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FRANCE 2030
PROGRAMME DE RECHERCHE
NUMÉRIQUE POUR L'EXASCALE

External Partners

Hélène Barucq
Christophe Prud'homme

Exa-MA Call for one PhD funding

Exa-MA Co-Funded PhD Call (2025)

New Call for 2025

- **Open to**: External partners (public/private) proposing **one PhD** project.
- **Funding**: 50% Exa-MA, 50% external partner.
- **Deadline**: **Friday, Jan 31, 2025 (5pm)**, PDF to *lucas.pernollet@cea.fr*.
- **Decision**: By **Feb 21, 2025**.

Key Selection Criteria

1. **Fit with Exa-MA** (research WPs, demonstrators, scientific goals).
2. **Relevance** & **non-overlap** with existing Exa-MA/NumPEx PhDs.
3. **Open Science** commitment (open-access publications, open-source software).
4. **Identified candidate** preferred (internships highly encouraged).

Exa-MA Co-Funded PhD Call (2025)

Application Details (One PDF)

- **Project Title, Keywords, Scientific Scope**
- **Work-Package Alignment** (Exa-MA WPs), demonstrators, software plans
- **Partners & License** info, **Timeline**
- **CV** of candidate (if identified)

Contact & Questions

- **Email**: *lucas.pernollet@cea.fr*
- **Institutions** eligible for Exa-MA side of funding:
  - Univ. Strasbourg | Inria | CEA | École Polytechnique | Sorbonne Université

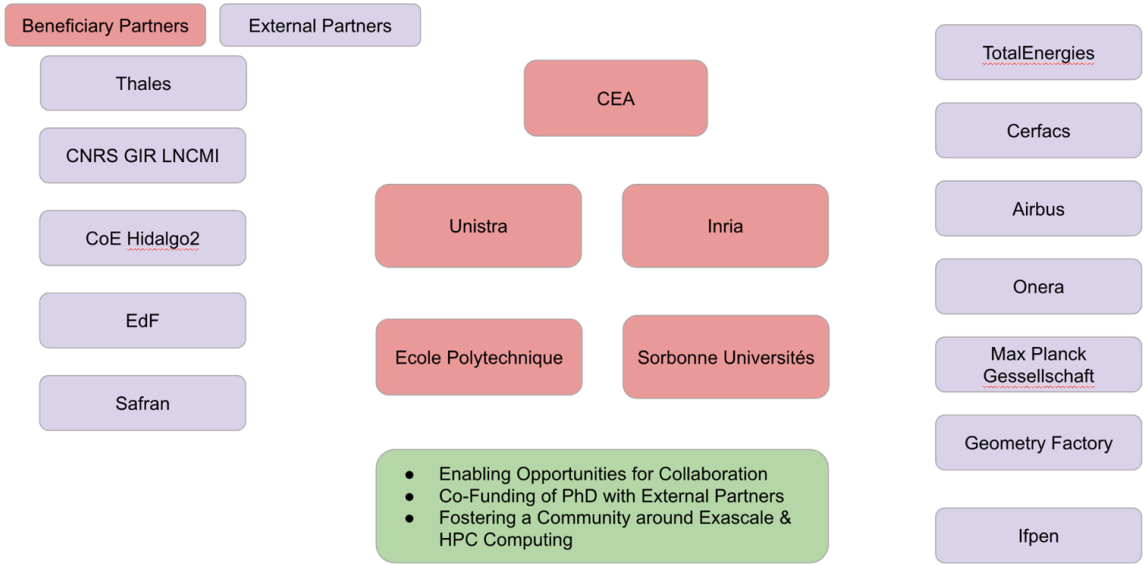
➢ Text of the Call

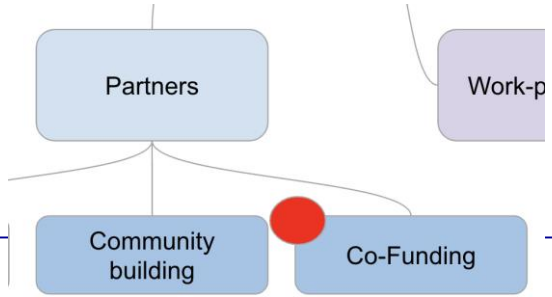
External Partners

Exa-MA co-funds 3 PhD thesis with

- **via 2 calls**
  - **Dec 2023**: 3 projects submitted
    - board composed of people from inside and outside NumPEx.
    - 2 projects co-funded
      - Ecole Polytechnique / ONERA
        High-order adaptive time coupling for multiphysics simulations
      - INRIA Alpines/ IFPEN+ONERA
        Neural Linear Solvers and Preconditioners for General Sparse Matrices
- **via existing half PhD funding**
  - INRIA Makutu/ TotalEnergies

A modular HPC-oriented Library for Numerical PDE resolution: from building blocks to AI-Dirven scheme Generation





Co-funding Opportunities & Half-PhD Funding

- Are there **specific research areas** (WP1–WP7) where you might co-fund a PhD or postdoc?
- What **challenges** do you foresee in setting up or managing such joint positions (e.g., administrative hurdles, timeline constraints)?
- How can we **maximize mutual benefits** (e.g., knowledge transfer, shared IP, extended collaborations) from a half-funded PhD?
- In what **timeframe** would you consider starting a co-funded project?

NumPEx Call for Projects

The NumPEx call

- **Total budget: 4MEuros/Up to 5 funded 4-years projects**

- **Single call with 3 different topics** :

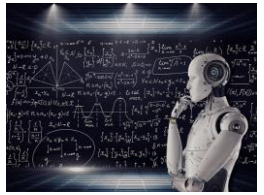
  1. AI4HPC – HPC4AI
     - SW for the efficient training of large-scale science-driven AI models
     - Open call for AI for HPC
  2. Programming models for accelerated architectures
  3. Efficient workflows for scientific data processing, the case of SKA

- **Details**:

  - Deadline : 1st of April 2025
  - All information and scientific document:

https://anr.fr/PEPR-NumPEx-AAP-2024

AI for HPC/HPC for AI

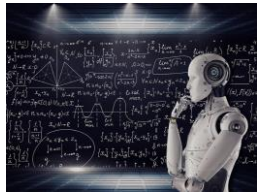


- **1st topic: open call on AI for HPC**
  - HPC codes and applications have an increasing complexity
  - Foster projects using AI to enhance the scalability and the efficiency of large-scale applications on exascale systems

  - **Example of focus areas:**
    - **AI for code optimization** (automated translatation, performance-specific optimization, performance bottleneck identification, test generation, etc)
    - **AI for enhanced I/O** (event tracking in massive data, anomaly detection, checkpoint optimisation, etc)
    - **AI for HPC/HPDA workflows** (AI-coupled HPC/HPDA workflows, automated configuration and workflow orchestration, …)
    - **… but this is an open call, which is not limited to these topics**

  - **1 4-years project with a budget between 500 and 800k€**

AI for HPC/HPC for AI



- **2nd topic: call on HPC for AI**
  - **HPC for the high performance training of large-scale science-driven AI models**
  - Improving the training efficiency of large AI models
    - Investigating training models beyond data parallelism: pipeline model parallelism, tensor parallelism, sequence and context paralellism, etc.
    - Asynchronous and decentralized optimizers
    - Improved communications
    - …
  - Deliver software building blocks that can be adapted to different architectures
  - Validation with an application demonstrator

  - **1 4-years project with a budget between 500 and 900k€**

Programming models for accelerated arch.

- **Call on improved programming models for accelerated architectures**
  - **Axis 1: Code generation for accelerated arch. ensuring performance portability**
    - Evaluation of a programming environment for designing application demonstrators capable of efficiently leveraging accelerated architectures
    - Code optimization for accelerators, particularly at the level of its intermediate representation within the context of kernels in the chosen prog. environment.
    - Scheduling of compute kernels on heterogeneous architectures
    - …
    - Priviledged framework is Kokkos, but alternatives could be considered if properly justified
  - **Axis 2: Evaluation of other programming models** (AI-based frameworks, accelerators other than GPUs, etc)
  - **Axis 3: Accelerating code porting for accelerated arch.**
  - **1 to 2 4-years projects with a budget between 500 and 1,8M€ (total budget)**

Efficient workflows for scientific data processing

- **Highly interoperable workflows for scientific data processing**
  - Focus on SKA, allowing diverse exascale data processing and analysis workflows across a continuum of HPC/Cloud infrastructures
  - **Co-develop and deliver interoperable HPC/HPDA/AI workflows** accounting for the diverse processing pipelines (data logistics and ingestion, processing, archiving, visualisation, etc) … **the goal is not to improving basic software components**.
  - Close collaboration with the French radio-astronomy community to build scientific workflows based on few diverse and relevant scientific use-cases., especially SKA-France, LOFAR/NenuFAR
  - Interaction with French national and regional computing centers and data centers
  - As a co-developement activity, a strong interaction with Exa-AToW and Exa-DI projects is expected; the hired team is expected to be integrated in the NumPEx computation and data team (CDT).
  - **1 4-years project with a budget between 500 and 550k€**

Guidelines

- **Eligibility**:
  - All French academic are elegible beneficiary partners
  - Industrial and international partners are welcome, but won't be beneficiary partners
  - NumPEx beneficiary partners are elegible

- **Teams and project:**
  - The goal is to build well-structured and coherent projects (not the aggregation of independent contributions)
  - Only few large projects will be funded

- **Integration within NumPEx:**
  - The goal of the AAP is to complement the NumPEx program, **the integration with NumPEx is key**
  - It is expected that **the projects will be transverse to different NumPEx projects**
  - **Need to propose an integration plan**:
    - with the **existing NumPEx projects**
    - NumPEx aims at delivering software components; **integration within the NumPEx software production**
    - with the **NumPEx software/application co-design activity (Exa-DI project)**; propose application demonstrators, etc.

Further questions

- **Don’t hesitate to get in touch with:**
  - **the AAP contact point:**

    PEPR-NumPEx@agencerecherche.fr

    numpex_aap@groupes.renater.fr
  - **the NumPEx project leaders**
- **More details about NumPEx:** https://numpex.org
- **Feel free to contact us if you plan to submit a proposal**

NumPEx Call for Projects (AI, GPU/Accelerators, etc.)

- Do you have **proof-of-concept** ideas or ongoing work that could scale up under NumPEx call?
- Where do you see **immediate synergy** between your R&D pipeline and Exa-MA/NumPEx objectives (AI4HPC, HPC4AI, GPU acceleration, etc.)?
- Are there any **non-technical barriers** to applying for NumPEx calls (administrative, contractual, etc.) that we can address together?
- Would you be interested in joining forces to answer NumPEx call ?

Open Discussions

What we expect from you

Your Exascale Needs & Ambitions

- Which **applications or use cases** in your organization require exascale computing?
- **Challenges** you face.

Potential Collaboration Avenues

- **Co-funding projects**: Half-PhD funding, interns, short-term placements.
- **Software integration**: Adopting or contributing to Exa-MA/NumPEx toolchains.
- **Training & workshops**: Shared courses, hackathons, or custom training sessions.

Resource Constraints & Fairness

- **Limited bandwidth**: We need to manage expectations and workload.

Why Collaborate with Exa-MA/NumPEx?

- **Access to HPC expertise** & cutting-edge methods.
- Early insights into **exascale-ready** algorithms & software.
- **Community building**: Expand networks, join EU & national calls, co-author papers.

Co-funding Opportunities & Half-PhD Funding

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Application Demonstrators & PC5 Working Groups

- **Which application domains or use cases** in your organization could benefit most from exascale-ready methods and algorithms?
- Have you identified **specific bottlenecks** that Exa-MA /NumPEx could help overcome?
- Which **PC5 working groups** or subtopics align best with your current or future R&D interests?
- How could we **streamline integration** of your use cases with our existing or planned demonstrators?

Software Development & Environments

- Which **open-source or proprietary software tools** are you already using for HPC or exascale?
- Would you contribute to the Software and Demonstrators Excel sheet ?
- Are you facing any **technical gaps** (e.g., portability, performance, advanced numerical methods) that Exa-MA/NumPEx software could address?
- How do you usually handle **continuous integration (CI), testing, and benchmarking** for HPC software?
- Could you **contribute code, expertise, or user feedback** to Exa-MA’s software environment (e.g.,packaging, benchmarking…)?

Training and Training Working Group

Shared Workshops and Courses

- Are there specific HPC or exascale topics your teams would like to explore through short courses or internal workshops with Exa-MA/NumPEx?
- Could we co-develop tutorials, hackathons, or summer schools to upskill researchers and students?

Internships and Visiting Programs

- Are you interested in hosting interns, visiting PhD students, or postdocs from our consortium (or vice versa) to strengthen knowledge exchange?

Joint Curriculum Development

- Could we collaborate with university partners to **create or refine** specialized courses on HPC/exascale, machine learning, or advanced numerical methods?

Train-the-Trainer Initiatives

- Would your organization benefit from an “train-the-trainer” program, where Exa-MA/NumPEx equip your leads to train others internally?

Certification or Credentialing

- Is there value in developing some form of *certification* in HPC/Exascale best practices for staff, which we could co-brand or co-organize with external partners?

Learning Platforms & Resources

- How can we share existing/future training materials (recorded lectures, tutorials, code samples) so that your teams can learn at their own pace?

Continuing Professional Education

- Are there opportunities to collaborate on HPC short courses for professional engineers, data scientists, or domain experts within your organization?

Participation in EU Calls & Larger Collaborations

- Have you **identified upcoming EU calls** (e.g., Horizon Europe, EuroHPC) that overlap with Exa-MA/NumPEx topics?
- Are you looking for **partners or consortia** to join, especially in HPC, AI, or advanced computing proposals?
- What would be a **win-win scenario** for collaborating on an EU proposal (e.g., providing testbeds, software integration, domain expertise)?

Other Opportunities & Open Discussions

- What are **other collaborative models** (short-term consultancy, visiting scientists, hackathons, industry–academia secondments) we could explore?
- Which **domain challenges** (multiphysics, big-data assimilation, HPC resilience) do you think are under-addressed and could be tackled jointly?
- Are there **new trends** (quantum HPC, hybrid HPC+AI workflows, HPC in the cloud) where we might pool resources?

Closing Thoughts / Call to Action

- **Contact Points**: Who in your organization can drive or champion these collaborations?
- **Next Steps**: What immediate actions or follow-up meetings should we schedule?
- **Feedback Loop**: Which communication channel (Slack, mailing list, monthly calls,workshops,yearly general assembly…) would you prefer to keep the conversation active?

WP1: Discretization

P. Alliez (INRIA, Nice), H. Barucq (INRIA, Pau), I. Ramière (CEA, Cadarache),

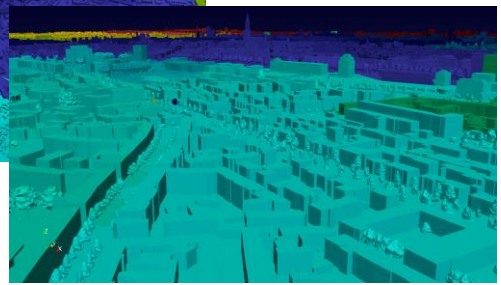
WP1

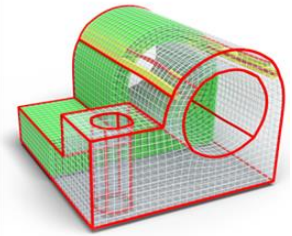
Key Objectives

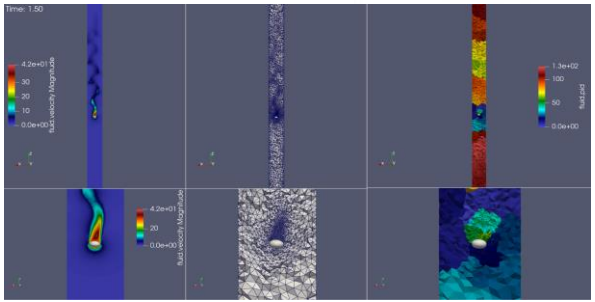
- Geometric and discrete domain representations
- Advanced numerical methods dedicated to physics-based simulation and parallel computing

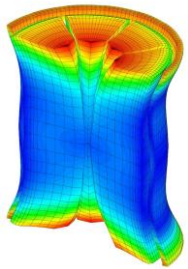
Tasks

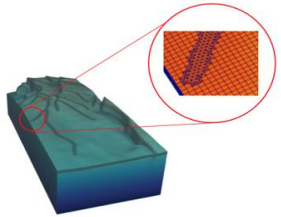
- Mesh generation
  - Large-scale, non-conforming
  - Unconditional robustness
  - Hexahedral block grids
- Adaptive Mesh Refinement
  - Unstructured grids
  - Cartesian or block grids
- Non-conforming finite elements
  - Treffz and HDG methods
- Error control in time and space
- Multiphysics coupling
  - Efficient and generic partitioned coupling
  - High-order time adaptive coupling
- Multiscale coupling











WP2: Model order, Surrogate, Scientific Machine Learning methods

E. Franck (INRIA, Strasbourg), S. Lanteri (INRIA,Nice)

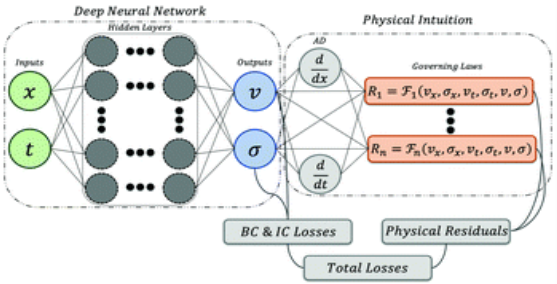
WP2: order reduction and SciML

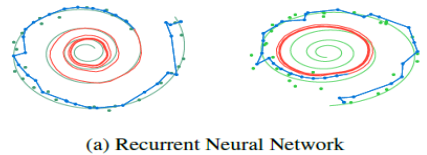
Key Objectives

- PINNs for high dimensional parametric PDE
- Neural operator and fast prediction

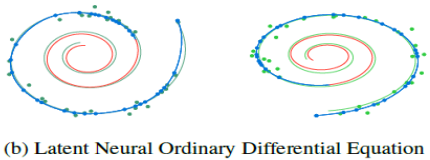
Tasks

- Physic Informed Neural Networks
  - High dimensional parametric space and sampling
  - Domain decomposition
  - Training methods
- Neural operator
  - General and unstructured meshes
  - Complex and multiscale PDE
  - Coupling with forward and inverse solvers
- Reduced order modeling
  - (Non intrusive) Reduced Basis/Non linear compressive reduced basis
  - Auto-encoder/POD + NN hyper-reduction
  - Explicability for learning methods
  - Closure for kinetic equations
- Low/high fidelity models

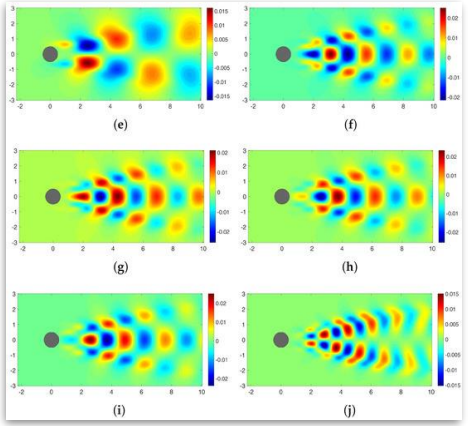


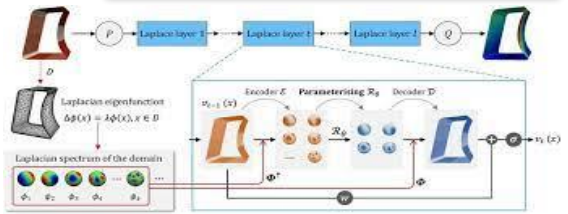


(a) Recurrent Neural Network



(b) Latent Neural Ordinary Differential Equation





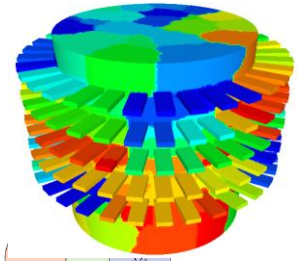
WP3: Solvers

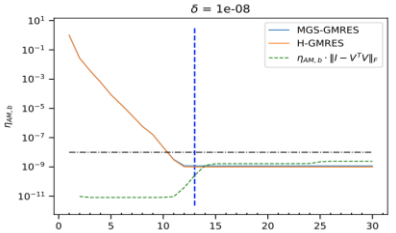
V. Faucher (CEA, Cadarache), L. Giraud (INRIA, Bordeaux),
F. Nataf (INRIA, Paris)

WP3: Solvers

Key Objectives

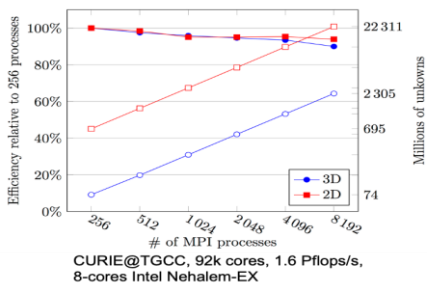
- Design novel generic scalable numerical algorithms
- Enable multi-precision for prescribed accuracy
- Leveraging communication avoiding/hiding, mixed arithmetic and data compression



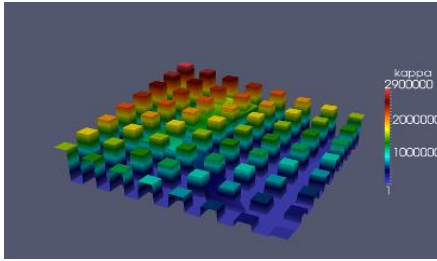


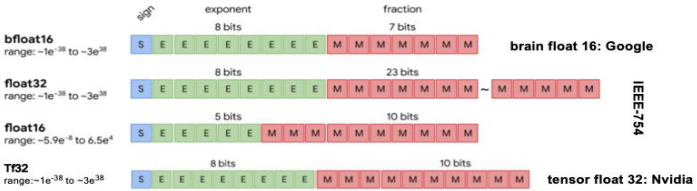
Tasks

- Robust and scalable solvers
  - Adaptive precision (link with PC2), auto tuning tools
  - Multi-level Domain decomposition with provable efficiency
  - Resiliency
- Scalable coupled physics solvers
- Open source libraries: HPDDM, Composyx, MEDCoupling, PROMISE, use cases via WP7 and interactions with PC2 Exa-Soft



CURIE@TGCC, 92k cores, 1.6 Pflops/s, 8-cores Intel Nehalem-EX





WP4: Inverse Problems and Data Assimilation

M. Asch (UNISTRA,Amiens), H. Barucq (INRIA,Pau), A. Vidard (INRIA,Grenoble)

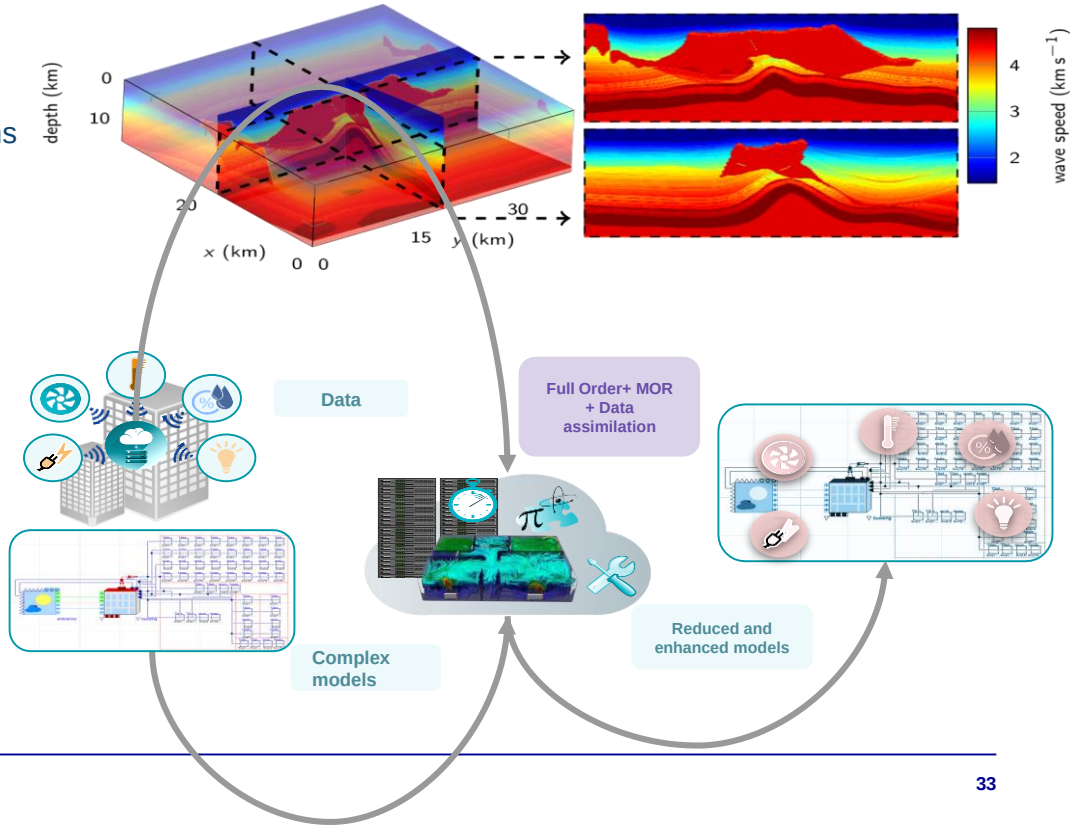
WP4: Inverse Problems and Data Assimilation

Key Objectives

- Improve deterministic inversion methods
- Design new stochastic methods for inverse problems
- Improve observation strategies
- Implement multi-fidelity schedules at exascale

Tasks

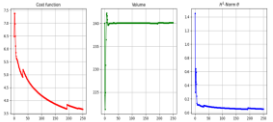
- Deterministic methods
- Stochastic methods
- Observations
- Multifidelity: modelling and inverse problems

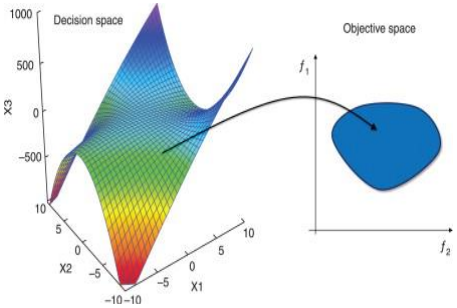


WP5: Optimization

El-Ghazali Talbi(INRIA,Lille)

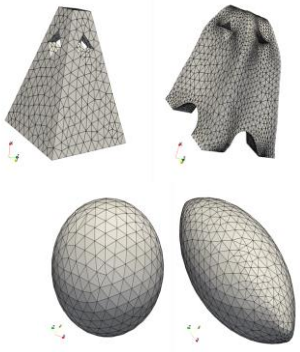
WP5: Optimization





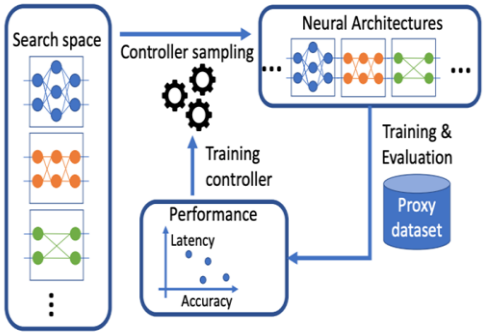
Key Objectives

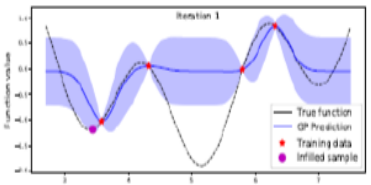
- Solving big optimization problems (decision variables, many-objectives, expensive objectives, big data) using exascale decomposition
- Inverse, continuous, discrete and mixed optimization problems
- Exact, heuristic and data driven optimization algorithms



Tasks

- Exascale combinatorial and continuous optimization
  - Exact optimization (Branch and bound, tree search)
  - Heuristic optimization (Computational intelligence)
- Exascale surrogate-based optimization
  - Multi-fidelity models
  - Coupling of surrogates, optimization and sampling
- Exascale shape optimization
  - Involving multiphysics models
- Exascale optimization for AutoML (Automated design of deep NN)





WP6: Uncertainty Quantification

C. Gauchy(CEA,Saclay), J. Garnier(EP)

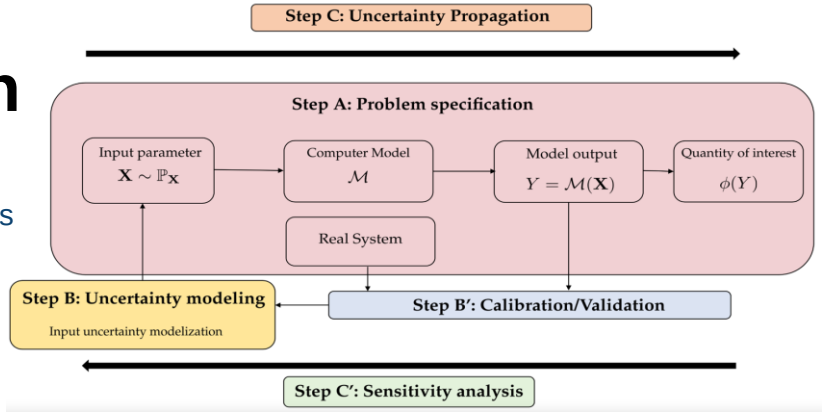
WP6: Uncertainty Quantification

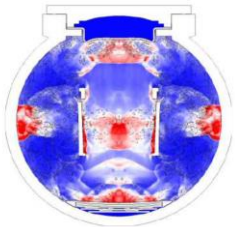
Key Objectives

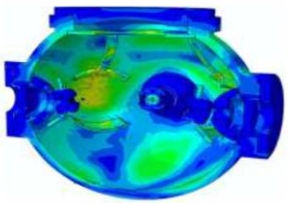
- Uncertainty Quantification for multi-physics and/or multi-scale problems
- Uncertainty propagation, sensitivity analysis, robust inversion

Tasks

- Kernel-based sensitivity analysis for high-dimensional data
- UQ in a PDE solving framework
  - Propagation of uncertainties on the initial conditions
  - UQ on meshes for exascale applications
  - Stochastic spectral methods
- Surrogate modeling for UQ
  - UQ for surrogate models under physical constraints
  - Tractability of Bayesian approaches for Gaussian Process Regression with high-dimensional inputs
  - Metamodels for nested, chained and coupled codes
- Acceleration of the bricks of the UQ process steps by leveraging exascale calculations







WP7: Software

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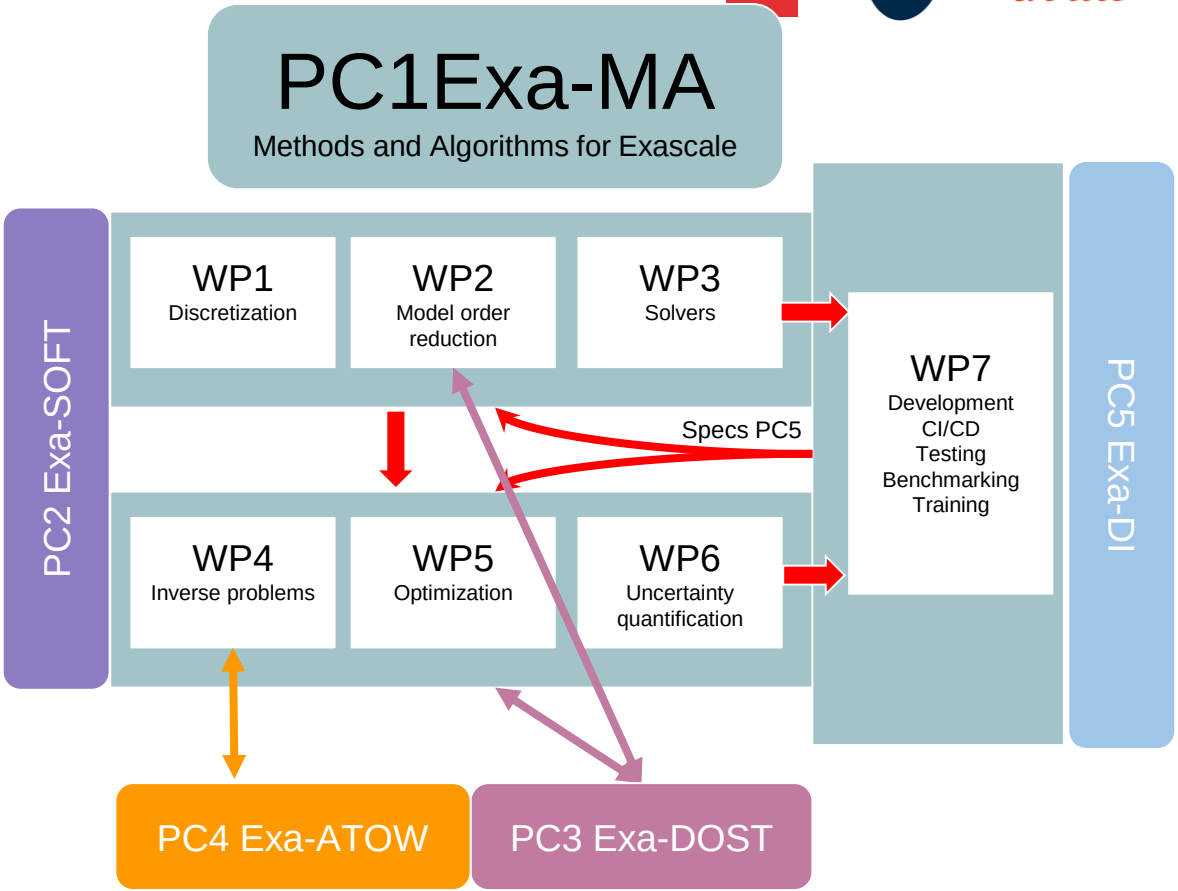
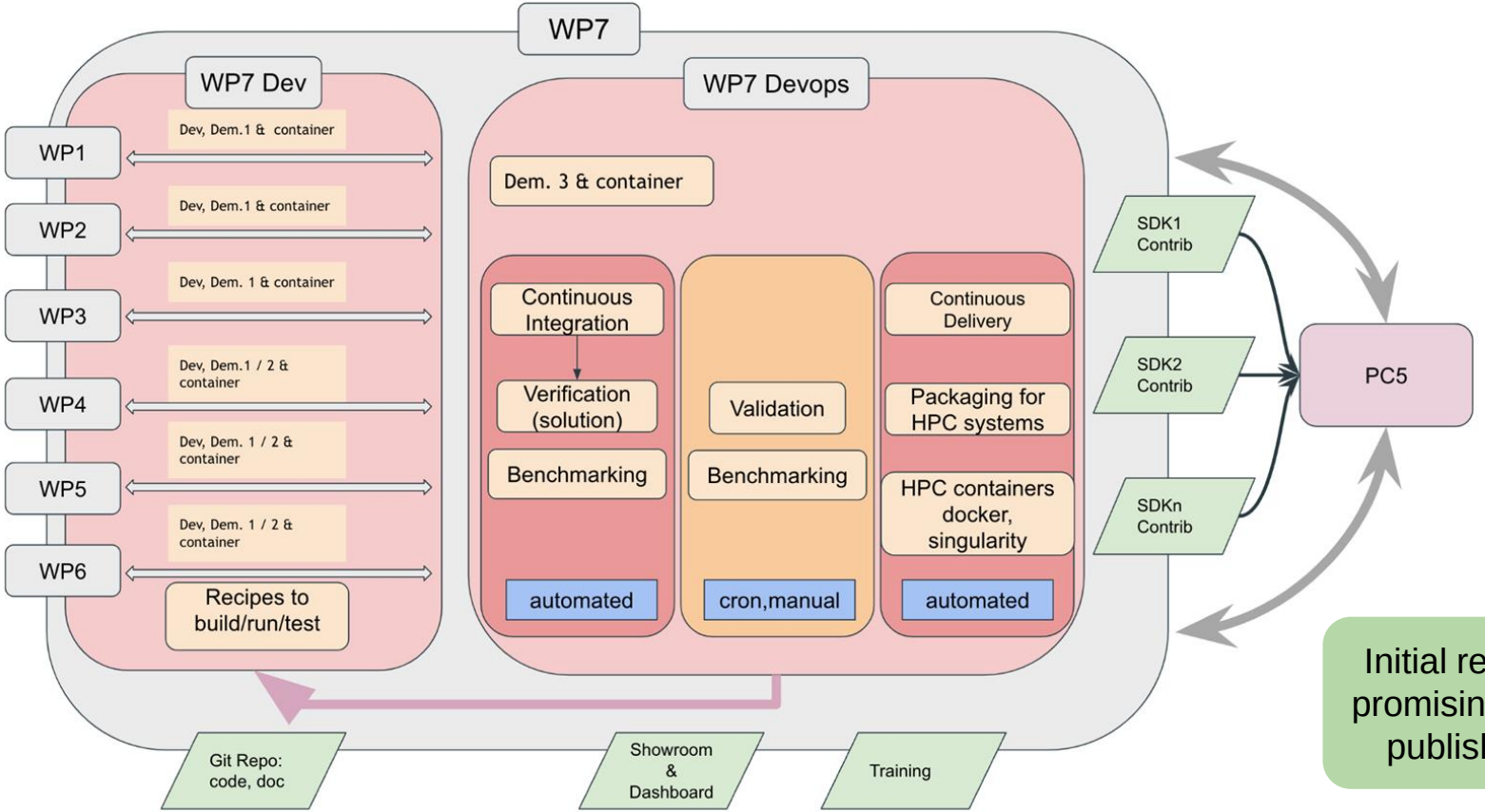
WP7 Software

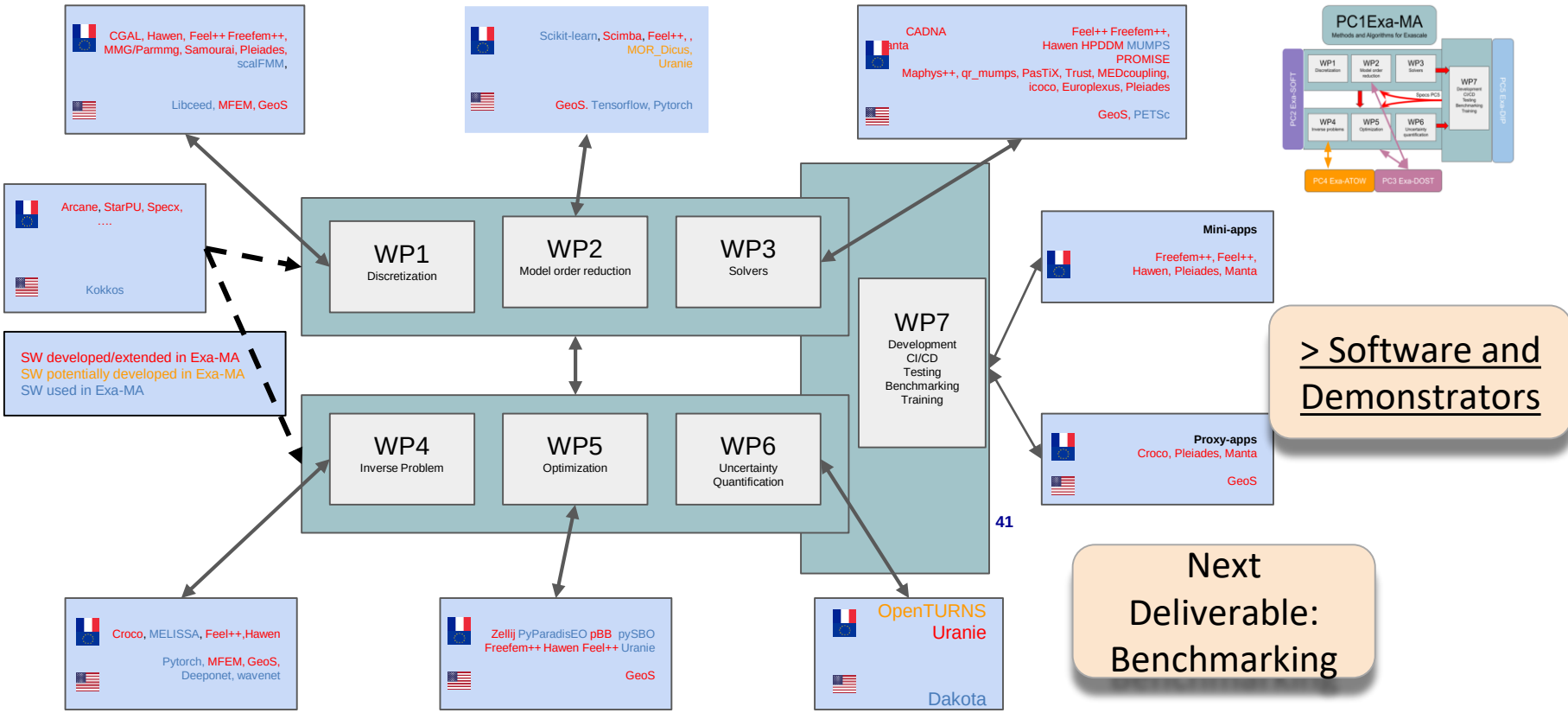
A transverse workpackage

- **Developing Software**
  - **Contribute to development** locally or on WP topics
  - **Port** to pre-exascale/exascale supercomputers
  - **Test including benchmarking** to verify exascale capabilities and handling of identified challenges from simple to advanced software
  - **Deliver software packages** in the framework proposed by ExaDIP in terms of CI/CD;
- **Coordinating and contributing co-design** activities within Exa-MA with ExaDIP, Contribute Software Develop Kit
- **Enabling a showroom** of Exa-MA results
- **Building training material** from the results of Exa-MAa
- **Interaction with all other WPs** + PC2, PC3, PC4, PC5





Initial results promising and published


CGAL, Hawen, Feel++ Freefem++, MMG/Parmmg, Samourai, Pleiades, scalFMM,
Libceed, MFEM, GeoS
Scikit-learn, Scimba, Feel++, , MOR_Dicus, Uranie
GeoS. Tensorflow, Pytorch
CADNA
anta
Feel++ Freefem++, Hawen HPDDM MUMPS PROMISE
Maphys++, qr_mumps, PasTiX, Trust, MEDcoupling, icoco, Europlexus, Pleiades
GeoS, PETSc
PC1Exa-MA
Methods and Algorithms for Exascale
WP1
Discretization
WP2
Model order reduction
WP3
Solvers
WP4
Inverse Problem
WP5
Optimization
WP6
Uncertainty Quantification
WP7
Development
CI/CD
Testing
Benchmarking
Training
PC2 Exa-SOFT
PC2 Exa-DIP
PC4 Exa-ATOW
PC3 Exa-DOST
Arcane, StarPU, Specx, ...
Kokkos
SW developed/extended in Exa-MA
SW potentially developed in Exa-MA
SW used in Exa-MA
Mini-apps
Freefem++, Feel++, Hawen, Pleiades, Manta
Proxy-apps
Croco, Pleiades, Manta
GeoS
Croco, MELISSA, Feel++,Hawen
Pytorch, MFEM, GeoS, Deeponet, wavenet
Zellij PyParadisEO pBB pySBO
Freefem++ Hawen Feel++ Uranie
GeoS
OpenTURNS
Uranie
Dakota
41
> Software and Demonstrators
Next Deliverable: Benchmarking

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