Damping Ring

S. Guiducci

AAP Review

Tsukuba 20 April 2009

Talk overview

- Critical R&D
  - **E-cloud**
  - **low-emittance**
  - **Fast kickers**
- Design & integration
- Minimum Machine (3km ring studies)

Program Outline

		Minimum Machine	Technical Design, and Costing	Critical R&D
TDP Phase I	2008	Specify tasks.	Specify scope.	Continue critical R&D for cost reduction and risk mitigation: •electron cloud; •fast kickers; •low-emittance tuning.
	2009	Perform studies.	Perform technical design and costing work in support of revising the baseline configuration.	
	Start 2010	Revise baseline configuration.		
TDP Phase II	2010 – 2012		Complete work for TDR (end 2012).	Complete critical R&D.

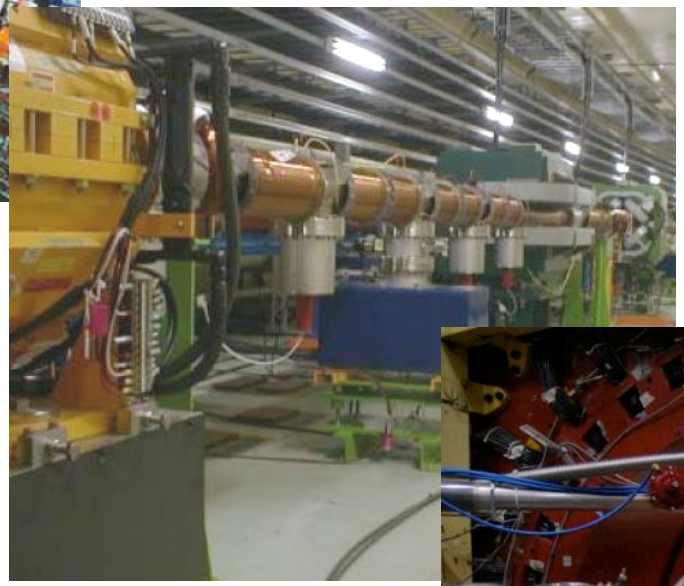
Critical R&D: Electron Cloud

DAΦNE

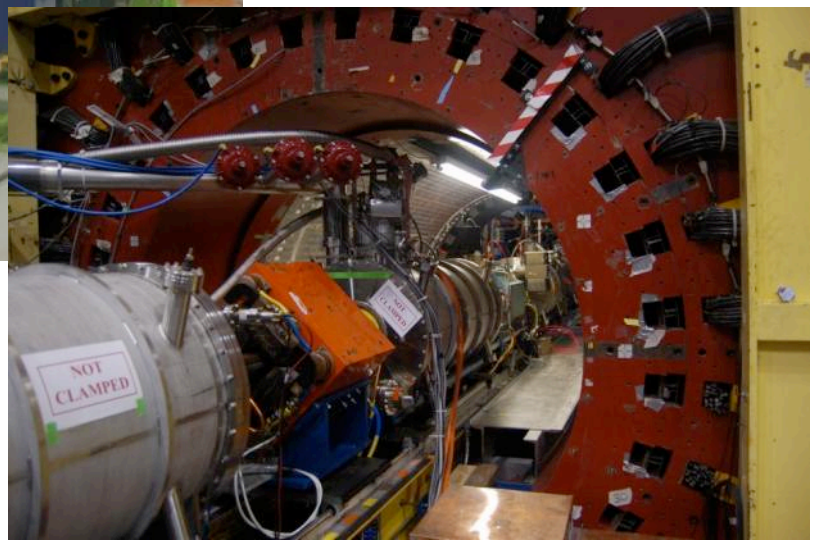
CesrTA Test Facility/ Electron Cloud

M. Palmer - Saturday 18 April, 14:00

KEKB



CesrTA



E-Cloud Collaboration:

- ANL
- Cornell
- FNAL
- INFN/LNF
- KEK
- LBNL
- SLAC

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)

E-cloud

- Effective mitigation techniques are available:
  - **Some have been demonstrated**
  - **Some will be tested in the next months**
- They allow us to be optimistic that it should be possible to achieve the DR design performance with a single positron ring
- Simulation codes are being developed and benchmarked with beam measurements
- It is important to gain more and more confidence in these codes in order to have a correct evaluation of the e-cloud impact on the positron DR
- What needs to be evaluated is which mitigation techniques are needed to guarantee a safe performance and which is their impact on the vacuum chamber design, including reliability, impedance budget and cost.

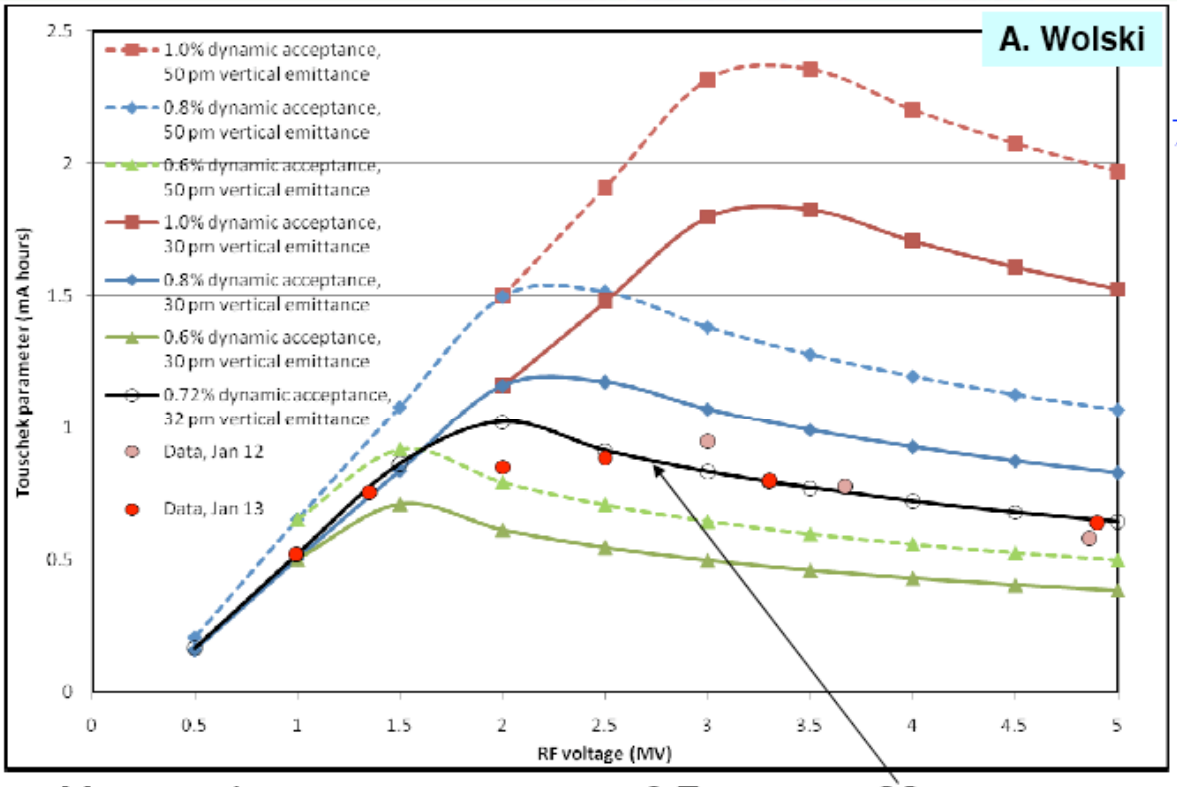
Low-Emittance Tuning

- ILC damping rings are specified to operate with 2 pm vertical emittance.
- Swiss Light Source has recently achieved 3 pm.
- **Diamond has achieved 2 pm!**
- Low-emittance tuning program includes work at:
  - **ATF: motivated by ATF2, studies of fast ion instability, and demonstration for ILC damping rings;**
  - **CesrTA: motivated by studies of electron cloud in ultra-low emittance regime;**
  - **Cockcroft Institute: in support of ATF and CesrTA programs, and ILC damping rings design.**
- Issues include: alignment and stabilisation specifications; diagnostics and instrumentation functionality and performance; design of coupling correction system; development of effective tuning techniques...

CesrTA - LET

Cornell University
Laboratory for Elementary-Particle Physics

First Detailed Optics Correction ⇨ Touschek Study ⇨ xBSM Measurement (Preliminary)



$$\frac{1}{\tau} = \frac{1}{d} + \frac{i_{bunch}}{b}$$

Touschek Parameter

LET tuning in CesrTA

D. Rubin

Saturday 18 April, 14:00

Measured energy acceptance ~ 0.7% → ε_v ~ 32pm
From xBSM σ_v ~ 15±5 μm → ε_v ~ 38pm
Appear to be within a factor of ~2 of the 20pm target

LET - ATF

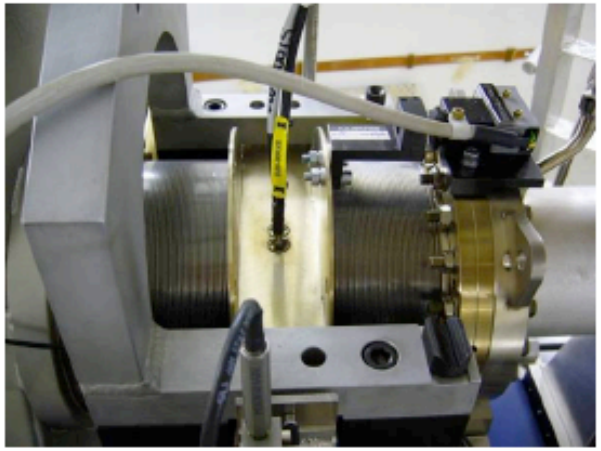
- 2 pm is a TDP R&D plan deliverable for ATF
- 4 pm has been achieved in 2004
- LET was based on Orbit Response Matrix analysis correcting iteratively orbit dispersion and coupling
- In 2007, after the same tuning procedure, 20-30 pm were measured?
  - **During 2008 DR magnets were realigned**
  - **A BPM upgrade program is in progress**
- This week:
  - **ε_y ~ 10 pm measured by X-SR**
  - **ε_y ~ 5 pm measured by Laser Wire**
- The resolution of the measurement systems needs further check/improvement but progress is in the good direction

Comparison of ILC DR with achieved beam emittances

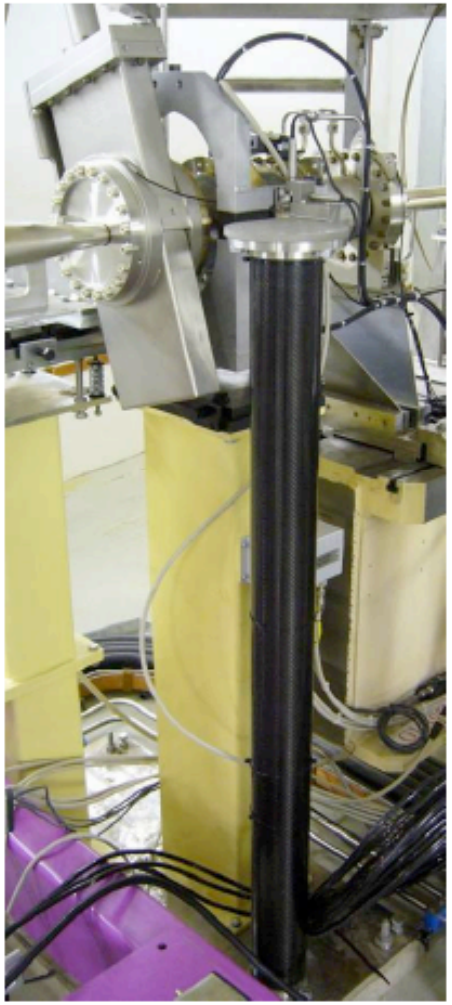
	E (GeV)	C (m)	ε_x (nm)	ε_y (pm)	κ (%)	$\gamma\varepsilon_x$ (μm)	$\gamma\varepsilon_y$ (nm)
Spring-8	8	1430	6	5	0.08	94	78
ILC-DR	5	6400	1	2	0.2	10	20
Diamond	3	561	2.7	2	0.07	16	12
SLS	2.4	288	6	3.2	0.05	28	15
ATF	1.28	138	1	4	0.4	3	10

- 2 pm achieved in Diamond (EPAC08)
- All ATF, SLS and Diamond have achieved a normalized emittance below the DR goal

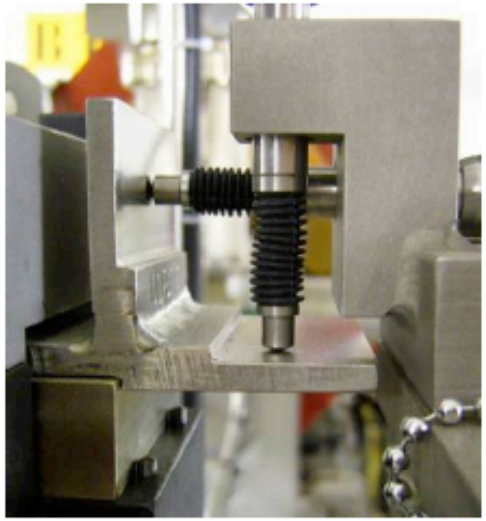
Design work: building on experience



BPM and bellows chamber



Reference pillar supporting linear encoders



Linear encoders to monitor BPM position with respect to reference pillar

Courtesy,
DIAMOND Light Source

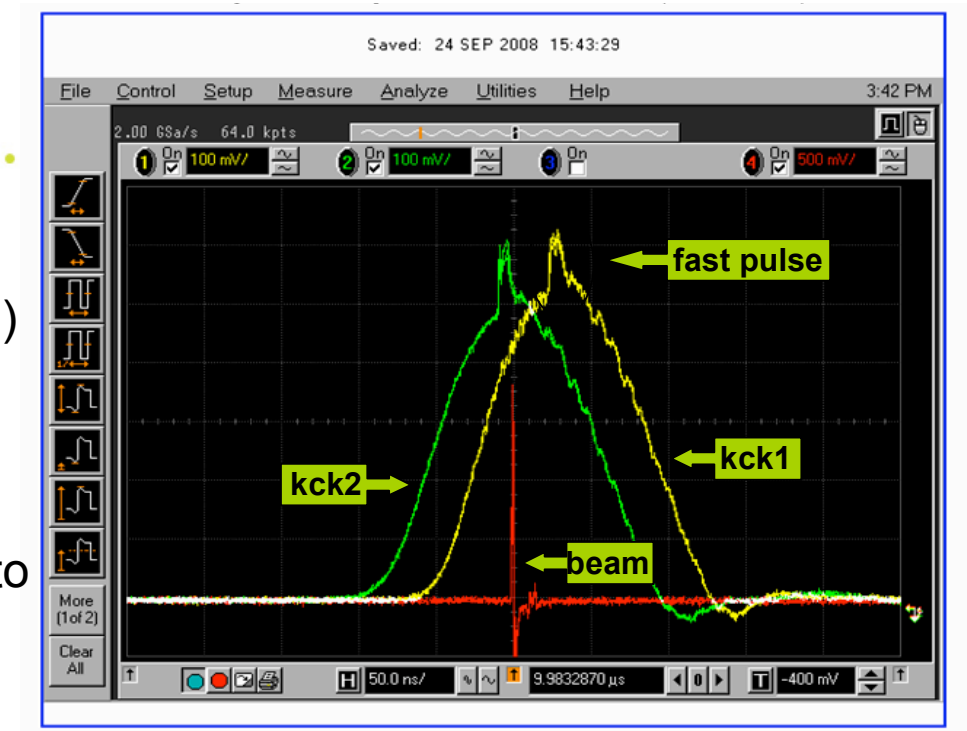
Fast Kicker R&D

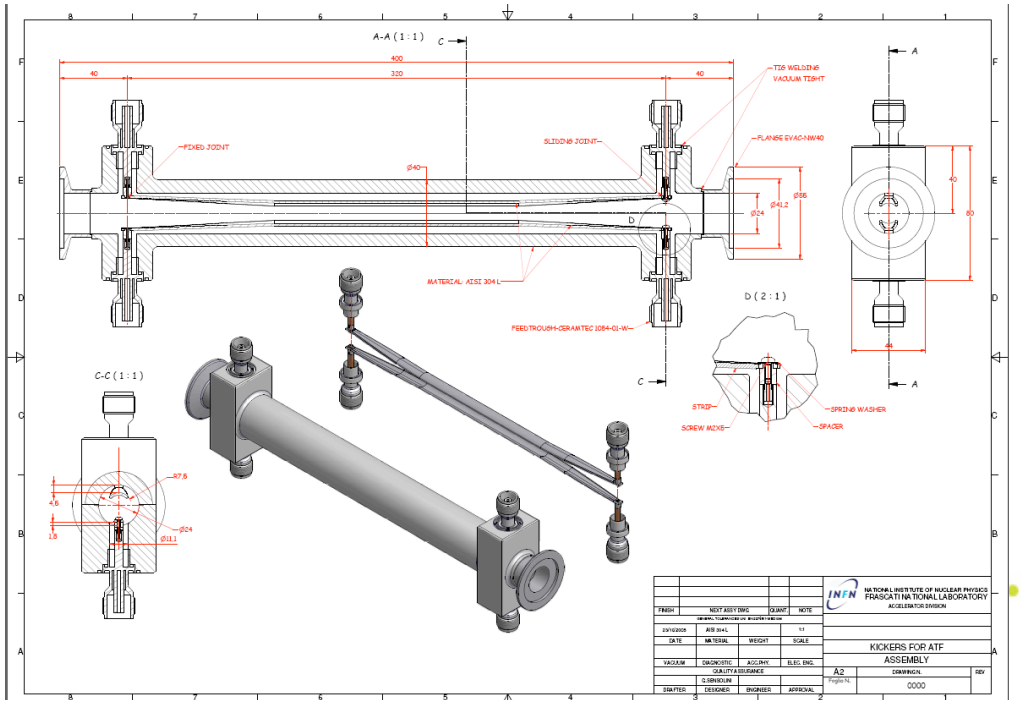
- The goal is to develop and demonstrate a high-reliability fast kicker that meets the ILC specifications for damping ring injection and extraction.

Pulse amplitude	10 kV
Bunch spacing	3 ns
Pulse repetition rate	6.6 MHz
Pulse stability	~ 0.1%

- R&D program includes activities at SLAC, INFN/LNF and KEK.

- 24kV FIDs have been tested in the electron ring kickers (“hybrid” configuration)
- They worked well for ~ one month, then one FID failed followed by the other one after one more week of test in the lab
- Interactions with the firm are in progress to improve reliability



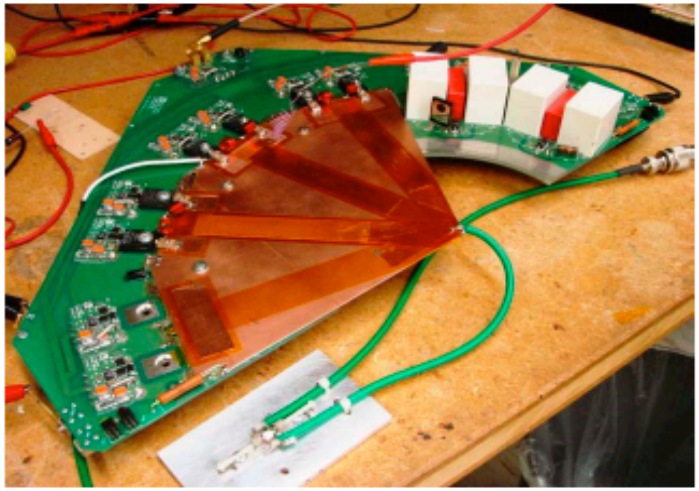


- Short kicker for tests at ATF
- Fabrication in progress
- Ready by the end of April

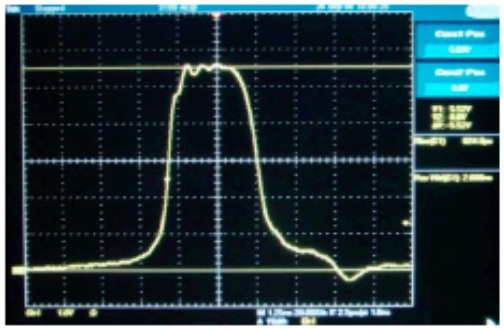
Fast Injection/Extraction Kickers: SLAC

DSRD 2-ns Prototype Tests

4 ns kicker modulator for ATF DR ready by end of 2009 to deliver at KEK in 2010

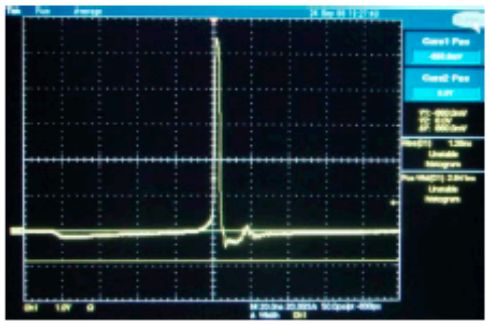


Amplitude	kV	4.4
Impedance of Feeder	Ohm	50
Rise Time	nsec	<1
Pulse Width	nsec	2.9



Waveform detail:

1.25 ns/div

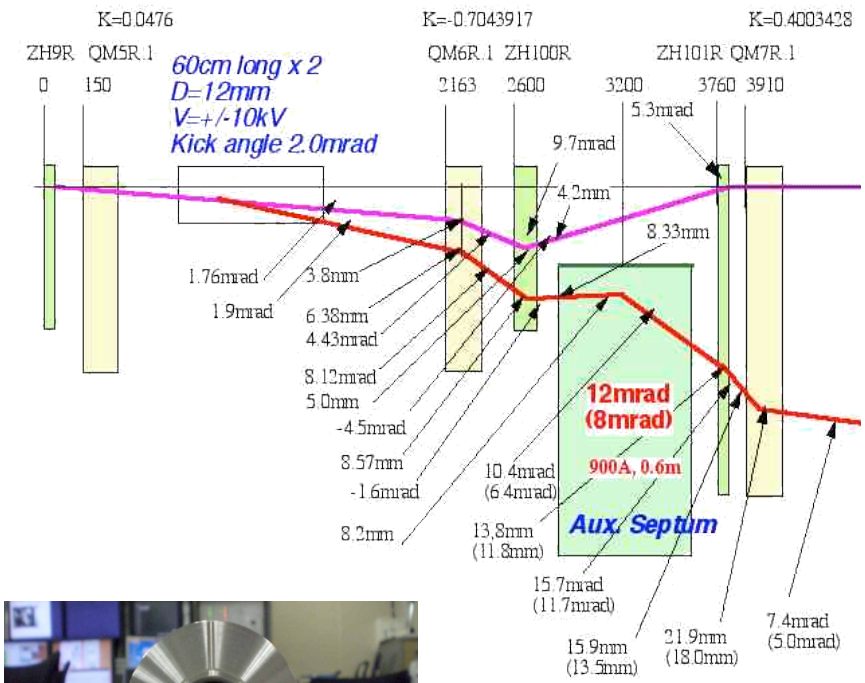


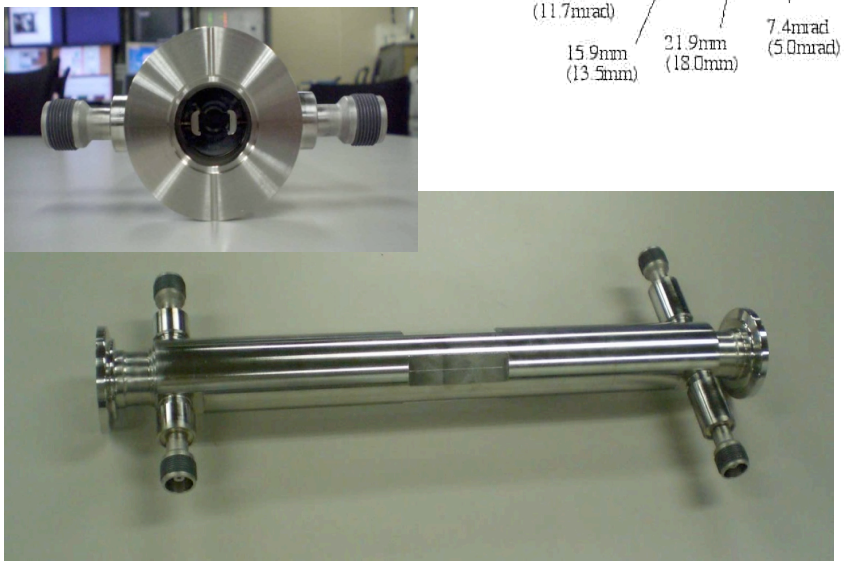
Pre/post pulse:

20 ns/div

It's crucial that FID is not the only provider!

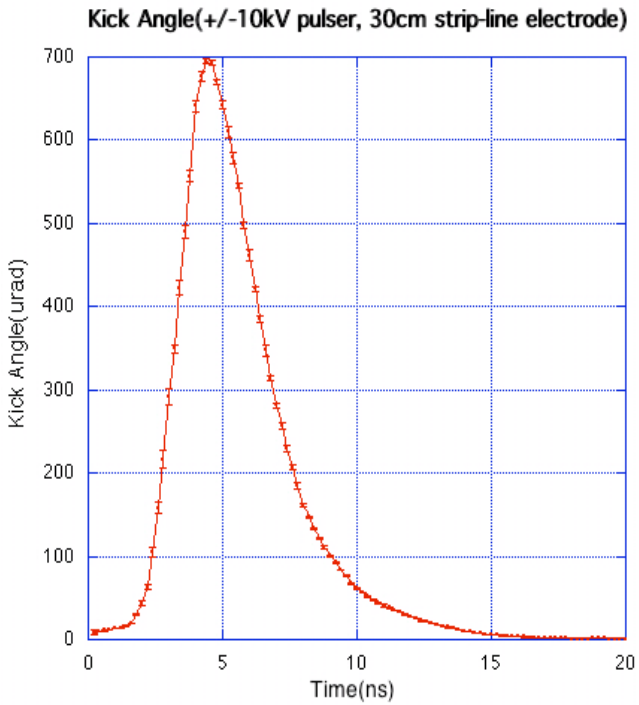
Fast kicker development





The beam extraction design from DR to the extraction line and the preliminary beam test in DR was carried out. To solve the geometrical restriction, the design includes a pulse bump system and a auxiliary septum magnet.

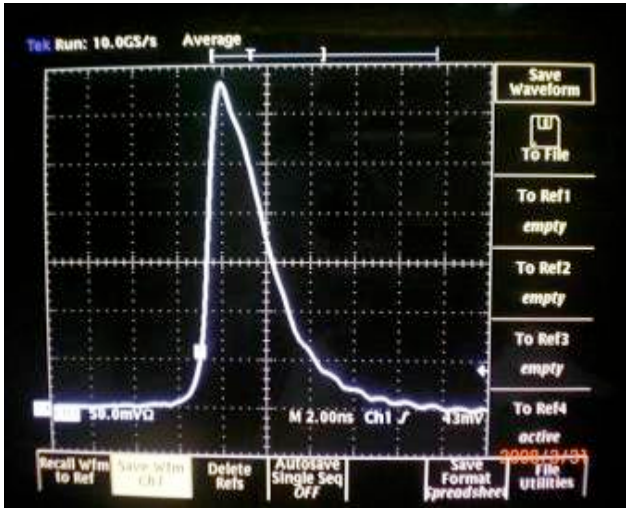
The beam kick test in DR measured 0.7mrad of the kick angle by using +/-10kV pulse generator, which is enough to get 2mrad by using 2 unit of the pulse generator and 60cm long strip-line.



Beam kick profile

Fast Kicker R&D at ATF

Pulser: FID FPG 10-6000KN

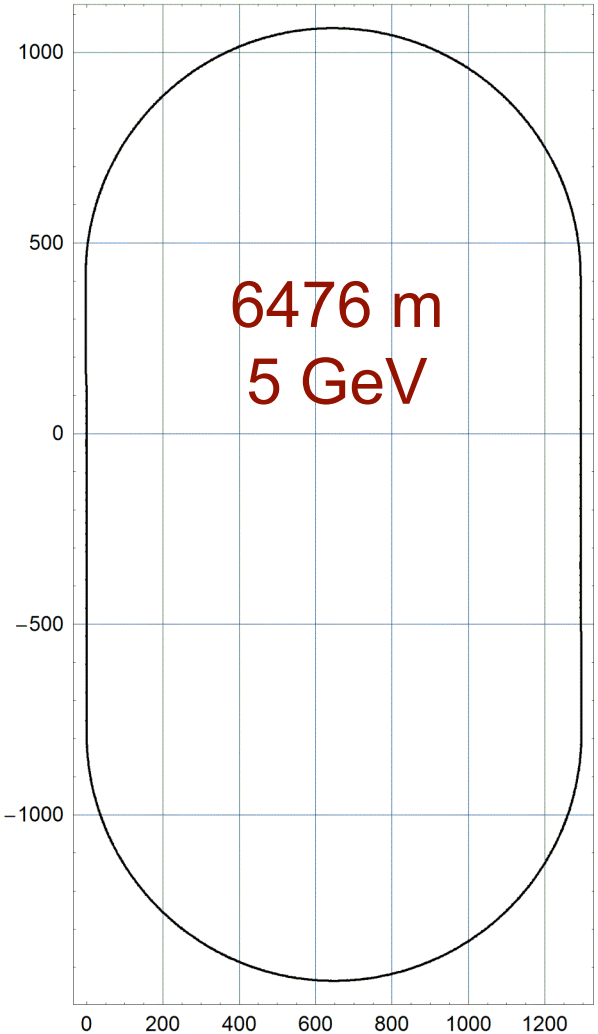


Maximum output voltage	10 kV
Rise time, 10 – 90%	< 1 ns
Rise time, 5 – 95%	< 1.2 ns
Pulse duration at 90% peak amplitude	0.2 – 0.3 ns
Pulse duration at 50% peak amplitude	1.5 – 2.0 ns
Output pulse amplitude stability	< 0.7%
Maximum pulse repetition frequency	6.5 MHz
Number of pulses per burst	110 (max)
Burst repetition frequency	5 Hz

Satisfies requirements for 3 ns bunch distance in DR

Beam extraction test:January 2009, this failed due to broken pulsers by high level radiation near extraction area.
After we will repair the pulsers and install them behind concrete shield block, beam extraction test will be done again in this year (May).
We are preparing good cables, and then we will measure the effect of the cables in this April.

Design & integration



Present baseline: DCO lattice

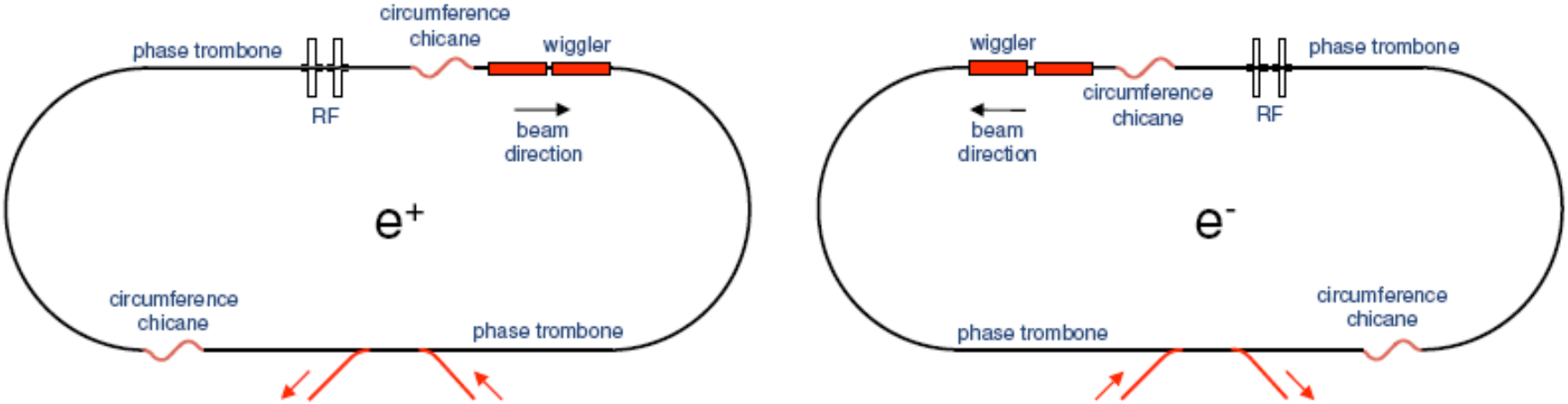
- Arcs consist of a total of 192 FODO cells
- Flexibility in tuning momentum compaction factor, between 1.3×10^{-4} and 2.8×10^{-4}
- Racetrack structure has two similar straights containing:
  - **injection and extraction in opposite straights**
  - **phase trombones**
  - **circumference chicanes**
  - **rf cavities**
  - **"doglegs" to separate wiggler from rf and other systems**
  - **wiggler**

RDR is based on the OCS lattice, a new baseline was chosen at the Sendai meeting (March 08):

• A lower momentum compaction allows shorter bunch length for the same RF voltage

• Clustering of major components near the two proposed access shafts to reduce cost

Lattice Design at CI



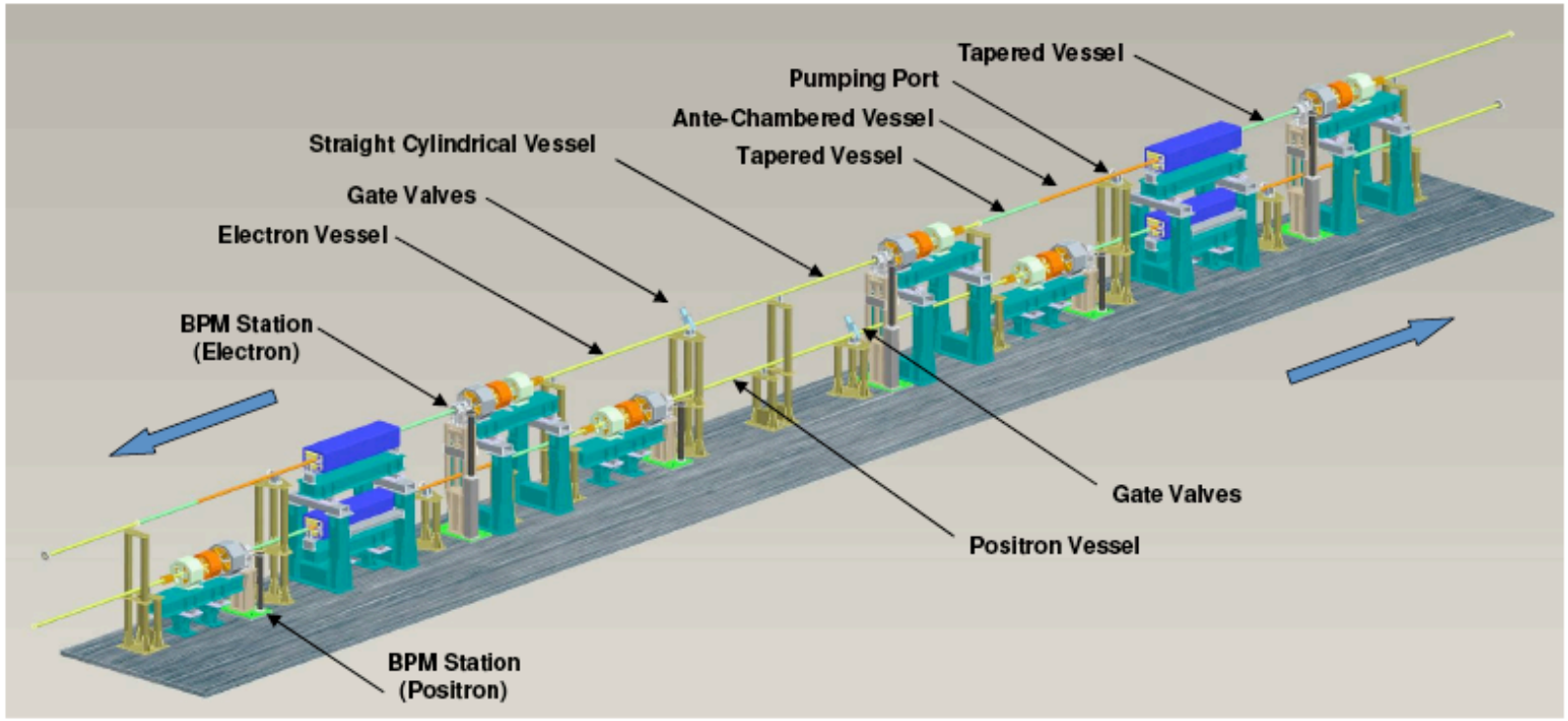
Modifications have been made to the straight sections according to the requirements for the central injector integration scheme proposed for the "Minimum Machine":

Injection and extraction are now in a single straight in each ring

Beams circulate in opposite directions in the two rings

Vacuum Design and cost estimate at CI

Goal: to design and cost vacuum system and vacuum/bpm/magnet supports.



Design and costing for the arc cells will be complete by end of April.

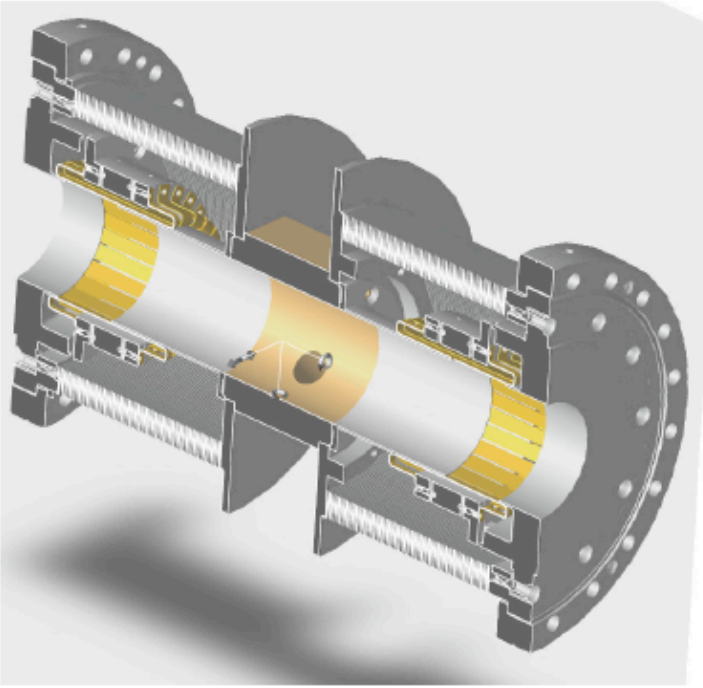
Work will then begin on the straight sections.

Vacuum Design and Impedance modeling at CI

Design work includes components expected to make dominant contributions to the machine impedance, e.g. bpms and bellows.

Studies in 2008 raised concerns about the impedance from the bellows.

A new bellows design with improved rf shielding, based on a design from INFN-LNF, has been implemented in the model, and is now being studied.

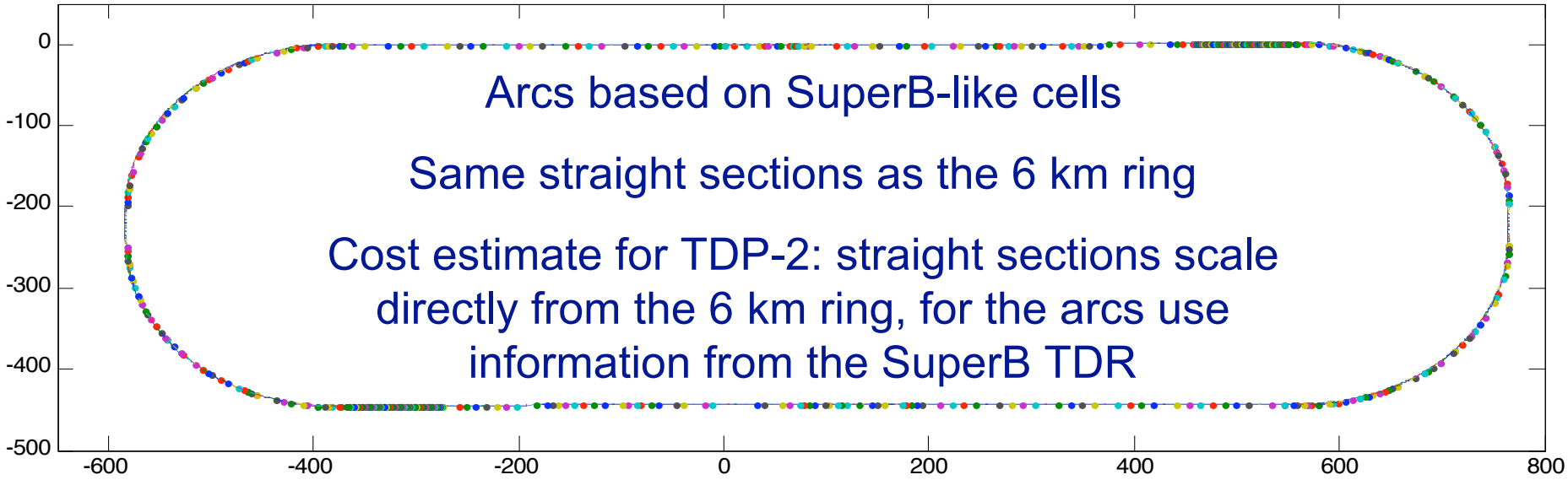


Wakefield modeling

Goal: to develop an impedance model as vacuum designs become available, and evaluate beam stability. Work will proceed through the Technical Design Phase.

Thanks to:
Fabio Marcellini,
Giancarlo Sensolini
(INFN-LNF).

Minimum Machine: New 3 Km layout

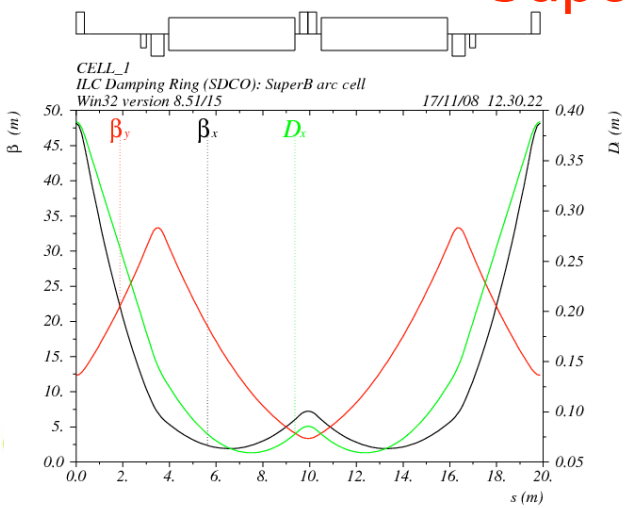


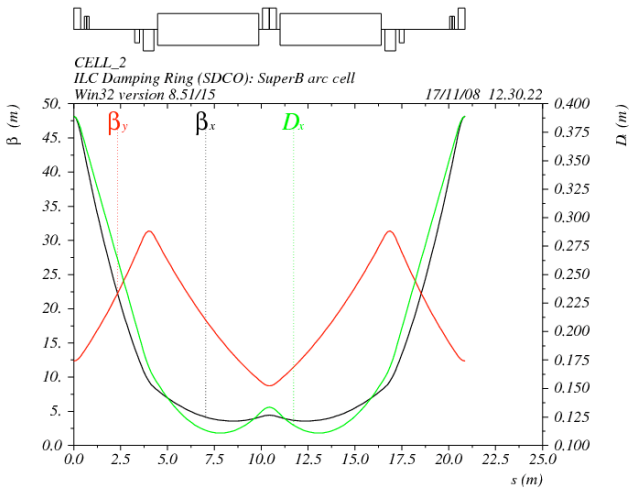
Arcs based on SuperB-like cells

Same straight sections as the 6 km ring

Cost estimate for TDP-2: straight sections scale directly from the 6 km ring, for the arcs use information from the SuperB TDR

SuperB-like cells





Lattice and Dynamic Aperture optimization done before summer

M. Biagini

Minimum Machine

- Main implication for the damping rings is that the “low power” parameter set allows to achieve the nominal DR performance with a 3 km circumference
  - **Number of bunches in the ring is halved:1320**
  - **Average current and bunch separation remain constant**
  - **Relaxed kickers requirements:**
    - Bunch spacing 6 ns
    - Pulse repetition rate 3MHz
- For the RDR baseline we are aiming at 3 ns bunch spacing (6 MHz rep rate): this would allow 2640 bunches in a 3 km ring
- Reducing the circumference makes it possible also reducing the beam energy for example to 4.2 GeV:
  - **This would make the bunch compressor easier reducing the longitudinal emittance**

Plans for future coordination and communication

- Monthly ILCDR WebEx collaboration meetings, coordinated with CesrTA collaboration meetings, started on 17 September 2008 (most recent 4 March 2009). Agendas and Presentations are at the Cornell wiki:
  https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/TeleConference
- 2009 CesrTA Workshop, June 25-26 at Cornell
  - **Discussion on the strategy to apply e-cloud R&D results to DR design**
- ALCPG09 , 28 September-3 October - Organize a DR session with the largest participation:
  - **Crucial R&D**
  - **Technical Design**
  - **Discussion on Minimum Machine configuration**