Development of carrier-envelope phase stabilized, multi-mJ, sub-5fs laser system for high-order harmonic generation on solid target

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Thomas Oksenhendler
(Fastlite)

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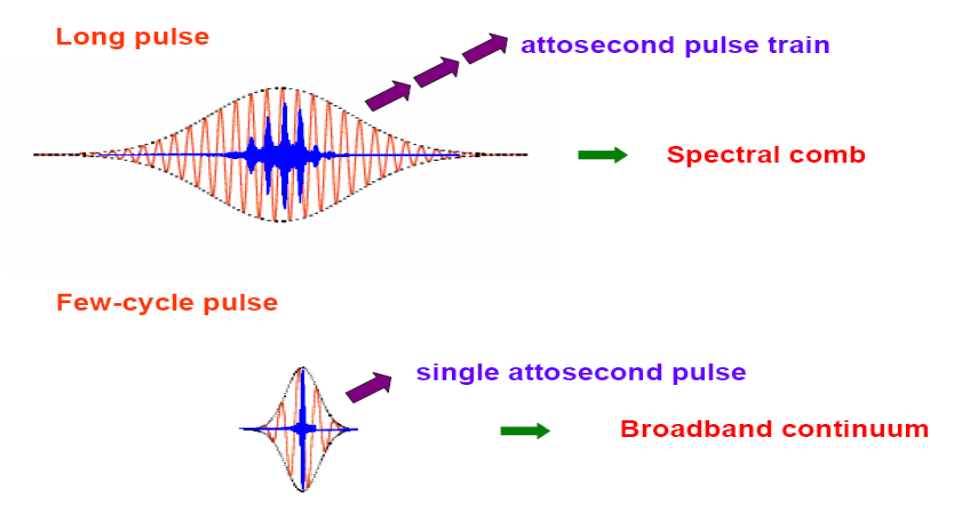
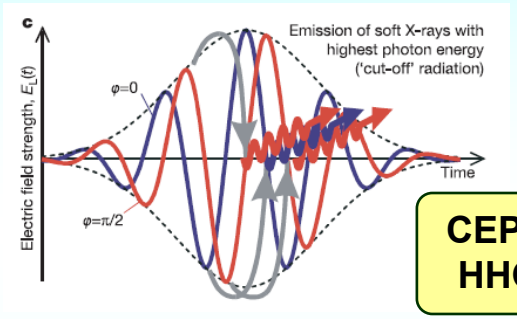
(Femtolasers)

Requirement of CEP stabilized few-cycle pulses for attosecond pulse generation



Attosecond (10^{-18}s) pulse generation and its applications in the research of ultra-fast phenomena attract a lot of attentions in recent years.



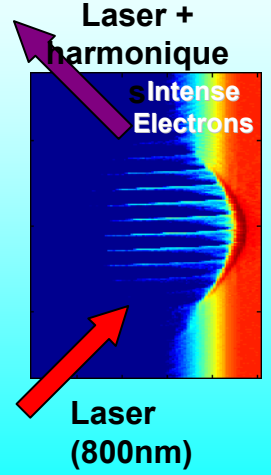
CEP influence on HHG generation

Figure from: A. Baltuska, Nature, 42, 611 (2003)

Our motivation: Plasma mirror study and attosecond pulse generation from solid target (several orders higher efficient than gas media) by using few-cycle laser pulses at 1kHz.

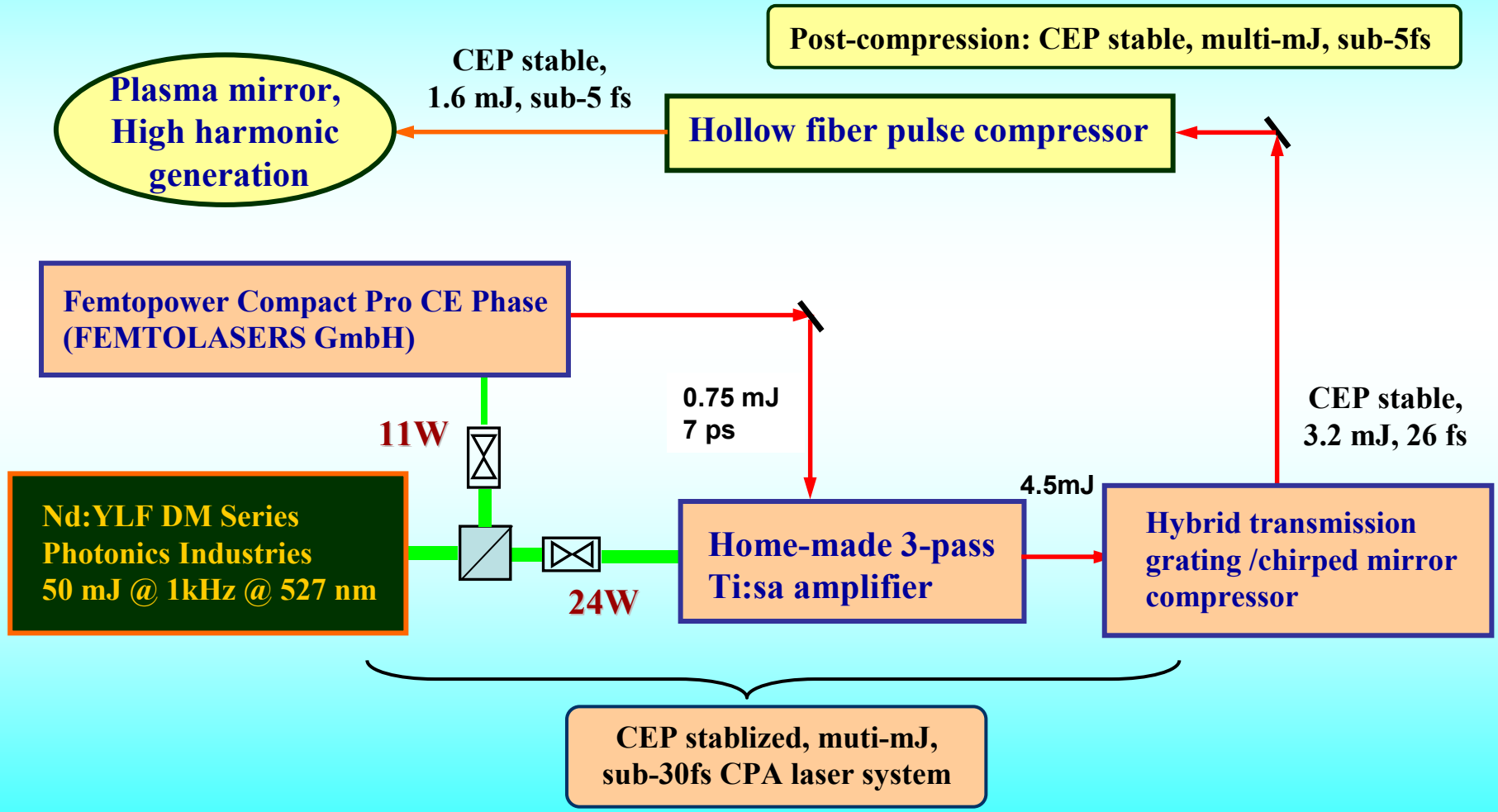
$$I > 10^{17} W/cm^2$$

- ✓ multi-mJ
- ✓ sub-5fs (<2 cycles)
- ✓ CEP stabilized
- ✓ High beam quality



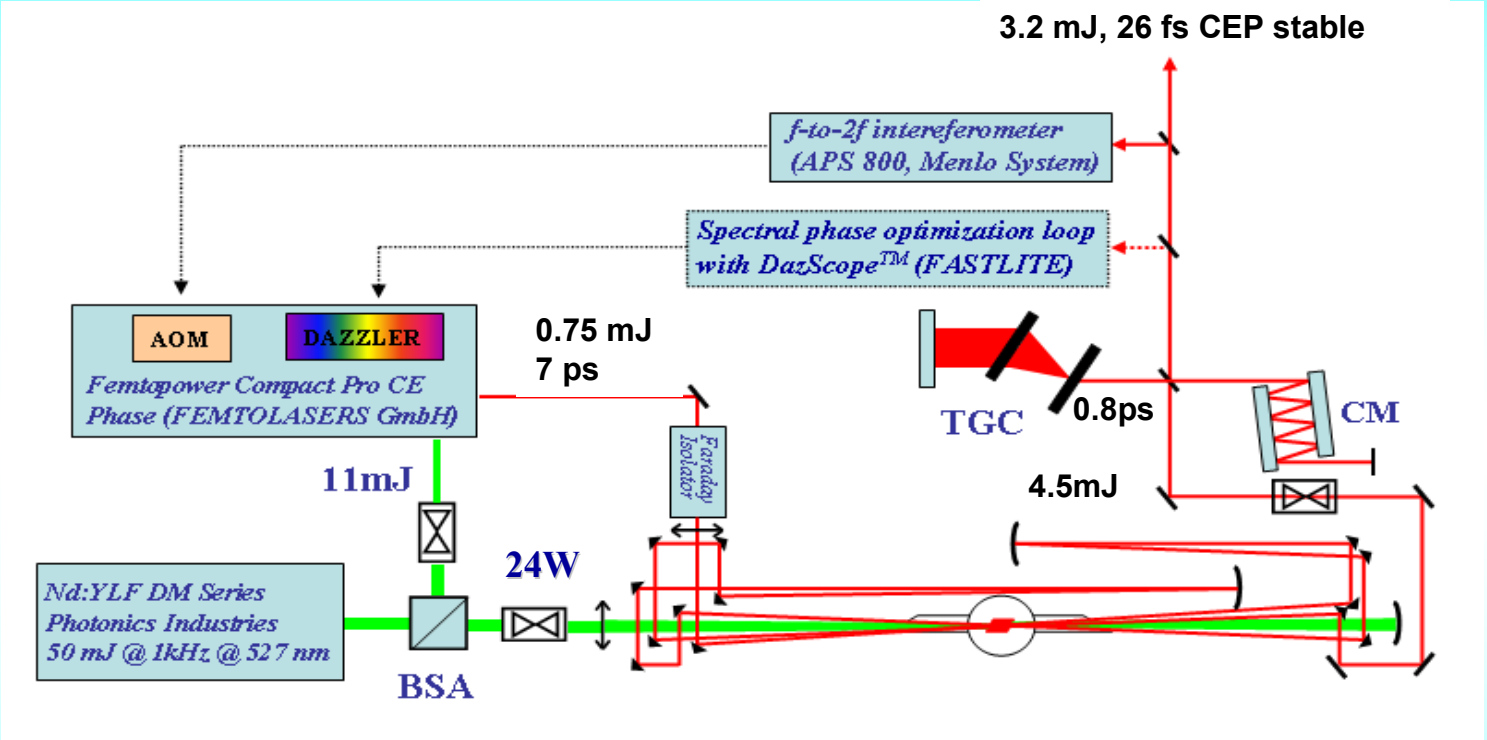
N. Naumova et al, Physics of Plasmas. 12, 056707 (2005)
P. Gibbon et al, Phys. Rev. Lett., 76, 50 (1996)

Layout of the whole laser system (salle noire)



L. Canova et al., Opi. Lett. 34, 1333 (2009)
X. Chen et al., Appl. Phys. B 99, 149 (2010)

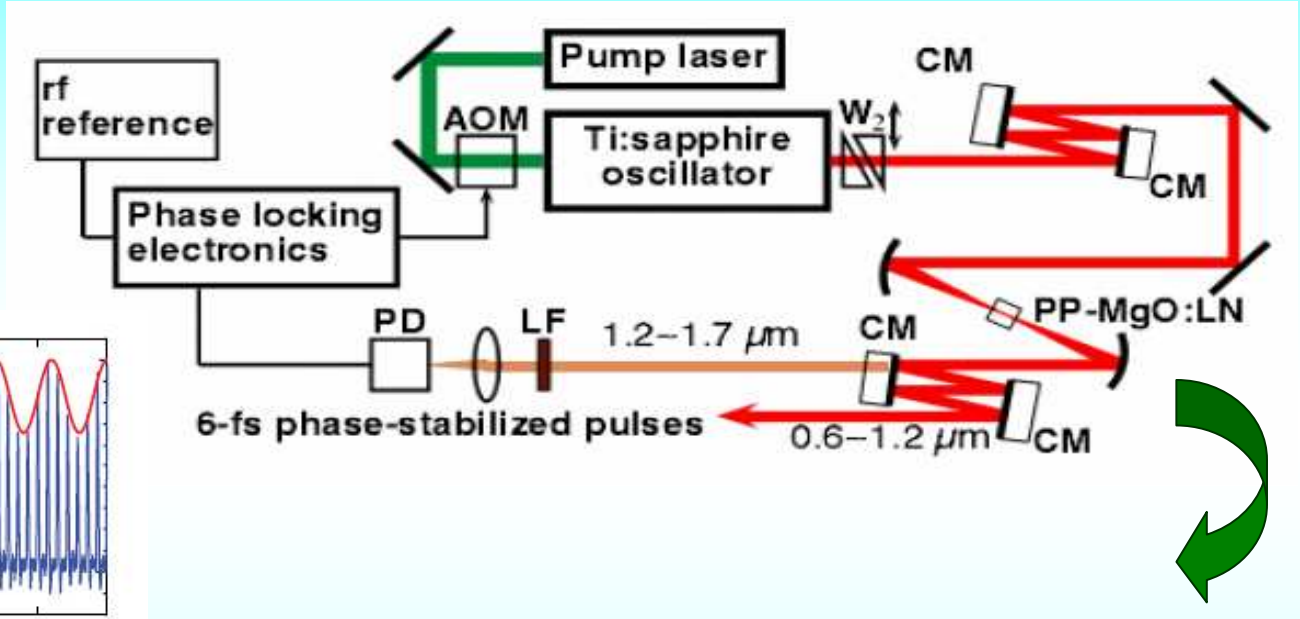
CEP-stablized, muti-mJ, sub-30fs CPA laser system

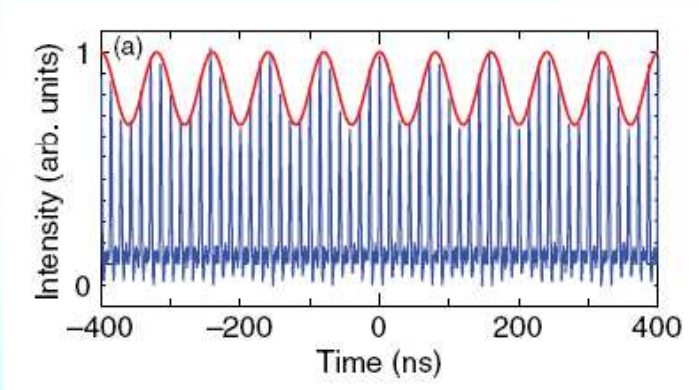


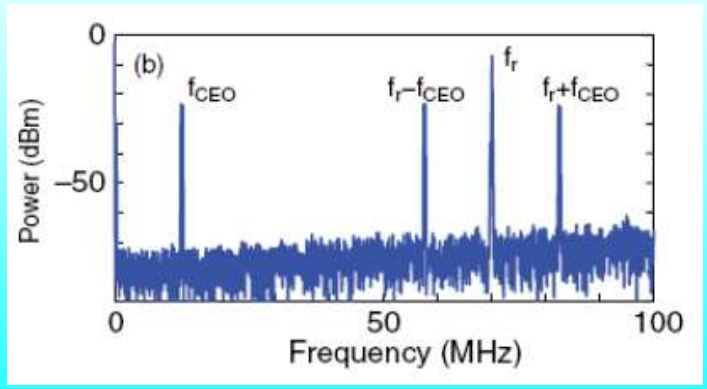
CEP stabilization of CPA laser system=

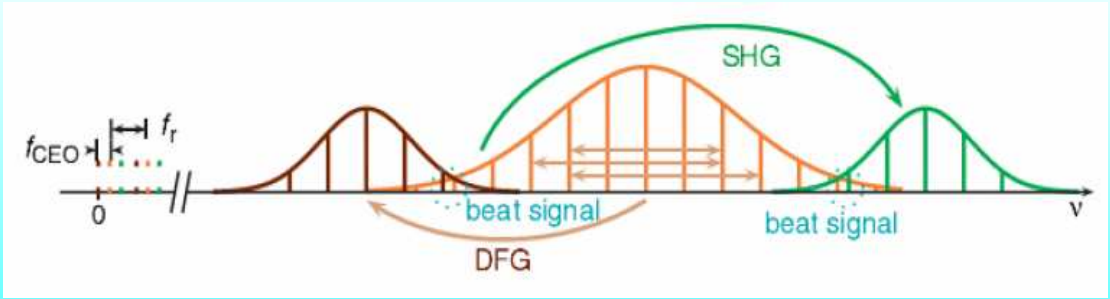
- Stabilization of CEP offset of the oscillator
- Subsequently pre-compensation of the slow drift introduced during amplication and compression

CEP-stabilization of the oscillator



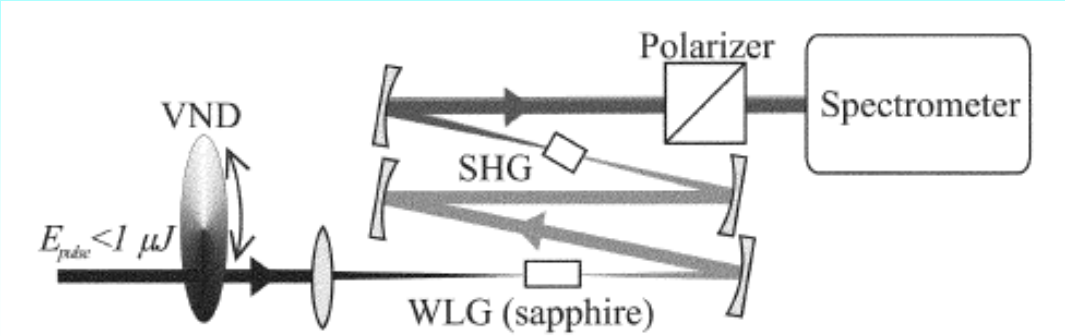


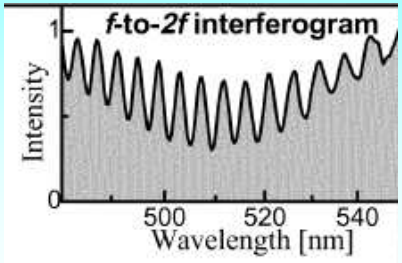




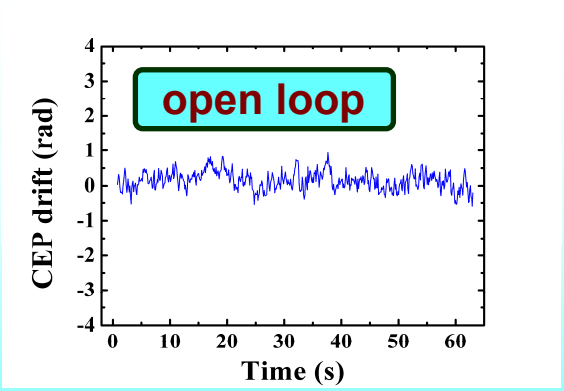
$$\Delta\varphi = 2\pi\omega_{CEO} / \omega_{rep}$$

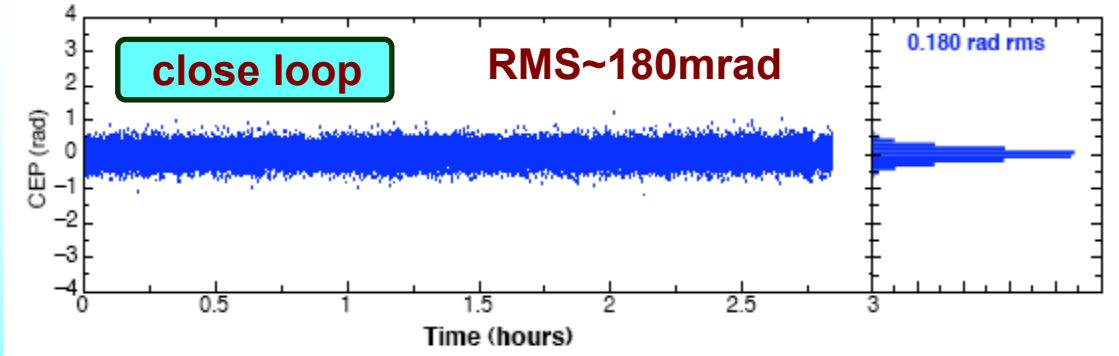
CEP stabilization of amplified pulses





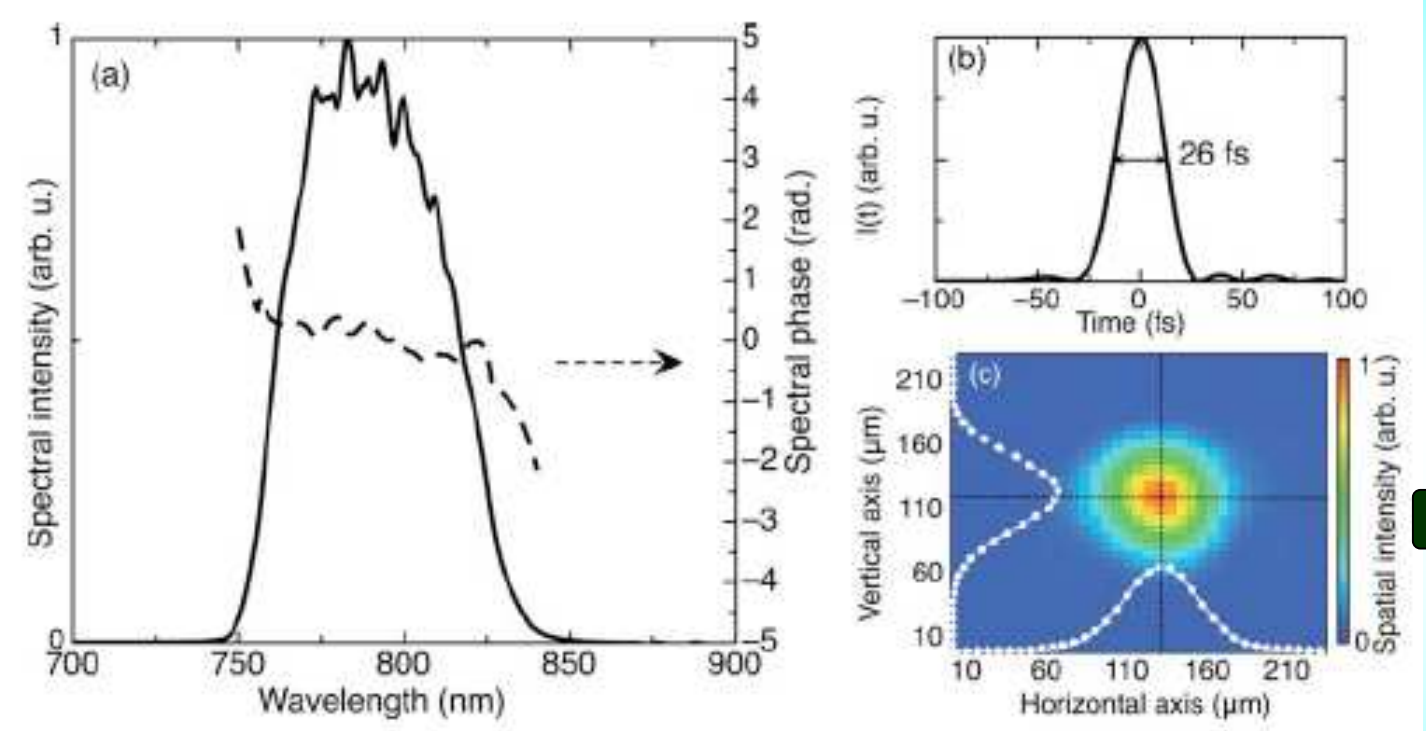
Scheme of the f-to-2 f interferemeter





Measured CEP drift with APS 800 Menlo system (Acquisition time=1 ms)

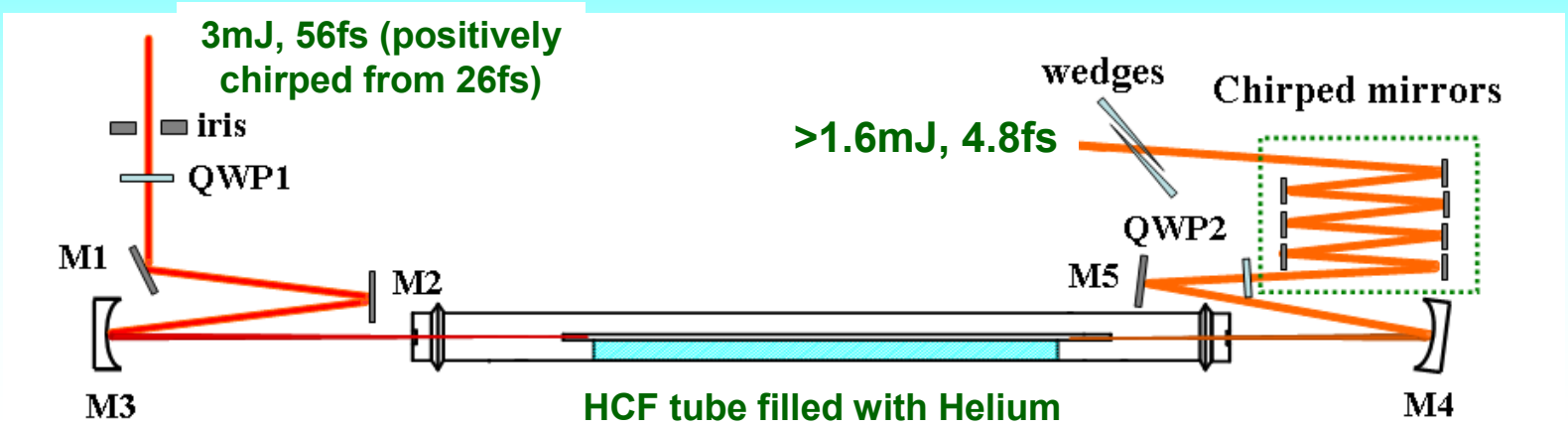
Characteristics of the driving laser output

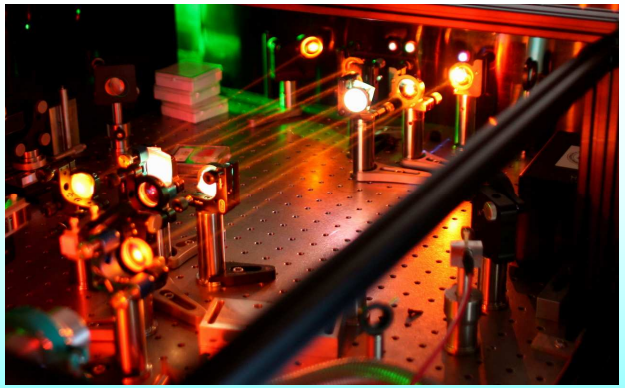


M^2=1.2

SPIDER measurement after spectral phase optimization with AOPDF and spatial intensity distribution in far-field

Pulse compression via HCF technique



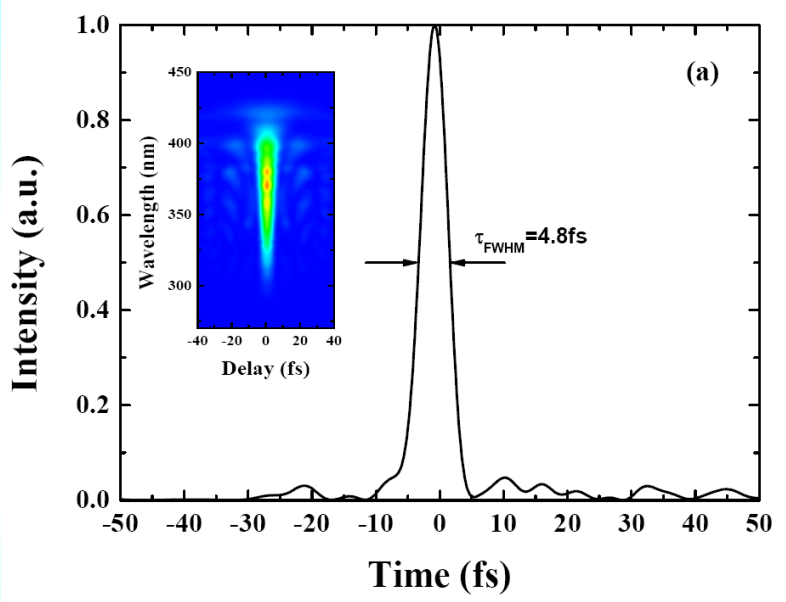


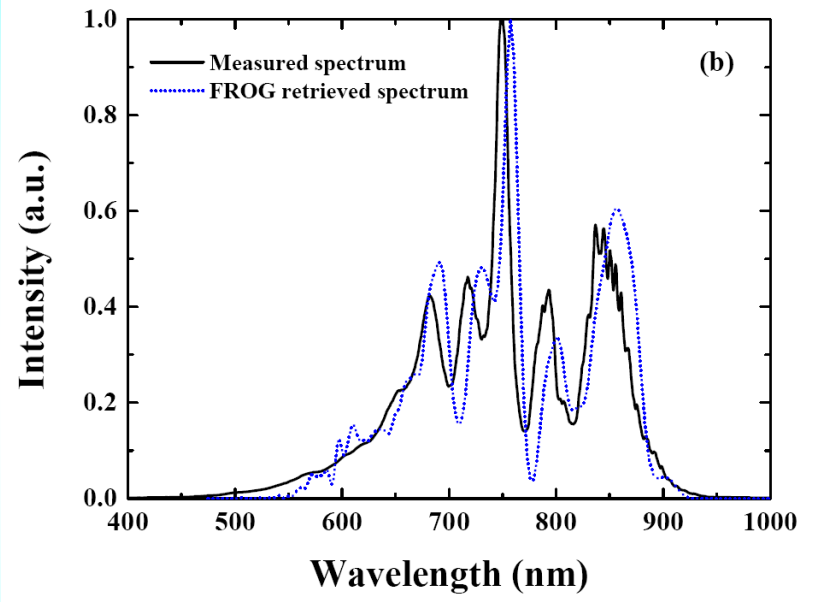
Advantages of HCF technique:

- ***spatially uniform spectrum broadening***
- ***excellent output beam profile***

M. Nisoli, Appl. Phys. Lett. ***68****, 2793 (1996).*
X. Chen et al., Opt. Lett. 34, 1588 (2009)

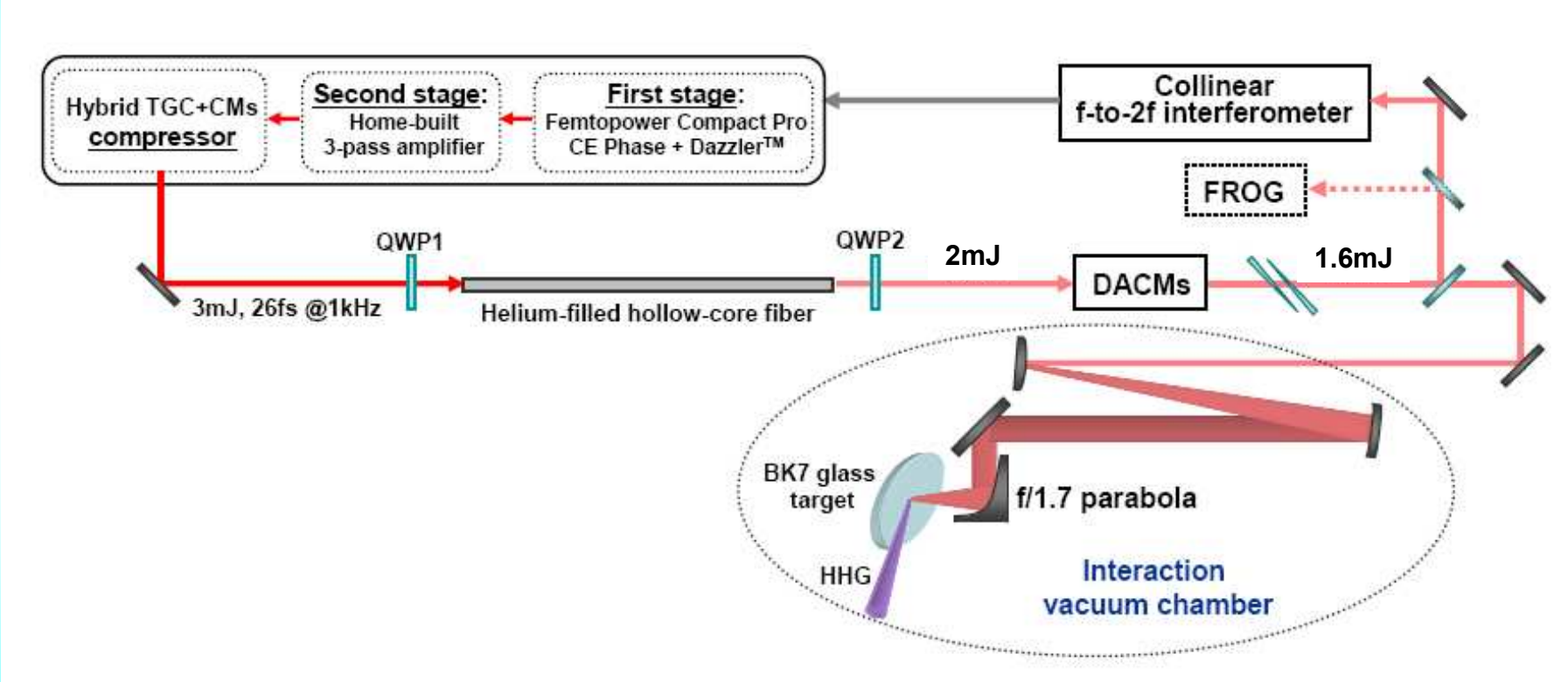
Optimal compression result



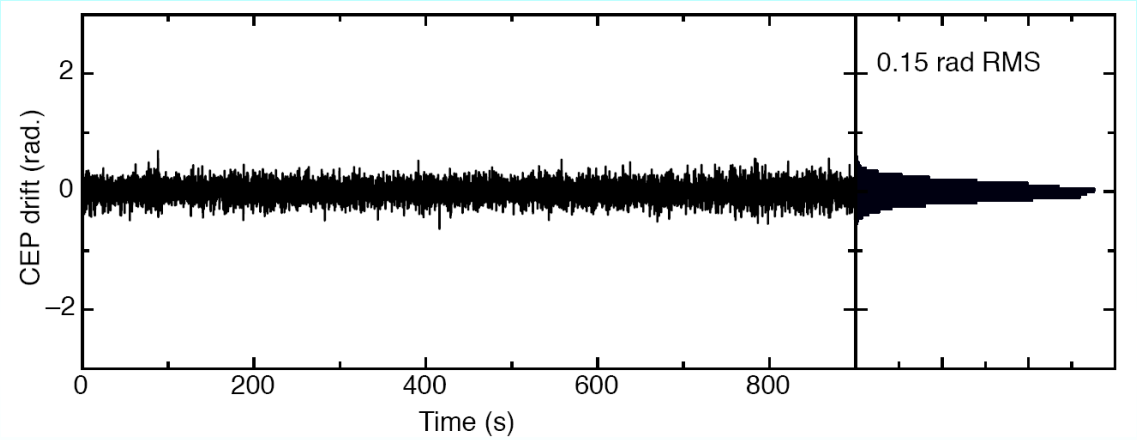


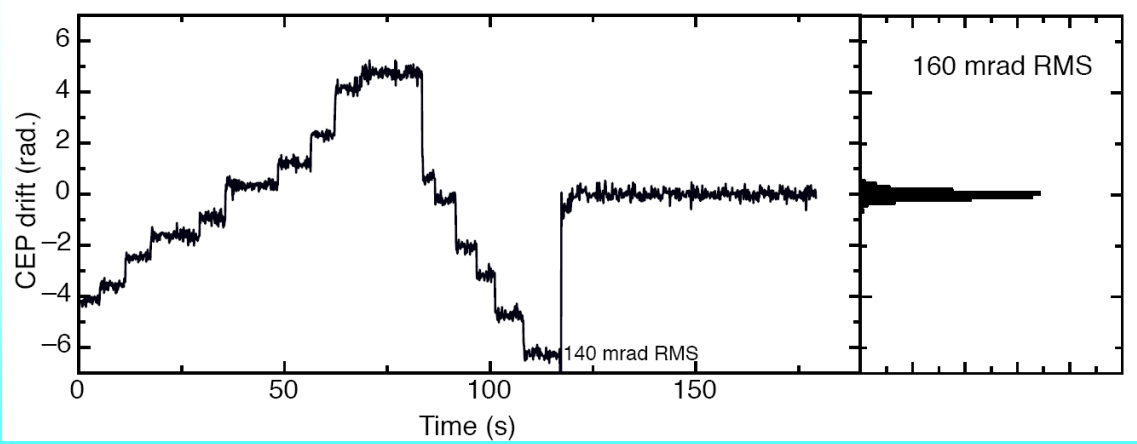
FROG (Frequency-Resolved Optical Gating) measurement result of the compressed pulses after chirped mirrors

CEP-stable, multi-mJ, sub-5fs laser source

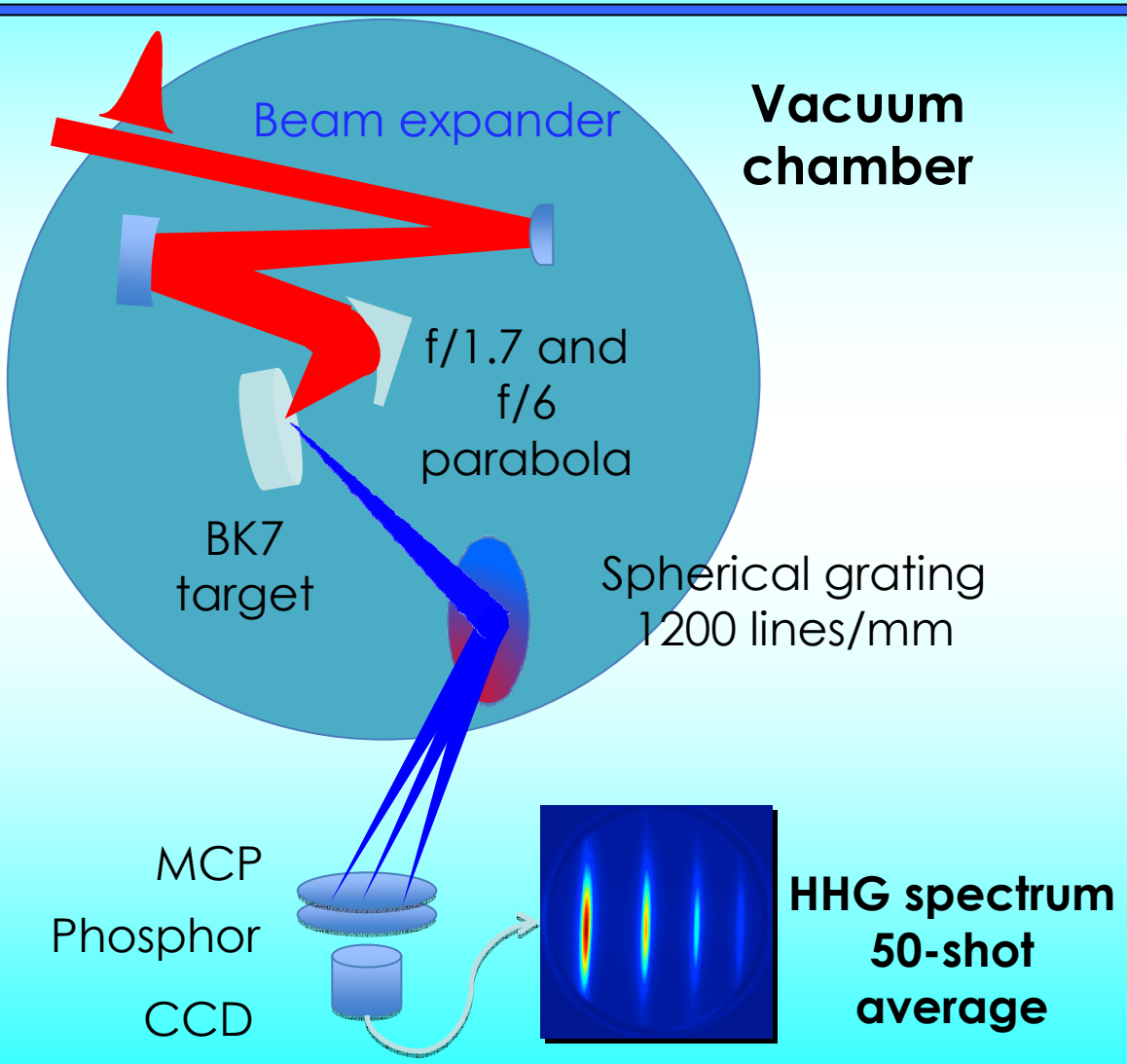


CEP-stabilization and control of the sub-5fs pulses



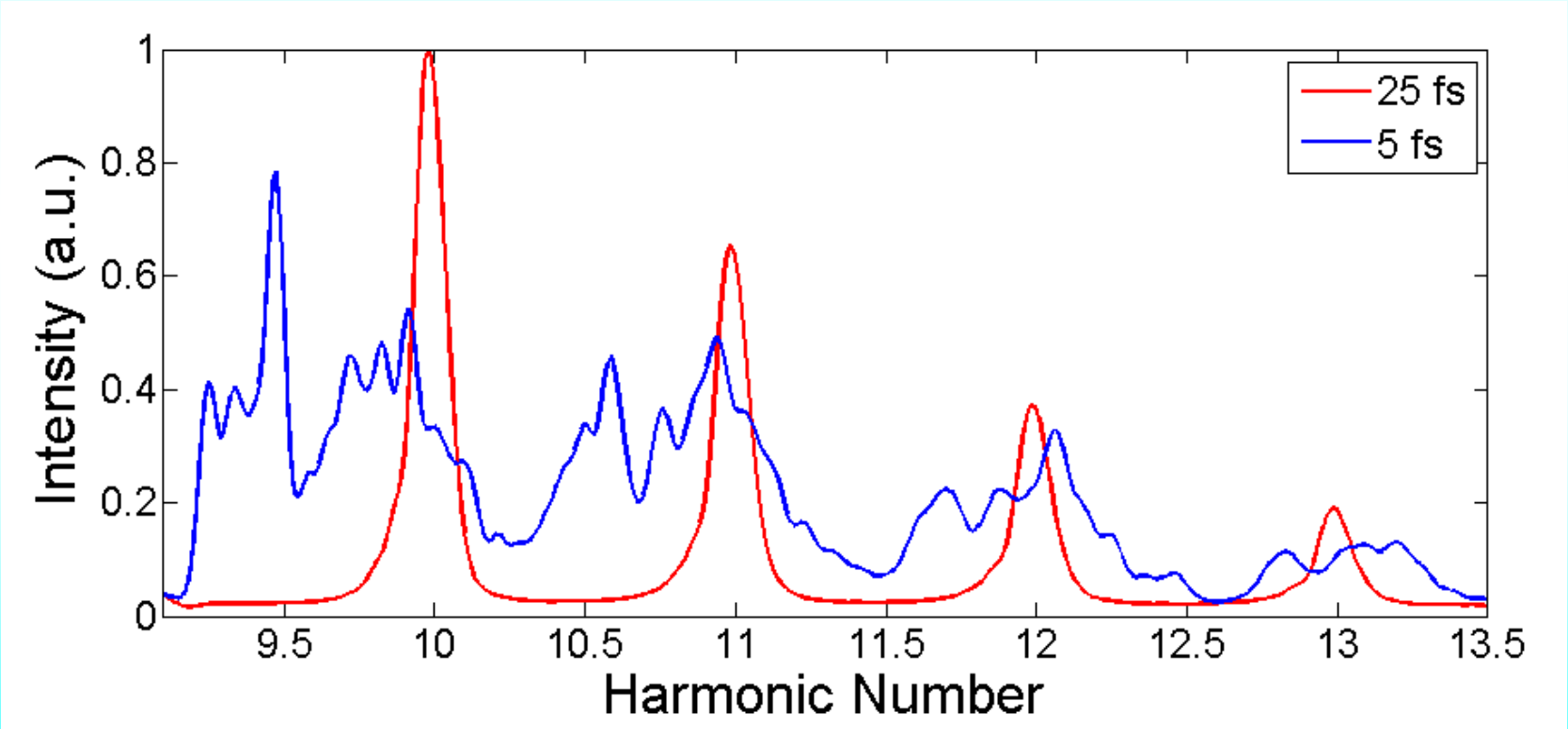


HHG experimental setup

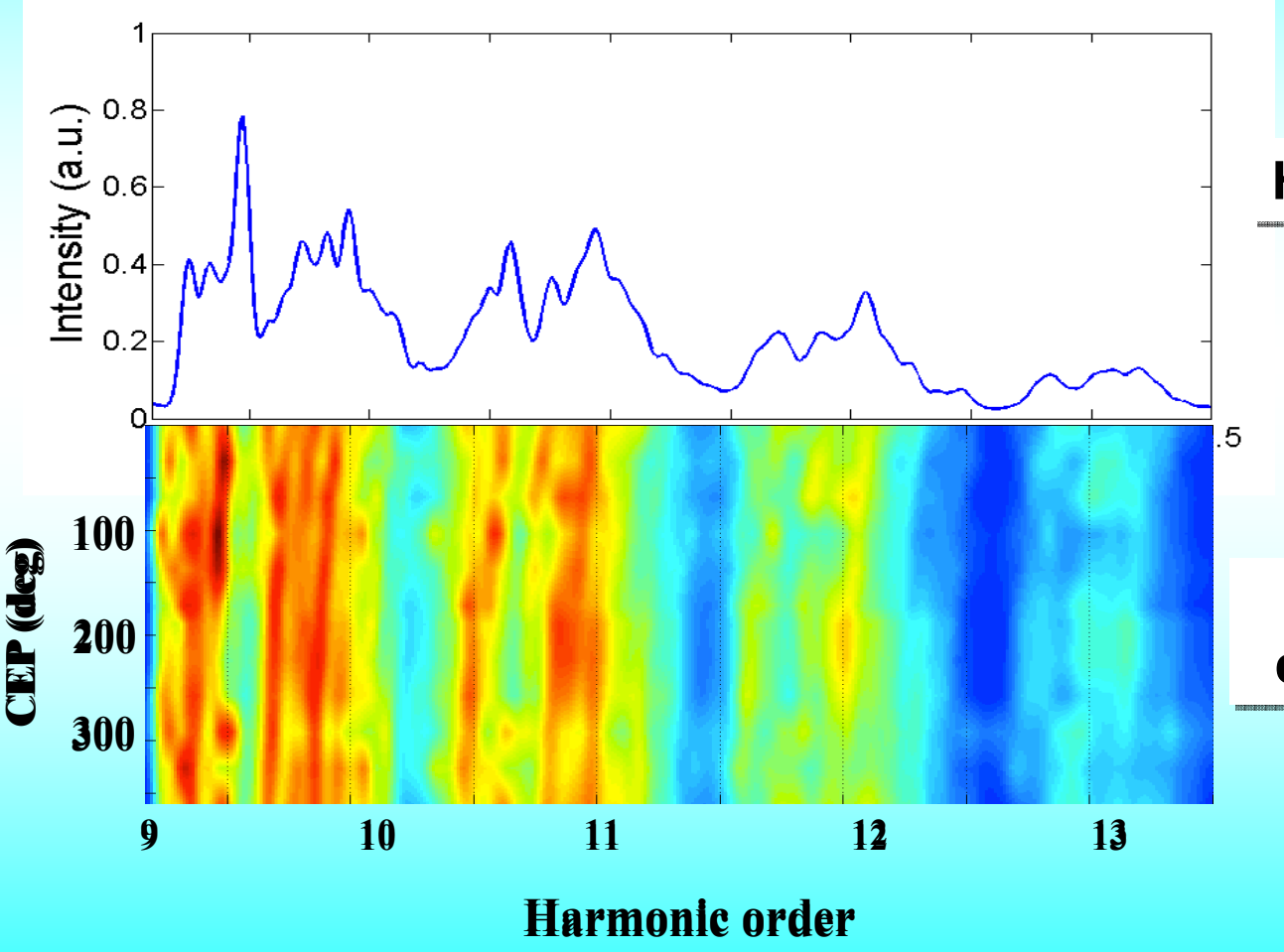


First ‘few-cycle’ HHG results

HHG spectrum: 5 fs ~ 3×10^{17} W/cm^2



CEP dependence



HHG spectra

CEP dependence

Future with laser update to 10mJ

- circular polarization
- Helium gas
- input pulse pre-chirping
- larger core fiber (~ 400 mm)
- CEP-stable, 5mJ, 5fs (1 TW)
- « compact » setup
- $I_{max} = 10^{19}$ W/cm^2


Thank you for
your attention!