International Linear Collider at Stanford Linear Accelerator Center

ILC R&D Status Reports: *End Station A Program*

November 7, 2005

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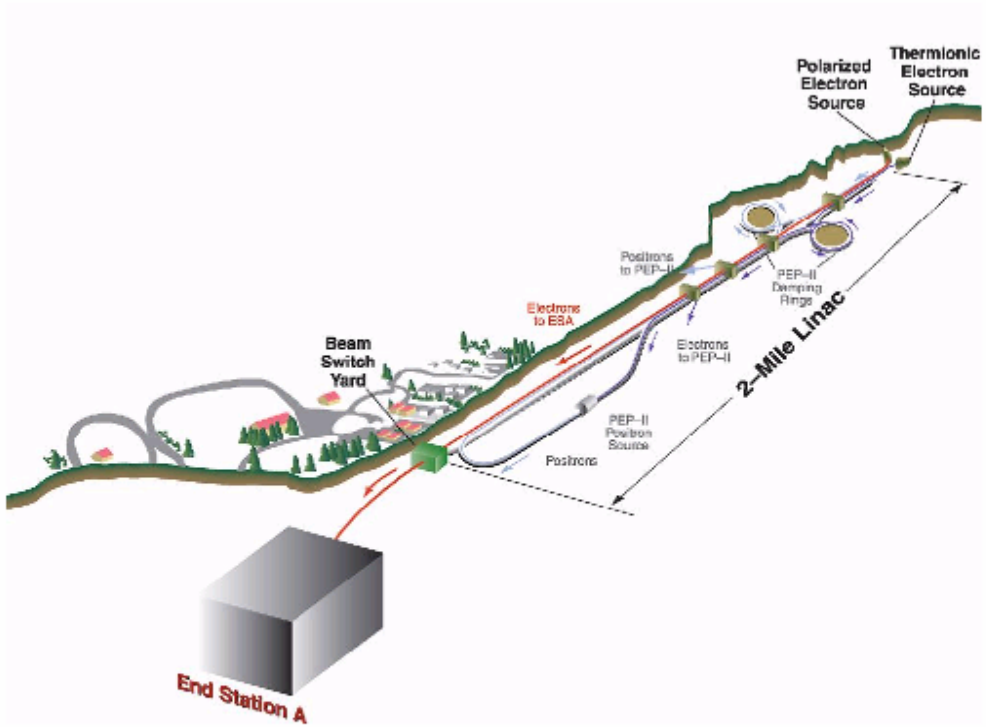
SLAC's End Station A Test Facility
for Prototypes of Beam Delivery and IR Components



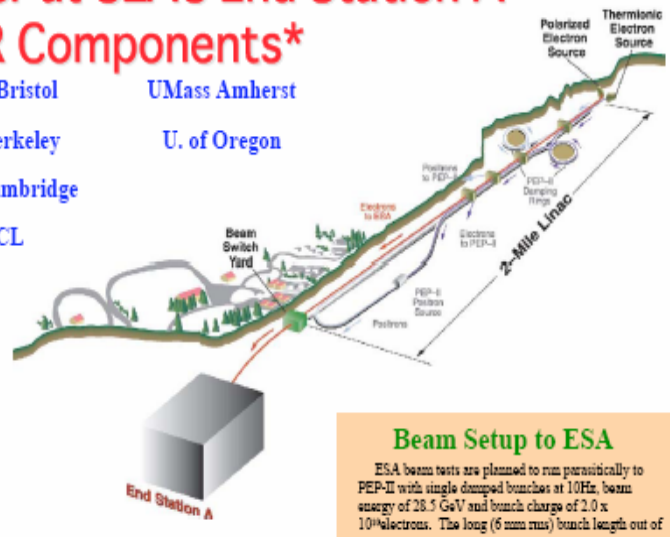
The SLAC Linac can deliver damped bunches with ILC parameters for bunch charge and bunch length to End Station A (ESA). A 10Hz beam at 28.5 GeV energy can be delivered to ESA, parasitic with PEP-II operation. During the engineering design phase for the ILC over the next 5 years, we plan to use this facility to prototype and test key components of the Beam Delivery System (BDS) and Interaction Region (IR).

ESA Home	Meetings	Mailing List	Projects	Participants	Documentation

A Test Facility for the *International Linear Collider* at SLAC End Station A For Prototypes of Beam Delivery and IR Components*

International Linear Collider at Stanford Linear Accelerator Center

CCLRC	LLNL	QMUL	U. of Bristol	UMass Amherst
CERN	Lancaster U.	SLAC	UC Berkeley	U. of Oregon
DESY	Manchester U.	TEMF TU Darmstadt	U. of Cambridge	
KEK	Notre Dame U.	U. of Birmingham	UCL	



Abstract:

http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

The SLAC Linac can deliver damped bunches with ILC parameters for bunch charge and bunch length to End Station A. A 10Hz beam at 28.5 GeV energy can be delivered there, parasitic with PEP-II operation. We plan to use this facility to test prototype components of the Beam Delivery System and Interaction Region. We discuss our plans for this ILC Test Facility and preparations for carrying out experiments related to collimator wakefields and energy spectrometers. We also plan an interaction region mockup to investigate effects from backgrounds and beam-induced electromagnetic interference.

Collimator Wakefield Measurements

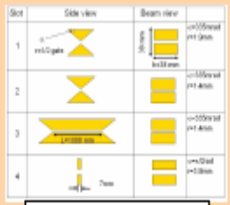


Fig. 1: Collimator insertion planned for a first set of measurements.

At the ILC, collimators are required to remove halo particles (having large amplitudes relative to the ideal orbit) to minimize damage to beam line elements and particle detectors and to achieve tolerable background levels. Short-range transverse wakefields excited by these collimators may perturb beam motion and lead to both emittance dilution and amplification of position jitter at the IP. The goal of the ESA tests is to find optimal materials and geometry for the collimator jaws to minimize wakefield effects while achieving the required performance for halo removal. The collimators will be rectangular in transverse section with a shallow longitudinal taper, long relative to the ~300μm ILC bunch length.

Initial ESA measurements will measure resistive wakes in copper and study two-step tapers. Two sets of four collimator insertions will be used, and Fig. 1 shows the first set of four collimator insertions we plan to install in the Collimator Wakefield Box. The first insertion has been used previously in measurements at 1.19 GeV.

Beamline Configuration

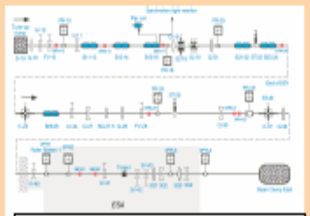


Fig. 2: A-Line from the Turn-up dump in the Beam Switchyard at the end of the Linac to End Station A. Downstream of IV-40 the beamline elements used for E158 (shown in Figure) have been removed in preparation for the ILC tests.

Fig. 3: Elevation View of beamline elements in ESA for Stage 1 commissioning. Chicane magnets, shown in Fig. 5, will be added for Stage 2.

A-line beam elements are shown in Fig. 2. There are six 2-degree bend magnets (B11-B16) before the SL-10 momentum slits, where the beam dispersion is 5 meters. Six additional dipoles (B21-B26) are located after SL-10. Following B26 the dispersion and dispersion gradient are zeroed using Q19 and Q20. The Synchrotron Light Monitor system images visible SR from the center of B15 onto a ccd camera for energy spread and energy jitter diagnostics.

The ESA configuration downstream of IV-40, planned for a first stage of measurements, is shown in Fig. 3. We plan to commission operation of the Collimator Wakefield Box that is being relocated from the ASSET region of Linac Sector 2. We also plan to commission rf cavity BPMs being relocated from the Linac and from the E158 experiment. New signal processing electronics is being developed for that purpose. These ESA bpms will be used both for energy spectrometer commissioning and for wakefield kick diagnostics. Two wire scanners will be used for beam spotsize and emittance measurements. A bunch length monitor measuring coherent transition radiation from a thin foil is being considered.

Transverse beam sizes for the tests planned are expected to be 100-200 μm rms at either the Collimator Wakefield Box or the energy chicane BPMs. Simulation results showing 100 μm rms spotsize for collimator wakefield studies is shown in Fig. 4.

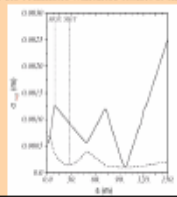


Fig. 4: Beam size in ESA after the last A-line bend. Beam has 100 μm rms spotsize at the Collimator Wakefield Box (s=95 meters).

Beam Setup to ESA

ESA beam tests are planned to run parasitically to PEP-II with single damped bunches at 10Hz, beam energy of 28.5 GeV and bunch charge of 2.0 x 10^{10}electrons. The long (6 mm rms) bunch length out of the damping ring can be compressed in the Ring-to-Linac transfer line and in the 24.5-degree A-line bend from the Linac to ESA to achieve ~300μm bunch length in ESA.

Bunch Length

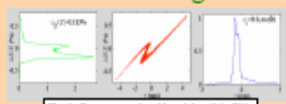


Fig. 6: Energy spread and bunch length in ESA.

Fig. 6 shows results from a simulation using LITrack of the (correlated) energy and bunch length distributions in ESA. The bunch charge is 2.0 x 10^{10} electrons. The beam energy, energy spread and bunch length at i) Damping Ring (DR) exit, ii) after Ring-to-Linac (RTL) bunch compressor, iii) end of Linac and iv) ESA are shown in Table 1.

Table 1: Energy spread and bunch length from DR to ESA.

	Beam Energy	Energy spread rms	Bunch Length rms
DR exit	1.19 GeV	0.07%	6 mm
After RTL	1.19 GeV	1.6%	720 μm
End of Linac	28.5 GeV	0.15%	720 μm
ESA	28.5 GeV	0.15%	300 μm

Bunch length diagnostics include a transverse RF deflecting cavity at the end of the Linac and a nearby off-axis screen, and the SLM energy diagnostic in the A-Line. These can be used to measure the bunch length and energy-z correlation at the end of the Linac. We plan to measure R56 in the A-line by correlating the beam phase in ESA with an energy dither we impose on the beam.

Energy Spectrometer Prototypes

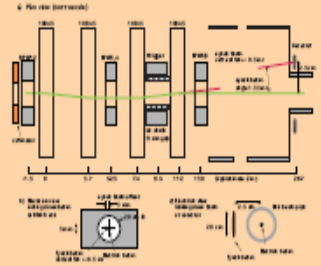


Fig. 5: Chicane configuration, beam trajectory (green) and SR stripe photons from wiggler (red) in ESA for BPM and SR stripe-energy spectrometer measurements.

At the ILC, beam energy measurements with an accuracy of 100-200 parts per million (ppm) are needed for the determination of particle masses, including the top quark and Higgs boson. Energy measurements both upstream and downstream of the collision point are foreseen by two different techniques. Upstream, a LEP-style beam position monitor (BPM) spectrometer is envisioned to measure the deflection of the beam through a dipole field. Downstream of the IP, an SLC-style spectrometer is planned to detect stripes of synchrotron radiation (SR) produced as the beam passes through a string of dipole magnets.

In the ESA tests, we plan to implement the BPM and synchrotron stripe spectrometers in the same chicane (Fig. 5), which will have the same 5mm dispersion at mid-chicane and similar dipole fields (~1kG) as the currently designed upstream ILC energy chicane. The SR stripe distance from the electron beam will have an effective dispersion of 20 mm. The ILC SR stripe chicane will have a similar bend angle to the beam direction as for the ESA tests, but a longer lever arm, giving even larger effective dispersion at the detector plane. The ILC SR stripe chicane will also have an additional wiggler in the first leg of the chicane, which is a possible upgrade for the setup in ESA.

*Work supported in part by U.S. Department of Energy contract DE-AC02-76SF00515, and by the Commission of the European Communities under the 6th Framework Programme "Structuring the European Research Area", contract number RIDS-011899.

ILC-World

World-Wide Studies of ILC Physics and Detectors

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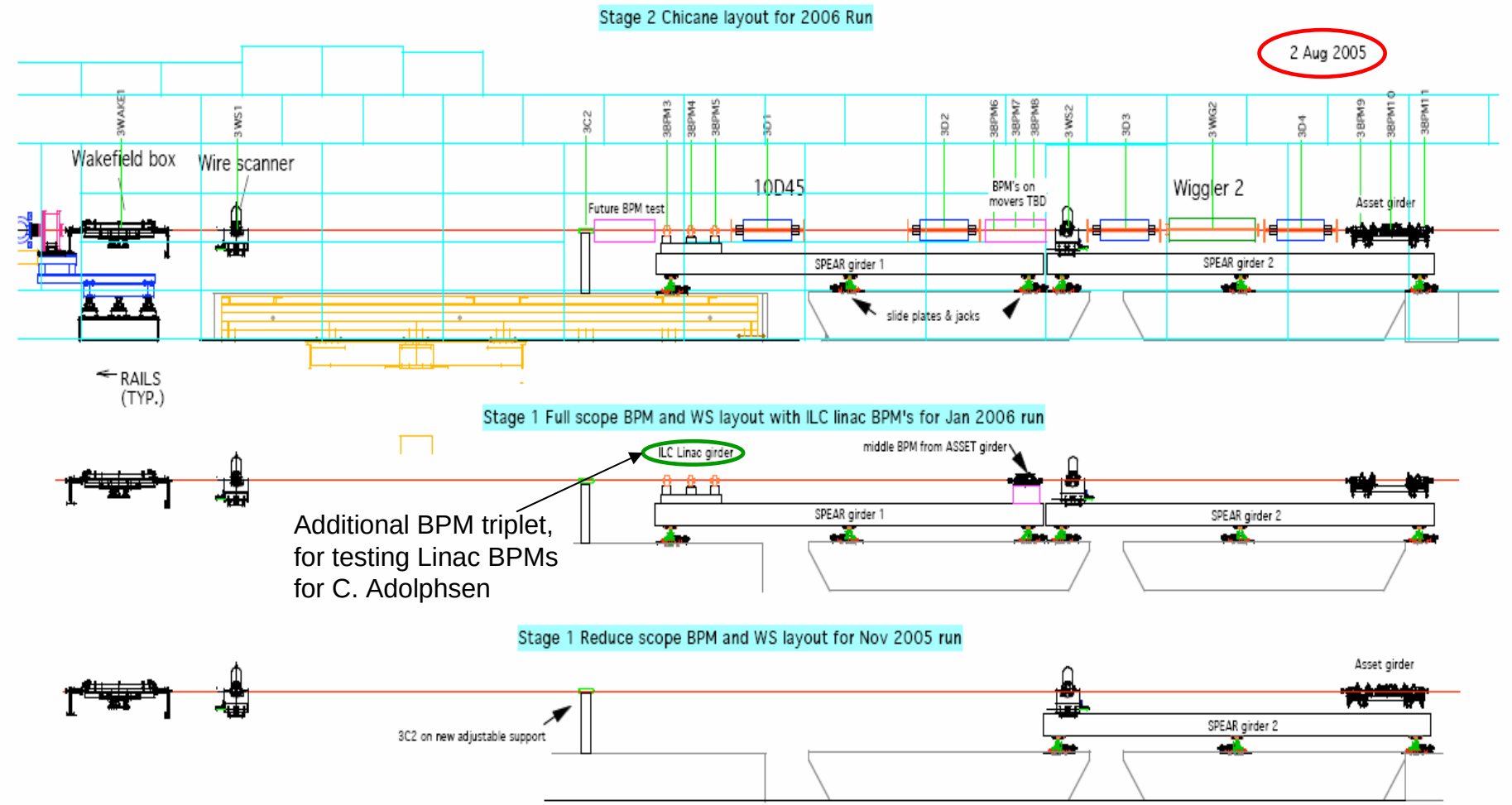
Equipment Layout **Planned**

(dates indicated were requests to SLAC in August)



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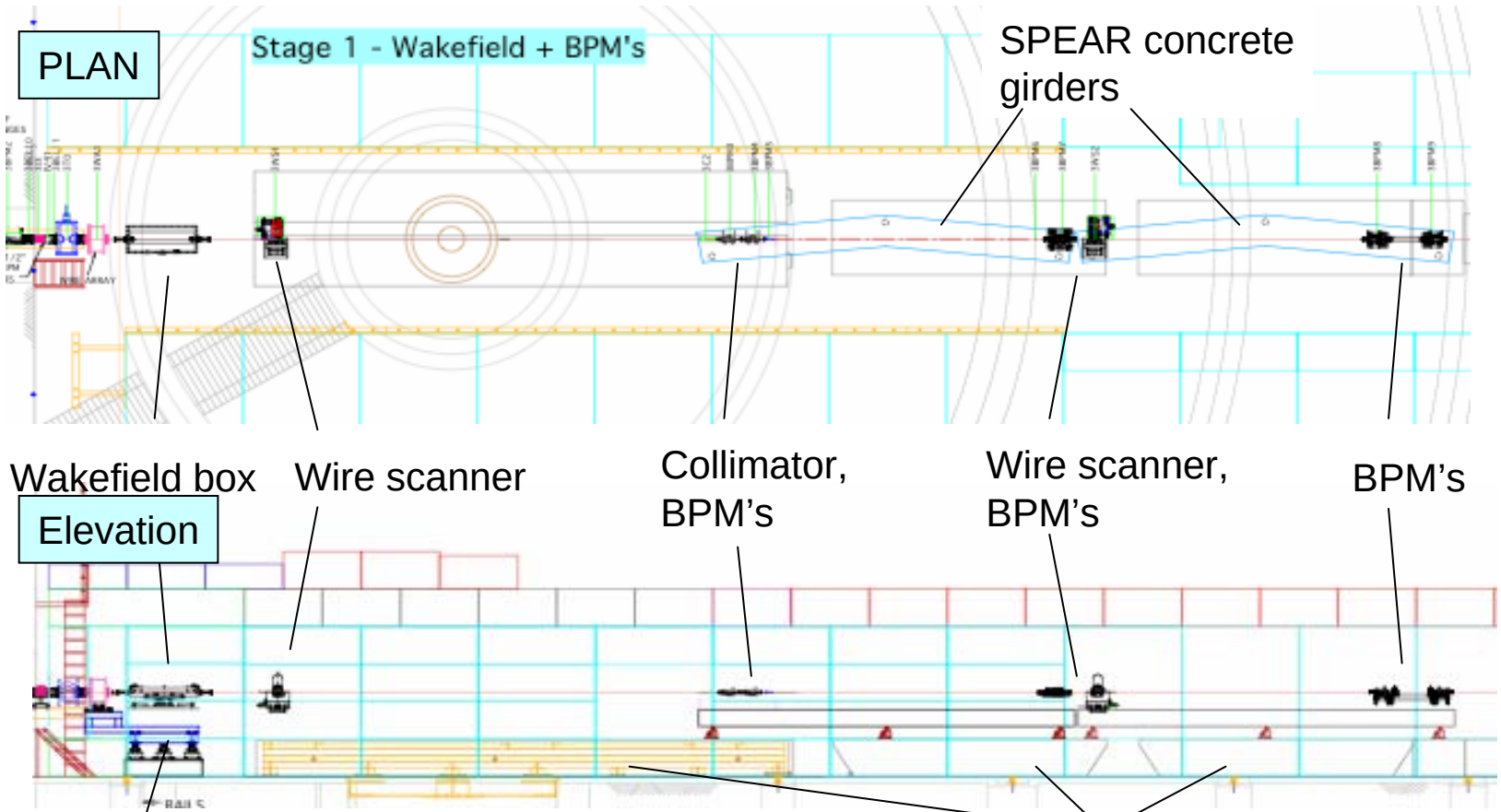
Equipment Layout for **Stage 1** (no magnets)



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Accelerator Scheduling Committee (J. Seeman, Chair)

November 4, 2005

Proposed SLAC Accelerator Schedule

ESA:

T-469	November 16-18, 2005
ILC	January 4-9, 2006
ILC	Feb 23-Mar 6, 2006 (Tentative)
ILC	May 17-31, 2006 (Tentative)
GLAST	June 1-July 31, 2006 (Tentative)

"The running schedule for FFTB and ESA are listed as "tentative" after February 2006 because the "estimated" date to turn off FFTB for LCLS construction varies between March 1 through June 1."

- GLAST run won't happen before Jan. 1, 2007 (may move to CERN)
- requesting May run move to late June or July

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Focus of initial FY05 Program for Stage 1 tests:

1. Infrastructure:
   - DAQ (both SCP and experimental, ala E-166)
   - Wire scanners for spotsize, emittance measurements
   - (simple/crude) bunch length diagnostics ala SLC
   - A-line commissioning for single bunch, low emittance beams
     (+ need to solve some vacuum and profile monitor problems)

2. T-474 for Energy BPM spectrometer commissioning
   (+ testing C. Adolphsen's new Linac rf BPMs
   + testing Oregon detector for T-475)

3. Collimator Wakefield Measurements,
   - Relocating and commissioning ASSET collimator wakefield box
   - Will use existing "E-158" BPMs and "new" T-474 BPMs to measure wakefield kicks; similar requirements as T-474 on BPM resolution and stability

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Other Beam Tests in ESA being discussed

1. **BPM test stations**
   - **nanobpms for ATF?**
2. **IP BPMs/kickers (necessary for fast inter-train and intra-train feedbacks)**
   - **Sensitivity to backgrounds, rf pickup**
   - **QMUL grad student and RA investigating possible ESA tests for FONT**
   - **Plan to submit test beam proposal in December**
3. **EMI impact on beam instrumentation or Detector electronics**
   - **Plans to characterize EMI along ESA beamline in progress using antennas and fast scopes (PI?); SLD VXD3 tests? Funding?**
4. **Bunch length and longitudinal profile measurements**
   - **electro-optic, Smith-Purcell, coherent transition radiation, other?**
5. **Spray beam or fixed target to mimic pairs, beamsstrahlung, disrupted beam**
   - **for testing synchrotron stripe energy spectrometer, IP BPMs, BEAMCAL**
6. **IR Mockup?**
   - **Mimick beamline geometry at IP within ±5 meters in z and ±20 cm radially**
7. **Single Particles (electrons, photons, pions)**

   1-25 GeV particles with 1 or less particles/bunch at 10Hz for ILC Detector tests

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ESA Beam Tests in LCLS Era?

- controls issues?
- low bunch charge, if use LCLS gun
- pulsed magnets to share LCLS beam?

SLAC MEMORANDUM

July 23, 2005

TO: John Cornuelle, Persis Drell, John Galayda

FROM: Ted Fieguth, David Schultz, Mike Woods

SUBJECT: Test Beams to ESA in LCLS era

Dave Schultz, Ted Fieguth and Mike Woods met to discuss capabilities and issues for providing test beams to End Station A in the LCLS era. Dave is Systems Manager for the electron beam for LCLS Construction; Ted is SLAC's Test Beam Co-ordinator and Mike is a SLAC research physicist developing a test beam program in ESA for the ILC project. We considered use of primary beam for beam instrumentation and accelerator physics studies, such as for the tests proposed for ILC.[1] We also considered use of secondary beams to provide single particles/bunch of electrons, pions or protons for detector tests; a description of this capability and recent beam tests was presented in a talk by Ted Fieguth.[2] GLAST, for example, plans to use this secondary beam capability for an ~2-month test beam run in Fall 2006.[3] We considered using the 14 GeV LCLS beam from the new rf gun at Sector 20, as well as possible higher energy LCLS beams. And we considered beams up to 50 GeV using the existing gun at CID. For beam with the CID gun, we envision single bunch operation.[4] High energy primary beams would most likely want to use the Damping Rings to achieve low emittance; secondary beams would not require the Damping Rings, though low emittance may improve compatibility with the LCLS modifications to the Linac.

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Project Updates

1. **T-474: BPM Energy Spectrometer** (M. Hildreth, D. Miller are co-PIs)
   - BPM signal processing: Y. Kolomensky from UC Berkeley responsible for this; developing new BPM processors. Will use SIS waveform digitizers procured by UK.
   - Seismic and stray field measurements were taken by summer students from UC London and Notre Dame. (ESA Technotes 2005.2 and 2005.3 for the seismic measurements.)
   - Had short test beam to SL-10 to verify SCP readout of A-line BPMs with FFTB beam parameters (single bunch, 28.5 GeV, 2e10 bunch charge). SCP readout ok for first bpms in A-line. Downstream ones not diagnosed due to i) no A-line profile monitors working, ii) A-line SLM not working, iii) Q10 polarity backwards
   - Support stand for ASSET bpms: design is complete and ready for fab.
   - Cableplant in progress.

2. **T-475: Synch Stripe Spectrometer** (E. Torrence PI)
   - Oregon detector installed in A-line at SLM location for initial tests

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Project Updates (cont.)

3. T-480: Collimator Wakefields (P. Tenenbaum, N. Watson are co-PIs)

- New collimators are being manufactured in UK. First 5 are being shipped now.
- Stand with FFTB movers is installed in ESA.
- Collimators from previous ASSET tests were inspected and significant oxidation was found on Cu collimators -- believed due to problems in baking. Oxide layer could have significant effect on wakefield kicks measured.
- James Bong assisting with cableplant and SCP database, together with Doug McCormick. Cables are ready to install.

4. Linac BPMs (C. Adolphsen and G. Bowden)

- BPM triplet with new rf bpms will be installed ~ Feb. 1
- Will use same electronics and DAQ as T-474 bpms

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Project Updates (cont.)

3. Wire Scanners and Collimator

- 2 SLC WS4 wire scanners are in ESA and ready for installation on beamline; will be used for spotsize and emittance diagnostics.
- 1 Linac collimator with burnthru monitor is ready for installation.

4. Mechanical: Design, fab, installation, alignment

- B. Brugnoletti and R. Rogers for design; CEF/M. Racine for fab and installation
- Pre-alignment is done for elevation, offset beamline and reference markers
- Stands for wakefield box, 1st wire scanner and collimator are complete; 2nd wire scanner stand in fabrication; stand for ASSET bpms: fab drawings just being submitted

5. Bunch Length Diagnostics

- Simple detector ala SLC being prepared by S. Walston, with assistance from Doug McCormick. Will look at pickup at a ceramic toroid gap in 4 frequency bands.
- Following commissioning run, will assess future measurements with UK colleagues and SLAC experts (P. Bolton interested)

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Project Updates (cont.)

6. Magnets for Stage 2

- 4 10D45s for the chicane are in ESA; need refurbishing.
- 2-meter SPEAR Wiggler is in ESA
- Work needed on supports and earthquaking
- Work needed on power supplies, cableplant and electrical safety issues (need to identify group/person to assist with this)

7. Safety

- SOC presentation made May 26. Working with following committees: i) earthquaking, ii) hoisting & rigging, iii) electrical and iv) radiation physics
- ESA revalidation: complete for secondary beams (T-469 has run), but not yet for primary beams. Issues: PPS upgrade – cost and resource estimate being prepared by Ray Larsen and Patrick Bong; interim radiation physics measures being prepared by Sayed Rokni.
- Presentation to radiation physics committee on RP for Stage 1 and PPS upgrade to be held in early December
- Electrical safety: addressing legacy cableplant issues with electrical safety officer; new cableplant has stringent installation criteria. Memo submitted on this to electrical safety officer and chair of electrical safety committee.

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All SLAC beamlines need to be re-validated following the 2004 electrical accident. ESA has been revalidated for secondary beams, but not yet for primary beams.

Many action items for this are being resolved. One outstanding issue currently being addressed is review of the ESA PPS.

(additionally, need to satisfy requirements for radiation physics, electrical, hoisting and rigging, and earthquaking prior to running)

Stanford Linear Accelerator Center

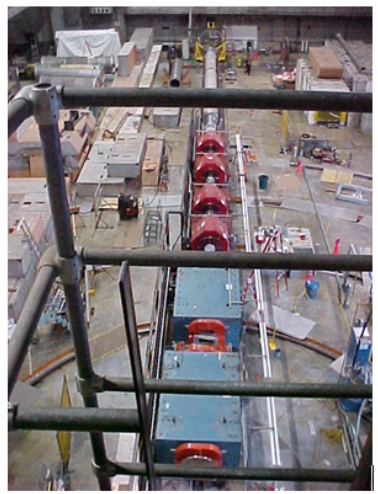
Report of the

Validation Review

of the

End Station A Restart Plan

July 2005



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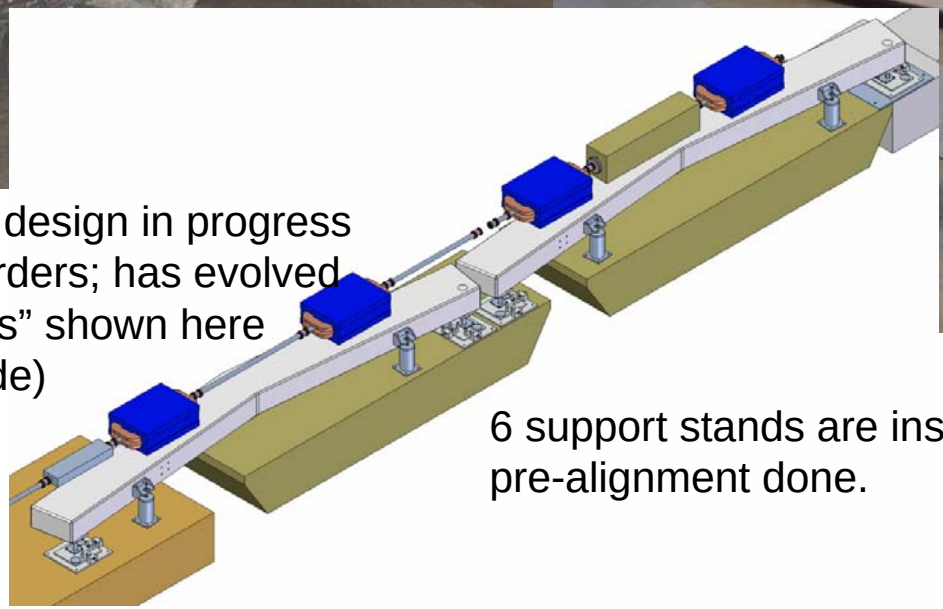
One of 2 SPEAR girders with 10D90 magnets moved to ESA in 2004

2 SPEAR girders ready for installation of beamline components; Sept. 2005

Earthquaking design in progress for SPEAR girders; has evolved from "bumpers" shown here (4 on each side)



6 support stands are installed on E158 girders and pre-alignment done.

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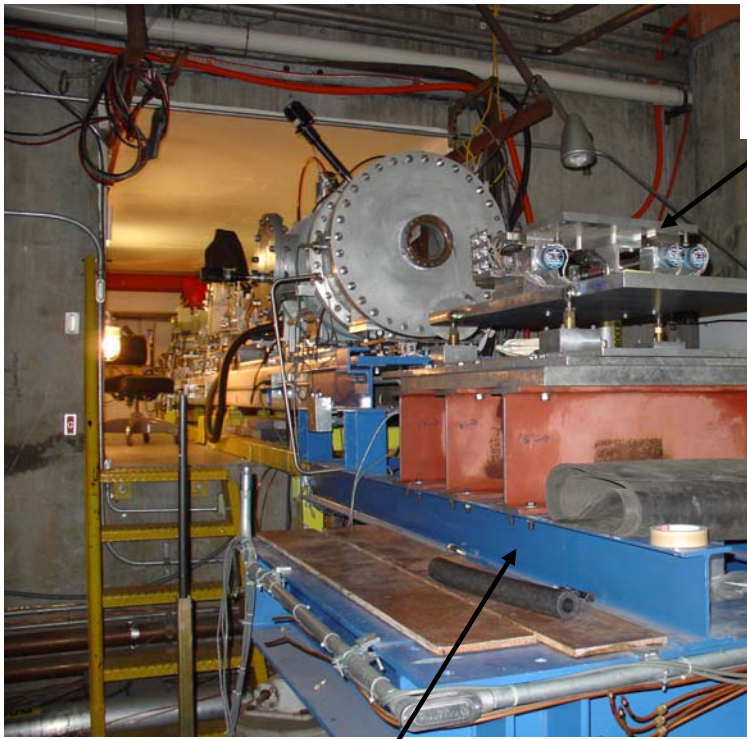

Support stand for Collimator Wakefield Box, using 3 FFTB movers

E158 Target stand

Inside bunker, looking east

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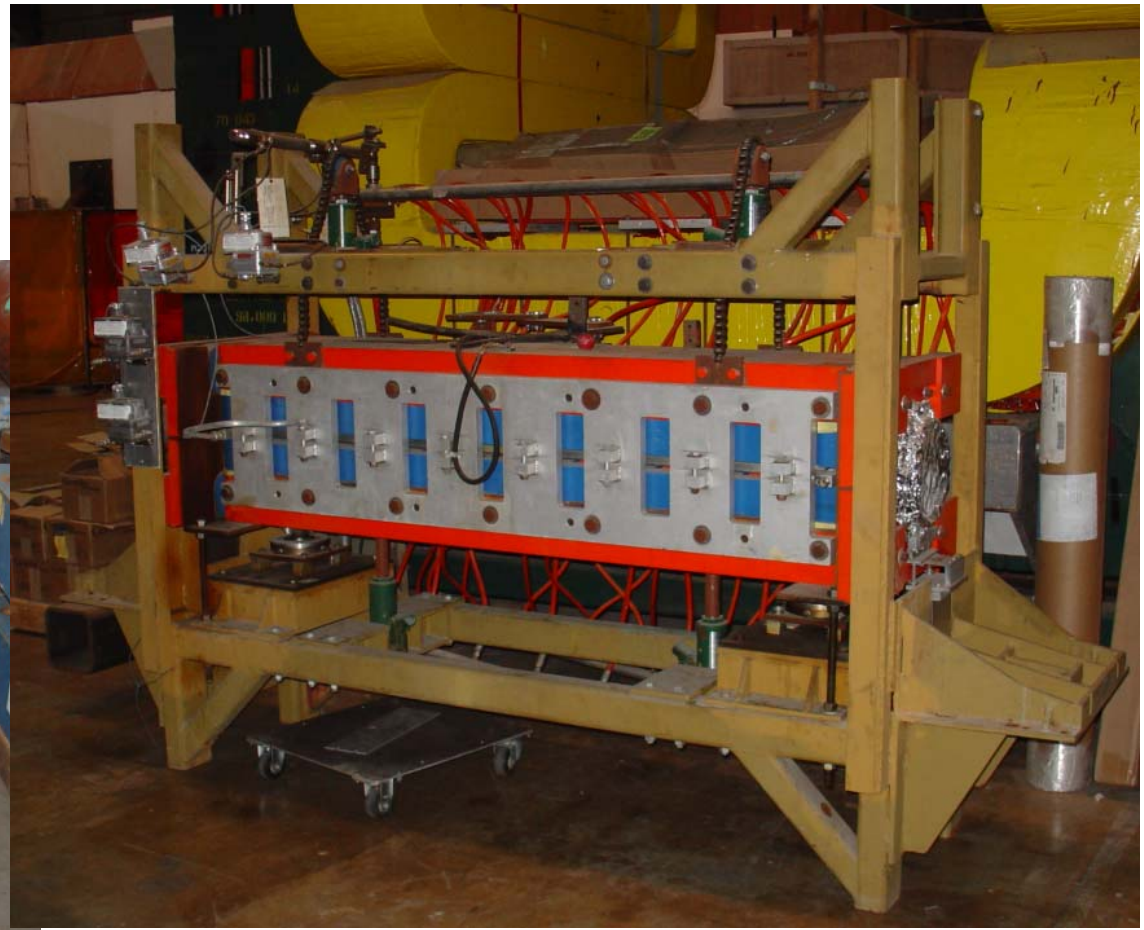
10D45 magnets for chicane



SPEAR wiggler in ESA for T-475

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3C2 collimator and burn-thru monitor on support stand; ready to install

3WS1 wire scanner (in background) and its new support stand; ready to install

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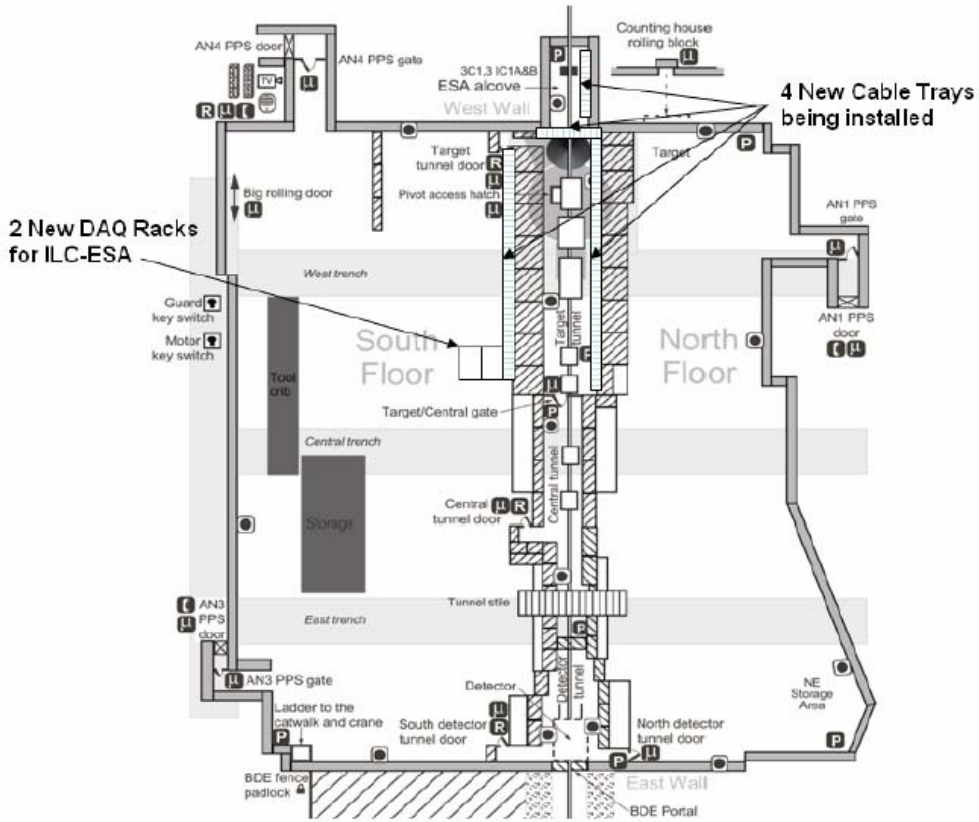

Figure 5: Plan View of ESA taken from an ESA PPS Upgrade Proposal in 2002.

Figure 2: New ILC-ESA DAQ racks in ESA are installed on the outside of the beamline concrete bunker. Rack B061-02 contains a slave VME crate, connected by fiber optics to the master VME crate in ChA; a Camac crate; 2 NIM crates and a C.A.E.N. HV crate (48

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Figure 8: Cable Trays on West Wall of ESA

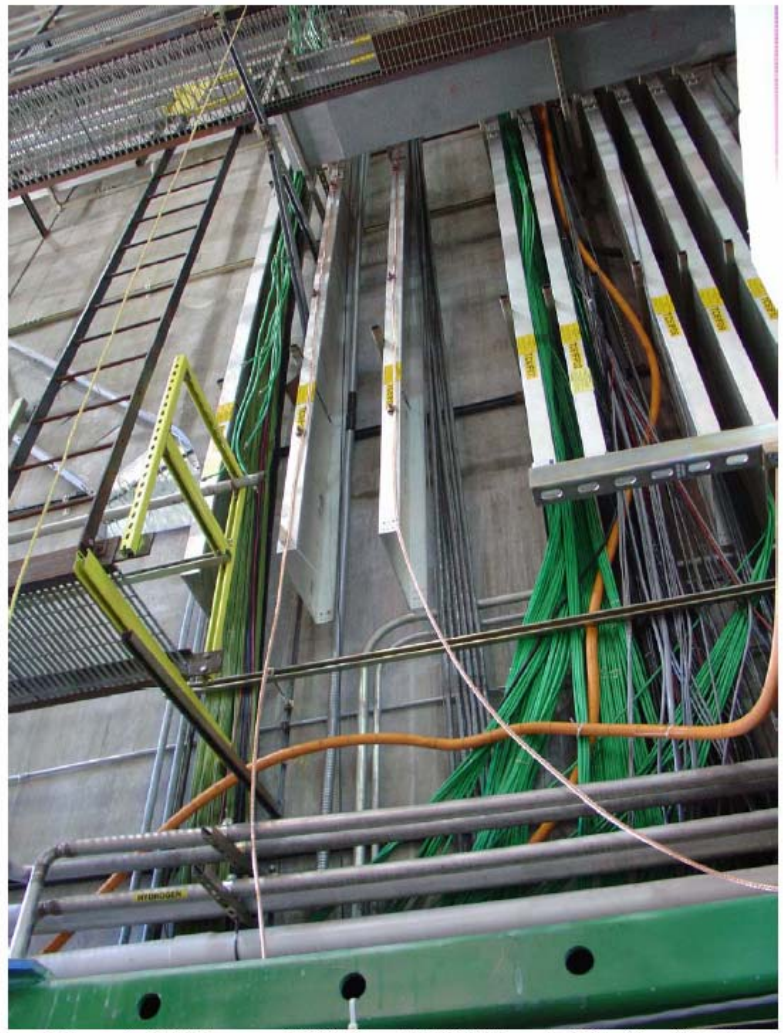

Figure 9: 2 Cable trays, TC61F05 and TC61F06, on the ESA West Wall that have been cleared and are being grounded. They will have dividers installed to separate HV and signal cables.