Joint Belle-II & SuperB Background Workshop
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The Rad-Bhabha background simulation for SuperB

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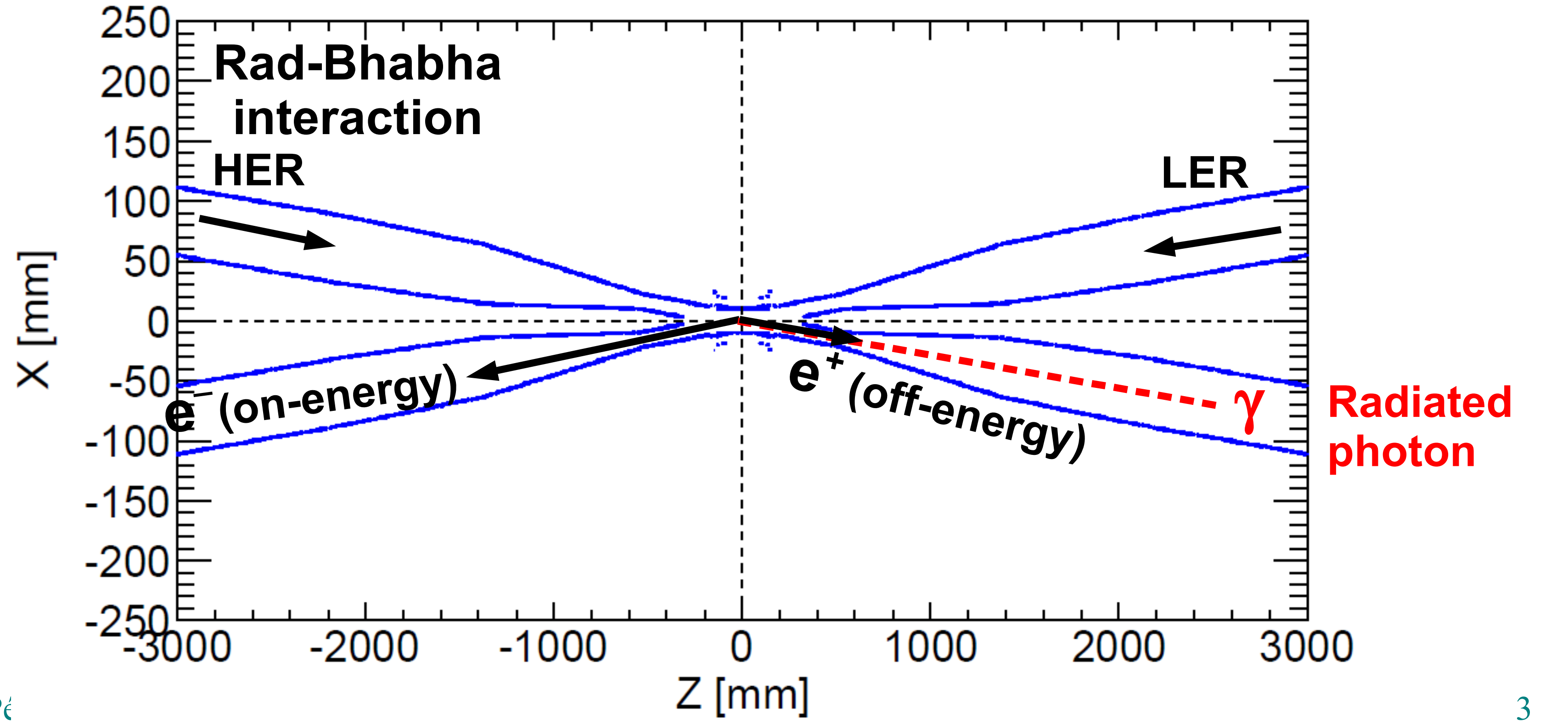
On behalf of the SuperB Collaboration

Outline

- **Backgrounds from radiative Bhabha (Rad-Bhabha) events**
- **The Rad-Bhabha event generator for SuperB: BBBREM**
- **The final focus:**
  - Geometrical model
  - Beam-line magnetic model
- **Losses at the beam-pipe due to Rad-Bhabha**
- **Summary**

Backgrounds from Rad-Bhabha

- **Rad-Bhabha is one of the main background sources for SuperB**
- **Background: off-energy particles hit beam-pipe downstream and debris go into the detector**
- **Accurate evaluation requires a careful modelling of the final focus**
  - Geometrical model: beam-pipe, magnets, shields, cryostat, …
  - Magnetic model: field from the different elements along the beam-line



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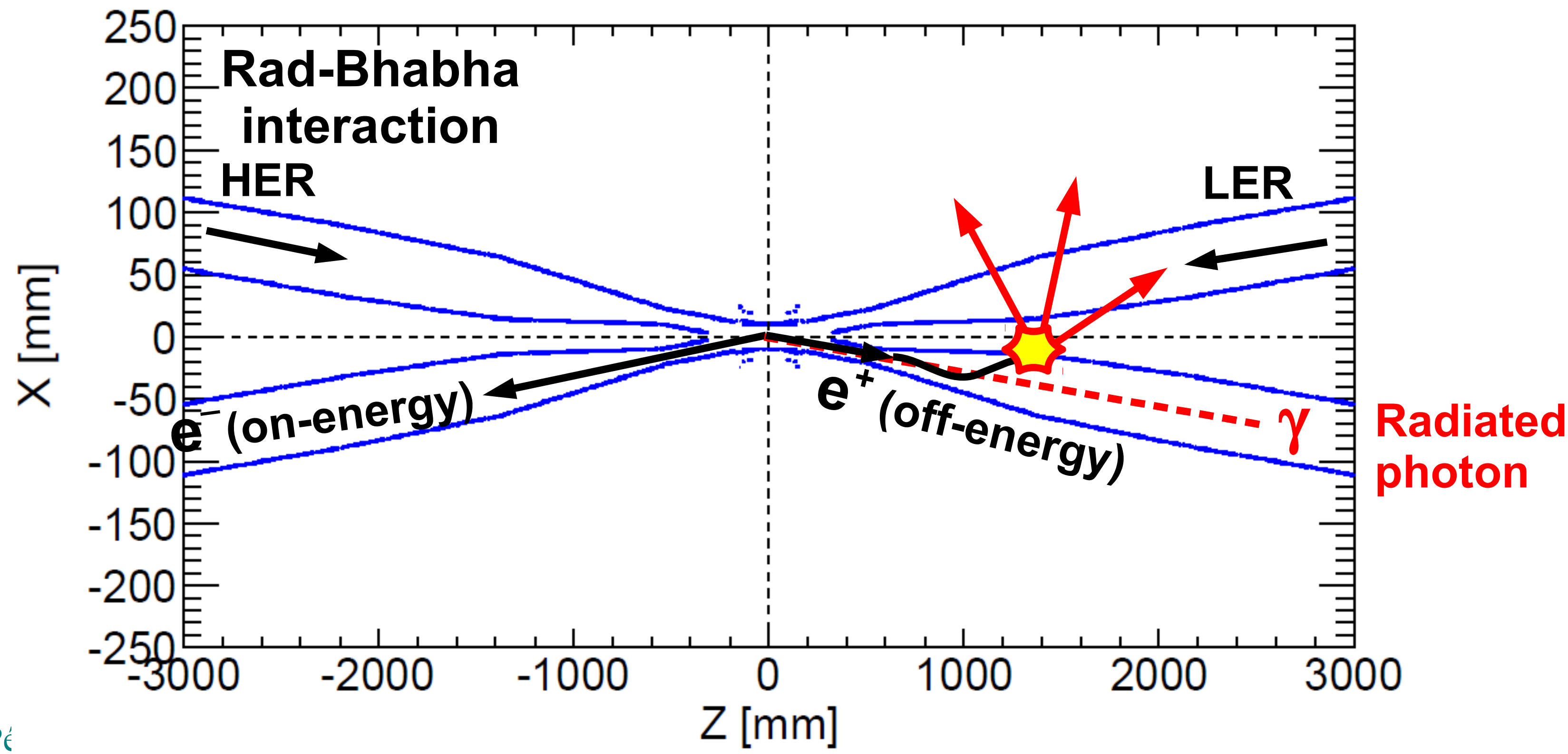

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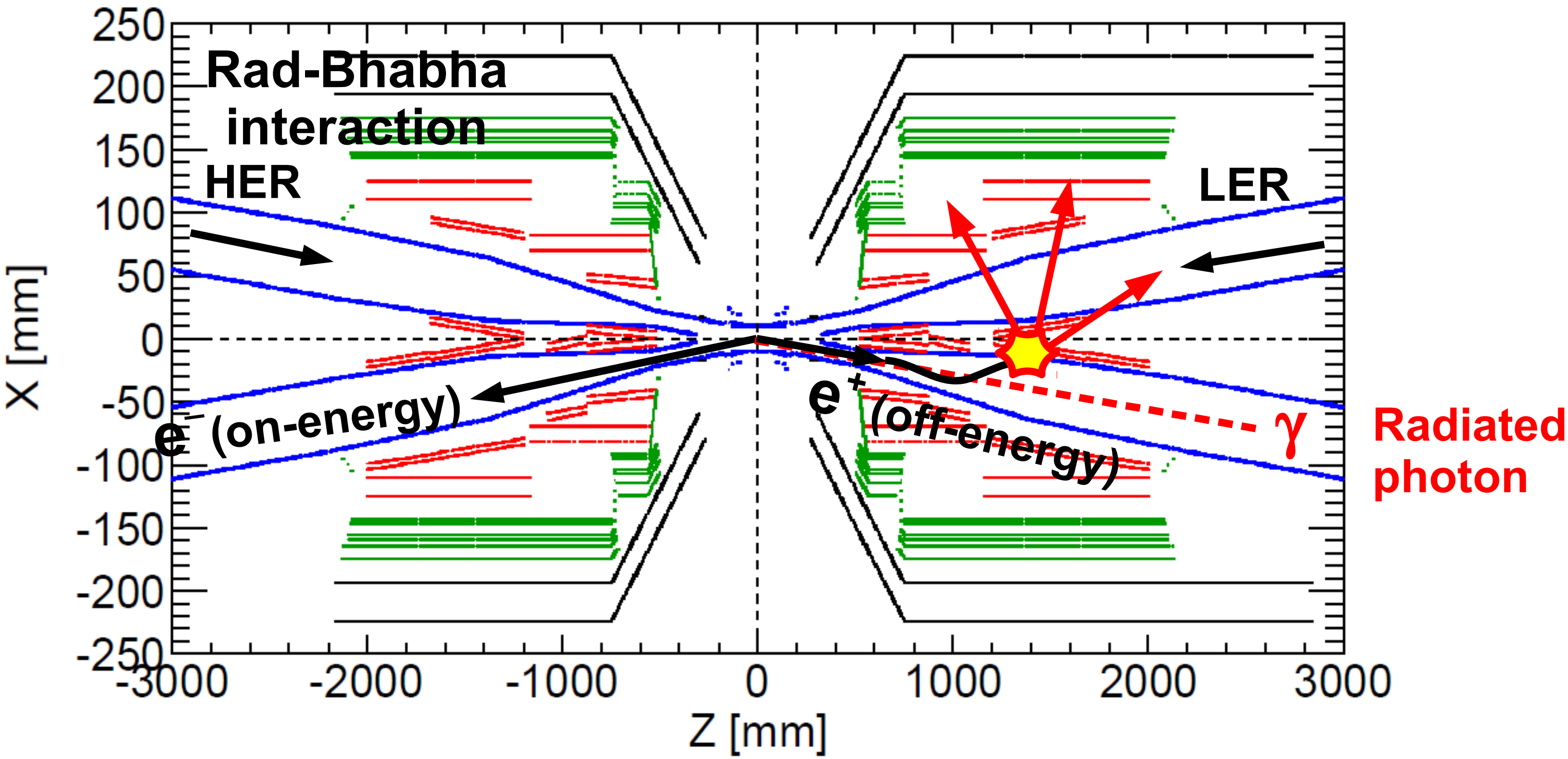


BBBREM event generator

- **Use BBBREM to generate the Rad-Bhabha primaries**

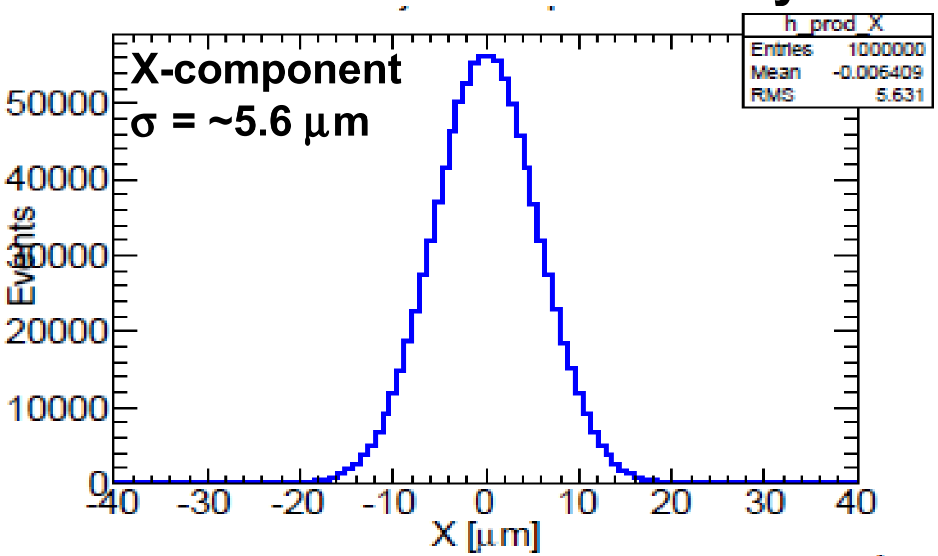
  R. Kleiss and H. Burkhardt, arXiv: hep-ph/9401333

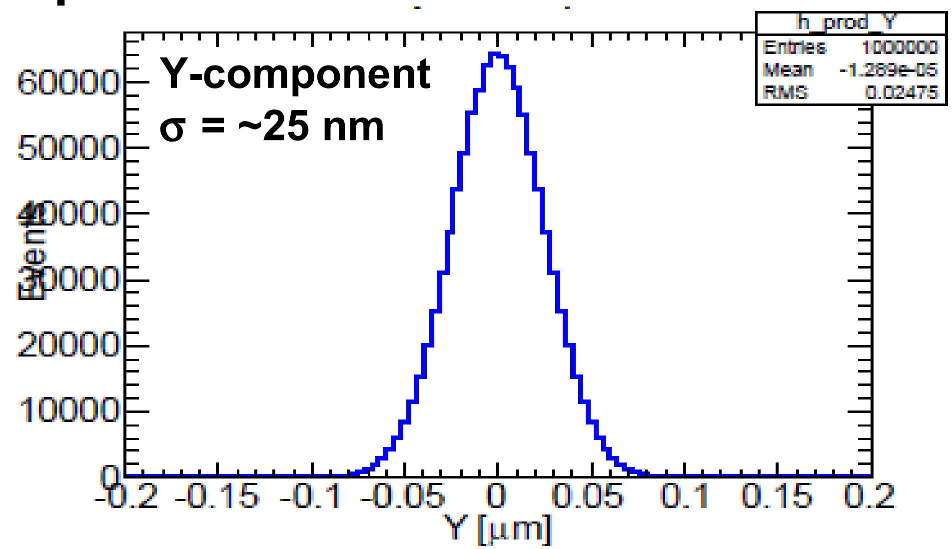
- **Features:**
  - Correct simulation of the angular deflection of the outgoing leptons and photons
  - Correct simulation of the luminous region shape and size
- **Parameters:**
  - ROOTS: total incoming CM energy
  - RK0: radiated photon energy cut-off fraction
  - NEVENT: number of events
  - NRAN: flag for source of random number (fixed to 2 for simple additive quasi-random number algorithm)
  - Beams parameters (HER/LER) at the IP →

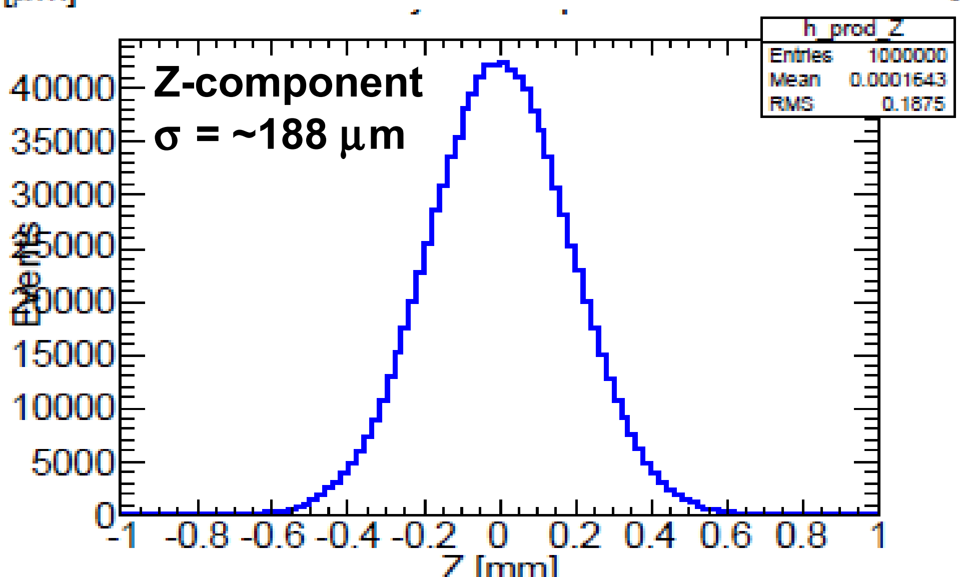
	HER(e+)	LER(e-)
E(GeV)	6.69	4.18
$\sigma(X)$(μm)	7.33	8.70
$\beta(X)$(mm)	26.0	32.0
$\sigma(Y)$(nm)	36.0	35.0
$\beta(Y)$(μm)	253.0	205.0
$\sigma(Z)$(mm)	5.0	5.0
$\Delta E/E$ (%)	0.1	0.1
α_z(mrad)	−30	+30
N (10^{10})	5.08	6.56

BBBREM event generator (Some Plots)

Primary vertex position

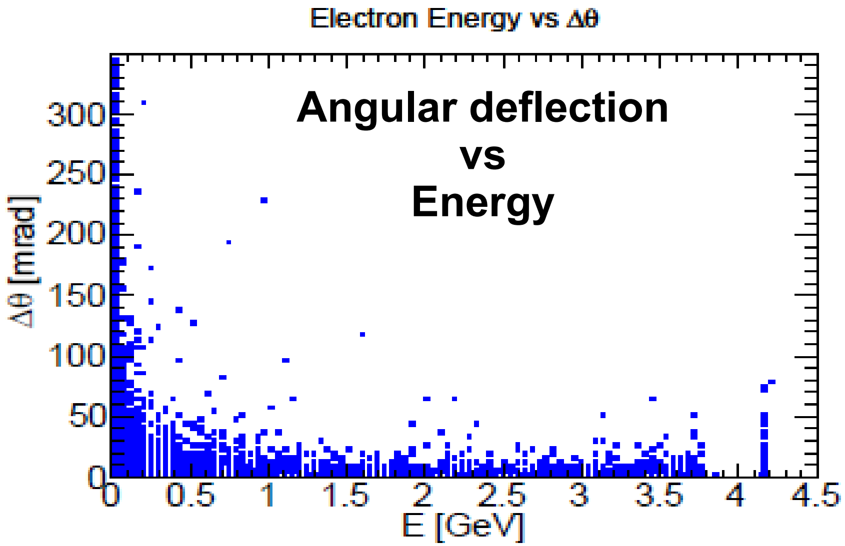


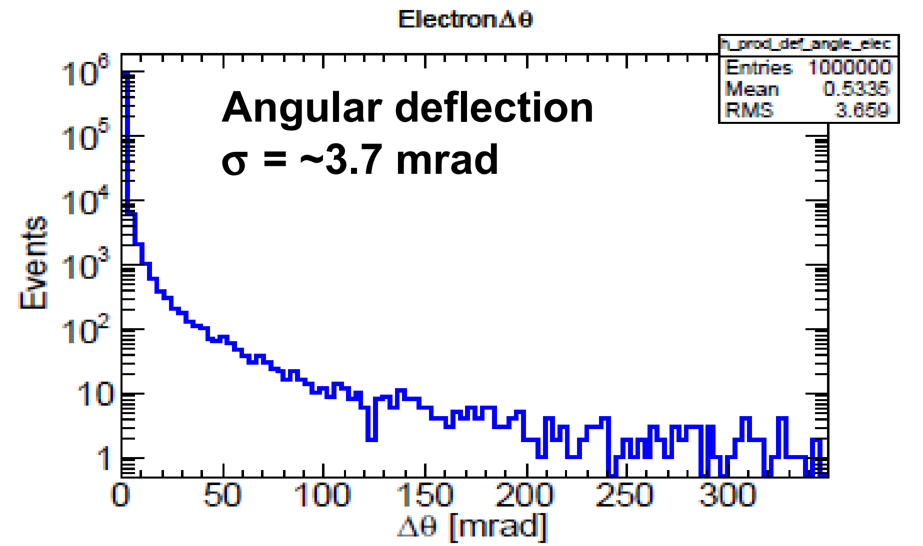


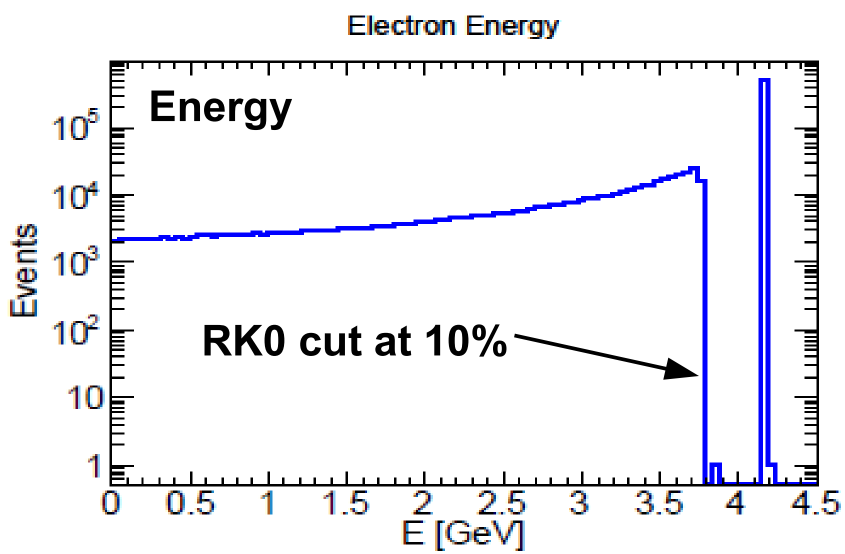


BBBREM event generator (Some Plots)

Outgoing electron



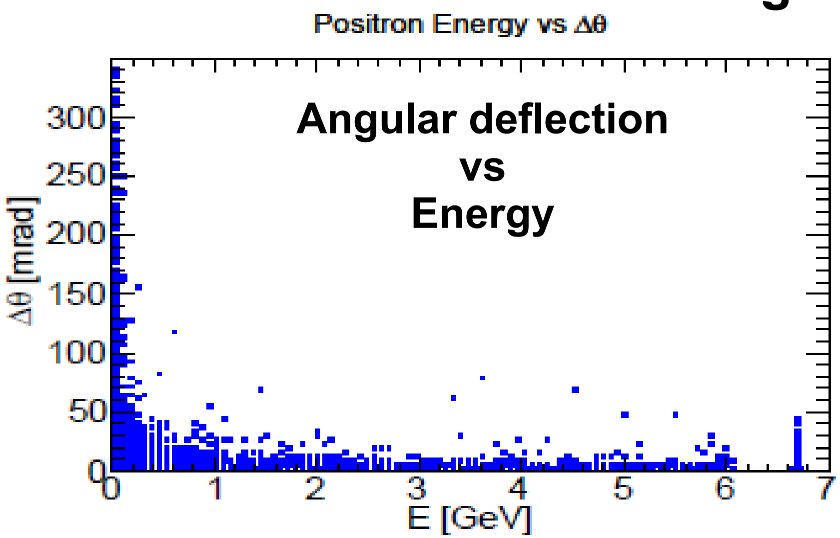


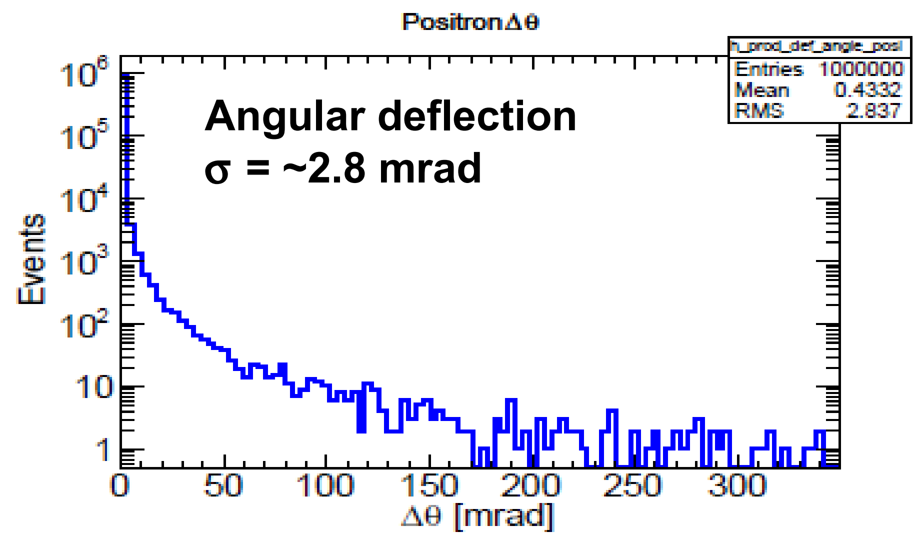


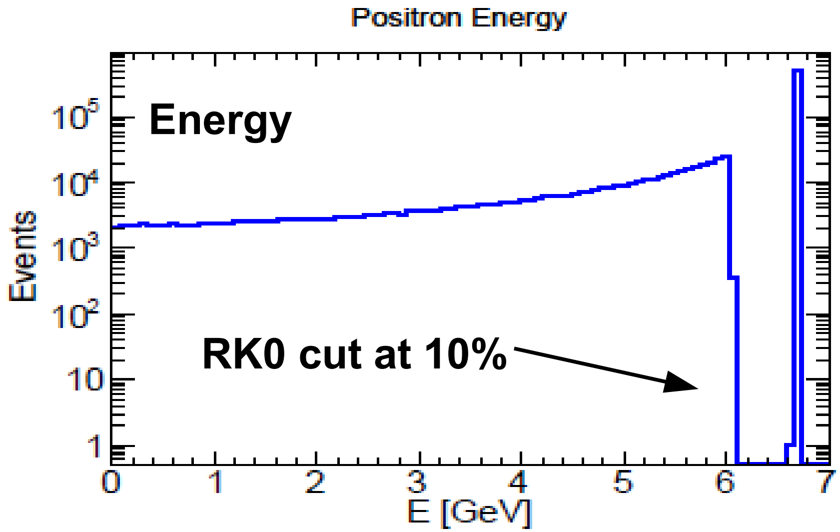
- Radiated photon cut-off fraction 10%
- Angular deflection of outgoing leptons taken into account

BBBREM event generator (Some Plots)

Outgoing positron



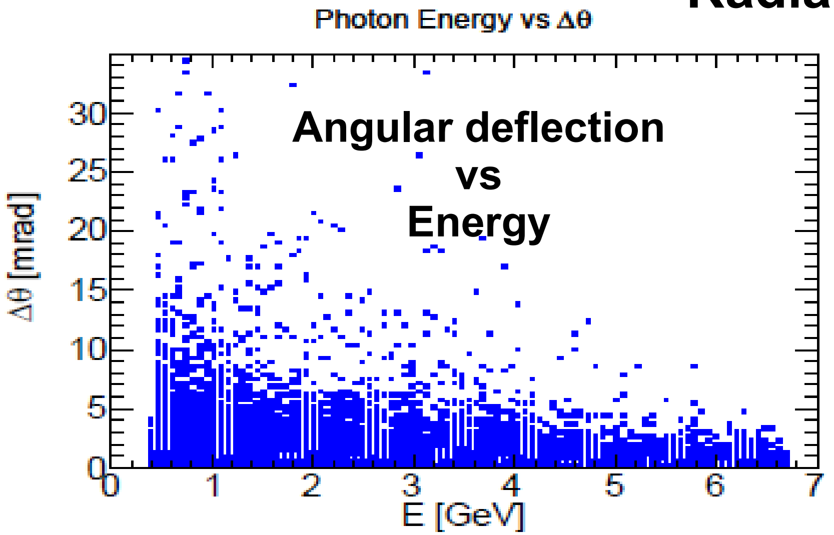


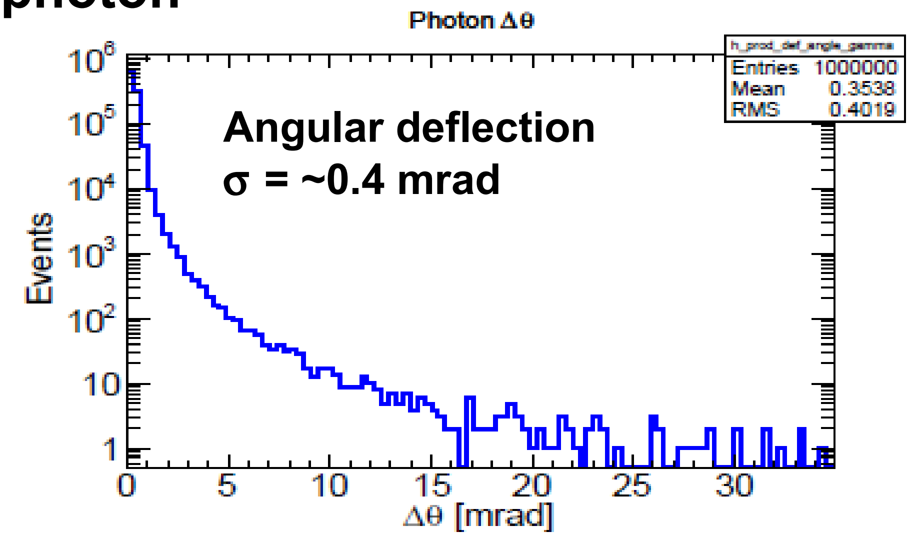


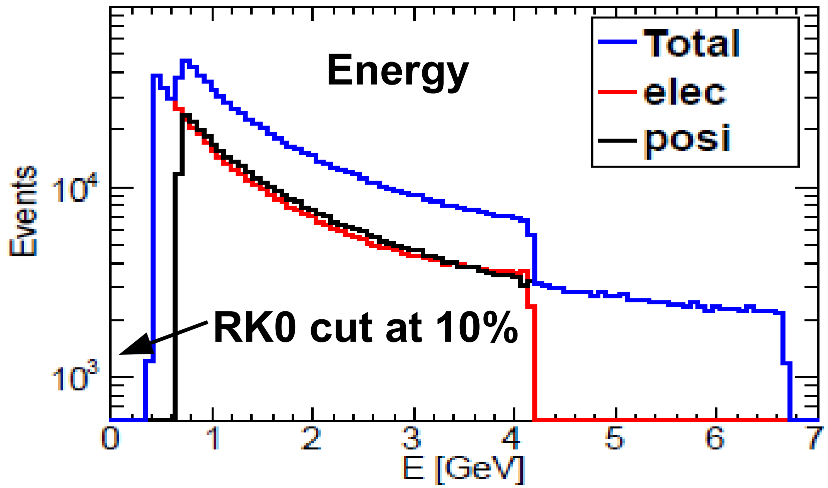
- **Radiated photon cut-off fraction 10%**
- **Angular deflection of outgoing leptons taken into account**

BBBREM event generator (Some Plots)

Radiated photon



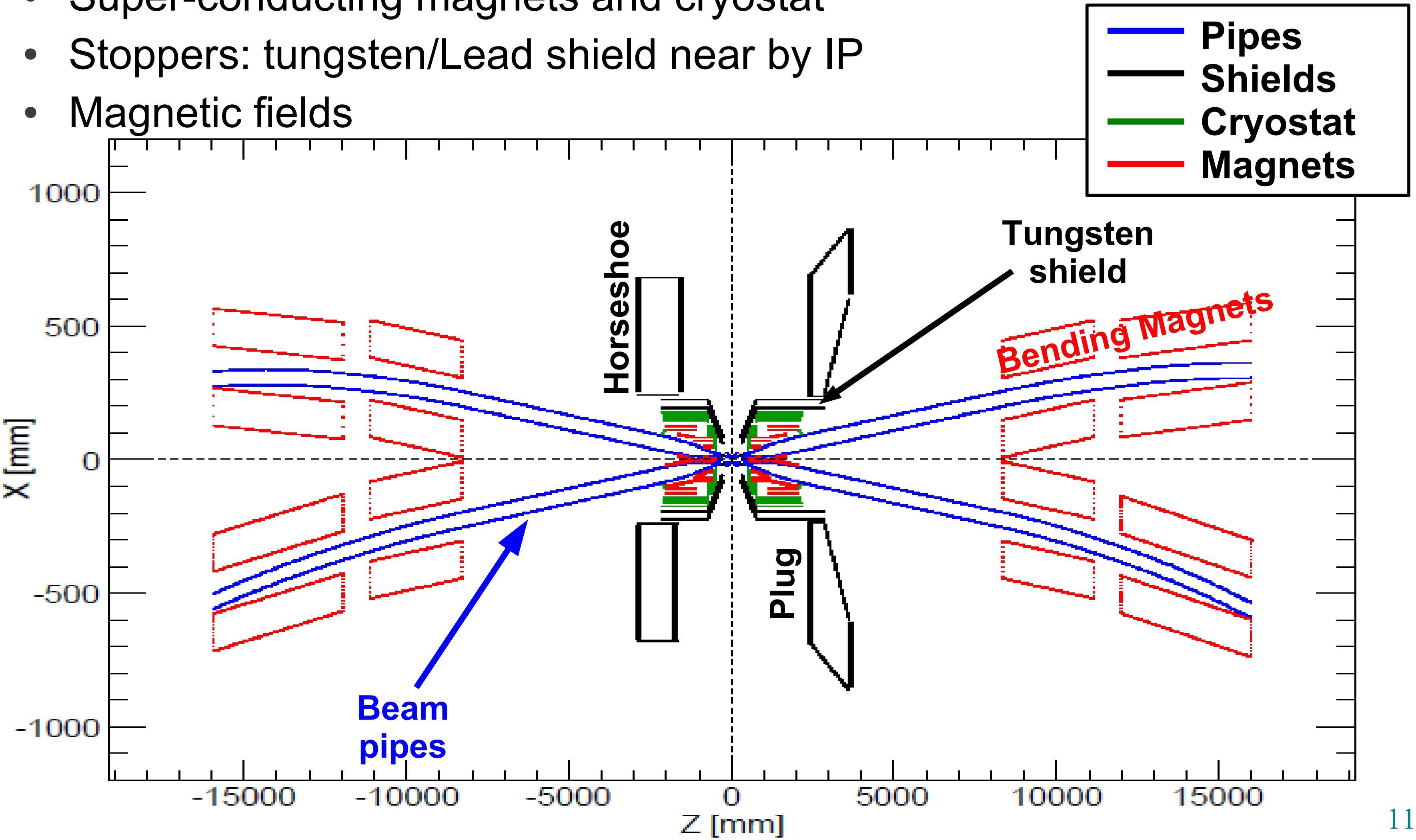




- Radiated photon cut-off fraction 10%
- Radiated photon moves essentially without any delfection

Final Focus (FF) Geometrical Model

- **Detailed Geant4 (Bruno) model of the FF from -16 to 16 mts from IP**
  - Beam pipes
  - Super-conducting magnets and cryostat
  - Stoppers: tungsten/Lead shield near by IP
  - Magnetic fields



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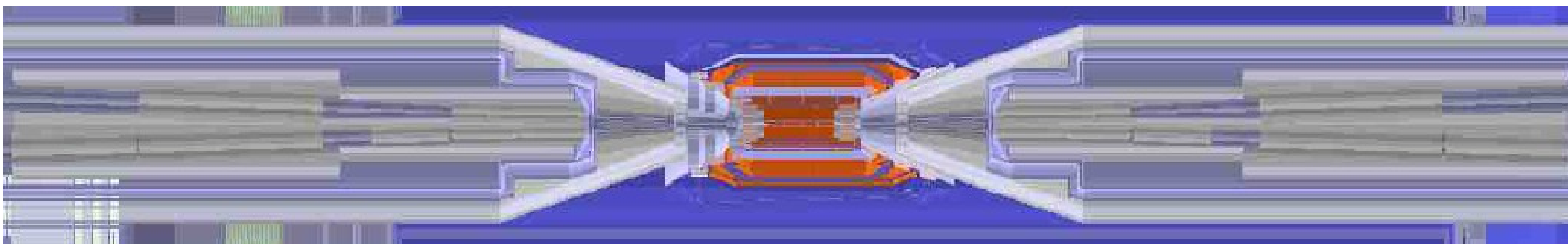
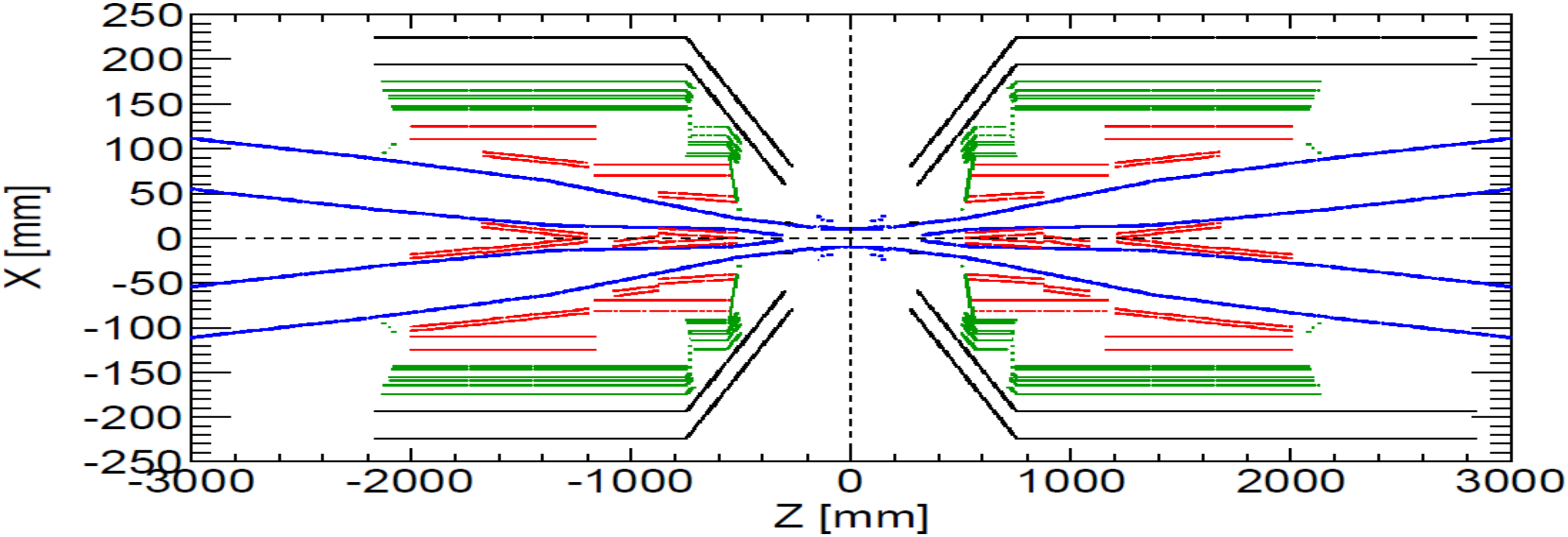
Pipes
Shields
Cryostat
Magnets





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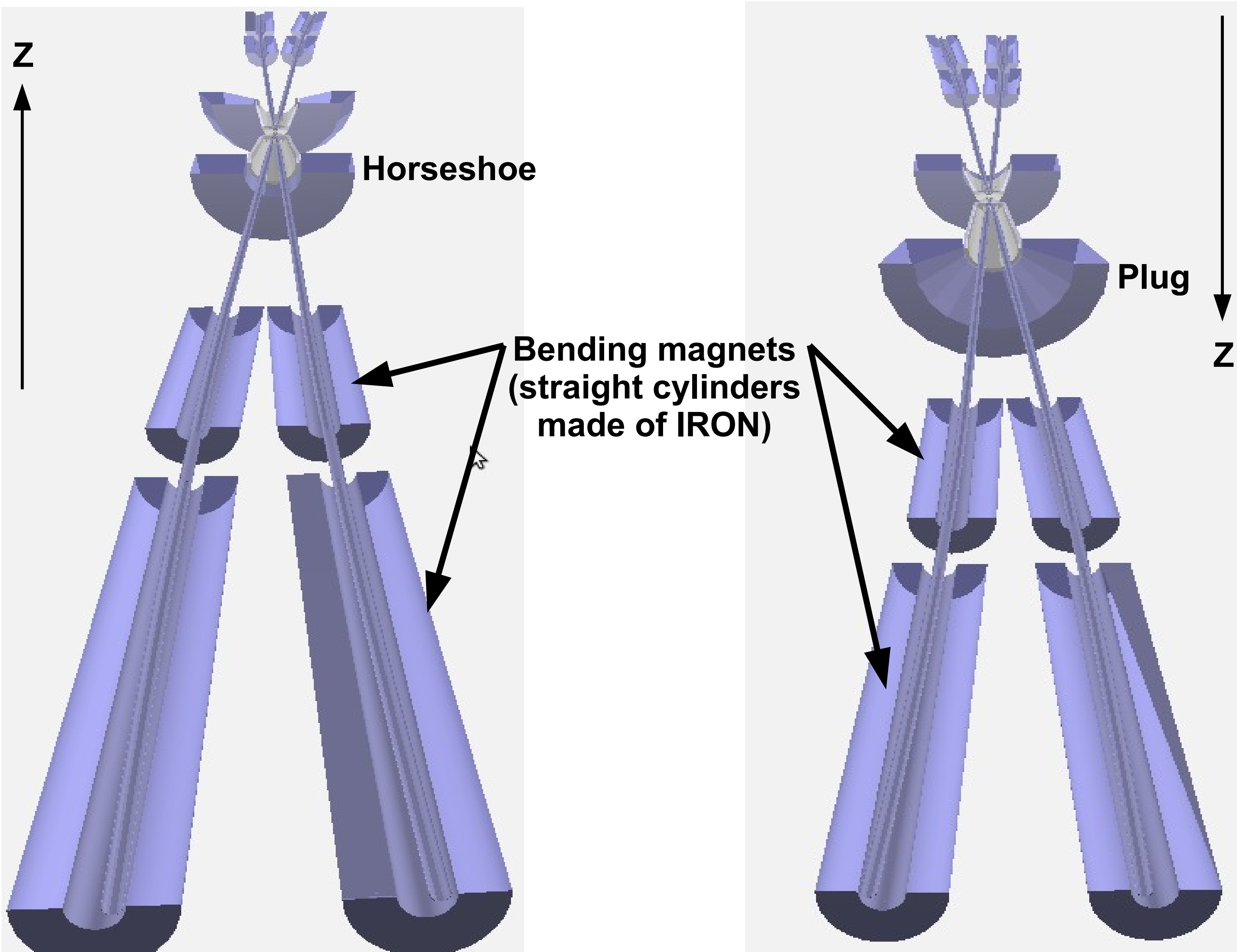
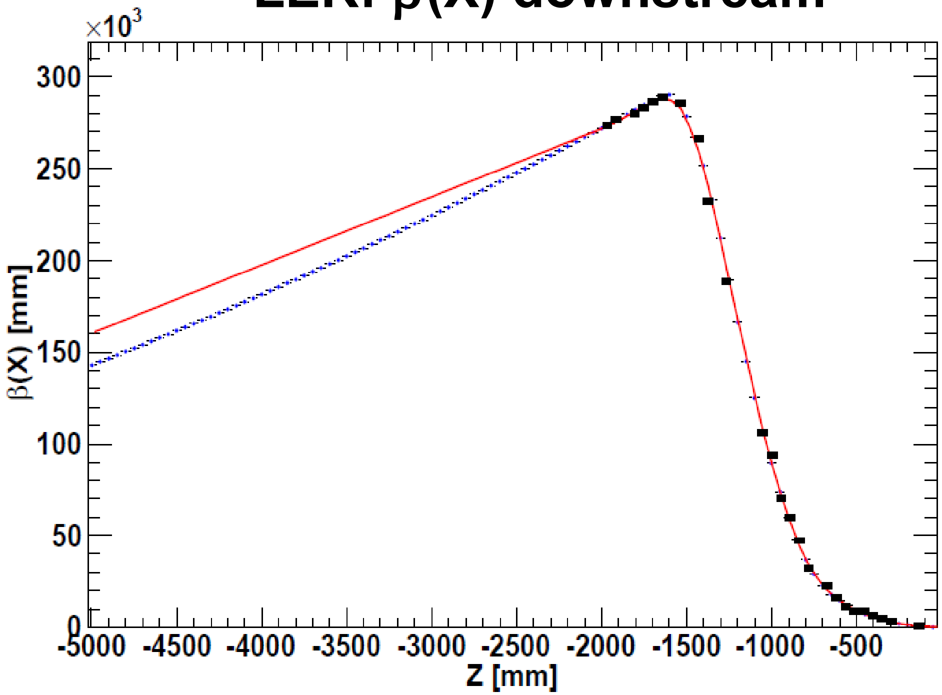


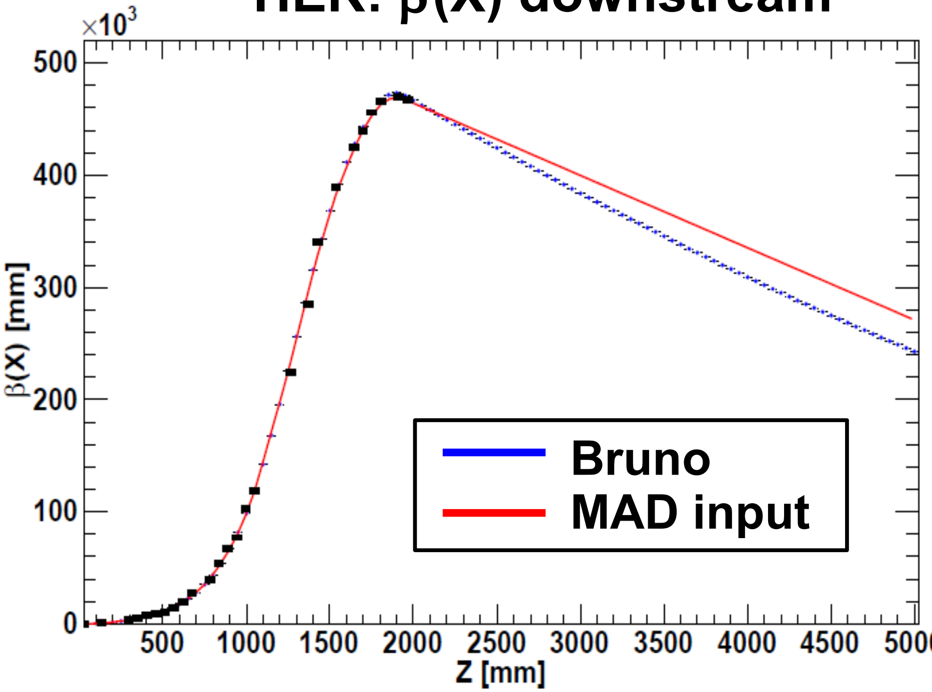
Beam-line Magnetic Model

- **Magnetic model directly extracted from MAD simulation from Mike Sullivan**
- **Features:**
  - Dipoles and Quadrupoles are perfect (no higher order components)
  - Fields modelled only inside cylinders, zero elsewhere (no fringing effects)

LER: β(X) downstream



HER: β(X) downstream



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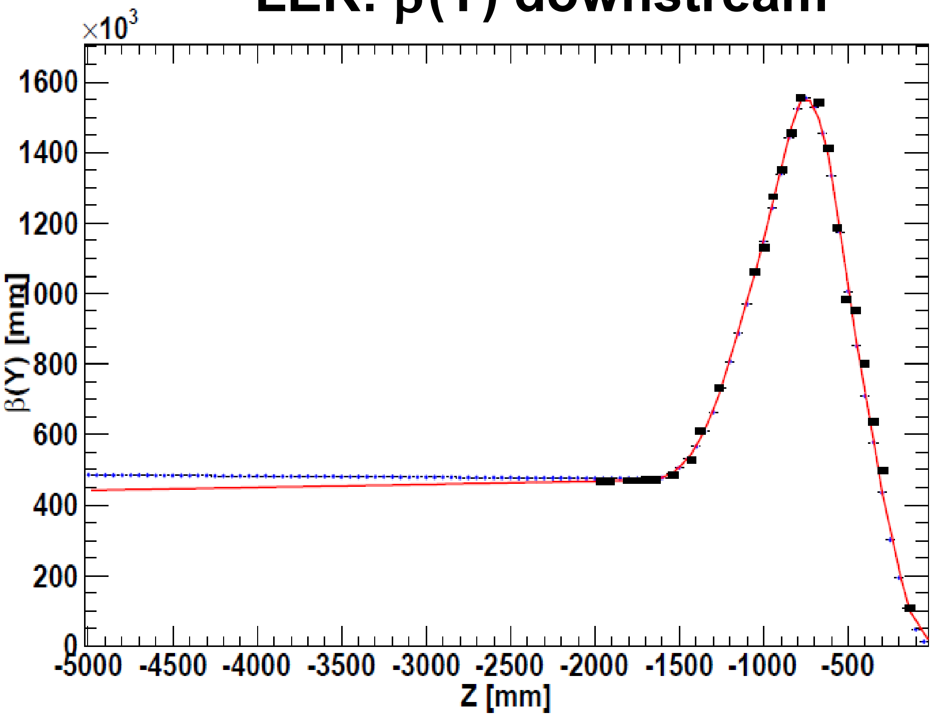

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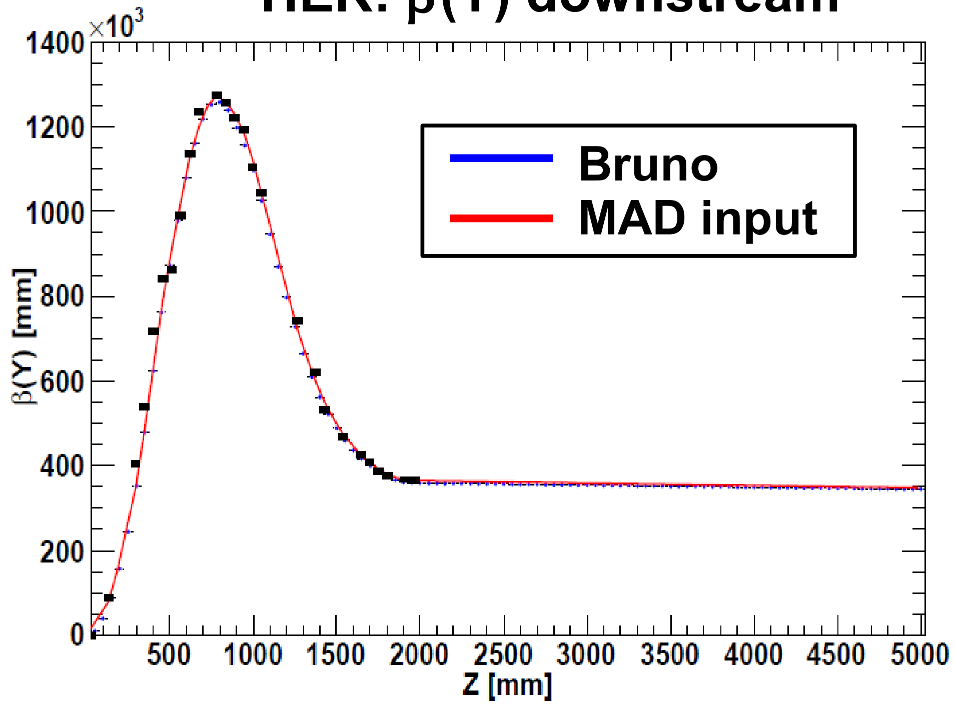


Rad-Bhabha Losses at the Beam-pipe

- **Evaluate the rate at which particles are lost at the beam-pipe due to Rad-Bhabha to understand backgrounds**
- **Assumptions:**
  - Luminosity (L) = $10^{36} cm^{-2} s^{-1}$ = 10^{9} mb^{-1} Hz
  - RK0 = 10% $\Rightarrow$ cross-section (σ) = 152 mb
  - Bunch-crossing frequency (f_c) = 226.73 MHz
  - N-interactions/bunch-crossing = $(L \times \sigma)/f_c$ = 669.6
- **Losses near by the IP (-3 to 3 mts) are mainly due to off-energy electrons and positrons (E < 1.5 GeV)**

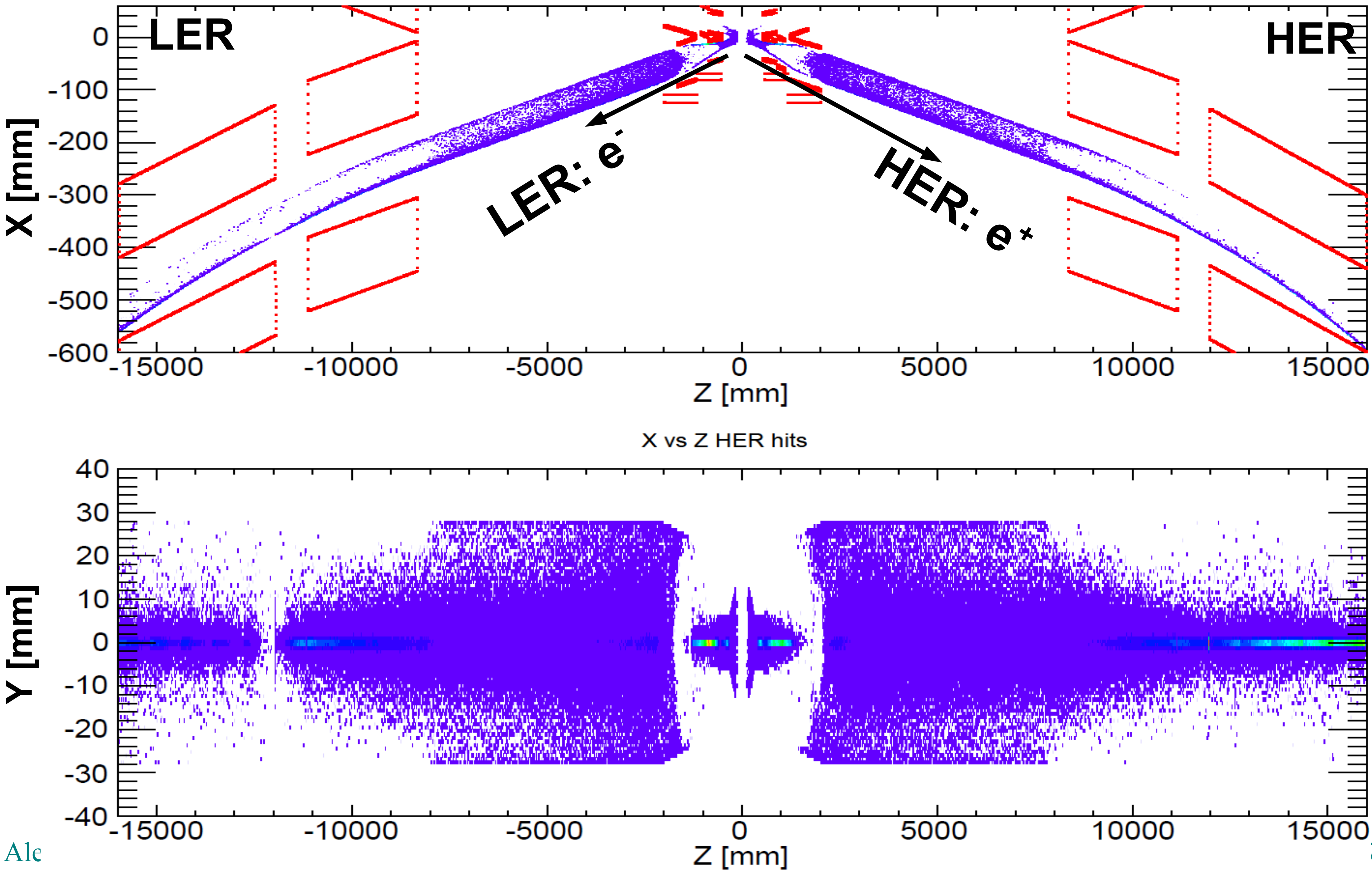
$\Rightarrow$ rate ~ 17.7 GHz

- **Losses far away IP (> 3 mts) are due to**
  - Slightly off-energy electrons/positrons
  - Radiated photon: moves straight and hits beam-pipe at the 1st bend (main contribution by a factor of 4)

$\Rightarrow$ rate ~ 230.0 GHz (main contribution beyond 8mts)

Rad-Bhabha Losses at the Beam-pipe: e^+e^-

- **V12-sf11 layout: HER = e^+ (6.69 GeV) and LER = e^- (4.18 GeV)**



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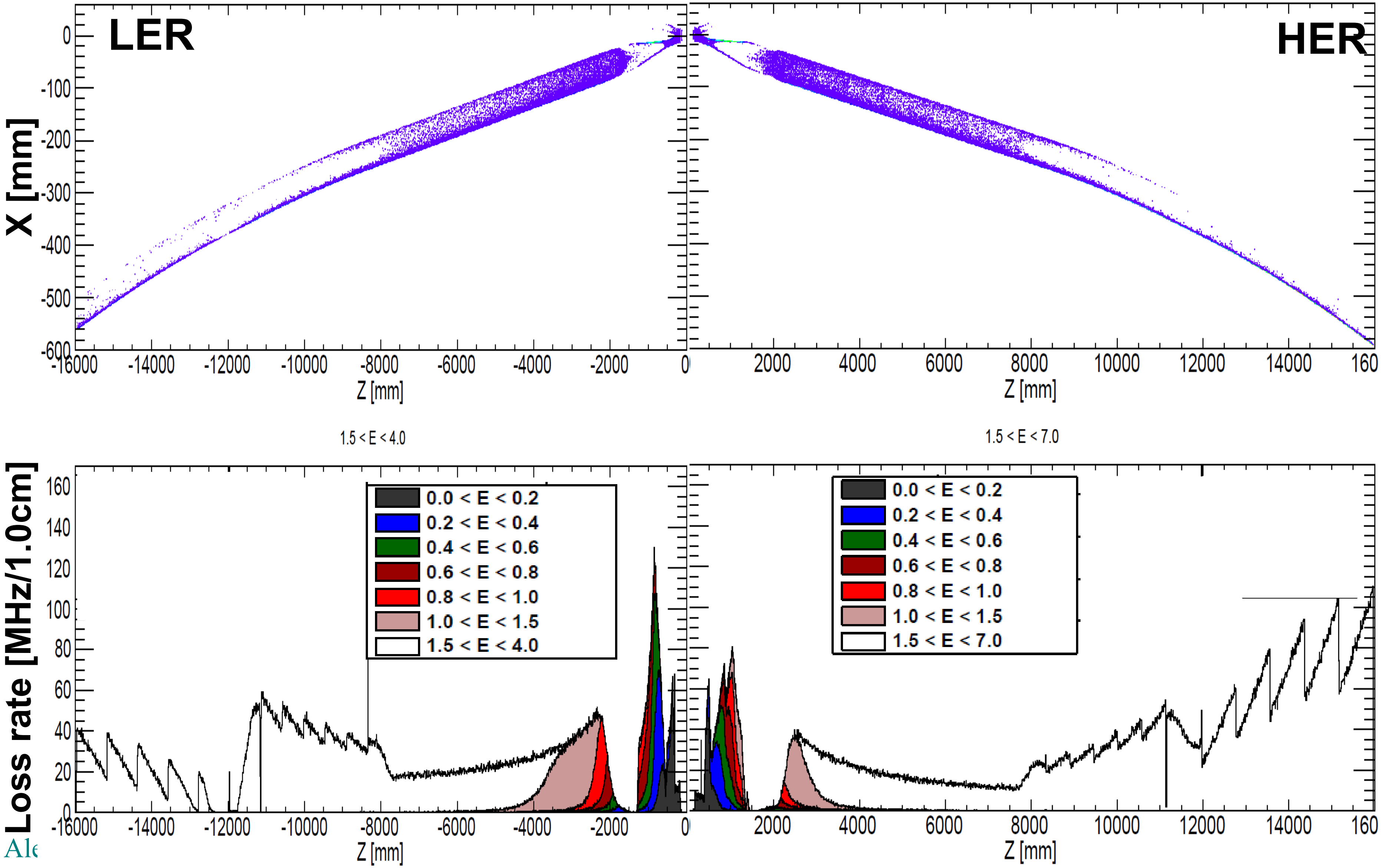

Ale

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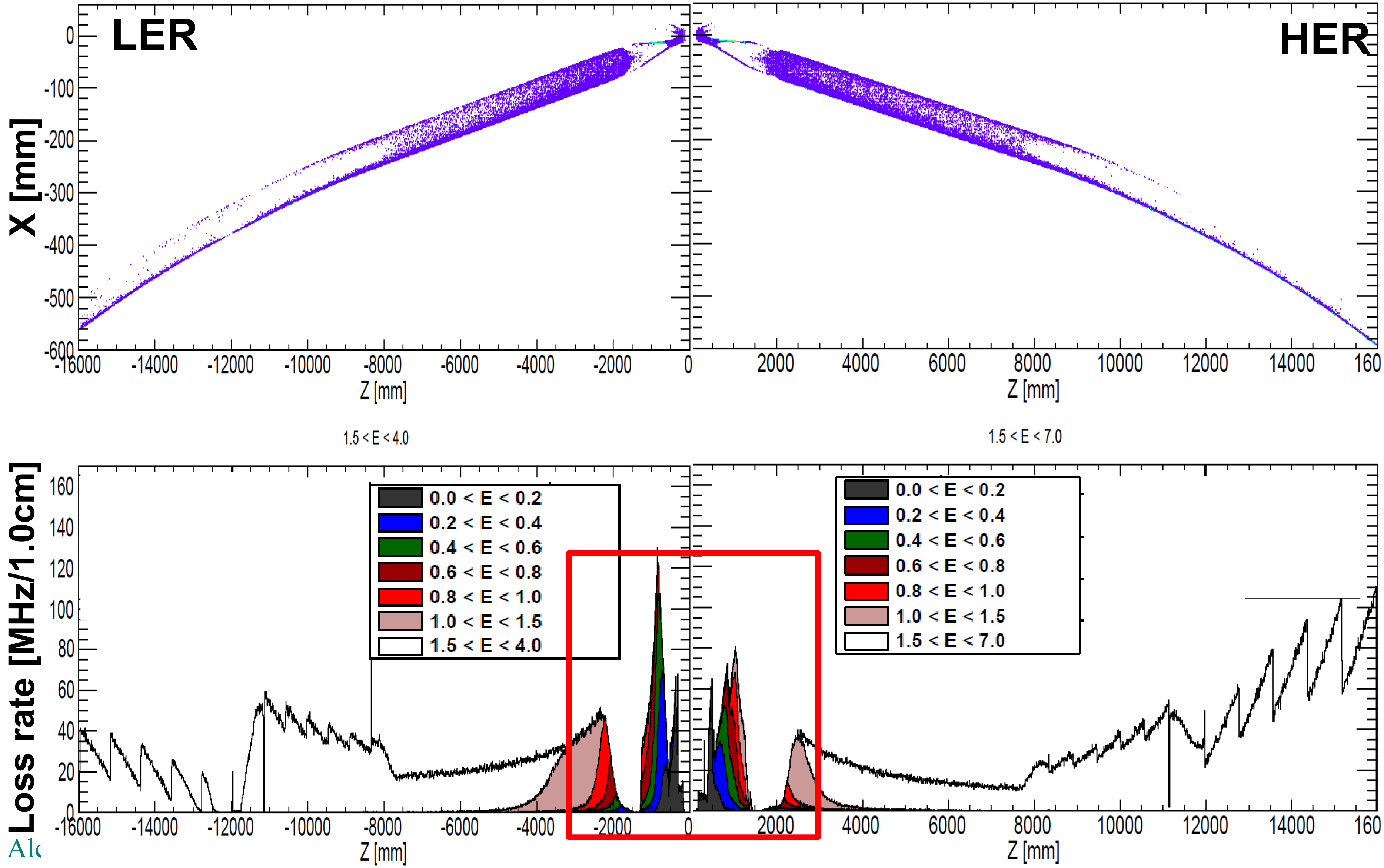

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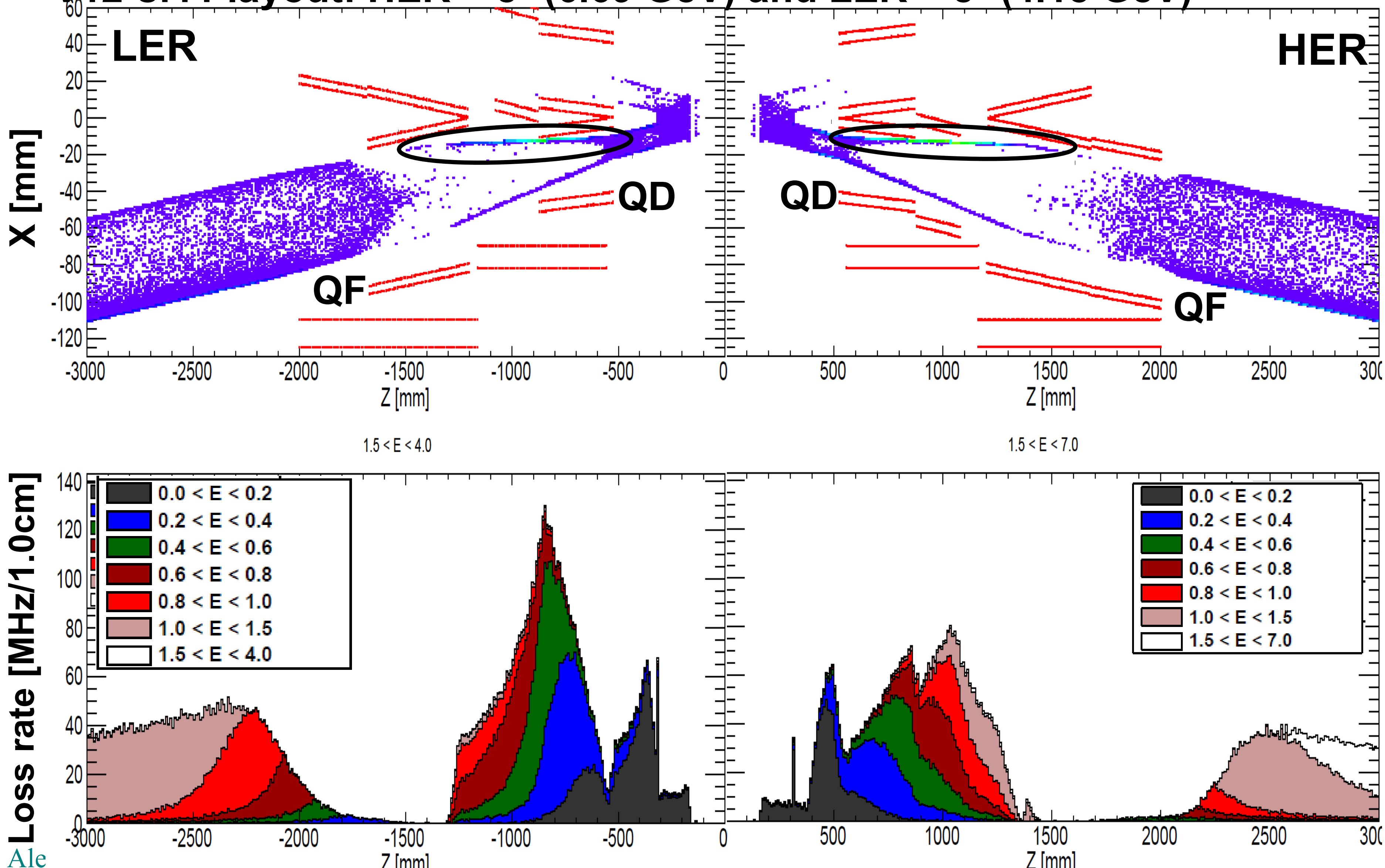

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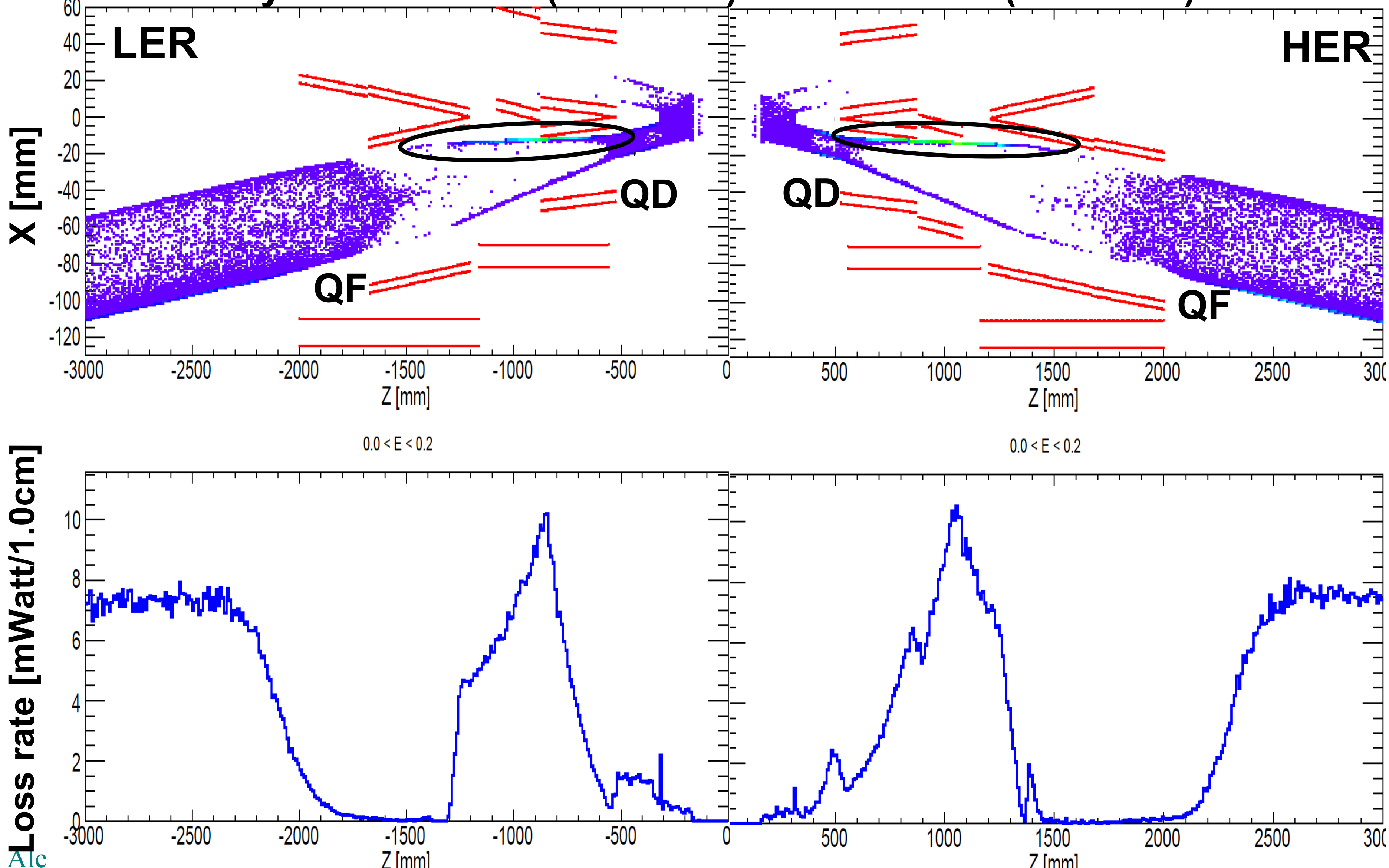

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Rad-Bhabha Losses at the Beam-pipe: rad-γ

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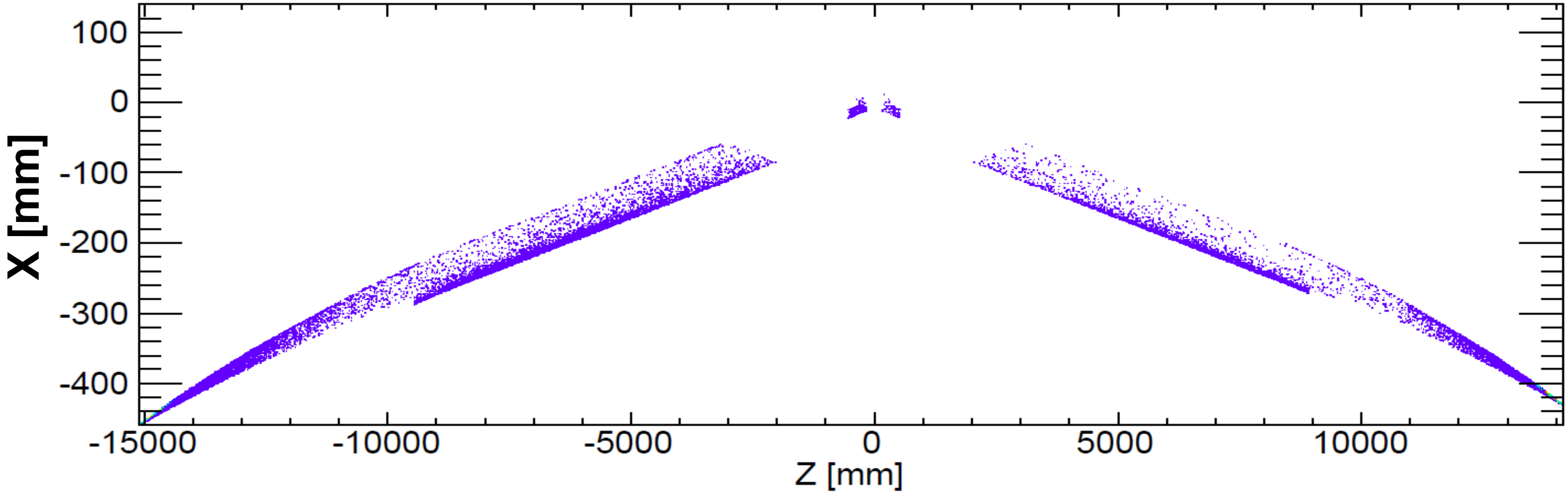

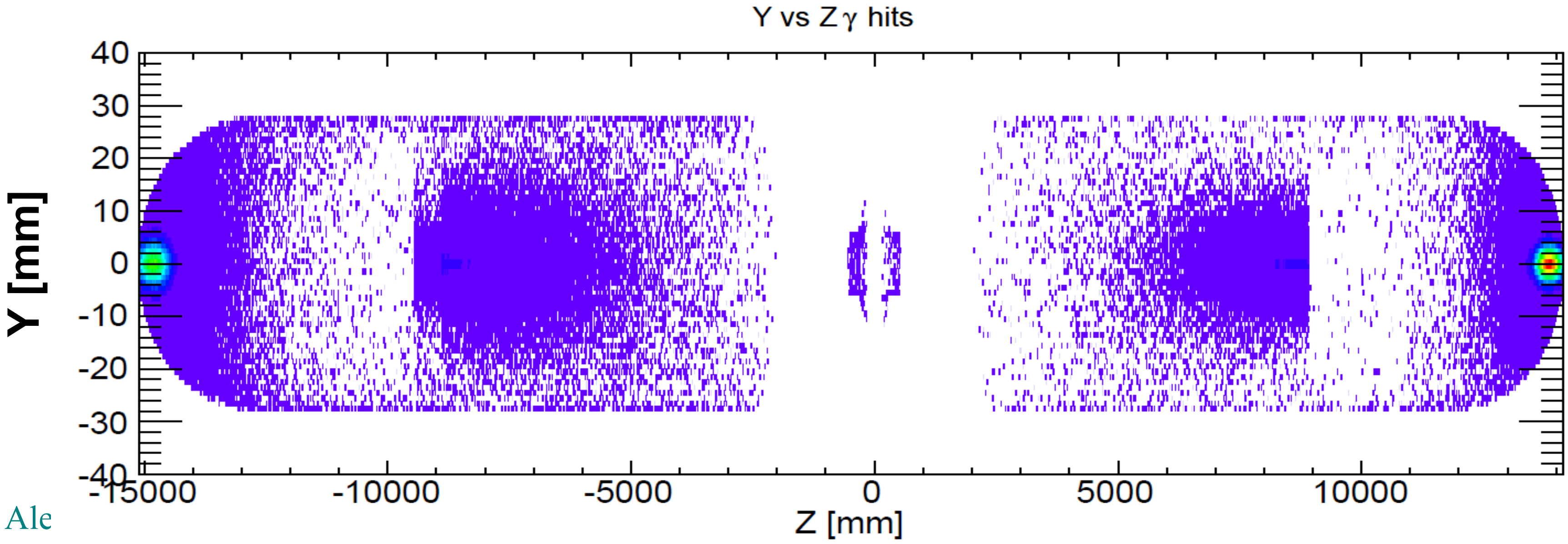

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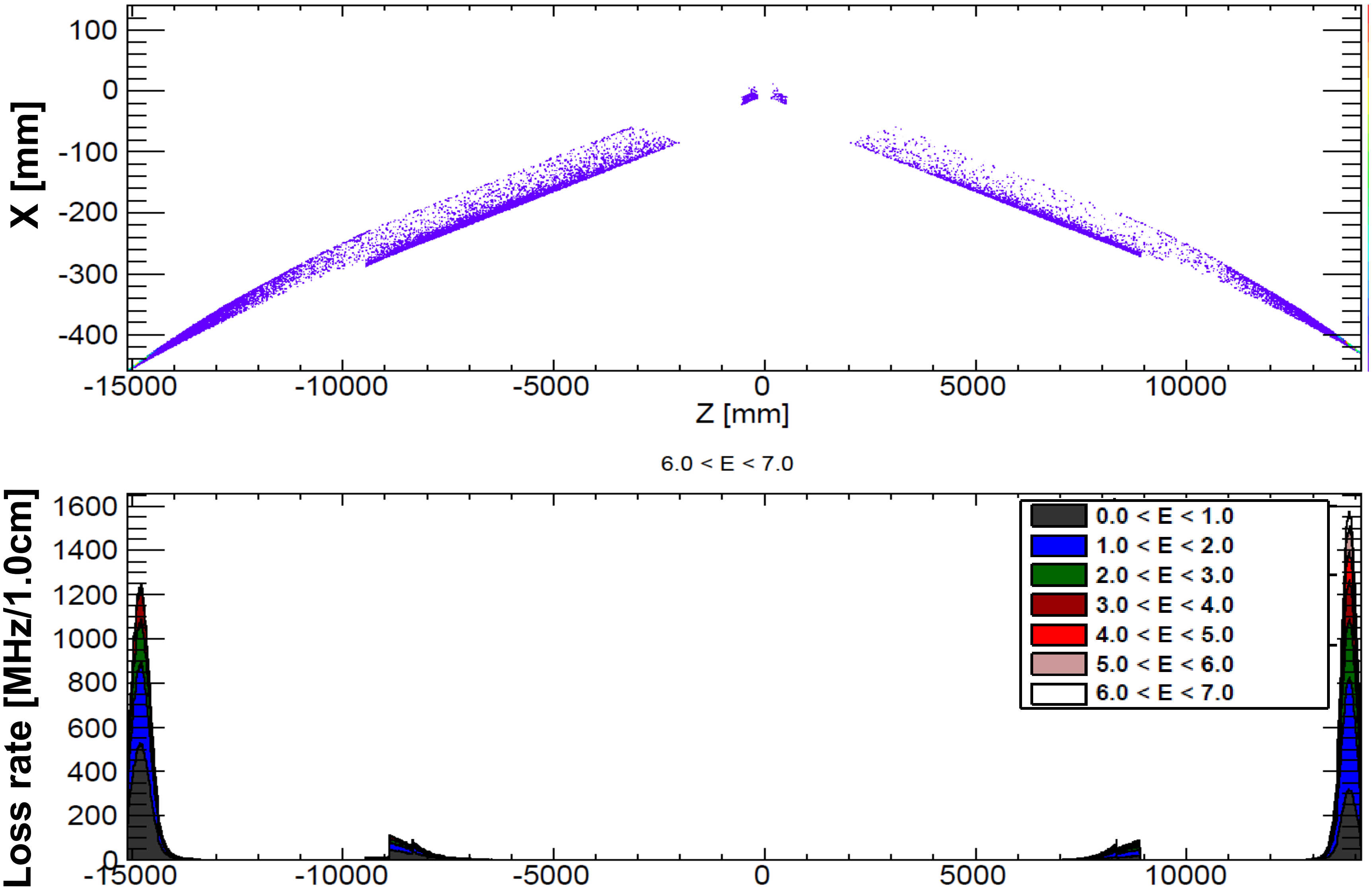

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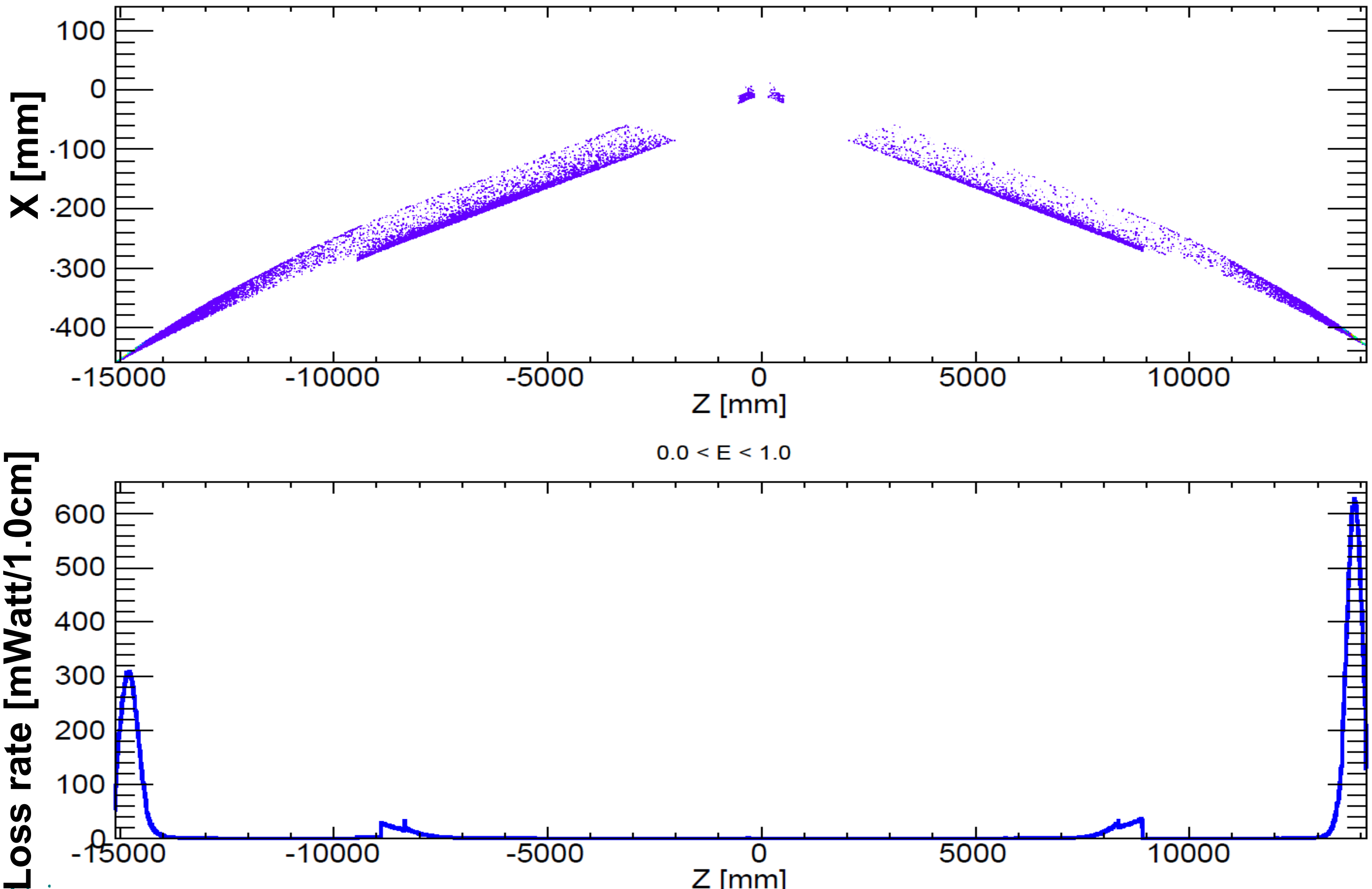


Rad-Bhabha Losses at the Beam-pipe

Total rates around the IP (-3 to 3 mts)

HER
positron rates

E range (GeV)	Rate (GHz)
0.0 – 1.0	4.735
1.0 – 2.0	2.789
2.0 – 3.0	0.025
3.0 – 4.0	0.003
4.0 – 5.0	0.003
5.0 – 6.0	0.003
6.0 – 7.0	0.005
0.0 – 7.0	7.563

LER
electron rates

E range (GeV)	Rate (GHz)
0.0 – 1.0	7.863
1.0 – 1.5	2.289
1.5 – 2.0	0.031
2.0 – 2.5	0.007
2.5 – 3.0	0.004
3.0 – 3.5	0.005
3.5 – 4.2	0.003
0.0 – 4.2	10.202

Summary

- **Rad-Bhabha is one of the main background contributions for SuperB detector**

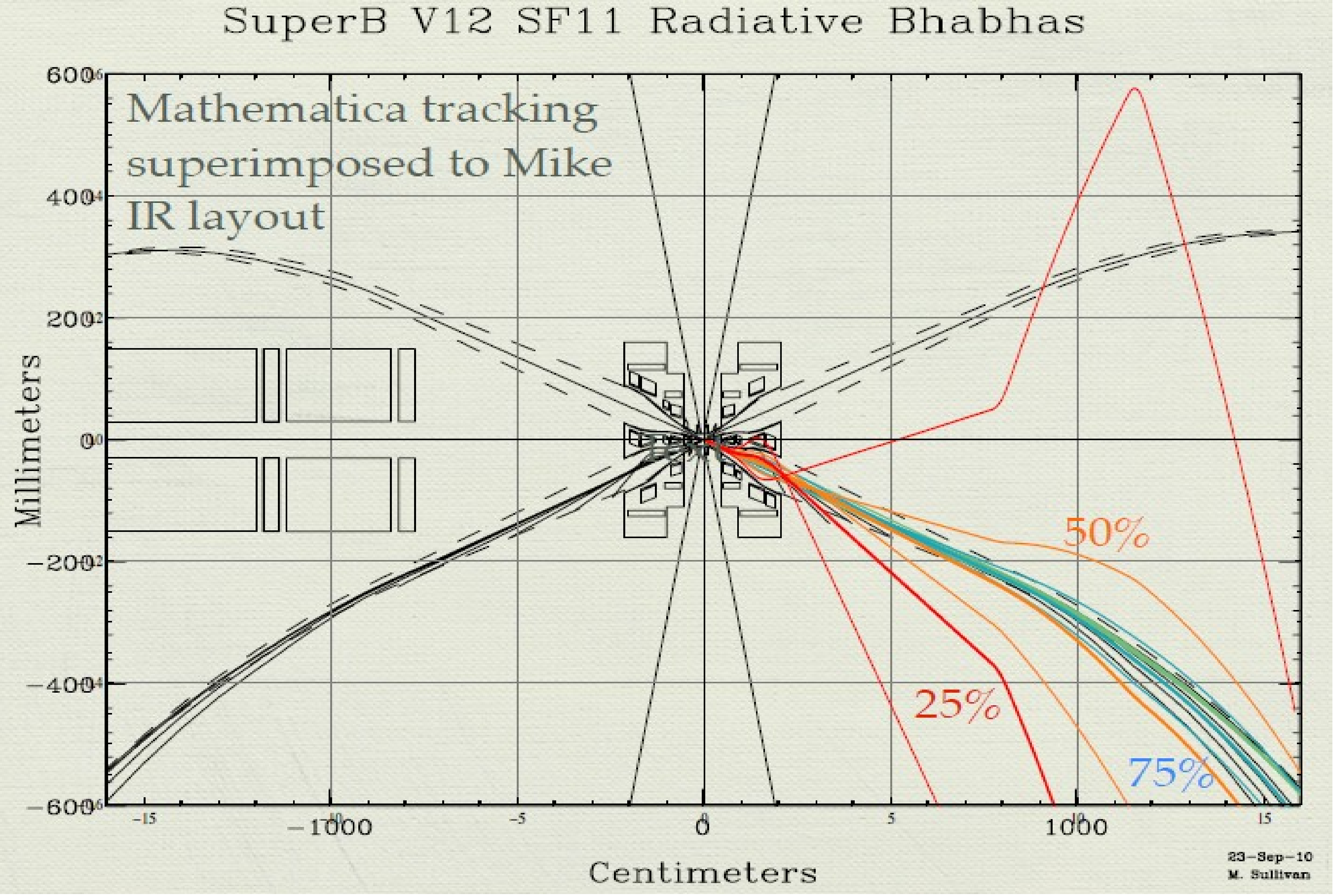
- **Accurate evaluation needs a careful model of material and magnetic fields inside the final focus (Fully detailed Geant4 model)**

- **Use BBBREM generator for primaries. Features**
  - Angular deflection of outgoing particles
  - Luminous region

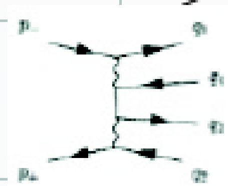
- **Evaluate loss rates at the beam-pipes to better understand this background**

Backup

Backgrounds from Rad-Bhabha

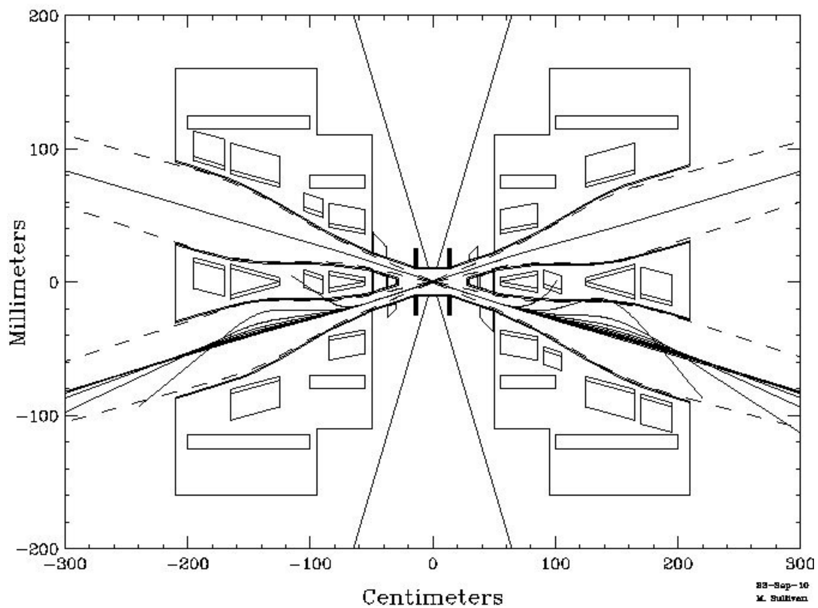


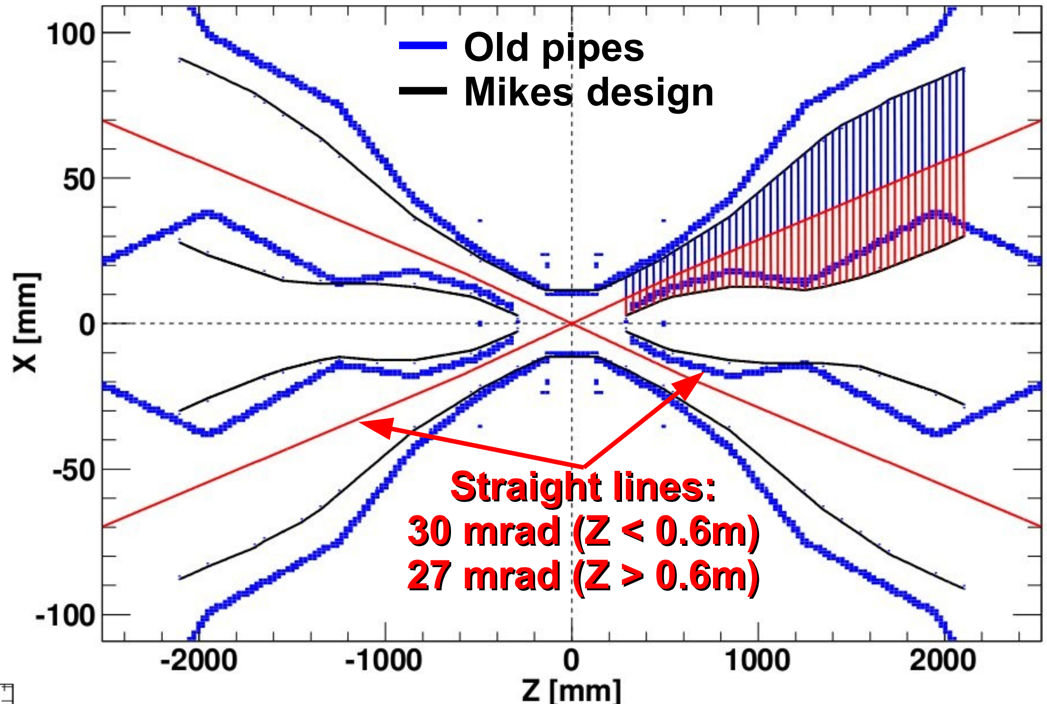
Backgrounds from Rad-Bhabha

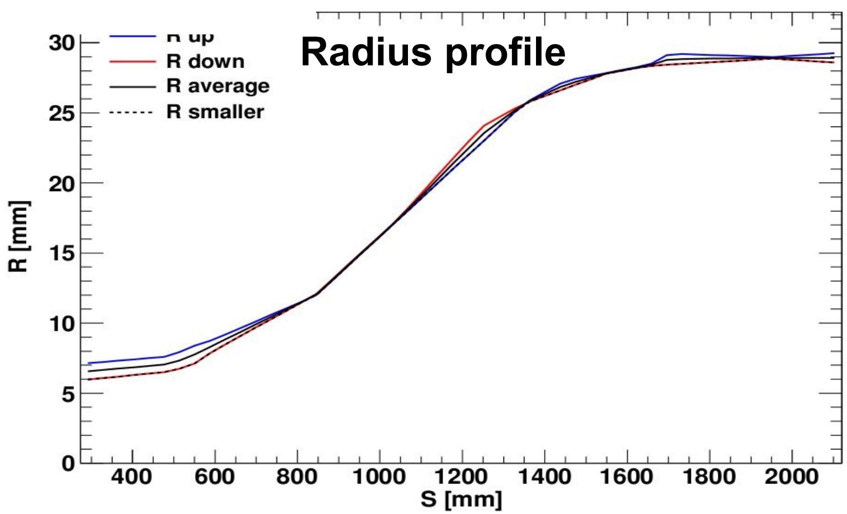
	Cross section	Evt/bunch xing	Rate
Radiative Bhabha	~340 mbarn (Eγ/Ebeam > 1%)	 ~850	0.3THz
e^+e^- pair production	~7.3 mbarn	 ~18	7GHz
e^+e^- pair (seen by L0 @ 1.5 cm)	~0.3 mbarn	~0.8	0.3GHz
Elastic Bhabha	O(10^{-4}) mbarn (Det. acceptance)	~250/Million	100KHz
Υ(4S)	O(10^{-6}) mbarn	~2.5/Million	1 KHz
	Loss rate	**Loss/bunch pass**	**Rate**
Touschek (LER)	14kHz / bunch (+/- 2 m from IP)	~7/100	14 MHz

V12 SF11 Final Focus

Mikes drawings

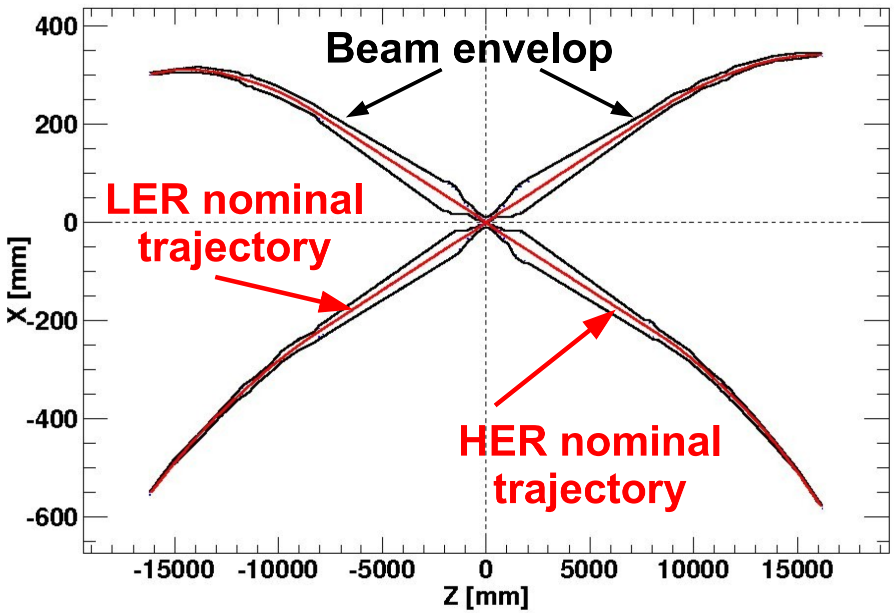


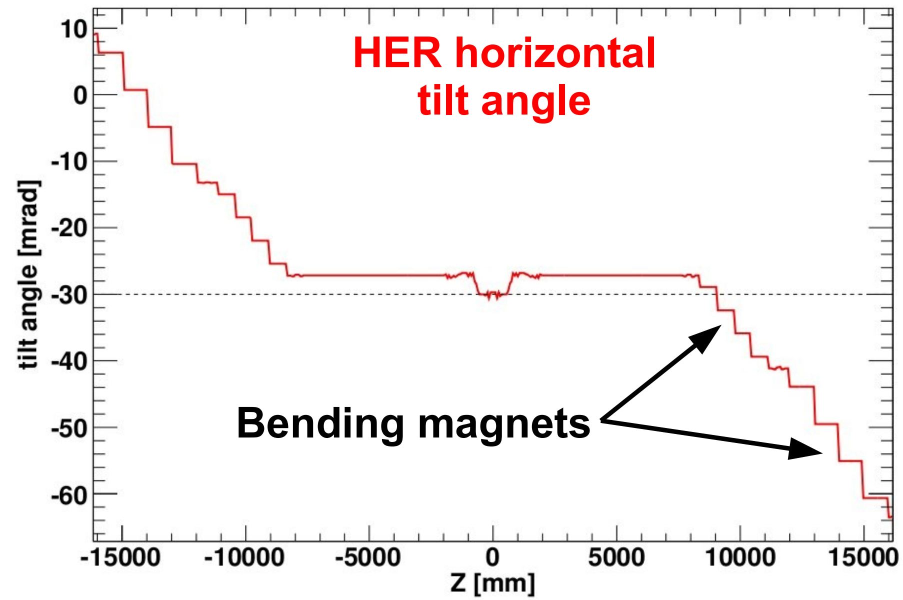




- **Use Mike Sullivan's drawings as inputs (no information on the vertical dimensions)**
- **Out of that get:**
  - Curves with the pipes walls
  - Calculate pipes radius profile as a function of distance to IP
- **Use straight pipes with constant radius from 2.4 m on until 1st bend**

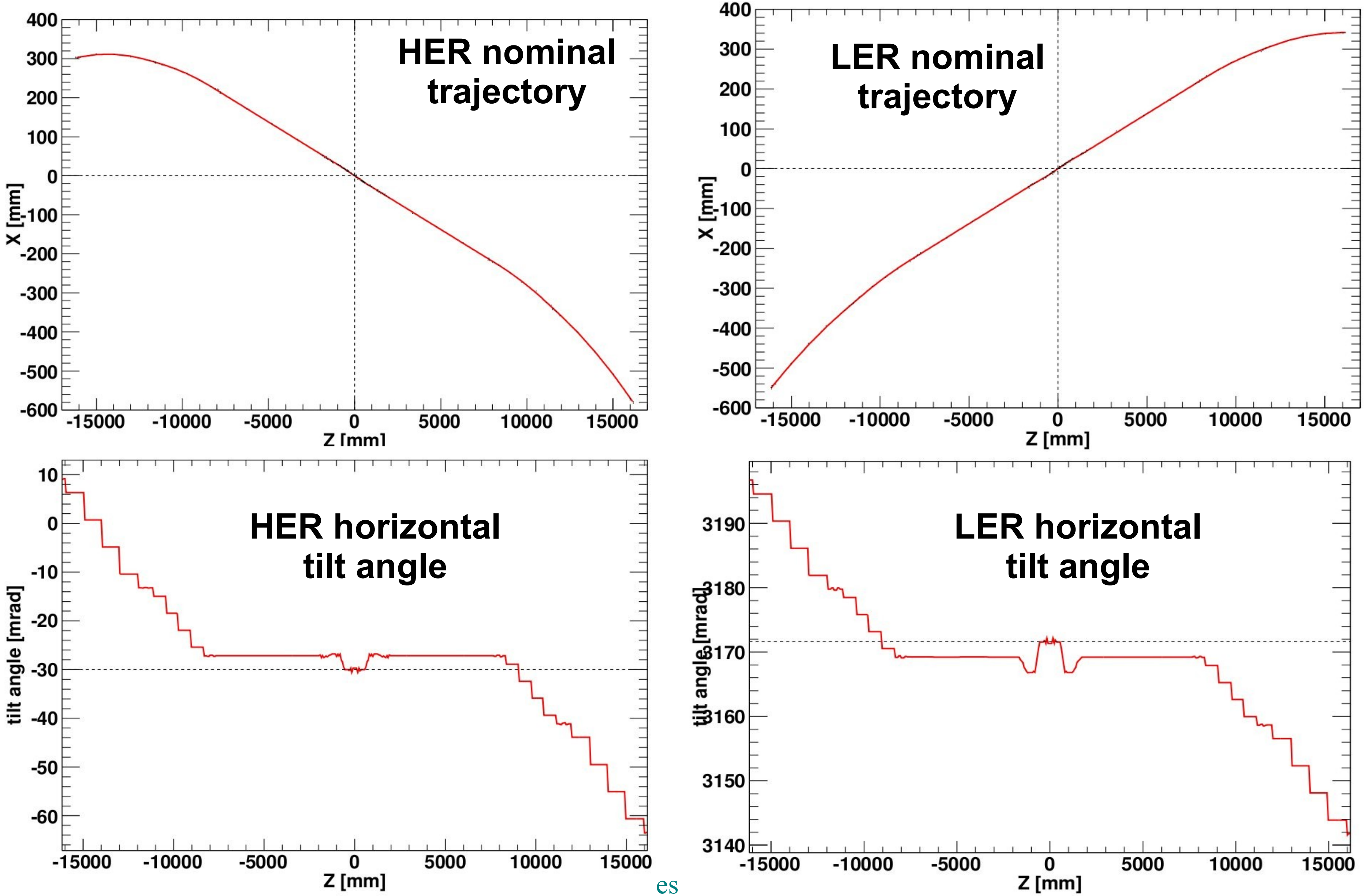
V12 SF11 nominal trajectories





- Beam pipe design only up to ~2m from IP
- After that only have beam envelop ($10\times\sigma_X$ and $10\times\sigma_Y$ beam sizes) up to ±16m from IP
- Essentially two horizontal tilt before 1st bend:
  - 30mrad near IP (Z < 0.6m)
  - 27 mrad up to 1st bend
- Will try to use two straight sections for the beam pipe modeling

V12 SF11 nominal trajectories



Geometrical model of beam-pipe at bending

- **Previously:**
  - Pipes inside bending magnets modelled as torus
  - Torus gives some navigation problems when testing geometry with Geant4
- **Currently:**
  - Pipes inside bending magnets are modelled as the union of straight pipe sections (5) that follows the bending curvature