Beam test results from the Large Prototype TPC with GEM modules

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Performance goal of the LC-TPC

1. $e^+e^- \rightarrow ZH(Z \rightarrow \mu\mu/ee) + X$ (Recoil mass measurement)
2. $H \rightarrow \mu\mu$ (Rare decay Br. measurement)

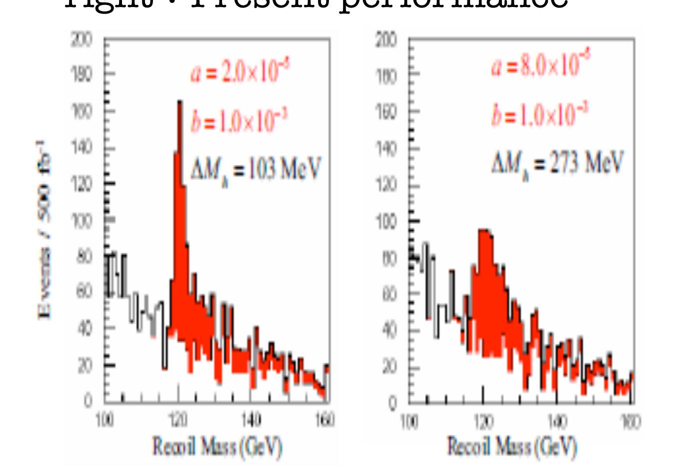
To measure Higgs mass with ~100MeV accuracy by these processes, tracker should have 200 measurement points and 50~100μm resolution for each point (if B = 3~4T).

Two track separation is also important for PFA to improve jet energy resolution.

Recoil mass measurement

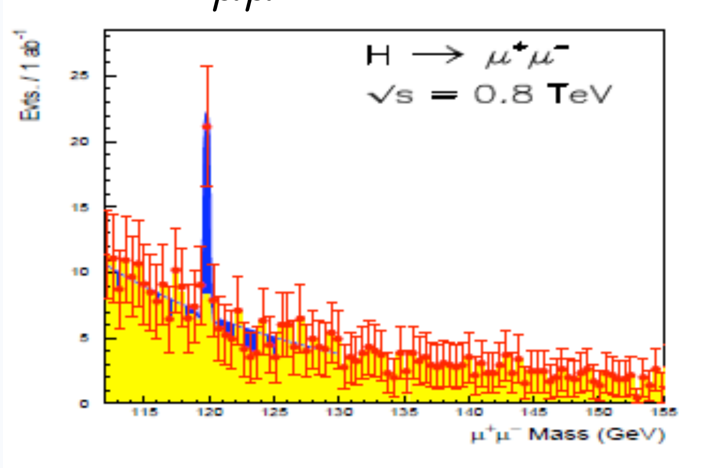
left : Performance goal

right : Present performance

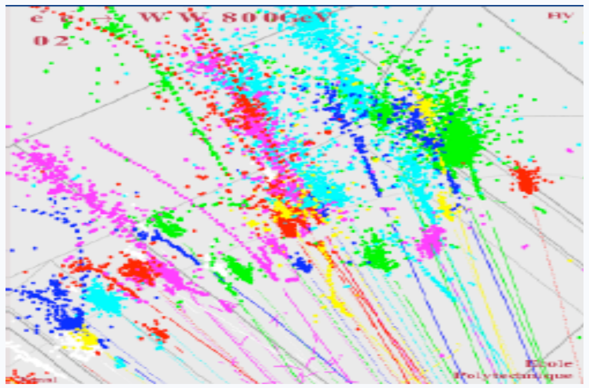


Rare decay Br. measurement

$H \rightarrow \mu\mu$



PFA: recognition of jet clusters



TPC Large Prototype (LP1) Beam Test at DESY using EUDET Facility

Goals of LP1 Beam Test

- To study, in practice, design and fabrication of all components of MPGD TPC in larger scale; field cage, endplate, detector modules, front end electronics, and field mapping of non uniform magnetic field.
- To demonstrate full-volume trucking in non-uniform magnetic field, trying to provide a proof for the momentum resolution at LC TPC
- To demonstrate dE/dX capability of MPGD TPC
- To study effects of detector boundaries
- To develop methods and software for tracking, alignment, calibration, and corrections

Field cage (DESY)

Maximum drift length ~ 60 cm

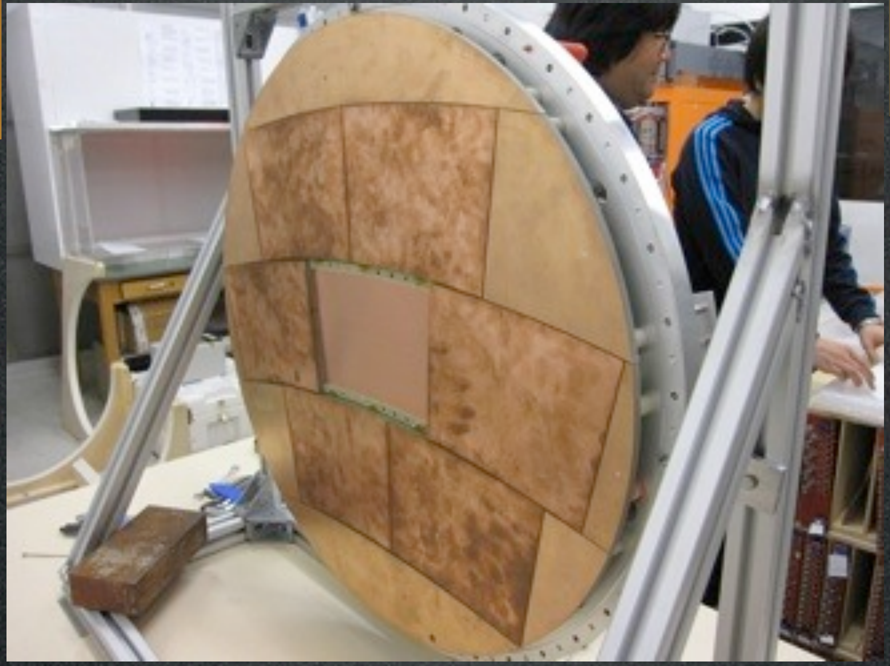
Diameter ~ 70 cm

Readout modules are prepared several sub-groups

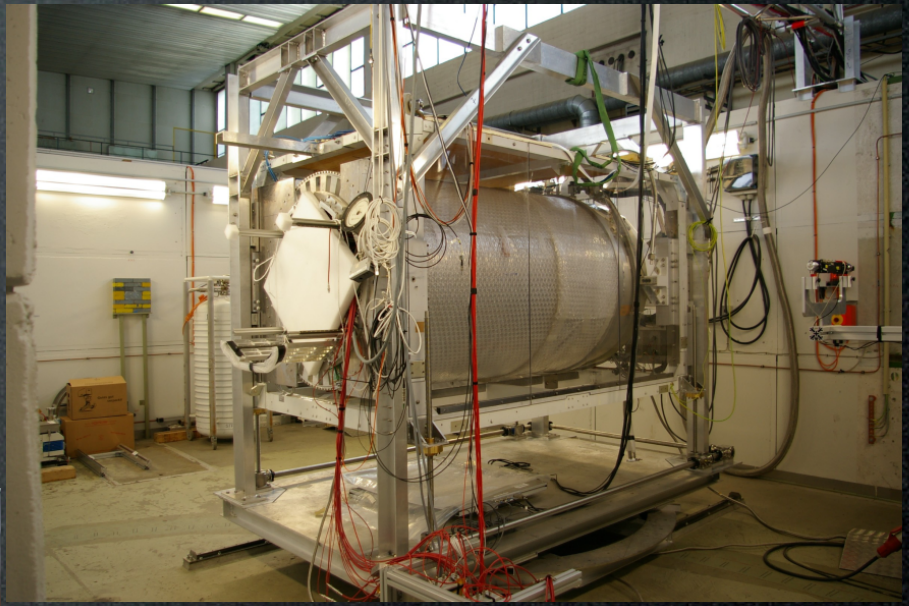
- GEM (Asia, Bonn, DESY)
- Micromegas (Saclay/Canada)
- TimePix (NIKHEF, Bonn)

⋮

Calibration has been done by Victoria University.



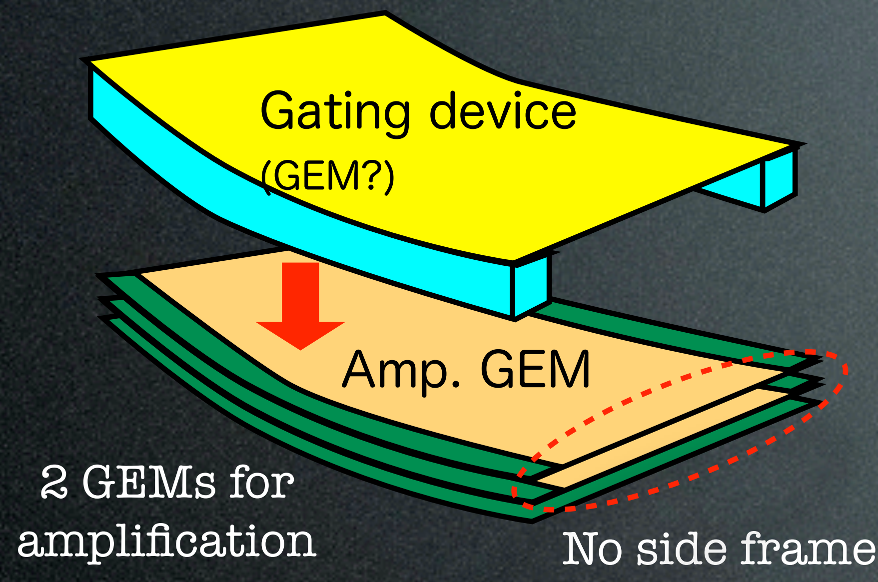
End plate (Cornell Univ.)



Magnet (KEK)

Magnet
- B = 1T
- thickness 20%X_0
- moving table with linear scaler

GEM module

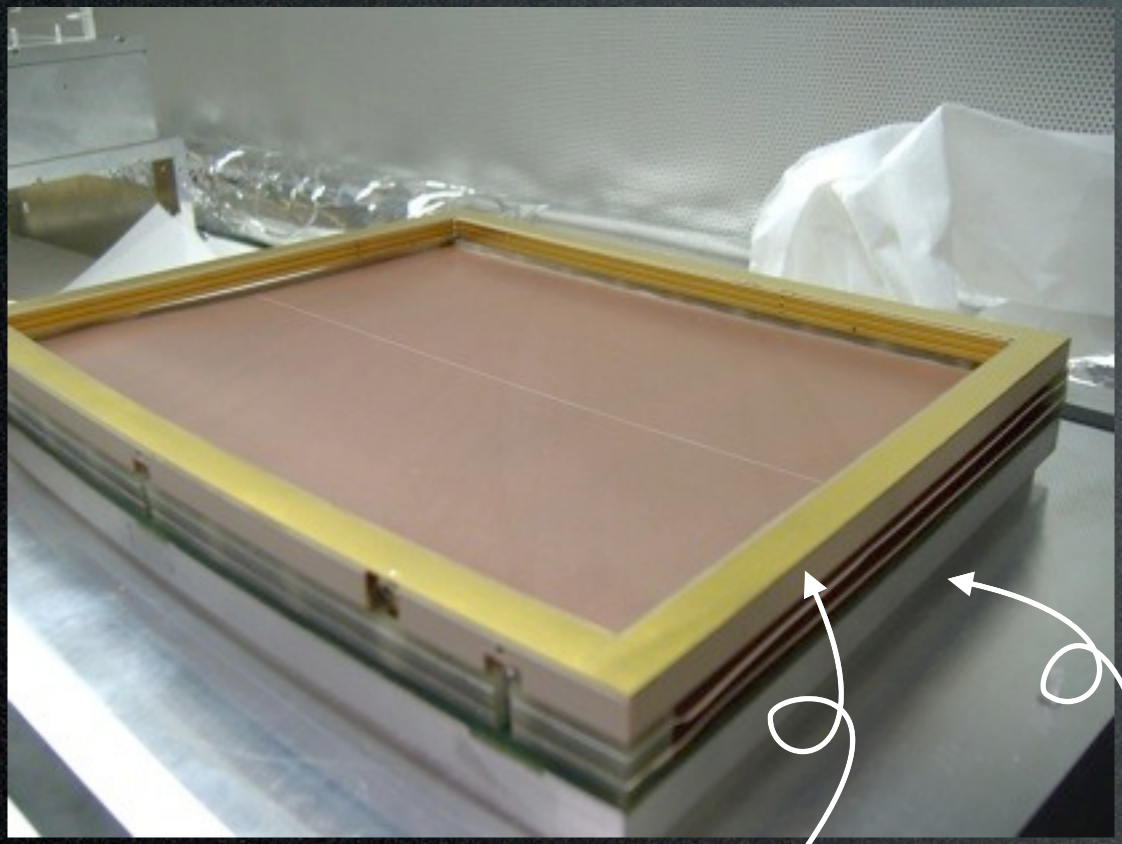


Concept

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

Since transmission efficiency of our gating device is at most 50% so far, 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.

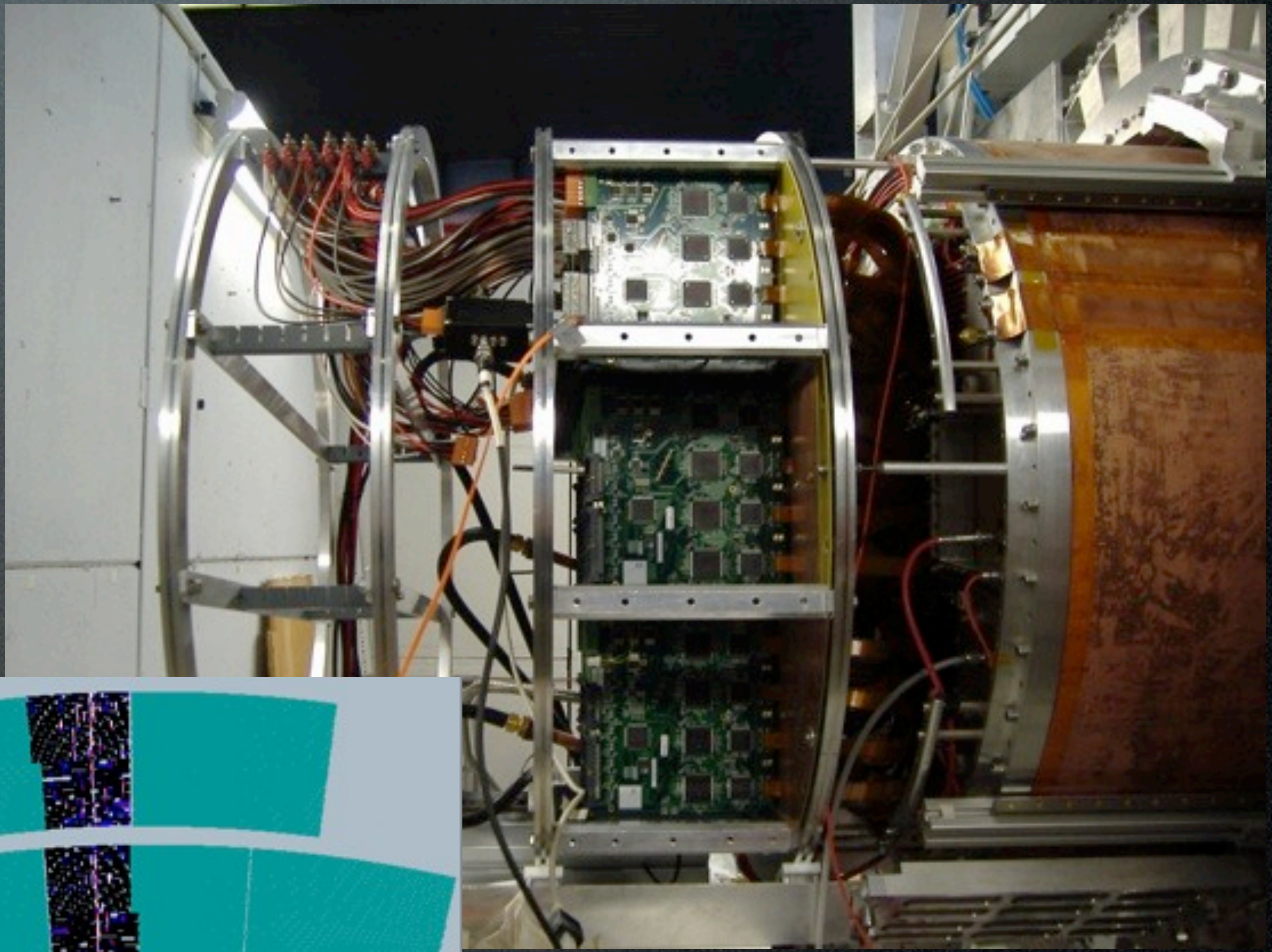
PCBs designed and produced by **Tsinghua University**

Readout electronics

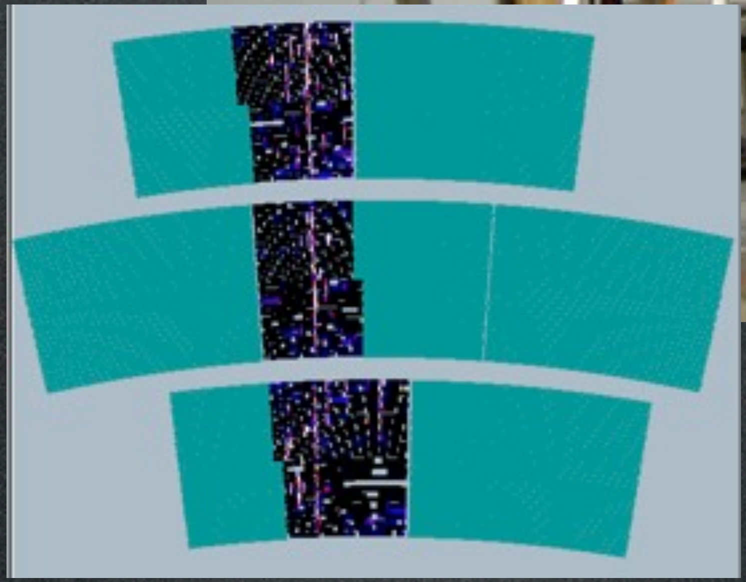
PCA16 + ALTRO electronics are developed by **Lund University** / **CERN**.
(which are originally built on ALICE TPC readout.)

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

Readout electronics mounted to LP1



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



Analysis framework

Two reconstruction software.

- Common analysis software ・・・ Marlin TPC

  With Track-Making-Kalman-Filter -Processor, Kalman filter algorithm is used both in track finding and track fitting

  Input data format : lcio

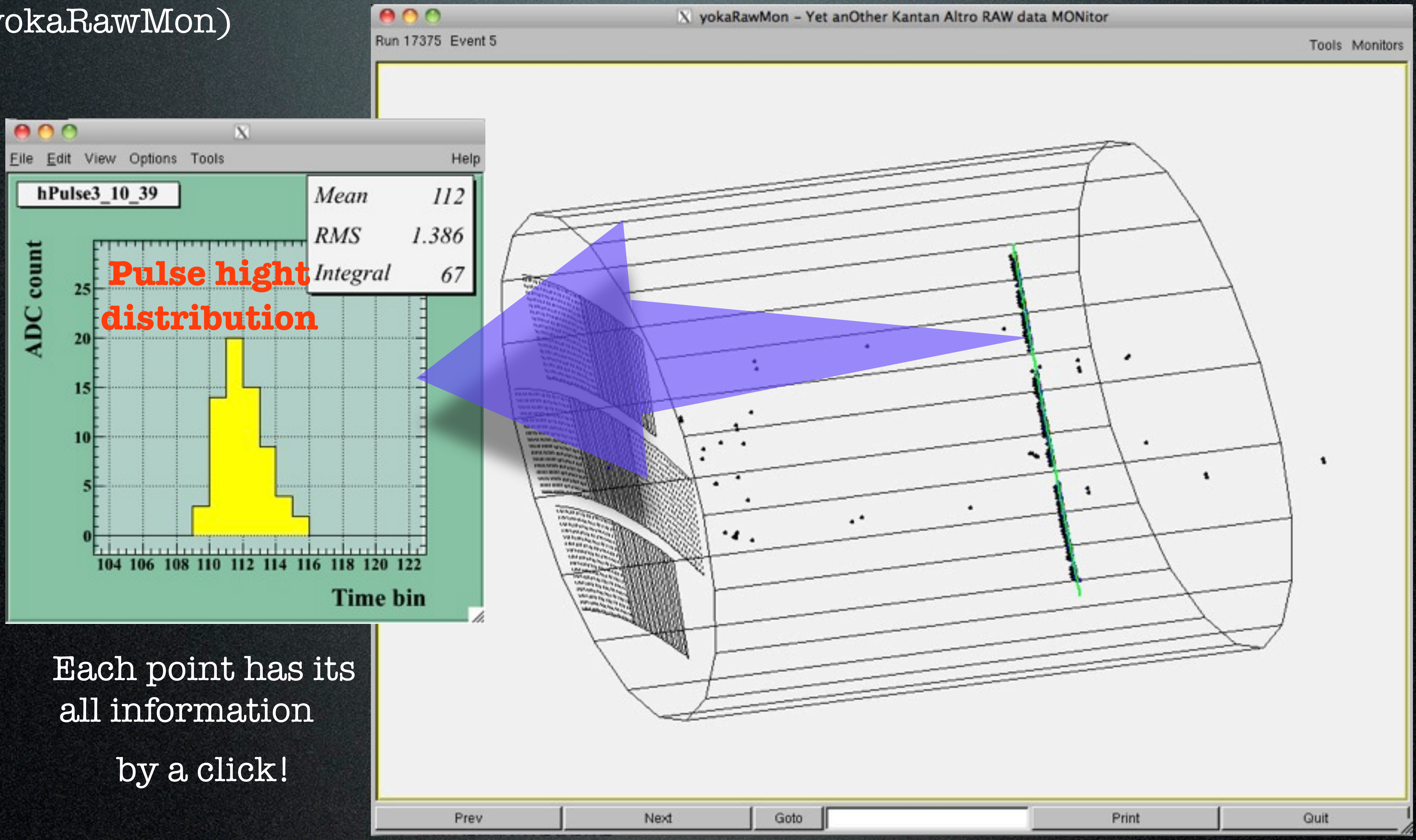
- Local analysis software ・・・ yokaRawMon

  Kalman filter algorithm is used only in track fitting

  Input data format : rawdata (binary)

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)

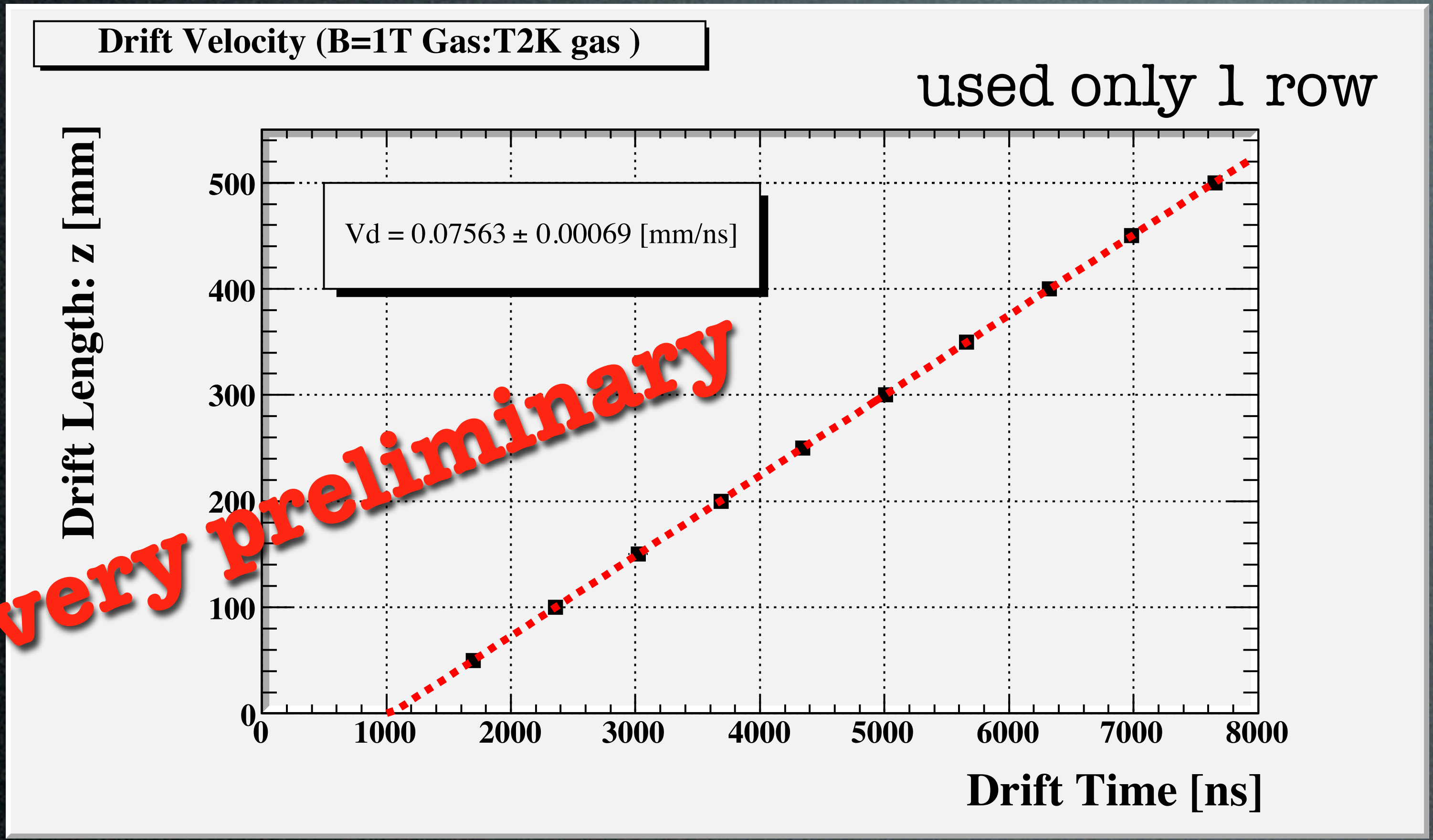


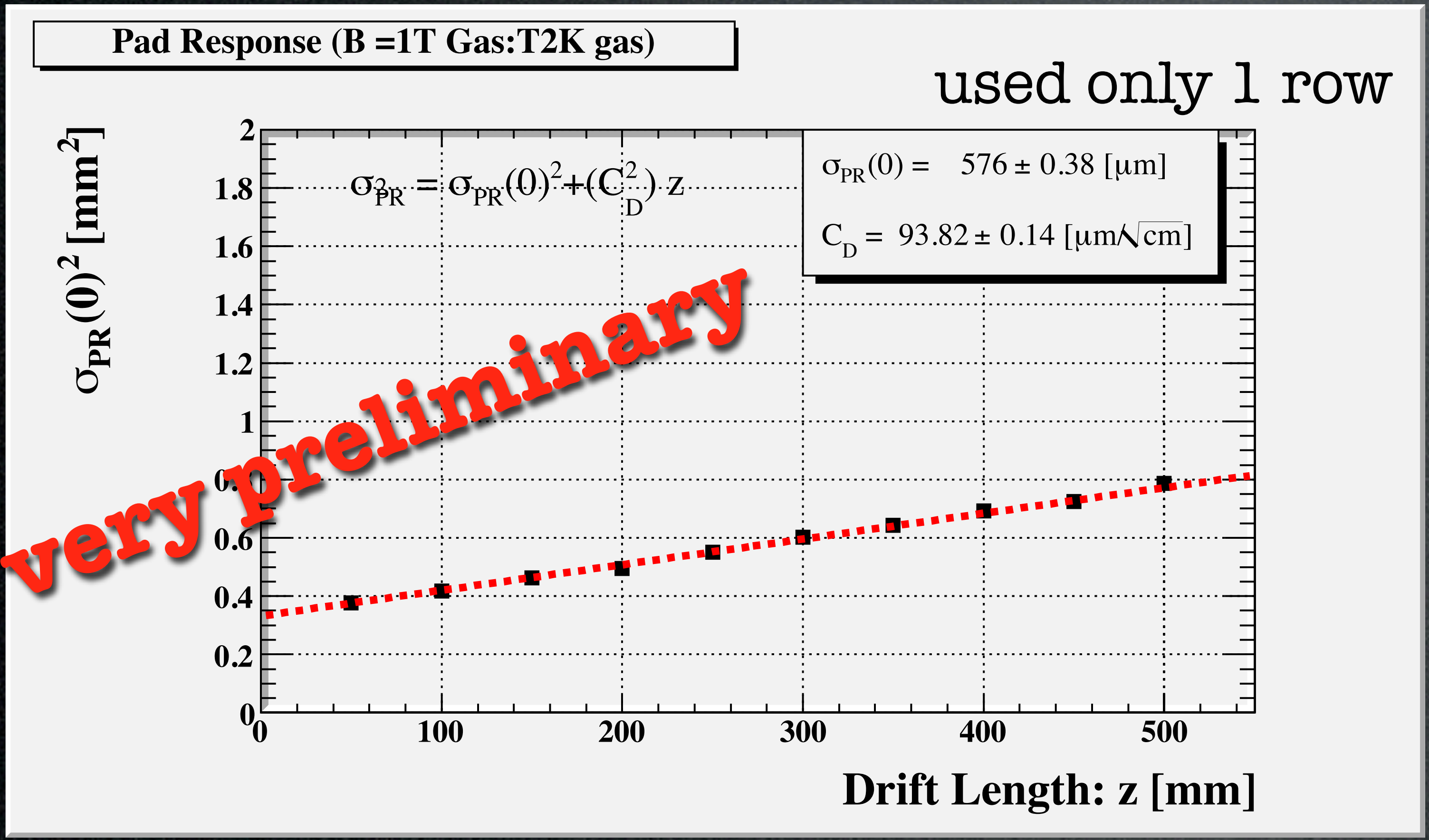
Each point has its all information

by a click!

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

V_D = 7.563 ± 0.07 [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

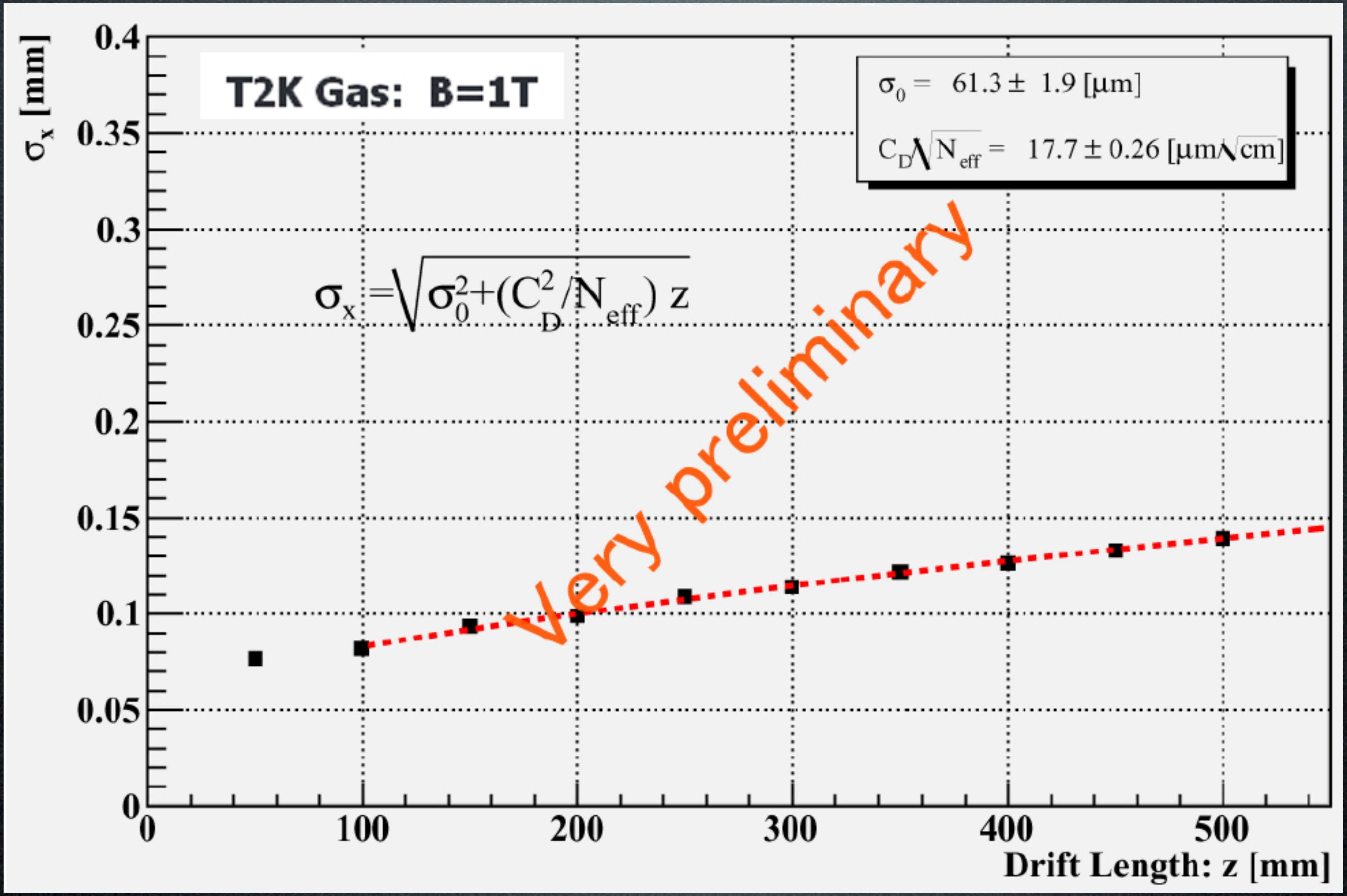
C_D = 94.1 ± 1.2 [μm/sqrt(cm)]

Magboltz prediction (v. 8.5)

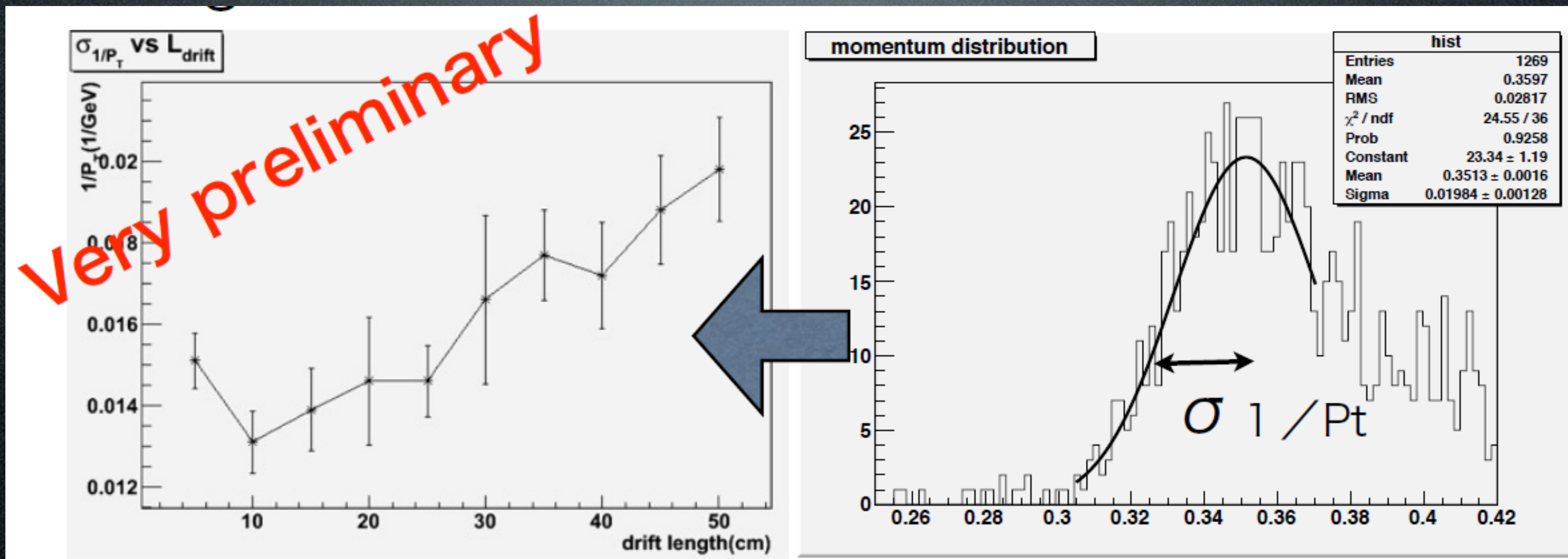
C_D = 94.3 ± 1.9 [μm/sqrt(cm)]

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

Point resolution



Momentum resolution



used Marlin TPC

without any aliment correction

Summary

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

Future plan

software development (Marlin TPC)

beam test with pion beam

beam test with new electronics (s-ALTRO)

Advanced end plate electronics

bump bonding electronics

CO_2 cooling

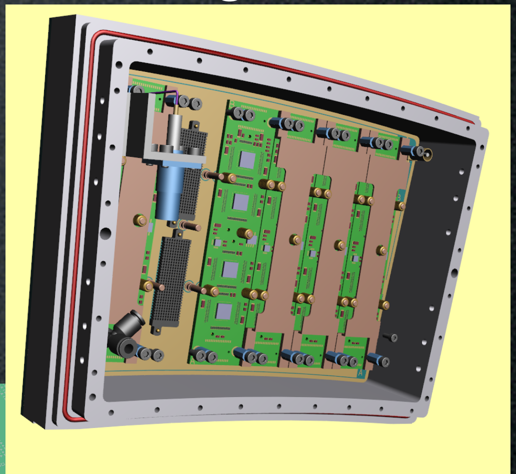
Some comments for Advanced endplate R&D

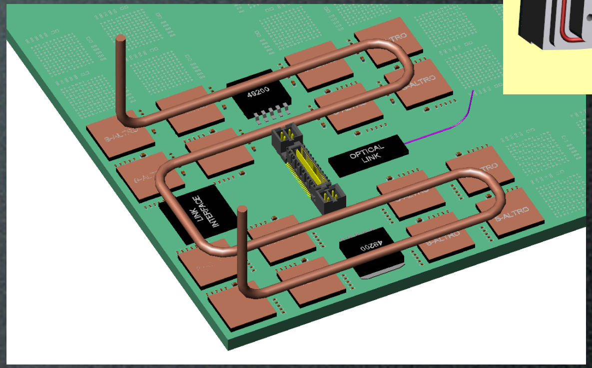
For next beam test, we are developing new electronics.

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.

Micromegas module:





electronics behind module!

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.

Backup