Analysis of Data from a prototype TPC for the ILC

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Summer Student Session

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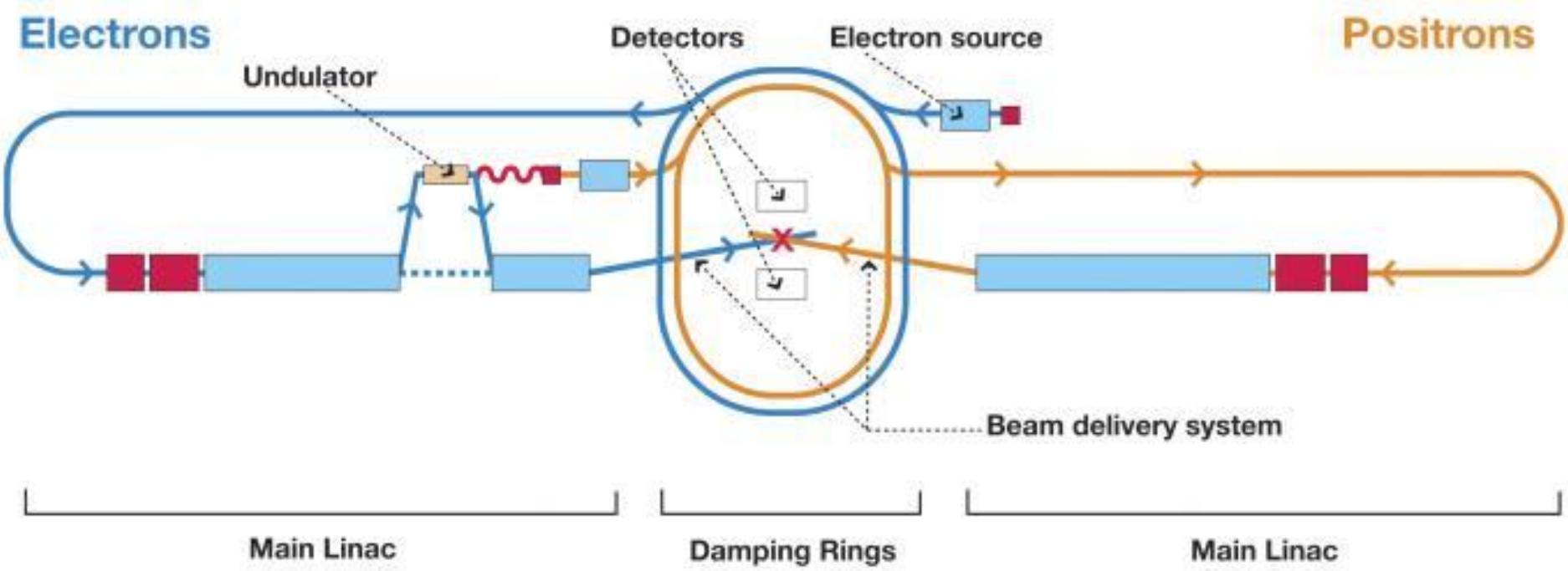
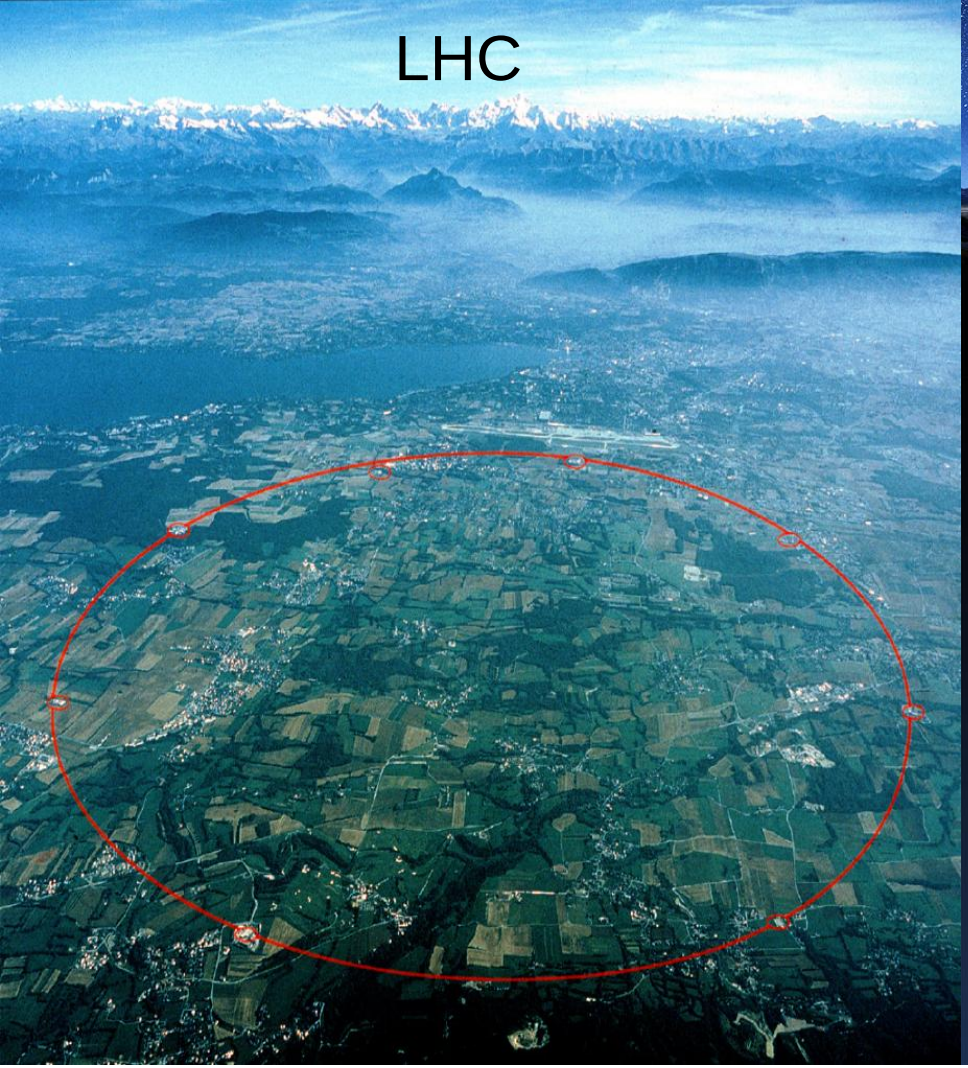
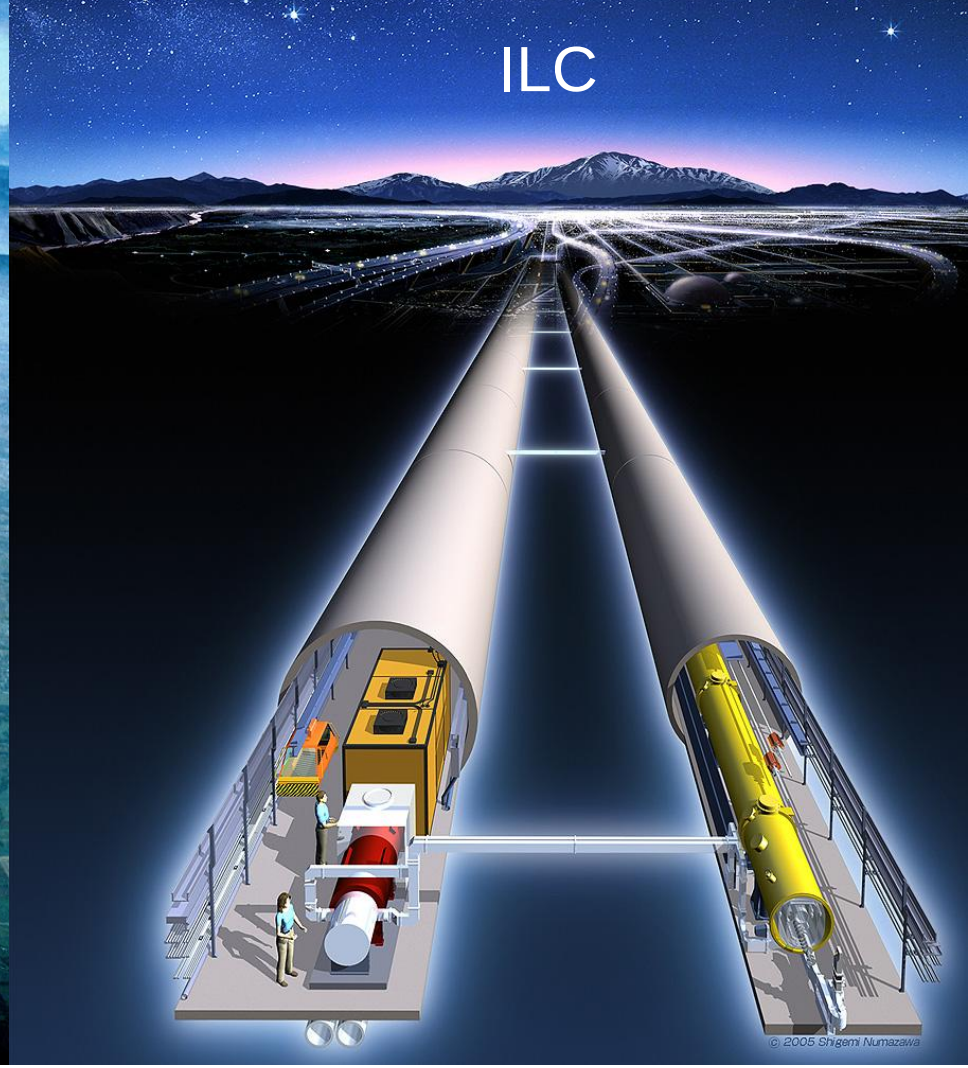
International Linear Collider

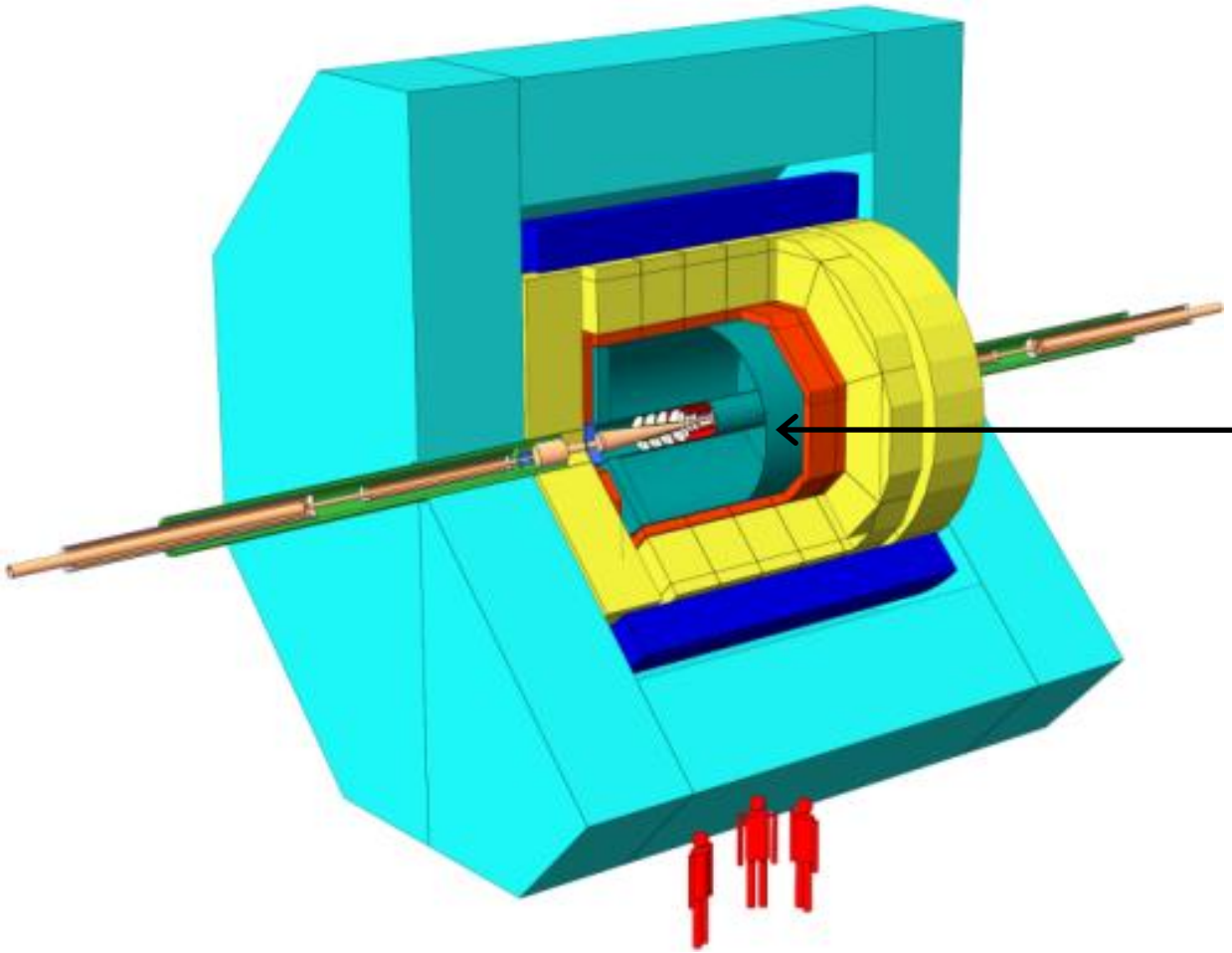
- 500GeV , 30km
- Possible extension 1TeV , 50km



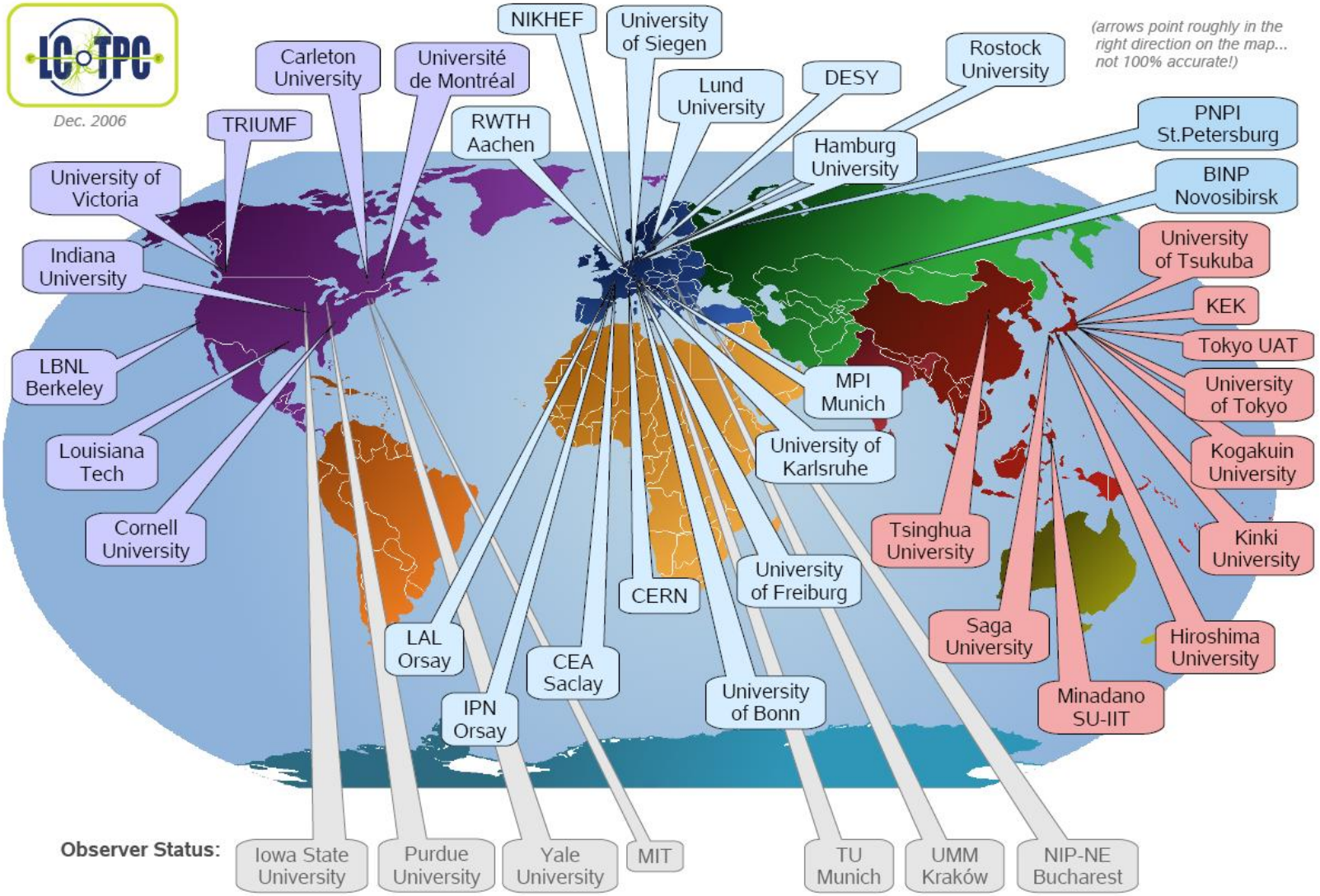

LHC


ILC
© 2005 Shigemi Numazawa

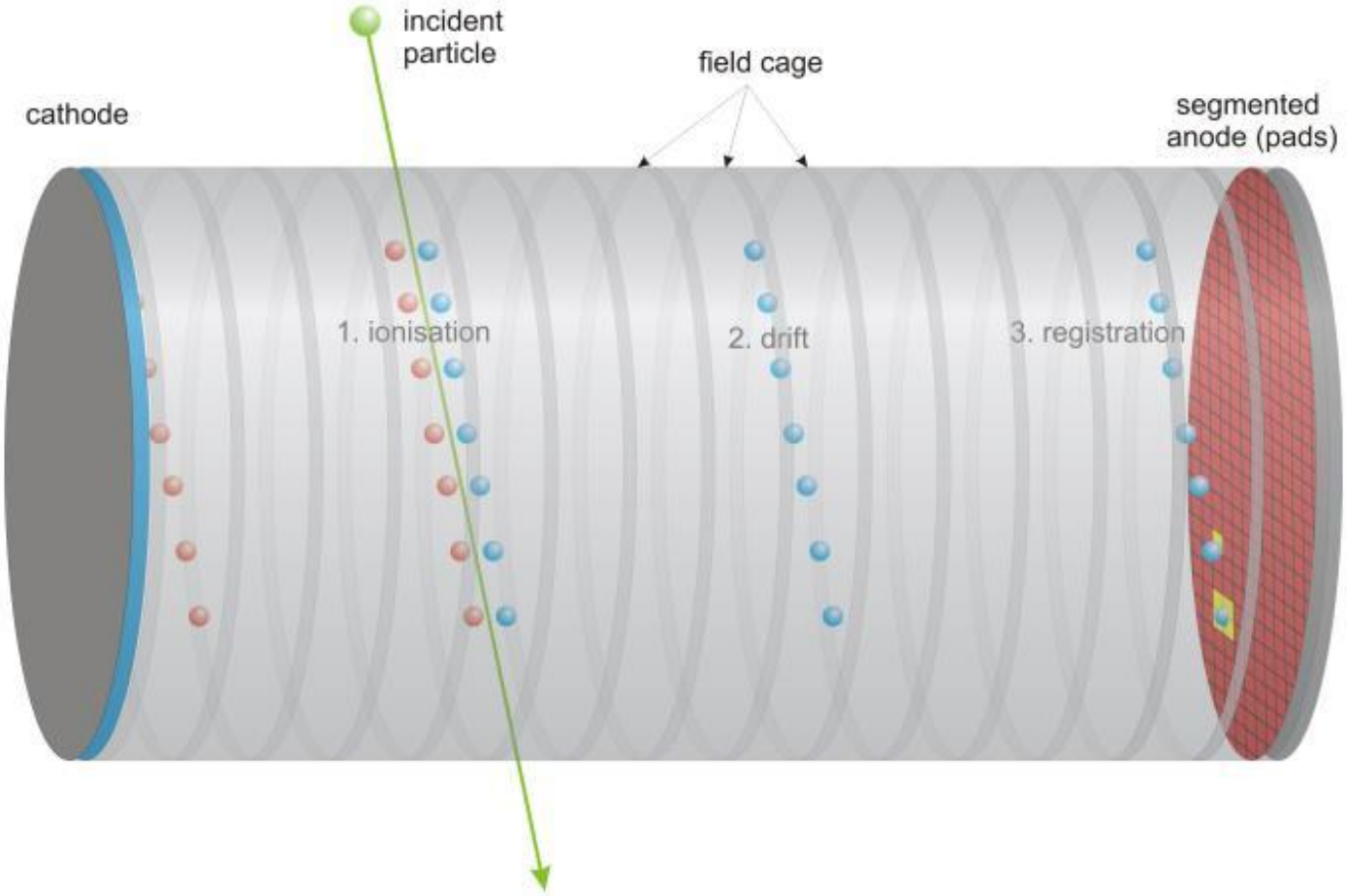
International Large Detector (ILD)



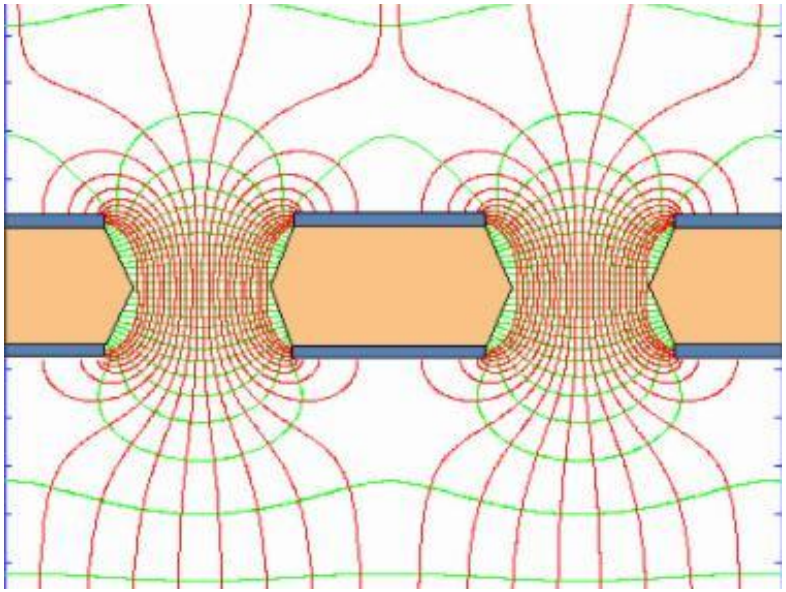
LCTPC Collaboration



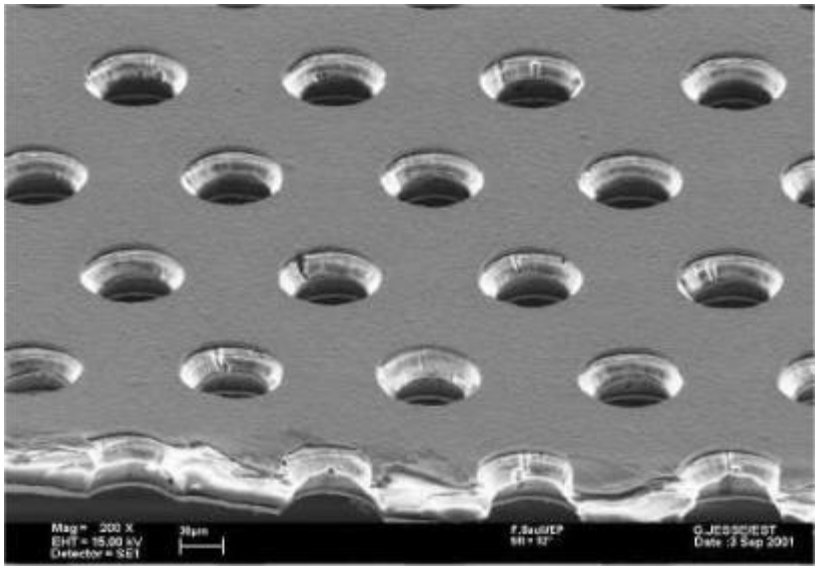
Time Projection Chamber (TPC)



Gas Electron Multiplier (GEM)



Field lines and equipotentials in the GEM holes as a potential is applied between the two metal sides.

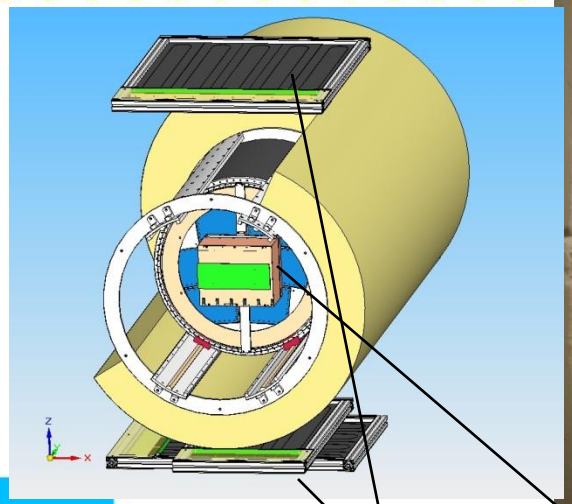


SEM image of a GEM electrode, etched on a metal-clad, 50 µm thick polymer foil.

Typical dimensions are:

Diameter = 70 µm and pitch = 140 µm.

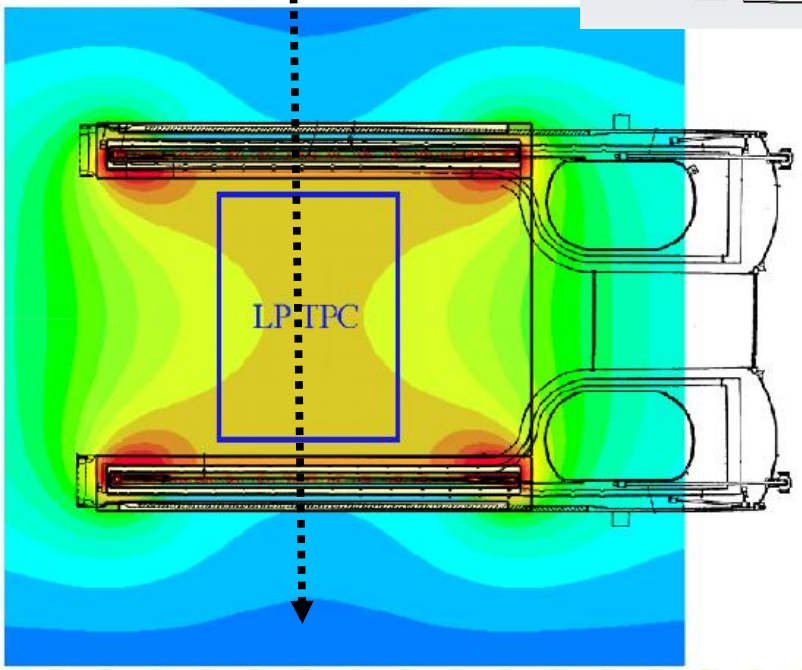
DESY Setup

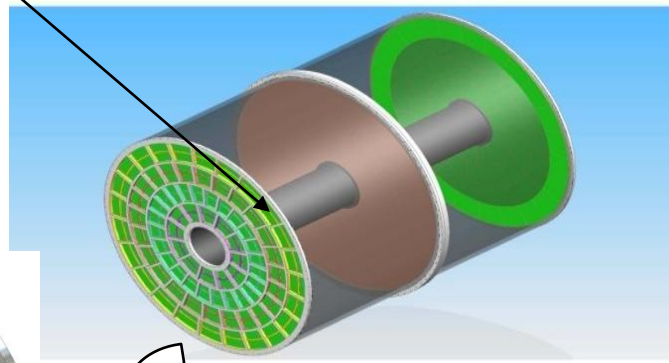


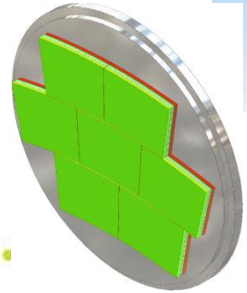
Cosmic Trigger Setup

LP as half part of a TPC

TOP VIEW



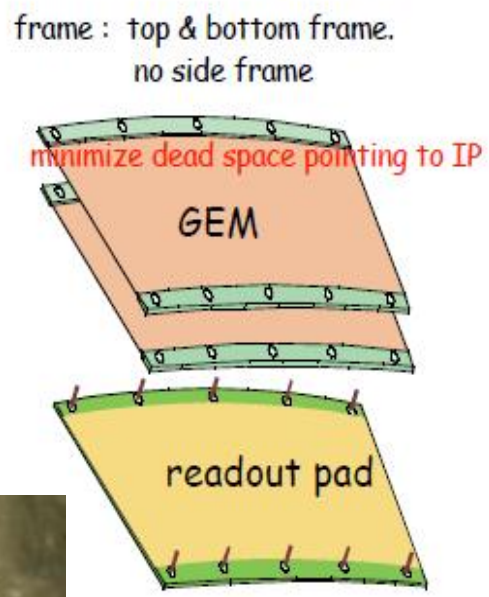


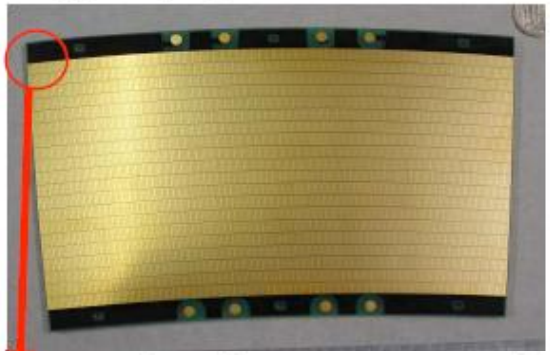


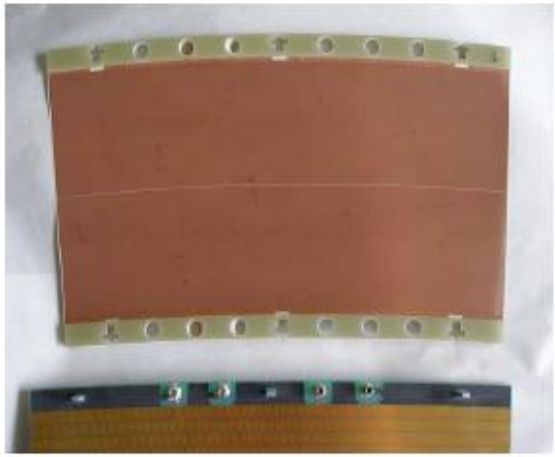
LP endplate

Double GEM Structure

GEM Structure from University of Saga and KEK in Japan.



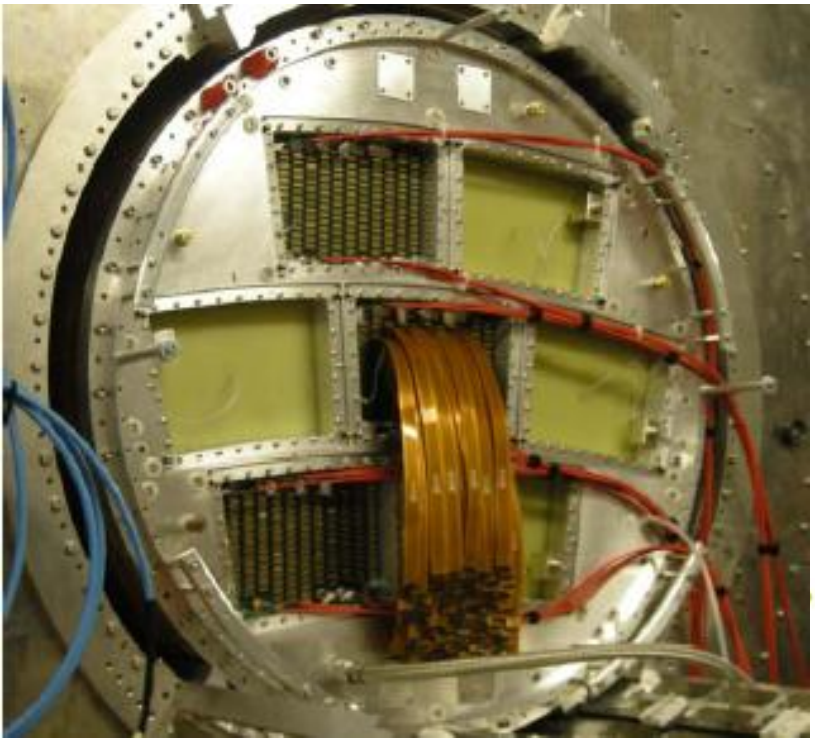




28 pad rows, 176/192 pads/row

⇒5152 channels/module!

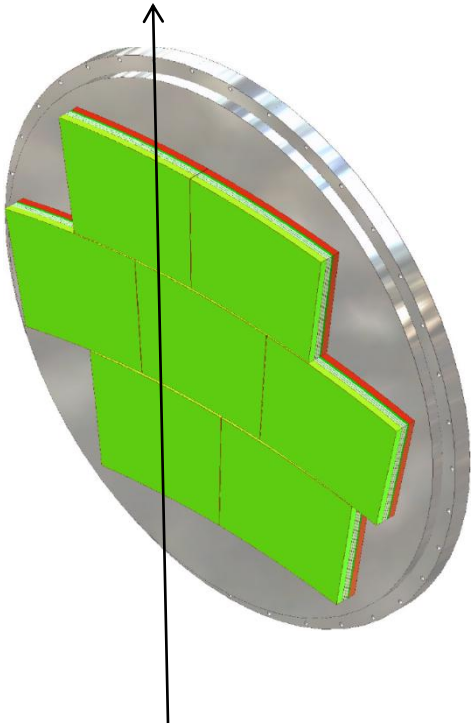
Pad size: ~1.1mm x 5.6mm



Test Beam Data

- 4 runs (each of 20000 events), April 2009

- 5 GeV electron beam
- Zero suppression data
- Only 3 modules used



MARLIN

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

- **highly modular software framework**
  - Digitisation
  - Reconstruction
  - Analysis
- **These modules (processors) can be called on one by one using a steering file.**

Software/Computing

Tools needed...

- LCIO (Linear Collider Input/Output)
- GEAR (Geometry API for Reconstruction)
- LCCD (Linear Collider Conditions Data)

Processors

Data Structure/ LCIO class	Processor Name	Collection Name
TrackerRawData	TrackerRawDataToDataConverter	AltroRawData
TrackerData	ADCPulseConverter	TPCData
TrackerPulse	HitTrackFinderTopo ChannelMapper	TPCPulses
TrackerHit	SimpleTrackSeeder	TPCHits TPCTrackCandidates
Track	TrackFinder (various)	TPCSeedTracks
Track		TPCTracks

Additional Processors

Processor Name	output	purpose
AIDAProcessor	*.root or *.xml	Create AIDA file
ConditionsProcessor		reads in channel mapping
LCIOOutputProcessor	*.slcio files	
XYZDistributionProcessor		Fills x, y and z Hits into an AIDA histogram
HeprepProcessor	*.heprep	For visual display of data (using jas3)

Steering file

Steering files define the all of the processors to be used and the order in which they are called.

Here all of the global and processor specific parameters are defined.

```
<marlin xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://ilcsoft.desy.de/marlin/marlin.xsd">

    <execute>
        <processor name="MyAIDAProcessor"/>
        <processor name="MyConditionsProcessor"/>
        <processor name="MyTrackerRawDataToDataConverterProcessor"/>
        <processor name="MyADCPulseConverterProcessor"/>
        <processor name="MyChannelMapperProcessor"/>
        <processor name="MyHitTrackFinderTopoProcessor"/>
        <processor name="MySimpleTrackSeederProcessor"/>
        <processor name="MyLCIOOutputProcessor"/>
        <processor name="MyXYZDistributionProcessor"/>
        <processor name="MyHepRepOutputProcessor"/>
    </execute>

    <global>
        <parameter name="LCIOInputFiles"> /scratch/data/charles/workdirectory/readout-6850_0.slcio </parameter>
        <parameter name="GearXMLFile" value="/scratch/data/charles/MarlinTPC_trunk/examples/GEAR_geometries/gear_LP_endplate_7GEM_modules.xml"/>
        <parameter name="MaxRecordNumber" value="2"/>
        <parameter name="SkipNEvents" value="0"/>
        <parameter name="SupressCheck" value="false"/>
        <parameter name="Verbosity" value="MESSAGE3"/>
    </global>
```

Steering file

```
<processor name="MyHitTrackFinderTopoProcessor" type="HitTrackFinderTopoProcessor">
<!--HitTrackFinderTopoProcessor calculates TrackerHits from TrackerPulses-->
 <!--Name of the input TrackerPulses collection-->
 <parameter name="InputTrackerPulses" type="string" lcioInType="TrackerPulse"> TPCPulses </parameter>
 <!--Name of the output Tracks collection-->
 <parameter name="OutputTrackCandidates" type="string" lcioOutType="Track"> TPCTrackCandidates </parameter>
 <!--Name of the output TrackerHits collection-->
 <parameter name="OutputTrackerHits" type="string" lcioOutType="TrackerHit"> TPCHits </parameter>
 <!--Optional: Name of the input collection containing the TPC conditions data-->
 <!--parameter name="InputTPCConditions" type="string" value="TPCConditions"/-->
 <!--Maximum number of empty consecuitve pads in hit (default: 1)-->
 <parameter name="MaxEmptyPads" type="int" value="1"/>
 <!--Maximum number of subsequnetly missing hits (default: 1)-->
 <parameter name="MaxSkipRows" type="int" value="1"/>
 <!--Maximum time between pulses in a hit in ns (default: 200.)-->
 <parameter name="MaxTimeSpread" type="float" value="200"/>
 <!--Minimum size of hit / Minimum number of Pads (default: 1)-->
 <parameter name="MinHitSize" type="int" value="1"/>
 <!--Minimum number of hits on track (default: 5)-->
 <parameter name="MinTrackHits" type="int" value="5"/>
 <!--Set to 1 for the second half TPC, which look into the negative z direction (default: 0)-->
 <parameter name="NegativeZDirection" type="int" value="0"/>
 <!--if not 0 the output hits collection is set transient (default: 0)-->
 <parameter name="SetOutputHitsTransient" type="int" value="0"/>
 <!--if not 0 the output trackscollection is set transient (default: 0)-->
 <parameter name="SetOutputTrackCandidatesTransient" type="int" value="0"/>
 <!--Optional: Set drift velocity in case there is no conditions data in mm/us-->
 <!--parameter name="VDrift" type="float" value="45."/-->
</processor>
```

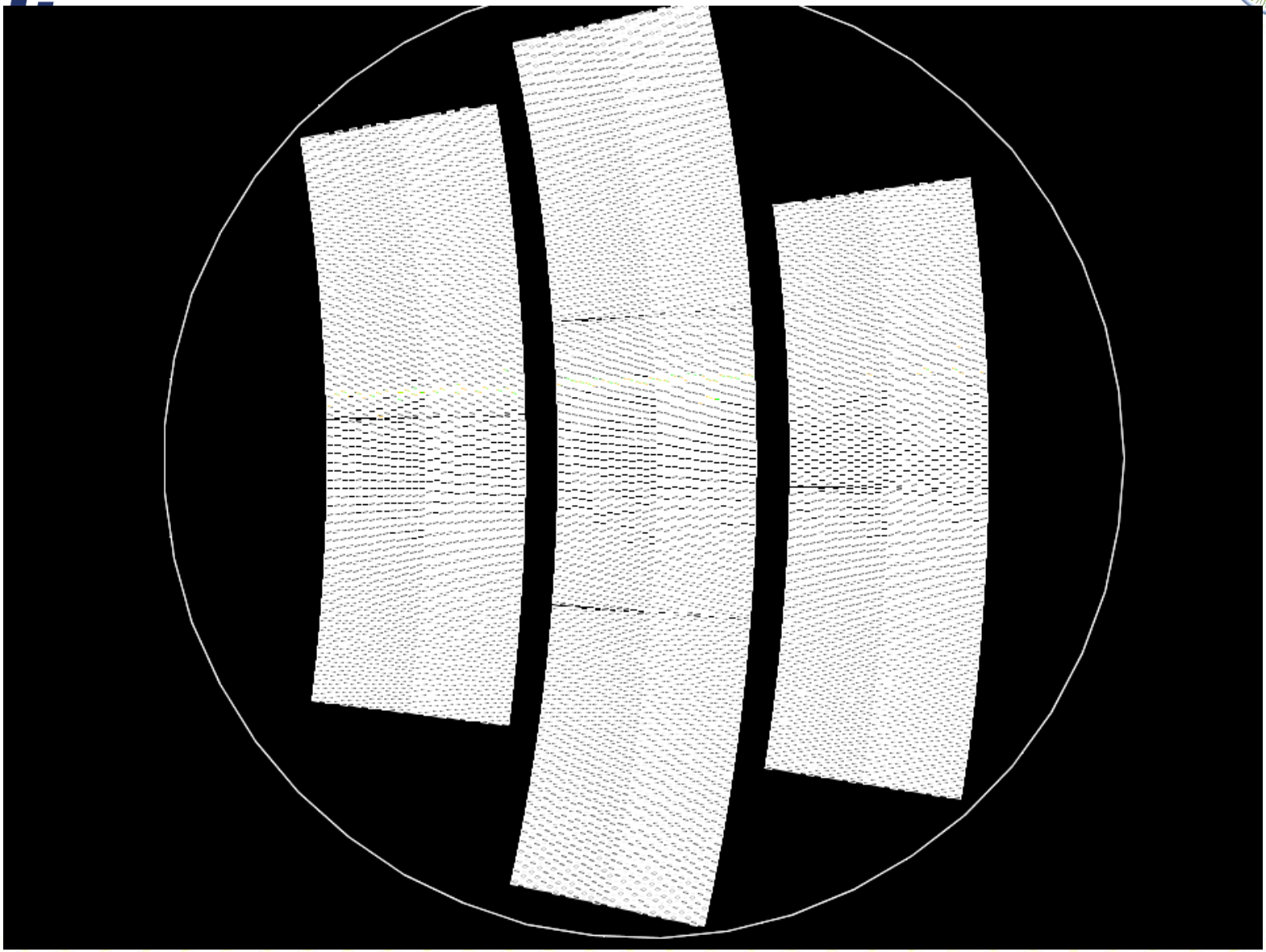
Steering file

```
<processor name="MyHitTrackFinderTopoProcessor"
<!--HitTrackFinderTopoProcessor calculates Track
 <!--Name of the input TrackerPulses collection-
 <parameter name="InputTrackerPulses" type="stri
 <!--Name of the output Tracks collection-->
 <parameter name="OutputTrackCandidates" type="s
 <!--Name of the output TrackerHits collection--
 <parameter name="OutputTrackerHits" type="strin
 <!--Optional: Name of the input collection cont
 <!--parameter name="InputTPCConditions" type="s
 <!--Maximum number of empty consecuitve pads in
 <parameter name="MaxEmptyPads" type="int" value
 <!--Maximum number of subsequnetly missing hits
 <parameter name="MaxSkipRows" type="int" value=
 <!--Maximum time between pulses in a hit in ns
 <parameter name="MaxTimeSpread" type="float" va
 <!--Minimum size of hit / Minimum number of Pad
 <parameter name="MinHitSize" type="int" value="
 <!--Minimum number of hits on track (default: 5
 <parameter name="MinTrackHits" type="int" value
 <!--Set to 1 for the second half TPC, which loc
 <parameter name="NegativeZDirection" type="int"
 <!--if not 0 the output hits collection is set
 <parameter name="SetOutputHitsTransient" type="
 <!--if not 0 the output trackscollection is set
 <parameter name="SetOutputTrackCandidatesTransi
 <!--Optional: Set drift velocity in case there
 <!--parameter name="VDrift" type="float" value=
</processor>
```

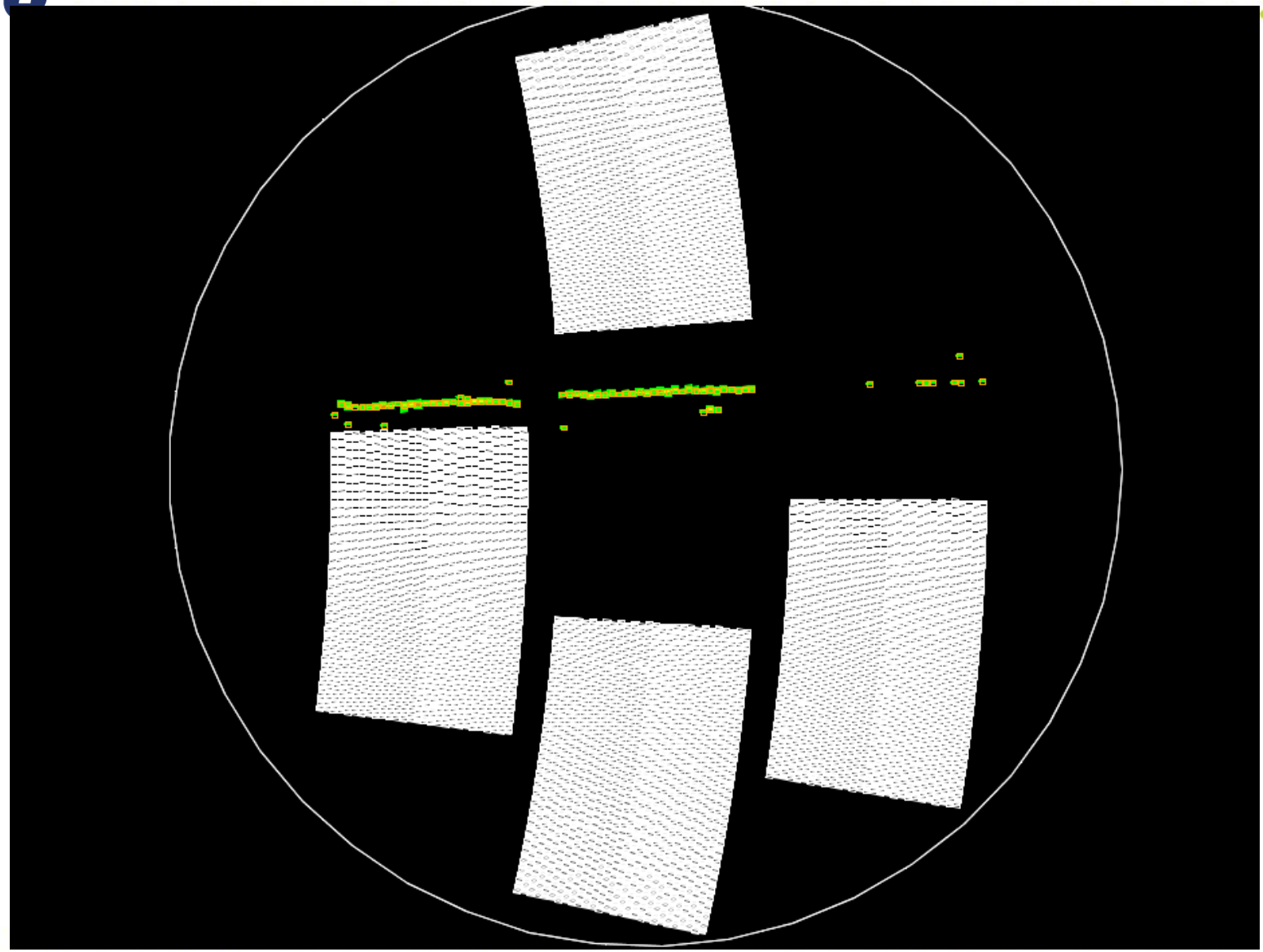
```
/**
 * description of the processor which will be displayed in the
 * steering file autometicly generated by
 * marlin (use MarlinTPC -x (XML-format) or MarlinTPXC -l (text format))
 */
_description = "HitTrackFinderTopoProcessor calculates TrackerHits from TrackerPulses" ;


// register steering parameters: name, description, class-variable, default value
registerInputCollection(    LCIO::TRACKERPULSE,
                            "InputTrackerPulses" ,
                            "Name of the input TrackerPulses collection"  ,
                            _inputTrackerPulsesCollectionName ,
                            std::string("TPCPulses") ) ;

registerOutputCollection(   LCIO::TRACKERHIT,
                            "OutputTrackerHits" ,
                            "Name of the output TrackerHits collection"  ,
                            _outputTrackerHitsCollectionName ,
                            std::string("TPCHits") ) ;

registerOutputCollection(   LCIO::TRACK,
                            "OutputTrackCandidates" ,
                            "Name of the output Tracks collection"  ,
                            _outputTracksCollectionName ,
                            std::string("TPCTrackCandidates") ) ;

registerOptionalParameter(  "InputTPCConditions",
                            "Optional: Name of the input collection containing the TPC conditions data",
                            _inputTPCConditionsCollectionName,
                            tpcconddata::TPCConditions::getDefaultColName() ) ;

registerProcessorParameter( "SetOutputHitsTransient" ,
                            "if not 0 the output hits collection is set transient (default: 0)"  ,
                            _outputHitsTransient,
                            int(0));

registerProcessorParameter( "SetOutputTrackCandidatesTransient" ,
                            "if not 0 the output trackscollection is set transient (default: 0)"  ,
                            _outputTrackCandidatesTransient,
                            int(0));

registerProcessorParameter( "MaxEmptyPads" ,
                            "Maximum number of empty consecuitve pads in hit (default: 1)"  ,
                            _maxEmptyPads ,
                            int(1)) ;
```

Processor file

Results



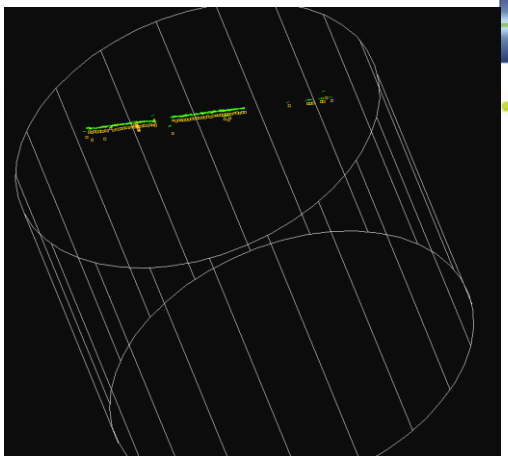
Results

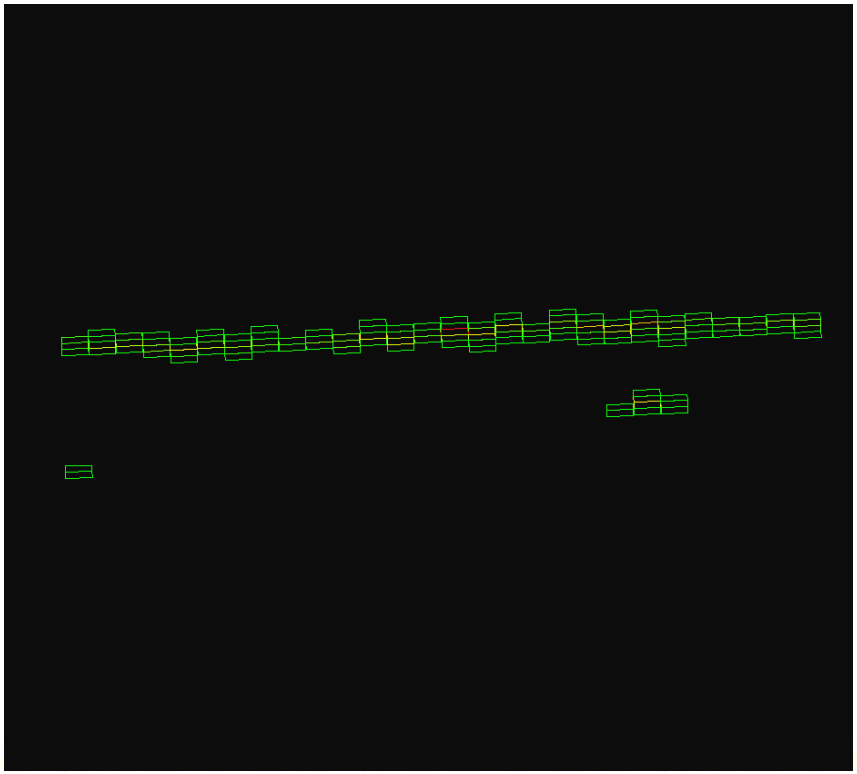


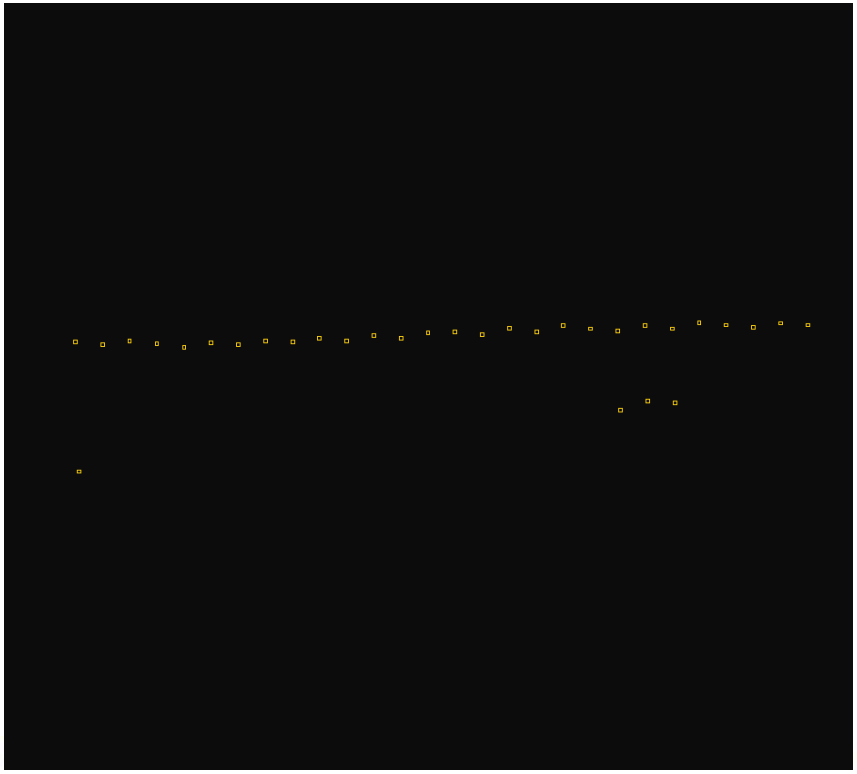
Results

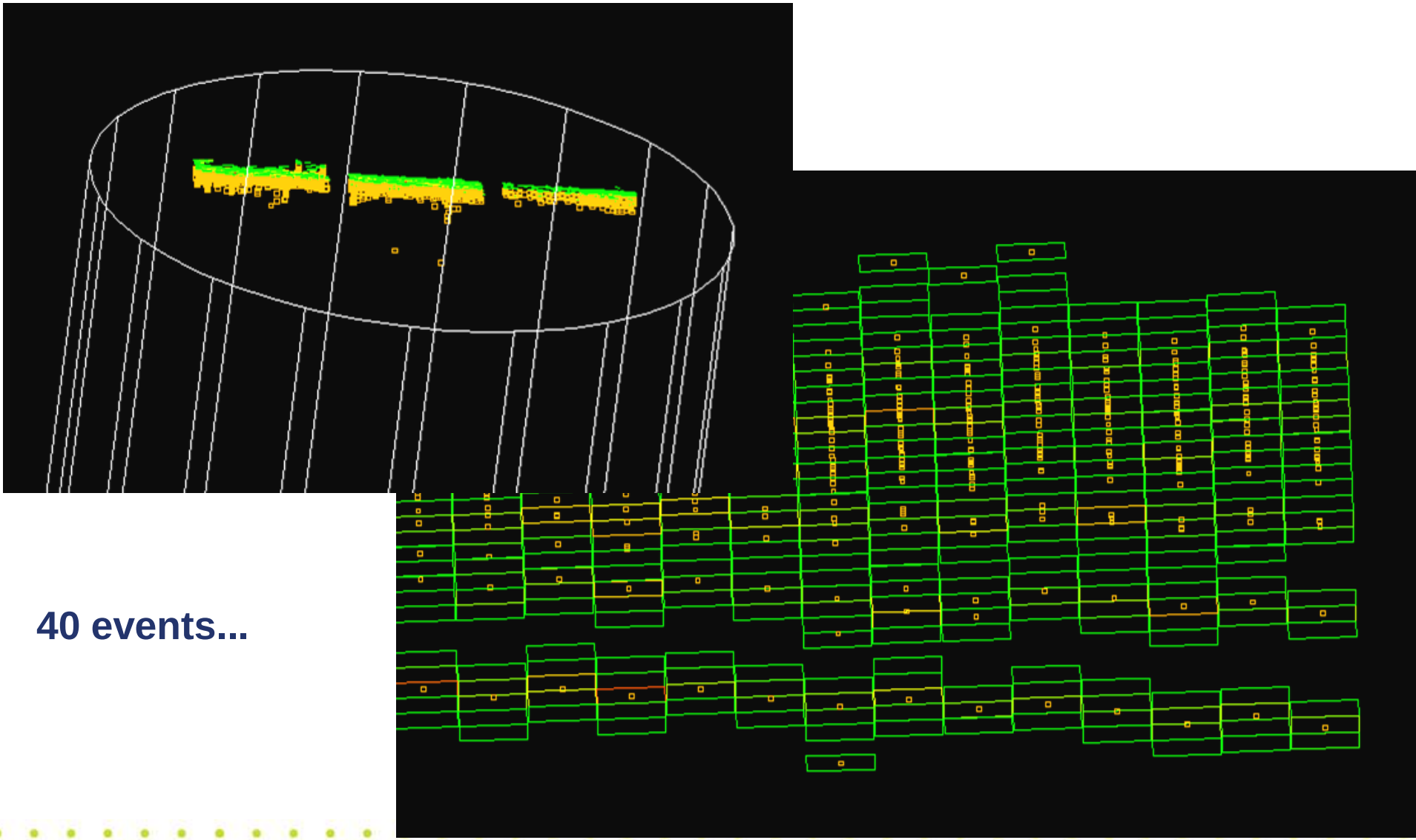
One event displayed,

TPCPulses & TPCHits showed



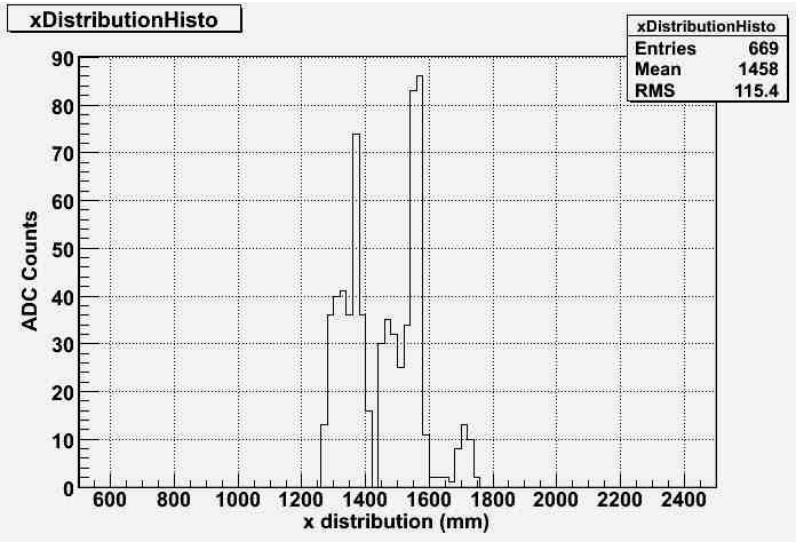


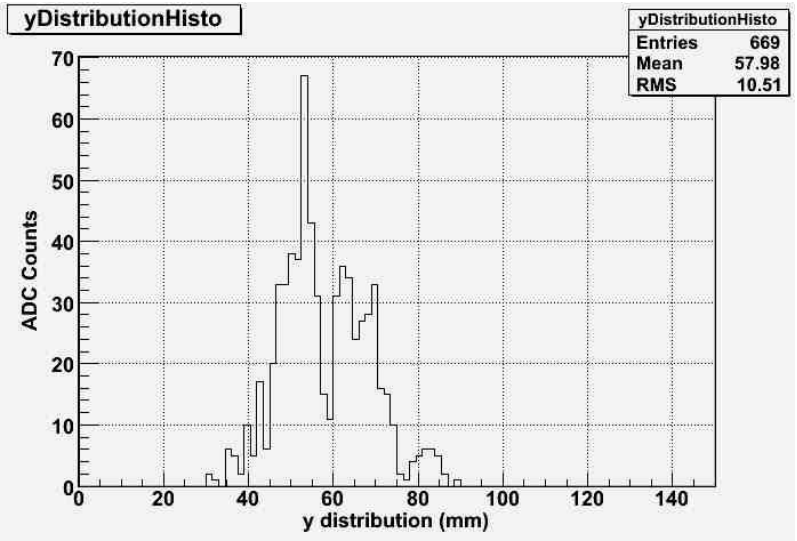


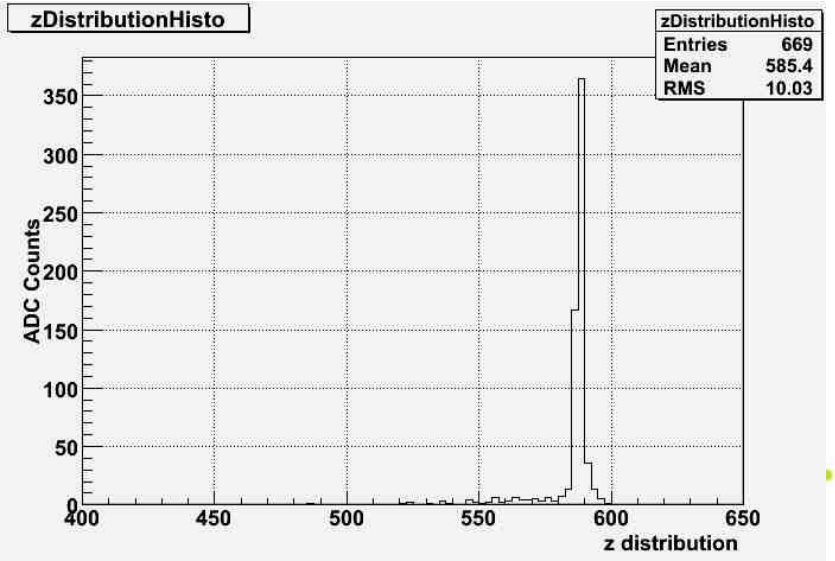


40 events...

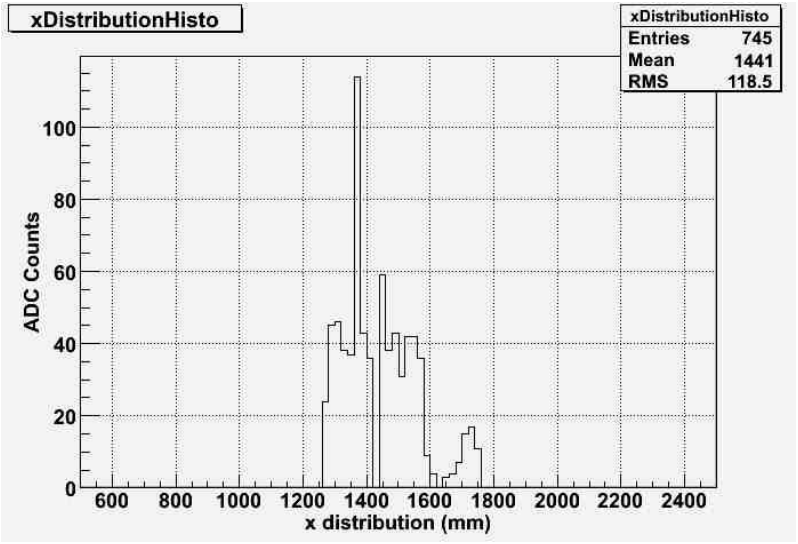
Run #7065

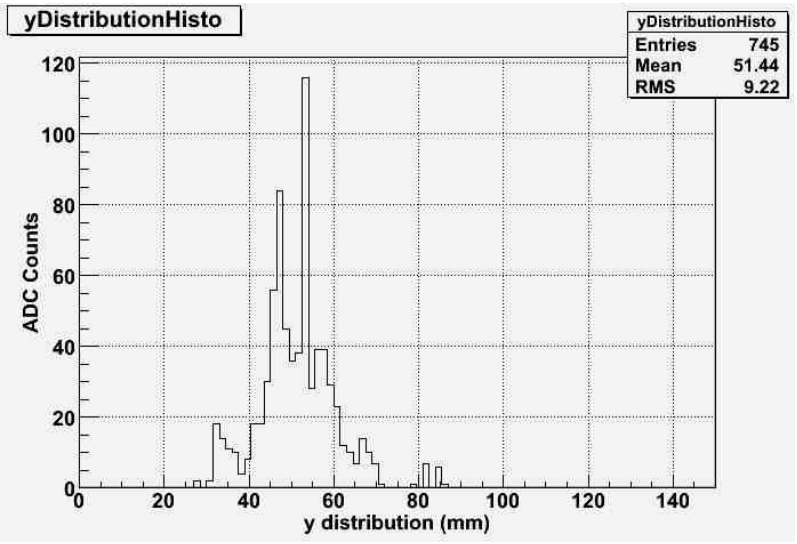

xDistributionHisto
xDistributionHisto
Entries 669
Mean 1458
RMS 115.4
ADC Counts
x distribution (mm)

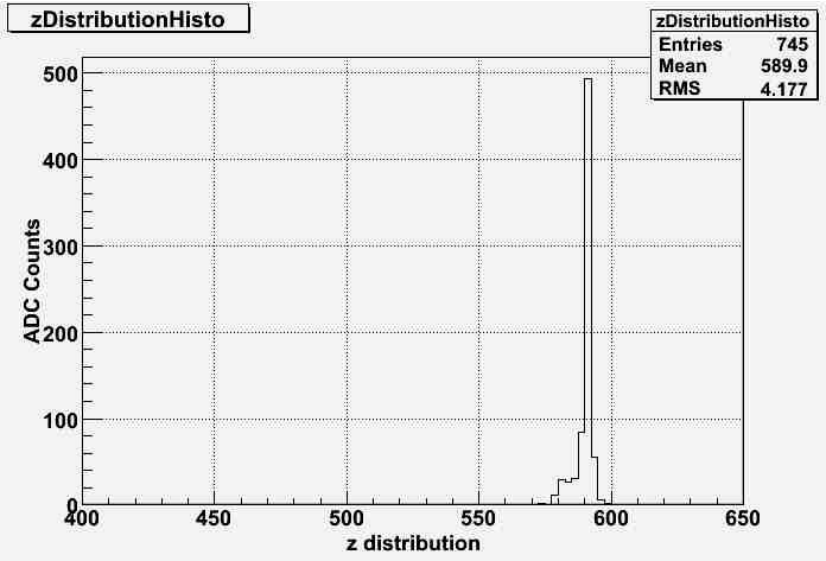

yDistributionHisto
yDistributionHisto
Entries 669
Mean 57.98
RMS 10.51
ADC Counts
y distribution (mm)


zDistributionHisto
zDistributionHisto
Entries 669
Mean 585.4
RMS 10.03
ADC Counts
z distribution

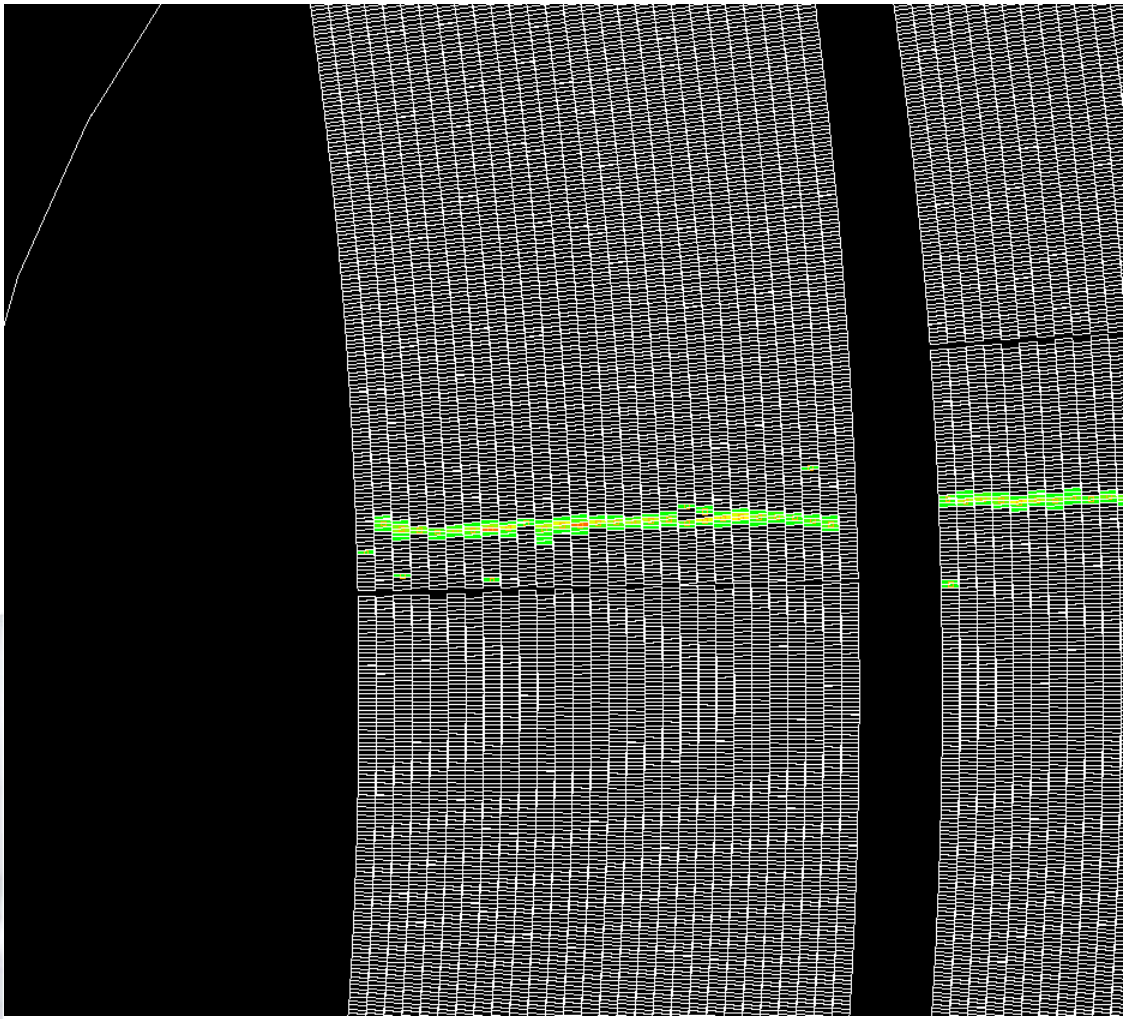
Run # 7050

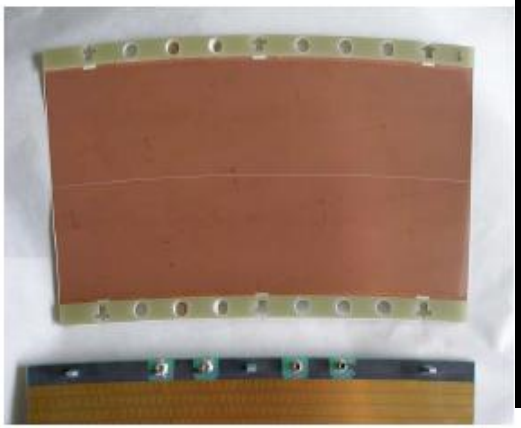

xDistributionHisto
xDistributionHisto
Entries 745
Mean 1441
RMS 118.5
ADC Counts
x distribution (mm)


yDistributionHisto
yDistributionHisto
Entries 745
Mean 51.44
RMS 9.22
ADC Counts
y distribution (mm)

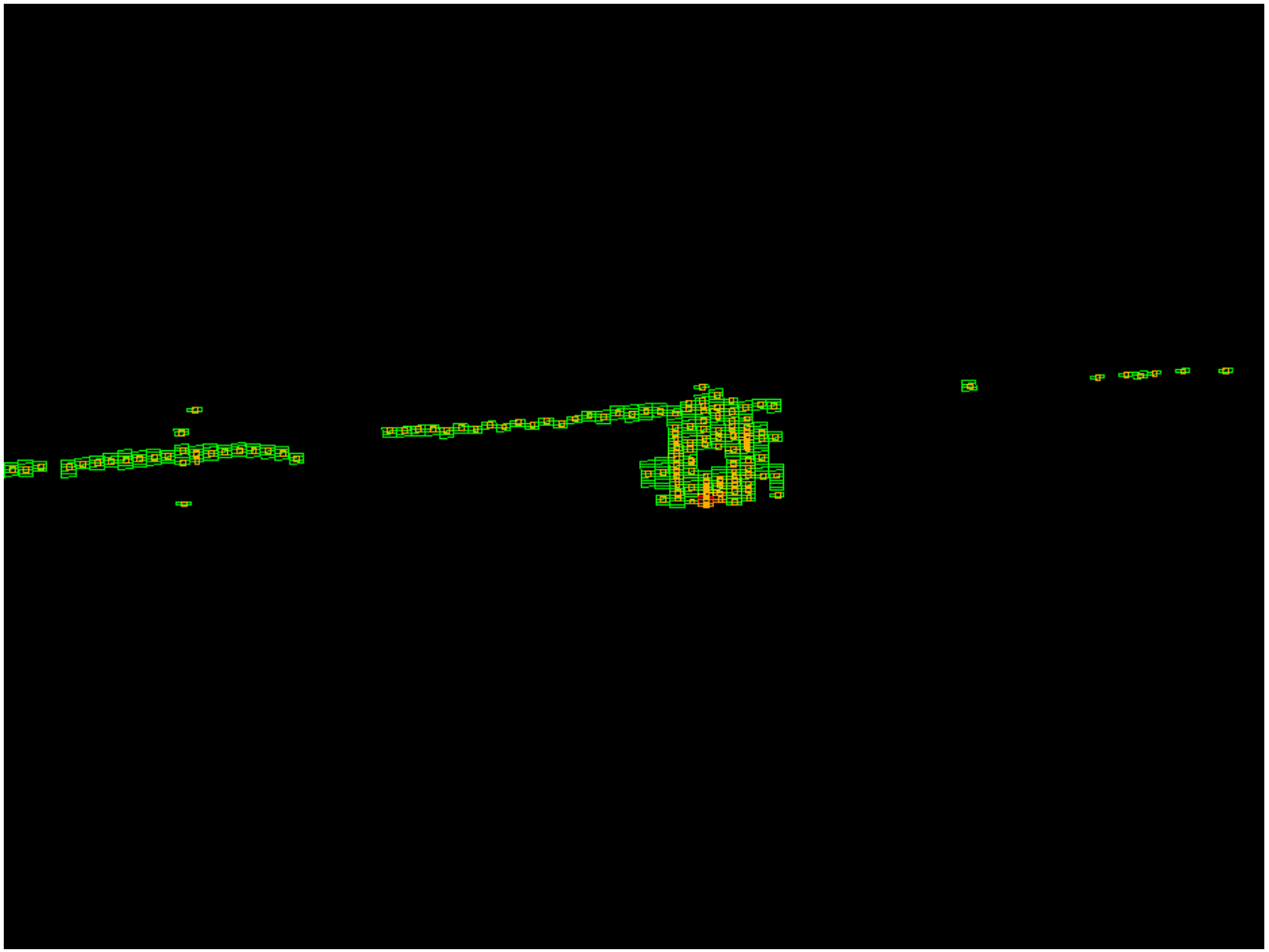

zDistributionHisto
zDistributionHisto
Entries 745
Mean 589.9
RMS 4.177
ADC Counts
z distribution

Non-straight tracks





Curler found



Summary & Outlook

- Data successfully reconstructed verifying the following processors;
  - **TrackerRawDataToDataConverterProcessor**
  - **ADCPulseConverterProcessor**
  - **HitTrackFinderTopoProcessor**
  - **ChannelMapperProcessor**
  - **ConditionsProcessor**

- Further work needed into order to successfully determine TPCSeedTracks and Track finding techniques

Thank you!

- Thank you to my supervisor Klaus Dehmelt
- The FLC group
- Joachim Meyer and DESY

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THANK YOU FOR YOUR ATTENTION!