



Comparison of 2mrad and 14/20 mrad extraction lines

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19 July 06

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Comparison of 2 mrad and 14/20 mrad Crossing Angle Extraction Lines

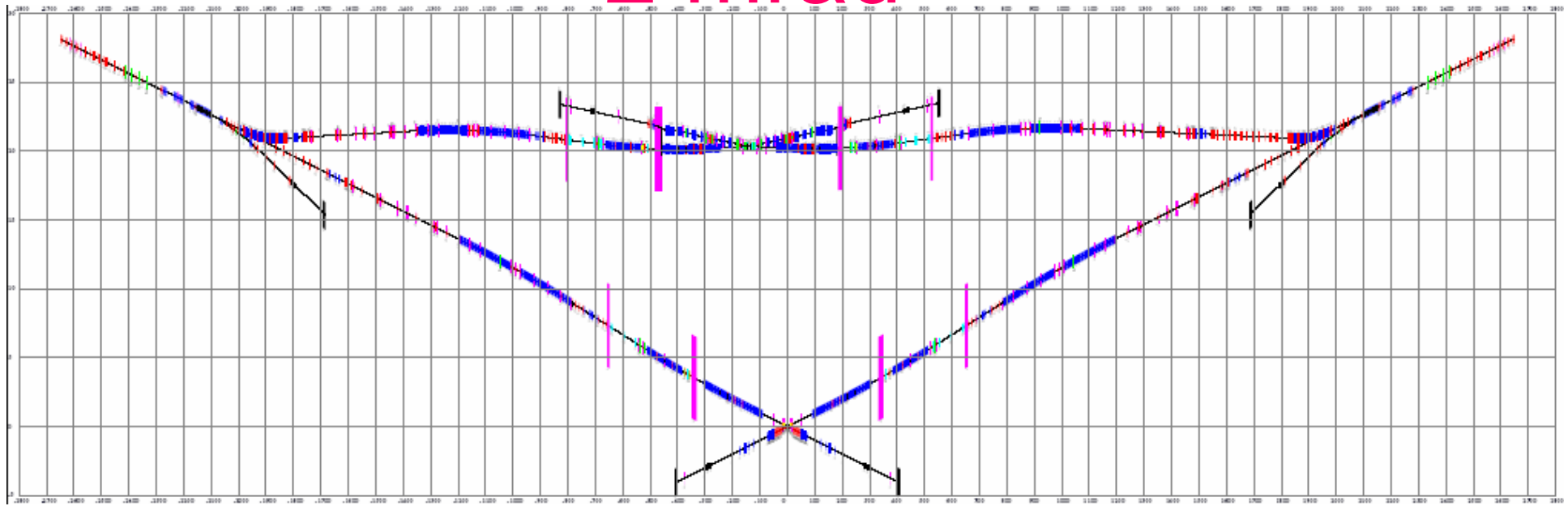
**Ken Moffeit, Takashi Maruyama, Yuri Nosochkov, Andrei Seryi and
Mike Woods**
SLAC

William P. Oliver
Tufts University

Eric Torrence
University of Oregon

BDS Layout

2 mrad

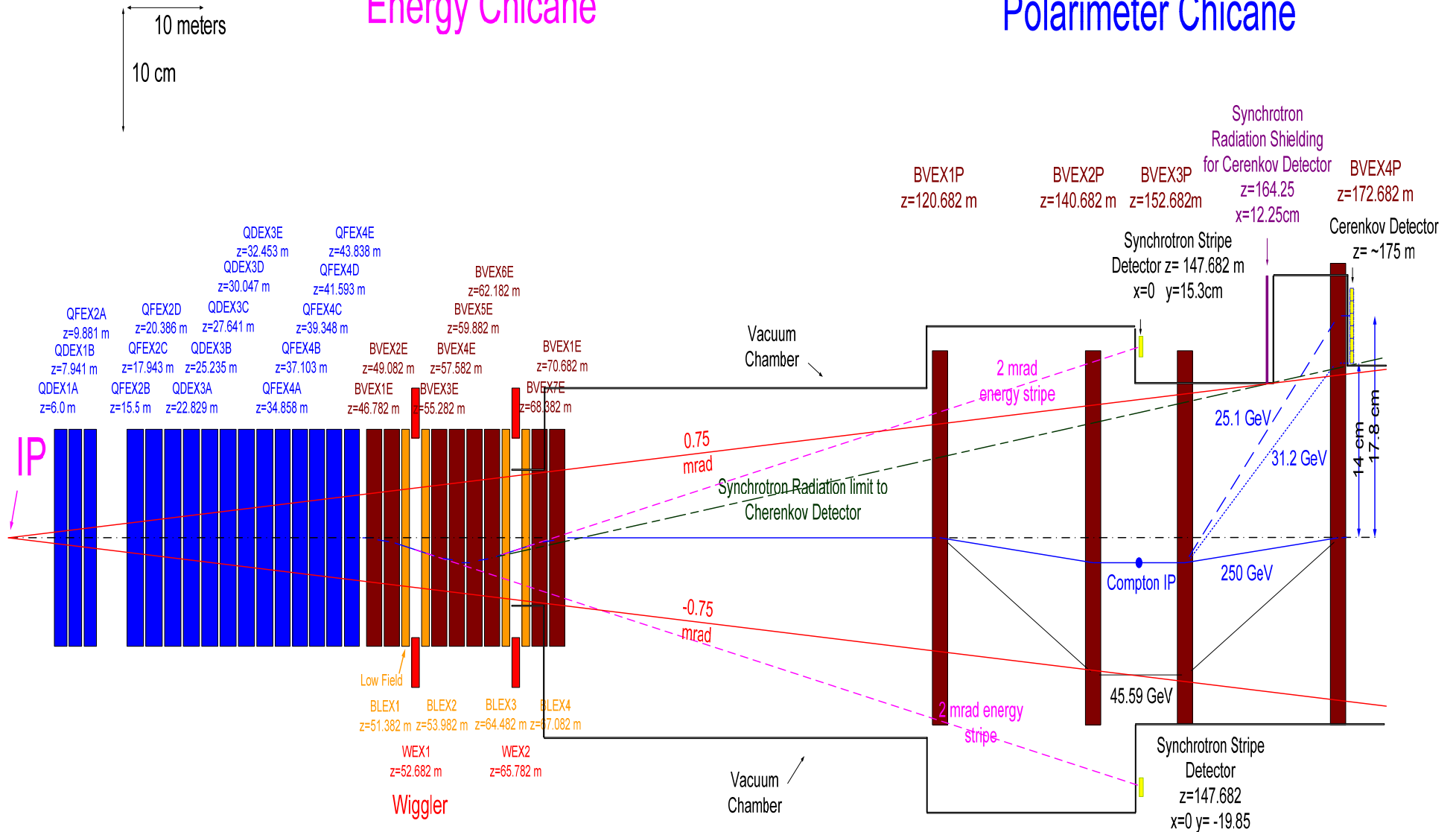


14/20 mrad

14/20 mrad Extraction Line

Energy Chicane

Polarimeter Chicane



19 July 2006

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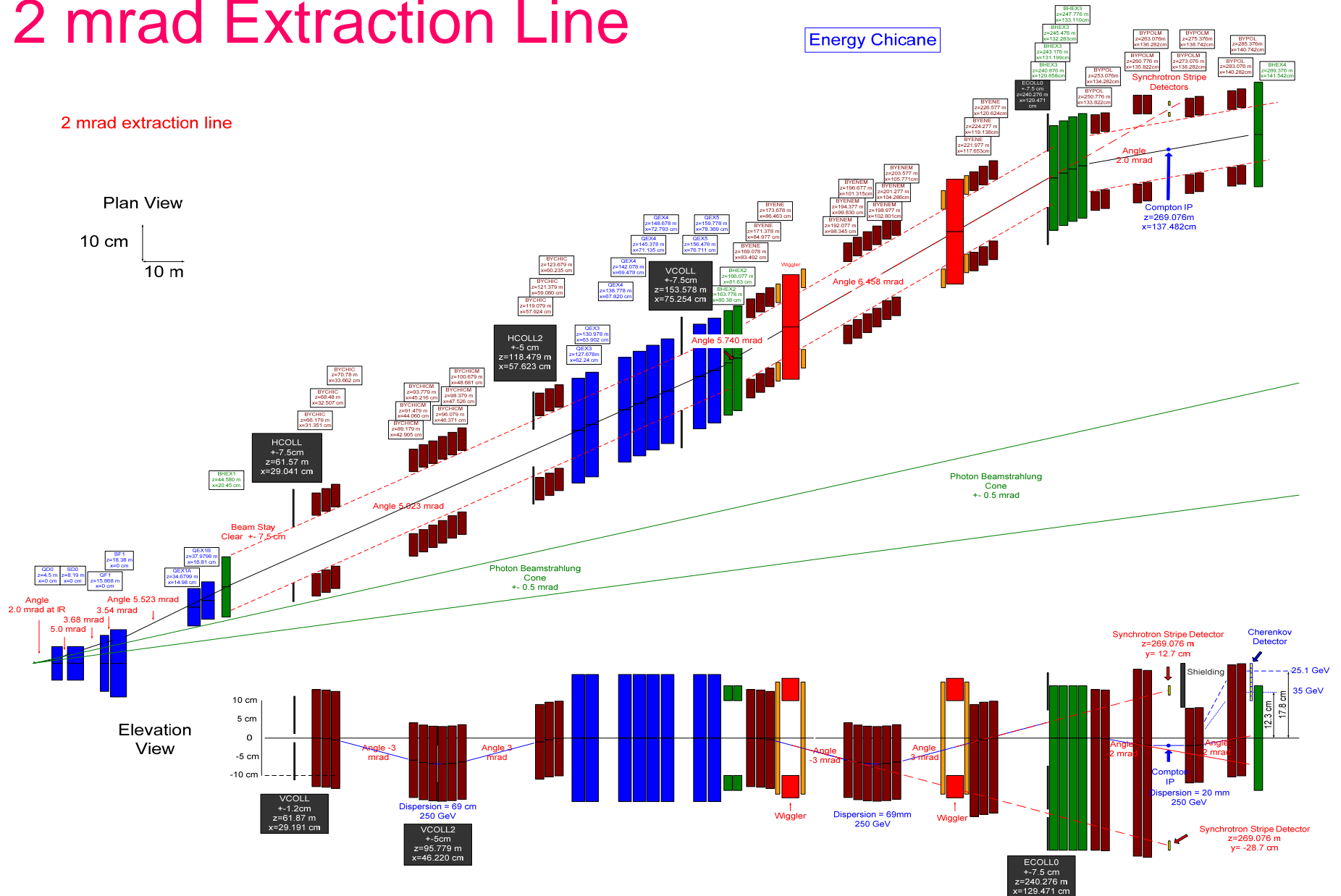
2 mrad Extraction Line

2 mrad extraction line

Plan View
10 cm
10 m

Energy Chicane

Polarimeter Chicane



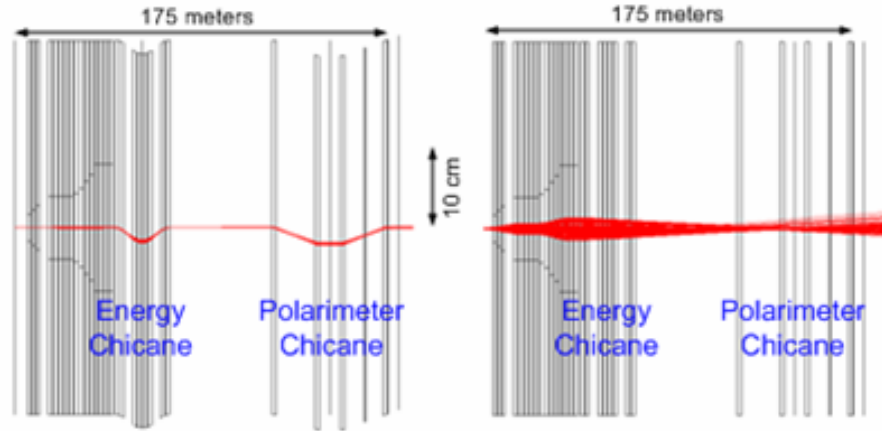
19 July 2006

Ken Moffeit

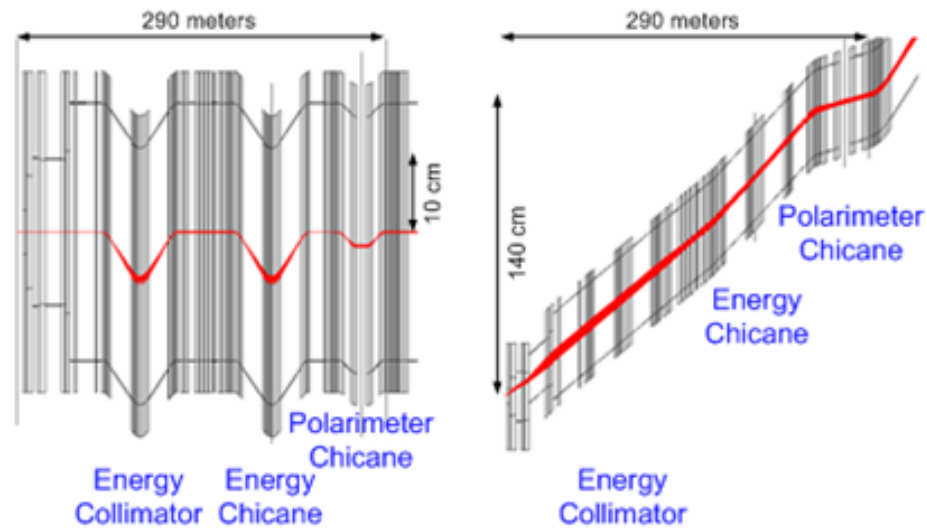
Elevation View

Plan View

20 mrad Extraction Line



2 mrad Extraction Line



The extraction line transport is simulated using the program GEANT.

Disrupted beam events were taken from files prepared by Andrei Seryi.

For these studies files:

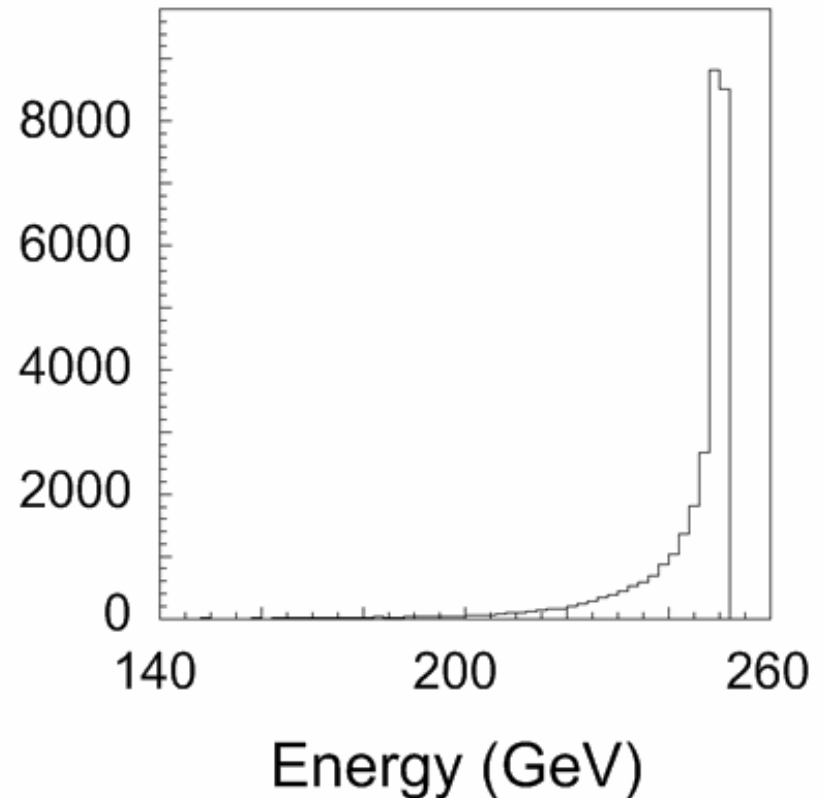
cs11 corresponds to a normal ILC beam (mean energy 244.3 GeV and RMS 10.84 GeV)

cs13 with parameters set for large-y (mean energy 243.1 GeV and RMS 11.14 GeV).

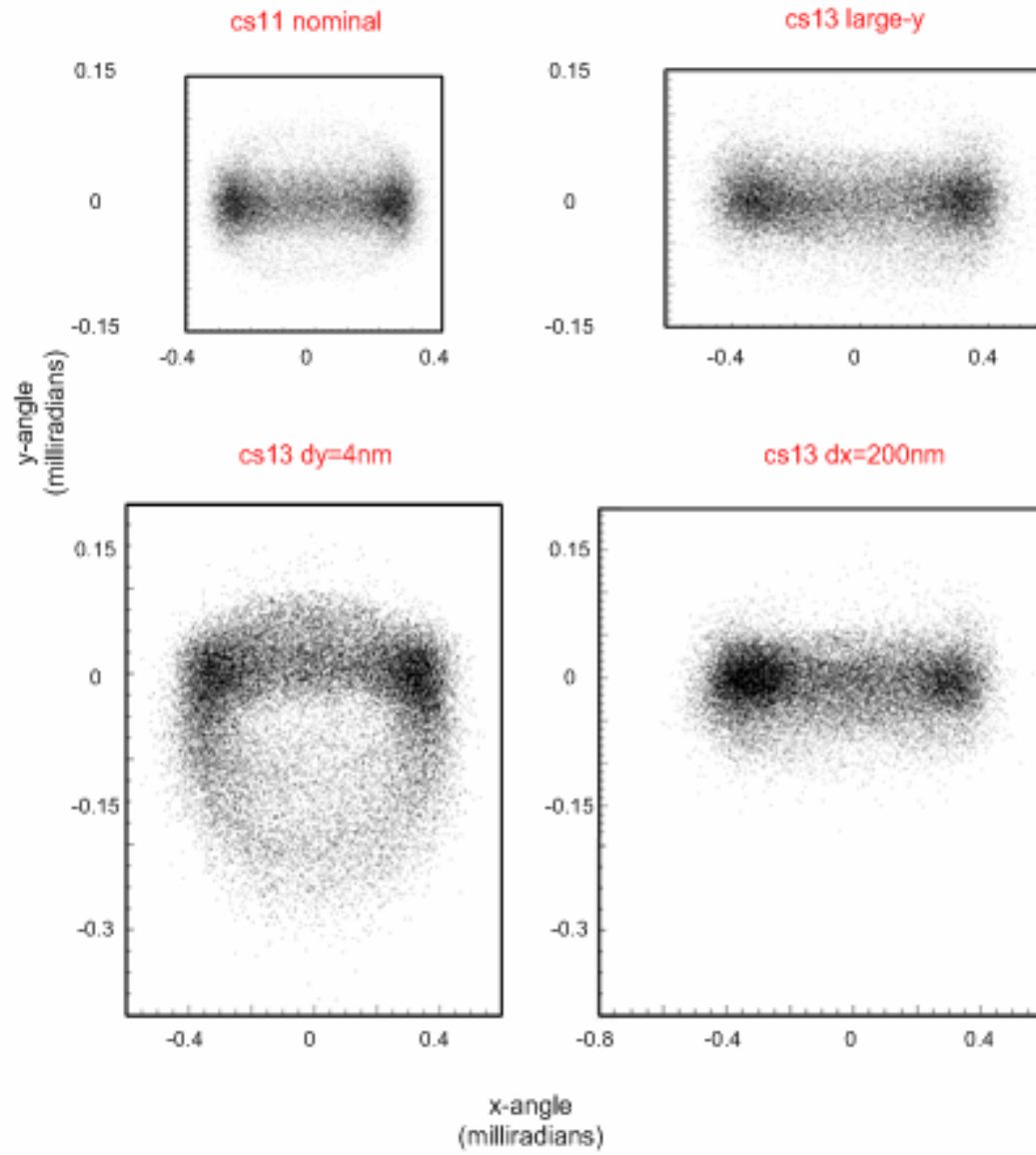
cs13 dy = 4nm gives large-y parameter data sets with the centroid of the beams missing by 4nm in the vertical (mean energy 242.2 GeV and RMS 12.05 GeV)

cs13 dx =200nm has beams missing by 200nm in the horizontal (mean energy 243.3 GeV and RMS 10.94 GeV)

e+e- Interaction Region



e+e- Interaction Region

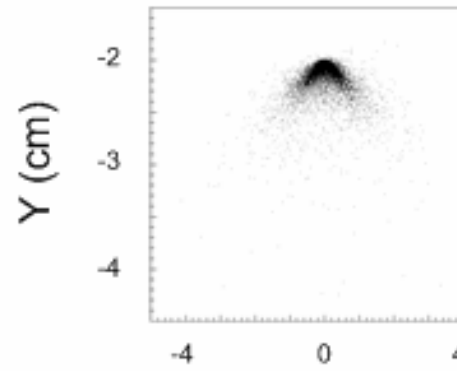


Compton IP

20 mrad

No beam particles lost between IR and Compton IP

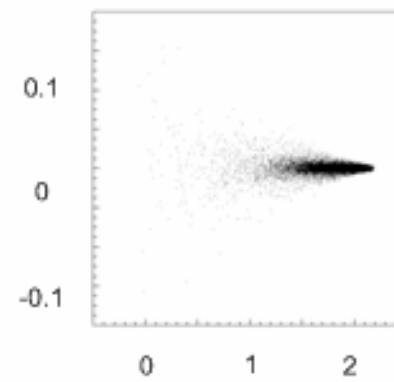
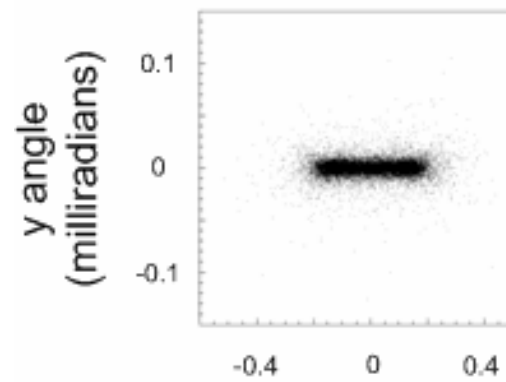
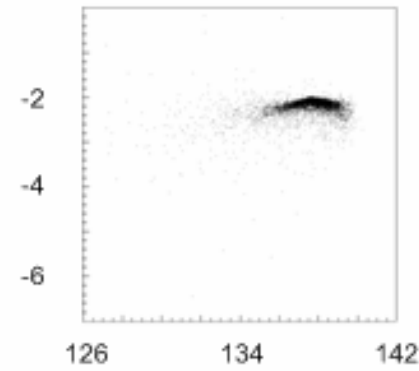
Compton IP $z=147.682$ m



2mrad

3 out of 30,000 beam particles lost between IR and Compton IP

Compton IP $z=269.07$ m



X angle (milliradians)

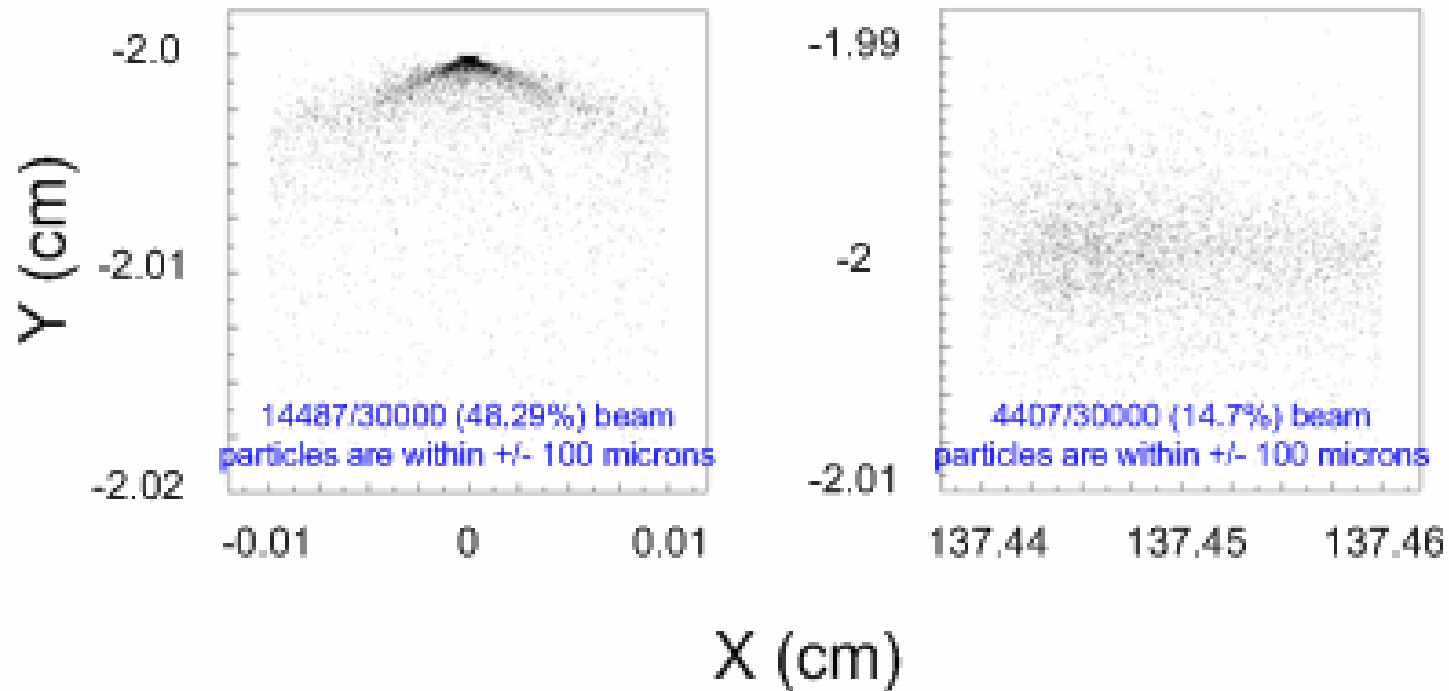
Compton IP

20 mrad

2mrad

Compton IP $z=147.682$ m
 $-2.019 < y < -1.999$ cm
 $\text{abs}(x) < 0.01$ cm

Compton IP $z=269.07$ m
 $\text{abs}(y+2) < 0.01$ cm
 $\text{abs}(x-137.45) < 0.01$ cm



Spin Precession

$$\theta_{spin} = \gamma \frac{g-2}{2} \cdot \theta_{bend} = \frac{E(\text{GeV})}{0.44065} \cdot \theta_{bend}$$

Change in Bend Angle	Change in Spin Direction at 250 GeV	Longitudinal Polarization Projection
1 mrad	32.5 °	84.3%
275 μrad	8.9 °	98.8%
100 μrad	3.25 ° =56mrad	99.8%

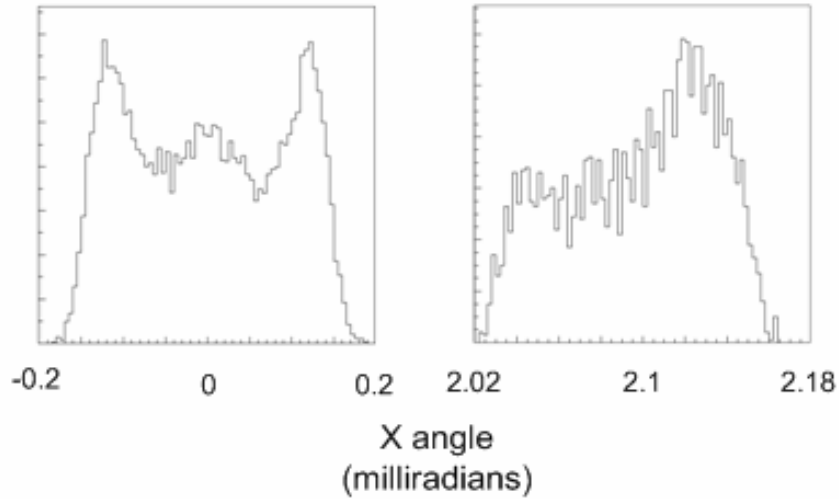
Change in spin direction for various bend angles and the projection of the longitudinal polarization. Electron beam energy is 250 GeV.

20 mrad

2mrad

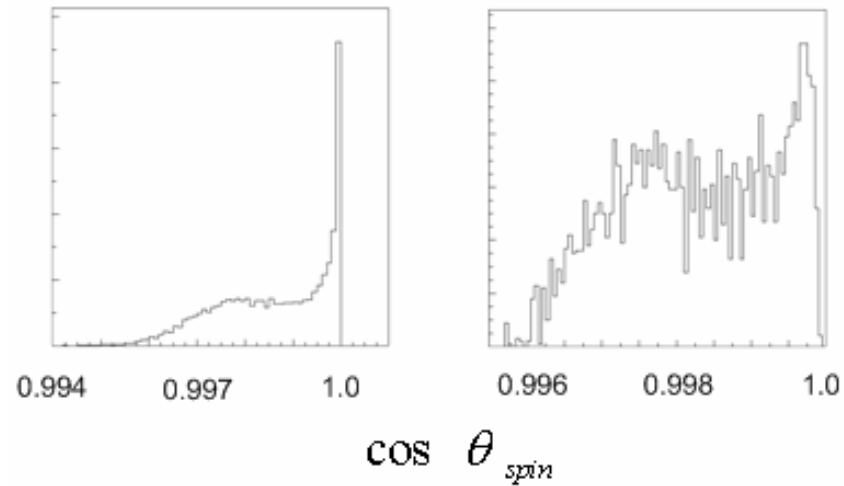
Compton IP z=147.682 m
-2.019<Y<-1.999cm
abs(x)<0.01cm

Compton IP z=269.07m
Abs(y+2)<0.01cm
abs(x-137.45)<0.01cm



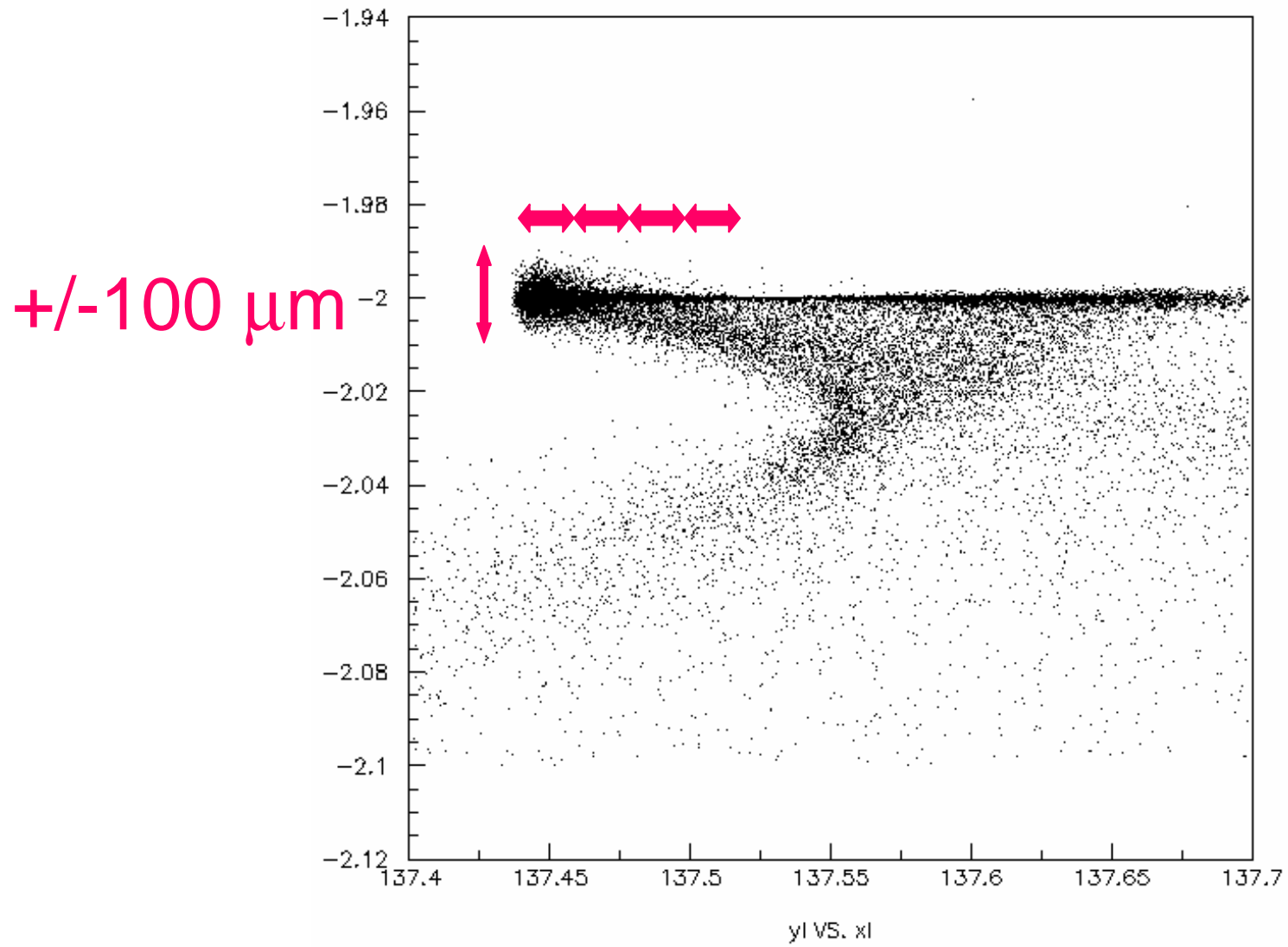
Average Spin projection P = 99.85%

Average Spin projection P = 99.83%



2mrad

x vs y



2mrad Extraction Line: Beam accepted and polarization projection for various ± 100 micron selections about the x value of the beam at the Compton IP. In each case $\text{abs}(y+2.0\text{cm}) < 100$ microns and $\text{abs}(x-137.45)$.

x \pm 100 microns	%Beam within ± 100microns in x & y	Polarization Projection
137.45	14.7	99.83
137.47	6.0	99.89
137.49	4.8	99.94
137.51	3.8	99.94

20mrad Extraction Line with $2.019 < y < -1.999$ cm and $\text{abs}(x) < 0.01$ cm

Condition (file name)	%Beam within +/- 100microns in x & y	Polarization Projection
Nominal Beam Condition (cs11)	48.3	99.85
Large y (cs13)	36.7	99.76
Large y horizontal offset 200nm (cs13_dx200)	37.2	99.75
Large y vertical offset 4nm (cs13_dy4)	32.8	99.75

2 mrad Extraction Line with $\text{abs}(y+2) < 0.01$ cm and $\text{abs}(x-137.45) < 0.01$ cm

Condition (file name)	%Beam within +/- 100microns in x & y	Polarization Projection
Nominal Beam Condition (cs11)	14.7	99.83
Large y (cs13)	7.6	99.83
Large y horizontal offset 200nm (cs13_dx200)	8.9	99.82
Large y vertical offset 4nm (cs13_dy4)	6.0	99.83

Beam Losses from the e+e- IR to the Compton Detector Plane

20 mrad Crossing Angle Extraction Line

Condition (file name)	Losses	Beam	Lost Beam
Nominal Beam Condition (cs11)	0	34883	$<0.5 * 10^{-4}$
Large y (cs13)	0	30000	$<0.6 * 10^{-4}$
Large y horizontal offset 200nm (cs13_dx200)	0	30000	$<0.6 * 10^{-4}$
Large y vertical offset 4nm (cs13_dy4)	0	30000	$<0.6 * 10^{-4}$

2 mrad Crossing Angle Extraction Line

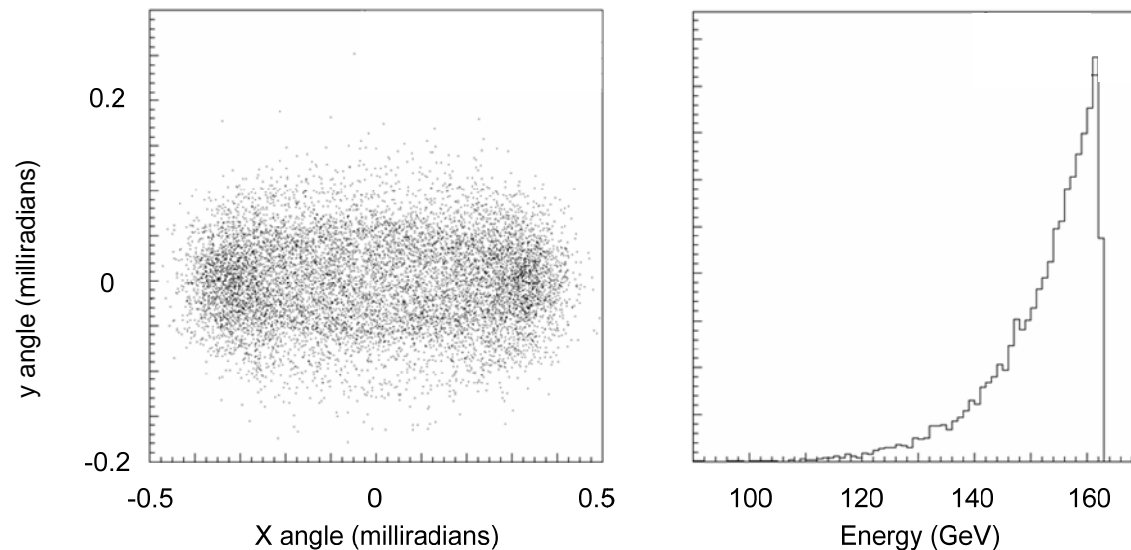
Condition (file name)	Losses	Beam	Lost Beam
Nominal Beam Condition (cs11)	4	30000	$1.3 * 10^{-4}$
Large y (cs13)	9	30000	$3 * 10^{-4}$
Large y horizontal offset 200nm (cs13_dx200)	7	30000	$2.3 * 10^{-4}$
Large y vertical offset 4nm (cs13_dy4)	18	30000	$6 * 10^{-4}$

Beam Losses

Beam losses were further studied by using a file with the tails of the disrupted beam having events with energy less than 0.65 of the beam energy or the angle greater than 0.5 mrad:

http://www.slac.stanford.edu/~seryi/ILC_new_gp_files/cs11_hs/tail1_lt_0_65E0_or_gt_500urad.dat

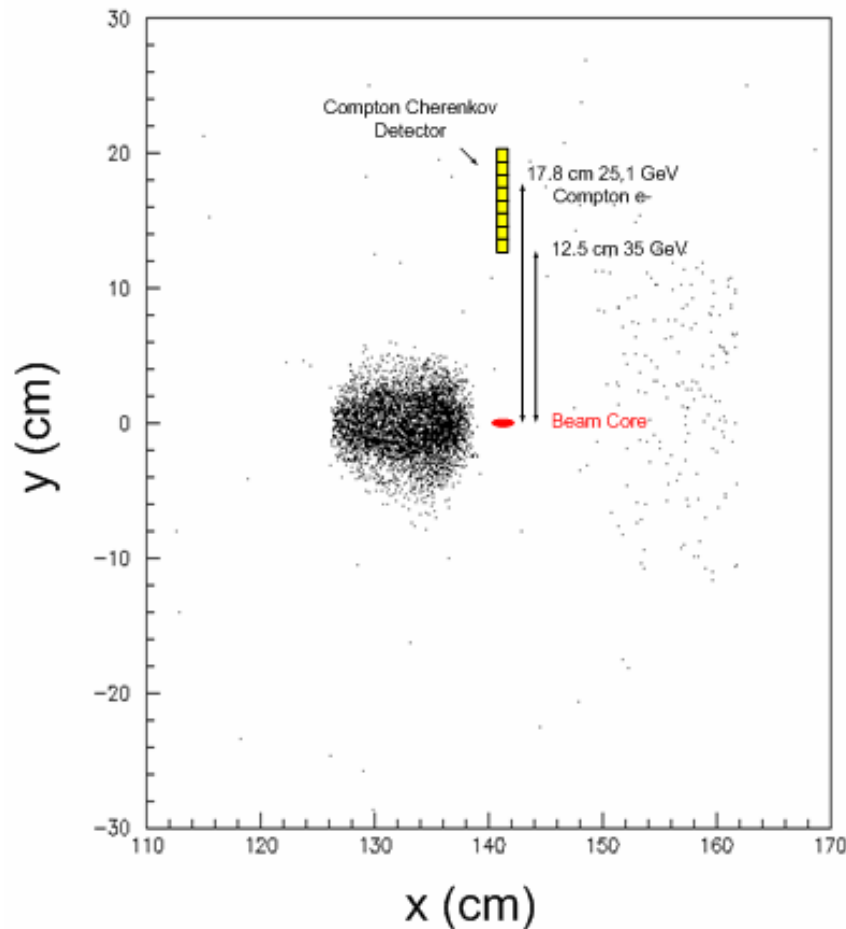
e+e- Interaction Point



2mrad extraction line

Only 5899 of the 10,503 particles continue to the Compton Detector plane.
This represents a loss of $2.62 \cdot 10^{-4}$ of the 17.59 million original beam tracks.

Compton Detector Plane
 $z=288.37$ m



Estimate ~ 50 photons/cm² are in the region of the Cherenkov counter cells for each bunch of $2 \cdot 10^{10}$ electrons

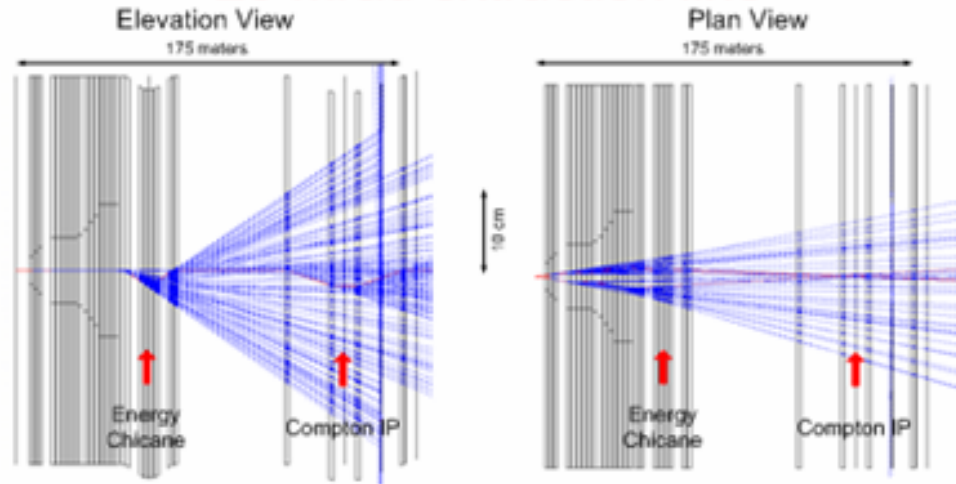
Only $\sim 20\%$ above 10 MeV

Can reduce by local shielding of Cherenkov Detector

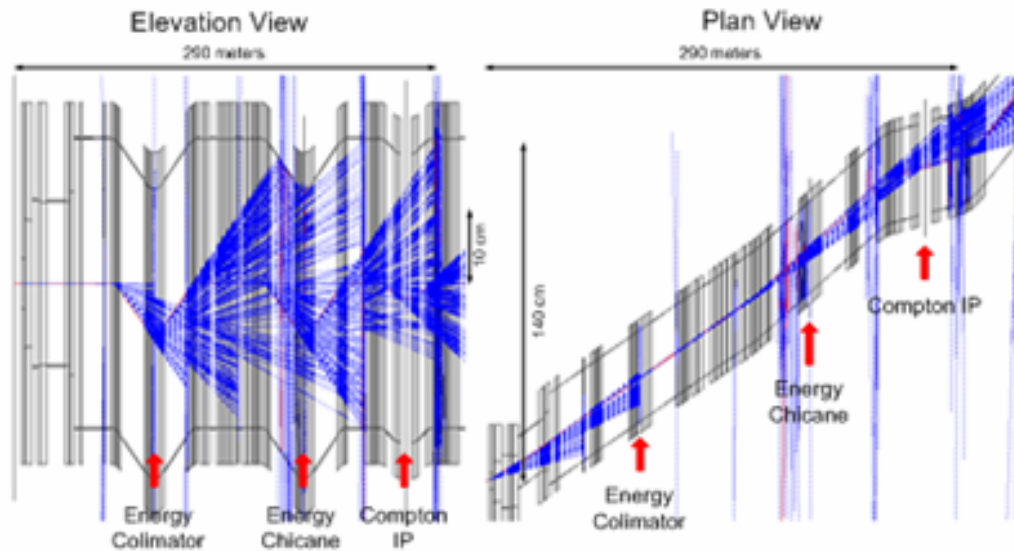
Compton Signal ~ 650 backscattered electrons per GeV or >1000 per 1cm cell

Synchrotron Radiation

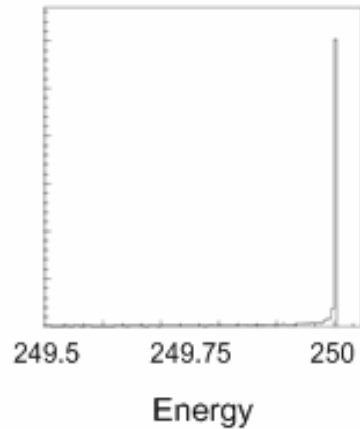
20 mrad extraction line



2 mrad extraction line

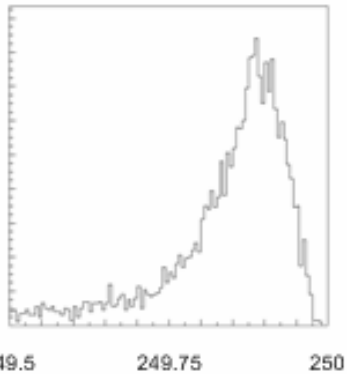


e+e- Interaction Point
z=0

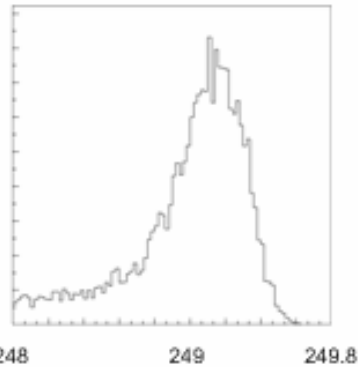


Center of Energy Spectrometer

20 mrad extraction line
z=59.732m
Peak at 249.881 GeV
Loss 119.4 MeV



2 mrad extraction line
z=198.82m
Peak at 249.146 GeV
Loss 854.1 MeV



Energy (GeV)

Table IV: Energy Loss from Synchrotron Radiation between the e+e- IR and the Center of the Energy Chicane.

a) 20 mrad Crossing Angle Extraction Line

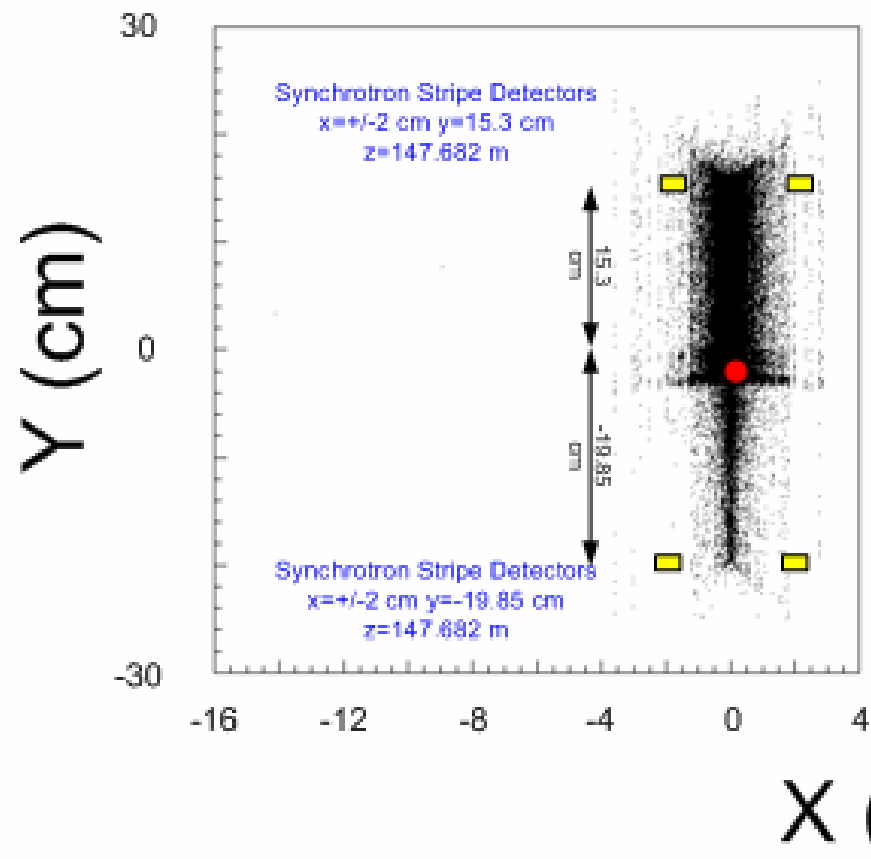
Condition (file name)	Energy Loss (MeV)
Nominal Beam Condition (cs11)	119.4
Large y (cs13)	123.0
Large y horizontal offset 200nm (cs13_dx200)	122.7
Large y vertical offset 4nm (cs13_dy4)	124.3

b) 2 mrad Crossing Angle Extraction Line

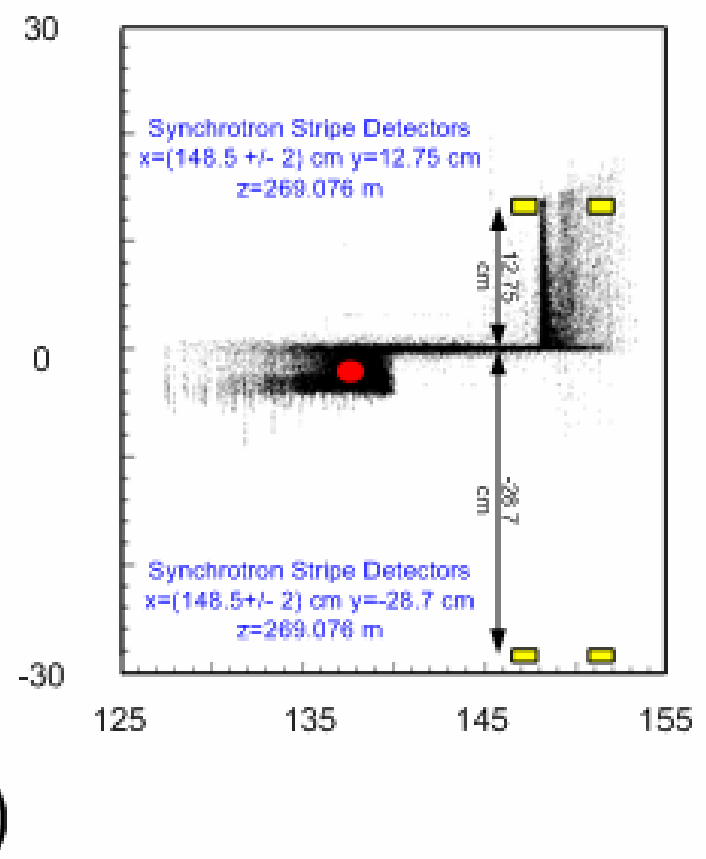
Condition (file name)	Energy Loss (MeV)
Nominal Beam Condition (cs11)	854.2
Large y (cs13)	854.2
Large y horizontal offset 200nm (cs13_dx200)	828.5
Large y vertical offset 4nm (cs13_dy4)	859.4

Compton IP

20 mrad extraction line
 $z=147.682\text{m}$



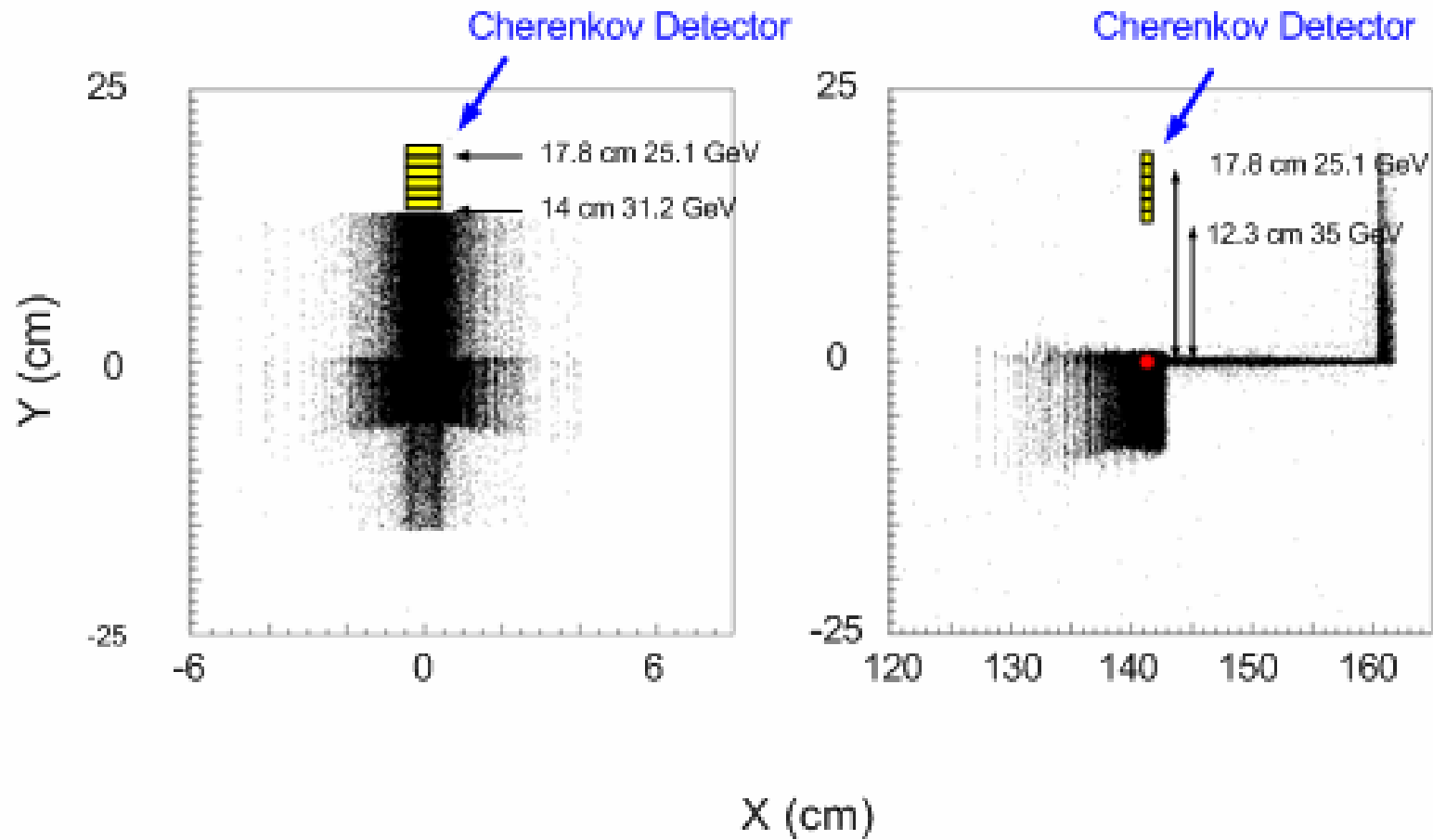
2 mrad extraction line
 $z=269.076\text{m}$



Compton Detector Plane

20 mrad extraction line

2 mrad extraction line



Conclusions

The 20 mrad extraction line has:

- Core of beam within ± 100 microns has between 32 and 48% of the beam.
- The polarization projection is 99.75 to 99.85% at the Compton IP.
- No beam losses from e+e- IR to Compton detector plane out of 17.6 million beam tracks.
- Beam energy loss due to synchrotron radiation to the middle of energy chicane ($z=59.7$ m) is only ~ 110 MeV and does not show variation with beam conditions.
- The collimator at $z=164.25$ meters needs to be designed. It absorbs the synchrotron radiation above the 0.75 mrad beam stay clear allowing the Cherenkov detector to begin at $y\sim 14$ cm.

The 2 mrad extraction line has:

- There are **large beam losses** between e+e- IR and Compton detector plane ($>2.6 \times 10^{-4}$ are lost) giving secondary backgrounds of mainly photons in the region of the Cherenkov Detector.
- A small percentage of beam is hit by laser spot ± 100 microns ($\sim 15\%$) at the Compton IP and results in **low Compton luminosity**.
- There are **large beam energy losses** (~ 850 MeV) due to synchrotron radiation between IR and the center of the energy chicane at $z=198.82$ meters.
- **Synchrotron radiation** at Cherenkov Detector is favorable. The detector only sees the synchrotron radiation from the magnets of the polarimeter chicane, and this is contained between -9 and $+2$ cm. The first cell of the Cherenkov Detector starts at $+10$ cm.