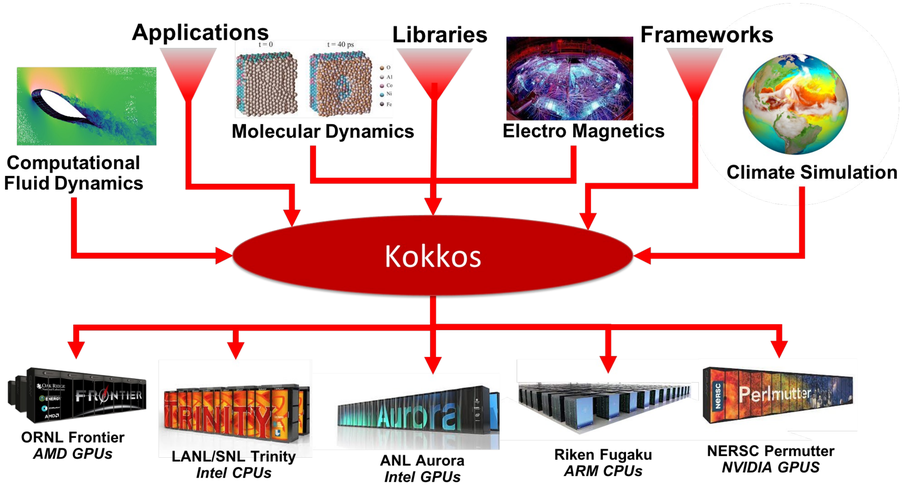
kokkos

Paving the Way to ExaScale

Sandia, Oak Ridge, Argonne and Lawrence Berkeley National Laboratories
C.R. Trott, D. Lebrun-Grandie, *N. Ellingwood, J. Ciesko, N. Liber, B. Turcksin, D. Arndt, R. Gayatri, N. Morales, A. Powell, E. Harvey, D. Lee, C. Clevenger, D. Ibanez*

C++ Performance Portability for Everyone

Kokkos Provides: *Vendor-Independent Isolation Layer*



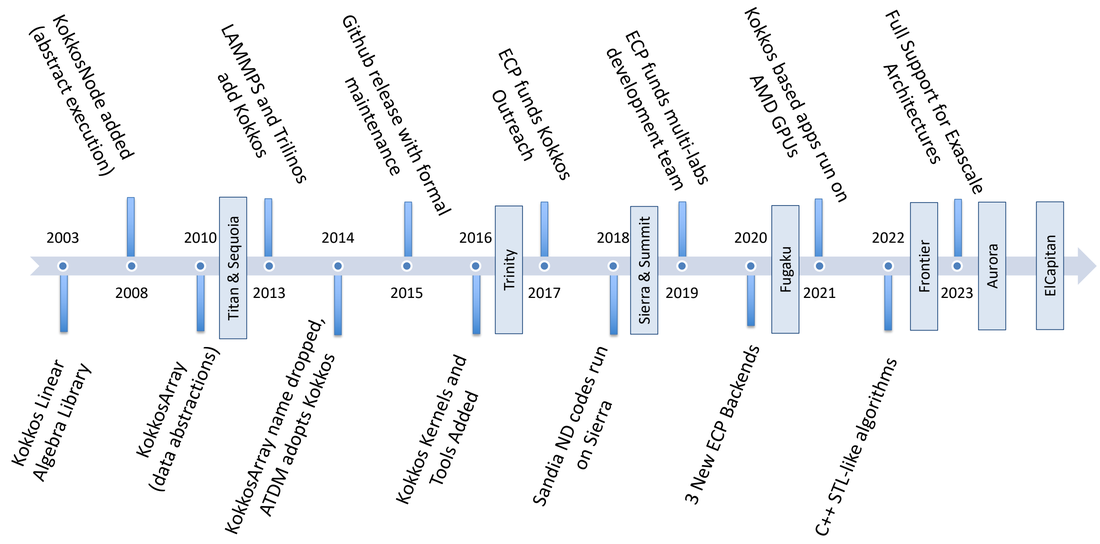
Multi-Lab Collaboration: *Local Support at Leading HPC Facilities*

Kokkos Core: ***C.R. Trott, D. Lebrun-Grandie***, *N. Ellingwood, J. Ciesko, N. Liber, B. Turcksin, D. Arndt, R. Gayatri, N. Morales, A. Powell, E. Harvey, D. Lee, C. Clevenger, D. Ibanez, M. Simberg*

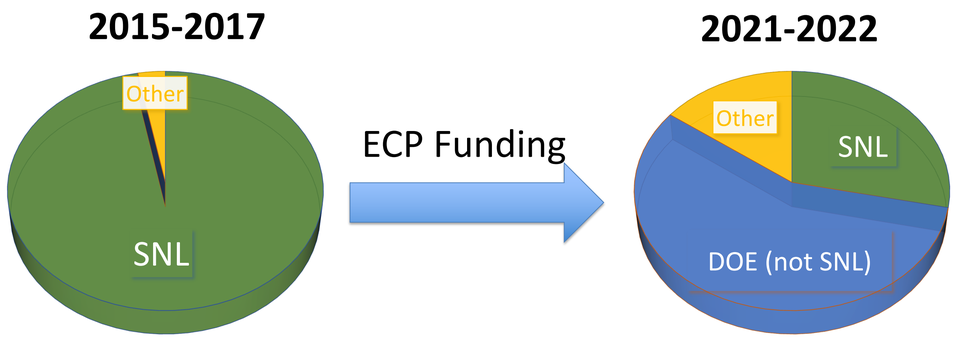
Kokkos Kernels: ***S. Rajamanickam, L. Berger,*** *N. Ellingwood, K. Kim, C.R. Trott, V. Dang, L. Berger, E. Harvey*

Kokkos Tools: *C.R. Trott, V. Kale, D. Lebrun-Grandie, D. Ibanez, S. Moore, A. Powell*

Development Timeline



Kokkos-Core Contributions

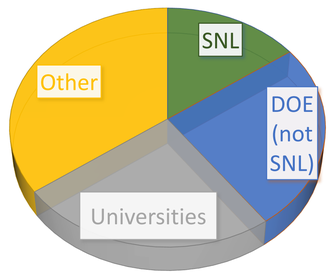


- Most of Kokkos-Tools and Kokkos-Kernels development still at Sandia
- ISO C++ Contribution well distributed over labs

Kokkos Uptake

https://kokkosteam.slack.com

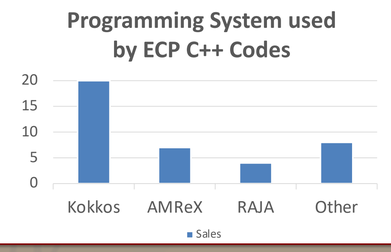
- >1000 Registered Users
- >130 Institutions



Kokkos @ Sandia National Laboratories
- Primary Programming Model for ASC and CSSE
- Used instead of CUDA/HIP/OpenCL/OpenMP

Applications and Libraries
- Estimated 150-300 HPC projects using Kokkos
- On the order of three-dozen apps run science and engineering production runs with Kokkos
  - Many apps use multiple Kokkos based libraries
- Similar distribution as the Slack User

Kokkos @ DOE Exascale Computing Project
- >50% of C++ codes in ECP use Kokkos
- <10% of C++ codes use directly CUDA/HIP/SYCL/OpenMP



Comparison with other Programming Models

	Kokkos	RAJA	OpenMP	OpenACC	SYCL/OneAPI
Uses Vendor Supported Toolchain on each System	✓	✓	✓		
Reference Semantics of Base Data Structures	✓	✓	✓	✓	✓
Parallel Unsequenced Loops as primary model	✓	✓		✓	✓
Explicitly connects data structure / execution resource	✓	✓	✓	✓	✓
Configurable Data Layouts	✓	✓			
Expose special function hardware	✓	✓	✓	✓	✓
Nested Parallelism	✓	✓	✓	✓	✓
Math Libraries/Tools	✓	✓	✓	✓	✓
Interoperability with low level vendor model	✓	✓	✗	✗	
Makes Simple Things Simple	✓	✓	✓	✓	

Major Kokkos Capabilities developed via ECP

HIP / SYCL / OpenMPTarget Backends
- Support for Frontier, Aurora and ElCapitan
- AMD support via HIP now considered mature
- SYCL support is stable but not yet mature – compilers still change a lot
- OpenMPTarget support is experimental – significant compiler issues prevented maturation in time for machine availability

Kokkos Lectures
- 15 hours of recording available online in 8 lectures
- Each lecture comes with exercises and their solutions
- Over 12,000 aggregate views on Youtube

C++ STL like Algorithms Support
- Support standard interfaces and interfaces taking Kokkos Views
- Makes Kokkos more accessible to typical C++ developers

ISO C++ Proposals
- AtomicRef in C++20 – atomic operations and non-atomic allocations
- MDSpan in C++23 – multidimensional arrays with layouts
- Linear Algebra for C++26 – support BLAS natively in C++

National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY

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ST 2.3.1.04 SNL ATDM PMR
ST 2.3.1.18 RAJA/Kokkos