MarlinTPC

A Common Software Framwork for TPC Development

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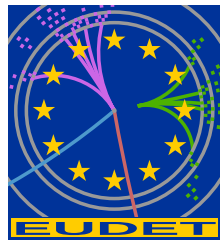
for the LC-TPC Collaboration

IEEE Nuclear Science Symposium
Dresden, Oct. 21, 2008



MarlinTPC

A simulation, digitisation, reconstruction and analysis package for TPC development

Requirements for TPC R&D studies

- Geometry
  - Prototypes
  - Large collider detectors
- Simulation / Digitisation
  - Study detector effects
  - Realistic raw data
- Reconstruction
  - Stand alone (for prototypes: no track seed, no vertex constraint)
  - Various possible readout techniques
- Analysis
  - Ready-to-use standard analyses
  - Plots for prototype commissioning

$\Rightarrow$ MarlinTPC should be highly flexible and modular

ILCSoft Core Packages

LCIO: Linear Collider Input Output persistency framework

Event data model provides data classes

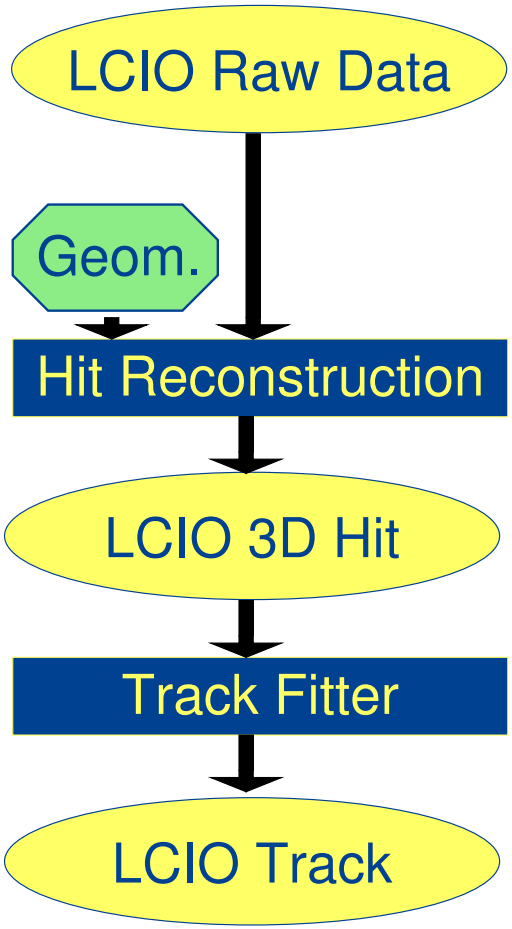
- Raw data
- 3D space points (hits)
- Tracks
- ...

Marlin: Modular Analysis & Reconstruction for the Linear Collider

- Computing tasks implemented as so called *processors*
- LCIO data classes as input / output interfaces
- Steering files control data flow

GEAR: Geometry API for Reconstruction

API to programme against
⇒ code independent of specific detector implementation



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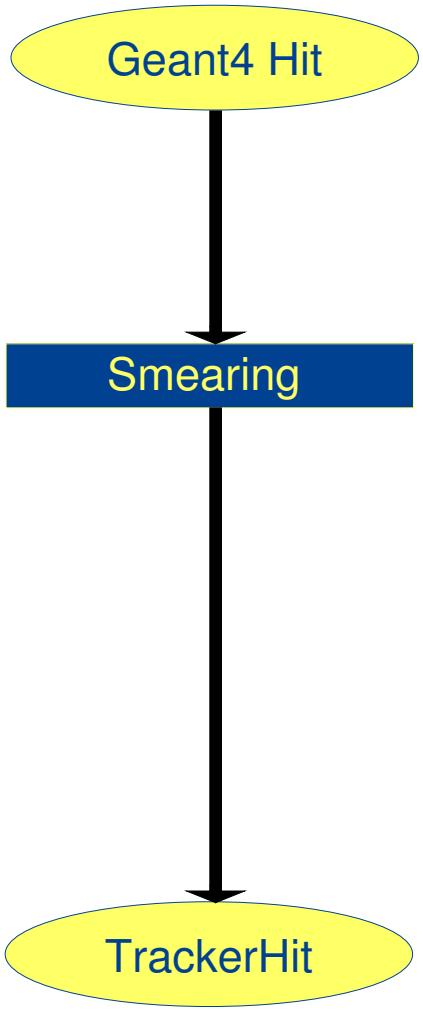
Simple "Digitisation"

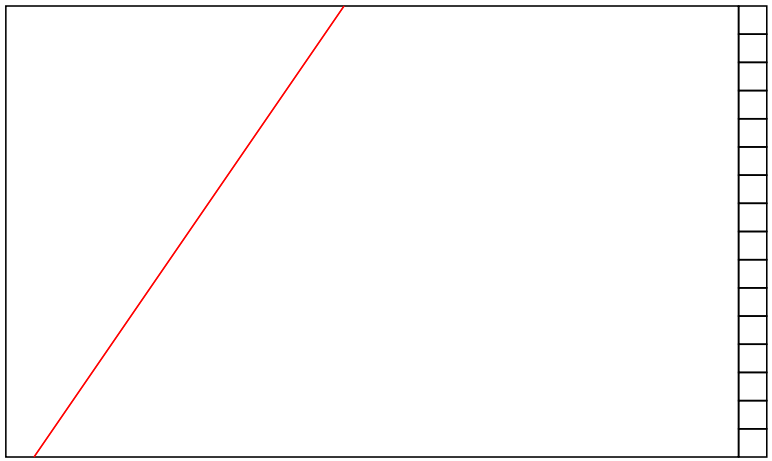


- Detector response is implemented in "intelligent" smearing
- Fast (good for mass production)

Why is this not sufficient for detector R&D?

- 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

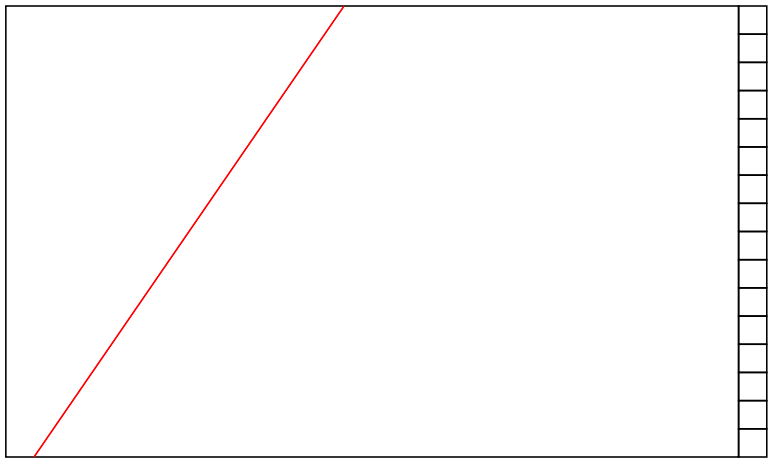
DAQ in a TPC



- TPC takes a long time to read out ($\mathcal{O}$ 150 BX)
- Electronics records many 2D pictures with readout frequency

$\Rightarrow$ 3D picture with *voxels*

DAQ in a TPC

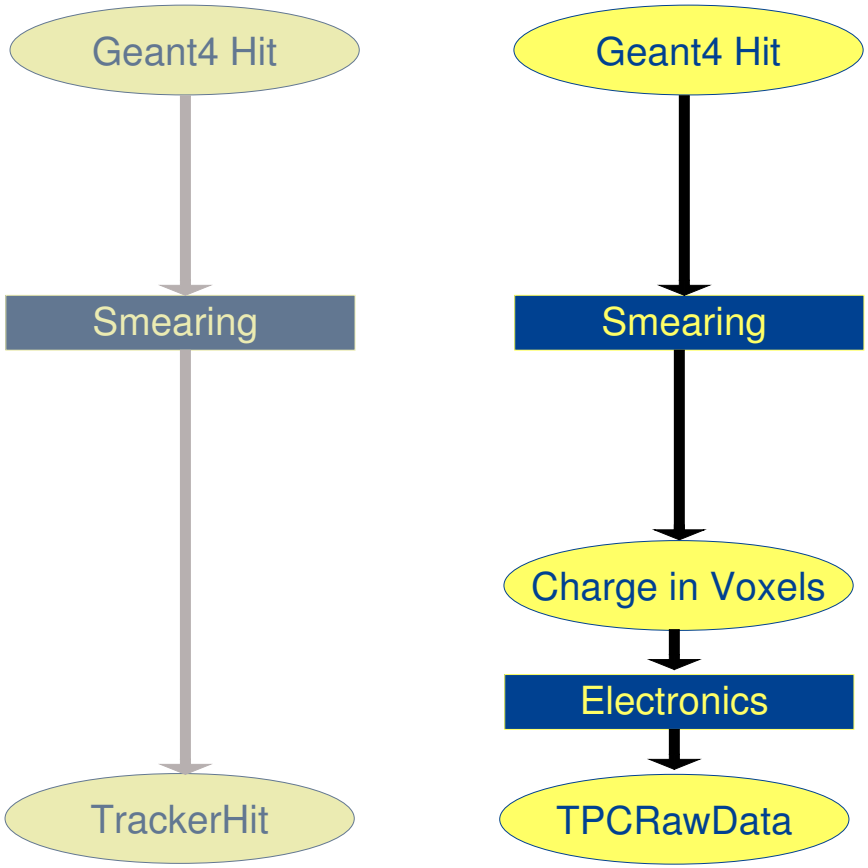


- TPC takes a long time to read out ($\mathcal{O}$ 150 BX)
- Electronics records many 2D pictures with readout frequency

$\Rightarrow$ 3D picture with *voxels*

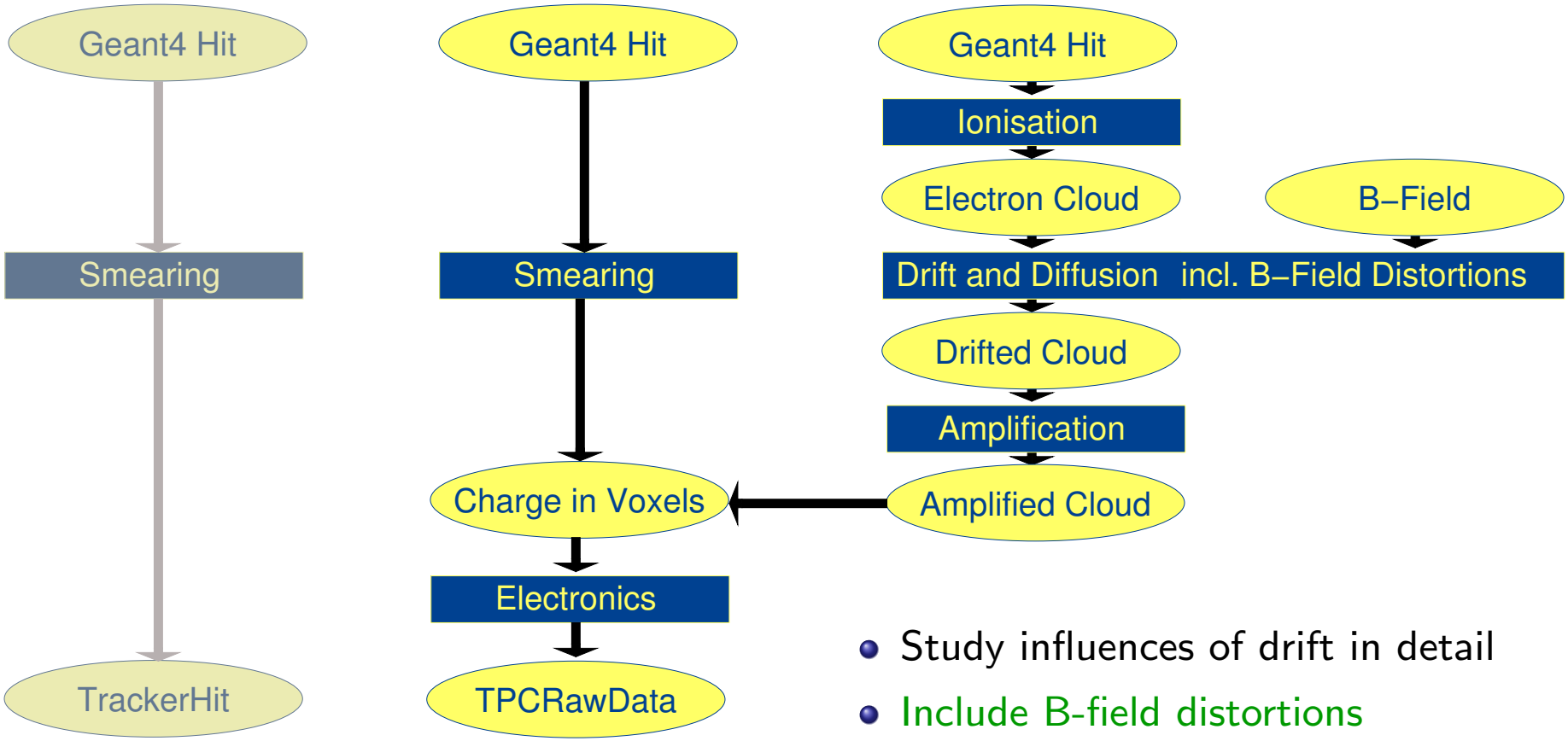
- Tracks from multiple events simultaneously in the TPC
- TPC makes one large 3D picture per bunch train
- Matching with silicon tracker and calorimeter to determine BX

Digitisation in MarlinTPC



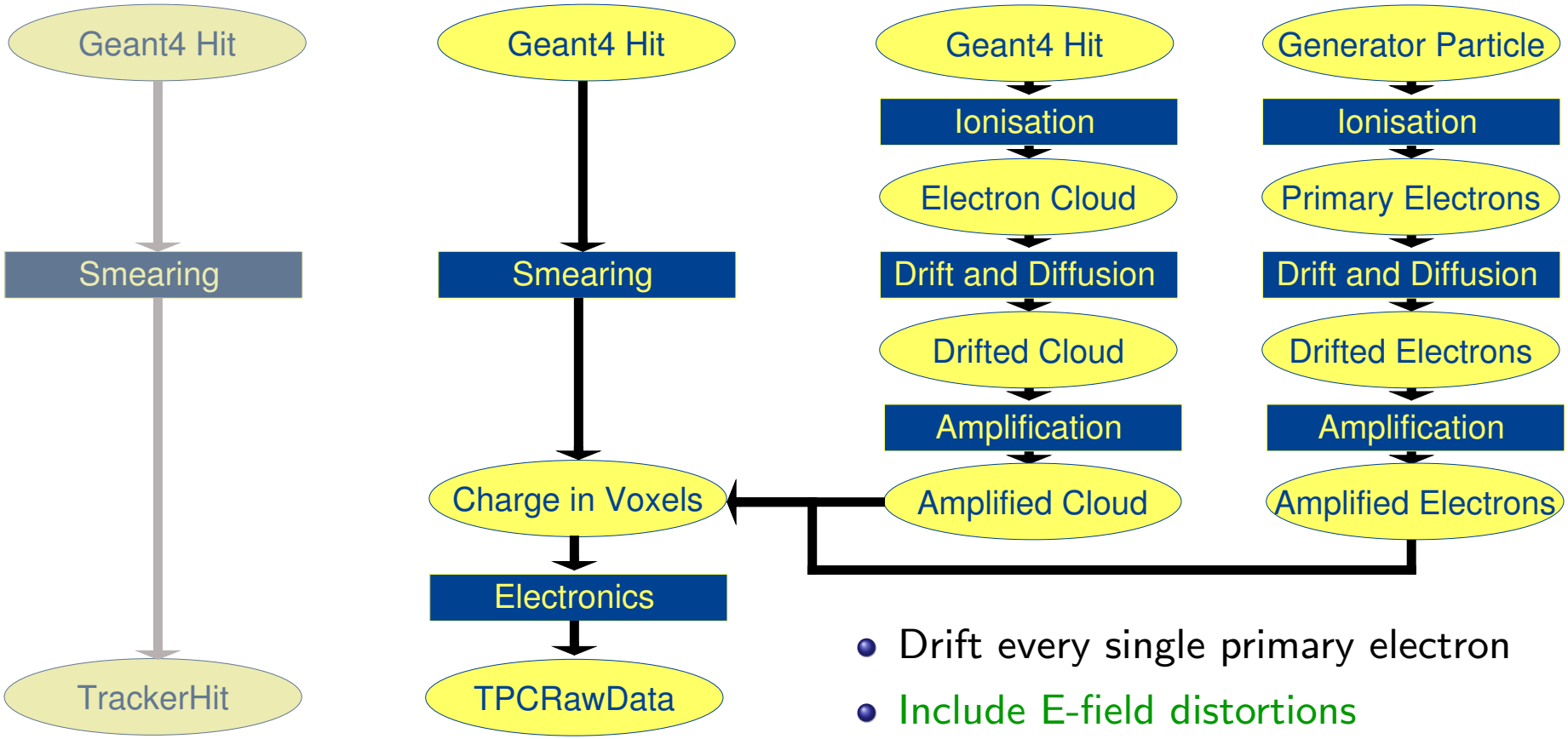
- Map of voxels resembles readout electronics
- Automatically implements event pile-up
- Background can be added
- Electronics specific converter provides realistic raw data

Digitisation in MarlinTPC



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

Digitisation in MarlinTPC

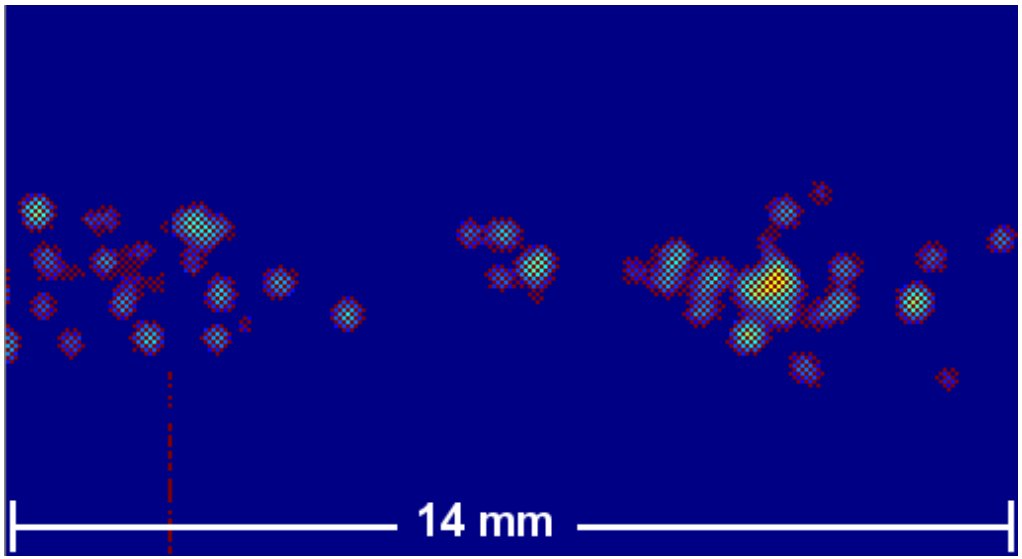


- Drift every single primary electron
- Include E-field distortions
- Even more detailed simulation of gas amplification

Primary Electron Digitisation

Why do we want to track every primary electron?

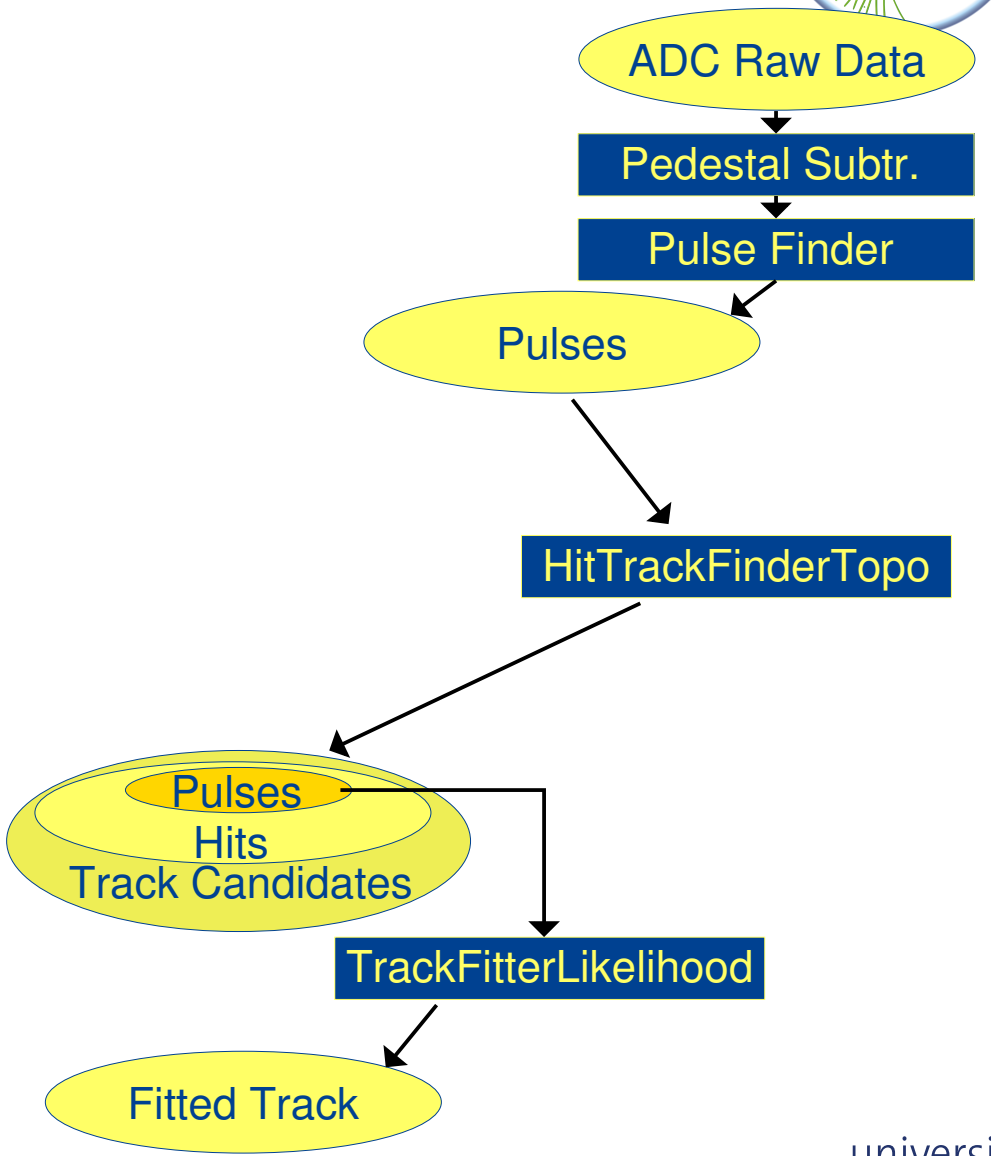
- TimePix Chip with 55×55 µm^2 pixels
  is able do resolve individual ionisation clusters and single electrons



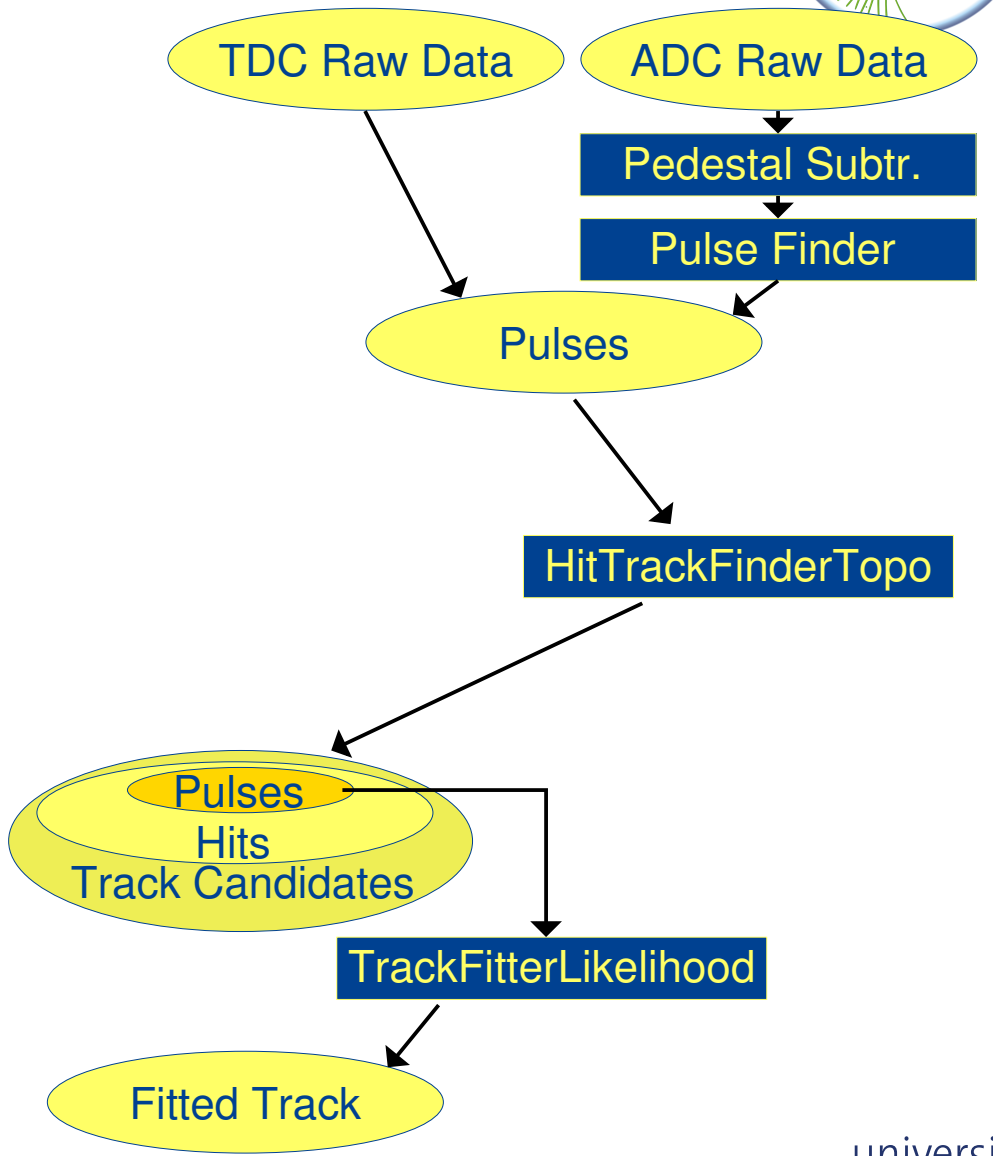
PixelMan Event Display

- Transfer coefficients in GEM readout are taken into account using binomial statistics
- Ion backdrift can be calculated

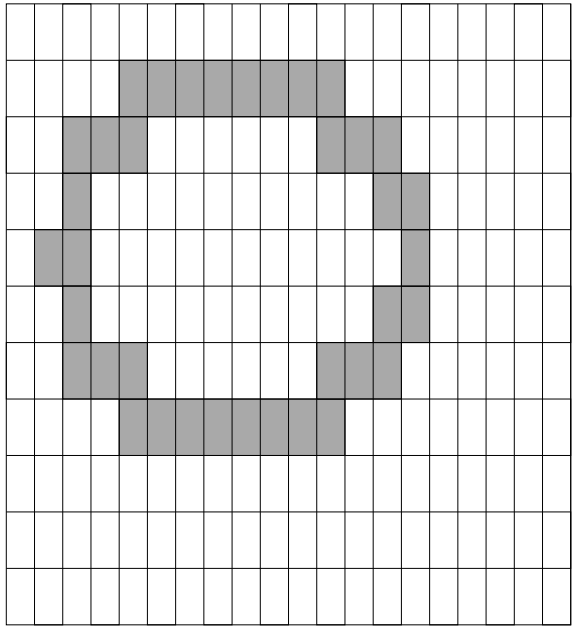
Reconstruction



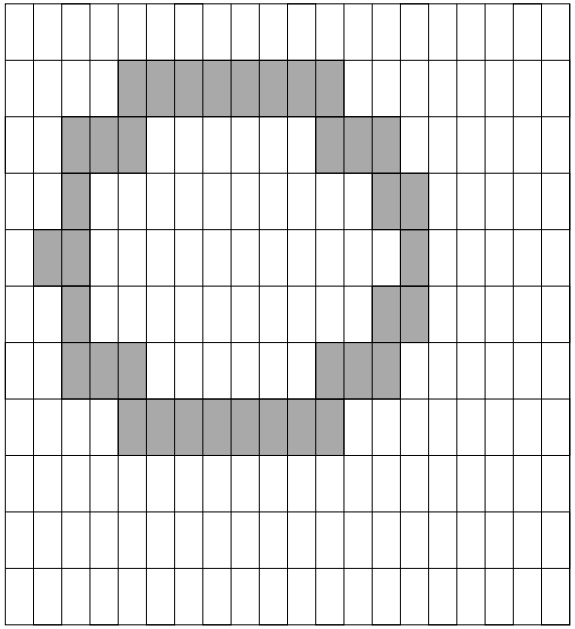
Reconstruction

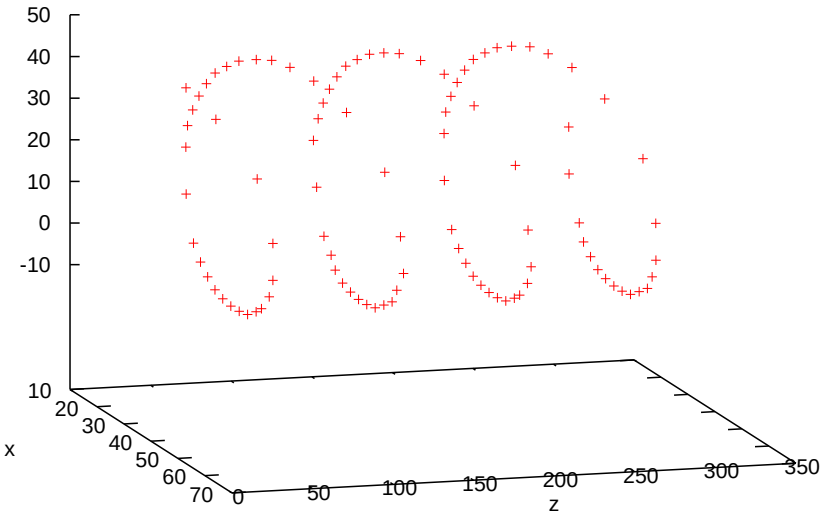


HitTrackFinderTopoProcessor



HitTrackFinderTopoProcessor





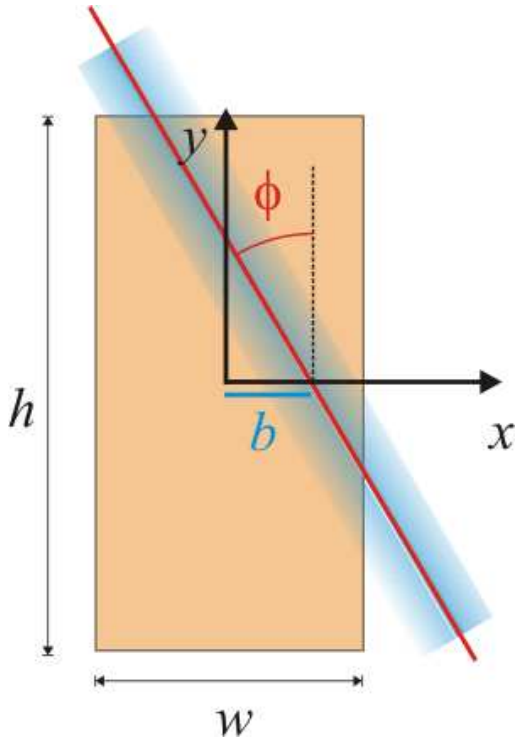
- Uses pulses on pads (pad geometry from GEAR)
- Searches for contiguous areas
- Independent of trajectory, no track hypothesis
- Works in 3D

TrackFitterLikelihood

- The pad response can only be calculated correctly if angle of track wrt. pad row is known.
- This cannot be done on hit basis

⇒ Do it globally for the whole track

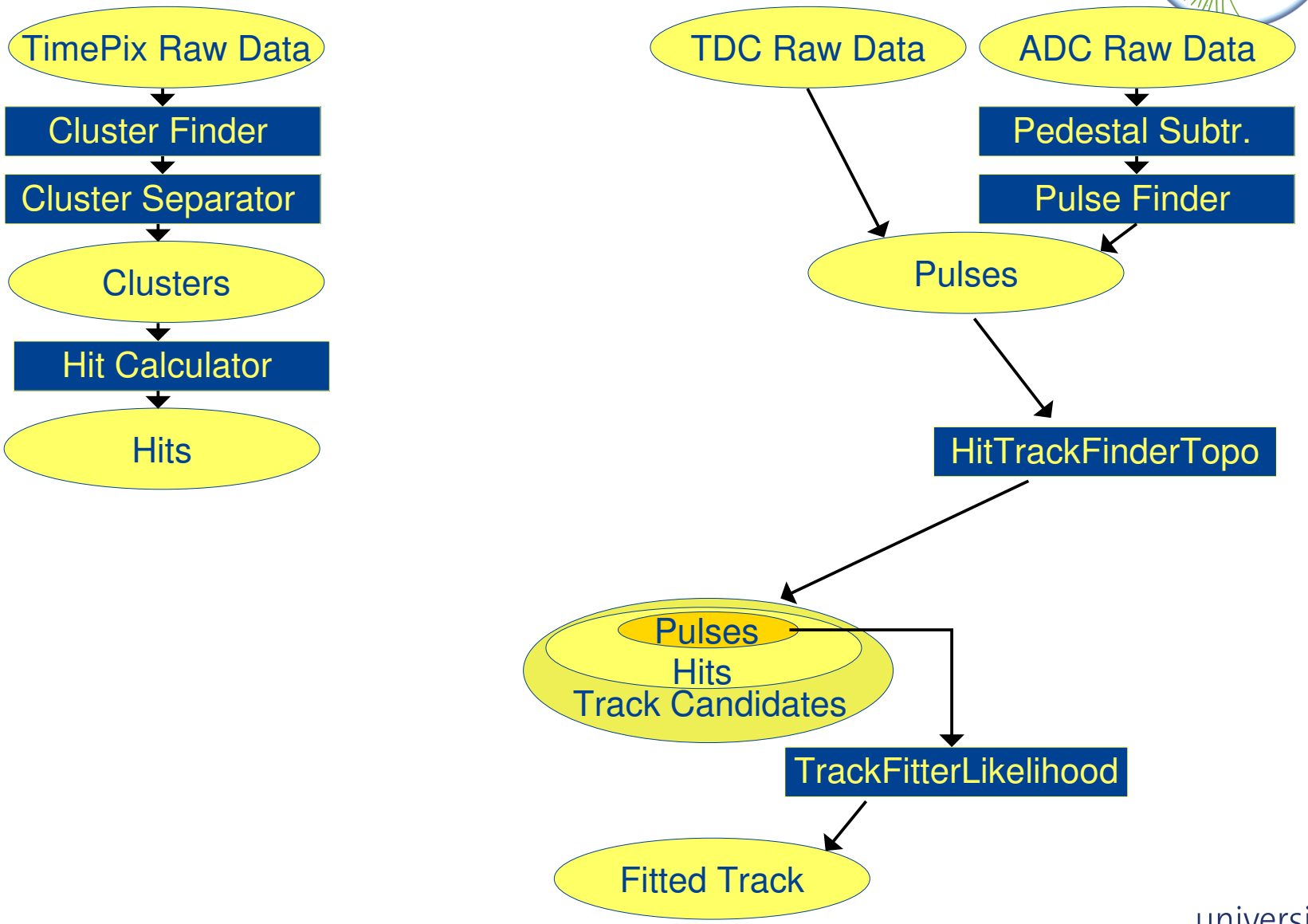
- Calculate likelihood of charge distribution on a single pad row for given track parameters, assuming Gaussian distribution along the track
- Sum up log(likelihood) on all pad rows to get global likelihood
- Maximise the log(likelihood) by varying the track parameters



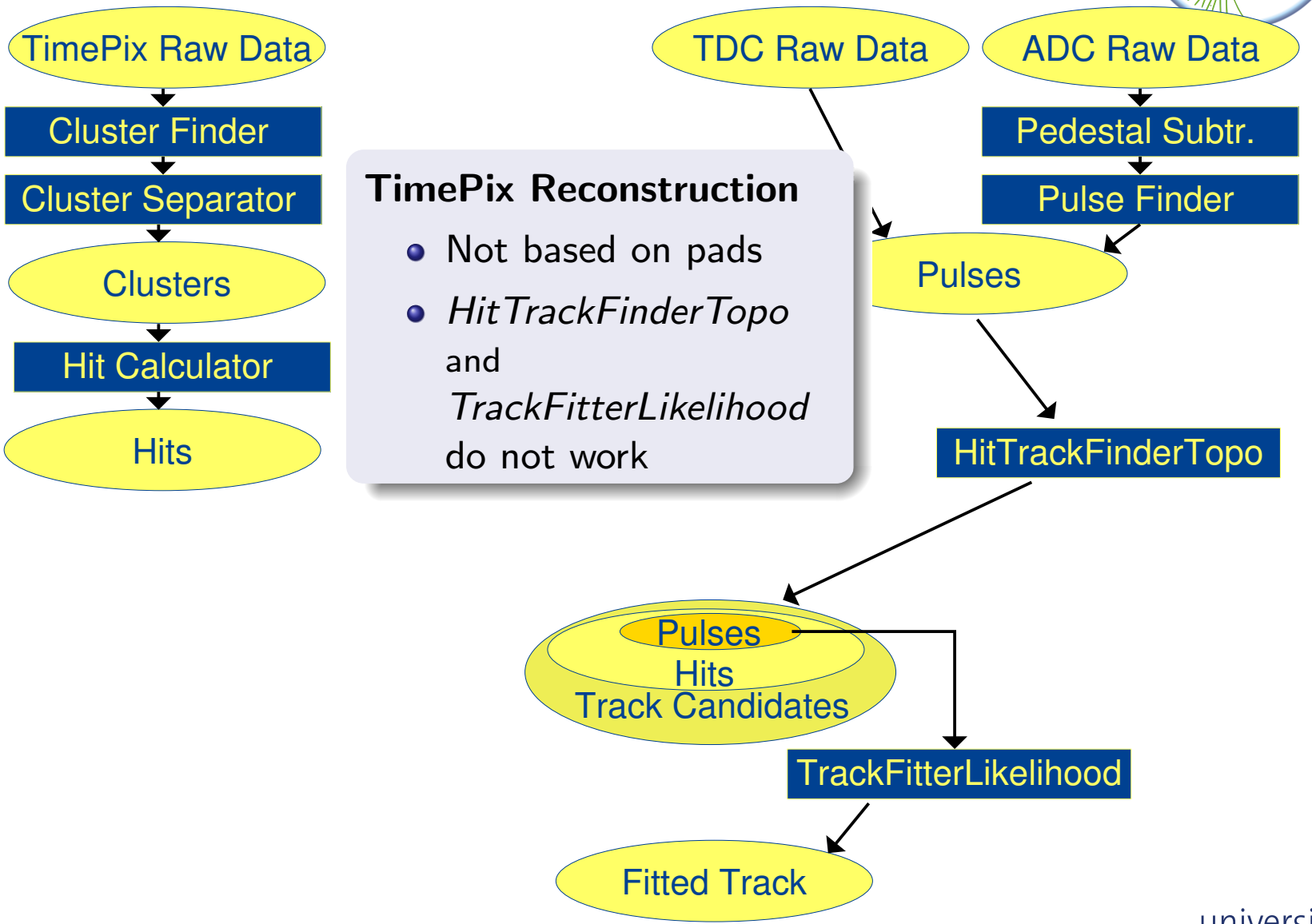
Implementation uses electron cloud drifter

⇒ Track fit includes field distortions

Reconstruction



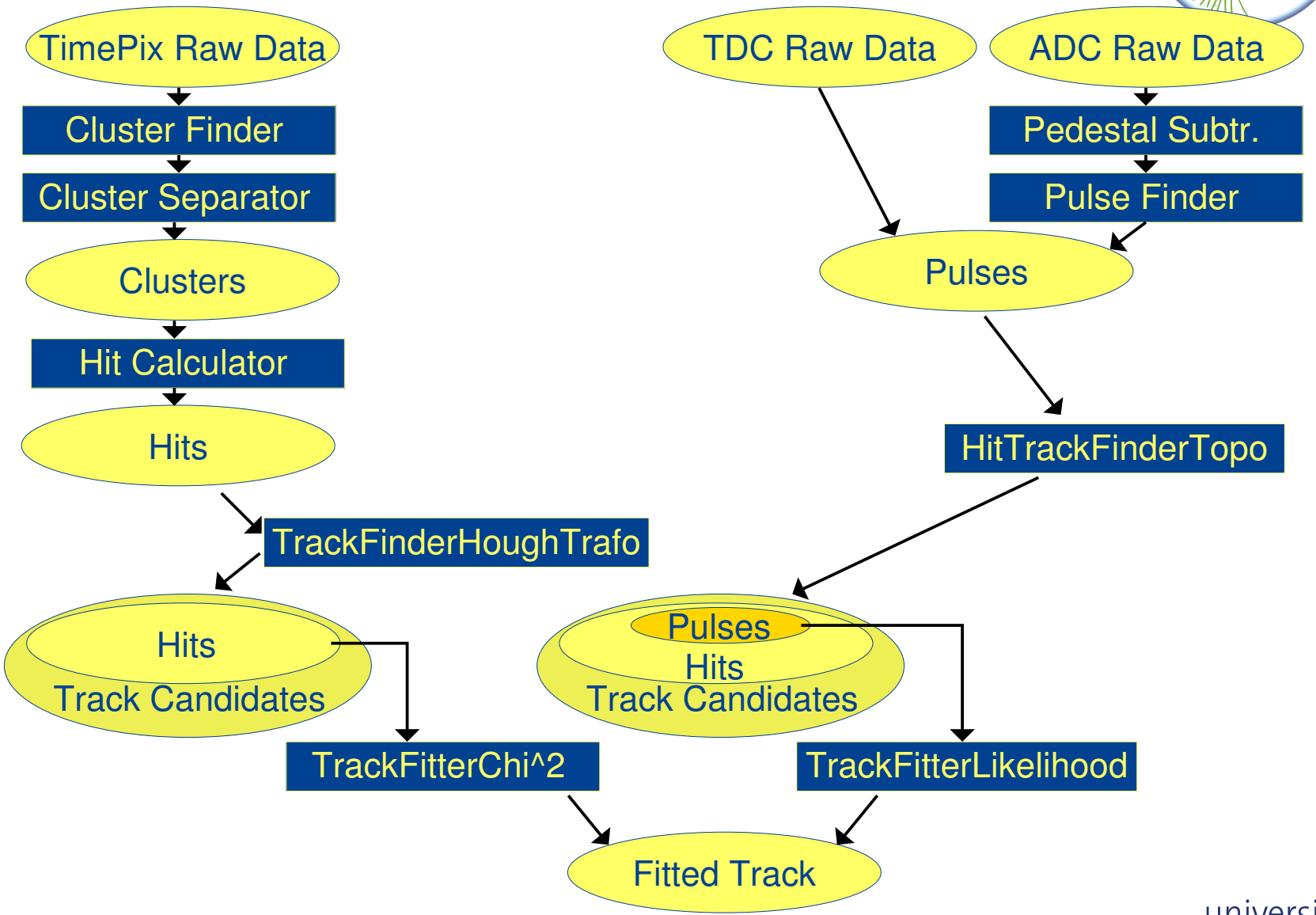
Reconstruction



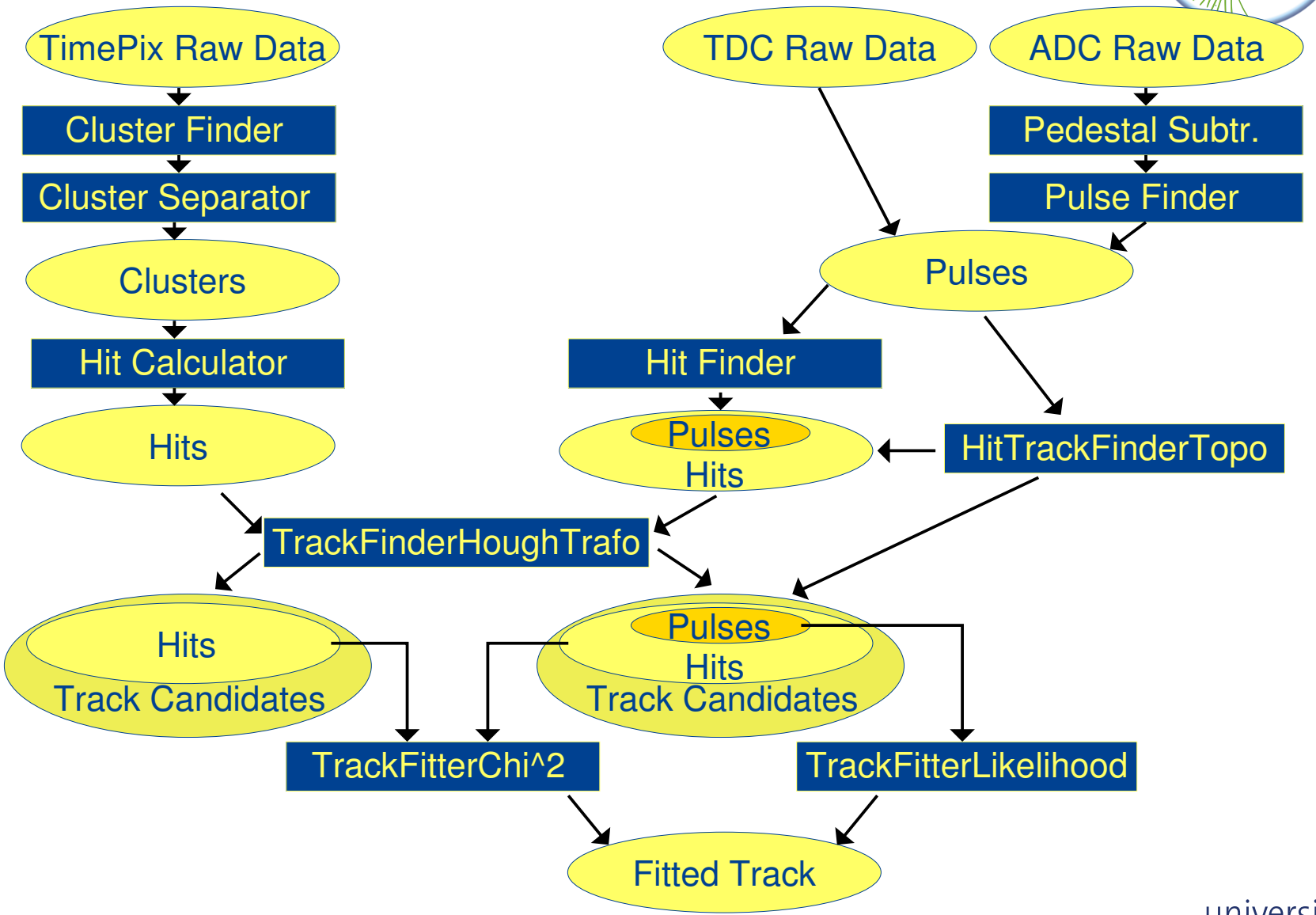
TimePix Reconstruction

- Not based on pads
- *HitTrackFinderTopo* and *TrackFitterLikelihood* do not work

Reconstruction



Reconstruction



Analysis

Requirements:

- Plots for detector commissioning
  - Occupancy diagrams
  - Efficiency histograms
  - Number of hits and tracks
  - ...
- Default analyses
  (agreed on at the first LC-TPC Analysis Jamboree in 2006)
  - Residual distributions
  - Spatial resolution
  - Track parameters
  - Cluster sizes
  - ...

Example: Geometric-Mean Resolution

- Track fit with all hits (n fit) yields to small resolution values (biased estimator)
- Track fit without the test hit ($n-1$ fit) yields too pessimistic values
- Geometric mean is an unbiased estimator

$$\sigma_{\text{Geo}} = \sqrt{\sigma_n \cdot \sigma_{n-1}}$$

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Summary

MarlinTPC

- Highly modular
- Powerful digitisation
  - Realistic raw data
  - Realistic event pile-up
  - Fast branch and detailed branches
- Flexible reconstruction
  - Specialised and multi-purpose processors
  - Different kinds of readout

MarlinTPC is the default reconstruction and analysis tool for the joint LC-TPC Large Prototype test beam starting this autumn.

Next Steps:

- Data challenge:
  Testing of all functionality with MC and prototype data
- Improve E- and B-field distortion corrections

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Backup

Digitisation incl. Ion Backdrift