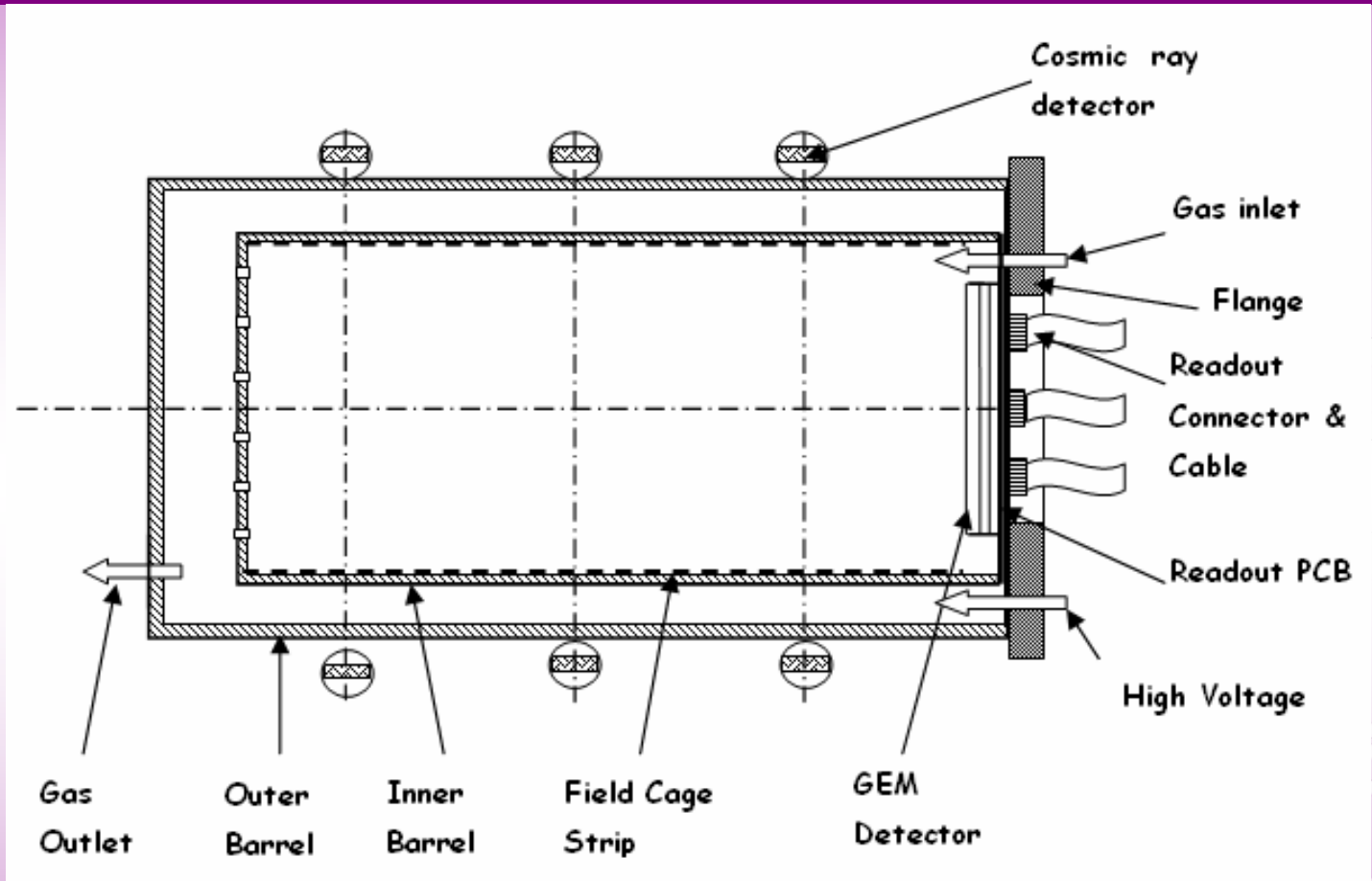
Performance Study of TU-TPC Prototype Using Cosmic-ray

- Tsinghua University TPC group
- CDC group: » KEK
  » Saga University

Yulan Li
Tsinghua University

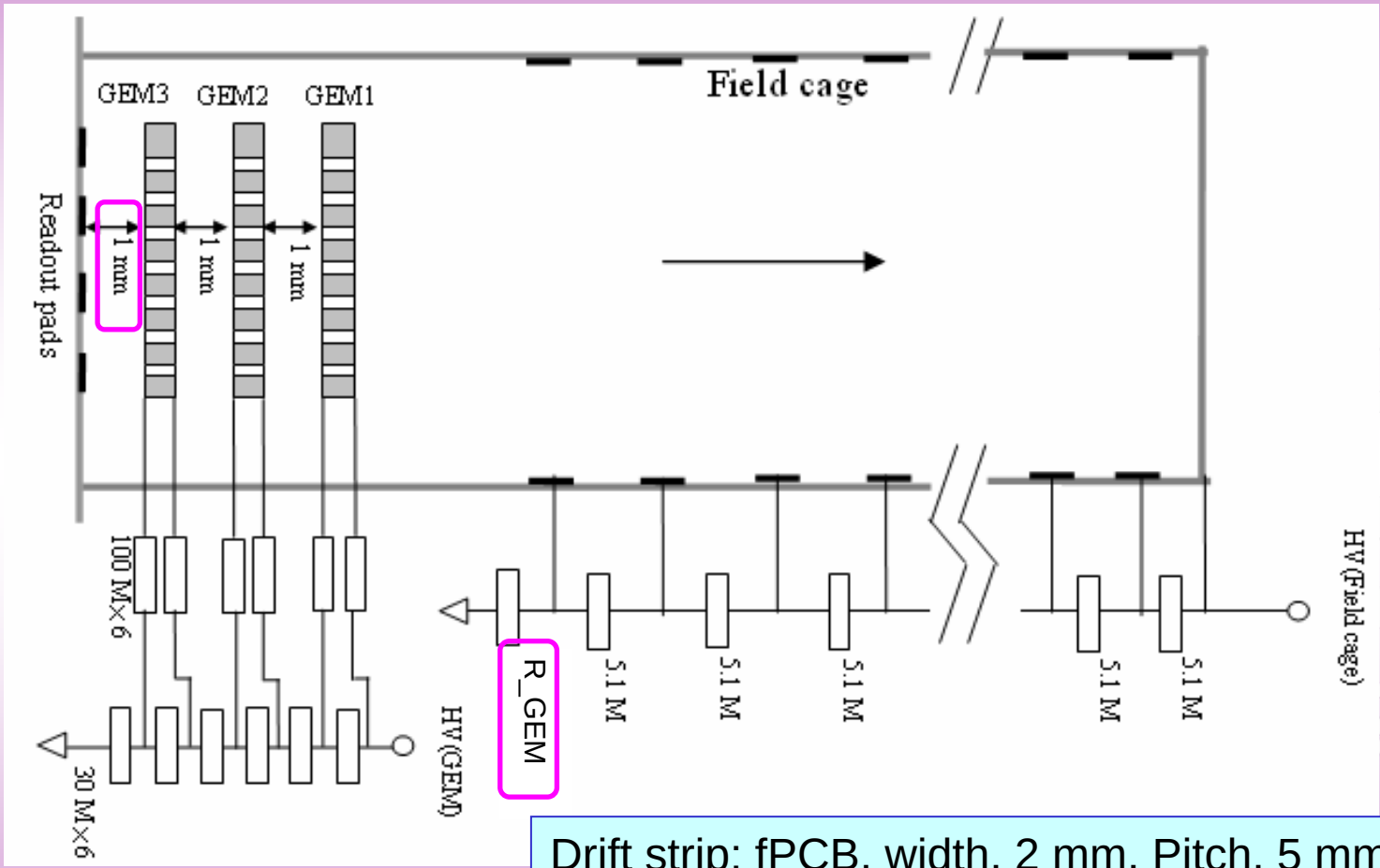
Scheme of TU-TPC prototype



Readout detector: triple-GEM, CERN standard GEM foils, 10 cm × 10cm;

Drift length: 50 cm

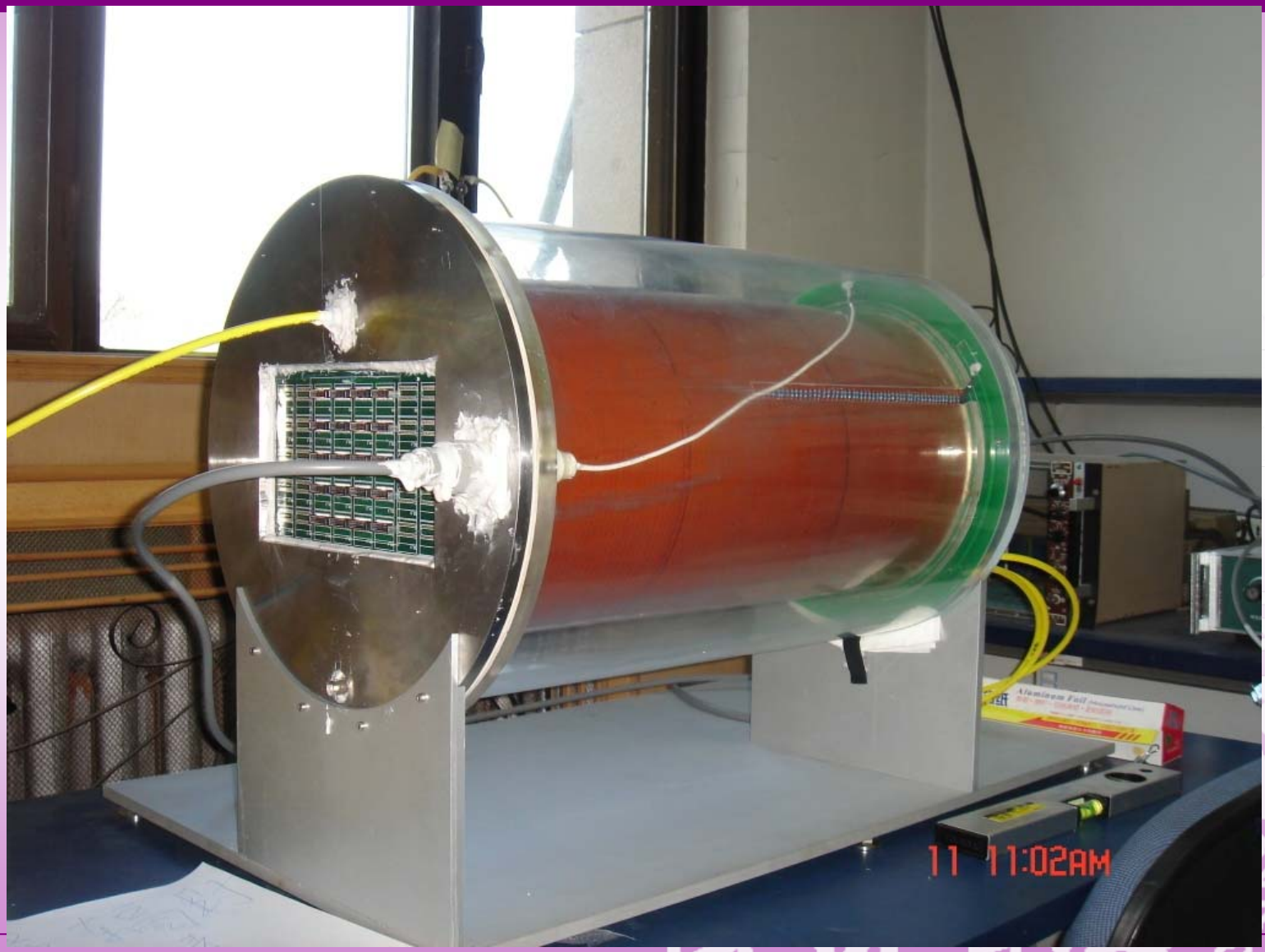
High voltage distribution



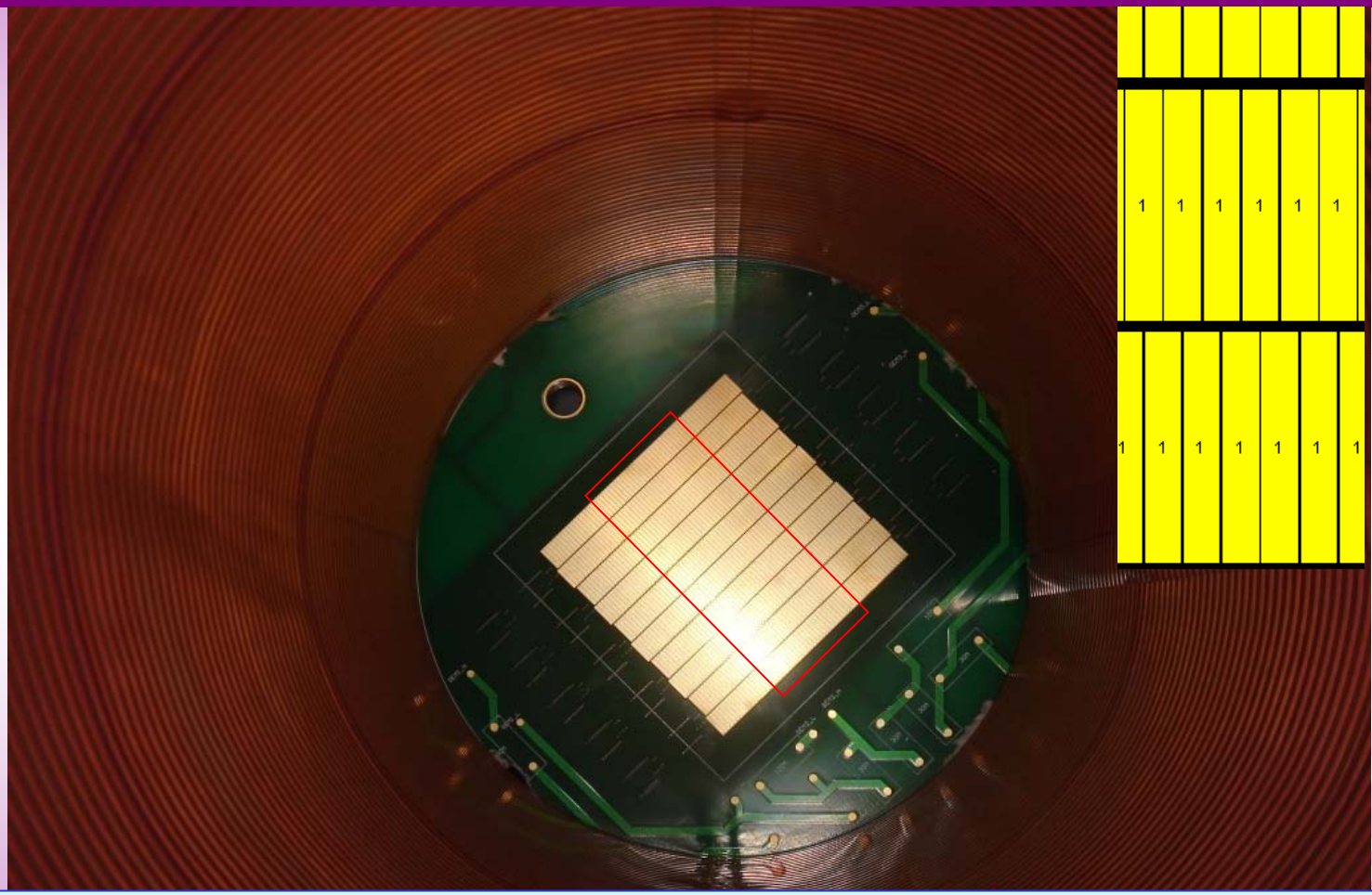
Drift strip: fPCB, width, 2 mm, Pitch, 5 mm

R_GEM: variable, to match the surface potential of the top GEM foil

The prototype: photograph



Prototype: readout pad



Readout pad: size, 9.5 mm × 1.5 mm (Pitch: 10 mm × 1.6 mm), staggered

10 x 62 pads placed, only 10 x 32 pads read out due to the limitation of electronic channel number.

Whole system

TU-TPC Studies @ KEK

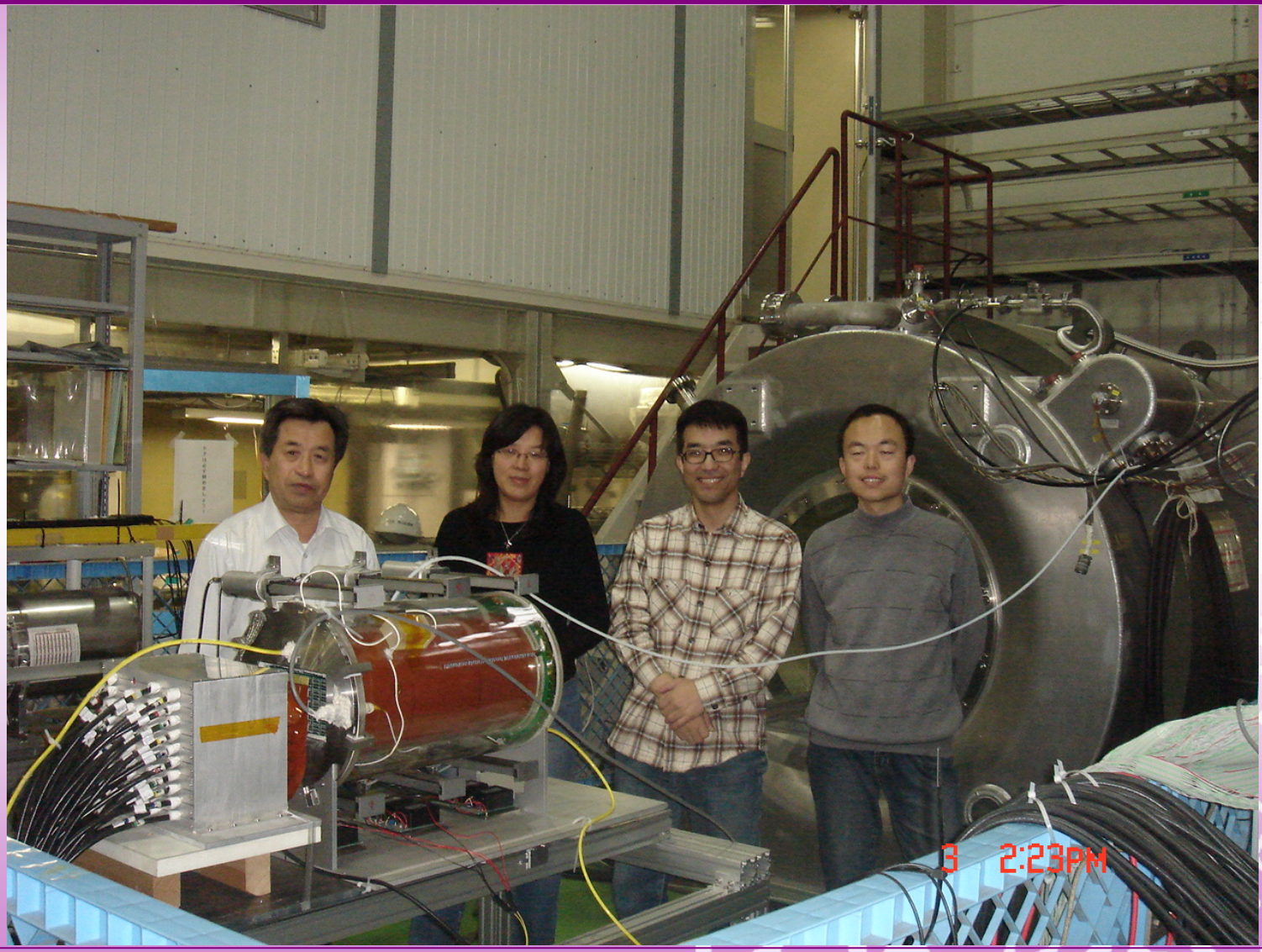
- Cryo center, KEK
- Nov.29 - Dec.25, 2007
- B=1T
- Analysis package: DoubleFit
- Test conditions:

Some modification:

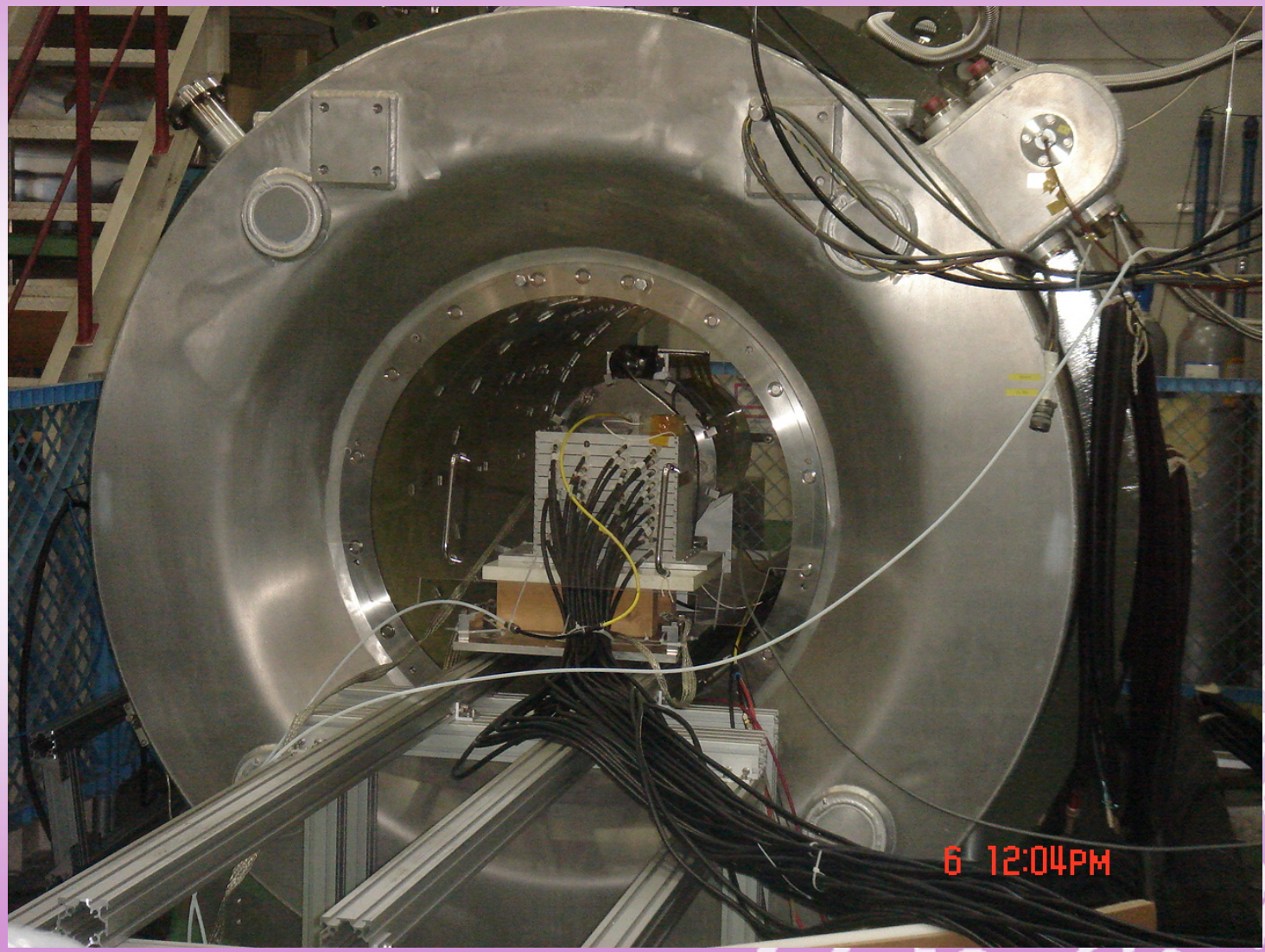
1. cosmic-ray trigger system:
   - Large crystal: 50 cm ×15 cm
   - PMT: fine mesh, R5924
2. R_GEM moved outside of chamber

Gas	V_{GEM} (V)	E_{drift} (V/cm)	Garfield Simulation Value	
			V_{drift} (cm/μs)	C_d (μm/√cm)
P10	370	134.6	5.5	129
P10	370	122.1	5.4	122
Ar:Iso:CF_4=94:3:3	265	145.2	5.4	80.3
Ar:Iso:CF_4=94:3:3	260	123.5	4.7	81.8

TU-TPC Studies @ KEK (Cont.)

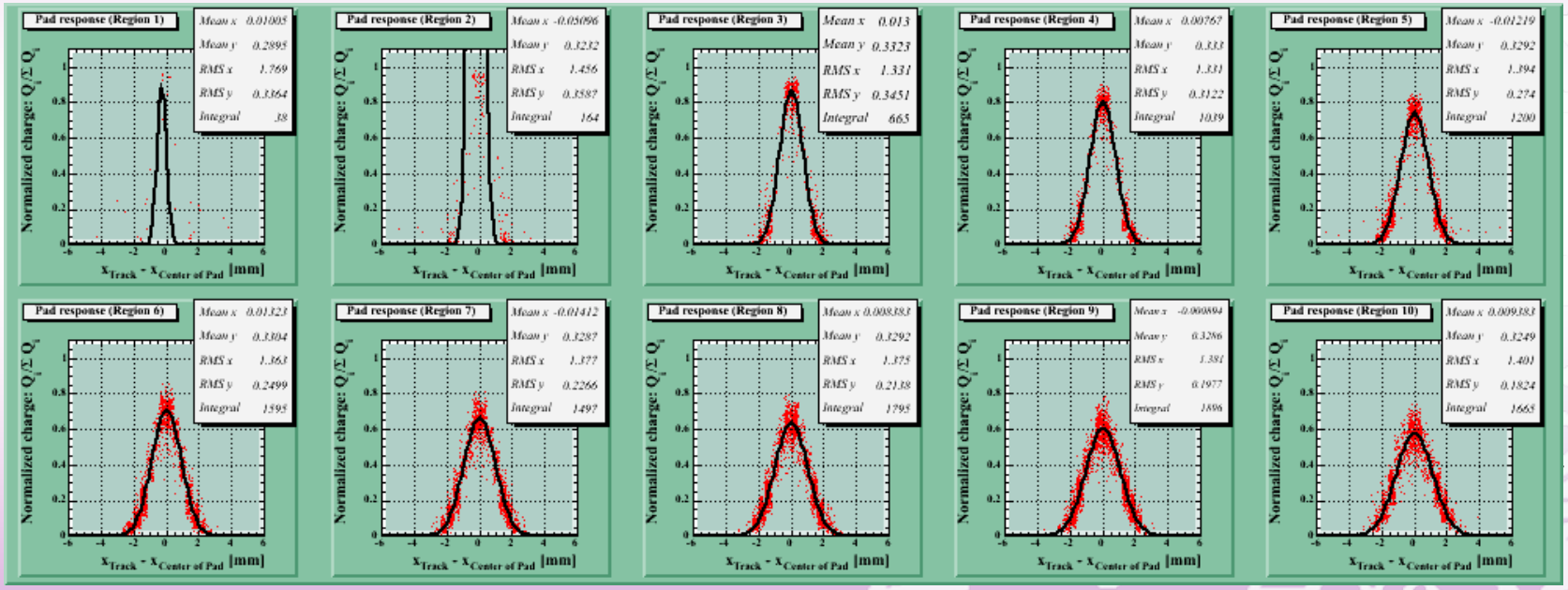


TU-TPC Studies @ KEK (Cont.)



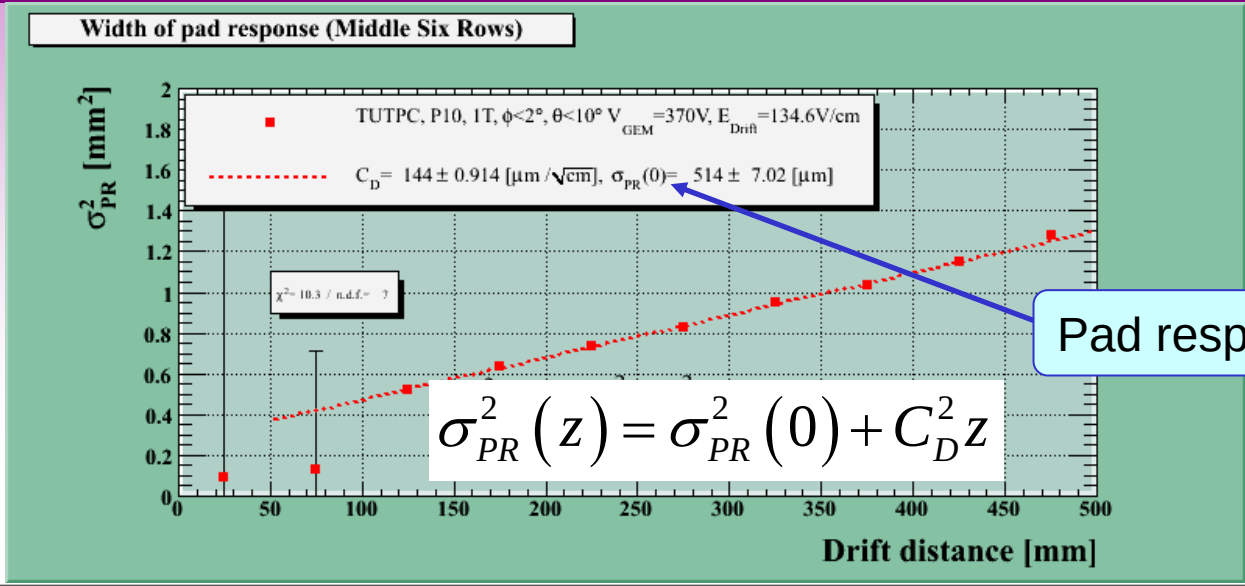
Pad Response

- Pad Response: the average fraction of charge falling on a given pad, as function of the distance between the track and the pad center for different z regions



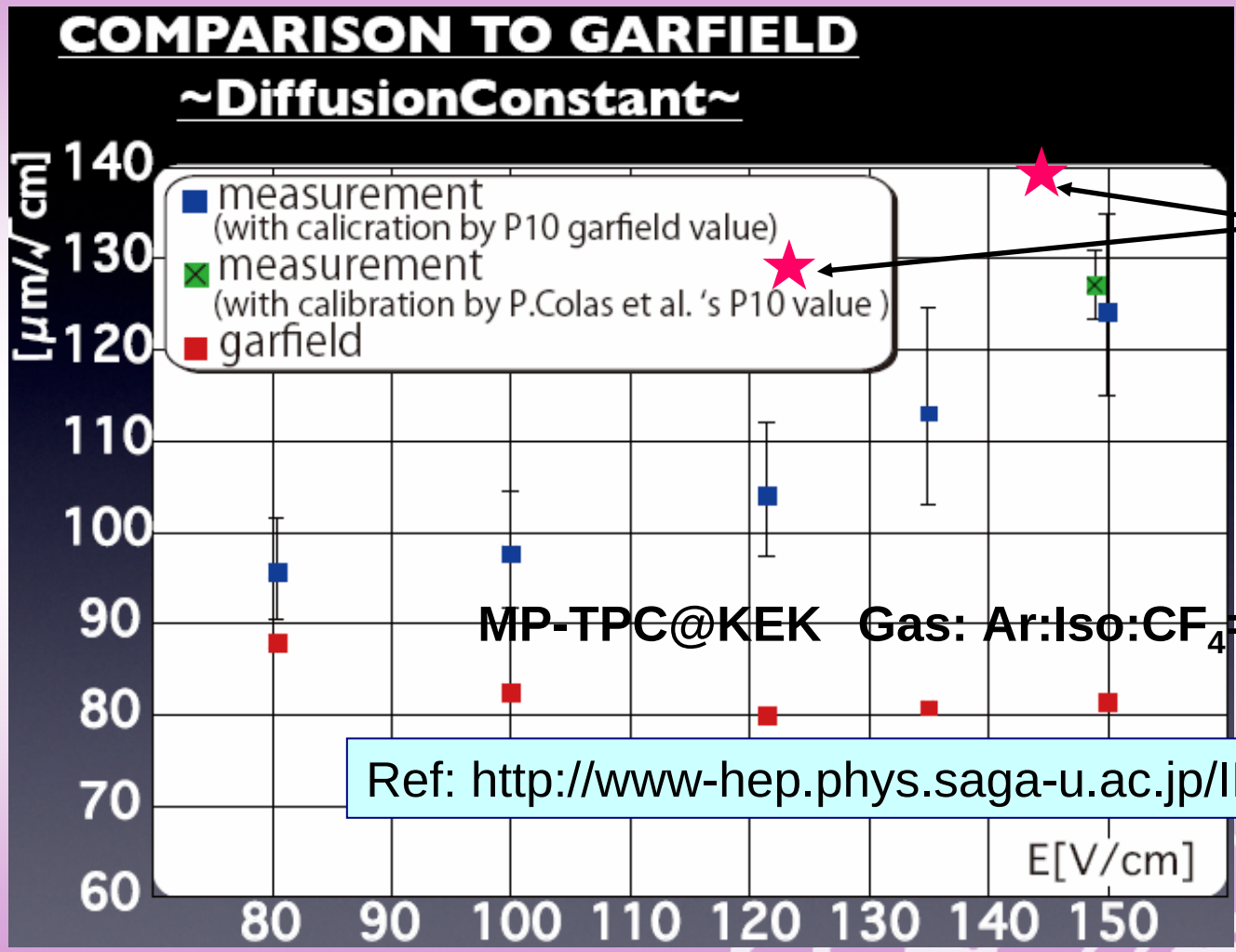
Middle 6 rows are used in the following analysis

Transverse Diffusion Constant C_D



Gas	V_{GEM} (V)	E_{drift} (V/cm)	C_d (μm/√cm)	
			Garfield simulation	Measurement
P10	370	134.6	129	144 ± 0.914
P10	370	122.1	122	141 ± 0.959
Ar:Iso:CF4=94:3:3	265	145.2	80.3	139 ± 0.663
Ar:Iso:CF4=94:3:3	260	123.5	81.8	130 ± 0.79

C_D-Comparison

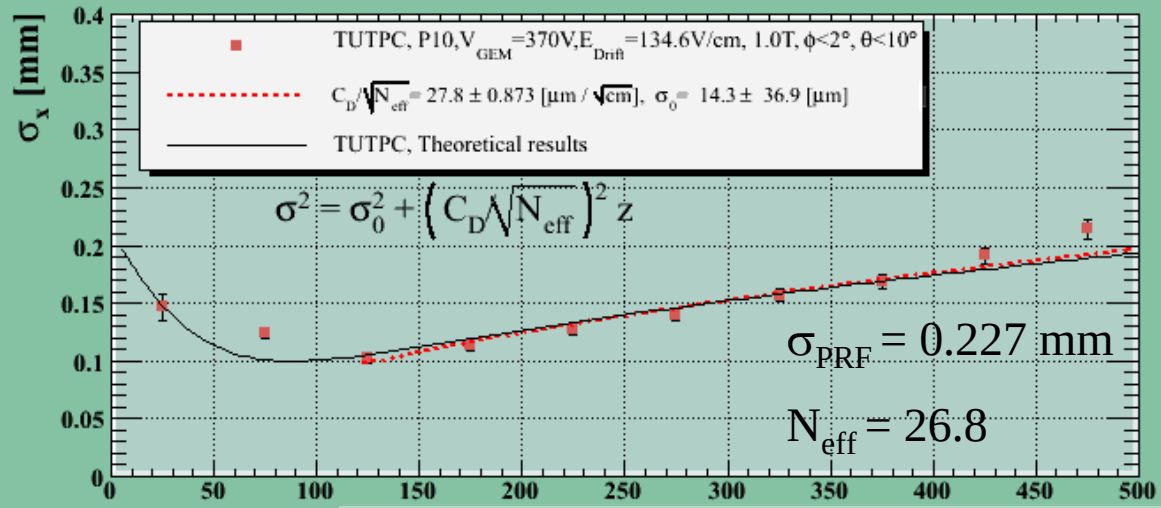


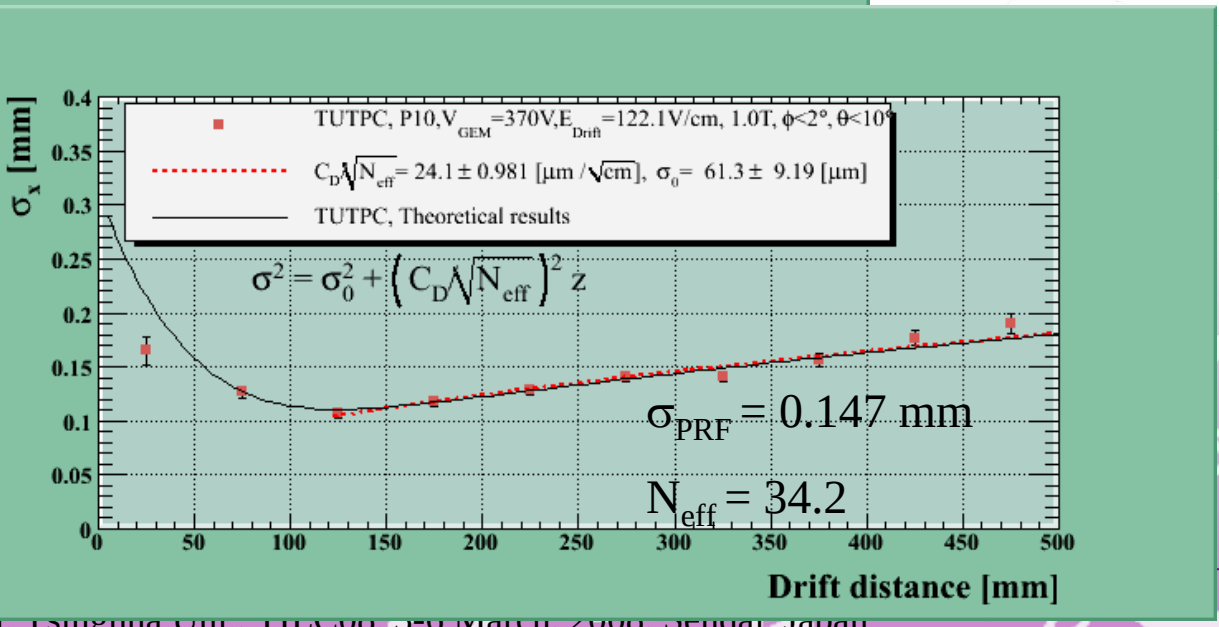
TU-TPC

MP-TPC@KEK Gas: Ar:Iso:CF_4=94:3:3, B=1T

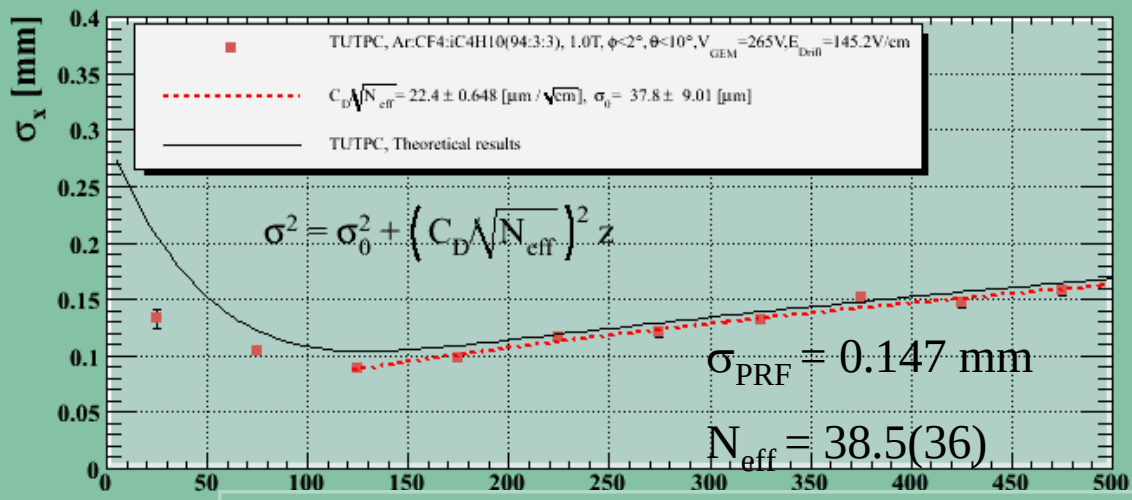
Ref: http://www-hep.phys.saga-u.ac.jp/ILC-TPC

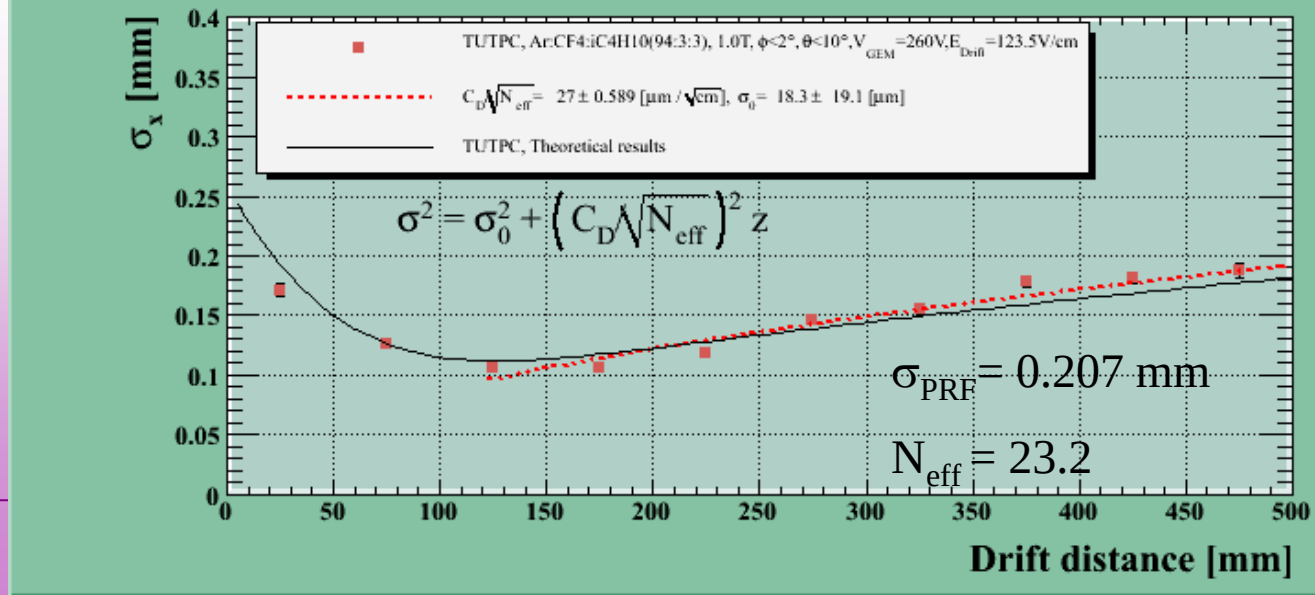
x resolution – P10 Gas





x resolution – Ar:Iso:CF_4=94:3:3 Gas





Pad response ~ Hodoscope

Pad response @ $z_{drift}=0$

Diffusion in GEM detector

Theoretical:

$$\sigma_{PR}^2(0) = \frac{w^2}{12} + C_{D,GEM}^2 \times Z_{GEM}$$

In analysis:

$$\sigma_{PRF}^2 = \sigma_{PR}^2(0) - \frac{w^2}{12}$$

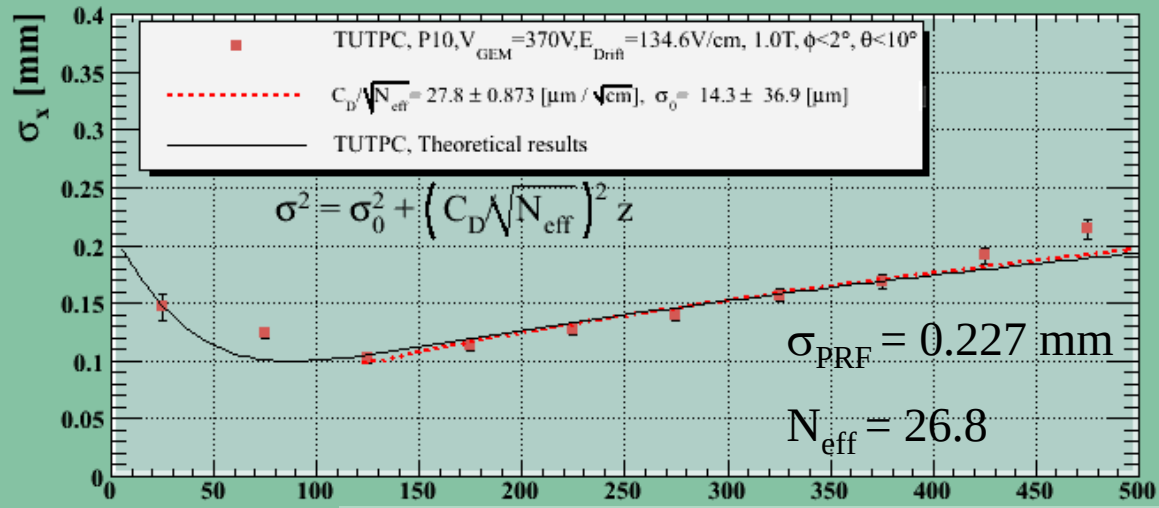
Gas	V_{GEM} (V)	$\sigma_{PR}(0)$ (mm)	σ_{PRF} (mm)		$C_{D,GEM}\sqrt{3\times 0.1}$ (mm)
			Measurement	Analytical fit	
P10	370	0.514	0.226	0.227	0.273
	370	0.484	0.145	0.147	0.273
Ar:Iso:CF_4=94:3:3	265	0.485	0.149	0.147	0.219
	260	0.505	0.205	0.207	0.219

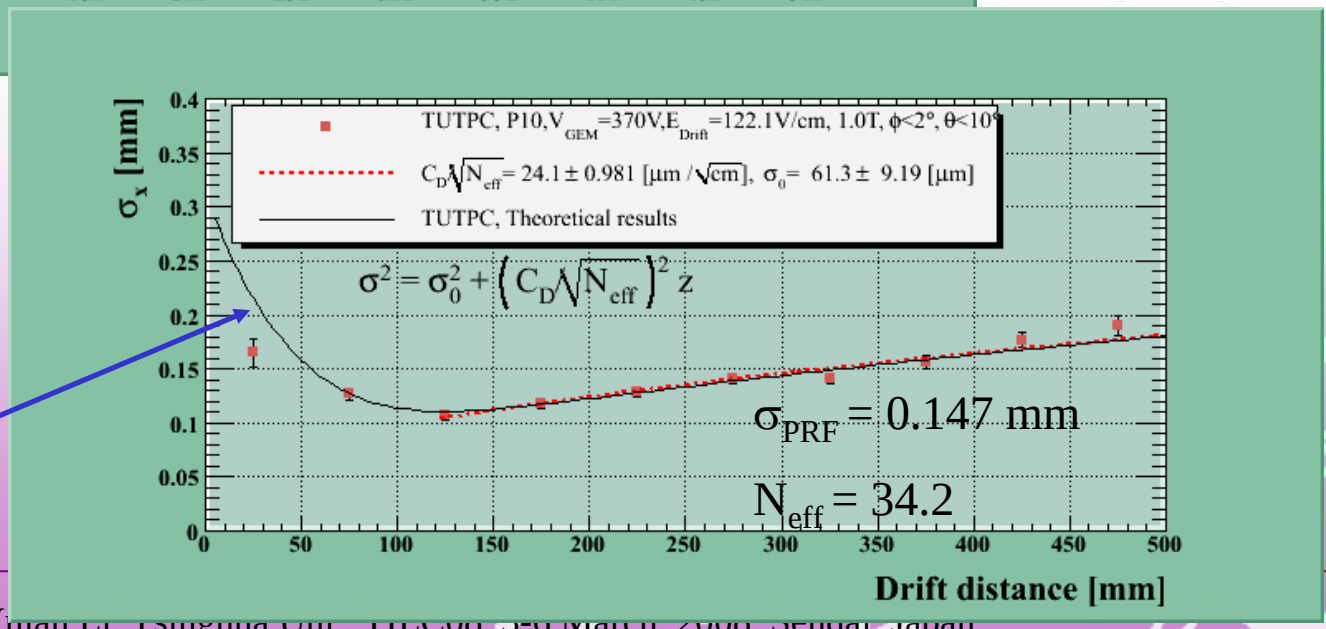
What happens if the above two values are different?

If diffusion is too small, the hodoscope effect will be more obvious.

We need defocus the electron in readout detector.

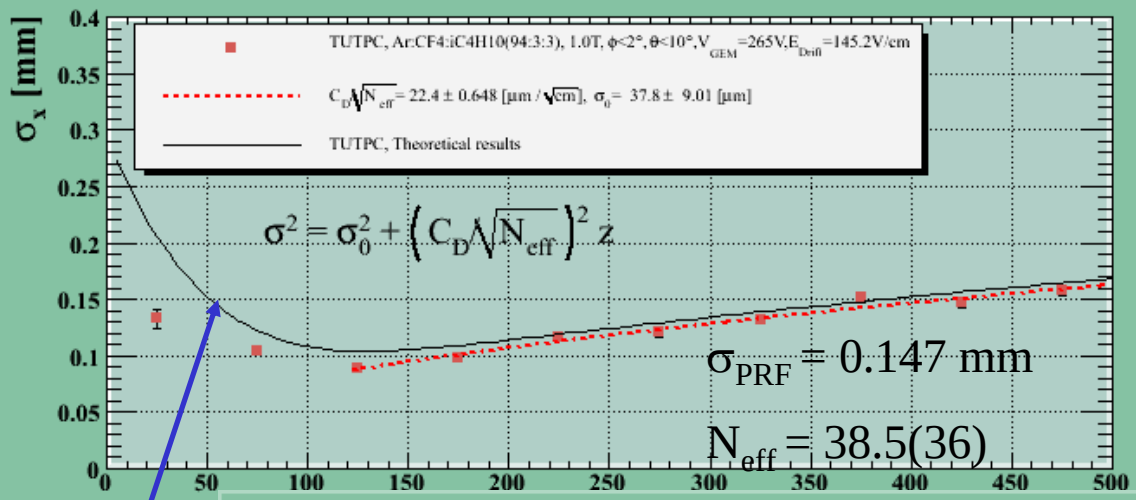
Pad response ~ Hodoscope (cont.)



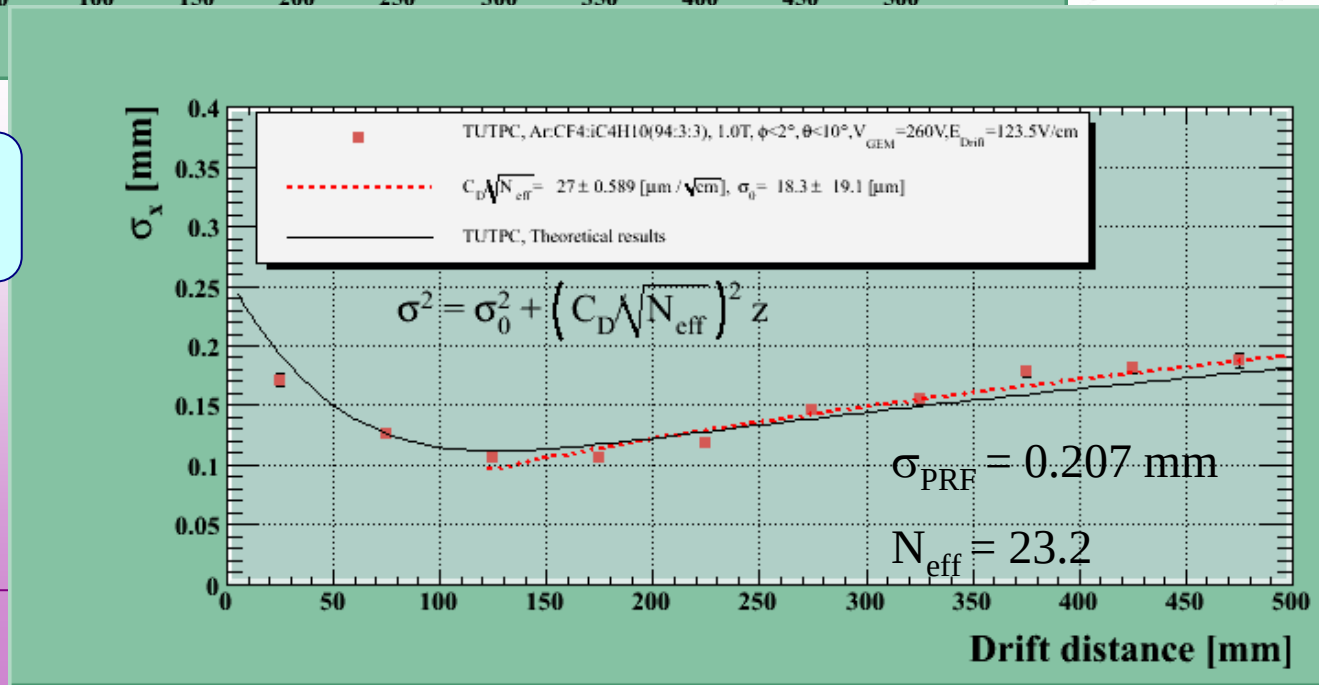


Hodoscope effect more obvious

Pad response ~ Hodoscope (cont.)



Hodoscope effect more obvious



N_{eff}-Comparison

- TU-TPC result (B=1T)

Gas	E_{drift} (V/cm)	V_{GEM} (V)	N_{eff} (H=10 mm)	N_{eff} (rescaled to H=6.3 mm)
P10	134.6	370	26.8	16.9
	122.1	370	34.2	21.6
Ar:Iso:CF_4=94:3:3	145.2	265	38.5	24.2
	123.5	260	23.2	14.6

- MP-TPC result

  (B=1T, Ar:Iso:CF_4=94:3:3)

E[V/cm]	N_{eff}
80	23±9
100	21±11
120	25±12
135	24±12
150	21±7

Ref: http://www-hep.phys.saga-u.ac.jp/ILC-TPC

Conclusion & Discussion

TU-TPC studies @ KEK (B = 1T) shows:

- Resolution can be as good as 100 μm @ Z ≈ 100 mm
- Measurement points fit the analytical formula very well
  - The analytical formula was confirmed again
  - Hodoscope effect ~ Pad response
    - Help us to understand MPGD-TPC more deeply
- For C_D:
  - For P10, a little larger than the simulation values
  - For Ar:Iso:CF_4, quite larger than simulation, same as MP@KEK test
- For N_{eff}:
  - More study are need
    - ? $N_{eff} \sim V_{GEM}$, we are expecting larger N_{eff} for larger V_{GEM}

Future Plan

- **The prototype is setting up again in Tsinghua**
- **More studies will be given in a quieter condition**
  - But without magnetic field