

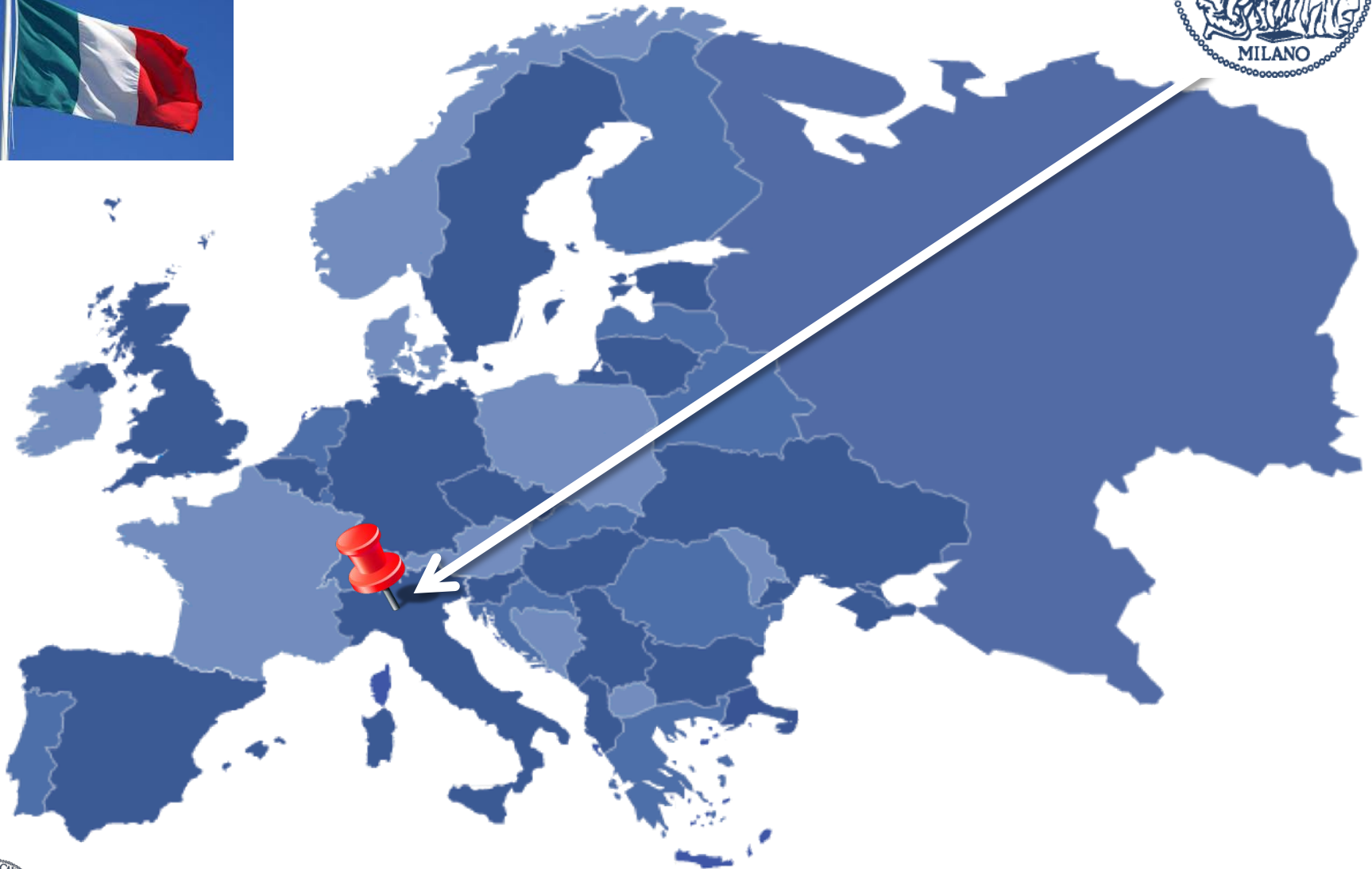


# **Salvatore Stagira**

**Dipartimento di Fisica  
Politecnico di Milano**

**MEDEA kick off meeting – Berlin, 19-20 January 2015**

# Where we are



# Milano



POLITECNICO  
DI MILANO

MEDEA kick off meeting – Berlin, 19-20 January 2015

# Politecnico di Milano *in a nutshell*



- Engineering, Architecture and Design Faculties
- Two main campuses located in Milan, five more in Lombardy region
- ~6700 freshmen each year

## PhD School Key facts & figures:

- ☐ 3 years of duration
- ☐ 18 Doctoral Programmes
- ☐ ~1100 PhD candidates
- ☐ 33% international students
- ☐ Candidates from 60+ countries



# Physics Department @ POLIMI



10 full professors  
25 associate professors  
14 assistant professors  
17 technicians & admin.  
~ 30 post-docs  
~ 40 PhD students (Physics)

## 5 research lines (>40 laboratories):

RL1 - Ultrashort light pulse generation and applications to the study of ultrafast phenomena in matter

RL2 - Solid state lasers and photonic devices

RL3 - Photonics for health, food and cultural heritage

RL4 - Epitaxial growth and nanostructure fabrication

RL5 - Electronic, optical and magnetic properties of low-dimensional systems

***Intensive collaboration with CNR (Photonics and Nanotechnology Institute)***

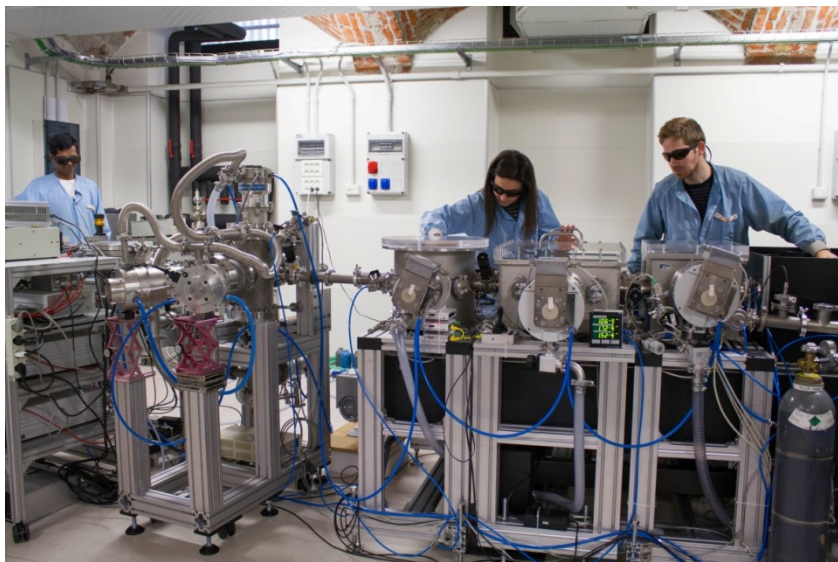
# Expertise inherent to MEDEA

- **Development and characterization of ultrafast and intense laser sources from the MIR to the UV**
- **Study and exploitation of “classic” nonlinear optics**
- **Applications to ultrafast spectroscopy of inorganic, organic and biological materials**
- **Investigation of strong-field optical phenomena in atoms, molecules and nanostructures**
- **Attosecond Science**



# Laboratories

# High-energy Attosecond Science Lab

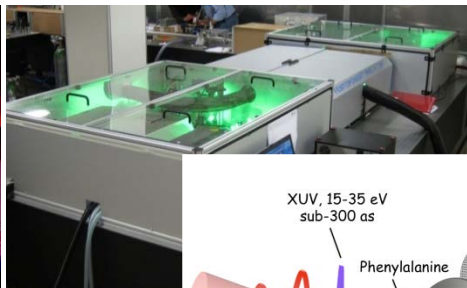
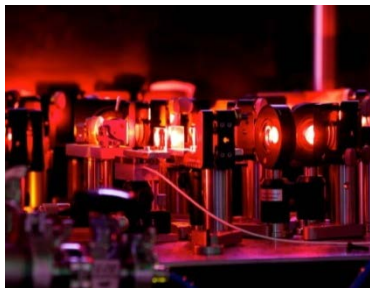


## Driving laser source:

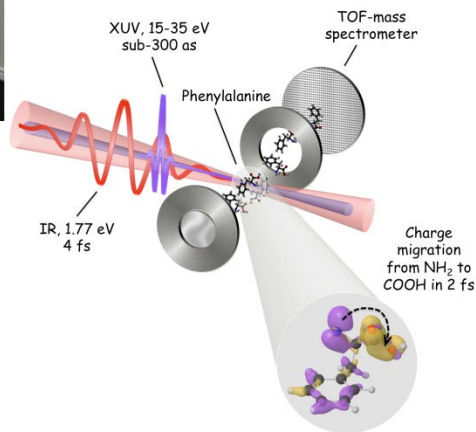
Sub-4 fs pulses, 2.5-mJ energy  
1 kHz repetition rate

## XUV source:

250 as pulses, **few nJ energy**  
17-50 eV energy range



**CNR IFN**  
Istituto di Fotonica e Nanotecnologie



## UV pump-XUV probe:

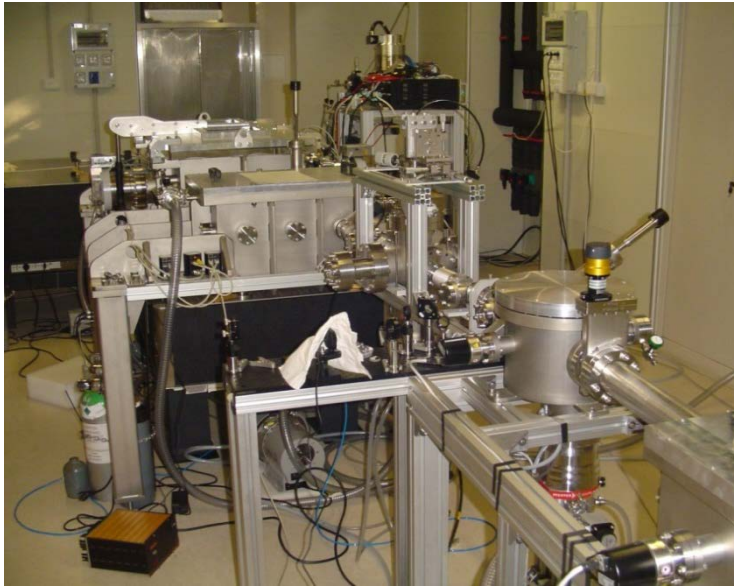
Sub-2 fs **UV pulses**, few- $\mu\text{J}$  energy,  
1 kHz by 3<sup>rd</sup> harmonic



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# High-rep rate Attosecond Science Lab



## Driving laser source:

5 fs pulses

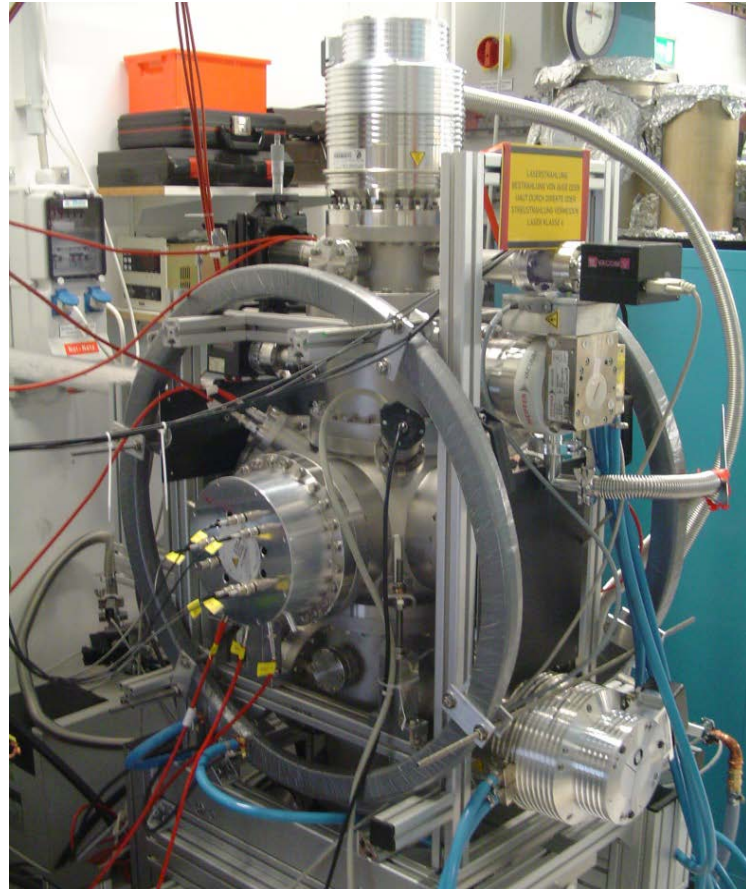
2 mJ energy

10 kHz repetition rate

## XUV source:

360 as pulses

15-30 eV energy range



Alexander von Humboldt  
Stiftung/Foundation



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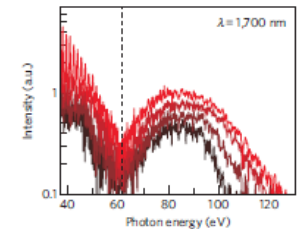
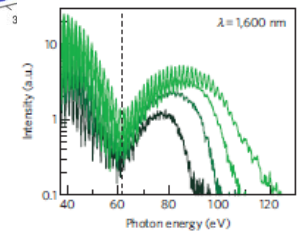
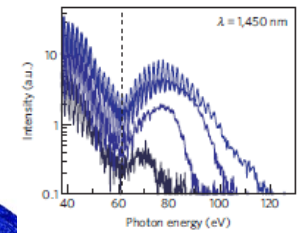
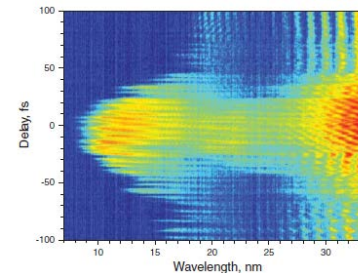
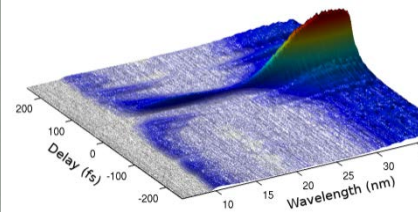
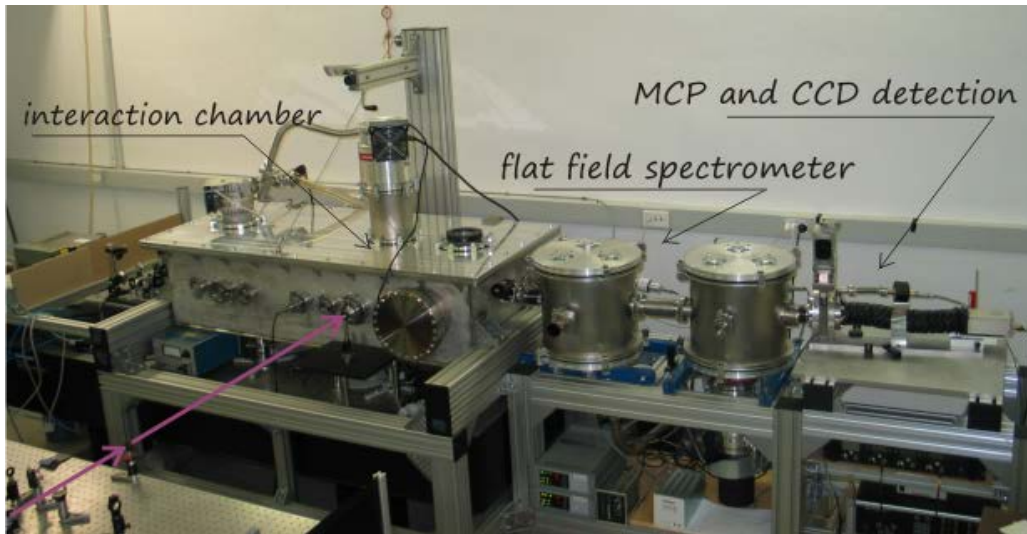
# Mid-IR Laser Laboratory for Strong-Field Physics

**TW Ti:sapphire laser system**

60 fs, 120 mJ, 10 Hz

**IR parametric source**

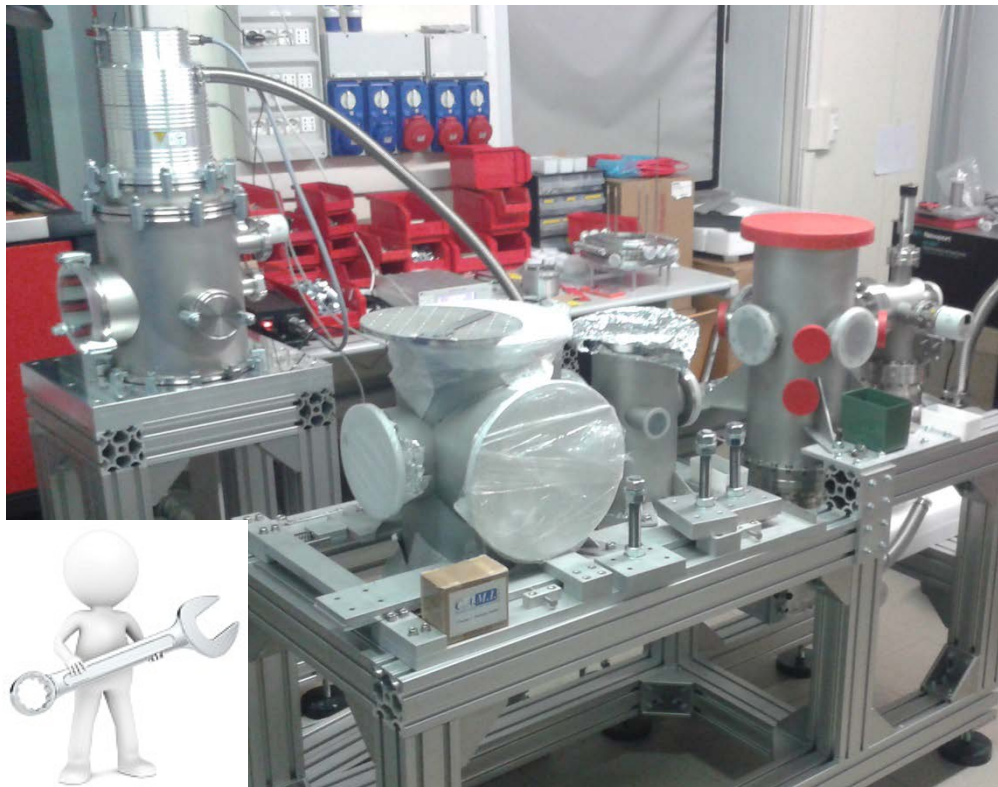
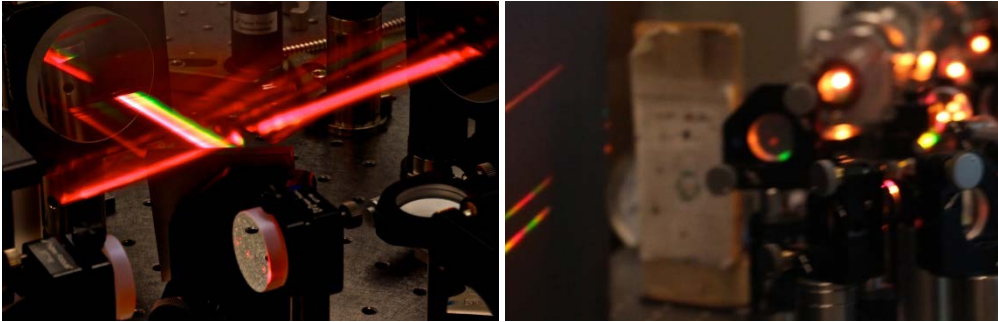
1.2 to 1.8  $\mu\text{m}$ , 20 fs, 1.5 mJ



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# Molecular Imaging Lab



## Driving laser source:

<22 fs pulses

15 mJ energy

1 kHz repetition rate



## XUV spectrometer

- gratings @ 10 nm and 1 nm
- stigmatic/astigmatic
- harmonic polarization detection

## VMI spectrometer

for electrons up to 200 eV



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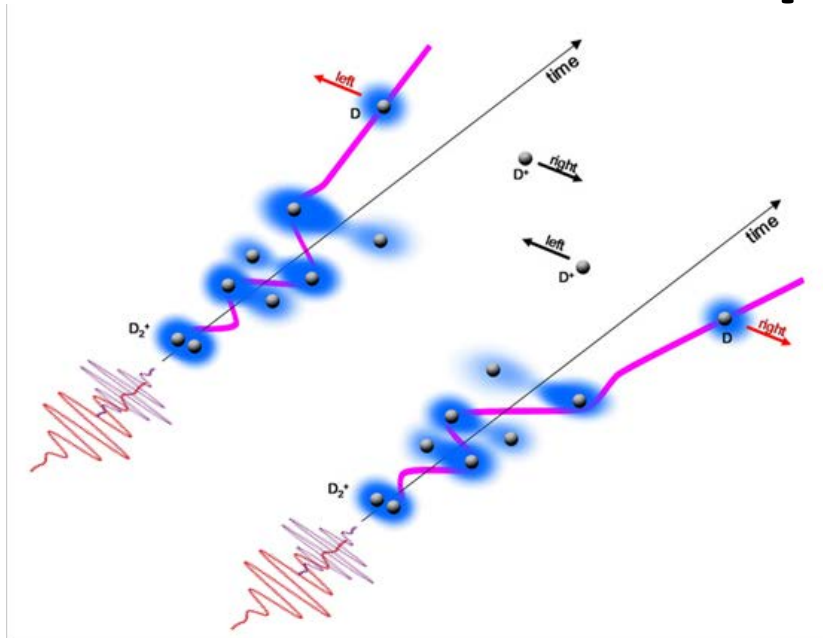
# Major research topics

# Current research topics

## in attosecond science

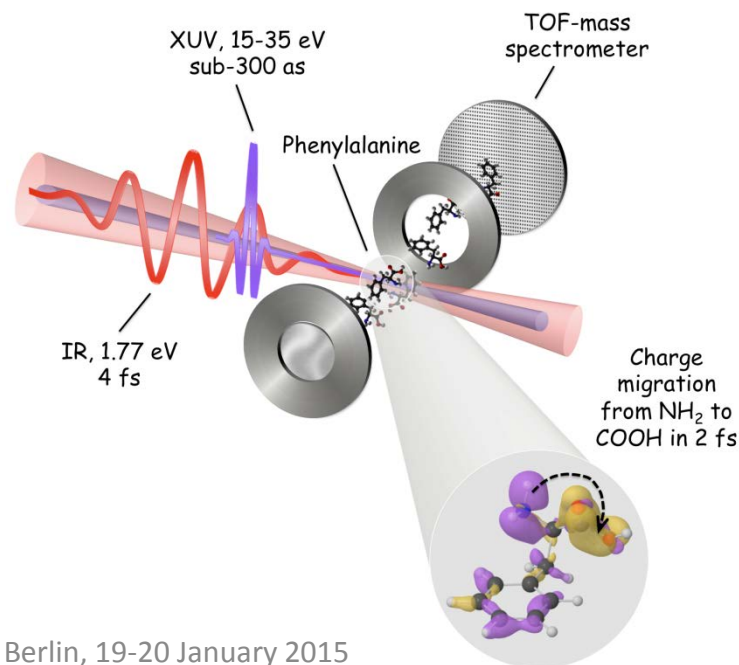
Follow and control **charge localization** and autoionization mechanisms in small molecules ( $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ , ...)

- Velocity Map Imaging (**VMI**)
- attosecond absorption spectroscopy



Study **ultrafast electronic motion in biomolecules** after prompt photo-ionization

→crucial role in fundamental biological mechanisms such as transmission of biological signals in proteins and DNA

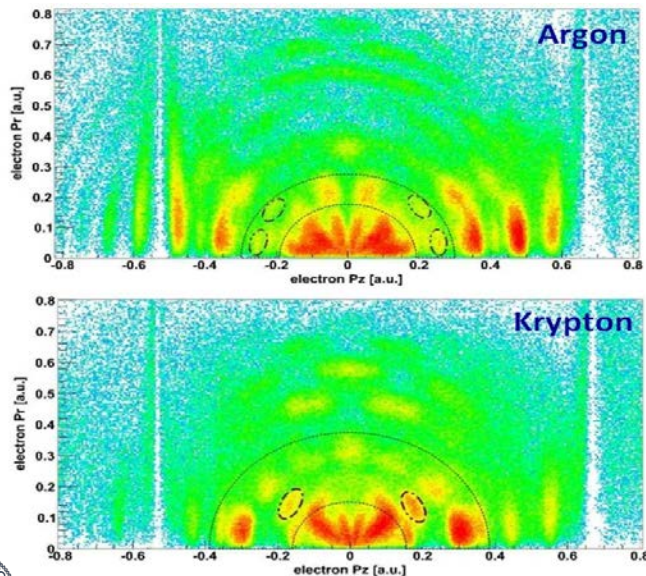
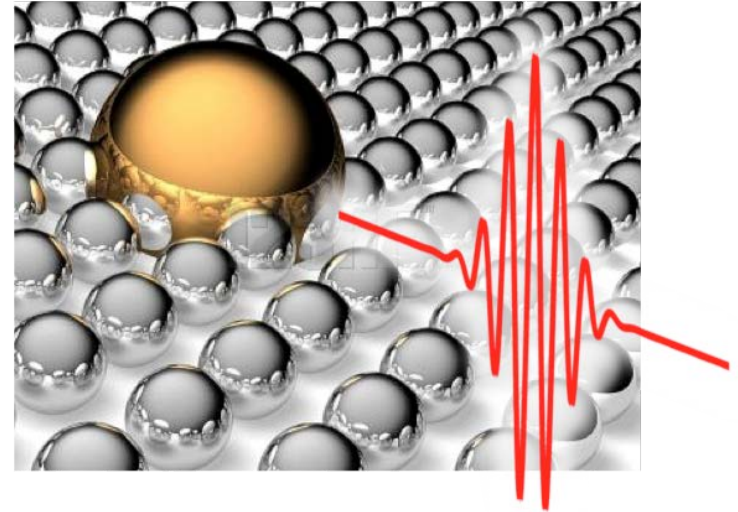




# Current research topics in attosecond science

Control **collective electron dynamics** in  
**nanostructured materials**  
(fs to sub-fs time scales)

→ Control of electron dynamics in nano-  
materials can revolutionize modern  
electronics: much higher computation and  
communication speeds



Investigation of **correlated electron motion** in atoms and molecules

- **Reaction Microscope** technique

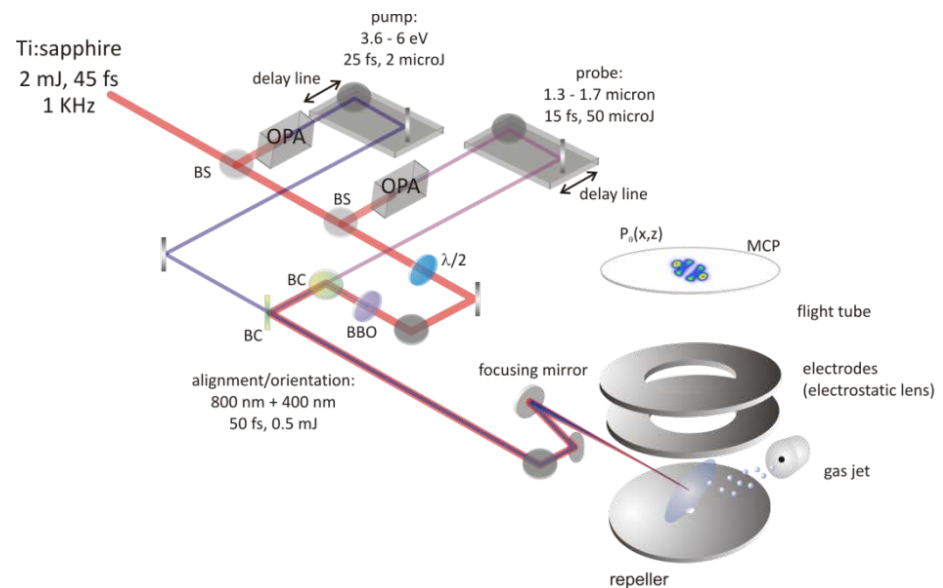
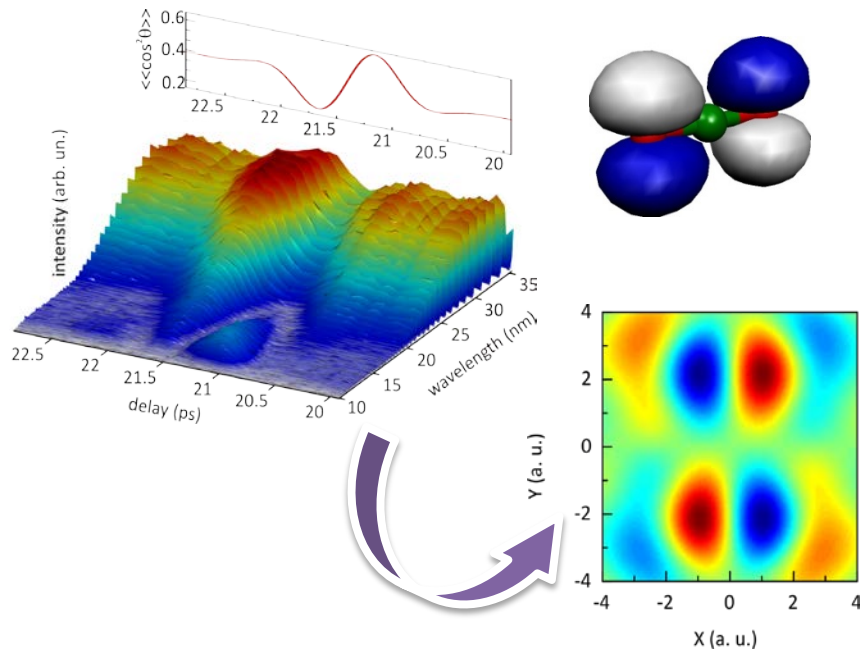
→ Making a movie of the full  
atomic/molecular dynamics after photo-  
ionization

# Ultrafast Molecular Imaging

Molecular orbital tomography:

real time imaging of evolving electronic structures in complex molecules

- by high-order harmonics
- by laser induced electron diffraction (VMI)



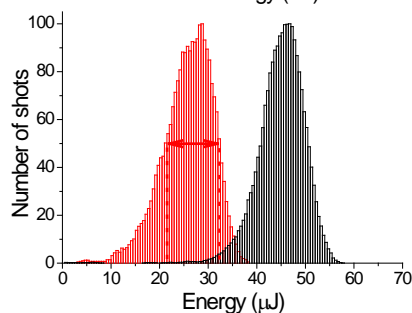
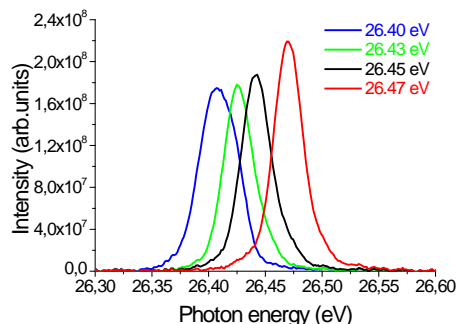
- direct access to the structure of excited states
- visualization of conical intersections
- coherent control in chemical reaction

# External activities: FERMI@ELETTRA



## *First seeded FEL user facility*

	FEL 1	FEL 2
<i>Energy</i>	20-100 $\mu\text{J}$	5-30 $\mu\text{J}$
<i>Photon energy tunability</i>	14-62 eV	56-308 eV
<i>Pulse duration</i>	100 fs	100 fs



- ❖ Ideal source for investigating nonlinear resonant effects in the XUV region
- ❖ Access granted to best-ranked proposal submitted in Calls for Proposal

***First beamtime granted to POLIMI (G. Sansone) in December 2012***

# **Supervision of ESRs in MEDEA**

# Early Stage Researcher (main supervision)

- ESR POLIMI-1:

**WP 2.1 Femtosecond non-linear XUV spectroscopy**

- ESR POLIMI-2:

**WP 3.1 High harmonic spectroscopy of electronic structure  
and multi-electron dynamics**



# ESRs (secondments)

ESR AMPL-1 CEP-stabilized multi-kHz regenerative amplifiers for attosecond experiments			
1 <sup>st</sup> Supervisor : Dr. P.M. Paul (10%)		WP 1.1; Duration: 36 Months; PhD enrolment: Yes (considering a 9 month extension)	
Planned secondments	Start	Dur.	Content of the training
<b>POLIMI</b> 2 <sup>nd</sup> Supervisor Dr. G. Sansone (10%)	27	4	Implementation of coincidence measurements with multi-kHz laser system for the investigation of attosecond dynamics in diatomic molecules. Research Management School (TSM)
<b>CEA</b> 3 <sup>rd</sup> Supervisor Dr. J. F. Hergott (10%)	34	4	Development of CEP fast feedback loops. Knowledge of enterprises and surroundings (TSM) Dynamical studies using HHG from aligned molecules (RTM)
<b>CAEN</b> Dr. Alessandro Iovene (7%)	38	1	Implementation of fast digitizers
ESR AU-1 Kinetic energy release spectra in dissociative ionization of diatomic molecules			
1 <sup>st</sup> Supervisor : Prof. L. Madsen (10%)		WP 1.1; Duration: 36 Months; PhD enrolment: Yes	
Planned secondments	Start	Dur.	Content of the training
<b>MAD</b> 2 <sup>nd</sup> Supervisor Dr. A. Palacios (10%)	26	4	Ab initio simulations of the dynamics of two-electron linear molecules on super computers TSMs available at MAD
<b>AMPL</b> 3 <sup>rd</sup> Supervisor Dr. F. Canova (10%)	35	1	Managing time schedule production (TSM) How to manage and industrial project (TSM)
<b>POLIMI</b> Prof. M. Nisoli (10%)	39	1	Interpretation of experimental data on dissociative ionization of N <sub>2</sub> and O <sub>2</sub> molecules
ESR DESY Attosecond dynamics in conformer-selected amino acids			
1 <sup>st</sup> Supervisor : Prof. J. Küpper (15%)		WP 1.2; Duration: 36 Months; PhD enrolment: Yes	
Planned secondments	Start	Dur.	Content of the training
<b>PHOTEK</b> 2 <sup>nd</sup> Supervisor Dr. P. Kapetanopoulos (5%)	23	6	Design and optimization of Even-Lavie valve for fragile molecules. Investigation of the optimal conditions (backing pressure and temperature) for the generation of cold beams of conformer-selected amino acids. TSMs available at PHOTEK
<b>POLIMI</b> 3 <sup>rd</sup> Supervisor Dr. G. Sansone (5%)	33	2	Management and optimization of renewable energy sources (TSM) Second order autocorrelator (RTM)
<b>AU_exp</b> Prof. H. Stapelfeldt (2%)	37	1	Adiabatic and non-adiabatic alignment techniques (RTM) Introduction to scientific teaching (TSM)
ESR FEMTO Generation of mid-IR CEP-stabilized pulses			
1 <sup>st</sup> Supervisor : Dr. A. Assion (8%)		WP 4.1; Duration: 36 Months; PhD enrolment: Yes (considering a 9 month extension)	
Planned secondments	Start	Dur.	Content of the training
<b>POLIMI</b> 2 <sup>nd</sup> Supervisor: Prof. S. Stagira (10%)	15	3	Development of setups for the measurement and stabilization of CEP of mid-IR pulses Alignment of a hollow fiber compressor (RTM)
<b>CEA</b> 3 <sup>rd</sup> Supervisor: Dr. T. Ruchon (10%)	29	2	Dynamical studies using HHG in aligned molecules Innovation management in enterprise (TSM) Knowledge of enterprises and surroundings (TSM)



# Conclusions

- *Location:* Milano is a very dynamic city, ideal for ESRs
- *Human aspects:* POLIMI is a young, international environment stimulating sharing of ideas among ESRs and acquisition of *soft skills*
- *Science:* expertise, labs and activities fit the project goals and may stimulate interdisciplinary collaborations of ESRs with other scientists