

Working Group 3b: Damping Rings

Summary

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2nd ILC Workshop, Snowmass
Plenary Summary Session

August 19, 2005

Contents

1. Review of strategy and organization for making configuration recommendation.
2. Summary of progress by Task Forces (9), and plans for next steps.
3. Contents of configuration recommendation (the configuration options).
4. Plans for finalizing the work by middle of November 2005.

1. Review of strategy and organization for making configuration recommendation

Task forces have been charged to study the key issues

The task forces (and co-ordinators) are:

1. Acceptance (Y. Cai, Y. Ohnishi)
2. Emittance (J. Jones, K. Kubo)
3. Classical Instabilities (A. Wolski)
4. Space-Charge (K. Oide, M. Venturini)
5. Kickers and Instrumentation (T. Naito, M. Ross)\
6. Electron Cloud (K. Ohmi, M. Pivi, F. Zimmermann)
7. Ion Effects (E.-S. Kim, D. Schulte, F. Zimmermann)
8. Cost Estimates (S. Guiducci, J. Urakawa, A. Wolski)
9. Polarization (D. Barber)

The **various configuration options are being studied**, using the seven “reference” lattices as a basis, and applying a consistent set of analysis techniques and tools.

The **goals** of the task forces are to produce information that can be used to inform the configuration selection.

Work is in progress. There are roughly 30 active participants altogether, and 36 talks have been given. All three regions are strongly represented.

Seven “reference” lattices span the configuration space

Lattice Name	Energy [GeV]	Circumference [m]	Cell Type
PPA	5.0	2824	PI
OTW	5.0	3223	TME
OCS	5.0	6114	TME
BRU	3.7	6333	FODO
MCH	5.0	15935	FODO
DAS	5.0	17014	PI
TESLA	5.0	17000	TME

Note: cell type is important because of the potential impact on sensitivity to magnet misalignments, sensitivity to collective instabilities etc.

2. Summary of progress by Task Forces, and plans for next steps

Acceptance Issues: Progress

TF1: Acceptance Issues (Chair: Y. Cai and Y. Ohnishi)

Y. Cai, Acceptance Issues for ILC Damping Rings

J. Urban, Dynamic aperture studies at Cornell

A. Wolski, Dynamic aperture and lattice symmetry

M. Palmer, CESR-c wiggler experience

J. Gao, Analytical estimation of dynamic aperture limited by wigglers in a damping ring

J. Gao, ILC parameter choice (a very low charge case)

C. Mitchell, Computation of transfer maps from surface data using elliptical co-ordinates

Summary of Dynamic Aperture Study with Multipole Errors and Single-mode Wigglers (Cai's talk)

NAME	C (km)	E (Gev)	s_z (mm)	DA (s_{inj}) d=0%	DA (s_{inj}) d=0.5%	DA (s_{inj}) d=1.0%	<DA> (s_{inj})
OTW	3	5	6	4.51	3.19	1.68	3.13
PPA	3	5	6	7.65	6.57	4.05	6.09
OCS	6	5	6	5.25	4.74	4.40	4.80
BRU	6	3.74	9	4.21	3.76	2.59	3.52
TESLA	17	5	6	3.62	2.11	1.11	2.28
MCH	16	5	9	4.58	4.01	2.66	3.75
DAS	17	5	6	4.89	3.38	2.40	3.55

Acceptance Issues: Plans

Statement of Tasks of TF1

Determine dynamic aperture of the lattices

- Specification of multipole errors (Cai, July 1)

- Frequency analysis (Wolski, Xiao, July 15)

- Ideal lattices & linear wigglers (Ohnishi, Urban, July 15)

- Lattice with multipole errors & single-mode wigglers (Urban, Ohnishi, July 15)

- Benchmark wiggler codes (Venturini, Wan, Dragt, September 15)

- Lattice with multipole errors and full nonlinear wigglers (Urban, Cai, August 15, October 15)

- Lattice with alignment errors, multipole errors, and full nonlinear wigglers (Ohnishi, Borland, October 1, October 15)

Determine the injection efficiency and beam loss

- Define physical apertures (Wolski, Guiducci, August 1, September 1)

- Realistic positron distribution & without physical aperture (Reichel, Xiao, August 15, October 15)

- Realistic positron distribution, physical apertures, multipole errors, nonlinear wigglers (Guiducci, Emery, September 1, October 15)

Results can be found at Wolski's website: <http://www.desy.de/~awolski/ILCDR>

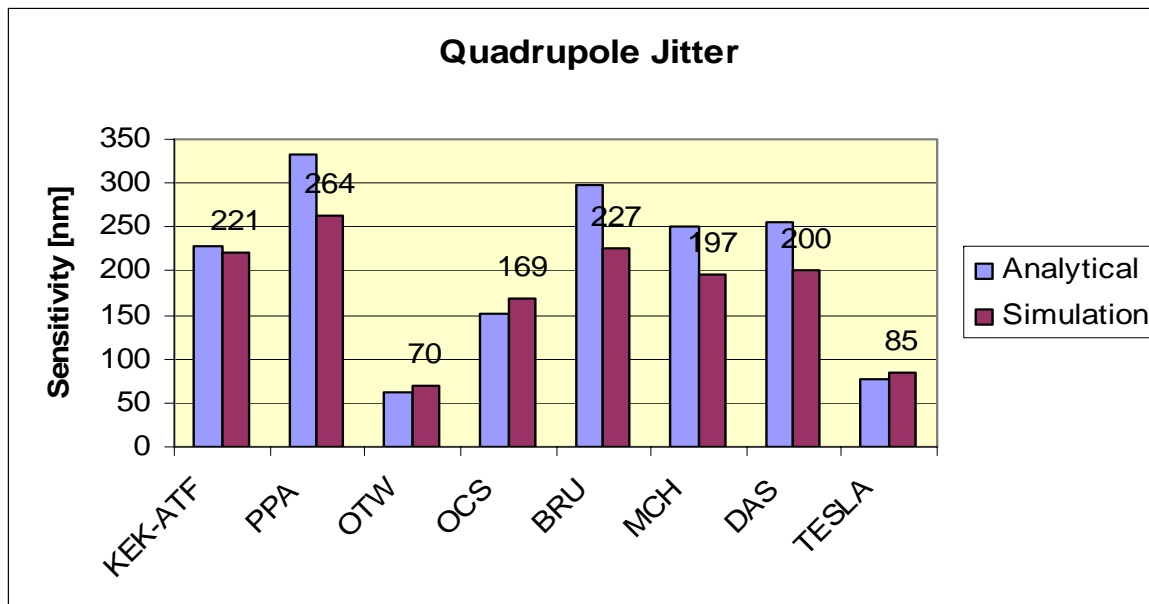
Low-Emittance Tuning: Progress and Plans

TF2: Emittance (Chair: J. Jones and K. Kubo)

J. Jones, Preliminary simulations of low emittance tuning

A. Wolski, Sensitivity estimates

K. Kubo, Magnet misalignment, external field sensitivities and low emittance tuning



(Wolski's talk)

Summary of Work So Far

Work has been done to estimate both the uncorrected jitter tolerances and the tolerances with tuning algorithms.

Currently the tuning tolerances have been separated into two essentially disparate algorithms.

Work has started on investigating the effects of stray field errors on the vertical emittance.

Simulation codes have been partially verified against each other, and give confidence in the different implementations of emittance calculation.

What's Next?

Simulations need to be extended to include (amongst others)

- A larger variety of error sources

- A more direct comparison of the various methods of tuning

 - Orbit & Dispersion correction versus separated dispersion correction.

 - Orbit correction using dipolar correctors or quadrupole movers.

- Coupling bumps (where applicable)

Classical Instabilities: Progress and Plans

TF3: Classical Instabilities (Chair: A. Wolski)

A. Wolski, Classical instabilities in ILC damping rings

G. Stupakov, ILC damping rings stability study

A simple estimate for the microwave threshold...(A. Wolski's talk)

We can use the Keill-Schnell-Boussard criterion to estimate the impedance (Z/n) at which we expect to see an instability:

$$\frac{Z}{n} = Z_0 \sqrt{\frac{\pi}{2}} \frac{\gamma \alpha_p \sigma_\delta^2 \sigma_z}{N_0 r_e}$$

	PPA	OTW	OCS	BRU	MCH	DAS	TESLA
γ	9785	9785	9914	7319	9785	9785	9785
$\alpha_p [10^{-4}]$	2.83	3.62	1.62	11.9	4.09	1.14	1.22
$\sigma_\delta [10^{-3}]$	1.27	1.36	1.29	0.973	1.30	1.30	1.29
$\sigma_z [\text{mm}]$	6	6	6	9	9	6	6
$N_0 [10^{10}]$	2.4	2.2	2	2	2	2	2
$Z/n [\text{m}\Omega]$	187	299	134	622	510	94.8	100

Compare with measured values:

APS: measured $Z/n \sim 500 \text{ m}\Omega$ (240 m Ω from impedance model)

Y.-C. Chae et al, "Broadband Model Impedance for the APS Storage Ring," PAC 2001.

DAΦNE: measured $Z/n \sim 530 \text{ m}\Omega$ in electron ring (260 m Ω from impedance model),
and $Z/n \sim 1100 \text{ m}\Omega$ in positron ring

A. Ghigo et al, "DAΦNE Broadband Impedance," EPAC 2002.

ILC DR TF3 tasks to be completed by mid-November 2005

Develop a parameterized impedance model (including RW, HOM and BB components) that can be applied to each of the reference lattice designs.

G.Stupakov, K.Bane, S.Heifets

Calculate the microwave instability threshold and TMCI threshold (based on the impedance model) for each of the reference lattice designs.

G.Stupakov, K.Bane, S.Heifets

Calculate coupled-bunch growth rates for each of the reference lattice designs.

G.Stupakov, K.Bane, S.Heifets

Calculate IBS emittance growths in each of the reference lattice designs.

A.Wolski

Estimate Touschek lifetime in each of the reference lattice designs.

A.Wolski

Identify and explain preferred configuration(s) based on analysis of relevant effects.

Space-Charge Effects: Progress and Plans

TF4: Space-charge (Chair: M. Venturini)

M. Venturini, Space-charge simulations in MaryLie/Impact

Y. Ohnishi, Space-charge simulations in SAD

J. Gao treated space charge problems analytically in
His talk of parameter choice

Task Force on Space Charge

Good progress has been made. A number of lattice designs have already been analyzed, tune scans performed.

Tentative current assessment for ideal lattices:

Can a 2pm vertical emittance be maintained at design working point?

	Tesla w/o b.	Tesla w/ b.	MCH w/o b	MCH w/ b.	OCS	BRU
SAD	NO	YES		YES	YES	NO
MLI			YES	YES	YES	

Goals for the next 2 months

Understand/resolve some differences in results between the two codes (in particular for non-design working points)

Extend study to include lattice errors, realistic model of wigglers

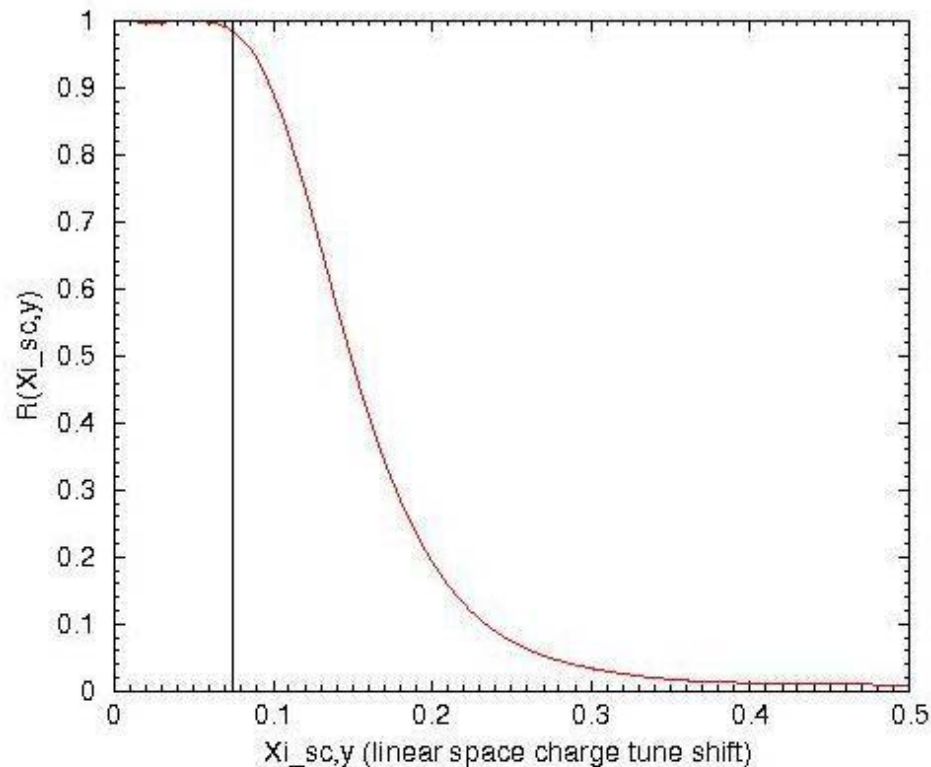
Provide final assessment of lattices

People:

Oide & collaborators, MV; **P. Spentzouris** (FNAL) has volunteered much appreciated help to provide further bench-mark with his code, possibly using a strong-strong model.

Parameter proposal for ILC

Particle survival
ratio at the
ejection



Space charge tune shift

Kickers and Instrumentation: Progress and Plans

TF5: Kickers and Instrumentation (Chair: T. Naito and M. Ross)

T. Naito, ATF kicker studies

R. Larsen/M.Ross, Inductive adder pulsters

H. Weise, DESY FET pulsters

G. Gollin, FNAL Fourier series kicker studies

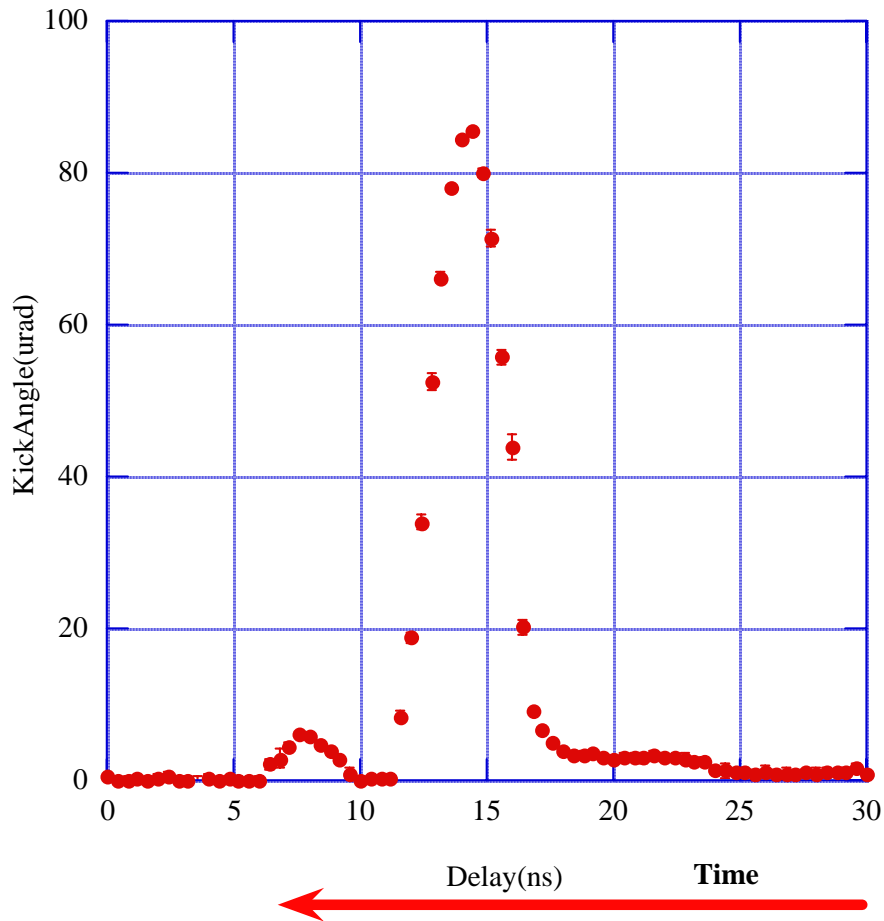
P. Raimondi/S.Tantawi, RF kickers

J. Urakawa, Instrumentation R&D at KEK-ATF

Measurement result of FPG5-3000M

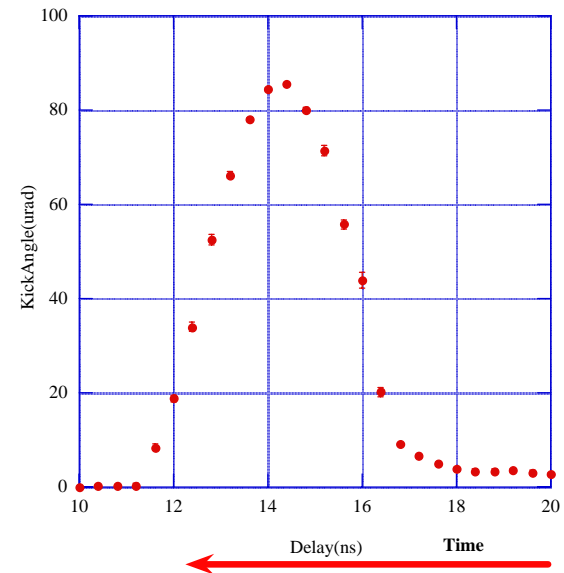
(Naito's talk, KEK)

Pulse timing v.s. kick angle(FID FPG-3000M)



Rise time~3.2ns
Kick angle ~85μrad
(calc. 94.7μrad)

Pulse timing v.s. kick angle(FID FPG-3000M)



Expanded horizontal scale

ILC DR kicker – preparation for BCD decision

Input from WG3b:

Kicker specs: (long list)

geometry, field, uniformity (sextupole), N, impedance

Rise time, rate, fall time, droop, stability, reliability

To Do items for TF5:

Develop present (baseline C. D.) design:

Naito's specification

- 1) Performance improvement of the pulser (the rise time, the droop within the pulse train, the repetition rate, etc.) (not only FID pulser).
- 2) Beam kick test with complementary pulse
- 3) Kick angle stability measurement by the beam
- 4) Design and fabrication of the optimized strip line electrode
- 5) Consider the 6MHz, 6000 (?) pulses operation

TF5 Schedule- fall 2005

Proposed Tests:

Droop (KEK), FID durability(?), stability (SLAC/LBL),
complementary pulse (KEK), high rate (DESY)

Proposed Design: Optics constraints, stripline

Evaluation and analysis:

Baseline document to include – demonstrated – and/or projected:
6 ns performance (8 buckets of 1300 → 6.15ns bunch spacing)
3 ns performance (4 buckets of 1300 → 3.08ns)
Risk assessment → what RD is needed in 06.

Write-up

Electron Cloud: Progress and Plans

TF6: Electron Cloud (Chair: K. Ohmi and M. Pivi)

K. Ohmi/M.Pivi, Progress summary and plans for next steps

K. Ohmi, Measurement results from KEK-B

M. Pivi, Plans for electron cloud studies at PEP-II

K. Ohmi, Photoelectron build-up in damping ring vacuum chambers

M. Pivi, Code comparisons and simulation benchmarking

Task Force 6: Plans Towards a Configuration Selection

Specify SEY limits from electron cloud

The electron cloud effects are among the criteria to be considered when choosing the circumference, bunch charge and bunch spacing, chamber apertures, wiggler design, antechambers, photon stops, clearing electrodes etc. It is a technical challenge to reduce the surface secondary electron yield SEY to stable low values ($SEY < 1.2-1.3$) in accelerator vacuum chambers.

Deliverables:

- SEY limits to the onset of an electron cloud with a density level below the threshold for an instability.
- Cloud density thresholds for single-bunch instability and for coupled-bunch instability with large growth rates
- Tune shifts induced by an electron cloud

TF6 tasks necessary to complete the deliverables

- (1) Electron cloud build-up simulations for the different regions ((1.a) arcs, (1.a) straights, (1.b) wigglers) considering different secondary electron yields.
 - (2) Single-bunch wake fields and thresholds of the fast single-bunch TMCI -like instability are estimated by simulations
 - (3) Coupled-bunch wake fields and growth rates are inferred from e-cloud build up simulations
 - (4) Electron induced tune shifts will be calculated and compared
- Predictions of electron build up from different simulation codes are compared and benchmarked.

People who will perform the tasks: Contributions are highly welcome !

M.Pivi (tasks: 1,2,3,4), L.Wang (1,1.b,4), F.Zimmermann (1,2,3,4)
K. Ohmi (1,2,3,4) and X. Dong (1,2),
C. Vaccarezza (1.b) R. Wanzenberg (1,2).

Communication: international phone conference is set every 3 weeks

Ion Effects: Progress and Plans

TF7: Ion Effects (Chair: E.-S. Kim and D. Schulte)

E.-S.Kim, Simulation of Fast Ion Instability in 3 km Damping Ring

The fast-ion instability is one of the criteria to be considered when choosing circumference, bunch charge and bunch spacing.

Methodology for future studies of TF7

Pertinent parameters for three different rings (17 km, 6 km and 3 km circumference) will be compiled, including beam size in arcs, wiggler, and straights, bunch spacing, tunes, and average beta functions.

Trapping condition of ions inside the train is evaluated at injection and at extraction.

The rise times in the different sections will be computed analytically, again for injection and extraction, when ions are trapped, and a global rise time calculated for each ring, both for extraction and injection; the maximum acceptable train length can be determined for each ring.

Ion induced tune shifts will be compared.

Simulations will be performed to verify the differences between rings or ring sections.

Expressions of interest, tools, 1st results

- S. Heifets (SLAC) has offered to look at ways to speed up the ion-instability simulations. He wrote a note for Snowmass pointing out the *need to treat the nonlinear saturation regime of the instability*, and showing how to do this.
- T. Raubenheimer (SLAC) has provided an example excel spreadsheet which could be used for points 2) and 3).
At a CO pressure of 0.03 nTorr, the analytical e-folding growth times are a few 100 ms for the arcs of the TESLA 17-km and FNAL 6-km ring
- N. Walker (DESY) is interested in simulating and understanding ion effects in wigglers and undulators.
- T. Raubenheimer has written a PIC simulation code for the fast beam-ion instability. Also, the HEADTAIL PIC code for electron-cloud instabilities (by G. Rumolo and F. Zimmermann (CERN)) could be modified for simulations of ion instabilities (by D. Schulte and F. Zimmermann (CERN)). There are also non-PIC ion codes by K. Ohmi (KEK) and E.-S. Kim (PAL).

Other contributions are highly welcome!

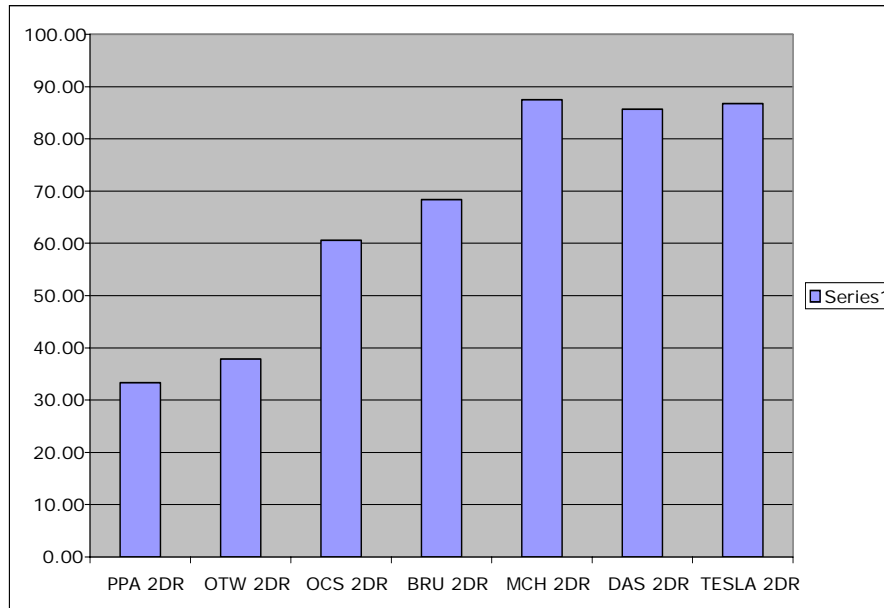
Cost Estimates: Progress and Plans

TF8: Cost Estimates (Chair: S.G., J.U. and A.W.)

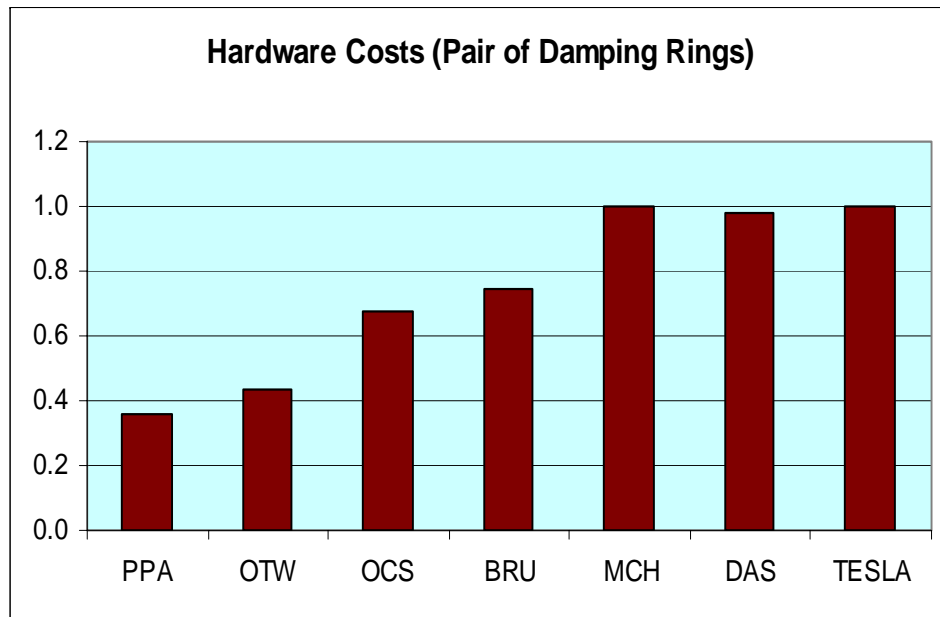
S.Guiducci/J.Urakawa/A.Wolski

L. Emery, Multi-objective optimization for damping ring

Produce parameterized cost model to allow relative comparison of the principle damping ring configuration options.



Total cost for 7 lattice (S. Guiducci)



Total cost for 7 lattice (A. Wolski)

Polarization: Progress and Plans

TF9: Polarization

Ian Bailey, Cockcroft Institute / University of Liverpool

Small group centred on Cockcroft Institute, UK

D. P. Barber (DESY), I. R. Bailey (Liverpool), J. A. Clarke (Daresbury), L. Malysheva (Liverpool), G.A. Moortgat-Pick (Durham / CERN), D. J. Scott (Daresbury)

Use SLICKTRACK (new MC simulation) to evaluate damping ring designs

Compare with MERLIN

Mid-November is very soon...

Will attempt to provide depolarisation results for a few representative damping rings

Which?

Need corrector coils to be in lattice (as must run on an ensemble of machines)

After 2005 - Will maintain rolling study of damping ring designs

Test Facilities and other issues

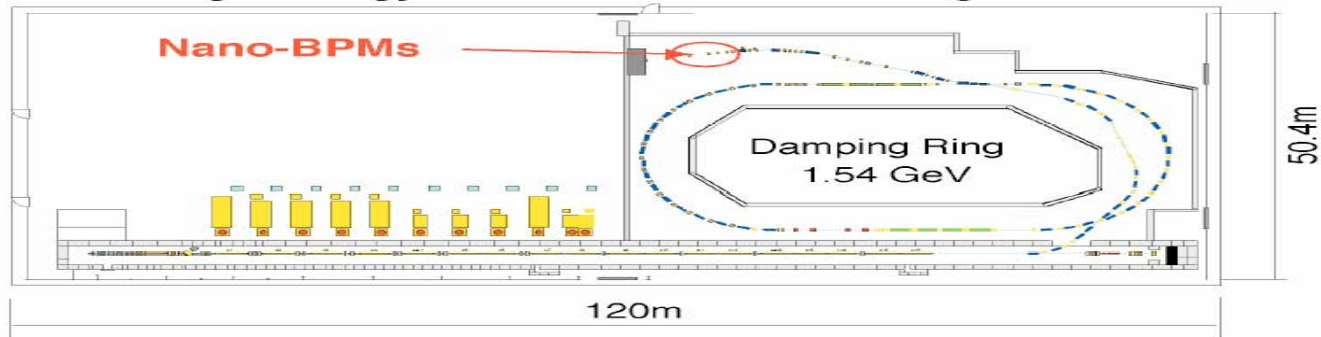
Test Facilities and Other Issues (Chair: J. Urakawa)

J. Urakawa, Plans for KEK-ATF (ATF2)

M. Palmer, Plans for CCSR (June 2008)

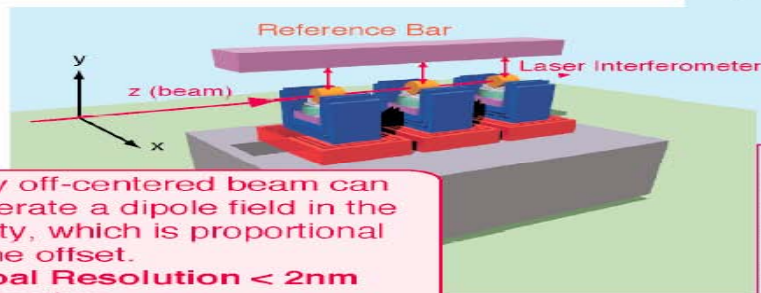
Important study at ATF is Nano-BPM & Feed-forward for Final Focus System.

ATF at High Energy Accelerator Research Organization



Cavity-BPM system with nanometer resolution (Nano-BPM)

KEK Nano-BPM



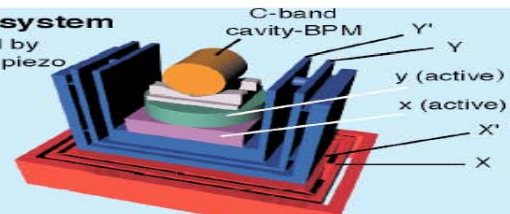
Only off-centered beam can generate a dipole field in the cavity, which is proportional to the offset.

Goal Resolution < 2nm

-expecting

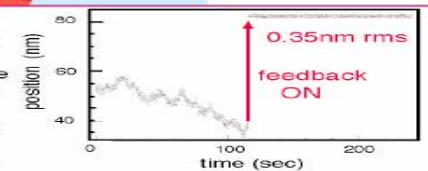
$S/N > 2$ for 1nm offset

Mover system
control by
hinge & piezo

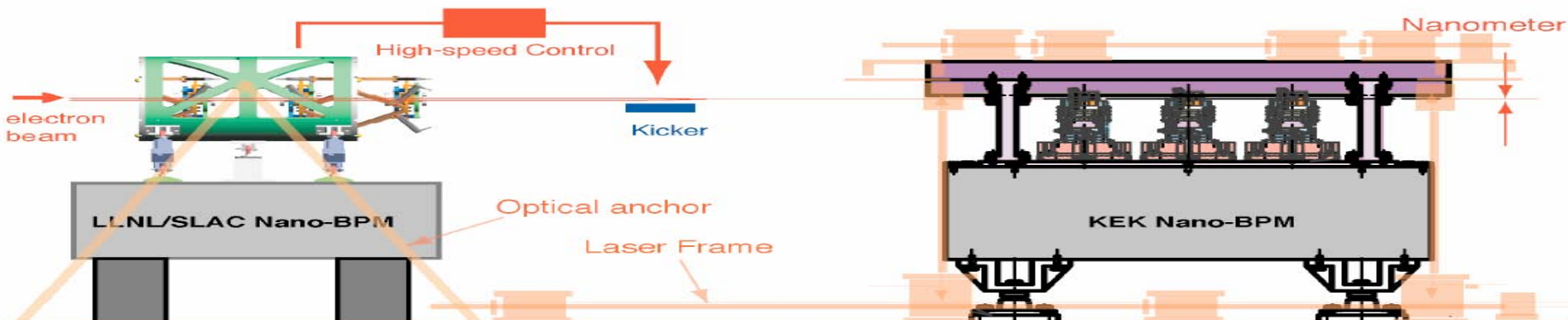


BPM stabilization

Each BPM will be stabilized by the active feedback. Its movements relative to the reference bar are monitored by laser interferometer. A test bench results show that the stabilization can be achieved at sub-nanometer.



Two Nano-BPMs and High-speed Control System



3. Contents of the Configuration Recommendation

Contents of the Configuration Recommendation (1)

Circumference and layout

- ~ 17 km dogbone

 - Are coupling bumps needed to reduce impact of space-charge effects?

- 3 km or 6 km ring

 - Single rings

 - Stacked rings (perhaps as an “upgrade” to allow 6000 bunches)

Charge and number of bunches

- ~ 3000 bunches, ~ 6000 bunches...

Beam energy

- < 5 GeV

- 5 GeV

- > 5 GeV

Contents of the Configuration Recommendation (2)

Injection scheme

Pattern in which bunches are extracted and replaced

Injected beam parameters

Injected emittances

Injected energy spread

Extracted beam parameters

Extracted emittances

Extracted energy spread

Extracted bunch length

6 mm

9 mm

Contents of the Configuration Recommendation (3)

Kicker technology

“Conventional”: strip-line (or similar) with fast pulser

“Exotic”: RF deflecting cavities, Fourier kickers...

Wiggler technology

Hybrid

Superconducting

RF technology

Normal conducting

Superconducting

Vacuum system

Residual pressure

Aperture

Techniques for suppressing electron-cloud

4. Plans for finalizing the work by middle of November 2005.

The Next Steps

The Task Forces will complete their studies by mid November 2005. The results of the studies will be documented in a report that will:

- describe the seven “reference” lattices
- describe the analysis tools and methods
- present the analysis results
- provide an “executive summary”:
 - configuration recommendations
 - remaining R&D that is required

We shall hold a **mini-workshop** in mid November 2005 to reach consensus on the configuration recommendations, and prepare (at least) the executive summary.

- It has been proposed to hold the workshop at either **CERN** or **TRIUMF**.
- A systematic process for reaching consensus on the configuration options will be drafted by the **WG3b** conveners, and **agreed by the community in advance**.

Status of the debate...

The injection/extraction kickers should be strip-line (or similar) devices powered by fast pulsers.

“Conventional” kicker technology has developed so that 17 km or 6 km damping rings are feasible. 3 km rings may also be possible, but at present have higher technical risk.

It is still important to document thoroughly the work that has been done on alternative kicker technologies.

Further studies are needed to make a firm decision on the circumference. However, a very promising option appears to be a 6 km circumference ring, possibly using rings in pairs to provide adequate bunch spacing (for electron cloud, bunch number increasing...)

Other options need further information and debate.

We have an organized international effort to produce the necessary information.

We have a plan for presenting a well-documented recommendation to the GDE.

Thanks...