ILC/CLIC Common Issues for Damping Rings

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CLIC08

CERN 16 October 08

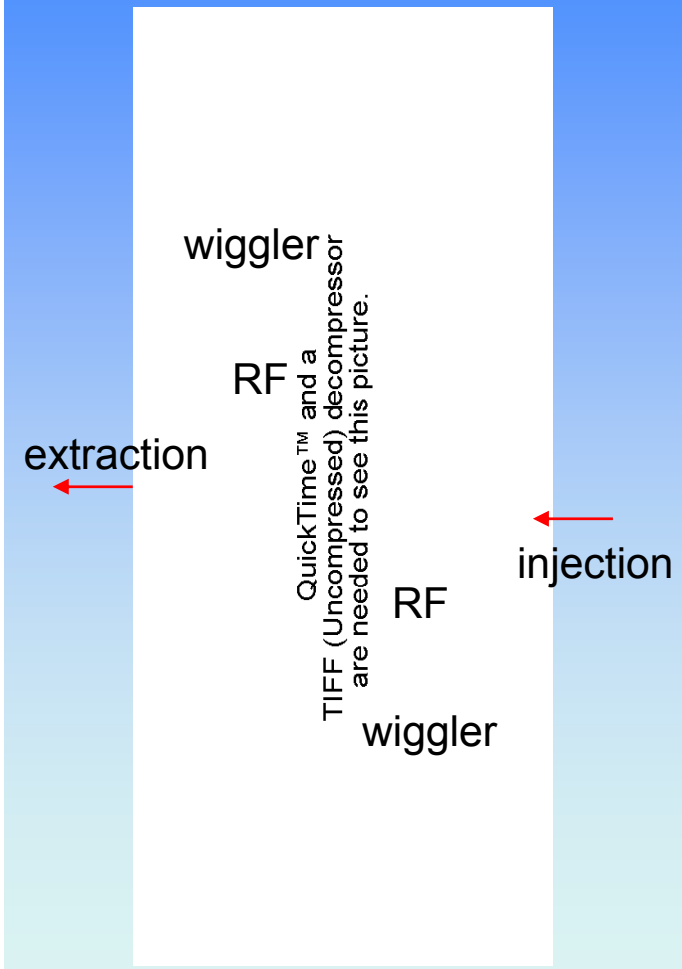
ILC Damping Ring Layout

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Two 6.4 km, 5 GeV damping rings are located in a shared tunnel around the interaction region

ILC Reference Design Report (RDR) presented at the Beijing GDE Meeting, IHEP, 4-7 February 2007
(http://www.linearcollider.org/cms/)

DCO Lattice



Arcs consist of a total of 192 FODO cells

Flexibility in tuning momentum compaction factor, given by phase advance per arc cell:

72º --> α_p=2.8 10^{-4}

90º --> α_p=1.7 10^{-4}

100º --> α_p=1.3 10^{-4}

Two straights containing:

injection and extraction

phase trombones

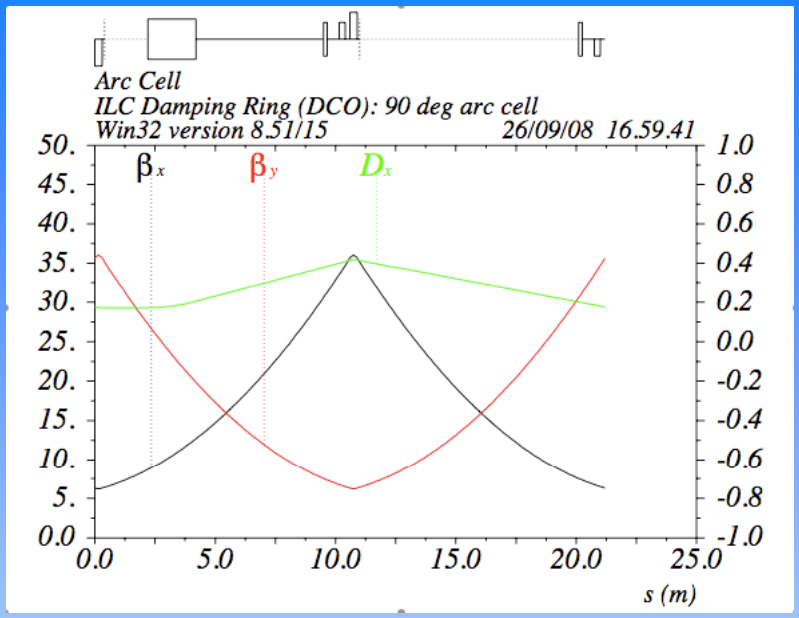
circumference chicanes

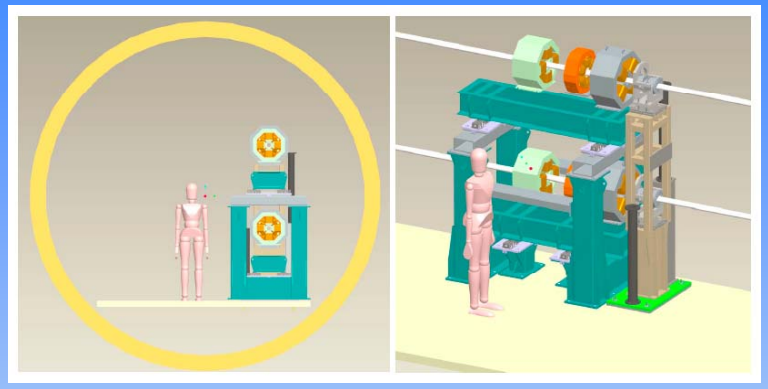
RF cavities

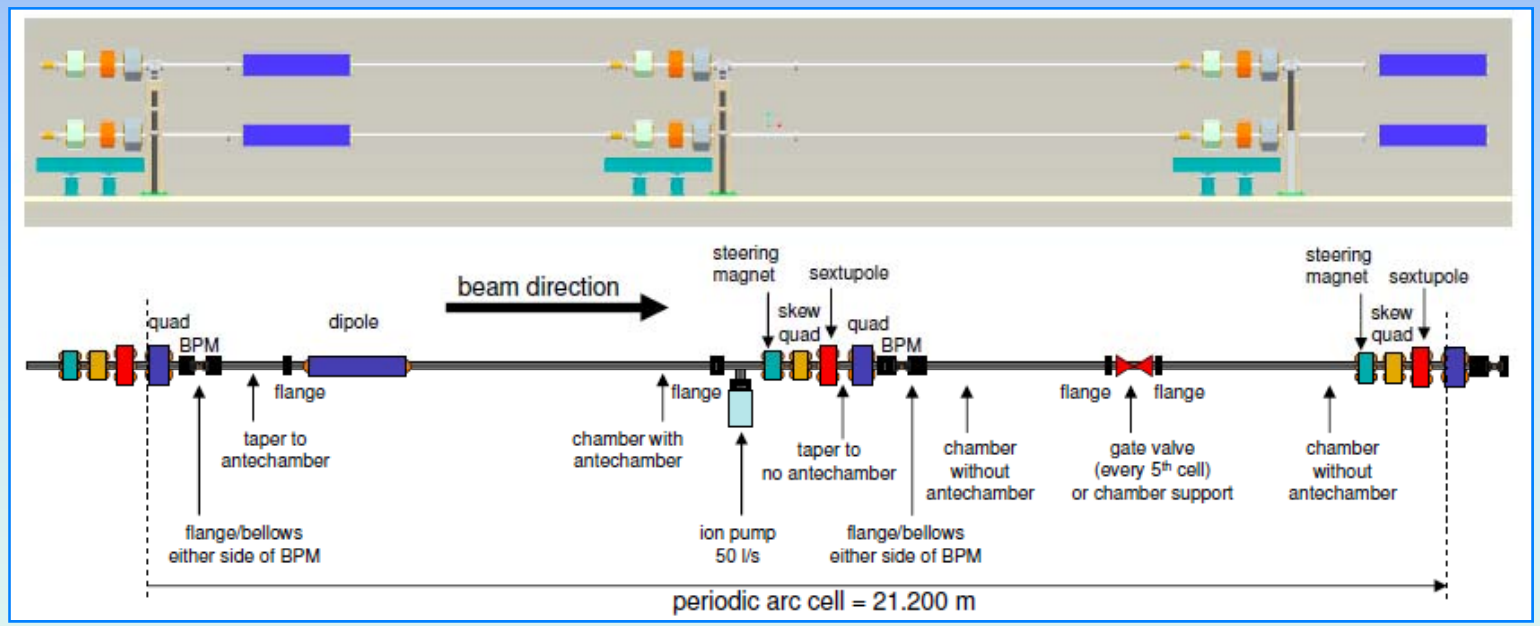
"doglegs" to separate wiggler from RF

wiggler

Cell Layout


Arc Cell
ILC Damping Ring (DCO): 90 deg arc cell
Win32 version 8.51/15
26/09/08 16.59.41
βx
βy
Dx
50.
45.
40.
35.
30.
25.
20.
15.
10.
5.
0.0
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.0
5.0
10.0
15.0
20.0
25.0
s (m)



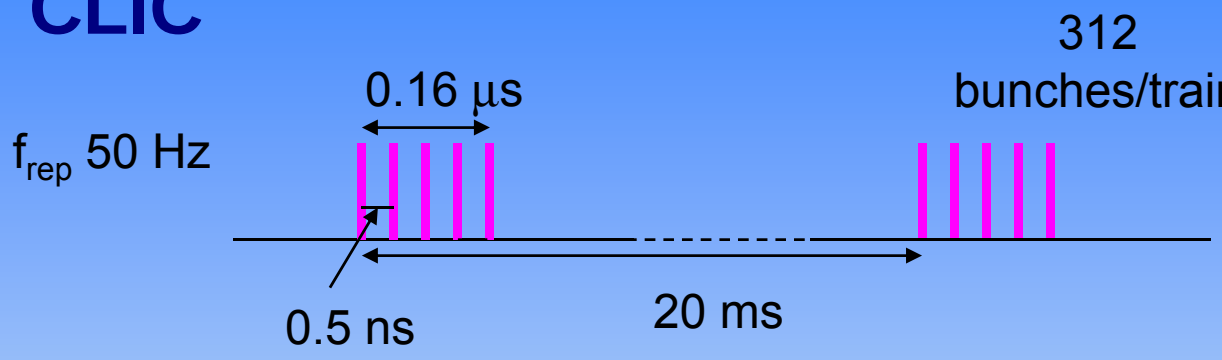

beam direction
steering magnet
sextupole
skew quad
quad
BPM
dipole
flange
taper to antechamber
flange/bellows either side of BPM
chamber with antechamber
ion pump 50 l/s
taper to no antechamber
chamber without antechamber
gate valve (every 5th cell) or chamber support
periodic arc cell = 21.200 m

ILC/CLIC DR Parameters

	ILC	CLIC
Energy (GeV)	5	2.4
Circumference (m)	6476	365
Bunch number	2700 - 5400	312
N particles/bunch	2×10^{-10}	3.7×10^{-9}
Damping time τ_x (ms)	21	1.5
Emittance $\gamma\varepsilon_x$ (nm)	4200	381
Emittance $\gamma\varepsilon_x$ (nm)	20	4.1
Momentum compaction	$(1.3 - 2.8)\times10^{-4}$	0.80^{-4}
Energy loss/turn (MeV)	8.7	3.9
Energy spread	1.3×10^{-3}	1.4×10^{-3}
Bunch length (mm)	9.0 - 6.0	1.53
RF Voltage (MV)	17 - 32	4.1
RF frequency (MHz)	650	2000

DR Time structure

CLIC



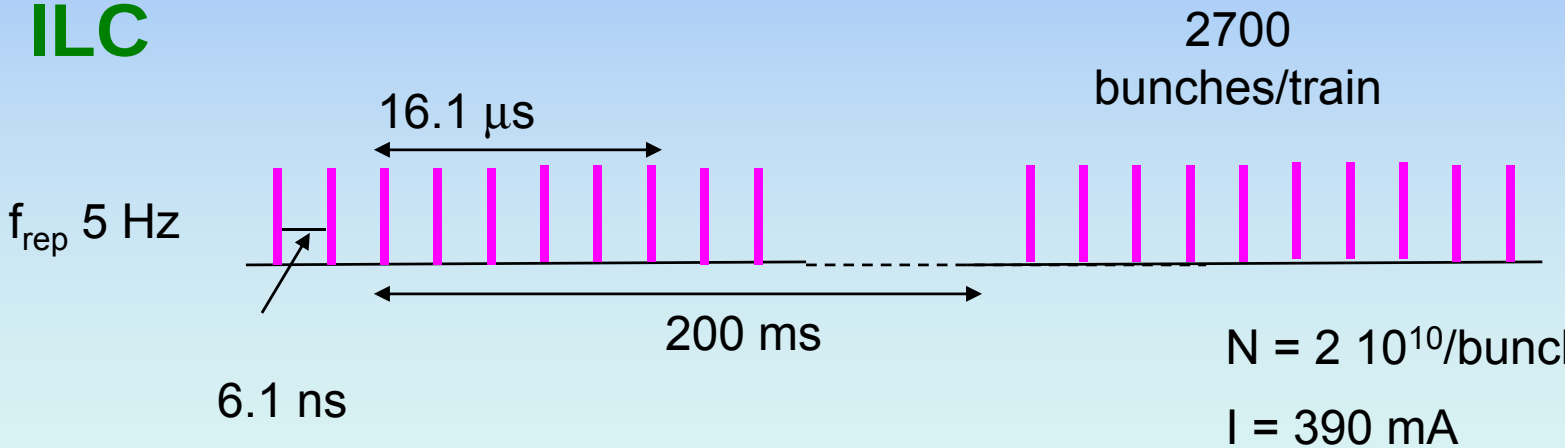
N = 4.1 10^9 /bunch

I = 170 mA

I_{ave} = 1.3 A over the train

I_{peak}= 20 A

ILC



N = 2 10^{10}/bunch

I = 390 mA

I_{ave} = 0.52 A over the train

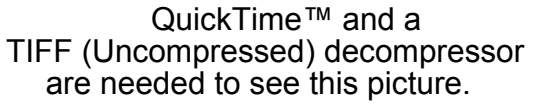
I_{peak}= 25 A

Common issues

- Ultra low emittance
- e-cloud
- Fast ion
- IBS
- Wiggler dominated ring

ILC/CLIC Common Issues at Test Facilities

- CesrTA: Electron cloud; ultra-low emittance. Validate modelling codes for e-cloud and demonstrate mitigation techniques in a low emittance regime relevant for the ILC damping rings.
- ATF
- Demonstrate reliable operation with vertical emittance $\varepsilon_y < 4$ pm (if possible 1pm)
- Fast ion instability study
- DAFNE
- Characterisation of e-cloud build-up and instability thresholds


QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.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are needed to see this picture.

Low emittance studies at ATF

- KEK-ATF achieved 4pm vertical emittance
- At present emittance is higher, studies and cures are being pursued with the objective of 4 pm and below: 2pm --> 1pm
  - Magnet re-alignment
  - New BPM electronics: Better resolution and stability.
  - Reduce BPM offset error.
  - Reduce optics error
  - Repeat BBA corrections: Orbit, Vertical dispersion and coupling

Low emittance studies at CESR-TA

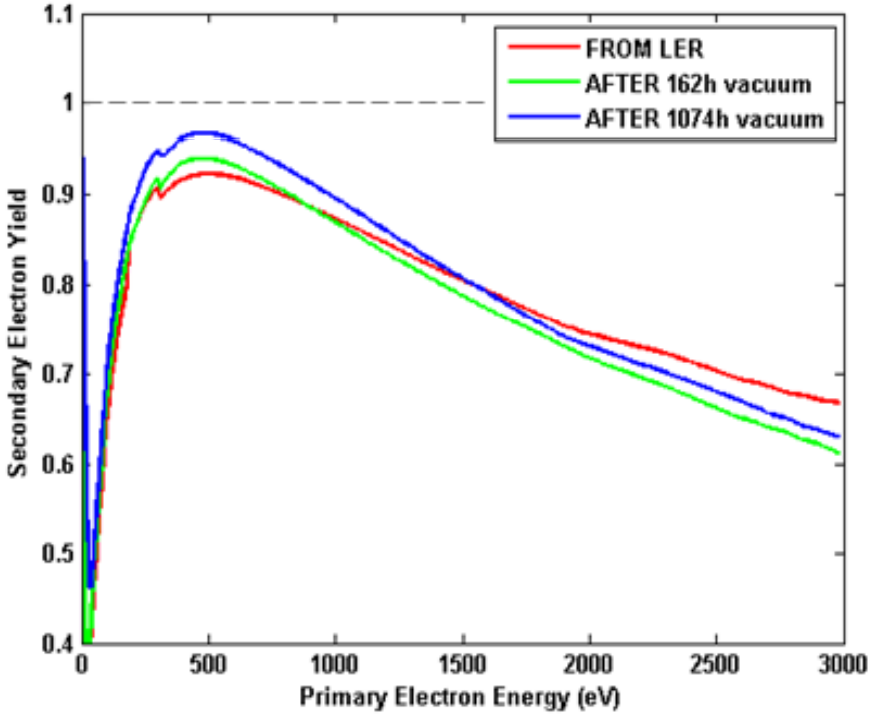
- The low emittance can be achieved at low energy (~2.5 Gev) with 12 wigglers (B_{peak} = 1.9 T), 90% of the energy radiated in the wigglers
- The minimum emittance, at the DR nominal bunch current, largely depends on IBS
- Low emittance tuning algorithms can be developed and tested
- X-ray beam size monitor
  - 32 element linear photomultiplier array enables multi-turn bunch by bunch vertical beam size measurements with 2-3 μm resolution
  - Allows for real time low emittance tuning using dispersion and coupling bumps

e-cloud

- The highest priority for the ILC DR is development and test of e-cloud mitigation techniques
- At SLAC measurements have been done on chicanes and test chambers installed in the PEP-II ring. This program will continue in the CESR-TA collaboration.
- Tests on clearing electrodes are in progress at KEKB.
- At CESR-TA the ring is being modified to perform e-cloud studies in the low emittance regime

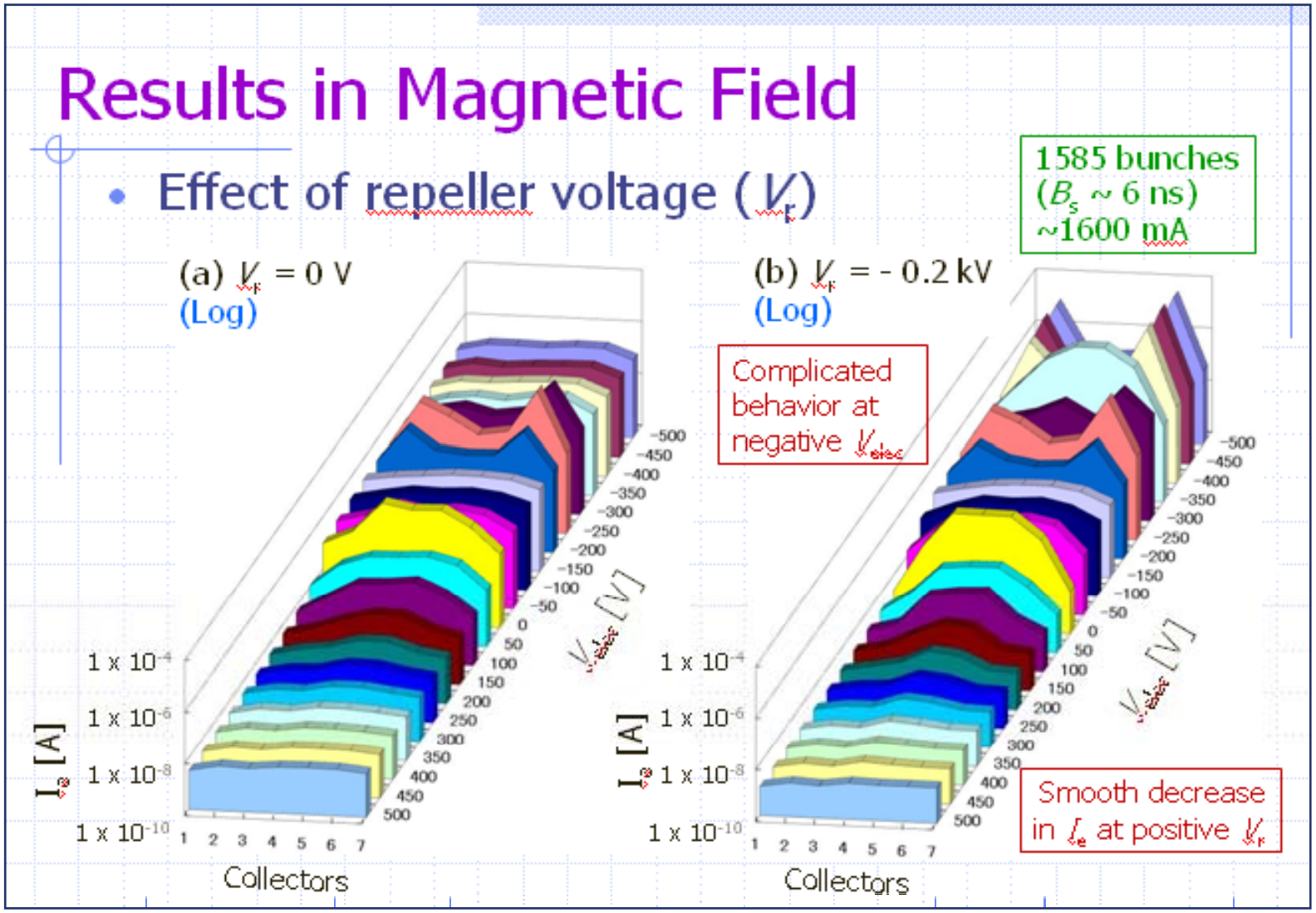
Conditioning surfaces in PEP-II: M. Pivi, SLAC

Secondary Electron Yield (SEY) recontamination after long term exposure in vacuum environment



Effect of recontamination in vacuum: SEY < 1 (!) for TiN sample in stand-by in vacuum after the conditioning period in PEP-II LER. In vacuum pressure typical of an accelerator environment: 1.0e-9 torr, 10:1 H2:CO.

Clearing Electrodes in KEKB: Y. Suetsugu, KEK

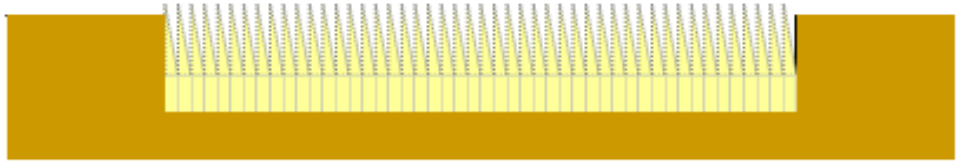


Mitigation tests in CesrTA: M. Palmer, Cornell

Cornell University
Laboratory for Elementary-Particle Physics

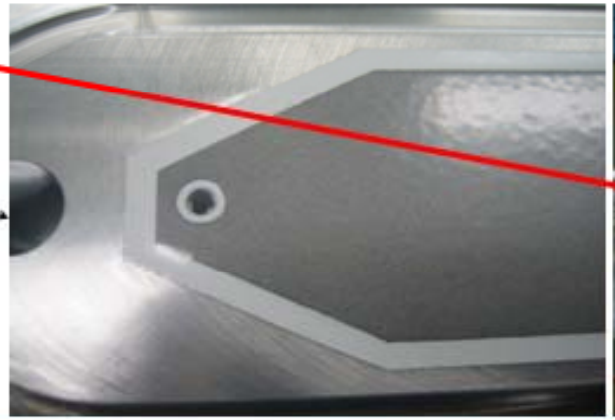
Mitigation Techniques

- Wiggler extrusion split into top/bottom halves ⇨ provides exposed vacuum chamber surface for modifications
  - Possibility of adding grooved surface
  - Tungsten Electrode (hot spray) on alumina – see talk by Suetsugu



Propose to pursue this option next

For feed-through Looking at options for low impact feedthroughs



Suetsugu, et al. ILCDR07_KEK

July 10 2008 *ILCDR08 - Cornell University* *8*

Recommendation for mitigation as input for DR design: Discussion All

DR element	% ring	Antechamber	Coating	Additional Mitigation	Remarks
DRIFT in STRAIGHT	33	No	NEG	Solenoid	Groove if necessary
DRIFT in ARC	56	Downstream of BEND only	NEG	Solenoid	Groove if necessary
BEND	7	Yes	TiN	Grooves and Electrodes	
WIGG	3	Yes	TiN	Electrodes and Grooves	
QUAD	1	Downstream BEND / WIGG	TiN	Grooves and Electrodes	

Preliminary table to be completed as input for Technical Design Phase. Goal is to turn all Red colors to Green in the next two years.

Other mitigations under development! (ex: Carbon coating CERN)

Recent Fast Ion Work at ATF

Studies will continue with ongoing improvements: lower emittance, controlled pressure bump, etc.

Experimental Results measured by laser wire in DR

Table 2: vacuum pressure in 2004

ion pump status	11mA	26mA	31mA
normal	4.0×10^{-6} Pa	6.0×10^{-6} Pa	6.5×10^{-6} Pa

2007

20pm

10pm

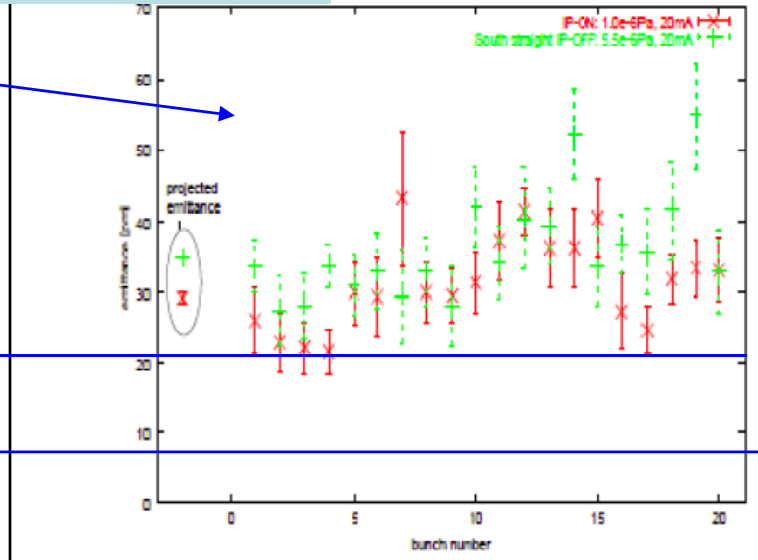


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

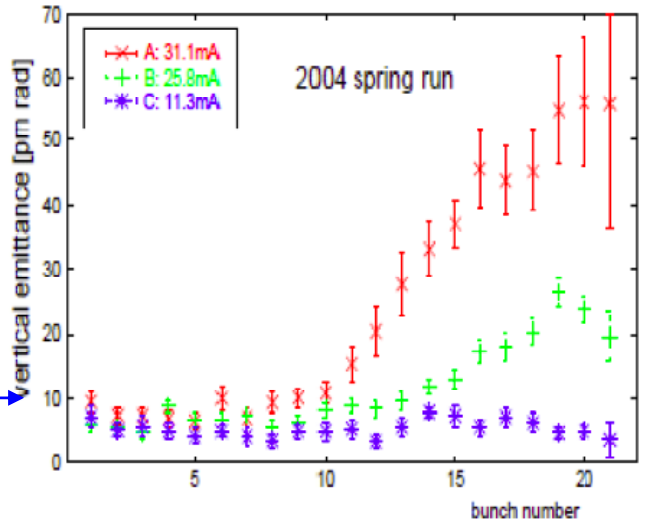


Figure 10: data taken in 2004

Wigglers

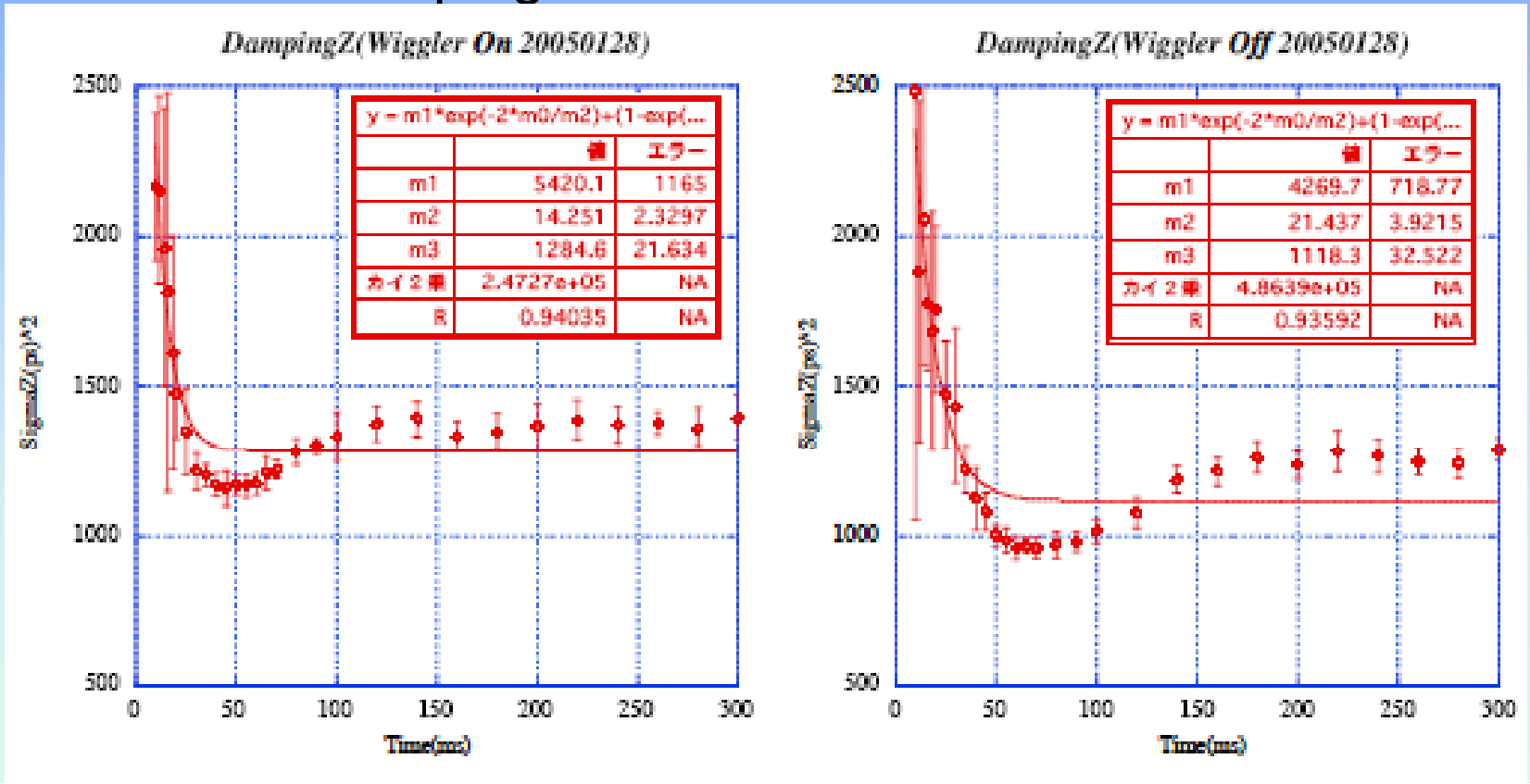
- Extensively used to reduce damping time and emittance and to mitigate IBS effect
- CESR-c type superconducting wiggler: good aperture, very good field quality and proven performance.
  - Number of wigglers 88
  - Peak field 1.6 T
  - Period 0.40 m
  - Unit length 2.45 m
  - Vertical aperture 5 cm
  - Pole width 20 cm

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

ATF with wigglers

Four wigglers (L=2m, λ=0.4 m, B=1.4 T)
The IBS growth effects after damping are observed at the horizontal beam size, the bunch length and the energy spread.

Reduction of damping time and of IBS effect observed with



Damping Ring Monthly Meetings

- ILC Damping Rings Teleconference 3rd Wednesday of each month:
  - Wednesday 22 October
  - Wednesday 19 November (ILC workshop at FNAL)

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/TeleConference#ILC_Damping_Rings_Teleconference

- CesrTA Collaboration Meetings 2nd Tuesday:
  - October 14, 2008 - 5pm US Eastern
    https://wiki.lepp.cornell.edu/ilc/bin/view/Public/CesrTA/#Meeting_Pages

- CLIC Damping Rings Meetings - coming soon

Conclusions

- There is already an intense interaction between ILC/CLIC in the community working on the crucial issues: ultra low emittance and e-cloud mitigation.
- It is very important to strengthen the collaboration and include also other beam dynamics and technical aspects.