ELI-ALPS Research Institute
TOWARDS THE SHARP END OF ATTOSCIENCE

Commissioning Progress and Access Status

ELI ALPS Research Institute

Katalin Varjú

ELI ALPS, Science Director

ELI ERIC Users Workshop
Szeged (hybrid) 3 – 4 November, 2022

SZÉCHENYI 2020

HUNGARIAN GOVERNMENT

European Union
European Regional Development Fund

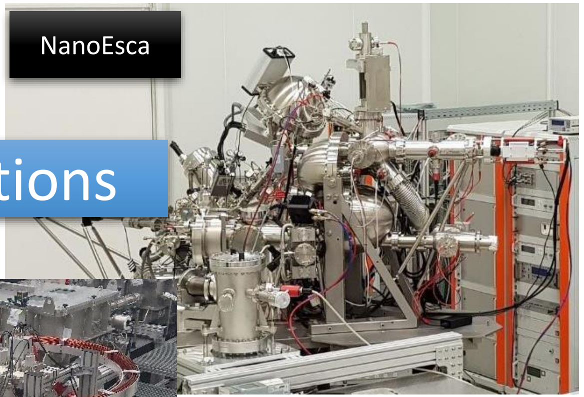
INVESTING IN YOUR FUTURE

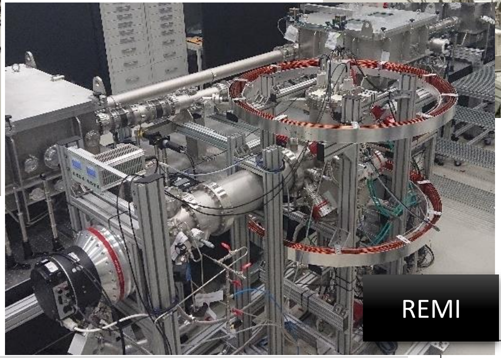
Portfolio of research opportunities
Capacity, Capability and Uniqueness

Lasers

Endstations

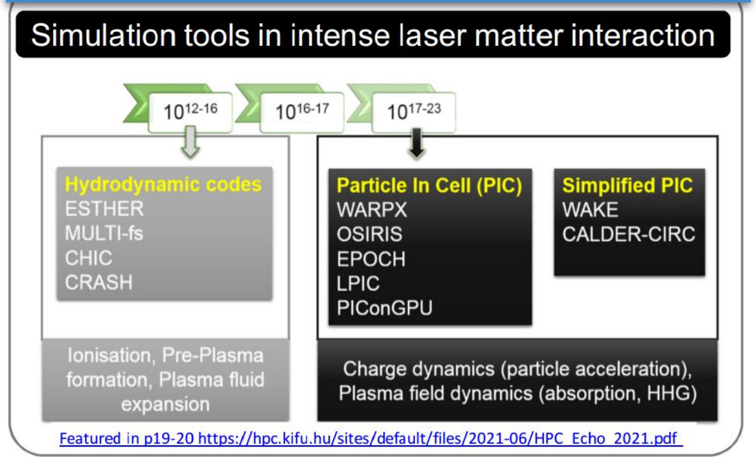
NanoEsca



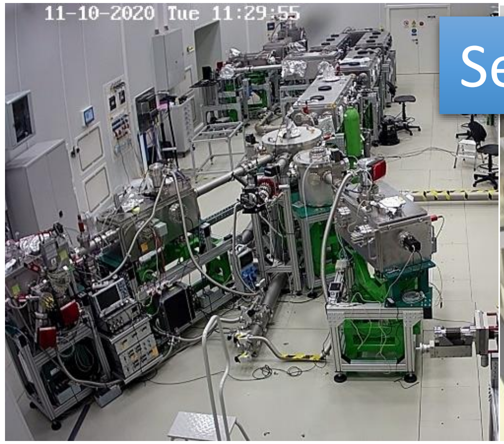


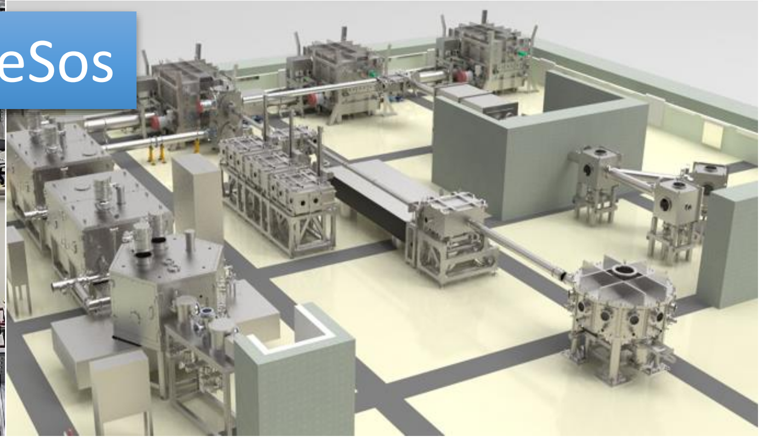
REMI

Simulation tools

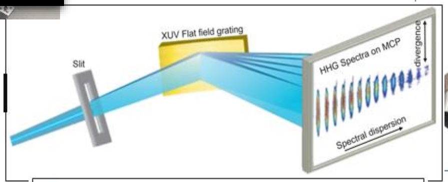


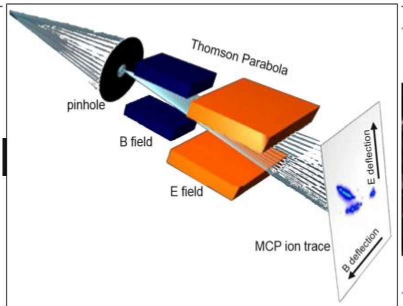
SeSos

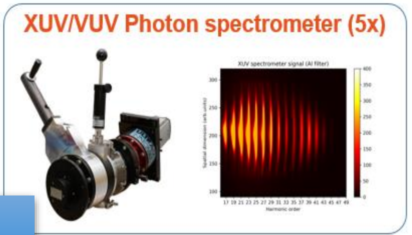


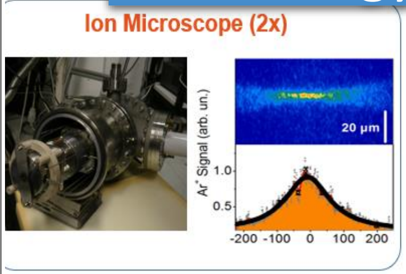


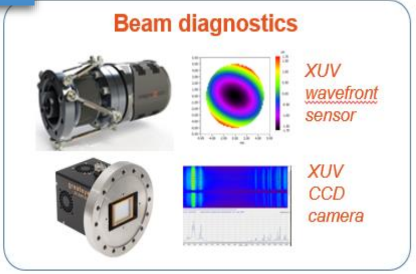
Metrology





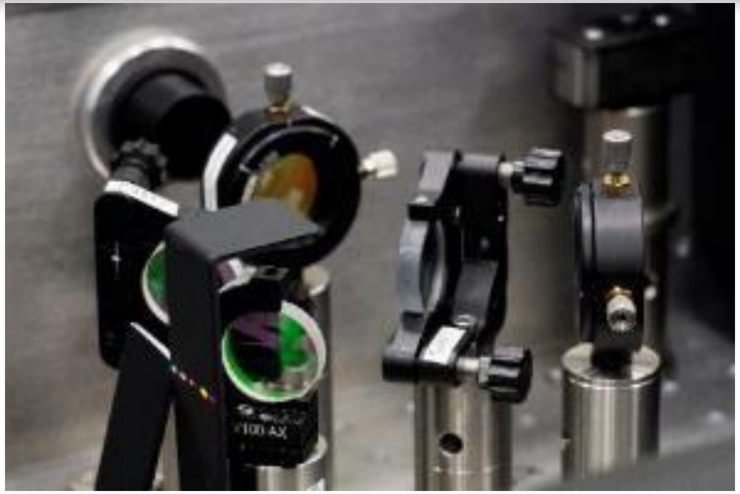


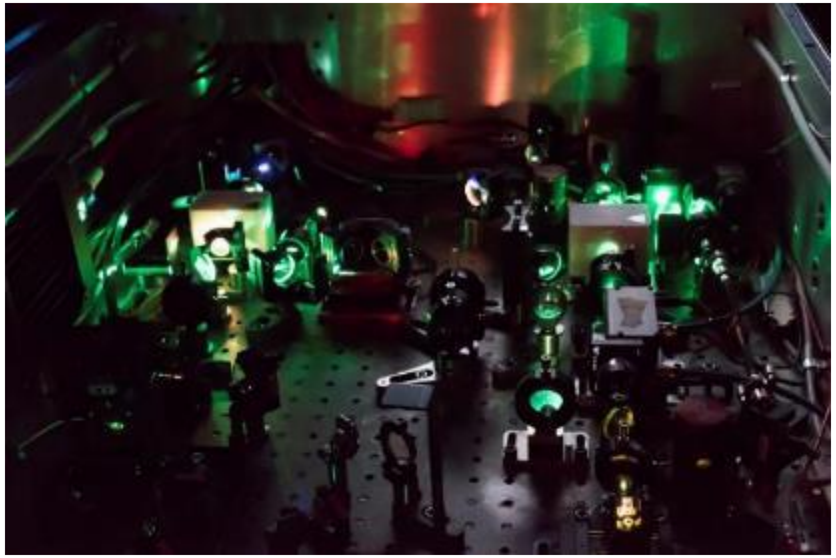




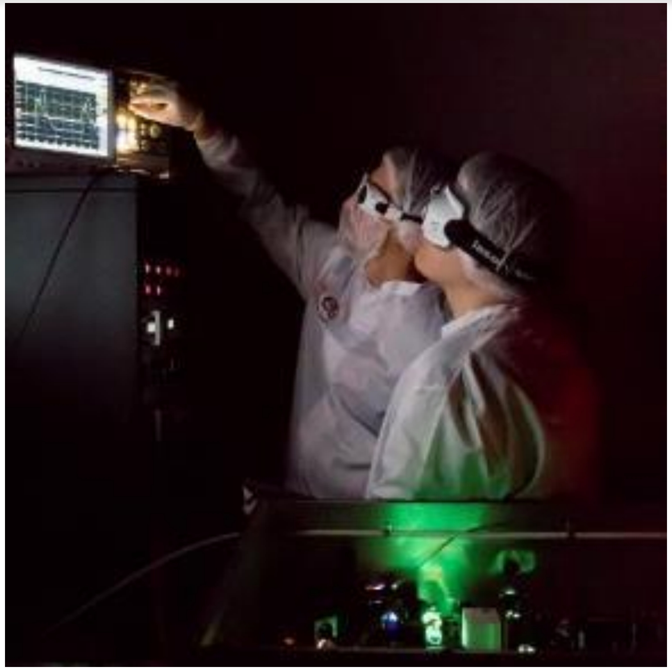
Virtual tour of ELI ALPS I. building

Virtual tour of ELI ALPS II. laboratories





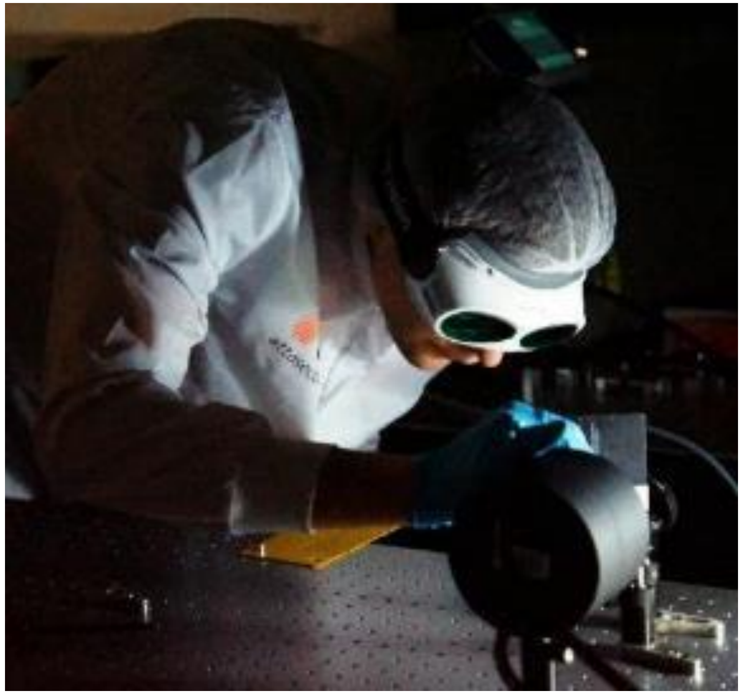
Virtual tour of ELI ALPS III. people



Open positions in

Laser science, AMO, condensed matter and plasma physics

@ junior, postdoc and technician level



Laser parameters & status

user ready
by Q2 2023
by Q4 2023

	Parameters	Status	Date for user access
HR1	***100 kHz, 30 fs, 1.8 mJ*** ***100 kHz, <7 fs, 1 mJ***	CEP stability unresolved, will be treated Q2 2023	***Available to users***
HR2	*100 kHz, <6 fs, 5 mJ, CEP*	Under development (current status 76 fs, 6.3 mJ or 9 fs, 3.5 mJ)	by Q1 2023
HR Alignment	*1 kHz, 7 fs, 1 mJ*	Under procurement	by Q3 2023
MIR	***100 kHz, <42 fs, 130 μJ, CEP*** ***100 kHz, <20 fs, 70 μJ, CEP***	recommissioned in new lab	***Available to users***
MIR-HE	*3.2um, 1 kHz, CEP:* *<50 fs, 20 mJ or <25fs, 10 mJ* *1.6um, 1 kHz, CEP:* *<100 fs, 12 mJ*	Under development	*by Q2 2023*
SYLOS 2	***1 kHz, <7.5 fs, >30 mJ, CEP***	flat top profile > 30 mJ; Gaussian beam profile >24 mJ	***Available to users***
SYLOS 3	*1 kHz, <8 fs, >120 mJ, CEP*	Under development	by Q4 2023
SYLOS Alignment	***10 Hz, <12 fs, >40 mJ***	postcompressed pulses on target: >10 mJ, <4.5 fs	***Available to users***
SYLOS Alignment 2	*10 Hz, 15 fs, 40 mJ, 850 nm*	Under procurement	by Q4 2023
HF PW	*10 Hz, <17 fs, 34 J* *2.5 Hz, 25 fs, ~7-10 J*	Under development (current status 10 Hz, 24 fs, 10 J)	by 2025 by Q2 2023
THz Pump	***1 kHz, 100 fs, 4 mJ*** ***50 Hz, <0.5 ps, 0.5 J, synch***	pump-probe schemes in development	***Available to users***

Secondary source parameters & status

user ready
by Q2 2023
by Q4 2023

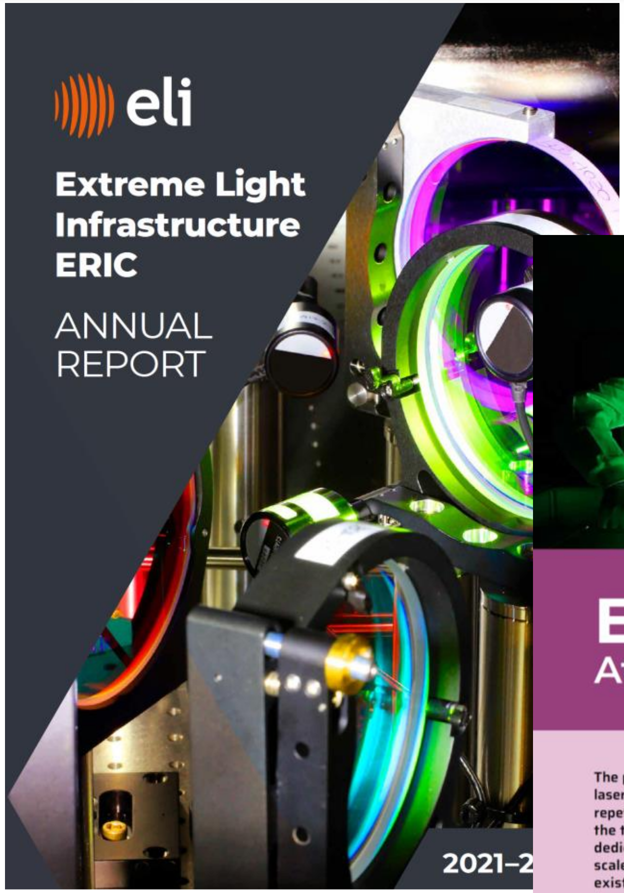
Secondary Source	Specs Achieved	Status	Date for user access
GHHG HR1 & 2 GAS (LTA4)	>270 pJ @ generation, >50 pJ on target; 166 as; @100 kHz; 30-70 eV	train of atto pulses, CEP of driver not resolved	Available to users with HR1 Q2 2023 (HR2)
GHHG HR1 & 2 CONDENSED (LTA3)	current status 170 pJ @ generation XUV monochromator installed	train of atto pulses XUV mono resolution 100-400 meV	Available to users with HR1 Q2 2023 (HR2)
GHHG SYLOS COMPACT (LTA2)	400 nJ @ generation in Ar, ~1 µJ in Xe	2-photon XUV process observed pol gating in development setting up Flagship proj	Available to users Q4 2022
GHHG SYLOS LONG (LTA1)	400 nJ @ generation in Ar, ~1 µJ in Xe	in commissioning (XUV flux studies)	by Q1 2023
SHHG SYLOS (MTA)		Under construction on site	by Q3 2023
SHHG PW (HTA)		Under construction on site	by Q3 2023
MIR HE GEN ATTO		Under development	by Q3 2023
NLTSF / THz SPECTROSCOPY (THz)	energy: 10 µJ at source, 5 µJ at sample useful spectral content: 0.15-2 THz peak THz field at sample: ≥450 kV/cm	recommissioned in new lab, pump-probe schemes THz – THz – white light – green	Available to users
THz HIGH ENERGY (THz)	energy ~ 1 mJ, @50 Hz useful spectral content 0,15 – 1,5 THz	pump-probe schemes in development	Available to users
ELECTRON- SYLOS (MTA)		Under construction on site	by Q3 2023
ELECTRON PW (HTA)		Under development	by Q4 2023

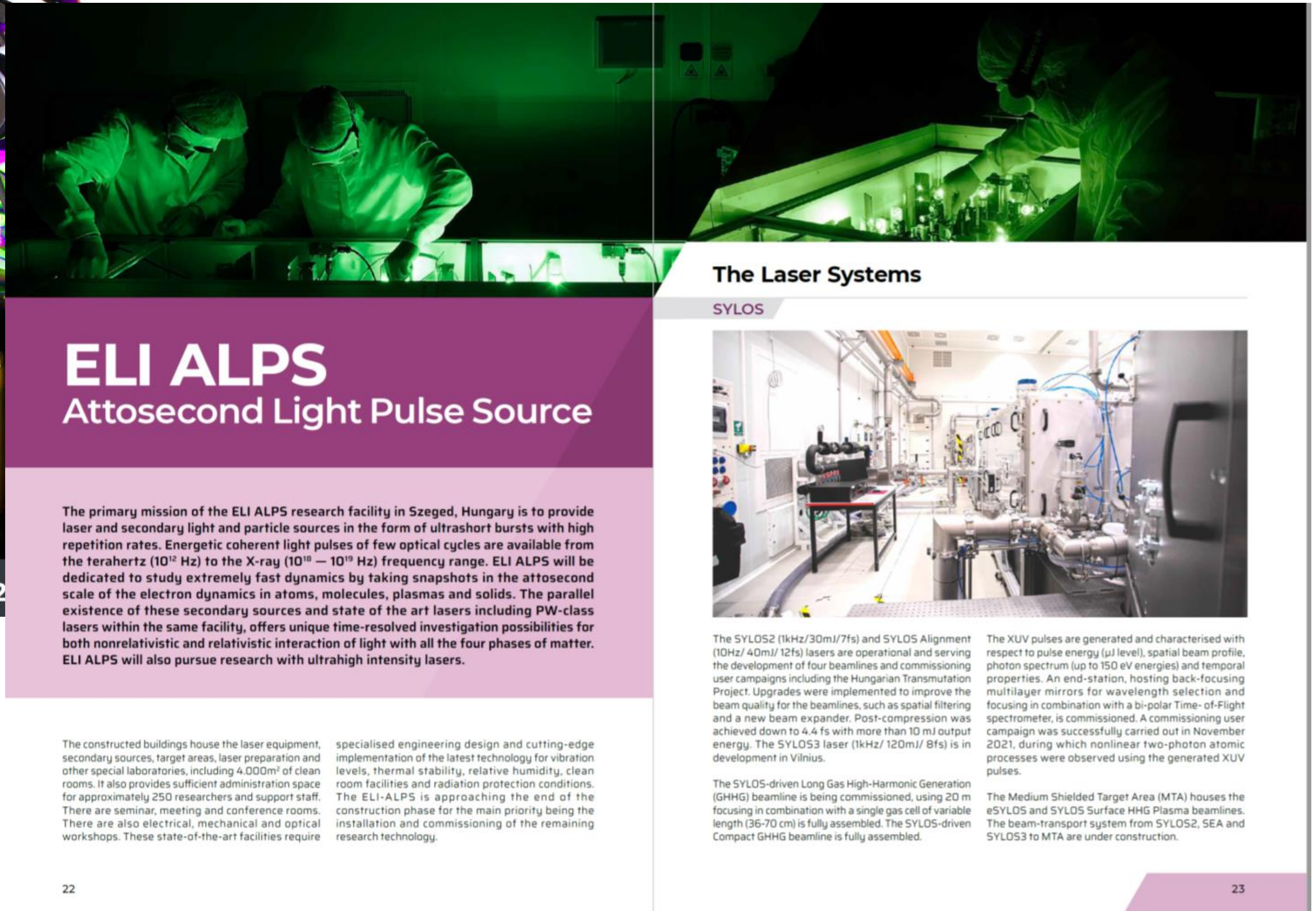
Experimental stations implementation status

user ready
by Q2 2023
by Q4 2023

Experimental Stations	Status	Date for user access
REACTION MICROSCOPE / COLTRIMS	*installed on HR GHHG*	*available to users*
VMI SPECTROMETER ENDSTATION	*tested on HR GHHG, adaptation to MIR ongoing*	*available to users*
CONDENSED MATTER STATION (NANOESCA)	*internal VUV source, CEP stable oscillator, HR GHHG source*	*available to users*
MAGNETIC BOTTLE e SPECTROMETER (IMPULSE) – *collab FORTH*	*under development*	*Q1 2024*
NANOSCIENCE & NANOFABRICATION	*electron beam lito + focused ion beam*	*available to users*
NANOSCIENCE: time resolved ELLIPSOMETRY	*under internal development*	*Q3 2023*
NANOSCIENCE: Scanning Nearfield Microscope	*under procurement*	*Q3 2023*
LIDT and LASER MACHINING test station	*under internal development*	*Q2 2023*
CHEMICAL REACTION CONTROL STATIONS (GPRC; TAS)	*transient absorption setup for condensed samples on HR, gas phase reaction control on SYLOS*	*available to users*
LIQUID JET ENDSTATION – *collab LMU*	*commissioning tests ongoing*	*Q2 2023*
MULTIDIMENSIONAL SPECTROSCOPY (FEMTOBIOLOGY) – *collab BRC*	*under development*	*Q2 2023*
RADIOBIOLOGY / BIOMEDICAL LAB	*standard biology toolset* *zebrafish embryo test model for radiobio studies* *Radiobiology toolset (irradiator, dosimetry setup)*	*available to users*
eSYLOS IRRADIATION FACILITY (for biol, *chem, phys samples, dosimetry*)	*under internal development*	*Q3 2023*
eSYLOS X-RAY GENERATOR	*under internal development*	*Q3 2023*
HIGH FIELD PHYSICS STATION (PW)	*under internal development*	*Q3 2023*
THz PUMP – XUV PROBE	*under internal development*	*Q2 2023*
CHEMICAL PREP LAB	*standard chemistry toolset*	*available to users*

ELI ERIC facilities recent advances – annual report





ELI ALPS
Attosecond Light Pulse Source

The primary mission of the ELI ALPS research facility in Szeged, Hungary is to provide laser and secondary light and particle sources in the form of ultrashort bursts with high repetition rates. Energetic coherent light pulses of few optical cycles are available from the terahertz (10^{12} Hz) to the X-ray (10^{18} — 10^{19} Hz) frequency range. ELI ALPS will be dedicated to study extremely fast dynamics by taking snapshots in the attosecond scale of the electron dynamics in atoms, molecules, plasmas and solids. The parallel existence of these secondary sources and state of the art lasers including PW-class lasers within the same facility, offers unique time-resolved investigation possibilities for both nonrelativistic and relativistic interaction of light with all the four phases of matter. ELI ALPS will also pursue research with ultrahigh intensity lasers.

The constructed buildings house the laser equipment, secondary sources, target areas, laser preparation and other special laboratories, including 4.000m² of clean rooms. It also provides sufficient administration space for approximately 250 researchers and support staff. There are seminar, meeting and conference rooms. There are also electrical, mechanical and optical workshops. These state-of-the-art facilities require specialised engineering design and cutting-edge implementation of the latest technology for vibration levels, thermal stability, relative humidity, clean room facilities and radiation protection conditions. The ELI-ALPS is approaching the end of the construction phase for the main priority being the installation and commissioning of the remaining research technology.

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The Laser Systems

SYLOS

The SYLOS2 (1kHz/30mJ/7fs) and SYLOS Alignment (10Hz/ 40mJ/ 12fs) lasers are operational and serving the development of four beamlines and commissioning user campaigns including the Hungarian Transmutation Project. Upgrades were implemented to improve the beam quality for the beamlines, such as spatial filtering and a new beam expander. Post-compression was achieved down to 4.4 fs with more than 10 mJ output energy. The SYLOS3 laser (1kHz/ 120mJ/ 8fs) is in development in Vilnius.

The SYLOS-driven Long Gas High-Harmonic Generation (GHHG) beamline is being commissioned, using 20 m focusing in combination with a single gas cell of variable length (36-70 cm) is fully assembled. The SYLOS-driven Compact GHHG beamline is fully assembled.

The XUV pulses are generated and characterised with respect to pulse energy (μJ level), spatial beam profile, photon spectrum (up to 150 eV energies) and temporal properties. An end-station, hosting back-focusing multilayer mirrors for wavelength selection and focusing in combination with a bi-polar Time-of-Flight spectrometer, is commissioned. A commissioning user campaign was successfully carried out in November 2021, during which nonlinear two-photon atomic processes were observed using the generated XUV pulses.

The Medium Shielded Target Area (MTA) houses the eSYLOS and SYLOS Surface HHG Plasma beamlines. The beam-transport system from SYLOS2, SEA and SYLOS3 to MTA are under construction.

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ELI ALPS technological highlights – developments initiated by user requirements

1. Postcompression of laser pulses @ high energies

    Process is scalable, preparing to apply to all lasers.
    Increased peak power.
    Improved temporal resolution

    MIR (5.4 cycles to 1.9 cycles)
    SEA (4.13 cycles to 1.2 cycles)
    SYLOS – ongoing

2. Developing secondary sources (attosecond beamlines)

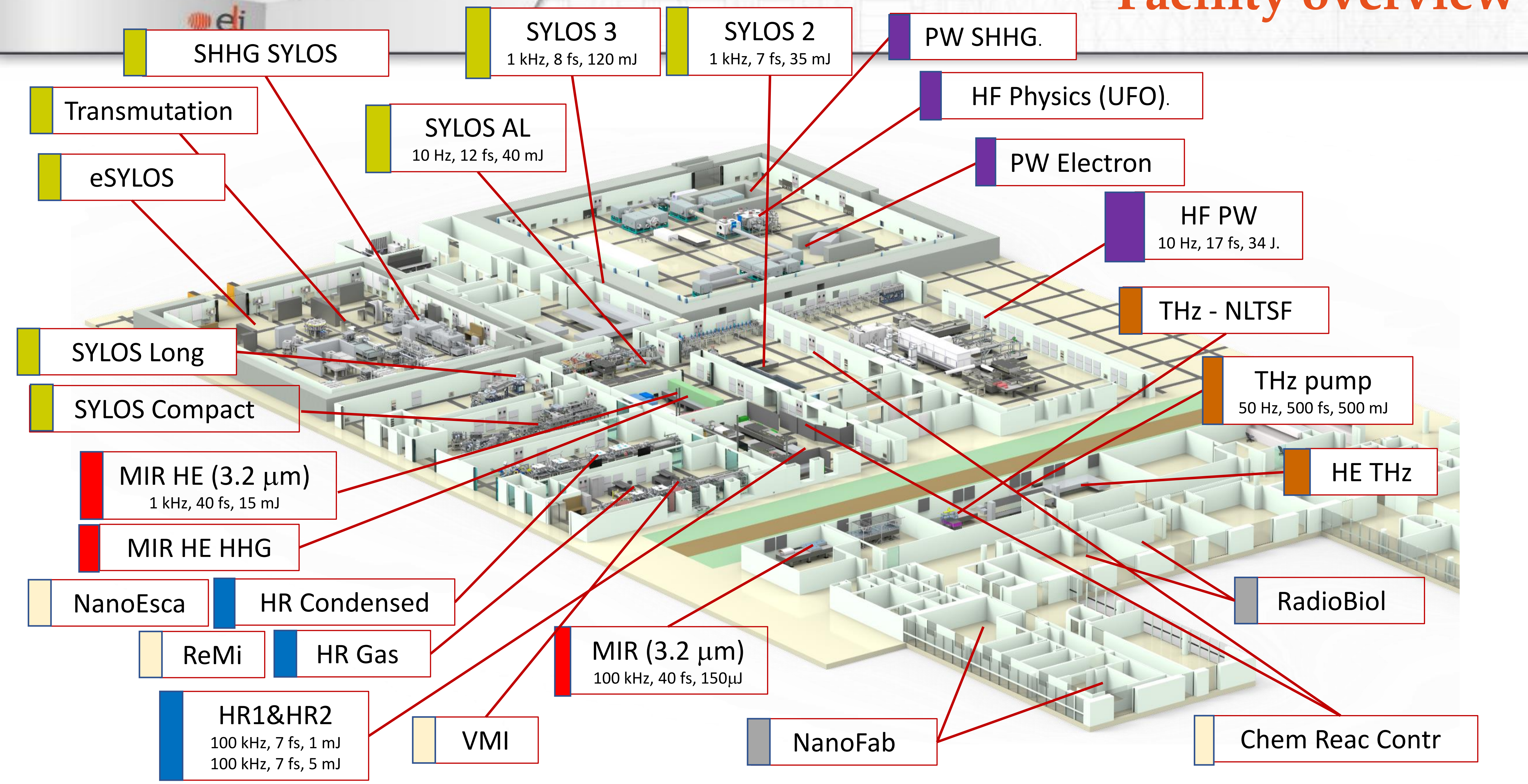
    Improving the flux (reached nonlinear regime)
    Improving temporal characteristics, incl. Polarization gating (towards single attopulse generation)

3. Increasing the versatility of pump-probe schemes on multiple lasers (THz, HR)

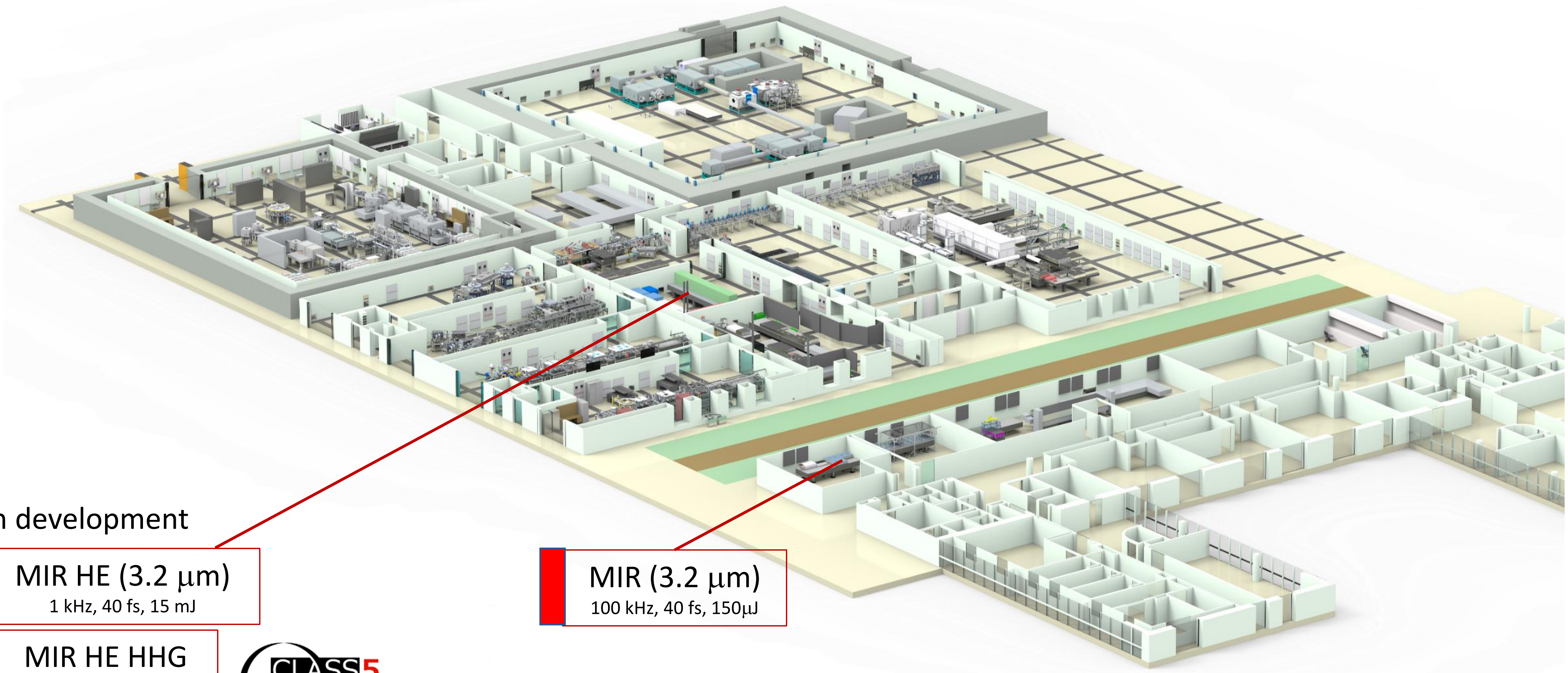
    2nd harmonic generation, 4th harmonic generation, white-light generation

All the developments have been requested by users, to be able to do next generation experiments, to reach parameters not accessible elsewhere.

Facility overview



MIR activity ~ 3μm



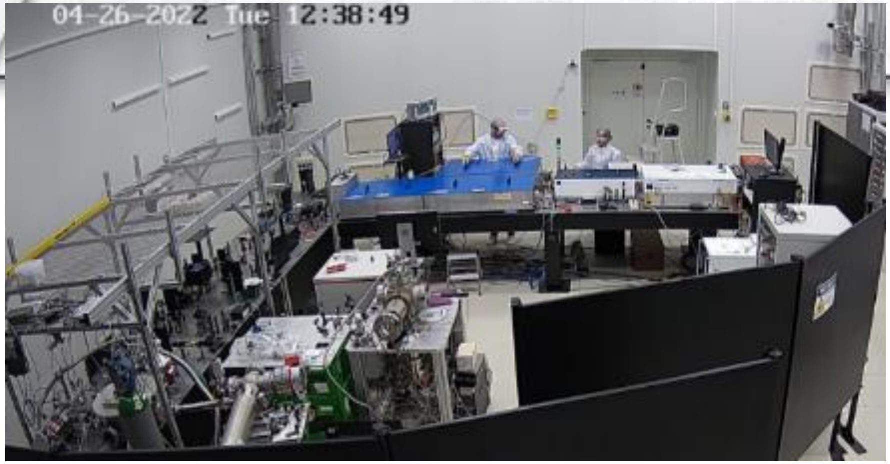
in development

MIR HE (3.2 μm)
1 kHz, 40 fs, 15 mJ

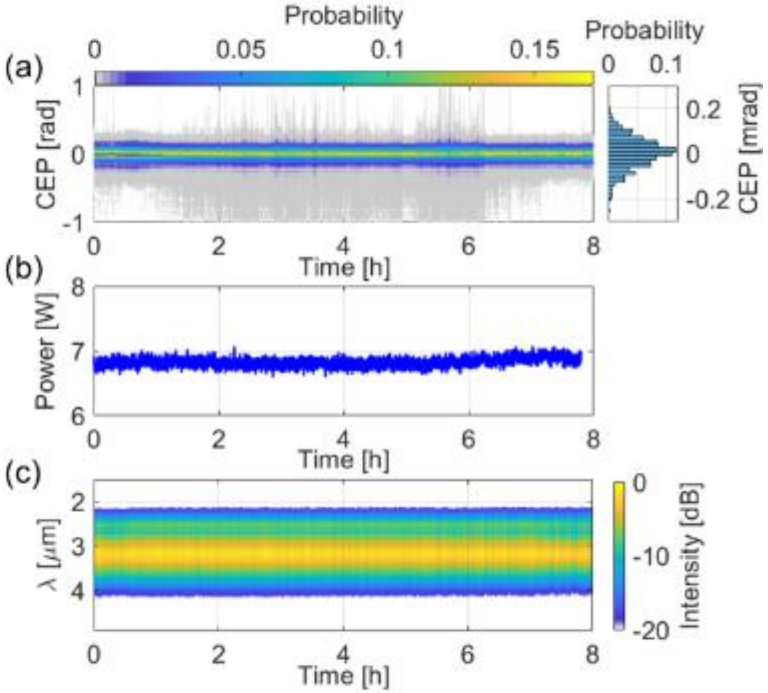
MIR HE HHG

MIR (3.2 μm)
100 kHz, 40 fs, 150μJ

Status of MIR laser

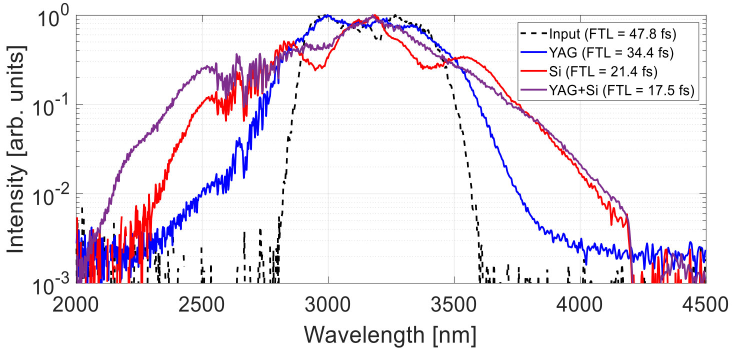


user ready



@10 kHz, active feedback loop, 82 mrad RMS
95% of points within [-150, +150]
0.9 % power stability
2.4 % pulse-to-pulse E stability

Spectral broadening in cystal pairs
(YAG & Si, BaF2 & Si)



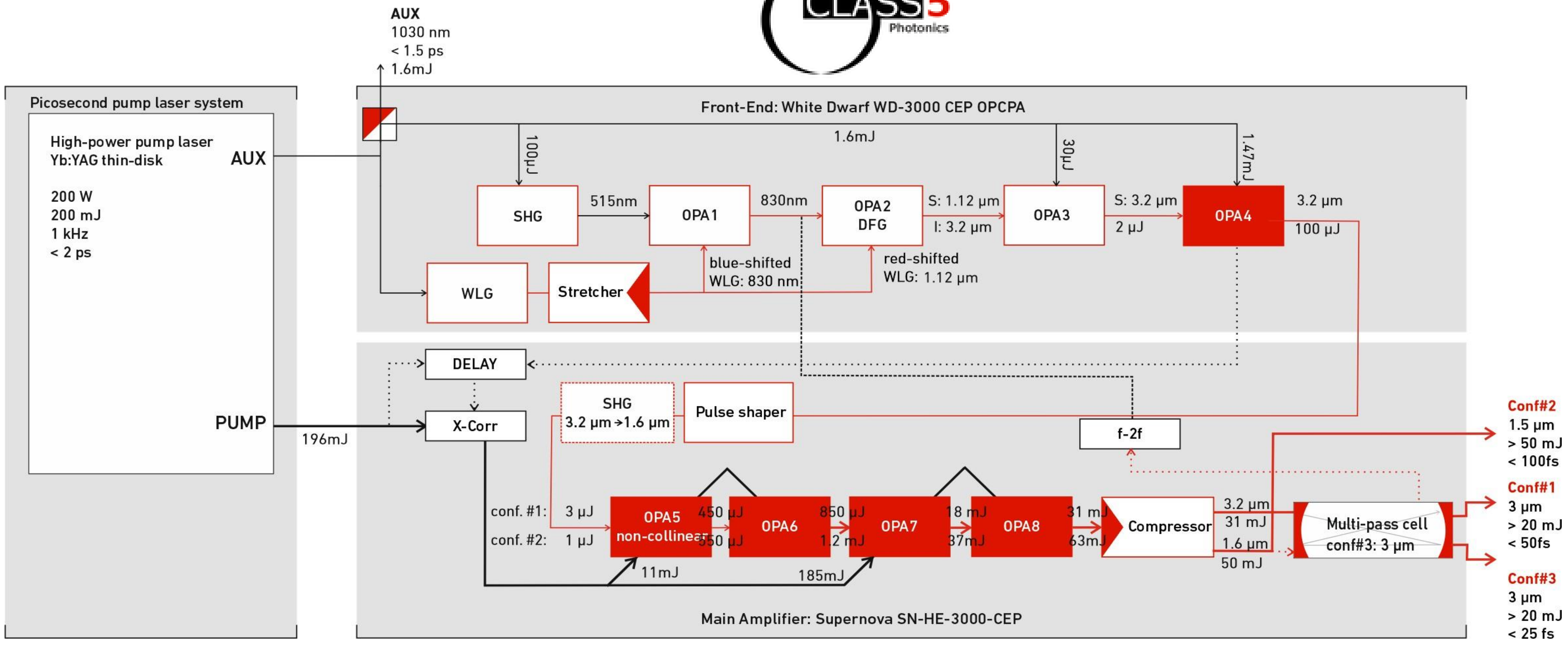
INPUT
11W, 110 μJ, 50 fs

OUTPUT
88 μJ, (17.5 fs) 1.9 o.c.@ 3 μm

Available diagnostics:
Spectrometer 1.5-5 um (Mozza, Fastlite)
Scanning FROG all reflective, down to sub-2 cycles @ 3μm
TIPTOE, down to single cycle @ UV to MIR.
Single-shot CEP detection (Fringeezz, Fastlite 10 kHz; TOUCAN, ELI-ALPS, 100 kHz)
Beam profilers (IRC912 MIR CCD camera, Ophir Nanoscan, Pyroview DIAS Infrared Bolometric camera)
Wavefront sensor (SID4-DWIR, Phasics)

	Parameters	Status	Operation due date
MIR	*100 kHz, <40 fs, 0.15 mJ, CEP* *100 kHz, 17.5 fs, 88 μJ, CEP* FASTLITE	*Operational*	*since October 2017*

MIR-HE laser - overview



HE-ATTO
(water window & keV)

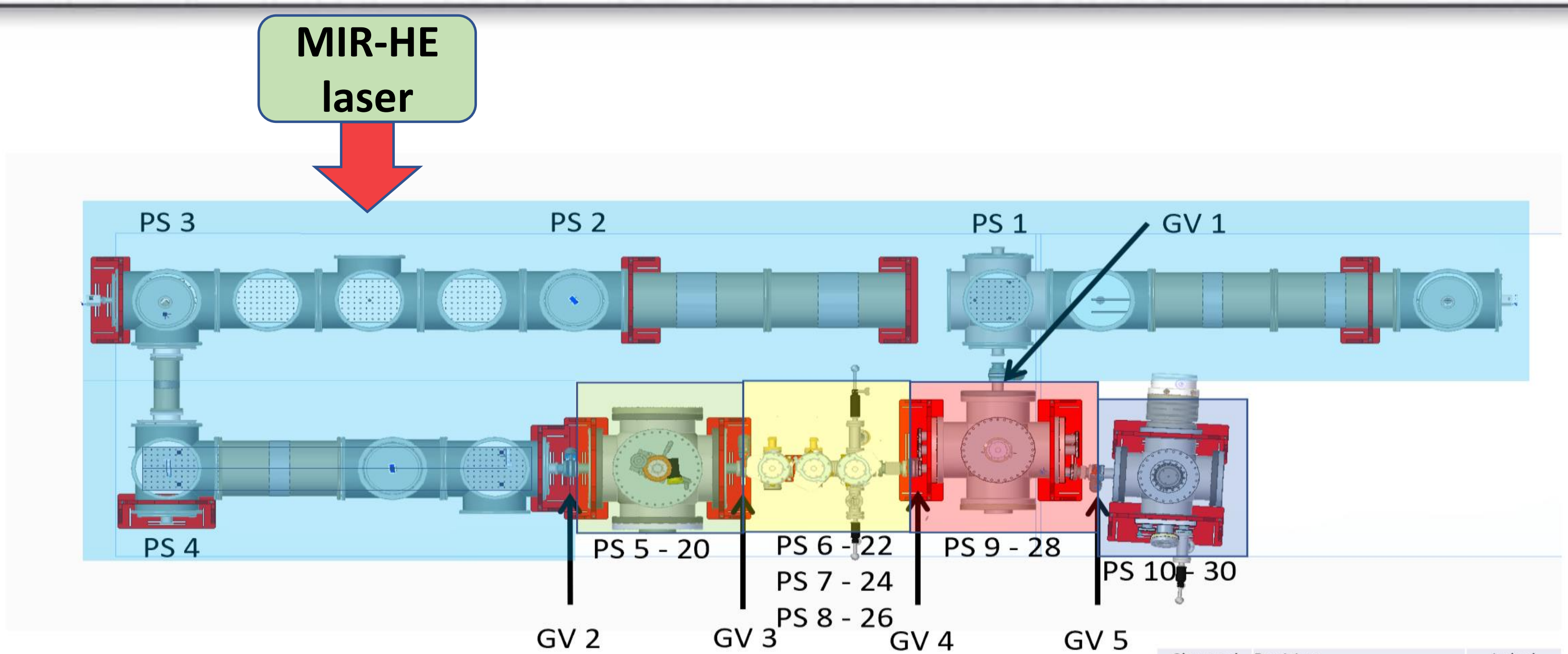
Configuration	Central wavelength [nm]	Pulse enegry [mJ]	Pulse duration [fs]
#1	3200	20	<50 (**5 cycles**)
#2	1600	12	<100 fs
#3	3200	10	<25 (**2.5 cycles**)

All configurations CEP stable (passive via DFG + feedback)

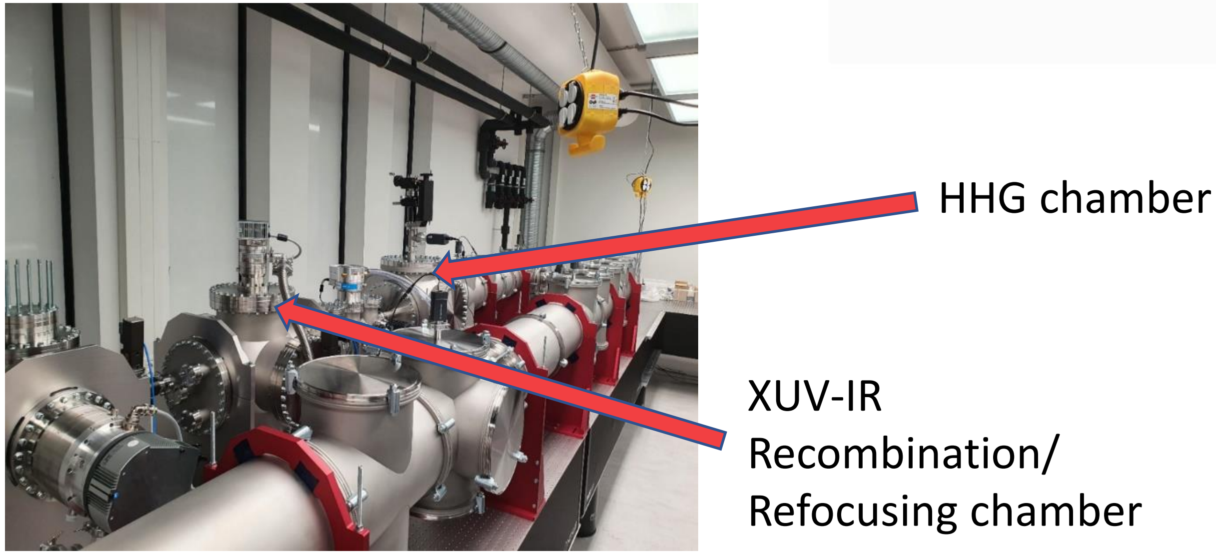
MIR-HE atto - overview

	Parameter	Specification MIR-HE ATTO
1.1	GHHG maximum photon energy at the interaction point driven by pulses from configuration#1 or configuration#3	1200eV
1.2	GHHG maximum photon energy at the interaction point driven by pulses from configuration#2	500eV
1.3	GHHG XUV/Soft X-ray photon flux at the interaction point driven by pulses from configuration#2	$\sim 10^9$ ph/s/10% BW @300eV

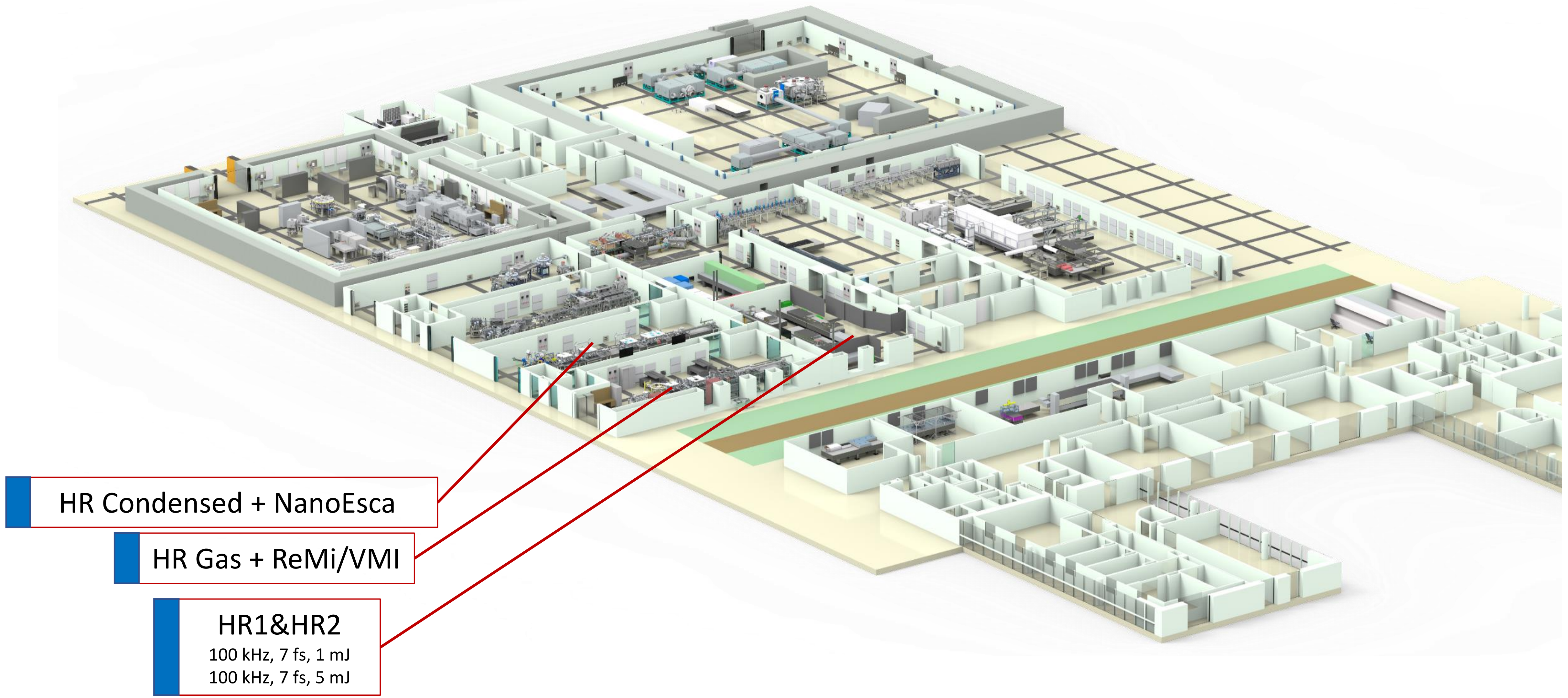
Table 2.1: Specifications of the MIR-HE ATTO.



Channel	Position	Label
20	HHG chamber	PS 5
22	Cross 1	PS 6
24	Cross 2	PS 7
26	Cross 3	PS 8
28	Refocusing chamber	PS 9
30	Experimental chamber	PS 10



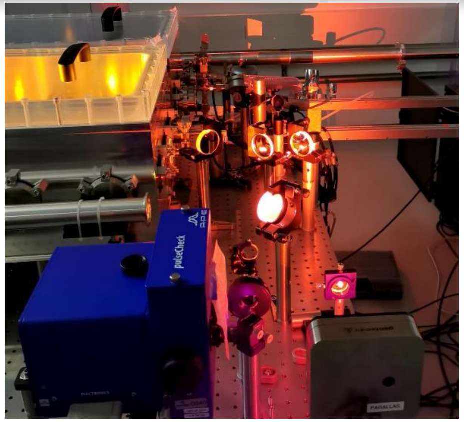
HR activity 100 kHz

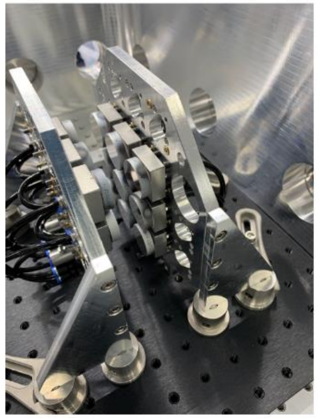


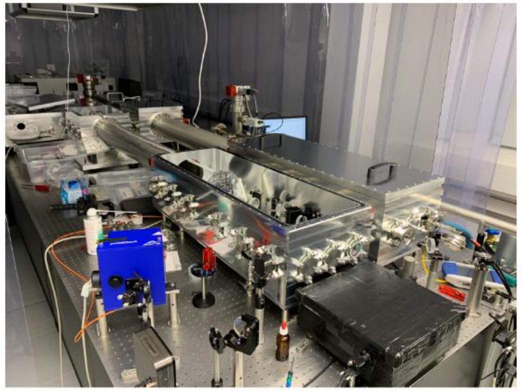
Status of HR lasers

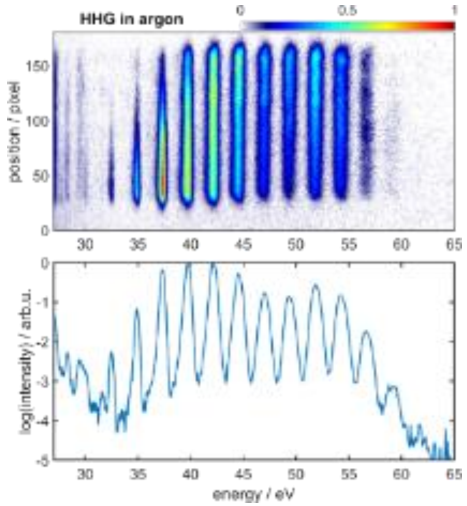
HR1: user ready

- fiber laser technology
- double MPC concept for postcompression<7fs









	Parameters	Status	User readiness
HR1	*100 kHz, 40 fs, 1.5 mJ* *100 kHz, <7 fs, 1 mJ, CEP*	*Operational*	*since Dec 2017* *Aug 2021*
HR2	100 kHz, <6 fs, 5 mJ, CEP	In development	by Q4 2022

Development status of HR2 laser

user ready in Q3 2023

Frontend

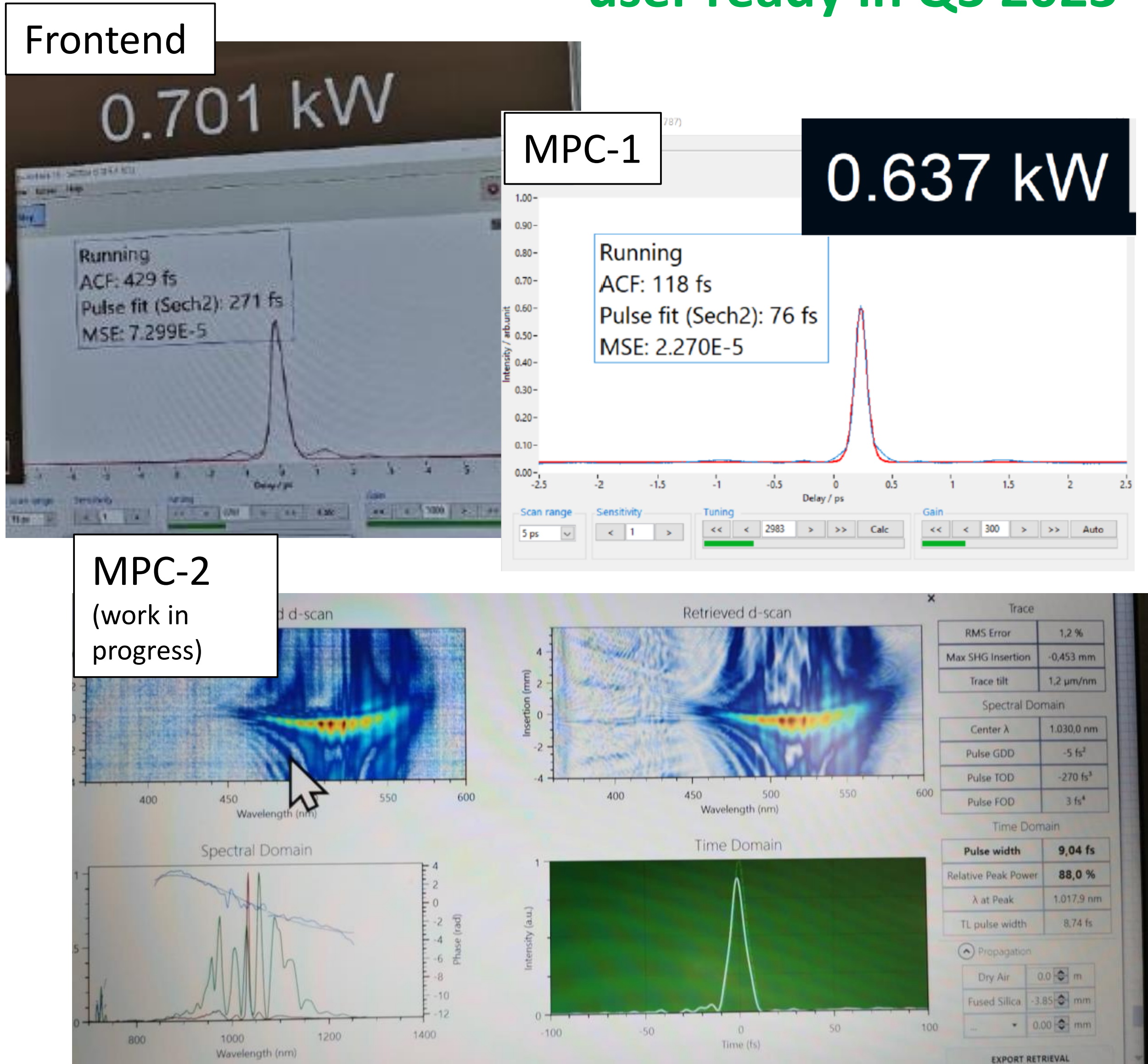
- Set at moderate power of 7.2 mJ, but capable of >10 mJ (270 fs, 100 kHz, >1 kW)

Post-compression

- First post-compression (MPC-1): Long-term tested at 6.3 mJ (±0.6% for 8 hours) 76 fs (chirped, ~50 fs FTL) (capable of < 40 fs pulses)
- Second post-compression step (MPC-2): work in progress (currently 9 fs, 3.5 mJ but now only a ~ 15W sample beam is compressed for CEP tests)

To do list

- CEP: High priority
- System should be ready by March 2023.



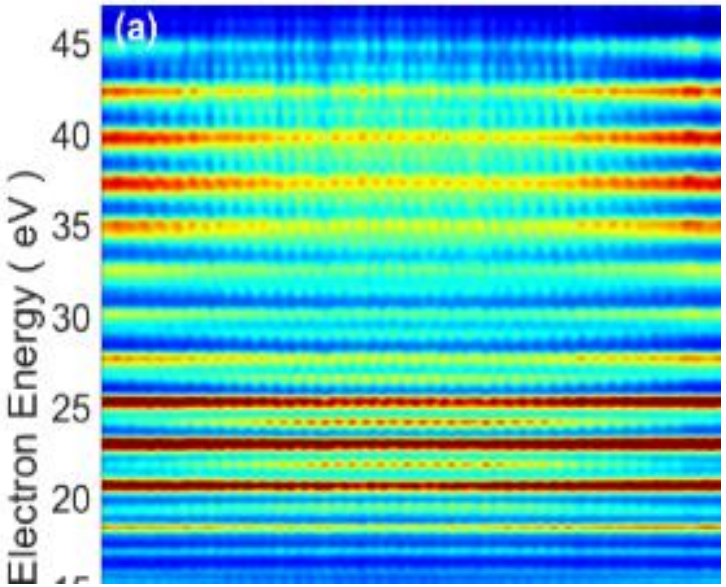
Status of HR GHHG Gas beamline (LTA-4)

user ready

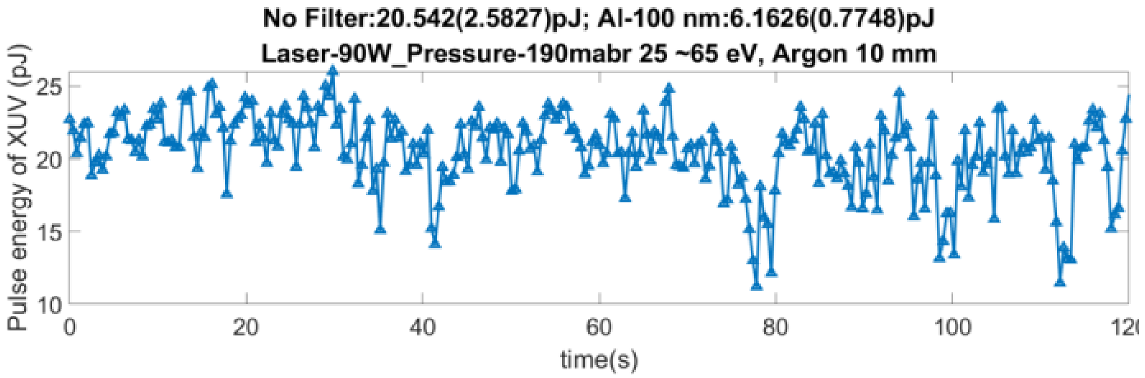
- **XUV-IR pump-probe** studies on **gaseous targets** at **100 kHz**
- diagnostics for the temporal, spectral and spatial characterization of the XUV pulses
- **flexible reconfiguration** according to user needs (target area between CH04 nd CH05)

Peng Ye *et al., J. Phys. B: At. Mol. Opt. Phys.* **53** 154004 (2020)

Peng Ye *et al.*, *Ultrafast Science* 2022, 9823783 (2022)



~166 as,
~250 pJ generated,
~50 pJ on target
@ 100 kHz



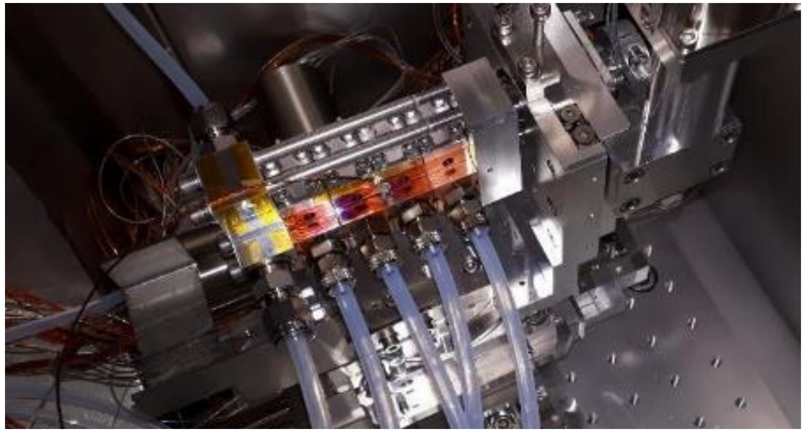
<u>**Highest flux attosecond pump-probe beamline running at 100 kHz**</u>

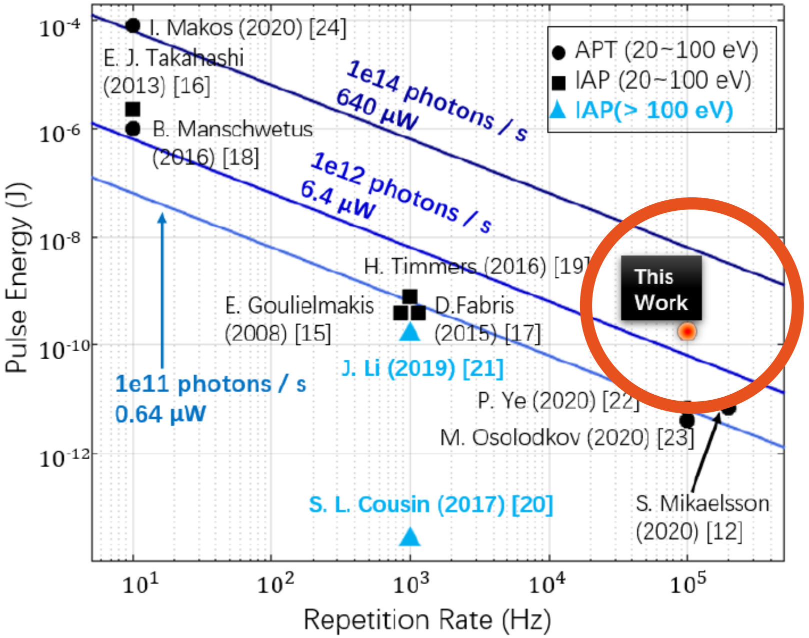
- **19%** transmission from generation to target
- **51 pJ** APT on target (**267 pJ** at generation)

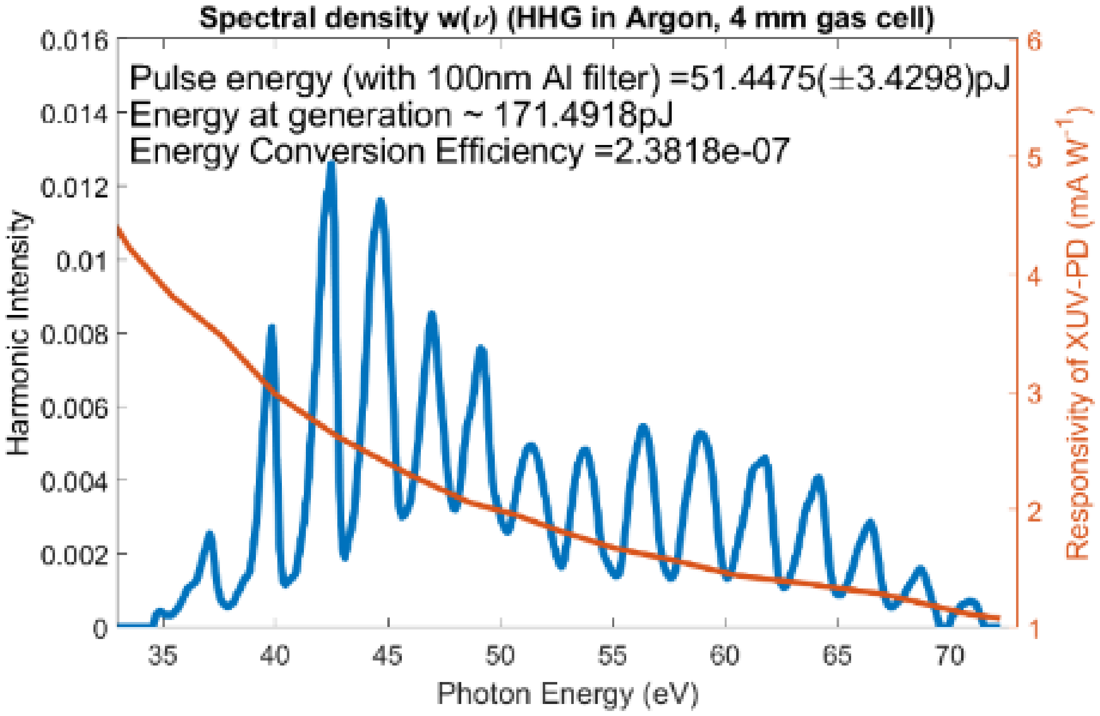
Results of HR GHHG Gas beamline (LTA-4)

user ready

specially designed, cooled static HHG cell







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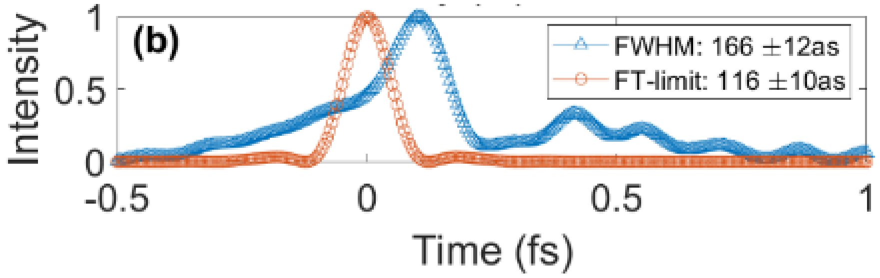
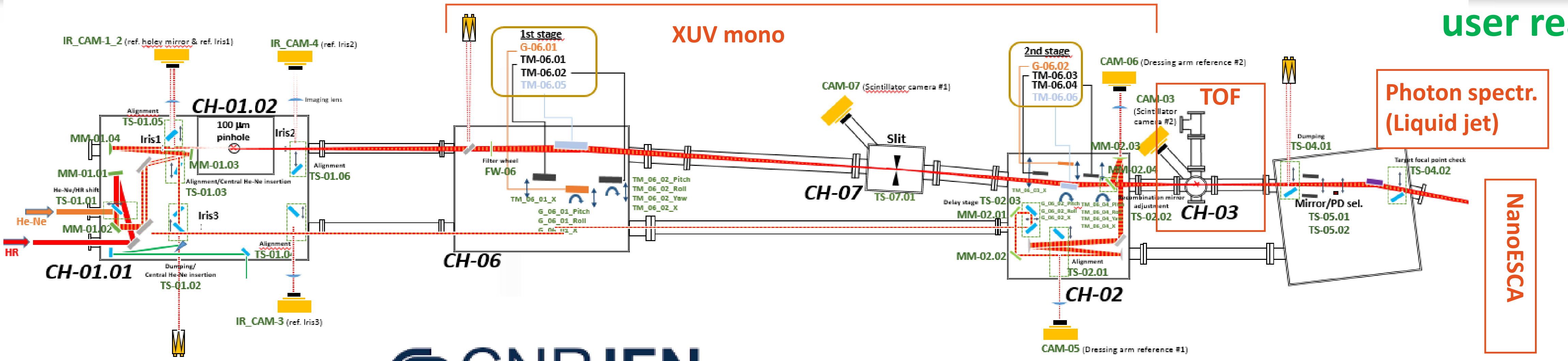


Peng Ye *et al.*, *Ultrafast Science* 2022, 9823783 (2022)

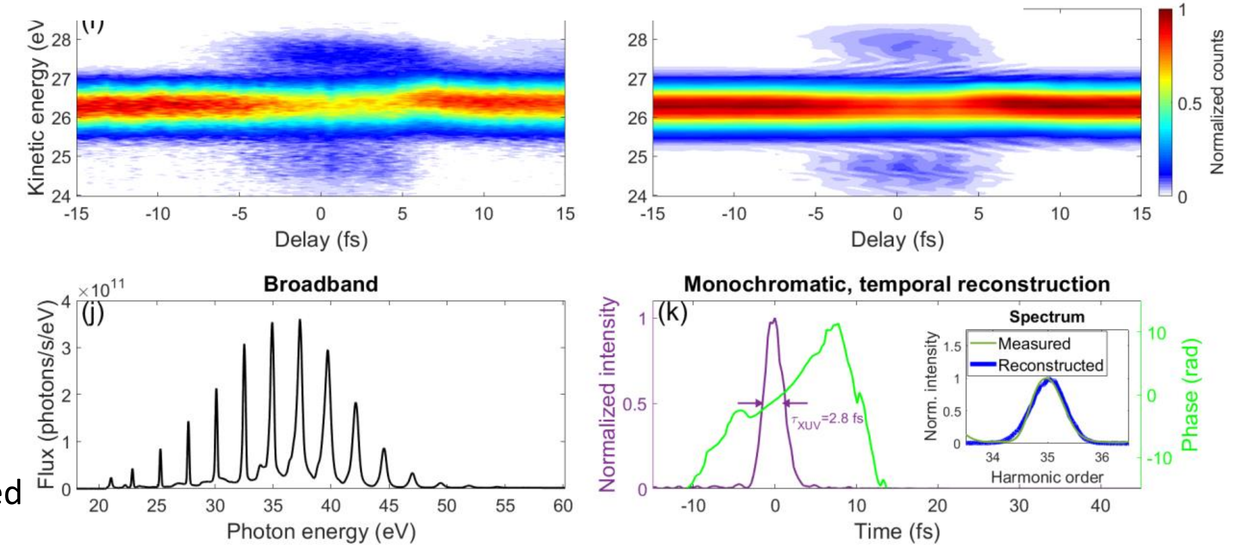
HR GHHG Cond beamline + XUV mono (LTA3)

user ready



CNR IFN Istituto di Fotonica e Nanotecnologie

Supports condensed matter end-stations with XUV-IR pump-probe capabilities



T. Csizmadia et al., “Spectrally tunable ultrashort monochromatized extreme-ultraviolet pulses at 100 kHz”, under submission

Monochromatized XUV pulses with few femtosecond duration

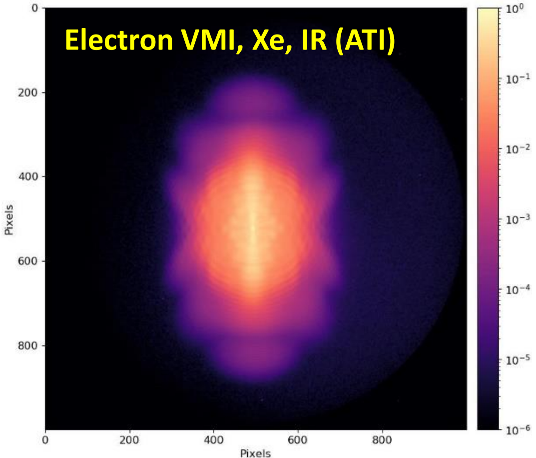
Experimental stations for gas phase studies

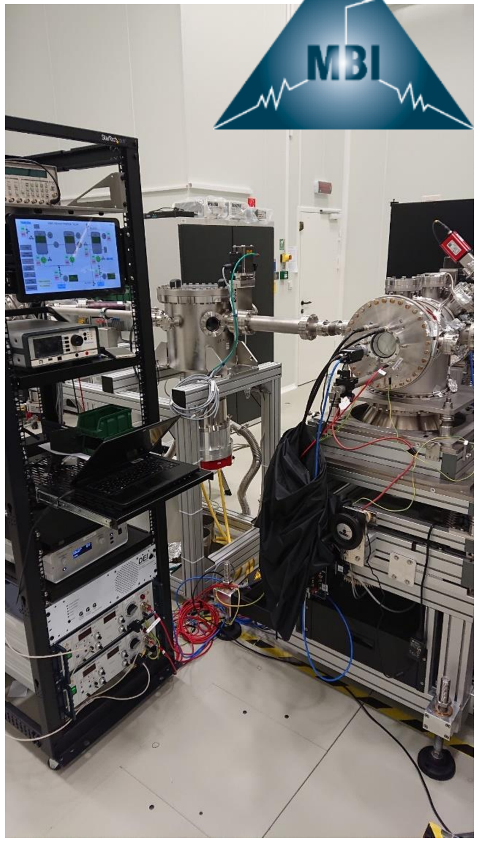
user ready

mobile stations

VMI-ES

to obtain energy- and angle resolved information on ions and electrons resulting from the photoionization or photofragmentation of atoms, molecules or nanoparticles

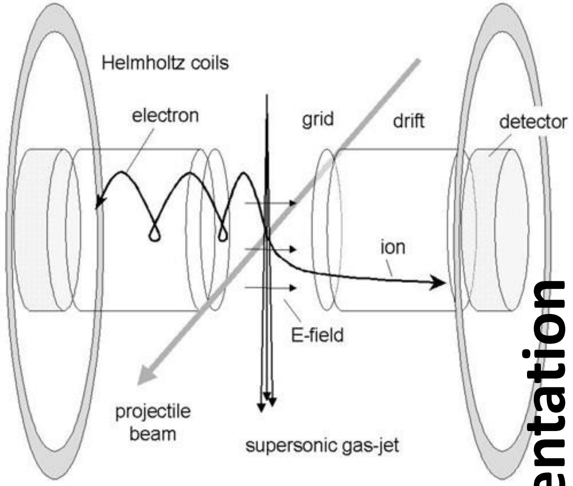


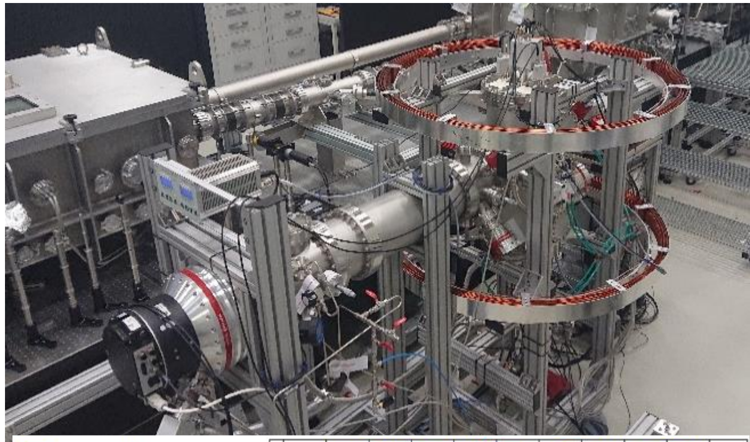


ReMi / Coltrims

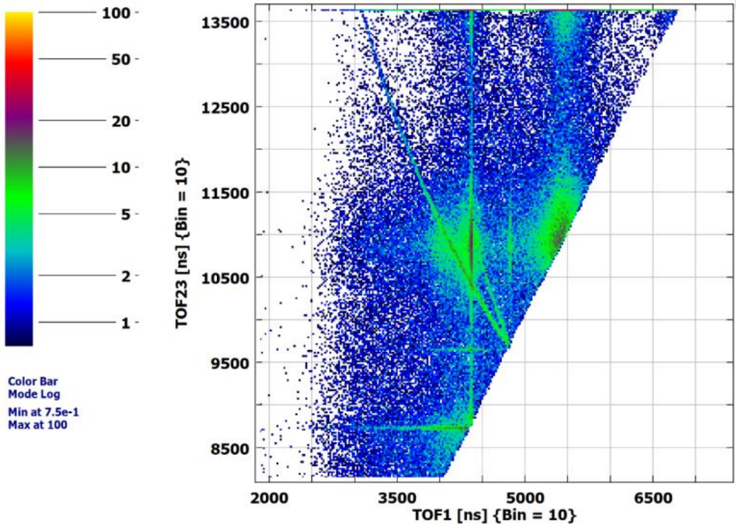
Kinematically complete experimental study of ion and electron fragments detected in coincidence

RoentDek Handels GmbH
UHV-Detectors
Supersonic Gas Jets
Multifragment Imaging Systems

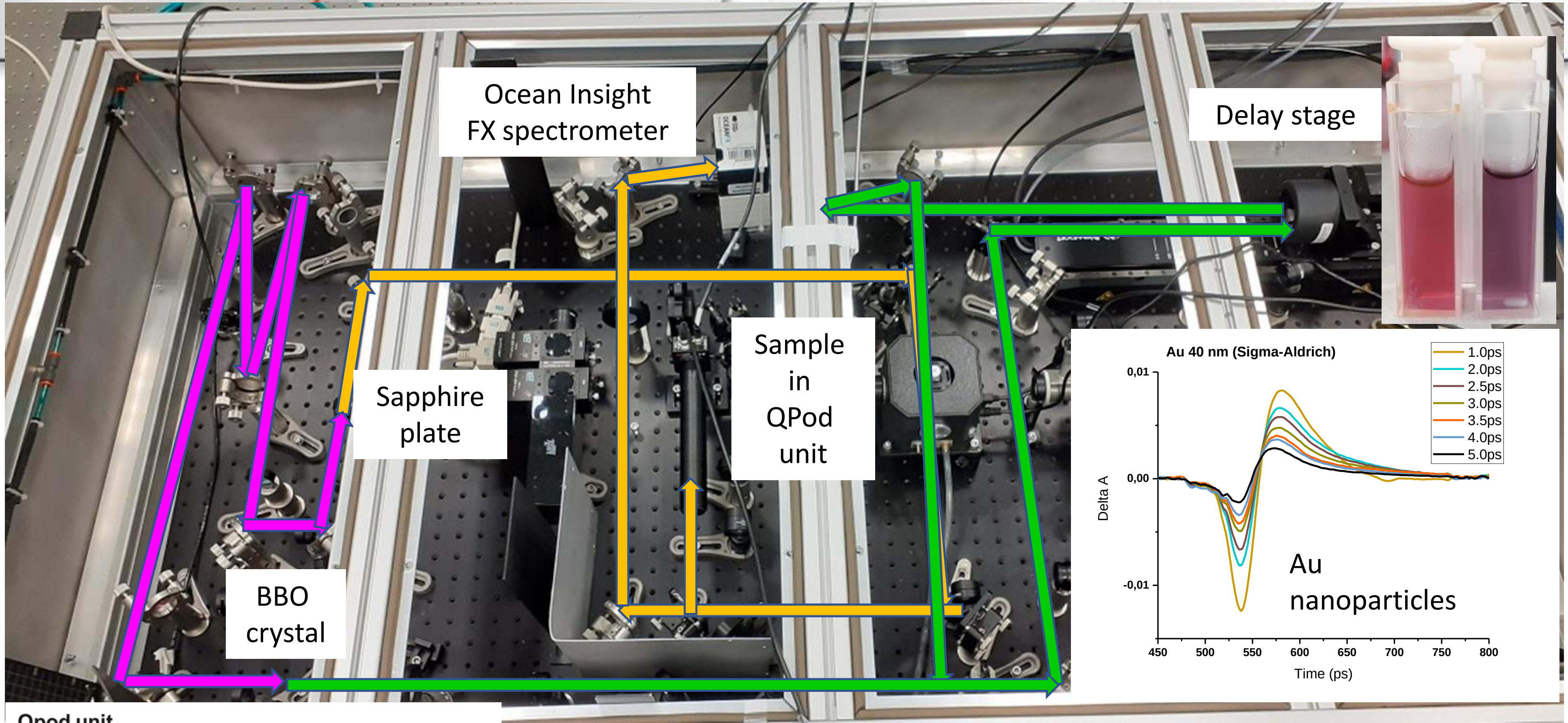




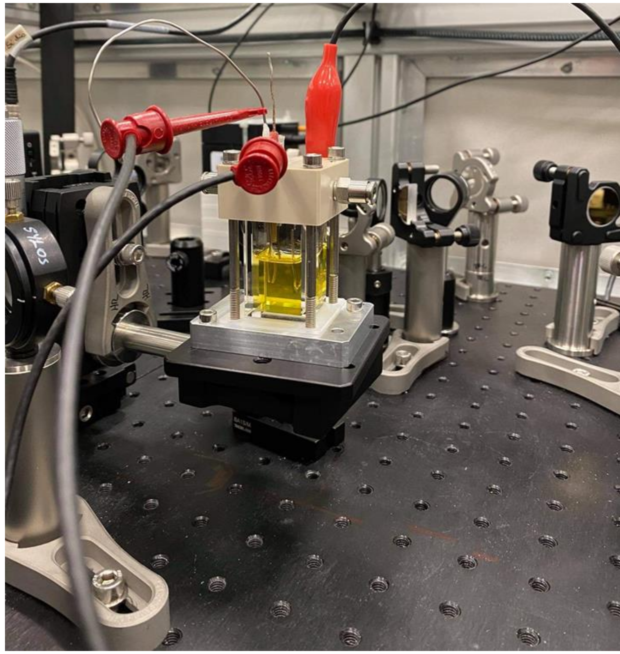
CO_2 fragmentation

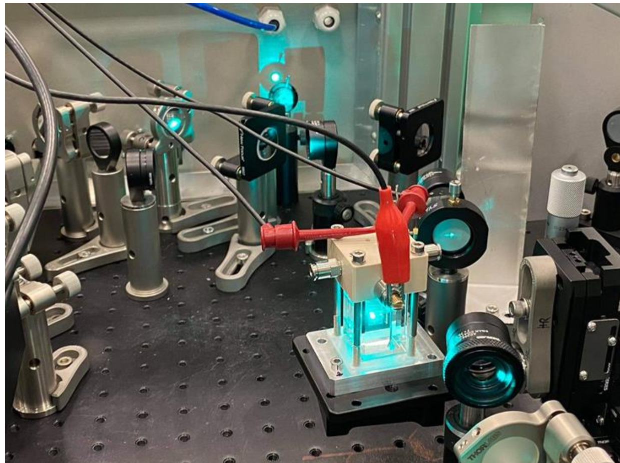


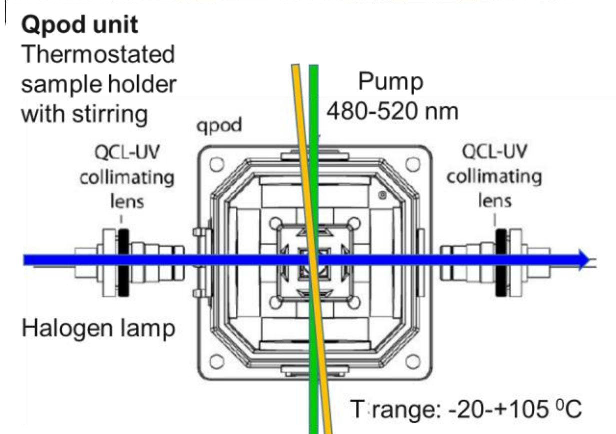
Transient Absorption Spectrometer (TAS) setup

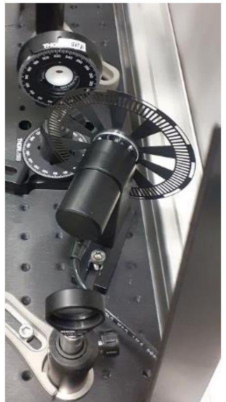


user ready





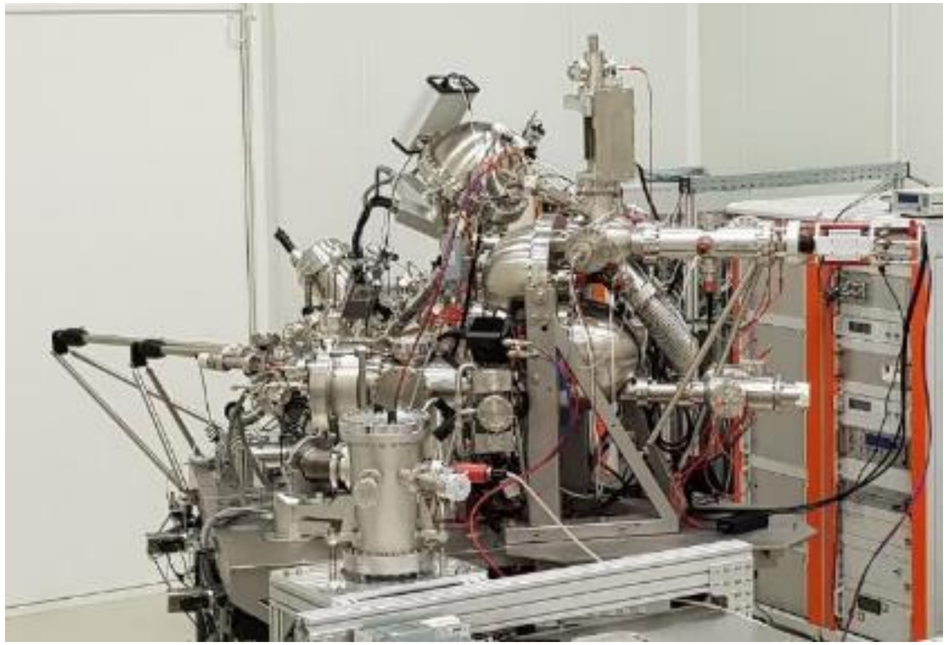




White light (probe beam) generation with sapphire plate
Green or UVC light (pump beam, SH) generation with BBO crystals (~25-40 fs, 100 kHz)
Optical chopper used at 6 kHz for Lock-in measurements and 2 kHz for measuring the spectra

System: NanoESCA end station coupled with CEP oscillator

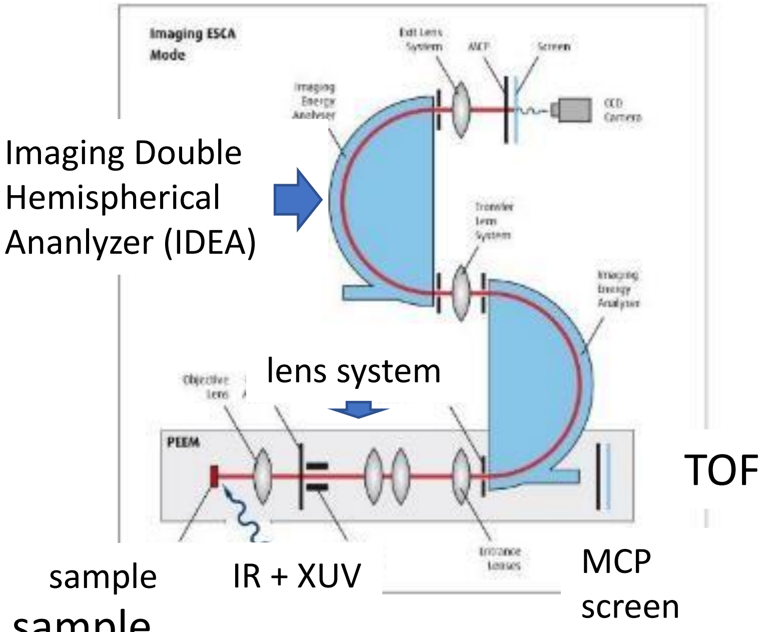
user ready



scientaomicron

Spin domains on an iron plate
(recorded at ELI w Hg lamp)

M. Escher et al., J. Phys.: Condens. Matter 17 (2005) S1329

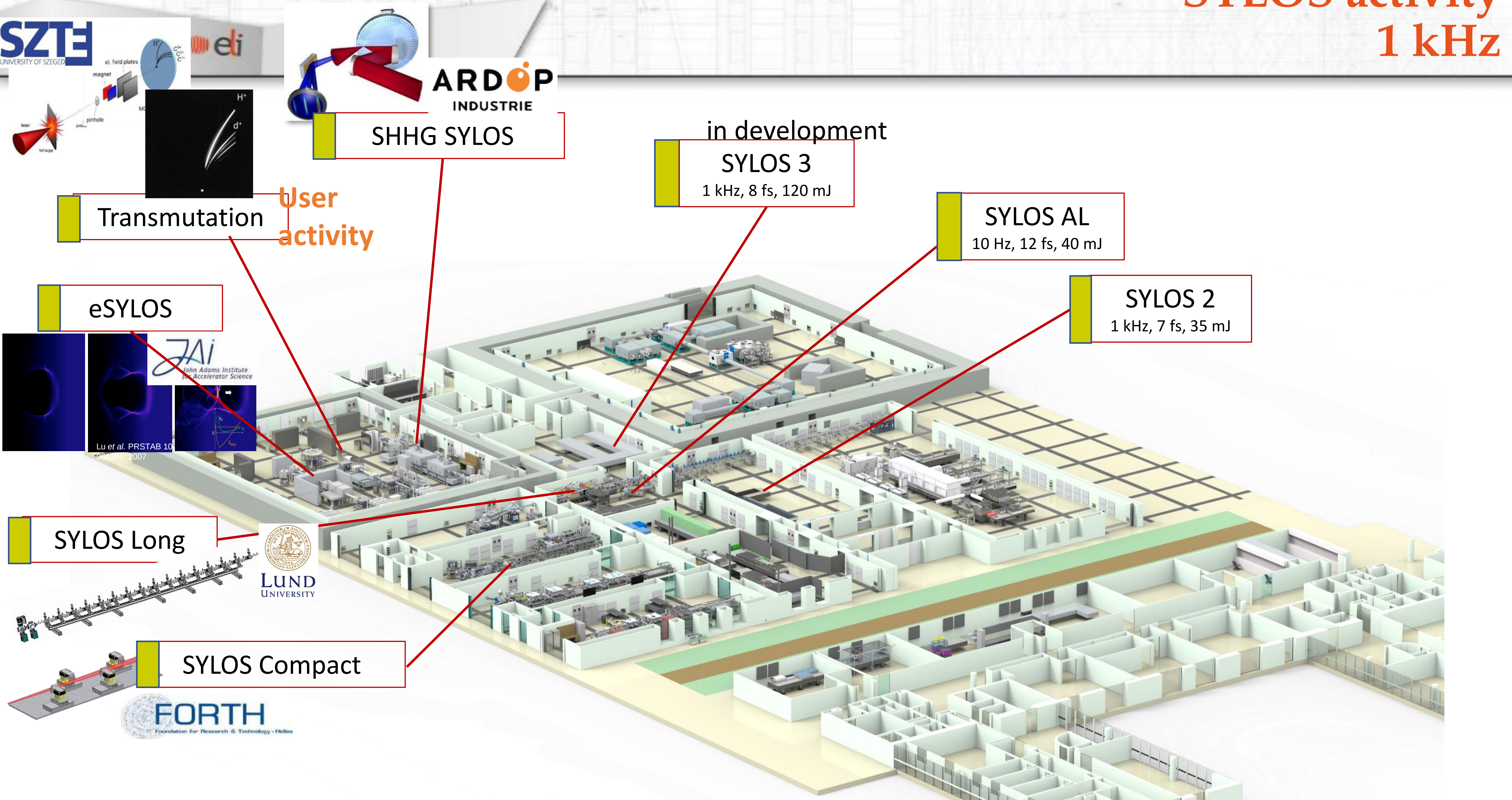


Core capabilities, at **80 MHz fs CEP oscillator**:

- Photoemission Electron Microscopy (PEEM) mode: laterally resolved microscopy of the sample surface
- Imaging Photoelectron Spectroscopy mode: lateral and energy resolution
- Momentum microscopy: imaging of the momentum space with energy resolution
- Spin dependent imaging in both real and momentum space with a state-of-the-art Au/Ir(100) imaging spin filter

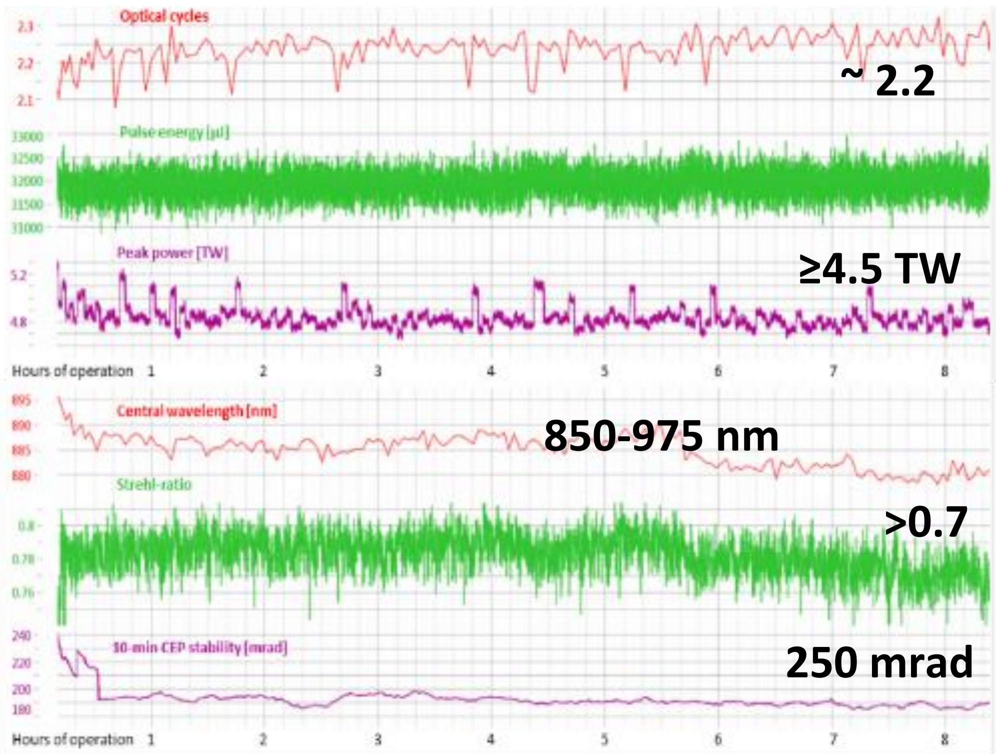
D. Vasilyev et al., J. Electron Spectr. Relat. Phenom. 199 (2015) 10

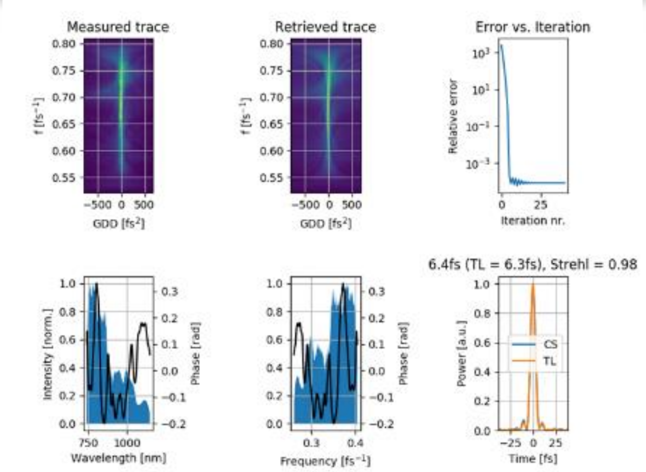
SYLOS activity
1 kHz



Status of SYLOS2 laser

user ready





LIGHT CONVERSION

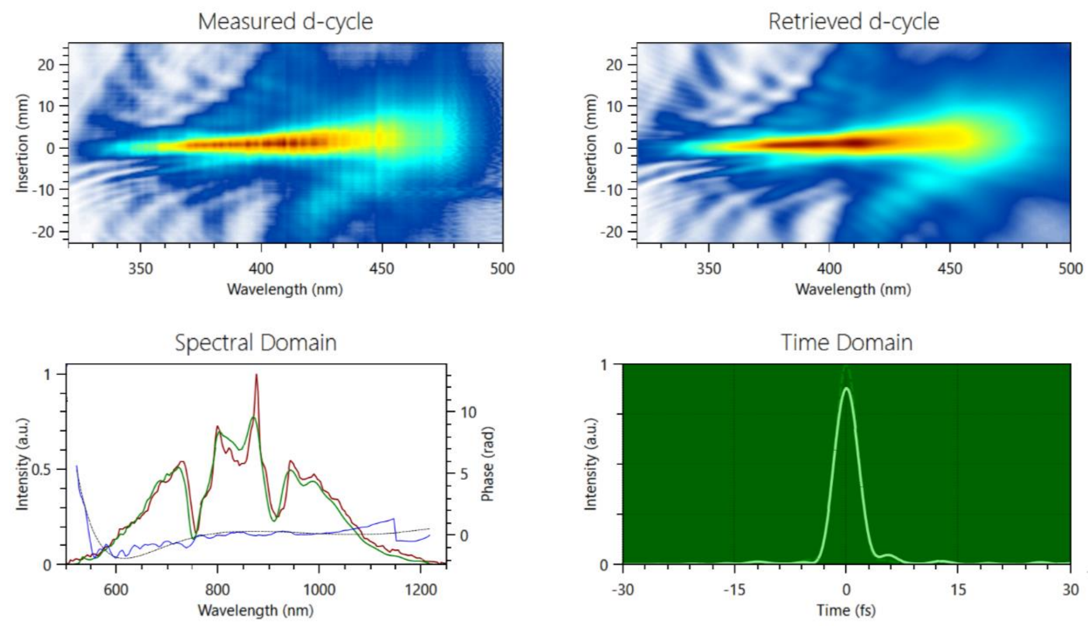
EKSPLA

	Parameters	Status	User readiness
SYLOS 2	*1 kHz, <6.5 fs, 30 mJ, CEP*	*Operational*	*since May 2019*
SYLOS alignment	*10 Hz, <12 fs, >40 mJ*	*Operational*	*since Jan 2019*

Thin plate compression of the SEA laser

Sz. Toth, et al., *3 TW single-cycle pulses enabled by thin plate postcompression*, Optics Letters (submitted, 2022)

user ready



Trace	
RMS Error	0.8 %
Max SHG Insertion	0.76 mm
Trace tilt	19.6 μm/nm
Spectral Domain	
Center λ	825.1 nm
Pulse GDD	$-10\ fs^2$
Pulse TOD	$-6\ fs^3$
Pulse FOD	$135\ fs^4$
Time Domain	
Pulse width	**3.79 fs**
Relative Peak Power	**88.0 %**
λ at Peak	799.7 nm
TL pulse width	3.52 fs

Propagation

Figure 1.2: SHG d-cycle retrieval results and resulting pulse in the spectral and time domain. (Top-left) Measured, calibrated d-cycle trace. (Top-right) Retrieved d-cycle trace. (Bottom-Left) Red line: Measured linear spectrum. Green line: Retrieved linear spectrum. Blue line: Retrieved spectral phase. Black line: 4th order polynomial fit of the spectral phase. (Bottom-right) Dashed green: Temporal intensity profile of the transform limited pulse. Light Green: Temporal intensity profile of the measured pulse. Measurement: **(2022/07/29 16:14:27), High Resolution**

Add comments to retrieval

Measurement device:

- D-cycle NIR (Sphere U. P.)
- 500 – 1250 nm
- Scanning

sphere ULTRAFAST PHOTONICS

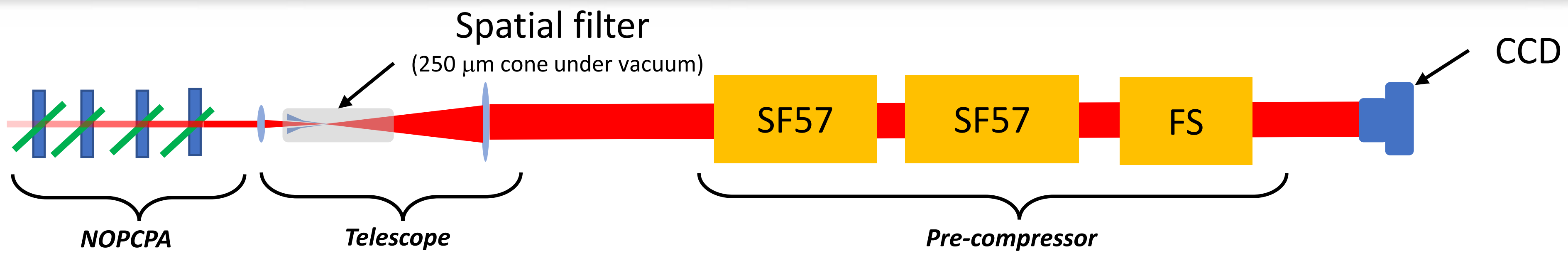
Compressed pulse:

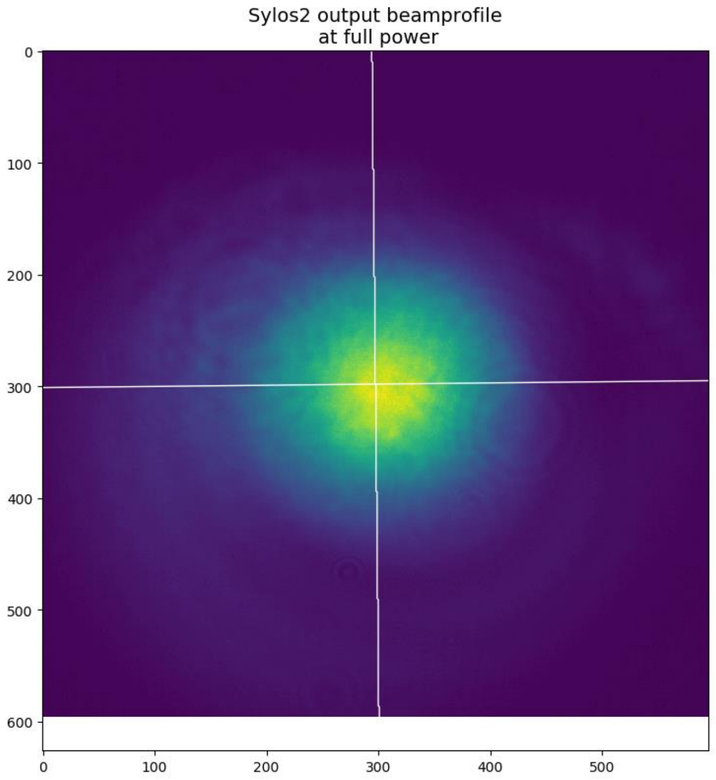
- FTL: 3.52 fs
- Measured: 3.79 fs

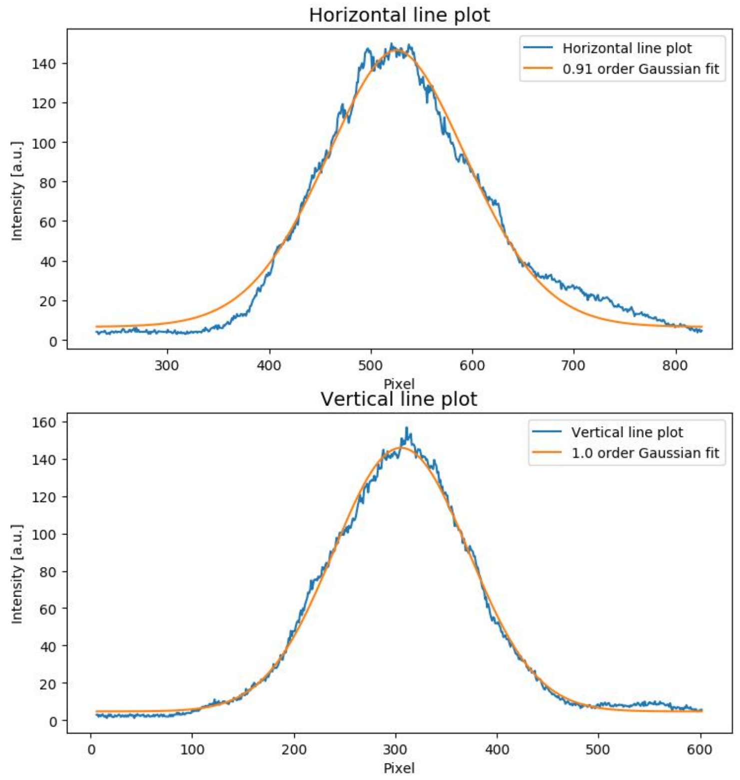
1.4 optical cycle
12 mJ energy

~ single cycle laser pulses achieved at >10mJ pulse energy level.

Status of SYLOS2 laser
Spatial filtering





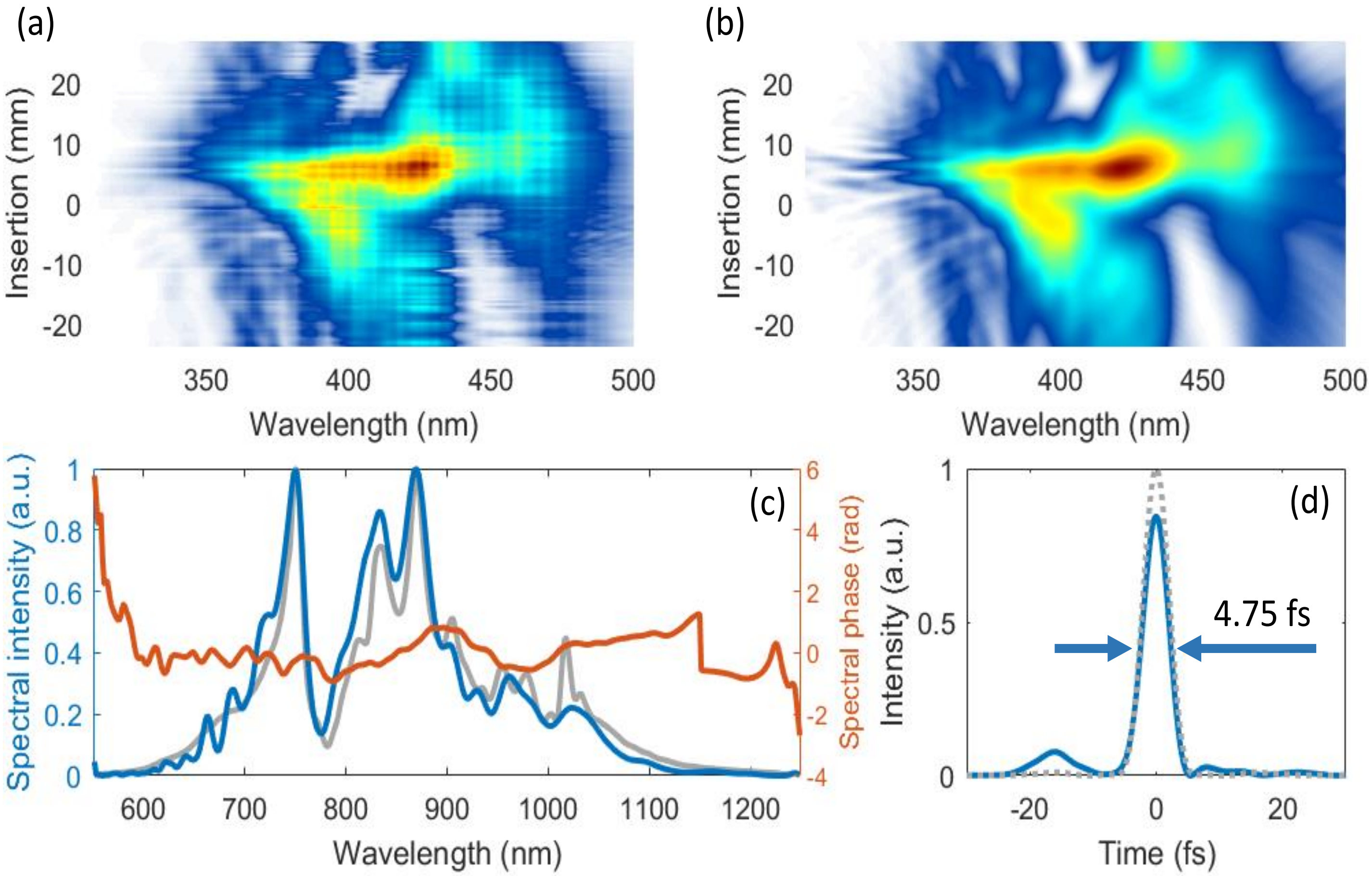


Output parameters:

- *Transmission: >80%*
- ***Energy: >24mJ Gaussian beam profile***

Status of SYLOS2 laser
Post-compression

Very similar optical setup as it was used for the Sylos Experimental Alignment post-comperssion



Measured (a) and retrieved (b) d-scan traces, measured (blue) and retrieved (grey) fundamental spectra with the retrieved spectral phase (c), and finally the FTL (dashed grey) and retrieved (solid blue) pulse temporal profiles (d).

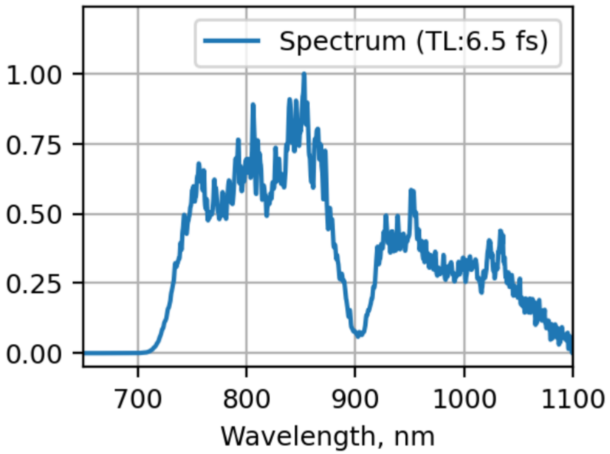
Compressed pulse:

- Pulse duration: **4.75 fs**
- Energy: **16 mJ** with 0.6% RMS stability

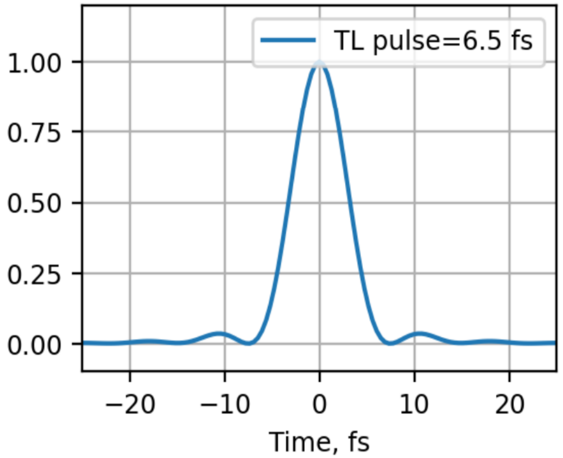
Under further investigation!

Status of SYLO3 laser
DL3 Factory Acceptance Test

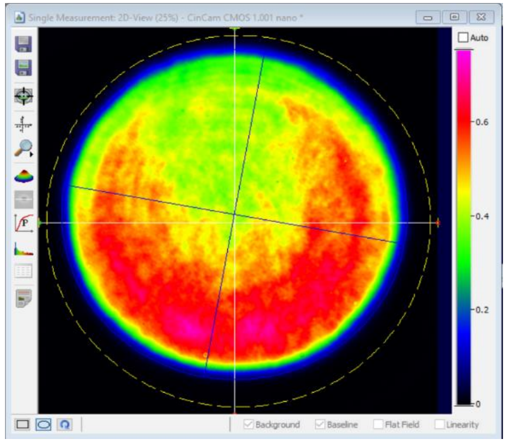
„DL3 Partial FAT: Demonstration of the operational capability of pre-amplifier and pump laser of SYLOS 3 laser system"



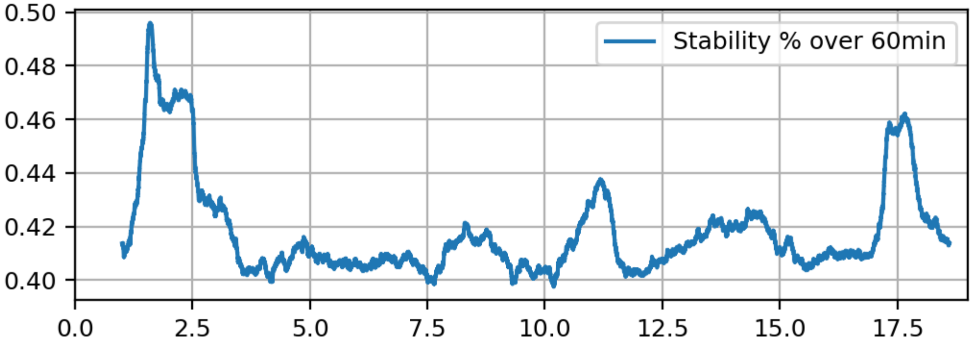
Measured output spectrum of the front-end



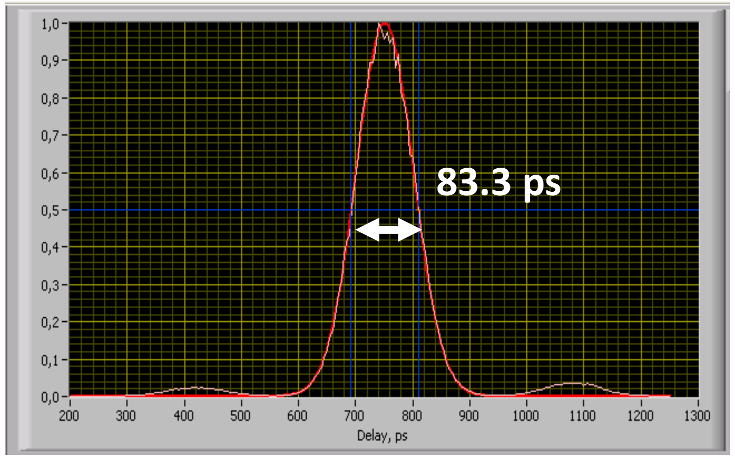
Calculated transform-limited pulse duration



Measured typical beam profile of PPL

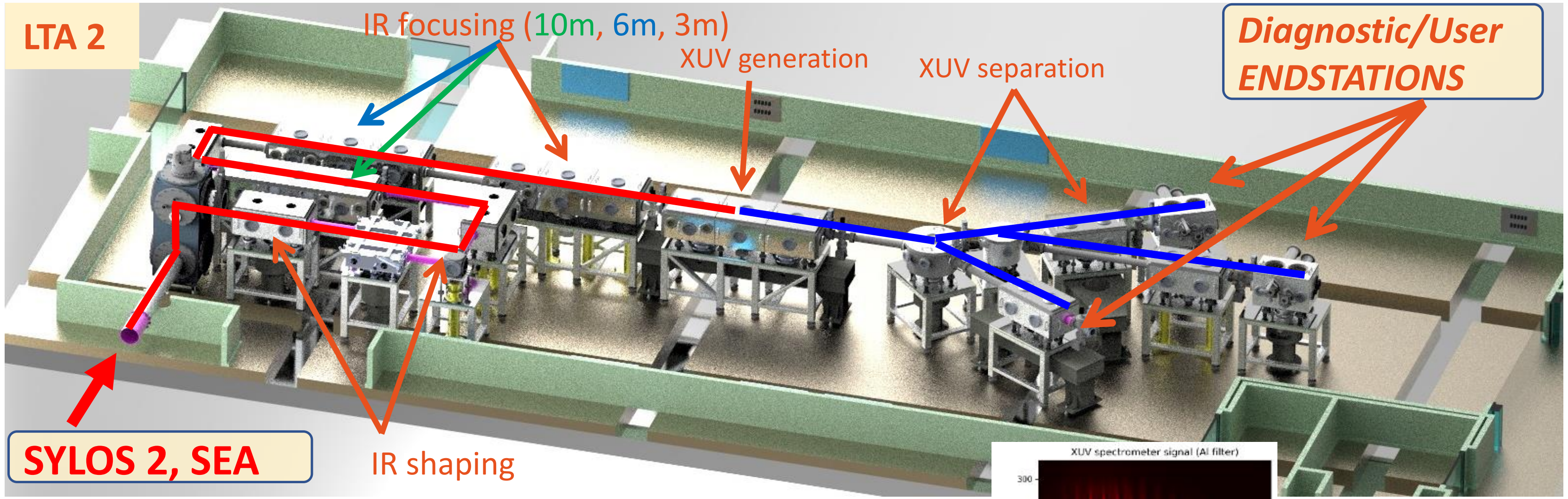


Output energy stability of the front-end over 60 min



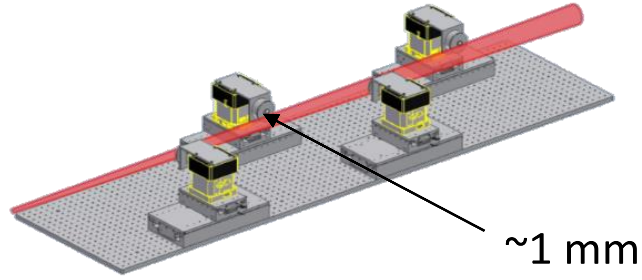
Measured typical pulse duration of PPL

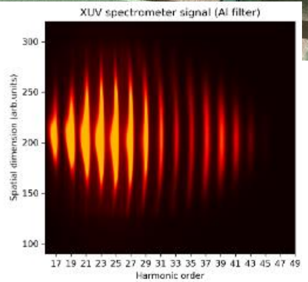
SYLOS GHHG Compact in commissioning



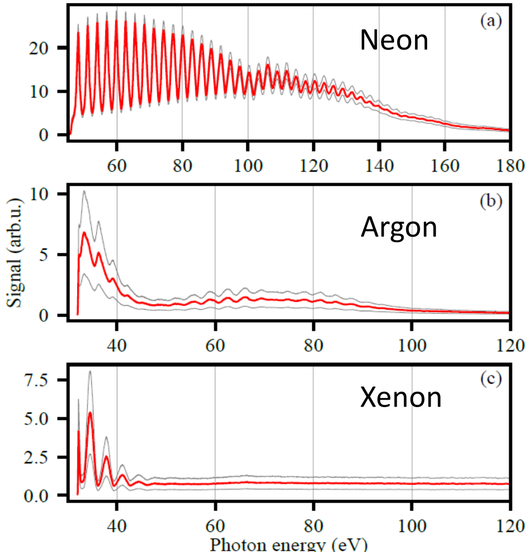
user ready

Phasematching regime:
High pressure targets & lose focusing





XUV spectra



IR drivers

SYLOS 2
35 mJ, 7 fs,
Gaussian 4-6cm
Rep rate: 1 kHz

SEA
40 mJ,12 fs
Super Gaussian 4-6 cm
Rep rate: 10 Hz

Developed by:

FORTH
Foundation for Research & Technology - Hellas

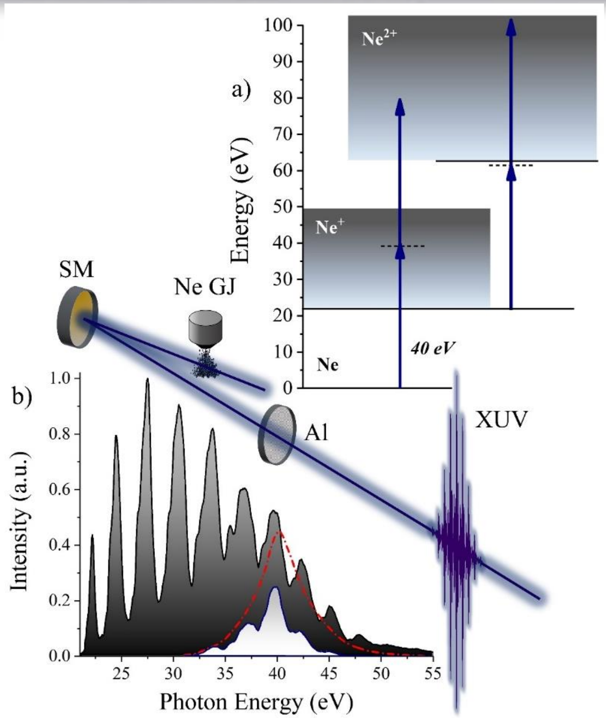
Kühn, et al., *The ELI-ALPS facility: the next generation of attosecond sources*, J. Phys. B **50**, 132002 (2017)

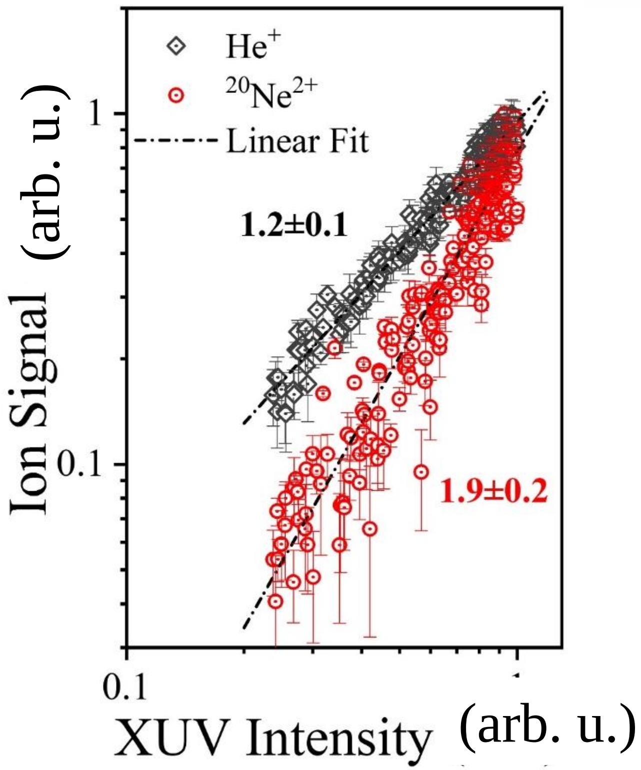
Nayak, et al., *Multiple ionization of argon via multi-XUV-photon absorption induced by 20-GW high-order harmonic laser pulses*. Phys Rev A, **98**(2), 023426. (2018)

Orfanos, et al., *Two-XUV-photon double ionization of neon*, Phys Rev A (in print)

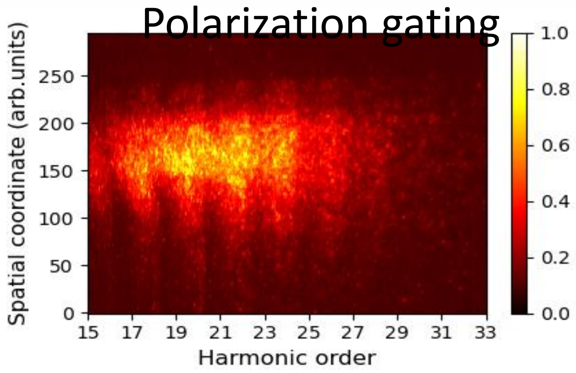
Nayak, et al., *The Compact beamline at ELI-ALPS*. (manuscript in prep)

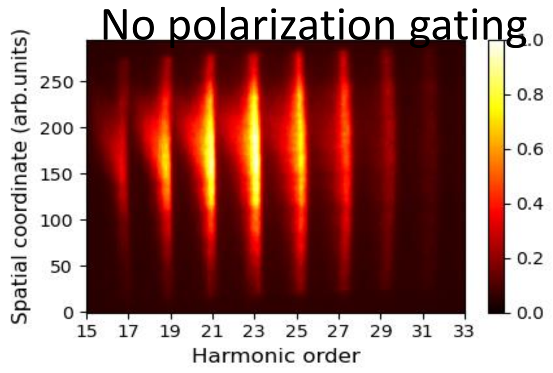
SYLOS GHHG Compact in commissioning by users

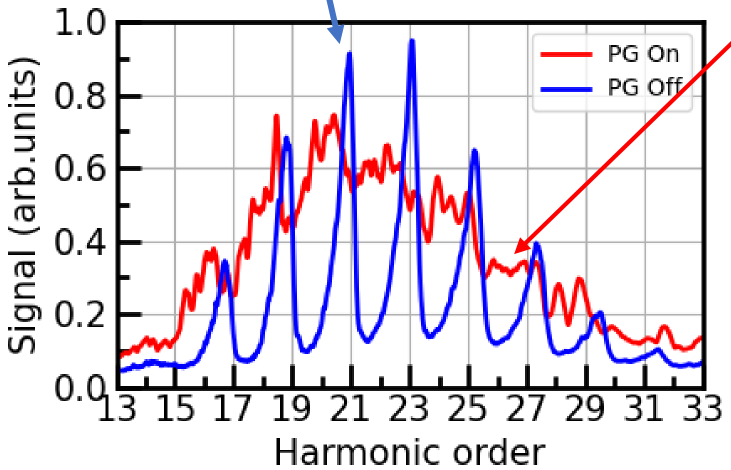




I. Orfanos et al. PRA (in print)



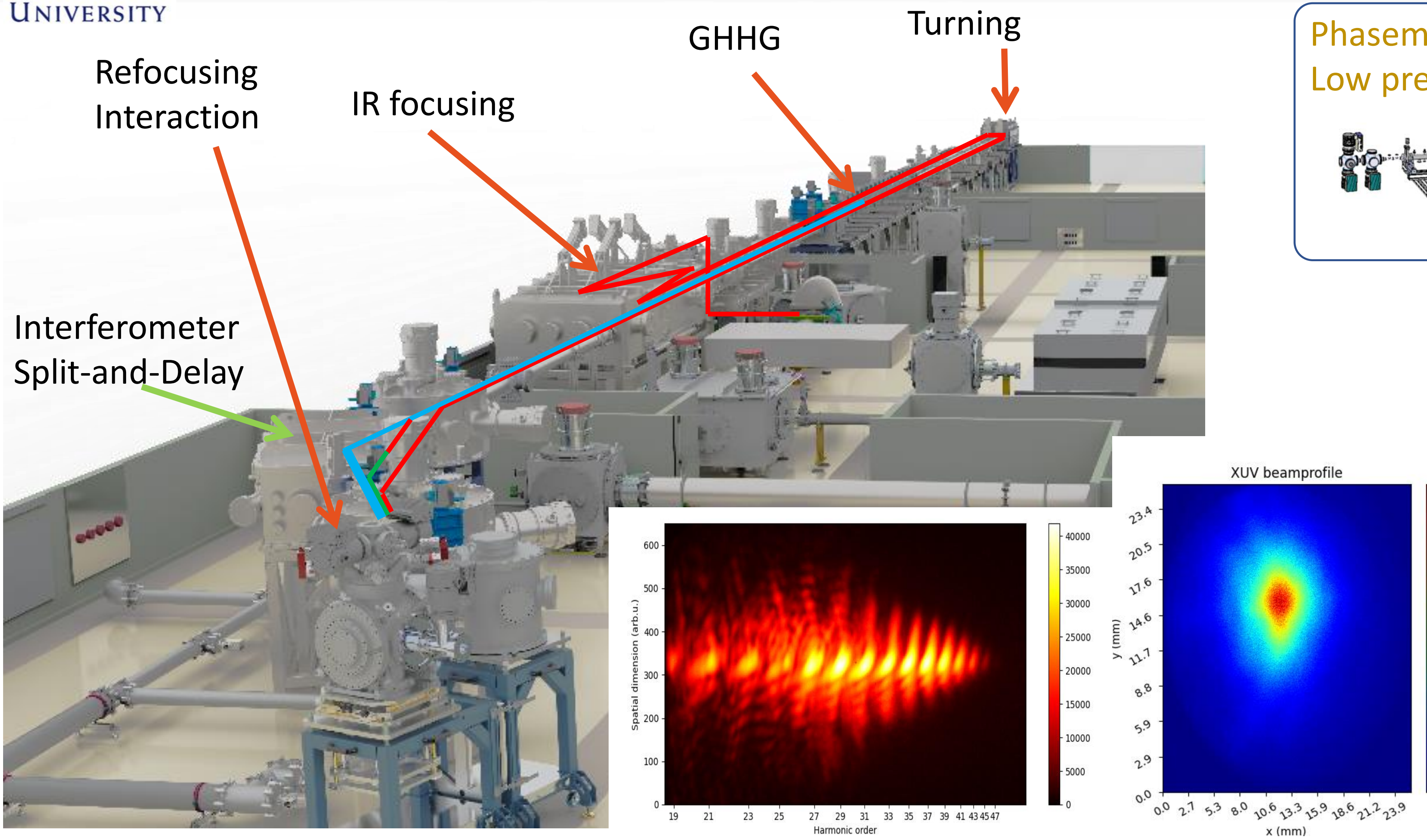




„photon energies of this work are the highest of a harmonic comb, that have induced so far a hybrid direct and sequential two photon ionization process"

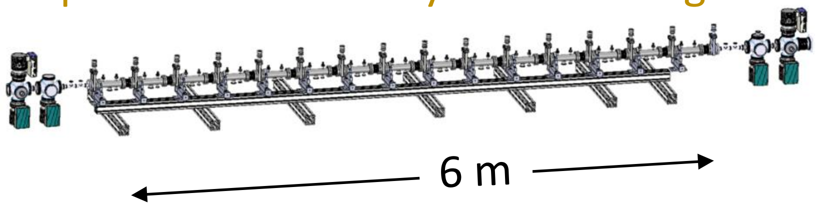
SYLOS GHHG Long in commissioning

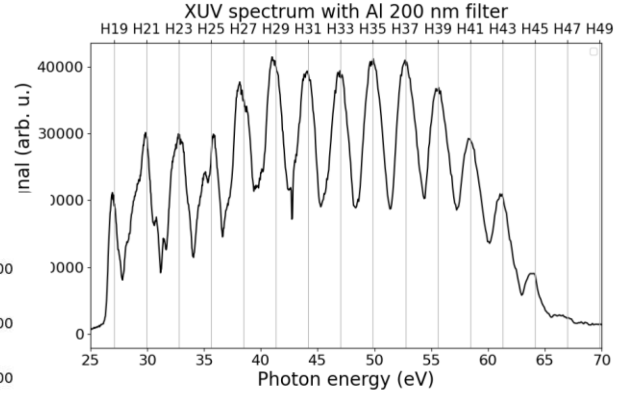
user ready by Q1 2023

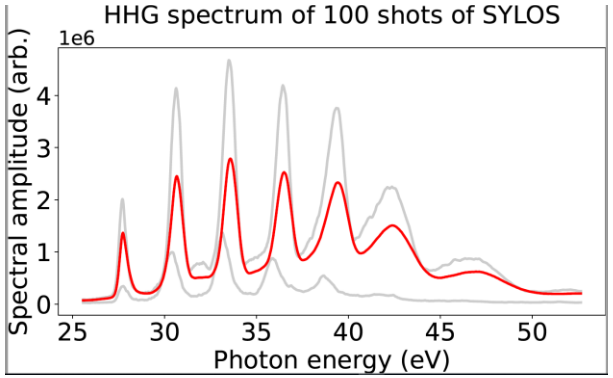


Phasematching regime:

Low pressure cell & very lose focusing





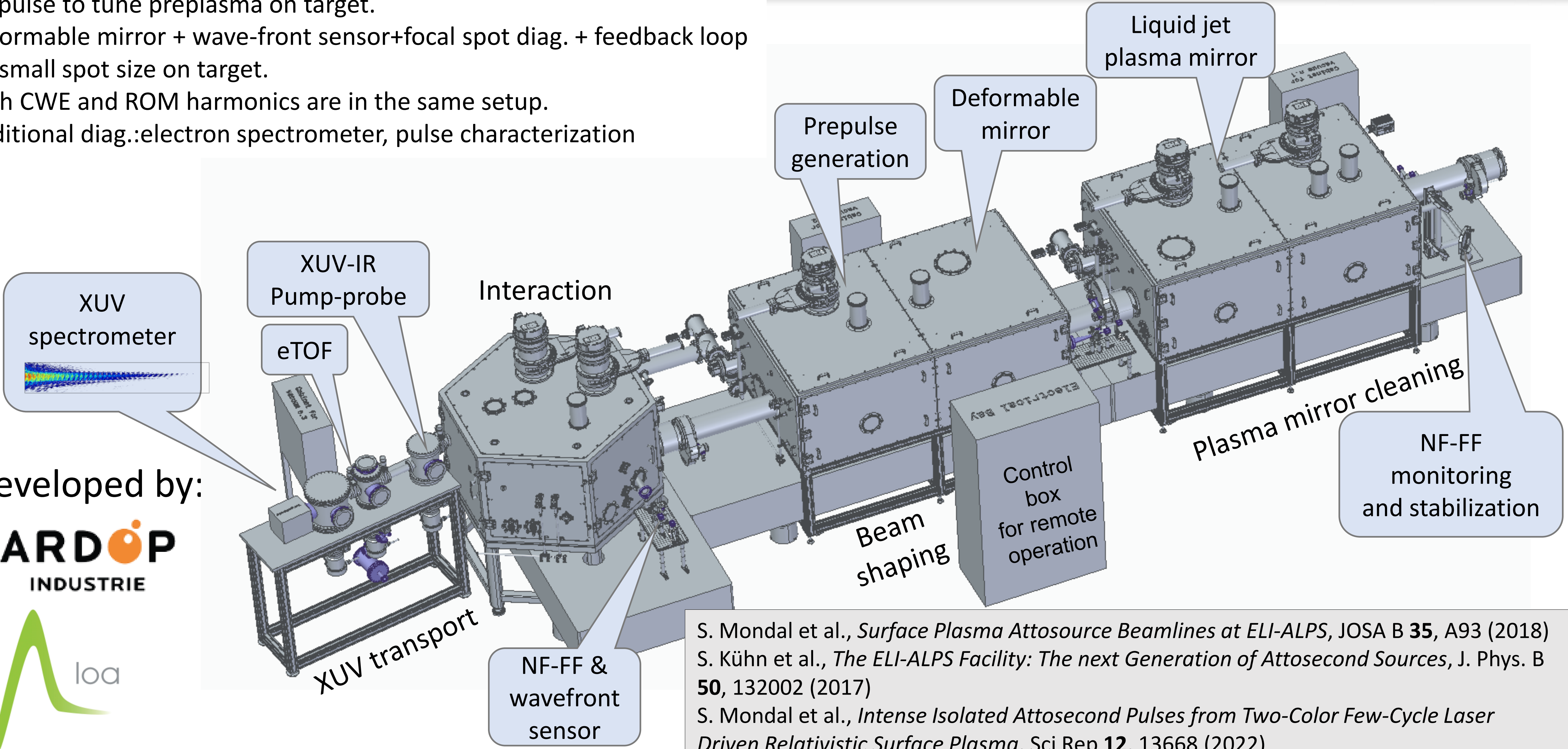


Kühn, et al., *The ELI-ALPS facility: the next generation of attosecond sources*, J. Phys. B **50**, 132002 (2017)

Appi, et al., *Generation of high-flux high-order harmonics in long beamlines (in preparation)*

SYLOS SHHG in development

Featuring:
Pulse contrast cleaning using liquid jet plasma mirror.
Interferometric stabilized high-speed rotating target for kHz expt.
Prepulse to tune preplasma on target.
Deformable mirror + wave-front sensor+focal spot diag. + feedback loop for small spot size on target.
Both CWE and ROM harmonics are in the same setup.
Additional diag.:electron spectrometer, pulse characterization



Developed by:

ARDOP INDUSTRIE

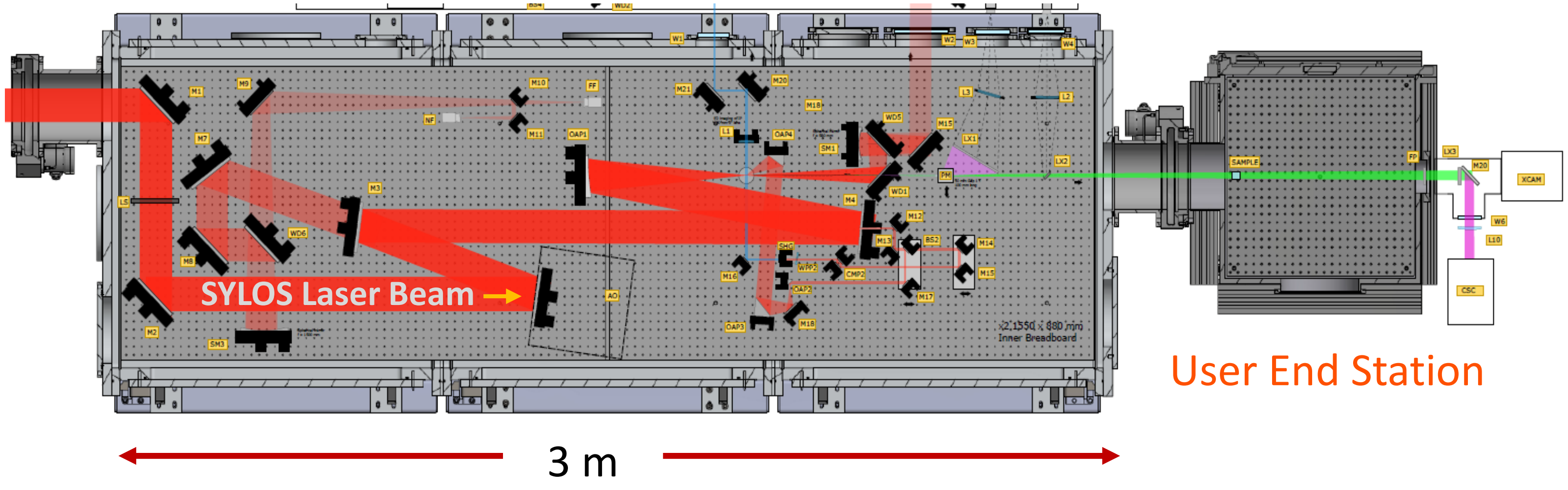
loa

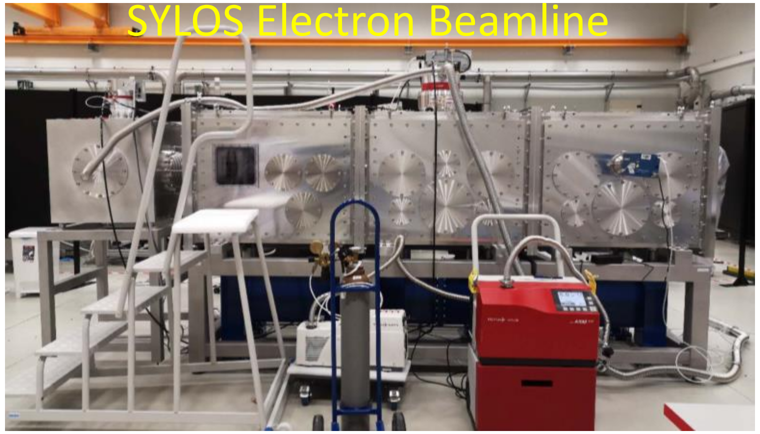
S. Mondal et al., *Surface Plasma Attosource Beamlines at ELI-ALPS*, JOSA B **35**, A93 (2018)
S. Kühn et al., *The ELI-ALPS Facility: The next Generation of Attosecond Sources*, J. Phys. B **50**, 132002 (2017)
S. Mondal et al., *Intense Isolated Attosecond Pulses from Two-Color Few-Cycle Laser Driven Relativistic Surface Plasma*, Sci Rep **12**, 13668 (2022)

SYLOS electron acceleration in development

user ready by Q3 2023

Developed by: John Adams Institute for Accelerator Science





Zs. Lécz et al., *Substantial enhancement of betatron radiation in cluster targets*, Phys. Rev. E **102**, (2020) 053205

D. Papp et al., *Highly efficient few-cycle laser wakefield electron accelerator*, Plasma Phys. Control. Fusion **63** (2021) 065019

T. L. Audet et al., *Ultrashort, MeV-scale laser-plasma positron source for positron annihilation lifetime spectroscopy*, Phys. Rev. Accel. Beams **24**, (2021) 073402

R. Polanek et al., *1 kHz laser accelerated electron beam feasible for radiotherapy uses: A PIC–Monte Carlo based study*, Nuclear Inst. and Methods in Physics Research, A 987 (2021) 164841

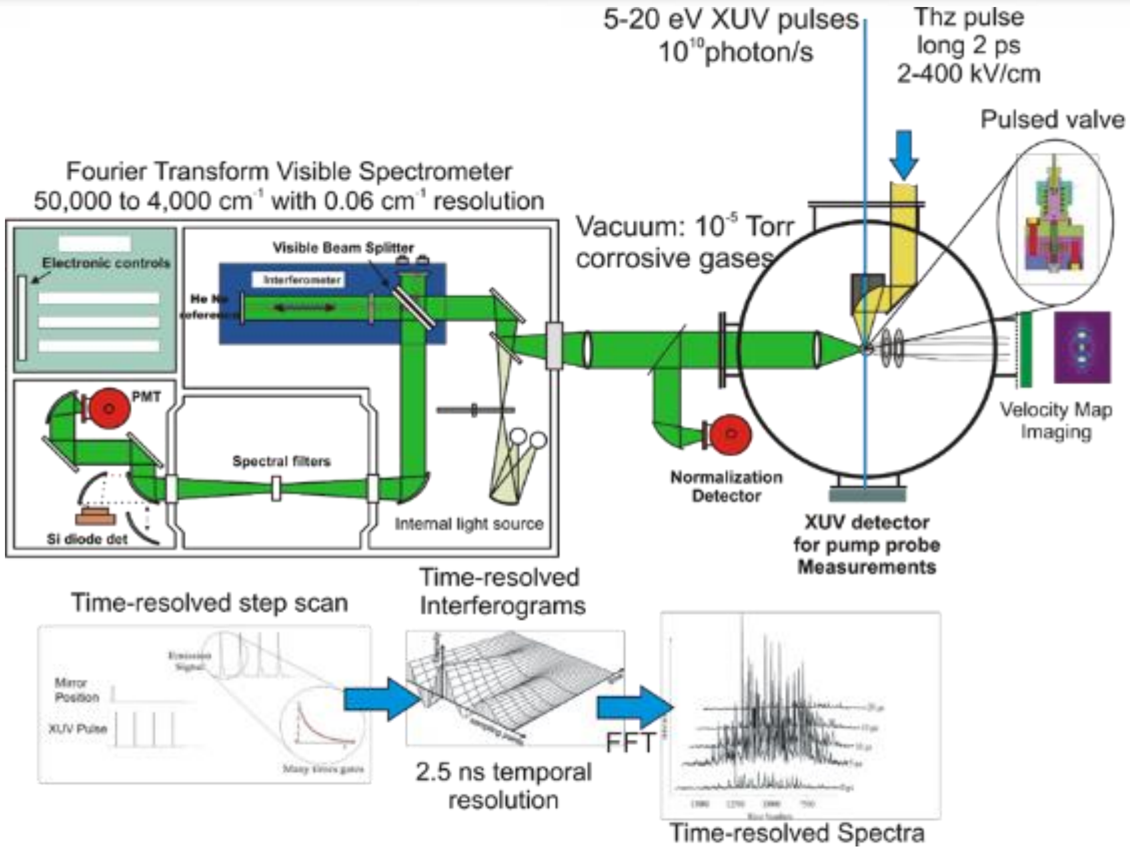
D. Papp et al., *Laser Wakefield Photoneutron Generation with Few-Cycle High Repetition Rate Laser Systems*, Photonics (in press 2022)

Zs. Lécz et al., *Acceleration of GeV-class electron bunches by sub-Joule few-cycle laser pulses* (Submitted 2022)

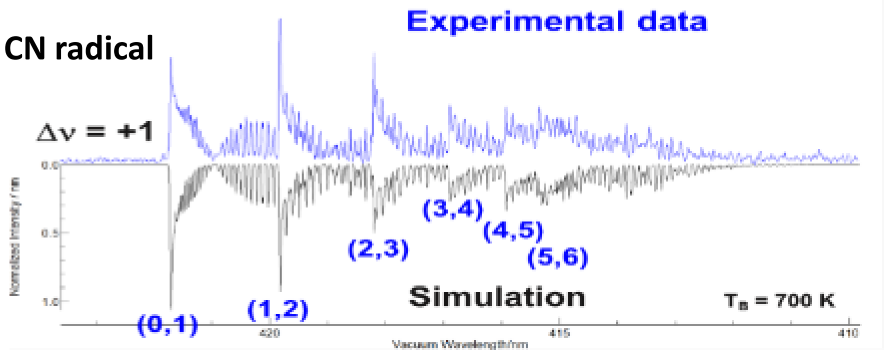
Gas phase reaction-control station
Time-resolved studies

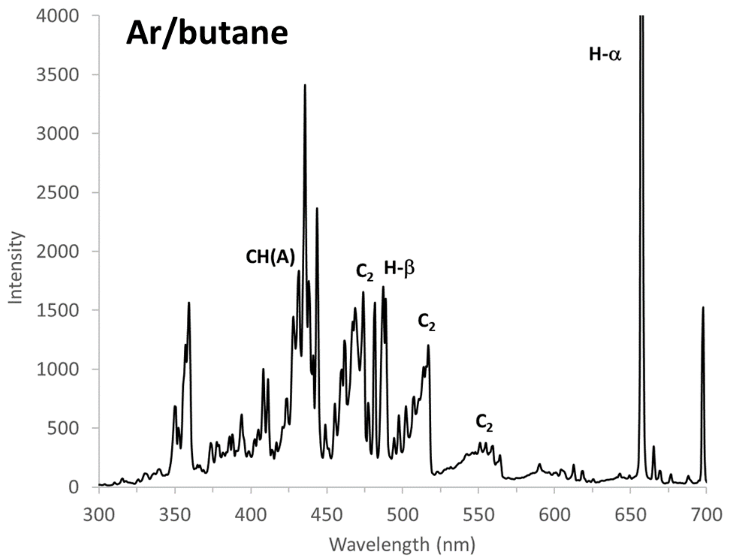
user ready mobile station

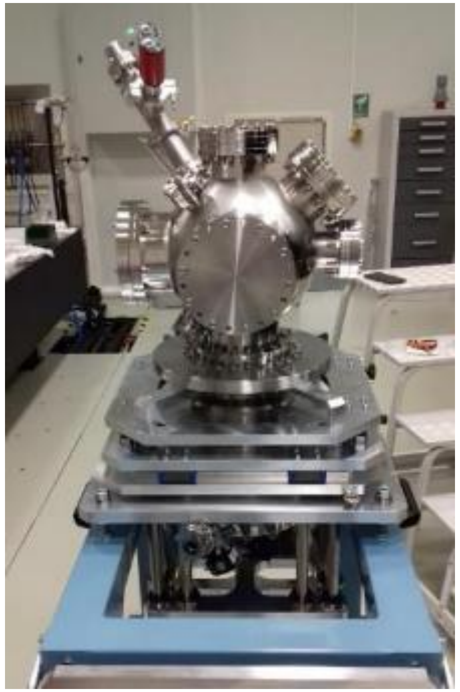
Photodissociation/Coulomb explosion experiments in gas phase
driven by SYLOS laser (891 nm, 1 kHz, 8 fs, 300 μJ/pulse)



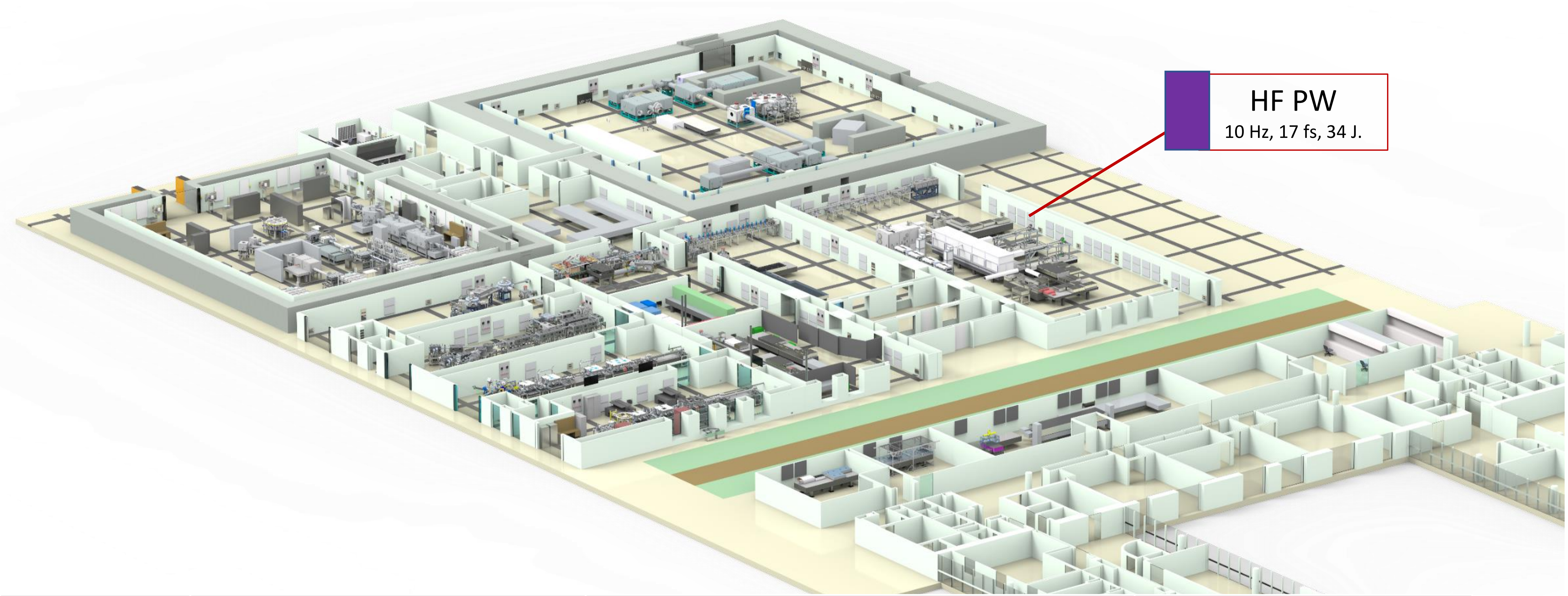
Excitation: IR/XUV/attosecond/terahertz (double pump)
Probe: Time-resolved Fluorescence spectra
Spectral Resolution: 0.06 cm^{-1}
(50000 cm^{-1}-400cm^{-1})
Time resolution: 2.5 ns
Pressure: 1E-4 Torr, jetcooled







HF PW activity
10 Hz



	Parameters	Status	Operation due date
HF PW	*10 Hz, <17 fs, 34 J* *2.5 Hz, 25 fs, ~7-10 J*	Under development (current status 10 Hz, 22 fs, 10 J)	by 2025 by Q2 2023

Output of TWIN amplifier

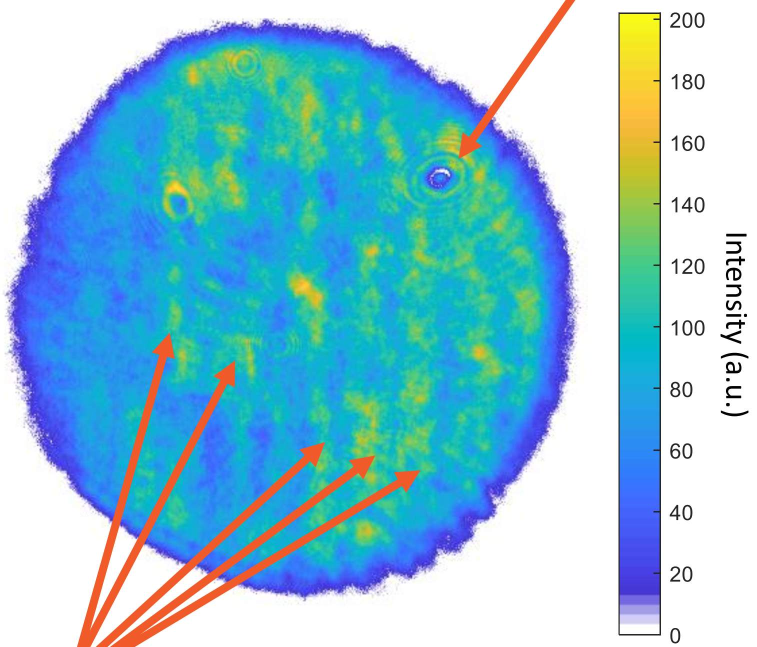
Current status:

- TWIN 1 amplifier: 14.3 J @ 10 Hz
- TWIN 2 amplifier: inactive

Amplitude

Damage of deformable mirror in TWIN 2

Near field of TWIN 2



Streams in coolant flow in TWIN 1 laser head

TWIN 1 energy

- 14.3 J average
- 0.64% RMS
- 6.4% PTP

measured for 1 minute with Gentec QE95LP

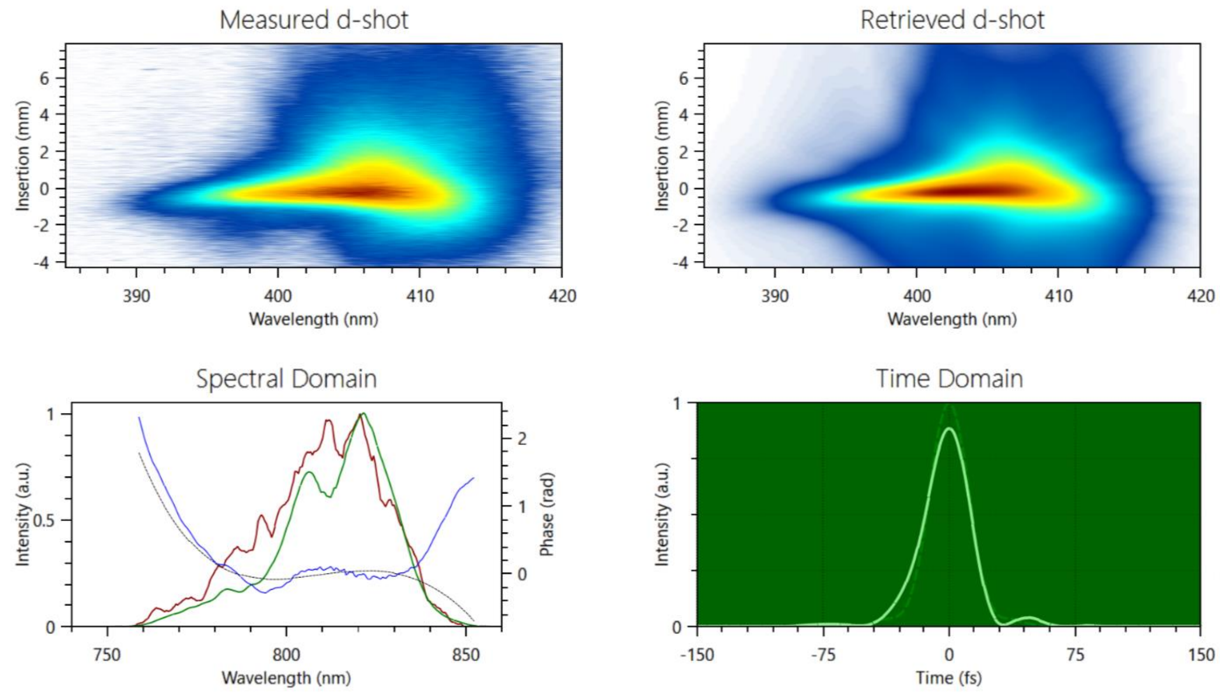
Diagnostics after compressor

Amplitude

Compression in diagnostic bench

- **Center of beam measured**
- Single-shot D-scan (D-Shot R, 700-900 nm)
- Compressor not aligned perfectly for diagnostic bench
- FTL only 27.4 fs

- Wizzler measurement of AT last week: 22-24 fs



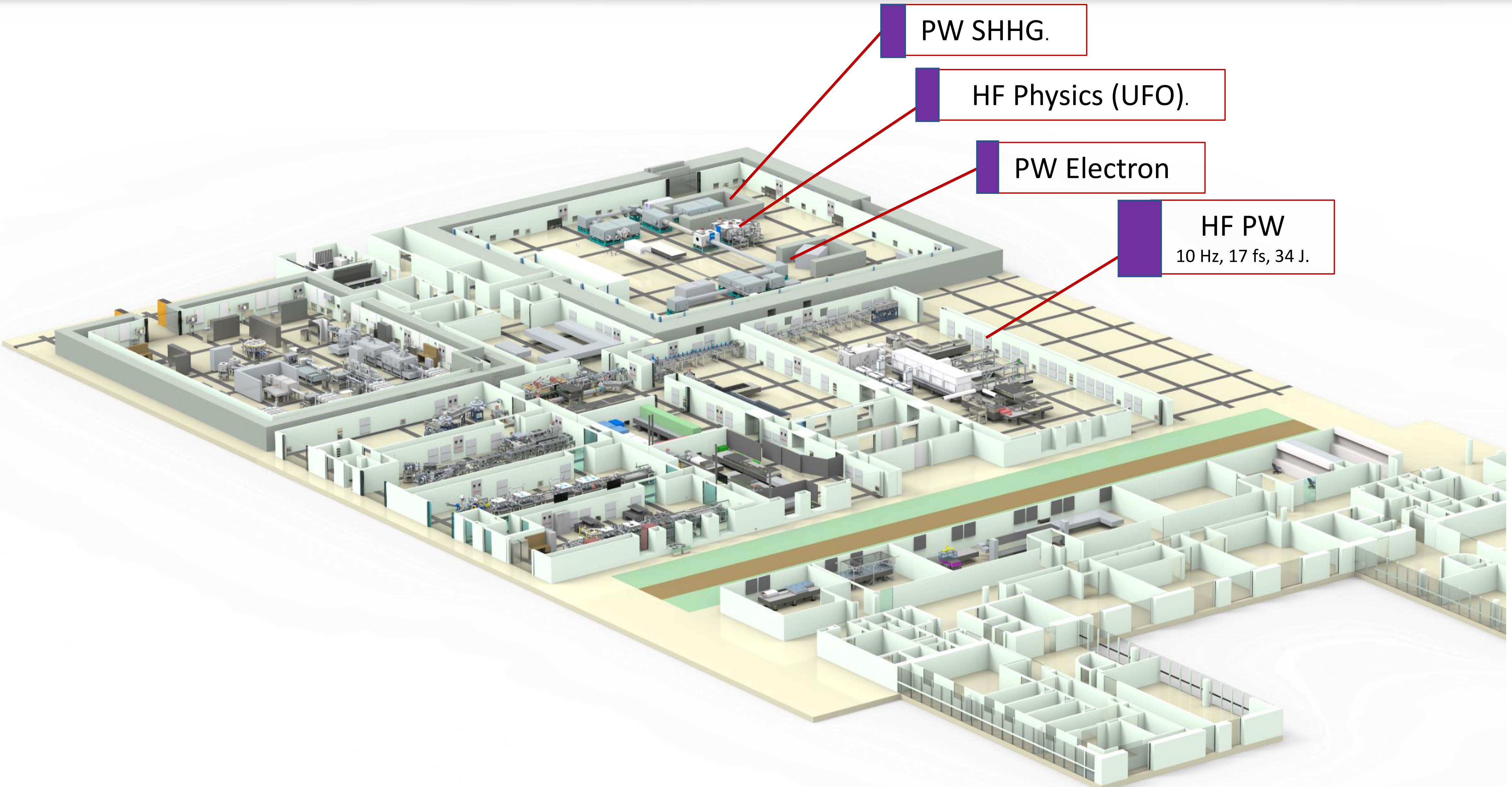
Trace	
RMS Error	2.0 %
Max SHG Insertion	-0.286 mm
Spectral Domain	
Center λ	813 nm
Pulse GDD	-36 fs^2
Pulse TOD	3,599 fs^3
Time Domain	
Pulse width	**30.4 fs**
Relative Peak Power	**89 %**
TL pulse width	27.4 fs

Propagation

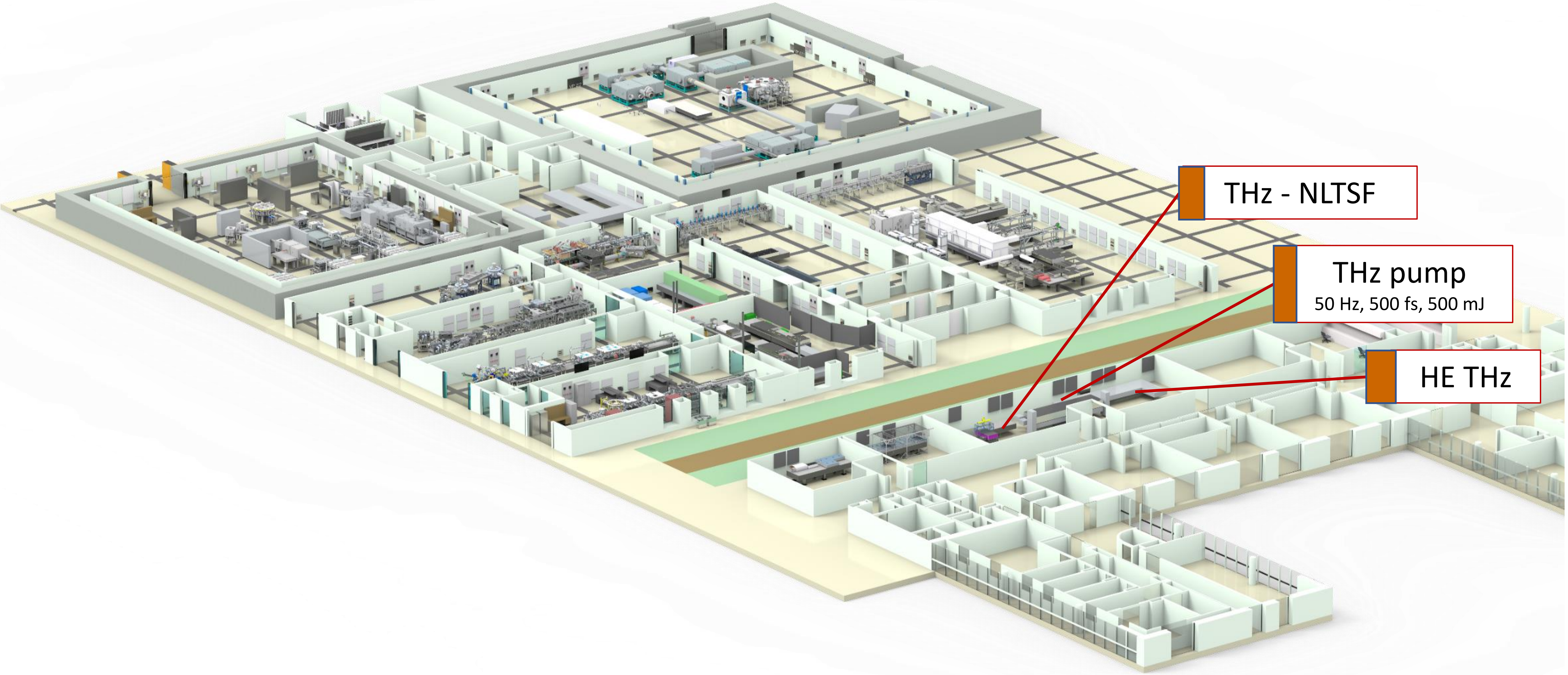
Figure 3.2: SHG d-shot retrieval results and resulting pulse in the spectral and time domain. (Top-left) Measured, calibrated d-shot trace. (Top-right) Retrieved d-shot trace. (Bottom-Left) Red line: Measured linear spectrum. Green line: Retrieved linear spectrum. Blue line: Retrieved spectral phase. Black line: 4th order polynomial fit of the spectral phase. (Bottom-right) Dashed green: Temporal intensity profile of the transform limited pulse. Light Green: Temporal intensity profile of the measured pulse. Measurement: **(2022/10/26 09:29:00)**

Add comments to retrieval

PW driven high field interactions



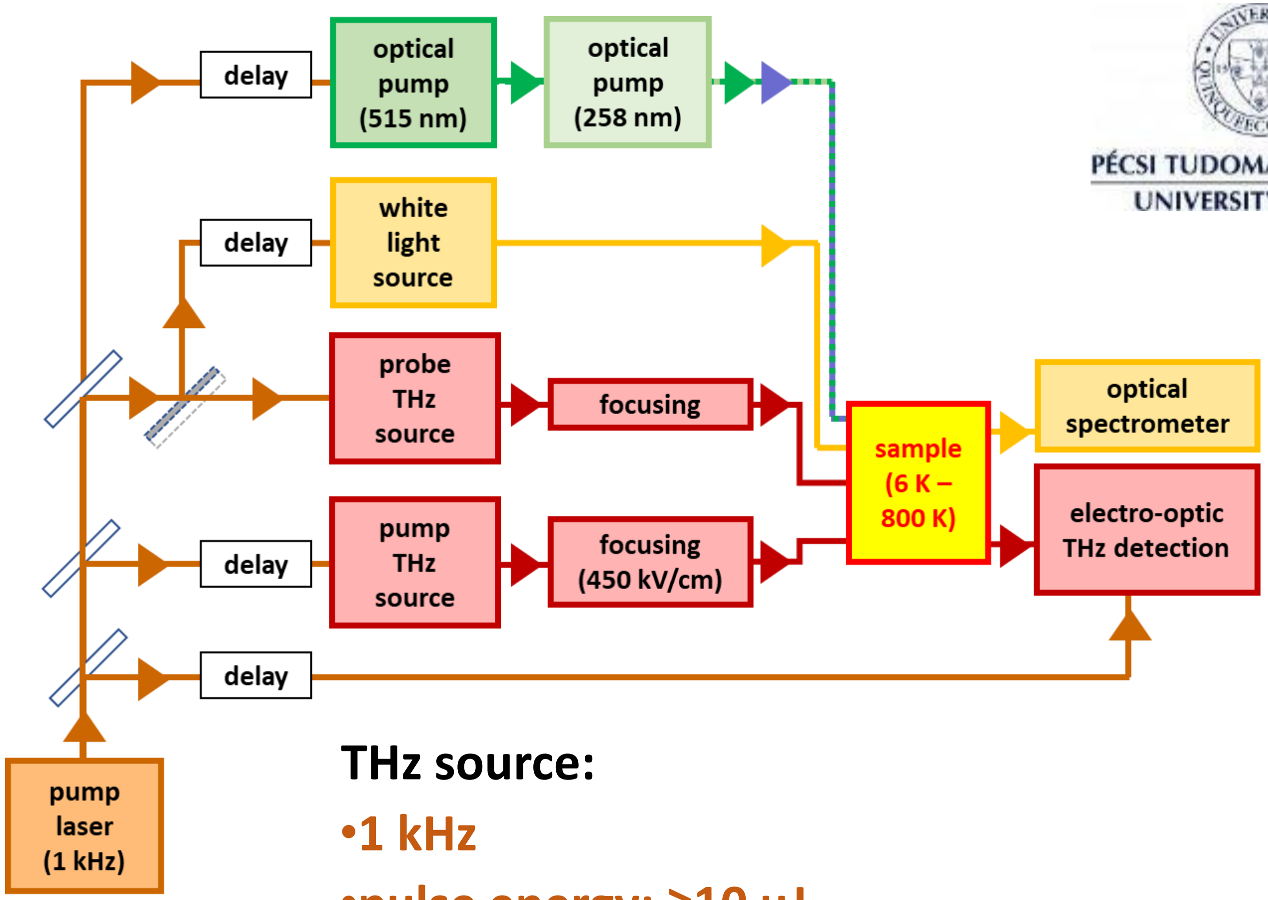
THz activity
0.15-1.5 THz



NLTSF: equipment developments

50% of user experiments require major facility development.

user ready



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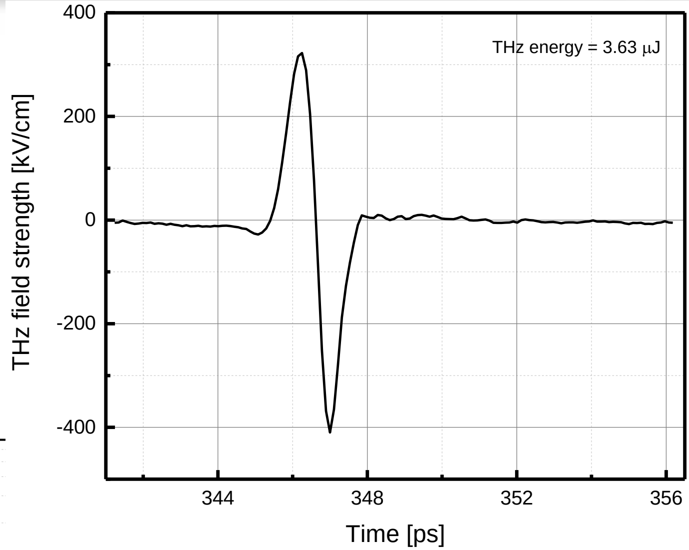
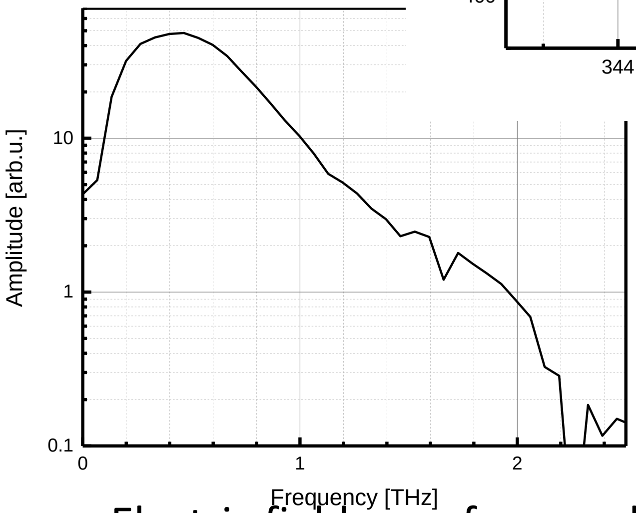




THz source:

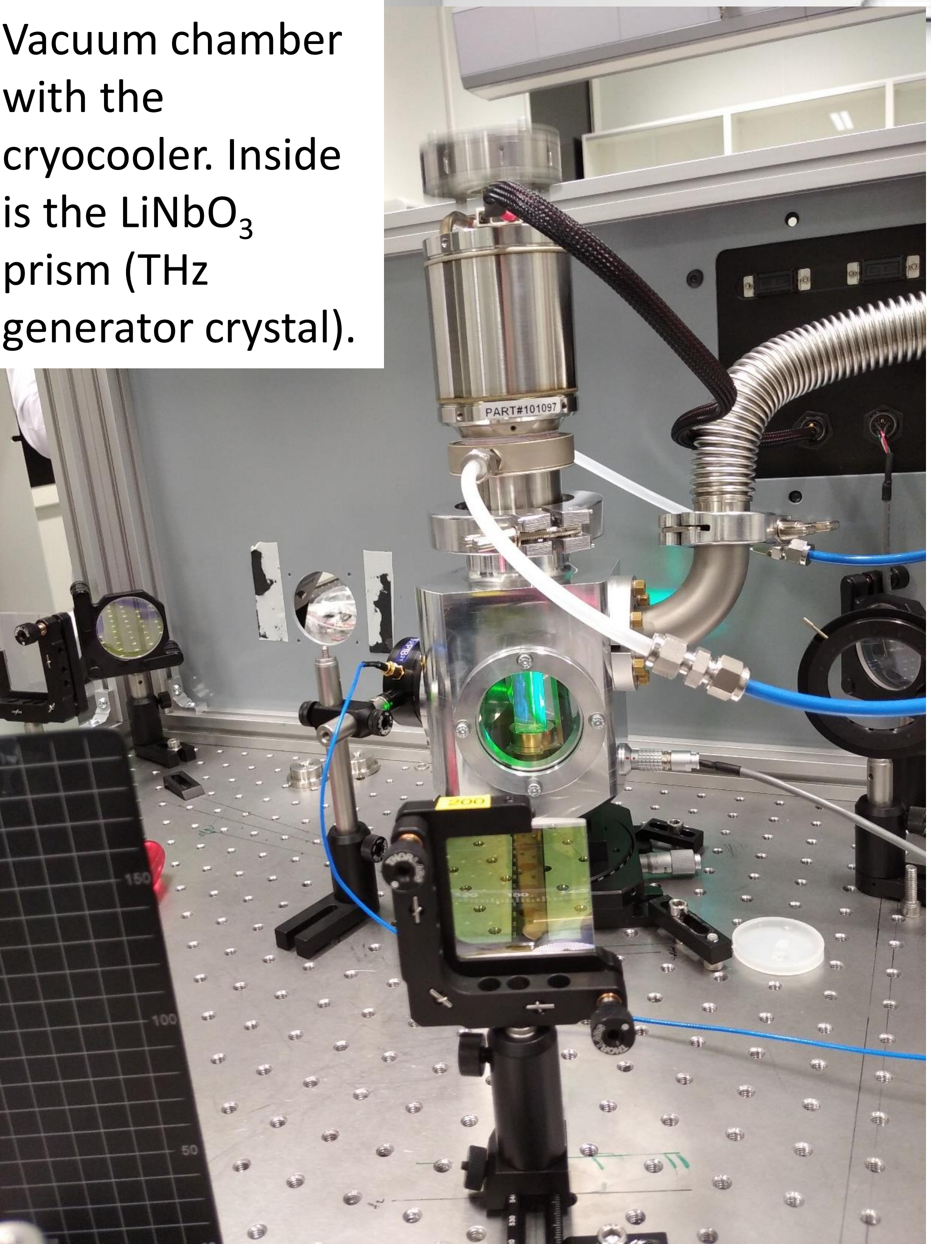
- **1 kHz**
- **pulse energy: ≥10 μJ**
- **peak THz field at the sample: ≥200 kV/cm**

Electric field waveform and amplitude spectrum of the pump THz source (from ongoing recommissioning after facility relocation). The peak electric field strength is > 400 kV/cm.

High-Energy Terahertz (HE-THz) source

user ready

Vacuum chamber with the cryocooler. Inside is the $LiNbO_3$ prism (THz generator crystal).



Parameters from site-acceptance test (SAT)

- THz pulse energy: > 1 mJ
- Repetition rate: 50 Hz
- THz waveform: single cycle
- Spectral range: 0.1 – 1 THz
- Spectral amplitude peak at 0.25 THz
- Synchronized short-pulse output: 0.8 µm | 100 fs | 1 mJ | 1 kHz

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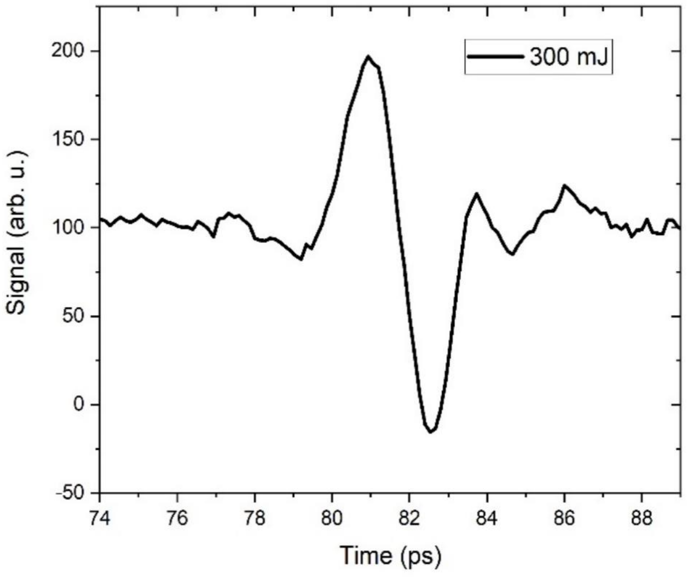
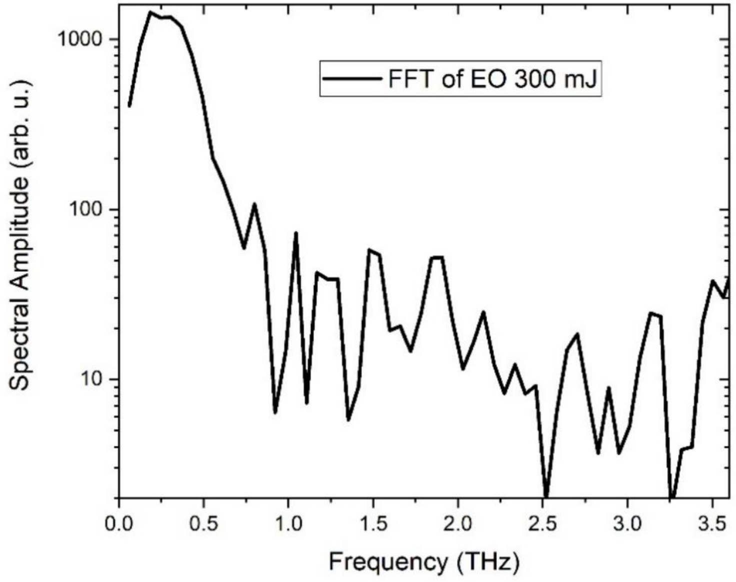


waveform of high-energy THz pulses measured by electro-optic sampling

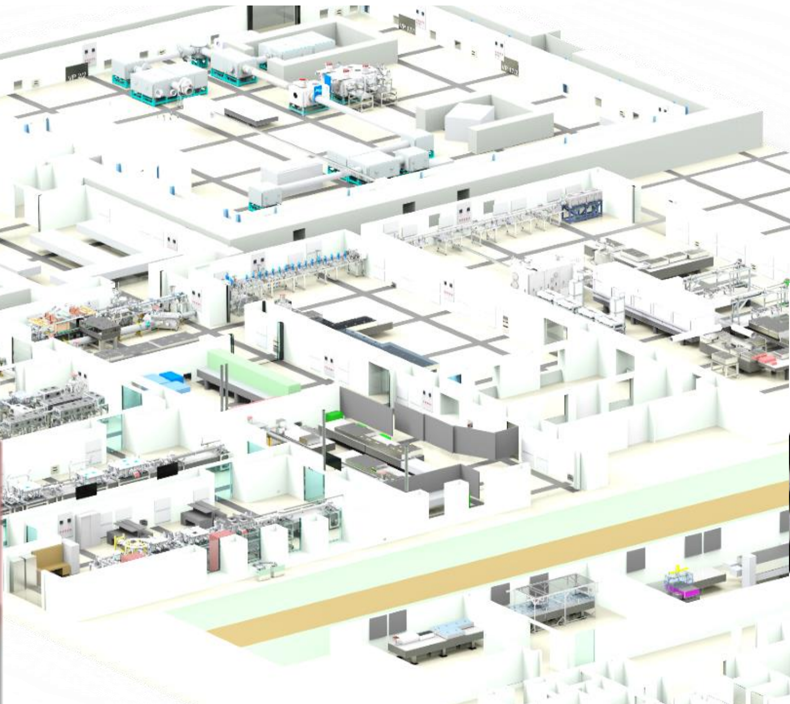


amplitude spectrum obtained by Fourier transformation of the waveform

Auxilliary facilities

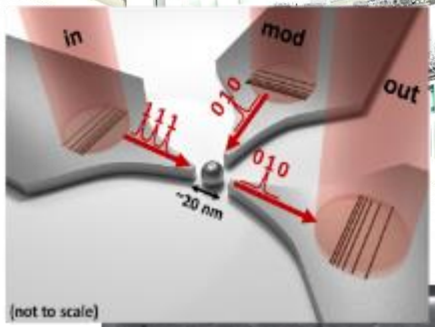
user ready

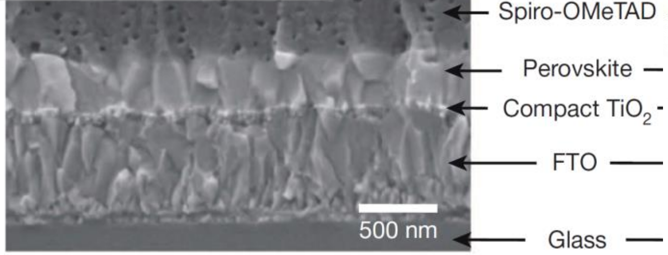
Mechanical and electrical workshops
(incl rapid prototyping)
Optical workshop for custom optics and coatings
(incl advanced metrology)



Zebrafish embryo model to investigate radiobiological effects of pulsed radiation.

FIB, EBL
Nanofabrication unit, optoelectronical sample preparation, nanooptics research, condensed matter analysis





ELI ERIC User Call(s)

https://www.eli-laser.eu

THANK YOU FOR YOUR ATTENTION!

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- **1st Call runs October 2022 through March 2023**
- **The 2nd call will be published January 2023**