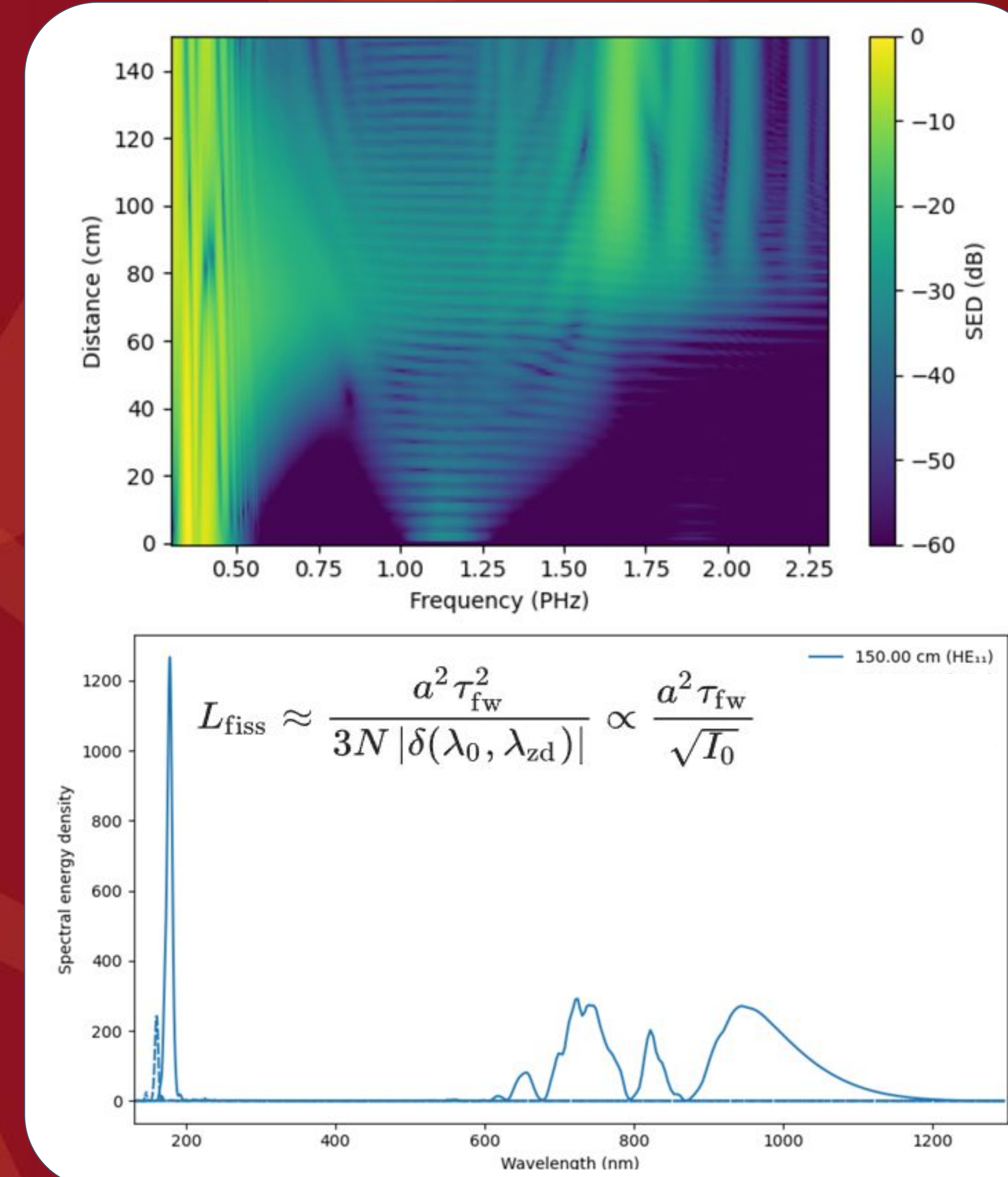
Tuning Resonant Dispersive Waves and Soliton Continua Using Hollow Core Fibers for Femtosecond Pump-Probe Spectroscopy

Rose Wilson[1,2], Jose Godinez Castellanos[2,3], Kirk Larsen[2], Felix Allum[2], Ruaridh Forbes[2], Matt Bain[2]

1. College of Science, The University of Arizona, Tucson, AZ
2. Linac Coherent Light Source, SLAC National Accelerator Laboratory, Menlo Park, CA
3. Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, CA

Contact: rosewilson@arizona.edu

SLAC NATIONAL ACCELERATOR LABORATORY | U.S. DEPARTMENT OF ENERGY | Stanford University | THE UNIVERSITY OF ARIZONA

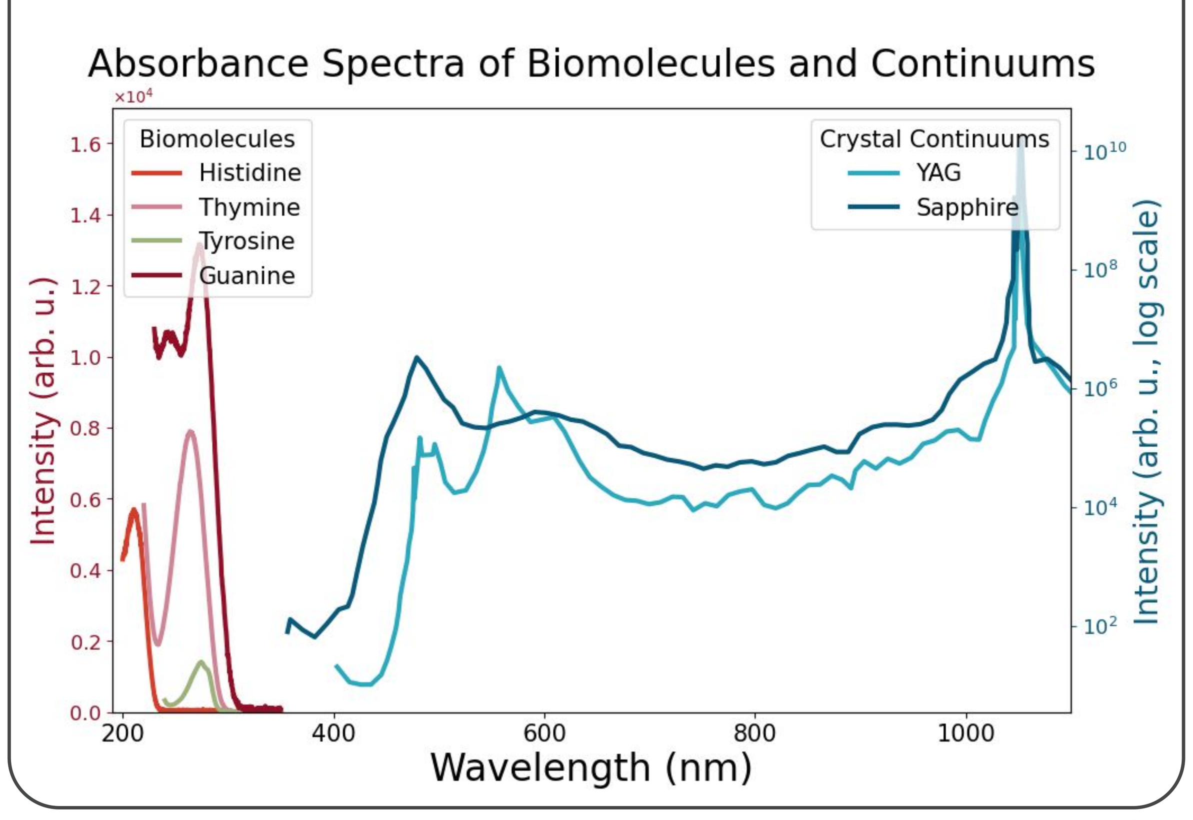


GOAL

Use hollow core fibers to extend the probing window into the deep UV of electronic transient absorption spectroscopy.

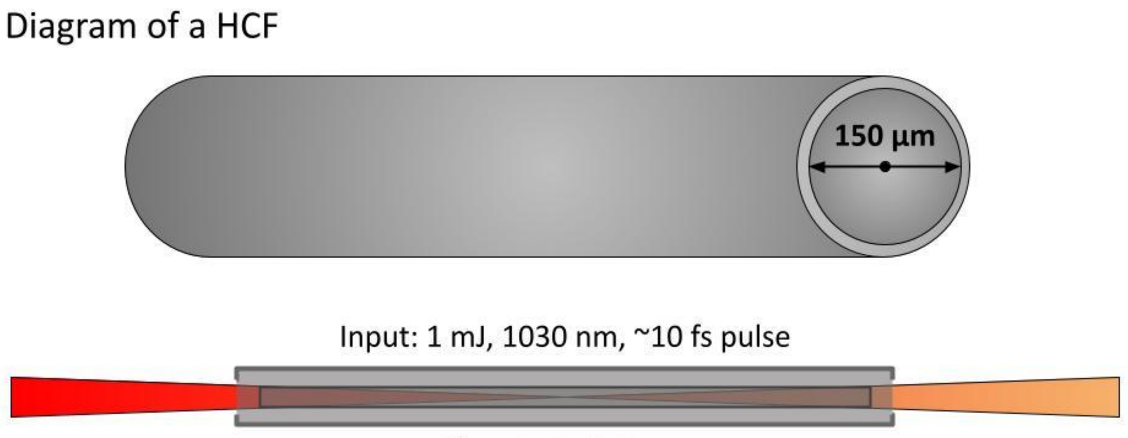
MOTIVATION

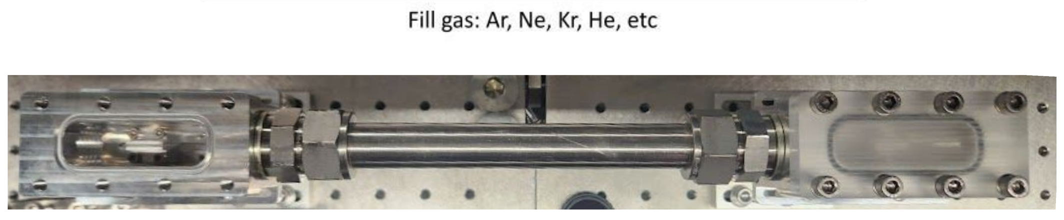
Current methods of creating a white light continuum for transient absorption (TA) spectroscopy only measure down to a wavelength of 350 nm. However, many molecules absorb light at a shorter wavelength of the UV-vis spectrum:

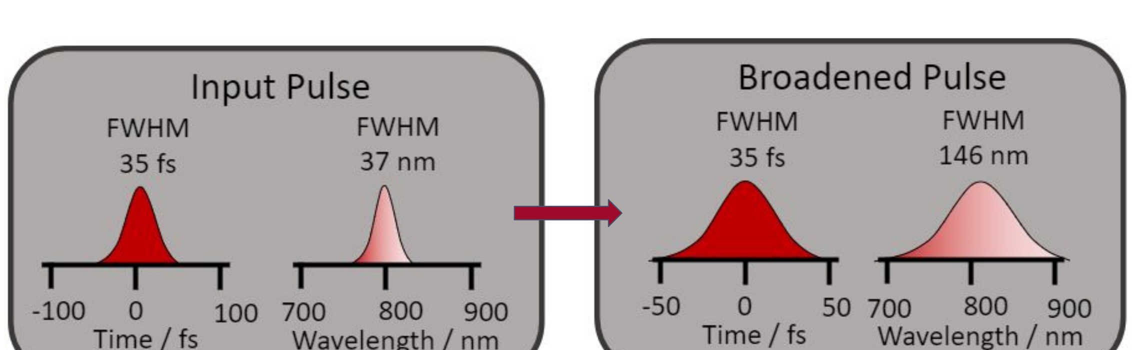


HOLLOW CORE FIBERS (HCFs)

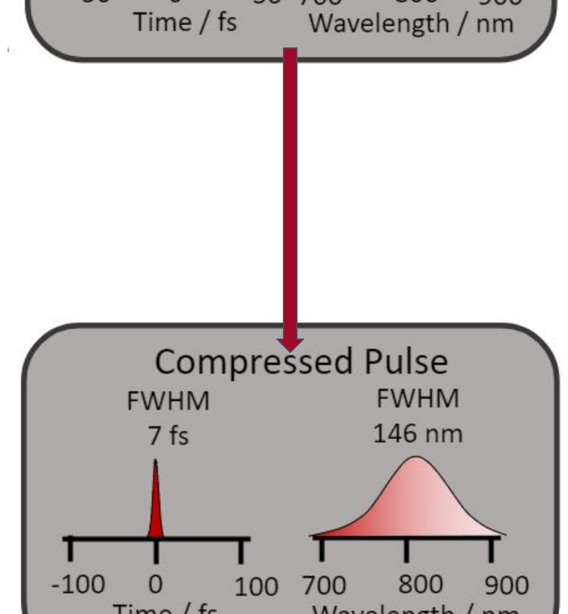
Diagram of a HCF



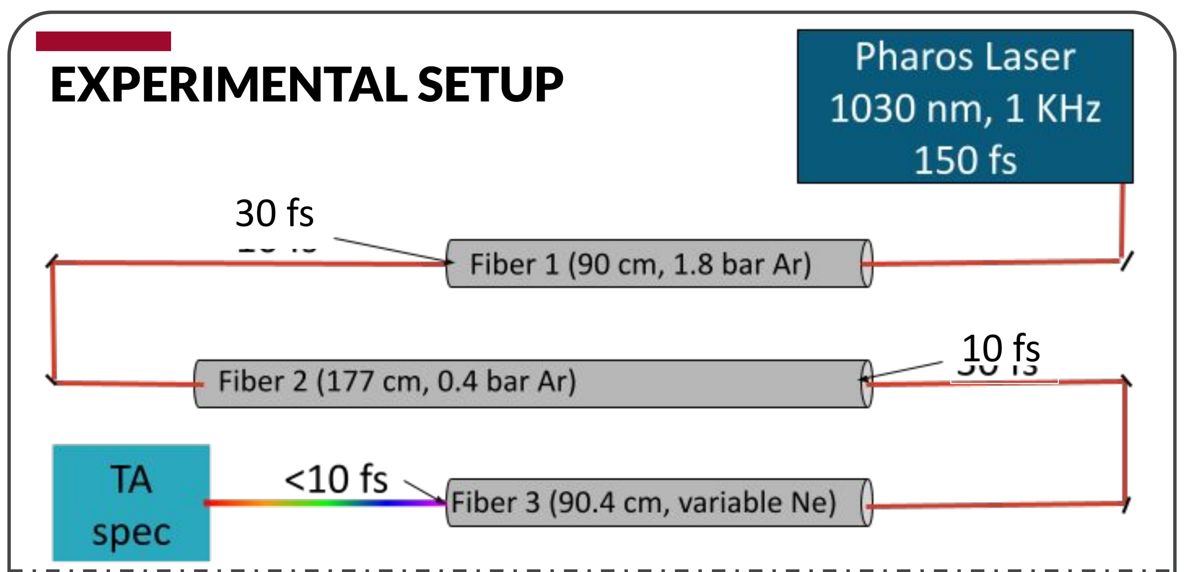


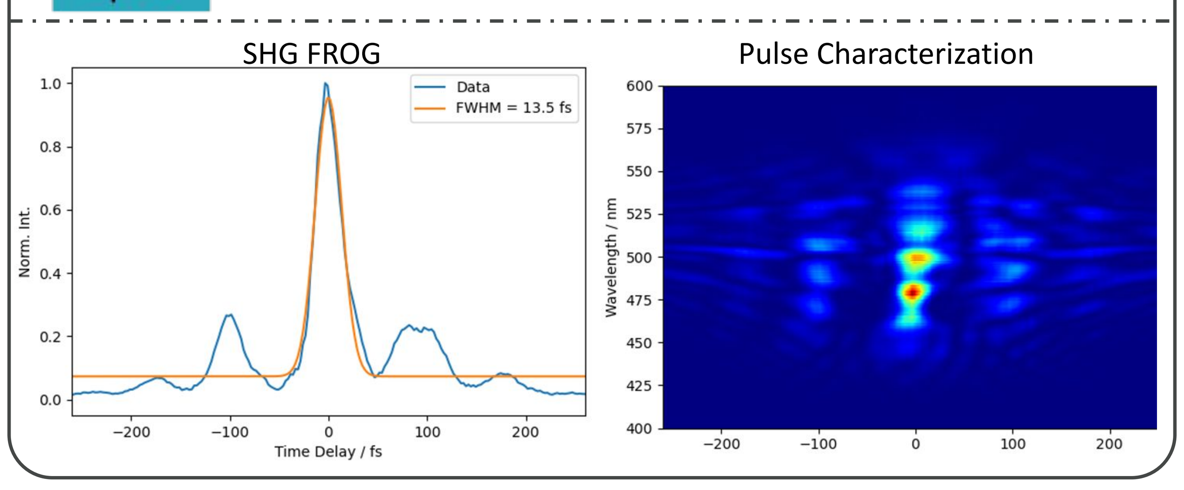


Self-phase modulation in the fiber causes spectral broadening which is later compressed. Under the right conditions, this can lead to resonant dispersive wave (RDW) emission and soliton formation.

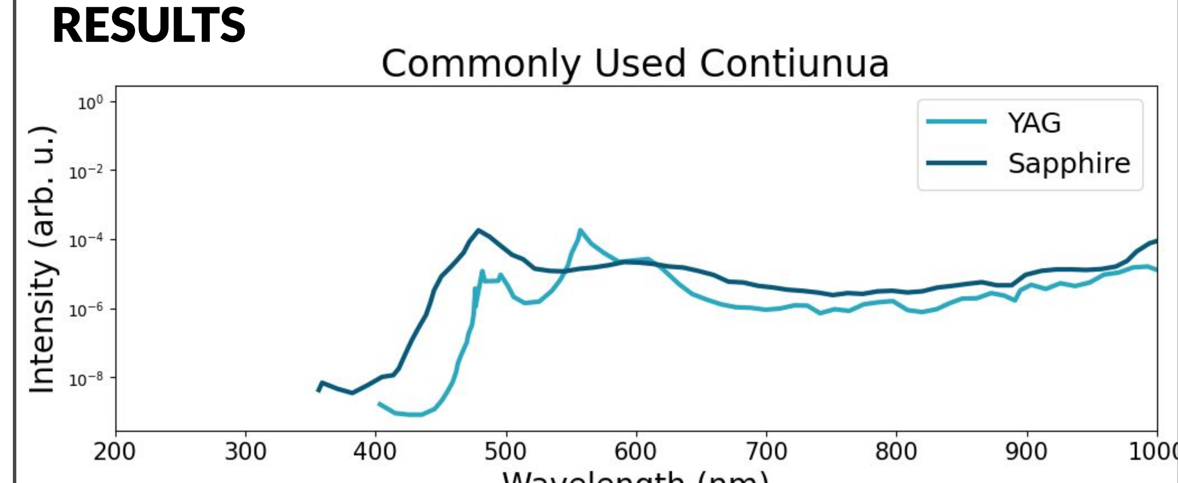


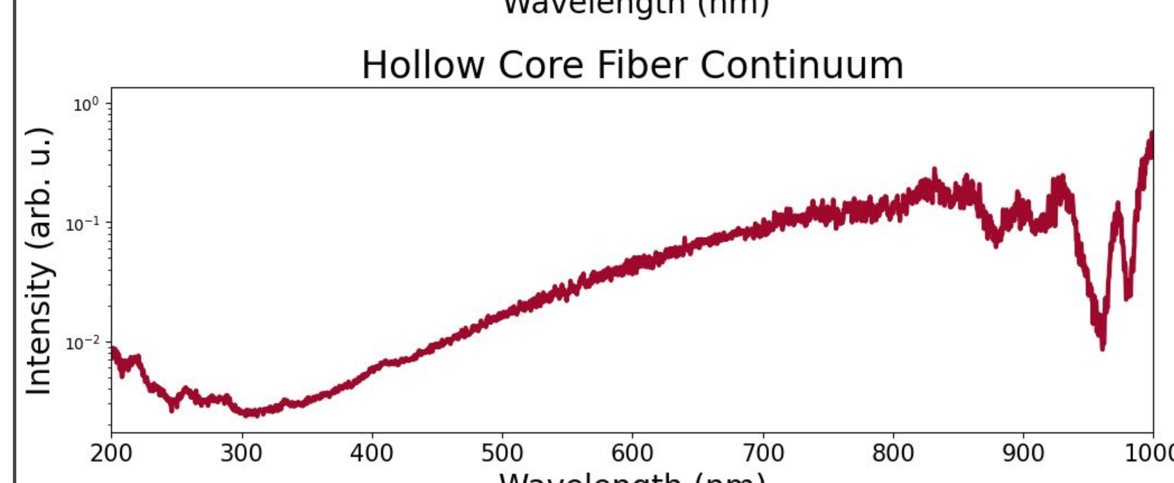
EXPERIMENTAL SETUP

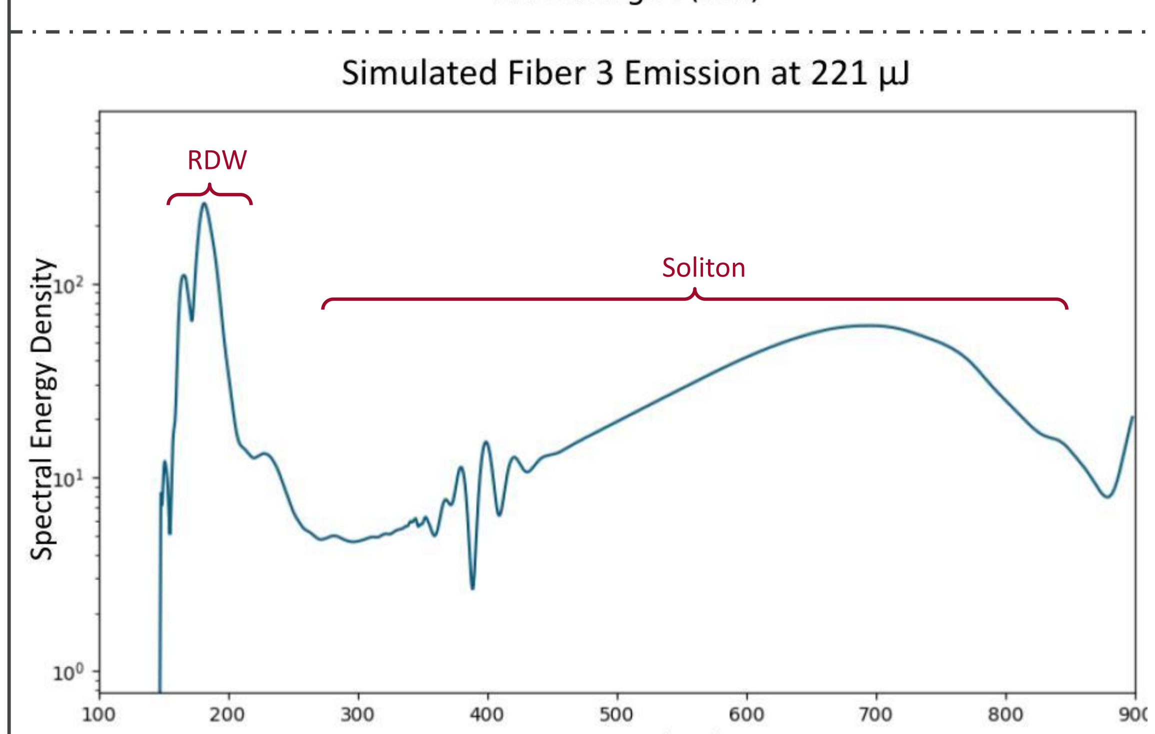


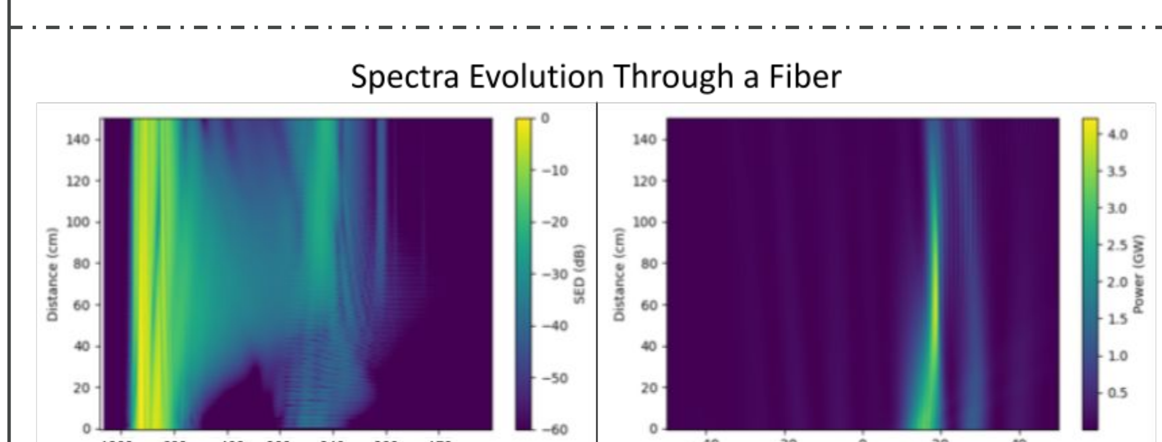


RESULTS

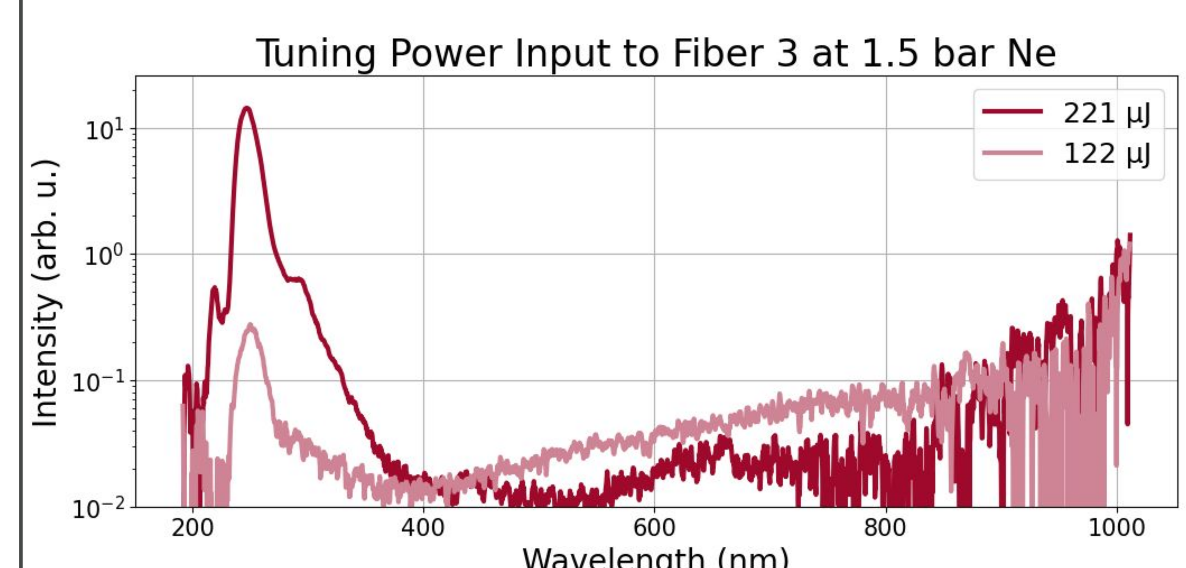


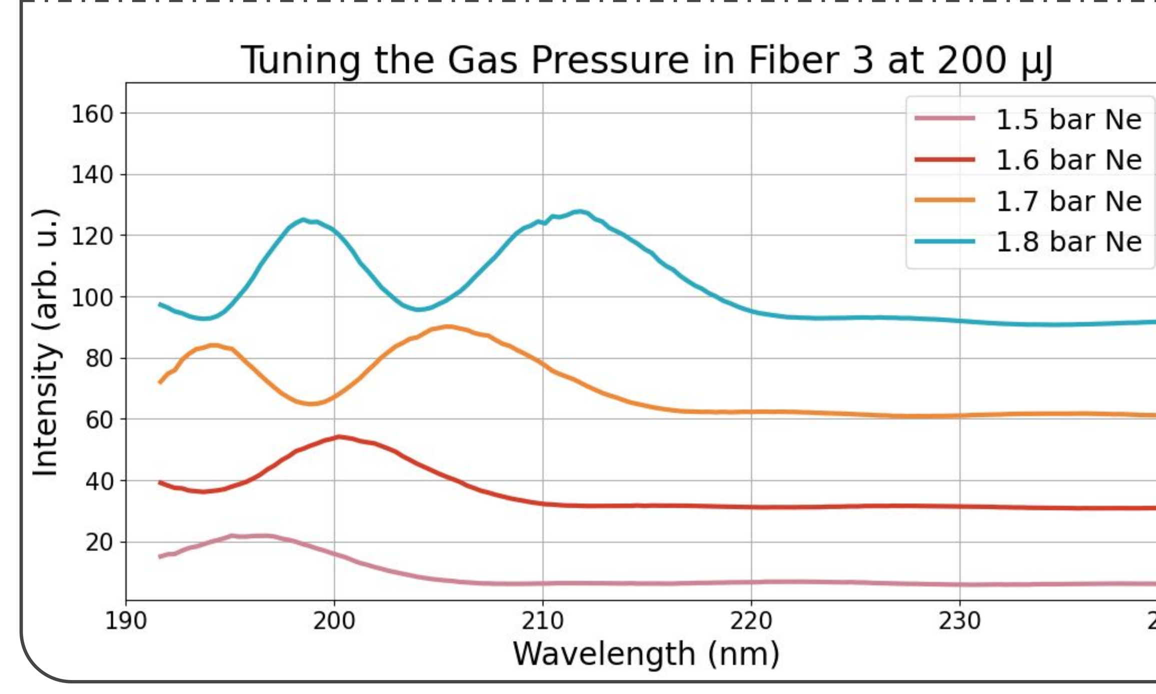






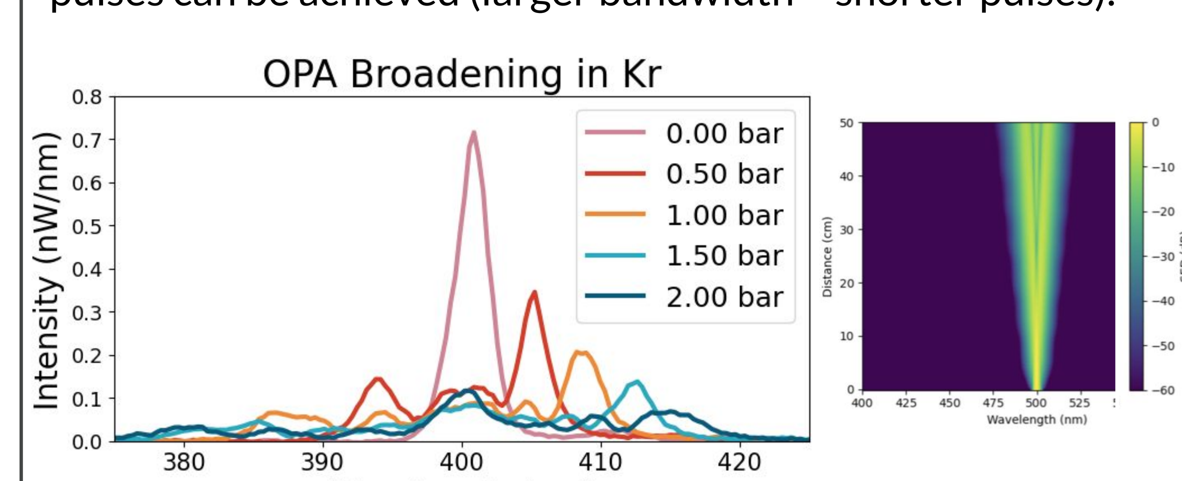
TUNABILITY





ANOTHER USE FOR HCFs: OPA BROADENING

An optical parametric amplifier (OPA) is a light source that emits tunable wavelength pulses, and OPAs are used in several LCLS hutches. By coupling a HCF to an OPA, shorter pulses can be achieved (larger bandwidth = shorter pulses).

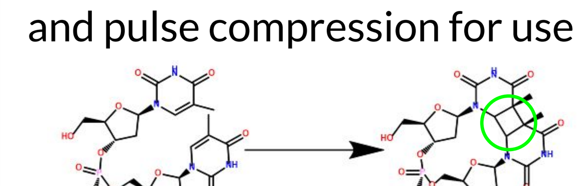


CONCLUSIONS

By tuning the soliton continuum, we can produce a brighter ultrafast pulse that extends to at least 200 nm, which is a 150 nm extension from other methods into the UV region.

NEXT STEPS

Finish building a TA setup to start analyzing the deep UV spectrum of liquid samples, scale to a rep rate of 20 KHz. Combine this with a RDW pump pulse to achieve better temporal resolution. Continue optimizing OPA broadening and pulse compression for use in LCLS hutches.



Thymine Dimerization (<70 fs)

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

Proton transfer following water ionization (<40 fs)

ACKNOWLEDGEMENTS

Luna, the program used for creating nonlinear optical simulations, was developed by the Lupo lab at Heriot-Watt University. I'd like to thank the LCLS intern program team, SLAC, and the DOE for making this internship possible. I'd like to give a special thanks to my mentor Matt Bain for his guidance and support and to my colleagues Jose and Kirk for introducing me to the epic highs and lows of laser alignment.

REFERENCES

[1] Travers, J.C., Grigorova, T.F., Brahms, C., Belli, F. High-energy pulse self compression and ultraviolet generation through soliton dynamics in hollow capillary fibres. Nat. Photon Articles. 13, 547-554 (2019)

[2] I. Gražulevičiūtė et al. Supercontinuum generation in YAG and sapphire with picosecond laser pulses. Lithuanian Journal of Physics. 55, 110–116 (2015)