

Self-referenced spectral interferometry for ultrashort infrared pulse characterization

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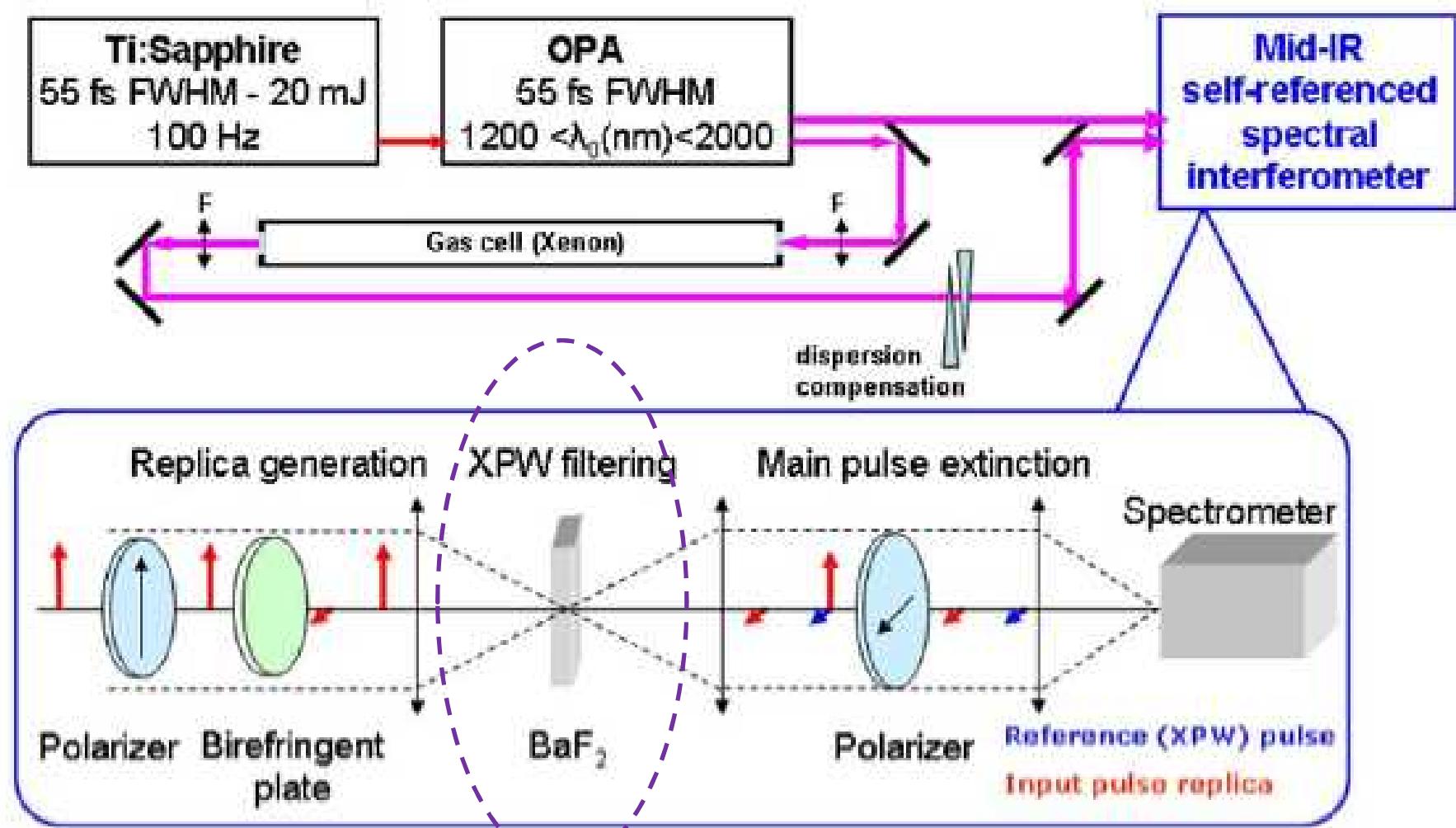
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Woongmo Sung

Short wavelength IR spectral range (SWIR) and Self-referenced spectral interferometry (SRSI)



XPW: Cross-polarized wave generation

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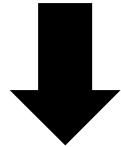


$$\frac{dA}{dz} = -i \gamma_{\parallel} |A|^2 A, \quad (1a)$$

$$\frac{dB}{dz} = -i \gamma_{\perp} |A|^2 A, \quad (1b)$$

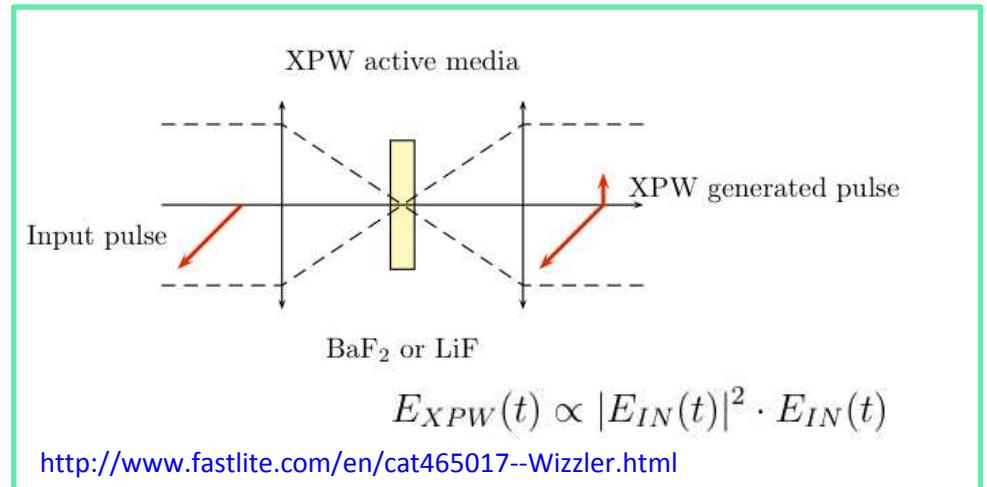
$$\gamma_{\parallel} = \gamma_0 [1 - (\sigma/2) \sin^2(2\beta)]$$

$$\begin{aligned} \gamma_{\perp} &= -\gamma_0 (\sigma/4) \sin(4\beta), \quad \text{with} \quad \gamma_0 = (6\pi/8\lambda n) \chi_{xxxx}^{(3)} \\ \sigma &= [\chi_{xxxx}^{(3)} - 2\chi_{xyyx}^{(3)} - \chi_{xxyy}^{(3)}] / \chi_{xxxx}^{(3)} \end{aligned}$$



$$A = A_0 \exp(-i \gamma_{\parallel} A_0^2 L), \quad (2a)$$

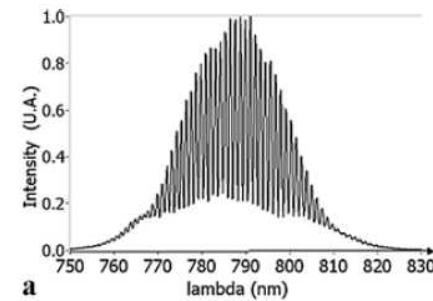
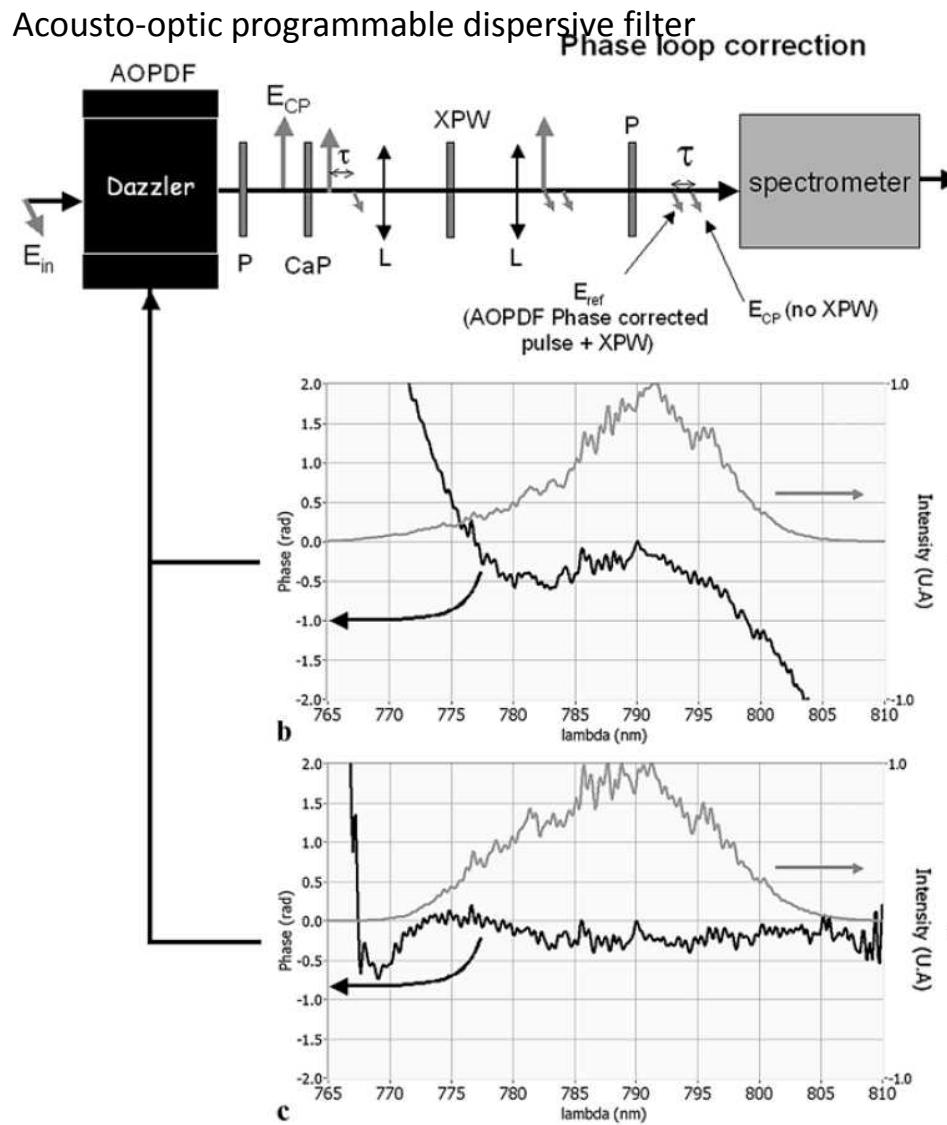
$$B = A_0 (\gamma_{\perp} / \gamma_{\parallel}) [\exp(-i \gamma_{\parallel} A_0^2 L) - 1]. \quad (2b)$$



*Advantages

- 1) **Timely shorter** than input pulse.
- 2) **Less spectral phase evolution** than input pulse.

Application of SRSI – controlling input pulse's temporal profile



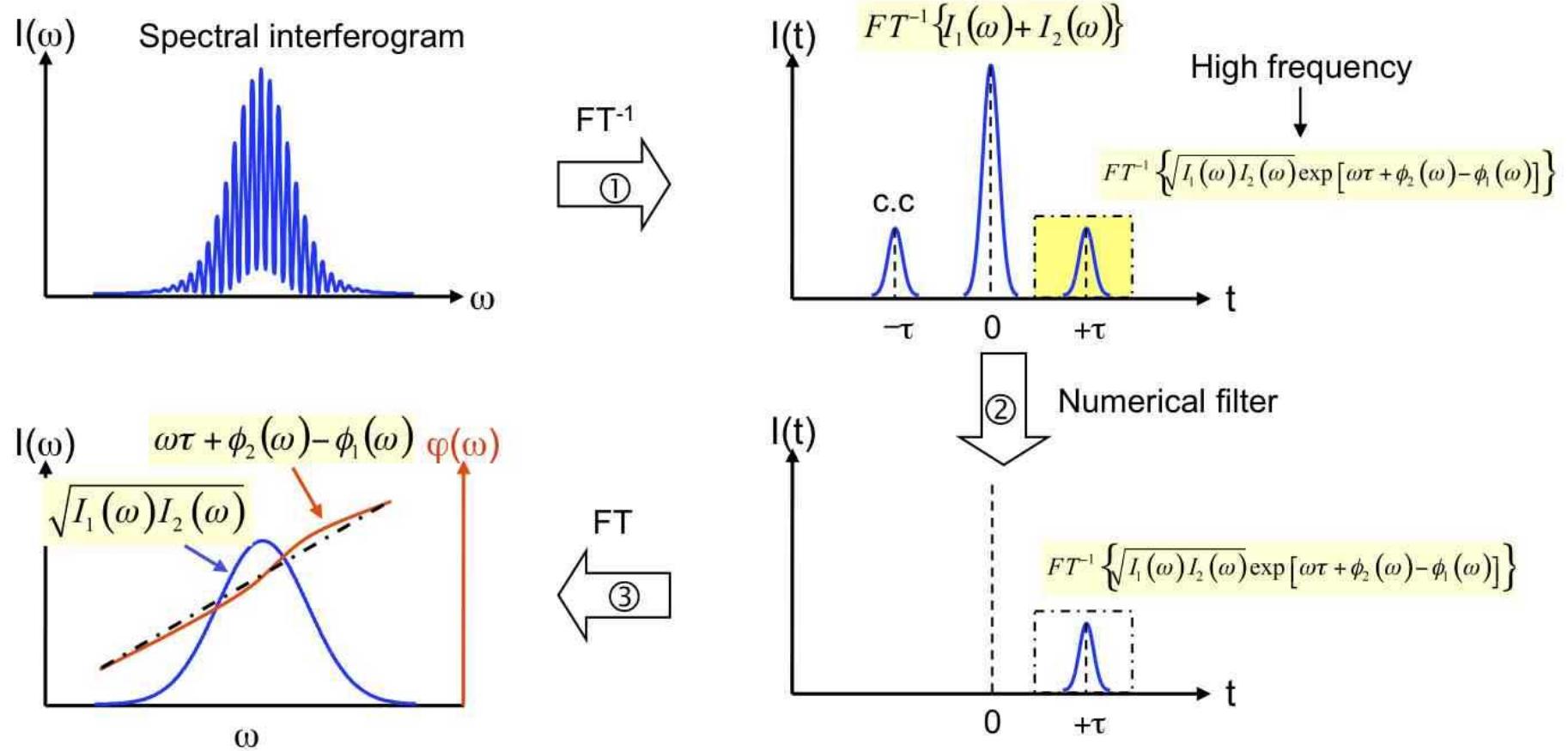
Inverse
Fourier transform
+
filtering
+
Fourier transform

1st measure

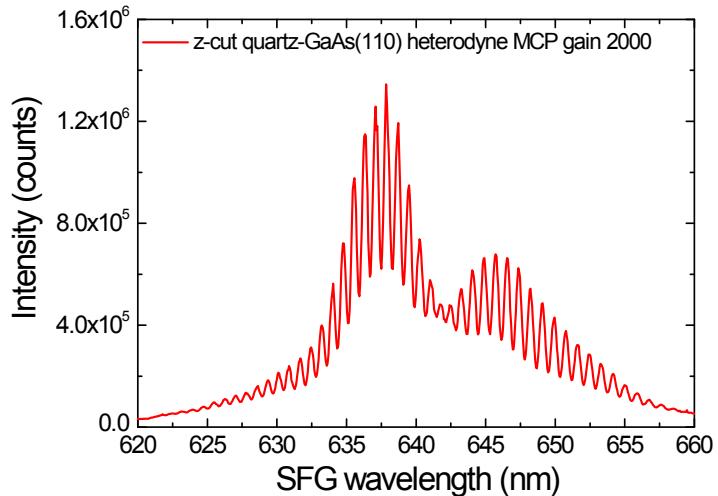
⋮

3rd iteration

Fourier-Transform Spectral Interferometry (FTSI)



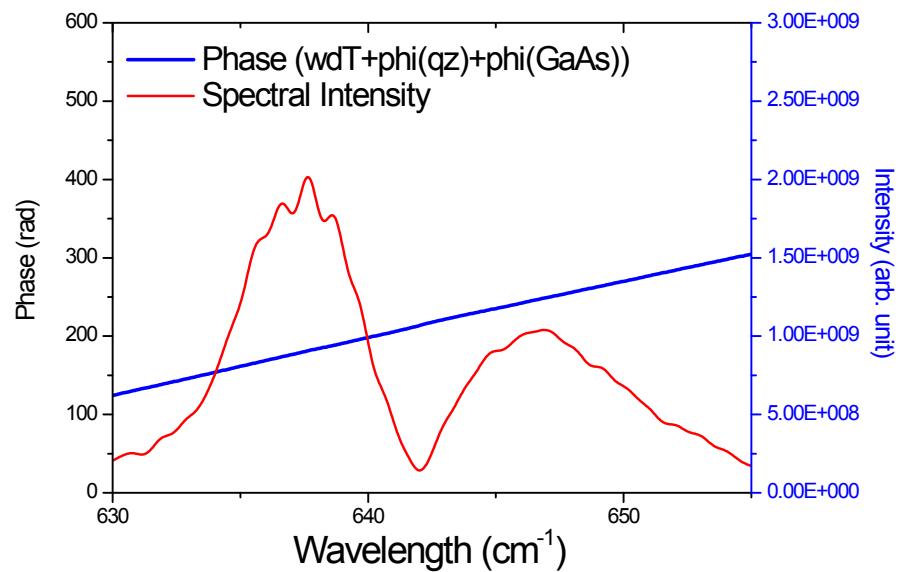
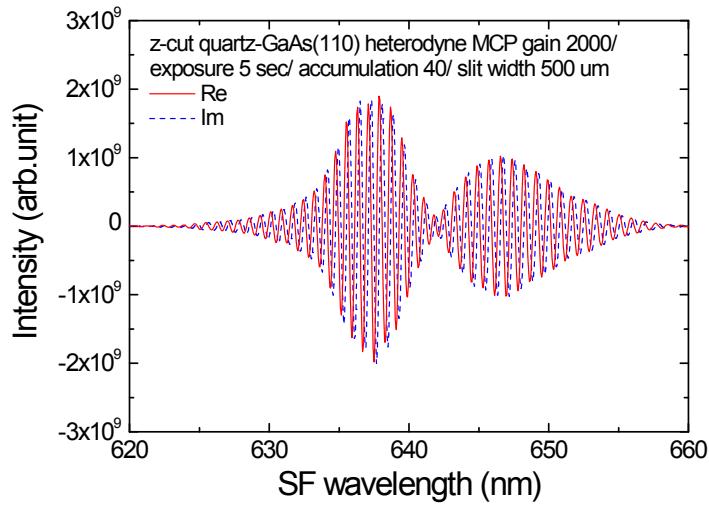
Temporal profile of HDSFG spectra of z-cut quartz (our data)



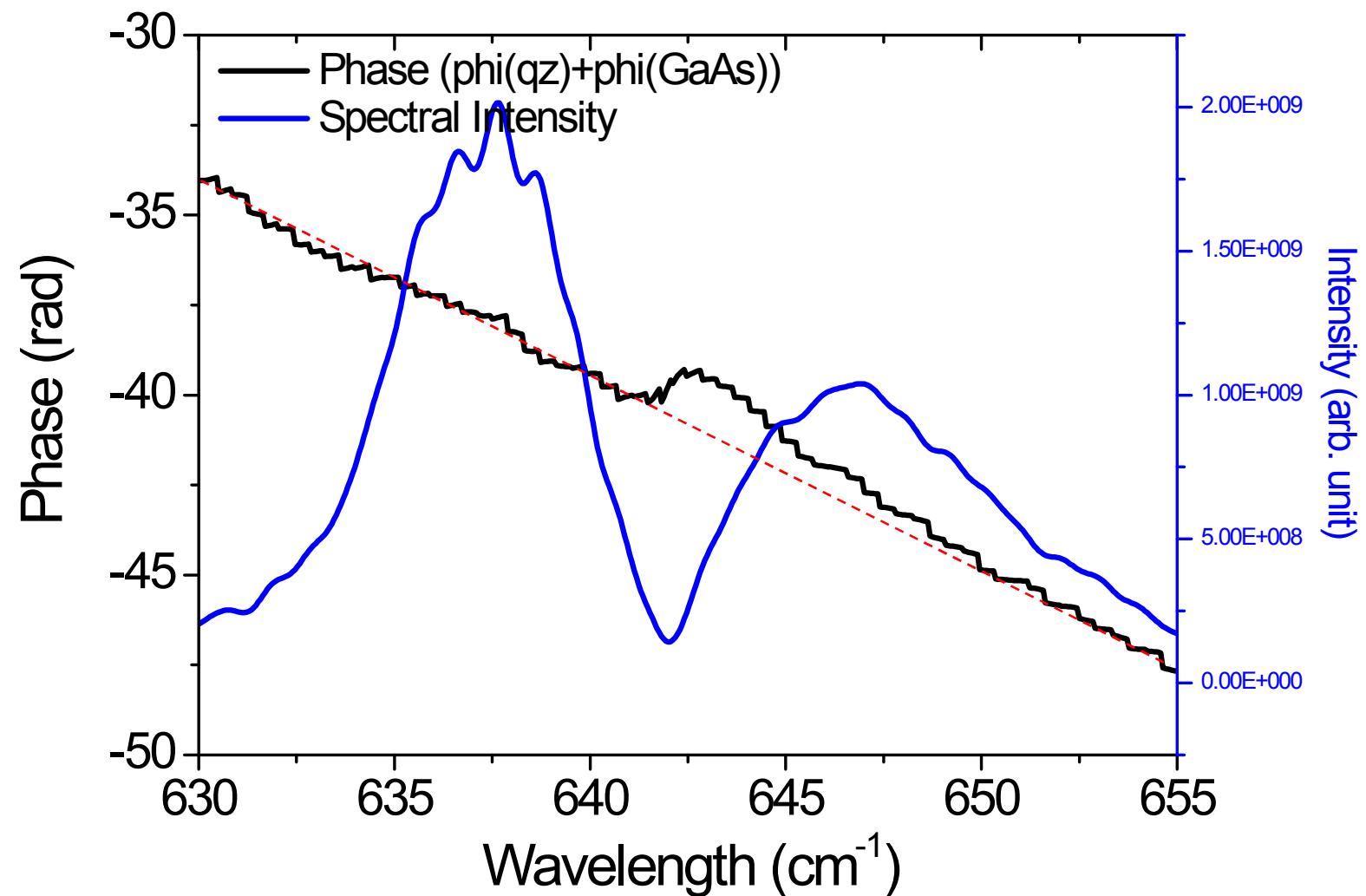
$$E_{LO}(\omega)E_{ref}(\omega)^* e^{-i\omega\Delta T}$$

$$\text{Re} : E_{LO}(\omega)E_{ref}(\omega)^* \cos \omega\Delta T$$

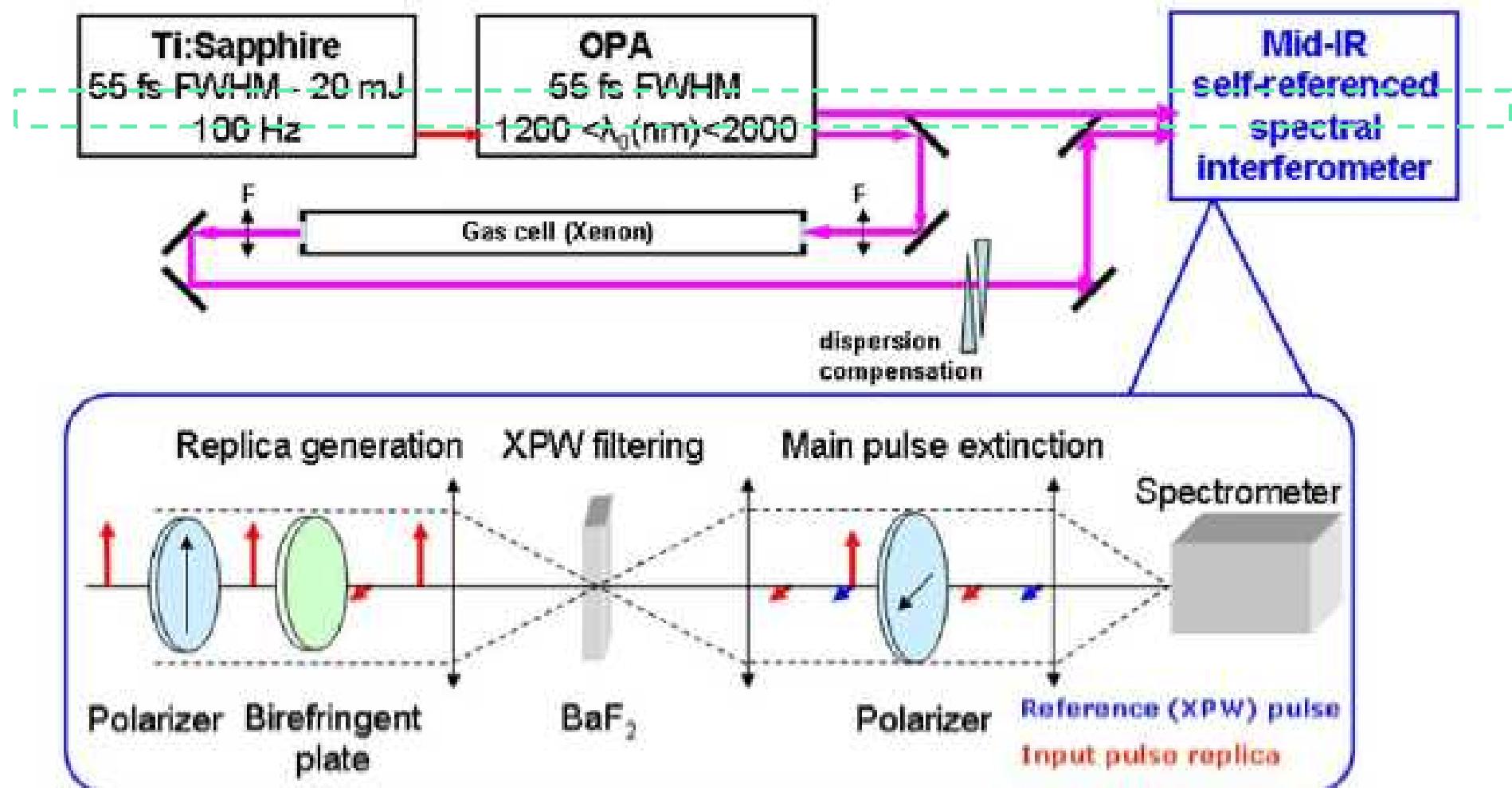
$$\text{Im} : iE_{LO}(\omega)E_{ref}(\omega)^* \sin \omega\Delta T$$



Temporal profile of HDSFG spectra of z-cut quartz (our data)



(1) Commercial OPA output



Experimental Result – OPA output

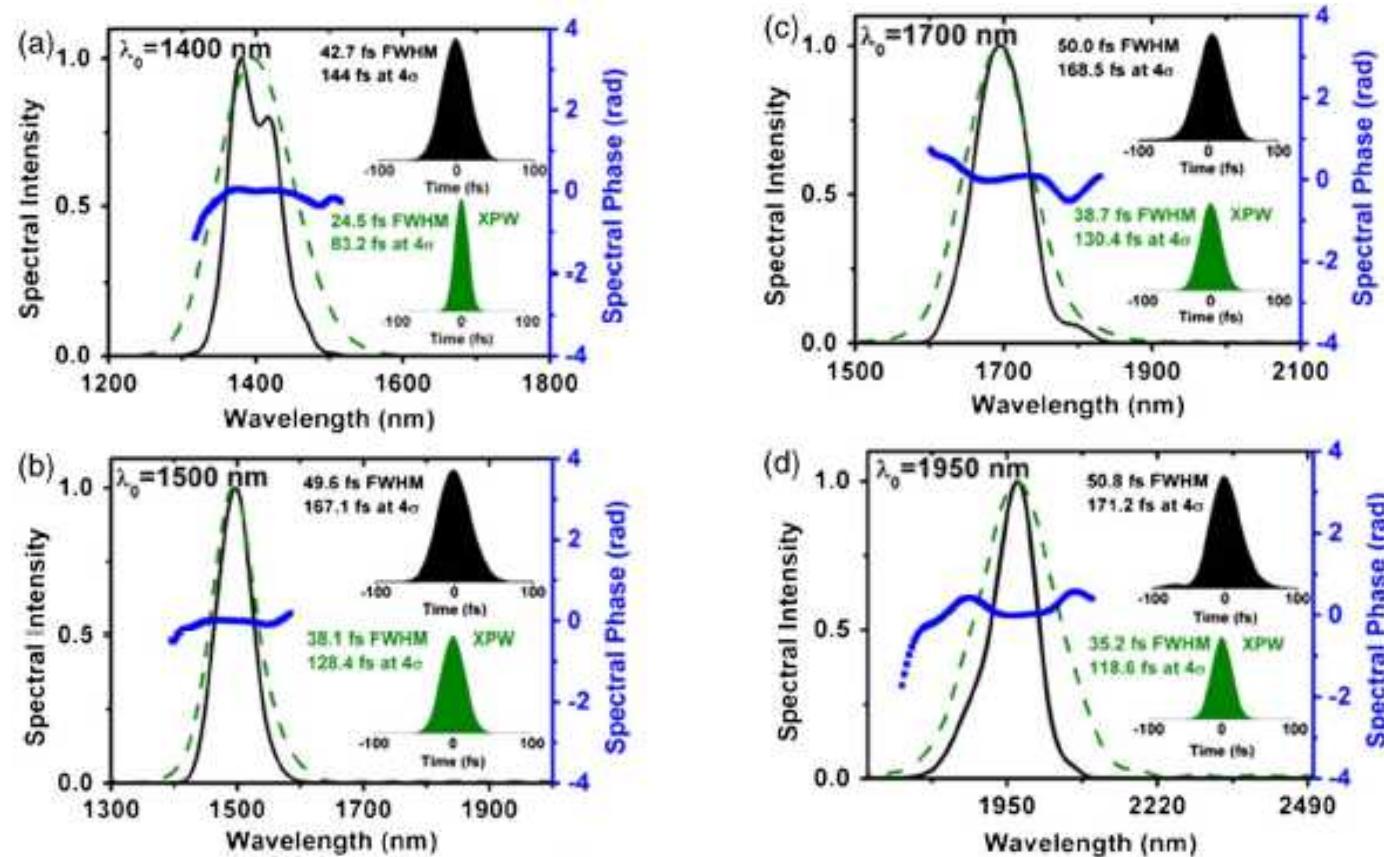
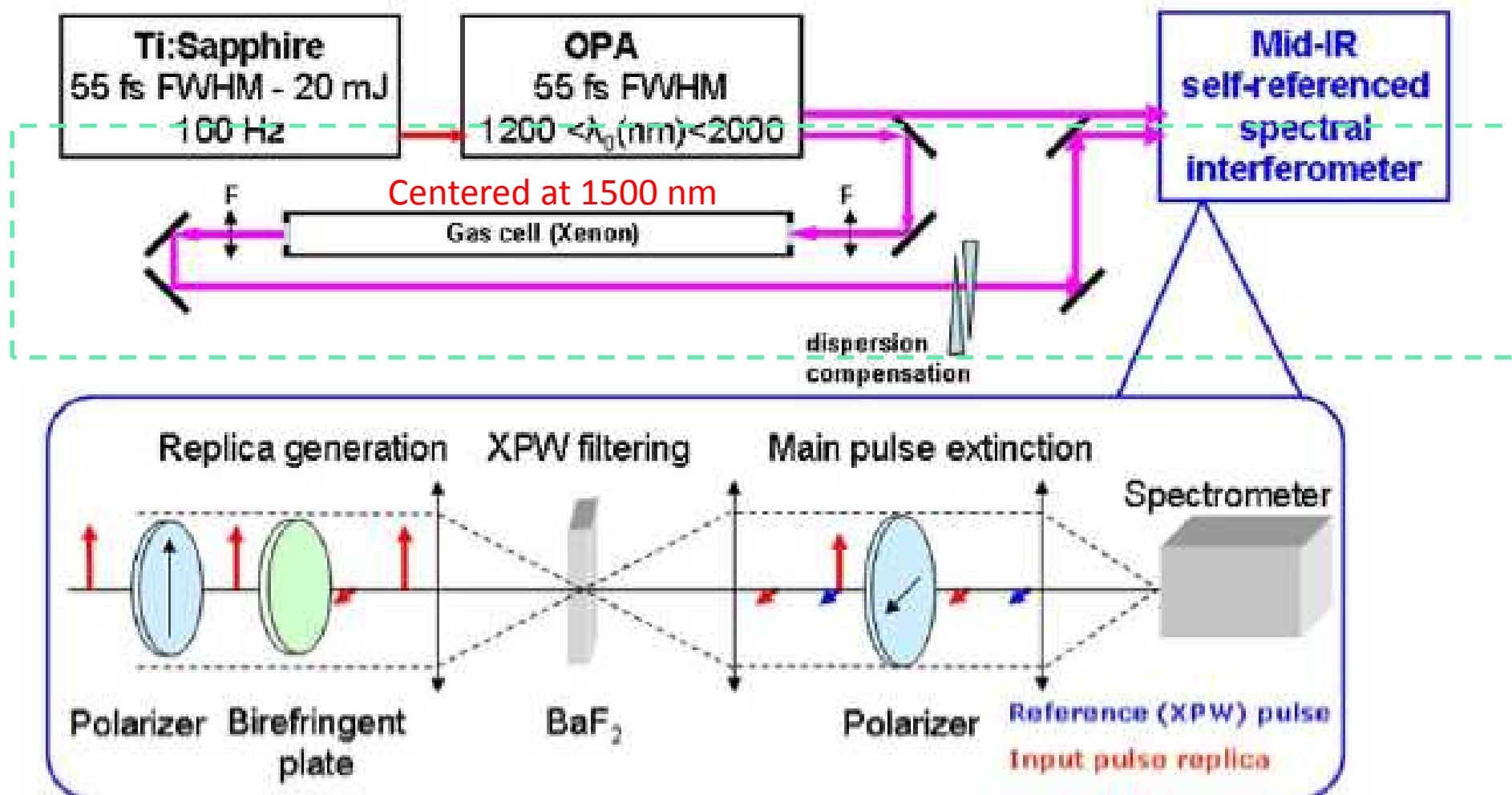


Fig. 2. (Color online) Single-shot measured spectrum (black solid curve), spectral phase (blue squares), and pulse intensity (black inset) after the OPA at (a) 1400 nm, (b) 1500 nm, (c) 1700 nm, and (d) 1950 nm. The measured XPW spectra (green dashed curve) and retrieved XPW FL pulses (green inset) are also shown.



(2) OPA output → Gas cell (few cycle operation)



Experimental Result – OPA output

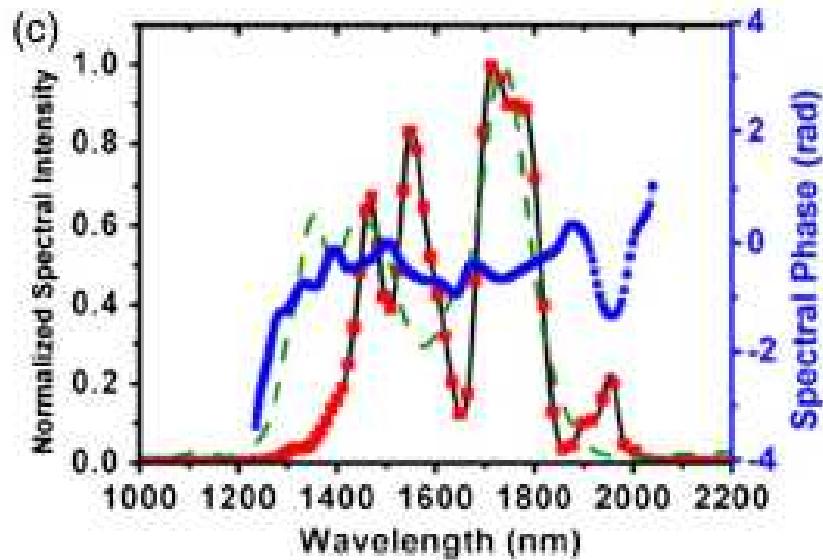
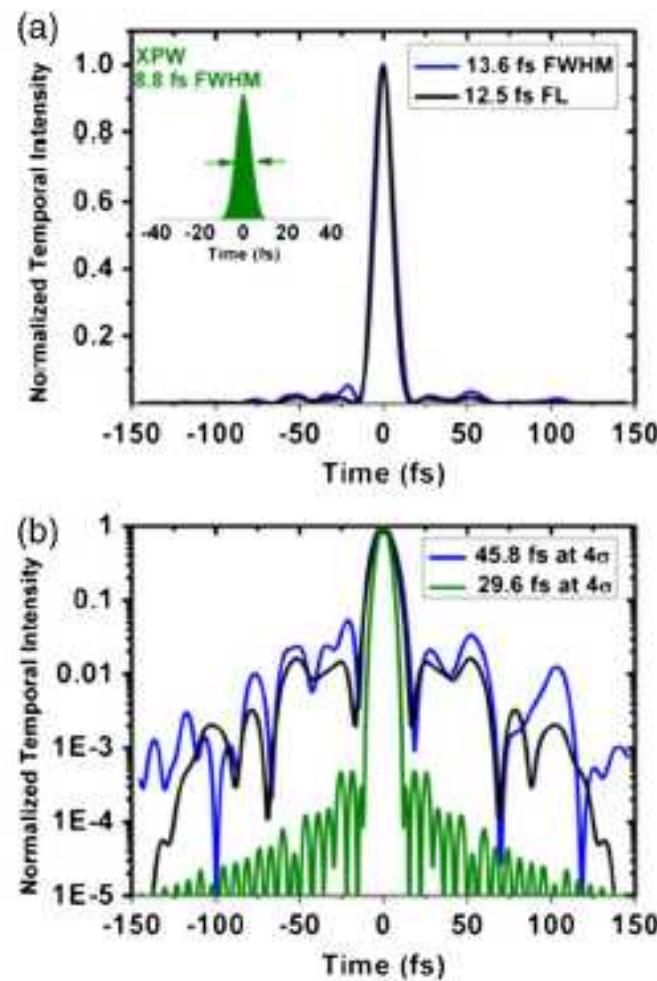
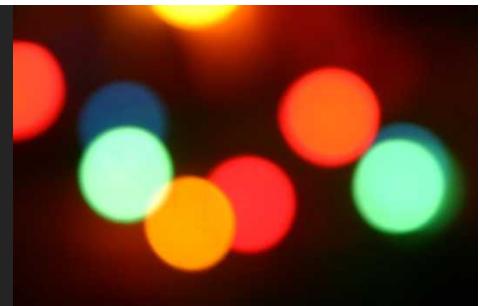


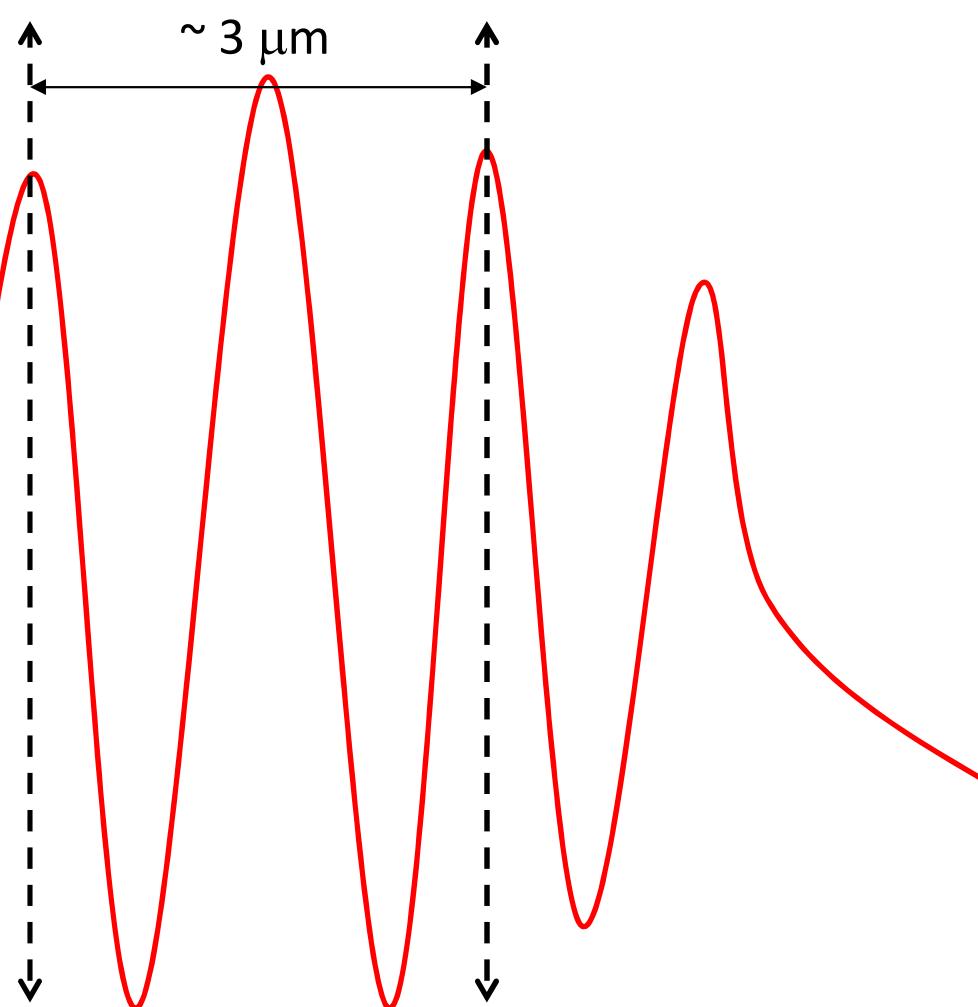
Fig. 3. (Color online) Single-shot reconstructed temporal profile of the 13.6 fs FWHM pulse (blue curve) on an (a) linear and (b) logarithmic scale. The Fourier limit is 12.5 fs FWHM (black curve). The retrieved XPW FL pulse is shown in green. (c) Measured (red squares) and reconstructed (black solid curve) normalized spectra and spectral phase (blue squared curve) of the compressed pulse. The normalized XPW spectrum is displayed as a green dashed curve.

13.6 fs in FWHM from filamentation



$$\frac{3 \cdot 10^{-6} m}{3 \cdot 10^8 m/s} \sim 10 \text{ fs}$$

13.6 fs –
2.5 cycle
of pulse
centered
at 1500
nm



Summary



In this Letter, we successfully adapted the SRSI technique to the SWIR spectral region to fully characterize multicycle pulses (55 fs) across the 1.4–2 μm spectral range in single-shot operation. The device has furthermore shown its capability to characterize ultrabroadband 2.5-cycle pulses with spectra covering 1.3–2 μm . Finally we note that the presented setup could be directly used for characterization of broadband pulses in the 2–5 μm spectral range provided that a suitable spectrometer is available.