High average power (& high peak power) lasers of ELI-ALPS

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4th April, 2017

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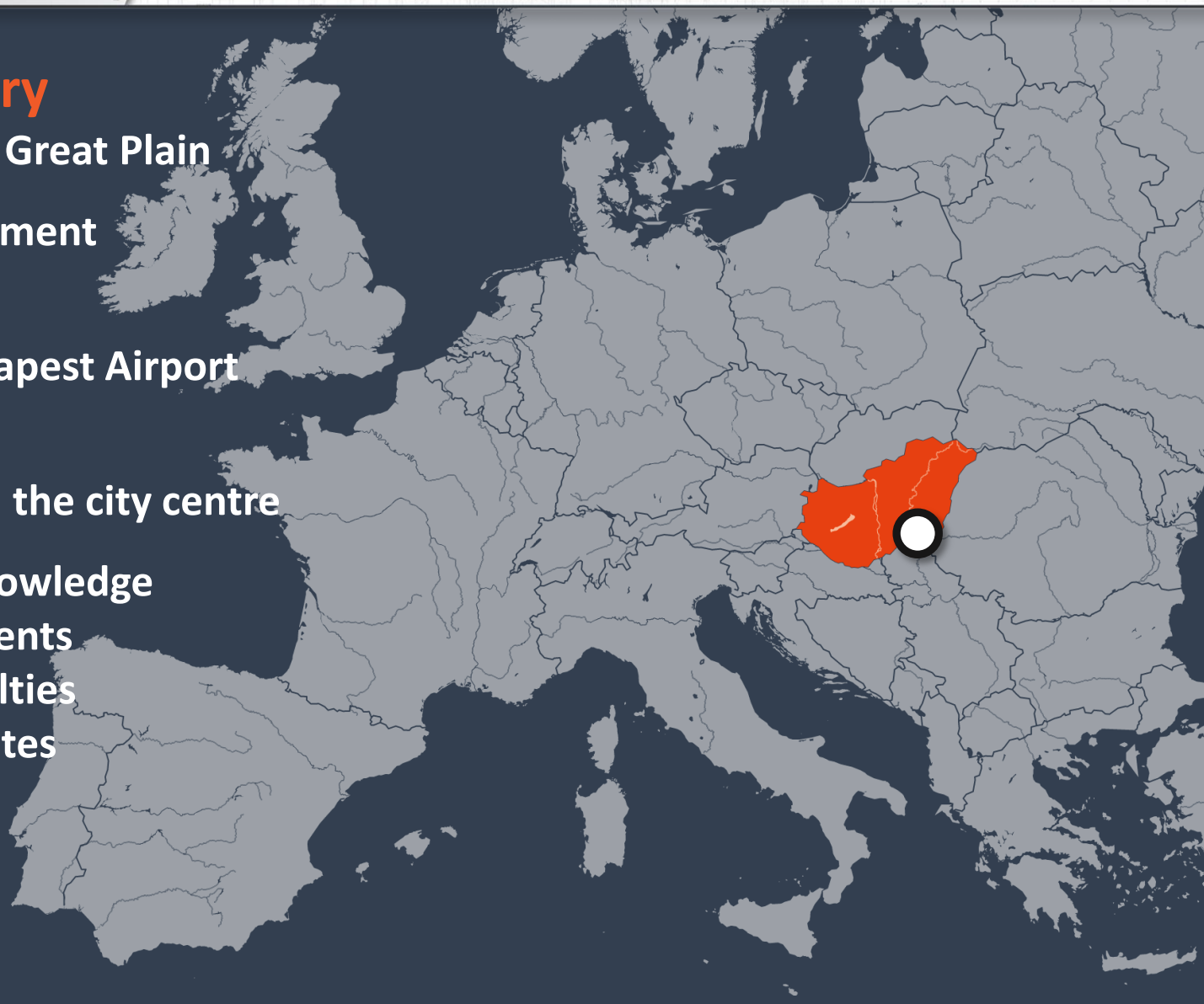
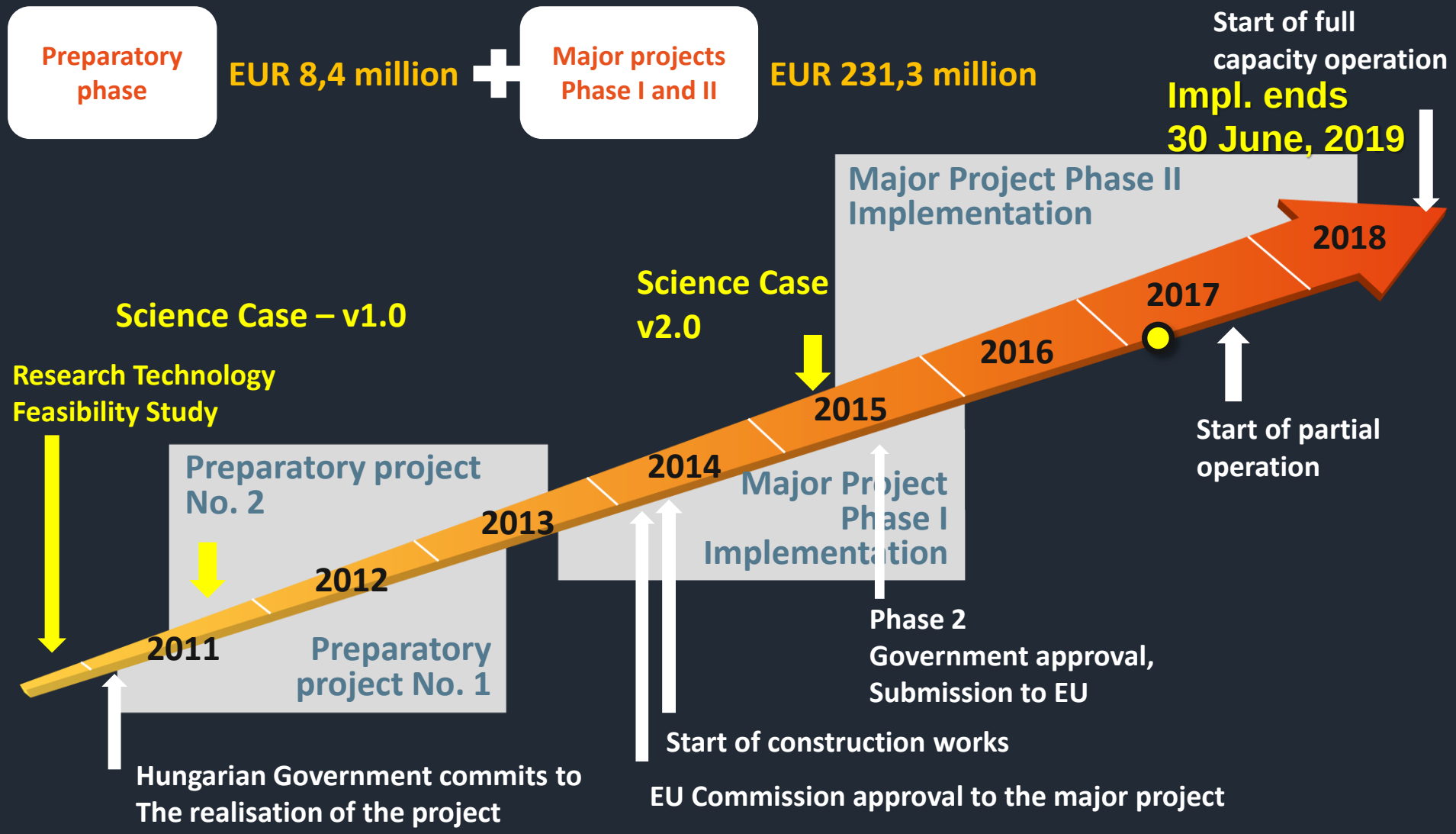
ELI-ALPS

Szeged, Hungary

- Szeged, Southern Great Plain
- Brownfield investment
  100 / 10 ha
- 160 km from Budapest Airport
  on motorway M5
- 5 km from Szeged the city centre
- Szeged: city of knowledge
  25 thousand students
  11 university faculties
  2 research institutes
  +1: ELI



Status of the project
Milestones



MISSIONS OF ELI-ALPS

1) To generate X-UV and X-ray femtosecond and attosecond pulses, for temporal investigation at the attosecond scale of electron dynamics in atoms, molecules, plasmas and solids.

ATTOSECOND Beamlines & User Facility

2) To contribute to the technological development towards high average power, high peak intensity lasers.

SCIENTIFIC PROGRAM

1 Laser research and development

2 Research and development of secondary sources

3 Atomic, molecular and nanophysical research

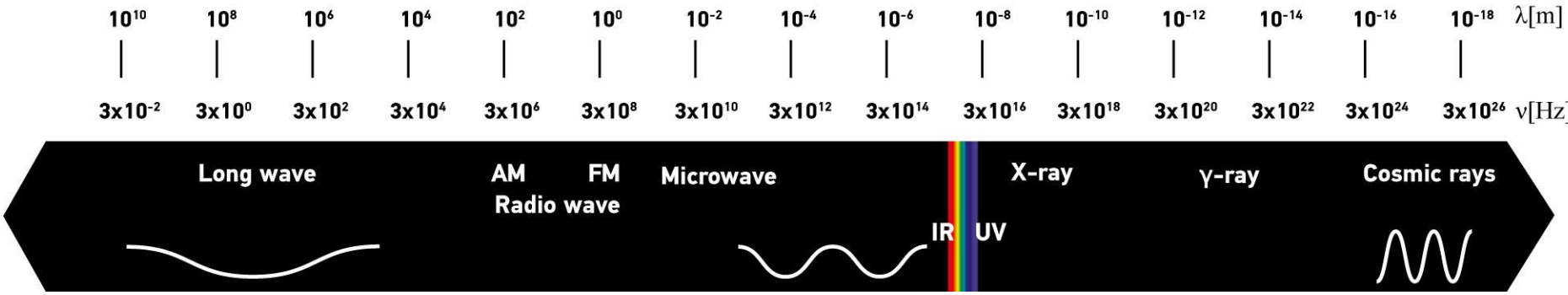
4 Applied research activities:
biomedicine, materials science

5 Industrial applications

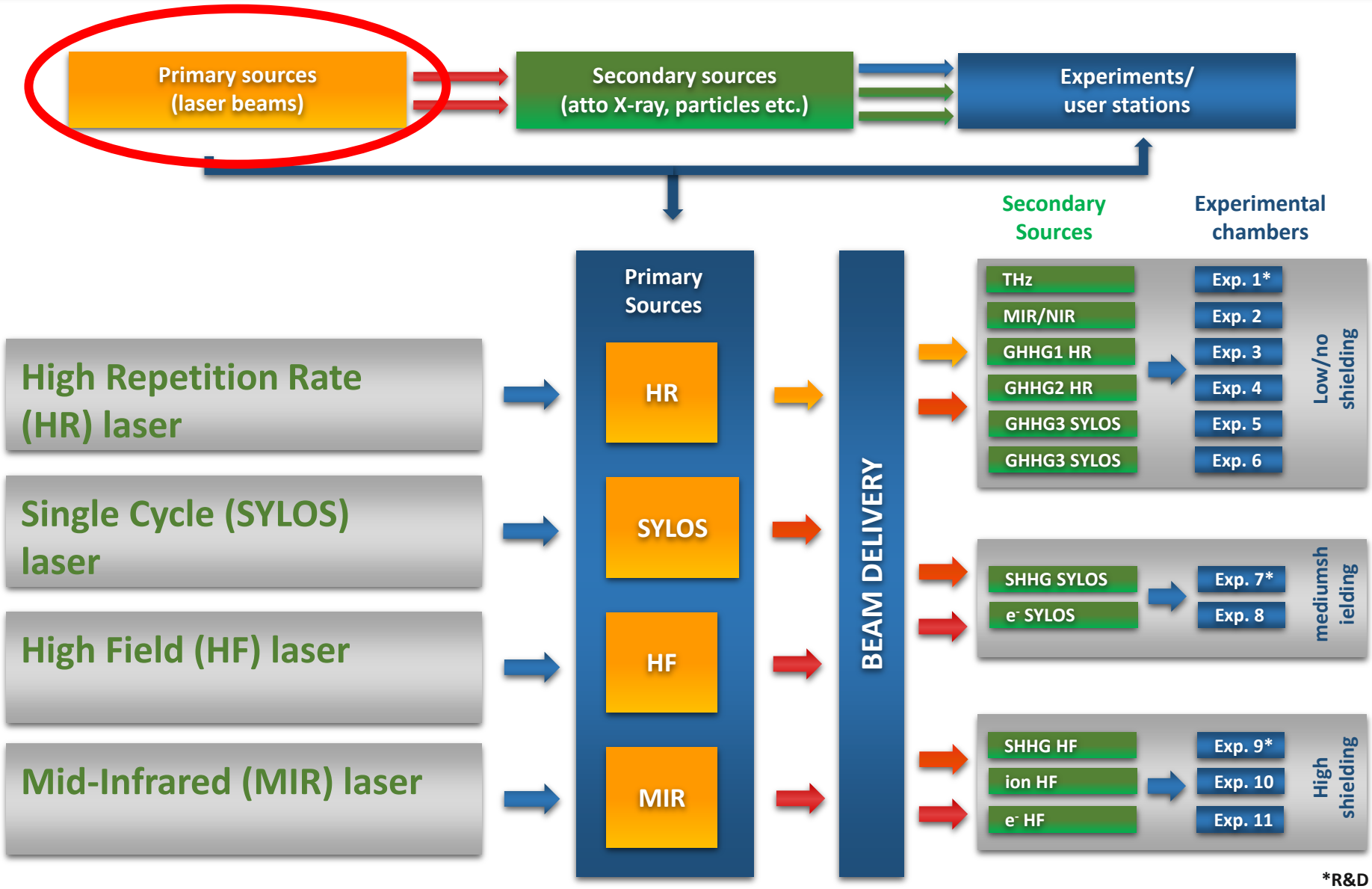
See in details: www.eli-alps.hu

THE GOAL OF ELI-ALPS

To provide light sources of
the shortest possible light pulses (few cycles),
in the broadest possible spectral regime (XUV – THz),
at the highest possible repetition rate (10Hz-100kHz).

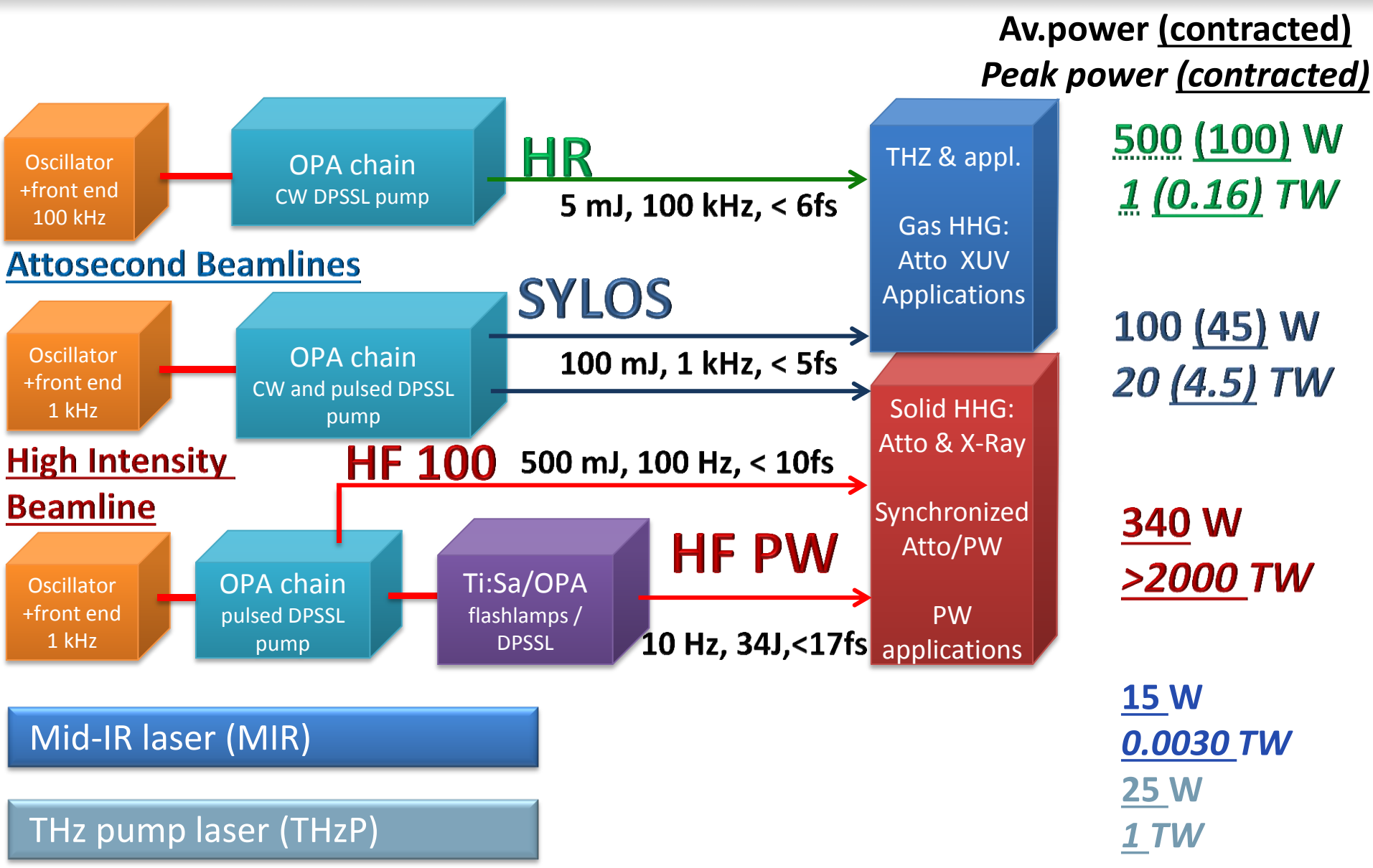


SCHEMATICS OF ELI-ALPS



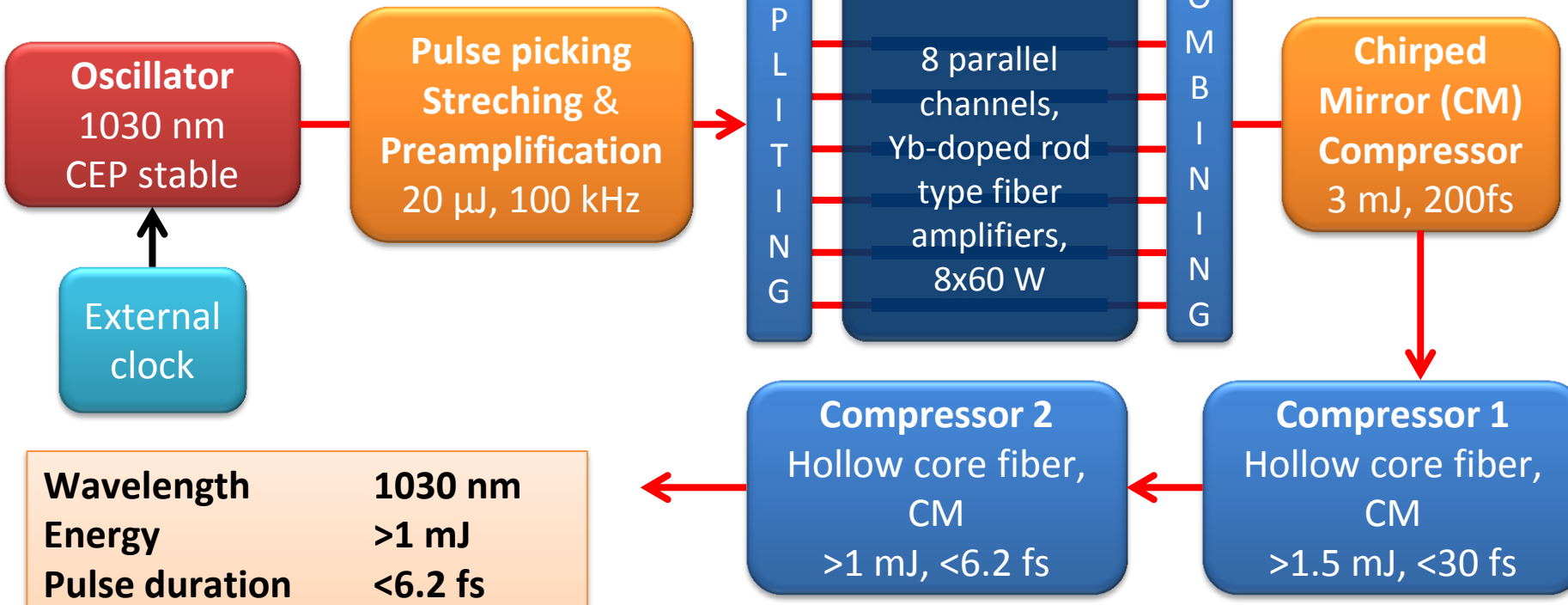
*R&D

LASER SYSTEMS OF ELI-ALPS



HR (1) LASER

IAP FSU Jena + Fraunhofer IAF + Active Fiber Systems GmbH



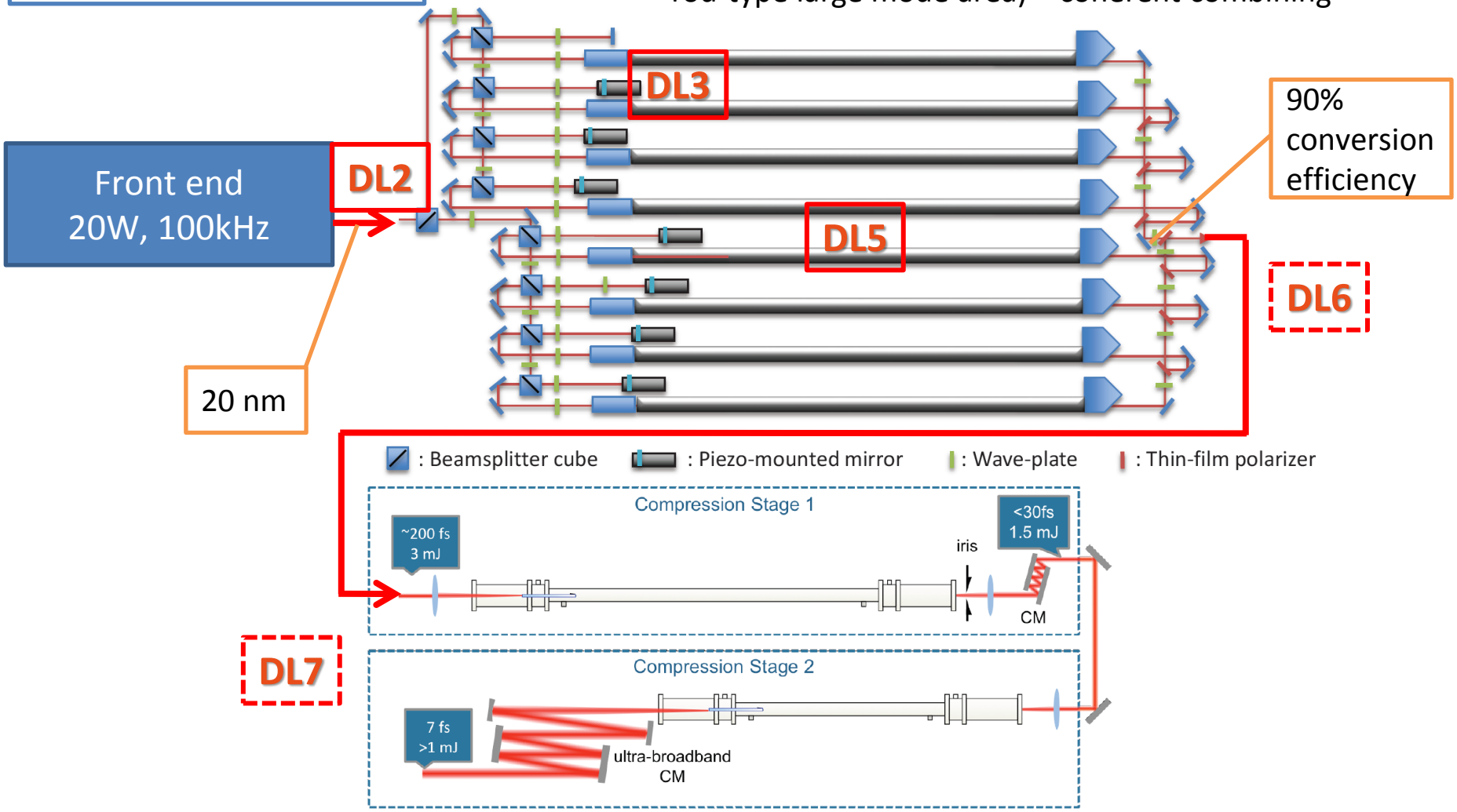
Wavelength	**1030 nm**
Energy	**>1 mJ**
Pulse duration	**<6.2 fs**
Rep.rate	**100 kHz**
CEP stability	**<100 mrad**
Energy stability	**0.8%**
Strehl ratio	**0.9**

FAT: May, 2017, SAT: July, 2017

HR SYSTEM: BASIC LAYOUT

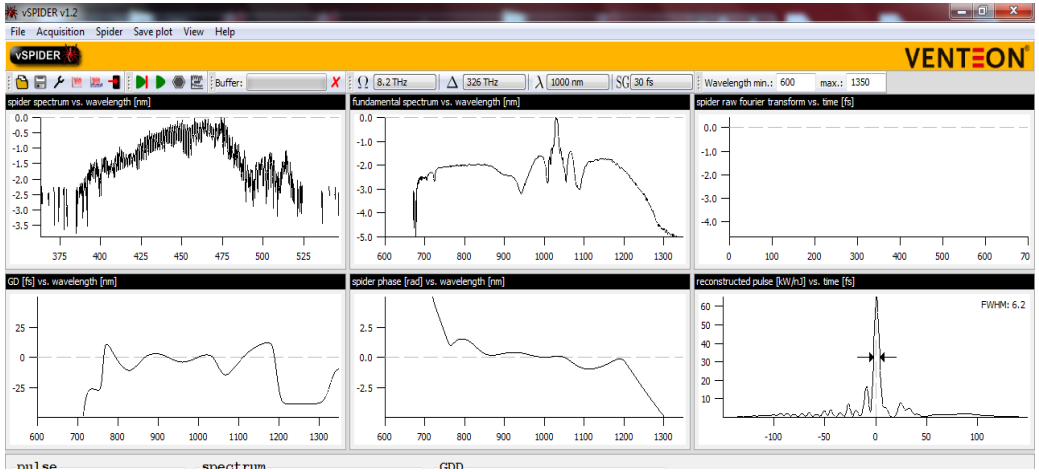
Footprint ≈ 5.5·1.2m²

8-channel main amplifier (ytterbium-doped rod-type large mode area) + coherent combining

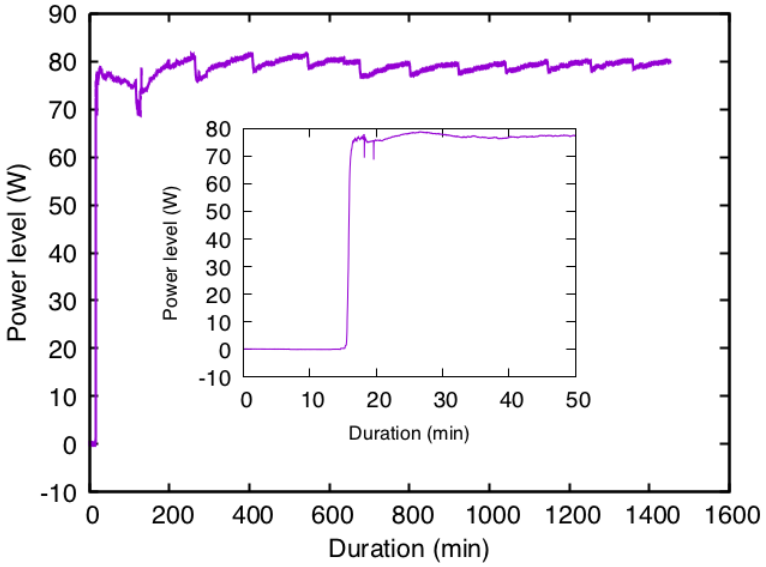


Major results of DL8 (11-12 October, 2016)

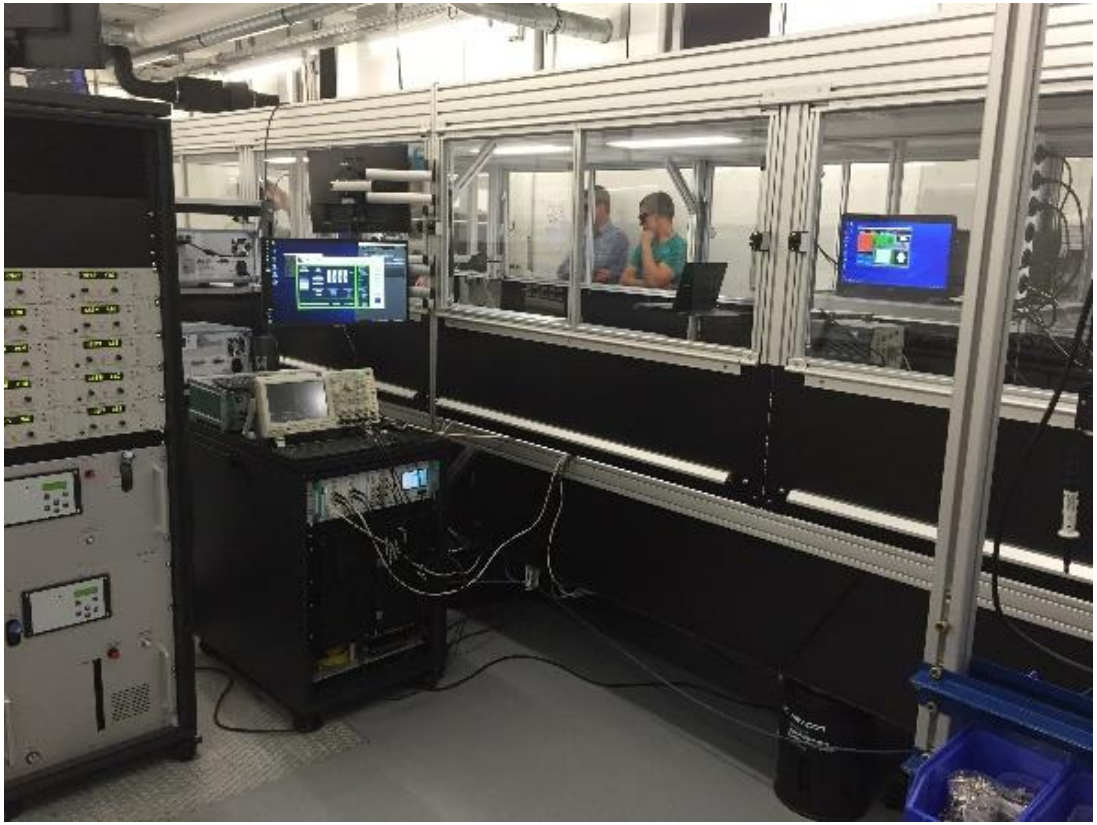
Output: 0.75 mJ, <6 fs

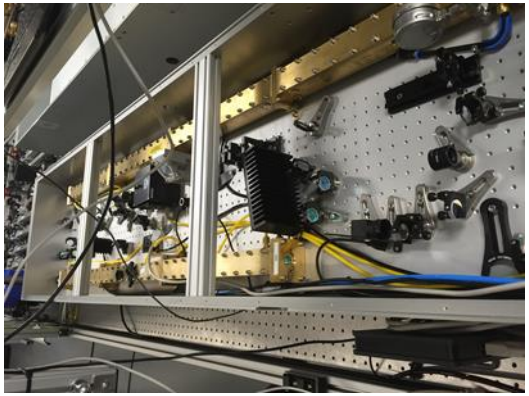


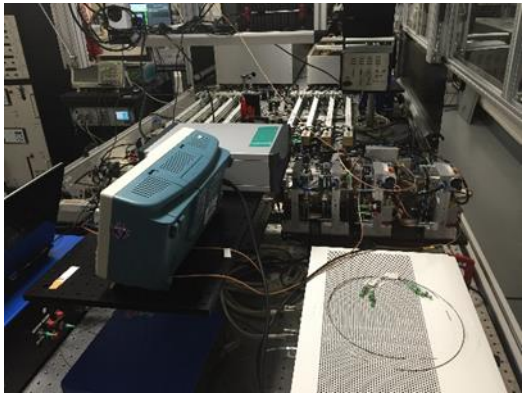
24h continous test



Current status







HR 2 laser

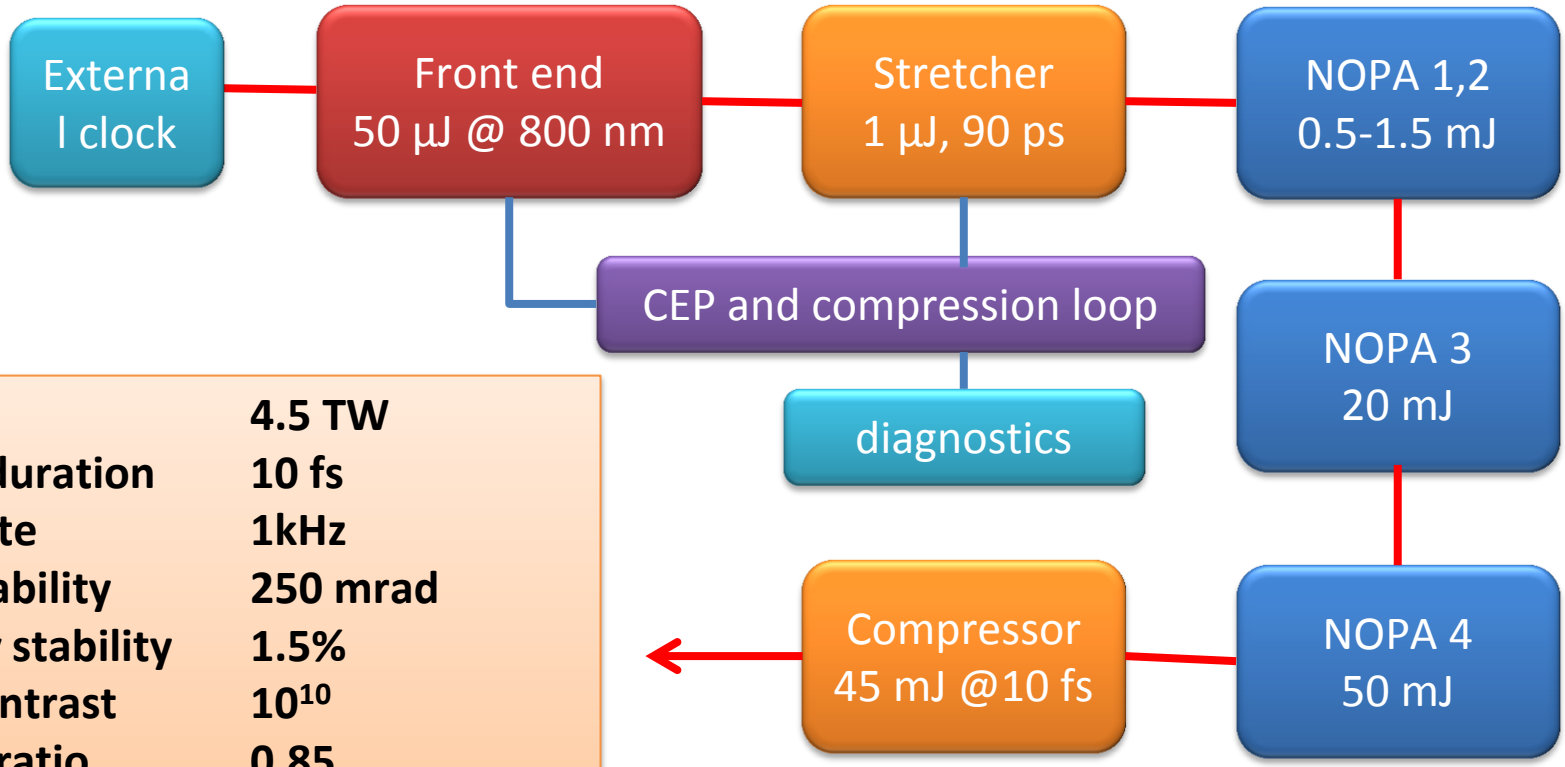
Pulse energy: ≥ 5mJ
Duration: <6fs (1.75 cycles)
Energy stability: <0.8% rms
CEP stability: <250mrad
Wavelength range: 500-1400nm
λ_0: 1030 nm
Strehl ratio: >0.95 (!)

FCPA
Average power / fiber amp: >100W
No fiber amps: 16
Coherently combined average power: >1.2kW
Duration: 200fs (-300fs)
λ_0: 1030nm

Under contracting
Installation and trial run ends April 2019

SYLOS (1) LASER

EKSPLA + Light Conversion consortium

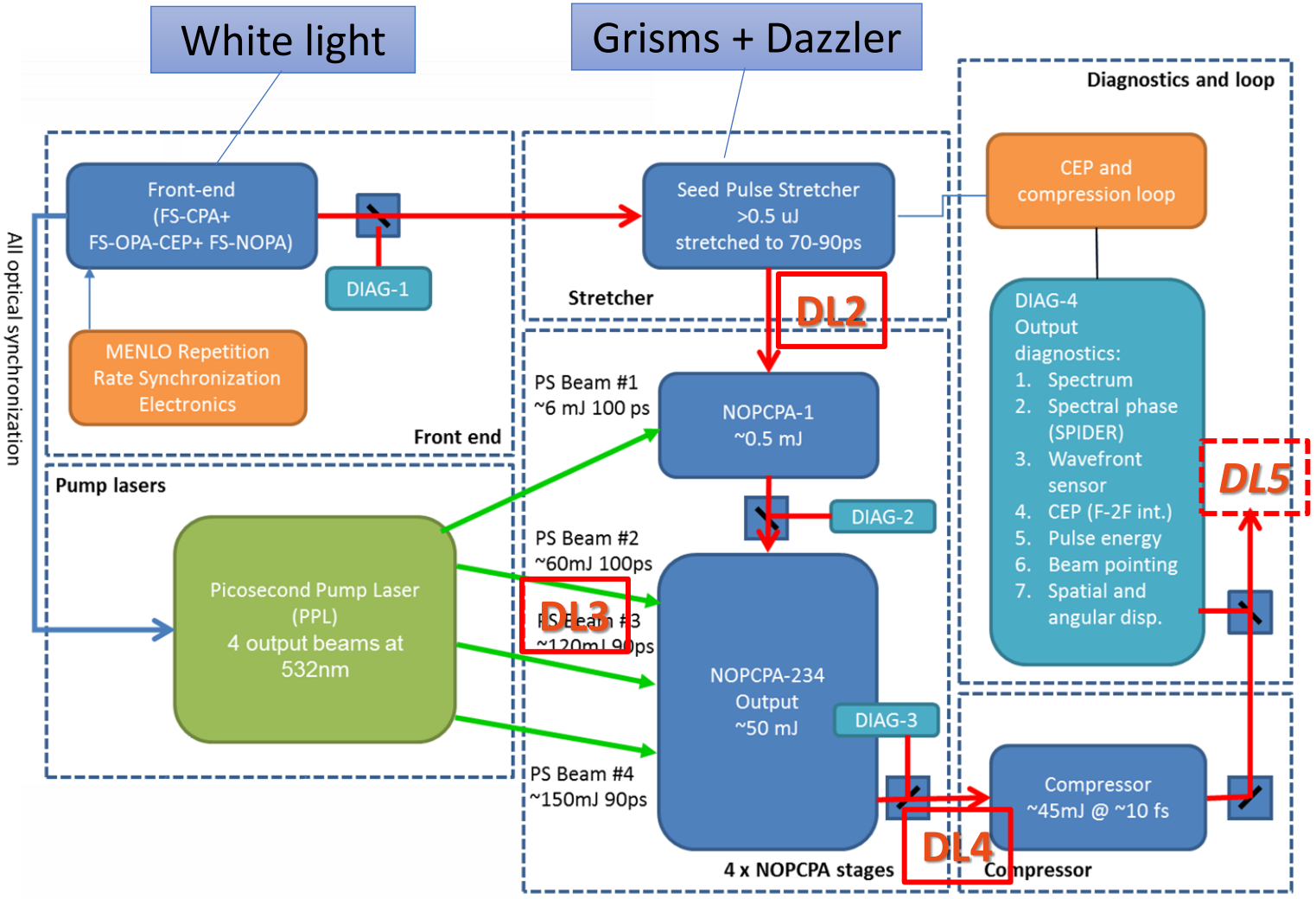


Power	**4.5 TW**
Pulse duration	**10 fs**
Rep.rate	**1kHz**
CEP stability	**250 mrad**
Energy stability	**1.5%**
ASE contrast	**10^{10}**
Strehl ratio	**0.85**
Central λ	**850 nm (-900 nm)**
Beam ∅	**60 mm**
Optics ∅	**100 mm**

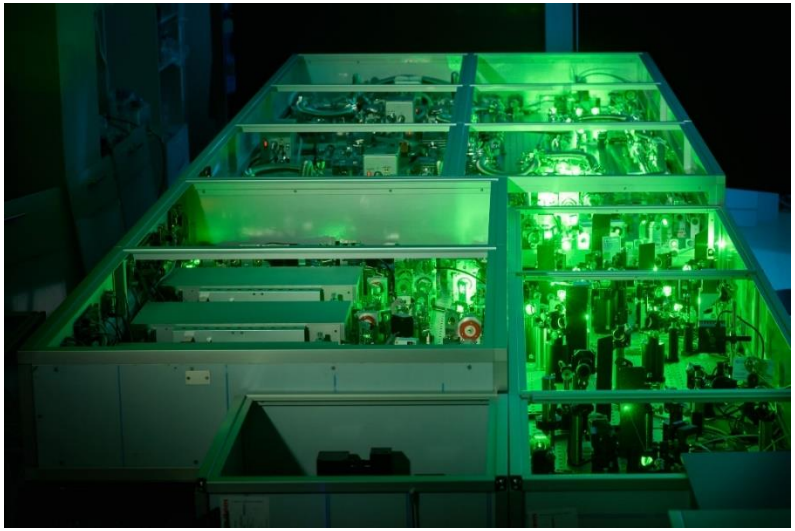
FAT: March, 2017, SAT: August, 2018

R&D for SYLOS (2) -> under contracting

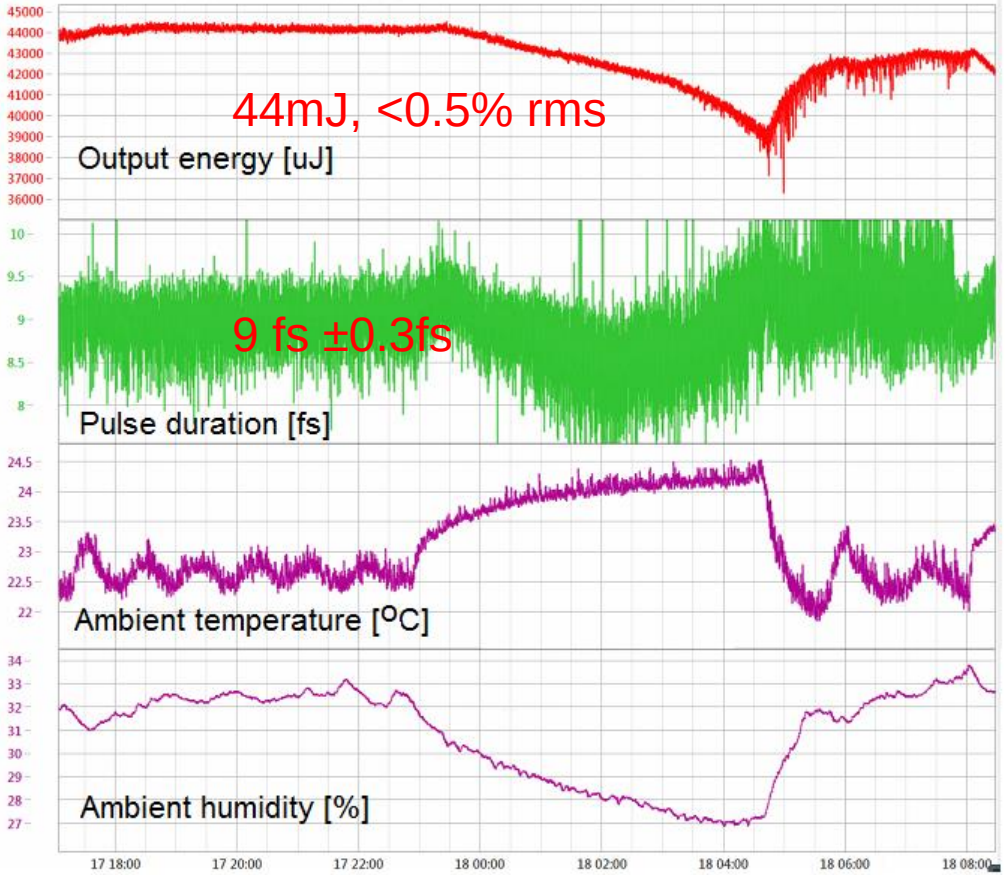
SYLOS I: SCHEMATIC LAYOUT OF OPTICS

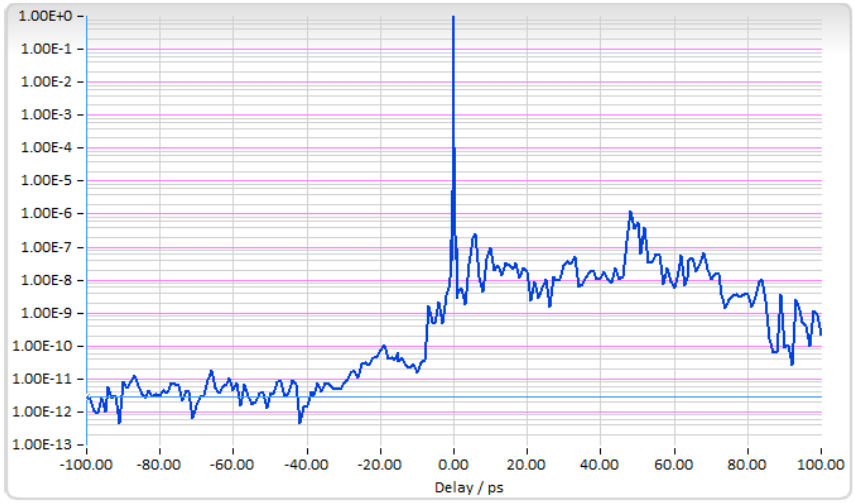


DL5: FULL SYSTEM WITH PARTIAL COMPRESSION (*17-18th May*, 2016)



15 h continous test





SYLOS1 is fully completed, incl 6 month trial period

Recent paper on SYLOS1

Research Article | Vol. 25, No. 5 | 6 Mar 2017 | OPTICS EXPRESS 5797

Optics EXPRESS

53 W average power CEP-stabilized OPCPA system delivering 5.5 TW few cycle pulses at 1 kHz repetition rate

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Abstract: We present a high peak and average power optical parametric chirped pulse amplification system driven by diode-pumped Yb:KGW and Nd:YAG lasers running at 1 kHz repetition rate. The advanced architecture of the system allows us to achieve >53 W average power combined with 5.5 TW peak power, along with sub-220 mrad CEP stability and sub-9 fs pulse duration at a center wavelength around 880 nm. Broadband, background-free, passively CEP stabilized seed pulses are produced in a series of cascaded optical parametric amplifiers pumped by the Yb:KGW laser, while a diode-pumped Nd:YAG laser system provides multi-mJ pump pulses for power amplification stages. Excellent stability of output parameters over 16 hours of continuous operation is demonstrated.

SYLOS 2: IMPLEMENTATION ROADMAP

SYLOS 2A

Broaden the bandwidth to support sub- 2 cycle, CEP stable operation

New dispersion management system (2 alternatives)

New amplification system (2 alternatives)

Under contracting

Developed by Spring 2018

To be installed by August 2018

Peak power: ≥4.5TW
Duration: <7fs (2.2 cycles)
Energy stability: <1% rms
CEP stability: <250mrad
Wavelength range: 600-1400nm
λ_0: 850-975nm

SYLOS 2B

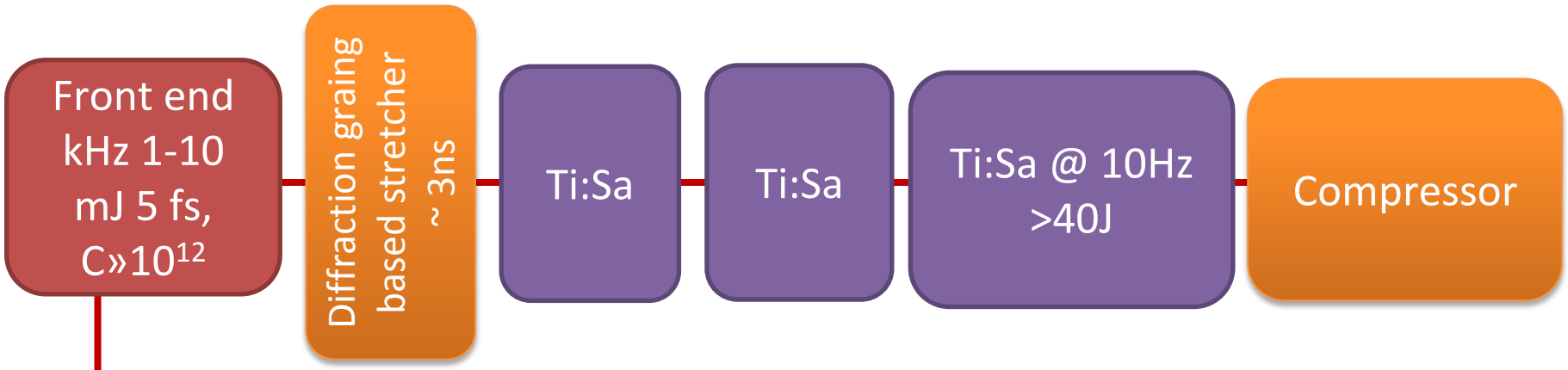
Enhance the energy by 4x at the sub- 2 cycle, CEP stable operation

New pump lasers

Expected to be completed by Summer 2019

HF PW LASER

Amplitude Technologies



Seed for HF 100

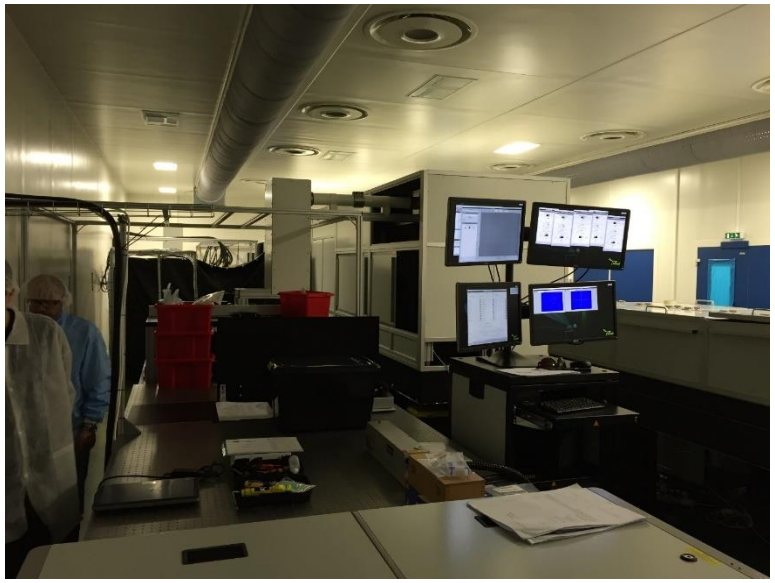
Rep.rate	100Hz
Pulse duration	<10fs
Energy	1 mJ
CEP	250mrad

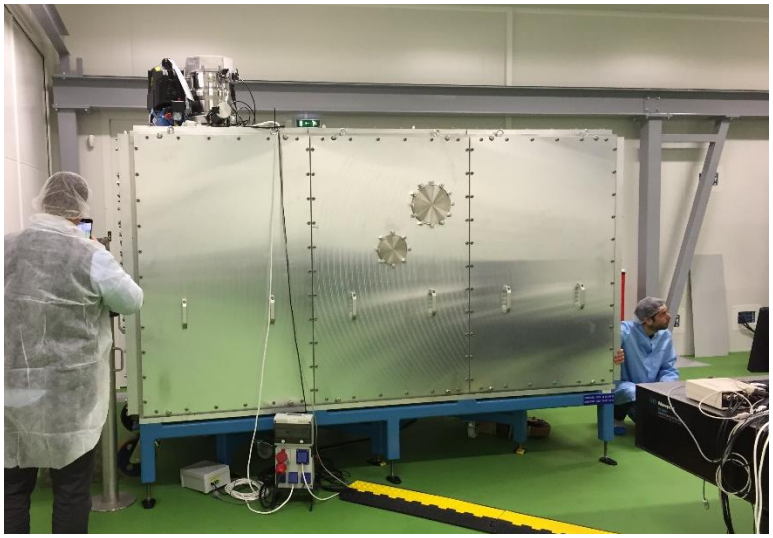
Power	2 PW
Pulse duration	17fs
Rep.rate	10Hz
Energy stability	1.5%
ASE contrast	10^{11}
Strehl ratio	0.9
Central λ	800 nm
Beam ∅	240 mm
Optics ∅	300 mm

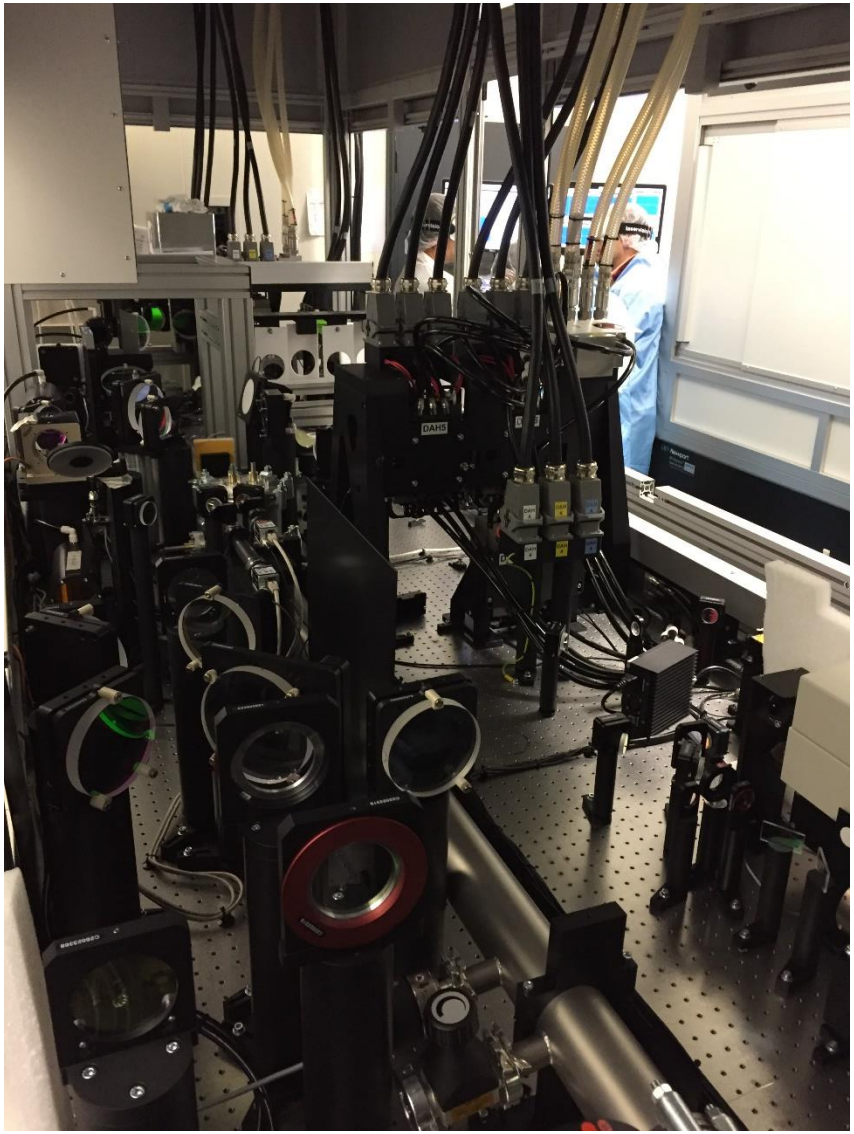
FAT: September 2017, SAT: December, 2018

Internal R&D for 500 mJ @ < 100Hz, 10fs

The entire system is under construction





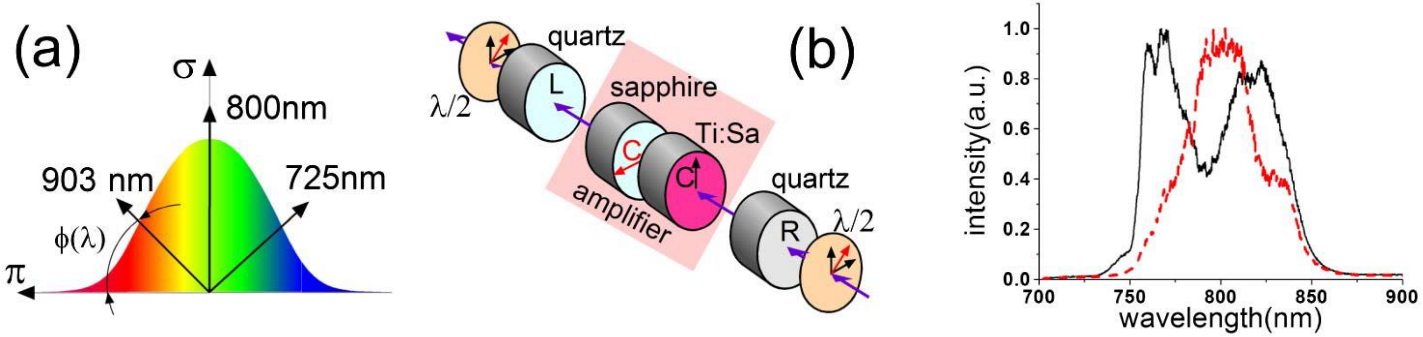


HF 100: IMPLEMENTATION ROADMAP

Internal development of the key elements / technology (2017 – 2018)

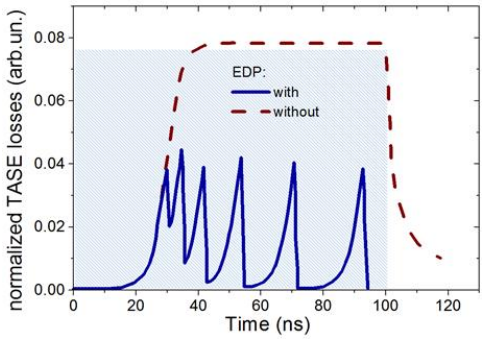
A) Polarization-encoded CPA in Ti:sapphire: a way toward few-cycle PW lasers

Kalashnikov et al., Opt. Lett. **41**, 25 (2016)



B) Design of a thin disk amplifier with extraction during pumping

Chvykov et al., Opt. Exp. 24, (3721) 2016



Implementation (2018/19-

Gradually, depending on budget (the priority is after SYLOS2, HR2)

LASER IMPLEMENTATION STATUS

	Next DL	Due	SAT
Sylos 1	*Completed*		2A: July 2018
HF PW	Partial system	October 2017	December 2018
MIR	Full OPCPA	May 2017	*July 2017*
HR 1	Full system FAT	May 2017	*August 2017*
THzP	TDR	April 2017	September 2018

BUILDING Complex

„A”

Main experimental hall

6200 m²

„B”

Labs, workshops, machinery

7900 m²

„C”

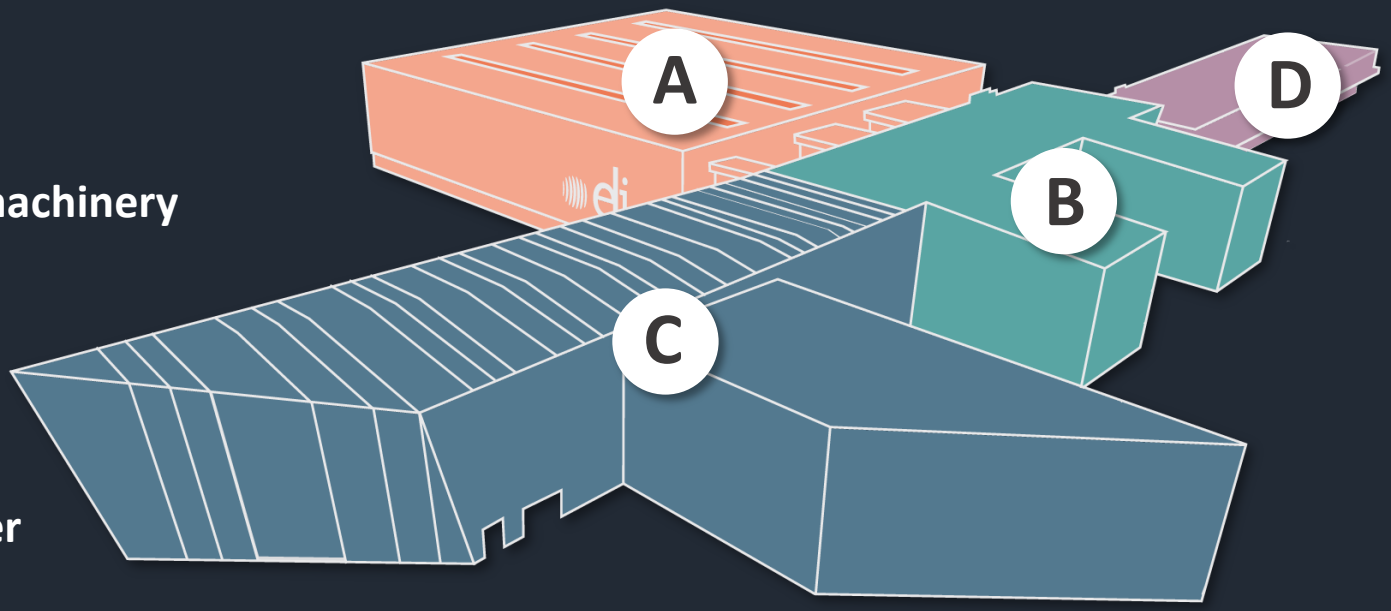
Offices, conf center

7400 m²

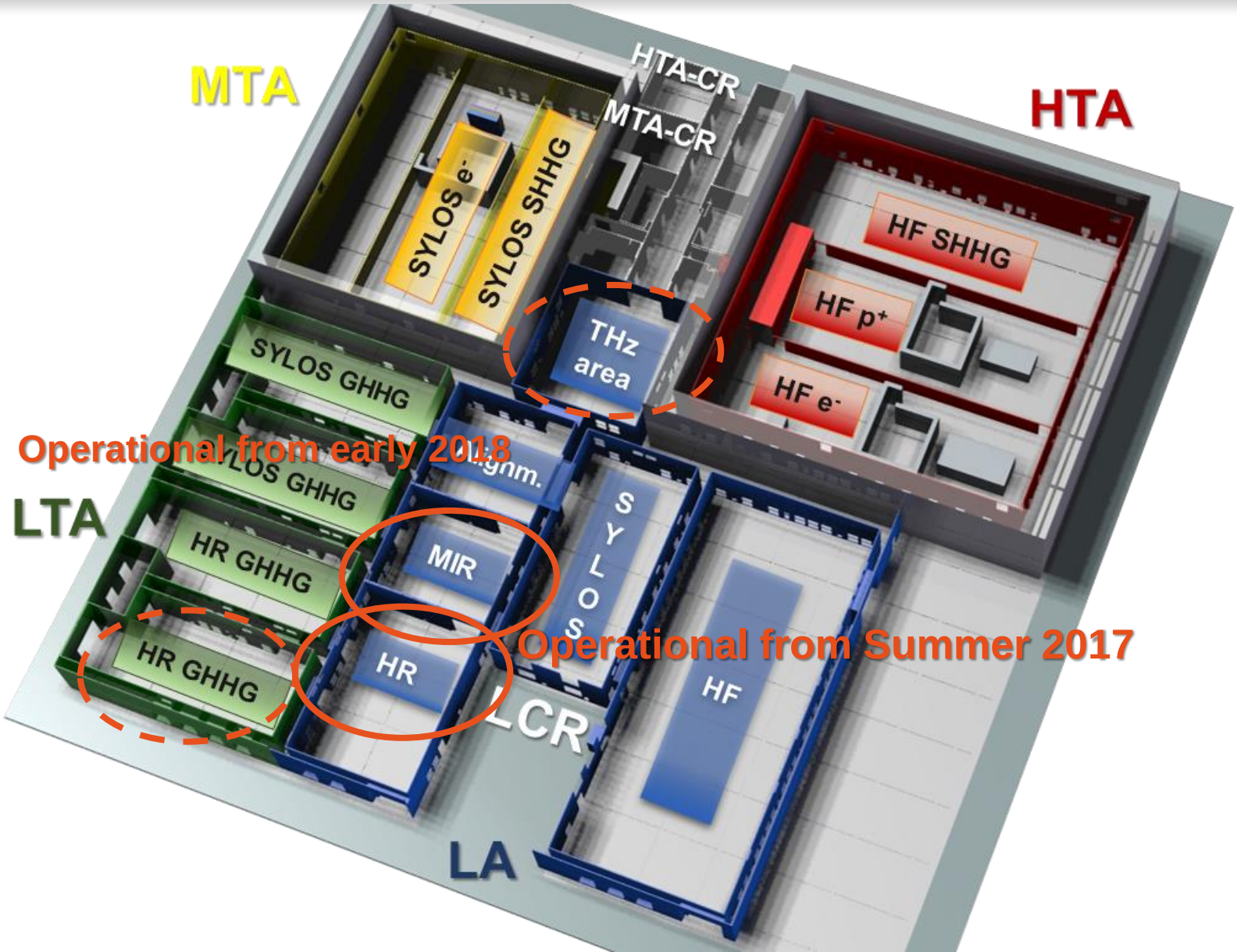
„D”

Workshop, maintenance, storage

2900 m²



Equipment and activity in Building A 2017



Birds' view – February 2017

THANK YOU FOR YOUR ATTENTION!

eli attosecond

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