

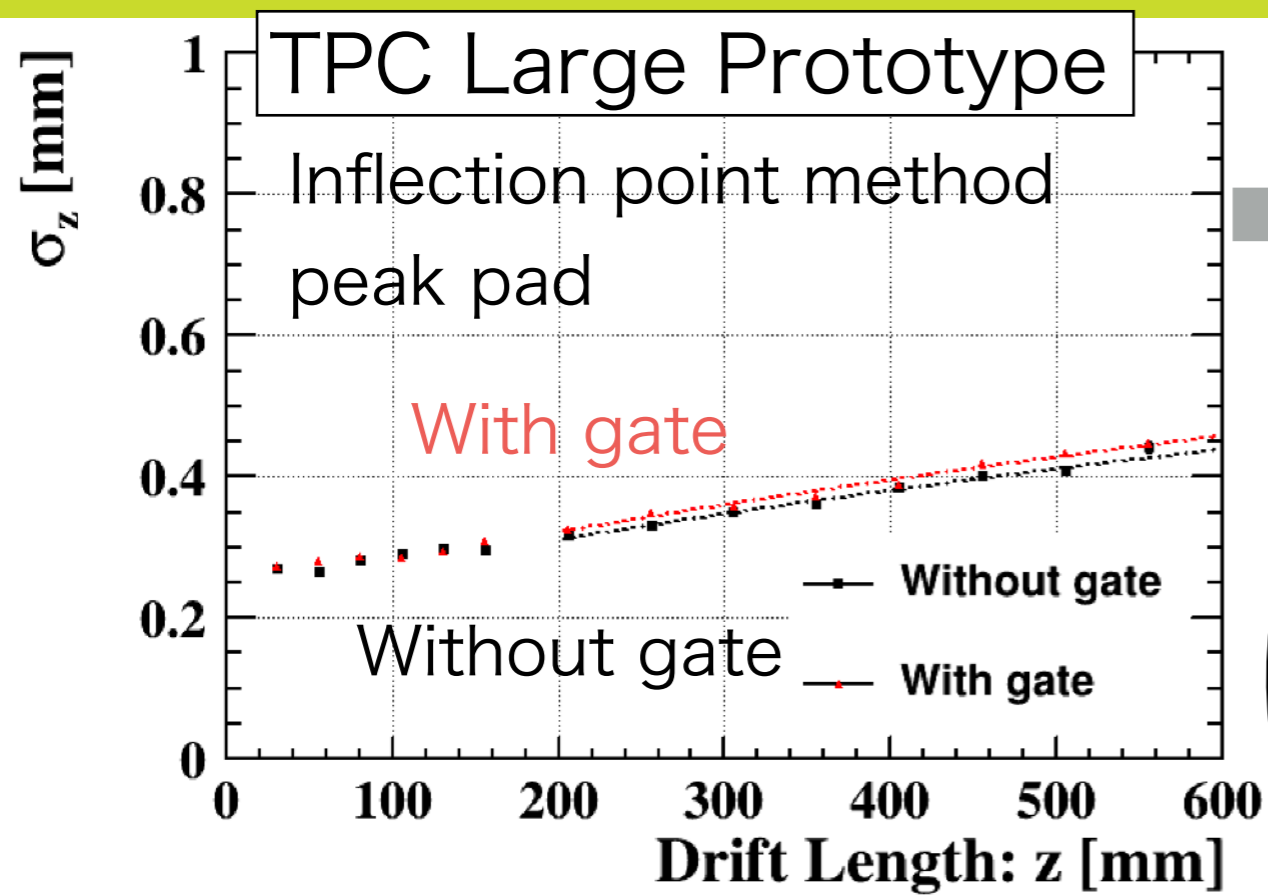
# z resolution study of ILD-TPC with Gating Device

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2021.11.18 LCTPC WP meeting

# Can we achieve z resolution goal?



Real-size TPC

$$\sigma_z = \sigma_z(z, \cancel{B})$$

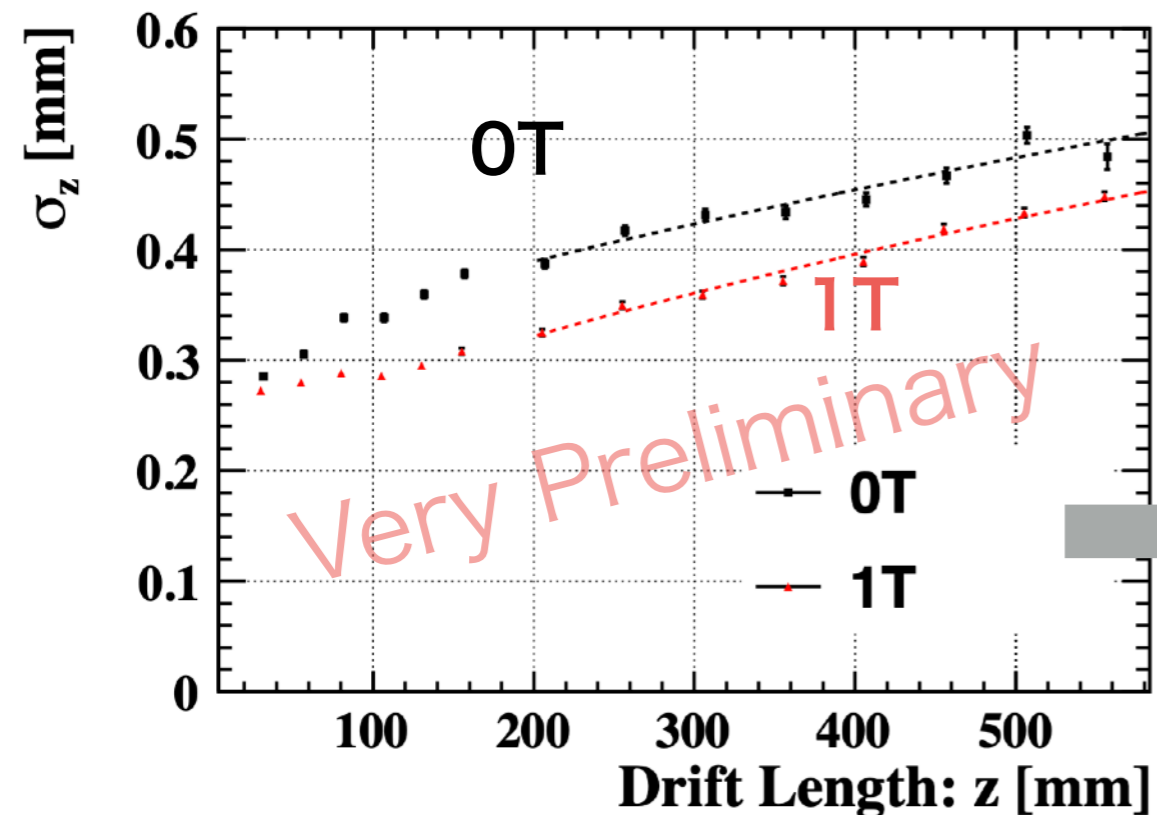
$$\sigma_z = \sqrt{\sigma_0^2 + (C_{dL}^2 / N_{eff}) z}$$

	$\sigma_0$ [ $\mu\text{m}$ ]	$C_{dL} / \sqrt{N_{eff}} \mu\text{m} / \sqrt{\text{cm}}$
With gate	$219 \pm 7$	$52.3 \pm 0.9$
Without gate	$228 \pm 7.7$	$48.2 \pm 1.1$

$$z=220\text{cm} \rightarrow \sigma_z=0.8 \pm 0.1 \text{ mm}$$

This assumption is correct?

	$\sigma_0$ [ $\mu\text{m}$ ]	$C_{dL} [\mu\text{m} / \sqrt{\text{cm}}]$
0T	$283 \pm 12$	$51.9 \pm 1.9$
1T	$219 \pm 7.4$	$52.3 \pm 0.9$

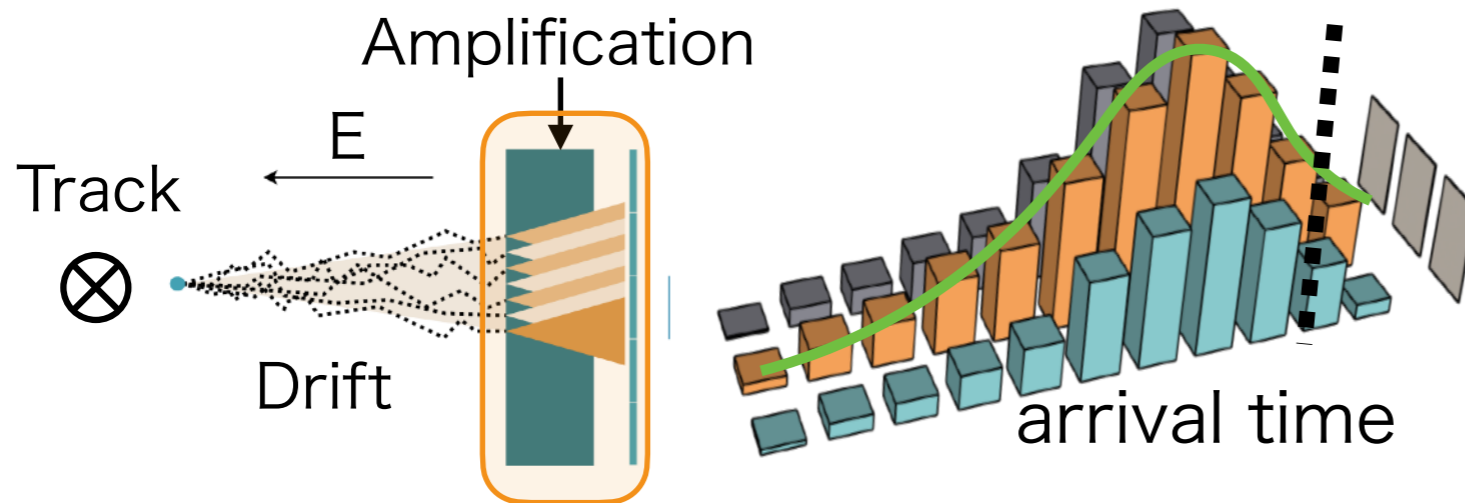


Significantly different! ~20%

$\rightarrow z$  resolution seems to depend

on B field

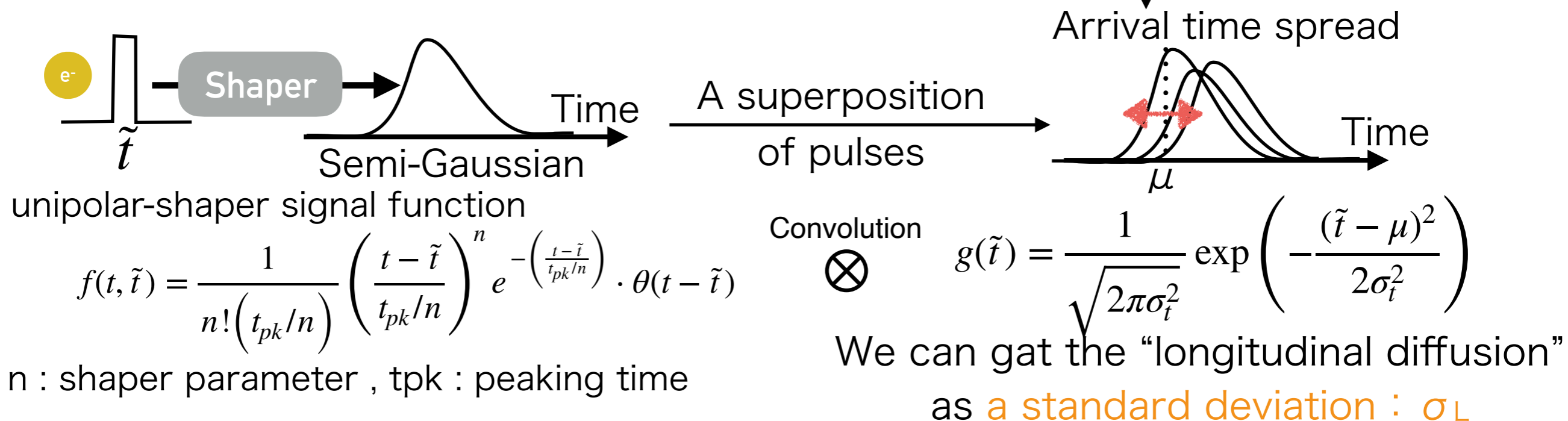
# z resolution & pulse



Pulse shape affect the z-resolution

What determines the pulse?

**Assumption** The average pulse shape is determined only by the properties of the shaper and the longitudinal diffusion

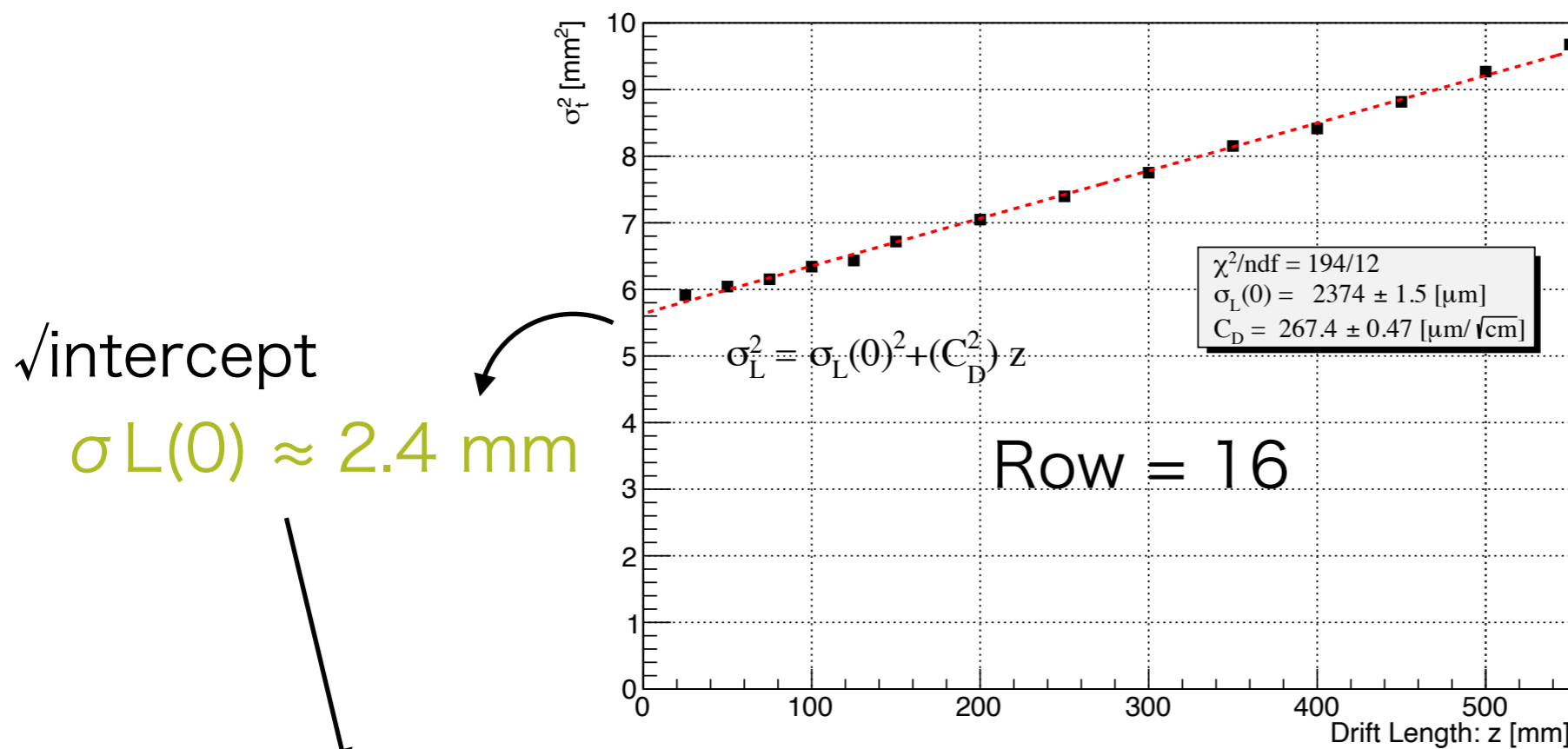


$$\sigma_L^2 = \sigma_0^2 + C_{dL}^2 \cdot z$$

$\sigma_t = \sigma_L / v_{drift}$   
 $C_{dL}$ : Diffusion constant

# CdL Result (With nominal shaper parameters)

By using convolution method, we calculated  $C_{dL}$  of test beam data  
 (From spec sheet) Input :  $n = 3$  ,  $tpk = 120$  ns



$C_{dL} \approx 267.4 \text{ um}/\sqrt{\text{cm}}$

Difference between theory :  $\sqrt{(2.374 \text{ mm})^2 - (1.082 \text{ mm})^2} = \underline{2 \text{ mm}}$

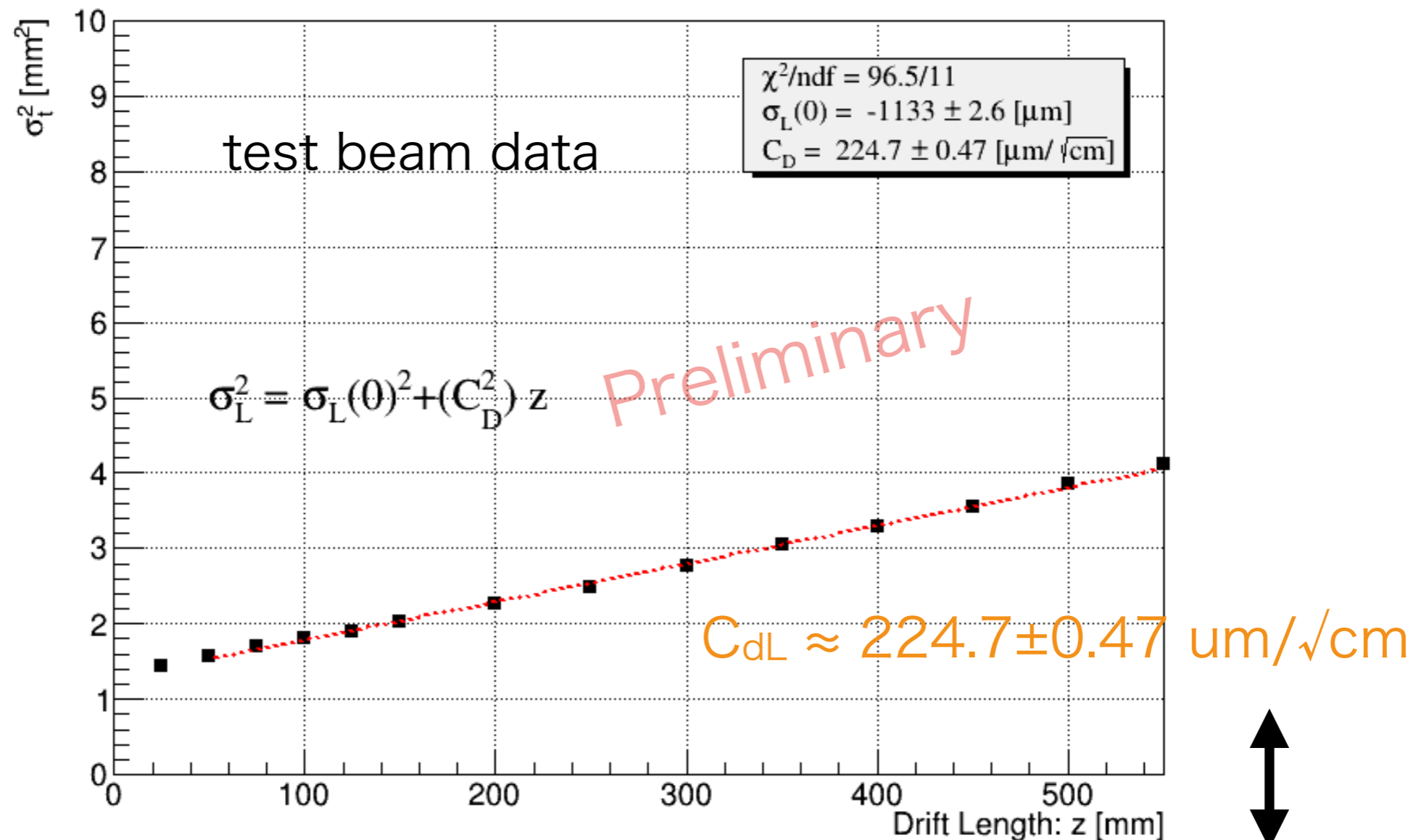
Magboltz Simulation

	1 T	0 T
Temperature[K]	291.28	291.11
Pressure[hPa]	1010.79	1007.29
$C_{dL}[\mu\text{m}/\sqrt{\text{cm}}]$	<b>226.1 ± 1.54%</b>	224.4 ± 2.64%

Inconsistent with Garfield++ simulation

# Retry with Adjusted shaper parameter

Input :  $n = 3$  ,  $tpk = 135$  ns, Row = 16 (Specification sheet:  $tpk = 120$ )



Magboltz:  $C_{dL} = 226 \pm 1.5\%$

This method of  $C_{dL}$  estimation is rather sensitive to the input shaper parameters

# What are the possible smearing effects?

## Future plans

Is the pulse shape really according to spec sheet?

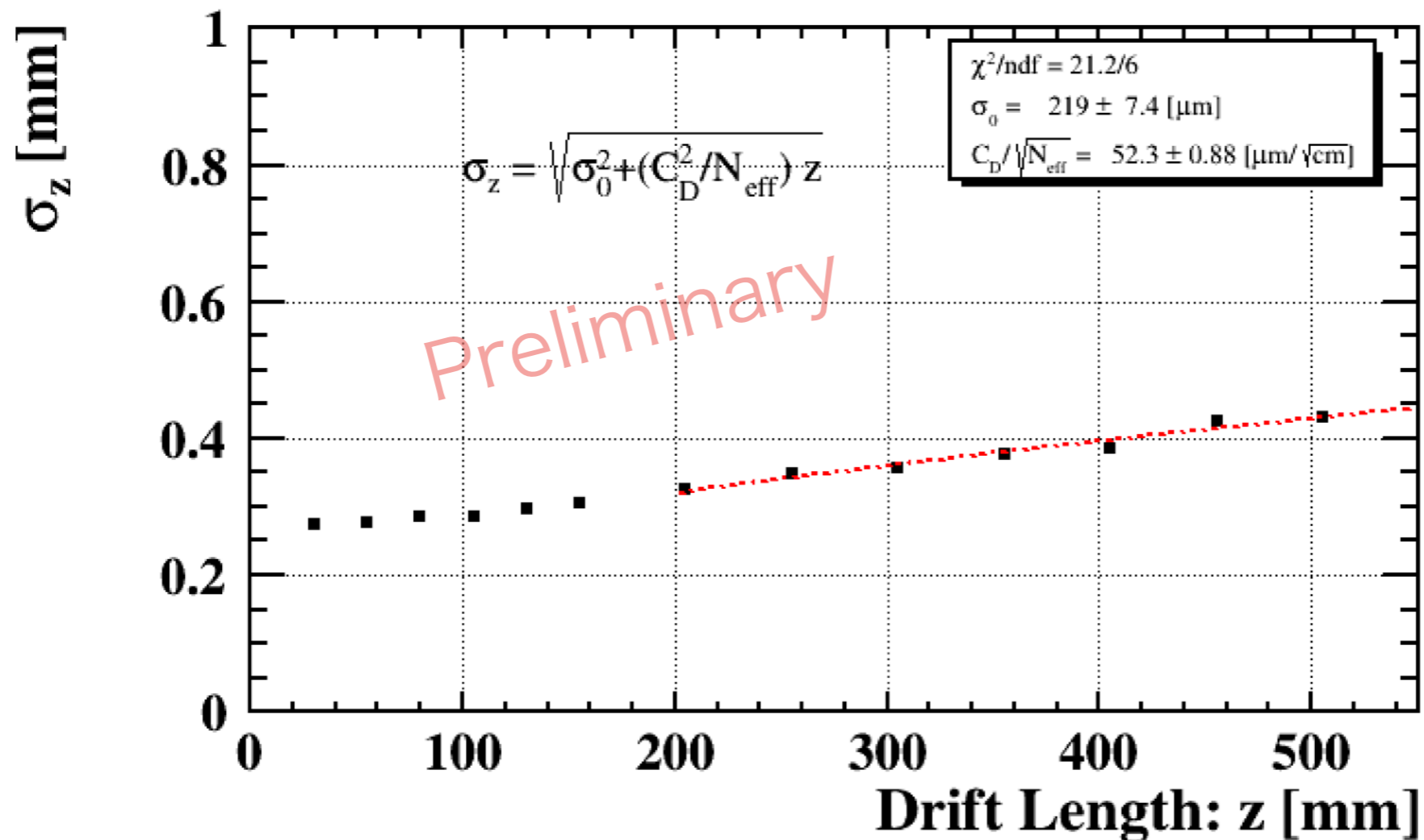
- Shaper parameter  $n=3$ ,  $t_{pk} = 120\text{ns}$  are from specification sheet

→ We are planning to measure pulse shape directly



# Another way to estimate $C_{dL}$

If we assume that  $N_{\text{eff}}$  is the same as in the  $r\phi$  resolution at same time, we can also estimate  $C_{dL}$  from the analysis of  $z$  resolution



Using 1 pad

$N_{\text{eff}} = 23.9 \pm 0.7$  (From  $r\phi$  analysis)  
 $C_{dL}/\sqrt{N_{\text{eff}}} = 52.3 \pm 0.9 \text{ }\mu\text{m}/\sqrt{\text{cm}}$

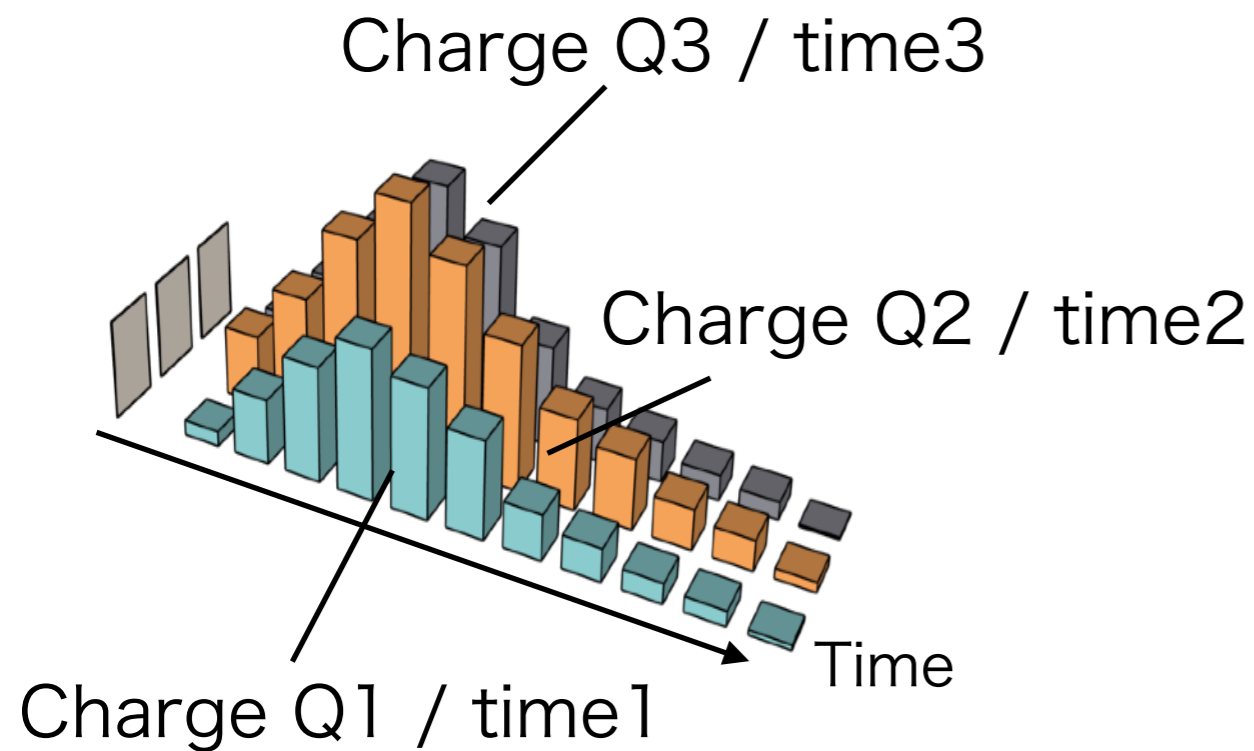


$C_{dL} \sim 256 \text{ }\mu\text{m}/\sqrt{\text{cm}}$

Improve time calculation method?

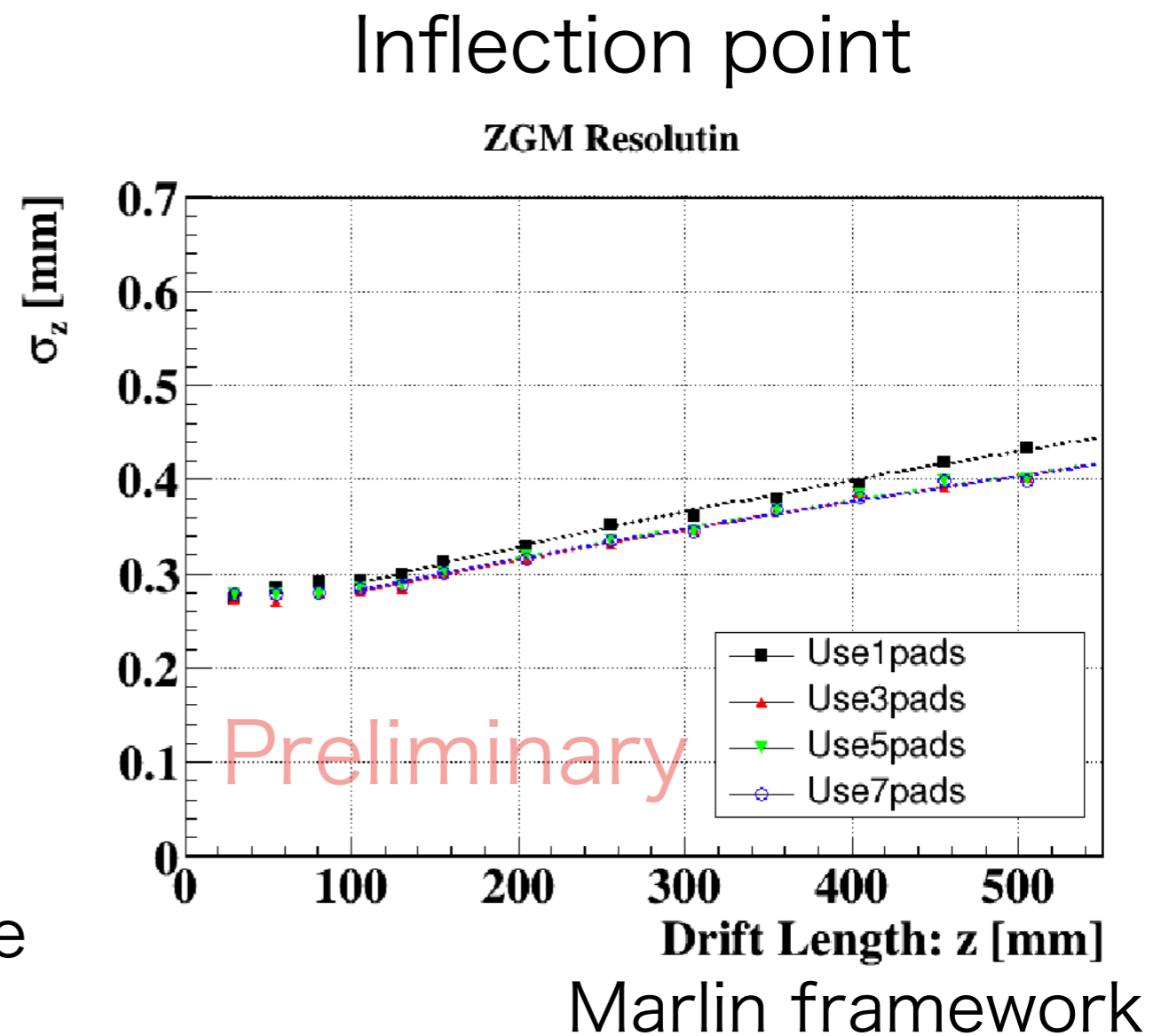
# Time Calculation Method Comparison

Comparison of z resolution for various **pad numbers**



$$\frac{1}{\sum_i Q_i} \sum_i Q_i \times time_i$$

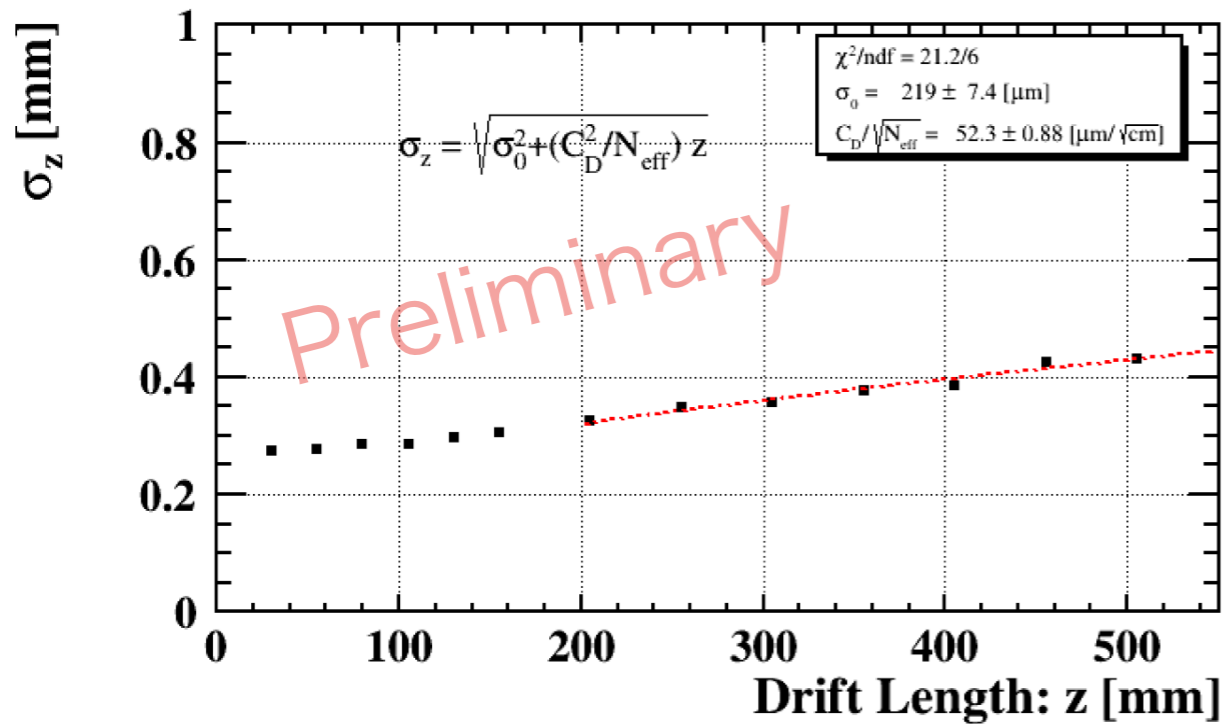
Add pulse time weighted by charge



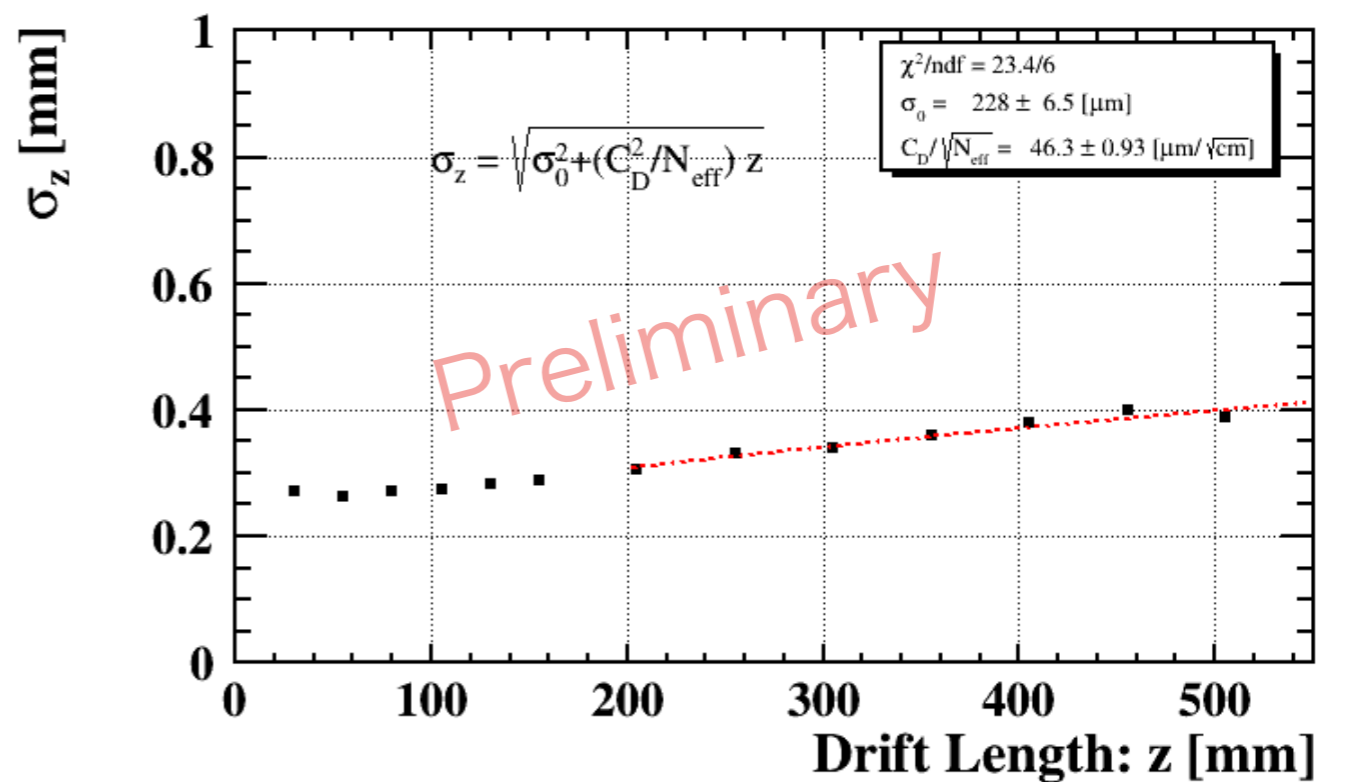
z resolution using **3 pads or more** is better than when using 1 pad



# Re-estimate $C_{dL}$



Using 1 pad



Using **All** pad

$N_{\text{eff}} = 23.9 \pm 0.7$  (From  $r\phi$  analysis)  
 $C_{dL}/\sqrt{N_{\text{eff}}} = 52.3 \pm 0.88 \mu\text{m}/\sqrt{\text{cm}}$

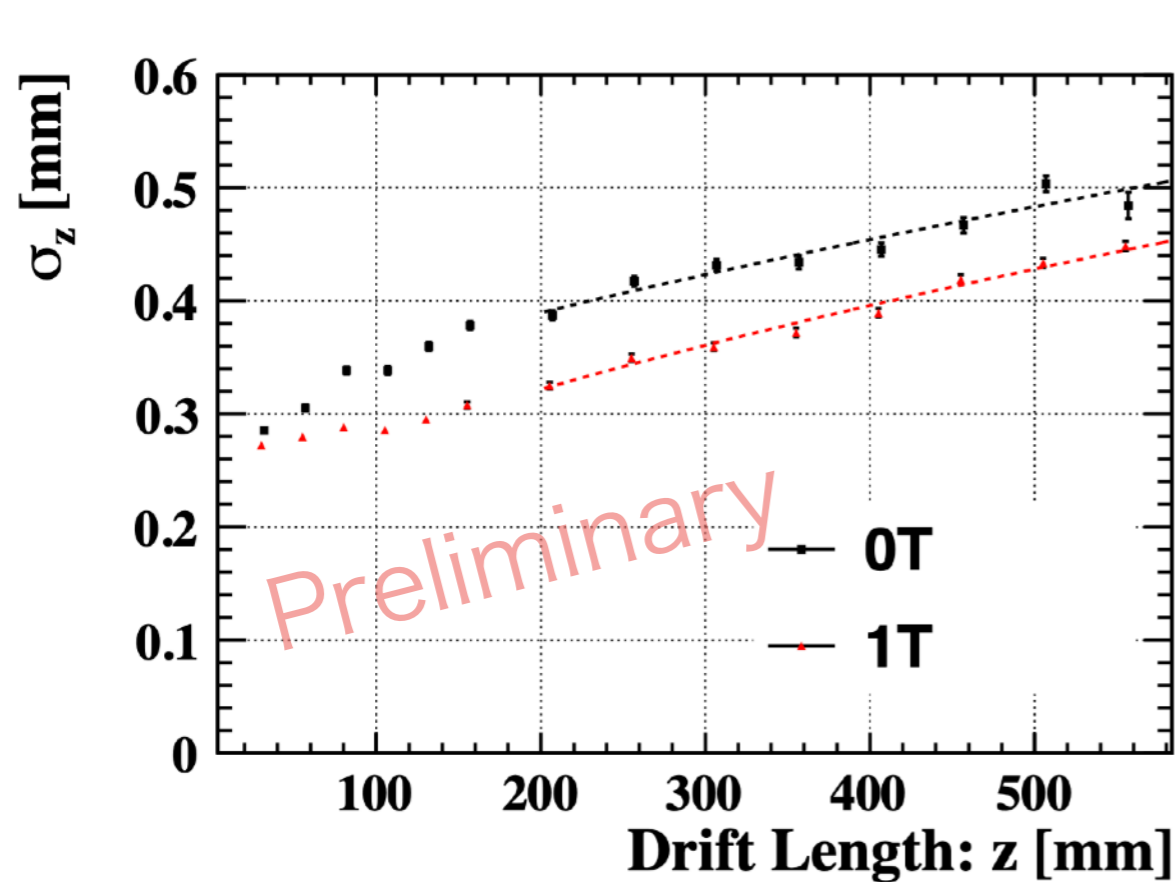
$C_{dL} \sim 256 \mu\text{m}/\sqrt{\text{cm}}$

$N_{\text{eff}} = 23.9 \pm 0.7$  (From  $r\phi$  analysis)  
 $C_{dL}/\sqrt{N_{\text{eff}}} = 46.3 \pm 0.93 \mu\text{m}/\sqrt{\text{cm}}$

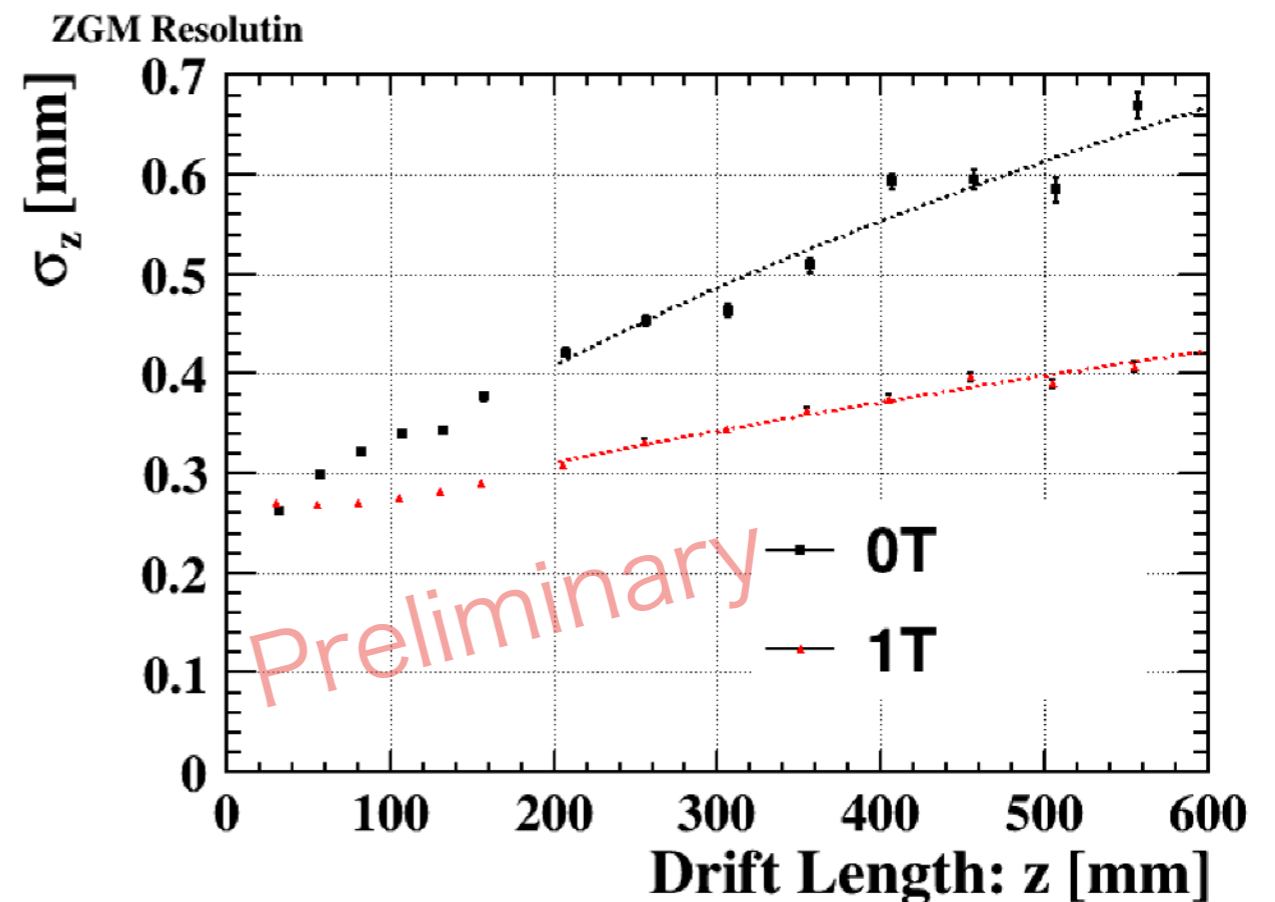
$C_{dL} = 226.3 \pm 5.6 \mu\text{m}/\sqrt{\text{cm}}$

Consistent with Magboltz simulation

# Re-estimated the z resolution



Using 1 pad



Using **All** pad

- The z resolution with 0T is worse than using 1 pad though the z resolution with 1T is better.

This is caused by the method of combining pulse information?  
Add pulse time weighted by charge → susceptible to electronic noise in particular for tail pads in the hit in question

# Conclusion

- ✓ We performed the beam test with the gating device
- ✓ We improved the z coordinate estimation method
- ✓ With improved method, the resultant CdL value turned out to be consistent with Magboltz simulation

## Future work

- \* Is the  $t_{pk} = 120$  correct? → We are planning to measure ALTRO output pulse shape
- \* Improve the method to combine pads