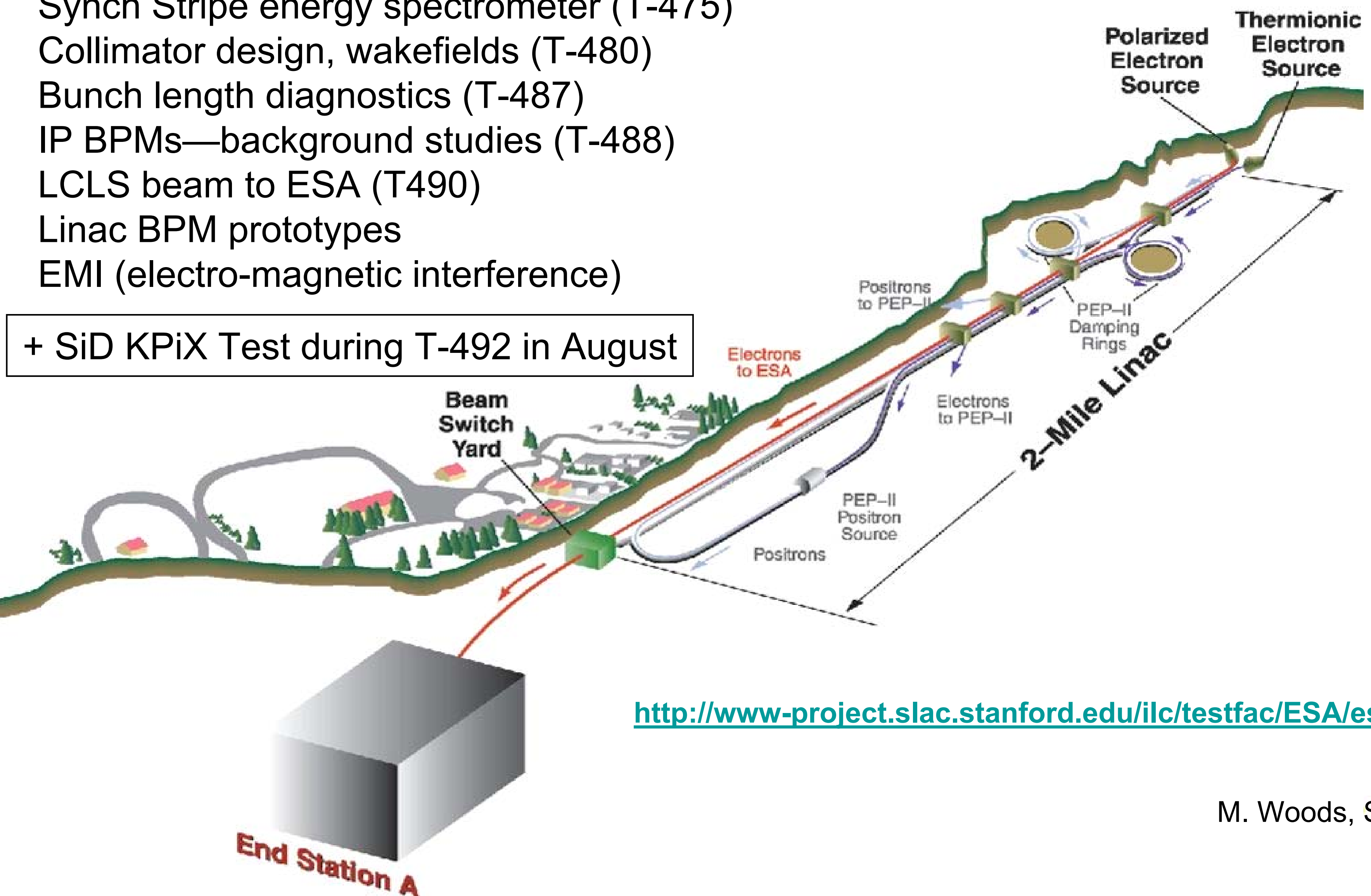
ILC Beam Tests in End Station A

ALCPG Meeting, September 6, 2007

BPM energy spectrometer (T-474/491)
Synch Stripe energy spectrometer (T-475)
Collimator design, wakefields (T-480)
Bunch length diagnostics (T-487)
IP BPMs—background studies (T-488)
LCLS beam to ESA (T490)
Linac BPM prototypes
EMI (electro-magnetic interference)

+ SiD KPiX Test during T-492 in August



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

M. Woods, SLAC

ESA Program and the ILC

Machine-Detector Interface at the ILC

- Impact of ILC Parameters on Detector design and Physics reach
- Impact of Detector designs on ILC design and parameters
  - (L,E,P) measurements: Luminosity, Energy, Polarization
  - Forward Region Detectors
  - Collimation and Backgrounds
  - IR Magnets, Crossing Angle
  - EMI (electro-magnetic interference) in IR

MDI-related Experiments at SLAC's End Station A

- Collimator Wakefield Studies (T-480)
- Energy spectrometer prototypes (T-474/491 and T-475)
- IR background studies for IP BPMs (T-488)
- EMI studies

Beam Instrumentation Experiments in ESA

- Rf BPM prototypes for ILC Linac (part of T-474)
- Bunch length diagnostics for ILC (includes T-487)

ILC Beam Tests in End Station A

6 test beam experiments approved: **T-474, T-475, T-480, T-487, T-488, T-490**

2006 Runs:

i. January 5-9 commissioning run
ii. April 24 – May 8, Run 1
iii. July 7-19, Run 2

2007 Runs:

i. March 7-26, Run 3
ii. July 5-8, T490 w/ LCLS beam
iii. July 9-25, Run 4

+ requesting two runs in FY08

Some References

ILC-ESA Overview:

- *Test Beam Studies at SLAC End Station A for the International Linear Collider*, M. Woods et al., SLAC-PUB-11988, EUROTEV-REPORT-2006-060, contributed to European Particle Accelerator Conference (EPAC 06).

T-474 BPM Energy Spectrometer:

- *A prototype energy spectrometer for the ILC at end station A in SLAC*, A. Lyapin *et al.*, EUROTEV-REPORT-2007-039, Contributed to Particle Accelerator Conference (PAC 07).
- *Magnetic Measurements and Simulations of a 4-Magnet Dipole Chicane for the International Linear Collider,.* S. Kostromin et al., Paper THPMS038 contributed to PAC 07.

T-480 Collimator Wakefields:

- *Measurements of the Transverse Wakefields Due to Varying Collimator Characteristics*, S. Molloy et al., SLAC-PUB-12597, Contributed to PAC 07.
- *GdfidL Simulations of Non-Linear Tapers for ILC Collimators*, J.D.A. Smith, Paper TUPMS092 contributed to PAC 07.
- *Computations of Wakefields in the ILC Collimators*, J. D.A. Smith and C.J. Glasman, Paper TUPMS093 contributed to PAC 07.

T-488 Electromagnetic Backgrounds:

- *Simulation of ILC feedback BPM signals in an intense background environment,* A. Hartin *et al.*, EUROTEV-REPORT-2007-041, Contributed to Particle Accelerator Conference (PAC 07).
- *Electromagnetic background tests for the ILC interaction-point feedback system,* P.N. Burrows *et al.*, SLAC-PUB-12758, EUROTEV-REPORT-2007-031, contributed to PAC 07.

Bunch Length Diagnostics:

- *Picosecond Bunch length and Energy-z correlation measurements at SLAC's A-Line and End Station A,* S. Molloy et al., SLAC-PUB-12598, contributed to PAC 07.

EMI Studies:

- *Disruption of Particle Detector Electronics by Beam Generated EMI*, G. Bower et al., SLAC-PUB-12613, contributed to PAC 07.

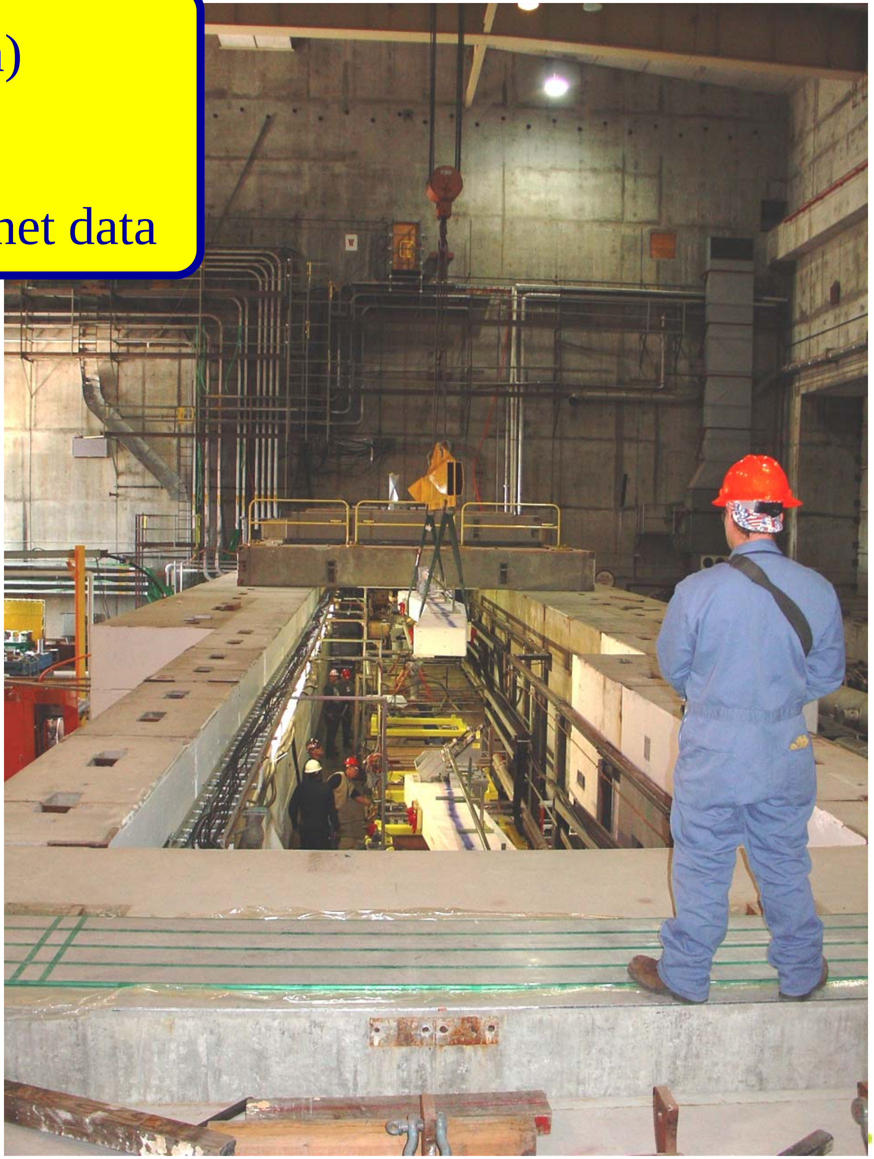
Beam Parameters at SLAC ESA and ILC

Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
Bunch Charge	1.6×10^{10}	2.0×10^{10}
Bunch Length	300-500 μm	300 μm
Energy Spread	0.2%	0.1%
Bunches per train	1 (2*)	2820
Microbunch spacing	- (20-400ns*)	337 ns

*possible, using undamped beam

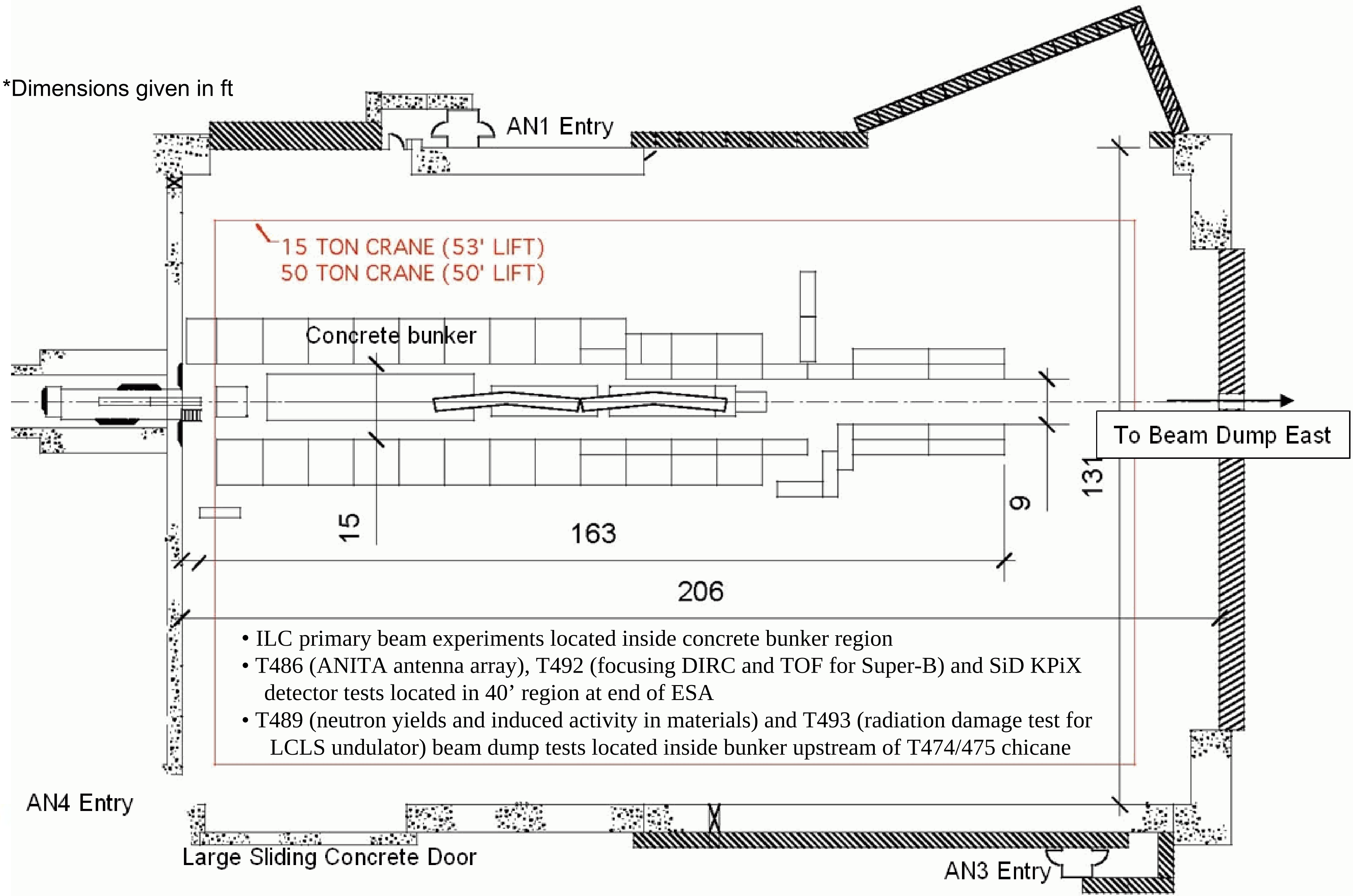
End Station A (ESA)

- ESA is large (60m x 35m x 20m)
- 50/10 t crane
- Electrical power, cooling water
- DAQ system for beam and magnet data



End Station A Facility and Experimental Layout in 2006-08

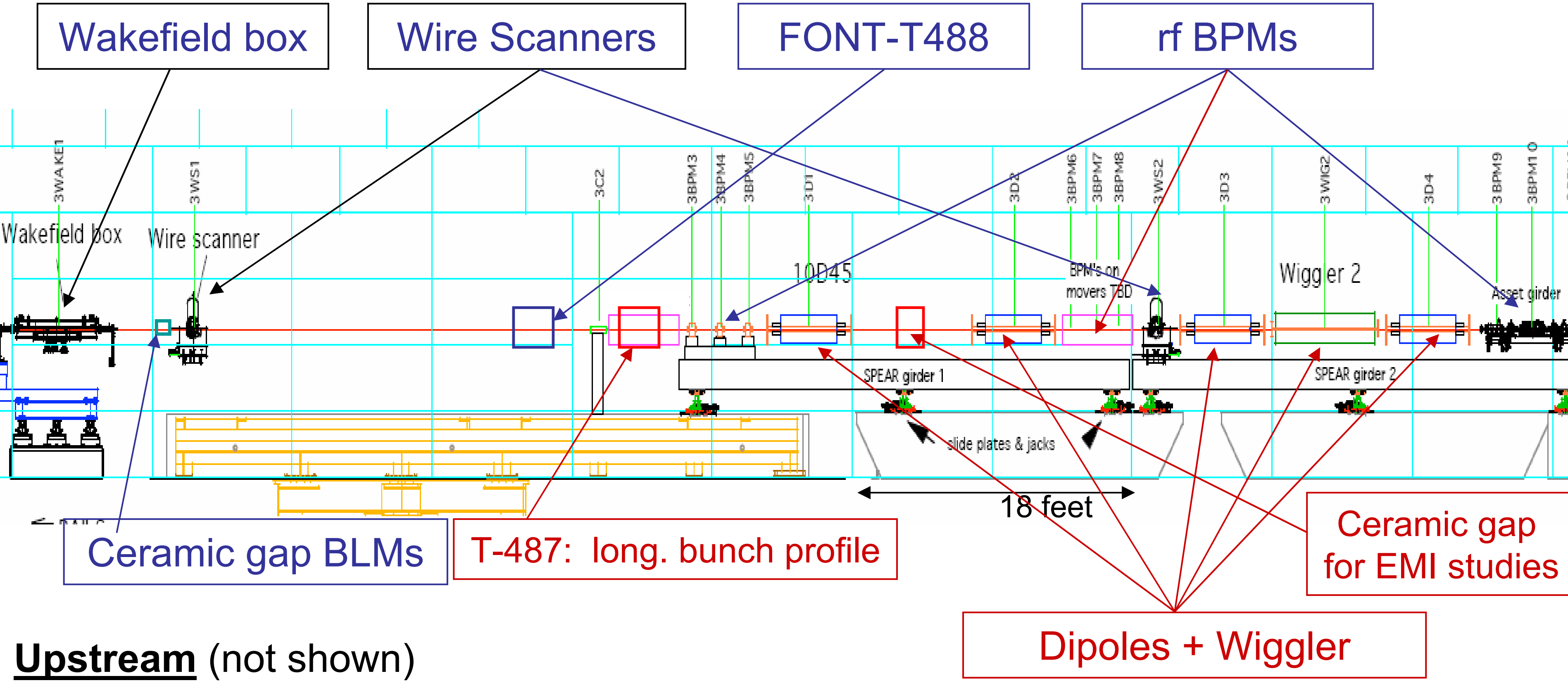
*Dimensions given in ft



- ILC primary beam experiments located inside concrete bunker region
- T486 (ANITA antenna array), T492 (focusing DIRC and TOF for Super-B) and SiD KPiX detector tests located in 40' region at end of ESA
- T489 (neutron yields and induced activity in materials) and T493 (radiation damage test for LCLS undulator) beam dump tests located inside bunker upstream of T474/475 chicane

ESA Equipment Layout

blue=FY06
red=new in FY07



Upstream (not shown)

4 rf BPMs for incoming trajectory
Ceramic gap w/ rf diode detectors (16GHz, 23GHz, and 100GHz) and 2 EMI antennas

Downstream (not shown)

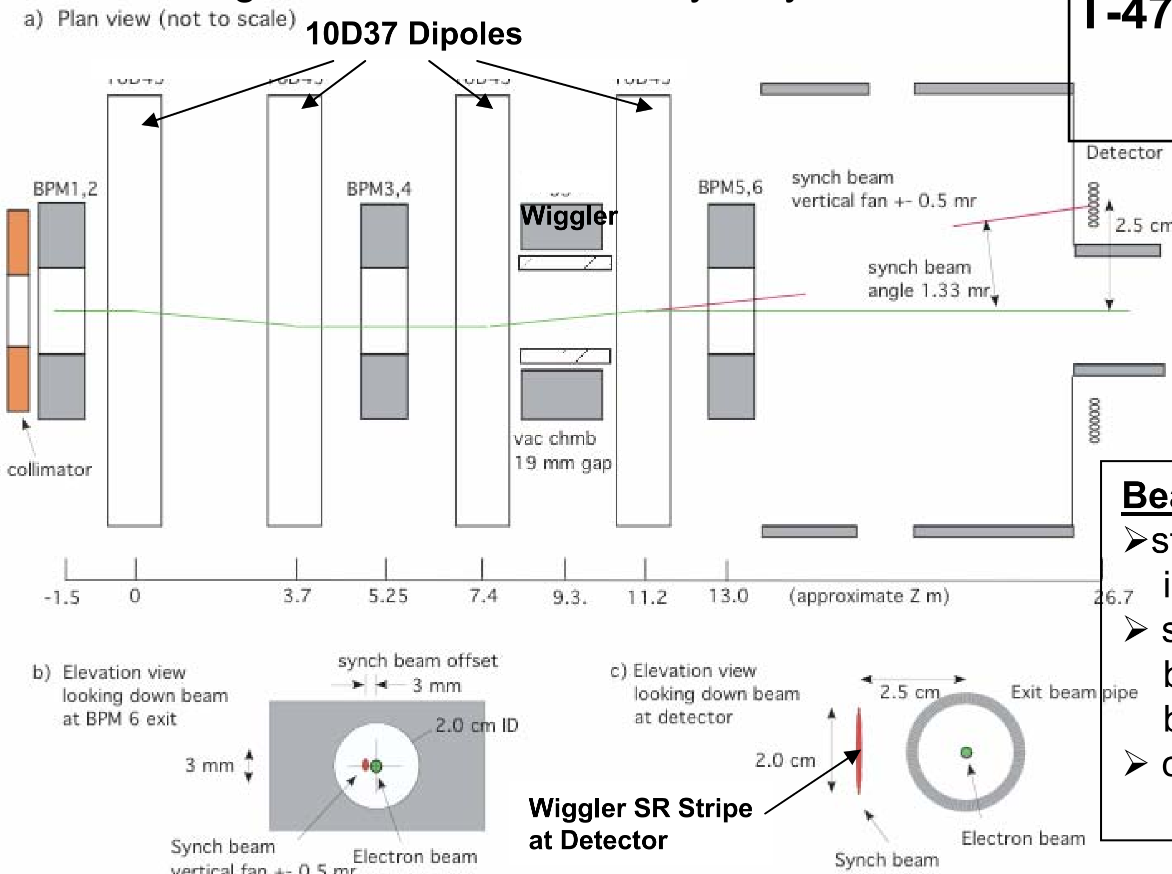
T475 Detector for Wiggler SR stripe

T-474, T-475: Energy Spectrometers

- Precision energy measurements, 50-200 parts per million, needed for Higgs boson and top quark mass msmts
- BPM (T-474) & synch. stripe (T-475) spectrometers will be evaluated in a common 4-magnet chicane.
- These studies address achieving the ILC precise energy measurement goals: resolution, stability & systematics

T-474 BPM Energy Spectrometer Collaborators:
U. Cambridge, DESY, Dubna, Royal Holloway, SLAC, UC Berkeley, UC London, U. of Notre Dame

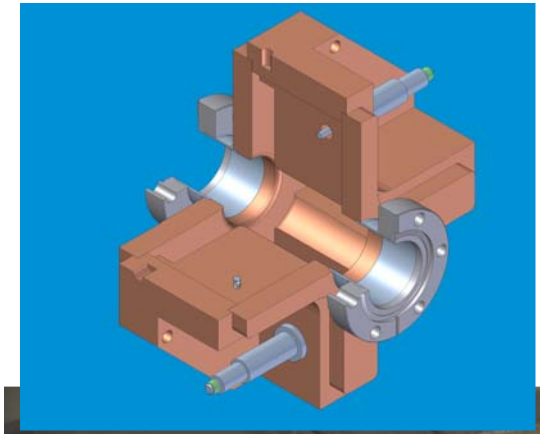
T-475 Synch Stripe Spectrometer Collaborators:
U. of Oregon, SLAC



For BPM spectrometer
- **$\delta E/E$=100ppm → δx= 500nm, at BPMs 3-4**
- **Dipole B-field ~ 1kGauss**
  - **these are same as for ILC design**

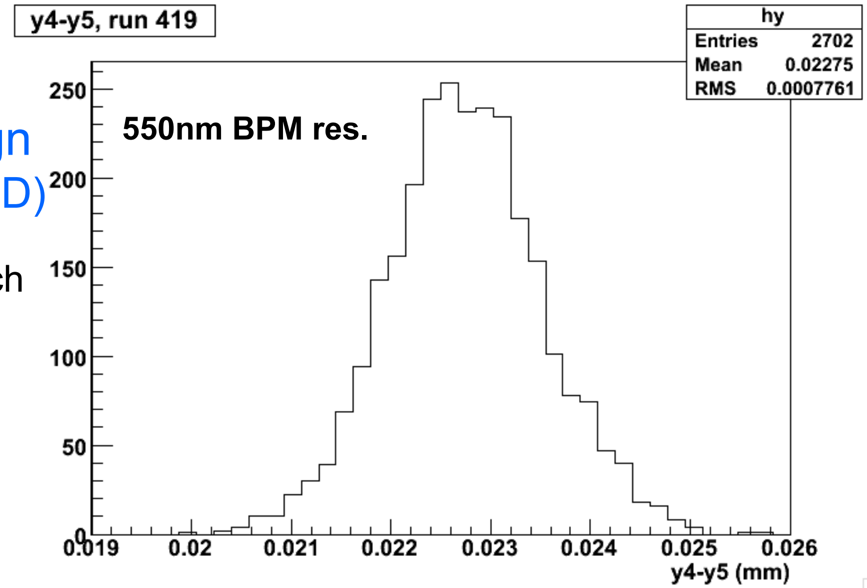
Beam Tests
- study calibration procedure, which includes reversing the chicane polarity,
- study sensitivity to: beam trajectory, beam tilt, bunch length, beam energy, beam shape, …
- compare T-474 and T-475 results and compare with A-line energy diagnostics

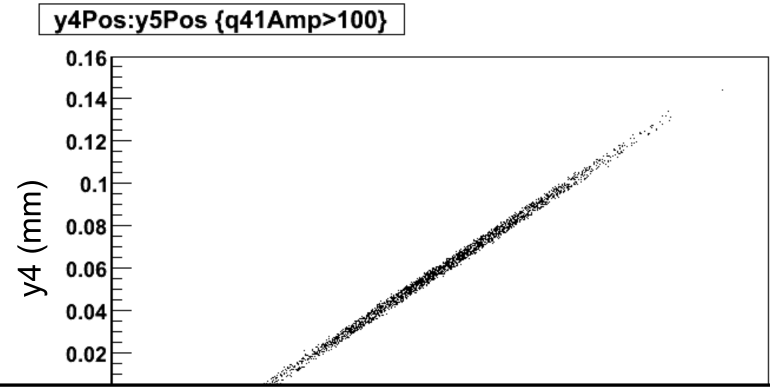
T-474 Run 1 Prelim. Results for Prototype Linac rf BPMs



S-Band BPM Design
(36 mm ID, 126 mm OD)

Q~500 for single bunch resolution





New Linac BPM Prototype
(C. Adolphsen, G. Bowden, Z. Li)
→ **used as BPM3-5 for T-474**

Also investigating how T-474 setup can be used to test micron-level stability relevant for ILC Linac quad/bpm modules.

New UK spectrometer BPM prototype

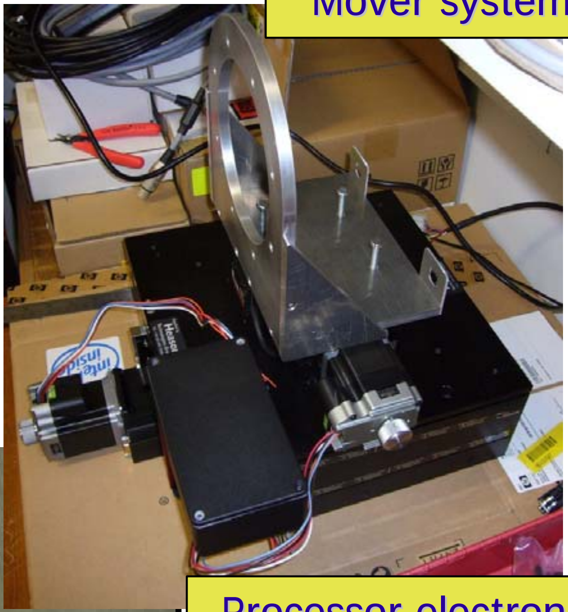
Optimized design (A. Lyapin) :

- high resolution : ~ 100 – 200 nm
- aperture
- monopole suppression
- own reference cavity

developed by UCL/RHUL/MSSL

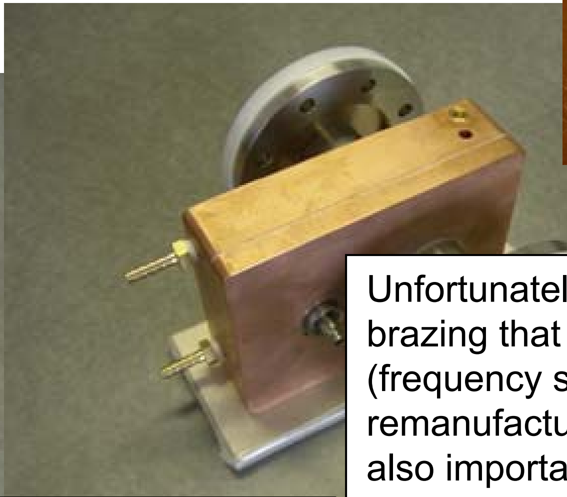
mechanically rigid mover system

Installed in ESA for Run 4 in July '07



Mover system

Dipole cavity, 2878 MHz



Reference cavity

Processor electronics

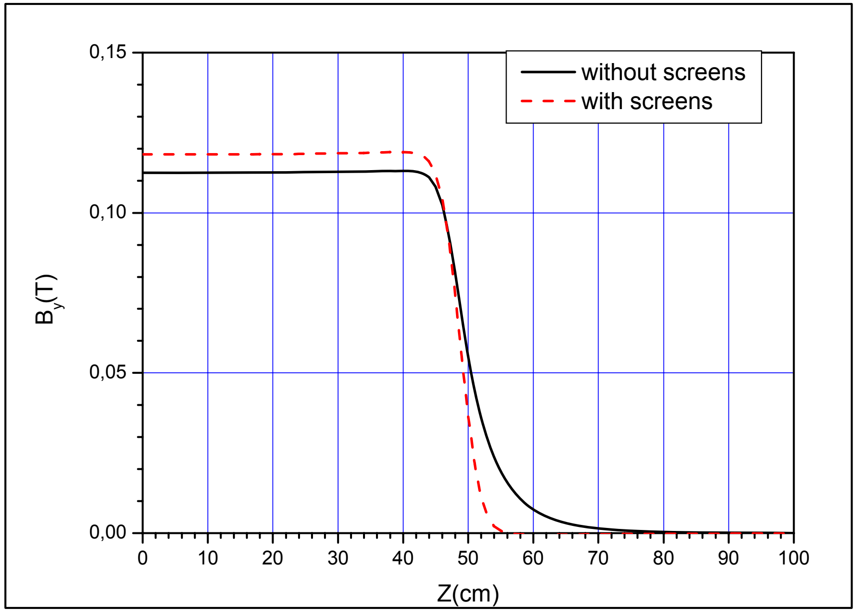
Unfortunately these new BPMs had poor brazing that compromised their performance (frequency shift, x-y coupling). Will remanufacture for 2008 runs. 2007 analysis also important – may yield important information on manufacturing tolerances; in principle, all Information is present in data to reconstruct good x,y measurement capabilities.

Magnetic measurements

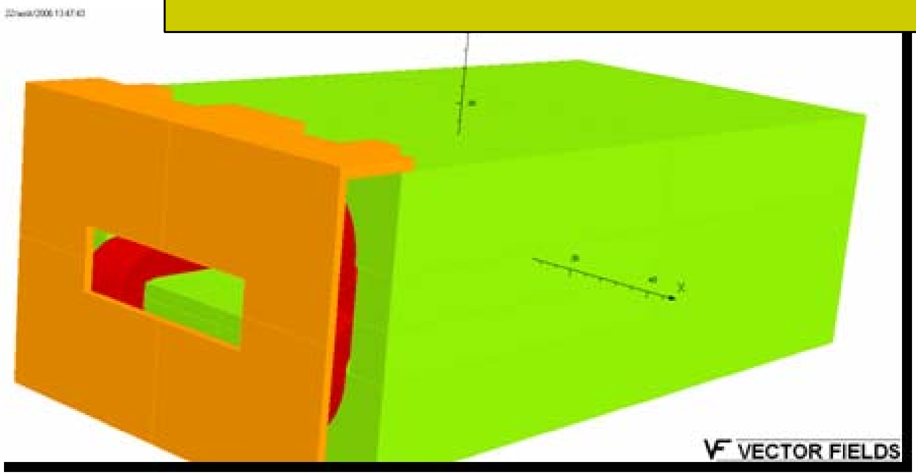
Simulation of magnets carried out by N. Morozov (Dubna)

Mag. measurements at SLAC testlab (SLAC/Dubna/Zeuthen)

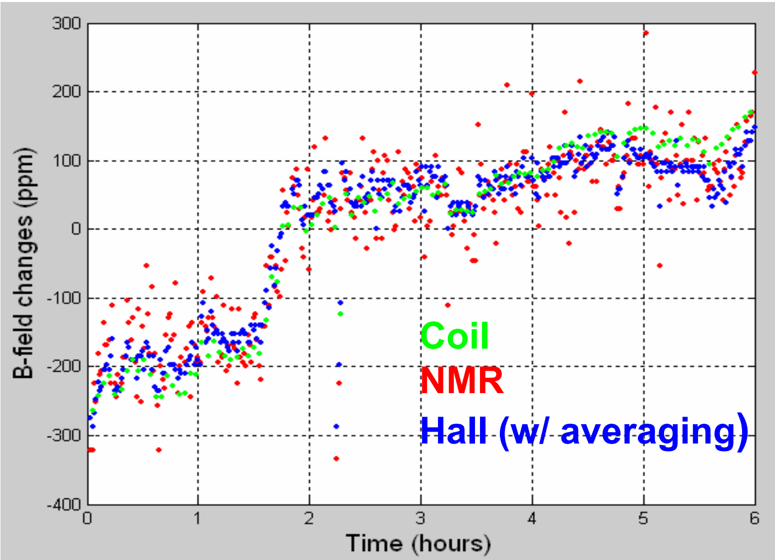
- magnetic field integral 10^{-4} uniformity region is ±15 mm
- region for possible NMR probe use is X*Z= ±7*±40 cm
- relative contribution of the fringe field to the total field integral is 22%
- maximal level of the magnetic field in return yoke is no more 0.4 T
- temperature factor for the magnetic field integral is $6.1\times10^{-5}\times1/C°$
- Screens to reduce fringe fields

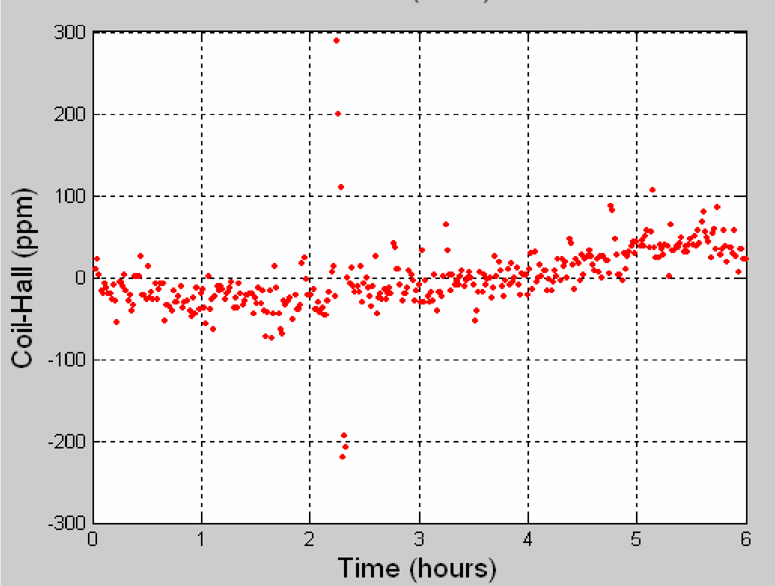


Model simulation using “Vector Fields”



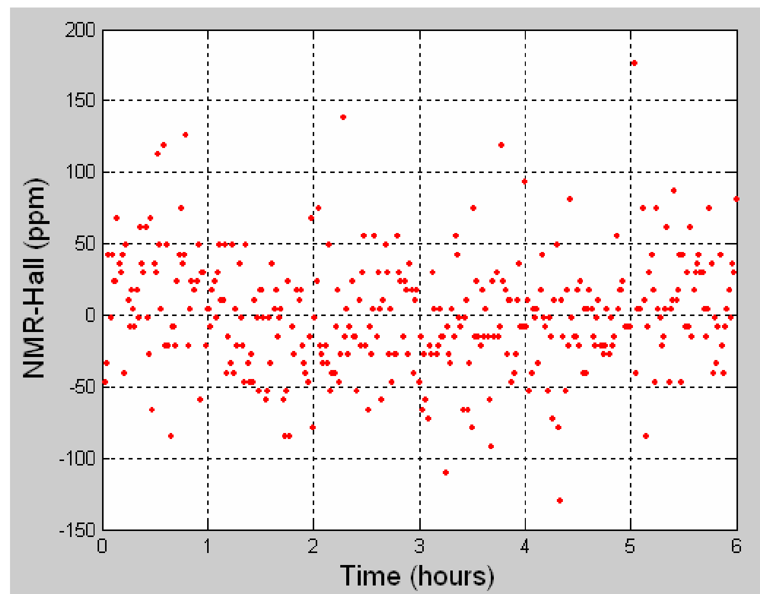
Magnetic Measurement Test Lab Data for Chicane Magnet at Operating Field of 1kGauss





Magnet Test Lab Data

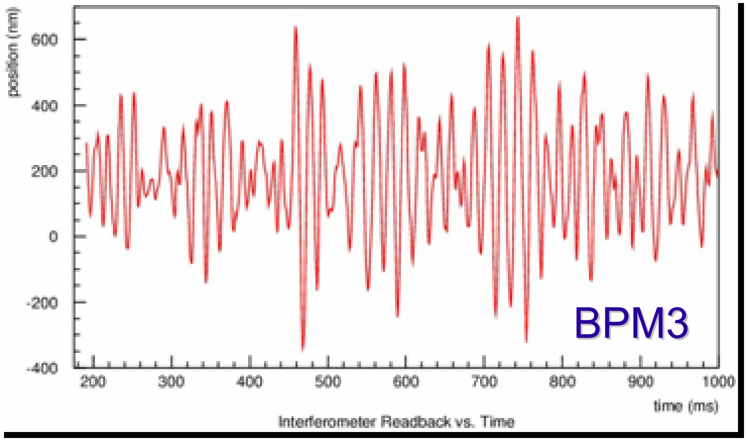
- standardization procedure
- stability and reproducibility tests
- test agreement of rotating coil, NMR, Hall
- additional zero field tests with coil, Hall, fluxgate magnetometer

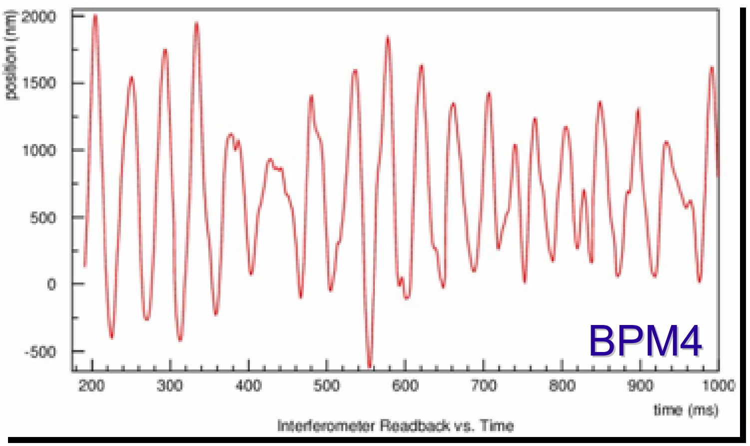


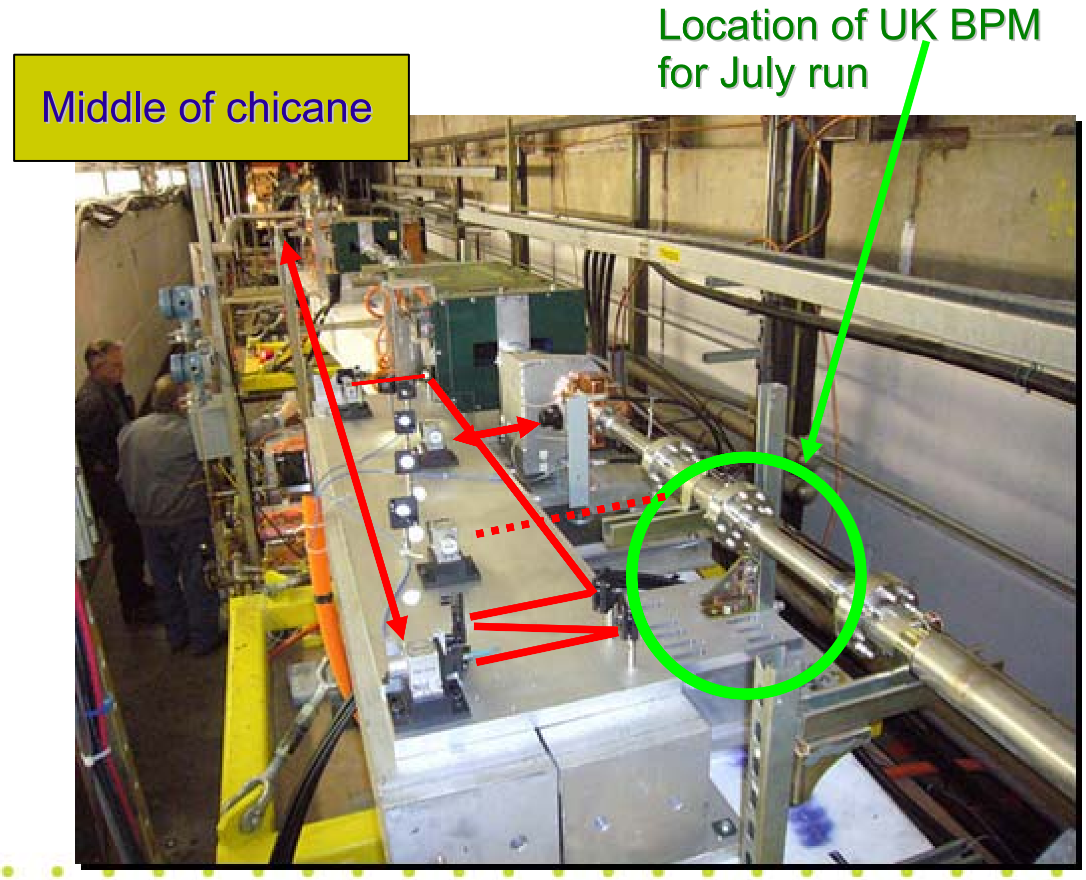
Interferometer

(M. Hildreth, Notre Dame)

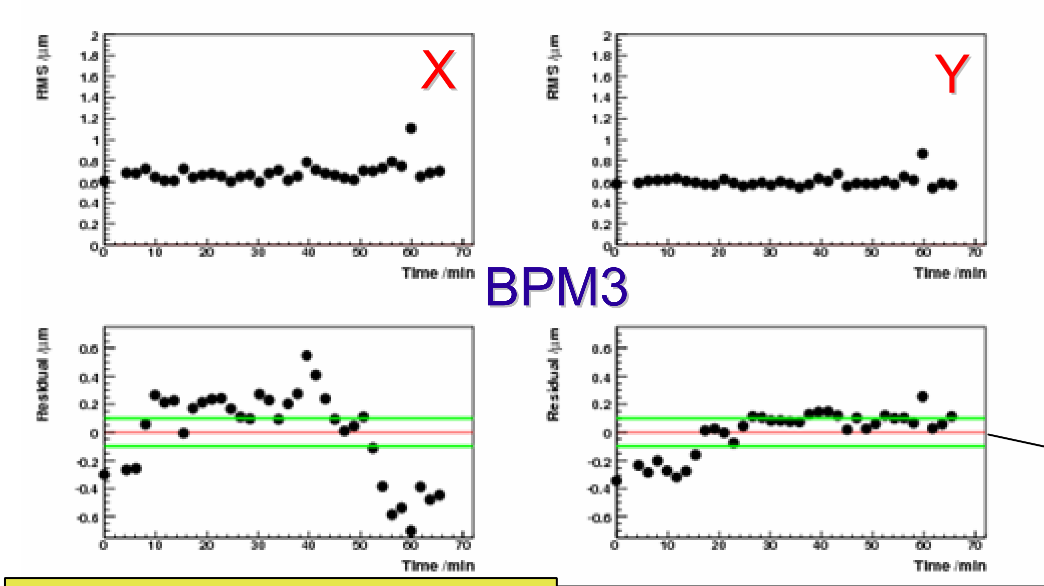
- Sub-nm resolution, installation itself stable over 1 hour within 30 nm with fixed mirrors
- Relocated for march '07 run (previously on ILC cold linac prototypes)
- Monitor center of chicane + one head left for new UK BPM
- 1 BPM in front of chicane, send laser beam down long PVC pipe







Stability results, FY06 running

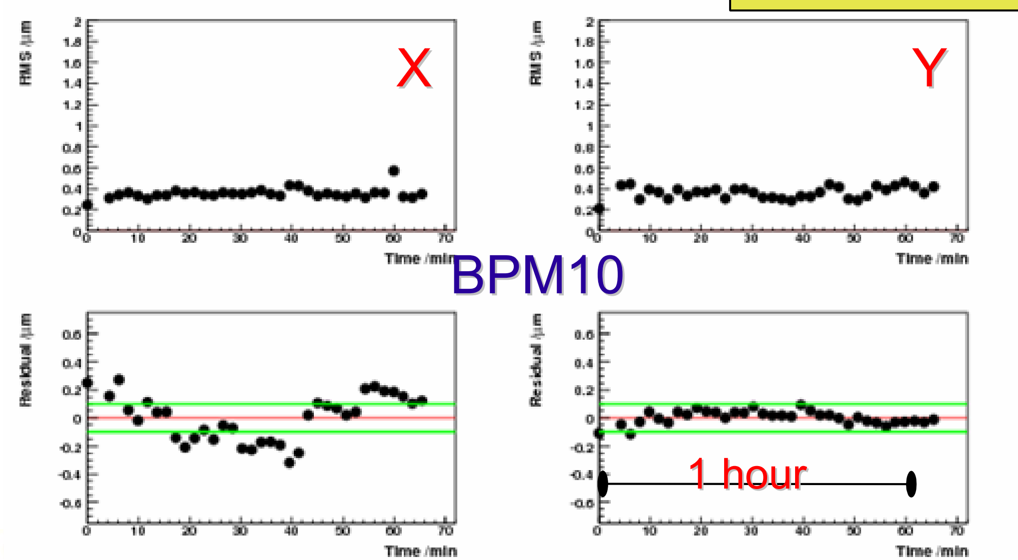


- Using SVD algorithm to predict position from spectator BPMs
- Resolution given by RMS of residual
- Stability given by drift of residual

+/- 100 nm (+/- 20 ppm)

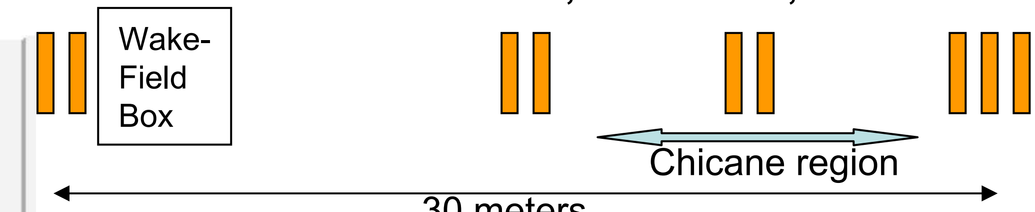
ILC cold linac prototype

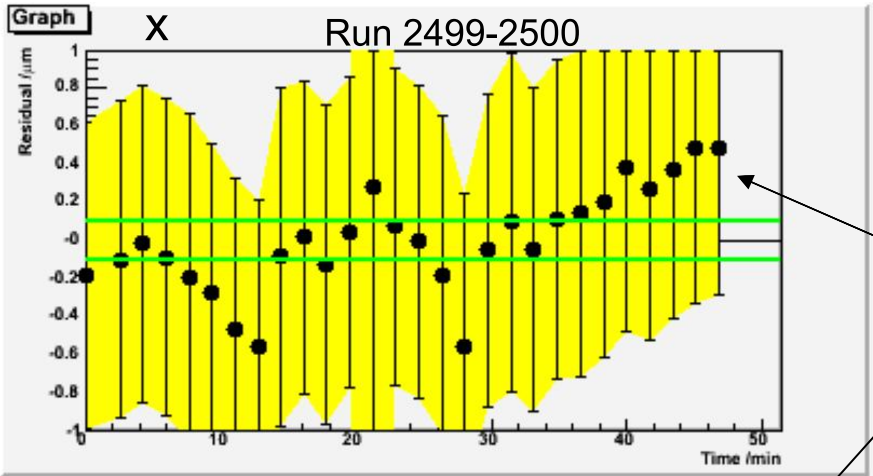
SLC cavities

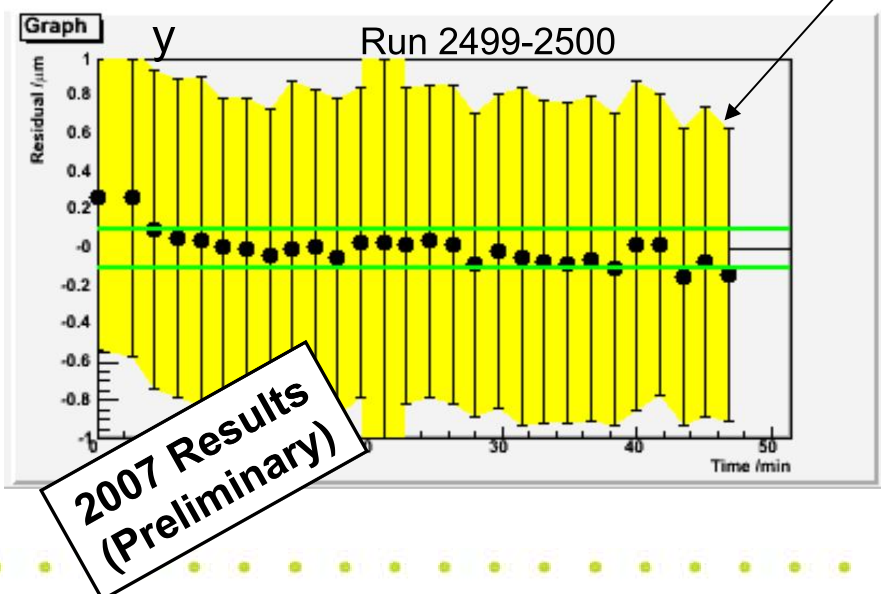


- Drifts can be seen over course of 1 hour
  - no gain monitoring available yet
  - correlate with temperature
- Orbit stability shows to be +/- 1 μm over the course of an hour and RMS on the level of 1 μm

T474: Resolution & Stability Linking BPM Stations in ESA







❖ **use BPMs 1,2 and 3,5 and 9-11 to fit straight line**
- predict beam position at BPMs 4
- plot residual of BPM 4 wrt predicted position

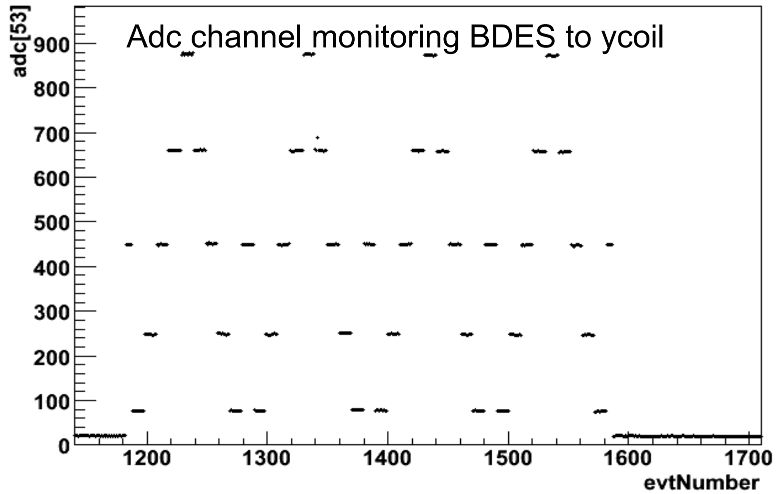
*0.5μm → 100 ppm
"error" bars shown are rms resolution

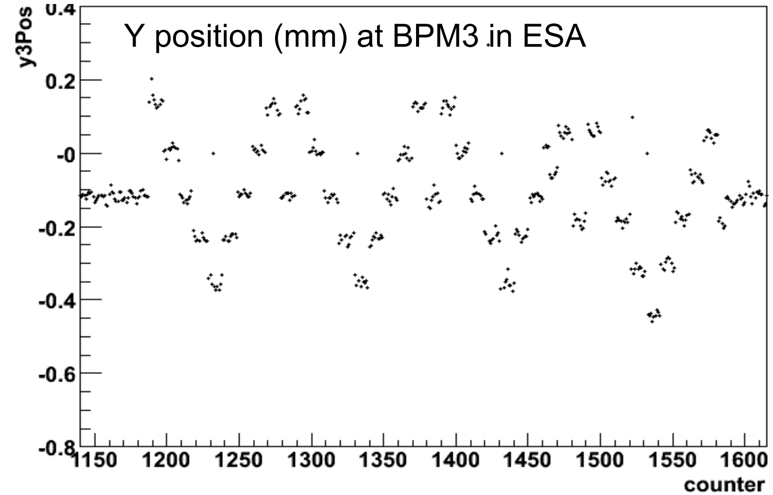
→ a primary purpose of T-474 is to investigate long-term (hours) stability at sub-micron level, and study dependence on beam parameters and environment (temperature, magnetic fields) and electronics stability (calibration tone system important)

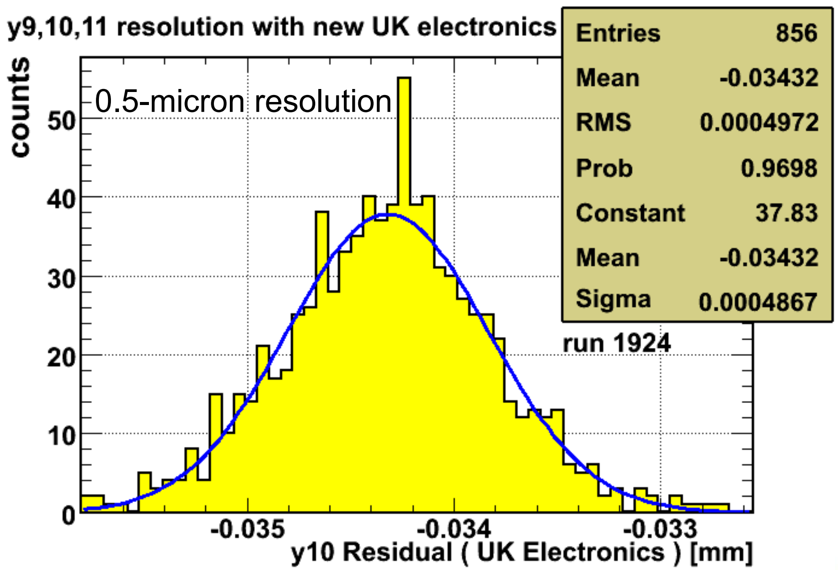
→ stability studies very important for ILC Linac BPM and quad magnetic center stability requirements (also of interest for system of 40 RF BPMs for LCLS undulators)

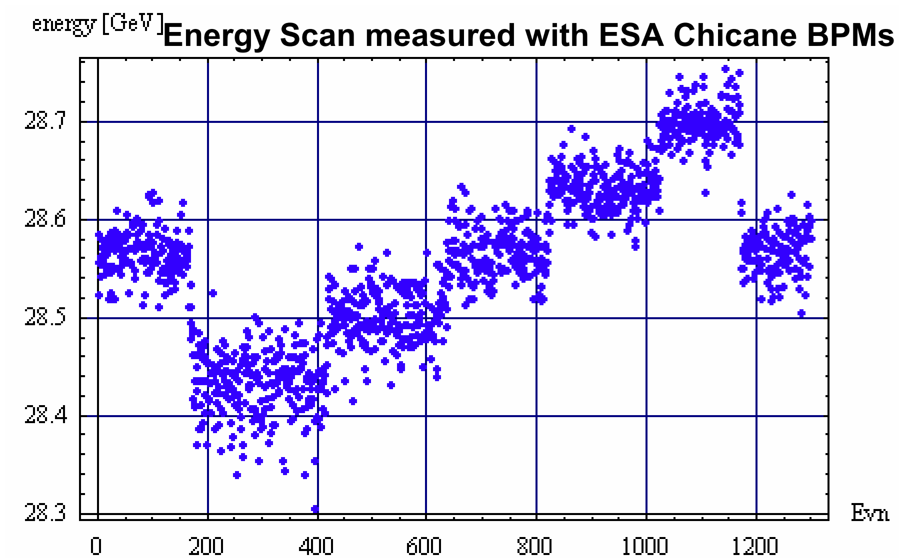
T474 Calibration and Energy Measurements

Helmholtz coil dithering for fast BPM calibrations





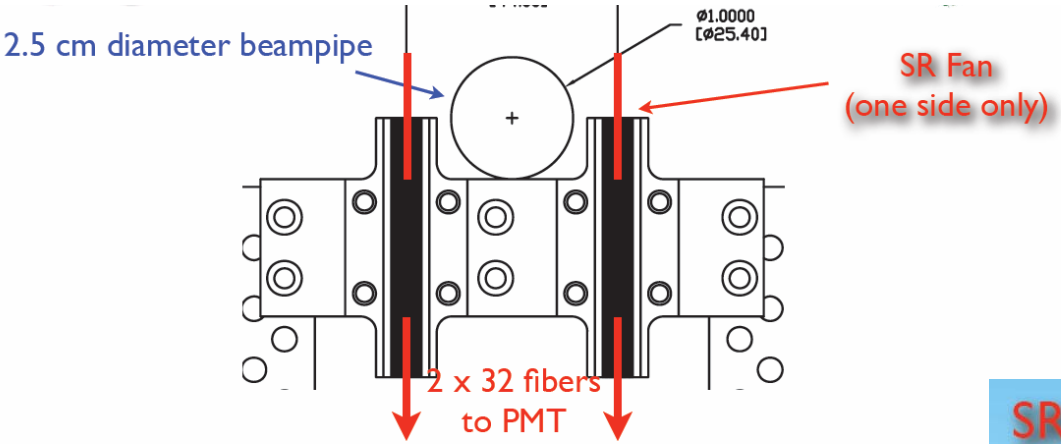




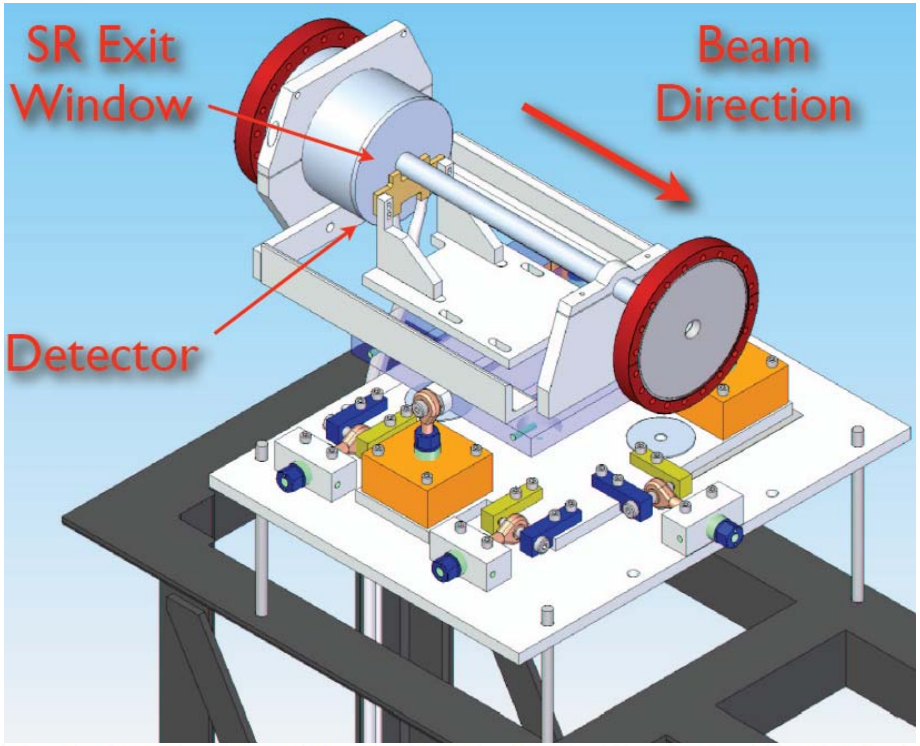
T-475: Wiggler Magnet

Wiggler was originally installed in 1981 at SPEAR. It was used both for the HEP program to increase luminosity, and to supply hard x-rays to 3 experimental stations for SSRL. (Support girder is from SPEAR II and the 4 chicane dipoles are from the "15-line" that injected Linac beam into SPEAR!)

T-475 Detector



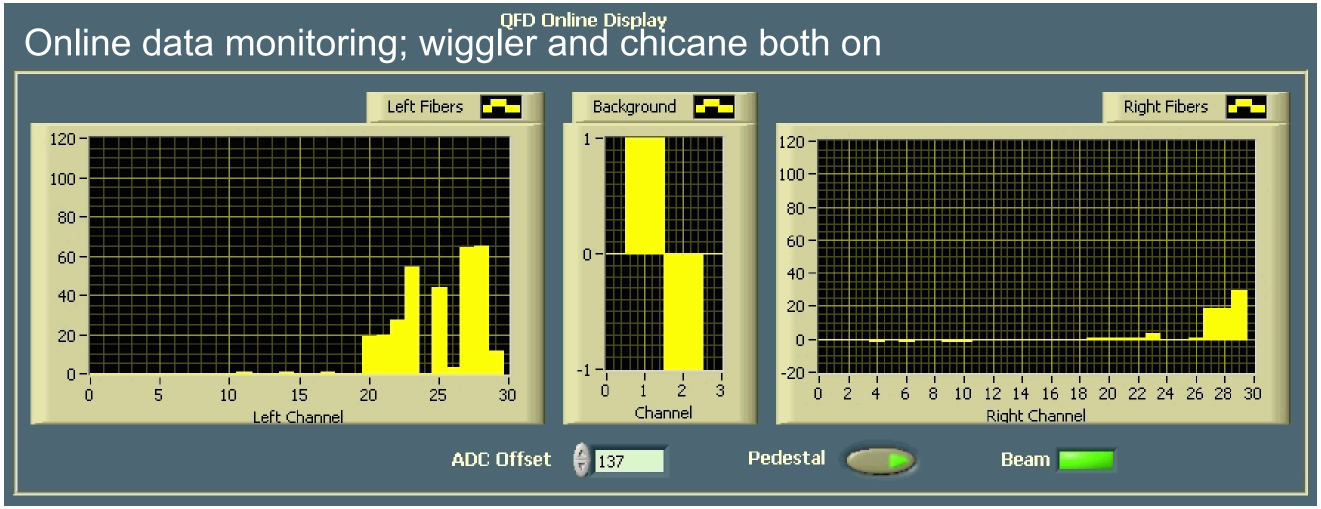
- 64 x 140 micron (100 micron active) deep UV fibers
- Spaced on 200 micron pitch w/ grooves engraved on Invar
- Fibers held in place with Indium foil "gasket"

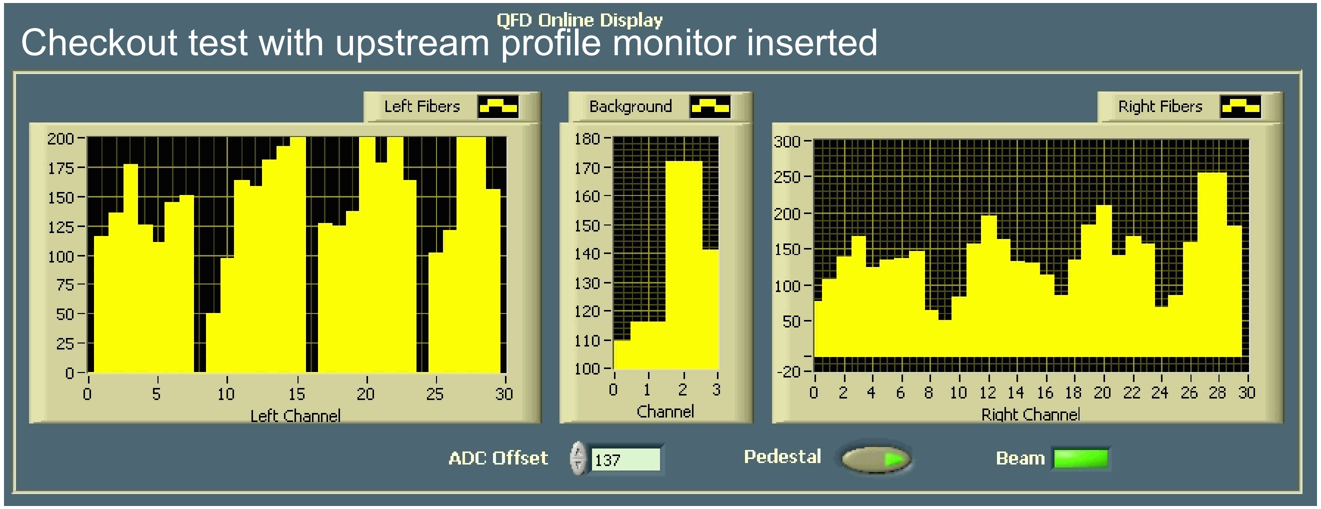


PMT is 64-ch Hamamatsu 7546 multi-anode PMT, readout by CAEN 2 VME adcs

T-475 Detector

Installed for Run 4, July ’07





4 channels disconnected
(Left 0, 8, 16, 24)

Preliminary results:

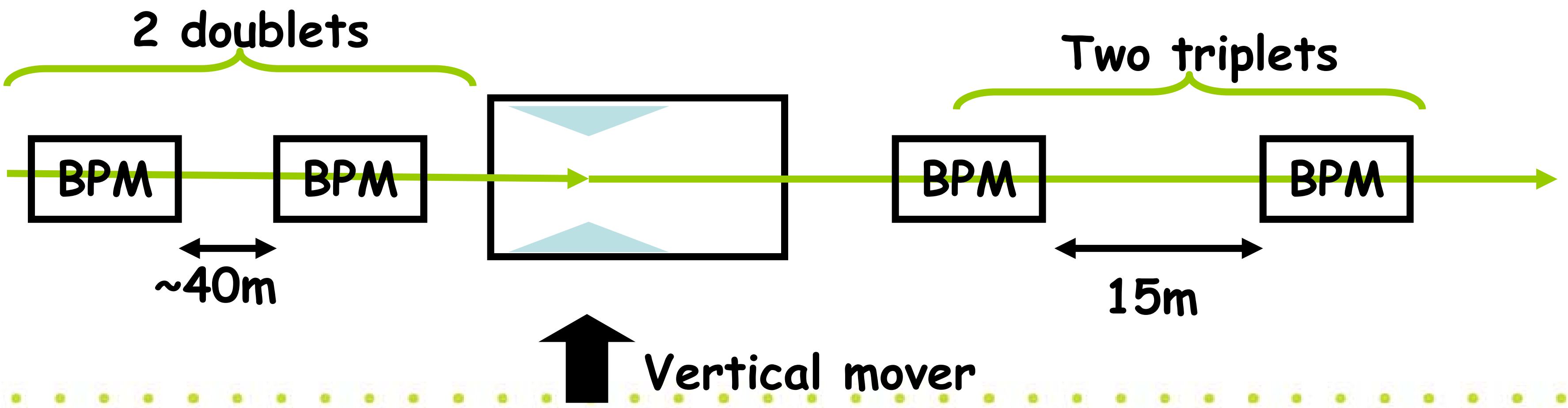
- ***negligible backgrounds when chicane or wiggler are off***
- ***unexpected ringing of signal and larger crosstalk than expected***

T-480: Collimator Wakefields

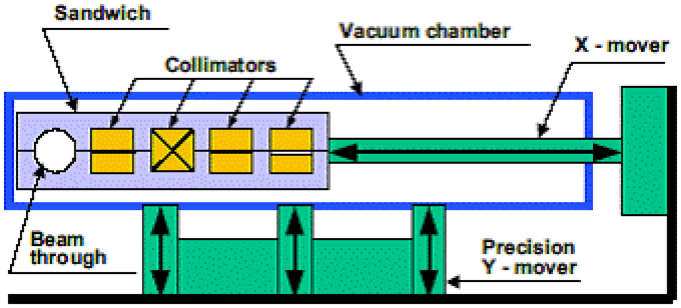
Collimators remove beam halo, but excite wakefields.
Goal: determine optimal collimator material and geometry
→ Beam Tests address achieving ILC design luminosity.

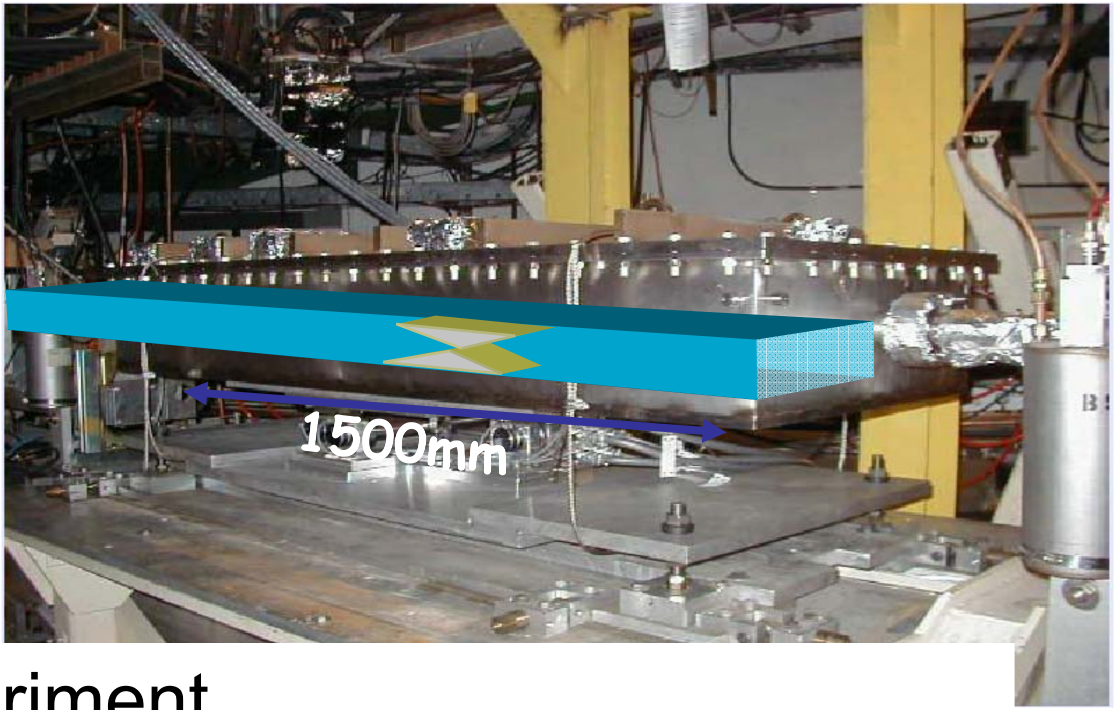
PIs: Steve Molloy (SLAC), Nigel Watson (U. of Birmingham)
Collaborating Institutions: U. of Birmingham, CCLRC-ASTeC + engineering, CERN, DESY, Manchester U., Lancaster U., SLAC, TEMF TU

Concept of Experiment

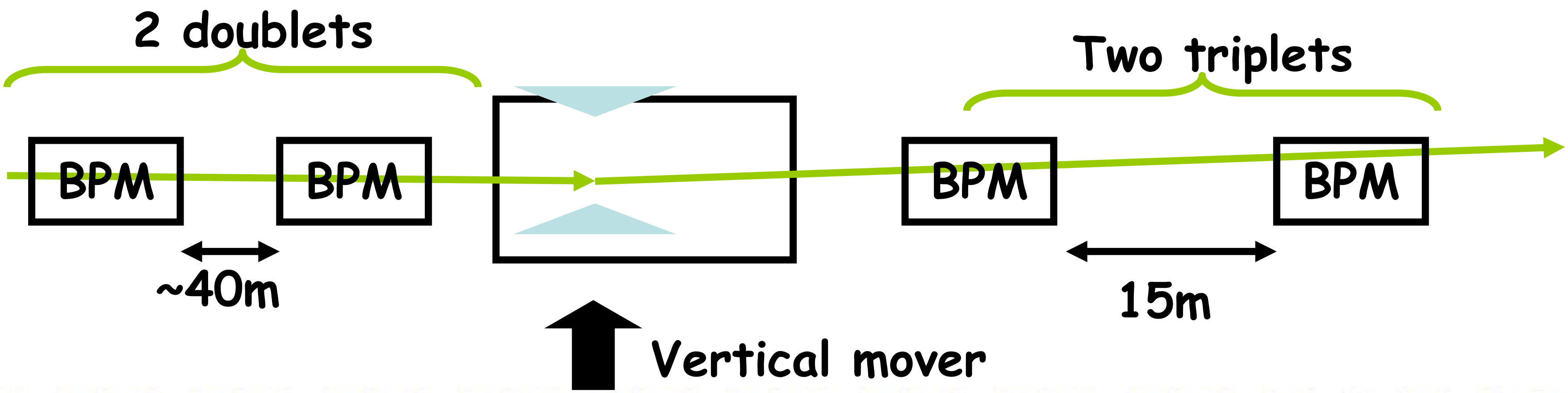


T-480: Collimator Wakefields

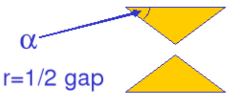
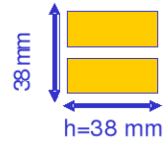
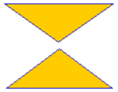
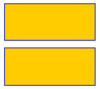
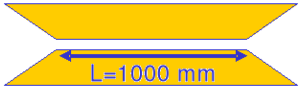
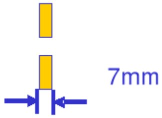


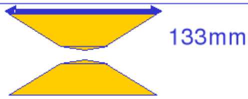
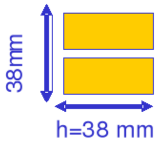
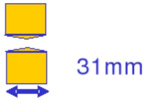
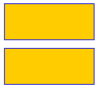
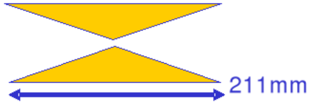
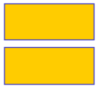
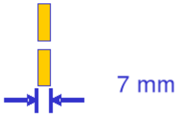


Concept of Experiment



T-480 Collimators 2006 Runs 1,2

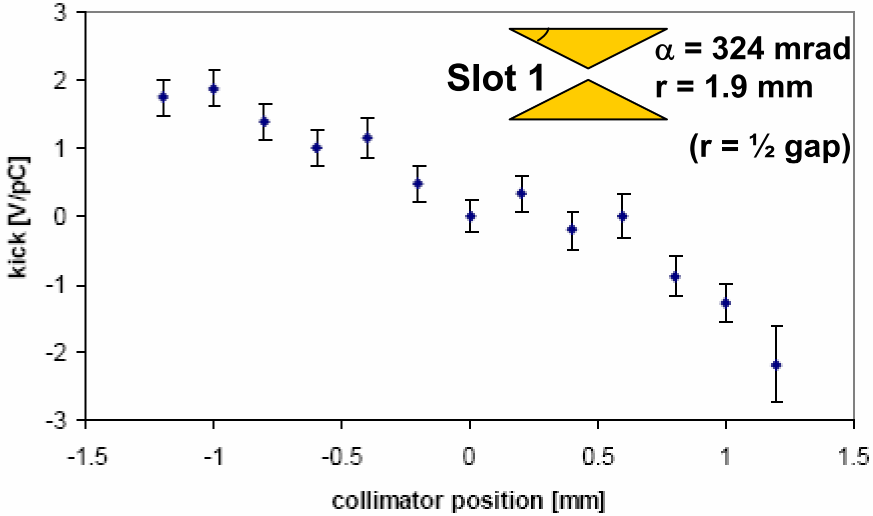
Collim. #	Side view	Beam view	Revised 4-May-2006
1			α=324mrad r=2.0mm
2			α=324mrad r=1.4mm
3			α=324mrad r=1.4mm
4			$\alpha=\pi/2$rad r=4.0mm

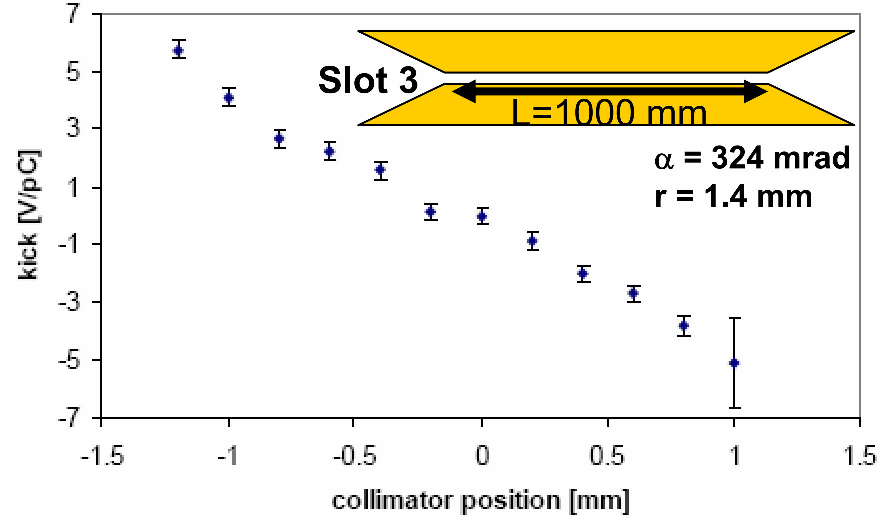
Collim.#	Side view	Beam view	Revised 4-May-2006
8			r_1 =4.0mm r_2 =1.4mm α_1=289mrad α_2=166mrad
7			$\alpha_1=\pi/2$ rad α_2=166mrad r_1=4.0mm r_2=1.4mm
6			α=166mrad r=1.4mm
5			$\alpha=\pi/2$rad r=1.4mm

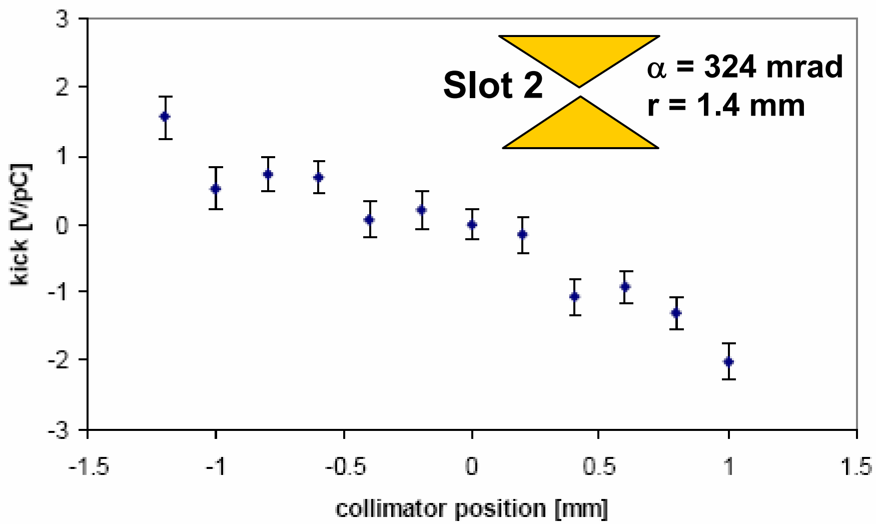
- Collimator #1 is identical to one from previously measured at Sector 2 in the Linac
- Analytical prediction for #7 and #8 is identical, but 3D simulation hints at differences.
- #3 will have a much larger resistive component than the others.
- This set explores a wide range of taper angles.

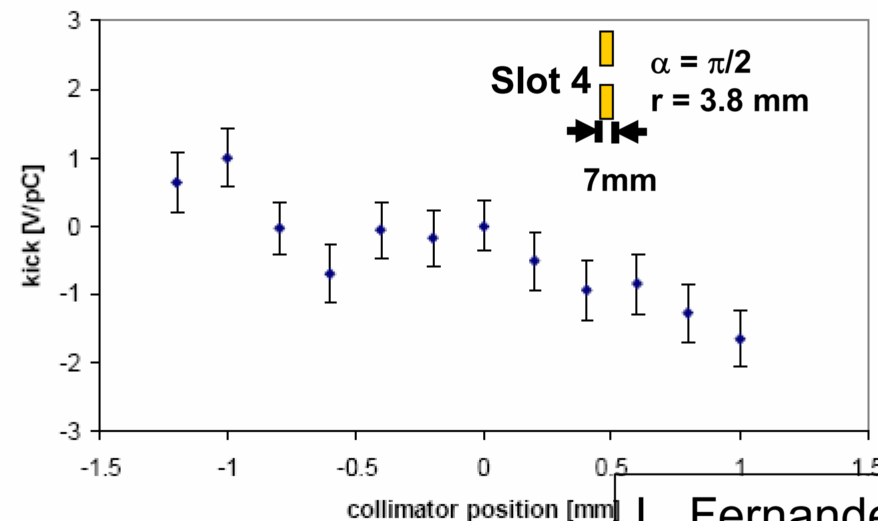
T-480 Preliminary Results from 2006 Data

Sandwich 1 Collimators:









L. Fernandez

T-480 Preliminary Results from 2006 Data

Collimator	**Measured[4] Kick Factor** V/pc/mm (χ^2/dof) **Linear fit**	**Measured[4] Kick Factor** V/pc/mm (χ^2/dof) **Linear + Cubic Fit**	**Analytic Prediction[1] Kick Factor** V/pc/mm	**3-D Modelling Prediction[2] Kick Factor** V/pc/mm
1 (Sand1,Slot1)	1.4 ± 0.1 (1.0)[3]	1.2 ± 0.3 (1.0)	1.1	1.7
2 (Sand1,Slot2)	1.4 ± 0.1 (1.3)	1.2 ± 0.3 (1.4)	2.3	3.1
3 (Sand1,Slot3)	4.4 ± 0.1 (1.5)	3.7 ± 0.3 (0.8)	6.6	7.1
4 (Sand1,Slot4)	0.9 ± 0.2 (0.8)	0.5 ± 0.4 (0.8)	0.3	0.8
5 (Sand2,Slot1)	1.7 ± 0.3 (2.0)	1.7 ± 0.3 (2.2)	2.3	2.4
6 (Sand2,Slot2)	1.7 ± 0.1 (0.7)	2.2 ± 0.3 (0.5)	2.3	2.7
7 (Sand2,Slot3)	0.9 ± 0.1 (0.9)	0.9 ± 0.3 (1.0)	2.4	2.4
8 (Sand2,Slot4)	3.7 ± 0.1 (7.9)	4.9 ± 0.2 (2.6)	2.3	6.8

[1]Assumes 500-micron bunch length
[2]Assumes 500-micron bunch length, includes analytic resistive wake; modelling in progress
[3]Kick Factor measured for similar collimator described in SLAC-PUB-12086 was (1.3 ± 0.1) V/pc/mm
[4]Still discussing use of linear and linear+cubic fits to extract kick factors and error bars

→ Goal is to measure kick factors to 10%

L. Fernandez

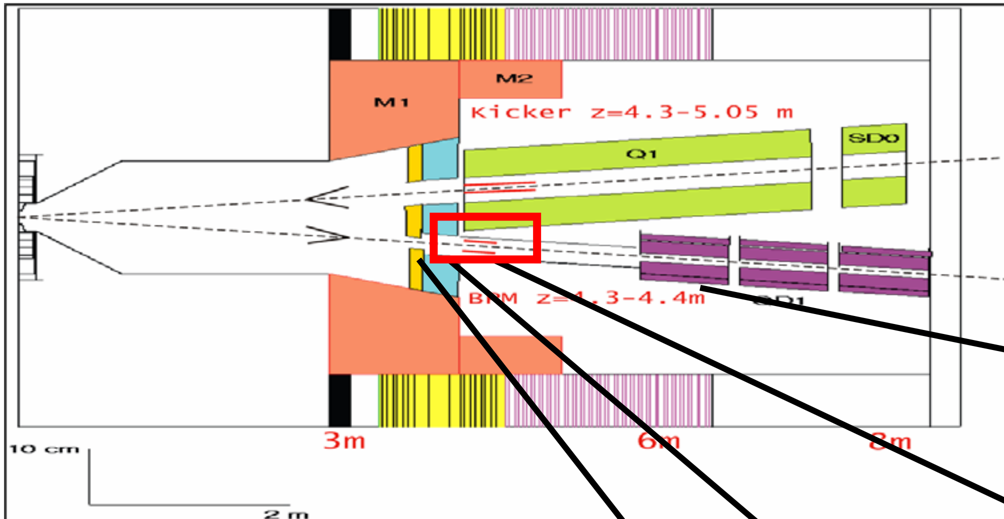
T-480 Collimators for 2007 Runs 3,4

Collim.#	Side view	Beam view	Revised 27-Nov-2006
6	~211mm, α, 1.4mm	38mm, h=38 mm	α=166mrad r=1.4mm (1/2 gap)
10	α, =21mm		α=166mrad r =1.4mm
11	α, =21mm		α=166mrad r =1.4mm
12	α, =21mm		α=166mrad r=1.4mm

Collim.#	Side view	Beam view	Revised 27-Nov-2006
13	OFE Cu, α_2, =21 mm, ~52 mm	38mm, h=38 mm	$\alpha_1=\pi/2$ rad α_2=166mrad r_1=4.0mm r_2=1.4mm
14	Ti6Al4V, α_2, =21 mm, ~52 mm		$\alpha_1=\pi/2$ rad α_2=166mrad r_1=4.0mm r_2=1.4mm
15	α_2, =21 mm, ~125 mm		$\alpha_1=\pi/2$ rad α_2=50mrad r_1=4.0mm r_2=1.4mm
16	OFE Cu, =21 mm		non-linear taper r=1.4mm

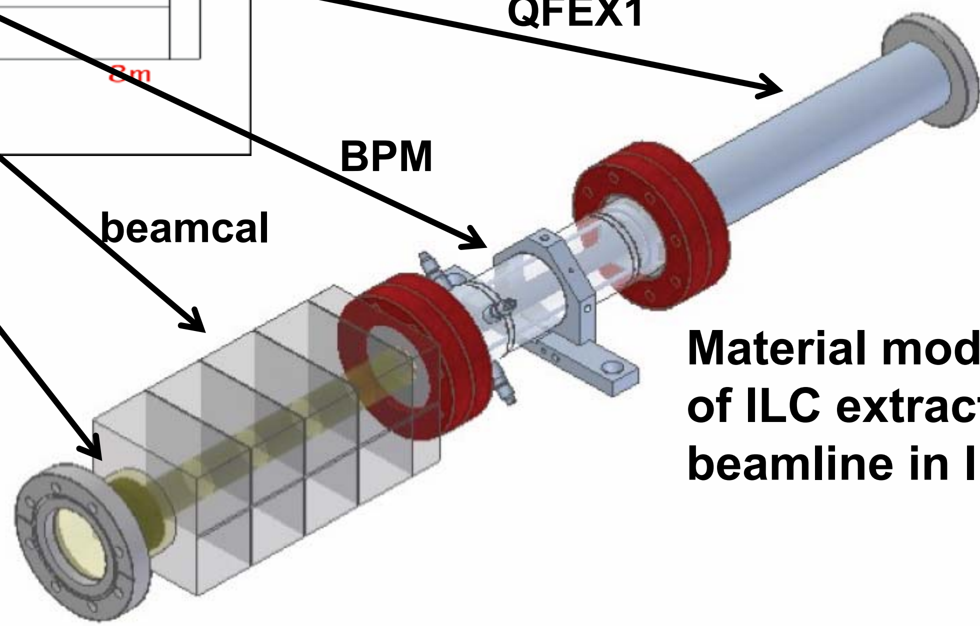
- Collimator #6 identical to #6 from 2006.
- This set investigates the effect of material and surface finish on the kick.
- #16 tests a smooth impedance change.

T-488: IR Mockup for FONT IP BPM studies



IR Extraction Line

PI: Phil Burrows, U. of Oxford
Collaboration: U. of Oxford, Daresbury Lab, SLAC

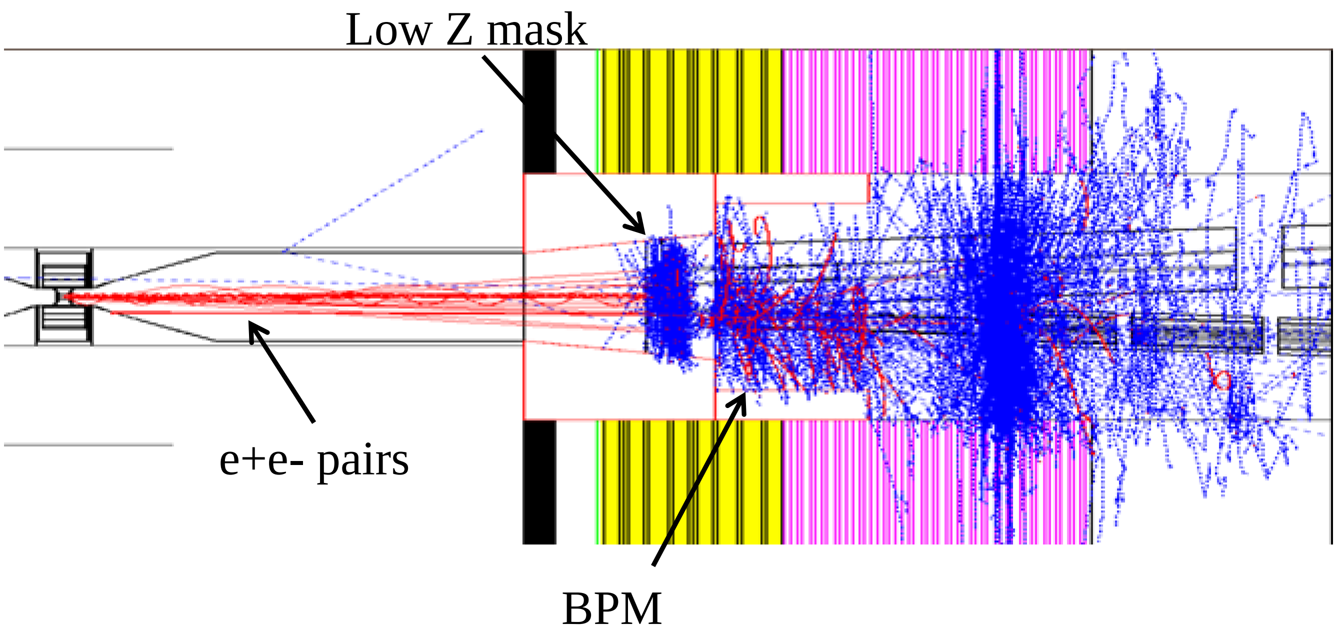


Material model of ILC extraction beamline in IR

Beam Test

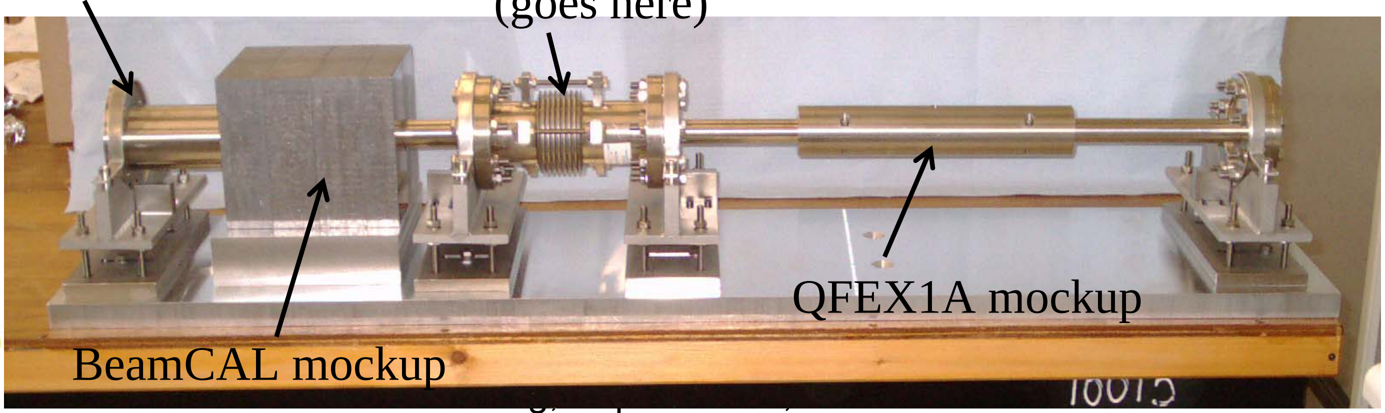
- simulate ILC pairs hitting components in forward region of ILC Detector near IP bpms, exceeding maximum ILC energy density of 1000 GeV/mm^2 by up to factor 100

T-488: IR Mockup for FONT IP BPM studies

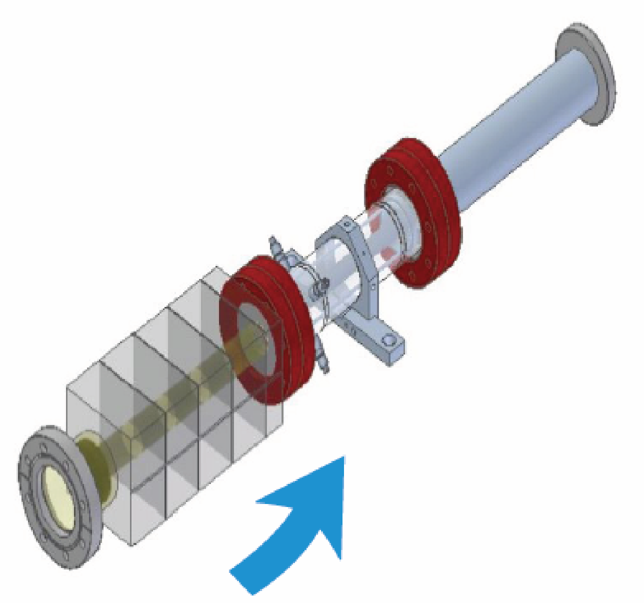


EM Backgrounds at ILC

T-488 FONT Test Module

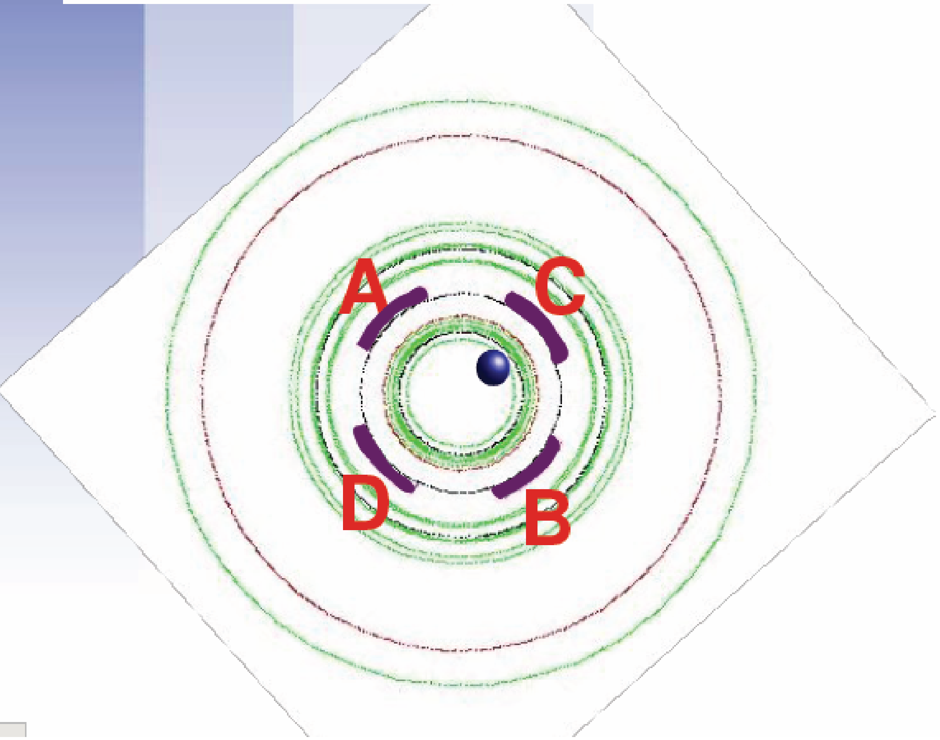


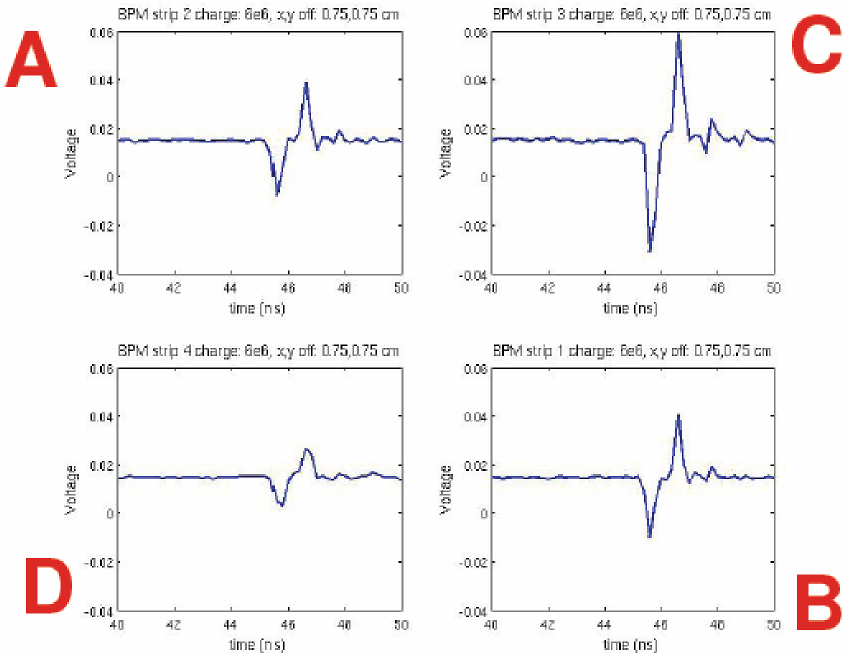
28



Data I - beam offset r=1.06cm

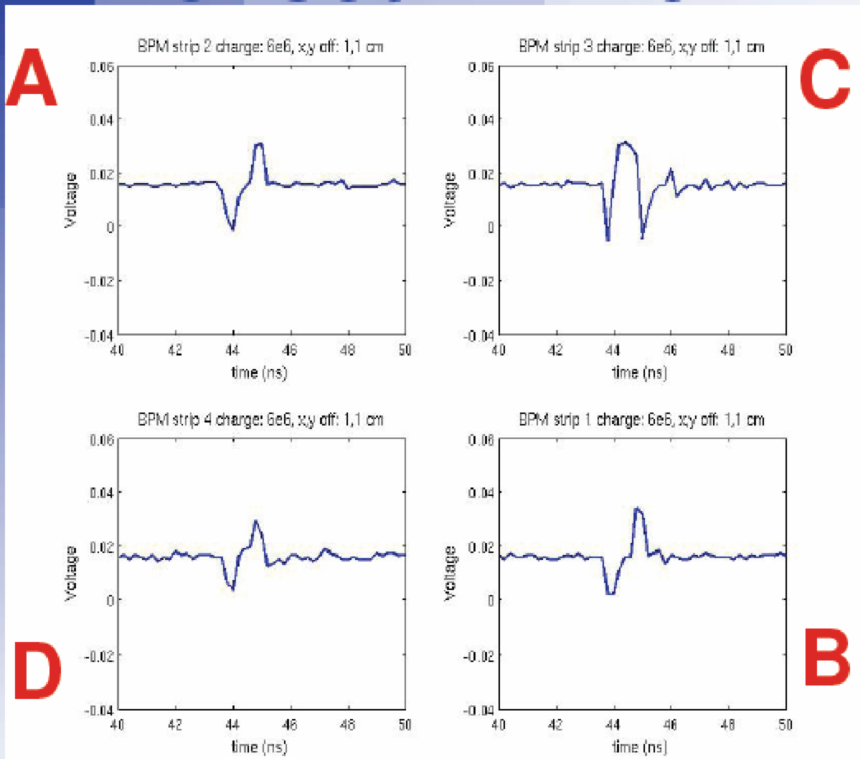
- offset towards upper right strip C
- stripline C shows enhanced signal
- stripline D shows diminished signal
- stripline A,B same

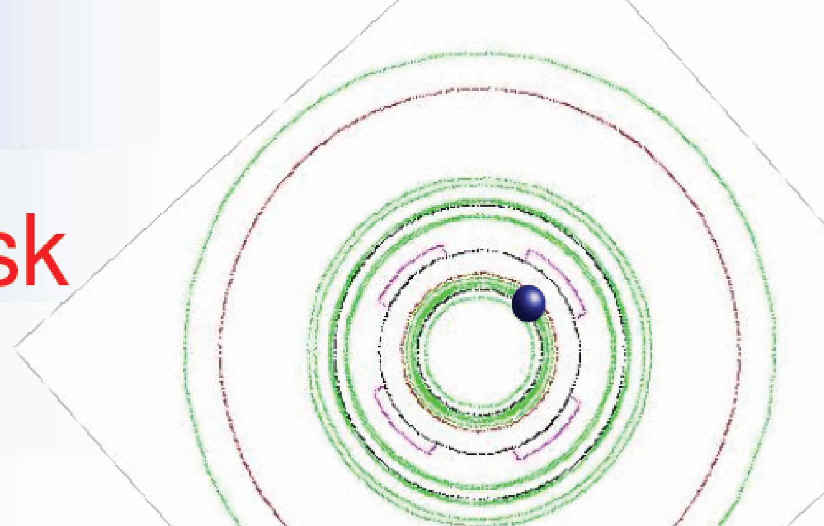




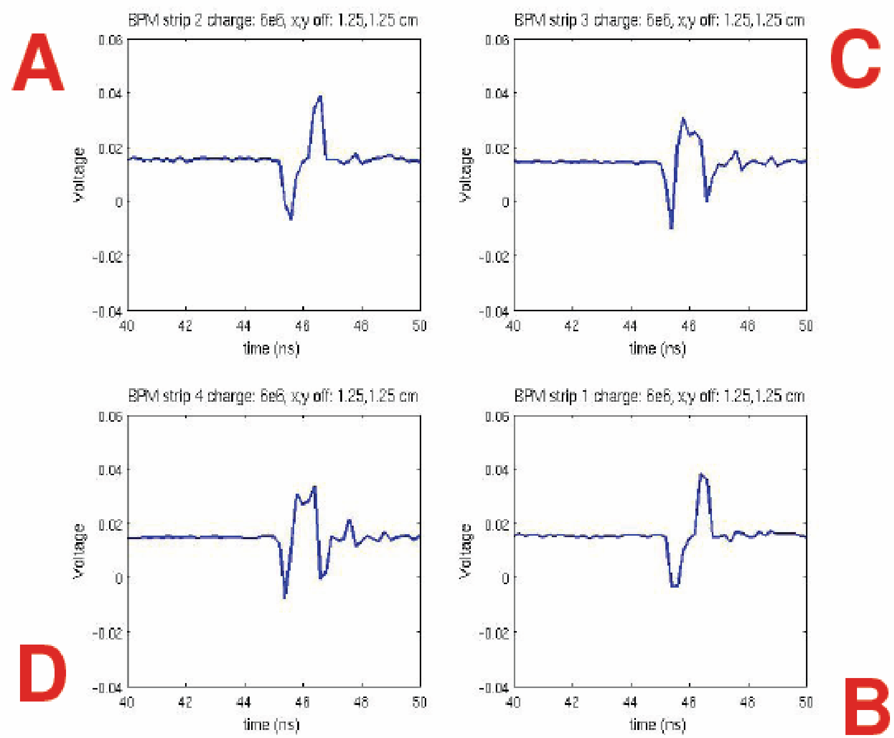
DATA II - beam offset impinging on lowZ mask

offset=1.41cm



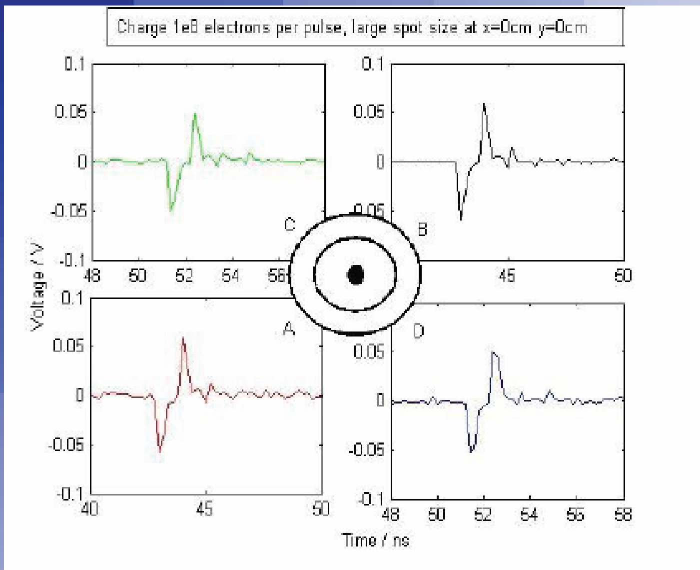


offset=1.75cm

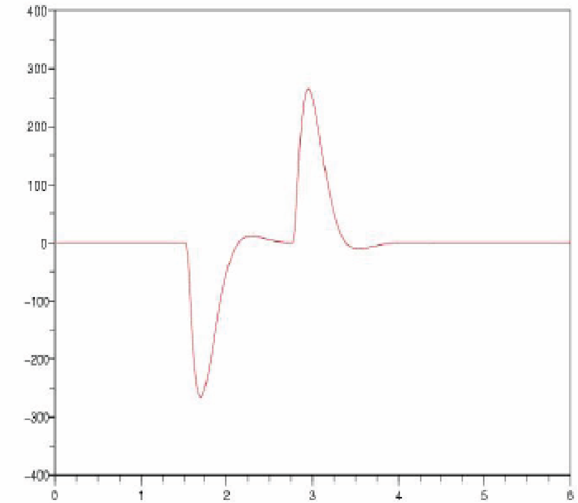


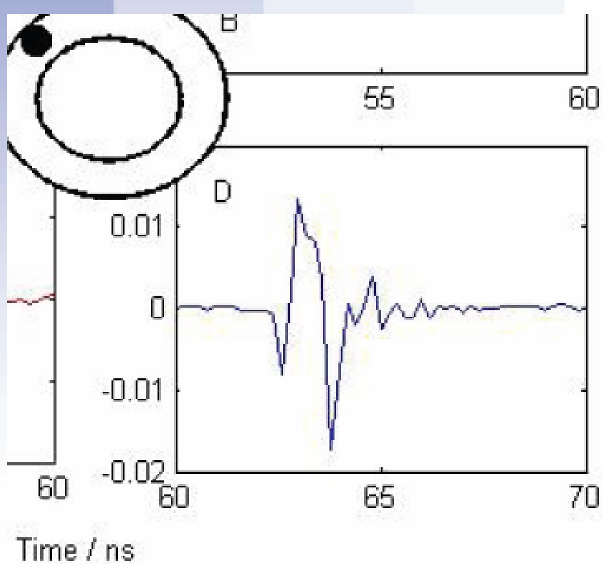
- 'noise' appears on furthest and nearest strips with fluctuating weights
- noise sensitive to offset

Simulation III – comparison with data

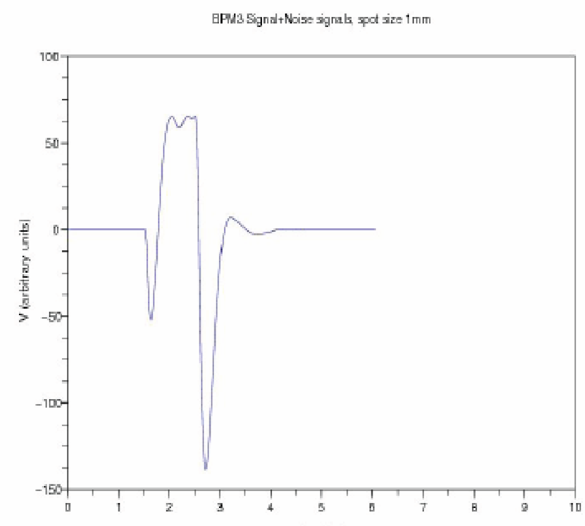


Broaden a simulated signal pulse by passing through a 2nd order 1.2 GHz Butterworth Low pass filter





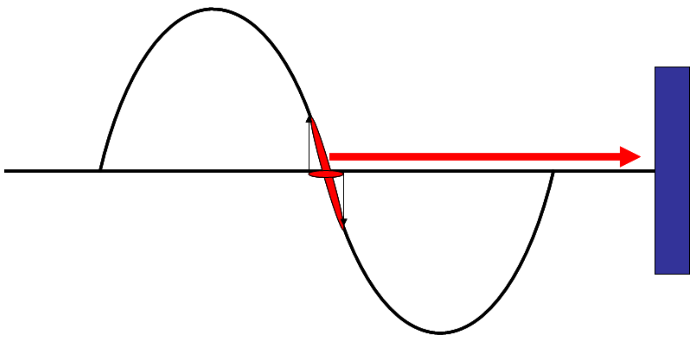
Apply scheme for adding the effect of stripline hits to produce 'noise'. 'Signal' is determined by beam charge and offset

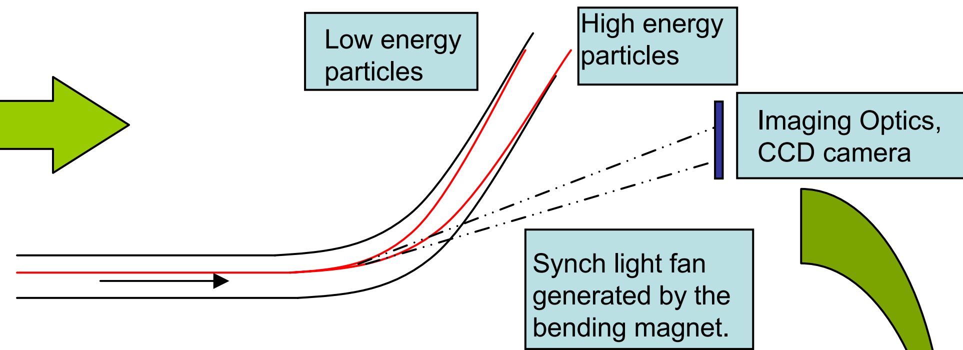


Summary

- **FONT@ESA Jul06 & Mar07 data**
  - **LowZ:** raw stripline signals as beam x_offset varies
  - **1,3,5% thin radiator:** raw stripline signals with beam on axis
  - **processor:** full set of processor data for all configurations
- **Data trends**
  - **LowZ offset in x:** noise appears in the strips closest and furtherest from the initial beam offset
  - **thin radiator:** Either position drift, jitter and/or noise from direct hits on BPM striplines of ~2% of the signal
- **Simulations**
  - used GEANT to obtain time dependence of secondary emission and relative weights of noise and signal – good match with signal shapes
  - ILC 14mrad geometry with high luminosity beam parameter would produce 10 times **less** noise due to hits on striplines than peoduced in the Mar07 ESA test
- **Conclusions**
  - maximum noise at the ILC feedback BPM striplines ~0.2% of signal – Probably outweighed by jitter
  - FONT@ESA experiment successfully concluded with positive message

Linac Bunch Length Measurements with xverse RF cavity

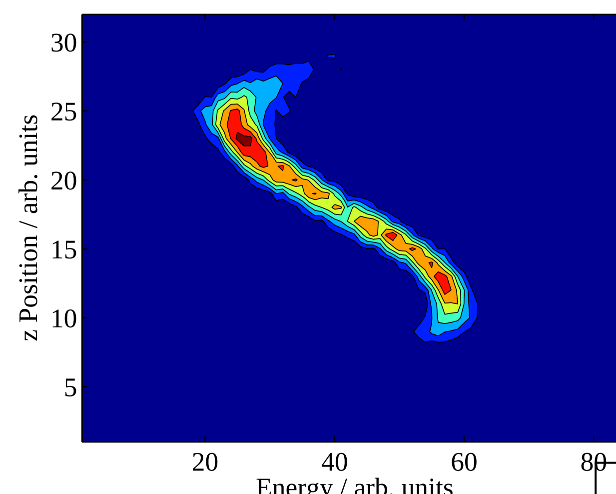




S-band transverse cavity (LOLA) gives vertical kick to particles, proportional to their longitudinal position in the bunch

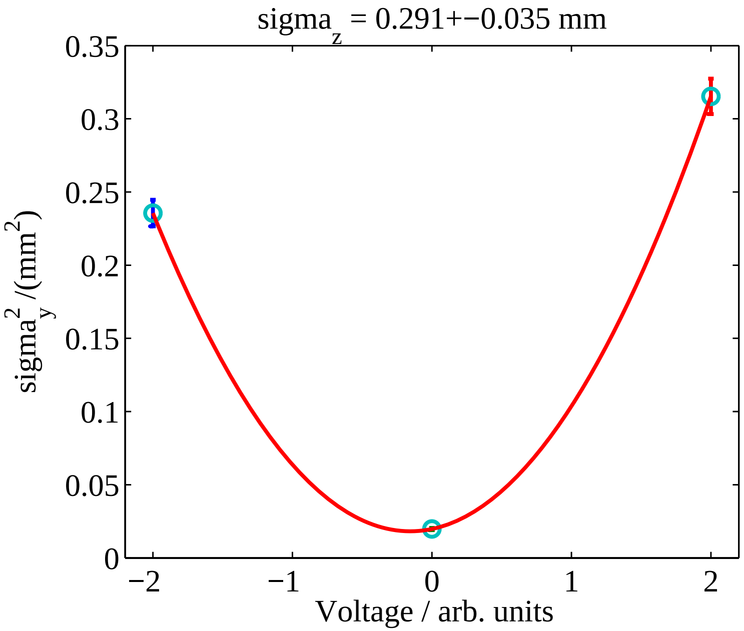
- A-line bend magnet generates a SR fan that is imaged on a ccd camera.
- Width of image gives energy spread.
- height of image gives bunch length

→ digitized image also gives energy-z correlation



S. Molloy

Bunch Length Calculation



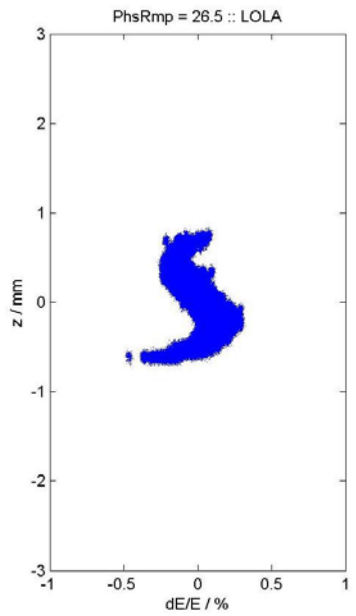
- Vertical size of image has 3 components:
  - Bunch length (z)
  - Bunch height (y)
  - Bunch tilt (dy/dz)
- Bunch length is extracted from a parabolic fit to 3 measurements
  - LOLA on
  - LOLA on at opposite phase
  - LOLA off

S. Molloy

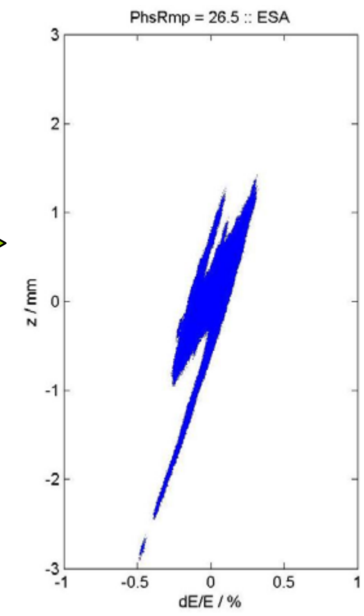
Bunch Length in ESA

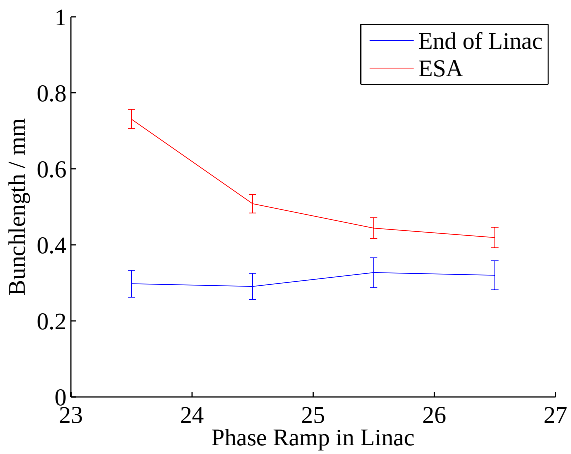
Create a several thousand particle bunch in Matlab with the measured distribution.

Use the R56 (0.465 m) of the A-line to calculate the distribution in ESA.



$$\begin{pmatrix} L_2 \\ dP_2/P_2 \end{pmatrix} = \begin{pmatrix} 1 & R_{56} \\ 0 & 1 \end{pmatrix} \begin{pmatrix} L_1 \\ dP_1/P_1 \end{pmatrix}$$



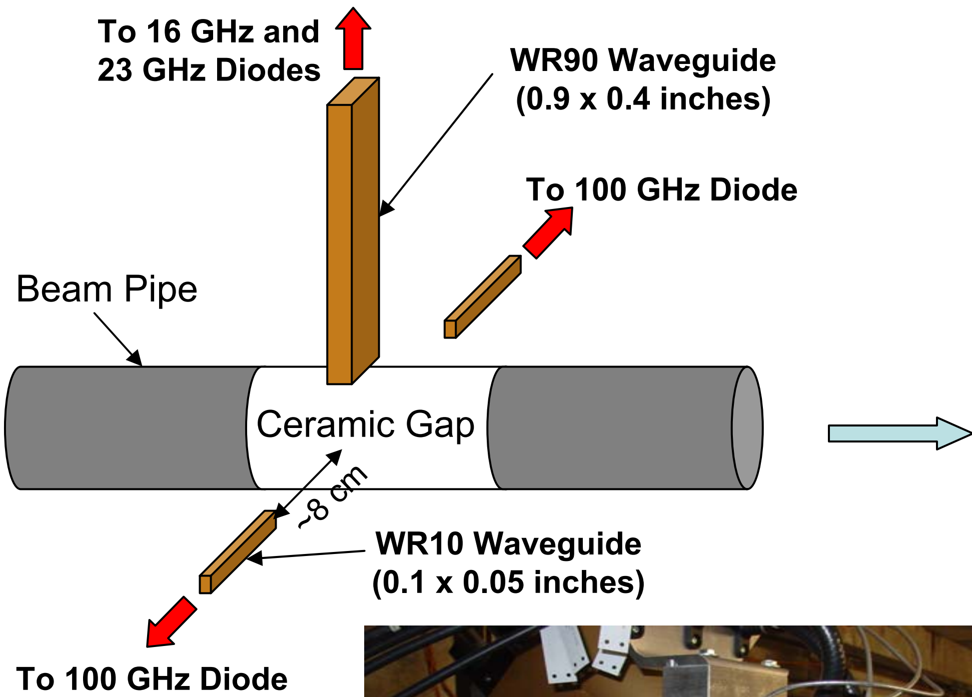


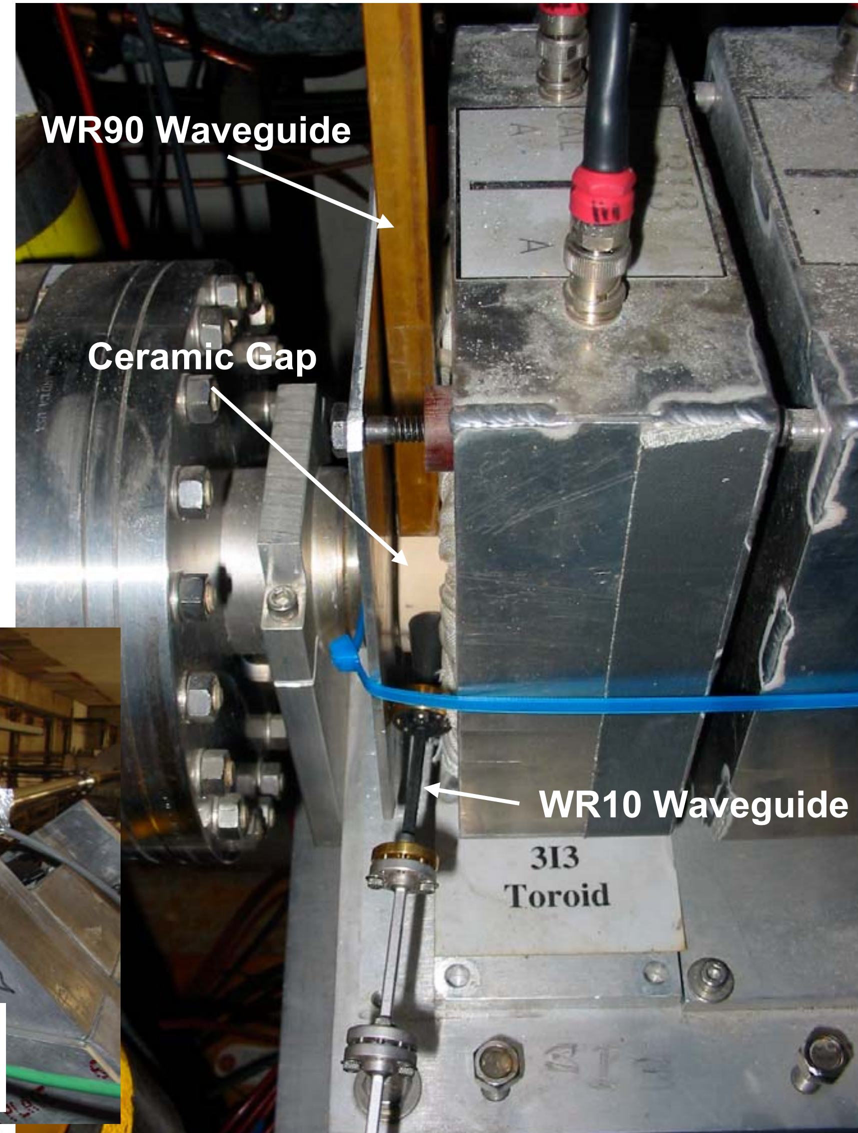
Measurements were made for a series of linac phase settings to change the E-z correlation.

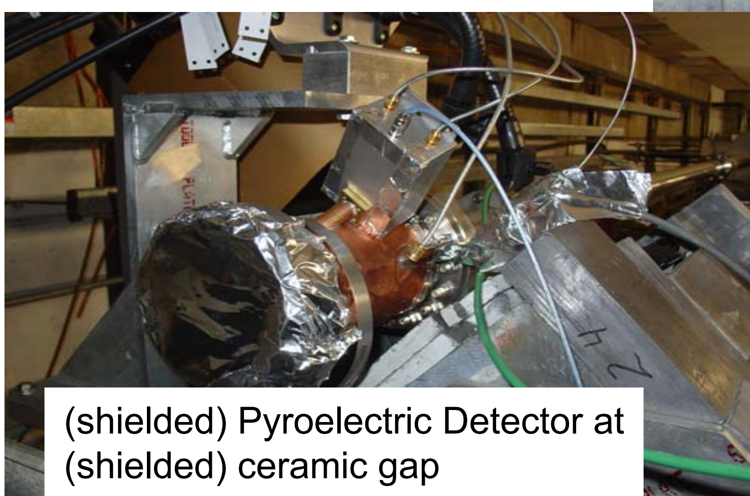
Bunch lengths of ~400 -> 800 microns were achieved.

S. Molloy

RF Bunch Length Detectors in ESA

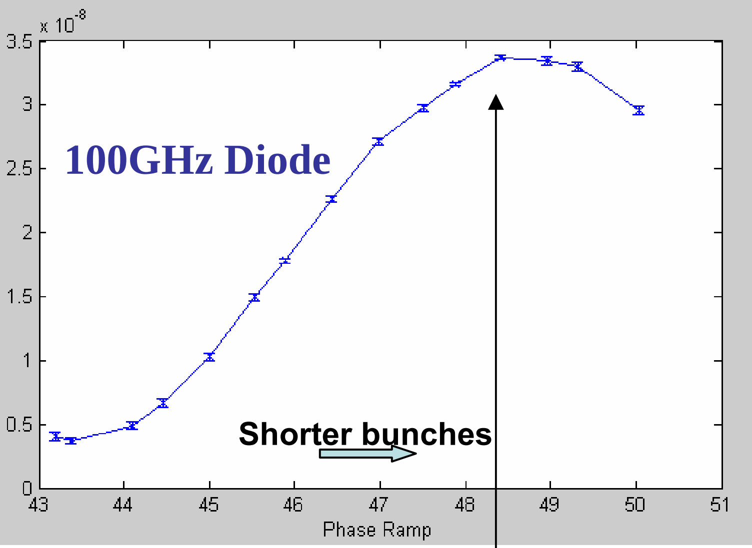


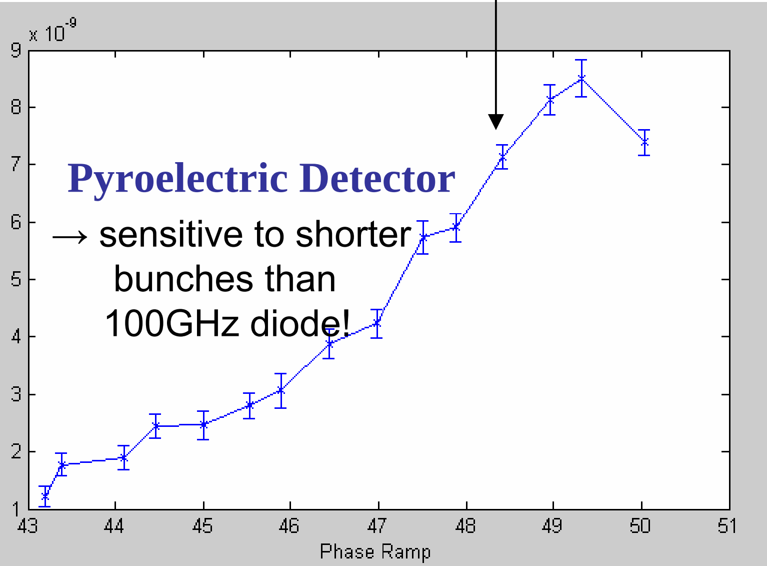




(shielded) Pyroelectric Detector at
(shielded) ceramic gap

Bunch Length Measurements vs Linac rf Phase

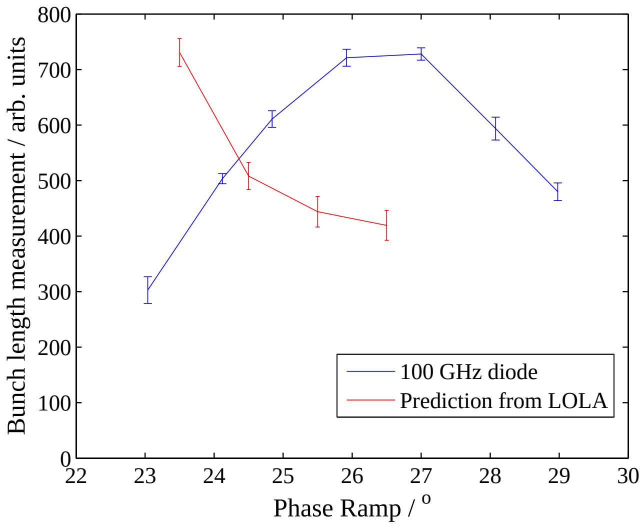




Radiated Power Spectrum at Ceramic Gap

$$P(\omega) \propto Q^2 \cdot \exp\left(-\frac{\omega^2 \sigma_z^2}{c^2}\right)$$

for σ_z=500um, 1/e decrease is at f=100GHz



Predicted ESA bunch length (in μm) and measured 100GHz diode signal, during a phase ramp scan

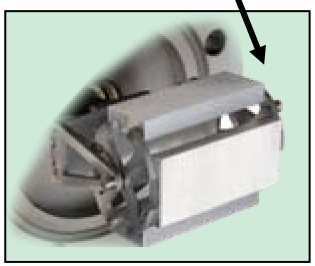
16, and 23GHz Diodes were insensitive to bunch length

(phase ramp determines relative timing of beam wrt accelerator rf)

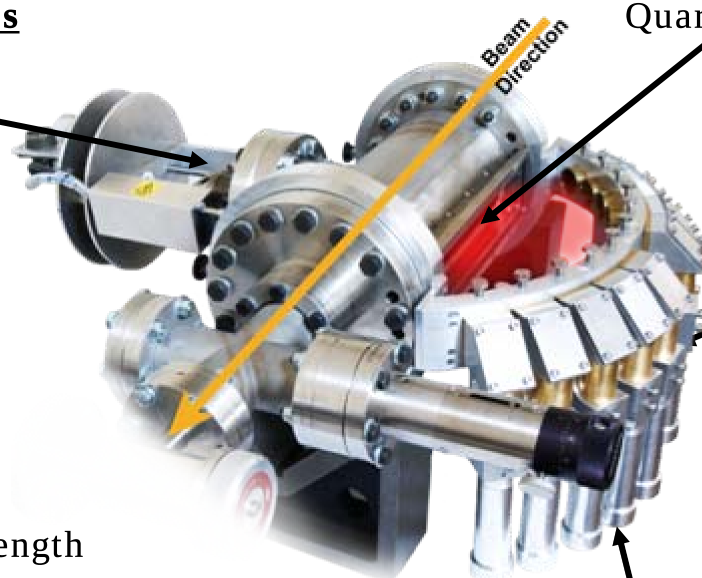
T487: Longitudinal Bunch Diagnostics for the ILC

PI: G. Doucas (Oxford U.),
Collaborating Institutions: U. of Oxford, Rutherford Appleton Lab, U. of Essex, Dartmouth College, SLAC

Carousel of 3 gratings and 'blank'

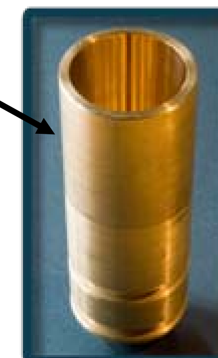


Quartz Window



Winston Cone

• Collects and concentrates the light seen.

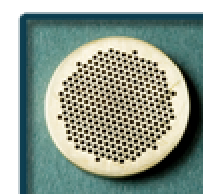


•Expands observable wavelength range.
• Quick measurement turnaround.
• Allows '**true**' SP signal to be found (i.e. '*grating – blank grating*' signal = true SP signal).

11 **Pyroelectric Detectors**

•Inexpensive, room temperature detectors.

Waveguide Array Plate Filter



•Far infrared filter, designed to reject non- SP wavelengths.

G. Doucas

T487 – Prelim. Analysis for March Run

• First SP experiment in the GeV region.

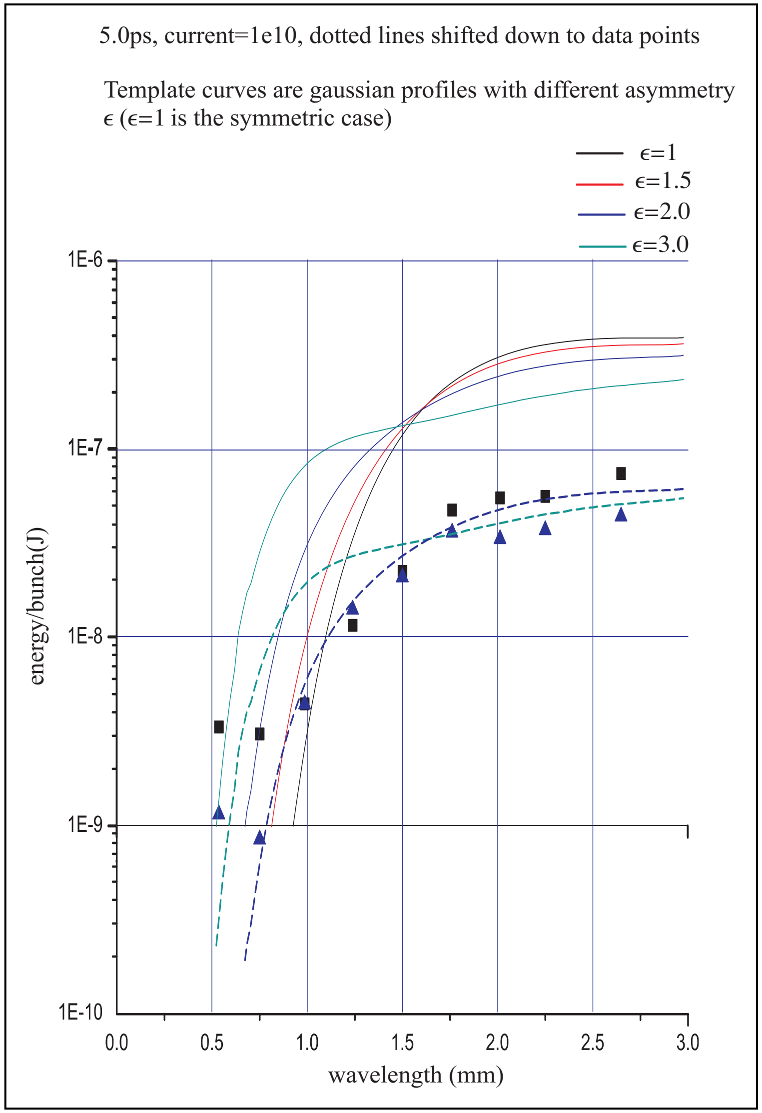
•Analysis of the SLAC data is in the very early stage.
  - •Need cross-referencing of detector responsivities.
  - • Also, absolute detector calibration (not easy).

• However, initial impressions from the data are **very encouraging**:
  - • New electronics performed well.
  - • Good signal-to-noise ratio.
  - • a change in the SLAC bunch length was clearly observable.
  - • overall signal levels and onset of signal saturation suggest a bunch length with a sigma of about 1.5-1.8ps (90% of the particles inside 5-6ps).

• Current analysis method is a Least Squares fit to a number of 'template' distributions; in progress, with specially developed code.
  - • It provides an approximation to a simple profile, but *not a unique* answer. Alternative analysis may be possible.

G. Doucas

T487 – Preliminary Analysis from March Run

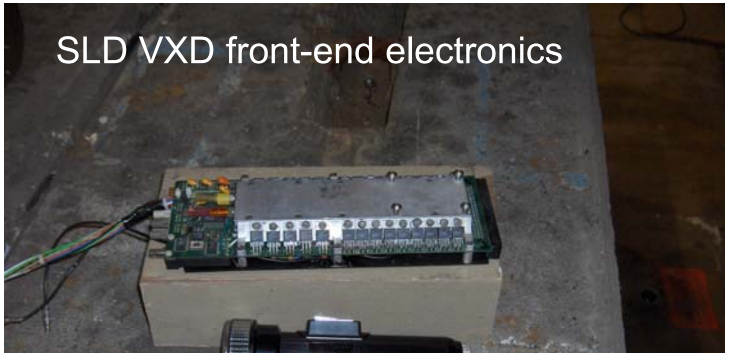


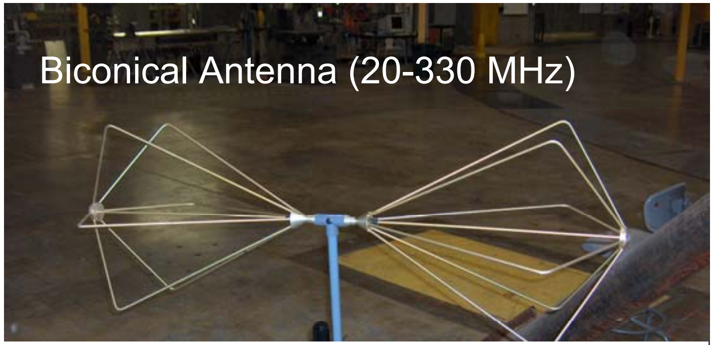
- Two sets of data from the 1.5mm grating (Charge=1e10)
- Template curves are asymmetric gaussian bunch profiles.
- Assumed bunch length=5ps (90% of particles)
- Measured levels are lower than expected for this bunch length (→ requires accurate detector calibration)
- Overall signal level and rise towards 'saturation' suggest a bunch length of about 5-6ps (90% of particles)

G. Doucas

EMI Studies at SLAC ESA

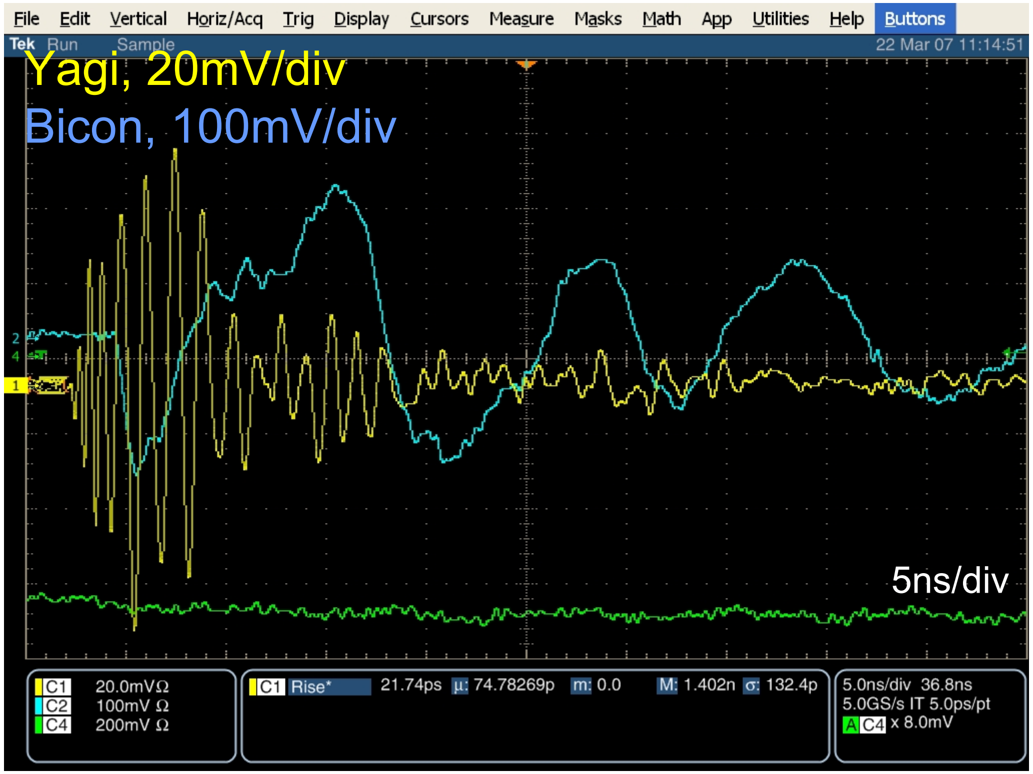
G. Bower (SLAC), N. Sinev (U. Oregon), Y. Sugimoto (KEK)

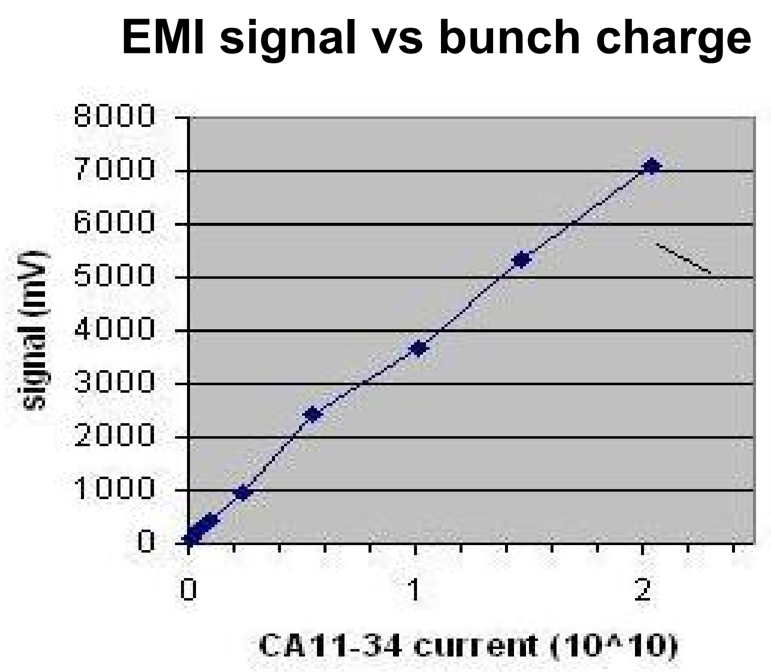




- EM fields within the beam pipe are contained by the small skin depth.
- But dielectric gaps emit EM radiation out of the beam pipe.
- Common "gaps" are camera windows, BPM feedthroughs, toroid gaps, etc.

EMI Measurements near ceramic gap

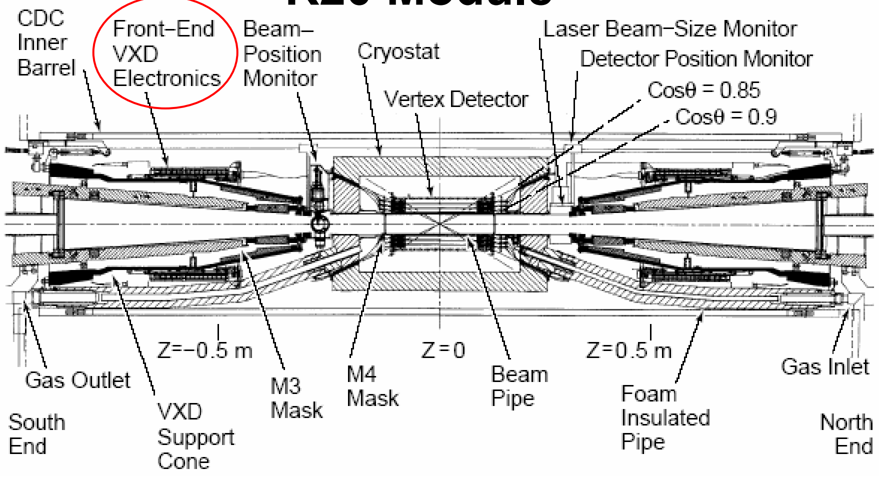


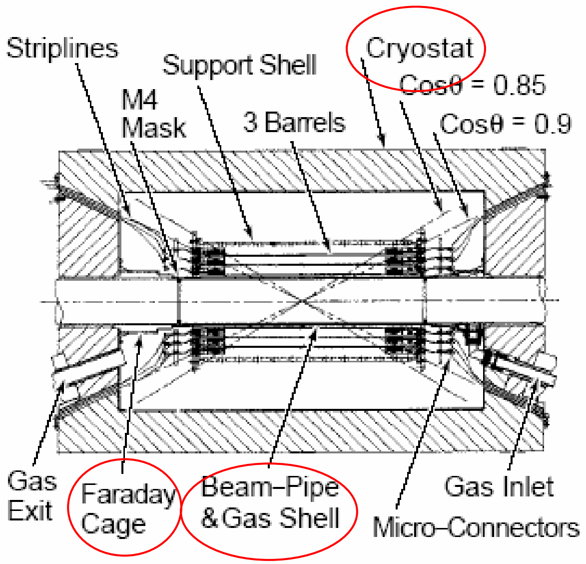


- Antennas placed near (~1 m) gaps observed EMI up to ~20 V/m.
- Pulse shapes are very stable over widely varying beam conditions, indicating they are determined by the geometry of beam line elements.
- Pulse amplitudes varied in proportion to the bunch charge but were independent of the bunch length. Observe ~1/r dependence on distance from gap.

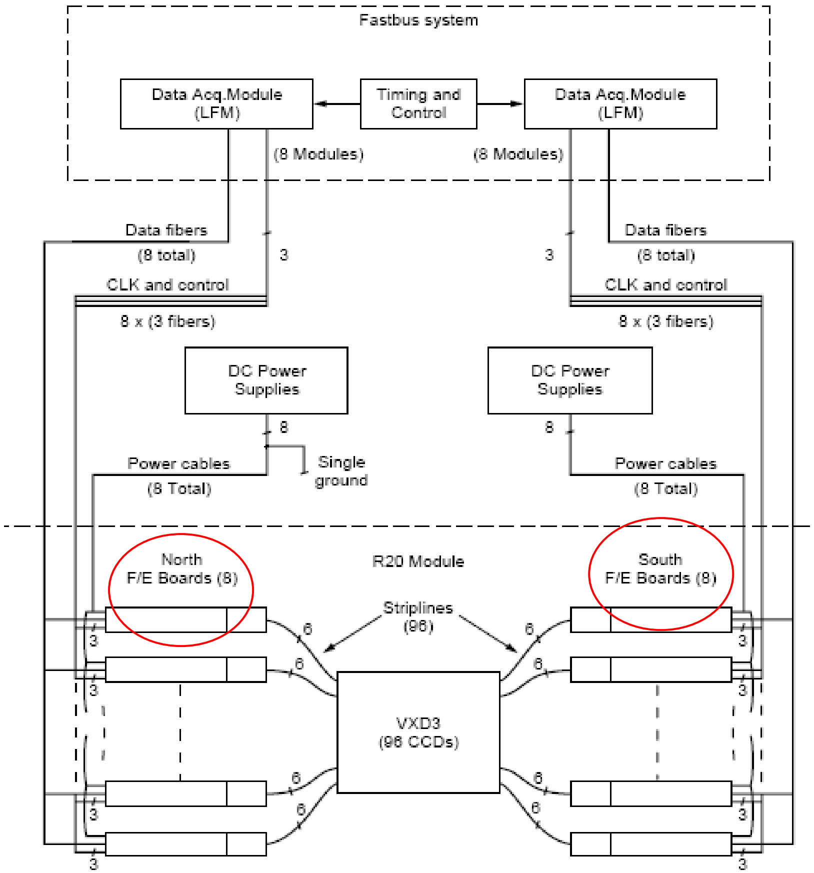
SLD Vertex Detector

R20 Module





Electronics



VXD electronics failures: observations

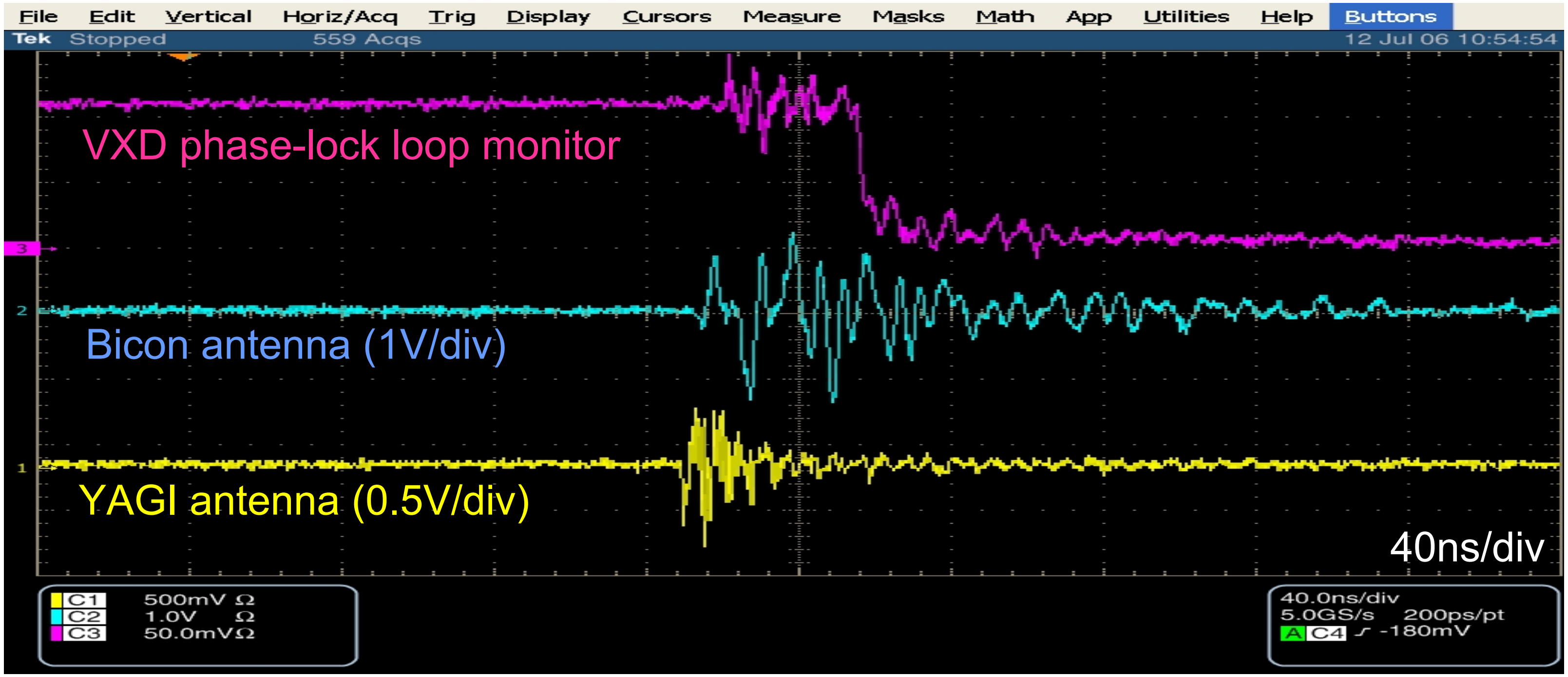
EMI Shielding Tests, July 2006

- Placing just the SLD VXD board inside an aluminum foil shielded box stopped the failures.
- Covering the gap also stopped failures.
  - ➢ failures not due to ground loops or EMI on power/signal cables
  - ➢ failures are due to EMI emitted by gap
  - ➢ what frequencies are important?

EMI Shielding Tests, March 2007

- A single layer of common 5mil aluminum foil was placed over the ceramic gap and clamped at both ends to provide an image current path.
- The antenna signal amplitude was reduced by >x10.
- EMI from upstream sources limited the resolution.
- The aluminum foil gap cover stopped VXD failures.
- A 1 cm x 1 cm hole in the gap foil cover emitted enough EMI to cause about 50% VXD failure rate at ~1m distance. (With no foil rate would be 100% at this distance.)
- There was no failure with a 0.6 cm x 0.6 cm hole.

SLD VXD electronics studies

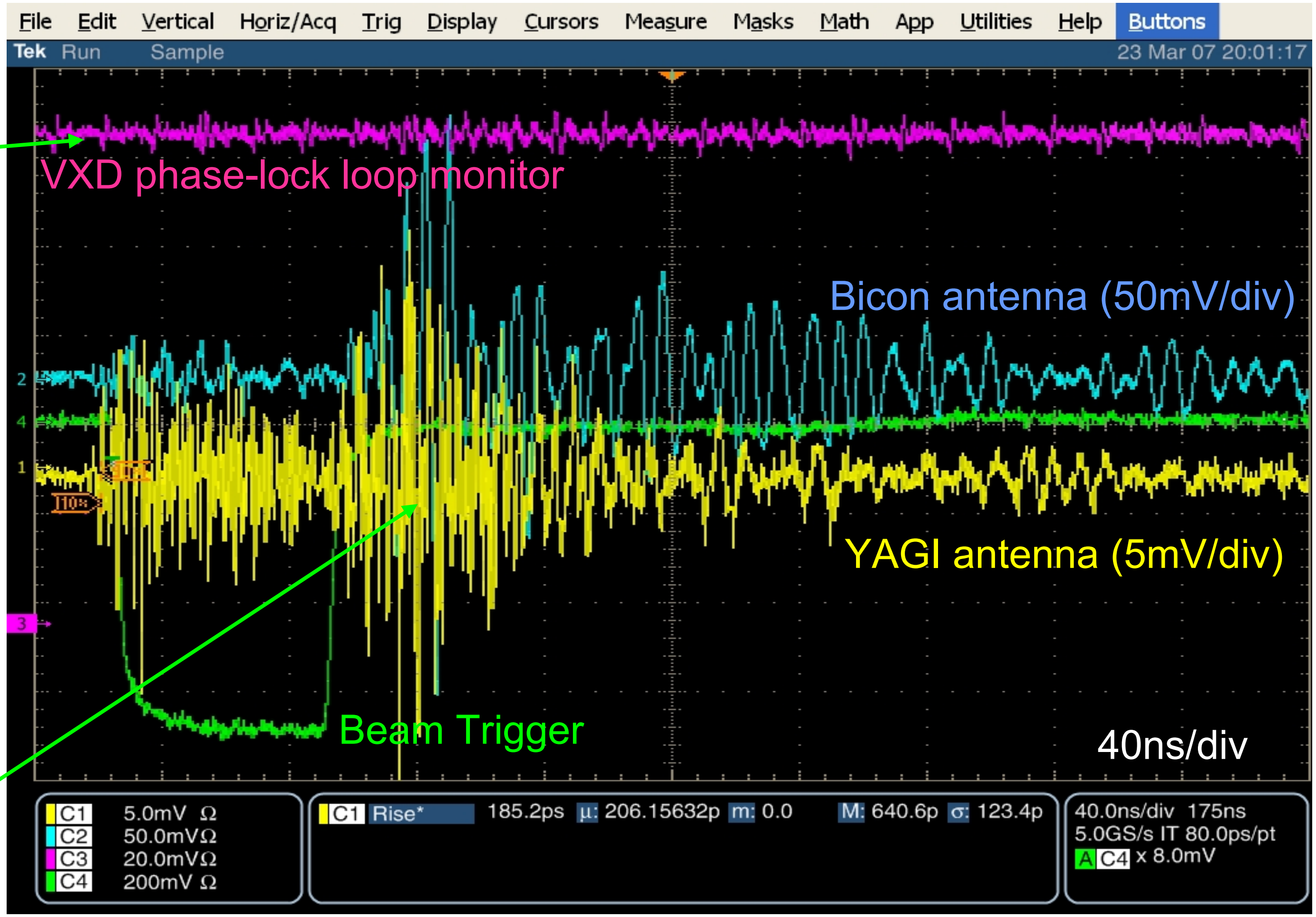


→ VXD front-end electronics placed near ceramic gap. When exposed to sufficient EMI the phase-lock loop monitor signal drops.

- Phase lock loop lost lock on about 85% of beam crossings when the module was exposed to ~20 V/m of EMI (YAGI measurement on 2.5GHz bandwidth scope)
- Phase lock loop lost lock failure rate drops to 5% at ~1 V/m of EMI.

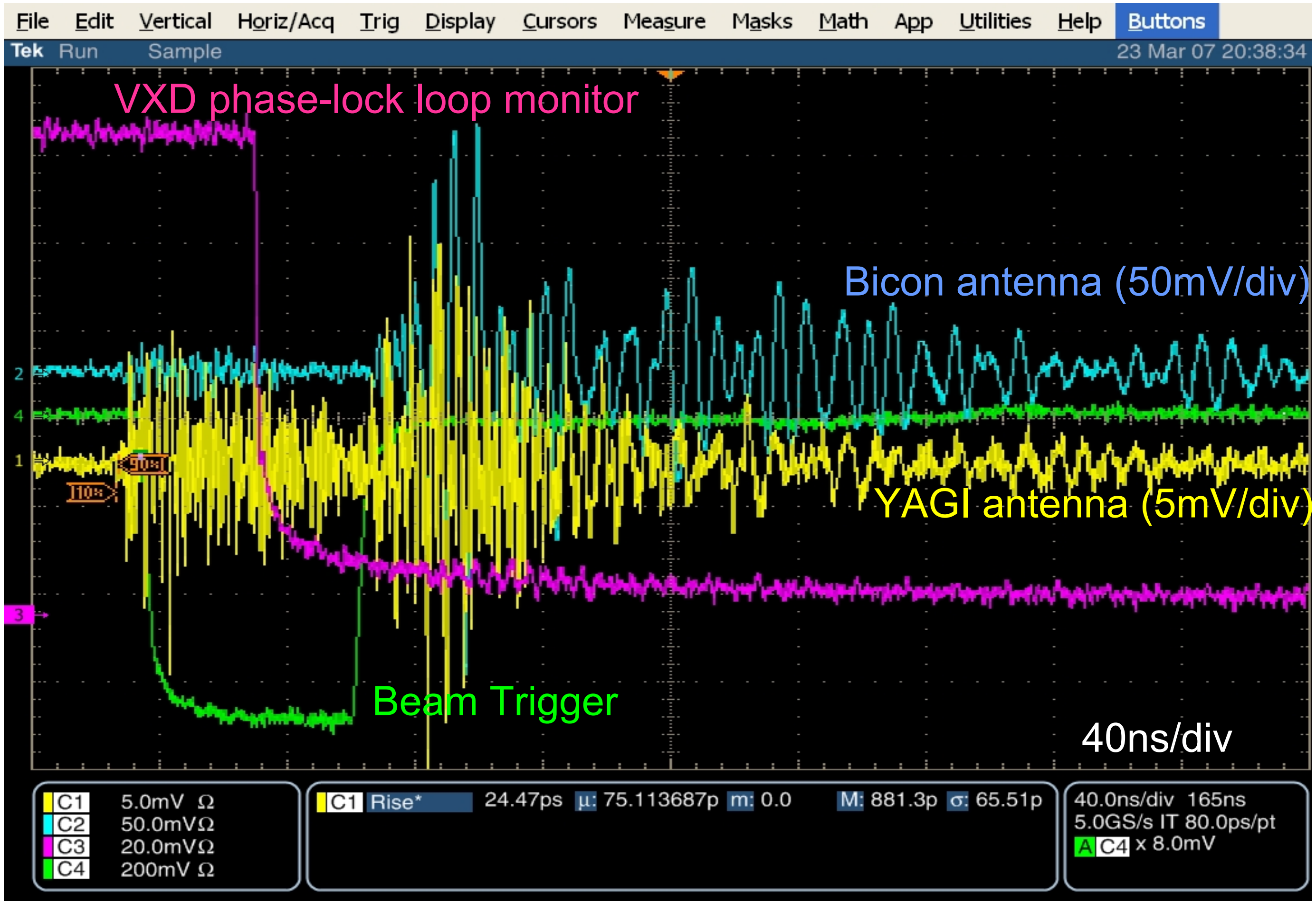
Antenna Signals, gap covered with Al foil

no failures



EMI from gaps (toroids, …) downstream

Antenna Signals, 1cm^2 gap in foil



→ observe VXD electronics failure, but little change in antenna signals

→ indicates VXD electronics sensitive to EMI at higher frequencies than seen by YAGI; dimensions indicate sensitivity at ~30GHz

VXD electronics failures: observations

EMI Shielding Tests, July 2007

- used 23GHz diode detector for diagnostics, in addition to YAGI and Bicon antennas; and used SLD VXD electronics module
- characterized EMI leakage from "shielded" gap with i) 10mm x 10mm hole, ii) 6mm x 6mm hole, iii) bnc connector: unterminated, terminated and with Al foil cover
- also measured directionality of EMI unshielded and "shielded" gap with holes

Observations:

- ➢ EMI leakage thru 10mm x 10mm hole observed with 20GHz diode and with failures of SLD VXD electronics module; not observed with YAGI or Bicon antennas
- ➢ observe EMI leakage through the bnc connector on 20GHz diode; no change when Terminator added. EMI leakage vanishes when add Al foil cover either to bnc Connector or to bnc terminator.
- ➢ observe failure of SLD VXD electronics module when placed next to bnc connector. Similar results as for the 20GHz diode—failures eliminated when cover the bnc with Al foil

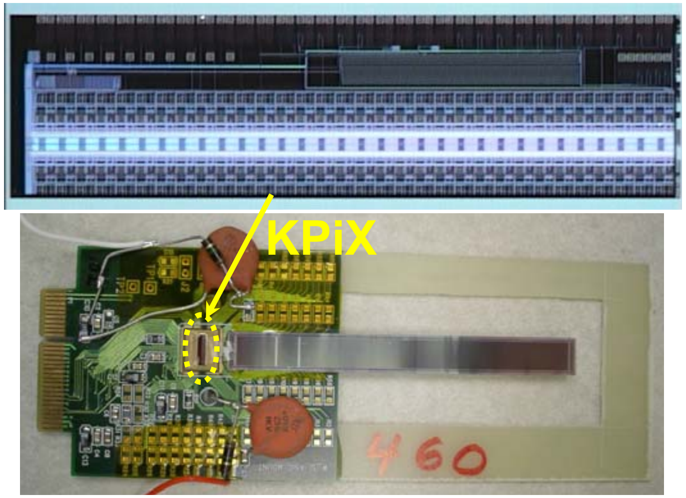
SiD KPiX Test Aug. 13-20, 2007

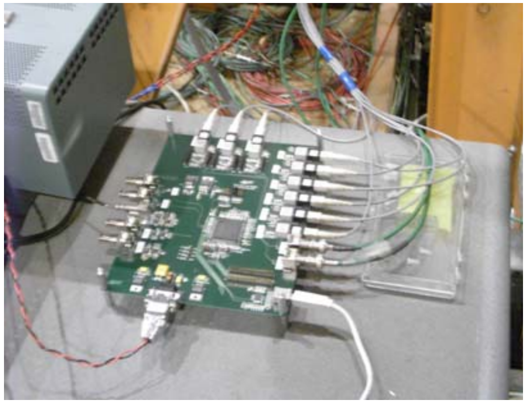
(T. Nelson and R. Herbst, SLAC)

KPiX readout chip being developed at SLAC for SiD concept

- Si-W ECal, Si Outer Tracker, GEM HCal, Muons?
- 32X32=1024 channels, currently a 2X32 prototype
- Pulsed-power operation delivers 20μW/channel average with ILC timing

Testing performance under beam conditions with three planes of spare Si (50 um width) microstrip sensors from CDF Layer 00





Local DAQ board w/ FPGA; fiber bundle to detector, and USB to local PC w/ ethernet

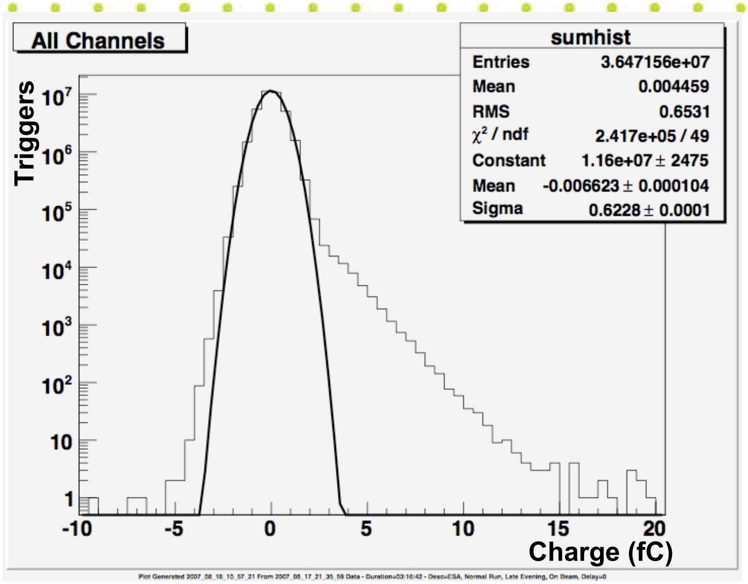
SiD KPiX Test Aug. 13-20, 2007

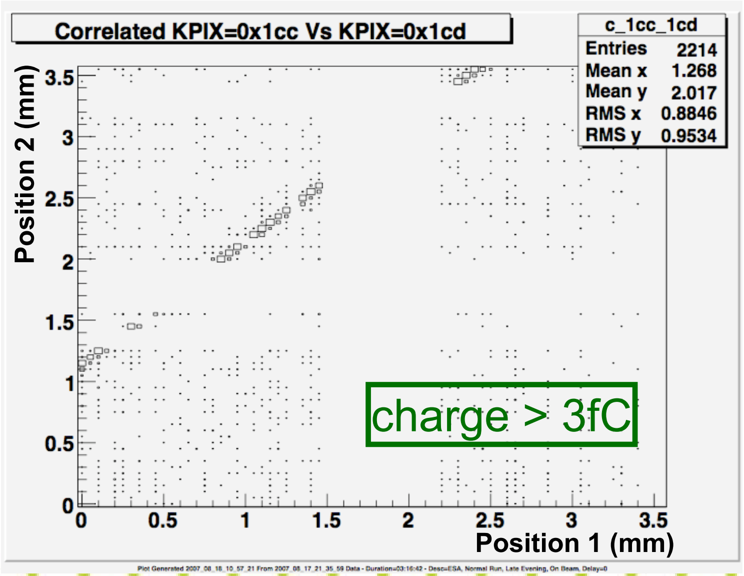
Results at right from 3 hours data

Beam: 0.25 electrons/pulse, 10 GeV
0.2% momentum bite
2mm rms beam radius

(secondary electron beam using 1nC 13.6 GeV primary LCLS beam incident on 0.5-r.l. Be target at end of Linac)

- Signal clearly visible in raw data
- Multi-plane coincidence will result in a clean Landau
- Alignment not perfect, but 3-d tracking with full dataset should be possible
- Performed short tests of various readout modes and chip settings





Future for continuing ILC-ESA Test Beam Program?

FY08 → continue program in ESA, requesting 5 weeks of Beam Tests (some with 13.6 GeV LCLS beam and some with 28.5 GeV beam, parasitic to PEP-II)

→ beam scheduling with LCLS commissioning looks ok

→ reduced funding available from SLAC, but major installations are complete; still working out ILC funding

FY08 Program:

T474 BPM Energy Spectrometer: new RF BPM from UK at mid-chicane, expand calibration tone system, expand interferometer system, reduce vibrations

T475 SR-stripe Energy Spectrometer: fix problems with crosstalk and signal ringing, possible visible SR-light detector

T480 Collimator Wakefields: additional collimators to measure

T487 Smith-Purcell bunch length diagnostics: measure polarization of S-P radiation, provide realtime diagnostics on longitudinal profile

EMI studies: measure leakage from rf cables, connectors (also, pursue tests of SLD VXD electronics module failures at commercial company for EMI source, up to 40GHz and 200V/m)

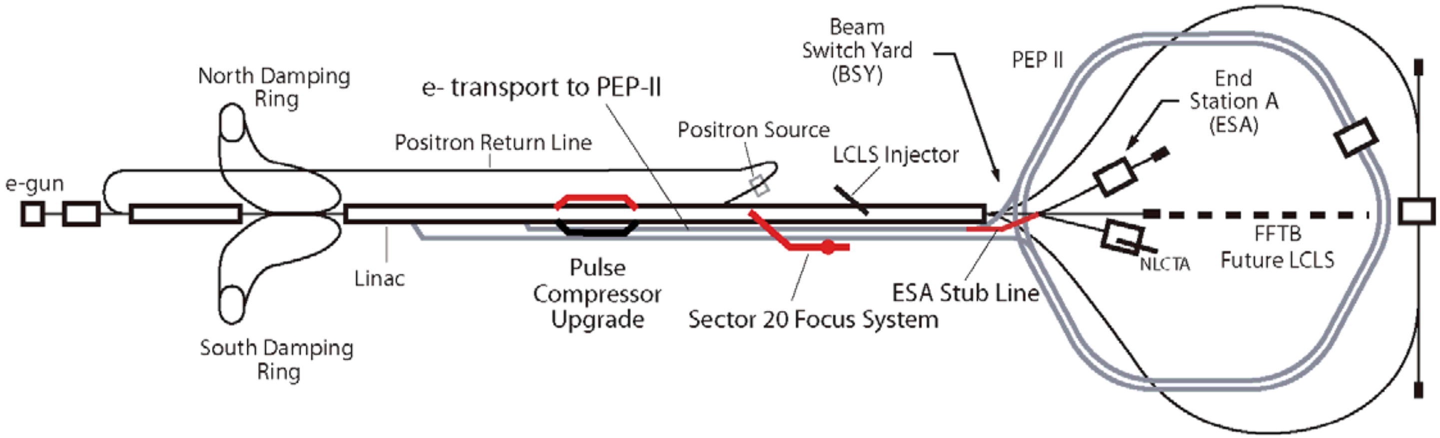
Linac Quad/BPM Tests: new support stand and x-y mover systems for 2 BPMs; probe micron-level stability for Linac Quad-BPM system

(possible tests related to Damping Ring electron cloud program being considered)

Detector tests: upgraded KPiX for SiD (allow self-triggering with charge sharing corrections, address known noise problems, new pulse shaping), possibly with prototype ECAL Si Detectors; other?

Test Beams at SLAC beyond FY08

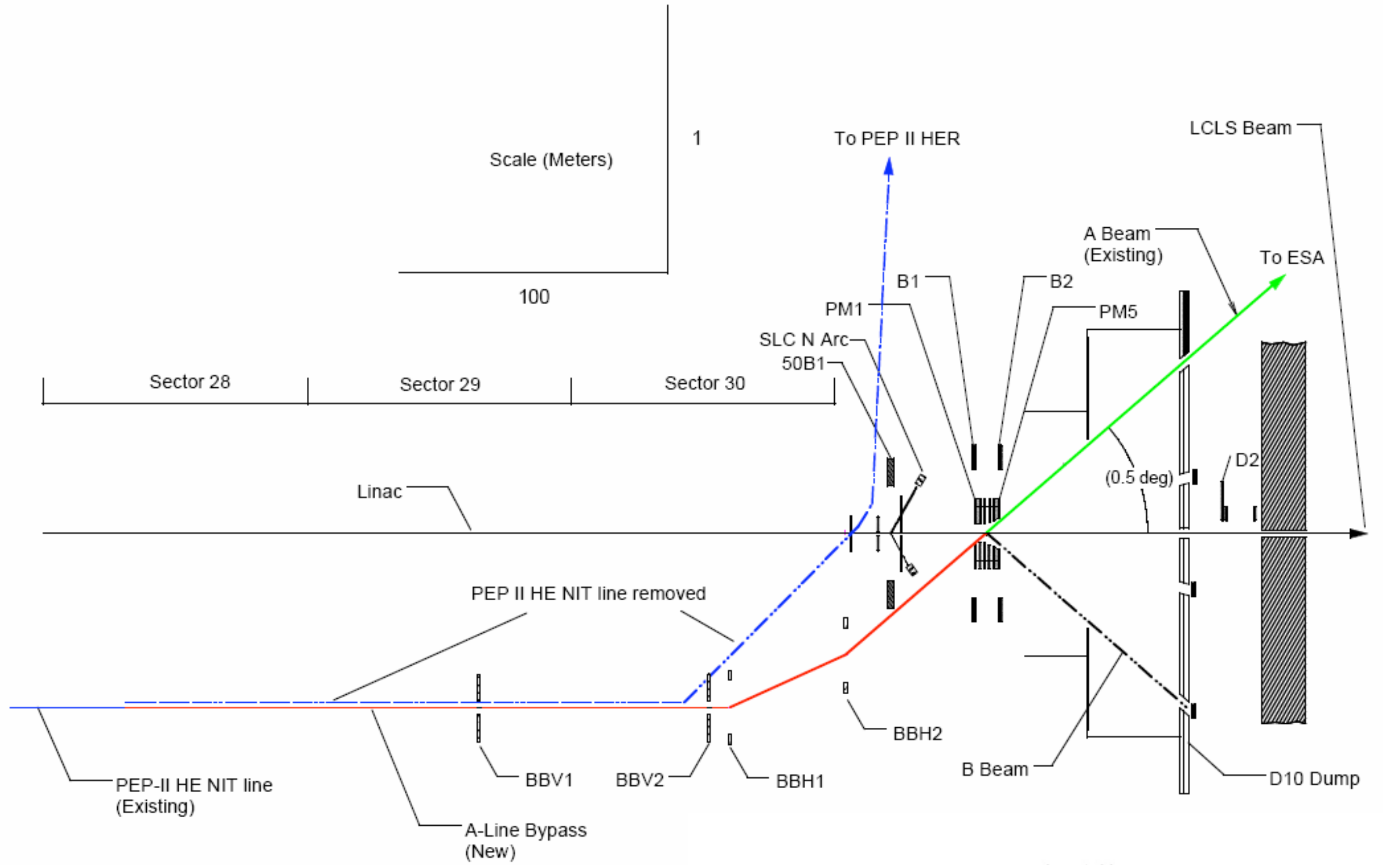
Updated SABER proposal being submitted this month to DOE:
***S**LAC **A**ccelerated **B**eams for **E**xperimental **R**esearch*



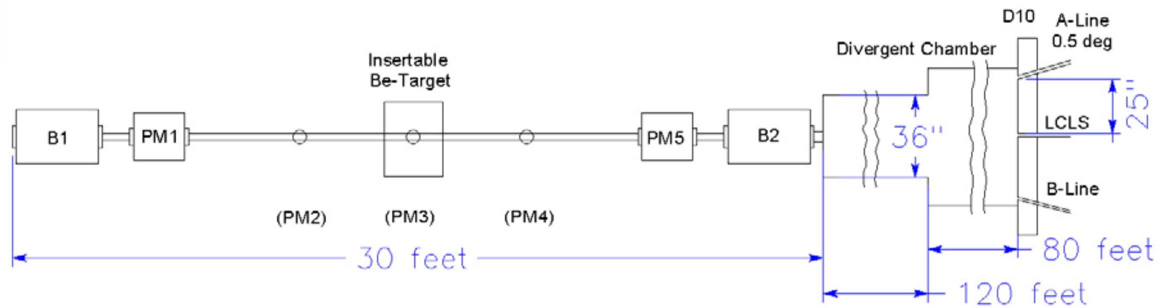
2 Experimental Regions:

1. 24 GeV beam to new Sector 20 Experimental Region for advanced accelerator physics: plasma and dielectric wakefield acceleration + other experiments requiring high energy densities
2. General purpose test beam facility in ESA: primary beams for accelerator research, secondary beams for detector R&D, beam dump experiments for radiation physics studies. Initially limited to 12-GeV electron beam, with later upgrade to 24 GeV.

SABER Bypass to A-Line and ESA



expanded view of current pulsed magnet region



Summary

Very successful program of ILC beam tests in ESA in 2006 and 2007!

Biggest Efforts:

T-480 Collimator Wakefield Study

- Results essential for ILC collimator design
- Minimize risk for emittance degradation to IR and for achieving design luminosity

T-474 and T-475 Energy Spectrometer Prototypes

- Experimental results needed to demonstrate ability to meet design goals for precise energy measurements for the ILC physics program.

FY08 → continue program, requesting 5 weeks of Beam Tests
→ beam scheduling with LCLS commissioning looks ok
→ reduced funding available from SLAC, but major installations are complete; still working on finalizing ILC funding for program

FY09 and beyond (LCLS era, parasitic operation with PEP-II ends at end of FY08)
→ ESA PPS upgrade needed for continued ESA operation
→ updated SABER proposal includes ESA test beam facility together with advanced accelerator experimental facility; being submitted to DOE this month