Extraction Line Diagnostics

ILC-BDIR WG4 Interim Workshop
Royal Holloway University of London

Eric Torrence
University of Oregon

Mea Culpa

Real Work

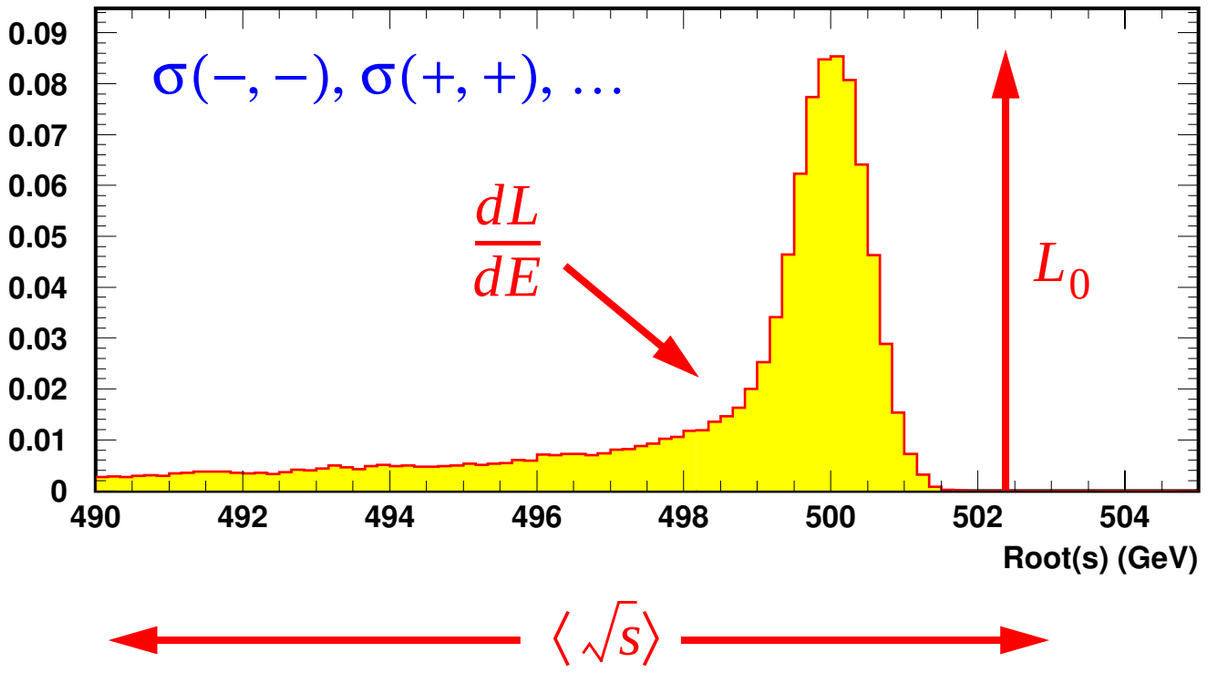
- SLAC/BNL/UK/France 2 mRad consortium (Yuri)
- Ken Moffeit (Woods, myself)

Outline

- X-line instrumentation overview
- 20 mRad instrumentation reminder
- 2 mRad instrumentation design
- Polarization issues
- Spectrometry issues

Instrumentation = Energy Spect. + Polarimetry

Mistakes (of course) are mine



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

Instrumentation Goals

Goals often defined by what is considered "achievable"

- $\langle \sqrt{s} \rangle$ understood to 50-100 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, 0.1% with P_+

- Absolute luminosity
  ALCPG view: $\Delta L \sim 0.2\%$ ("easy")
  Tesla 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 $\sigma_{q\bar{q}}$

Baseline goals for high energy, high luminosity running

Use mixture of beam-based and physics-based observables
Redundancy is key to precision

Why Downstream?

Polarimetry

- That's what was done at SLC
- Diagnostic for IP spin depolarization
- Easier spin vector alignment?
- Main detector backgrounds?

Energy Spectrometry

- WISRD-style complimentary to upstream BPM
- Possible to monitor IP disruption
- Potential to get info on lumi spectrum

General strategy for high accuracy measurements: redundancy and complementarity

Downstream Instrumentation Constraints

Designing an extraction line at High Energy and High Luminosity is difficult (impossible?)

Instrumentation needs imply the following additional constraints

Polarimetry

- Spin vector parallel at Compton and main IP
  jitter tolerance - spin vector alignment
- Secondary focus at point of high dispersion
  polarimeter chicane
- Desire for favorable transfer function (R_{22})
- Quiet location for detector at compton endpoint

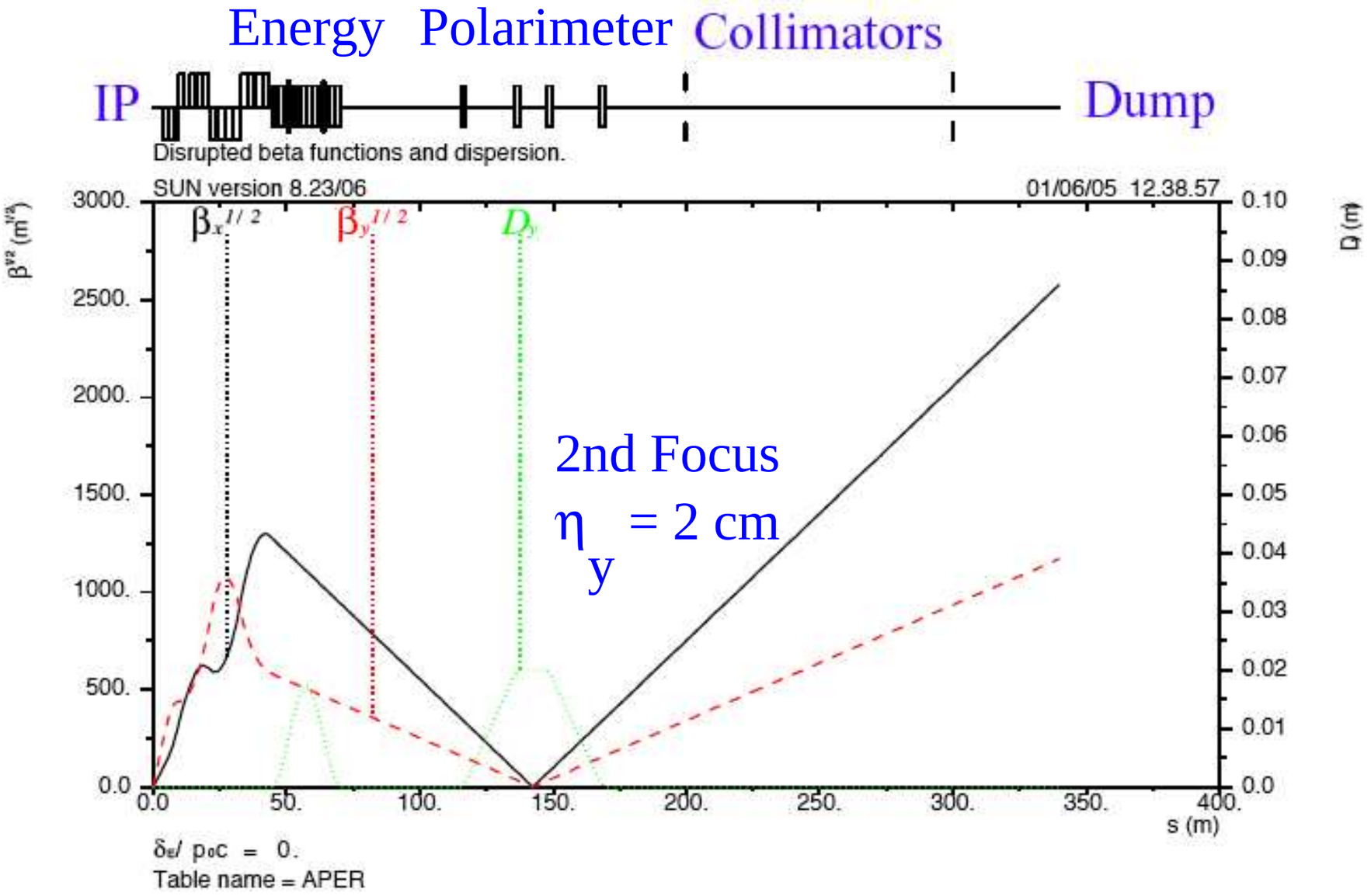
Spectrometry

- Production of “signal” synchrotron radiation
- Line of sight to SR detectors outside beam stayclear
- Secondary focus at SR detector plane

Additional constraints must be satisfied with realistic magnets, apertures, beam losses, and backgrounds (still to be done!)

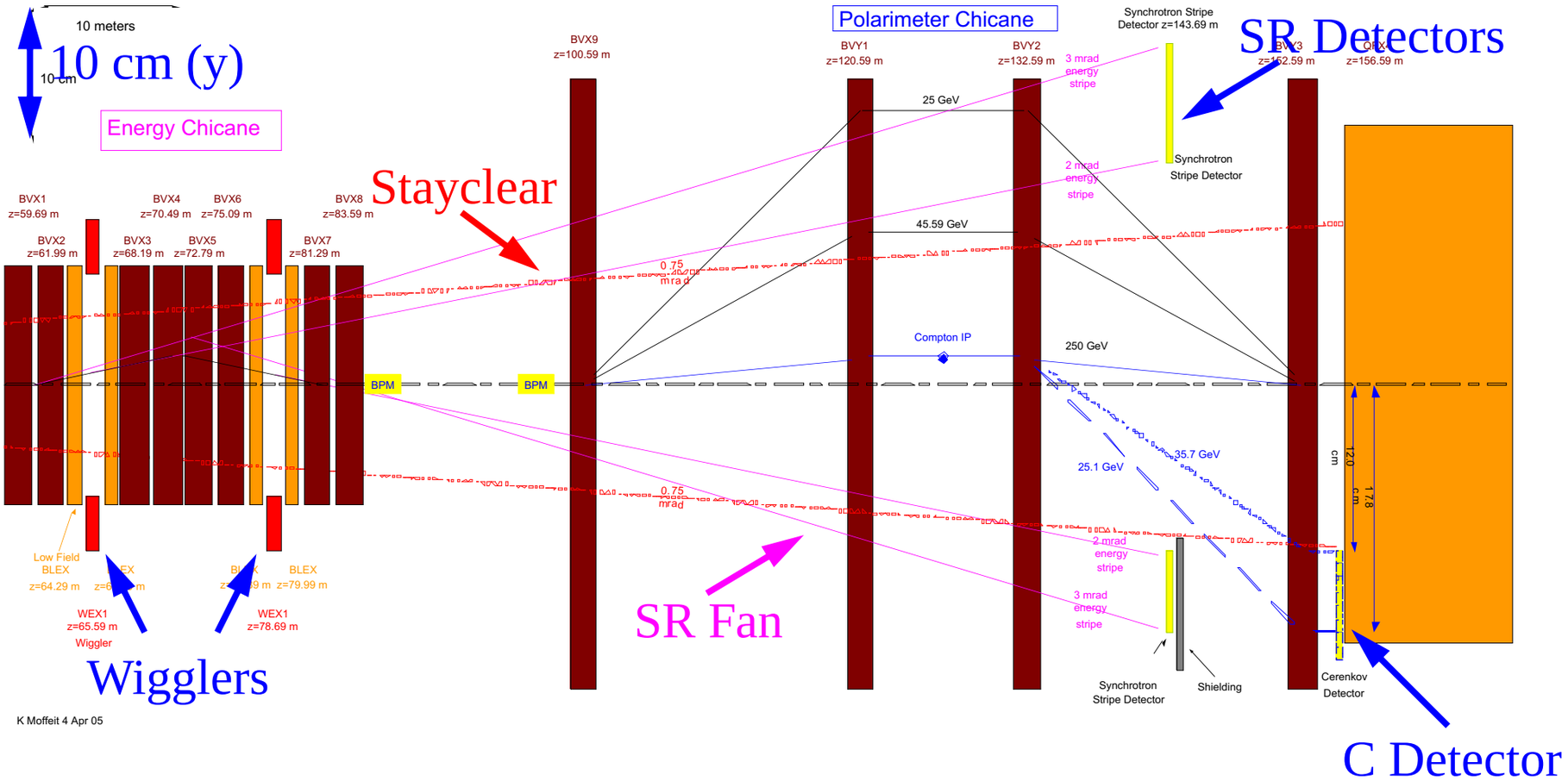
20 mRad optics design

Yuri Nosochkov - June 1st



20 mRad instrumentation layout

Ken Moffeit - LCWS



Key Points/Issues

- Apertures: 20 cm gap for “wigglers”, 20x40 cm for Pol Chicane dipoles

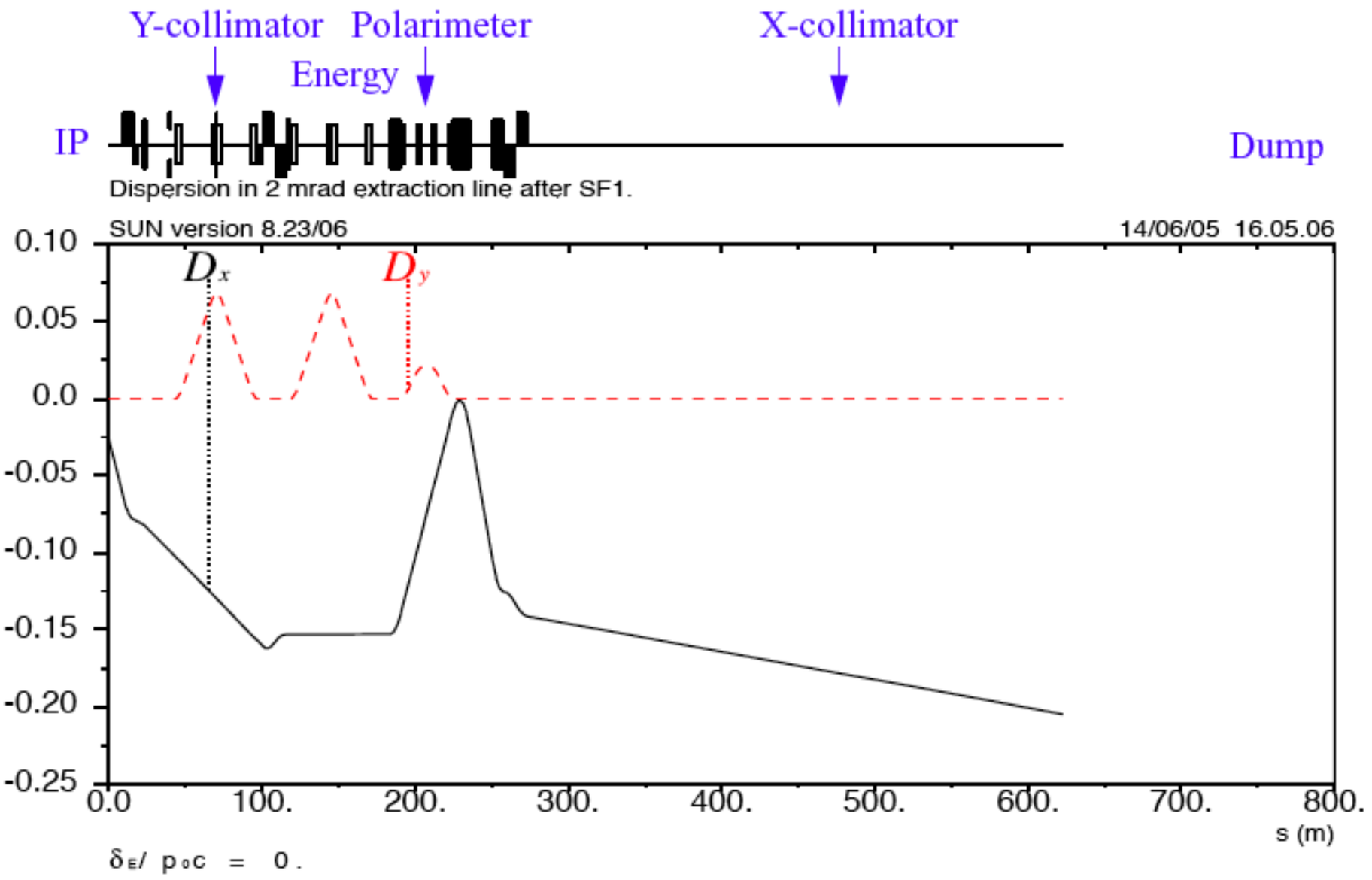
  Energy bandwidth, SR line-of-sight, stayclear, Compton endpoint

- SR detectors slightly downstream of 2nd focus - resolution issue

- Detectors very tight to nominal stayclear - background issue

2 mRad optics design

Yuri Nosochkov



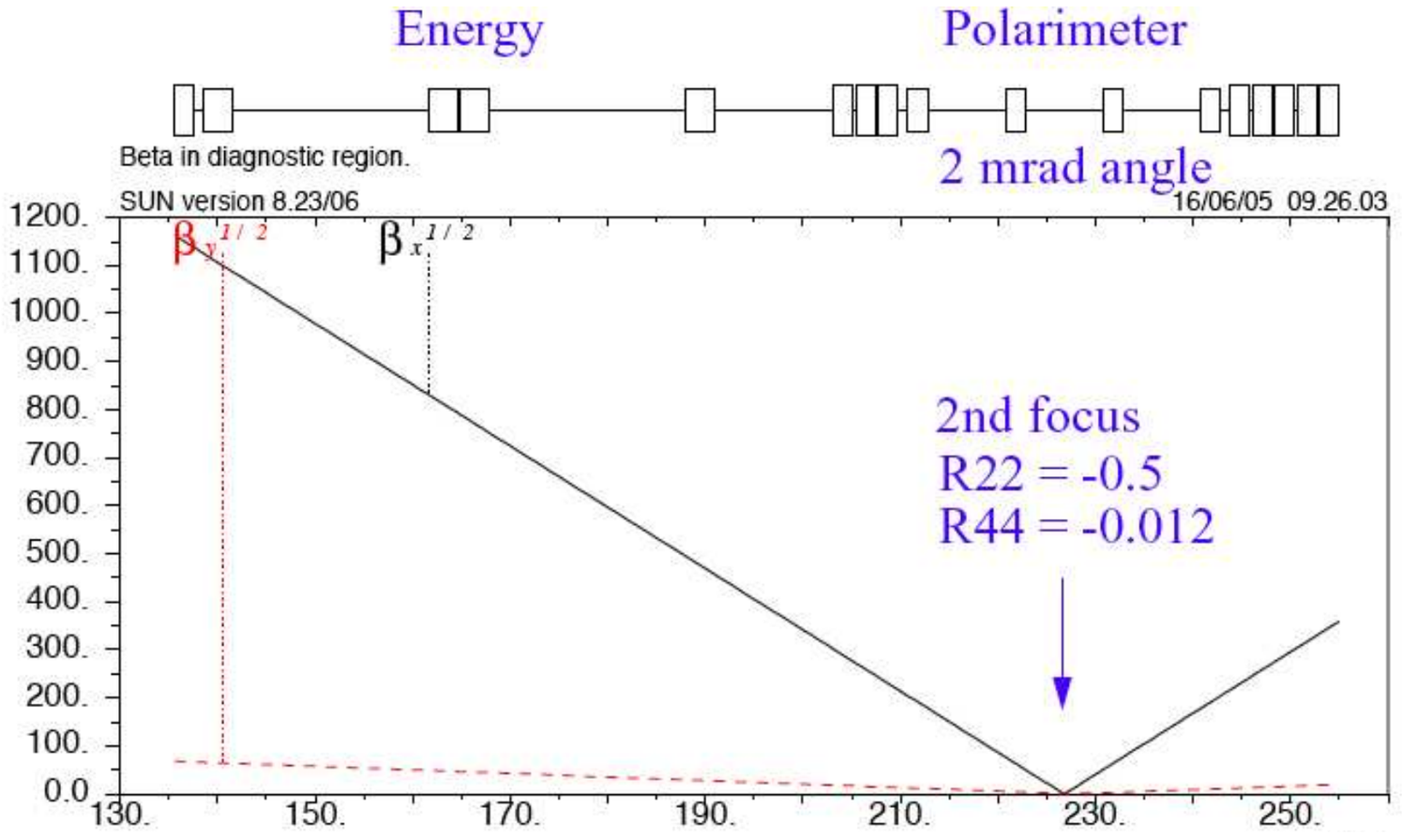
Three vertical chicanes!

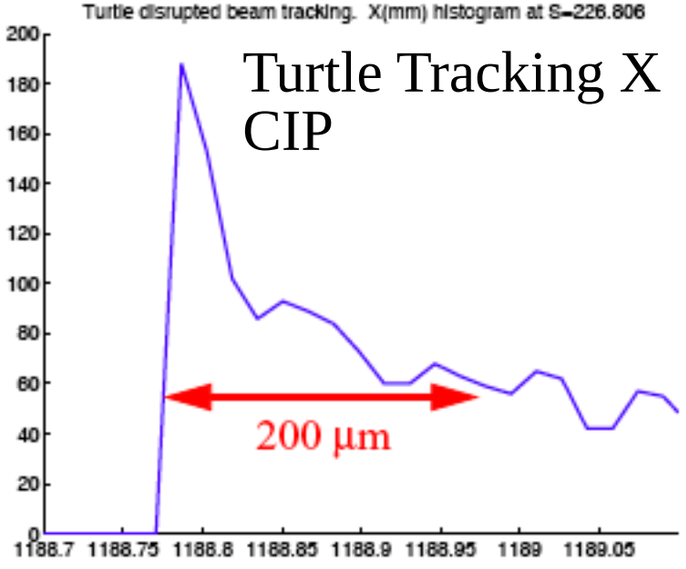
Energy collimation at ~10% E_{nom}

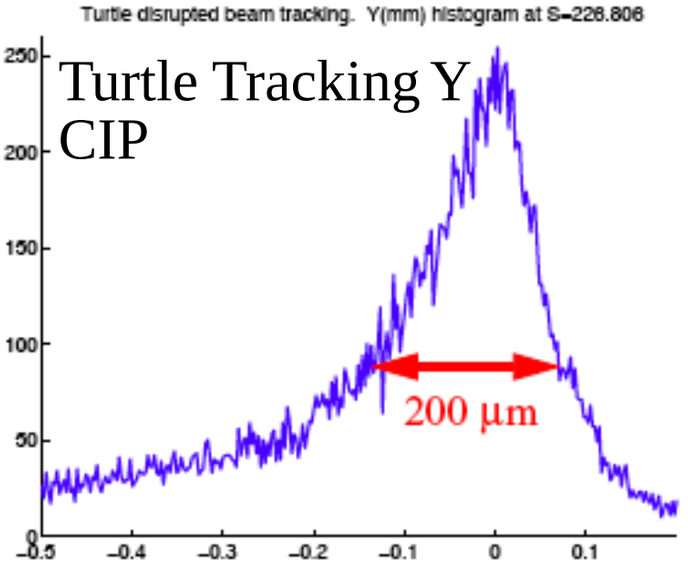
Parallel beam at compton IP

2 mRad optics design

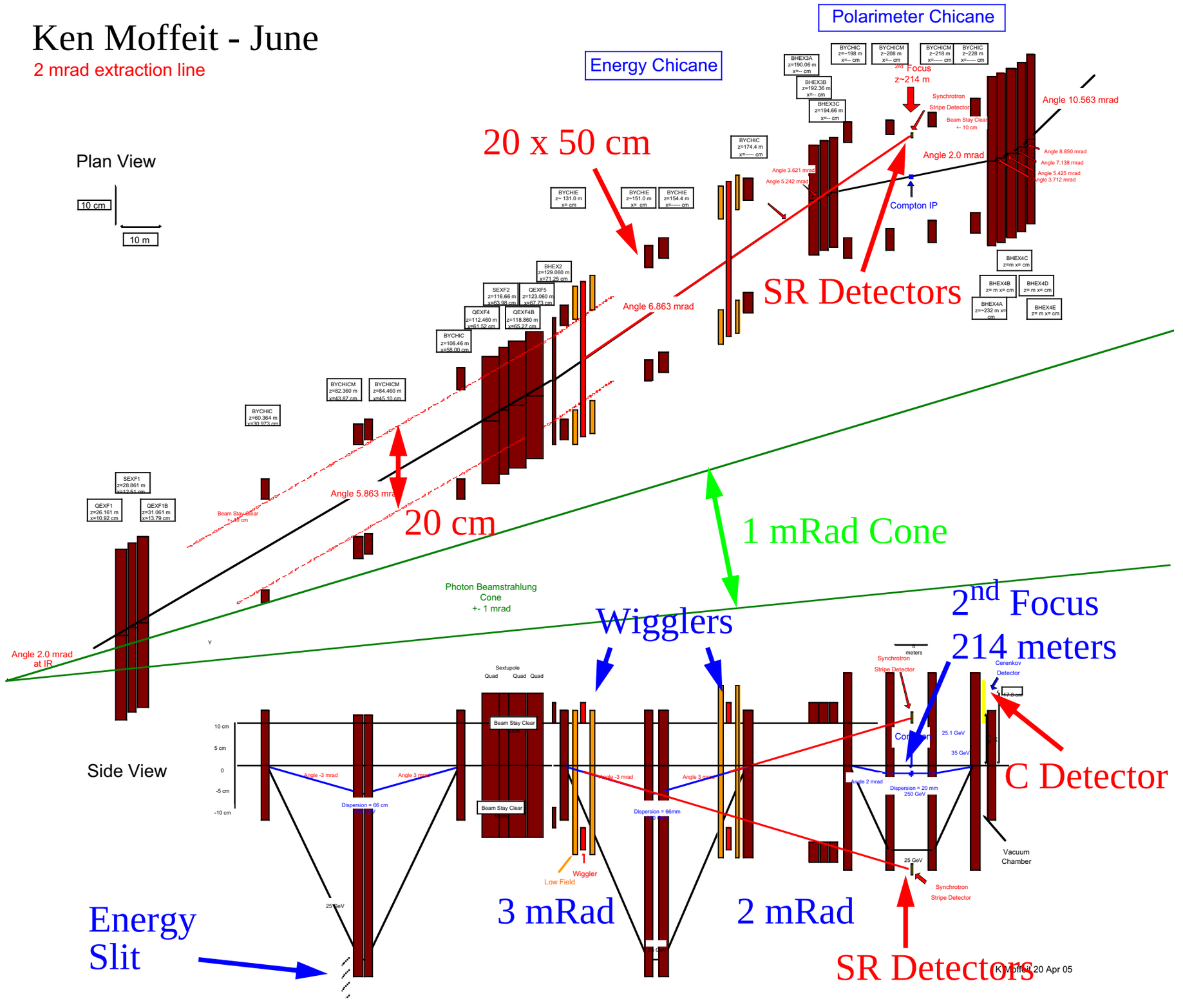
Yuri Nosochkov







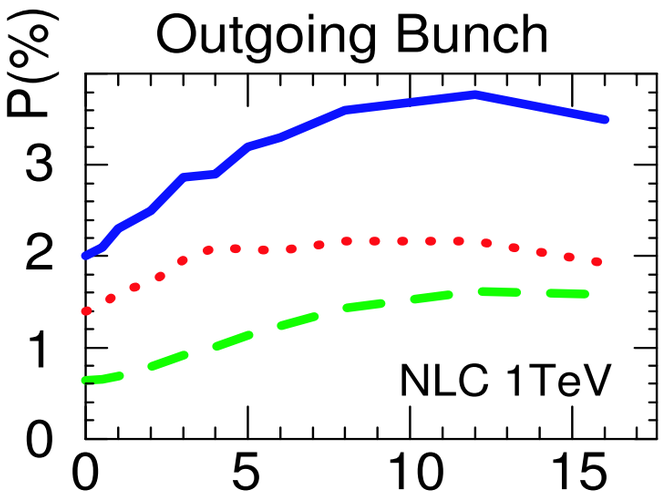
2 mRad instrumentation layout



IP-Polarimeter differences

Depolarization in collision

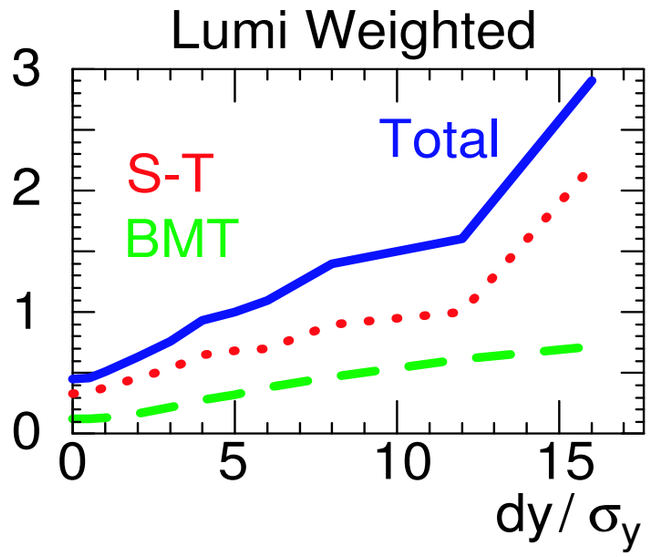
- Sokolov-Ternov and BMT precession
- Overall lumi-weighted ~ 1/4 total depol.
- ΔP_{lum} ~ 0.5%, should be re-evaluated with modern machine parameters



IP-polarimeter spin precession

$$\Delta\theta = \gamma\frac{(g-2)}{2}\theta_0$$

- 1000x amplification, need spin vector longitudinal and parallel to ~ 50 μRad
- Harder with 2 IPs (double spin rotators)
- Must worry about solenoid in x-angle

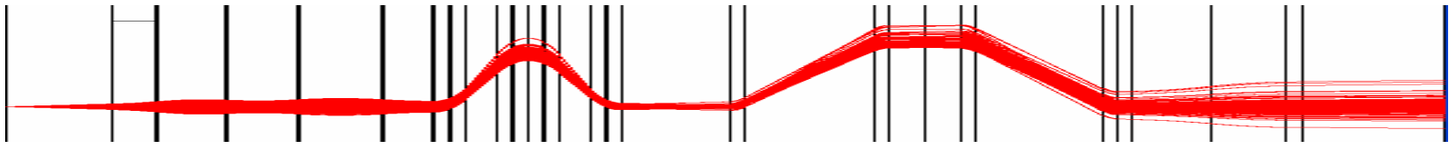


New IP simulation (GuineaPig) with spin transport may help guide arguments here

Ultimately want to measure these effects

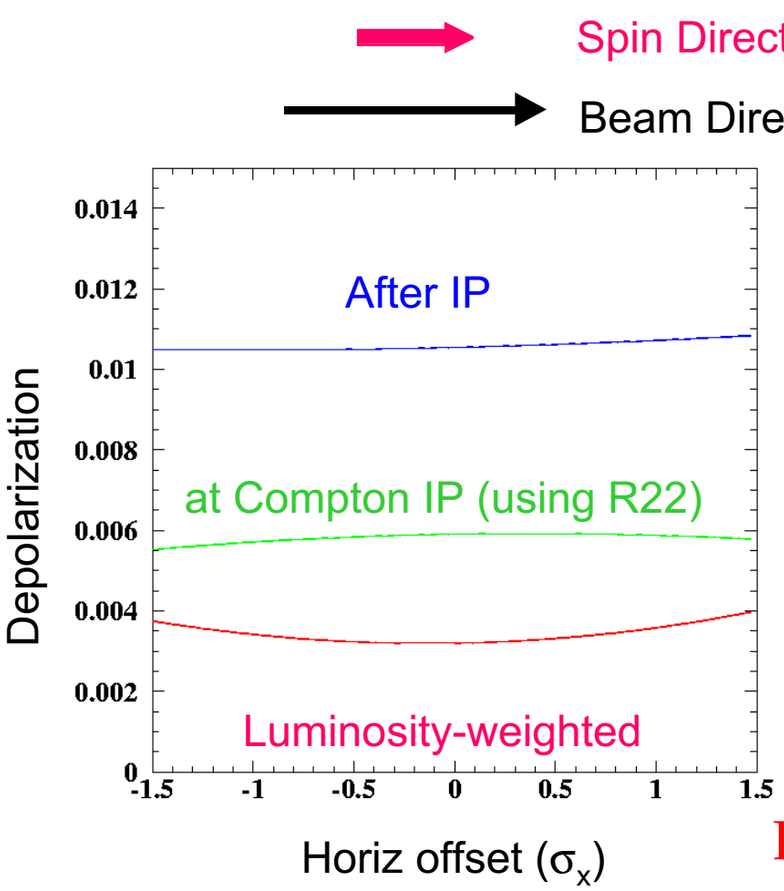
R_{22}

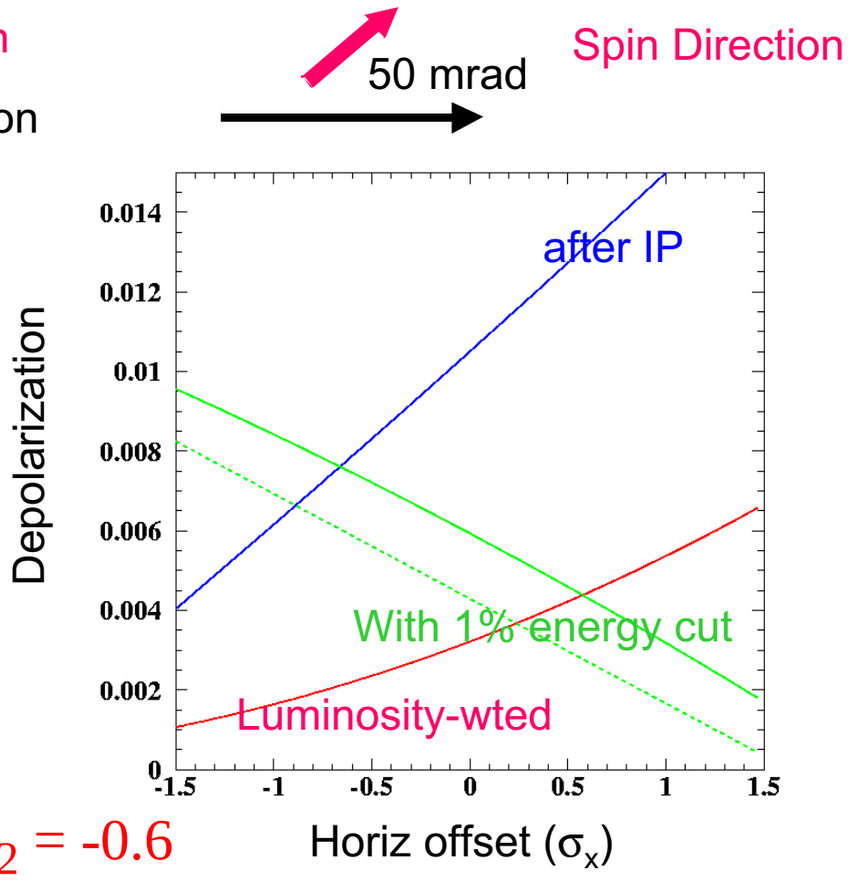
IP Energy Polarimeter



$$|x\rangle_{chicane} = R\,|x\rangle_{IP} \text{ where } x = \{x, x', y, y', \delta E/E\}$$

R_{22} most important as horizontal angles dominate

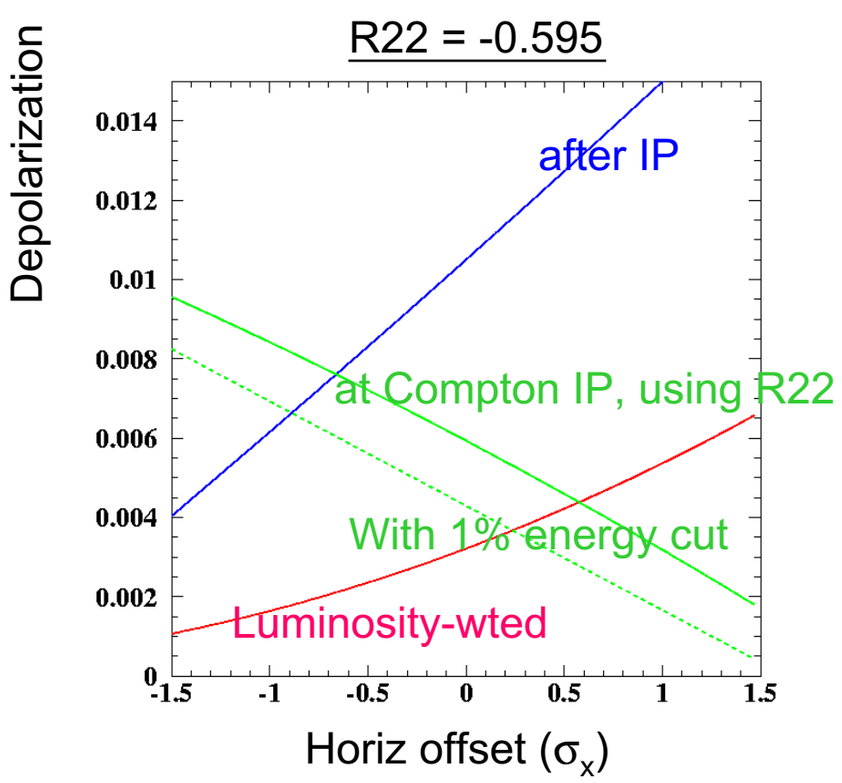


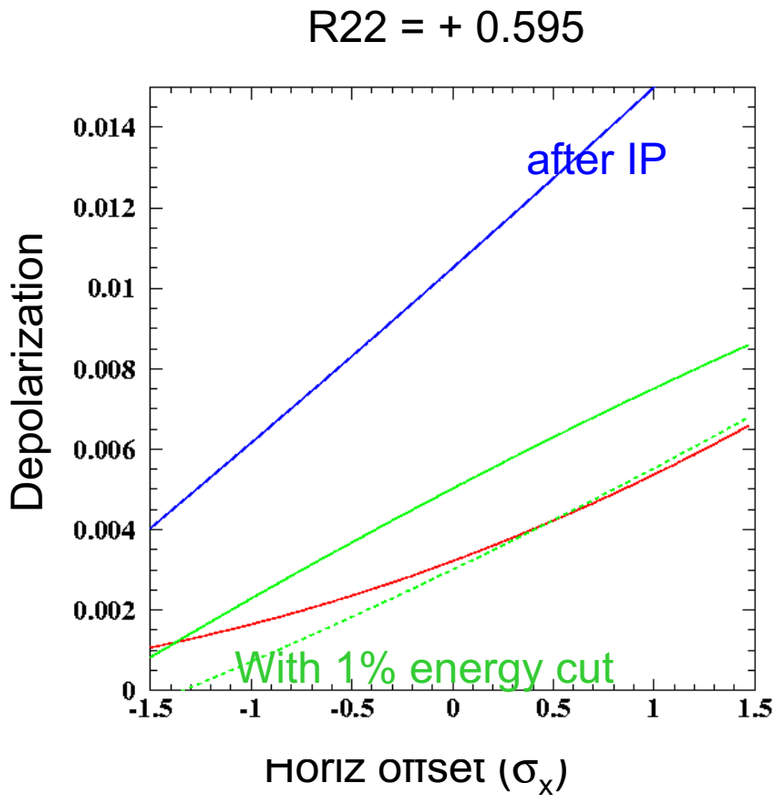


$R_{22} = -0.6$

Negative vs. Positive

Ken Moffeit - LCWS





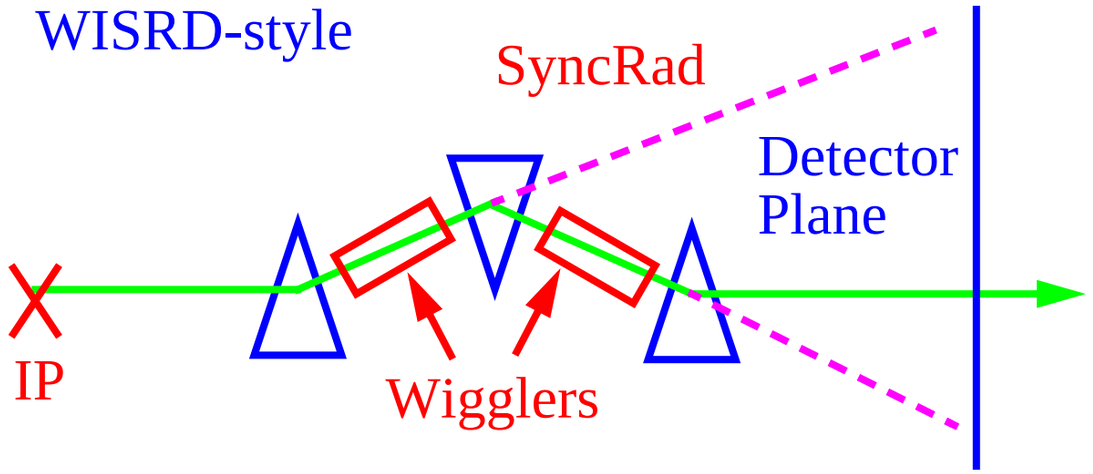
(Moffeit, Mönig, Woods, Schuler, Nososchkov)

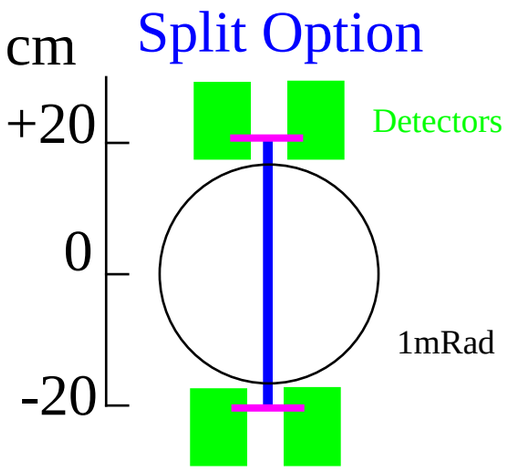
My understanding is that positive R_{22} possible,
at expense of longer 2 mRad extraction line

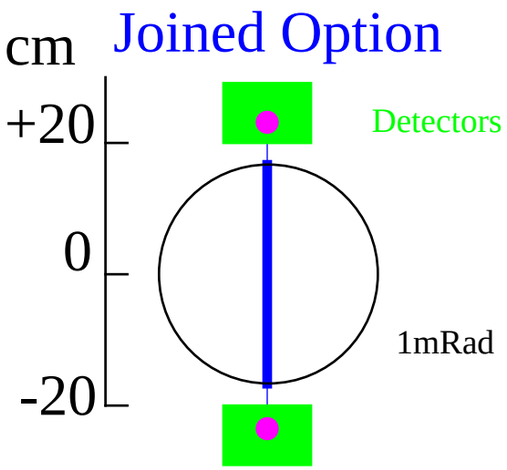
Only BMT, S-T (spin flip) evolution not included (need GP/Cain)

Wiggler Design

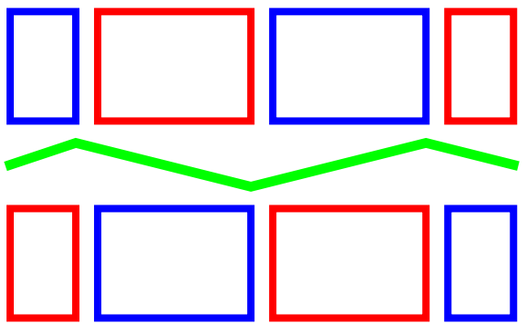
- Focus at detector plane
- Wigglers reduce alignment systematics
- Wigglers can be turned off for bgd studies
- Up/down to maximize $\Delta y/l$ (resolution)



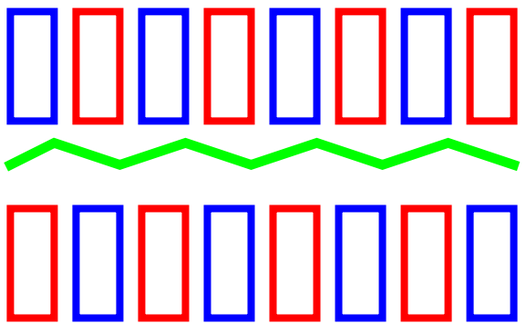




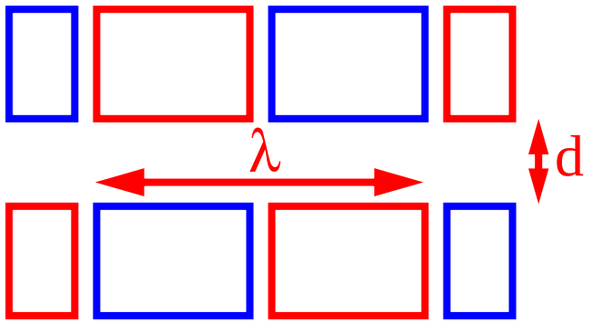
Large λ wiggler



Small λ + Soft Bends



Aperture constraints



$\lambda_{min} \approx 2d$?

Large 20 cm aperture unsuitable for “traditional” wigglers

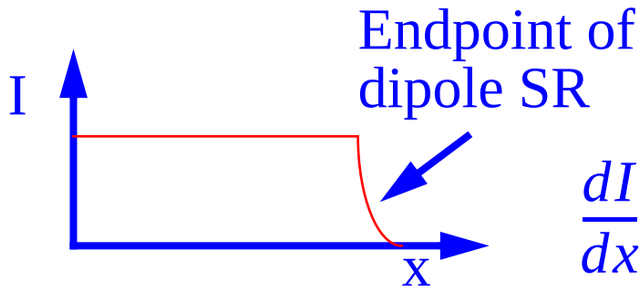
Dipole SR background

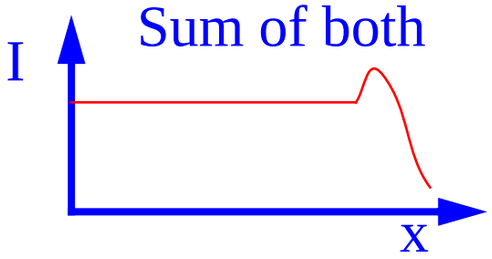
E_{beam}	E_{crit} (MeV)
50	0.3
250	34
500	275

(for 1 mRad/m)

$$E_{crit} = 3hc\gamma^3/(2\rho)$$

Need Wigglers at all?





Too sensitive to width?

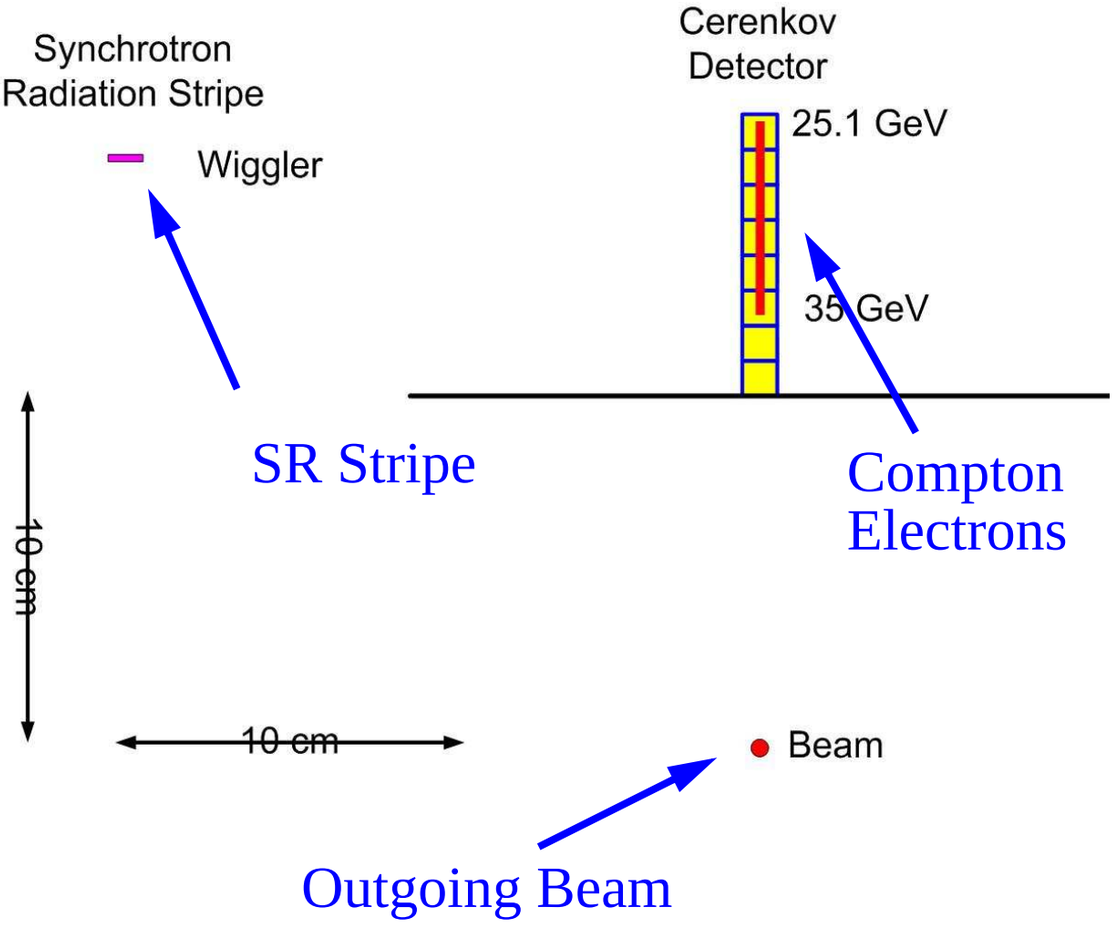
Subtract wiggler-off background?

2 mRad detector plane

Horizontal bend to align IP - CIP spin vectors

Separates SR and Compton signal

Looks very nice



2 mRad detector plane

Dipole SR is potentially a serious background problem for both detectors...

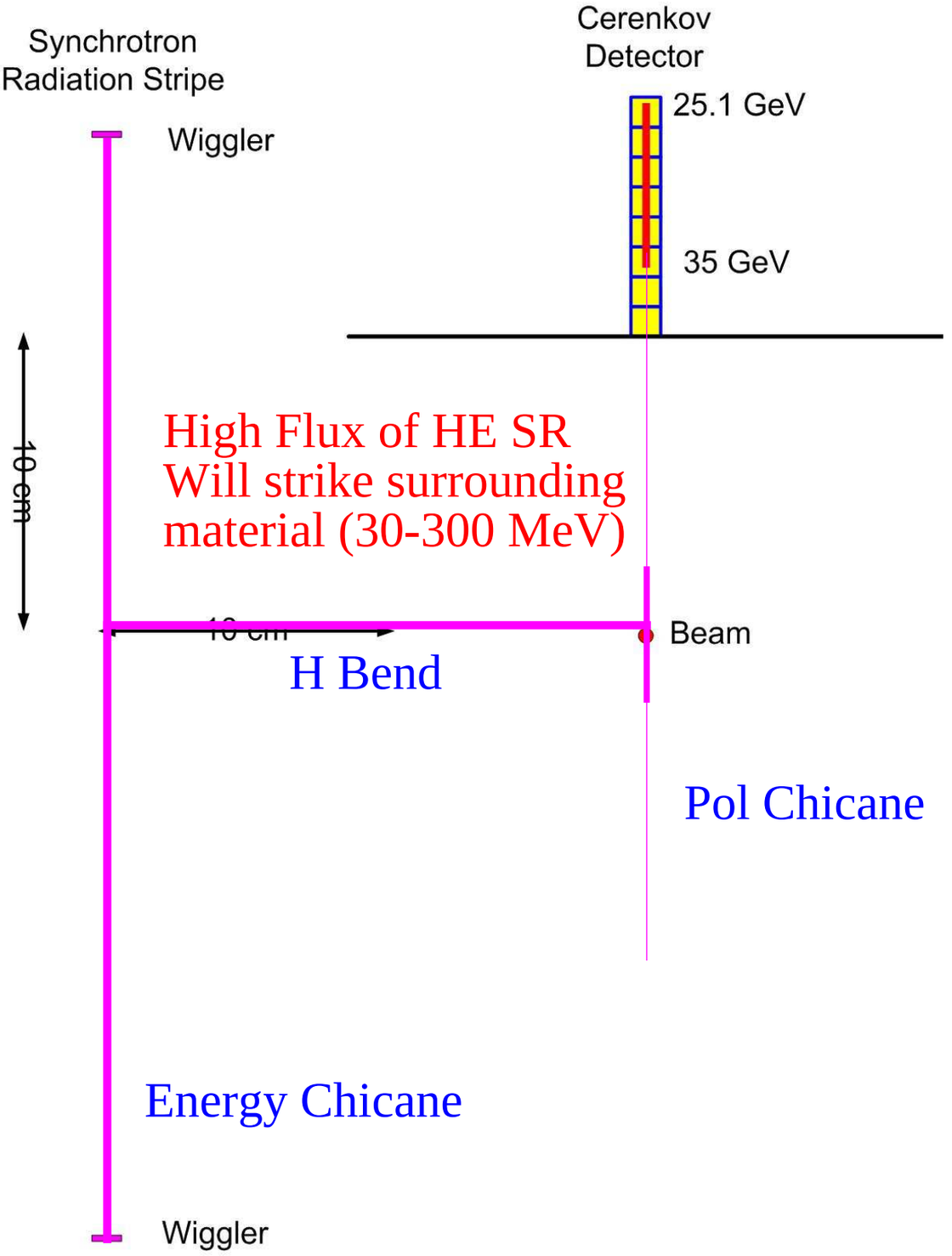
Gas Cerenkov: 10 MeV

Quartz Fiber: 0.7 MeV

Need careful study of backgrounds and shielding options

Not at all clear whether this will work!

(2 mRad or 20 mRad)



Summary and Plans

Summary

- 2 mRad vertical crossing-angle w/ diagnostic chicanes available for E_{beam} = 250 GeV
- Not obviously worse than 20 mRad solution
- No detailed study showing any of this will work!

Immediate Plans

- I have so far failed to get BDSIM running for X-line studies, but Orsay group (Olivier Dadoun) have this working now (IP->dump)
- Have 2 mRad and 20 mRad model available for spectrometer (and eventually polarimeter) performance and background studies by Snowmass
- Start some real thought on wiggler design/usage

Longer Term

- Incorporate realistic solenoid, DID, anti-solenoid, final doublet fringing field, etc
- Detailed Geant4 detector description