NERSC is the mission computing facility for the U.S. Department of Energy Office of Science

- Largest funder of physical sciences research in the U.S.
- Diverse user community
  - 8,000 active users, 900 projects
  - 700 applications (sim, data, AI)
- We design for our workload
  - Many jobs at many scales (40% of hours go to capability jobs)
  - Small, incoherent I/O
  - Not just checkpoint/restart!
2020 NERSC by the Numbers

9 BILLION CORE HOURS USED IN 2020

>1,800 Refereed Publications Cited NERSC

Data Stored 240 Petabytes
NERSC's infrastructure for science

Cori (Cray XC-40)
2,388 Haswell + 9,668 KNL nodes

Cori Scratch
Cray ClusterStor 9000 (Lustre)
30 PB, 700 GB/sec

Burst Buffer
DataWarp
1.8 PB
1.5 TB/s

Archive
IBM TS4500 (HPSS)
240 PB, 30-100 GB/s

Community FS
IBM ESS GL8c (GPFS)
128 PB, 150 GB/s
1,536 GPU nodes
1x AMD Epyc 7763
4x NVIDIA A100
4x Slingshot NICs

1,536 CPU nodes
2x AMD Epyc 7763
1x Slingshot NIC

Slingshot
200 Gb/s
2-level dragonfly

16x MDS + 274 OSS
1x AMD Epyc 7502P
2x Slingshot NICs
24x 15.36 TB NVMe

24x Gateway nodes
2x Slingshot NICs
2x 200G HCAs

2x Arista 7804 routers
400 Gb/s/port
> 10 Tb/s routing

External Facilities
HPC Centers
Telescopes/Beamlines
Cloud

SAN
SAN
WAN

Community File System
128 PB Spectrum Scale

SAN

External Facilities
HPC Centers
Telescopes/Beamlines
Cloud

Slide credit: Glenn Lockwood
NERSC Data Archive

45 years of data archived by the scientific community
- 20,000 cartridges in 3 IBM TS4500 libraries

HPSS software in production since 1998
- 2 systems:
  - Archive – user-facing: 240PB
  - Regent – center backups: 35PB

High utilization
- Active archive: > 30 - 40% retrieval rate
- 1.4 - 1.7x yearly growth

Unique environmental controls
- IBM integrated cooling libraries: enable operation in green data centers
  - 1st DOE site to use this technology
- Library particulate/AQI monitoring
2020 - 2021 Projects and Milestones

1. HPSS Upgrade
2. Modernized DevOps Processes, Tools & Automation
HPSS Upgrade

- 1st HPSS upgrade in 8 years
  - Accomplished via remote work
  - 6 day scheduled outage, 1 year planning
  - Joint Dev/Ops effort
    - Integration of local mods and new HW
  - Numerous process enhancements
    - Install automation, test & issue tracking
- SW Updates:
  - Metadata: DB2 9.7 → 11.1 on flash
  - Latest Globus/HPSS interface (DSI)
  - Upgraded HSI/HTAR
- Retired:
  - 6 IBM P55A/AIX servers - 2008
  - 3 IBM DS3500 metadata arrays - 2009
  - 1 Team Lead
Adapting the model of Continuous Improvement, our team has taken steps to make local HPSS software maintenance more efficient, simplified, and automated.

**FOCUS AREAS**
- Version control
- Issue tracking
- Local patches
- Automated build
- Automated deployment
- Test case management
- Documentation

**TOOLS**
- GitLab
- yum
- TestRail
- docker
- xCAT
- MARKDOWN

* NERSC-developed source code

Slide credit: Melinda Jacobsen
Operational Challenges

1. Data Loss Incident
2. Drive & Accessor Issues
3. AQI
Data Loss

04/2021
- Mount issues with AG1126JD
  - EOM tape, 16TB, 1400 files

05/2021
- Attempts to read data via repack, force migrate, etc.
- Engaged IBM recovery after a month of read attempts - 68 files/1.7TB remaining
- Enabled Media Validation in TS4500s but eventually disabled it

09/2021
- Tape copy returned from IBM. Crease found at beginning of tape (BOT), files in that section unreadable
  - Tape copy has zero-padded files where there was damage
  - To do:
    - Restore files that are intact (non-padded)
    - Contact users to see if they're interested in zero-padded files
Drive & Accessor Issues

05/2021
- Upgrade 55F drive FW from A14 to B12 tensioning fix
- Upgrade TS4500 FW from 1.7.0.1 to 1.7.0.3
  - 12 drive failures after update (10%)
  - Increase* in tape & drive errors - ~2/day
    - * we enabled library reporting - previous rate(?)

08/2021
- Dual Accessor failure TS4500-1
  - Library down 4 hours
  - Accessor B failed due to worn pivot belt and severed X-track cable - blocked access to data cartridges
  - Accessor A failed twice for unknown reasons - no issues found

09/2021
- TS4500-2 Accessor A failed due to track obstruction
  - Accessor B unable to clear it
  - Accessor A failed again due to X-track cable short
  - Pursuing preventative library maintenance w/IBM
- Upgrade 55F FW from B12 to B8F
- Upgrade TS4500 FW from 1.7.0.3 to 1.7.0.4
  - 6 drive failures post update

Photo credit: Kirill Lozinskiy
Accessor Obstruction Detail

Metal shavings

Photo credit: Kirill Lozinskiy
aqi and particulate monitoring

ibm documentation specifies iso 14644-1
class 8 standard:
data centers must meet the cleanliness level of iso 14644-1 class 8. for data centers without

<table>
<thead>
<tr>
<th>class</th>
<th>maximum particles/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥0.1 μm</td>
<td>≥0.2 μm</td>
</tr>
<tr>
<td>≥0.3 μm</td>
<td>≥0.5 μm</td>
</tr>
<tr>
<td>≥1 μm</td>
<td>≥5 μm</td>
</tr>
</tbody>
</table>

- aqi and airborne particulate monitoring are critical during ca fire season to maintain class 8 spec
- monitoring: multiple particulate sensors within the data center, one in ts4500-2, purpleair site
- recent incidents:
  - 09/2020: tape io disabled 5 consecutive days
  - 08/2021: 2 aqi incidents of several hours each
- data center aqi mitigation has improved
  - still looking for a solution
2021 Staffing Update
HPSS Staffing Changes

HPSS Team Lead Wayne Hurlbert retired after 30 years

- Wayne's legacy includes fundamental NERSC system design principles:
  - Use of Enterprise tape
  - "SuperMover" concept
  - Highly parallel disk and tape IO
  - Excellent system reliability and user ratings

SSG welcomes GL Kristy Kallback-Rose

- Glenn Lockwood returned to research in 2020
- Kristy became acting GL and accepted permanent position in 2021
- Kristy brings many years of storage systems and management experience at NERSC and IU

NERSC HPSS welcomes Francis Dequenne and Owen James

- Francis, formerly at a UK site, joined NERSC in 01/2021 bringing decades of storage experience
- Owen joins HPSS from NERSC OTG. Owen has been our advocate since 2016, leading several high visibility HPSS projects in his former role
- Leo Saavedra from NRAO to join soon (remote)
Special Thanks

Rosario Martinez, HPSS Software Intern
- Joined NERSC HPSS Dev Team through the Community College Internship program then returned as a limited term employee, 01/2021 - 06/2021
- Rosario's work includes containerized HPSS client setup and porting NERSC HPSS authentication utilities to Python 3
- Now completing CS degree at Georgia Tech
NERSC HPSS Team

Rocko
Group Lead & TC Rep
[Kristy Kallback-Rose]

Parker
HPSS Development
[Melinda Jacobsen]

Rosie
DevOps & Systems Deployment
[Kirill Lozinskiy]

Cleo
DevOps & Systems Deployment
[Francis Dequenne]

Noni
DevOps & Systems Deployment
[Owen James]

Zoe
DevOps & Systems Deployment
[Nick Balthaser]
Upcoming Projects & Works in Progress

1. Operational Projects
2. HPSS Development
3. Center Initiatives
Upcoming Operational Projects

Clearing Long Term Backlog
Multi-year building move and year long HPSS upgrade left significant HW and operational backlog

**TS1160 drive/JE media update** for Large COS
- Drives in boxes since 06/2020

**Fibre Channel Refresh** 💰💰💰
- Cisco 9513s > 10YO, EOL 04/2022
- Over 400 ports needed for disk and tape

**TS4500-4 purchase/installation**
- Rapidly filling up 3 TS4500s
- "Integrated cooling" feature - approaching last sale date

**HPSS Upgrade** - again
- HPSS 7.4.3 EOL 2016
- Target 8.3
HPSS development at NERSC

**Containerized Clients**
On Perlmutter users work within containers orchestrated by Kubernetes
- NERSC HPSS clients including FUSE will need to be able to operate and transfer data from within a containerized environment
  - Ongoing work at NERSC to containerize HSI/HTAR and Globus
  - Melinda covered this topic in detail on 10/13

**SuperFacility API**
- NERSC effort to automate common HPC tasks & operations, e.g. job status queries, data transfers, etc. via REST API
  - Ongoing work at NERSC to determine how this will be applied to HPSS clients and data transfers

**HTAR Enhancements**
- Size limitation, UID/GID, pathname issues deferred over 10 years
- Will feature newer TAR format (PAX) & Index file
- Planned for HPSS release 10.1
NERSC Center Initiatives

Making data searchable across NERSC, particularly within HPSS
- **Possible use of UDAs** for data tagging
- Rich metadata for describing and locating files - probably external to HPSS

Resilience

Interest at NERSC in increasing system reliability and uptime
- Designing systems resistant to:
  - Component failure
  - Environmental (e.g. power, earthquake, AQI) issues
  - Cybersecurity attack
  - Data loss/corruption
- Near term HPSS solutions:
  - RAIT, E2EDI
- Long term:
  - Power, network, environmental controls
  - Cross-site cooperation for DR
  - RAIL?
Future Directions

Goals

- Ensure Archive is *Exascale-ready*
  - **Automated data movement** between tiers* - file system integration is key
    - Ongoing GHI and FUSE evals
  - Extreme speed and capacity
    - Parallelism in network, disk, and tape systems

- Continuing DevOps process improvements:
  - Labor-intensive task and deployment automation
    - Continued use and evaluation of automated deployment and system management tools
  - Remote system management

Thank you!

Questions?
2020 NERSC by the Numbers

2020 NERSC USERS ACROSS US AND WORLD

50 States + Washington D.C.
46 Countries
2020 NERSC by the Numbers

7,887 Annual Users from ~1,750 Institutions + National Labs

- 29% Graduate Students
- 20% Postdoctoral Fellows
- 16% Staff Scientists
- 11% University Faculty
- 6% Undergraduate Students
- 6% Professional Staff

- 61% Universities
- 30% DOE Labs
- 5% Other Government Labs
- 2% Industry
- 1% Small Businesses
- <1% Private Labs