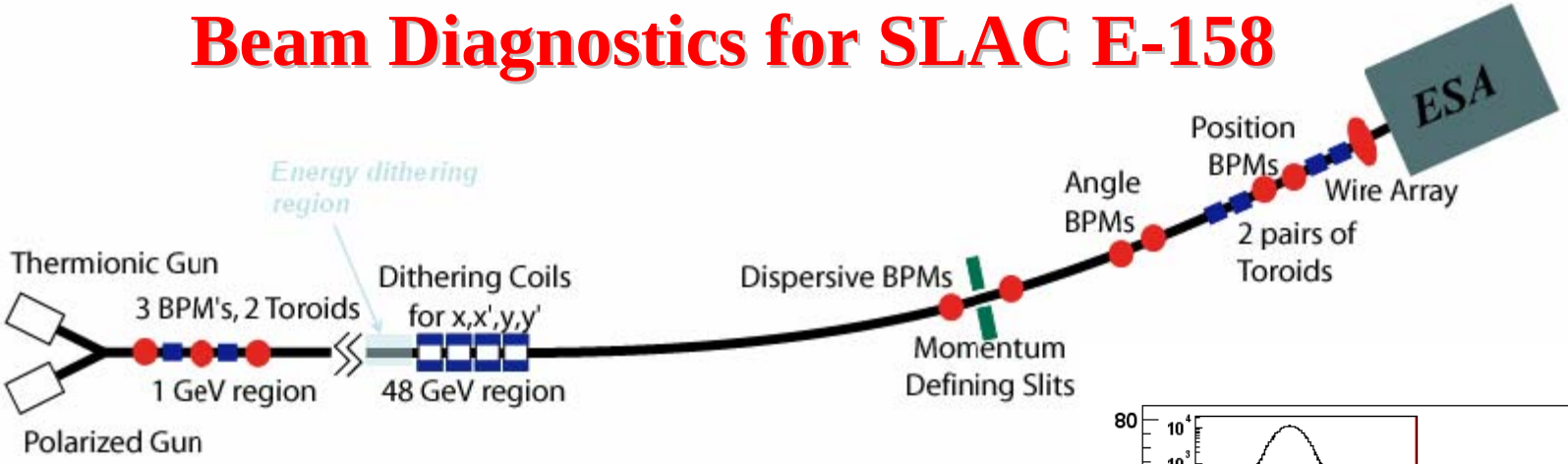
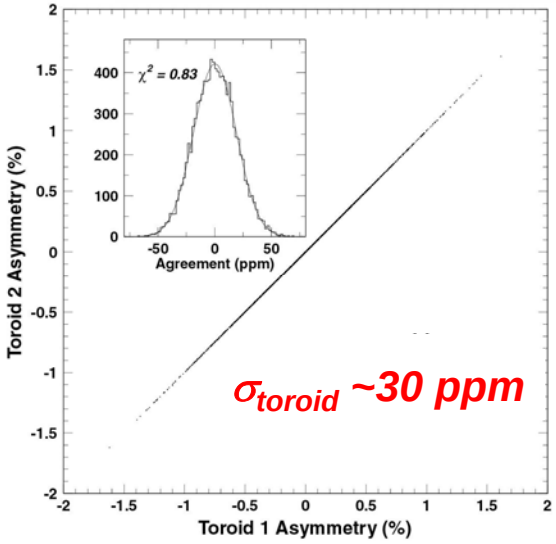
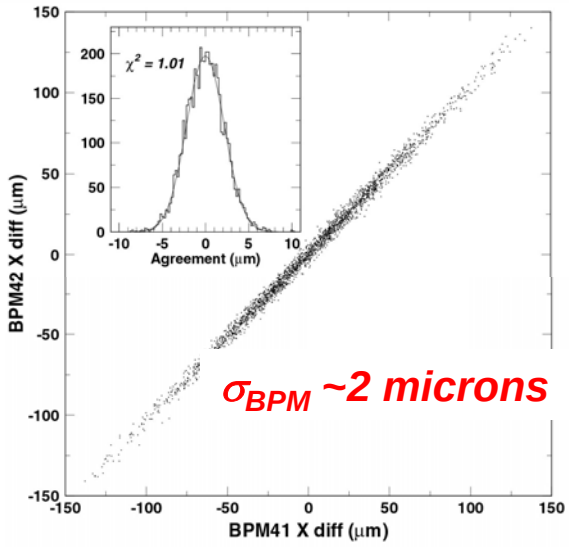
Beam Tests for Energy Spectrometers at SLAC ESA and KEK ATF

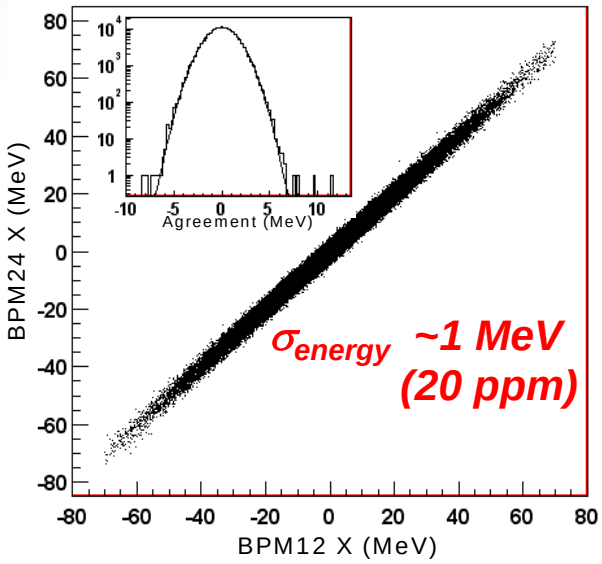
M. Woods, SLAC
Snowmass 2005

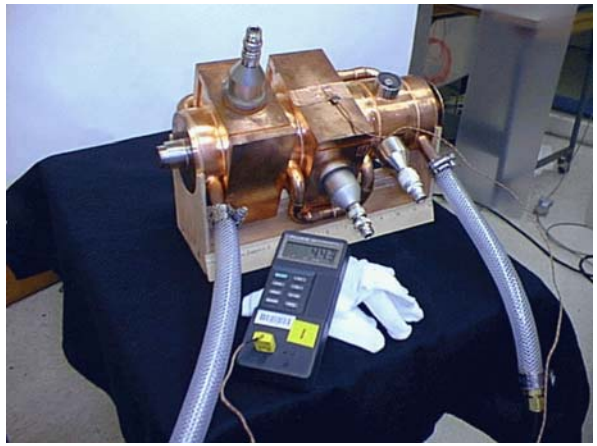
Beam Diagnostics for SLAC E-158







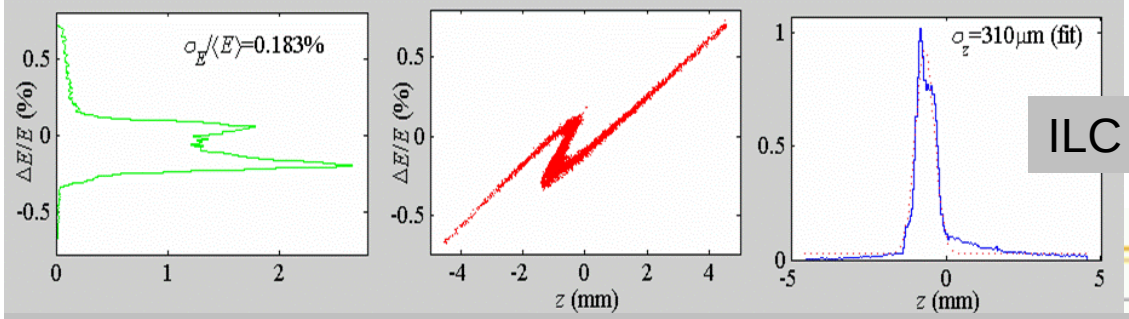




In ESA, position resolution ~ 2 microns/pulse
angle resolution ~ 0.05 μrad/pulse

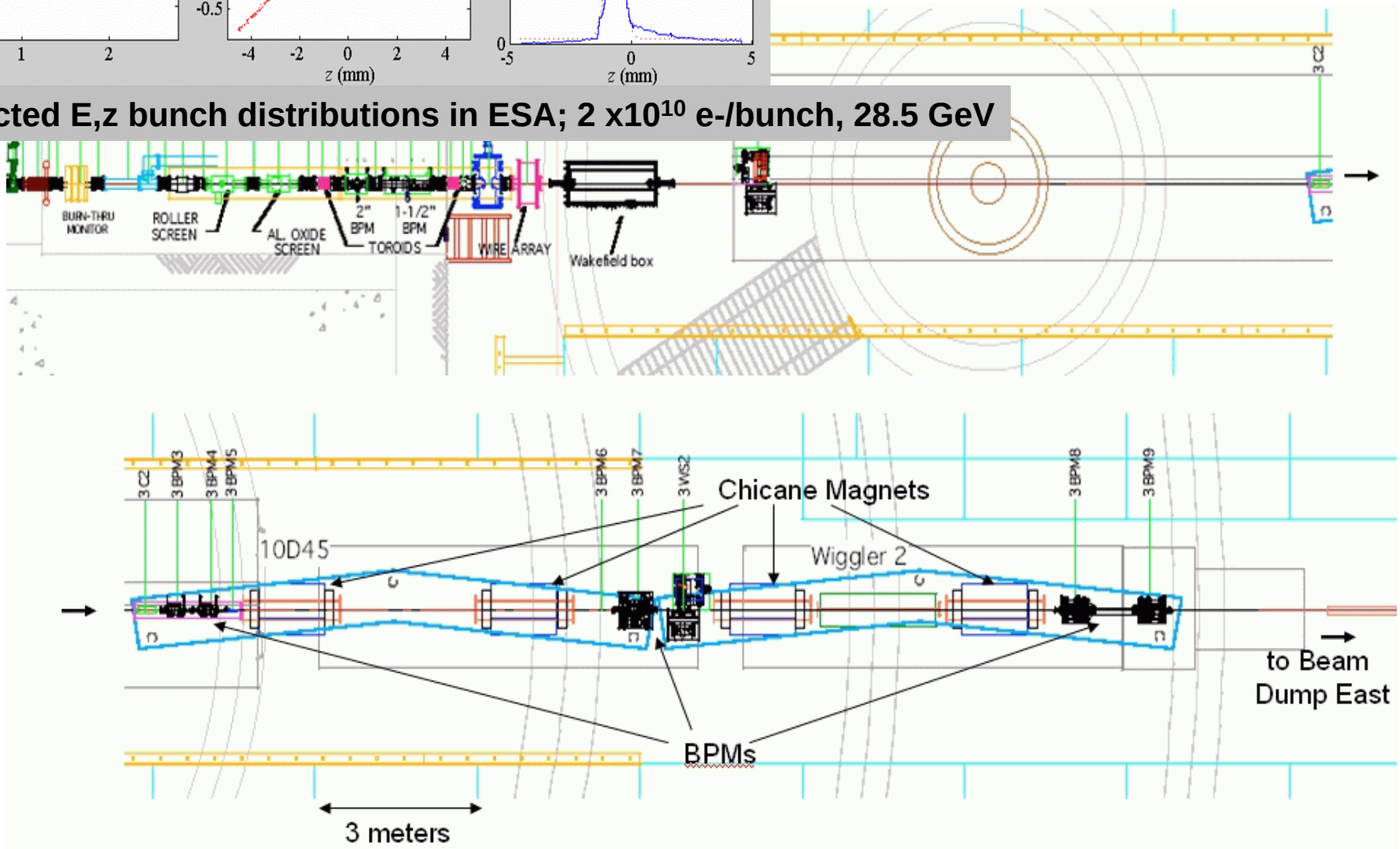
For ILC tests, plan to initially use SLAC Linac rectangular rf cavities, with 0.8” clear aperture

End Station A Test Facility

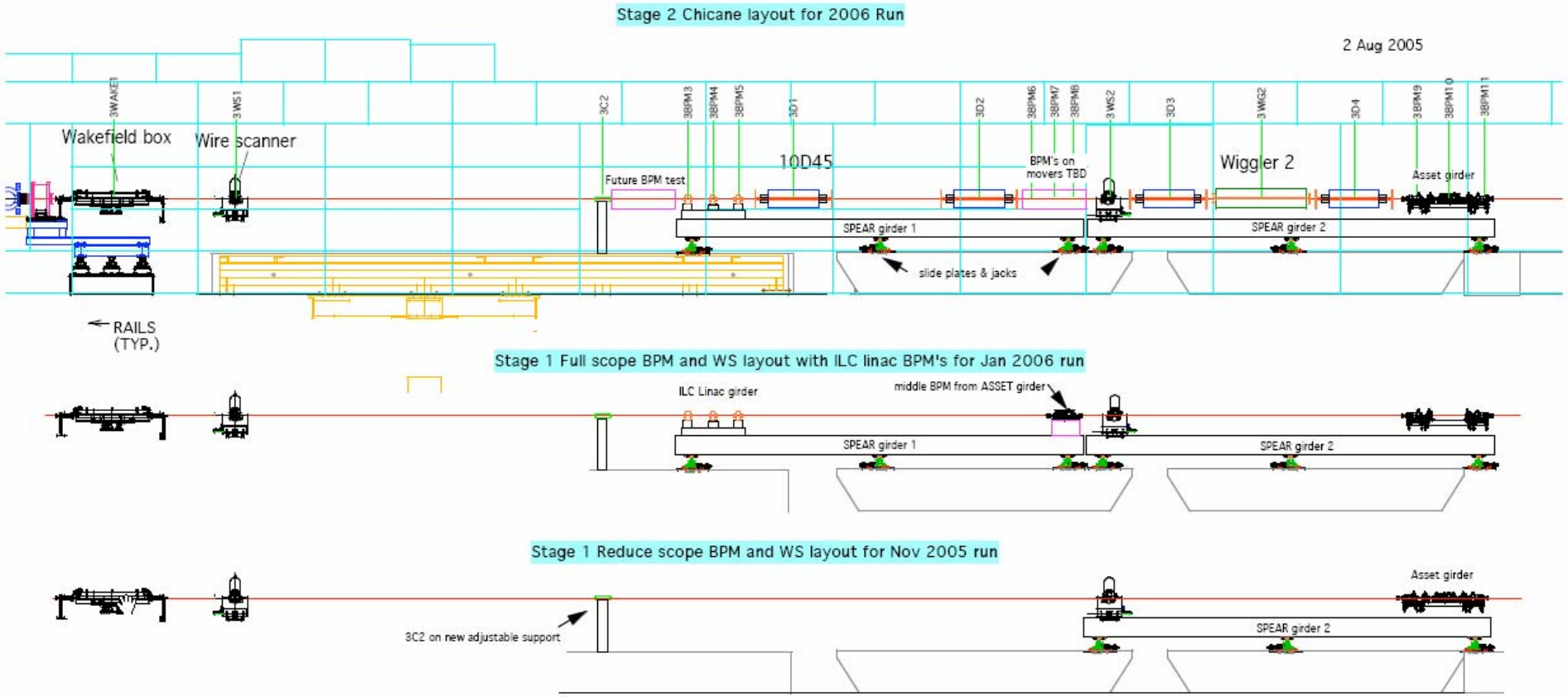


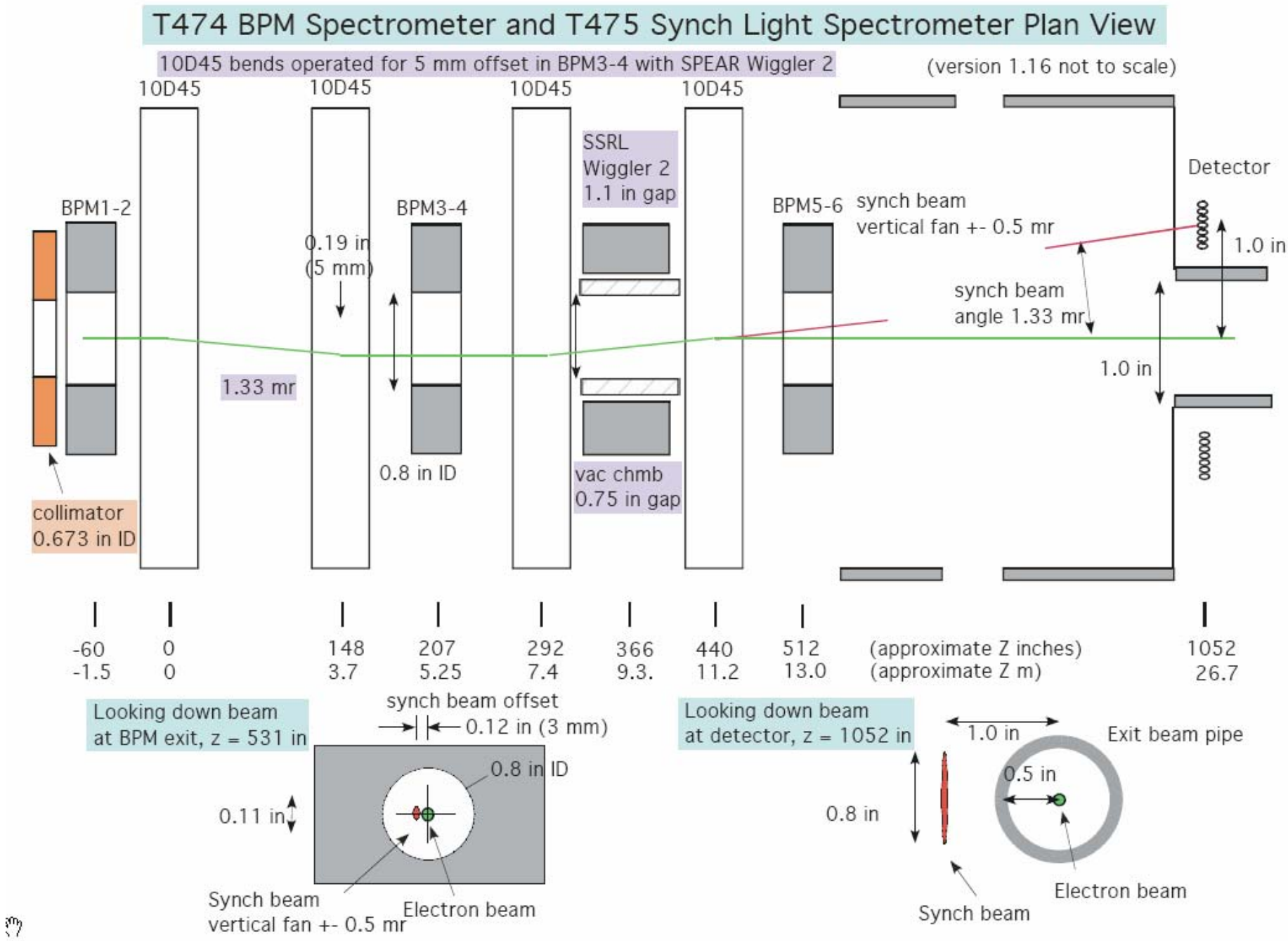
ILC bunch charge and bunch length

Predicted E,z bunch distributions in ESA; 2 x10^{10} e-/bunch, 28.5 GeV

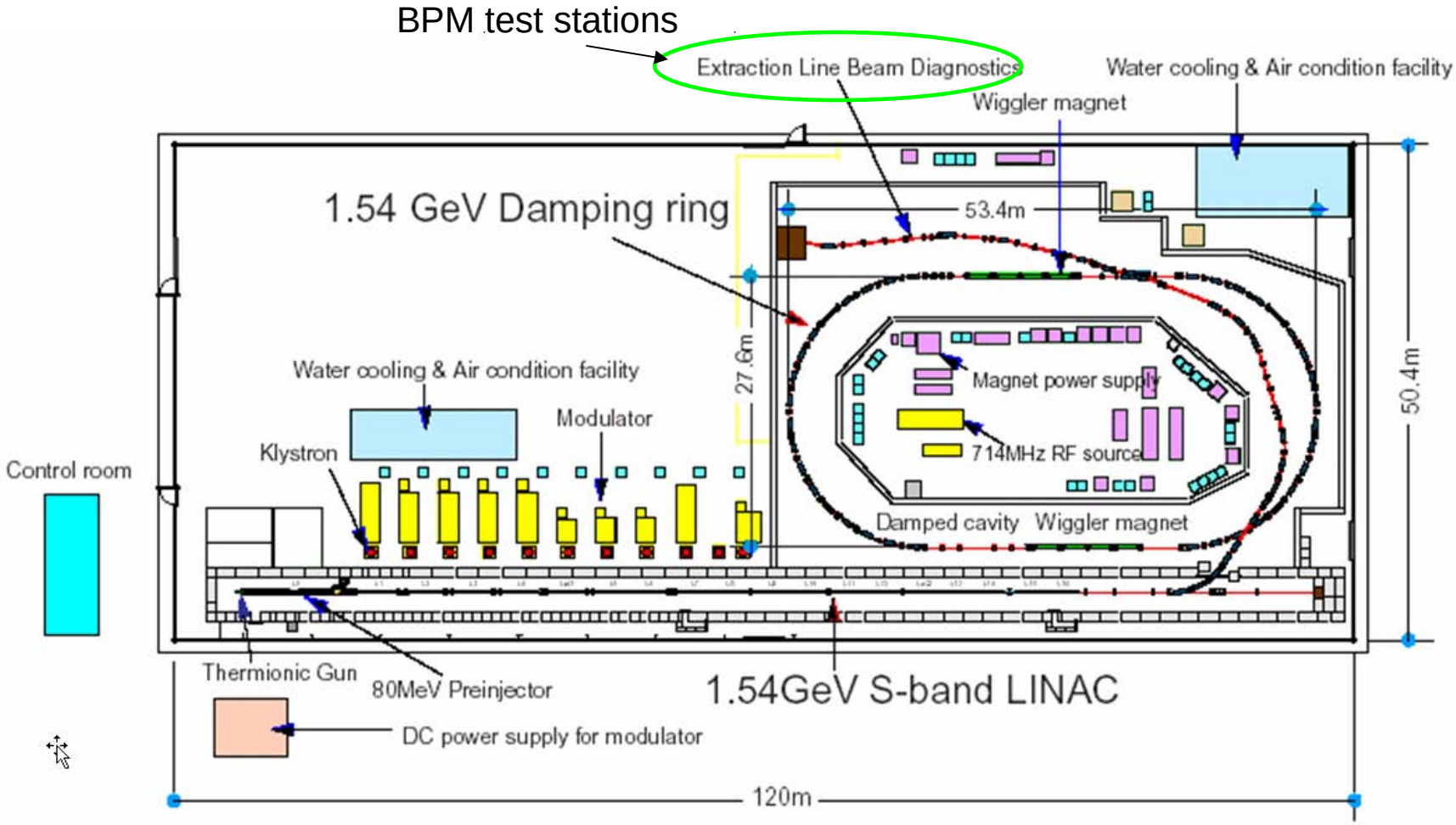


ESA Test Beam Plans in 2005-2006




T474 BPM Spectrometer and T475 Synch Light Spectrometer Plan View
10D45 bends operated for 5 mm offset in BPM3-4 with SPEAR Wiggler 2
(version 1.16 not to scale)
10D45
10D45
10D45
10D45
SSRL
Wiggler 2
1.1 in gap
Detector
BPM1-2
BPM3-4
BPM5-6
synch beam
vertical fan +- 0.5 mr
0.19 in
(5 mm)
1.0 in
synch beam
angle 1.33 mr
1.33 mr
1.0 in
0.8 in ID
vac chmb
0.75 in gap
collimator
0.673 in ID
-60
-1.5
0
0
148
3.7
207
5.25
292
7.4
366
9.3.
440
11.2
512
13.0
(approximate Z inches)
(approximate Z m)
1052
26.7
Looking down beam
at BPM exit, z = 531 in
synch beam offset
0.12 in (3 mm)
0.8 in ID
0.11 in
Synch beam
vertical fan +- 0.5 mr
Electron beam
Looking down beam
at detector, z = 1052 in
1.0 in
Exit beam pipe
0.5 in
0.8 in
Electron beam
Synch beam

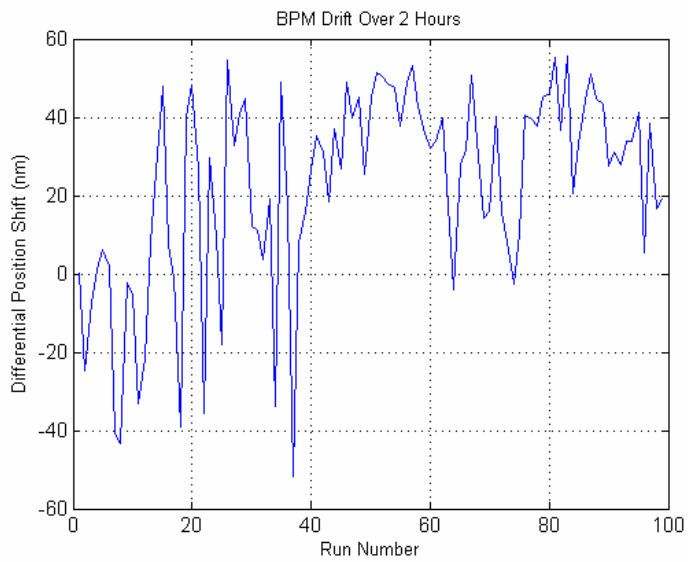
Test Facility at KEK ATF

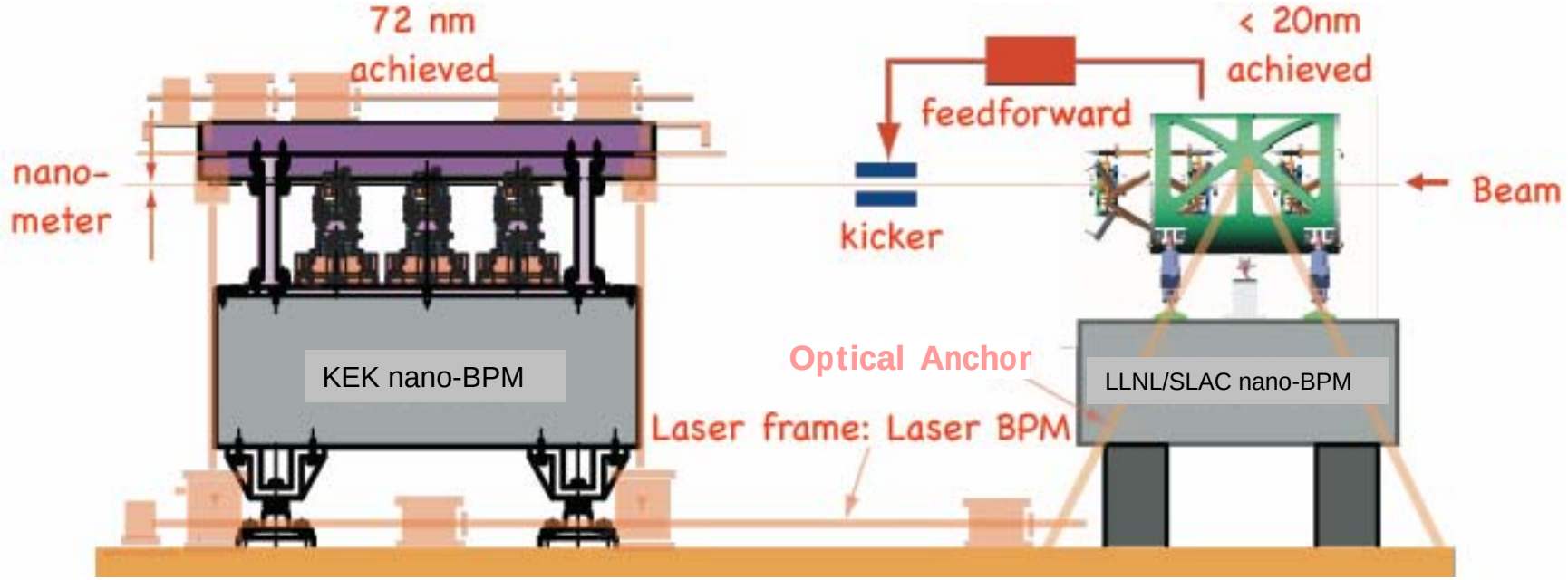


Test Facility at KEK ATF

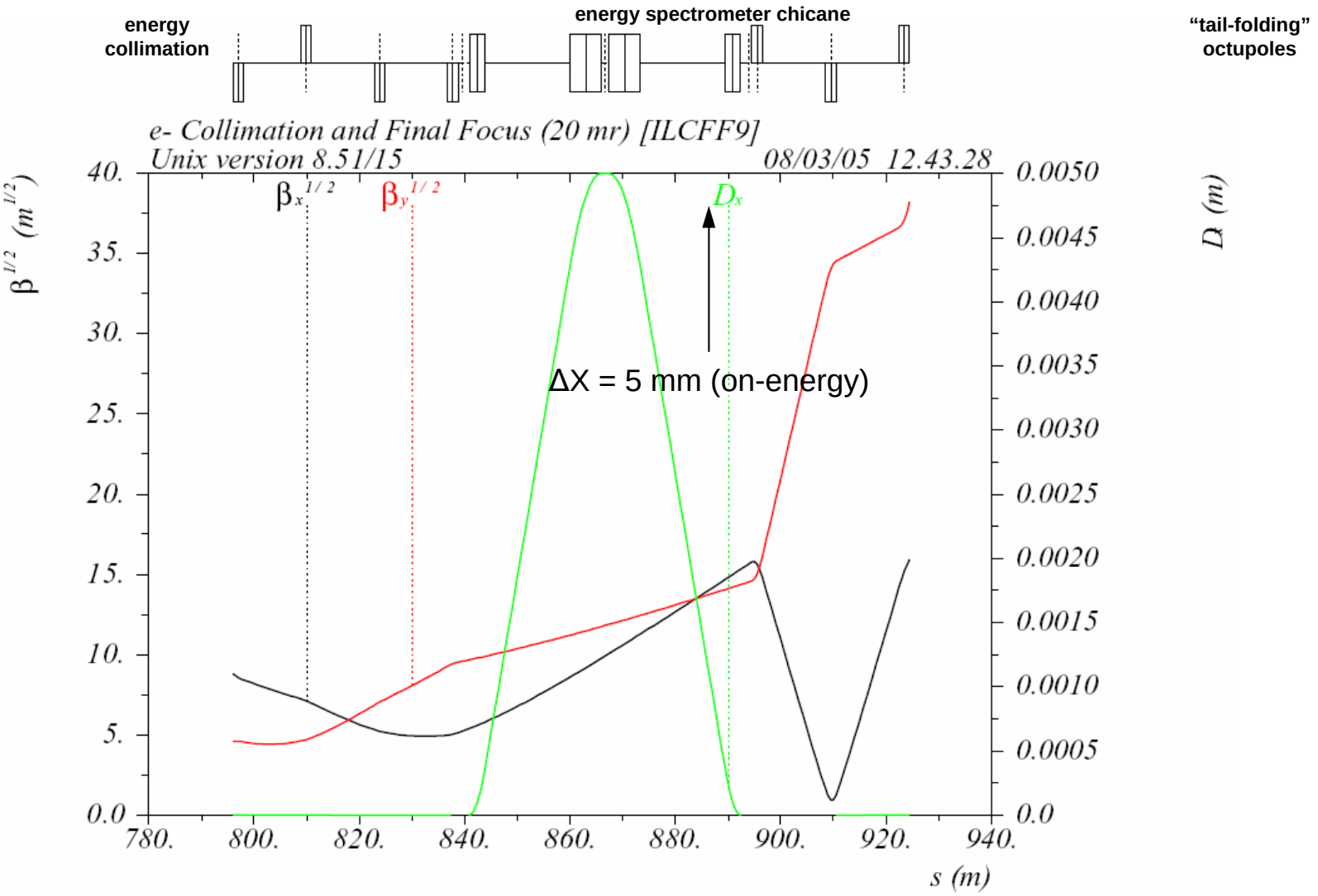
Nano-BPMs for spectrometer studies in extraction line

- two pairs of BPM triplets
- optical straightness monitor under development
- stability tests underway



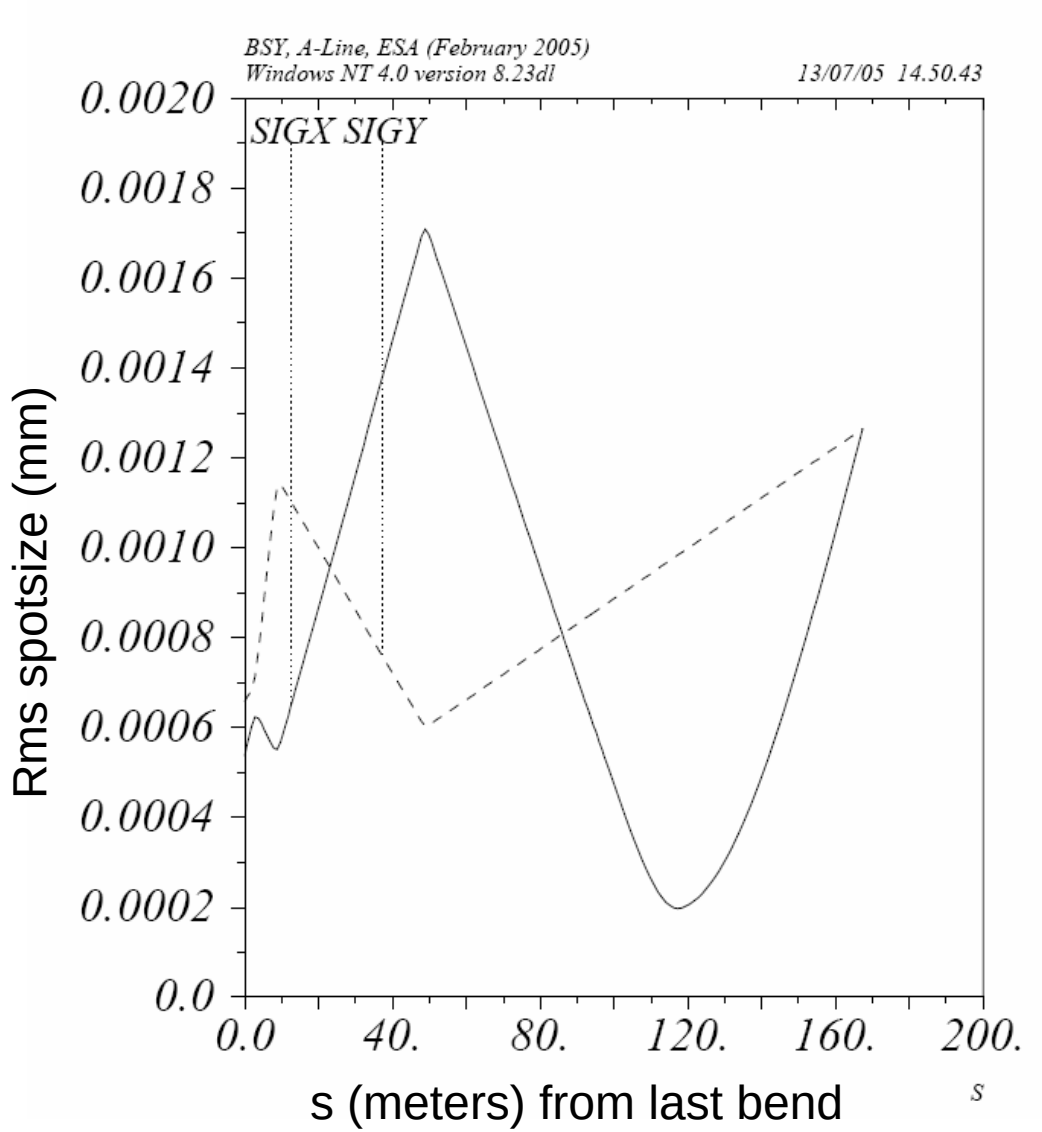


Beta functions and Dispersion for ILC BPM energy chicane



-~factor 3 in horizontal spotsize (σ_x ~10-30 microns) over 50-meter length of chicane; sensitivity to bunch shape changes?

Spotsizes in ESA for energy spectrometer studies



ESA energy chicane is from ~112-125 meters.

Can shift xwaist location to study effect of x2-3 change in x spotsize over chicane.

Beam Test programs (with initial focus on BPM spectrometer)

1. BPM resolution already demonstrated
   - for 5mm dispersion at mid-chicane, 500nm resolution gives 100ppm/bunch or 1ppm/sec
   - BPMs should have dynamic range of +-500μm; want to center bpms to 50 μm
2. BPM stability
   - Need to demonstrate <500nm stability of horizontal BPM offsets over length of spectrometer (20-50 meters) over timescales corresponding to calibration timescale (10 minutes?)
   - Stability of electronics as well as mechanical stability needed; distinguish by having pairs or triplets of bpms at pre-chicane, mid-chicane and post-chicane
   - Monitoring BPM offsets wrt straight line – optical and beam-based msmts
   - **Relative BPM offsets of mid-chicane bpms (or middle bpm in short triplet) should not depend on bunch charge, bunch length, bunch tilt, bunch shape, electronics gain, halo -- need to study effects varying these**
3. Stability of magnet Bdl and stray fields
   - Over calibration timescale
   - Stray fields stable when chicane polarity is changed? (need to worry about magnetic materials nearby)

Beam Test programs (cont.)

4. BPM calibration
   - Use mover with optical encoder with 10ppm accuracy;
   - Can use mover on one BPM to calibrate it and then bootstrap to calibrating other bpms using a corrector and known lever arms
   - do BPMs give reliable measurements during move?
   - How often is BPM calibration needed? Electronics stability; temperature
   - Can do fast 100-micron moves for BPM calibration in between spectrometer calibrations
5. SR stripe detector commissioning
   - Initially commission prototype detector in A-line at the SLM (synchrotron light monitor) port to demonstrate signal response in fibers to synchrotron light from 28.5 GeV electrons
6. Spectrometer calibration

   reverse polarity of chicane; move BPMs to recenter them – optical encoder on BPM mover and knowledge of Δ(Bdl) gives beam energy after corrections for any beam trajectory change
   - Are energy measurements possible when spectrometer magnets are being ramped and bpms are simultaneously moved?
   - How frequently does spectrometer need calibration?
   - How quickly can calibration be done?

Beam Test programs (cont.)

6. ESA Spectrometer tests
   - 4-magnet chicane common to BPM and SR stripe spectrometers
   - Choose dipole B-fields and dispersion at mid-chicane same as ILC
   - Energy jitter measurements
     - compare results from BPM and SR spectrometers and A-line high dispersion (500mm) BPMs, which should have <100ppm resolution
   - Energy beam dithering measurements
     - dither beam energy at end of Linac, and compare results from BPM and SR spectrometers and A-line BPMs; repeat this study for different beam trajectories thru spectrometer; also repeat for different bunch charge, bunch length, bunch shape, electronics gain, halo
   - Trajectory beam dithering measurements
     - dither beam trajectory at end of Linac, leaving energy unchanged
     - compare results from BPM and SR spectrometers and A-line BPMs; repeat this study for different beam trajectories thru spectrometer; also repeat for different bunch charge, bunch length, bunch shape, electronics gain, halo