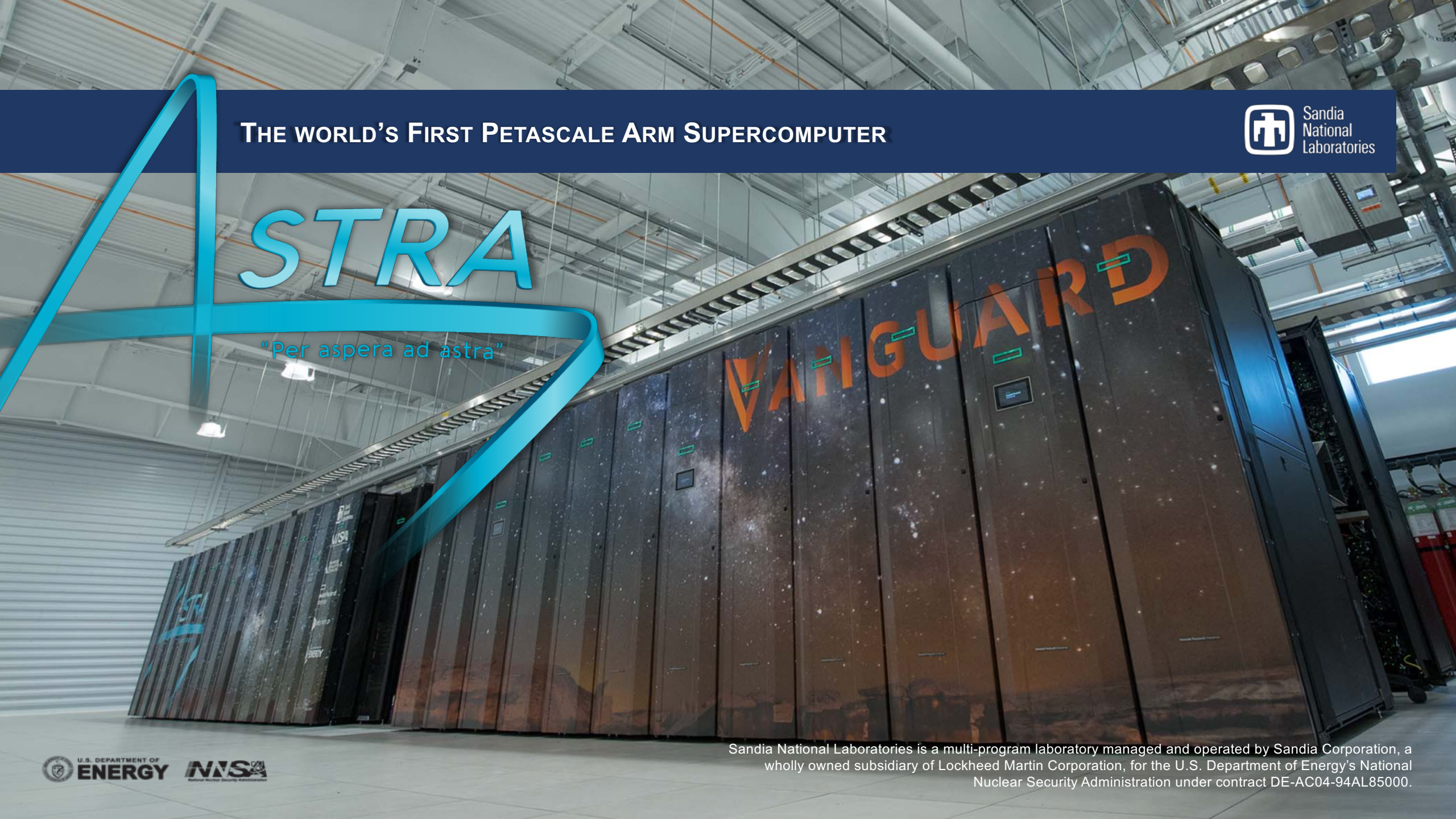
THE WORLD'S FIRST PETASCALE ARM SUPERCOMPUTER

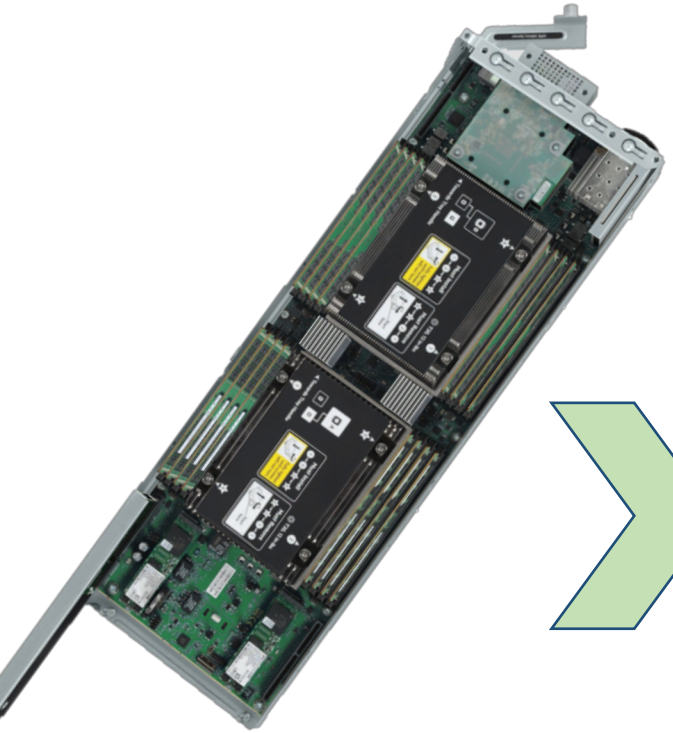
Sandia National Laboratories



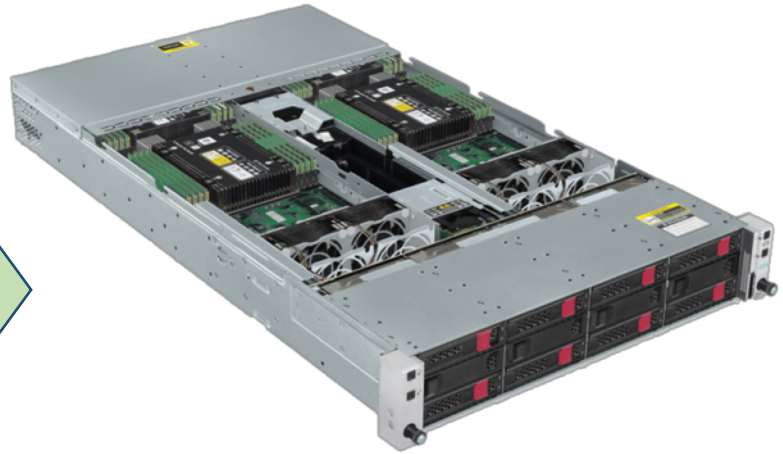
U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

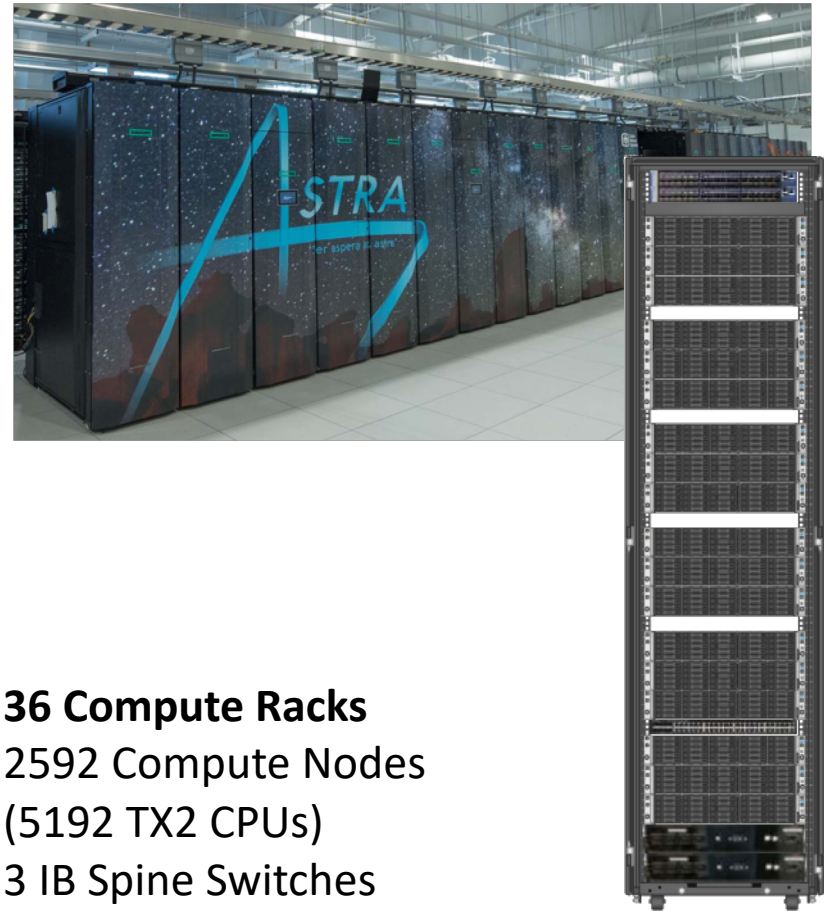
Astra – the First Petascale Arm Supercomputer



Cavium ThunderX2
28 cores, 4-way SMT
128GB RAM

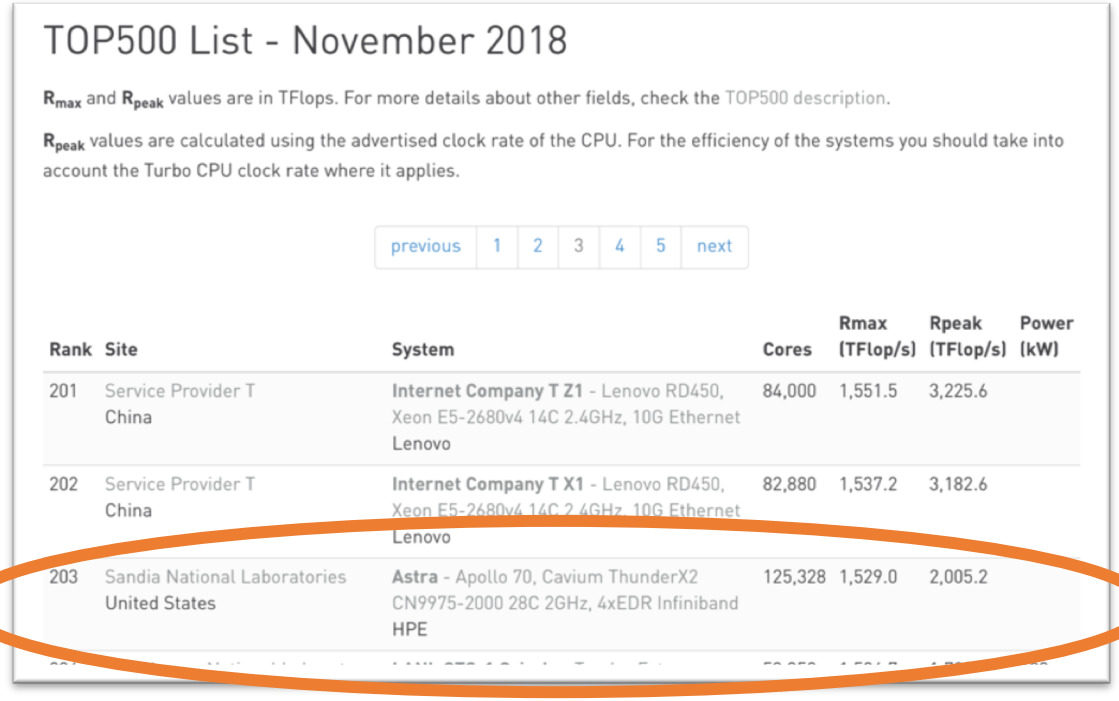


4-Way Node Chassis
18 chassis per rack
6-way chassis per IB switch



36 Compute Racks
2592 Compute Nodes
(5192 TX2 CPUs)
3 IB Spine Switches

Arm Enters the Top-500 Listing for November 2018



TOP500 List - November 2018

R_{max} and R_{peak} values are in TFlops. For more details about other fields, check the TOP500 description.

R_{peak} values are calculated using the advertised clock rate of the CPU. For the efficiency of the systems you should take into account the Turbo CPU clock rate where it applies.

previous | 1 | 2 | 3 | 4 | 5 | next

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
201	Service Provider T China	**Internet Company T Z1** - Lenovo RD450, Xeon E5-2680v4 14C 2.4GHz, 10G Ethernet Lenovo	84,000	1,551.5	3,225.6	
202	Service Provider T China	**Internet Company T X1** - Lenovo RD450, Xeon E5-2680v4 14C 2.4GHz, 10G Ethernet Lenovo	82,880	1,537.2	3,182.6	
203	Sandia National Laboratories United States	**Astra** - Apollo 70, Cavium ThunderX2 CN9975-2000 28C 2GHz, 4xEDR Infiniband HPE	125,328	1,529.0	2,005.2	

35	51	**DGX Saturn V** - NVIDIA DGX-1, Xeon E5-2698v4 20C 2.2GHz, Infiniband EDR, NVIDIA Tesla P100 , Nvidia NVIDIA Corporation United States	60,512	3,307.0	67.42
36	203	**Astra** - Apollo 70, Cavium ThunderX2 CN9975-2000 28C 2GHz, 4xEDR Infiniband , HPE Sandia National Laboratories United States	125,328	1,529.0	66.94
37	42	[illegible] E5-2695v4 18C 2.1GHz, Aries interconnect , Cray Inc. ECMWF United Kingdom	[illegible]	[illegible]	65.46

LINPACK – Top-500 Rank: **203**

HPCG – Top-500 Rank: **36**

These are exciting times – credible server/HPC processors which are now being proven out by the community

NNSA/ASC Vanguard Program

A proving ground for next-generation HPC technologies in support of the NNSA mission

Sandia has a history with Arm in the NNSA/ASC testbed program

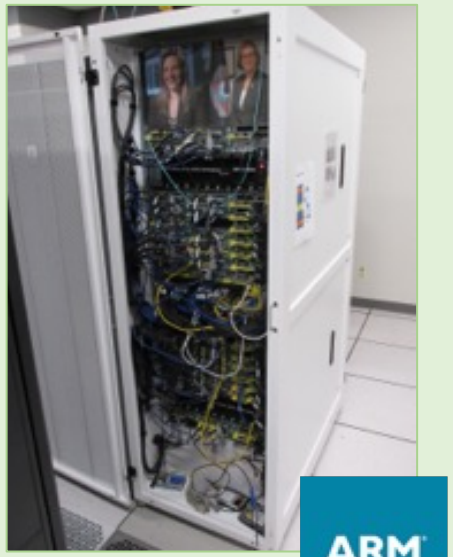
2014

Hewlett Packard Enterprise

ARM

Hammer

Applied Micro
X-Gene-1
47 nodes



ARM

Sullivan

Cavium ThunderX1
32 nodes

2017

Hewlett Packard Enterprise

ARM

Mayer

Pre-GA Cavium
ThunderX2
47 nodes

2018

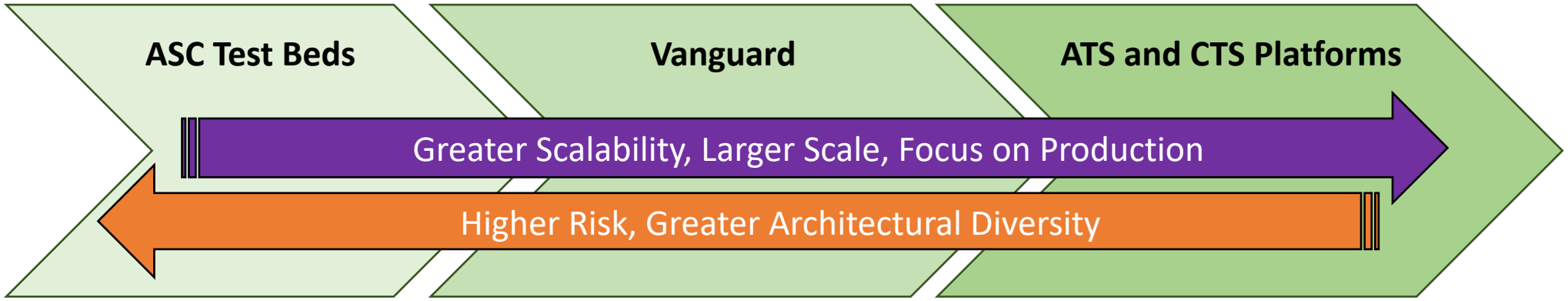
Hewlett Packard Enterprise

ARM

Vanguard/Astra

HPE Apollo 70
Cavium ThunderX2
2592 nodes

Where Vanguard Fits in our Program Strategy



Test Beds

- Small testbeds (~10-100 nodes)
- Breadth of architectures Key
- Brave users

Vanguard

- Larger-scale experimental systems
- Focused efforts to mature new technologies
- Broader user-base
- Not Production
- **Tri-lab resource but not for ATCC runs**

ATS/CTS Platforms

- Leadership-class systems (Petascale, Exascale, ...)
- Advanced technologies, sometimes first-of-kind
- Broad user-base
- Production Use

Vanguard Program: Goals and Aims

Prove viability of advanced technologies for NNSA/ASC integrated codes, at scale

- Expand the HPC-ecosystem by developing emerging yet-to-be proven technologies
  - Is technology viable for future ATS/CTS platforms supporting ASC mission?
  - Increase technology AND integrator choices
- Buy down risk and increase technology and vendor choices for future NNSA production platforms
  - Ability to accept higher risk allows for more/faster technology advancement
  - Lowers/eliminates mission risk and significantly reduces investment
- Jointly address hardware and software technologies

NNSA/ASC Advanced Trilab Software Environment (ATSE) Project

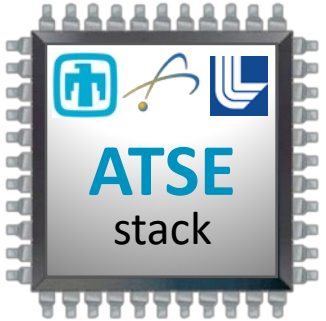
- Advanced Tri-lab Software Environment
  - Sandia leading development with input from Tri-lab Arm team
  - Will be the user programming environment for Vanguard-Astra
  - Partnership across the NNSA/ASC Labs and with HPE
- Lasting value
  - Documented specification of:
    - Software components needed for HPC production applications
    - How they are configured (i.e., what features and capabilities are enabled) and interact
    - User interfaces and conventions
  - Reference implementation:
    - Deployable on multiple ASC systems and architectures with common look and feel
    - Tested against real ASC workloads
    - Community inspired, focused and supported

Hewlett Packard Enterprise

Sandia National Laboratories

Lawrence Livermore National Laboratory

Los Alamos NATIONAL LABORATORY



ATSE is an integrated software environment for ASC workloads

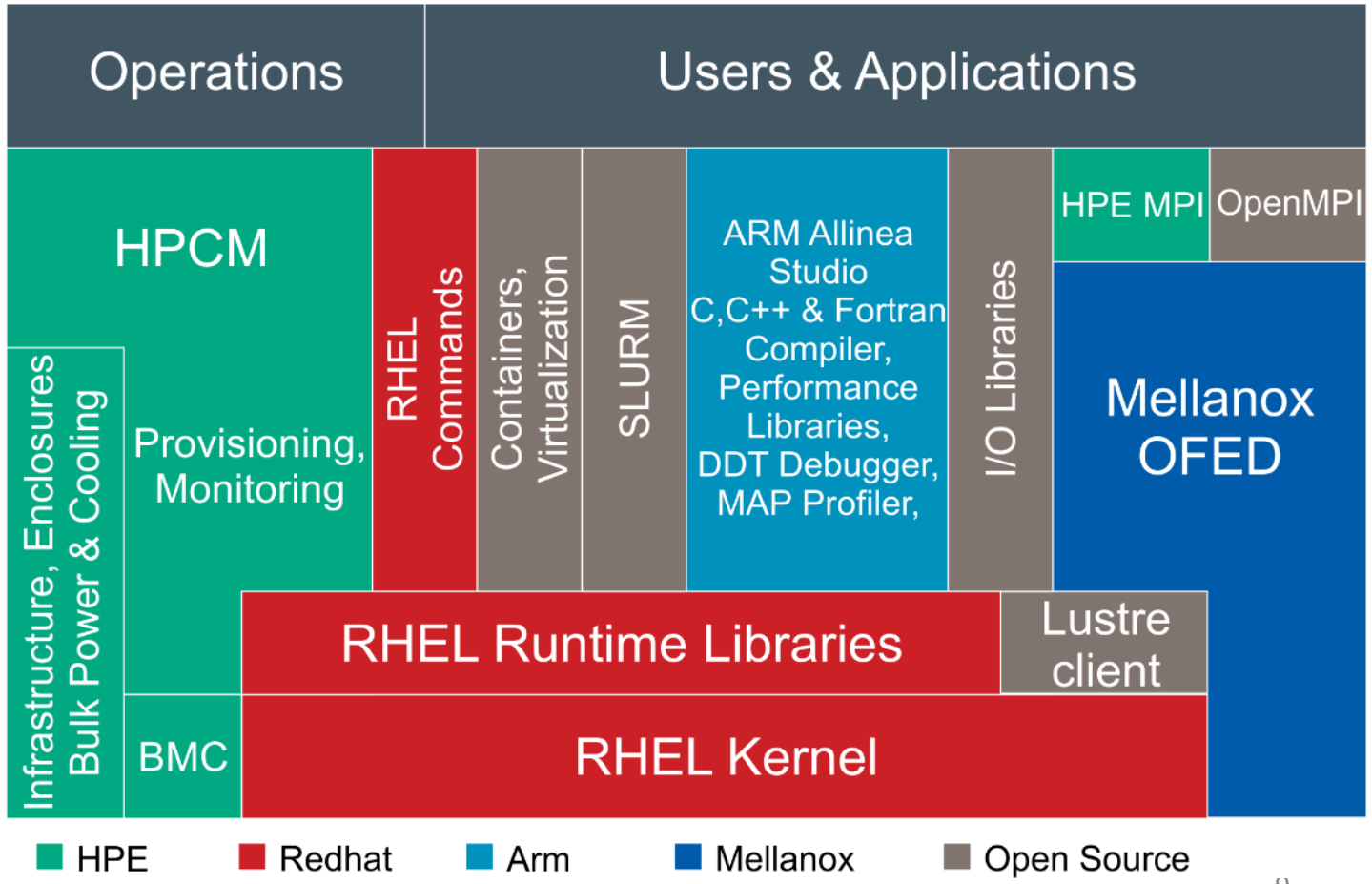
ATSE Collaboration with HPE's HPC Software Stack

HPE's HPC Software Stack

HPE:

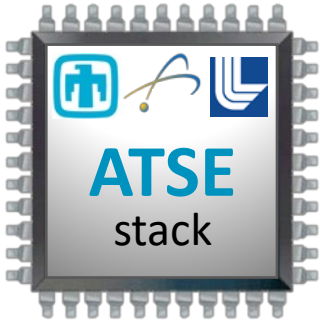
- HPE MPI (+ XPMEM)
- HPE Cluster Manager

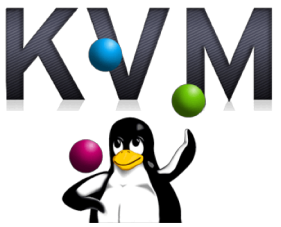
- Arm:
  - Arm HPC Compilers
  - Arm Math Libraries
  - Allinea Tools
- Mellanox-OFED & HPC-X
- RedHat 7.x for aarch64

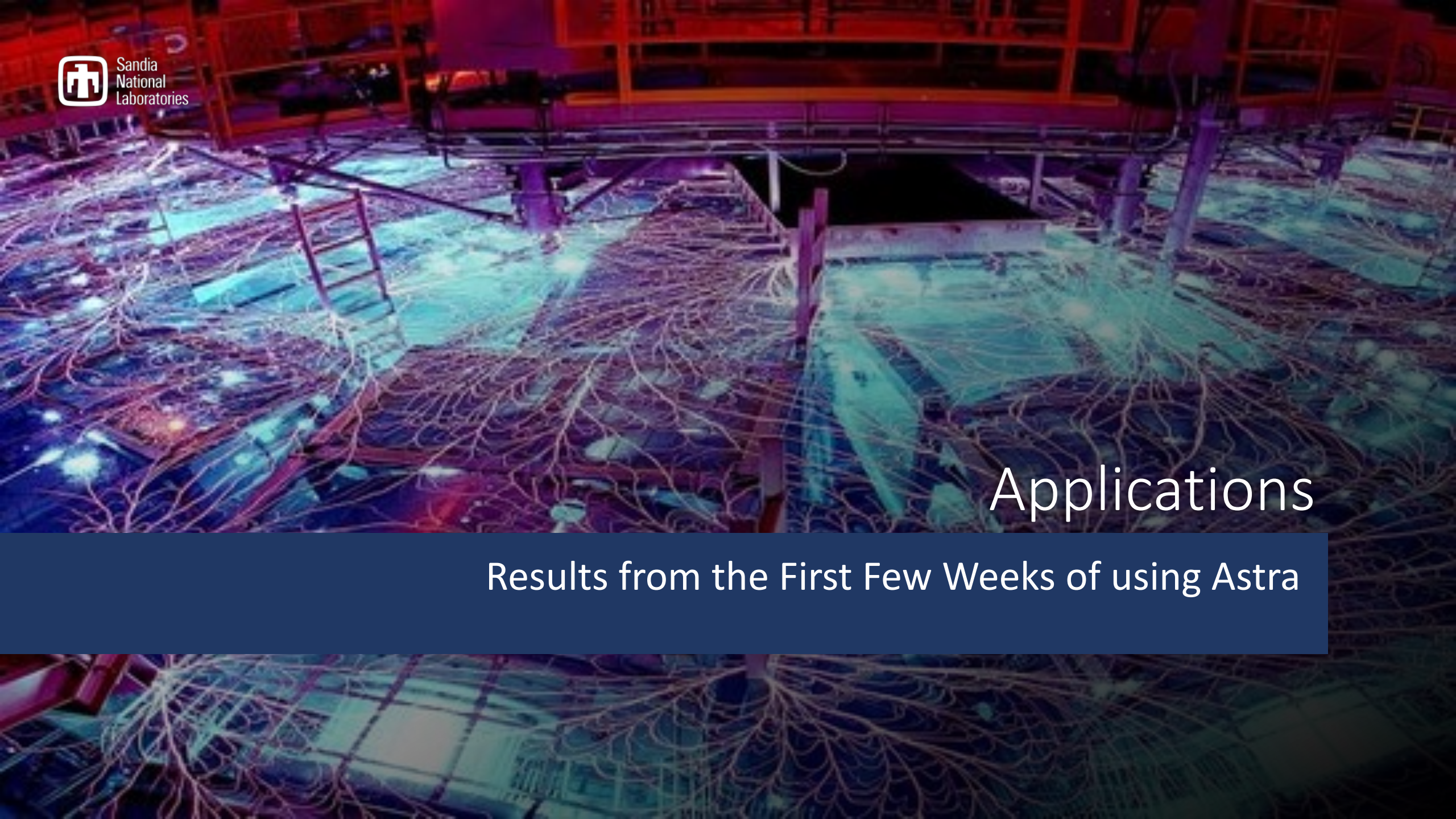


ATSE R&D Efforts – Developing Next-Generation NNSA Workflows

- Workflows leveraging containers and virtual machines
  - Support for machine learning frameworks
  - ARMv8.1 includes new virtualization extensions, SR-IOV
- Evaluating parallel filesystems + I/O systems @ scale
  - GlusterFS, Ceph, BeeGFS, Sandia Data Warehouse, …
- Resilience studies over Astra lifetime
- Improved MPI thread support, matching acceleration
- OS optimizations for HPC @ scale
  - Exploring spectrum from stock distro Linux kernel to HPC-tuned Linux kernels to non-Linux lightweight kernels and multi-kernels
  - Arm-specific optimizations







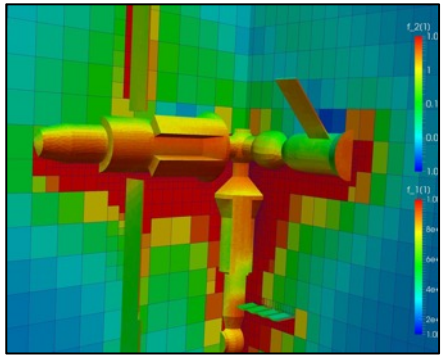
Applications

Results from the First Few Weeks of using Astra

Early Results from Astra

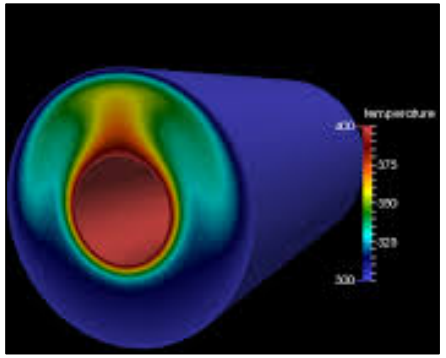
System has been online for around two weeks , incredible team working round the clock, already running full application ports and many of our key frameworks

Baseline: Trinity ASC Platform (Current Production (LANL/SNL)), dual-socket Haswell



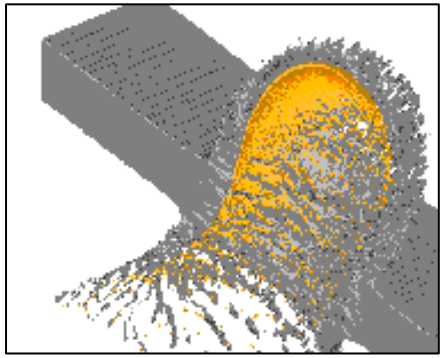
Monte Carlo

1.60X



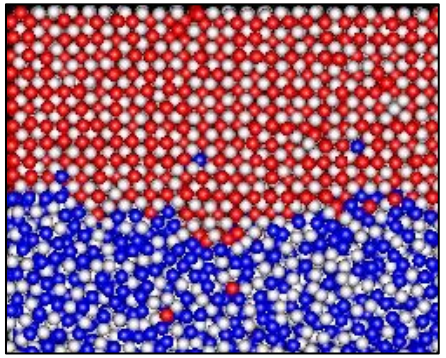
CFD Models

1.45X



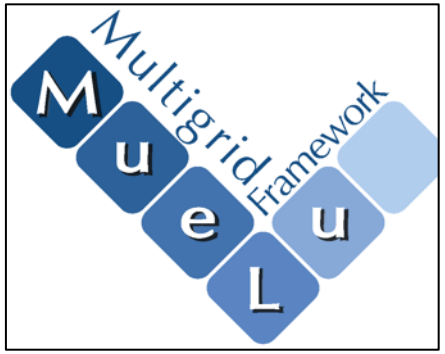
Hydrodynamics

1.30X



Molecular Dynamics

1.42X



Linear Solvers

1.87X

Update on Compilers for the Arm Architecture

Functional Application Porting activities have been underway for few months

- Mainly focused on trying to get “framework” packages built (e.g. Trilinos) and then a range of application codes
- Just intended to guide our initial functional checks (but these do check real computation paths)

- Compiler ”bundle” from the NNSA/ASC labs is being collected for Vanguard/Astra assessments and compiler works
- Compilers are fairly robust
- Focus now is on improving performance/code generation

Application	Ported?
SPARTA	
SPARC	
CTH	
Xyce	
NALU	
EMPIRE	
VPIC (LANL)	
LAMMPS	
SSPARKS	
PENNANT	
Sweep3D	
MiniFE	
LULESH	

New Facility, New Machine in Under a Year

It Takes an Incredible Team…

- DOE Headquarters:
  - Thuc Hoang
  - Marc Anderson
- Sandia Procurement
- Sandia Facilities
- Colleagues at LLNL and LANL
  - Trent D'Hooge
  - Mike Lang
  - Rob Neely
  - Dave Rich
  - Dave Richards
- Incredible team at Sandia

- HPE:
  - Mike V. and Nic Dube
  - Andy Warner
  - John D'Arcy
  - Steve Caruso
  - Lori Gilbertson
  - Cheng Liao
  - John Baron
  - Kevin Jamieson
  - Tim Wilcox
  - Charles Hanna
  - Mike Craig
  - And loads more …

- Cavium/Marvel:
  - Giri Chukkapalli
  - Todd Cunningham
  - Larry Wikelius
  - Kiet Tran
  - Joel James
  - And loads more…
- ARM:
  - ARM Research Team!
  - ARM Compiler Team!
  - ARM Math Libraries!
  - And loads more…

Great Collaboration, Exciting Times, Watch out for More on Astra over the Coming Year

Exceptional Service in the National Interest

http://vanguard.sandia.gov