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A Methodology for Determining Self-Consistency of Stark Broadening Predictions in a Multi-Element HED Plasma

T.S. Lane[1], P.M. Kozlowski[1], G.P. Loisel[2], M.K. Flaugh[1], J. E. Bailey[2],
G. A. Rochau[2], T.E. Steinberger[1], M.E. Koepke[1]

[1]West Virginia University, WV, USA
[2]Sandia National Laboratories, NM, USA

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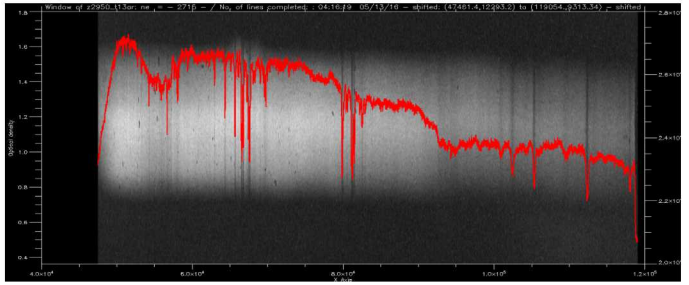
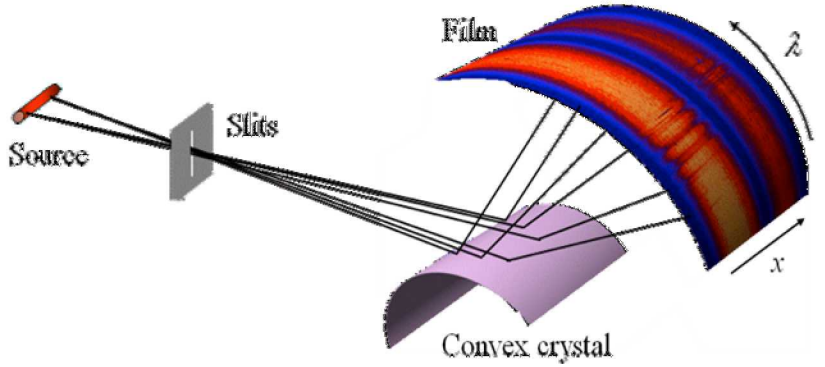
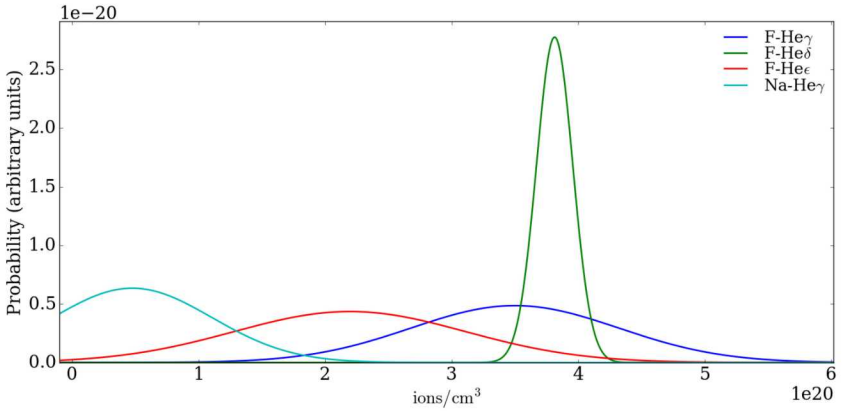
Stark broadening is used as a density diagnostic in many plasma experiments, including the Z iron opacity experiments.

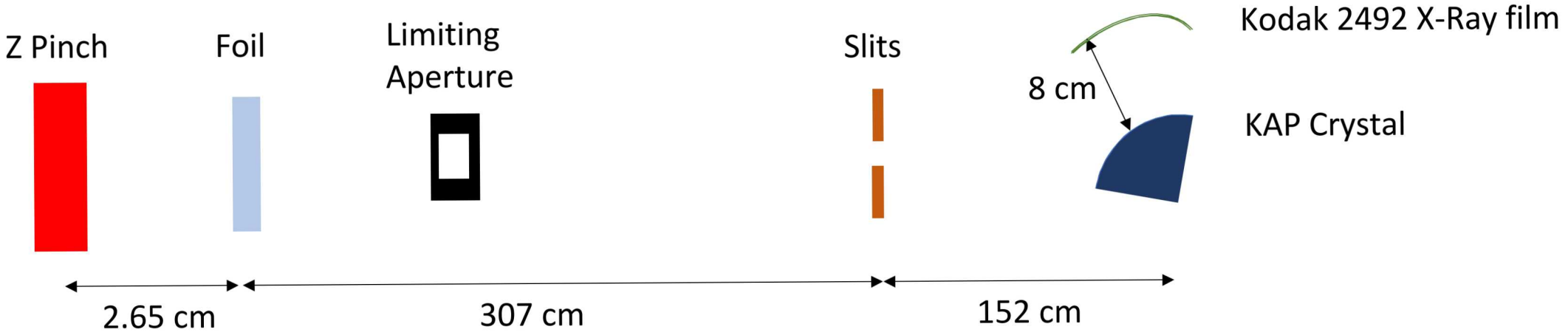
- Mg, Na and F spectra are simultaneously acquired to compare and contrast density diagnostic consistency in the range of 50-60eV and densities of ~2×10^{21} electrons/cc.
- This initial data is being analyzed and interpreted with PrismSPECT.
- Here, we discuss the methodology.

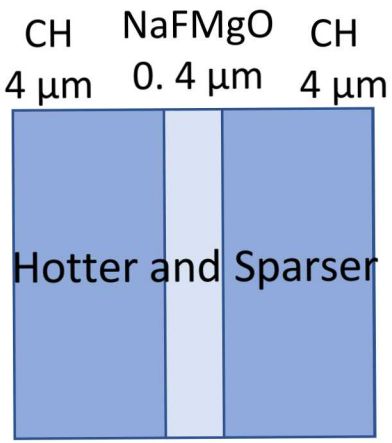


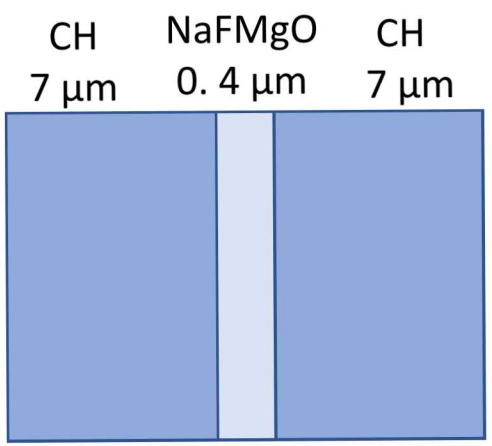


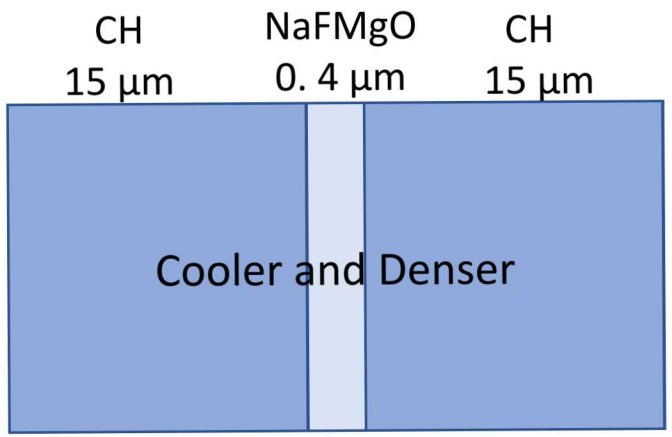


Pinch x-rays drive and backlight a plasma, yielding absorption spectra.









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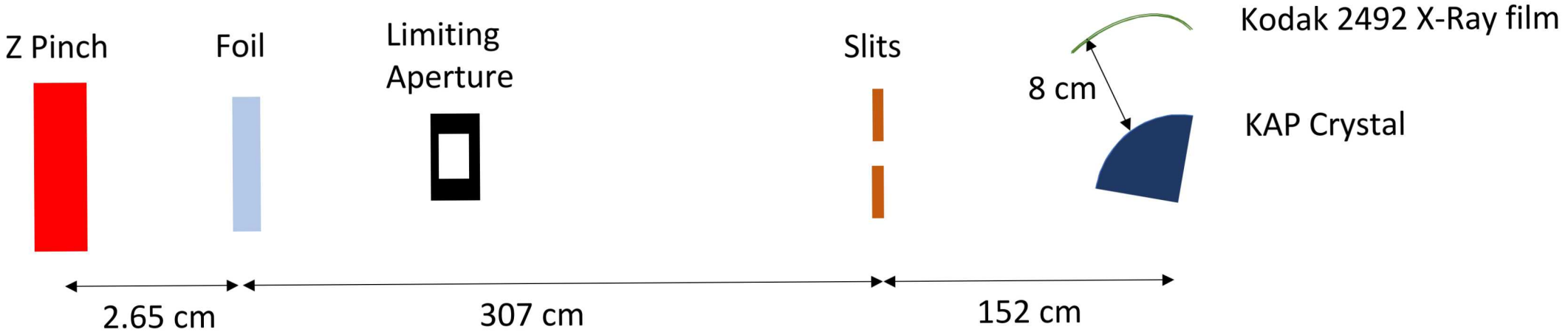
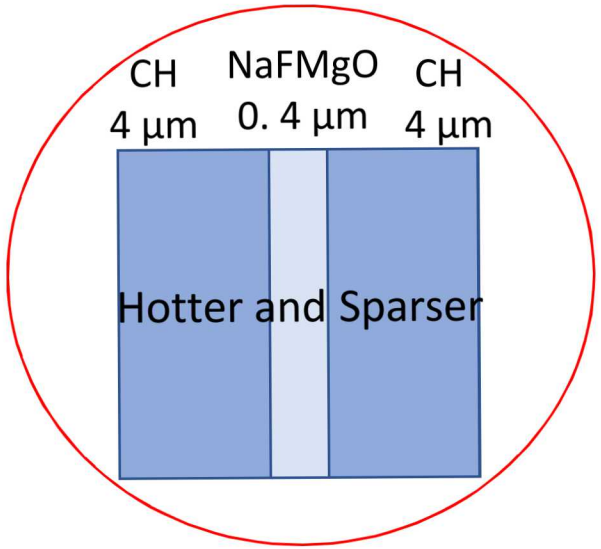
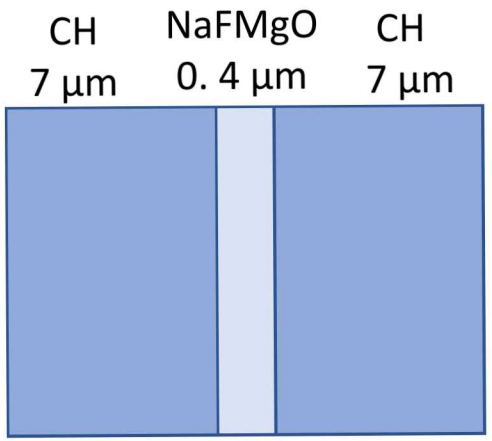
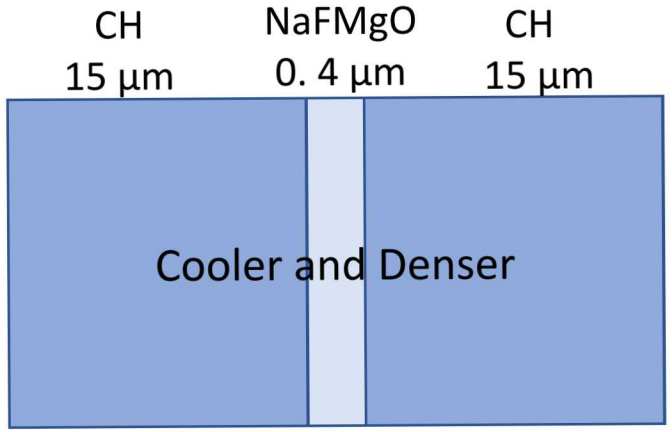
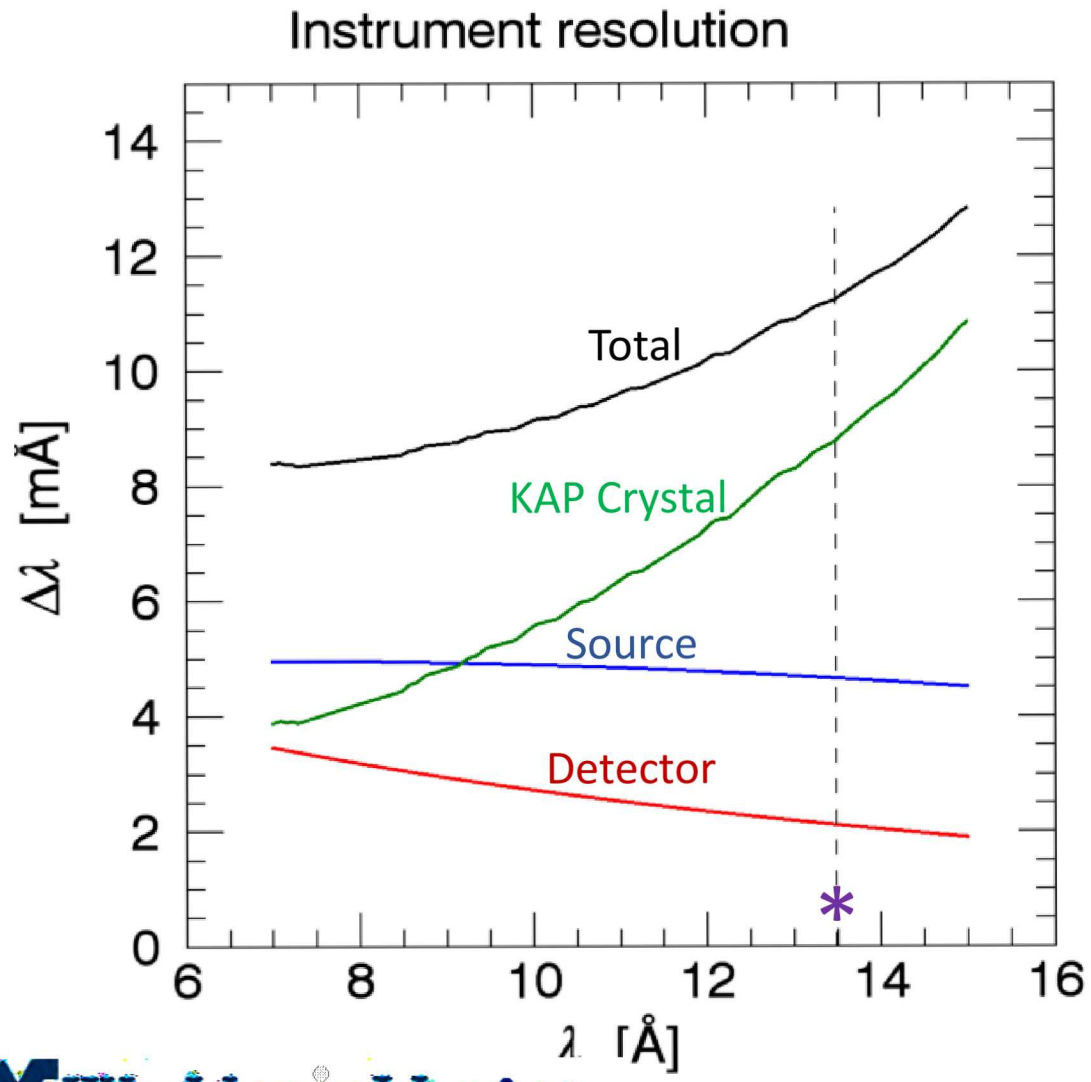


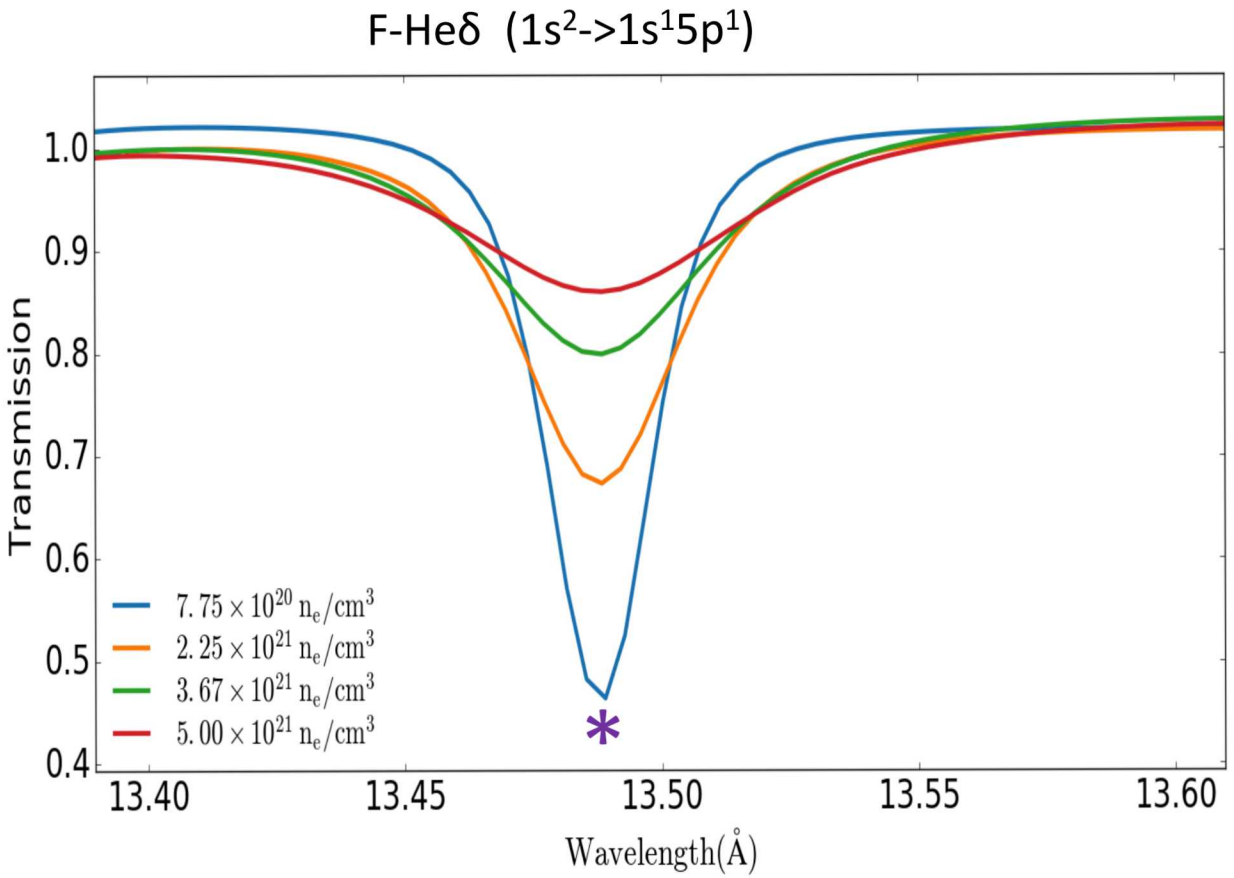






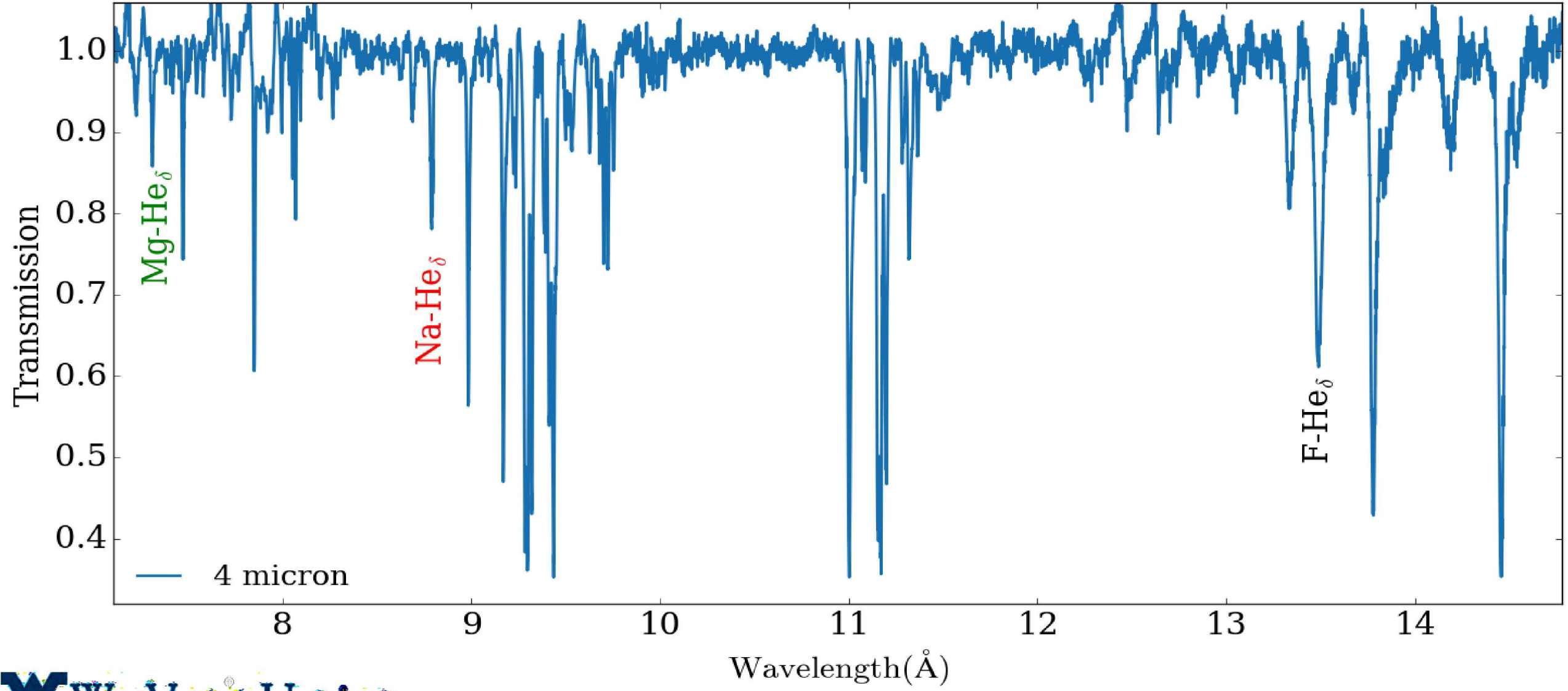
Stark broadening dominates all observed linewidth contributions.



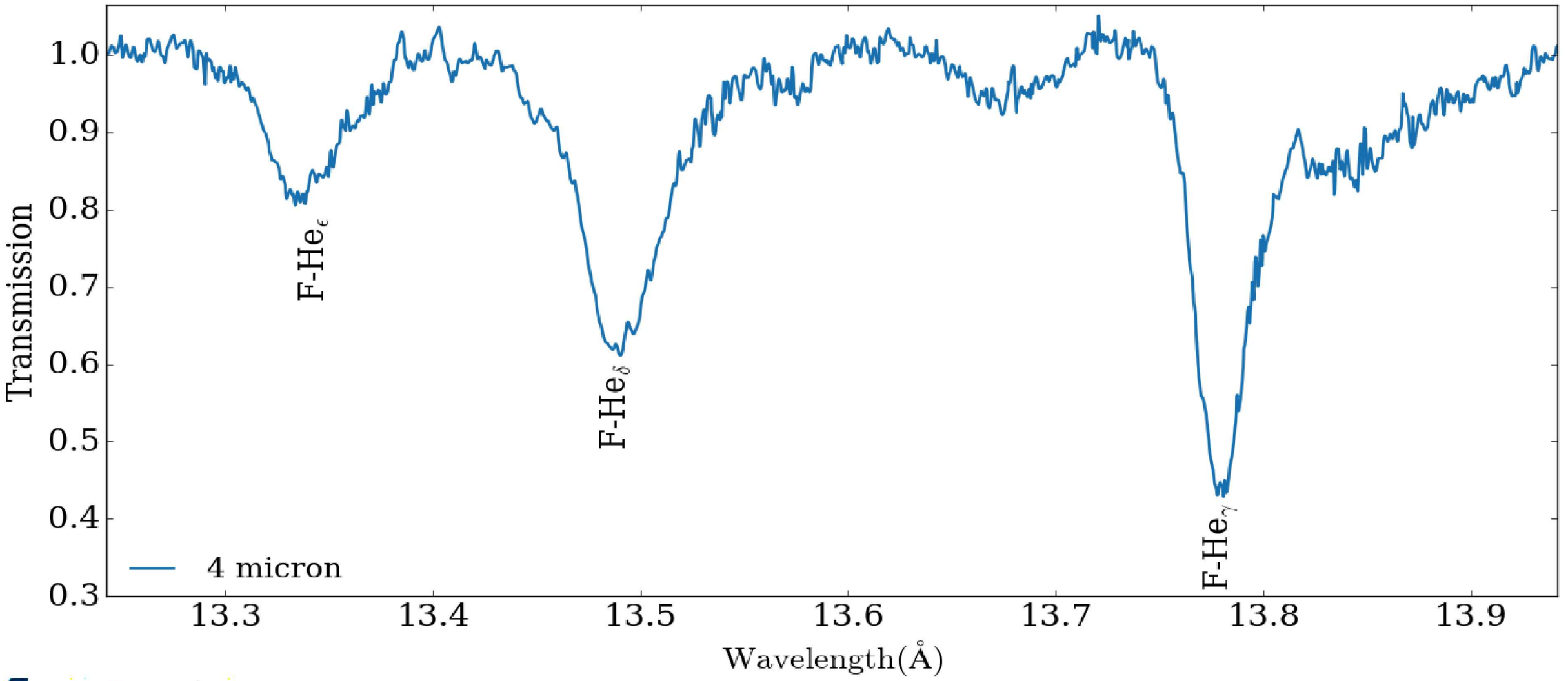


Even the smallest electron density shown here has the width of the line as ~20mÅ, well above our instrument resolution

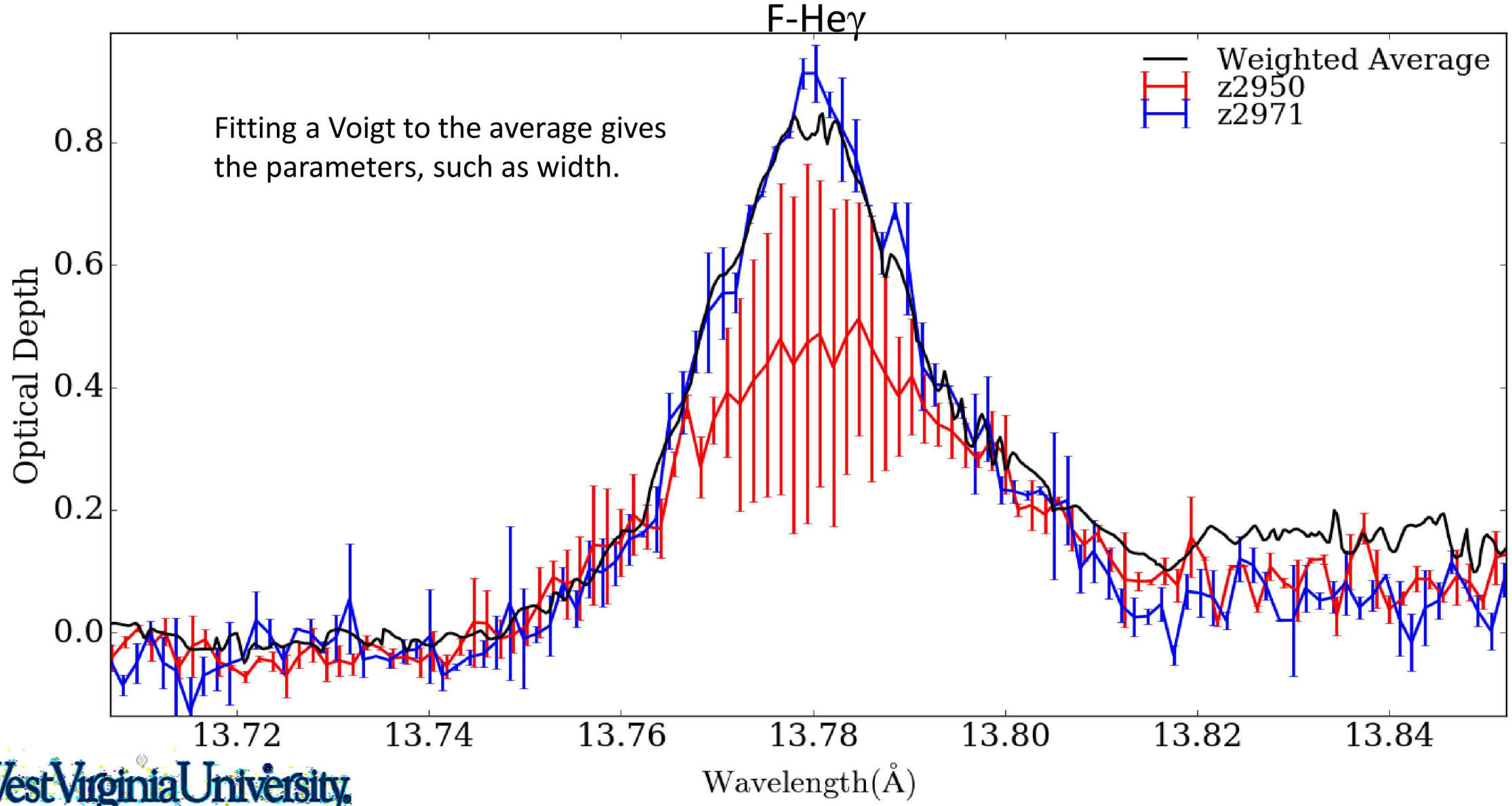
Absorption features of three elements acquired thanks to uniquely broadband backlighter and spectrometer range.



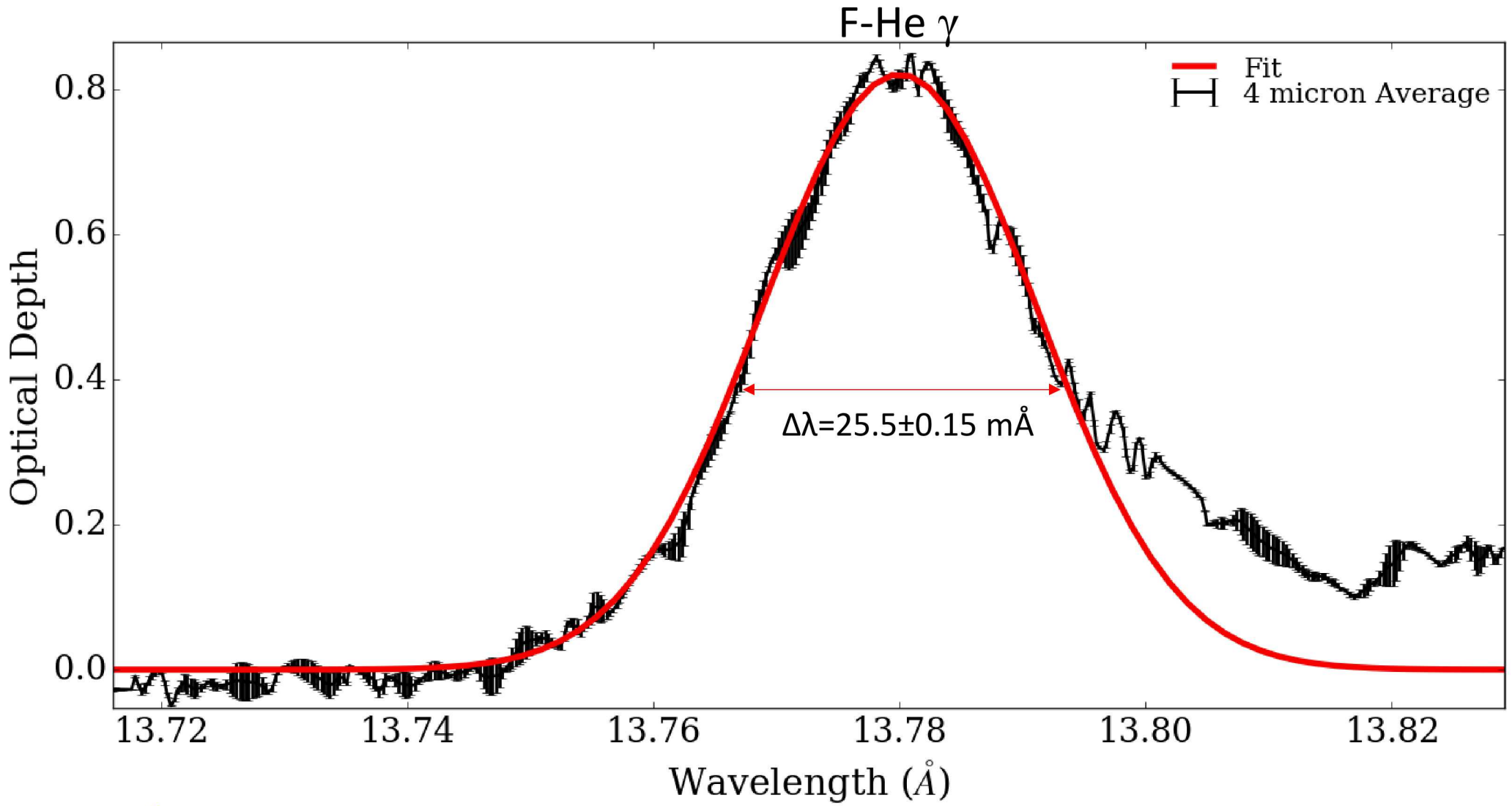
He-like charge state is the highest observed charge state in the plasma.



Uncertainty is acceptable on each spectrum; precision improves with multiple spectra.



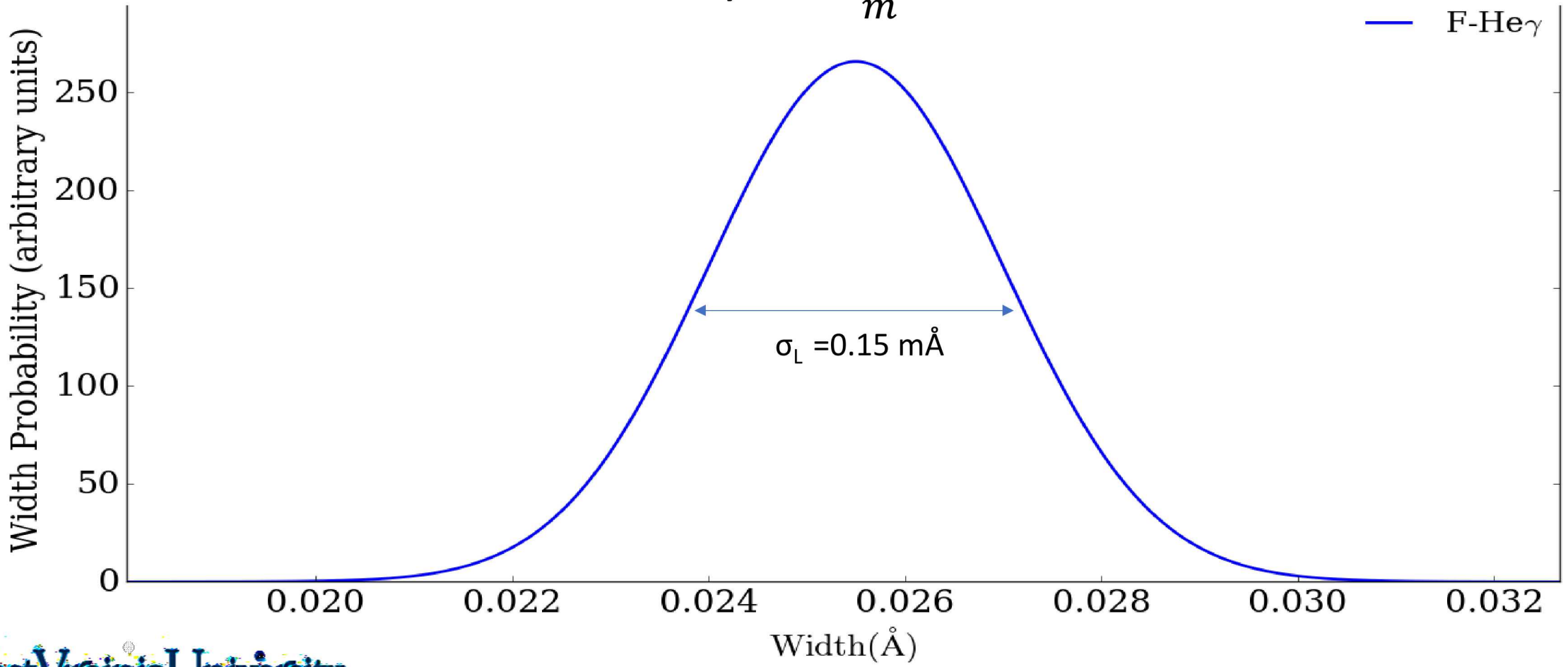
Determining electron density from spectra is based on the weighted-average linewidth.



The linewidth uncertainty (σ_L) translates into an electron density uncertainty (σ_n).

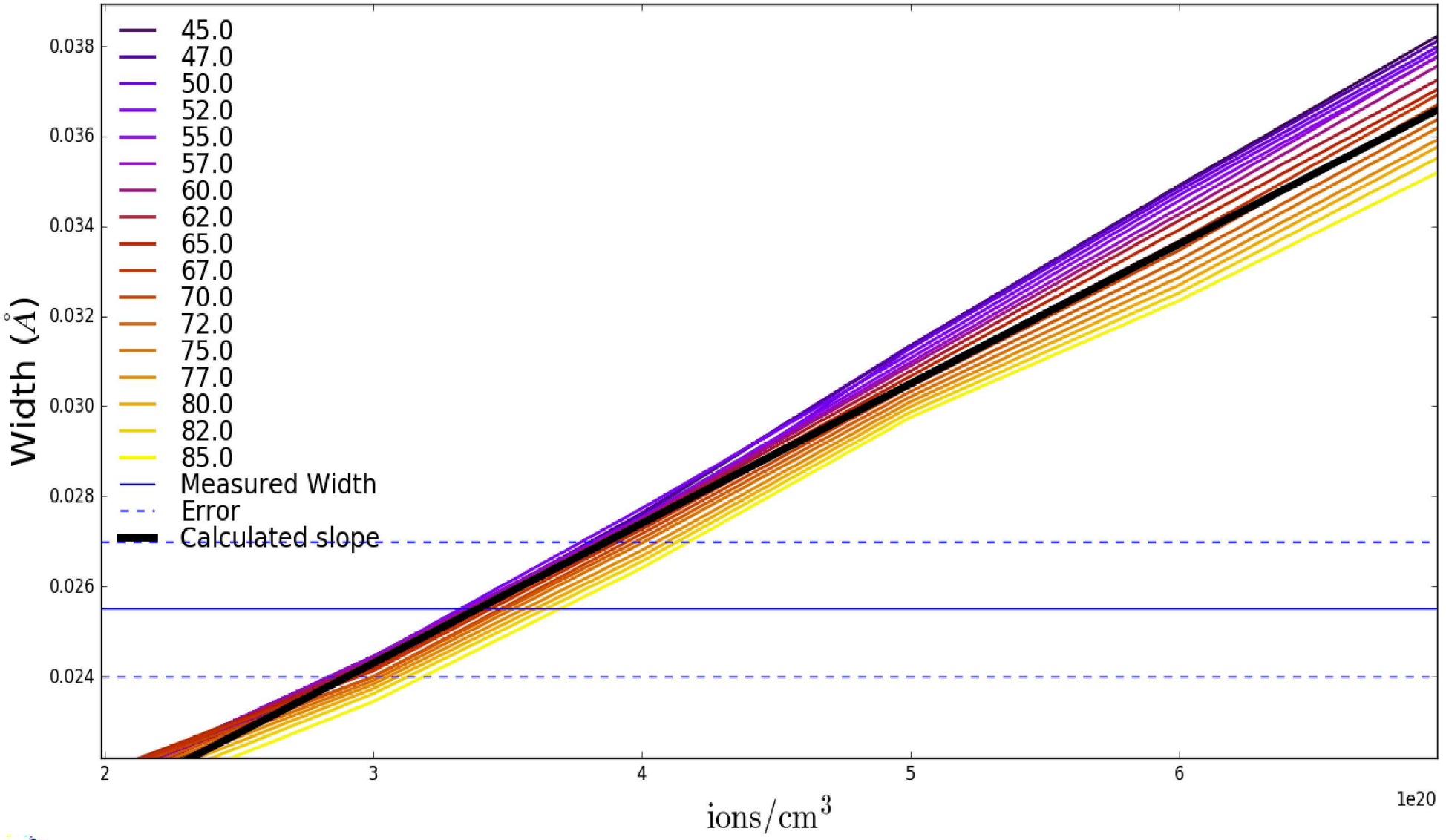
$$\text{Probable Width} = m * Probable\ Density + b$$

$$\text{Density} = \frac{Width - b}{m}$$



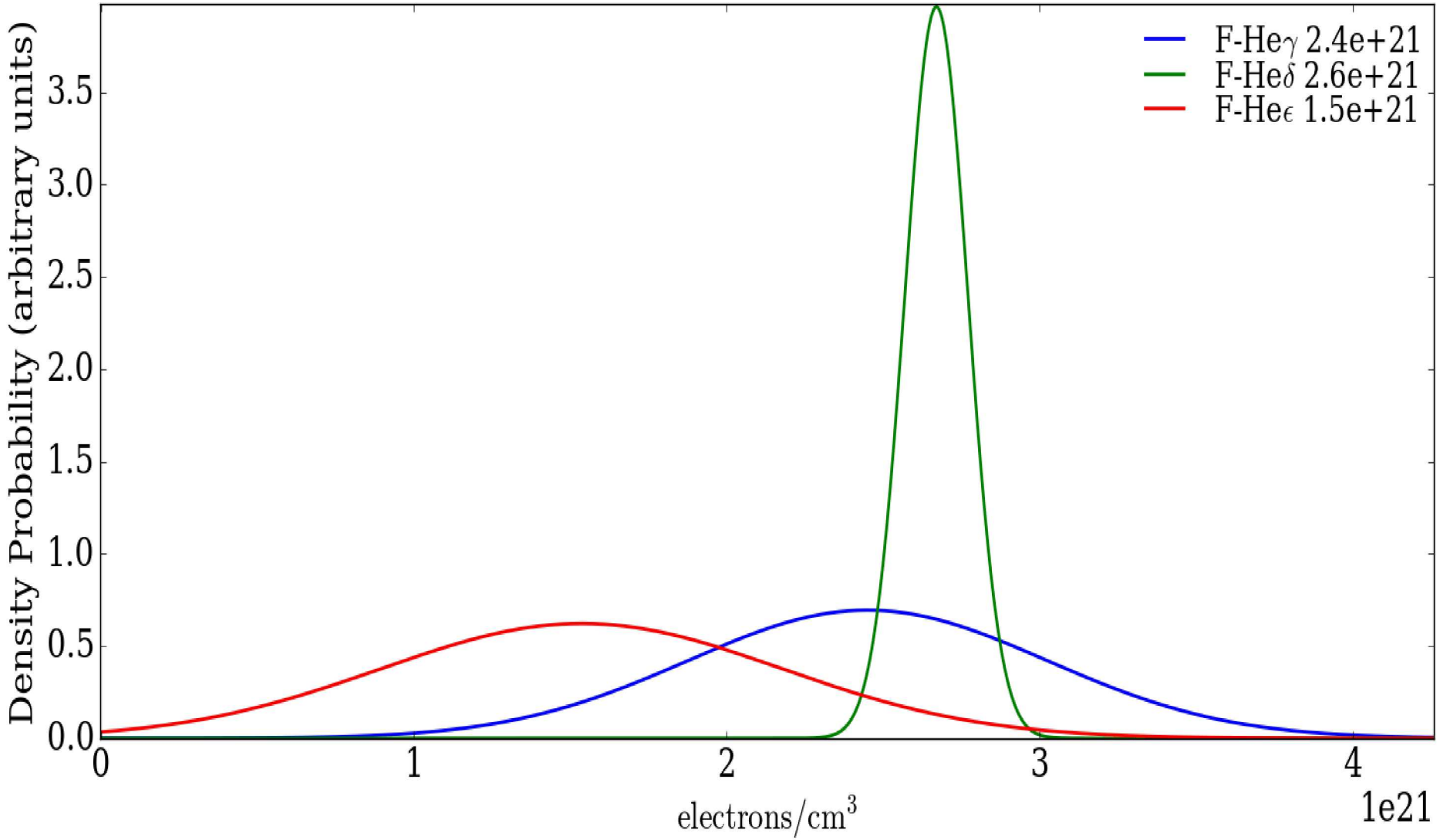
The width-temperature-density relationship is determined using PrismSPECT.

$$\text{Density} = \frac{Width - b}{m}$$



Thus each line's width (Δλ) translates into an electron density (n_e).

Agreement between F-Heγ and F-Heδ, and F-Heε and F-Heγ suggests that electron density lies ~2.3X10^{21} electrons/cc



Conclusion and Future Work

- High quality data (SNR and spectral range) were acquired
- Methodology has been established to gauge diagnostic consistency.

- Repeat this process for the He-like Na and Mg lines.
- Repeat this process for multiple tamper thicknesses.
- Complement with theory, such as Griem approximation's predictions.
- Involve models, such as MERL, in the predictions.
- Study the effects of density gradients on measured linewidths and quantify the role they play.

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Questions?