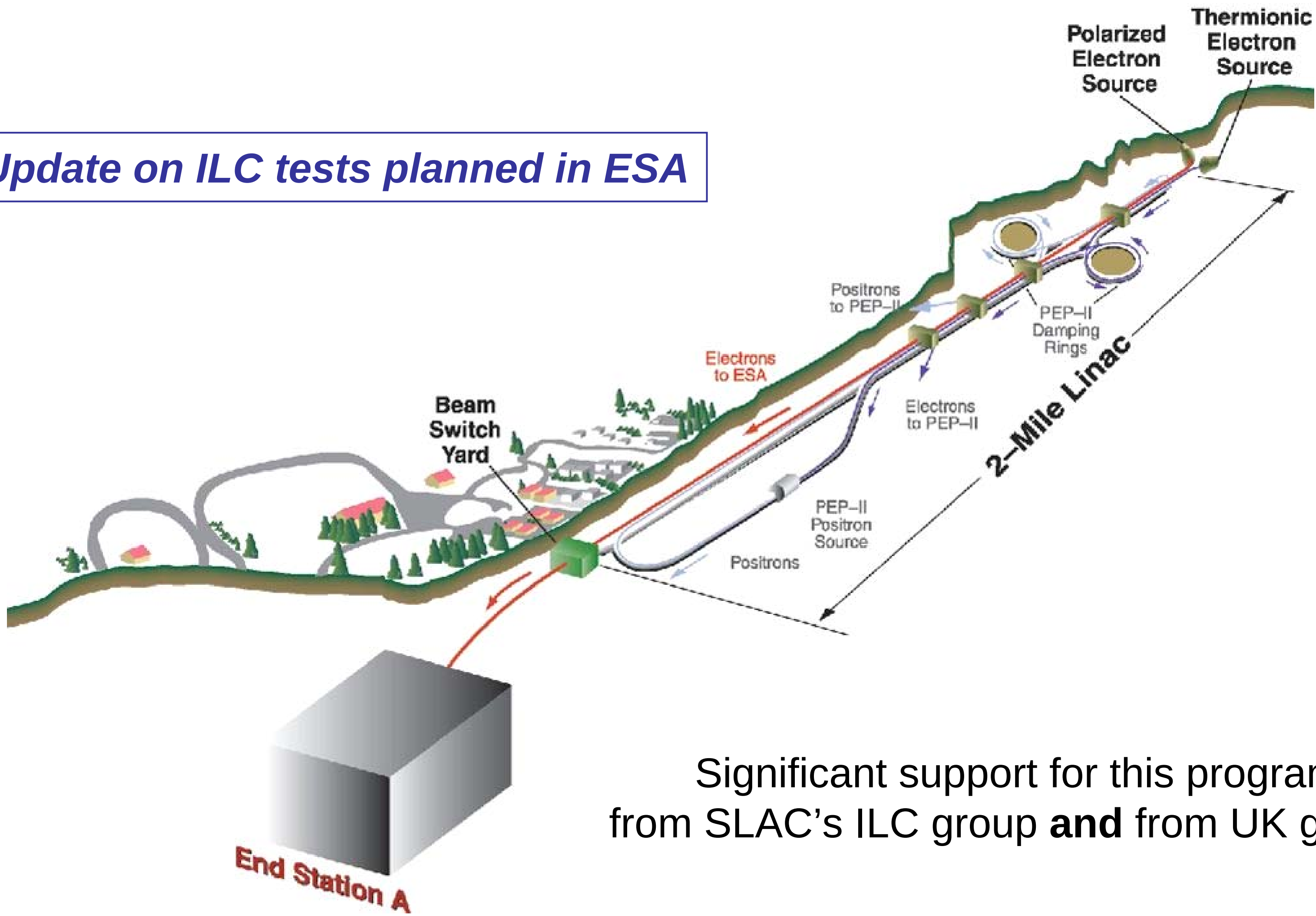
End Station A Test Facility
for Prototypes of Beam Delivery and IR Components at the ILC

Update on ILC tests planned in ESA



Significant support for this program
from SLAC's ILC group **and** from UK groups

International Linear Collider
at Stanford Linear Accelerator Center

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

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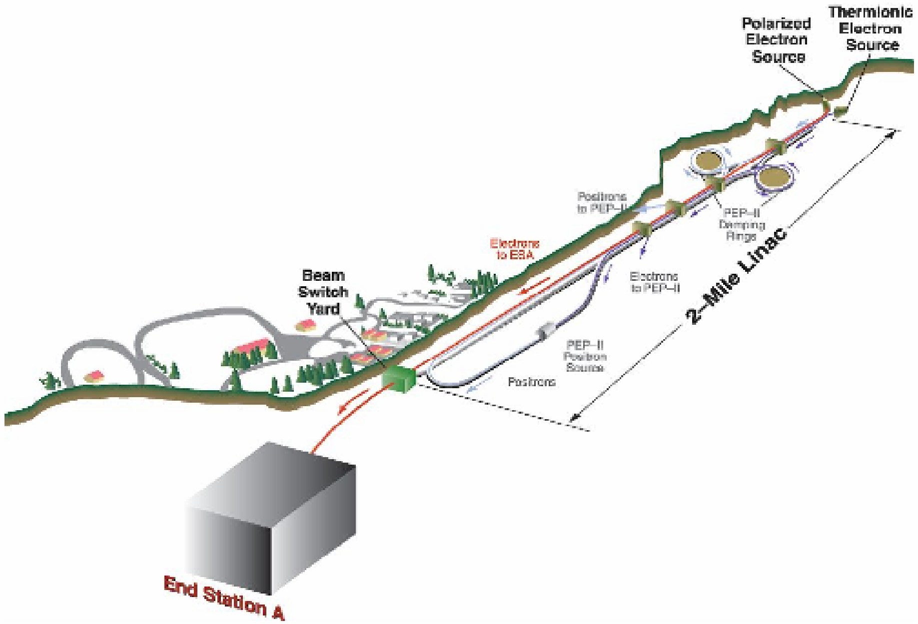
SLAC's End Station A Test Facility
for Prototypes of Beam Delivery and IR Components



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	Safety

NEW! PAC Paper and Poster: A TEST FACILITY FOR THE INTERNATIONAL LINEAR COLLIDER AT SLAC END STATION A, FOR PROTOTYPES OF BEAM DELIVERY AND IR COMPONENTS

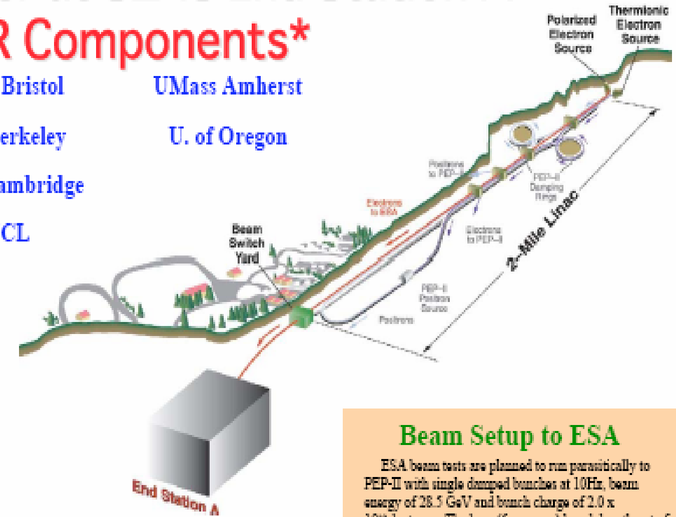
A Test Facility for the *International Linear Collider* at SLAC End Station A For Prototypes of Beam Delivery and IR Components*

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.

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.

Collimator Wakefield Measurements

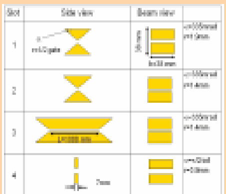


Fig. 1: Collimator insertions planned for a first set of measurements.

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

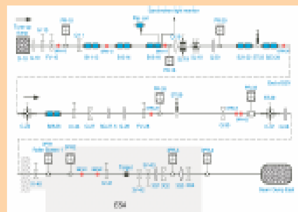


Fig. 2: A-Line from the Tune-up dump in the Beam Switchyard at the end of the Linac to End Station A. Downstream of IV-40 the beamline elements used for E158 (shown in Figure) have been removed in preparation for the ILC tests.

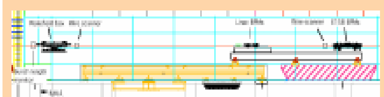


Fig. 3: Elevation View of beamline elements in ESA for Stage 1 commissioning. Chicane magnets, shown in Fig. 5, will be added for Stage 2.

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-41, 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.

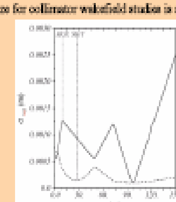


Fig. 4: Beam size in ESA after the last A-line bend. Beam has 100 µm rms spotsize at the Collimator Wakefield Box (s=95 meters).

Bunch Length

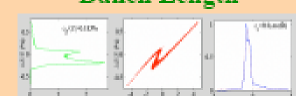


Fig. 6: Energy spread and bunch length in ESA.

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	1.0%	720 µm
End of Linac	28.5 GeV	0.10%	720 µm
ESA	28.5 GeV	0.10%	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

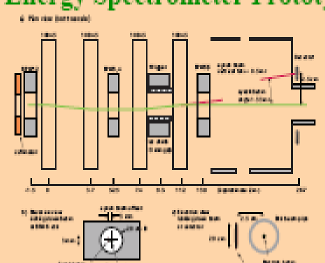


Fig. 5: Chicane configuration, beam trajectory (green) and SR stripe photons from wiggler (red) in ESA for BPM and SR stripe-energy spectrometer measurements.

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.

ILC-World

*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.

World-Wide Studies of ILC Physics and Detectors

Beam Parameters

Parameter	SLAC ESA	ILC-500
Repetition Rate	10 (up to 30) Hz	5 Hz
Energy	28.5 GeV	250 GeV
e^- Polarization	(85%)	>80%
Train Length	Single bunch; (up to 400 ns possible)	1 ms
Microbunch spacing	20-400 ns	337 ns
Bunches per train	1 (or 2)	2820
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Energy Spread	0.15%	0.1%

First Beam Tests

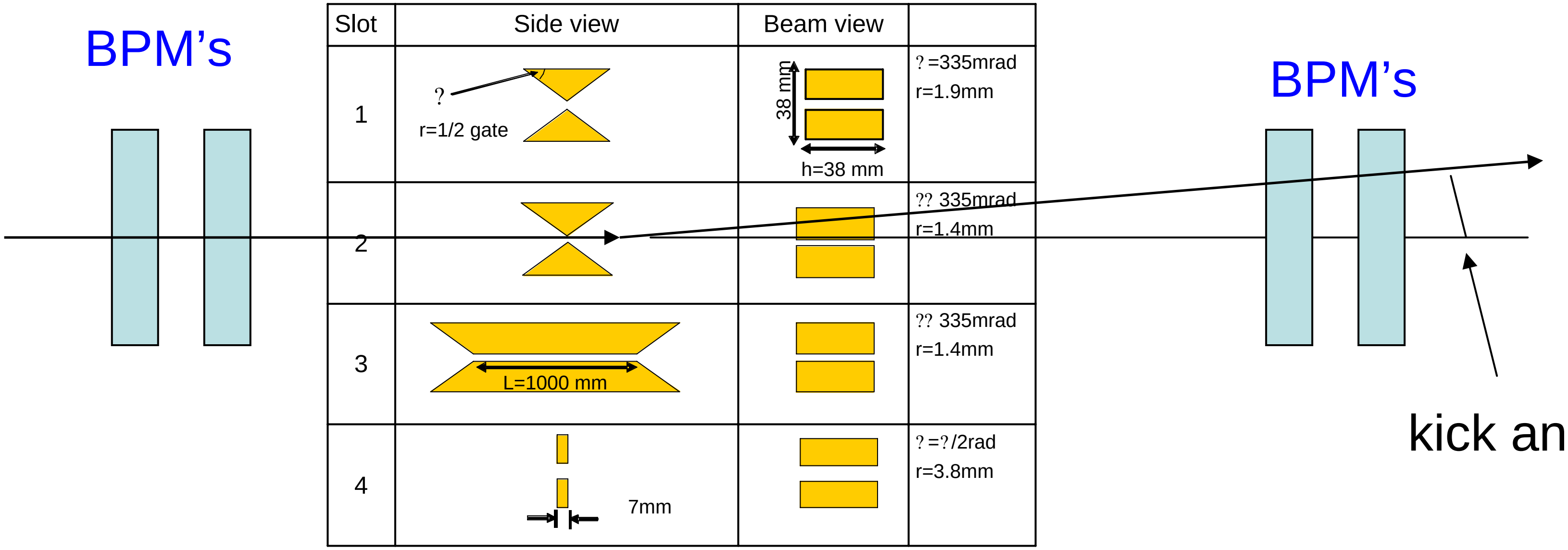
1. **Energy BPMs (T-474)** (PIs are Mike Hildreth, U. of Notre Dame and David Miller, University College London)
   - **mechanical and electrical stability at 100-nm level**
   - **BPM triplet defines straight line. Monitor BPM2 offset over time scales of minutes, hours**
   - **2 adjacent BPMs to test electrical stability, separate from mechanical**

2. **Synchrotron stripe diagnostics (T-475)** (PI is E. Torrence, U. of Oregon)
   - **test chicane scheme with wiggler magnet**
   - **characterize detector (quartz fiber / other) performance and capabilities**

3. **Collimator wakefield tests (T-480)** (PIs are P. Tenenbaum, SLAC, and N. Watson, U. of Birmingham)
   - **use 28 GeV ~10^{10} e/pulse, 10 Hz with ~100 micron spot size**
   - **collimator wakefield box from previous tests in ASSET**
   - **precision BPM's from E158 and for T-474**
   - **measure beam kick from multiple collimator shapes and materials**

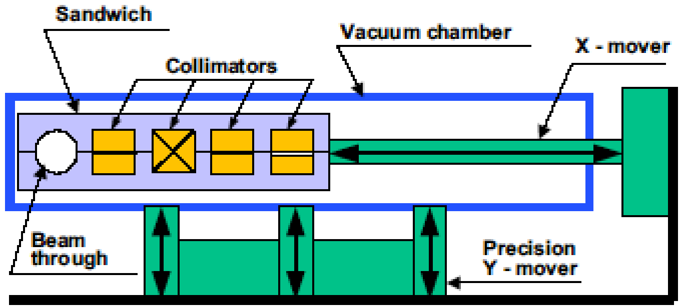
T-480: Collimator Wakefields

Collimators remove beam halo, but excite wakefields. Goal is to determine optimal collimator material and geometry.



Slot	Side view	Beam view	
1	? r=1/2 gate	38 mm h=38 mm	? =335mrad r=1.9mm
2			?? 335mrad r=1.4mm
3	L=1000 mm		?? 335mrad r=1.4mm
4	7mm		? =?/2rad r=3.8mm

Beam's eye view

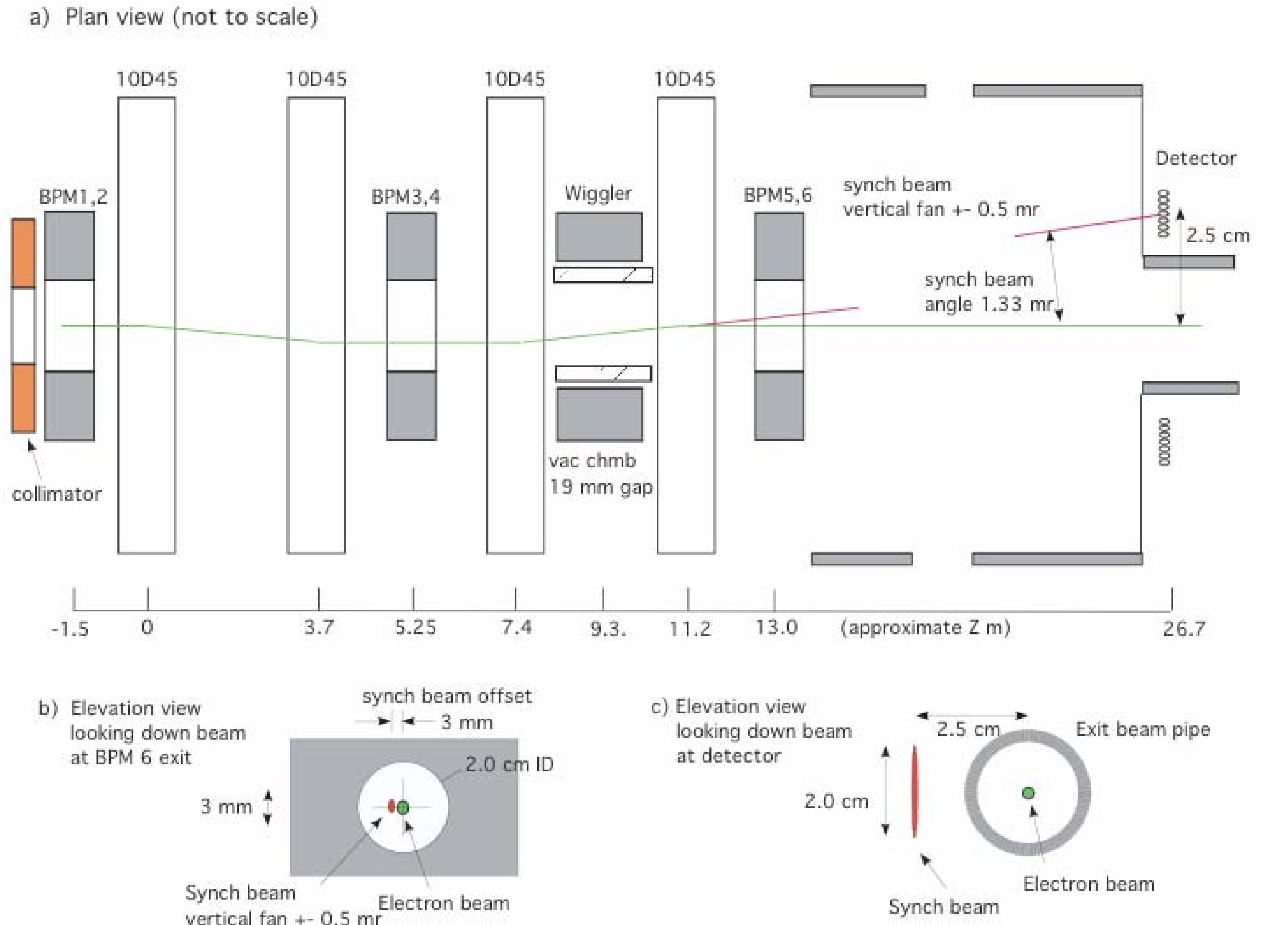


Wakefield Box

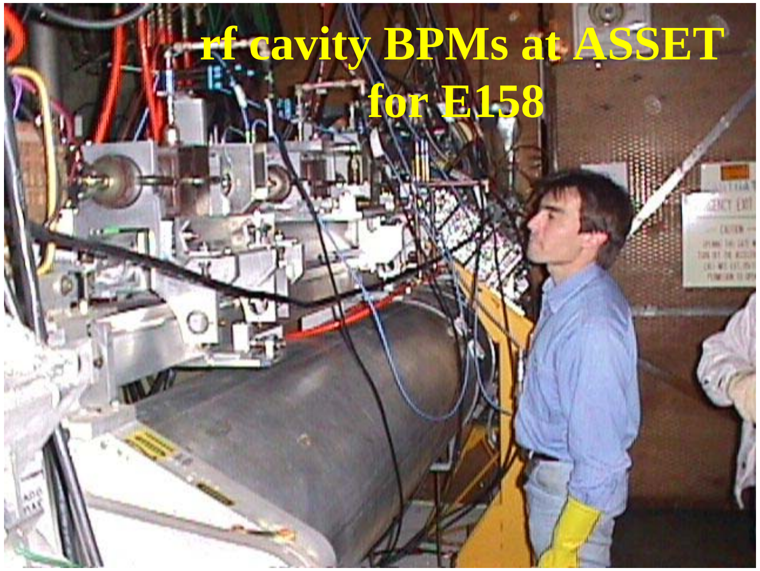
8 new collimators for 2 sandwich boxes, being fabricated in UK

T-474, T-475: Energy Spectrometers

Precision energy measurements to 50-200 parts per million are needed for Higgs boson and top quark mass measurements. BPM and synchrotron stripe spectrometers will both be evaluated in a common 4-magnet chicane.



BPMs for T-474


rf cavity BPMs at ASSET for E158

Initially, will use SLAC Linac BPMs. New electronics based on nanobpm work at KEK, being developed by UC Berkeley.

3 0.8”-diameter rf cavity BPMs moved from SLAC Linac to End Station A


rf cavity BPM

New BPMs, optimized for energy spectrometer, to be designed at University College London and in collaboration with BPM experts at SLAC and KEK

Detector Prototype for T-475

(at U. of Oregon)

Quartz fiber SR prototype

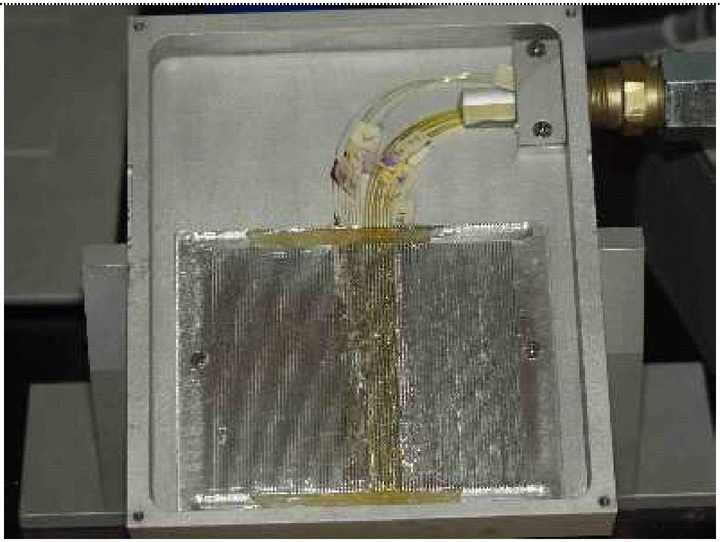
- Intrinsically fast
- E > 200 keV threshold
- Lower crosstalk
- multi-anode PMT readout
- Easy gain adjust

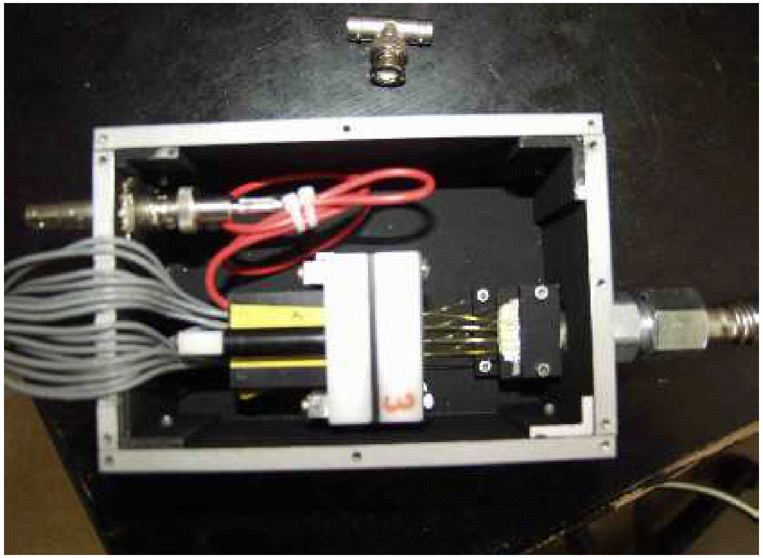
Prototype Geometry

8 x 100 µm fibers (Left)

8 x 600 µm fibers (Right)

1 mm pitch





Multi-anode PMT

Up to 64 ch. readout

Single HV input

High gain

Other Detector Possibilities

Wisrd-style wires

Diamond/silicon strips

Visible or UV imaging (CCD)

Pinhole-style imaging

Beam and Experimental Equipment

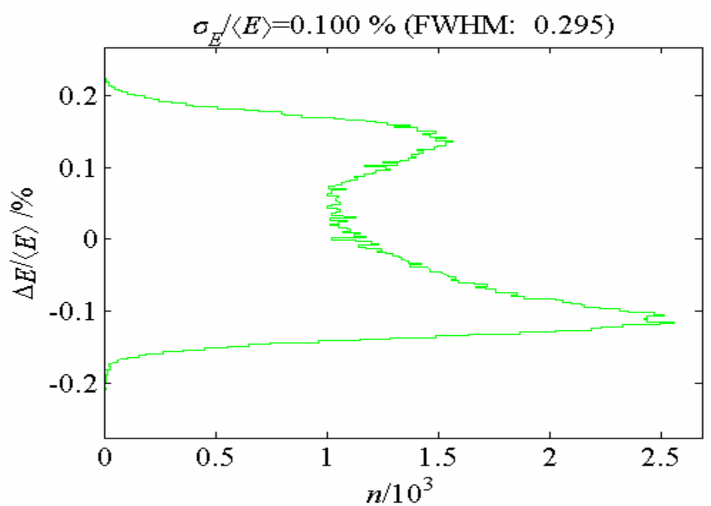
1. **Beam**
   - 28 GeV, (1-2)·10^{10} e-/pulse, 10 Hz
   - Compatible with PEP2 and BaBar, alternates with FFTB
   - Beam to Beam Dump East

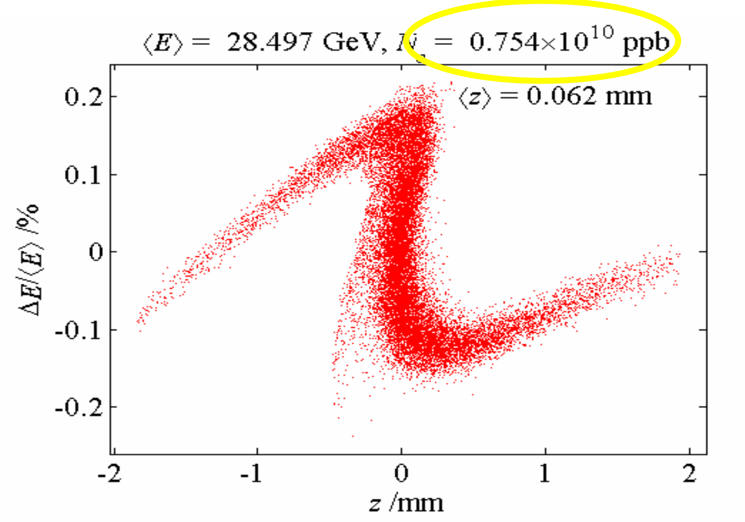
2. **Equipment**
   - Many components from SPEAR, SLC, ESA programs
   - Some new detectors, BPM's, electronics, cables, sensors, etc
   - Redesigned beamline, support stands, electronics

3. **Infrastructure**
   - Standard A-line
   - E158 huts, AC power, DC power, LCW
   - ESA alcove instrumentation (beam containment, BPM's)
   - E158 beam containment and rad protection ion chambers
   - Standard Beam Dump East systems

Simulation results for short bunches in ESA

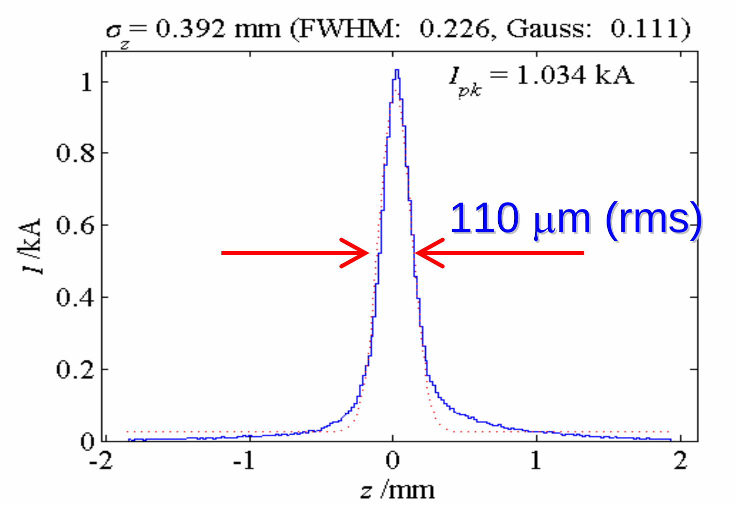
(P. Emma, SLAC)





parameters

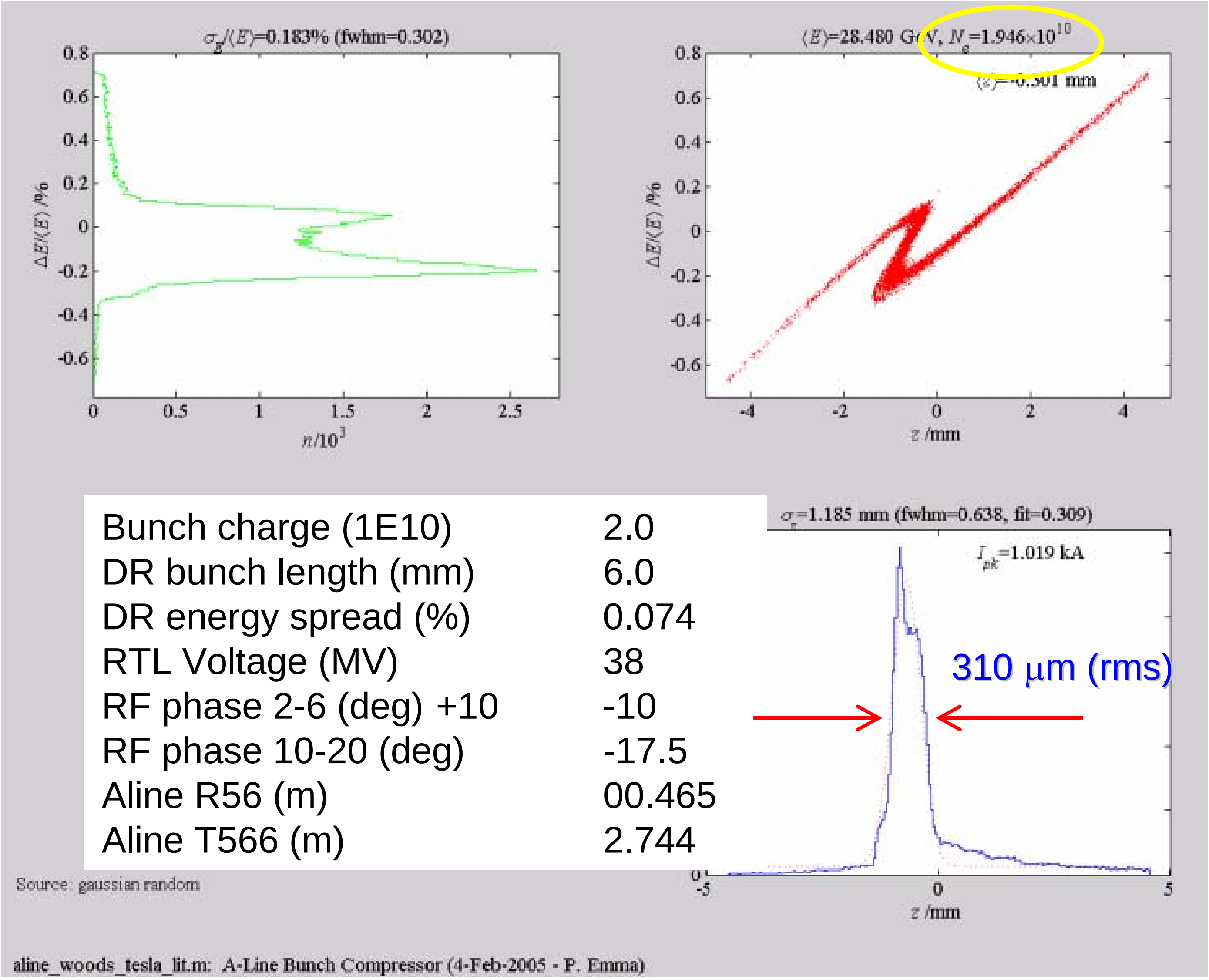
σ_z(DR) = 5 mm
σ_δ(DR) = 0.07%
V(RTL) = 39 MV
R_{56}(RTL) = 590 mm
φ(2-6) = +10 deg (BNS)
sec-10 chicane **OFF**
φ(10-20) = –9 deg (BNS)



_woods_lit.m: A-Line Bunch Compressor (4-June-2004 - P. Emma)
JL-2004 15:18:37

Simulation results for short bunches in ESA (cont.)

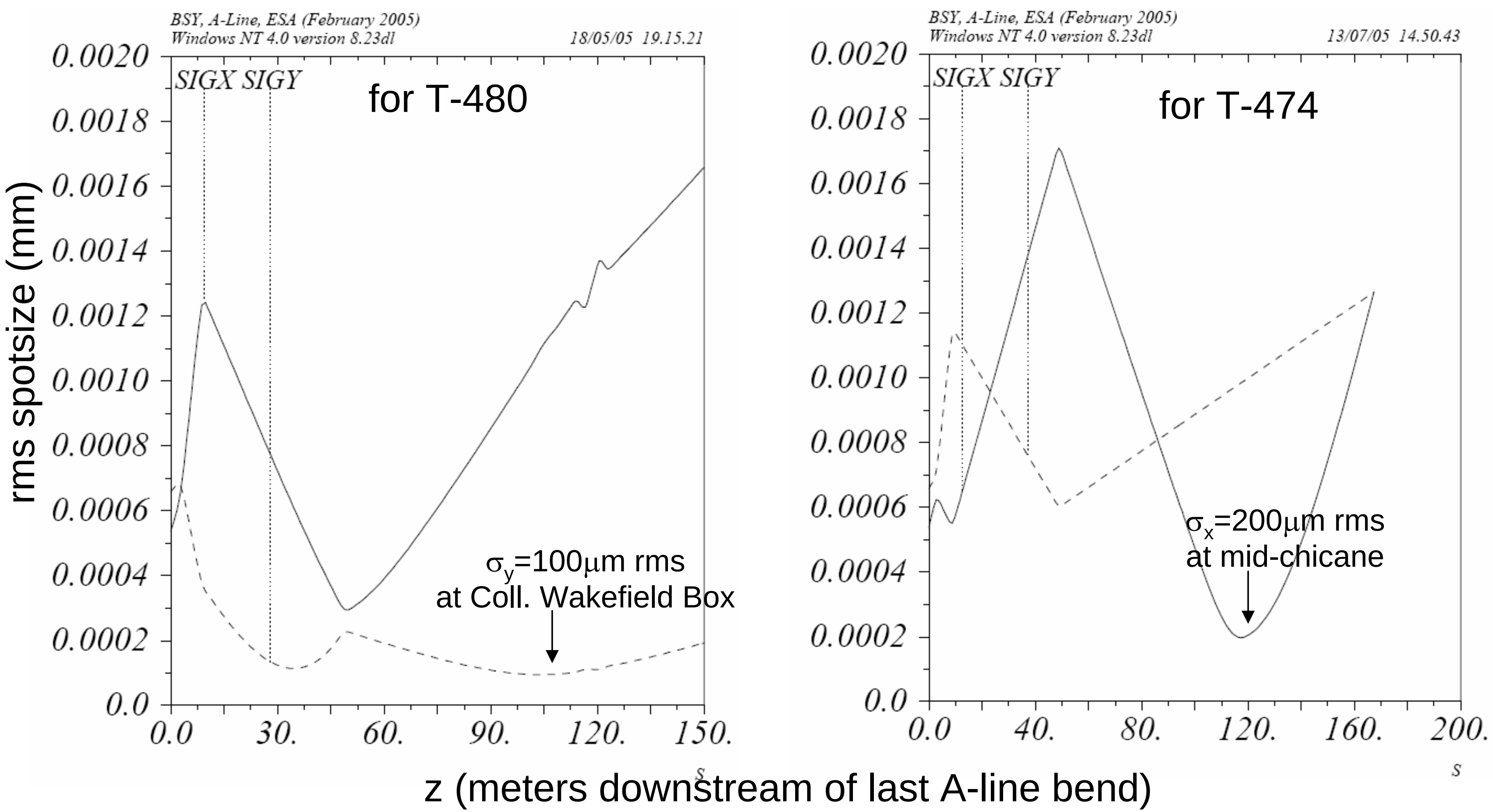
(P. Emma, SLAC)



Bunch charge (1E10)	2.0
DR bunch length (mm)	6.0
DR energy spread (%)	0.074
RTL Voltage (MV)	38
RF phase 2-6 (deg) +10	-10
RF phase 10-20 (deg)	-17.5
Aline R56 (m)	00.465
Aline T566 (m)	2.744

Simulation results for spotsizes in ESA

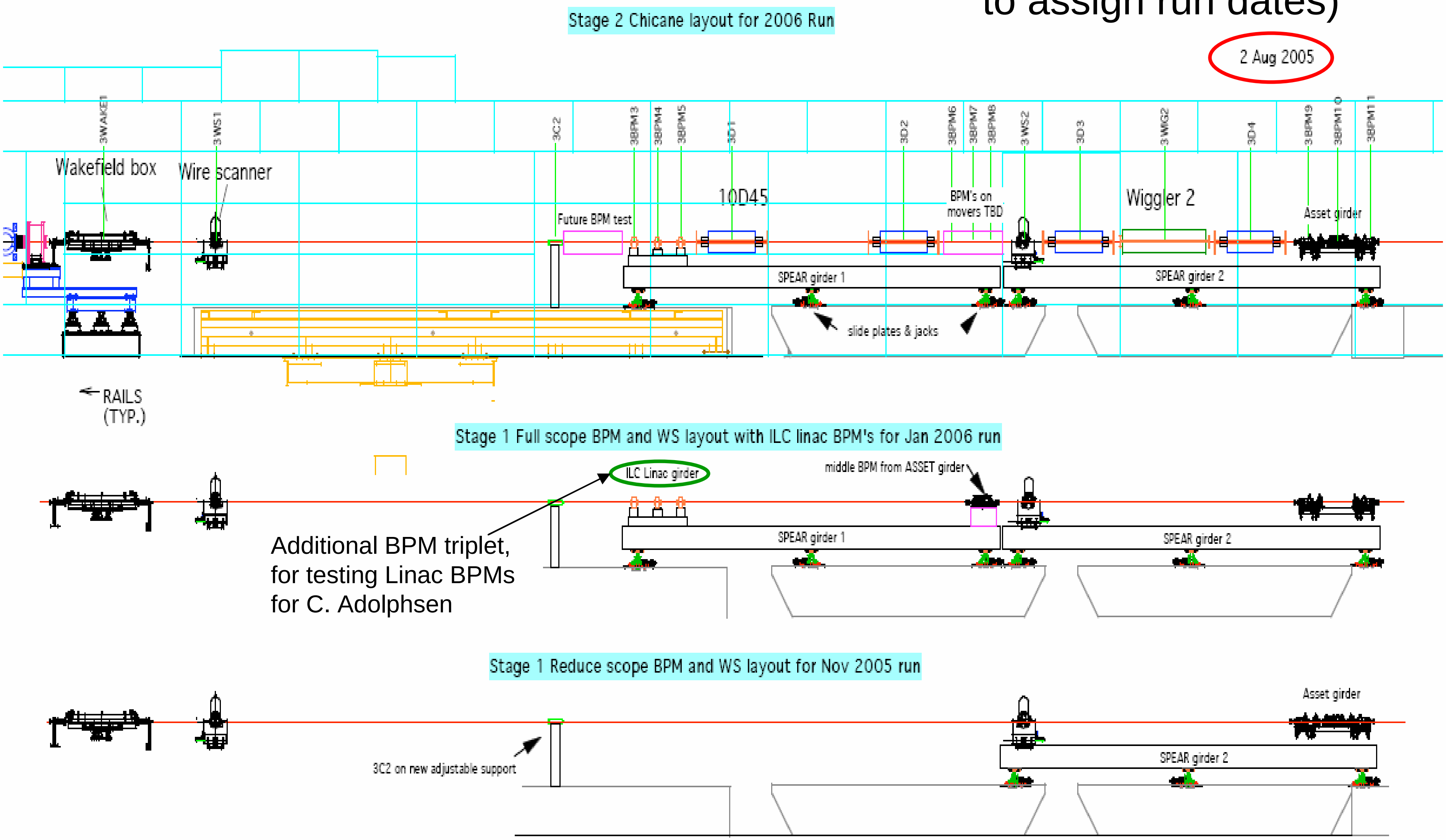
(F. Jackson, CCLRC)



International Linear Collider at Stanford Linear Accelerator Center

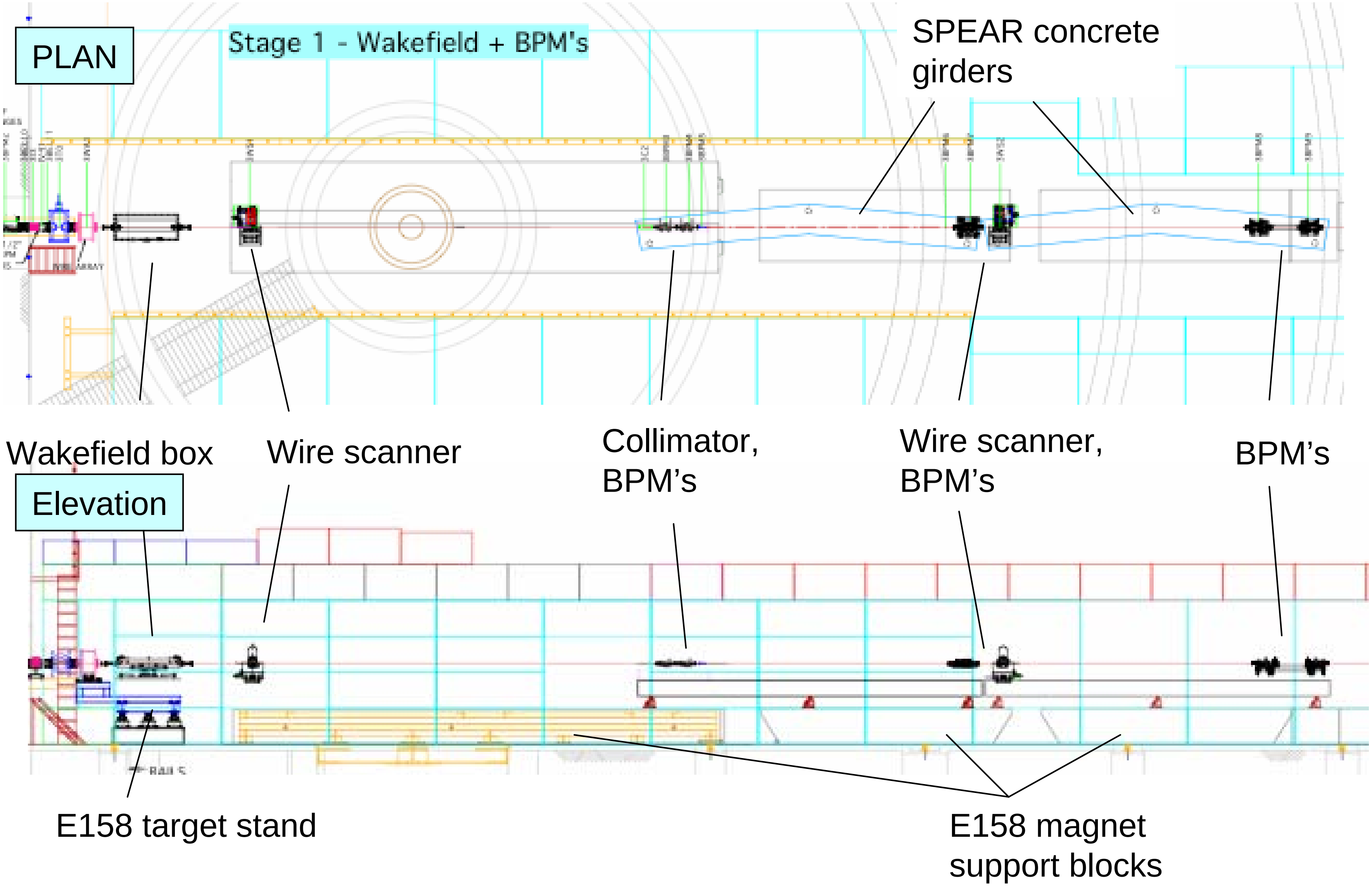
Equipment Layout **Planned**

(dates indicated are requests to SLAC; waiting for accelerator scheduling committee to assign run dates)



Equipment Layout for **Stage 1**

(no magnets)



Proposed Schedule to SLAC

Installation in two stages

Stage 1 - wakefield box, 2 wire scanners, BPM's, no magnets –
5-day checkout run in Nov. 2005;
10-day run in late January.

Stage 2 - add 4-magnet chicane, wiggler,
synchrotron light detector ~June 2006

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

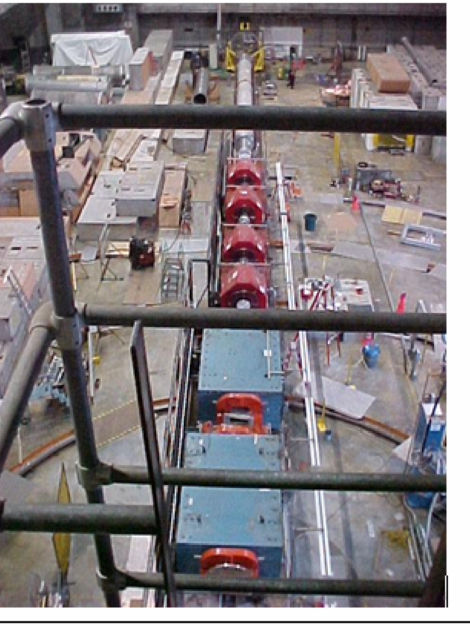
Report of the

Validation Review

of the

End Station A Restart Plan

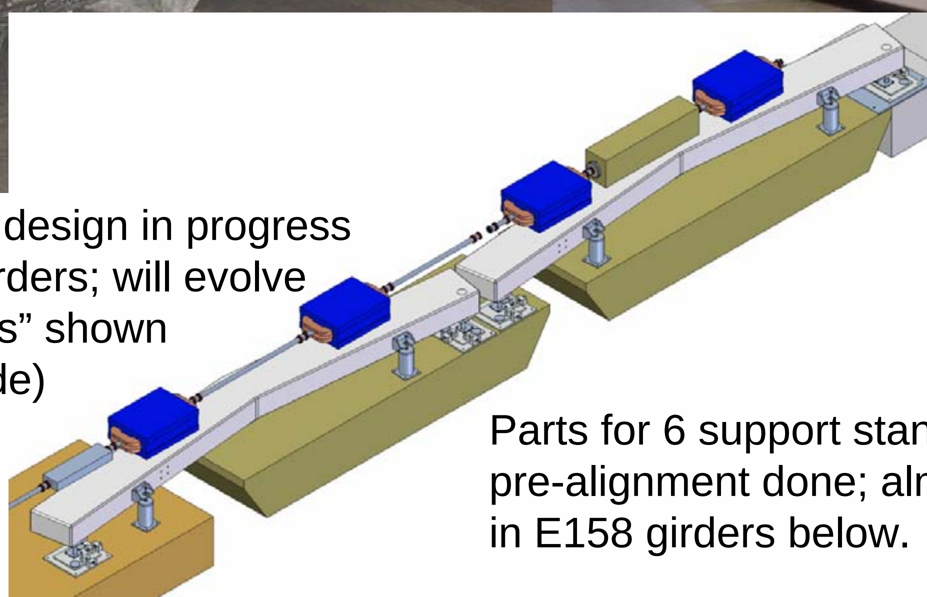
July 2005



Using (old) SPEAR girders for mounting beamline equipment

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

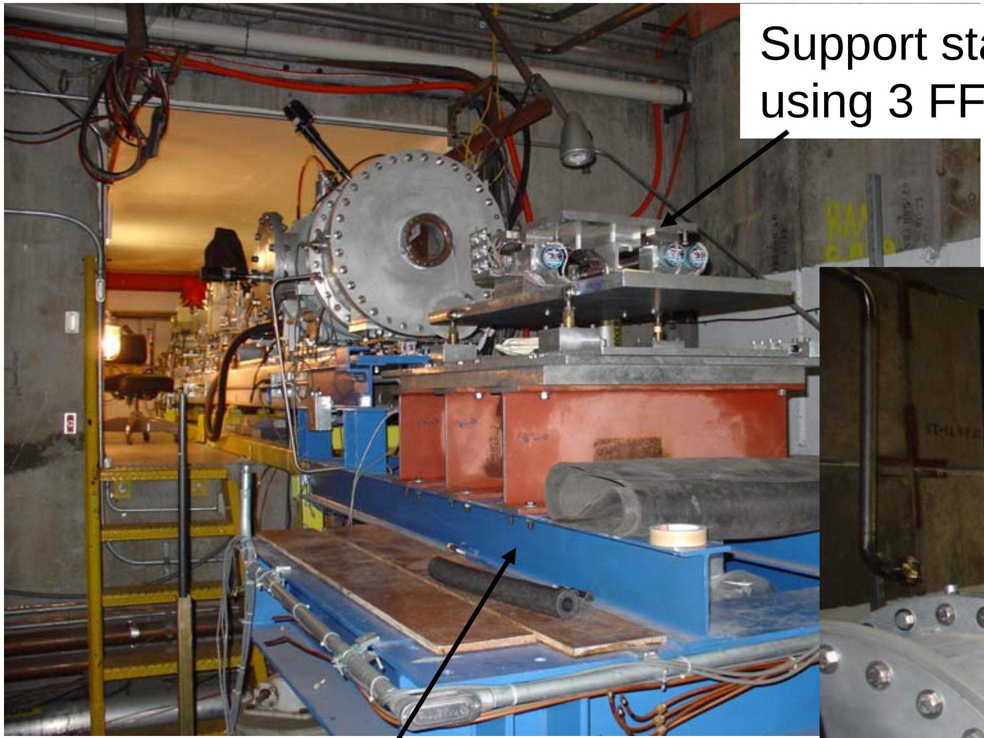
2 SPEAR girders ready for installation of beamline components; Sept. 2005



Earthquaking design in progress for SPEAR girders; will evolve from “bumpers” shown (4 on each side)

Parts for 6 support stands ready and pre-alignment done; almost ready to drill bolt holes in E158 girders below.

Support stand for Collimator Wakefield Box, using 3 FFTB movers



E158 Target stand

Inside bunker, looking east

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
   - 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

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

Other Beam Tests in ESA being discussed

1. **BPM test stations**
   - **Adolphsen's Linac bpms, 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**
3. **EMI impact on beam instrumentation or Detector electronics**
   - **Plans to characterize EMI along ESA beamline in progress using antennas and fast scopes (D. Bailey, U. of Bristol); SLD VXD3 tests?**
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