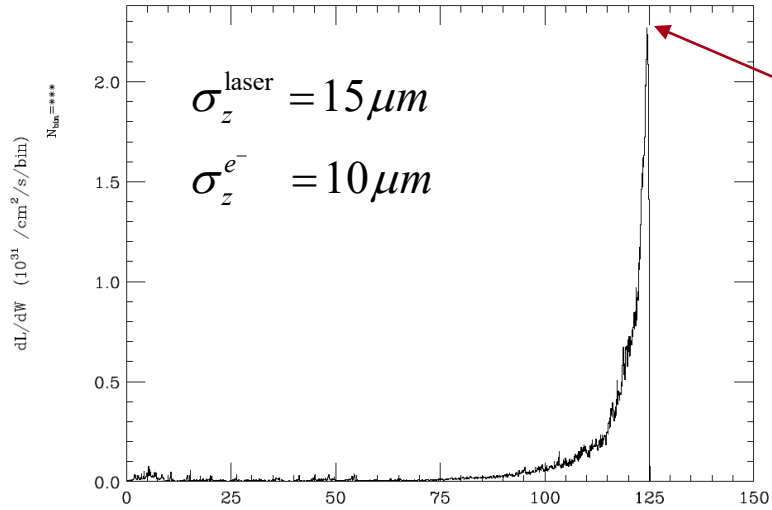


BB Deflection Separation of Electron Bunches

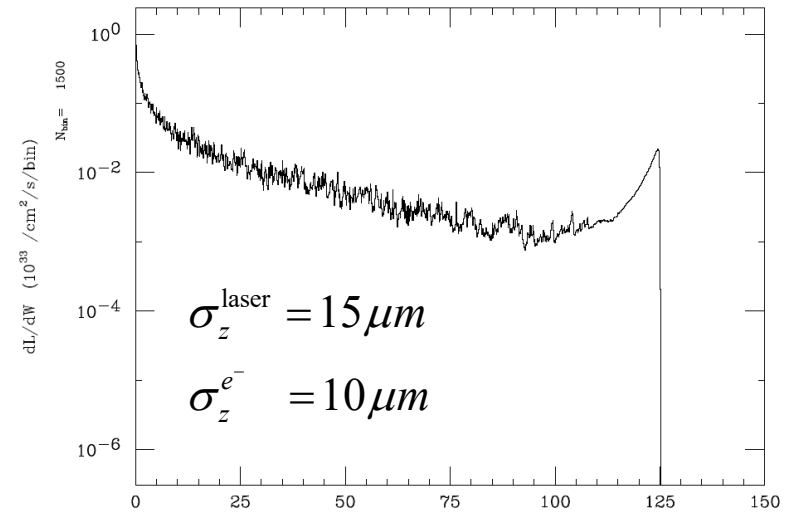
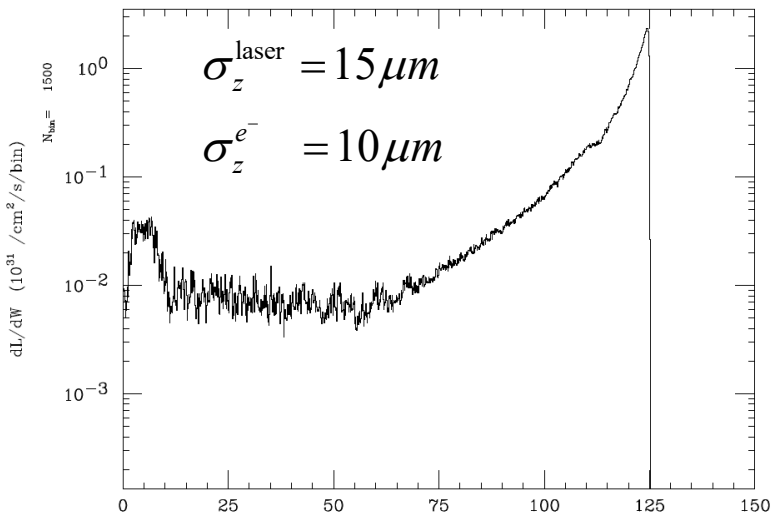
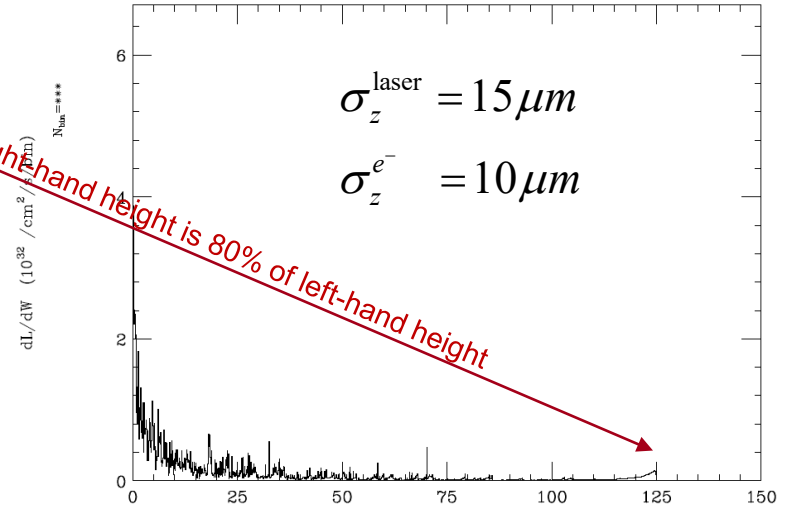
Tim Barklow
XCC Meeting
Feb 24, 2021

Very Large Beamstrahlung Luminosity for Head-on $e^- e^-$ Collisions

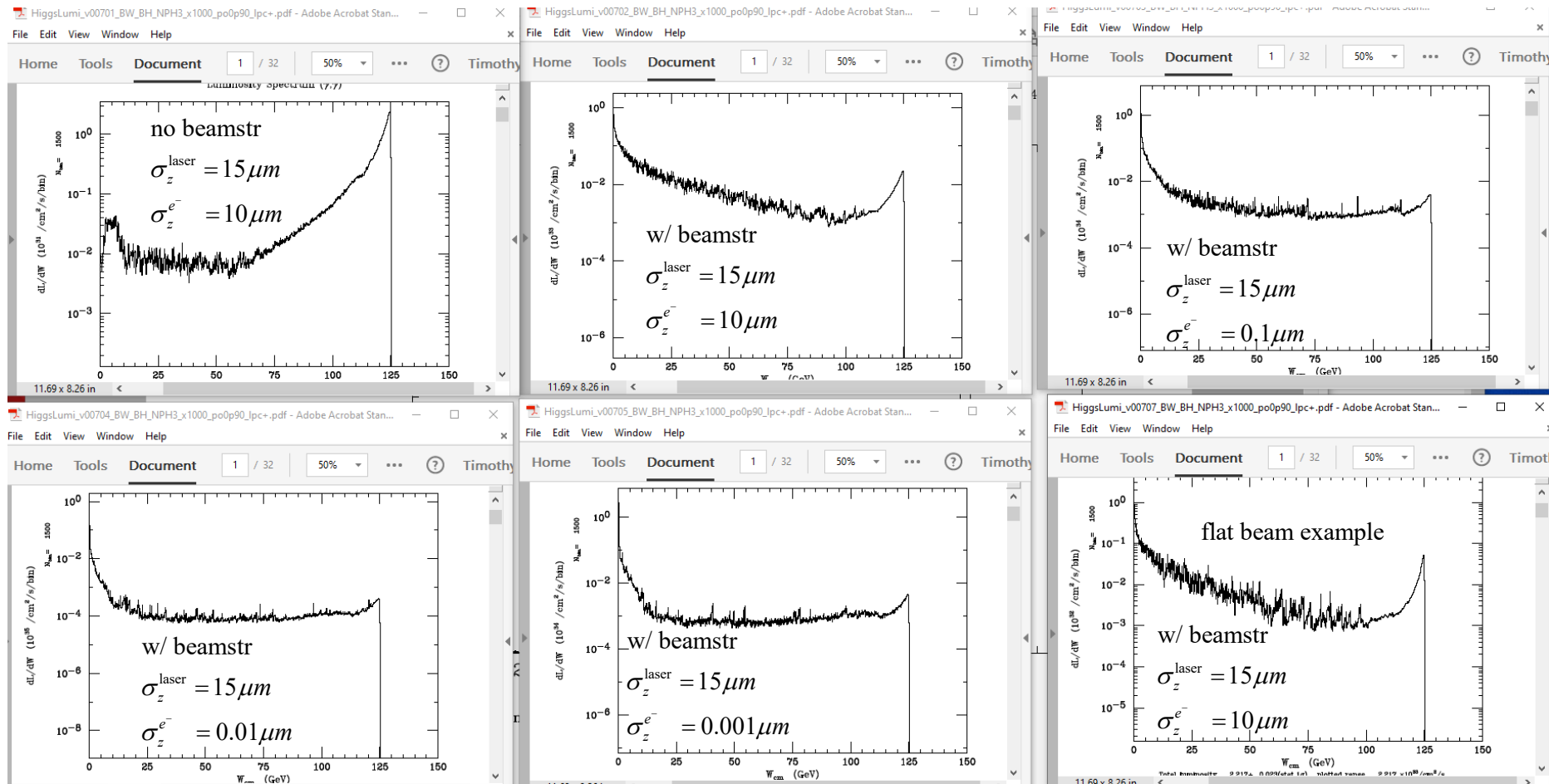
No beamstrahlung



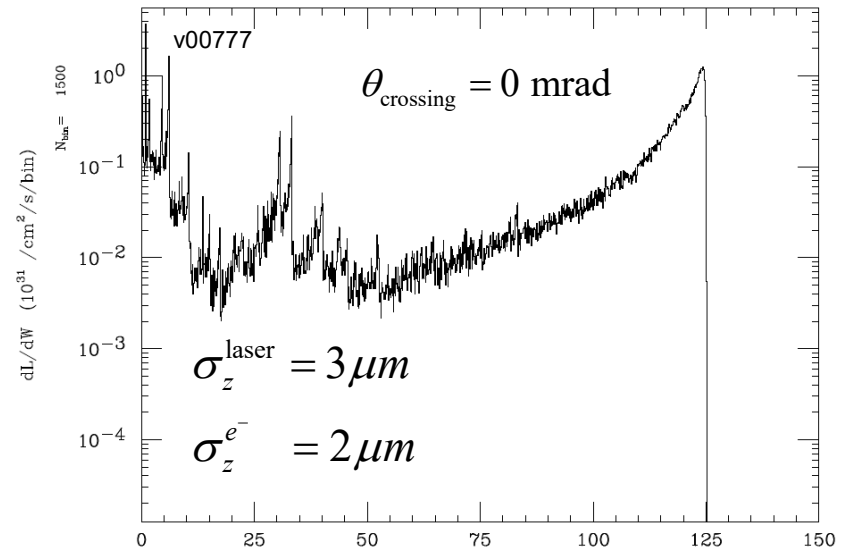
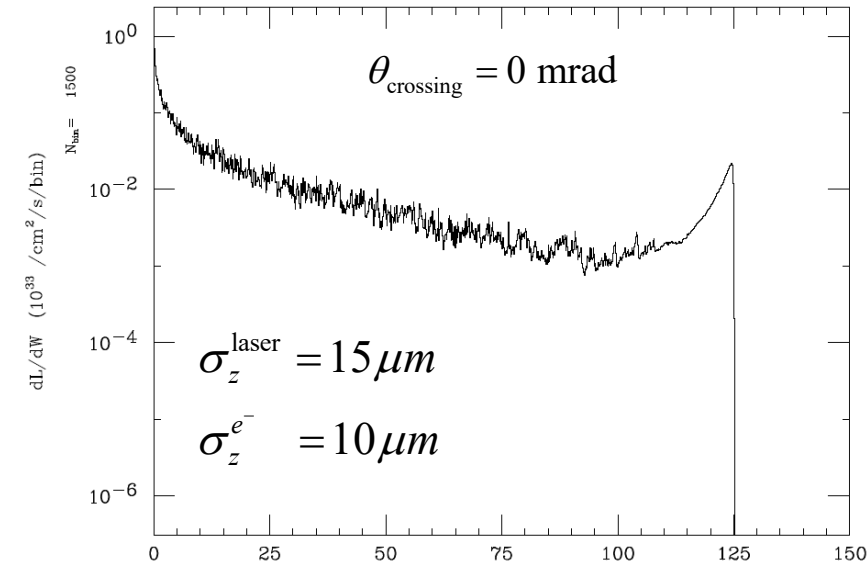
With beamstrahlung



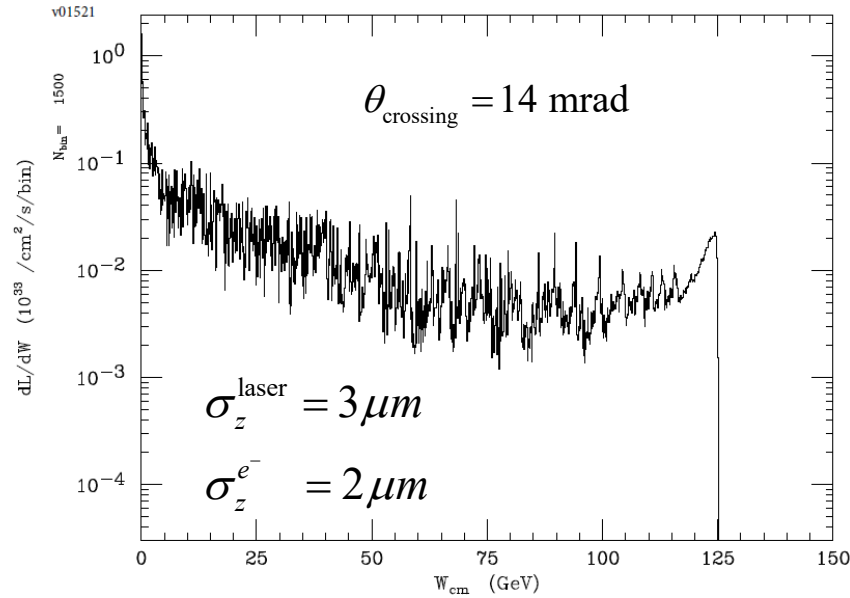
Shortening only the e^- bunch doesn't solve the problem



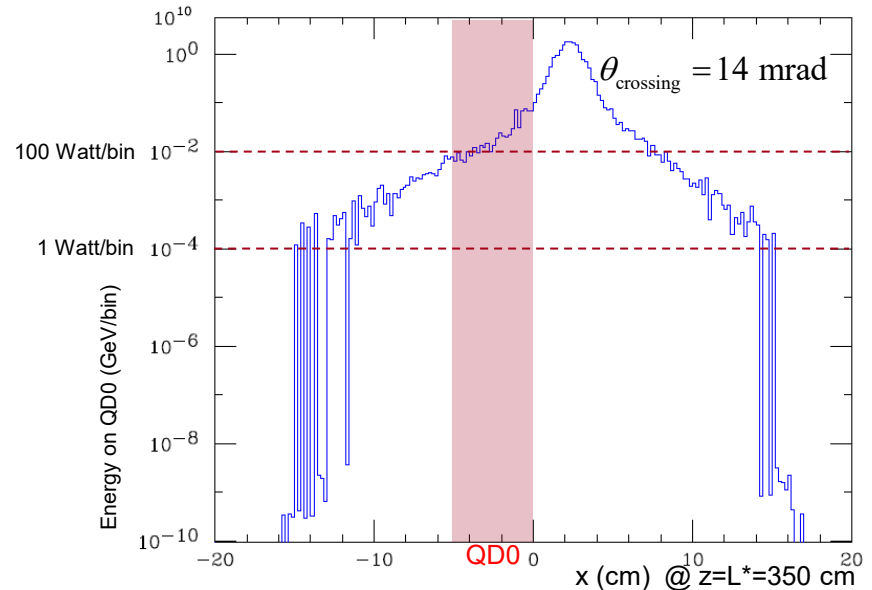
Shortening both the XFEL and e⁻ bunches is more promising



But the beamstrahlung lumi advantage disappears when a minimal crossing angle is included.



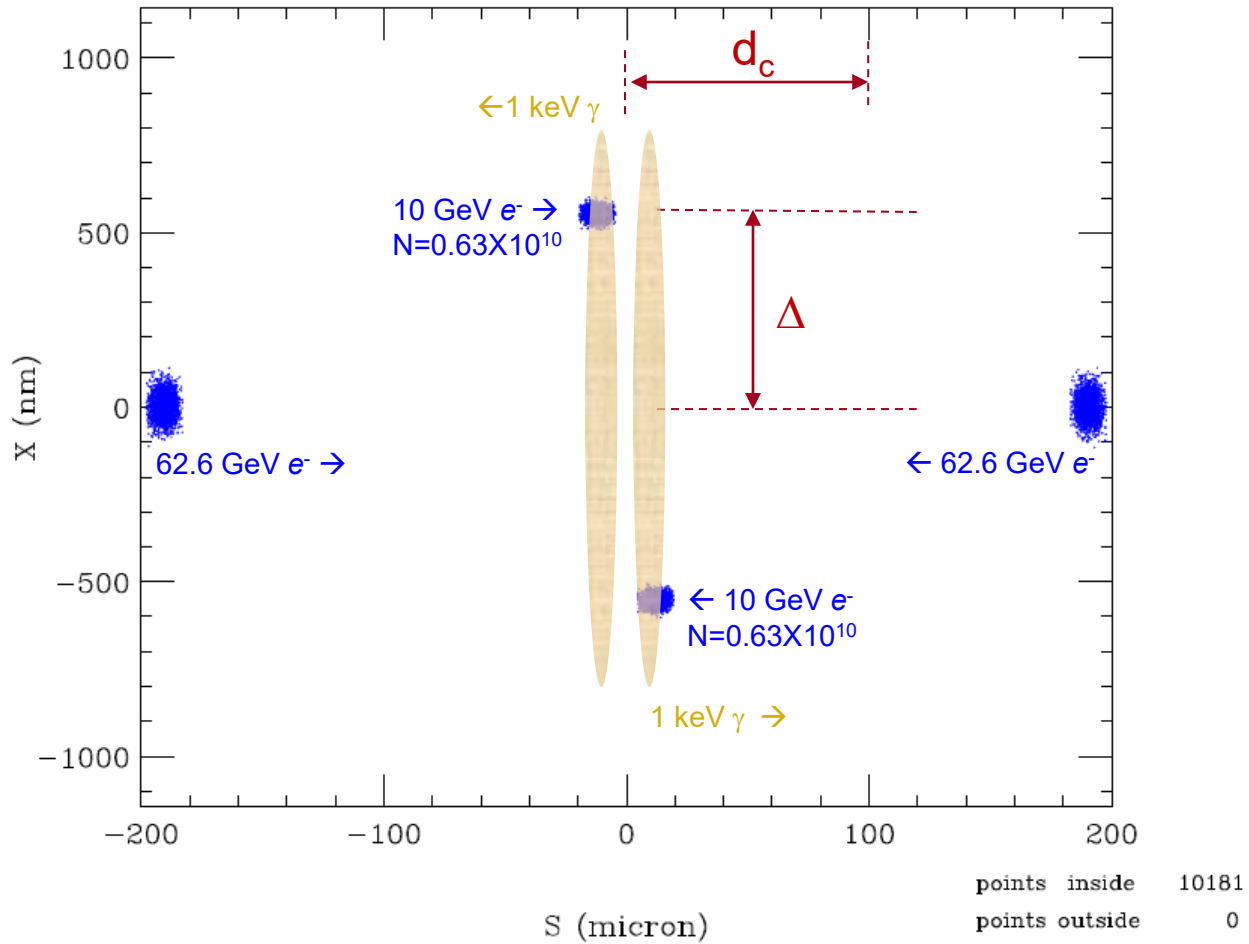
And too many hard electrons scattered into QD0 at $\theta_{\text{cross}} = 14$ mrad $\rightarrow$ would need larger $\theta_{\text{cross}} \sim 40$ mrad



BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.19037\text{mm}$

20210223(081414) CAIN2.42

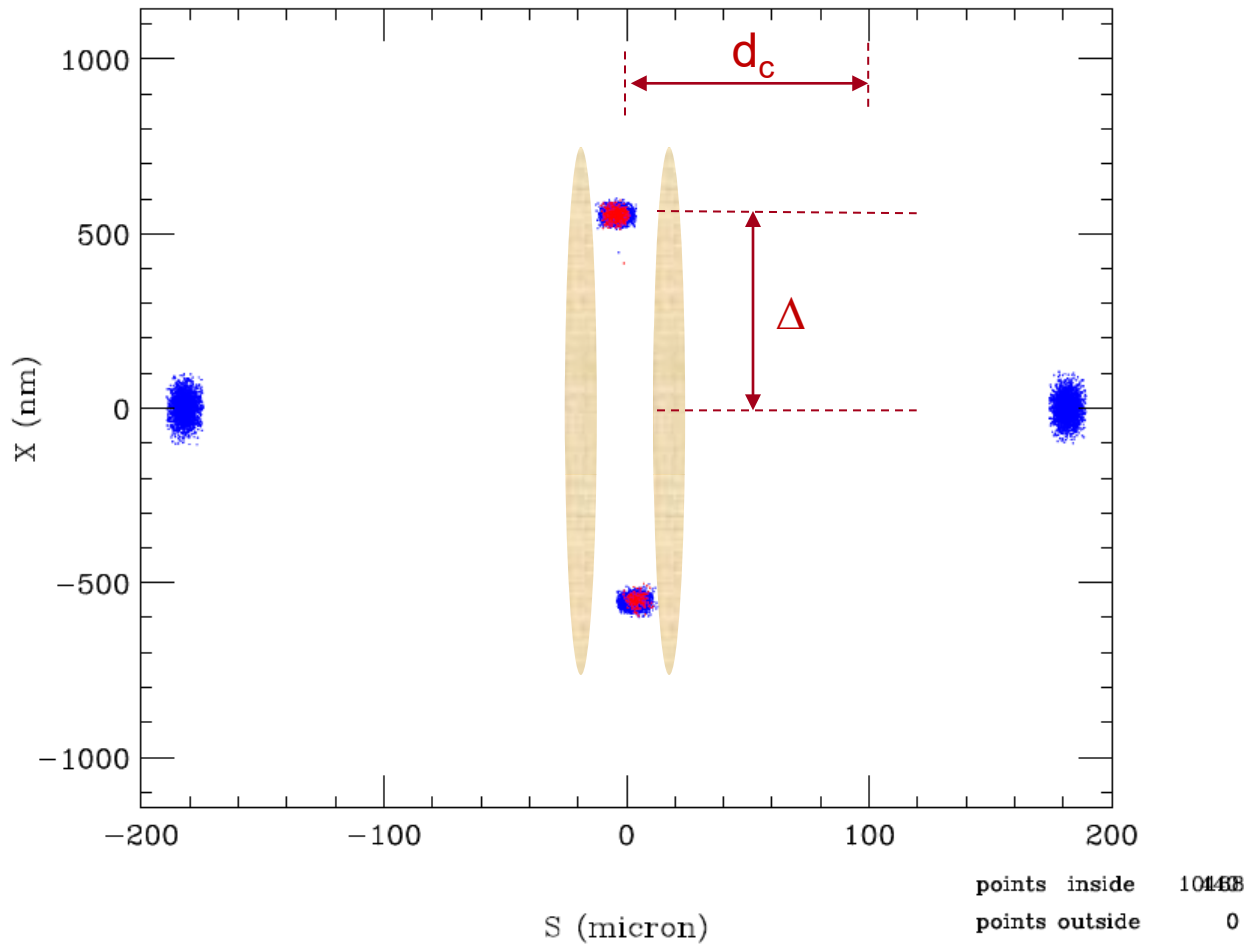


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.18179\text{mm}$

20210223(081414)

CAD2.42

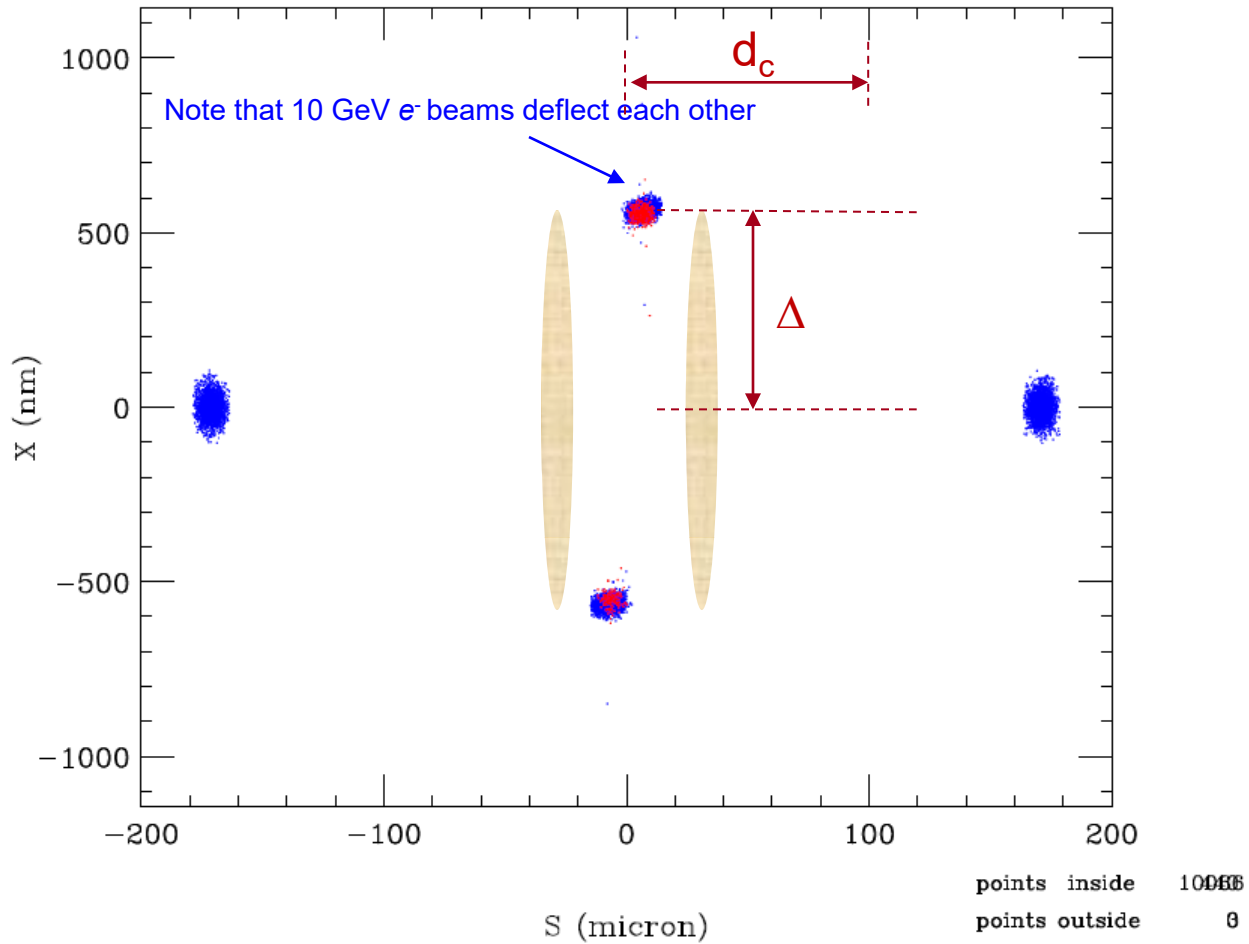


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.17107\text{mm}$

20210223(081414)

CAD2.42

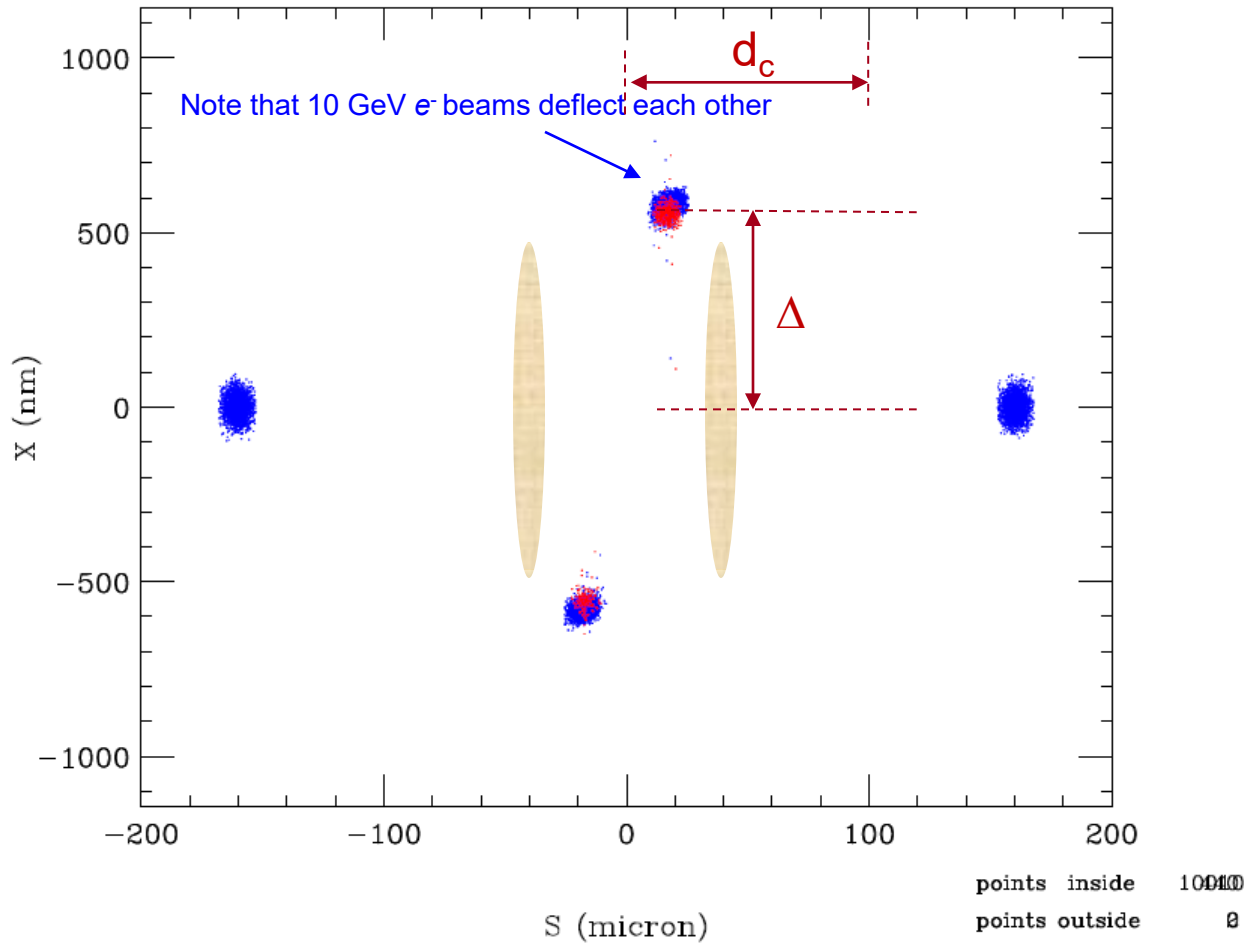


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.16036\text{mm}$

20210223(081414)

CAD2.42

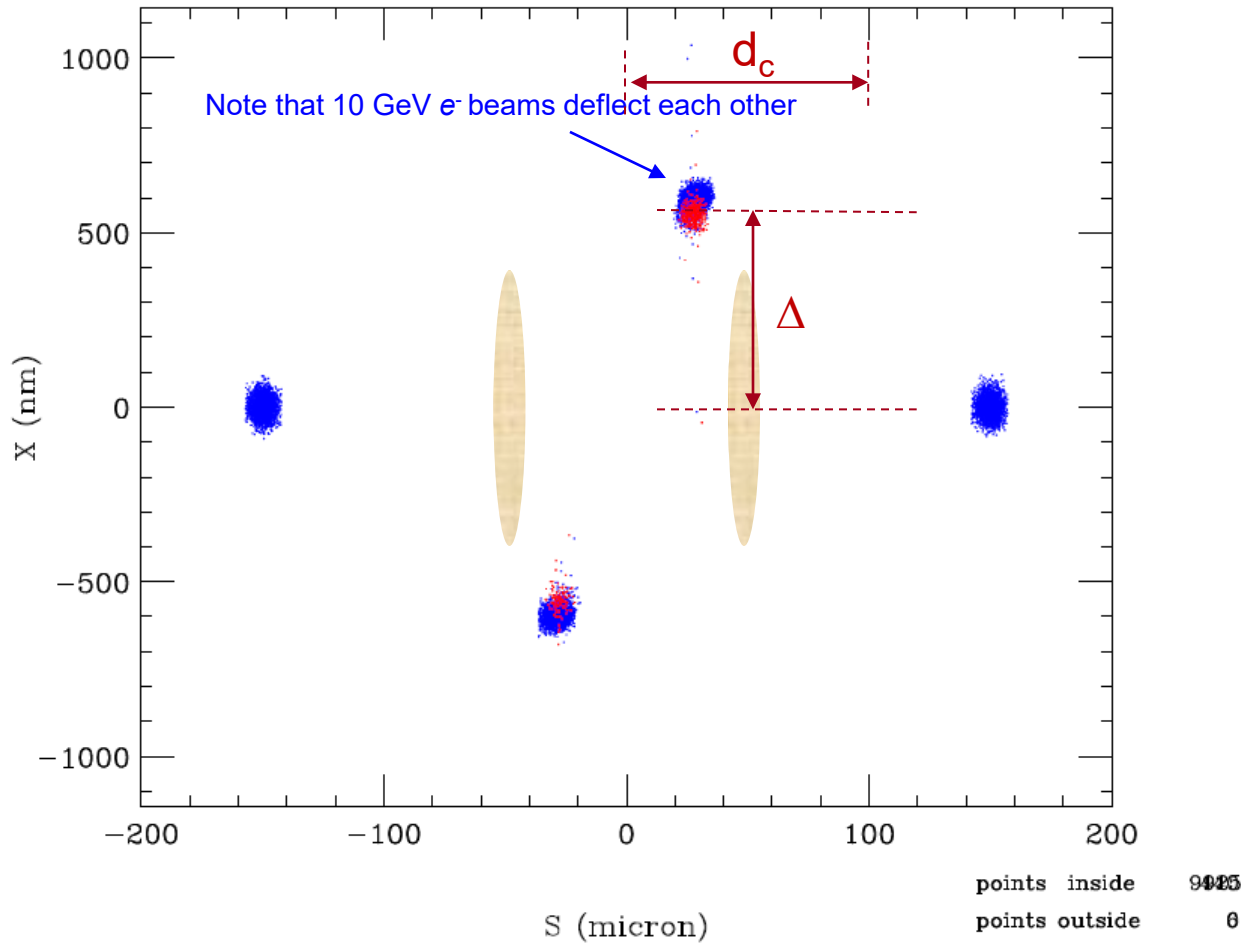


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.14964\text{mm}$

20210223(081414)

CAD2.42

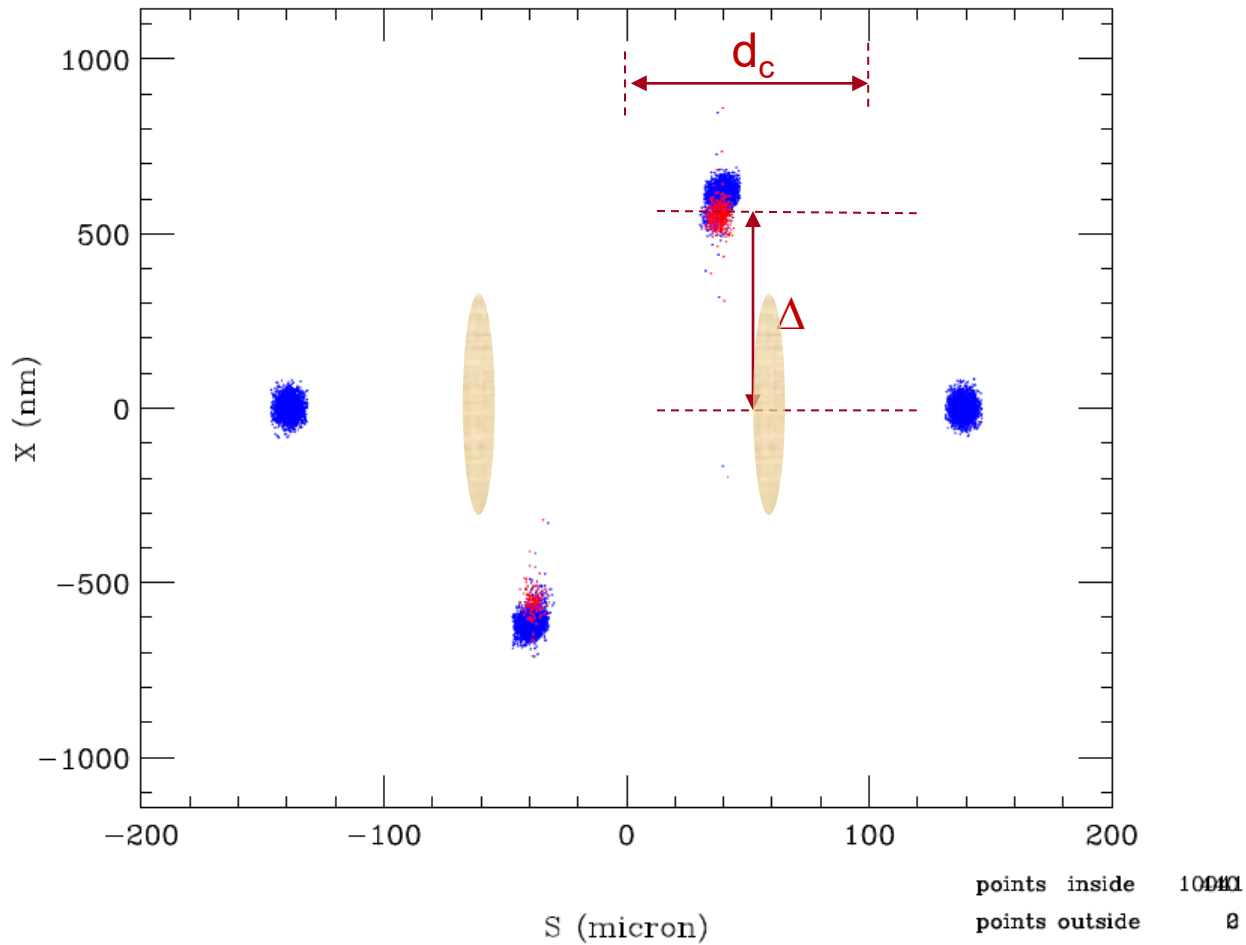


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.13892\text{mm}$

20210223(081414)

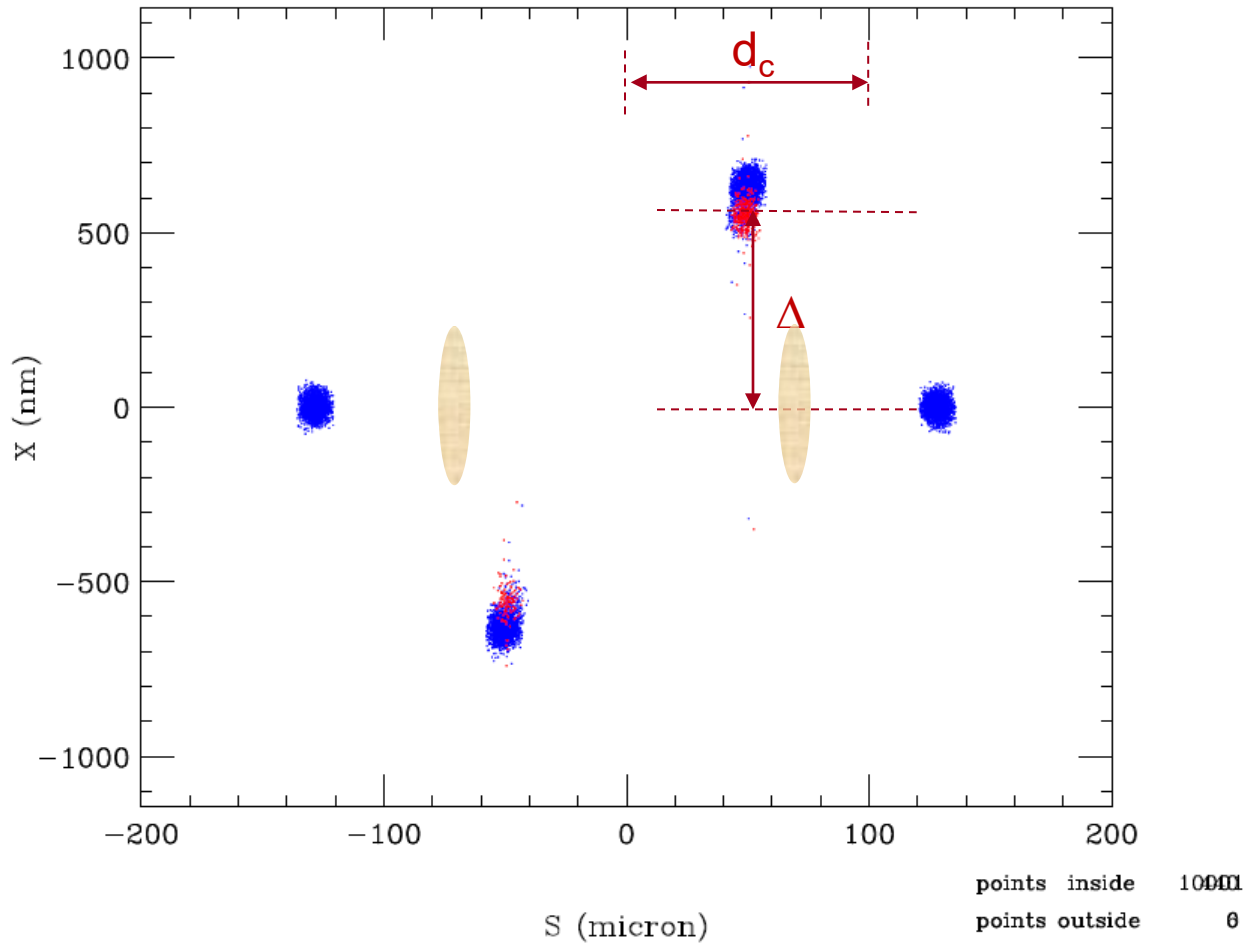
CAD2.42



BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.12820\text{mm}$

20210223(081414) CAIN2.42

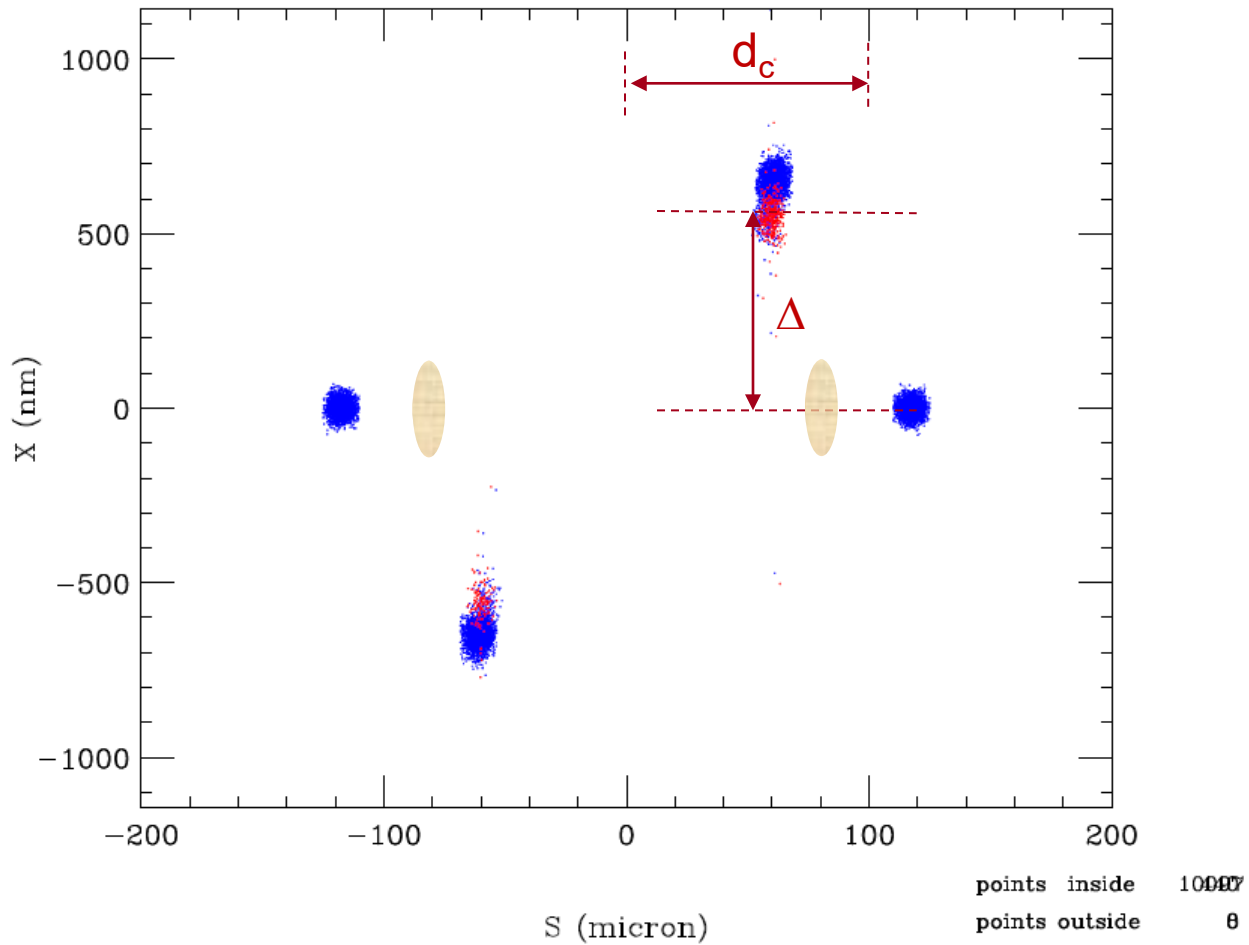


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.11748\text{mm}$

20210223(081414)

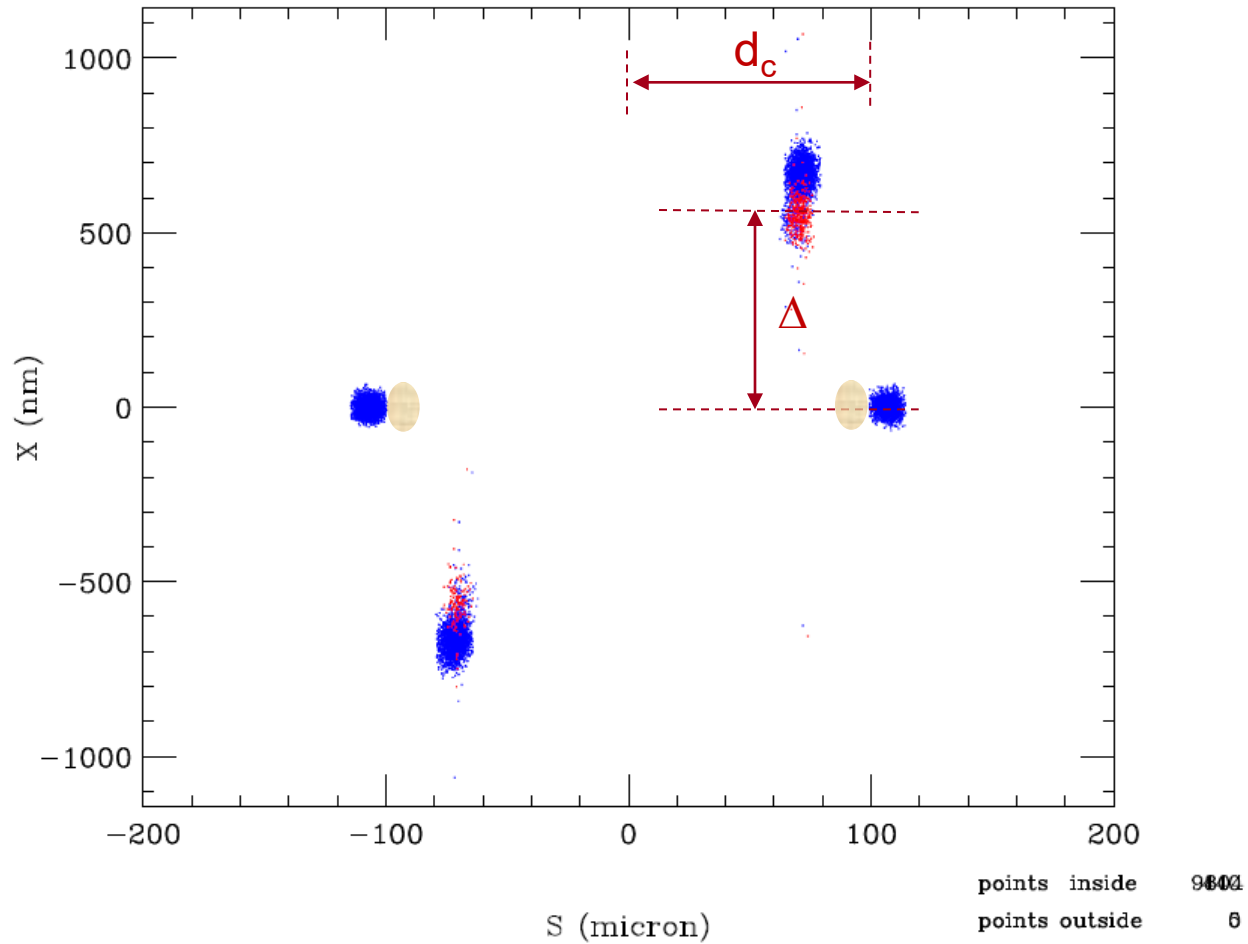
CAD2.42



BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.10676\text{mm}$

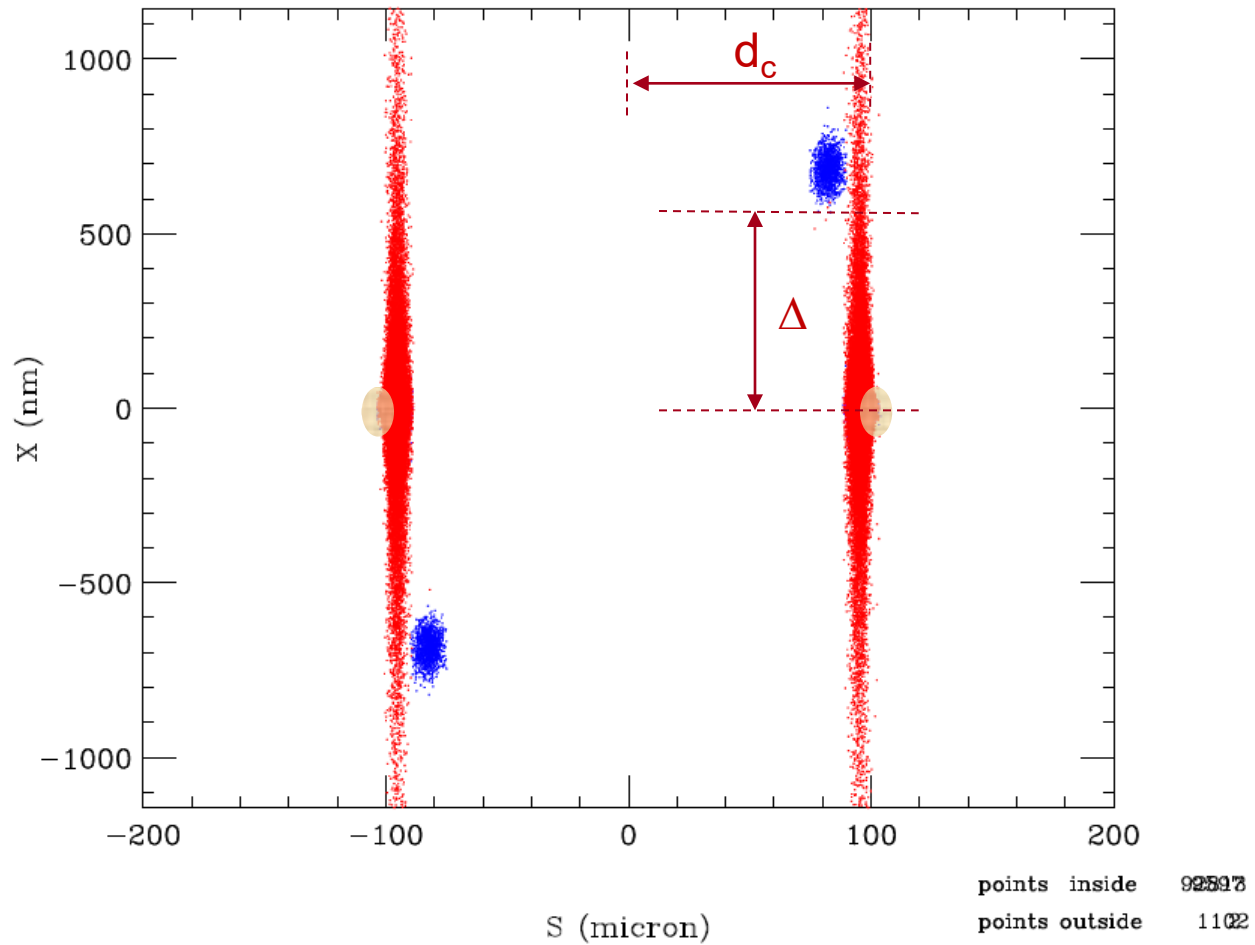
20210223(081414) CAIN2.42



BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.09605\text{mm}$

20210223(081414) CAIN2.42

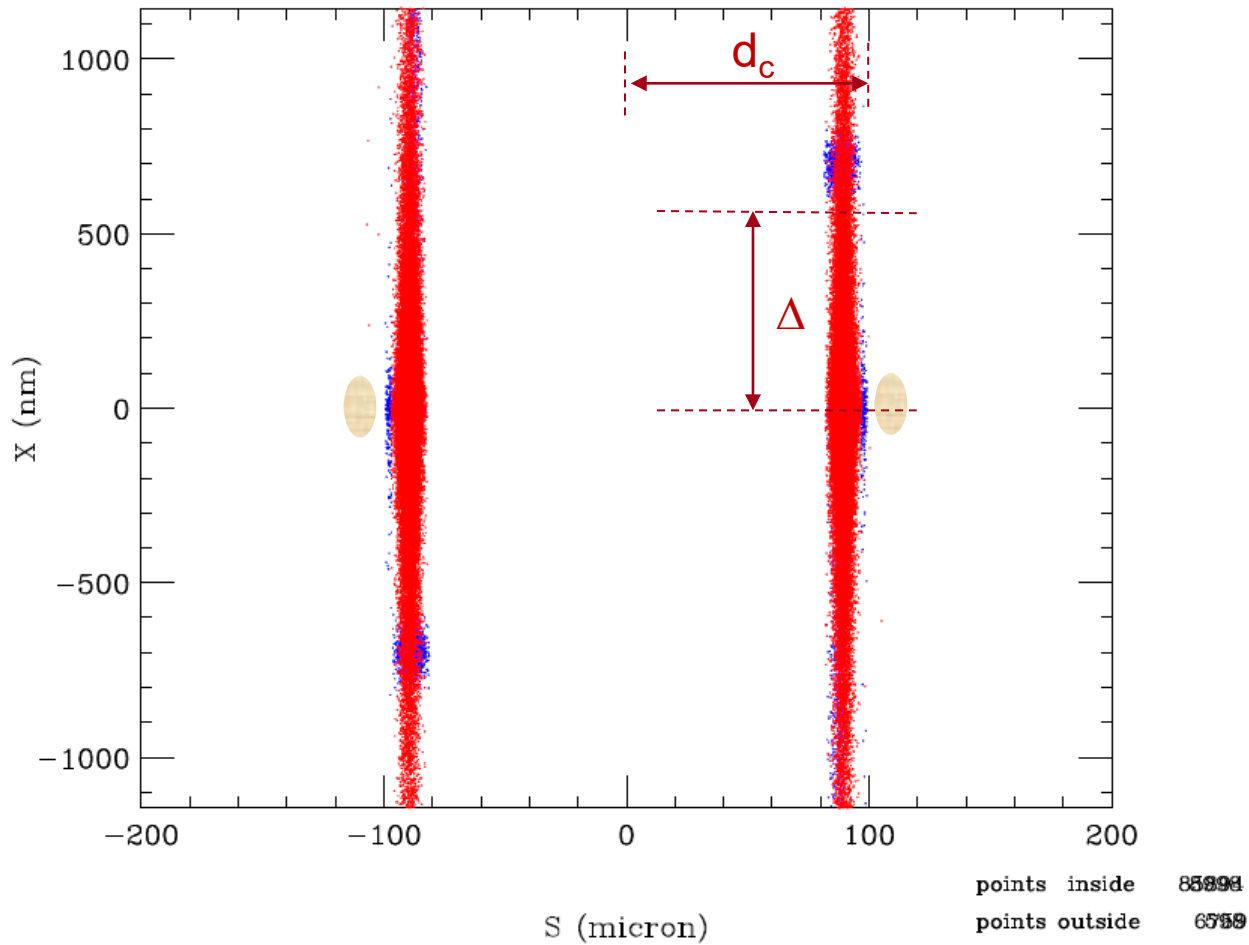


BB Deflection to Separate Electron Bunches

ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
 $t = -0.08961\text{mm}$

20210223(081414)

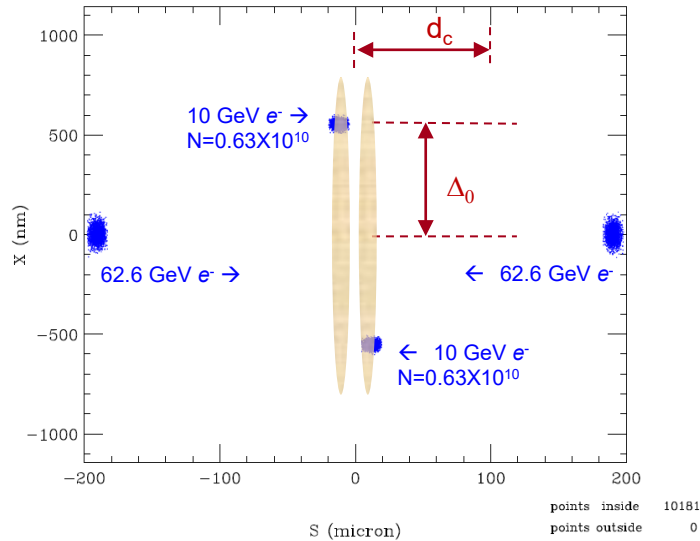
CAD2.42



BB Deflection to Separate Electron Bunches

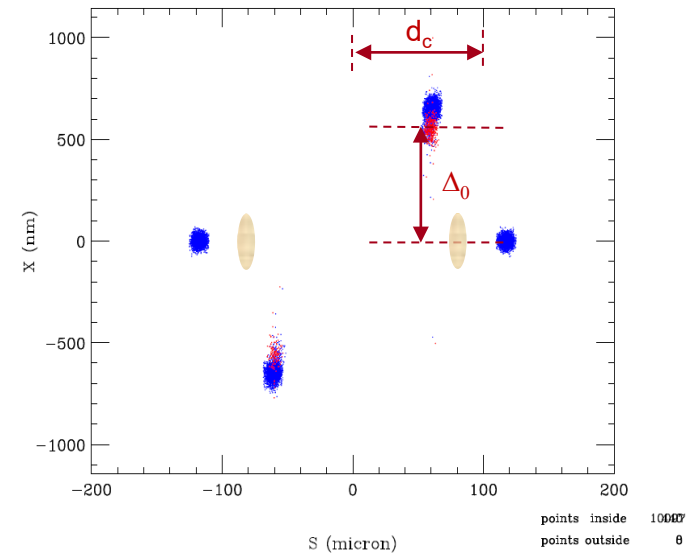
ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
t = -0.19037mm

20210223(081414) CAIN2.42



ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
t = -0.11748mm

20210223(081414) CAIN2.42



Two deflector beams separated by $2\Delta_0$ at $s = 0$

They get a kick $\theta_d = \frac{2r_e N_d}{\gamma_d (2\Delta_0)}$, where $\gamma_d = \frac{10 \text{ GeV}}{m_e}$, N_d = bunch pop. of 10 GeV beam

The distance Δ between the 62.6 GeV and 10 GeV beams near the Compton IP is

$\Delta = \Delta_0 + (d_c - \Delta_s)\theta_d = \Delta_0 + (d_c - \Delta_c)\frac{r_e N_d}{\gamma_d \Delta_0}$, where Δ_c = offset of kick point w.r.t. Compton IP,

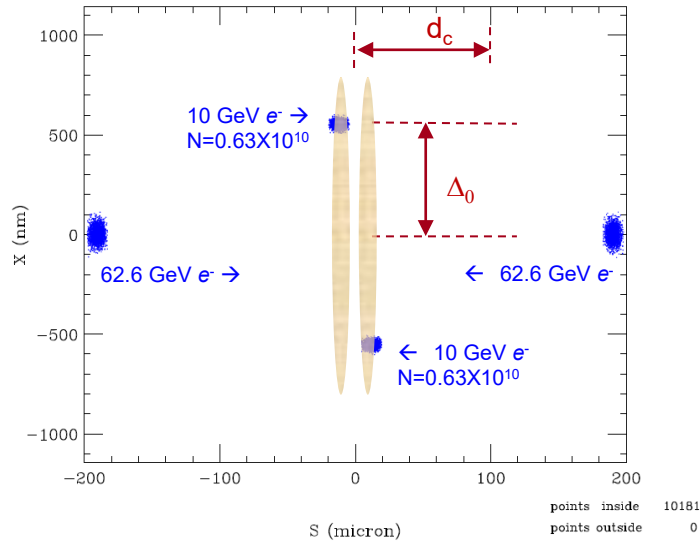
so that the 62.6 GeV beam gets a kick of

$$\theta = \frac{2r_e N_d}{\gamma \Delta} = \frac{2r_e N_d}{\gamma} \frac{1}{\Delta_0 + (d_c - \Delta_c)\frac{r_e N_d}{\gamma_d \Delta_0}}, \text{ where } \gamma = \frac{62.6 \text{ GeV}}{m_e}.$$

Other Deflector Beam Energies

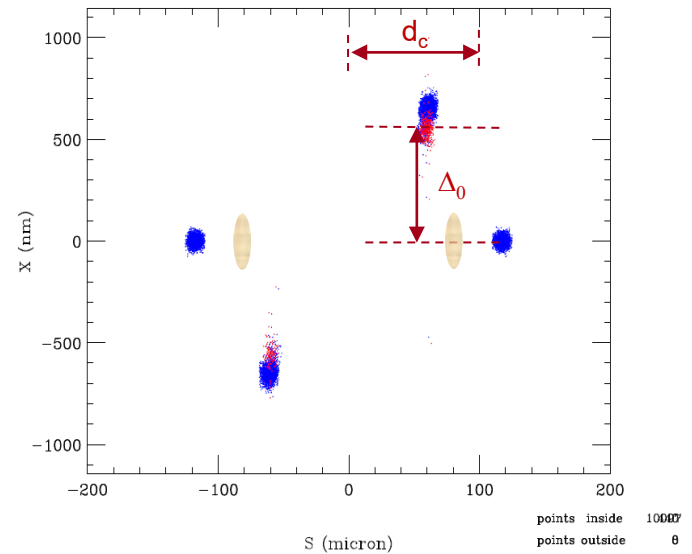
ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
t = -0.19037mm

20210223(081414) CAIN2.42



ILC $\gamma\text{-}\gamma$ for a Higgs Factory 3
t = -0.11748mm

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What about other deflector beam energies?

$$\Delta_0 = \frac{r_e N_d}{\gamma \theta} + \sqrt{\frac{r_e^2 N_d^2}{\gamma^2 \theta^2} - \frac{s_d r_e N_d}{\gamma_d}} = \frac{r_e N_d}{\gamma \theta} \left[1 + \sqrt{1 - \frac{s_d \gamma^2 \theta^2}{r_e \gamma_d N_d}} \right], \quad s_d = d_c - \Delta_c \quad \Delta_c = \frac{\text{offt}}{2} \text{ in CAIN input parlance}$$

$$\Rightarrow \theta_{\max} = \frac{1}{\gamma} \sqrt{\frac{r_e \gamma_d N_d}{s_d}}, \quad N_{d_{\min}} = \frac{s_d \gamma^2 \theta^2}{r_e \gamma_d}, \quad \gamma_{d_{\min}} = \frac{s_d \gamma^2 \theta^2}{r_e N_d}$$

e.g., $\theta = 0.4$ mrad (the kick used in the 10 GeV plots) & $\gamma_d = \frac{1 \text{ GeV}}{0.000511 \text{ GeV}} = 1956.9 \Rightarrow N_{d_{\min}} = 4.3 \times 10^{10}$

To achieve the same kick with a 1 GeV beam we need $N_d = 4.3 \times 10^{10}$ (instead of $N_d = 0.63 \times 10^{10}$).

Other Deflector Beam Energies

$$\Delta_0 = \frac{r_e N_d}{\gamma \theta} + \sqrt{\frac{r_e^2 N_d^2}{\gamma^2 \theta^2} - \frac{s_d r_e N_d}{\gamma_d}} = \frac{r_e N_d}{\gamma \theta} \left[1 + \sqrt{1 - \frac{s_d \gamma^2 \theta^2}{r_e \gamma_d N_d}} \right] = \frac{m_e r_e N_d}{E \theta} \left[1 + \sqrt{1 - \frac{s_d E^2 \theta^2}{m_e r_e E_d N_d}} \right] \quad \delta = s_d \frac{\theta_1}{62.607}$$

$$\Rightarrow \theta_{\max} = m_e \sqrt{\frac{r_e E_d N_d}{m_e s_d}} \quad , \quad N_{d_{\min}} = \frac{d_c \theta^2}{m_e r_e E_d} \quad , \quad E_{d_{\min}} = \frac{d_c \theta^2}{m_e r_e N_d} \quad \text{for } E=1 \text{ GeV \& } m_e, E_d \text{ in GeV}$$

$$\theta_{\max} = 1.2 \times 10^{-7} \sqrt{E_d N_d} \quad , \quad N_{d_{\min}} = 6.94 \times 10^{13} \frac{\theta^2}{E_d} \quad , \quad E_{d_{\min}} = 6.94 \times 10^{13} \frac{\theta^2}{N_d} \quad \text{for } E=1 \text{ GeV \& } E_d \text{ in GeV}$$

$N_d (10^{10})$	$E_d (\text{GeV})$	$\theta_1 (\text{mrad})$	$\theta_{62.607} (\text{mrad})$	$\sigma_{d_z} (\mu\text{m})$	$\Delta_f (\mu\text{m})$	$N_{d_{\min}} (10^{10})$	$E_{d_{\min}} (\text{GeV})$	$\theta_{1_{\max}} (\text{mrad})$	$\theta_{62.607_{\max}} (\text{mrad})$	$\delta_{\max} (nm)$
	1	25.29	0.4039			4.3				
0.63		25.29	0.4039				7.04			
1		25.29	0.4039				4.44			
.63	10			3	33.63			30.1	0.481	40.0
.63	30			3	33.63			52.2	0.833	69.3
1	5							26.8	0.428	
2	10			3	33.63			53.7	0.857	71.3
2	10			5	41.63				0.857	67.9
2	10			10	61.63				0.857	59.3
2.5	10			3	33.63			60.0	0.958	79.7
2.5	10			5	41.63				0.958	75.9
2.5	10			10	61.63				0.958	66.3
3	10			3	33.63			65.7	1.050	87.3
3	10			5	41.63			65.7	1.050	83.1
3	10			10	61.63			65.7	1.050	72.6
5	10			3	33.63			84.9	1.355	112.7
5	10			5	41.63					107.3
5	10			10	61.63					93.7
.63	30							52.2	0.834	