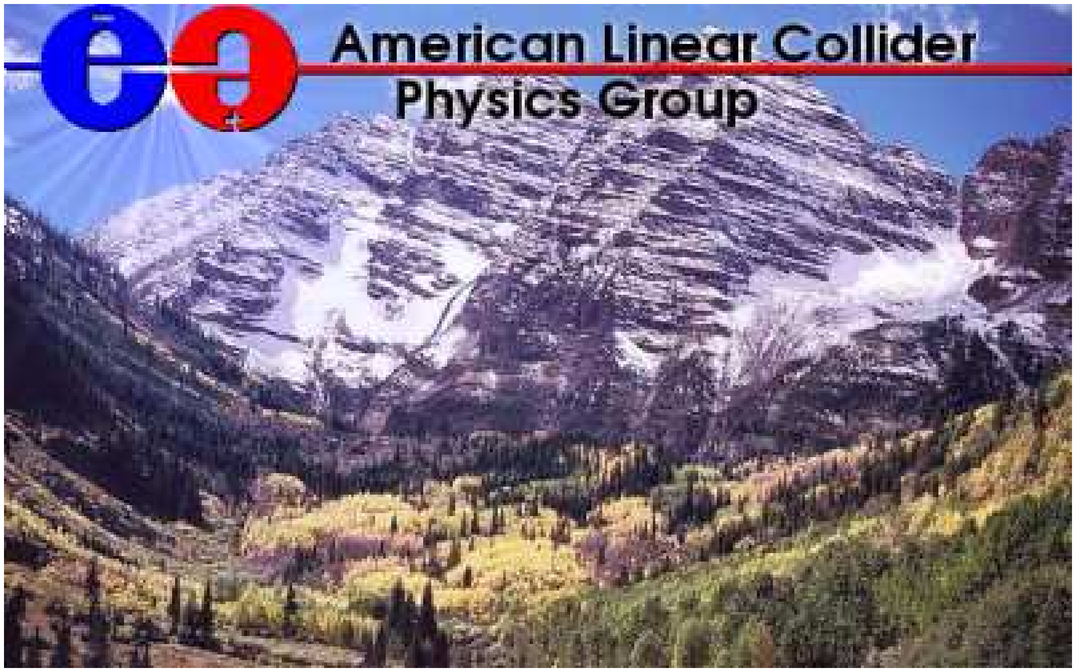
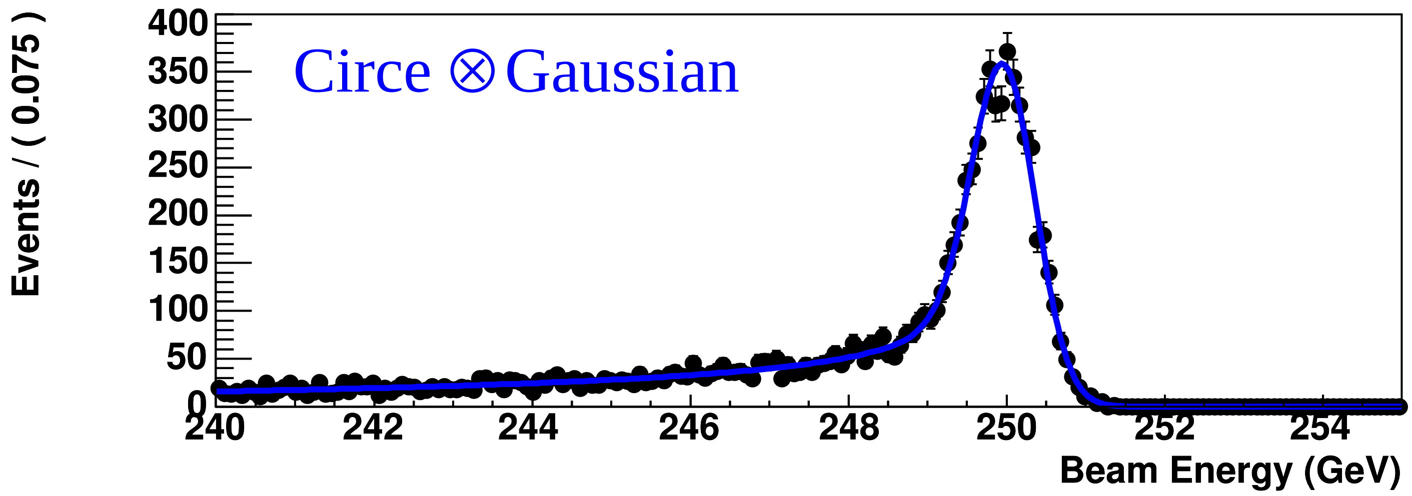
# Extraction Line Spectrometry




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

Eric Torrence
University of Oregon

# Outgoing Energy Spectrum




Downstream beam energy distribution

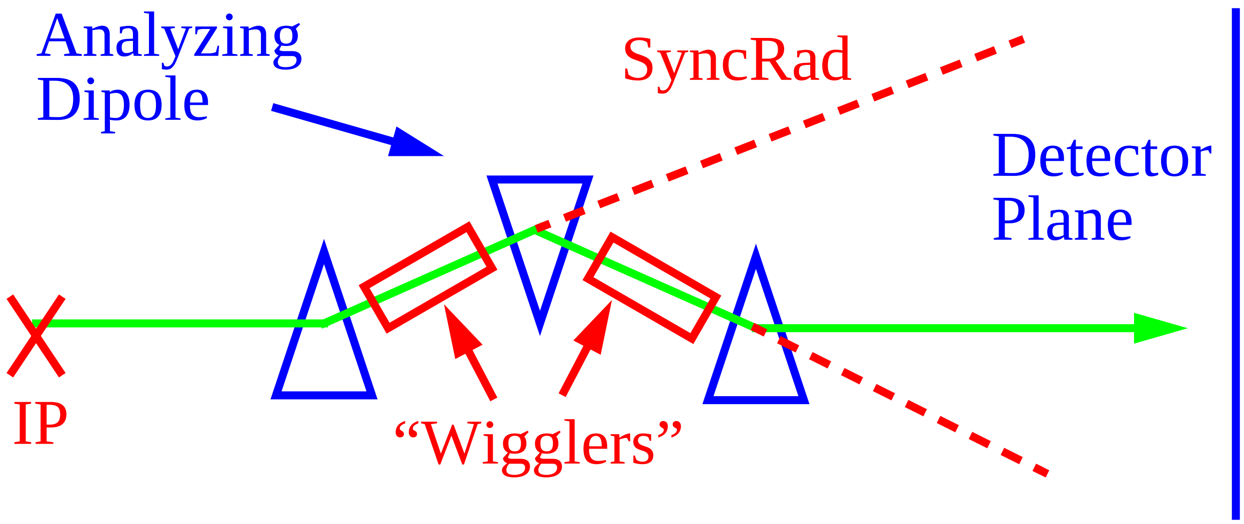
- Not the same as $\sqrt{s}$ spectrum
- Peak highly correlated to incoming $E_{beam}$
- Tail predicted by Guinea Pig, sensitive to collision parameters

Downstream goals

- Measure absolute energy of incoming bunch (peak position)
- Measure incoming energy spread (peak width)
- Measure disrupted beam spectrum (tail)

Tail measurement is at worst a collision diagnostic.
At best, this can be used to validate collision models.

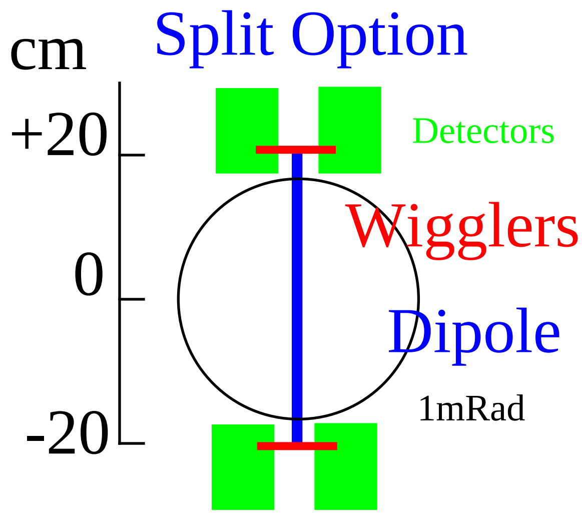
# X-Line Spectrometer Overview




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

Detector Plane

- L ~ 100m, > 2 mRad bend
- large λ wiggler - SR “tee”
- detector ~ 100 μm pitch
- Δy = 40 cm
  40 μm precision required
- < 125 MeV/100 μm
  for 250 GeV beam
- Single arm gives energy spread



# Design Features

## Advantages

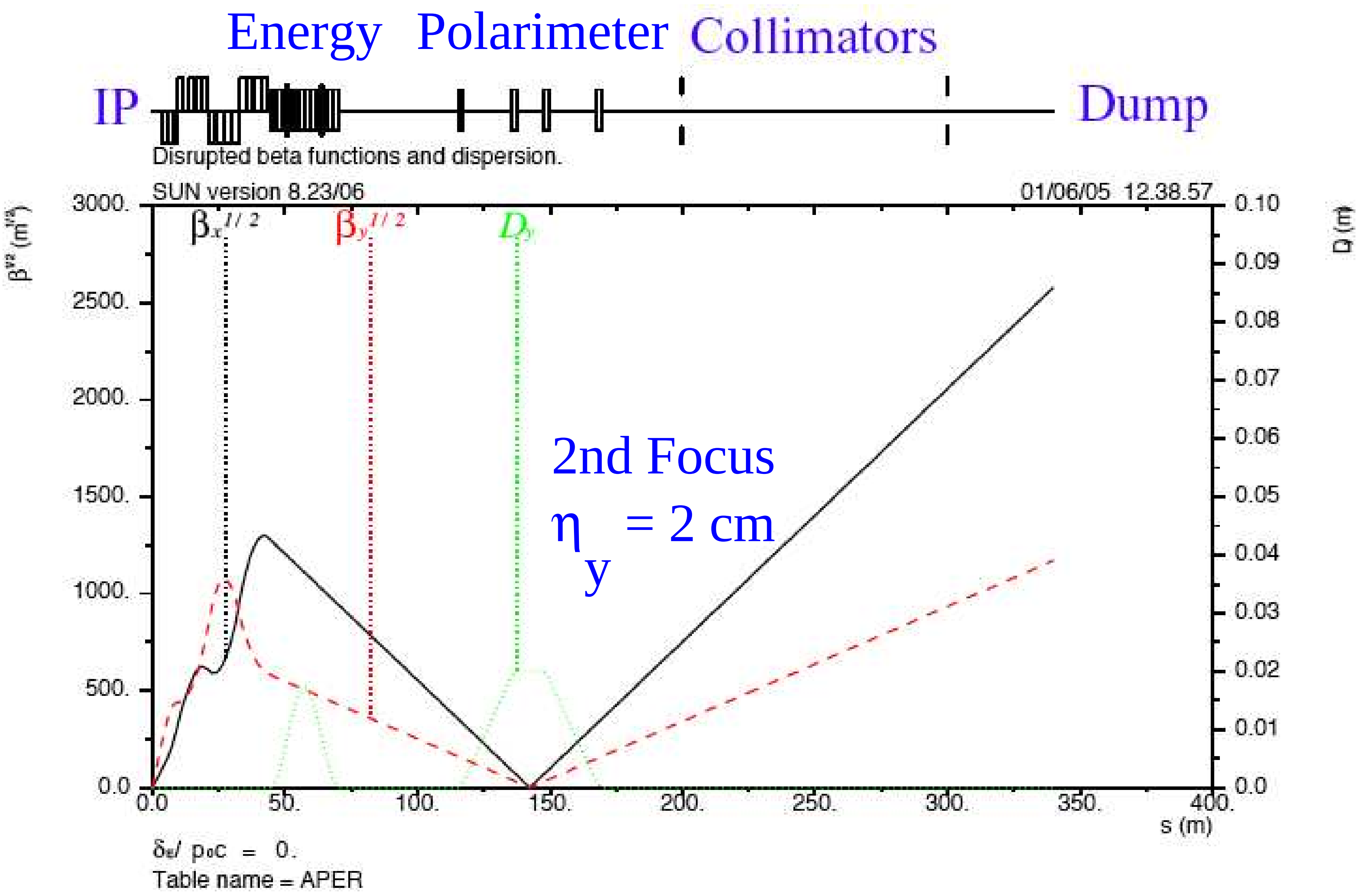
- Neutral particles avoid stray fields
- Compact detector plane, 10s μm absolute accuracy
- Longitudinal positions need < 1 cm accuracy
- Very passive device, high reliability
- Natural to measure pulse-to-pulse

## Disadvantages

- Must get SR out to quiet detector location
- Need large apertures in X-line
- Detector plane must sit at secondary focus
- Very dependent upon optics configuration
- Must worry about detector backgrounds

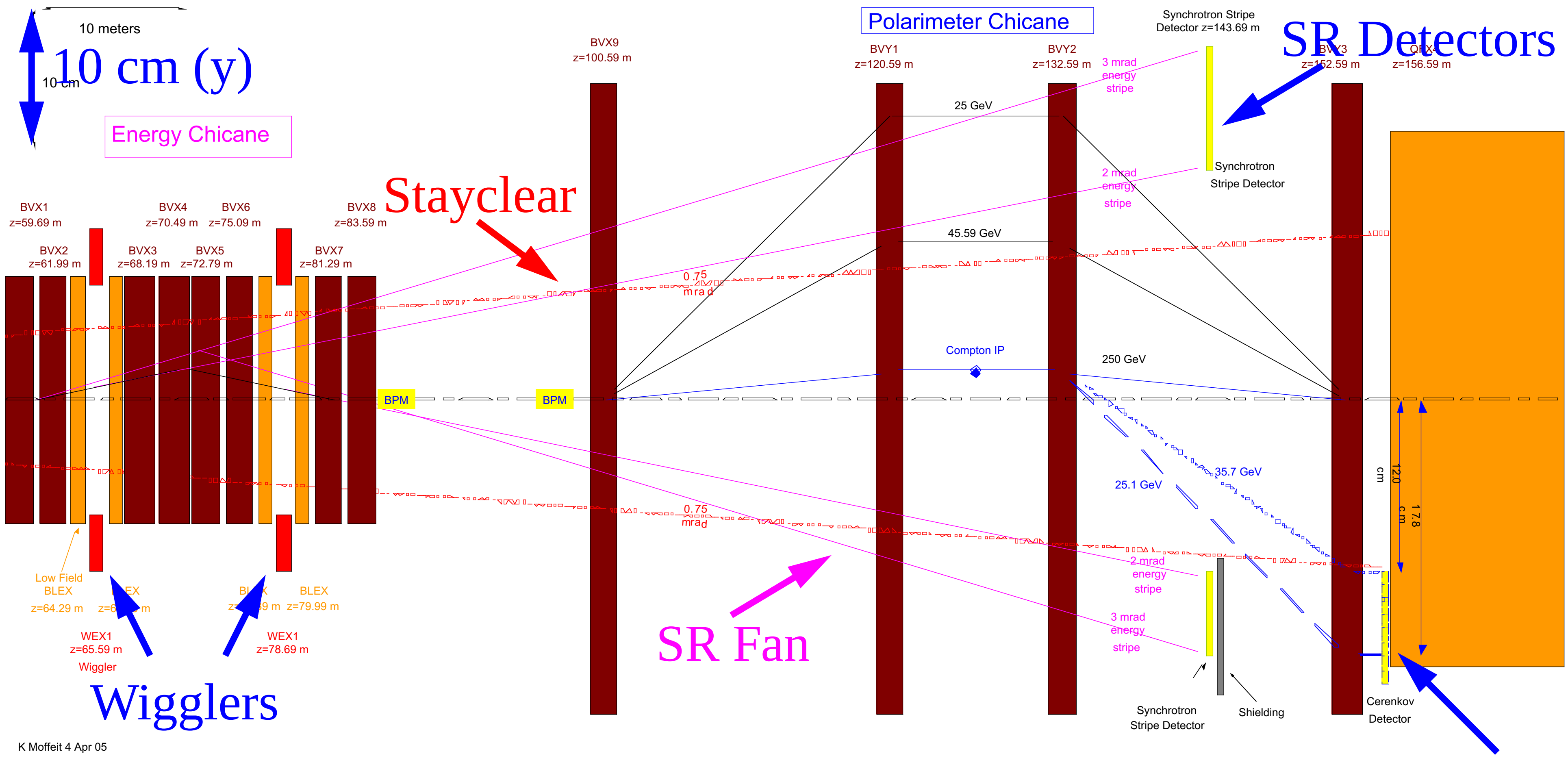
# 20 mRad Optics Design

Yuri Nosochkov - June 1st



# 20 mRad Instrumentation Layout

Ken Moffeit - LCWS




## Key Points/Issues

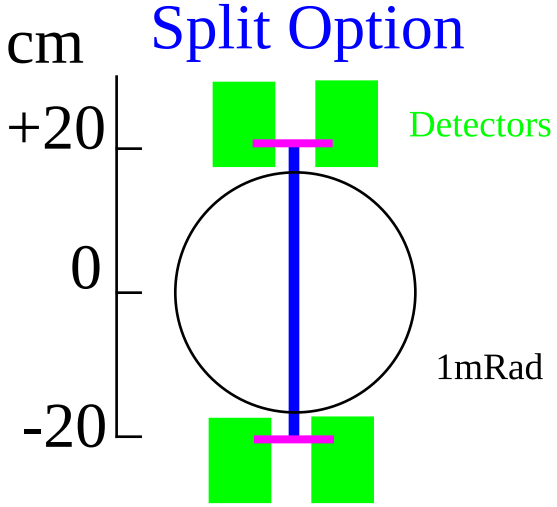
- Apertures: 20 cm gap for “wigglers”, 20x40 cm for Pol Chicane dipoles

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

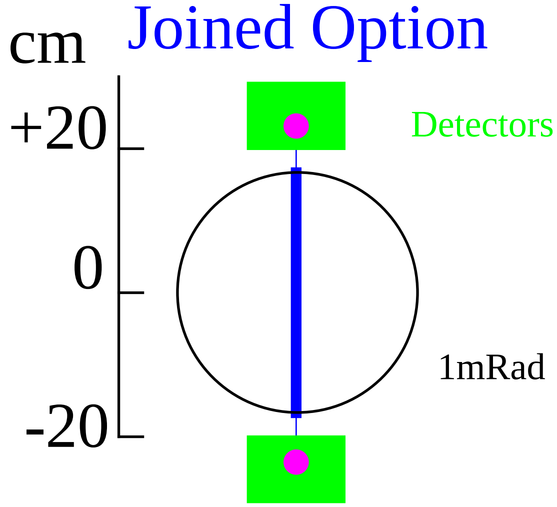
- SR detectors slightly downstream of 2nd focus - resolution issue

- Detectors very tight to nominal stayclear - background issue

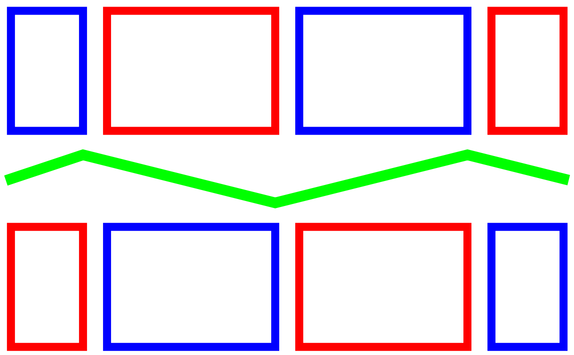
Split Option



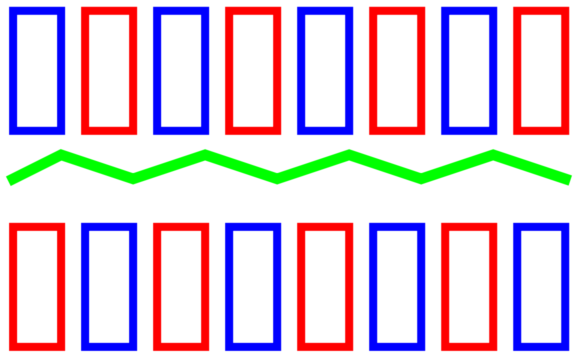

Joined Option




Large λ wiggler



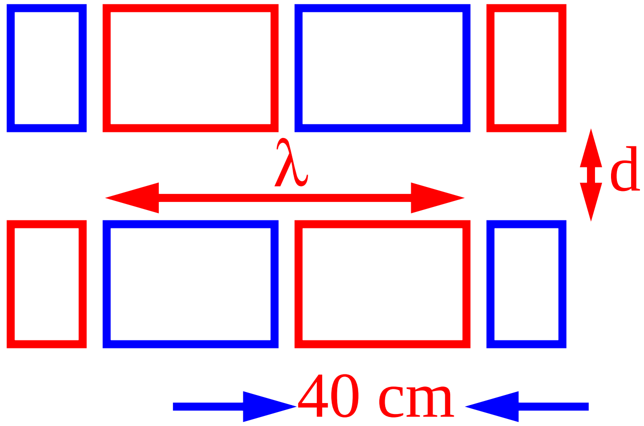
Small λ + Soft Bends



More signal with smaller λ, must include soft bends

Better separation from background with large λ, weaker signal

Aperture constraints




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

Large 20 cm aperture unsuitable for “traditional” wigglers

Place a few 40 cm (?) dipole poles back-to-back (more to boost signal)
SR stripe on detector should be around +/- 10 cm (perhaps less?)
Bend Strength ~ 0.1 mRad / 20 cm -> 0.5 mRad/meter

Dipole SR energies

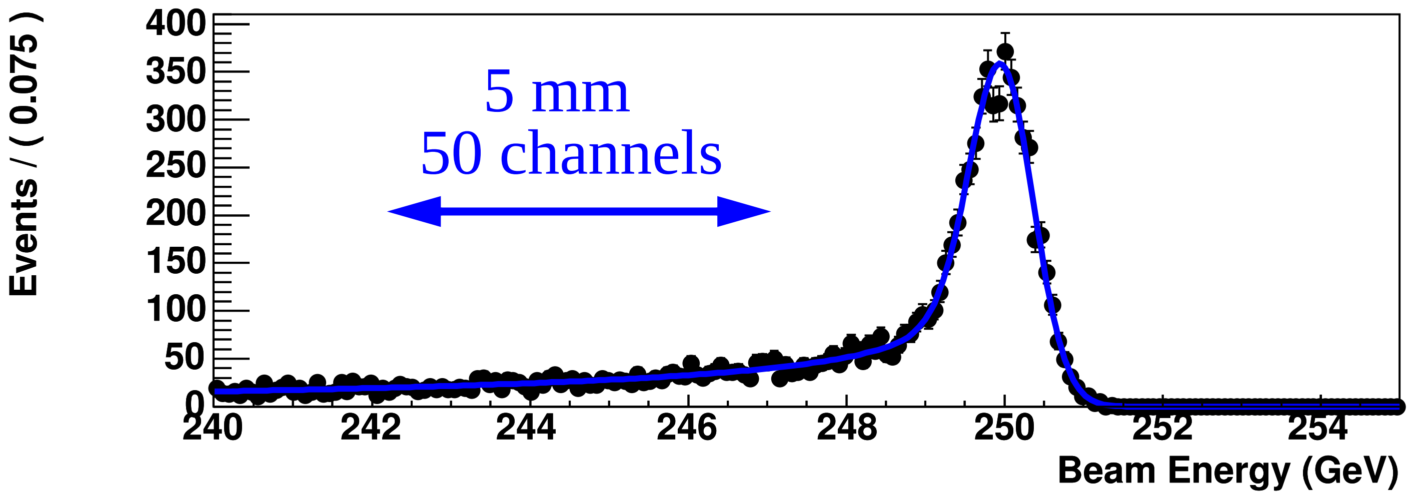
| $E_{beam}$ | $E_{crit}$ (MeV) |
|---|---|
| 50 | 0.15 |
| 250 | 17 |
| 500 | 138 |

(for 0.5 mRad/m)

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

Too low for 50 GeV beams (larger field at expense of signal intensity?)

Analyzing dipoles have similar bend angles (must avoid at 500 GeV)



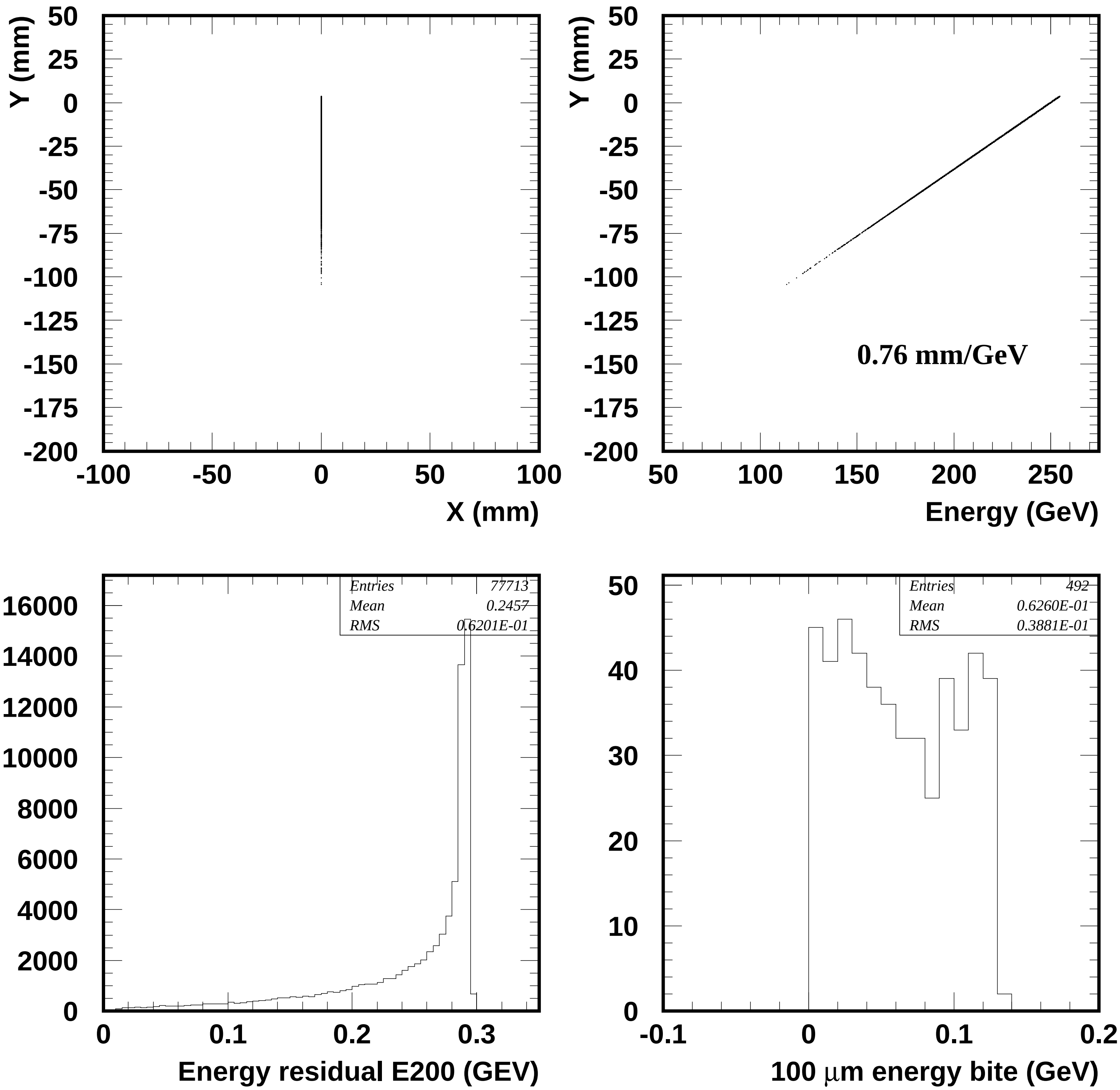

Beam Energy mapped to y position on detector plane
Order 1 GeV/mm sampled at 100 μm pitch

Use quartz fibers: low efficiency, but rad hard and some background tolerance. Large dynamic range with MAPMTs. 64 channels/PMT.

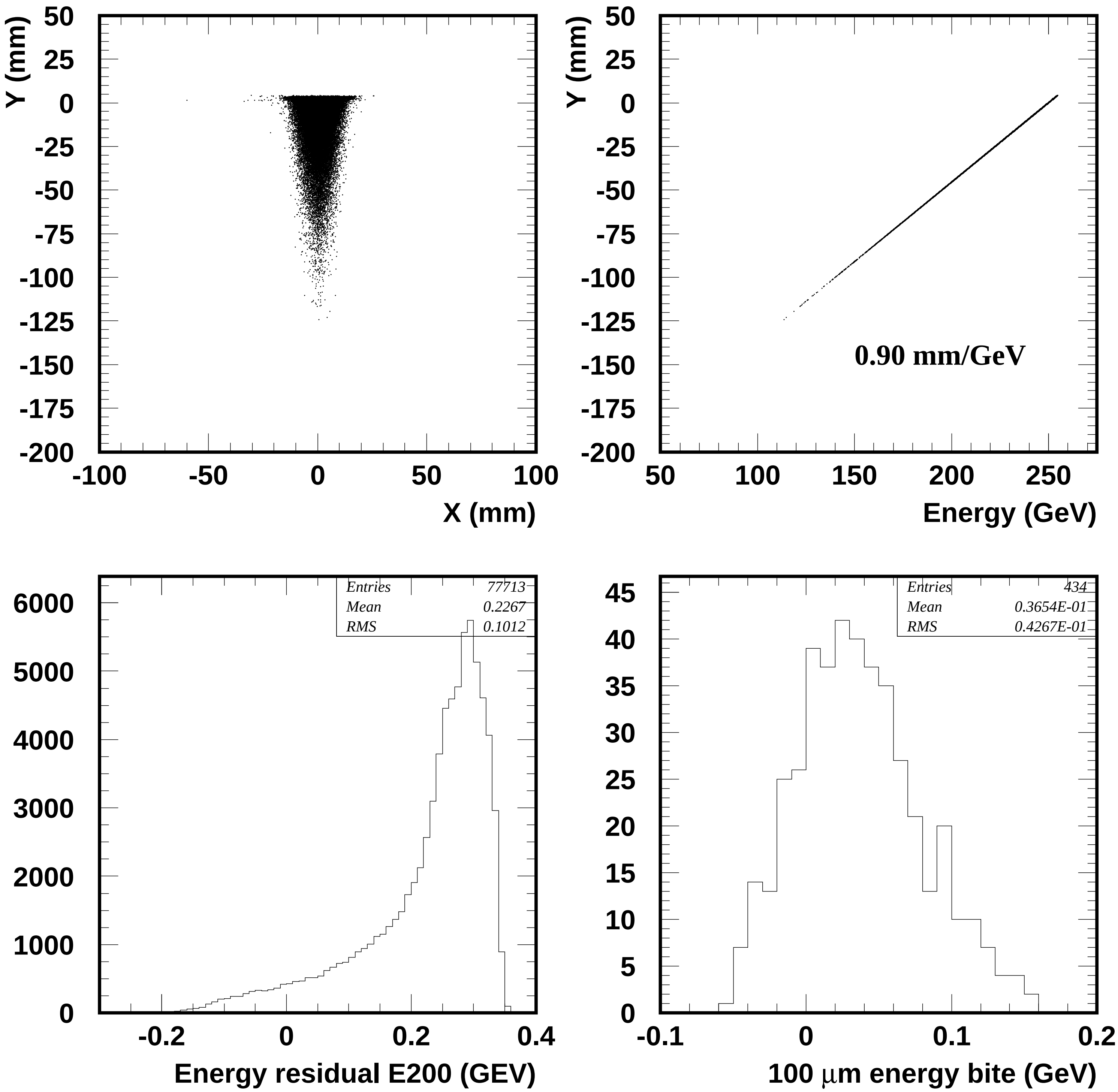
Sampling to 50% of Enom would require ~ 20 cm detector.
Reduce pitch to ~ 1 mm outside of core,
use larger fibers (600 μm?) to boost signal intensity.

Total channel count: [128 (fine) + 256 (coarse)] x 4
27 cm active length per stripe, 24 PMTs per beam.

# Projected beams at 2nd Focus

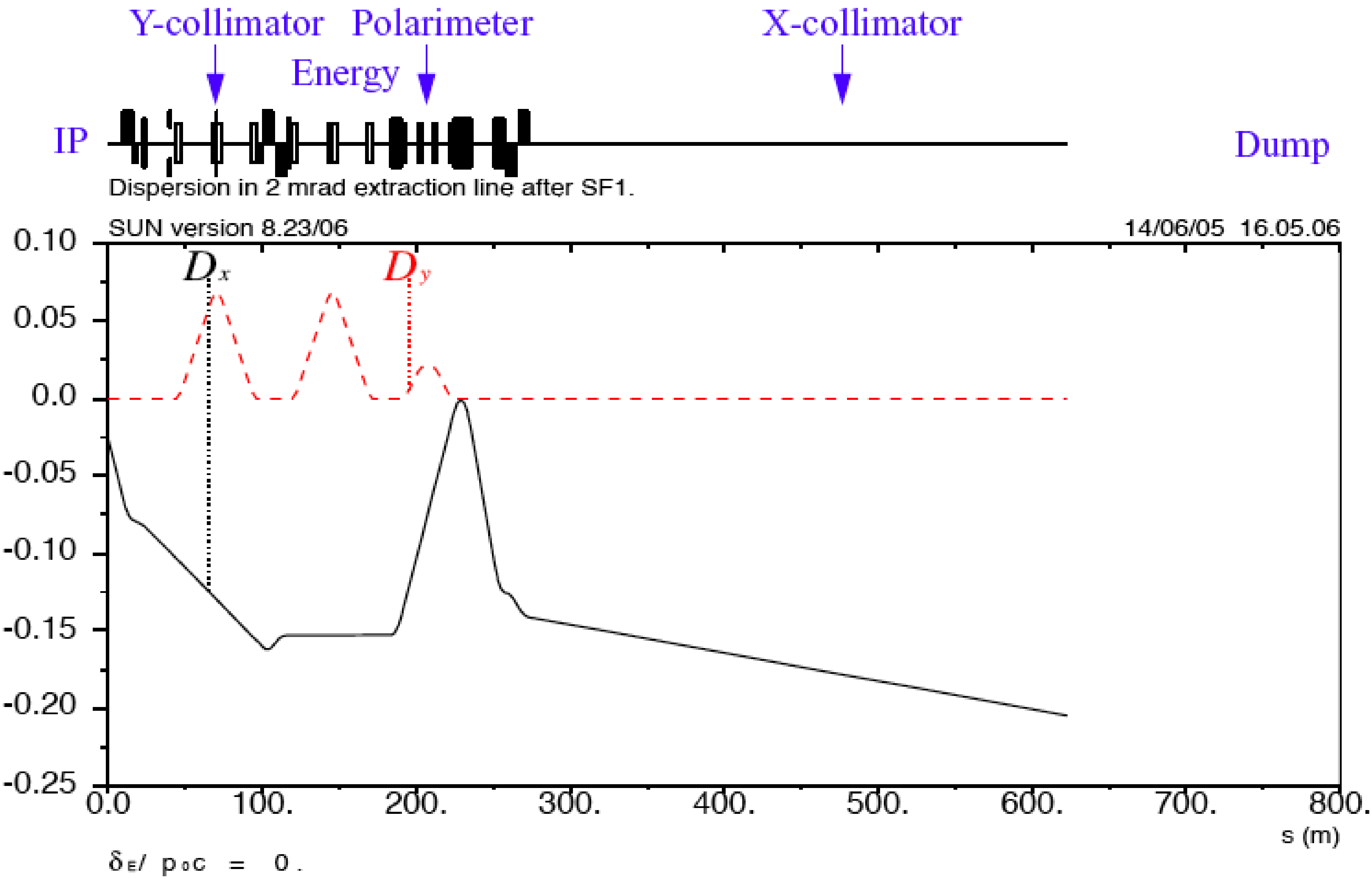


# Projected Beam at Detector Plane



# 2 mRad Optics Design

Yuri Nosochkov

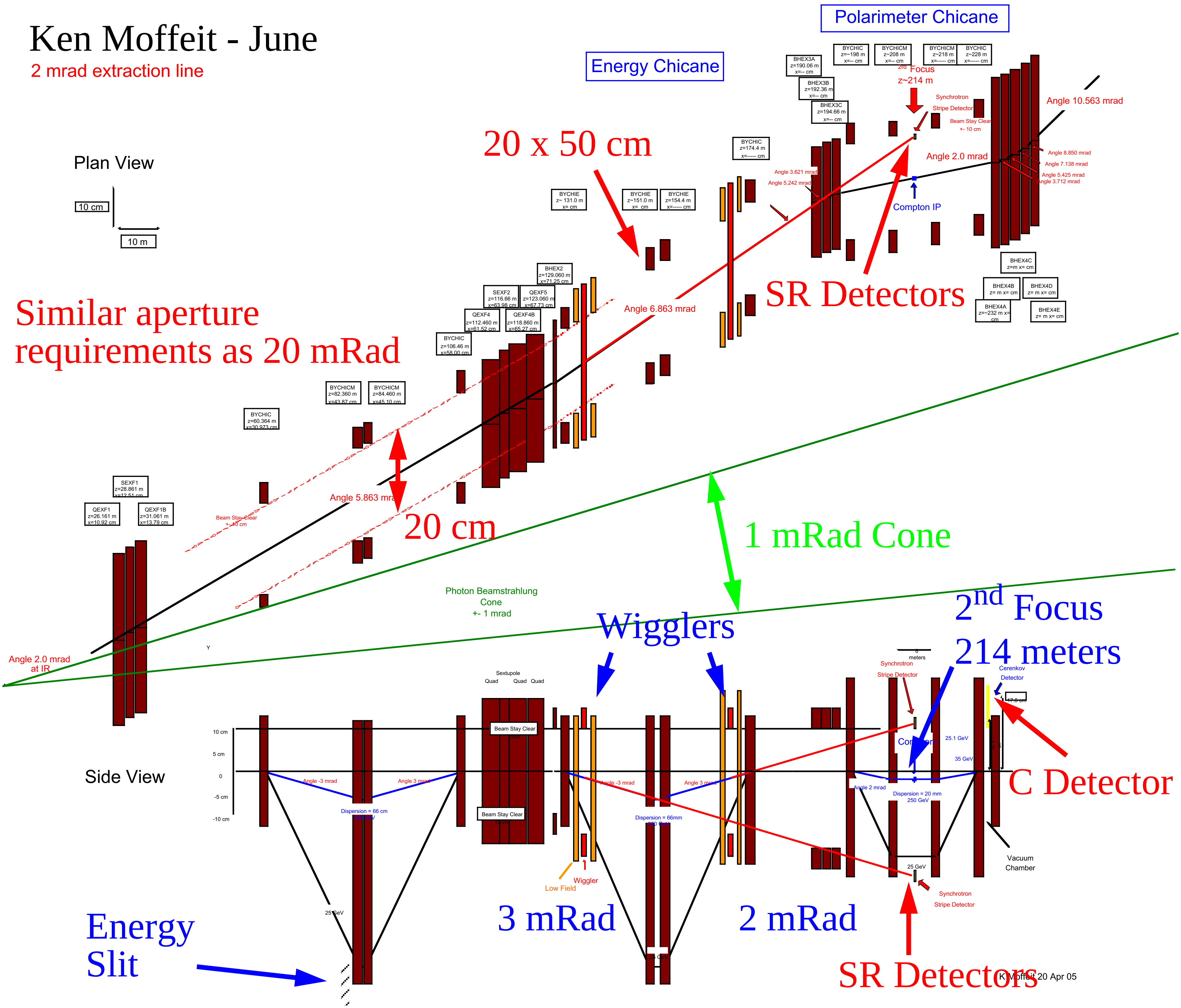



Three vertical chicanes!

First defines energy acceptance

Energy collimation at ~10-20% $E_{nom}$

# 2 mRad Instrumentation Layout



# 2 mRad Detector Plane

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

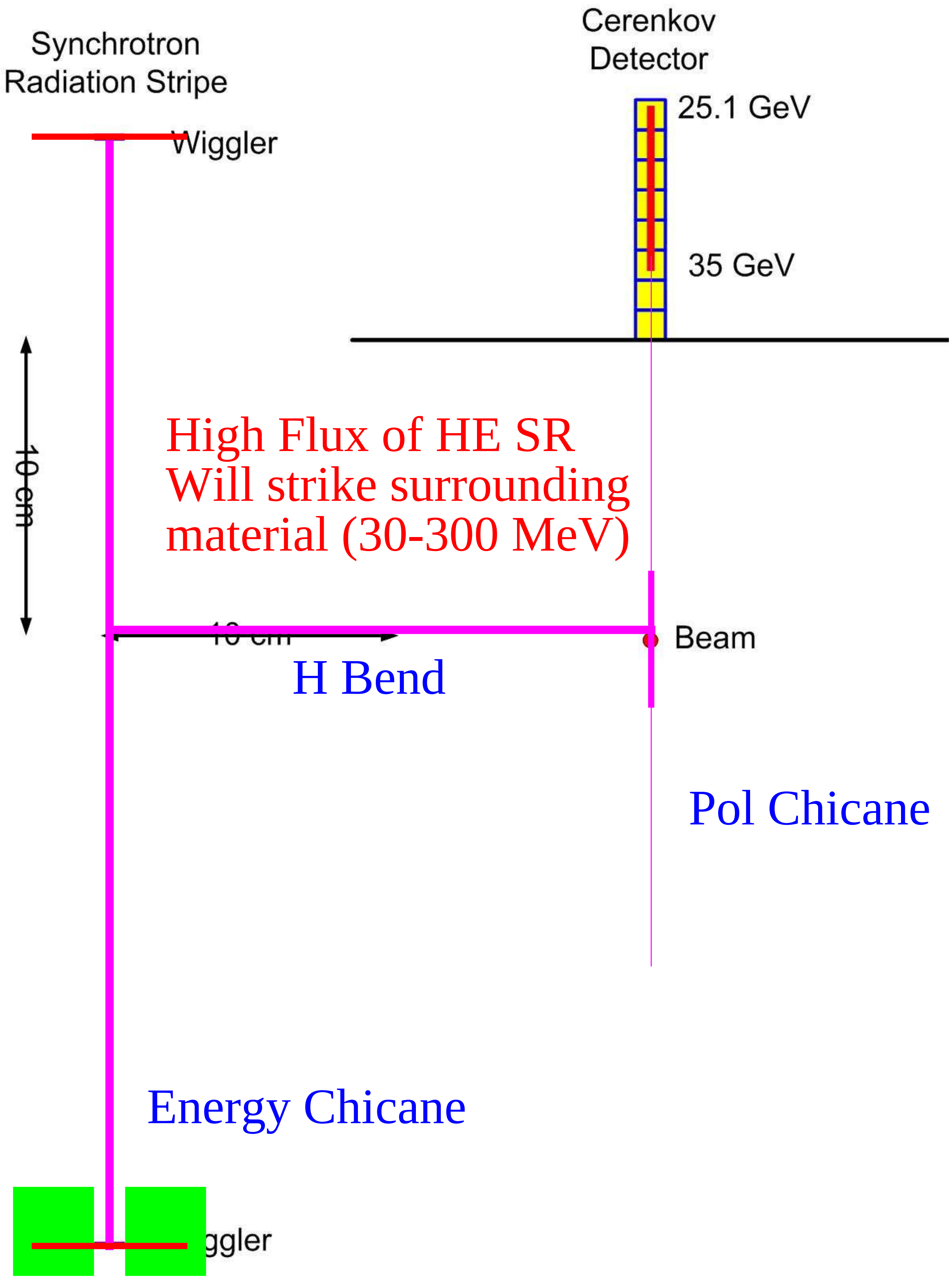
Gas Cerenkov: 10 MeV

Quartz Fiber: 0.7 MeV

Need careful study of backgrounds and shielding options. Separation of detectors, no BSL a plus.

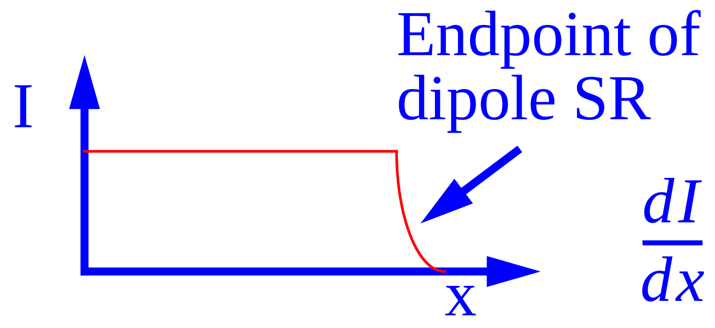
Not at all clear whether this will work!

(2 mRad or 20 mRad)



# Crazy Idea

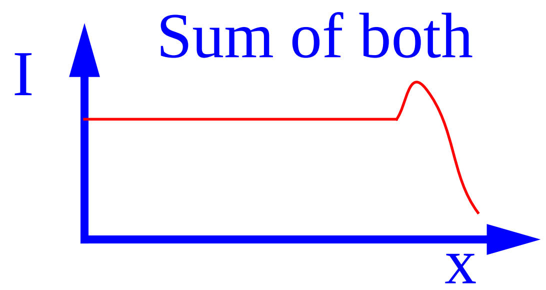
Do we need wigglers at all?




Could measure endpoint of analyzing dipole SR directly

Energy spectrum related to derivative of intensity,
very sensitive to widths.

Forget about avoiding dipole SR




Subtract wiggler-off background?
Probably biases peak position too much.

# Conclusions

## Current Design

- No obvious show-stoppers in conceptual design
- Quartz fibers proposed for detector plane
  Imminent beam test to verify efficiency
- Detector tolerances appear reasonable
- Large but not impossible magnets for X-line

## Next Steps

- Explore optics layout and intrinsic resolution
- Begin simulations with BDSIM
- Gradually improve accurately of fields and material
- Evaluate 2 mRad and 20 mRad in detail