Beam test results from the Large Prototype TPC with GEM modules

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on behalf of LC-TPC collaboration

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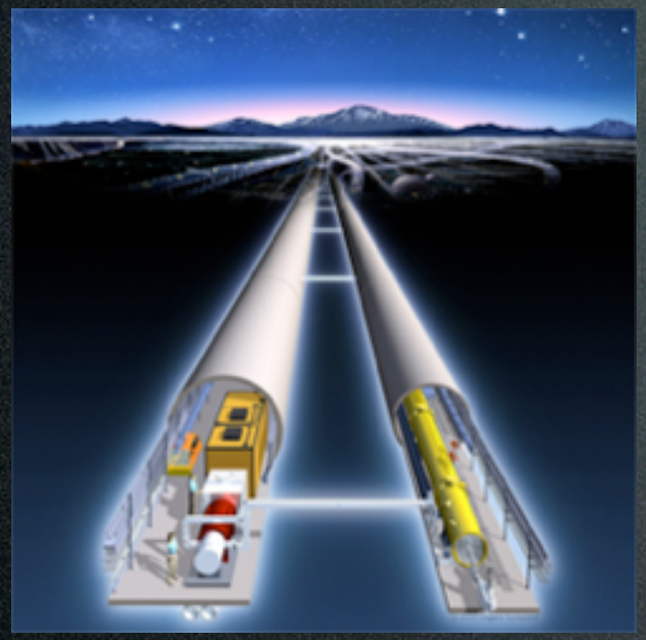
INTRODUCTION



International Linear Collider (ILC)

is expected to reveal Higgs properties in detail .

A TPC is natural candidate for the ILC central tracker because of its very good performance in past collider experiments.

To test multi-module readout system for the LC-TPC, we have built Large Prototype TPC (LP1) which is based on EUDET program.

We had a beam test at DESY with this TPC in Sep. 2010.

Readout modules are prepared several sub-groups

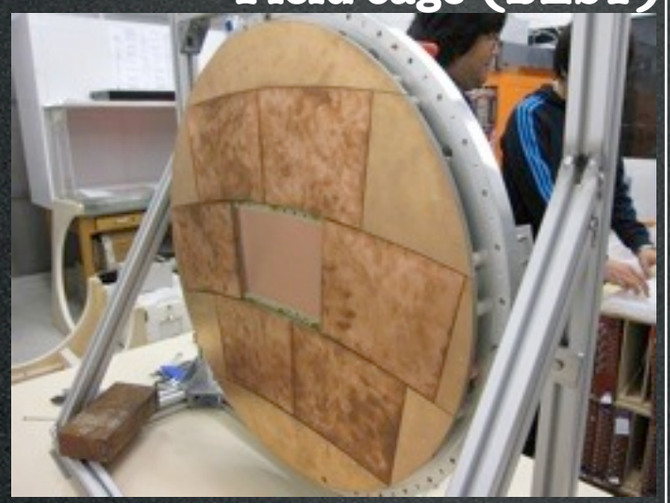
- GEM (Asia, Bonn, DESY)
- Micromegas (Saclay/Canada)
- TimePix (NIKHEF, Bonn)

⋮

Calibration has been done by Victoria University.

Field cage (DESY)

Magnet (KEK)



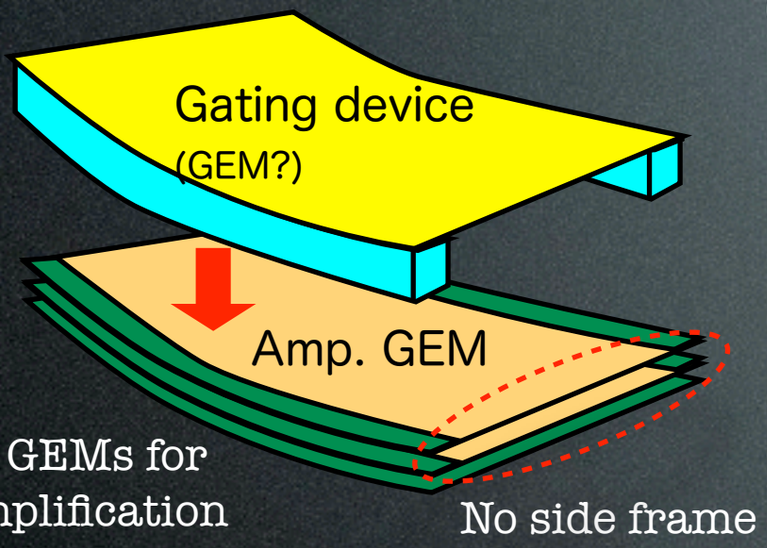
End plate (Cornell Univ.)

Our motivation

is to measure momentum resolution with multi module readout system.

We had developed GEM-modules which can be installed to LP1 endplate.
In the beam test we used these GEM modules.

GEM module

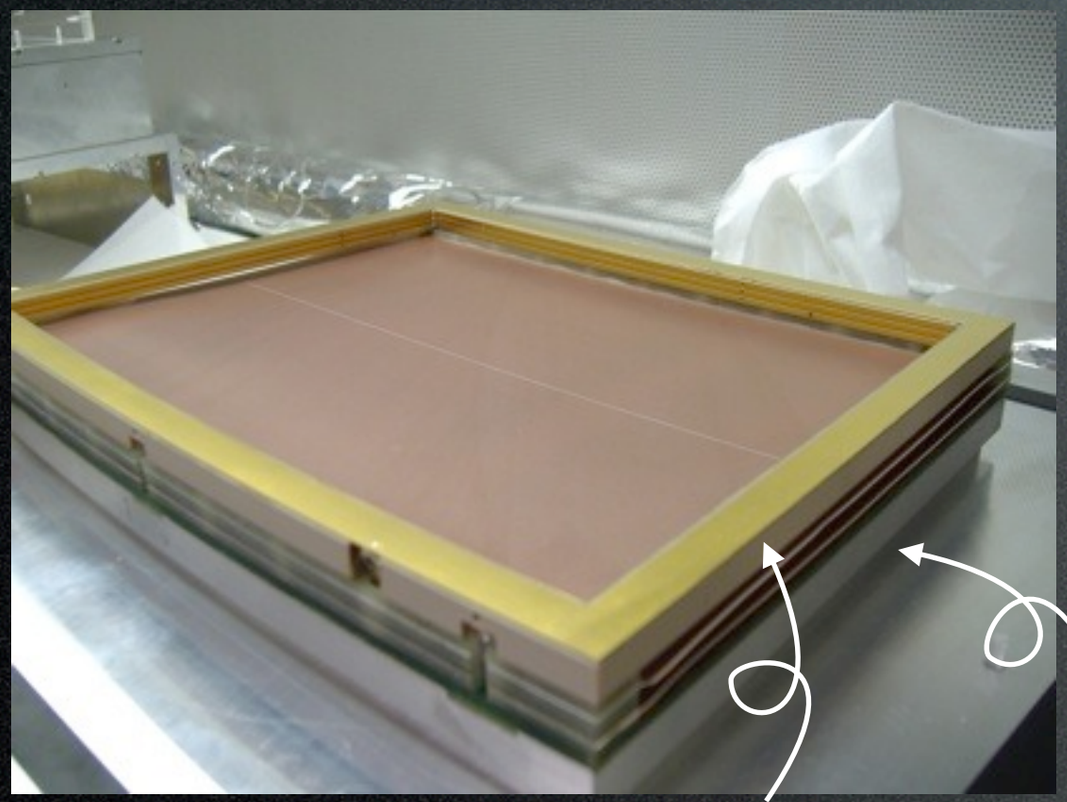


Concept

Simple structure ⟶ 100μm thick GEM with double GEM configuration

Minimum dead region ⟶ No side frame

To avoid ion back drift, we might need a gating device.



GEM module with “Field shaper”

... Real life

We tested the module without gating device at this moment.

To match our modules to LP1 endplate, we prepared “Field shaper” instead of gating device.

PCBs designed and produced by **Tsinghua University**

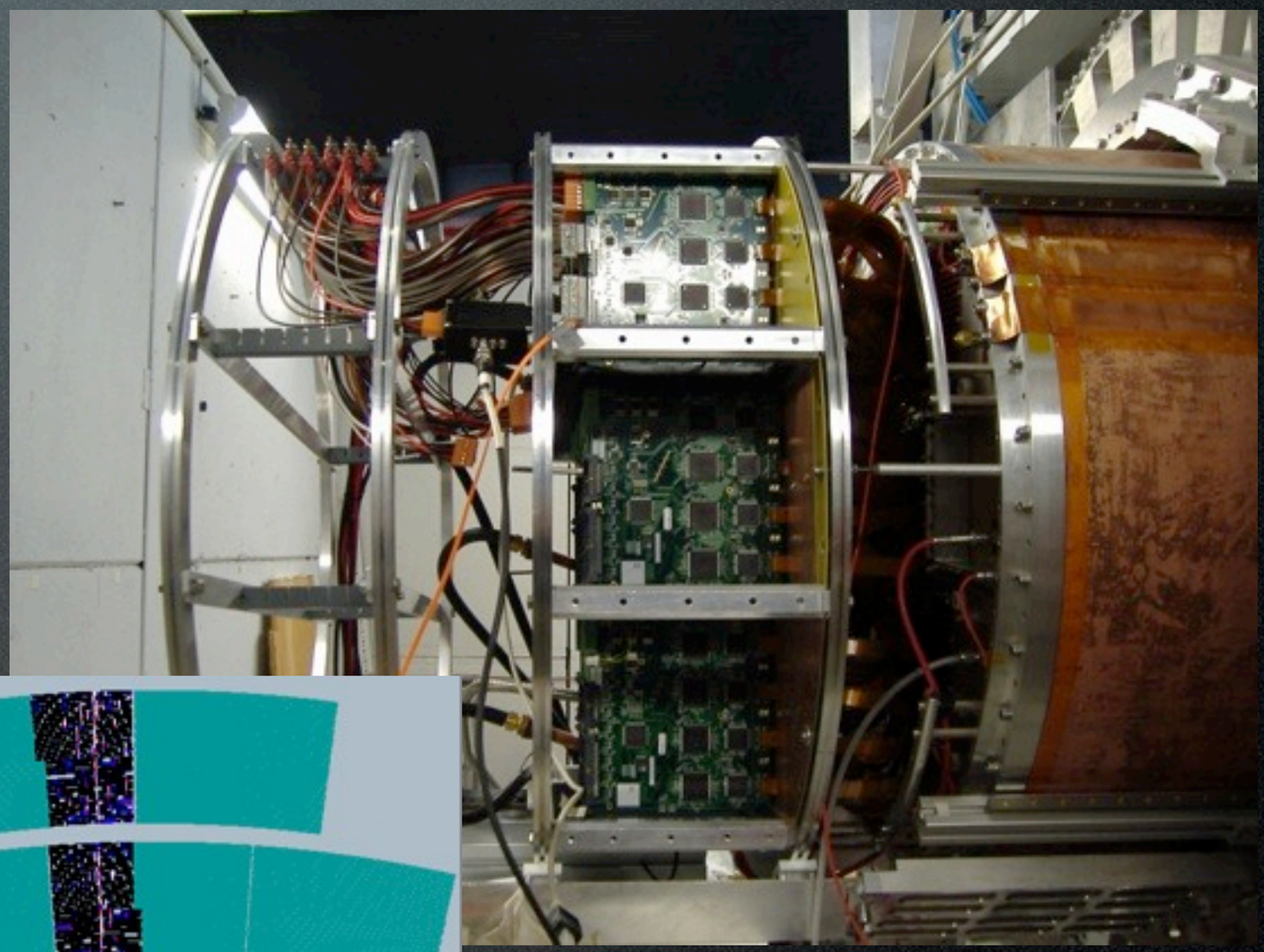
Readout electronics

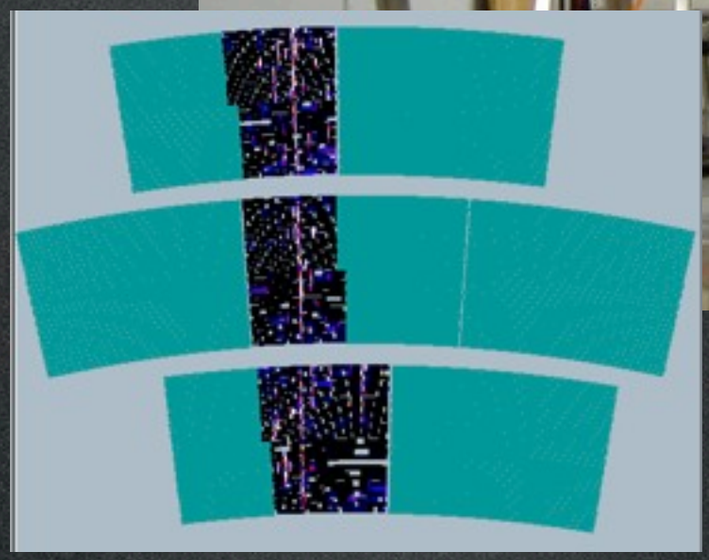
The front end electronics are developed by **Lund University** / **CERN**.
(which are originally built on ALICE TPC readout.)

A channel
- programable gain, shaping time and polarity
- 1000 samples, 10 bit resolution, 20 MHz sampling (subset 40 MHz)

In this beam test,
we used 7616 channels with air cooling system and temperature monitoring system for electronics.

Readout electronics mounted to LP1





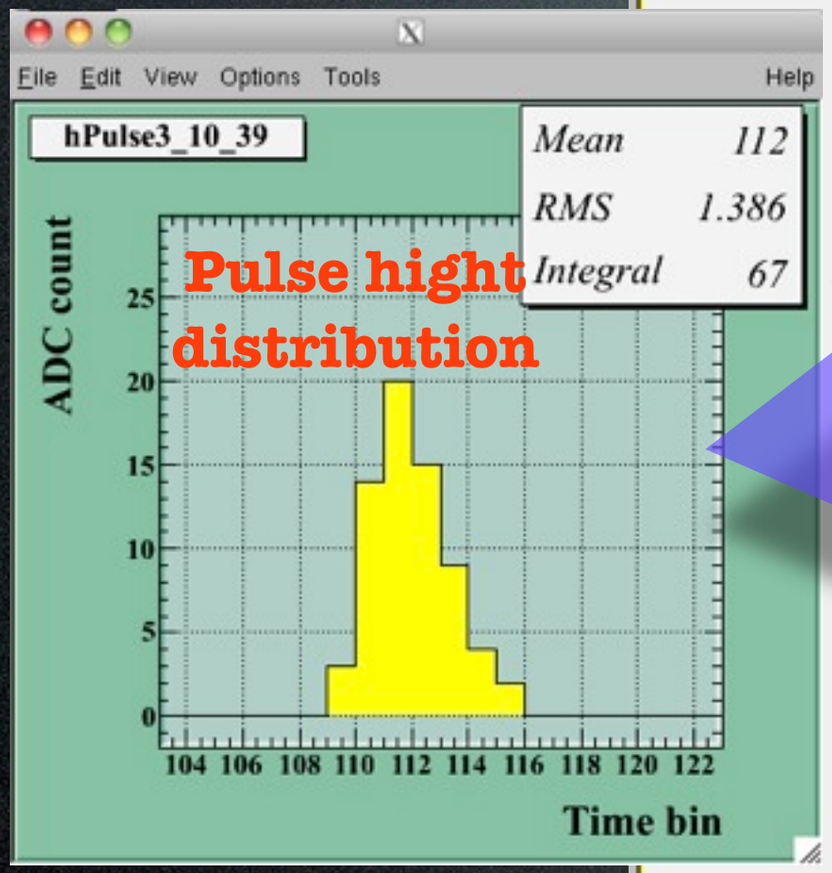
Analysis framework

- Common analysis software . . . Marlin TPC
- Local analysis software . . . yokaRawMon

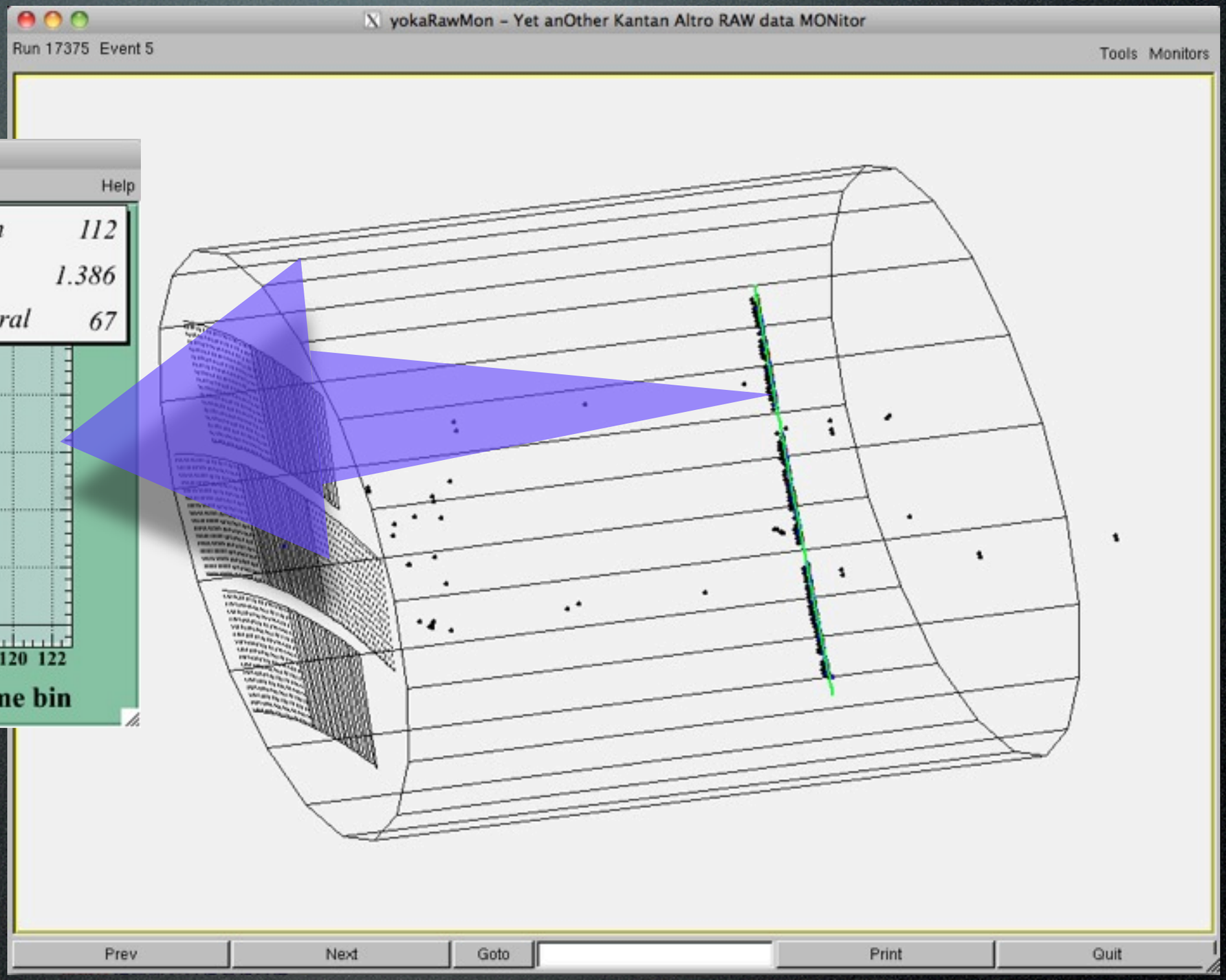
Differences	Marlin TPC	yokaRawMon
input data format	lcio	rawdata (binary)
versatility	○	×
Interactive event display	×	○
compatibility with ROOT	△	○
strictness of coding	tight	loose

At this moment, since there is no way to read LCIO format (reconstructed data by Marlin TPC) with ROOT framework, I used yokaRawMon for this report.

Event Display (yokaRawMon)

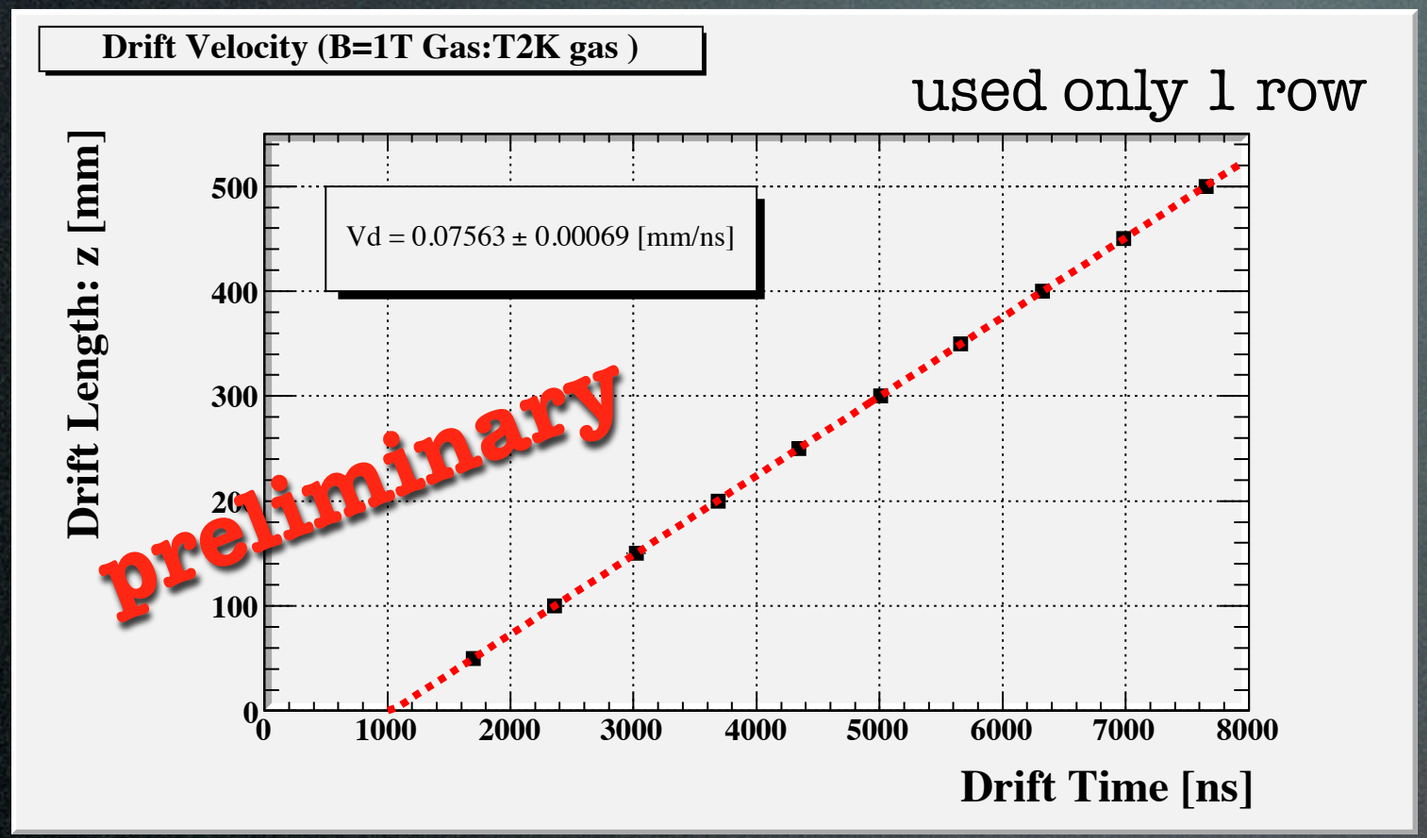


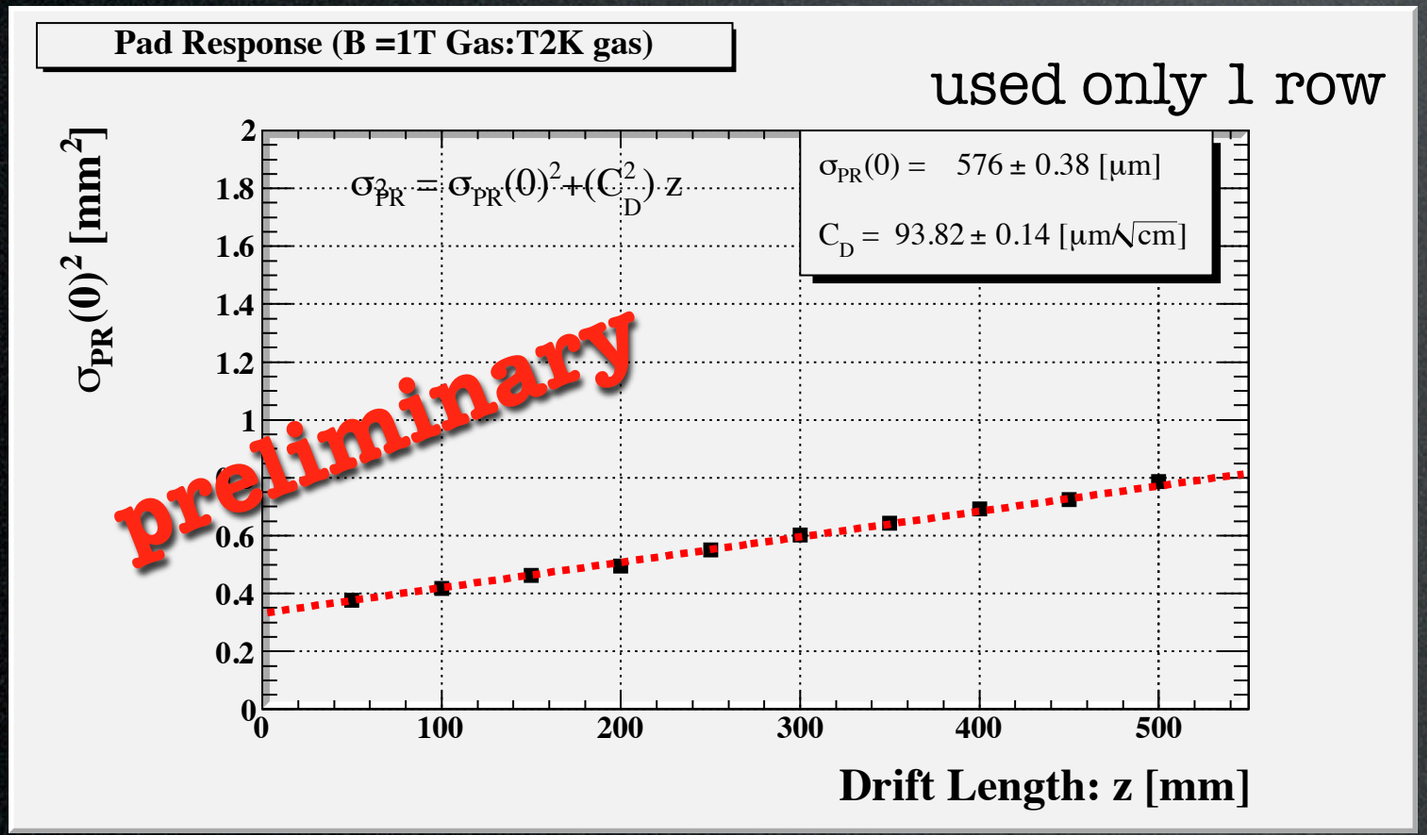
Each point has its all information!



Since this is useful to check the system, Marlin TPC also should have this kind of event display.

Gas property check





Event/Track selection
- # of tracks in a event = 1
- ndf > 140

Drift velocity

When all rows are considered

~~**V_D = 7.5634 ± 0.0003 [cm/μs]**~~

Magboltz prediction (v. 8.5)

V_D = 7.509 ± 0.002 [cm/μs]

(T=290[K], P=1[atm], 200ppm H_2O)

Diffusion constant

When all rows are considered

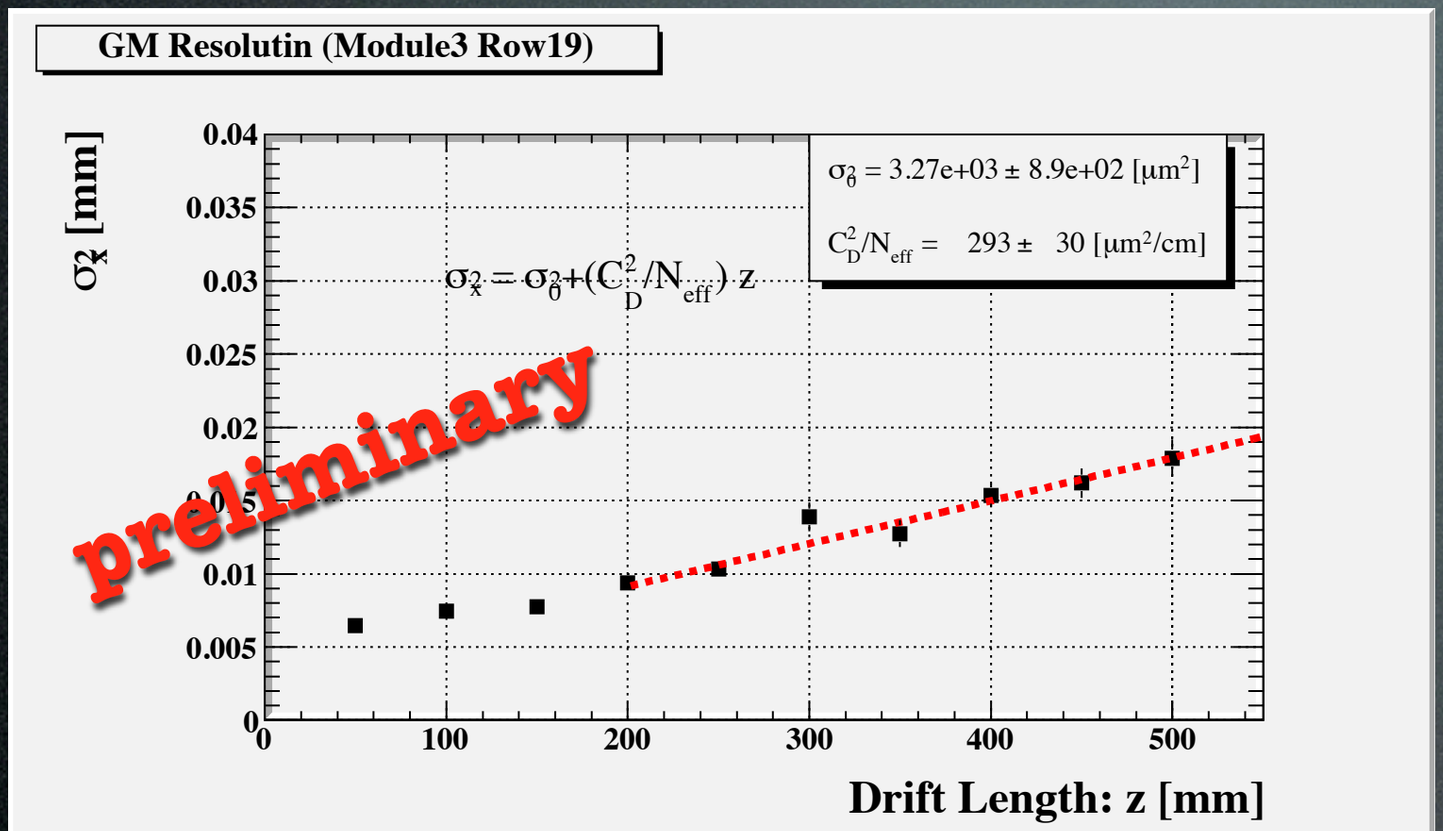
~~**C_D = 94.1 ± 1.2 [μm/sqrt(cm)]**~~

Magboltz prediction (v. 8.5)

C_D = 94.3 ± 1.9 [μm/sqrt(cm)]

(T=290[K], P=1[atm], 200ppm H_2O)

Point resolution



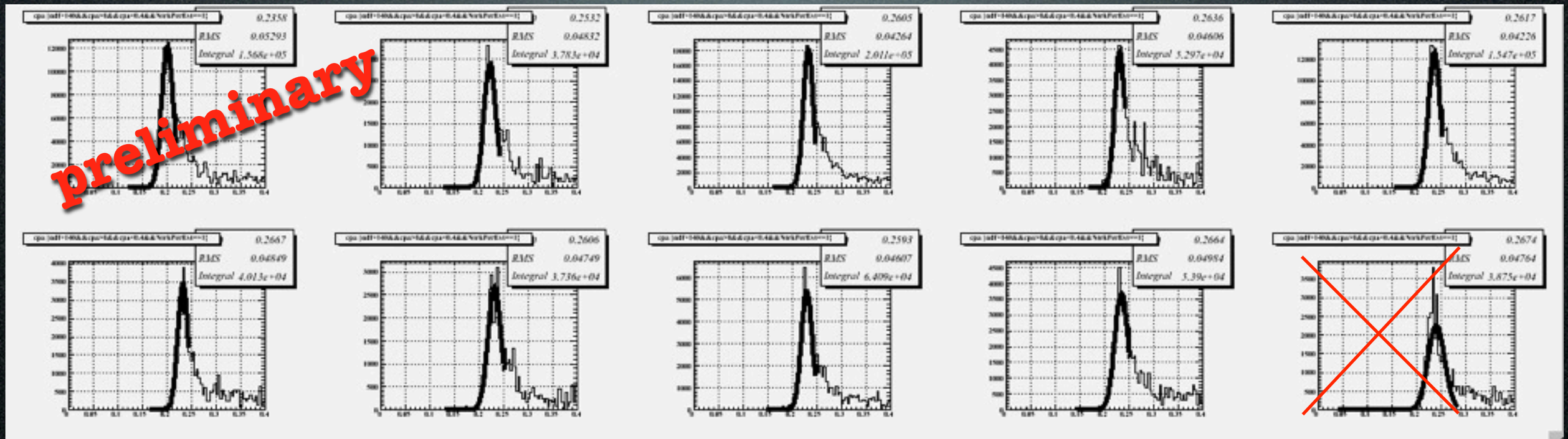
Event/Track selection
- # of tracks in a event = 1
- ndf > 140

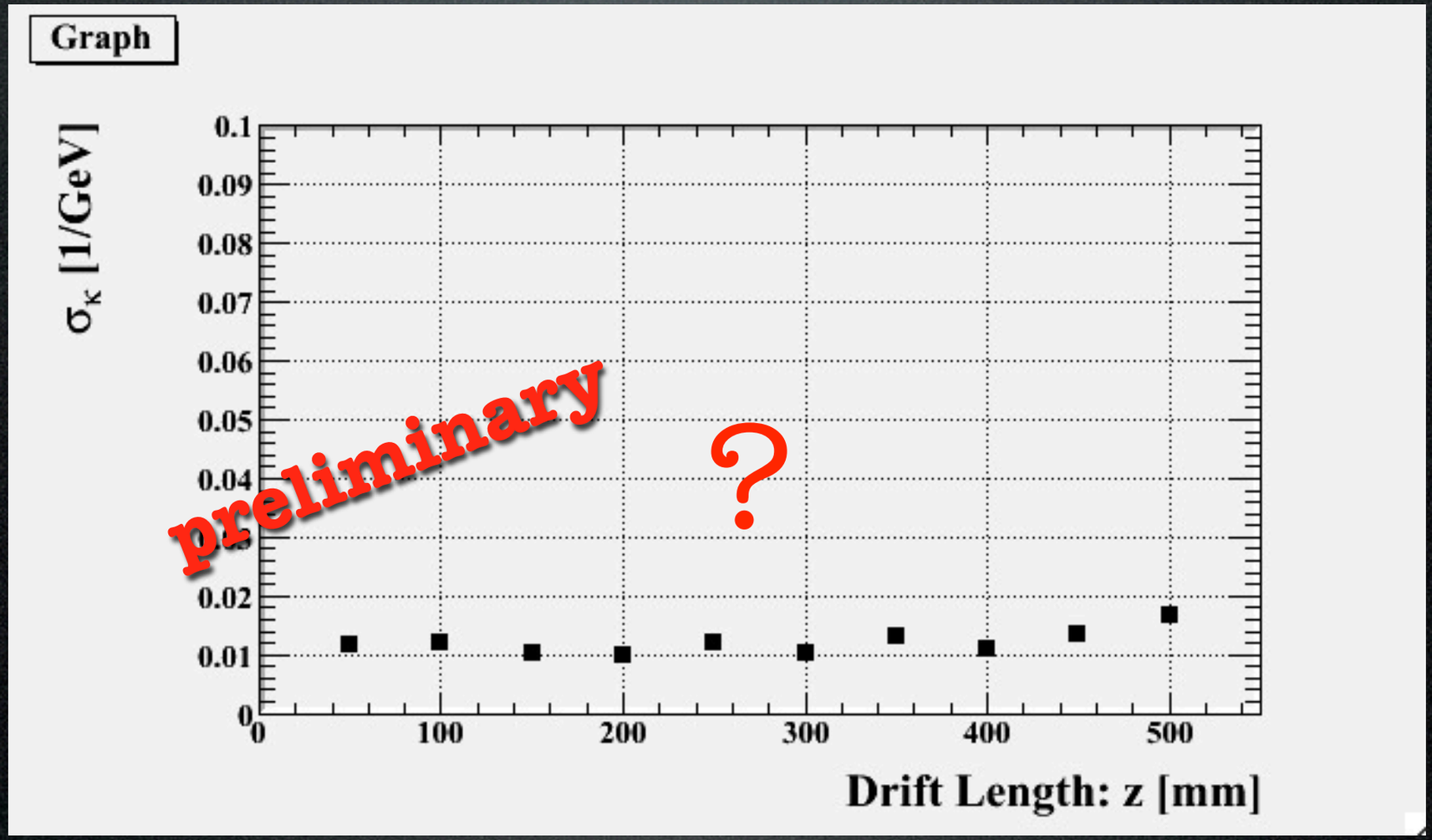
When all rows are considered

$C_D^2/Neff = 291.4 \pm 5.8$

⟶ Neff = 30.4 ± 1.0

Momentum resolution





Summary

We tested multi GEM module readout system.
- gas property were checked.
- point resolution
- momentum resolution

Future plan

Retake beam ~~test~~ data

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things to be fixed
- Distortion caused by field shaper
- new GEM module to be solved discharge problem

take different beam energy data to calibrate alignment correction

beam condition (time dependence)

software development (Marlin TPC)

beam test with pion beam

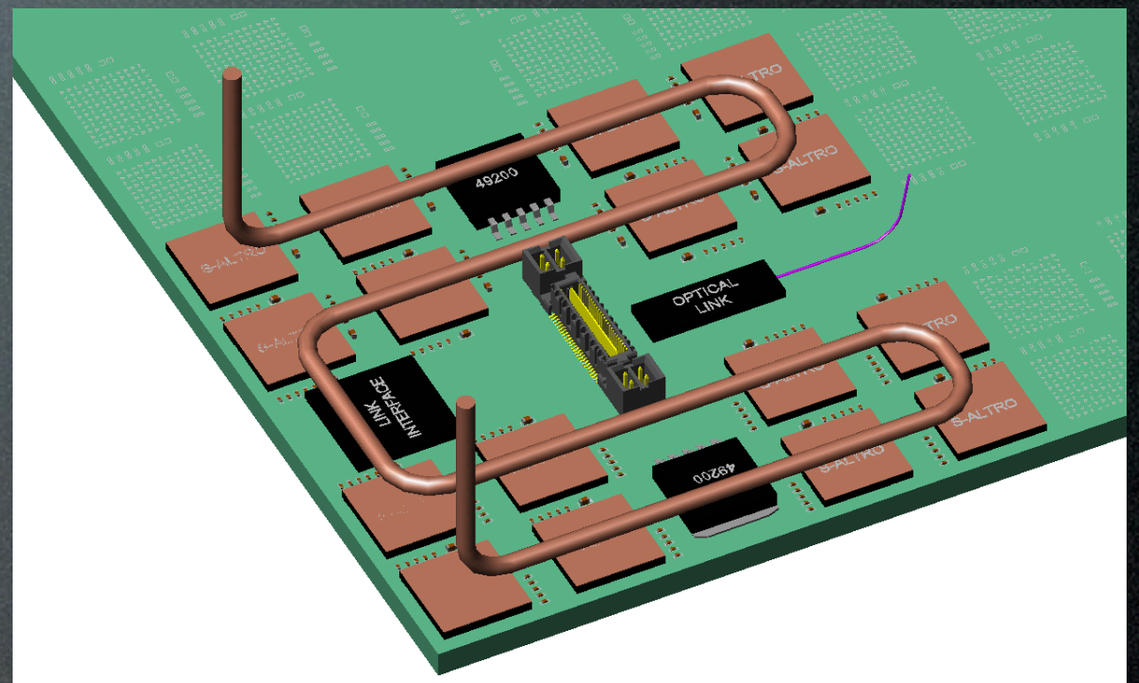
Advanced end plate electronics
- bump bonding electronics
- CO_2 cooling

Some comments for Advanced endplate R&D

Motivation

The electronics will be implemented in high density to reduce amount of materials.
(Goal : thickness 15% X_0)

There will be heat problem due to high density electronics.



To solve this problem,

we are considering to use 2 phase CO_2 cooling system, which can achieve temperature uniformity and low amount of materials. We are preparing FPGA dummy board, which generates heat instead of the real front end board, and planing to do a cooling test with the dummy board at NIKHEF.
At the same time, the infrastructures for the CO_2 cooling test are being prepared at KEK.
Another essential thing to solve heat problem is power pulsing.
We are also planing to do power pulsing test with FPGA dummy board.