

Julia for High-Performance Computing Minisymposium

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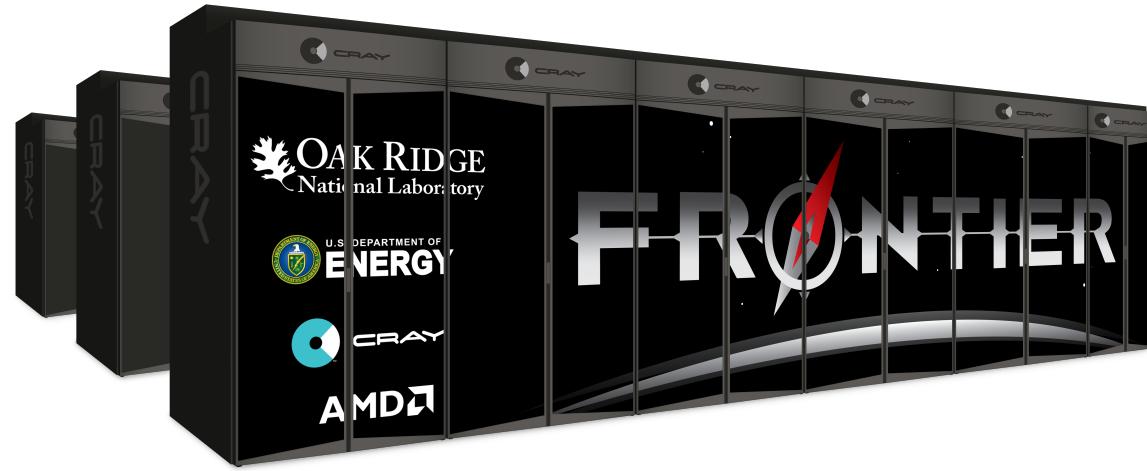
Prepared for: Julia for HPC Minisymposium at JuliaCon 2022

ORNL is managed by UT-Battelle, LLC for the US Department of Energy



Goals of the Minisymposium

- The current landscape of Julia for HPC
- Provide an informative and collaborative venue
- Potential collaboration and opportunities for engagement around Julia in HPC
- Establish Julia as an end-to-end codesign and interoperable language and ecosystem
- Promote the people behind Julia for HPC

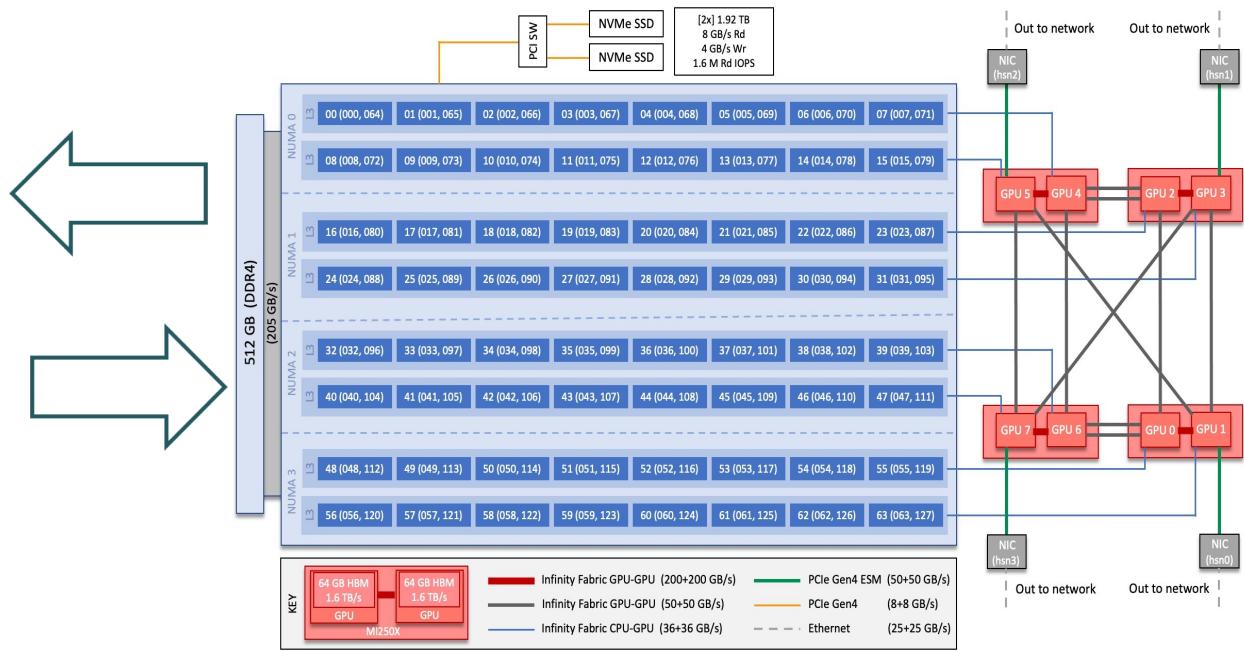
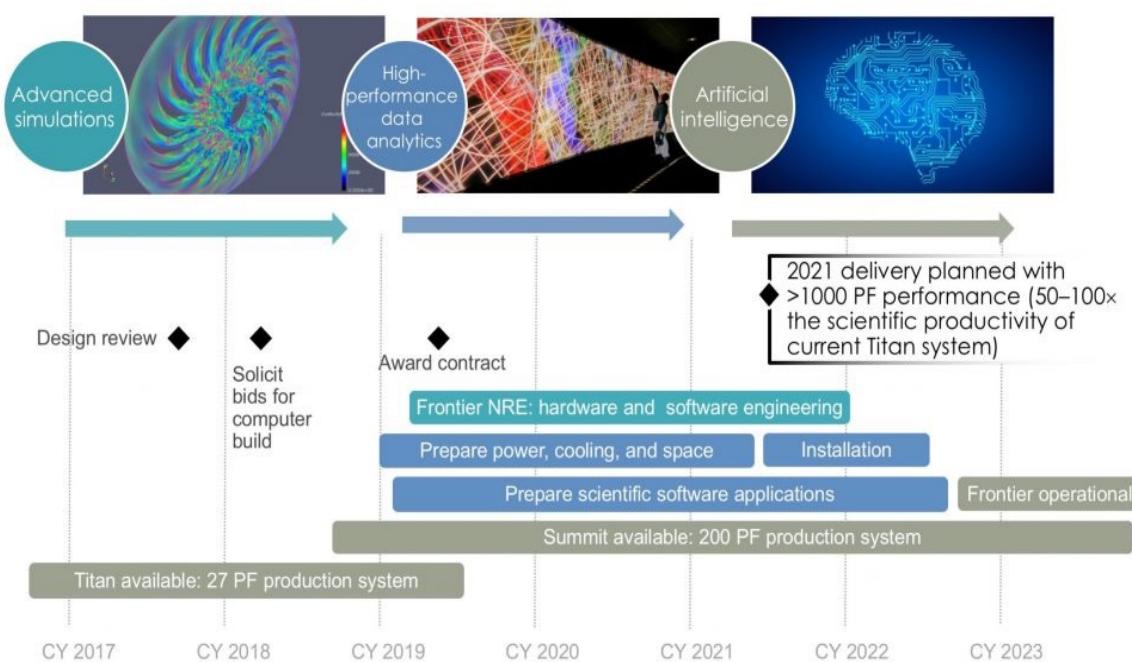


JULIA FOR HPC
JuliaCon 2022 Minisymposium

Rethink how we do Computing

- Scientific programming is HARD (specially on Supercomputers, aka Leadership Computing Facilities, LCFs)
- Software is our “specialized science equipment” for science
- There is still a lot of plumbing to be done
- Programming productivity is always a challenge
- Barrier to entry from idea to portable performance
- AI/ML+HPC is a multidisciplinary co-design challenge
- How to leverage ECP legacy?

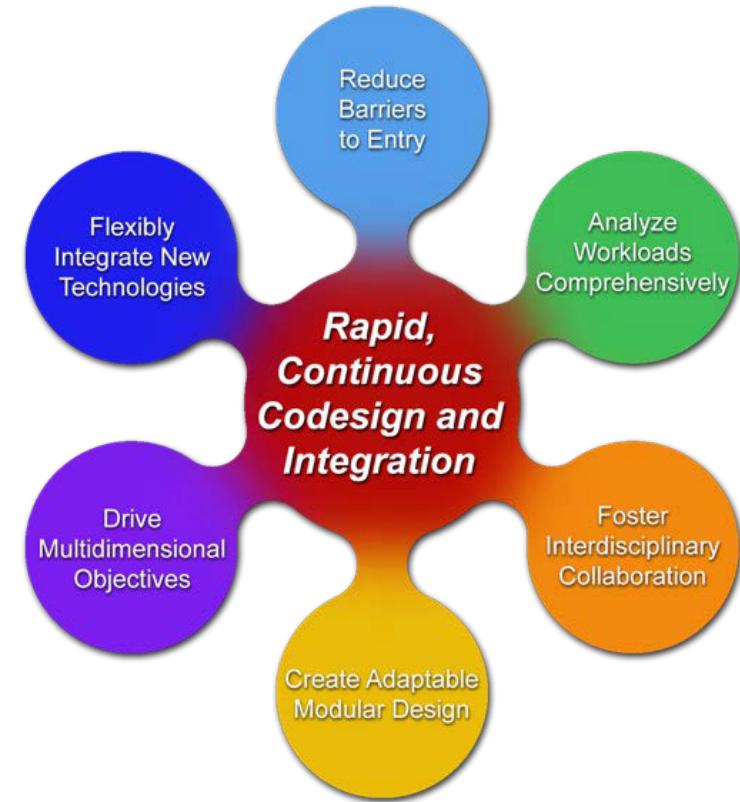
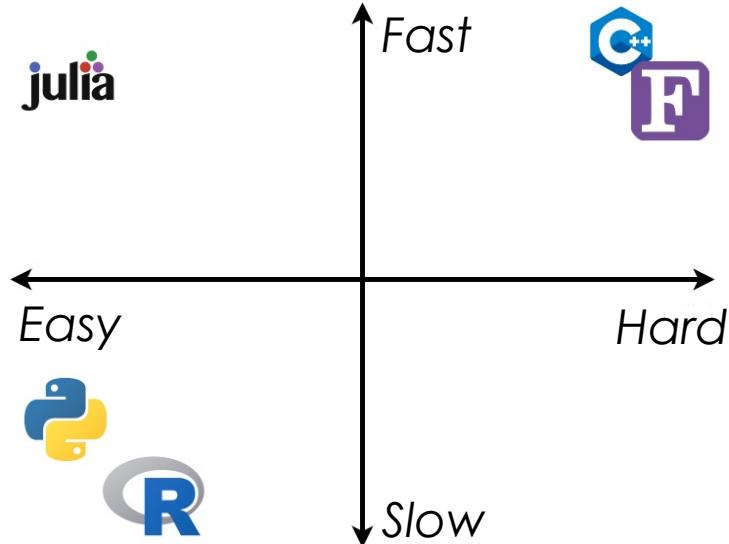
“Can a machine translate a sufficiently rich mathematical language into a sufficiently economical program at a sufficiently low cost to make the whole affair feasible?”
----- Backus on Fortran (1980)



The case for Julia: science Domain Specific Language (DSL) “front-end” to LLVM

- Designed for “scientific computing” (Fortran-like) and “data science” (Python-like)
- Performant code via LLVM, JIT or AOT compilation
- Create “energy efficient” codesign synergies
- Julia is a unifying workflow language

Home → SIAM Review → Vol. 59, Iss. 1 → 10.1137/141000671
← Previous Article | Next Article →
Julia: A Fresh Approach to Numerical Computing
Jeff Bezanson, Alan Edelman, Stefan Karpinski, and Viral B. Shah
<https://doi.org/10.1137/141000671>
PDF BibTeX SECTIONS Tools
Abstract
Bridging cultures that have often been distant, Julia combines expertise from the diverse fields of computer science and computational science to create a new approach to numerical computing. Julia is designed to be easy and fast and questions notions generally held to be “laws of nature” by practitioners of numerical computing:
• High-level dynamic programs have to be slow.
• One must prototype in one language and then rewrite in another language for speed or deployment.
• There are parts of a system appropriate for the programmer, and other parts that are best left untouched as they have been built by the experts.
• We introduce the Julia programming language and its design---a dance between specialization and abstraction. Specialization allows for custom treatment. *Multiple dispatch*, a technique from computer science, picks the right algorithm for the



Key question: “What novel approaches to software design and implementation can be developed to provide performance portability for applications across radically diverse computing architectures?” from Reimagining Codesign for Advanced Scientific Computing: Unlocking Transformational Opportunities for Future Computing Systems for Science. DOE Report <https://doi.org/10.2172/1822198>

ORNL/CCSD efforts

- Projects:
 - **ECP PROTEAS-TUNE:** research performance on Exascale system of different programming models including Python Numba and Julia (W Godoy, J Vetter). SRP-HPC mentor
 - **ECP Proxy Apps:** evaluating Julia as a proxy to understand parallel I/O characteristics (W Godoy, P Fackler, G Watson)
- External Engagements with Julia HPC
 - Monthly meetings with stakeholders
 - [JuliaCon 2022 HPC minisymposium](#)
 - Julia HPC Position paper in the works
 - [ECP BoF Session on Rapid Prototyping for HPC using Julia, Python Numba, Flang](#)
- Internal Engagements
 - Tutorials at ORNL Software and Data Expo
 - Julia Workshop for ORNL Science:
<https://ornl.github.io/events/jufos2022/>

Bridging HPC Communities through the Julia Programming Language

Journal Title
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JULIA FOR HPC

JuliaCon 2022 Minisymposium



Live Talks! Register About Join Discord Schedule Sponsors

Julia for High-Performance Computing

Carsten Bauer, Michael Schlottke-Lakemper, Hendrik Ranocha, Johannes Blaschke, Jeffrey Vetter

07/26/2022, 10:00 AM — 1:00 PM EDT

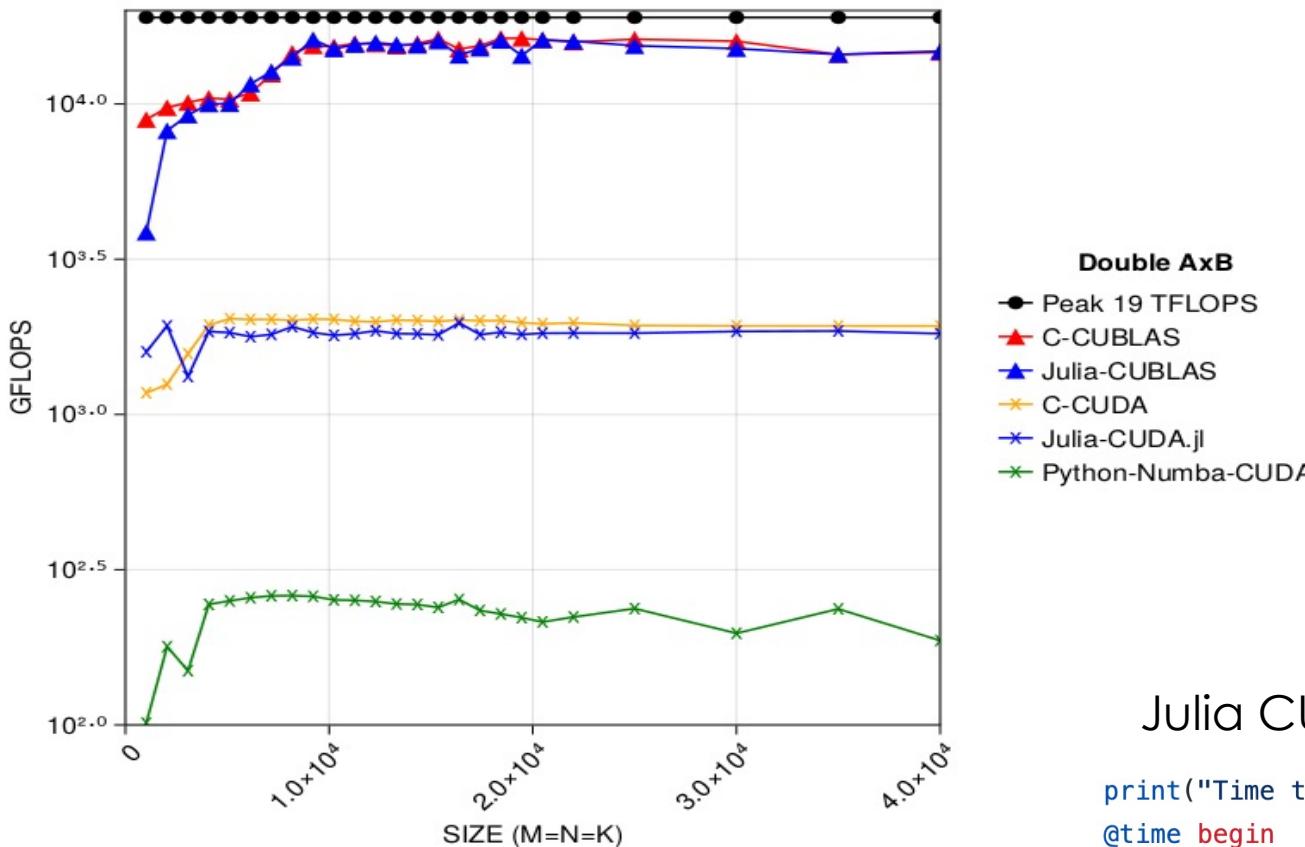
Green

Abstract:

The "Julia for HPC" minisymposium aims to gather current and prospective Julia practitioners in the field of high-performance computing (HPC) from multidisciplinary applications. We invite participation from industry, academia, and government institutions interested in Julia's capabilities for supercomputing. The goal is to provide a venue for Julia enthusiasts to share best practices, discuss current limitations, and identify future developments in the scientific HPC community.

Wombat ARM Neoverse CPU + NVIDIA A100 GPU Results for Matrix Multiplication

- <https://github.com/williamfgc/simple-gemm/tree/main/results>



Julia and Python's Numba kernel portability,
performance, and productivity on heterogeneous
exascale nodes

William F. Godoy, Pedro Valero-Lara, T. Elise Dettling, Christian Trefftz, Ian Jorquera,
Thomas Sheehy, Ross G. Miller, Marc Gonzalez-Tallada, Jeffrey S Vetter
Oak Ridge National Laboratory
{godoywf}, {valerolarap}, {dettlingte}, {trefftzci}, {jorqueraid}, {sheehytb}, {rgmiller}, {gonzaleztal}, {vetter}@ornl.gov

Julia CUBLAS

```
print("Time to simple gemm ")
@time begin
    C = A * B
    CUDA.synchronize()
end
```

Julia hand-rolled gemm

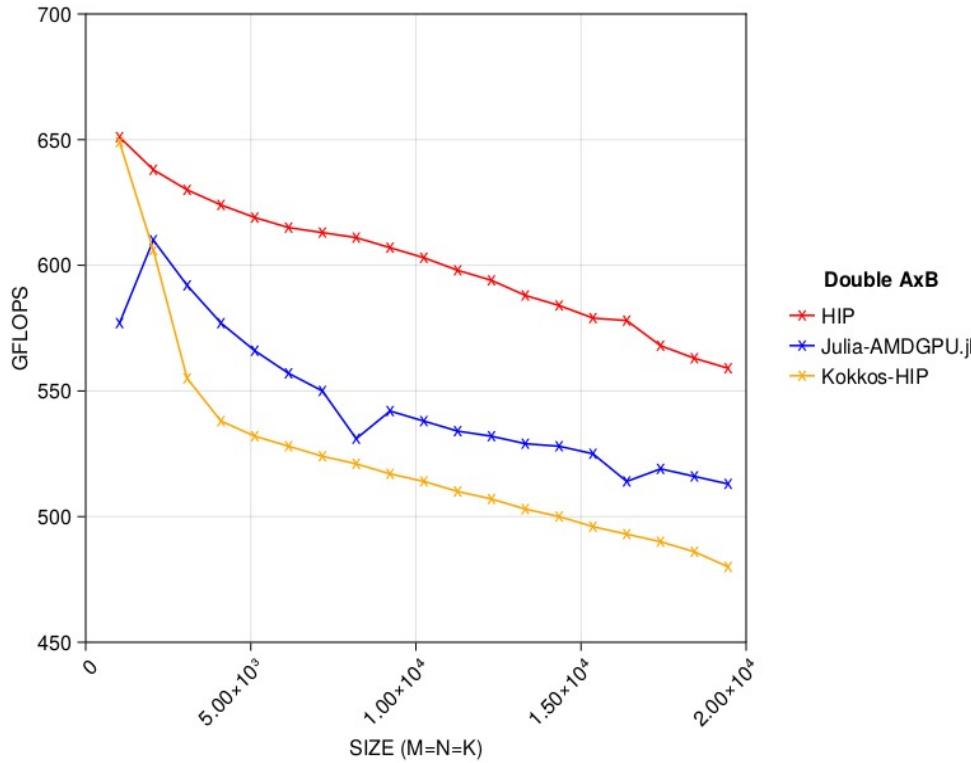
```
function gemm64!(
    A::CUDA.CuDeviceMatrix{Float64,1},
    B::CUDA.CuDeviceMatrix{Float64,1},
    C::CUDA.CuDeviceMatrix{Float64,1},
)

    row = (CUDA.blockIdx().x - 1) * CUDA.blockDim().x + CUDA.threadIdx().x
    col = (CUDA.blockIdx().y - 1) * CUDA.blockDim().y + CUDA.threadIdx().y
    sum = Float64(0.0)

    if row <= size(A, 1) && col <= size(B, 2)
        for i = 1:size(A, 2)
            @inbounds sum += A[row, i] * B[i, col]
        end
        C[row, col] = sum
    end
    return
end
```

Crusher, Frontier's testbed AMD EPYC 7A53 + AMD MI250X GPU

- <https://github.com/williamfgc/simple-gemm/tree/main/results>



Julia hand-rolled GEMM

<https://ptsolvers.github.io/GPU4GEO/posts/julia-amdgpu-crusher/> credit: Ludovic Rass

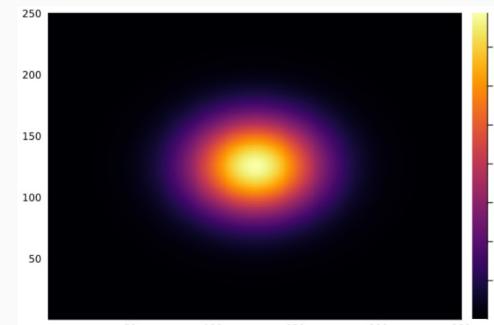
Julia multi-AMDGPU test solver to run on OLCF test system

June 25, 2022 2-minute read
julia • amdgpu • coding

We successfully launched a test simulation of a 2D linear diffusion on AMD MI250x using ROCm-aware MPI on OLCF Crusher system.

ROCM-aware MPI (AMDGPU.jl & ImplicitGlobalGrid.jl)

Ludovic Räss

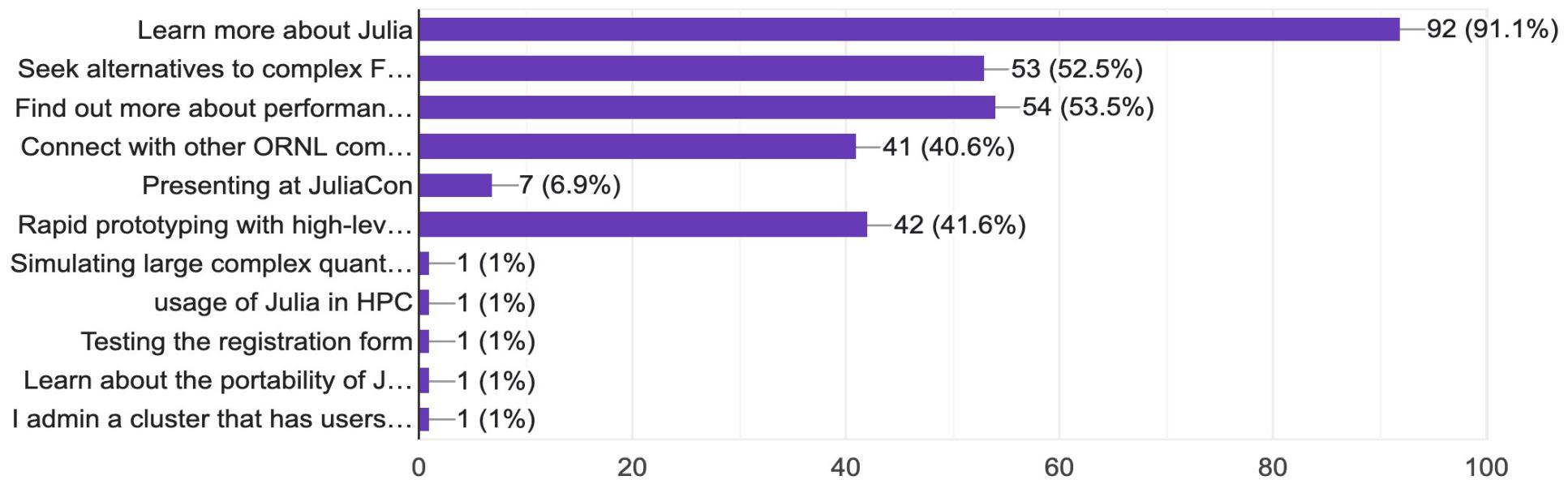


Final Thoughts

- Julia is still “new” to the large majority, but interest and momentum are real
- Results from registered participants to JuFOS: <https://ornl.github.io/events/jufos2022/>

Why are you interested in the event?

101 responses



Final Thoughts

- Can Julia help scientists invest more time in science?
- What investments are needed in Julia for HPC?
- Can Julia help bridging social barriers between AI, data science and HPC?
- What's the language and community roadmap, locally and externally?
- What's the ROI for ORNL scientists adopting Julia?
- People: active community, helpful and enthusiastic

- 0:00: *William F Godoy (ORNL) & Michael Schlottke-Lakemper (U Stuttgart/HLRS)*: **Julia for High-Performance Computing**
- 0:05: *Samuel Omlin (CSCS)*: **Scalability of the Julia/GPU stack**
- 0:15: *Simon Byrne (Caltech/CliMA)*: **MPI.jl**
- 0:25: Q&A
- 0:30: *Tim Besard (Julia Computing)*: **CUDA.jl: Update on new features and developments**
- 0:40: *Julian Samaroo (MIT)*: **AMDGPU.jl: State of development and roadmap to the future**
- 0:50: Q&A
- 1:00: *Albert Reuther (MIT)*: **Supporting Julia Users at MIT LL Supercomputing Center**
- 1:10: *Johannes Blaschke (NERSC)*: **Supporting Julia users on NERSC's "Cori" and "Perlmutter" systems**
- 1:20: Q&A
- 1:25: *Michael Schlottke-Lakemper (U Stuttgart/HLRS)*: **Running Julia code in parallel with MPI: Lessons learned**
- 1:35: *Ludovic Räss (ETH Zurich)*: **Julia and GPU-HPC for geoscience applications**
- 1:45: Q&A, Discussion & Wrap up

Acknowledgements

This research was supported by the Exascale Computing Project (17-SC-20-SC), a joint project of the U.S. Department of Energy's Office of Science and National Nuclear Security Administration, responsible for delivering a capable exascale ecosystem, including software, applications, and hardware technology, to support the nation's exascale computing imperative.

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Sponsors:

The [Exascale Computing Project](#),
[PROTEAS-TUNE](#), [Proxy App](#) and [SRP-HPC](#) sub-projects.

The [ASCR Bluestone Project](#)

12:30 EDT

[Julia in HPC](#)

 [Valentin Churavy](#), [Michael Schlotte-Lakemper](#), [Johannes Blaschke](#)

 07/28/2022, 12:30 PM — 2:00 PM EDT  BoF

The Julia HPC community has been growing over the last years with monthly meetings to coordinate development and to solve problems arising in the use of Julia for HPC.

The Julia in HPC Birth of the Feather is an ideal opportunity to join the community and to discuss your experiences with using Julia in HPC

Thanks to the audience. Enjoy the Minisymposium!
We also have a BoF on Thursday!