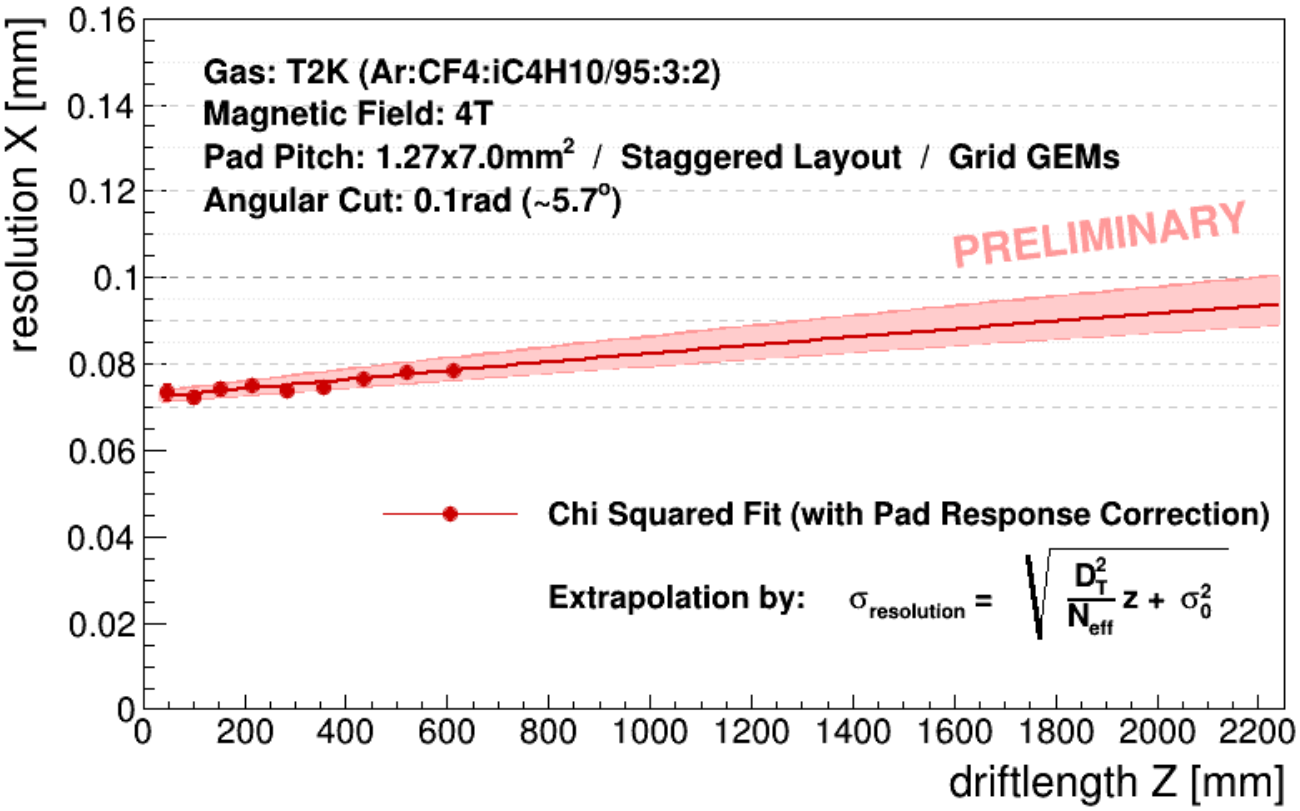
N_{eff} in 4T GEM Data

LCTPC Analysis Meeting – 22.07.2014

R. Diener

Introduction - Discussion Start

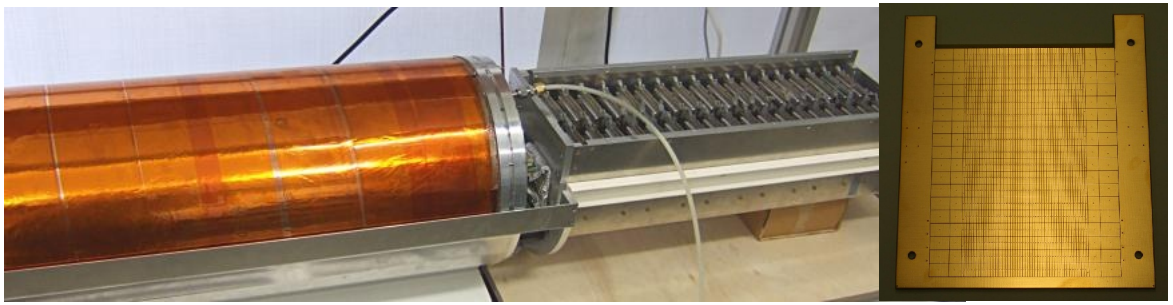
- 4T GEM data resolution plot with extrapolation

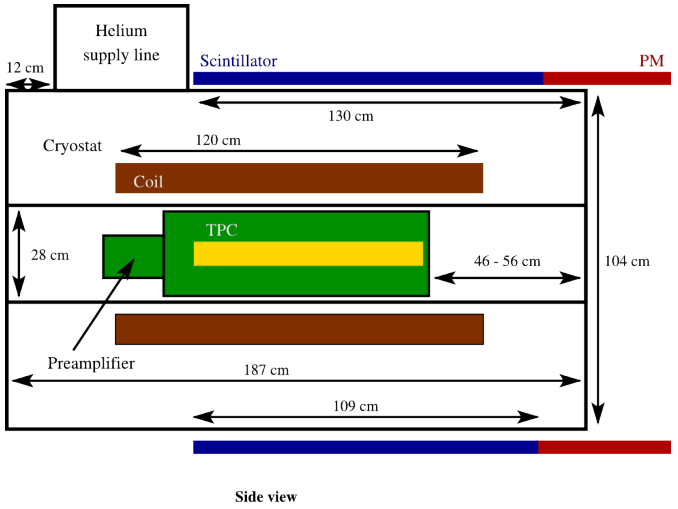


- Question over LCTPC mailing list:
  N_{eff} and σ_0 from resolution extrapolation to 2.2 m of 4T MediTPC data with T2K

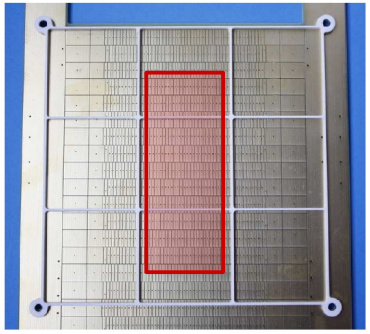
Introduction - Measurement Setup

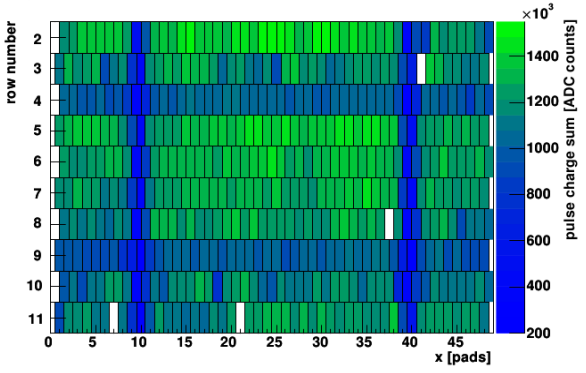
- MediTPC:
  - Length: 800 mm, Ø: 270 mm
  - Sensitive: ~ 60 x 90 x 660 mm^3
  - Pad pitch: 1.27 x 7.0 mm^2
- Triple Grid-GEM setup
  - 2 x 2mm transfer (1500V)
  - 1 x 3mm induction (3000V)
- 250V/cm drift field
- Read-out: Aleph electronics
- Gas T2K (runs at 1,3,3.5 and 4T)
- Statistics limited:
  - Data taken with GridGEM prototype
    → rather hard X-range cut (between inner two bars)
    → no smaller Z-binning possible
  - Dead pad in the X center



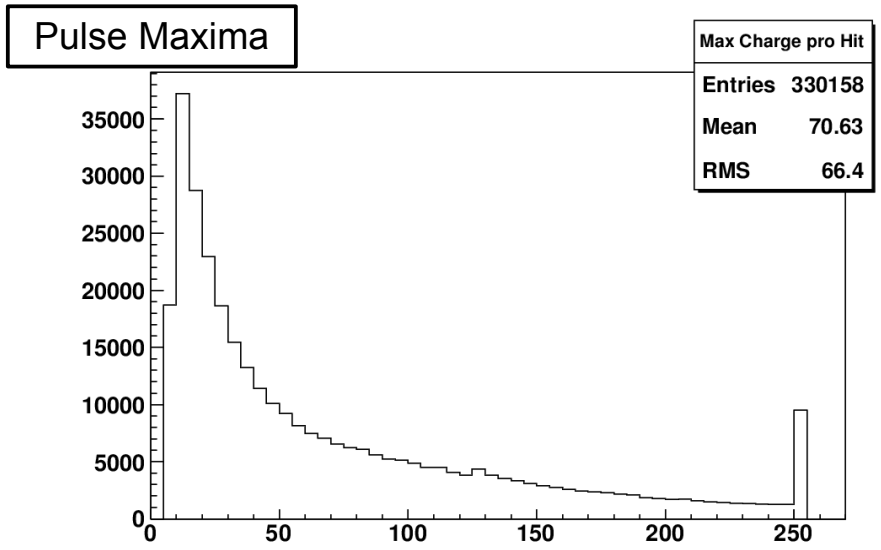


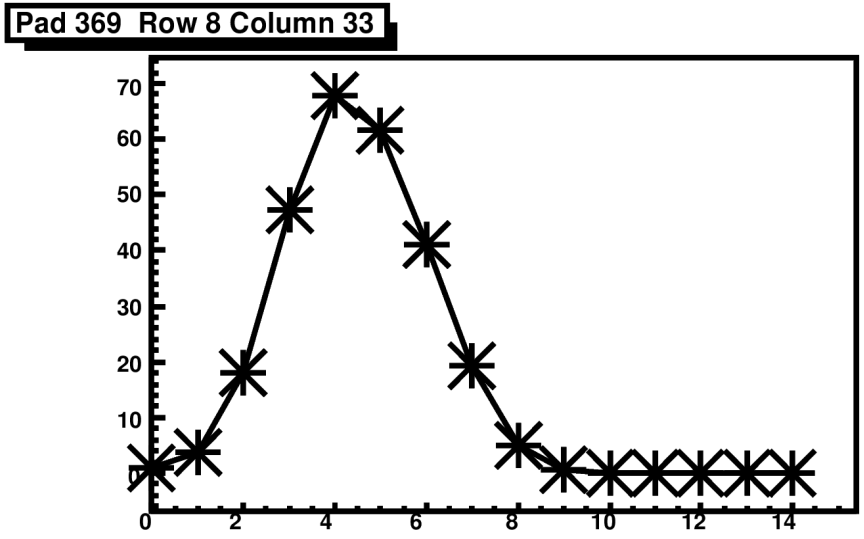
Side view

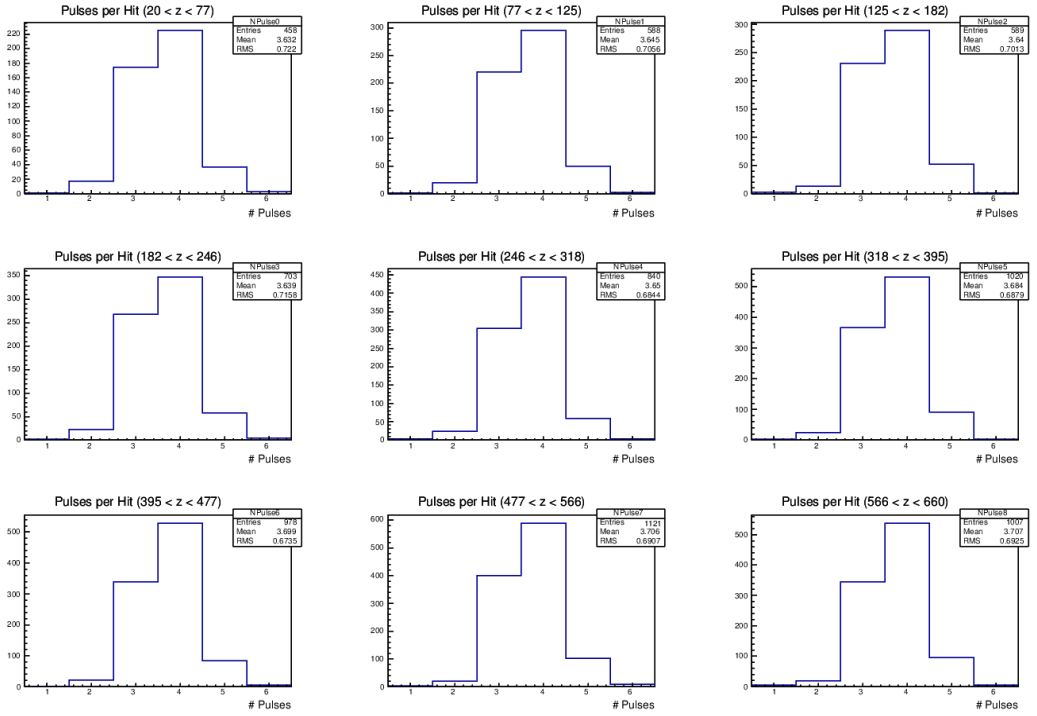


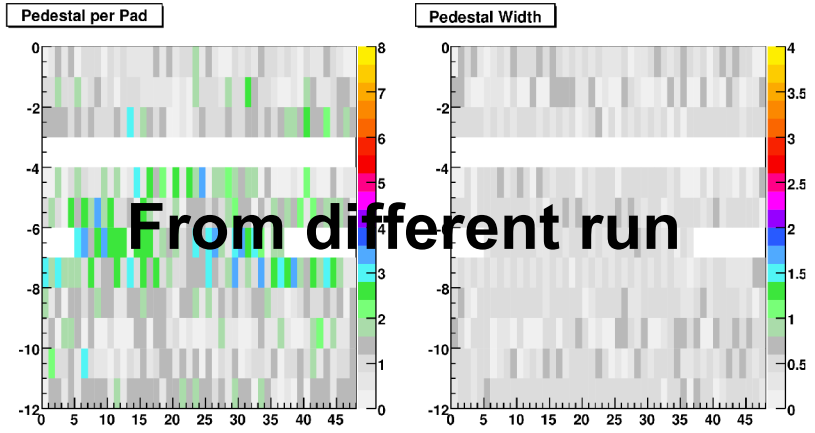


Introduction - Data Quality



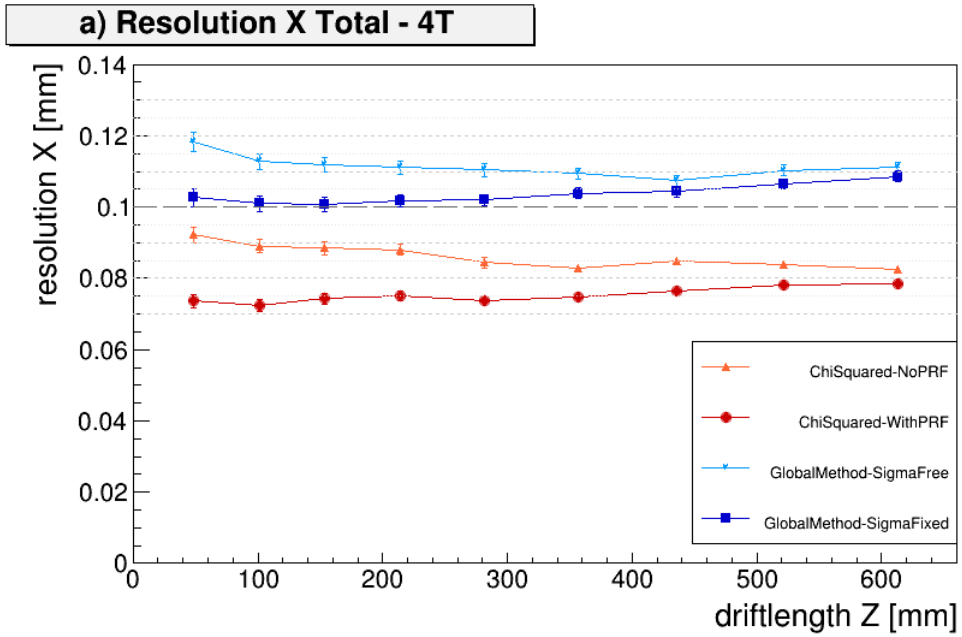






Introduction - Reconstruction

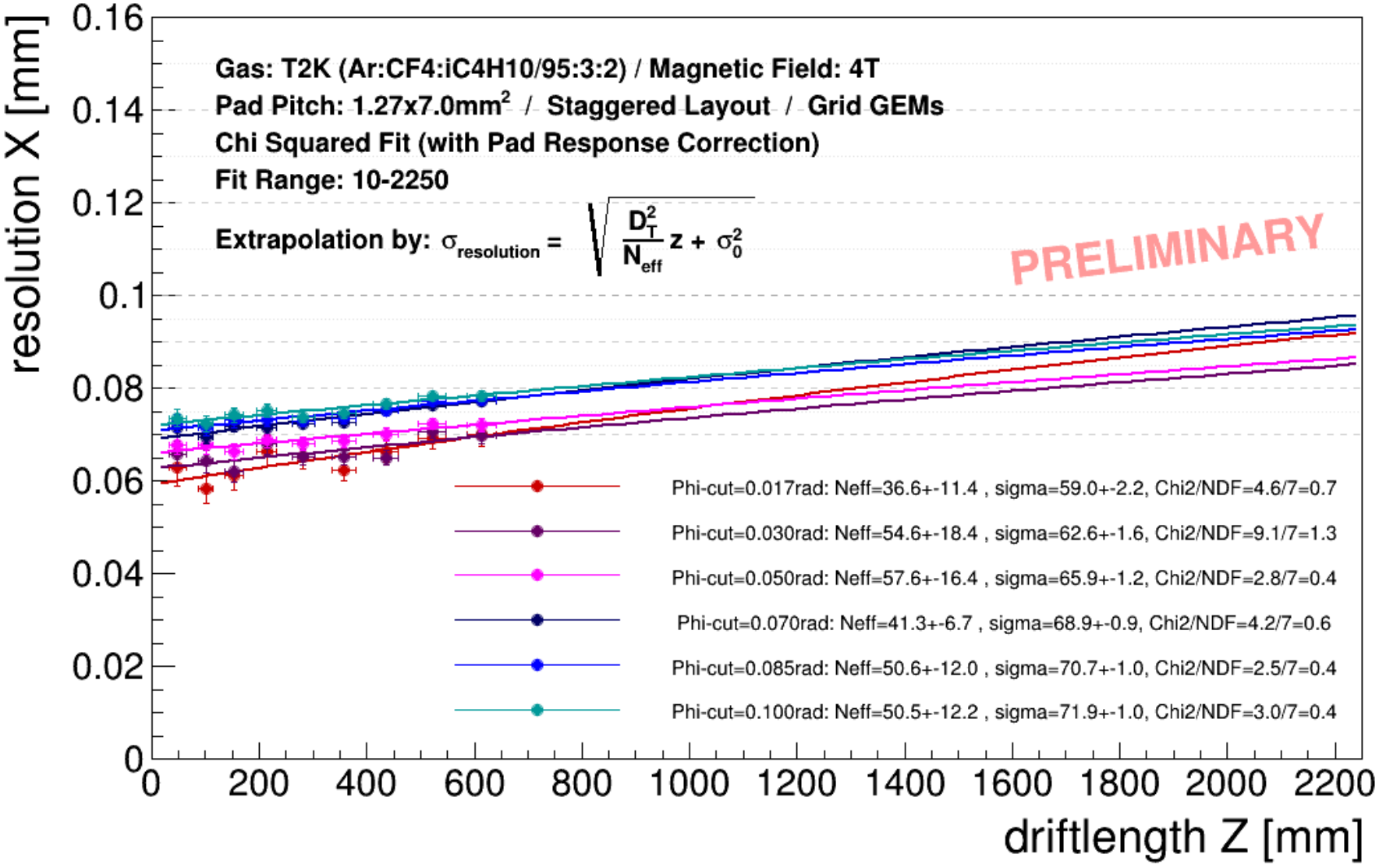
- Reconstruction with MultiFit
  - Global likelyhood fit not working as expected; reason still unclear
  - Pad Response Correction (PRC)
  - Chi Squared Fit (track shape: circle)
  - Distortion correction (mean residual deviation of an “independent” sample)



- N_{eff} in LP usually between ~20 and ~30
- MediTPC: higher amplification, longer pads

- Suggestions from Keisuke and Makoto in the discussion:
  - Use of different angular cuts
  - Fit different ranges
  - Replace σ_0^2 in fit function by $A(0,0)/N_{eff}$,with $A(0,0)$ from PRF fit

Resolution & Extrapolation



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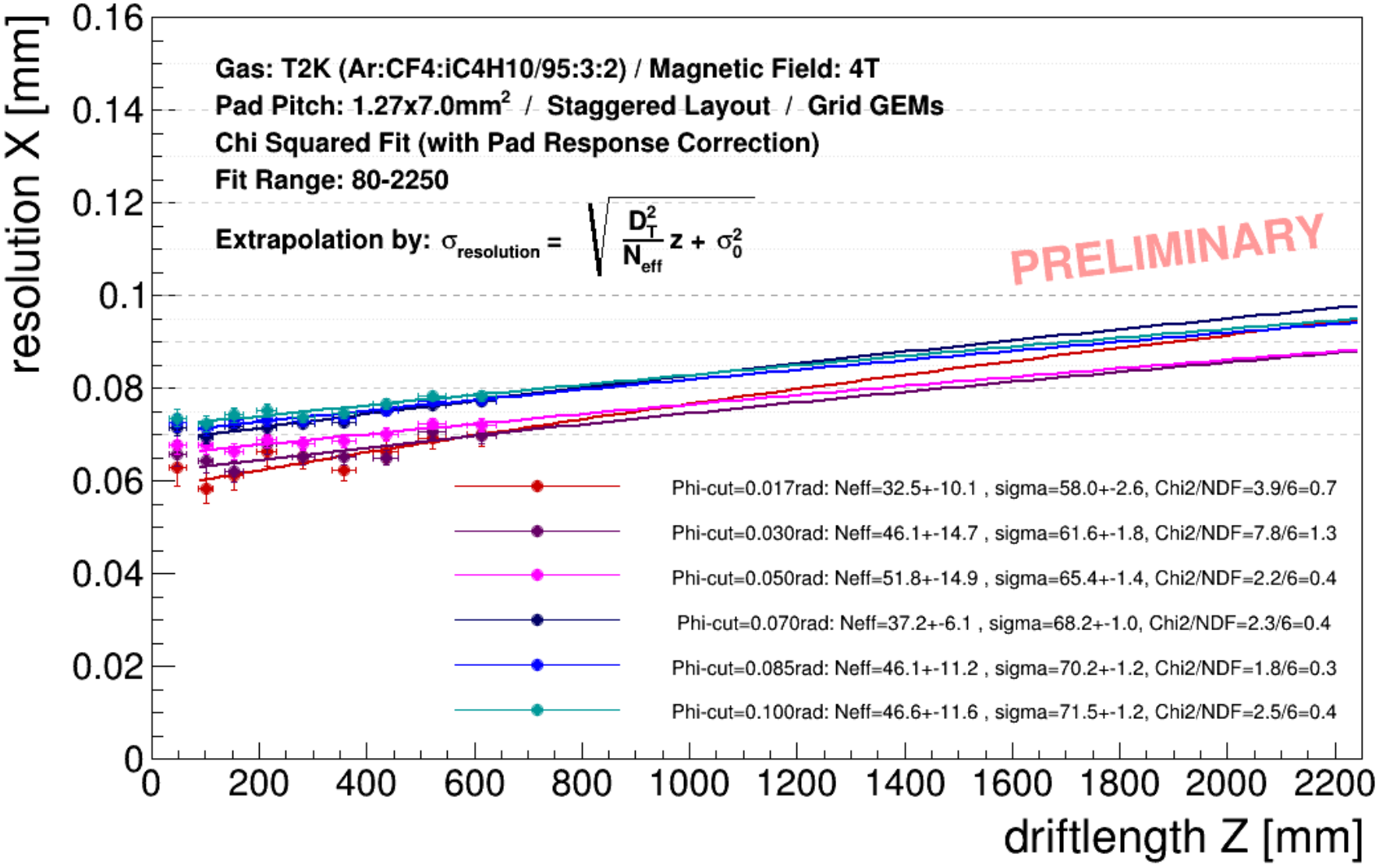

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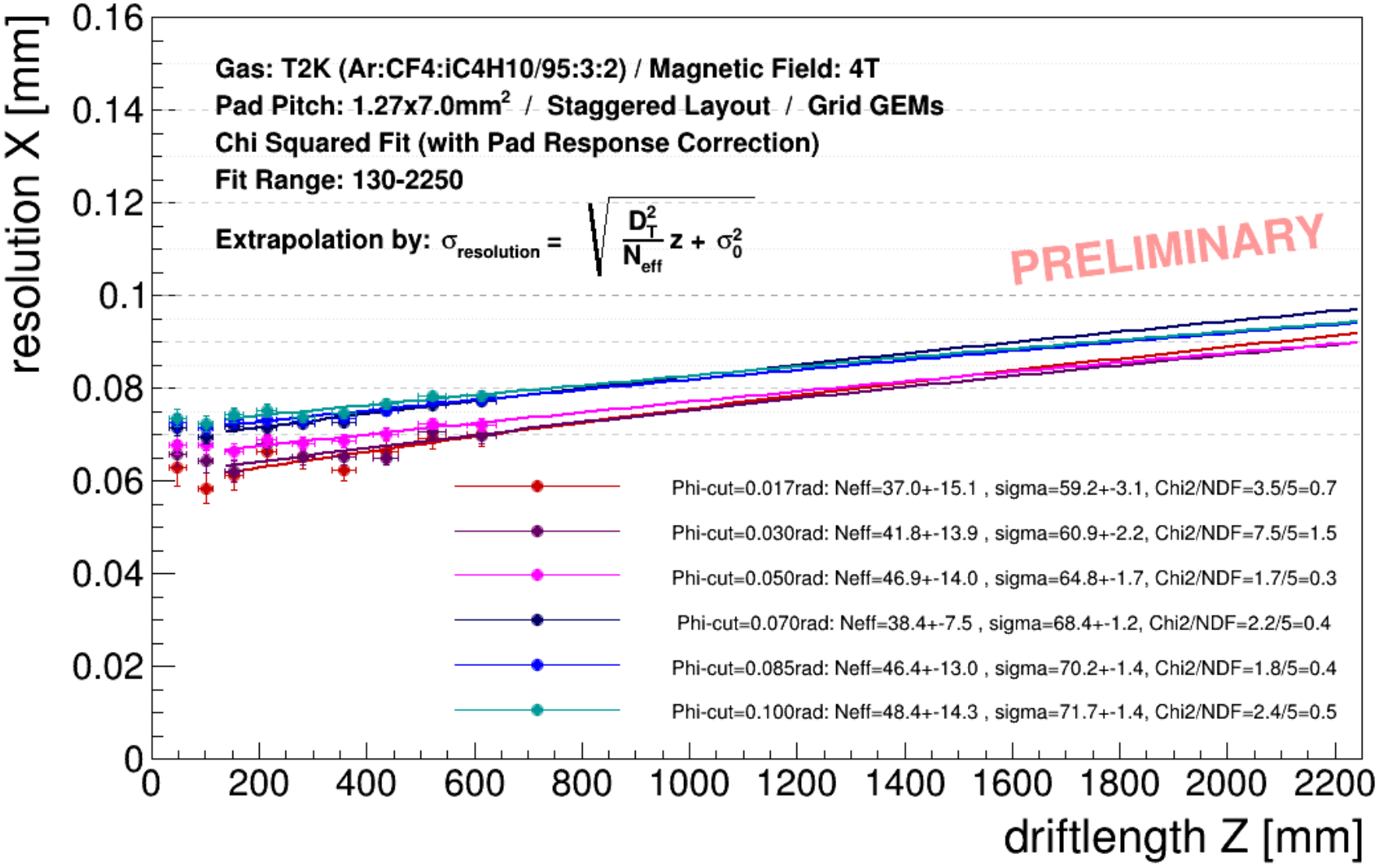

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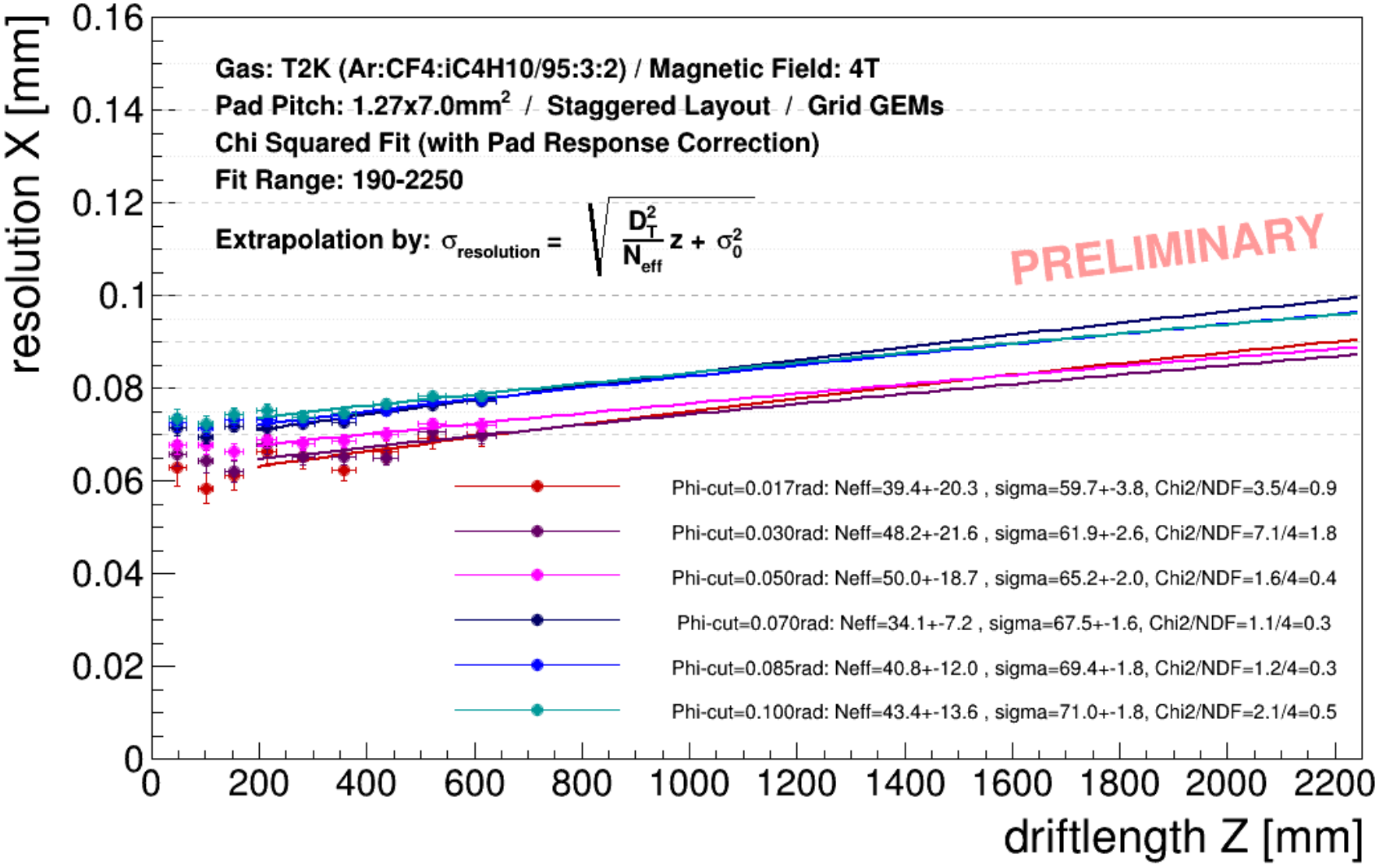

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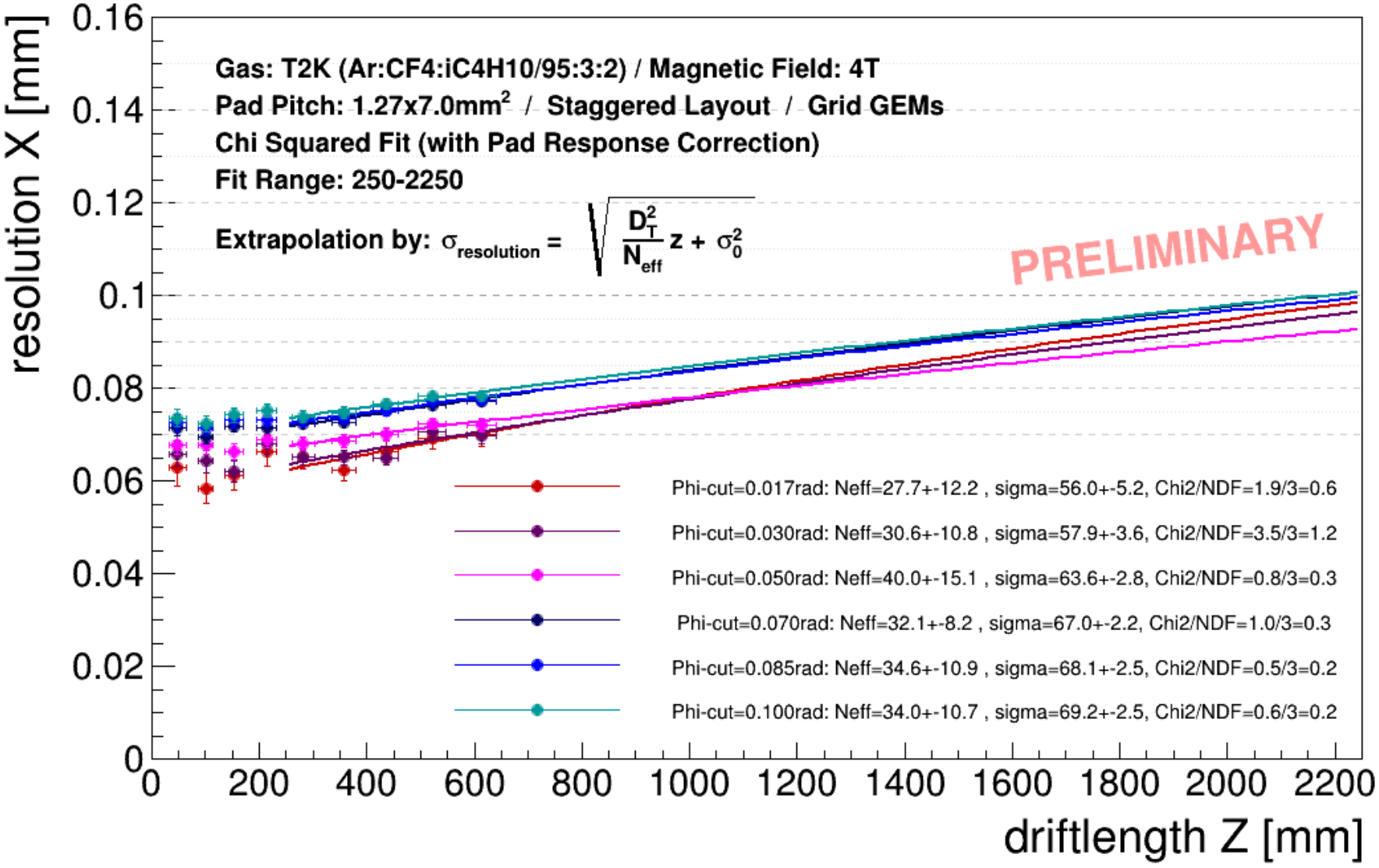

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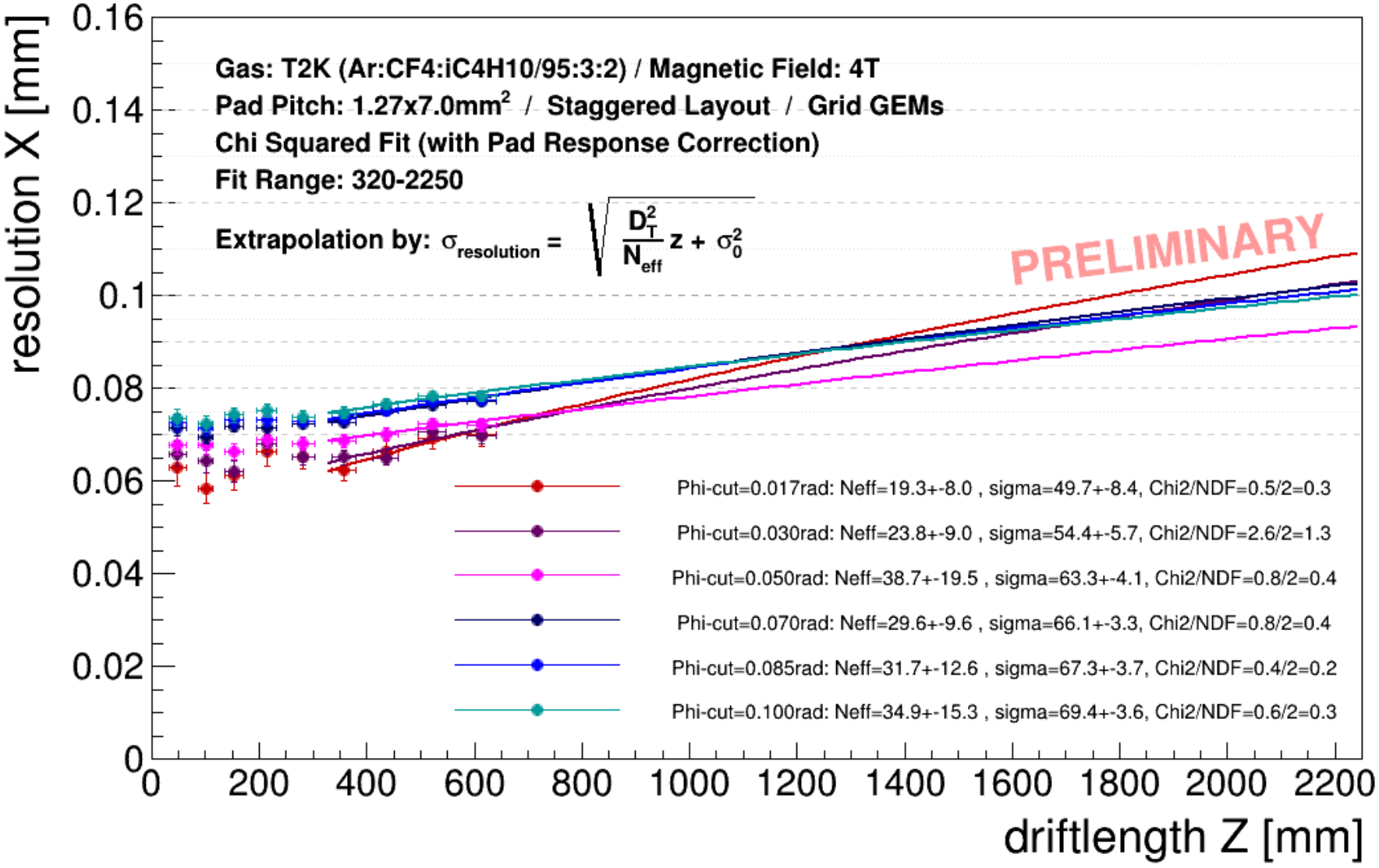


Results Discussion

- Comparably high values for N_{eff}
- Rather large error of up to 50% on N_{eff} from fit with:

$$\sigma = \sqrt{\frac{D_T^2 z}{N_{eff}} + \sigma_0}$$

where N_{eff} and σ_0 are free parameters

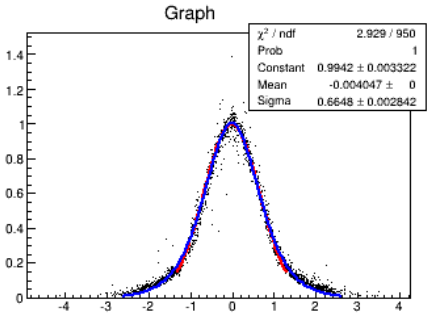
- Idea: try fit with the modified formula (ony N_{eff} as free parameter):

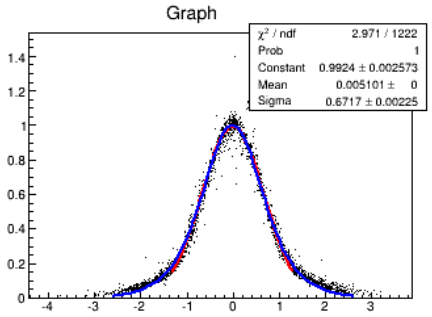
$$\sigma = \sqrt{\frac{D_T^2 z + A(0,0)}{N_{eff}}}$$

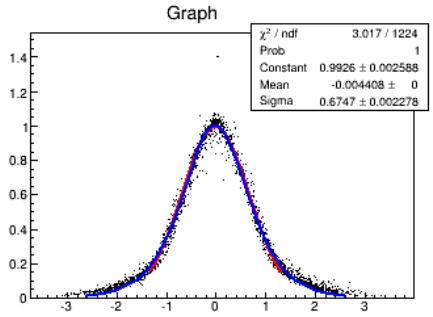
- Todo: determine value of *A(0,0)* from PRF width

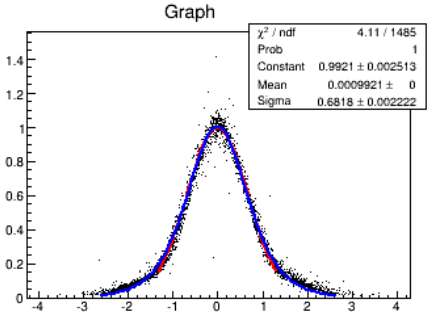
Fit of PRF width (phi cut: 1°)

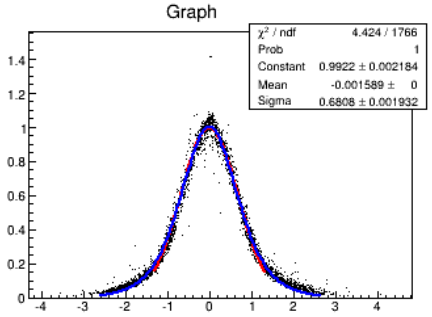
- Standard Gaussian in the range about ±2σ ; width=σ
- Suggested PRF function from MM processors: $\frac{4 \cdot e^{c \cdot x}}{\left(e^{c \cdot x}+1\right)^2}$ width: 0.5 * FWHM

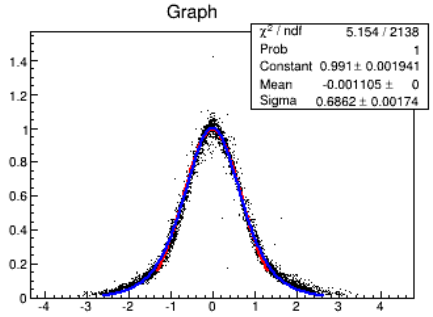


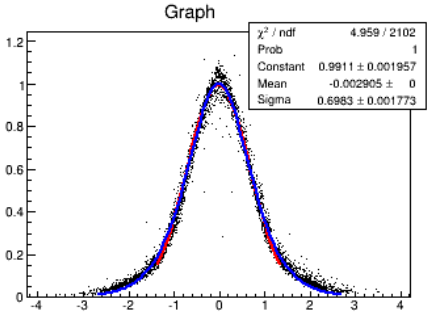


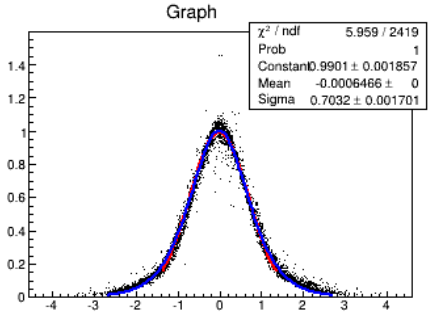


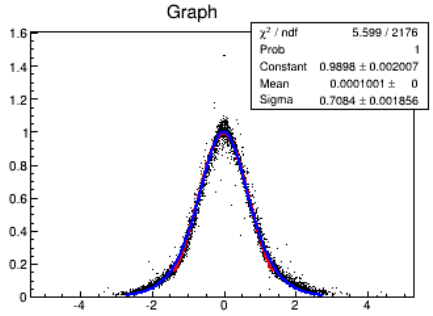






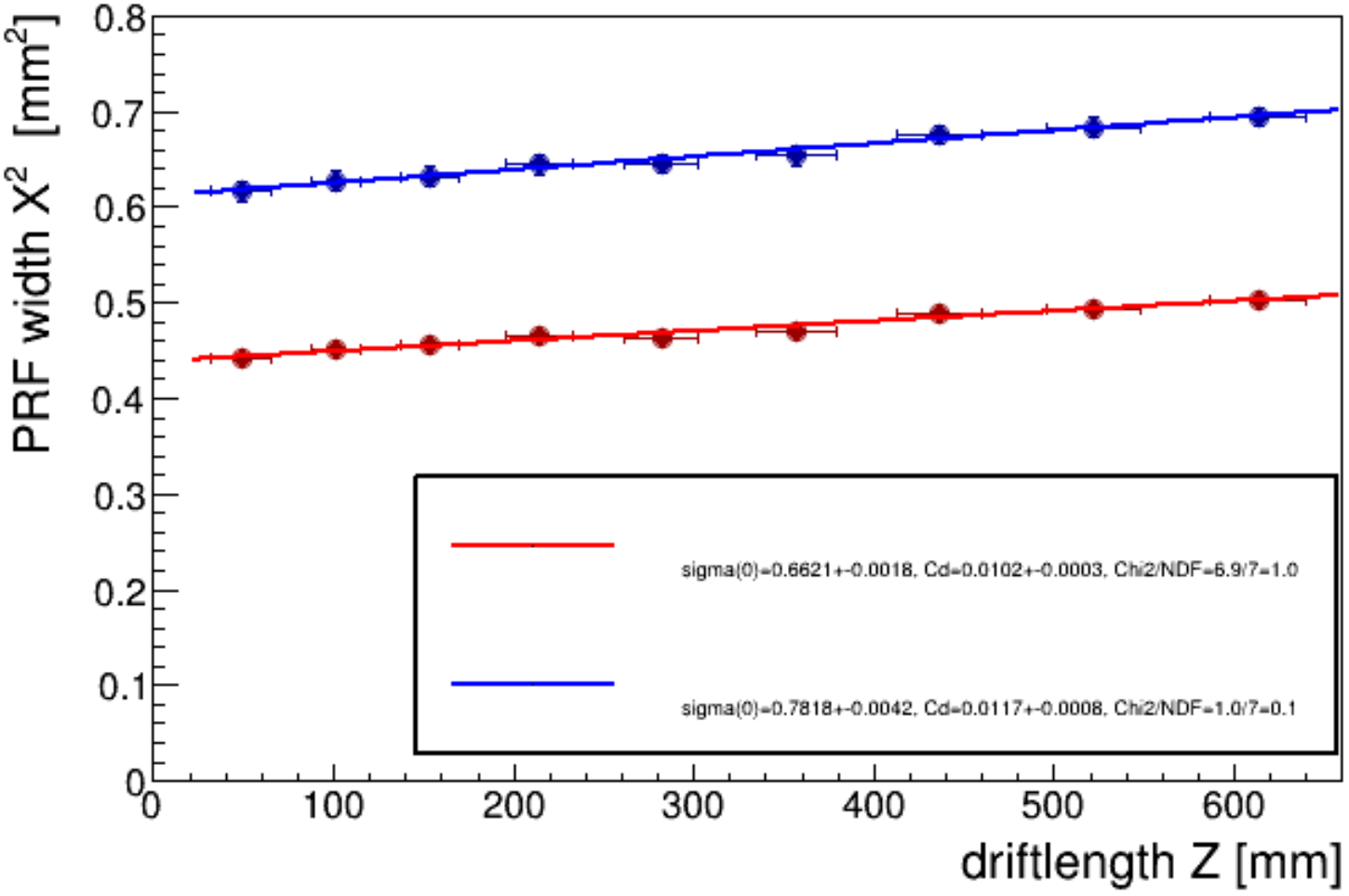






Sigma$_{PR}$(0) and D$_T$

- Determination of $\sigma_{PR}(0)$ and C_D from straight line fit



- From Magboltz simulation:

$D_T = 0.0443 \ \frac{mm}{\sqrt{mm}}$ and $\sigma_{PRF} = 0.264719$ mm =: defocussing

Determination of A(0,0)

- Formula from
  "Spatial resolutions of GEM TPC. A novel theoretical formula and its comparison to latest beam test data", 2014 JINST 9 03002, (3.15), page 7:

$$A(0,0)=\int_{-1/2}^{+1/2} d\left(\frac{\tilde{x}}{w}\right)\left(\sum_a (aw)\,F_a(\tilde{x})-\tilde{x}\right)^2 \quad , while\ \sigma_0^2 = A(0,0)/N_{eff}$$

$$F_a(\tilde{x})=\int_{(a-1/2)\cdot w}^{(a+1/2)\cdot w} dx\,P(x-\tilde{x})$$

- Assuming a Gaussian as PRF function:

$$P(x-\tilde{x}) := \frac{1}{\sqrt{2\pi}\cdot\sigma_{prf}}\cdot e^{\frac{-(x-\tilde{x})^2}{2\sigma_{prf}^2}} \qquad \sigma_{prf}=\sqrt{\sigma_{PR}(0)^2-\frac{w^2}{12}}$$

- Integral (sum, integral ...) solved with Mathematica:

```
N[ ∫_-0.5^0.5 ( Sum[ (a * w) * ( ∫_((a-0.5)*w)^((a+0.5)*w) (1 / (√(2 π) * sigmaprf)) * e^(-(x-t*w)^2/(2*sigmaprf^2)) dx ), {a, -5, 5}] - t * w )^2 d(t) ]
```

  - N[ ] = solve numerically
  - Limits of sum over pads "*a*" don't influence results (in reasonable range)
  - "*t*" stands for $\frac{\tilde{x}}{w}$ and $d\left(\frac{\tilde{x}}{w}\right)$ was substituted

Results

- Data (Gaussian fit):

$$\sigma_{PR}(0)=0.662071\,mm\,,\ \sigma_{PRF}=0.551298\,mm\,,\ A(0,0)=0.0000480264\,mm^2$$

- Data (PRF fit):

$$\sigma_{pr}(0)=0.781757\,mm\,,\ \sigma_{PRF}=0.69046\text{mm}\,,\ A(0,0)=6.99099\cdot10^{-7}\,mm^2$$

- Defocussing from Magboltz:

$$\sigma_{PRF}=0.264719\,mm\,,\ A(0,0)=0.0147229\,mm^2$$

$$using\ \sigma_{PRF}[mm]=\sqrt{4\cdot0.1\cdot D_{t,1500\text{V}}+3\cdot0.1\cdot D_{t,3000\text{V}}}\,,\ with\ D_{t,1500\text{V}}=0.277481\,\frac{mm}{\sqrt{cm}}\,,\ D_{t,3000\text{V}}=0.361838\,\frac{mm}{\sqrt{cm}}$$

- Test with expected values assuming σ_0 = 0.060 mm and N_{eff} = 30

$$A(0,0)=\sigma_0^2\cdot N_{eff}=0.108$$

$$using\ \sigma_{prf}=0.05\,mm\rightarrow A(0,0)=0.101082\,mm^2$$

$$\sigma_{PR}(0)=\sqrt{\sigma_{PRF}^2+\frac{w^2}{12}}\approx0.37\,mm\,,\ w=1.27\,mm$$

Temporary Conclusion

- N_{eff} rather high compared to LP data but within large errors
- Fit gets unstable when range too small (not enough data points?)
  - Tried to use smaller drift length bins, but statistic too small (GridGEM data → rather small X range in cut)
- Stabilizing fit with modified function $\sigma = \sqrt{\frac{D_T^2 z + A(0,0)}{N_{eff}}}$
  - PRF width values from data seem much too large, A(0,0) value much too small
  - Is the function in Mathematica correct?
  - Other effects not taken into account?
    - Angular effect on PRF width seems to be negligible with the 1° phi cut
- **Outlook**: reconstruction and anlaysis of MediTPC data in MarlinTPC
- **Thanks to Keisuke and Peter for their help and valuable input!**