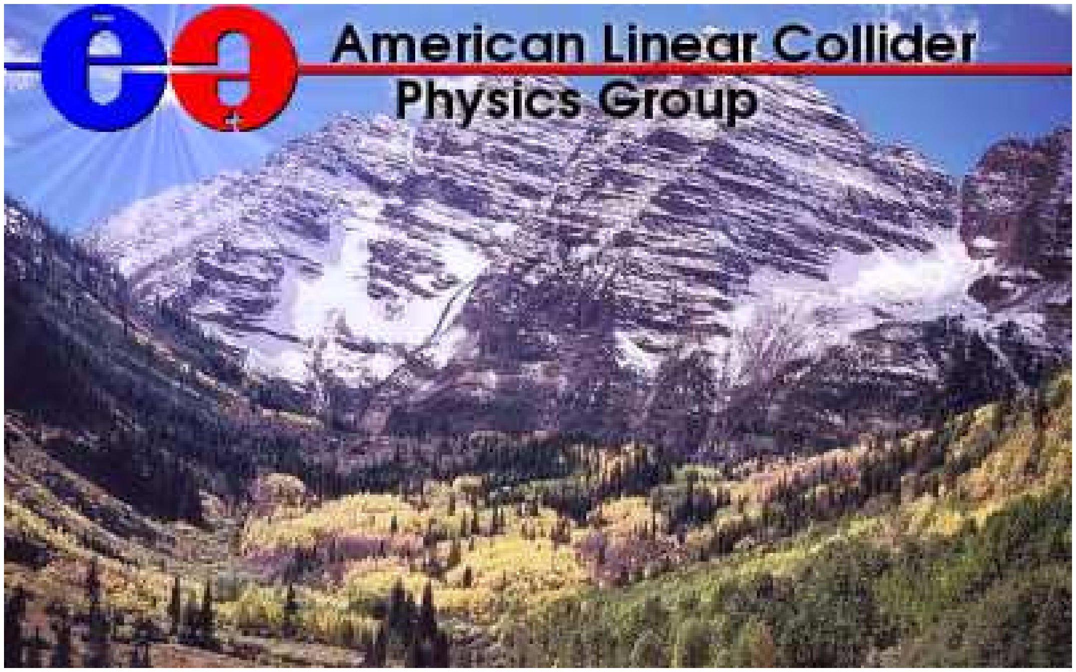
Energy and Luminosity Spectrum



2005 International Linear Collider Physics and Detector Workshop
and Second ILC Accelerator Workshop
Snowmass, Colorado, August 14-27, 2005

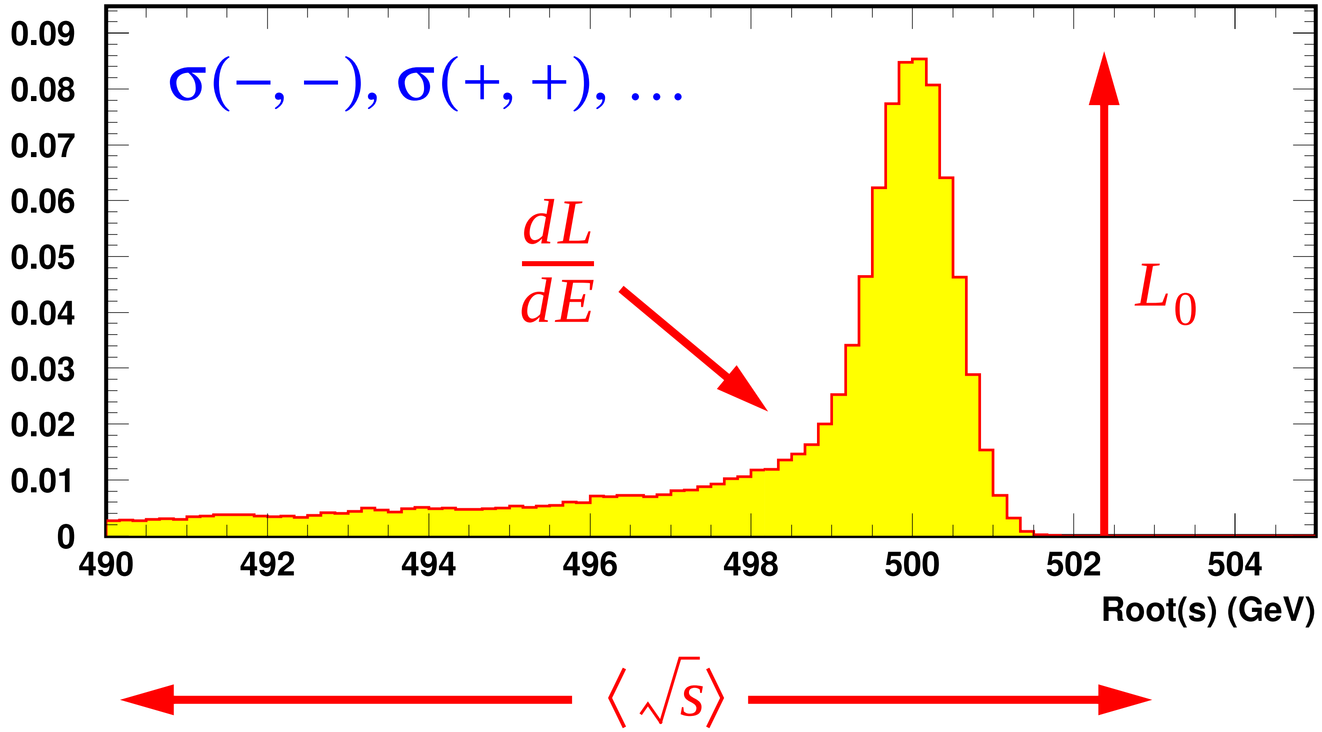
Eric Torrence
University of Oregon
Input from S. Boogert and M. Hildreth

Outline

- MDI Questions
- Upstream RF-BPM Spectrometer
- Downstream SR Spectrometer
- Additional Machine Diagnostics
- Physics Reference Reactions
- Putting it all Together
- Work Plan

Focus on CDR issues
and critical work for detector concept groups

Apologies for the text-heavy nature of this talk...



Fundamental Goal

Spin-dependent absolute collision energy spectrum

Typical Components

- Beam Energy
- Beam Energy Width
- Beam Polarization
- Absolute Luminosity
- Differential Luminosity Spectrum

All are intrinsically related in fundamental goal

14. Do you anticipate a need for both upstream and downstream polarimetry and spectrometry? What should be their precision, and what will the effect of 2 or 20 mr crossing angle be upon their performance.

SiD Reply: Both

Long reply (M. Woods) stressing redundancy and complimentary systematics for both.

GLD Reply: Both

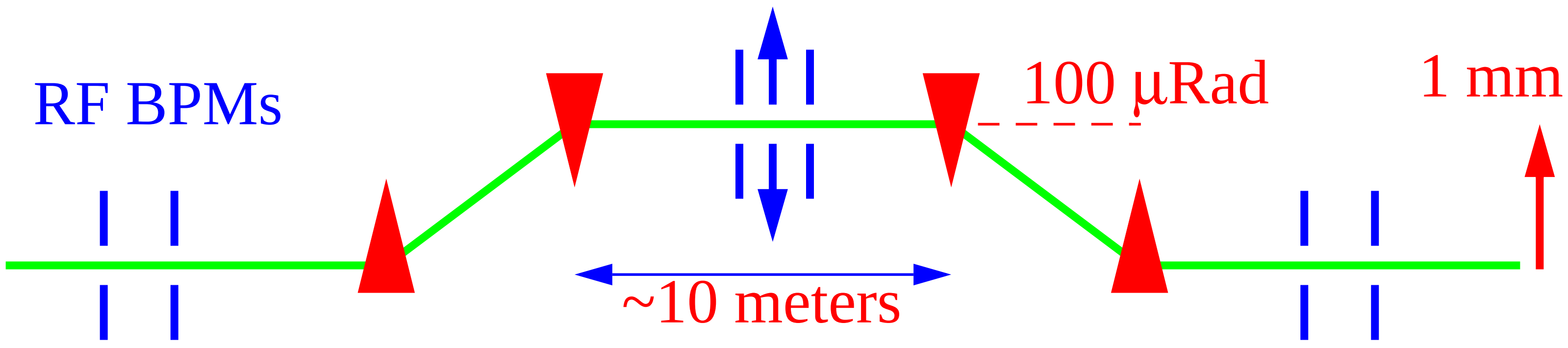
Short reply, similar sentiment. Also highlighted difficulty of downstream measurements.

LDC Reply:

Should be answered in common amongst all concepts.

The ball is in our court here.
Pressure will be to reduce costs. Far too early to give up on both upstream and downstream.

Need to assess performance in 2 mRad and 20 mRad



- Bends ~ 100 μRad, 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 ramping chicane (bipolar best)

Concept, Layout, and Design

Many details to be refined,
but basic concept is probably good enough for CDR

Operational Strategy

- What is the operational strategy? What kind of ramps and how often?
- What limits luminosity during ramps? Can machine auto-correct?
- Ramp strategy must be consistent with precision field maps!

Real thought needed here
Needs to be decided for CDR (in my opinion)
Need space for extra correctors? Optics problems?

Upstream Spectrometer Issues

Inspired by M. Hildreth email

BPM Issues

- nBPM gives 20-30 nm, but aperture too small
- Mechanical stability over length limits to ~100 nm?
- Need dedicated spectrometer BPM design
  (one plane only? rectangular designs?)
- Is 1000:1 range:precision rule of thumb absolute?
- Is this really just an electronics issue?

Work has already started, but more spectrometer-specific BPM efforts necessary.

Magnet Issues

- Magnet technology (warm steel vs. SC)
- Field mapping and in-situ instrumentation
- End-fields dominate $\int Bdl$ uncertainty

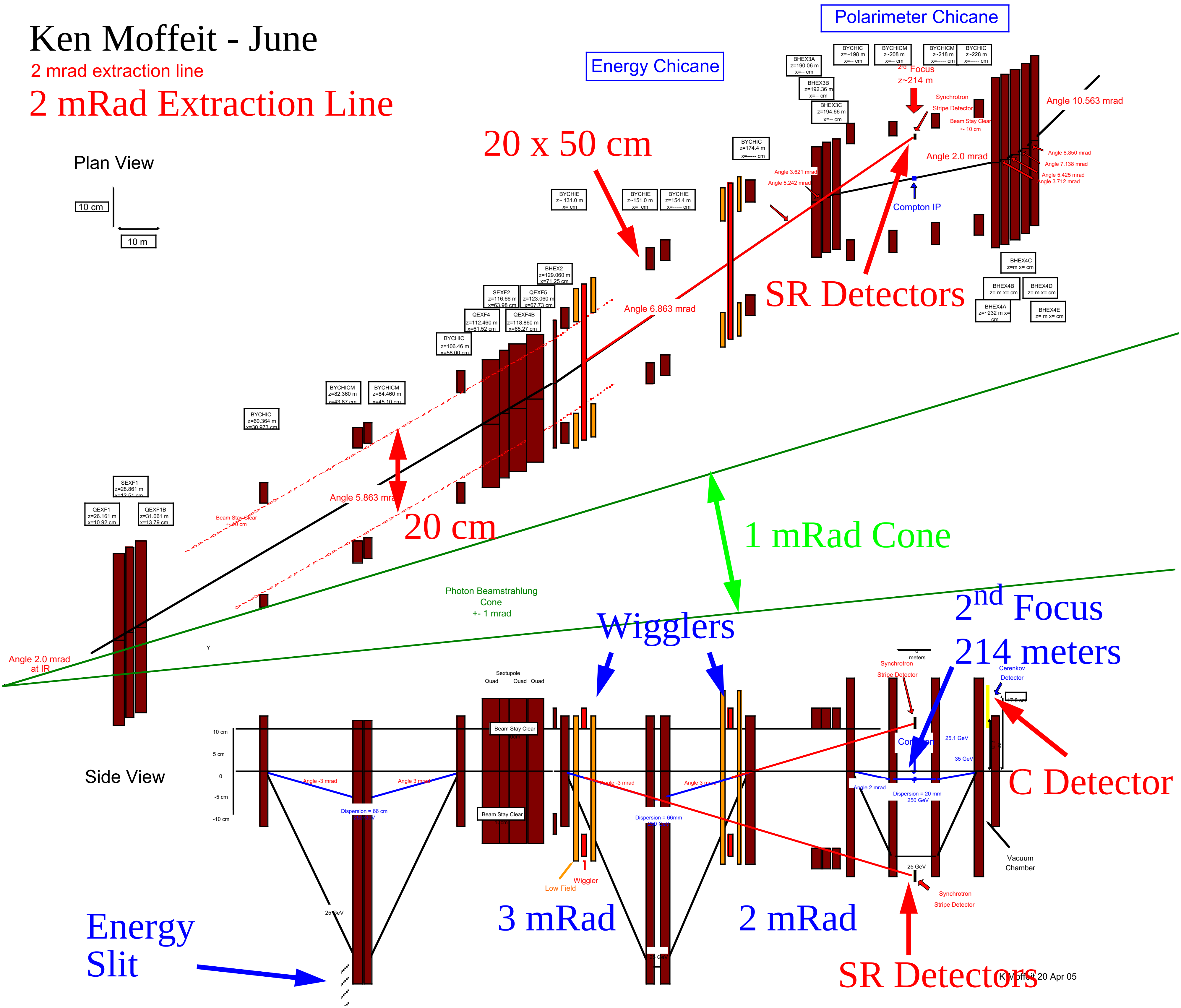
Not necessarily CDR issues, but need serious work

Downstream Spectrometry

Ken Moffeit - June

2 mrad extraction line

2 mRad Extraction Line



Downstream Spectrometer Design

What is done

- Basic concept and detector strategy
- Sketch of 2 mRad and 20 mRad extraction geometry to accommodate spectrometer and polarimeter

What is not done

- Feasibility of components - large apertures, shielding e.g.: wiggler is not at all “standard” or “trivial”
- Simulation of beam transport including realistic tracking, stray doublet fields, solenoid, DID, etc.

Key Work

- Get IP to dump simulation working with BDSIM, gradually include more realistic features.
- Specify/design realistic elements, esp. wiggler
- Assess 2 mRad and 20 mRad performance including background estimates, shielding, stayclear tolerances, etc.

Interested parties welcome here...

Machine Diagnostics

Need to have specifications in CDR for additional machine instrumentation useful for energy and lumi-spectrum measurements

- Energy spread at end of linac

Continuous relative monitor of core energy width.

Conventional wisdom is “wire scanner” at chicane.
Where does the fit in the instrumentation section?
What is the expected performance?

- Energy vs. z bunch profile

This would be tremendously useful for monitoring linac wakefield effects, key part of collision biases.

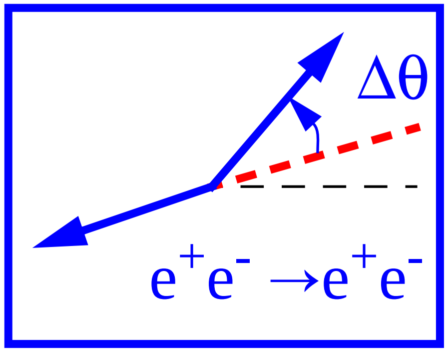
Does this really work at the ILC, where does it fit, can it be used as more than an MD diagnostic?

Input from machine instrumentation people needed...

Physics Reference Channels

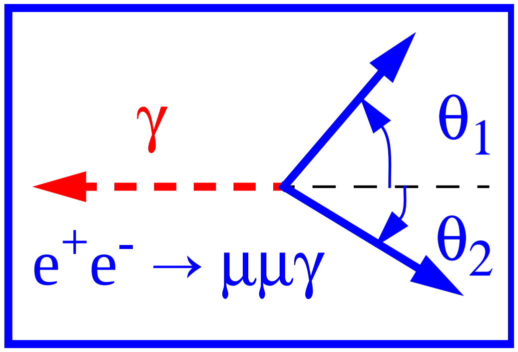
Bhabha acolinearity

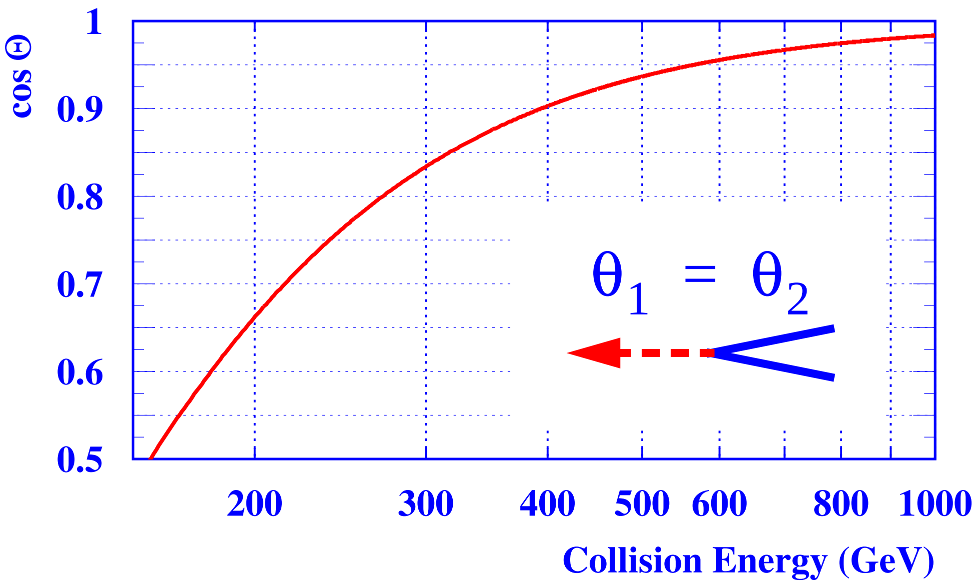
- Best input for lumi spectrum shape
- Strong requirements on performance of forward tracking and calorimetry? $\theta \sim 200$ mRad
- Reasonably well studied analysis



$\mu^+\mu^-\gamma$ “Radiative Returns”

- Potentially best measure of $\langle \sqrt{s} \rangle$
  correct for any collision bias
- Only possibility for WW threshold?
- Actually used at LEPII
  serious detector systematics





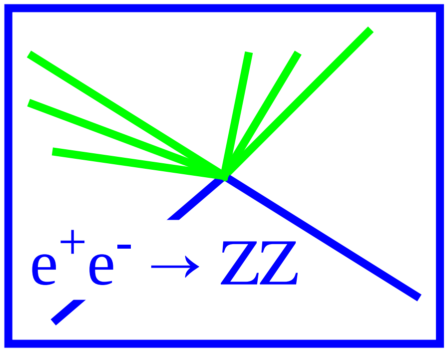
Need precise tracking to ~100 mRad

$\delta\Theta \approx 0.1\%$ per event (Γ_Z limit)

Absolute angle known to 10^{-4}

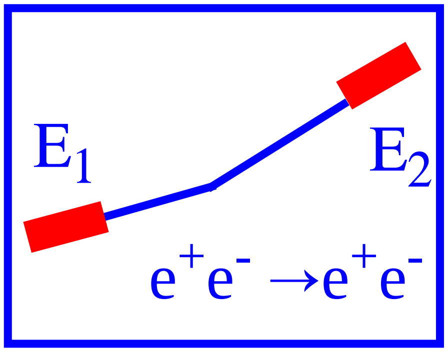
Not a CDR issue for machine,
but directly impacts detector concepts

$ZZ \rightarrow qqll$



- Useful as cross check of $\langle\sqrt{s}\rangle$
- Lower statistics, but
  less detector systematics than Zγ
- Only briefly considered (that I am aware of)
- Ultimate resolution/accuraccy unknown...

Bhabha/Mu-pairs direct energy/momentum



- Could potentially cross-check drifts in $\langle\sqrt{s}\rangle$
- Limited by detector calibration and resolution
- Already envisioned for detector calibration?

Also related: t-channel WW for polarization

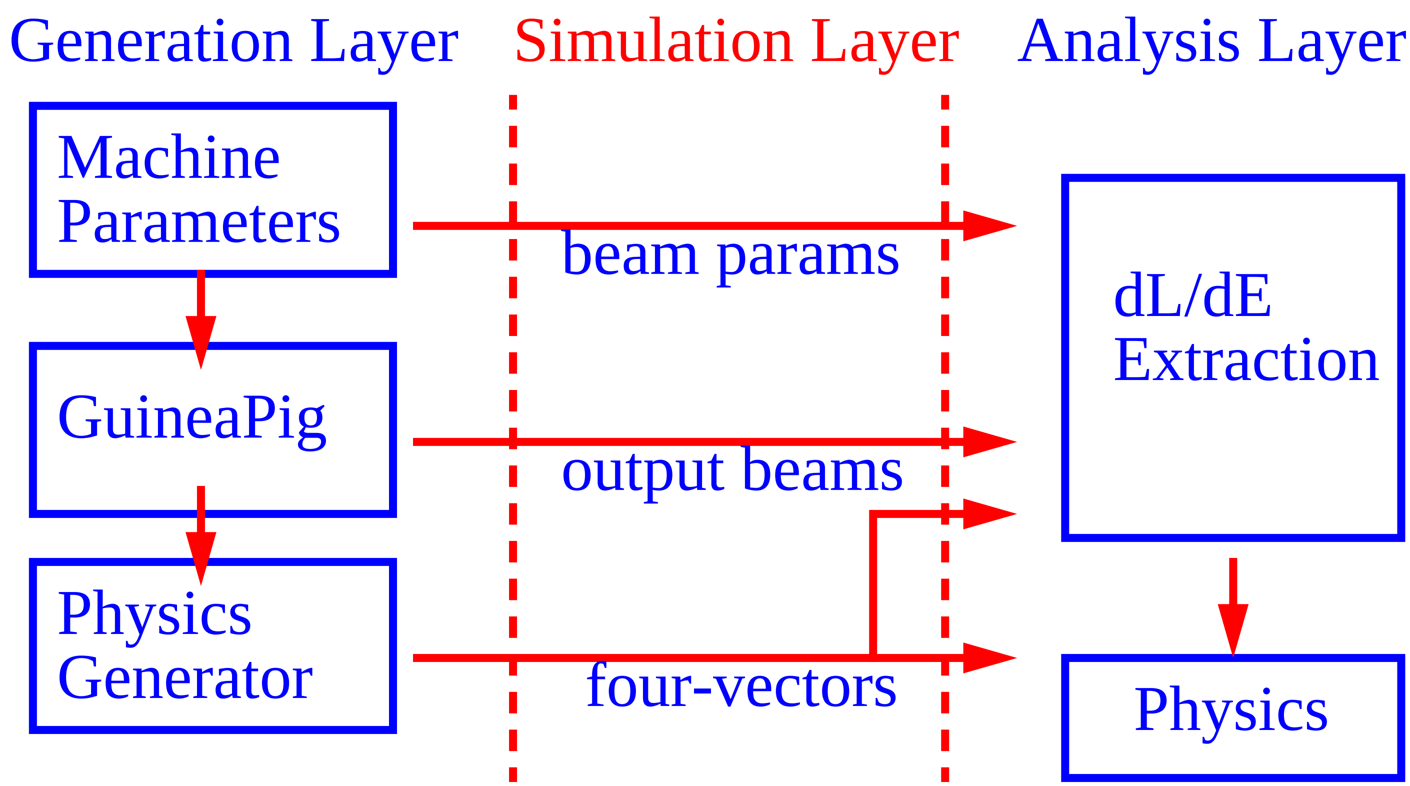
Need more detector effort on forward tracking, esp. systematics.
Forward tracking needs as much care as lumi monitor...

Possibility to design specific calorimeter rings to improve performance?

Physics benchmarks do include Bhabhas and μμγ
need to raise awareness of importance in some detector groups

Putting it all Together

Need to demonstrate that lumi spectrum can be extracted from available inputs and fed back into physics analysis



Partly technical check of parameterization and technique,
partly demonstration that there aren't loopholes in logic.

Exploit G. White's work on IP feedback simulations
Integrate into ILC generators for easy use by physics groups.

S. Boogert - working on extracting machine parameters from Glen's files into convenient format for generators...

Possible Snowmass Work

BPM performance and operational strategy

D. Miller, M. Hildreth, M. Ross?

IP -> Dump Simulations

E. Torrence w/ help from BDSIM experts (i.e.: Carter)

Statement on Machine Diagnostics

M. Ross, G. Blair?

Highlight Reference Physics Reactions to Concepts

T. Barklow, others?
Worth preparing a short talk on this for concepts?

Full Lumi Spectrum extraction and application

S. Boogert