Software for LC-TPC Test Beams

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LC-TPC Collaboration Meeting
DESY, Hamburg, 21.09.2009

Software for LC-TPC Test Beams

The Goal

Common software for LC-TPC prototype data taking, reconstruction and analysis.

The Way

Use ILCSoft:

1. DAQ: **EUDAQ**
2. Store data: **LCIO**
3. Framework: **Marlin**
4. Geometry description: **GEAR**
5. Conditions data: **LCCD**
6. Reconstruction and analysis for TPCs: **MarlinTPC**

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Common Data Acquisiton

Operate several modules with different DAQ systems in the TPC
(+ silicon strip sensors outside)

- Run Control
  - Each subsystem has to know when to start and stop
- Event Building
  - Subevents from different compenents have to be combined
- Synchronisation
  - Software synchronisation: Event numbers must match
  - Hardware: Mutual wait of the subdetectors
    Slowest detector limits the overall event rate

  $\Rightarrow$ **T**rigger **L**ogic **U**nit

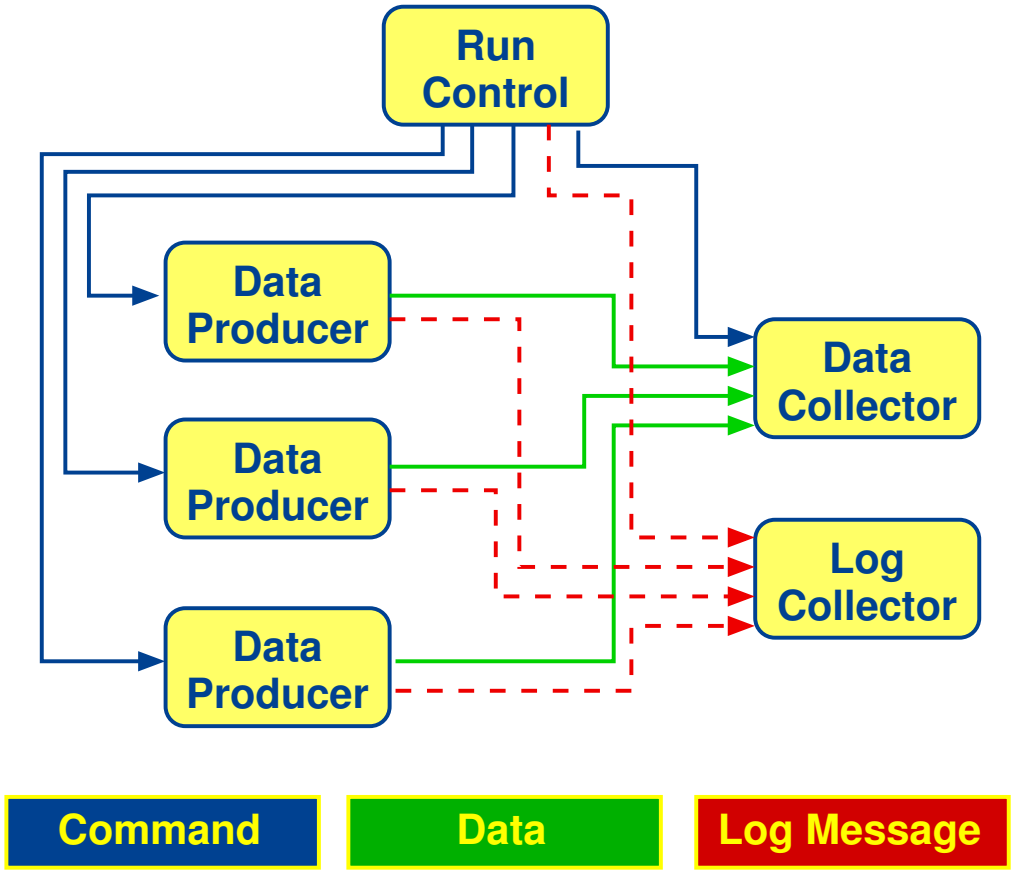
EUDAQ: The EUDET Data Acquisition System

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
- New: Plugin mechanism
  LCIO converter plugin for every raw data format
- Data collector writes common LCIO file



EUDAQ: Status

- Each subsystem has to provide a Data Producer and an LCIO Converter Plugin
- Each subsystem has to synchronise with the TLU

DAQ	Producer	Converter Plugin	HW Sync.
ALTRO	×	✓ [1]	✓
AFTER	×	×	×
TDCs	×	×	×
Timepix	✓	✓	✓

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

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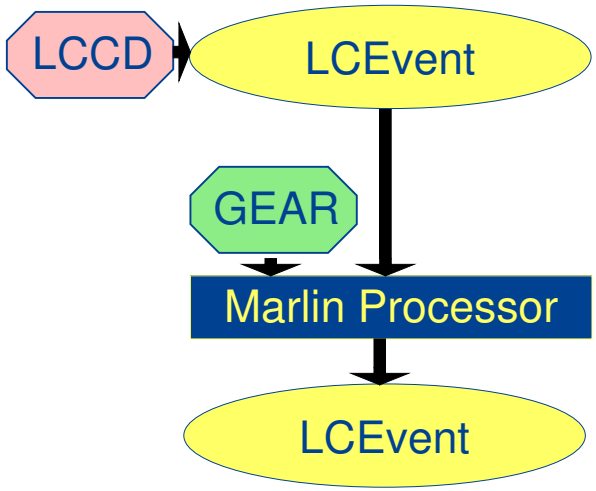
Marlin

Modular **A**nalysis and **R**econstruction for the **LIN**ear collider

Marlin is a C++ reconstruction framework for LCIO data.

- Controls the data flow
- Each computing task is performed by a "processor"
- Interface between the processors: LCEvent
- Programme flow is controlled with XML steering files
- Provides an interface to GEAR and LCCD



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Linear **C**ollider **I**nput/**O**utput

- Event Data Model
- Provides Data Classes
- Implementations for JAVA and C++

Data Class	**Description**
LCEvent	Contains collections of one event (bunch crossing)
LCCollection	Collection of data classes of a certain type e. g. TrackerRawData
MCParticle	Particle from the MC generator
SimTrackerHit	Charge deposition in the detector
TrackerRawData	ADC values from the TPC
TrackerData	Calibrated raw data
TrackerPulse	Charge and time of a pulse in one electronics channel
TrackerHit	3D hit with charge information
Track	Helix parametrisation of the fitted track
LCGenericObject	User defined data class

Object browser to look at the data is missing!

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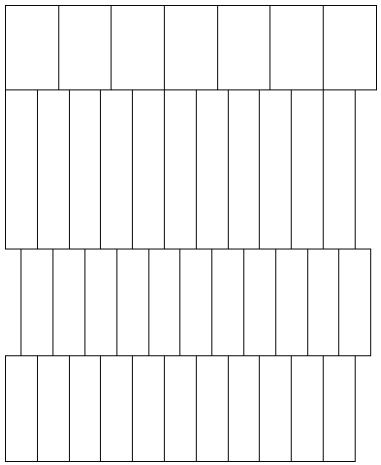
Data From Different Groups

DAQ System	DAQ writes	LCIO converter	Module	On the GRID
AFTER	raw data	✓	Micromegas	NO
ALTRO	raw data	✓ [1]	Japanese GEM	YES
			Std. GEM	NO
TDC	raw data	✓	Micromegas	
Timepix	LCIO		2 Quad + GEMs	NO

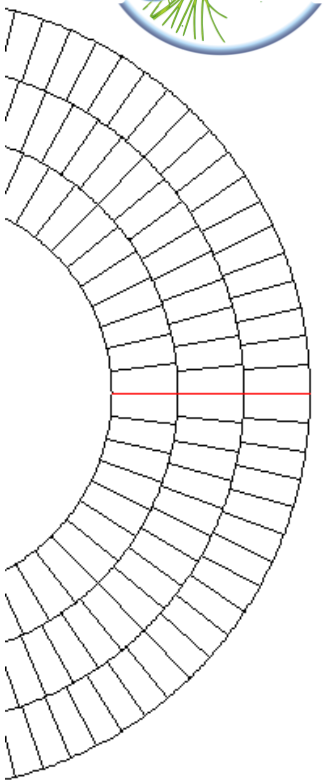
(1) Does not work for new data format 4.2 after firmware update

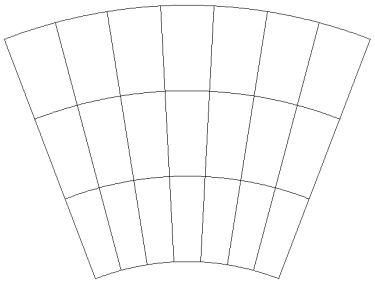
Pad Layouts in GEAR



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

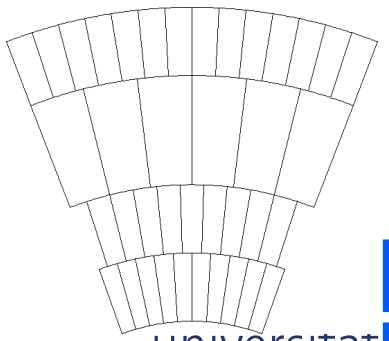
- **FixedPadSizeDiskLayout**
  - Polar Geometry
  - Complete circle
  - *All* pads have the same size





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

- **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



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Multiple Modules in GEAR

- A pad plane provides local coordinates
- Pad planes are embedded in modules
- Modules can be
  - rotated
  - translated
  - have different pad planes
  - have different coordinate types (Cartesian/polar)
- GEAR provides conversions
  - local $\longrightarrow$ global
  - global $\longrightarrow$ local

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Status of GEAR Descriptions

Exact geometry (size and position of pads) is provided by an XML file

Module	**XML File**	**Publicly available**
Micromegas	✓	NO
Japanese GEM	×	NO
Std. GEM	✓	NO
Timepix + GEMs	✓	NO

LCCD

The **L**inear **C**ollider **C**onditions **D**ata toolkit

- User-defined data classes can be stored in LCIO files or a data base
- A Marlin processor provides this information during runtime

Data needed	TPCCondData	Available for test beam run				
		Japanese GEM		Micro-megas	Std. GEM	Timepix + GEM
		ALTRO	TDC			
Channel mapping	✓	✓	✓	✓	✓	
Channel quality	✓	×	×	×	×	×
Pedestals	✓	×	×	×	×	×
v_{drift} + Diffusion	✓	×	×	×	×	×
Gas conditions	✓	✓	✓	✓	✓	✓
E-field settings	✓	×	×	×	×	×
B-field settings	×					
HV settings	×					
Field maps	✓			×		
Electronics	×					
Calibration	×					

LCCD

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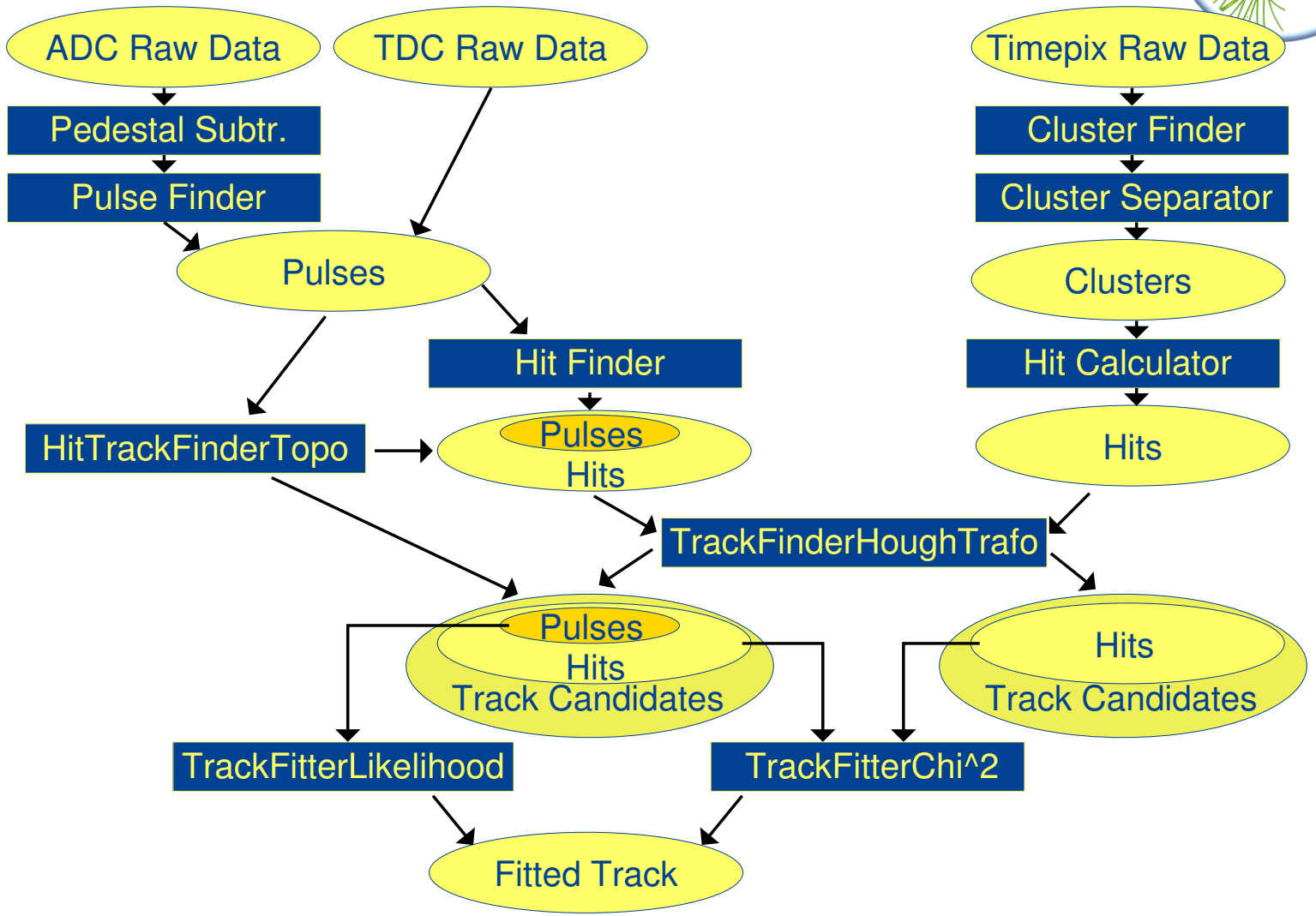
Gas conditions	✓	✓	✓	✓	✓	✓
E-field settings	✓	×	×	×	×	×
B-field settings	×					
HV settings	×					
Field maps	✓					
Electronics	×					
Calibration	×					

Test data base for LCCD gas data running on a DESY desktop computer

MarlinTPC Reconstruction Overview



MarlinTPC Reconstruction Status

Processor	Tested with	Geometry	Multi Module	Limitations
PedestalSubtractor	real data	indep.	✓	
PulseFinder	real data	indep.	✓	
ChannelMapper	real data	indep.	✓	
TopoFinder	Toy MC	all	✓	one track per module
TrackFinderHough	real data	indep.	indep.	only straight tracks
TrackSeeder	Toy MC	indep.	indep.	unstable on real data
LikelihoodFitter	MC	all	×	requires good gain calibration
Chi^2-Fitter	not operational yet			
LinearRegression	real data	indep.	indep.	only straight tracks no errors
ClusterFinder	real data	Timepix	✓	only per chip
ClusterSeparator	real data	Timepix	✓	bad performance
HitCalculator	real data	Timepix	indep.	

Most available processors simply fill histograms
(x-, y-, z-distributions, track parameters, carge per hit etc.)

Software infrastructure
Templates, processors and helper classes which simplify the analysis.

Example:

- CutApplicationProcessor
  - Most common cuts can be used right away
  - No need to implement cuts manually in your code
  - No need to recompile

MarlinTPC Calibration

Processor	Tested with	Geometry	Multi Module	Limitations
PedestalCalculator	real data	indep.	✓	
Likelihood Fitter	Uses B-field map			
Gas Gain Calibration	missing			
Electronics Calibration	missing			
Drift Velocity Calibration	missing			
Dead / Noisy Channels	missing			

Toy MonteCarlos don't need calibration.
Calibration has to be developed with real data!

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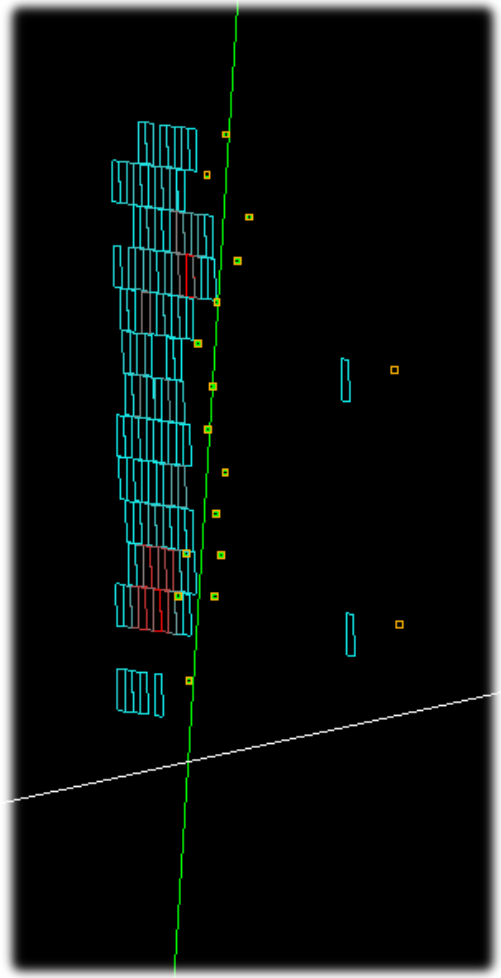
Event Display

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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Log Book

There is an online log book at
https://ttfinfo.desy.de/LP1elog/index.jsp

- It turned out to be cumbersome to use
- Sometimes fails at all
- Mostly unused

We need a Run Data Base with the possibility to

- store data files with the entries
- sytematically browse the runs
- automatically store information from the run control

Documentation

- Doxygen documentation exists for all clases
  - Ok for experienced users if the source code provides the infos for Doxygen
  - Some classes are not documented
  - Does not provide an overview (MarlinTPC: more than 50 processors)
  - Does not give an idea about the concept
- There is no manual
- The ILCSoft Wiki pages are empty
- Examples are not running
- You have to know which packages to install

It is realy hard to get started!

Conclusions

- DAQ
  - LCIO converters exist
  - Producers for EUDAQ are still missing
- MarlinTPC: Basic reconstrustion chain is working
  - Most of the processors tested with MC data
  - Performance has to be improved
- GEAR
  - Framework can describe all exsting pad layouts
  - Multiple modules incl. coordinate transformations
  - Users have to provide geometry descriptions
- Conditions data has to be made available
  - Define missing data classes for calibration
  - Set up a data base
- Calibration tools have to be made using real data
- Documentation is laregely missing
  - Write introduction / overview and tutorials
  - Provide running examples for all processors