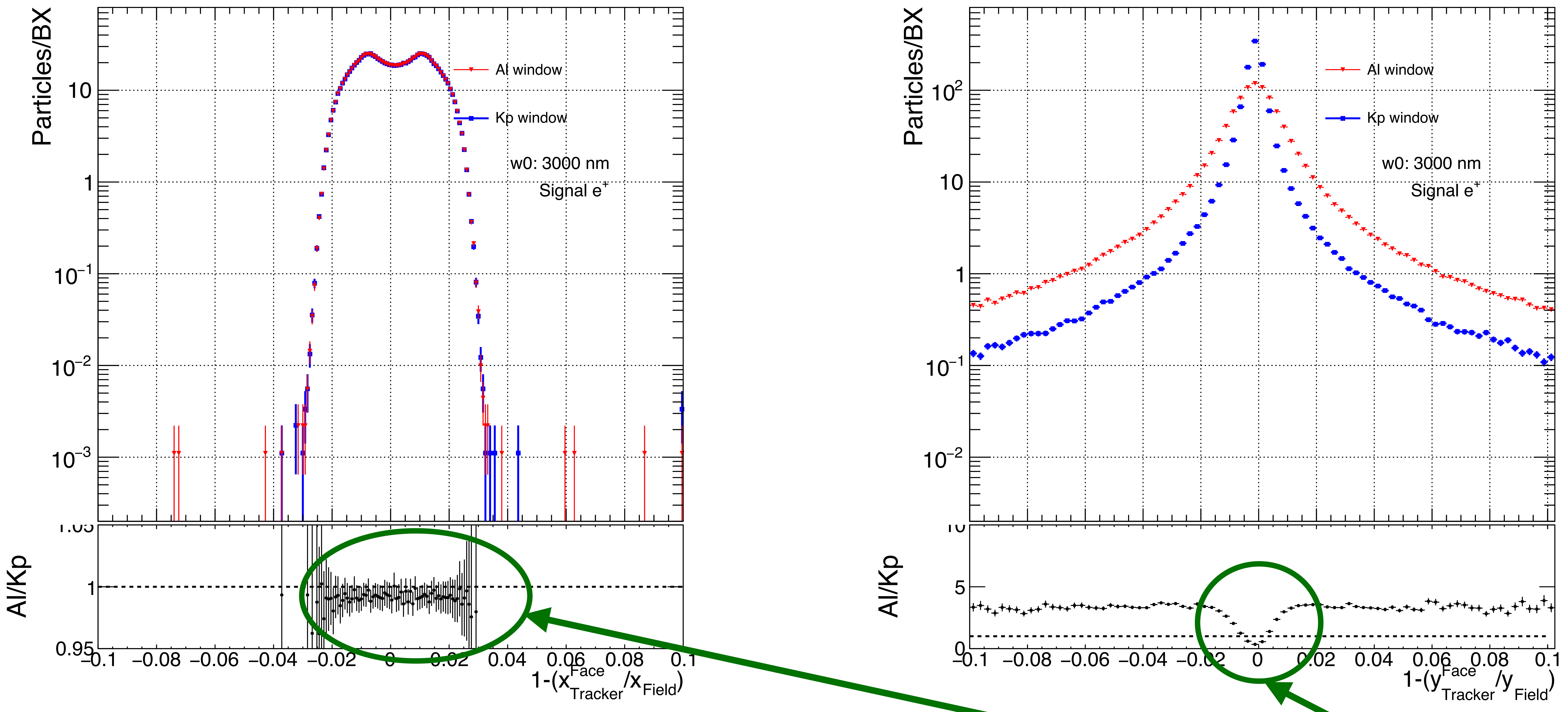
Signal positrons: Comparison with Aluminium window and Kapton window - An update

Arka Santra, May 18, 2021
Weizmann Institute of Science,
Rehovot, Israel

- e+laser hics setup
- Comparison between
    - Exit window of 200 um of Kapton (Kp).
    - Exit window of 500 um of Aluminum (Al).
  - Looked at the signal positron particles:
    - ($x^{\mathrm{Face}}_{\mathrm{Tracker}}$, $y^{\mathrm{Face}}_{\mathrm{Tracker}}$) is the position of track at the face of the tracker first layer, coming from Geant4 simulation.
    - x_{Field} is the x position of the track at the face of the tracker first layer, calculated analytically given the magnetic field and momentum of the signal particle at the IP .
    - y_{Field} is the y position of the track at the face of the tracker first layer, calculated analytically given the p_y and p_z of the signal particle at the IP .

Position distribution for signals: Al window and Kapton window



More particles for Kapton window around 0

- (1 - $x^{\mathrm{Face}}_{\mathrm{Tracker}}/x_{\mathrm{Field}}$) distributions for different window.
- Similar distribution for (1 - $y^{\mathrm{Face}}_{\mathrm{Tracker}}/y_{\mathrm{Field}}$).
- For Kapton window, more particles populate ($x_{\mathrm{Field}} - x^{\mathrm{Field}}_{\mathrm{Tracker}}$) ~ 0 than that for aluminum window.
    - Similar conclusion for y position.

Summary

- Aluminum window distorts signal tracks more than Kapton window.
  - The difference between calculated (x,y) and simulated (x,y) is larger for Aluminum window.
  - But the distortion is **negligible**, ~1.3%.
  - **Not a problem** in signal tracks if we use Aluminium window.

Back up

Electron in a *B*-field of a dipole

- Motion of electron in a uniform magnetic field
  - $qBv = mv^2/R \longrightarrow p = qBR \longrightarrow p[\text{GeV}] = 0.3 \cdot B[\text{T}] \cdot R[\text{m}]$

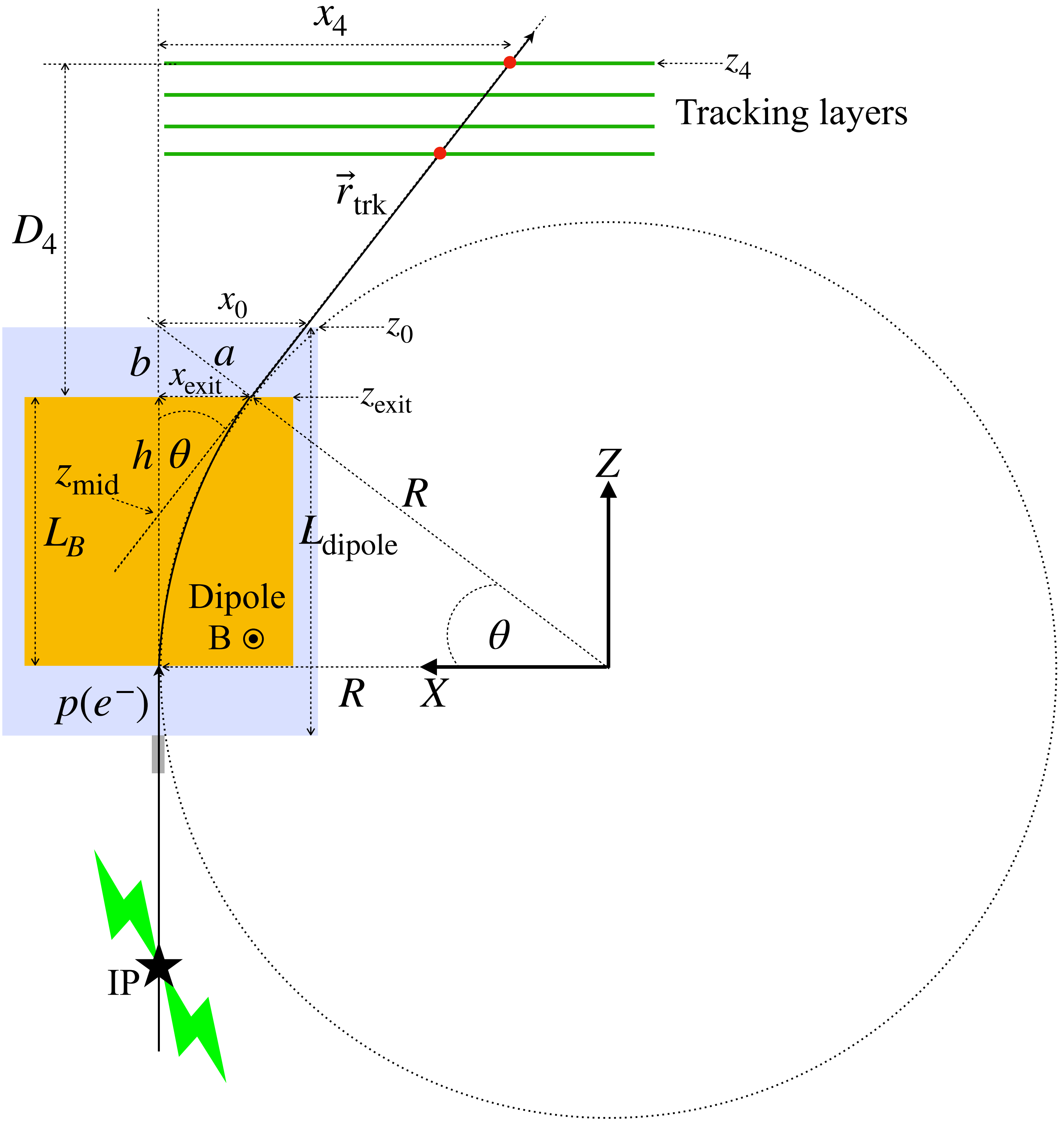
- Getting the momentum from two measurements in the first layer ($\vec{r}_1$) and the last layer ($\vec{r}_4$) of the tracker

- Getting the predicted position in the exit plane and in the last layer

Positions prediction

$$p[\text{GeV}] = 0.3 \cdot B[\text{T}] \cdot R[\text{m}]$$

$$R = \frac{p}{0.3B}$$



Circle equation wrt the origin at the centre of the circle defined by the track: $X^2 + Z^2 = R^2$

$$Z_{exit} = L_B \longrightarrow X_{exit} = \sqrt{R^2 - L_B^2}$$

$$x_{exit} = R - X_{exit} = R - \sqrt{R^2 - L_B^2}$$

Tangent equation: $Z = m \cdot X + c$. The tangent gradient, m, is -1 over the gradient of the radius at the point where the tangent is defined, i.e.: $m = -1/(\Delta Z/\Delta X)$ at the point (Z_{exit}, X_{exit})

$$m = -1/(\Delta Z/\Delta X) = -(X_{exit} - 0)/(Z_{exit} - 0) = -\left(\sqrt{R^2 - L_B^2}\right)/L_B = -\sqrt{\frac{R^2}{L_B^2} - 1}$$

Using the point (Z_{exit}, X_{exit}) we get the intersection: $c = Z - m \cdot X$

$$c = L_B - \left(-\sqrt{\frac{R^2}{L_B^2} - 1}\right) \cdot \sqrt{R^2 - L_B^2} = L_B + \frac{R^2 - L_B^2}{L_B} = \frac{R^2}{L_B}$$

$$Z_{tangent} = -\sqrt{\frac{R^2}{L_B^2} - 1} \cdot X_{tangent} + \frac{R^2}{L_B}$$

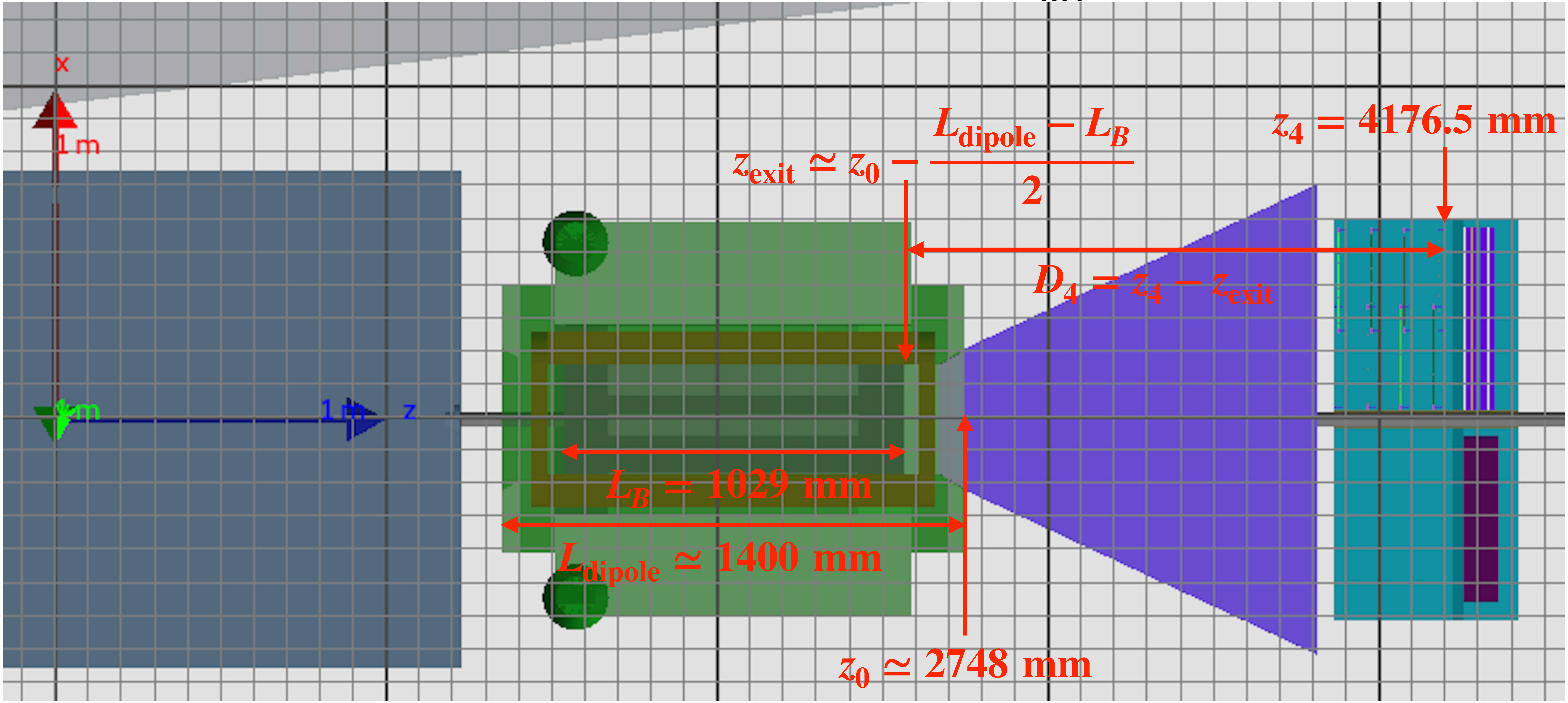
$$X_{tangent} = \left(\frac{R^2}{L_B} - Z_{tangent}\right)\frac{L_B}{\sqrt{R^2 - L_B^2}}$$

Putting $Z_4 = L_B + D_4$ or $Z_0 = L_B + \frac{L_{dipole} - L_B}{2} = \frac{L_B + L_{dipole}}{2}$ or $Z_{exit} = L_B$ in the $X_{tangent}$ expression, it is possible to get the prediction for the distance x from the beam axis ($z = 0$), recalling that: $x = R - X_{tangent}$

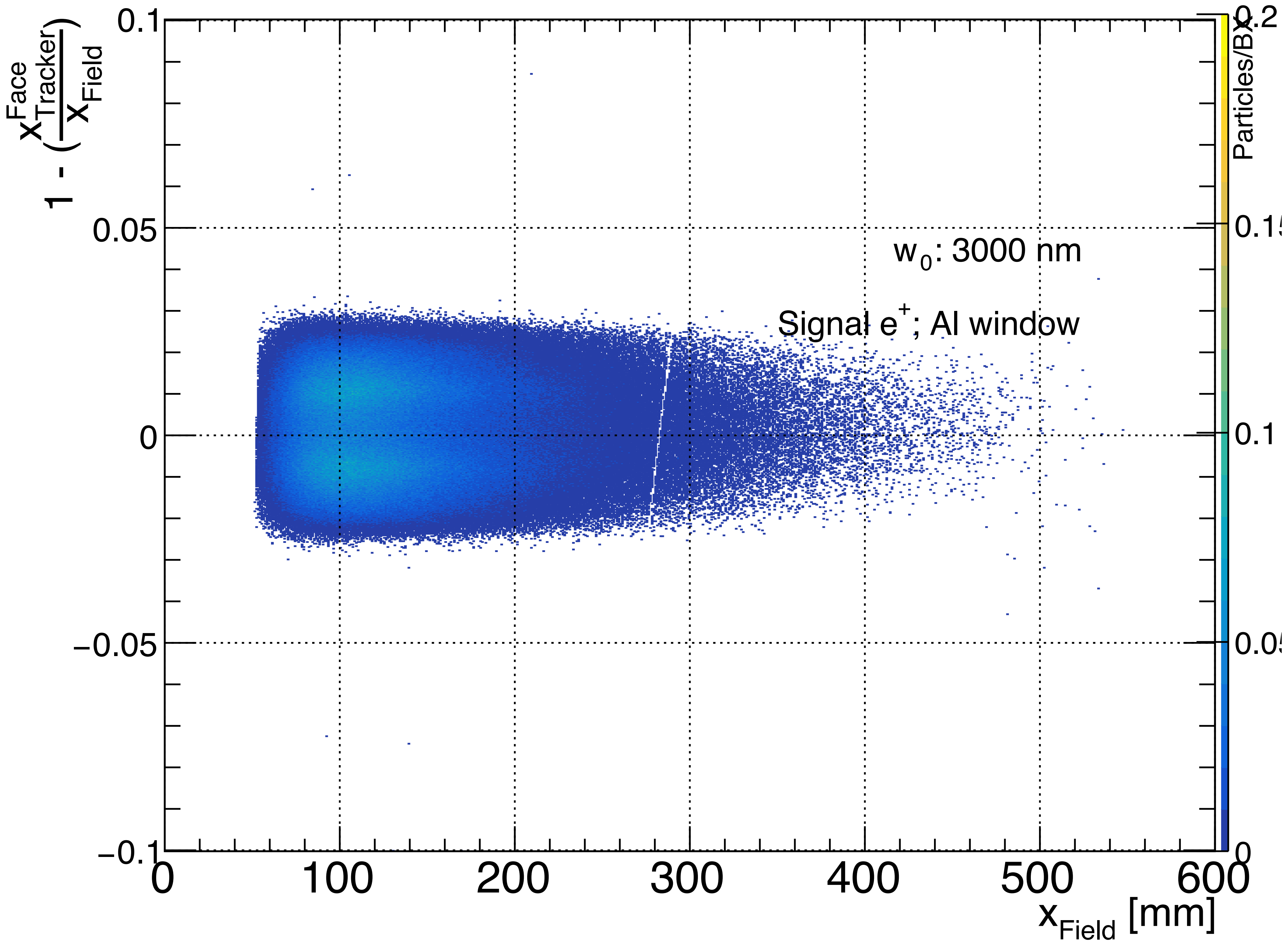
Numbers

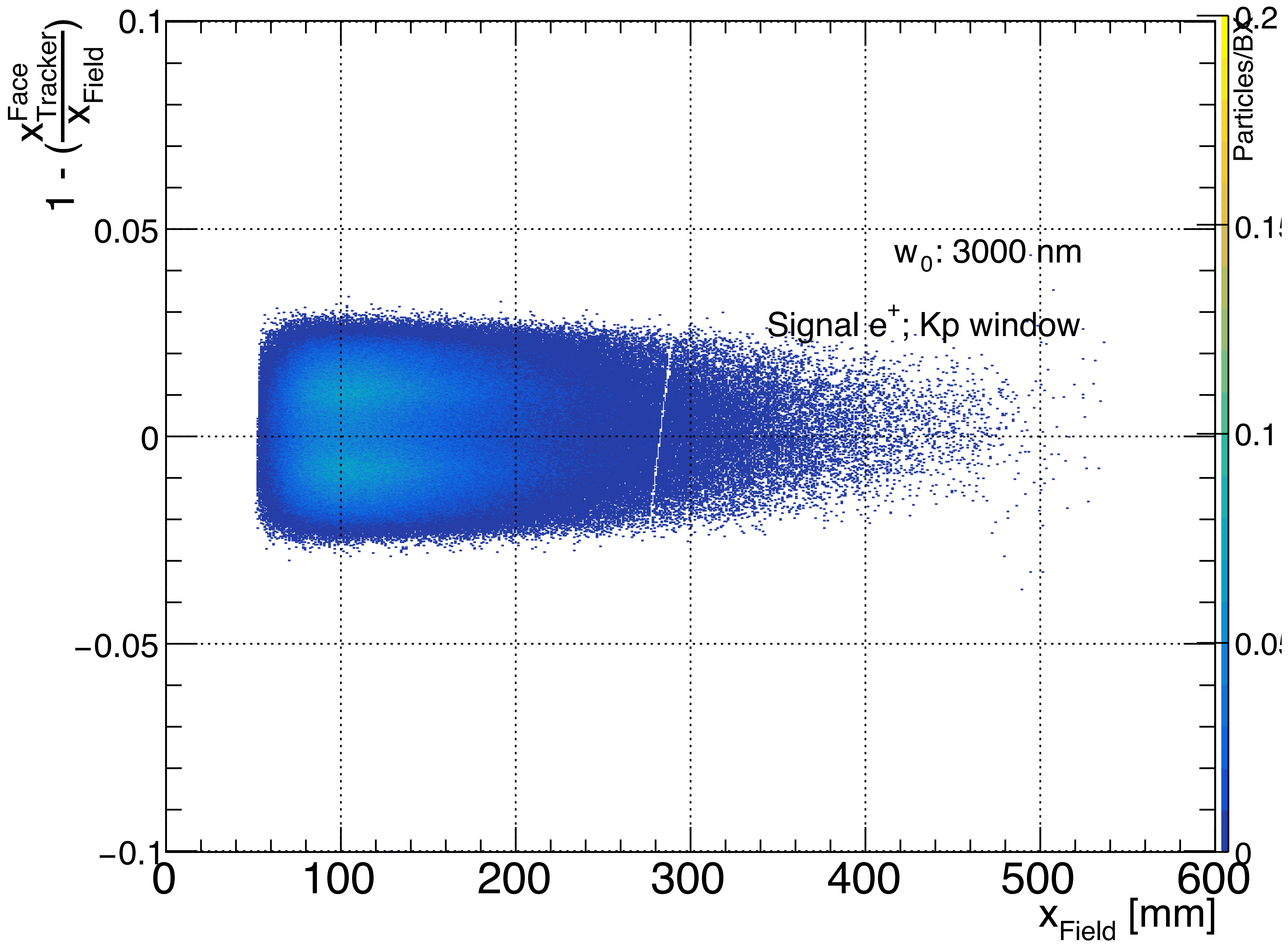
z4: 4176.5 [mm], z0: 2748 [mm], zExit: 2562.5 [mm], D4: 1614 [mm]

Beginning of Magnetic active volume: 1533.5 mm

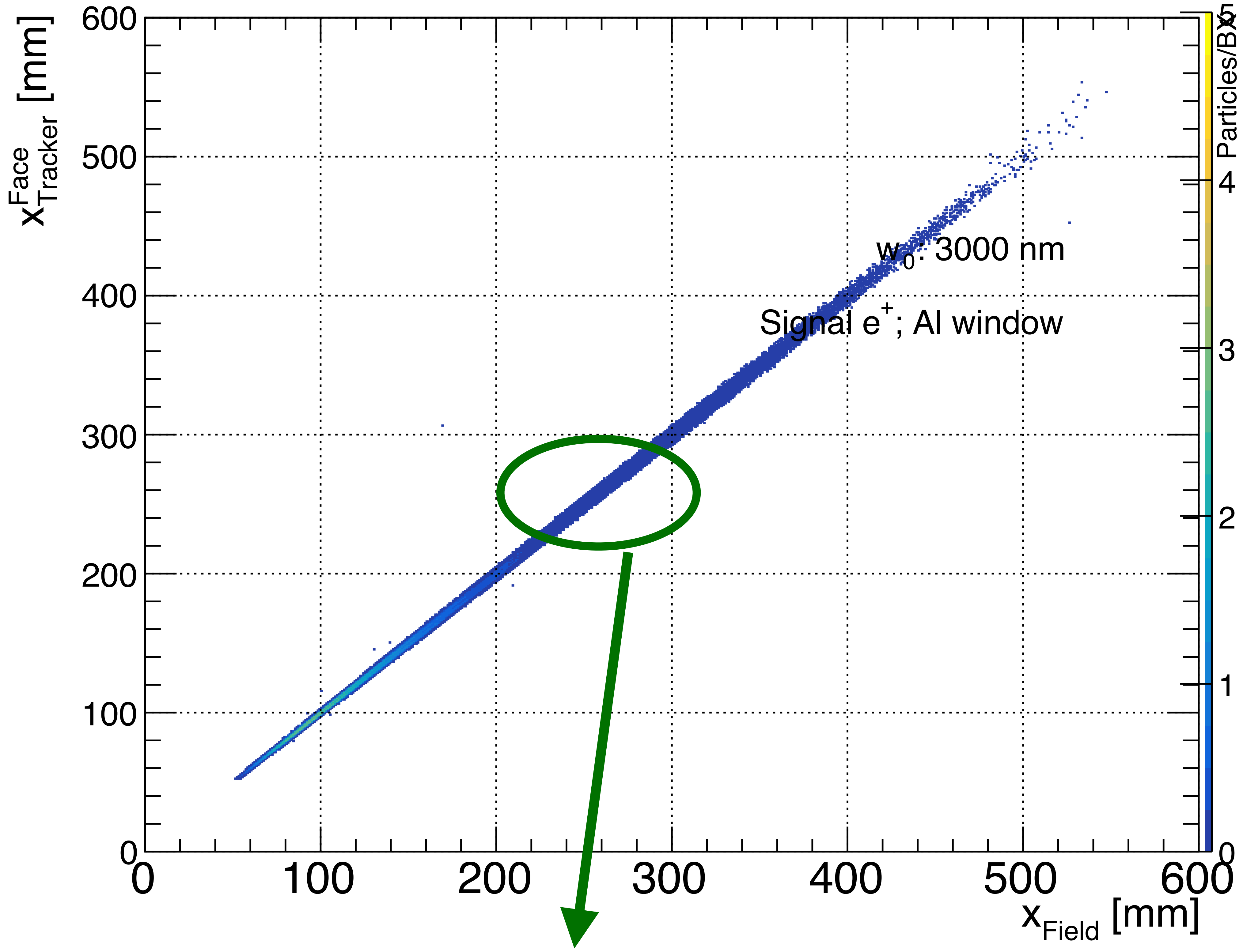


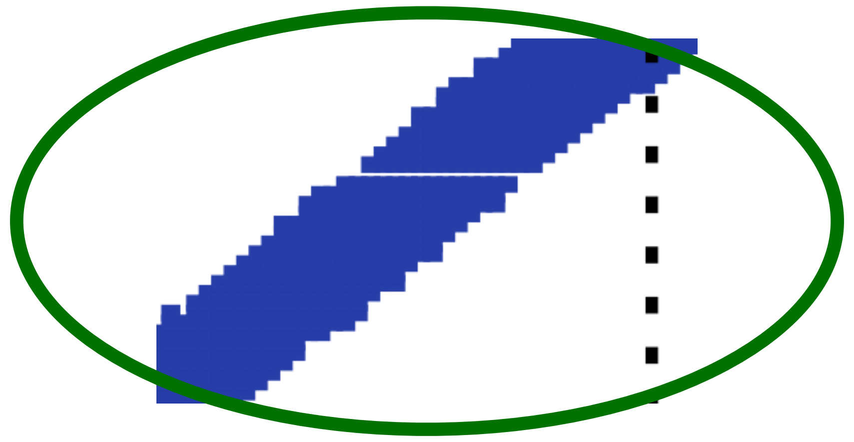
2D distribution of 1- ($x^{Face}_{Tracker}/x_{Field}$) vs x_{Field}

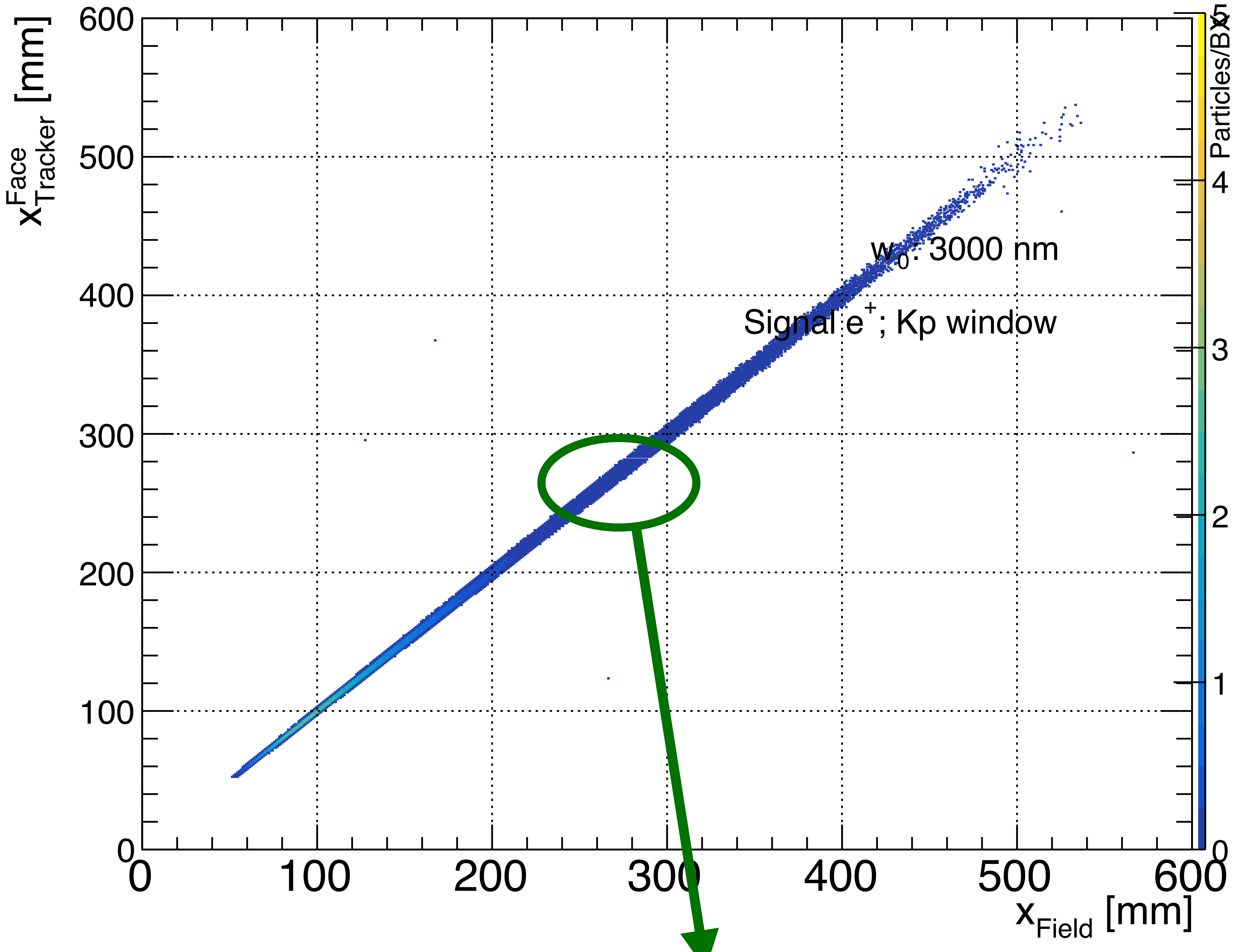


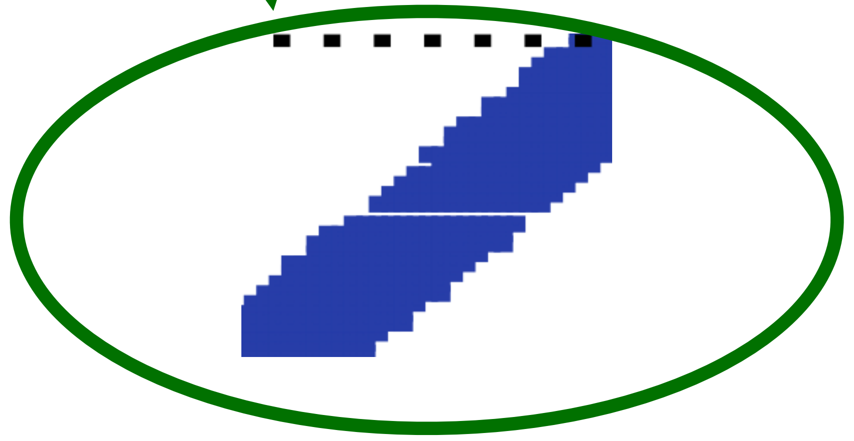


2D distribution of 1- $(x^{Face}_{Tracker}/x_{Field})$ vs x_{Field}



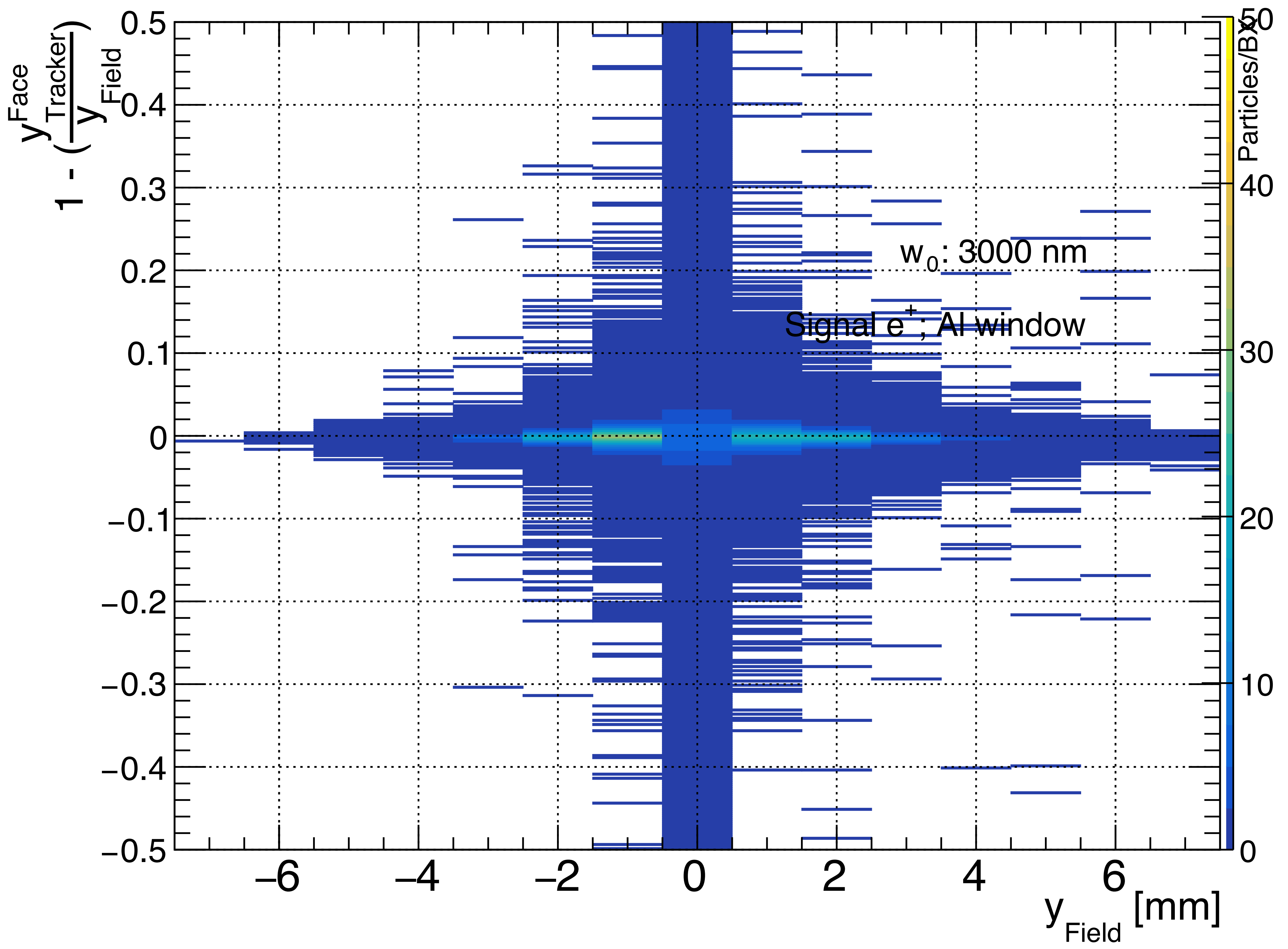


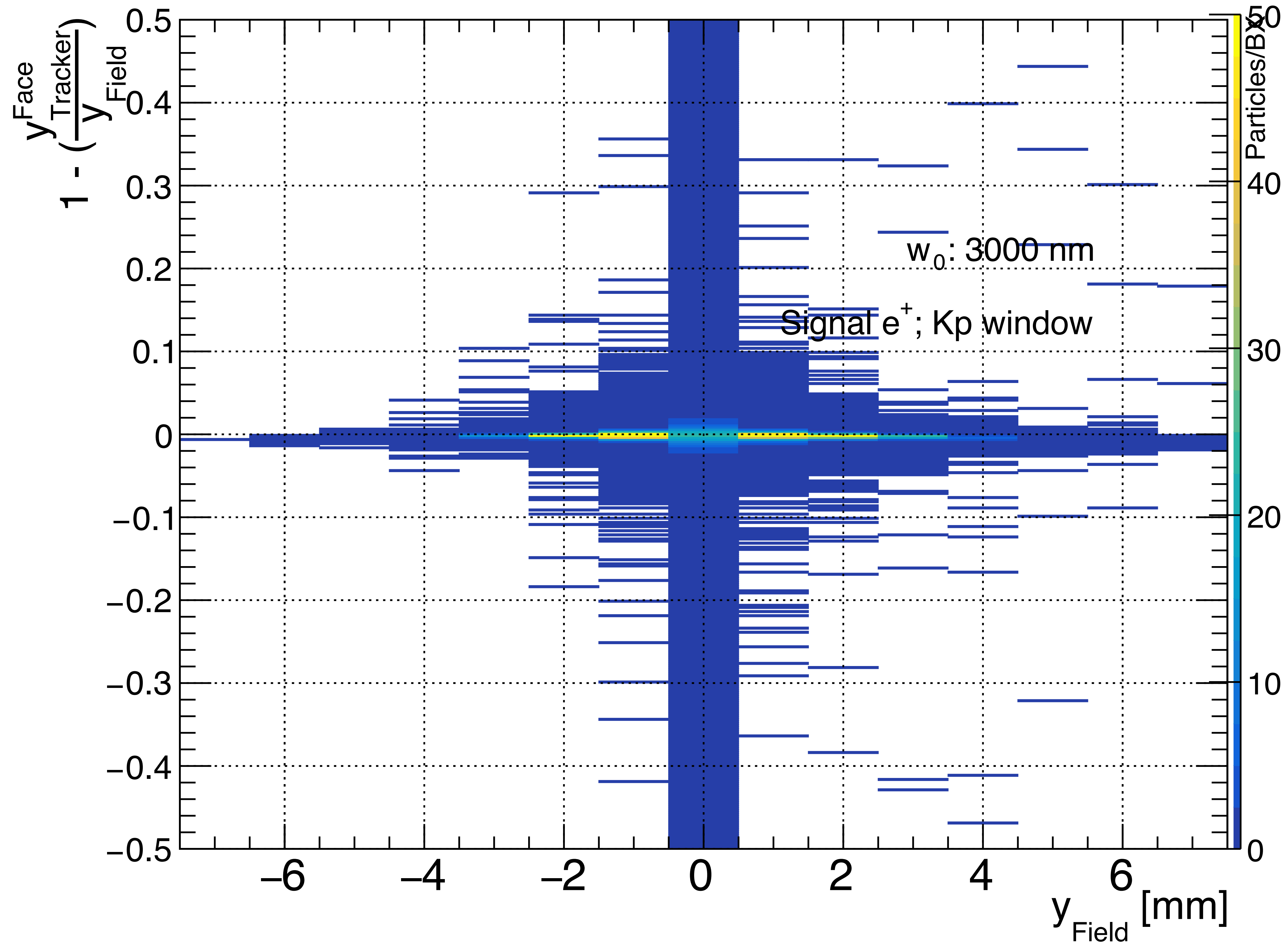




x_{Field} is continuous, while $x^{Face}_{Tracker}$ is discontinuous at the junction of two staves

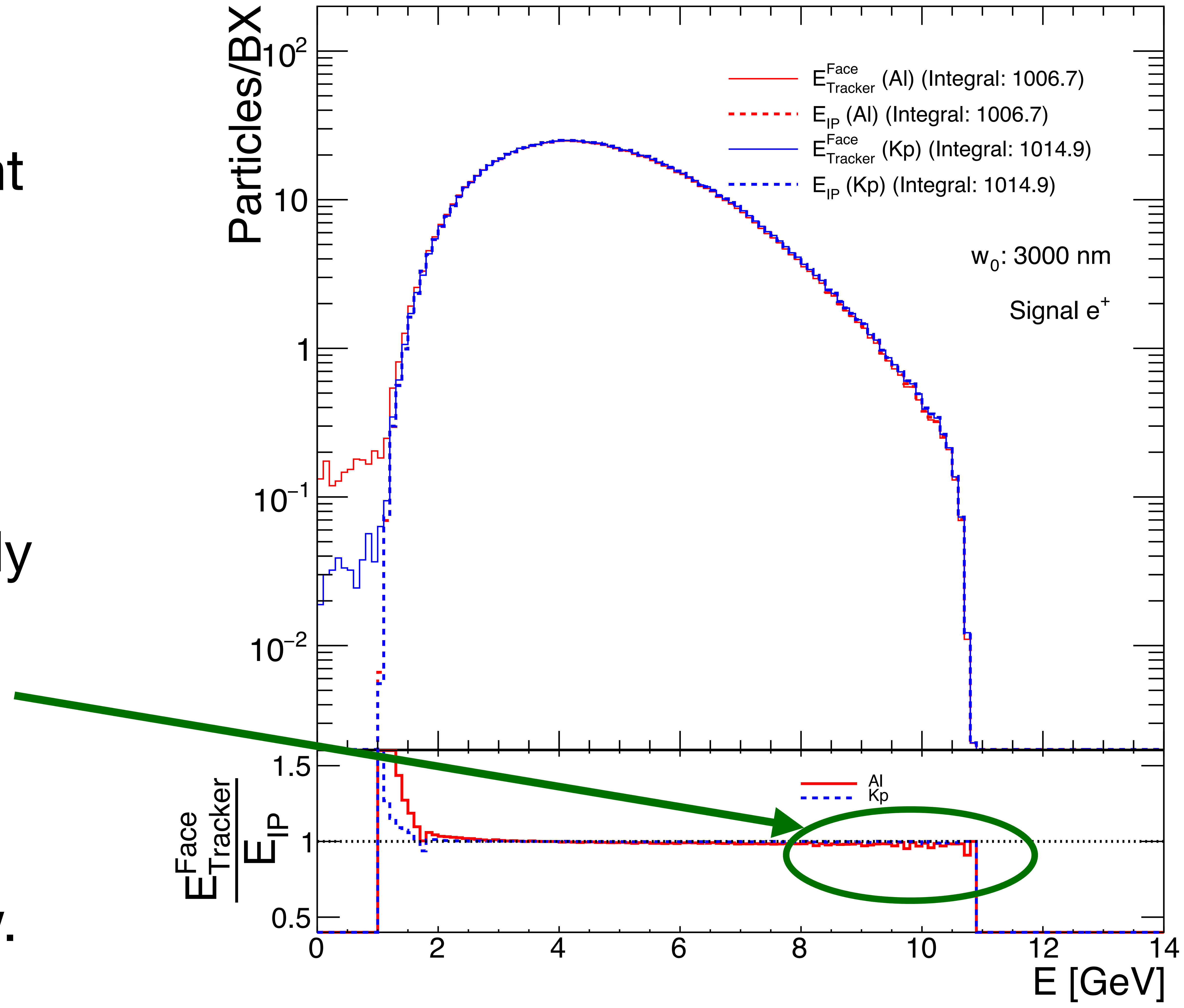
2D distribution of 1- ($y^{Face}_{Tracker}/y_{Field}$) vs y_{Field}





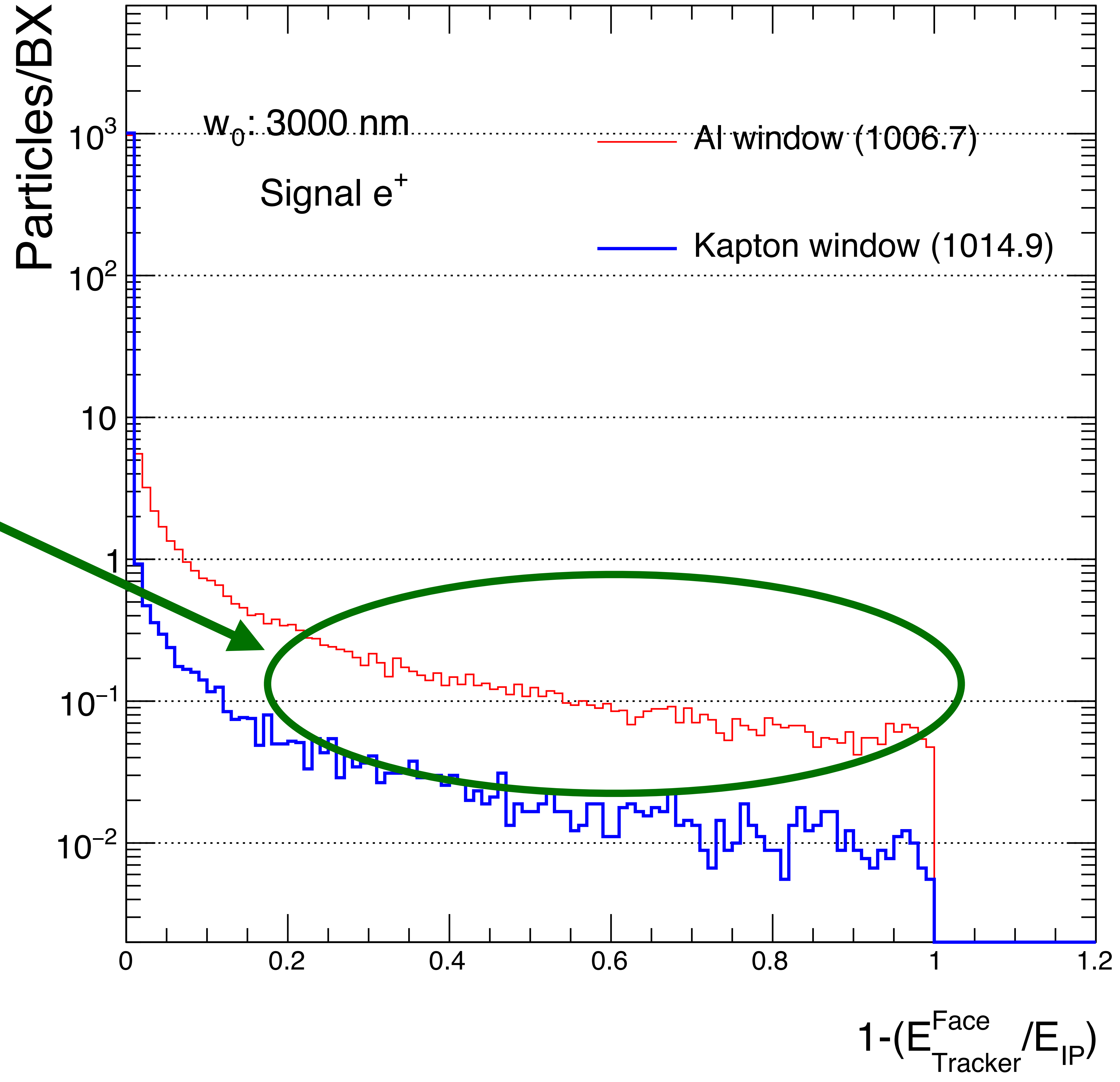
Energy distribution for signals: Al window and Kapton window

- $E_{Tracker}^{Face}$ and E_{IP} distributions for different window
- E_{IP} distributions are almost similar for both the window: expected
- For Aluminium window, $E_{Tracker}^{Face}$ is slightly less than E_{IP} at $E > 8$ GeV.
  - This is not visible for Kapton window.
- Not very informative plot to distinguish between Al window and Kapton window.

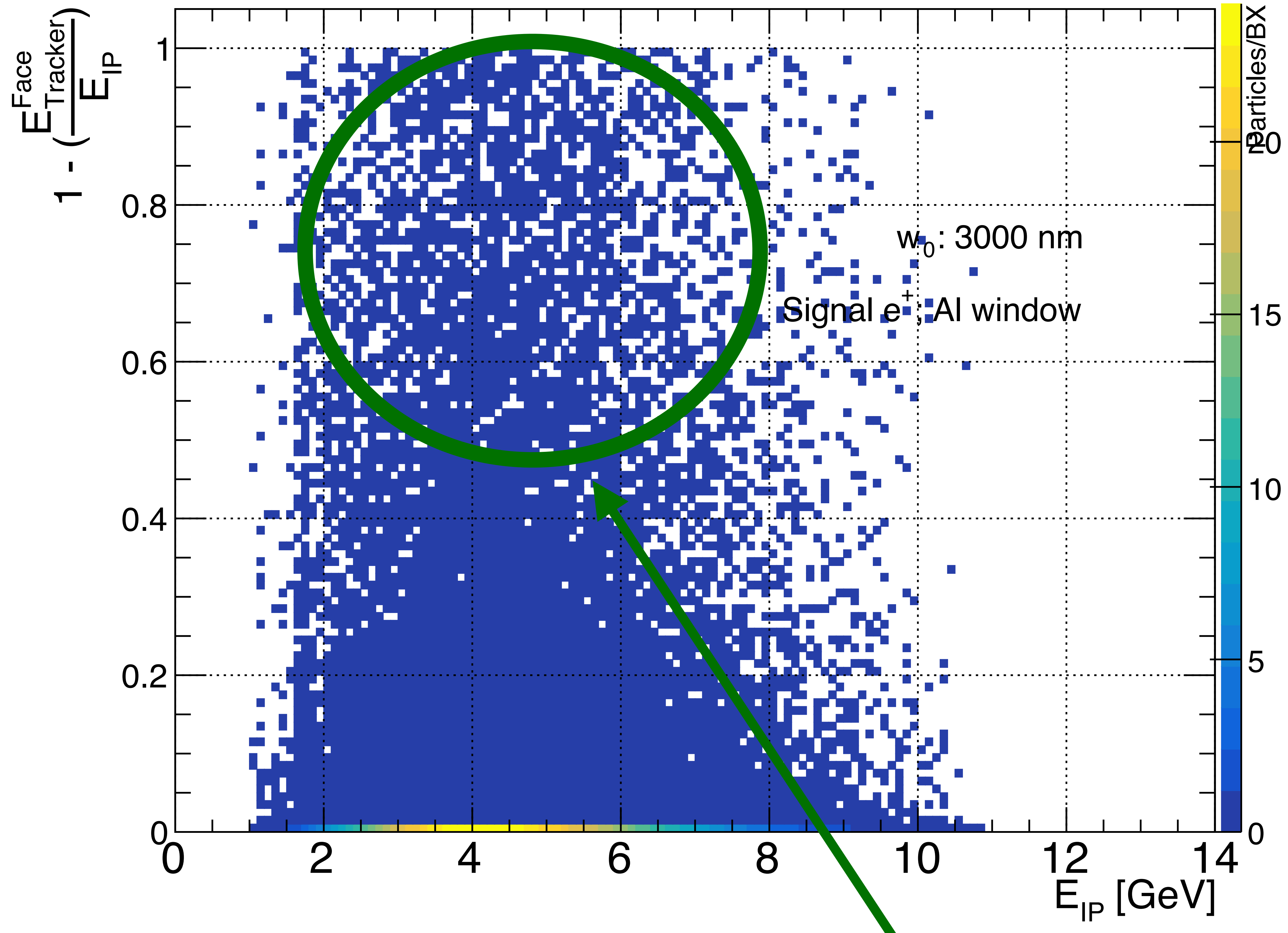


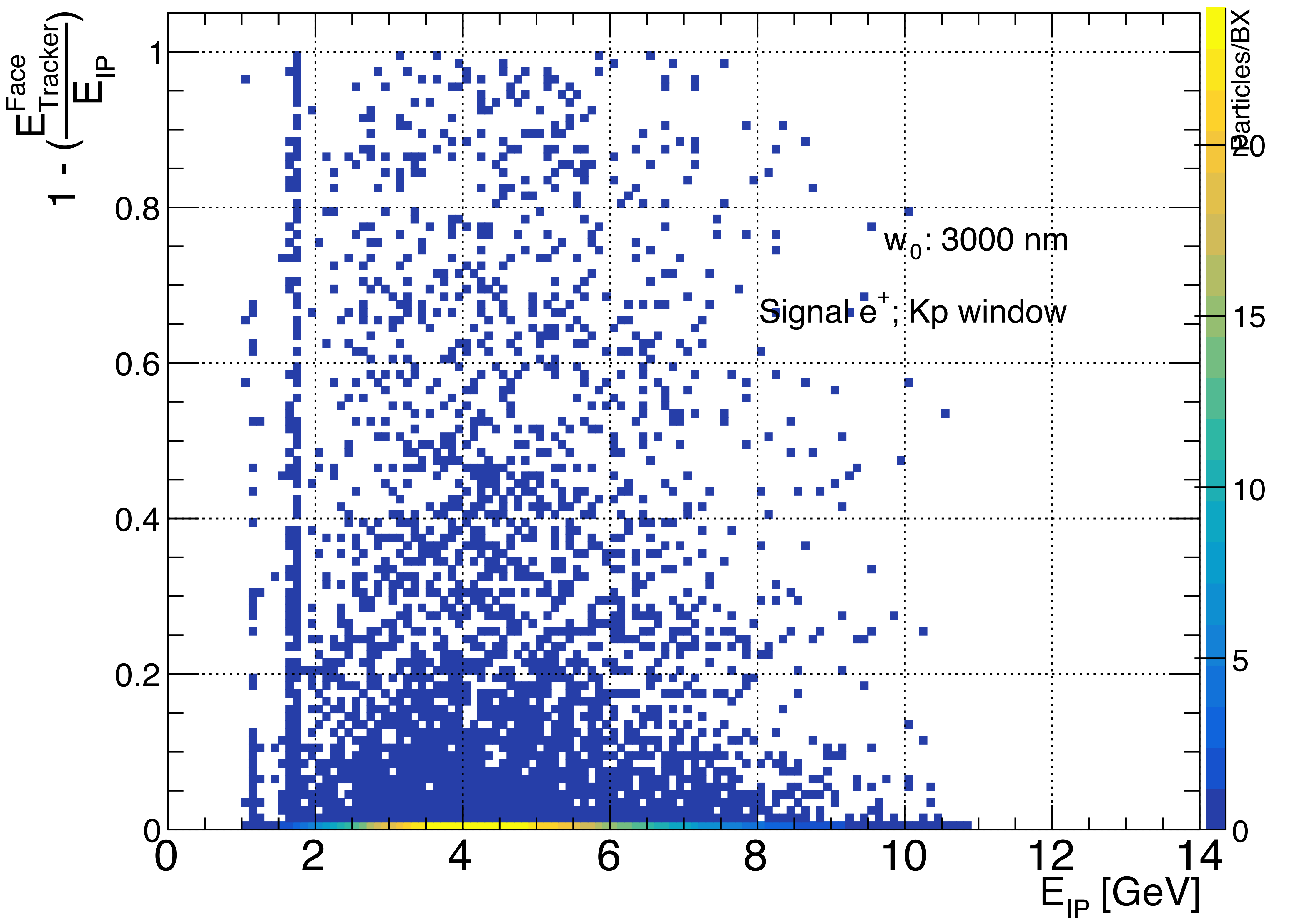
1- ($E^{Face}_{Tracker}/E_{IP}$): Prominent difference of Al window and Kapton window

- For aluminum window more tracks are distorted compared to Kapton window.
- Fraction of tracks distorted for Al window: 1.3%
- Fraction of tracks distorted for Kp window: 0.2%
    - Distortion is measured as the fraction of tracks where 1- ($E^{Face}_{Tracker}/E_{IP}$) is greater than 10%.



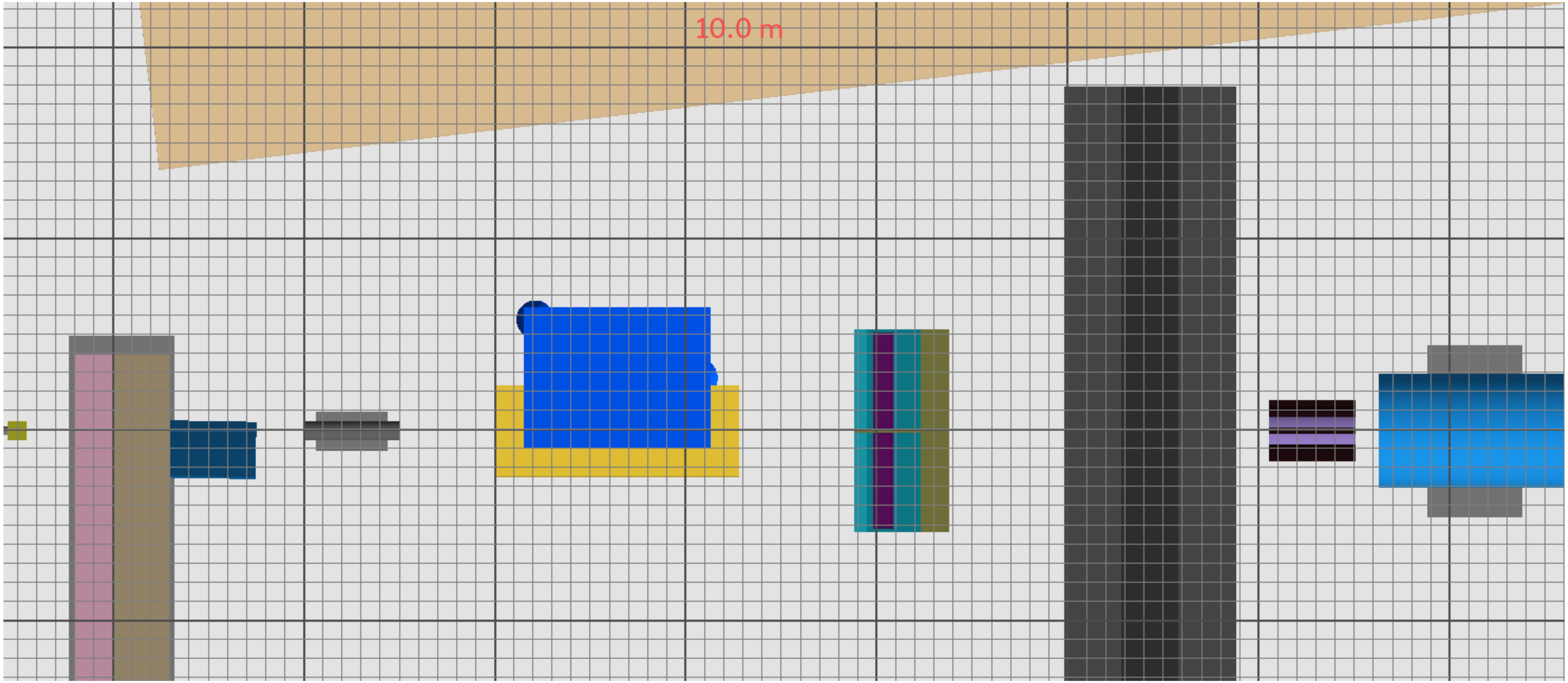
2D distribution of 1- $(E^{Face}_{Tracker}/E_{IP})$ vs E_{IP}





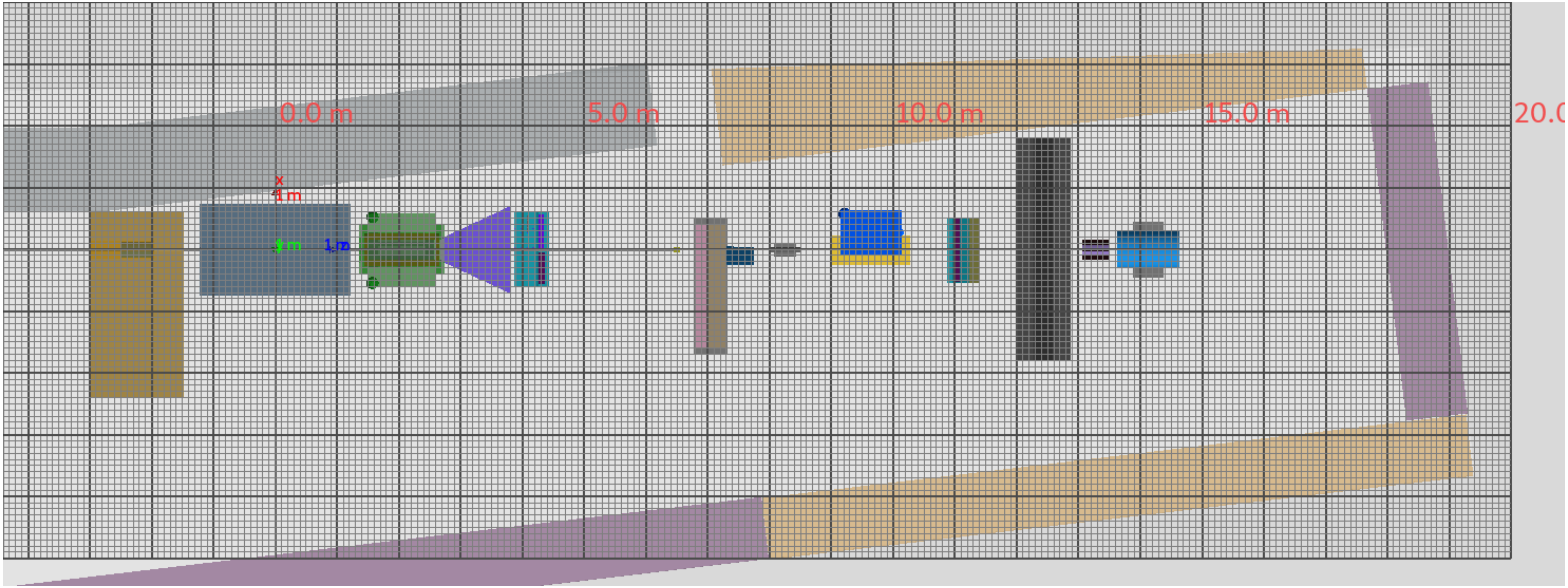
For Aluminium window, tracks with energy 3 GeV to 5 GeV are more distorted

The subsystems near the beam dump



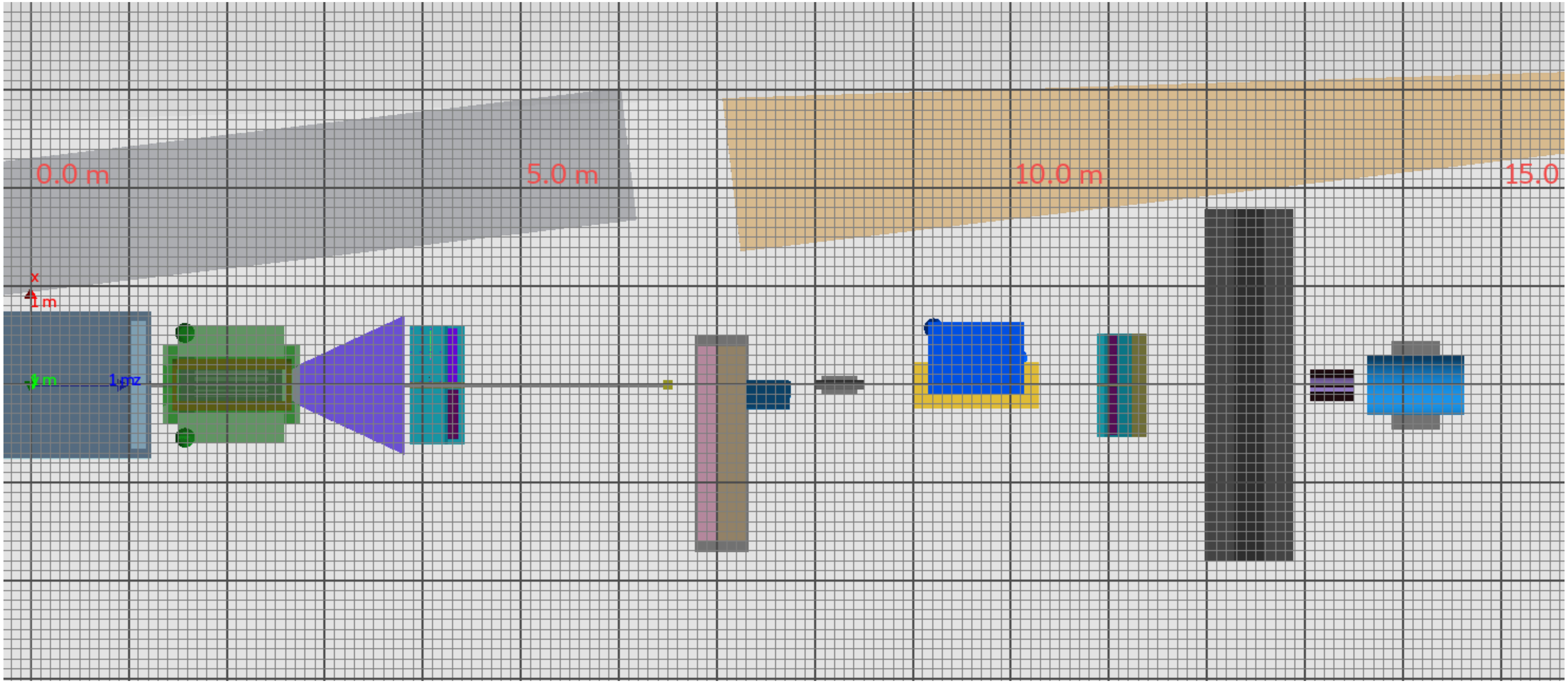
Plots from Sasha

The entire subsystem



Plots from Sasha

The subsystems from the IP to beam dump



Plots from Sasha