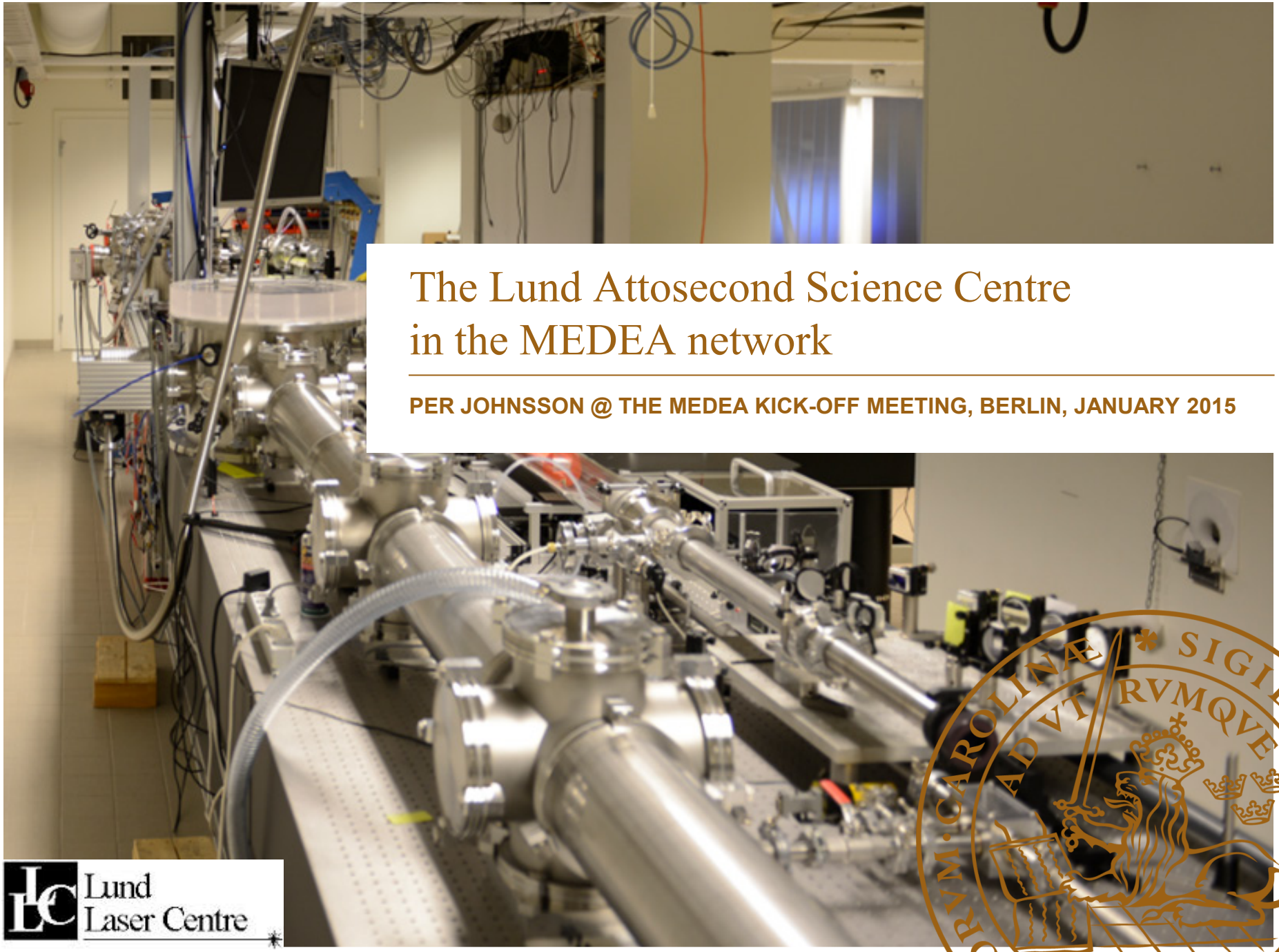


# The Lund Attosecond Science Centre in the MEDEA network

PER JOHNSSON @ THE MEDEA KICK-OFF MEETING, BERLIN, JANUARY 2015

Lund Laser Centre

# Lund University

- Founded in 1666
- 47 700 students (individuals)
- 7 500 employees
  - 840 professors
  - 4 350 lecturers/researchers and doctoral students
- Turnover EUR 850 million (USD 1 180 million)
  - 1/3 education, 2/3 research

# Faculties

- Medicine
- Engineering
- Science
- Social Sciences
- Humanities and Theology
- Economics and Management
- Law
- Fine and Performing Arts (Music, Theatre, Fine Art)

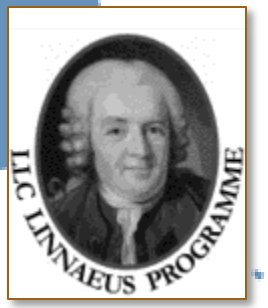
# The Lund Laser Centre (LLC)

- An organisation for laser, optics and spectroscopy research

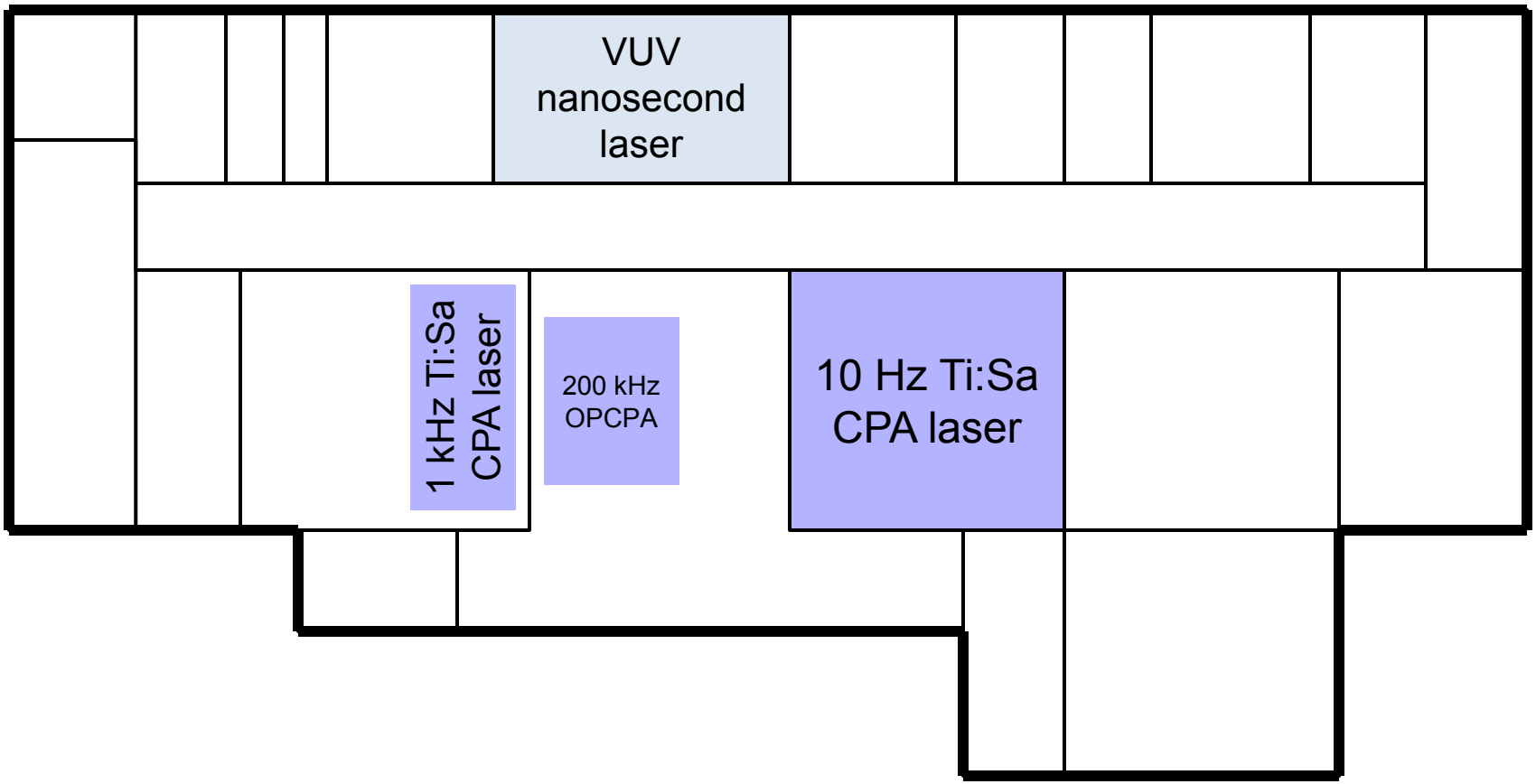
**Accessible laboratories**
- High-power laser laboratories
- Atomic and molecular laser spectroscopy laboratories
- Coherent transient spectroscopy laboratory
- Femtochemistry laboratories
- Combustion diagnostics laboratories
- Mobile systems for coherent anti-Stokes Raman (CARS) measurements and laser-induced fluorescence.
- Mobile laser radar system
- Biomedical laser laboratories

***Members***
- Atomic Physics
- Chemical Physics
- Combustion Physics
- Atomic Astrophysics

***Facilities***
- High-Power Laser Facility
- MAX IV
- Combustion Centre
- Medical Laser Centre




# The High-Power Laser Facility



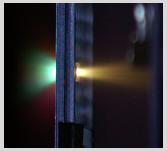
# Ultra-high Intensity Laser Physics

Olle Lundh

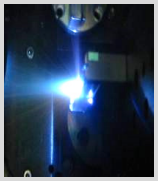
Claes-Göran Wahlström

**40 TW pulses @ 10 Hz**

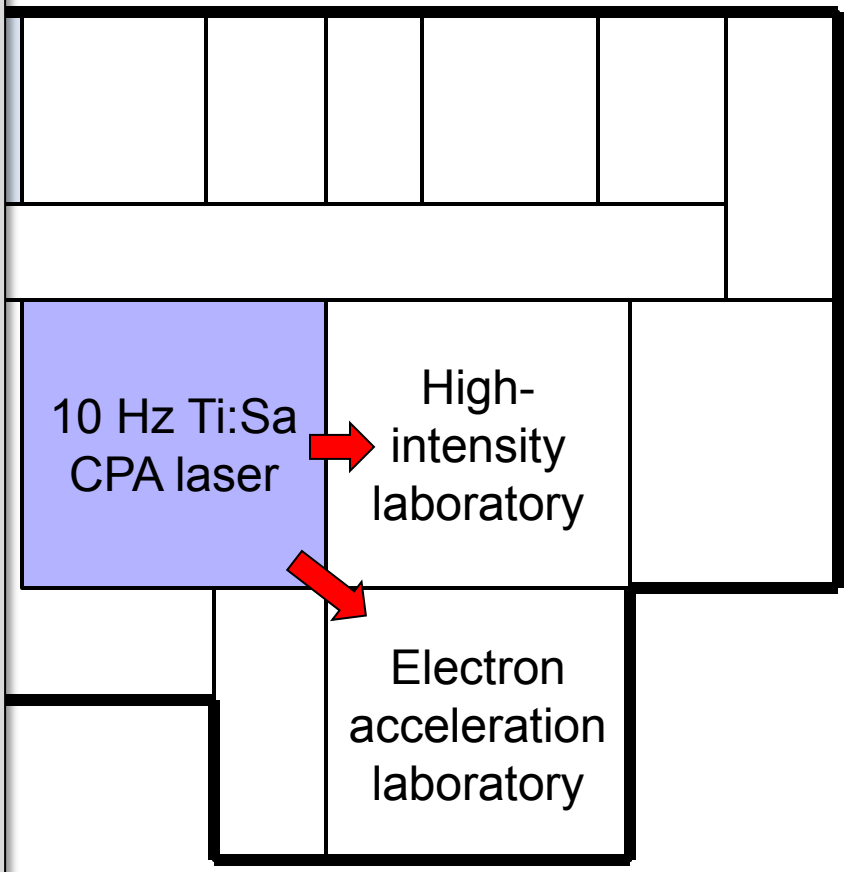
200 MeV electrons



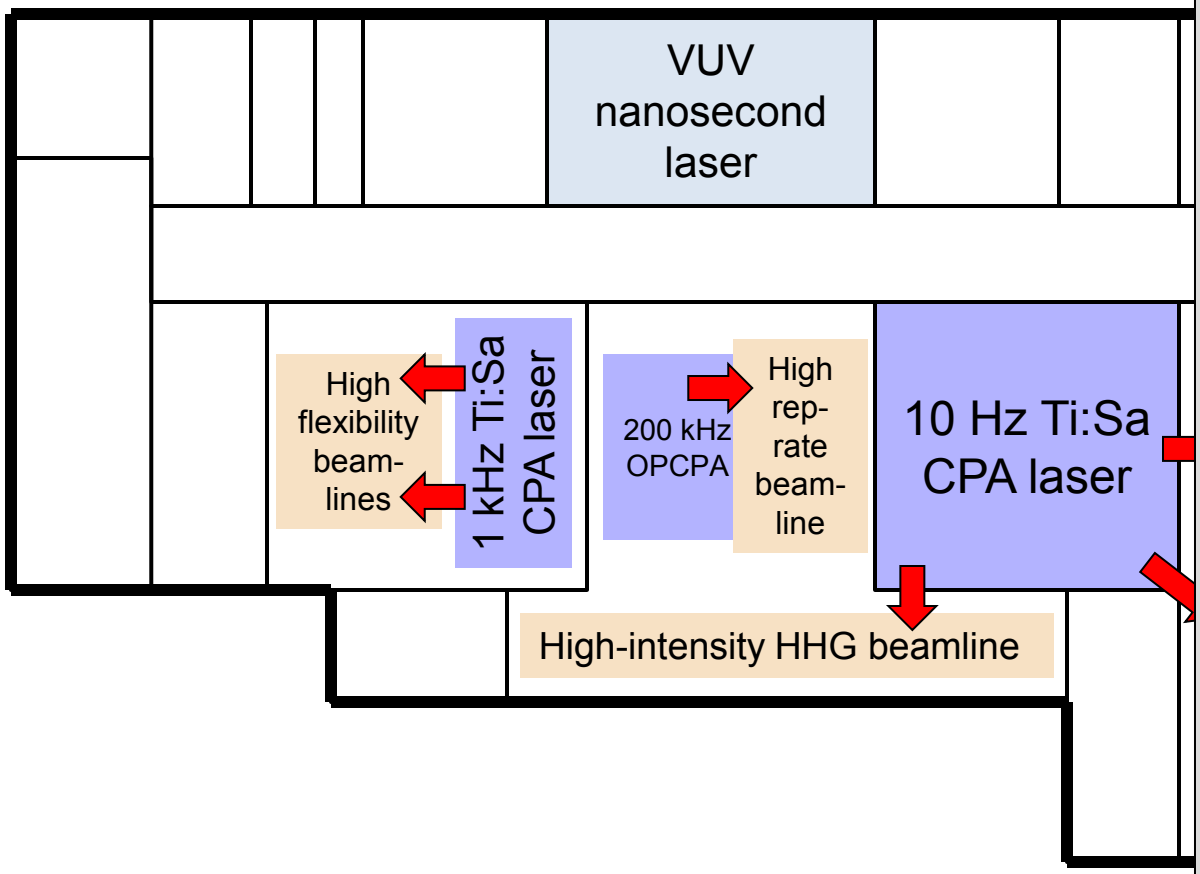
10 MeV protons



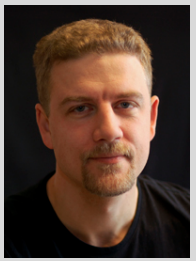
18.9 nm X-rays
(Betatron radiation)



# The Lund Attosecond Science Centre




Anne L'Huillier



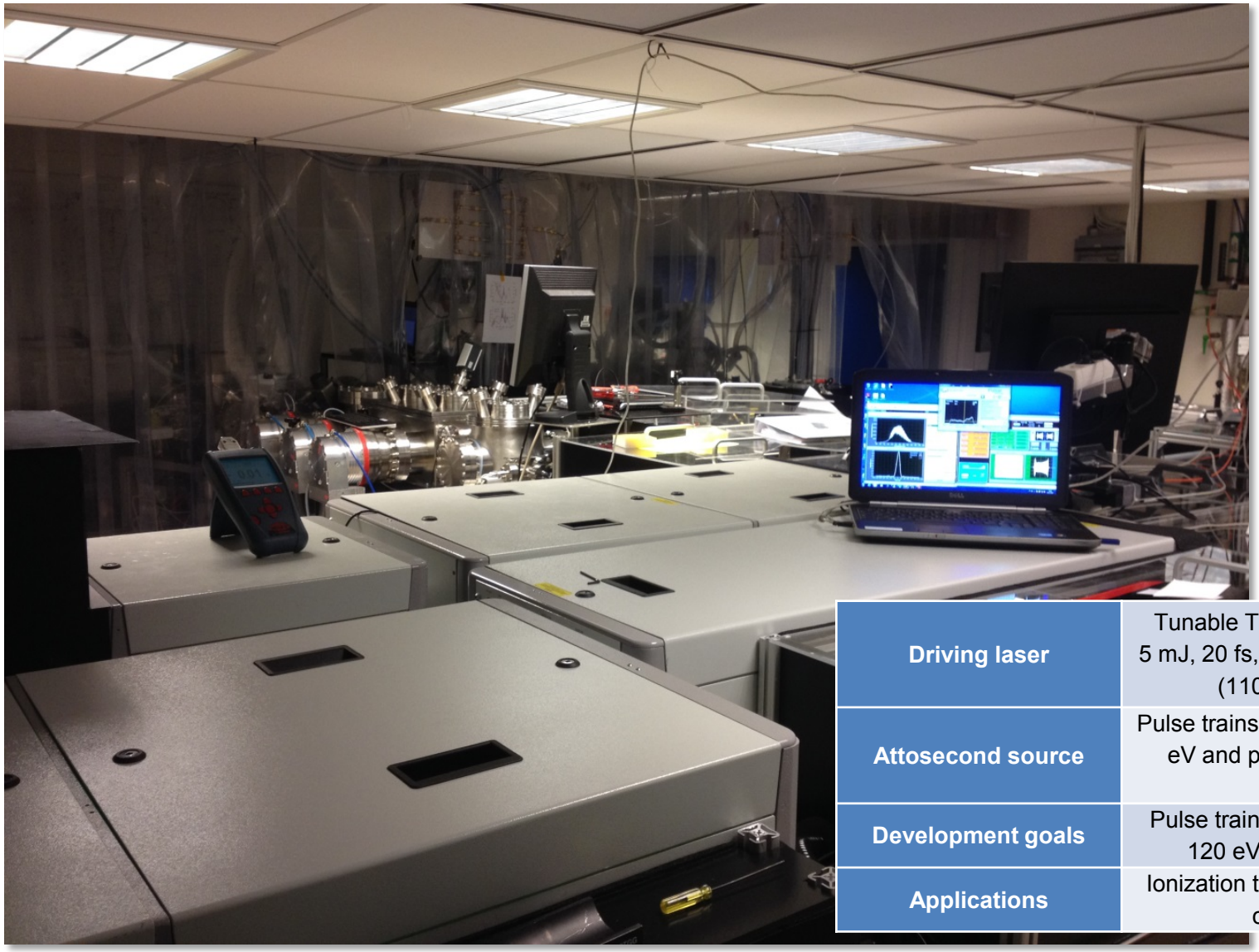
Johan Mauritsson

Per Johnsson

Mathieu Gisselbrecht

Cord Arnold

# The high flexibility beamlines

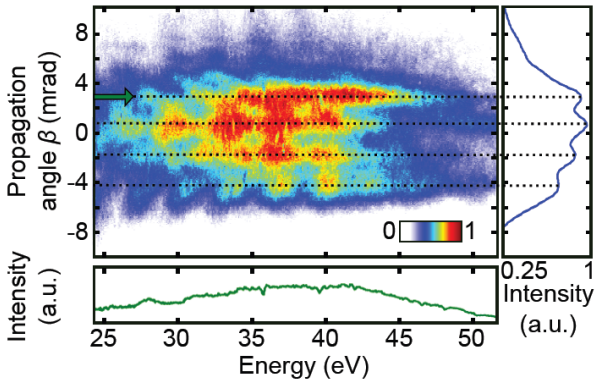


| | |
|---|---|
| **Driving laser** | Tunable Ti-Saph CPA, 770-830 nm, 5 mJ, 20 fs, 1 kHz (CEP-stable) + OPA (1100-1800 nm, <1 mJ) |
| **Attosecond source** | Pulse trains and single pulses @ 17-50 eV and pulse trains @ 50-150 eV (OPA) |
| **Development goals** | Pulse trains and single pulses @ 70-120 eV and 50-150 eV (OPA) |
| **Applications** | Ionization timing, electron correlation, charge migration |

# The high flexibility beamlines

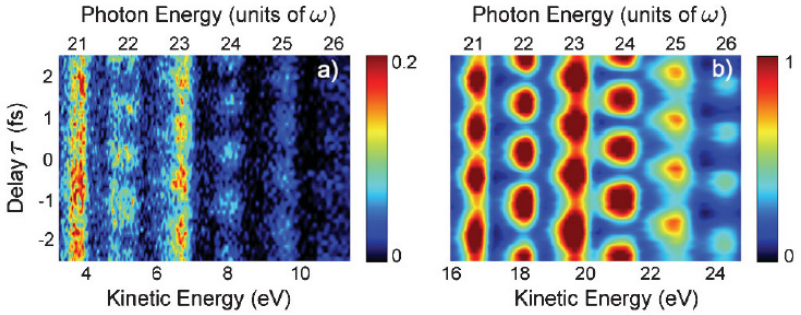
## Noncollinear optical gating

M. Louisy, *et al. manuscript in preparation*



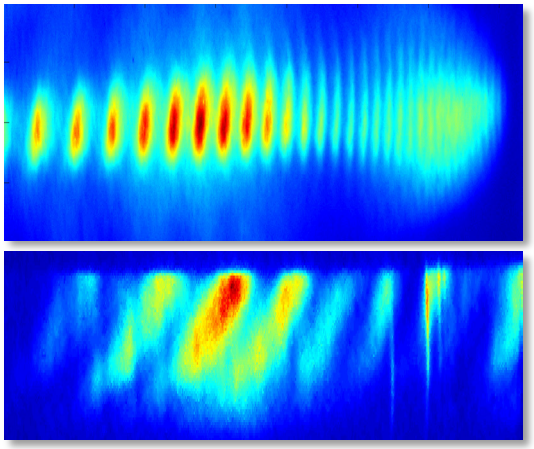

## Ionization time delays

K. Klünder, *et al.*, *Phys. Rev. Lett.* **106**, 143002 (2011)



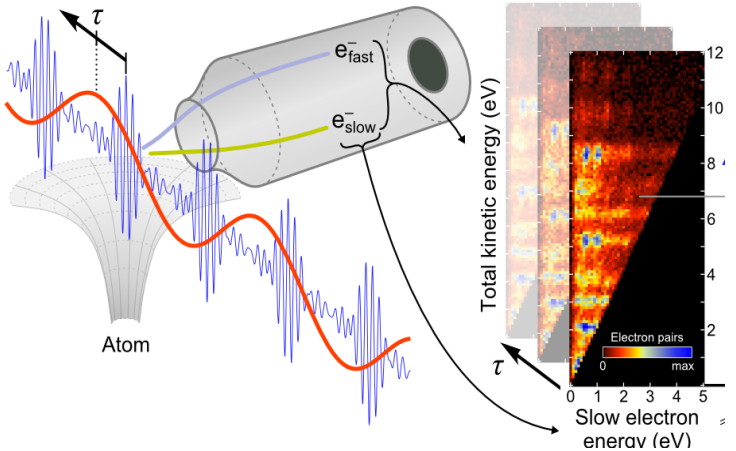

## Transient absorption measurements

S. Bengtsson & E. Witting-Larsen, *work in progress*

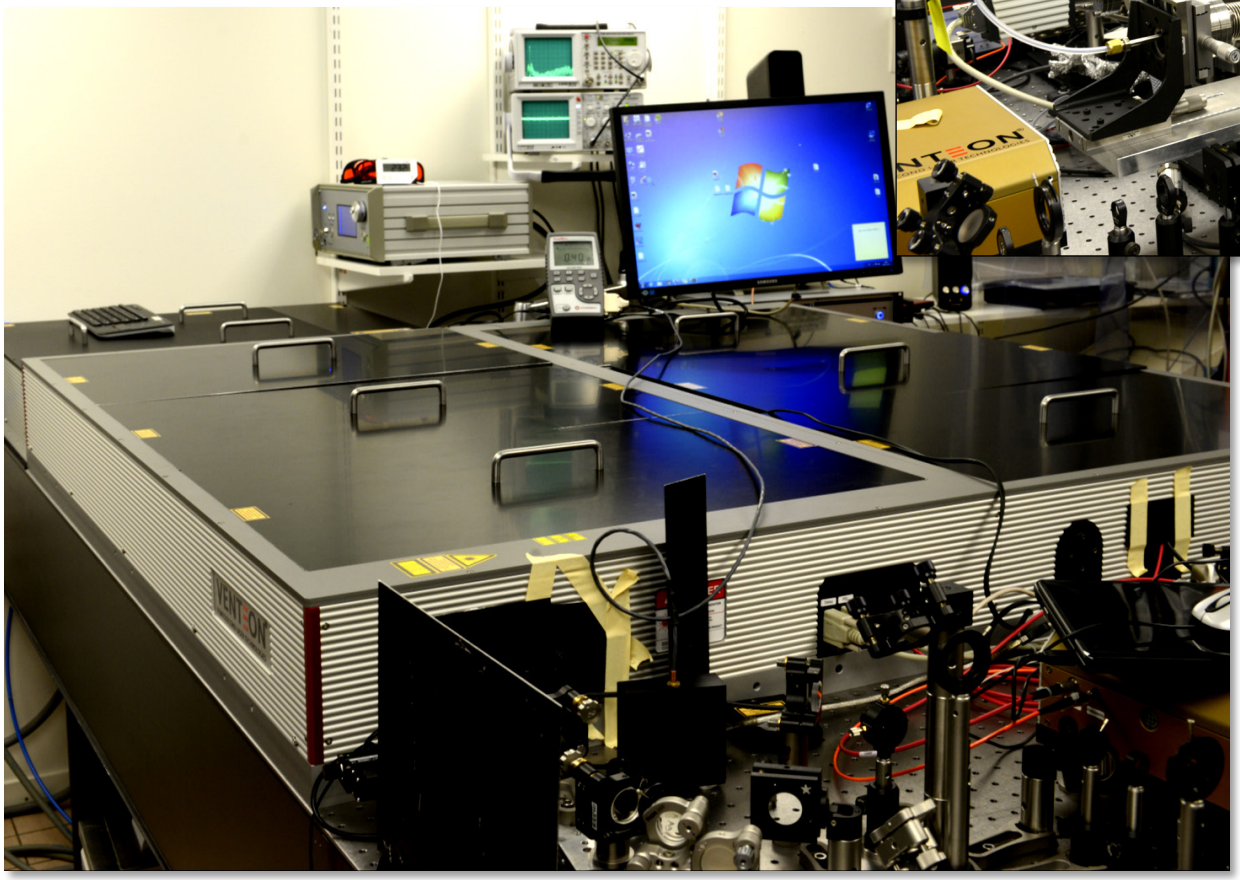


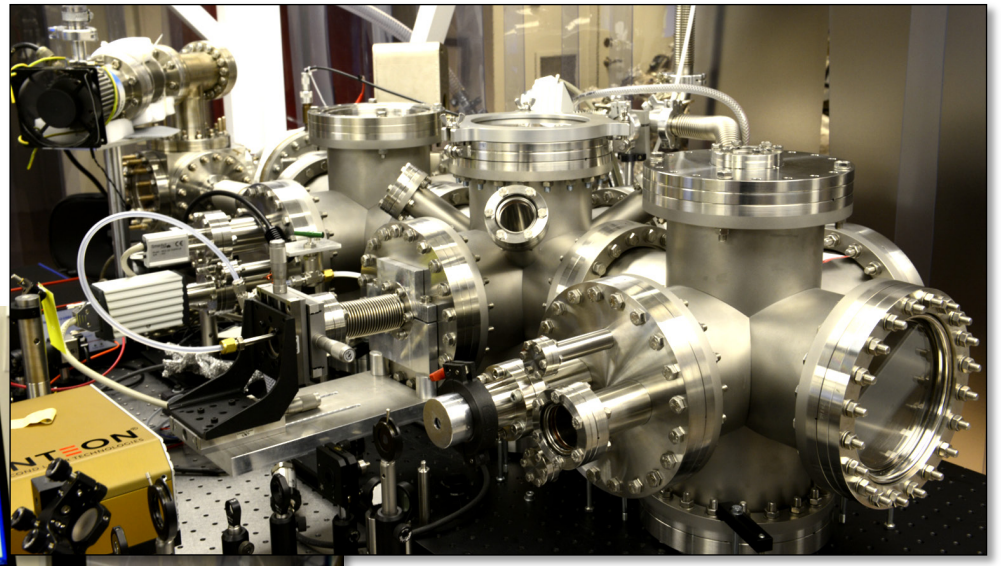
## Double ionization

E. P. Månsson, *et al.*, *Nature Phys.*, **10**, 207 (2014)



# The high repetition rate beamline



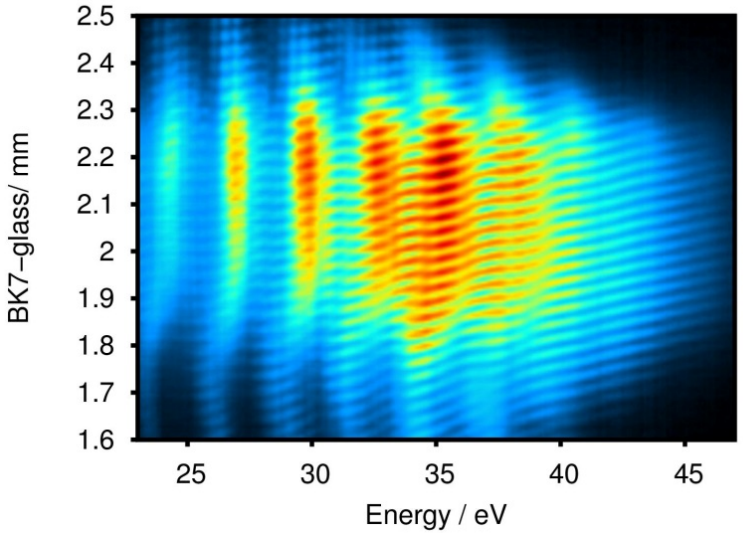


| | |
|---|---|
| **Driving laser** | OPCPA, 850 nm, 10 μJ, <7 fs, 200 kHz, CEP-stable |
| **Attosecond source:** | Pulse trains (2-4 pulses) @ 17-50 eV |
| **Development goals** | Single attosecond pulses at high-repetition rate |
| **Applications** | Time-resolved spectroscopy, electron correlations |

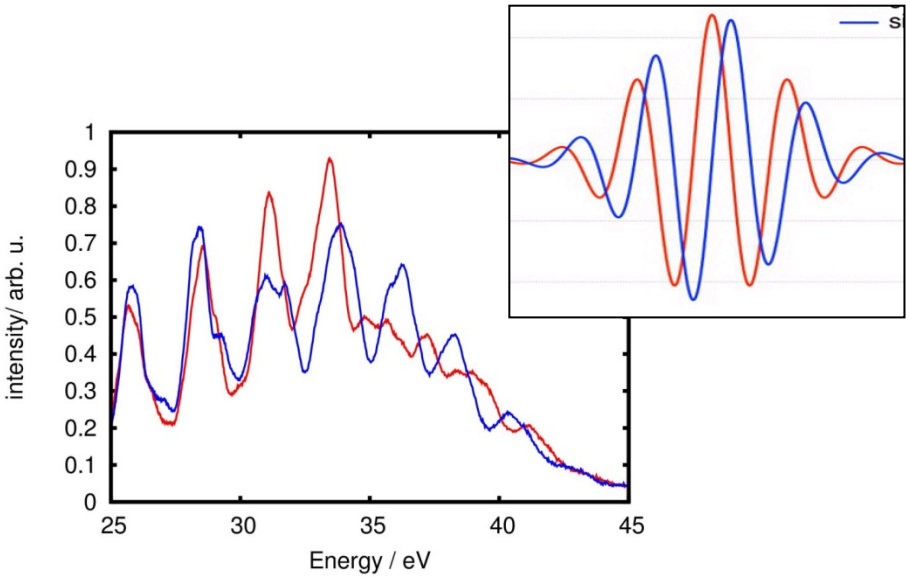
# The high repetition rate beamline

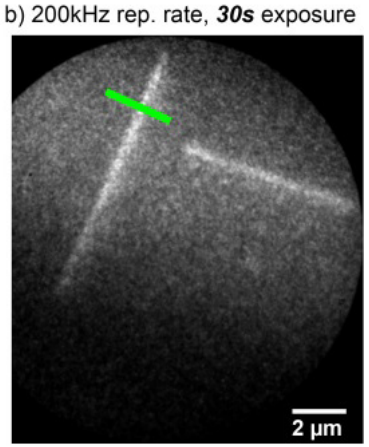
## CEP-dependent HHG

P. Rudawski, *et al. manuscript in preparation*




*Collaboration with Venteon & Univ. Hannover*

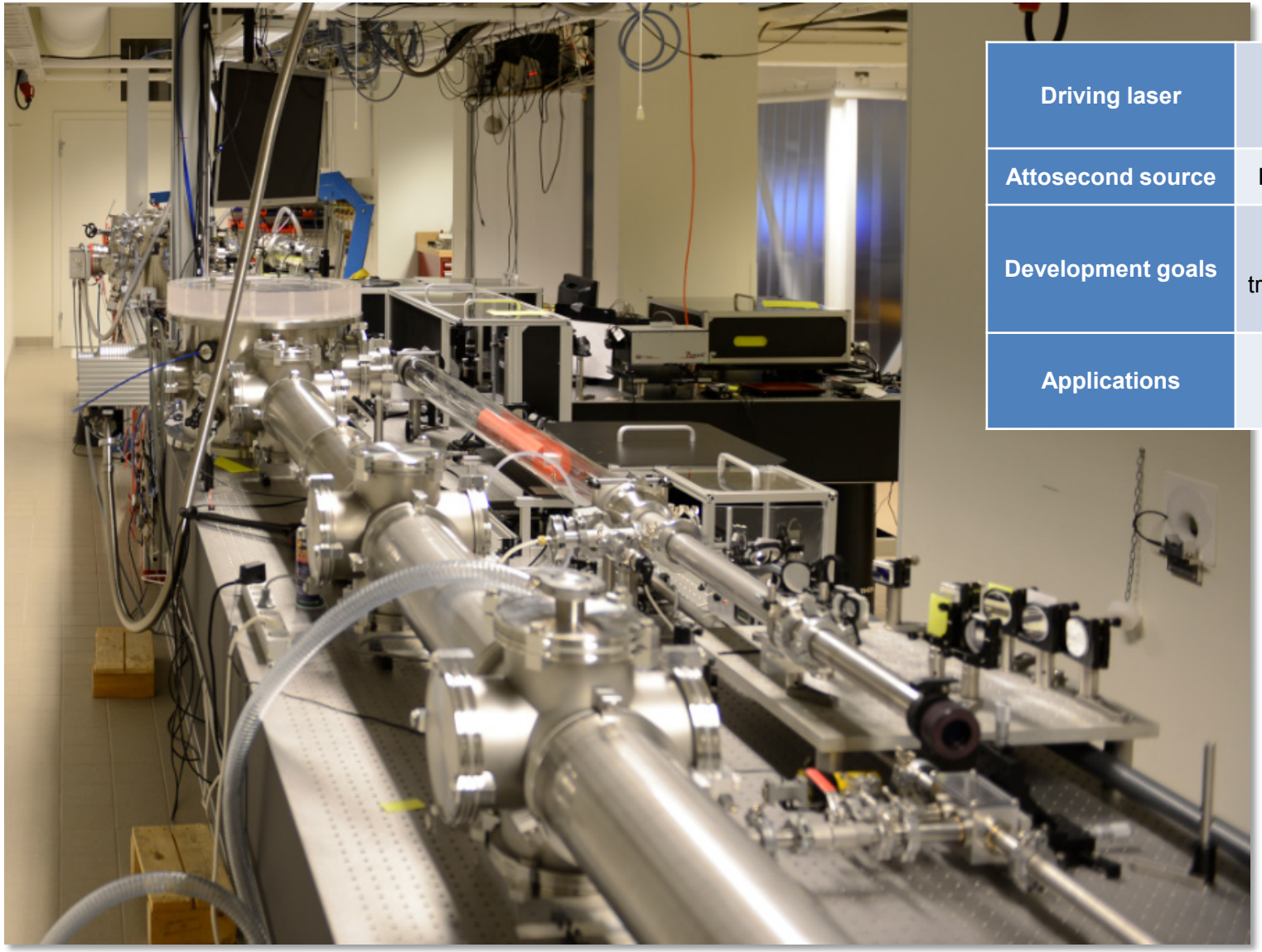



## First PEEM measurements

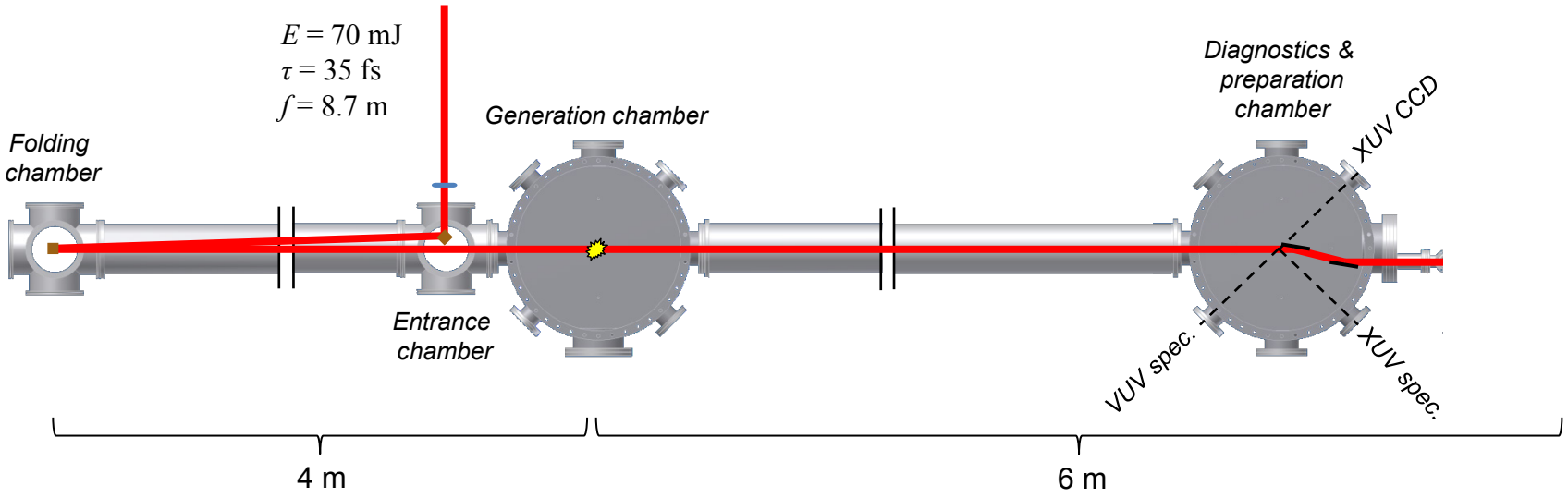
Courtesy of Anders Mikkelsen

# The high-intensity HHG beamline



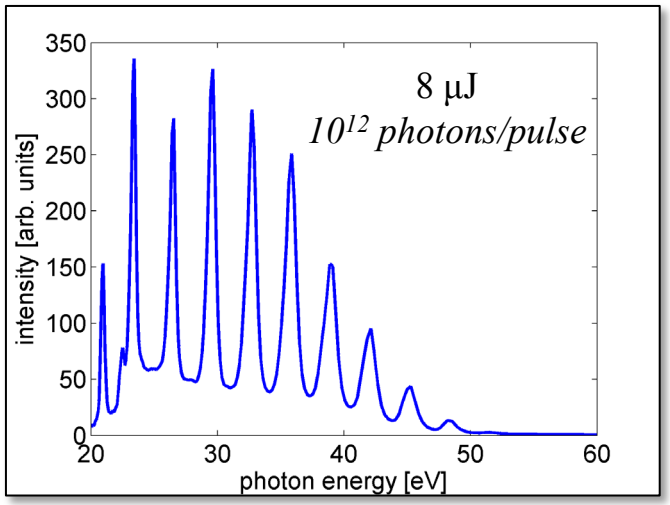
| | |
|---|---|
| **Driving laser** | Ti:Saph CPA, 800 nm, 100 mJ, 35 fs, 10 Hz |
| **Attosecond source** | Pulse trains @ 17-95 eV |
| **Development goals** | Very energetic single attosecond pulses and trains for XUV-XUV pump-probe |
| **Applications** | Multi-photon processes, Charge migration, coherent imaging |

# The high-intensity HHG beamline



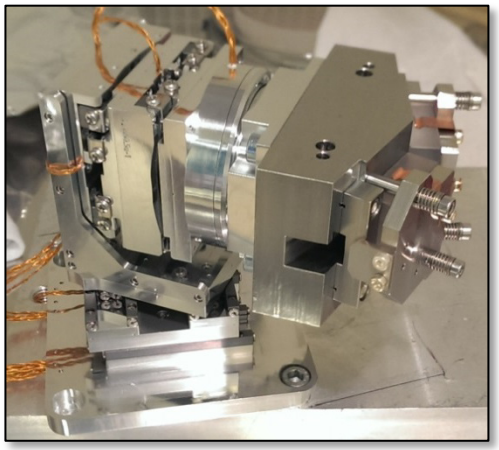

## HHG in argon

B. Manschwetus, *et al. manuscript in preparation*



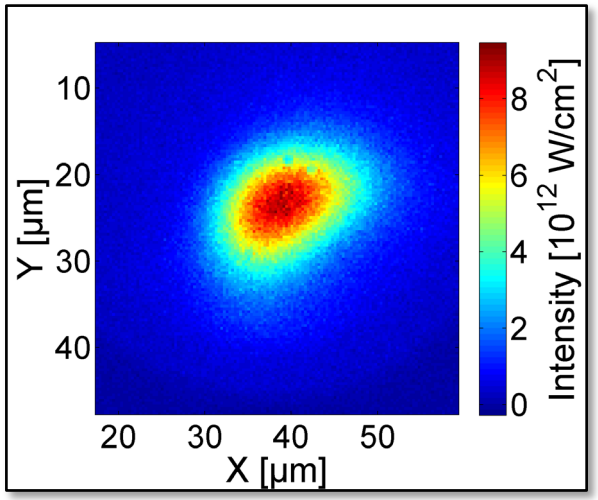

## Double toroidal mirror

*f* = 20 cm



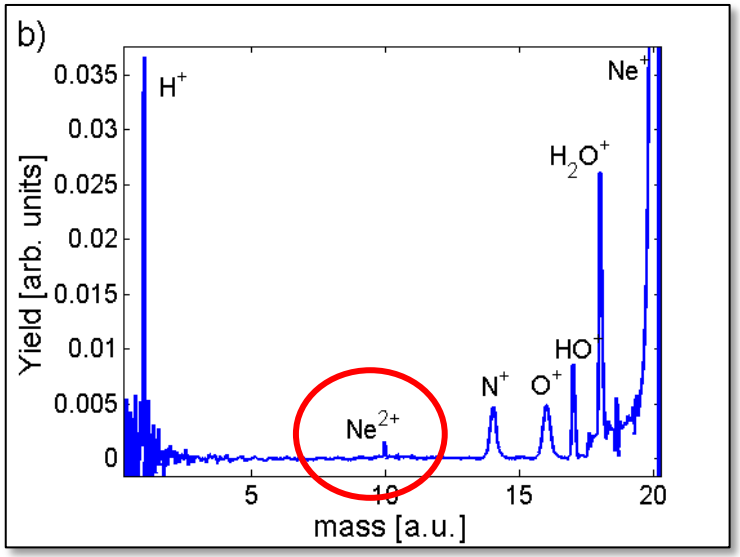
## XUV focal spot

Peak intensity ~$10^{13}$ W/cm$^2$

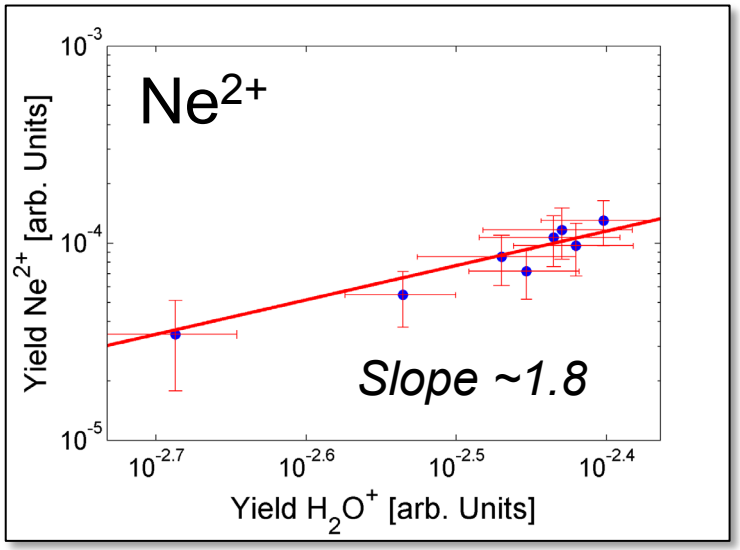


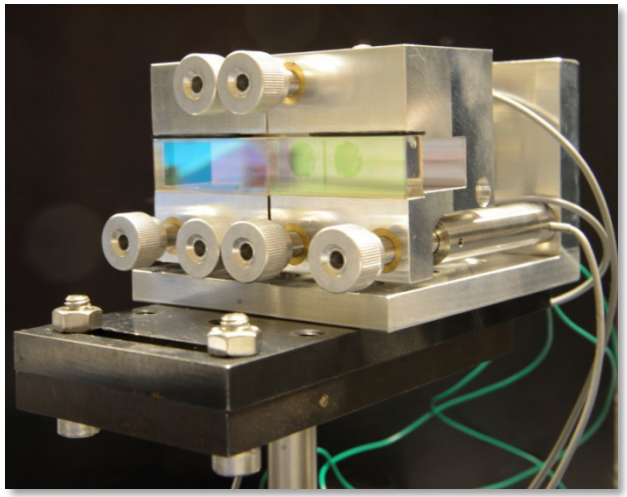
# The high-intensity HHG beamline

## TOF from ionization of Neon



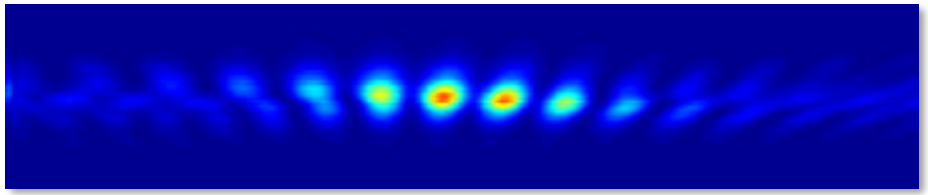

## Process order



## New split-and-delay unit

All-reflective IR autocorrelation



# Lund ESRs in MEDEA

**ESR LUND-1 (secondment @ Venteon, MPIK and CEA)**
*Anne L'Huillier*

***WP 1.1:*** Development of high-repetition rate lasers for electronic correlation and electron-nuclear coupling in small systems

- Upgrade OPCPA & attosecond source
- **MS1** (M24): Demonstration of high rep-rate SAPs
- Develop and implement coincidence techniques at the source
- **D1.1** (M24) : Perform high-repetition rate photoelectron/-ion spectroscopy
- Implement compact XUV-IR pump-probe setup
- **MS2** (M30): Demonstration of XUV-IR cross-correlation
- **D1.4** (M48): Perform pump-probe experiments with femtosecond and attosecond time resolution on large molecules

# Lund ESRs in MEDEA

**ESR LUND-2 (secondment @ Photek, DESY and MBI)**
*Per Johnsson*

***WP 3.2:*** Ultrafast electron imaging

- Implement cold high-density molecular beam with VMIS
- Implement schemes for MFPAD measurements
- **MS17** (M36): Static imaging using HHG
- **D3.3** (M48): Dynamical structure by HHG

# Lund training tasks

**Video tutorials**

- Reconstruction of attosecond pulses
- Introduction to strong-field physics

**Research training modules (RTMs) & scientific courses**

- Optimization of HHG
- Optical ray-tracing (FRED)
- Numerical methods using the TDSE (Prof. Schafer)
- Light-matter interaction

**Transferrable skills modules (TSMs)**

- Technical writing for publication
- Introduction to teaching and learning in higher education

# 2018: Final network meeting in Lund