

Optics for Compton Spectrometer

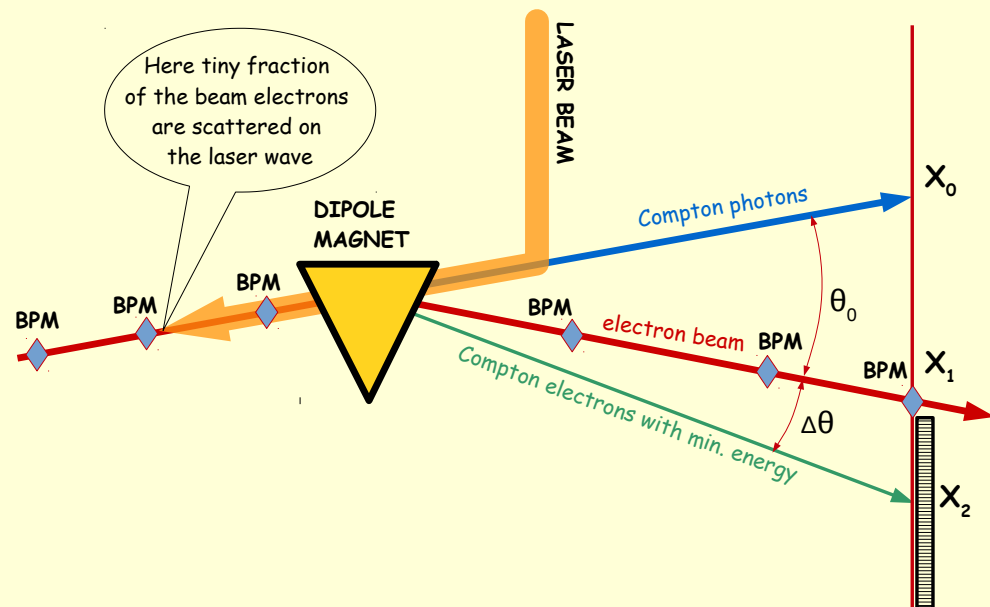
K. Oide, based on suggestions by Nickolai Muchnoi, Alain Blondel

30 Nov. 2017

XIth FCC-ee Energy Calibration and Polarization WG meeting

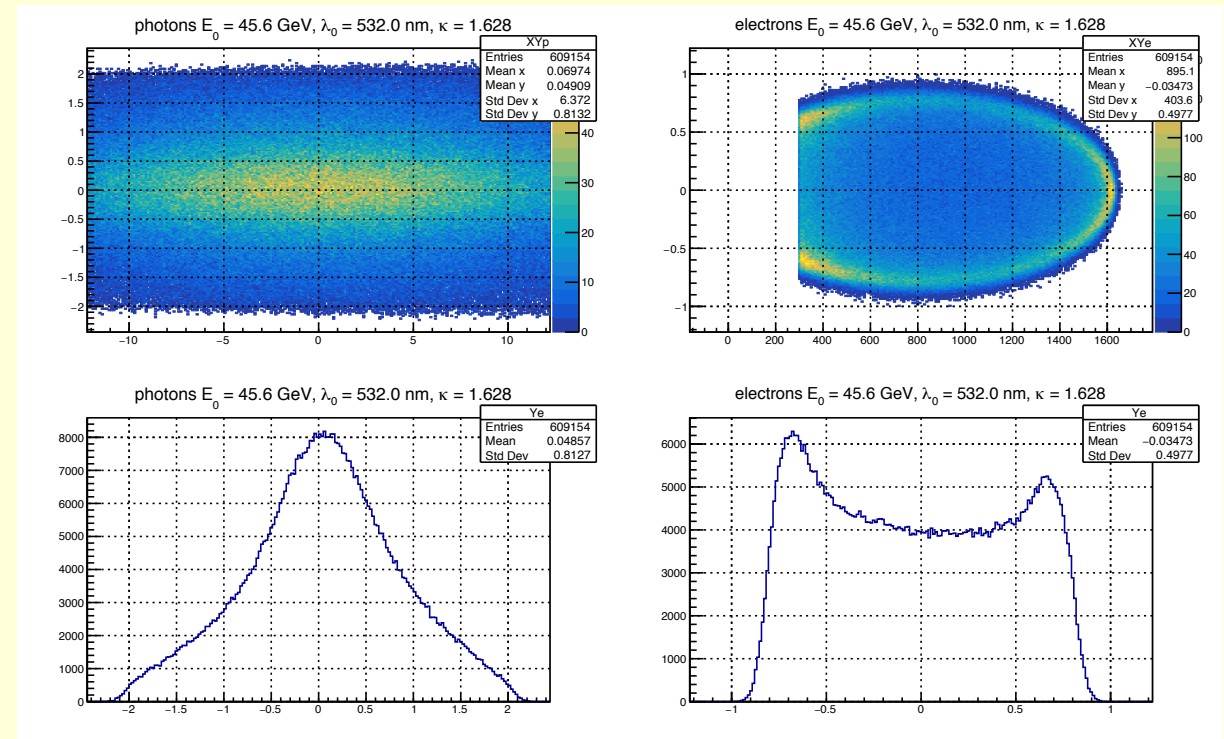
Inverse Compton Spectrometer for energy calibration

Spectrometer with laser calibration



$$\text{Access to the beam energy: } E_0 = \frac{\Delta\theta}{\theta} \times \frac{(mc^2)^2}{4\omega_0}$$

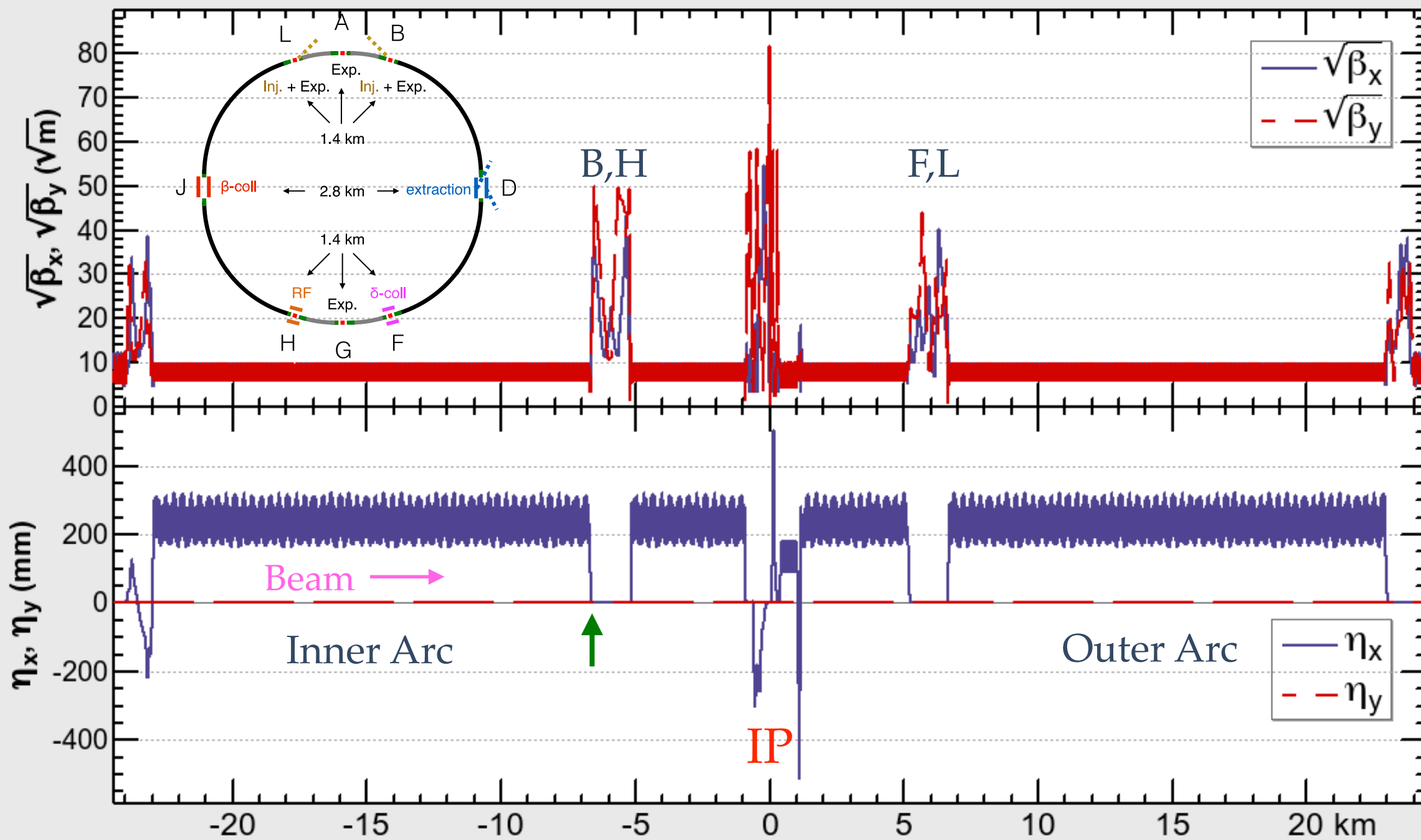
FCC-ee, 45.6 GeV, 2.33 eV, $P_{\perp} = 0.4$

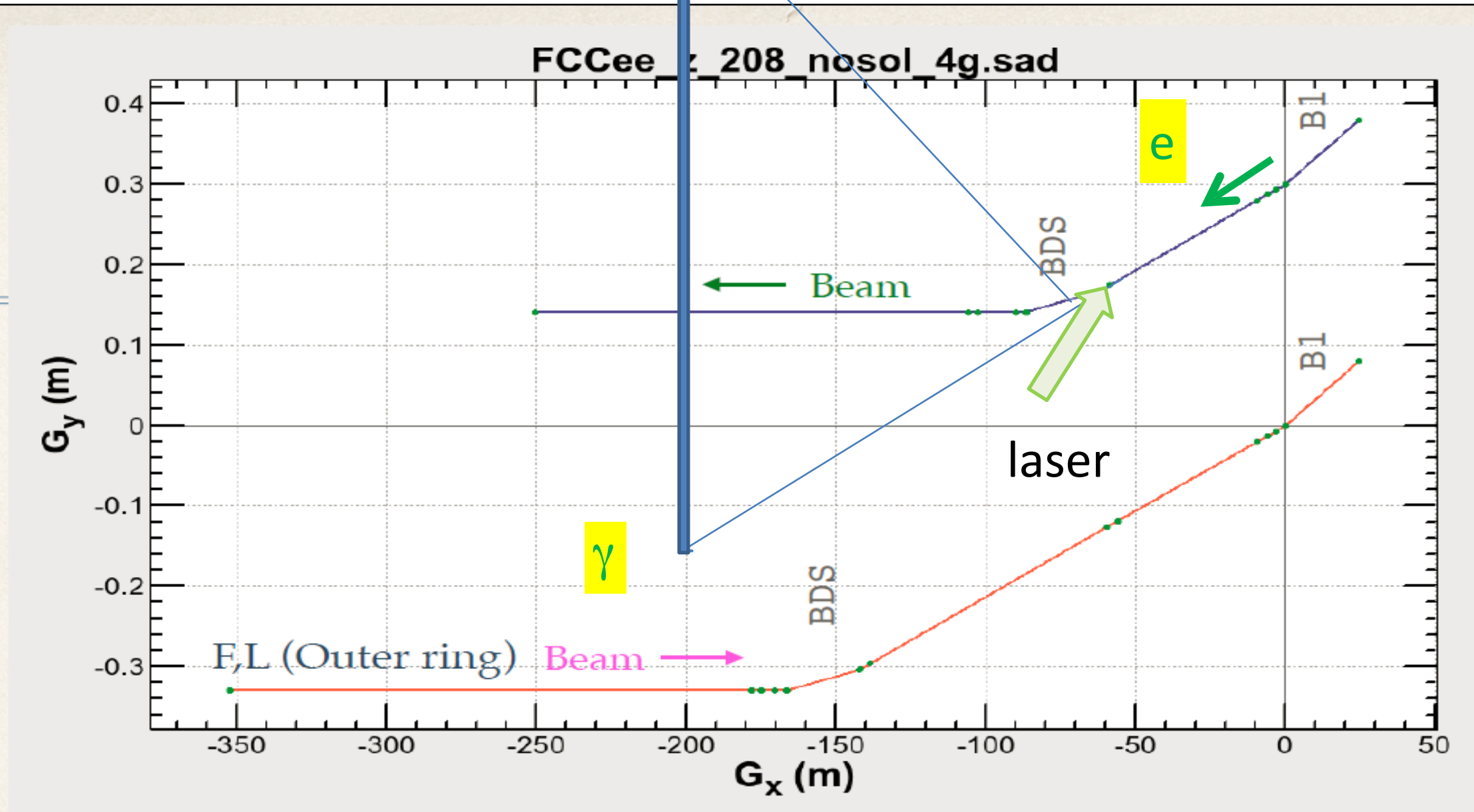


- ❖ The scattering parameters are estimated from the 2D distributions of the scattered photons and electrons.
- ❖ Does not rely on the BPM readings.
- ❖ Quadrupoles after the dipole are unfavorable.

Possible Location for the spectrometer

FCCEe_z_210_nosol_1.sad





The dispersion suppressor dipole (BDS):

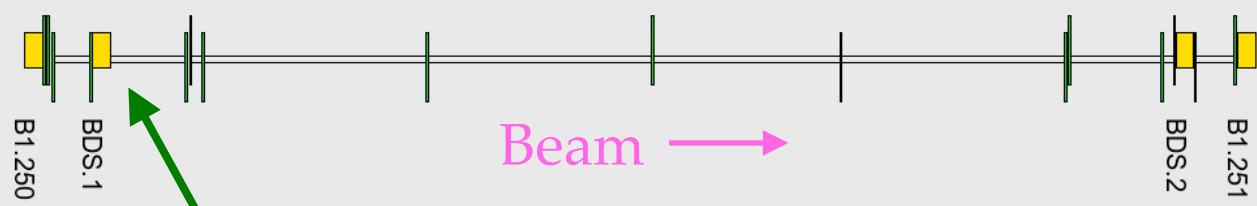
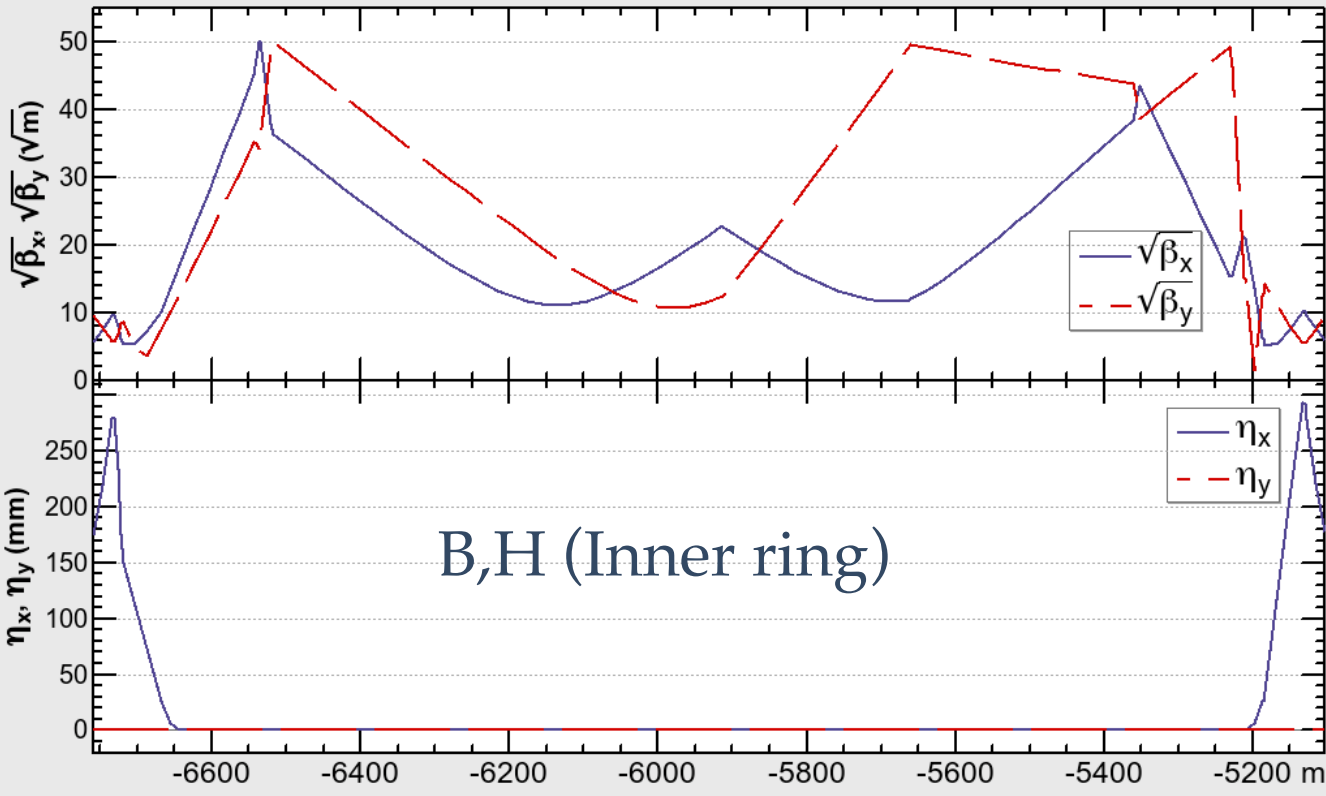
Require that there is no quadropole on the trajectory of the outgoing electrons of the lowest energy

```

;
BEND   BDS      =(L =24.119925292770883  ANGLE =.002134100603580931  E1 =.5  E2 =.5 )
;

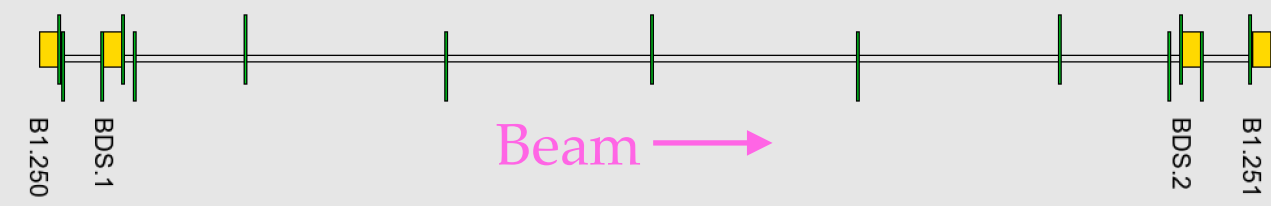
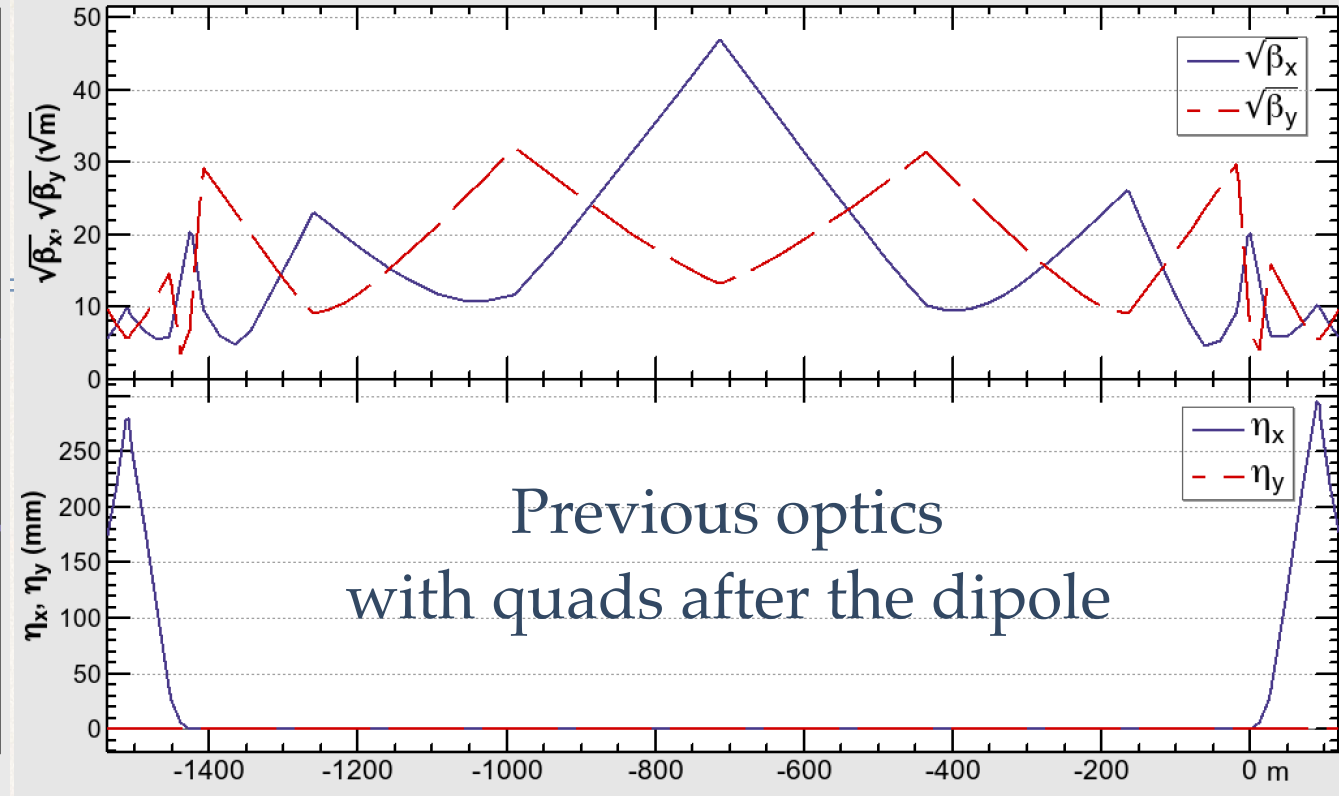
```


FCCEe_z_210_nosol_1.sad



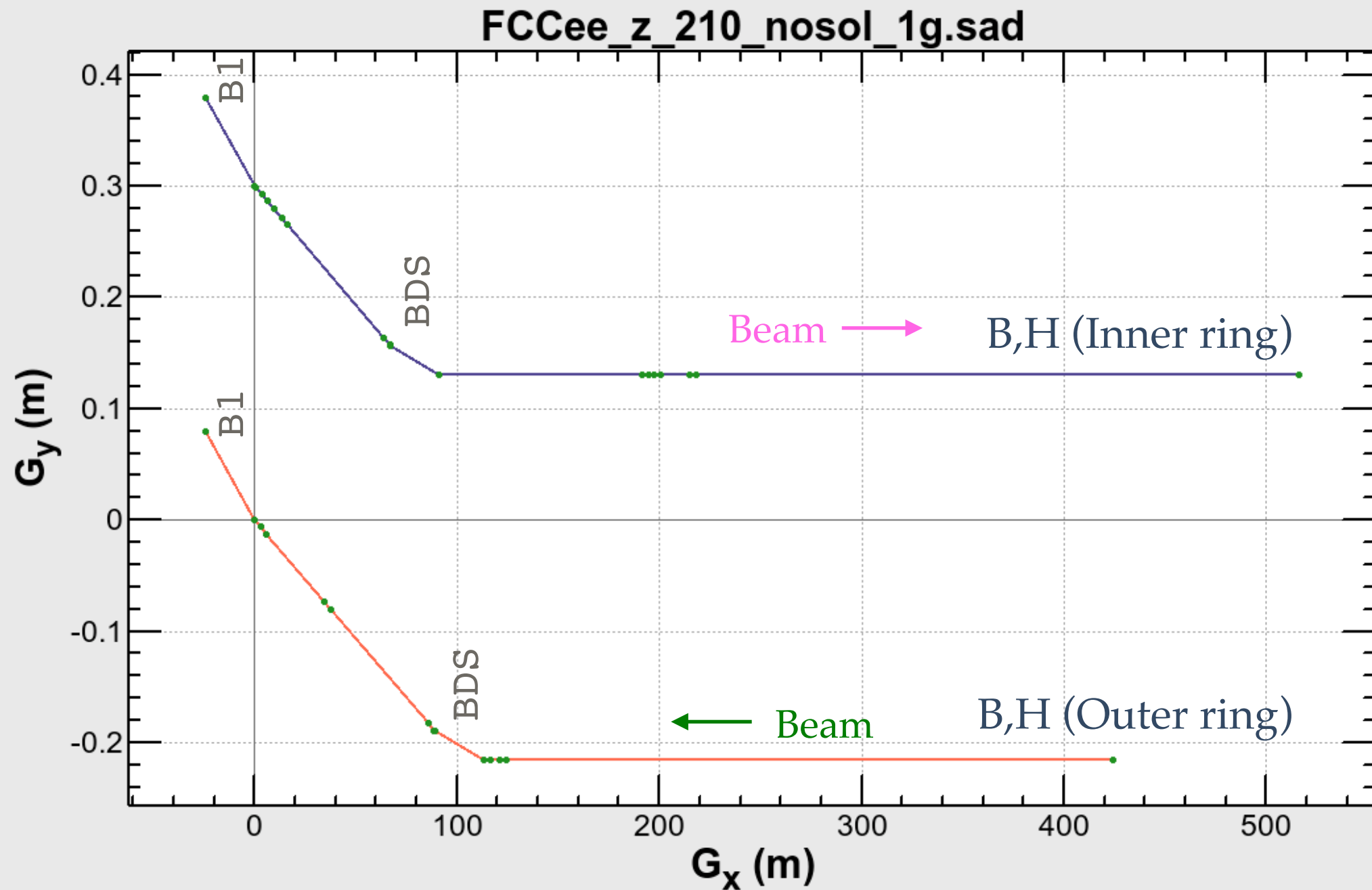
No quads after the dipole for 100 m.

FCCEe_z_208_nosol_4.sad



The dispersion suppressor dipole (BDS):

```
;
BEND  BDS      =(L =24.119925292770883  ANGLE =.002134100603580931  E1 =.5  E2 =.5 )
;
```

The dispersion suppressor dipole (BDS):

```

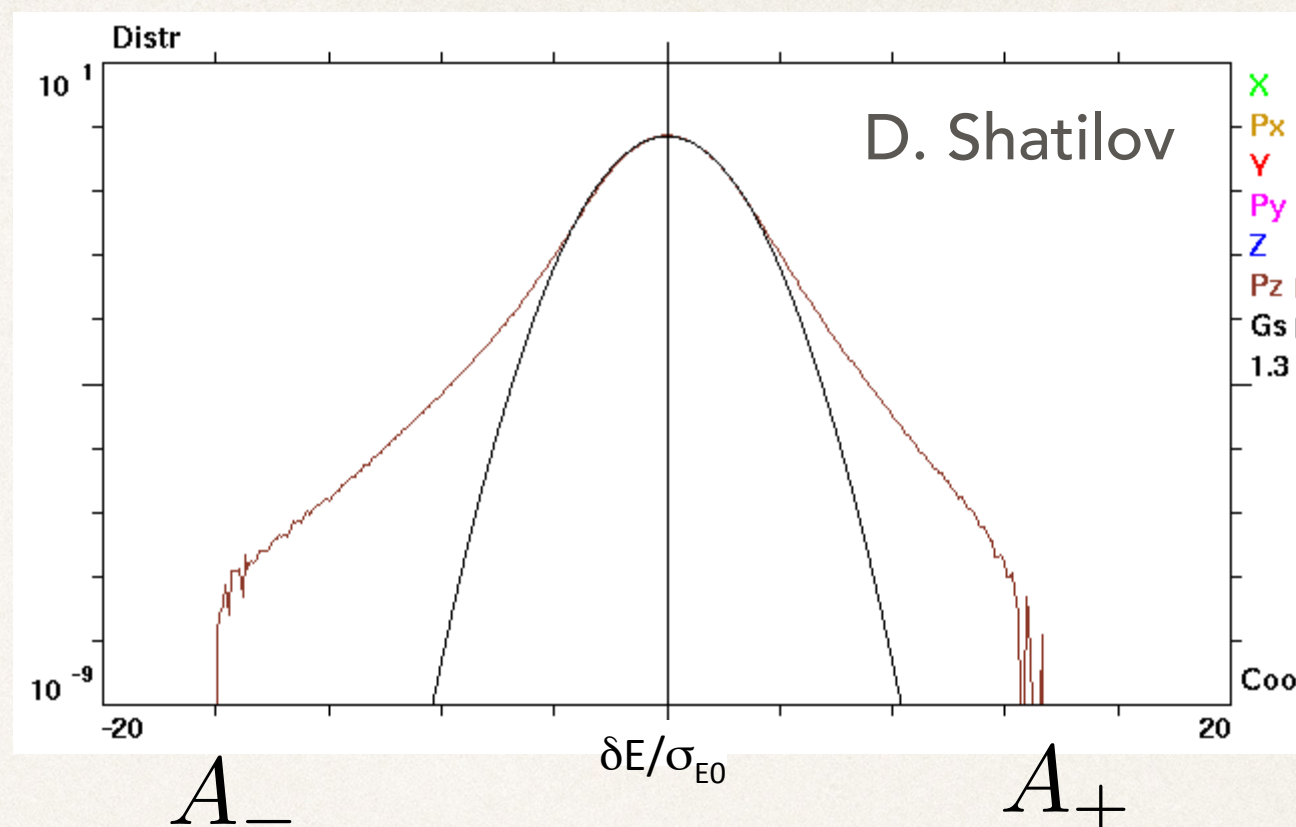
;
BEND BDS      =(L =24.119925292770883  ANGLE =.002134100603580931  E1 =.5  E2 =.5 )
;

```


E = 182.5 GeV

$\sigma_{E0} = 0.00153$, $\sigma_E = 0.00193$,
Black line: Gauss with $\sigma_E = 1.3 \sigma_{E0}$

Energy acceptance: 2.5% = $16.3 \sigma_{E0}$



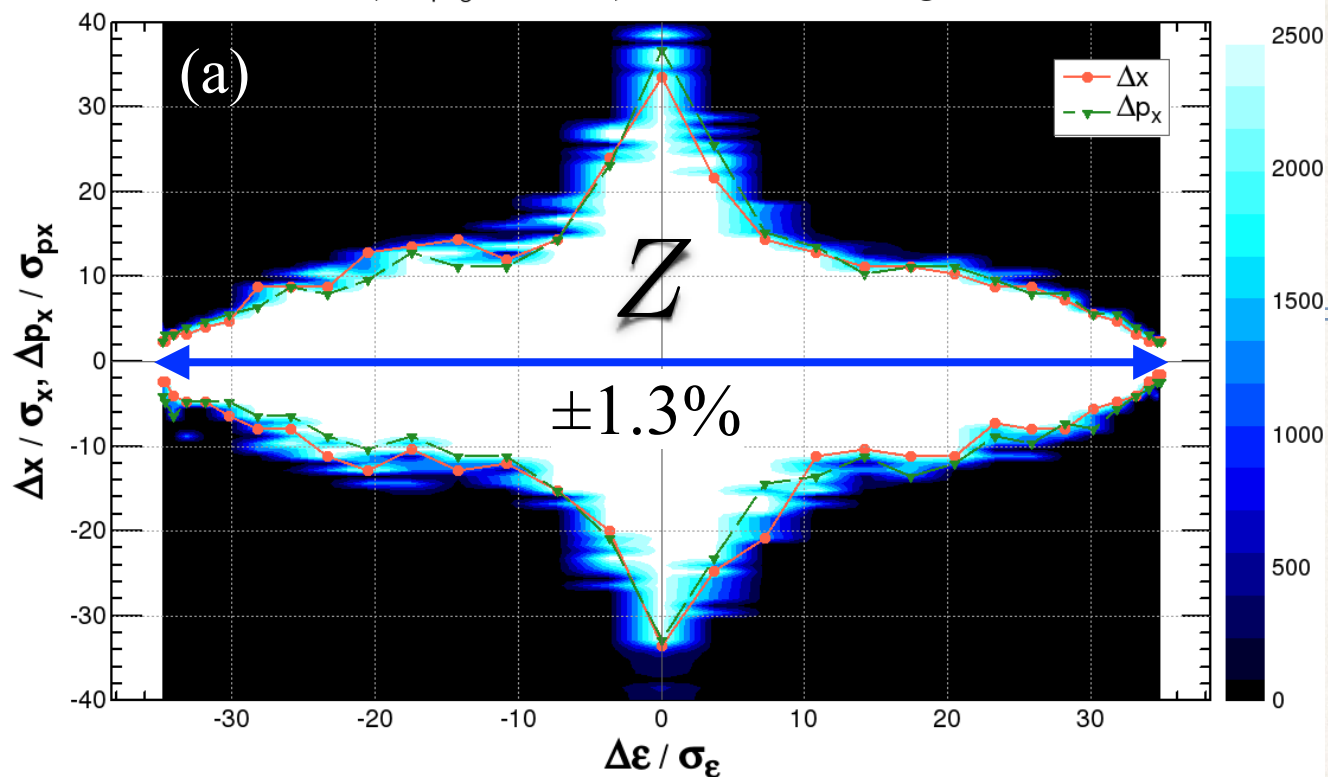
- ❖ The expected energy distribution of the beam has asymmetric tail due to beamstrahlung (D. Shatilov, as above).
- ❖ Thus the required momentum acceptance should be asymmetric: Wider aperture in the negative side.
- ❖ The aperture of the positive side can be expressed as the summation of damping and diffusion terms in a half synchrotron period:

$$A_+ \approx -A_- \exp(-\alpha_z/2\nu_s) + 3\sigma_{\delta,BS} \sqrt{1 - \exp(-\alpha_z/\nu_s)}$$

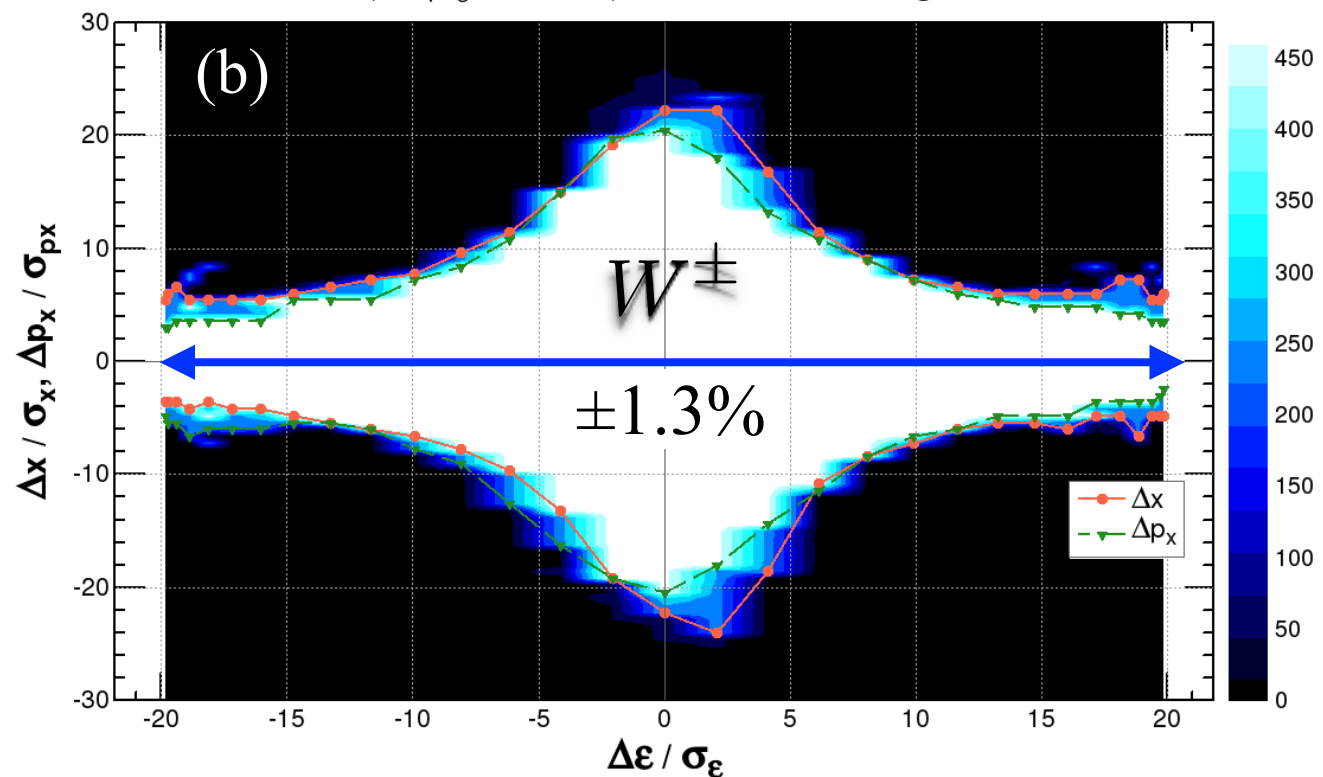
with the longitudinal damping rate α_z .

Dynamic Aperture — looks OK for all energies

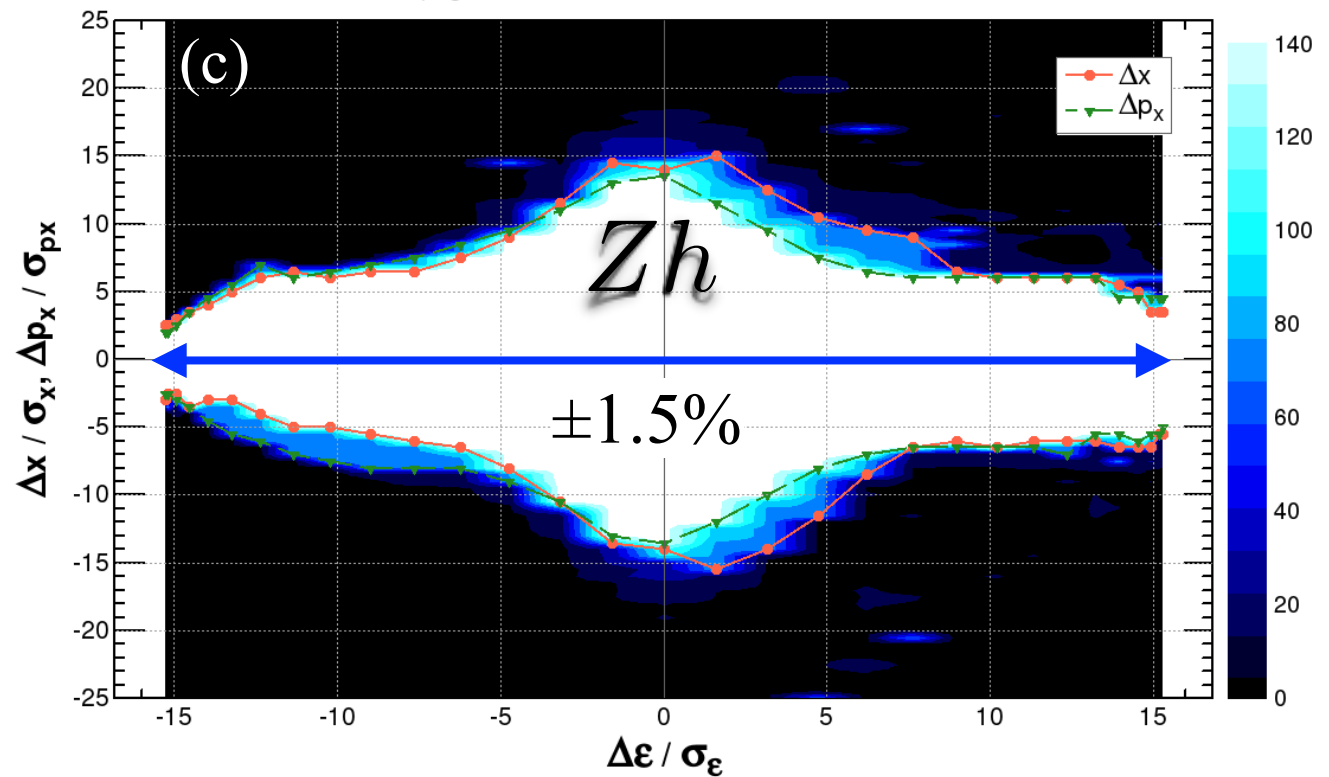
FCCee_z_211_nosol_3.sad: $\epsilon_x = .26$ nm, $\epsilon_y/\epsilon_x = 0.38\%$, $\sigma_\epsilon = 0.037\%$, $\sigma_z = 3.5$ mm,
 $\beta_{x,y} = \{.15$ m, .8 mm}, $v_{x,y,z} = \{269.1380, 269.2199, -0.0245\}$, Crab Waist = 97%
 2550 turns, Damping: each element, Touschek Lifetime: 13785 sec @ $N = 4 \times 10^{10}$



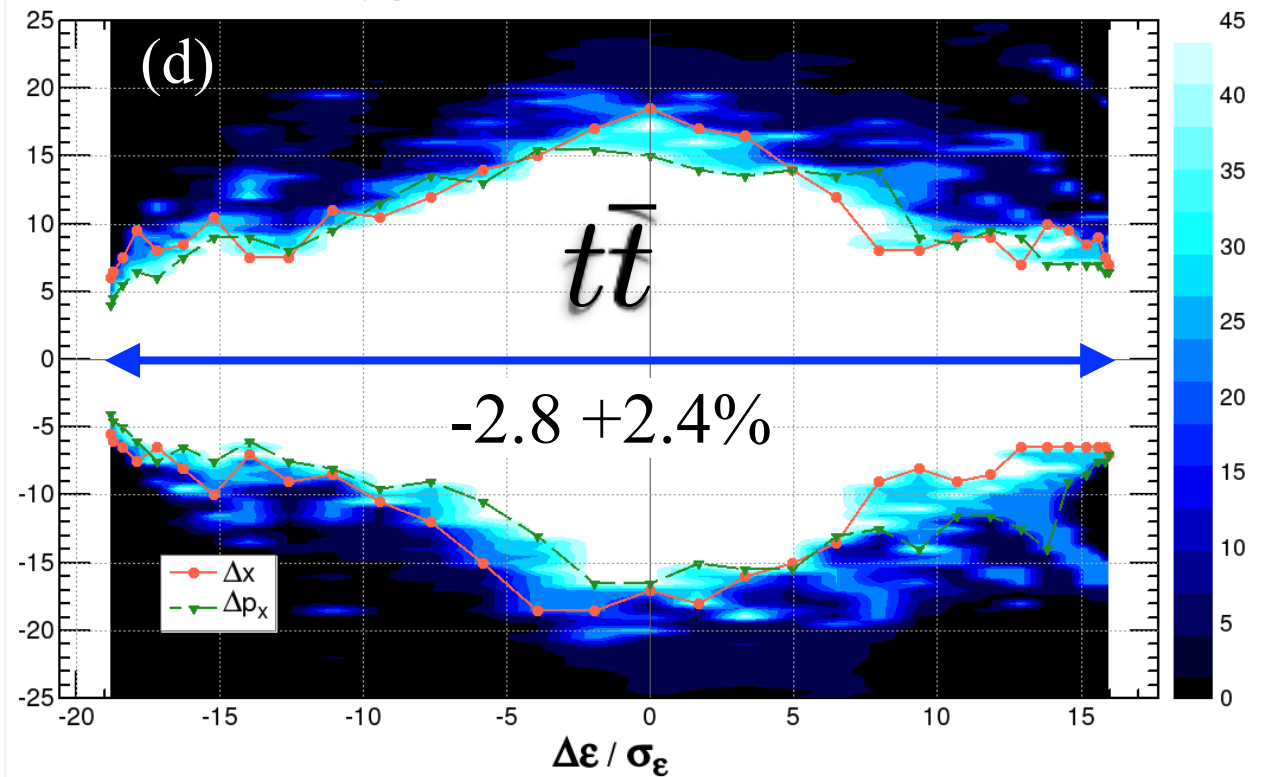
FCCee_w_211_nosol_3.sad: $\epsilon_x = .28$ nm, $\epsilon_y/\epsilon_x = 0.36\%$, $\sigma_\epsilon = 0.065\%$, $\sigma_z = 3.3$ mm,
 $\beta_{x,y} = \{.2$ m, 1 mm}, $v_{x,y,z} = \{389.1538, 389.2196, -0.0227\}$, Crab Waist = 90%
 475 turns, Damping: each element, Touschek Lifetime: 58401 sec @ $N = 4 \times 10^{10}$



FCCee_h_211_nosol_11.sad: $\epsilon_x = .62$ nm, $\epsilon_y/\epsilon_x = 0.16\%$, $\sigma_\epsilon = 0.098\%$, $\sigma_z = 3.2$ mm,
 $\beta_{x,y} = \{.3$ m, 1 mm}, $v_{x,y,z} = \{389.1294, 389.1985, -0.0354\}$, Crab Waist = 85%
 145 turns, Damping: each element, Touschek Lifetime: 942357 sec @ $N = 4 \times 10^{10}$



FCCee_t_211_nosol.sad: $\epsilon_x = 1.43$ nm, $\epsilon_y/\epsilon_x = 0.20\%$, $\sigma_\epsilon = 0.149\%$, $\sigma_z = 2.5$ mm,
 $\beta_{x,y} = \{1$ m, 1.98 mm}, $v_{x,y,z} = \{389.1038, 389.1762, -0.0680\}$, Crab Waist = 50%
 45 turns, Damping: each element, Touschek Lifetime: 9.49E7 sec @ $N = 1 \times 10^{10}$



Summary

- ❖ The optics of the inner ring of the short straight section B, H are modified to install the Compton spectrometer.
- ❖ Quadrupoles are removed after the dispersion suppressor dipole (BDS) for 100 m.
- ❖ Dynamic aperture looks OK at ttbar, and in progress for other energies.
- ❖ An optimization of DA with asymmetric momentum acceptance has been tried fo ttbar.