Software for TPC R&D
A Status Report from the EUDET JRA2 Activities

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Overview

- EUDAQ
  - LCIO plugin mechanism
  - Integration of the TPC
- Geometry Description: GEAR
  - New pad layouts
  - Multiple TPC readout modules
- MarlinTPC
  - Reconstruction
  - Simulation
  - New features

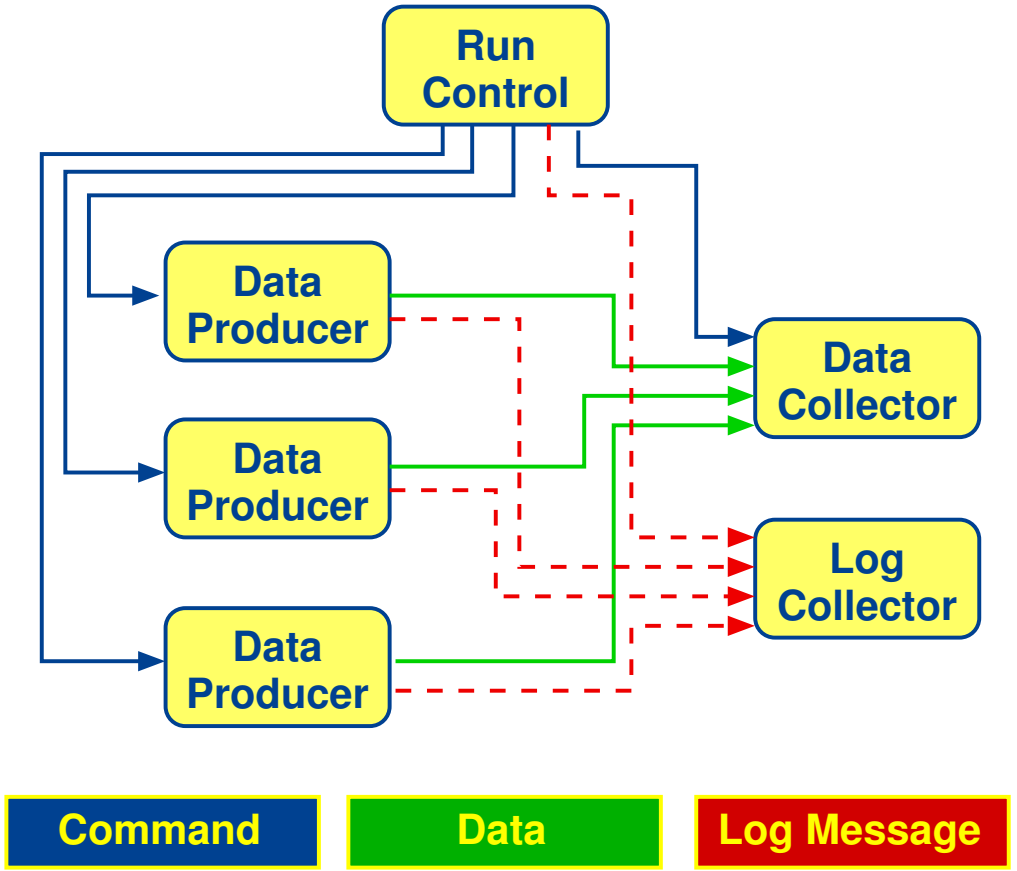
EUDAQ: The EUDET Data Acquisition System

DataProducer: Data class which can easily be integrated in DAQ systems

- Receives commands from Run Control
- Sends data to Data Collector
- Sends messages to Log Collector

DataCollector:

- Receives raw data
- Performs event building
- Data collector writes common file
- New: LCIO Plugin mechanism



LCIO Plugin

- The producer sends raw data, not LCIO
  - Producers can run directly on the DAQ hardware (FPGA)
  - `eudaq::RawDataEvent` is a container for a raw data block, implements TPC/IP streaming
  - Data collector can also dump raw data stream for debugging

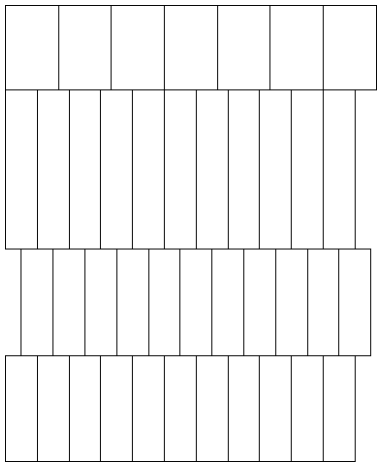
- The data collector has to know how to convert to LCIO⇒ Plugin
  - Base class defines interface
  - User provides the plugin together with the producer
  - Can be loaded at run time

Status for the TPC:

DAQ	Producer	Converter Plugin
ALTRO for LP	×	✓ [1]
ALTRO USB (Bonn)	✓	✓
AFTER	×	×
TDCs	×	×
Timepix	✓	✓

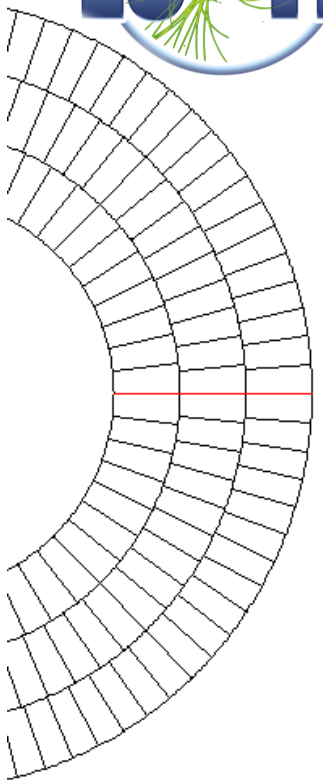
(1) Does not work for new data format 4.2 after firmware update

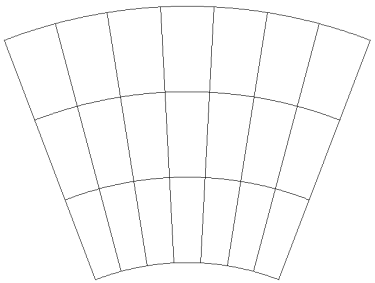
Pad Layouts in GEAR



- **RectangularPadRowLayout**
  - Cartesian Geometry
  - All pads in one row are equal
  - Pad size and number of pads may vary from row to row

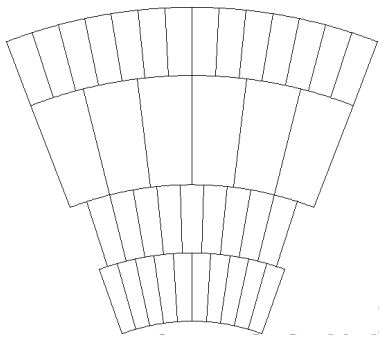
- **FixedPadSizeDiskLayout**
  - Polar Geometry
  - Complete circle
  - *All* pads have the same size





- **New: FixedPadAngleDiskLayout**
  - Polar Geometry
  - Segment of a circle
  - All pads have the same angle

- **New: VersatileDiskRowLayout**
  - Polar Geometry
  - Segment of a circle
  - All pads in one row are equal
  - Pad size and number of pads may vary from row to row



Multiple Modules in GEAR

A realistic TPC end plate (EUDET LP) consists of multiple modules
$\Rightarrow$ introduce TPCModule in GEAR

TPCModule

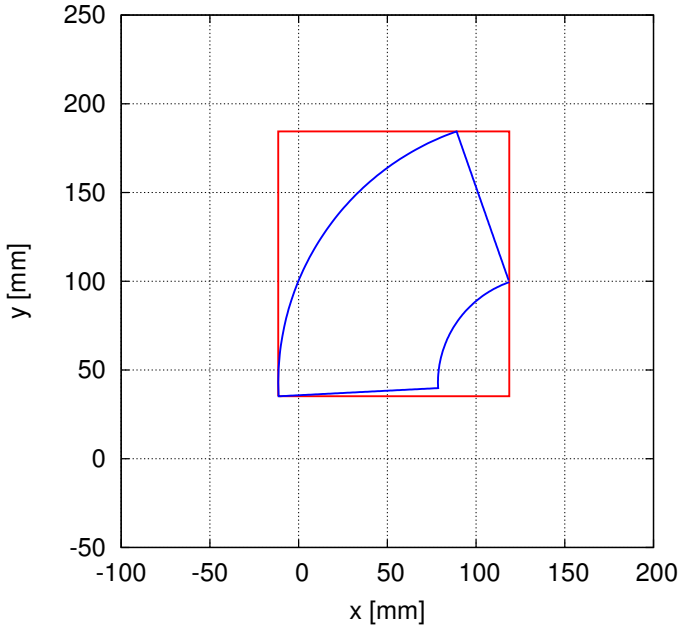
- derived from PadRowLayout2D
- contains a pad layout implementation

$\Rightarrow$ full backward compatibility and transparency in user code

Coordinates:

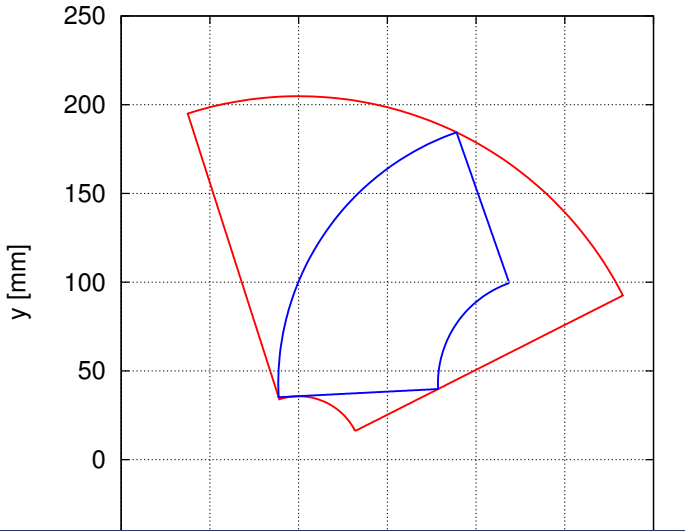
- Pad plane implementation provides local coordinates
- Module has offset and angle to global coordinate system
- Accessing the pad plane through the module automatically provides correct global coordinates

Example: Plane extent

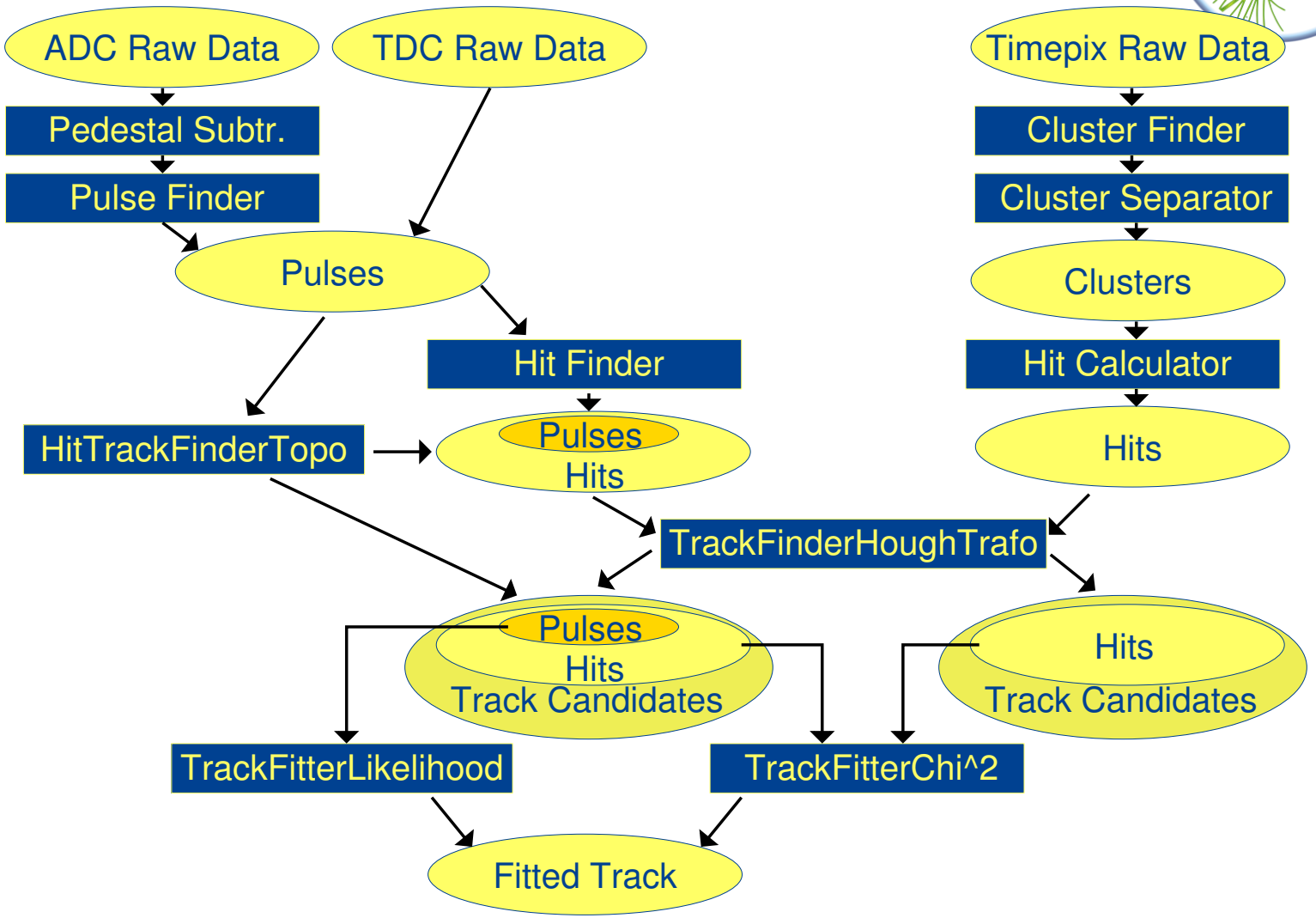


↑ global Cartesian coordinates

↓ global polar coordinates



MarlinTPC Reconstruction Overview



MarlinTPC Reconstruction Status

Status last year:

- Chain is ready, but only tested with toy MC

Requirements for LP:

- Multiple modules
  - Include gear multiple modules in processors (✓)
  - Add ModuleID to conditions data classes (e. g. pedestals) (✓)
  - Alignment (✓)
- Data taking with magnetic field
  - Helical track fit (✓)[1]
- Calibration (×)
  - Toy MC does not need calibration
  - Has to be developed with read data

[1] only simple fit without correct treatment of covariance matrix

Alignment

Alignment is possible:

- Calculate offsets manually
- Hard-code offsets in GEAR xml files

Goal: Apply alignment at run time using LCCD

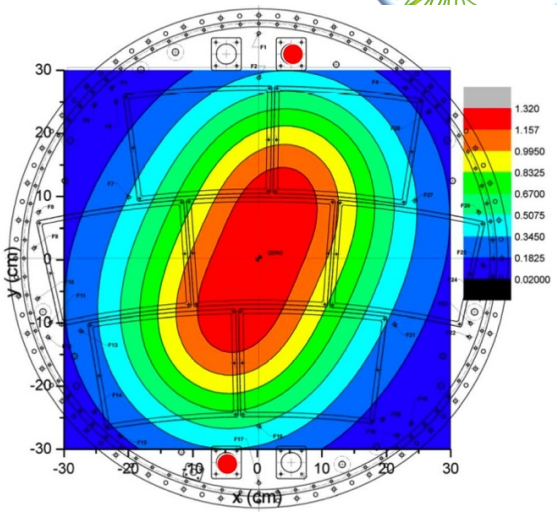
- Extend functionality of TPCModule?
- Write a wrapper class?
  - Inherit from TPCModule?
  - Have an instance of TPCModule?

Can we implement it transparent and backward compatible, without breaking existing user code?

Photodot Reconstruction

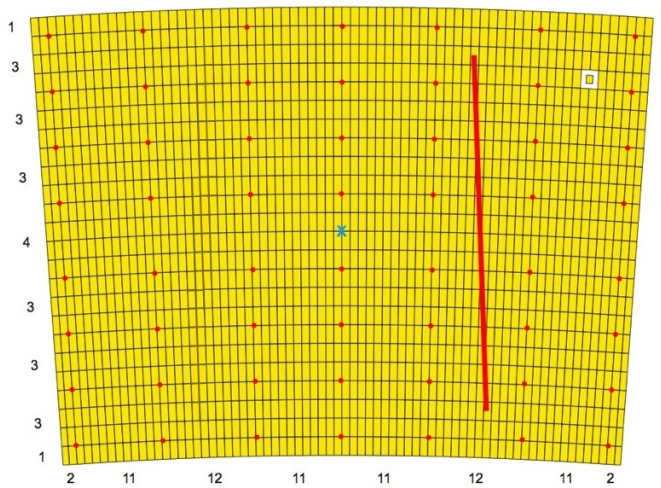
Signal generation:

- Pattern of aluminium dots on the cathode
- UV-Laser can be coupled in at the anode side
- Electrons are released on the cathode only on the aluminium



PhotodotReconstructionProcessor

- knows the geometry pattern
- reconstructs dots and compares them to real position
- Valuable tool to investigate field distortions (E- and B-field)
- Calibrate drift velocity



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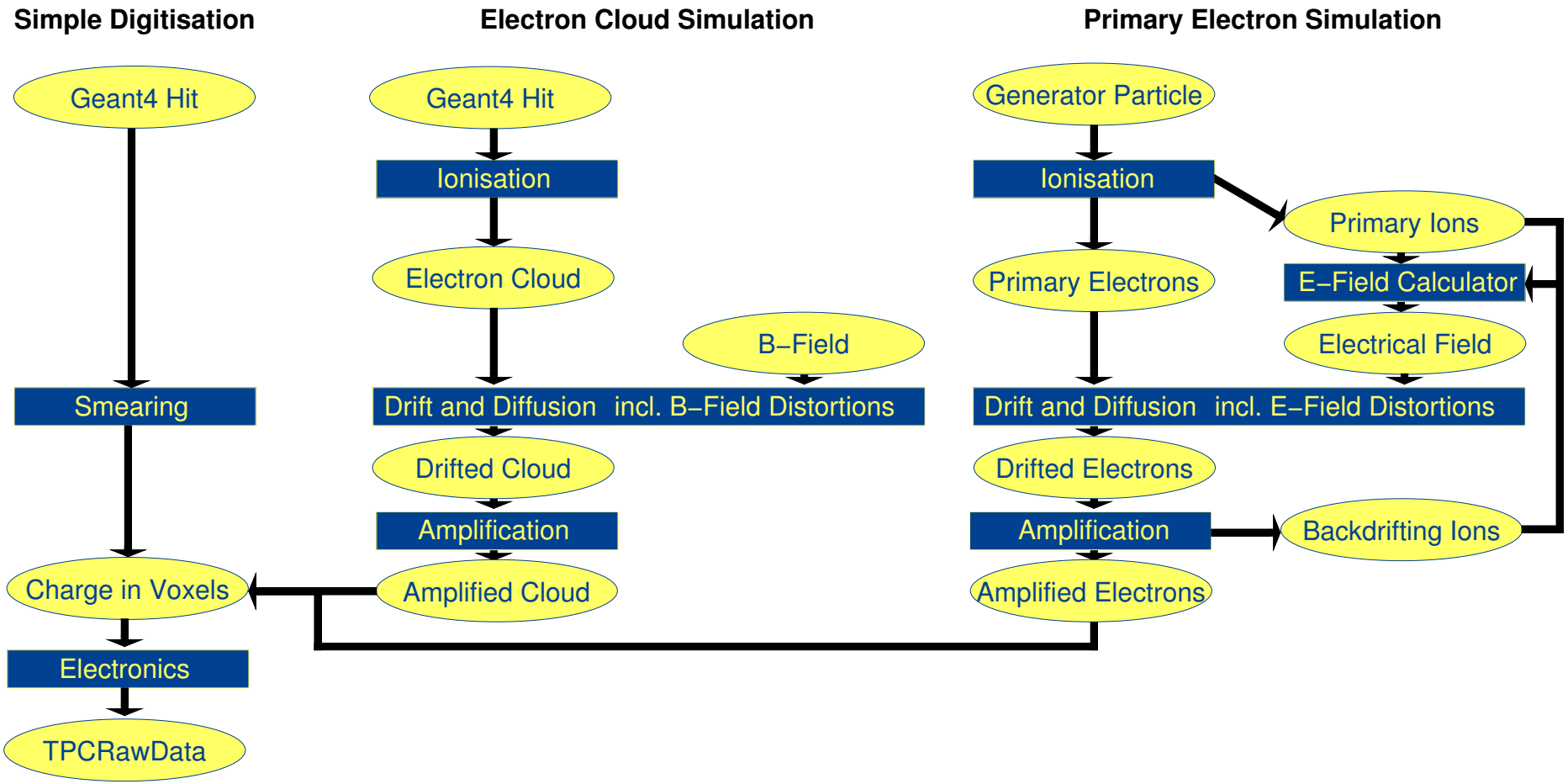
Simulation / Digitisation



E-Field Calculations

E-Field from backdrifting ions:
Current method: Calculation of E-field is approximated by neglecting the boundary conditions at the end caps (TPC as an infinitely long cylinder).

Comparison with exact solution (see Stefan Rosseger, CERN-OPEN-2009-003) shows significant deviations. Approximation is probably not good enough.

Results and implementation are being revisited.

MarlinTPC Calibration

Conditions data classes in MarlinTPC (TPCCondData):

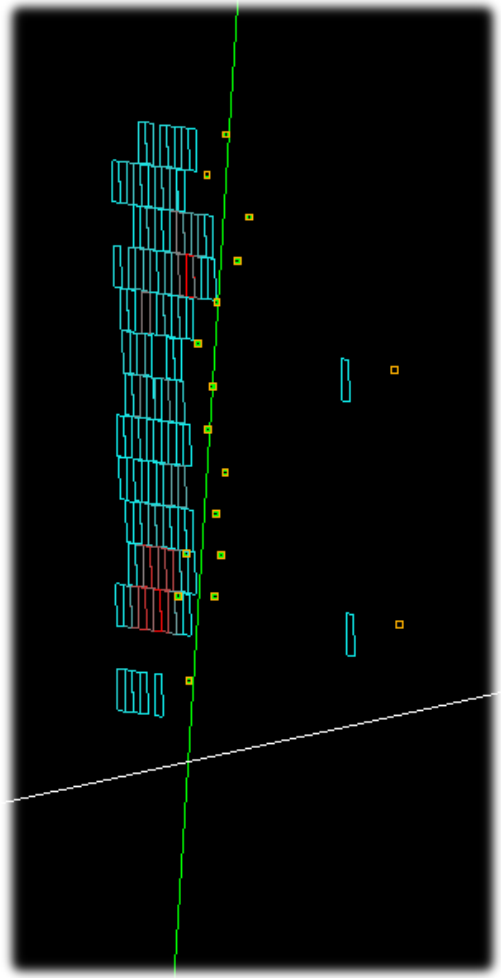
ADCChannelMapping	Mapping HW Channel ↔ GEAR PadIndex / ModuleID
ChannelCorrection	Channel quality flags and calibration factors
FieldSetting	Fields and voltages in drift volume and readout structure
GasConditions	Gas mixture, pressure, temperature
Pedestal	Pedestals on individual channels
TimePixPixelMode	Running conditions of Timepix (Time or Charge mode)
TPCConditions	Calibrated drift velocity, diffusion coefficients . . .
WeatherConditions	Environmental temperature, pressure . . .

- Revisit existing classes
- Implement missing classes like Electronics description
- Setup of database has started. Discussions with colleagues from Calice, who have already done this exercise

Event Display

For development of geometry descriptions and fist checks during data taking a graphical viewer is needed.

HepRepOutputProcessor produces HepRep XML file which can be displayed e. g. with Wired/JAS3



Event display shows

- TPC
- GEAR pad plane
- Charge on pads
- 3D hits
- Tracks

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Conclusions

- EUDAQ
  - LCIO plugin mechanism
  - Producers and plugins for Altro and Timepix
- GEAR
  - New pad layout classes for existing prototypes
  - Multiple modules incl. coordinate transformations
- MarlinTPC
  - All reconstruction processors are multi module capable
  - Performance has to be improved
  - Develop calibration tools with real data
  - Photodot reconstruction
  - Simulation: E-Field from IB being revisited
  - EventDisplay: HepRepOutputProcessor + Wired/JAS3
- Conditions data
  - Define missing data classes for calibration
  - Set up a data base