Results from the October 2014 CERN test beam of LumiCal

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on behalf of the FCAL collaboration

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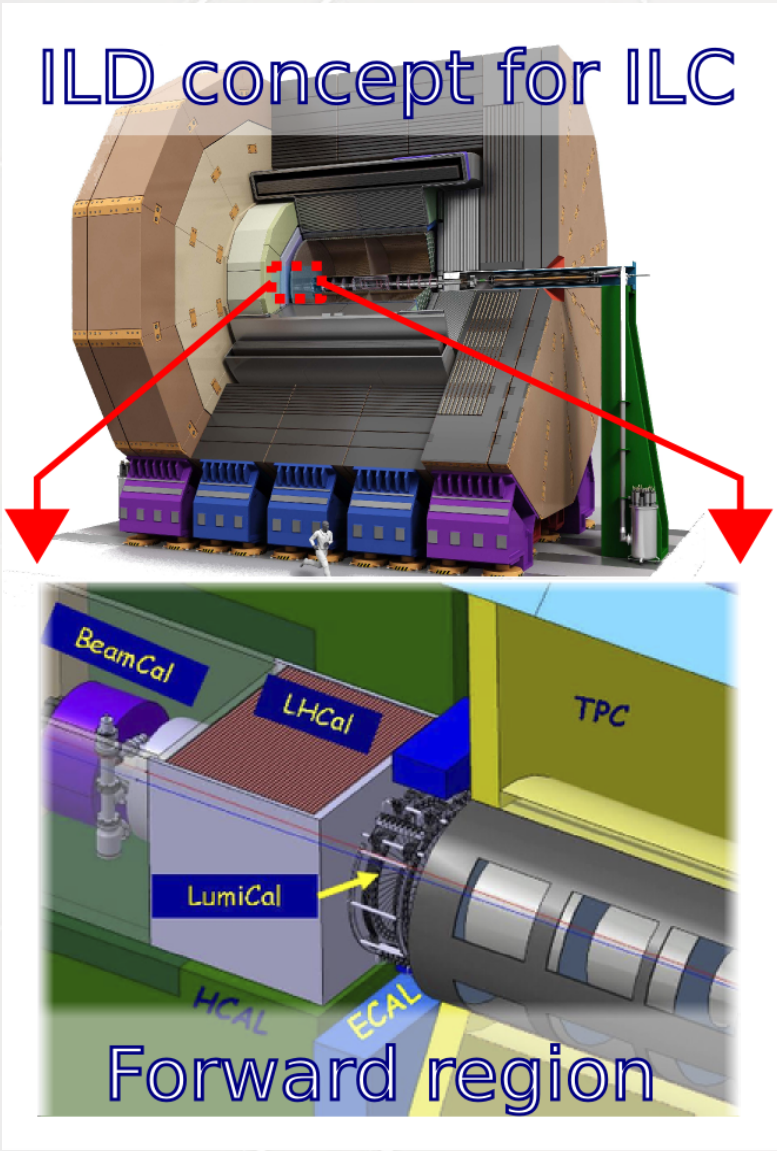
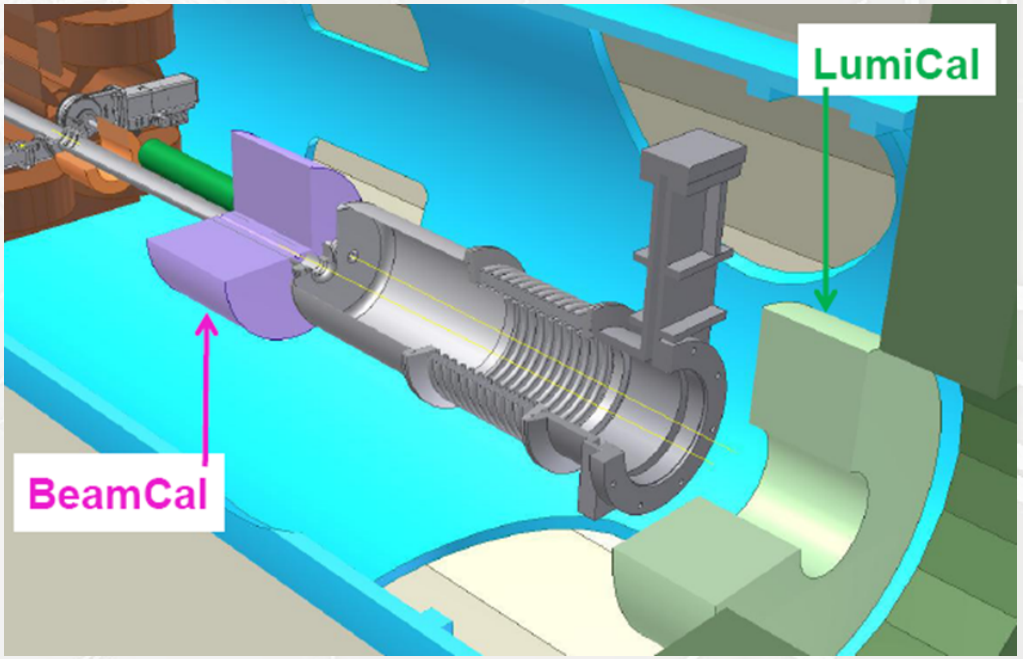
FCAL

Detectors at ILC and CLIC



Optimisation of the design of the very forward region of LC detector

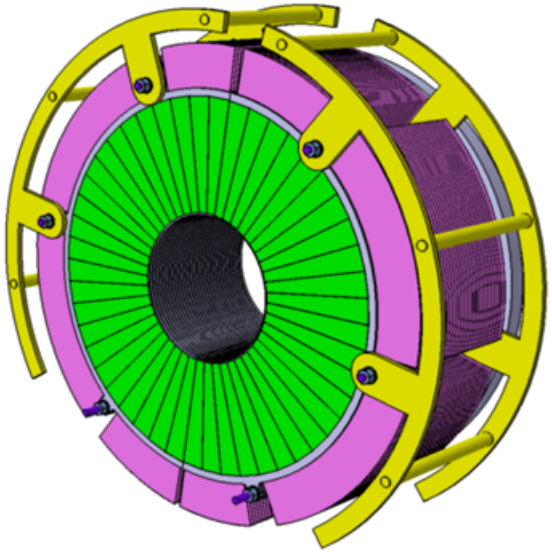
- Precision luminosity measurement
- Fast feedback and beam tuning
- Detector hermeticity



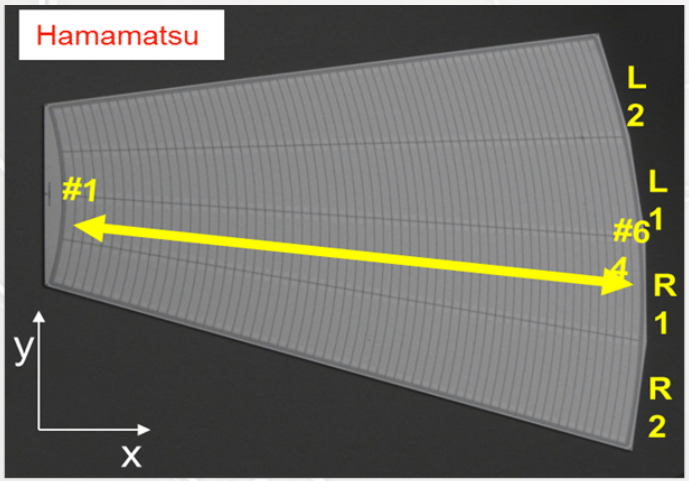
Luminosity in e^+e^- collider

Requirements on the luminosity measurement:

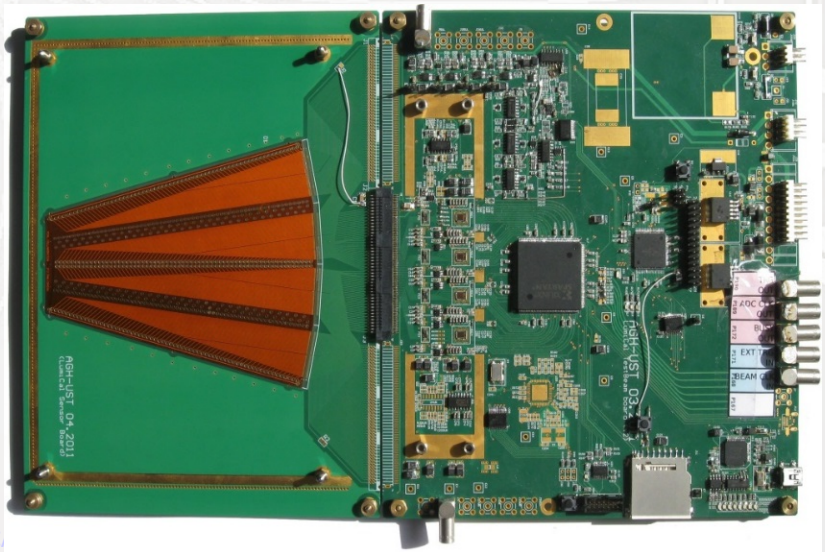
- Precise measurement of the luminosity
- (10^{-3} at ILC, 10^{-2} at CLIC)
- Low angle physics
- Challenge: Beamstrahlung



Sensor technology: Silicon pad sensors, radially segmented, 64 pads, each 320µm thick



Fully functional sensor plane, glued on a 3.5mm PCB



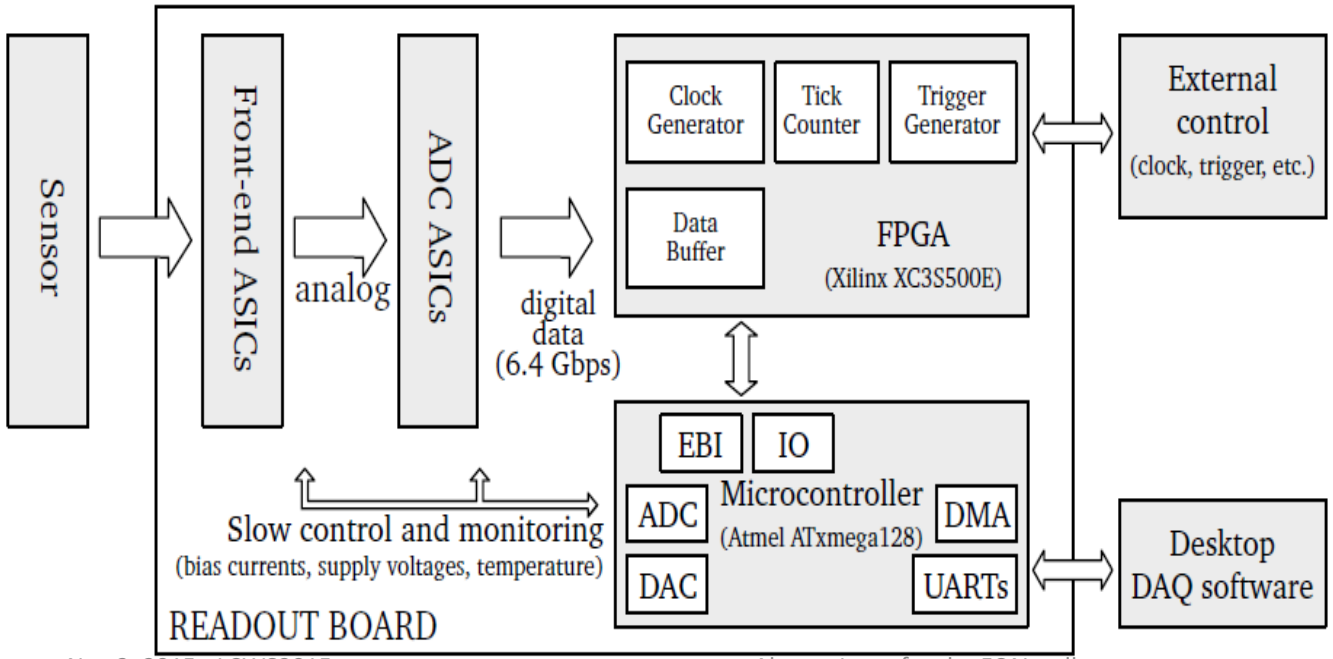
Test Beam objectives

The objective of this test beam was to demonstrate for the first time that the base-design for the forward calorimeters is reasonable and well understood.

- Test and demonstration, for the first time, a multi-plane operation of the prototype forward detector system.
- Study the development of the electromagnetic shower in a precise and well known structure and compare with MC simulations.
- Try to apply a reconstruction algorithm on raw data and particle tagging (electron and hadrons).
- Attempt to measure energy resolution and the precision of the polar angle reconstruction.

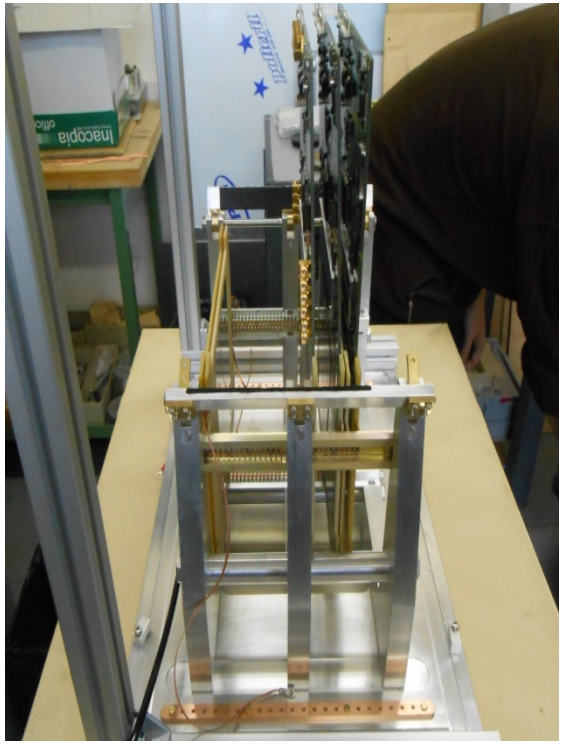
LumiCal Basic Plan

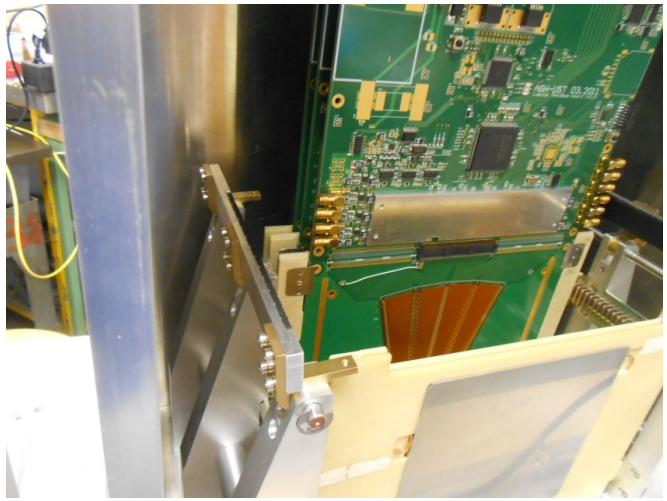
- The basic plan is a complete detector module equipped with first level DAQ.
- It includes the complete readout chain: Si-sensor, kapton fan-out, front-end electronic and multichannel 10-bit pipeline ADC ASIC.
- ASIC is controlled by FPGA based data concentrator.
- The complete module has 4 multi-channels chips with 8 channels each.

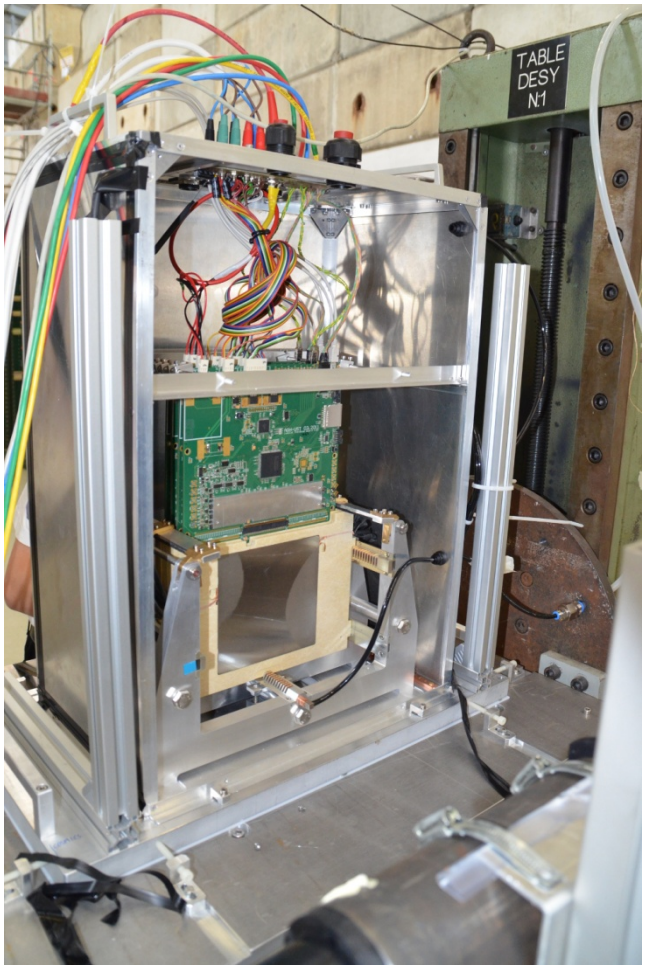


Multi - layer prototype

This test beam was based on a dedicated rigid structure for precise alignment of sensor and absorber planes, as a prototype calorimeter



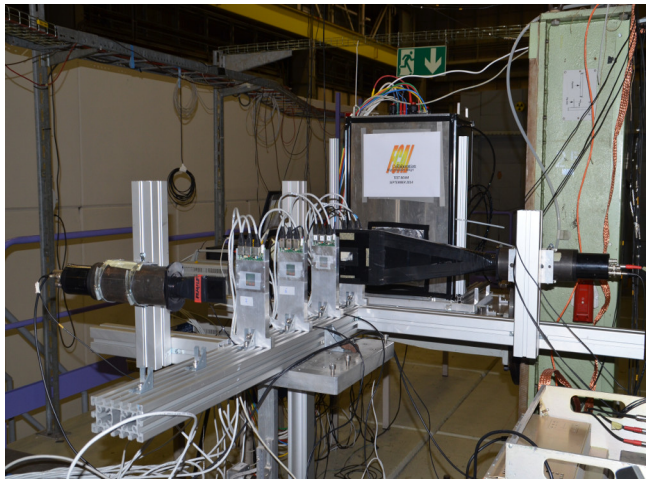




Set up

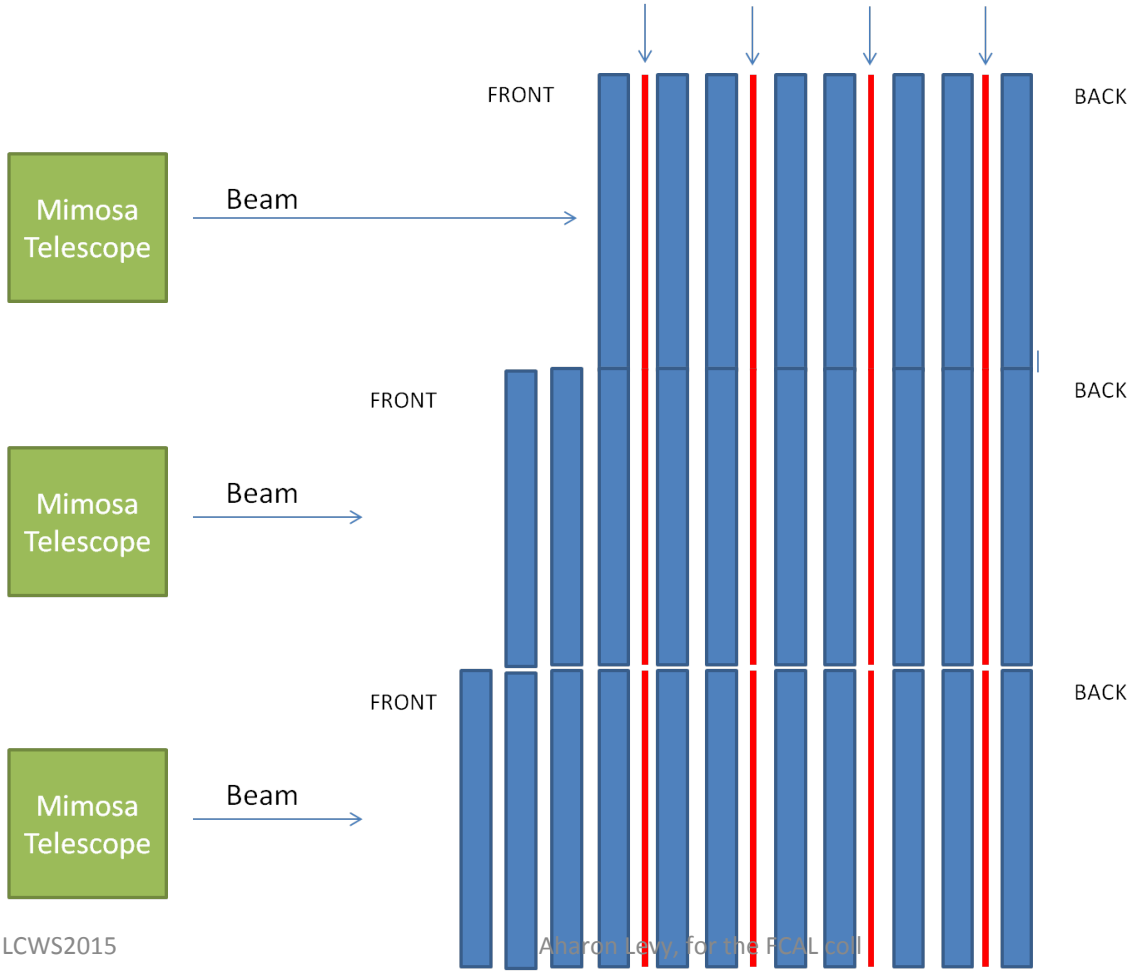
The beam test was held in beam-line T9 for one week between 22-29 of October.

We used 4 LumiCal planes inside the rigid structure as the calorimeter prototype, with 4 MIMOSA sensors in front as beam Telescope for tracking. (EUDET Telescope – not available; got help from the Aarhus group (Thank you!!)).



Configuration

During test beam we used 3 different configuration for the calorimeter :



Beam conditions

For all configurations we used a 5 GeV negatively charged beam.

For all configurations we took:

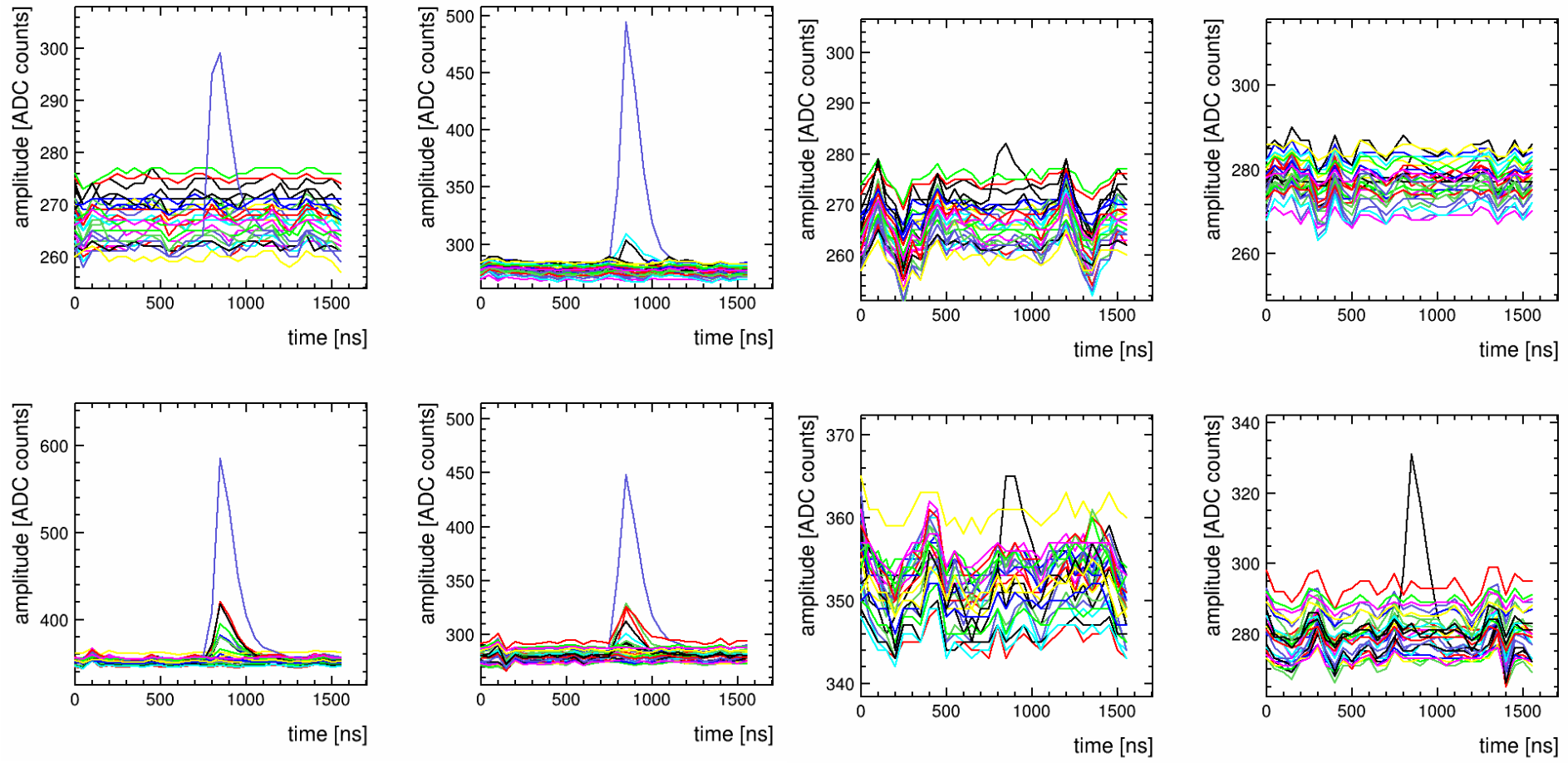
1. **Electron and Muons,**
2. **Hadrons (anticoincidence of e^- & μ^-).**

Runs/ events	e^- & μ^-	Hadron
Configuration 1	75 / 30k	4/20k
Configuration 2	60/36k	1/2k
Configuration 3	55/45k	8/38k

Signal processing

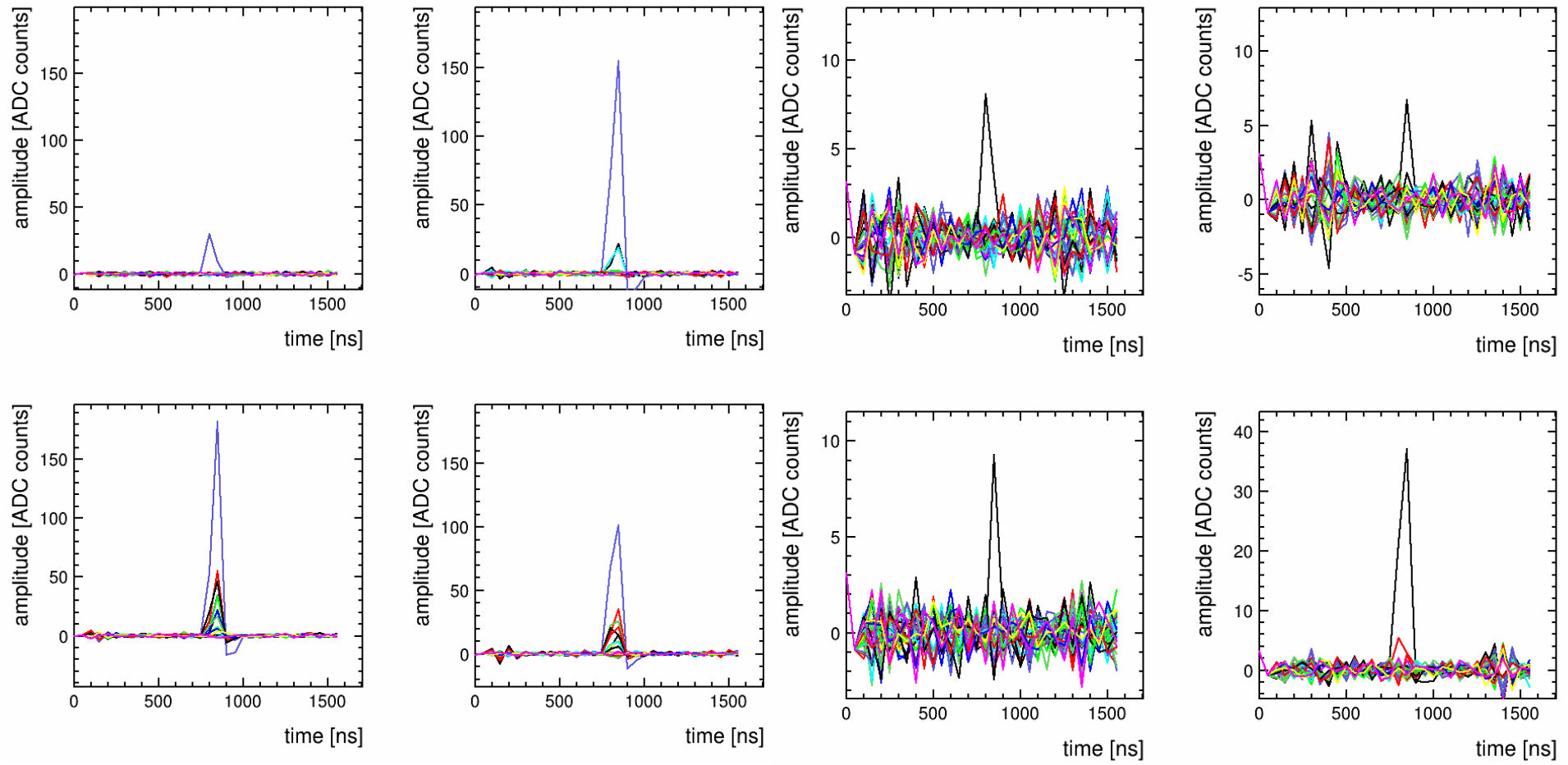
- **For each event, the basic steps of signal processing were used, which included:**
  - ❖ **Base-line removal and RMS calculation for each channel (samples 0 - 14).**
  - ❖ **CMN subtraction.**
  - ❖ **Deconvolution filter of CR-RC shape (T_{smp} = 50nsec, τ = 68nsec).**

A single event – raw



- electron
- muon

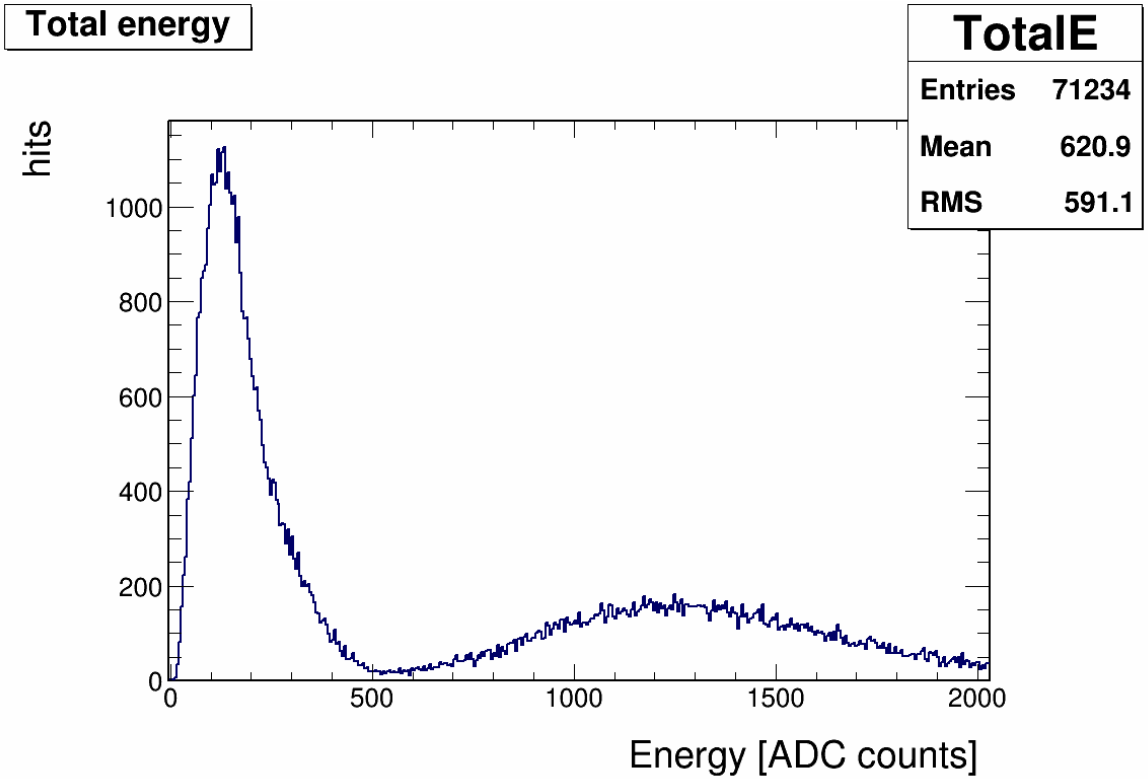
A single event – after processing



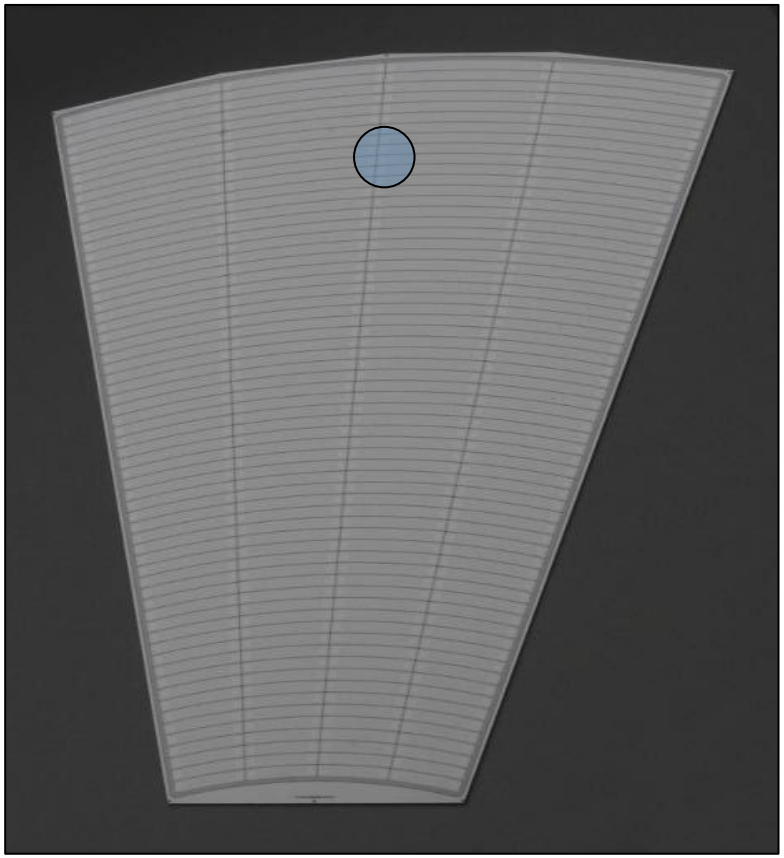
- electron
- muon

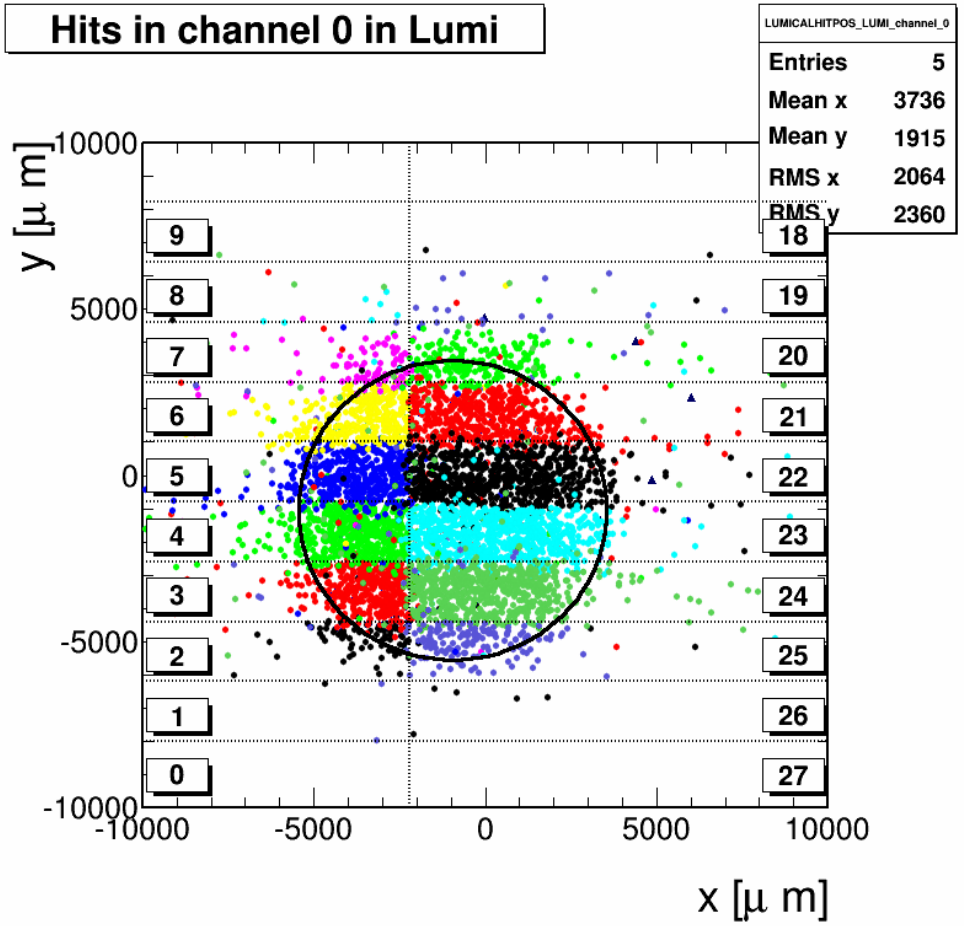
electron-muon separation

Separation of electrons from muons is done by a cut on the raw total energy (550 ADC counts), sum of all 128 channels in the stack for one event.

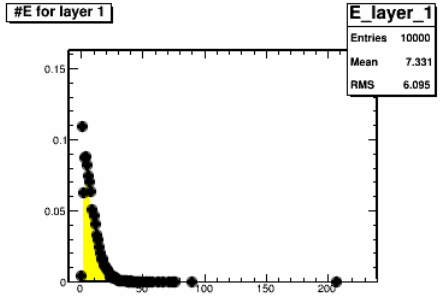


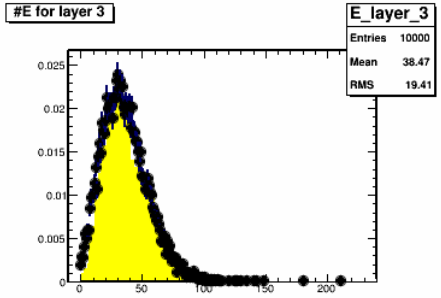
Telecope and LumiCal track-matching

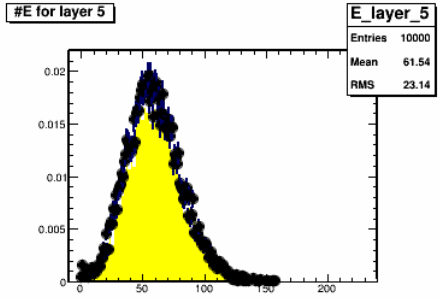


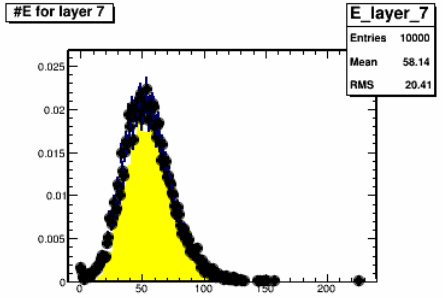


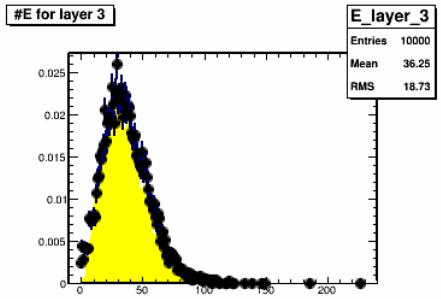
Layer energy distribution

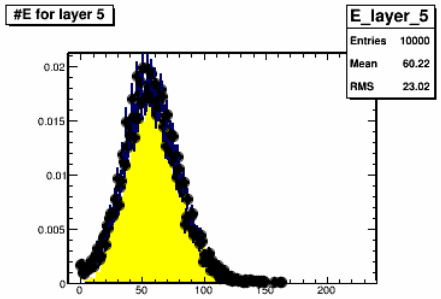


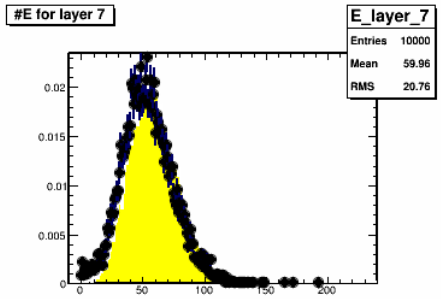


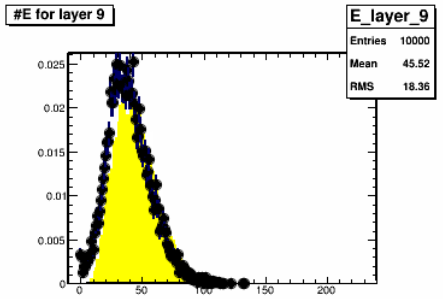


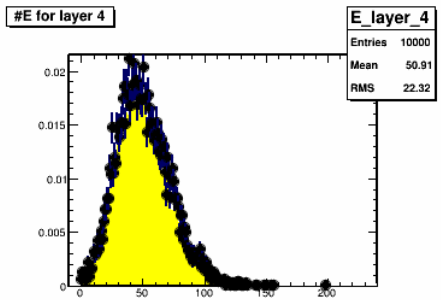


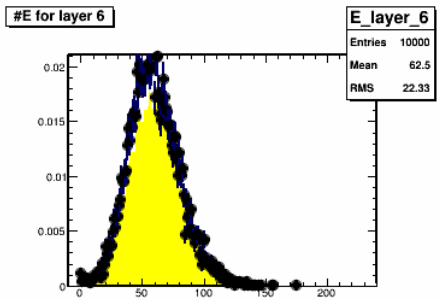


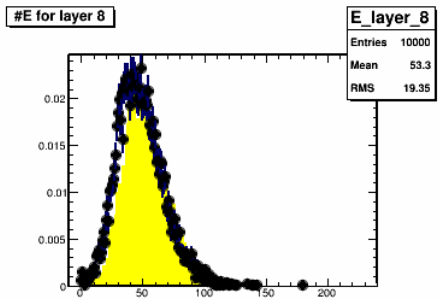




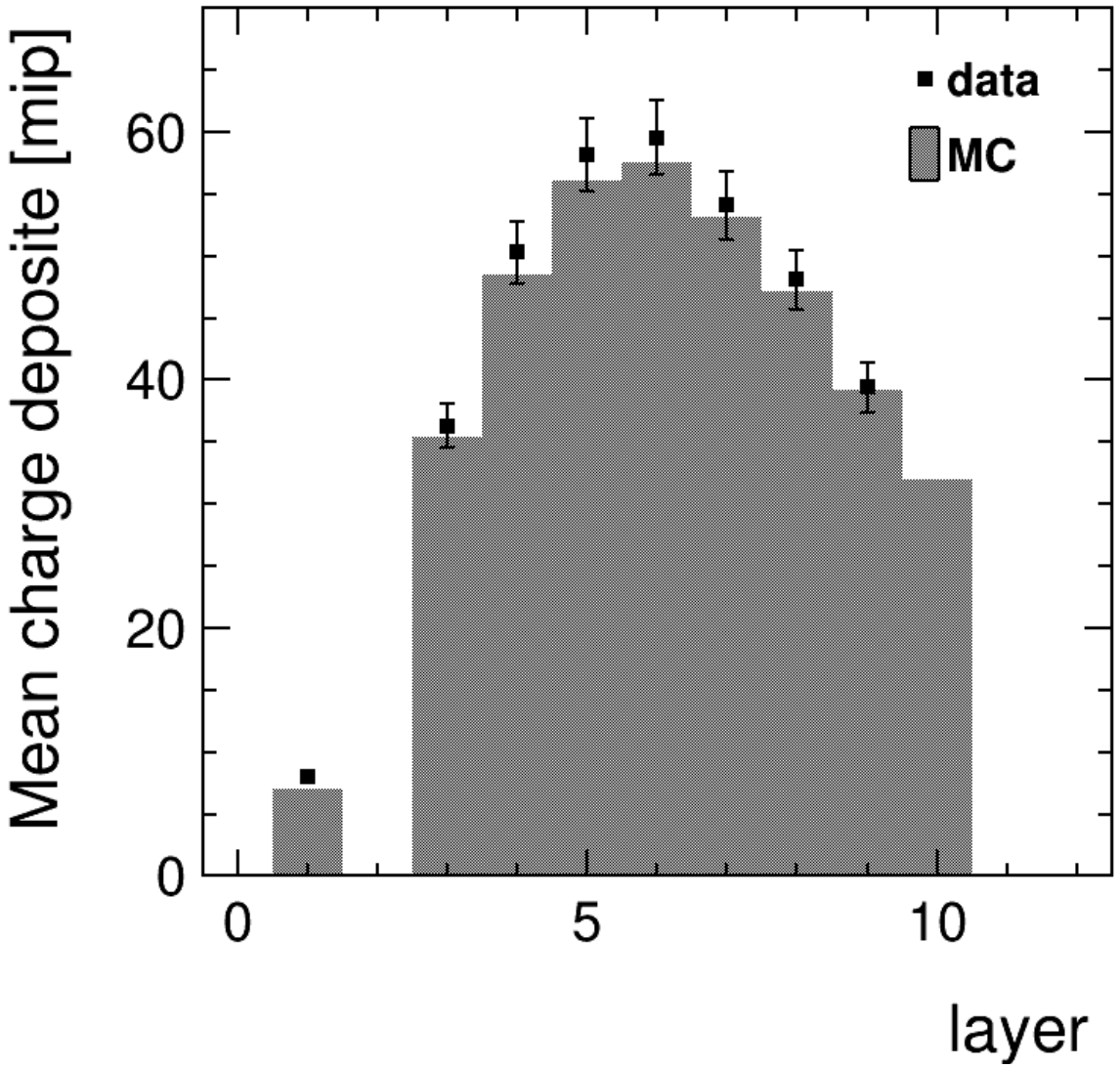








Mean energy deposited per layer



Analysis plan & summary

Basic beam test analysis is done (at last…..)

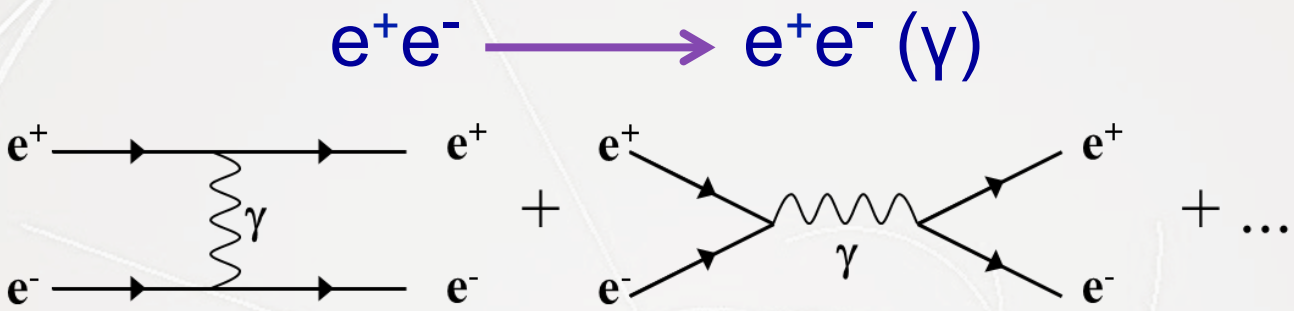
- **Offline calibration. √**
- **LumiCal basic signal processing. √**
- **Reconstruction of track and Telescope alignment. √**
- **Synchronisation and LumiCal alignment. √**
- **Online (Muon) calibration. √**
- **Study E.M. showers development (compare with DD4HEP simulation) √.**

to do:

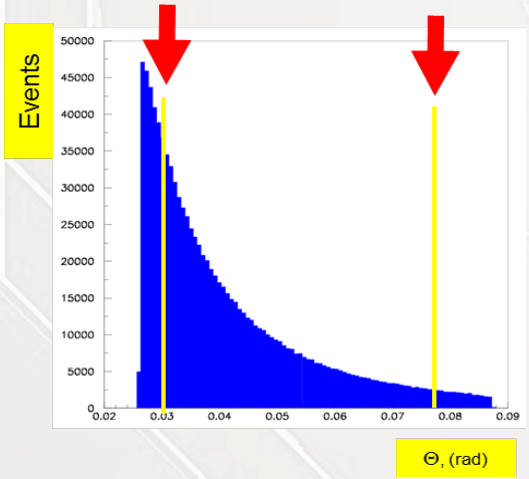
- **Molière radius…**
- **Compare hadron, muon and electron runs.**
- **Apply clustering and reconstruct showers for spatial and angular resolution.**
- **……..**

Luminosity at e^+e^- collider

Bhabha scattering at low polar angles is used as a gauge process



$$\frac{d\sigma_B}{d\theta} = \frac{2\pi\alpha_{em}^2}{s}\frac{\sin\theta}{\sin^4(\theta/2)} \approx \frac{32\pi\alpha_{em}^2}{s}\frac{1}{\theta^3}$$



$$\mathcal{L} = N/\sigma$$

Count Bhabha events

From theory