



Beam Instrumentation Overview

November 14th, 2004

WG4 - Beam Delivery/Interaction Region

First ILC Workshop

KEK

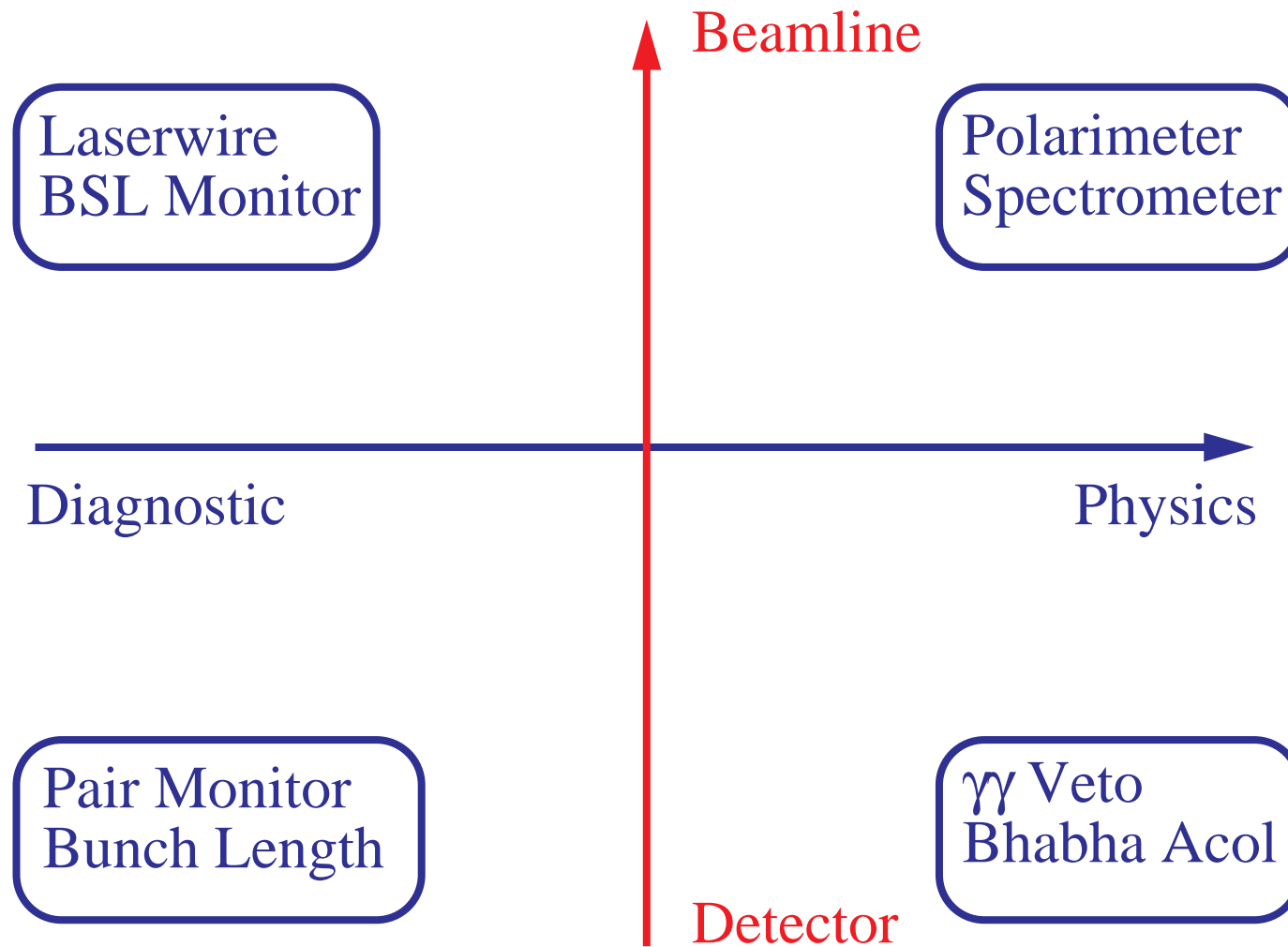
Eric Torrence

University of Oregon

- Largely personal viewpoint
- Re-written to remove head-on references



Topics

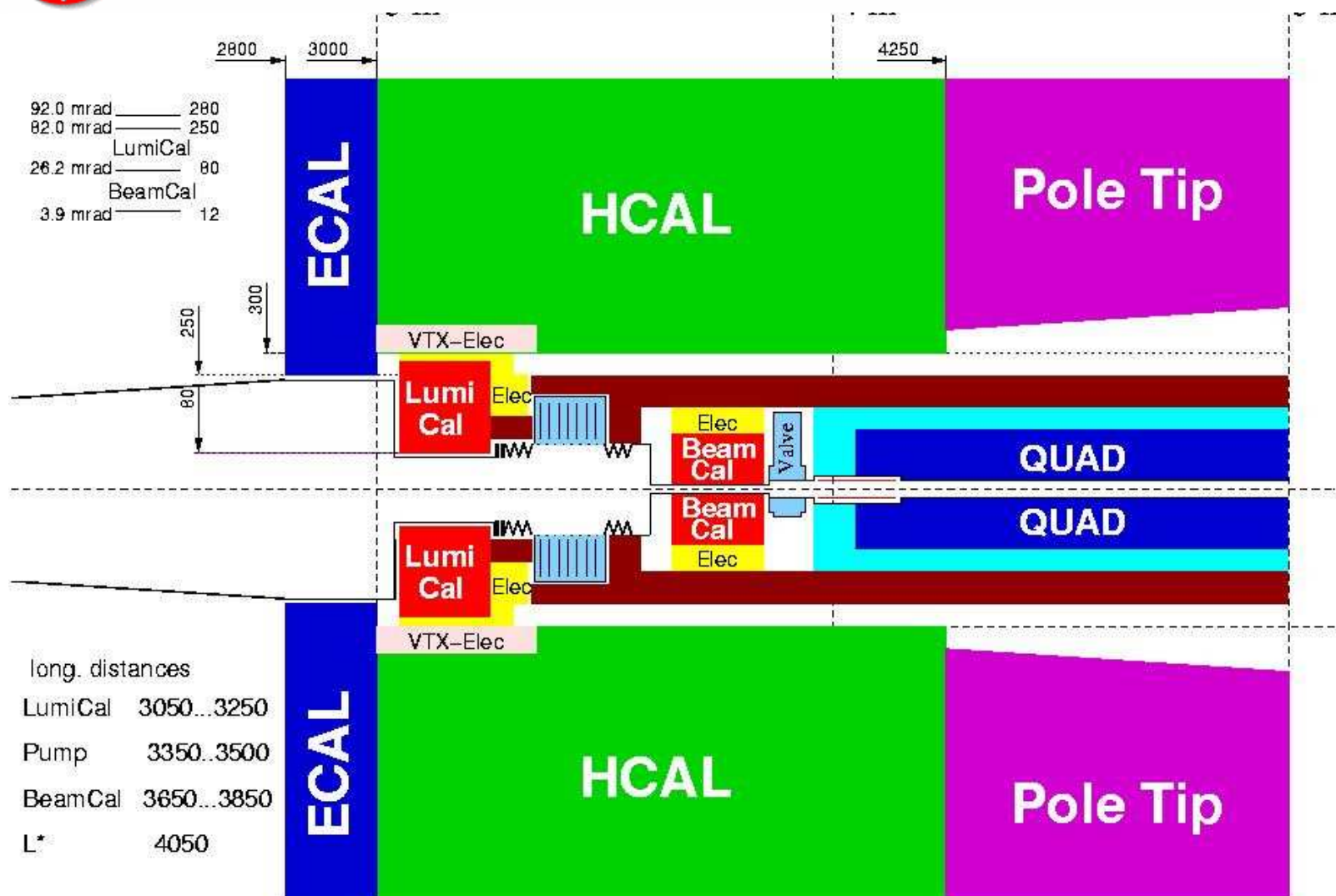


Wide variety of topics

Very broad overview...



Forward Detector Overview



$L^*=4$ m Proposal (Achim Stahl, Paris)

- Mask/Overlap ~ 50 - 100 mRad Critical for Hermeticity
- Lumi Monitor ~ 20 - 50 mRad Outside pair backgrounds
- $\gamma\gamma$ Tagger ~ 5 - 20 mRad Identify $\gamma\gamma$ electrons
- Pair Monitor ~ 5 - 20 mRad Machine diagnostics

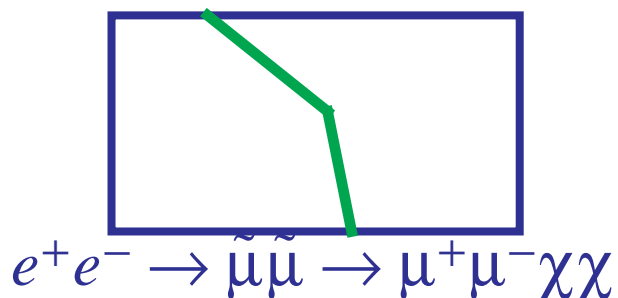
Could be provided one detector
Could optimize separately for each function



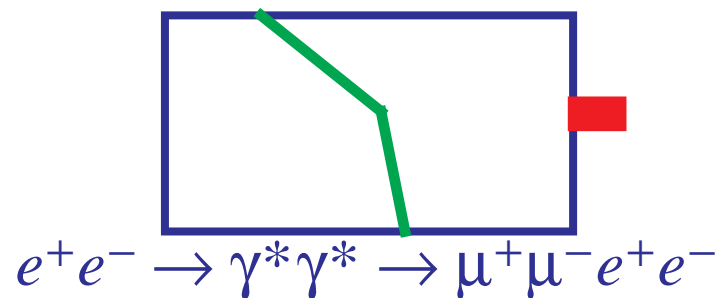
Electron Hermeticity



SUSY



Two Photon



Min. forward angle e^- veto determines $\Delta m = m_{\chi^-} - m_{\chi^0}$ sensitivity

Veto - Inefficiency gives false signal

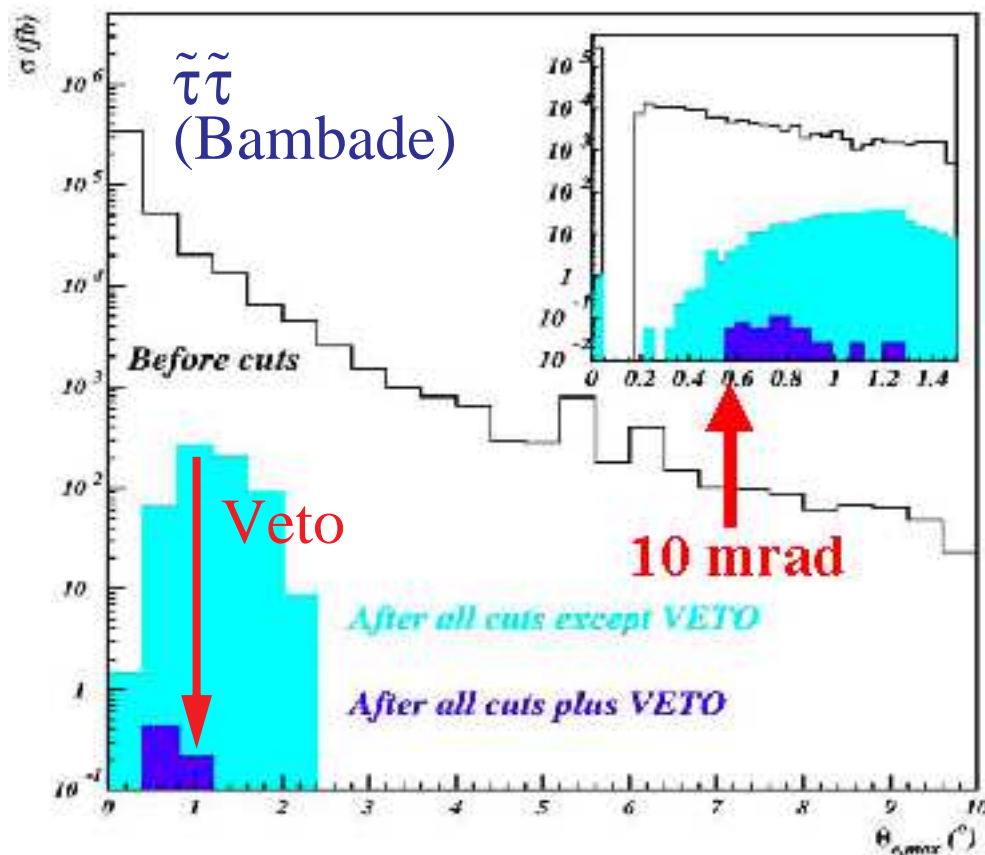
To reach ~ 1 fb sensitivity

need fakes $< 0.1\%$ or $\epsilon(e^-) > 99.9\%$

Some cracks/holes are OK if they are well localized

Bulk of detector must be very efficient

Demonstrate in test beam



Personally not convinced of viability with variation in pair background

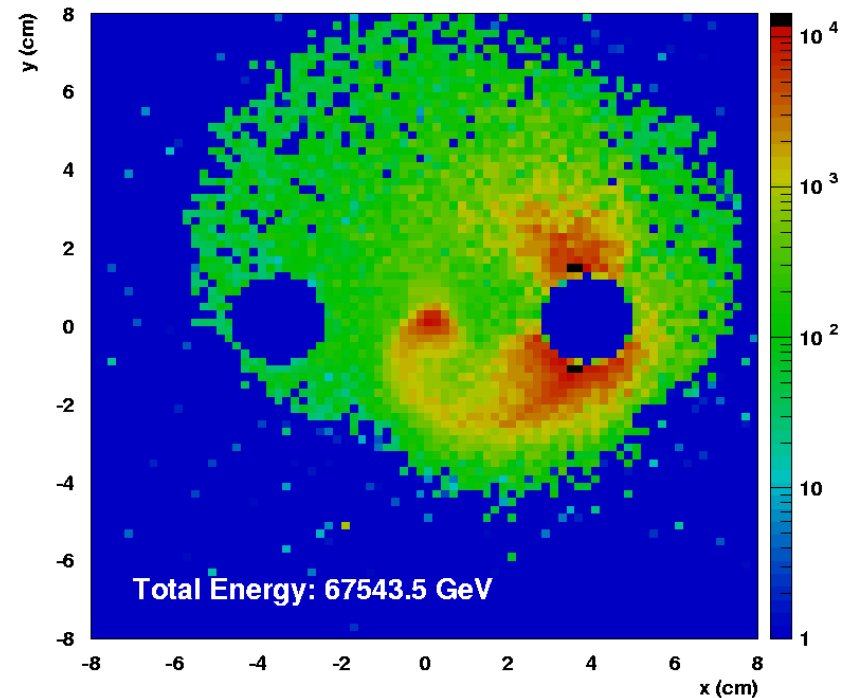
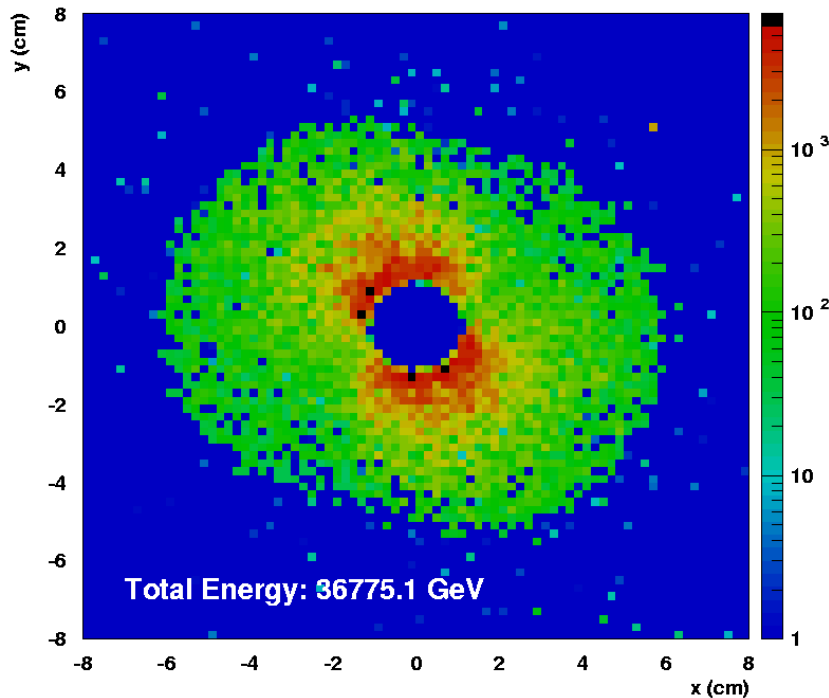


Pair Monitor



Head-on

20 mRad Crossing Angle



Pair distribution gives snapshot of beam collision
On paper, powerful sensitivity to collision parameters
(e.g. Lohmann, bunch width, length, offset, waist, etc.)

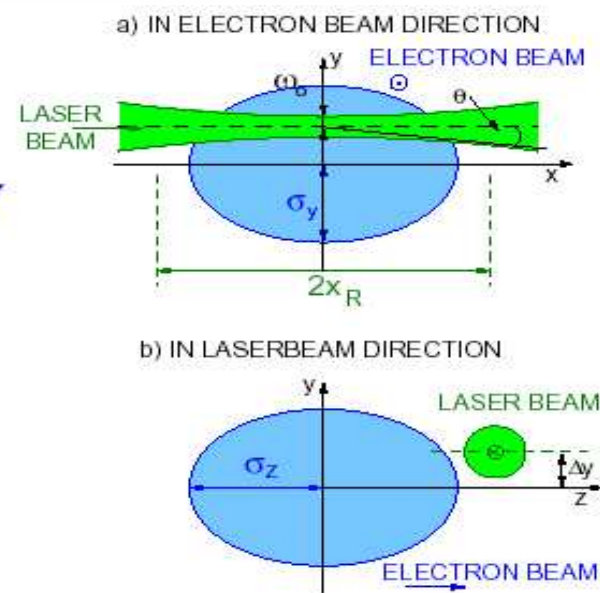
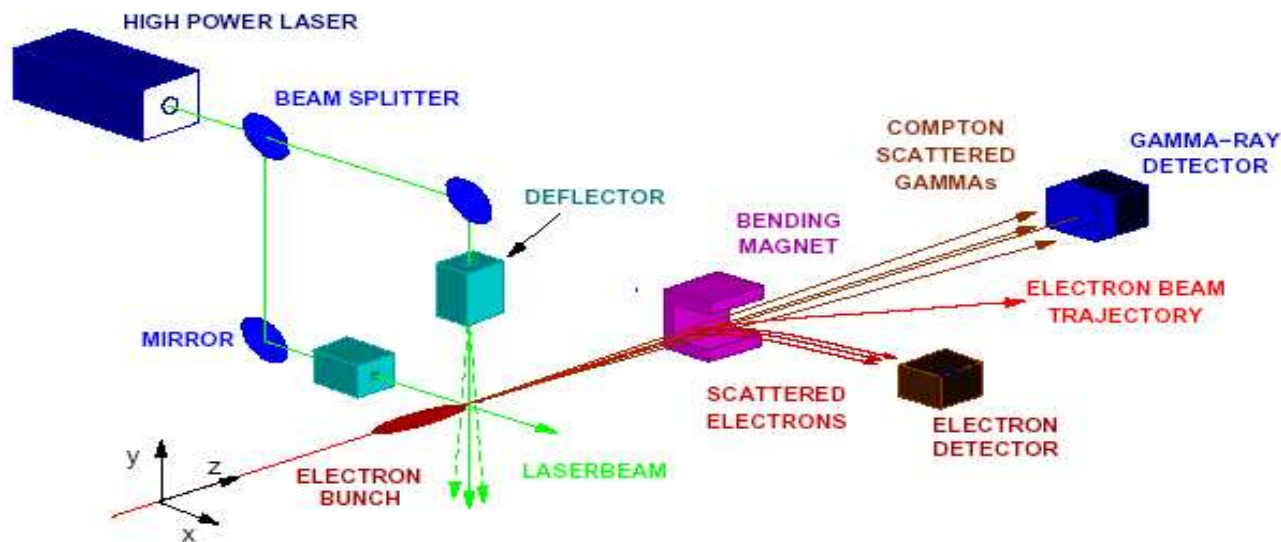
Questions

- **Will this really work?** Possible to extract orthogonal observables with realistic beam jitter, asymmetries, etc?
- Is this **mandatory** for luminosity, or just **icing on the cake**?
- Are distortions due to x-angle (even with dipole windings) **catastrophic**?

Possible advantage of small crossing angle



Laser Wire



Operational at PETRA, complimentary effort underway at ATF

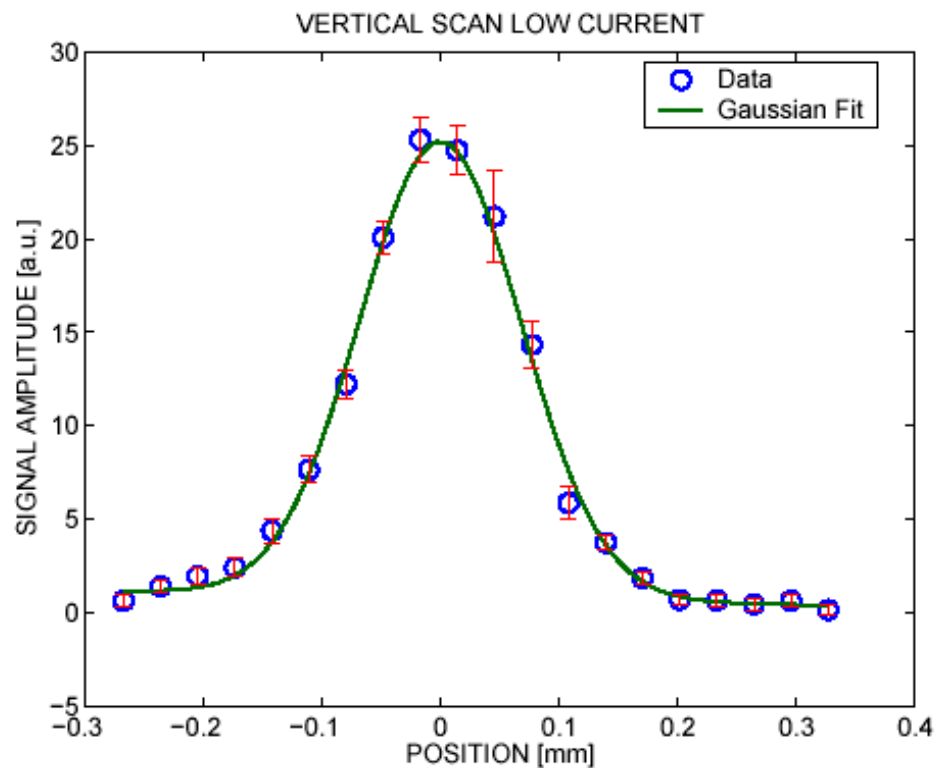
$O(100 \mu\text{m})$ fast scan at PETRA
Developing $6 \mu\text{m}$ for ATF

Mandatory for operation as
production diagnostic?

Where does it go, how is it used?

Design and sim. for BDS underway

Defining real-estate critical, particularly around IP





Diagnostic Instrumentation



Proposed “exotic” diagnostics include
Laserwire, SR monitor, pair monitor, bunch length, nBPM

Question: which are strictly required,
and which would simply be nice to have?

Need to define instrumentation needs for both
operations and tuning/startup phase

What is really needed? How is it to be used?
Where does it go?

Also should consider useful main detector information

- Pair monitor, fast lumi monitoring
- Luminous region σ_z from $\mu^+\mu^-$
- Background signals
- \sqrt{s} profile

Design to be directly available to machine DB
and feedbacks like any other beam instrumentation

Same true in reverse...



Physics Needs

- $\langle \sqrt{s} \rangle$ understood to 100-200 ppm - m_H, m_t, m_X

Beam energy necessary but not sufficient

- Polarization $\Delta P \sim 0.25\%$ - A_{LR} at high energy

Goal for polarimeter, could use better

- Absolute luminosity

My view: $\Delta L \sim 0.2\%$ (“easy”)

Zeuthen view: $\Delta L \sim 0.01\%$ (“very hard”)

LEP expt. 3.4×10^{-4} Theory 5.4×10^{-4}

Motivations given are σ_Z and $\sigma_{q\bar{q}}$

Design Philosophy

Precision measurements require redundant information
and meaningful cross-checks to be believable

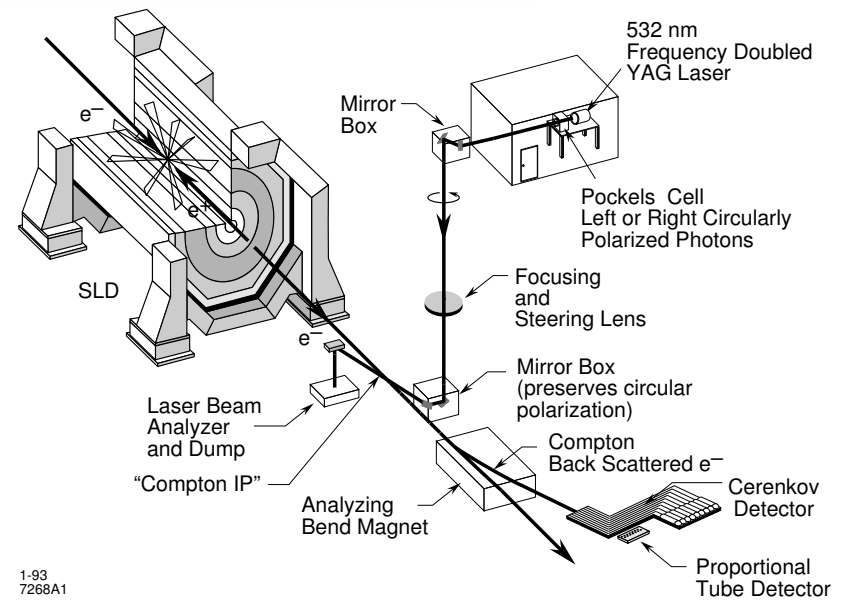
Use physics channels where possible

Reduce dependence on beam-beam simulations



Basic principle well understood

Location and some design details missing



Downstream Polarimeter

- Measure collision effects (lumi-weighted $\sim 1/4$ of total depol.)
- Significant effects at 1 TeV ($\Delta P_{lum} \sim 0.5\%$, should be re-evaluated)

Mitigated by W^+W^- , but lose cross-check

P_{e^+} also helps, but only if fast reversals

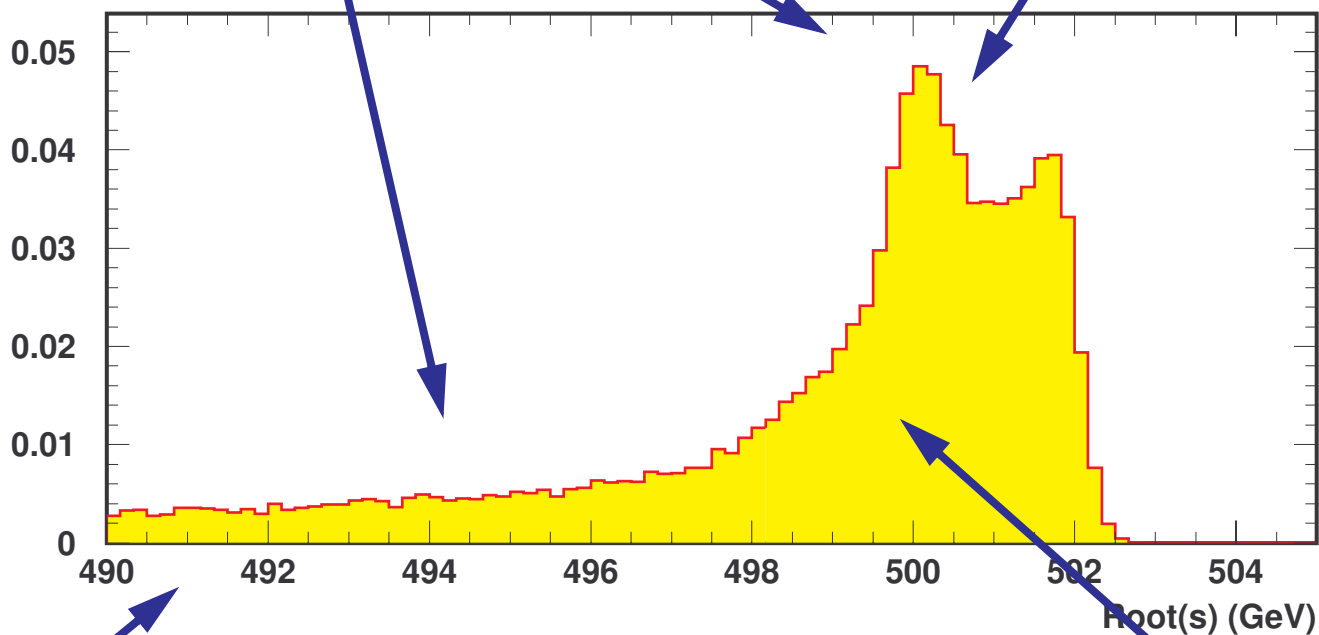
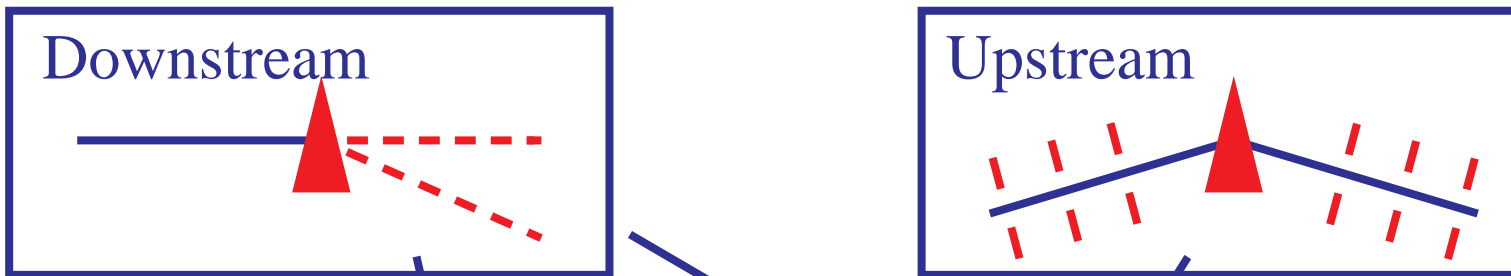
IP spin alignment

- Longitudinal and parallel to polarimeter
- Difficult with 2 IPs? Upstream polarimeter after final bend...
- Need solenoid compensation to control orbit

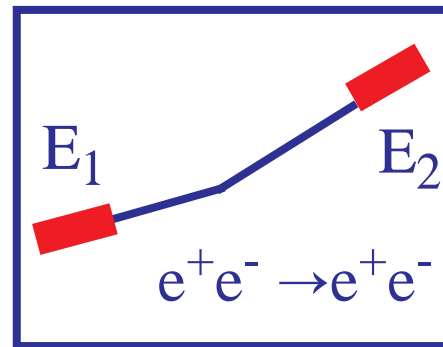
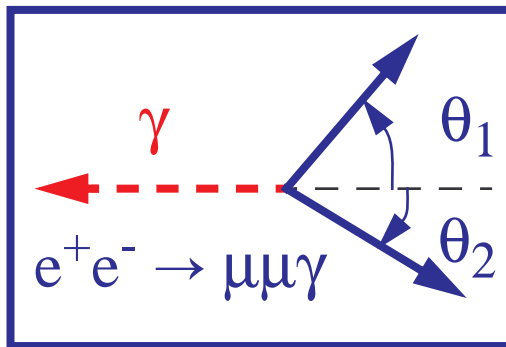
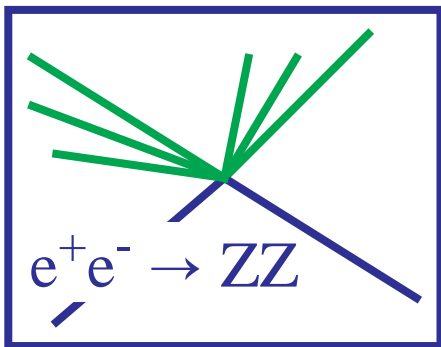
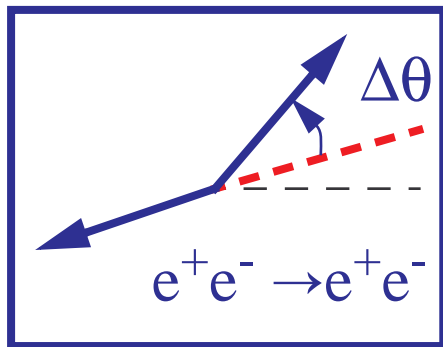
Compatibility in extraction line with other diagnostics



Collision Energy Observables



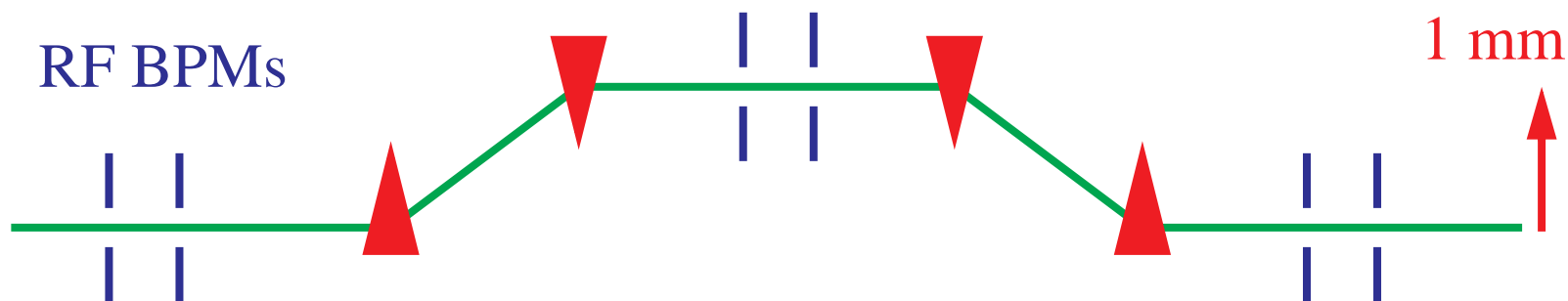
$\langle \sqrt{s} \rangle$



Need coordinated effort to put the pieces together and demonstrate precision on a real physics analysis



Spectrometer Designs

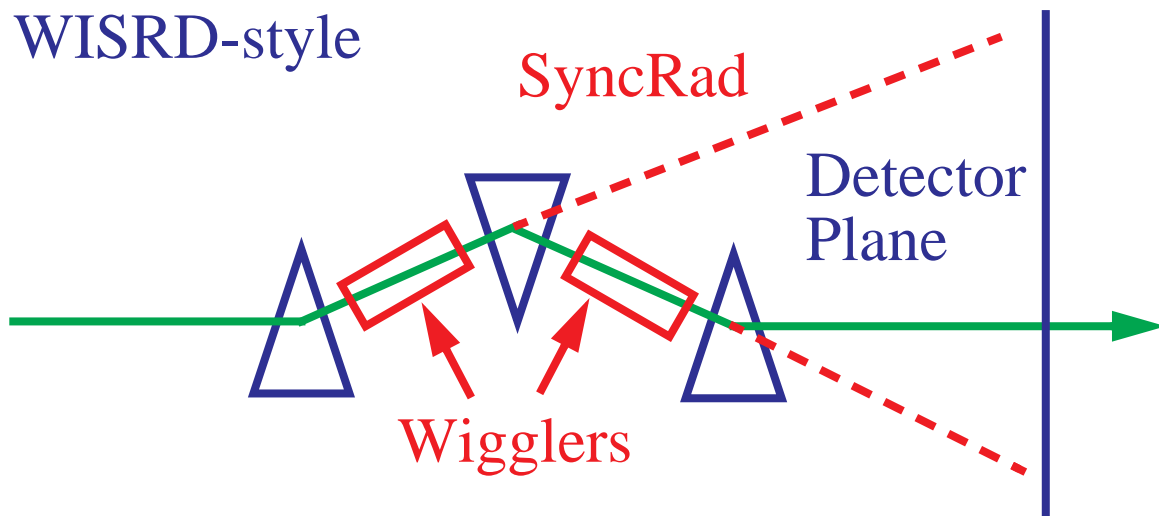


- Bends $\sim 100 \mu\text{Rad}$, lengths 10 m, 1 mm bump
- Need 100 nm (or better) resolution **and accuracy**
- Move BPMs to the beam (keep same relative position)
- Calibrate alignment by turning off chicane

Upstream only, very difficult to control all systematics

- Downstream only
- few mRad bends
- Detect SR
- **Collision diagnostic?**

Must operate in difficult x-line environment



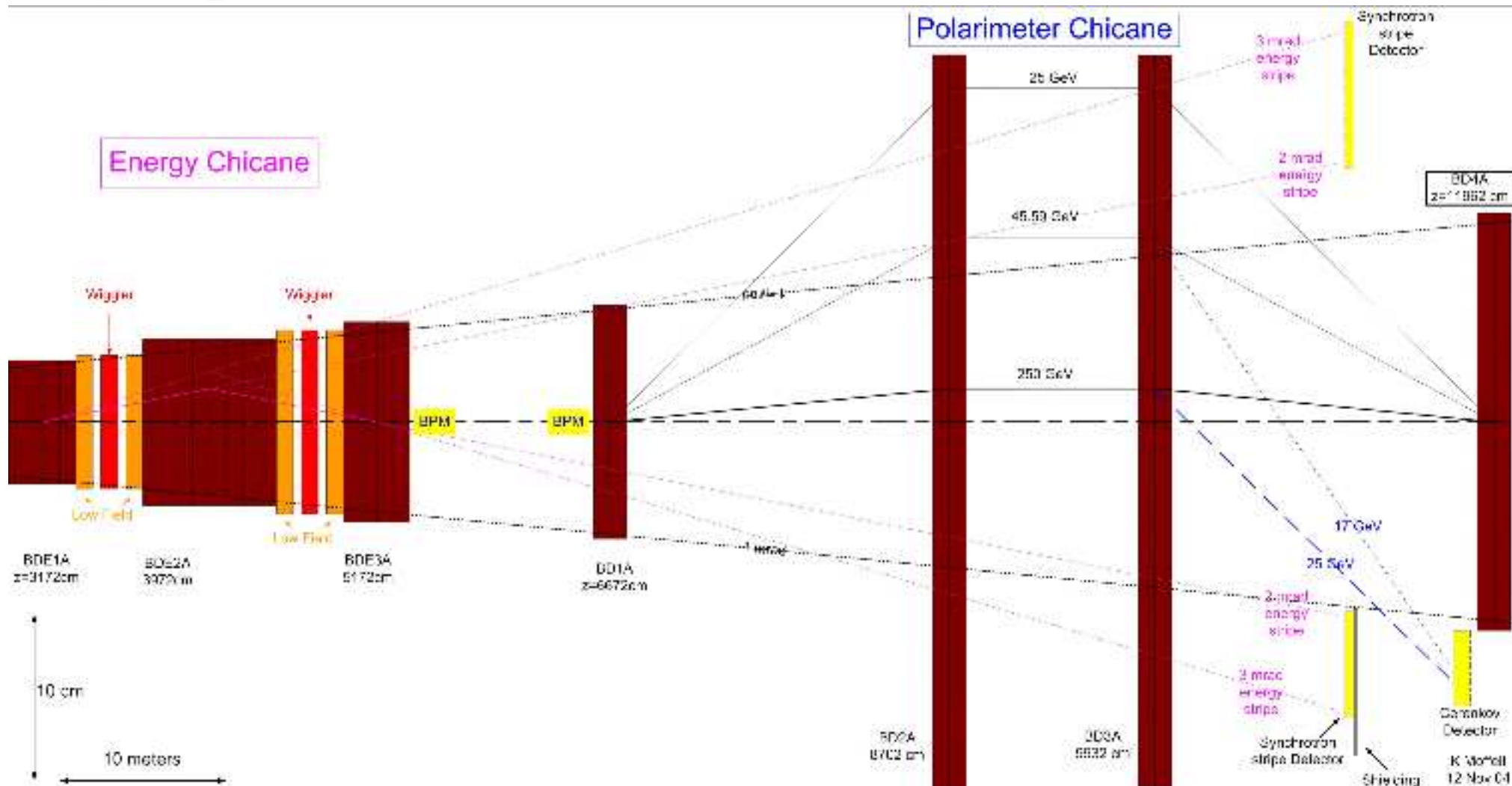
Highly complimentary approaches

Both challenging for 100 ppm absolute measurements

Personally wouldn't believe either without full-scale prototype



X-line layout



Difficult to please everyone

Considering designs with separate polarimeter and spectrometer

X-line must also extract beam safely with tolerable backgrounds...

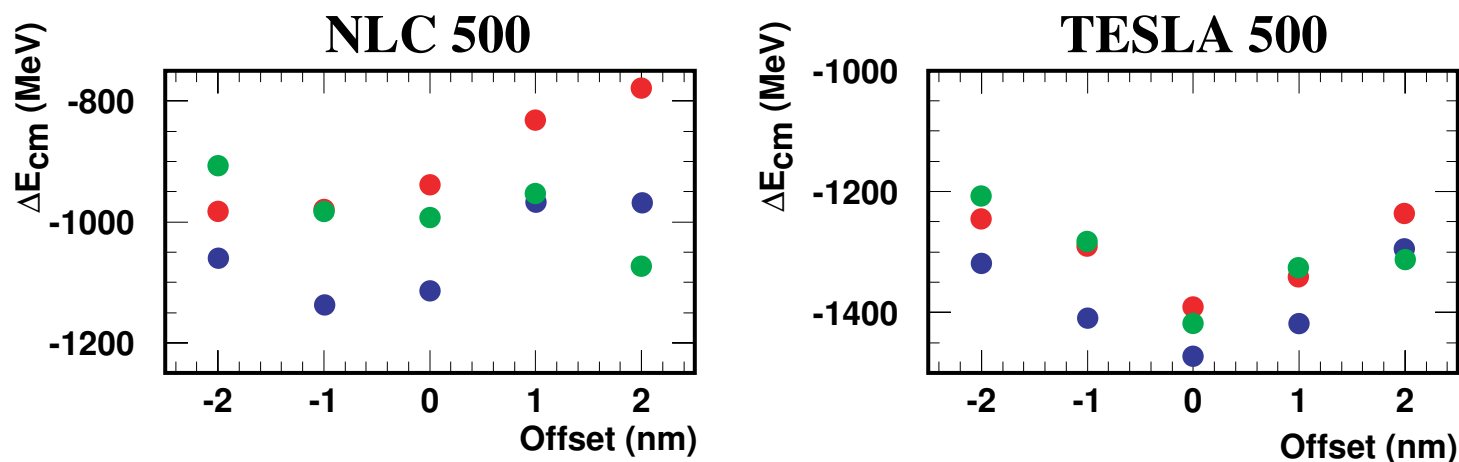
Need to understand if additional diagnostic instrumentation must be accommodated!



Collision Biases



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



Bias sensitive to fine details of the collision process,
not completely reflected in **Bhabha $dL/d\sqrt{s}$ measurement**

(E vs. z vs. L correlations)

Proposed Solutions (all speculative)

- Downstream spectrometer
- Calibrate with ZZ or Z γ (loose one cross-check)
- Monitor with Bhabha energy, muon curvature
- Accelerator solution

Not an easy problem
Would like a real observable,
reduce simulation dependence



$\gamma\gamma$ Veto in Forward Detector

- How well can this really work?
- How significant is hole vs. other inefficiencies?

More detailed detector designs/simulations + beam tests

Diagnostic Instrumentation

- What is really needed for operations and tuning?
- Where does this go and how is it used?
- Do all critical technologies exist?

Specify requirements and
develop instrumentation design

Physics Instrumentation

- What does downstream really buy you?
- Can you survive without it (physics channels)?
- What is the cost/risk of upstream vs. downstream?

Design and simulation of complete BDIR region
with all foreseen instrumentation

Demonstration analysis with real physics observable

Time for a philosophy shift
inclusive inquiry -> directed, prioritized research

Do we need spectrometers at all?



Can we simply use $\langle L \rangle$ and $\langle \sqrt{s} \rangle$ from physics reactions?

Contrived Example - Lineshape Scan



$$N = \int \frac{dL}{ds} \sigma(s) ds \text{ not } N = \langle L \rangle \cdot \sigma(\langle s \rangle)$$

Need $dL/d\sqrt{s}$ spectrum including both inter-bunch and intra-bunch variations

Some Observations

- No idea if this is significant, real study needed
- Depends upon variance in L and \sqrt{s}
- Need to consider effects of IP feedbacks
- Could also be correlated to polarization...

Fast spectrometer and luminosity monitor
could be very useful (even relative)