# BUILDING JUPITER: FROM PROCUREMENT TO DEPLOYMENT

## RIKEN FUGAKUNEXT APPLICATION SEMINAR

2 December 2025 | Andreas Herten and colleagues (esp. J. Badwaik / M. Bode) | Forschungszentrum Jülich, JSC

# Content





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# About JUPITER

- **JUPITER**: First European exascale supercomputer
  - Procured by EuroHPC JU, BMFTR (Federal Ministry of Research, Technology, and Space), MKW (NRW Ministry of Culture and Science)
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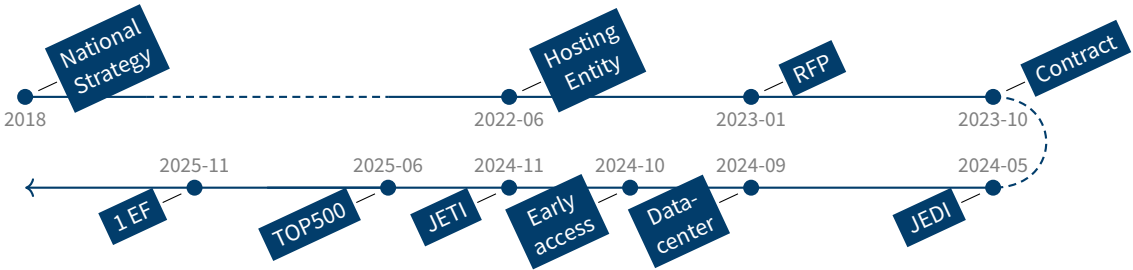




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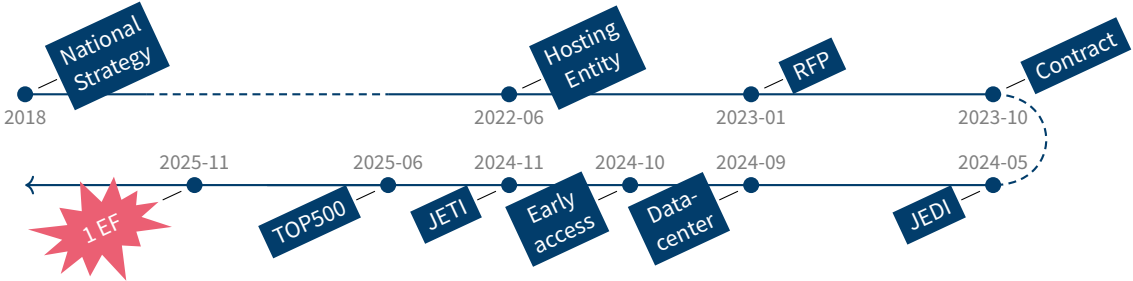




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# JUPITER System Overview

- ParTec/Eviden consortium
- Implementing Modular Supercomputing Architecture


ParTec MODULAR SUPERCOMPUTING

EVIDEN

NVIDIA

SIPEARL

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# JUPITER System Overview

- ParTec/Eviden consortium
- Implementing Modular Supercomputing Architecture
- JUPITER Booster: High scalability, 1 EFLOP/s HPL, $>$ 40 EFLOP/s FP8
  $\approx$ 6000 nodes: 4$\times$ Grace-Hopper superchip, 4$\times$ network
- JUPITER Cluster: High versatility, high memory-to-compute ratio
  $\approx$ 1300 nodes: 2$\times$ SiPearl Rhea1 (HBM), 1$\times$ network

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  $\approx$ 1300 nodes: 2$\times$ SiPearl Rhea1 (HBM), 1$\times$ network
- Network: 200/400 Gbit/s NVIDIA InfiniBand NDR (DragonFly+)
- Storage: 29 PB flash, 310 PB HDD, 370 PB tape
- Energy: 17 MW limit (HPL); direct liquid-cooled, energy re-use
- Modular data center of containers


ParTec MODULAR SUPERCOMPUTING

EVIDEN

NVIDIA

SIPEARL

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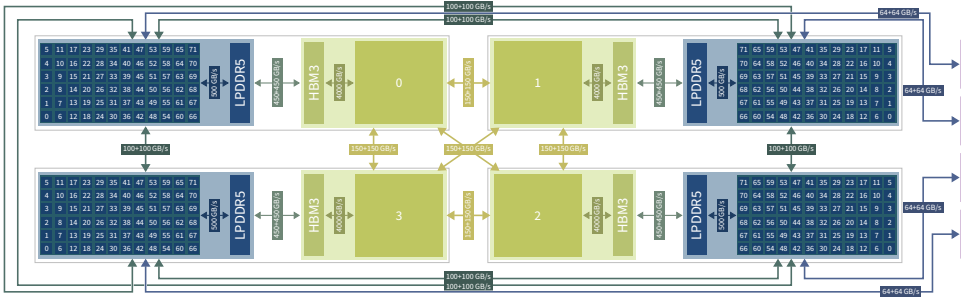
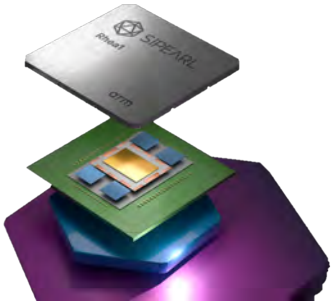
# JUPITER Booster Node Design




- 4× GH200 superchip (*CG4*)
  - Hopper: 132 SMs
  - Grace: 72 Arm Neoverse-V2 cores
  - 900 GB/s NVLink C2C
  - 120 GB LPDRR5X memory, 500 GB/s (CPU)
  - 96 GB HBM3 memory, 4000 GB/s (GPU)
- TDP superchip: 680 W
- GPU-to-GPU: NVLink 4, 300 GB/s per pair
- CPU-to-CPU: cNVLink, 200 GB/s per pair
- Cache coherence between all GPUs and CPUs
- 4× NDR200 InfiniBand (200 Gbit/s)

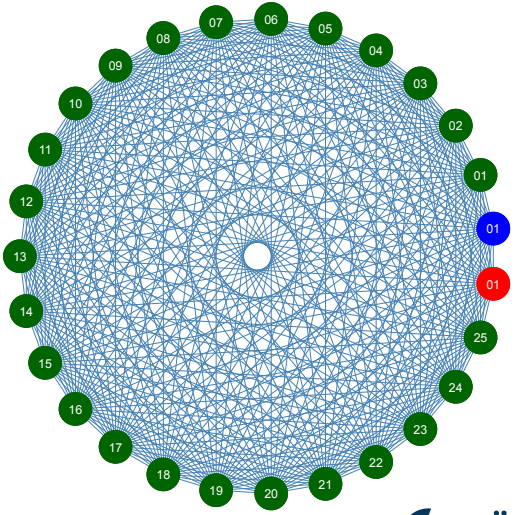
# JUPITER Cluster Node Design

- CPU-based based design (no accelerators)
- Nodes with 2 × SiPearl Rhea1 CPU, each
  - 80 Neoverse-V1 cores
  - 256 GB DDR5 memory
  - 64 GB HBM memory
- Origins in European HPC ecosystem:
  EPI, EUPEX, and further projects
- To be deployed soon



# JUPITER Network

- NVIDIA Mellanox InfiniBand NDR
- Dragonfly+ topology
  - 27 Dragenfly groups
  - Inside each group: full fat tree
- Adaptive routing, SHARPv3



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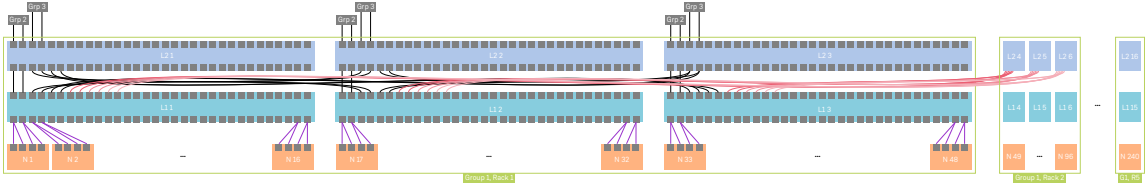
# JUPITER Network




- In group *intra*
  - 5 racks
  - 240 nodes
  - 15 L1 (lower), 16 L2 (upper) switches
  - Per rack: 48 nodes, 192 GH200
  - Link bandwidth from HCA to L1: 200 Gbit/s; from L1 to L2: 400 Gbit/s
- Beyond group *inter*
  - 16 links to each other group
  - Link bandwidth 400 Gbit/s



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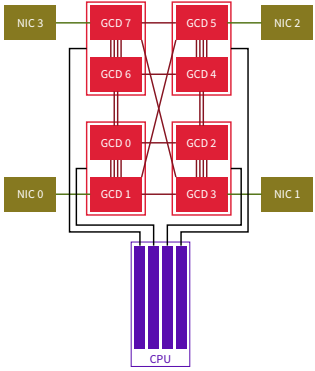
# Other Exascale Systems

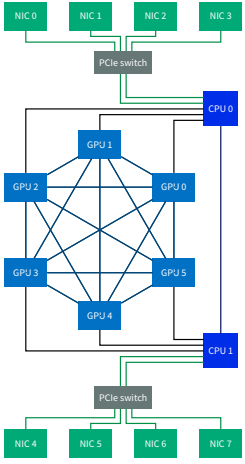
## Frontier

ORNL, USA: 1.2 EFLOP/s



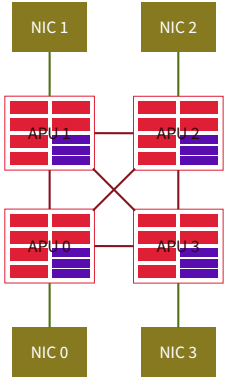

## Aurora

ANL, USA: 1 EFLOP/s



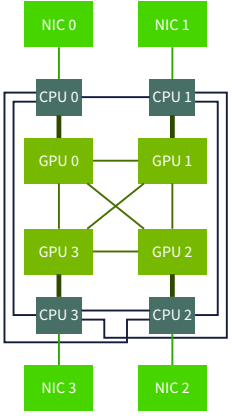

## El Capitan

LLNL, USA: 1.7 EFLOP/s




## JUPITER

JSC, DE: 1.0 EFLOP/s



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# Overview Exascale Systems

## Unique features

| | |
|---|---|
| Frontier | AMD GPUs in GCD design (two chip dies), few cores |
| Aurora | 6 Intel GPUs, HBM-equipped Intel CPUs |
| El Capitan | AMD APU design, no *host* memory |
| JUPITER | Superchip design, tight combination between CPU-GPU |

## Overview

| System | Nodes | *per Node* | | | | | *per GPU* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | TFLOP/s[§] | GPUs | CPUs | NICs | Cores | TFLOP/s | Cores | NICs |
| Frontier | 9604 | 141 | 4 | 1 | 4 | 64 | 35 | 16 | 1 |
| Aurora | 10 624 | 95 | 6 | 2 | 8 | 112 | 16 | 19 | 1.3 |
| El Capitan | 11 136 | 156 | 4 | *4* | 4 | 96 | 39 | 24 | 1 |
| JUPITER | 5884 | 175* | 4 | 4 | 4 | 288 | 43 | 72 | 1 |

*§: HPL value divided by number of nodes; for theoretical values, see appendix*

**: For TOP500-reported HPL run with 5735 nodes*

*MDC Concrete Foundation; Andreas for scale*



Photos by Herwig Zilken / FZJ


*Delivery of*
*IT Module 2*

Photo by Herwig Zilken / LZ

*Installation of Compute Blades in IT Module 1*

Photo by Hedwig Zilken / FZJ


MOC bird's eye view
Photo by Sascha Kreklau / FZJ

*Inside of IT module*

Photo by Sascha Kreklau / FZJ


*Inauguration Tent*

Photo by Jenö Gellinek / FZJ


*Thomas Lippert and the press*

Photo by Jenö Gellinek / FZJ


*Friedrich Merz in speech*

Photo by Kurt Steinhausen / FZJ


*Buttons! So many Buttons!*

# JUPITER TOP500

- TOP500 Nov 2025: #4 world, #1 EU
- 1000.184 PFLOP/s HPL
  *1 JUGENE (2008) over* 1 EFLOP/s


LLview job report of HPL job


*Certificate from first listing in June 2025*

# JUPITER TOP500

- TOP500 Nov 2025: #4 world, #1 EU
- 1000.184 PFLOP/s HPL
  *1 JUGENE (2008) over* 1 EFLOP/s
- Green500 Nov. 2025: JUPITER #14
  (63.3 GFLOP/(s W) no dedicated run)
  Jun. 2025: JEDI #1 (72.7 GFLOP/(s W), many tricks)


LLview job report of HPL job


*Certificate from first listing in June 2025*

# Preparations

**Benchmarks**: Applications

- Intensive benchmarking endeavor
- Many community applications

**JEDI**: Preparation system

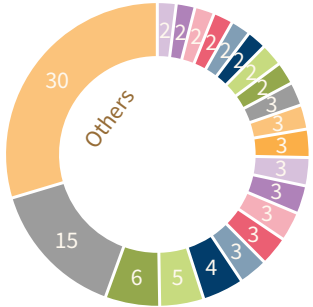
- 48 nodes (⅕ DragonFly group)
- May 2024: #1 Green500 (72.7 GFLOP/(s W))

**JUREAP**: Research & Early Access Program

- $>$ 130 participants
- 33 Lighthouse Applications selected (EU+DE)


# JSC Workload

- JSC: HPC resources for Forschungszentrum campus, state (NRW), Germany, Europe
- Compute time through peer-review
- Heterogeneous workload
- Physics, climate, biology, chemistry, AI, …
- **Goal:** Respect current & anticipated workload in procurements of new systems; incl. domains, methods, programming languages, profiles




*Programs / GPUh (2020)*
*JUWELS Booster*



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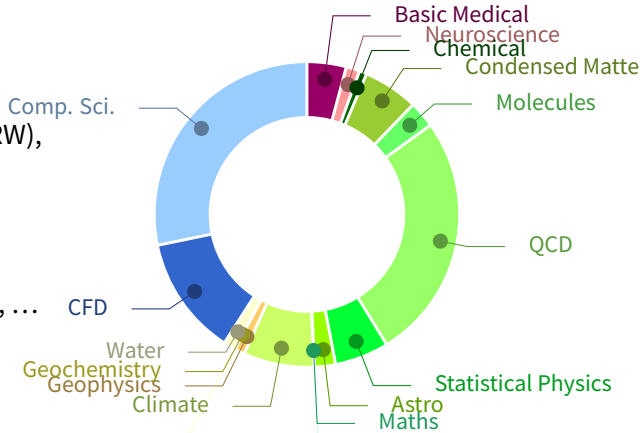


*Compute Time per Domain (2024-1)*
*JUWELS Booster*



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# Framework

- Procuring entity: EuroHPC JU
- Hosting entity: JSC
- Procurement: JSC, with support from EuroHPC, national ministries
- Compute time allocations: GCS (Germany), JU (Europe)
- 500 M€ project budget

- Strong investment from all sides →

  replicability, reproducibility, reusability $_{R}R^{R}$

- Benchmarks
  - **Applications** (Base TCO, High-Scaling, MSA)
  - Synthetic
- JUPITER Cluster **and** Booster



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# Evaluation Target

Mainly: Total Cost of Ownership (TCO)

- Proposals ranked by *workload intensity* (*how much workload over system lifespan*)
- Also energy consumption respected (simplified)
- Master formula: calculate value for ranking
- Normalized metric/FOM: runtime
- Applications-based

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New: High-Scaling Benchmarks

- For Exascale procurement → respect large-scaleness of system
- Run dedicated workload on entire system
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- Method:

*Full* JUWELS Booster Workload

vs. → Efficiency

20× workload on *full* JUPITER Booster

  - *Full*: 50 PFLOP/s vs. 1000 PFLOP/s th. peak
  - Instructions/rules to determine workload
  - Memory variants: (tiny,) small, medium, large




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Also: Synthetic benchmarks

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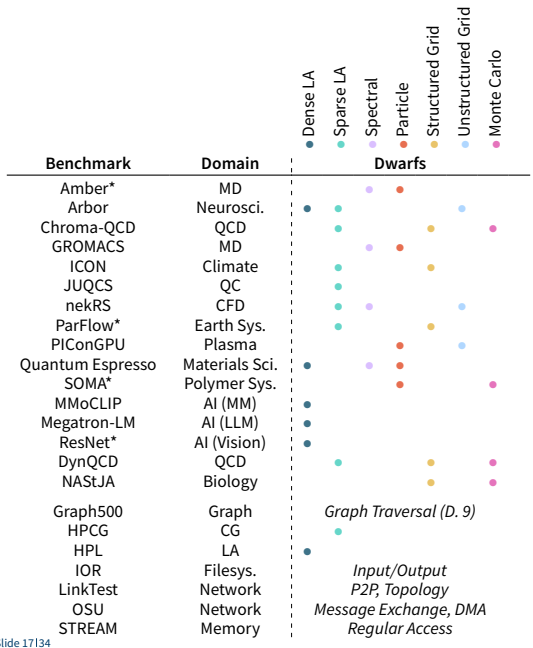
# Benchmarks Overview

- 16 application benchmarks (4 de-selected for actual procurement)
  Cross-section of domains and methods, 3× AI
- 7 synthetic benchmarks
- Extensive descriptions
- Right: Patterns of 7 Dwarfs



# Infrastructure

- Preparation system: JUWELS Booster (73 PFLOP/s peak, 44 PFLOP/s HPL), JURECA-DC (15 PFLOP/s, 9 PFLOP/s)
  Dependencies: EasyBuild; versioned environment modules
- JUBE workflow environment for every benchmark, similar structure; implicit documentation; platform-independence through inheritance
  → Continuous Benchmarking with *exaCB*
- Extensive description (incl. guidelines, rules), similar structure
- Git, Git submodules for sources (if possible)
- Management: Teams with captains and domain scientists, meetings every 2 weeks, hackathons, scale days, *11 step program*, Gitlab issues

```
- name: systemParameter
  init_with: platform.xml
  parameter:
    - name: preprocess
      _: $modules
    - name: executable
      _: myapp
    - name: args_exec
      _: input.json
    - name: queue
      tag: "baseline|scaling_base|scaling
      _: booster
    - name: queue
      tag: "exa_tiny|exa_small|exa_medium
      _: largebooster
```

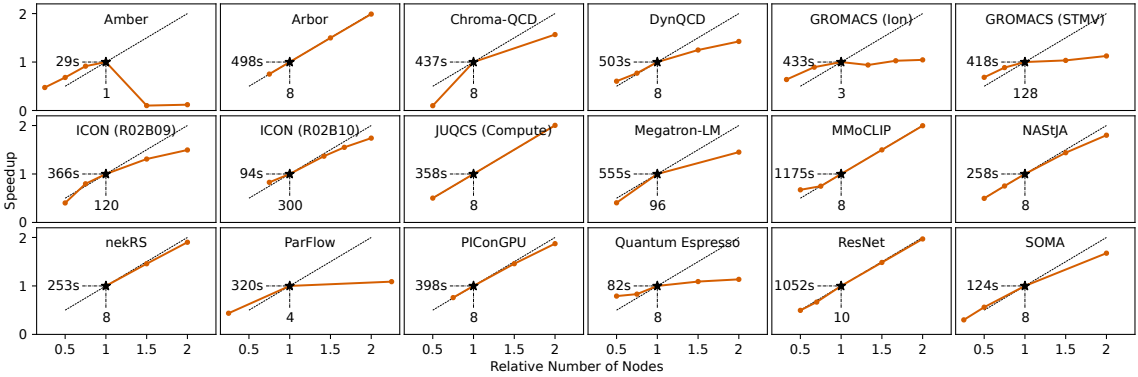
*JUBE example*

# Grand Table Benchmark Details

- Languages, models, libraries
- Licenses
- References nodes Base, High-Scaling
- Memory variants
- Execution targets

| | Application Features | | | Execution Targets | | |
|---|---|---|---|---|---|---|
| | Benchmark Name | Progr. Language, [Libraries, ]Prog. Models | Licence | Nodes Base | Nodes High-Scale $N^{\text{Mem Vars}}$ | Module/ Device (B, B, C, M) |
| Application | Amber* | Fortran, CUDA | *Custom* | 1 | | ✓ |
| | Arbor | C++, CUDA/HIP | BSD-3-Clause | 8 | $642^{T,S,M,L}$ | ✓ |
| | Chroma-QCD | C++, QUDA, CUDA/HIP | JLab | 8 | $512^{S,M,L}$ | ✓ |
| | GROMACS | C++, CUDA/SYCL | LGPLv2.1 | 3/128 | | ✓ |
| | ICON | Fortran/C, OpenACC/CUDA/HIP | BSD-3-Clause | 120/300 | | ✓ |
| | JUQCS | Fortran, CUDA/OpenMP | *None* | 8 | $512^{S,L}$ | ✓ ✓ |
| | nekRS | C++/C, OCCA, CUDA/HIP/SYCL | BSD-3-Clause | 8 | $642^{S,M,L}$ | ✓ |
| | ParFlow* | C, Hypre, CUDA/HIP | LGPL | 4 | | ✓ |
| | PIConGPU | C++, Alpaka, CUDA/HIP | GPLv3+ | 8 | $640^{S,M,L}$ | ✓ |
| | Quantum Espresso | Fortran, ELPA, OpenACC/CUF | GPL | 8 | | ✓ |
| | SOMA* | C, OpenACC | LGPL | 8 | | ✓ |
| | MMoCLIP | Python, PyTorch, CUDA/ROCm | MIT | 8 | | ✓ |
| | Megatron-LM | Python, PyTorch/Apex, CUDA/ROCm | BSD-3-Clause | 96 | | ✓ |
| | ResNet* | Python, TensorFlow, CUDA/ROCm | Apache-2.0 | 10 | | ✓ |
| | DynQCD | C, OpenMP | *None* | 8 | | ✓ |
| | NAStJA | C++, MPI | MPL-2.0 | 8 | | ✓ |
| Synthetic | Graph500 | C, MPI | MIT | 4/16/all | | ✓ |
| | HPCG | C++, OpenMP, CUDA/HIP | BSD-3-Clause | 1/4/all | | ✓ ✓ |
| | HPL | C, BLAS, OpenMP, CUDA/HIP | BSD-4-Clause | 1/16/all | | ✓ ✓ |
| | IOR | C, MPI | GPLv2 | -/> 64 | | ✓ ✓ |
| | LinkTest | C++, MPI/SIONlib | BSD-4-Clause+ | all | | ✓ ✓ ✓ |
| | OSU | C, MPI, CUDA | BSD | 1/2 | | ✓ ✓ ✓ |
| | STREAM | C, CUDA/ROCm/OpenACC | *Custom* | 1 | | ✓ ✓ |

# TCO Base Result Grid




Execution on reference number of nodes ($x = 1$) resulting in reference timing ($y = 1$); absolute numbers super-imposed; strong scaling to $0.5\times$ - $2\times$



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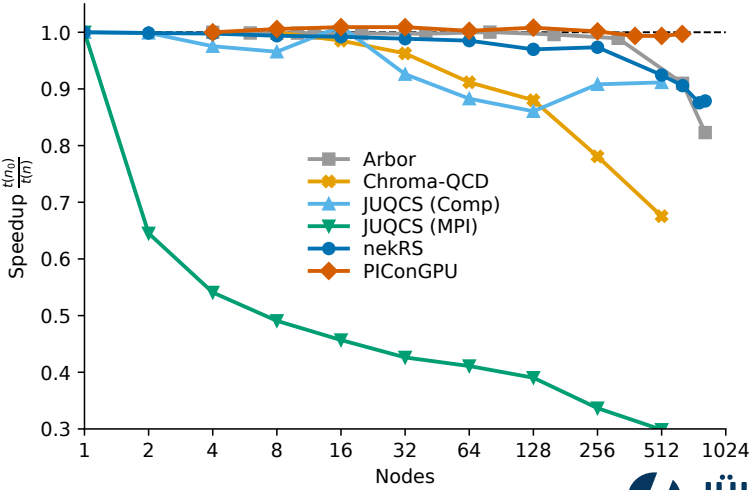
# High-Scaling Results

Weak-scaling relative to reference up to 642 nodes (50 PFLOP/s th.)



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# High-Scaling Results

Weak-scaling
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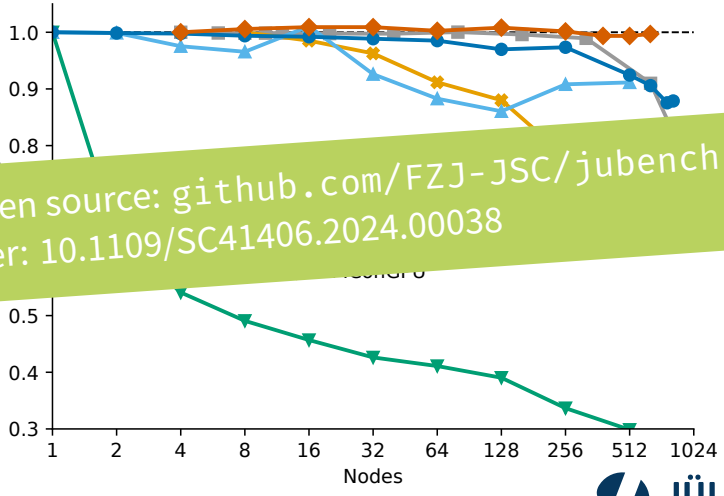


All benchmarks open source: github.com/FZJ-JSC/jubench
Paper: 10.1109/SC41406.2024.00038



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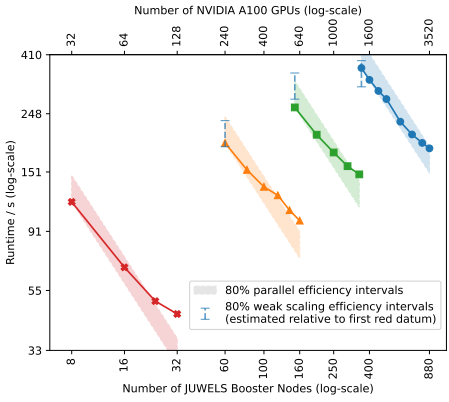
# JUREAP Overview

- Competitive early access program since 2024
- Open phase: 130 proposals
- Various domains, methods (simulation, AI)
- Preparations on JEDI, JUWELS, other EU systems
- **Reproducibility, continuous integration (*exaCB*)**
- Lighthouse application: peer-reviewed selection, 15🇪🇺+18🇩🇪 apps

→ Currently preparing intensively (*pre-production*) for imminent production runs

- *Also*: GCS AI competition



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- [illegible] apps

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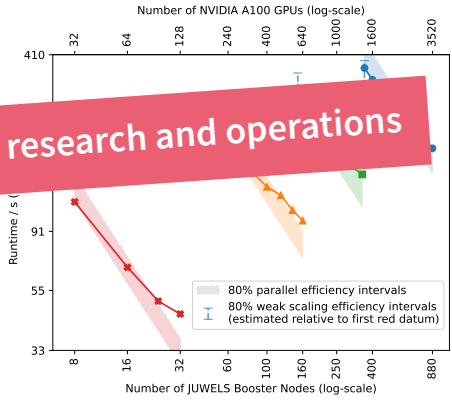
**Goal:** Make benchmarking core for HPC research and operations



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exacb.pages.jsc.fz-juelich.de

**Features**

- Continuous Benchmarking for HPC
- Template-based declarative syntax
- Reduced barrier to entry for CI/CB
- Reproducible benchmarks (JUBE, …)
- Ease of sharing workflows
- Pre-defined runs, experiments

→ Currently extending, publishing

JUREAP default example:

```yaml
include:
 - component: jureap/jube@v3.2
   inputs:
    prefix: "jedi.strong.tiny"
    variant: "strong.tiny"
    machine: "jedi"
    queue: "all"
    project: "cjsc"
    budget: "zam"
    jube_file: "simple.yaml"
```


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Energy measurement example:

```yaml
include:
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    machine: "jedi"
    queue: "all"
    project: "cjsc"
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    jube_file: "simple.yaml"
```



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# exaCB

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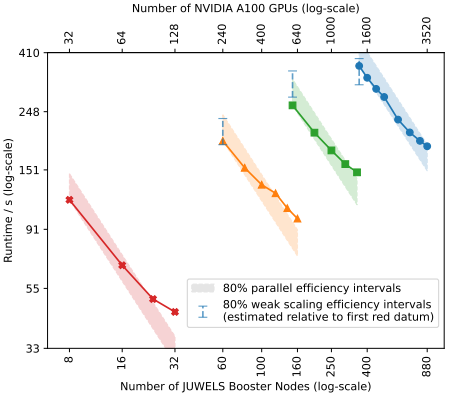




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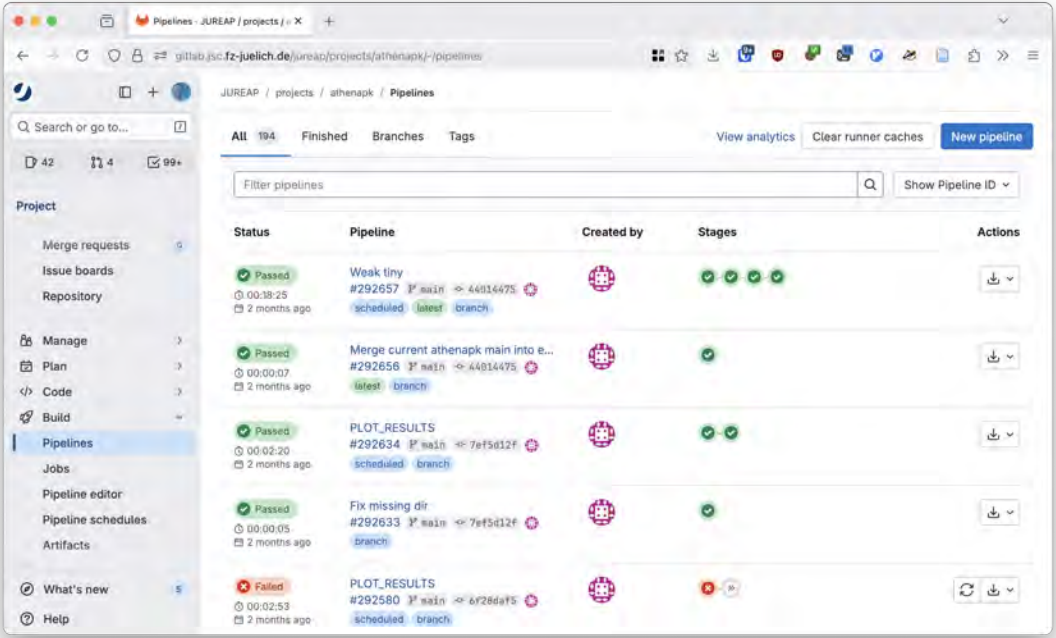
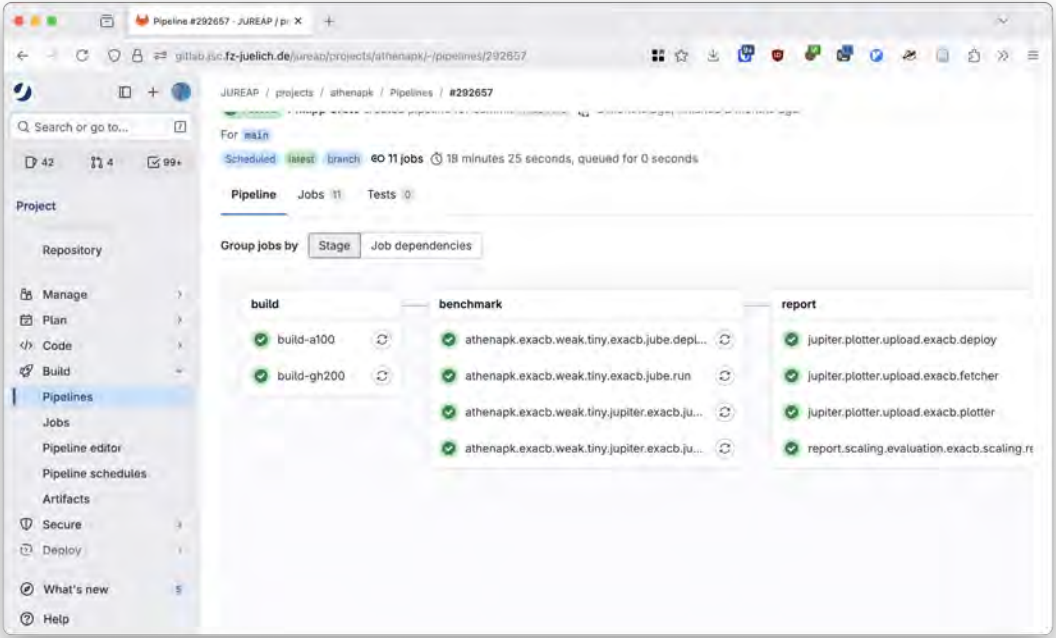

Pipelines · JUREAP / projects / athenapk
gitlab.jsc.fz-juelich.de/jureap/projects/athenapk/-/pipelines
JUREAP / projects / athenapk / Pipelines
Search or go to...
42
4
99+
Project
Merge requests
Issue boards
Repository
Manage
Plan
Code
Build
Pipelines
Jobs
Pipeline editor
Pipeline schedules
Artifacts
What's new
Help
All 194
Finished
Branches
Tags
View analytics
Clear runner caches
New pipeline
Filter pipelines
Show Pipeline ID
Status
Pipeline
Created by
Stages
Actions
Passed
00:18:25
2 months ago
Weak tiny
#292657 main 44014475
scheduled latest branch
Passed
00:00:07
2 months ago
Merge current athenapk main into e...
#292656 main 44014475
latest branch
Passed
00:02:20
2 months ago
PLOT_RESULTS
#292634 main 7ef5d12f
scheduled branch
Passed
00:00:05
2 months ago
Fix missing dir
#292633 main 7ef5d12f
branch
Failed
00:02:53
2 months ago
PLOT_RESULTS
#292580 main 6f28daf5
scheduled branch


Pipeline #292657 · JUREAP / pi
gitlab.jsc.fz-juelich.de/jureap/projects/athenapk/-/pipelines/292657
Search or go to...
42
4
99+
Project
Repository
Manage
Plan
Code
Build
Pipelines
Jobs
Pipeline editor
Pipeline schedules
Artifacts
Secure
Deploy
What's new
Help
JUREAP / projects / athenapk / Pipelines / #292657
For main
Scheduled latest branch 60 11 jobs 18 minutes 25 seconds, queued for 0 seconds
Pipeline Jobs 11 Tests 0
Group jobs by Stage Job dependencies
build
build-a100
build-gh200
benchmark
athenapk.exacb.weak.tiny.exacb.jube.depl...
athenapk.exacb.weak.tiny.exacb.jube.run
athenapk.exacb.weak.tiny.jupiter.exacb.ju...
athenapk.exacb.weak.tiny.jupiter.exacb.ju...
report
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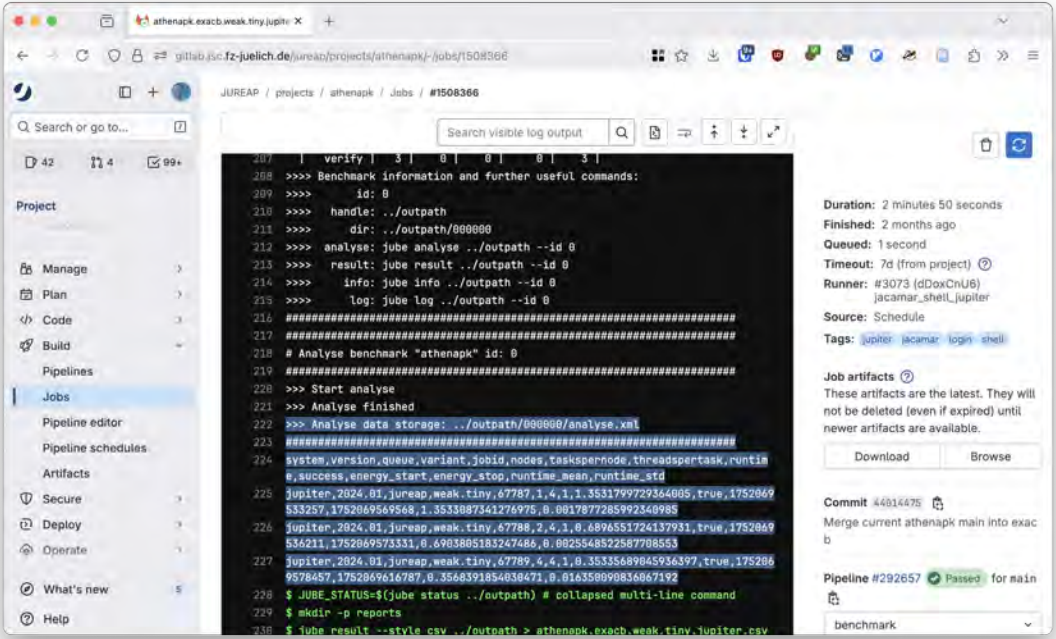
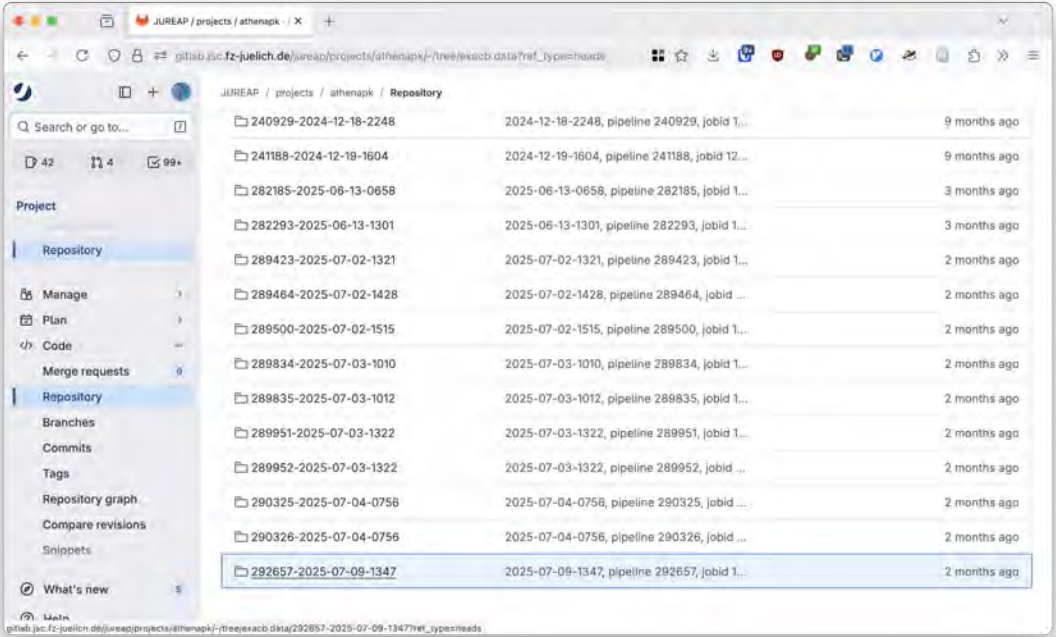

athenapk.exacb.weak.tiny.jupiter
gitlab.jsc.fz-juelich.de/jureap/projects/athenapk/-/jobs/1508366
Search or go to...
42
4
99+
Project
Manage
Plan
Code
Build
Pipelines
Jobs
Pipeline editor
Pipeline schedules
Artifacts
Secure
Deploy
Operate
What's new
Help
JUREAP / projects / athenapk / Jobs / #1508366
Search visible log output
| verify | 3 | 0 | 0 | 0 | 3 |
>>>> Benchmark information and further useful commands:
>>>> id: 0
>>>> handle: ../outpath
>>>> dir: ../outpath/000000
>>>> analyse: jube analyse ../outpath --id 0
>>>> result: jube result ../outpath --id 0
>>>> info: jube info ../outpath --id 0
>>>> log: jube log ../outpath --id 0
# Analyse benchmark "athenapk" id: 0
>>> Start analyse
>>> Analyse finished
>>> Analyse data storage: ../outpath/000000/analyse.xml
system,version,queue,variant,jobid,nodes,taskspernode,threadspertask,runtime,success,energy_start,energy_stop,runtime_mean,runtime_std
jupiter,2024.01,jureap,weak.tiny,67787,1,4,1,1.3531799729364005,true,1752069533257,1752069569568,1.3533087341276975,0.0017877285992340985
jupiter,2024.01,jureap,weak.tiny,67788,2,4,1,0.6896551724137931,true,1752069536211,1752069573331,0.6903805183247486,0.0025548522587708553
jupiter,2024.01,jureap,weak.tiny,67789,4,4,1,0.3533568904593639?,true,1752069578457,1752069616787,0.3568391854030471,0.016358090836067192
$ JUBE_STATUS=$(jube status ../outpath) # collapsed multi-line command
$ mkdir -p reports
$ jube result --style csv ../outpath > athenapk.exacb.weak.tiny.jupiter.csv
Duration: 2 minutes 50 seconds
Finished: 2 months ago
Queued: 1 second
Timeout: 7d (from project)
Runner: #3073 (dDoxCnU6) jacamar_shell_jupiter
Source: Schedule
Tags: jupiter jacamar login shell
Job artifacts
These artifacts are the latest. They will not be deleted (even if expired) until newer artifacts are available.
Download
Browse
Commit 44014475
Merge current athenapk main into exacb
Pipeline #292657 Passed for main
benchmark


JUREAP / projects / athenapk
gitlab.jsc.fz-juelich.de/jureap/projects/athenapk/-/tree/exacb.data?ref_type=heads
Search or go to...
42
4
99+
Project
Repository
Manage
Plan
Code
Merge requests
Repository
Branches
Commits
Tags
Repository graph
Compare revisions
Snippets
What's new
JUREAP / projects / athenapk / Repository
240929-2024-12-18-2248 2024-12-18-2248, pipeline 240929, jobid 1... 9 months ago
241188-2024-12-19-1604 2024-12-19-1604, pipeline 241188, jobid 12... 9 months ago
282185-2025-06-13-0658 2025-06-13-0658, pipeline 282185, jobid 1... 3 months ago
282293-2025-06-13-1301 2025-06-13-1301, pipeline 282293, jobid 1... 3 months ago
289423-2025-07-02-1321 2025-07-02-1321, pipeline 289423, jobid 1... 2 months ago
289464-2025-07-02-1428 2025-07-02-1428, pipeline 289464, jobid ... 2 months ago
289500-2025-07-02-1515 2025-07-02-1515, pipeline 289500, jobid 1... 2 months ago
289834-2025-07-03-1010 2025-07-03-1010, pipeline 289834, jobid 1... 2 months ago
289835-2025-07-03-1012 2025-07-03-1012, pipeline 289835, jobid 1... 2 months ago
289951-2025-07-03-1322 2025-07-03-1322, pipeline 289951, jobid 1... 2 months ago
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290326-2025-07-04-0756 2025-07-04-0756, pipeline 290326, jobid ... 2 months ago
292657-2025-07-09-1347 2025-07-09-1347, pipeline 292657, jobid 1... 2 months ago
gitlab.jsc.fz-juelich.de/jureap/projects/athenapk/-/tree/exacb.data/292657-2025-07-09-1347?ref_type=heads

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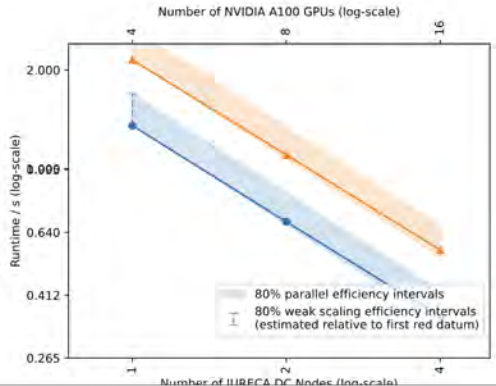
42 4 99+
Project
Repository
Manage
Plan
Code
Merge requests 0
Repository
Branches
Commits
Tags
Repository graph
Compare revisions
Snippets
What's new 5
Help

July 9, 2025

## 1 Evaluation Plot

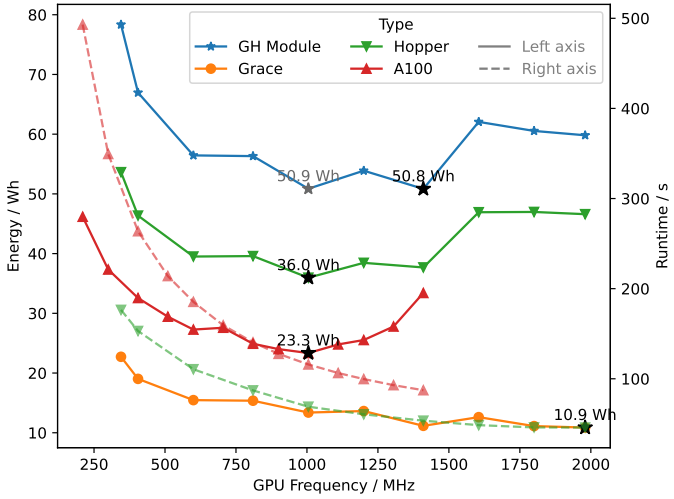


# First JUPITER Results

# GH200/A100 Application Performance/Efficiency

- Test application: MPTRAC
- Lagrangian transport of particles
- Analysis of Energy-to-Solution for Grace, Hopper, GH200; A100
- Horizontal: Different GPU clock frequencies

→ Energy-saving potential

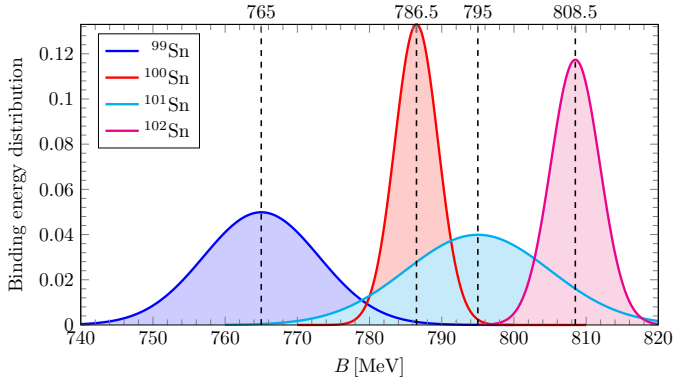





JÜLICH Forschungszentrum

# QCD Lattice Calculation of Tin

- FZJ work simulating Sn isotopes
- Fine lattice, many nodes of JUPITER
- First ab-initio calculation; insight: binding energy below extrapolated values
- Preprint on arXiv (2509.08579)

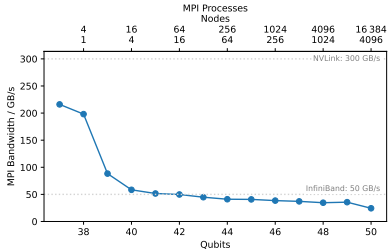


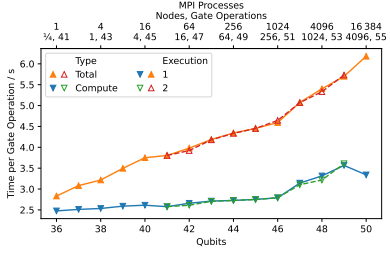



JÜLICH Forschungszentrum

# Quantum Computing: JUQCS

- Universal Quantum Computer Simulator
- Very communication network (HPC network)
- Long-term investment (JUWELS, JUPITER; benchmark suite, JUREAP)
- **JUPITER: Record-breaking 50 Qubit simulation**
  - 16 384 GH200 ($2^{14}$); GPU for simulation, but CPU+GPU memory together (2 PB)
  - Constant memory exchange
  - Advanced data encoding
  - 11× speed-up over previous 48 Qubit record (K computer)



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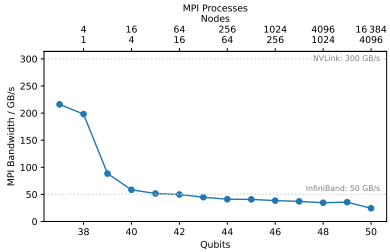
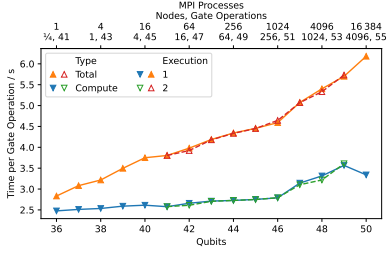
→ arXiv 2511.03359



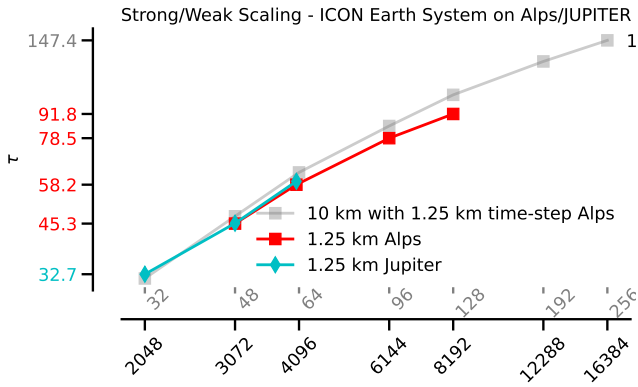



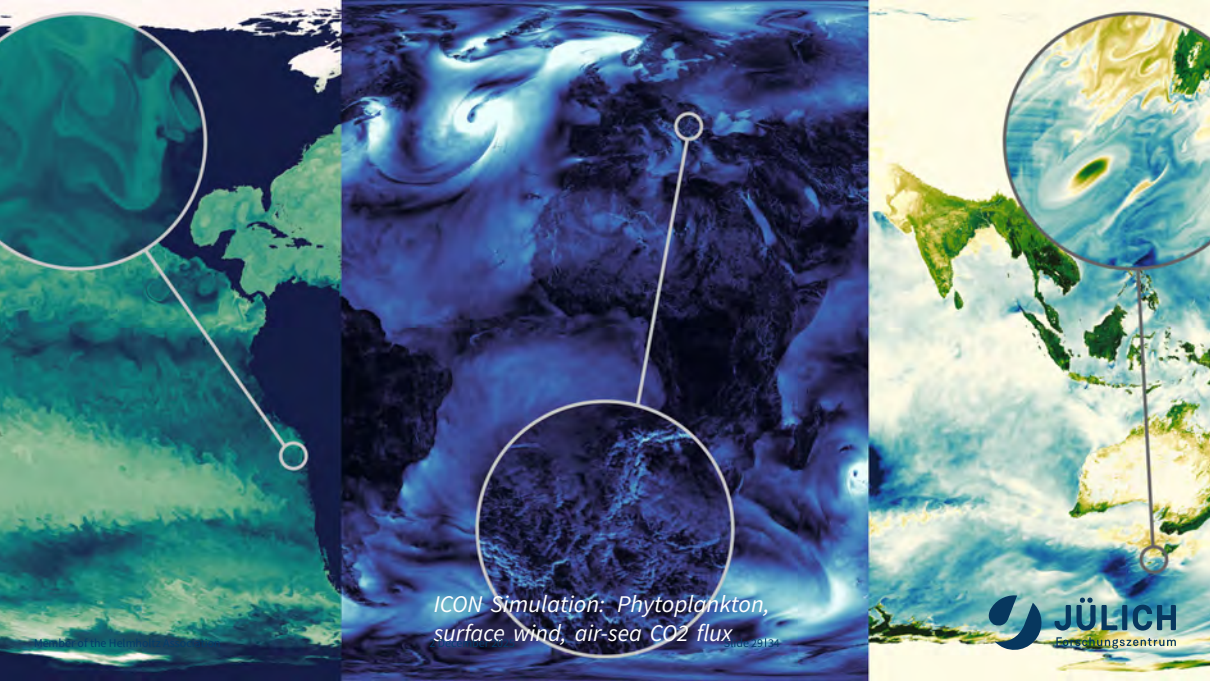



JÜLICH Forschungszentrum

# ICON

- **ICON**: European weather/climate model by Max Planck Institute for Meteorology, DKRZ, and others
- Components for simulation of atmosphere, ocean, land, …
- Early JUREAP target
- Simulation of full Earth System at 1.25 km resolution
  - 20 480 GH200 of JUPITER
  - Full superchip: CPU (ocean, land) and GPU (atmosphere)
  - 145 days simulated days per real day




ICON Simulation: Phytoplankton, surface wind, air-sea CO2 flux
JÜLICH
Forschungszentrum

# ICON

- **ICON**: European weather/climate model by Max Planck Institute for Meteorology, DKRZ, and others
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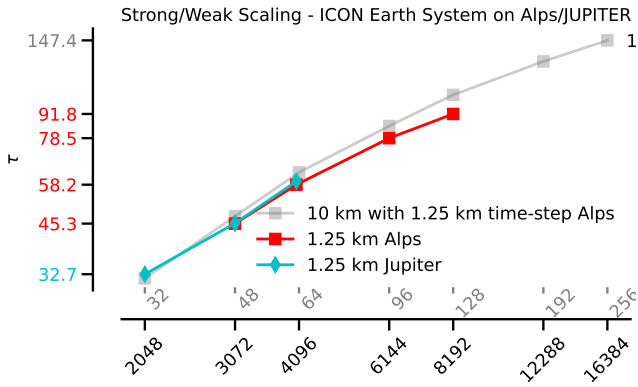
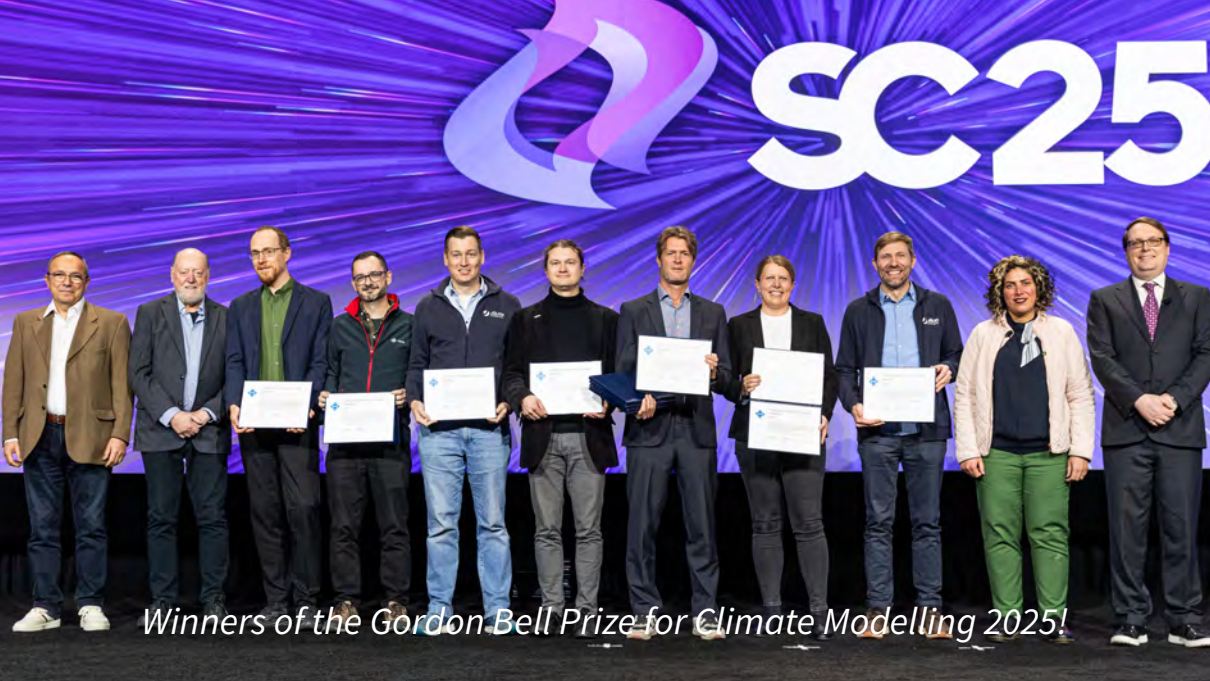
→ DOI 10.1145/3712285.3771789




SC25




*Winners of the Gordon Bell Prize for Climate Modelling 2025!*


ACM Gordon Bell Prize for Climate Modelling
2025
PRESENTED TO

# Conclusion

# Conclusions

- JUPITER: European exascale system, just inaugurated
  - 24 000 GH200 with plenty of performance
  - TOP500: #1 Europe, #4 world
- Application-first approach
- JUPITER Benchmark Suite with community involvement; sustainability
- JUREAP: Competitive program for early access of JUPITER
- exaCB: Make benchmarking first-class
- First results from users coming in

# Conclusions

- JUPITER: European exascale system, just inaugurated
  - 24 000 GH200 with plenty of performance
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- JUPITER Benchmark S olvement; sustainability
- JUREAP: Competitive p of JUPITER
- exaCB: Make benchmarking first-class
- First results from users coming in

*Thank you for your attention!*

*a.herten@fz-juelich.de*



JÜLICH Forschungszentrum

# JUPITER

## The Arrival of Exascale in Europe

fz-juelich.de/jupiter | #exa_jupiter

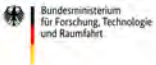
Funding Agencies:

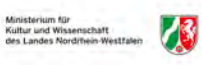
EuroHPC

Federal Ministry of Education and Research

Ministry of Culture and Science of the State of North Rhine-Westphalia

# JOINING FORCES









**fz-juelich.de/jupiter**

# Appendix

# GPU Performance Details

| Vend. | System | Device | TDP | Compute Performance *Float Precision* | | | | | | | Memory | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 64 | $64^{M}$ | 32 | $32^{M}$ | $16^{M}$ | $8^{M}$ | $8^{S}$ | Size | BW |
| | | | W | TFLOP/s | | | | | | | GB | TB/s |
| AMD | Frontier | MI250X | 560 | 48 | 96 | 48 | 96 | 383 | | | 128 | 3.2 |
| | El Capitan | MI300A | 760 | 61 | 123 | 123 | 123 | 981 | 1961 | 3922 | 128 | 5.3 |
| Intel | Aurora | PVC | 600 | 52 | | 52 | 419 | 839 | | | 128 | 3.2 |
| NVIDIA | JUPITER | GH200 | 680 | 34 | 67 | 67 | 494 | 989 | 1979 | 3958 | 96 | 4 |

# GPU Performance Details

Matrix Compute

Sparse+Matrix Compute

| Vend. | System | Device | TDP | Compute Performance *Float Precision* | | | | | | | Memory | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 64 | $64^{M}$ | 32 | $32^{M}$ | $16^{M}$ | $8^{M}$ | $8^{S}$ | Size | BW |
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| NVIDIA | JUPITER | GH200 | 680 | 34 | 67 | 67 | 494 | 989 | 1979 | 3958 | 96 | 4 |

Superchip TDP

TF32



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# Application Descriptions

## TCO

| | |
|---|---|
| Amber | Molecular dynamics; STMV use-case; single node |
| ParFlow | Hydrology; ClayL use-case |
| SOMA | Polymer simulation; Monte-Carlo |
| ResNet | AI: Computer vision; TensorFlow |
| DynQCD | Particle physics; CPU-only |
| GROMACS | Molecular dynamics: GluCL, STMV use-cases; multi-node |
| ICON | Climate simulation; atmosphere with R02B09, R02B10; many nodes |
| Megatron-LM | AI: LLM; PyTorch |
| MMoCLIP | AI: Mixed-Modal (text, image); PyTorch |
| Quantum ESPRESSO | Electronic structure; Car-Parrinello test-case |
| NAStJA | Biology; CPU-only, MPI-only |

## TCO & High-Scaling

| | |
|---|---|
| Arbor | Neuroscience; busyring benchmark |
| Chroma | Particle physics; hybrid-Monte-Carlo test; QUDA with JIT; max 512 nodes |
| JUQCS | Quantum computer simulator; gate-based simulation; communication-heavy; max 512 nodes; Cluster-Booster version (MSA) |
| nekRS | Fluid dynamics; Rayleigh-Bénard convection use-case |
| PIConGPU | Plasma physics; Kelvin-Helmholtz instability use-case |

# JUPITER Application Benchmarks

- JUPITER: Largest procurement to date
- >18 months of work
- >30 people involved
- 1(-3) associated people (*captains*) per benchmark
- Meetings every two weeks
- Gitlab issue tracker, status tracker (11 points)

1. Source code available
2. Input data available
4. JUBE integration
11. Description, documentation




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# Lessons Learned

Performance models useful, even if simple

Domain decomposition scripts/rules for unknown system makeup

Intensive feedback for app devs

Verification is hard

*Applications*

Suite: resource-intensive → aim for short turnaround times during dev

Artificially limit benchmarks on prep system to mimic future system

Extensive, balanced execution rules/guidelines

*Benchmarks*

Multi-system procurement → benchmark balance 😰

Collaboration, tools

Bias towards incremental update

Limiter: time, on *all* sides → reuse!

*Procurement*

# Benchmark Suite Availability

- All benchmark workflows, descriptions, data released online
- Code GitHub `jubench` meta-repository, Zenodo meta-record
  Individual repos: Arbor Amber Chroma-LQCD GROMACS ICON JUQCS Megatron-LM MMoCLIP nekRS ParFlow PIConGPU Quantum ESPRESSO ResNet SOMA DynQCD (CPU) NAStJA (GPU) Graph500 HPCG HPL IOR LinkTest OSU Micro-Benchmarks STREAM STREAM (GPU)
- Paper SC24 Proceedings, arXiv:2408.17211
  Including extensive SC reproducibility appendix

*GitHub*

*Proceedings*



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