



**SAMOFAR**

MSR Summer School

2017, July 2

Lecco



**POLITECNICO**

MILANO 1863

**The leading University in Italy for  
Architecture, Design and Engineering**



POLITECNICO DI MILANO

150°

1863-2013

**THE LARGEST SCHOOL OF ENGINEERING, ARCHITECTURE AND DESIGN IN ITALY**

3 Schools of Engineering, 2 Schools of Architecture, 1 School of Design.

**ONE OF THE MOST OUTSTANDING TECHNICAL UNIVERSITIES**

QS World University Ranking 2015, Engineering & Technology category:

**24<sup>th</sup>** in the World, **7<sup>th</sup>** in Europe, **1<sup>st</sup>** in Italy.



# POLITECNICO DI MILANO: TECHNOLOGY, CREATIVITY, CULTURE

3

Politecnico di Milano has kept in its logo (from Raffaello's painting) an original and creative attitude



AY 2015-2016

STUDENTS

PROFESSORS &  
RESEARCHERS

(perm. staff)

## ARCHITECTURE

6 957

297

29% of graduated in Italy

3 out of 10

## DESIGN

3 542

94

78% of graduated in Italy

8 out of 10

## ENGINEERING

27 485

925

19% of graduated in Italy

1 out of 5



POLITECNICO MILANO 1863

## A COSMOPOLITAN ATMOSPHERE

Many programs taught entirely in English,  
Specializing Master and Short post-graduation courses.

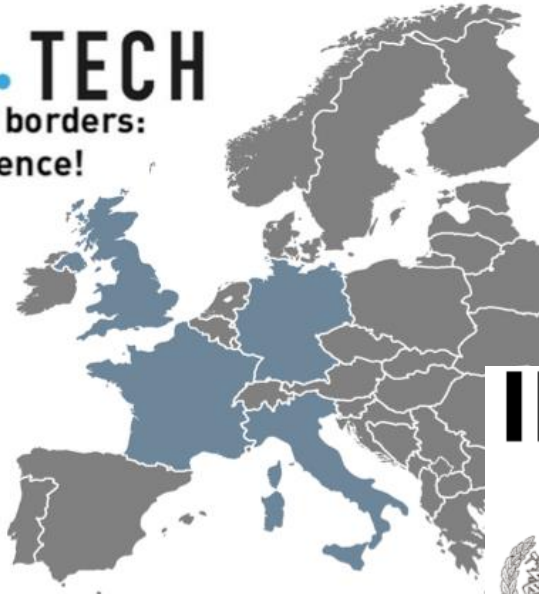
International students coming from more than 100 different countries.

- 1 483 Bachelor of Science
- 2 010 Master of Science
- 305 PhD



# COMPETITION & COLLABORATION: POLIMI NETWORKS IN EU

**ALLIANCE TECH**  
European Campus without borders:  
a real international experience!

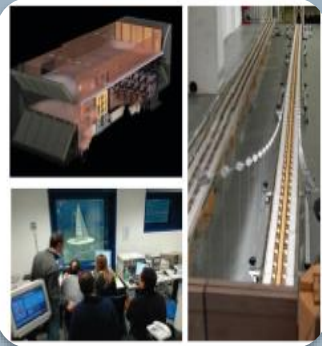


**IDEA League**



**POLITECNICO MILANO 1863**

# Large research infrastructures



## **WIND TUNNEL**

One of the most advanced laboratories in the world for tests on aerospace system aerodynamics and wind effects structures



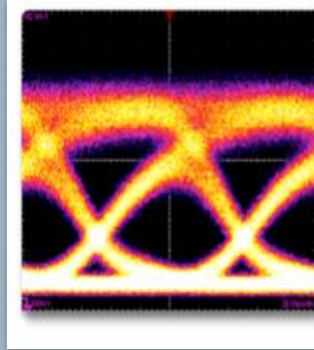
## **La.S.T.**

Laboratory for the Safety of Transport



## **L.P.M**

Experimental activities on materials and structures



## **PoliFAB (clean room)**

Micro-nano fabrication facility  
micro- and nano technologies,  
Silicon photonics,  
Biosensors, MEMS, advanced materials



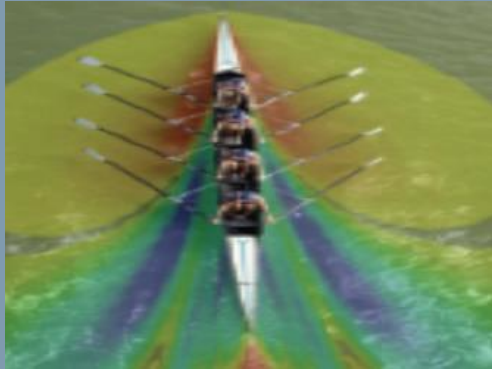
## **Building B18: Energy Department new Labs.**

Chemical and Nuclear Division:  
Advanced integrated labs for catalysis and catalytic processes and nuclear engineering





# Large research infrastructures



## **MOX Mathematical modelling and scientific computing**

- Application to several academics and industrial realities



## **IIT@POLIMI Center for Nano Science and Technology**

- Artificial retina/eye,
- Carbon nanocomposites,
- Hybrid solar cells



## **EIT ICT Satellite Node**

- Smart spaces
- Cloud, networking
- Security, privacy
- Smart energy



# Joint Research Centers

## Transports



**BOMBARDIER**  
TRANSPORTATION



**so/GEFI** GROUP



## Chemistry



## Energy



## Elettrical & Appliance

**Rold**research

**SIEMENS**



## Cultural Heritage



VENERANDA FABBRICA DEL DUOMO DI MILANO

## Health and Medical



## ICT & Analytics

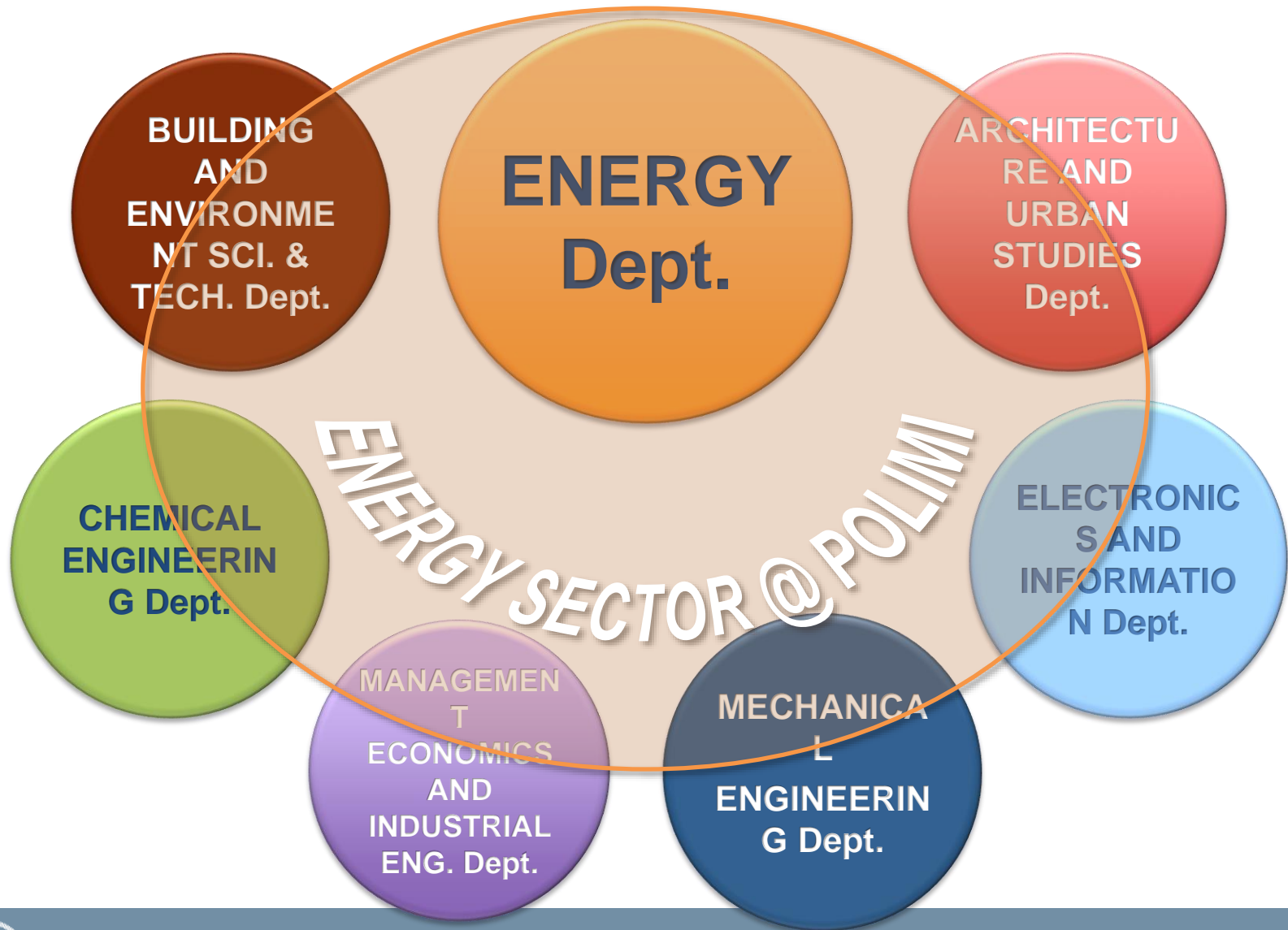


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# ENERGY: A STRATEGIC SECTOR FOR POLIMI

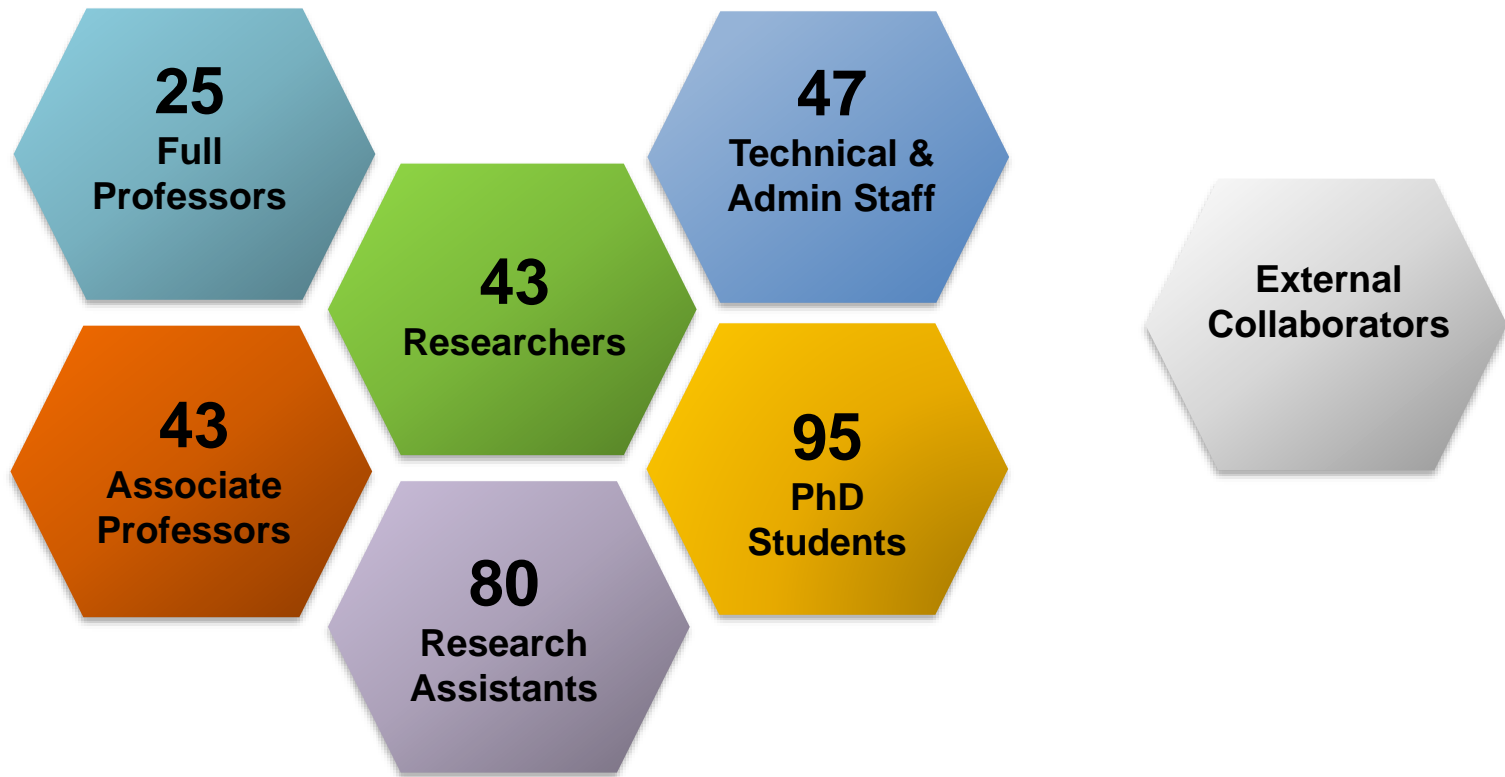
A multidisciplinary approach



# DEPARTMENT OF ENERGY

## A COMPLETE TEAM

About **330 scholars**,  
plus several external collaborators



Updated April 2016



# DEPARTMENT OF ENERGY FACILITIES



BL25 - Via Lambruschini, 4 – Milano  
Campus Bovisa



B12 - Via La Masa, 34 – Milano  
Campus Bovisa



B18 - Via La Masa, 34 – Milano  
Campus Bovisa



19 - CeSNEF - Via Ponzio, 34/3 – Milano  
Campus Leonardo

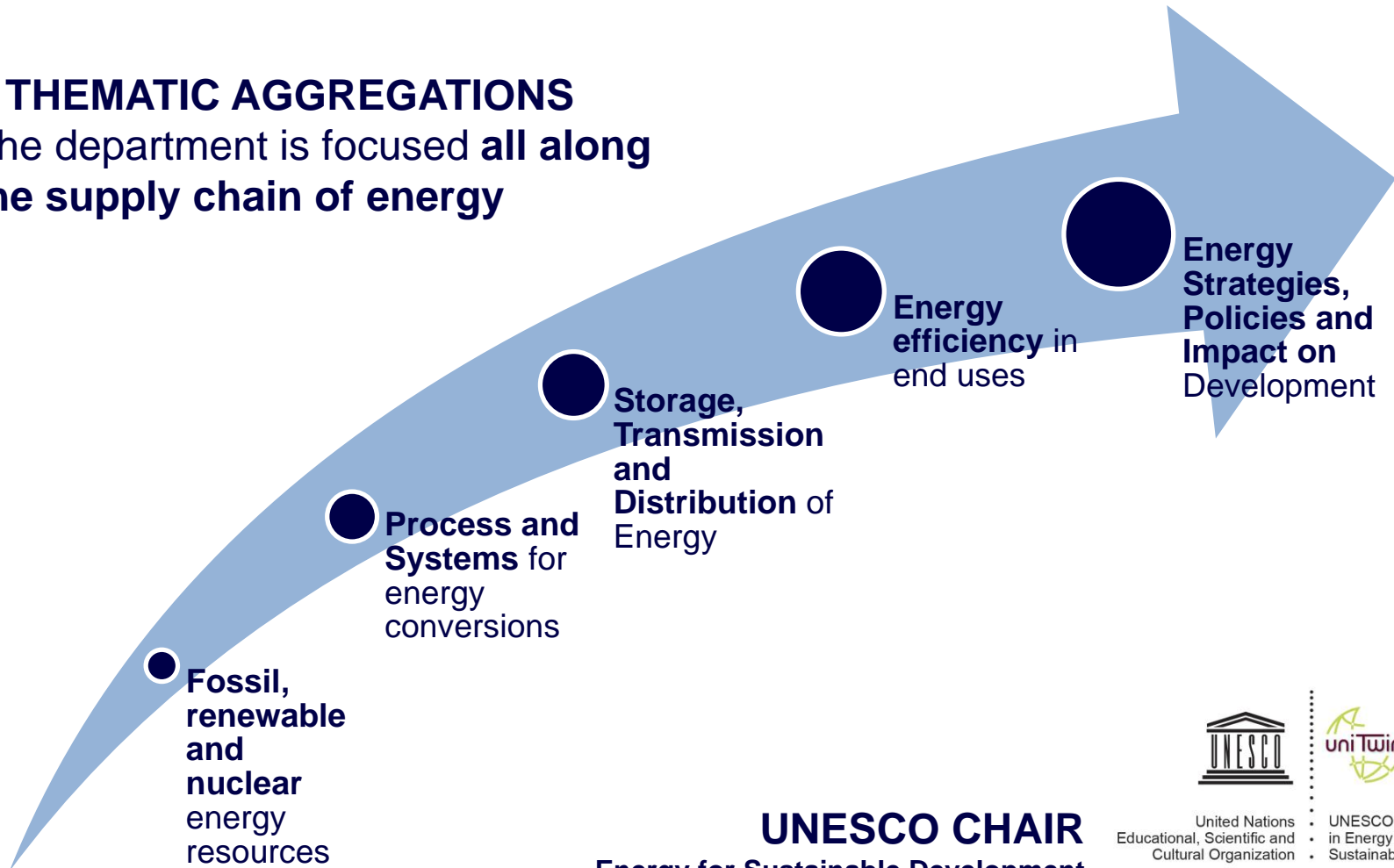


# DEPARTMENT OF ENERGY

## INTERDISCIPLINARY APPROACH

### 5 THEMATIC AGGREGATIONS

The department is focused **all along**  
**the supply chain of energy**



**UNESCO CHAIR**  
Energy for Sustainable Development



United Nations  
Educational, Scientific and  
Cultural Organization



UNESCO Chair  
in Energy for  
Sustainable Development



POLITECNICO  
DI MILANO



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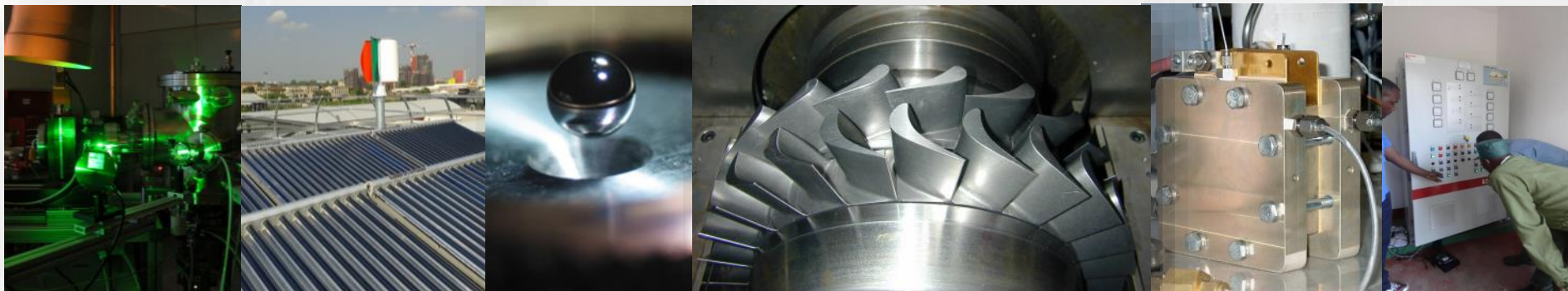
# DEPARTMENT OF ENERGY

## INTERDISCIPLINARY APPROACH

### 5 SPECIALIZED DIVISIONS

Joint researches to study, analyze, develop knowledge, technologies and strategies related to production, conversion, transport, distribution and final use of energy:

1. CHEMICAL TECHNOLOGIES AND PROCESSES and NANOTECHNOLOGIES
2. ELECTRICAL ENGINEERING
3. NUCLEAR ENGINEERING
4. FLUID DYNAMIC MACHINES, PROPULSION and ENERGY SYSTEMS
5. THERMAL ENGINEERING and ENVIRONMENTAL TECHNOLOGIES





## History

- First educational programme in Nuclear Engineering (1956)
- First research nuclear reactor in Italian Universities (1959)



## Today

- >40 new students per year, one of the largest in Europe
- MSc in Nuclear Engineering + PhD programme
- Brand-new experimental labs
- Access to TRIGA research and training reactor (Pavia)

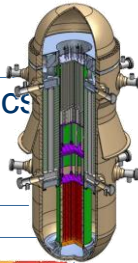




## Largest NE Division in Italian Universities

### Nuclear Reactors group

thermal hydraulics (experim.&modelling), thermal mechanics  
fuel performance, dynamics & control, safety analysis,  
economics



### RAMS group

soft methods (fuzzy, neural networks,...) for maintenance  
reliability optimization and risk analysis purposes



### Radiochemistry group

wet- and pyro-processes for partitioning, confinement in  
inorganic matrices, methods for waste characterisation



### Radiation Protection group

dosimetry, radon, decommissioning processes



### Radiation Measurement & Instrumentation group

medical applications, electronics for radiation measurement  
devices



### Reactor Physics and Contaminants group

MCNP methods for neutronics and particle transport  
contaminant transport in porous media



# New experimental laboratories (2015)

16



- New, advanced experimental labs for research, training, education
- Nuclear sector and chemical-energy sector
- More than 6000 m2 brand new areas, more than 15M€ investment



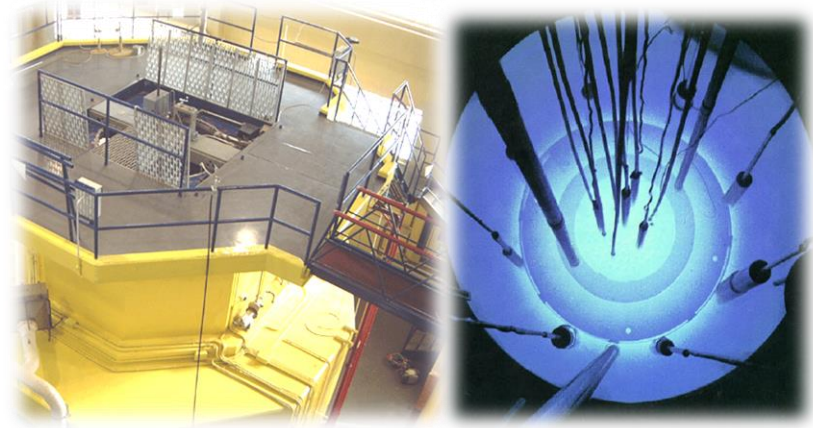
The labs allow developing fundamental research on nuclear issues at international level, as well as applied research in industrial, medical and environmental fields.

- Radiochemistry
- Contaminants Migration
- Radiation Protection
- Health physics
- Nuclear Instrum. & Measurements
- Nuclear Electronics
- Ionizing Radiation Metrology





TRIGA research reactor (at Pavia)  
for Training and R&D activities



TRIGA MarkII (250 kW)



SIET labs (at Piacenza)

World-class, large scale exp. labs for safety systems and thermalhydraulic tests, for nuclear reactor components and systems

CNAO (at Pavia)

Sincrotron for adrontherapy, for medical applications



# Main expertise & activities of POLIMI – NRG Nuclear Reactors Group



## Thermal Fluid Dynamics & Passive Safety

- » theoretical and experimental investigation of two-phase flow systems (delta-P, dry-out, instabilities)
  - » innovative Steam Generators and Nat. Circ. Passive Safety Systems for New Generation Reactors
  - » access to in-house and external Large Scale Facilities (SIET labs and TRIGA reactor)

## Simulation & Control, Multiphysics, Reduced Order Modelling

- » multiphysics approach: neutronics, fluid dynamics and thermal mechanics in the same simulator
- » object-oriented and ROM models for flexible and fast running simulators, for new control strategies

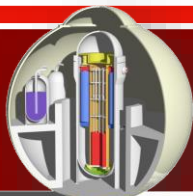
## Economics

- » development of simulation tools for the analysis of economics and financial features of SMRs, for evaluation of deployment scenarios and policy management decisions

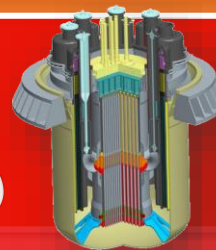
## Fuel Cycle & Performance, Thermal Mechanics

- » characterization and performance of innovative fuel and cladding materials (ad-hoc routines for TRANSURANUS and BISON codes), including analysis for optimal core configurations and fuel burn-up

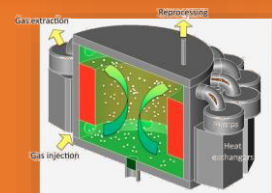
**Small Modular  
Reactors  
(IRIS, FlexBlue)**



**Lead Fast  
Reactors  
(ADS, ALFRED)**



**Molten Salt  
Reactors  
(SAMOFAR)**



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[www.nuclearenergy.polimi.it](http://www.nuclearenergy.polimi.it)



# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

### The city: Lecco

*“We voyaged by steamer down the Lago di Lecco, through wild mountain scenery, and by hamlets and villas, and disembarked at the town of Lecco. [...]. It was delightful. We had a fast team and a perfectly smooth road. There were towering cliffs on our left, and the pretty Lago di Lecco on our right, ...”*

Mark Twain, Innocents Abroad, chapter 21.



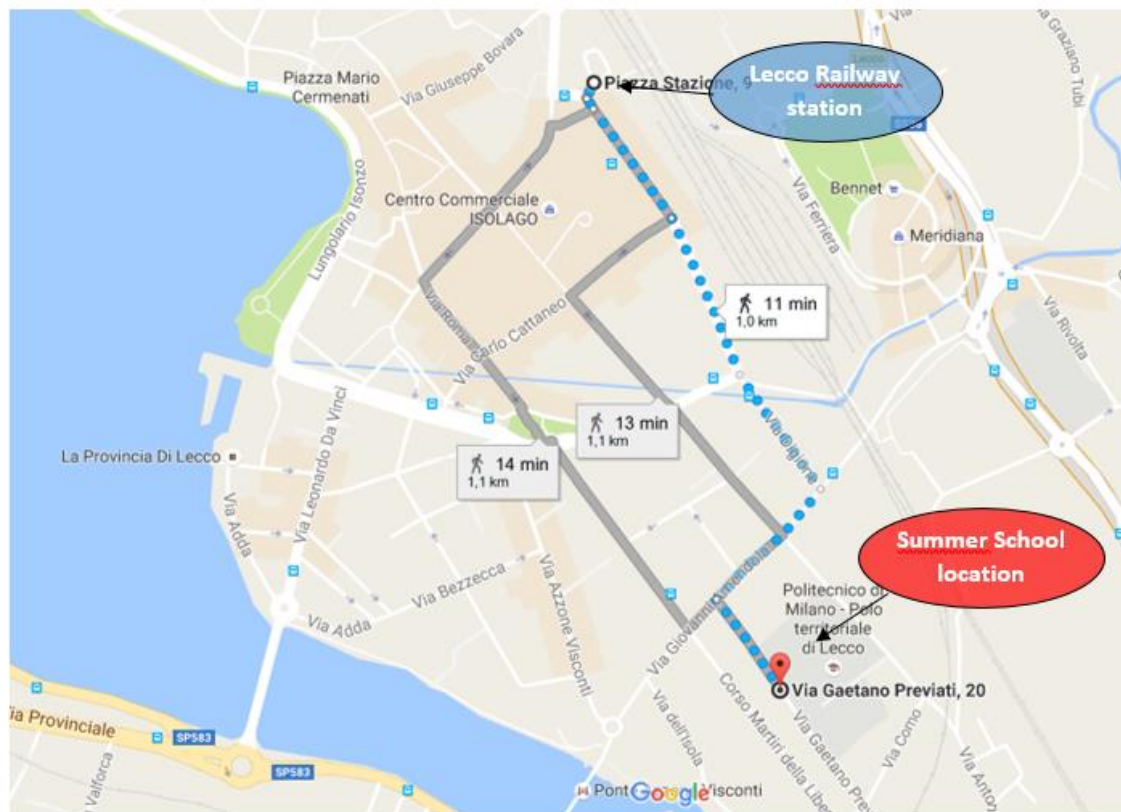


# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

The location: PoliMi campus



Politecnico di Milano, Lecco Campus, Via G. Previati 1/c, 23900 Lecco.



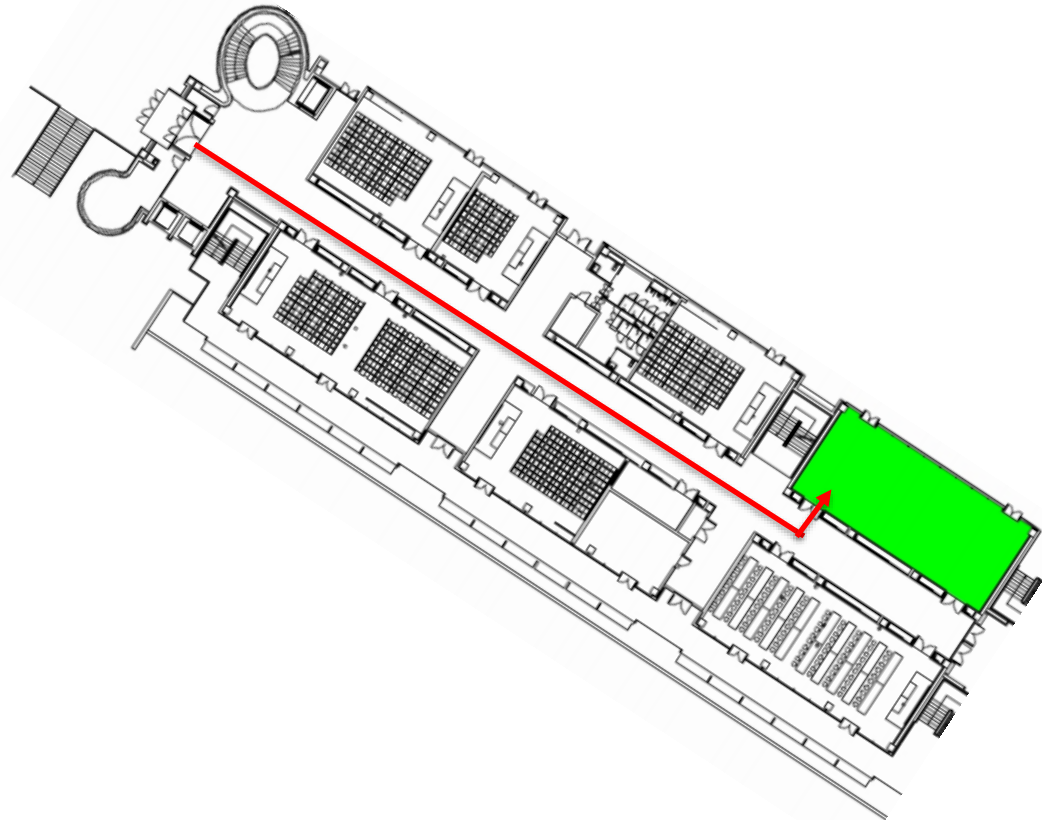
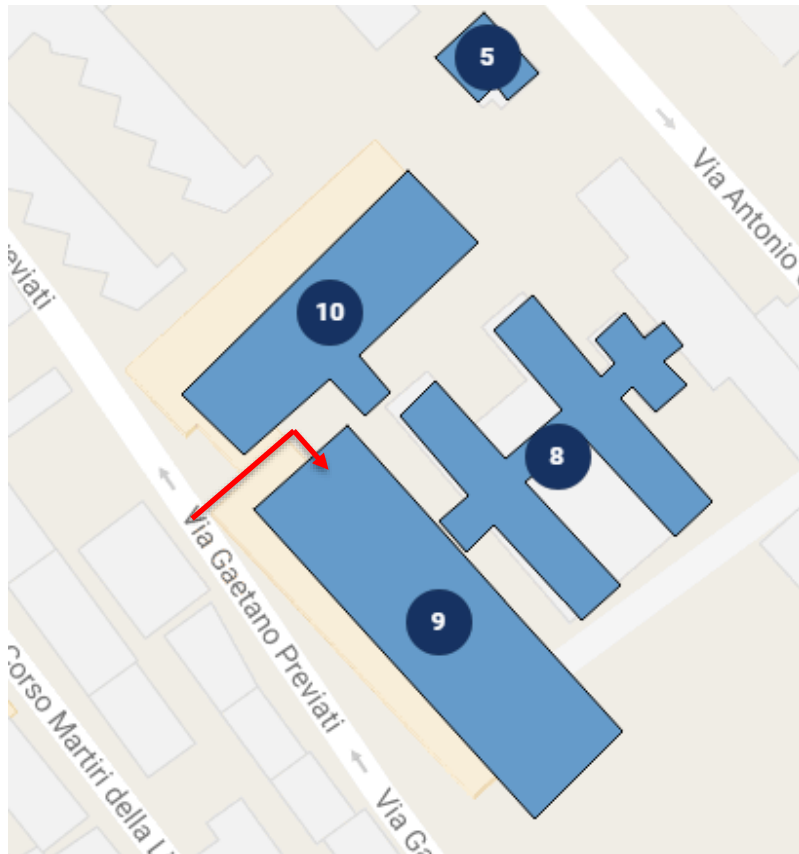
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# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

Lecture room: B0.4 – Building 9 – Ground Floor



H0.5 – Building 8 – Ground Floor for parallel session and/or suitcases

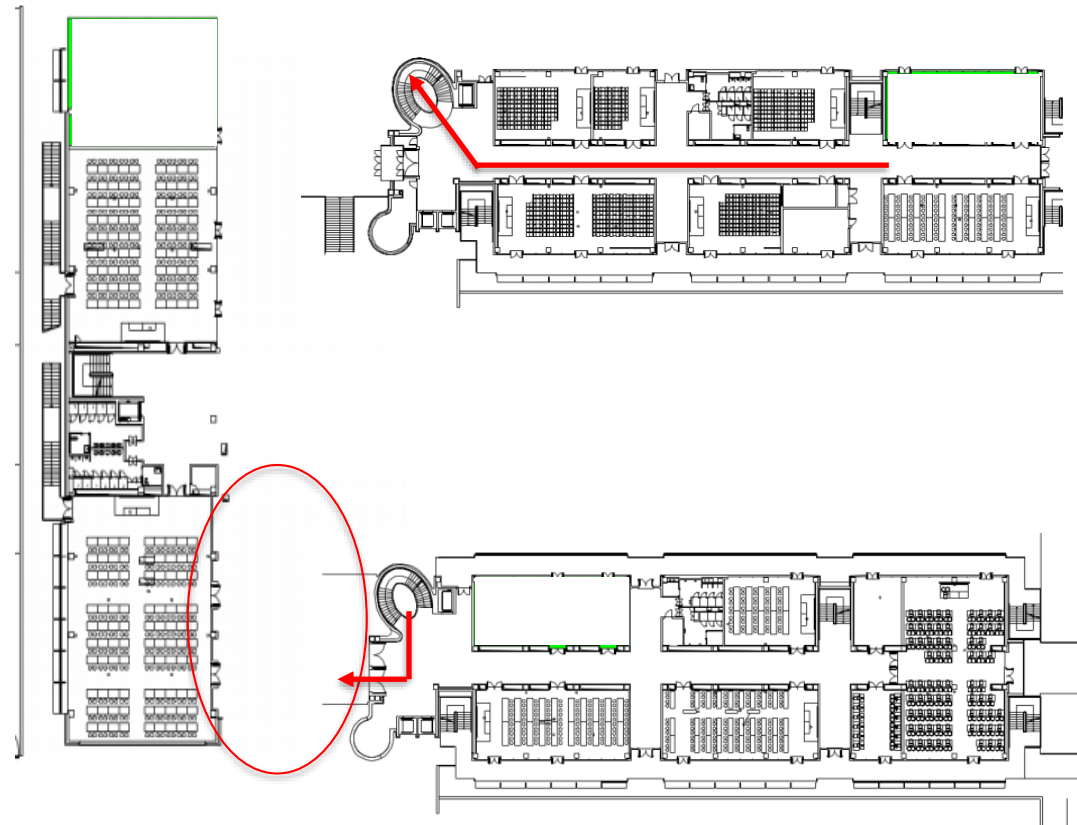
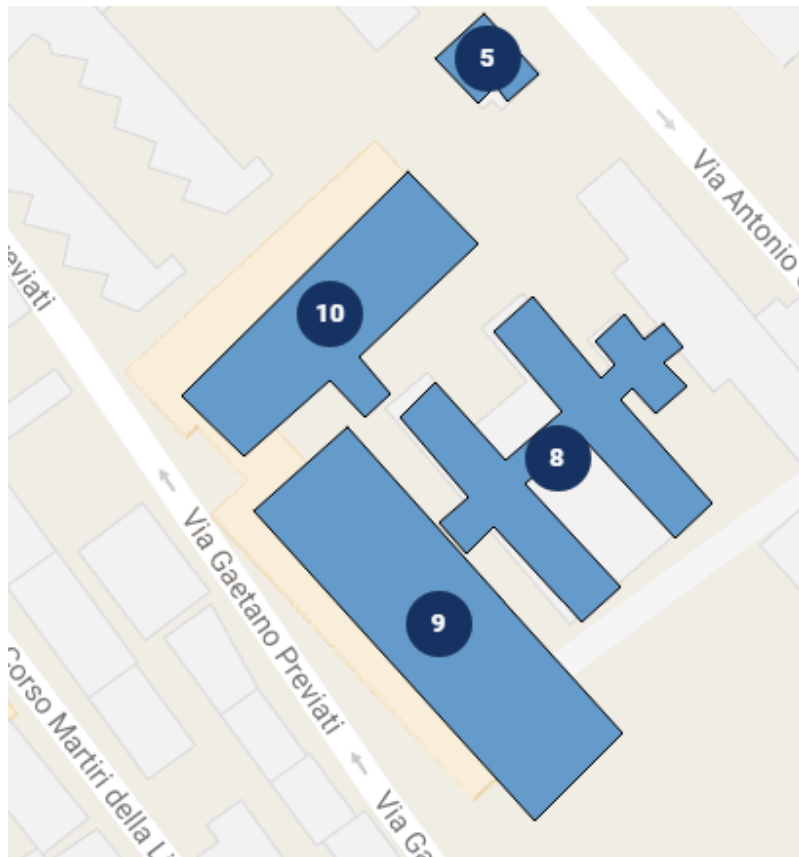


# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

Poster session + Welcome drink on Sunday  
OpenSpace between building 9 and building 10 – First Floor



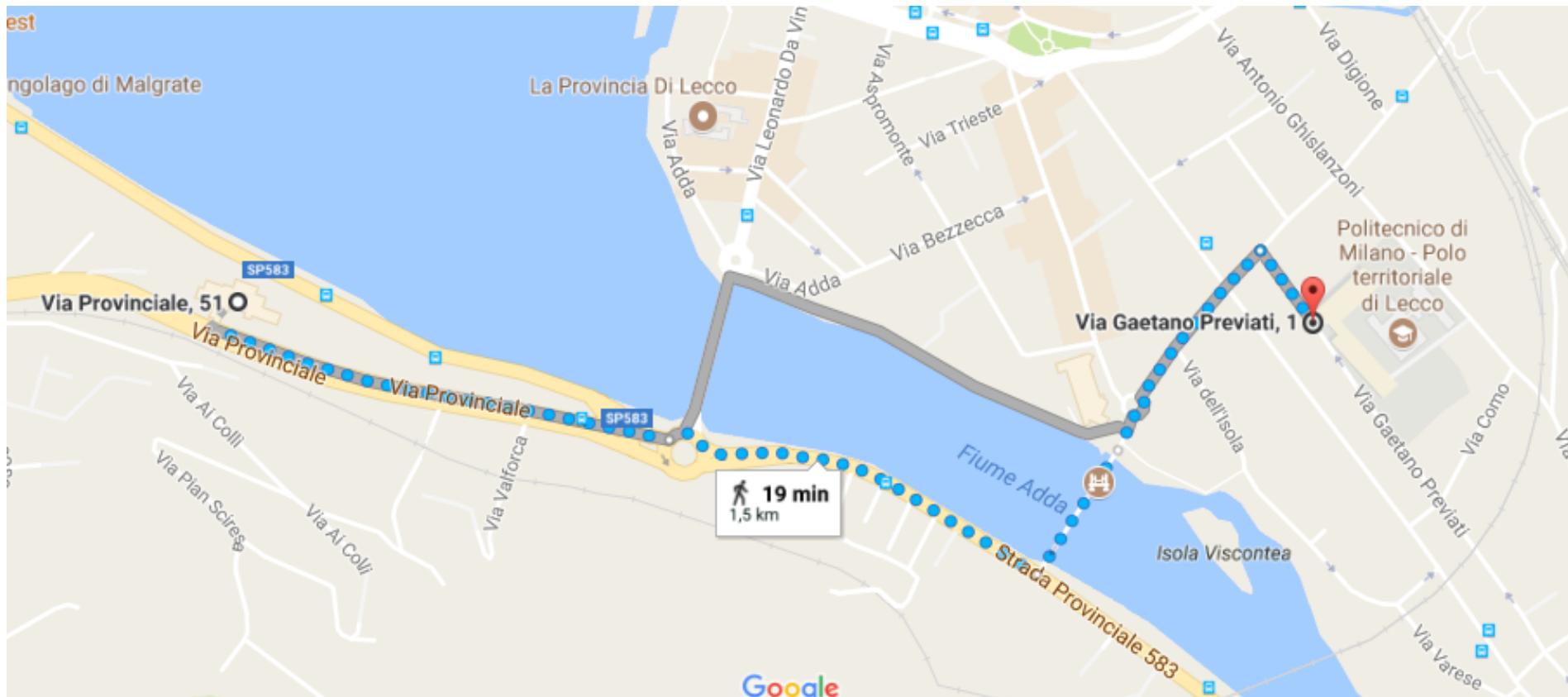
# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

Dinner on Monday @ 8 pm

**“L’altro Griso” restaurant - Via Provinciale, 51, 23864 Malgrate (Lecco)**



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# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

### Summer School Programme

Sunday July 2, 2017		
15:30-16:00	Registration	
16:00-16:10	Welcome by Politecnico di Milano	Antonio Cammi (PoliMi)
16:10-16:50	Lessons from the past: MSR in the fifties and sixties	Cyril Rodenburg (Terrestrial Energy)
16:50-17:30	Historical MSR programme in Russia	Victor Ignatiev (Kurchatov Institute)
17:35-19:00	<i>Poster Sessions and welcome cocktail</i>	<i>All</i>





# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

### Summer School Programme

Monday July 3, 2017		
09:00-09:45	MSR Concepts	Jan Leen Kloostermans (TU Delft)
09:45-10:30	Neutronics of MSR	Sandra Dulla (POLITO)
10:30-11:00	<i>Coffee break</i>	
11:00-12:30	Integral Safety Analysis	Elsa Merle (CNRS)
12:30-14:00	<i>Lunch break</i>	
14:00-14:45	Fuel cycle aspects of MSR	Jiri Krepel (PSI)
14:45-15:30	Thermal-hydraulics and CFD	Pablo Rubiolo (CNRS)
15:30-16:00	<i>Coffee break</i>	
16:00-16:45	Multiphysics simulation of MSR	Danny Lathouwers (TU Delft)
16:45-17:30	Control Strategies of MSR	Stefano Lorenzi (POLIMI)
20:00	<i>Dinner &amp; Best poster award</i>	





# Molten Salt Reactor Summer School

## Lecco, Como Lake, Italy

2-4 July 2017

### Summer School Programme

Tuesday July 4, 2017		
09:00-10:30	Kinetics and dynamics (incl noise analysis) of MSR	Imre Pázsit (Chalmers Univ)
10:30-11:00	<i>Coffee break</i>	
11:00-12:30	Thermodynamics analysis of salts Physico-Chemical properties of salts	Ondrej Benes (ITU)
12:30-14:00	<i>Lunch break</i>	
14:00-15:30	Materials and metals in MSR	Victor Ignatiev (Kurchatov Institute)
15:30-16:00	<i>Coffee break</i>	
16:00-17:30	Reprocessing of salt	Sylvie Delpech (CNRS)

Lectures will be video recorded and published on the Samofar Youtube channel

**Your opinion matters: An online survey will be sent to you by email. Give us a feedback!**

