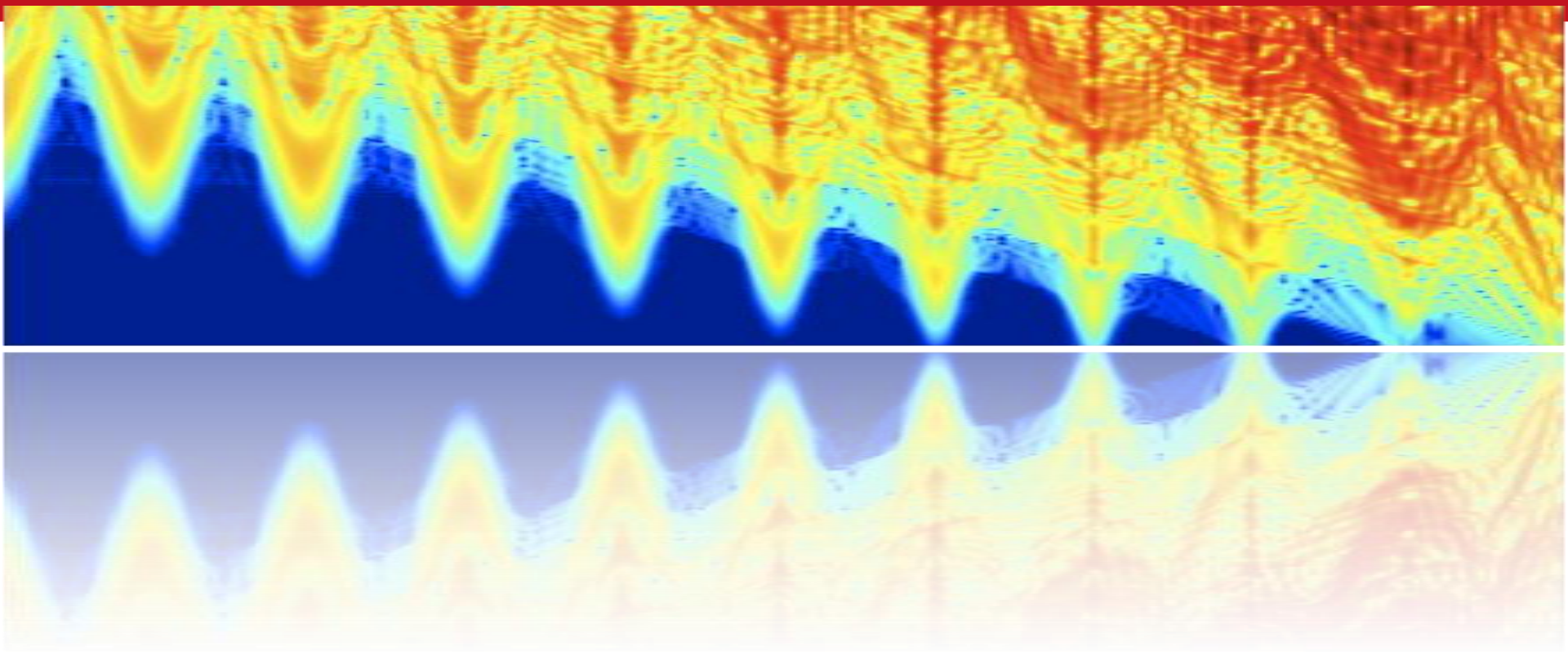
Attosecond sources based on HHG



Amelle ZAIR

Kings College London, Department of Physics, Strand, London UK

EPSRC
Pioneering research and skills

Laserlab Europe

Time seen from an electron point of view

Age of Earth (1.4 10^{17} sec)

Homo-Sapiens (1.2 10^{10} sec)

1 year (3.1 10^{7} sec)

Human Heartbeat (1 sec)

PC calculation (nsec = 10^{-9} sec)

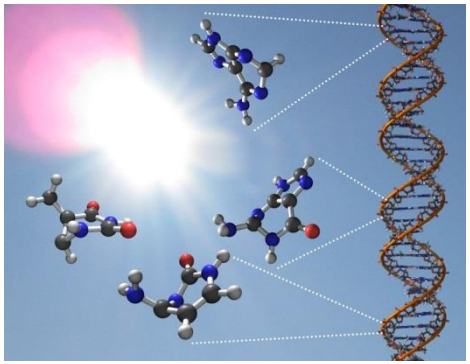
Fastest computer Calculation (psec = 10^{-12} sec)

Molecular reaction and nuclear motion (fsec = 10^{-15} sec)

Electronic motion (asec = 10^{-18} sec)

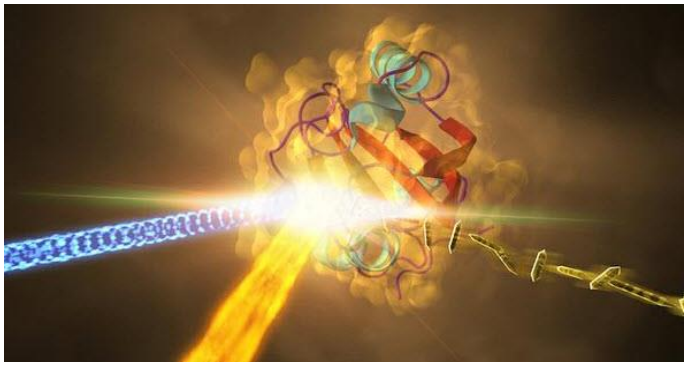
Motivation: following dynamics from atto to femto

Photo-stability (damages)



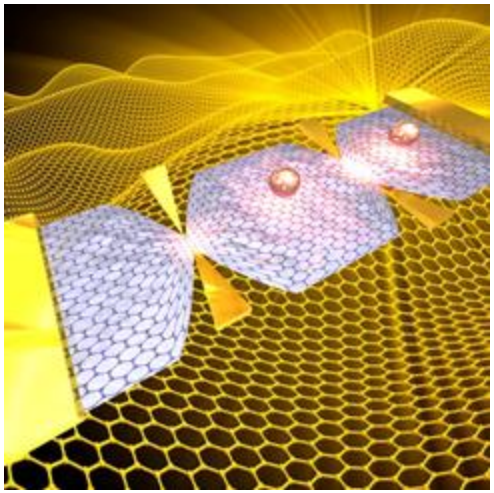
nucleobasis

Ultra-fast photo-induced properties



Photocatalysis (PYP)

Ultra-fast switching of current



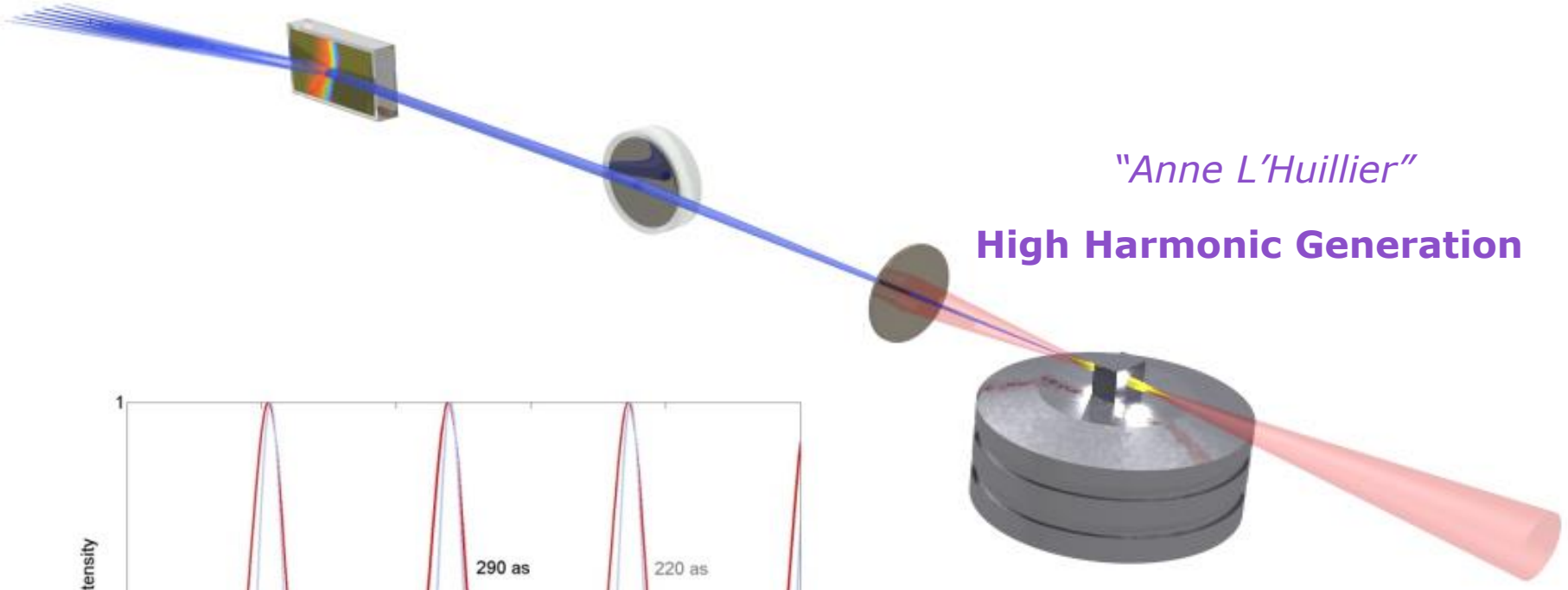
Quantum nano-optoelectronics

J. Tenboer et al., Science 346 6214 (2014)
M. Barbatti et al., PNAS 107 (2010)
F. Koppens ERC Consolidator (2017)

Shortest flash of coherent light ever produced

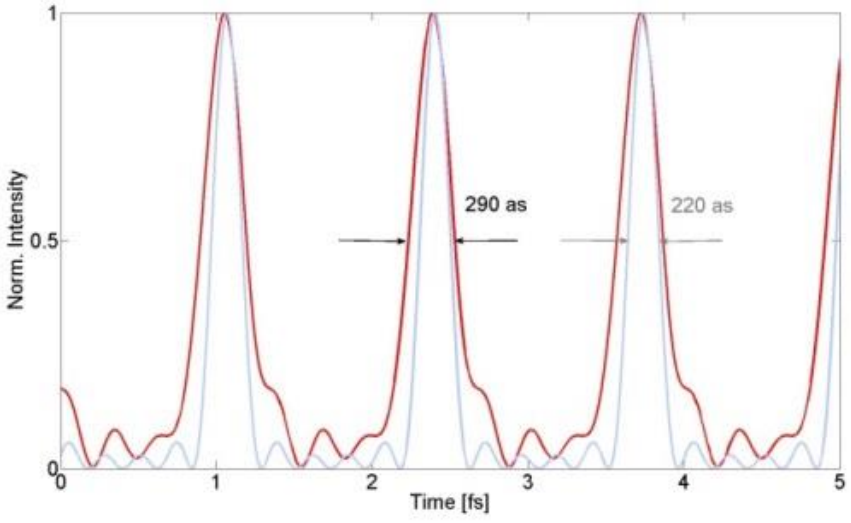
"our generation! And the new generation"

Attosecond XUV pulses

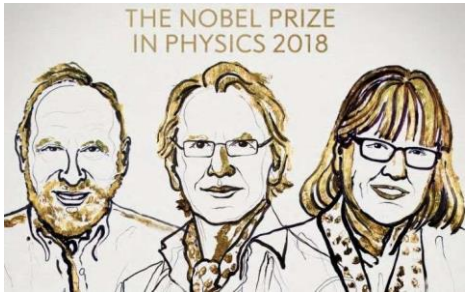


"Anne L'Huillier"

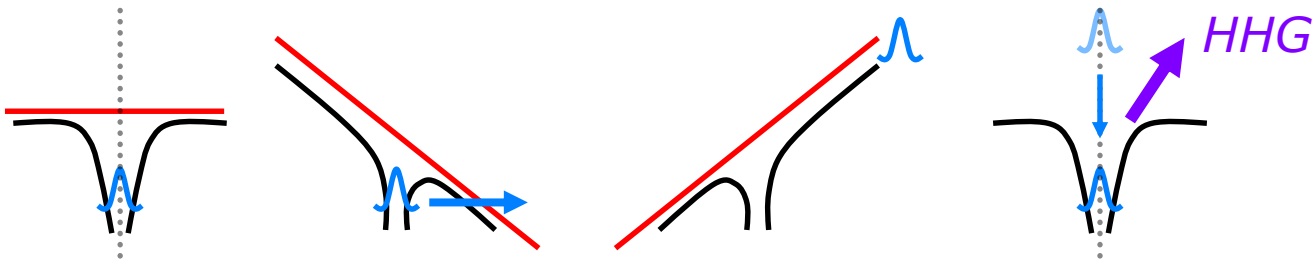
High Harmonic Generation



Ti:Sa Femtosecond CPA laser



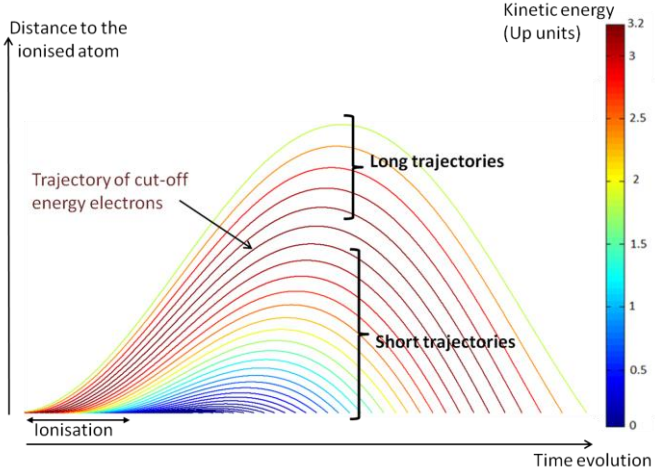
Conceptual idea of attosecond source based on HHG
Flexibility of table top !



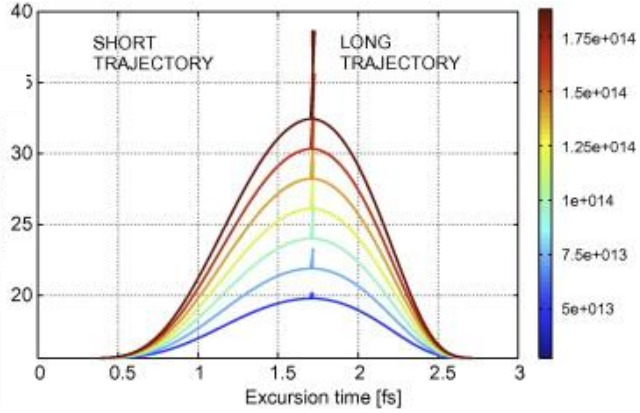
Atomic potential I_p *1: Tunneling* *2: Free e⁻ propagation* *3: Radiative recombination*

$$\hbar\nu_q = I_p + E_c \le I_p + 3.17U_p$$

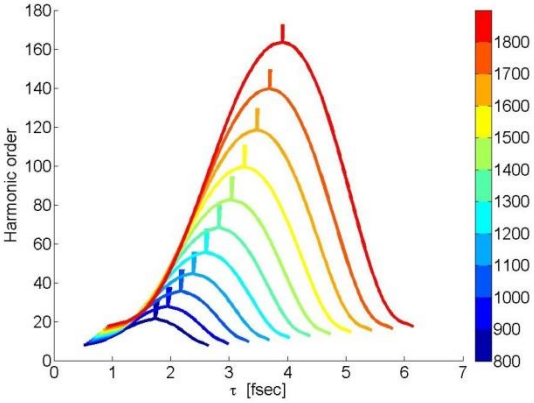
Sub-cycle trajectories



Time-frequency mapping

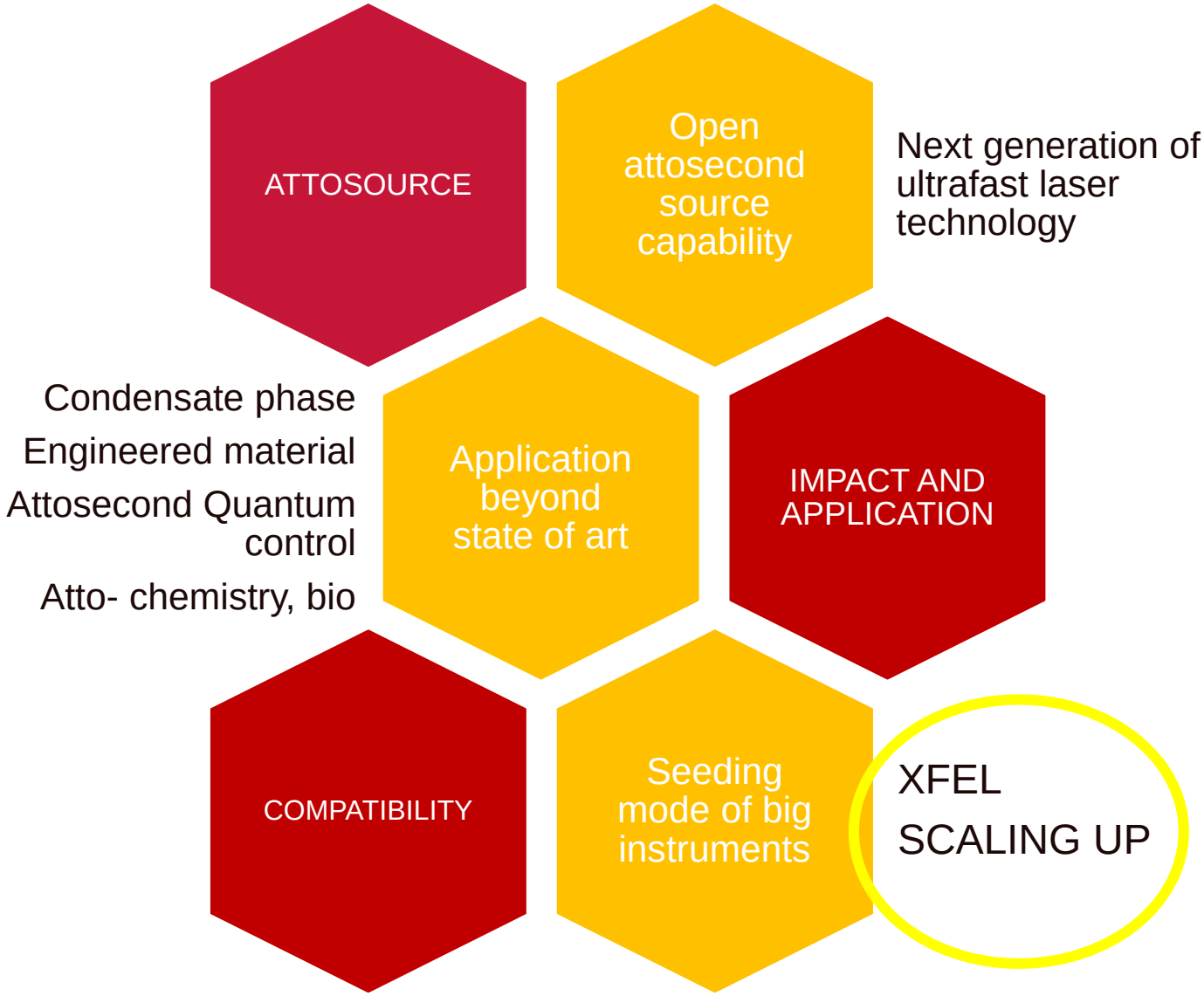


Time-frequency scaling



K. J. Schafer et al.,PRL 70, 1599 (1993)
P. B. Corkum PRL 71,1994 (1993)
M. Lewenstein et al., PRA 49, 2117 (1994)

Challenge roadmap and vision strategy of atto@kings



Why and how seeding XFEL

- Improve longitudinal coherence and brilliance
- Improve stability of pulse energy and wavelength
- Produce ultrashort pulse and its control is becoming possible
- Synchronisation od seed and XFEL
- Reduction of saturation length

Adaptability required from the seed:

- Xray range accessible at high reprate
- Polarisation match
- Multi-colour for pump-probe X-X'
- CEP (new!)?

Candidates:

- HHG (XFEL = amplifier)
- FEL seeding XFEL
- Laser

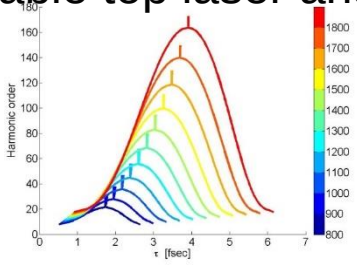
(electron beam manipulation to HHG)

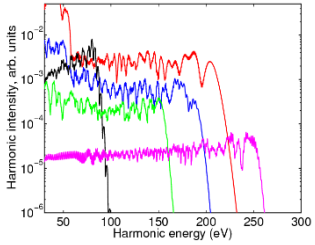
Solution from the flexibility of table top laser and table top HHG

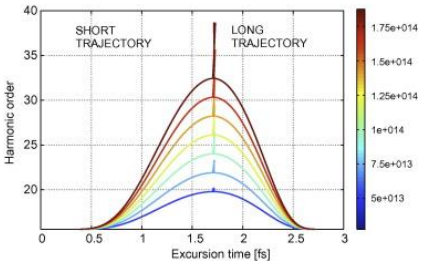
Longer wavelength

Synthesised laser field

High intensity







High repetition rate laser system for attosource: last achievements

Thin disk intracavity generation

Labaye et al., OL 42, 24, 5170-5173 (2017)

320 W intracavity power
17.5 MHz
High pressure Xe cell
Up to 24 eV
2.6 10^8 ph/s @13.2 eV

Fs oscillator intracavity HHG

Mils et al., RSI 90, 8, 083001 (2019)

60 MHz
Ar
Up to 40 eV
10^11 ph/s

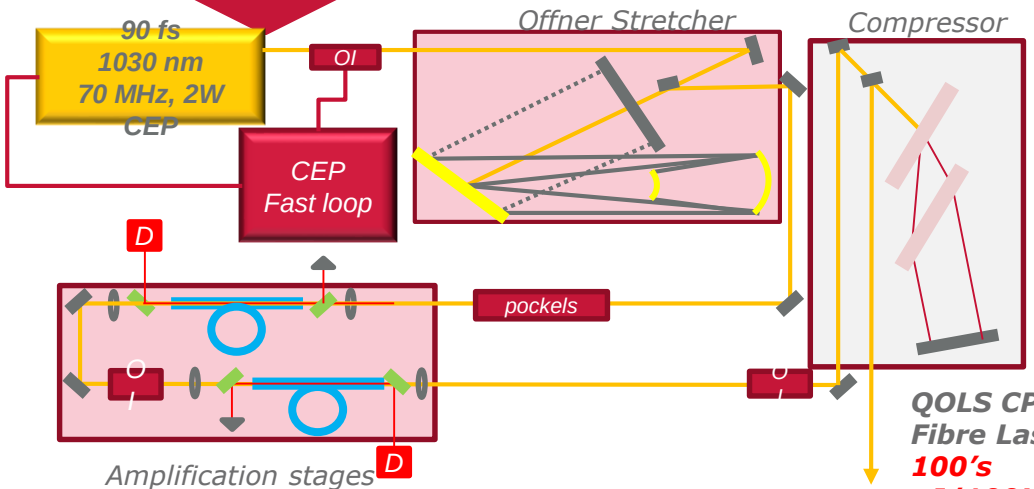
CPA Yb

Being publish by diverse group
Originally Jena, Bordeaux
Now MBI, ELI-ALPS, King's

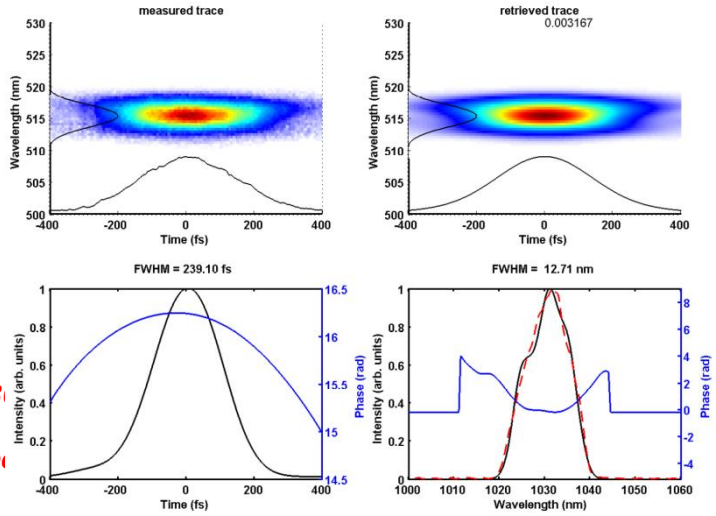
100KHz/1 MHz
Ar
Up to 40 eV
10^11 ph/s
ATTO and scalable

High reprate compact Yb CPA technology in UK

ATTOSOURCE



QOLS CPA
Fibre Laser
100's µJ/100KHz
300fsec/103 nm
CEP stabilise
HHG experiment



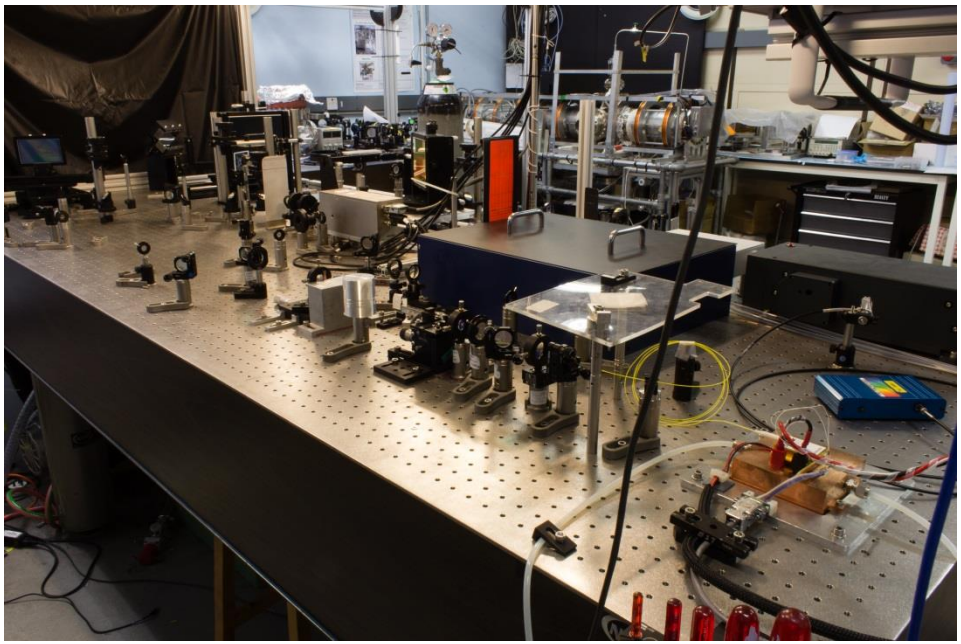
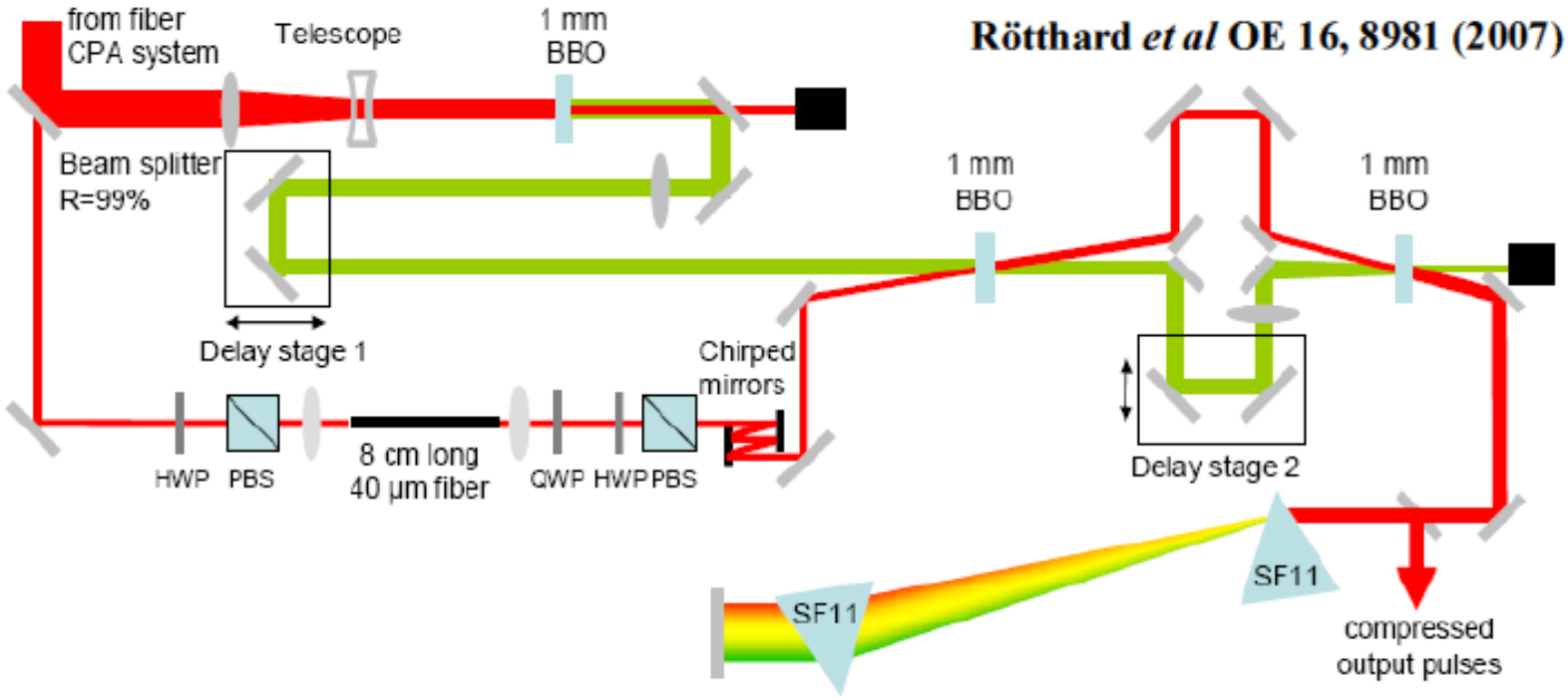
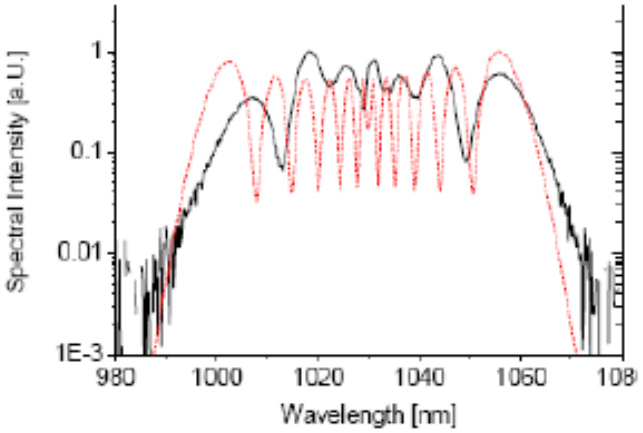


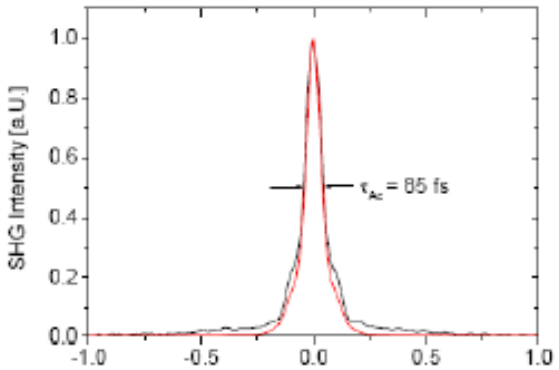
Table top !
After compression
8.5 µJ
100 KHz
240 fs @ 1030nm

*S. Driever et al., **Fiber Lasers** XI 8961-108 (2014)*
A. Zair in preparation (2020)

Yb CPA pumping OPCPA technology







47 µJ

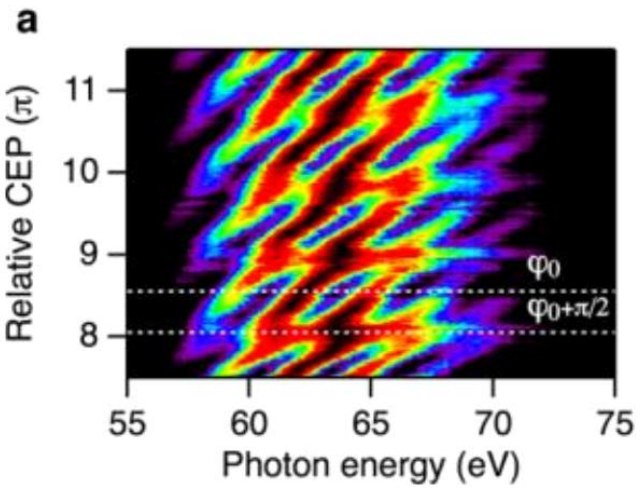
100 kHz

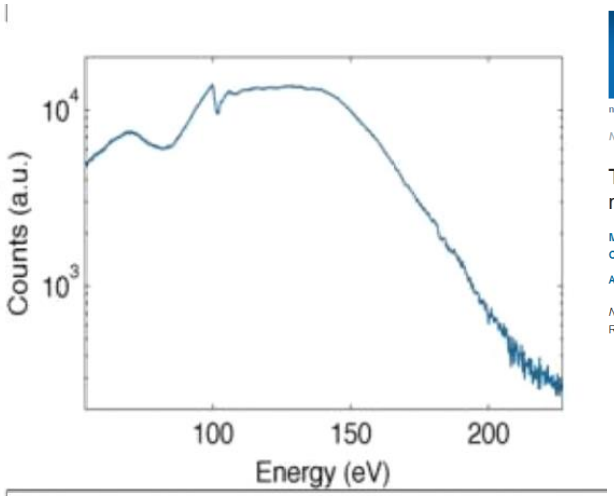
57 fs

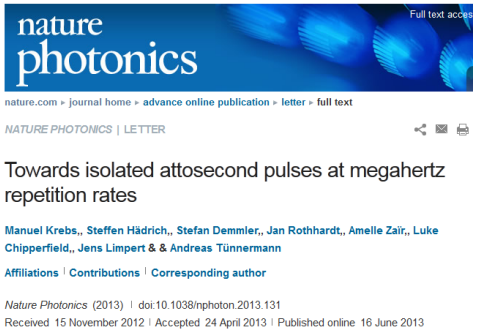
Pc = 500 MW

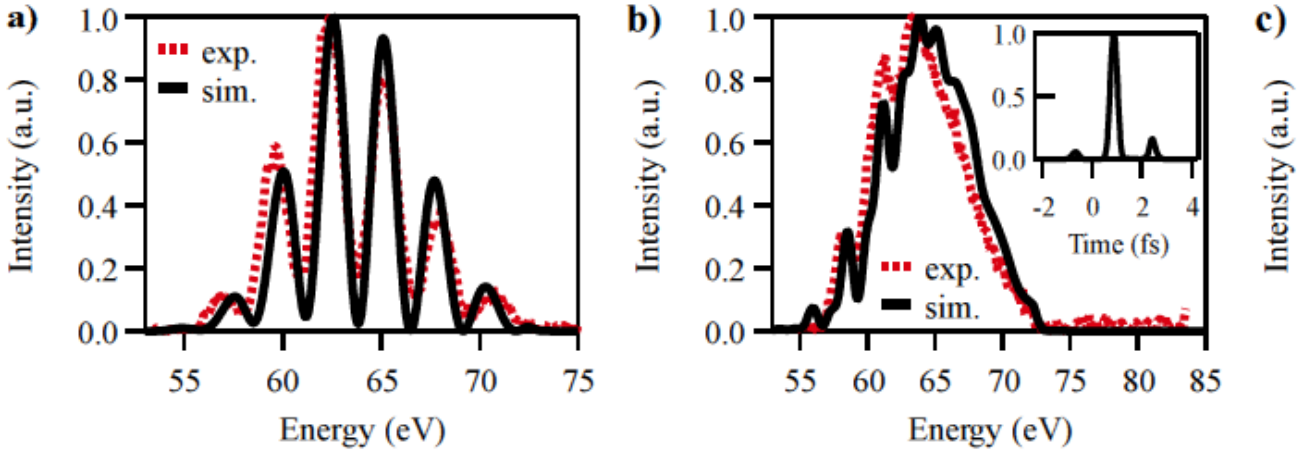
MHz HHG

Megahertz repetition rate isolated attosecond pulse generation









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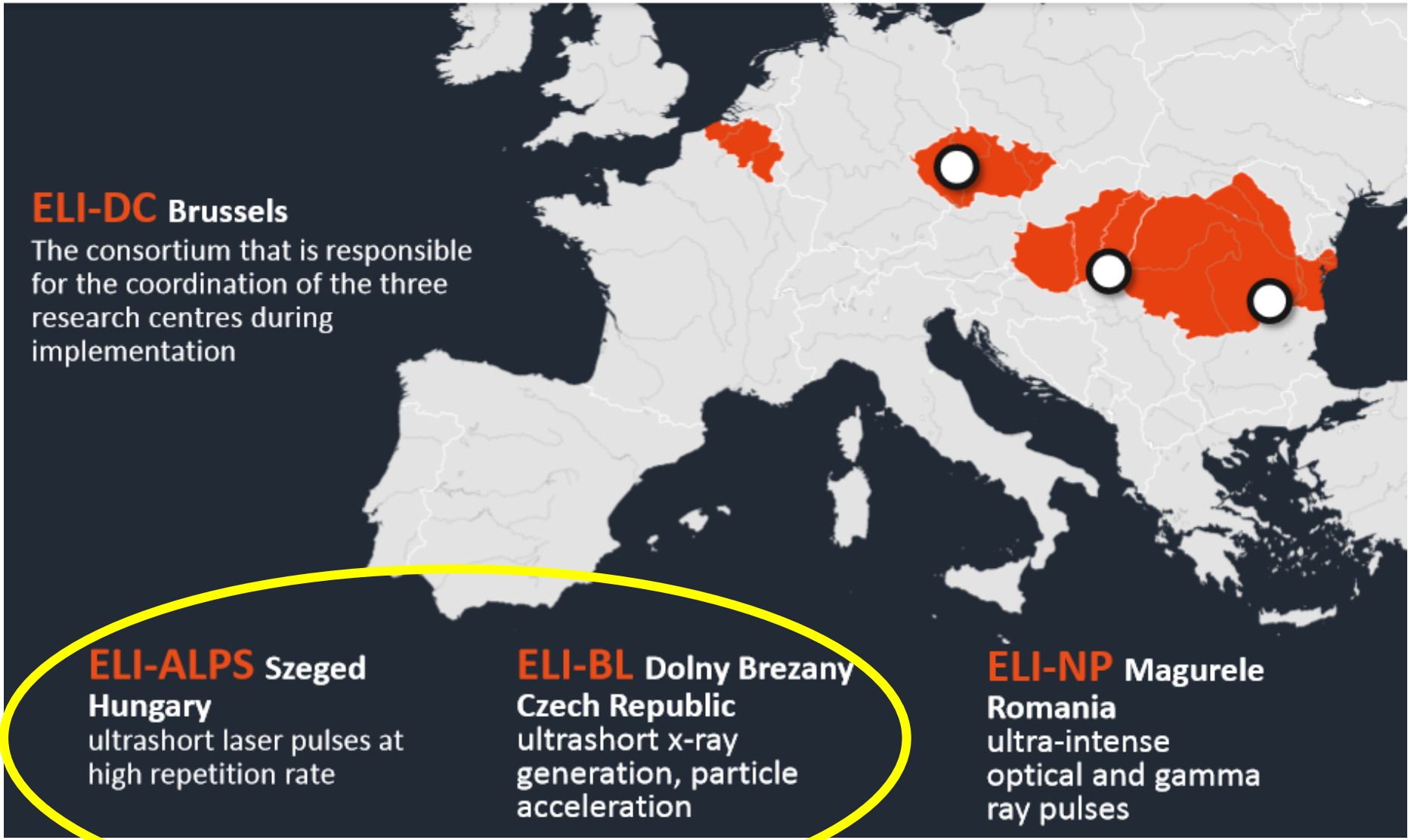
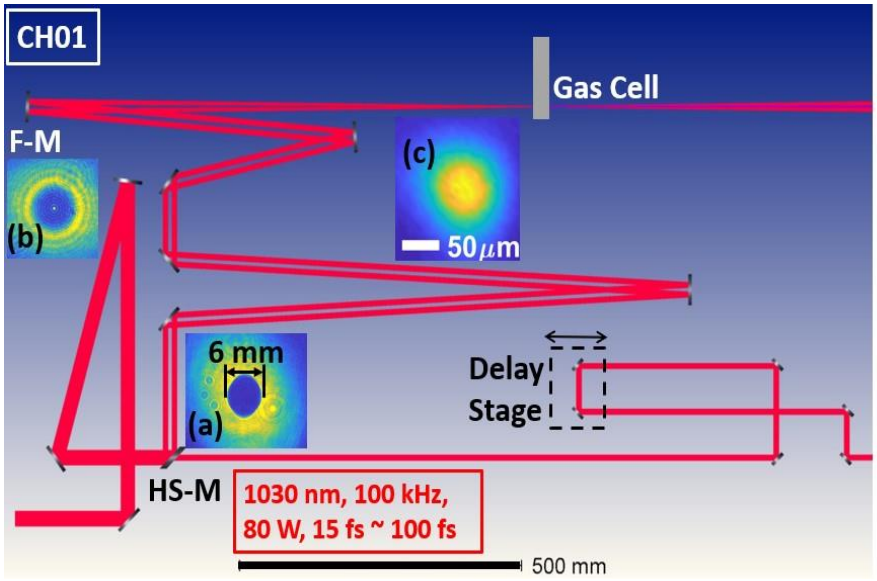
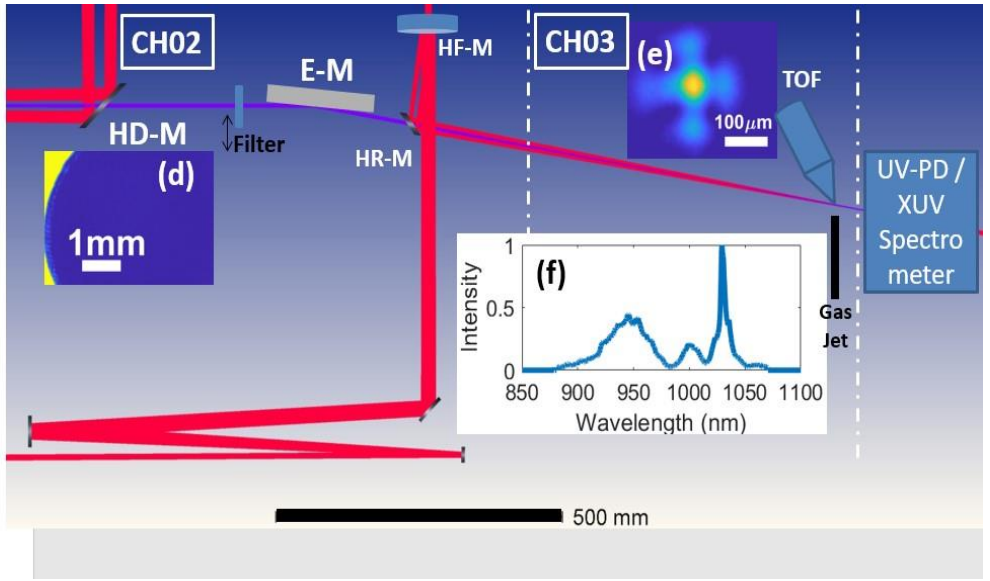
Rapid growth of infrastructure ELI project

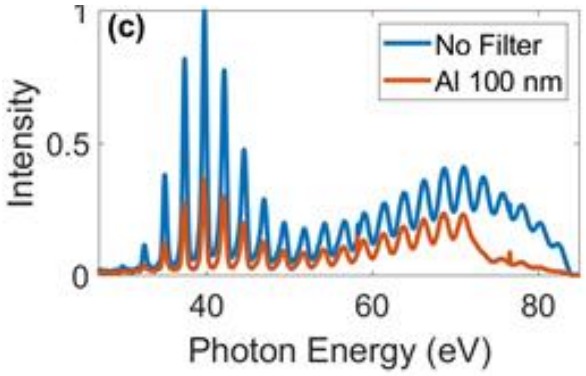


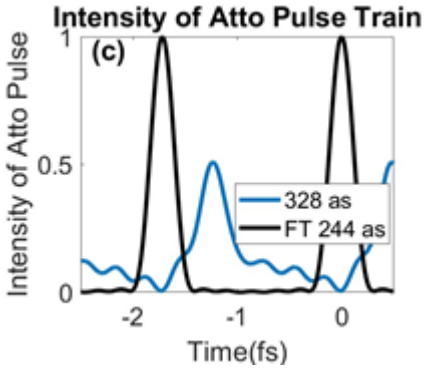
First ELI-ALPS HHG ATTOsource ‘100 KKz

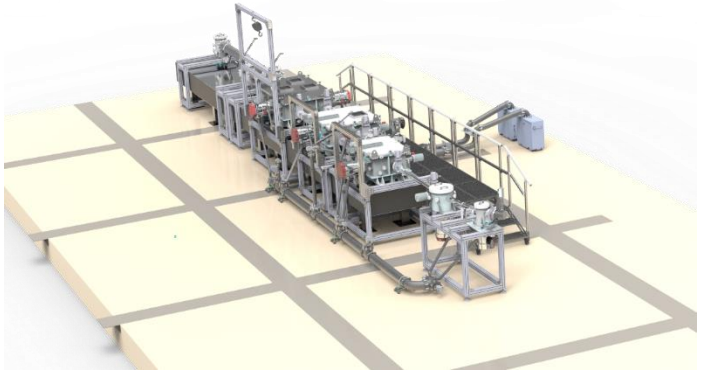




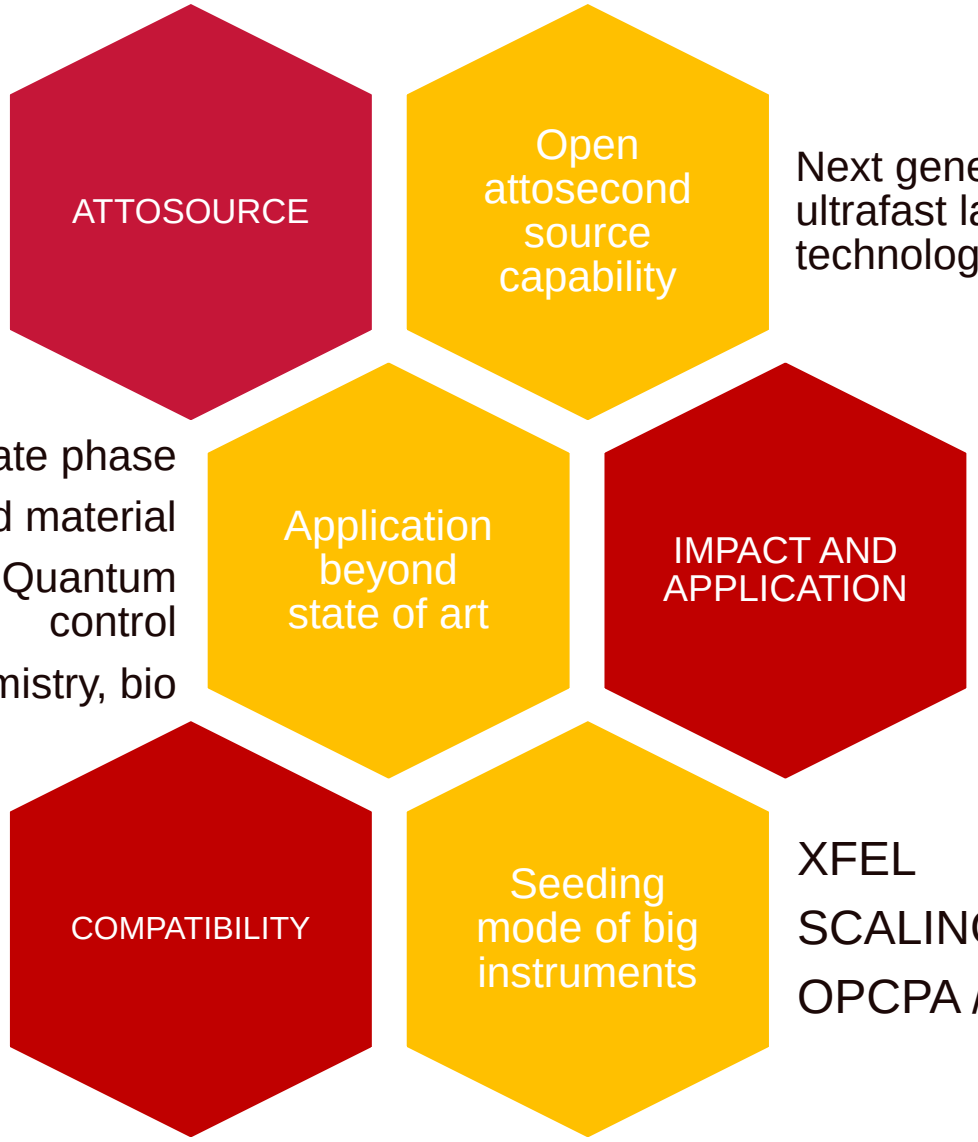
Proof of operation: temporal profile from RABITT







Potential of merging HHG and XFEL is huge



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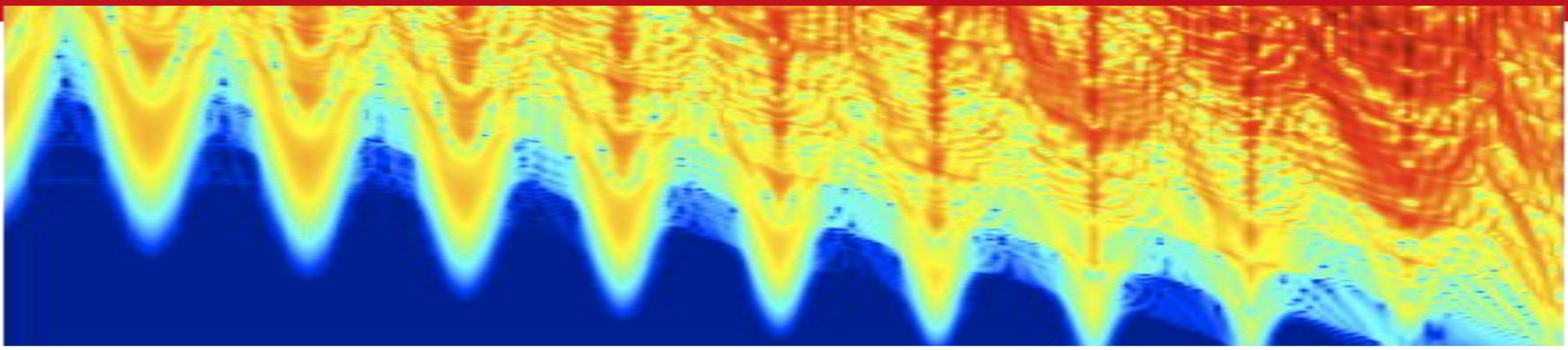
Thank you



Imperial College London [Jon Marangos and John Tisch
Jena [Jens limpert and Andreas Trunman]
ELI-ALPS [Harshitha NG, Tamas Csizmadia, Leni Gulyas, Peng Ye]
ETHZ [Ursula Keller and Thomas Sudmayer]