Electrical properties of various gas mixtures for active target detector application

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Motivation

The goal of the project is to study properties of various gas mixtures that will be used as targets in a new active target detector, TexAT (Texas Active Target). Specifically, electron drift velocities and gas gain coefficients are studied and compared to the values simulated by the Garfield package. The main motivation for the project is to provide accurate information on electrical properties for TexAT target gasses, which are essential input parameters for track reconstruction in TexAT.

TexAT

Texas Active Target (TexAT) is an active target detector system under development at the Cyclotron Institute. TexAT utilizes a time projection chamber (TPC) surrounded on five sides by Si/CsI detectors. TexAT is a 4π detector that allows for high resolution and high efficiency nuclear reaction studies with radioactive beams. With a vast collection of information, TexAT will produce a detailed, accurate 3-D reconstruction of reactions between target gases and incoming ions. Once completed, TexAT will be housed at the Cyclotron Institute and will be used for experiments concerning structure of exotic nuclei and nuclear astrophysics with radioactive beams.

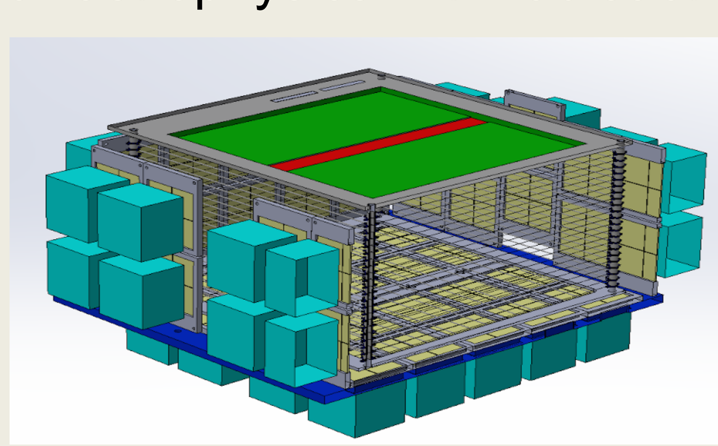


Figure 1. General view of TexAT detector.

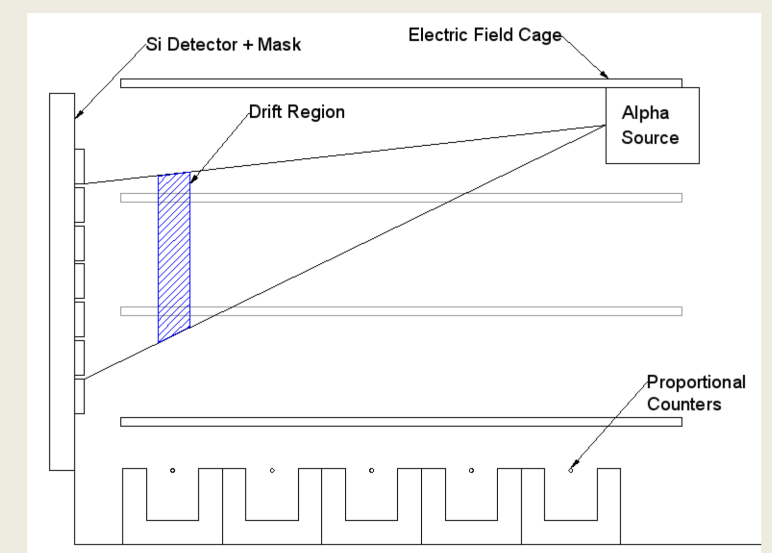
- Si detectors-yellow
- CsI detectors-cyan
- Micromegas plate-green/red

Approach

- Use TPC consisting of proportional counters and an electric field cage, expose the gases to a 5.4MeV alpha-emitter
- Electrons from alpha-induced ionization drift toward TPC wires and undergo Townsend avalanche near the wires
- The readout and timing start is triggered by alpha-particle hitting the Si detector.
- Timing between Si and wire signals determine drift time, and thus drift velocity.
- Testing He+4%CO_2, He+10%CO_2, Methane, and Isobutane

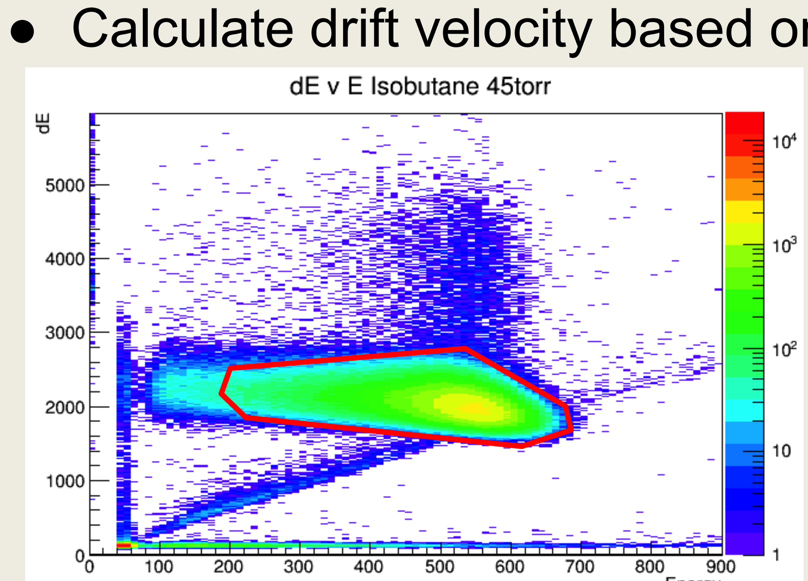
Experimental Setup

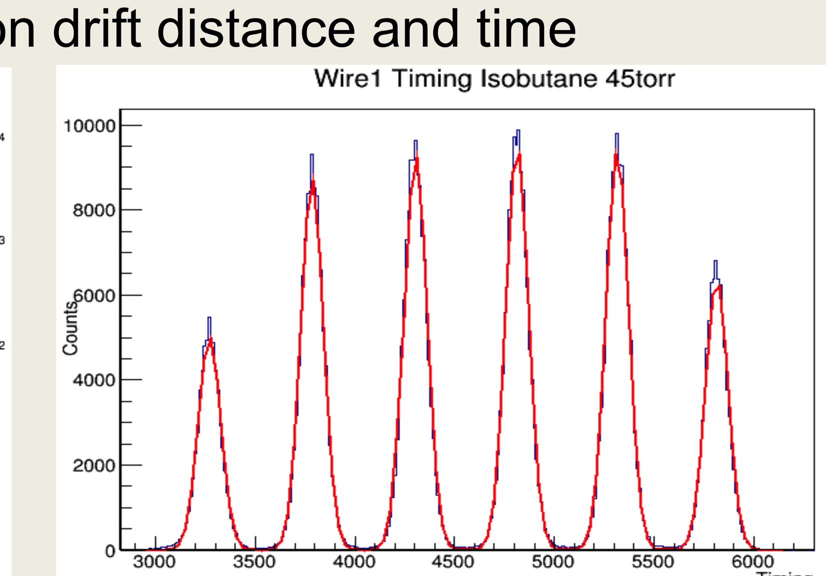
- TPC contains 5 proportional counters along bottom
- Mask with 6 horizontal slits on Si detector is used to define the alpha-particle tracks
- Tested geometry with α source inside and outside of E-field cage



Data Interpretation

- Apply cut to dE v E graph to eliminate background noise
- Fit gaussian to wire timing peaks, use differences in peaks to determine drift time
- Use geometry of setup to determine distance of drift region
- Calculate drift velocity based on drift distance and time





Simulations

- Garfield(++) simulator used to drift e^-
- Sims ran with same parameters as experimental runs (gas, pressure, E-field)
- Compared to experimental data to check reliability

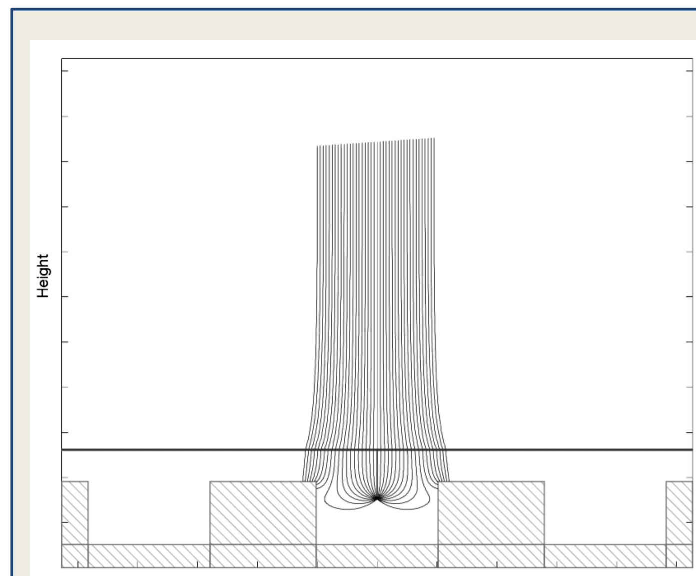


Figure 2. Drifting electron paths towards prop. counters.

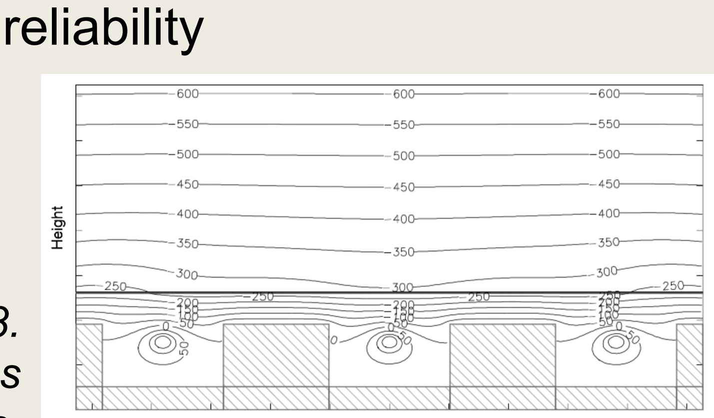
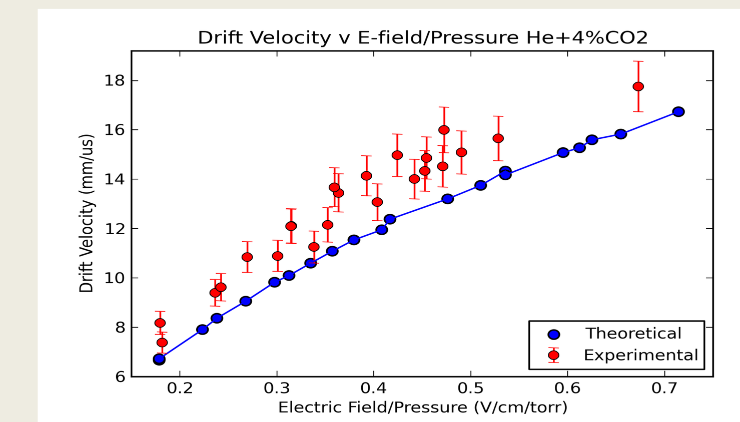
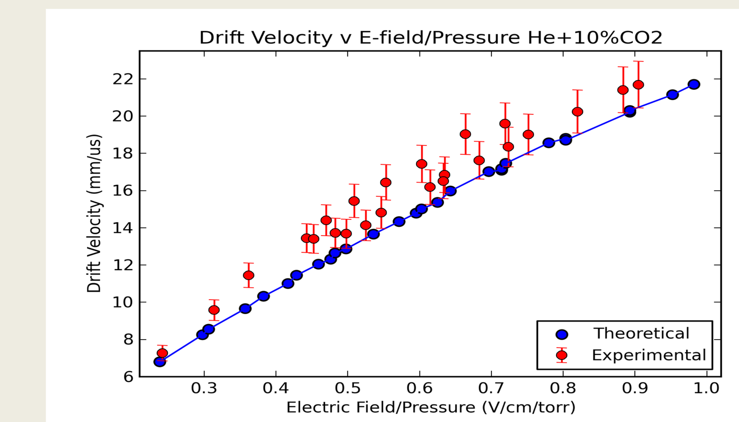
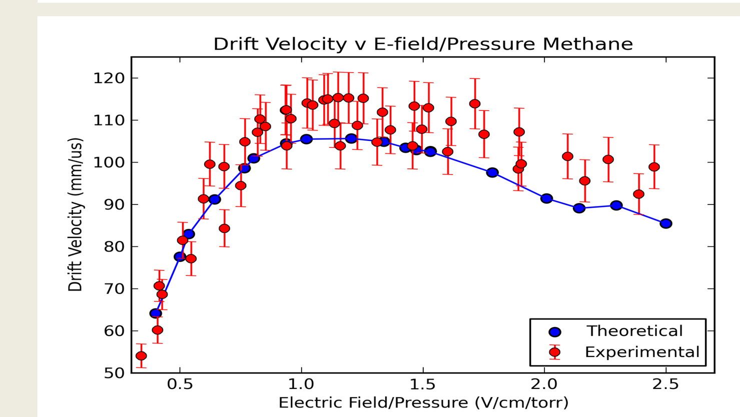


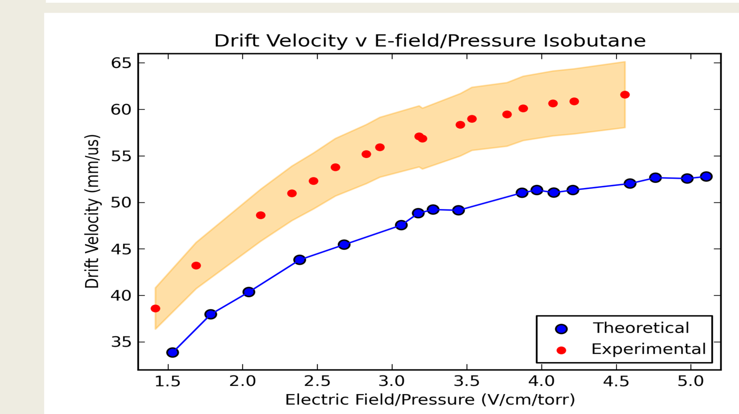
Figure 3. Equipotential lines near prop. counters.

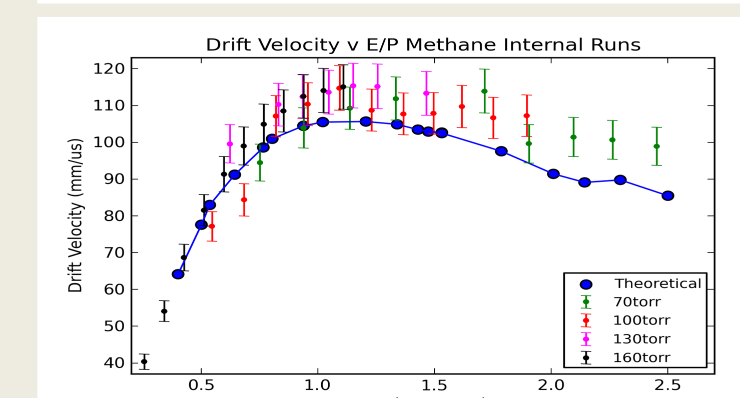
Results

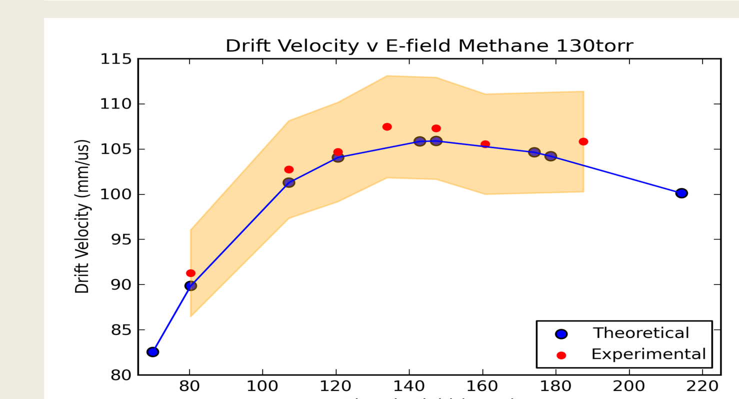












Gas	Exp/Sims
He+4%CO_2	1.15
He+10%CO_2	1.10
Methane	1.03
Isobutane	1.18

- 5% systematic error shown in error bars
- Fit simulation data, calculate % discrepancy between experimental and simulated data
- Both helium mixtures had nearly identical drift velocities
- Methane was fastest gas, peaking around 110 mm/μs
- Discrepancies increase with decreased pressure

Conclusions

Based on these results, methane is the gas that matches closest with the simulations, as it only varies from the simulations by 3% on average. The helium mixtures were comparable, with both exhibiting similar drift velocities and deviations from the simulations.

The discrepancy in the isobutane tests likely arises from a distortion in the electric field caused by the alpha source, as our simulations assumed a constant electric field and the alpha source resembled a small metal disc that was acquiring charge as testing progressed. Further testing is needed to more accurately confirm the deviations for isobutane.

Acknowledgements

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