

The background is a solid green color with a collage of faint, semi-transparent physics-related diagrams. These include a block diagram of a signal processing chain with multipliers and amplifiers, a particle detector cross-section with a central square and a horizontal line of sensors, a graph of energy spectra with multiple peaks, a schematic of a particle beamline with a dipole magnet and rectangular components, and a 3D perspective drawing of a particle detector or accelerator component.

Energy Spectrometer for the ILC

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BPM energy spectrometer collaboration

UCL: Filimon Gournarnis, Alexey Lyapin, Matthew Wing

Cambridge: Mark Slater, David Ward

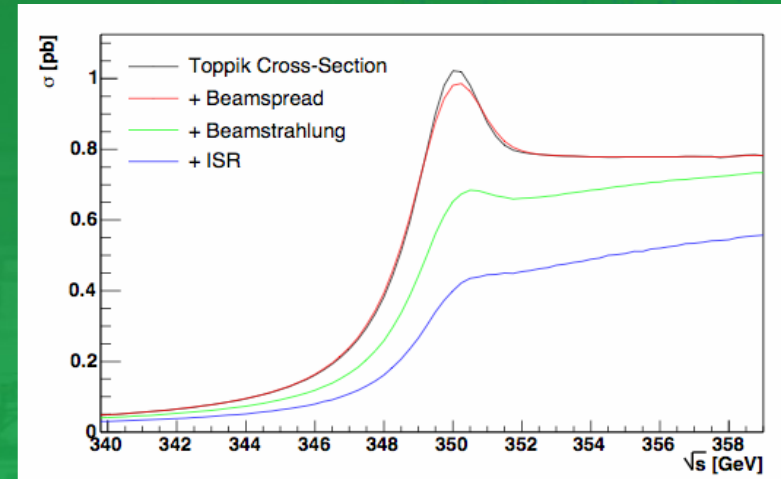
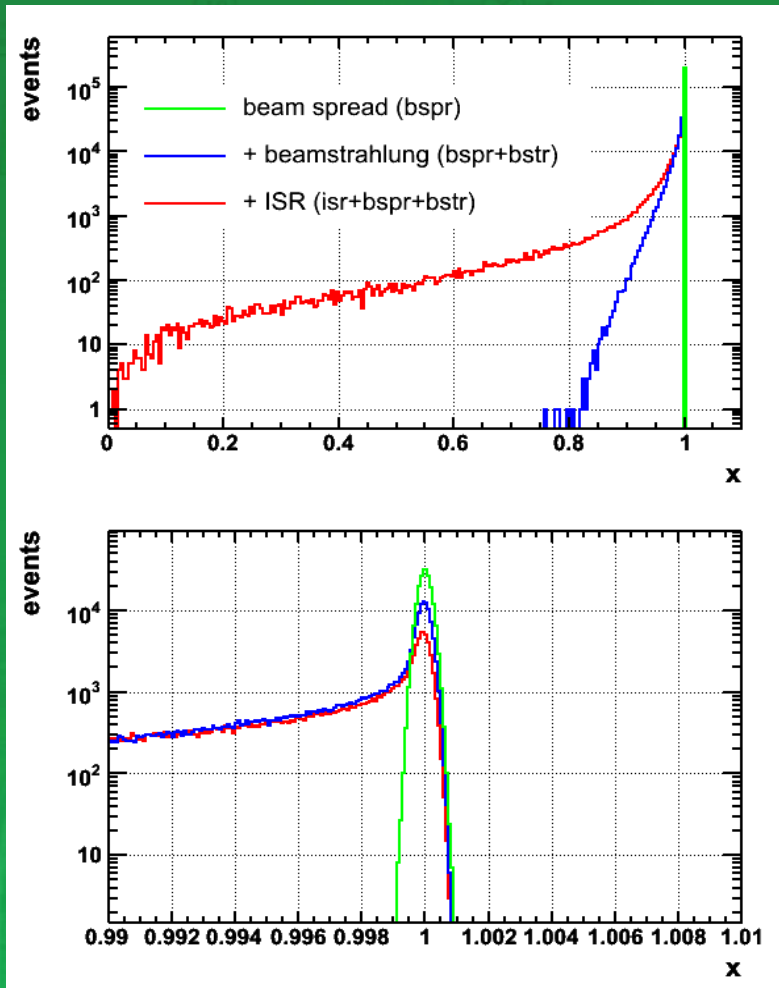
RHUL: Stewart Boogert

DESY-Zeuthen: Heinz-Jeorgen Schreiber, Michele Viti

JINR (Dubna): Viktor Duginov, Nikolay Morozov

In collaboration with SLAC, KEK, UC Berkley, LLNL, BINP...

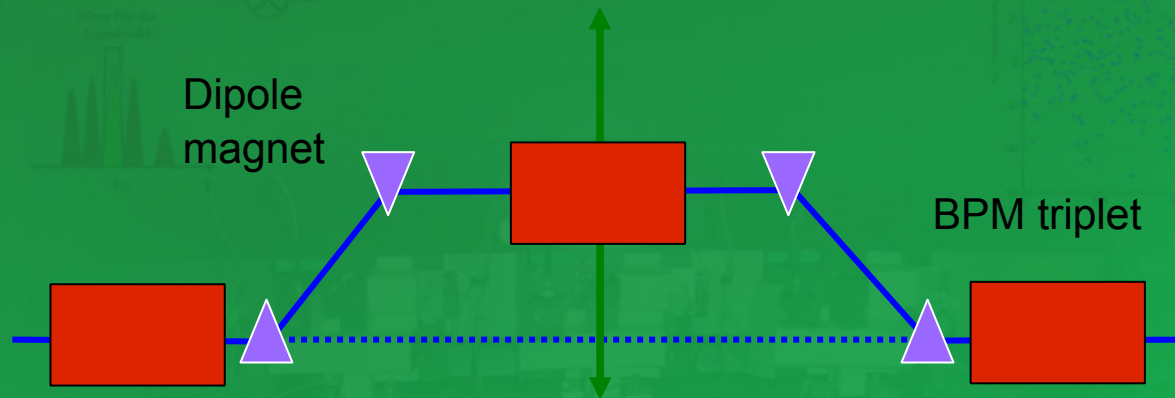
Luminosity spectrum



Precision threshold scan
measurements:

- Energy loss effects have to be taken into account
- Absolute beam energy measurement of 1 part in 10^4
- Spectrometers up- and downstream

BPM spectrometer requirements



- Chicane
 - 4 magnets
 - 5 mm maximum deflection
 - Bipolar operation
- Measurement time
 - Single bunch
 - Bunch train
 - 1 hour / 1 day
- Mode of operation affects BPM design
 - Operation of chicane (frequency of ramping)
 - Frequent return to low energy?
 - Essential design beam energies
 - 50, 175, 250 & 500 GeV
 - Move BPMs to null dipole signal
- Single bunch information useful for machine operation?

ILC spectrometer tasks

Spectrometer analysis:

- Systematic effects in the spectrometer chicane
- Backgrounds
- Impact of the spectrometer chicane on the beam (energy bandwidth etc)
- Possible modes of operation
- Possible machine modes
- Positive and negative scenarios

BPM analysis

- Resolution
- Range of the best operation
- Multibunch operation
- Calibration
- Stability
- Bunch shape effects
- Machine related issues

Magnets:

- Field strength
- Length
- Synchrotron radiation
- Field mapping
- Online monitoring
- "Zero" field measurement

Alignment

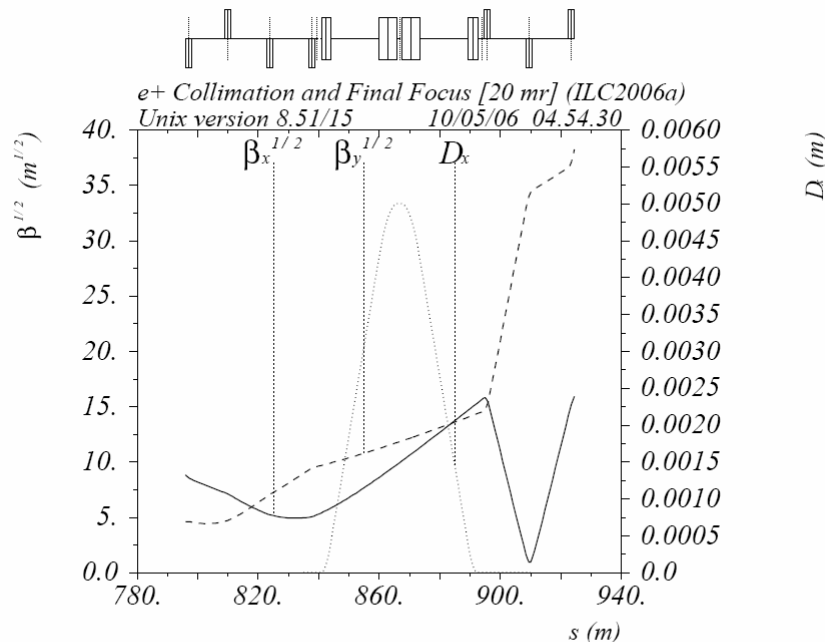
- Initial BPM alignment
- Intra-triplet BPM movement
- Triplet to triplet movement

Movers

- Calibration + 5 mm offset
- Specification

Alternative methods???...

ILC spectrometer in UK



$\delta E/p_0 c = 0.$

Table name = TWISS

- Luminosity spectrum simulations
- Spectrometer analysis:
 - Started with a simulation of systematic effects in the spectrometer chicane
 - Backgrounds simulation
 - Improving existing analysis of the impact of the spectrometer chicane on the beam (energy bandwidth etc)
- BPM analysis
- BPM design and production
- Movers for BPMs

BPMs in the spectrometer

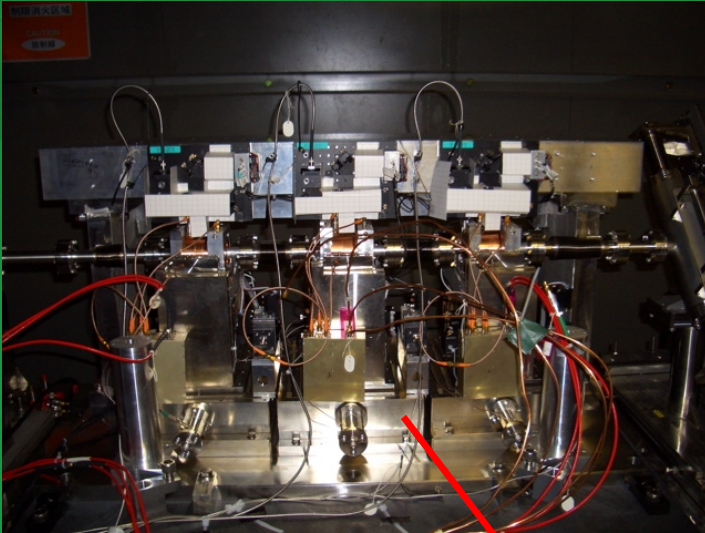
- Essential part of diagnostic
 - 9 BPMs per spectrometer x 4 beam lines ~36 BPMs
 - Requirements different from Linac BPM requirements
 - Requires detailed design work now

Spectrometer BPM requirements

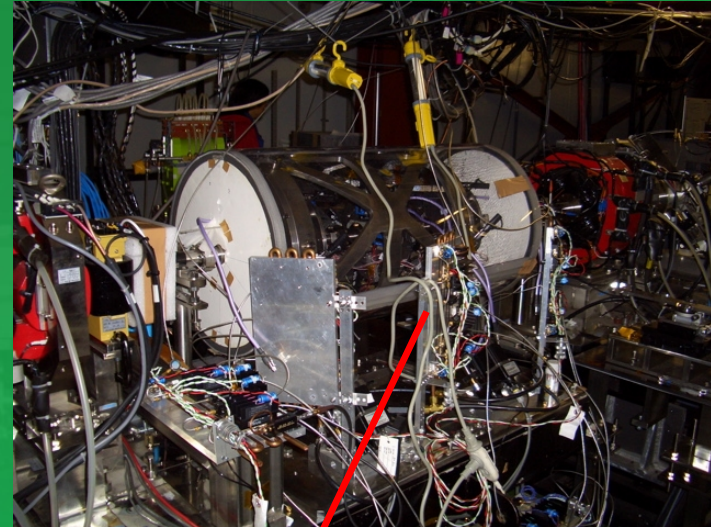
- Spectrometer BPM will probably set the most stringent requirements on BPM design
 - Aperture
 - **Resolution**
 - Dynamic range (1000:1)
 - **Stability (intrinsic and electronics)**
 - Accuracy
 - Calibration
 - Backgrounds
- Existing BPM designs are far from optimal for an energy spectrometer
 - Button and strip-line not seriously considered
 - ATF/ATF2 - aperture
 - Reentrant - resolution/stability?
 - Generic pill box cavity
- Machine
 - Bunch angle, position & charge jitter
 - Aperture
- Spectrometer
 - Movement range
 - Stray fields
 - Emittance dilution
- BPM
 - Resolution already achieved (See ATF results)
 - Scaling of resolution as function of cavity size
 - Design for stability (monopole rejection)

NanoBPM collaboration at ATF

KEK BPMs on flexure piezo movers



BNP BPMs in SLAC/LLNL frame

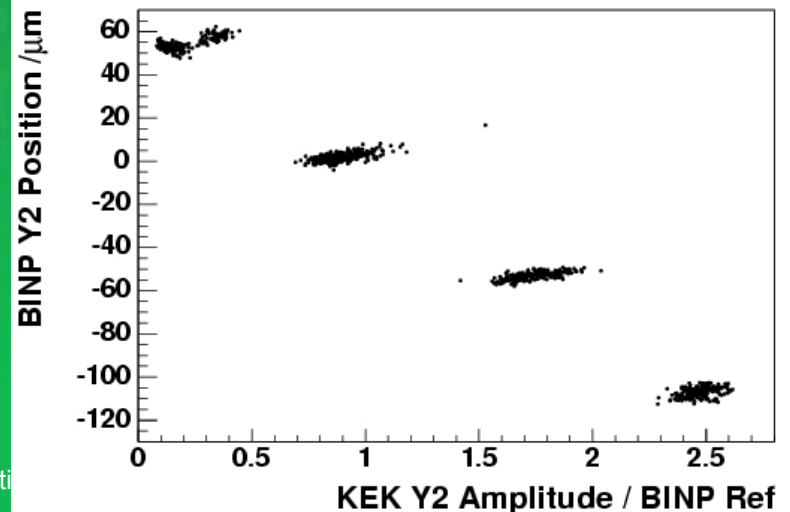
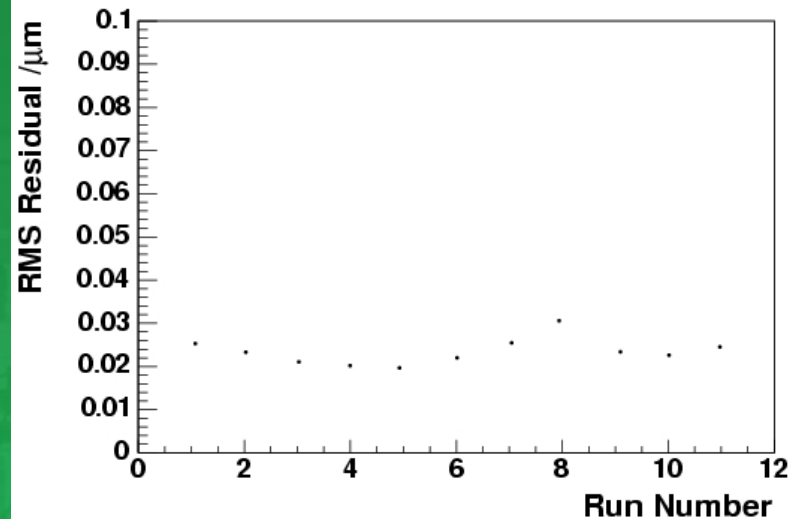


- Experiment to test the best BPM resolution among with the other BPM properties, systematics and stability

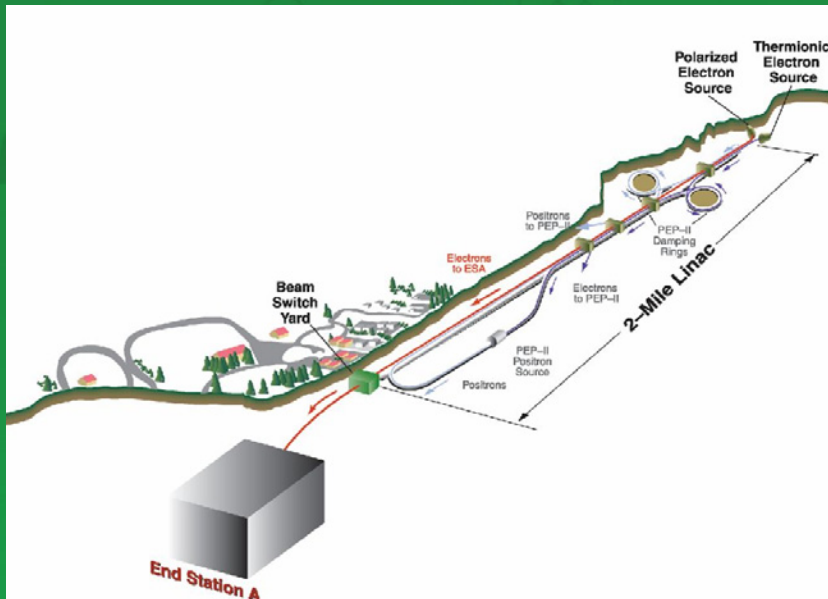
Energy spectrometer meeting, JINR, May 2006

Results from ATF

- April 2006 data
 - Fitting algorithm
 - Calibration using hexapod movers
 - Resolution for the best runs ~ 18 nm
 - Short and long term drifts less than 100 nm
 - LO sources locking improved
 - KEK BPMs coupling to the reference cavity fixed
 - Cross-calibration with corrector magnets



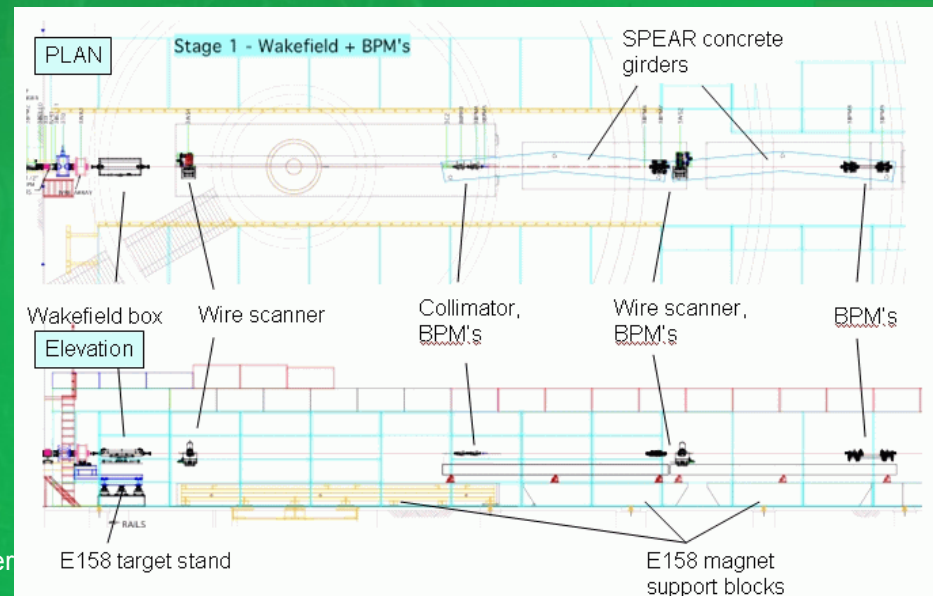
SLAC ESA spectrometer activities



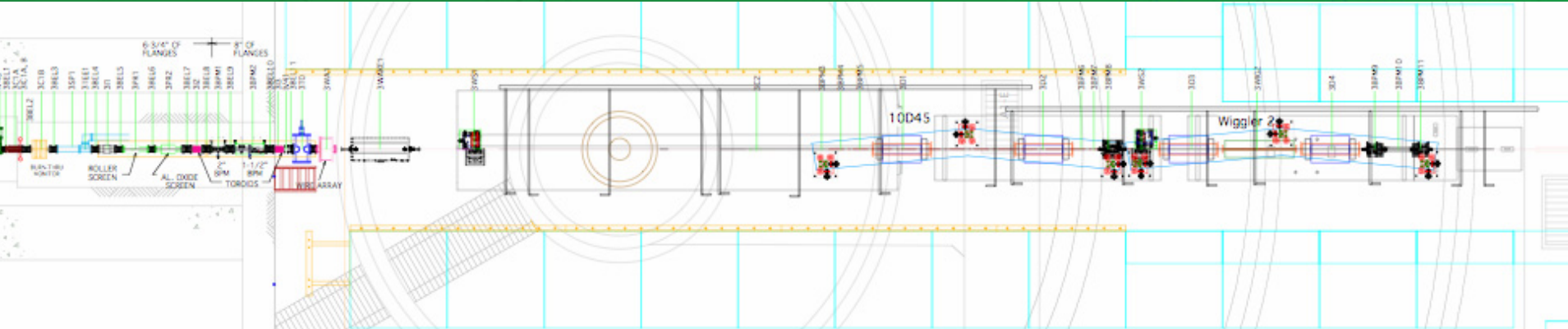
- One of the primary tests is a 4-magnet chicane spectrometer
- High energy beam test
- Commissioning run in Jan 2006 to test the BPMs and electronics, other diagnostics installed
- Preliminary old (not nano-) cavity BPM resolution with the new electronics $\sim 1\mu\text{m}$

- Two more runs next year with magnets installed
- Planning to add/replace BPMs around 2007 with higher resolution ones now designed in UCL

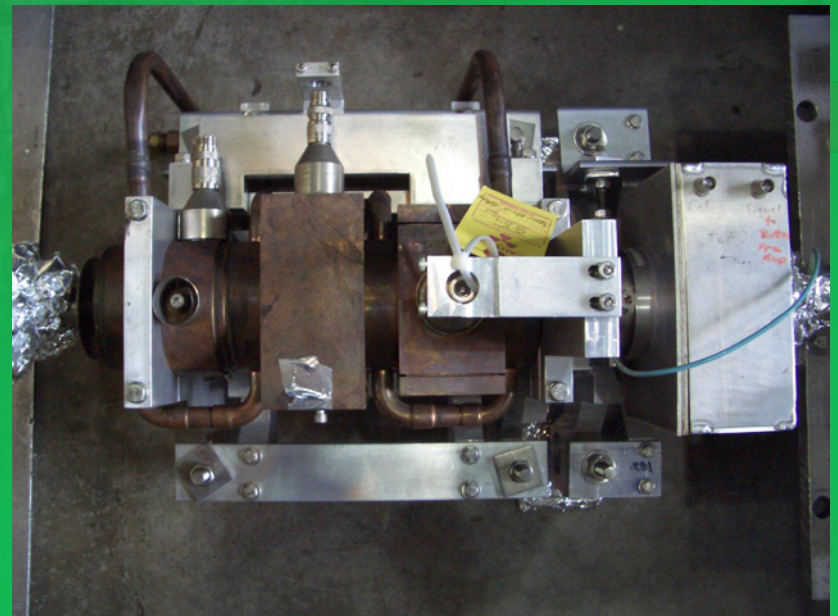
Energy spectrometer



End station A programme

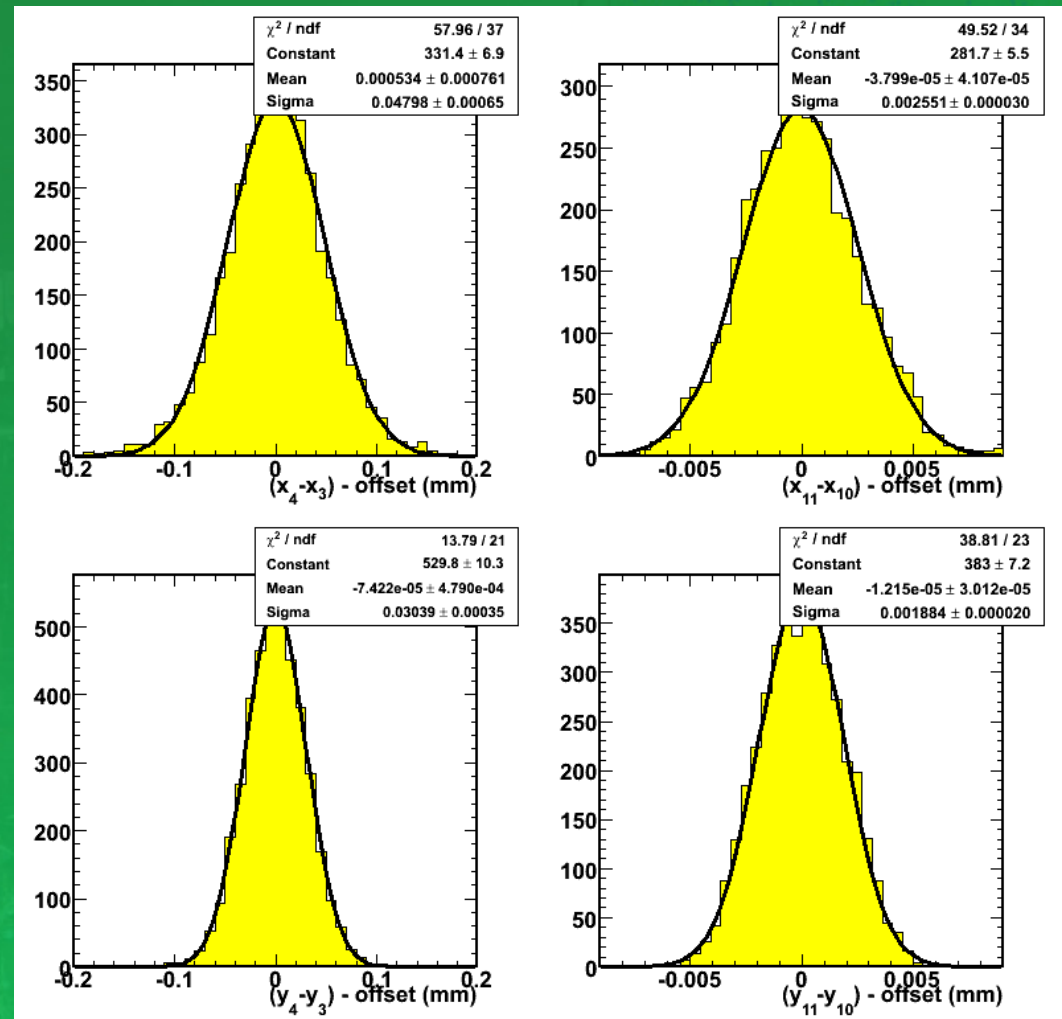


- Plans to test chicane ideas at ESA
 - Using old SLAC cavities
 - Test of chicane ideas and identification of possible problems
 - Test system of other general ILC and spectrometer specific BPM designs
 - New RF electronics
 - Resolution $\sim 1\mu\text{m}$
- First tests in January and April 2006, chicane tests in 2007...

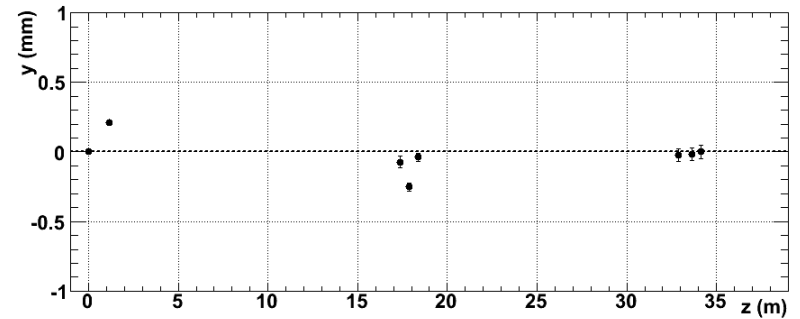
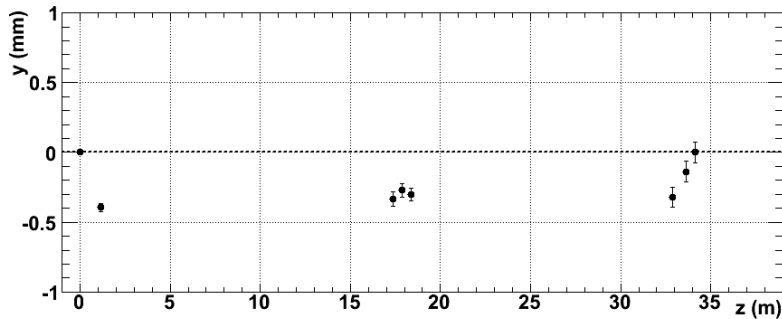
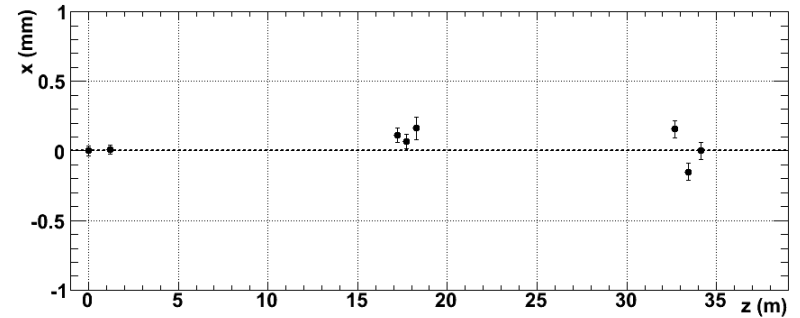
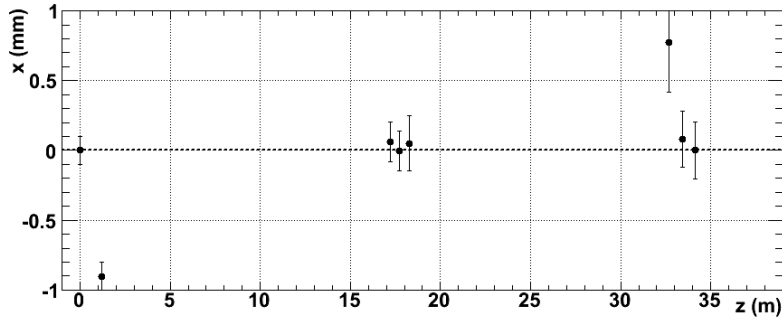


Results from ESA

- Commissioned 2 BPM triplets, including the new Linac BPMs
- Resolution data
 - Resolutions of $<1\mu\text{m}$ were achieved
 - Dynamic range $\pm 1\text{ mm}$
 - Resolution of the Linac BPMs still worse (few μm), should improve significantly with the analysis tuned to the different decay rate/bandwidth



Results from ESA



- BPM alignment
 - 3 sets aligned within $\pm 200 \mu\text{m}$
 - Distance between sets ~ 20 m
- See ESA related talk by B. Maiheu...

Need optimized BPM design

- Cavity BPMs, no alternative yet
 - Positive experience with ATF/ATF2 cavities
 - Need a bigger aperture for machine protection
 - Scale ATF2 design to a lower frequency
 - See BPM talk...

As a summary

- Still more questions than answers
- Spectrometer geometry/layout
 - Is the existing design optimal? (Z to 1TeV running?)
- Accelerator
 - Is the existing chicane acceptable for the machine?
 - Sets limits on dipole magnet requirements (quadrupole, sextapole contributions)
 - More specific information on the beam at chicane location
- BPM
 - Resolution $\sim 100\text{nm}$, stability $\sim 200\text{nm}$ quite possible
 - Scale existing cavity designs for spectrometer
 - High gain electronics and readout readily available
- Operation
 - Calibration with Z running
 - Frequency. How long can the calibration with Z be maintained
 - Systematic effects using $\sim 50\text{GeV}$ calibration up at 500 GeV ?
 - Magnet ramping
- Magnets
 - Must begin discussion with magnet designers