Analysis of test beam & cosmic ray data taken by GEM or MWPC equipped prototype TPC

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ILC TPC Analysis Jamboree
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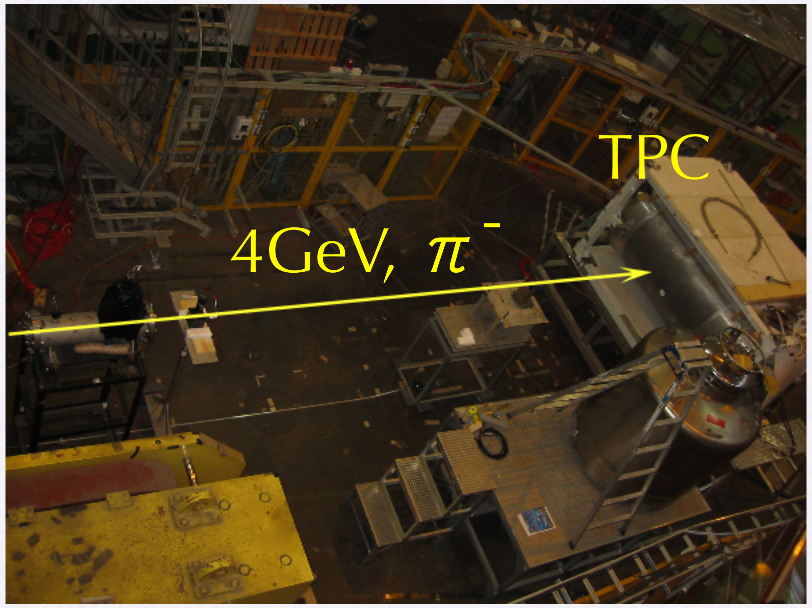
First of all,

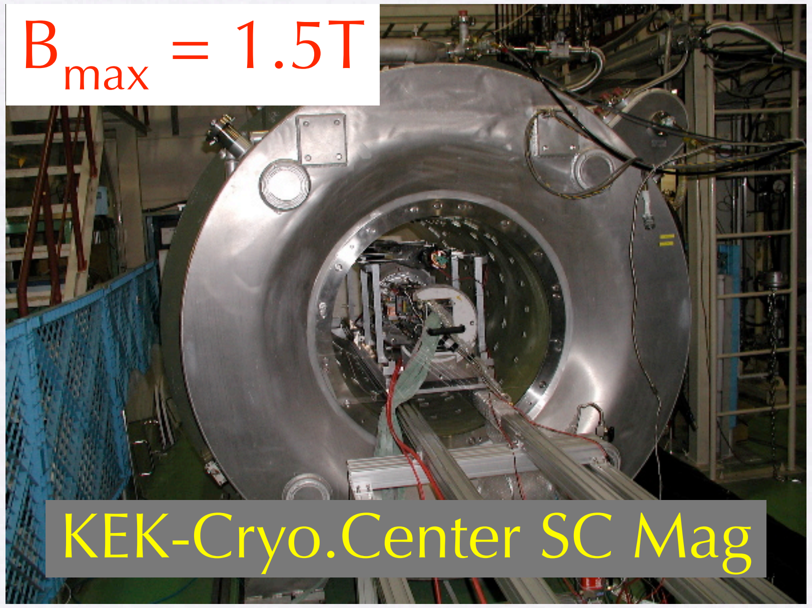
- On the first day of this workshop I learned a lot of methods and techniques concerning the track reconstruction and resolution measurement from the various group.
  - Comes up with new idea
  - Improve our analysis and results ("numbers")
- In this talk, I intend to present not numbers but current our understandings of the prototype-TPC behavior.
  - Pad response analysis -> Z-dep of charge spread on pads
    - Comparison with Magboltz for gas property (C_D)
  - Transverse spatial resolution analysis -> Z-dep of sigma_x
    - Difference of B-field, gas, track angle & gas amplification device

Facilities for Beam/CR tests

- Superconducting solenoid & KEK-12GeV PS (π 2) for beam tests



- Superconducting solenoids at DESY and KEK-Cryogenic Center for cosmic-ray tests



Readout scheme & data sets

<table>
<tr><td>Gas amp. dev</td><td colspan="4">GEM</td><td colspan="5">MWPC</td></tr>
<tr><td>Features</td><td colspan="3">Triple GEM (Standard CERN)
1.5 mm transfer & 1 mm induction gap</td><td>+ resistive anode</td><td colspan="5">1 mm anode-cathode thin gap
2 mm anode-wire spacing</td></tr>
<tr><td>Pad geom. [mm]
Width (pitch) x Length (pitch)</td><td colspan="2">1.17 (1.27) x 6 (6.3) staggered</td><td>2 (2.3) x 6 (6.3)</td><td>2 (2.3) x 6 (6.3)</td><td colspan="5">2 (2.3) x 6 (6.3)</td></tr>
<tr><td>B-field [T]</td><td>0T</td><td>1T</td><td>1T</td><td>1T</td><td>0T</td><td>1T</td><td>0T</td><td>1T</td><td>4T</td></tr>
<tr><td>Beam/CR</td><td colspan="2">Beam</td><td>CR</td><td>Beam</td><td colspan="2">Beam</td><td colspan="3">CR</td></tr>
<tr><td>Gas</td><td>P5 (100V/cm)</td><td>P5 (100V/cm), P5 (50V/cm), TDR</td><td>TDR</td><td>P5 (50V/cm)</td><td colspan="5">TDR</td></tr>
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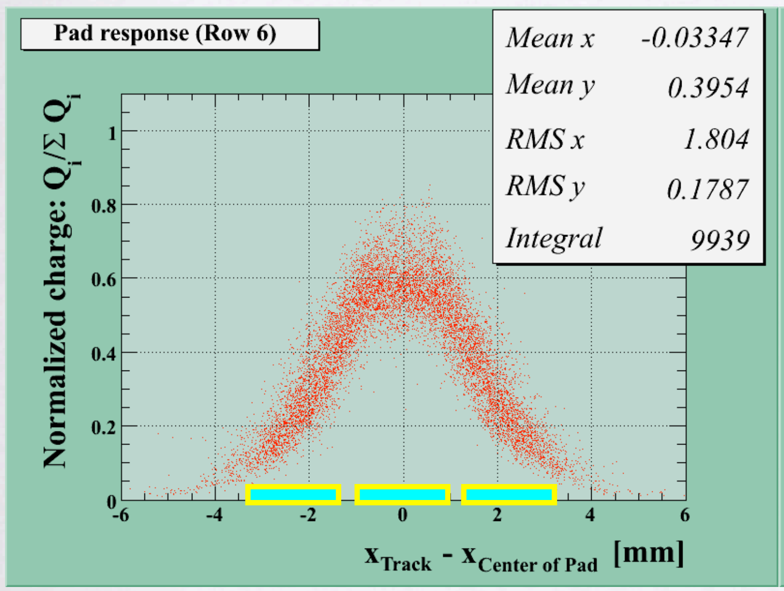
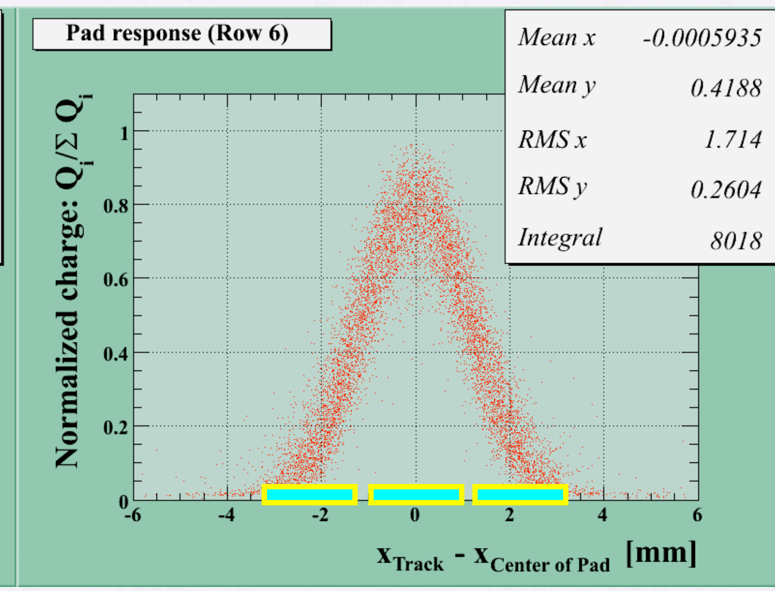
- MicroMEGAS KEK test beam data -> Previous talk in detail

Pad response analysis

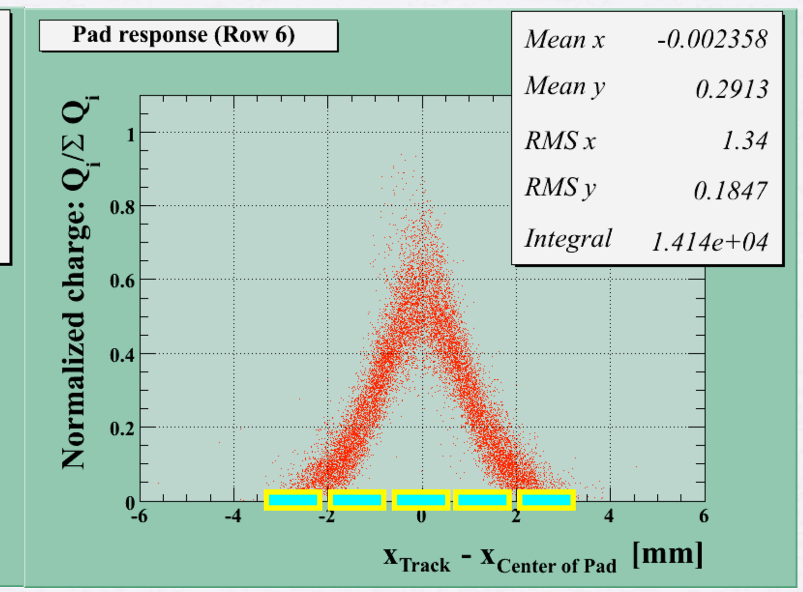
❖ Method: Charge fraction vs X_track - X_pad-center



MWPC (1T, TDR, 2.3mm pitch)



GEM (1T, TDR, 2.3mm pitch)

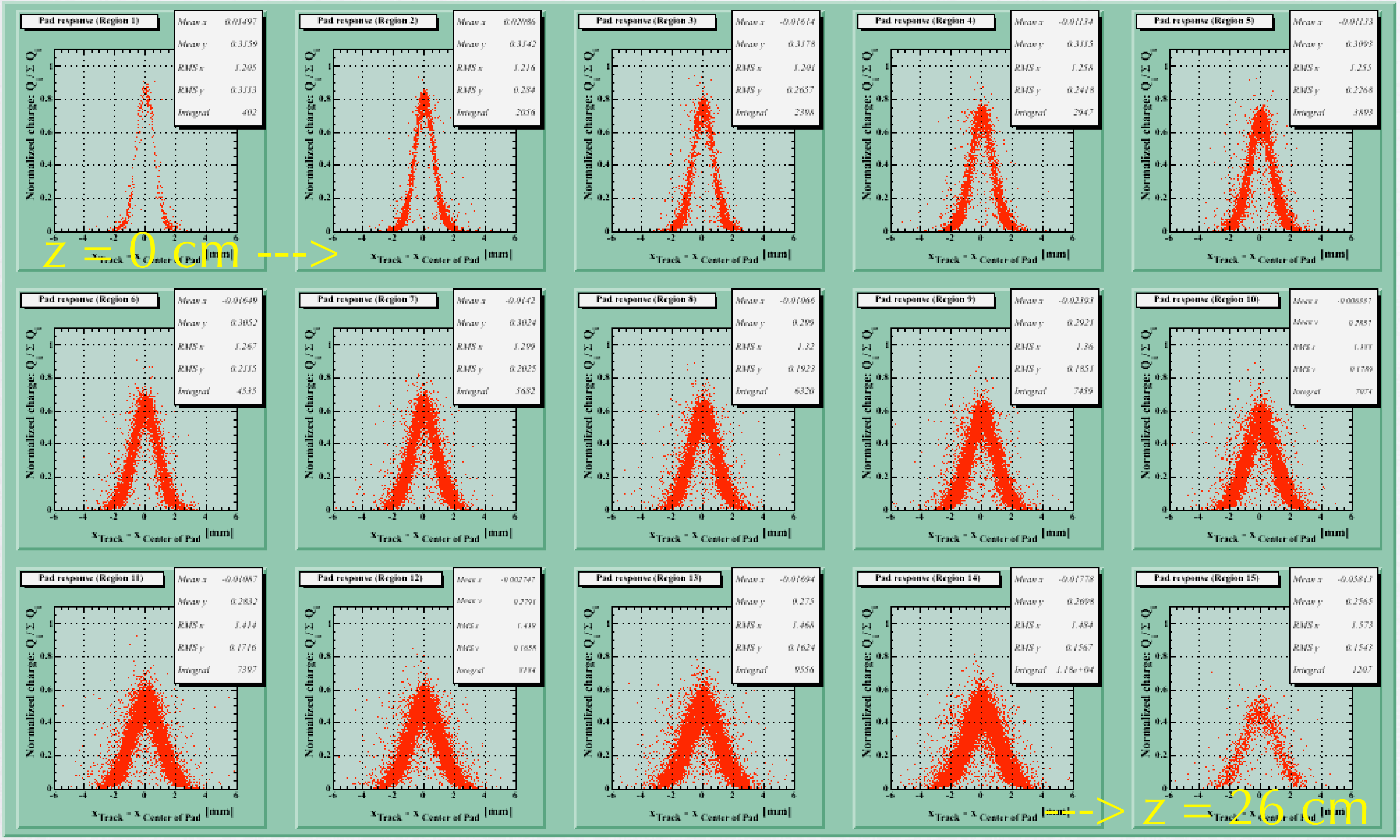


GEM (1T, P5, 1.27mm pitch)

- Plot Q_i/Q_{tot} against $(X_{track} - X_{pad\text{-}center})$ for different drift region
- Reject single & double pad hits for pad response analysis
- Divide the plot into different X-Slices and fit each slice with a gaussian
- Plot the sigma as a function of drift length

Z-dep of pad response

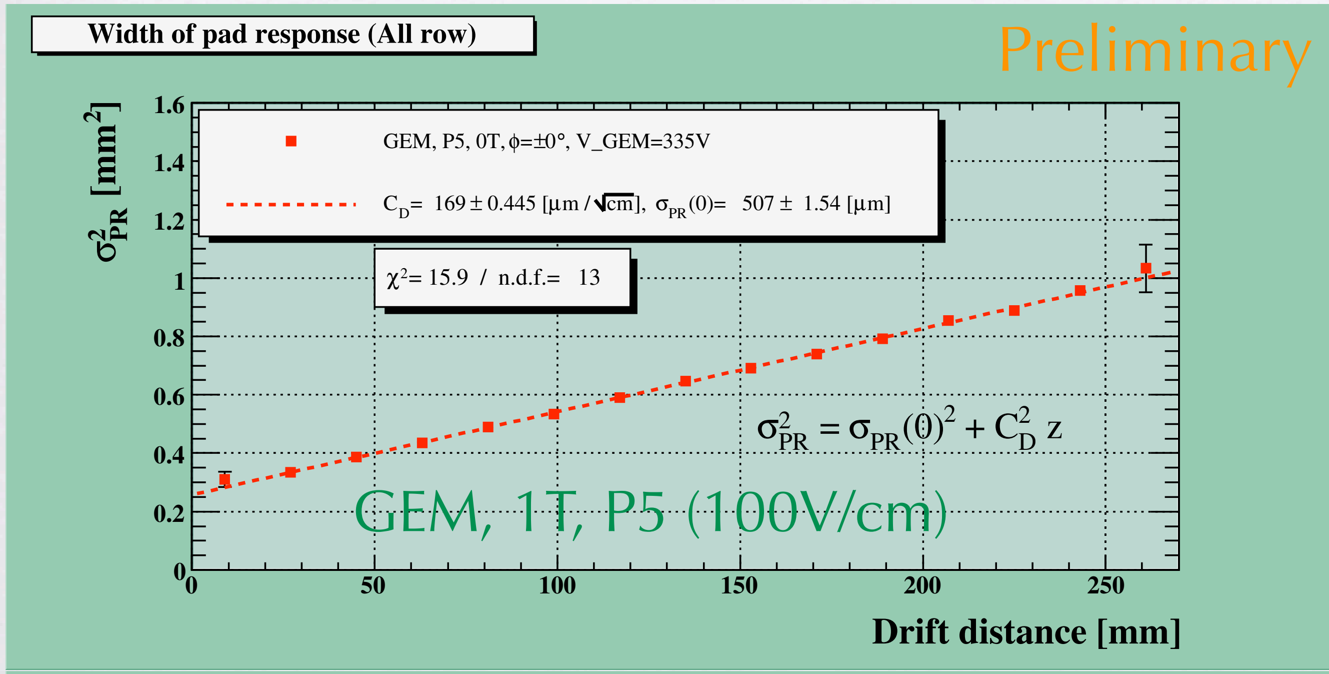
- GEM, 1T, P5(100V/cm), 1.27mm pitch for N_{bin} = 15

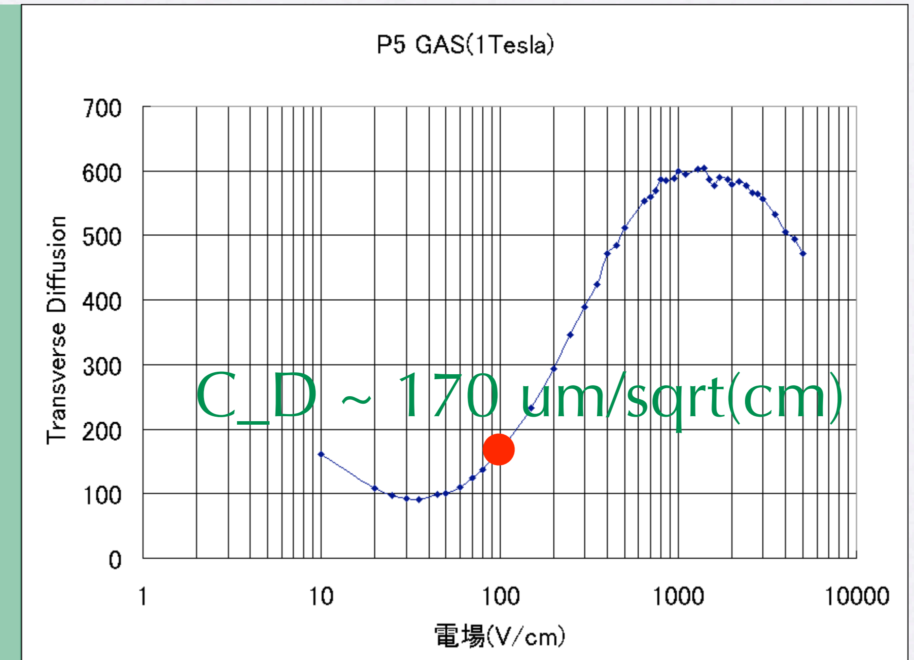


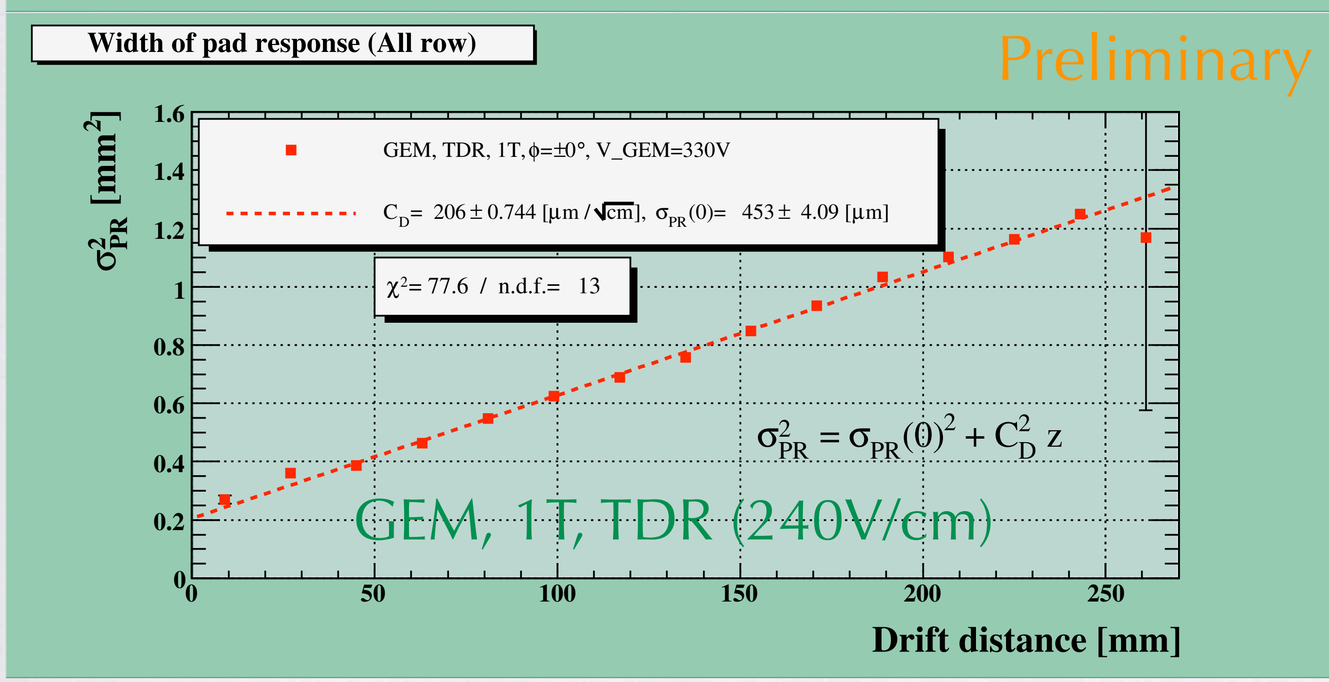
Z-dep of pad response width

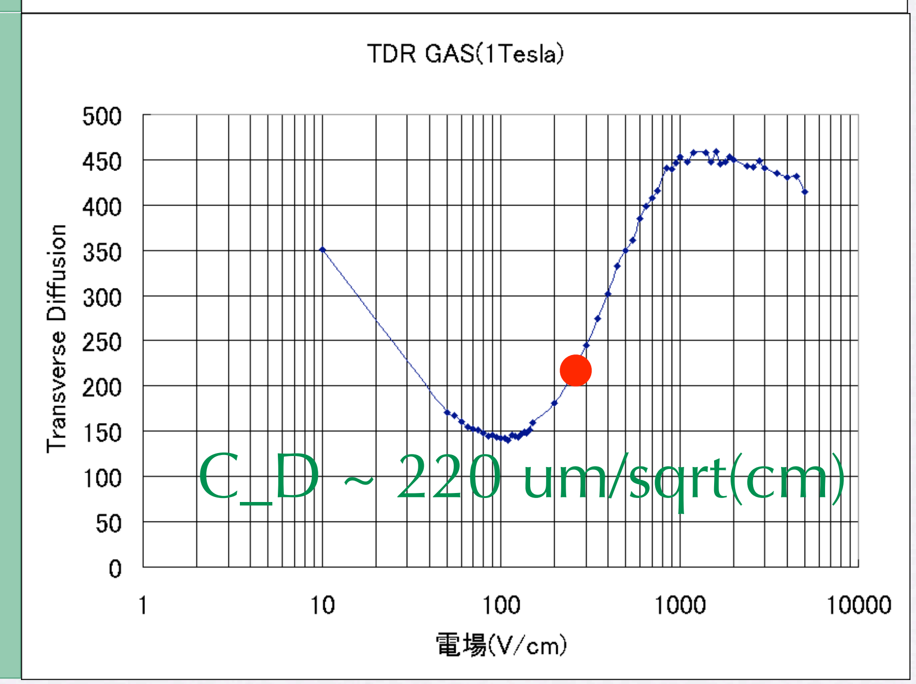
Experiment (Sigma_PR vs Z)

Magboltz (C_D vs E_drift)

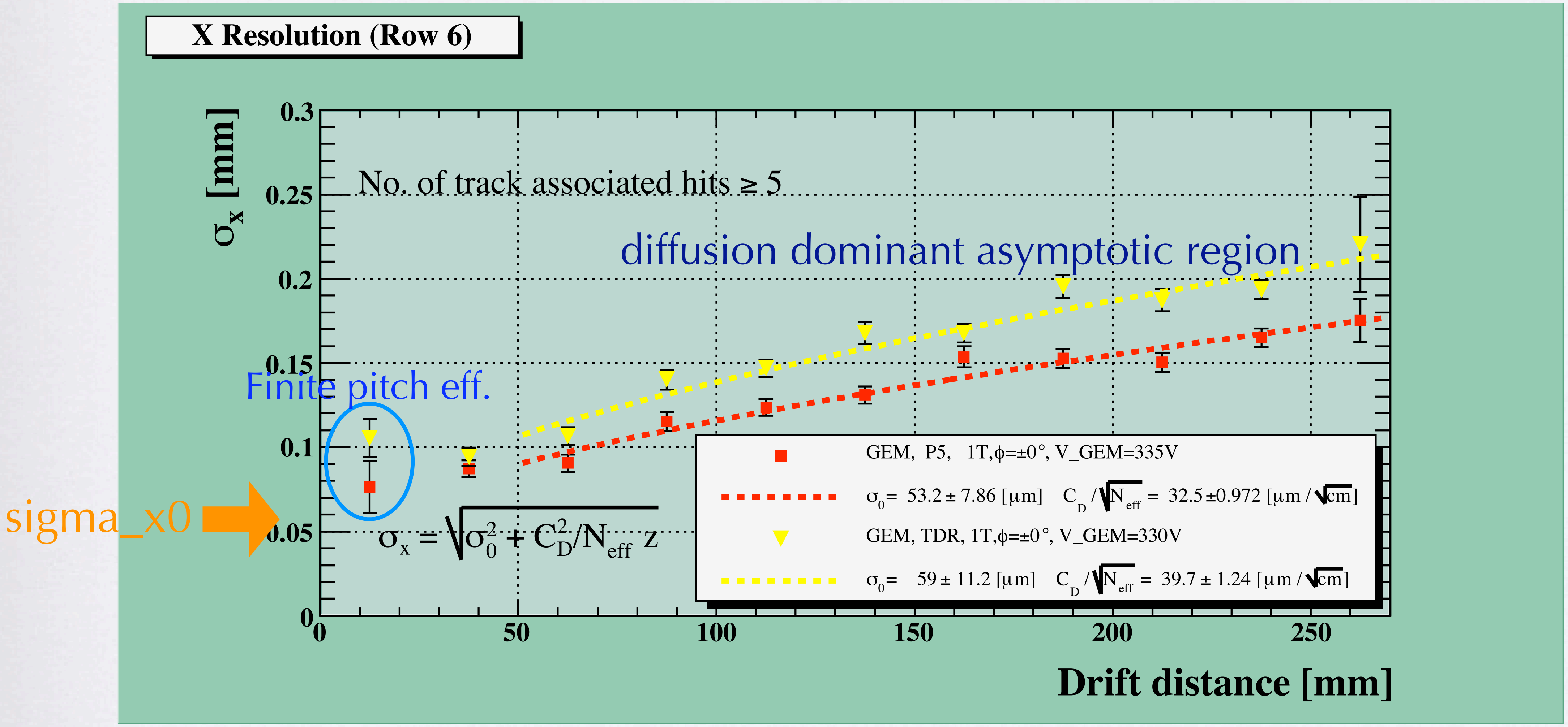








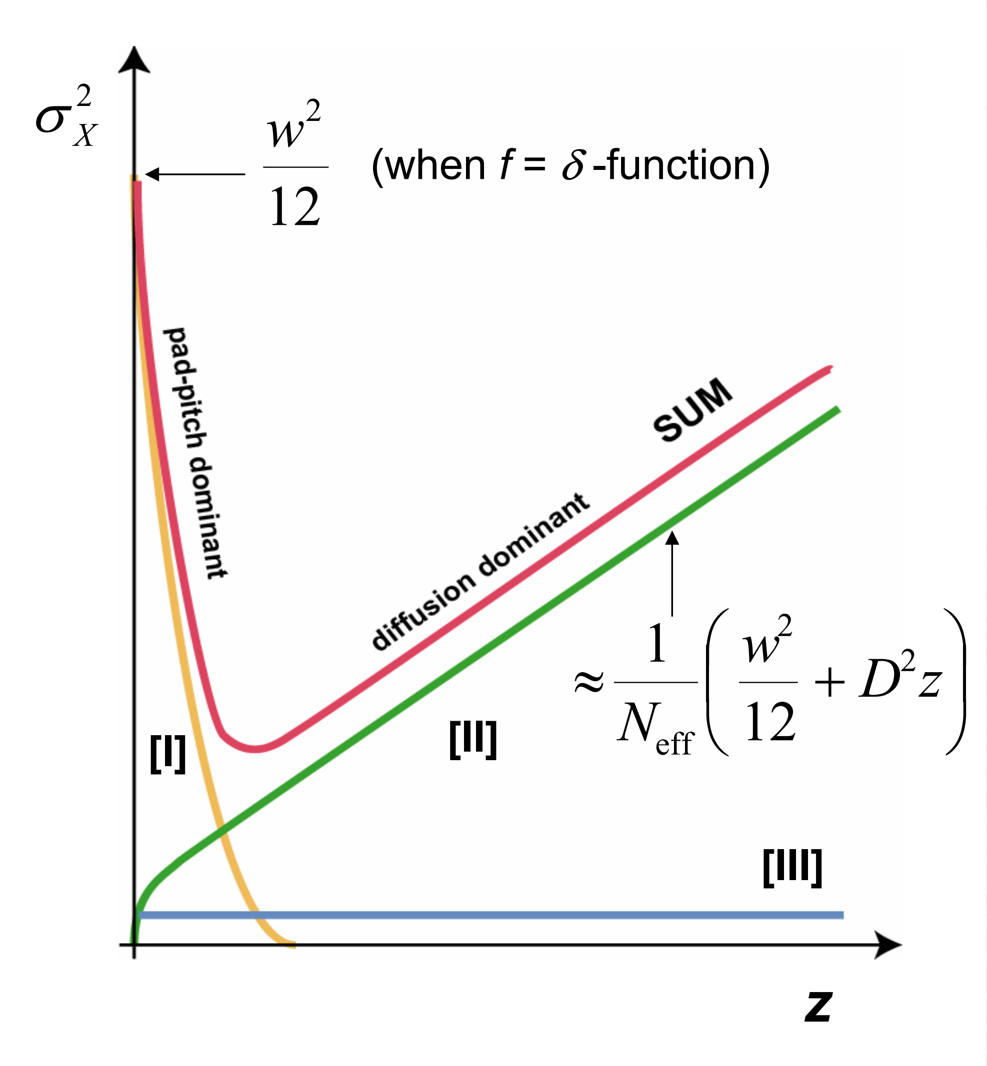
X-resol (GEM, 1T, P5 & TDR)



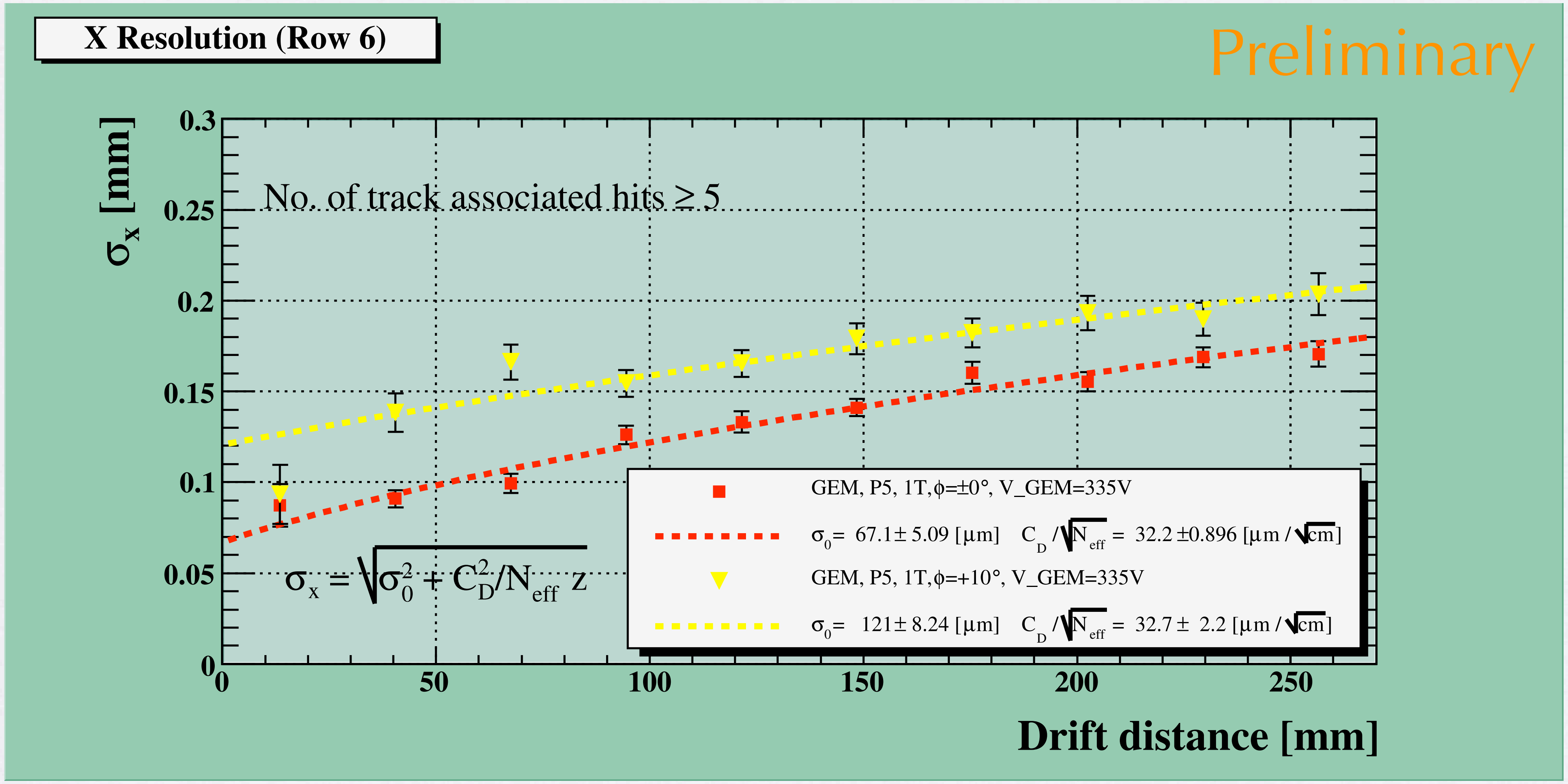
- GEM voltage was adjusted to get same pulse height
- N_eff ~ 27 (P5), 30 (TDR)
- In the case of P5, degradation of sigma_x at short distance is smaller due to large diffusion at transfer region -> Decreasing hodoscope eff.

Understanding of sigma_x0

- If width of avalanche can be ignored (PRF = δ-function),
  $\sigma_{x0}^2 \sim 1/N_{eff} * (w^2/12)$
  $\sim 67\ \mu m\ (N_{eff} = 30)$
  $\sim 71\ \mu m\ (N_{eff} = 27)$
- In the case of GEM,
  PRF seems to be not δ-function;
  $\sigma_{x0}^2 < 1/N_{eff} * (w^2/12)$
- σ_{x0} can be calculated from PRF, but PRF of GEM is unknown!
- To obtain deeper understanding of σ_{x0}, shape & width of PRF should be estimated by dedicated experiment and/or realistic MC calculation.

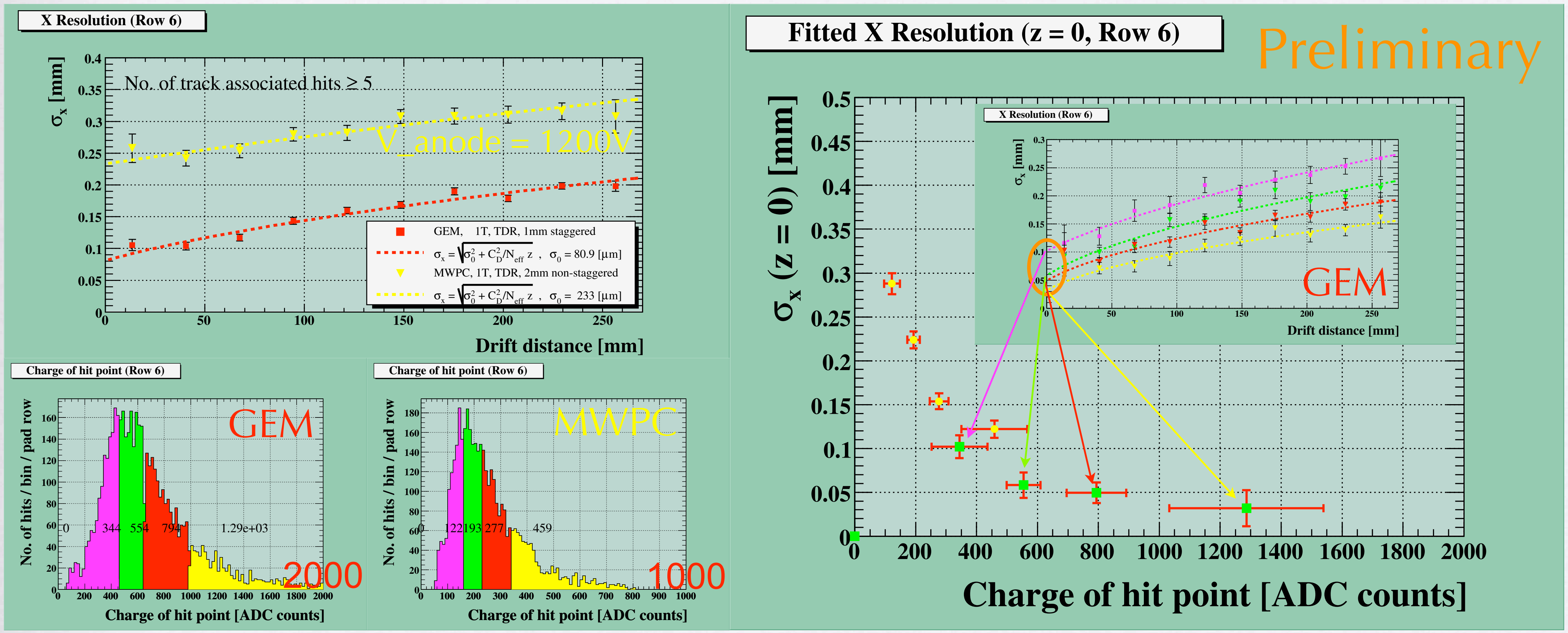


X-resol (GEM, 1T, P5, ϕ=0&10)



- sigma_0 of phi = 10 deg data is significantly larger because of angular pad effect.
- diffusion term is comprable -> effect of phi-dependence is negligible for x-resolution at long drift distances

PH-dep of sigma_x0
(1T, TDR, GEM & MWPC)

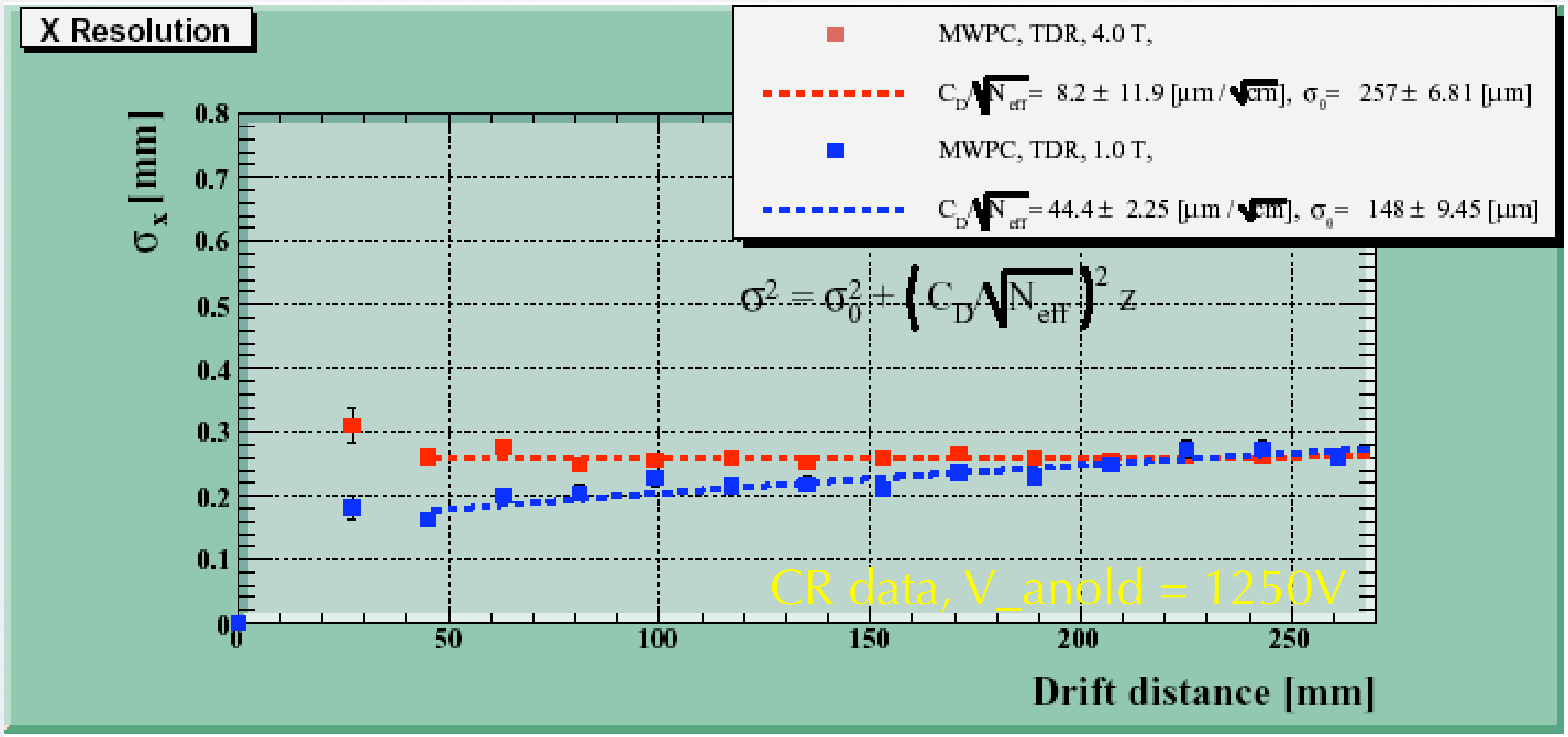


Pulse hight dist.

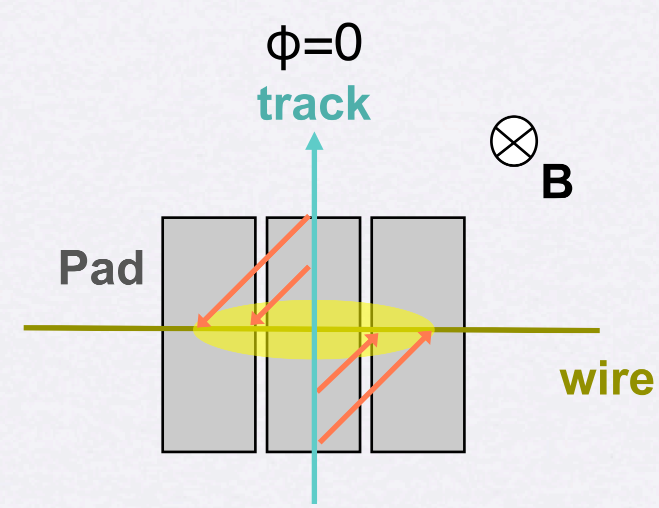
sigma_0 as a function
of pulse hight

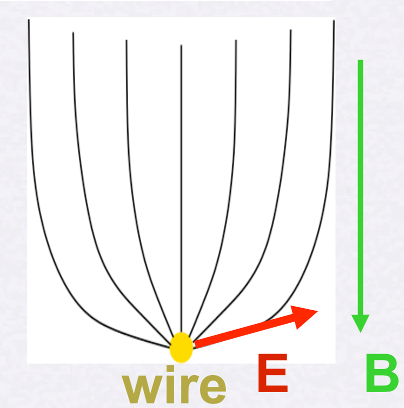
- GEM: 1 mm staggered, MWPC: 2 mm non-stagg. pad (1T, TDR)
- S/N ratio was small in the case of MWPC readout -> large sigma_0

X-resol (MWPC, TDR, 4T & 1T)



- In the case of MWPC, sigma_x0 get worth due to ExB effect at higher magnetic field





Summary

- Performance studies of prototype TPC with triple GEM or MWPC were performed using test beam and cosmic ray.
- Transverse diffusion and spatial resolution were measured as a function of drift distance up to 26 cm.
- Diffusion constants were found to be consistent with those given by Magboltz simulation.
- To obtain deeper understanding of sigma_x0 for GEM, shape and width of PRF of GEM should be determined.
- "Ultimate" MWPC readout may also work, but with poorer granularity and larger ExB effect.
- We accumulated a lot of experiences and understandings for the prototype TPC toward the consolidation phase.