Proposal for Use of PEP-II as a Linear Colliders Test Facility

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PEP-II - SLAC

- PEP-II positron-electron collider operated 1998-2008, with peak Luminosity 1.2□10^{34} cm^{-2} s^{-1} and beam currents > 3 A

PEP-II Records

Last update: April 8, 2008

Peak Luminosity

12.069×10^{33} $cm^{-2}sec^{-1}$ — August 16, 2006

1722 bunches 2900 mA LER 1875 mA HER

Integration records of delivered luminosity

Best shift (8 hrs, 0:00, 08:00, 16:00)	339.0 pb^{-1}	Aug 16, 2006
Best 3 shifts in a row	910.7 pb^{-1}	Jul 2-3, 2006
Best day	858.4 pb^{-1}	Aug 19, 2007
Best 7 days (0:00 to 24:00)	5.411 fb^{-1}	Aug 14-Aug 20, 2007
Best week (Sun 0:00 to Sat 24:00)	5.137 fb^{-1}	Aug 12-Aug 18, 2007
Peak HER current	2069 mA	Feb 29, 2008
Peak LER current	3213 mA	Apr 7, 2008
Best 30 days	19.776 fb^{-1}	Aug 5 – Sep 3, 2007
Best month	19.732 fb^{-1}	August 2007
Total delivered	557 fb^{-1}	

PEP-II turned off April 7, 2008

Proposal for the Operation of a Linear Collider Test Accelerator in the PEP-II at SLAC

- An accelerator test facility is needed to demonstrate feasibility of Linear Colliders (LC) systems.
- To reduce construction costs for DR, design decisions were made that can be justified only by a continuing experimental R&D program and require validation in a test facility.
- We propose to operate a Linear Collider Test Accelerator (LCTA) facility making use of the PEP-II High Energy Ring (HER) at SLAC.
- The LCTA proposal can be in combination with the PEP-X light source proposal.
- With few modifications, PEP-II provides a unique opportunity to validate key decisions on the timescale of a LC, CLIC and/or ILC

Linear Colliders Test Accelerator

- Goals are: 1) to run both electron and positron beams in the HER with the ultra-small emittancies to provide a full feasibility test of the Linear Colliders Damping Rings (DR) and 2) to de-magnify a beam to unprecedented <10 nm vertical beam size in a dedicated extraction line as a test of the Beam Delivery System (BDS).

Very High Priority topics for ILC and CLIC:

• Ultra-low emittance tuning and operation	(DR)
• Intra-beam Scattering	(DR)
• CLIC SC wigglers prototype feasibility tests	(DR)
• Electron cloud effects (at ~1 pm emittance)	(e+ DR)
• Ion effects and beam patterns configurations	(e- DR)
• Injection Extraction Kickers	(DR)
• Ultra-small Beam Sizes in an Extraction Line	(BDS)

Other High Priority topics: High gradient RF accelerator cavities, bunch compression, injection extraction kickers, diagnostics and instrumentation.

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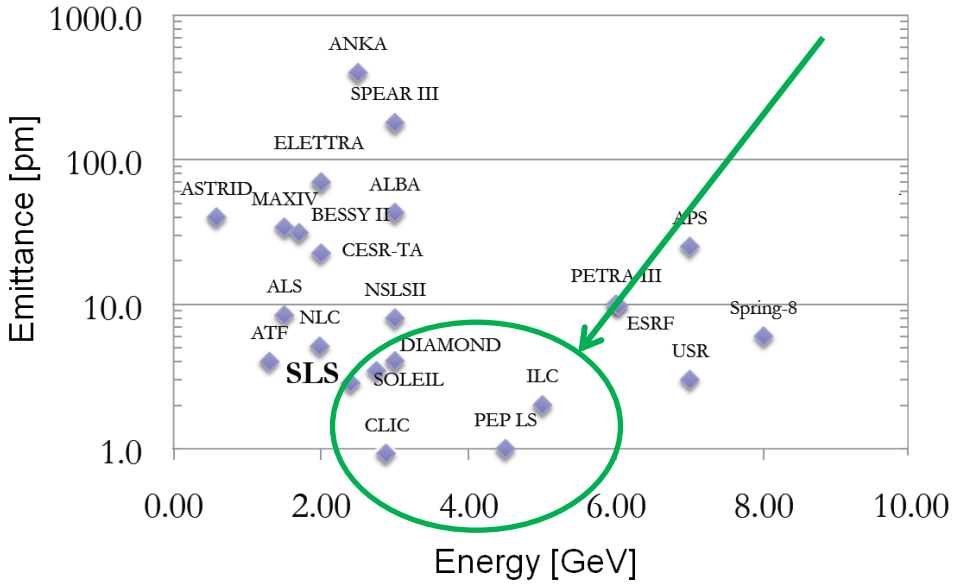
Linear Colliders Test Accelerator

In the PEP-II HER, by increasing the phase advance, lowering the beam energy and the installation of 50 meter 1.5 T wiggler sections, the vertical emittance is reduced to < 1 pm at 2.86 GeV (CLIC-DR) or to 2 pm at 5 GeV (ILC-DR).



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Linear Colliders Test Accelerator

	CesrTA	ILC	CLIC	LCTA/ PEP-II
Energy [GeV]	**2 - 5**	**5**	**2.86**	**2.86 – 8**
Circumference [m]	764	3200	493	2199
εx [nm-rad, 0 curr.]	2.5	0.6	0.07	0.3
εy [**pm**-rad, 0 curr.]	7	**2**	**0.9**	**0.9**
Beam Current [A]	0.06	0.4	0.35	>0.5
Number of bunches	45	1300	312	1100
Bunch population	2 x10^{10}	2 x10^{10}	4.1 x10^{9}	2 x10^{10}
spacing, bs [ns]	4	6	0.5	4
σz [mm]	9	6	1.4	9
α	6.7 x10^{-3}	3.3 x10^{-4}	6 x10^{-5}	-

LCTA - Extraction Line

IP Nominal parameters and LCTA/PEP-II extraction line parameters.

	ILC IP	CLIC IP	LCTA – EXT LINE
Energy, E0 [GeV]	250	1500	2.86
Norm. Emittance, $\gamma\varepsilon x$ [um]	10	0.66	2
Norm. Emittance, $\gamma\varepsilon y$ [um]	0.04	0.02	0.005
$\beta^* y$ [mm]	0.4	0.068	0.1
Vertical Beam Size [nm]	5.7	1	**9**
Bunch length [um]	300	44	9000

Factor 4 smaller than ATF2 goals

Funding and Support

- U.S. DOE
- The CERN Council might substantially support a CLIC-zero test facility, in particular for DR and BDS studies.
- International Collaboration (similarly to ATF2 model)

Project Timeline

Project lifetime: FY13-18

- Submit request for CD0.
- Set Working Group LCTA.
- Preliminary optics design and Cost Estimate in 3 months.
- Conceptual Design Report for CD1 in 3-6 months. Documentation for CD2 in 6-12 months.

Supporting slides

LCTA Cost Estimate

HER preparation work for operations

PR02	M&S (k$)	cost/year (k$)	Reference
Redesign optics in IR-2 as regular PEP-II Straight Section			
Dismantling	**2,000**		Kharakh
Fabrication of 15 QUAD and installation (alternatively take magnets **from LER**)	**1,000**		Kharakh
Fabrication 4" stainless steel vacuum chambers (alternatively take chambers **from LER**)	**300**		Kharakh
Vacuum chamber supports, power supplies, cabling	**700**		Kharakh
Installation of floor in IR-2 (can re-use the pavement used during PEP-II commisioning)	**1,000**		Debarger
ALL REGIONS:			
Re-inject water that have been drained	**1,000**		Sullivan
Missing material that have been removed since shutdown: need items counting.			
INTERMEDIATE POWER SUPPLIES	1,000		PCE
CAMACs	1,000		Controls
MCORs	1,000		"
Control System	-		"
Positron injection in the HER region PR08			
New beam line, Kicker, Septum (alternatively **redeploy LER** injection line to the HER)	**3,000**		Kharakh
Move RF station from PR08 to other straight section	**2,000**		Kharakh
Linac			
Injection system. By-pass, BCS system to date	500		Uli
PEP-II Operations			
consider LCTA operating 120-150 day/year		-	Seeman

HER upgrade for LCTA - Share Costs amongst International Collaboration

Wigglers: 50 m fabrication and installation in straight section or IR-2 region	3,000		Kharakh
BPM upgrade	2,500		Smith
BPM: new modules replacement	**1,500**		Wittmer
Beam size monitor. Either replace first monitor / interferometer or build new.	**3,000**		Fisher
Horizontally move a number of magnets to configure for a periodic lattice	**-**		
Extraction Line for Final Focus - 10 nm beam size	**6,000**		ATF2
Install experimental test chambers (also redeploy from CesrTA), magnets, diagnostics, electronics	**3,000**		CesrTA
Total	**33,500**		

Minimal Design Modification Option for a Low Emittance PEP-II lattice (Yuri Nosochkov).

Parameters

	3 GeV		4.5 GeV		6 GeV	
	No wiggler	Wiggler	No wiggler	Wiggler	No wiggler	Wiggler
Emittance, nm	2.2	0.36	5.0	0.80	8.9	1.44
Bunch length, mm	3.01	4.96	2.99	9.16	3.85	14.53
Energy spread, %	0.020	0.074	0.030	0.110	0.040	0.147
Damp. time, x/y/s, ms	1009/1014/508	107/107/53	299/300/151	32/32/16	126/127/64	13/13/7
Momentum compaction	1.33e-3		1.33e-3		1.33e-3	
Betatron tune, x/y	31.19 / 32.23		31.19 / 32.23		31.19 / 32.23	
Synchrotron tune	0.031	0.069	0.047	0.056	0.048	0.047
Chromaticity, x/y	-45.8 / -41.2	-46.0 / -41.2	-45.8 / -41.2	-46.0 / -41.2	-45.8 / -41.2	-46.0 / -41.2
Energy loss/turn, MeV	0.043	0.412	0.220	2.088	0.695	6.597
RF voltage, MV	3.9	19.0	13.3	19.0	19.0	19.0

- Voltage is limited to 19 MV - the present maximum value in HER.
- The wiggler is included in straights 2 and 6 and has the following parameters: total wiggler length (poles+gaps) = 76.4 m, wiggler period = 0.4 m, pole length = 0.1 m, gap length = 0.1 m, pole field at 4.5 GeV = 1.35 T assuming flat field model.

Vertical emittance can be reduced ~1pm, assuming 0.2-0.3% coupling and 0A bunch current.

Linear Colliders Test Accelerator

Major work:

- Positrons injection into HER
- Final Focus Extraction Line <10 nm beam size
- Install experimental test chambers (also redeploy from CesrTA), magnets, diagnostics, electronics
- Installation of wiggler magnet section
- Installation of CLIC prototype wigglers
- Instrumentation: X-ray beam size monitor, BPMs