



Resume of Sparse Days in Saint-Girons IV

Computational linear algebra and new frontiers in high performance computing: artificial intelligence, high performance data analytics and quantum computing

19-22 June, 2022

<https://sparsedays.cerfacs.fr/en/>

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Overview

Sparse Days at Saint-Girons IV was held on 19-22 June 2022 in the city of Saint-Girons, in the Ariège region. This was the fourth meeting in a series of international workshops involving researchers from academia, research labs and industry working in sparse linear algebra and, more generally, computational linear algebra and optimization. The first meeting in the series was held in 1994 as a precursor to the International Linear Algebra Year (ILAY) in 1995 and 1996, hosted by CERFACS. Subsequent Sparse Days at Saint-Girons meetings were held in 2003 and 2015.

As in previous meetings, the scope of Saint-Girons IV was not restricted to the aforementioned topics but covered a much broader range of topics related to high performance computing (HPC) and applied mathematics. Data analysis and artificial intelligence (AI), for example, are becoming increasingly important within the HPC research community. Extracting meaningful information from raw, unstructured data or training deep neural networks on large datasets are extremely computationally intensive tasks that require the development of mathematical algorithms that are accurate and reliable. At the same time, the algorithms need to be scalable and computationally efficient on modern supercomputers, including large distributed memory heterogeneous architectures with, for example, accelerators such as GPUs. AI is also increasingly used to accelerate or improve traditional scientific computing and numerical simulation workflows. Because of this, a new discipline, High Performance Data Analytics (HPDA) is being formed at the crossroads between high performance computing and AI and data analysis. Notably, AI techniques have also been used for software development purposes (e.g., GitHub Copilot, Google's Pitchfork, ChatGPT)

Another topic that has recently attracted considerable interest in the HPC community is quantum computing. Quantum technologies offer the potential to achieve substantial acceleration for the solution of selected classes of problems. Work has recently been published investigating the use of quantum computing in computational linear algebra; for example, it has been shown that quantum computers can solve linear systems of equations exponentially faster than classic computers. Nevertheless, quantum computing is still in its early stages, and its connection with traditional high-performance computing is still not clear.

We are already planning Saint-Girons V, the next in the series. In this conference, we will seek to further foster interactions and new collaborations between the HPC and computational algebra, AI and data analysis, and quantum computing communities. For this reason, two dedicated sessions on artificial intelligence and quantum computing, respectively, were included in the programme for Saint-Girons IV..

The conference in a glimpse

The Sparse Days in Saint-Girons IV conference was co-organized by IRIT-INPT and the CERFACS centre of Toulouse with the support of many private and academic institutes in Toulouse. The conference was hosted by the city of Saint-Girons (Ariège) starting on June 19, until the morning of June 22 and was closed by a special event at the ENSEEIHT engineering school of Toulouse on June 22 afternoon.



103 researchers attended the conference over three days in a very warm and friendly environment. 62 of the participants were from French academic or private institutes, 14 from other European countries (Belgium, Czech Republic, Germany, Italy, Norway, and UK) and 27 from out of Europe (mostly USA but also Armenia, Canada, China, Japan, and Saudi Arabia). 75 participants were from academic institutes and 28 from private companies.

One notable fact of the Sparse Days in Saint-Girons IV conference was that 27 participants were PhD or Master students. Thanks to the financial support of the conference from private, local authority and academic sponsors, the registration fees, the accommodation and participation fees in the social events were fully funded for all students by the conference organization. Out of these 27 students, 9 presented their work in the form of an oral presentation and 9 in the form of a poster (preceded by a two-minute “poster-blitz” presentation).

The scientific program included 38 15-minute presentations grouped into 11 sessions over two and a half days.

The conference programme

Day 1, June 20

- **Session 1, Sparse direct methods, combinatorics, graphs I:** this session was opened by a brief welcome talk by Iain Duff (Cerfacs), co-organizer of the conference. This was followed by four talks focusing on topics related to direct methods for sparse linear systems, combinatorics and algorithms for large graphs. The first talk about non-negative matrix factorization was presented by John Conroy (IDA, USA) followed by a presentation by John Gilbert (UCSB, USA) on methods for aggregating communications in parallel sparse algorithms. Tim Davis (Texas A&M, USA) presented his recent work on the GraphBLAS package for efficient computations on large graphs; the session was closed by a talk by Luce Le Gorrec (Univ. of Strathclyde, UK) on her recent work on scalable partitioning of large graphs.
- **Session 2, High performance computing I, quantum computing:** this session was opened by a plenary talk by Jack Dongarra (UTK, USA) on mixed-precision linear algebra algorithms. This was followed by a talk by Jean-Baptiste Harry from NEC, one of the conference sponsors, illustrating the features of the SX-Aurora TSUBASA board produced by the company. Bob Lucas (Ansys, USA) presented his work on the use of the D-Wave quantum annealer for computing the nested dissection ordering of large graphs. The session ended with a talk by Marc Baboulin (Univ. Paris-Saclay) on linear algebra kernels in quantum algorithms.
- **Session 3, Iterative and hybrid solvers:** this session started with a talk by Pierre Matalon (Univ. di Milano, Italy) on algebraic multigrid solvers followed by a talk from Yongseok Jang (ONERA, France) on a randomized GMRES solver with deflated restarting. Christie Louis Alappat (FAU-EN, Germany) presented his work on level-based blocking techniques for sparse iterative solvers and then Alexis Montoisson (Polytech. Montreal, Canada) closed the session with a talk on the Krylov.jl software package that implements a wide range of sparse, iterative solvers natively in the Julia language.
- **Session 4, Artificial intelligence, machine learning I:** this session was opened by a talk by Sherry Li (LBNL, USA) on machine learning methods for autotuning sparse linear solvers. This was followed by a presentation from Michela Taufer (UTK, USA) on artificial intelligence methods and tools for HPC resource management. The session was closed by Michael Kirby (CSU, USA) with a talk on autoencoder neural networks for supervised sparse non-linear principal component analysis.
- **Poster blitz:** this session was meant to give students the opportunity to present their posters and invite the participants to the poster sessions. This consisted in a sequence of nine two-minutes talks.

Day 2, June 21

- **Session 5, Sparse direct methods, combinatorics, graphs II:** This session began with a talk by Philip Knight (Univ. of Strathclyde, UK) who presented his work on methods for scaling matrices to doubly-stochastic form. This was followed by a presentation by Esmong Ng (LBLN, USA) on high performance sparse factorization. The session ended with a talk by Elisa Riccietti (ENS-Lyon, France) on optimization methods for computing matrix factorizations.
- **Session 6, High performance computing II:** Somesh Singh (Inria, France) opened this session with a presentation on parallel hashing methods for hypergraphs. Next Joseph Touzet (ENS Paris-Saclay, France) presented his work on distributed simulation of quantum dynamics. This was followed by a talk by Ewa Deelman (Univ. of Southern California, USA) on management systems for executing scientific workflows on cyberinfrastructures. Next, Dzenek Dostal (National supercomputing center, Czech Republic) presented his work on unpreconditioned TFETI methods. Finally, Antoine Jego (IRIT-INPT, France) concluded this session with a presentation on the use of task-based parallel programming models for mathematical algorithms.
- **Session 7, Low rank approximation, variable precision, randomization I:** this session was opened with a talk by Laura Grigori (Inria, France) on randomization techniques for solving linear systems and eigenvalue problems. Next Theo Mary (CNRS-LIP6, France) presented his work on adaptive precision sparse solvers. This was followed by a presentation by Edmond Chow (Georgia Institute of Technology, USA) on a software for H2 hierarchical matrices relying on the proxy point method. George Turkiyyah (KAUST, Saudi Arabia) concluded this session presenting his work on randomized, tile low-rank factorizations.
- **Session 8, Low rank approximation, variable precision, randomization II:** This session was opened by a talk by Esragul Korkmaz (Inria, France) on low-rank approximations in sparse direct solvers. This was followed by a presentation by Marek Felsoci (Inria, France) on methods for solving coupled FEM/BEM linear systems. Finally, Bastien Vieuble (IRIT-INPT, France) presented his work on a mixed precision preconditioned GMRES solver.
- **Session 9, High performance computing III:** the last session of this day included a plenary talk by Satoshi Matsuoka (RIKEN, Japan) who presented some of the main features of the Fugaku supercomputer and an overview of some of the most challenging applications that were designed for it.

Day 3, June 22

- **Session 10, Least squares problems and optimization I:** this session began with a talk by Jennifer Scott (Univ. of Reading, UK) on the solution of large linear least squares with equality constraints. Next, Andy Wathen (Oxford University) presented his recent work on preconditioning methods for normal equations and least squares. Jemima Tabeart (University of Edinburgh) then made a talk on Stein-based preconditioners for weak-constraint 4D-var problems followed by a talk by Nicolas Nadisic (Université de Mons) on matrix-wise L0-constrained Sparse Nonnegative Least Squares.
- **Session 11, Least squares problems and optimization II:** The last session of the conference was opened by a talk by Alexandre Scotto Di Perrotolo (ISAE SUPAERO) on randomized limited memory preconditioners for variational data assimilation followed by a presentation by Michal Kocvara (University of Birmingham) on an interior-point method for Lasserre relaxations of unconstrained binary quadratic optimization problems. Finally, Mike Saunders (Stanford University) closed this session with a presentation on the NCL algorithm for constrained optimization.

Special event at ENSEEIHT

On the afternoon of Wednesday June 22nd, a special event was organized at the ENSEEIHT engineering school of Toulouse on the theme of high performance computing. Although this event was part of the Sparse Days in Saint-Girons conference program, the attendance was opened (free of charge) to a broader public. Overall more than 200 people registered and roughly 150 attended the event. Besides the conference participants, the rest of the attendance was from both academic and industrial institutes in the Toulouse region.

The event was opened by a foreword from Dr Catherine Lambert from the Cerfacs centre. This was followed by a keynote talk by Jack Dongarra (University of Tennessee Knoxville, USA) entitled "An Overview of High Performance Computing and Future Requirements". This talk provided a historical survey of high performance computing from the perspective of the most influential researcher of this domain who was recently awarded the prestigious Turing Award for the numerous important contributions he has made to this discipline. This presentation also discussed future evolutions of supercomputer architectures and presented some promising research subjects in the field of high performance computing. A second keynote talk by Satoshi Matsuoka (RIKEN supercomputing center, Japan) entitled "Life with and after Fugaku --- Exascale and Beyond" presented the architecture of the Japanese Fugaku supercomputer, formerly the most powerful supercomputer of the world, as well as some of the most successful problems that were solved leveraging the massive computing power of this system. Based on the lesson learned during the construction and use of Fugaku, Matsuoka presented some insights on the future evolutions of supercomputing systems and applications.

The two talks were followed by a panel discussion where Dongarra and Matsuoka participated along with Catherine Lambert (Cerfacs, France), Sherry Xiaoye Li (Lawrence Berkeley National Laboratory, USA), Michel Daydé (CNRS, France) and Jean-Marc Pierson (IRIT-UPS,

France). This panel of experts of high performance computing and applications discussed some of the hot topics in this domain, including the need for designing novel, scalable algorithms capable of exploiting the massive power of modern supercomputers as well as the importance of reducing the power consumption of supercomputing infrastructures through carefully designed components and algorithms.



Jack Dongarra holds an appointment as University Distinguished Professor of Computer Science in the Electrical Engineering and Computer Science Department at the University of Tennessee and holds the title of Distinguished Research Staff in the Computer Science and Mathematics Division at Oak Ridge National Laboratory (ORNL); Turing Fellow at Manchester University; an Adjunct Professor in the Computer Science Department at Rice University. He is the director of the Innovative Computing Laboratory at the University of Tennessee. He is also the director of the Center for Information Technology Research at the University of Tennessee. He specializes in numerical algorithms in linear algebra, parallel computing, the use of advanced-computer architectures, programming methodology, and tools for parallel computers. Jack Dongarra is the recipient of the 2021 ACM Turing Award.



Satoshi Matsuoka from April 2018 has been the director of Riken Center for Computational Science (R-CCS), the top-tier national HPC center for Japan, developing and hosting Japan's flagship 'Fugaku' supercomputer which has become the fastest supercomputer in the world in all four major supercomputer rankings in 2020 and 2021 (Top500, HPCG, HPL-AI, Graph500), along with multitudes of ongoing cutting edge HPC research being conducted, including investigating Post-Moore era computing. He was the leader of the TSUBAME series of supercomputers that had also received many international acclaims, at the Tokyo Institute of Technology, where he still holds a professor position, to continue his research activities in HPC as well as scalable Big Data and AI, in both institutions. His commendations include the Fellow positions in societies/conferences ACM, ISC, and the JSSST; the ACM Gordon Bell Prize in 2011 & 2021 and the IEEE Sidney Fernbach Award in 2014, all being one of the highest awards in the field of HPC; the Technical Papers Chair and the Program Chair for ACM/IEEE Supercomputing 2009 and 2013 (SC09 and SC13) respectively as well as many other conference chairs, and the ACM Gordon Bell Prize selection committee chair in 2018.

Social program

The program of the conference included two main social events. The first was a welcome banquet which was held on the evening of June 19 upon reception of the conference participants. The second was a gala dinner on June 20, preceded by a reception of the conference participants at the Saint-Girons Town Hall. Both events took place at the Carré de l'Ange restaurant in the city of Saint-Lizier. The gala dinner was animated by a folk music and dance show presented by the local "les Bethmalais" group. The majors of Saint-Girons and Saint-Lizier as well as the president of the Ariège regional council also attended the gala dinner.



Conclusions

Three highlights characterized the Sparse Days in Saint-Girons IV:

- Thanks to the financial support of the conference sponsors, the registration and accommodation costs of **27 PhD students** were fully funded by the conference organization, allowing 18 of them to present their work.
- The introduction of other topics related to **HPC** and **applied mathematics**, such as **HPDA** and **quantum computing**.
- At a time when many people were still very nervous about COVID and, despite the risk of facing some travel restrictions in the US and Asia, the conference, held entirely in person, attracted **75 participants from academic institutes and 28 from private companies**, of which 62 were from France, 14 from other European countries (Belgium, Czech Republic, Germany, Italy, Norway, and UK) and 27 from outside Europe (US, Armenia, Canada, China, Japan, and Saudi Arabia).

This meeting offered the conference organization the chance to honour two academics who led the launch of the first Sparse Days in Saint-Girons in 1994.

Gene Golub, who died in 2007, was a leading pioneer in the field of numerical analysis, creating algorithms and software that allowed researchers to run large engineering and scientific calculations effectively on computers. He was president of SIAM, Society for Industrial and Applied Mathematics, and founded the SIAM Journal on Scientific Computing (SISC) and the SIAM Journal on Matrix Analysis and Application (SIMAX). As the driving force behind the International Linear Algebra Year (ILAY), he launched the Sparse Days in Saint-Girons by asking Cerfacs, which he visited regularly, to organize its first event.

Roland Glowinski, who died in spring 2022, was known for his work in applied mathematics, in particular numerical solution and applications of partial differential equations and variational inequalities. He was a member of the French Academy of Sciences and Fellow of the American Mathematical Society. As director of Cerfacs in 1994, he played a key role in bringing together the human and financial resources needed to organize the first Saint-Girons conference

All participants also had the opportunity to congratulate **Jack Dongarra**, one of the pillars of the conference, who received the ACM Turing Award 2021 for his pioneering concepts and methods that have changed the world of computing.

At the next meeting, Saint-Girons V, scheduled for June 2026, special efforts will be made to **increase the number of PhD students** and to provide more time in the programme for scientists to exchange and discuss new research topics.

A new scientific committee will be set up for this fifth meeting. Headed by Iain Duff, it will include Jack Dongarra and Satoshi Matsuoka, along with other renowned scientists in the field of HPC, HPDA and quantum computing. Its main objective will be to prepare the programme of the conference, organized by a committee headed by Pierre-Henri Cros.

Sponsors

The Sparse Days in Saint-Girons IV organizing committee would like to thank all the sponsors of the conference for their support which was essential for the success of the event.

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