Activity report for the period 2005-2012 prepared for the audit of the School of Basic Sciences (FSB)

Chair of Modelling and Scientific Computing

Alfio Quarteroni
November 20, 2012

EPFL, Lausanne (Switzerland)
MATHICSE Mathematics Institute of Computational Science and Engineering
People
## Current Senior scientists

<table>
<thead>
<tr>
<th>Name</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simone Deparis</td>
<td>1/8/06</td>
<td></td>
</tr>
<tr>
<td>Luca Dedè</td>
<td>15/8/11</td>
<td></td>
</tr>
<tr>
<td>Ricardo Ruiz Baier</td>
<td>1/2/09</td>
<td></td>
</tr>
<tr>
<td>Aymen Laadhari</td>
<td>1/9/11</td>
<td></td>
</tr>
<tr>
<td>Toni Lassila</td>
<td>1/12/10</td>
<td></td>
</tr>
<tr>
<td>Cristiano Malossi</td>
<td>1/10/12</td>
<td></td>
</tr>
</tbody>
</table>

**Prev. affil.**
- MIT
- ICES Univ. Texas, Austin
- Univ. Concepcion
- LJK Grenoble I
- Aalto Univ. Helsinki
- CMCS

## Former Senior scientists

<table>
<thead>
<tr>
<th>Name</th>
<th>Start Date</th>
<th>End Date</th>
<th>Previous Affiliation</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Matteo Astorino</td>
<td>1/5/10</td>
<td>31/4/11</td>
<td>INRIA Paris</td>
<td>Symetis S.A.</td>
</tr>
<tr>
<td>Erik Burman</td>
<td>1/10/02</td>
<td>31/10/07</td>
<td>EPFL</td>
<td>Univ. Sussex</td>
</tr>
<tr>
<td>Paolo Crosetto</td>
<td>1/10/11</td>
<td>31/7/12</td>
<td>CMCS</td>
<td>JSC Jülich</td>
</tr>
<tr>
<td>Davide Detomi</td>
<td>1/4/04</td>
<td>31/11/09</td>
<td>MOX Milan</td>
<td>CD-adapco</td>
</tr>
<tr>
<td>Marco Discacciati</td>
<td>1/7/07</td>
<td>31/3/11</td>
<td>RICAM Linz</td>
<td>UPC Barcelona</td>
</tr>
<tr>
<td>Gilles Fourestey</td>
<td>15/11/08</td>
<td>31/08/10</td>
<td>LJK Grenoble I</td>
<td>CSCS Lugano</td>
</tr>
<tr>
<td>Nicola Parolini</td>
<td>1/12/04</td>
<td>30/6/07</td>
<td>CMCS</td>
<td>MOX Milan</td>
</tr>
<tr>
<td>Christophe Prud’homme</td>
<td>1/10/03</td>
<td>31/8/06</td>
<td>Paris VI</td>
<td>Univ. Strasbourg</td>
</tr>
<tr>
<td>Gianluigi Rozza</td>
<td>1/5/08</td>
<td>10/10/12</td>
<td>MIT</td>
<td>SISSA Trieste</td>
</tr>
</tbody>
</table>
# PhD students

## Past (14)

- **Rozza Gianluigi**: Shape design by optimal flow control and reduced basis techniques: applications to Haemodynamics. 2005
- **Mastalli Diego**: Optimal control of mass transfer in peritoneal dialysis. 2006
- **D'Angelo Carlo**: Multiscale modelling of metabolism and transport phenomena in living tissues. 2007
- **Sapelza Klaus**: Multilevel preconditioners for elliptic problems with multiple scales. 2007
- **Winkelmann Christoph**: Interior penalty finite element approximation of NS equations and application to free surface flows. 2007
- **Stamm Benjamin**: Stabilization strategies for discontinuous Galerkin methods. 2008
- **Quaini Annalisa**: Algorithms for fluid-structure interaction problems arising in Haemodynamics. 2009
- **Pena Gonçalo**: Spectral element approximation of the incompressible NS equations in a moving domain and applications. 2009
- **Crosetto Paolo**: Fluid-Structure Interaction problems in Haemodynamics: parallel solvers, preconditioners, and applications. 2011
- **Manzoni Andrea**: Reduced Models for optimal control, shape optimization and inverse problems in Haemodynamics. 2012
- **Malossi Cristiano**: Partitioned solution of geometrical multiscale problems for the Cardiovascular system. 2012
- **Quinodoz Samuel**: Numerical simulation of Orbitally Shaken Reactors. 2012
- **Iapichino Laura**: Reduced Basis methods for parametrized PDEs in repetitive and complex networks with application to CFD. 2012

## Ongoing (9)

- **Popescu Radu**: 2010 from Universitatea Politehnica din Bucuresti. Parallel algorithms and implementation techniques for FE modelling.
- **Grandperrin Gwenol**: 4/2010 from EPFL. Scalable preconditioning techniques for Navier-Stokes equations.
- **Colciago Claudia**: 11/2011 from Politecnico di Milano. Reduced order models for FSI problems in Haemodynamics.
- **Chen Peng**: 3/2011 from EPFL. Uncertainty quantification for stochastic PDEs.
- **Negri Federico**: 5/2012 from Politecnico di Milano. Reduced basis for optimal control.
- **Forti Davide**: 11/2012 from Politecnico di Milano. Domain decomposition based FSI algorithms for highly nonlinear elastic arterial models.
Teaching
Numerical Analysis.
Quarteroni, from 2005-06 to 2011-12, in the Bachelor programs in Mathematics and Life Sciences;
Deparis, Ruiz-Baier, in 2012-13, in the Bachelor programs in Mathematics and Life Sciences;
Burman, Deparis, Discacciati, Quarteroni, Rozza, from 2005-2006 to 2009-10;
in the Bachelor programs in Civil, Electrical, Environmental, Mechanical, Material Engineering,
Micro-Engineering, and Informatics.

Introduction to the Finite Elements Method.
Quarteroni, since 2005-06, Burman, (in 2006-07), in the Bachelor programs in Mathematics and Physics (in 2005-06); in the Master programs in Financial Engineering (in 2008-09) and Computational Science and Engineering (since 2009-10).

Numerical Approximation of PDEs.
Burman, Deparis, Discacciati from 2005-06 to 2010-11, in the Bachelor (in 2005-06 and 2006-07) and Master programs in Mathematics, Applied Mathematics (since 2010-11), Financial Engineering (in 2008-09) and Computational Science and Engineering (since 2009-10).

Geometry.
Deparis, since 2012-13, in the Bachelor program in Mechanical Engineering.
Bachelor’s and Master’s courses

**Numerical Analysis and Computational Mathematics.**

_Dedè, Deparis_ since 2009-10, *in the Master program in Computational Science and Engineering.*

**Programming Concepts in Scientific Computing.**

_Deparis_, since 2012-13, *in the Master program in Computational Science and Engineering.*

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**Semester Projects.**

_Burman, Dedè, Deparis, Discacciati, Quarteroni, Rozza_, since 2005-06, *in the Bachelor and Master programs in Mathematics, Applied Mathematics, Computational Science and Engineering, Life Sciences, and Engineering.*

**52 projects** since 2005-06, **6** currently *in progress:*

- 2005-06: 1
- 2006-07: 4
- 2007-08: 8
- 2008-09: 9
- 2009-10: 11
- 2010-11: 5
- 2011-12: 14
Advanced Topics in Numerical Modelling of PDEs.
Discacciati, Quarteroni, Rozza, in 2009-10; in the Doctoral program in Mathematics.
Dedè, Quarteroni, Rozza, in 2011-12; in the Doctoral program in Mathematics.

Computational Mechanics by Isogeometric Analysis.
Dedè, since 2012-13; in the Doctoral program in Mathematics.

Computational Mechanics by Reduced Basis Methods.
Rozza, from 2008-09 to 2011-12; in the Doctoral programs in Mathematics and Mechanical Engineering.

Mathematical Modelling and Numerical Simulations I.
Quarteroni, in 2009-10; in the Doctoral program in Mathematics.

Mathematical Modelling and Numerical Simulations II.
Quarteroni, in 2010-11; in the Doctoral program in Mathematics.

The courses can be selected also as optional Master courses for Mathematics and Applied Mathematics programs.
Master’s projects & theses, internships/stages

**Master Projects at EPFL:** 15 since 2005
- 2005: 3 - O. Grandjean, B. Stamm, L. Walter;
- 2006: 1 - G. Steiner;
- 2008: 1 - A. Maurice;
- 2009: 1 - S. Quinodoz;
- 2010: 4 - G. Grandperrin, F. Gelsomino, L. Lakatos, M. Rime;
- 2011: 1 - P. Chen;

**Master Thesis in exchange at EPFL:** 18 since 2005
- 2005: 2 - S. Invernizzi and A. Quaini (*from Politecnico di Milano*);
- 2006: 1 - R. Milani (*from Politecnico di Milano*);
- 2007: 1 - F. Polidoro (*from Politecnico di Milano*);
- 2008: 2 - D. De Santis and M. Perrone (*from University of Rome Tor Vergata*);
- 2009: 2 - C. Günther (*from RWTH Aachen*), C. Marchesini (*from Politecnico di Milano*);
- 2010: 3 - D. Lupo Conti, A. Trezzini, and S. Zampini (*from Politecnico di Milano*);
- 2011: 3 - D. Baroli (*Insubria University, Como*), A. Koshakj and F. Negri (*from Politecnico di Milano*);
- 2012: 4 - D. Forti (*from Politecnico di Milano*), P. Pacciarini (*from University of Pavia*),
  A. Tagliabue (*from Insubria University, Como*), W. Wriggers (*from University of Rostock*).

**Mentoring of Master Projects, Internships, and Stages outside EPFL**
*(Academy and Industry).* In the **Master programs in Mathematics, Applied Mathematics, Computational Science and Engineering.**

**Internships and Stages at EPFL:** 2 in 2012

*Wednesday, November 21, 2012*
Publications and awards
Highlighted honors and awards

**Quarteroni:**
- SIAM Fellow (2009-)
- Member of SIAM Board of Trustees (2009-)
- Fellow of the European Academy of Sciences (2010)
- Member of Accademia Nazionale dei Lincei, Roma (Italian National Academy of Sciences), (2004-)
- Member of the Lombard Academy of Science (Istituto Lombardo di Scienze e Lettere) (1995-)
- Appointed as Expert of SATW (the Swiss Academy of Engineering Sciences) (2012-)
- Plenary Speaker at the International Congress of Mathematicians, Madrid (2006)
- Fanfullino d’oro della Riconoscenza, Città di Lodi (2006)
- Premio Scientifico Capo D'Orlando, Museo Mineralogico Campano (2006)

**Rozza:**
- ECCOMAS best Ph.D. thesis 2005
- Springer CSE prize 2009

**Manzoni:**
- BGCE Student Paper Prize, SIAM CS&E Conf., Reno USA, 2011
External grants and funding
## Grants 2005-2012: Organized by funding source

### ERC:
- **Advanced grant Mathcard:** Mathematical modeling and simulation of the cardiovascular system (2009-2013)
- **Proof-of-concept grant MATH2WARD:** (2013)
- **FP7 ICT project VPH2:** Virtual pathological heart (2008-2011)
- **Haemodel:** Mathematical model of haemodynamics (2002-2006)

### CTI:
- **Chronodial:** Partnership with Debiotech SA & Insel Hospital (2003-2005)
- **Alinghi-EPFL:** Yacht design and simulation (2001-2007)

### Swiss National Science Foundation (NSF):
- **Interface operators for FSI and applications** (2005-2007)
- **FEM for Navier-Stokes equations with free surface** (2006-2007)
- **C/DG FE approximation of differential problems with multiple scales in heterogeneous media** (2006-2008)
- **Interface operators and solution algorithms for FSI problems with applications** (2008-2010)
- **Reduced basis methods for the optimization of complex systems** (2009-2011)
- **Synergia:** Orbitally shaken bioreactors (2009-2012)
- **Numerical simulation of sailing boat: dynamics and shape optimization** (2011-2013)
- **Domain-Decomposition-Based FSI algorithms for highly nonlinear and anisotropic elastic arterial wall models in 3D for the prediction of transmural stress-distributions** (2012-2015)
- **Model reduction strategies for control, optimization and uncertainty quantification of parametrized systems** (2012-2015)

### Others:
- **HP2C:** HPC for cardiovascular system simulation (2010-2012)
- **IST Lisbon-EPFL initiative:** 2 ongoing PhD theses
- **LNCC Brazil-EPFL joint project:** Modeling and simulation of human cardiovascular system with applications to diagnosis, treatment and surgical planning of cardiovascular diseases (2010-2012)
- **Icare project:** Solar impulse (2004-2007)
- **SRE project:** Sport and rehabilitation engineering (2004-2007)
Main collaborations
Collaborations and synergies

**Collaborations within EPFL:**
- LBTC (Biotechnology)
- LCSB (Systems biotech)
- LMH (Hydraulic machines)
- LTC (Material science)
- LTS4 (Signal processing)

**Industrial and academic partners in CH:**
- Insel Hospital (Bern)
- Debiotech SA
- Alinghi
- CHUV - UNIL
- Solar impulse

**Collaborations with ETH domain**
Several research projects with CSCS

**International collaborations:**
- U Texas
- Imperial College
- MIT
- Campus Biomedico
- SANDIA Labs
- U Grenoble I
- Politecnico Milano
- IST Lisbon
- Paris VI
- LNCC Brazil
- Emory U
- U Concepcion
Methodologies
• **Isogeometric** concept: the basis functions are used for the geometry representation and then also for the Analysis.

• Encapsulation of the **exact** geometry representation in the Analysis.

• **Smooth** basis functions (**NURBS**, basis for CAD)

\[
\text{IGA, } p = 2, \text{ globally } C^1
\]

\[
\text{NURBS vs FEA, Laplace problem}
\]

\[
\text{FEA : } n = (pn_{el} + 1)^d \\
\text{IGA : } n = (p + n_{el})^d
\]
Isogeometric Analysis

Numerical Approximation of High Order PDEs

Bilaplacian / Elastic Plate model

Navier-Stokes equations in stream function formulation

Re = 5,000

Streamlines

Re = 1,000

Lid driven cavity problem

Vorticity

Wednesday, November 21, 2012
Numerical Approximation of PDEs on surfaces

**Laplace-Beltrami equation on a sphere**

find $u : \Omega \rightarrow \mathbb{R}$ s.t.:

$$-\Delta_{\Omega} u = f \quad \text{on } \Omega,$$

$$\int_{\Omega} u \, d\Omega = 0.$$
Heterogeneous PDEs and Virtual Control

Heterogeneous problems

Coupling of Navier-Stokes & Darcy problems

Domain Decomposition Methods

Geometrical Multiscale Modeling

\[ \Gamma_1 = \{ z = L \} \quad \Omega_2 \subset \mathbb{R}^3 \]

\[ \Omega_1^{Red} = (0, L) \]

\[ \Gamma_2 \subset \mathbb{R}^2 \]
Virtual Control with overlap

\[ \begin{align*}
A_1 u_1 &= f \quad \text{in } \Omega_1 \\
b.c. &= \text{on } (\partial \Omega_1 \setminus \Gamma_1)_{in} \\
u_1 &= \lambda_1 \quad \text{on } \Gamma_{in} \\
A_2 u_2 &= f \quad \text{in } \Omega_2 \\
b.c. &= \text{on } \partial \Omega_2 \setminus \Gamma_2 \\
u_2 &= \lambda_2 \quad \text{on } \Gamma \\
\end{align*} \]

\[ J(\lambda_1, \lambda_2) = \int_{\Omega_{12}} (u_1 - u_2)^2 \]

\( \lambda_1, \lambda_2 \) solutions of the MINIMIZATION PROBLEM

Virtual Control without overlap

\[ \begin{align*}
A_1 u_1 &= f \quad \text{in } \Omega_1 \\
b.c. &= \text{on } (\partial \Omega_1 \setminus \Gamma)_{in} \\
u_1 &= \lambda_1 \quad \text{on } \Gamma_{in} \\
A_2 u_2 &= f \quad \text{in } \Omega_2 \\
b.c. &= \text{on } \partial \Omega_2 \setminus \Gamma \\
u_2 &= \lambda_2 \quad \text{on } \Gamma \\
\end{align*} \]

\[ J(\lambda_1, \lambda_2) = \int_{\Gamma} (u_1 - u_2)^2 \]

\( \lambda_1, \lambda_2 \) solutions of the MINIMIZATION PROBLEM
Fluid problem: \( F(u, p; w, d) = 0 \) in \( \Omega_F(t) \)
Structure Problem: \( S(d; u, p) = 0 \) in \( \Omega_S(t) \)
Fluid mesh motion: \( M(\eta; d) = 0 \) in \( \Omega^0_F \)

Kinematic cond.: \( u = \dot{d} \) on \( \Gamma(t) \)
Dynamic cond.: \( \sigma_F(u, p)n_F = \sigma_S(d)n_S \) on \( \Gamma(t) \)
Geometric cond: \( \eta = d \) on \( \Gamma^0 \)

Preconditioners (either Monolithic and Segregated) based on:

- LDU factorization between fluid and solid,
- Specialized parallel preconditioners for fluid, solid and geometry respectively.
Reduced Order Models (ROMs) - Reduced Basis Method (RBM)

Discretization of a PDE using localized basis functions (FEM) leads to a sparse but very large linear system

\[ \mathbf{A}_h \mathbf{u}_h = \mathbf{f}_h \]

Sampling the parametric manifold of solutions to find a set of representative solutions ("snapshots")

\[ \mathbf{a}(\mathbf{u}_h, \mathbf{v}_h) = \mathbf{f}(\mathbf{v}_h) \quad \forall \mathbf{v}_h \in X_h \]

Projection of full-scale linear system to the reduced basis performed in an offline step

\[ \mathbf{A}_h \mathbf{Z}_N^T \mathbf{u}_N = \mathbf{Z}_N^T \mathbf{f}_h \]

\[ \mathbf{a}(\mathbf{u}_N, \mathbf{v}_N) = \mathbf{f}(\mathbf{v}_N) \quad \forall \mathbf{v}_N \in X_N \]

\[ \dim(X_N) \ll \dim(X_h) \]

Basis functions formed by snapshot solutions (RBM) lead to a dense but very small system
Reduced Order Models (ROMs) - Methodological developments

**THEORY**

\[ \| u_h - u_N \| = ? \]

Error estimators for nonlinear flow problems (A. Manzoni, G. Rozza)

\[ Y_i(\mu_i) = X_i + \mu_i \]

Geometric mappings and nonaffine parameterizations (T. Lassila, A. Manzoni)

Optimal control and shape design with reduced order models (A. Manzoni, F. Negri)

Reduced basis element domain decomposition method (L. Iapichino, G. Rozza)

Inverse problems and uncertainty quantification (T. Lassila, A. Manzoni)

**APPLICATIONS**
Software tools
Tools

LifeV
Multiscale finite element library
(lifev.org)

Paraview
Parallel Visualization Application
(paraview.org)

rbMIT © MIT Software

Finite volume library

OpenFOAM
(openfoam.org)

Vascular Modeling Toolkit
(vmtk.org)

Computational geometry and mesh

GMSH
(geuz.org/gmsh/)

rbMIT © MIT Software
Applications
Devices used to produce therapeutic proteins from mammalian cells.

- Shaking motion induces mixing and gas transfer between phases, but increases the stress on the cells;
- Different motion regimes stimulated by the shaking motion and rates.

Free surface
Acceleration from 0 to 60 RPM in 1 second.
Coarse (left) and fine (right) Finite Elements meshes.

Camera rotating with the OSR.
Orbitally Shaken Reactors (OSR)

Prediction and evaluation of the **mixing patterns** of the cells (particles) and properties of the OSR; calculation of the **interface area** (free surface) and other quantities of interest.

Solution of **interface problems**.

\[-\Delta u = f \text{ in } \Omega_i\]
\[u = 0 \text{ on } \partial\Omega\]
\[
\begin{bmatrix}
[u] = g_d \text{ on } \Gamma \\
\left[ \frac{\partial u}{\partial n} \right] = g_n \text{ on } \Gamma
\end{bmatrix}
\]

Different colors refer to different injection times of the particles.

Time: 50.000 (s)
Cardiovascular Applications

Aortic Arch

- Fluid mesh boundary layer (4 layers) proportional to the local vessel radius
- Mesh element size also radius-dependent
- Structure (4 layers) proportional to the local vessel radius
Cardiovascular Applications

LifeV

P. Crosetto (CMCS)

Time: 0.00
Cardiovascular Applications

Models:
- 3-D FSI Aorta
- 1-D arterial tree
  - 92 tapered elements
  - viscoelastic wall
- 0-D terminals
  - 47 Windkessel elements (RCR)

Coupling:
- Averaged/integrated quantities at the interfaces (flow rate or normal stress)
- Segregated approach for the solution of the coupled problem (Newton, inexact-Newton, or Broyden methods)
Time: 0.005 (s)

Pressure (dyn/cm²)
180000
175000
160000
150000
125000
100000
75000
60000

LifeV

Displacement (cm)
0.1
0.2
0.3
0.4

Velocity (cm/s)
25
50
75
100
120

1D-3D coupling

Cristiano Malossi @ CMCS

Wednesday, November 21, 2012
Yacht Engineering and design

Initial Concept → CAD Geometry

Numerical → New → Mesh
**Fluid-Structure Interaction (FSI)**, boat dynamics, free surface models, turbulence models.

(Alinghi SUI 100 - 2007)
Full FSI models for wind-sails simulations (M. Lombardi, N. Parolini):
• Shell model (MITC4) for the sails; Navier-Stokes+SST turbulence model for the fluid;
• Radial basis functions for transfer of loads between fluid and solid;
Solar Impulse

Flying without polluting

Bertrand Piccard & EPFL partnership
Solar Impulse

Numerical Fluid Dynamics Simulations

Multi-objective Optimization

Pareto curve, Structural weight vs. minimum night altitude

Altitude

Time (24h)
Highlights on some current research lines
Left ventricle is the chamber responsible for pumping oxygenated blood into the major organs and is driven by electromechanically activated contraction.

Cardiac tissue consists of cardiomyocytes aligned in the direction of fibers and collagen sheets, and is modelled using nonlinear orthoropic material laws.
Integrated model of the heart - Physiological aspects

- Resynchronization therapies
- Hypertrophy (concentric, eccentric) of the muscle
- Myocardial scarring and heterogeneities (influence on the ventricular flow dynamics, tissue elastic properties and reduced conductivity)

- Altered patterns of electrical signals may originate arrhythmias, yielding an ineffective mechanical contraction and poor fluid ejection volume.
Strongly coupled physical systems representing challenging frameworks on their own

- PDEs for electro-physiology
- ODEs for ionic activity
- PDEs for fluid dynamics
- PDEs for nonlinear elasticity
- Activation generation

Cardiac electro-fluid-structure coupling

[Ca]^{2+}
Integrated model of the heart - Cardiac electromechanics

**Models:**
- Orthotropic hyperelastic passive material
- Thermodynamically consistent anisotropic activation mechanism
- Bidomain equations for the electrophysiology

**Coupling:**
- Segregated approach for the solution of the electromechanics (Newton method and Picard iterations)
Integrated model of the heart - Fluid dynamics of the ventricle

Comparison of boundary condition effects on flow in patient-specific left ventricle

Time: 2.89

LifeV
MATH2WARD - Tools for real-time clinical applications

**OFFLINE**
- Long Time
- Large Device

**Simulation Database**

**Clinical Database**

**Statistical Database**

**ONLINE**
- Real Time
- Small Device

**Parametrization**

**Simulation**
Example of clinical interest - Real-time stroke risk prediction

- Atherosclerosis is a degenerative disease resulting in stiffening of the arteries and plaque buildup inside the lumen.
- Symptoms include stenosis (narrowing of arteries), embolisms (clogging), and thrombosis (formation of blood clots).
- In the worst case can lead to transient ischemic attacks, where plaque is dislodged and travels into the brain causing a stroke.
- About 60% of people aged 65-74 exhibit (asymptomatic) atherosclerosis of the carotid artery.

**Objective:** Develop noninvasive procedures relying on medical imaging techniques and computational simulations for real-time risk evaluation of asymptomatic carotid artery stenoses.
Reduced Order Models (ROMs) - Stenotic artery flow prediction

- Inverse shape and flow identification problem in patient-specific carotid artery
- Carotid bifurcation described by two parameters (CCA/ICA diameters)
- FEM solution time = 18 min, RBM solution time = 2 sec

\[ \text{FEM: } \dim(X_h) \approx 3 \cdot 10^5 \]
\[ \text{RBM: } \dim(X_N) = 15 \]
CADMOS
CADMOS - HPC collaborative

CADMOS
(Center for Advanced Modeling Science)

- Lemanic region collaboration
- Develops CSE competences
- New CSE chairs
- A 4096 nodes (4 racks) IBM BG/P, soon replaced by a BG/Q
- Lemanic (Vaud and Geneva cantons) contribution to the national HPCN strategy

UNIVERSITÉ DE GENÈVE

Unil | Université de Lausanne

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Alfio Quarteroni

EPF Lausanne

Wednesday, November 21, 2012
Organization

**Directive board**
- A. Quarteroni (Director)
- B. Chopard (President)
- K. Holliger
- G. Margaritondo
- O. Michielin
- G. Ritschard

**Steering Committee**
- Ph. Moreillon
- J-J. Paltenghi
- P. Spierer

**Council**
- P. Aebischer (EPFL)
- D. Arlettaz (UNIL)
- J-D. Vassalli (UNIGE)
CADMOS projects

- BlueBrain Project
- Computational chemistry
- Biophysics & Biochemistry
- Medical application
- CFD
- Plasma physics
- Atomic-scale phenomena
- Geophysics
- Mechanical engineering

Percentage of total usage