# Four collaborative competence centers for enabling software co-design

Marie-Christine Sawley
Intel Director Exascale Lab Paris
Salishan Conference, 24th April 2012

# Exascale Challenges

- Exploiting massive parallelism
  - How will existing applications scale?
  - Will there be new apps or models using new algorithms?
  - Data transfer (memory, interconnect) will become relatively more expensive
  - Requirements on (hierarchical) programming models, schedulers, languages, …


- Reducing power requirements
  - Must reduce the power requirement by a factor of at least 100
  - Is  a challenge also for SW (middleware and applications)
  - Optimize for performance and power

- Coping with run-time errors
  - Frequency of errors will increase, identification and correction will become more difficult
  - HPC middleware has to include  resiliency
  - Redesign applications to embed resiliency?


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# Intel European Exascale Labs

## Role

- Understand requirements for Exascale applications
- Provide feedback to Intel HW architects
- Provide guidance to application developers
- Build Exascale HW and SW prototypes
- Contribute to European and national projects

## Status

- Started 2010/2011 as co-design centers
- With leading European HPC R&D organizations
- In total ~70 researchers
- Joint R&D program with partners
- Part of Intel Labs Europe network with >1,500 R&D professionals

# Intel Exascale Labs — Europe

## Strong Commitment To Advance Computing Leading Edge:

*Intel collaborating with HPC community & European researchers*

*4 labs in Europe - Exascale computing is the central topic*

### ExaScale Computing Research Lab, Paris

GENCI, intel, CEA, UNIVERSITE DE VERSAILLES SAINT-QUENTIN-EN-YVELINES

Performance and scalability of Exascale applications

Tools for performance characterization

### ExaCluster Lab, Jülich

JÜLICH FORSCHUNGSZENTRUM, intel, PARTEC CLUSTER COMPETENCE CENTER

Exascale cluster scalability and reliability

### ExaScience Lab, Leuven

LEUVEN, UNIVERSITEIT GENT, Universiteit Antwerpen, universiteit hasselt, imec, intel

Comms avoiding algorithms

Architectural simulation

Scalable kernels and RT

### Intel and BSC Exascale Lab, Barcelona

BSC Barcelona Supercomputing Center, Centro Nacional de Supercomputación, intel

Scalable RTS and tools

New algorithms

www.exascale-labs.eu

*Signed Collaboration agreement*

Daresbury Science & Innovation Campus

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# France: Exascale Computing Research Center


Application Scalability

Application Performance Characterization/Optimization - from Core to Platform level

Geoscience, Life sciences, Energy/Environment

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Exascale computing research

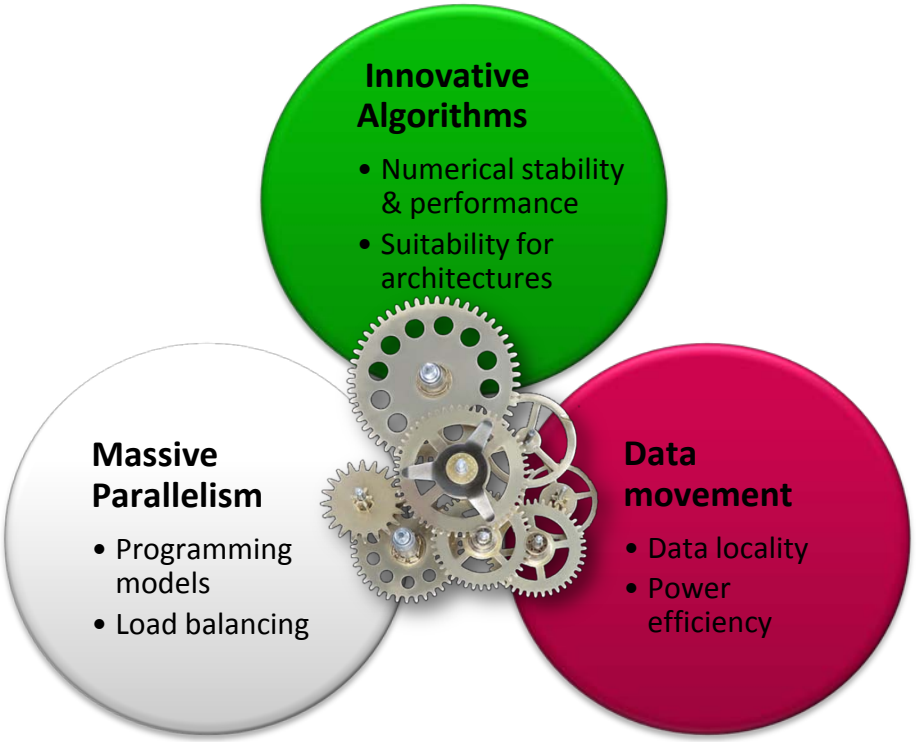
# Application co-Design at ECR

**Pave the way for Exascale science**

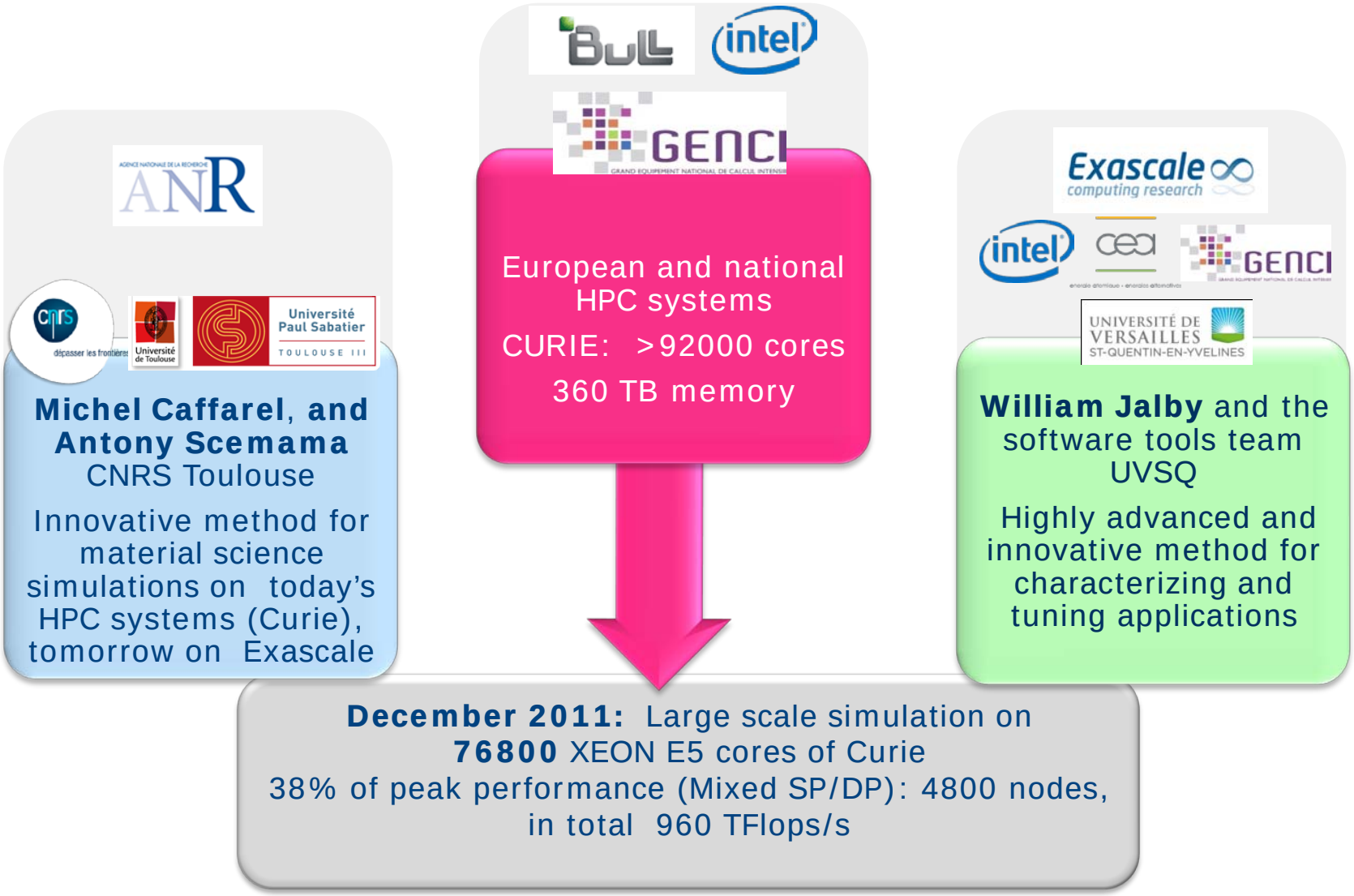
- Work with external scientists and partners
- Reach out to the community through Exascale app design guidelines

**Approach at ECR**

- Understand the **scientific trends** from today to 2018
- Characterize **relevant mini-apps** on existing HPC hardware and prototype
- Provide projections according to hardware trends
- Identify algorithm-specific bottlenecks for performance, power, resiliency, programmability, …



# Case study performance tuning

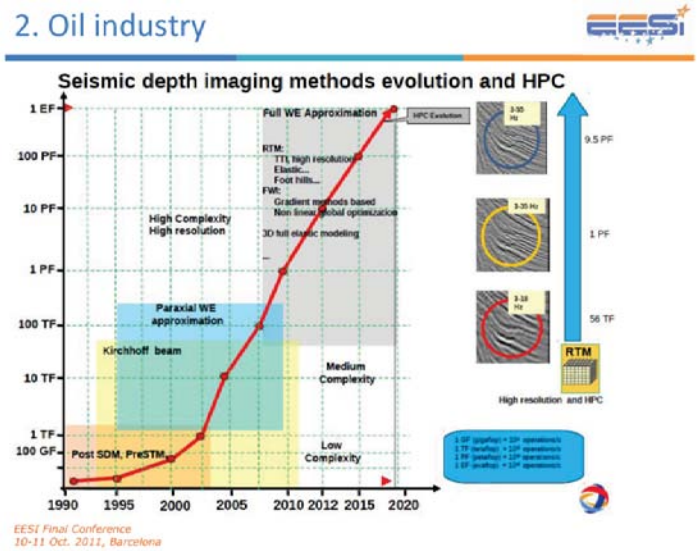


Exascale computing research

# Seismic Imaging at ECR

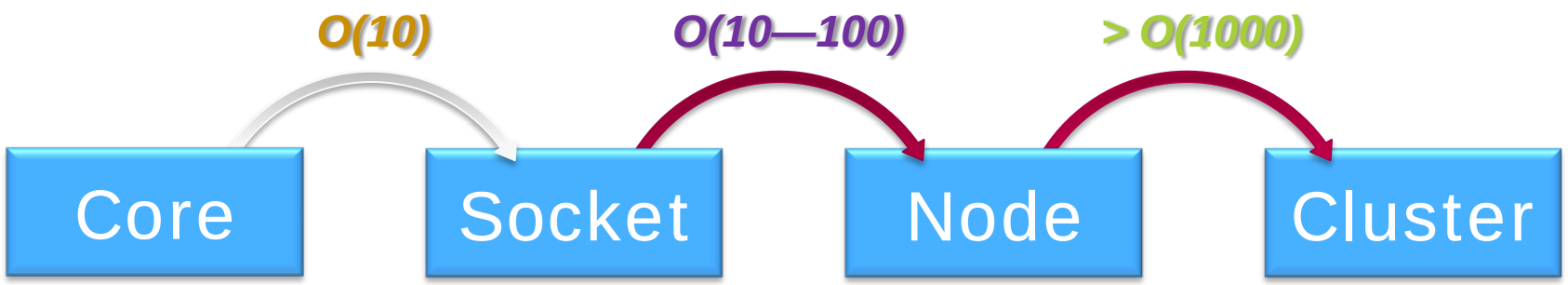
- Trends in seismic imaging
  - Tackle geophysical complexity
  - Exploit increasingly extensive amount of data from seismic acquisitions
  - Quantify uncertainty

- Collaboration goals
  - Characterize performance of seismic imaging kernels on current architectures
  - Help prepare for the future
    - Intel architectures, programming models
    - Numerical methods towards exascale seismic modeling



Exascale computing research

# Key Performance Factors for Seismic Inversion




Wave equation scheme

**Where is the parallelism?**

- Shots are independent
- Within a shot: speed up forward computation in parallel

- Ideal configuration: 1 shot / 1 node
- Memory requirements → # nodes

Boundary regions (PML) imbalance

MPI, domain decomposition

I/O scheme

# Spain: Intel and BSC Exascale Lab

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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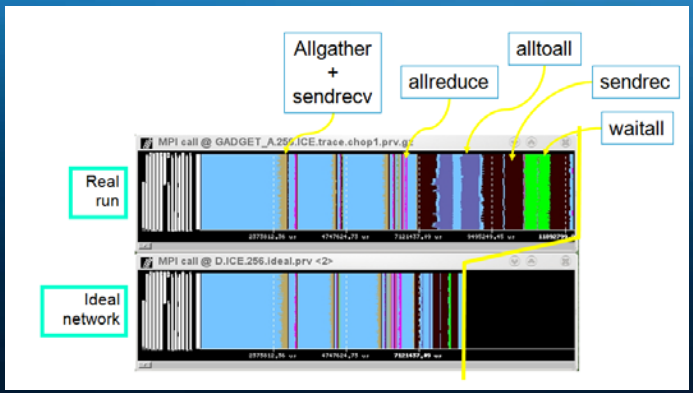
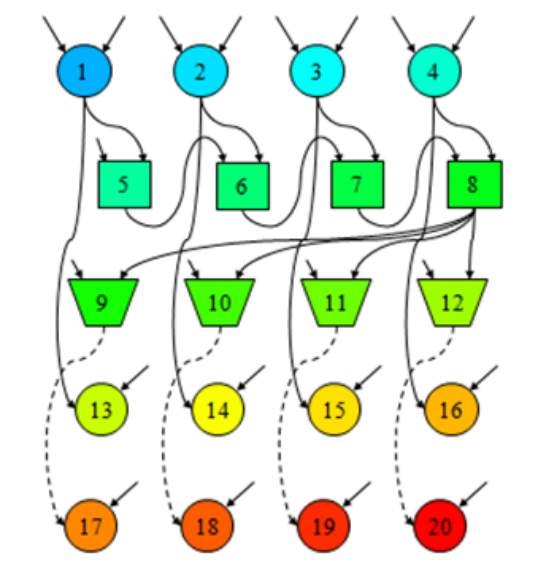
Scalable Performance tools

Scalable Run-time System

New Algorithms

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# Germany: Jülich ExaCluster Laboratory

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JÜLICH FORSCHUNGSZENTRUM

PARTEC CLUSTER COMPETENCE CENTER

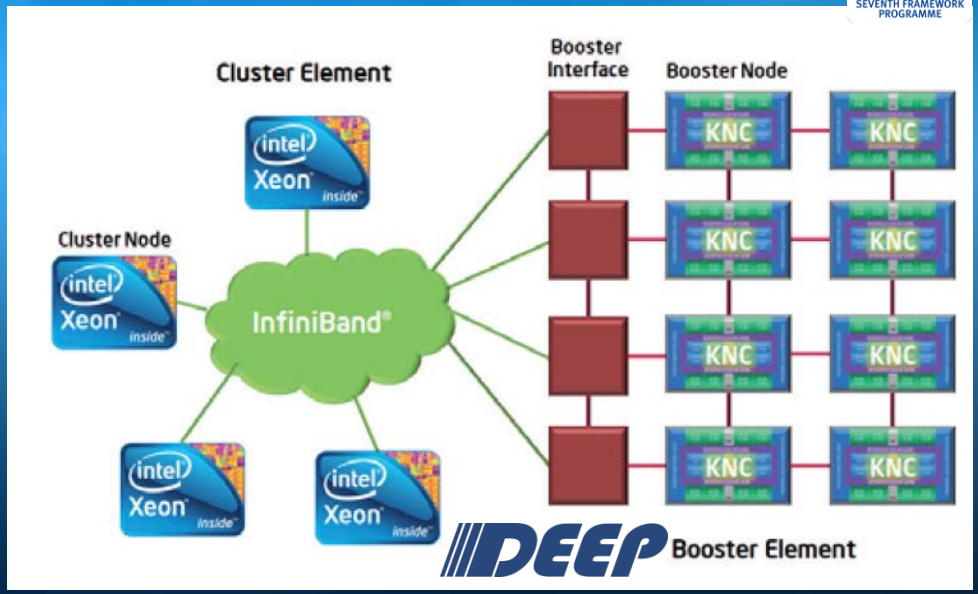
SW Scalability and Resilience

Exascale Cluster Architecture

Exascale Simulation and Tools

## The DEEP Architecture

SEVENTH FRAMEWORK PROGRAMME

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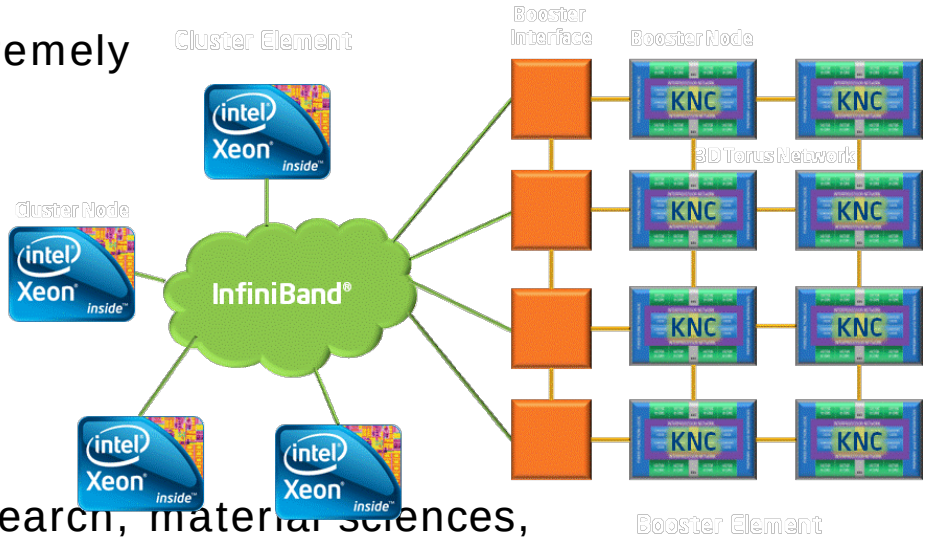
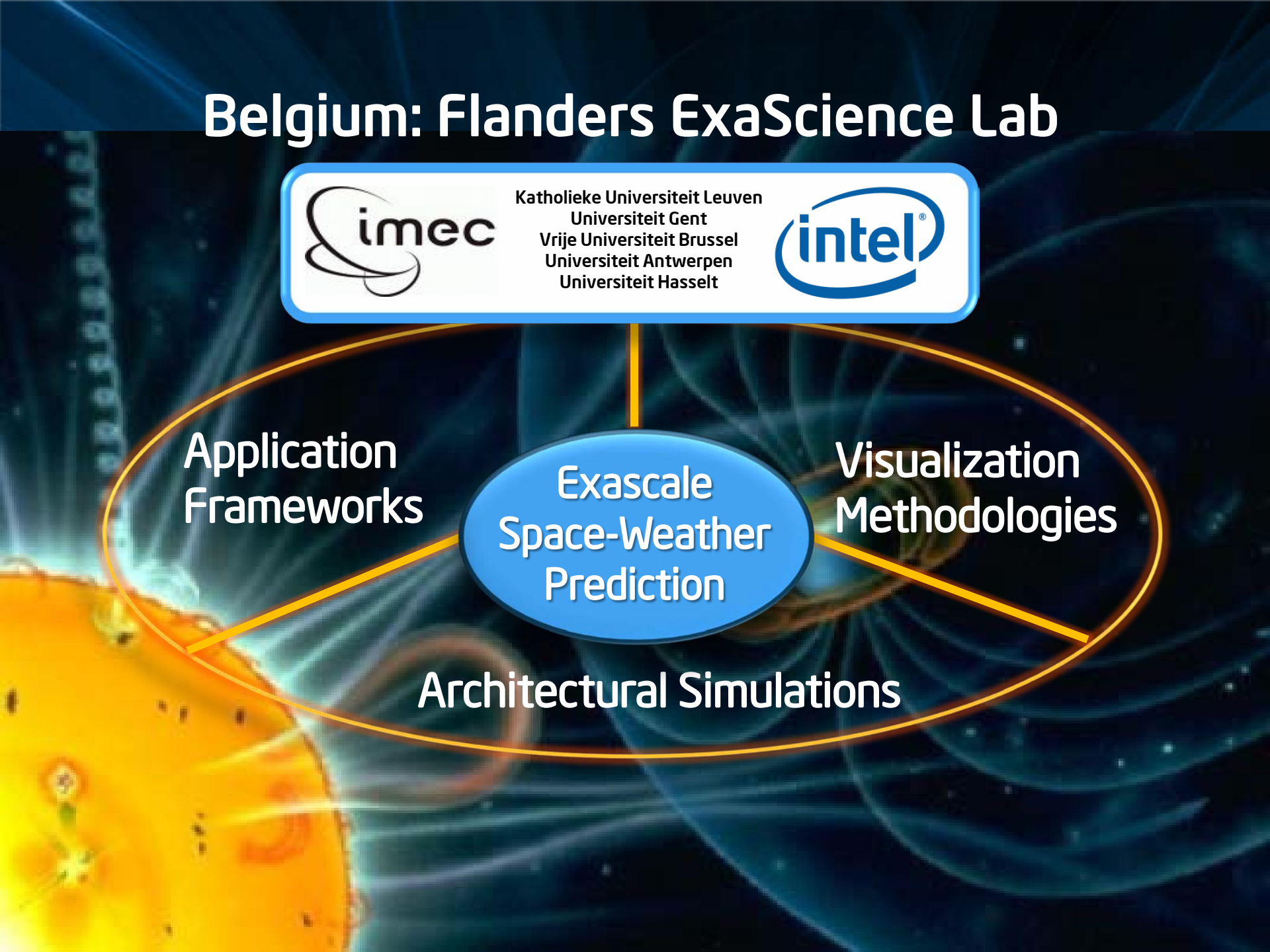
# DEEP – Dynamic Exascale Entry Platform

- Exascale prototype platform
  - Combine Intel® Xeon Cluster with extremely scalable Cluster of Intel® KNC boards
  - Achieve high packaging and energy efficiency by hot water cooling
- Runtime system and programming environment
  - Evolution of OmpSS model
- Six pilot applications
  - Life sciences, astrophysics, climate research, material sciences, engineering
- http://www.deep-project.eu

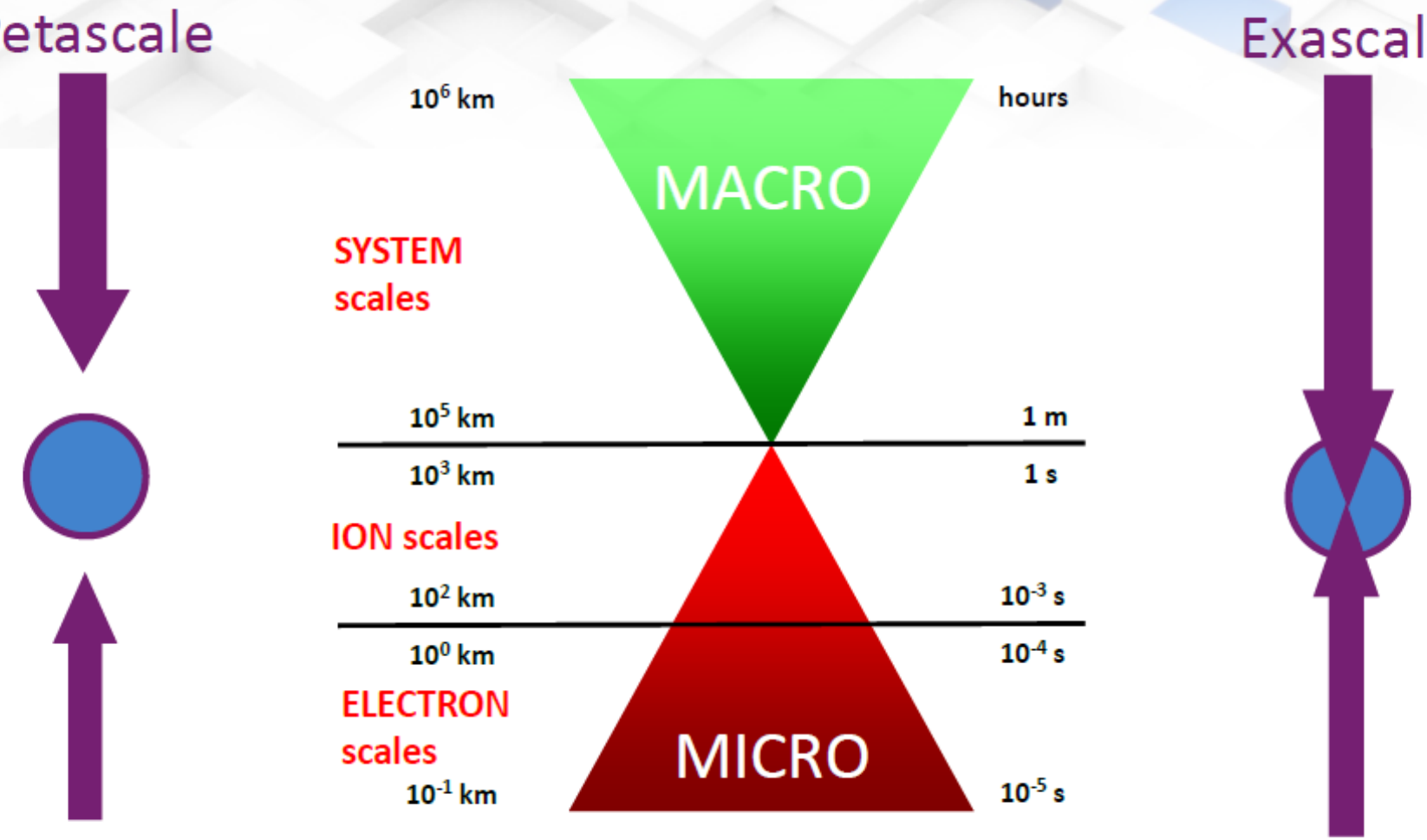



DEEP receives funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 287530

# Belgium: Flanders ExaScience Lab



# Multiscale – Multiphysics – Our Goals

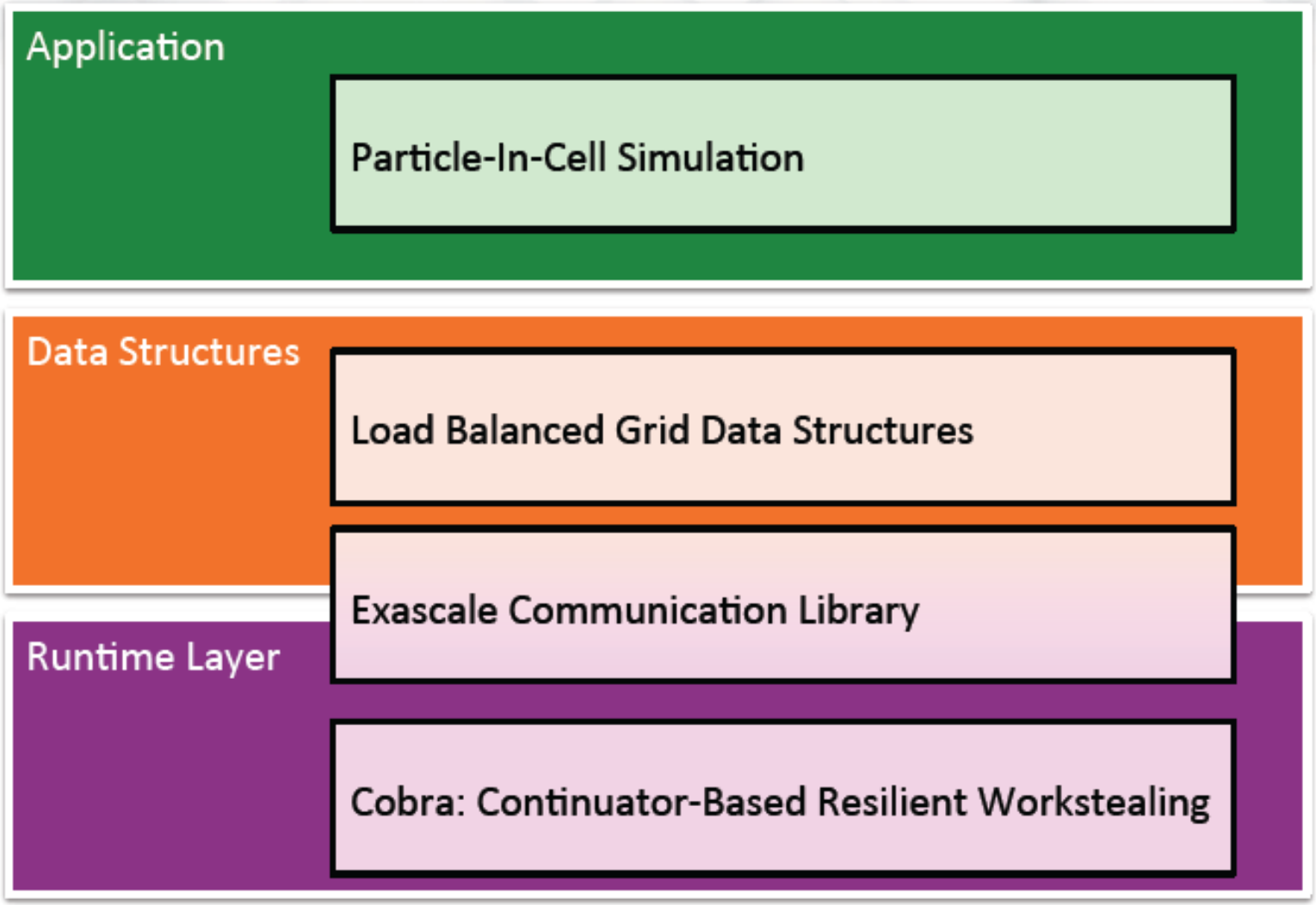



EXASCALE allows to bridge the micro-macro gap by increasing size and resolution by the needed 3 orders of magnitude

# OUTLINE


- Codesign
  - Algorithmic development
    - Implicit methods
    - Multilevel methods
  - Hardware Needs
    - Can the model be run on petascale?
    - Can the model be run on exascale?

# INFRASTRUCTURE



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- Michel Caffarel, CNRS and University of Toulouse, William Jalby, UVSQ and ECR Lab Chief Technologist


- More Information on
  - www.exascale-labs.eu
  - www.exascale-computing.eu
  - www.exascience.com