Simulations on the ion backdrift in large TPC for the ILC

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LCTPC-Collaboration Meeting

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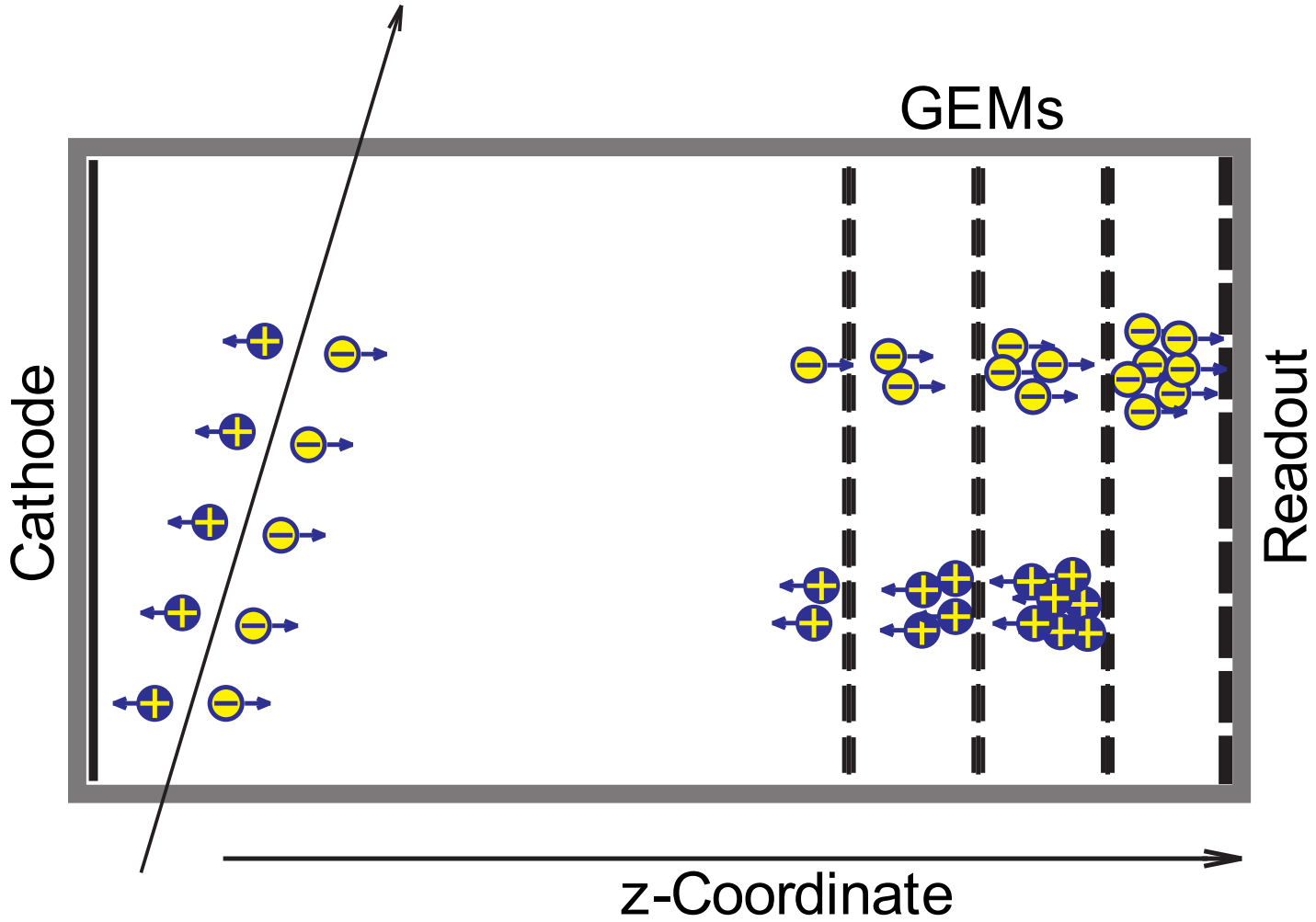
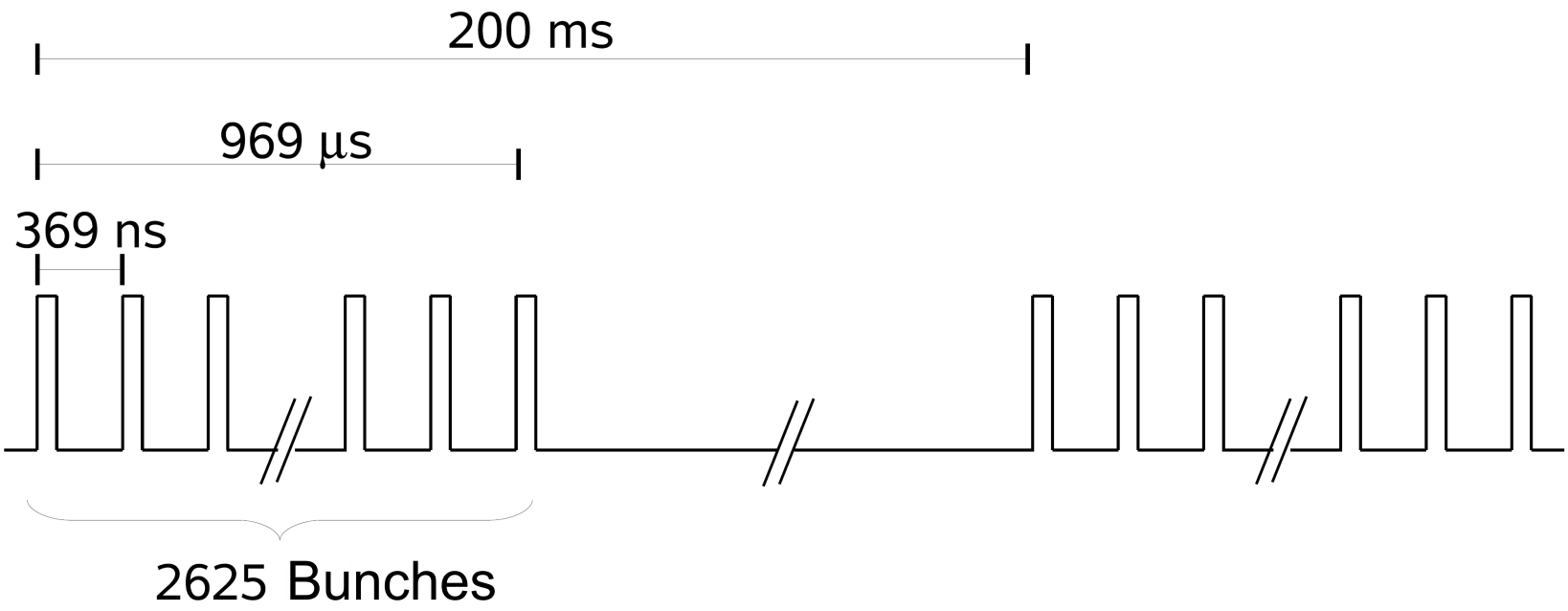
Ion backdrift



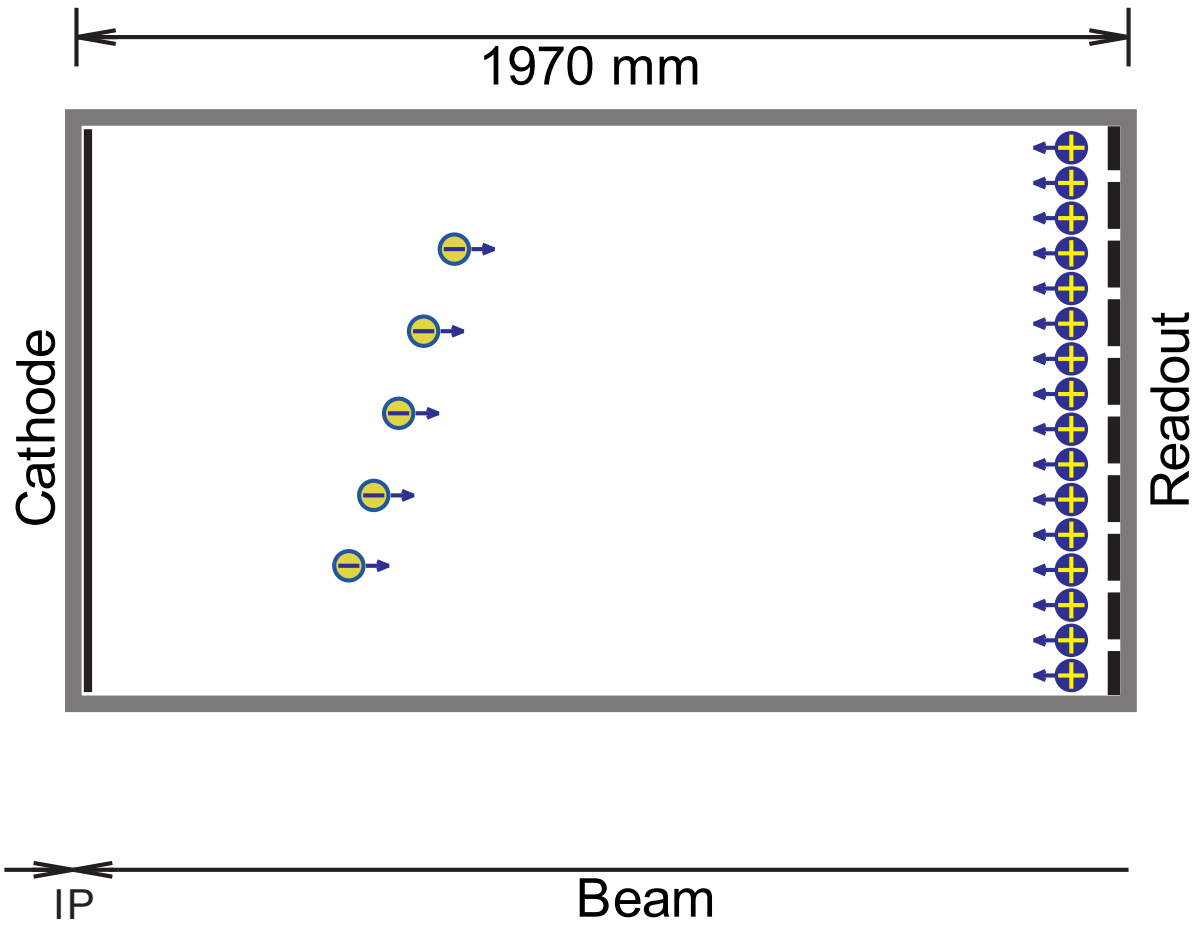
Ion backdrift: $I_B = \frac{\#\ e^-\ \text{on anode}}{\#\ \text{Ions on cathode}}$

Beam structure of the ILC



Beam structure:

- Pulsed beam with 5 **B**unch **T**rains per second
- 2625 bunches per BT
- 2×10^{10} particles per bunch
- 369 ns bunch spacing
- $\sim$199 ms BT spacing
- $\sim$1 ms BT length



Drift velocities:

$$v_{\text{Ions}} = 3,7 \frac{\text{mm}}{\text{ms}}$$

$$v_{e^-} = 44,8 \frac{\text{mm}}{\mu\text{s}}$$

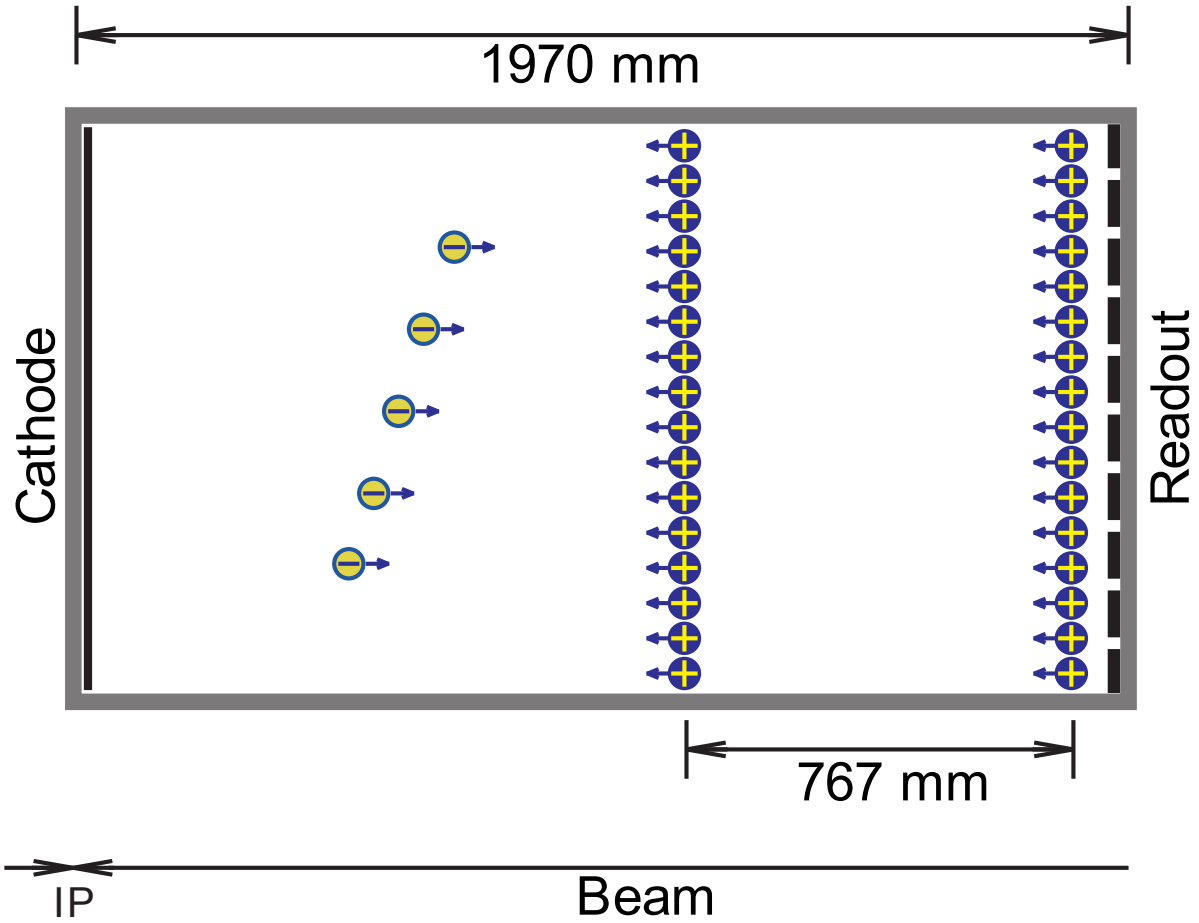
Drift durations:

$$t_{\text{Ions}} = 532,4 \text{ ms} \widehat{=} 2,7 \text{ BT}$$

$$t_{e^-} = 43,9 \ \mu\text{s} \widehat{=} 120 \text{ BX}$$

Gas: TDR (Ar 93%, CH_4%, CO_2 2%)

Drift field: $|E| = 240 V/cm$



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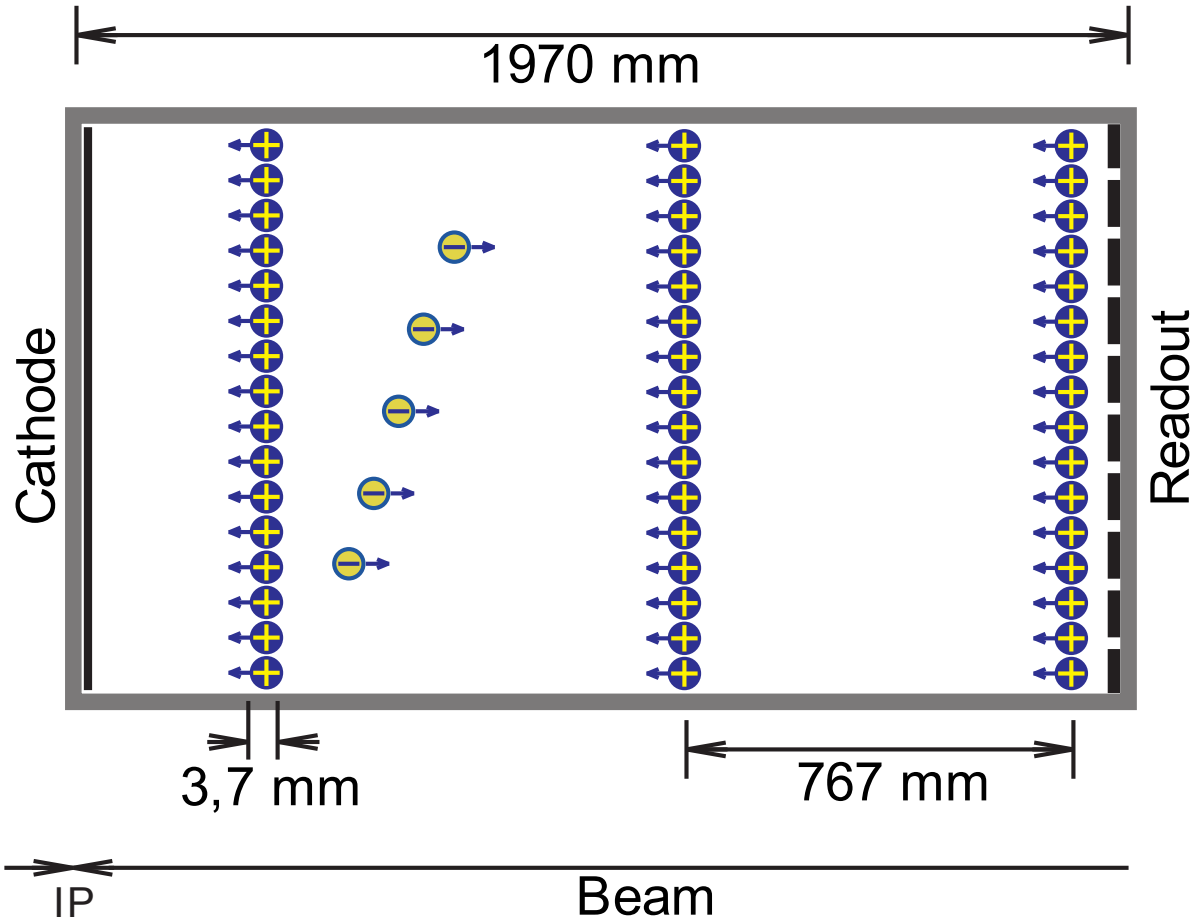

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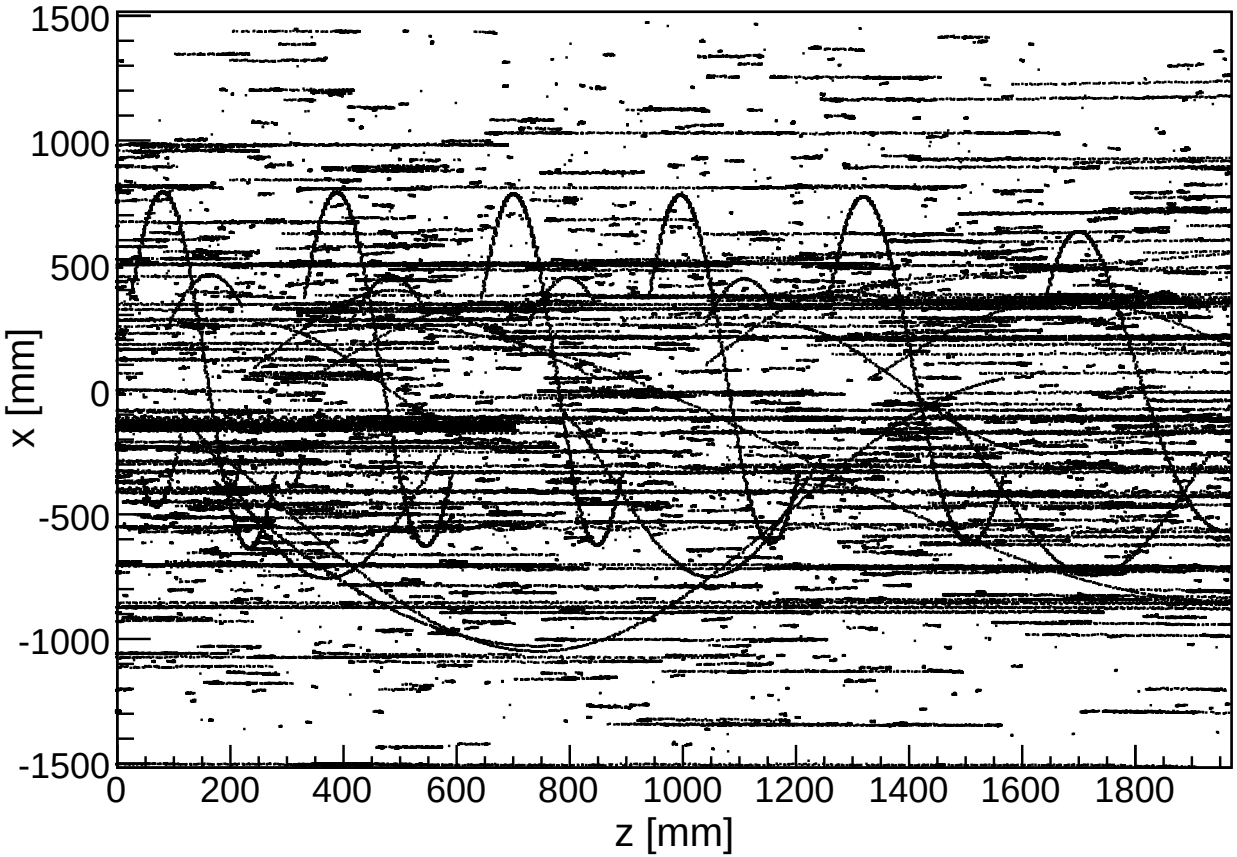
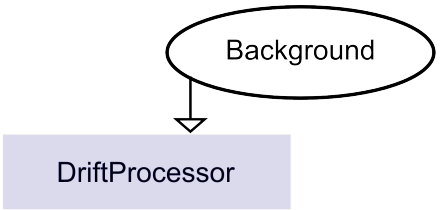
Ionizing background

Background of 100 BX in projection on the xz-plane



- Background from Beamstrahlung
- 3000 background events simulated by Adrian Vogel

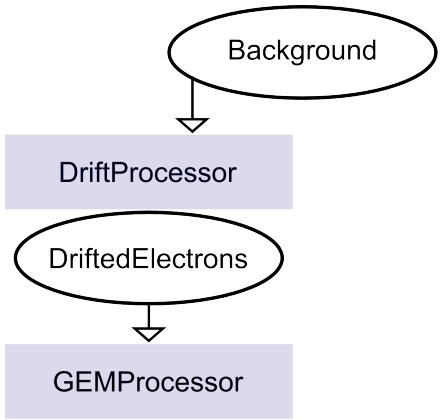
Simulation with MarlinTPC



DriftProcessor:

- Drifts electrons through the chamber
- Drift velocity and diffusion from simulation with MAGBOLTZ

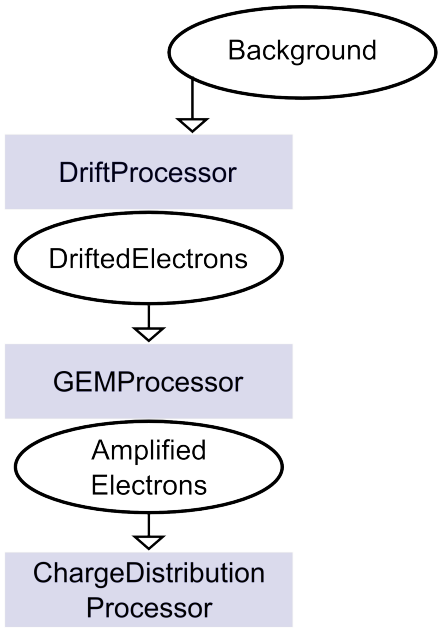
Simulation with MarlinTPC



GEMProcessor:

- Simulates amplification in tripple GEM-stack
- Parametrizations of collection, gain and extraction from measurements done at RWTH Aachen

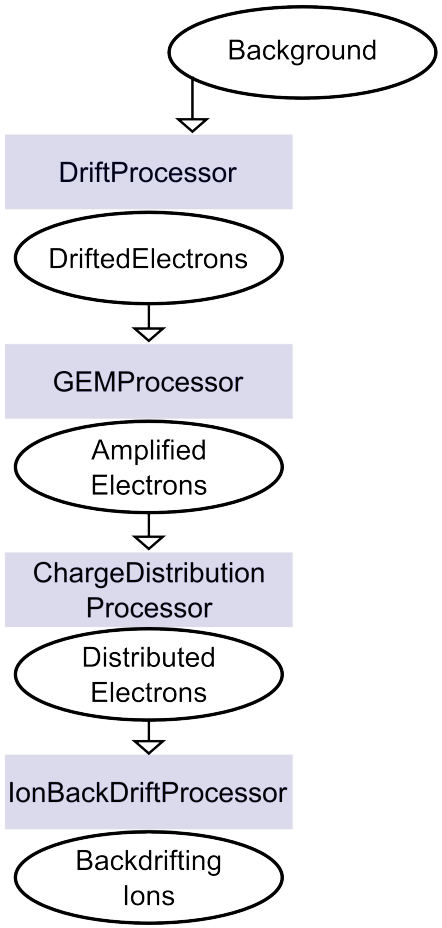
Simulation with MarlinTPC



ChargeDistribution Processor:

- Distributes charges on pads
- All GEAR pad geometries
- Can pile up charges

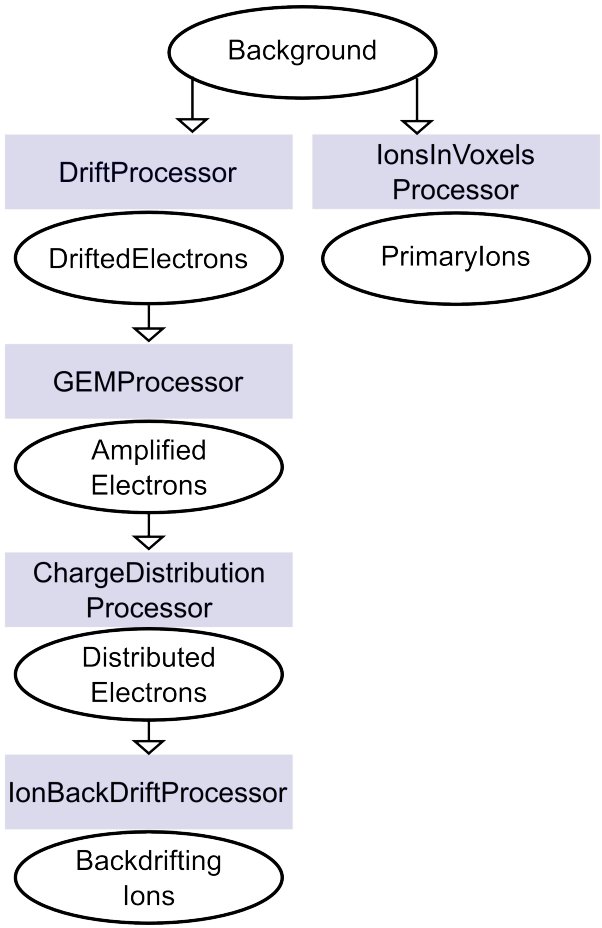
Simulation with MarlinTPC



IonBackDriftProcessor:

- Binning of backdrifting ions into voxels
- Parametrizations of measurements done at RWTH Aachen

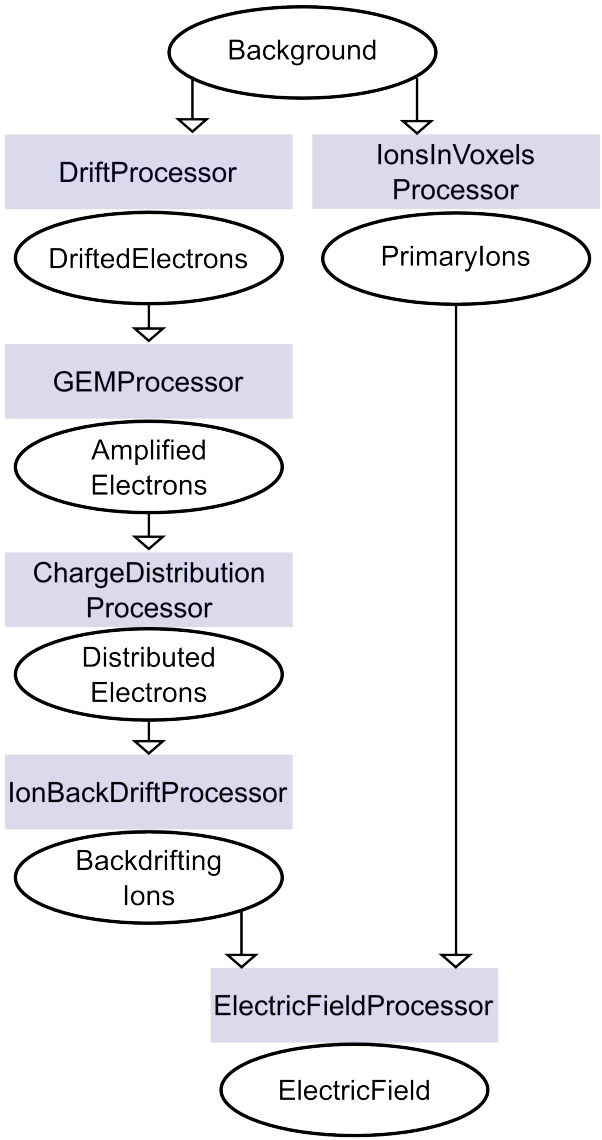
Simulation with MarlinTPC



IonsInVoxelsProcessor:

- Binning of primary ions into voxels

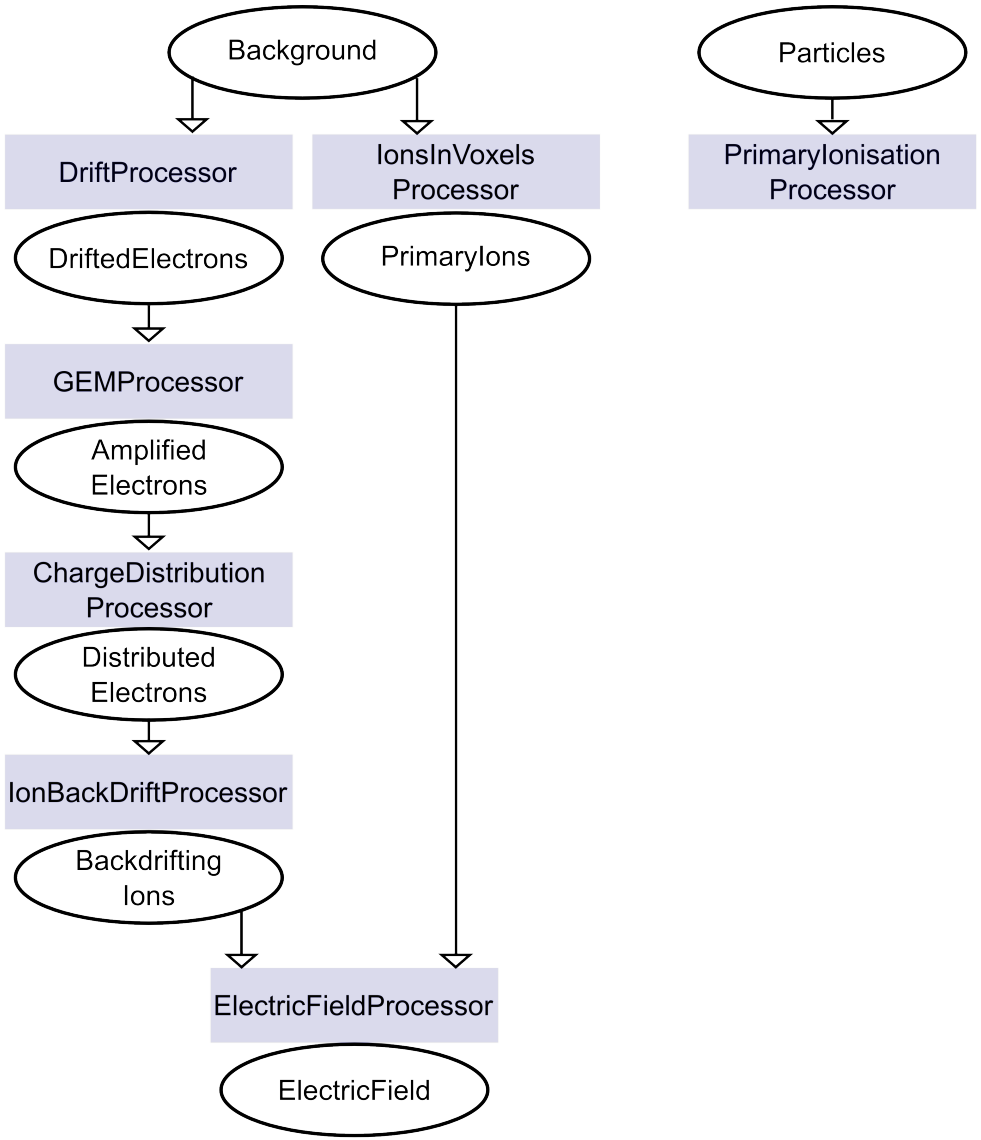
Simulation with MarlinTPC



ElectricFieldProcessor:

- Calculation of electric field vectors at discrete points

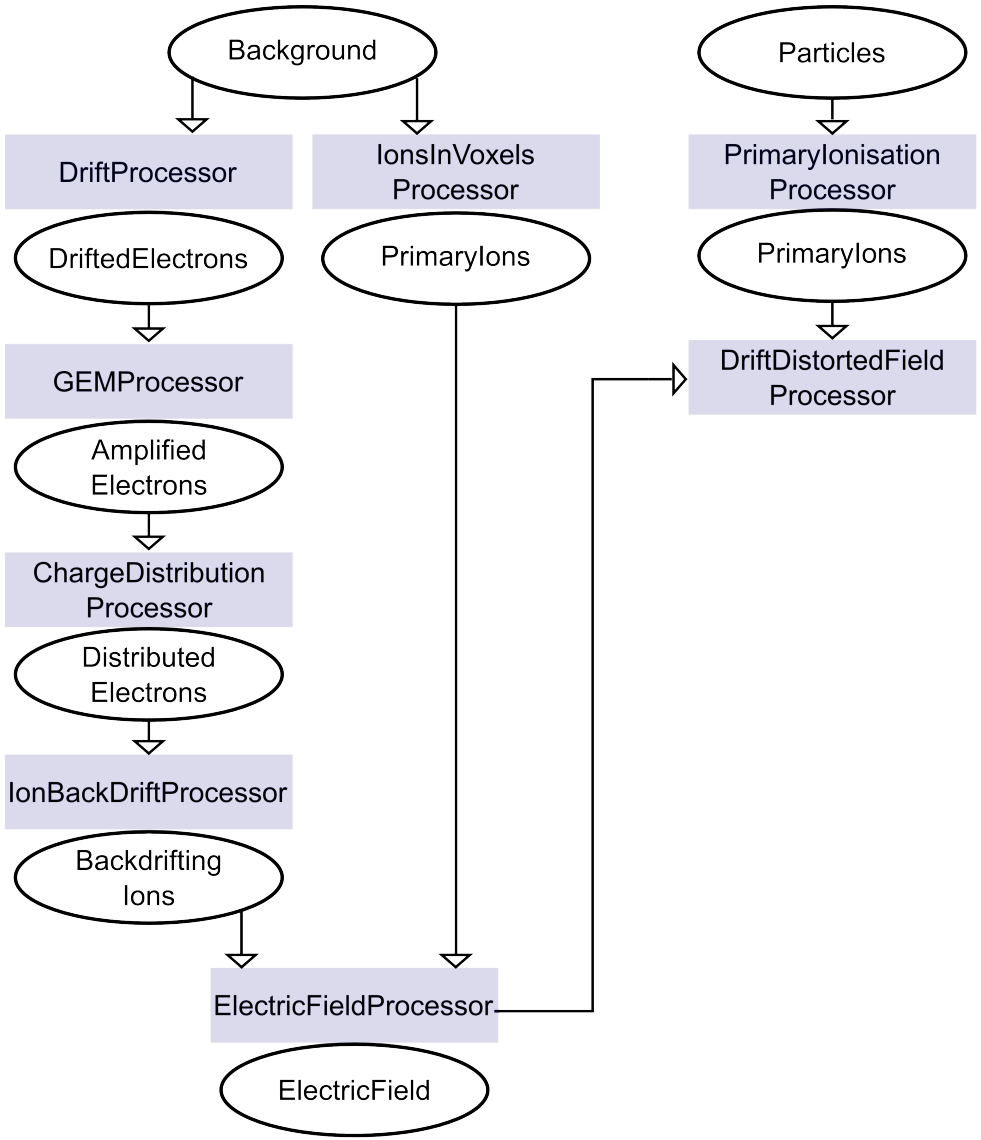
Simulation with MarlinTPC



PrimaryIonisationProcessor:

- Ionization along particle track
- With and without B-Field
- Cluster size and cluster distance from HEED

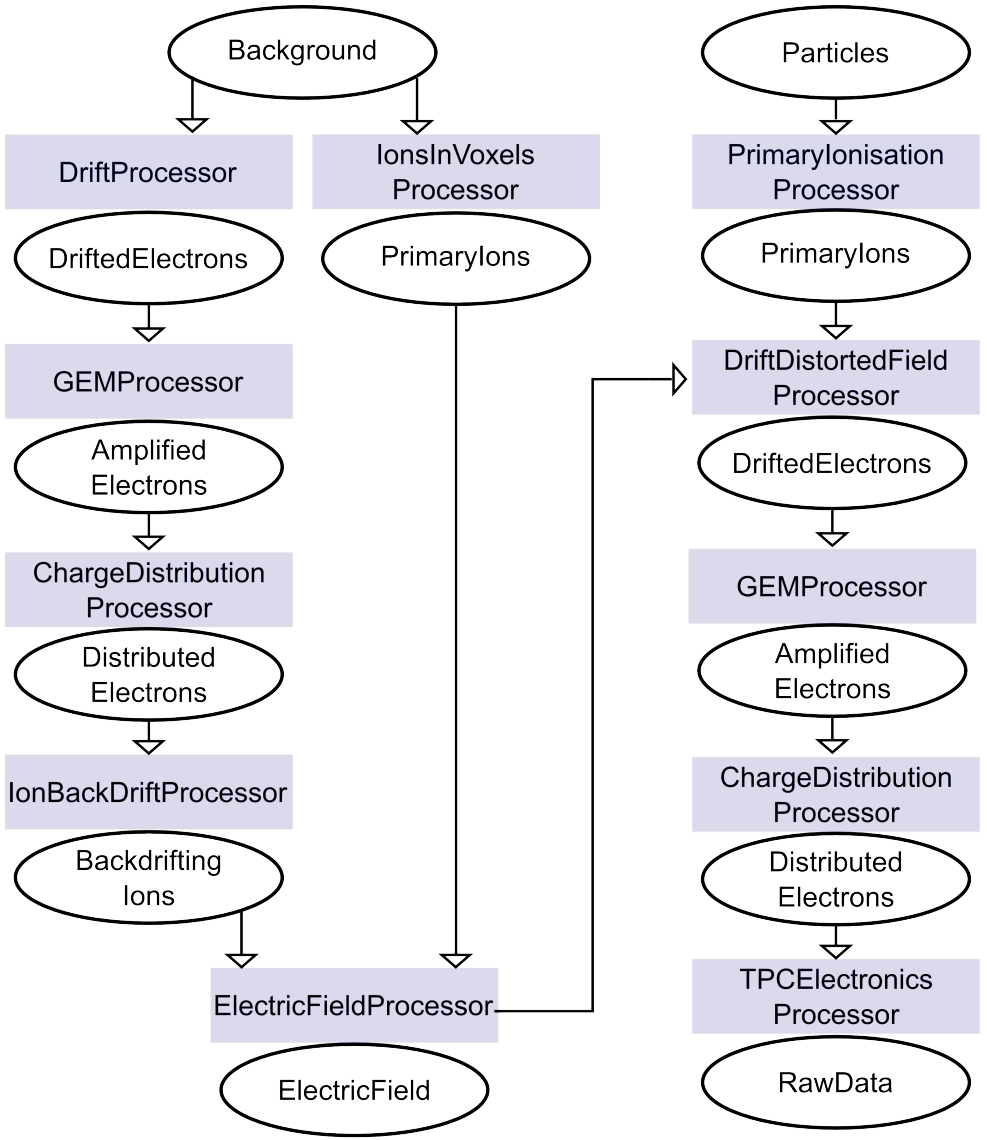
Simulation with MarlinTPC



DriftDistortedFieldProcessor:

- Like DriftProcessor
- Includes E-Field distortions
- Inlcudes B-Field distortions

Simulation with MarlinTPC



TPCElectronicsProcessor:

- Electronics binning and shaping
- Produces RawData

Simulation parameters

TPC parameters:

- Drift length: 1970 mm
- Outer radius: 1570 mm
- Inner radius: 315 mm
- Gas: TDR
  (93% Ar, 5% CH_4, 2% CO_2)
- Drift field: 240 V/cm
- Magnetic field: 4 T

GEM settings:

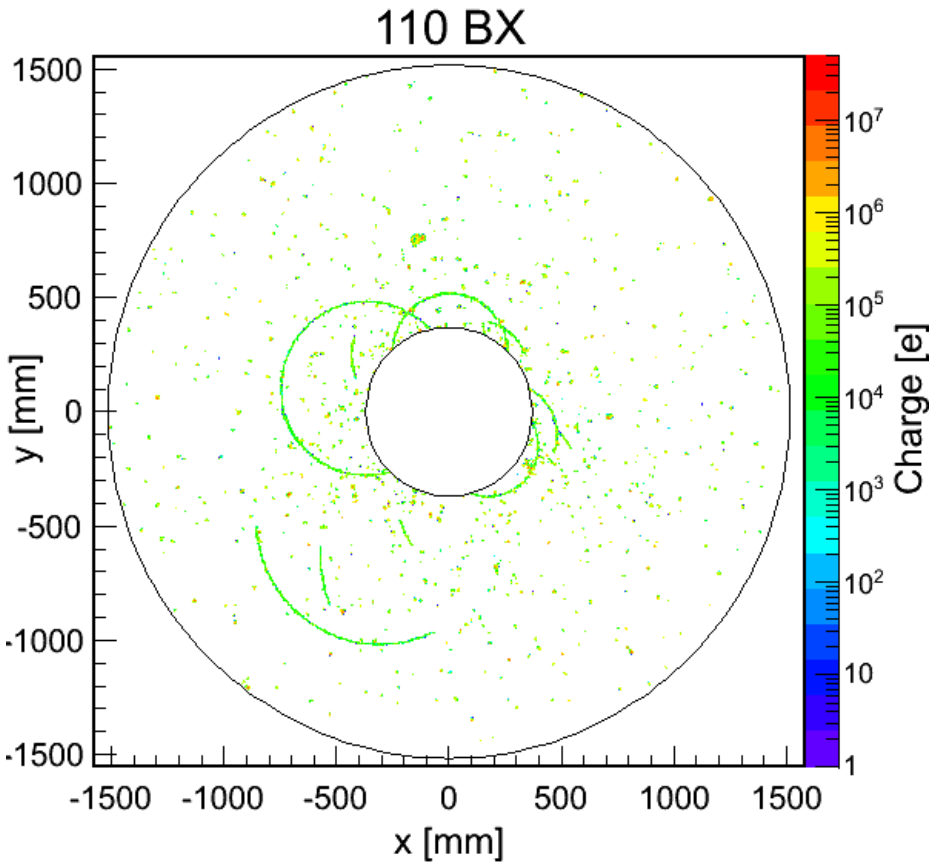
- First transfer field: 2500 V/cm
- Second transfer field: 2500 V/cm
- Induction field: 5000 V/cm
- GEM voltage: 330 V/cm each

$\rightarrow$ Amplification: $\approx 2 \times 10^4$
$\rightarrow$ Ion backdrift: 0.0605

Drift properties:

- Transverse diffusion: $82.47 \frac{\mu m}{\sqrt{cm}}$
- Longitudinal diffusion:
  $283.99 \frac{\mu m}{\sqrt{cm}}$
- Drift velocity: $44.8 \frac{mm}{\mu m}$
- Maximum drift time:
  $\approx 44\ \mu s \mathrel{\widehat{=}} \approx 120$ BX

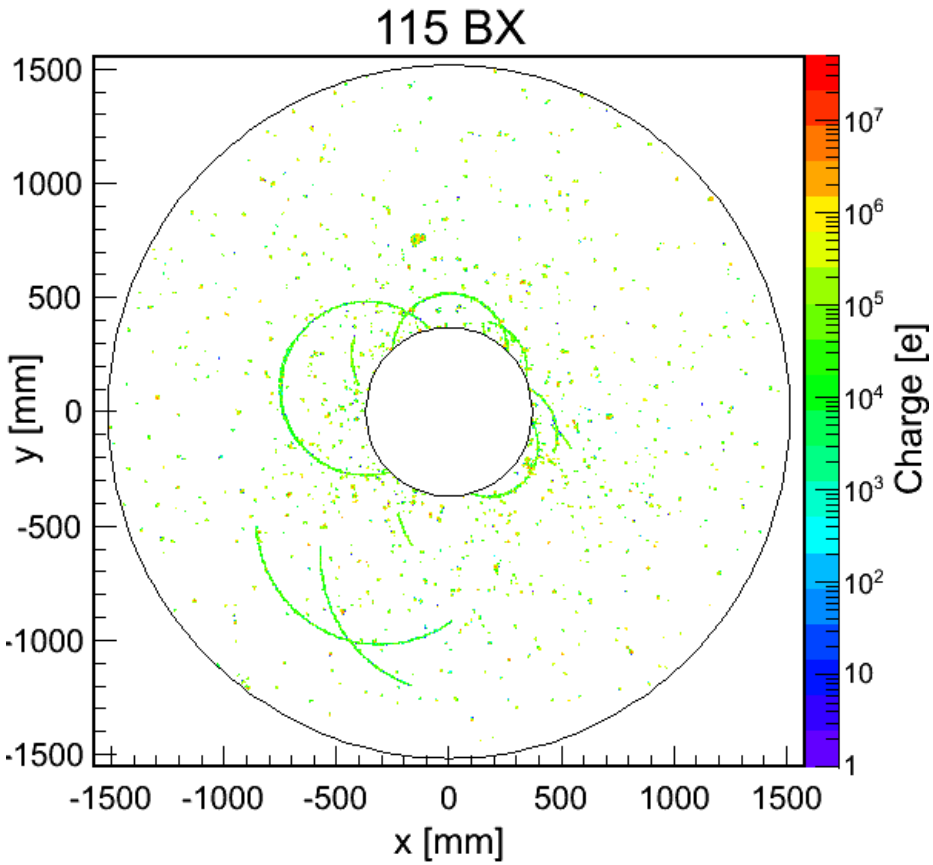
Ion discs



Ion discs:

- Ion discs from Beamstrahlung background
- No homogeneous charge distribution
- Single tracks visible
- Less charge depositions to higher radii

Ion discs



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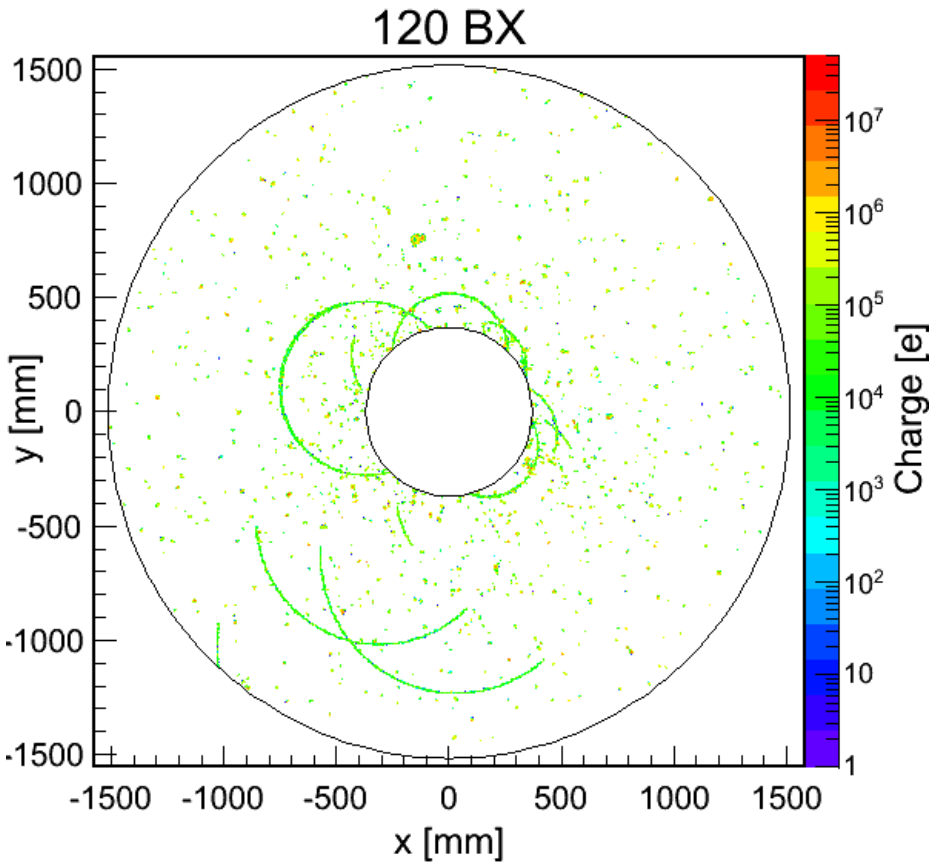

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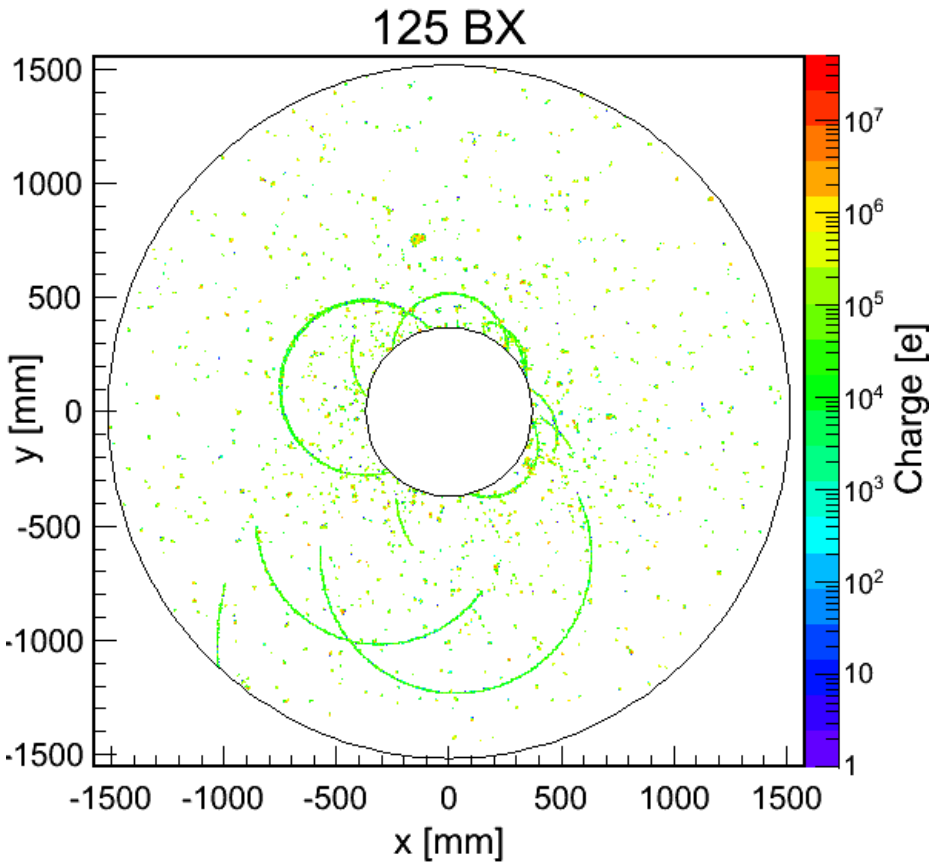

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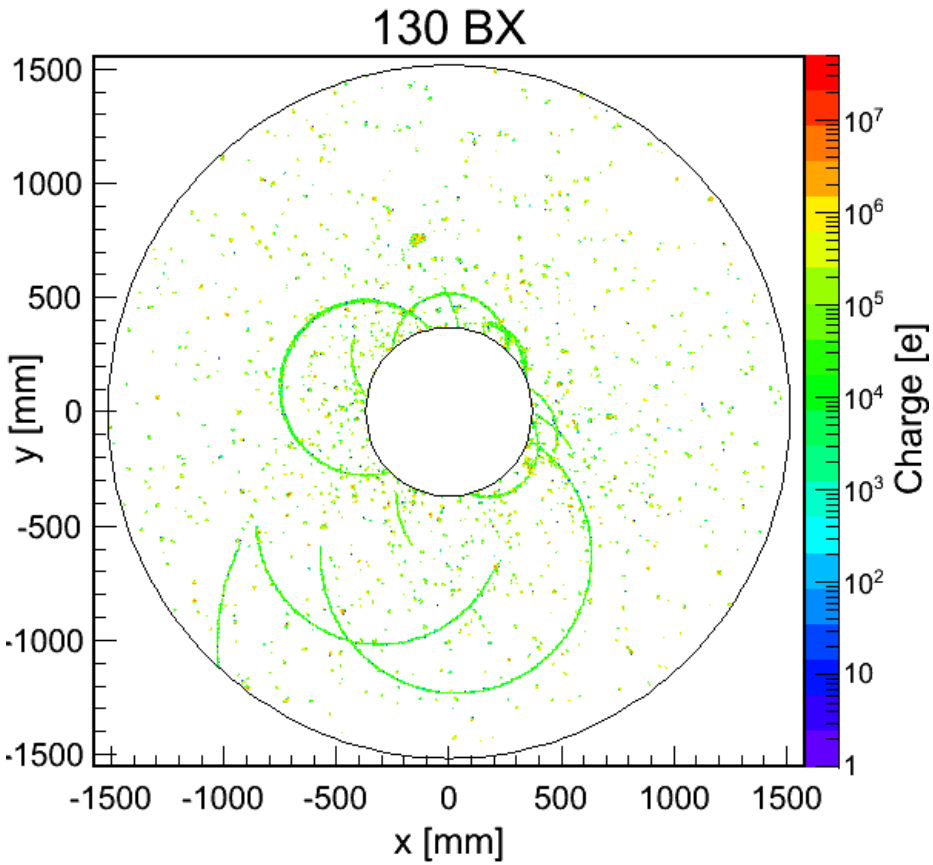

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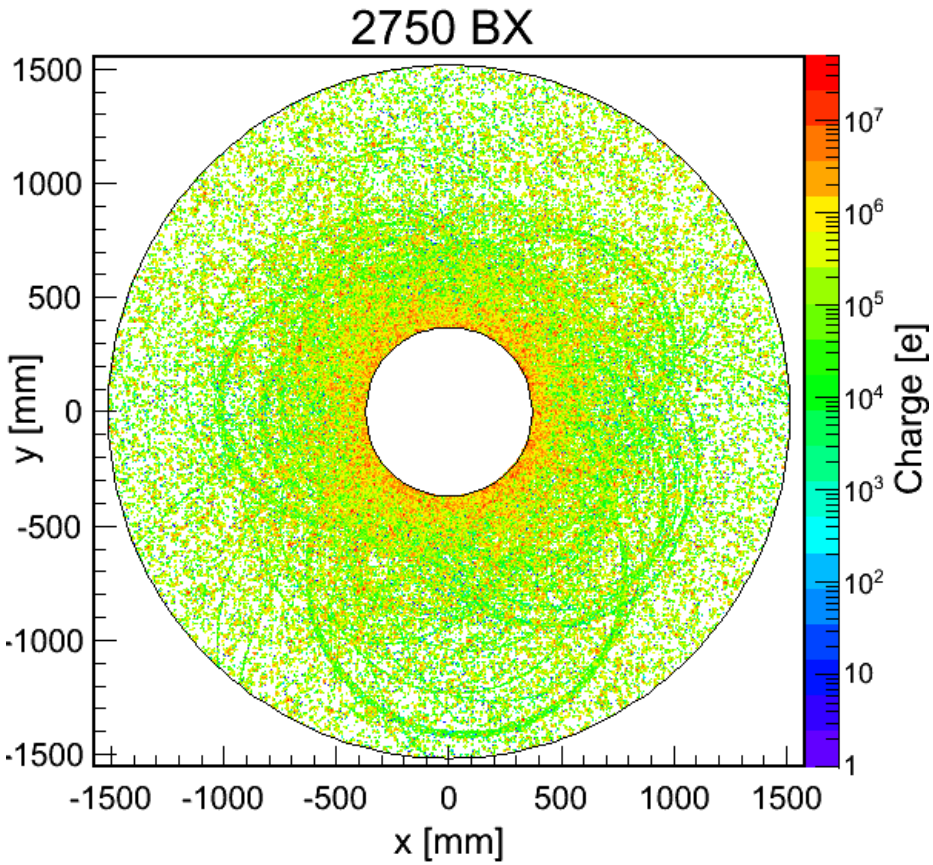

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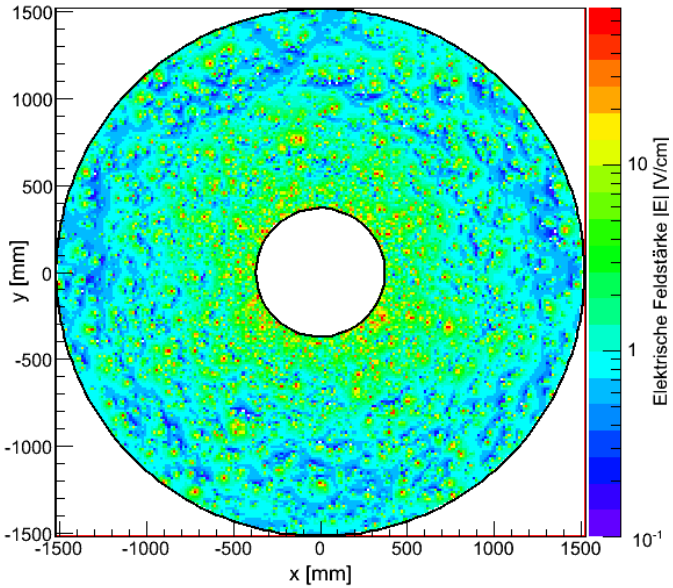
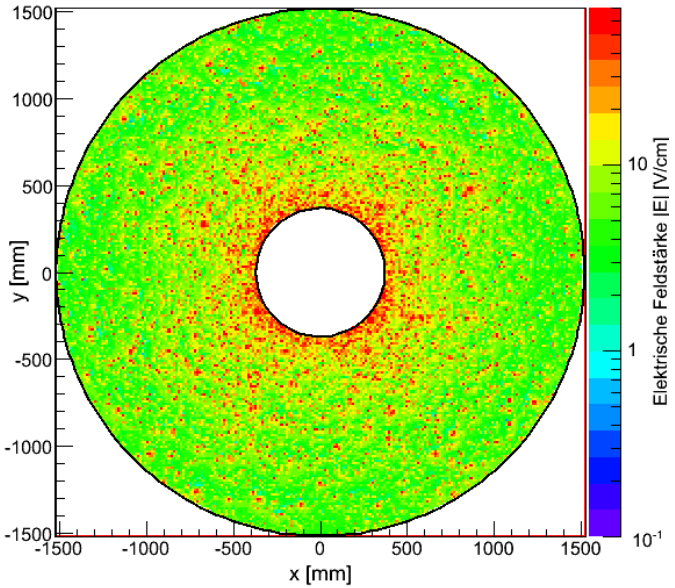
Field distortions

500 BX



2750 BX



Electric fields:

- Calculations with $\frac{1}{r}$−Potential
- Currently: Validation with exact solutions (see: Static Green's functions for coaxial cavity including an innovative representation by Stefan Rossegger)

ElectricField and GlobalFieldProcessor

ElectricField:

Manages electric fields:

- Calculation of electric fields ($\frac{1}{r}$-Potentials)
- Returns electric field at given position

GlobalFieldProcessor:

Manages electric and magnetic fields:

- Returns electric field at given position
- Returns magnetic field at given position
- Used by TrackFitterLikelihoodProcessor to correct for field distortions

Very similar interfaces and functionality
$\rightarrow$ They should be merged

Summary & Outlook

Summary

- Detailed simulation of the ion backdrift is available
- The resulting field distortions can be calculated to some extend

Outlook

- Merge ElectricField and GlobalFieldProcessor
- Add exact calculations of electric fields
- Detailed studies and analysis:
  - Influence on spatial and momentum resolution
- Simulations with several ion discs

$\longrightarrow$ Do we need an ion gate?