FIRST RESULTS OF BEAM-GAS SIMULATIONS IN THE IR

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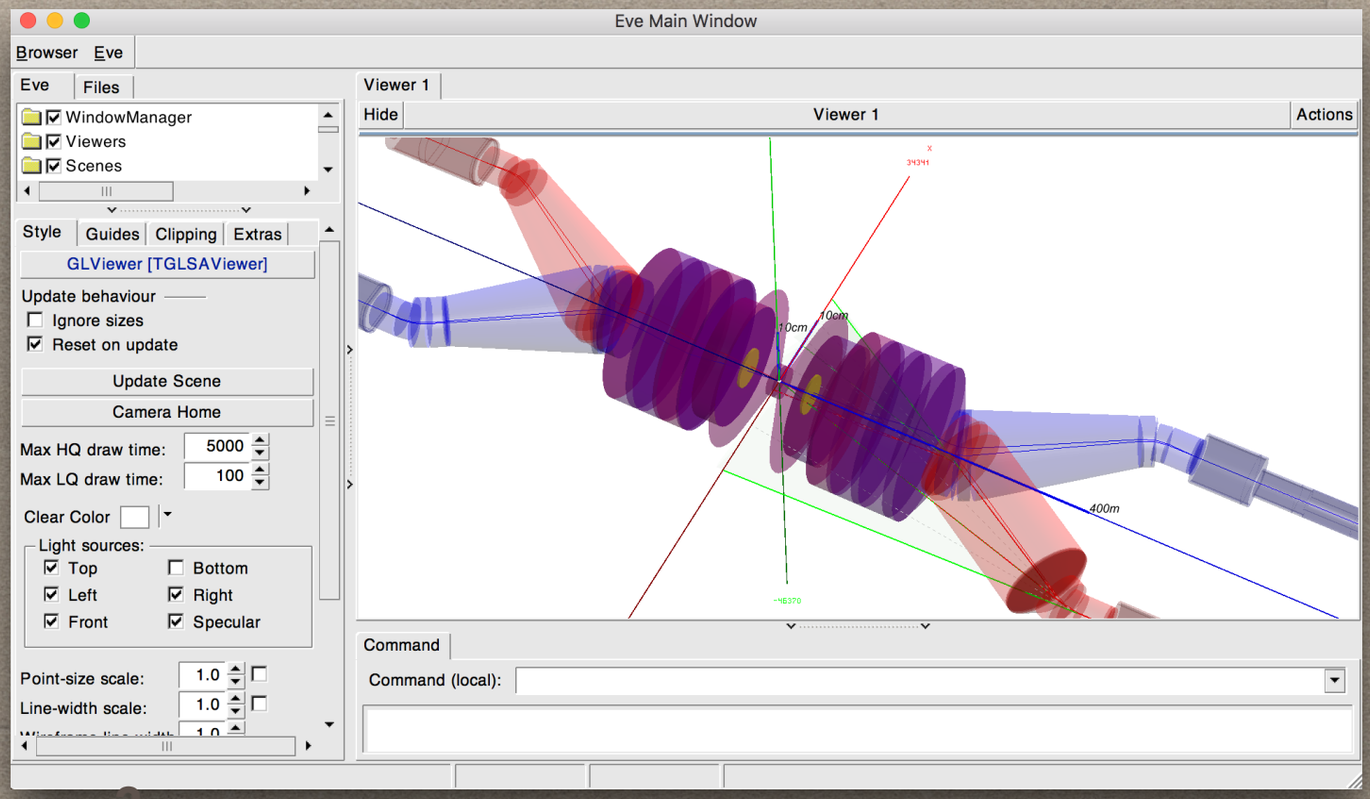
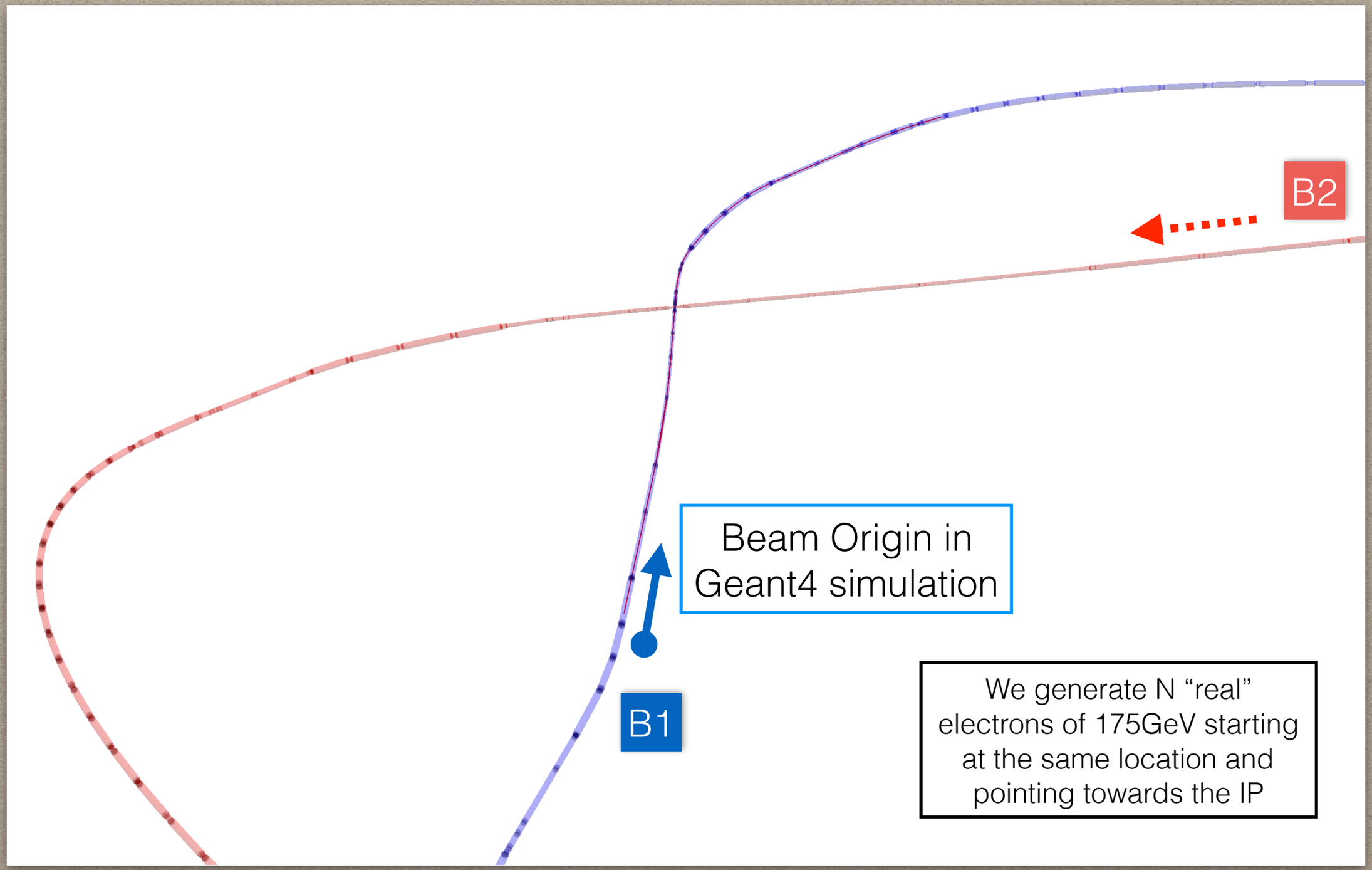
MDISIM TOOL

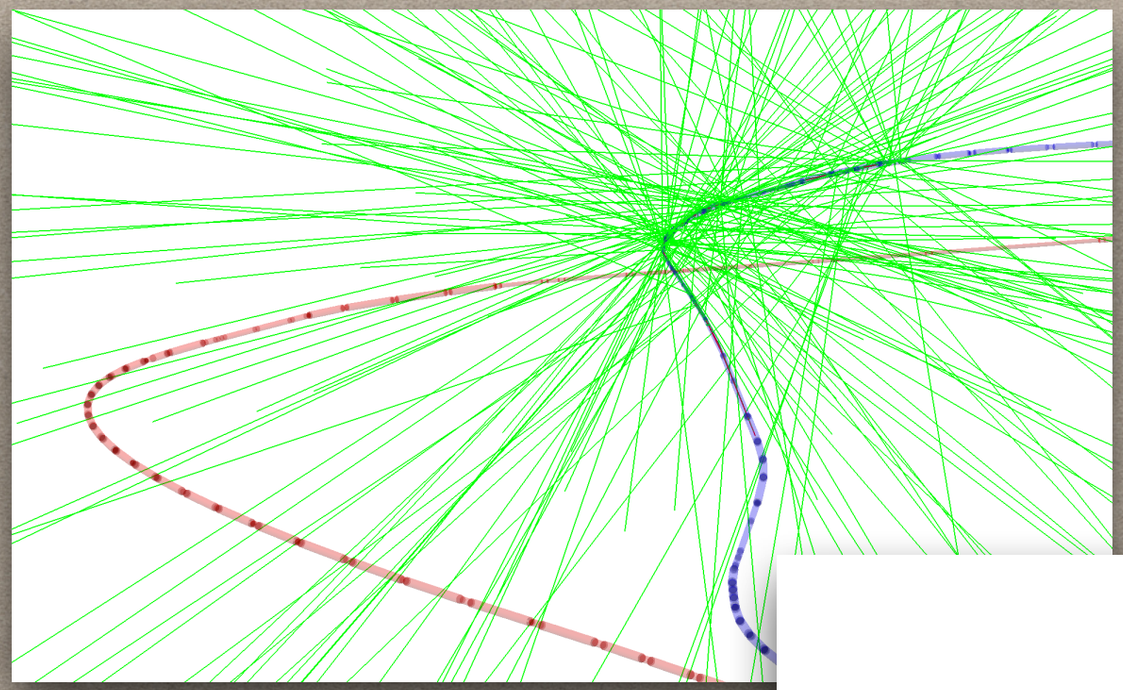
- Developed by Helmut Burkhardt (CERN), is a set of C++/Root classes that allow to:
- Run Madx on the desired lattice of the FCC
- Read Madx output, plot the lattice
- Calculate Synchrotron Radiation (Power Radiated, Critical Energy..) and plot it over the geometry using Root's TEve
- Import geometry and SR in Geant to perform full simulation

link

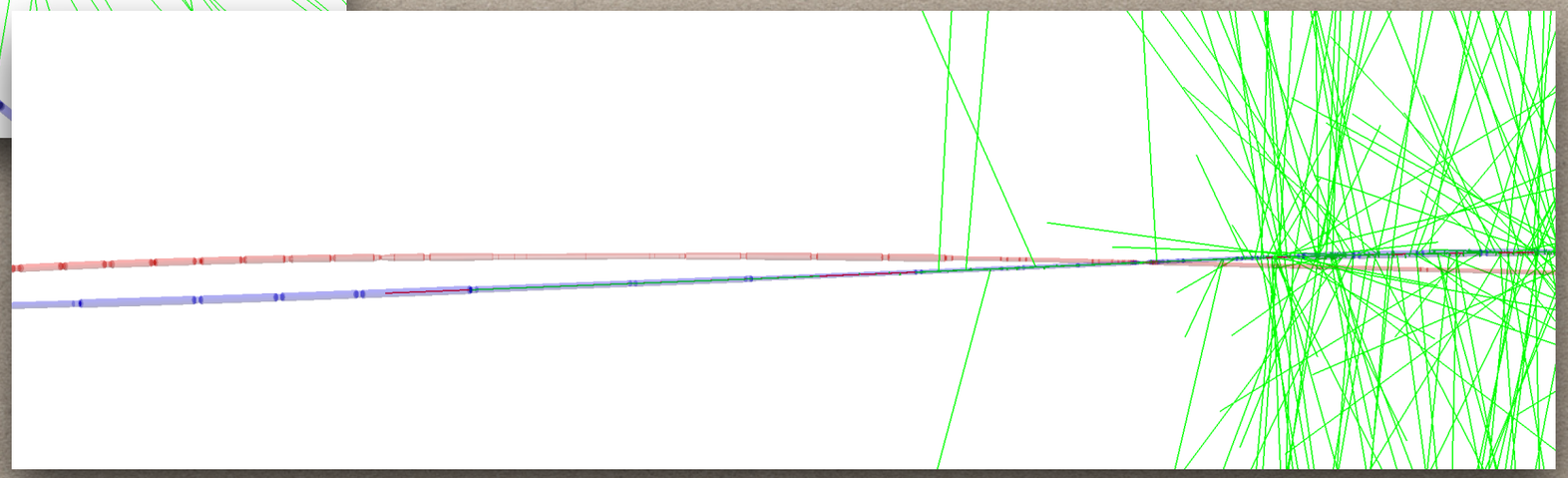



B2
Beam Origin in
Geant4 simulation
B1
We generate N “real”
electrons of 175GeV starting
at the same location and
pointing towards the IP

Synchrotron Radiation photons emitted



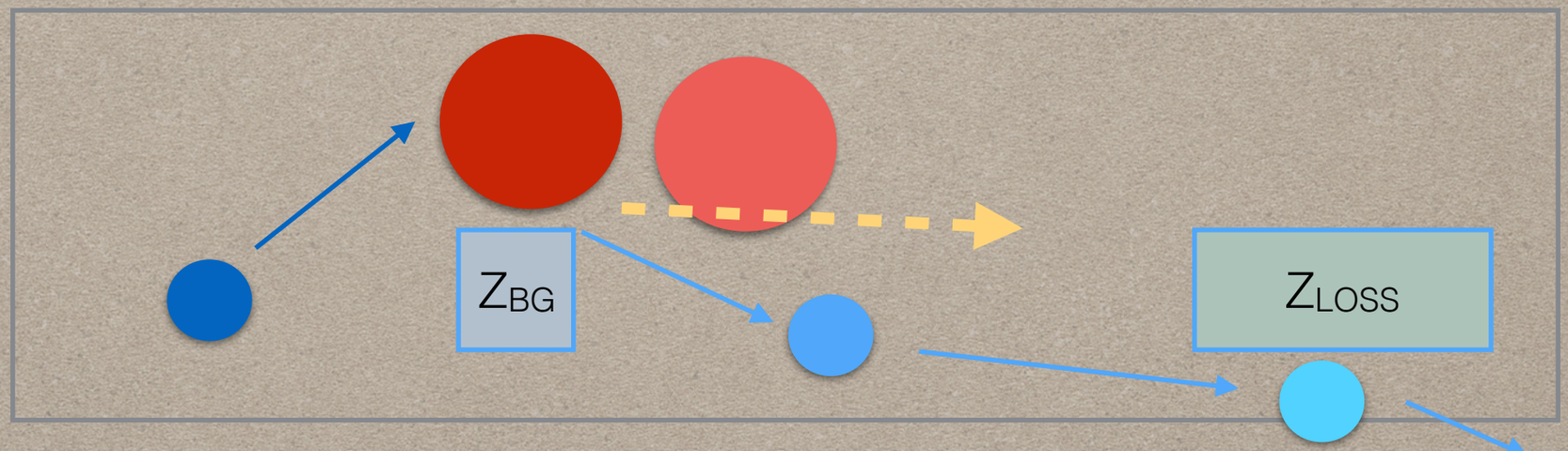
Transverse 50x zoom (needed to gain readability) creates apparent “huge deflections” in photon’s track!



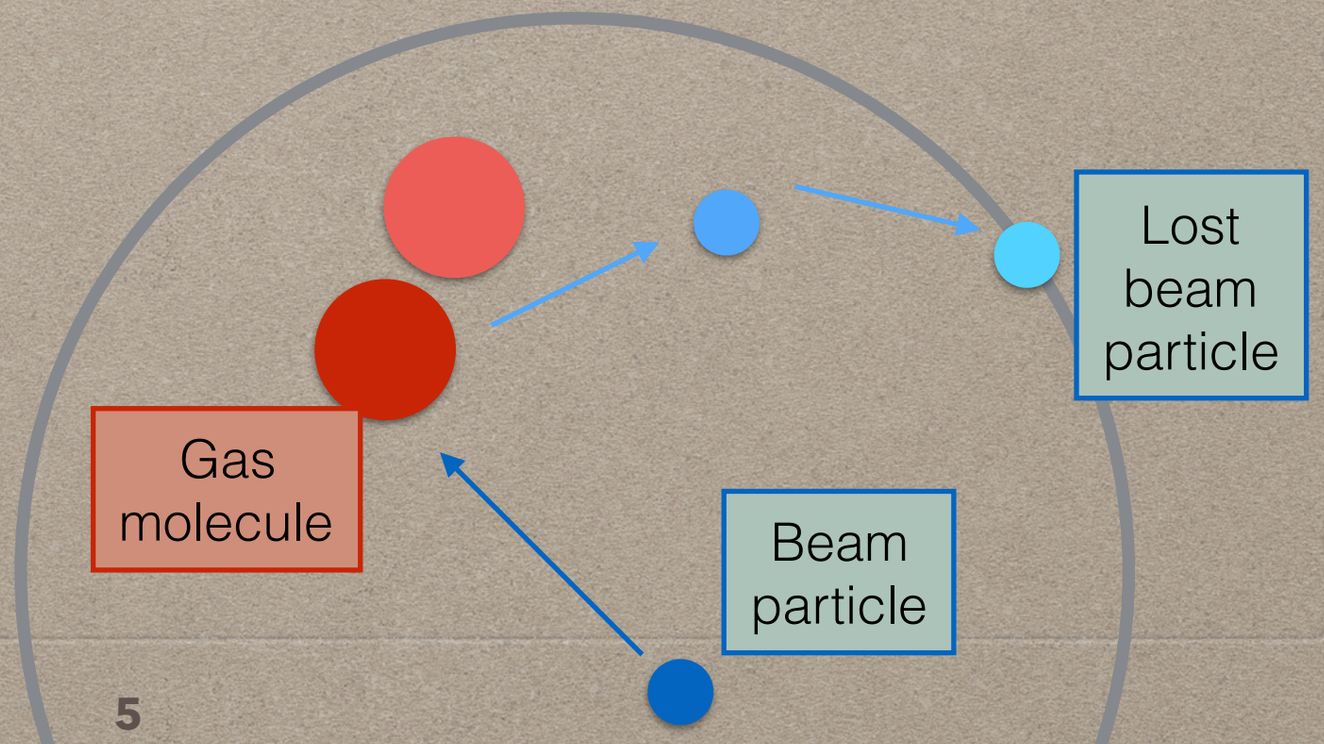
- The tool developed and tested for Synchrotron Radiation studies opens the way to several others possible applications
  - We now have in GEANT4 the beam pipe geometry and the beam characteristics!

BEAM GAS STUDIES

- Very rare process, due to very low density of Vacuum in the pipe



- However, within certain limits, can be “enlarged” by rising this density

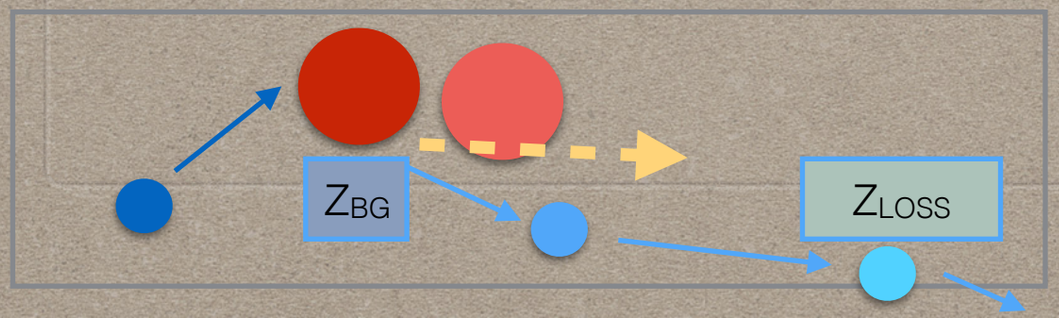


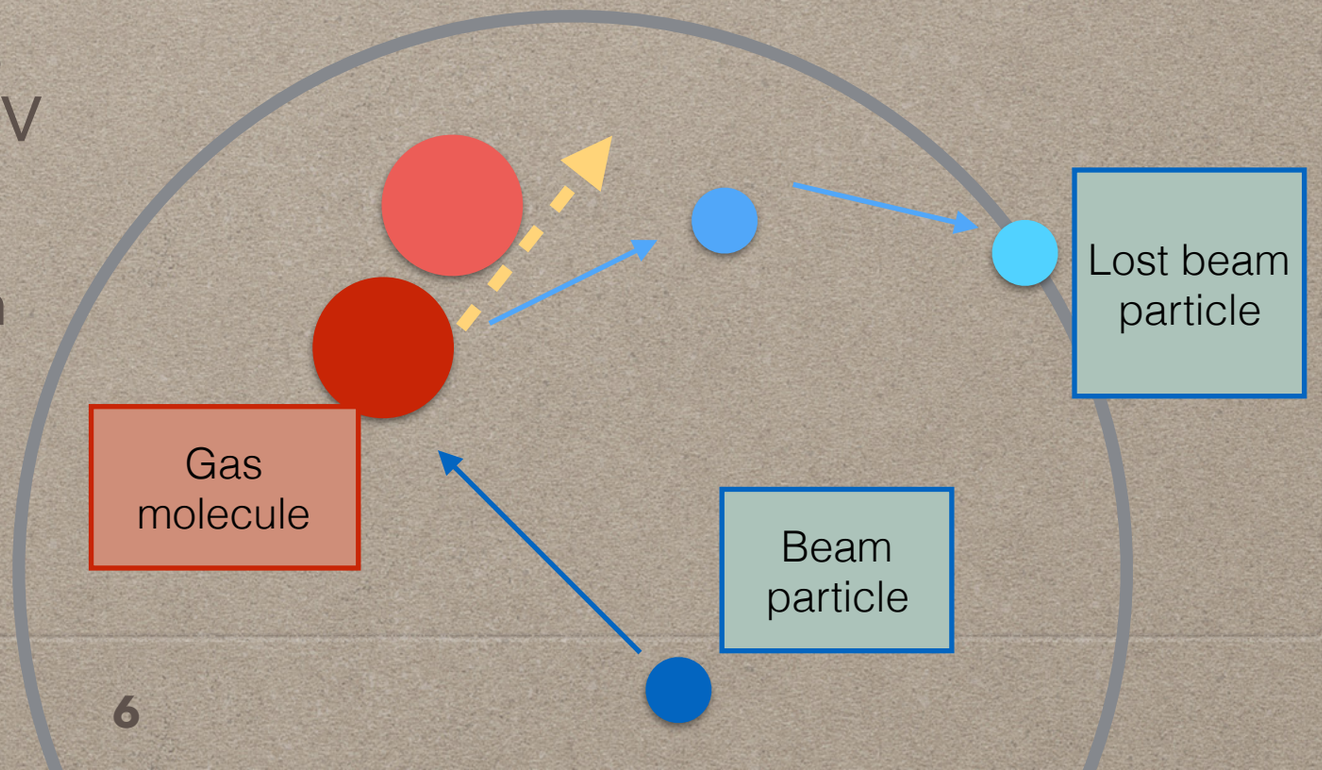
(INELASTIC) BEAM GAS

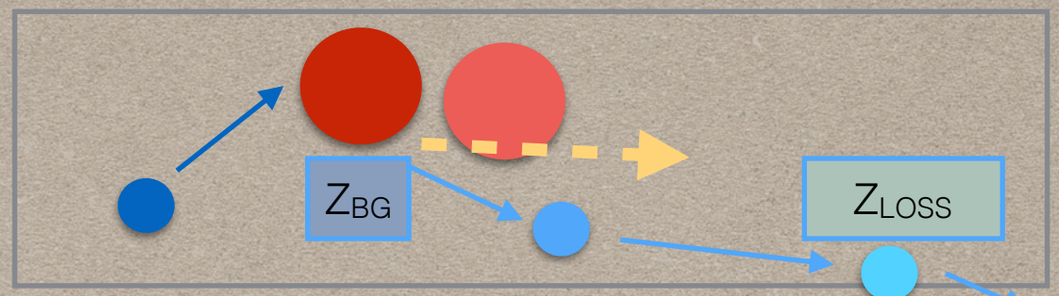
- A primary electron (realistic, 175GeV) beam is generated 500m from the IP
- Rising the Vacuum **density** of about **10 orders of magnitude** it is possible to start to see some Beam-Gas interactions:

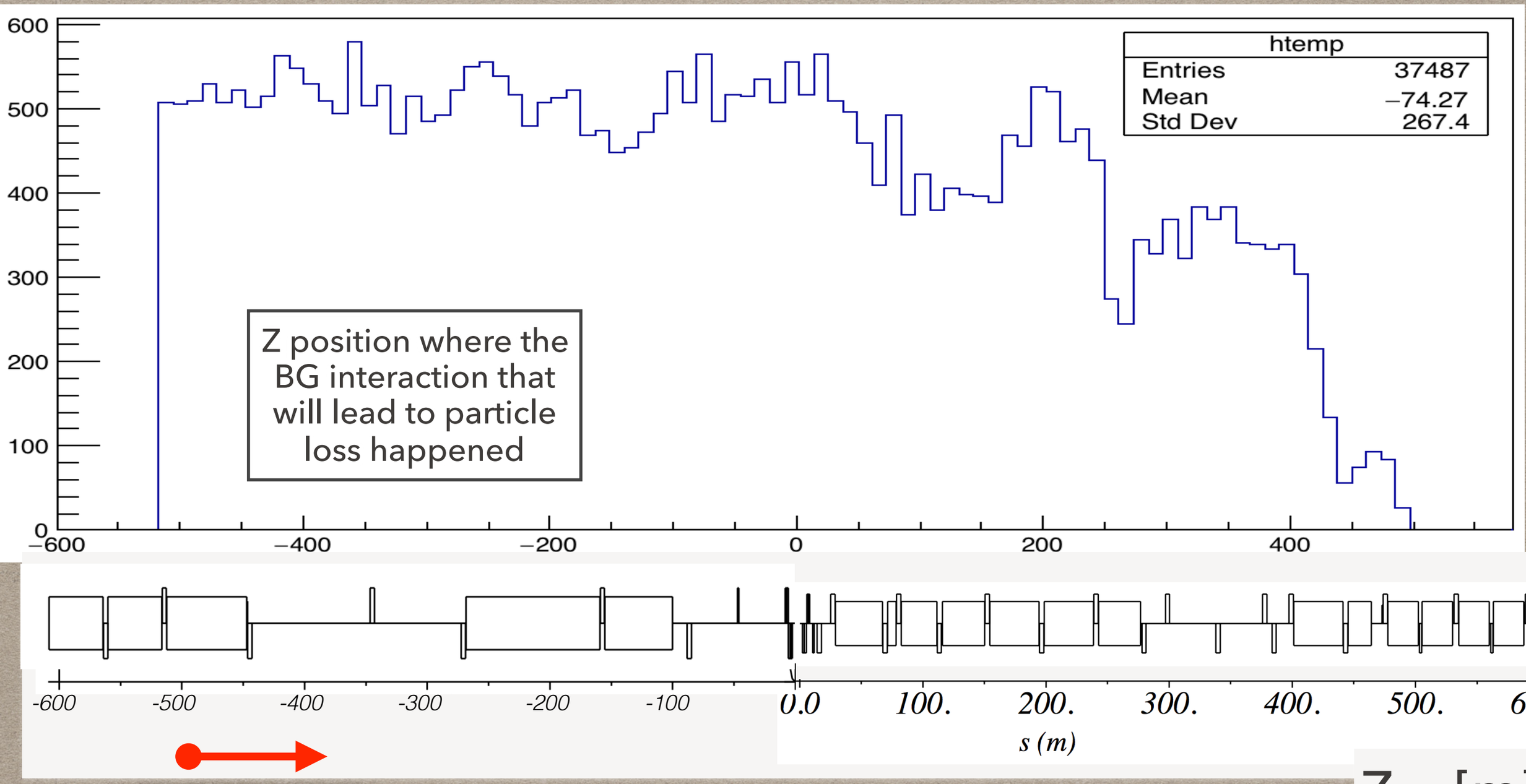
  $P_{real} \sim 5*10^{-9}$ mbar → $P_{MC} \sim 50$mbar!!!

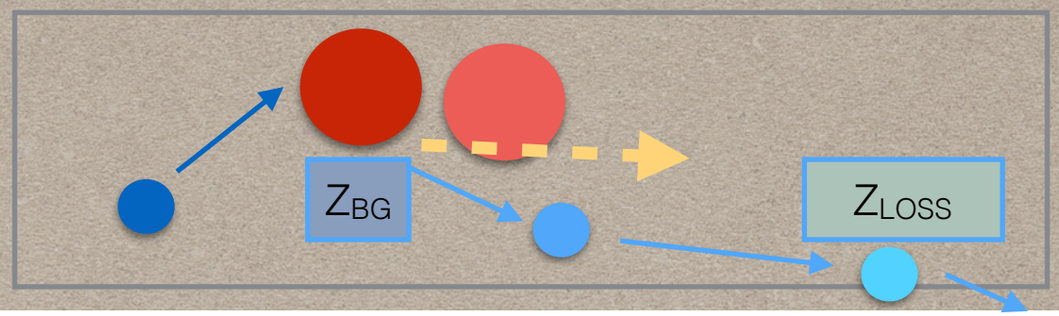
- Event recognition:
  - Primary electron undergoes "eBrem" process with >1GeV energy transfer
  - The primary electron is then lost in the pipe






Z_{BG}
Z_{LOSS}


htemp
Entries 37487
Mean −74.27
Std Dev 267.4
Z position where the BG interaction that will lead to particle loss happened
s (m)
Beam Origin
Z_{BG} [m]

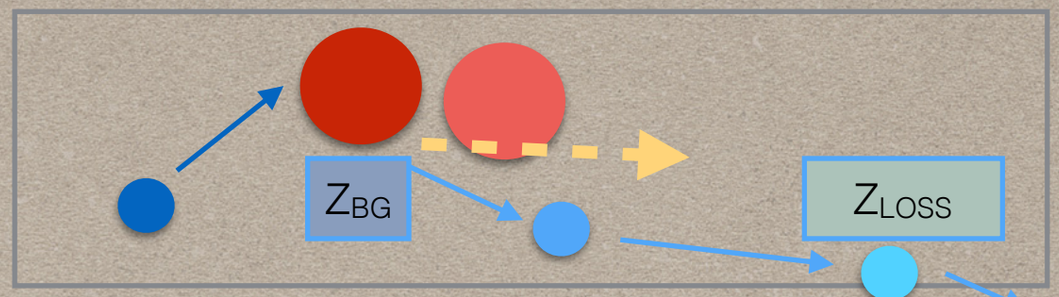


Energy lost by the primary in a BG interaction that will lead to particle loss

htemp	
Entries	37487
Mean	62.44
Std Dev	44.46

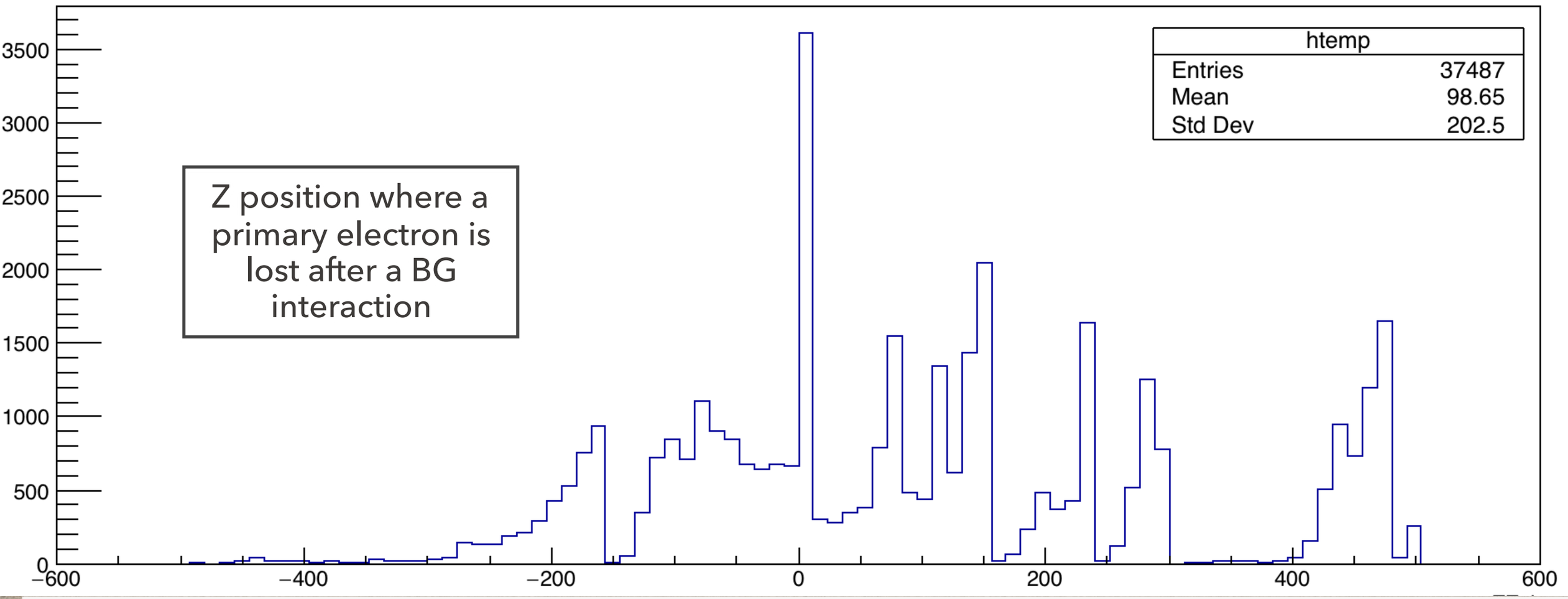
1400
1200
1000
800
600
400
200
0
0 20 40 60 80 100 120 140 160 180

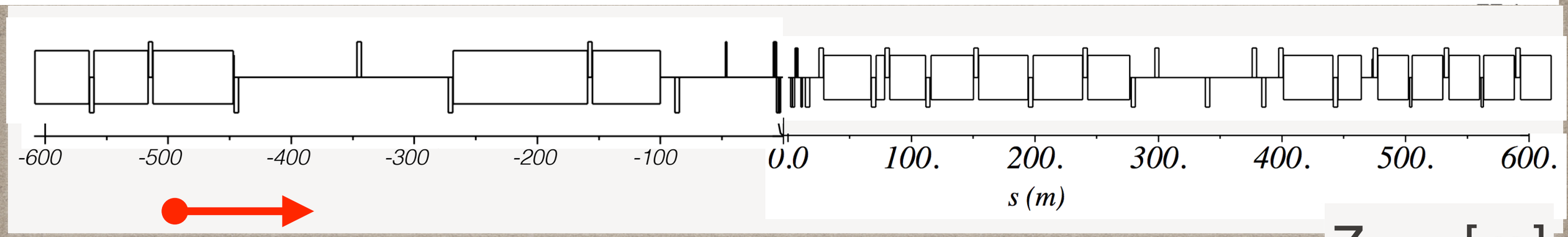
E_{BG} [GeV]



Z position where a primary electron is lost after a BG interaction

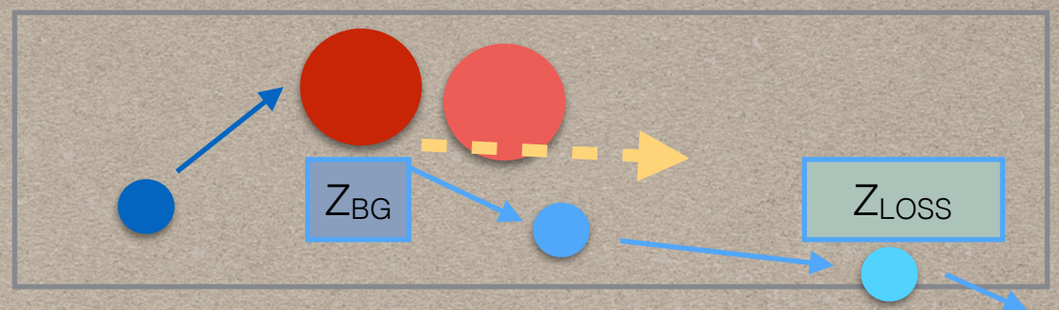
htemp	
Entries	37487
Mean	98.65
Std Dev	202.5





Beam Origin

Z_{LOSS} [m]



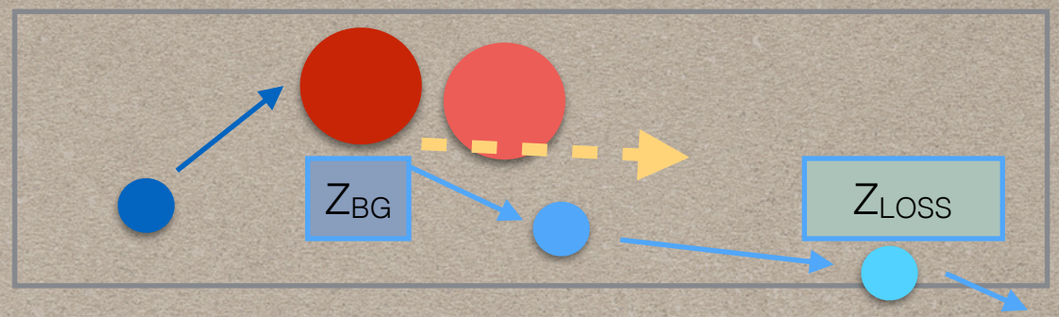
Z position where a primary electron is lost after a BG interaction

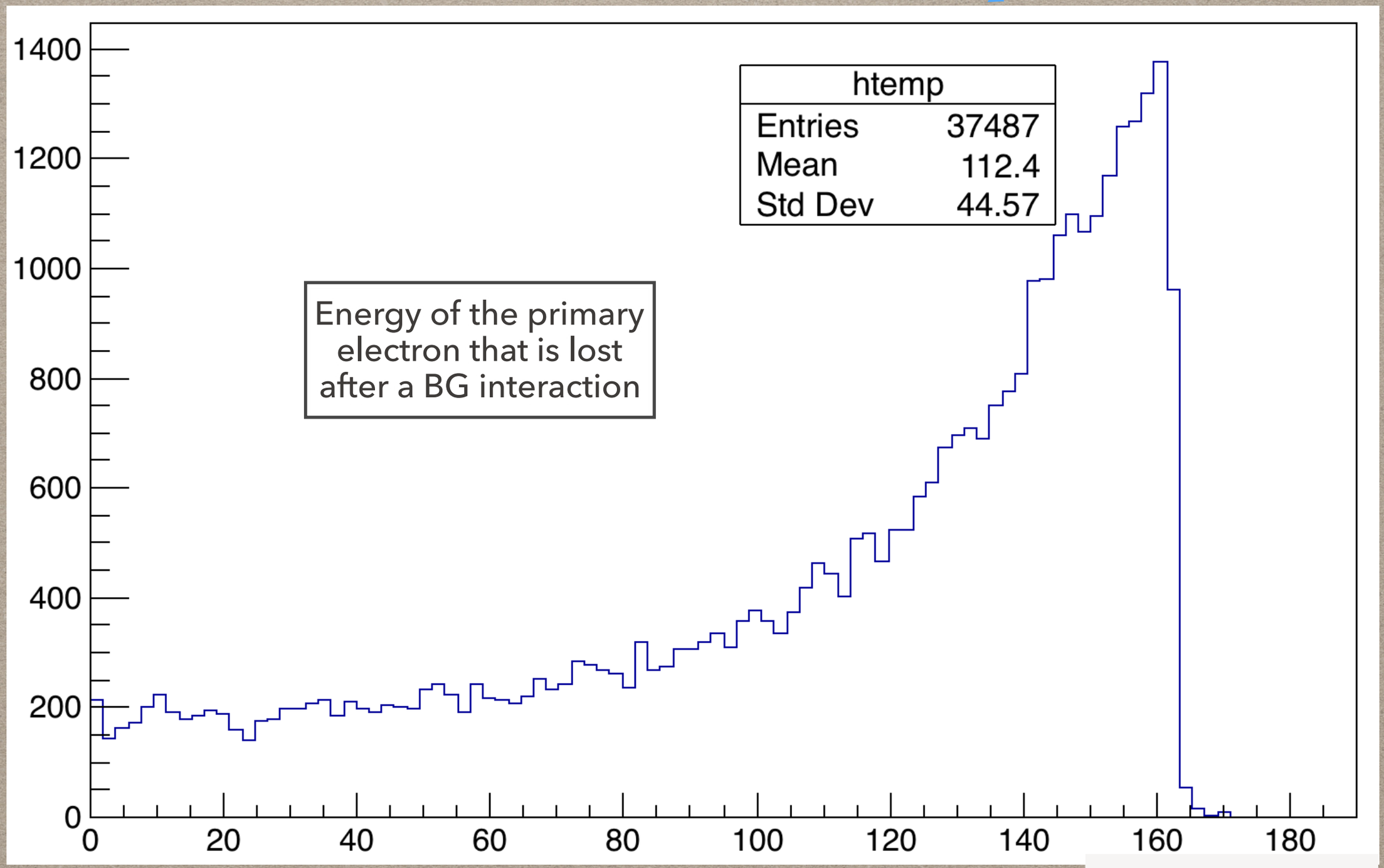
htemp	
Entries	7398
Mean	−2.905
Std Dev	22

Zoom around IP

The loss peak is around z=5m (first bend after IP!?)

Z_{LOSS} [m]


Z_{BG}
Z_{LOSS}

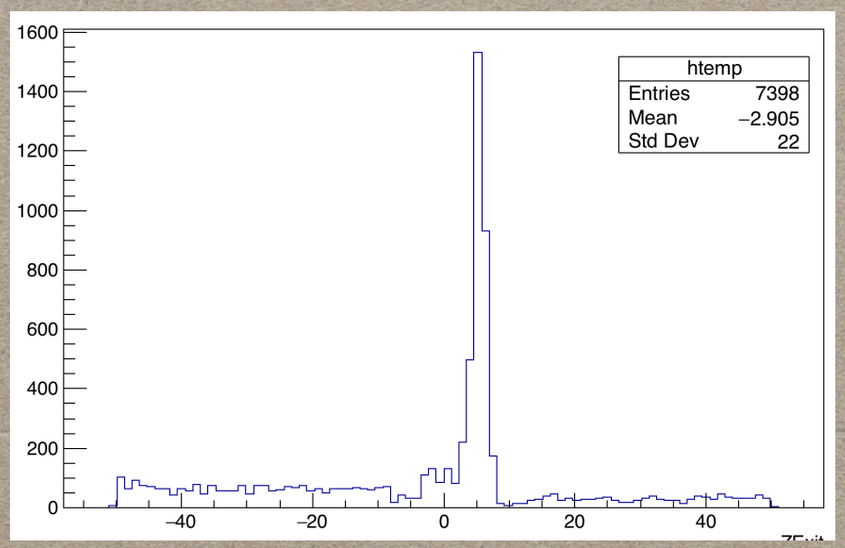

htemp
Entries 37487
Mean 112.4
Std Dev 44.57
Energy of the primary electron that is lost after a BG interaction
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
180
E_{LOSS} [GeV]

GOING QUANTITATIVE...

- If we simulate 10^8 primaries we obtain that ~1000 particles are lost in **±4m** around the IP...
  - What does it mean for a real case scenario?
- Electrons lost per bunch:

$$N^{e^-}_{loss}/b = \frac{N^{e^-}_{loss_{MC}}}{N^{e^-}_{prim_{MC}}} \times N^{e^-}_{bunch} : \frac{P_{MC}}{P_{Real}}$$

$$N^{e^-}_{loss}/b = \frac{1000}{10^8} \times 10^{11} : 10^{10} = N^{e^-}_{loss_{MC}} \times 10^{-7} = 10^{-4}$$



"calibration factor" from plot value to bunch

number of lost electrons per bunch

Simulating only interactions **±500m** from the IP!!

SUM-UP AND PERSPECTIVES

- MDISim enables to import the whole configuration (beam + geometry) in GEANT4 starting from MAD-X file
- Once in GEANT4, several studies can be done, including beam gas
- First results show that this approach is very powerful, having access to each process/interaction
- Given the high level of detail, a careful study must be done…