Comparison of 2mrad and 14/20 mrad extraction lines

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

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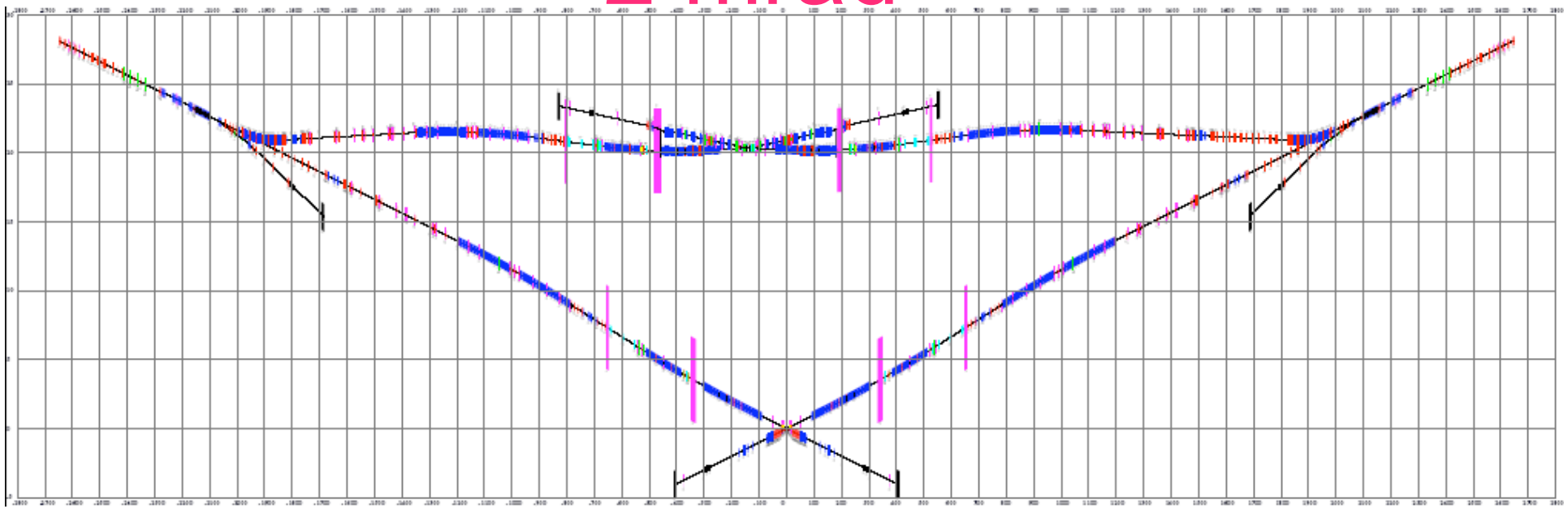
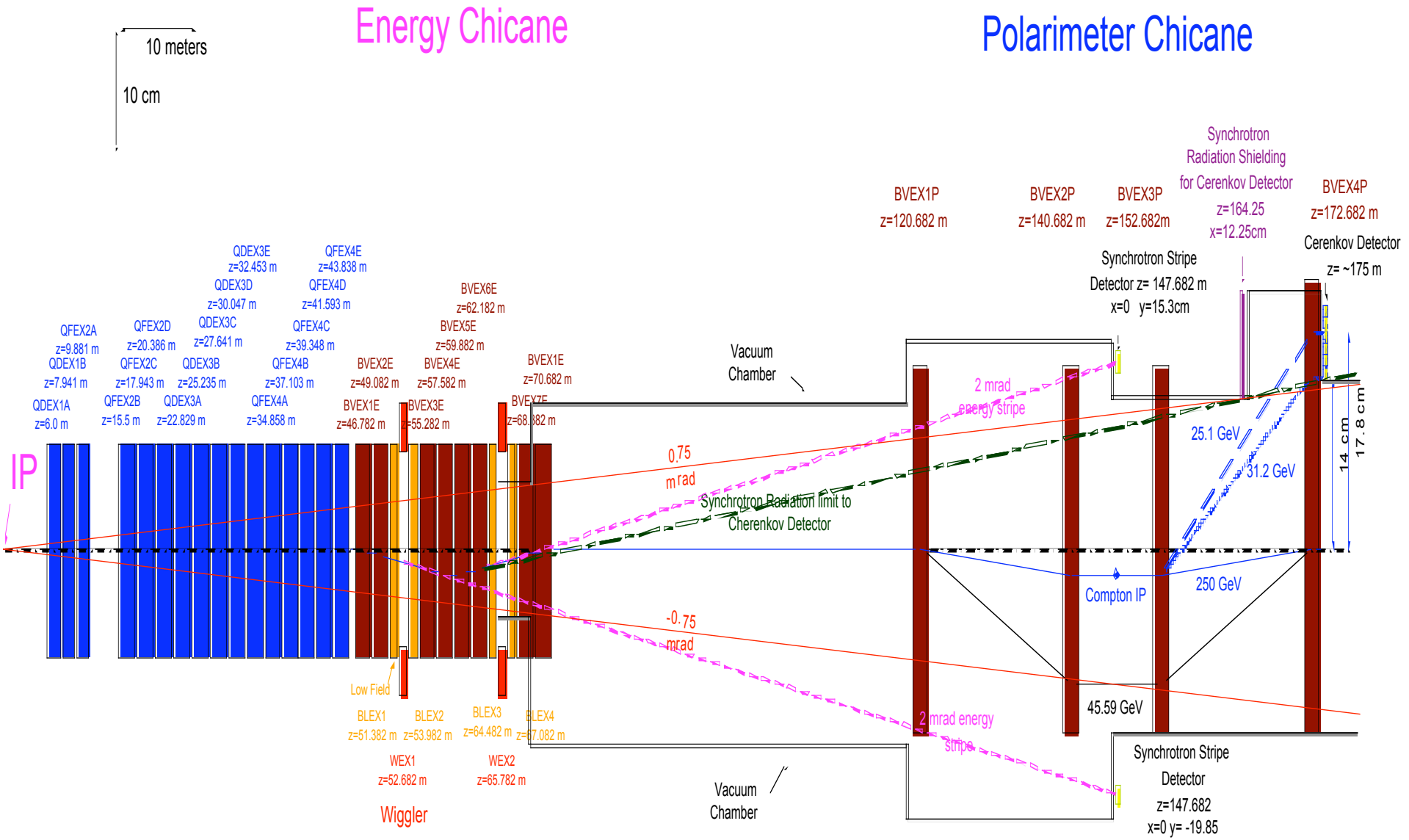
BDS Layout

2 mrad

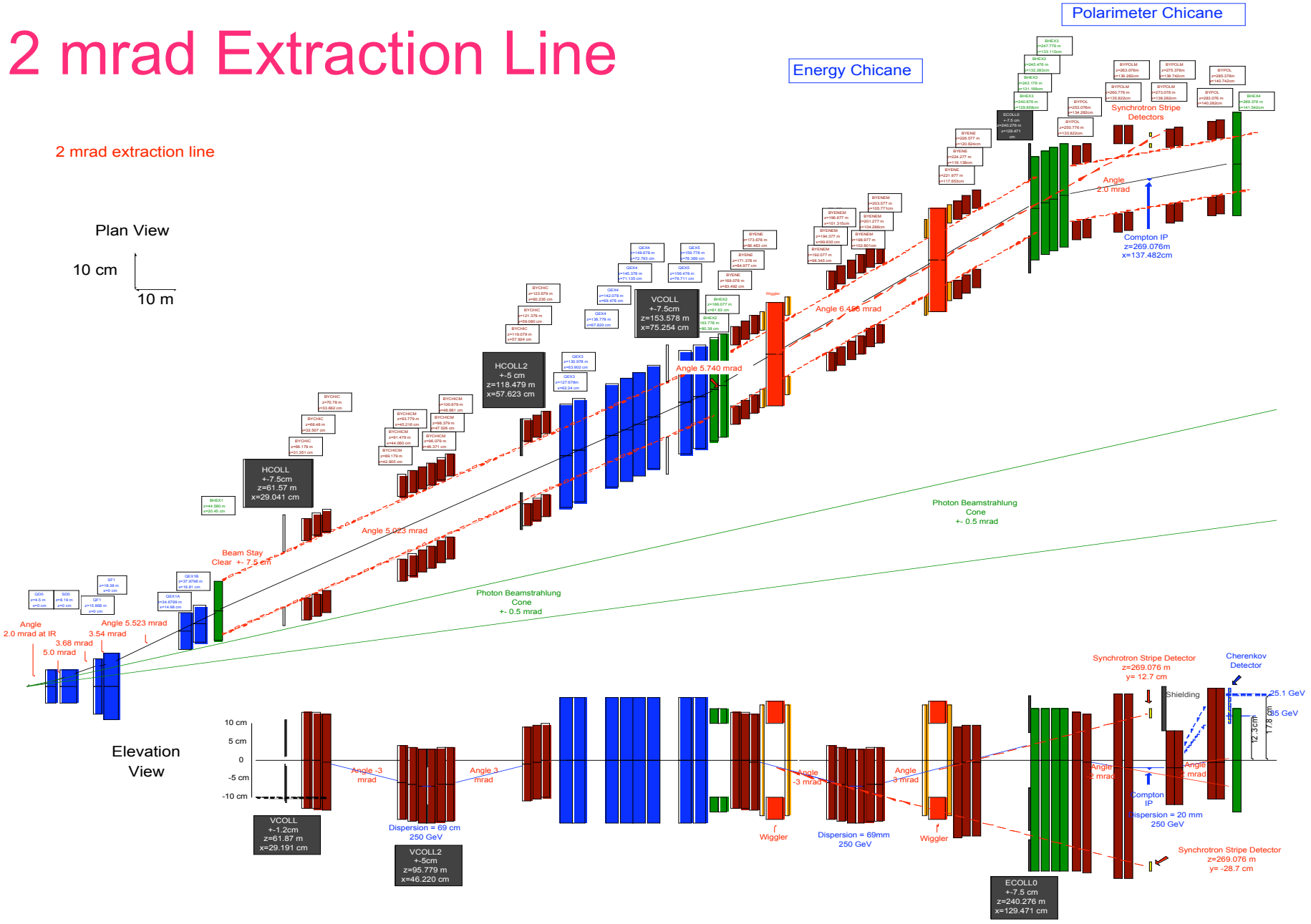


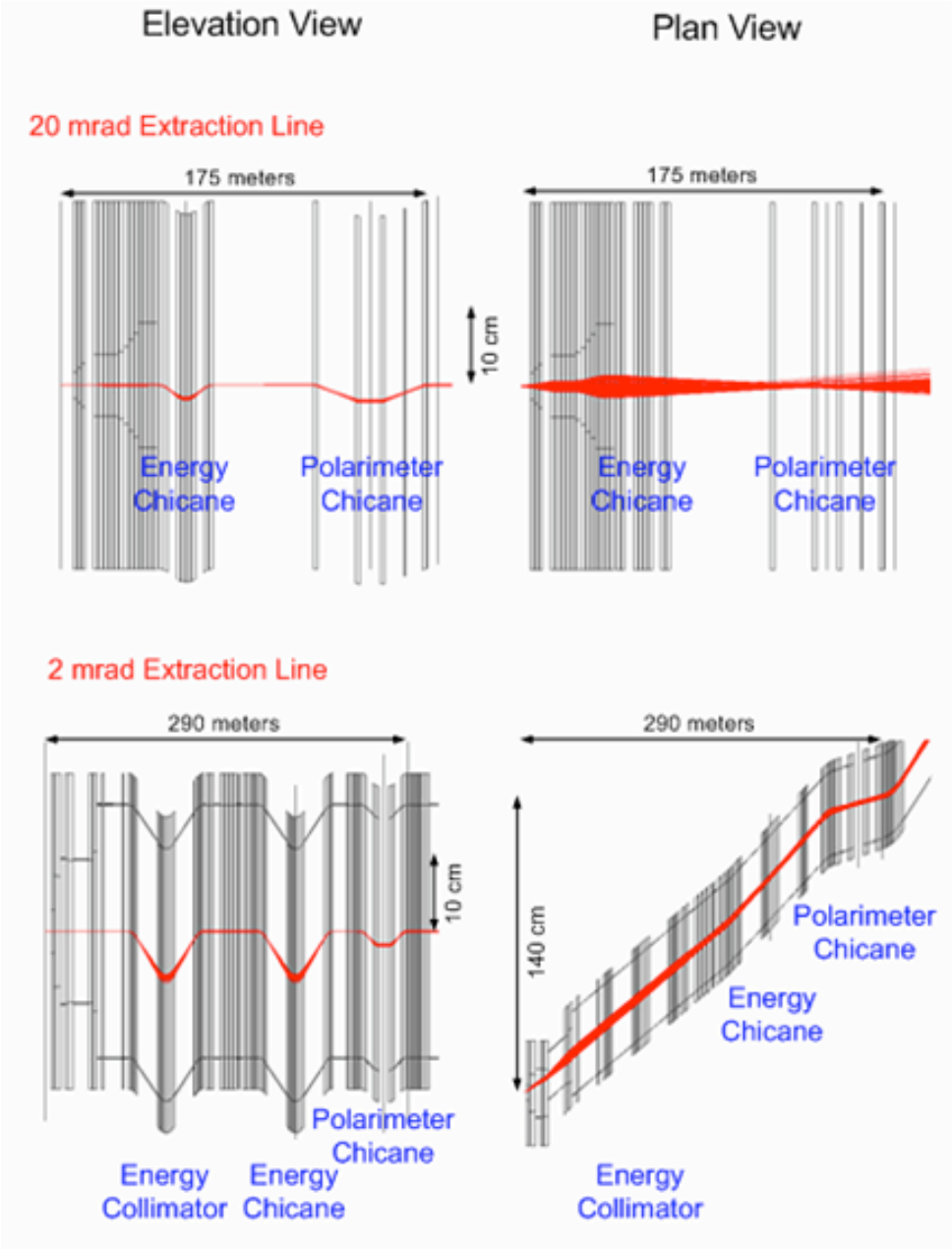
14/20 mrad

14/20 mrad Extraction Line



2 mrad Extraction Line




Elevation View
Plan View
20 mrad Extraction Line
175 meters
175 meters
10 cm
Energy Chicane
Polarimeter Chicane
Energy Chicane
Polarimeter Chicane
2 mrad Extraction Line
290 meters
290 meters
10 cm
140 cm
Polarimeter Chicane
Energy Chicane
Energy Collimator
Energy Chicane
Polarimeter Chicane
Energy Collimator

The extraction line transport is simulated using the program GEANT.

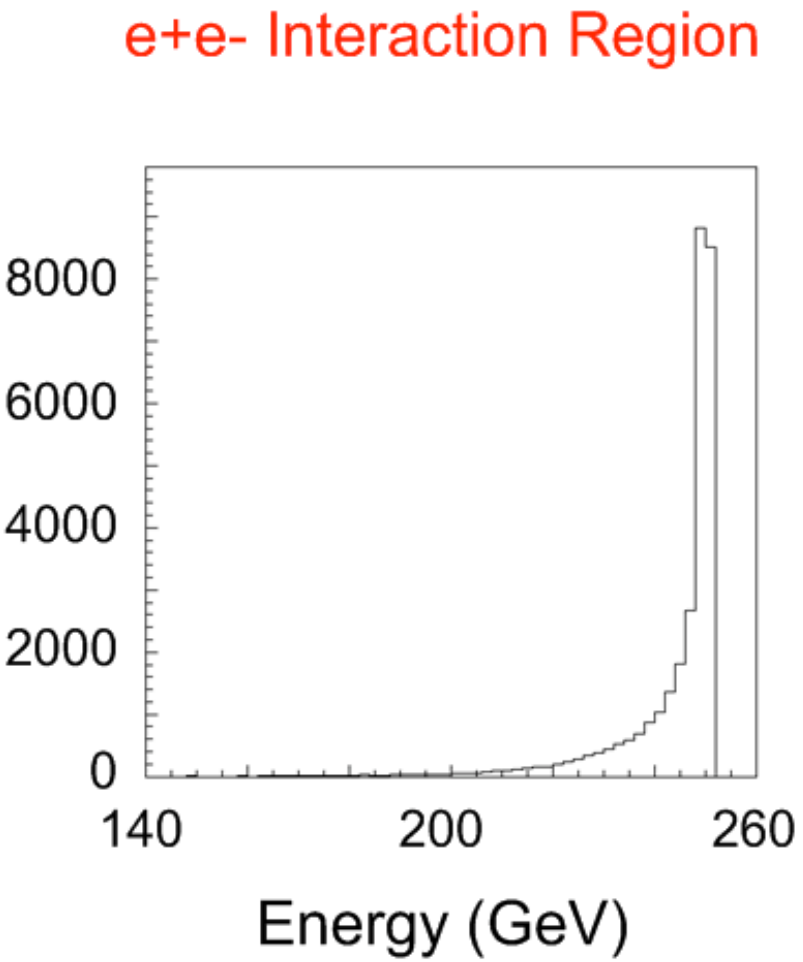
Disrupted beam events were taken from files prepared by Andrei Seryi.

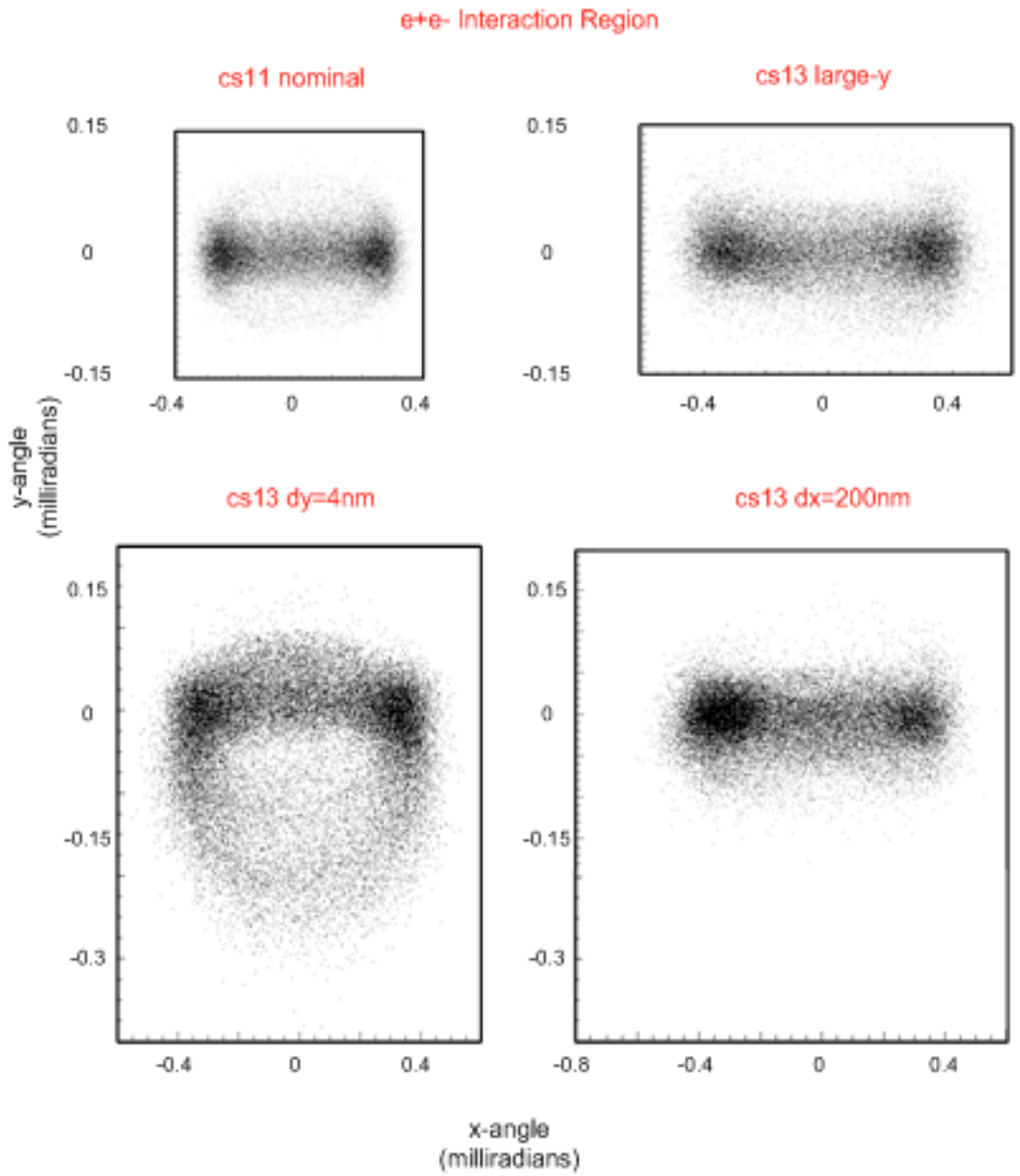
For these studies files:
cs11 corresponds to a normal ILC beam (mean energy 244.3 GeV and RMS 10.84 GeV)

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
cs11 nominal
cs13 large-y
cs13 dy=4nm
cs13 dx=200nm
y-angle
(milliradians)
x-angle
(milliradians)
0.15
0
-0.15
-0.3
-0.4
0
0.4
-0.8

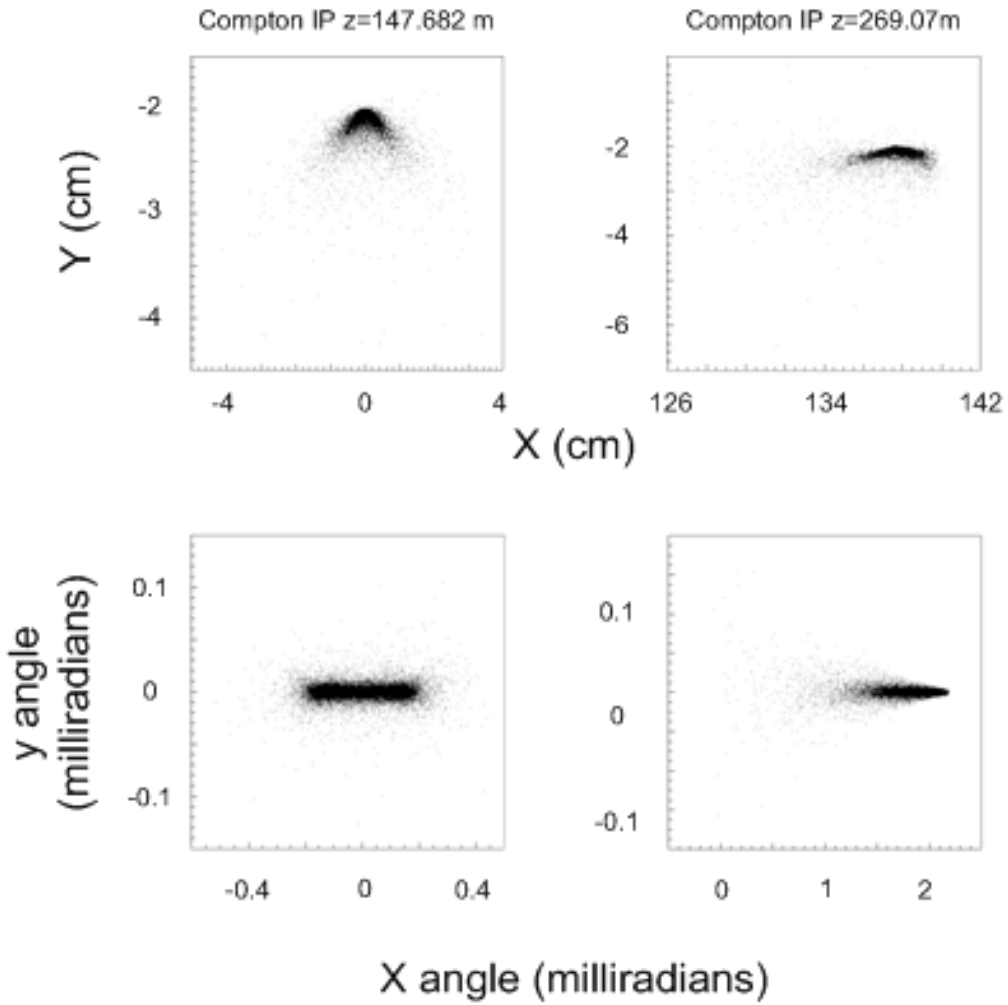
Compton IP

20 mrad

No beam particles lost between IR and Compton IP

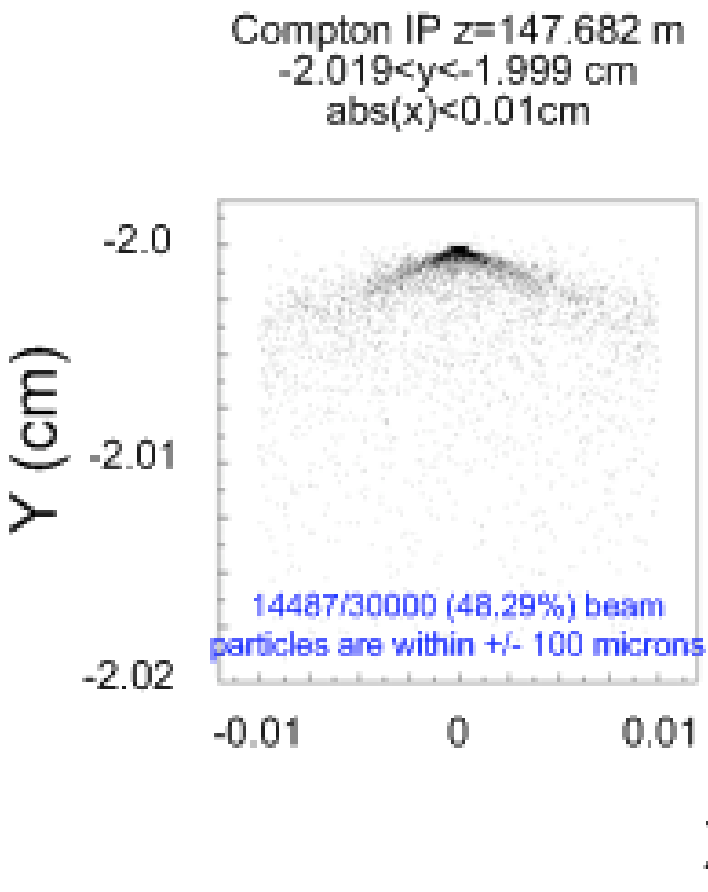
2mrad

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

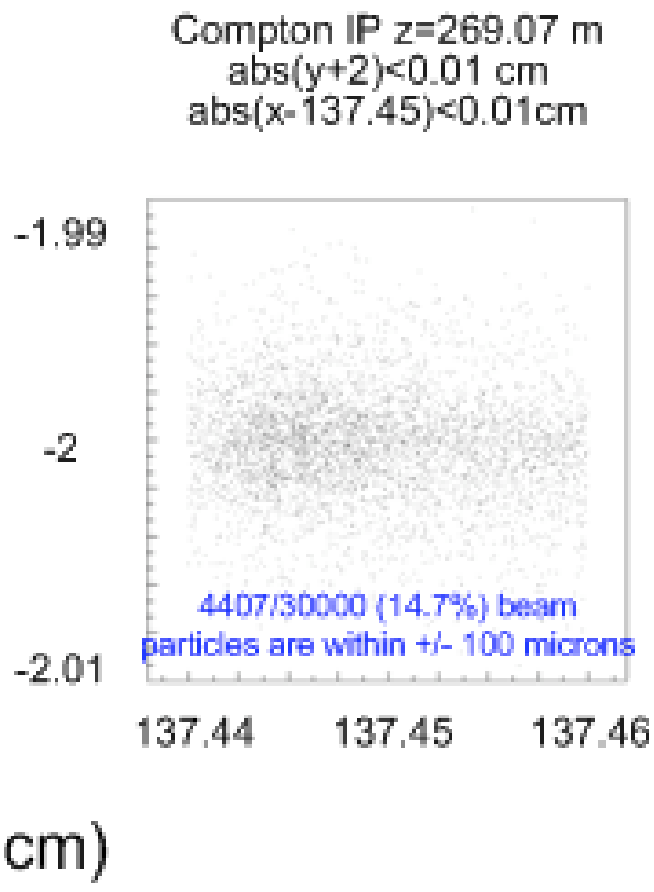


Compton IP

20 mrad



2mrad



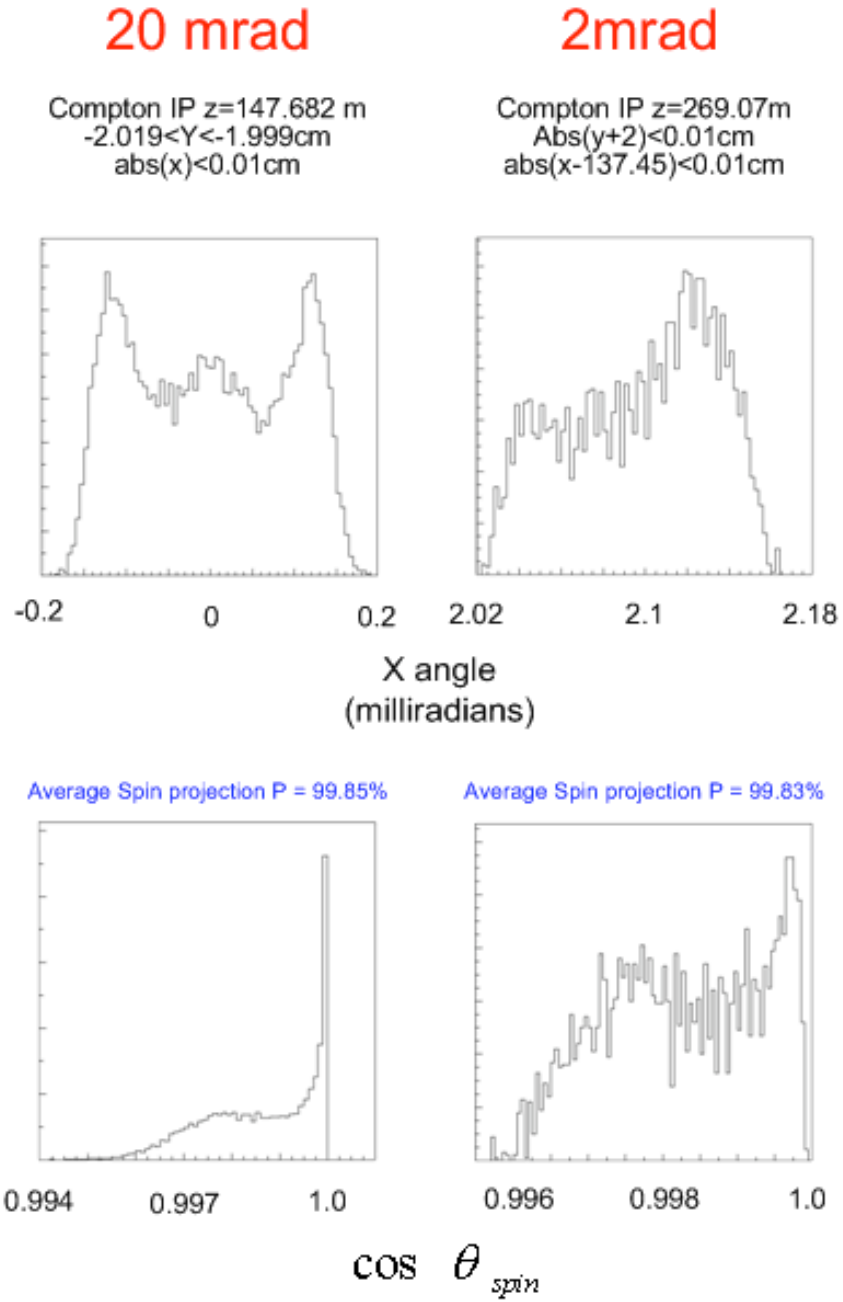
X (cm)

Spin Precession

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

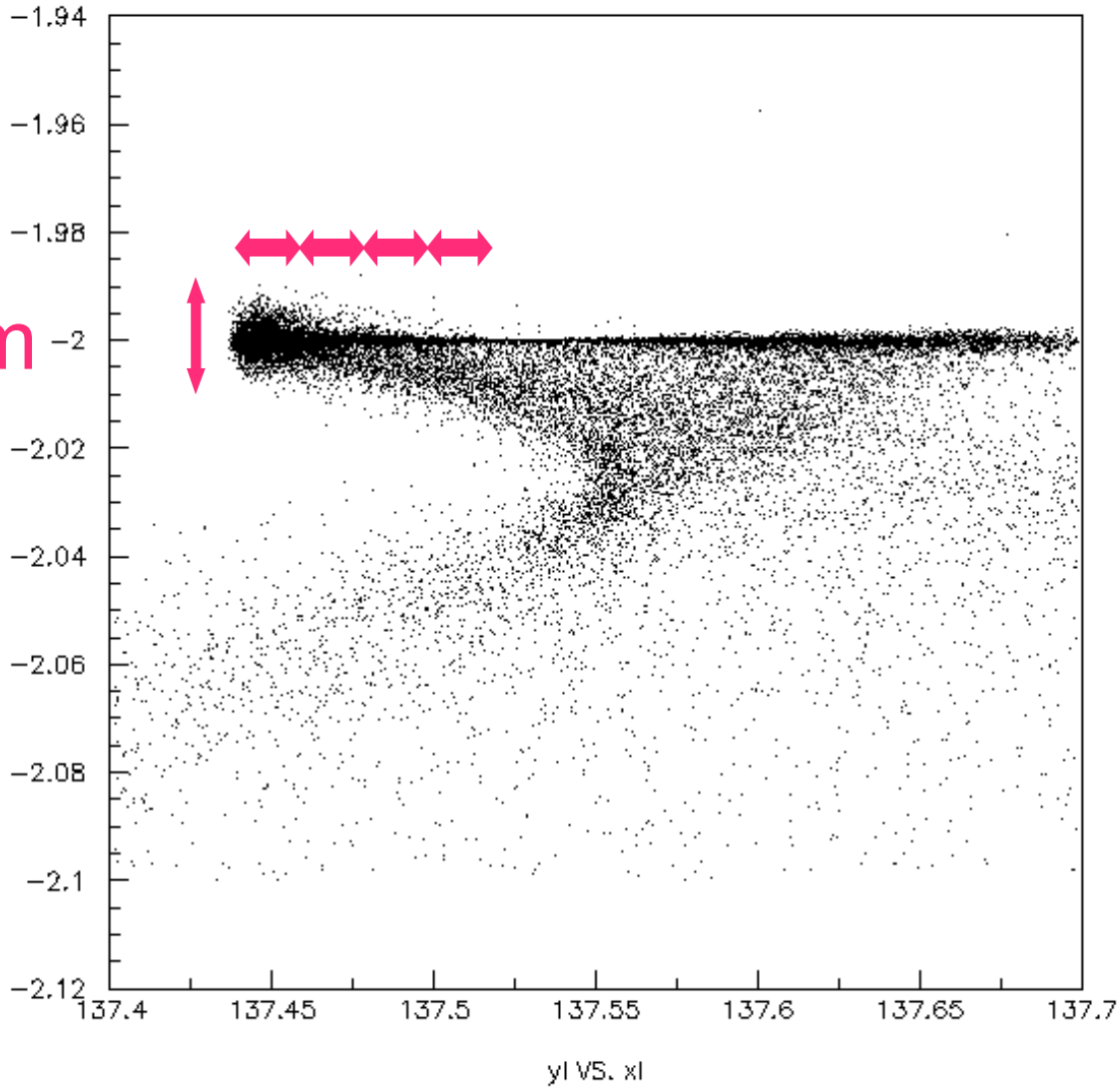
Change in Bend Angle	Change in Spin Direction at 250 GeV	Longitudinal Polarization Projection
1 mrad	32.5 ^{o}	84.3%
275 μrad	8.9 ^{o}	98.8%
100 μrad	3.25 ^{o} =56mrad	99.8%

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
-0.2
0
0.2
2.02
2.1
2.18
X angle
(milliradians)
Average Spin projection P = 99.85%
Average Spin projection P = 99.83%
0.994
0.997
1.0
0.996
0.998
1.0
cos θ spin

2mrad x vs y

+/-100 μm



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 abs(y+2.0cm)<100 microns and abs(x-137.45).

x +- 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<-1.999cm and abs(x)<0.01cm

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 abs(y+2)<0.01cm and abs(x-137.45)<0.01cm

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	$<0.6 * 10^{-4}$

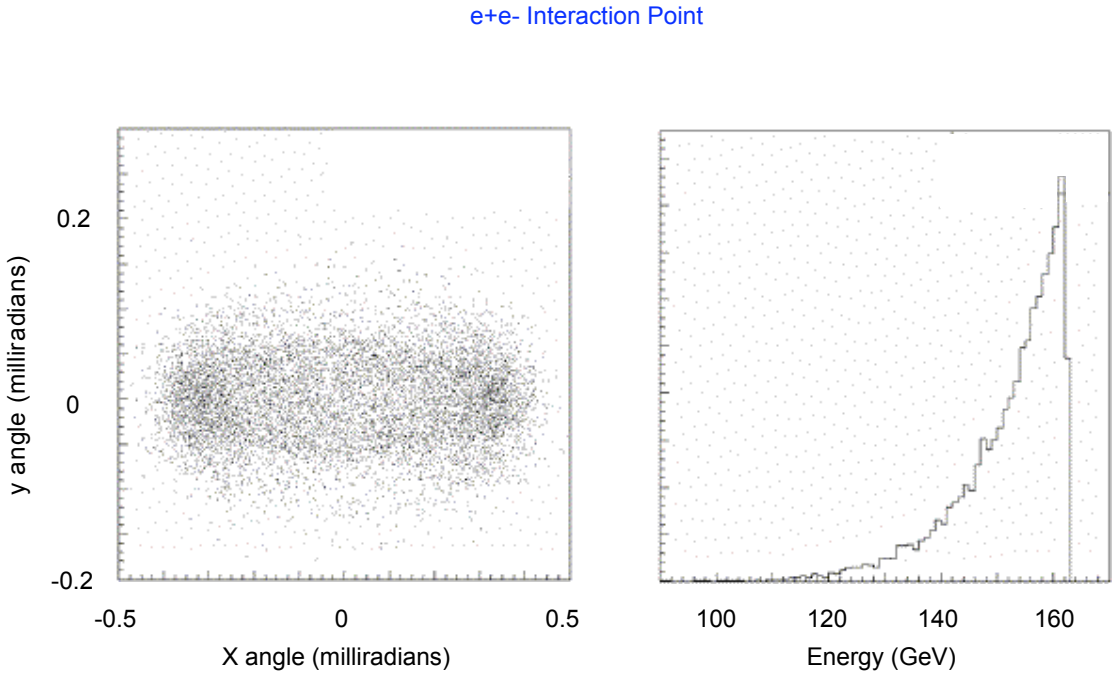
2 mrad Crossing Angle Extraction Line

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

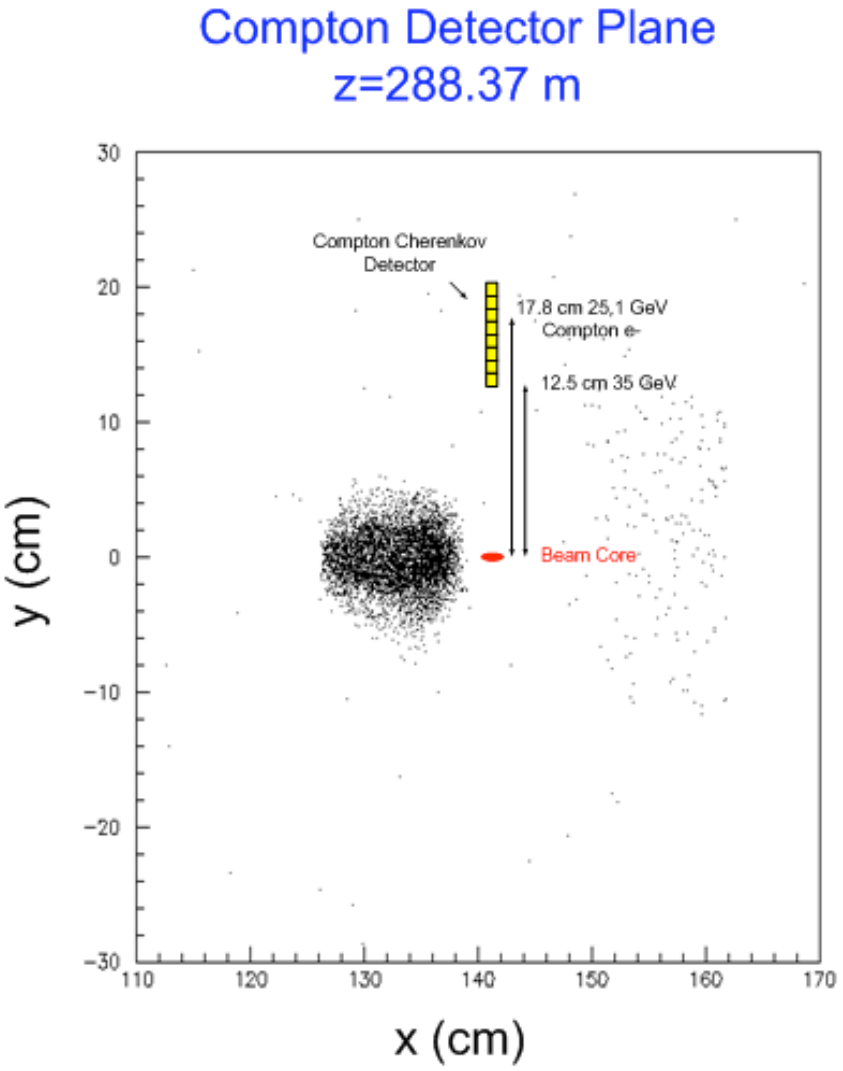
Beam losses were further studied by using a file with the tails of the disrupted beam having events with energy less than 0.65 of the beam energy or the angle greater than 0.5 mrad:

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



2mrad extraction line

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



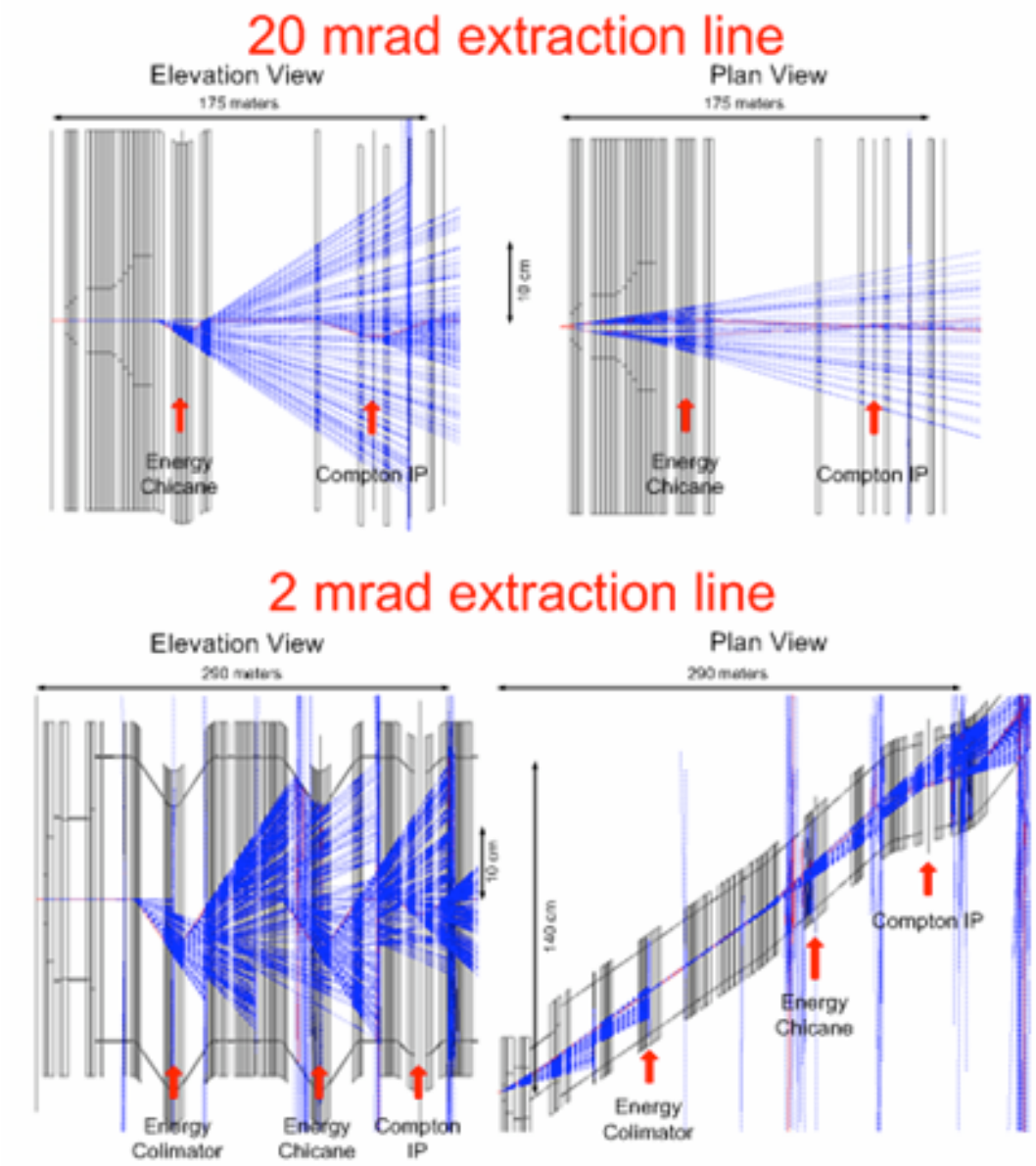
Estimate ~50 photons/cm^2 are in the region of the Cherenkov counter cells for each bunch of $2*10^{10}$ electrons

Only ~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



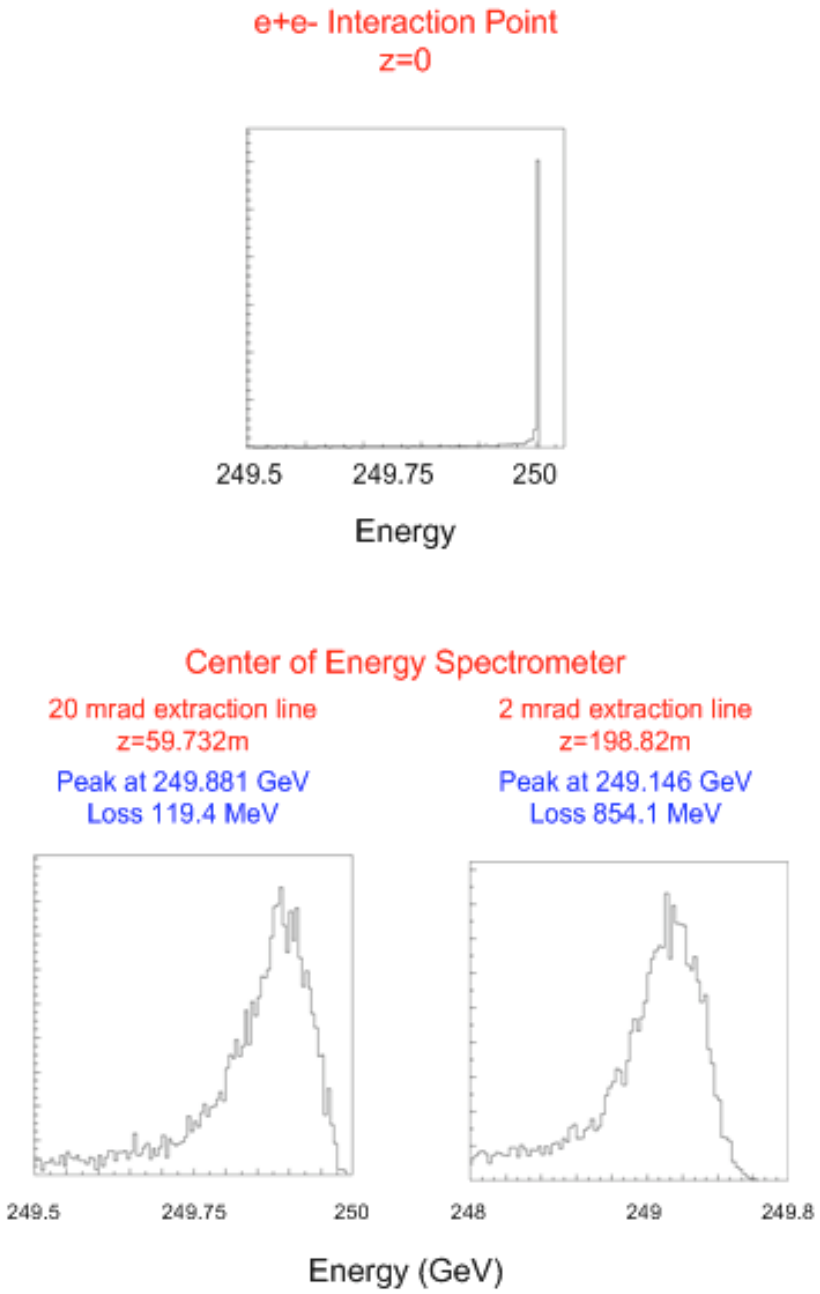


Table IV: Energy Loss from Synchrotron Radiation between the e+e- IR and the Center of the Energy Chicane.

a) 20 mrad Crossing Angle Extraction Line

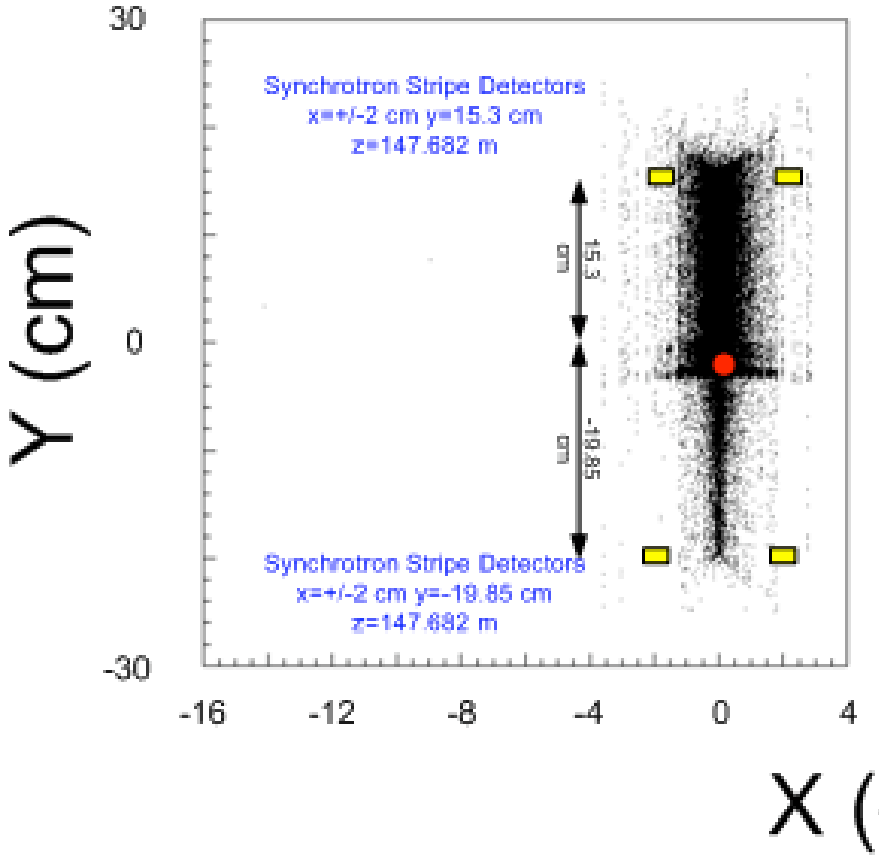
Condition (file name)	Energy Loss (MeV)
Nominal Beam Condition (cs11)	119.4
Large y (cs13)	123.0
Large y horizontal offset 200nm (cs13_dx200)	122.7
Large y vertical offset 4nm (cs13_dy4)	124.3

b) 2 mrad Crossing Angle Extraction Line

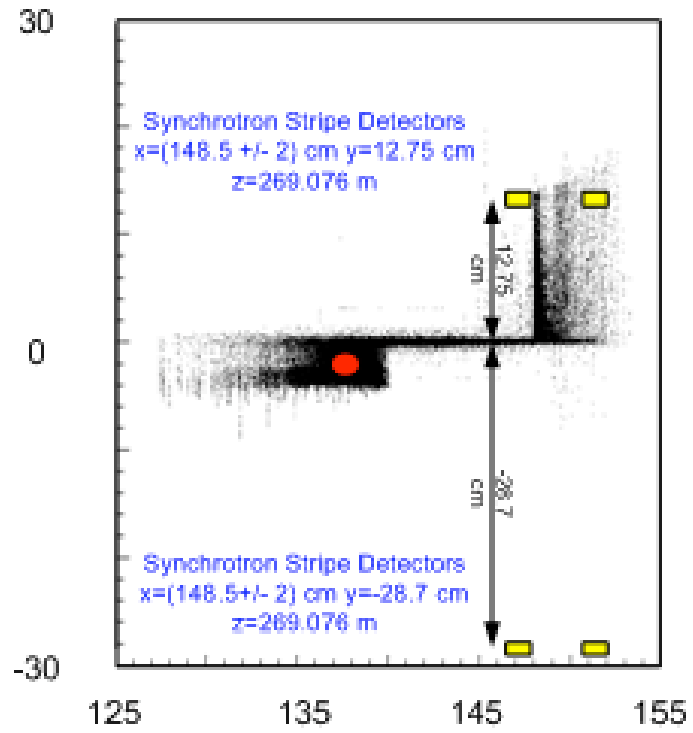
Condition (file name)	Energy Loss (MeV)
Nominal Beam Condition (cs11)	854.2
Large y (cs13)	854.2
Large y horizontal offset 200nm (cs13_dx200)	828.5
Large y vertical offset 4nm (cs13_dy4)	859.4

Compton IP

20 mrad extraction line
z=147.682m



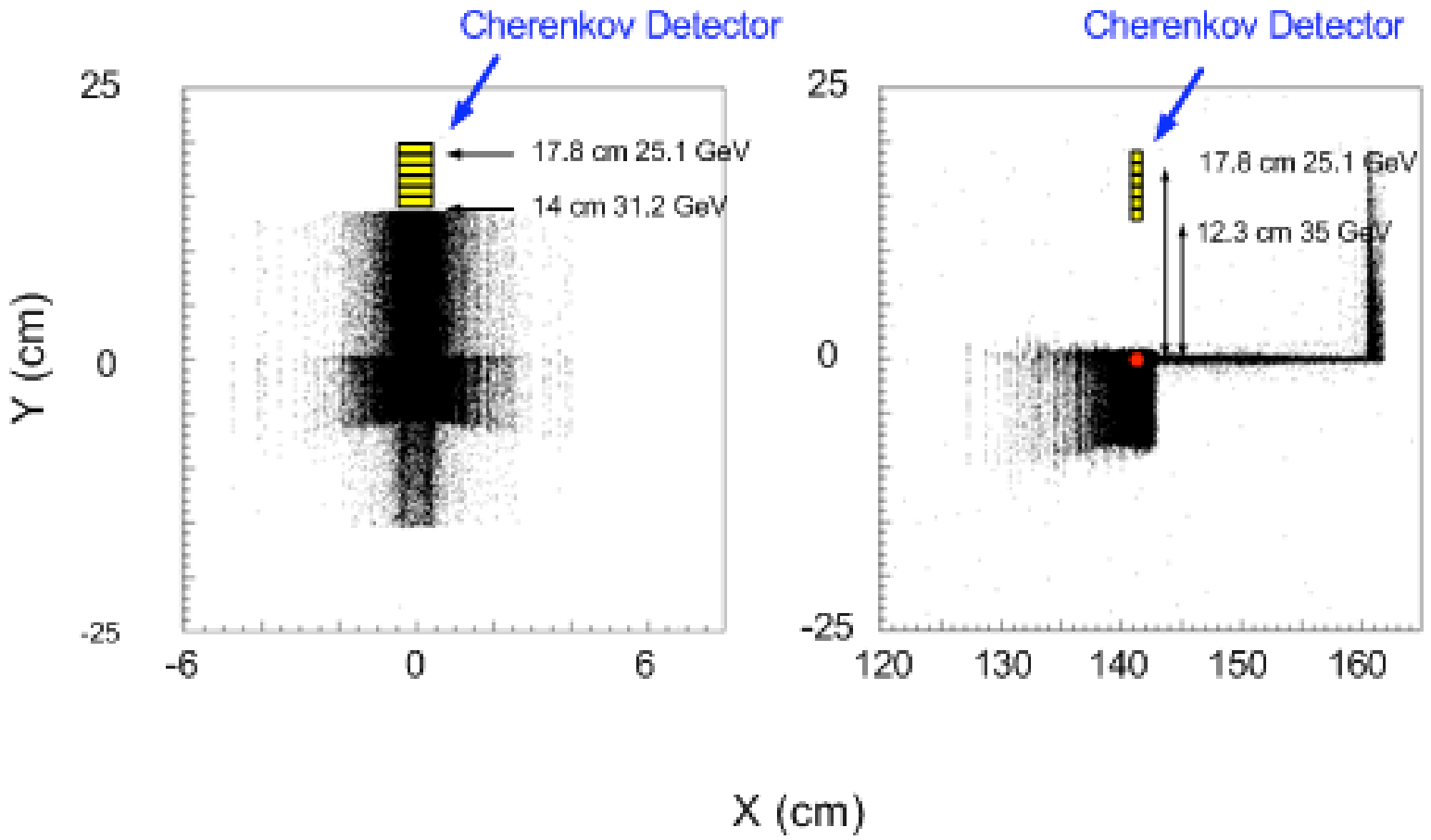
2 mrad extraction line
z=269.076m



Compton Detector Plane

20 mrad extraction line

2 mrad extraction line



Conclusions

The 20 mrad extraction line has:

•Core of beam within +-100microns 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~14 cm.

The 2 mrad extraction line has:

•There are large beam losses between e+e- IR and Compton detector plane (>$2.6*10^{-4}$ 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 (~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.