Development of a Prism Spectrometer for Ultrafast Deep-UV Spectroscopy

Alexander Pfistner (1) (2), Matt Bain (1), Kirk Larsen (1), Brian Kaufman (1)

1. SLAC National Accelerator Laboratory, USA 2. University of California, Los Angeles

SLAC NATIONAL ACCELERATOR LABORATORY U.S. DEPARTMENT OF ENERGY Stanford University UCLA

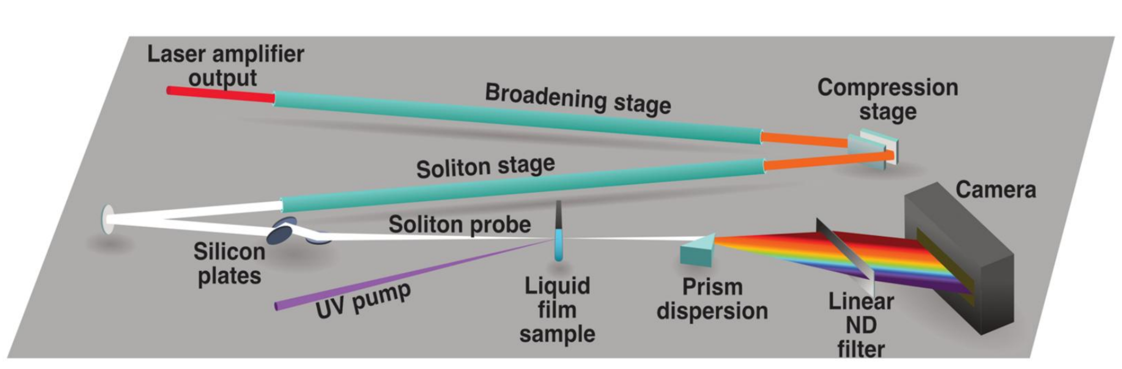
BACKGROUND

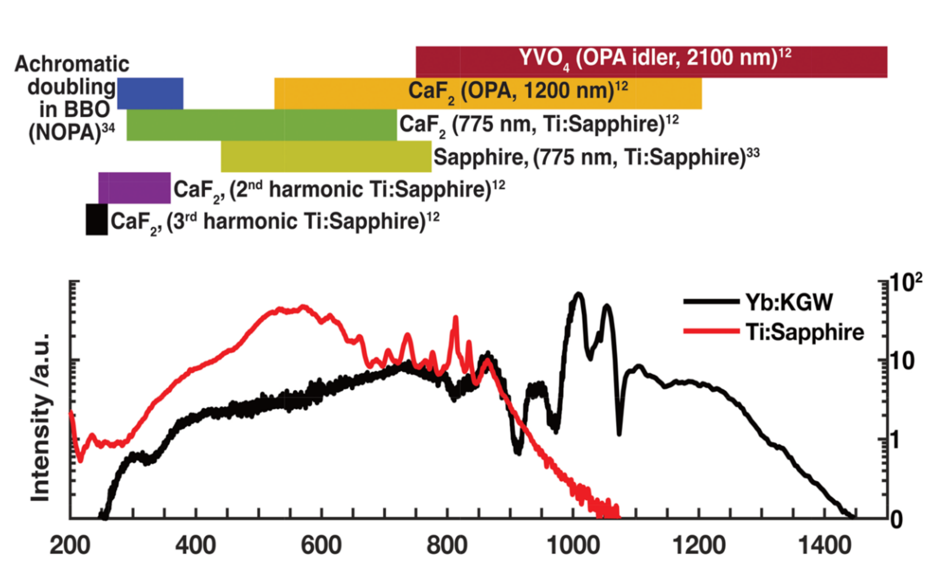
Transient absorption (TA) spectroscopy is a pump-probe technique for photochemical reactions. The pump pulse triggers the reaction, and the broadband probe pulse records how the sample's absorption spectrum changes. This essentially creates stop motion photography of molecules on the femtosecond time scale.

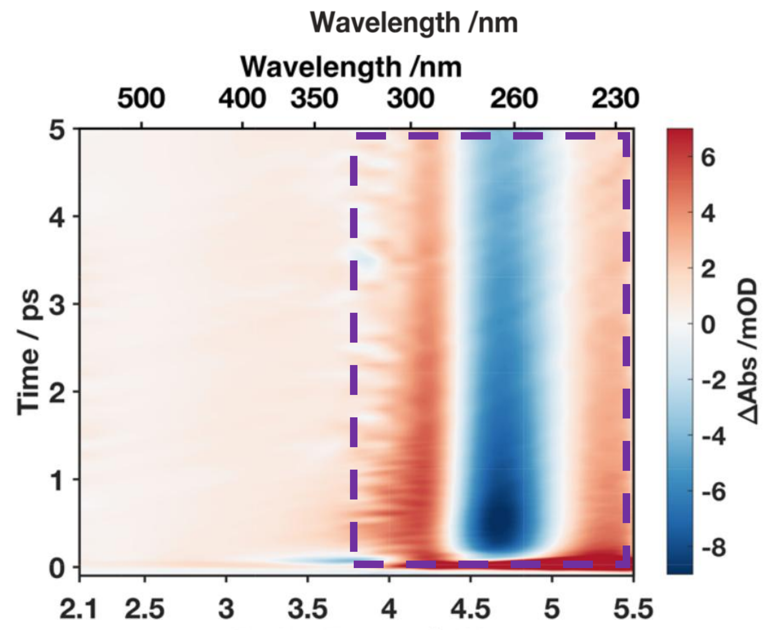
- Why Deep-UV?:
    - Enables improved measurement of ground state bleach recovery and stimulated emission for UV chromophores

EXPERIMENTAL SETUP

- Nonlinear propagation drives self-compression, generating a soliton-based continuum from gas filled hollow capillary fiber, that spans multiple octaves [1]



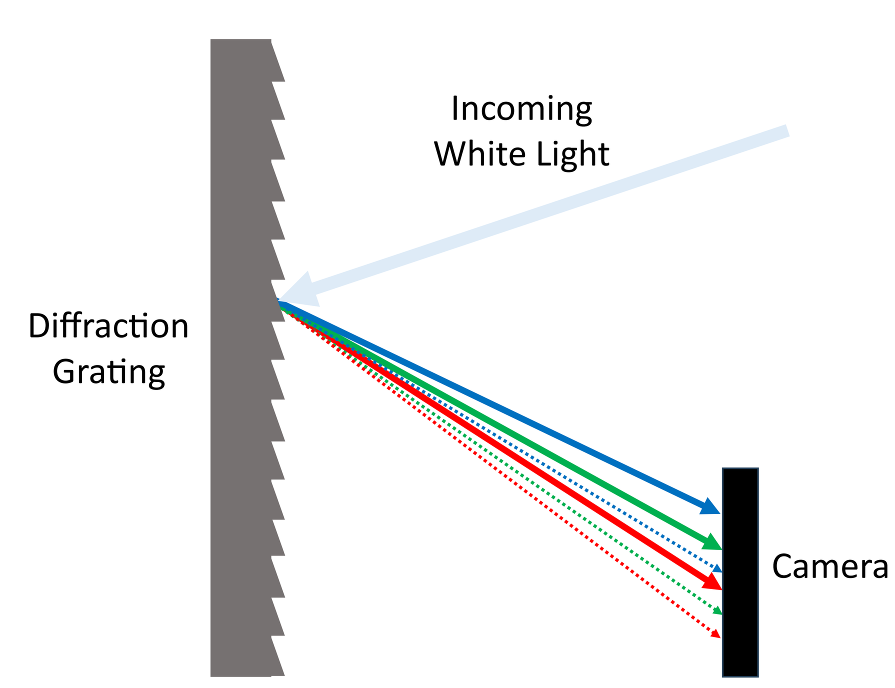




THE PRISM SPECTROMETER

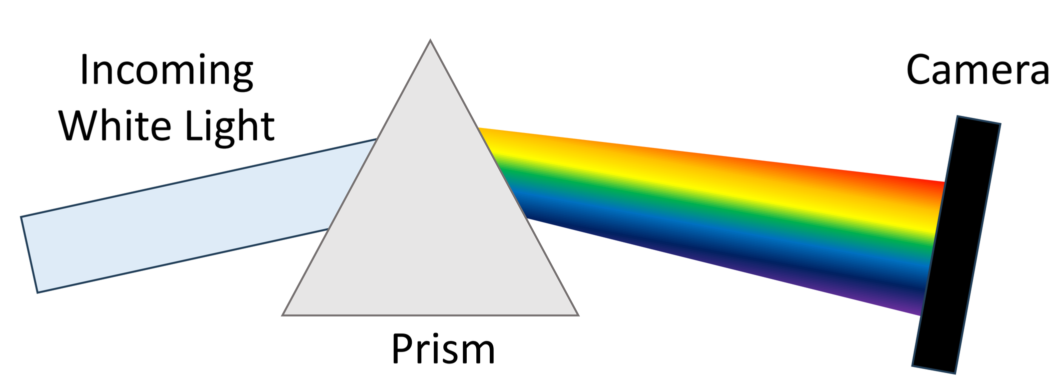
The multi octave problem: A typical design for spectrometers uses a diffraction grating to split the wavelengths; however, this approach fails here because our probe spans more than one octave, causing first and second order reflections to overlap, creating ambiguity in the camera's data. This is illustrated below:

Grating Spectrometer

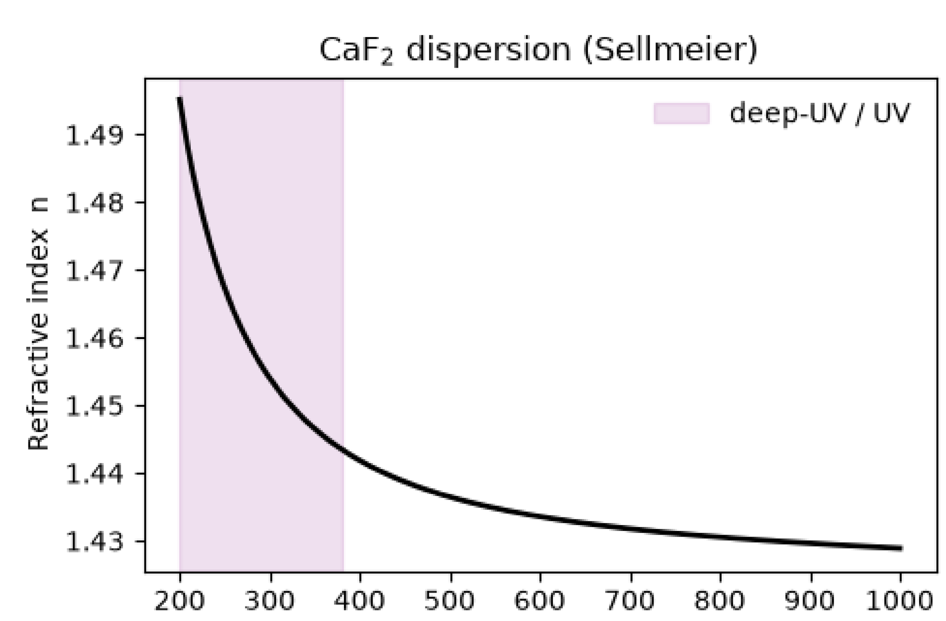


Instead, we use a prism spectrometer design which maps each wavelength to a unique pixel, removing the ambiguity. This is illustrated below:

Prism Spectrometer



The setup uses a CaF_2 prism whose refractive index is plotted below as a function of wavelength:

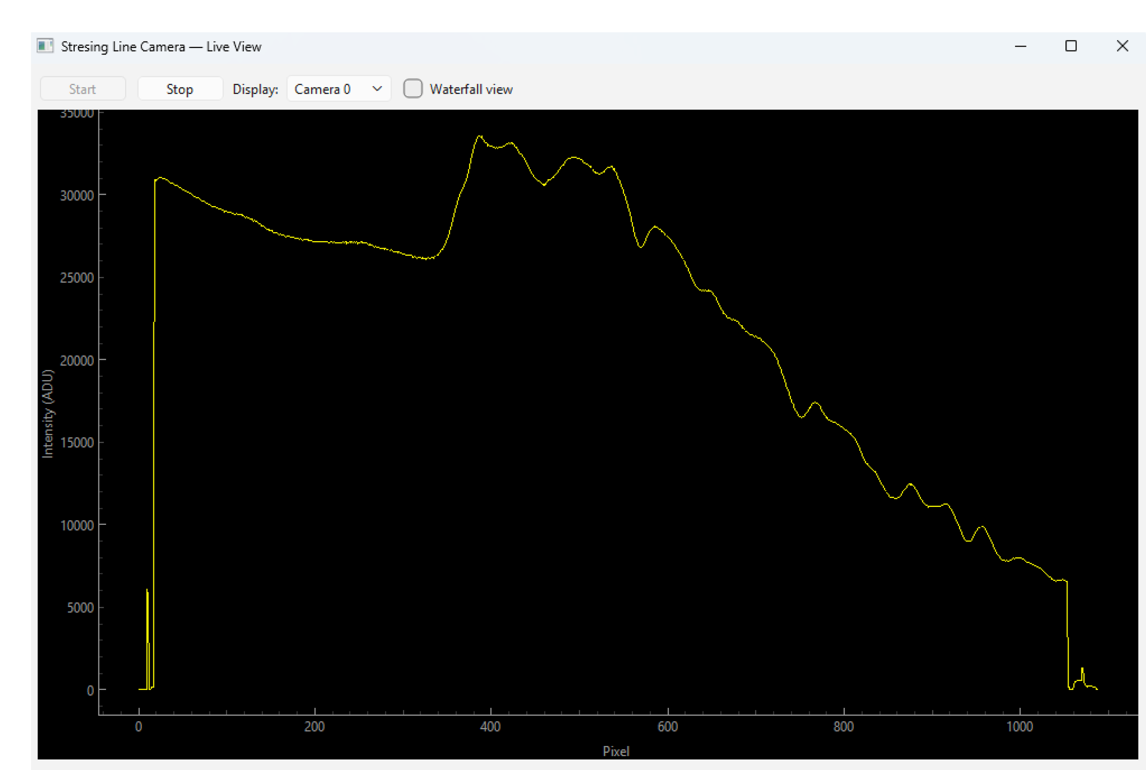


SETTING UP THE CAMERA

One of the most vital components of the spectrometer system is the line camera. This is a camera with a thin and long rectangular sensor that records the intensity of each wavelength. We used a Stresing camera with the following specifications:

Sensor	Hamamatsu S12600-1006
Sensitivity	200 nm – 1000 nm
MLR	3 kHz
Pixel Count	1024 x 58

The camera connects to a Stresing Camera Control 3010 unit. This unit is connected the Stresing PCIE board installed in the PC. With the hardware established, I developed a Python GUI to display the live data:



OUTLOOK

- Next step is to calibrate the camera with the prism so that each wavelength maps to the appropriate pixel
- We will also reconfigure the GUI to display intensity as a function of wavelength
- Once complete, this will have the capability to do experiments such as 2D spectroscopy in the deep-UV [2] and photochemistry of DNA bases

ACKNOWLEDGEMENTS

I would like to thank my mentor, Matt Bain, for his guidance and support this summer. Thank you to Kirk Larsen and Brian Kaufman for their support and troubleshooting help. Thank you to Florian Hahn and Gerhard Stresing for technical support with the Stresing camera. I am also grateful for Alan Fry and the work he has done to establish the LCLS summer internship. Finally, thank you to the Department of Energy and SLAC for facilitating such important science and opportunities.

pfistner@slac.stanford.edu
apfistner@ucla.edu

REFERENCES

[1] Godínez, J. *et al.* Ultrafast Solution-Phase Photochemistry Revealed by Multioctave Continuum Probe. *J. Phys. Chem. Lett.* **2026**, *17* (9), 2634–2643.

[2] Fresch, E., Camargo, F.V.A., Shen, Q. *et al.* Two-dimensional electronic spectroscopy. *Nat Rev Methods Primers* **3**, 84 (2023). https://doi.org/10.1038/s43586-023-00267-2