Electrical properties of various gas mixtures for active target detector application

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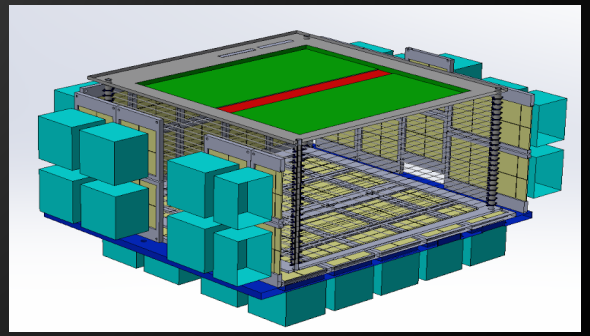
Texas Active Target (TexAT)

- New active target detector under development by Rogachev Group
- Time projection chamber (TPC) setup
- Gases will be used with TexAT
  - Target of beam
  - Active medium for tracking
- Will be used for detailed, precise 3-D track reconstructions from reactions of gases and rare isotope beams



Motivation

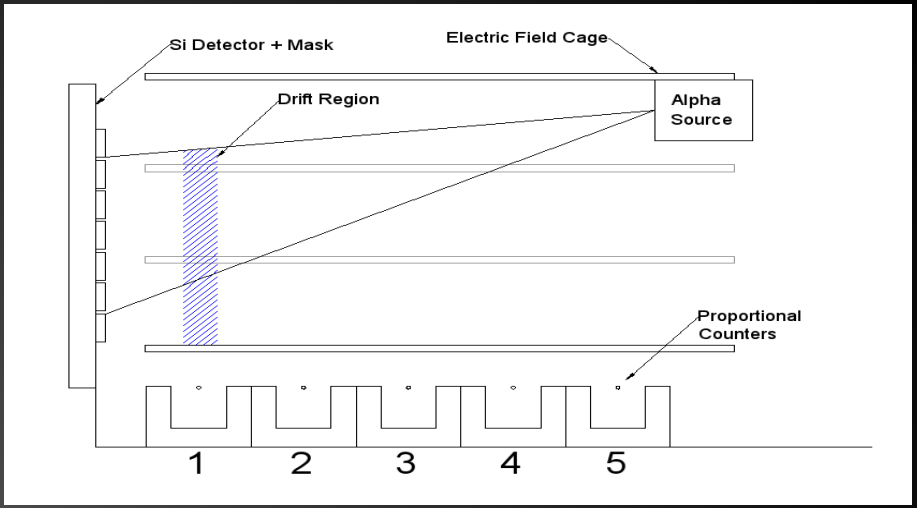
- TexAT will rely on simulations for gas properties:
  - Drift Velocity
  - Gas Gain
- Verification of simulators needed to provide uncertainties in track reconstruction
- Quantifying accuracy of Garfield++ drift simulation package

Approach

- Testing four potential target gases for TexAT
  - He+4%CO_2
  - He+10%CO_2
  - Methane
  - Isobutane
- TPC with applied electric field and proportional counters
- 5.4MeV alpha particles ionize gas, electrons drift and undergo Townsend avalanche near wires
- Alphas hit Si detector causing timing trigger on wires
- Use timing values to determine drift velocity

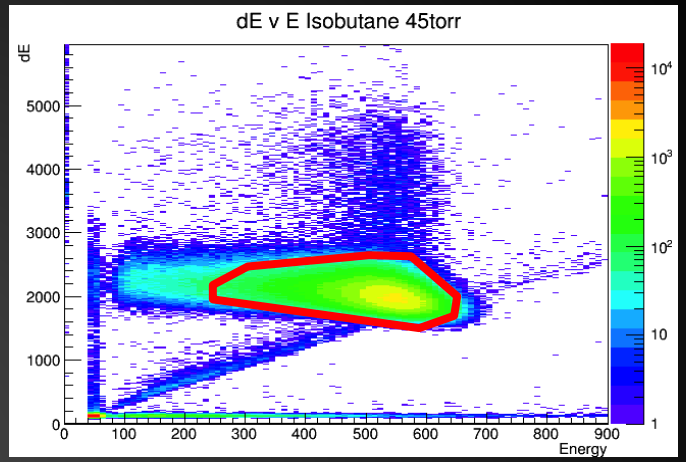
Setup

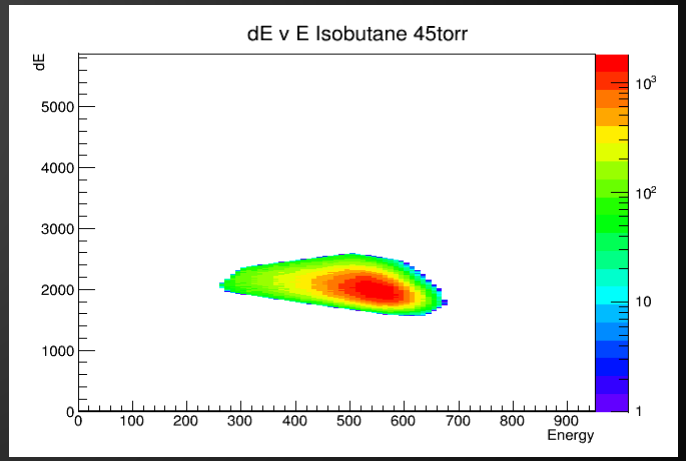
- Voltage applied to field cage surrounding TPC
- Mesh 3mm above wires
  - e^- undergo avalanche in region
- Si detector with 6-slit mask across from alpha source
  - Defines alpha tracks



Data Interpretation

- Apply cut around alpha energy deposits
- Ensures only timing signals from alphas, not from outside noise

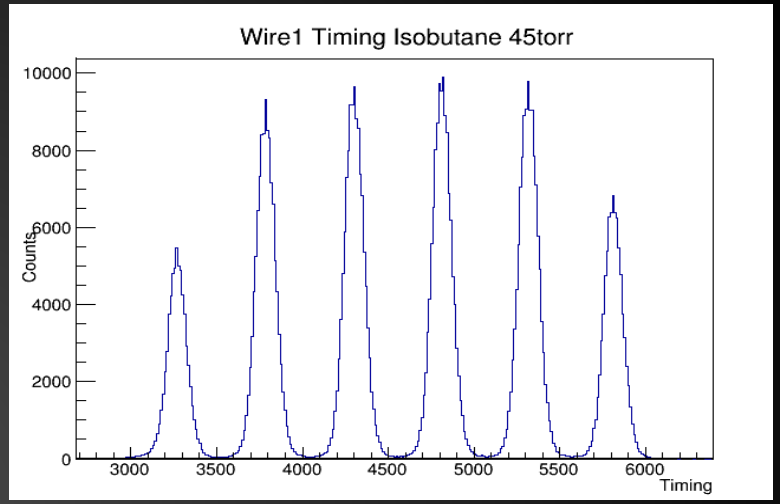


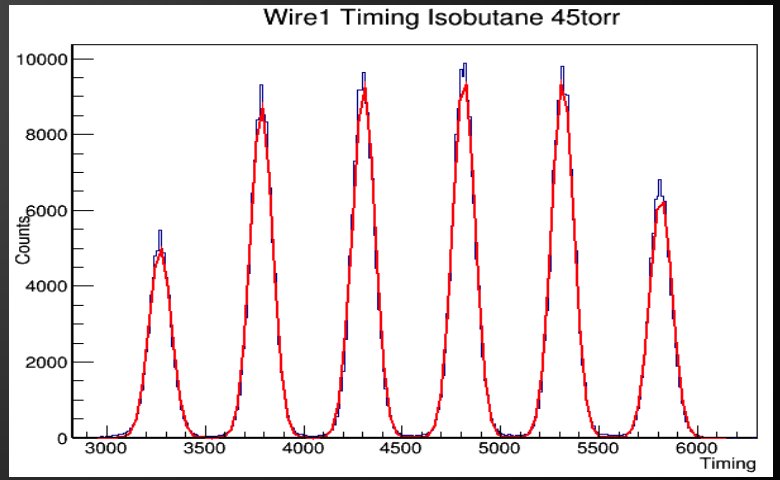


1 Channel = .6mV

Data Interpretation

- Fit gaussians to wire timing, use means to determine drift time
- Drift velocity can be calculated from drift time
- Averaged drift velocity of all 5 wires

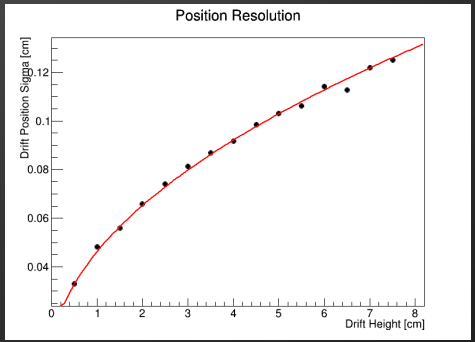


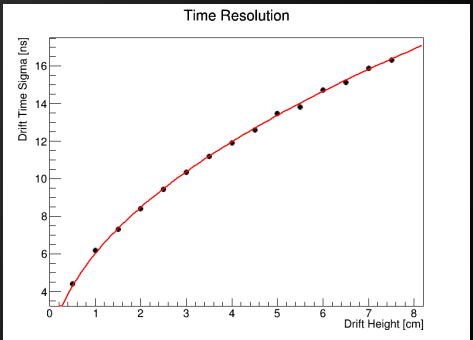


1 Channel = .25ns

Simulations

- Using Garfield++[1] drift simulation package
- Drifting e^- in same gas, pressure, and E-field
- Drifting every .5cm up to 10cm above floor
- Outputs drift velocity, timing and position resolutions

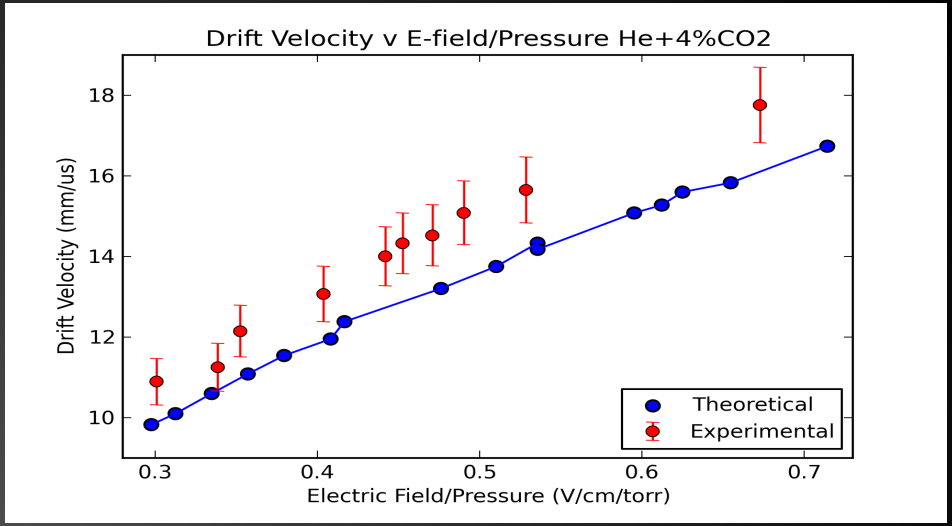


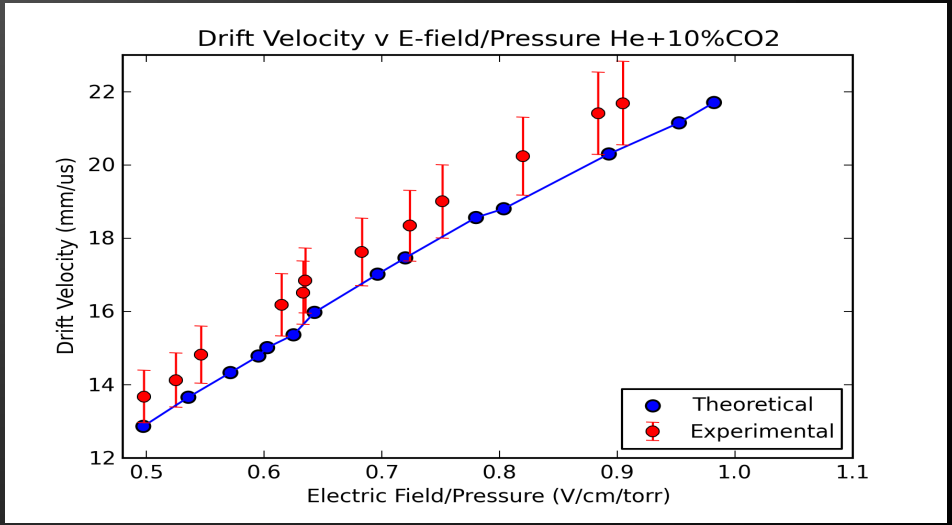


[1] <http://garfieldpp.web.cern.ch/garfieldpp/>

Results: Helium+CO_2

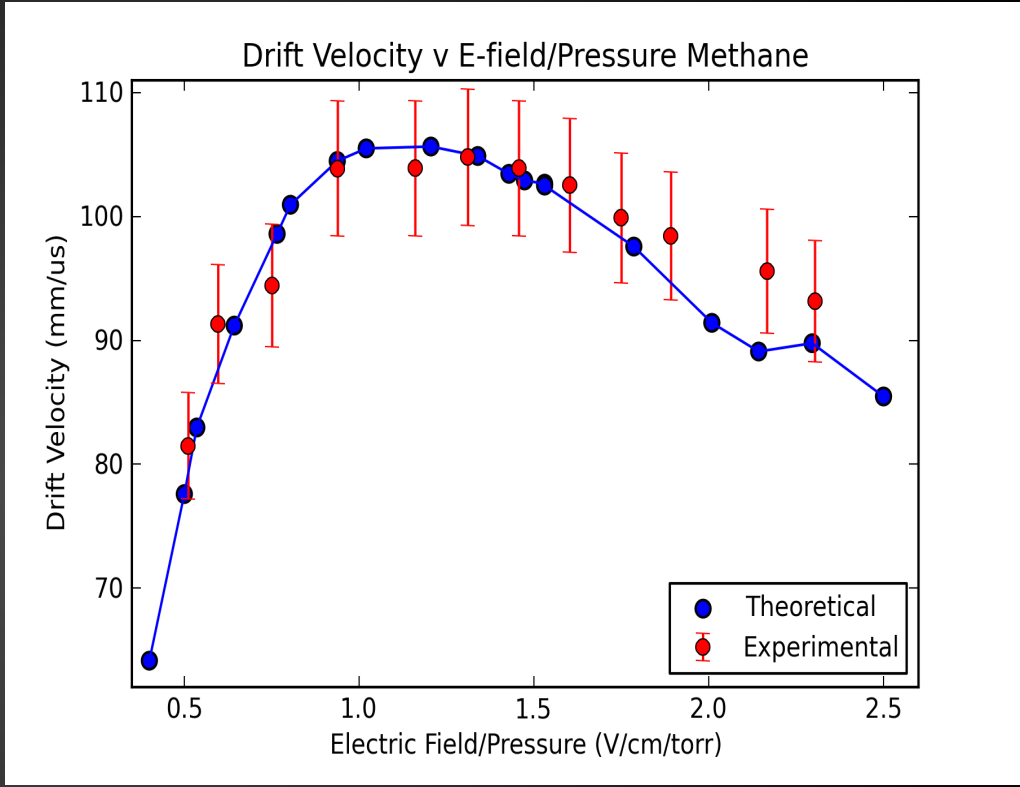
- 5% systematic uncertainty shown in error bars
  - mainly from uncertainty in E-Field and pressure/temperature
- Exp/Sims:
  - He+4%CO_2: 1.12
  - He+10%Co_2: 1.07
- Sims slightly underestimate drift velocity





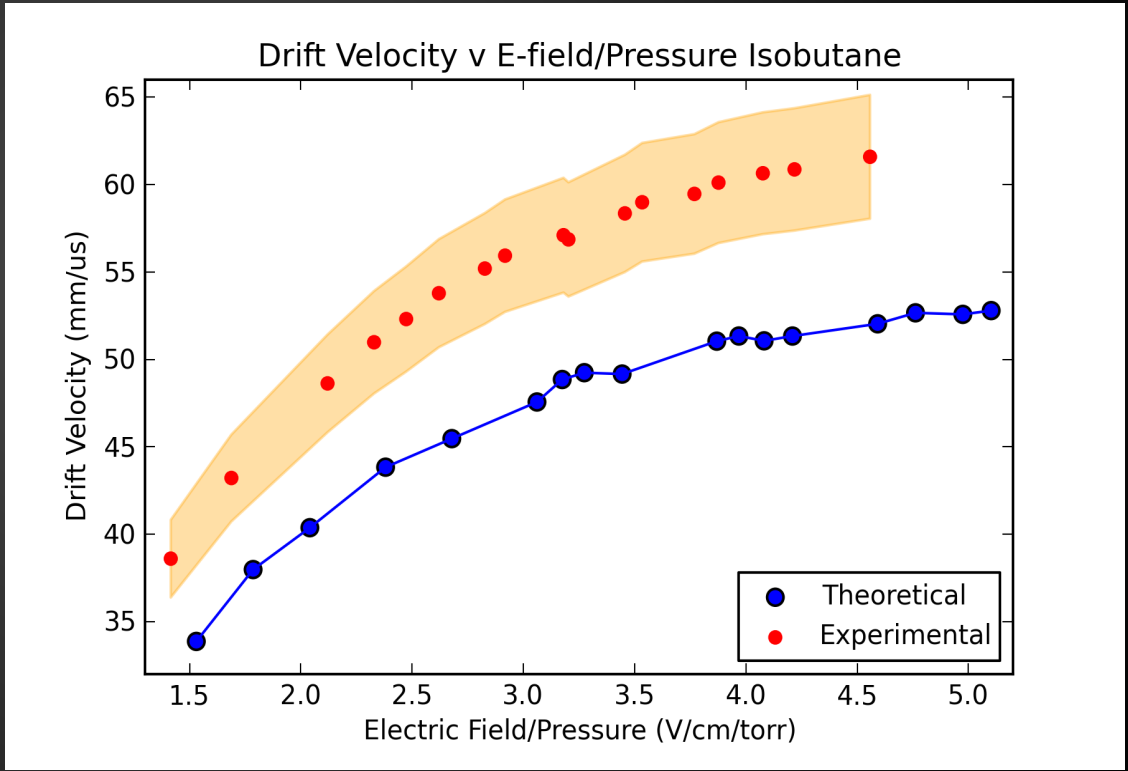
Results: Methane

- Best fit of all gases
- Exp/Sims: 1.02
- Deviations start to occur at higher E/P values



Results: Isobutane

- Systematic deviation apparent in Isobutane
- Experimental data is 18% higher on average



Conclusion

- Garfield underestimates drift velocities of $He+CO_2$ mixtures by 7-12%
- Methane had only 2% deviation between experimental and simulation values
- Isobutane exhibited a systematic deviation from simulation data
  - Requires further testing with higher pressures and different geometry

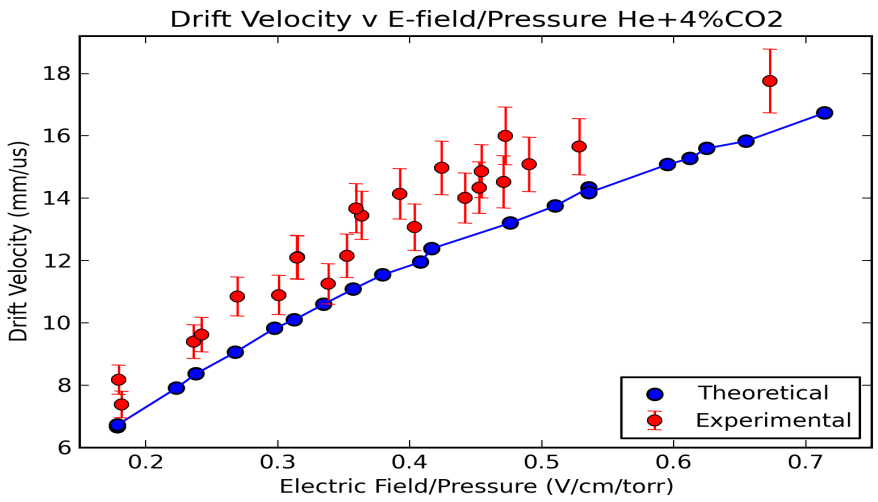
Moving Forward

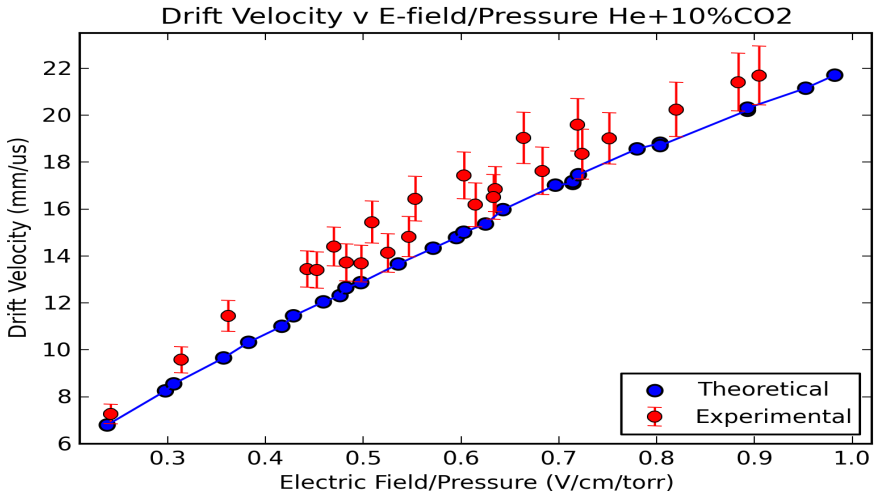
- Further testing of Isobutane gas
- Energy gains
  - Analyze data and run simulations
- Track reconstruction of alphas and electrons

- Special Thanks:
  - Dr. Rogachev
  - Dr. Koshchiy
  - Dr. Uberseder
  - Rogachev Group

Results

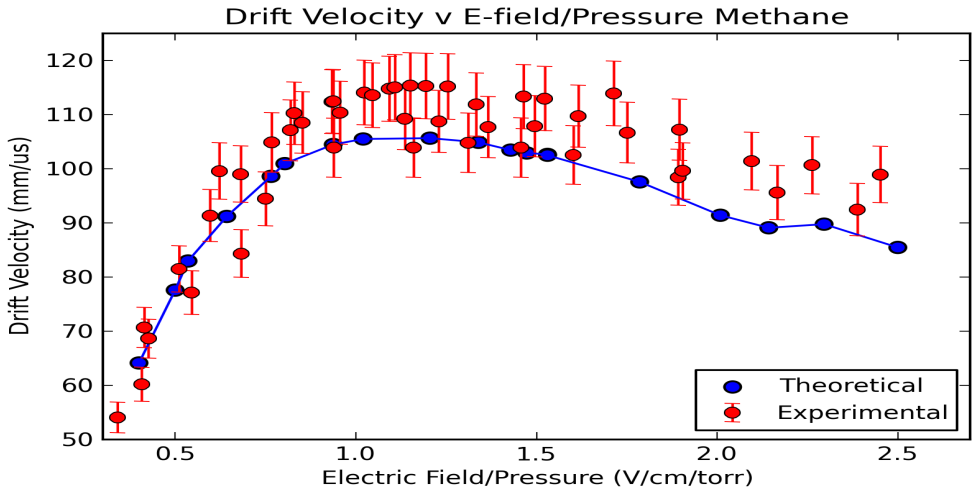
- Both He/CO_2 mixtures exhibited similar drift velocities and deviations from simulations
- 5% systematic deviation in error bars
- Exp/Sims:
  - He4%CO_2: 1.15
  - He10%CO_2: 1.10

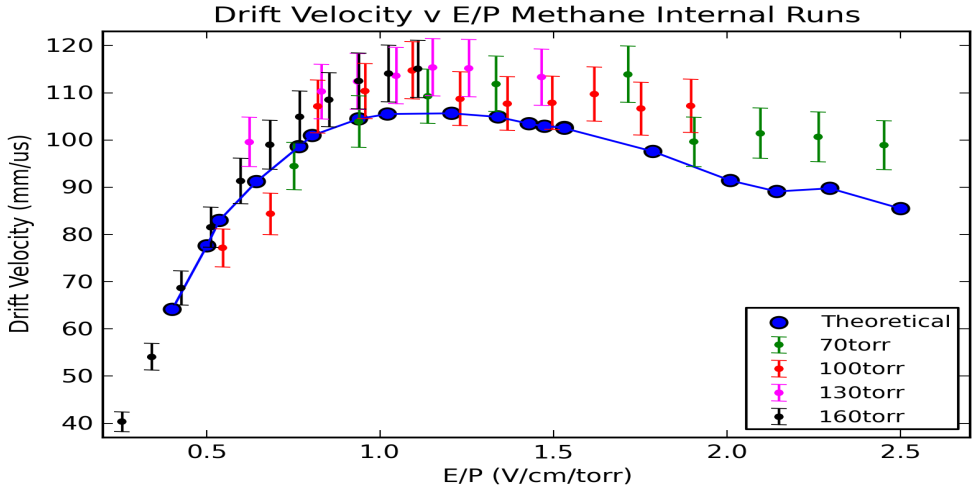




Results

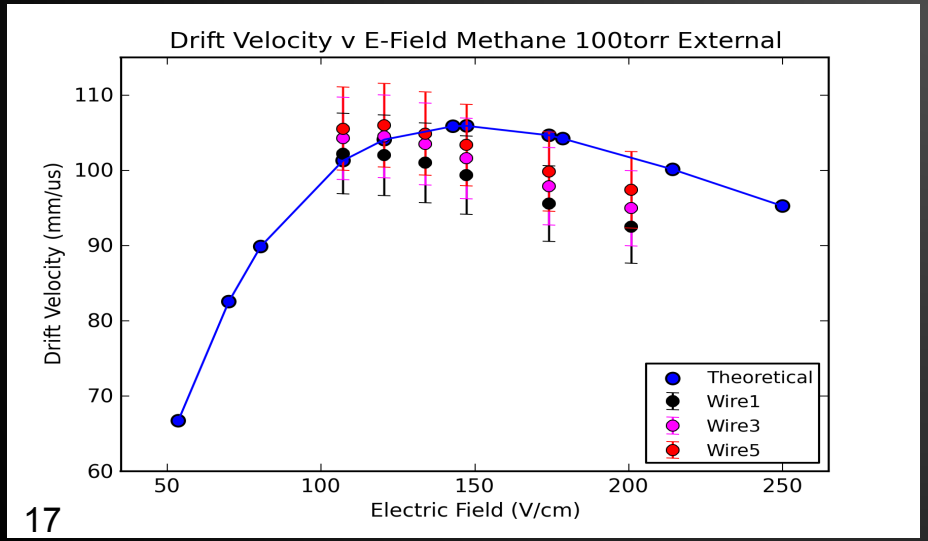
- Methane matched best of all gases
- Exp/Sims: 1.03
- Some deviations at lower pressure

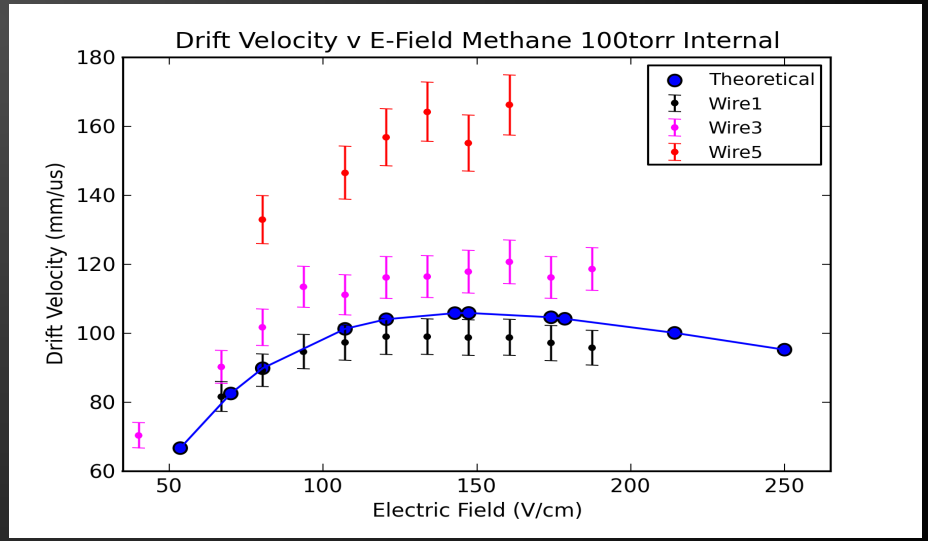




Evidence for Field Distortion

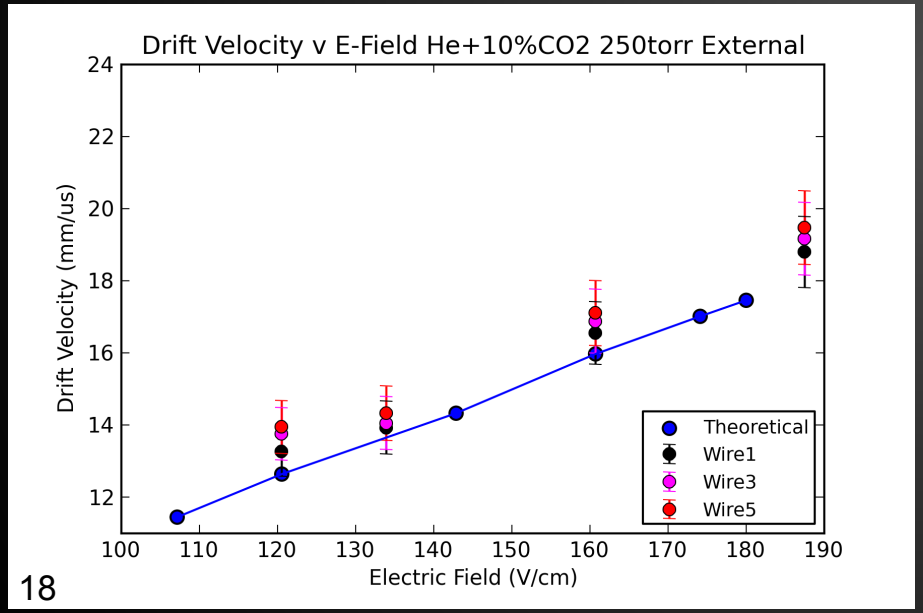
- Wires are consistent with external alpha source
- Deviations increase closer to source

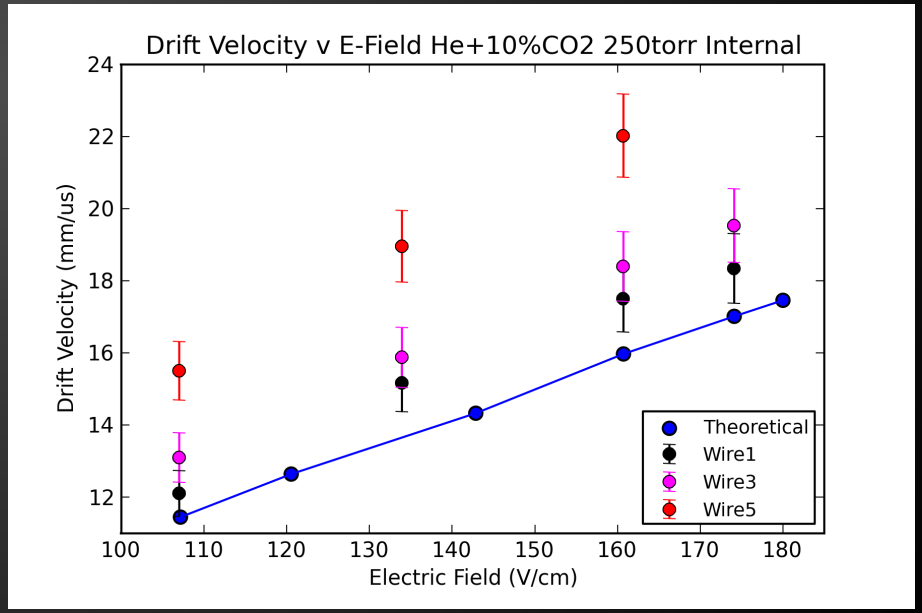


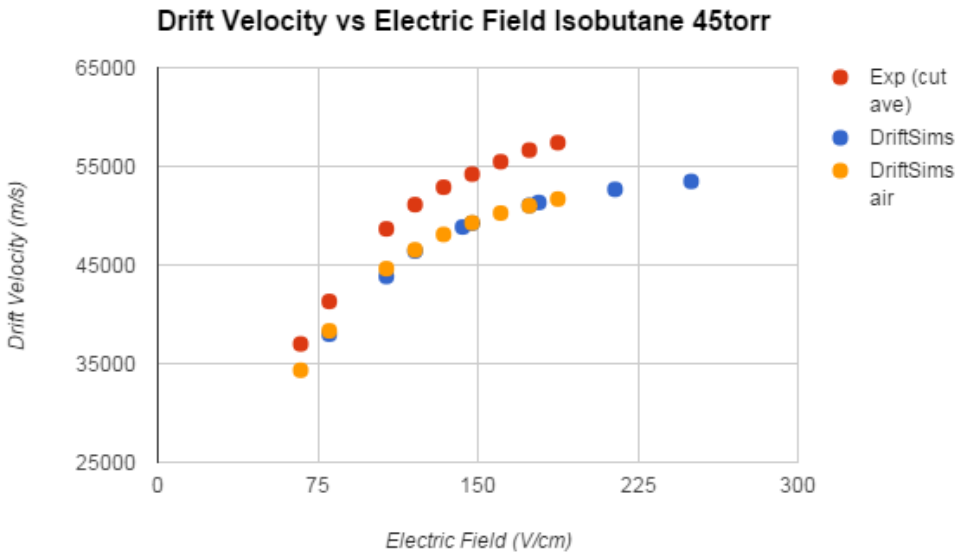


Evidence for Field Distortion

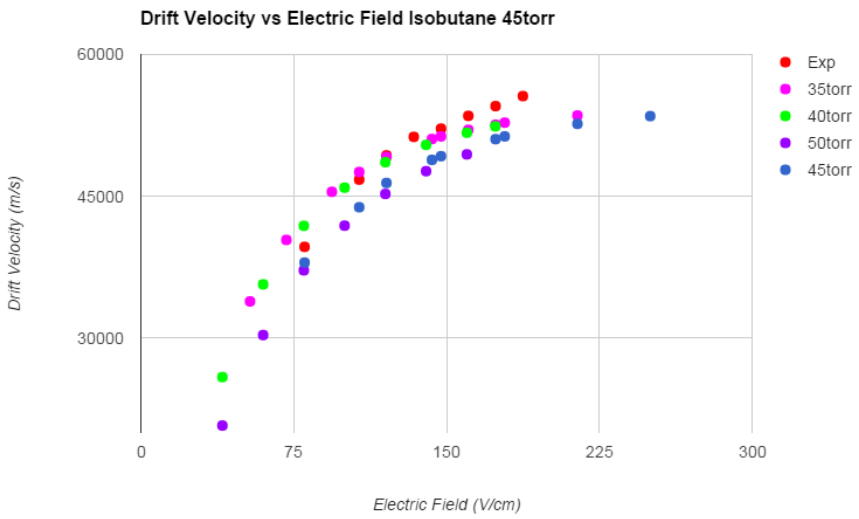
- Individual wires are compact
- Wires spread when alpha source is moved inside







- With 1.5% air in mixture



- Surrounding pressures