The use of the HERA Electron Ring in Conjunction with ILC Damping Rings

Damping Ring Collaboration Meeting May9, 2006

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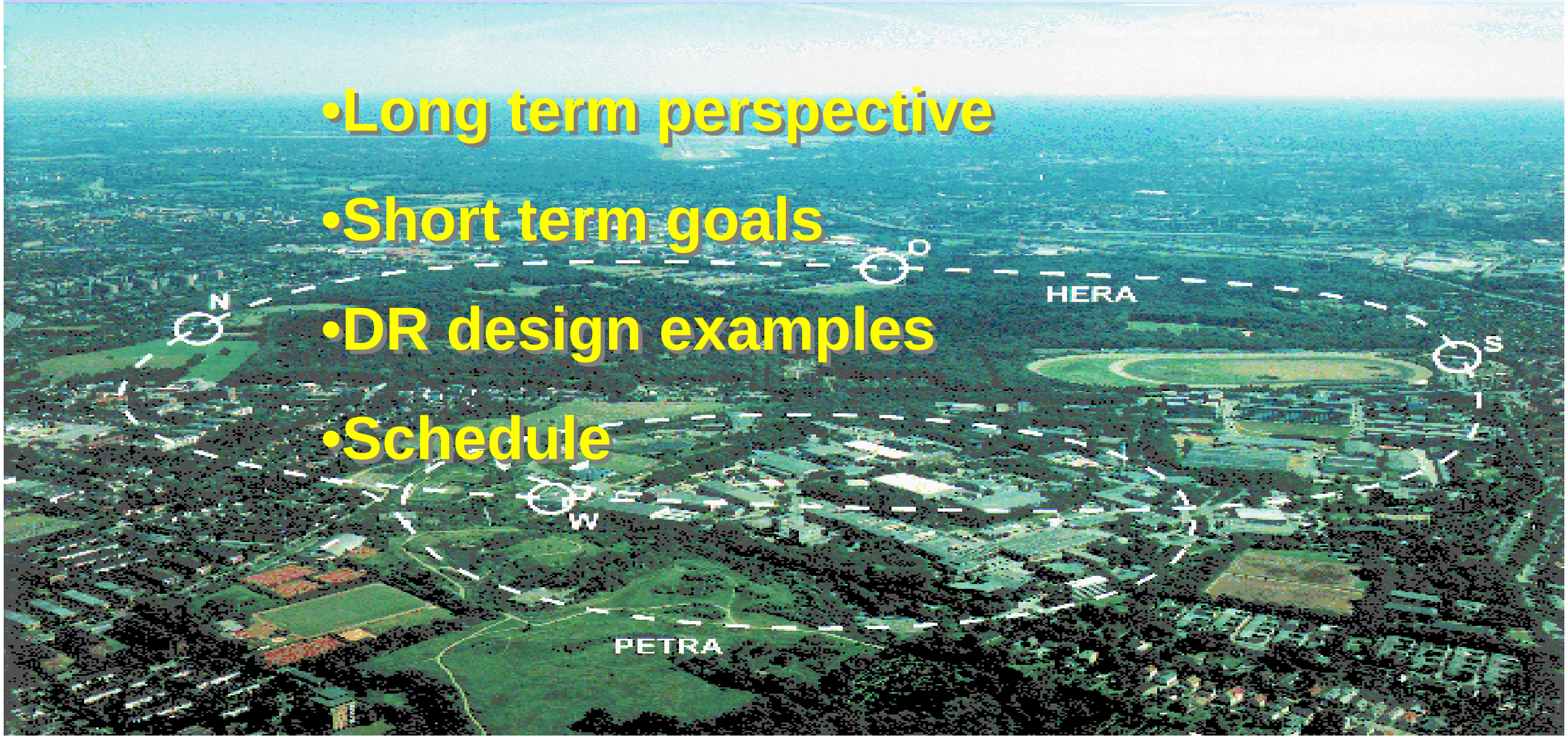
- Long term perspective
- Short term goals
- DR design examples
- Schedule



ILC Damping Rings

Most challenging accelerator problem:

- Very large beam currents (0.5A)
- Very small equilibrium emittance 1pm
- Strong damping
- Fast kickers required
- Strong transient beam loading
- Very broadband feedback systems
- Operation with high intensity positrons …

The challenging issues are coupled

(small emittance & high intensity)

There is a non-negligible risk that it might be difficult achieve

The performance goal of the damping rings.

Need design margins, impacts on cost, …

Decision on the size of the damping rings: 6 km (Snowmass 05)

ILC Damping Ring & HERA

Damping Ring Collaboration has concluded that the optimum circumference for the ILC damping rings is about 6km

it turns out, there exists one accelerator ring which matches almost perfectly the major design parameters of the ILC damping ring.

The HERA Electron Ring

- circumference of 6.36 km.
- magnets with good field quality
- large aperture
- sophisticated beam diagnostics,
- superconducting RF,
- a well conditioned copper vacuum pipe,
- build-in beam-based alignment capabilities

in addition

outstanding expertise of dealing with large el

strong interest in low emittance lattice.

No plans for any other use of HERA

This is a remarable constellation!

How make we make best use of it?

Four-Stage Approach in Using HERA for the ILC Damping Rings

Stage 0: HERA will be maintained as is (approved)

Stage I: Preparing the existing accelerator for its use as a DR

Stage II: Demonstration of the most pressing accelerator physics issues of the DR with HERA with moderate R&D-scale investments

Stage III: Modifying HERA into one of the ILC damping rings, commission it and demonstrate the required performance

Stage IV: Disassemble and reinstall the ring at the ILC site, re-commissioning and operate it as one of the damping rings

Stage III (long-term perspective)

Implement ILC DR in the HERA tunnel prior to re-installation at final destination.
using many of the existing components (magnets beam pipes)
satisfactory damping ring lattice.
Components replaced only if obviously insufficient or
if investigations beam test will tell so

- ➔ save costs by using existing components,
- ➔ allow an early feasibility and performance check of the damping rings to make sure that the machine performs as required to reach high luminosity quickly and reliably in the ILC.
- ➔ This even could be done before large investments are made.
- ➔ Most of the HERA components are likely sufficient for a demonstration of feasibility of the damping ring concept, even if one would prefer to replace some of them for a reliable production machine.
- ➔ Proceeding this way would leave open the option for alternative damping ring design at small penalty.
- ➔ Moreover, carrying over the experience from a previous version of the accelerator should be advantageous as well B-factories examples of the benefit of being able to carry over expertise from previous versions of the accelerator to the new machines)

This is a unique advantage!

Stage II (medium term perspective)

aim for the demonstration of the feasibility of some of the most challenging DR design issues
by performing accelerator experiments.

These experiments could include for example:

- the demonstration of high positron beam current of (250-500) mA without detrimental effects on vertical beam emittance
- achievement of the required small vertical beam emittance in the order of 10-12 m,
- the demonstration of effective beam based alignment techniques necessary to maintain the DR performance efficiently.

➔ believed to be achieveable for a demonstration experiment with a moderate R&D effort and with modest investments and additions to the present accelerator.

In order to define, to prioritize and to work out this demanding study programme, it is envisioned to involve the
GDE and
the strong international damping ring collaboration who would partly **assume ownership of the accelerator**.

Extended DR collaboration (DESY, EU-funding) provide high-tech equipment and improvements

YOUR INPUT NEEDED !!

Examples of needed systems:

- Broad-band transverse and longitudinal damper systems,
- Transient beam loading compensation feedback,
- Low emittance measurement techniques,
- Improved higher order mode damping of the s.c. cavities,
- Beam position monitor electronics with high resolution and features needed for low emittance tuning.

Coordination with other existing or planned damping-ring test facilities avoiding duplication and waste of resources.
smaller ring tests:

- fast kickers,
- wiggler prototype,
- measurement equipment
- Special beam pipe surface structures

Remedies for problems and improvements of insufficient design also would be tested better in smaller rings where a smaller number of equipment components needs to be supplied prior to ultimate (expensive) performance tests

Stage I (starting in 2007)

Preparing HERA for stage II

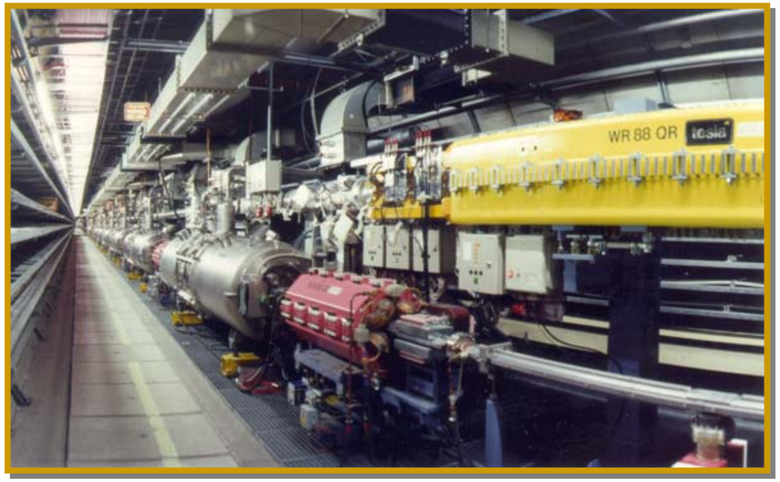
- Need new injection line
- Need to remove nc cavities from the ring
- Close the tunnel in the exp. Halls with shielding blocks
- Small modification of the lattice in the straight section

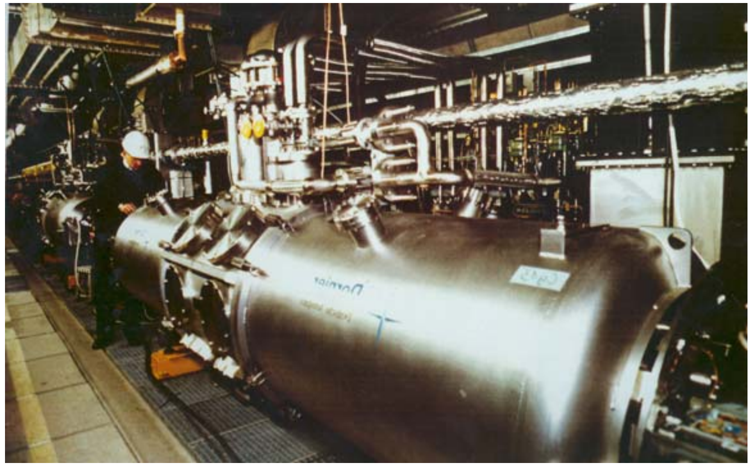
HERA Hardware

HERA as is can be used for many important tests and experiments without large modifications

Many HERA Components could be used for the final ILC damping rings (with moderate modernization and improvement:

Dipole Magnets,
Quadrupole magnets,
Sextupole Magnets, Correctors,
Powersupplies,
sc cavities,
RF klystrons,
RF ps+Modulator
vacuum chamber,
NEC and other vacuum pumps
polarimeters





Other equipment would have to be provided later
High resolution BPM,
fast kickers,
broadband feedback,
RF feedback
wigglers

Possible Not-too-Far-Term DR Studies in HERA

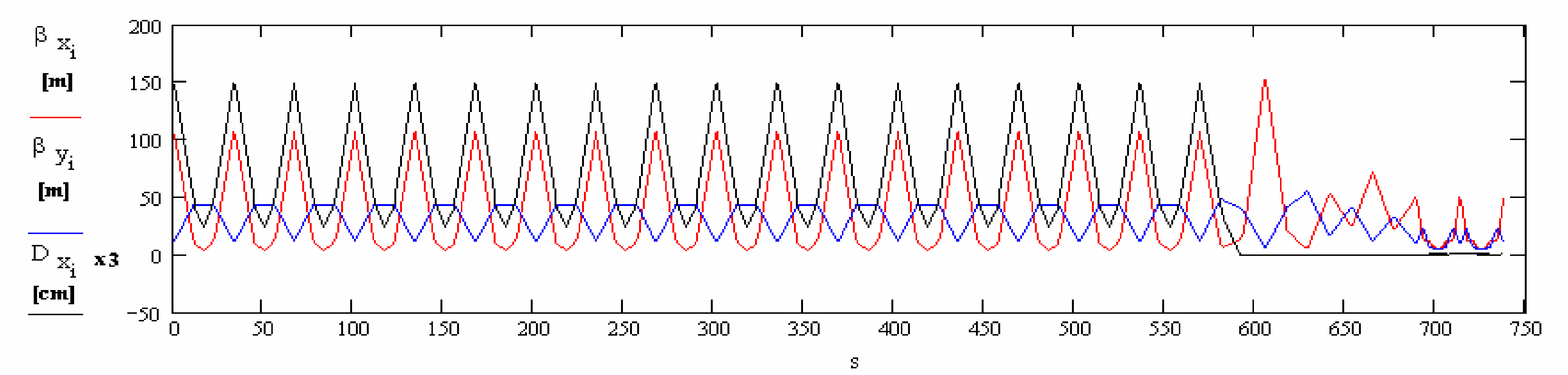
ISSUE	Additional Equipment Needed
• Storage of 250mA of positron with a bunch-spacing of 6-16 ns, • study of electron-cloud issues, testing of remedies	• De-install n.c. 500MHz cavities, RF feedbacks, 250MHz bandwidth MB damper improved HOM couplers at SCC
• Demonstration of 1pm vertical emittance • Demonstration of effective bba procedures	•Improved BPM electronics Additional BPMs Additional BBA circuitry Low ε Measurement equipment
• Polarization test measurements	

To be discussed and closely co-ordinated with GDE and DR collaboration!

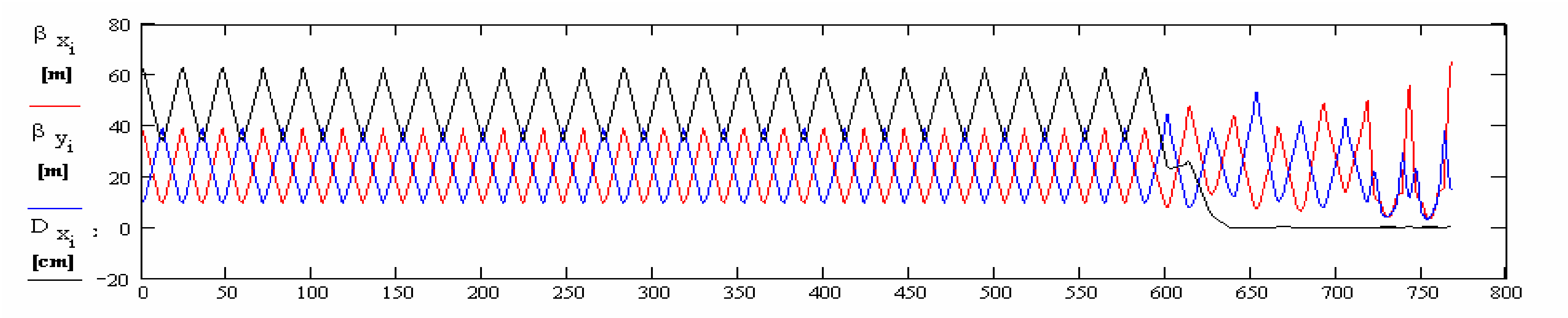
Examples for DR Lattices based on HERA

Octant structure with one dipole surrounded by 2 empty cells and 2 Wiggler sections

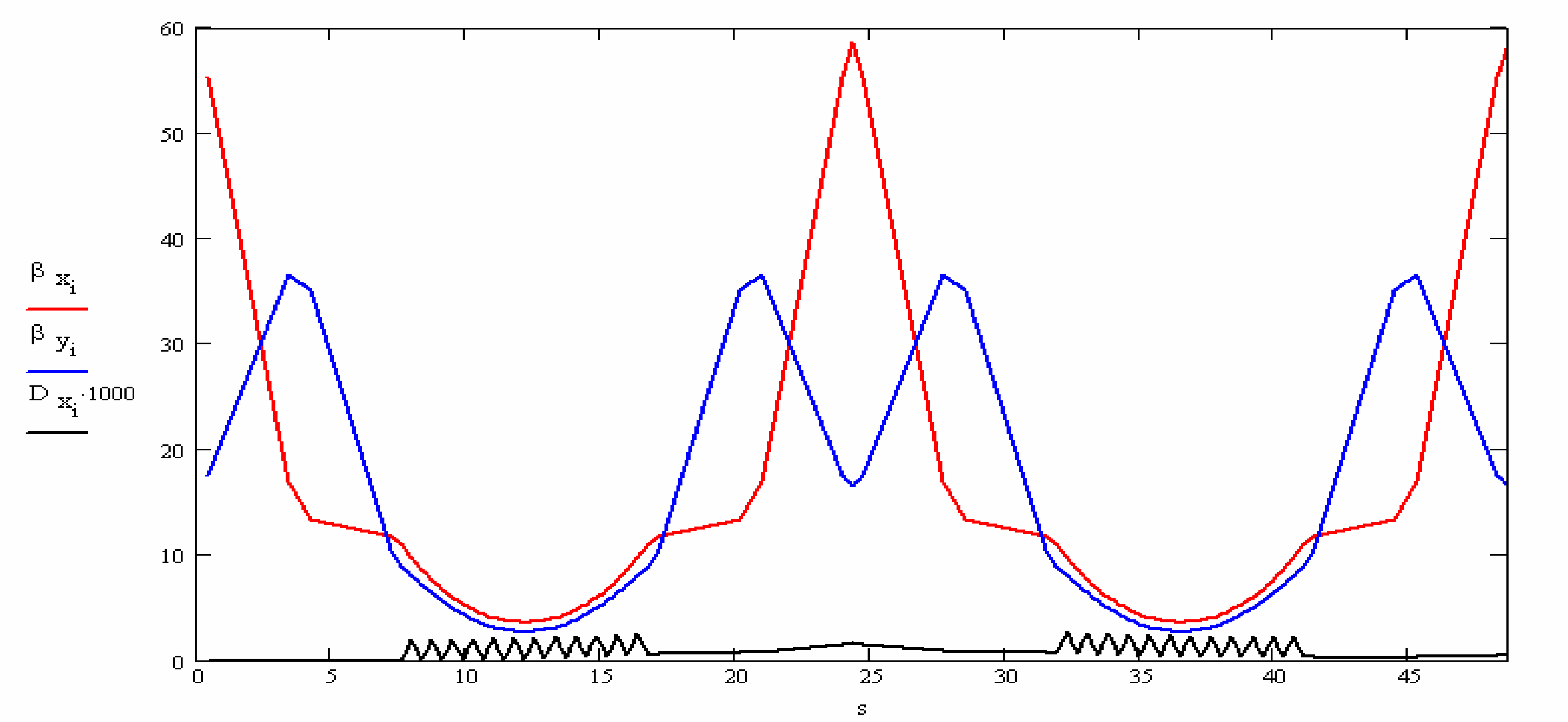
F-drift-D-O-D-drift-F   (this solution provides all the dipoles for 3 damping rings)



Octant Structure with FODO cell and 2 wiggler sections in the straight



Possible Wiggler Section

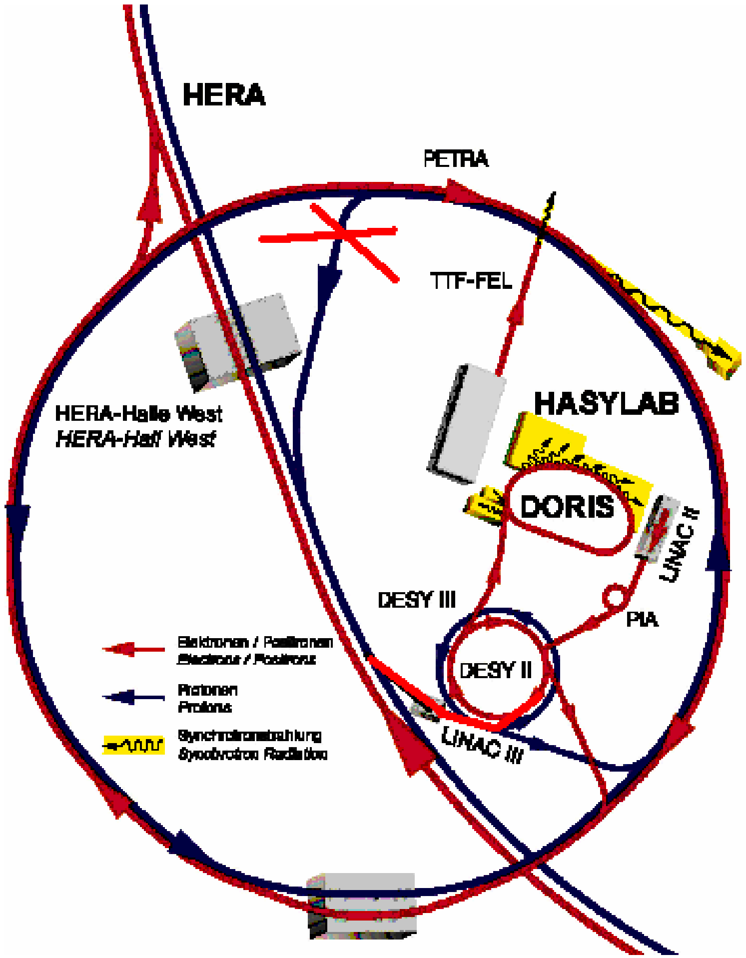


12 periods a 80cm, B~1T, 16 wiggler sections, 120m activ length

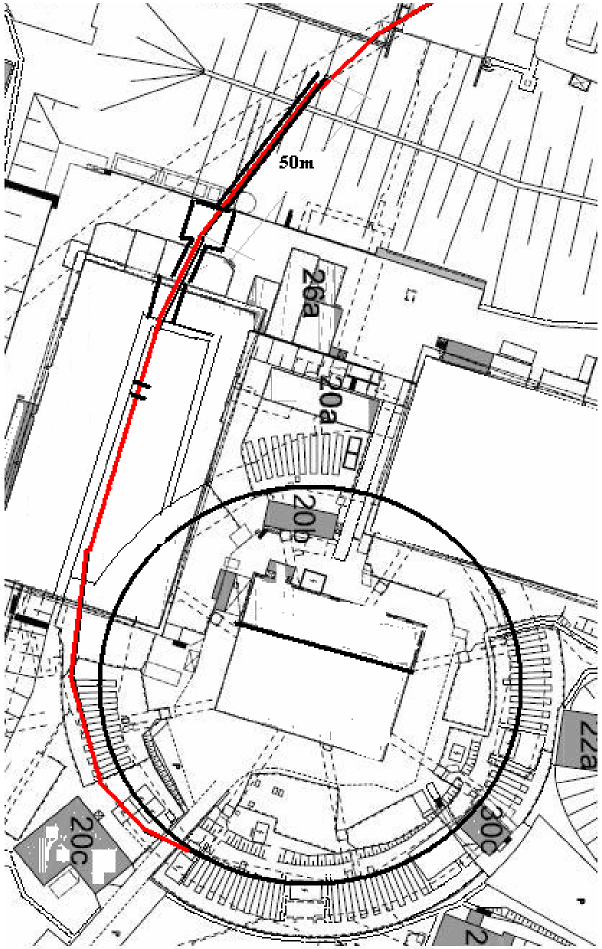
Example Parameter Set

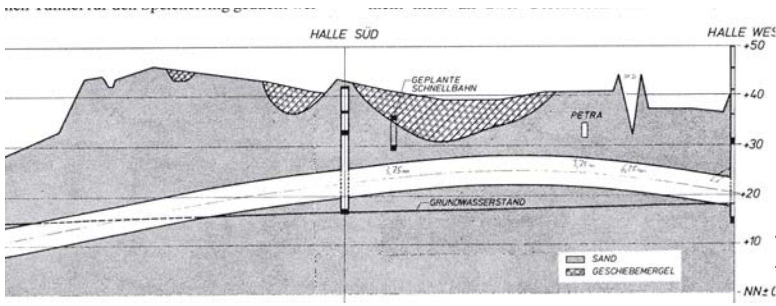
Parameter	unit	HERA Example 1	HERA Example 2	BD DR
Beam Energy	[GeV}	5	5	5
Circumference	[m]	6335.826	6335.826	6114
Harmonic Number	-	10560	10560	
RF Frequency	[MHz]	499.7	499.7	650
Arc- Optics	-	FDODF	FODO	FODO
Wiggler field	[T]	0.8	0.9	0.5
Wiggler active length	[m]	122.24	122.24	266
Norm. horiz. emittance	[µm]	2.48	3.26	5.6
Norm. Vertical emittance	[µm]	0.0	0.02	0.02
Hor. Damping Time	[ms]	16.4	13.8	14
Vert. Damping time	[ms]	16.4	13.8	14
Long. Damping time	[ms]	8.2	6.9	7
Dynamic Aperture	[rad·µm]	to be calc.	20	0.12
Bunch length	[mm]	0.8	0.6	6
rms energy spread	[10^{-3}]	1.2	1.02	1.3
RF Voltage capability	[MV]	40	40	19.3
Momentum compaction	[10^{-4}]	1.06	4.6	1.62
Energy Loss per Turn	[MeV]	3.23	3.84	14.3
RF Power for 0.5A	[MW]	1.61	1.92	1.4

New HERA-Injector needed

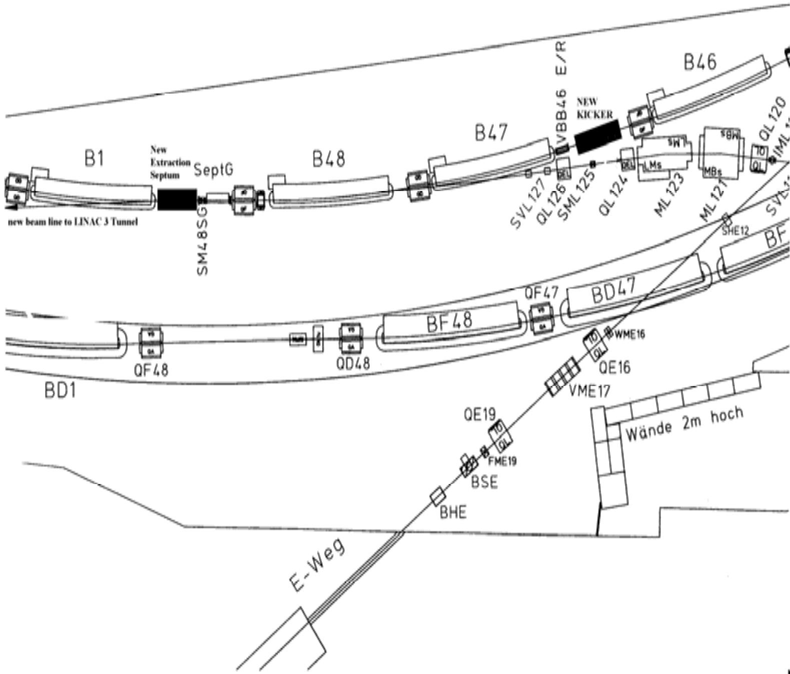


New Injector: Beamline from DESY to HERA





Ca
6m



Time Line

now - 6/2007	HERA e-p Operation, forming of DR Collaboration
6/2007- 6/2008	New e-Extraction from DESYII
7/2008 -7/2009	Install new beam line DESYII to HERA WL300
	De-install NC cavities,
8/2009-9/2009	Commission new injection
10/2009-6/2012	DR Test-runs with HERA „as-is“
	ILC damping ring design
7/2012?	ILC Project Start
7/2012-7/2014	Procurement of new DR components
7/2014-7/2015	Installation
7/2015-7/2017	DR Commissioning
7/2017-12/2018	De-installation-Re-installation at ILC site
1/2019	DR re-commissioning

next steps ...

Informal discussions with GDE	(done, in progress, successful)
Informal discussions with potential collaborators	(in progress, so far quite successful)
Informal discussion with technical groups	(in progress)
DR Ring Group at DESY started	(May 2006)
Preparation of „white book“, internal discussions DESY	(May 2006)
Discussion within DR Coll. & EuroteV/Care	(May 2006)
Proposal to GDE R&D Board	(May 2006)
Preparation of DESY Vorhaben for new Injection line	(May-August 2006)
DESY Vorhaben New Beam Line Submission	(August 2006)
DESY internal Resources planning and coord.	(June-December 2006)
Preparation of MOU between DESY & Collaborators	(June-December 2006)
DR MOU DESY & Collaborators	(June-December 2006)

Conclusions

This could be an exciting project,
It should be of considerable mutual benefit to DESY and the ILC

Immediate resources necessary to allow occasional test runs are very small (compared to what is foreseen to maintain the HERA complex)

There is work on planning and designing to do within the next few months

HERA was the result of an international collaboration (33% excl.bld's from outside Germany). It would be very much in line with the original spirit which lead to the construction of HERA if this machine could be further used for the benefit of the entire science community