

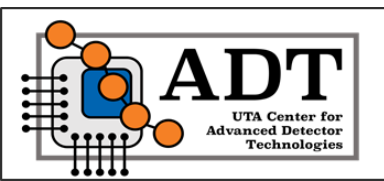


Measuring the transverse diffusion of electrons in gasses: A laboratory-scale demonstration of the physics capabilities of Q-Pix.

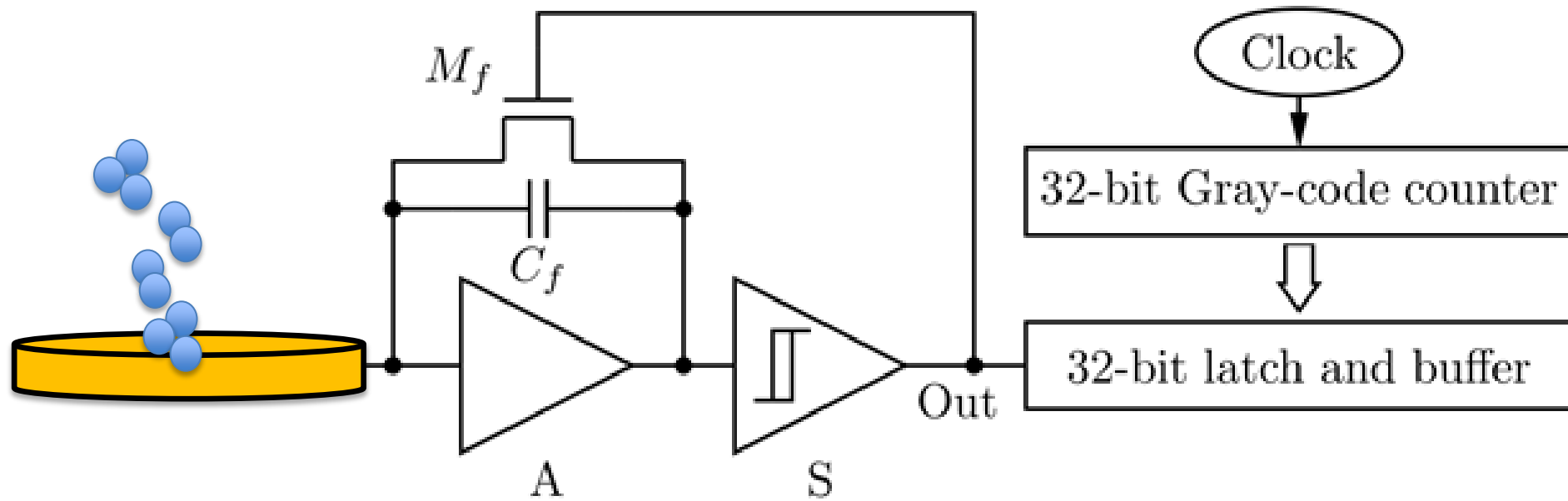
N. Hoch^a, O. Seidel^b, K. Keefe^b, A. B. Enriquez^b, I. Parmaksiz^b, A. D. Mcdonald^b,
V. A. Chirayath^b, W. Wei^a, H. Mahdy^b, M. Rooks^b, J. B. R. Battat^a, J. Asaadi^b

^a Physics Department, Wellesley College, Wellesley, MA 02481

^b Department of Physics, University of Texas at Arlington, Arlington, TX - 76019

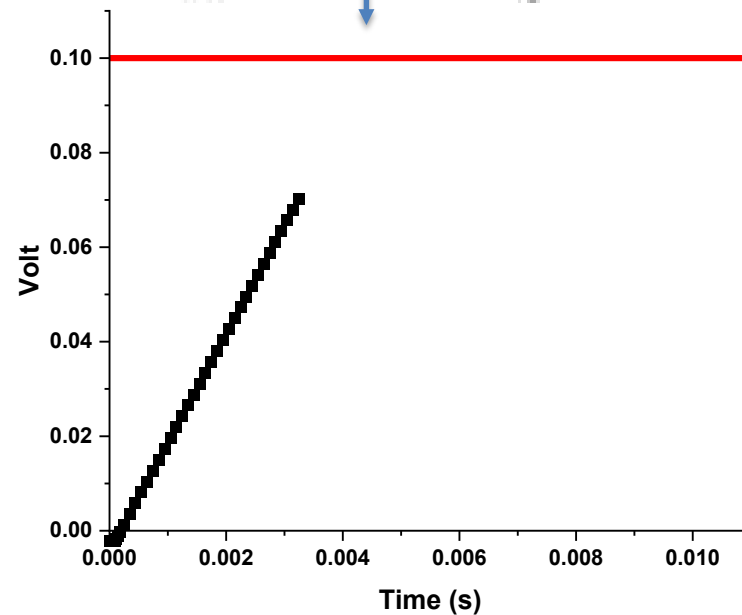
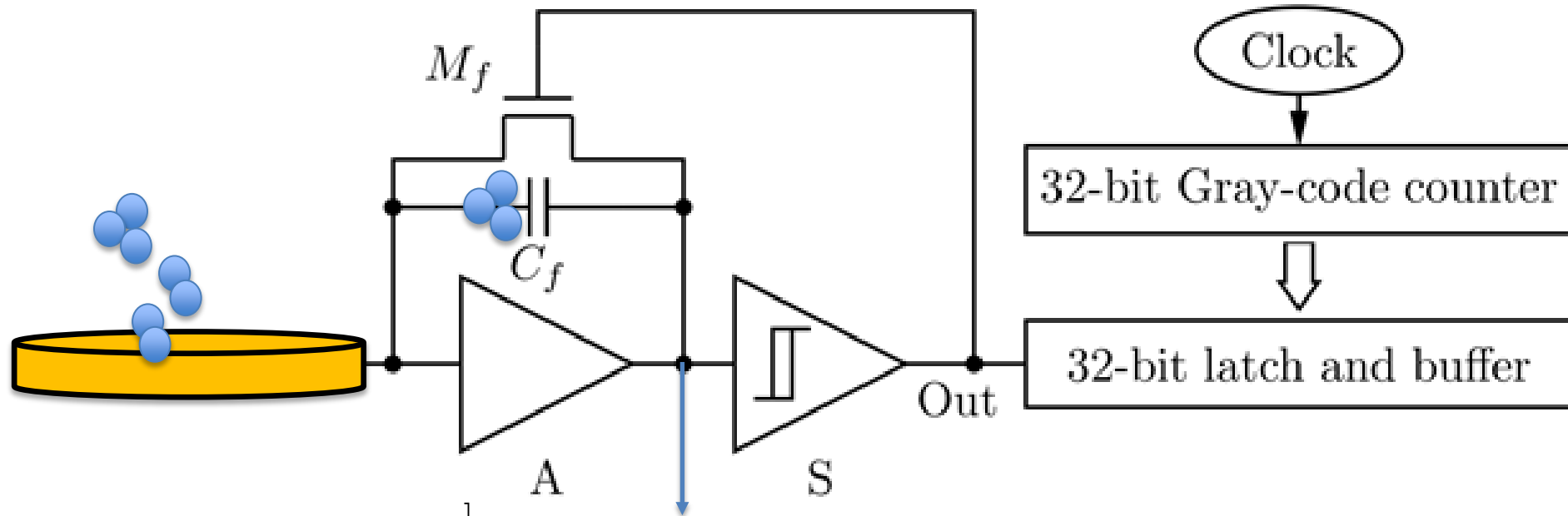


Q-Pix – Charge Integrate/Reset



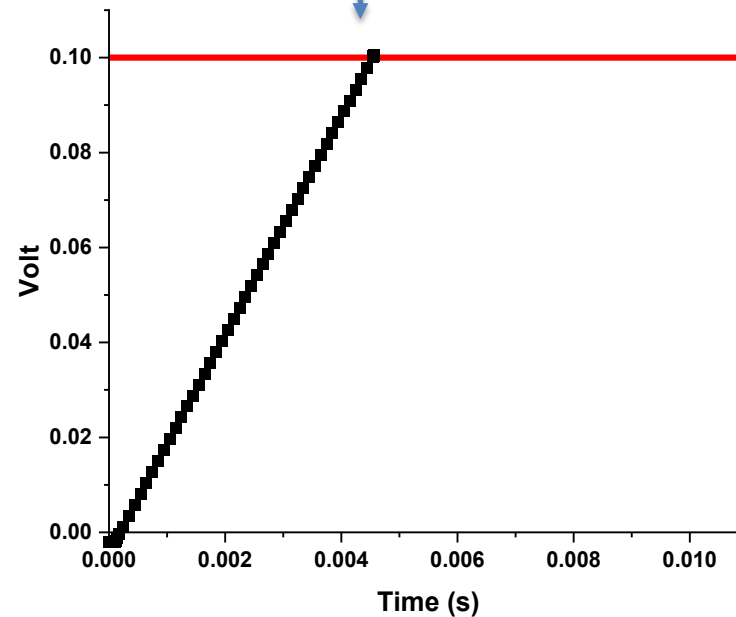
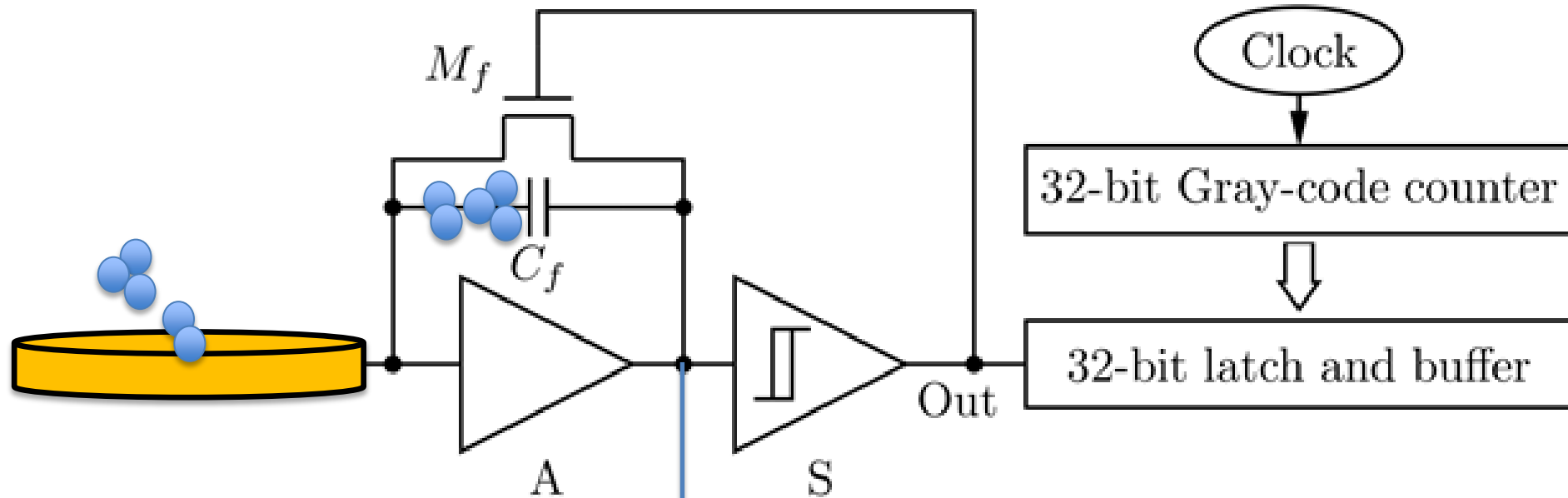
<https://arxiv.org/abs/1809.10213>

Q-Pix – Charge Integrate/Reset



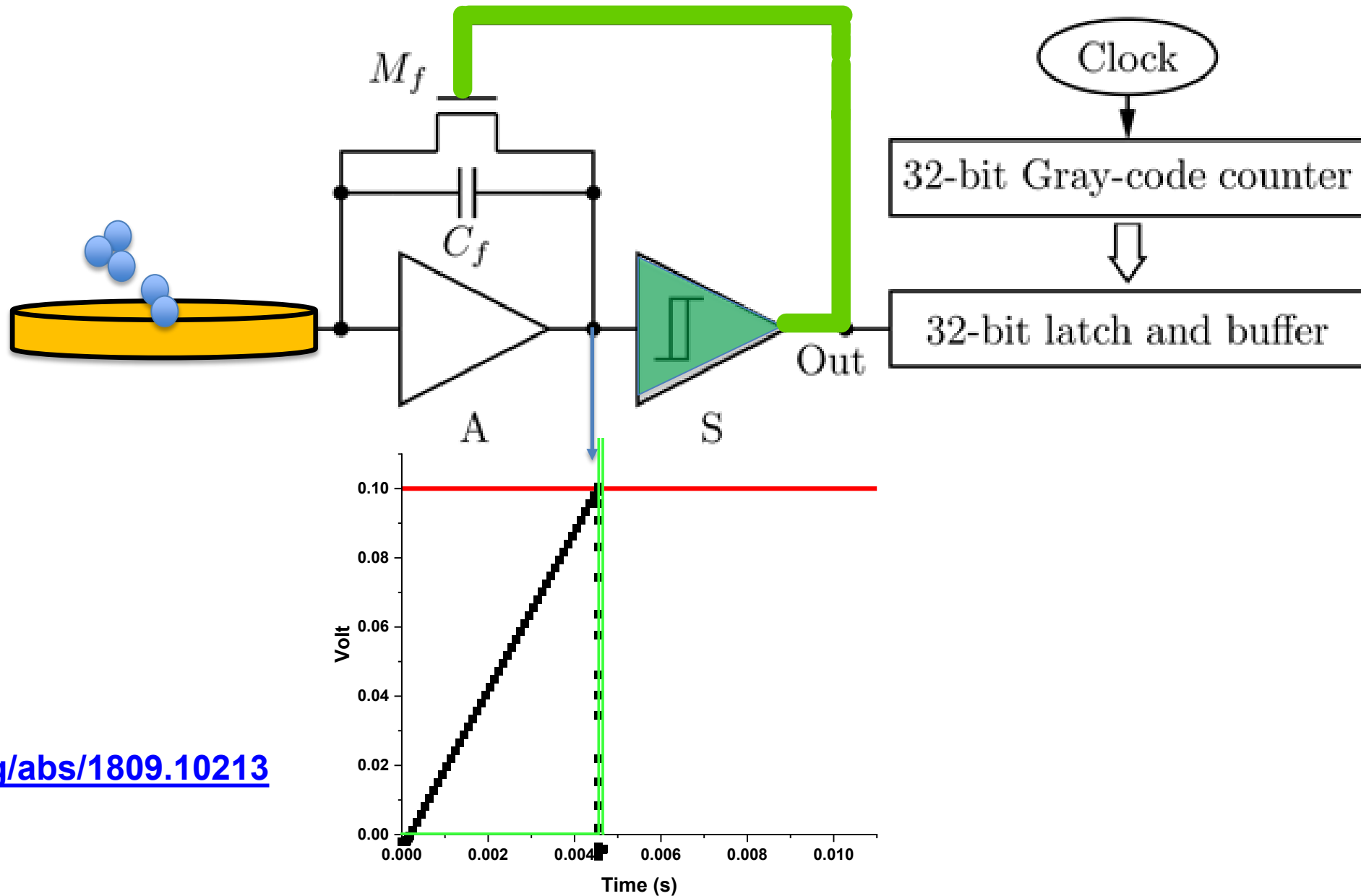
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Q-Pix – Charge Integrate/Reset



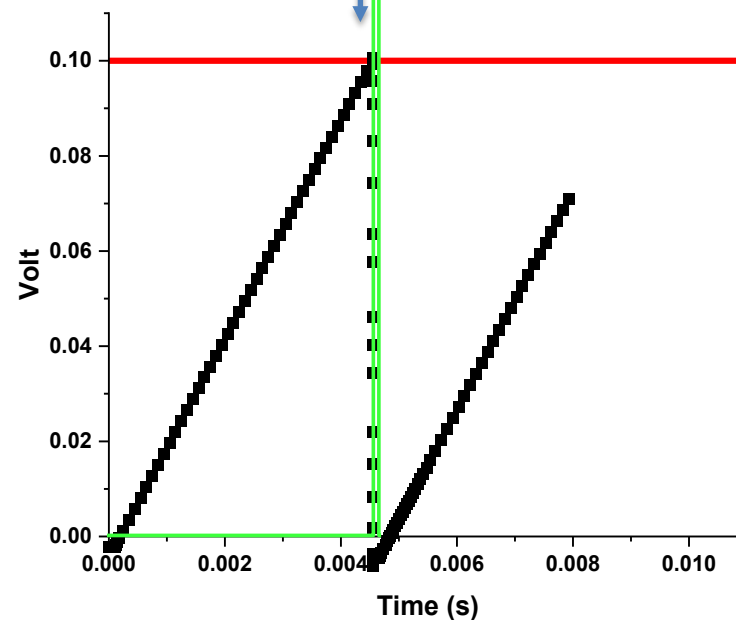
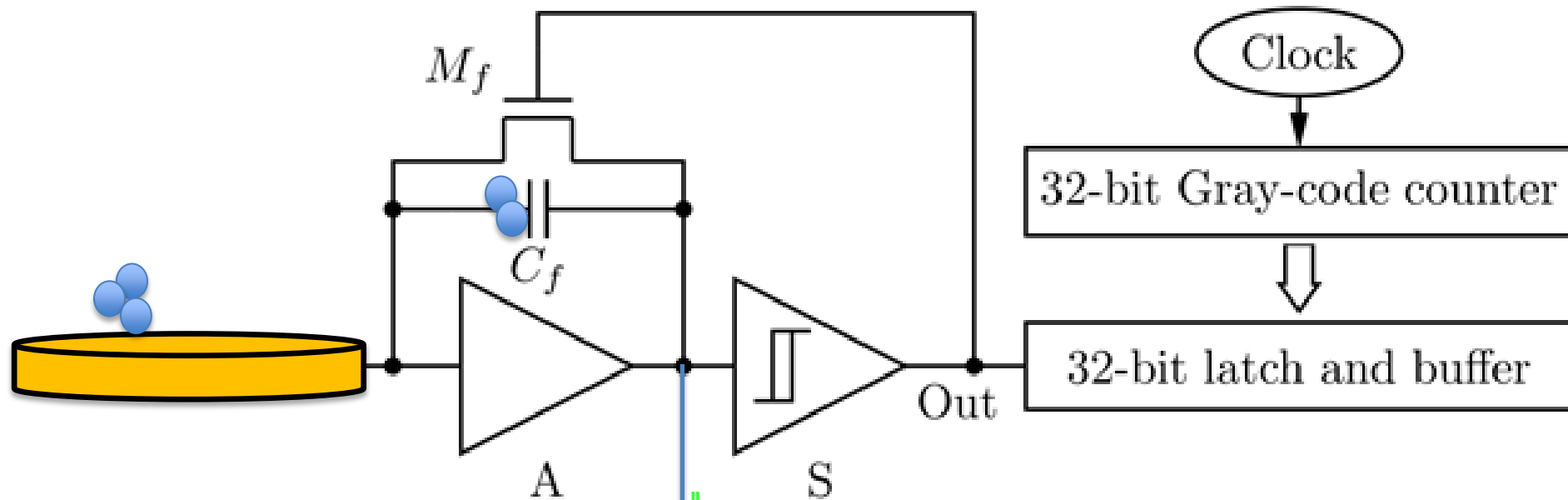
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Q-Pix – Charge Integrate/Reset



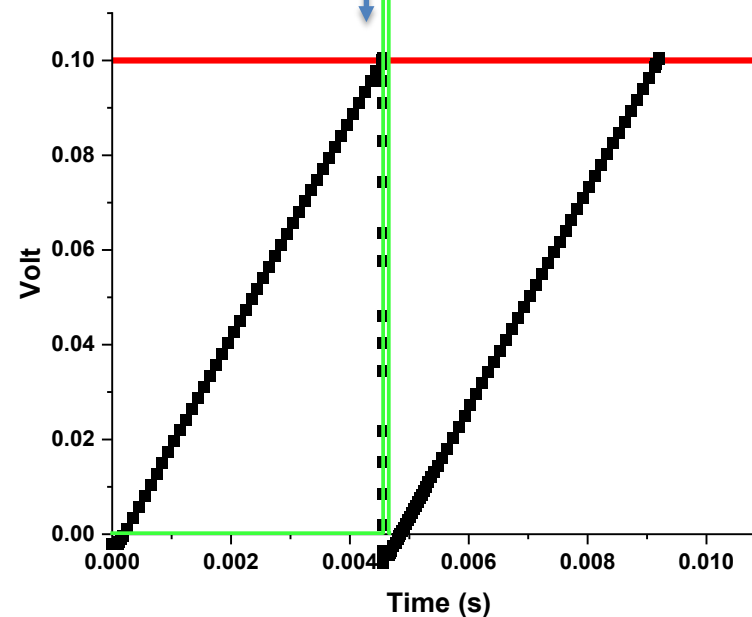
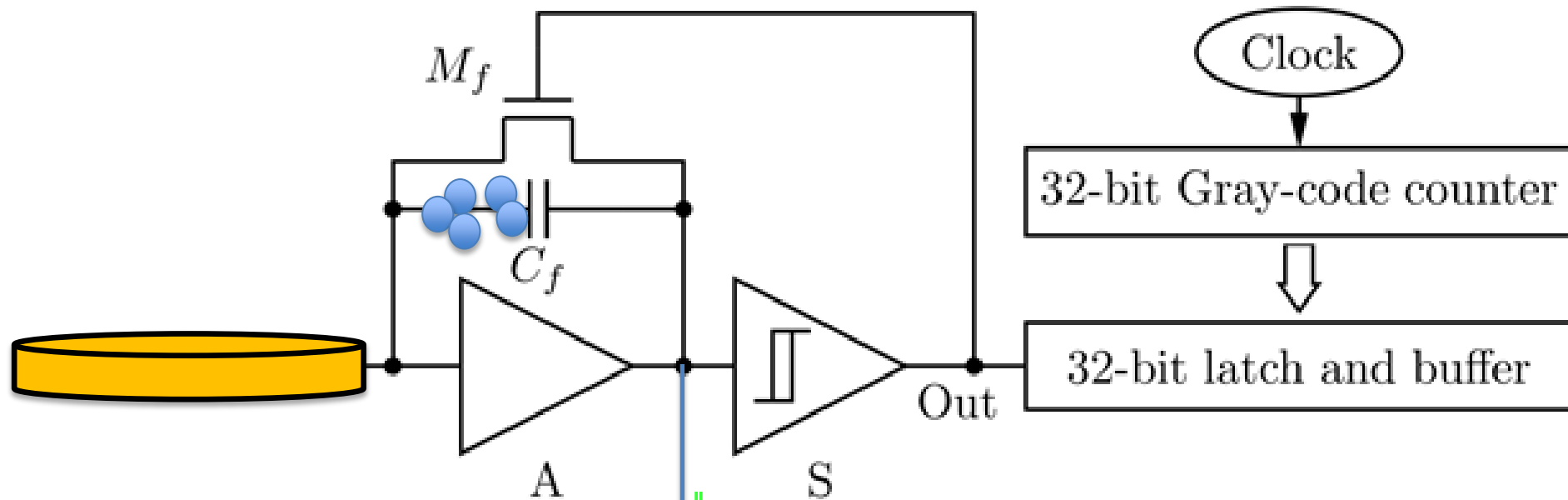
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Q-Pix – Charge Integrate/Reset



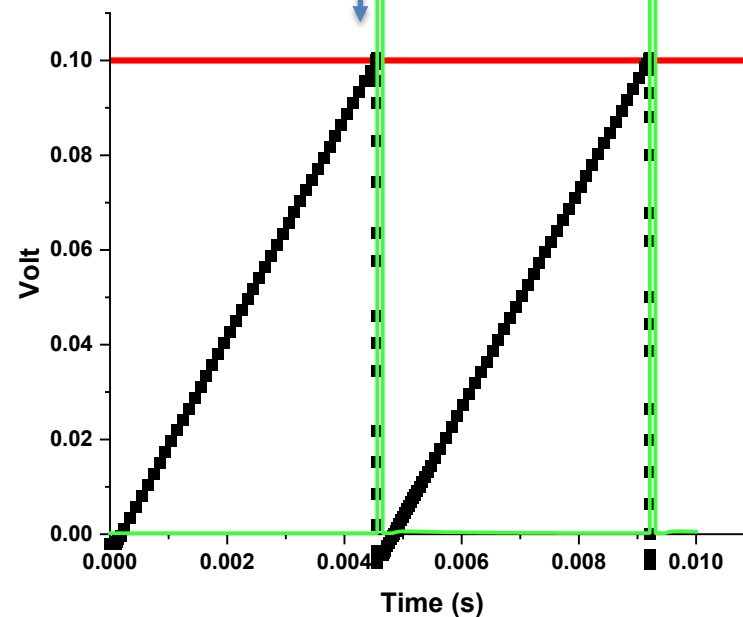
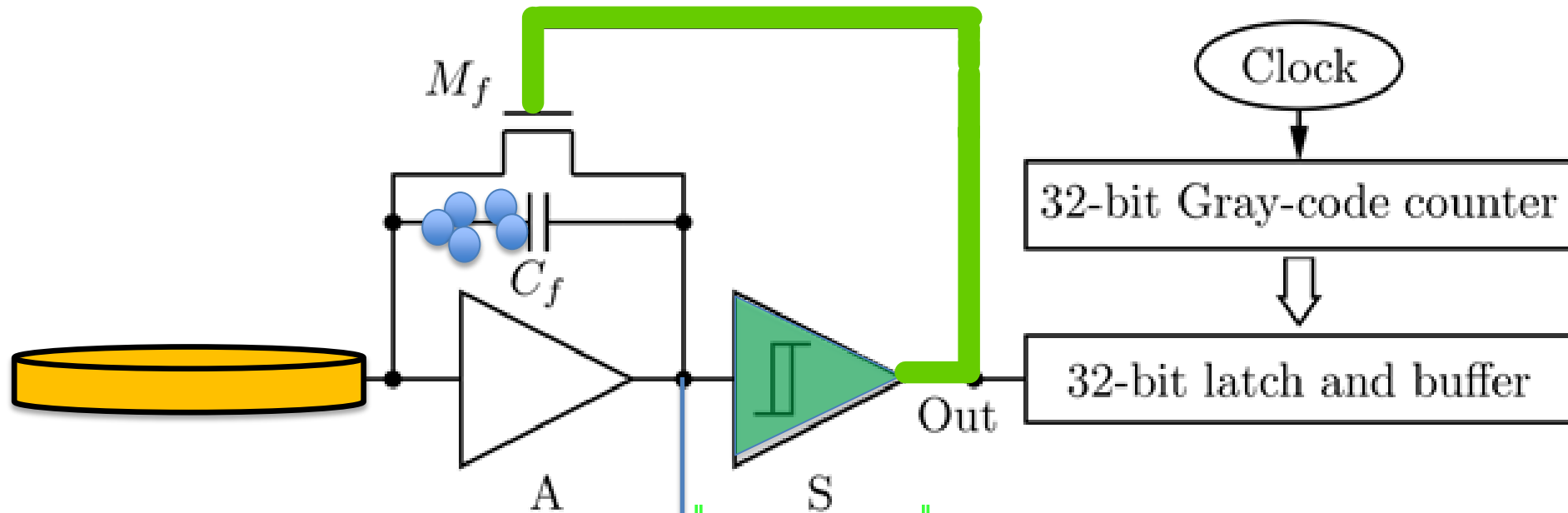
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Q-Pix – Charge Integrate/Reset



<https://arxiv.org/abs/1809.10213>

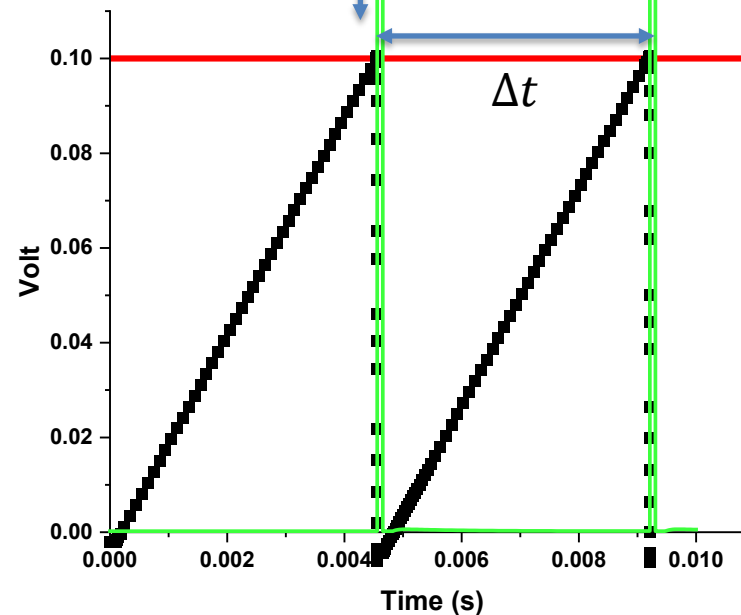
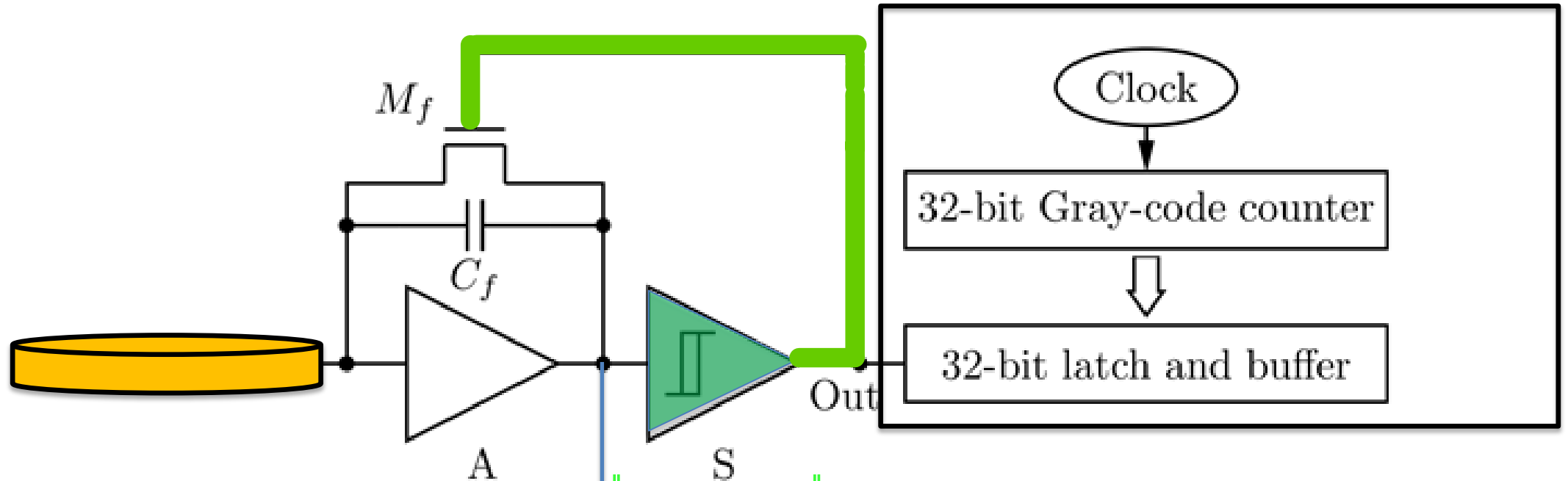
Q-Pix – Charge Integrate/Reset



<https://arxiv.org/abs/1809.10213>

Q-Pix – Charge Integrate/Reset

K. Keefe et al., CPAD 2023



$$I = \frac{q}{\Delta t}$$

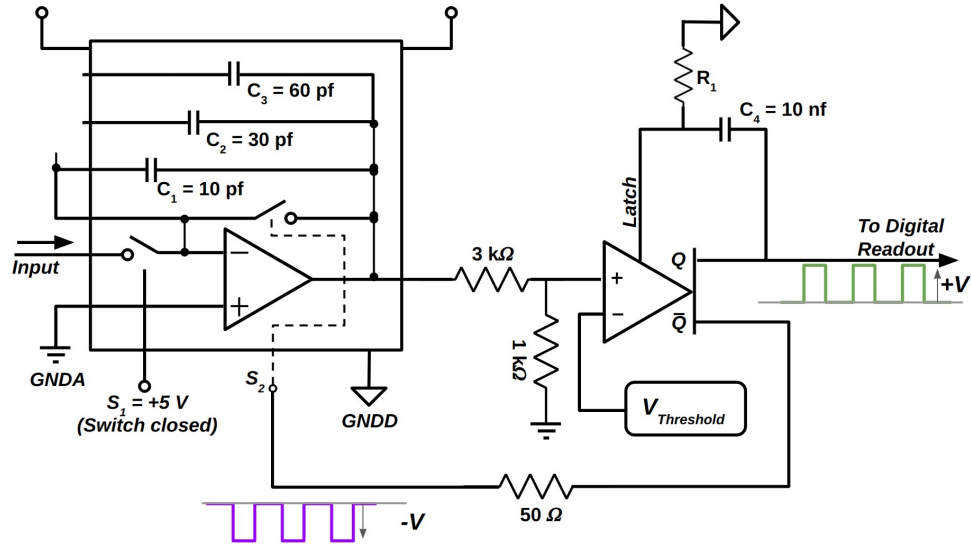
$q = \text{Charge per reset}$
 $\rightarrow \text{as small as } 1fC$
 $= 6250 \text{ electrons}$

<https://arxiv.org/abs/1809.10213>

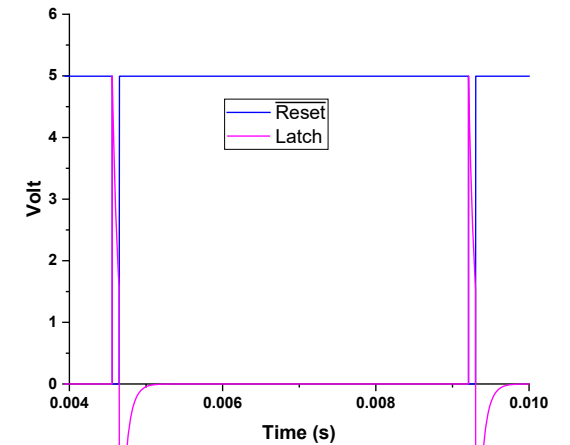
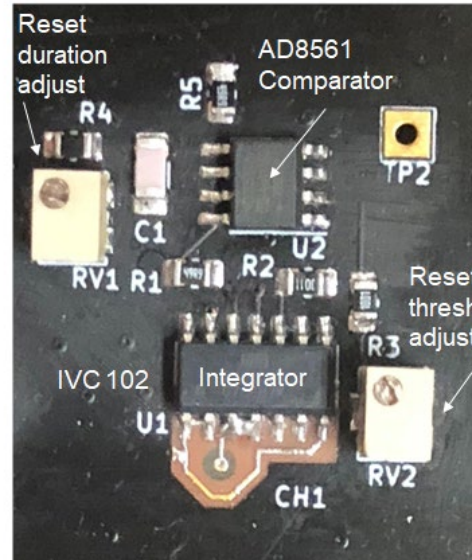
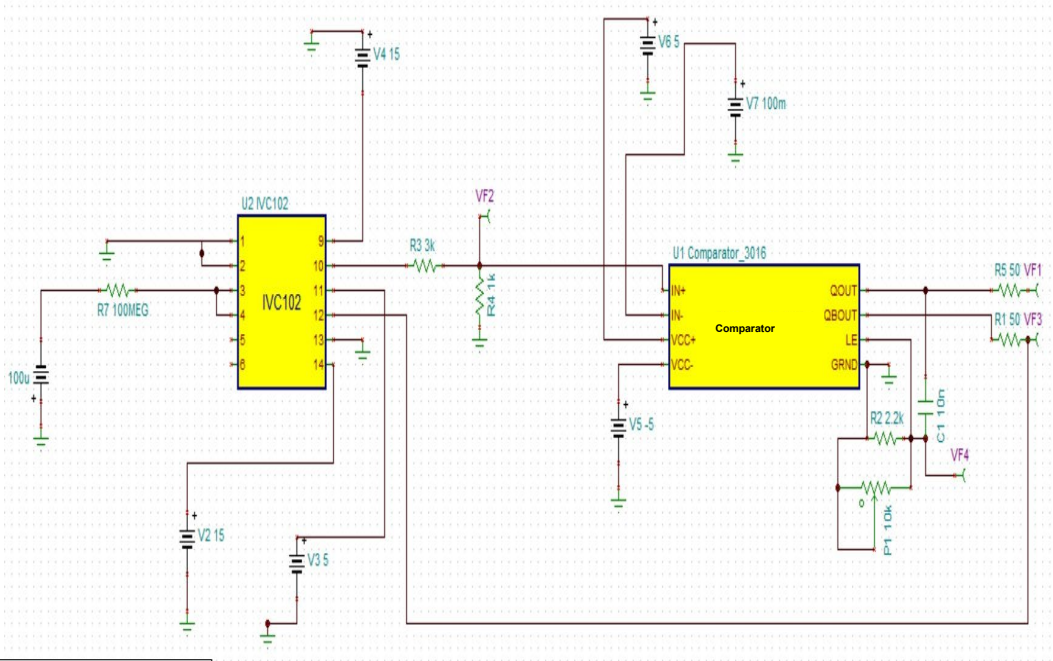
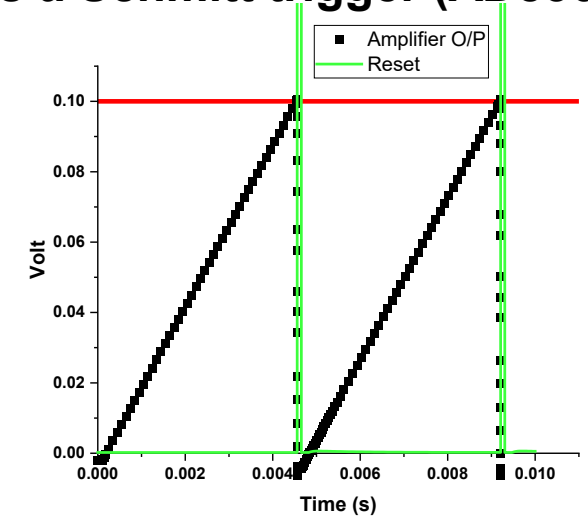
Opportunity for the technology

- **Phase 0: Demonstrate the capabilities of analog front-end and digital backend using commercial-off-the-shelf (COTS) components**
 - Q-Pix front-end demonstration using discrete OpAmp and CMOS transistors (Peng Miao, Yuan Mei, under preparation)
 - **Measurement of transverse diffusion of electrons in noble gas detectors using Q-Pix demonstrator made with COTS components (this talk)**
 - Investigation of Digital backend: Experiments and Simulation (K.Keefe et al., CPAD 2023).
 - Demonstration of Charge+Light read out (M. Rooks et al., CPAD 2023).
- **Phase 1: Testing the design in silicon**
 - The ASIC implementation of Q-Pix in TSMC 180 nm and Skywater 130 nm process.
- **Phase 2: Scaling up to large detectors**

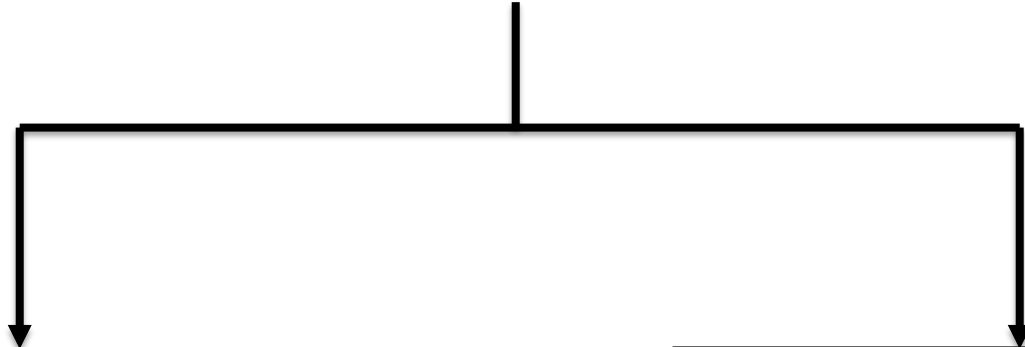
Q-Pix demonstration using COTS



1. IC chip with Q-Pix functionality: IVC 102 (Precision Switched Integrator Transimpedance Amplifier)
2. Comparator operated as a Schmitt trigger (AD8561)

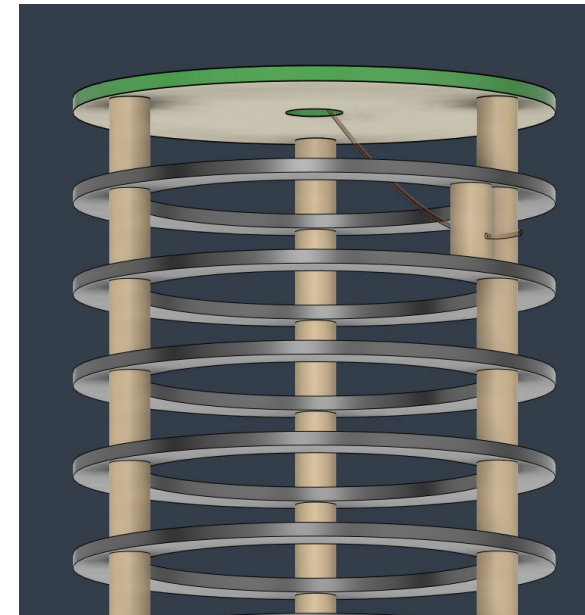
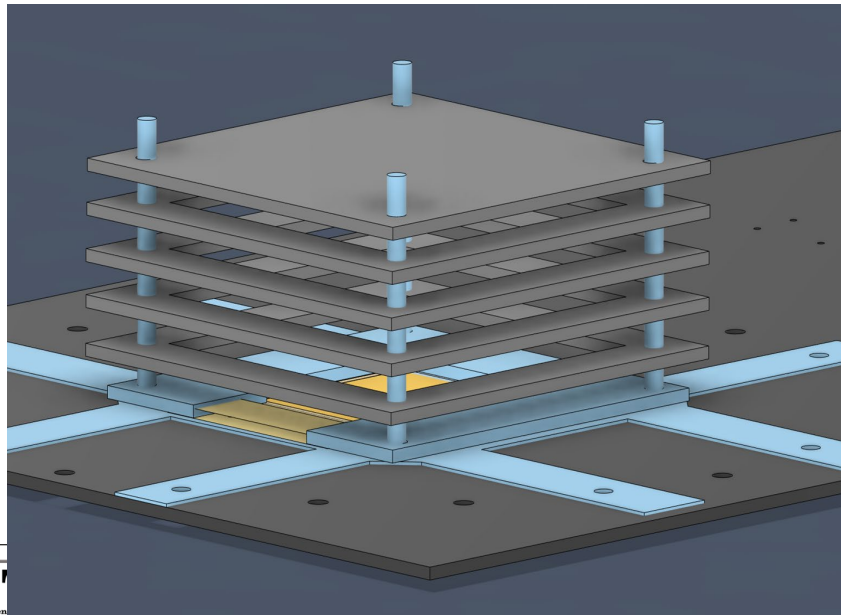


Measurement of transverse diffusion of electrons in noble gas detectors



5 cm drift setup @ Wellesley

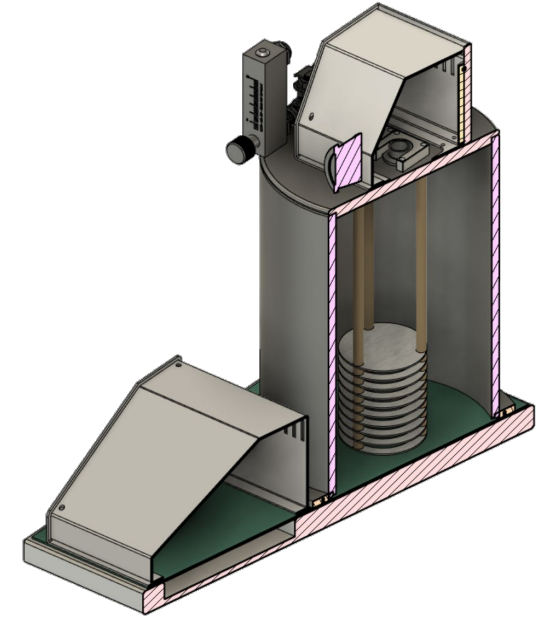
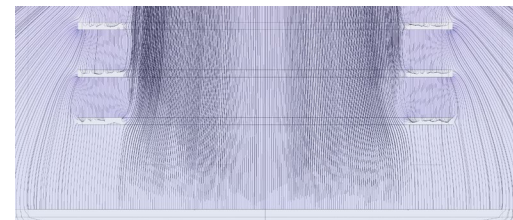
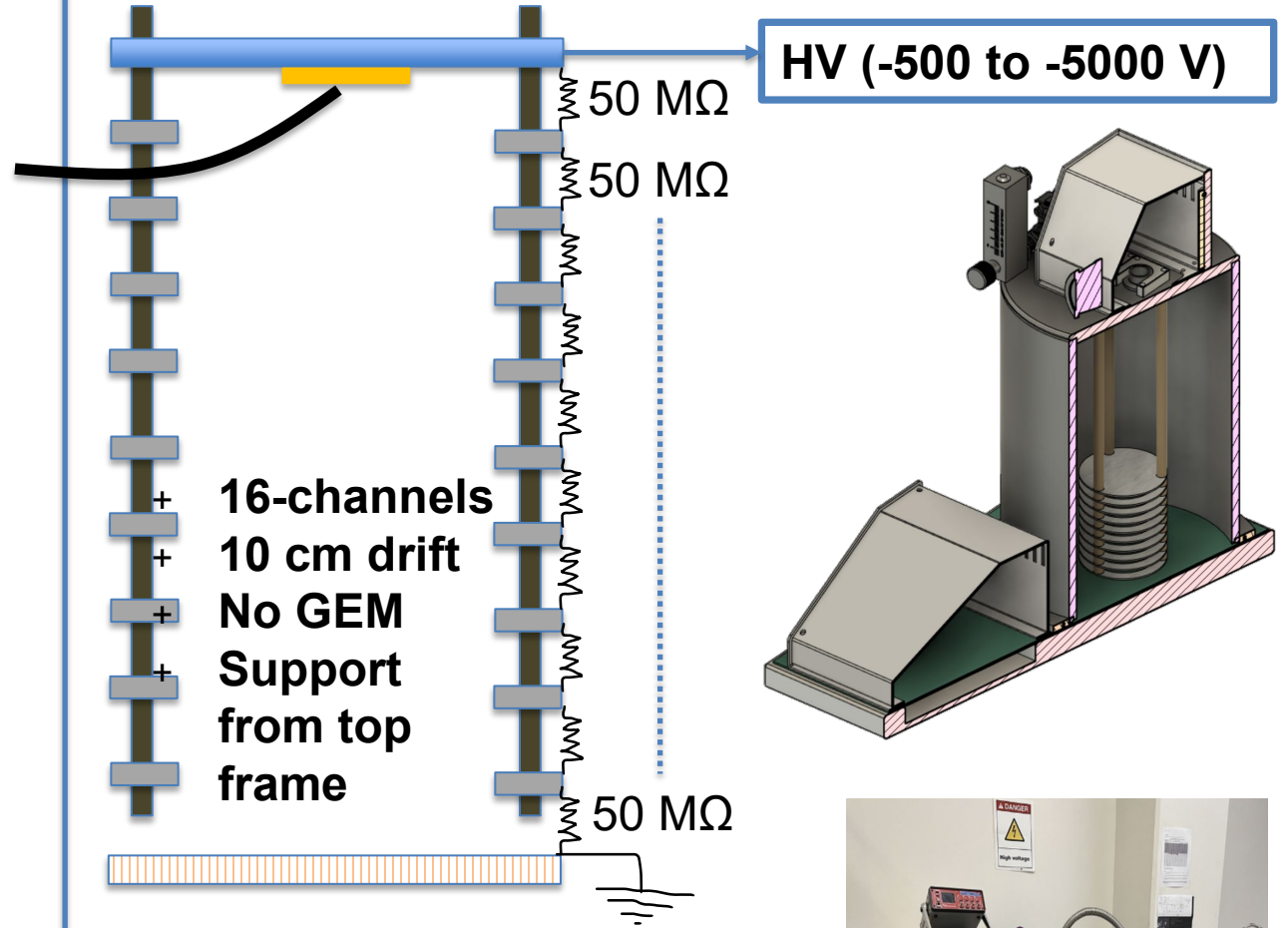
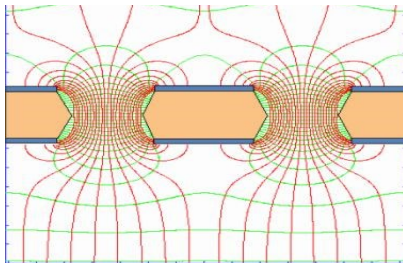
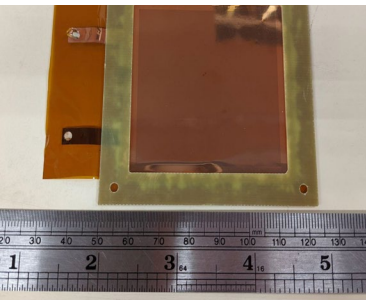
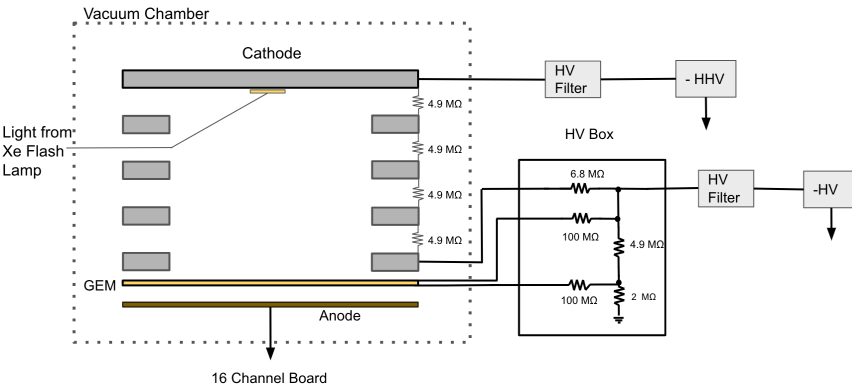
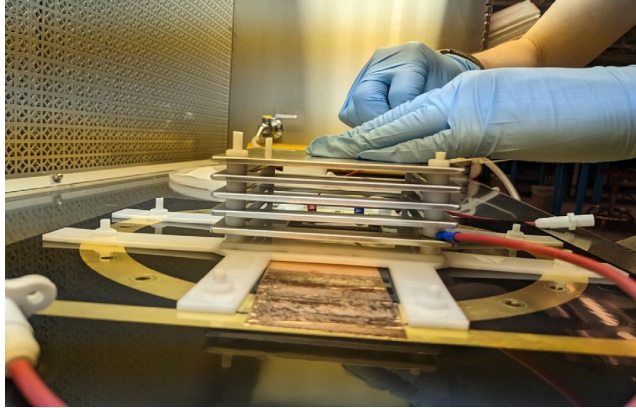
10 cm drift setup @ UTA



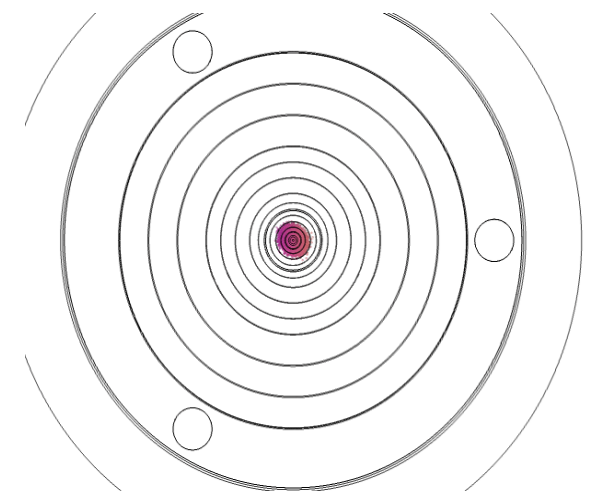
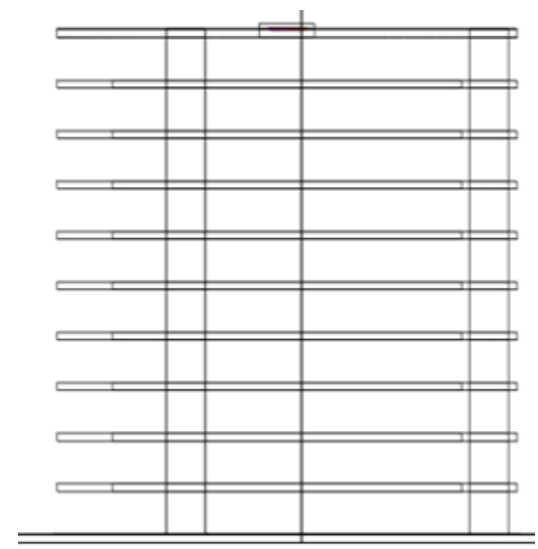
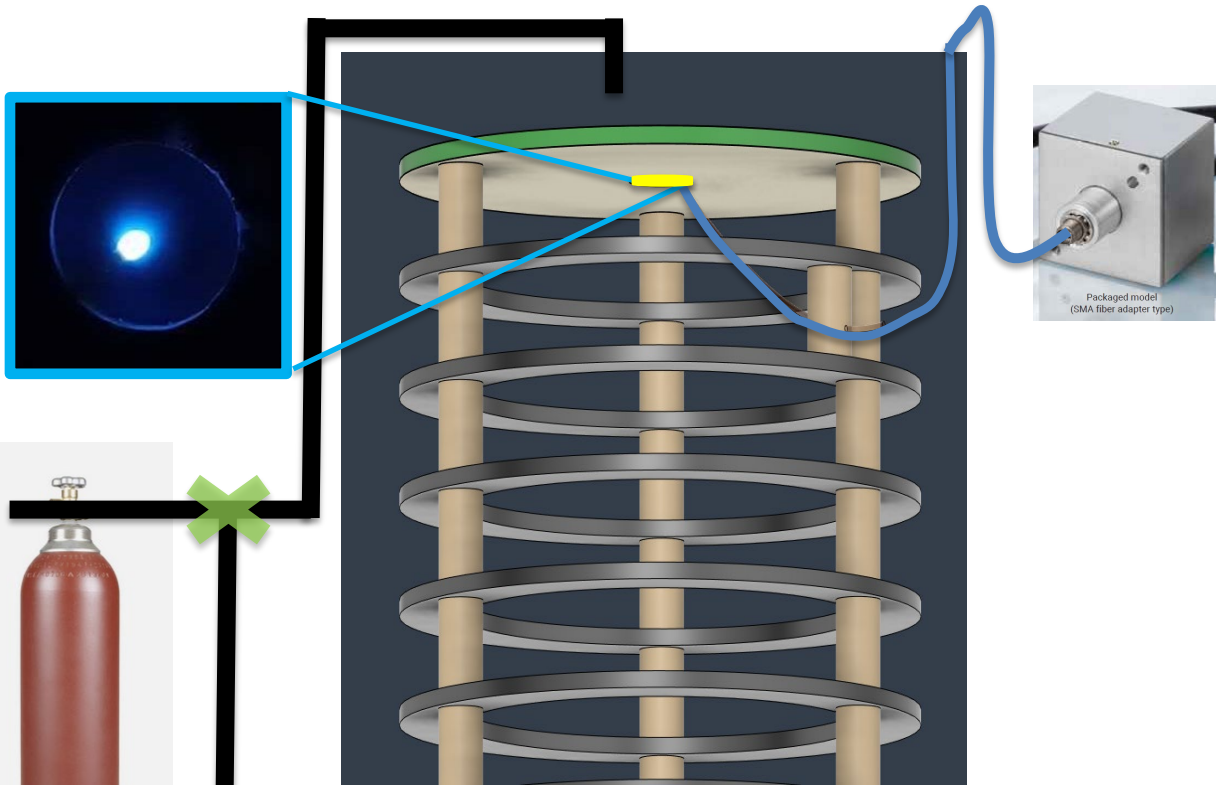
5 cm drift setup @ Wellesley

10 cm drift setup @ UTA

- + 16-channels
- + 5 cm drift
- + GEM
- + Electrode structure is supported on the anode



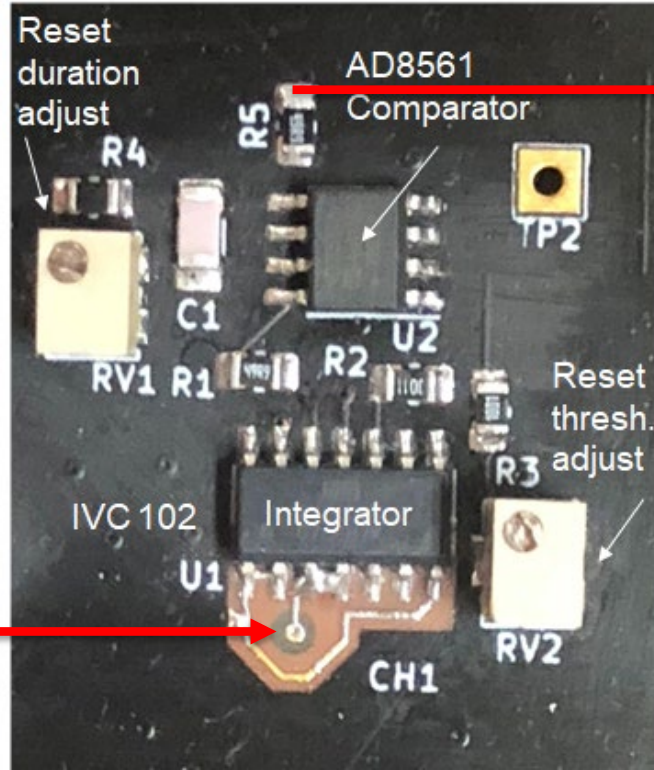
Experiment



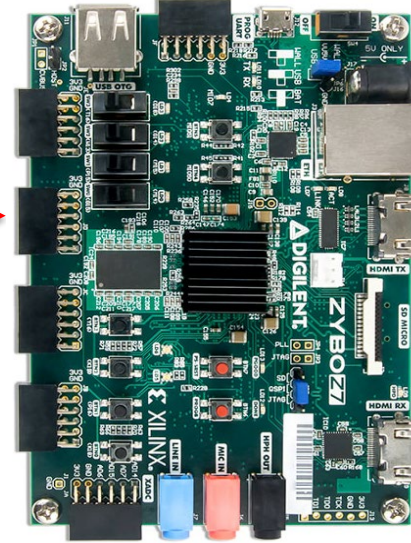
Data Acquisition

Zybo Z7-20

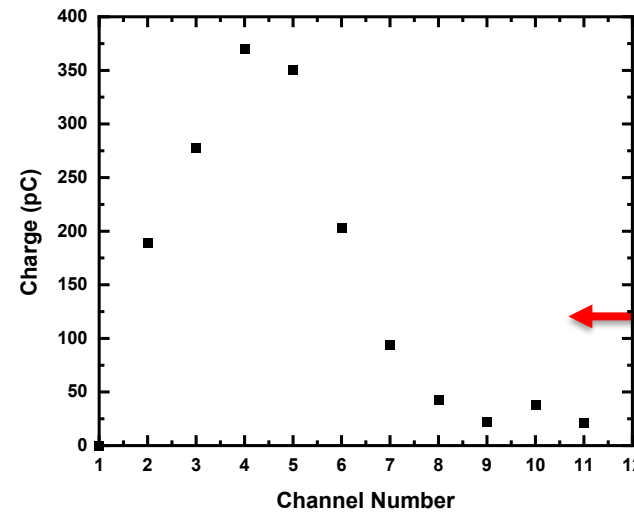
K.Keefe et al., CPAD 2023



Analog Front-end

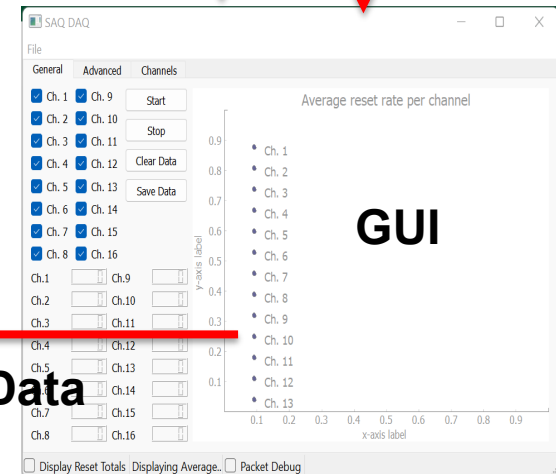


Digital Back-end
Programmable Logic + Software



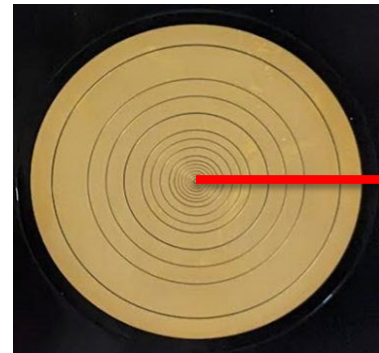
TCP

UDP



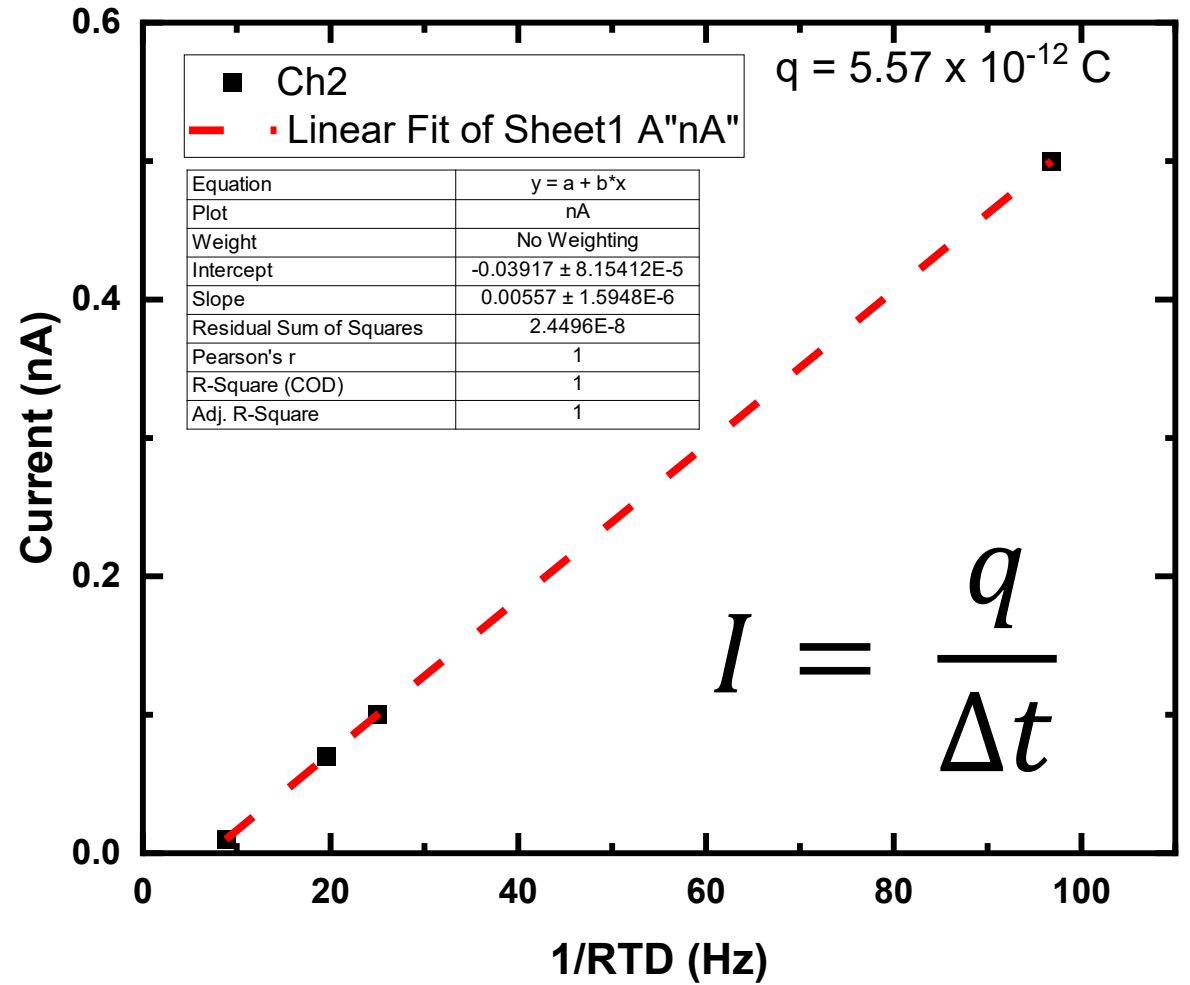
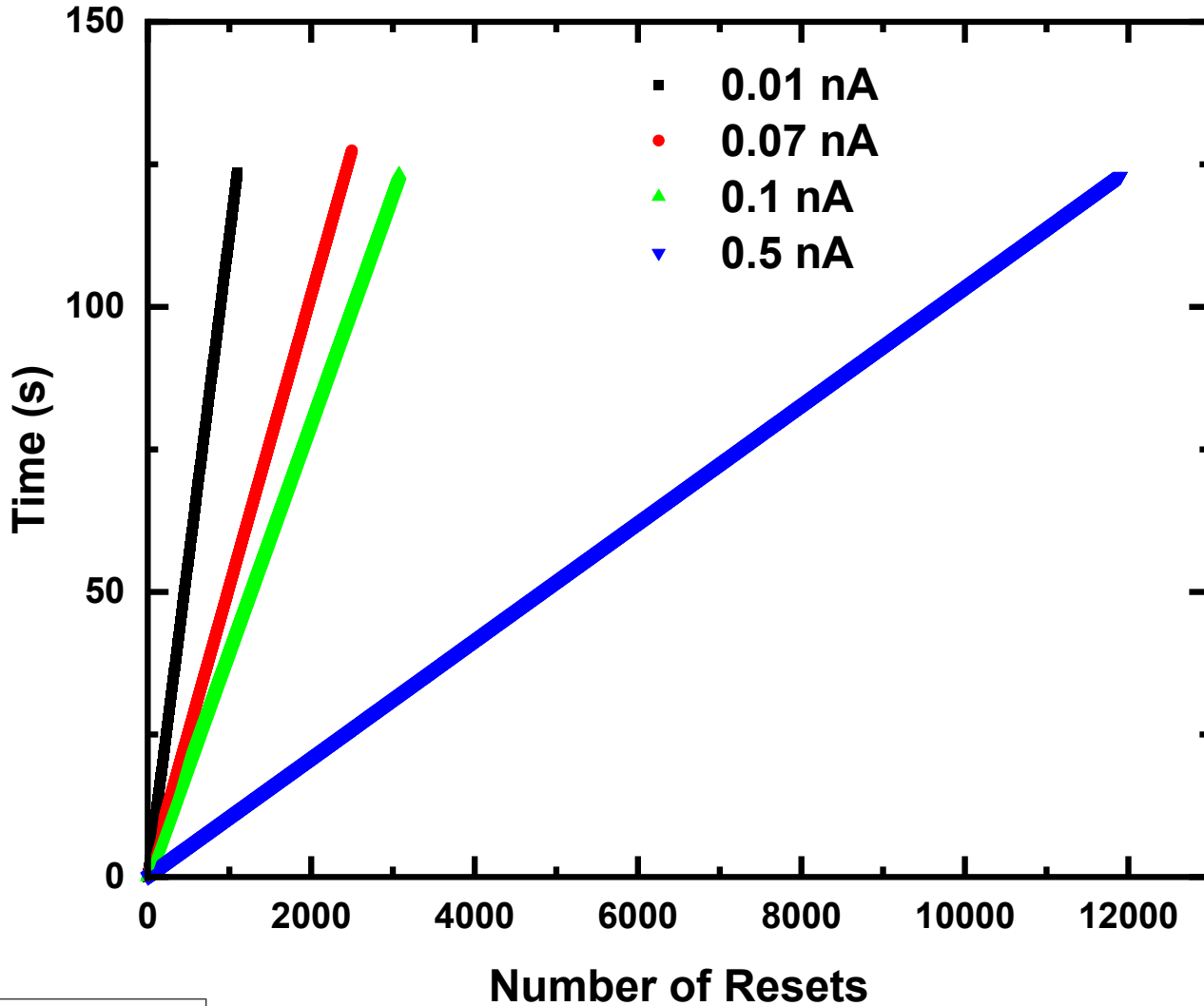
GUI

Data

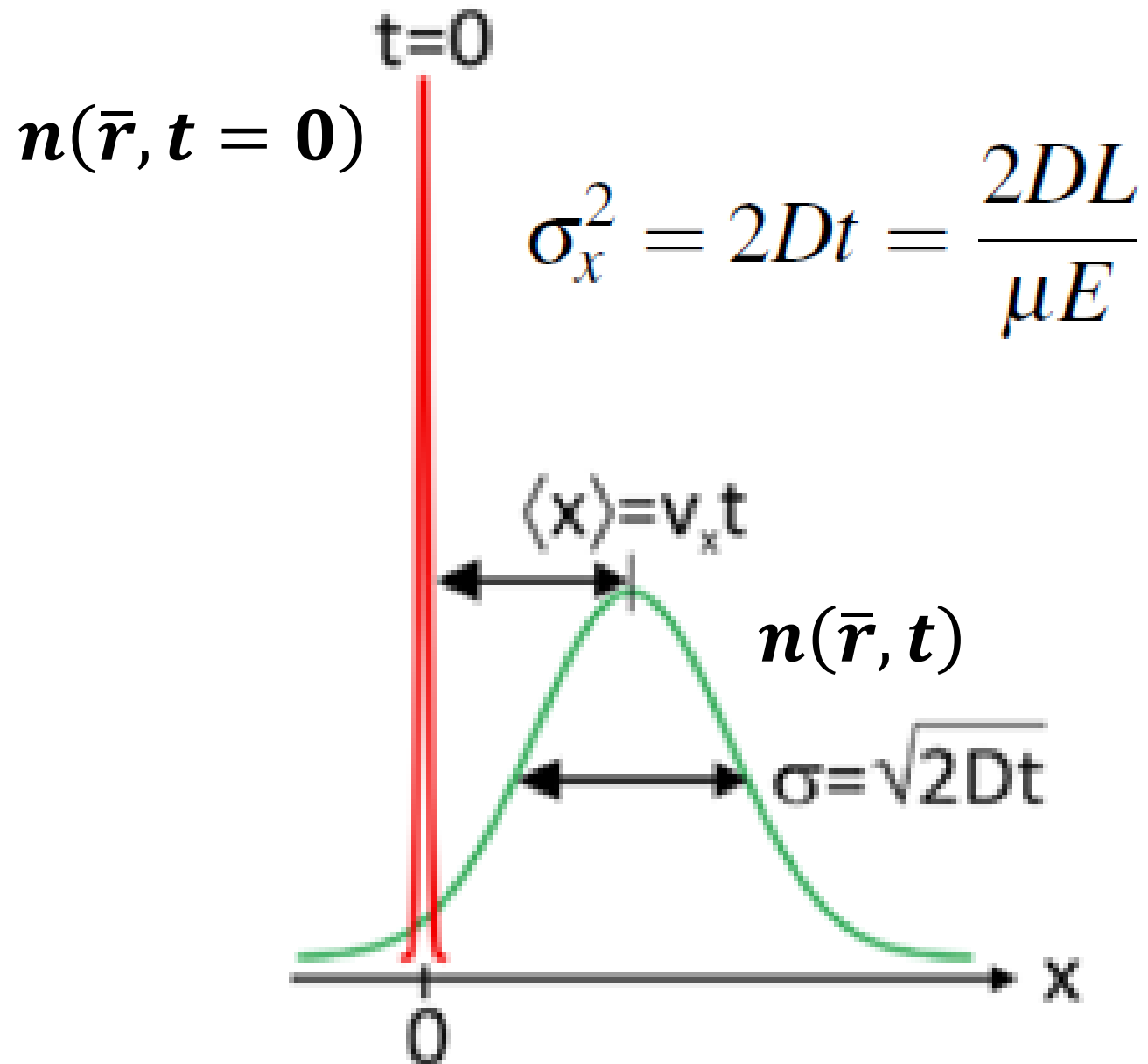


Calibration of channels

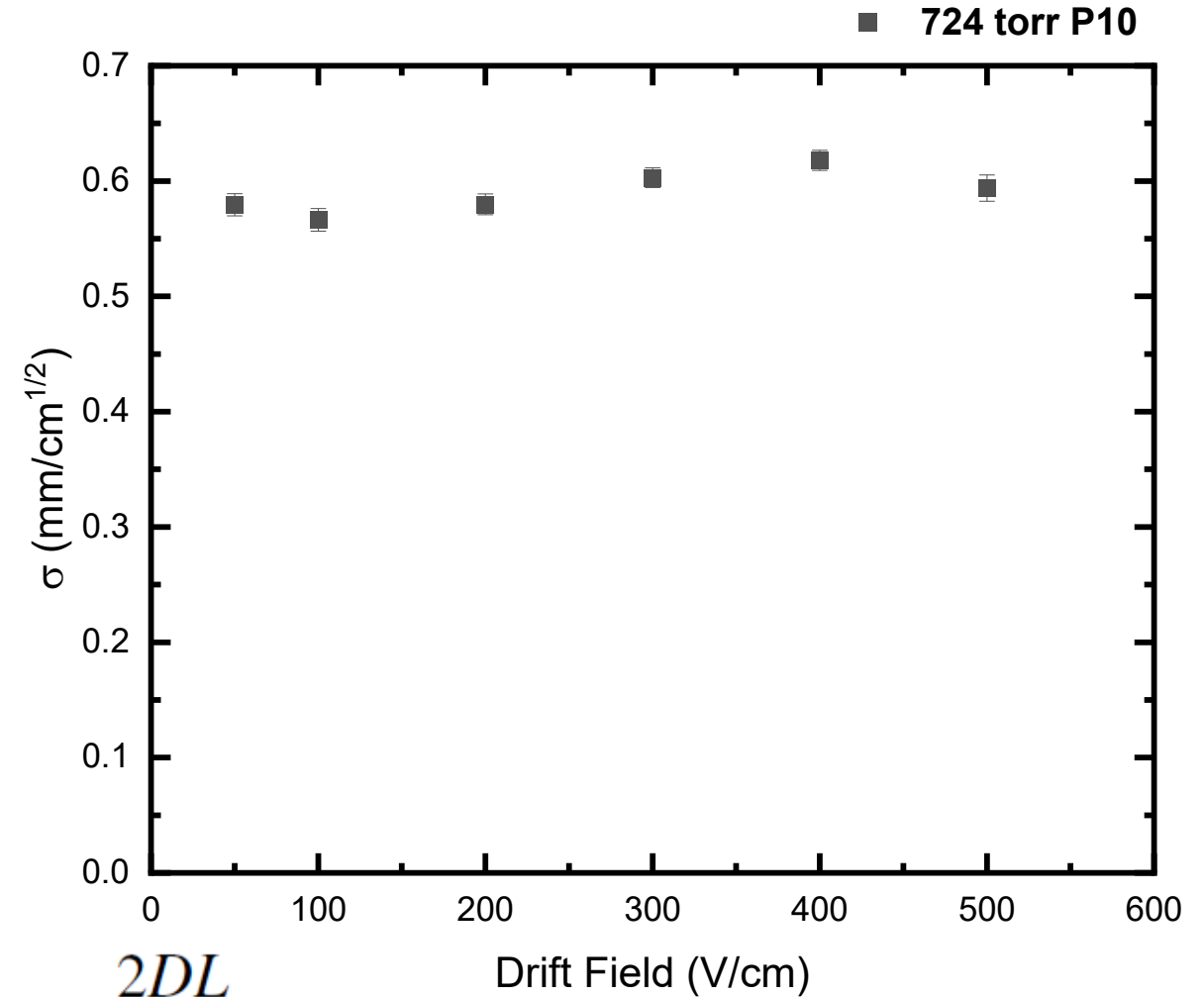
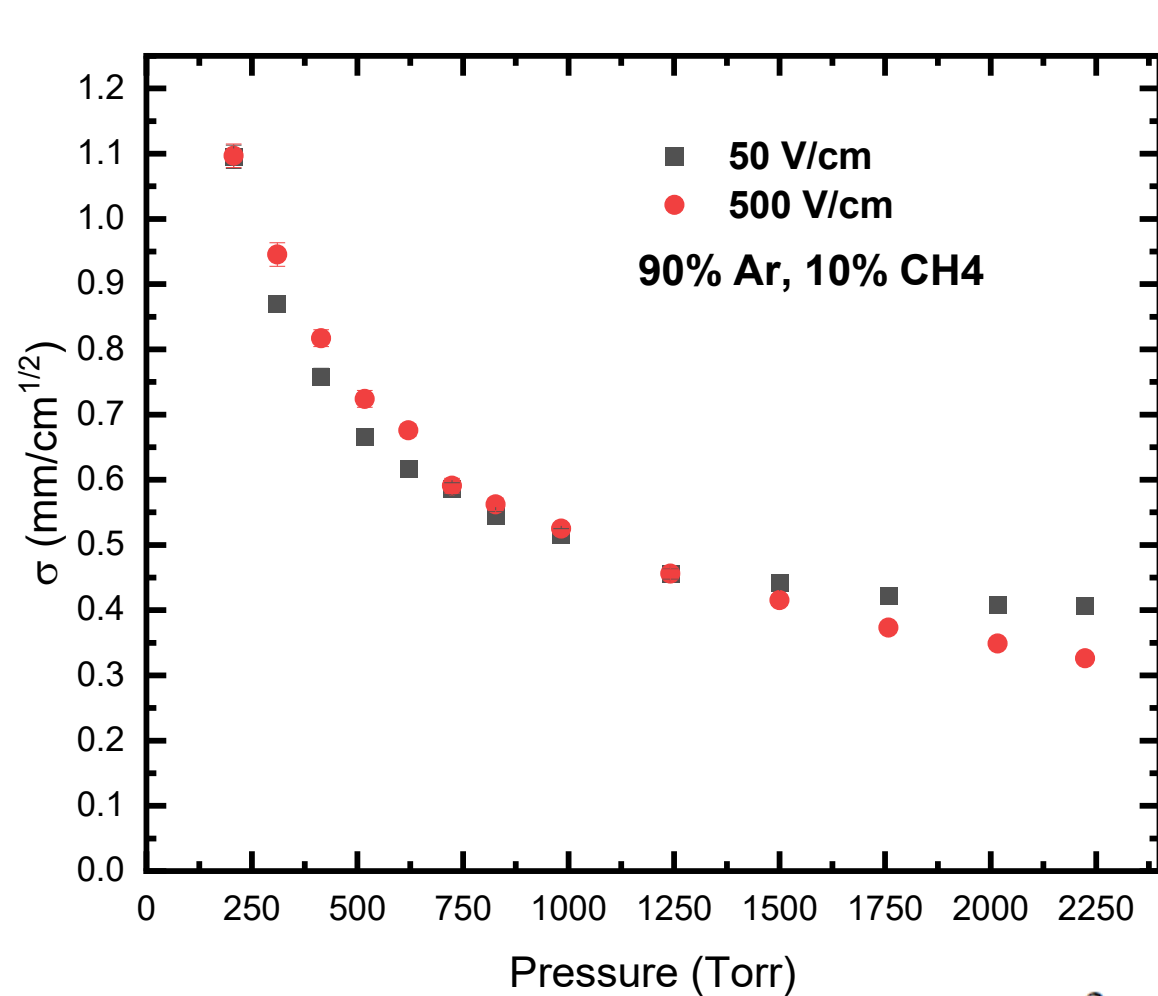
Ch2



Diffusion of Electrons in gasses

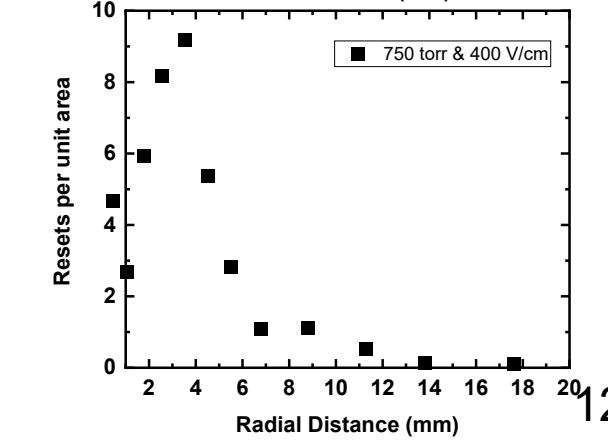
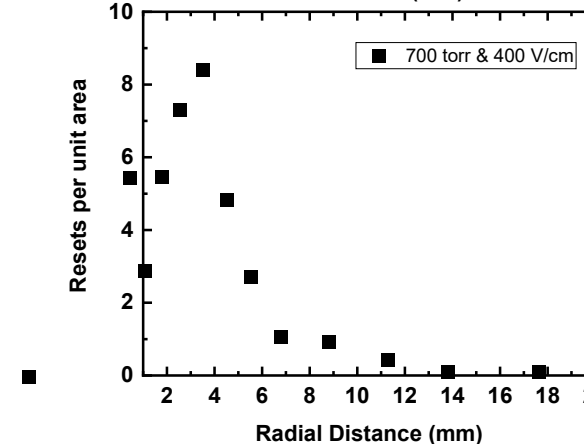
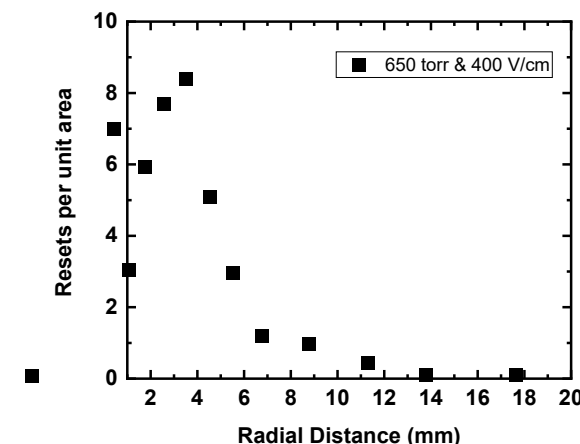
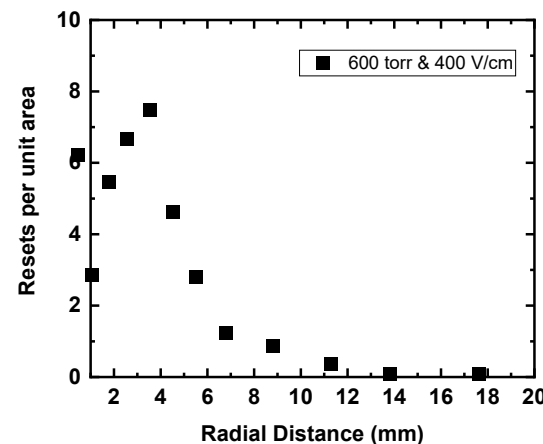
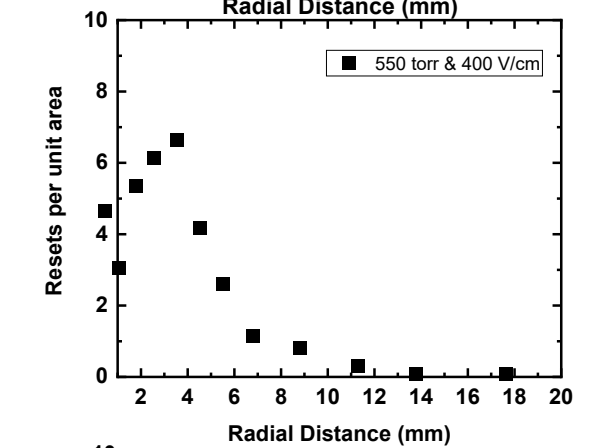
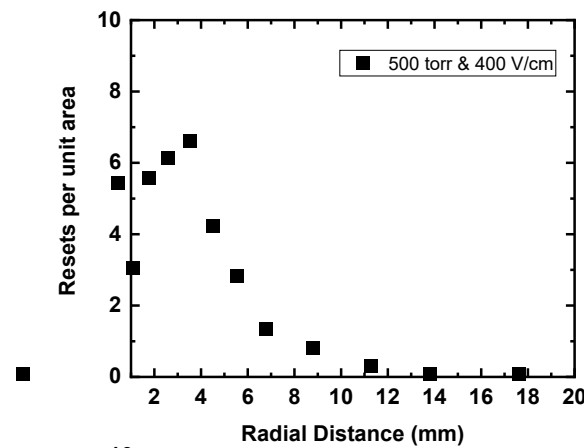
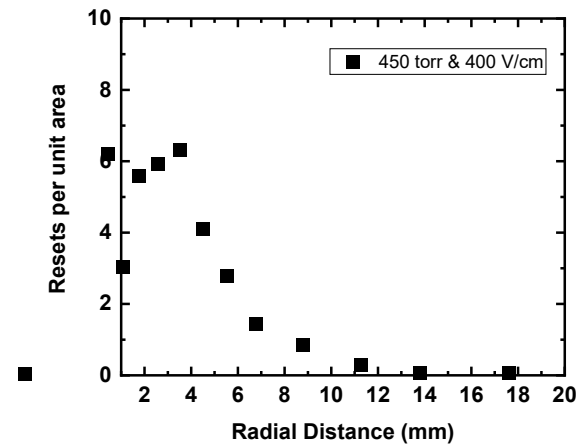
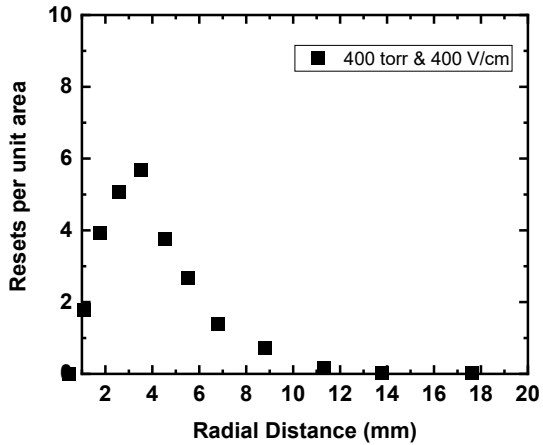
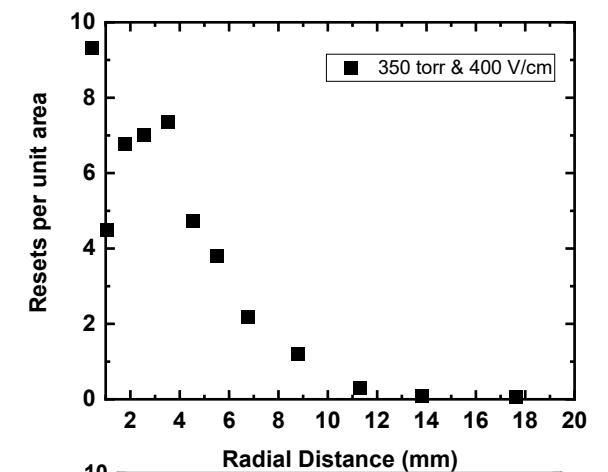
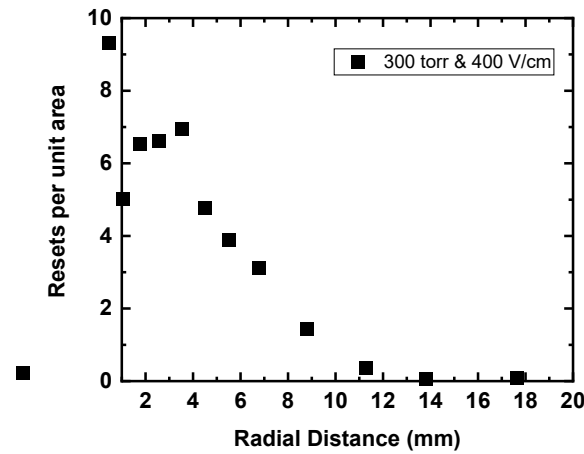
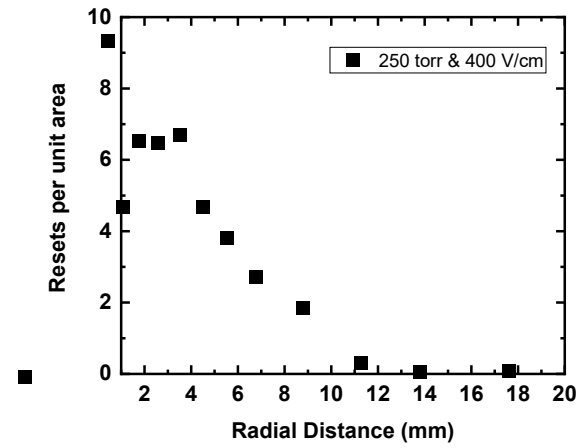
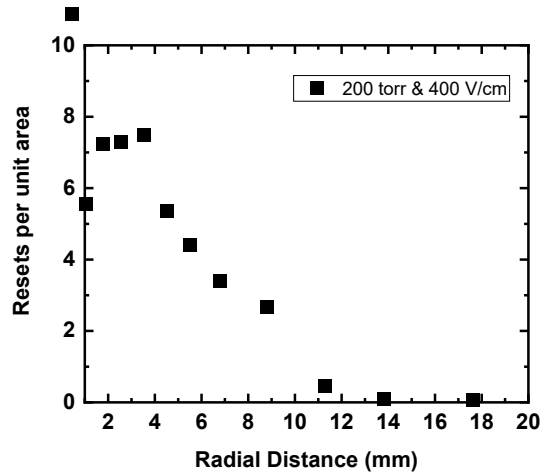


Monte Carlo Simulation of Electron Transport in Noble gas mixtures

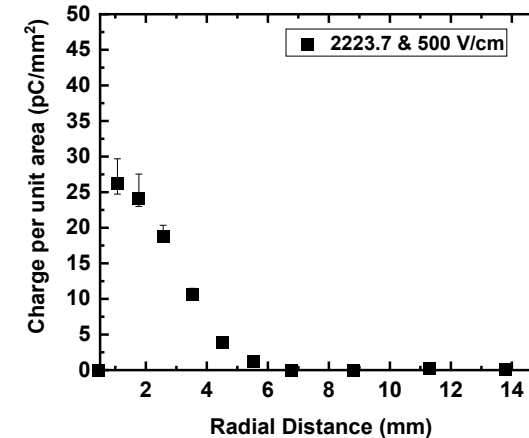
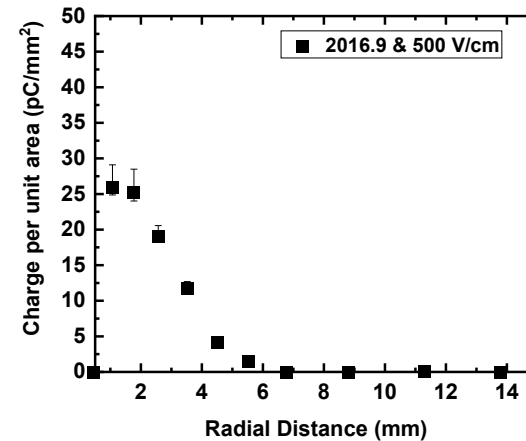
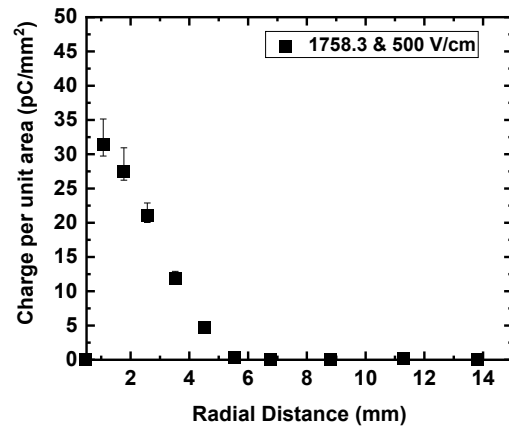
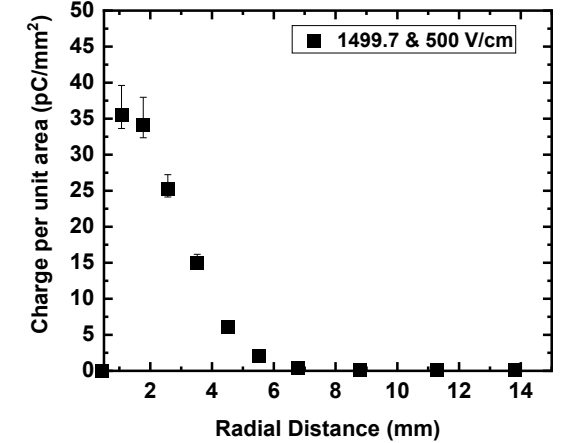
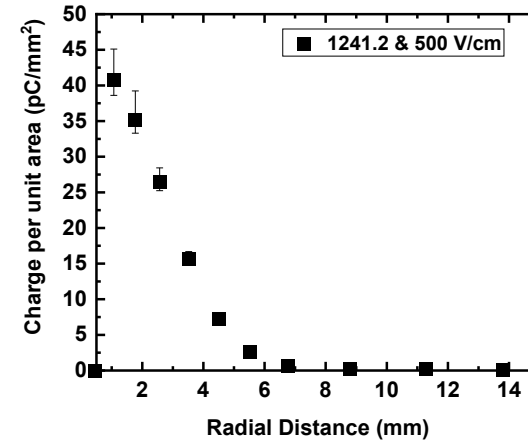
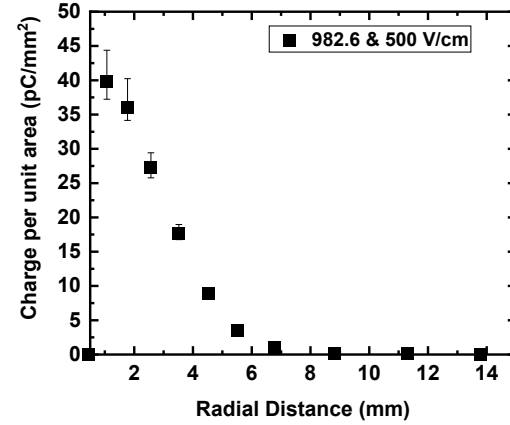
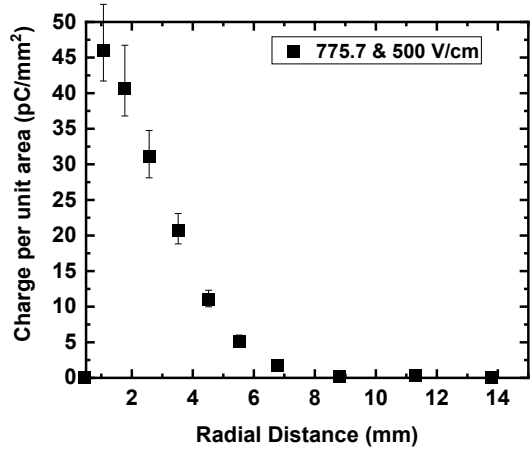
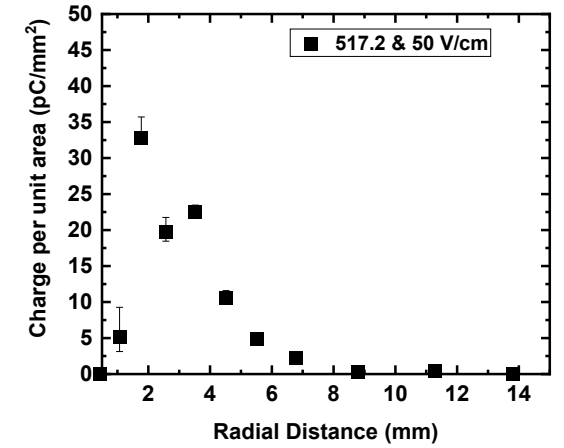
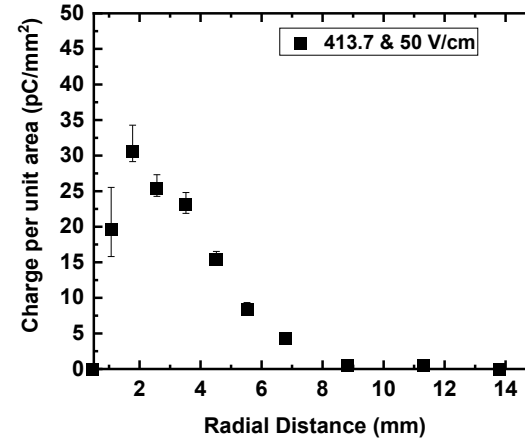
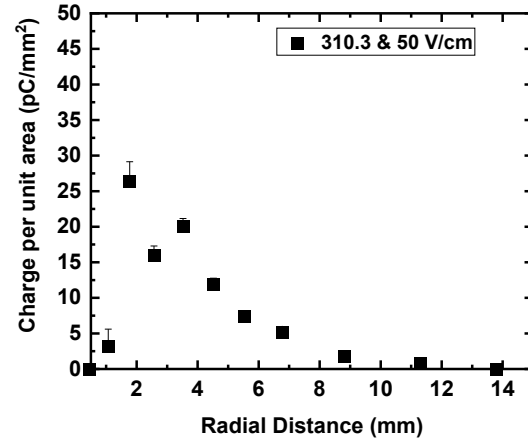
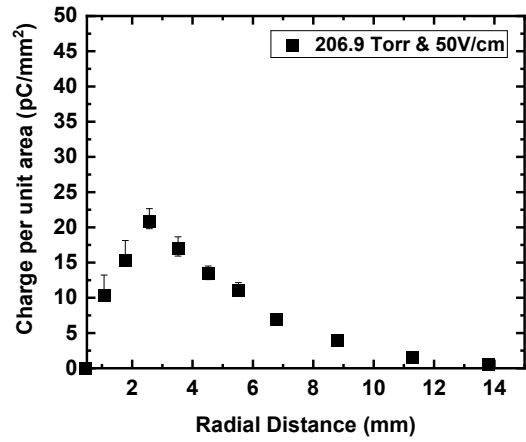


$$\sigma_x^2 = 2Dt = \frac{2DL}{\mu E}$$

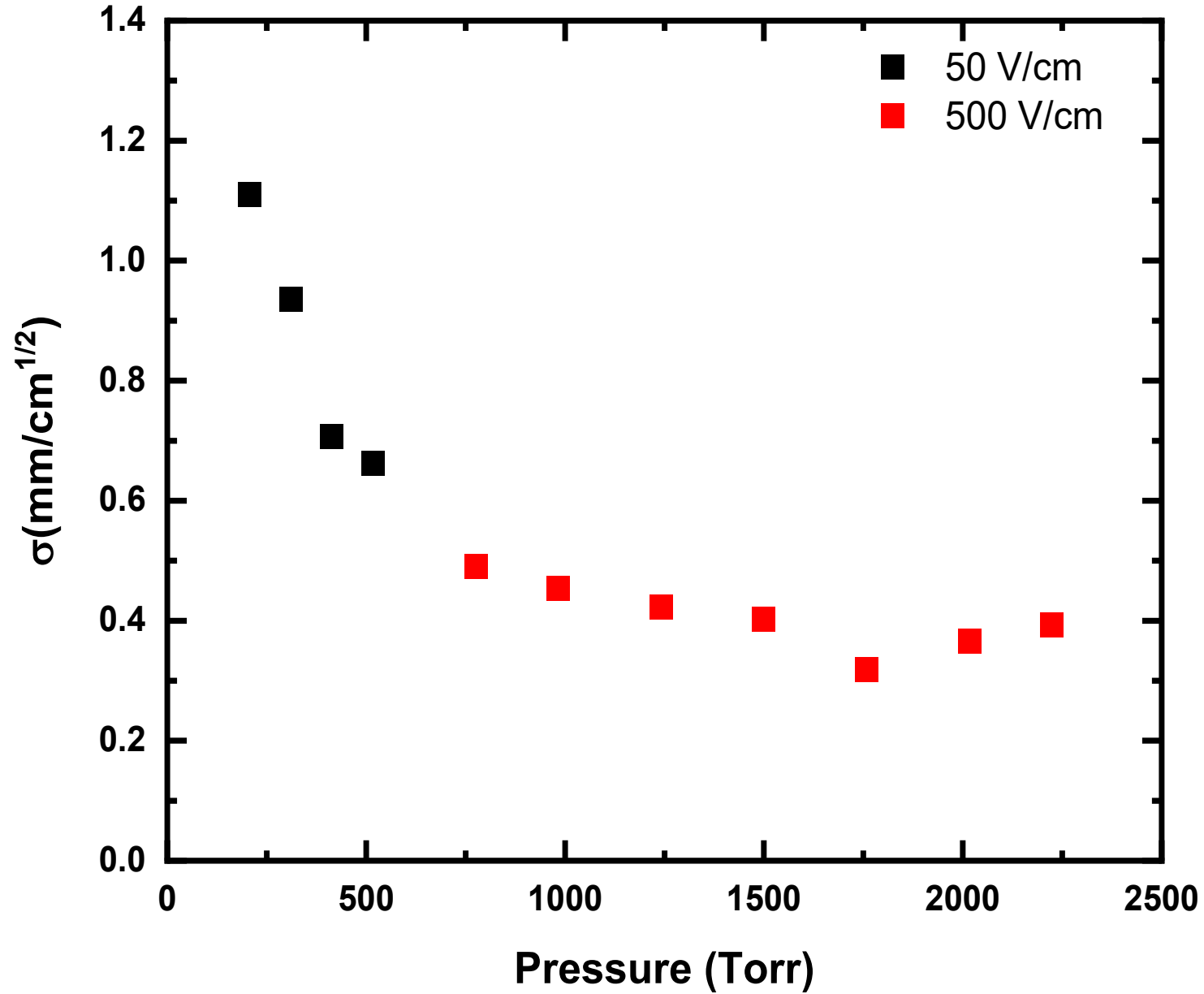
5 cm Drift: Diffusion as a function of Pressure



10 cm Drift: Diffusion as a function of Pressure



Transverse Diffusion of electrons in P10



Conclusions & Future Work

- Measured the transverse diffusion electrons in P10 as a function of pressure and electric field using the novel charge read-out concept Q-Pix.
- Preliminary results are consistent with the expected variation of transverse diffusion as a function of pressure or electric field giving confidence in the ability of Q-Pix to reconstruct ionization events.
- A more detailed analysis of the diffusion profiles considering the initial charge distribution ($n(\vec{r}, t = 0)$) is underway to deduce σ_T , which can then be compared to simulation results quantitatively.

Acknowledgments

Research is supported by awards DE-SC0020065, DE-SC 0000253485, FNAL-LDRD-2020-027

