E4S and Frank:
A Platform for CI/CD with GPUs

Trilinos Users Group Meeting (TUG'23)
https://trilinos.github.io/trilinos_user-developer_group_meeting_2023.html
10am - 10:30am MT
CSRI, Sandia National Laboratories, Albuquerque, NM

Sameer Shende
Research Professor and Director,
Performance Research Laboratory, OACISS, University of Oregon
President and Director, ParaTools, Inc.
https://e4s.io/talks/E4S_Frank_TUG23.pdf

UNIVERSITY OF OREGON

E4S

ParaTools

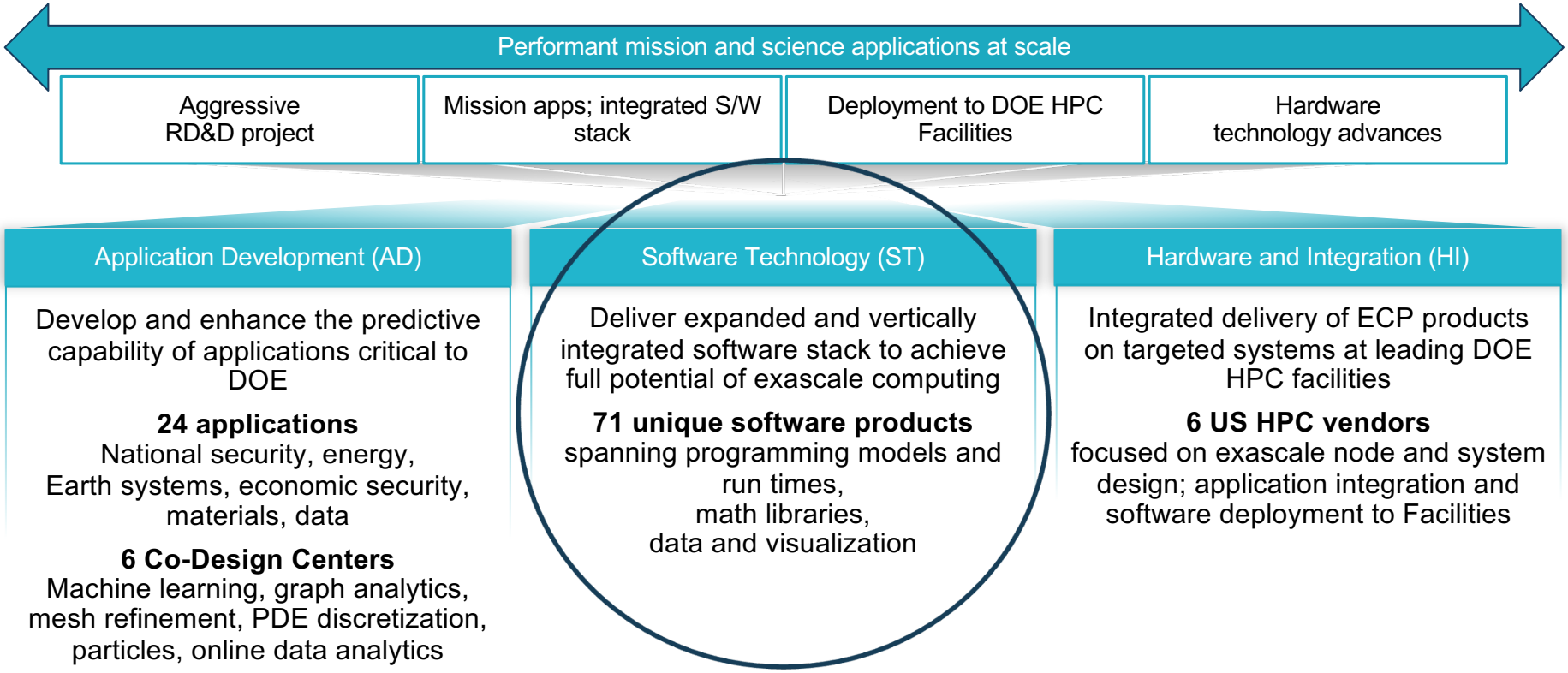
EXASCALE COMPUTING PROJECT

Challenges

- As our software gets more complex, it is getting harder to install and validate HPC tools and libraries correctly in an integrated and interoperable software stack
  - E4S and Frank – a platform for CI/CD!

Extreme-scale Scientific Software Stack (E4S)

ECP's holistic approach uses co-design and integration to achieve exascale computing

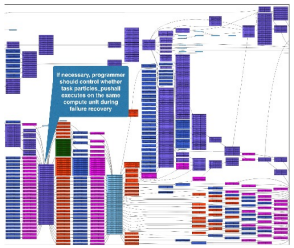


ECP **Software Technology (ST)**

Goal

Build a comprehensive, coherent software stack that enables application developers to productively develop highly parallel applications that effectively target diverse exascale architectures

- Prepare SW stack for scalability with massive on-node parallelism
- Extend existing capabilities when possible, develop new when not
- Guide, and complement, and integrate with vendor efforts
- Develop and deliver high-quality and robust software products



Extreme-scale Scientific Software Stack (E4S)

- E4S: HPC Software Ecosystem – a curated software portfolio
- A **Spack-based** distribution of software tested for interoperability and portability to multiple architectures with support for GPUs from NVIDIA, AMD, and Intel in each release
- Available from **source**, **containers**, **cloud, binary caches**
- Leverages and enhances SDK interoperability thrust
- Not a commercial product – an open resource for all
- Oct 2018: E4S 0.1 - 24 full, 24 partial release products
- Jan 2019: E4S 0.2 - 37 full, 10 partial release products
- Nov 2019: E4S 1.0 - 50 full, 5 partial release products
- Feb 2020: E4S 1.1 - 61 full release products
- Nov 2020: E4S 1.2 (aka, 20.10) - 67 full release products
- Feb 2021: E4S 21.02 - 67 full release, 4 partial release
- May 2021: E4S 21.05 - 76 full release products
- Aug 2021: E4S 21.08 - 88 full release products
- Nov 2021: E4S 21.11 - 91 full release products
- Feb 2022: E4S 22.02 – 100 full release products
- May 2022: E4S 22.05 – 101 full release products
- August 2022: E4S 22.08 – 102 full release products
- November 2022: E4S 22.11 – 103 full release products
- February 2023: E4S 23.02 – 106 full release products
- May 2023: E4S 23.05 – 109 full release products
- Aug 2023: E4S 23.08 – 115 full release products

https://e4s.io

Also include other products .e.g.,
AI: PyTorch, TensorFlow (CUDA, ROCm)
Co-Design: AMReX, Cabana, MFEM
EDA: Xyce

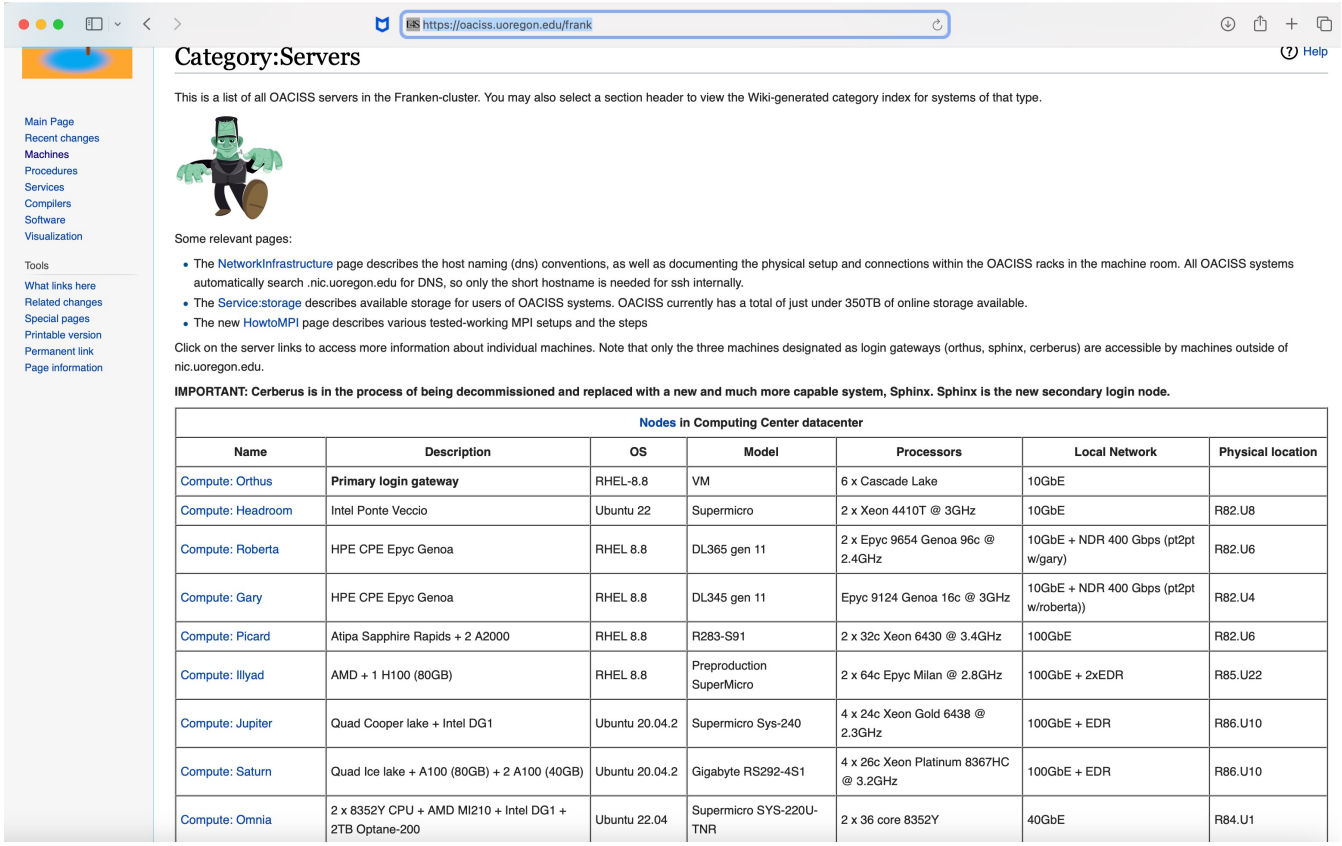
E4S: Extreme-scale Scientific Software Stack

- E4S is a community effort to provide open-source software packages for developing, deploying and running scientific applications on HPC platforms.
- E4S has built a comprehensive, coherent software stack that enables application developers to productively develop highly parallel applications that effectively target diverse exascale architectures.
- E4S provides a curated, Spack based software distribution of 100+ HPC, 50+ EDA (e.g., Xyce), and AI/ML packages (e.g., TensorFlow, PyTorch).
- With E4S Spack binary build caches, E4S supports both bare-metal and containerized deployment for GPU based platforms.
  - X86_64, ppc64le (IBM Power 9), aarch64 (ARM64) with support for GPUs from NVIDIA, AMD, and Intel
  - HPC and AI/ML packages are optimized for GPUs and CPUs.
- Container images on DockerHub and E4S website of pre-built binaries of ECP ST products.
- Base images and full featured containers (with GPU support).
- Commercial support for E4S through ParaTools, Inc. for installation, maintaining an issue tracker, and ECP AD engagement.
  - https://dashboard.e4s.io https://e4s.io/talks/E4S_Support_Sep23.pdf
- e4s-cl container launch tool allows binary distribution of applications by substituting MPI in the containerized app with the system MPI. e4s-alc is a tool to create custom container images from base images
- Quarterly releases: E4S 23.08 released on August 31, 2023: https://e4s.io/talks/E4S_23.08.pdf
- E4S for commercial cloud platforms: AWS image supports MPI implementations and containers with remote desktop (DCV).
  - Intel MPI, NVHPC, MVAPICH2, MPICH, MPC, OpenMPI

Frank: A platform for CI/CD at U. Oregon

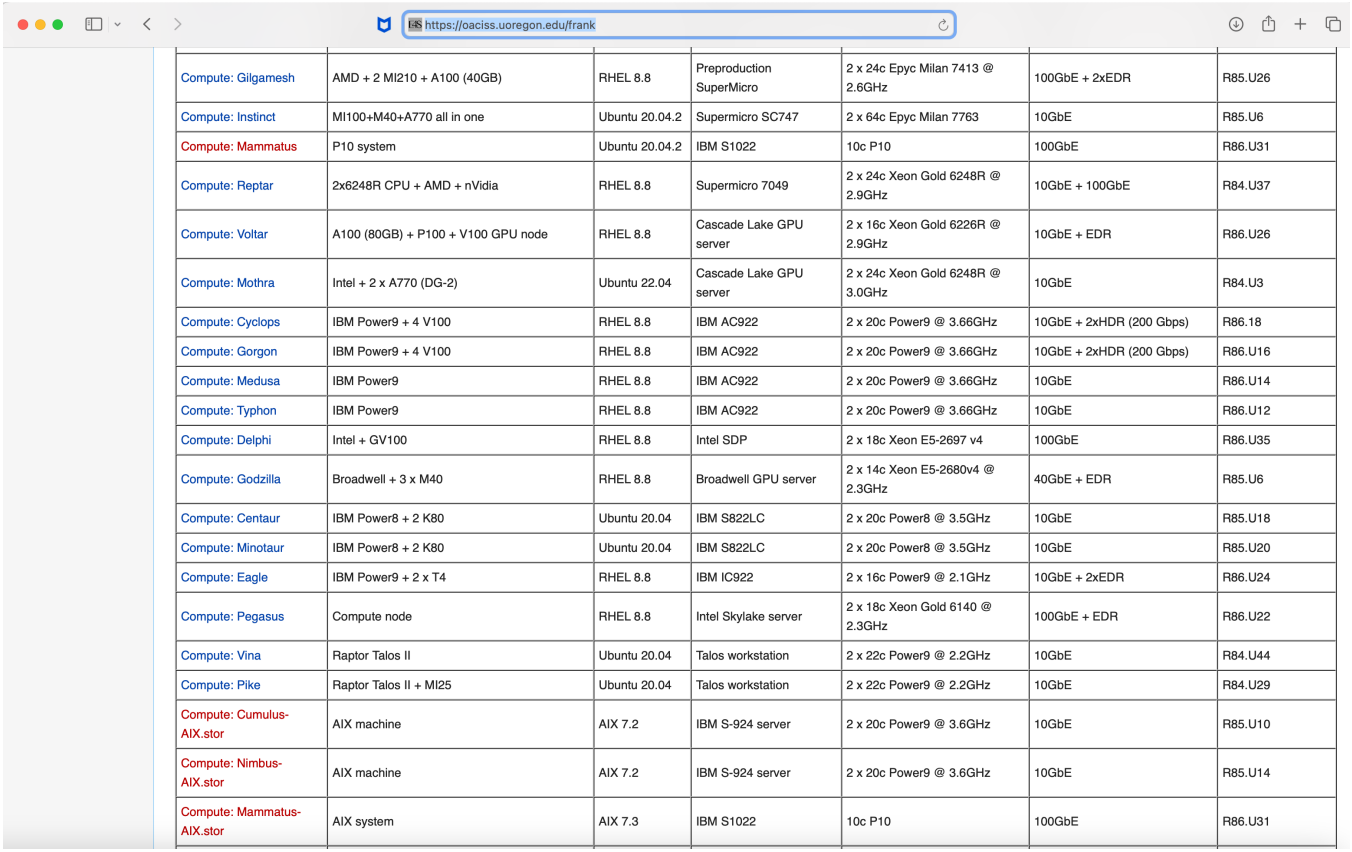
- Features GPUs from:
  - Intel (Data Center GPU Max 1100/PVC, DG1, DG2)
  - AMD (MI210, MI100, MI50, MI25)
  - NVIDIA (H100, A100 PCIe 80GB, A100 PCIe 40GB, A100 SXM4, A2000, V100 SXM2, P100…)
- Features CPUs from:
  - Intel (Sapphire Rapids, IceLake, CooperLake,…)
  - AMD (Epyc Genoa, Milan, Rome, …)
  - IBM (Power 10, Power 9, Power 8, …)
  - ARM (NVIDIA Orin, Xavier, Tegra, Apple M1, M2, SoftIron, …)
- Operating Systems
  - RHEL, SLES, Ubuntu, Debian, Mac OS X, AIX
  - HPE Cray Programming Environment (CPE)
- Fileservers
  - IBM Spectrum Scale (GPFS) GS4S all NVMe
  - BeeGFS
  - NFS

Frank: A platform for CI/CD at U. Oregon



https://oaciss.uoregon.edu/frank

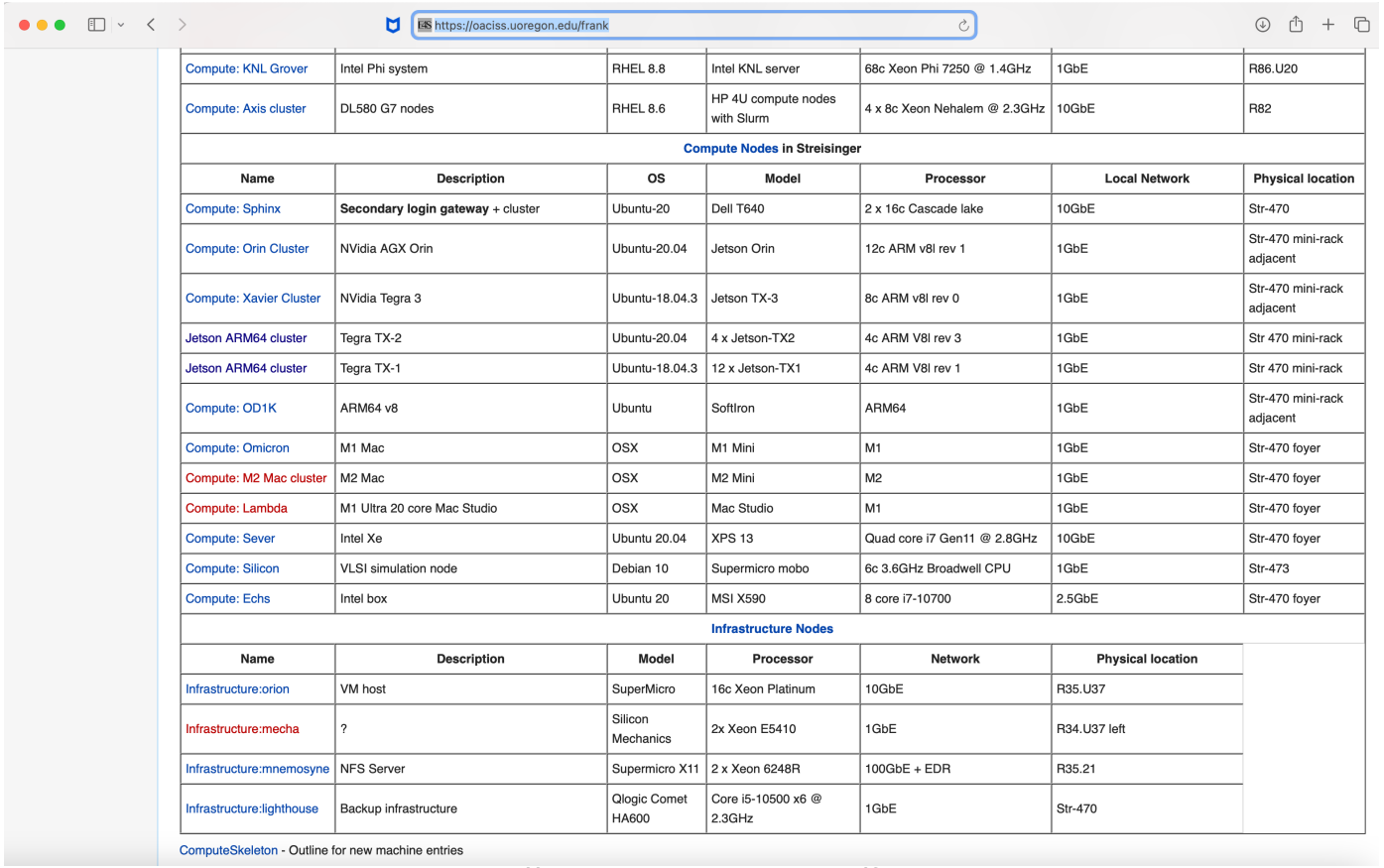
Frank: A platform for CI/CD at U. Oregon



Compute: Gilgamesh	AMD + 2 MI210 + A100 (40GB)	RHEL 8.8	Preproduction SuperMicro	2 x 24c Epyc Milan 7413 @ 2.6GHz	100GbE + 2xEDR	R85.U26
Compute: Instinct	MI100+M40+A770 all in one	Ubuntu 20.04.2	Supermicro SC747	2 x 64c Epyc Milan 7763	10GbE	R85.U6
Compute: Mammatus	P10 system	Ubuntu 20.04.2	IBM S1022	10c P10	100GbE	R86.U31
Compute: Reptar	2x6248R CPU + AMD + nVidia	RHEL 8.8	Supermicro 7049	2 x 24c Xeon Gold 6248R @ 2.9GHz	10GbE + 100GbE	R84.U37
Compute: Voltar	A100 (80GB) + P100 + V100 GPU node	RHEL 8.8	Cascade Lake GPU server	2 x 16c Xeon Gold 6226R @ 2.9GHz	10GbE + EDR	R86.U26
Compute: Mothra	Intel + 2 x A770 (DG-2)	Ubuntu 22.04	Cascade Lake GPU server	2 x 24c Xeon Gold 6248R @ 3.0GHz	10GbE	R84.U3
Compute: Cyclops	IBM Power9 + 4 V100	RHEL 8.8	IBM AC922	2 x 20c Power9 @ 3.66GHz	10GbE + 2xHDR (200 Gbps)	R86.18
Compute: Gorgon	IBM Power9 + 4 V100	RHEL 8.8	IBM AC922	2 x 20c Power9 @ 3.66GHz	10GbE + 2xHDR (200 Gbps)	R86.U16
Compute: Medusa	IBM Power9	RHEL 8.8	IBM AC922	2 x 20c Power9 @ 3.66GHz	10GbE	R86.U14
Compute: Typhon	IBM Power9	RHEL 8.8	IBM AC922	2 x 20c Power9 @ 3.66GHz	10GbE	R86.U12
Compute: Delphi	Intel + GV100	RHEL 8.8	Intel SDP	2 x 18c Xeon E5-2697 v4	100GbE	R86.U35
Compute: Godzilla	Broadwell + 3 x M40	RHEL 8.8	Broadwell GPU server	2 x 14c Xeon E5-2680v4 @ 2.3GHz	40GbE + EDR	R85.U6
Compute: Centaur	IBM Power8 + 2 K80	Ubuntu 20.04	IBM S822LC	2 x 20c Power8 @ 3.5GHz	10GbE	R85.U18
Compute: Minotaur	IBM Power8 + 2 K80	Ubuntu 20.04	IBM S822LC	2 x 20c Power8 @ 3.5GHz	10GbE	R85.U20
Compute: Eagle	IBM Power9 + 2 x T4	RHEL 8.8	IBM IC922	2 x 16c Power9 @ 2.1GHz	10GbE + 2xEDR	R86.U24
Compute: Pegasus	Compute node	RHEL 8.8	Intel Skylake server	2 x 18c Xeon Gold 6140 @ 2.3GHz	100GbE + EDR	R86.U22
Compute: Vina	Raptor Talos II	Ubuntu 20.04	Talos workstation	2 x 22c Power9 @ 2.2GHz	10GbE	R84.U44
Compute: Pike	Raptor Talos II + MI25	Ubuntu 20.04	Talos workstation	2 x 22c Power9 @ 2.2GHz	10GbE	R84.U29
Compute: Cumulus-AIX.stor	AIX machine	AIX 7.2	IBM S-924 server	2 x 20c Power9 @ 3.6GHz	10GbE	R85.U10
Compute: Nimbus-AIX.stor	AIX machine	AIX 7.2	IBM S-924 server	2 x 20c Power9 @ 3.6GHz	10GbE	R85.U14
Compute: Mammatus-AIX.stor	AIX system	AIX 7.3	IBM S1022	10c P10	100GbE	R86.U31

https://oaciss.uoregon.edu/frank

Frank: A platform for CI/CD at U. Oregon



Compute: KNL Grover	Intel Phi system	RHEL 8.8	Intel KNL server	68c Xeon Phi 7250 @ 1.4GHz	1GbE	R86.U20
Compute: Axis cluster	DL580 G7 nodes	RHEL 8.6	HP 4U compute nodes with Slurm	4 x 8c Xeon Nehalem @ 2.3GHz	10GbE	R82

Compute Nodes in Streisinger

Name	Description	OS	Model	Processor	Local Network	Physical location
Compute: Sphinx	**Secondary login gateway** + cluster	Ubuntu-20	Dell T640	2 x 16c Cascade lake	10GbE	Str-470
Compute: Orin Cluster	NVidia AGX Orin	Ubuntu-20.04	Jetson Orin	12c ARM v8l rev 1	1GbE	Str-470 mini-rack adjacent
Compute: Xavier Cluster	NVidia Tegra 3	Ubuntu-18.04.3	Jetson TX-3	8c ARM v8l rev 0	1GbE	Str-470 mini-rack adjacent
Jetson ARM64 cluster	Tegra TX-2	Ubuntu-20.04	4 x Jetson-TX2	4c ARM V8l rev 3	1GbE	Str 470 mini-rack
Jetson ARM64 cluster	Tegra TX-1	Ubuntu-18.04.3	12 x Jetson-TX1	4c ARM V8l rev 1	1GbE	Str 470 mini-rack
Compute: OD1K	ARM64 v8	Ubuntu	SoftIron	ARM64	1GbE	Str-470 mini-rack adjacent
Compute: Omicron	M1 Mac	OSX	M1 Mini	M1	1GbE	Str-470 foyer
Compute: M2 Mac cluster	M2 Mac	OSX	M2 Mini	M2	1GbE	Str-470 foyer
Compute: Lambda	M1 Ultra 20 core Mac Studio	OSX	Mac Studio	M1	1GbE	Str-470 foyer
Compute: Sever	Intel Xe	Ubuntu 20.04	XPS 13	Quad core i7 Gen11 @ 2.8GHz	10GbE	Str-470 foyer
Compute: Silicon	VLSI simulation node	Debian 10	Supermicro mobo	6c 3.6GHz Broadwell CPU	1GbE	Str-473
Compute: Echs	Intel box	Ubuntu 20	MSI X590	8 core i7-10700	2.5GbE	Str-470 foyer

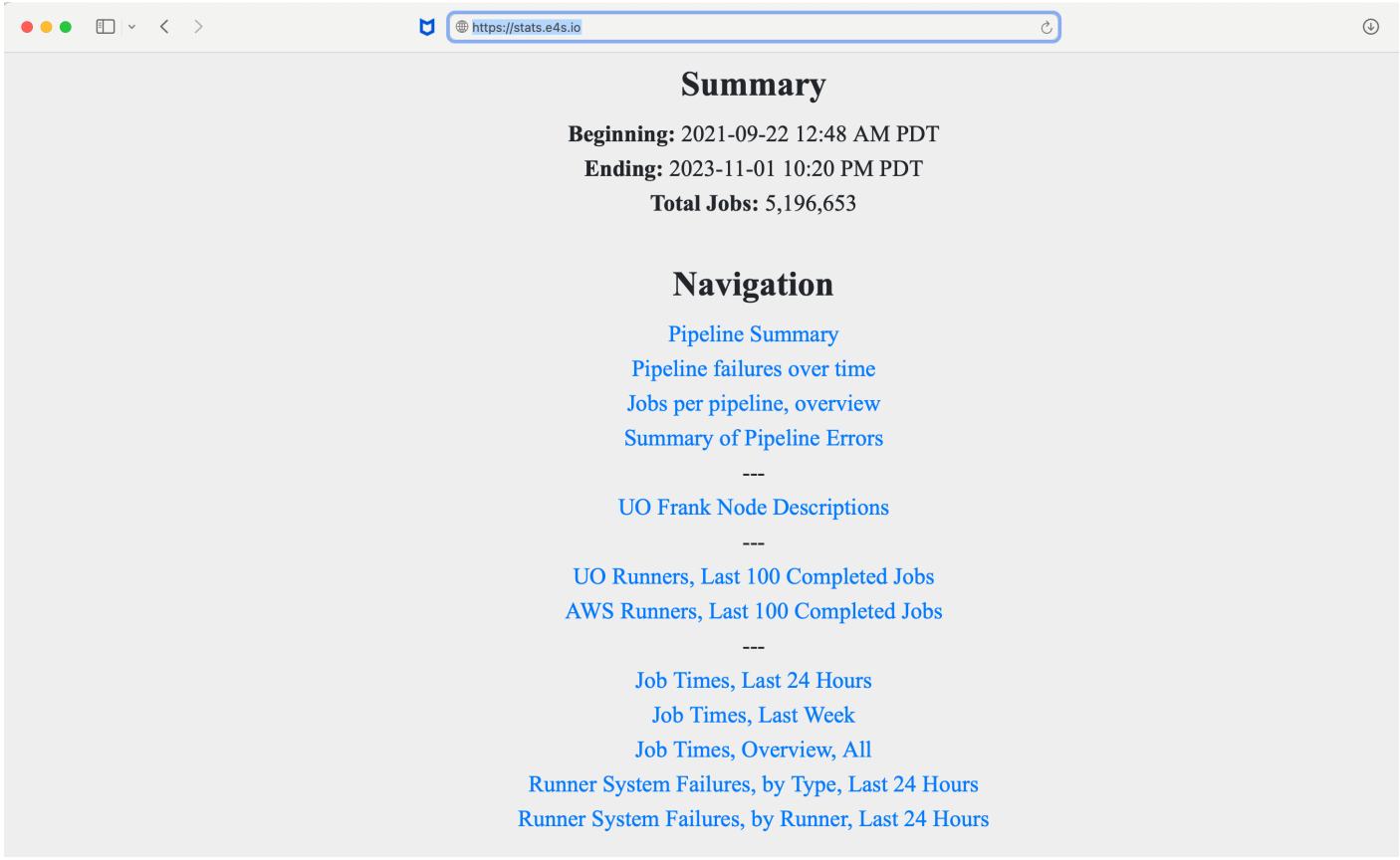
Infrastructure Nodes

Name	Description	Model	Processor	Network	Physical location
Infrastructure:orion	VM host	SuperMicro	16c Xeon Platinum	10GbE	R35.U37
Infrastructure:mecha	?	Silicon Mechanics	2x Xeon E5410	1GbE	R34.U37 left
Infrastructure:mnemosyne	NFS Server	Supermicro X11	2 x Xeon 6248R	100GbE + EDR	R35.21
Infrastructure:lighthouse	Backup infrastructure	Qlogic Comet HA600	Core i5-10500 x6 @ 2.3GHz	1GbE	Str-470

ComputeSkeleton - Outline for new machine entries

https://oaciss.uoregon.edu/frank

Spack PR Merge Jobs on Frank and AWS



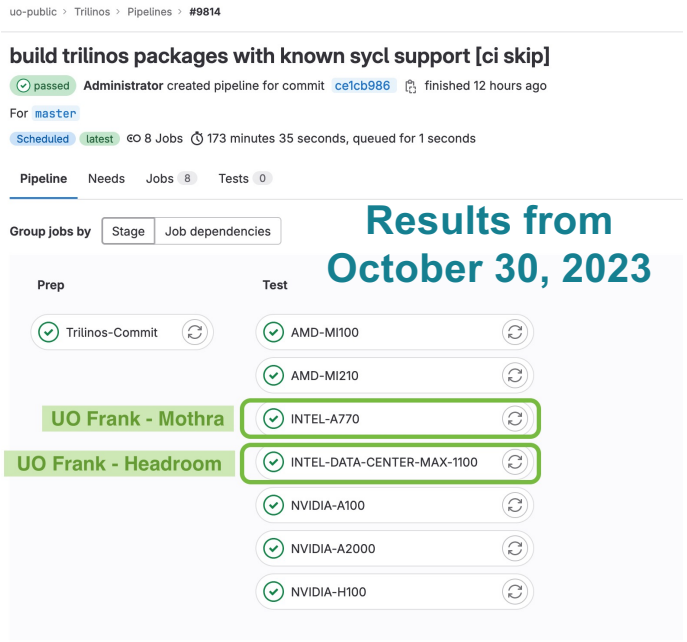
Over 5M jobs!

https://stats.e4s.io

Trilinos: SYCL Enabled Builds Added to Nightly Testing

- SYCL-enabled builds of Trilinos now tested nightly on:
  - Intel Data Center Max 1100 GPU (PVC)
  - Intel A770

- Packages built:
  - Tpetra
  - Zoltan2
  - Ifpack2
  - Amesos2
  - Belos



Spack Developer Workflow Integration

Trilinos development branch nightly builds now orchestrated using **Spack developer workflow**

https://spack-tutorial.readthedocs.io/en/lanl19/tutorial_developer_workflows.html

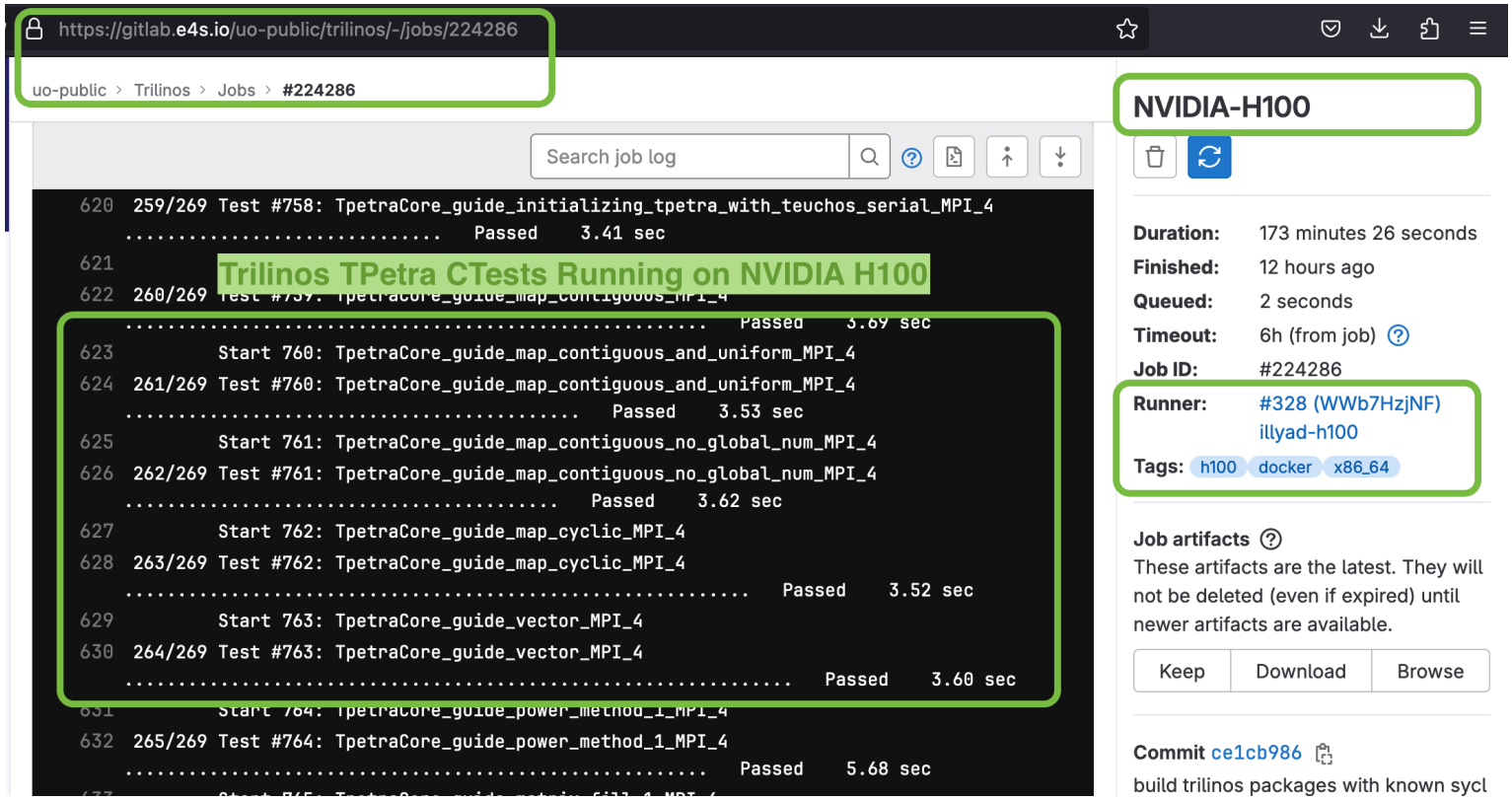
```
69
70  if [[ ! -d $TRILINOS_ROOT ]]; then
71    cmd git clone https://github.com/$TRILINOS_REPO $TRILINOS_ROOT
72    cmd git -C $TRILINOS_ROOT checkout $TRILINOS_COMMIT
73  else
74    echo $TRILINOS_ROOT already exists, proceeding without clone and checkout
75  fi
76
77  cmd cd $TRILINOS_ROOT
78  cmd spack dev-build --quiet -j$BUILD_PARALLELISM $(cat $TARGET_ENV/spec.txt)
79  cmd spack env deactivate
80  HASH=$(spack find --format "{hash:7}" trilinos)
```

1. Clone Trilinos, checkout development branch

2. Spack development build

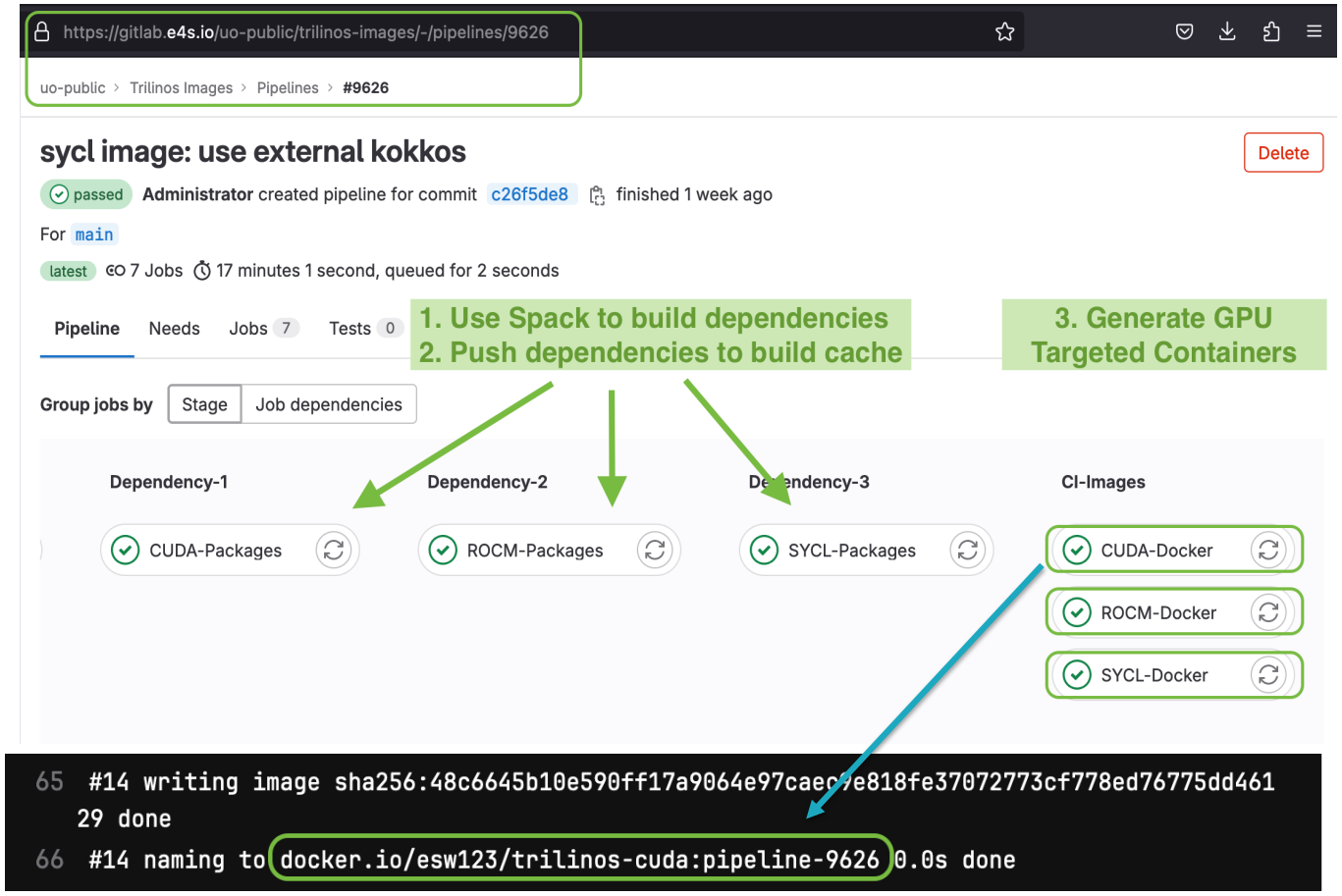
Script excerpt from https://gitlab.e4s.io/uo-public/trilinos/-/blob/master/ci.sh

Trilinos Ctests Run Post-build



Automated CI Container Image Creation

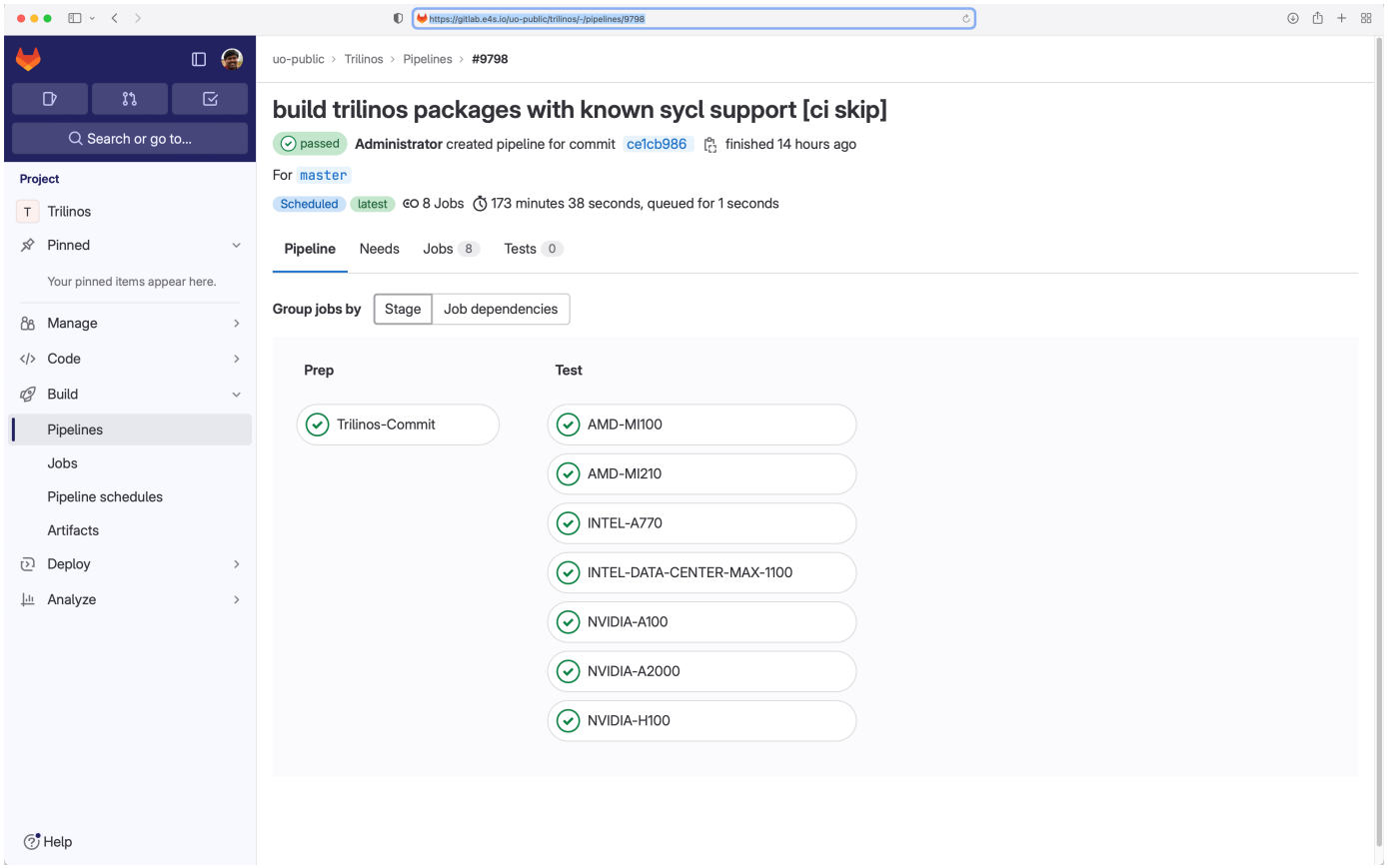
https://gitlab.e4s.io/uo-public/trilinos-images



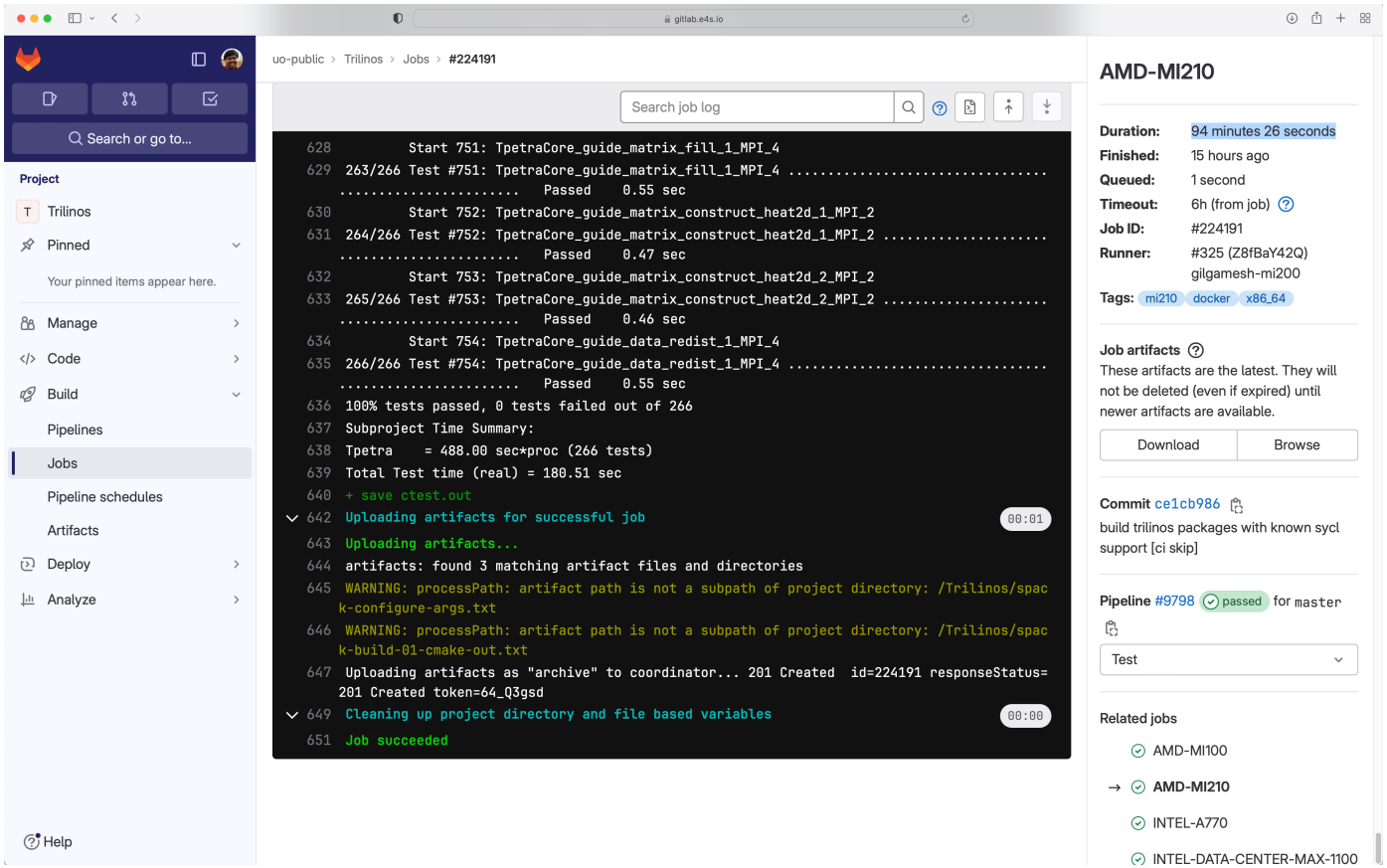
Automated CI Container Image Creation

- Automated generation of CI container images makes it easier to:
- Bring in changes from upstream Spack
- Bring in latest versions of Trilinos' dependencies
- Use of Spack developer workflows means nightly build configurations tested closely mimic the builds that end-users would install themselves if they use Spack

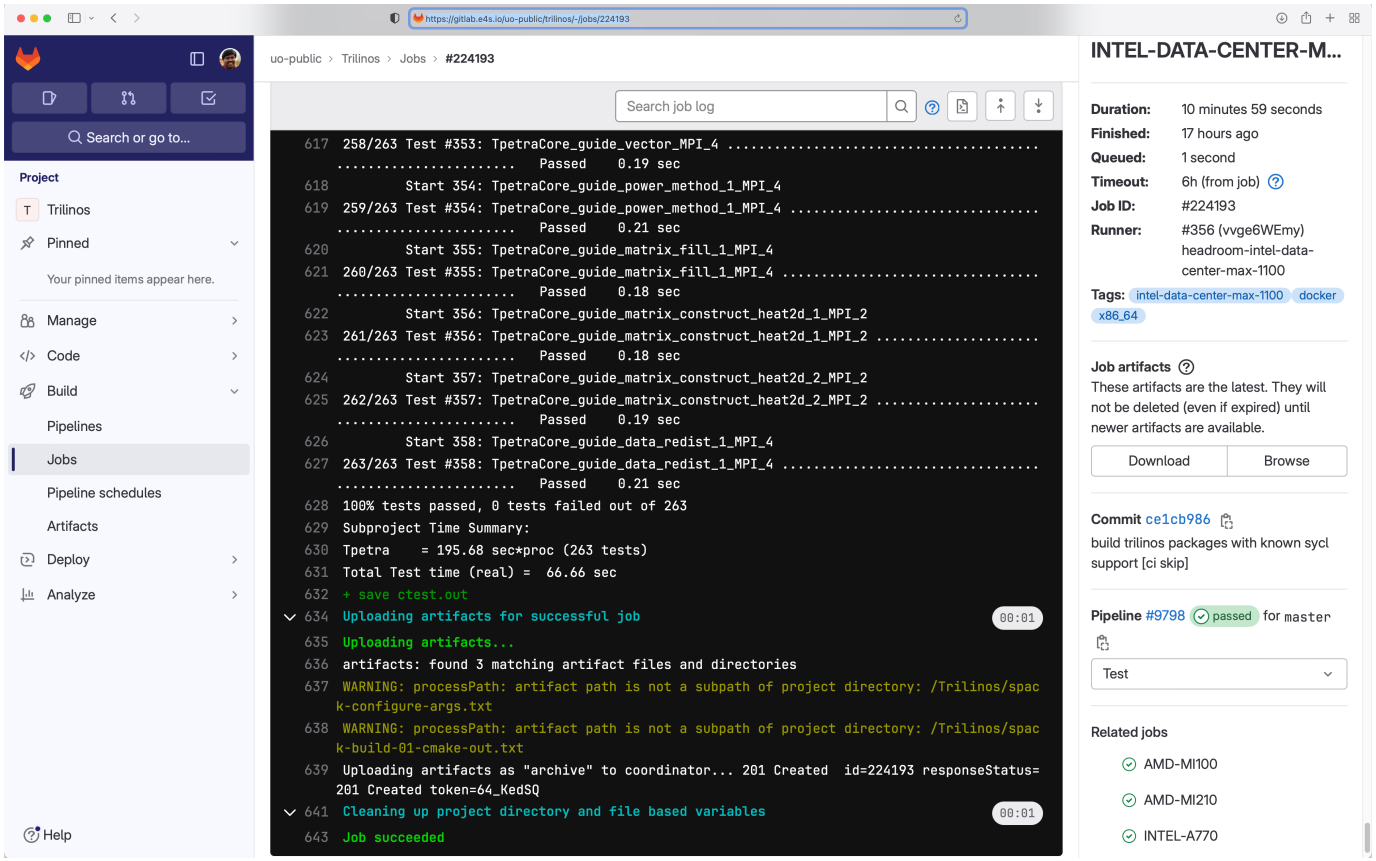
Trilinos nightly testing on 7 GPUs on Frank @ U. Oregon



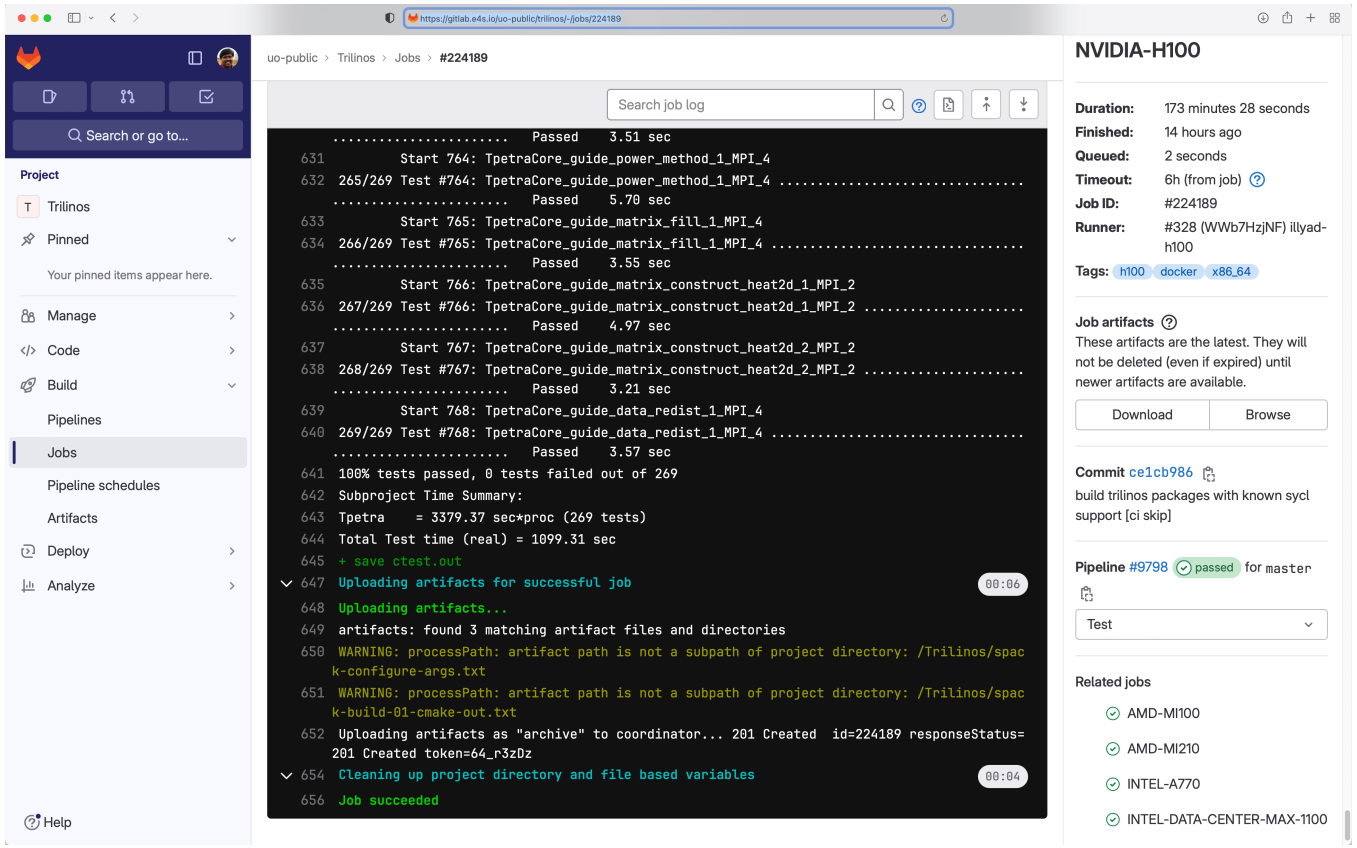
Trilinos Tpetra ctests nightly testing on AMD MI210 on Frank



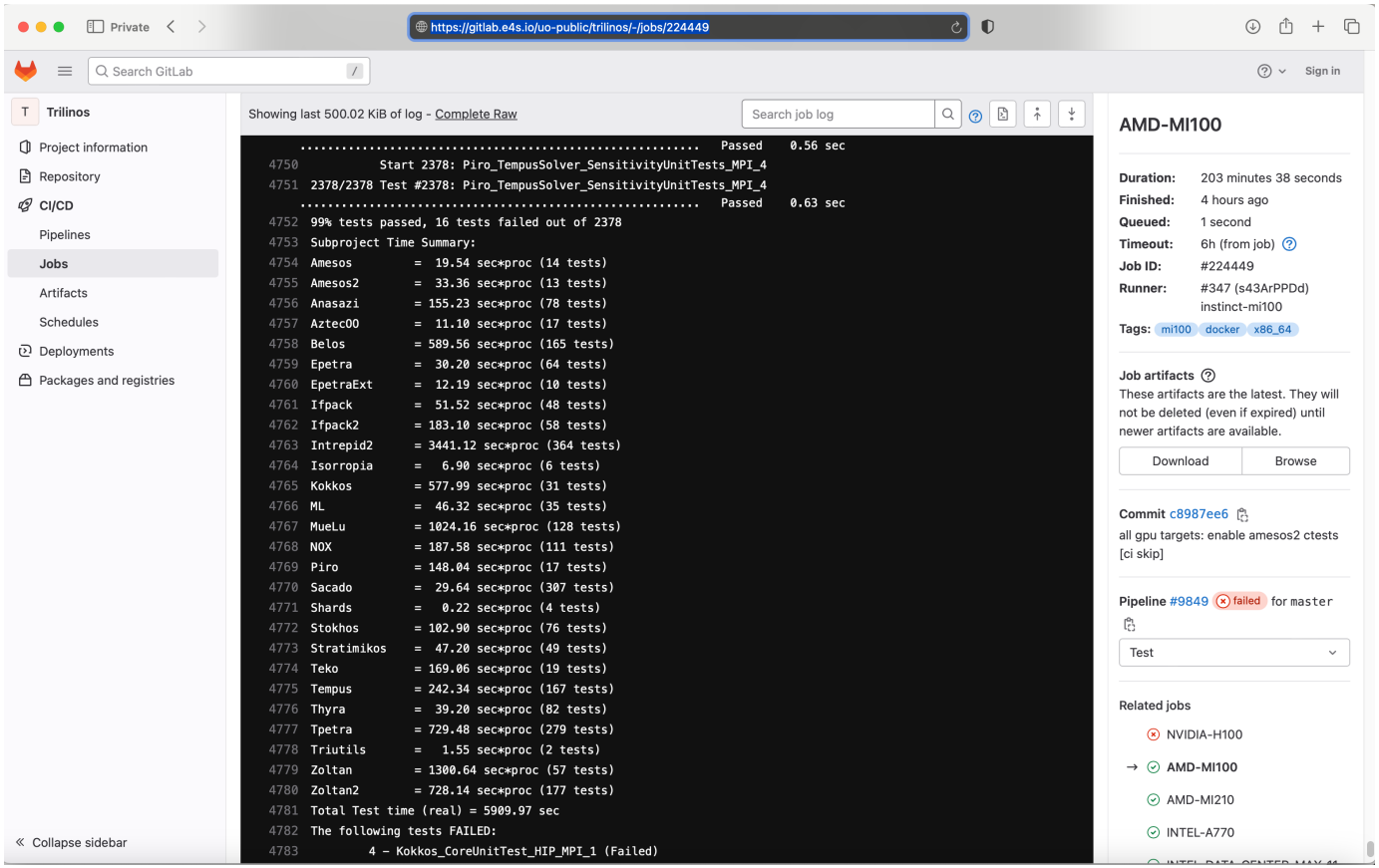
Trilinos nightly testing on Intel Data Center GPU Max 1100 (PVC)



Trilinos nightly testing on NVIDIA H100 on Frank



Triaging errors with expanded tests on AMD GPUs



- 2378 tests run
- 99% pass

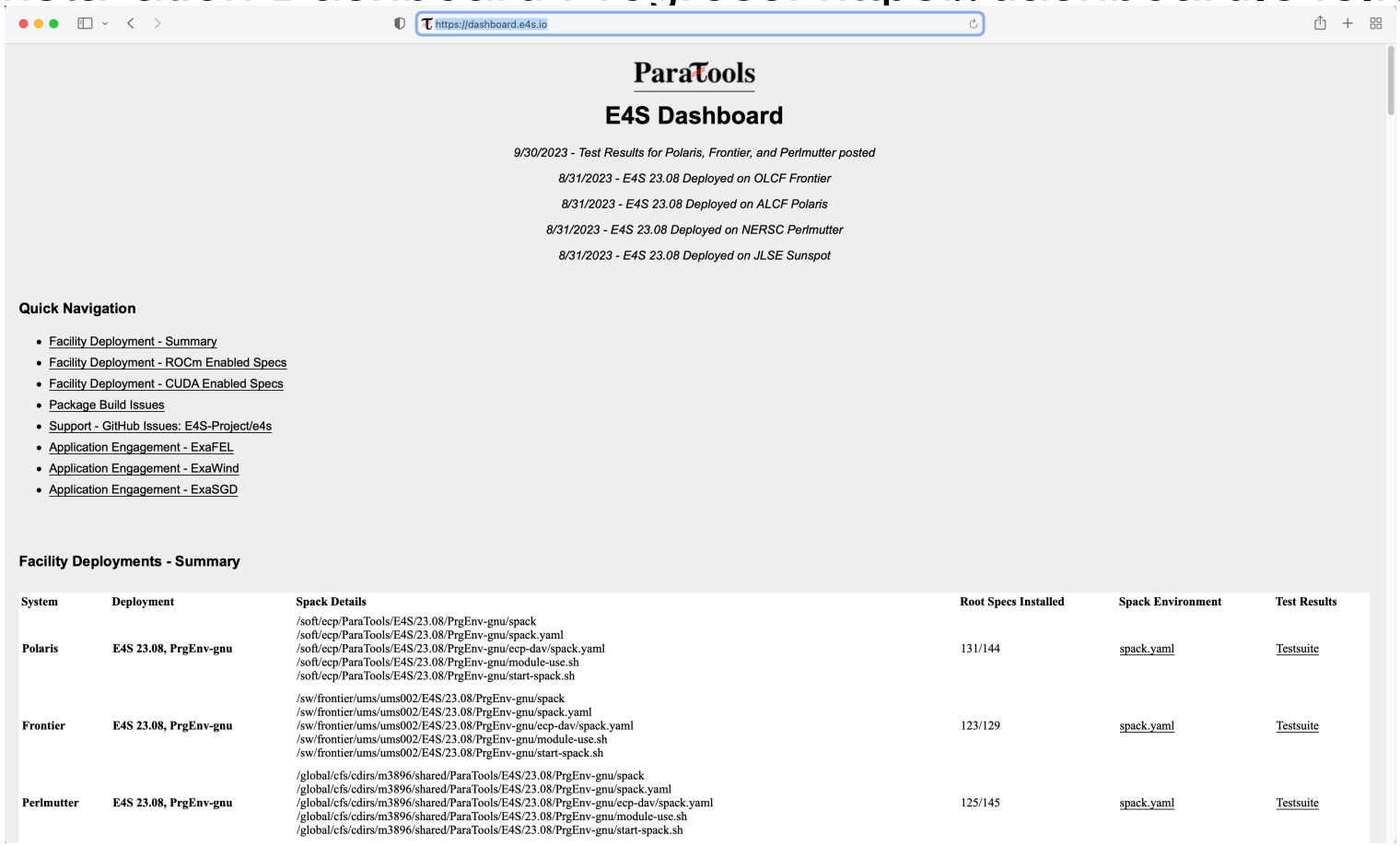
SYCL Enabled Trilinos Issue #12420

- When Trilinos is built with external SYCL-enabled Kokkos, the build works
- When Trilinos is built with vendored SYCL-enabled Kokkos, the build fails
- We are using External Kokkos for now
- **Trilinos SYCL build failing: llvm-foreach: Error: Device name missing. #12420**
- https://github.com/trilinos/Trilinos/issues/12420

Other Trilinos issues filed

- **Kokkos: Configure error with -DKokkos_ARCH_INTEL_XEHP=ON #12016**
- https://github.com/trilinos/Trilinos/issues/12016
- **ShyLU: ShyLU/ShyLUConfig.cmake:164 (include): could not find requested file: ../ShyLU_Node/ShyLU_NodeConfig.cmake #12048**
- https://github.com/trilinos/Trilinos/issues/12048

E4S installation Dashboard Progress: https://dashboard.e4s.io



https://dashboard.e4s.io

ParaTools

E4S Dashboard

9/30/2023 - Test Results for Polaris, Frontier, and Perlmutter posted

8/31/2023 - E4S 23.08 Deployed on OLCF Frontier

8/31/2023 - E4S 23.08 Deployed on ALCF Polaris

8/31/2023 - E4S 23.08 Deployed on NERSC Perlmutter

8/31/2023 - E4S 23.08 Deployed on JLSE Sunspot

Quick Navigation

- Facility Deployment - Summary
- Facility Deployment - ROCm Enabled Specs
- Facility Deployment - CUDA Enabled Specs
- Package Build Issues
- Support - GitHub Issues: E4S-Project/e4s
- Application Engagement - ExaFEL
- Application Engagement - ExaWind
- Application Engagement - ExaSGD

Facility Deployments - Summary

System	Deployment	Spack Details	Root Specs Installed	Spack Environment	Test Results
Polaris	E4S 23.08, PrgEnv-gnu	/soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/spack /soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/spack.yaml /soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/ecp-dav/spack.yaml /soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/module-use.sh /soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/start-spack.sh	131/144	spack.yaml	Testsuite
Frontier	E4S 23.08, PrgEnv-gnu	/sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack.yaml /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/ecp-dav/spack.yaml /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/module-use.sh /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/start-spack.sh	123/129	spack.yaml	Testsuite
Perlmutter	E4S 23.08, PrgEnv-gnu	/global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/spack /global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/spack.yaml /global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/ecp-dav/spack.yaml /global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/module-use.sh /global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/start-spack.sh	125/145	spack.yaml	Testsuite

E4S 23.08 installation on Frontier at ORNL with Trilinos 14.4.0

```
[sameer@login03.frontier ~]$ module avail

------------------------------------------------ /opt/cray/pe/lmod/modulefiles/mpi/gnu/8.0/ofi/1.0/cray-mpich/8.0 ------------------------------------------------
   cray-hdf5-parallel/1.12.1.5        cray-mpixlate/1.0.1.10              cray-parallel-netcdf/1.12.3.3     craype-dl-plugin-py3/22.06.1.2
   cray-hdf5-parallel/1.12.2.1 (D)    cray-mpixlate/1.0.1.11              cray-parallel-netcdf/1.12.3.7     craype-dl-plugin-py3/22.08.1
   cray-hdf5-parallel/1.12.2.3        cray-mpixlate/1.0.2          (D)    craype-dl-plugin-ftr/22.06.1.2    craype-dl-plugin-py3/22.09.1
   cray-hdf5-parallel/1.12.2.7        cray-parallel-netcdf/1.12.2.5       craype-dl-plugin-py3/21.02.1.3    craype-dl-plugin-py3/22.12.1   (D)
   cray-mpixlate/1.0.0.6              cray-parallel-netcdf/1.12.3.1 (D)   craype-dl-plugin-py3/21.04.1

--------------- /autofs/nccs-svm1_sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack/share/spack/lmod/linux-sles15-x86_64/cray-mpich/8.1.23/Core ---------------
   adios/1.13.1                       ginkgo/1.6.0-openmp              nco/5.1.6                      (D)    slepc/3.19.1-rocm
   adios2/2.9.1               (D)     ginkgo/1.6.0-rocm-openmp   (D)   netlib-scalapack/2.2.0         (D)    slepc/3.19.1               (D)
   alquimia/1.0.10                    globalarrays/5.8.2         (D)   omega-h/9.34.13                (D)    stc/0.9.0
   amrex/23.08-rocm                   h5bench/1.4                      openfoam/2306                         strumpack/7.1.3-openmp
   amrex/23.08                (D)     hdf5-vol-async/1.7               openpmd-api/0.15.1             (D)    strumpack/7.1.3-rocm-openmp (D)
   arborx/1.4.1-rocm                  hdf5-vol-cache/v1.1              papyrus/1.0.2                  (D)    sundials/6.5.1-rocm
   arborx/1.4.1               (D)     hdf5-vol-log/1.4.0               parallel-netcdf/1.12.3         (D)    sundials/6.5.1             (D)
   ascent/0.9.0-openmp                hdf5/1.14.0                (D)   paraview/5.11.1-rocm                  superlu-dist/8.1.2-rocm
   ascent/0.9.0               (D)     heffte/2.3.0-rocm                paraview/5.11.1                (D)    superlu-dist/8.1.2         (D)
   axom/0.7.0-openmp          (D)     heffte/2.3.0               (D)   parsec/3.0.2209                (D)    sz/2.1.12.5                (D)
   boost/1.83.0               (D)     hpctoolkit/2023.03.01-rocm       petsc/3.19.4-rocm                     tasmanian/7.9-rocm
   butterflypack/2.2.2-openmp (D)     hpctoolkit/2023.03.01      (D)   petsc/3.19.4                   (D)    tasmanian/7.9              (D)
   cabana/0.5.0-rocm                  hpx/1.9.1                  (D)   phist/1.11.2-openmp            (D)    tau/2.32.1-rocm
   cabana/0.5.0               (D)     hypre/2.29.0-rocm                plumed/2.9.0                   (D)    tau/2.32.1                 (D)
   caliper/2.10.0-rocm                hypre/2.29.0               (D)   precice/2.5.0                  (D)    trilinos/14.4.0-rocm
   caliper/2.10.0             (D)     lammps/20230802-openmp     (D)   pruners-ninja/1.0.1                   trilinos/14.4.0            (D)
   conduit/0.8.8              (D)     libcatalyst/2.0.0-rc3            pumi/2.2.7                     (D)    [illegible]                (D)
   darshan-runtime/3.4.4      (L,D)   libnrm/0.1.0                     py-cinemasci/1.3                      unifyfs/1.0.1
   datatransferkit/3.1-rc3    (D)     libpressio/0.95.1-openmp         py-h5py/3.8.0                         upcxx/2023.3.0-rocm
   dyninst/12.3.0-openmp      (D)     libquo/1.3.1               (D)   py-libensemble/0.10.2                 upcxx/2023.3.0             (D)
   ecp-data-vis-sdk/1.0-rocm          mercury/2.3.0              (D)   py-petsc4py/3.19.4                    veloc/1.6                  (D)
   ecp-data-vis-sdk/1.0       (D)     metall/0.25                (D)   py-warpx/23.08                        visit/3.3.3
   exaworks/0.1.0                     mfem/4.5.2-rocm                  quantum-espresso/7.2-openmp           vtk-m/1.9.0-openmp
   faodel/1.2108.1            (D)     mfem/4.5.2                 (D)   rempi/1.1.0                           vtk-m/1.9.0-rocm           (D)
   flecsi/2.2.1               (D)     mpifileutils/0.11.1        (D)   slate/2022.07.00-openmp               wannier90/3.1.0
   fortrilinos/2.3.0          (D)     nccmp/1.9.1.0              (D)   slate/2022.07.00-rocm-openmp (D)      xyce/7.6.0

-------------------------------- /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack/share/spack/lmod/linux-sles15-x86_64/Core --------------------------------
   aml/0.2.1           (D)     flit/2.1.0                   (D)   kokkos/4.1.00-rocm      (D)   nrm/0.1.0                   superlu/5.3.0          (D)
   argobots/1.1        (D)     flux-core/0.53.0             (D)   legion/23.06.0-rocm           openmpi/4.1.5               swig/4.0.2-fortran
   bolt/2.0            (D)     gasnet/2023.3.0-rocm               legion/23.06.0          (D)   papi/6.0.0.1                sz3/3.1.7
   chai/2022.03.0-rocm         gasnet/2023.3.0              (D)   libunwind/1.6.2         (D)   pdt/3.25.1            (D)   umap/2.1.0             (D)
   chai/2022.03.0      (D)     gmp/6.2.1                    (D)   loki/0.1.7              (D)   plasma/22.9.29              umpire/2022.03.1-rocm
   charliecloud/0.33           gotcha/1.0.4                 (D)   magma/2.7.1-rocm        (D)   qthreads/1.18         (D)   umpire/2022.03.1       (D)
   cray-mpich/8.1.23   (L,D)   kokkos-kernels/4.0.00-openmp (D)   mgard/2023-03-31-openmp       raja/2022.10.4-openmp       variorum/0.6.0
   darshan-util/3.4.4  (D)     kokkos/4.1.00-openmp               mpark-variant/1.4.0     (D)   raja/2022.10.4-rocm   (D)   zfp/0.5.5              (D)
```

E4S 23.08 installation on Frontier at ORNL with Trilinos 14.4.0

```
[sameer@login03.frontier ~]$ module avail

------------------------------------------------ /opt/cray/pe/lmod/modulefiles/mpi/gnu/8.0/ofi/1.0/cray-mpich/8.0 ------------------------------------------------
   cray-hdf5-parallel/1.12.1.5        cray-mpixlate/1.0.1.10              cray-parallel-netcdf/1.12.3.3     craype-dl-plugin-py3/22.06.1.2
   cray-hdf5-parallel/1.12.2.1 (D)    cray-mpixlate/1.0.1.11              cray-parallel-netcdf/1.12.3.7     craype-dl-plugin-py3/22.08.1
   cray-hdf5-parallel/1.12.2.3        cray-mpixlate/1.0.2          (D)    craype-dl-plugin-ftr/22.06.1.2    craype-dl-plugin-py3/22.09.1
   cray-hdf5-parallel/1.12.2.7        cray-parallel-netcdf/1.12.2.5       craype-dl-plugin-py3/21.02.1.3    craype-dl-plugin-py3/22.12.1   (D)
   cray-mpixlate/1.0.0.6              cray-parallel-netcdf/1.12.3.1 (D)   craype-dl-plugin-py3/21.04.1

--------------- /autofs/nccs-svm1_sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack/share/spack/lmod/linux-sles15-x86_64/cray-mpich/8.1.23/Core ---------------
   adios/1.13.1                       ginkgo/1.6.0-openmp              nco/5.1.6                      (D)    slepc/3.19.1-rocm
   adios2/2.9.1               (D)     ginkgo/1.6.0-rocm-openmp   (D)   netlib-scalapack/2.2.0         (D)    slepc/3.19.1               (D)
   alquimia/1.0.10                    globalarrays/5.8.2         (D)   omega-h/9.34.13                (D)    stc/0.9.0
   amrex/23.08-rocm                   h5bench/1.4                      openfoam/2306                         strumpack/7.1.3-openmp
   amrex/23.08                (D)     hdf5-vol-async/1.7               openpmd-api/0.15.1             (D)    strumpack/7.1.3-rocm-openmp (D)
   arborx/1.4.1-rocm                  hdf5-vol-cache/v1.1              papyrus/1.0.2                  (D)    sundials/6.5.1-rocm
   arborx/1.4.1               (D)     hdf5-vol-log/1.4.0               parallel-netcdf/1.12.3         (D)    sundials/6.5.1             (D)
   ascent/0.9.0-openmp                hdf5/1.14.0                (D)   paraview/5.11.1-rocm                  superlu-dist/8.1.2-rocm
   ascent/0.9.0               (D)     heffte/2.3.0-rocm                paraview/5.11.1                (D)    superlu-dist/8.1.2         (D)
   axom/0.7.0-openmp          (D)     heffte/2.3.0               (D)   parsec/3.0.2209                (D)    sz/2.1.12.5                (D)
   boost/1.83.0               (D)     hpctoolkit/2023.03.01-rocm       petsc/3.19.4-rocm                     tasmanian/7.9-rocm
   butterflypack/2.2.2-openmp (D)     hpctoolkit/2023.03.01      (D)   petsc/3.19.4                   (D)    tasmanian/7.9              (D)
   cabana/0.5.0-rocm                  hpx/1.9.1                  (D)   phist/1.11.2-openmp            (D)    tau/2.32.1-rocm
   cabana/0.5.0               (D)     hypre/2.29.0-rocm                plumed/2.9.0                   (D)    tau/2.32.1                 (D)
   caliper/2.10.0-rocm                hypre/2.29.0               (D)   precice/2.5.0                  (D)    trilinos/14.4.0-rocm
   caliper/2.10.0             (D)     lammps/20230802-openmp     (D)   pruners-ninja/1.0.1                   trilinos/14.4.0            (D)
   conduit/0.8.8              (D)     libcatalyst/2.0.0-rc3            pumi/2.2.7                     (D)    [illegible]                (D)
   darshan-runtime/3.4.4      (L,D)   libnrm/0.1.0                     py-cinemasci/1.3                      unifyfs/1.0.1
   datatransferkit/3.1-rc3    (D)     libpressio/0.95.1-openmp         py-h5py/3.8.0                         upcxx/2023.3.0-rocm
   dyninst/12.3.0-openmp      (D)     libquo/1.3.1               (D)   py-libensemble/0.10.2                 upcxx/2023.3.0             (D)
   ecp-data-vis-sdk/1.0-rocm          mercury/2.3.0              (D)   py-petsc4py/3.19.4                    veloc/1.6                  (D)
   ecp-data-vis-sdk/1.0       (D)     metall/0.25                (D)   py-warpx/23.08                        visit/3.3.3
   exaworks/0.1.0                     mfem/4.5.2-rocm                  quantum-espresso/7.2-openmp           vtk-m/1.9.0-openmp
   faodel/1.2108.1            (D)     mfem/4.5.2                 (D)   rempi/1.1.0                           vtk-m/1.9.0-rocm           (D)
   flecsi/2.2.1               (D)     mpifileutils/0.11.1        (D)   slate/2022.07.00-openmp               wannier90/3.1.0
   fortrilinos/2.3.0          (D)     nccmp/1.9.1.0              (D)   slate/2022.07.00-rocm-openmp (D)      xyce/7.6.0

-------------------------------- /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack/share/spack/lmod/linux-sles15-x86_64/Core --------------------------------
   aml/0.2.1           (D)     flit/2.1.0                  (D)   kokkos/4.1.00-rocm      (D)   nrm/0.1.0                   superlu/5.3.0          (D)
   argobots/1.1        (D)     flux-core/0.53.0            (D)   legion/23.06.0-rocm           openmpi/4.1.5               swig/4.0.2-fortran
   bolt/2.0            (D)     gasnet/2023.3.0-rocm              legion/23.06.0          (D)   papi/6.0.0.1                sz3/3.1.7
   chai/2022.03.0-rocm         gasnet/2023.3.0             (D)   libunwind/1.6.2         (D)   pdt/3.25.1            (D)   umap/2.1.0             (D)
   chai/2022.03.0      (D)     gmp/6.2.1                   (D)   loki/0.1.7              (D)   plasma/22.9.29                umpire/2022.03.1-rocm
   charliecloud/0.33           gotcha/1.0.4                (D)   magma/2.7.1-rocm        (D)   qthreads/1.18         (D)   umpire/2022.03.1       (D)
   cray-mpich/8.1.23   (L,D)   kokkos-kernels/4.0.00-openmp (D)  mgard/2023-03-31-openmp       raja/2022.10.4-openmp       variorum/0.6.0
   darshan-util/3.4.4  (D)     kokkos/4.1.00-openmp              mpark-variant/1.4.0     (D)   raja/2022.10.4-rocm   (D)   zfp/0.5.5              (D)
```

E4S 23.08 installation on Frontier at ORNL

```
[sameer@login03.frontier ~]$ source /sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/start-spack.sh

Lmod is automatically replacing "cce/15.0.0" with "gcc/12.2.0".


Lmod is automatically replacing "PrgEnv-cray/8.3.3" with "PrgEnv-gnu/8.3.3".


Due to MODULEPATH changes, the following have been reloaded:
  1) cray-mpich/8.1.23     2) darshan-runtime/3.4.0


Due to MODULEPATH changes, the following have been reloaded:
  1) darshan-runtime/3.4.0

The following have been reloaded with a version change:
  1) gcc/12.2.0 => gcc/11.2.0

[sameer@login03.frontier ~]$ which spack
/sw/frontier/ums/ums002/E4S/23.08/PrgEnv-gnu/spack/bin/spack
[sameer@login03.frontier ~]$ spack find -x
-- linux-sles15-zen3 / gcc@11.2.0 -------------------------------
adios@1.13.1          charliecloud@0.33      h5bench@1.4           libnrm@0.1.0          papyrus@1.0.2          raja@2022.10.4      trilinos@14.4.0
adios2@2.9.1          conduit@0.8.8          hdf5@1.14.0           libpressio@0.95.1     parallel-netcdf@1.12.3 rempi@1.1.0         turbine@1.3.0
alquimia@1.0.10       cray-mpich@8.1.23      hdf5-vol-async@1.7    libquo@1.3.1          paraview@5.11.1        slate@2022.07.00    umap@2.1.0
aml@0.2.1             darshan-runtime@3.4.4  hdf5-vol-async@1.7    libunwind@1.6.2       paraview@5.11.1        slate@2022.07.00    umpire@2022.03.1
amrex@23.08           darshan-util@3.4.4     hdf5-vol-cache@v1.1   loki@0.1.7            parsec@3.0.2209        slepc@3.19.1        umpire@2022.03.1
amrex@23.08           datatransferkit@3.1-rc3 hdf5-vol-cache@v1.1  magma@2.7.1           pdt@3.25.1             slepc@3.19.1        unifyfs@1.0.1
arborx@1.4.1          dyninst@12.3.0         hdf5-vol-log@1.4.0    mercury@2.3.0         petsc@3.19.4           stc@0.9.0           upcxx@2023.3.0
arborx@1.4.1          ecp-data-vis-sdk@1.0   hdf5-vol-log@1.4.0    metall@0.25           petsc@3.19.4           strumpack@7.1.3     upcxx@2023.3.0
argobots@1.1          ecp-data-vis-sdk@1.0   heffte@2.3.0          mfem@4.5.2            phist@1.11.2           strumpack@7.1.3     variorum@0.6.0
ascent@0.9.0          exaworks@0.1.0         heffte@2.3.0          mfem@4.5.2            plasma@22.9.29         sundials@6.5.1      veloc@1.6
ascent@0.9.0          faodel@1.2108.1        hpctoolkit@2023.03.01 mgard@2023-03-31      plumed@2.9.0           sundials@6.5.1      visit@3.3.3
axom@0.7.0            flecsi@2.2.1           hpctoolkit@2023.03.01 mpark-variant@1.4.0   precice@2.5.0          superlu@5.3.0       visit@3.3.3
bolt@2.0              flit@2.1.0             hpx@1.9.1             mpifileutils@0.11.1   pruners-ninja@1.0.1    superlu-dist@8.1.2  vtk-m@1.9.0
boost@1.83.0          flux-core@0.53.0       hypre@2.29.0          nccmp@1.9.1.0         pumi@2.2.7             superlu-dist@8.1.2  vtk-m@1.9.0
butterflypack@2.2.2   fortrilinos@2.3.0      hypre@2.29.0          nco@5.1.6             py-cinemasci@1.3       swig@4.0.2-fortran  wannier90@3.1.0
cabana@0.5.0          gasnet@2023.3.0        kokkos@4.1.00         netlib-scalapack@2.2.0 py-h5py@3.8.0         sz@2.1.12.5         xyce@7.6.0
cabana@0.5.0          gasnet@2023.3.0        kokkos@4.1.00         nrm@0.1.0             py-libensemble@0.10.2  sz3@3.1.7           zfp@0.5.5
cabana@0.5.0          ginkgo@1.6.0           kokkos-kernels@4.0.00 omega-h@9.34.13       py-petsc4py@3.19.4     tasmanian@7.9
caliper@2.10.0        ginkgo@1.6.0           lammps@20230802       openfoam@2306         py-warpx@23.08         tasmanian@7.9
caliper@2.10.0        globalarrays@5.8.2     legion@23.06.0        openmpi@4.1.5         qthreads@1.18          tau@2.32.1
chai@2022.03.0        gmp@6.2.1              legion@23.06.0        openpmd-api@0.15.1    quantum-espresso@7.2   tau@2.32.1
chai@2022.03.0        gotcha@1.0.4           libcatalyst@2.0.0-rc3 papi@6.0.0.1          raja@2022.10.4         trilinos@14.4.0
==> 149 installed packages
[sameer@login03.frontier ~]$

[sameer@login03.frontier ~]$ spack find -x +rocm
-- linux-sles15-zen3 / gcc@11.2.0 -------------------------------
amrex@23.08   caliper@2.10.0        ginkgo@1.6.0           kokkos@4.1.00   paraview@5.11.1   slepc@3.19.1        tasmanian@7.9     upcxx@2023.3.0
arborx@1.4.1  chai@2022.03.0        heffte@2.3.0           legion@23.06.0  petsc@3.19.4      strumpack@7.1.3     tau@2.32.1        vtk-m@1.9.0
cabana@0.5.0  ecp-data-vis-sdk@1.0  hpctoolkit@2023.03.01  magma@2.7.1     raja@2022.10.4    sundials@6.5.1      trilinos@14.4.0
cabana@0.5.0  gasnet@2023.3.0        hypre@2.29.0           mfem@4.5.2      slate@2022.07.00  superlu-dist@8.1.2  umpire@2022.03.1
==> 30 installed packages
```

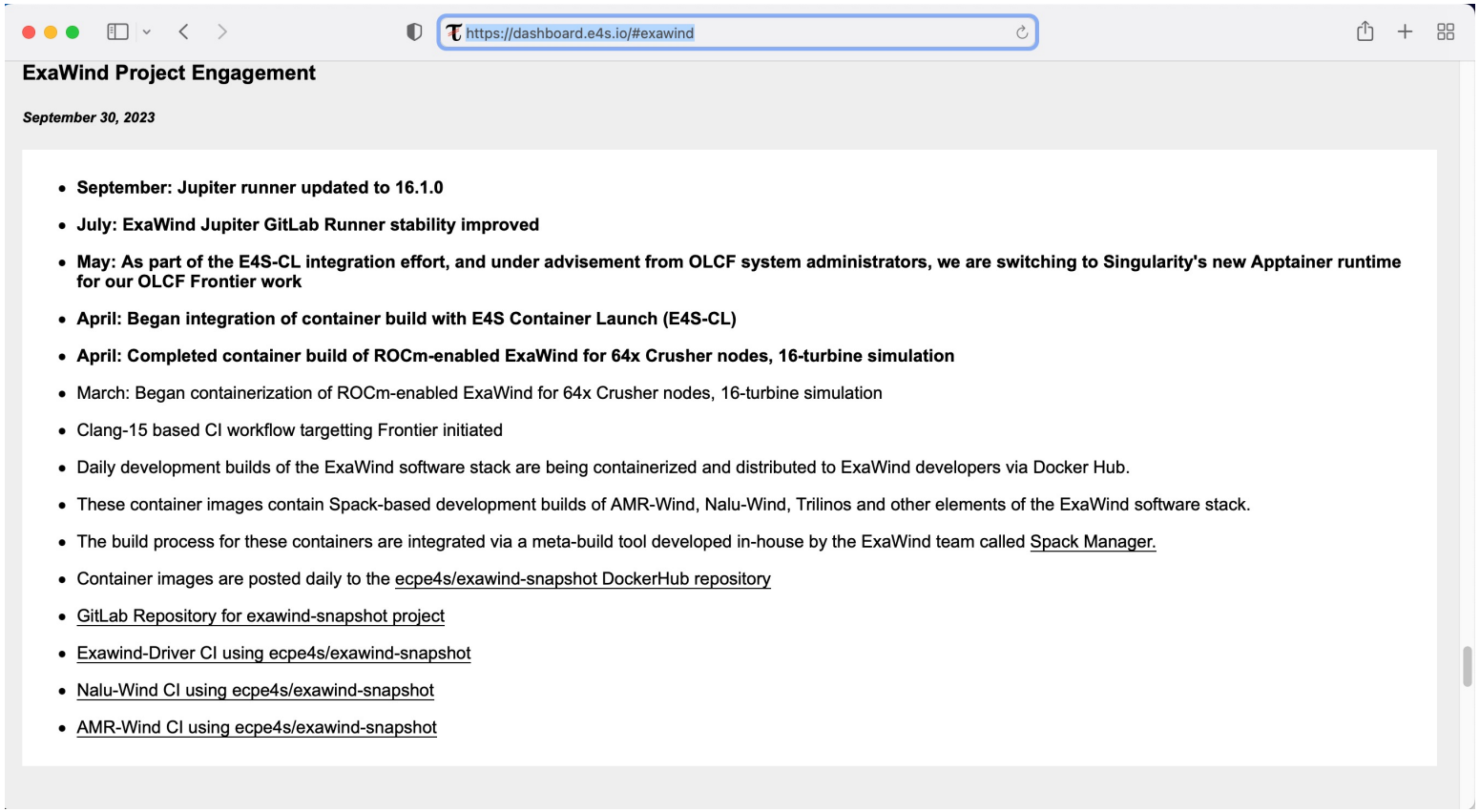
E4S 23.08 installation on Perlmutter at NERSC

```
sameer@perlmutter:login39:~> source /global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/start-spack.sh
sameer@perlmutter:login39:~> which spack
/global/cfs/cdirs/m3896/shared/ParaTools/E4S/23.08/PrgEnv-gnu/spack/bin/spack
sameer@perlmutter:login39:~> spack find -x
-- linux-sles15-zen3 / gcc@11.2.0 -------------------------------
adios@1.13.1          charliecloud@0.33      gotcha@1.0.4          kokkos-kernels@4.0.00  nccmp@1.9.1.0          pumi@2.2.7             superlu-dist@8.1.2
adios2@2.9.1          conduit@0.8.8          h5bench@1.4           kokkos-kernels@4.0.00  nco@5.1.6              py-cinemasci@1.3       superlu-dist@8.1.2
adios2@2.9.1          conduit@0.8.8          hdf5@1.14.2           lammps@20230802        netlib-scalapack@2.2.0 py-h5py@3.8.0          swig@4.0.2-fortran
alquimia@1.0.10       conduit@0.8.8          hdf5@1.14.2           lammps@20230802        nvhpc@23.7             py-jupyterhub@0.9.4    sz@2.1.12.5
aml@0.2.1             cray-mpich@8.1.25      hdf5-vol-async@1.7    legion@23.06.0         openfoam@2306          py-libensemble@0.10.2  sz3@3.1.7
amrex@23.08           cusz@0.3.1             hdf5-vol-async@1.7    legion@23.06.0         openmpi@4.1.5          py-petsc4py@3.19.4     tasmanian@7.9
amrex@23.08           darshan-runtime@3.4.4  hdf5-vol-cache@v1.1   libnrm@0.1.0           openpmd-api@0.15.1     qthreads@1.18          tasmanian@7.9
arborx@1.4.1          darshan-util@3.4.4     hdf5-vol-cache@v1.1   libpressio@0.95.1      papi@6.0.0.1           raja@2022.10.4         tau@2.32.1
arborx@1.4.1          datatransferkit@3.1-rc3 hdf5-vol-log@1.4.0   libpressio@0.95.1      papi@6.0.0.1           raja@2022.10.4         [redacted]
argobots@1.1          dyninst@12.3.0         hdf5-vol-log@1.4.0    libquo@1.3.1           papyrus@1.0.2          rempi@1.1.0            trilinos@14.4.0
ascent@0.9.1          faodel@1.2108.1        hdf5-vol-log@1.4.0    libunwind@1.6.2        parallel-netcdf@1.12.3 scr@3.0.1              [redacted]
axom@0.7.0            flecsi@2.2.1           heffte@2.3.0          loki@0.1.7             parsec@3.0.2209        slate@2022.07.00       umap@2.1.0
bolt@2.0              flecsi@2.2.1           heffte@2.3.0          magma@2.7.1            parsec@3.0.2209        slate@2022.07.00       umpire@2022.03.1
boost@1.83.0          flit@2.1.0             hpctoolkit@2023.03.01 mercury@2.3.0          pdt@3.25.1             slepc@3.19.1           umpire@2022.03.1
butterflypack@2.2.2   flux-core@0.53.0       hpctoolkit@2023.03.01 metall@0.25            petsc@3.19.4           slepc@3.19.1           variorum@0.6.0
cabana@0.5.0          flux-core@0.53.0       hpx@1.9.1             mfem@4.5.2             petsc@3.19.4           stc@0.9.0              veloc@1.6
cabana@0.5.0          fortrilinos@2.3.0      hpx@1.9.1             mfem@4.5.2             phist@1.11.2           strumpack@7.1.3        vtk-m@1.9.0
caliper@2.10.0        ginkgo@1.6.0           hypre@2.29.0          mgard@2023-03-31       plasma@22.9.29         strumpack@7.1.3        wannier90@3.1.0
caliper@2.10.0        ginkgo@1.6.0           hypre@2.29.0          mgard@2023-03-31       plumed@2.9.0           sundials@6.5.1         xyce@7.6.0
chai@2022.03.0        globalarrays@5.8.2     kokkos@4.1.00         mpark-variant@1.4.0    precice@2.5.0          sundials@6.5.1         zfp@0.5.5
chai@2022.03.0        gmp@6.2.1              kokkos@4.1.00         mpifileutils@0.11.1    pruners-ninja@1.0.1    superlu@5.3.0          zfp@0.5.5
==> 147 installed packages
sameer@perlmutter:login39:~> spack find -x +cuda
-- linux-sles15-zen3 / gcc@11.2.0 -------------------------------
adios2@2.9.1    chai@2022.03.0    heffte@2.3.0          kokkos-kernels@4.0.00  mfem@4.5.2        raja@2022.10.4    superlu-dist@8.1.2
amrex@23.08     cusz@0.3.1        hpctoolkit@2023.03.01 lammps@20230802        mgard@2023-03-31  slate@2022.07.00  tasmanian@7.9
arborx@1.4.1    flecsi@2.2.1      hpx@1.9.1             legion@23.06.0         papi@6.0.0.1      slepc@3.19.1      tau@2.32.1
cabana@0.5.0    flux-core@0.53.0  hypre@2.29.0          libpressio@0.95.1      parsec@3.0.2209   strumpack@7.1.3   umpire@2022.03.1
caliper@2.10.0  ginkgo@1.6.0      kokkos@4.1.00         magma@2.7.1            petsc@3.19.4      sundials@6.5.1    zfp@0.5.5
==> 35 installed packages
sameer@perlmutter:login39:~>
```

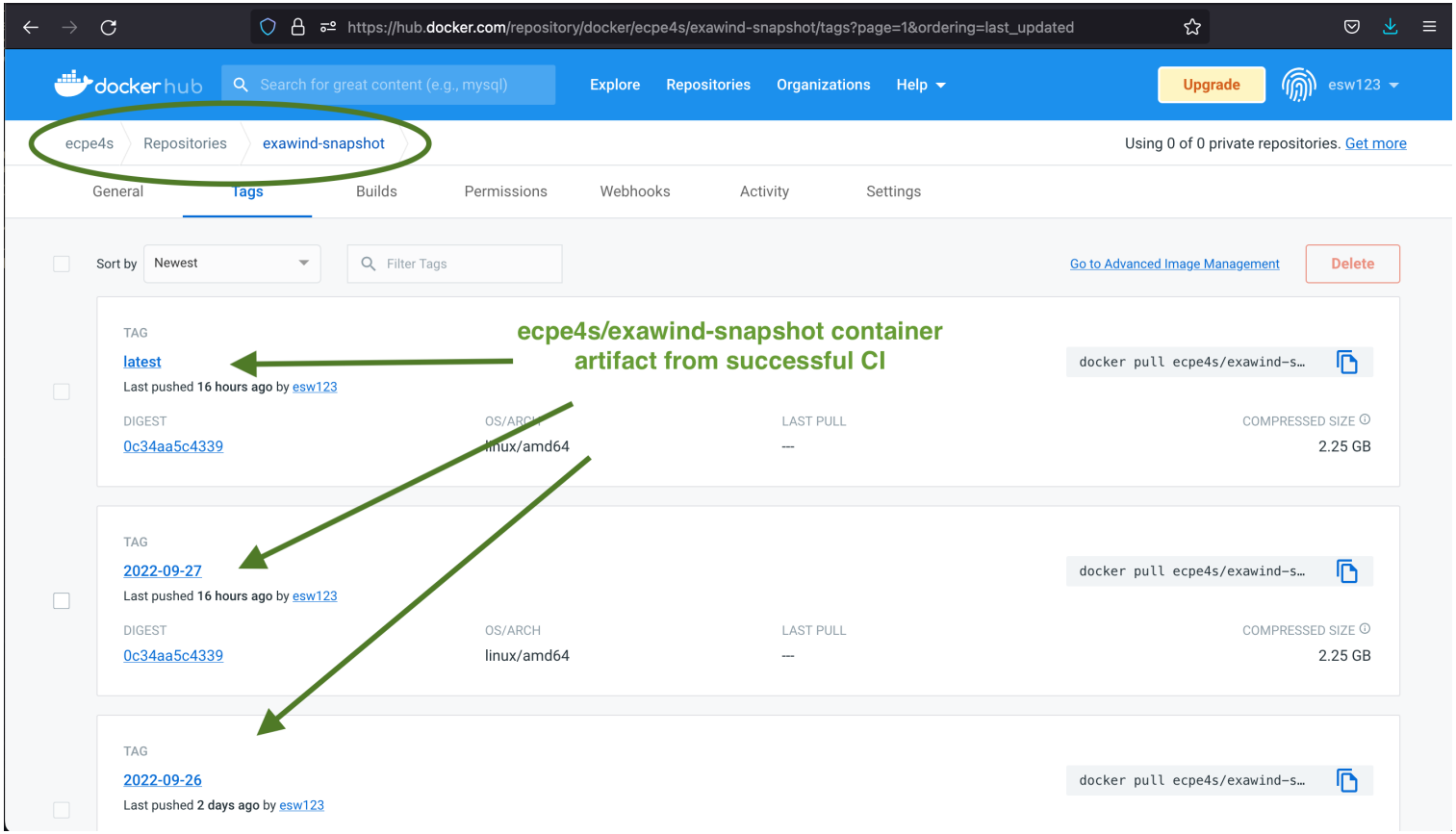
E4S 23.08 installation on Polaris at ALCF

```
sameer@polaris-login-01:~> source /soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/start-spack.sh
sameer@polaris-login-01:~> which spack
/soft/ecp/ParaTools/E4S/23.08/PrgEnv-gnu/spack/bin/spack
sameer@polaris-login-01:~> spack find -x
-- linux-sles15-zen3 / gcc@11.2.0 ------------------------------
adios@1.13.1          chai@2022.03.0          ginkgo@1.6.0          hpctoolkit@2023.03.01  magma@2.7.1           parallel-netcdf@1.12.3  quantum-espresso@7.2  tasmanian@7.9
adios2@2.9.1          charliecloud@0.33       ginkgo@1.6.0          hpctoolkit@2023.03.01  metall@0.25           parsec@3.0.2209         raja@2022.10.4        tasmanian@7.9
adios2@2.9.1          conduit@0.8.8           globalarrays@5.8.2    hpx@1.9.1              mfem@4.5.2            parsec@3.0.2209         raja@2022.10.4        tau@2.32.1
alquimia@1.0.10       conduit@0.8.8           gmp@6.2.1             hpx@1.9.1              mfem@4.5.2            pdt@3.25.1              rempi@1.1.0           trilinos@14.4.0
aml@0.2.1             conduit@0.8.8           gotcha@1.0.4          hypre@2.29.0           mgard@2023-03-31      petsc@3.19.4            scr@3.0.1
amrex@23.08           cray-mpich@8.1.16       gptune@4.0.0          hypre@2.29.0           mgard@2023-03-31      petsc@3.19.4            slate@2022.07.00
amrex@23.08           cusz@0.3.1              h5bench@1.4           kokkos@4.1.00          mpark-variant@1.4.0   phist@1.11.2            slate@2022.07.00      umap@2.1.0
arborx@1.4.1          darshan-runtime@3.4.4   hdf5@1.14.0           kokkos@4.1.00          mpifileutils@0.11.1   plasma@22.9.29          slepc@3.19.1          umpire@2022.03.1
arborx@1.4.1          darshan-util@3.4.4      hdf5@1.14.0           kokkos-kernels@4.0.00  nccmp@1.9.1.0         plumed@2.9.0            slepc@3.19.1          umpire@2022.03.1
argobots@1.1          datatransferkit@3.1-rc3 hdf5-vol-async@1.7    kokkos-kernels@4.0.00  nco@5.1.6             precice@2.5.0           stc@0.9.0             upcxx@2023.3.0
ascent@0.9.0          dealii@9.4.2            hdf5-vol-async@1.7    lammps@20230802        netlib-scalapack@2.2.0 pruners-ninja@1.0.1    strumpack@7.1.3       variorum@0.6.0
axom@0.7.0            dyninst@12.3.0          hdf5-vol-async@1.7    lammps@20230802        nrm@0.1.0             pumi@2.2.7              strumpack@7.1.3       veloc@1.6
bolt@2.0              faodel@1.2108.1         hdf5-vol-cache@v1.1   legion@23.06.0         omega-h@9.34.13       py-cinemasci@1.3        sundials@6.5.1        vtk-m@1.9.0
boost@1.83.0          flecsi@2.2.1            hdf5-vol-cache@v1.1   legion@23.06.0         omega-h@9.34.13       py-h5py@3.8.0           sundials@6.5.1        wannier90@3.1.0
butterflypack@2.2.2   flecsi@2.2.1            hdf5-vol-cache@v1.1   libcatalyst@2.0.0-rc3  openfoam@2306         py-jupyterhub@0.9.4     superlu@5.3.0         xyce@7.6.0
cabana@0.5.0          flit@2.1.0              hdf5-vol-log@1.4.0    libnrm@0.1.0           openmpi@4.1.5         py-jupyterlab@3.4.8     superlu-dist@8.1.2    zfp@0.5.5
cabana@0.5.0          flux-core@0.53.0        hdf5-vol-log@1.4.0    libpressio@0.95.1      openpmd-api@0.15.1    py-libensemble@0.10.2   superlu-dist@8.1.2    zfp@0.5.5
caliper@2.10.0        flux-core@0.53.0        hdf5-vol-log@1.4.0    libquo@1.3.1           papi@6.0.0.1          py-petsc4py@3.19.4      swig@4.0.2-fortran
caliper@2.10.0        fortrilinos@2.3.0       heffte@2.3.0          libunwind@1.6.2        papi@6.0.0.1          py-warpx@23.08          sz@2.1.12.5
chai@2022.03.0        gasnet@2023.3.0         heffte@2.3.0          loki@0.1.7             papyrus@1.0.2         qthreads@1.18           sz3@3.1.7
==> 157 installed packages
sameer@polaris-login-01:~> spack find -x +cuda
-- linux-sles15-zen3 / gcc@11.2.0 ------------------------------
adios2@2.9.1  caliper@2.10.0  flux-core@0.53.0  hpx@1.9.1             lammps@20230802  mgard@2023-03-31  petsc@3.19.4      strumpack@7.1.3  tau@2.32.1
amrex@23.08   chai@2022.03.0  ginkgo@1.6.0      hypre@2.29.0          legion@23.06.0   omega-h@9.34.13   raja@2022.10.4    sundials@6.5.1   umpire@2022.03.1
arborx@1.4.1  cusz@0.3.1      heffte@2.3.0      kokkos@4.1.00         magma@2.7.1      papi@6.0.0.1      slate@2022.07.00  superlu-dist@8.1.2  upcxx@2023.3.0
cabana@0.5.0  flecsi@2.2.1    hpctoolkit@2023.03.01  kokkos-kernels@4.0.00  mfem@4.5.2  parsec@3.0.2209  slepc@3.19.1  tasmanian@7.9  zfp@0.5.5
==> 36 installed packages
sameer@polaris-login-01:~>
```

Progress Report of E4S Support for ExaWind by ParaTools, Inc.

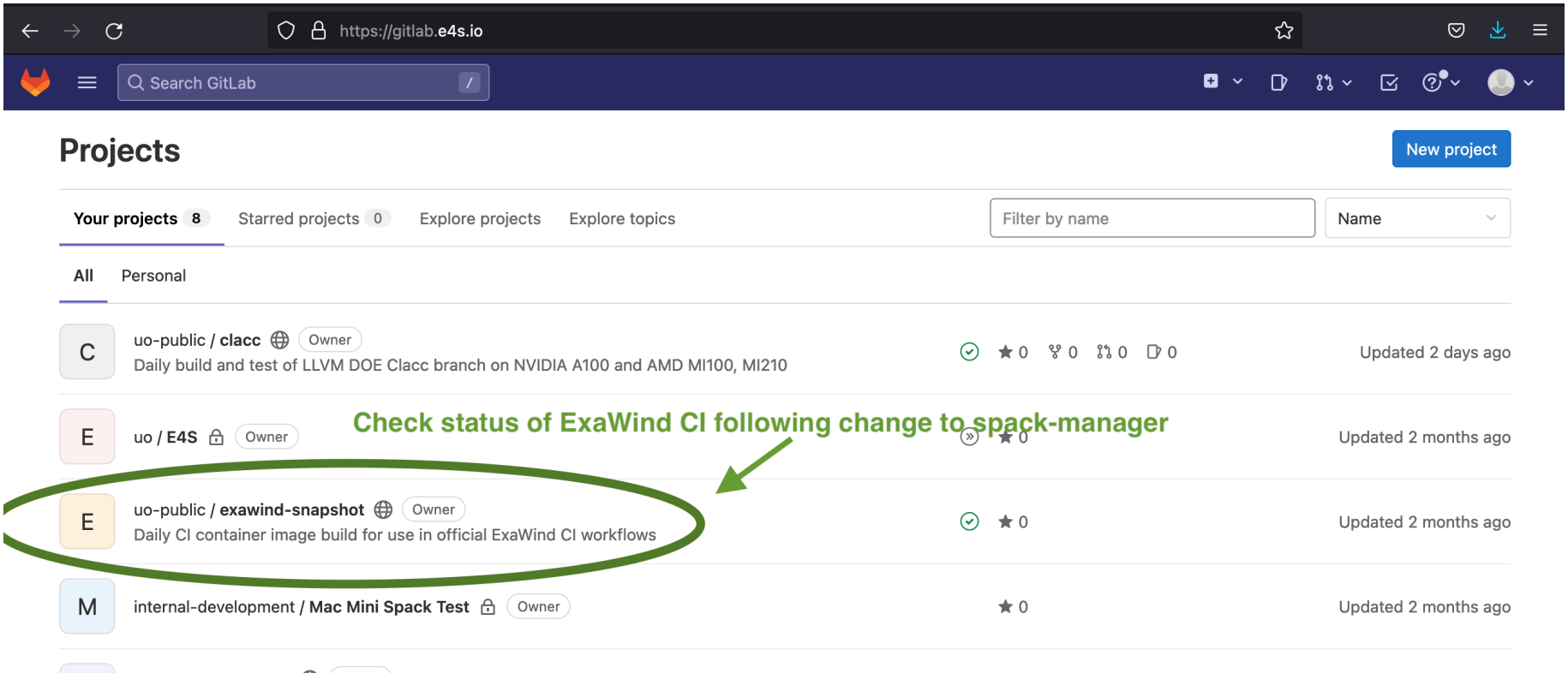


ExaWind CI: Container Image Artifacts on DockerHub



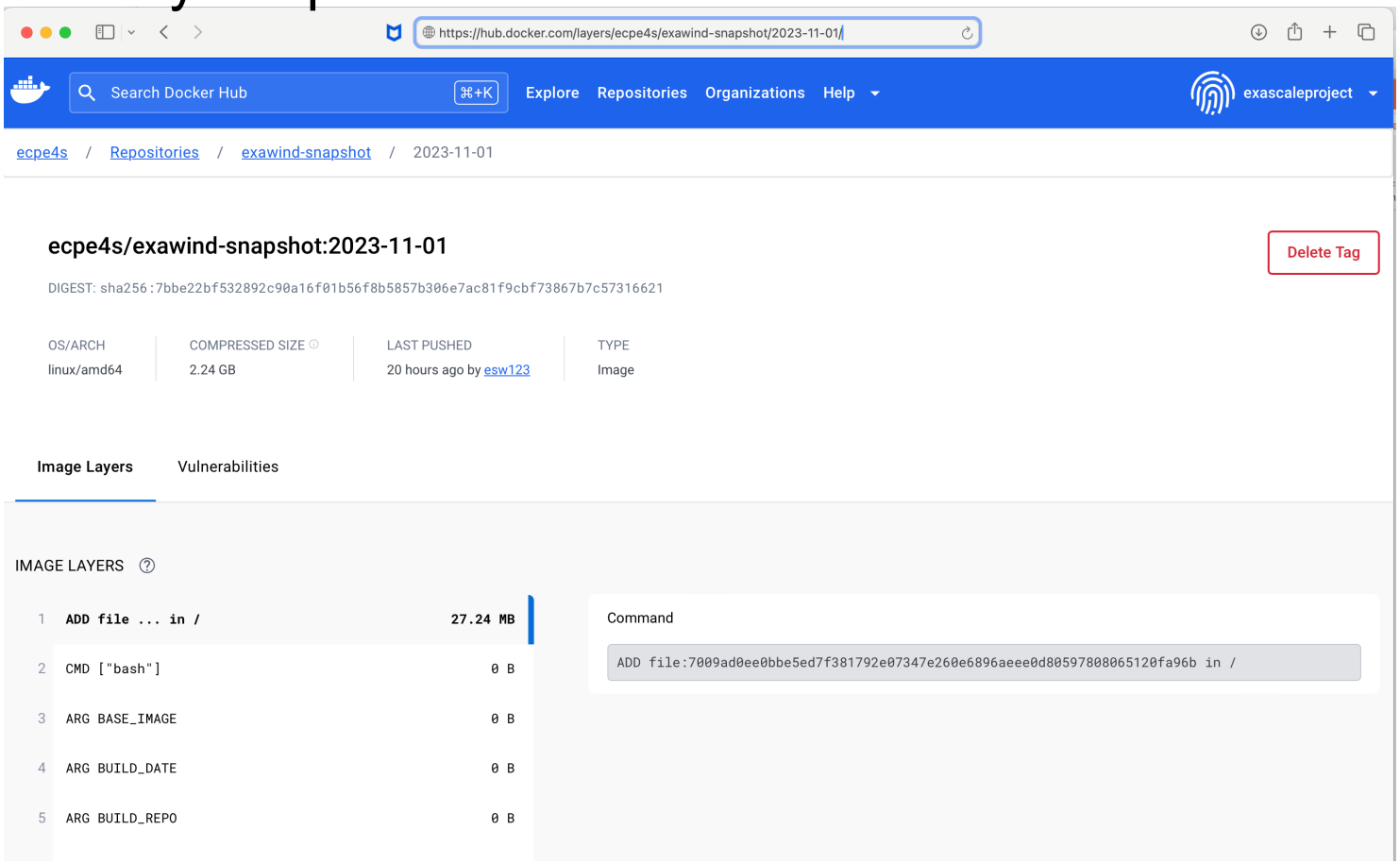
https://hub.docker.com/repository/docker/ecpe4s/exawind-snapshot/tags?page=1&ordering=last_updated

ExaWind CI: Exawind-Snapshot Project on gitlab.e4s.io



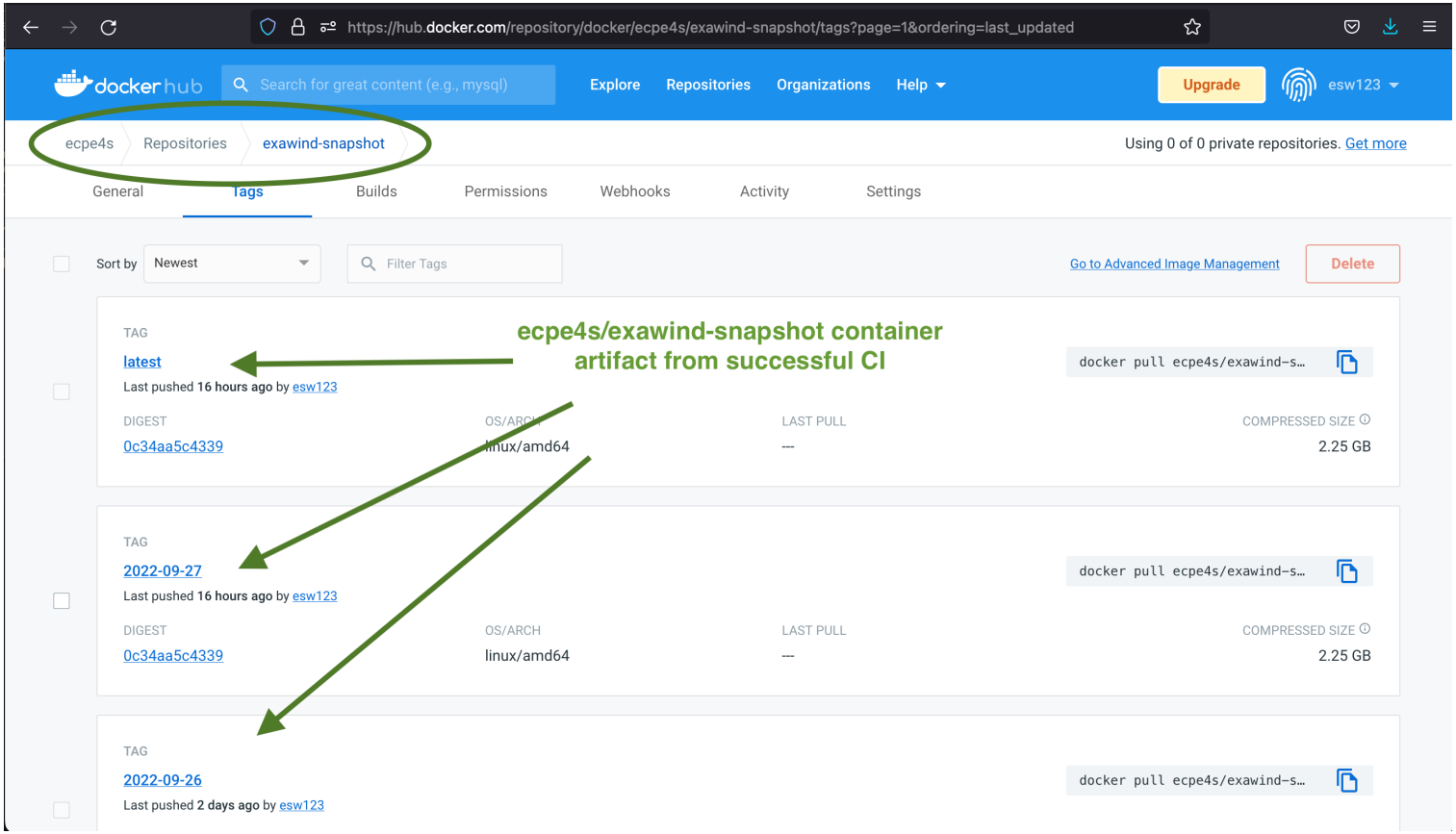
https://gitlab.e4s.io/uo-public/exawind-snapshot/-/pipelines

Exawind daily snapshot at DockerHub



2023-11-01

ExaWind CI: Container Image Artifacts on DockerHub



https://hub.docker.com/repository/docker/ecpe4s/exawind-snapshot/tags?page=1&ordering=last_updated

Thank you

https://www.exascaleproject.org

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Thank you to all collaborators in the ECP and broader computational science communities. The work discussed in this presentation represents creative contributions of many people who are passionately working toward next-generation computational science.