Study on the bias analysis and correction in MPGD μTPC mode

Zhujun Fang[1,2], Jiajun Tang[1,2] , Hang Zhou[1,2], Siqi He[1,2]

[1]*State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China*

[2]*Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China*

1. μTPC mode in MPGD

- Measuring **Time** in each strip
- For track with **large incident angle**
- **Good spatial resolution** (~50 μm)

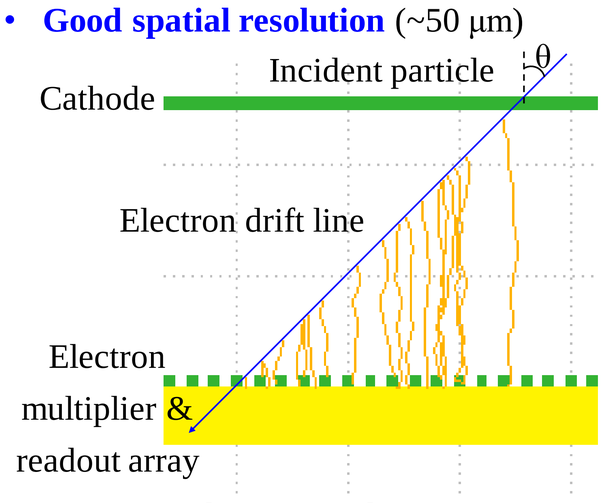


Fig. 1 Typical μTPC mode in MPGD.

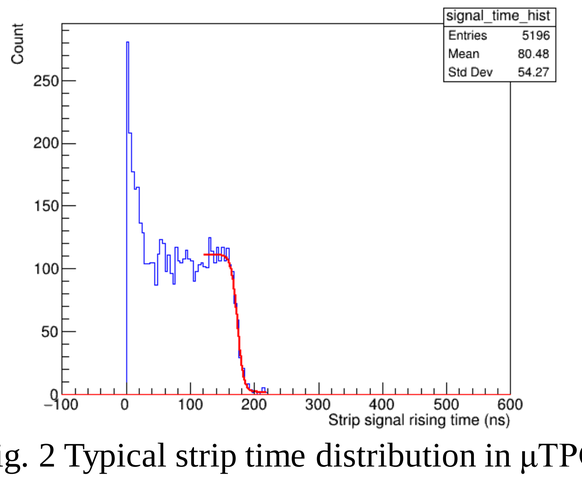
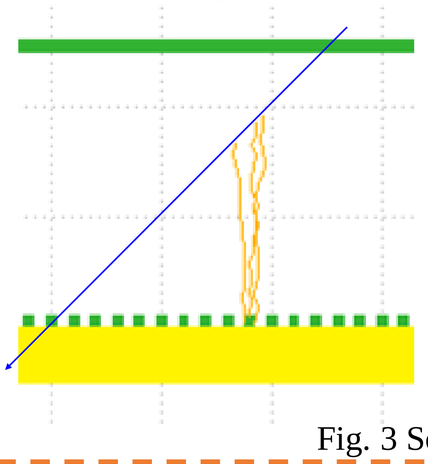
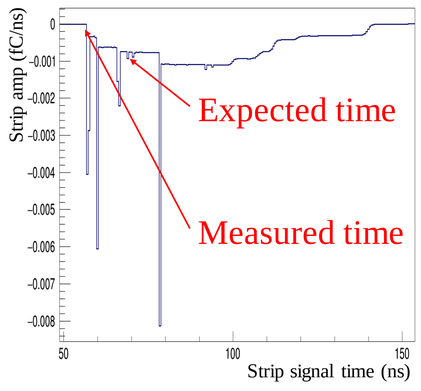


Fig. 2 Typical strip time distribution in μTPC.

2. Spatial measurement bias in μTPC mode

- Strip signal consists of **more than 1** primary electrons
- Signal of **1st electron** determines strip time, having a in-advanced **time bias**
- The reconstructed track is "lower" than real track, introducing **spatial bias**





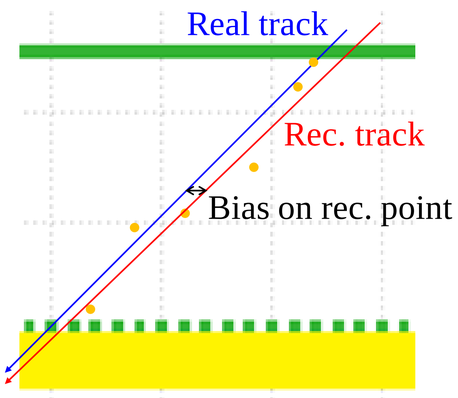


Fig. 3 Schematic of generation principle of spatial bias in μTPC mode.

3. Parameters influence the bias

- Track incident angle
- Drift length
- Gas property (electron drift velocity, diffusion coefficient)
- Magnetic field
- Strip width and pitch
- Timing resolution of electronic system

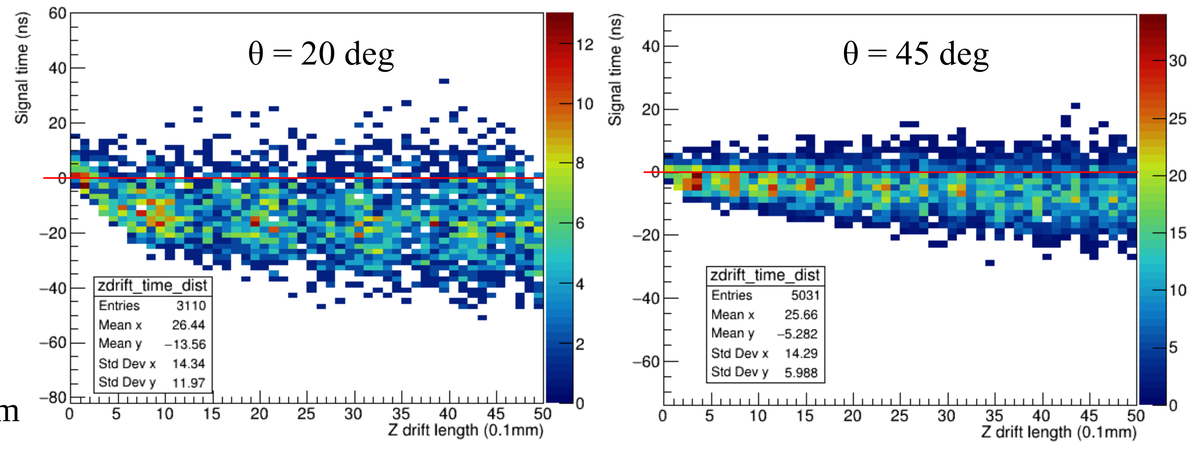


Fig. 4 Relationship between time bias and drift length, with different incident angle.

4. New algorithm to correct the bias

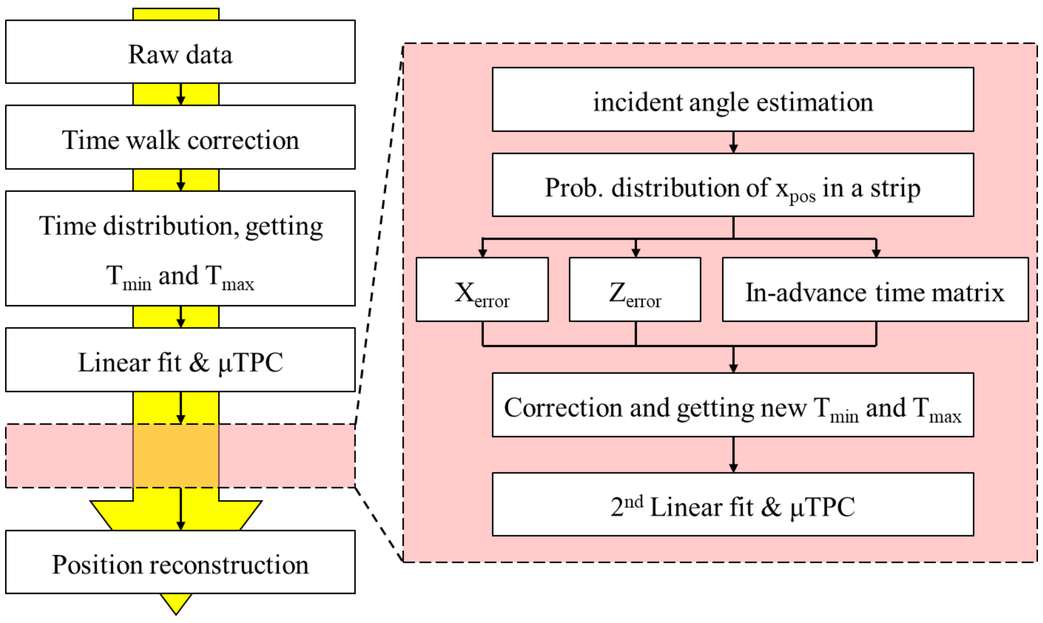


Fig. 6 New algorithm to correct bias in traditional μTPC mode.

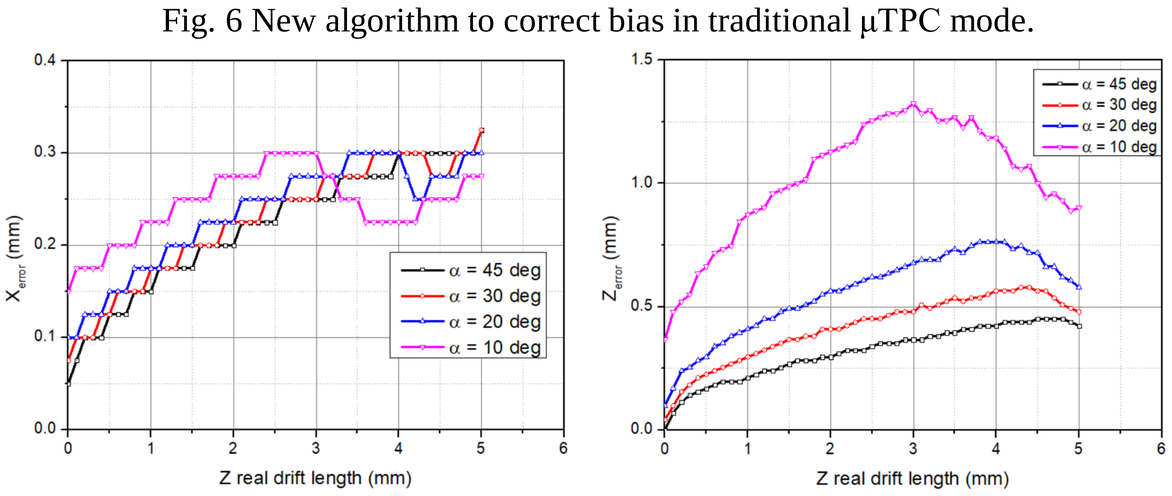


Fig. 7 X_{error} and Z_{error} distribution with various incident angle.

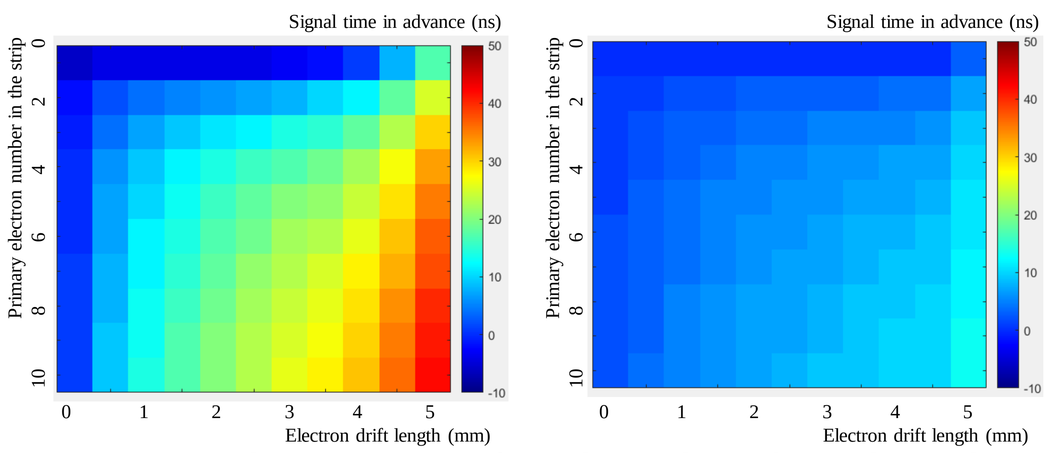
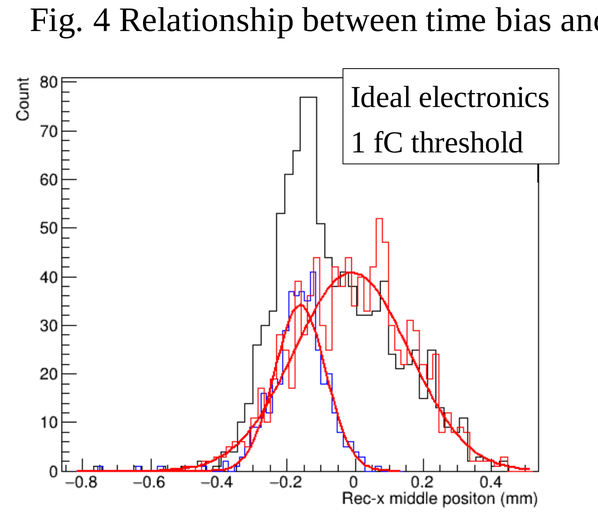


Fig. 8 Time advance matrix. Left: 10 deg angle. Right: 45 deg angle.



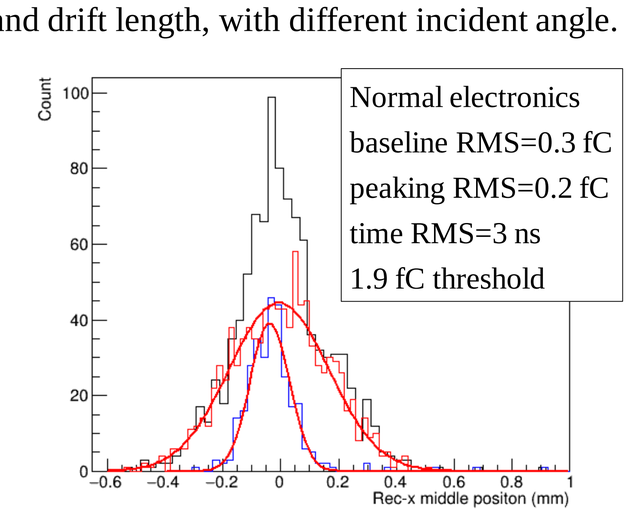


Fig. 5 Spatial resolution between μTPC (blue hist.) and charge-centroid (red hist.) with 10 deg incident angle and different electronics setting.

(Planar detector) Drift time correction based on electron diffusion analysis:

- Decrease spatial bias by 40%-75%
- Slightly improve spatial resolution

(Cylindrical detector, with magnetic field): Strip position correction based on empirical formula:

$$ID = ID_0 \pm \left(\frac{1}{2} - \frac{1}{N+1}\right) \cdot f_w(\theta)$$

- N is the primary electron number
- $f_w(\theta)$ is the weighting field-related parameter
- Decrease spatial bias significantly, with 1.4 GeV/c muon

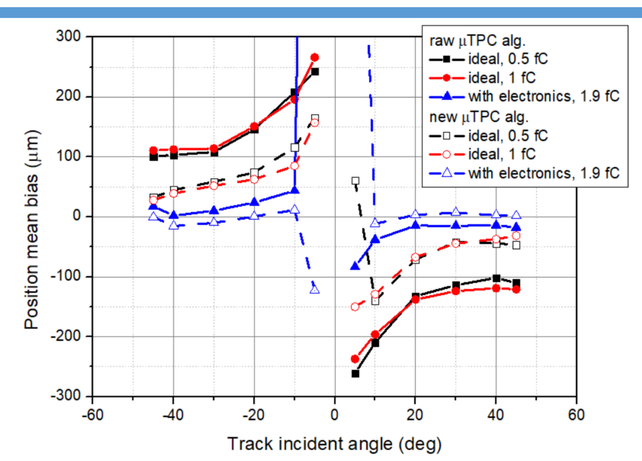


Fig. 9 Simulated bias correction performance.

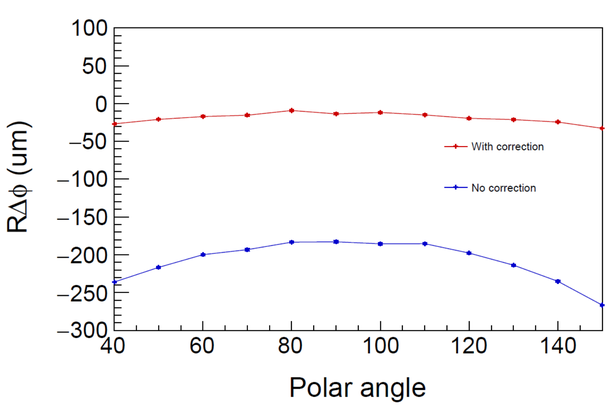


Fig. 10 Simulated bias correction performance.

5. Discussion and conclusion

- Theoretically, the μTPC mode has bias in spatial reconstruction , which is easily covered by the assembly error in planar detectors. In cylindrical detector, it is not negligible.
- New algorithms are developed to correct the bias, and should be optimized to cover all track incident angle range and cases.