Development of a Pixel Based TPC

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Overview

- R&D activities in Bonn
- MarlinTPC

TPC laboratory in Bonn

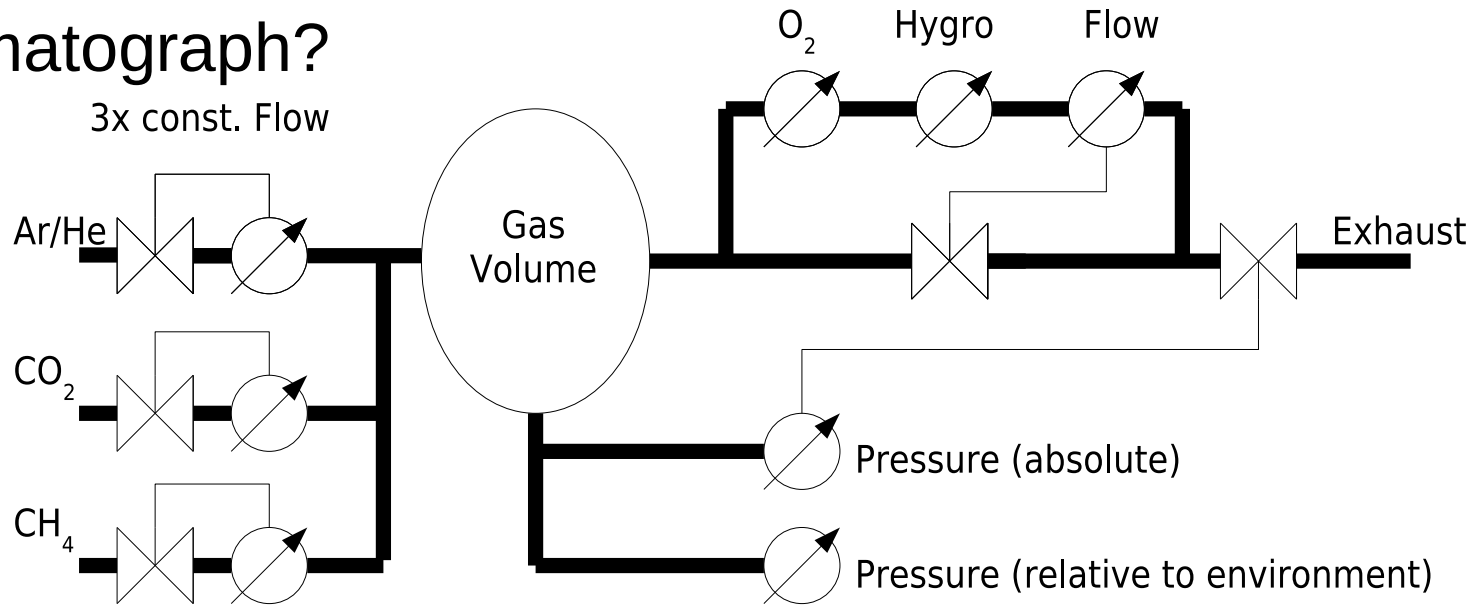
Currently being set up

- Gas system
- High voltage supply
- Laminar flow box
- Scintillator trigger system
- Small TPC field cage
- Readout electronics
- Hodoscope?

Gas System

Reuse flow meters and pressure controllers from ZEUS gas system

- Controlled by embedded PC
- Mixing of up to 3 gases
- Allows constant pressure operation
- Oxygen and water monitor
- Gas chromatograph?



Small TPC Field Cage

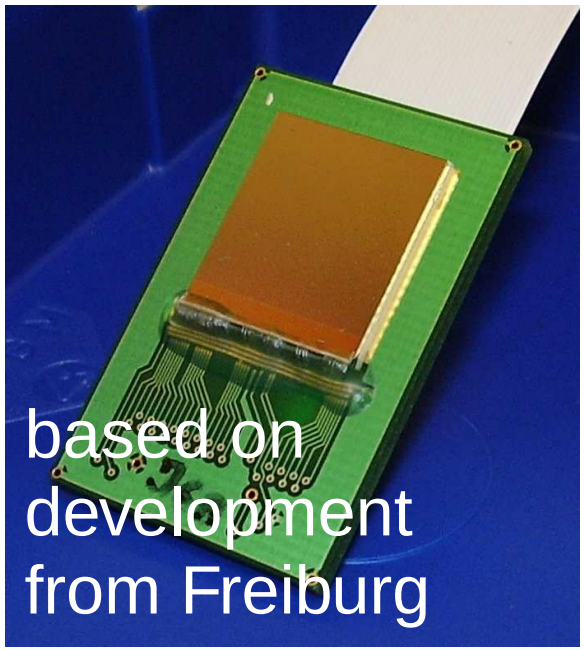
Clone of the Aachen field cage

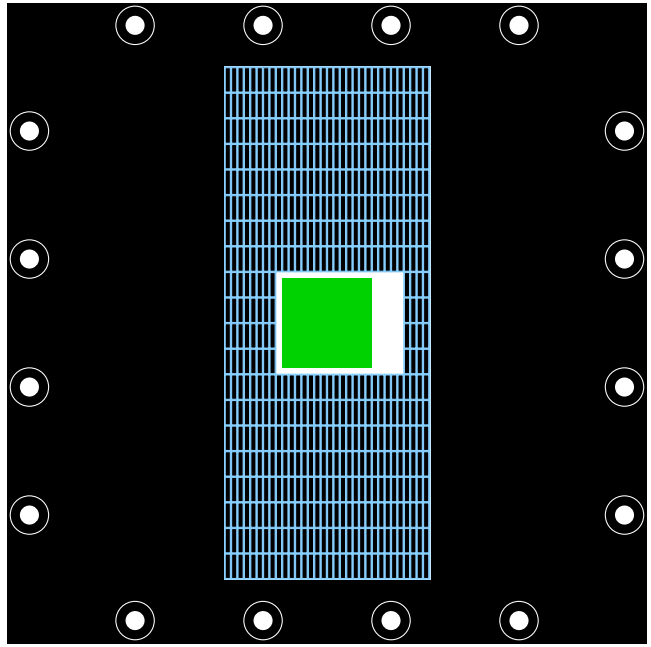
- 26 cm diameter
- 26 cm drift distance
- 3 GEM gas amplification system
- Fits into 5 T magnet at DESY

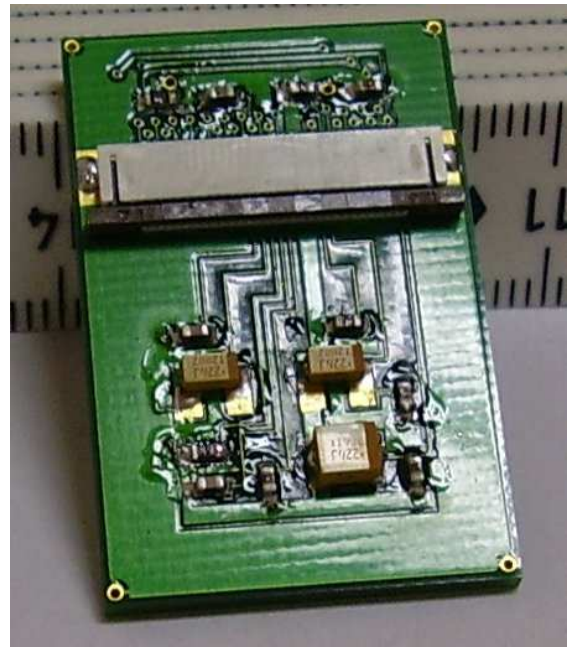
Combined TimePix and Pad Readout

TimePix Chip

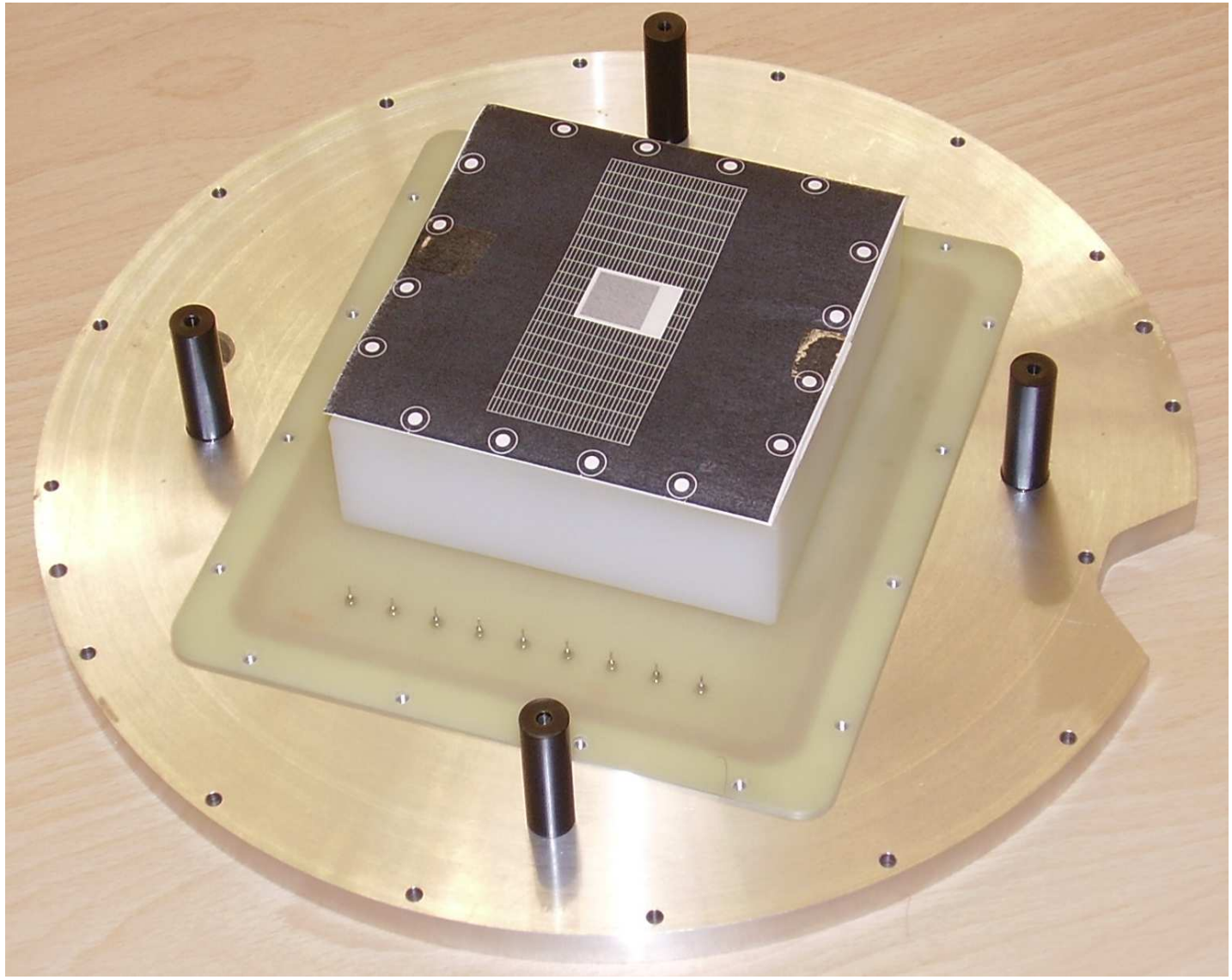
- 256×256 pixels per chip
- Pixel size: 55×55 µm²
- Each pixel can be operated in two modes
  - TOT (time over threshold): proportional to charge
  - TIME ≙ drift time



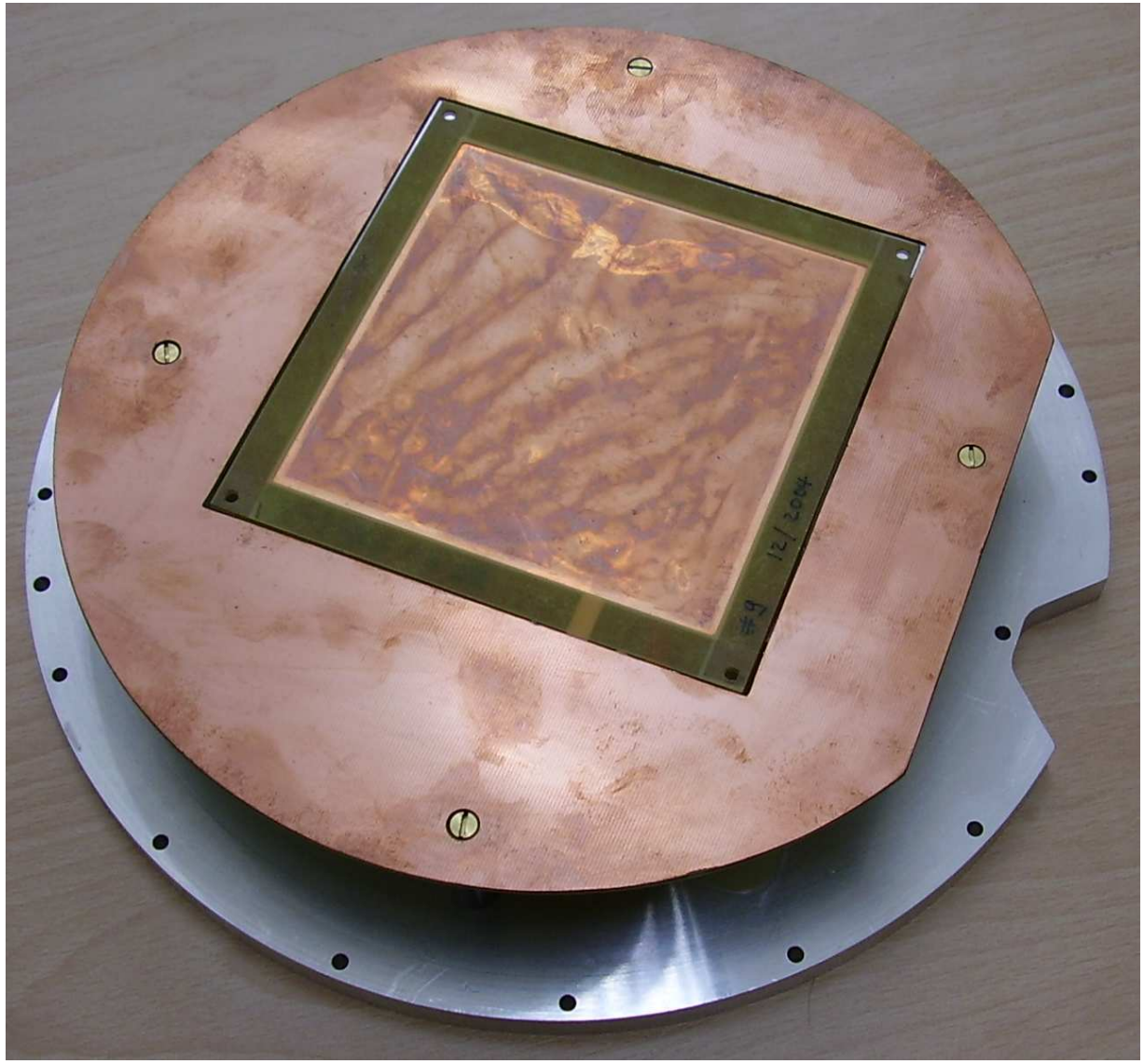




Readout

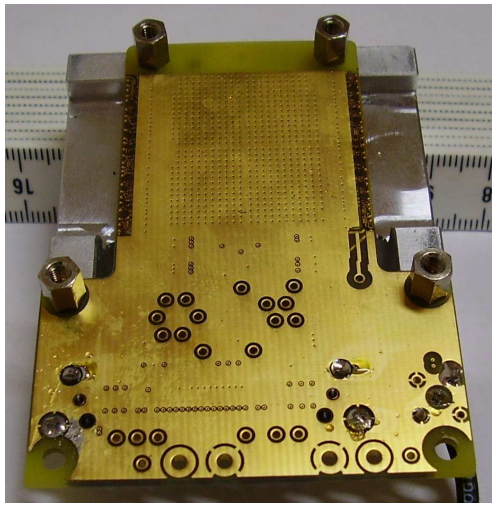


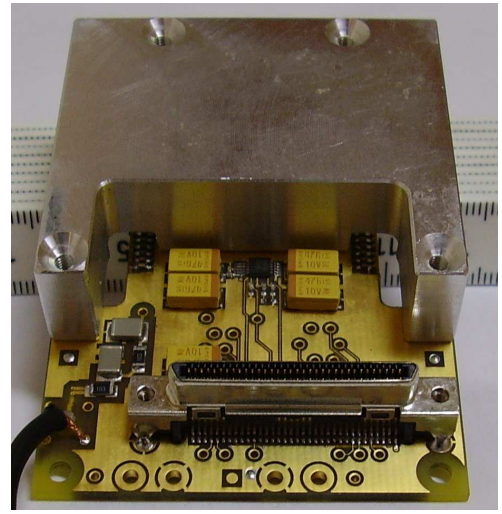
Shield With GEM



Module for the EUDET Prototype

- Based on the “Quad Board” designed at NIKHEF
- Two Quad Boards glued into PCB back plane
- Three standard GEMs (10×10 cm^2) surrounded by shield
- 1 mm gap between the GEMs
- Total height of active detector:
  6 mm + connectors / cooling element





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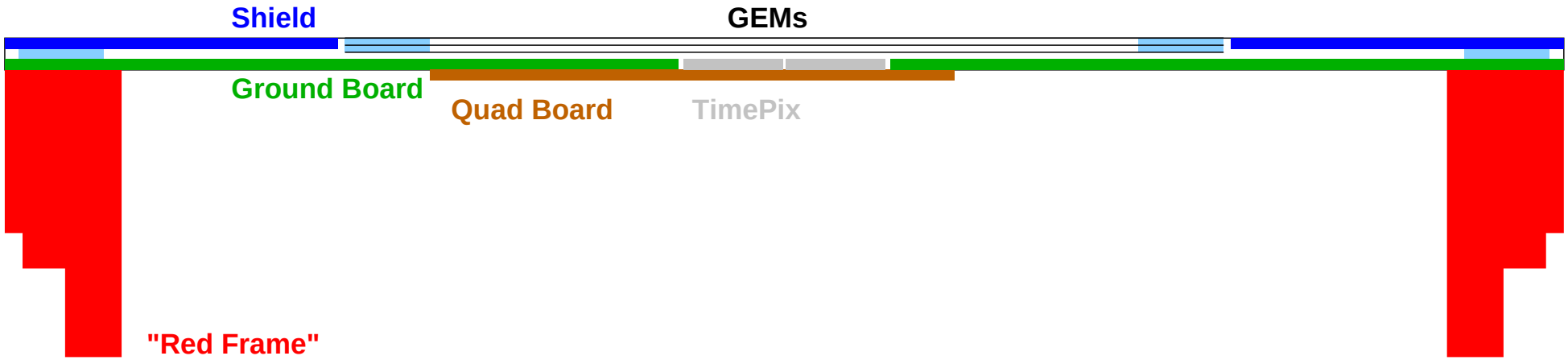

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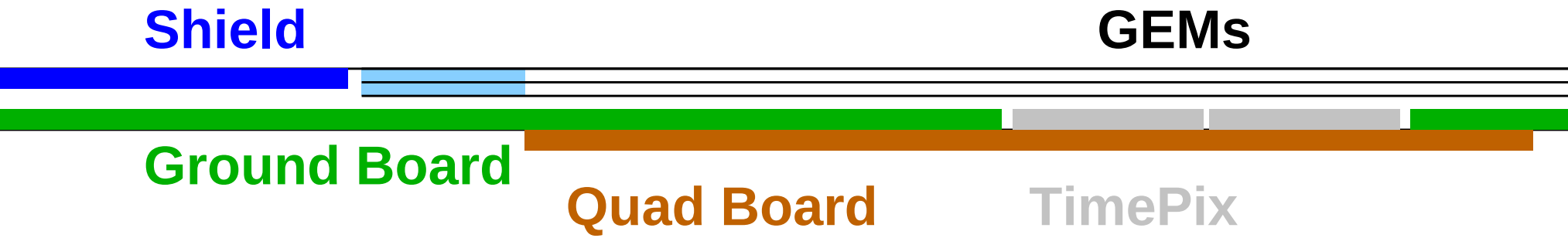
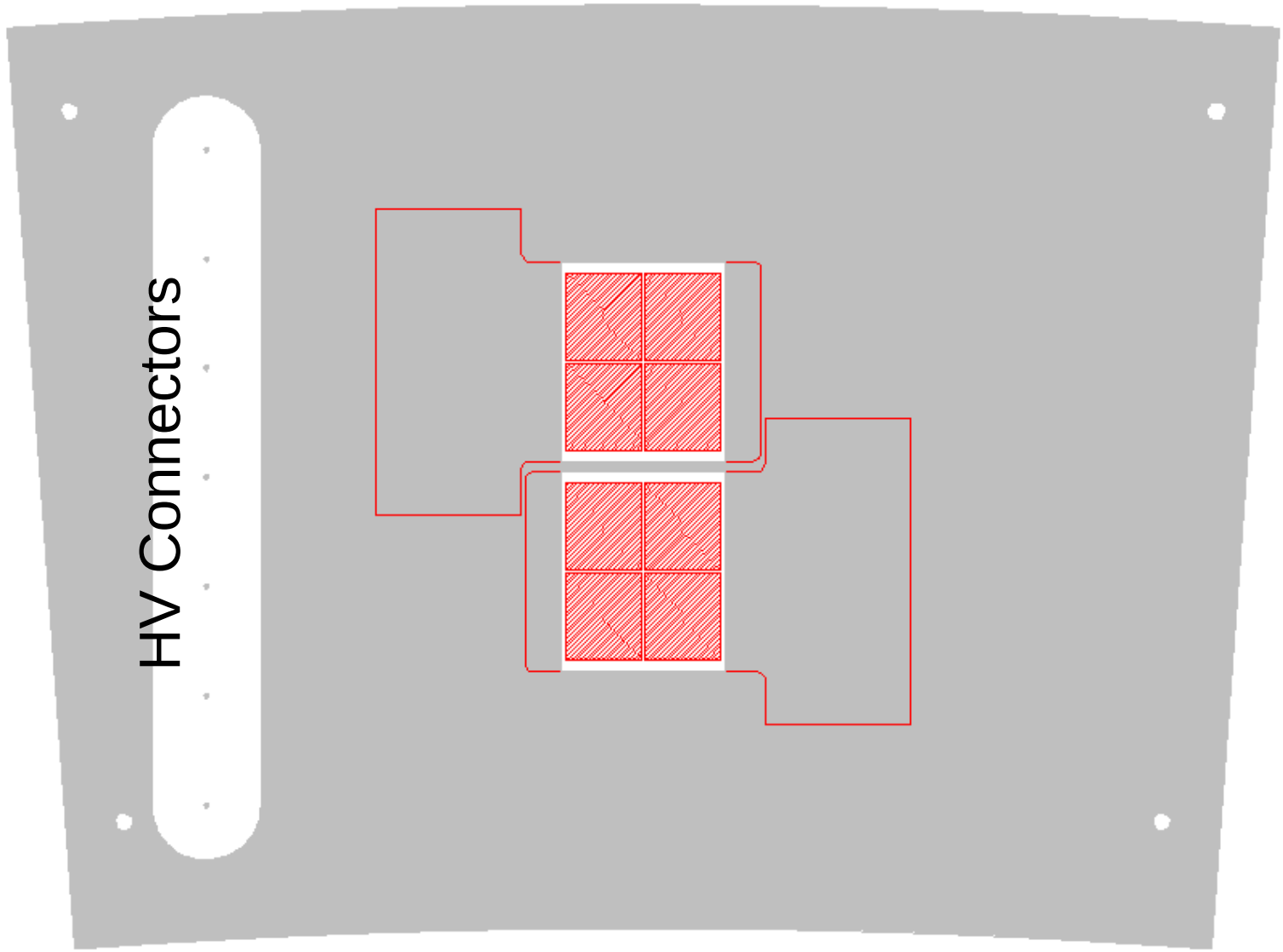
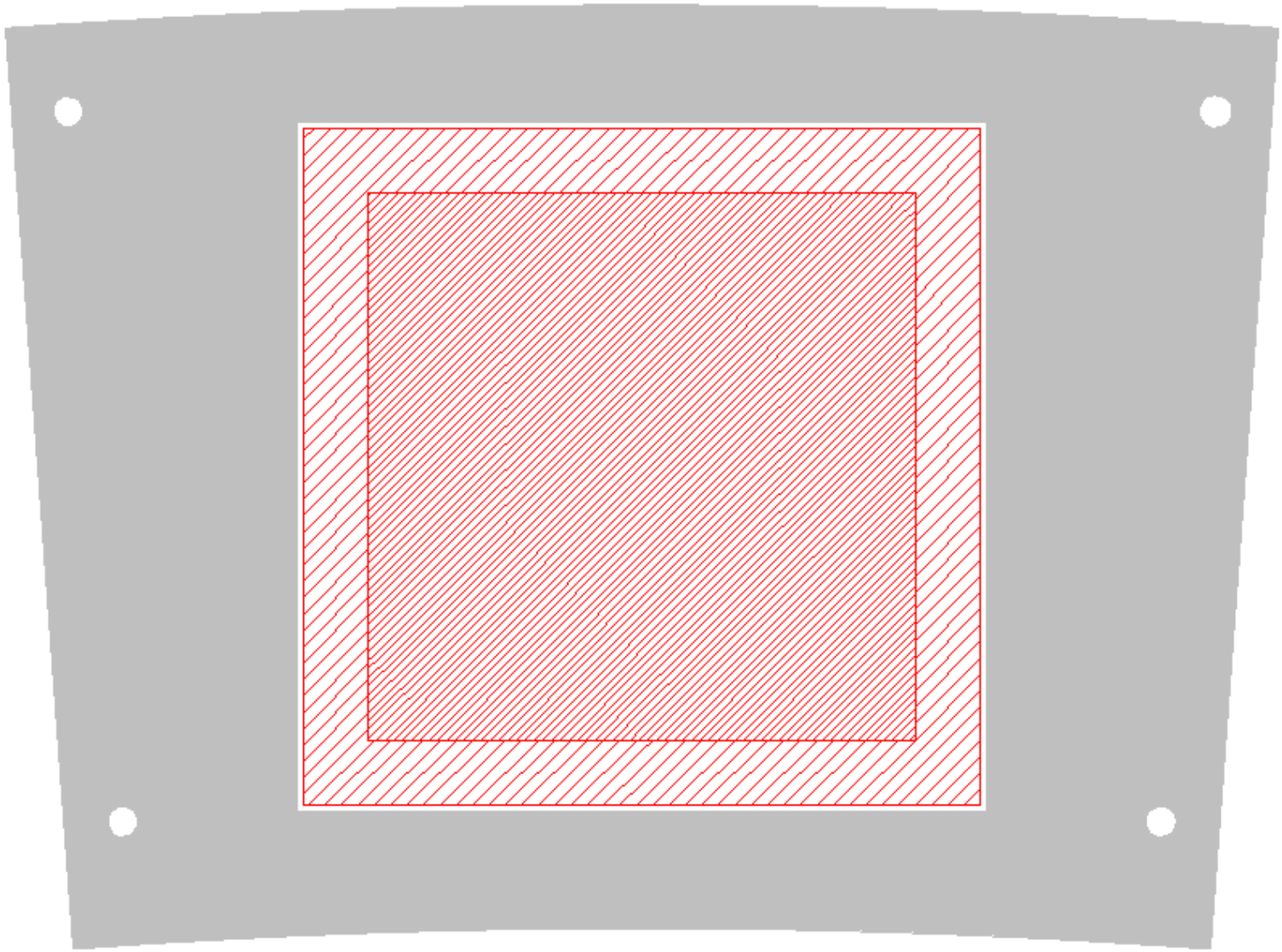


Ground Board With TimePixes



Shield With GEM



MarlinTPC

MarlinTPC is a TPC simulation, digitisation, reconstruction and analysis package for the Marlin / LCIO framework

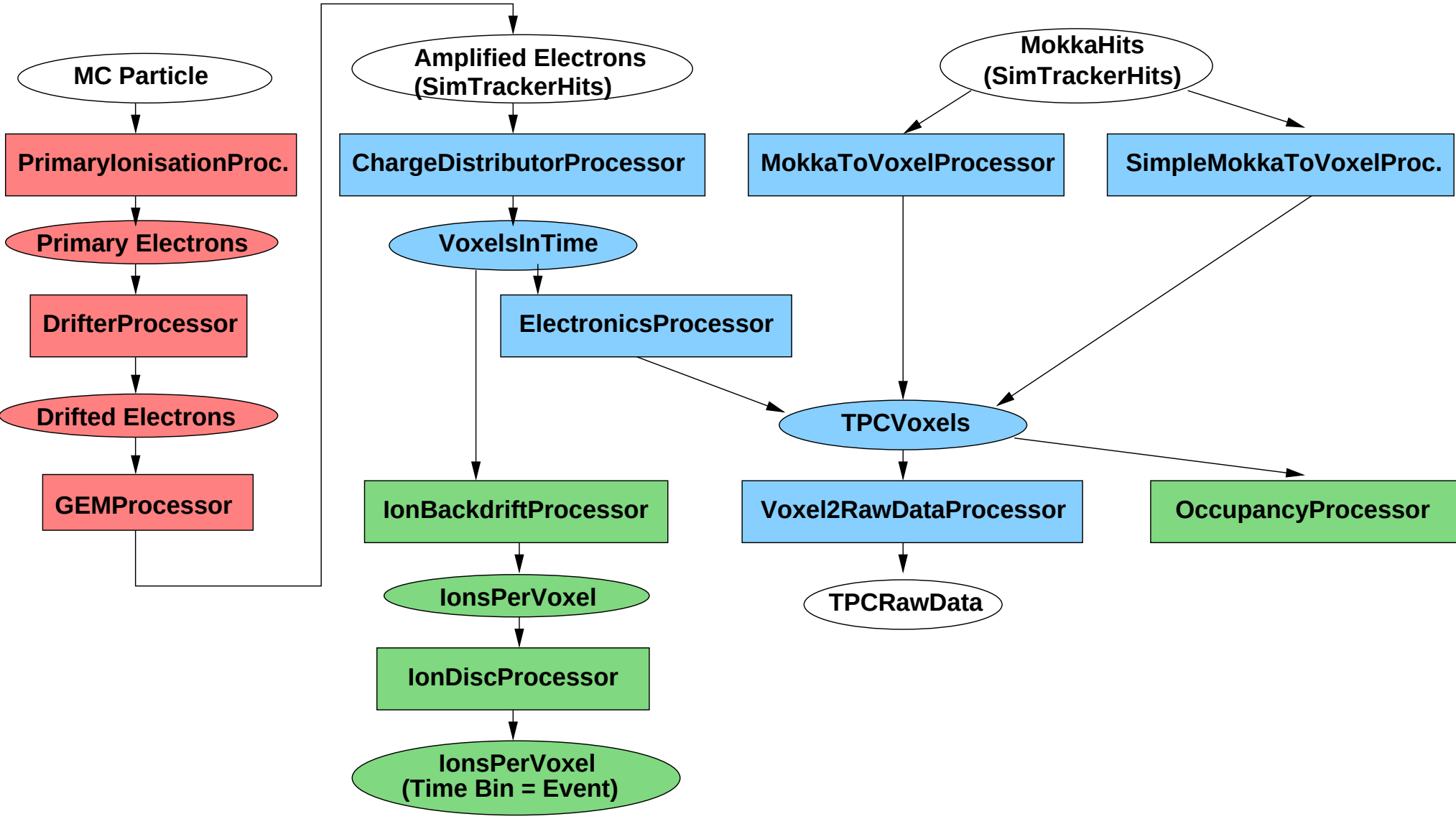
Developers: Jason Abernathy[1], Klaus Dehmelt[2], Ralf Diener[2], Jim Hunt[3], Matthias Enno Janssen[2], Martin Killenberg[4] Thorsten Krautscheid[4], Astrid Münnich[5], Martin Ummenhofer[4], Adrian Vogel[2], Peter Wienemann[4] and Simone Zimmermann[4]

1: University of Victoria — 2: DESY Hamburg — 3: Cornell University

4: University of Bonn — 5: RWTH Aachen

- Works for prototypes and ILC detectors (every TPC that can be described with GEAR)
- Works for Micromegas, GEMs and anode wires
- Independent of readout: TDCs, ADCs, TimePix
- Provides standardised analysis to allow better comparability

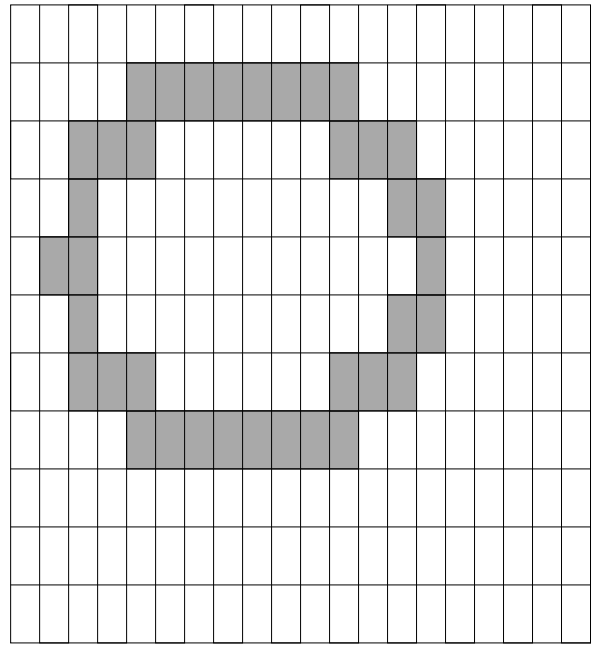
Simulation and Digitisation



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



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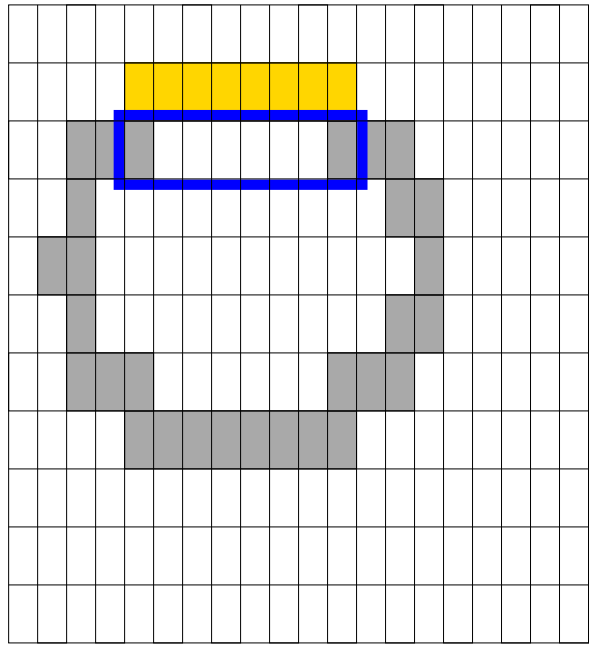

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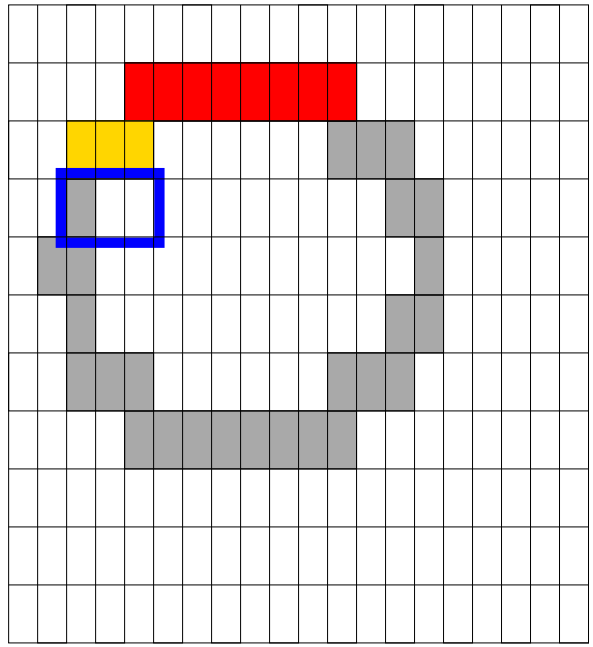

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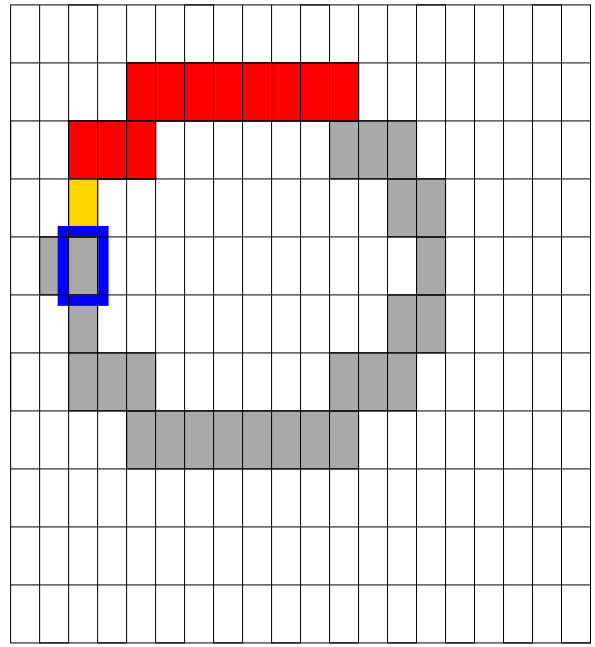

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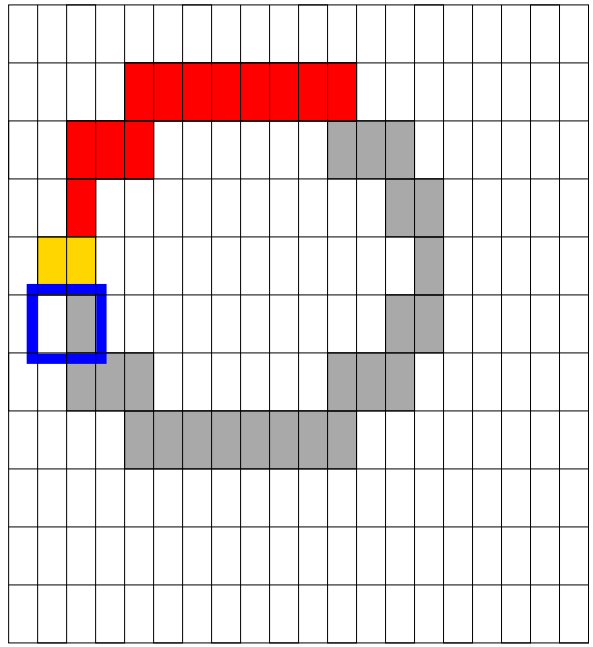

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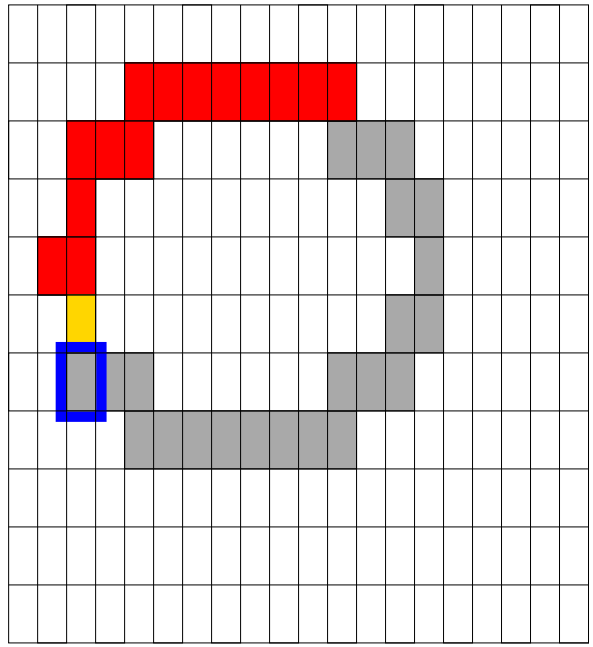

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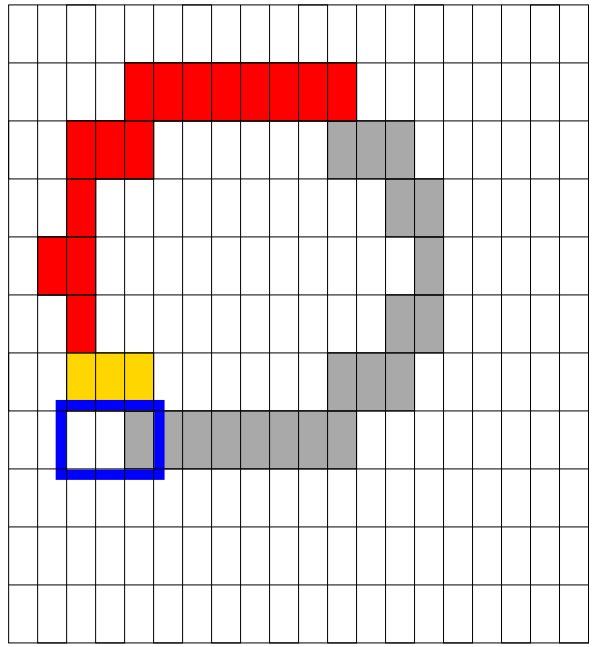

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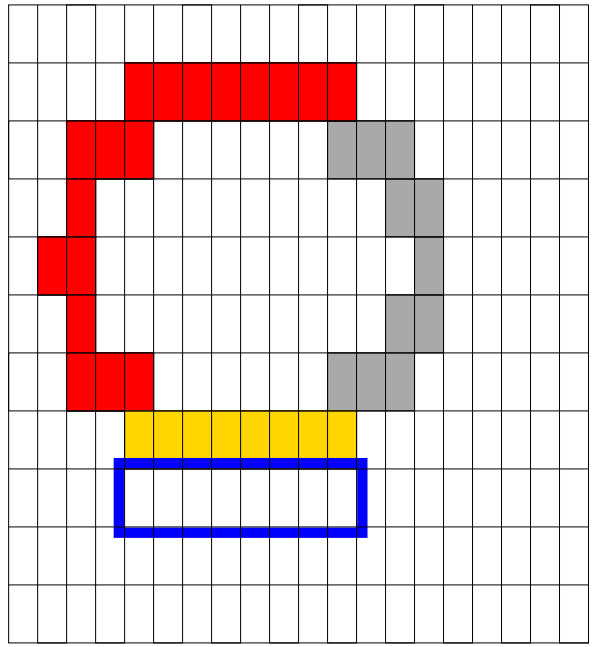

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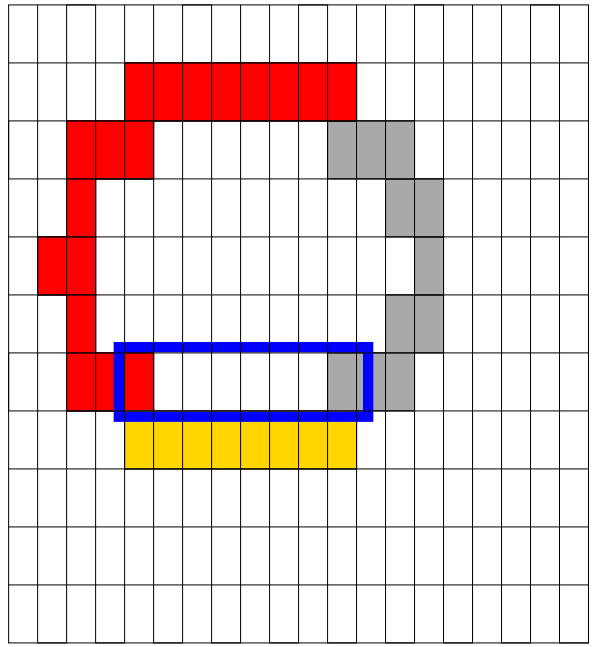

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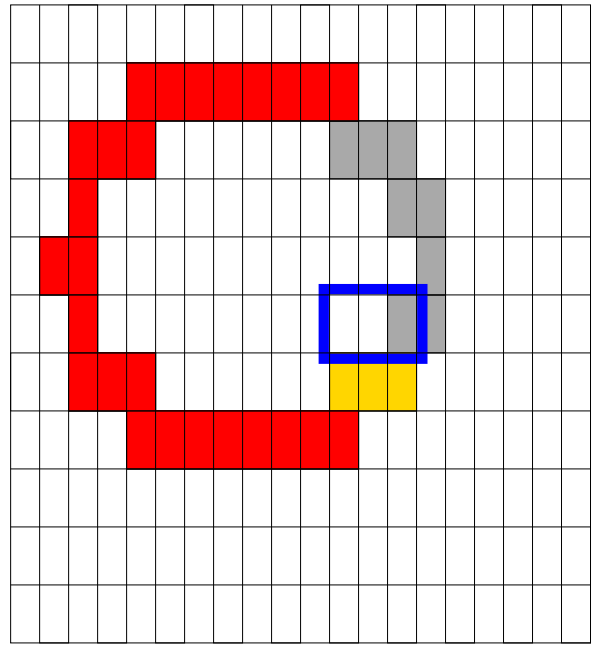

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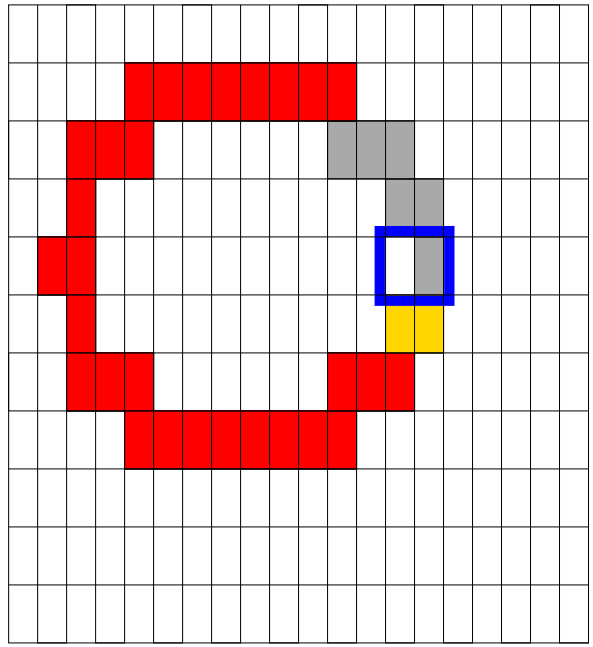

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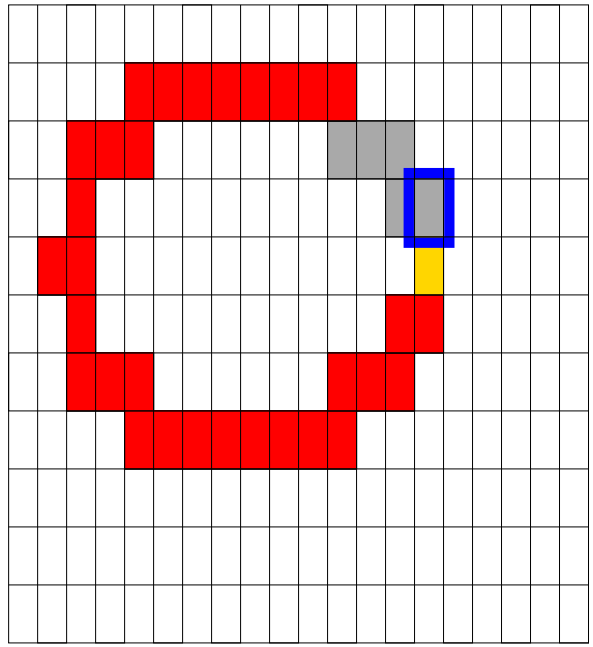

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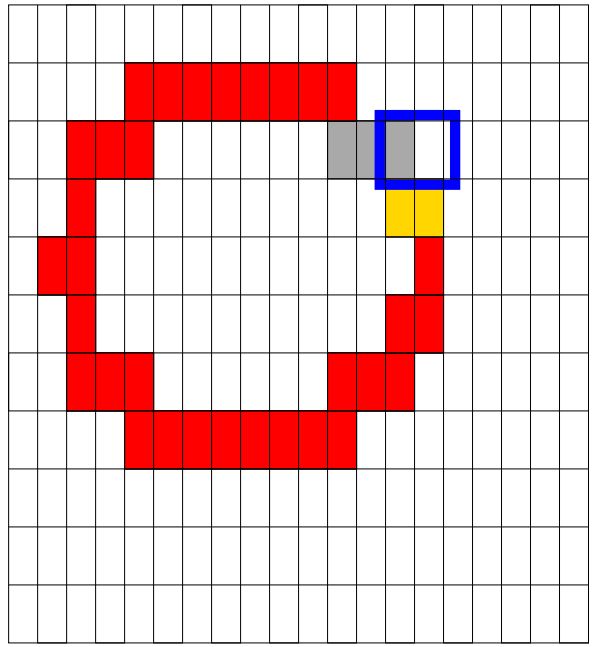

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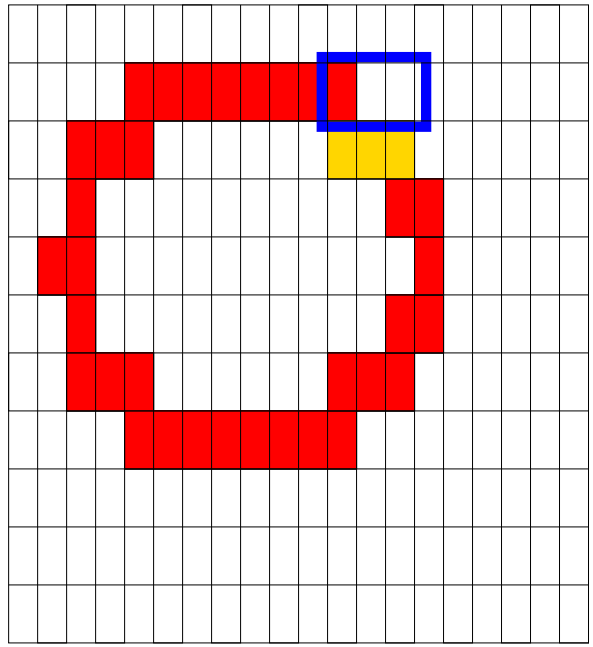

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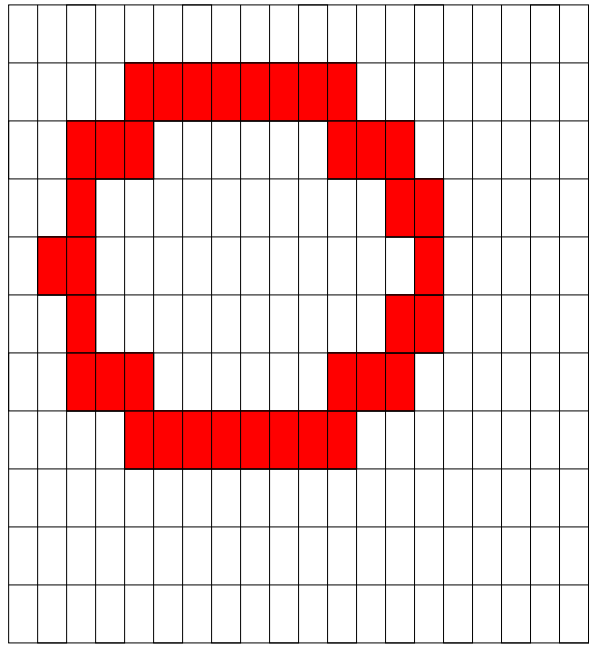
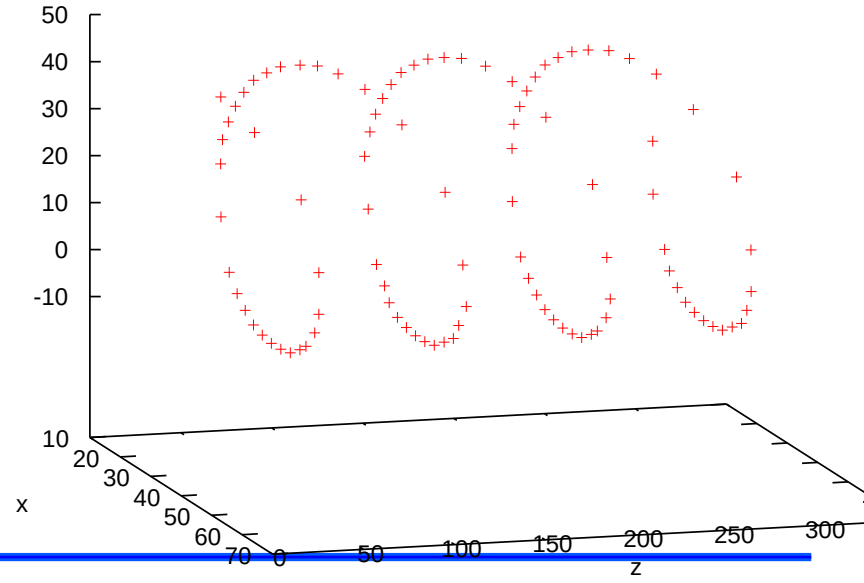




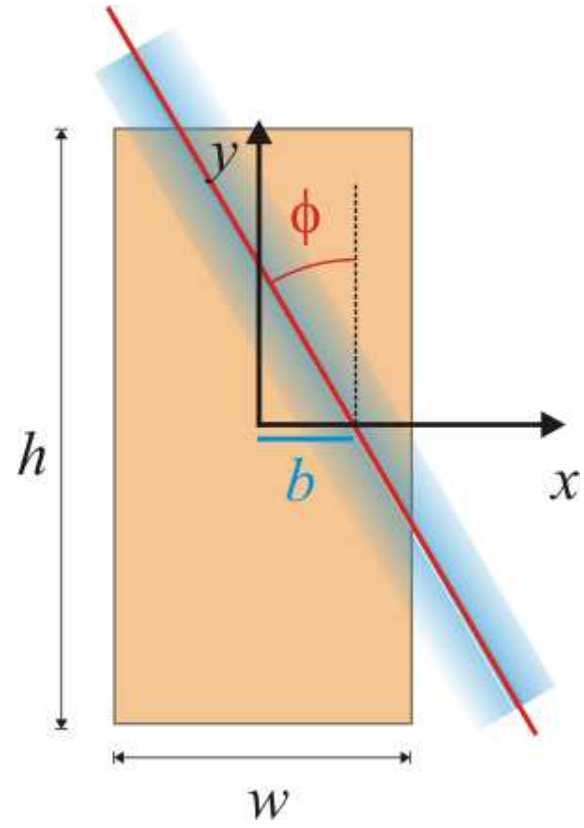
- Independent of trajectory, no track hypothesis
- Works in 3D

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

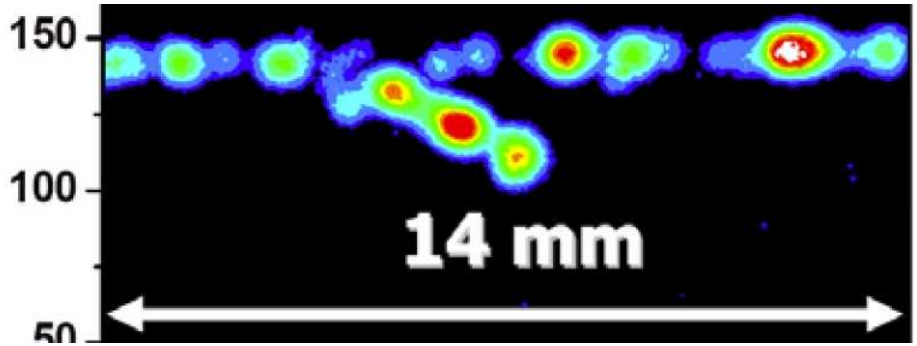
- Calculate likelihood of charge distribution on a single pad row for given track parameters, assuming Gaussian distribution along the track



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

TimePix Reconstruction

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



Freiburg test beam data

TimePix Reconstruction

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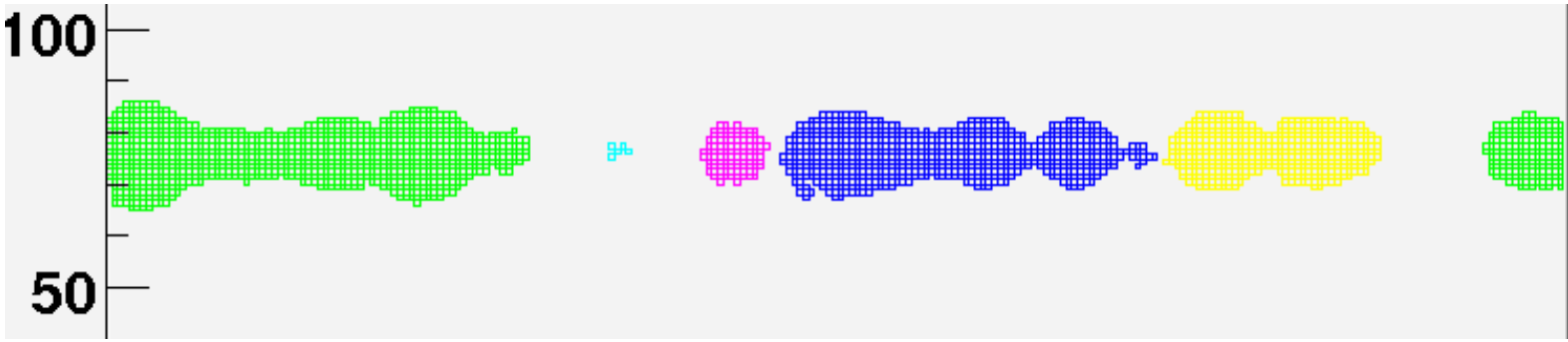

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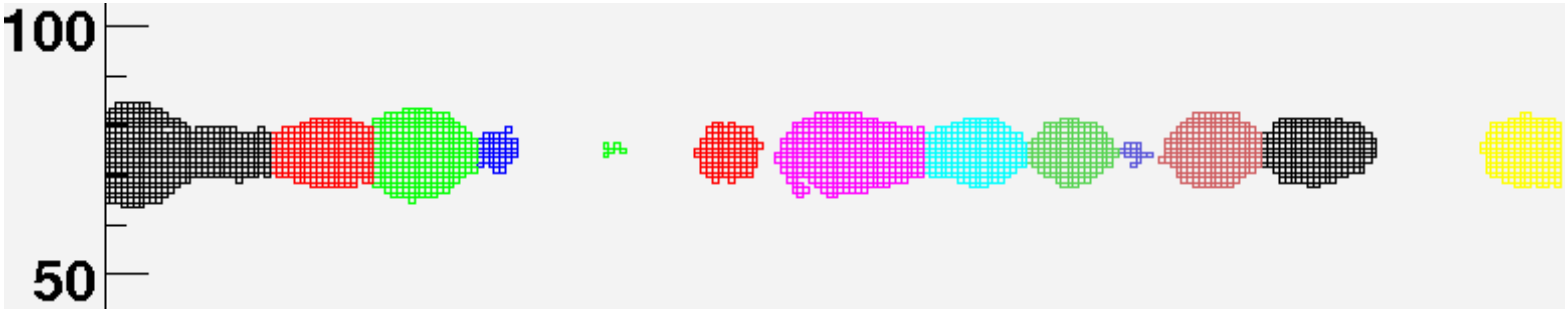

Freiburg test beam data

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)
- ...

Summary

TPC laboratory in Bonn being set up

- Small prototype
  3 standard GEMs and combined TimePix and pad readout
- Eudet LP module
  3 standard GEMs and 8 TimePix Chips

MarlinTPC software

- Simulation for detailed studies
- Digitisation for detailed and MOKKA data
- Reconstruction for various readouts
- Analysis
  http://ilcsoft.desy.de/portal/software_packages/marlintpc/