Test Beam Results and Tracker in Front of LumiCal

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On behalf of TAU FCAL group

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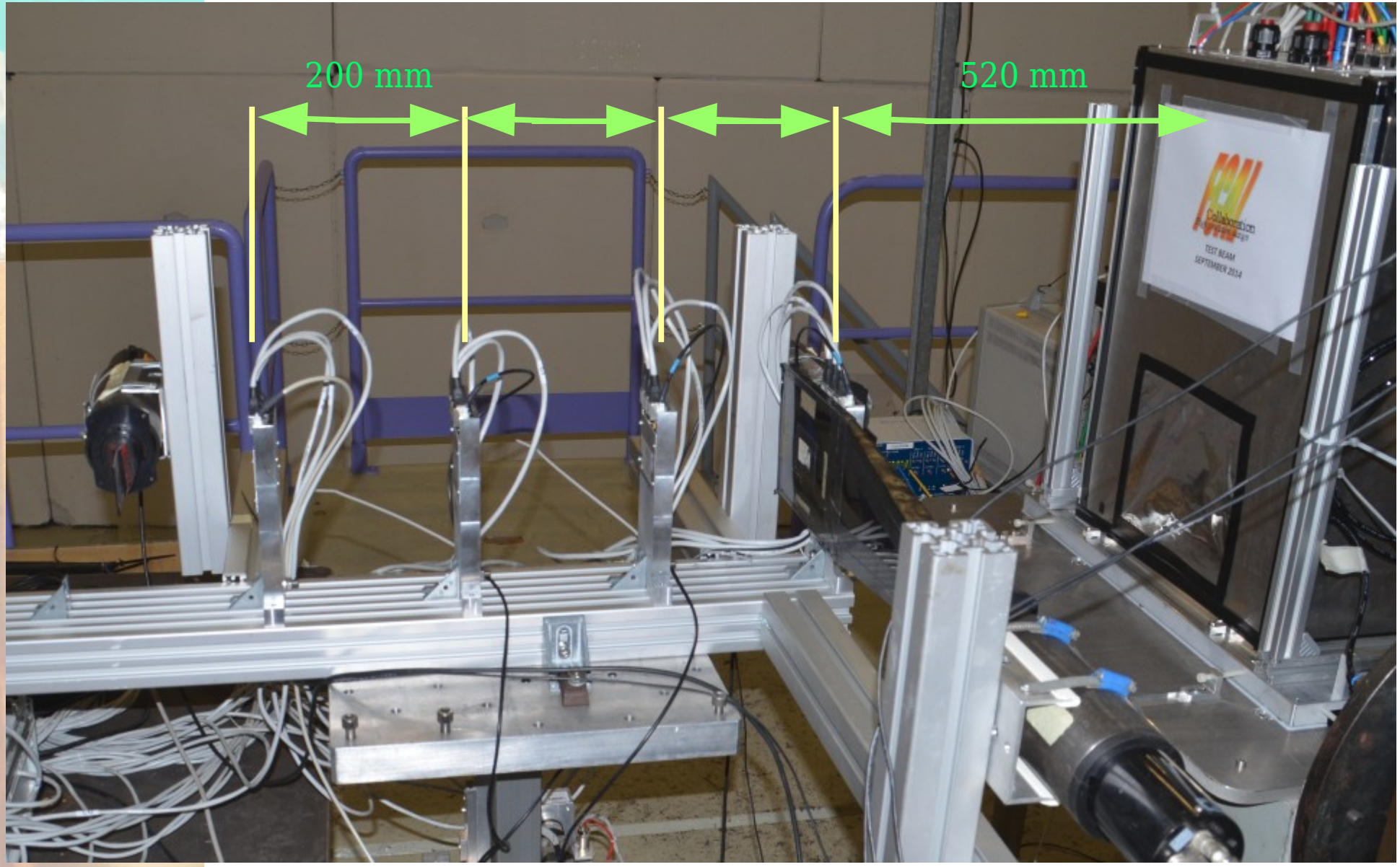
Overview

- LumiCal test beam goals and equipment
- LumiCal - telescope synchronization
- Test beam data processing
- Simulation of Tracking Detector in front of LumiCal
- Summary and plans

Test Beam Objectives

- Check for the first time multi-plane operation of the LumiCal prototype with 4 detector modules;
- Measure key parameters in multi-plane operation: baselines, noise, common-mode noise, signal-to-noise ratio, etc;
- Study the development of the electromagnetic shower in a precise and well known structure and compare with MC simulations.
- Check reconstruction algorithms on raw data and particle tagging (electron and hadrons).
- Attempt to measure energy resolution and the precision of the polar angle reconstruction.

Telescope and LumiCal Layout



Combining LumiCal with Telescope

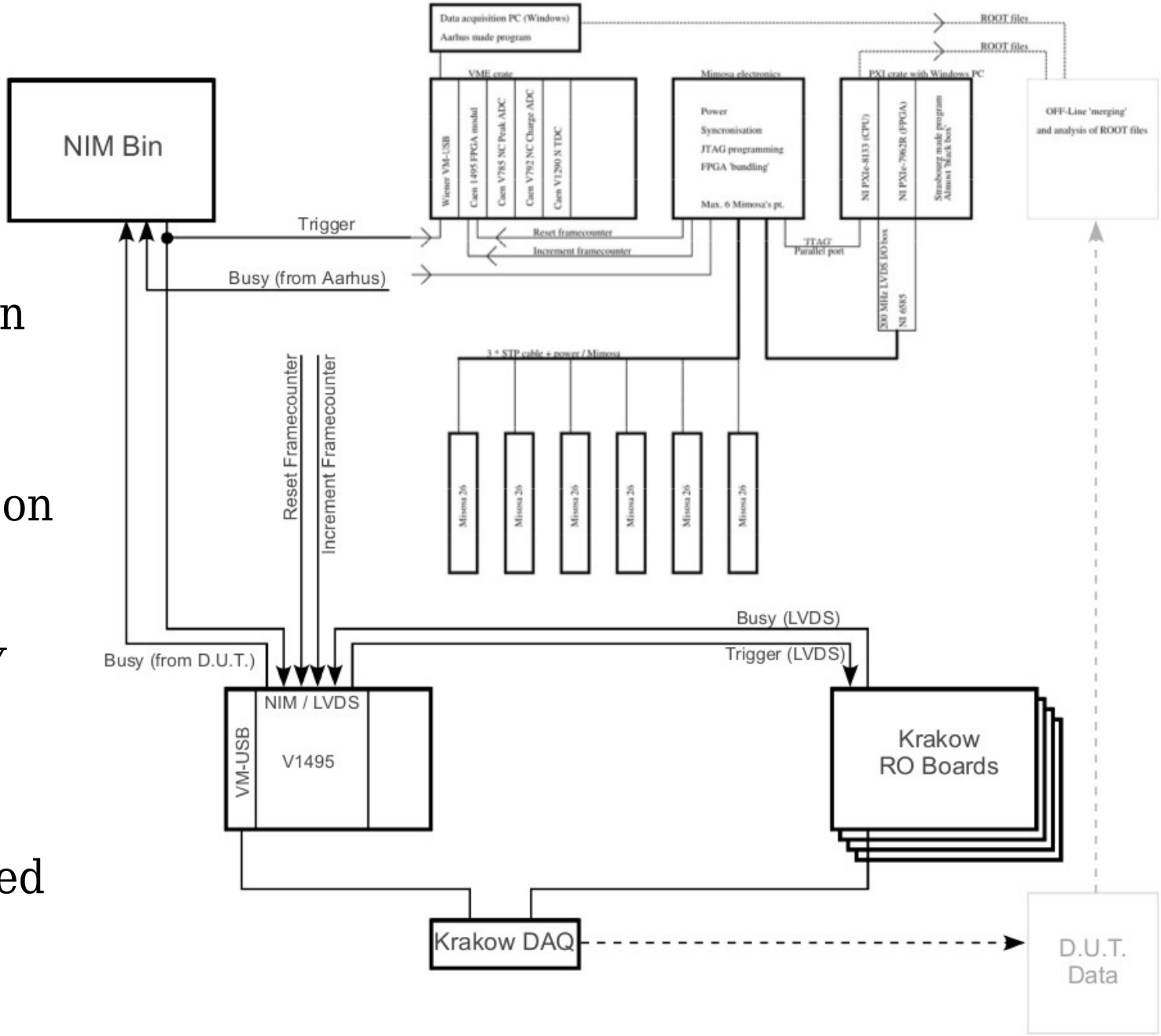
- In the past EUTelescope was used for FCAL detectors test beams, but this time it was not available...
- Aarhus University group kindly agreed to participate in beam test with their telescope.
- Since two systems used different DAQ the main issue was the synchronization between the event in the FCAL DAQ and the event in the MIMOSA Telescope DAQ.
- Constraints: time, minimum changes in each DAQ system.
- Technically the idea was to use MIMOSA hardware frame number and distribute signals Increment_Frame_Counter and Reset_Frame_Counter. And finally match between TLU number (FCAL) to Frame counter (MIMOSA).
- For this purpose:
  - AUX hardware based on v1495 I/O module was programmed and used;
  - AUX software in EUDAQ was developed;
  - Frame counter extracting from the MIMOSA file was implemented.

Combined LumiCal - Telescope System

Readout electronics study and modification was made by Krakow group.

AUX hardware based on v1495 I/O module accomplished by Hans Henschel, DESY Zeuthen group.

AUX software in EUDAQ was developed by Itamar Levy, TAU.



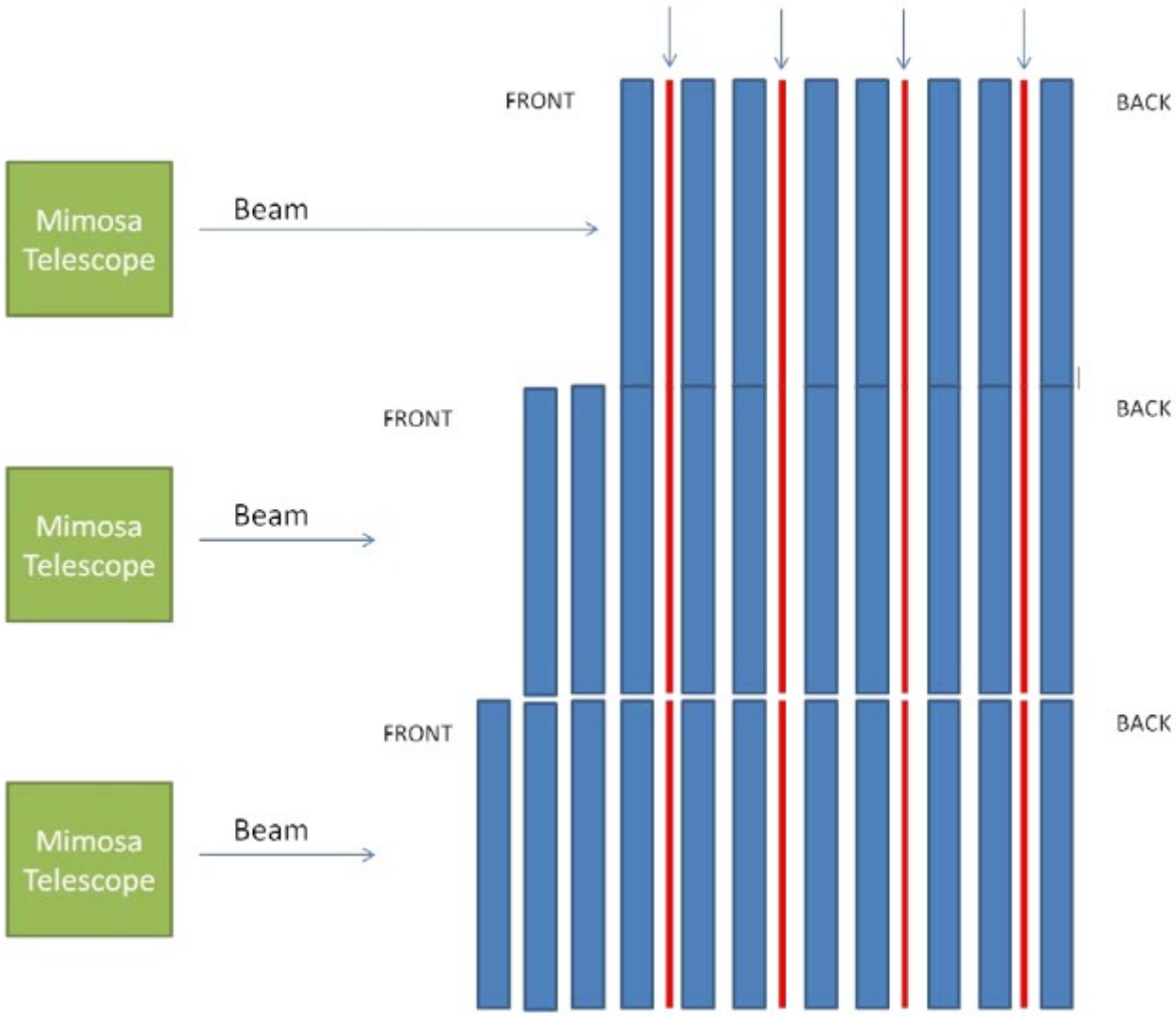
LimiCal Configurations

Three different configuration for the LumiCal were used.

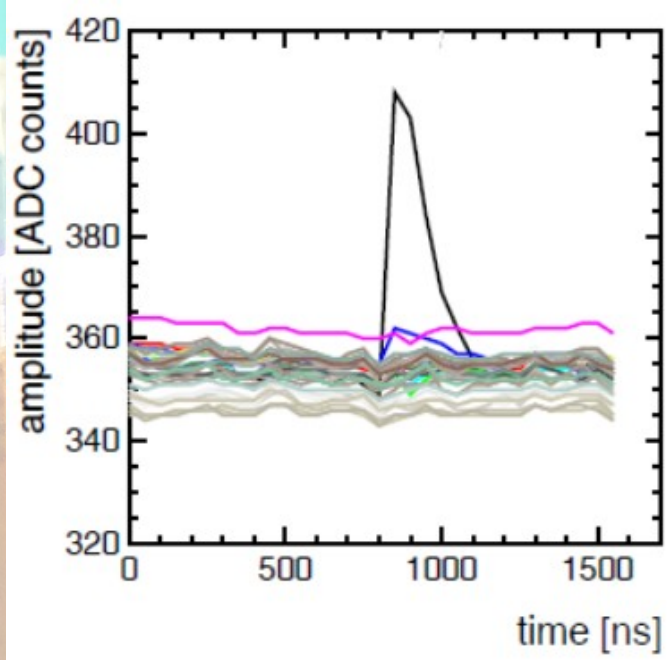
CERN PS beam at T9

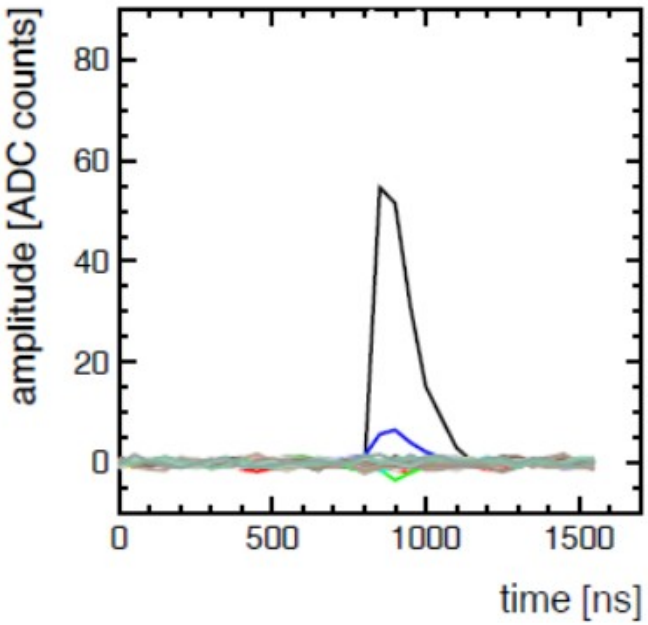
5 GeV beam;
Trigger on:
- Electrons and muons;
- Hadrons.

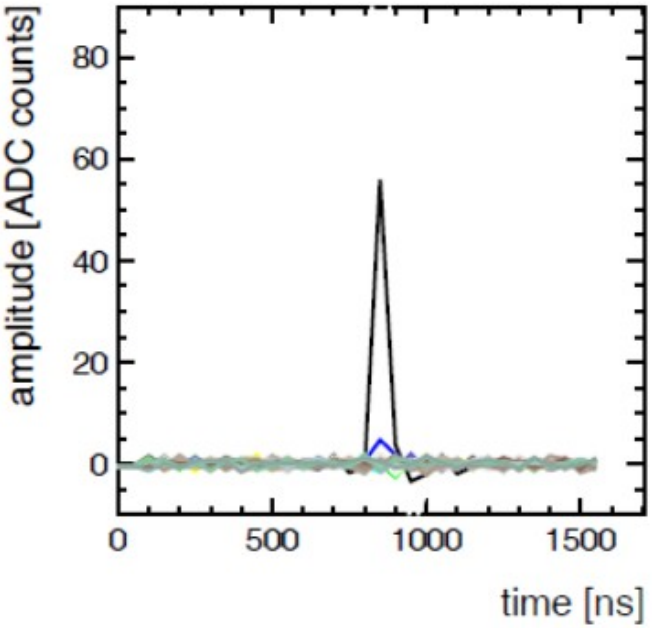
For different configuretions
55k-75k e- events
were collected.



LumiCal Signal Processing







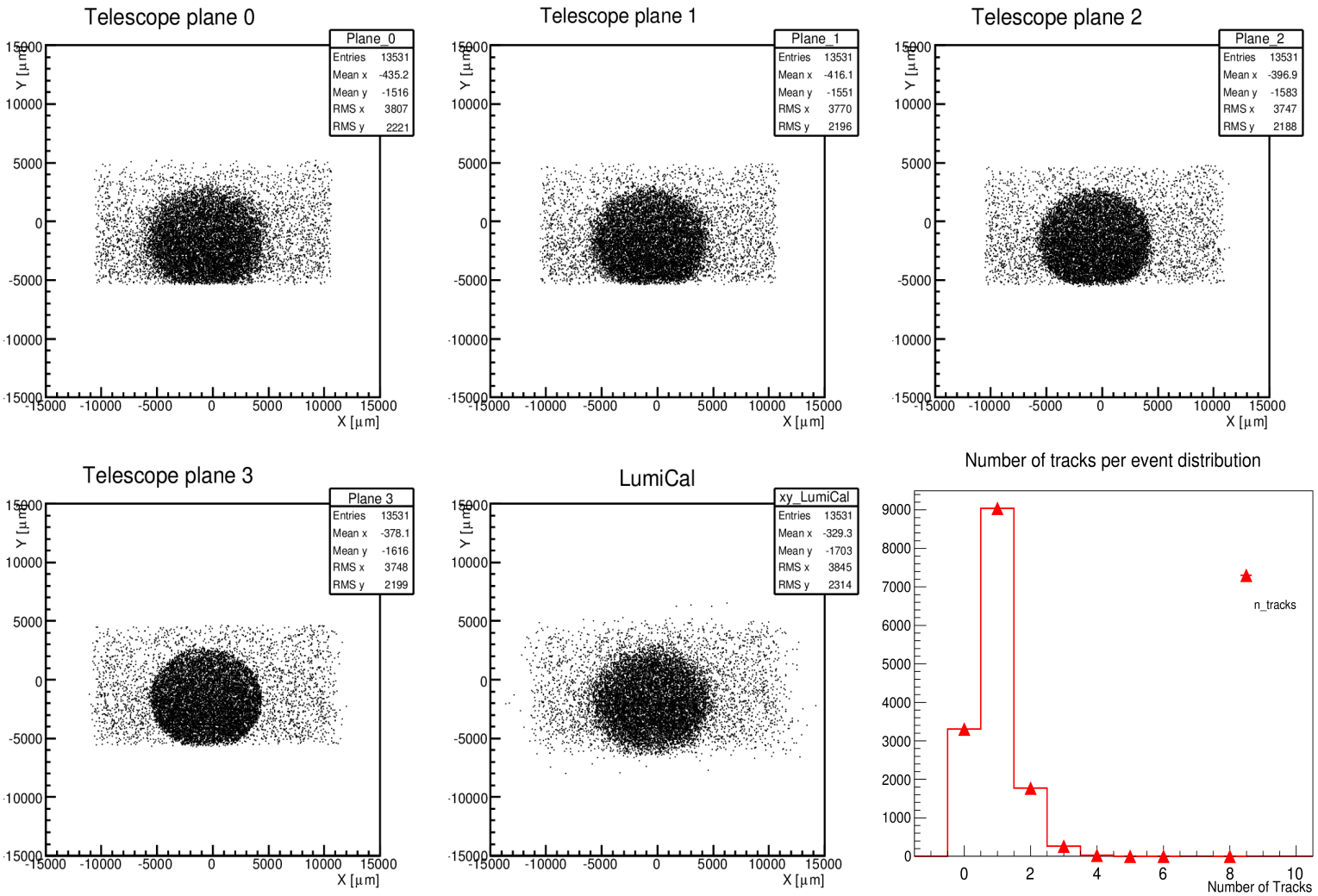
Raw data

Baseline and common mode noise correction

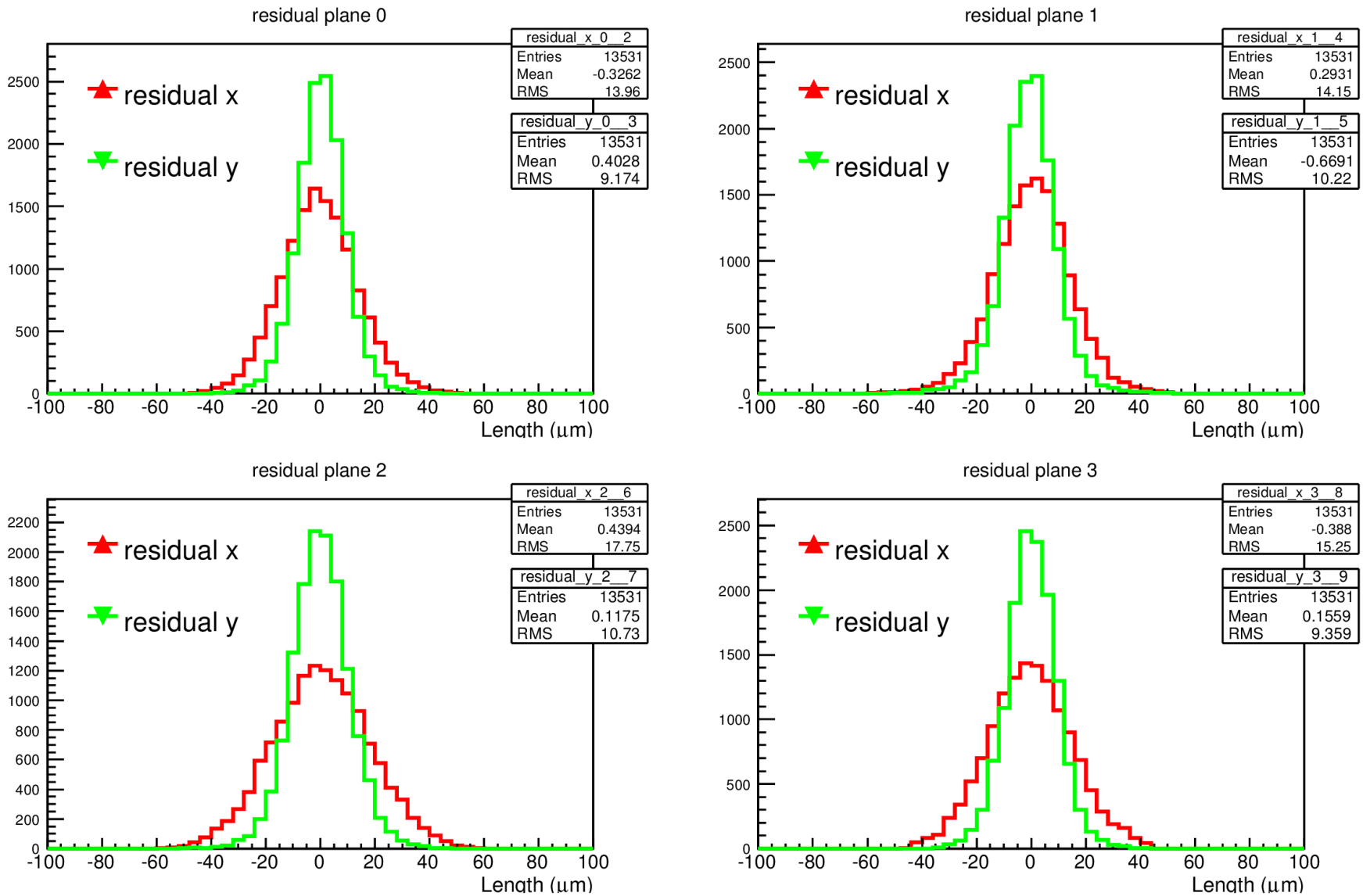
Deconvolution

Occupancy in Telescope

- Telescope data is reconstructed using TAF (TAPI Analysis Framework, IPHC, Strasbourg), a bit modified to enable synchronization with LumiCal;
- Alignment and tracking based on software from telescope group of Aarhus University.

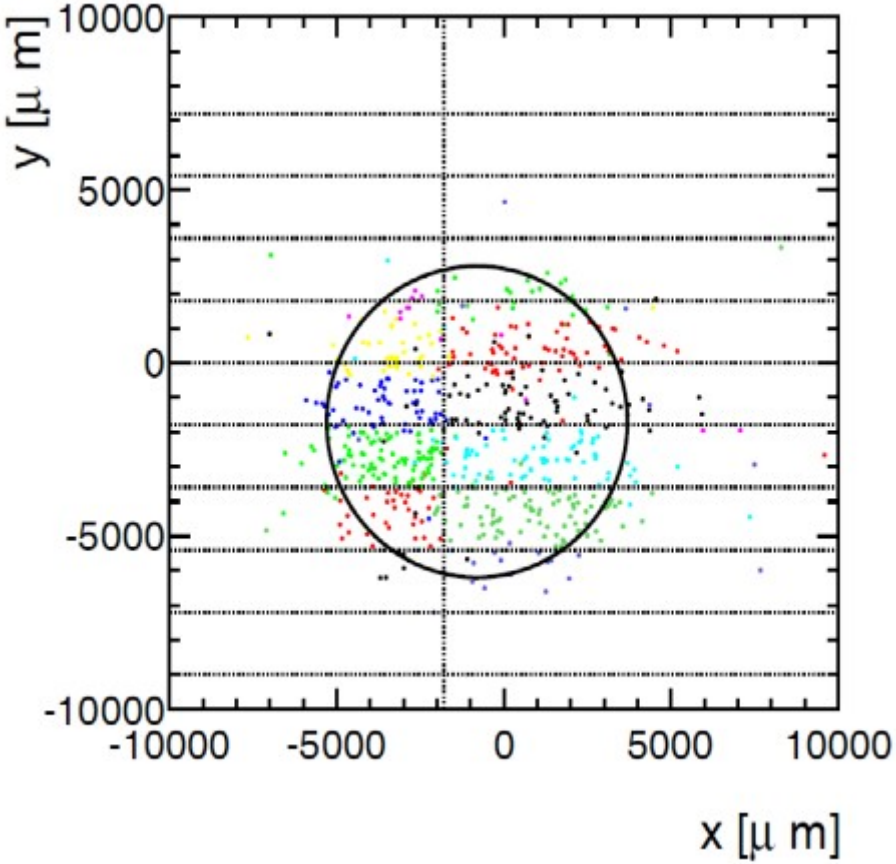


Track Residuals Distribution in Telescope



Test of LumiCal -Telescope Synchronization

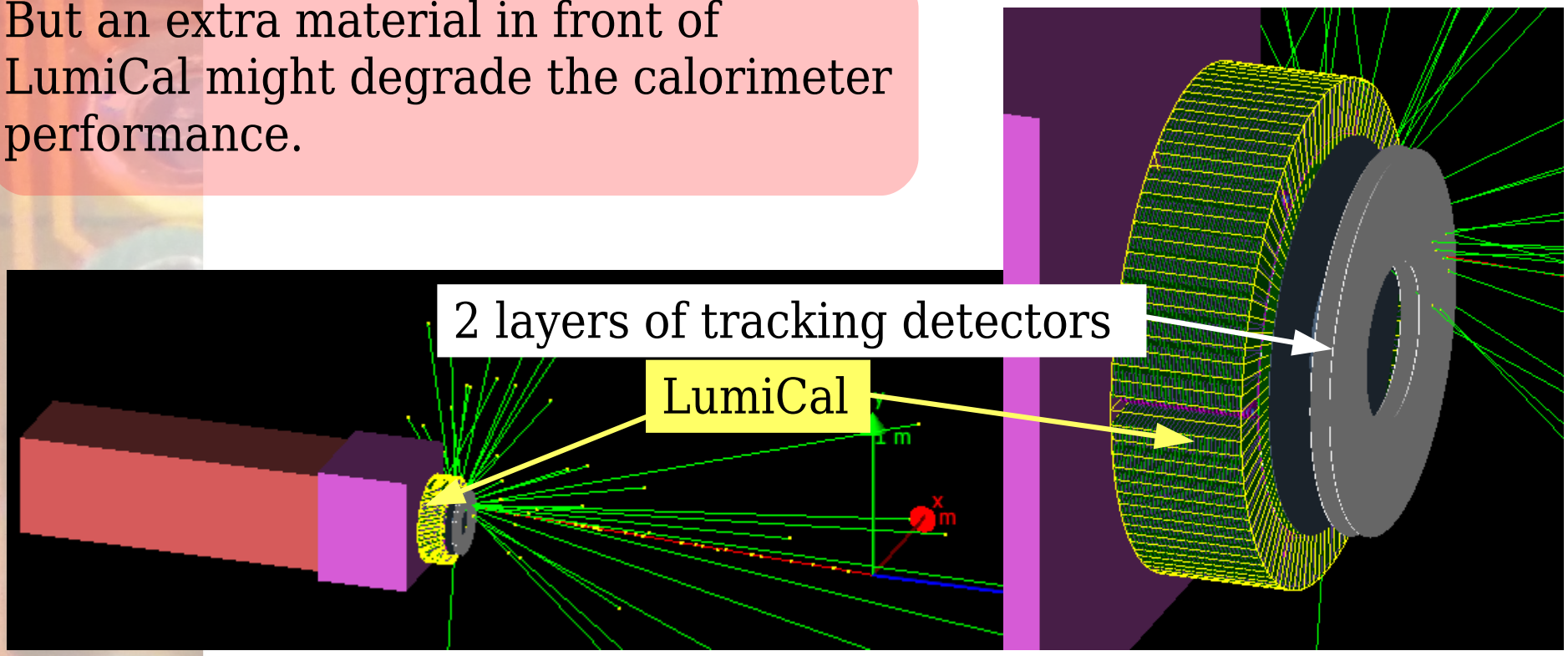
- Extrapolation of the tracks seen by the beam telescope to the first layer of LumiCal reproduces the round shape of the trigger scintillators.
- Position of the point is defined by the reconstruction of telescope data;
- Color of the point is defined by the channel which has a signal in LumiCal;
- The fact that this type of plot reproduce the pad structure of LumiCal sensor means that synchronization works successfully.



Tracking Detector in Front of LumiCal

- Improve polar angle measurement accuracy;
- LumiCal alignment;
- Provide more information to enable e/γ identification, important for various physics studies.

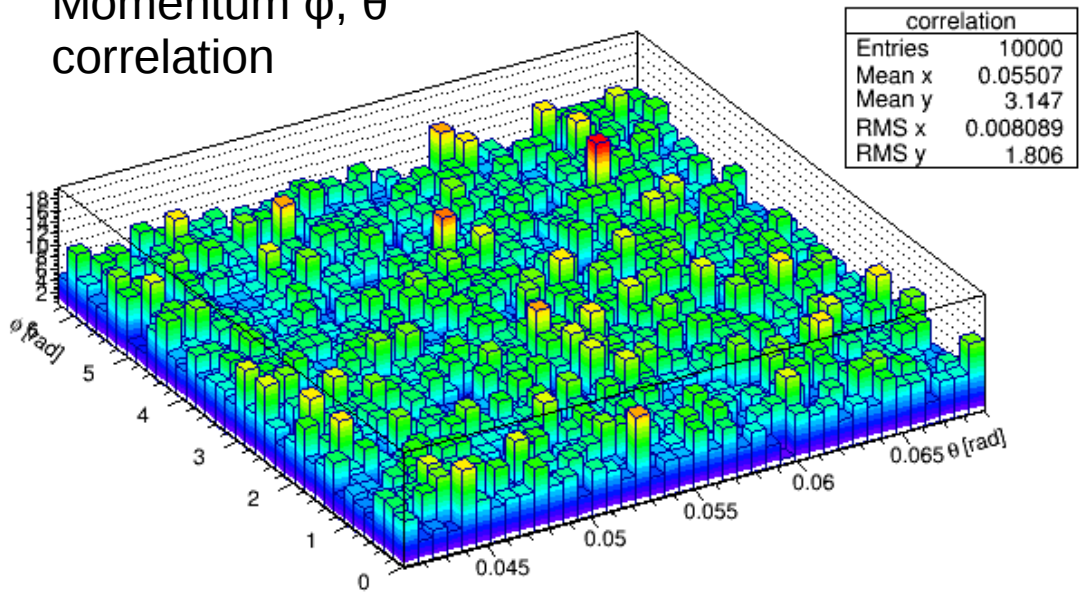
But an extra material in front of LumiCal might degrade the calorimeter performance.



Simulation

- Events with one e^-, 250 GeV;
- Uniformly distributed on momentum φ (0, 2π), θ (41, 69 mrad).

Momentum φ, θ correlation

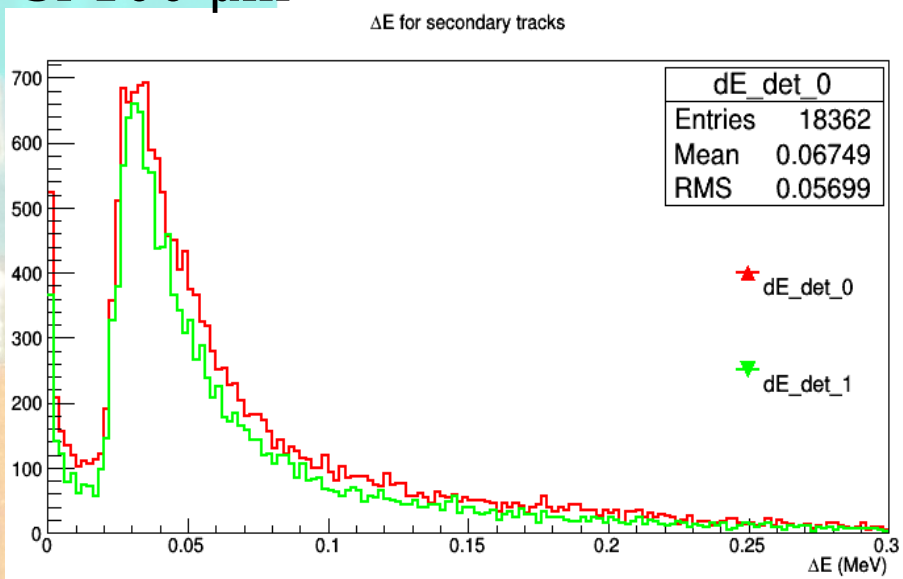


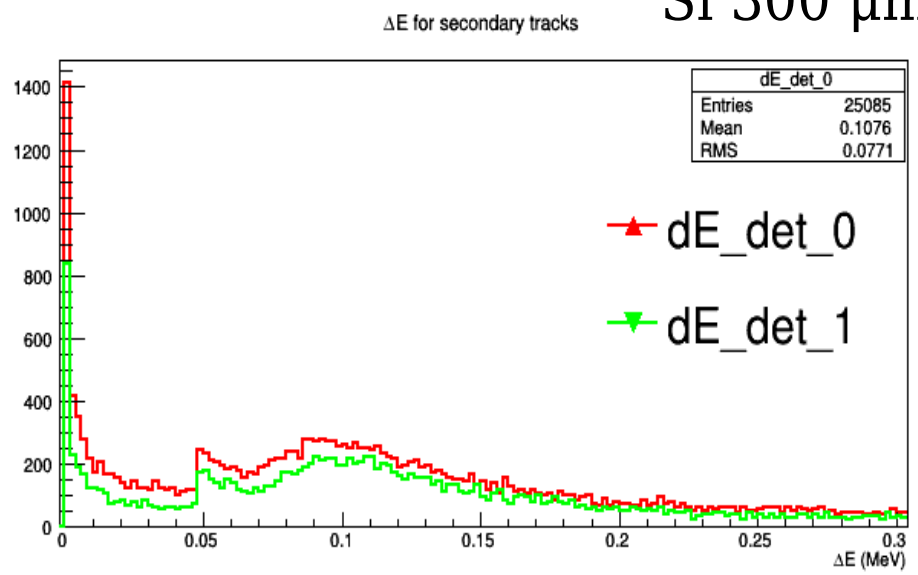
- LumiCal Simulation (LuCaS) Geant4 application was used.
- It is composed from modified Mokka classes with LumiCal geometry
- Recently LCIO output was implemented.

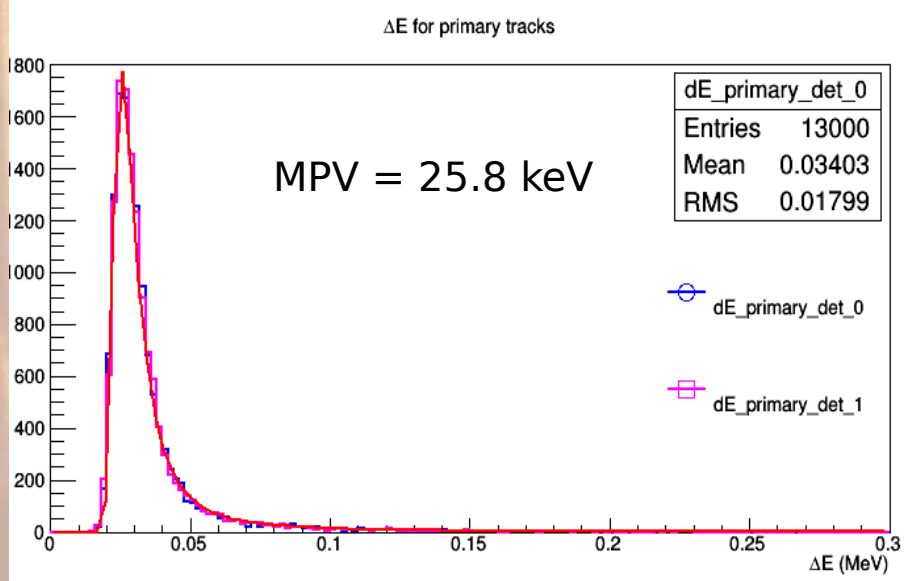
Charge Deposition in Tracker

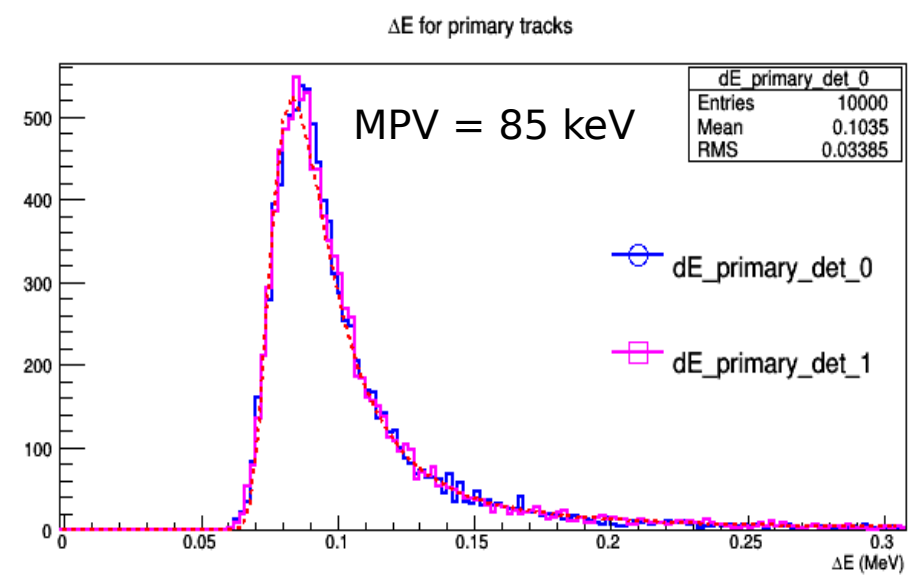
Si 100 µm

Si 300 µm



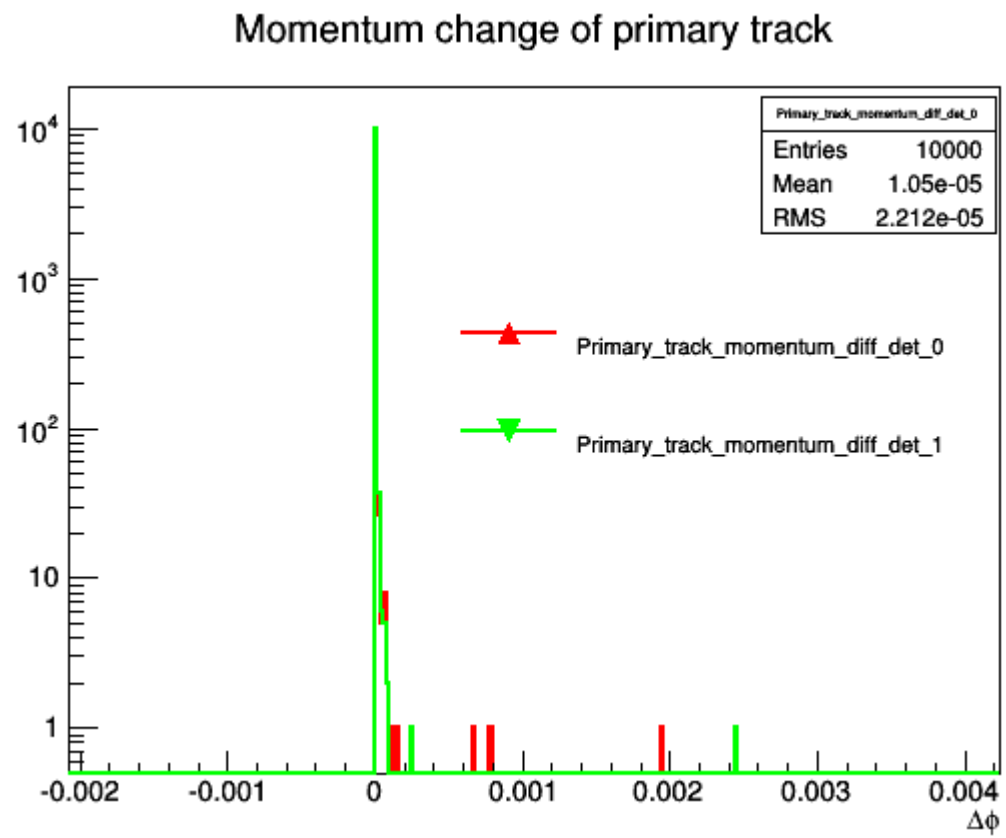




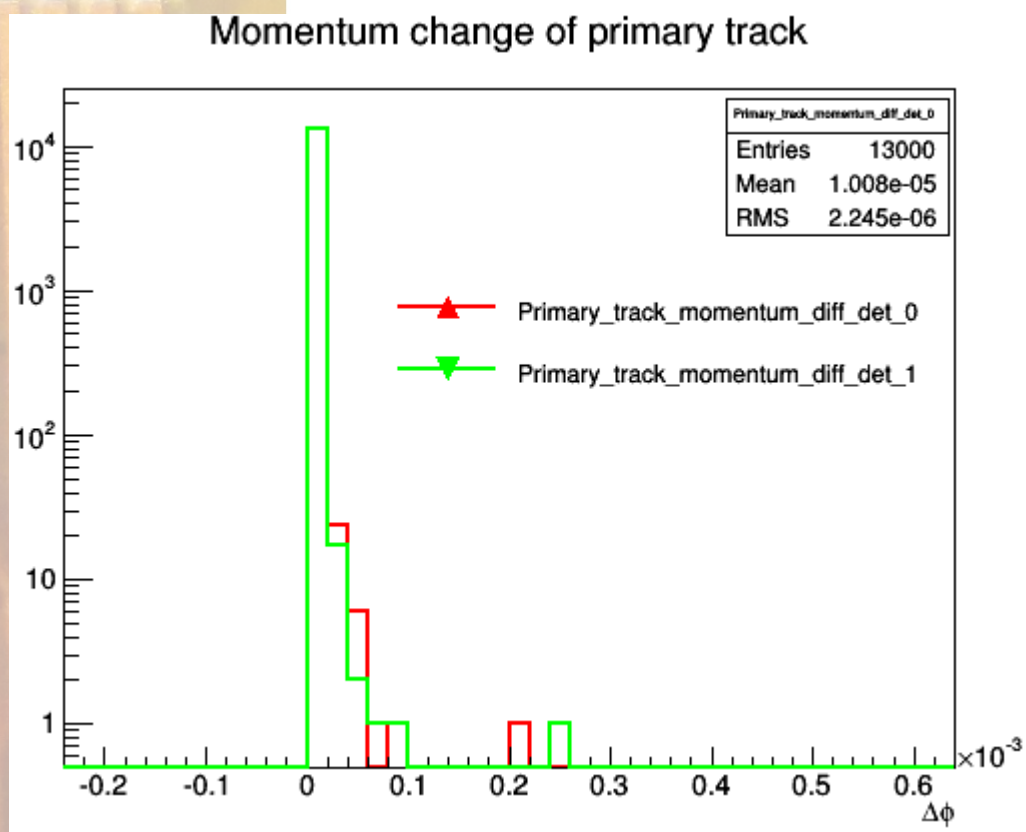


Momentum Change

Si 300 µm



Si 100 µm



LumiCal sensor angular pad size:

- viewed from the tracker ~6 mrad;
- from IP 0.8 mrad.

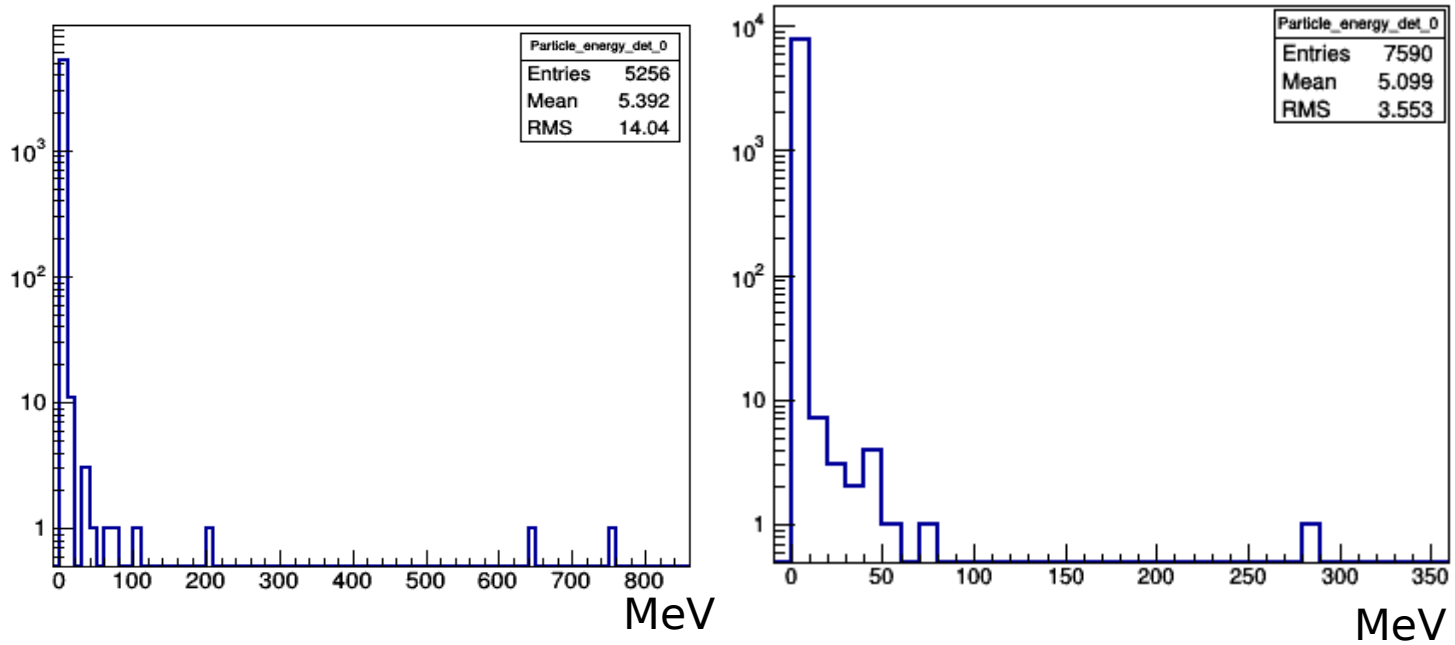
Δϕ for 100 µm Si is much less;

Energy Distribution of Secondary Particles

Only particles which leave the tracking detector in direction of LumiCal are considered:

- excluding 1 cm proximity around primary particle;
- excluding pad angular size in momentum direction around primary particle.

LumiCal energy resolution at 250 GeV is ~3.3 GeV.



Compared to this value the energy of secondary particles which arrives to LumiCal outside the cone is negligible.

Reconstruction in LumiCal

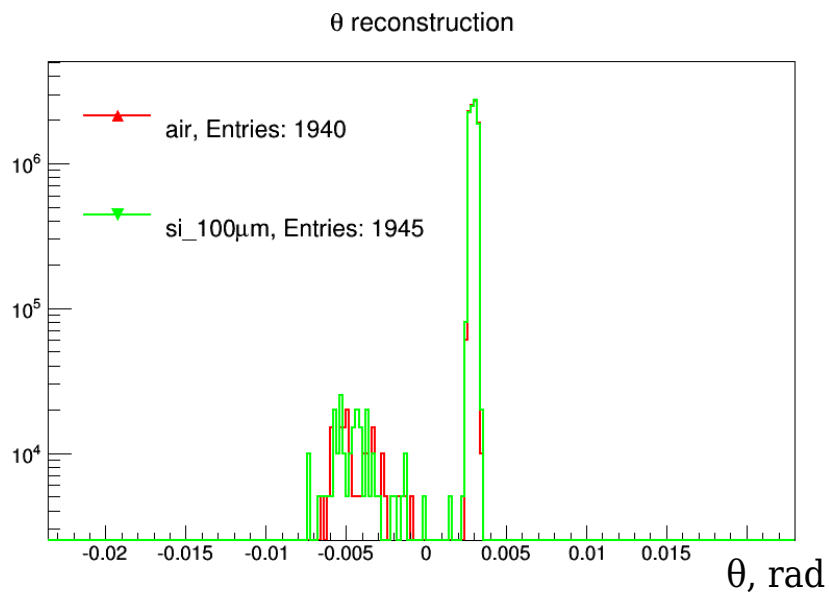
2 cases:

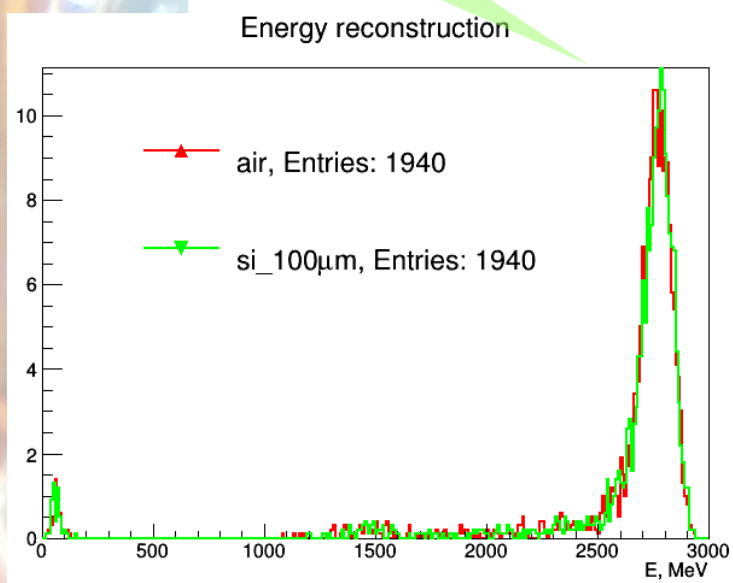
- without tracking detector, air;
- with 2 layer of 100 μm thick Si.

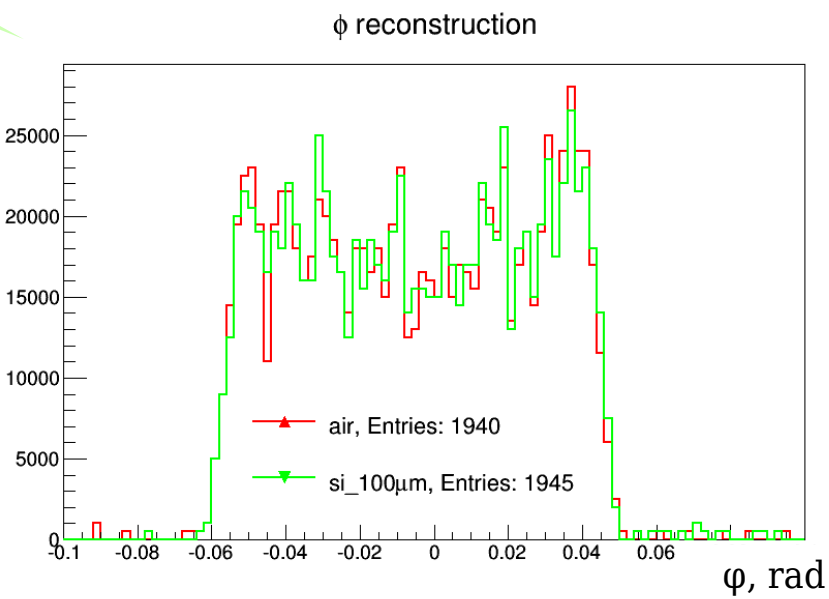
θ_gen – θ_reco;

φ_gen – φ_reco;

E_reco;







Summary

- Test beam of LumiCal prototype with four modules demonstrated good performance.
- Synchronization procedure between different DAQ systems of telescope and Lumical has been developed and successfully implemented.
- Test beam data analysis both for LumiCal and telescope are in progress.
- Several layer of silicone tracking detector in front of LumiCal would not affect significantly the accuracy of luminosity measurement.
- Next steps to check the reconstruction with background are in progress.