Ring Commissioning

Y. Funakoshi

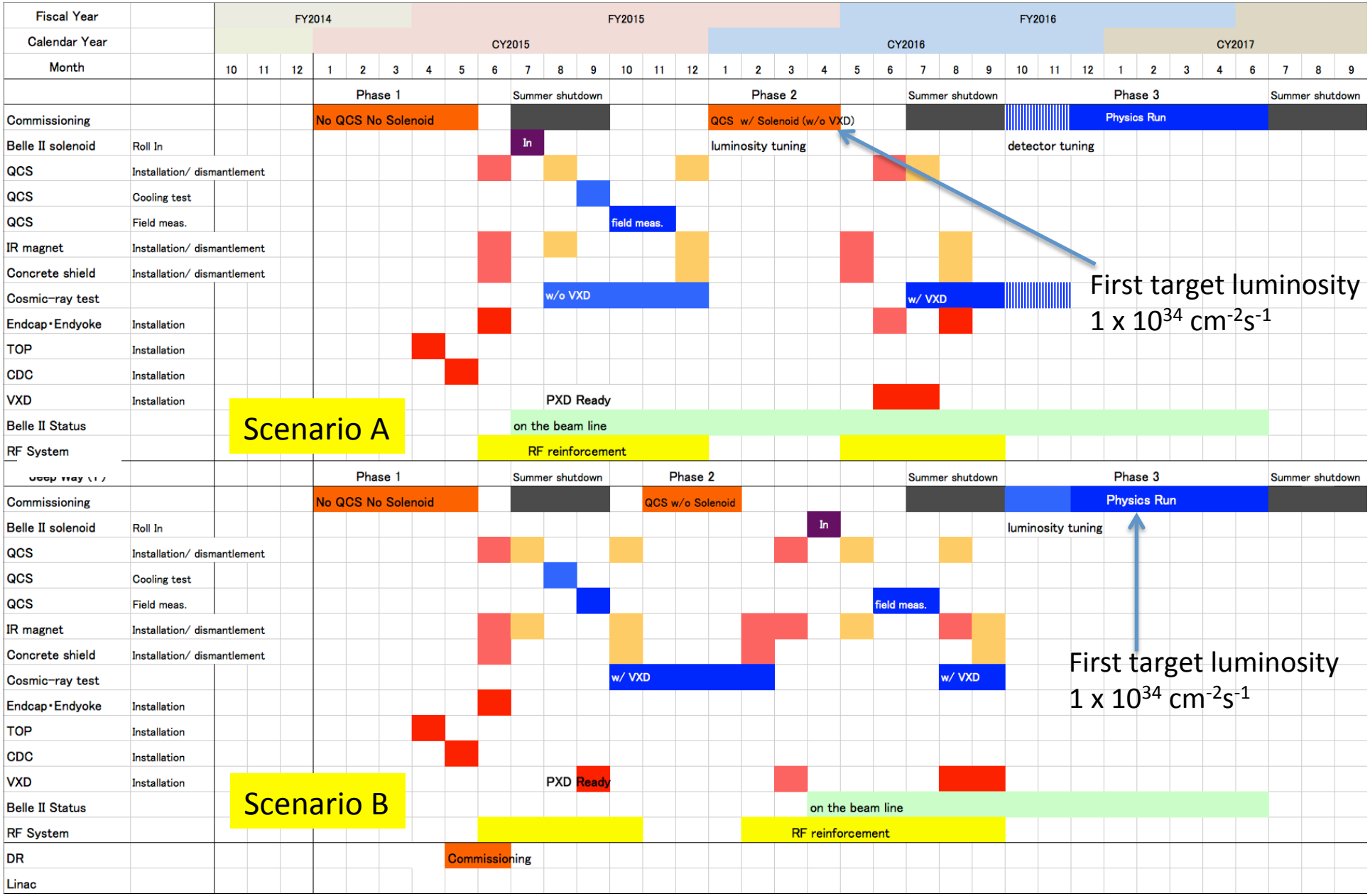
KEKB Review

2013. 03. 05

Commissioning schedule

- Start-up time of SuperKEKB
  - SuperKEKB commissioning is expected to start in January 2015.
- QCS schedule
  - Due to the background issues, the fabrication schedule of QCS's on the right side of IP will be delayed.
  - SuperKEKB commissioning will start w/o QCS magnets.
- Linac commissioning
  - Linac beams are expected to be ready by the SuperKEKB ring commissioning.
- Damping ring
  - Commissioning of damping ring will start sometime after commissioning of SuperKEKB rings. (May or June 2015)
- RF system reinforcement
  - Works for reinforcements will continue in FY2015 and FY2016 due to budget constraint.

Two possible scenarios



Consensus between SuperKEKB accelerator group and Belle II group

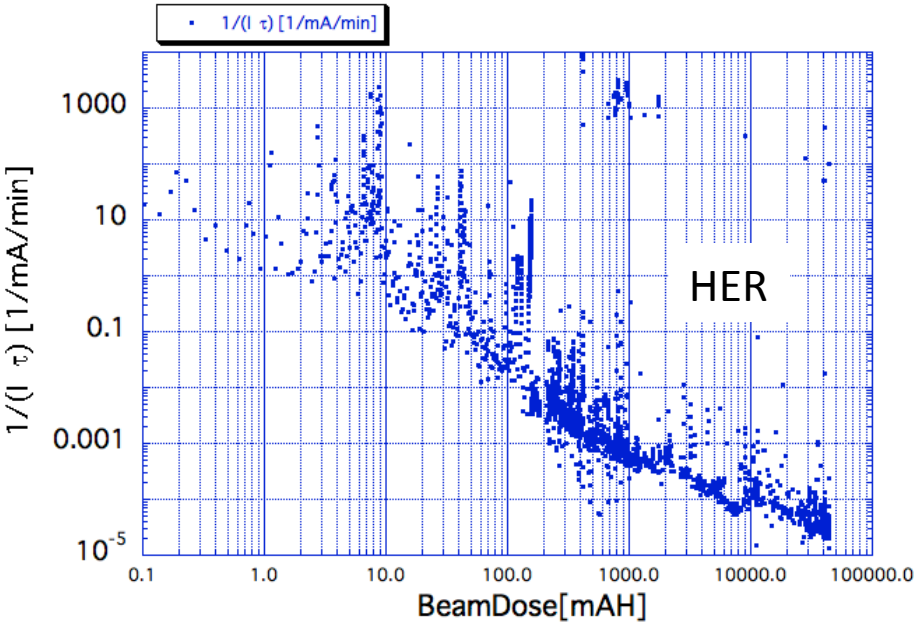
- To proceed with Scenario A (phase 2 commissioning with QCS and Belle II solenoid)
- To keep Scenario B (phase 2 commissioning with QCS without Belle II solenoid) as a backup option for some unexpected situations.

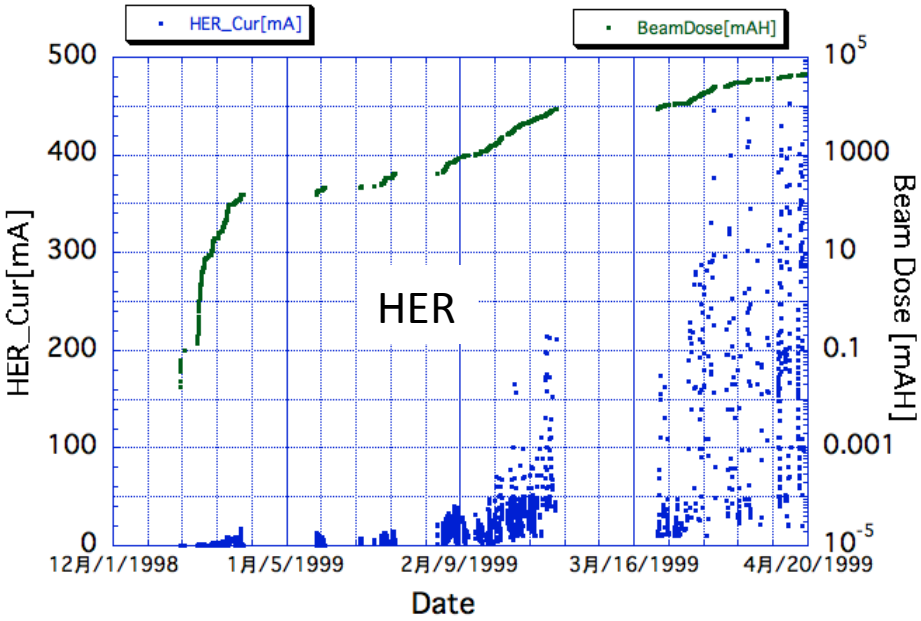
This proposal by the accelerator group was accepted at the Belle II EB meeting on Sep. 27th.

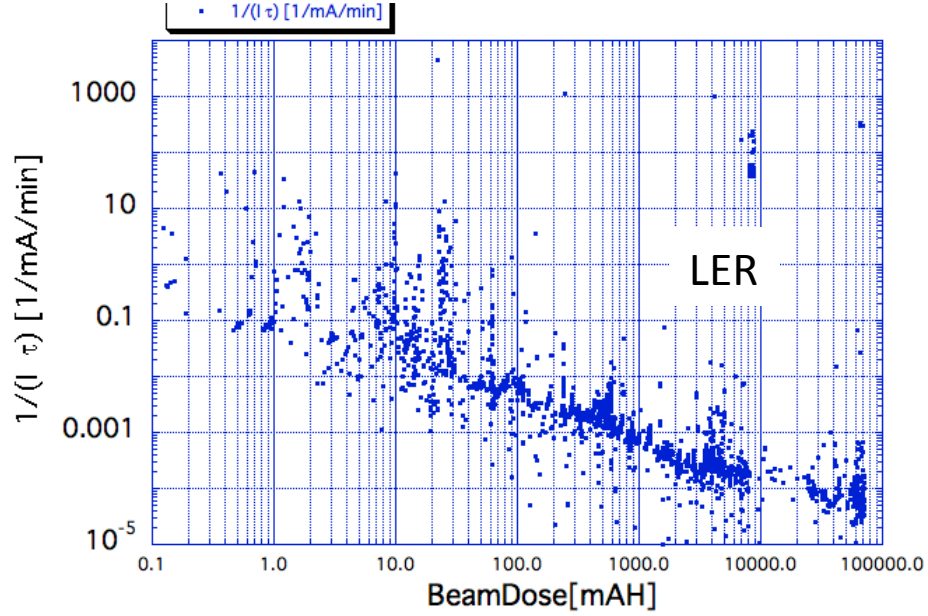
Procedures of machine commissioning

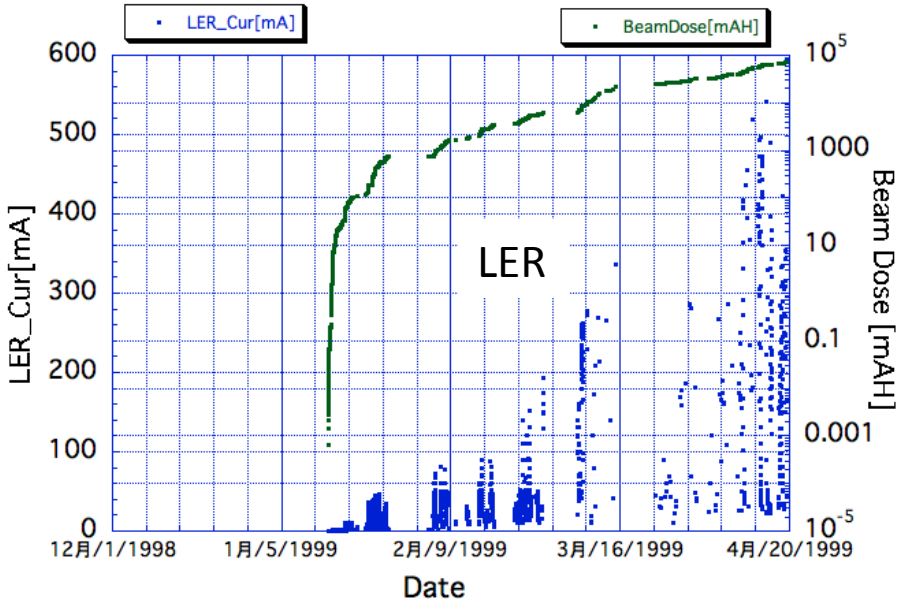
- Commissioning I :Basic commissioning of machine (~ 1.5 month)
  - Linac tuning
  - Damping Ring tuning (new at SuperKEKB)
  - BT tuning
  - Injection tuning (including beam timing and simultaneous injection)
  - COD correction, Optics correction (rough correction)
  - Tuning on beam abort system
  - Tuning on beam monitor system (including beam feedback)
  - Tuning and measurement on radiation safety
  - Tuning on other hardware systems
  - Test and debugging various kinds of control softwares
- Commissioning II : Vacuum scrubbing (>~3 months)
- Commissioning III : More sophisticated tuning
  - Optics measurements and corrections
    - Squeezing IP beta function (more difficult than KEKB)
    - Achieving a small x-y coupling (more difficult than KEKB)
  - Beam collision tuning and luminosity tuning (more difficult than KEKB)
  - Belle II beam background: study and tuning (more difficult than KEKB)
  - Increasing beam currents (final target is higher than KEKB)
  - Study on the other beam dynamics issues

Vacuum scrubbing at KEKB（HER/LER）









SuperKEKB Commissioning Meeting
2011.11.08 *Kikuchi, M.*

DR Commissioning

- LTR commissioning 2 days
- BPM commission
- First turn 1 day
- COD meas. and correction 2 day
- BPM commission
- Optics meas. 2 days
- RTL commissioning 2 days
- Injection to LER
- 25 Hz operation
- SR commission
- Vacuum scrubbing ~14 days

} ~ 9 days

} ~ 3 weeks

by wishful thinking

M. Kikuchi

Commissioning phase 1 (2015 Jan. ~ May)

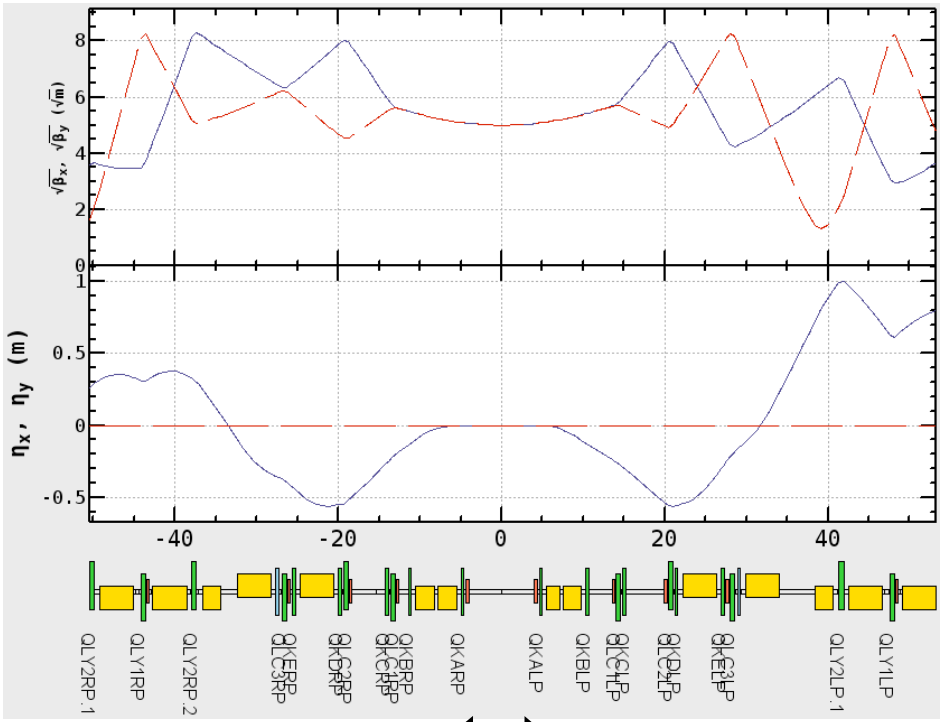
- Machine condition
  - No QCS, No solenoid (no Belle II)
- Tuning items
  - Special optics for phase 1
  - Commissioning item I (basic commissioning)
  - Commissioning item II (vacuum scrubbing)
    - HER beam current (~< 1A)
    - LER beam current (~ <0.5A with low emittance beam)
    - Belle II people request enough vacuum scrubbing in this phase (before Belle II roll-in).
      - At least one month with beam currents of 0.5 ~ 1 A.
  - Damping ring commissioning (from May or June)
    - If possible, we hope to check LER injection of the e+ beam from DR.
  - Commissioning III
    - Belle II Background study with Beast II Detector
    - Achieving a small x-y coupling
      - In phase 1, we can study without IR.
      - Beam size monitor will have to work (with low beam current ~30mA?).

H. Sugimoto

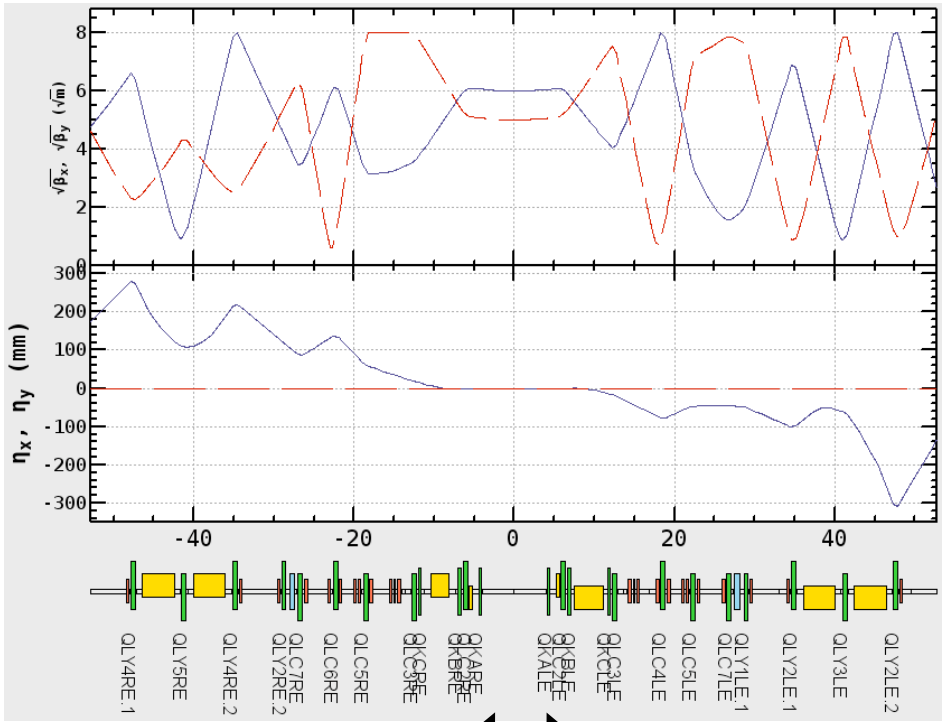
Phase 1 - Linear Optics -

- Optics W/O QCS and solenoid has been designed
- QCS and solenoid is replaced by drift space.
- Machine tuning except for IR is expected to be done in this phase.

LER



HER



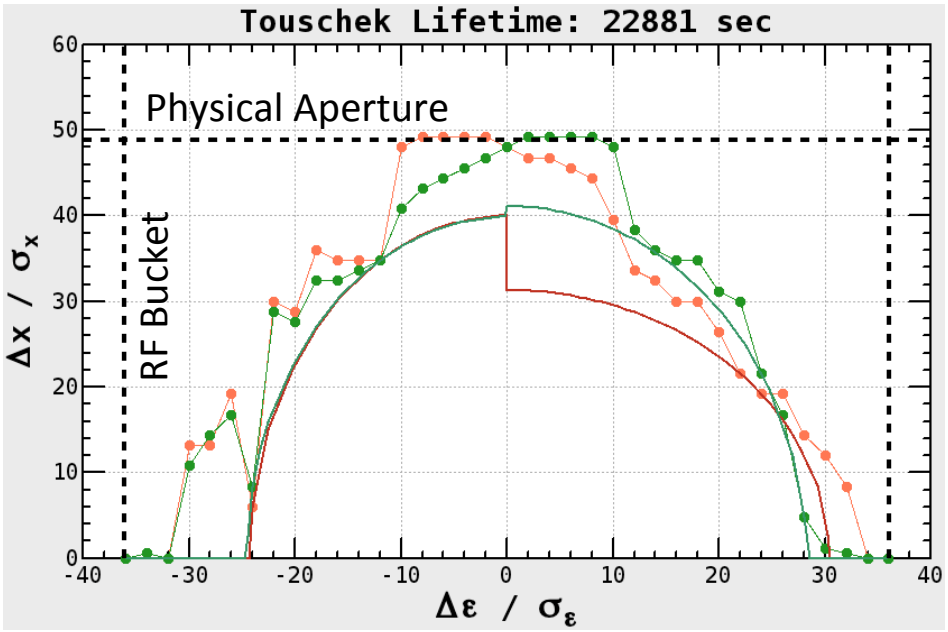
H. Sugimoto

Phase 1 - Dynamic Aperture -

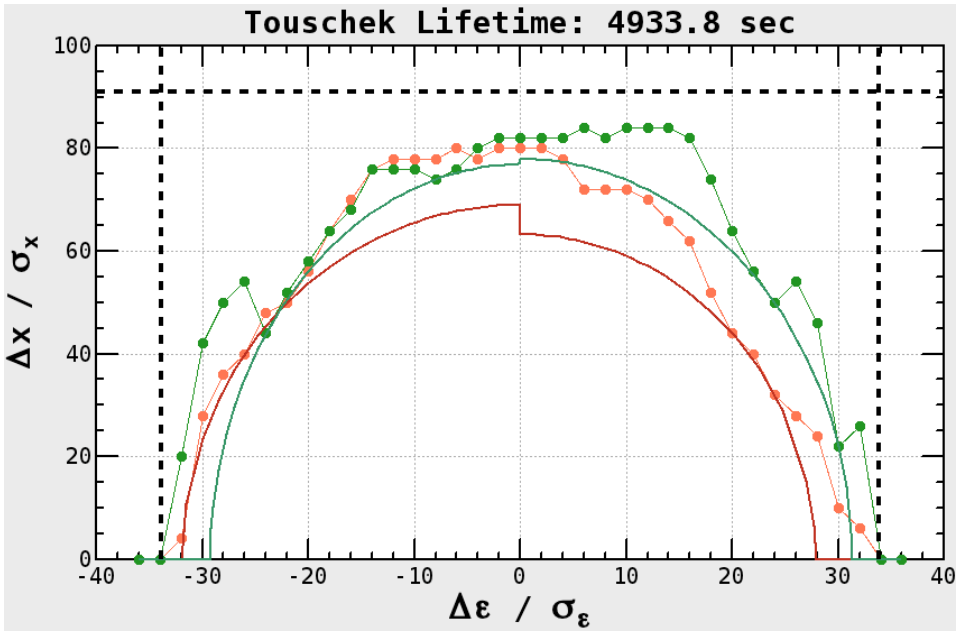
- DA example assuming,
  - Design bunch current.
  - 2% emittance ratio.
- Beam loss estimation is ongoing from view point of radiation protection.

→ Funakoshi-san's talk

HER Touscheck Life
~6.3 hours

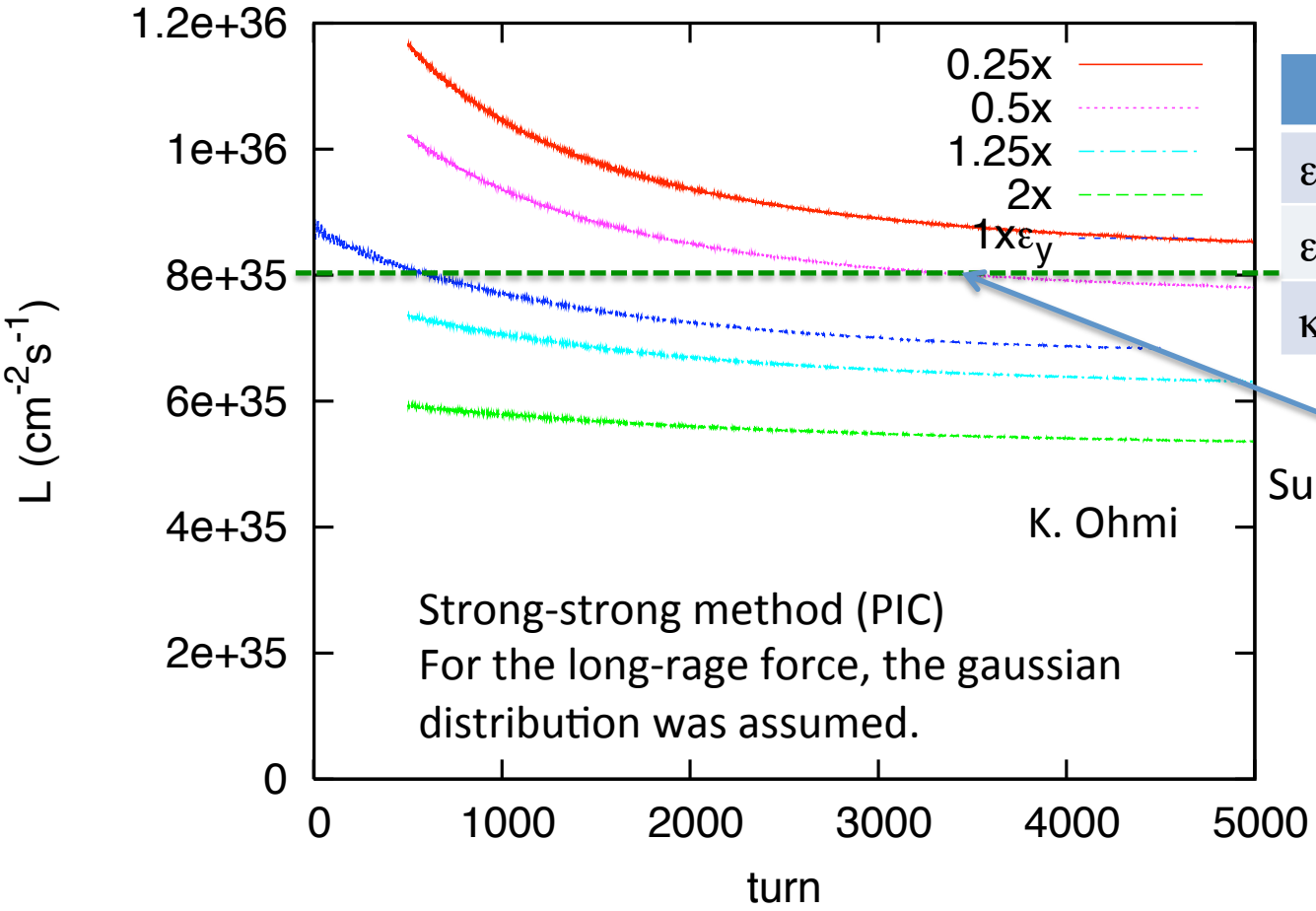


LER Touscheck Life
~1.4 hours



SuperKEKB beam-beam simulation

Lattice non-linearity and space charge effect is not considered.



SuperKEKB design

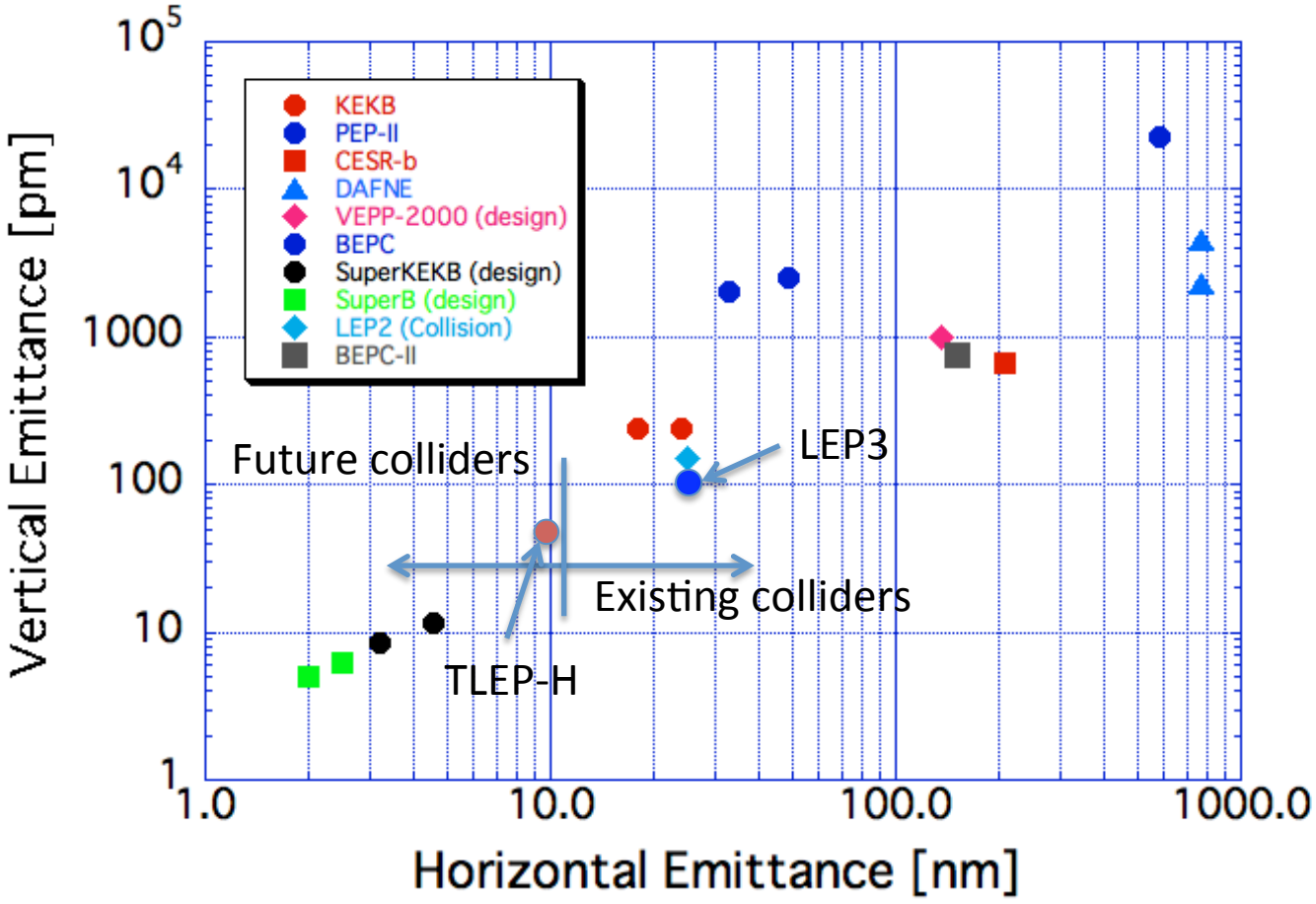
	LER	HER
ε_x [nm]	3.2	4.6
ε_y [pm]	8.64	11.5
κ [%]	0.27	0.25

SuperKEKB design luminosity

Smaller (single beam) vertical emittance gives higher luminosity. Much lower vertical emittance than the design (about half) will be needed to achieve the design luminosity. A tentative target of x-y coupling w/o beam-beam is 0.15%.

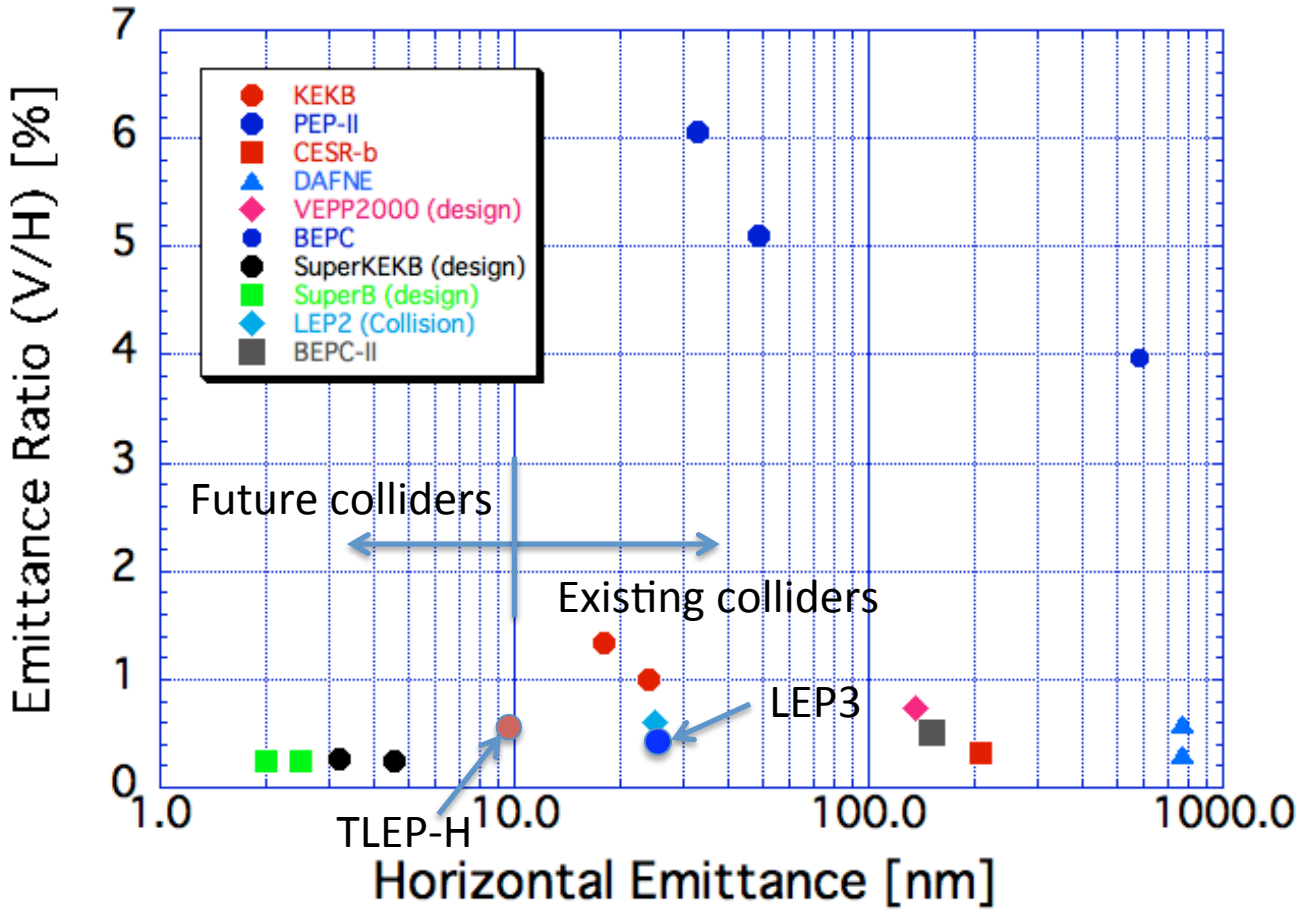
At SuperKEKB, low emittance tuning will be very important.

Comparison of emittances of colliders



From Beam Dynamics Newsletter No. 31
Courtesy of F. Zimmermann, H. Burkhardt and Q. Qin

Comparison of emittances of colliders [cont'd]



A Possible BEASTII Strategy

Modular design, where we can easily add/remove sub detectors as required

- Perhaps grouped into Inner BEAST, Outer BEAST
- Three configuration: T0, T1, T2

Y. Sakai

	All scenario BEASTII-T0 w/o QCS, w/o solenoid Phase 1	Scenario B BEASTII-T1 w/ QCS, w/o soldenoid Phase 2	Scenario A BEASTII-T2 w/QCS, w/ solenoid , No SVD, PXD Phase 2
ECL shielding	N	N	N
Diodes & beam abort	Y	Y	Y
Micro-TPCs	Y	Y	Y, in dock
BGO	N	Y	?
CDC prototype	N	Y	N
SVD, PXD ladders & monitors	N	Y	Y
Diamonds	Y	Y	Y

Outer Beast

Inner Beast

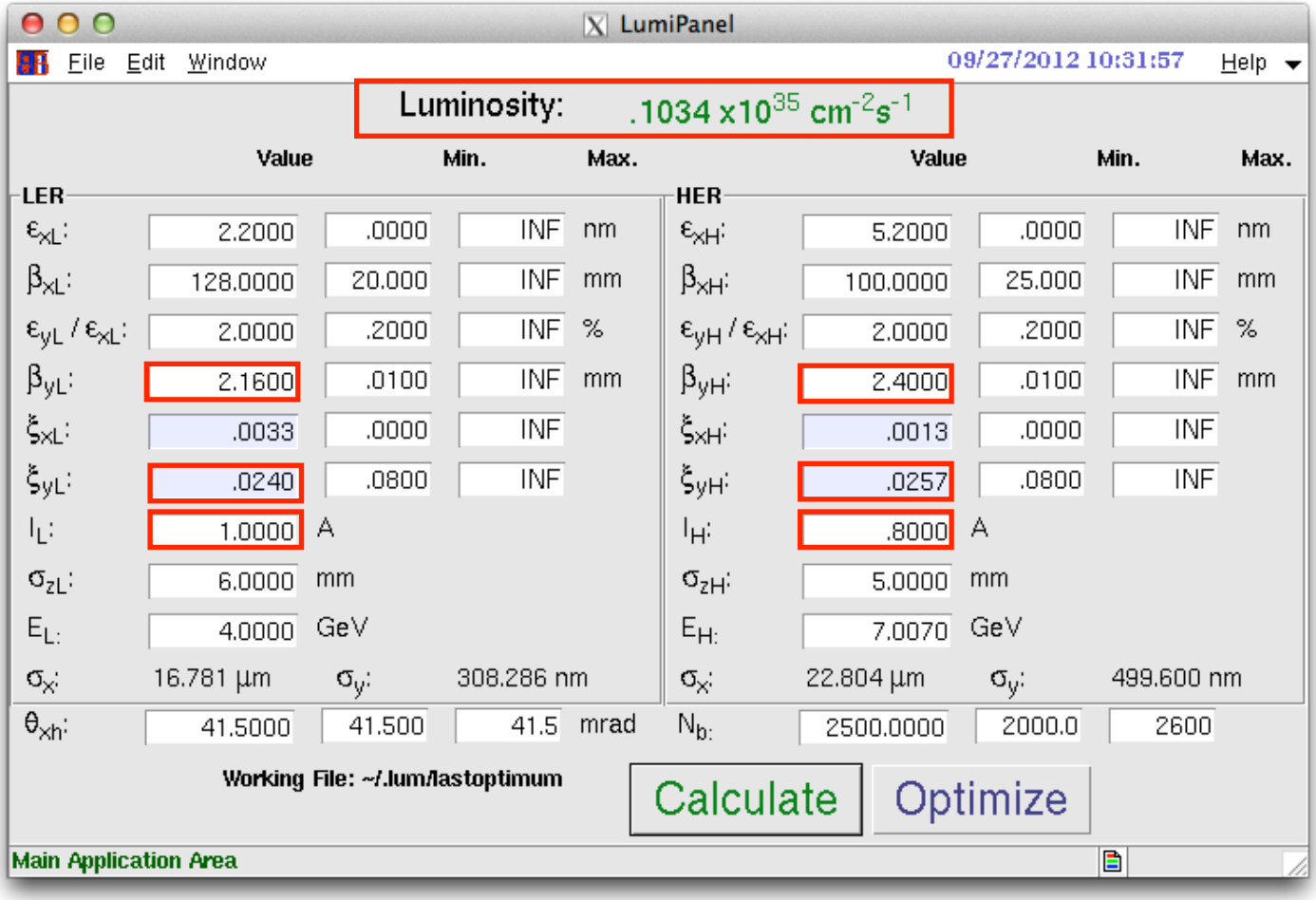
→ For BEASTII_T2, place some sub system in PXD DOCK space
→ Keep up development of all BEAST sub systems.

Commissioning phase 2 (2016 Jan. ~ April)

- Machine condition
  - With QCS, with Belle II (no VXD)
  - Full accelerator tuning, no physics run
  - Target luminosity at the end of this phase: 1 x 10^{34} cm^{-2} s^{-1}
- Tuning items
  - Injection tuning w/ Belle II detector starting from detuned optics
  - Commissioning item II (vacuum scrubbing)
    - Continue to increase beam currents
  - Commissioning III
    - Belle II Background study with Belle II (and with Beast II)
    - Achieving a small x-y coupling with IR
    - Squeezing IP beta functions
    - Collision tuning with the nano-beam scheme
      - Establishment of collision feedback
    - Other beam dynamics issues
    - Luminosity tuning

Detuned Optics (4x8)

Example of Parameters for 10^{34} $cm^{-2}s^{-1}$



β_x^*: x4, β_y^*: x8, coupling =2 %, ξ_y ~ 0.025, I_{LER} = 1 A.
The effect of intra-beam scattering is decreased in LER.

Commissioning phase 3 (2016 Oct. ~)

- Machine condition
  - With QCS, with Belle II including VXD
  - Continue full accelerator tuning. Physics run will start after some detector tuning period.
- Tuning items
  - Commissioning item II (vacuum scrubbing)
    - Continue to increase beam currents
  - Commissioning III
    - Achieving a small x-y coupling with IR?
    - Squeezing IP beta functions
    - Other beam dynamic issues
    - Continue luminosity tuning

Summary

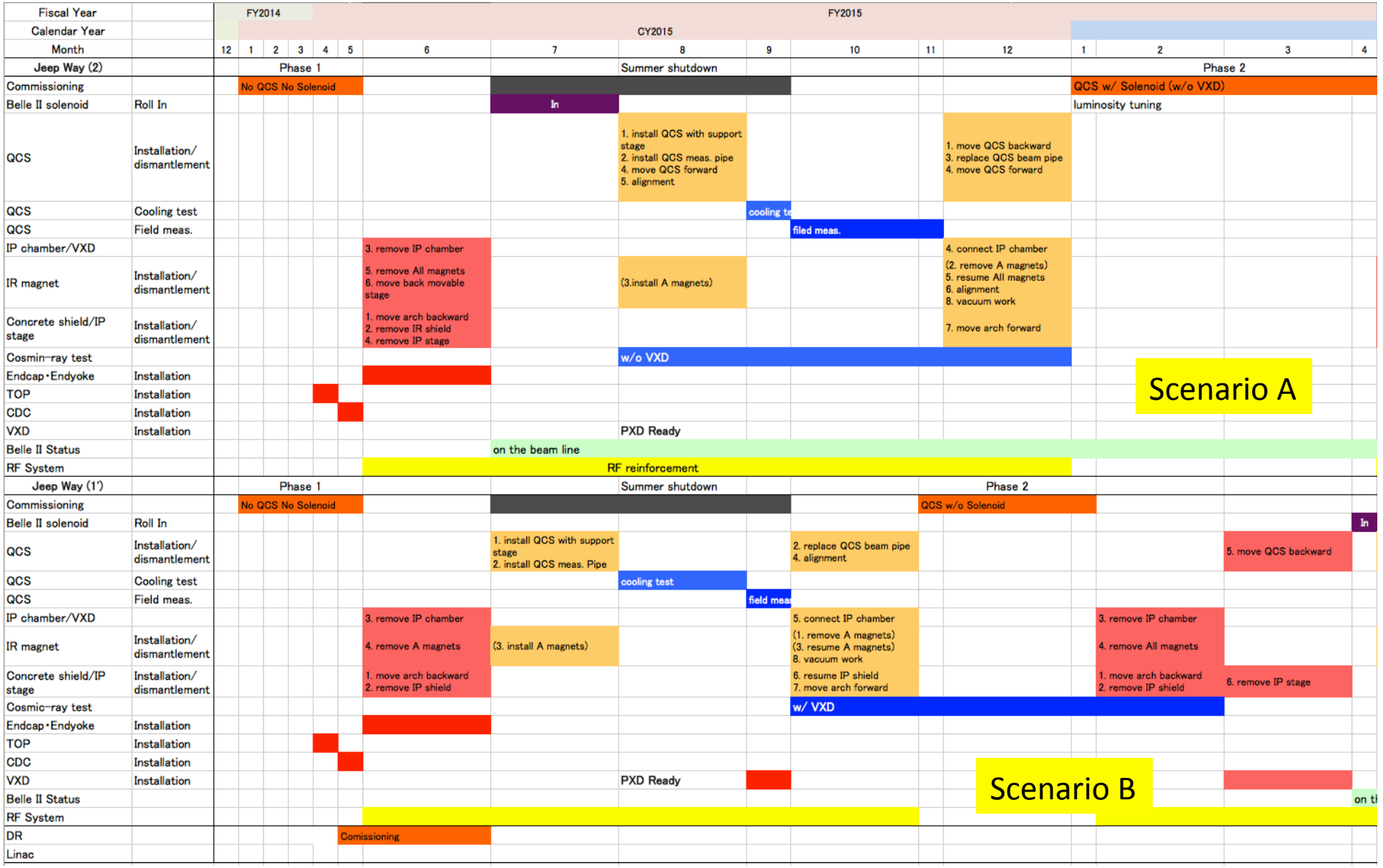
- The SuperKEKB accelerator ground and Belle II ground agreed that the ring commissioning will be done with 3 phases. There are two possible scenarios. Scenario A has the first priority. Scenario B is kept for the situation where Belle II schedule delays.
- Phase 1 (scenario A) (2015 Jan. ~ May)
  - No QCS, No Belle II
  - Basic commissioning, vacuum scrubbing, low emittance tuning, detector background (Beast II), DR commissioning
- Phase 2 (scenario A) (2016 Jan. ~ April)
  - w/ QCS, w/ Belle II (no VXD)
  - Full accelerator tuning, no physics run, detector background (Beast II)
  - Target luminosity = 1×10^{34} cm^{-2} s^{-1}
- Phase 3 (scenario A) (2016 Oct. ~)
  - w/ Belle II (w/ VXD)
  - Continue accelerator tuning, Belle II tuning, physics run will start.

Future prospects

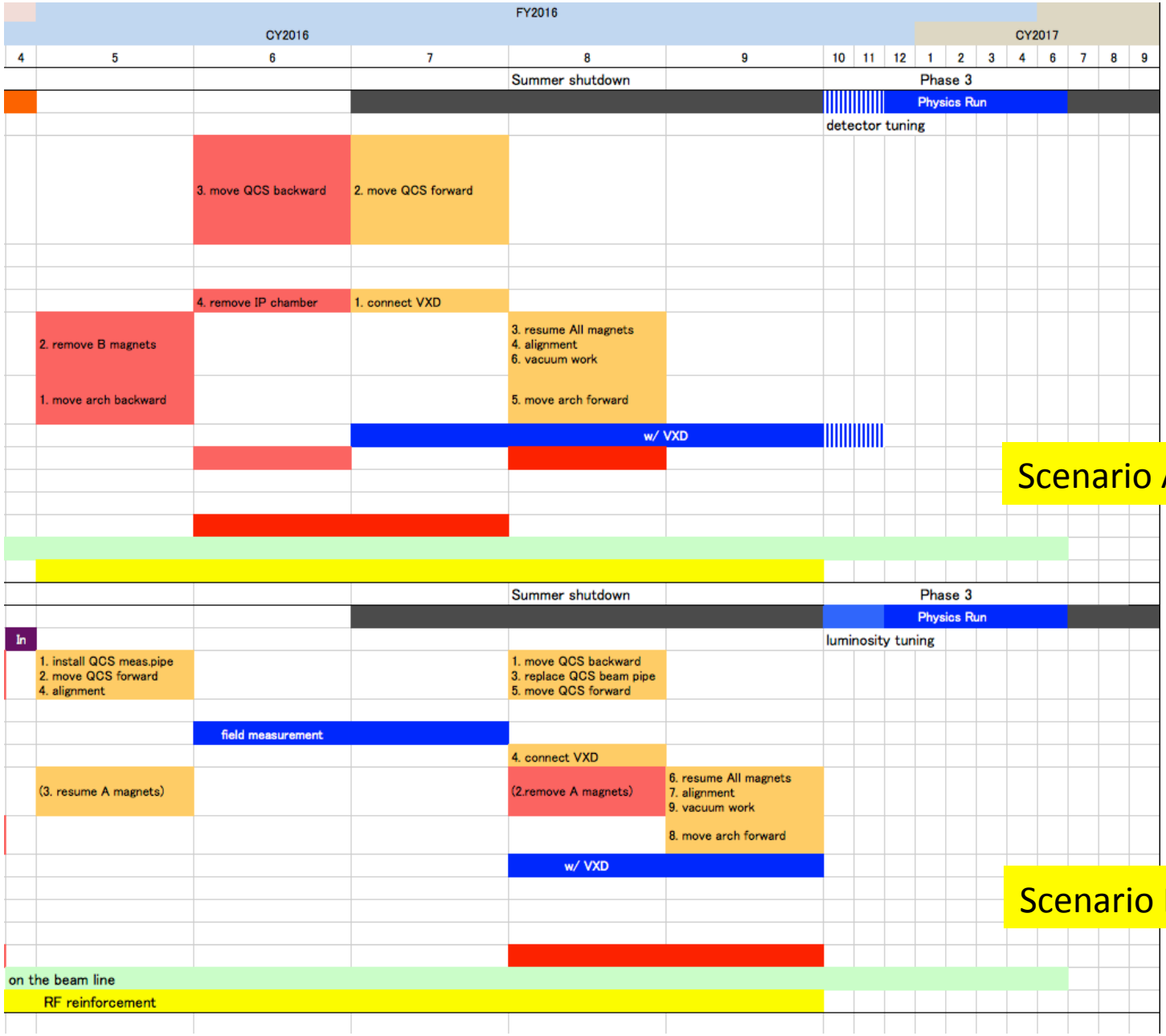
- Tasks to be done (from summer 2013)
  - More concrete and detailed scenarios for beam commissioning
  - Development of operation software
- Ask for your cooperation
  - SuperKEKB is an extremely difficult machine
    - Low-beta, Low-emittance, nano-beam scheme, high beam currents, high luminosity
  - Pioneer for new accelerator physics
  - Experiences in other laboratories are extremely helpful
    - SLAC, BINP, DAFNE, , SuperB, Cornell….

Spare slides

Detailed Schedule 1



Detailed Schedule 2



Comparison of two scenarios during commissioning phase 2

	Scenario A (w/ solenoid)	Scenario B (w/o solenoid)
Optics correction(1) Squeezing IP beta functions	We can do full tuning.	We can do something. But we will have to do tuning w/ Belle II solenoid almost from scratch.
Optics correction(2) Achieving a small x-y coupling	We can do full tuning.	We can do something. But we will have to do tuning w/ Belle II solenoid again anyway.
Collision tuning	We can do full tuning.	The beam collision may not be possible w/o Belle II solenoid.
Belle II background Study and tuning	The real beam background can be studied. Also some test detectors can be installed at the place of VXD.	Some studies can be possible.
Risk to Belle II	Maybe we can avoid the risks by adiabatic tuning (start from small beam currents, with detuned optics).	Less risk

Comparison of two scenarios (cont'd) during commissioning phase 2

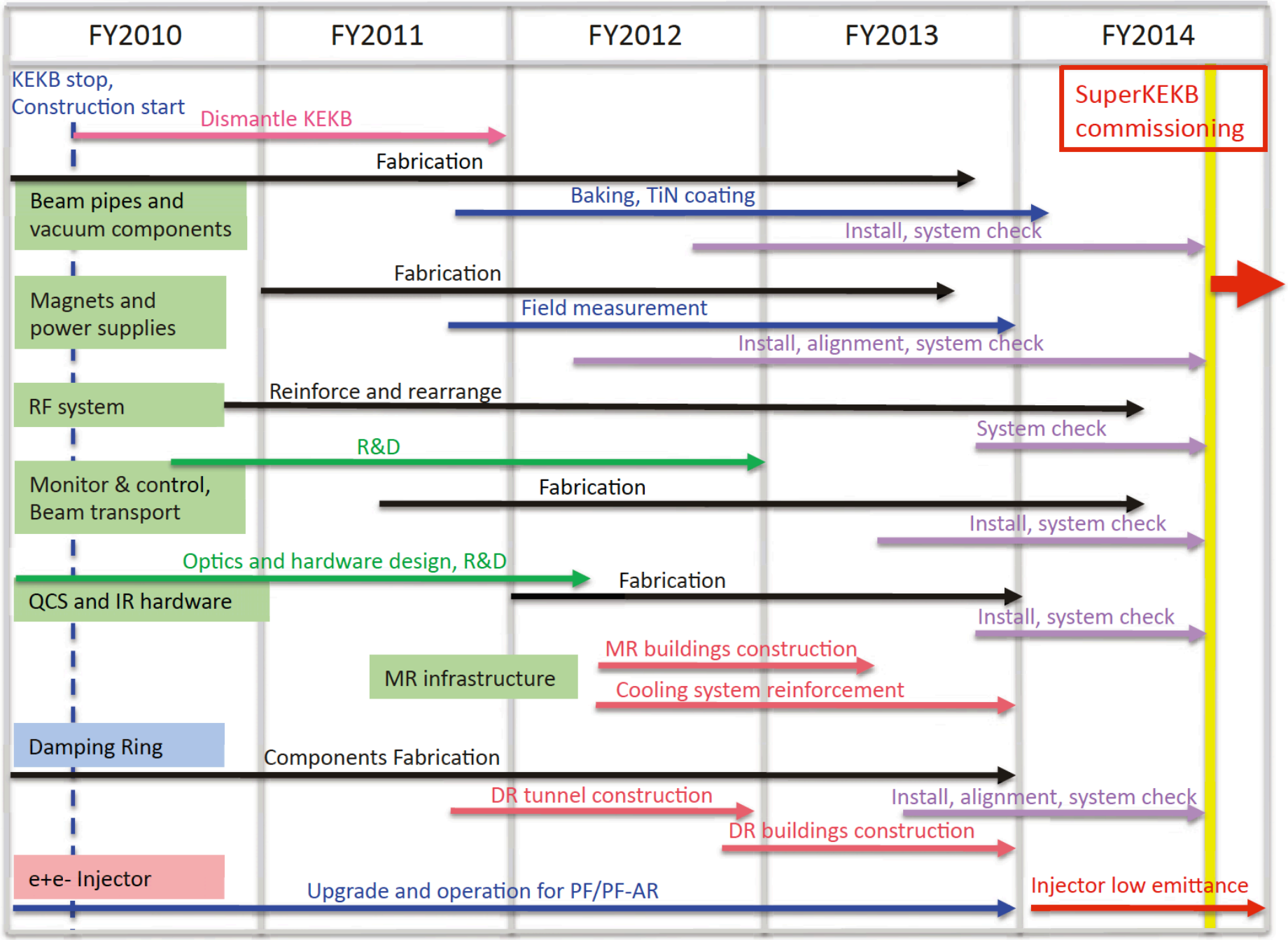
	Scenario A (w/ solenoid)	Scenario B (w/o solenoid)
Works for accelerator setup	Less works.	One more QCS field measurement. (heavier load to QCS group)
Cosmic-ray run w/ VXD	Less time before phase 3. Can also be done in the beginning of phase 3.	More time before phase 3.
Expected time for the first target luminosity (1×10^{34} $cm^{-2}s^{-1}$)	Earlier (maybe during phase 2).	Later (3～5 months after phase 3 start).

Commissioning III : More sophisticated tuning

- Optics measurements and corrections (1) : squeezing IP beta functions at IP
  - We will squeeze the IP beta functions with observing the beam lifetime, the injection rate and the Belle II background. This study can be done with small beam currents (~30mA).
  - QCS's are vital for this study. We can do something without solenoid (Belle II). However, we need to start tuning with solenoid (Belle II) almost from scratch.
  - This tuning is most important for the luminosity at SuperKEKB. A factor 20 of the luminosity gain is expected by squeezing beta functions.
    - The first target of vertical beta function at IP (βy^*) is 10 times larger values of the design values.
- Optics measurements and corrections (2) : achieving a small value of x-y coupling
  - We need to measure the beam size with x-ray monitor.
    - The beam size measurements will be possible with small beam currents with relatively high bunch currents.
    - We do not need the solenoid winding for clearing the electron clouds.
  - Although it is worthwhile to do this study w/o Belle II solenoid, we also need to do the study also with Belle II solenoid.
- Collision tuning
  - We have no experience on the beam collision with Nano-beam scheme.
    - Finding beam collision, establishing orbit feedback system（including dithering system）
    - Luminosity tuning like at KEKB (this kind of tuning will continue many years.)
  - It is worthwhile to do this tuning w/o solenoid. However, there is a possibility that the beam collision will not be possible w/o Belle II solenoid.
- Belle II (Beast II) background study, tuning

SuperKEKB Construction Schedule

Revised on April 1st 2012



M. Ono

Facilities

- Storage and staging areas needed for magnet and vacuum components.
- Need increased cooling water for klystrons and magnets:
  - 24 klystrons for ARES cavities, 8 klystrons for SCC
  - Magnet cooling water needs double (4 plants -> 8)
- Electricity:

Electricity Consumption: June-09

KEKB/KEK total

(Design option)	KEKB:MW	ΔMW	KEK:MW	ΔMW
Present(Average)	45		64	
Nano Beam: June-09	70.7	24.3	96	32
Upgrade: Feb.-09	94.8	49.8	120	56
Super: '07-July	102.6	57.6	128	64

Recent Design(Feb.-10): Add 2 ARES units--> +(3~4)MW