Measuring Pulse Width with an Autocorrelator

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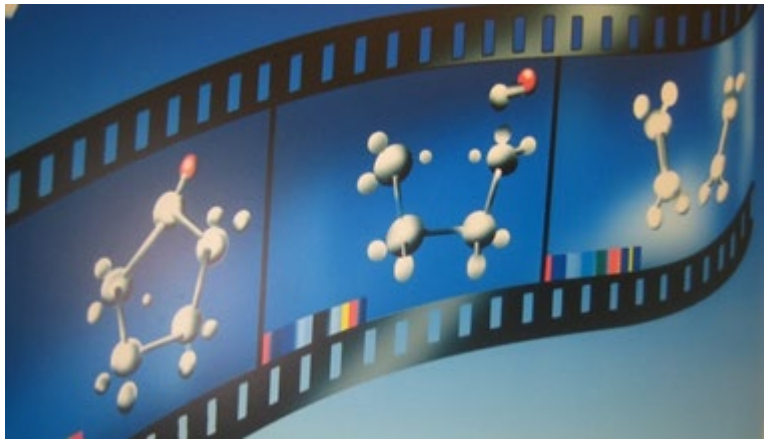
Funded by NSF

Background/Motivation

- **Goal:** create molecular movies of light-induced molecular reactions to be able to visualize the dynamics of the reaction

- **How:** use a femtosecond laser pulses to trigger the reaction and take snapshots of the reaction
  - pump-probe experiment



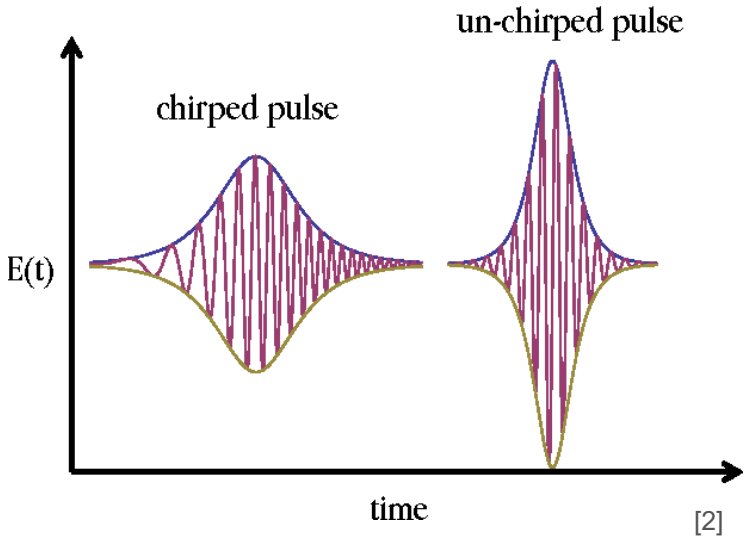
Pulse Width

- Important to characterize the pulse duration
  - “shutter speed”
  - laser pulse reference

- Can be measured using an autocorrelator setup
  - why use an autocorrelator?

Chirp

- Time dependent wavelength
- Causes inaccurate pulse width measurements in autocorrelator
- Want to be able to detect if a pulse is chirped



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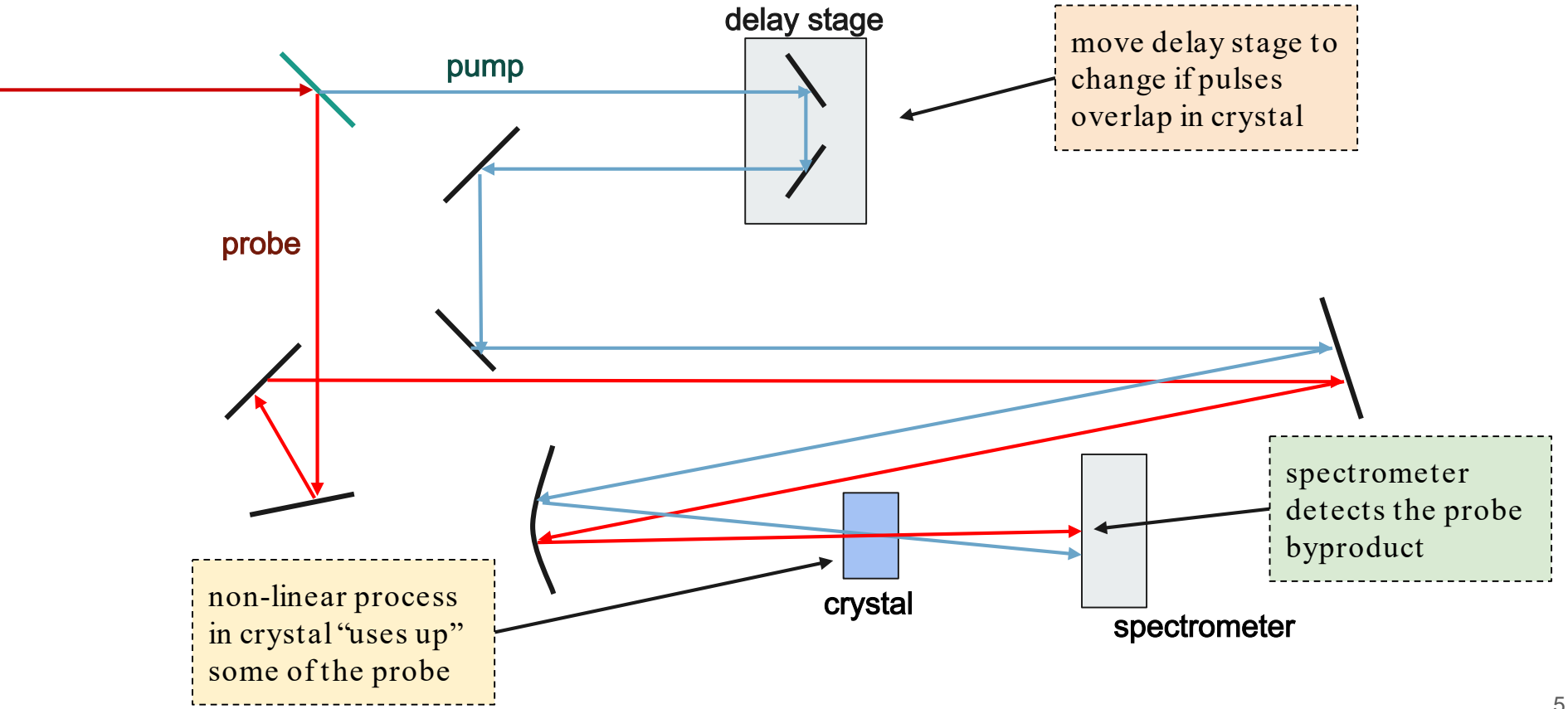
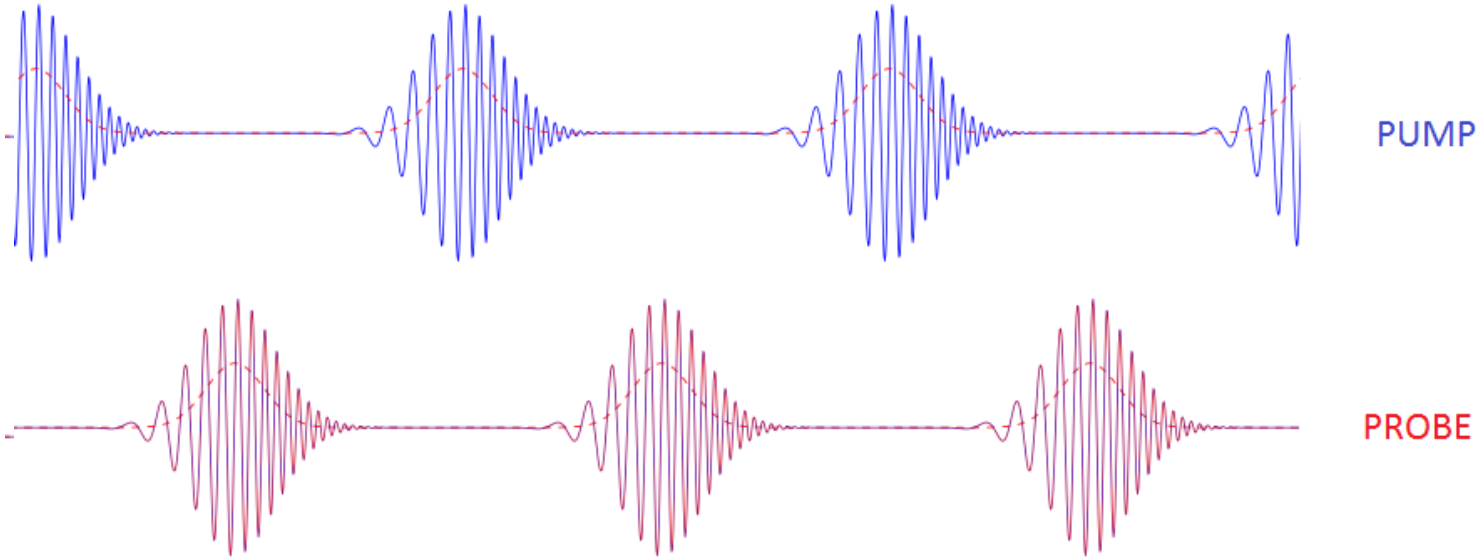
Autocorrelator Setup



How to Get Pulse Width

Step 1) Find time zero

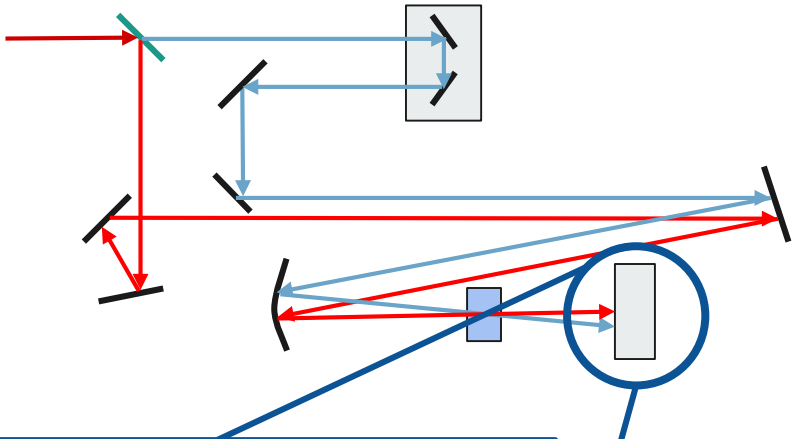
- what is time zero?

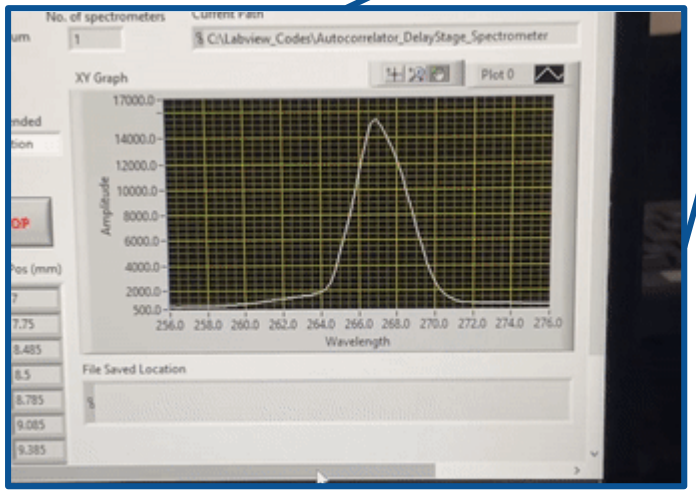


How to Get Pulse Width

Step 1) Find time zero

- spatial overlap by aligning optics
- temporal overlap by moving delay stage
- will see max depletion



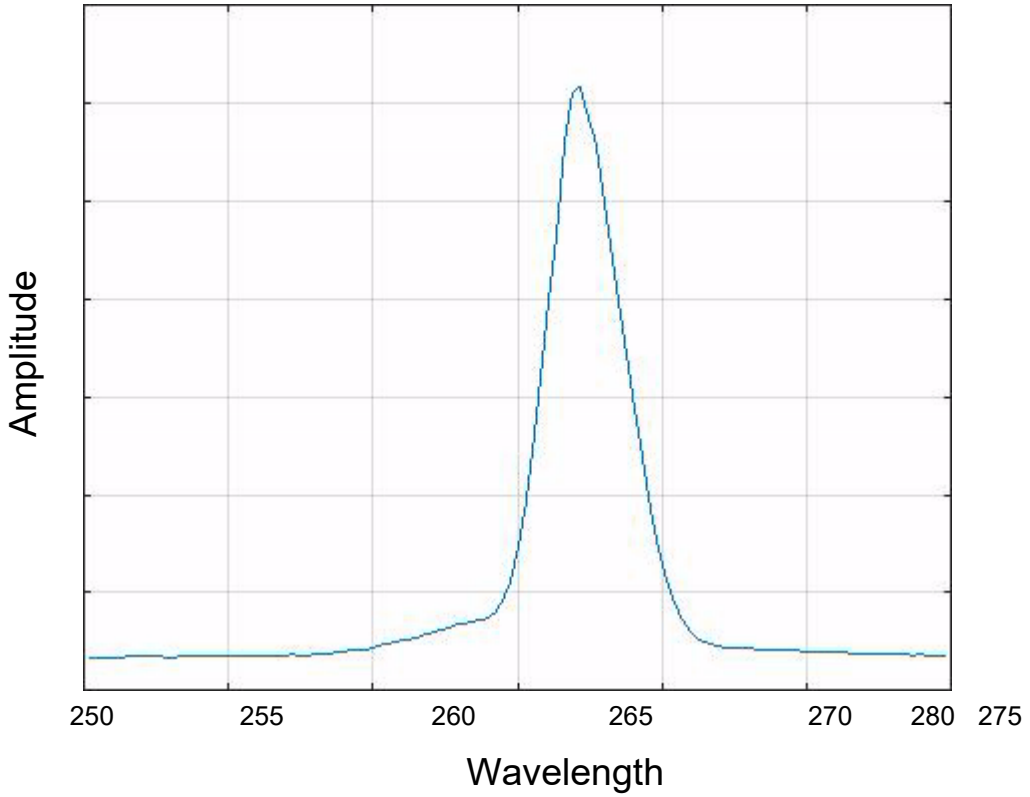


spectrometer signal

How to Get Pulse Width

Step 2) Take measurements

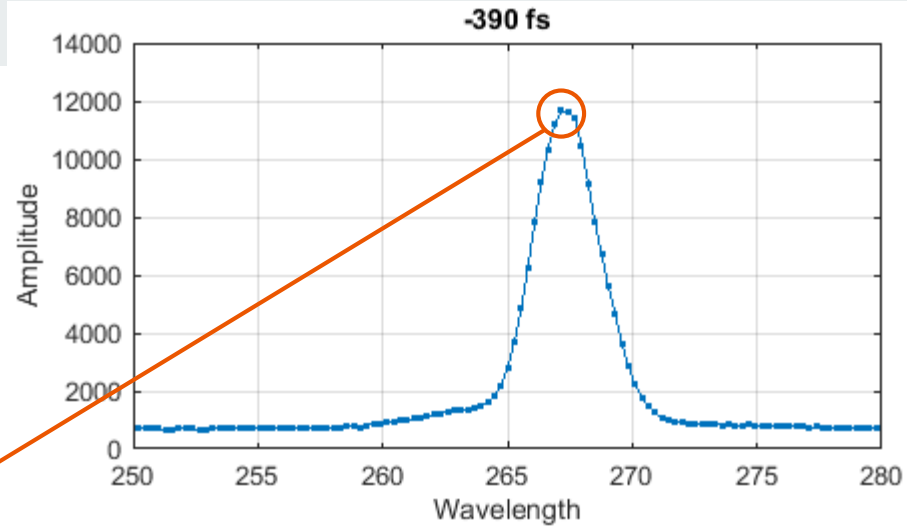
- take measurements at different delays moving through time zero
- take multiple runs

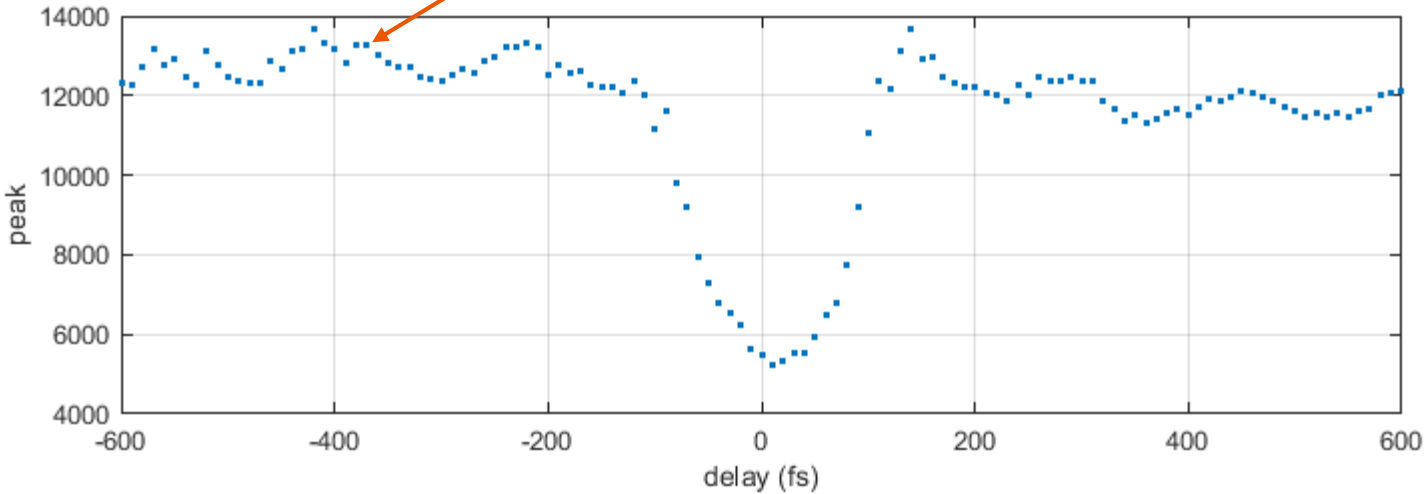


How to Get Pulse Width

Step 3) Analyze data

- plot sum of spectra over region vs delay
  - can use peaks

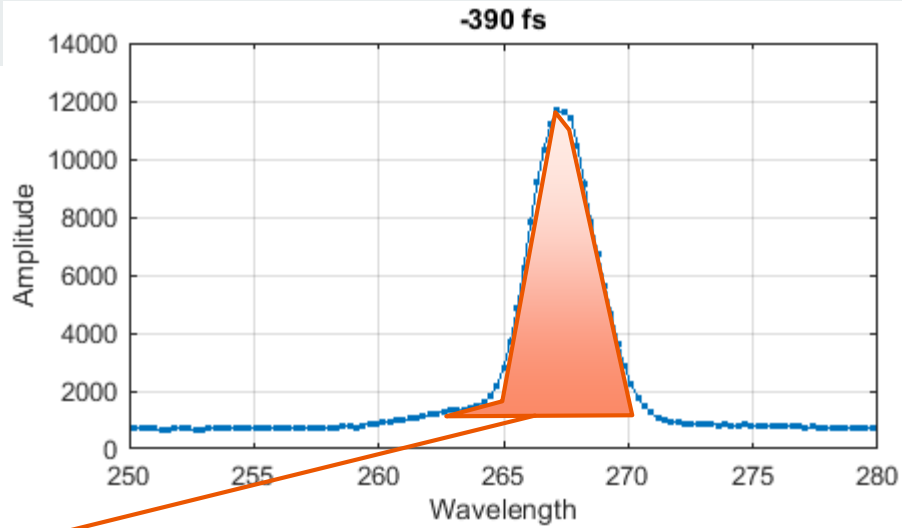


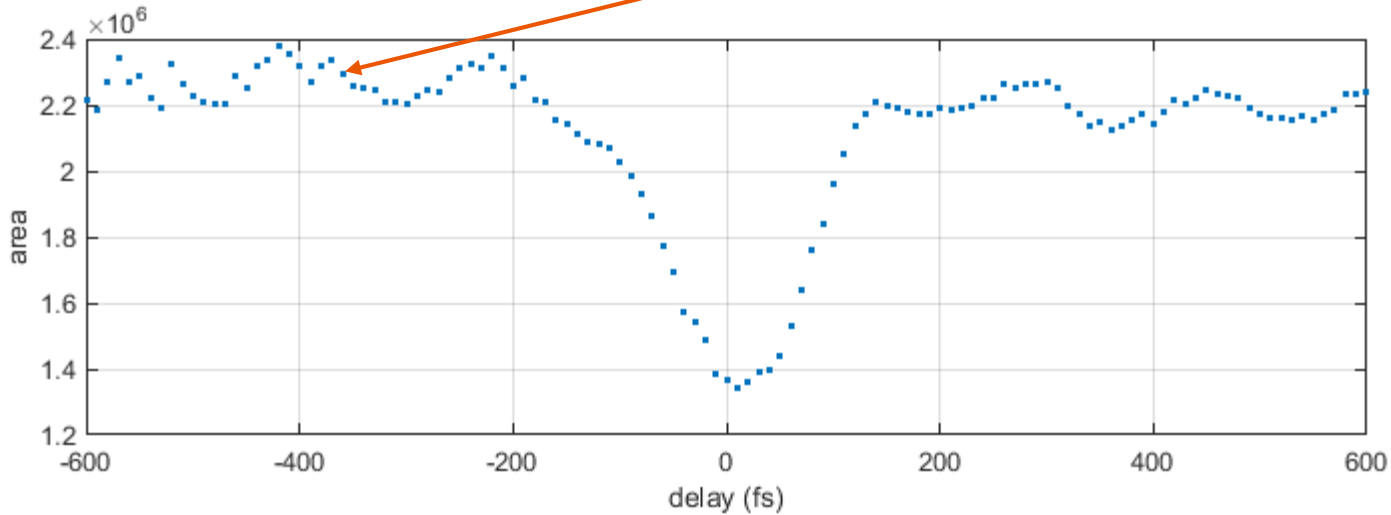


How to Get Pulse Width

Step 3) Analyze data

- plot sum of spectra over region vs delay
  - can use peaks
  - or area



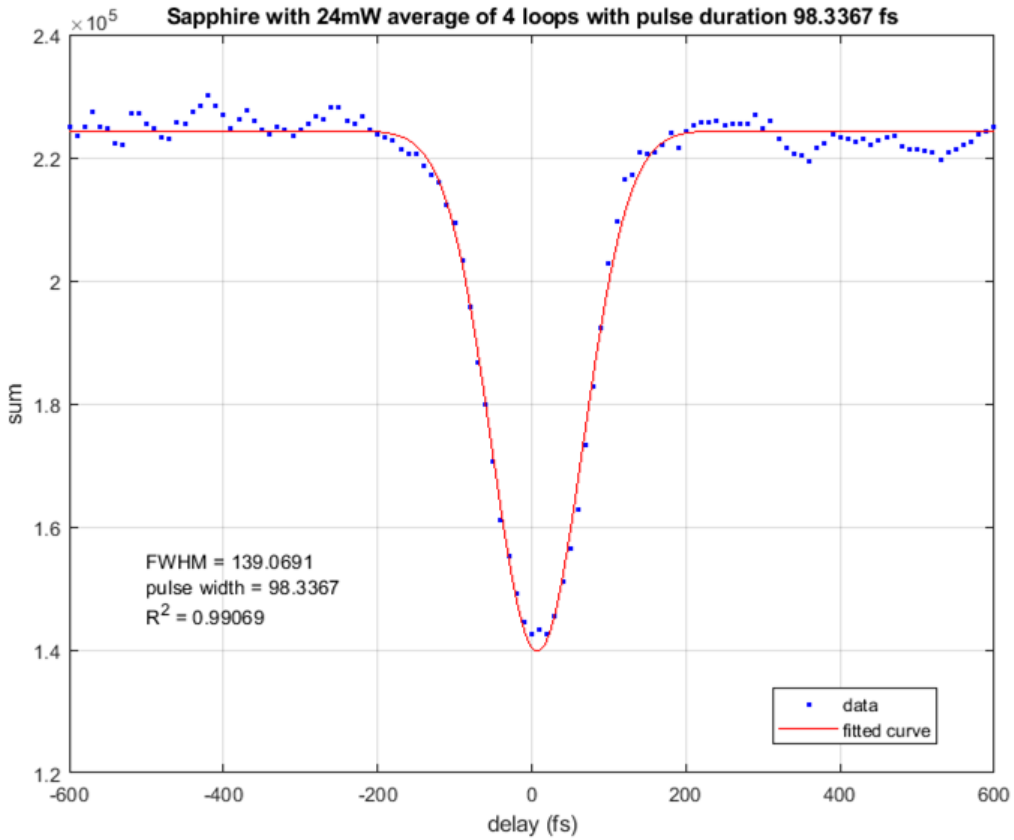


How to Get Pulse Width

Step 3) Analyze data

- plot sum of spectra over region vs delay
  - can use peaks
  - or area

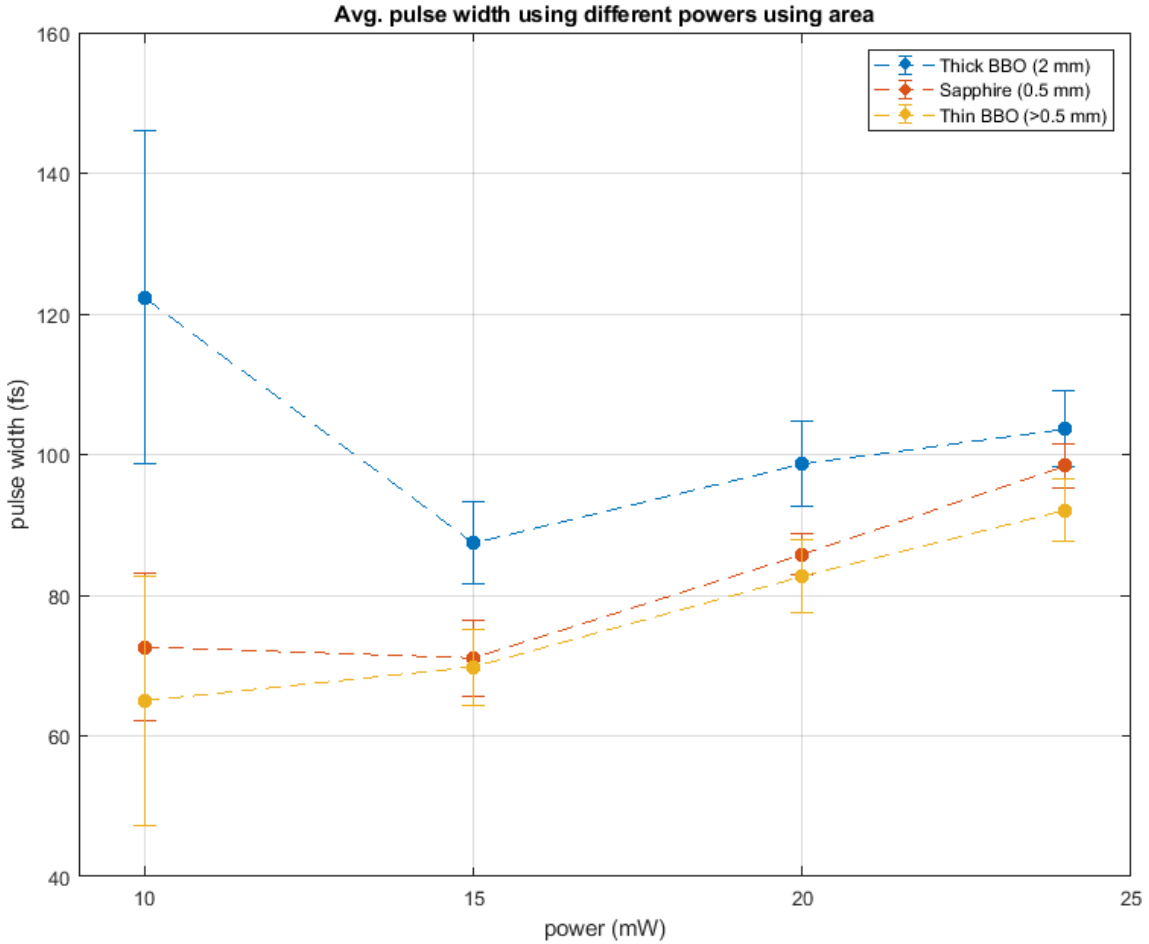
- fit a gaussian to deconvolute and get pulse width



FLAME 266 nm Uncompressed

Crystal type

- can analyze different powers and different crystals
- look into band gap of different crystals
- thicker crystals have greater PW
- increase in PW with power

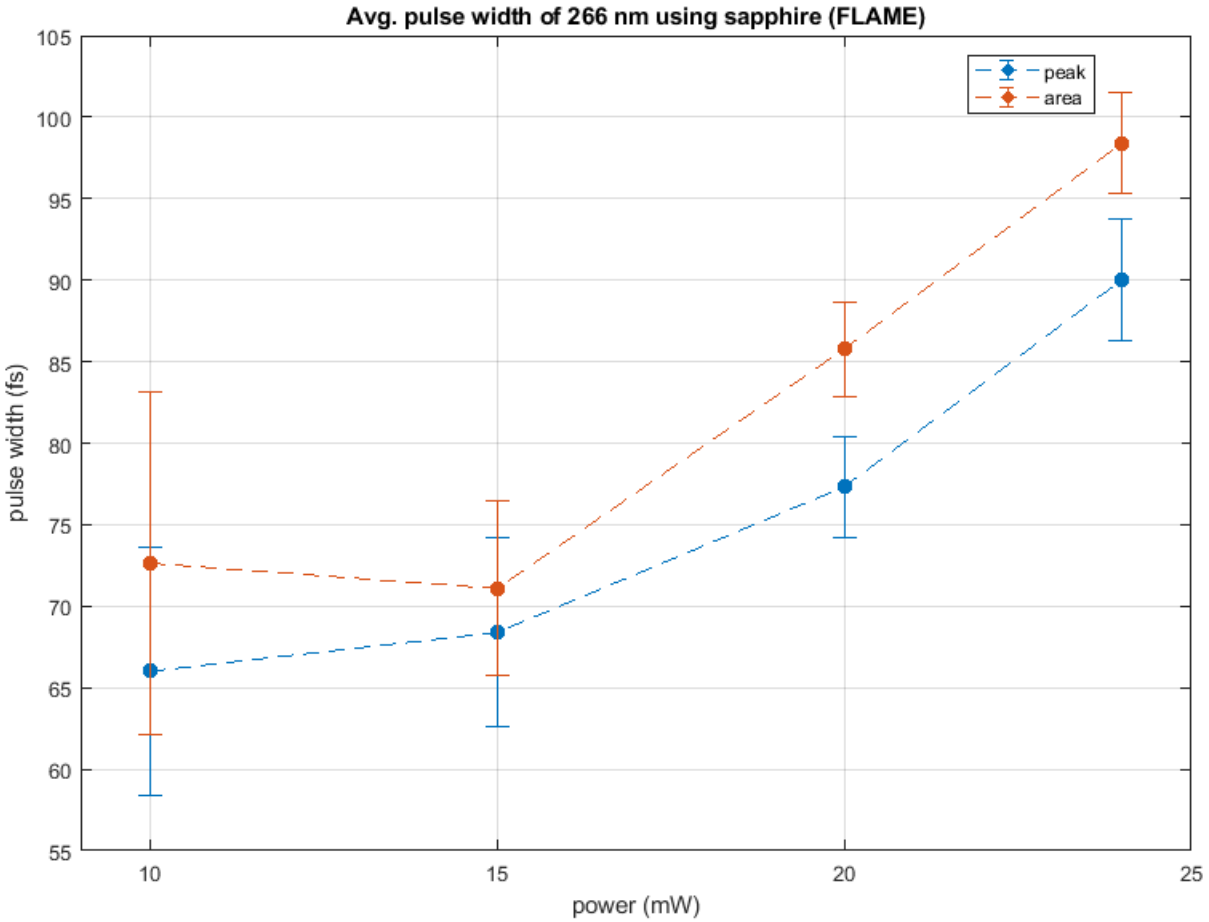


FLAME 266 nm Uncompressed

Peak vs Area

- can analyze different powers and using peak vs area values

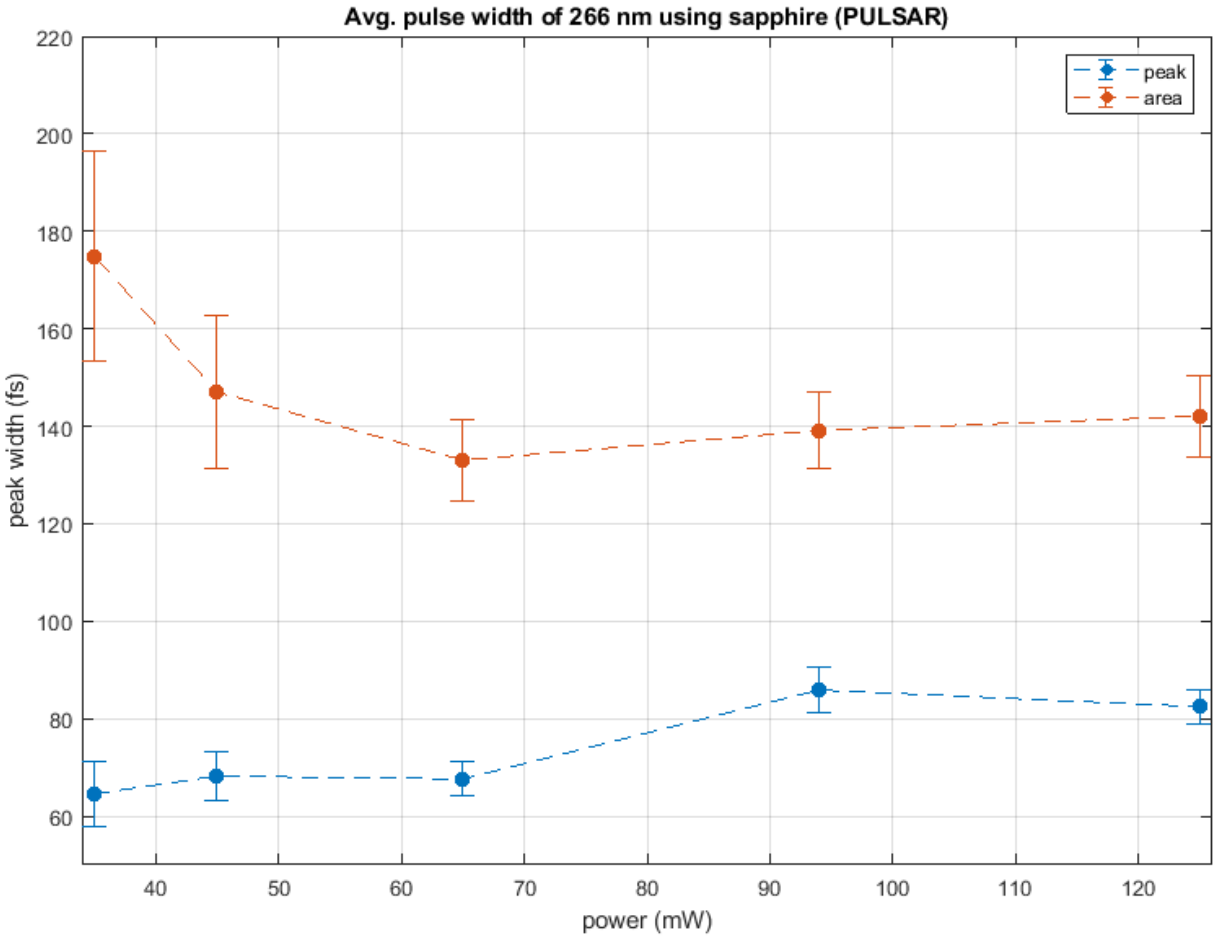
- Difference appears to be within error
  - about 10 fs



PULSAR 266nm Uncompressed

Peak vs Area

- see a huge difference between the area and peak measurements
  - 50 fs to 100 fs difference
- Area starts depleting before peak
  - chirp?

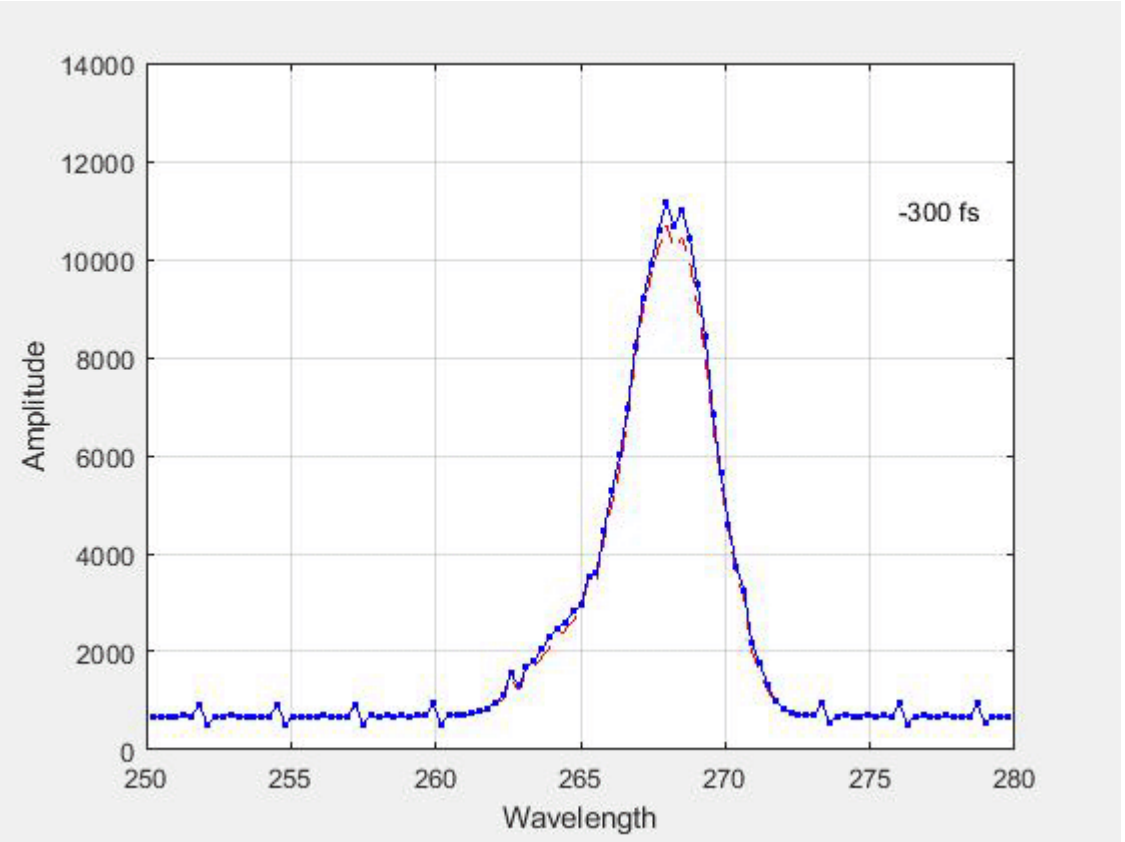


PULSAR 266nm Uncompressed

Chirp Evidence in Spectrometer Data

- can see the peak shift as the different wavelengths come in at different speeds
  - higher wavelengths faster

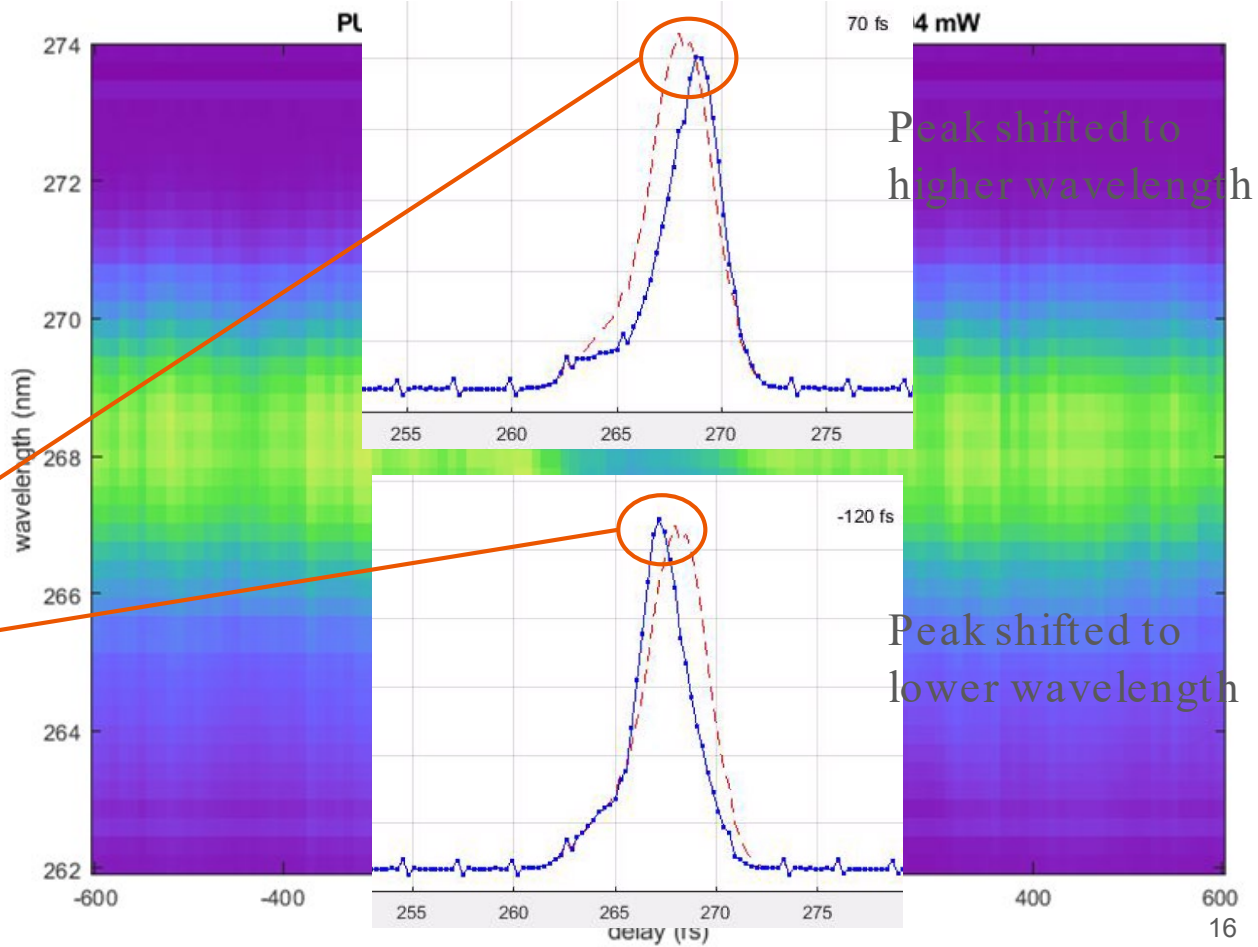
- follow the outline of the average spectra shape



PULSAR 266 nm Uncompressed

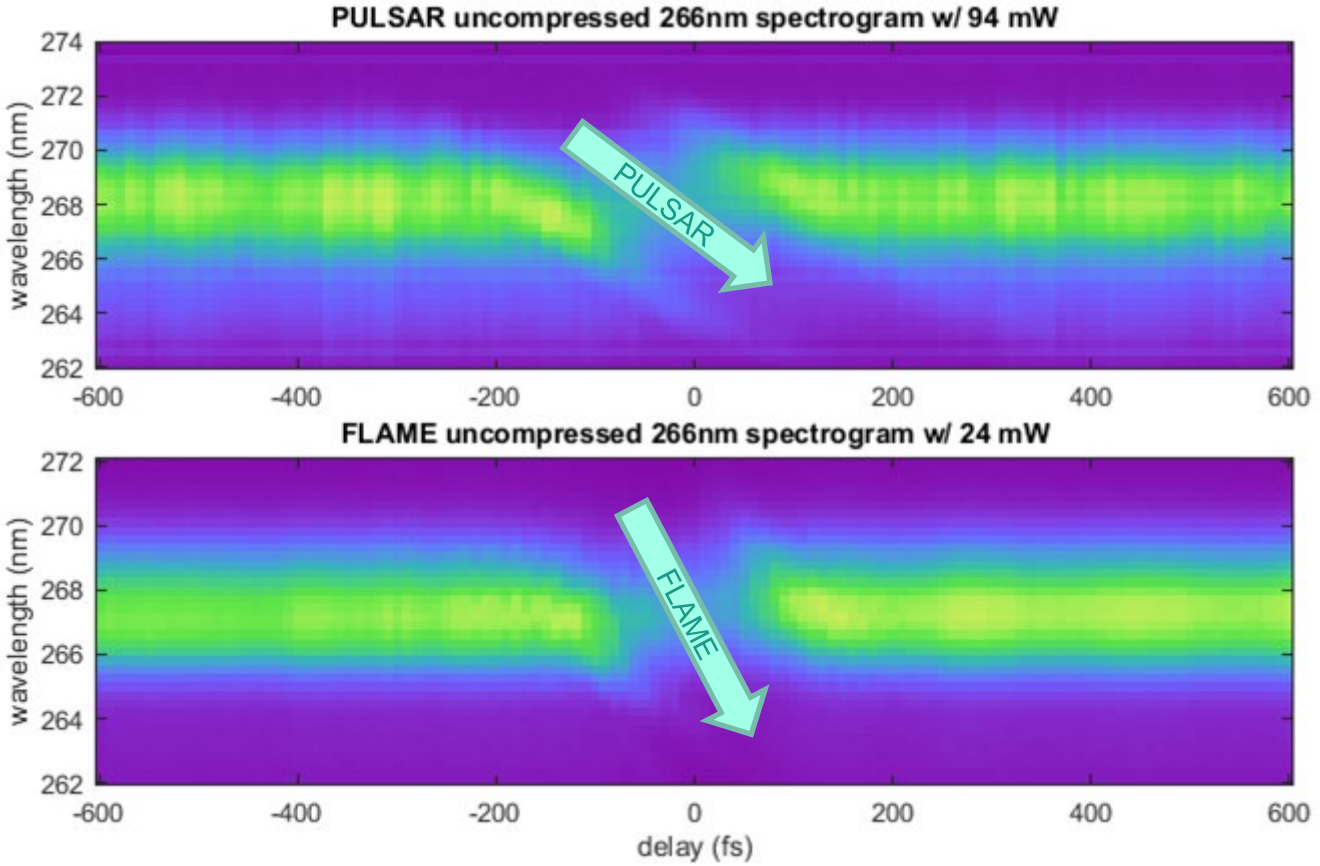
Autocorrelator 2D Spectrogram

- clearly see a diagonal signature in the depletion
- clearer visual of chirped pulse



PULSAR 266nm vs FLAME 266nm Spectrogram

- clearly see a diagonal signature in the depletion
  - Expect vertical slope when unchirped
- the FLAME data appears to have less of a slope compared to PULSAR

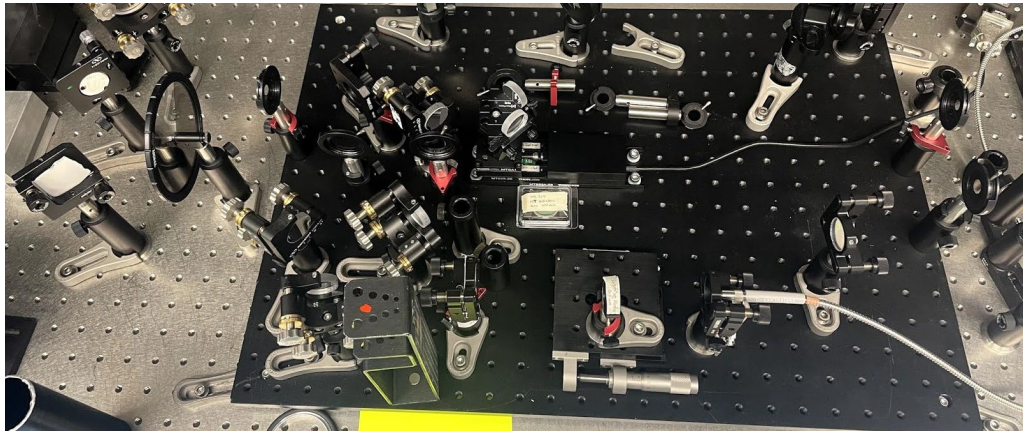


Conclusion

- The autocorrelator is a promising method for measuring pulse width

- Can be used as a chirp detection tool
  - Literature shows can extract FROG traces

- Future work: implementing noise/background subtraction techniques



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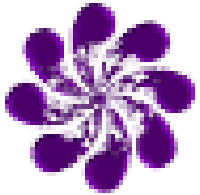

Thank you for your time!
Questions?

References

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Pulse Width for 200 nm from PULSAR

Pulse Width (PW) Measurement

- get PW of 151 +/- 13 fs
  - expect 140 fs
- very noisy