

Bruno Final Focus Modeling and some Background Studies

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CALTECH SuperB Workshop

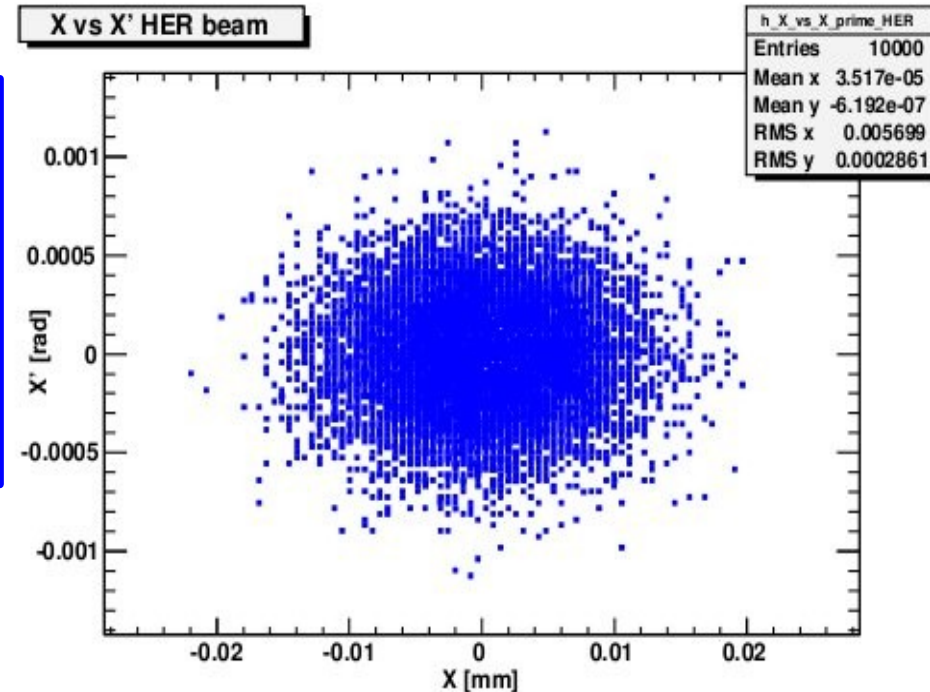
Outline

- **Final focus validation (v12 sf10 alyout)**
- **Final focus quality test**
- **Touschek background strategy**
- **Pair background and SVT occupancy (a rough estimate)**
- **Summary and outlook**

Final Focus Validation: The method (I)

- Use final focus v12 sf10 layout
- Generate particles (10k) with the beam parameters (HER and LER) at the IP:
 - All particles are generated at $Z = 0$ and at the nominal beam energy

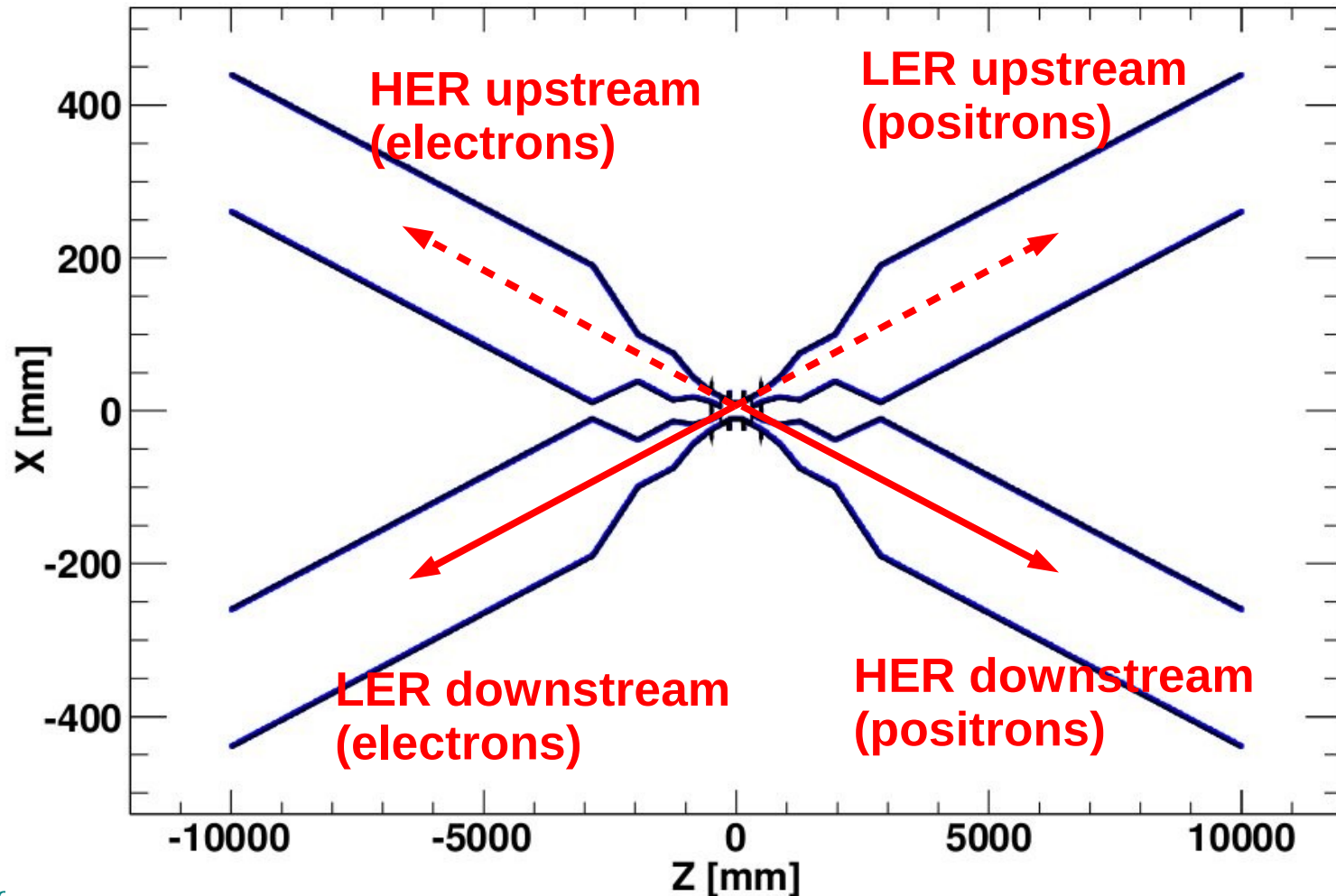
parameter	HER (e ⁺)	LER (e ⁻)
Energy	6.69 GeV	4.18 GeV
σ_x	7.3×10^{-3} mm	8.7×10^{-3} mm
β_x	26.0 mm	32.0 mm
σ_y	36.0×10^{-6} mm	35.0×10^{-6} mm
β_y	253.0×10^{-3} mm	205.0×10^{-3} mm
α_z	-30mrad	$\pi + 30$ mrad



- Feed this particles into Bruno which transport them into the final focus field
- Builds special scoring geometry to study beam optics (see next slides)
- Goal: comparison with design values

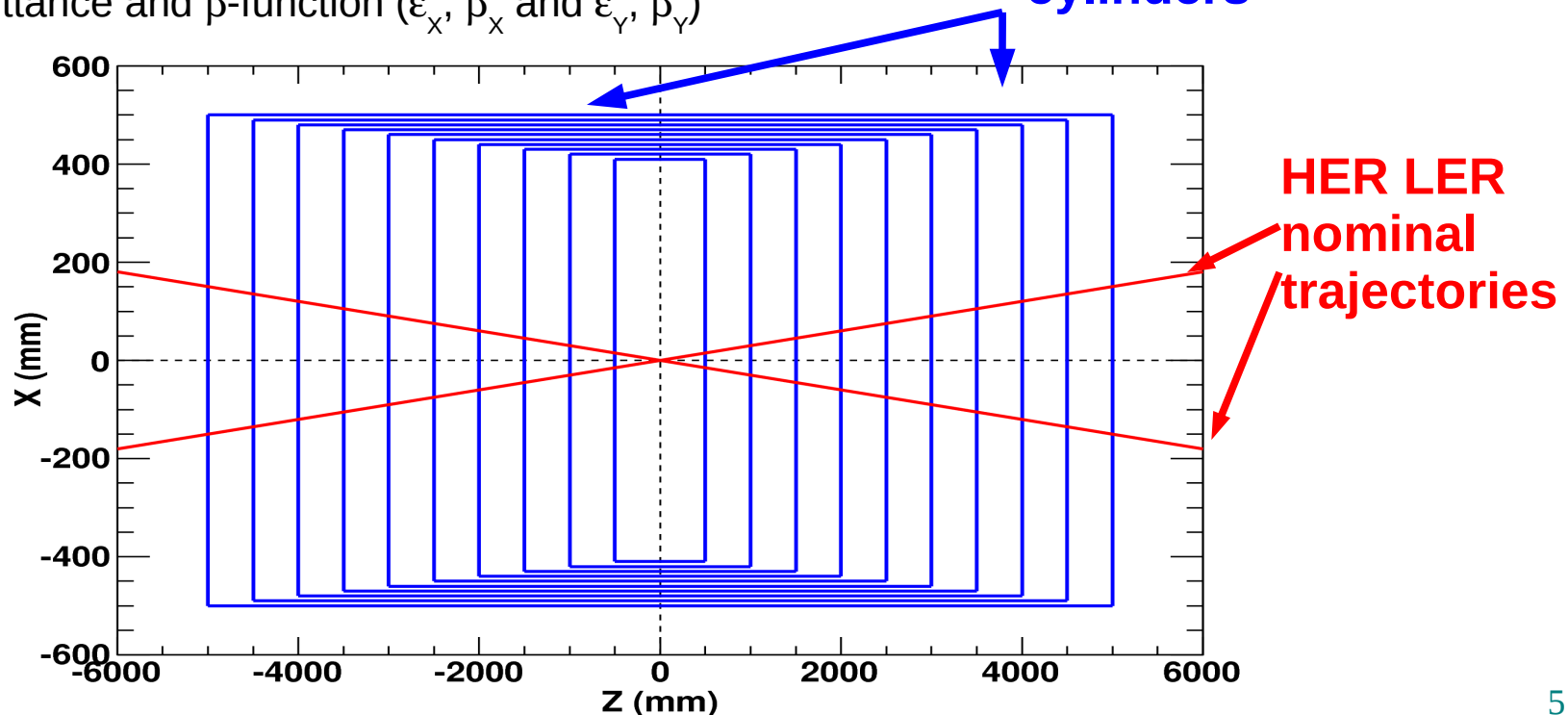
Final Focus Validation: The method (II)

- Can sketch down and up stream HER and LER magnetic modeling
 - Downstream: shoot particles with nominal parameters
 - Upstream: shoot particles with nominal parameters inverting momenta and charge



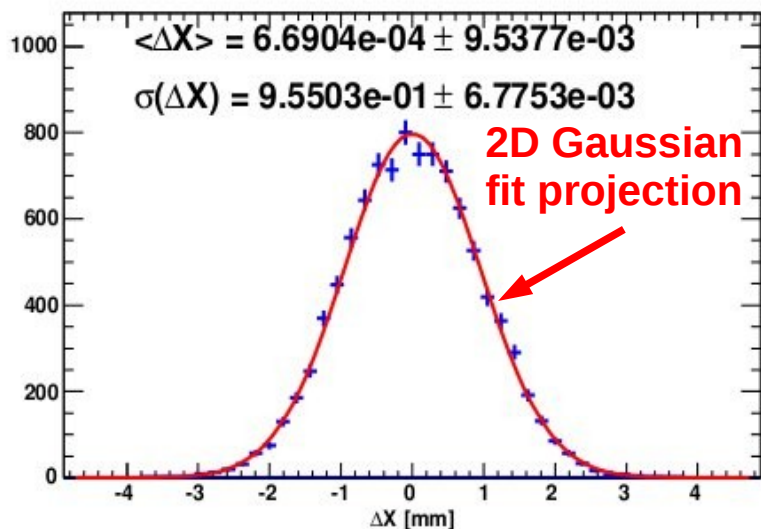
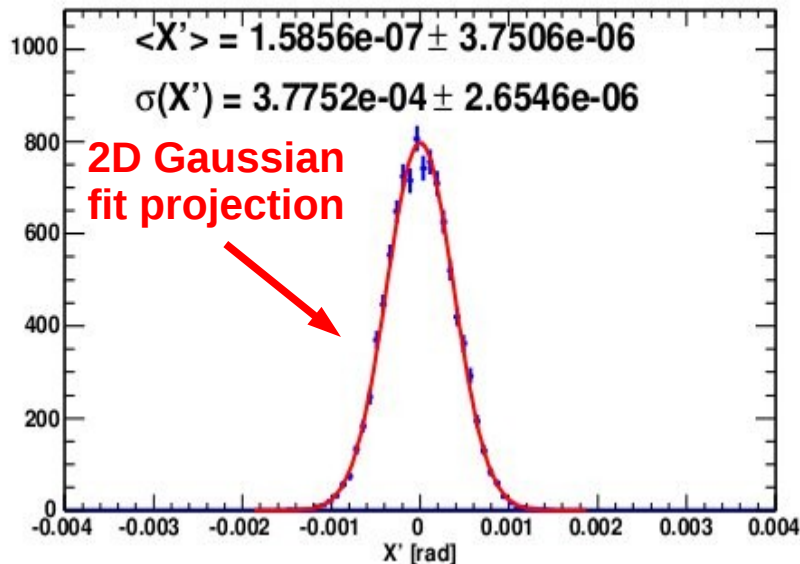
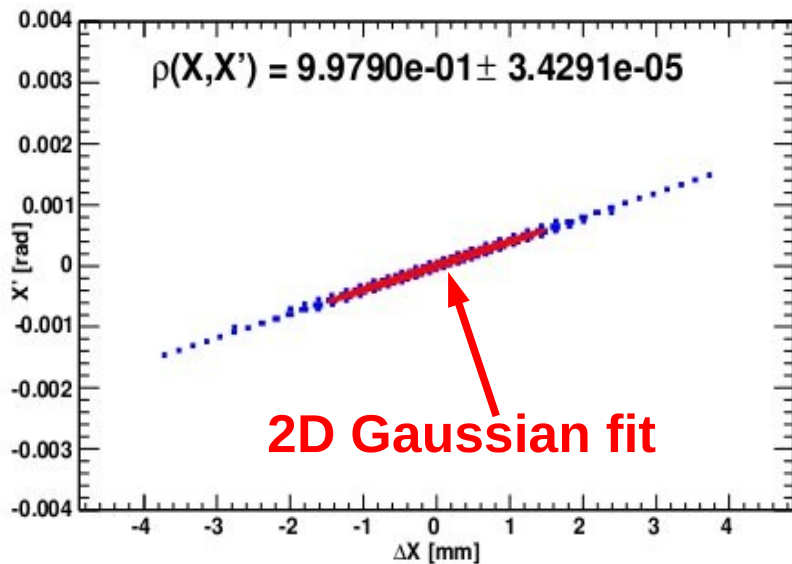
Final Focus Validation: The method (III)

- Build 100 scoring concentric cylinders (material is vacuum) along Z axis
 - Half lengths from 5 cm to 5 m. Step size is 5cm.
 - Radius from 40 cm to 50 cm. Step size is 1 mm.
- Use end-caps of scoring cylinders to sketch beam parameters as a function of Z coordinate
- Can calculate in this way quantities like:
 - Beam sizes and angular dispersion ($\sigma_x, \sigma(X')$ and $\sigma_y, \sigma(Y')$)
 - Emittance and β -function (ϵ_x, β_x and ϵ_y, β_y)



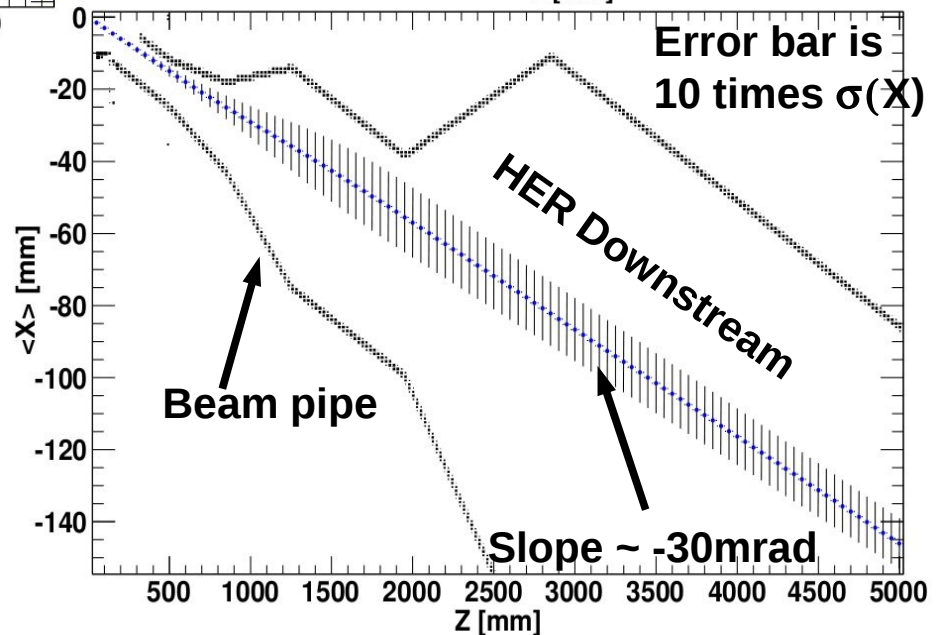
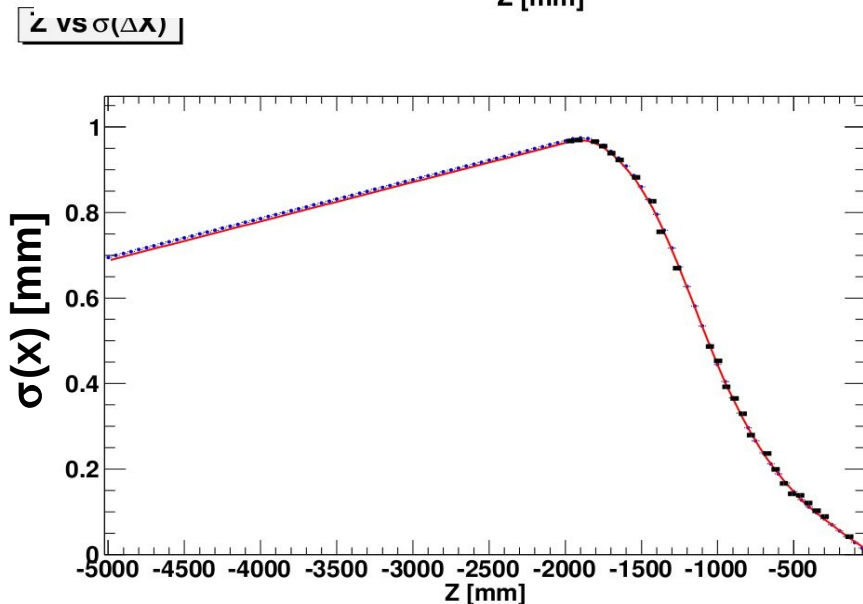
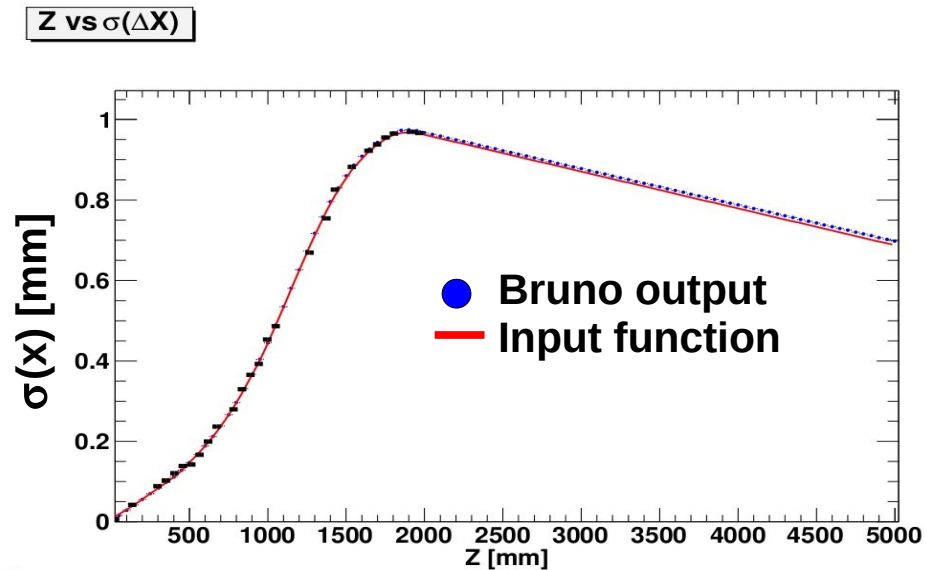
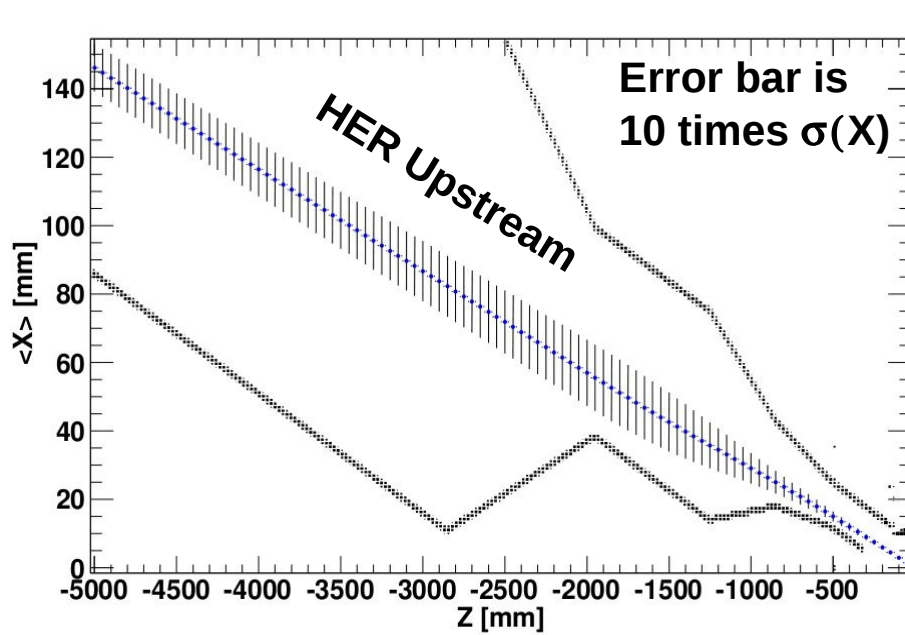
Final Focus Validation: Results HER (I)

HER: X and X' for Z scoring end-cap at 175 cm from IP

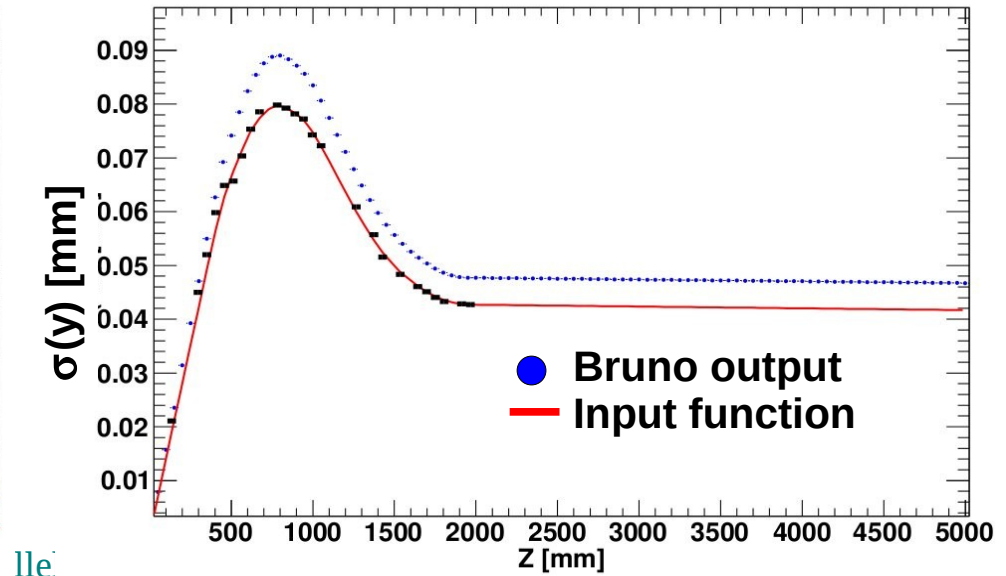
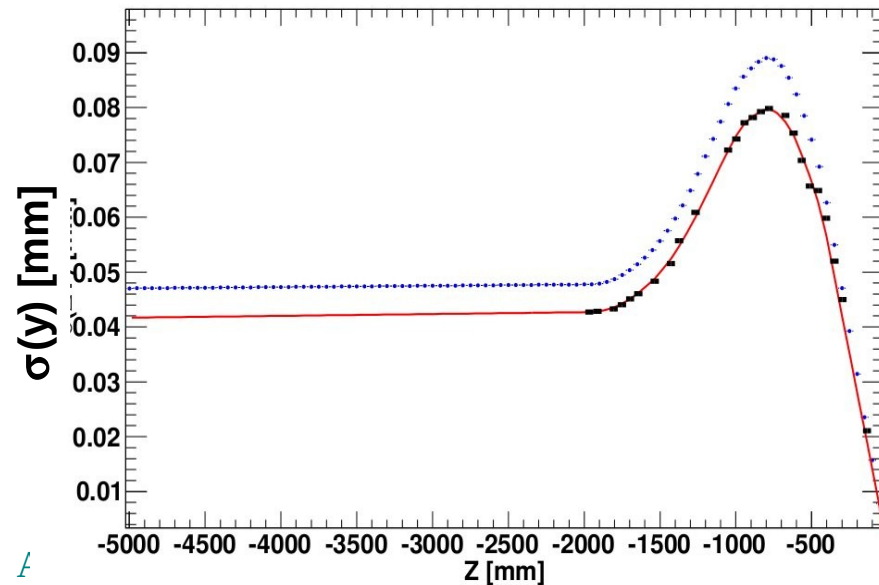
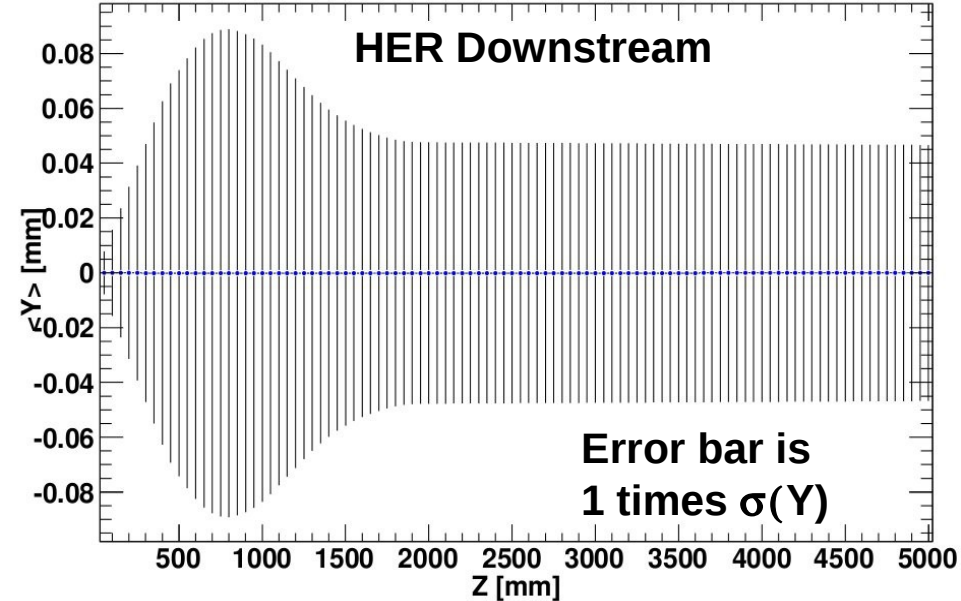
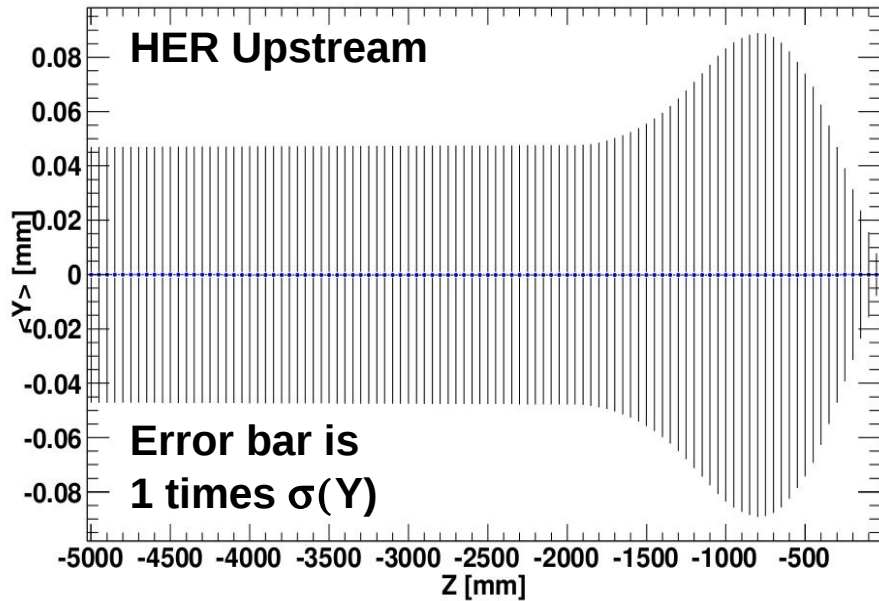


- The X and Y displacements, as well as the X' and Y' angular dispersions maintain their Gaussian behaviour as the beam evolves (as a function of Z), **as expected!**

Final Focus Validation: Results HER (II)



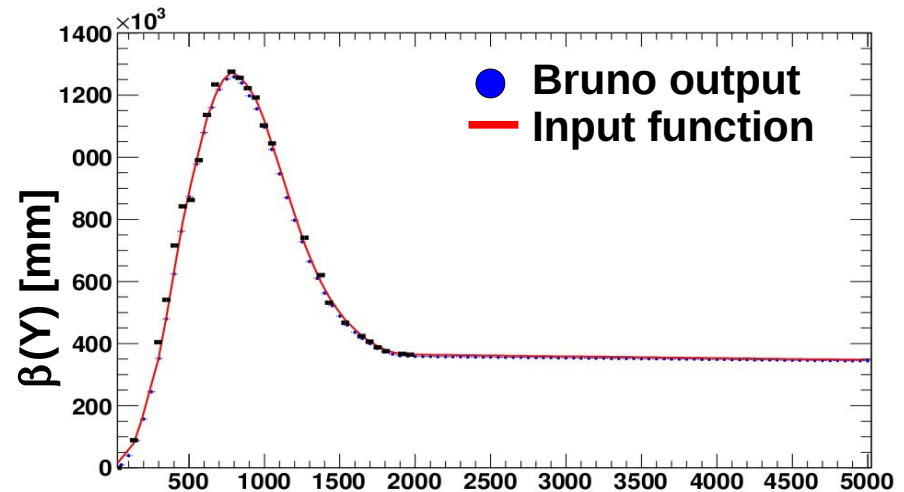
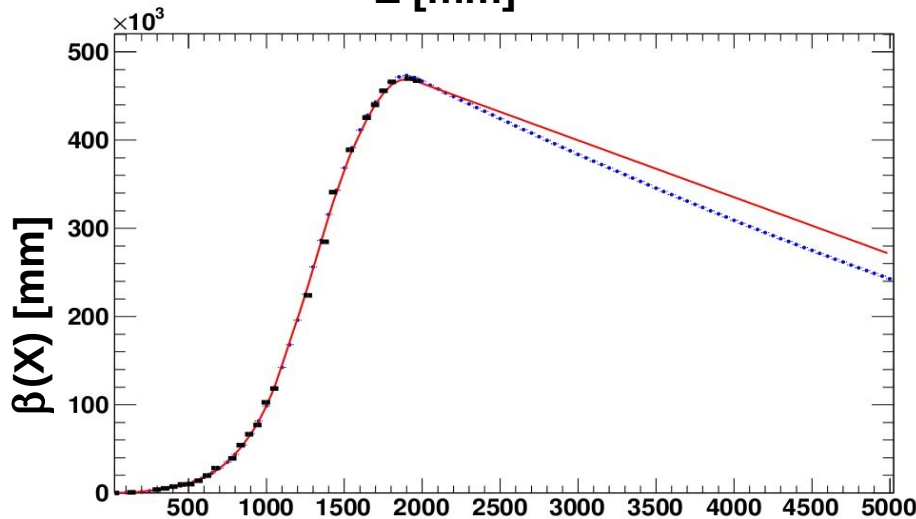
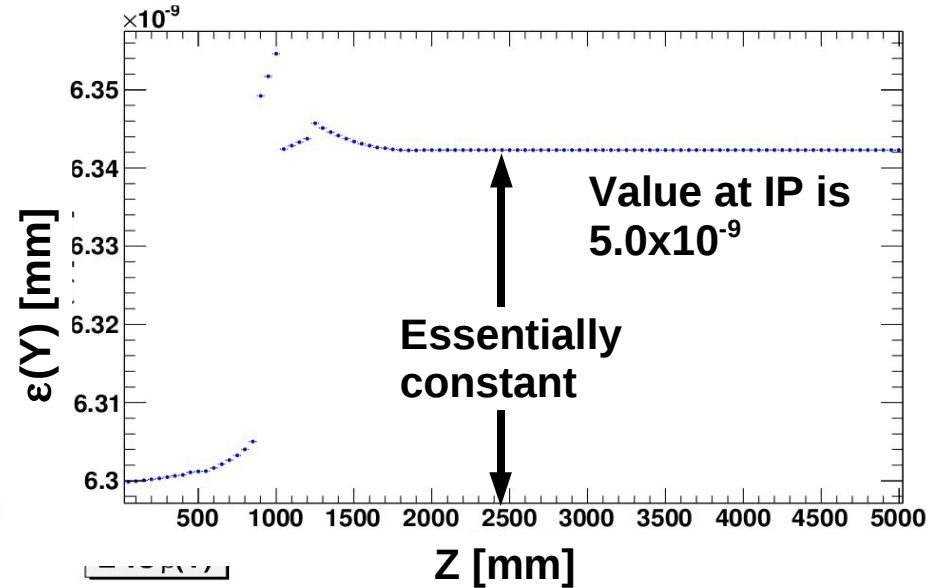
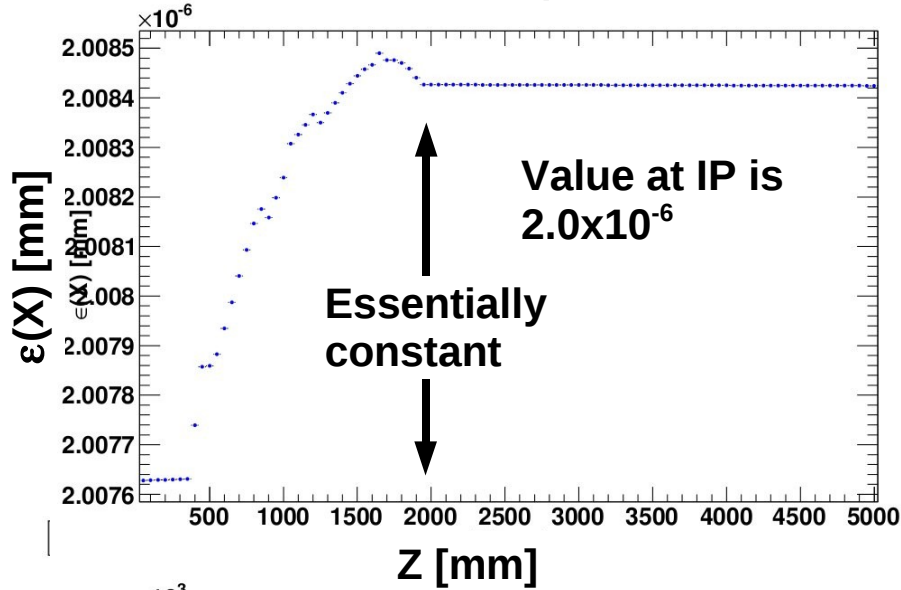
Final Focus Validation: Results HER (III)



Final Focus Validation: Results HER (IV)

Z vs $\epsilon(X)$

HER: ϵ and β as a function of Z scoring end-cap

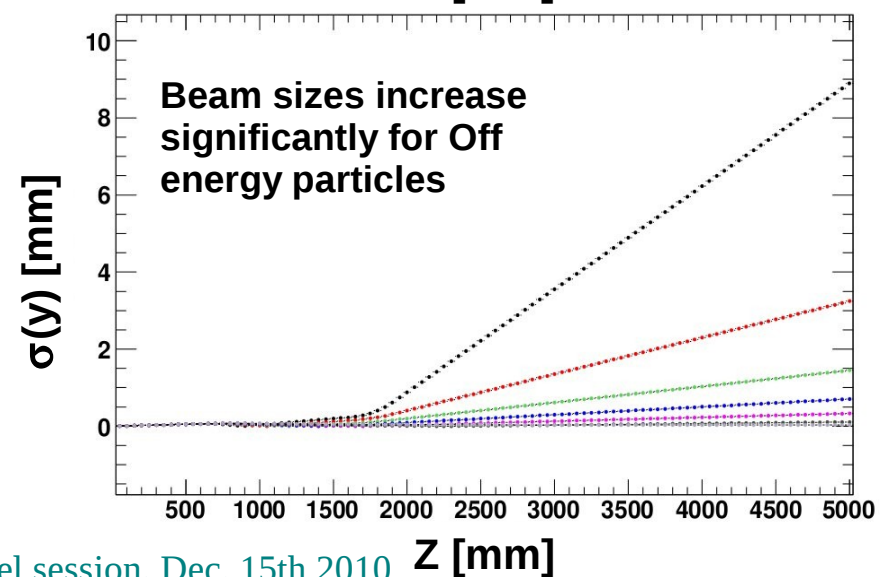
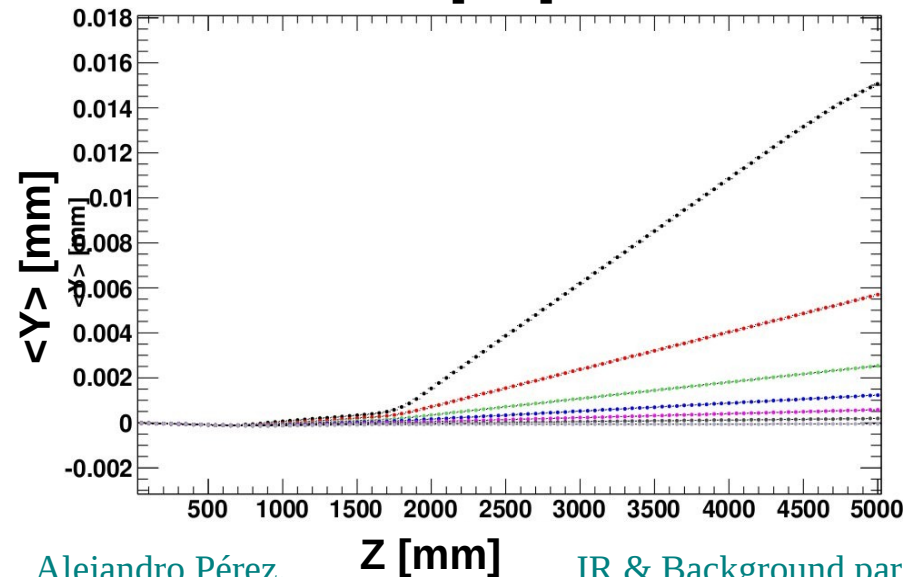
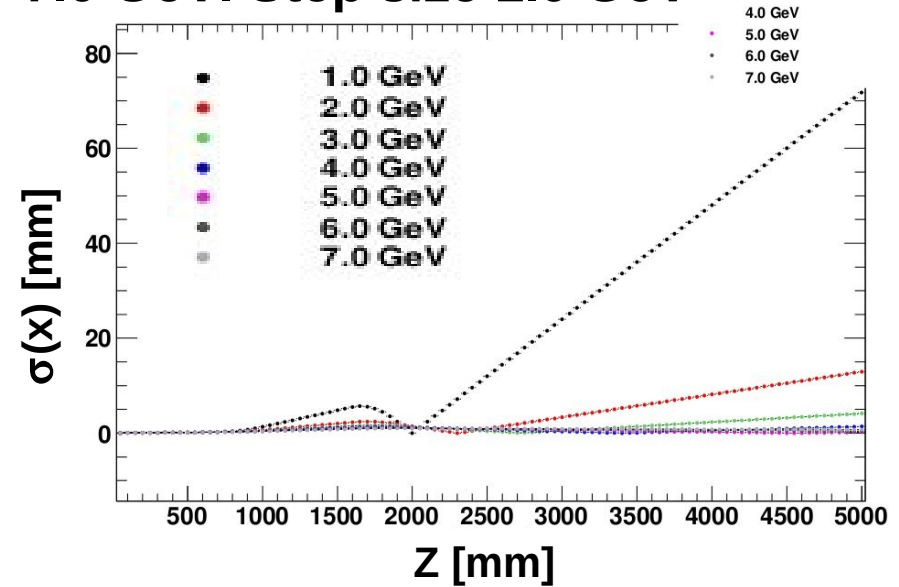
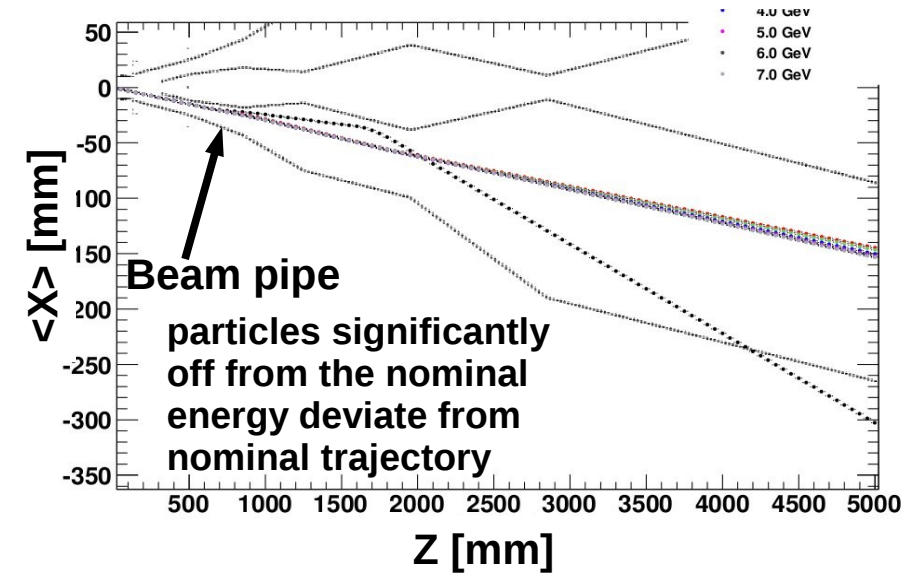


Final Focus QA tests

- **Off energy particles through the beam pipes:**
 - **HER:** Energy scan from 1.0GeV to 7.0GeV (step size 1.0GeV)
 - **LER:** Energy scan from 0.5GeV to 4.0GeV (step size 0.5GeV)
- **Use the concentric cylinders scoring boundaries to sketch the beam parameters: σ_x $\sigma(X')$ and σ_y $\sigma(Y')$**
- **Radiative Bhabha events:**
 - Use beam pipes as scoring boundaries
 - Study the minimum energy transfer to the photon ($\Delta E/E|_{\min}$) of those interactions that produces a hit in the beams
 - Can estimate the optimal $\Delta E/E|_{\min}$ parameter for full simulation radiative Bhabha production

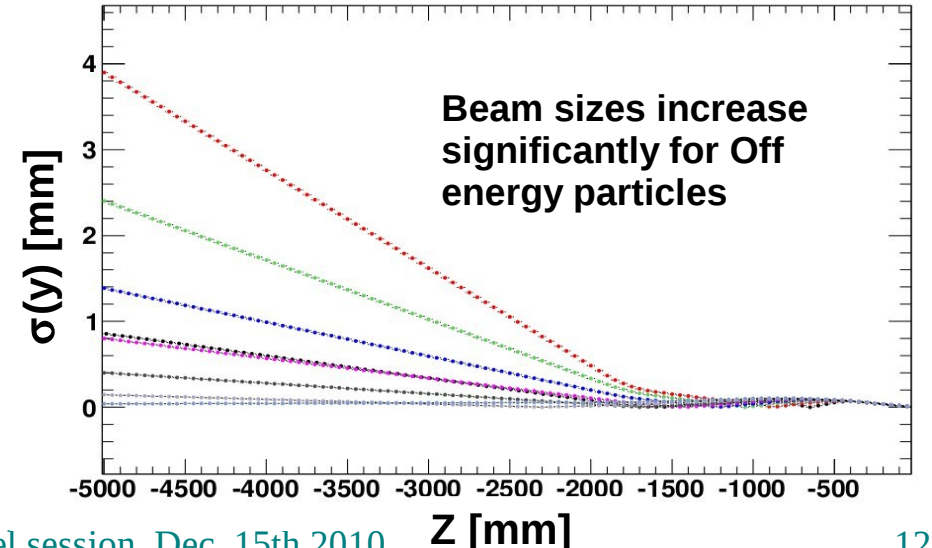
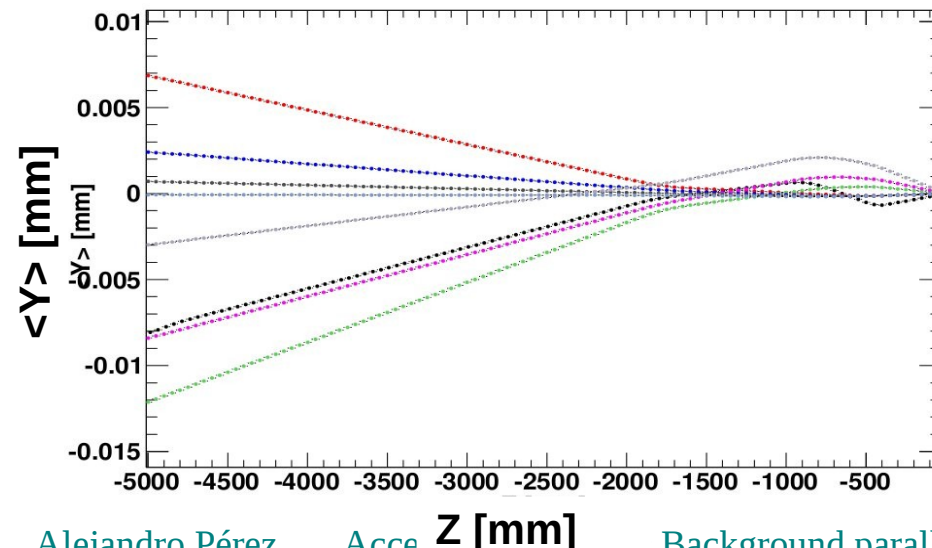
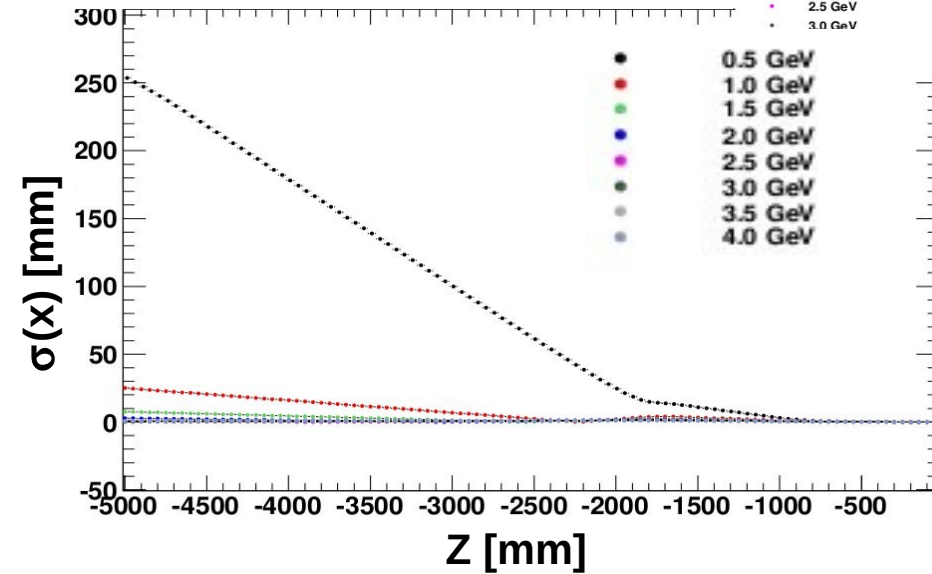
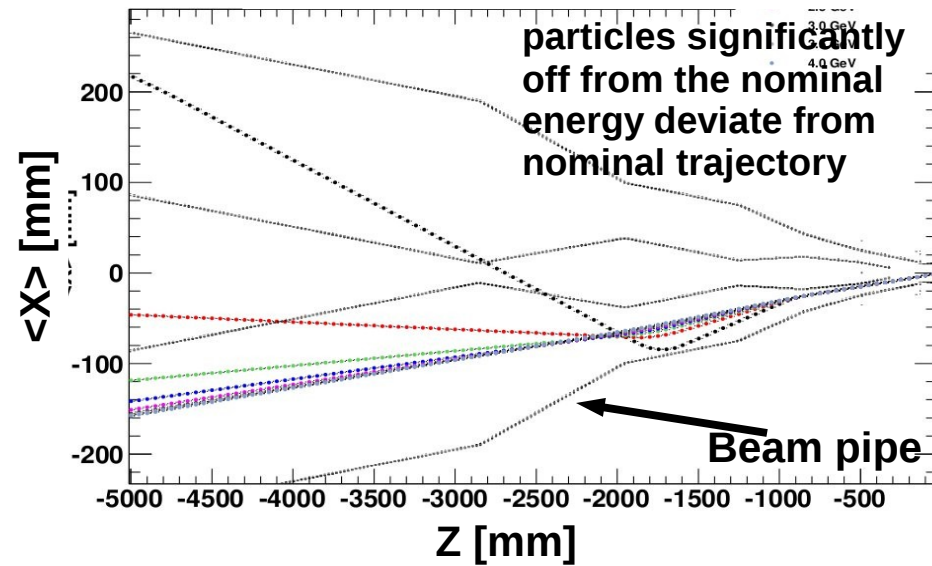
Final Focus QA: HER Off-energy particles

HER: scan from 1.0 GeV to 7.0 GeV. Step size 1.0 GeV



Final Focus QA: LER Off-energy particles

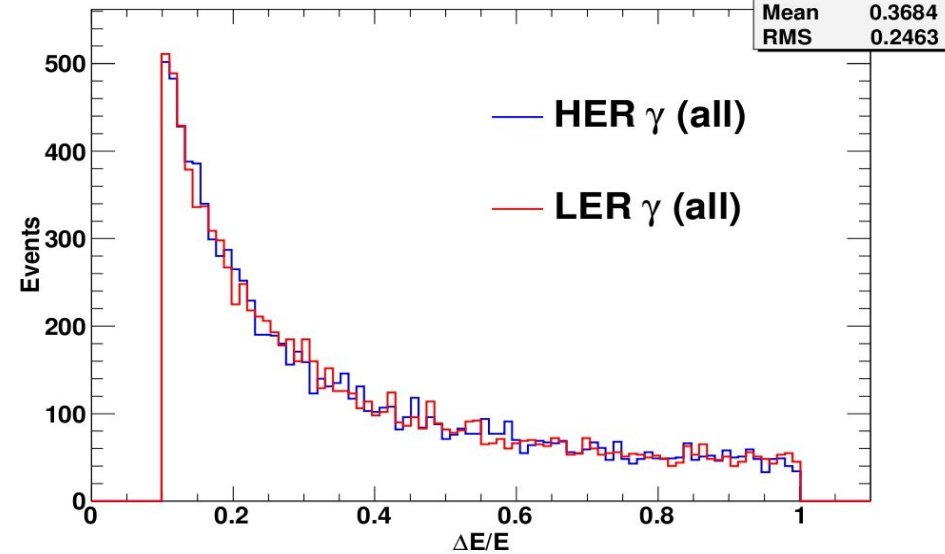
LER: scan from 0.5 GeV to 4.0 GeV. Step size 0.5 GeV



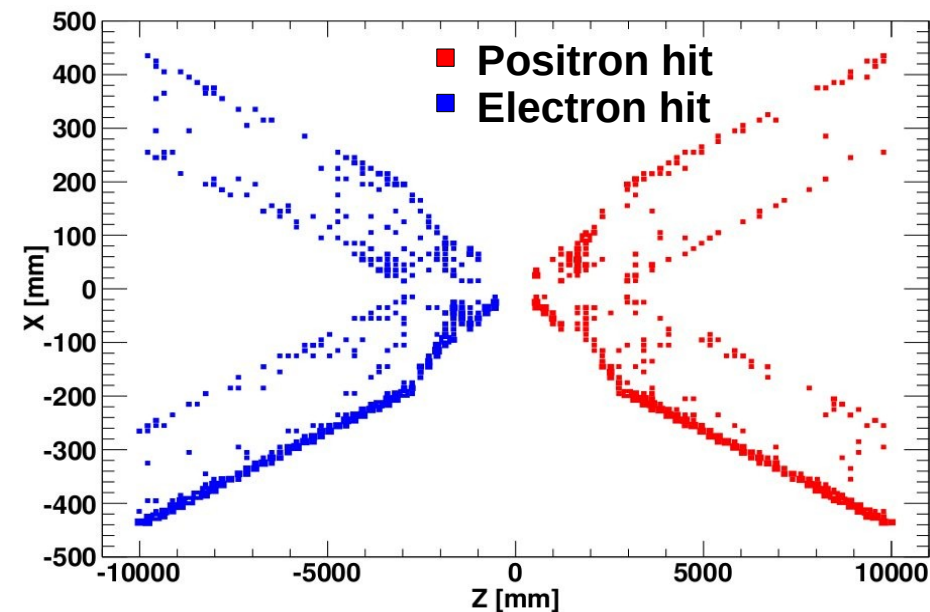
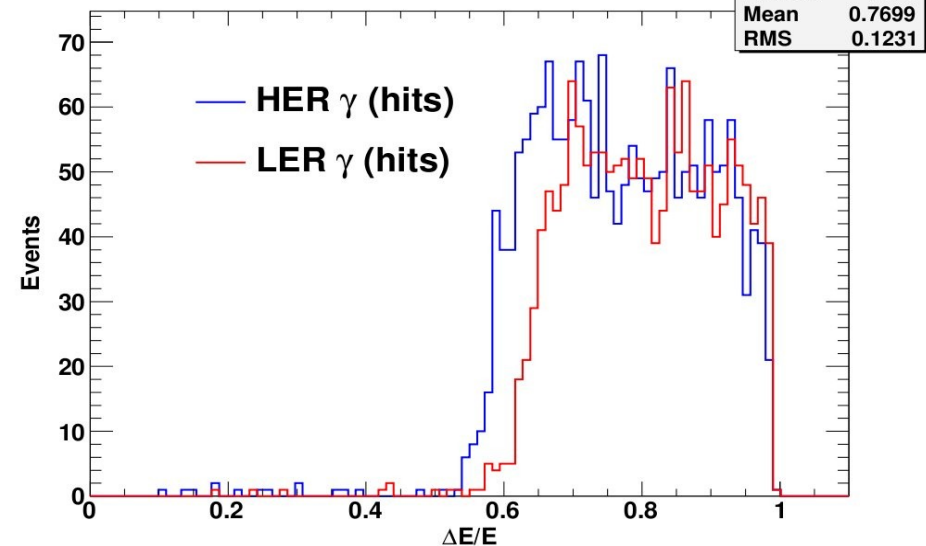
Final Focus QA: Radiative Bhabhas Study

- Simulate Bhabha interactions (10k) at the IP with $\Delta E/E|_{\min} = 1.0$
- Study location of hits at the beam pipes (1st hit)
- Study as well the $\Delta E/E$ distribution for those interactions that produce a hit
 - ⇒ input for full sim. Bhabha production
- Finds that only those interactions with $\Delta E/E > 0.5$ produce a hit

HER $\Delta E/E$ spectrum CM (all events)



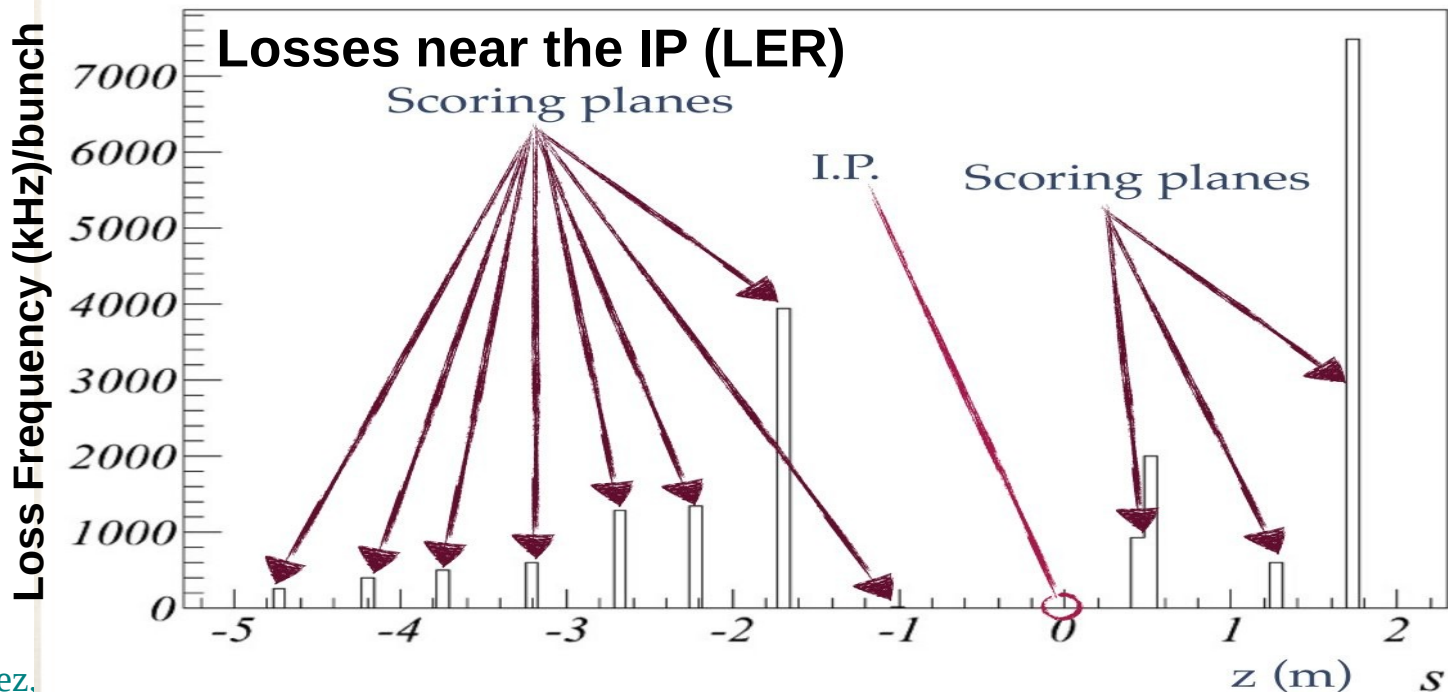
HER $\Delta E/E$ spectrum CM (hits events)



Touschek Background Strategy (I)

- **The Bruno primaries:** Manuela Boscolo developed a program to
 - Simulate both Touschek and the beam gas scattering along the beam line
 - Transport the scattered particles along the lattice
 - Detect the collisions of these particles with the beam pipes (scoring planes)
- **Typical output:**

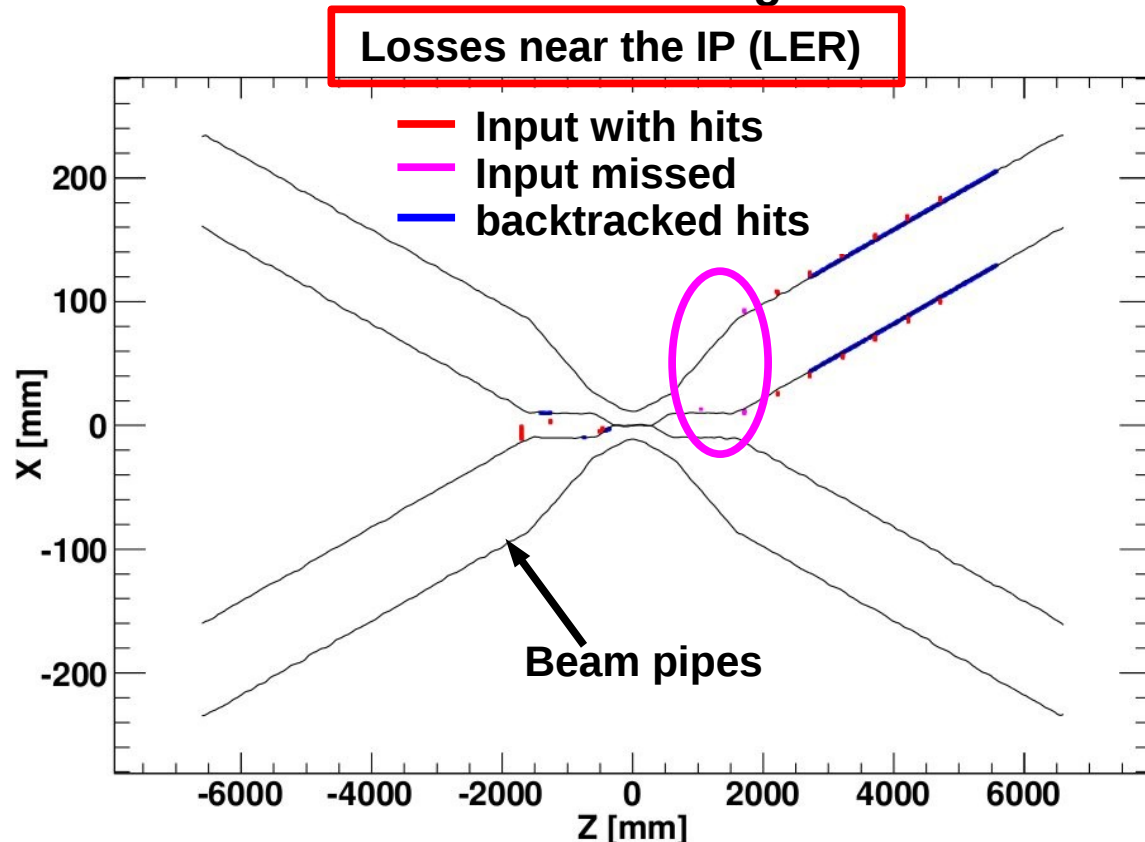
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0.456014E-01	-0.570537E-02	-0.280276E-04	0.113856E-04	1.71000	-0.252154E-01	0.755761	1
0.474620E-01	-0.592261E-02	-0.210435E-04	0.873927E-05	1.71000	-0.249482E-01	0.778852	1
0.432248E-01	-0.531700E-02	-0.179759E-04	0.663319E-05	1.71000	-0.236050E-01	0.997186	1
x (m)	$\frac{dx}{ds}$ (rad)	y (m)	$\frac{dy}{ds}$ (rad)	s (m)	$\frac{\Delta E}{E}$	f (KHz)	#turn



Touschek Background Strategy (II)

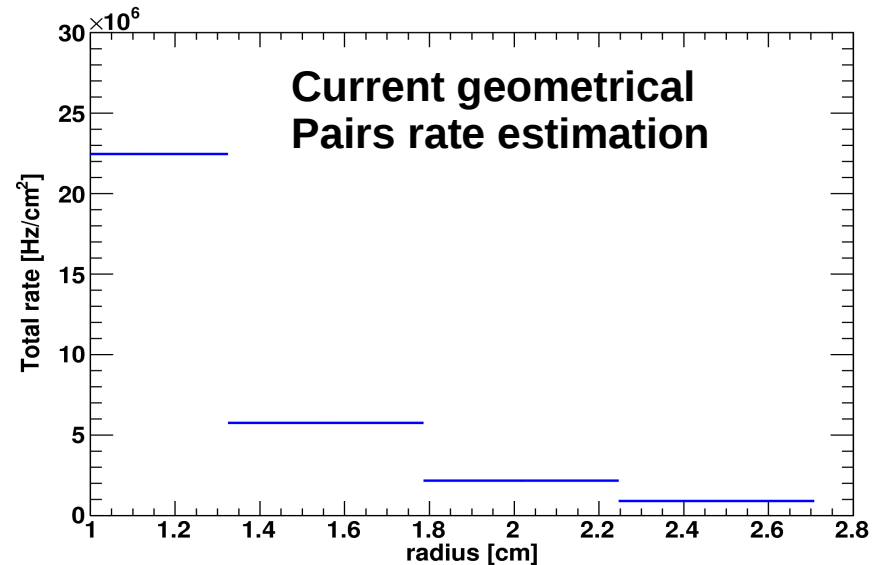
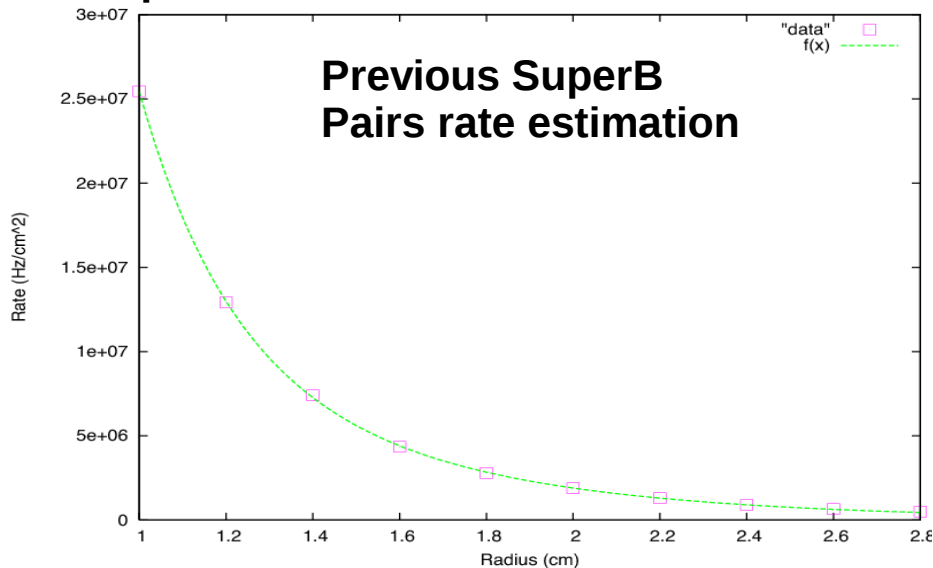
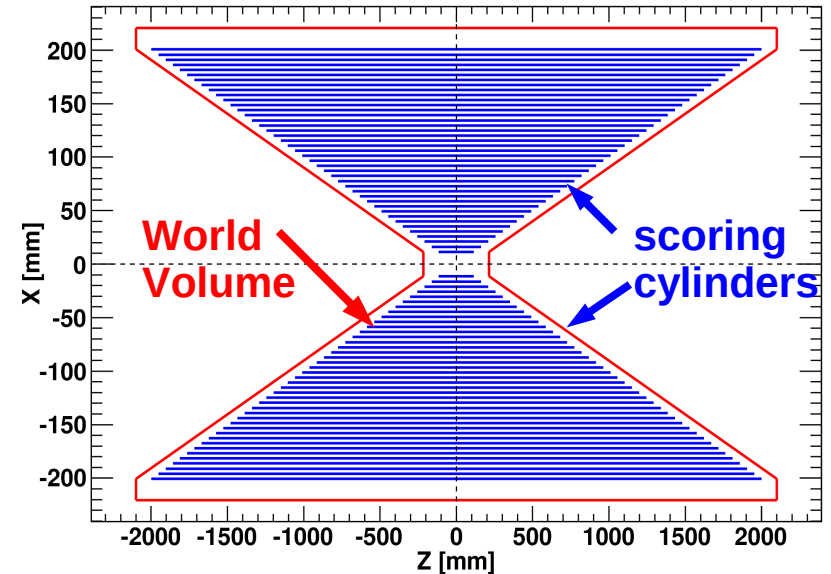
- Manuela program gives Touschek primaries outside the beam pipes
- Use Bruno to backtrack those primaries inside the beam pipe:
 - Use final focus geometry only
 - Use beam pipes as scoring boundaries
 - Invert momentum and charge of primaries for Bruno backtracking
- Use backtracked primaries with Inverted momentum and charge as full sim. input

- The method works for most of Manuela's primaries
- There is a small fraction that are missed in the backtracking
- Needs to agree on the final focus magnetic modeling and pipes geometry



Pairs backgrounds and SVT occupancy

- Pairs is an important background for SVT
- There is a disagreement between SuperB and Belle rates estimates (a factor of 10)
- Use Fast sim. to generate pairs production events
- Make an geometrical estimation of these rates by using SVT like boundaries (40):
 - radii go from 15 to 200mm (step size 5mm)
 - polar angle covers 100mrad in Fwd/Bwd
- Estimate rate vs radii
- Obtains results in agreement with previous SuperB estimation

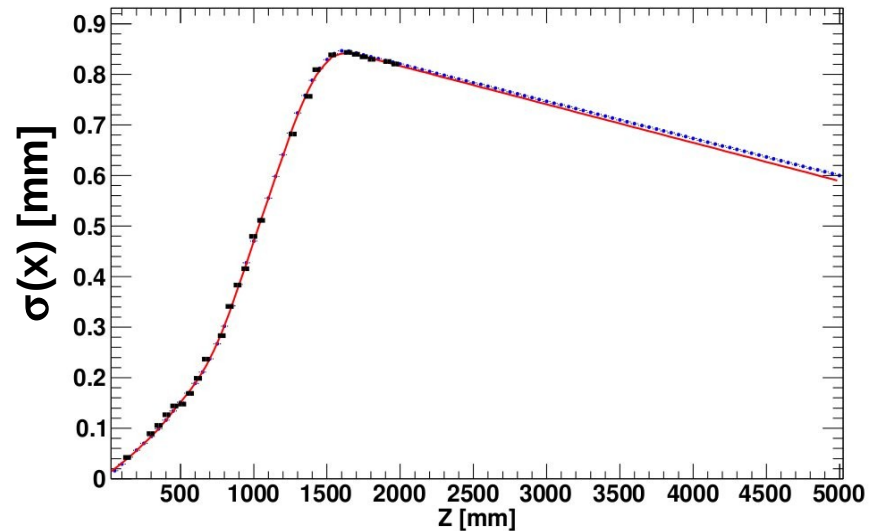
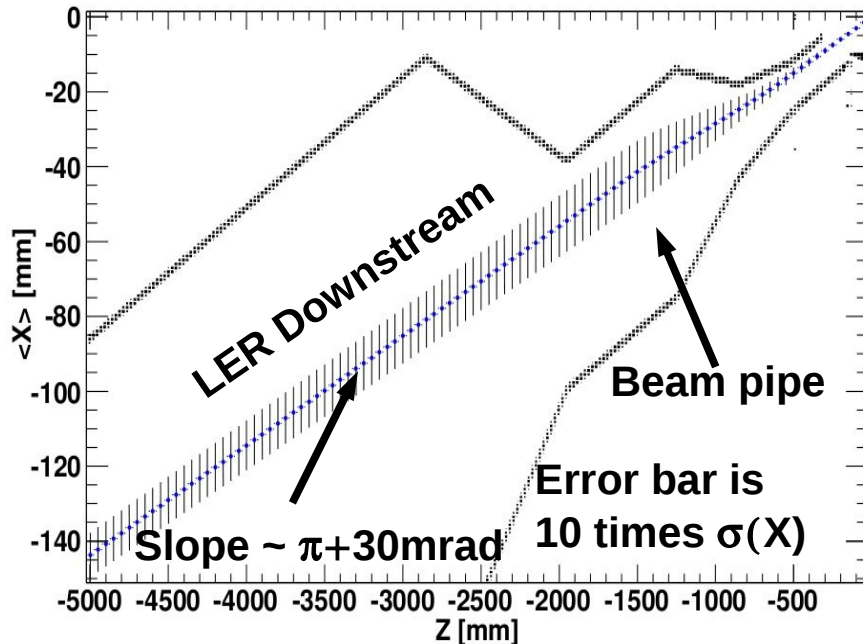
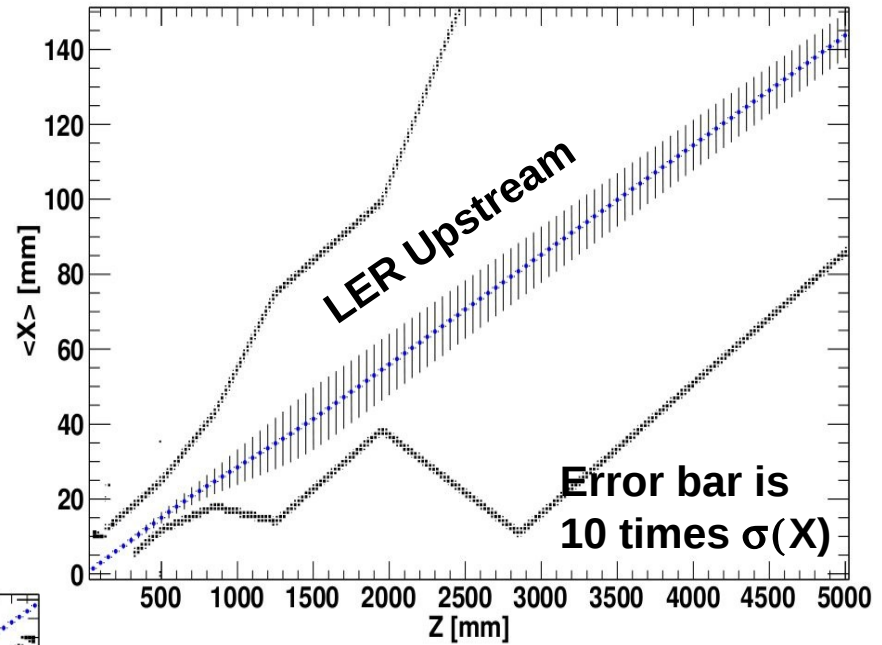
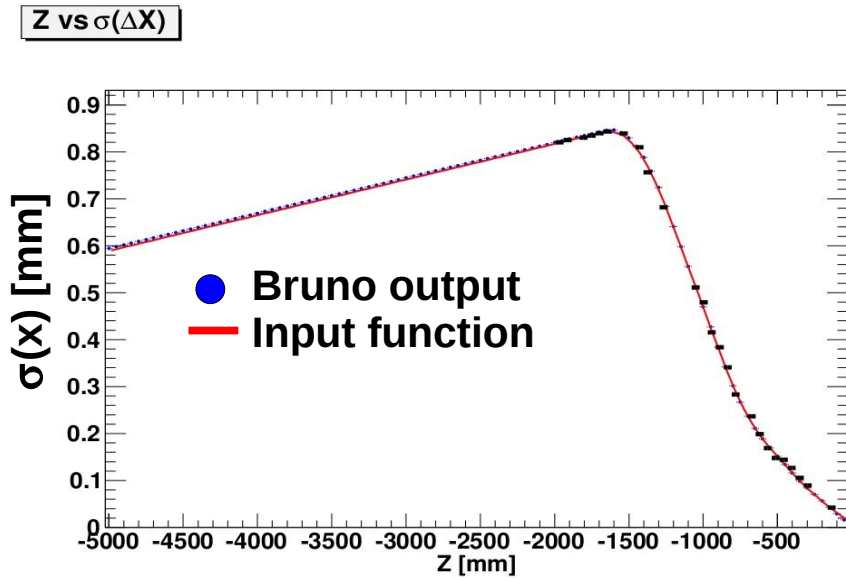


Summary and outlook

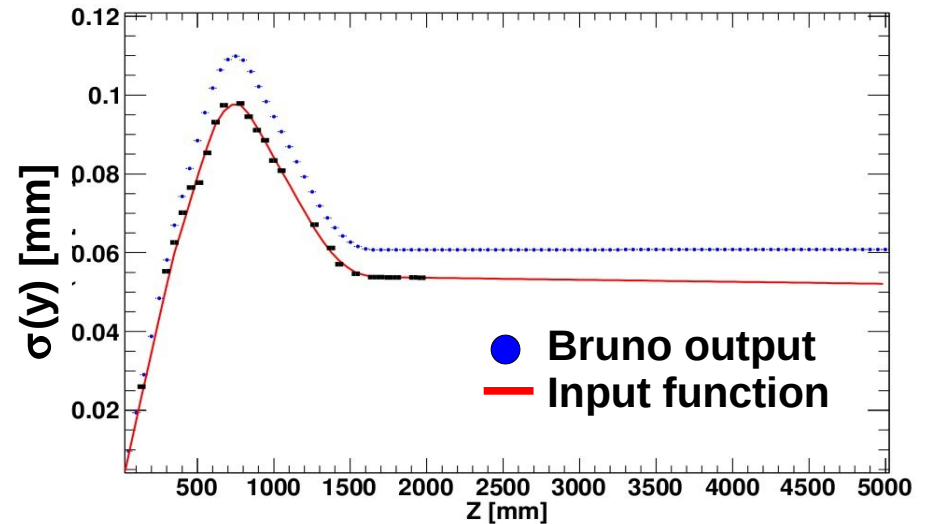
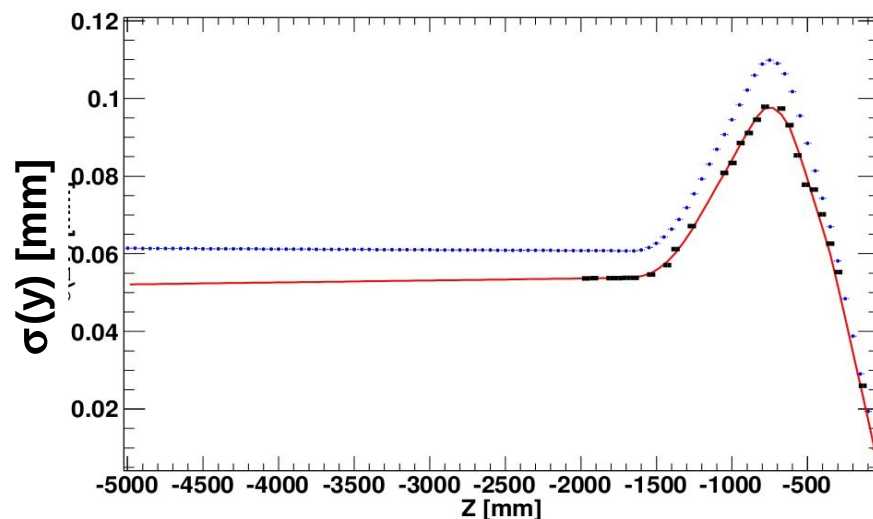
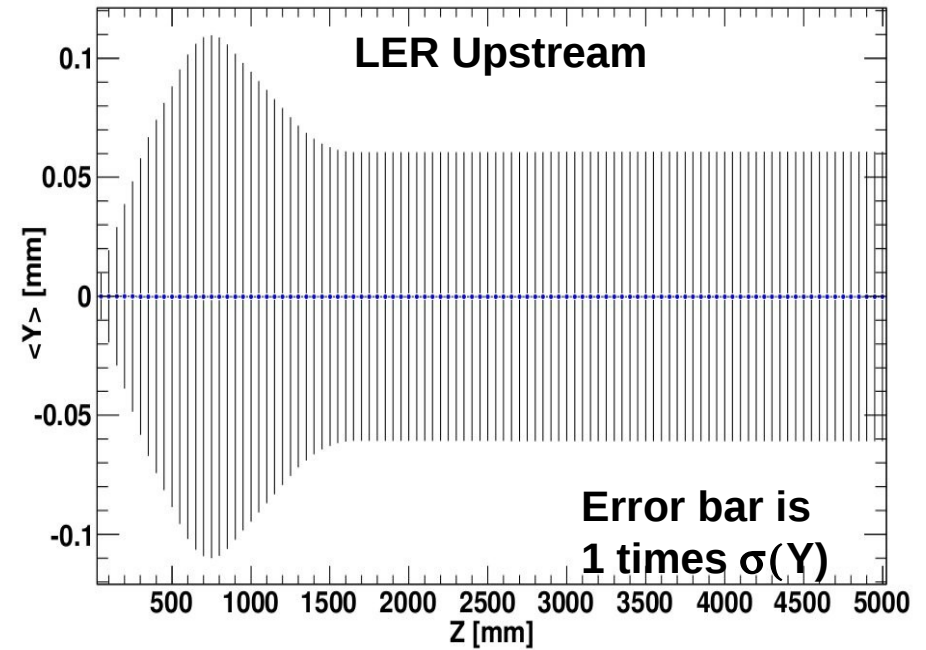
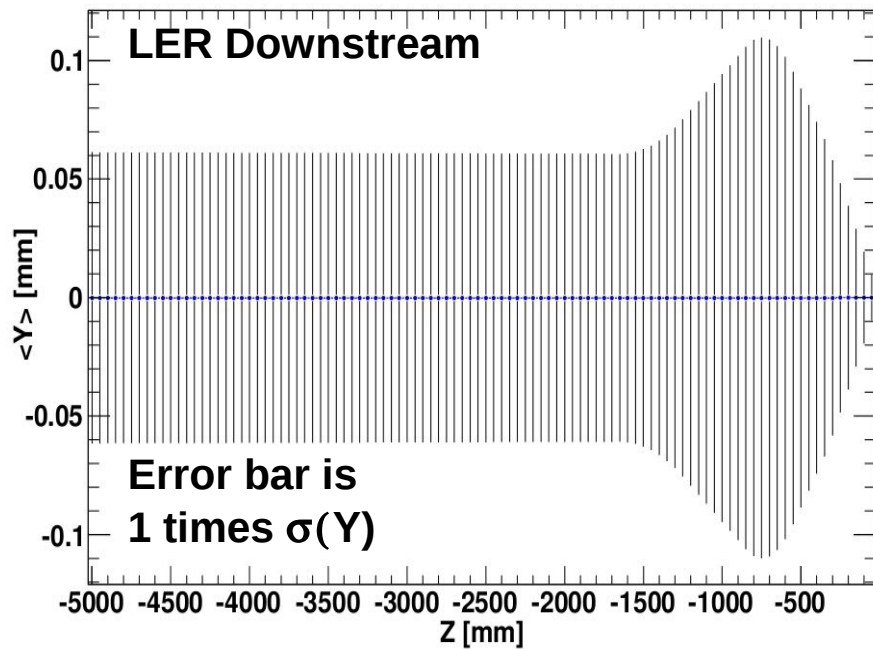
- **A validation machine for the Bruno final focus simulations is now in place**
- **Machinery can be used to**
 - Check the field configuration $\Rightarrow \sigma(X), \sigma(Y), \sigma(X'), \sigma(Y'), \varepsilon$ and β as a function of Z
 - Check the input geometry of pipes and magnets
- **Final focus quality test**
 - Scanned off-energy particles
 - Only very off-energy particles deviate significantly from nominal trajectory
 - Beam sizes increase as particles energies deviate from nominal
 - Radiative Bhabha events
 - Only those interactions with $\Delta E/E > 0.5$ produce a hit at the beam pipes
- **Touschek background strategy**
 - The method is already in place
 - Needs to agree with Manuela in the magnetic model and beam pipes geometry
- **Pair production background rates at SVT**
 - Machinery to produce pair backgrounds for Bruno using Fast sim.
 - Rough rate estimation in agreement with previous SuperB estimation

Backup

Final Focus Validation: Results LER (I)



Final Focus Validation: Results LER (II)



Final Focus Validation: Results LER (III)

Z vs $\epsilon(X)$ LER: ϵ and β as a function of Z scoring end-cap

