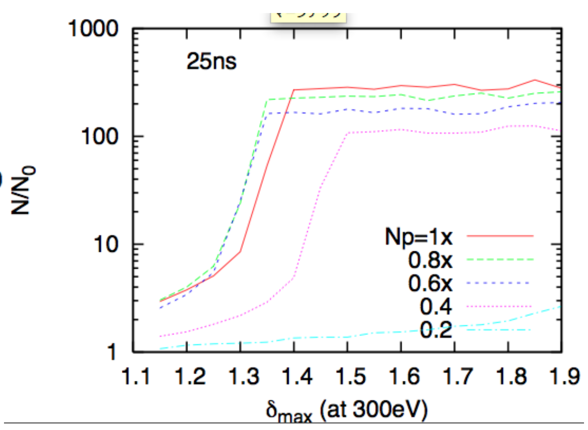
Electron cloud build up in FCC-hh

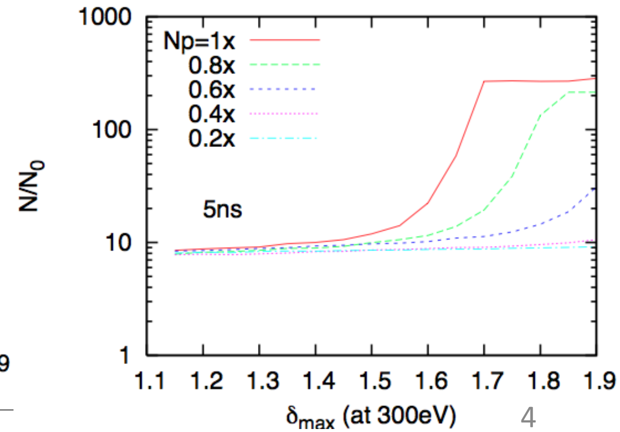
K.Ohmi

- Electron cloud issue is serious even in LHC. Parameter choice, 25ns or 50 ns spacing, bunch population, Lumi per col..., depend on the electron cloud status.
- Study of beam induced multipactoring for FCC-hh is started.
- Beam parameter (inj) E=3.3TeV, 25 ns or 5ns spacing
  - Secondary emission rate



Threshold of multipactoring

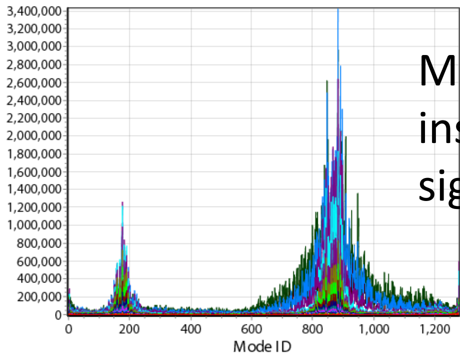




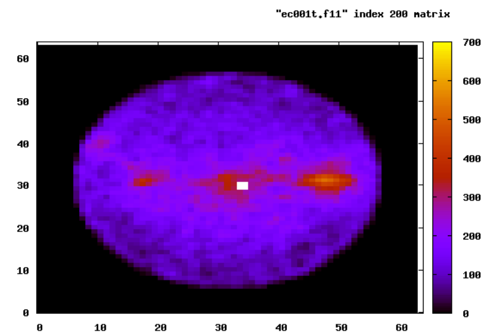
Electron cloud instability

K.Ohmi

- Experiences in KEKB
- Coupled bunch instability and suppression using bunch-by-bunch feedback.



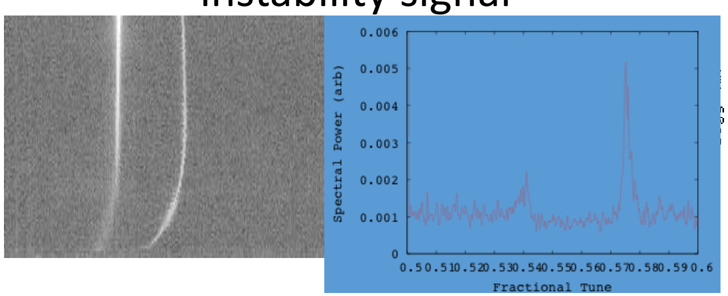
Measured instability signal



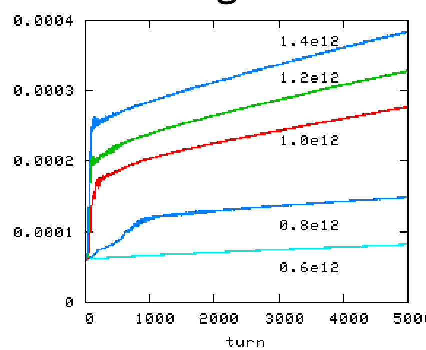
Simulation of the instability

- Single bunch instability and suppression using solenoid winding

Measured instability signal



Simulation of the emittance growth



Beam-beam effects in FCC-ee

K.Ohmi

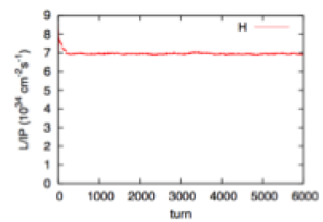
- Simulation of luminosity under Beamstrahlung and lifetime

Table 1: Calculated luminosity and bunch length.

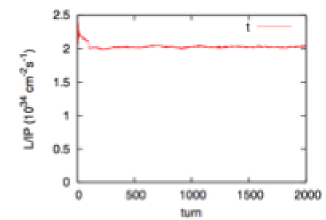
	TLEP/FCC-ee Z	Z (cr. w.)	W	t	H	Ce-pC
	luminosity $[10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}]$					
analyt.	28	219	12	6.0	1.7	1.8
w-s.	21	150	13	6.9	2.0	1.6
s-strong	—	—	—	7.5	2.2	1.6
	σ_z [mm]					
w/o BS	1.64	1.9	1.01	0.81	1.16	2.3
analyt.	2.56	6.4	1.49	1.17	1.49	2.7
w-s.	2.8	7.9	1.5	1.2	1.6	2.7
s-strong	—	—	—	1.3	1.72	2.9

Luminosity simulation

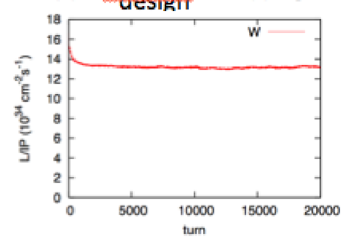
- H $L_{design}=6\times10^{34}$



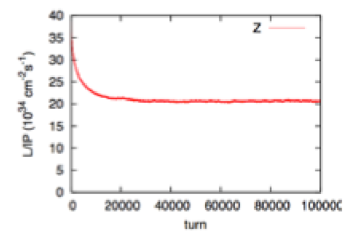
t $L_{design}=1.8\times10^{34}$



- W $L_{design}=12\times10^{34}$



Z $L_{design}=28\times10^{34}$



Beam tail distribution due to beamstrahlung

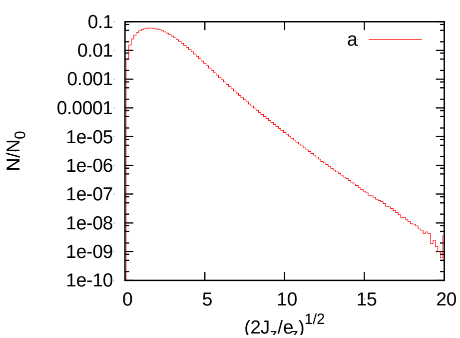


Table 2: Expected and simulated BS lifetime.

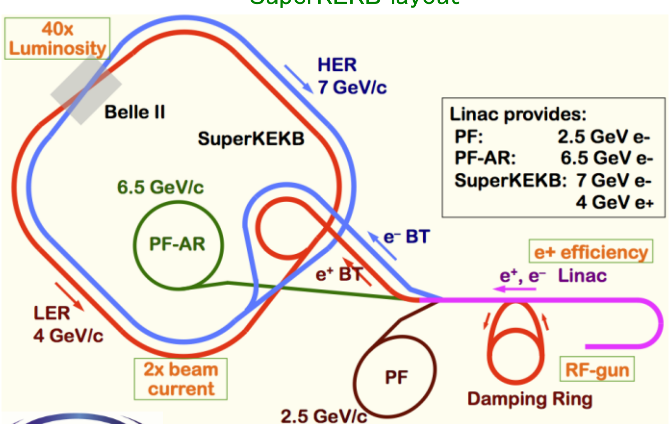
τ_{BS} [min]	TLEP-H	TLEP-t	CepC
analytical [9]	310	3.6	113
analytical [8]	1400	3.3	619
weak-strong (loss)	26	0.3	5.5
weak-strong (distr.)	33	0.3	—

K.Furukawa

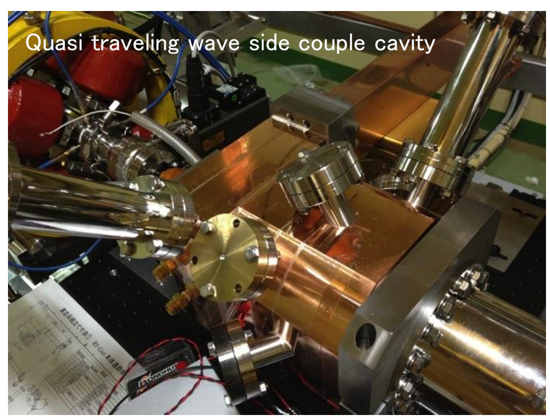
FCC-ee injector complex design based on SuperKEKB

- FCC-ee injector options
  - (a) Based on LHeC ERL, (b) Resources from LEP, or (c) Based on SuperKEKB injector
  - This work unit covers (c) with/without damping ring
  - Investigate and design the FCC injector based on experiences at KEK
- SuperKEKB injector
  - Higher electron/positron beam current for larger storage beam
  - Lower emmittance beam for higher collision rate
  - 4+1 ring simultaneous injection

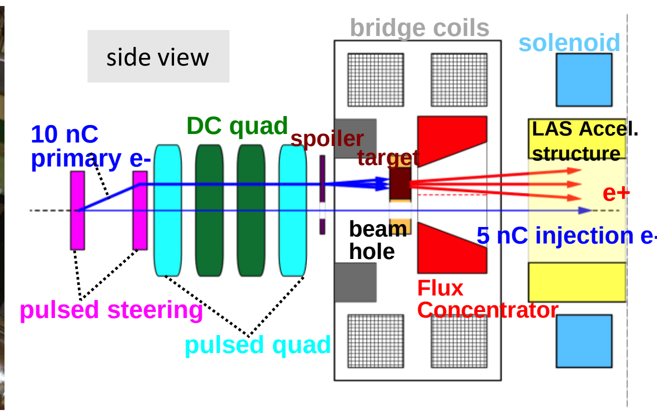
SuperKEKB layout



High current low energy−spread RF gun



High efficiency positron generator



High Field Superconducting Accelerator Magnet R&D at KEK Cryogenics Center

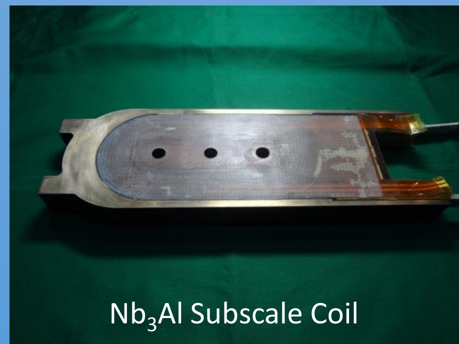
T.Ogitsu

NbTi LHC:MQXA&D1

MQXA:
High Field Q
D1:
Large Aperture D

Collaboration with
CERN
FNAL

A15 Coil R&D



Nb_3Al Subscale Coil
- Wind and React
- Common Coil

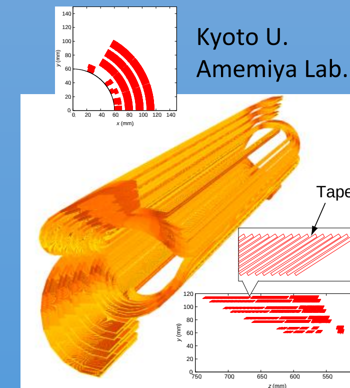
Collaboration with
NIMS
FNAL
LBNL
CERN

Conductor Property

Conductor Study
- Stress vs. Jc
- Strain Measurements by Neutron or X-ray

Collaboration with
JAEA
Tohoku U.
NIMS
CERN

HTS R&D



HTS Magnet R&D for Accelerator Applications
- React and Wind
- 3d Coil Shape

Collaboration with
Kyoto U.
NIRS
Toshiba
JAEA

Extend efforts with collaborators: High Field HTS, High performance A15, etc…

Collaboration with other Japanese institutes

Apply for grants with Kyoto-U, Tohoku-U, etc..

High Field Accelerator Magnet R&D towards FCC

A.Yamamoto

SRF developments for FCC-ee (and FCC-hh)

Objectives:

- **SRF cavity** and cryomodule technology development including reliable and cost-effective design, scalable to very large system.

- **RF power-system** development including High-level RF (HLRF) and Low-level RF reliable and cost-effective design.
  - A critically important example is the development of klystrons scalable to the 100 MW level and related energy efficiency issues.

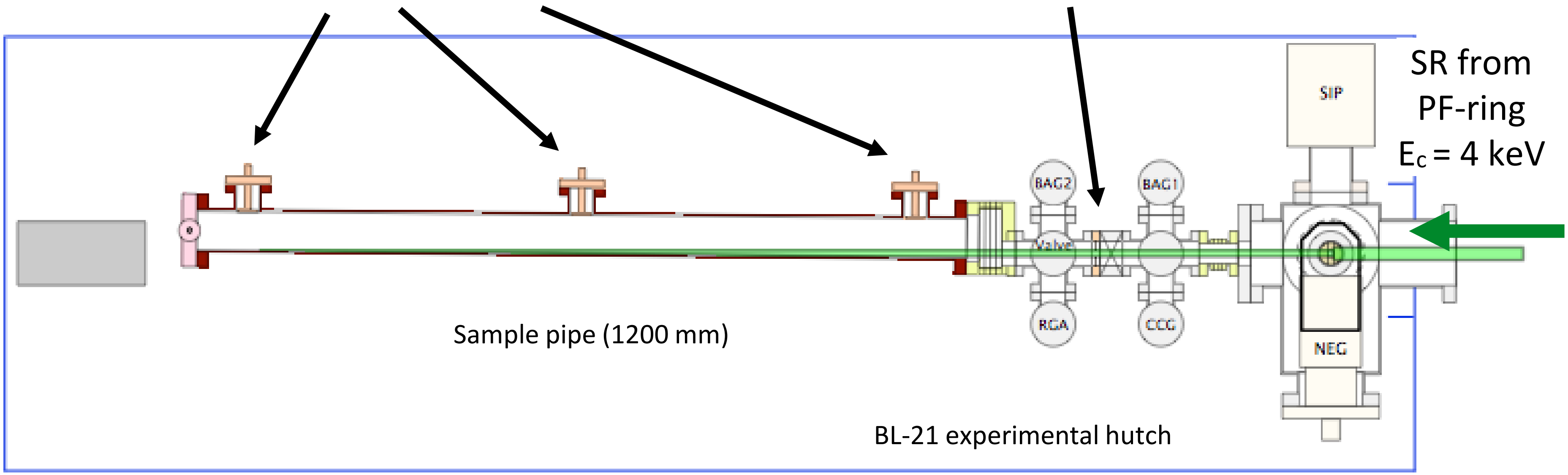
1.65 ms, 10 Hz Multi-beam Klystron

Y.Tanimoto

Experimental Study on Vacuum Chamber Properties under SR irradiation at KEK Photon Factory (2014-2015)

Photo-electron measurements for electron cloud study

Photodesorption measurements for vacuum pressure study



Various samples (prepared by CERN)

- surface coating: carbon, NEG, etc.
- temperature: RT, LN_2