MarlinTPC

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Introduction

- MarlinTPC is independent of the specific detector:
  - Works for prototypes and ILC detectors (every TPC that can be described with GEAR)
  - Works for Micromegas, GEMs and anode wires
  - Works for pads and pixel based readout
  - Independent of electronics: TDCs, ADCs ...
- Take advantage of the well defined LCIO and Marlin interfaces
  - Highly modular
  - Good reusability of code
  - Only little additional code to adapt to specific detector
- Provides standardised analysis to allow better comparability

Overview

- Simulation
- Digitisation
- Reconstruction
- Analysis

- Library for TPC conditions data based on LCCD

- Examples for getting started
- Validation

Simulation

Simulation package for detailed studies of a TPC.
Started off with TPCGEMSimulation and separated the simulation and the digitisation:

- Parameterised deposition of primary electrons, realistic clusters, delta electrons...
- Drift of electrons incl. diffusion
- Detailed simulation of amplification and charge transfer in a GEM stack, incl. gain fluctuations and collection / extraction efficiencies

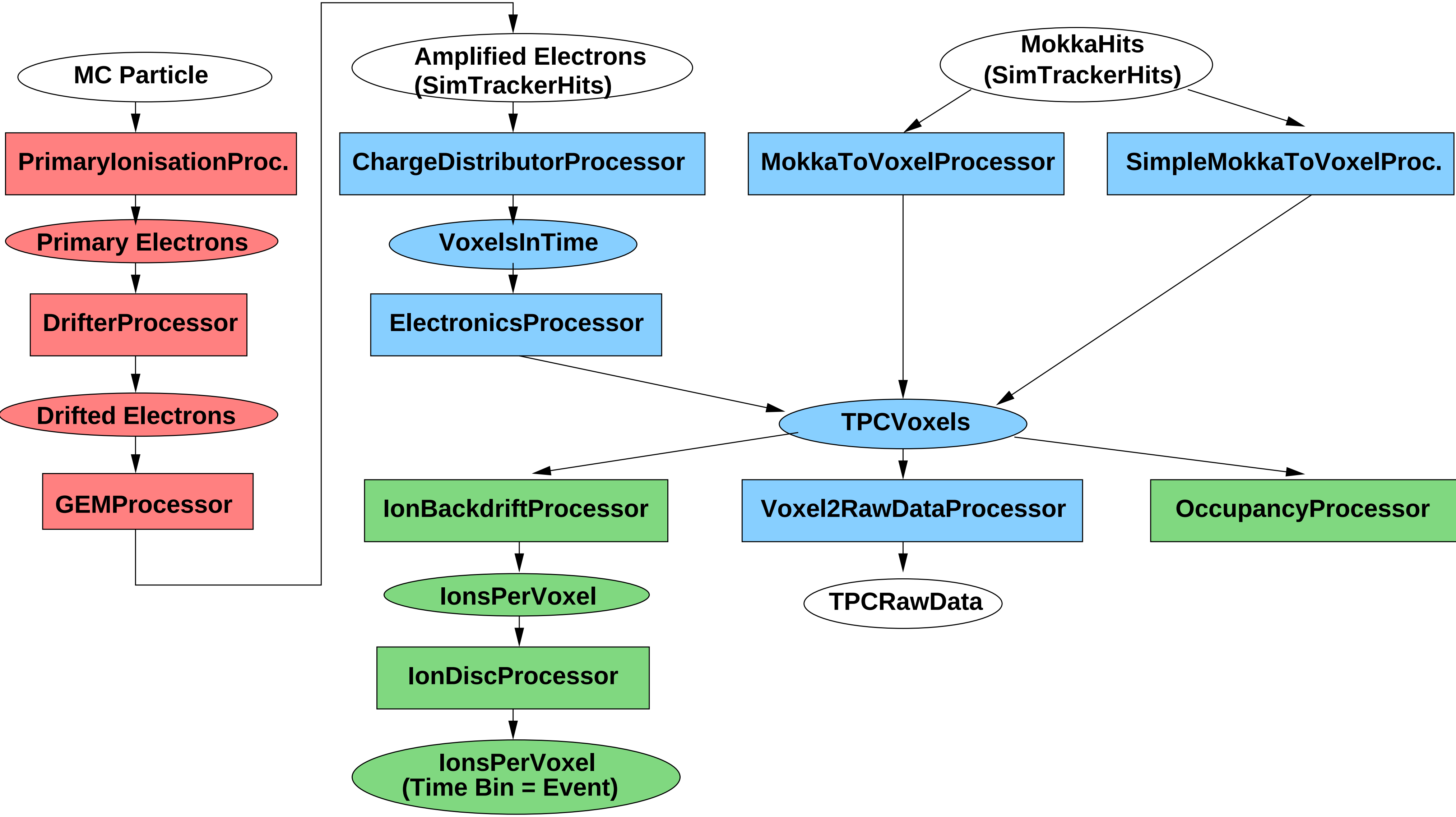
Every single primary electron is tracked in the TPC. This should provide data realistic enough for a silicon pixel readout.

Digitisation

- Provide `TrackerRawData` for use with reconstruction
  - Smearing of Mokka hits
  - Digitisation of detailed simulation incl. pulse shaping of electronics
- Pileup to have realistic data for one bunch train
- Ion Backdrift
  - Per event
  - “Ion disk” buildup per bunch train
- Occupancy

Under development

Simulation and Digitisation



Reconstruction

Reconstruction is complete now, implements all features of basic reconstruction chain

- Suitable for prototypes and collider detectors
- Positive and negative signal polarity
- Supports all pad geometries provided by GEAR

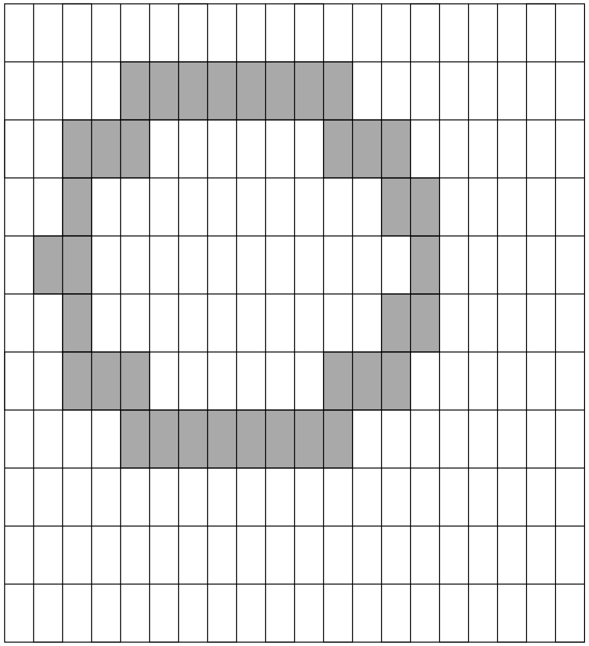
⇒ Ready for the large prototype!

Correction processors (gain, linearity, time shift, field homogeneity) still missing, to be developed with real data

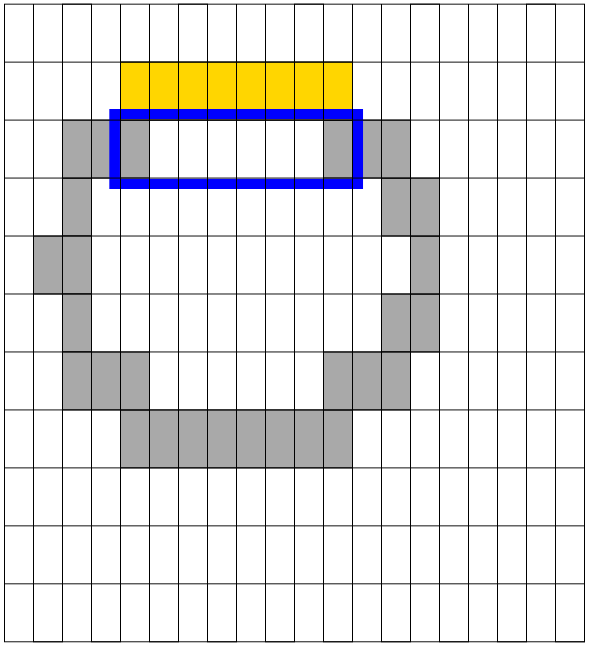
Reconstruction Data Flow

Data Structure	Processor Name	Collection Name
`TrackerRawData`		TPCRawData
	TrackerRawDataToDataConverter	
`TrackerData`		TPCConvertedRawData
	PedestalSubtractor	
`TrackerData`		TPCData
	PulseFinder	
	ChannelMapper	
	CountsToPrimaryElectronsProcessor	
`TrackerPulse`		TPCPulses
	HitTrackFinderTopoProcessor	
`TrackerHit`		TPCHits
`Track`		TPCTrackCandidates
	TrackSeeder	
`Track`		TPCSeedTracks
	TrackFitterLikelihood	
`Track`		TPCTracks

Topological Hit and Track Finder



Topological Hit and Track Finder



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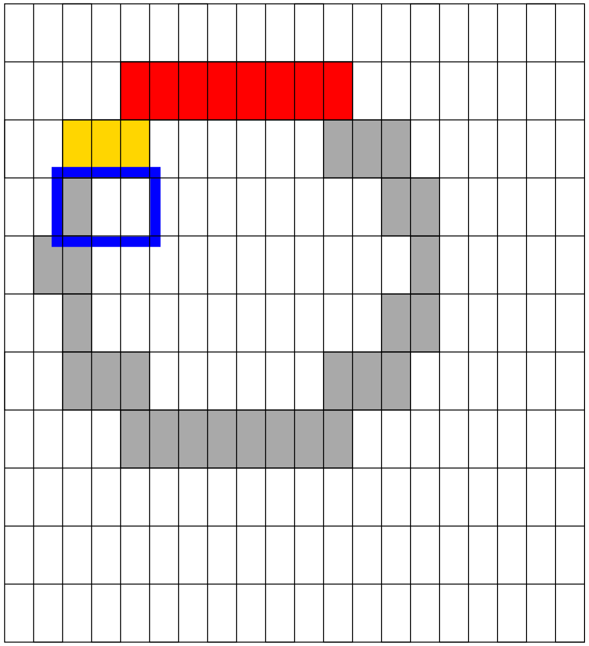

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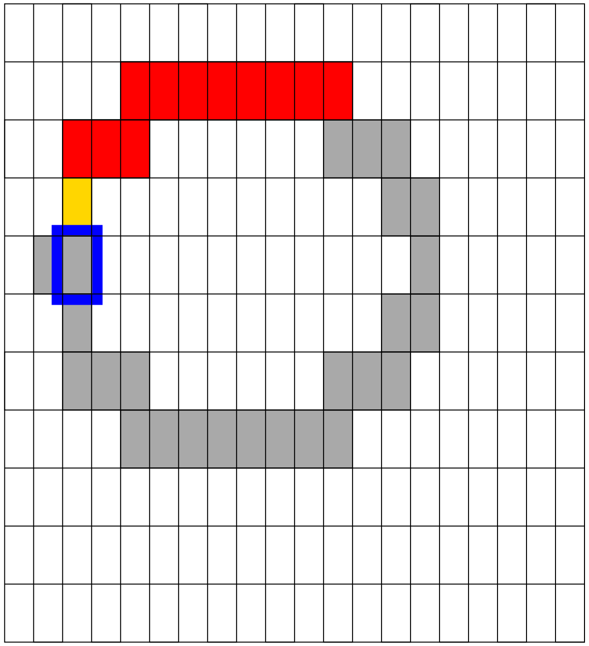

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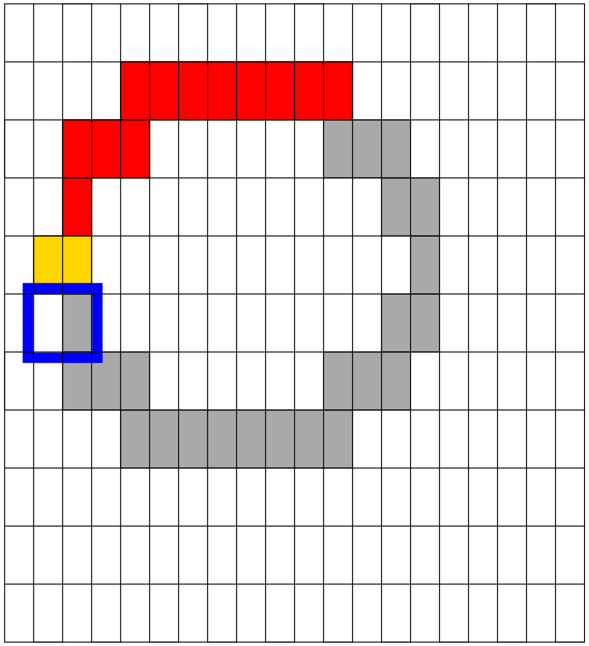

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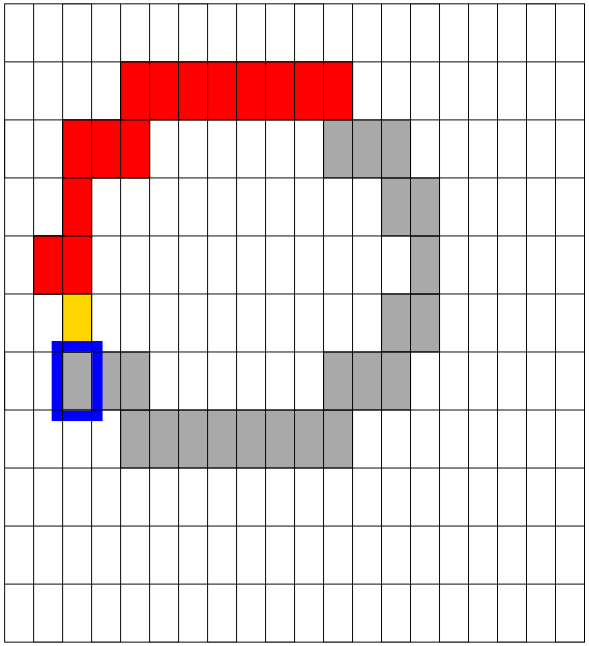

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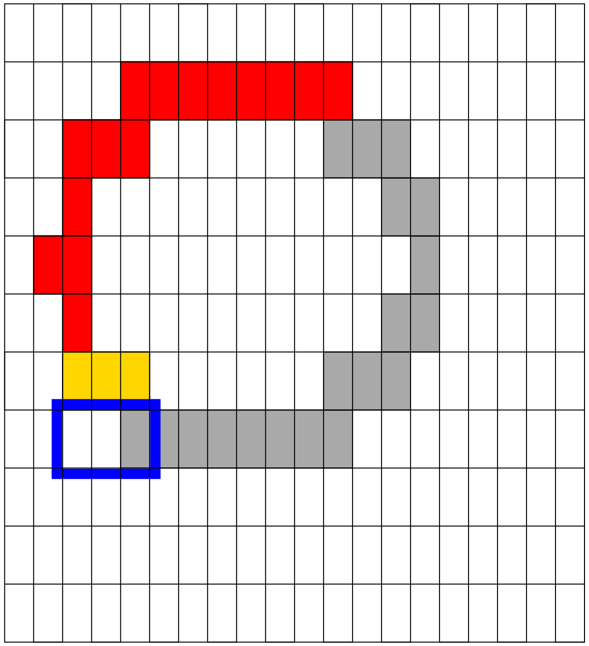

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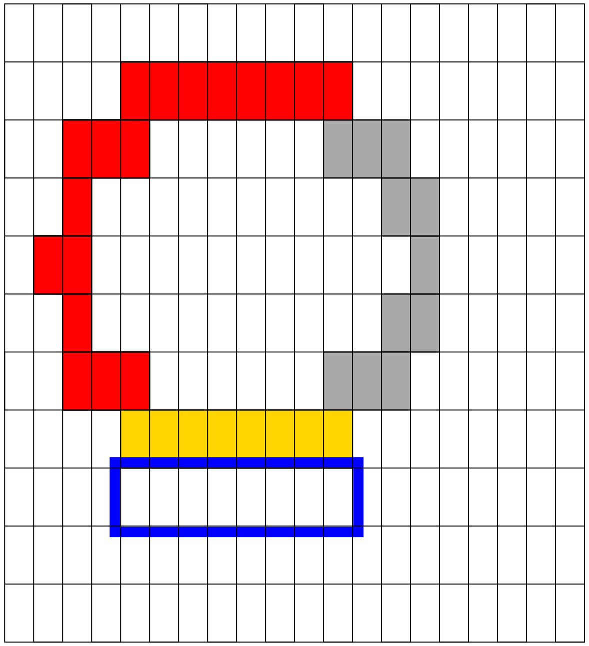

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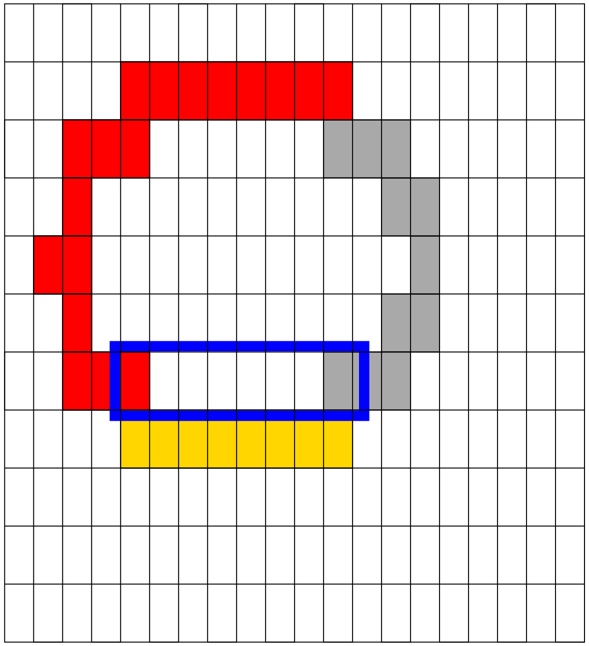

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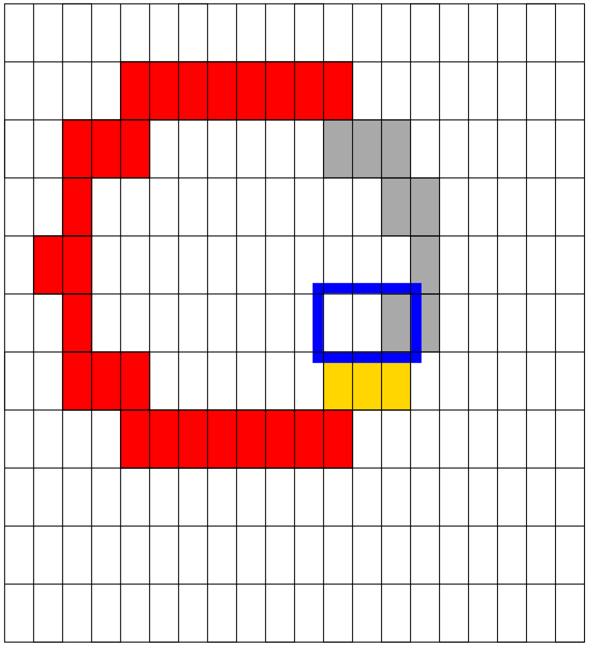

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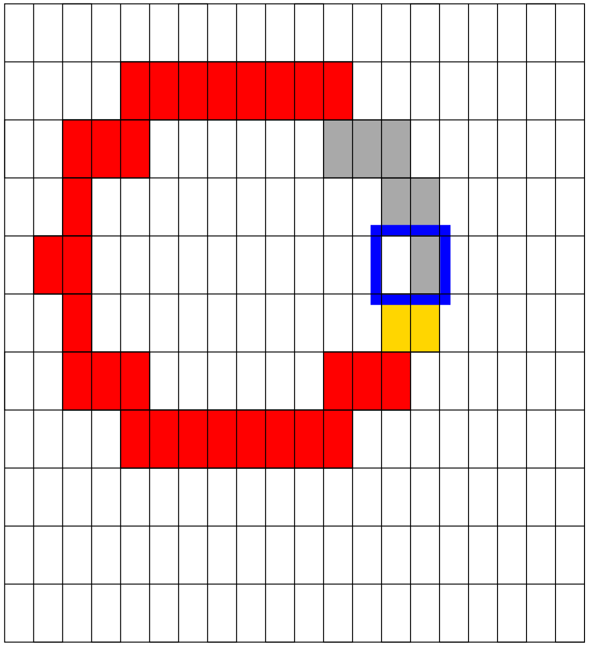

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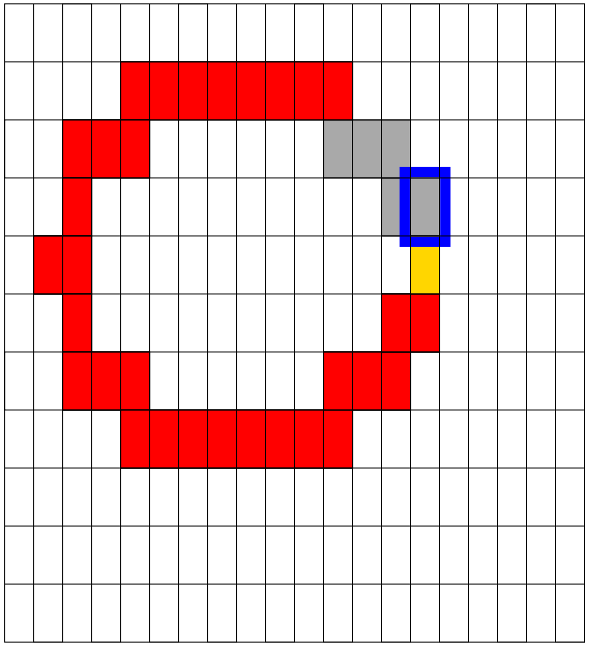

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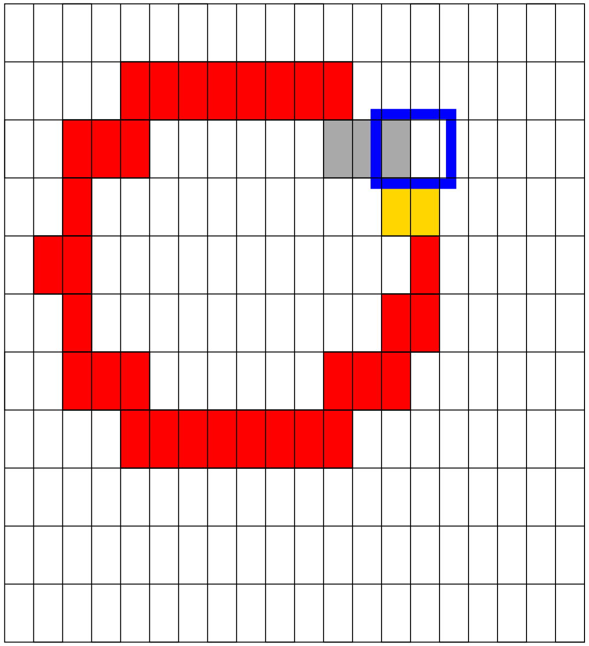

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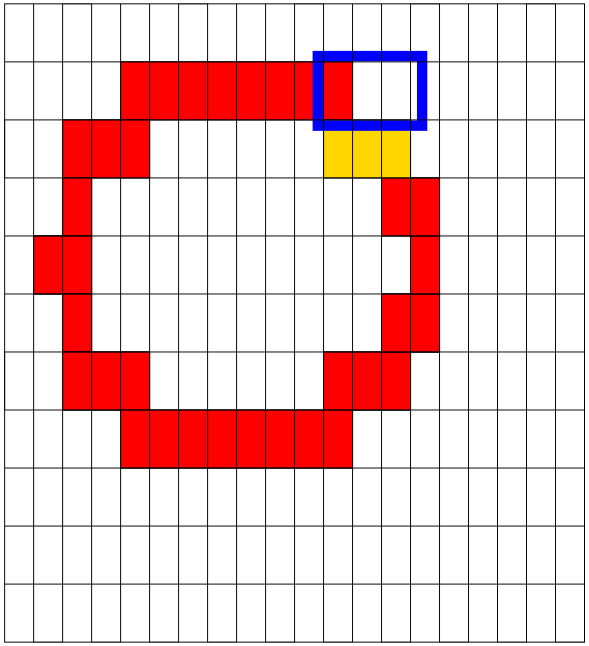

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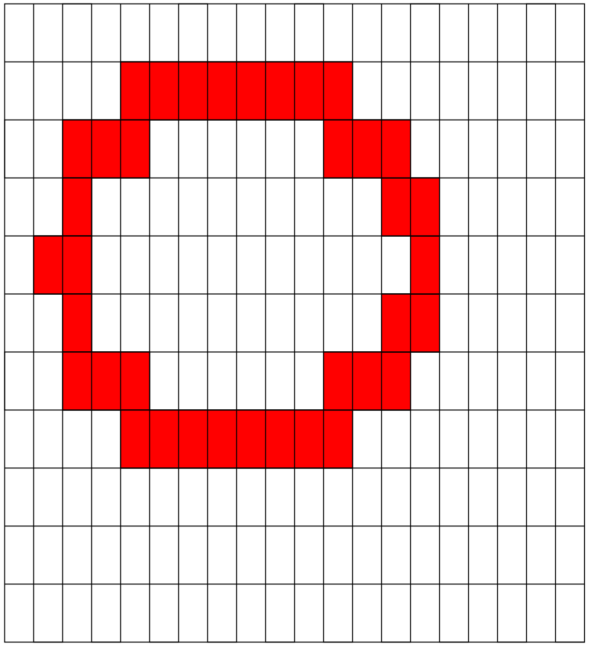
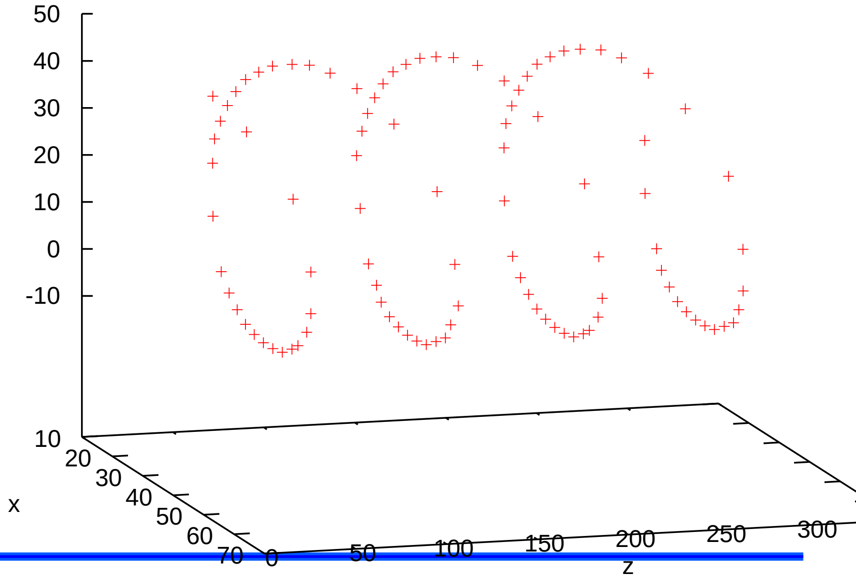




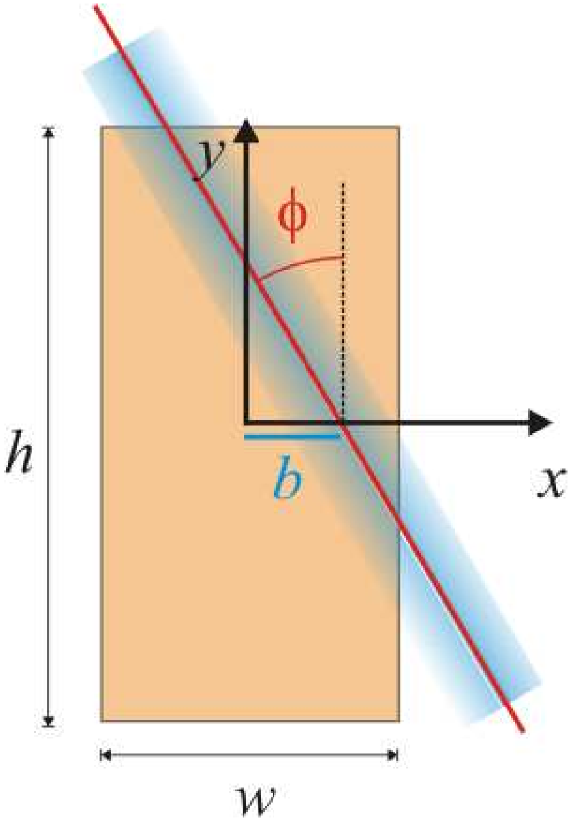
- Independent of trajectory, no track hypothesis
- Works in 3D

TrackFitterLikelihoodProcessor

- 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

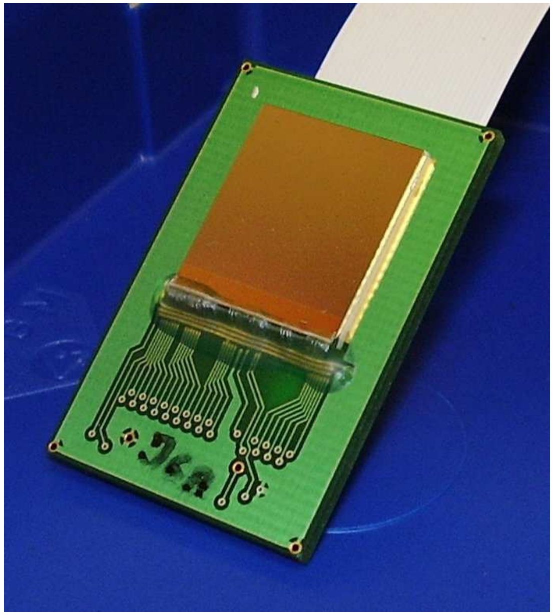


- Sum up log(likelihood) on all pad rows to get global likelihood
- Maximise the log(likelihood) by varying the track parameters

TimePix

Replace pads with readout chip to improve granularity

- 256×256 pixels per chip
- Pixel size: 55×55 µm^2 pixels
- Each pixel can be operated in two modes
  - TOT (time over threshold)
    proportional to charge
  - TIME
    drift time



Operating the pixels alternating in either mode in a checkerboard pattern allows to measure all the required information for a TPC

TimePix Data in LCIO

- **Raw Data:** `TrackerRawData`

  One entry per chip

  - `CellID0` = 0
  - `CellID1` = Chip number
  - `ADCValues` = All raw data from the chip

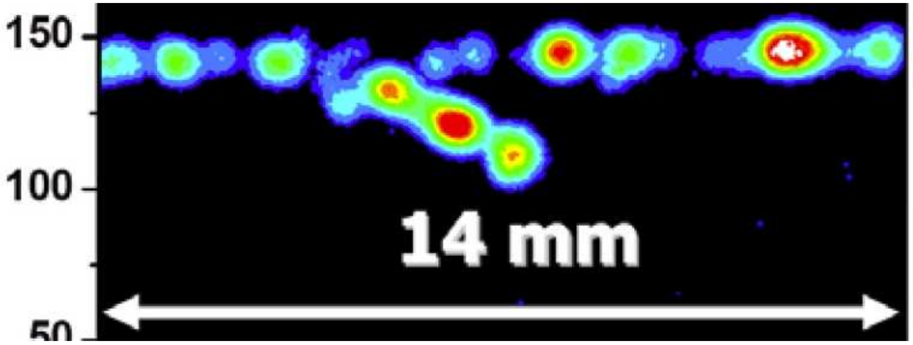
- **Zero Suppressed Raw Data:** `TrackerRawData`

  One entry per contiguous area in one row

  - `CellID0` = First pixel in area
  - `CellID1` = Chip number
  - `ADCValues` = Raw data of contiguous area

TimePix Reconstruction

Data Structure	Processor Name	Collection Name
TrackerRawData		TimePixRawData
	TimePixZeroSuppressionProcessor	
TrackerRawData		TimePixZeroSuppressedRawData
	TimePixClusterFinderProcessor	
TrackerHit		TimePixHitCandidates
	TimePixClusterProjectionSeparatorProcessor	
TrackerHit		TimePixSepHitCandidates
	TimePixHitCenterCalculatorProcessor	
TrackerHit		TimePixHits



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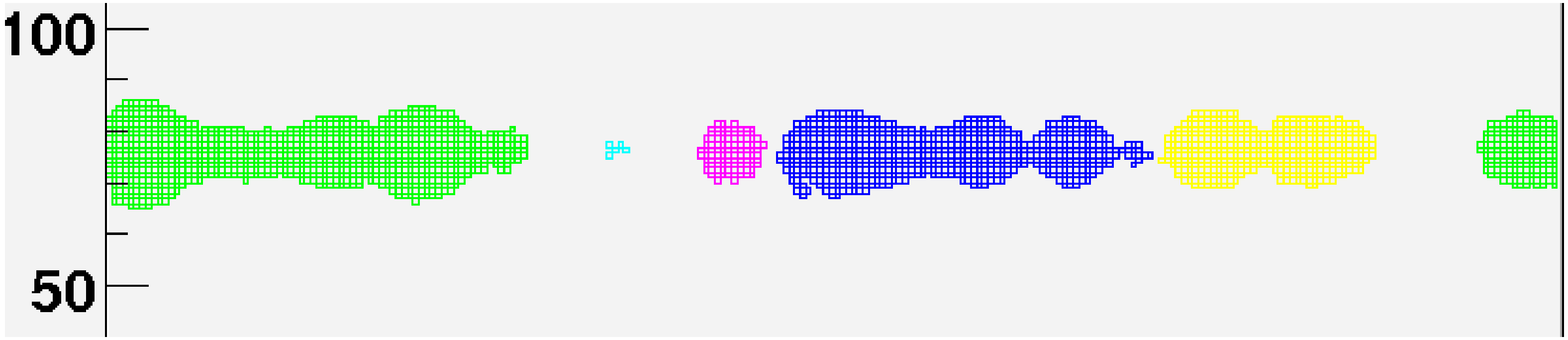

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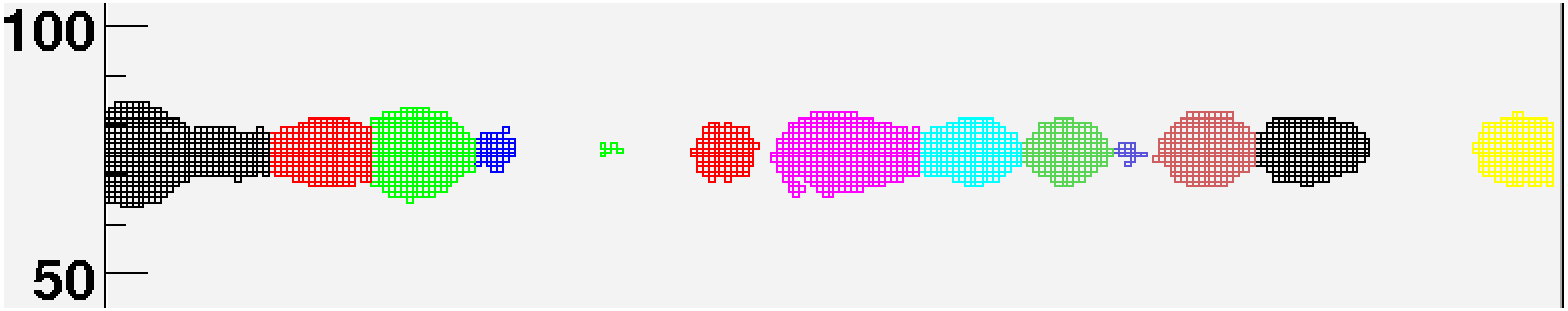

Analysis

Planned:
Provide a set of processors implementing the default analyses agreed on at first TPC Analysis Jamboree 2006 in Hamburg.

- Resolution using geometric mean of fits with and without the test row
- Resolution using external reference track (hodoscope or MC truth)
- Resolution in dependence on the drift distance
- Distribution showing number of 1-pad, 2-pad, 3-pad hits
- Bias plots (residuals vs. position on the pad)
- ...

Make System

MarlinTPC can now be built either

- as stand alone (Marlin) executable
- together with Marlin, located in the package directory
- with cmake

⇒ MarlinTPC is ready to be integrated into ilcinstall

Plans

- Test the reconstruction with real data and cross-check results with old reconstruction/analysis programmes
  - Converter for old TPCHits to use DESY data
  - Converter for Aachen test beam data (with hodoscope)
- Test MarlinTPC performance in Particle Flow Algorithms
- Simulation: Amplification with Micromegas
- Digitisation for TimePix
- Include TDCs in reconstruction chain

Conclusions

- Detailed simulation provides realistic data
- Digitisation incl. pileup is under development
- Reconstruction chain is complete now, provides basic functionality
- No analysis yet

Goals:

- Provide TPC simulation, digitisation, reconstruction and analysis for prototypes and ILC detectors
- Combine with / become part of the detector reconstruction packages

http://ilcsoft.desy.de/portal/software_packages/marlintpc/