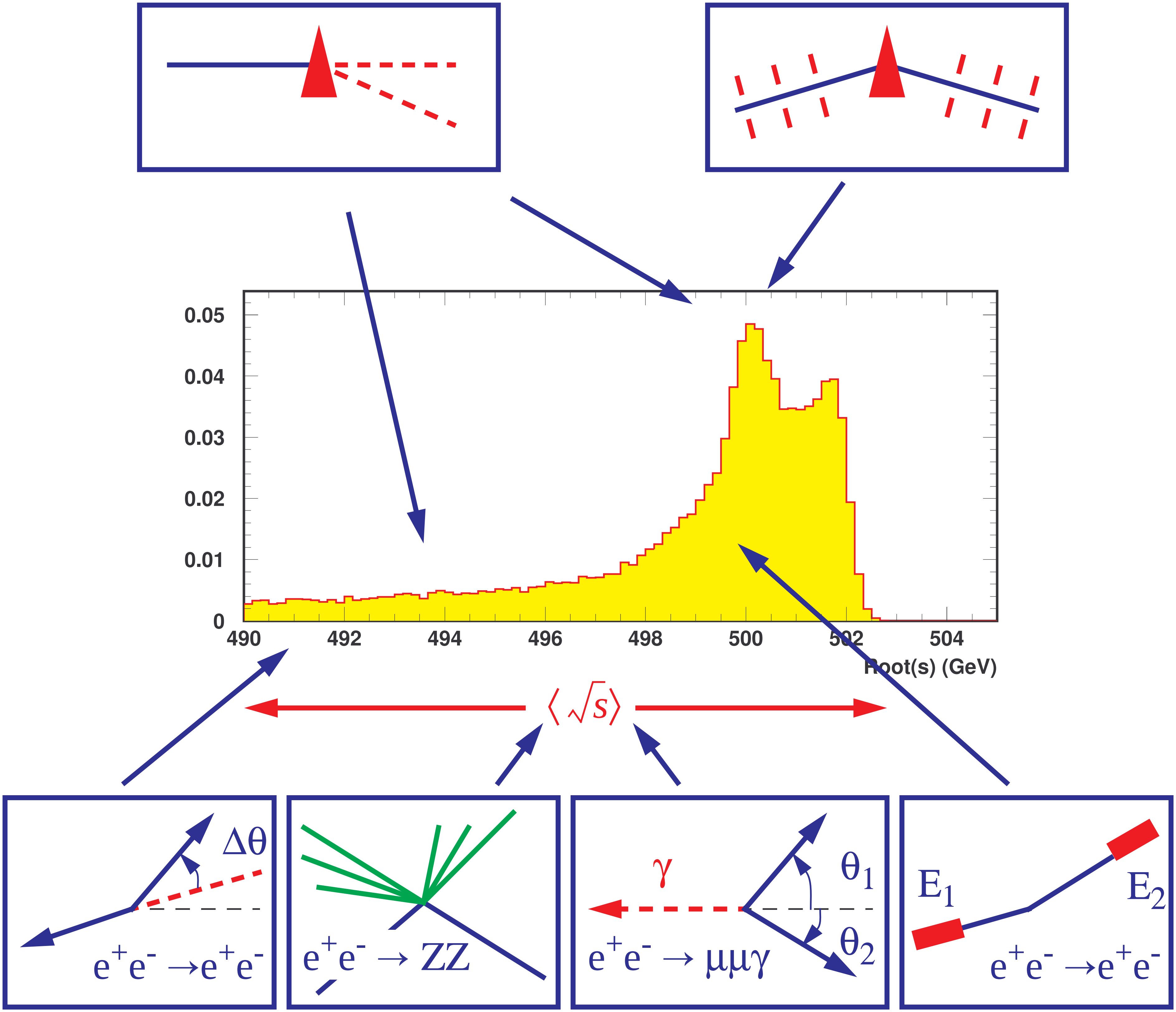
Energy Spectrometer Designs and Beam Tests

July 29th, 2004
Victoria Linear Collider Workshop
Victoria, BC

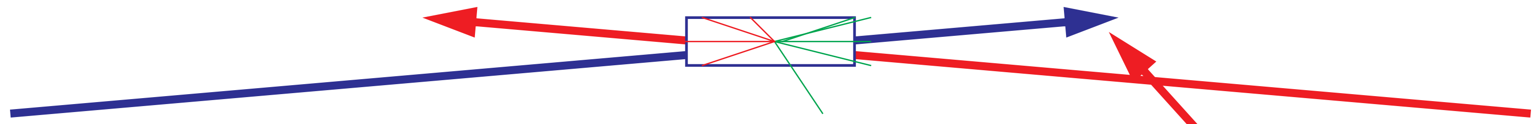
Eric Torrence
University of Oregon

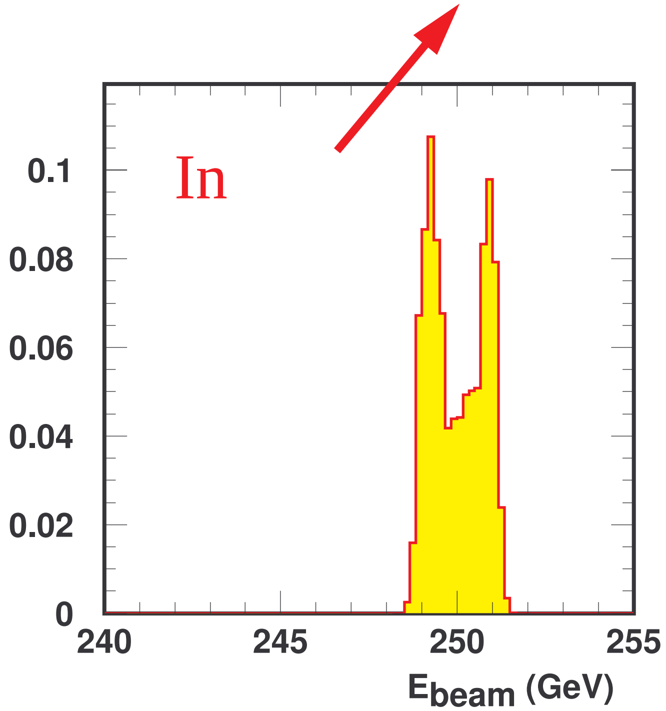
- Spectrometer Goals
- Post-IP observables
- Wisrd-style design and testbeams
- BPM-style design and testbeams

Energy Measurements

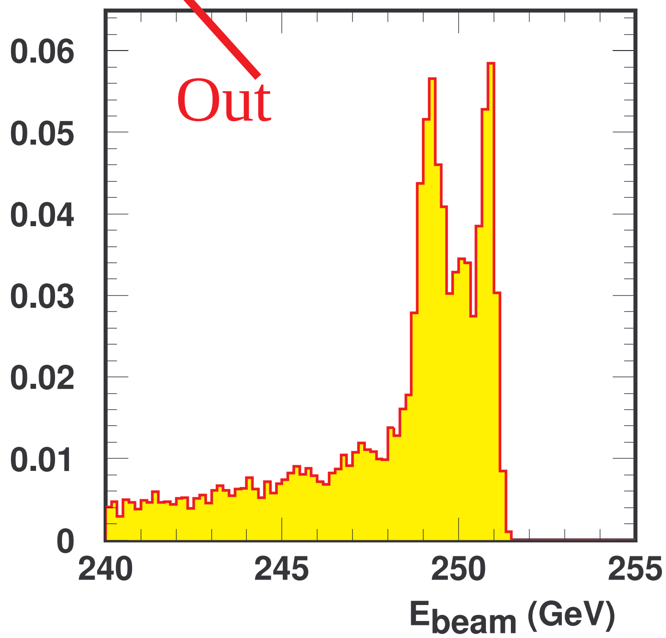


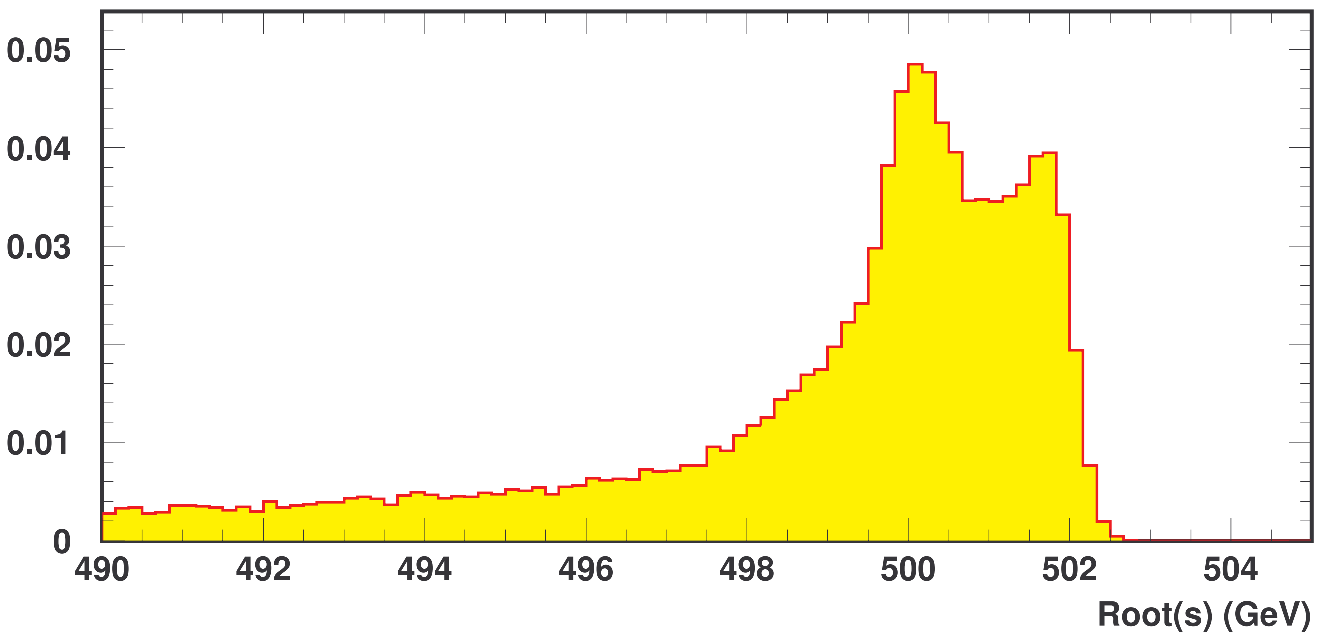
Spectrometer Dilemma





$$\langle E_b^+ \rangle + \langle E_b^- \rangle \neq \langle \sqrt{s} \rangle$$



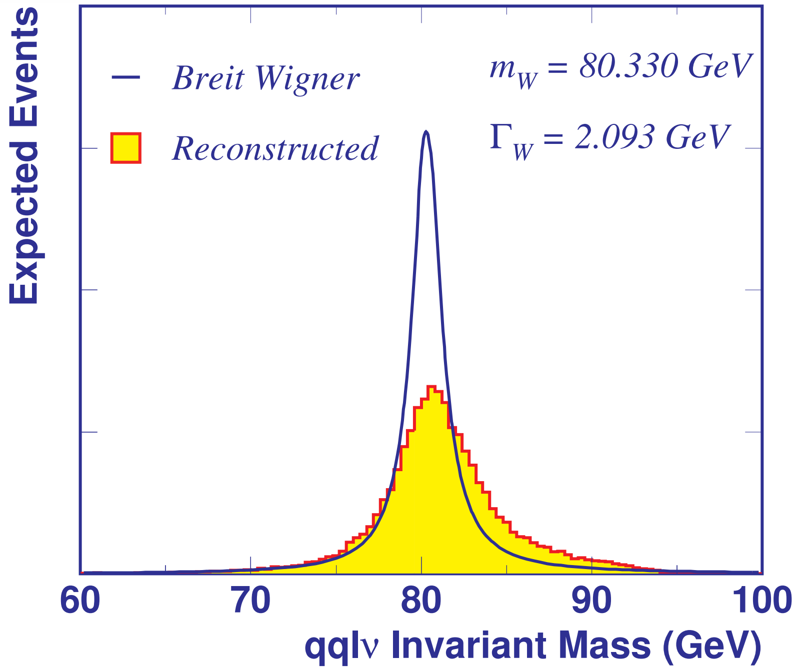


What can a beam energy measurement really tell you?

What really matters?

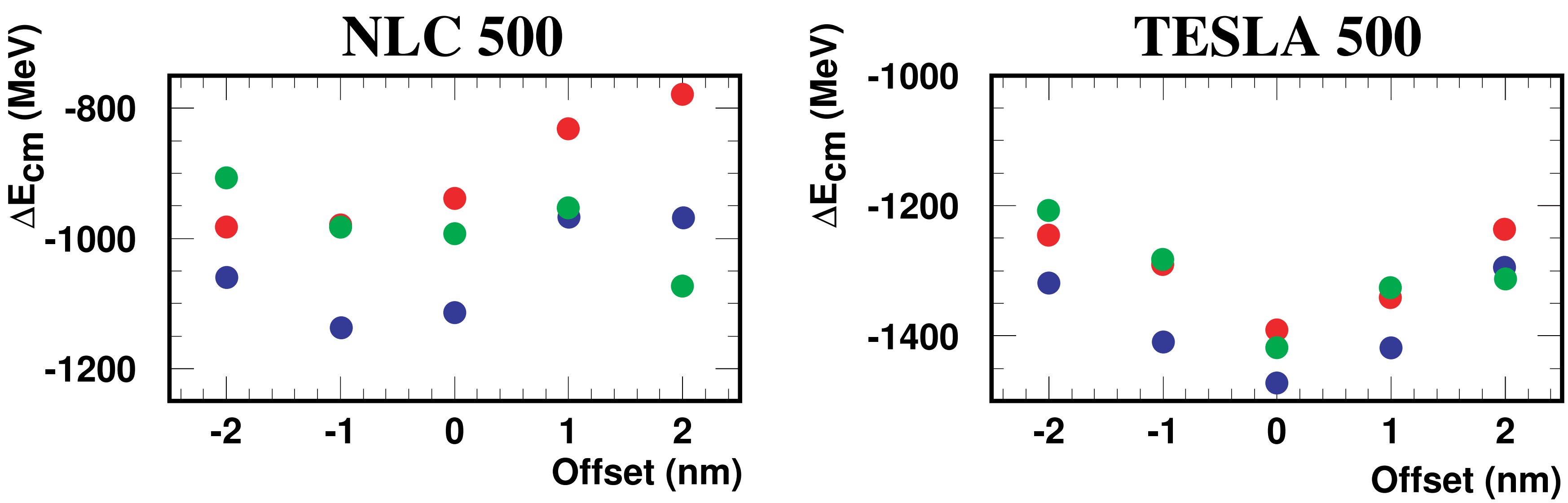
Variance and uncertainty of bias,
not the bias itself is the problem!

$\langle \sqrt{s} \rangle - \langle \sqrt{s'} \rangle$ from ISR is large...



Beam-beam interactions are not predictable like ISR

$\langle \sqrt{s} \rangle - 2\langle E_b^{in} \rangle$ vs. Vertical Offset (truncated range)



Need to measure this to understand to < 50 MeV

Guinea Pig Inputs

- Input NLC and TESLA TRC files
- Vary vertical offset by ±3 nm

30 GP runs per machine
Some estimate of 'realistic' variations

Guinea Pig Outputs

- lumi.ee.dat - Lumi weighted $\sqrt{s}$ spectrum
- beam.dat - Disrupted beam files

$\sqrt{s}$ is what we care about
Disrupted beam is what we can measure

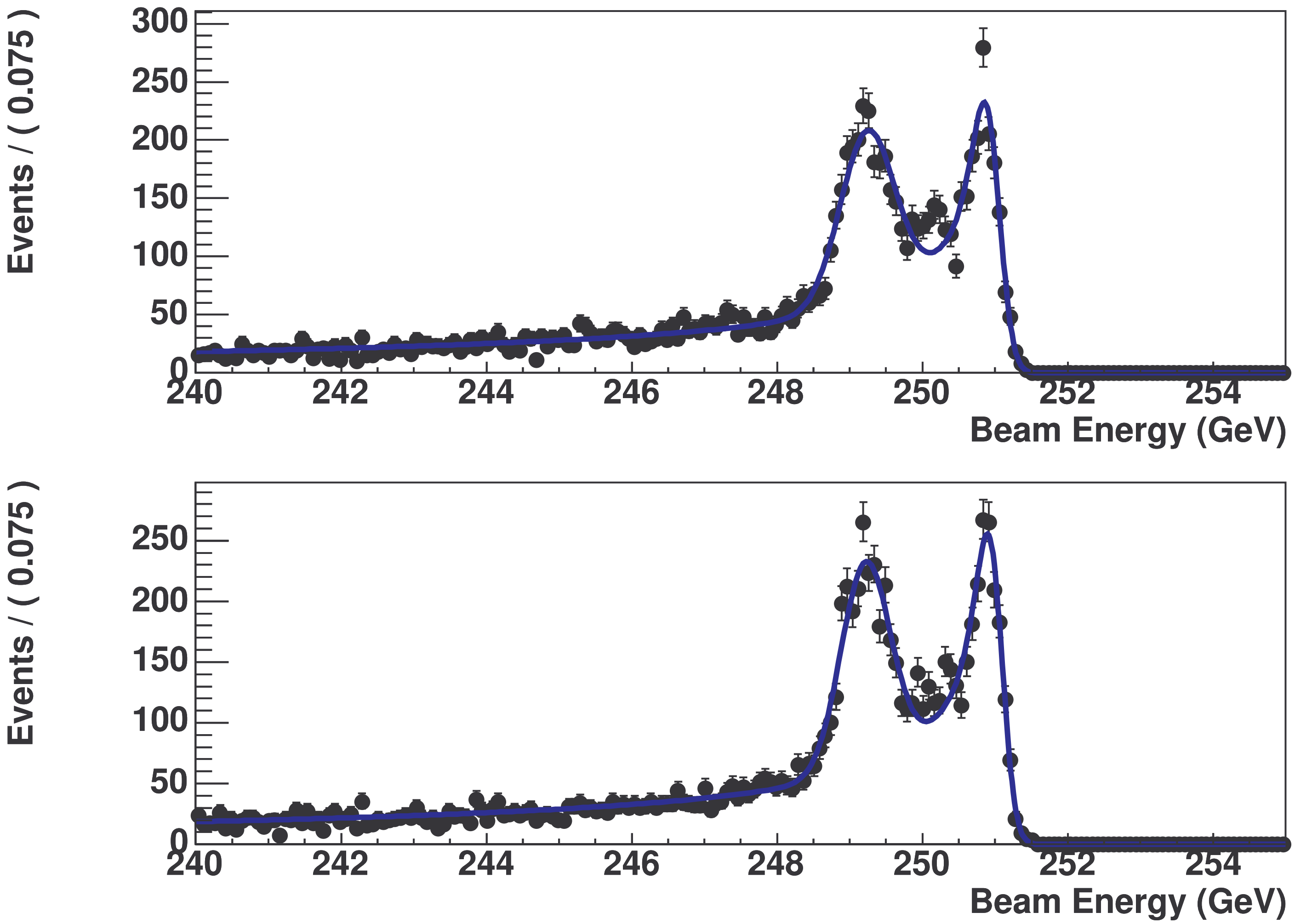
Analysis

Fit E_b^+ and E_b^-
(best a spectrometer could do)

Correlate $\langle\sqrt{s}\rangle$ to fit parameters
in truncated range +/- 10 GeV of peak

Precondition for full spectrometer simulation
(grad student working full time for Summer)

NLC Fit Example



Circe ⊗ Gaussian $P(E) = g(E; E_0, \sigma) + a_0 \int_E x^{a_1} (1-x)^{a_2} g(E') dE'$

where $x = E / E'$

Plus an extra Gaussian (NLC only)

Total of 8 parameters (5 for Tesla)

Implemented in RooFit, easy to make complicated observables

Correlation Examples

$\langle \sqrt{s} \rangle$ vs. $\langle E_b^+ \rangle + \langle E_b^- \rangle$

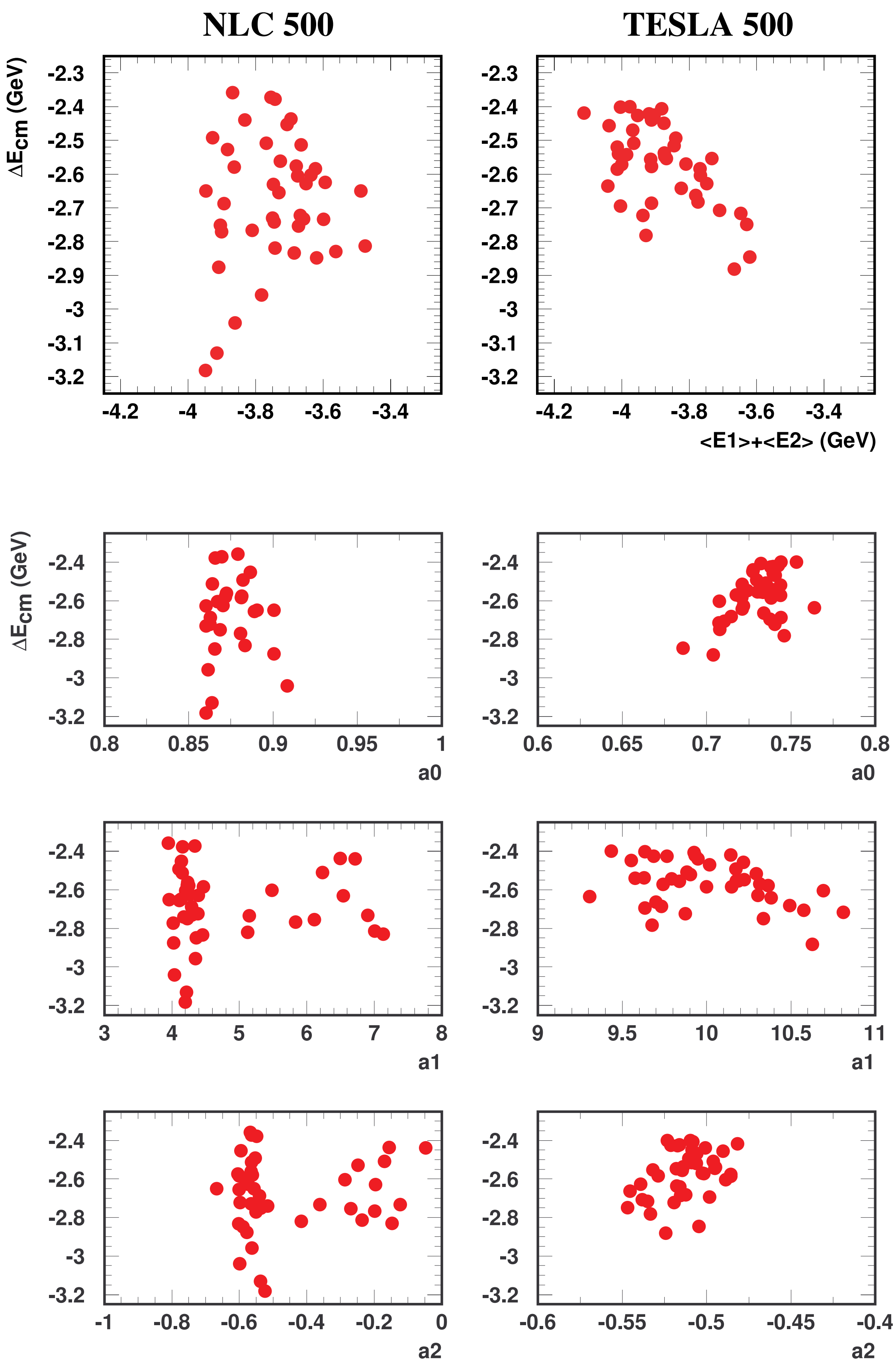
Modest (negative!) correlation seen with cold

Adequate if no beam-beam correlations?

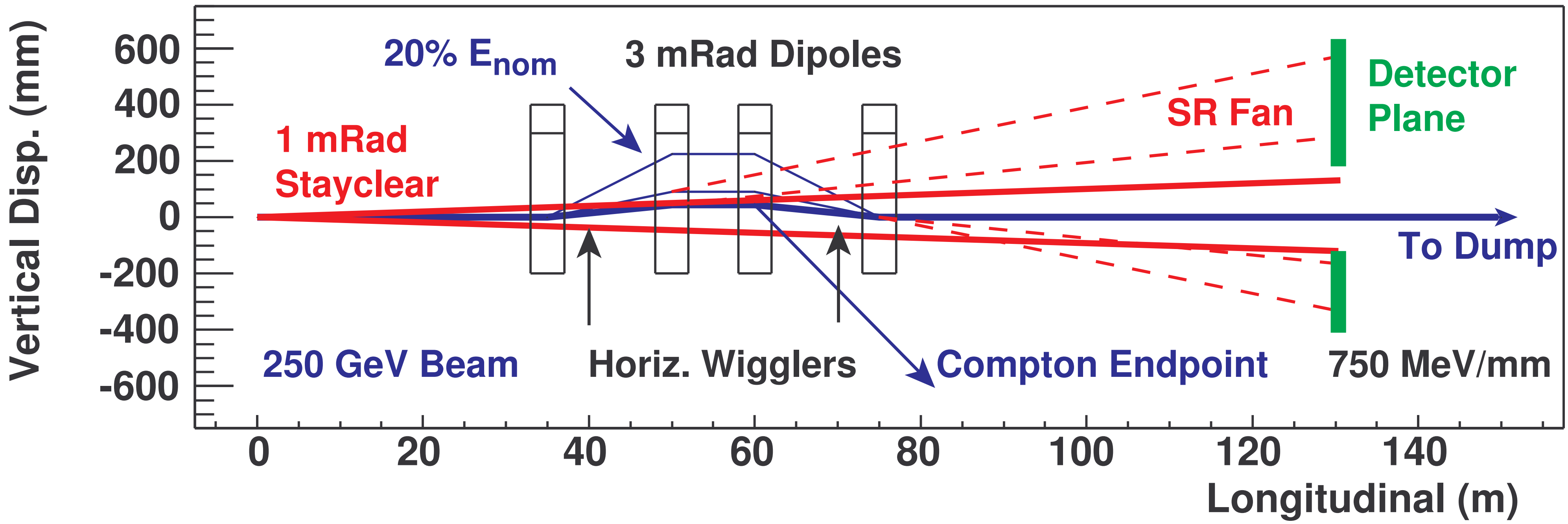
$\langle \sqrt{s} \rangle$ vs. Circe Parameters

Nothing jumps out

Work beginning on better observables (like tail fraction)

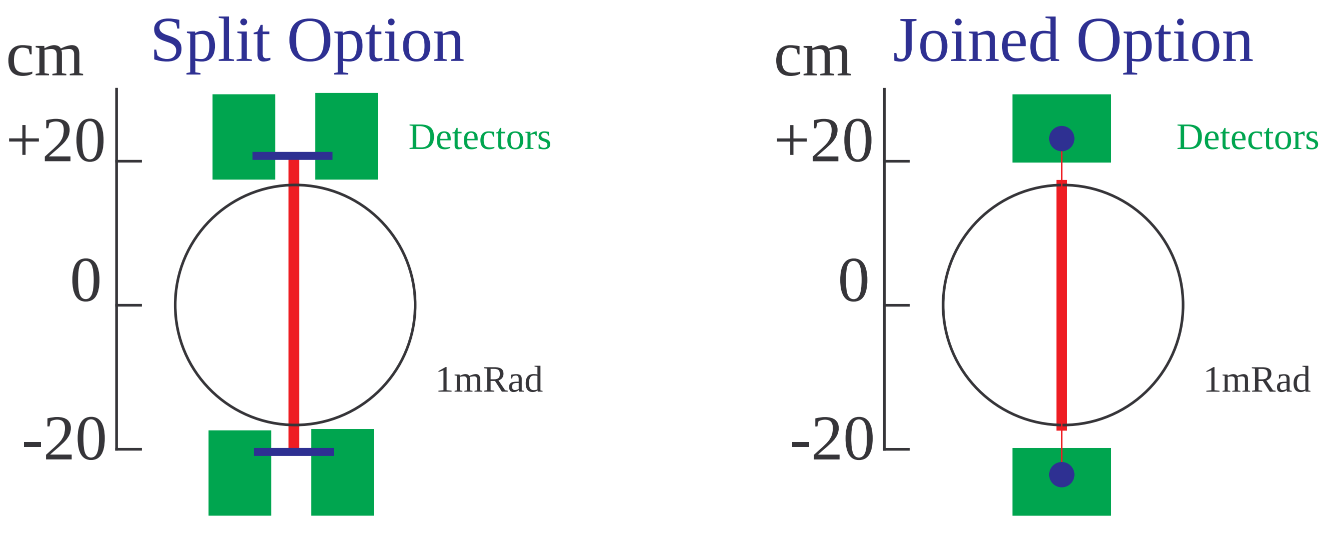


Extraction Line Design



Propagate output beams to detector plane

Detector Plane Concepts



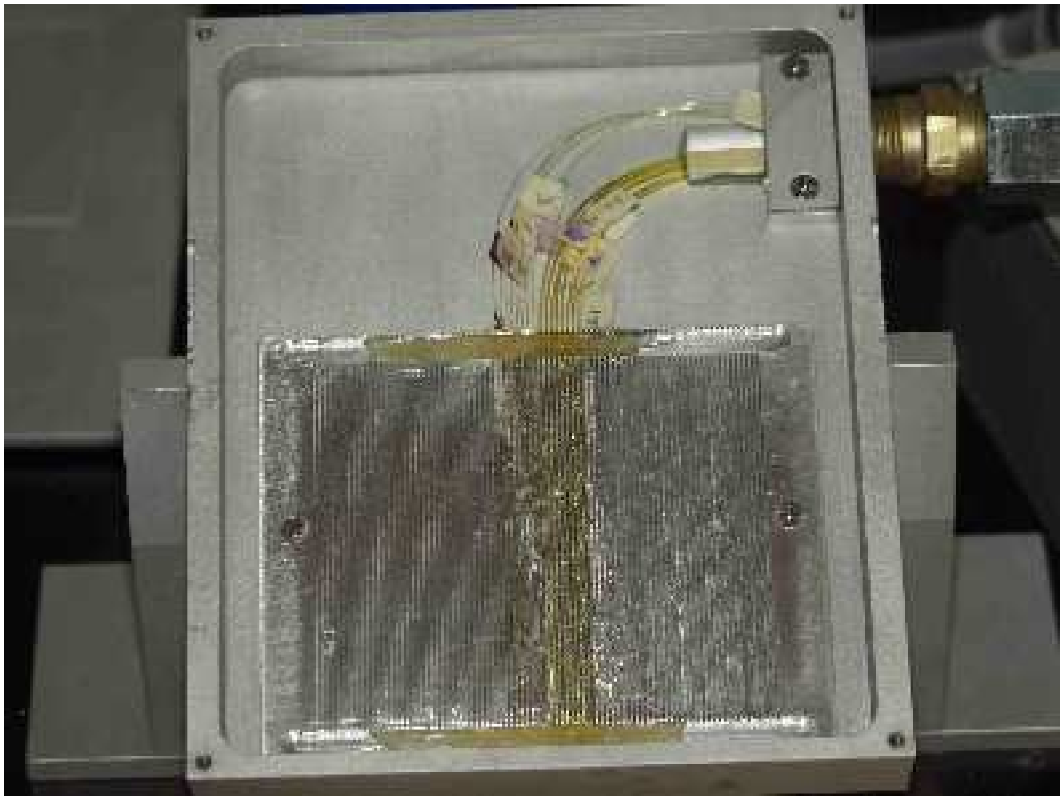
Large λ wiggler

Soft Bends

Detector R&D

Quartz fiber SR prototype

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

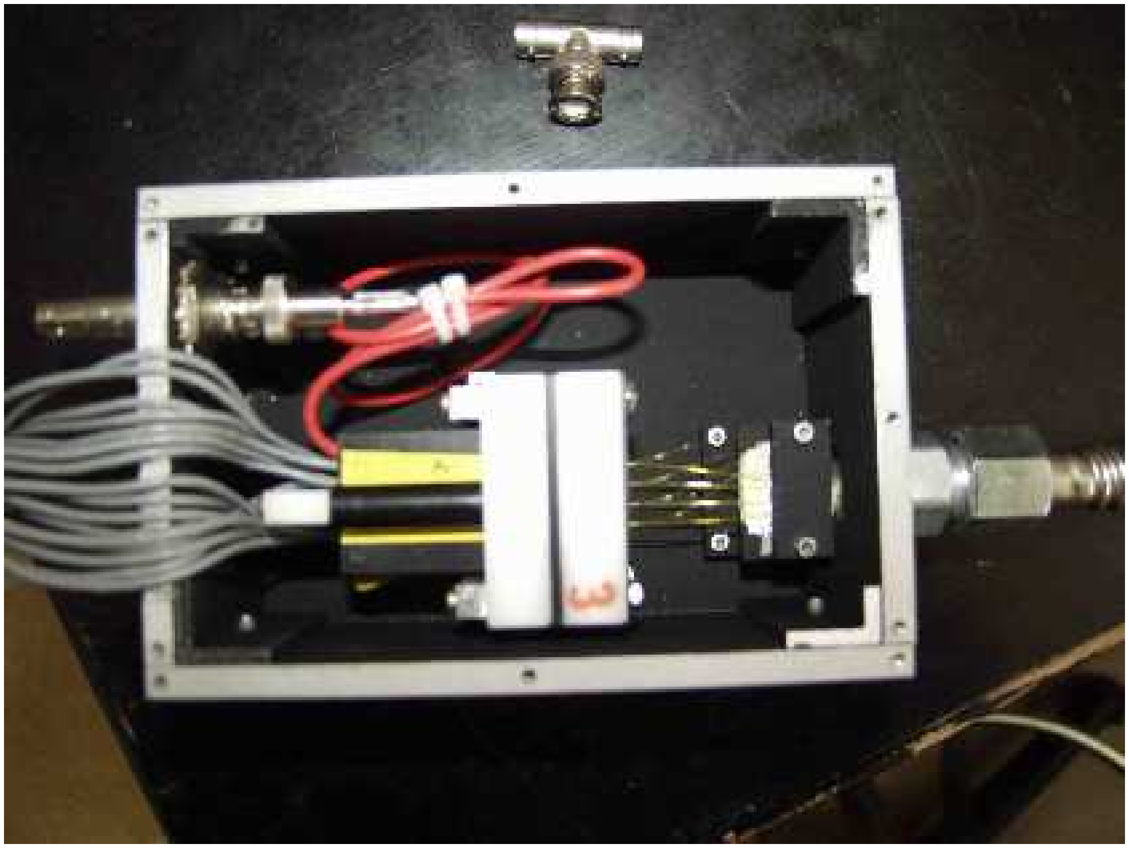


Prototype Geometry

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

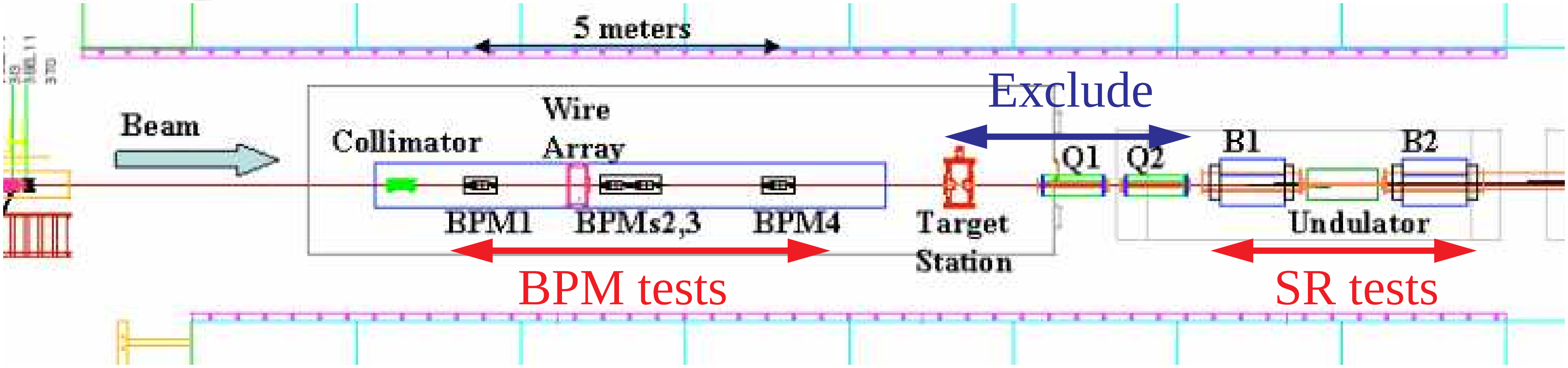
Diamond/silicon strips

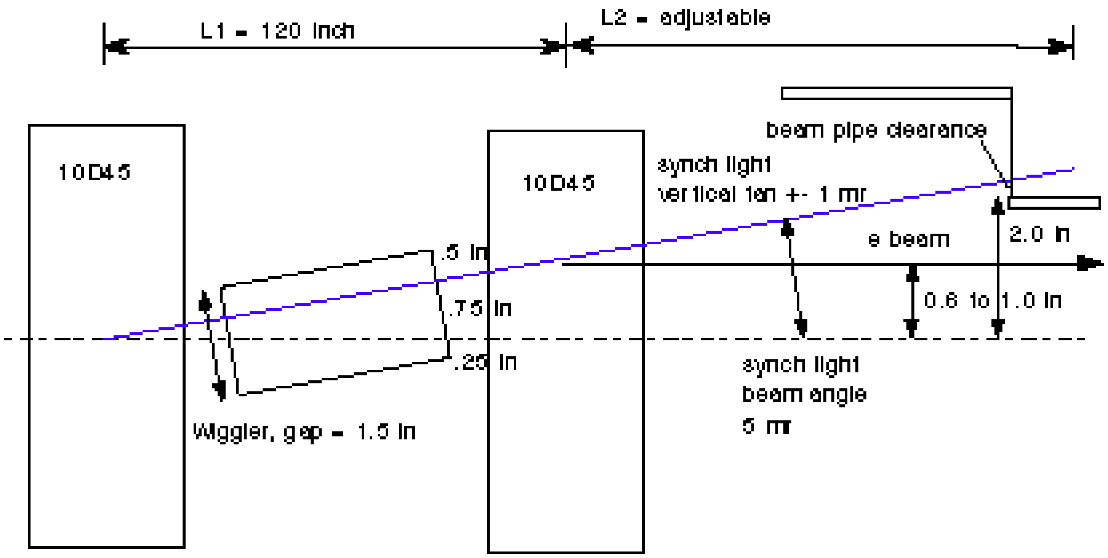
Visible or UV imaging (CCD)

Pinhole-style imaging

...

ESA Beam Tests





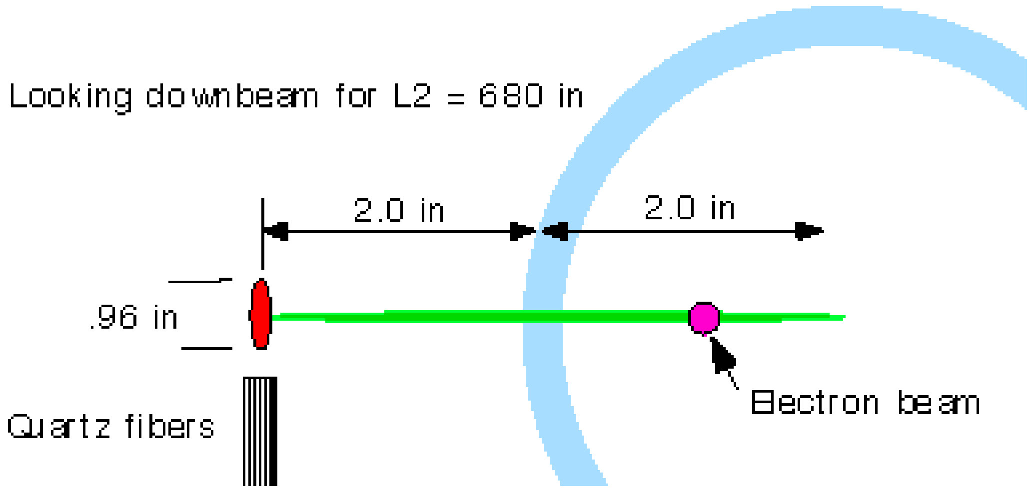
Use original spear wiggler

E_c = 0.9 MeV at 28 GeV e^-

E_c = 0.1 – 0.2 MeV from bends

Rough Guess: 3×10^6 PE/pulse

S/N ~ 100 – 1000



(TN-2004-7: Ray Arnold)

Detailed simulation starting

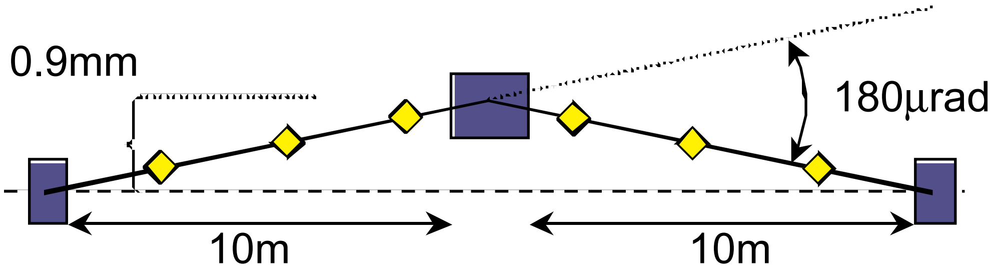
Compare various detectors

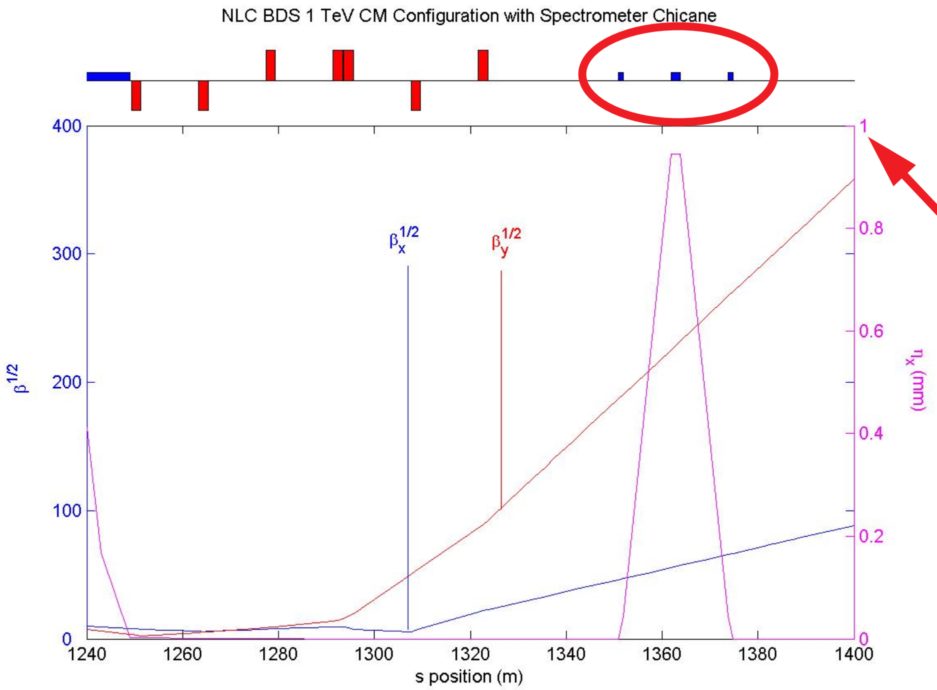
Quartz fiber array

Wisrd wire array

Visible CCD (diagnostic)

BPM-based Spectrometer





Design Parameters

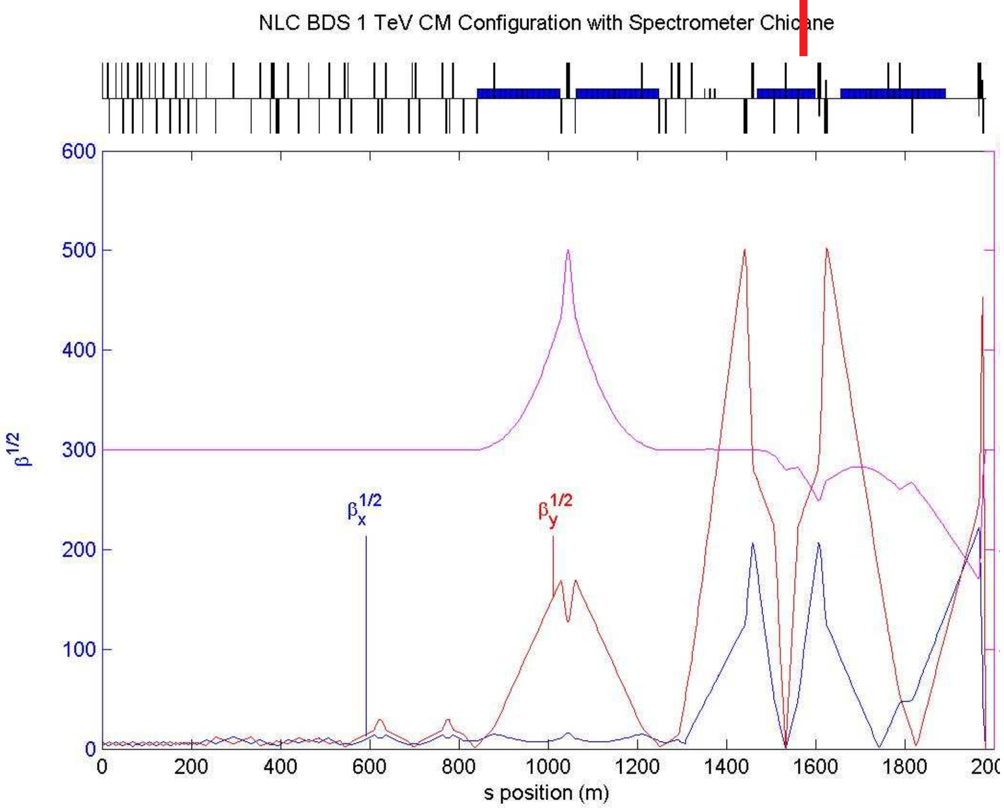
Limit energy growth
360 μRad -> 0.5%

Extra space for in/out triplets

Need 50-100 nm BPM resolution, stability, accuracy

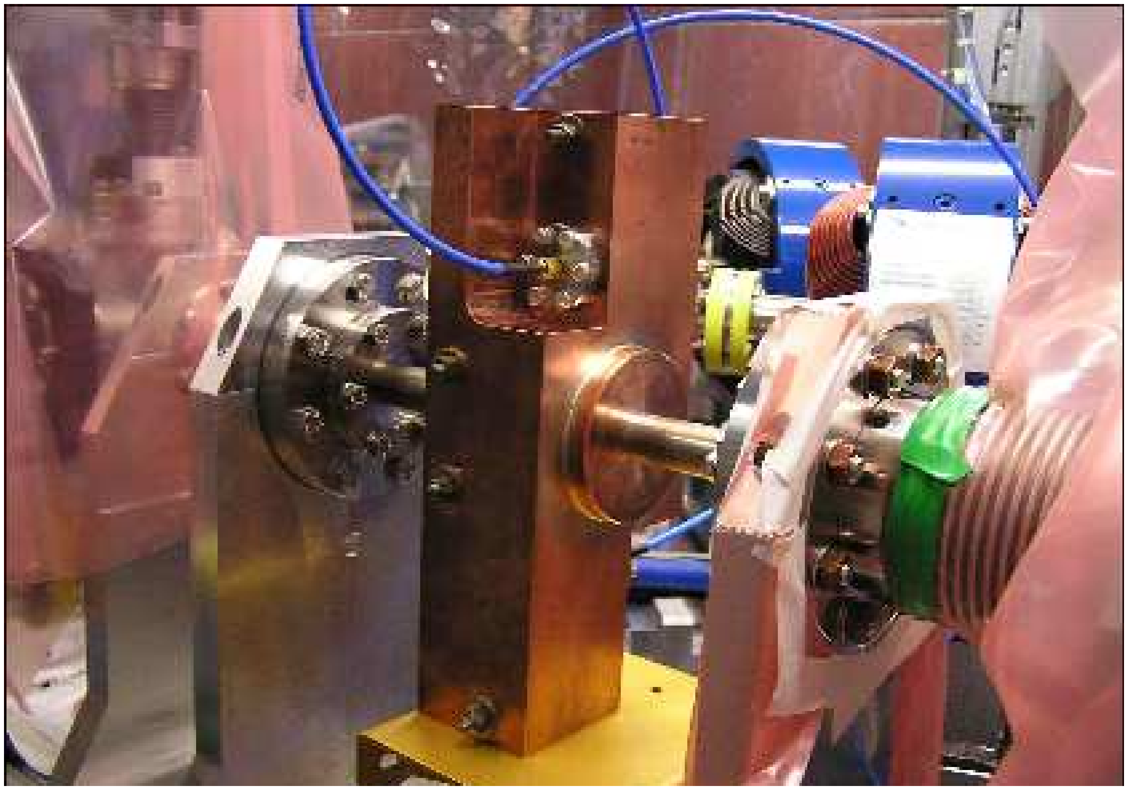
Tiny energy variation to IP

beta distribution
may not be ideal



DESY

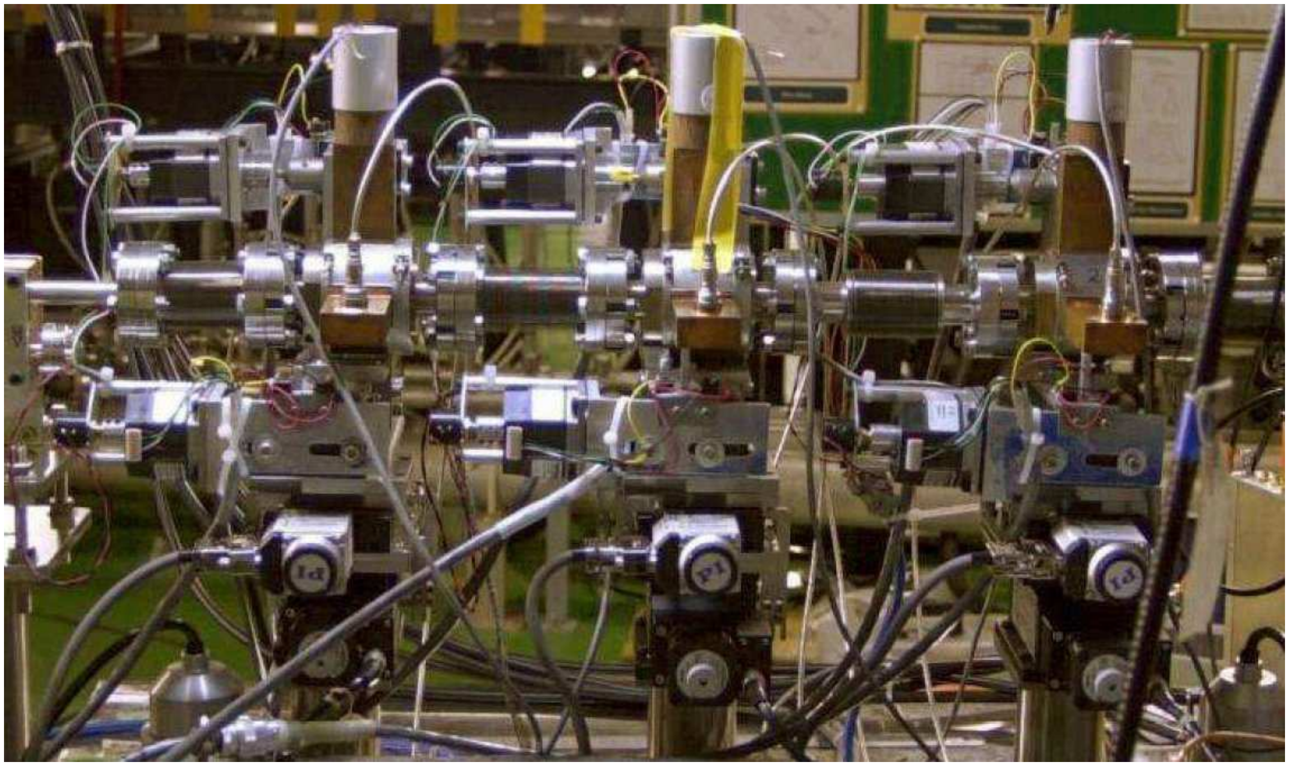
- 5.5 GHz BPM prototype
- Testing (now?) at ELBE linac (Dresden)
- τ ~ 16 ns expected
- 2 mV/100 nm estimated

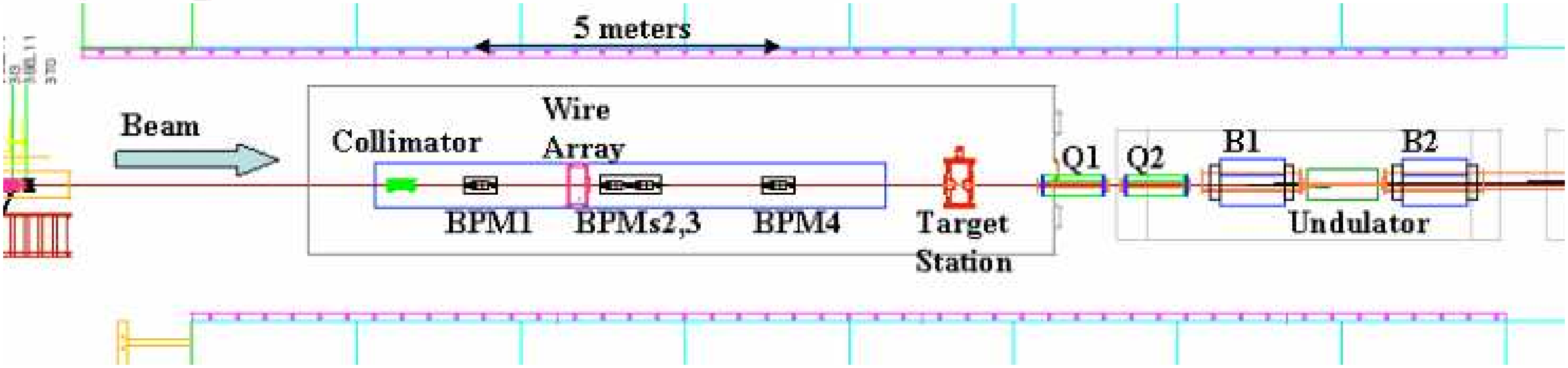


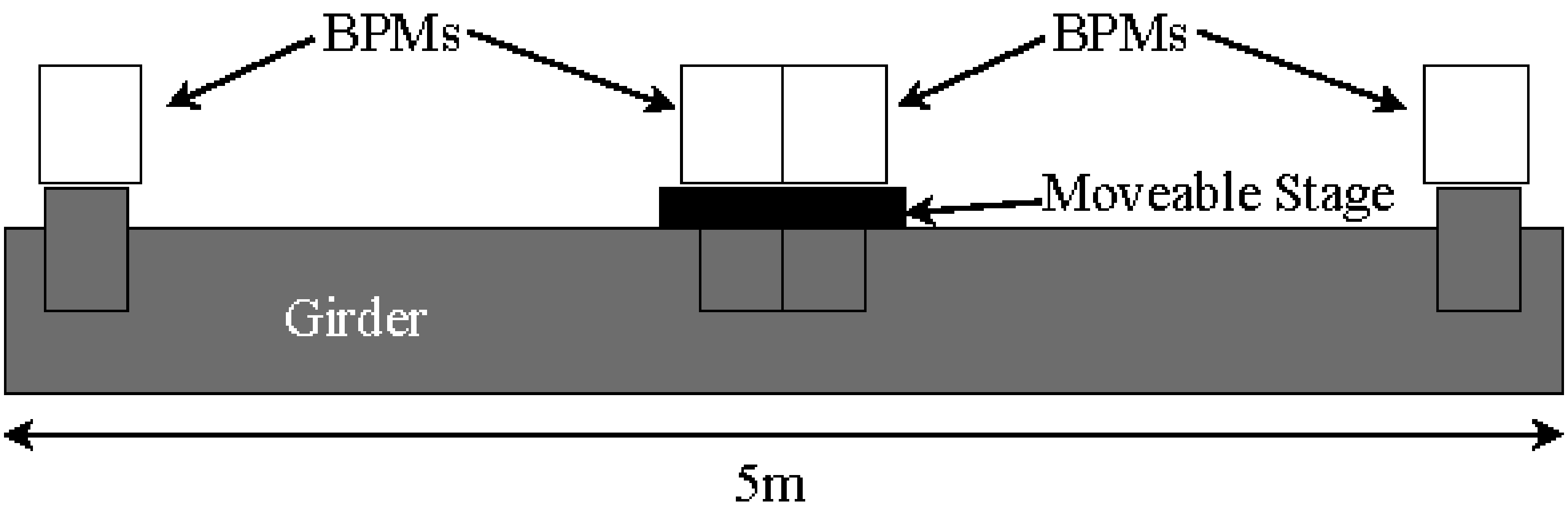
ATF - NanoBPM

- Multibunch tests
- sub-100nm observed

Installed LLNL super-girder, fancy interferometer...







Test mechanical and electrical stability, particularly in “hostile environment”

Explore sources of long-term drifts from 50 nm stability

Test time resolution of RF BPMs

Moveable stage tests response characteristics of BPMs

ESA spectrometer tests

Synchrotron detector test

- Verify simulation for quartz fiber response, S/N
- Demonstrate resolution
- Check "operational robustness"

Oregon, SLAC, ???

RF BPM test

- Mechanical and electrical stability
- RF response to "realistic beams"
- Time resolution

Notre Dame, Berkeley, UC London, Cambridge, SLAC

Timescale: Summer 2005

First steps towards ultimate goal:
Full scale spectrometer prototype

Timescale: Summer 2007?

Want to be able to reconstruct at least $\langle\sqrt{s}\rangle$ independently with spectrometers and physics-based measurements.

More work needed to show viability of downstream spectrometer to provide interesting information

Need more work on physics-based determinations

Neither spectrometer is a simple engineering exercise

Testbeam program in End Station A evolving to demonstrate hardware feasibility

Useful to reconsider some wacky ideas from the past?