TPC Simulation Tools

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Performance Comparison Pixel vs. Pad Meeting

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TPC Simulation and Digitisation

Requirements

- Timepix resolves every single electron
  $\Rightarrow$ Simulation and digitisation have to provide this level of accuracy
- Digitisation should provide realistic TPC raw data
- Full detector reconstruction to see performance in PFA?

Overview

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Mokka Drivers

- TPC06 (current default)
  - 200 charge depositions, each exactly in the middle of a pad row
  - Strange cathode (10 mm air gap between half TPCs)

- TPC07[1] (TPC06 with extension for low P_t tracks)
  - Charge from particles in low P_t tracks (default 10 MeV) is written to a special collection
    $\Rightarrow$ Dangerous: Delta electrons are not in the charge on the pad rows
  - Geant4 step width limiter (def. 1 mm) plus grouping (def. 5 mm)
  - Could be used with "low" P_t cut set to 3 TeV

- TPC04[2] (Adrian's driver)
  - Geant4 step width limiter (def. 5 mm)

Questions:

- Is the charge deposition realistic enough for pads (fluctuations)?
- Can the step width be reduced to fit for Timepix?

[1] Unofficial bug fixed version: TPC09
[2] Unofficial bug fixed version: TPC08

Energy per Hit in Geant4

For thin absorbers (see Geant4 Physics Reference Manual):

- Each atom has a base energy level E_0 and two excited levels E_1 and E_2.
- There is an exitation cross section and an ionisation cross section.
- There is a threshold for the energy transfer above which the electron is treated as δ-electron.
- The number of ionisations / excitations per step length are Poissonian distributed for each energy level.
- The energy loss is the sum of all ionisations and excitations.

PrimaryIonisationProcessor

Number of Clusters per cm

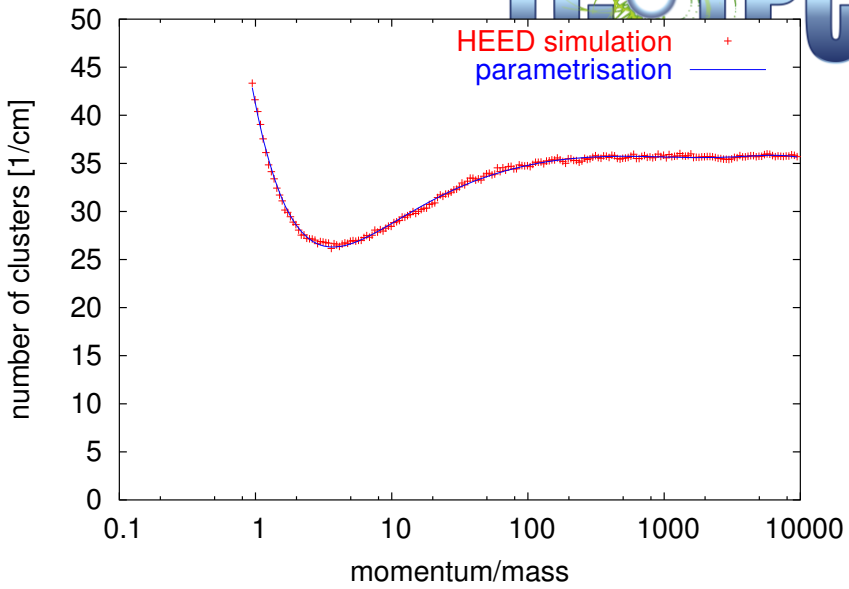
- Distribution derived from HEED
- Parameterised as polynomial approximation

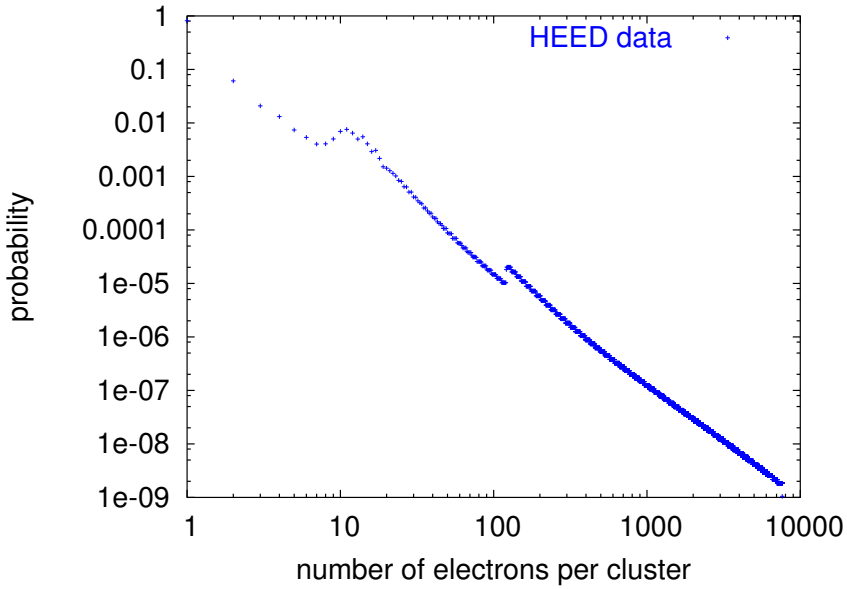
Number of Electrons per Cluster

- Distribution derived from HEED
- Implemented as lookup table

δ-Electrons

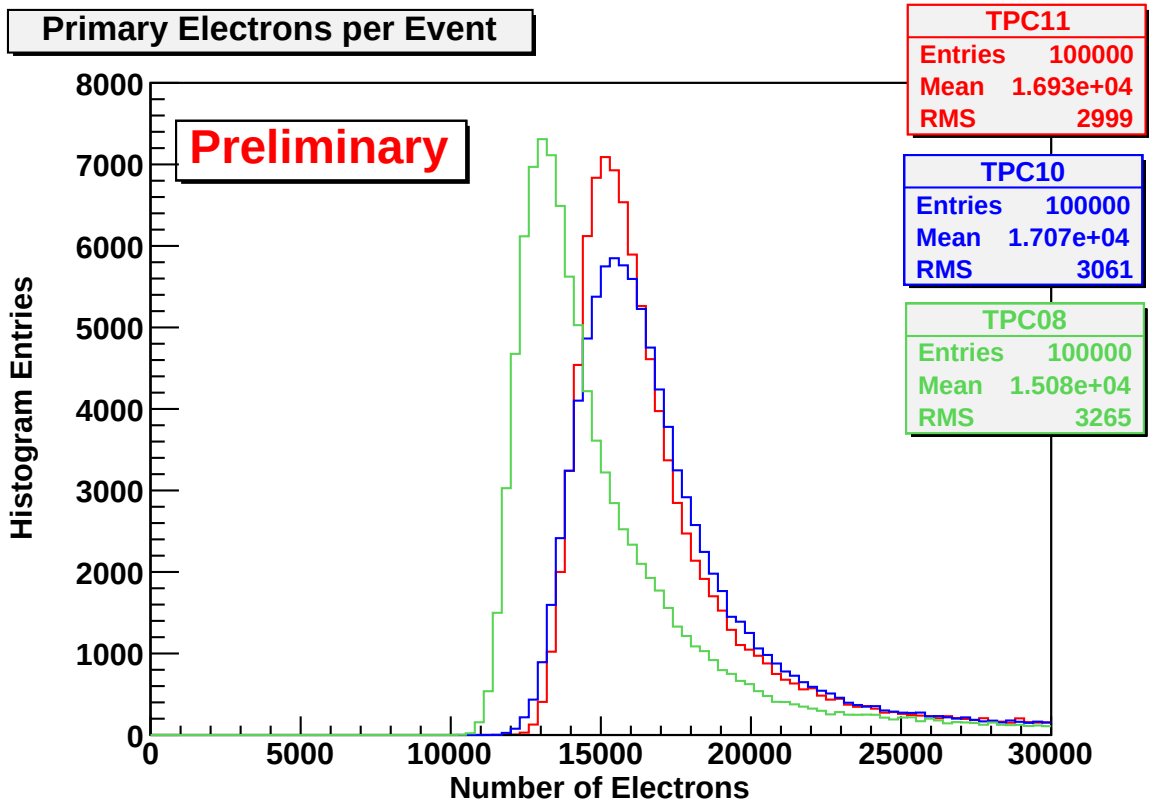
- Primary electrons with an energy corresponding to a range of > 100 µm are treated as δ-electron
- Range and multiple scattering comparable to HEED





PrimaryIonisationProcessor vs. Mokka

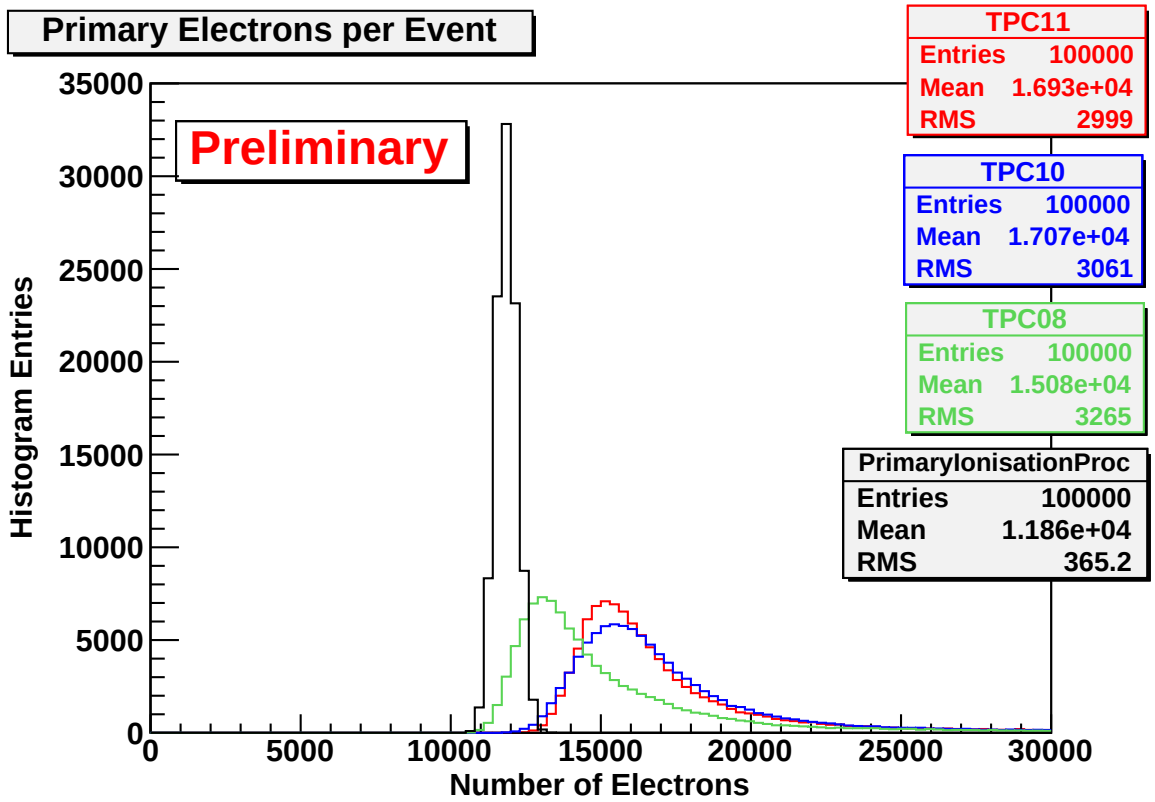
100,000 Muons with 200 GeV



- Different Mokka drivers are not consistent
- Distributions from Mokka have long tails

PrimaryIonisationProcessor vs. Mokka

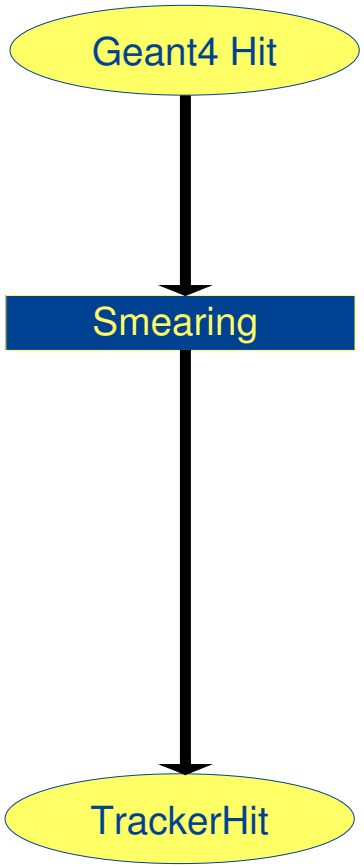
100,000 Muons with 200 GeV



- Different Mokka drivers are not consistent
- Distributions from Mokka have long tails
- Distribution from PrimaryIonisationProcessor has yet another energy and is very narrow (too narrow?)

Which one is correct?

ILCSoft TPCDigi

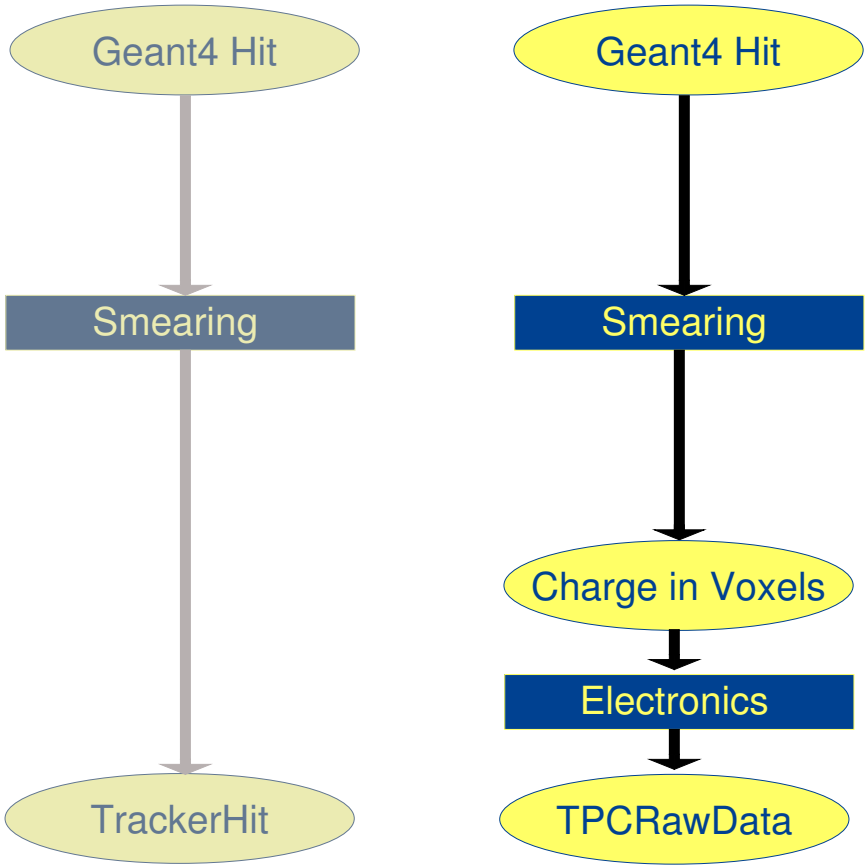


- Detector response is implemented in "intelligent" smearing
- Developed for LEPTracking

Why is this not sufficient?

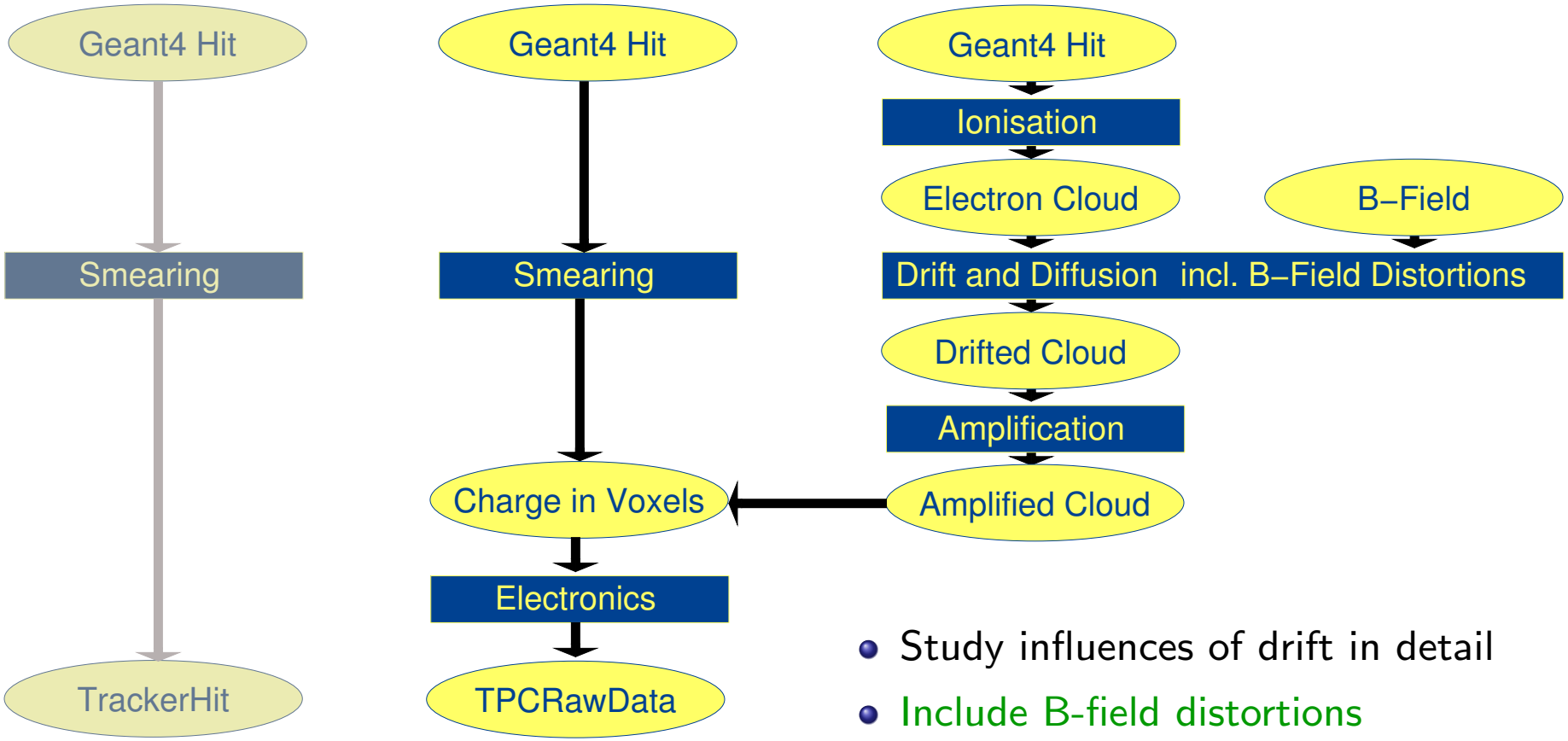
- Does not provide raw data (ADC counts on electronics channels)
- Completely skips pad geometry
- Skips major parts of the reconstruction
- No event pile-up
- Dead or noisy channels not included

Digitisation in MarlinTPC



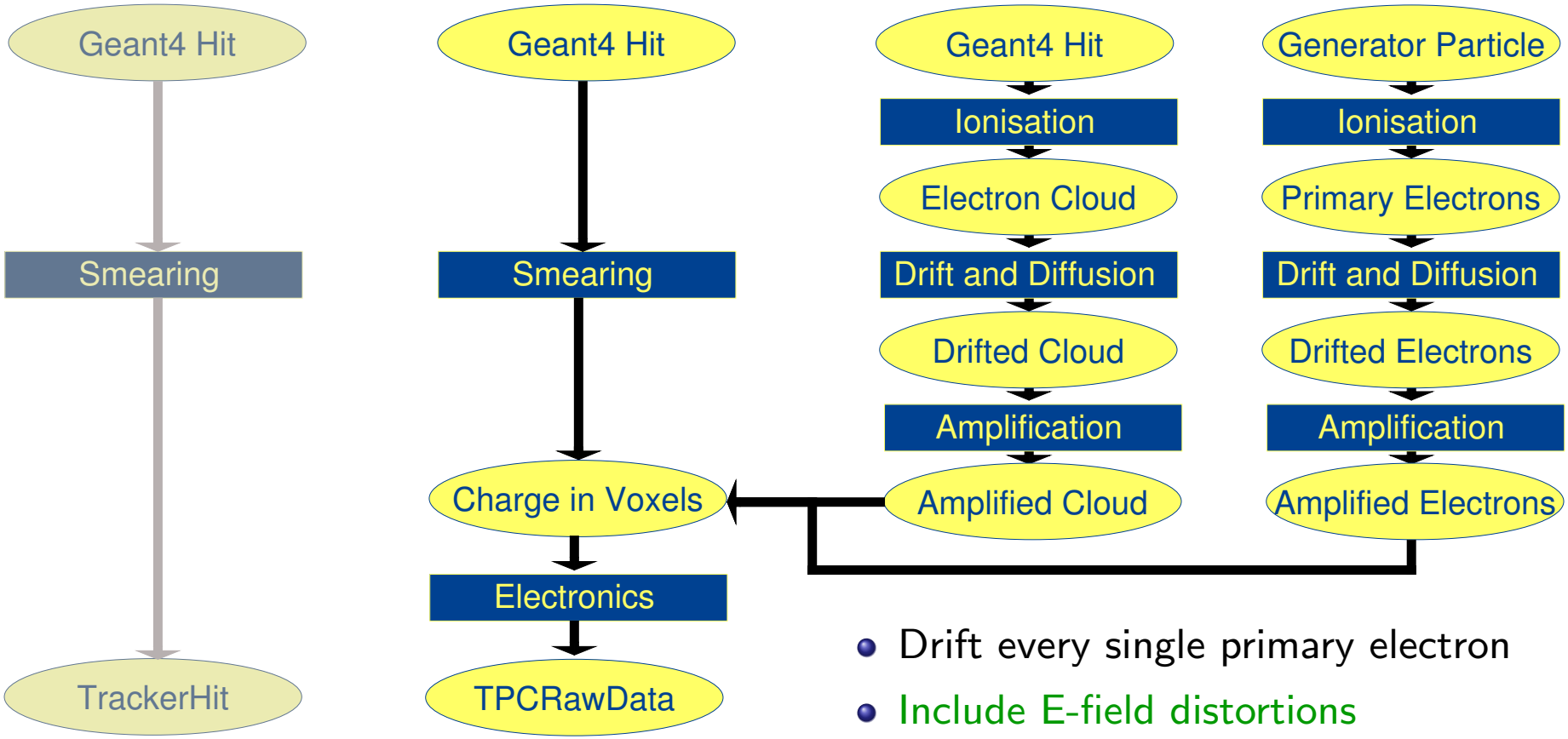
- Map of voxels resembles readout electronics
- Automatically implements event pile-up
- Background can be added
- Electronics specific converter provides realistic raw data

Digitisation in MarlinTPC



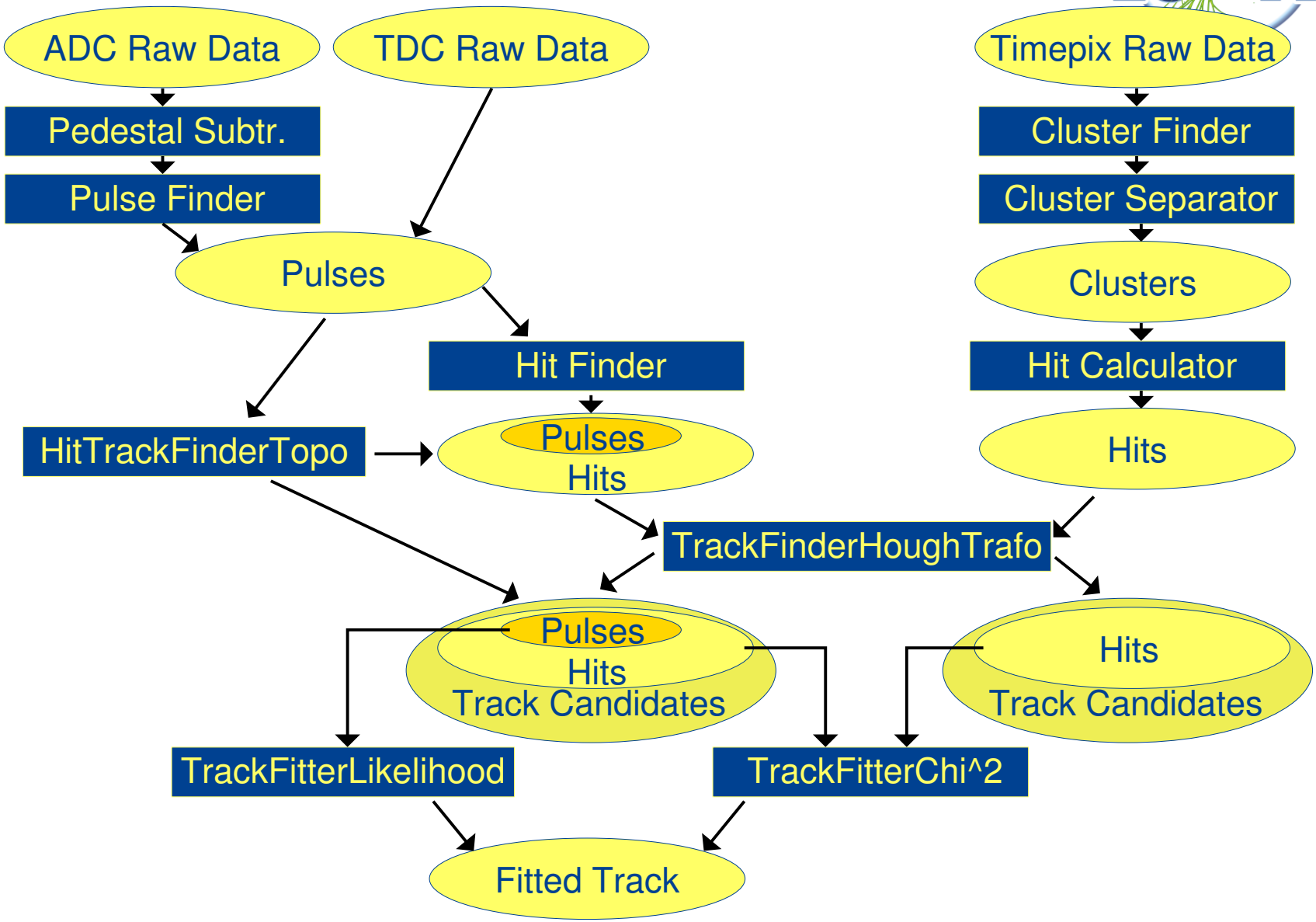
- Study influences of drift in detail
- Include B-field distortions
- Detailed simulation of gas amplification

Digitisation in MarlinTPC



- Drift every single primary electron
- Include E-field distortions
- Even more detailed simulation of gas amplification

Reconstruction



What Do We Need for Performance Studies?

Simulation

- Mokka or PrimaryIonisationProcessor under investigation

Digitisation

- OK for Timepix and pads
- Currently only one pad plane / chip
  - No dead space on module boundaries
  - Timepix is one huge chip covering one quadrant

Reconstruction

- Track finding for Timepix only linear $\longrightarrow$ extend Hough Transform to helix
- Need good track fitter
- Timepix: Identify and cut δ-electrons to have full advantage

Analysis

- Which are the observables we want to look at?
- Momentum resolution
- Spatial resolution
- ...