TPC module R&D

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13th Sep. 2011 @ Tohoku Univ.

TPC Performance Goal

Momentum Resolution $\delta(1/p_t) \sim 9 \times 10^{-5}$ /GeV/c (TPC only)

→ Spatial Resolution $\delta(x) \sim 100\ \mu m$ in ~ 3.5 T
with more than 200 measurement points

Tracking efficiency > 99 % (TPC only, Pt > 1 GeV/c)

Material Budget ~ 5% Xo (Barrel), 25% Xo (Endcap)

To achieve the goal we are developing **MPGD readout TPC**.

(1) Good spatial resolution in a strong magnetic field
(2) Good two-hit separation
(3) Minimize dead region
(4) Capability to suppress ion feed back

※ But recently we have become to consider a gating device will be needed even with MPGDs amplification.

What we need ?

Proof of principle of MPGD detector

✓ - Point resolution

This talk - Discharge probability (100μ thick SciEnergy GEM)

- Gating

Simulation

- Ion feed back

Build the detector modules for the ILD-TPC (and modify if needed)

- Field cage --> DESY
- Endplate --> Cornell Univ.

This talk △ - GEM structure

- Compact electronics --> CERN & Lund Univ.
- Cooling

Develop tracking software considering

✓ - tracking assuming uniform magnetic field

- tracking under non-uniform magnetic field

✓ - multi module readout

⇩

Demonstrate the performance

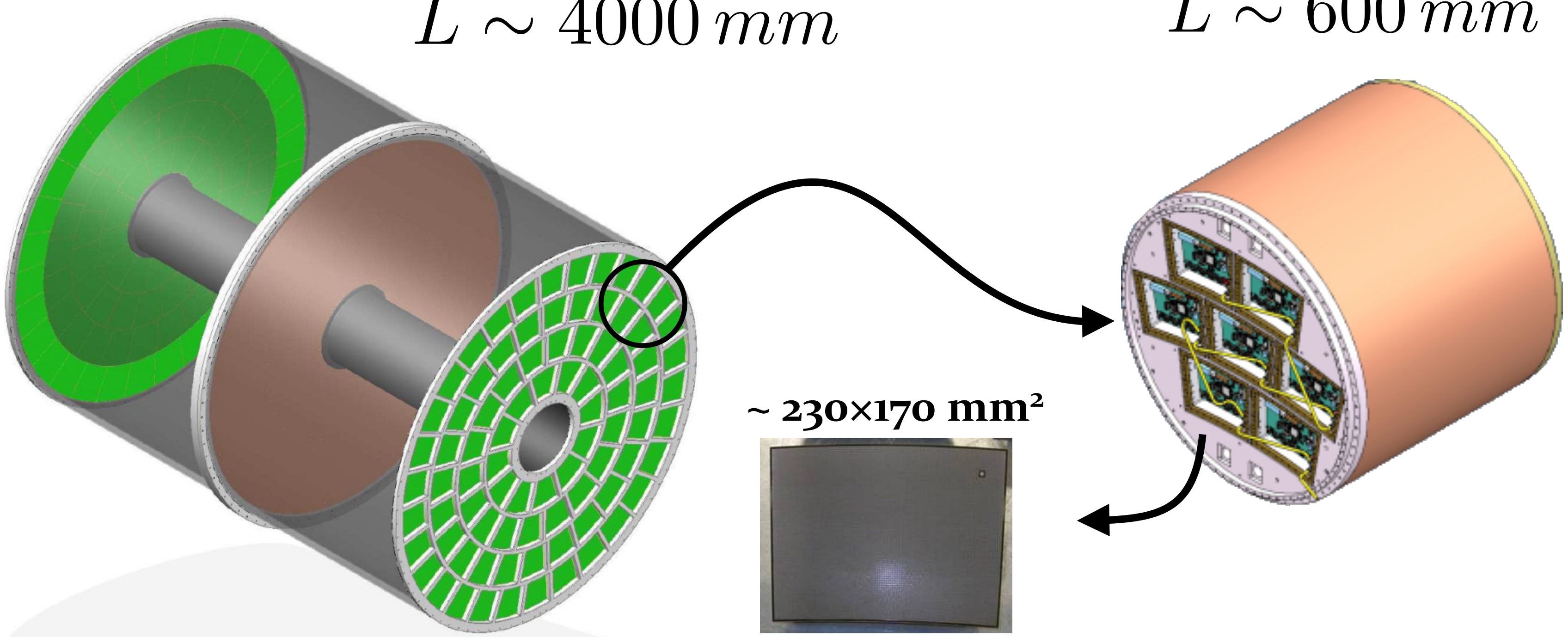
- momentum resolution,
- tracking efficiency,
- material budget

Beam Test with Large Prototype TPC

Large Prototype (LP) TPC setup was implemented to evaluate momentum resolution, module-boundary effect for tracking, field calibration and so on.

ILD TPC
$\phi \sim 3600\,mm$
$L \sim 4000\,mm$

LP TPC
$\phi \sim 700\,mm$
$L \sim 600\,mm$



~ 230×170 mm^2

Readout Module

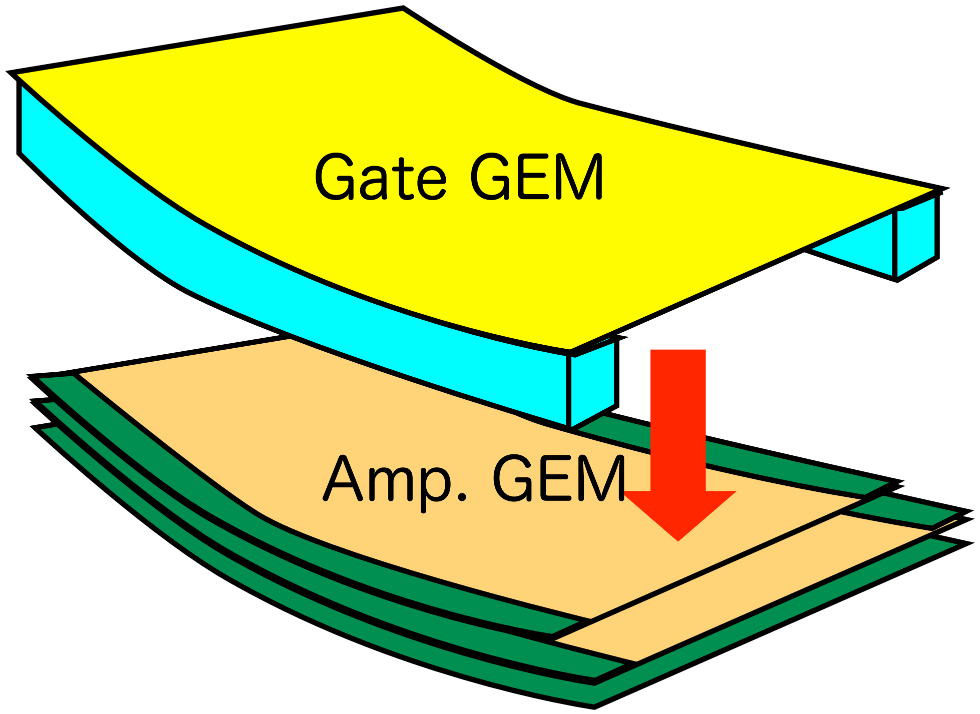
Magnet and Moving table in the beam test area @DESY

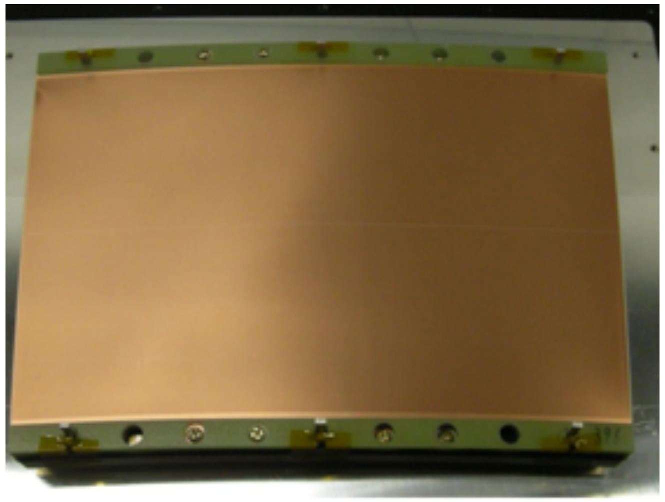
LP construction itself becomes R&Ds for Field Cage, Cathode plate, Endplate.

LP plays a role as a test bench for the readout module R&Ds.

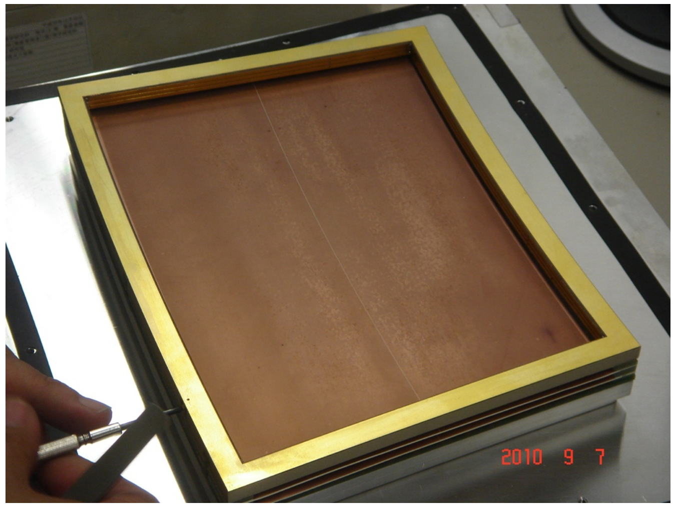
Several groups work on the different readout modules.
(Triple GEM, Double GEM, Micromegas + Pad Readout or TimePix readout).

Double GEM Module





100μmGEM



field shaper

Features

100μm thick GEMs (SciEnergy)
--> Double GEM configuration
Stretching structure without side frames
--> Minimize dead area

2 Segments to reduce the stored energy
--> Stability

Designed to be used with a gating GEM

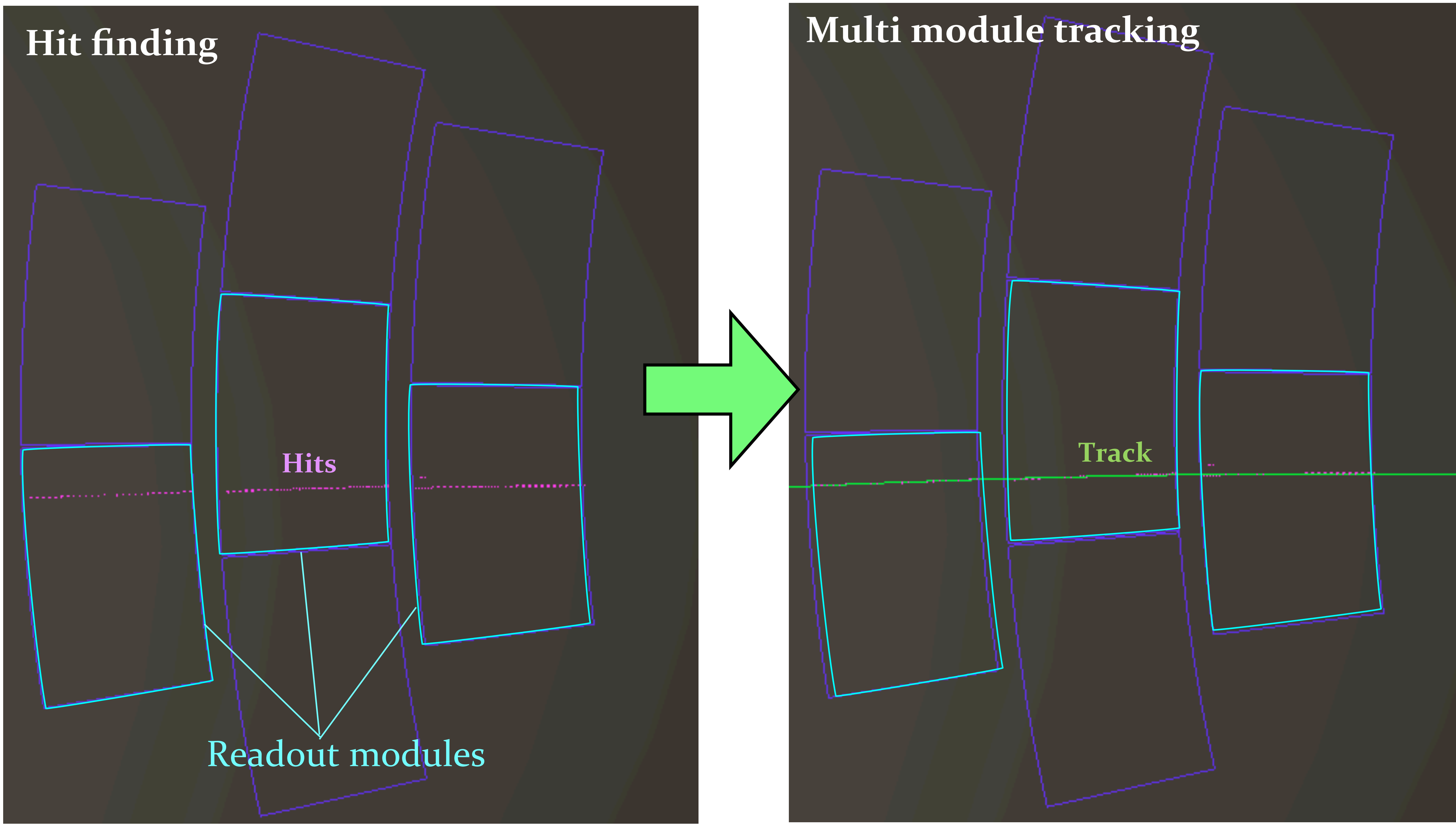
It is found that our special GEM (14μm thick, ϕ90μm) for gating doesn't satisfy our requirement. (electron transparency ~ 40%)

We replaced the gating GEM to a field shaper to concentrate on the test of amplification device. But we have to give up the test for boundary effect with this module because of the field shaper.

Results from the Beam Test (1)

Event display from LP beam test

5GeV electron beam

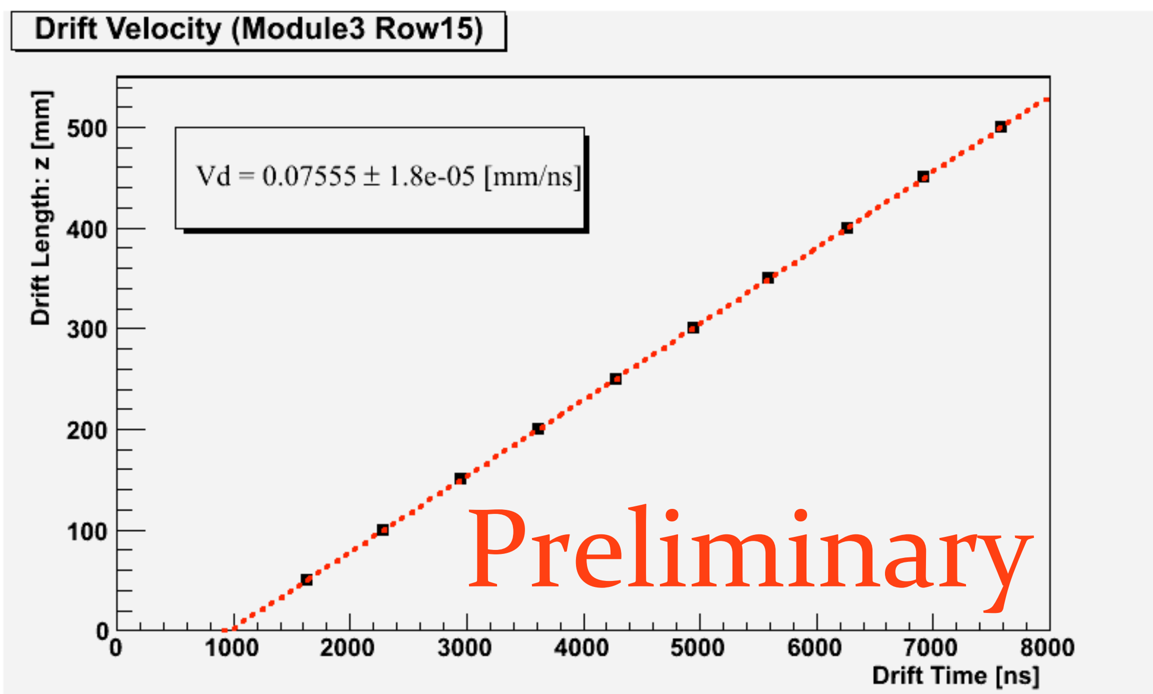


Results from the Beam Test (2)

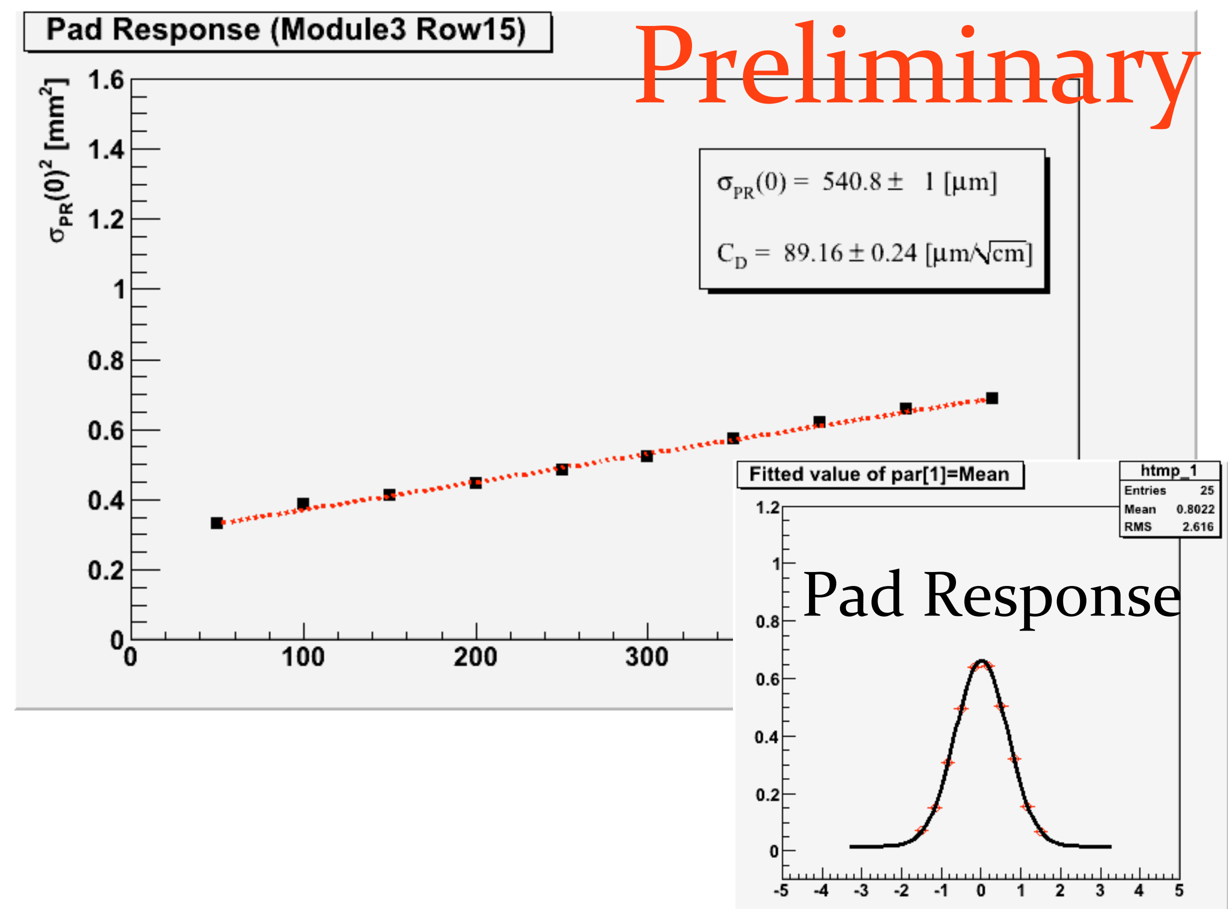
Gas property check from reconstructed data

B = 1 T
Gas: Ar-CF_4-isoC_4H_{10}(95:3:2)

Drift Velocity



Diffusion Constant



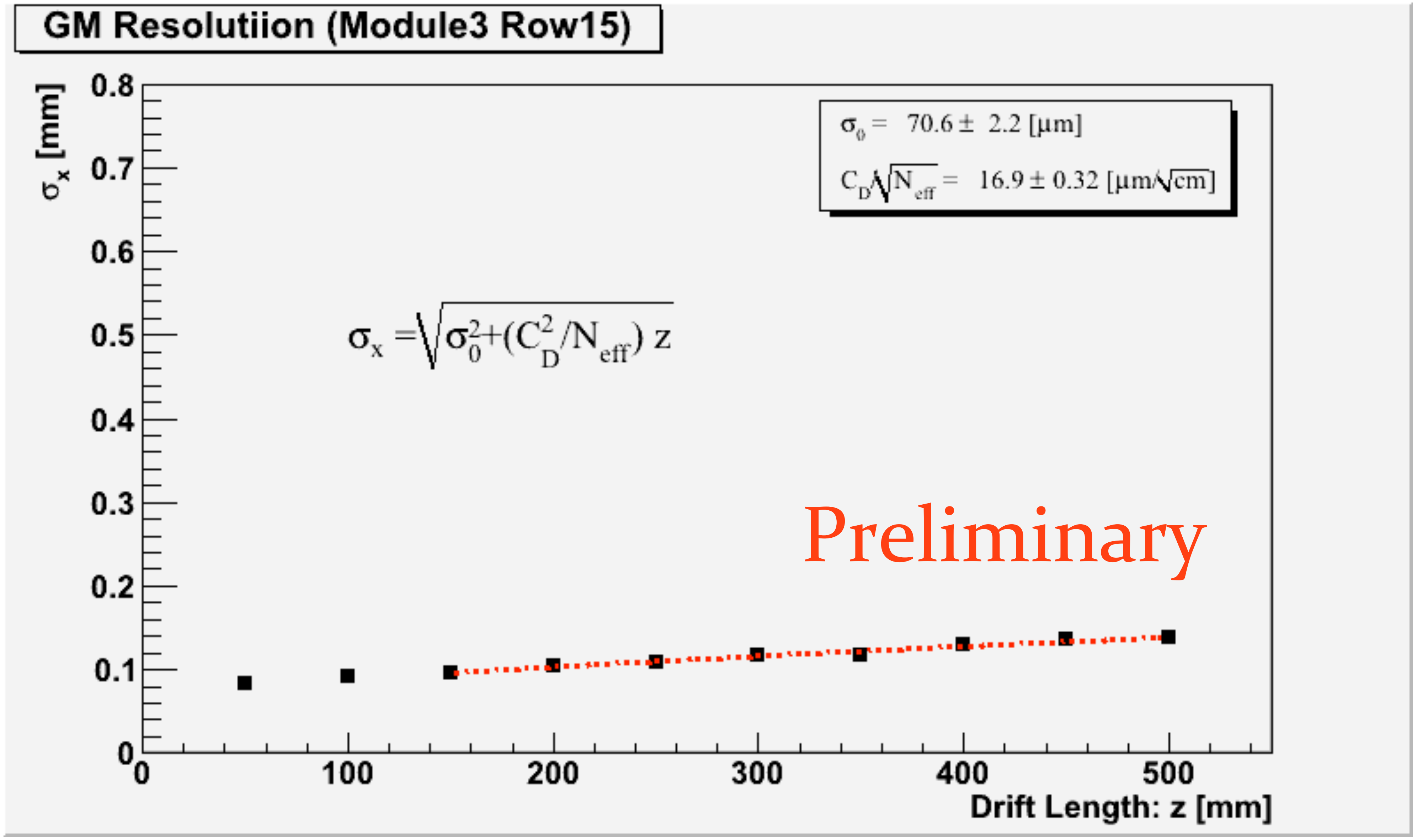
These results are consistent with our small prototype results and simulation (Magboltz)

Results from the Beam Test (3)

B = 1 T

Gas: Ar-CF_4-isoC_4H_{10}(95:3:2)

Point resolution

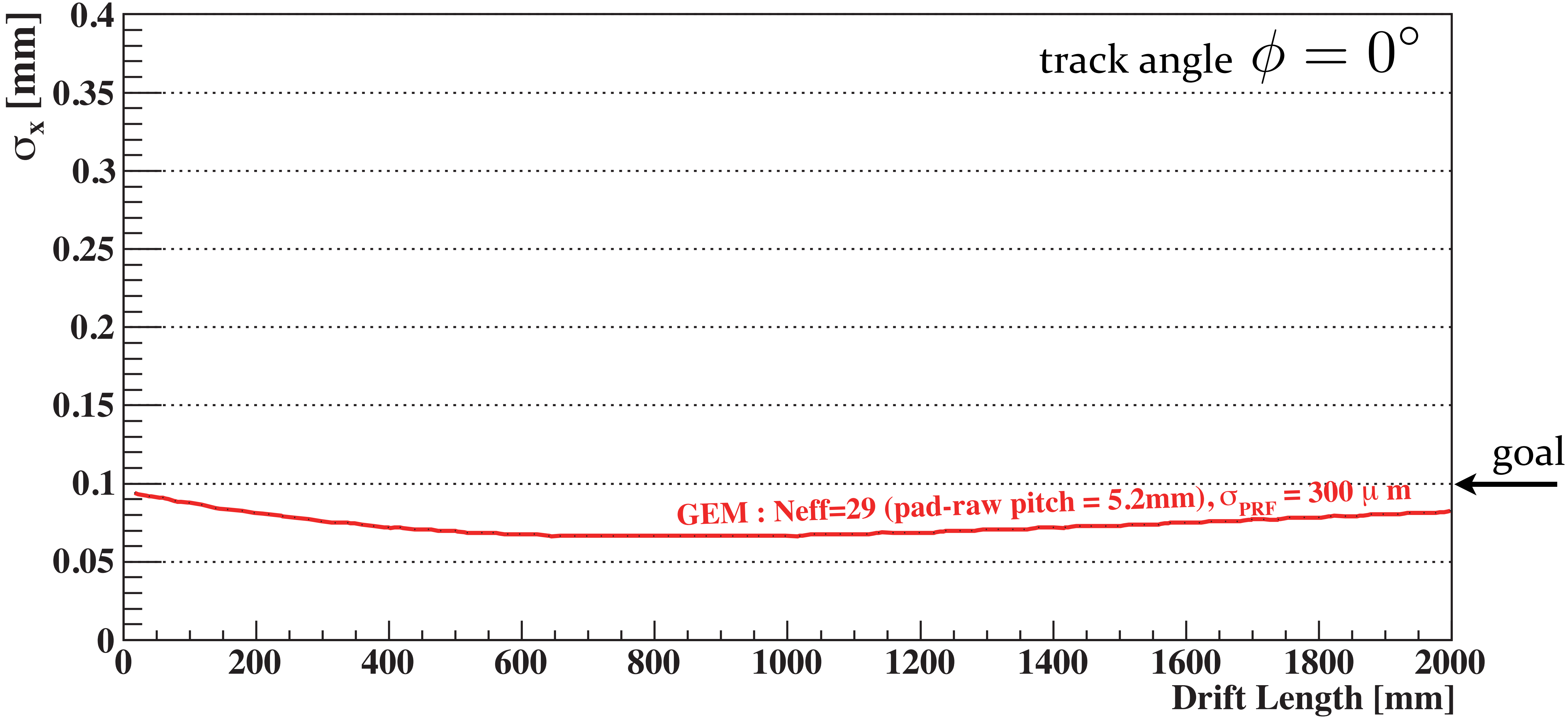


These results is also consistent with our small prototype result.

Extrapolation of point resolution to the ILD-TPC

σPRF depends on the length/field strength of transfer/induction gap

Analytic calculation assuming N_{eff} and σ_{PRF}



Double GEM seems to satisfy the requirement for the ILD-TPC performance in terms of point resolution.

But we should measure N_{eff} and σ_{PRF} **at 3.5 T** to validate the parameters used above.

Modified GEM

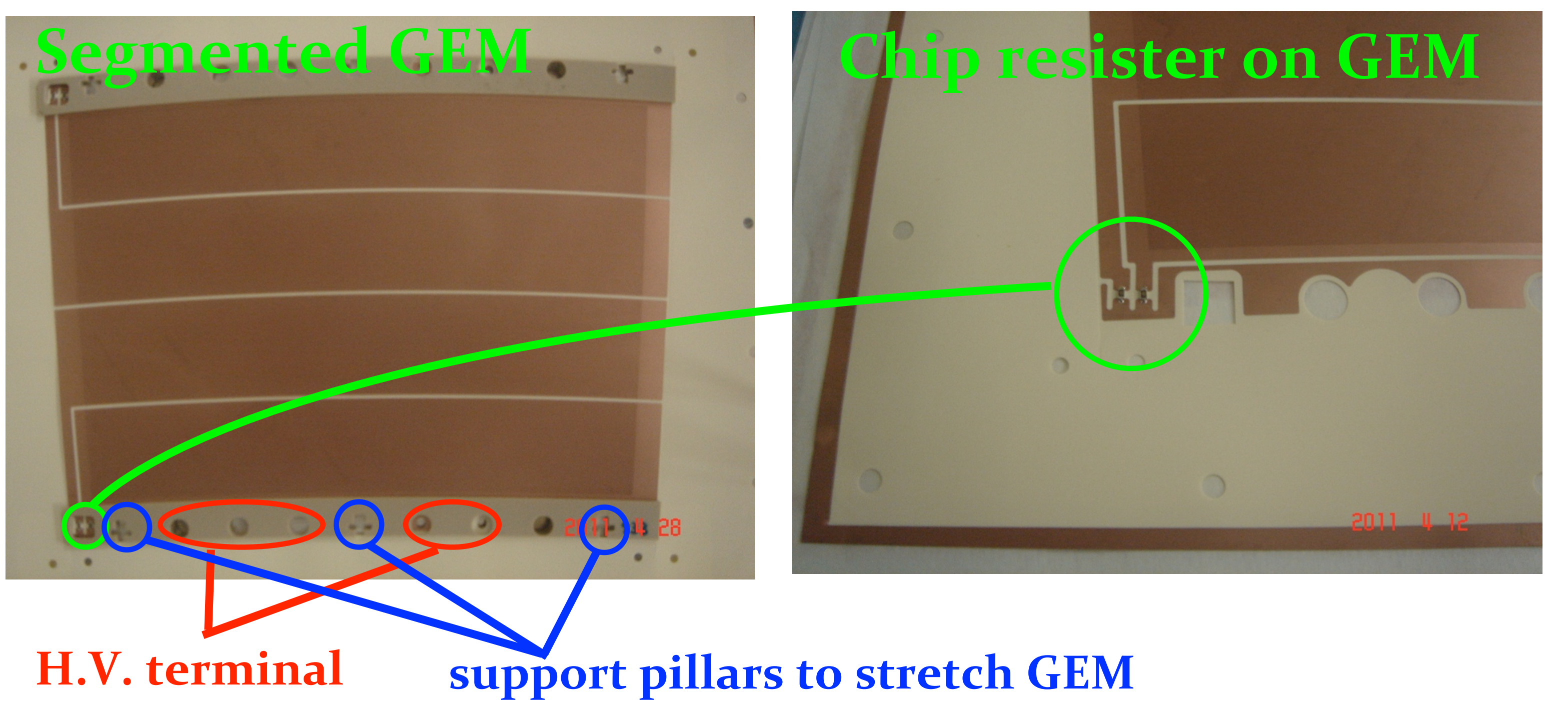
Previous modules often discharge.

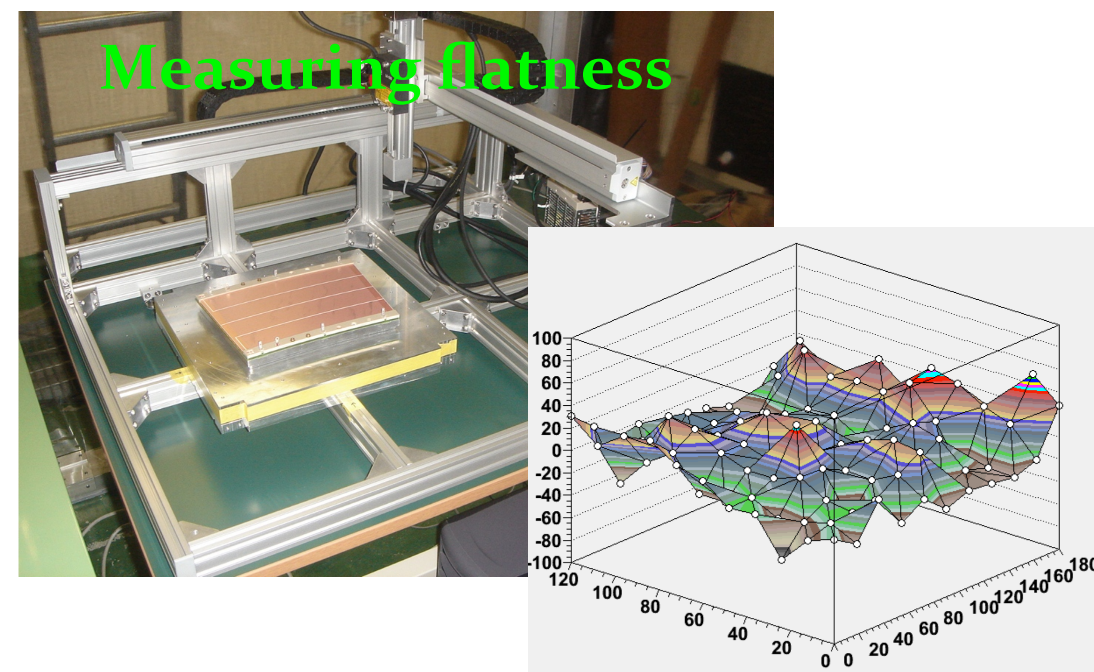
Difference compared with previous GEM

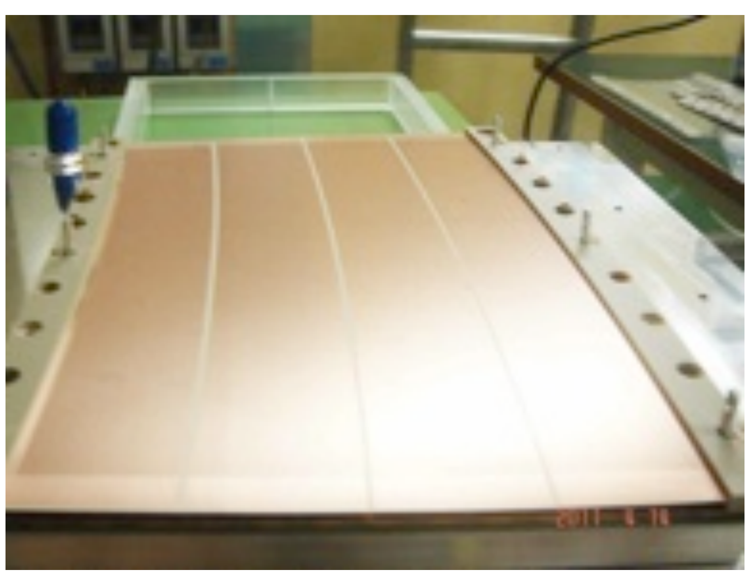
- Segmentation 2 --> 4 to reduce stored energy
- Chip resisters are implemented to divide into 4 segments.

Designed to be used with the field shaper.

--> We can't study boundary effect with this module






GEM flatness looks good

Test with this module will be done soon.
  check discharge probability
  any distortion ?

Will evaluate momentum resolution with multi modules

Remaining Issues & Plans

(1) Stable operation small prototype and LP 1

(2) Momentum resolution LP 1

Distortion --> will be fix by improved module
Module alignment
Tracking with non uniform magnetic field taken into account

(3) Module boundary effect new LP

(4) Gating device small prototype and LP 1

Conventionally used wire gating

Test with wire gating small prototype
- E x B effect at 3.5 T ?
- Stiff structure possible ?

Looking for new method (e.g. GEM gating) small prototype and new LP

(5) New Module new LP

Stretching structure
GEM design
Readout & Cooling See next talk by T. Fusayasu

(6) Estimation on Ion feed back --> The results are coming soon

Effect of primary ions in drift volume --> the most serious issue Give up TPC?
Effect of ion disk in drift volume --> Done by P. Schade OK with a gating device
Effect of ion disk between gating device and amplification device.

Conclusion

R&Ds for ILD-TPC is progressing on the international LCTPC collaboration.
We're developing
- Double GEM readout module
    - Flatness of the GEM is good (± 40μm)
    - Point resolution meet the goal
    - Module boundary effect and momentum resolution will be checked
    - We're discussing next design based on new readout.
- Tracking software with considering non uniform magnetic field

We will study
- Gating device
    - wire gating
    - GEM gating

Backup

Magbolts results

With 200ppm water V = 7.36 cm/μs ± 0.03%

Without water V = 7.53 cm/μs +- 0.02%

With 200ppm water Cd = 94.5 cm/μs ± 1.39%

Without water Cd = 94.2 cm/μs ± 1.48%