Brief summary of
3rd IDT WG2 DR/BDS/DUMP subgroup meeting

Toshiyuki OKUGI, KEK

2020/11/03

IDT WG2 meeting

3rd Meeting of DR/BDS/DUMP subgroup

Tuesday 27 Oct 2020, 22:00 → 23:00 Asia/Tokyo

https://agenda.linearcollider.org/event/8927/

22:00 → 22:20 **Fast Ion Instability (Feedback) / Electron Cloud Instability in ILC damping ring** 20m

Speaker: Toshiyuki Okugi (KEK)

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22:20 → 22:40 **Anti-solenoid and Anti-DID** 20m

Speaker: Karsten Buesser (DESY)

201027_Anti-DID.pdf

22:40 → 23:00 **Next meeting and later** 20m

Speaker: Toshiyuki Okugi (KEK)

IDTschedule_okugi_... TechnicalPreparatio...

The following 2 persons joined to IDT-WG2 and DR/BDS/DUMP subgroup.

Brett Parker (BNL)
Angeles Faus-Golfe (IJCLab)

The following 2 persons were invited to today's subgroup meeting in order to discuss the technical preparation for DR beam dynamics issues.

Ian Martin (Diamond Light Source)
Andy Wolski (Liverpool Univ.)

Present ILC DR lattice design

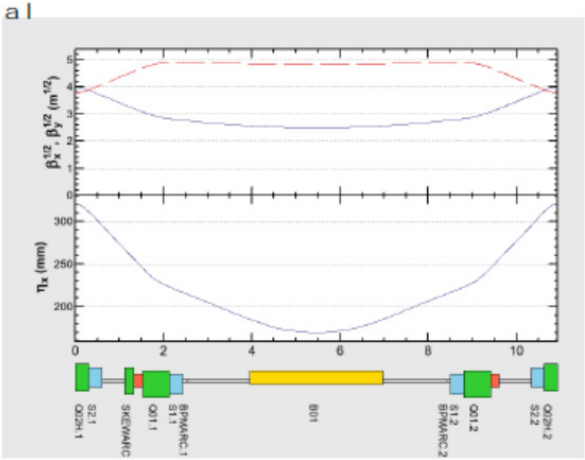
presented by K. Kubo at AWLC2017

Bending magnet was lengthen
with same TDR DR lattice.

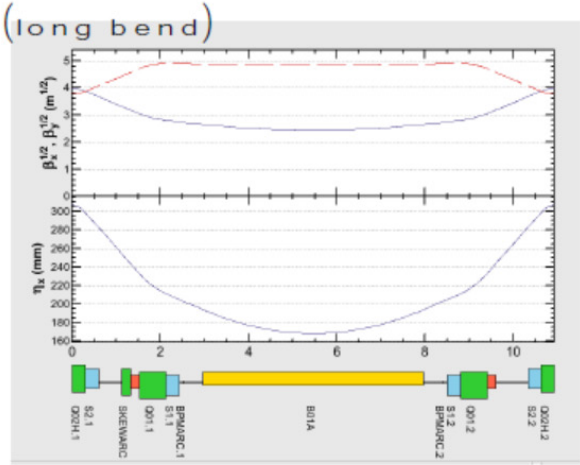
	Original	New (long bend)
Horizontal normalized Emittance (um)	5.74, 6.27 (IBS)	3.14, 3.97 (IBS)
Tune x/y	48.26/26.76	49.33/26.86
phase adv./cell /2pi x/y	0.21891 /0.08098	0.2250 /0.0808
Damping time x/y/z (ms)	23.9/23.9/11.9	25.5/25.5/12.8

Optics of Arc Cell

Original



New (long bend)

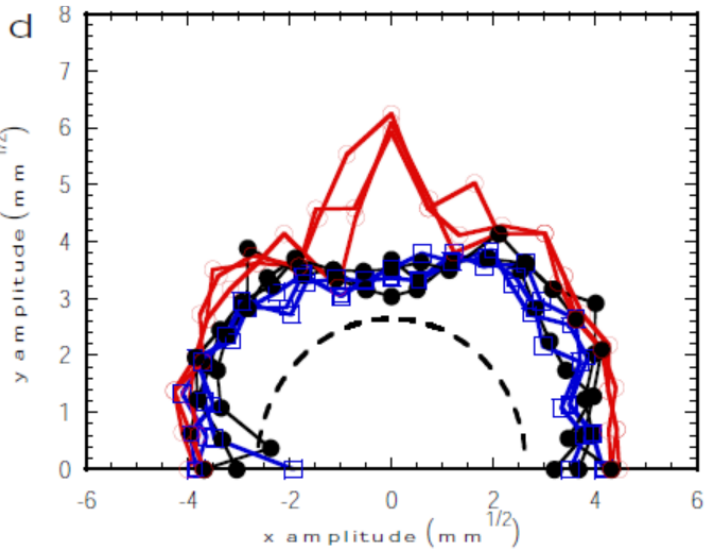


Dynamic aperture: long bend

Misalignment + correction

New arc cell: long (5 m) bend
tune/cell: x.225 y.0808
Tune: x49.33 y26.86

Quadrupole & sextupole offset: 50 um
Quadrupole roll: 100 urad
BPM offset: 100 um
BPM roll: 10 mrad
COD & Dispersion correction



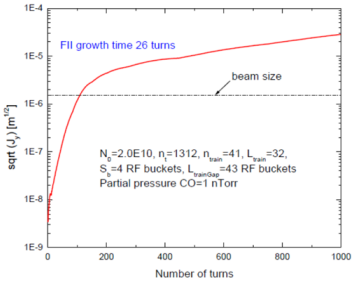
Fast Ion Instability (DR feedback)

Toshiyuki Okugi

Dynamic range of the feedback for FII

(TDR notation)

- ✓ *The dynamic range of the order of 90dB*
- ✓ *To minimize the quantization noise,*
  14-16 bit signal processing system



(Private discussion with Makoto Tobiyama)

Dynamic range of the processing system

- ✓ *KEKB used 8 bit processing system.*
- ✓ *SuperKEKB upgraded to 12 bit processing system.*
- ✓ *There are 14-16 bit processing system in the world,*
  but the frequency of the processing is fixed (That for SuperKEKB is flexible up to 1GHz),
  and the processing time will be slower.
- ✓ *When we will use 14-16 bit processing system, we must develop the system.*

Do we need the 14-16 bit processing system from KEKB, SuperKEKB experience ?

- ✓ *Since the center offset is subtracted by analog circuit for the FB,*
  the dynamic range is enough only for the amplitude of the beam oscillation.
- ✓ *Since the amplitude is nonlinear, and the growth time is large for the large amplitude,*
  the 8-bit processor is basically enough for SuperKEKB, too.
- ✓ *However, the upgrade from 8 bit to 12 bit was very helpful for SuperKEKB.*
  Since the COD and the injection position are sometimes changed,
  they must tune the analog parameters for 8 bit system (12 bit is not).
- ✓ *It seems enough for the usual machine for 12 bit processing system.*

FII growth time evaluation in ILC TDR

- ➢ ***KEKB***
  - ✓ *TDR description : 20 turns (the performance of the gain)*
  - ✓ *Nominal operation gain : 100 turns*
- ➢ ***SuperKEKB***
  - ✓ *Nominal operation gain : 100 turns*
  - ✓ *In the SuperKEKB, 100 turns is enough to dump not only FII, but also beam-beam effect.*
  - ✓ *Champion data : 50 turns*
  - ✓ *Actual performance is much better,*
    but the performance was not yet evaluated the data sampling system.
- ➢ ***ILC TDR***
  - ➢ *The growth time of the FII is strongly*
    depends on the beam size.
  - ➢ *The FII instability was evaluated to*
    - ✓ *sigmaY = 1.5 um*
    - ✓ *6 um @ minimum at arc section*
    - ✓ *5.5um assumed for Electron Cloud Instability .*

◆ **Simulation 1**

- ✓ Vacuum : 1×10^{-7} Pa with CO
- ✓ Filling pattern was a little bit different with ILC DR
- ✓ Evaluated growth time : **26 turn**

◆ **Simulation 2**

- ✓ Vacuum : 0.5×10^{-7} Pa (based on SPEAR3)
  (48% H2, 5% CH4, 16% H2O, 14% CO, 17% CO2)
- ✓ Evaluated growth time : 56 and 84 tune
  37 turn for high luminosity

(Private discussion with Kyo Shibata)

- ✓ 0.5×10^{-7} Pa is too low
  for I=0.4A storage ring
- ✓ Vacuum composition seems different
  for NEG pump.

What we should do about fast ion instability

Re-evaluation of FII growth time by simulation

- ✓ *reflecting expected vacuum and component ratio*
- ✓ *reflecting the current damping ring design, including beam size.*

Candidate : UK national light source, Cornell University

What we should do about DR feedback

1) For the dynamic range

Based on the experience of KEKB / SuperKEKB,
we would like to conclude that there is no problem with 12bit system.

2) For the damping time

Consider the necessity for the further technical investigation based on the results of the FII simulation.
⇒ If need, evaluate the performance of the damping time for the SuperKEKB feedback with DAΦNE

1 MUSD in total ?

☐ ***The cost of the SuperKEKB FB system***

- *Monitor chamber : 30 kUSD*
- *FB kicker chamber : 40 kUSD*
- *Cable : 50 kUSD*
- *BPM circuits (2) : 60 kUSD*
- *FB digital filter (2) : 100 kUSD*
- *Amplifier (4) : 130 kUSD*

Total : 410 kUSD

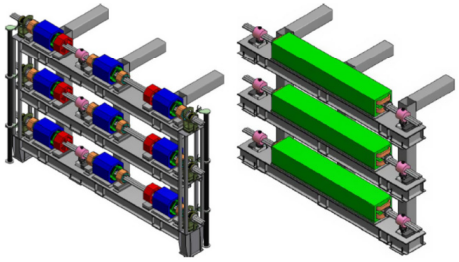
Electron Cloud Instability

Toshiyuki Okugi

Electron Cloud Instability

6.4.4.3 EC Instability

The above estimates of cloud density place an upper limit on the ring-averaged density of about $4 \times 10^{10}\mathrm{m}^{-3}$, about a factor of three below the expected single bunch instability threshold [110]. Thus operation in the baseline configuration is expected to have negligible emittance dilution from the EC. This operating margin should also minimize the possibility of any adverse impacts from sub-threshold emittance growth on the positron beam. For the high-luminosity upgrade, a second positron ring may be added if insufficient operating margin remains with a single ring.



2nd Positron DR
(only the space prepared for high luminosity upgrade)

Electron DR

Positron DR

Detail simulation, include the high luminosity upgrade.

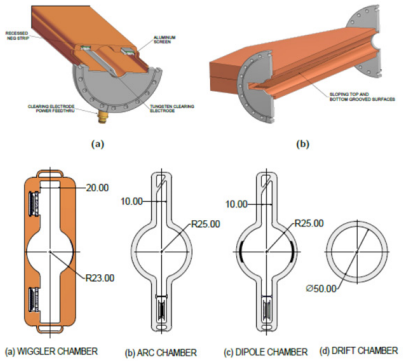
- ✓ *The simulation for nominal parameter for the present ILC DR design.*
- ✓ *The simulation for high luminosity option.*
  - ⇒ *Possibility to remove 2nd DR.*

Chamber design of ILC is same to that for SuperKEKB, except for aperture

- ✓ *Evaluated SEY is also same*
- ✓ *SuperKEKB is very good sample accelerator for ILC DR.*

Experience of electron cloud instability at SuperKEKB

- ➢ *They experience a fast ion instability at their 1st stage of commissioning at 1A beam current.*
  - ⇒ *They cured the problem*
    - ✓ *by covering the solenoid magnets to the bellows chambers.*
    - ✓ *by putting the permanent magnets to the straight pipes.*
  - ⇒ *After that, they have not had the fast ion instability.*
    (but current was 0.9A for collision experiment)
- ➢ *It seems good agreement with the evaluation and experiment.*



What we should do about electron cloud instability

Re-evaluation of electron cloud density considering the following

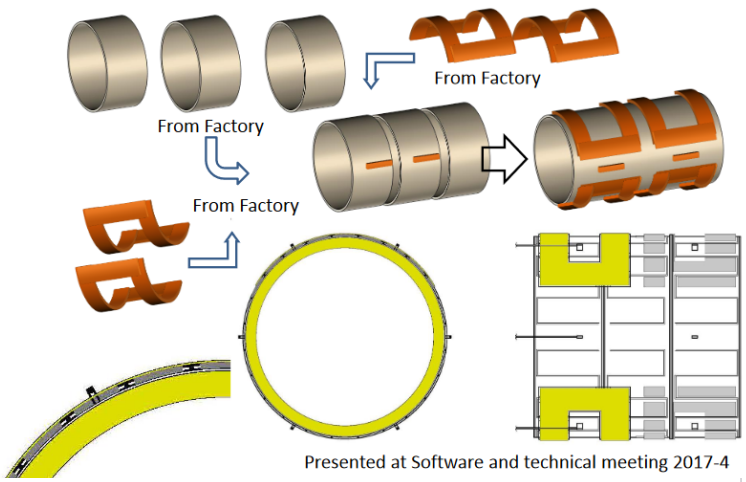
- ✓ *Simulation that reflects the design of the current damping ring*
- ✓ *Simulation of the parameters for the High Luminosity Option*

Candidate : UK national light source, Cornell University

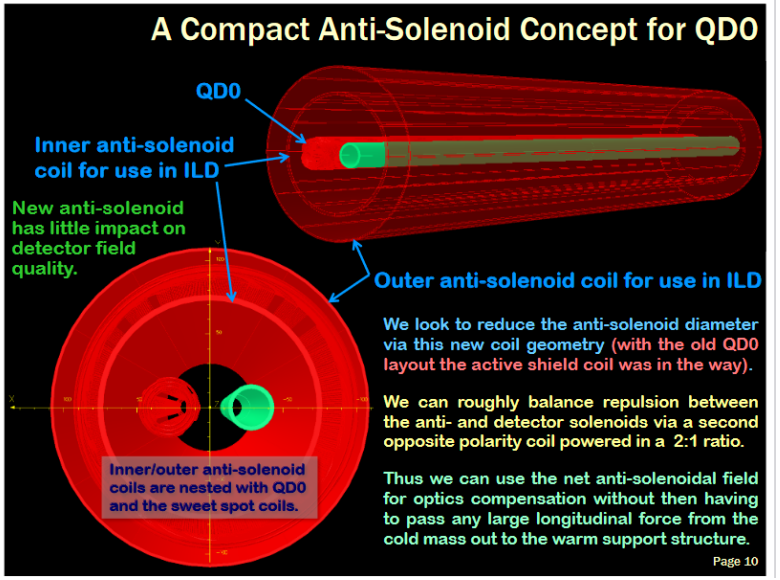
Anti-DID, Anti-solenoid

Karsten Buesser

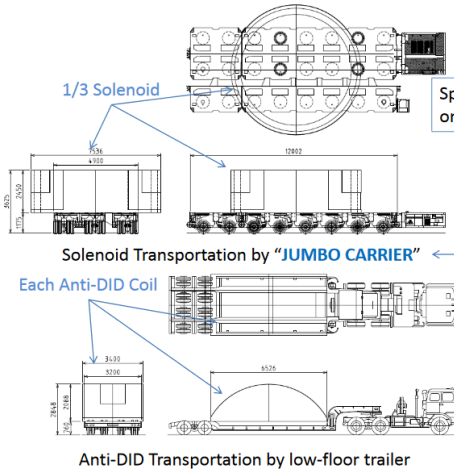
Outline of ILD magnet manufacturing process



Presented at Software and technical meeting 2017-4



Transportation Proposal by Toshiba



- From view point of transportation from factory to ILC site, solenoid and anti-DID size are considered.
- Anti-DID is smaller and simpler, which meet the field requirement.
- Anti-DID coils are wound in a factory and are set on solenoid in an assembly build on-site.

Discussion

Anti-DID

- A useful „nice-to-have" feature for the detectors
- Could be an additional tuning-knob for background suppression
- Engineering studies have been done to some extent
- In the end probably a cost-benefit issue to be decided by the detector collaborations
- R&D is required before detector TDR can be written, is in the domain of the detector concepts

Anti-Solenoid

- Compact BNL design seems feasible
- Space requirements for complete QD0 package are relevant for the detectors
  - forward region instrumentation, hermeticity

QD0 package including anti-solenoids is critical for the MDI

- A lot of R&D work remains to be done, at least on the detector side
  - engineering design of QD0 support, alignment, assembly, maintenance access
  - vibration issues
- R&D on QD0 magnet package itself seems to be an obvious task for the BDS WG
- At this time, R&D work is budget-limited

- *MDI (ILD) considers the anti-DID is a part of the detector.*
- *Anti-solenoid is an interface between a measuring instrument and an accelerator.*
  It remains the technical preparations as the QD0 package such as the vibration issues.

⇒ *We will consider it in the discussion of the technical preparation of Final Doublet as a common issue with Final Doublet.*

Meeting Schedule

Technical preparation, which is recommended by KEK ILC international WG
Technical preparation, which is necessary to write EDR

10/02	*Overall for DR/BDS*
10/13	*Beam Dump*
10/27	*FII (DR feedback), Electron cloud instability*
10/27	*Anti-DID, Anti-solenoid*
11/10	*Fast kickers / Injection kicker for e-driven positron source*
TBD	*Permanent magnet*
11/24	*Final doublet*
TBD	*Crab cavity (joint meeting with SCRF group ? ; not Tuesday)*
12/8	*Long-term stability test of IP beam size and position at ATF*
12/22	*Discussion about the summary table of DR/BDS/DUMP*

	Grade	Items	Technical Preparation	human resources [FTE]	budget [kUS$]	candiate collaoration	Presenter	Date
Damping Ring	A	Fast kicker	Long-term stability test			ATF (ATF3) collaboration		
	A	Fast Ion Instability	Feedback : system design	0.2	10	N/A	Toshiyuki Okugi	2020/10/27
	A		Feedback : damping time test	5	1000	DAΦNE	Toshiyuki Okugi	2020/10/27
	B		Evaluation by simulation	1	20	Diamond, Cornell	Toshiyuki Okugi	2020/10/27
	B	Electron Cloud	Evaluation by simulation	1	10	Diamond, Cornell	Toshiyuki Okugi	2020/10/27
	B (?)	Parmanent Magnet	System design					
	B (?)	Injection kicker for e-driven P-source	System design					
		RF system	Prototype test	N/A	N/A	N/A	N/A	
		Wiggler Magnet	Prototype test	N/A	N/A	N/A	N/A	
BDS, MDI	A	ATF3	Long-term stability test			ATF (ATF3) collaboration	Angeles Faus-Golfe	
	B	Final doublet (incl. Anti-solenoid)	System design (include the anti-solenoid)				Brett Parker	
	B		Vibration test				Brett Parker	
	B (?)	Crab cavity	System design				Yasuchika Yamamoto	
		Anti-solenoid	System design and vibration test	considered within FD package			Karsten Buesser	2020/10/27
		Anti-DID	System design	considered as detector matter			Karsten Buesser	2020/10/27
Beam Dump	A	17MW main dump	System design of water flow system				Nobuhiro Terunuma	2020/10/13
	A		System design of window sealing and remote exchange				Nobuhiro Terunuma	2020/10/13
	A		System design of countermeasure for failure				Nobuhiro Terunuma	2020/10/13
	A/B (?)		Robustness test of window				Nobuhiro Terunuma	2020/10/13
	B	300kW photon dump	System design				Nobuhiro Terunuma	2020/10/13

Rank	A	Technical preparation, which is recommended by KEK ILC international WG
	B	Technical preparation, which is necessary to write EDR