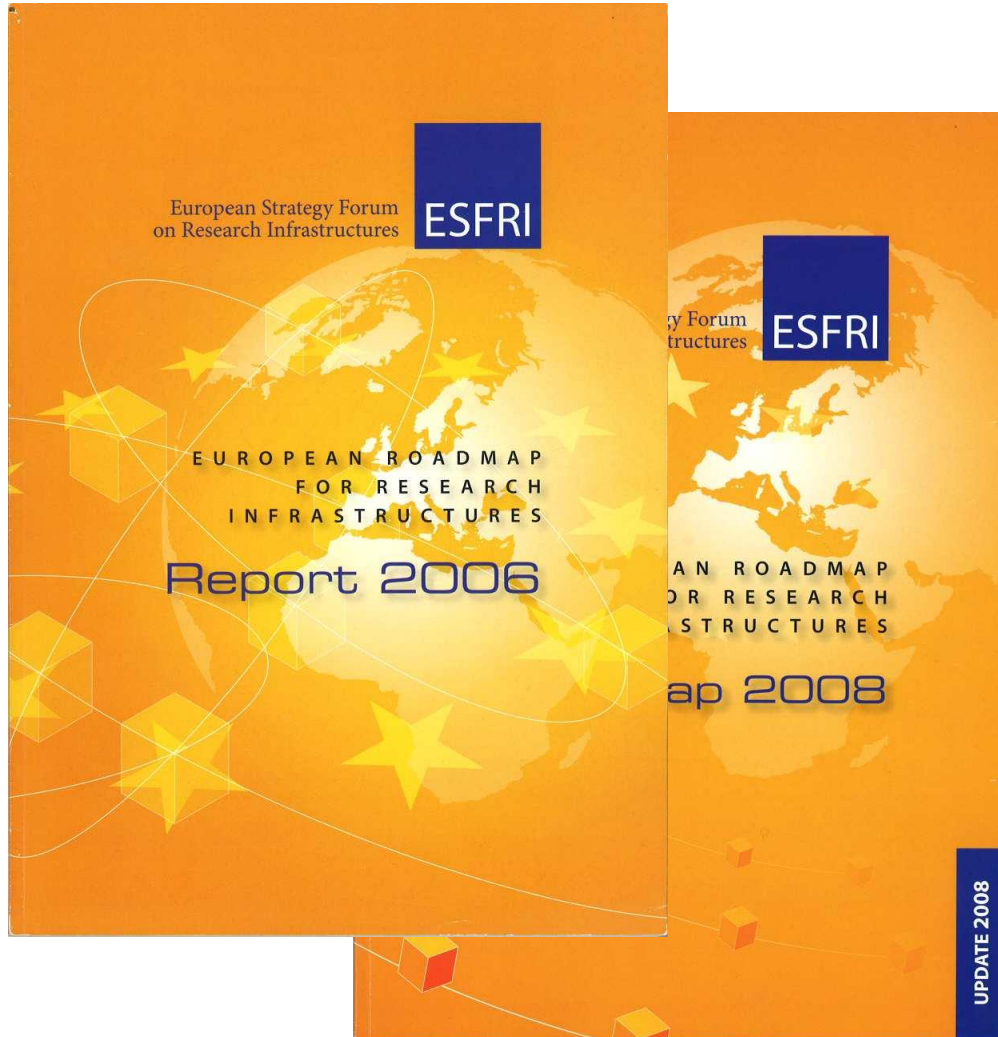


# **The lasers and the scientific equipment of ELI-ALPS: Schematics and implementation**

**Karoly Osvay**

**18th October, 2013**

# (Single-site) ELI in the ESFRI Roadmap



Physical Sciences and Engineering  
**ELI – Extreme Light Infrastructure**

The facility:  
 ELI will be an international research infrastructure open to scientists dedicated to the investigation and applications of laser matter interaction at the highest intensity level, i.e. more than 6 orders of magnitude higher than today's state of the art. ELI will comprise three branches: ultra high field science that will explore laser matter interaction up to the nonlinear QED limit including the investigation of pair creation and vacuum structure; attosecond laser science designed to conduct temporal investigation at the attosecond scale of electron dynamics in atoms, molecules, plasmas and solids; lastly, the high energy beam facility devoted to the development of dedicated beam lines of ultra short pulses of high energy radiation and particles up to 100GeV for users.

Background:  
 Laser intensities have increased by 6 orders of magnitude in the last few years. These are now so large that the laws of optics change in a fundamental way. This new optics field is called relativistic optics. Among the important by-products of this field are the generation of particle, x-ray and gamma-ray beams. The wealth of discoveries made in the relativistic regime justifies going further to the ultra-relativistic regime. One important aspect of ELI is the possibility to produce ultra-short pulses of high energy photons, electrons, protons, neutrons, muons, and neutrinos in the attosecond and possibly zeptosecond regimes on demand. Time-domain studies will allow unravelling the attosecond dynamics in atomic, molecular physics and plasma physics.

What's new? Impact foreseen?  
 ELI will be the first facility in the world dedicated to laser-matter interaction in the ultra-relativistic regime, providing unprecedented intensity levels. It will be the gateway to new regimes in physics. At the same time, it will also promote new technologies such as relativistic microelectronics with the development of compact laser-accelerators delivering >100GeV particles and photon sources. ELI will have a large societal benefit in medicine with new radiography and hadron therapy methods, in material sciences with the possibility to unravel and slow down the ageing process in a nuclear reactor and in environment by offering new ways to treat nuclear waste. The completed machine will provide laser pulses with a peak power above 200PW, a power level 200000 higher than the power of the entire European electric grid, but only for a millionth of a billionth of a second.



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**Construction costs 400M€**  
**Operation costs 50M€/year**

>Timeline  
 ELI is in its preparatory phase for 18 months, followed by two years of construction and a five-year construction period. The construction calls for three stages. The first phase will be completed in 2010, the second in 2012 and the third in 2015. The facility will operate from the fourth call.

>Estimated costs.

Preparation costs:	85 M€.
Total construction costs:	400 M€.
Operation costs:	50 M€/year.
Decommissioning costs:	30 M€.

>Website: [www.eli-laser.eu](http://www.eli-laser.eu)

UPDATE 2008

# Preparatory Phase: 2007-2010

**Coordinator: Gerard Mourou**

**D.coordinator: Georg Korn (MPQ)**

**D. project manager: Karoly Osvay**

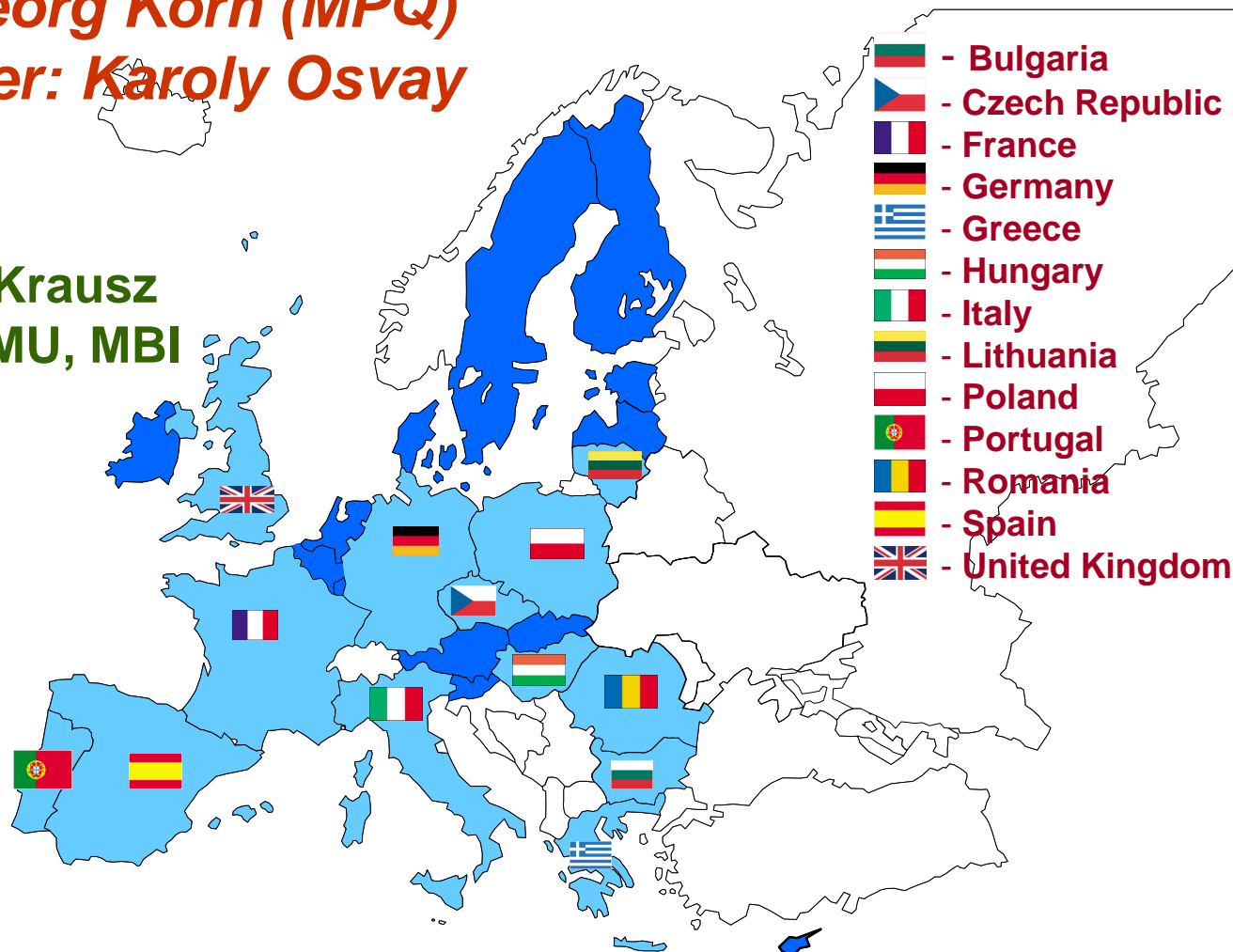
**EU support: 6M€**

**Germany:**

**Coordinator: Ferenc Krausz**

**Participants: MPQ, LMU, MBI**

**EU support: 880k€**



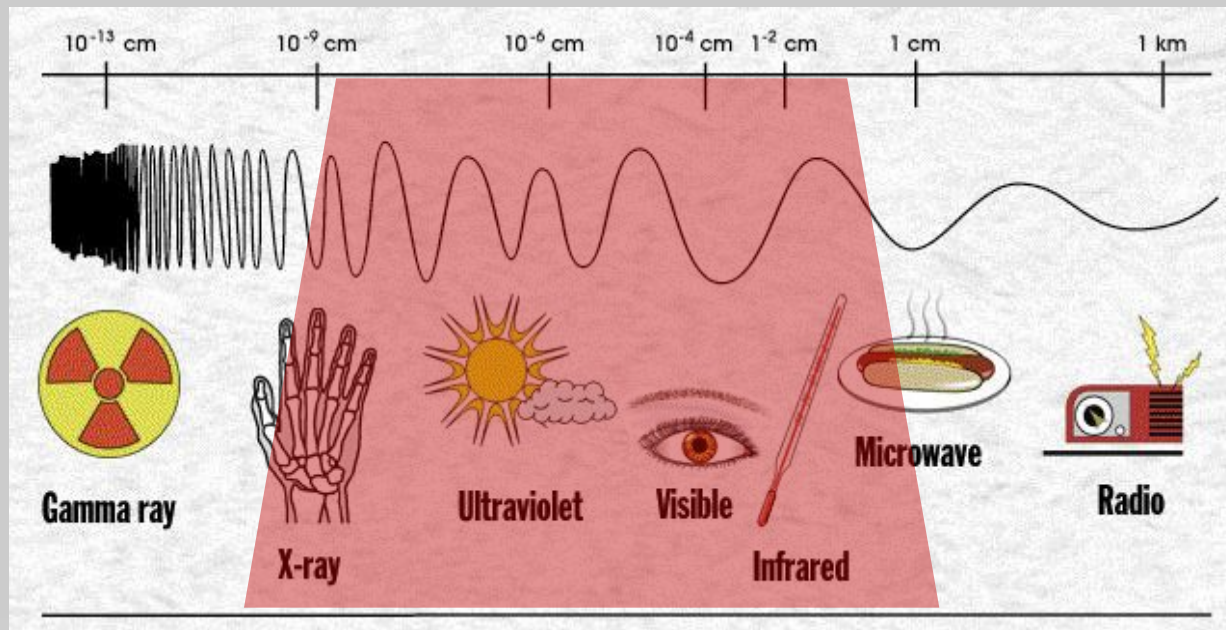


# Major missions of ELI-ALPS

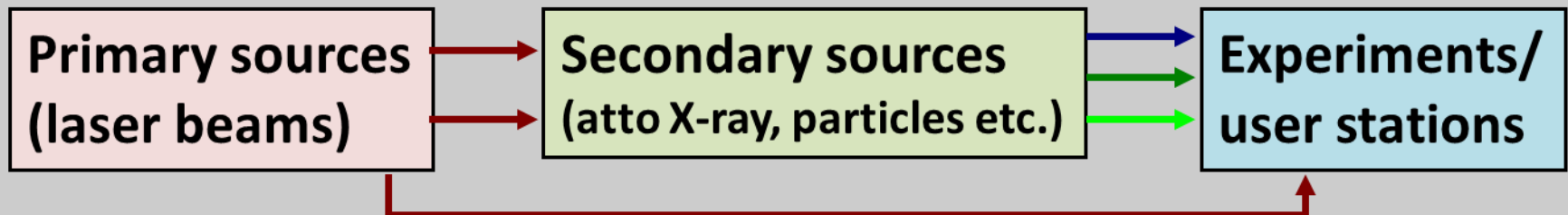
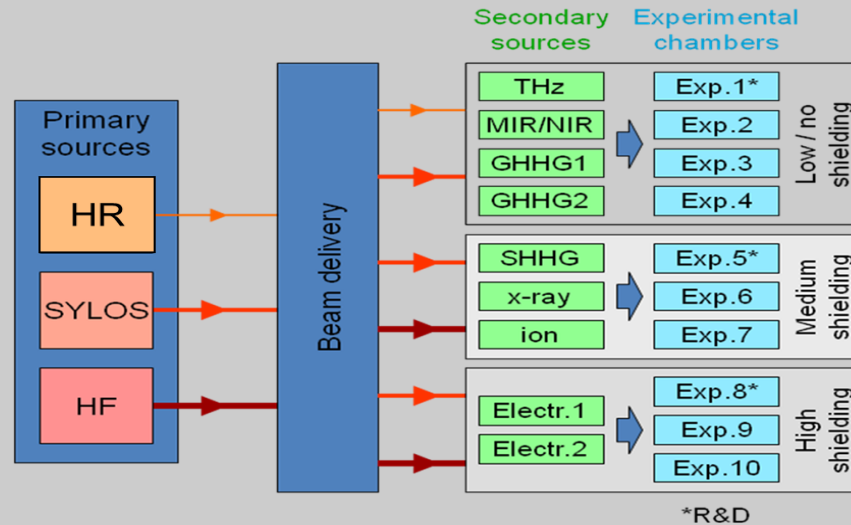
- 1) To generate X-UV and X-ray fs and atto pulses, for temporal investigation at the attosecond scale of electron dynamics in atoms, molecules, plasmas and solids.  
**ATTOSECOND Beamline & User Facility**
- 2) To contribute to the technological development towards 200PW  
**HIGH INTENSITY beamline**

# ELI-ALPS Light sources

The **shortest** pulse durations at the **widest** spectral range ...  
... at the **highest** repetition rate.



# Schematics of ELI-ALPS



# Strategy of Implementation

**Specs and basic designs**

**Minimize "on site" developments during Phase 1**

**Make R&D contracts to place of expertise**  
(RIs and universities)

**Make industrial contracts**

*Custom made systems at the cutting edge*

**Solve HR problems**

(Spread graduates and postdocs to participate in key developments & products.)

# Collaboration with industry

## Major areas

Lasers, optics, mechatronics, x-ray, THz sources, particles, diagnostics, vacuum tech, sci IT, control-command, safety)

## Clusters

- In Hungary: platform for laser technology  
platform for ELI-related training
- In Europe: direct & indirect contacts

## IP issues

- No direct IP acquisition.
- Support targeted R&D - create IP.
- Legal issues: balance between the needs of ELI-ALPS, interest of the industry, and the EU / national laws on public money.

# Design of ELI-ALPS I

## ELI-PP

Mission  
Basic scientific directions

## ELI-ALPS

July 2010 – Dec 2010  
Feasibility study for the Scientific Case of ELI-ALPS

March 2011 – June 2011  
Planned research Activities of ELI-ALPS



**Feasibility study of ELI-ALPS – part of project application to the EU.  
Completed: June, 2012**

# Design of ELI-ALPS II

**Conceptual Design Report**  
by the international community

*Research institutes and Universities*

**Part I (sources, sci. IT) is completed**  
**SAC approved**

**Part II (labs, workshops)**  
**is due Nov 2013**

**Technical design (TDR)**  
by the contractors

*Mainly industrial partners*

**Part I is due by Q3 2014**

# Conceptual Design Report

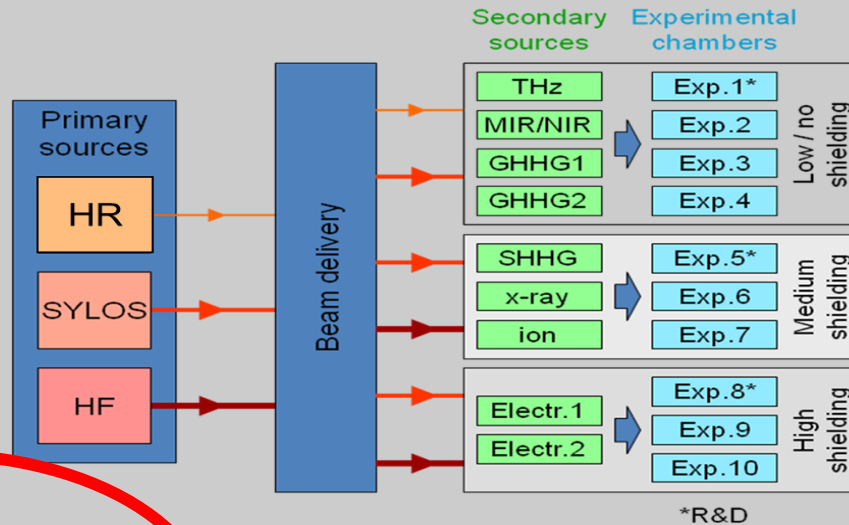
**Status: primary and secondary sources completed  
measurements completed**

## CO-AUTHORS:

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**Under completion: preparation, diagnostics labs, workshop, facility issues**

# Schematics of ELI-ALPS

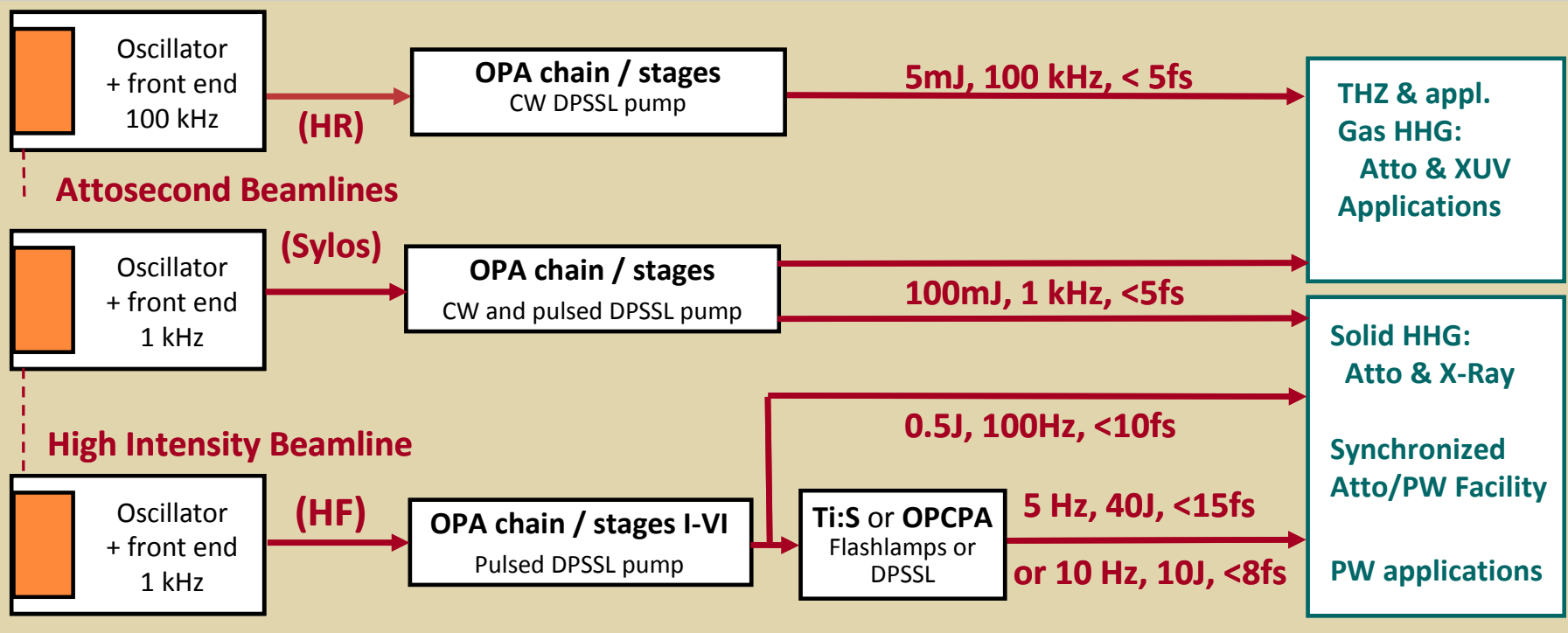


**Primary sources  
(laser beams)**

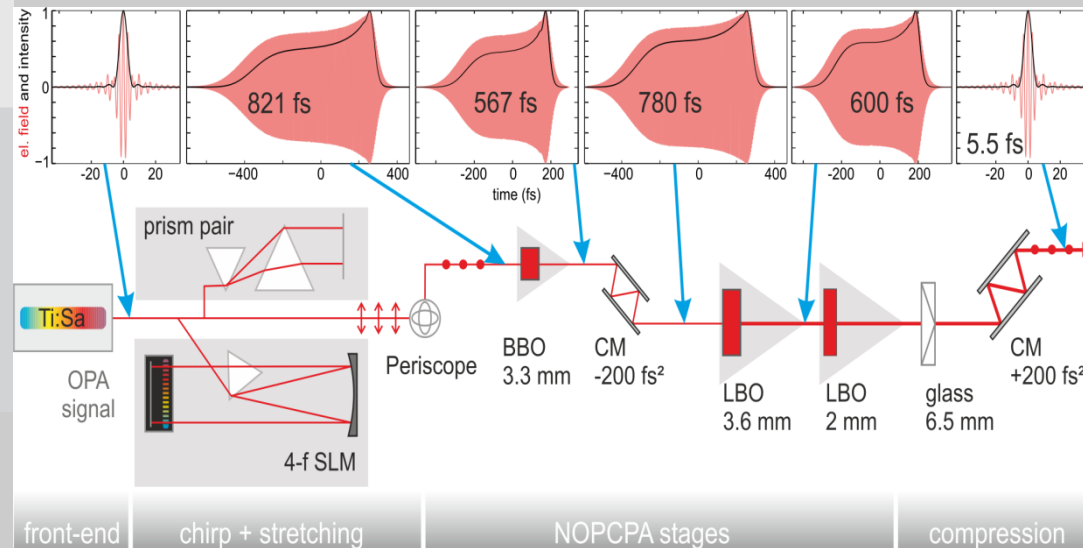
**Secondary sources  
(atto X-ray, particles etc.)**

**Experiments/  
user stations**

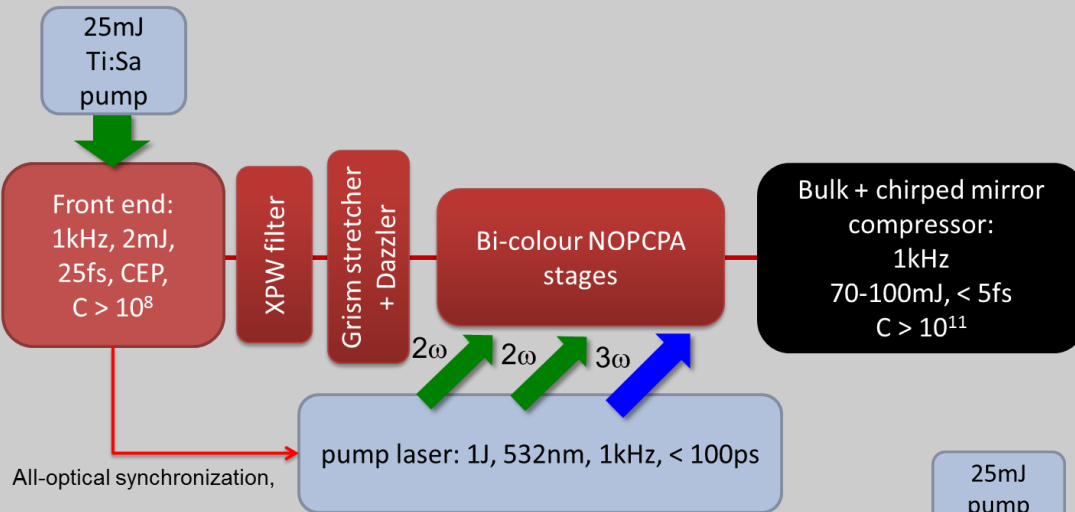
# Schematics of the major lasers



**NEW SZÉCHENYI PLAN**

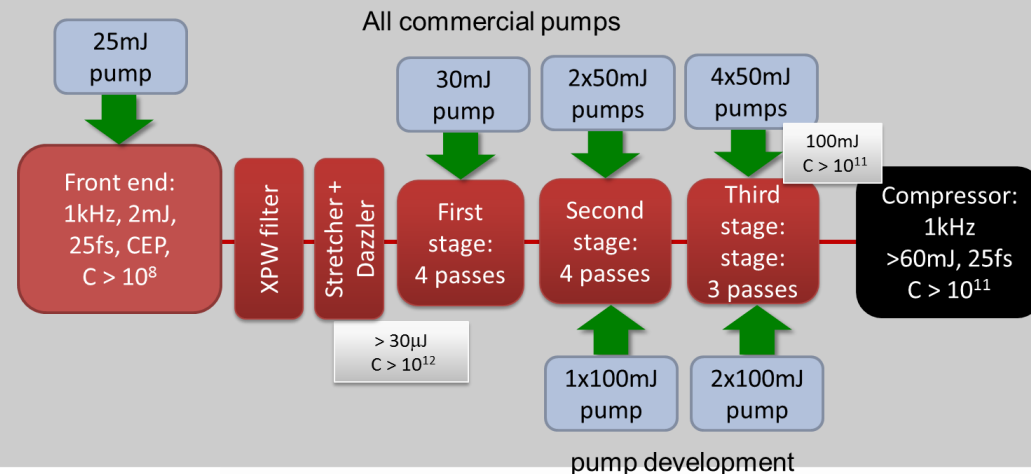


# Conceptual design of the SYLOS laser

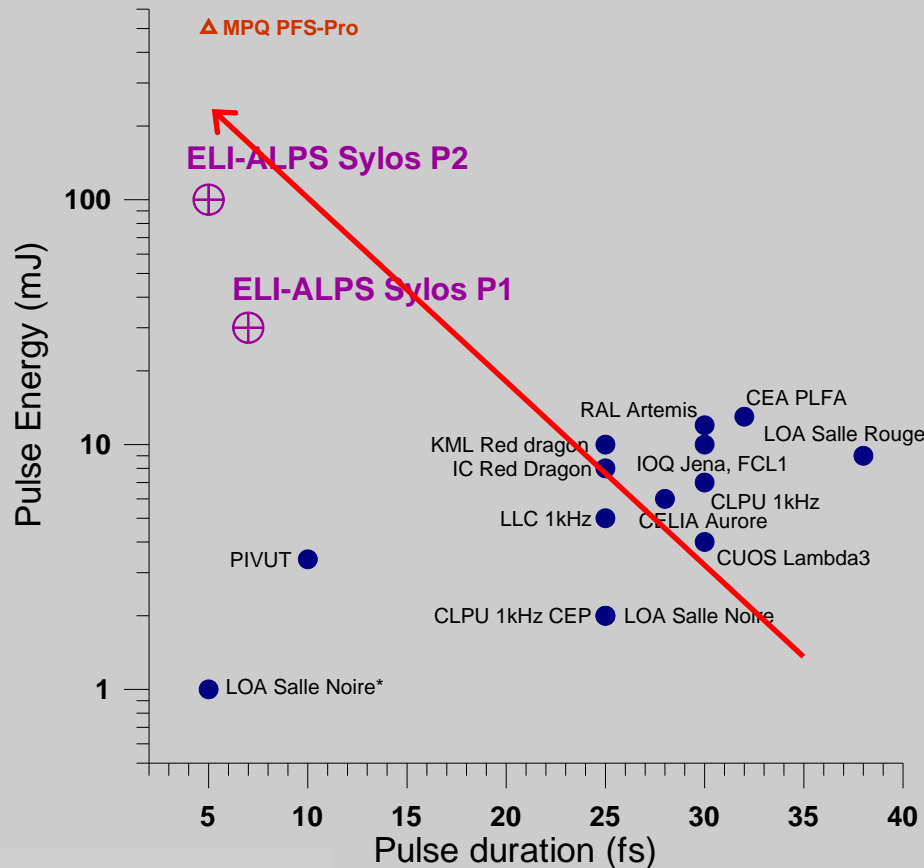


*By LOA, Palaiseau*

*By UFI, Garching*



# Benchmarking the Sylos (kHz) laser



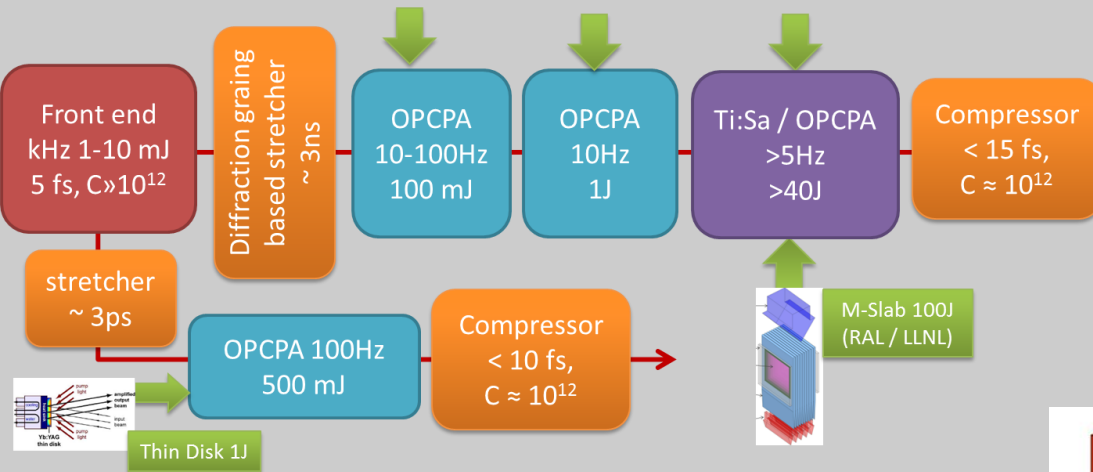
## Challenges for phase I

- pump source
- CEP stabilisation
- Optics
- Dispersion management
- Thermal issues

## Challenges for phase II

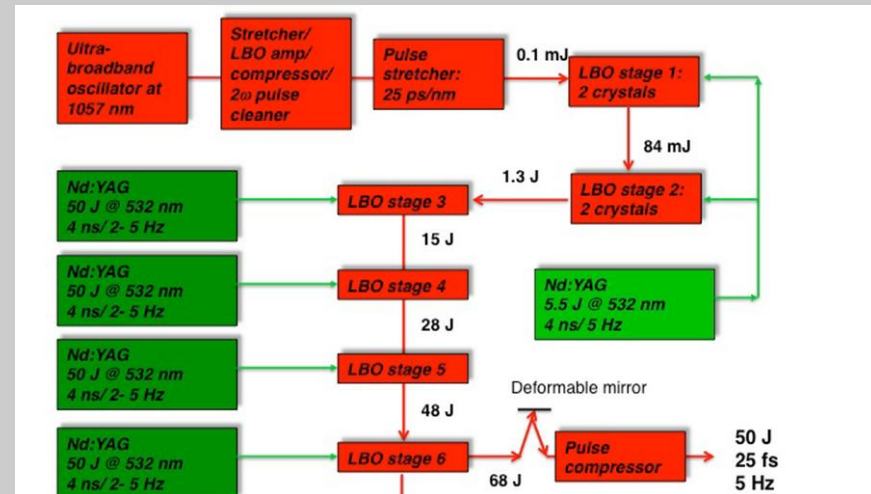
- **pump source**
- CEP stabilization
- **Optics**
- **Dispersion management**
- **OPA stability**  
(command / control)

# Conceptual design of the HF laser

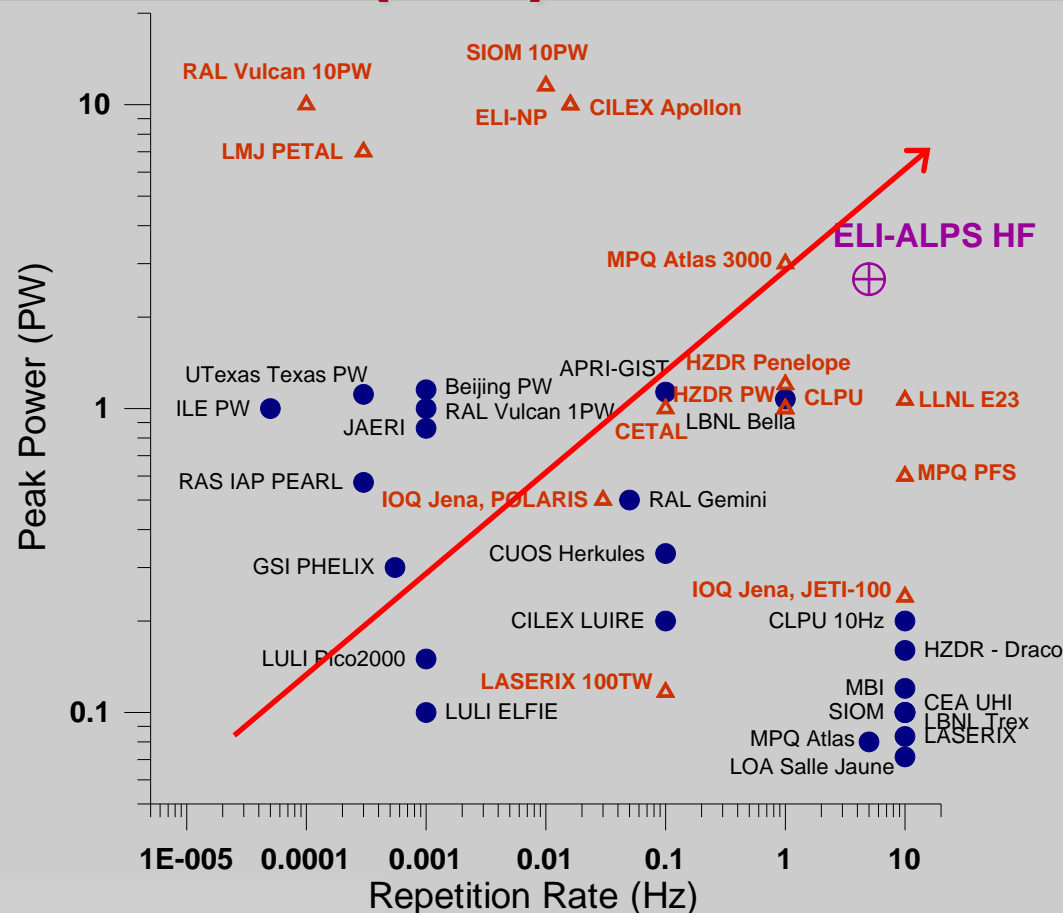


*By LLNL, LOA, MBI, RAL*

*By Uni Texas*



# Benchmarking the HF (PW) laser – Ti:S duty amp



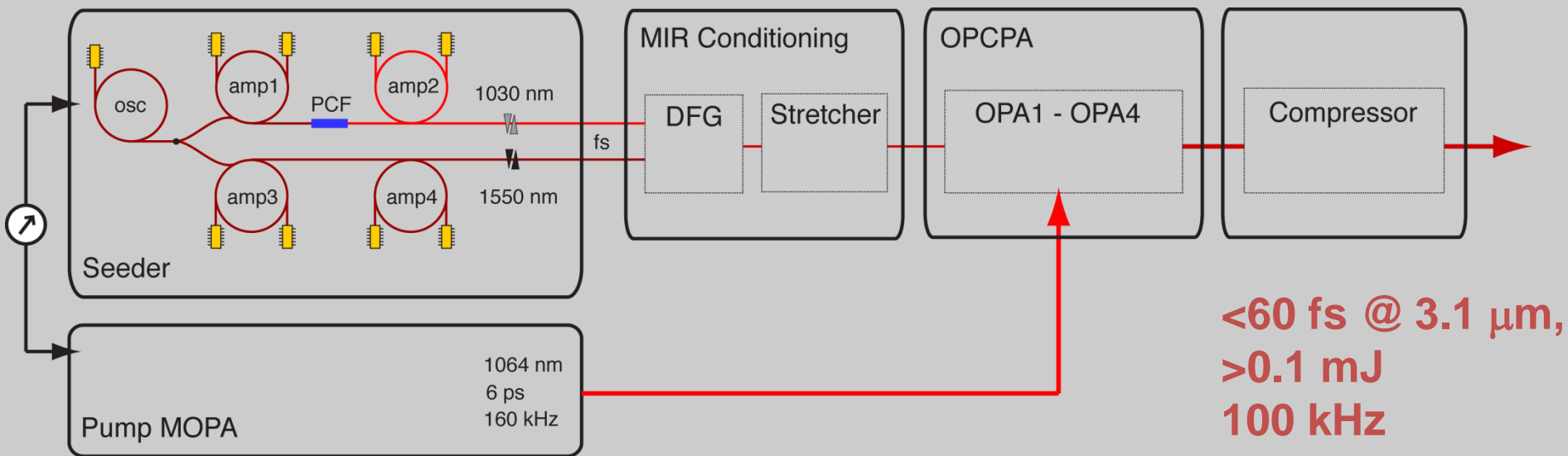
## Challenges for phase I

- Optics
- Dispersion management

## Challenges for phase II

- 100 Hz pump laser
- Dispersion management

# MIR laser



*By ICFO, Barcelona*

# Implementation of the lasers I

Via R&D projects

**ALPS HR laser**

100kHz, >4TW, <20fs, VIS-NIR, CEP

**ALPS MIR laser**

100kHz, 0,1mJ, <6 cycle, MIR

Submission deadline of R&D proposals is 7th November, 2013.

Q1 2016

Delivery

Q2 2015

# Implementation of the lasers II

## Public procurement – Q3 2013

**ALPS Sylos 1 laser**

1kHz, >4TW, <20fs, VIS-NIR, CEP

**ALPS HF PW laser**

≤5Hz, >2PW, <20fs, NIR

**Q3 2015**

**Delivery**

**Q1 2016**

**Laser R&D projects for elimination of technological bottlenecks**

## Public procurement – Q4 2014

**ALPS Sylos 2 laser**

1kHz, >20TW, 5fs, VIS-NIR, CEP

**ALPS HF 100 laser**

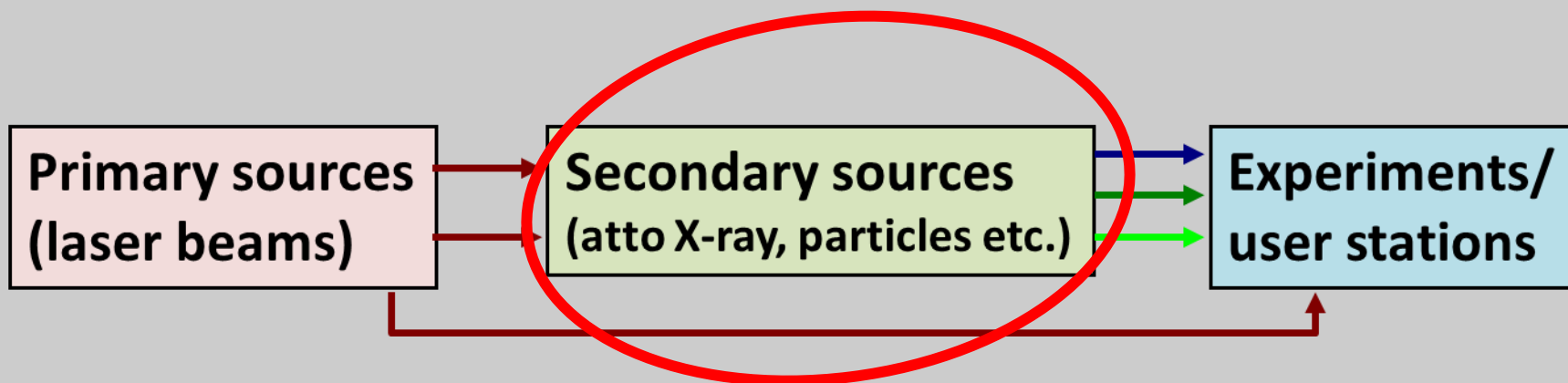
100Hz, >40TW, <12fs, NIR

**Q4 2016**

**Delivery**

**Q3 2016**

## Schematics of ELI-ALPS



**Prof Charalambidis' talk**

# Implementation of the secondary sources

Via R&D projects – Q4 2013

TDR of the beamlines  
TDR of the target areas

Delivery I: Q2 2014  
Delivery II: Q1 2015

Public procurements – Q2 2014

Hardware for the beamlines  
Hardware for the target areas

Delivery I: Q2 2015  
Delivery II: Q1 2016  
**By the same groups / contractors  
+ ELI-ALPS workforces**

Via R&D projects – Q4 2013

Implementation of the beamlines  
Implementation of the target areas

Delivery I: Q1 2016  
Delivery II: Q4 2017

# Location of ELI-ALPS and a planned Scientific Park

**ELI-ALPS**

**Planned  
Science Park**



# LAYOUT – Scientific areas

- Laser hall: 1350 m<sup>2</sup>
- Target areas: 2100 m<sup>2</sup>
- Optics labs: 330 m<sup>2</sup>
- Biology/chemistry/medical labs: 320 m<sup>2</sup>
- Diagnostics labs: 110 m<sup>2</sup>
- Mechanical workshops: 530 m<sup>2</sup>
- Electric / IT workshop: 200 m<sup>2</sup>



# Scientific Management – Preparation and CDR (2012-13)



SZÉCHENYI PLAN

Head: **K. Osvay**

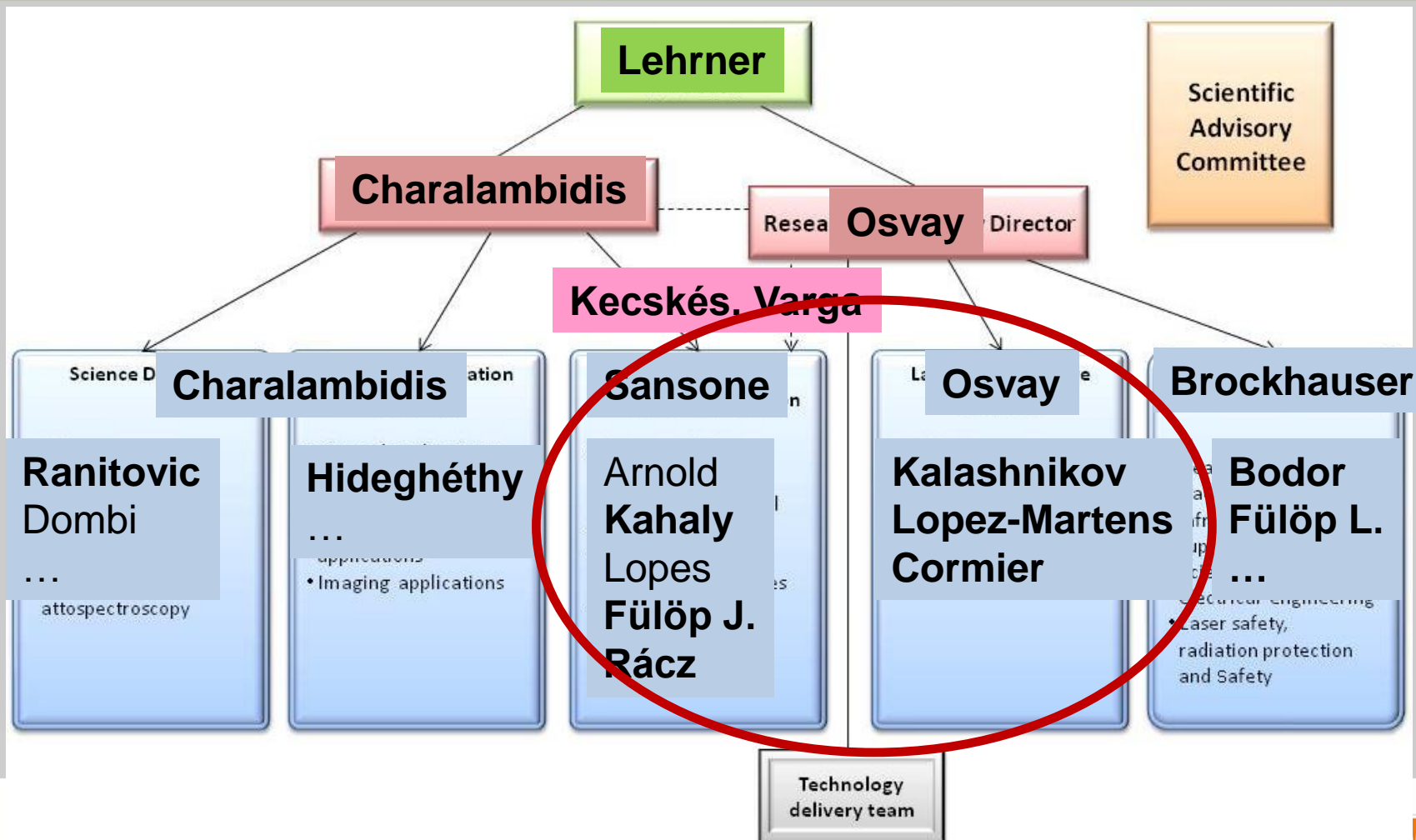
Assistant: *Aniko Varga*

Lasers: *M. Kalashnikov (MBI, Berlin)*  
*R. Lopez-Martens (LOA, Palaiseau)*  
**K. Osvay (ELI-Hu, Univ. Szeged, Szeged)**

Secondary sources: **D. Charalambidis (FORTH, Greece)**  
*Zs. Diveki (Imperial College, London)*  
*P. Dombi (Wigner RI, Budapest & MPQ, Garching)*  
*J. A. Fülöp (Univ. Pécs, Pécs)*  
*R. Lopez-Martens (LOA, Palaiseau)*  
*E. Racz (Obuda Univ., Budapest)*

IT and Radio protection: *L. J. Fülöp, T. Mosoni*  
*K. Bodor, I. Barna, P. Zagyvai*

# Sci Management – Current status (Sept 2013)



# Region of ELI-ALPS:

## Szeged

163 000 inhabitants  
30 000 students (10% foreigners)  
2600 researchers at  
- Uni Szeged  
- Biological Research Center,  
- Inst. for Cereal Research

Confucius Institute in Szeged

**University of Szeged:  
World ranking: in the top 500**

**The highest ranked Uni from underdeveloped regions.**



# Thanks for your attention!



National Development Agency  
[www.ujszechenyiterv.gov.hu](http://www.ujszechenyiterv.gov.hu)  
06 40 638 638



**HUNGARY'S RENEWAL**



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