SUMMARY
Radial ion drift velocity, electron temperature, plasma potential, and density profiles in front of a grounded boundary plate were obtained in a helicon plasma for \( \rho / a \) ranging from 0.34 to 1.60, to directly investigate the effects of ion-neutral collisions on cross field transport. Measurements indicate that such simple scalings do not rigorously predict the behavior of cross-field drift profiles in the presence of simple complications such as multi-dimensional flows. Results are compared to basic fluid models in order to gain further insight on possible complications affecting cross-field transport.

PLASMA POTENTIAL PROFILES VARY LITTLE WITH COLLISIONALITY
We vary the ion-neutral collisionality by changing the ratio of the ion gyro radius, \( r_i \), to the ion-neutral collision length, \( d \), from \( \rho / a = 0.34 \) to 1.60.

\( \rho / a \) compares the path length of an ion in a magnetic field to the characteristic decay length, due to ion-neutral collisions, of a flux of ions traveling through a background of neutral scattering particles.

\( \rho / a < 1 \) indicates a collisionless plasma.

\( \rho / a > 1 \) indicates a highly collisional plasma.

LASER INDUCED FLUORESCENCE MEASUREMENTS INDICATE RADIAL FLOW
LIF scheme for argon ions. Parallel injection requires selection of single Zeeman component for flow measurements.

Representative VDFs normalized to their maxima, at \( r = 0 \) (black triangles), and at \( r > 2.8 \text{ cm} \) (blue circles), with Gaussian fits overlaid. Data shown are for \( \rho / a = 1.00 \). Vertical lines show offset of Gaussian centroid from zero velocity indicating a drifting ion population.

FLows and Density in Boundary Sheath
With a Langmuir probe, radial profiles of density were recorded normal to the surface of the grounded plate for \( \rho / a = 0.34 - 1.60 \). The profiles of density are normalized by the peak density in the range of the scan, as indicated in the legend of each plot. For every value of \( \rho / a \), the ion density decreases with increasing distance from the center of the plasma and the ion temperature increases. The normalized density gradients, from just outside the plasma core to the edge, i.e. for 15 \( r / a > 0.3 \), are \( \left( \frac{n_i}{n_i} \right)_{min} = 10^3 \text{ cm}^{-3} \).

Electrostatic Fluctuations Appear for Two \( \rho / a \) Values
Floating probe spectra for \( \rho / a = \{a) 0.34, (b) 0.44, (c) 0.65, (d) 1.00, (e) 1.37, (f) 1.60 \}. The probe was located at \( r > 2.4 \text{ cm} \) in front of the plate. Peaks at 2.5 kHz and corresponding harmonics exist whenever the HELICON magnetic fields are active and are observed regardless of the existence of plasma.

CLASSICAL DIFFUSION MODEL PREDICTS FLOWS FOR MOST \( \rho / a \) VALUES
To determine whether the measured/potential and density gradients predicted by profiles, we compare the data to a classical cross-field drift-diffusion model. Schmitz et al. have argued that a kinetic approach is necessary for ion flow near an absorbing boundary, as when the boundary is within one ion gyro radius from the center of a flow tube. Here we use a basic fluid model and compare it to our measurements.

\[ \dot{n}(r, v) = -v \nabla \phi - v \times \mathbf{B} - \nabla \mathbf{v}_n - \lambda_{cal}(v) \mathbf{v}_n \]

where \( \phi \) is the electric potential, \( \nabla \mathbf{B} \times \mathbf{v}_n \) is the ion-neutral collision frequency, \( \lambda_{cal}(v) \) is the ion-neutral elastic collision cross section, \( n_i \) is the background neutral density, and \( v_{th} \) is the ion thermal velocity. The radial velocity is determined locally by the electric field and density gradient at that position. The radial velocity model then follows algebraically

\[ \nu_{rad} = - \frac{v_{th}^2}{\mu} \left( \frac{1 + \nu_{th}^2}{\nu_{th}^2} \right) \]

is the perpendicular ion mobility

\[ D_{perp} = \frac{v_{th}^2}{\mu} \left( \frac{1 + \nu_{th}^2}{\nu_{th}^2} \right) \]

is the perpendicular ion diffusion coefficient

To check whether the measured velocity, density and potential profiles agree with this model, logarithmic and polynomial functions were fit to data for \( v_{rad} \) and \( n_i \) respectively. Good estimates of \( \nu_{rad} \) for 4p–Ar elastic collisions exist for high energy collisions, but the exact values of \( \nu_{rad} \) for low energy collisions are less well known. Thus, \( \nu_{rad} \) was used as a fitting parameter. The potential and density fits were then put into the ion flow model equation to match to the \( v_{rad} \) data for 0.01 \( r / a < 0.05 \).

KEY RESULTS
- Spatially resolved LIF measurements of radial bulk ion flow in a partially-ionized, linear, magnetized device, show enhancement of cross-field, gradient aligned ion velocity profiles in the presence of low frequency electrostatic fluctuations.
- For \( \rho / a = 0.34, 1.00, 1.37 \) and 1.60, a classical drift-diffusion model with sigma consistent with literature was sufficient to describe the flow measurements.