Bfield at DESY testbeam and simulation

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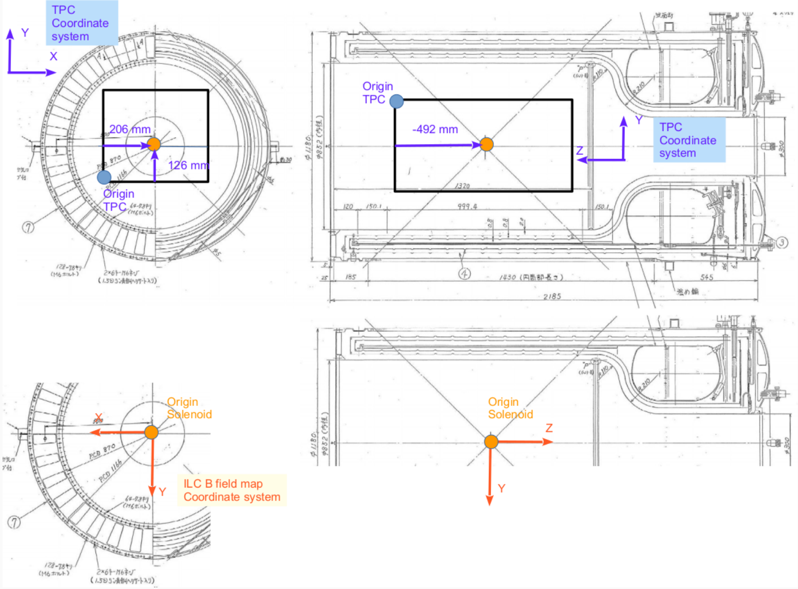
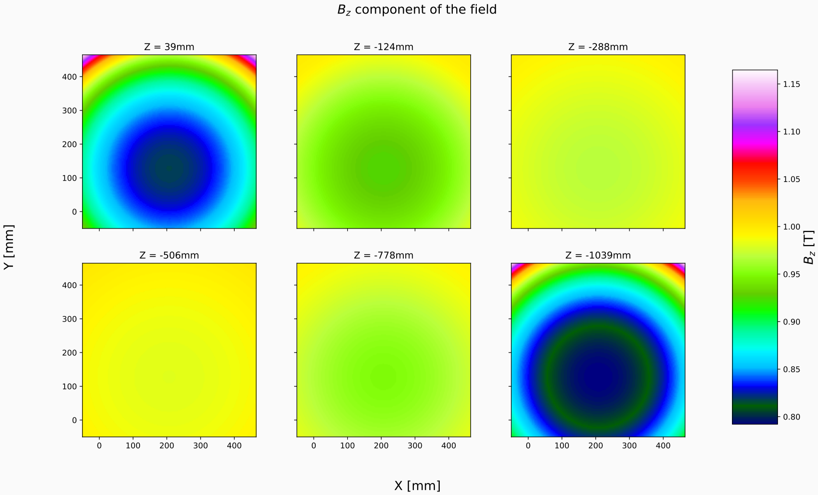
TPC geometry



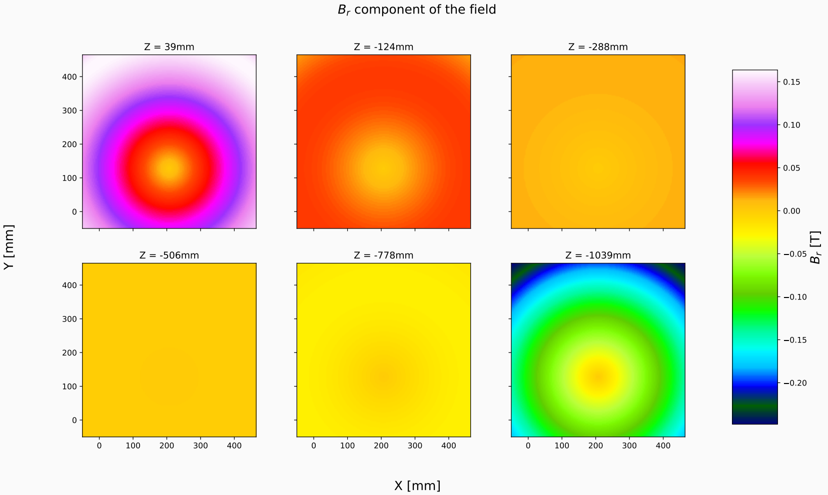
- $\vec{E}$ and $\vec{B}$ along Z
- Beam entering along X
- The TPC Y center is not aligned with solenoid axis

Longitudinal component of $\vec{B}$



3D viz at: https://pierre.granger.pages.in2p3.fr/page_test/field_Bz

Radial component of the $\vec{B}$



3D viz at: https://pierre.granger.pages.in2p3.fr/page_test/Bfield_DESY

The $\vec{E} \times \vec{B}$ effect

Langevin equation for an e^-:

$$\vec{v_D} = \frac{\mu}{1 + (\omega\tau)^2} \left(\vec{E} - \omega\tau \frac{\vec{E} \times \vec{B}}{\left\|\vec{B}\right\|} + (\omega\tau)^2 \frac{\vec{B}\left(\vec{E} \cdot \vec{B}\right)}{\vec{B}^2} \right)$$

where:

- $\mu = \frac{e\tau}{m}$ is the electron mobility
- $\omega = \frac{eB}{m}$ is the cyclotron frequency
- τ is the mean drift time between two collisions with gas molecules
- μ is approximated as $2.85\,\mathrm{m}^2\,\mathrm{V}^{-1}\,\mathrm{s}^{-1}$ in the following (with $E = 275\,\mathrm{V/cm}$)

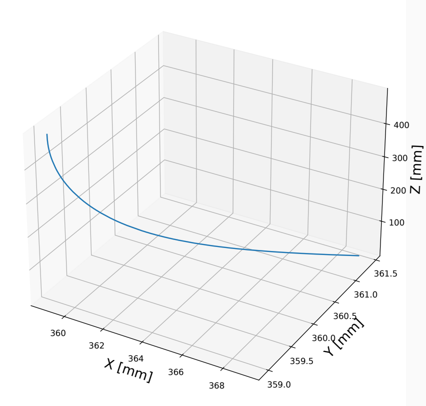
$\Rightarrow$ The two last terms introduce an angle in the drift direction with respect to the normal to the readout plane. Their relative importance depends on $\omega\tau$ and thus $\left\|\vec{B}\right\|$

Simulating the effect

Numerical integration

The $\vec{E} \times \vec{B}$ effect is simulated by integrating the Langevin equation numerically for ionisation electrons. The method used for numerical integration is Runge-Kutta 4.

Trajectory of electron emitted at (36, 36, 500) cm



- Integration step size of $0.01\,\mu s \sim 0.8\,\text{mm}$
- The displacement d is defined as the euclidean distance on the anode plane between the energy deposit with and without $\vec{B}$ field.

Using the simulation

$\vec{B}$ field data

↓

Numerical integration from starting positions on a grid (1 cm pitch)

↓

Calculating an associated projection map $\mathcal{M}(\vec{\mathbf{x}}) \to (x_{\text{anode}}, \tilde{y}, \tilde{z})$

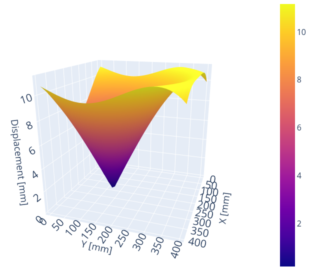
↓

For each simulated Edep segment in the TPC, arrival position of the electrons taken from $\mathcal{M}$

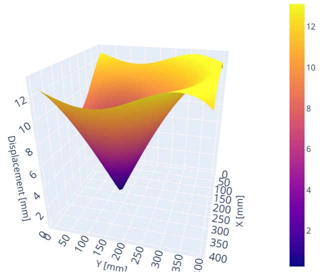
↓

Track on the anode

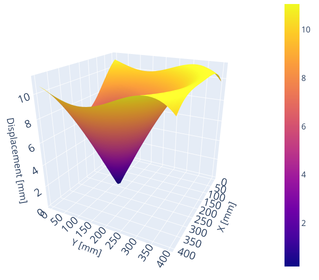
Displacements



Displacement on anode for 75cm drift distance



Displacement on anode for 50cm drift distance

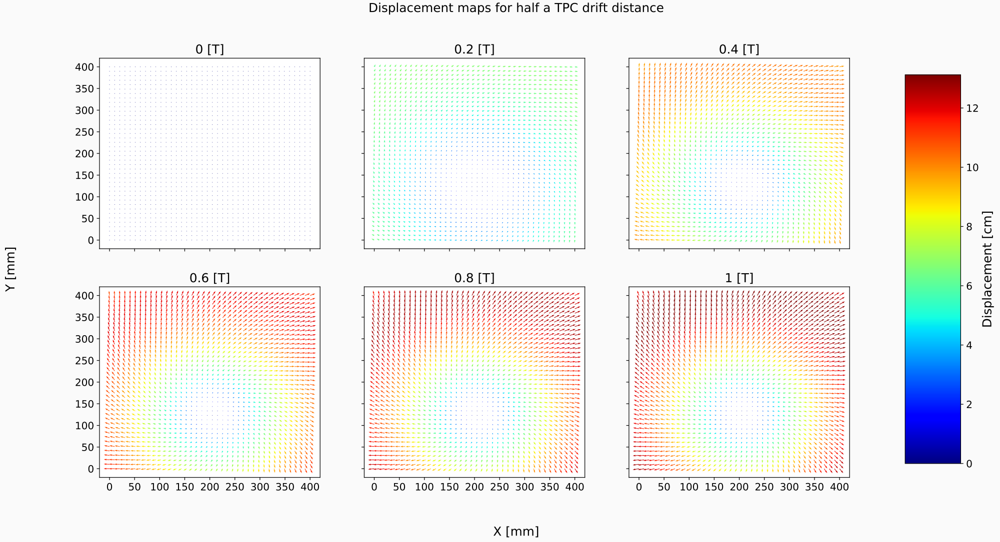


Displacement on anode for 25cm drift distance

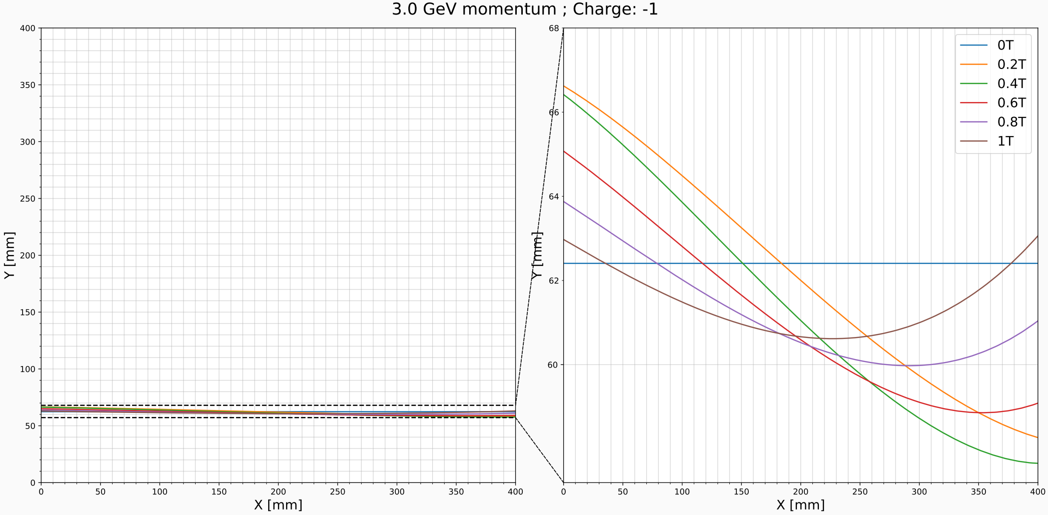
Displacements with respect to the no B field case for 1 T field.

The apparent displacement is maximum for tracks passing at half the TPC distance. Explainable by the cancellation of effects (B_r of opposite sign in the 2 TPC halves)

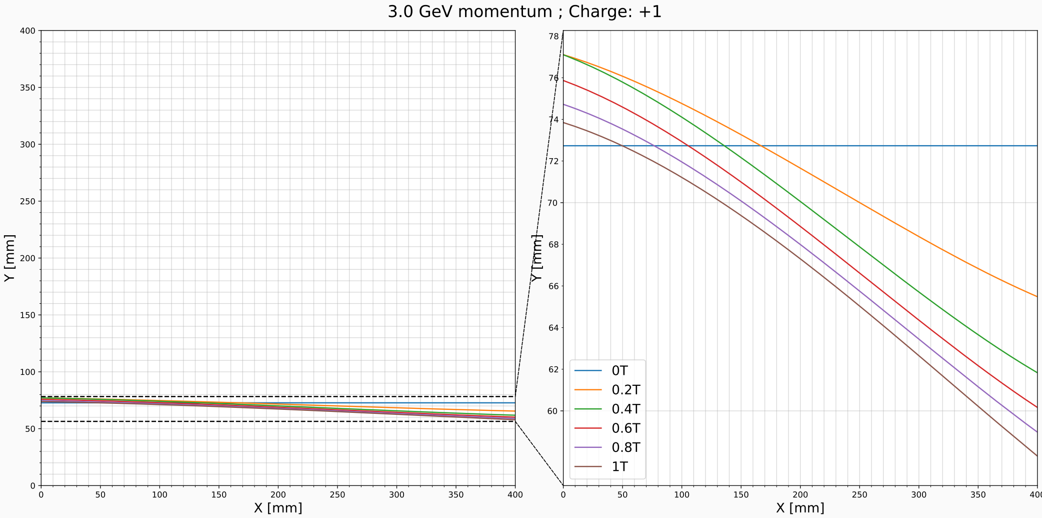
Displacements



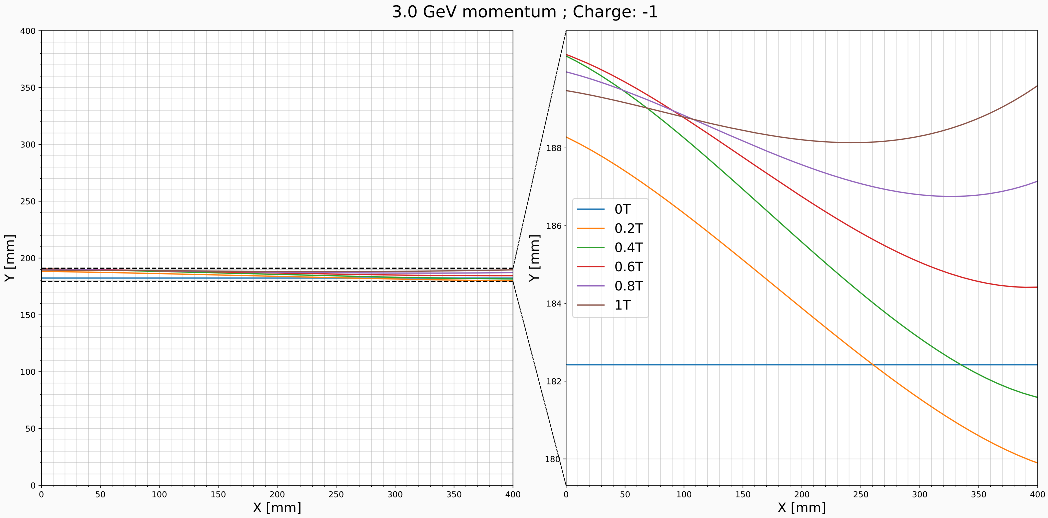
Track example



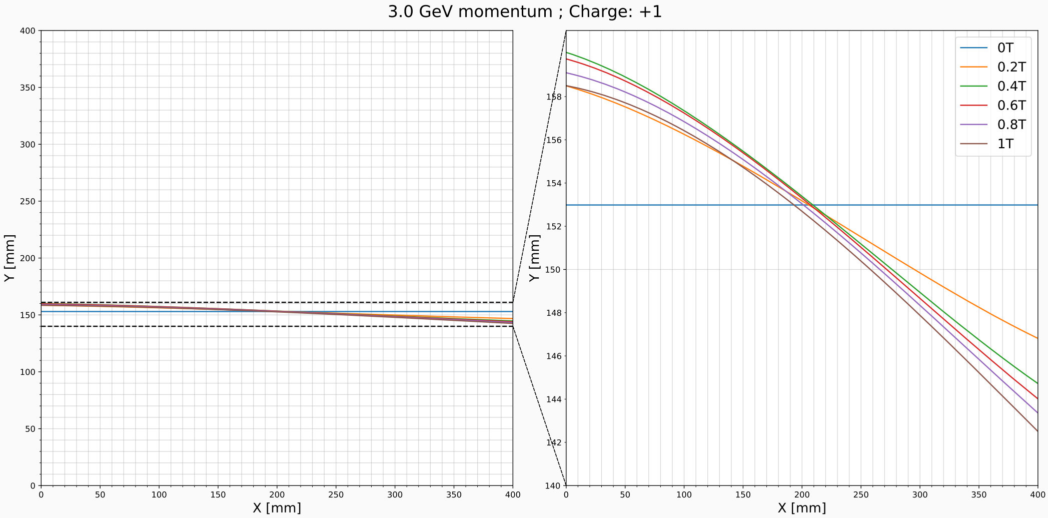
Track example



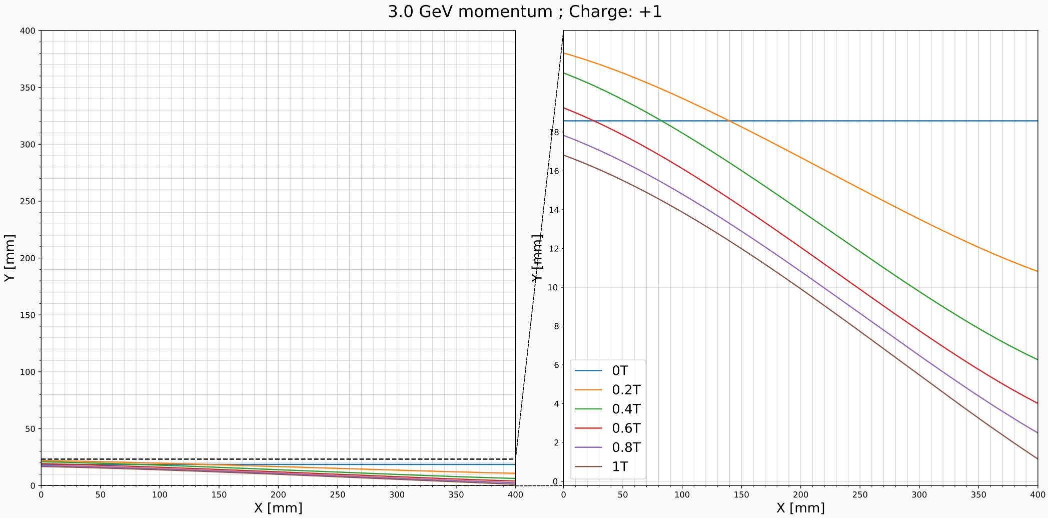
Track example



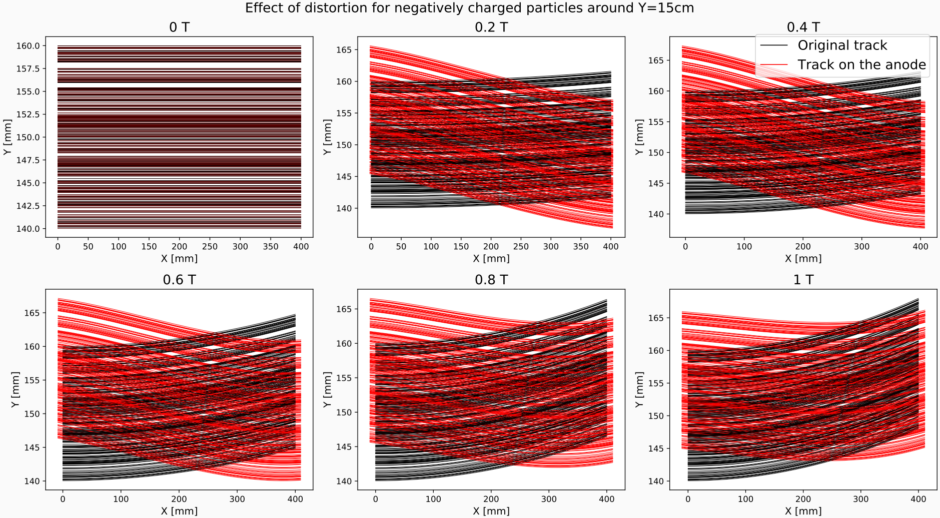
Track example



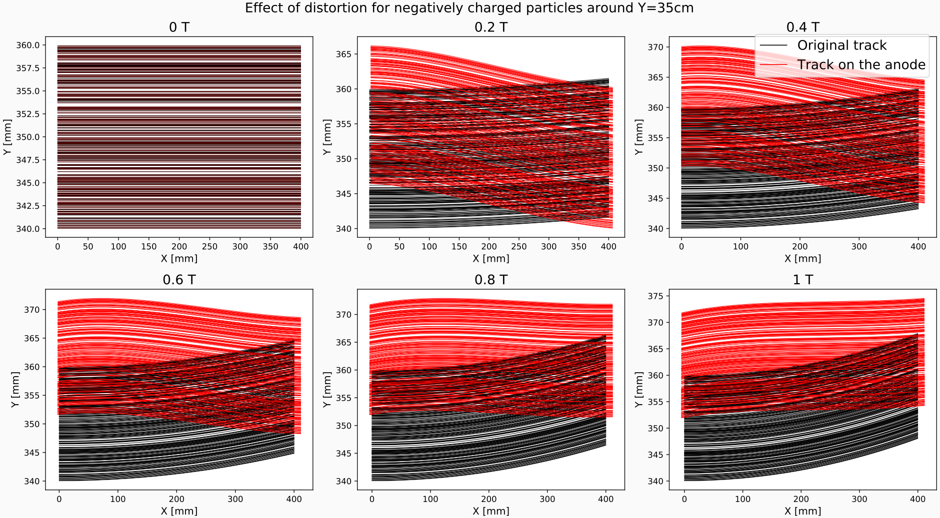
Track example



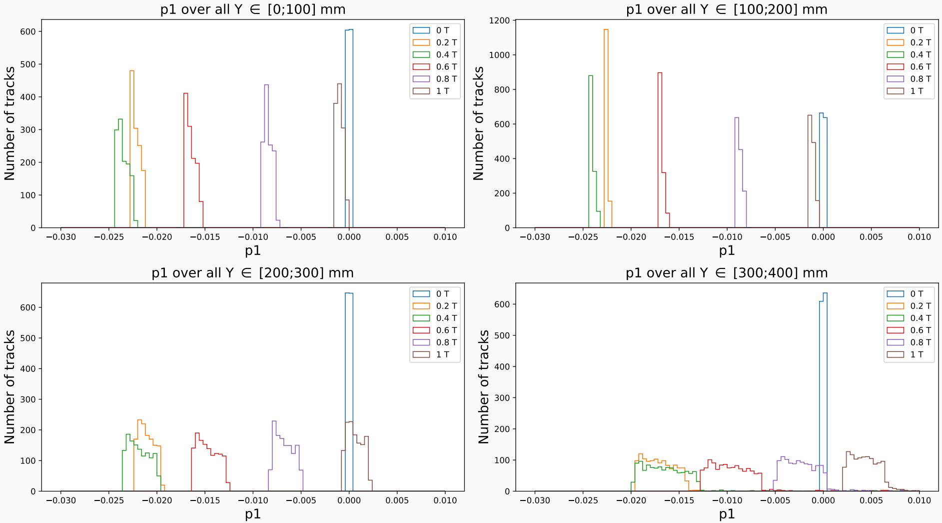
Simulated tracks



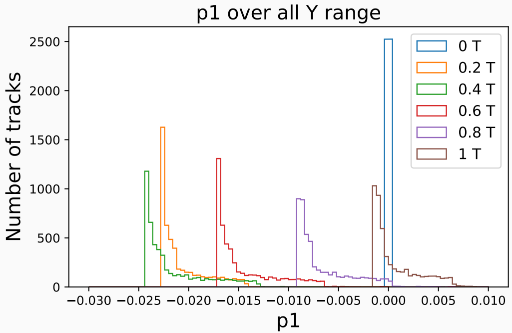
Simulated tracks



Fitting the tracks with a line



Summary



- First steps of trying to simulate the effect in order to take it into account in the reconstruction
- Results seem to be qualitatively in agreement with the data
- Still some parameters to better control as $\omega\tau$