Two-beam SPIDER for dual-pulse single-shot characterization

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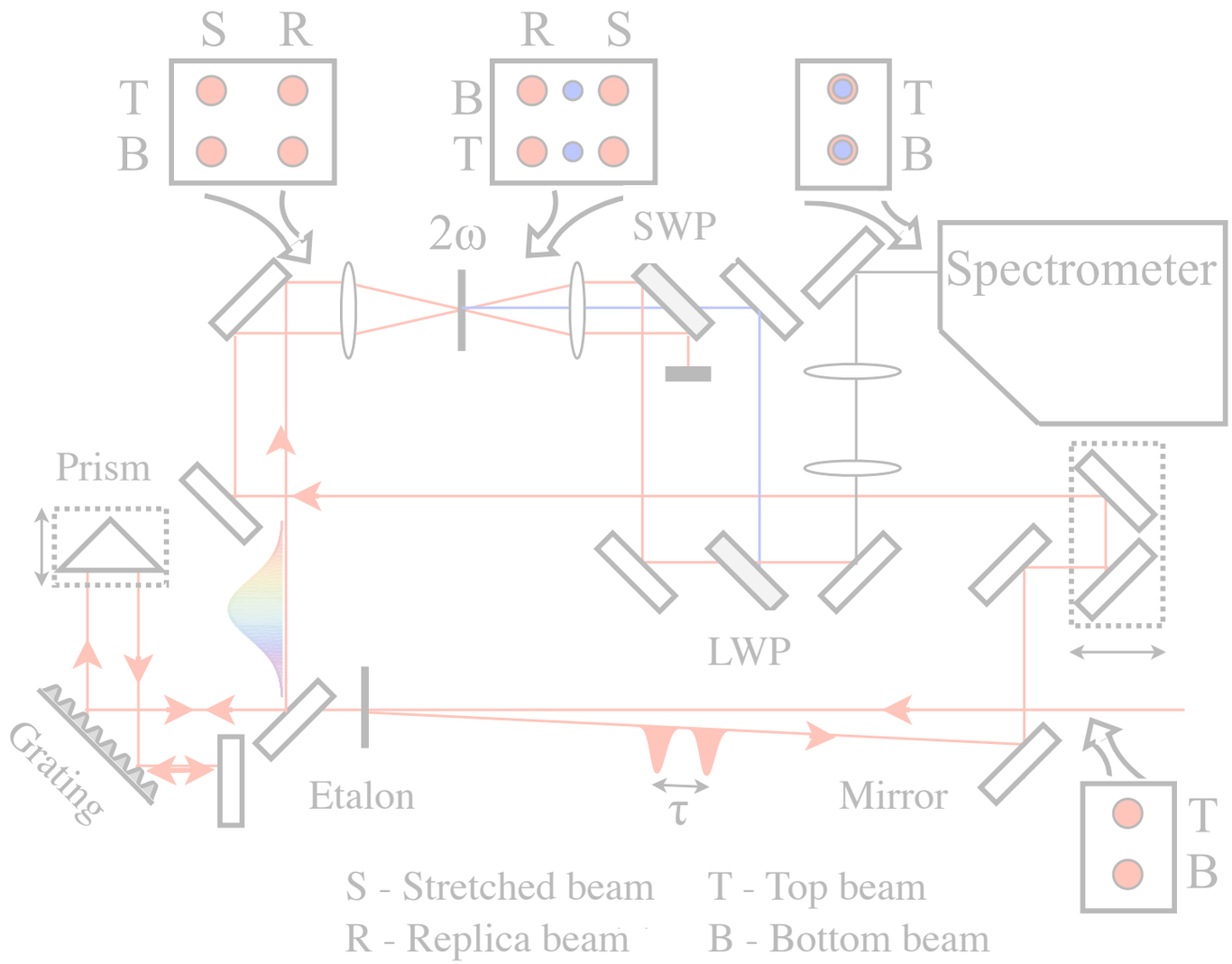
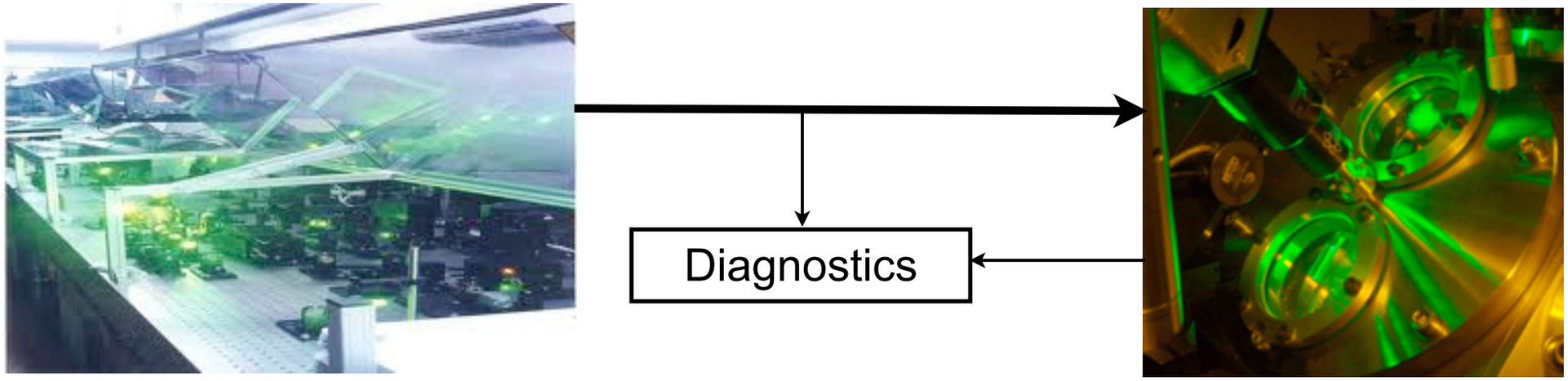
Outline

- **Motivation and potential applications**
- **Two-beam SPIDER (TB-SPIDER)**
  - **Optical layout**
  - **Experimental validation**
- **TB-SPIDER for phase amplification experiment**
- **Conclusions**

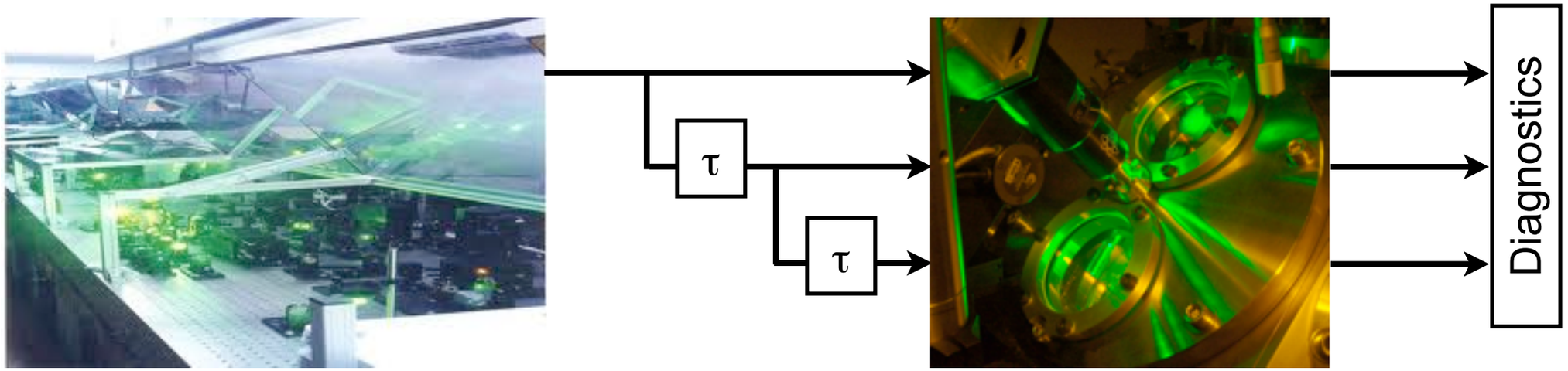


Simultaneous temporal characterization of multiple pulses can benefit ultrahigh intensity laser experiments

- **Pulse characterization/diagnostics in ultrahigh intensity systems**



- **Multi-beam probing of dynamic processes**

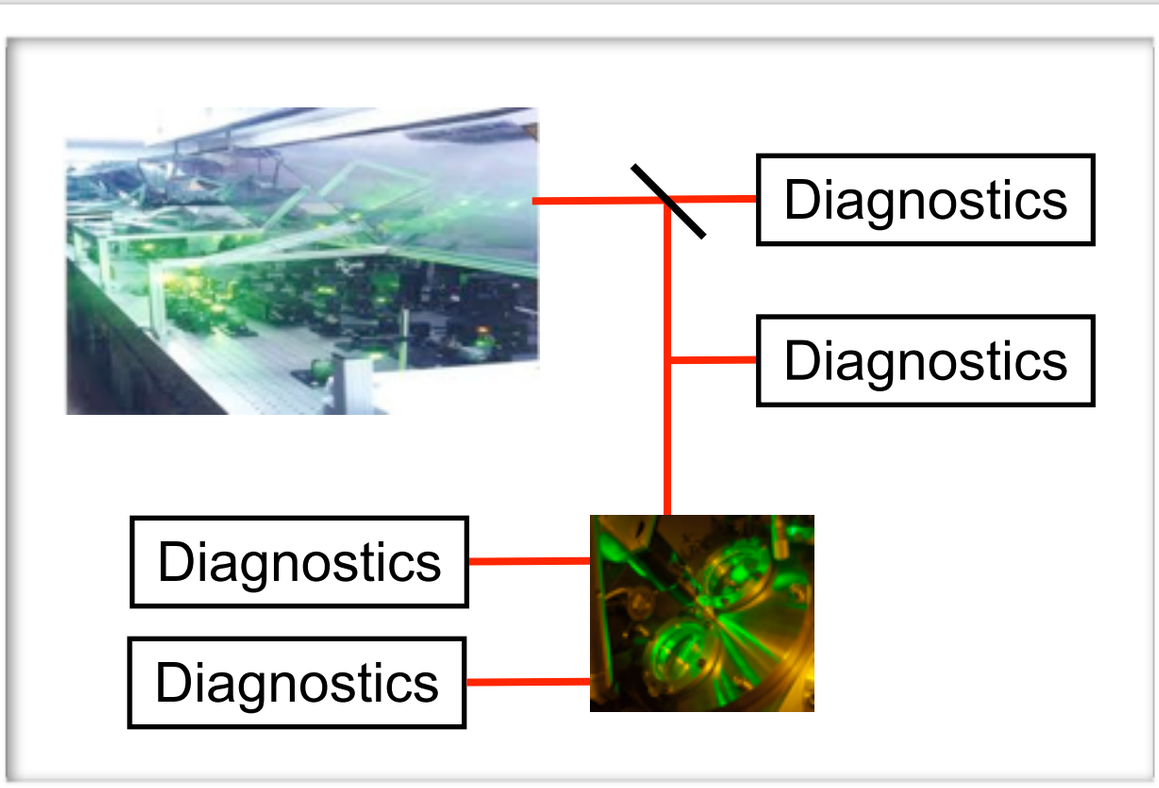


http://forum.pakistanidefence.com/lofiversion/index.php/t89796.html

http://sciencewise.anu.edu.au/articles/chalcogenide

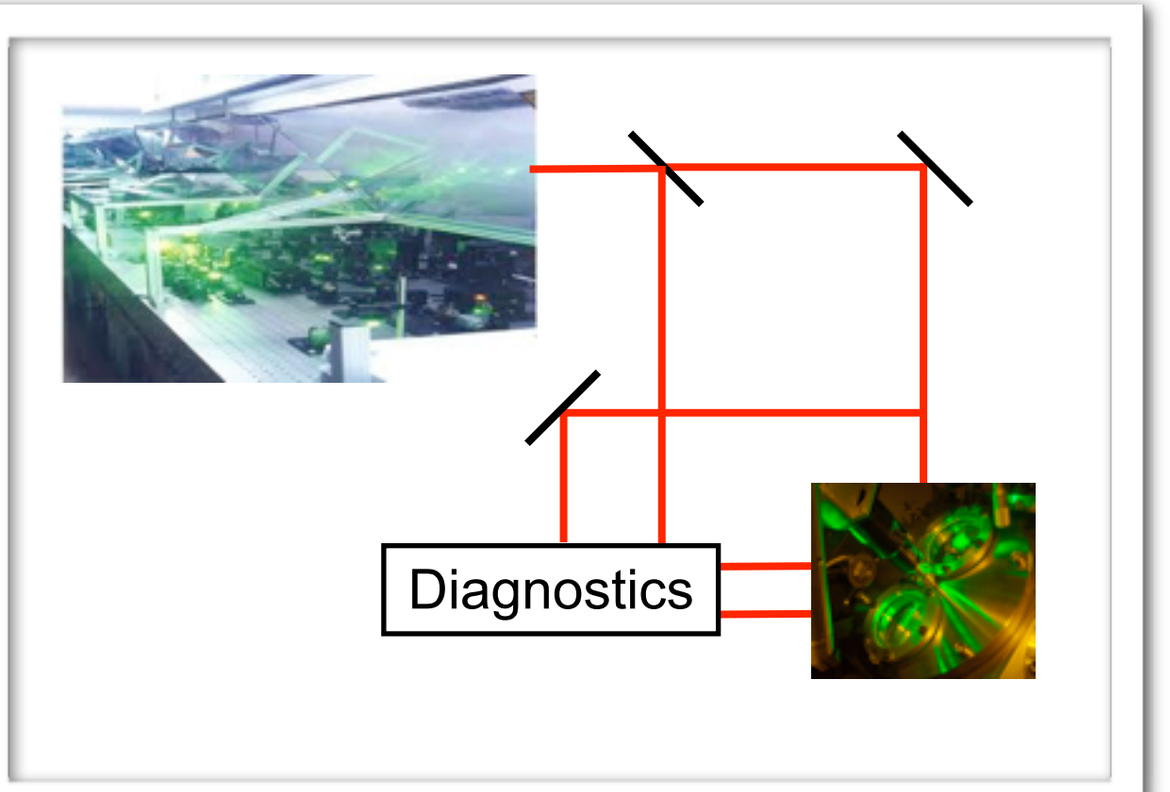
Multiple pulses can be measured by multiple instruments, but more convenient solutions are desired

Multiple instruments



- Large footprint
- Expensive
- Difficult/time-consuming to align

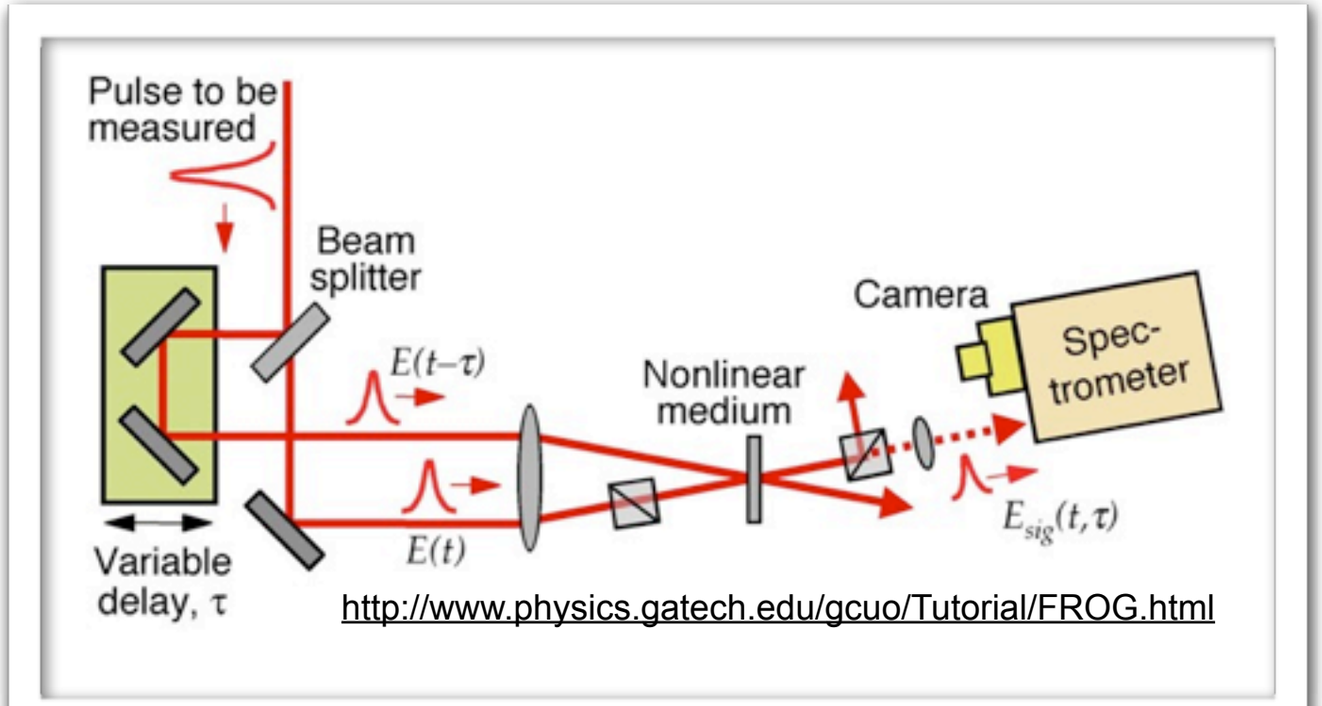
Single instrument with multiple beams



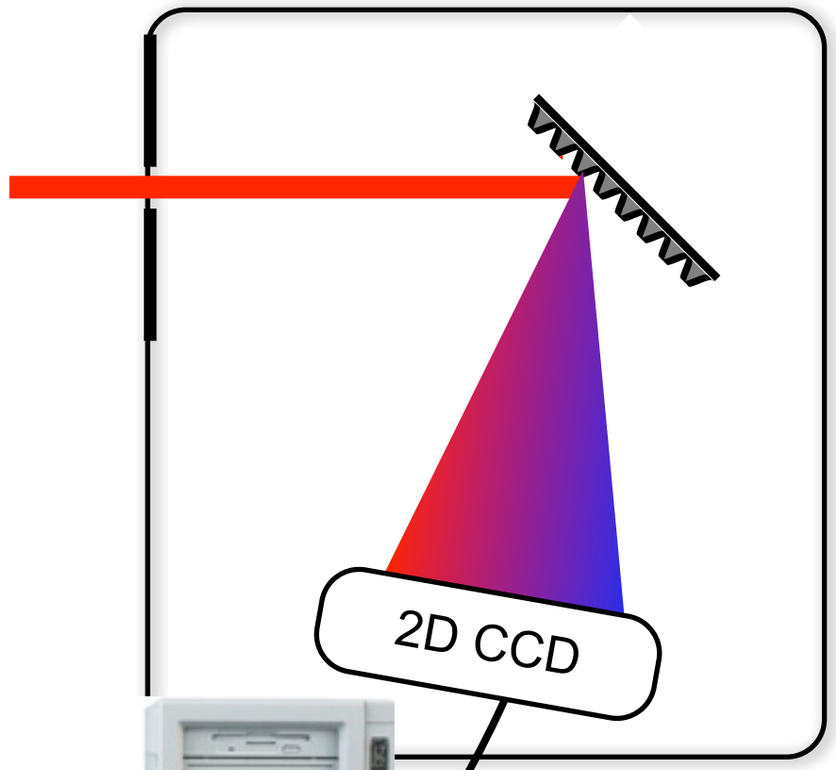
- Smaller footprint
- Less expensive

Candidate techniques for multiplexed temporal characterization

FROG



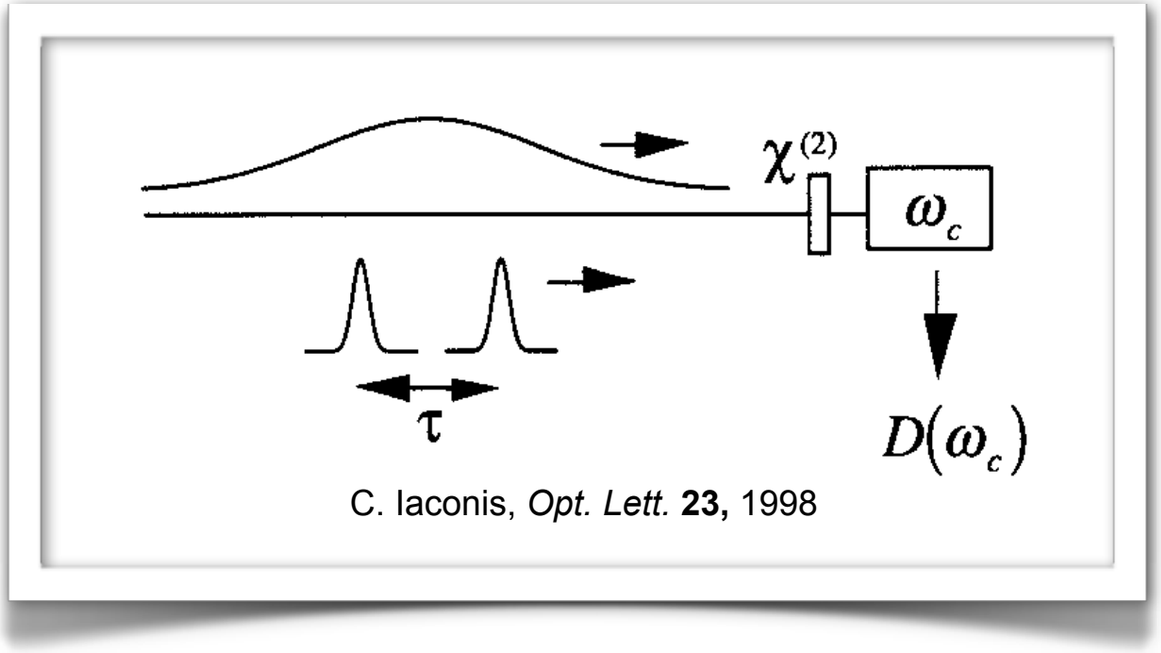
http://www.physics.gatech.edu/gcuo/Tutorial/FROG.html



- TREEFROG exists for twin-beam measurement
- Single-shot requires time-space encoding, which can be difficult for distorted beams
- Requires 2D spectrometer

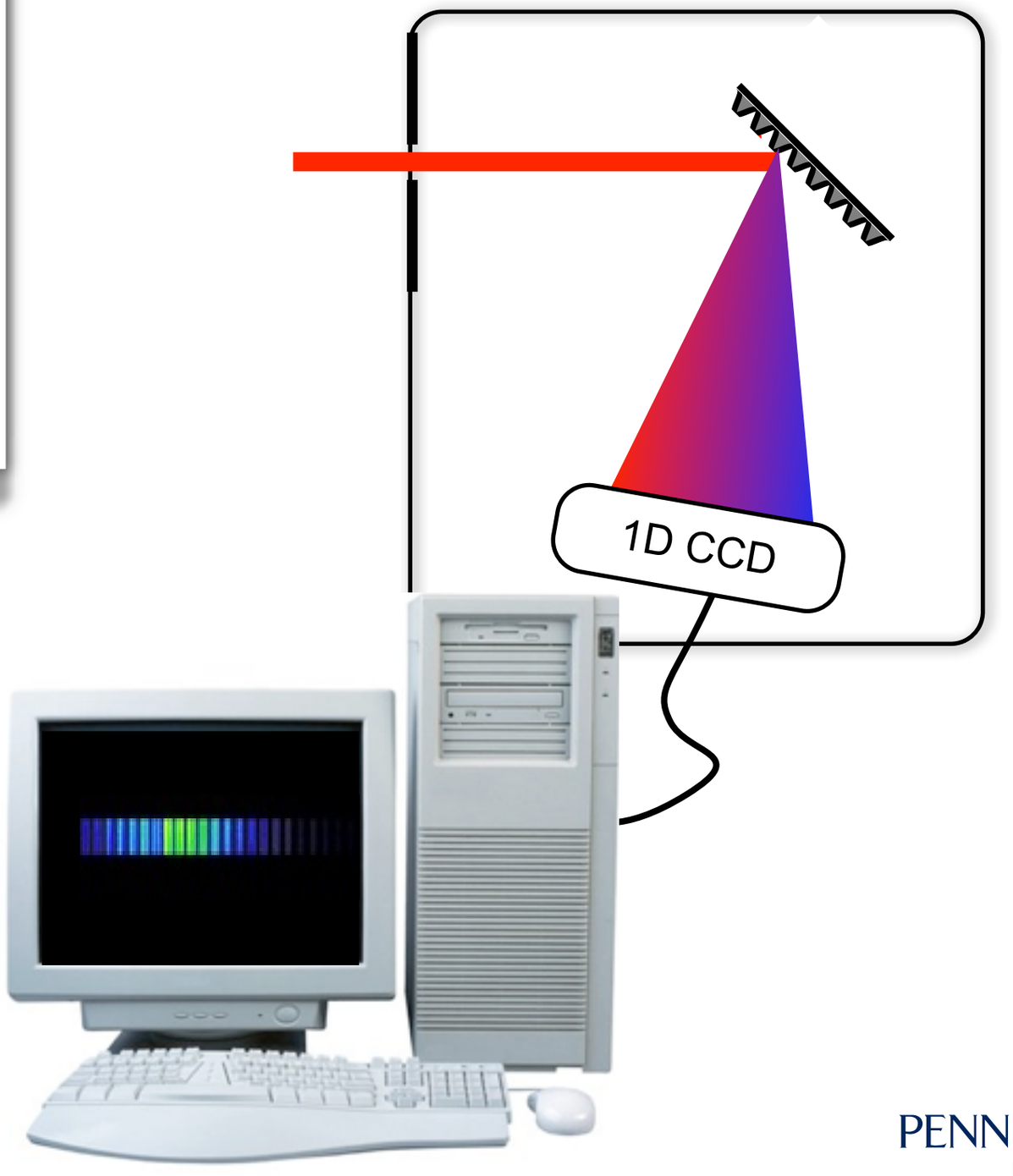
Candidate techniques for multiplexed temporal characterization (2)

SPIDER

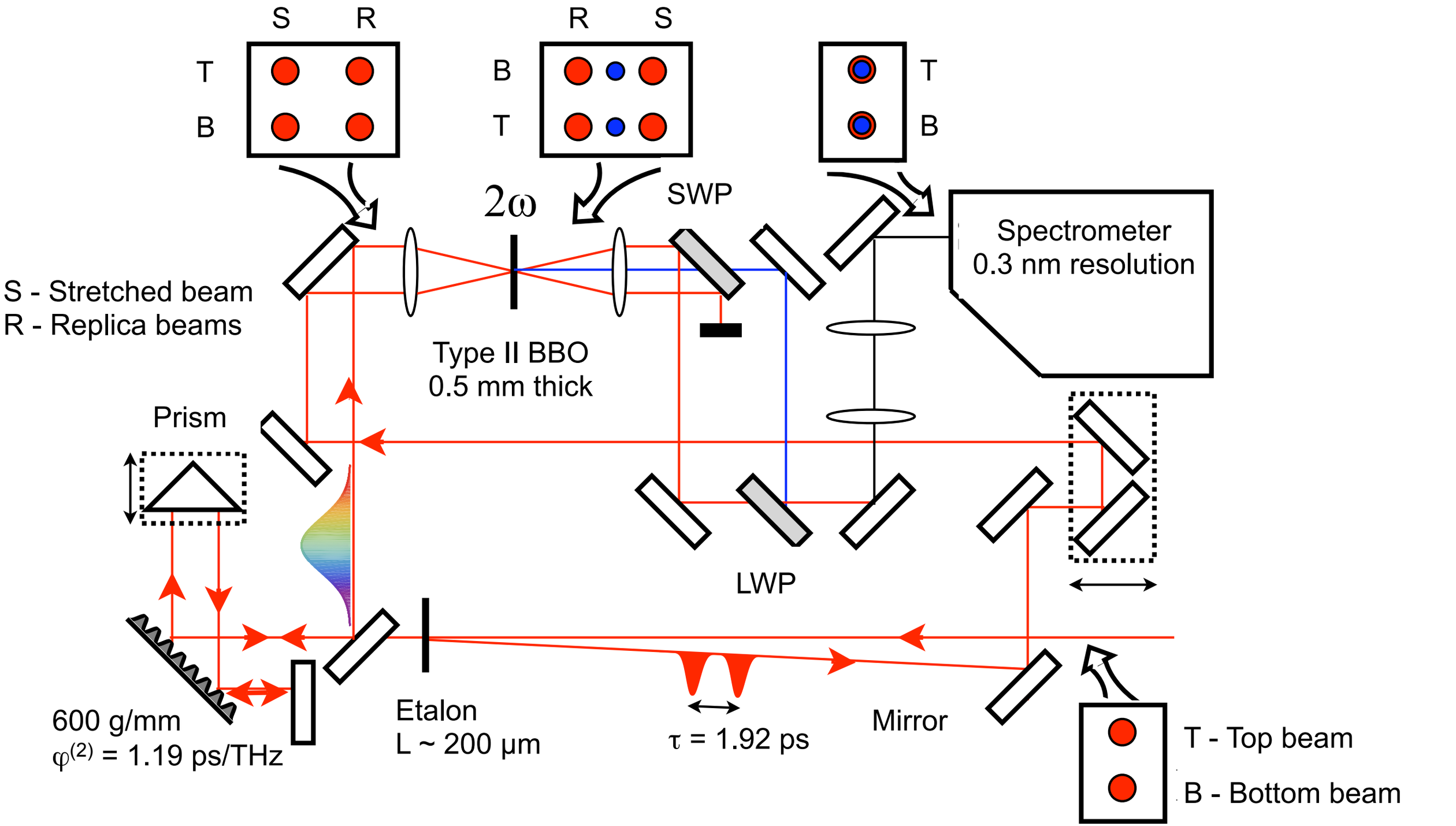


C. Iaconis, *Opt. Lett.* **23,** 1998

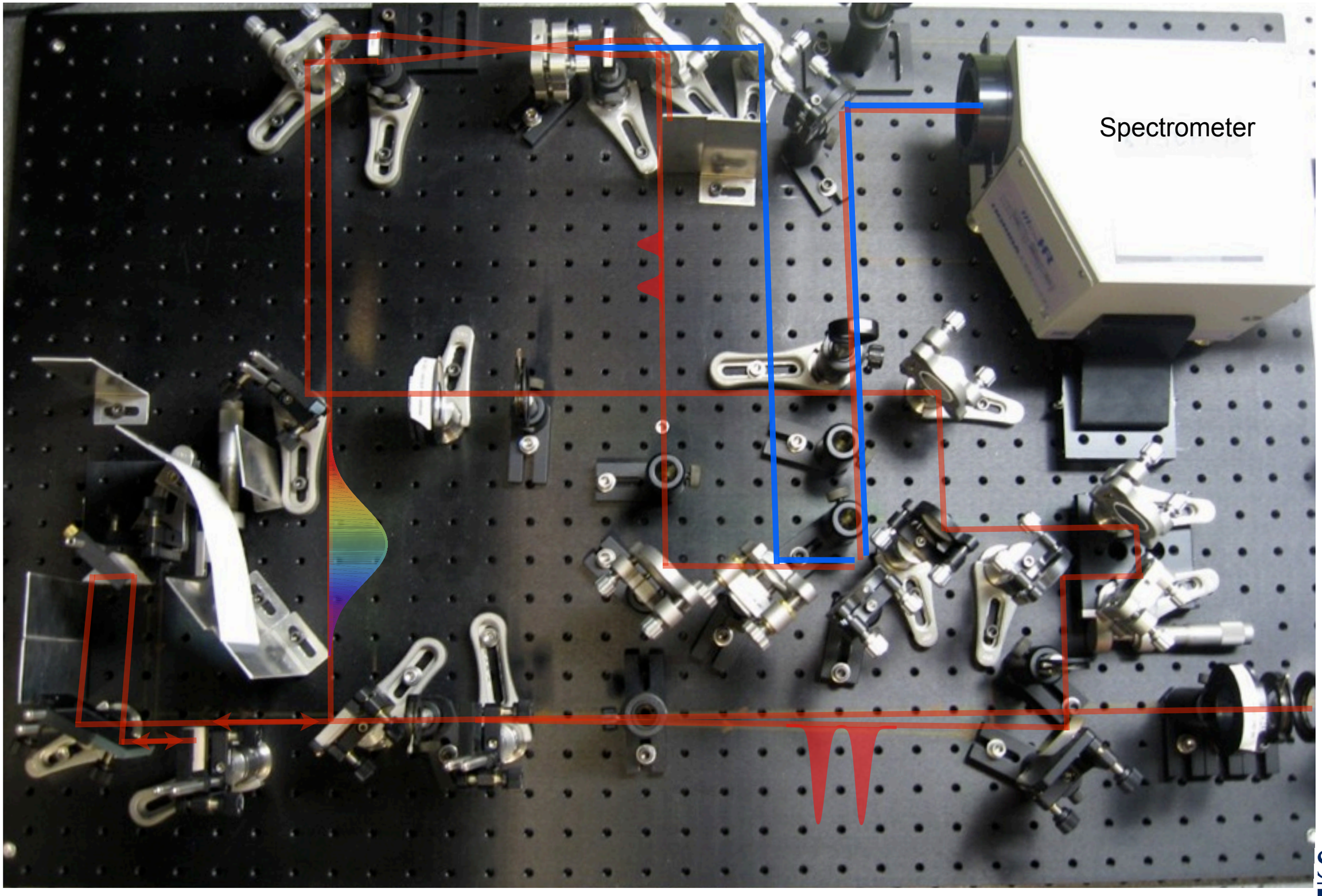
- Only requires 1D spectrometer for traditional implementation
- Vertical multiplexing provides a convenient method for multi-beam measurement



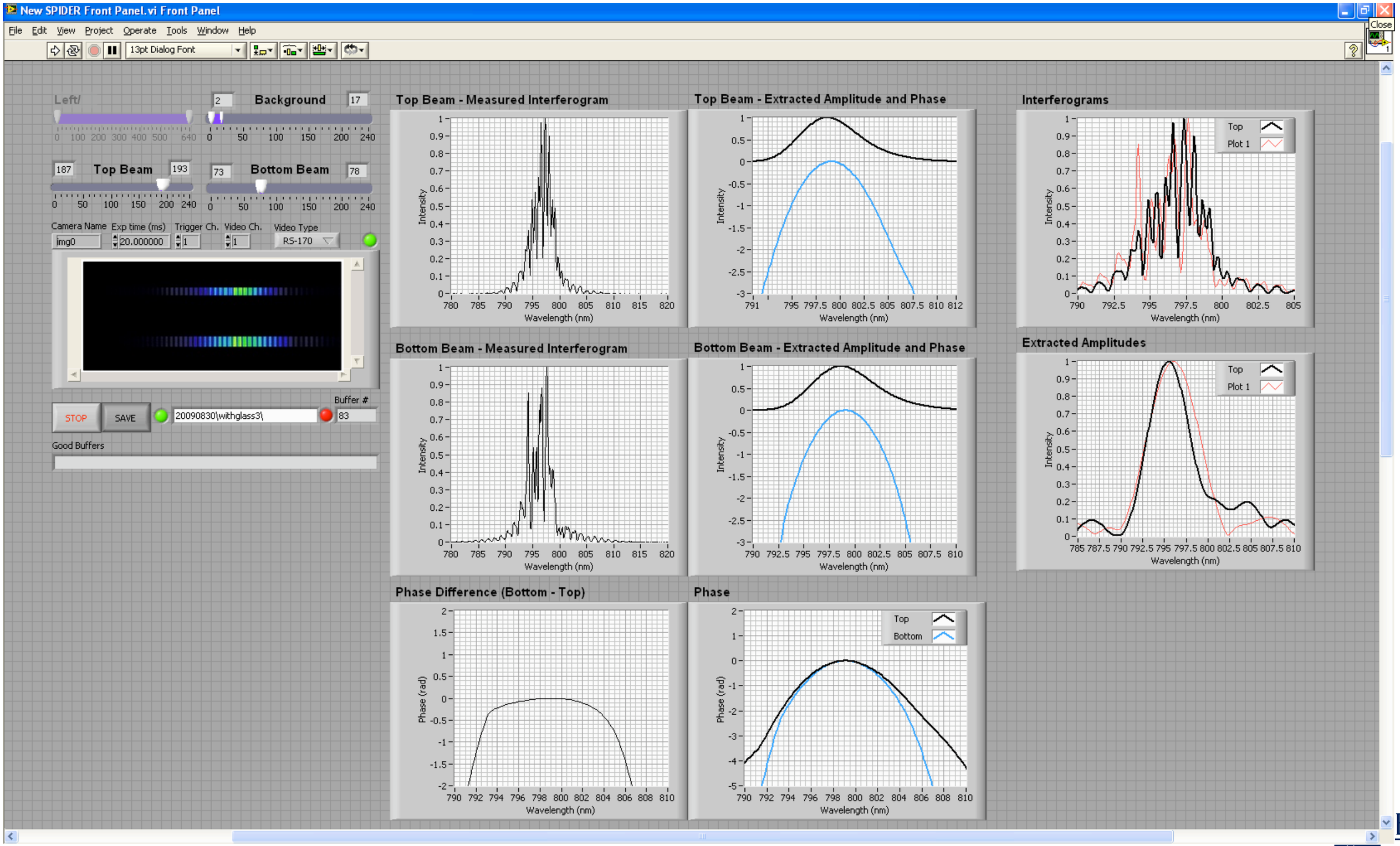
Implementation of TB-SPIDER



TB-SPIDER experimental layout

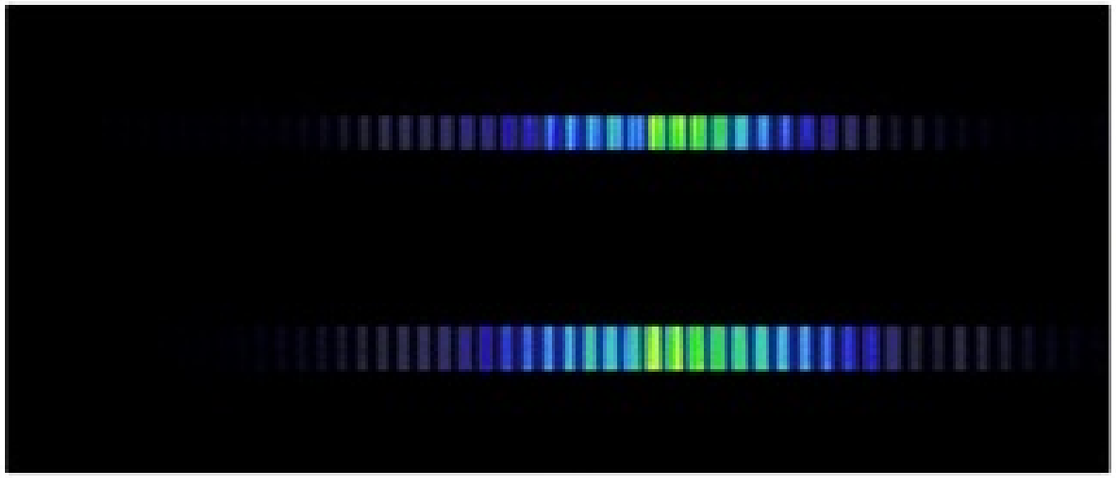


TB-SPIDER user interface



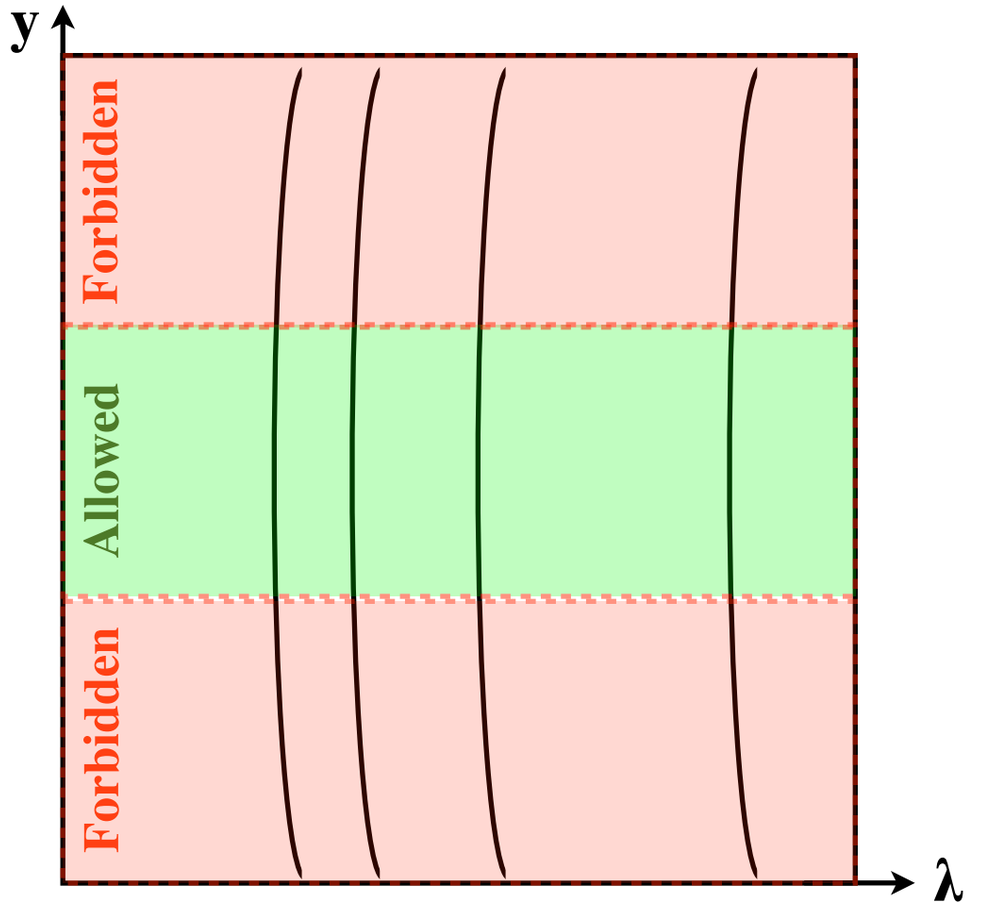
TB-SPIDER data acquisition and analysis

- The 2D spectrometer has additional degrees of freedom for alignment
- Ideal image from spectrometer:



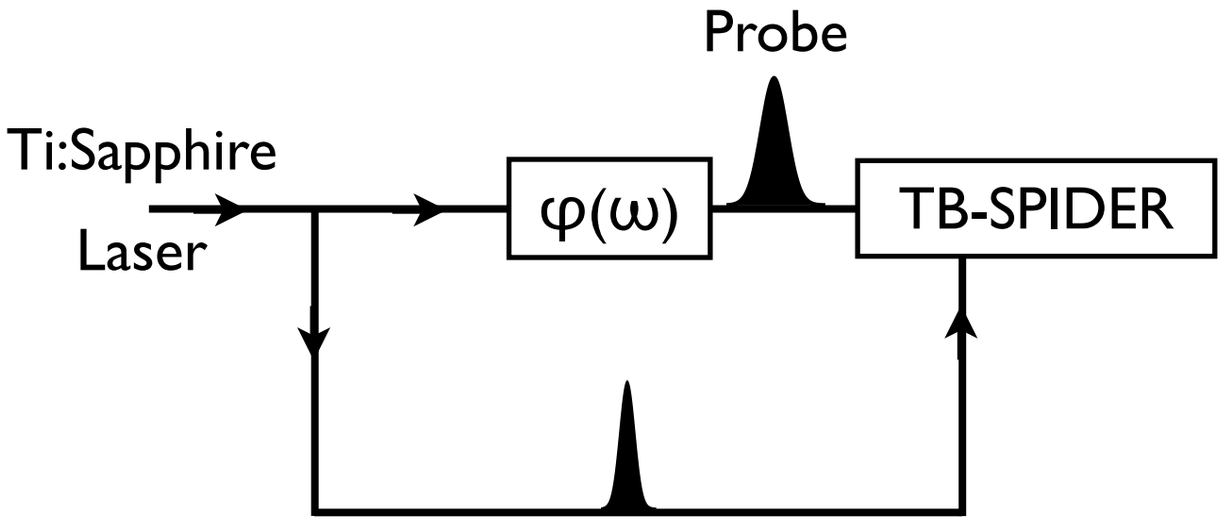
- Imaging system in the spectrometer can lead to curved field lines at the extremities of the image:

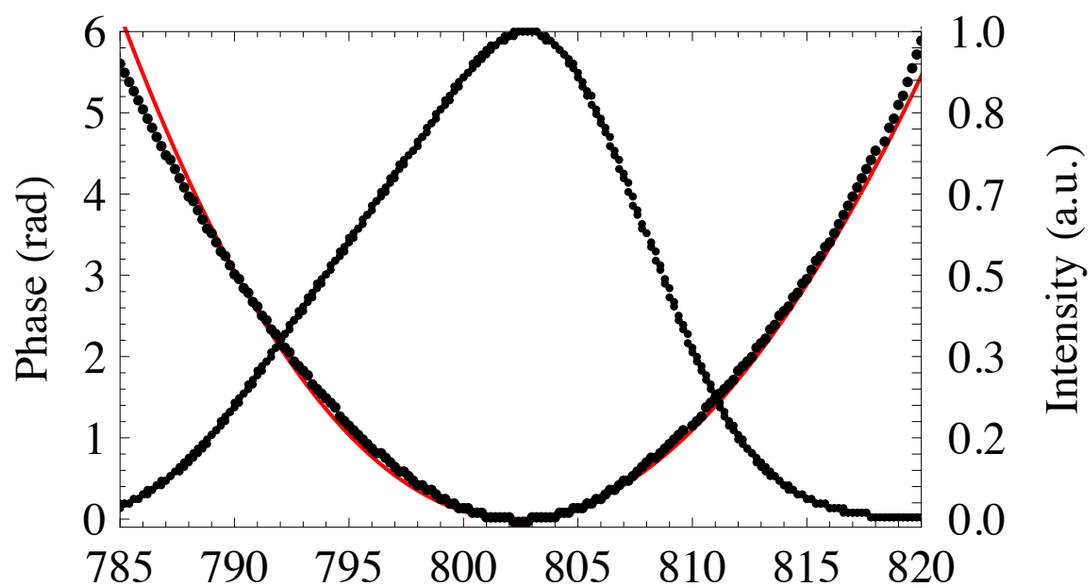
- Restricting beams to the center region of the entrance slit minimizes curvature
- Independent λ calibration for each beam



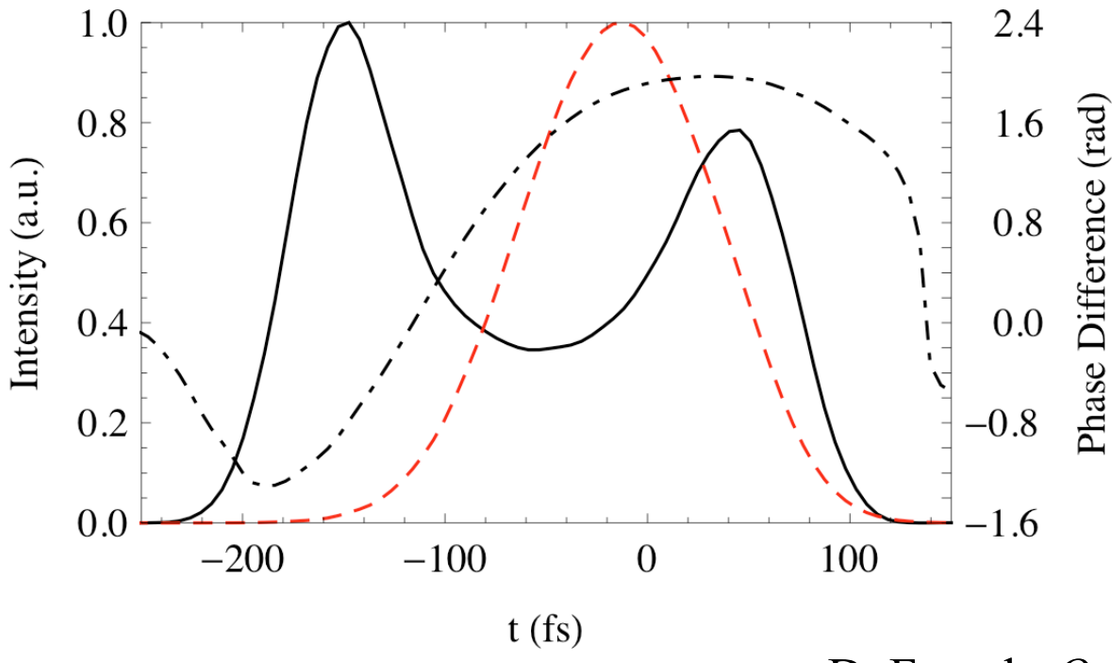
Experimental validation of TB-SPIDER

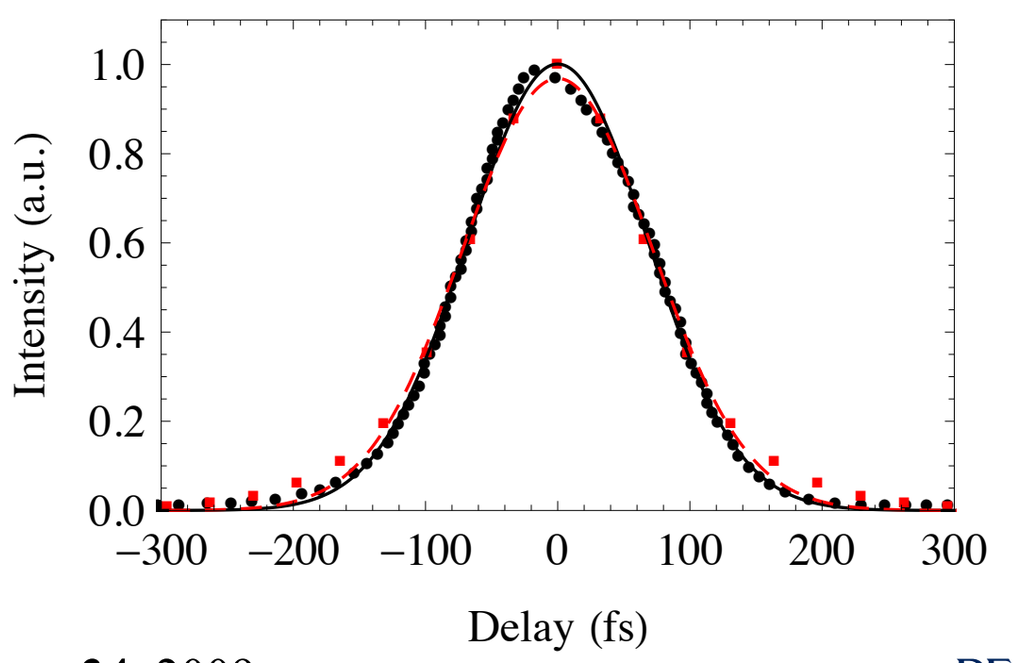
- **Measure dispersion for 10cm of glass**





Reference

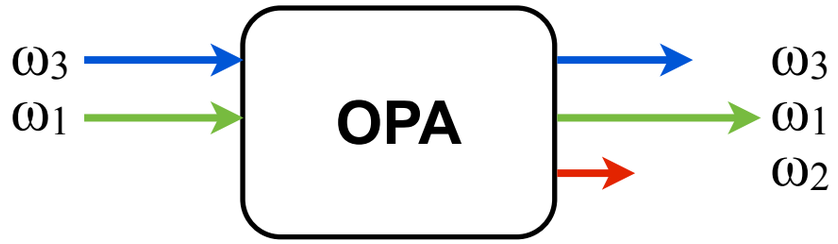




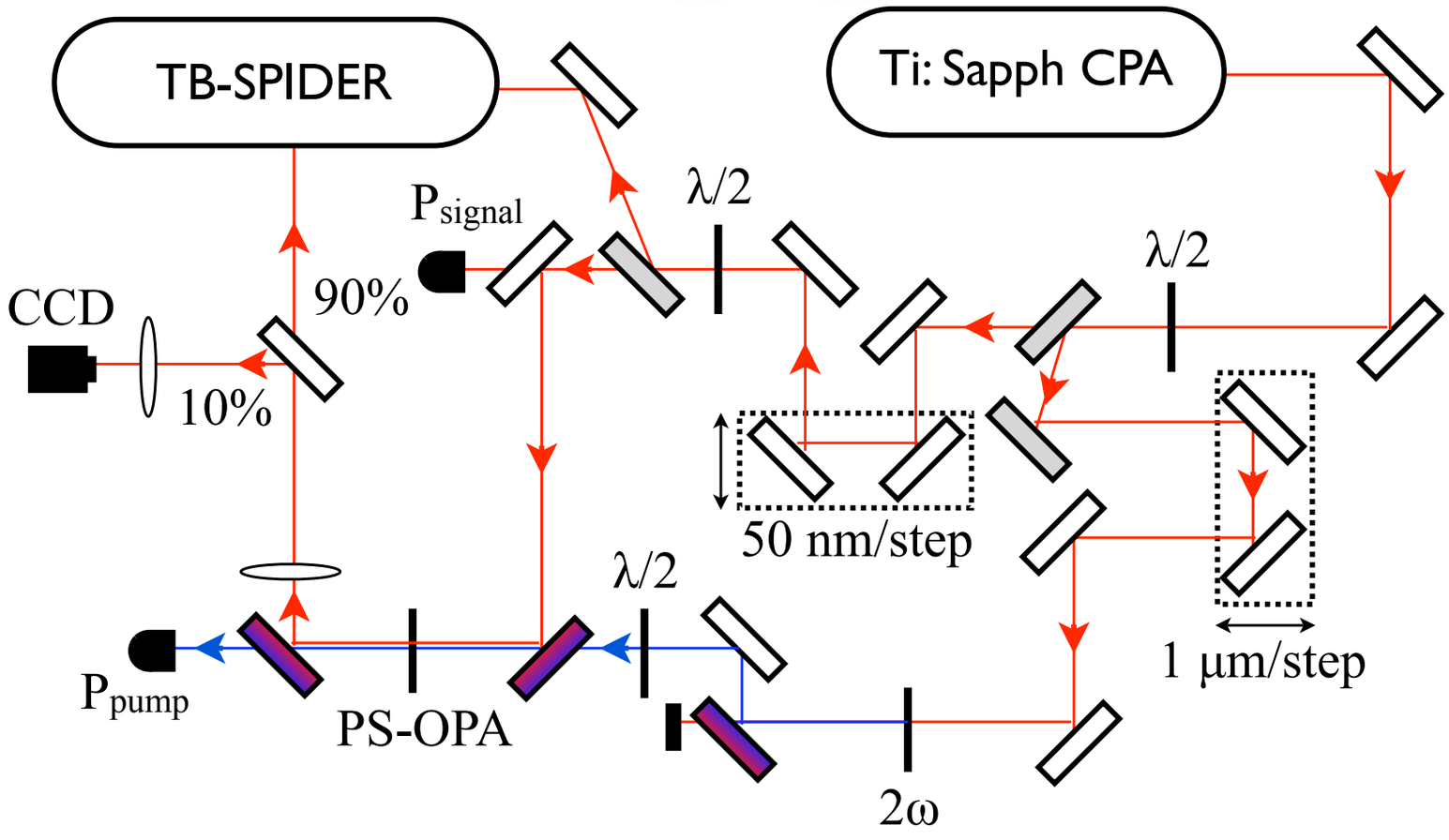
D. French, *Opt. Lett.*, **34**, 2009

TB-SPIDER was deployed as a diagnostic for a single-shot phase amplification experiment

Optical parametric amplification (OPA):

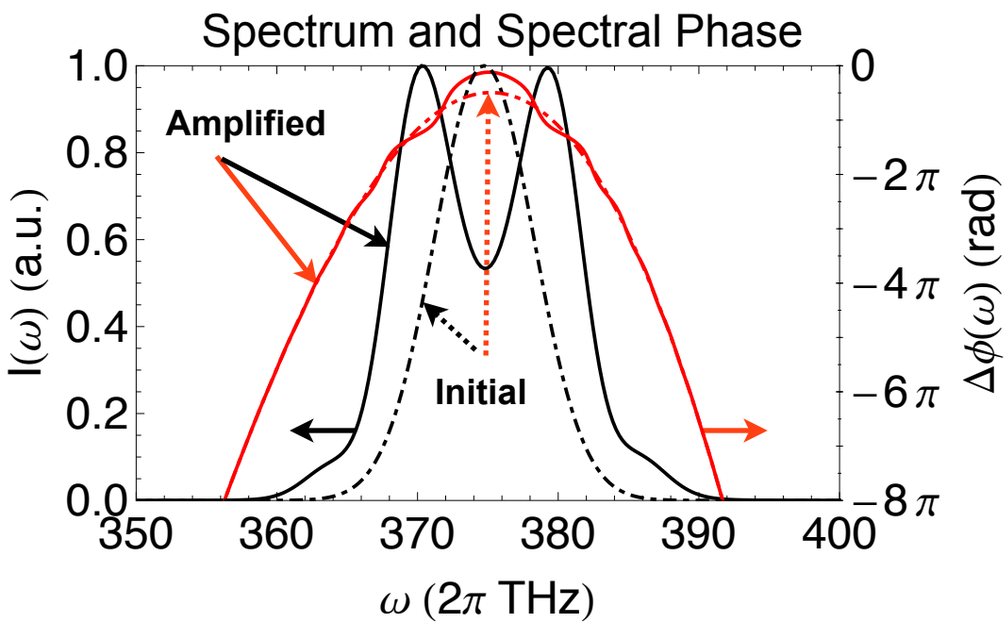


Phase-sensitive OPA (PSOPA):



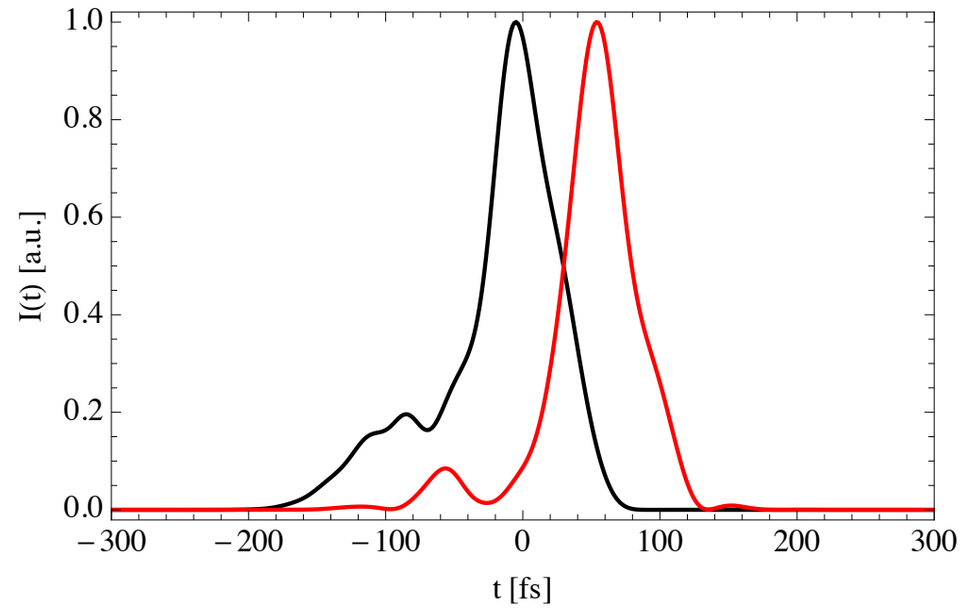
TB-SPIDER was deployed as a diagnostic for a single-shot phase amplification experiment (2)

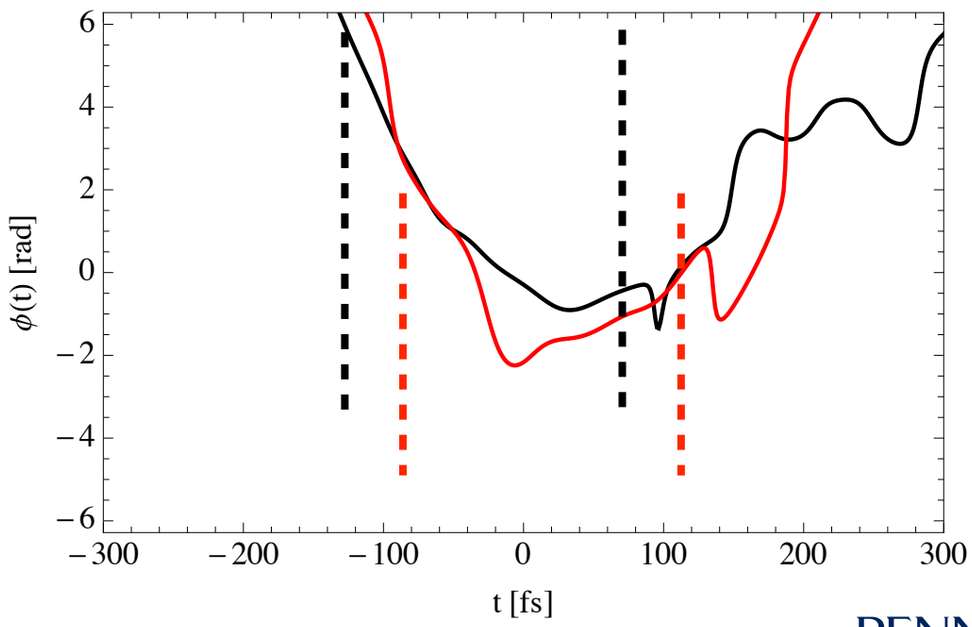
- The phase-sensitive OPA acts as a *phase* amplifier rather than an energy amplifier
- Ideally: $\Delta\phi_{out} = G\,\Delta\phi_{in}$
- Calculation



Y. Yin, "Phase-Sensitive Temporal Pulse Shaping for Ultrahigh Intensity Lasers," WP4, Wed. 4:30

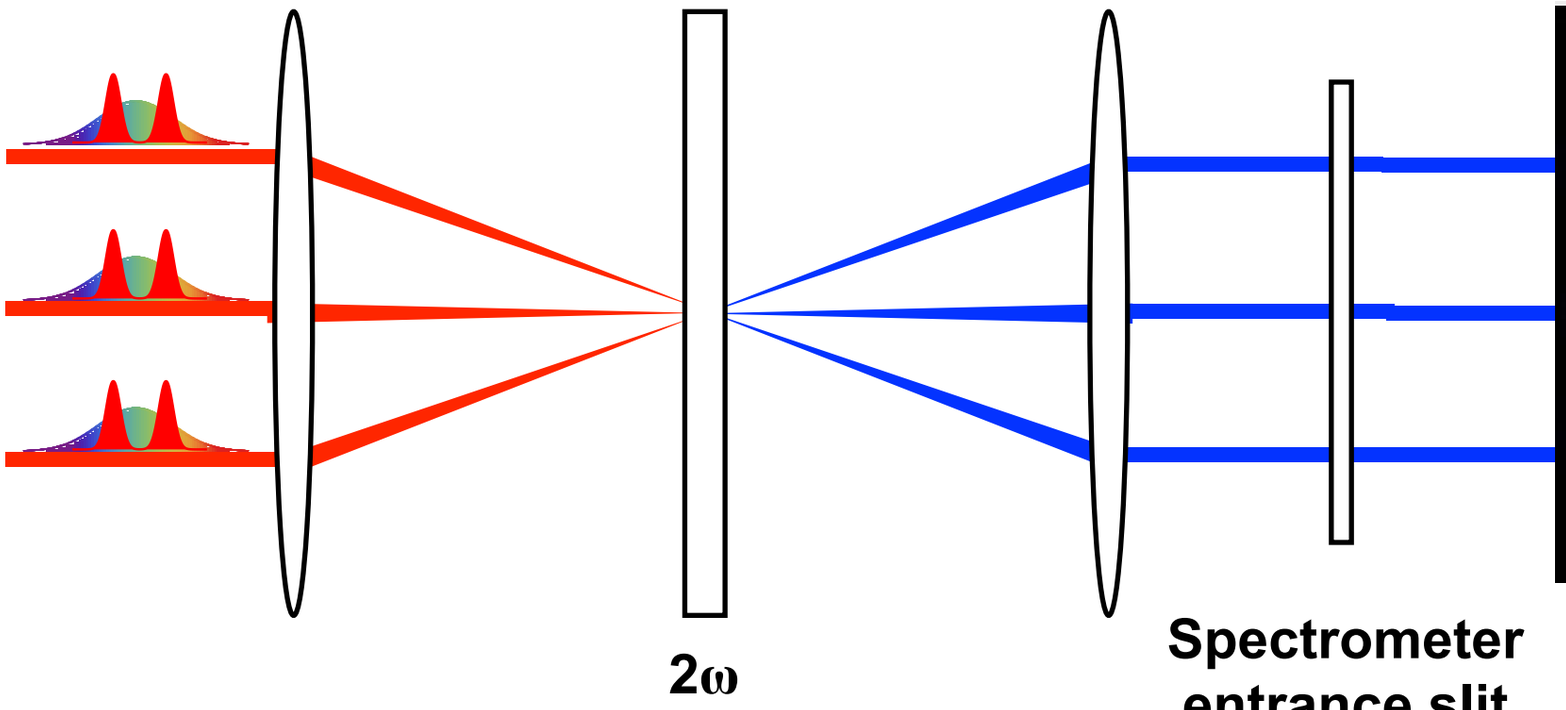
- Measurement

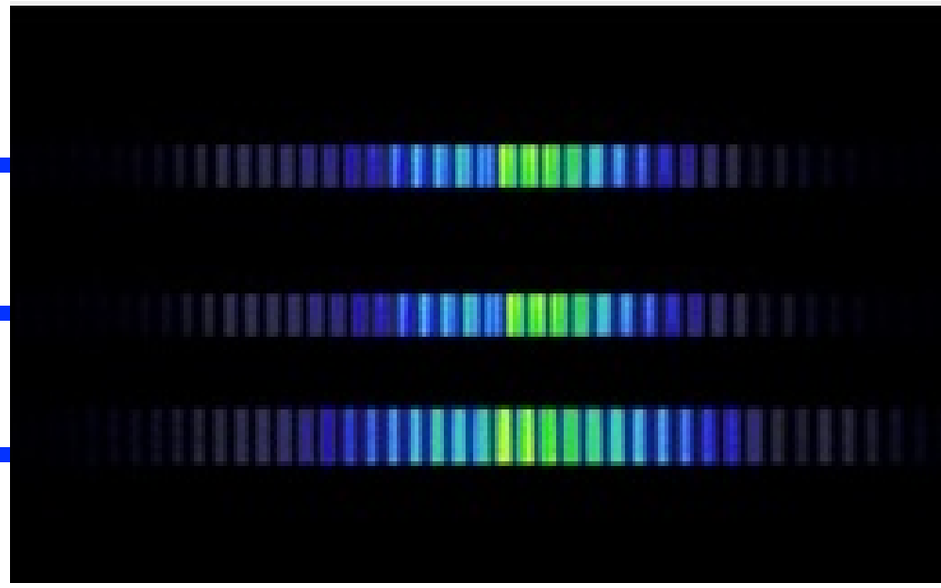




TB-SPIDER scaling for characterization of multiple pulses

- Design parameters
  - Acceptance angle of the nonlinear crystal
  - Beam size and overlap





Conclusions

- Conclusions
  - TB-SPIDER is capable of simultaneously measuring the amplitude and phase of two pulses on a single shot
  - TB-SPIDER reduces systematic errors in measurements of the effect of experimental systems on spectral phase

- Future work
  - Expansion of this technique for more than two beams
  - Redesign to make it easier to align reference and probe pulse injection
  - Use as standard diagnostic for current/future experiments