E4S: The Extreme-scale Scientific Software Stack Release 23.11

Release 23.11 notes

November 9, 2023

National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY | Office of Science

E4S 23.11: What's New?

- E4S includes 120+ HPC packages on ARM, x86_64, and ppc64le platforms, 110K+ binaries in E4S Spack Build Cache
- E4S includes new AI/ML packages: JAX, PyTorch, TensorFlow, Horovod, and LBANN. Updated Python tools including Jupyter notebook.
- E4S includes new applications: ExaGO and previously supported Xyce, Quantum Espresso, LAMMPS, WARPX, Dealii, and OpenFOAM
- E4S includes support for Intel oneAPI 2023.2.1 software (BaseKit and HPCToolkit) in containers on x86_64 with support for HPC packages built with Intel compilers
- New solvers that support SYCL and Intel GPUs for the first time: PETSc, SUNDIALS, and SLATE.
- GPU support: ARM64 (aarch64) with H100 (90) with CUDA 12.1 and NVHPC 23.9
- E4S includes support for CUDA architectures
  - 80 (A100), and 90 (H100) under x86_64
  - 70 under ppc64le (IBM Power 10)
  - 75, 80, and 90 (H100) under aarch64
- Updated E4S tools: Release 1.0 of e4s-alc (à la carte) customizes container images, e4s-cl (container launch) replaces MPI at runtime!
- New AWS E4S 23.11 image [ami-08c2daa0fb4864b90 in US-West-2 OR] with support for 50+ EDA tools with DCV and UPC++, CAF, and Chapel
- Adaptive Computing's ODDC platform for launching E4S images to AWS on multiple EFA enabled nodes using MVAPICH through a web browser
  - https://youtu.be/kudLzNGE9sU

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 120+ HPC, EDA (e.g., Xyce), and AI/ML packages (e.g., TensorFlow, PyTorch, JAX, Horovod, and LBANN).
- With E4S Spack binary build caches, E4S supports both bare-metal and containerized deployment for GPU based platforms.
  - X86_64, ppc64le (IBM Power 10), 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) and DOE LLVM containers.
- 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_Oct23.pdf
- E4S for commercial cloud platforms: AWS image supports MPI implementations and containers with remote desktop (DCV).
  - Intel MPI, NVHPC, MVAPICH2, MPICH, MPC, OpenMPI
- e4s-cl container launch tool allows binary distribution of applications by substituting MPI in the containerized app with the system MPI.
- Quarterly releases: E4S 23.11 released on Nov 9, 2023: https://e4s.io/talks/E4S_23.11.pdf

Extreme-scale Scientific Software Stack (E4S)

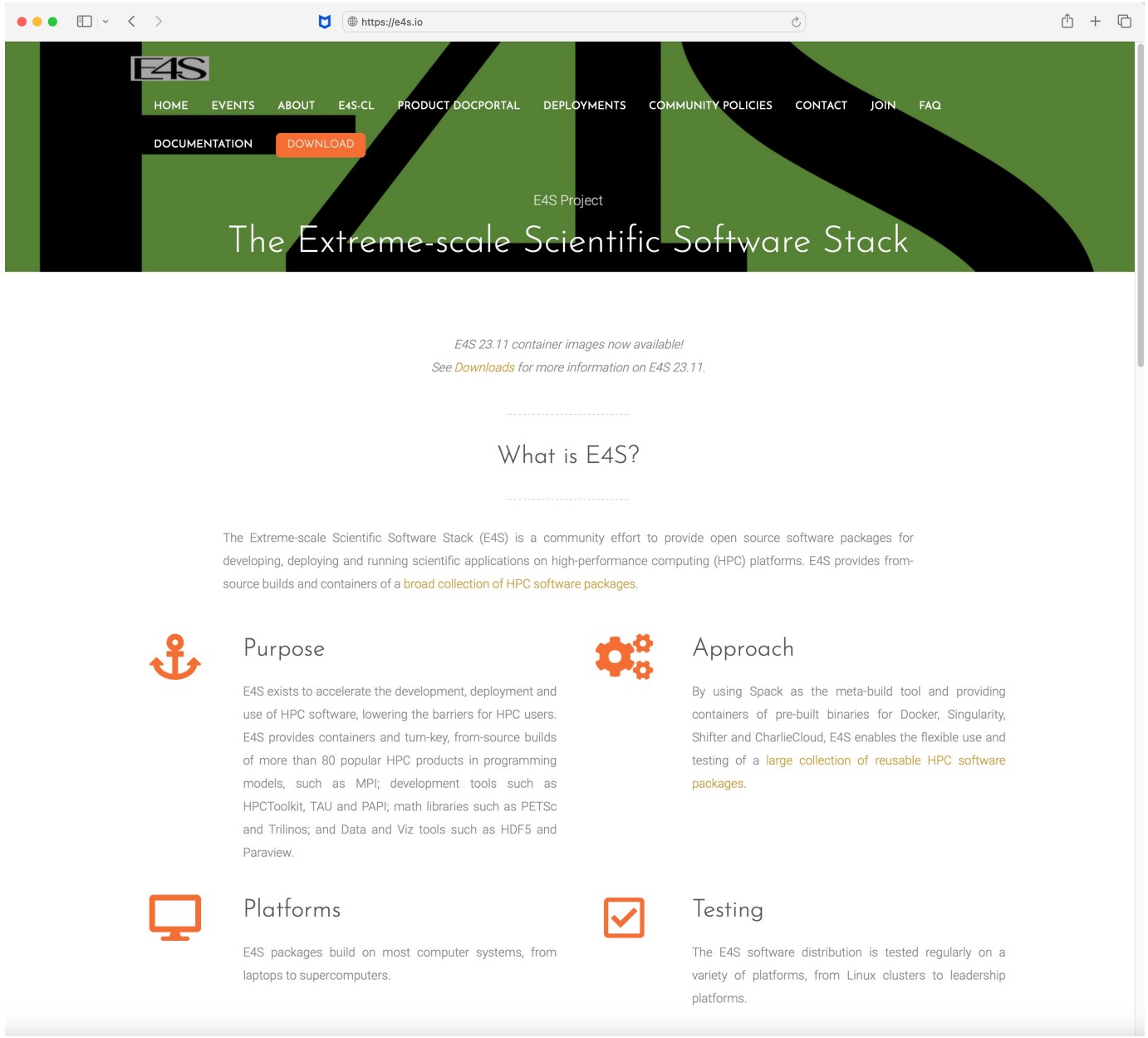
- E4S: HPC Software Ecosystem – a curated software portfolio
- A **Spack-based** distribution of software tested for interoperability and portability to multiple architectures with support for GPUs from NVIDIA, AMD, and Intel in each release
- Available from **source**, **containers**, **cloud, binary 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
- Nov 2023: E4S 23.11 – 120 full release products

https://e4s.io

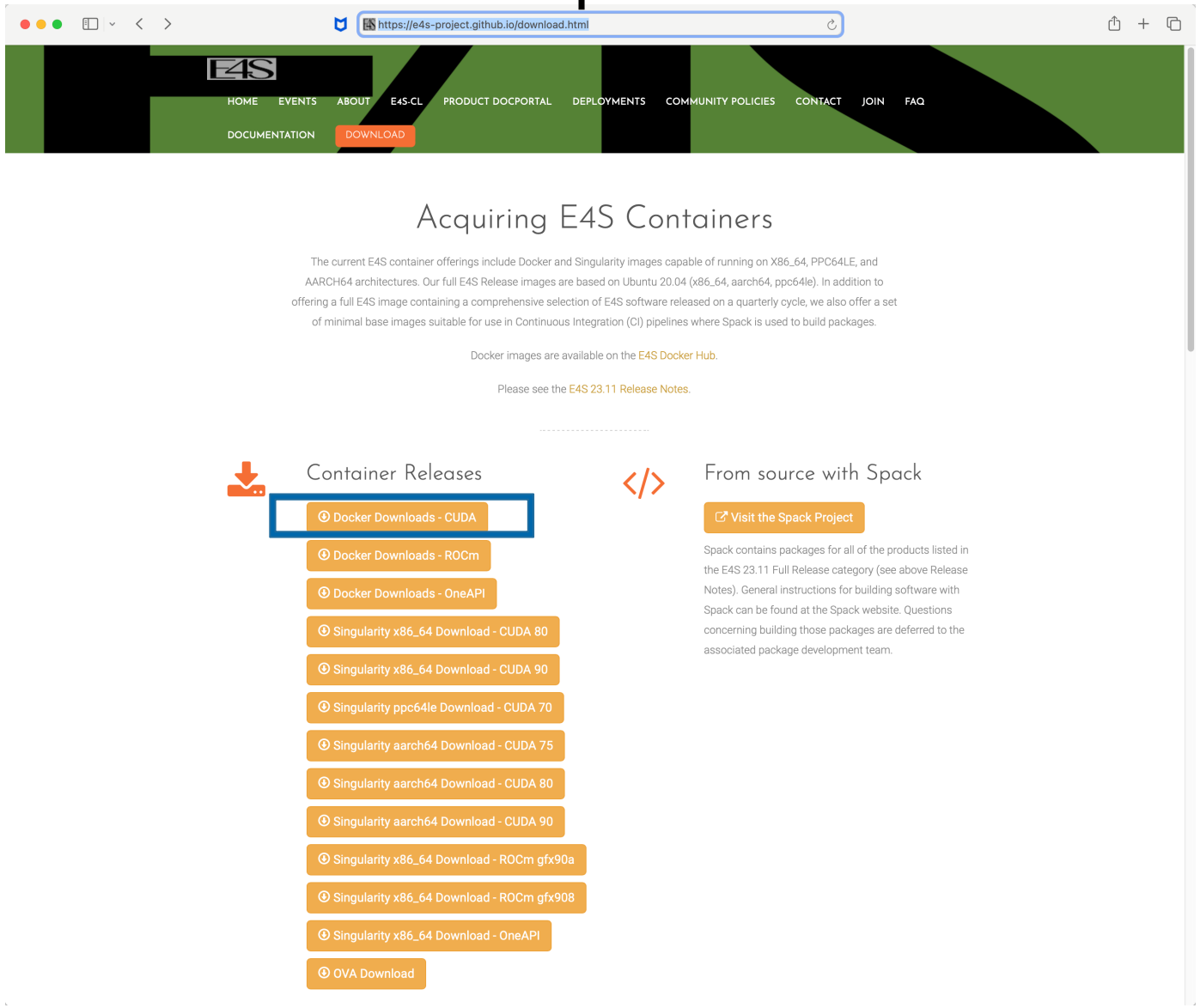
Lead: Sameer Shende
(U Oregon)

Also include other products .e.g.,
AI: JAX, PyTorch, TensorFlow, Horovod, LBANN
Co-Design: AMReX, Cabana, MFEM
EDA: Xyce

E4S Download from https://e4s.io

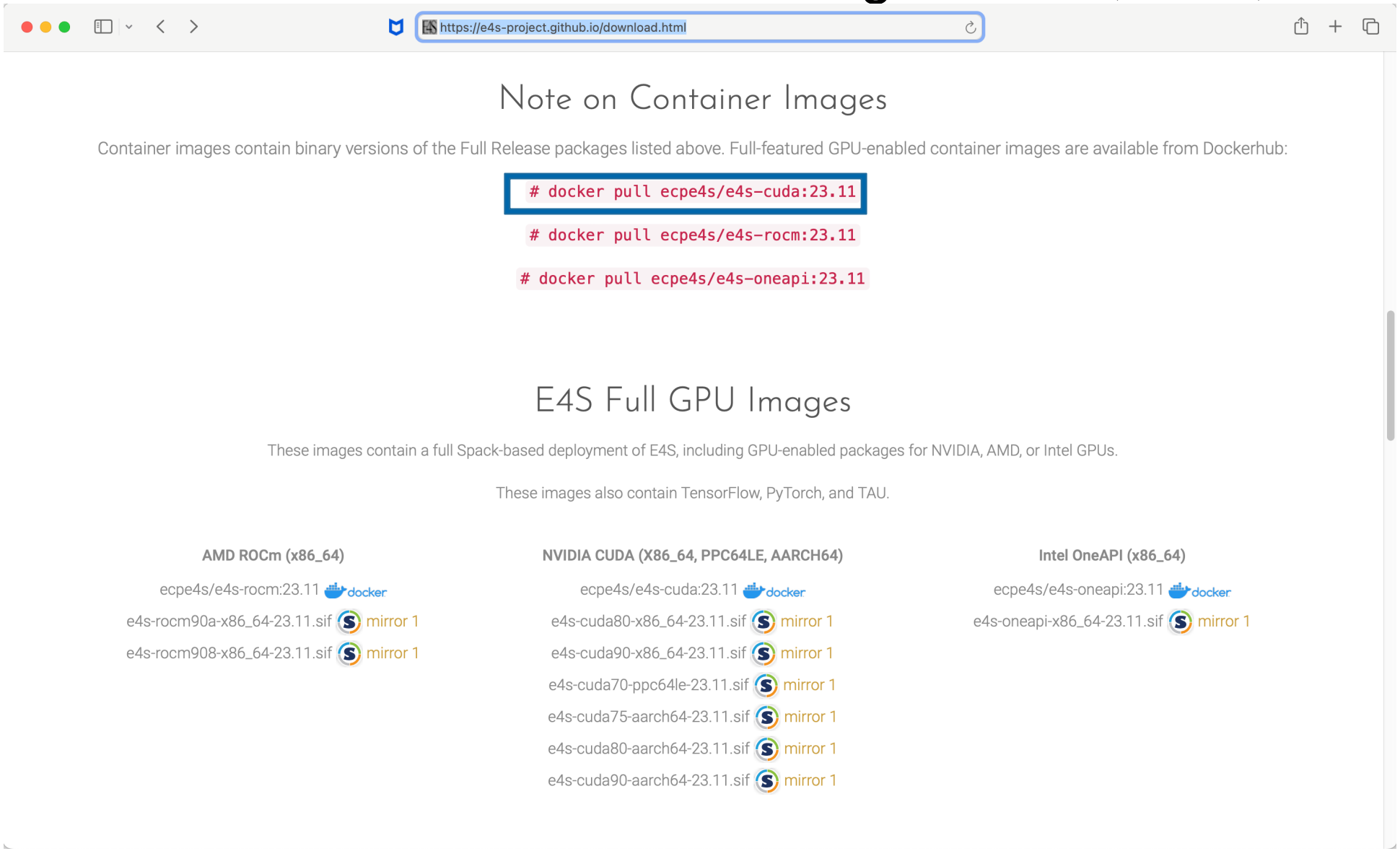


E4S Container Download from https://e4s.io



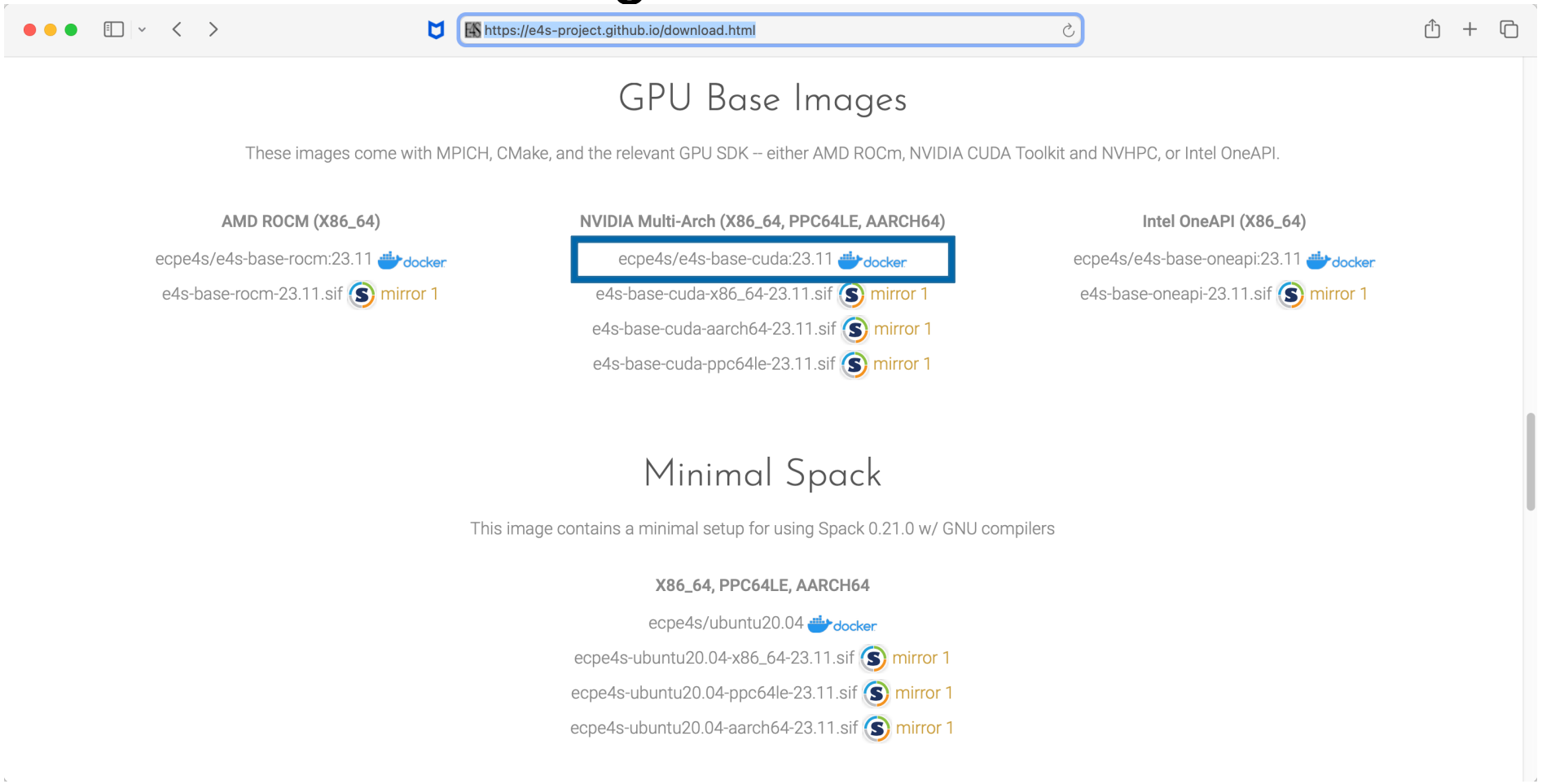
- Separate full featured Singularity images for 3 GPU architectures
- GPU full featured images for
  - x86_64 (Intel, AMD, NVIDIA)
  - ppc64le (NVIDIA)
  - aarch64 (NVIDIA)
- Full featured images available on Dockerhub
- 120+ products on 3 architectures

Download E4S 23.11 GPU Container Images: AMD, Intel, and NVIDIA



https://e4s.io

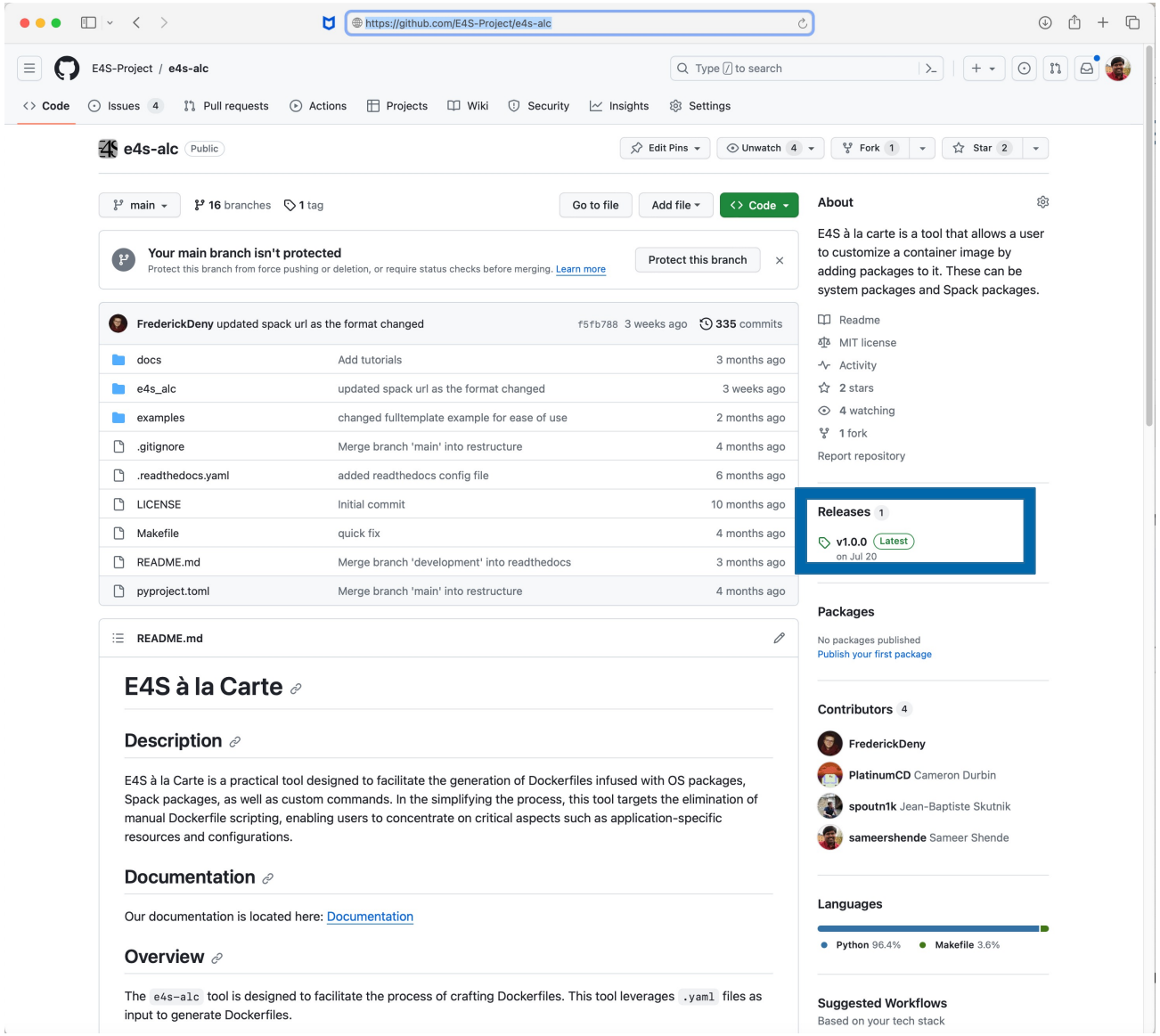
E4S base container images allow users to customize their containers



- Intel oneAPI
- AMD ROCm
- NVIDIA NVHPC and CUDA

https://e4s.io

e4s-alc: a new tool to customize container images. Version 1.0

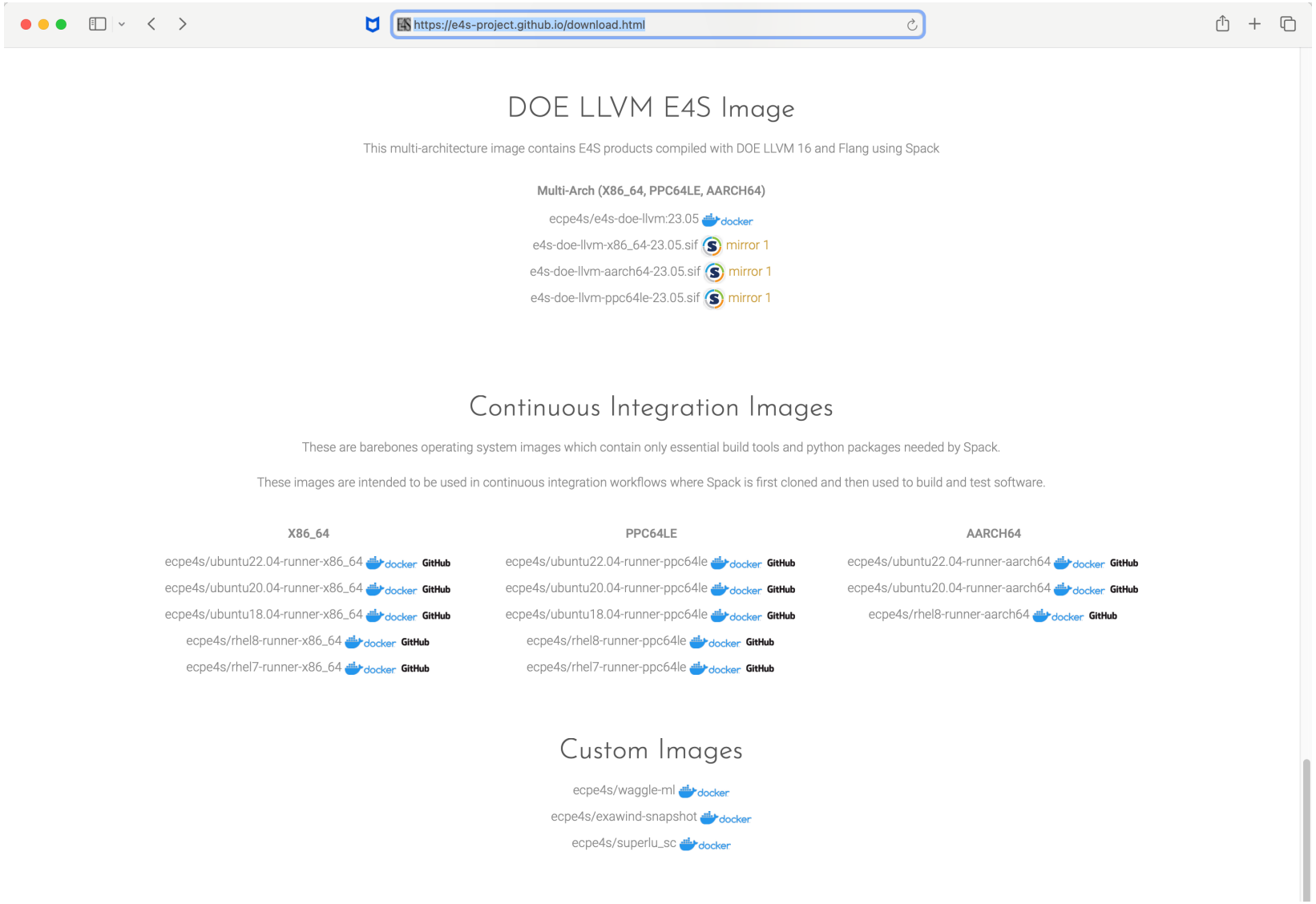


Add to a base image:

- Spack packages
- OS packages
- Tarballs
- Can create a Dockerfile

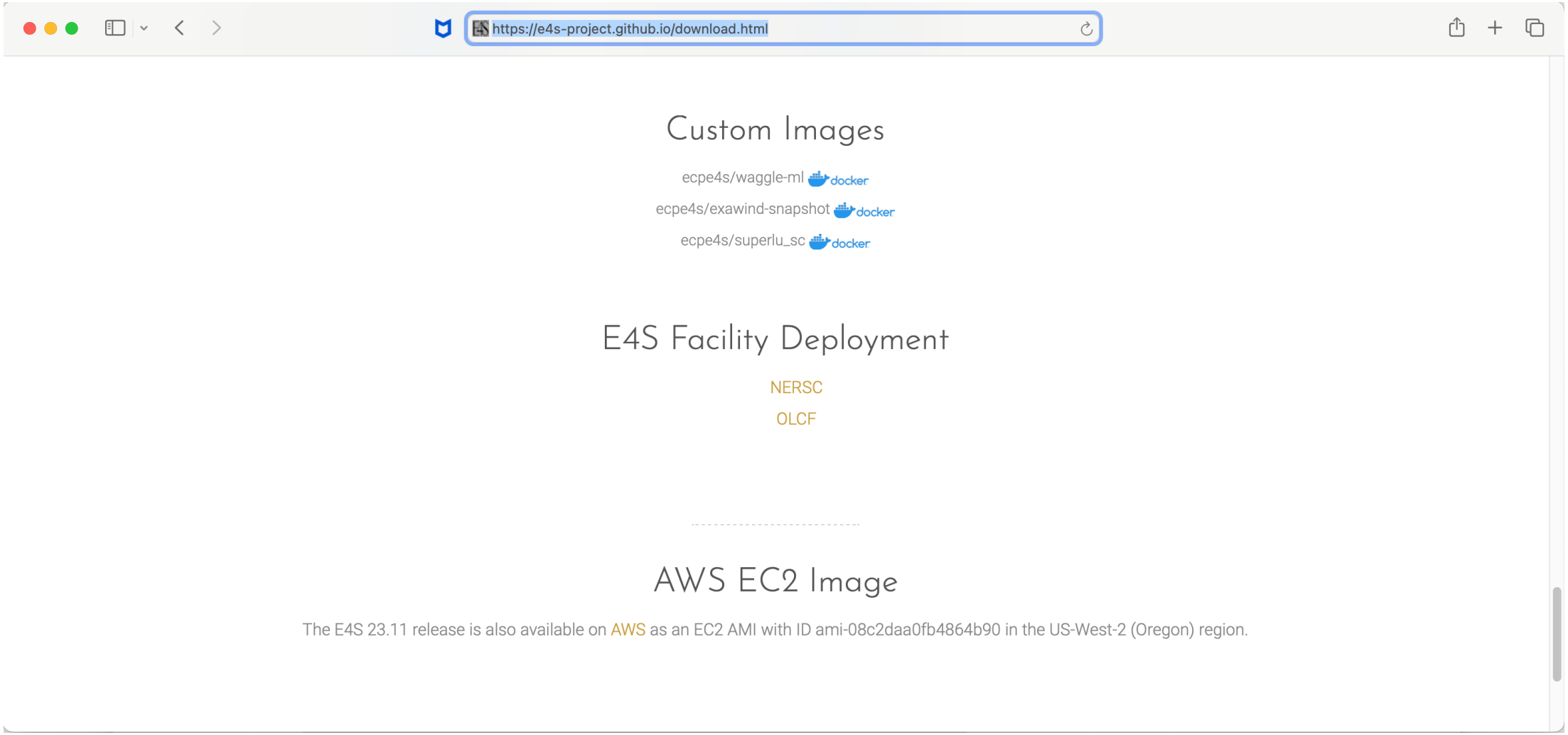
https://github.com/E4S-Project/e4s-alc

E4S DOE LLVM and CI images



https://e4s.io

E4S Facility Deployment and AWS EC2 Image

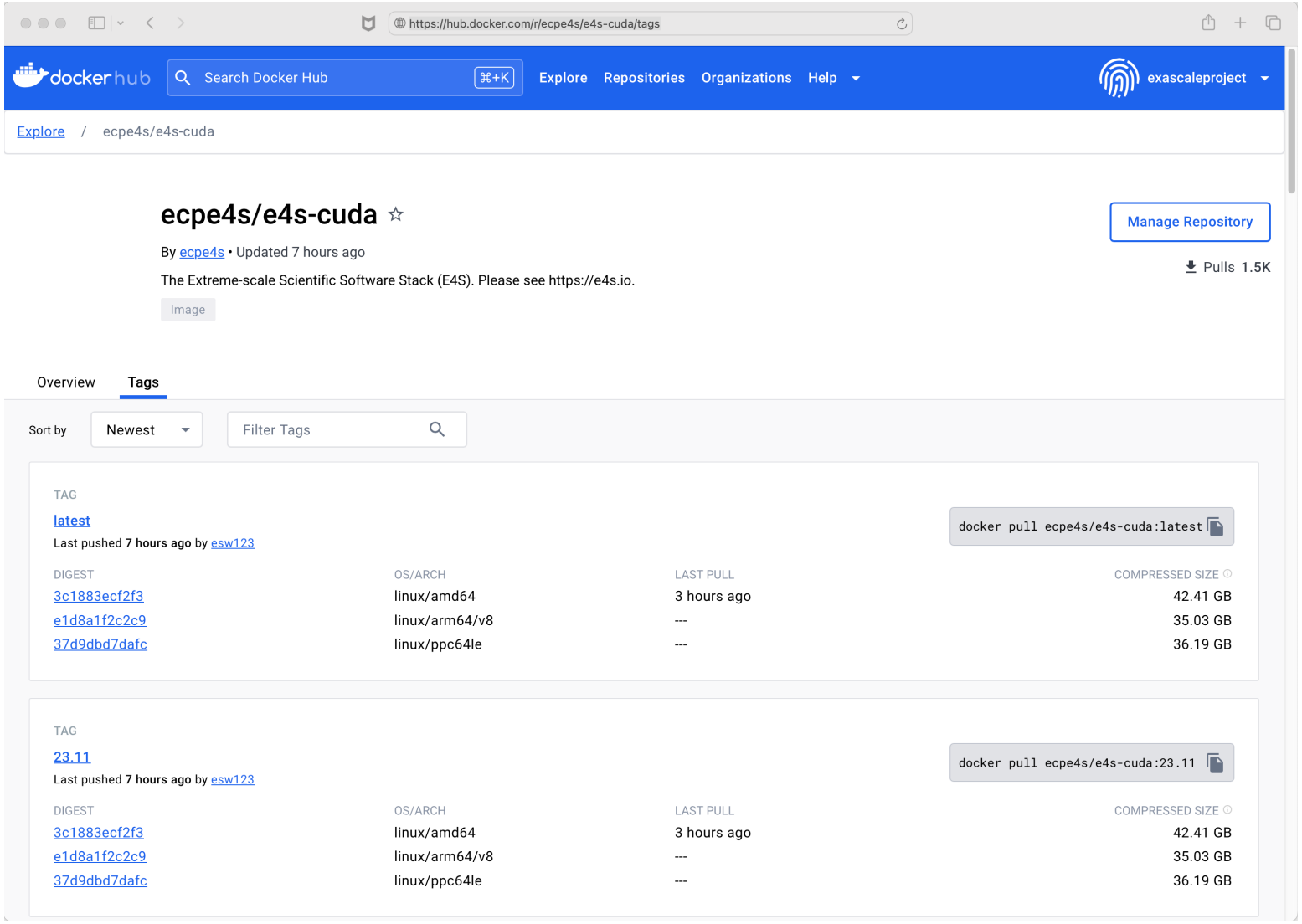


https://e4s.io

E4S 23.11 Detailed Documentation for Bare-metal Installation

https://e4s.io

E4S 23.11 full featured container release on Dockerhub



Architectures:

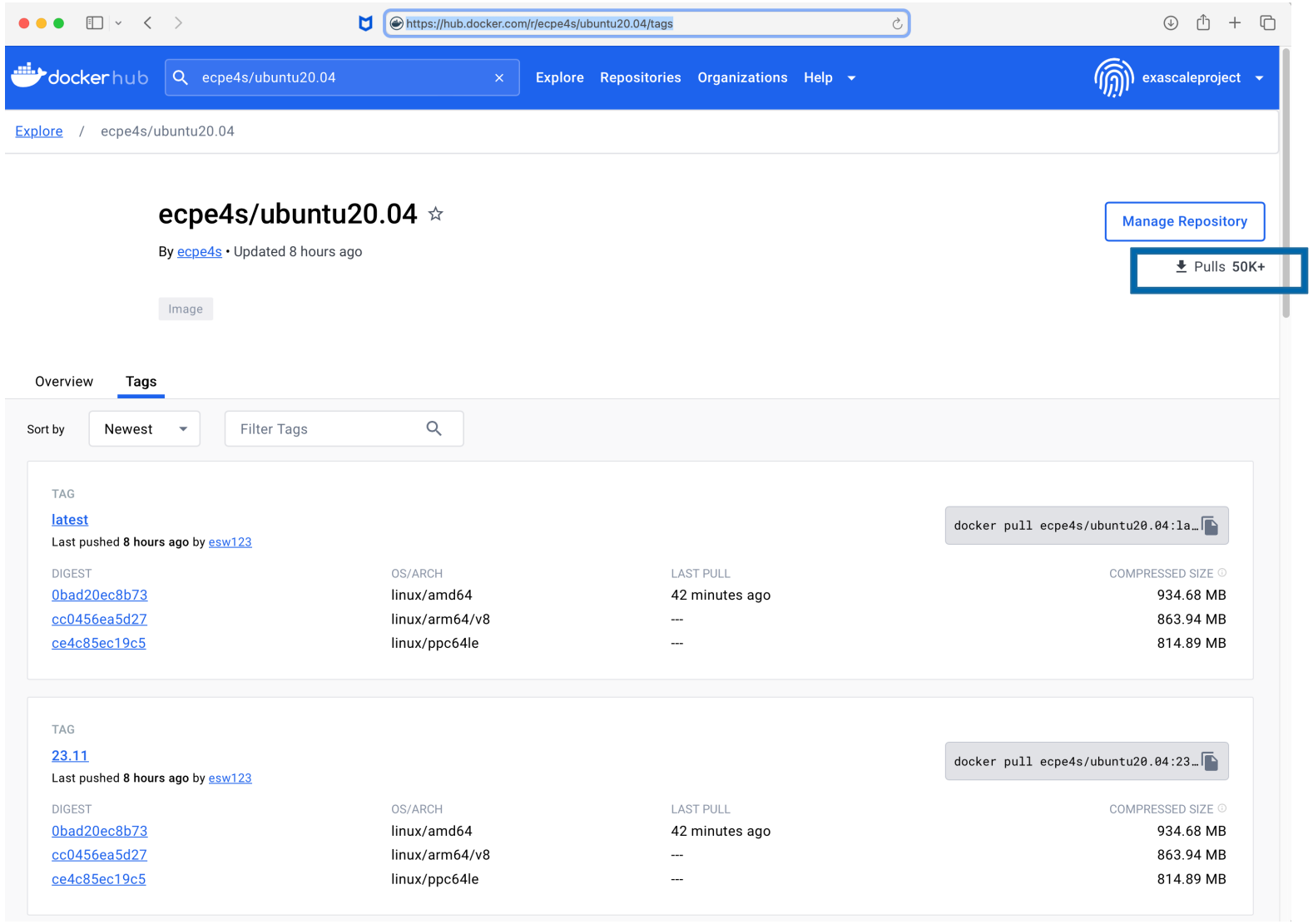
- x86_64
- aarch64
- ppc64le

Software:

- CUDA 12.1
- NVHPC 23.9
- ROCm 5.4.3
- oneAPI 2023.2.1

docker pull ecpe4s/e4s-cuda:23.11

E4S 23.11 base container release on Dockerhub

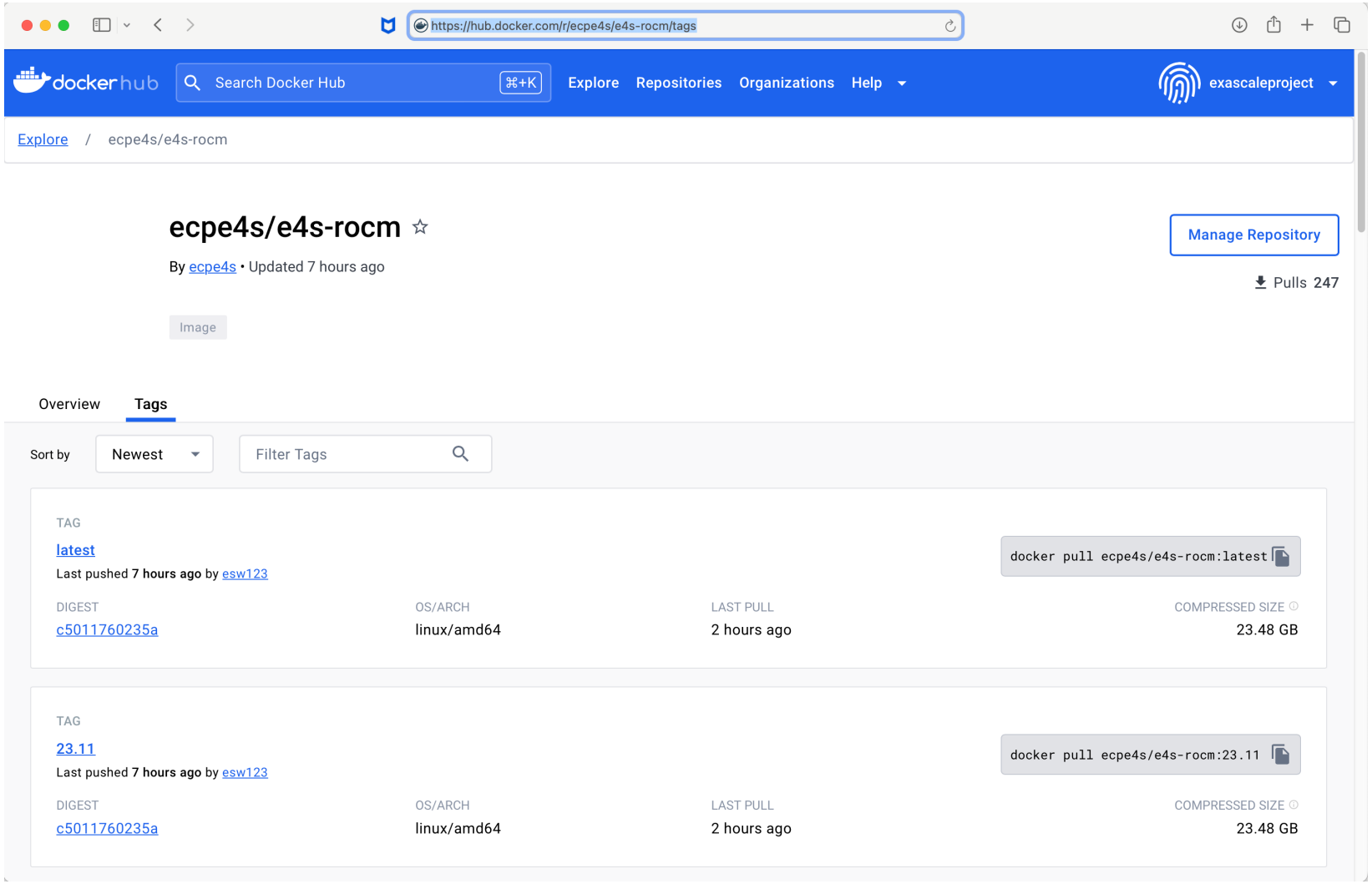


Architectures:

- x86_64
- aarch64
- ppc64le

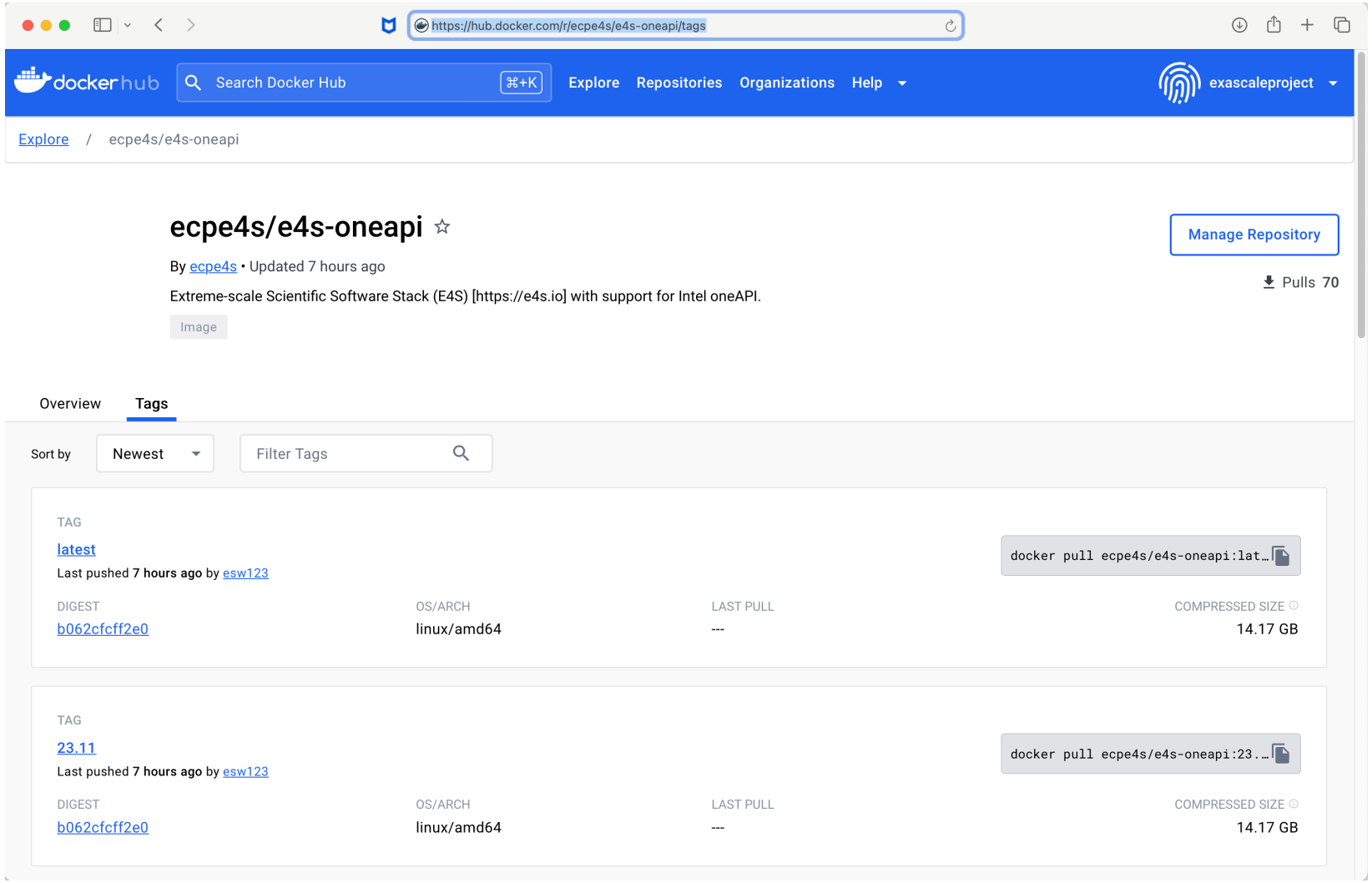
docker pull ecpe4s/ubuntu20.04

E4S 23.11 ROCm release on Dockerhub



docker pull ecpe4s/e4s-rocm:23.11

E4S 23.11 oneAPI release on Dockerhub



docker pull ecpe4s/e4s-oneapi:23.11

23.11 Release: 120+ Official Products + dependencies (gcc, x86_64)

1:	adios2	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/adios2-2.9.1-h3tqinydfwnmwed7n5o2uzqoakswh3f4
2:	alquimia	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/alquimia-1.1.0-onm5kxsvhlbblr6d3fsiegs2itkcdyk6
3:	aml	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/aml-0.2.1-delrfyzv4zumzjmtqdfydpkj2pk6iyze
4:	amrex	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/amrex-23.11-ynz45mrxpgtcxnspkefdaiu4reg2gdbf
5:	arborx	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/arborx-1.4.1-jayemxuy4wy4prvtvdyppjjbpyrsljr4
6:	argobots	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/argobots-1.1-33xjvt4kg6gzf7rvb3wvbegkmepr7of6
7:	ascent	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/ascent-0.9.1-nzcpmyjli4lvxcyom4y7s5rywddm5smh
8:	axom	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/axom-0.8.1-4t3dnemck5tejcklp3o4lozgbfnoz55t
9:	bolt	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/bolt-2.0-gifklfyhev3qvjzdjpilexsn2673plfg
10:	blaspp	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/blaspp-2023.08.25-nfokelfomg5gij2vnnwg3o3bodz75vhn
11:	bricks	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/bricks-2023.08.25-gkcb5rg3hndeo7xfzaolryvremrv3ajz
12:	butterflypack	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/butterflypack-2.4.0-f4ntve4pychsuh37vgl4742wqdm5letd
13:	cabana	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/cabana-0.6.0-t7p2le3r4yc7fnho5r2mp6hf7ggqdyem
14:	caliper	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/caliper-2.10.0-yrlzgojkho3xclwcmms3bvmiswofi5xt
15:	camp	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/camp-2022.10.1-incmpuin7zco4msqjntyiwrvicfheiha
16:	chai	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/chai-2022.03.0-ed3kqfctkdr2ictc2jr7azlz7rrdppwm
17:	charliecloud	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/charliecloud-0.34-ajmjxvqswluur4kju6376qyvk6fzosbd
18:	conduit	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/conduit-0.8.8-mdocwtkxzv46ruro32vacndjx4d5j6w6
19:	cusz	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/cusz-0.3.1-ntdhlqma2az44zpifdifycpi5r4isgzh
20:	darshan-runtime	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/darshan-runtime-3.4.4-npeaexztv4quv34mwyttf5smcn7bsp7b
21:	datatransferkit	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/datatransferkit-3.1.1-olylqich3xnxh6awwdsccs32s53ur7jd
22:	dealii	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/dealii-9.4.2-grhwhrhmhjhpqvvjpv7zbsxyueqbth44
23:	dyninst	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/dyninst-12.3.0-jpq4nsumxkdadyt5u7nzjum6dudrpic2
24:	ecp-data-vis-sdk	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/ecp-data-vis-sdk-1.0-cwsup4pwcyyvkunjlzrmyng27onzwo2z
25:	exago	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/exago-1.6.0-o6t23yyyiteoboyfsh5g7eppzoamas4l
26:	exaworks	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/exaworks-0.1.0-jmluakqyvfsobcg24quhxii5w7iul7my
27:	faodel	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/faodel-1.2108.1-ouhu6kdibo76dvf6rahuebmvowajia6l
28:	flecsi	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/flecsi-2.2.1-dzlu665k7kyjz5f6bilrdwrlcwjyja3c
29:	flit	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/flit-2.1.0-e7rg7rydnglbgvdzkal2iw74yxrmupvl
30:	flux-core	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/flux-core-0.55.0-hd6lzkme6z7yri7dbbp7bgbxg3fqqo7q
31:	flux-sched	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/flux-sched-0.28.0-k55ozusl77ellybb6ag2hh6qidxka3x5
32:	fortrilinos	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/fortrilinos-2.3.0-g66oaatp465tj2sd6lfm45dnai76mtpl
33:	gasnet	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/gasnet-2023.3.0-uipqxqhwzlqwpirm5rtakhmdd6tfjs57
34:	ginkgo	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/ginkgo-1.6.0-fpzzfp4a2jlfxmmm2my5qo36yeesunsl
35:	globalarrays	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/globalarrays-5.8.2-ykwomjrt6qqqmh7fbxcflrzbz26ghetv
36:	gotcha	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/gotcha-1.0.4-z7rm5dm3rxaw3kn2g573b2zpfz5wgtml
37:	gptune	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/gptune-4.0.0-q72dvdlmmovb5z2zbimhtwoznaeokkih
38:	h5bench	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/h5bench-1.4-v3guhc5jqmeuecycyadxczkze3ypbzaq
39:	hdf5	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hdf5-1.14.3-e3o7l3maue5q7dlnqy5vzp3rustrvpr2
40:	hdf5-vol-async	/spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hdf5-vol-async-1.7-xsnl4lew66itjrvdotgaxa6zv4wdrq7i

GPU runtimes

- AMD (ROCm)
  - 5.4.3
- NVIDIA (CUDA)
  - 12.1
- NVHPC
  - 23.9
- Intel oneAPI
  - 2023.2.1

23.11 Release: 120+ Official Products + dependencies (gcc, x86_64)

```
 41:  hdf5-vol-cache     /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hdf5-vol-cache-v1.1-o3ithsfbdfljikub2zdcskksdeuy5kkf
 42:  hdf5-vol-log       /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hdf5-vol-log-1.4.0-o2rafleuxj37eicnfo76vdm4yj4mayqd
 43:  heffte             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/heffte-2.4.0-zotcawyumj6w7x7x6ct5kk7t23kekspa
 44:  hpctoolkit         /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hpctoolkit-2023.08.1-ucnnmn7akxaa2xtqxocpo2mfy226yuv4
 45:  hpx                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hpx-1.9.1-w6m4c5isyl5bhrckbz6vgjkjhhvvdkcb
 46:  hypre              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/hypre-2.29.0-wptbvnvsuwpwjwurazz4byh4lz23gzuw
 47:  kokkos             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/kokkos-4.1.00-s3ooieibw7drk2ilou7sk3c3ogknpsvk
 48:  kokkos-kernels     /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/kokkos-kernels-4.0.00-gfjkpx65e5hcxoz7spmmcftm32l2lxkq
 49:  lammps             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/lammps-20230802-cfhvdnk46vzhav5vsmfvkyornuas4aq6
 50:  lapackpp           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/lapackpp-2023.08.25-3ca5zqvkj5xt7oknexpwyz5y4yarljfj
 51:  lbann              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/lbann-0.102-agv4zilw6voj4qwvynsx3eamp5tbnvng
 52:  legion             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/legion-23.06.0-ucrcoi4asmrbzbieat5ecprkfuthnei5
 53:  libcatalyst        /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/libcatalyst-2.0.0-rc4-22k754cwrbctvx6p74wjx3sqgeygibim
 54:  libnrm             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/libnrm-0.1.0-womilym3lmofvrdnp3m3iula6w2ejk4s
 55:  libpressio         /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/libpressio-0.95.1-nxihpzujdjvmqy3mh7ebc7jvbbl6symr
 56:  libquo             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/libquo-1.3.1-fmjil6uktvm7yadvjhd7s6z5l63brd2l
 57:  loki               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/loki-0.1.7-k7aot6cukc7fmeesvrzc5loq7tnjve5i
 58:  magma              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/magma-2.7.2-tufynjoedccdmuigslyzl7ulh44asxw2
 59:  mercury            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/mercury-2.3.1-pquyes2nsmqdq2dsrkcipvswvzvzhrgs
 60:  metall             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/metall-0.25-5hmjjral2hw5jnrmflhcbonvc5ix4jno
 61:  mfem               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/mfem-4.6.0-utldtctkh4uvfsusz5bhvugdr3pygdwe
 62:  mgard              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/mgard-2023-03-31-mionudselpx77meu4nm5wru7bog72z6q
 63:  mpark-variant      /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/mpark-variant-1.4.0-26er7ysumy4mc4kfmlompldgqpzw6fqv
 64:  mpich              /usr/local/mpich/install/mpich
 65:  mpifileutils       /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/mpifileutils-0.11.1-w33ilbeharizb3gfm7hkfv2q7imi7nje
 66:  nccmp              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/nccmp-1.9.1.0-3ilq5orjgpngkw3kl4crijy2mazqid6t
 67:  nco                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/nco-5.1.6-5zpx2ovgcrcaghha3uzqemrhmdl33kpq
 68:  netlib-scalapack   /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/netlib-scalapack-2.2.0-wk2wwukluwd7dpfiiu646l4i4bxdzwof
 69:  nrm                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/nrm-0.1.0-45g5mkvg4tpnxbtgksniz5fxf3mga5gn
 70:  omega-h            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/omega-h-9.34.13-lrulaqaxewfrbndrqbr6w2zeoo3qi6hz
 71:  openfoam           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/openfoam-2306-5rka2iigdbmy2d4zakyqntbhffb6jd5v
 72:  openmpi            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/openmpi-4.1.6-md4en5vmcqapt2z6iovgnfy3q33gu5f7
 73:  openpmd-api        /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/openpmd-api-0.15.2-u44qz4uaxqsjndzzkvdryvldzfkrxd64
 74:  papi               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/papi-6.0.0.1-72nk6zo54sjuosphlcmnwwwp5ttnlmbc
 75:  papyrus            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/papyrus-1.0.2-bd5qf5sfylujs6h3n7ejmjom2s6cmi6d
 76:  parallel-netcdf    /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/parallel-netcdf-1.12.3-buziznjbttqmvba5p4jfdauqpcexyylq
 77:  paraview           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/paraview-5.11.2-o4kqt5fg2o2g37tbwbelqjsrfjka3b27
 78:  parsec             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/parsec-3.0.2209-znyscwz6oa5vstw7x4ha7q3hjgayuwwy
 79:  pdt                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/pdt-3.25.1-ffhis4ch5zibi4vsgw7zygettdi5hkp3
 80:  petsc              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/petsc-3.20.1-b3vxtygpg4u6yll4bnfgv2bt7c5e4l76
```

EXASCALE COMPUTING PROJECT

23.11 Release: 120+ Official Products + dependencies (gcc, x86_64)

```
  81:  phist              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/phist-1.12.0-d75fvxutgfrls4bafazdzhybgkqxiopj
  82:  plasma             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/plasma-23.8.2-mrkwv4hbppmrpyla2hatas33zbbkgcxd
  83:  plumed             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/plumed-2.9.0-ffjtdwfp3jk3vnt3wx7g4brcbr3gles2
  84:  precice            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/precice-2.5.0-7x6rriuavukwzbzg2ugizyjghsirx6ha
  85:  pruners-ninja      /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/pruners-ninja-1.0.1-zaclredzria7t7md6rqr7ju5cqe3yoql
  86:  pumi               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/pumi-2.2.8-s7yku5wnpf34apqt7qzbh32po4apat57
  87:  py-cinemasci       /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/py-cinemasci-1.3-4cfdtca3lv4eimmf43sncdgl4srfdwlx
  88:  py-jupyterhub      /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/py-jupyterhub-1.4.1-fu7sfoxiihvikdcvkniavkhsl7iknl6d
  89:  py-libensemble     /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/py-libensemble-1.0.0-7xl3reeelev54lw76xk7c2o5z7zy5dgh
  90:  py-parsl           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/py-parsl-2023.08.21-lrrwng4d6sl2wdi73k56rx6za7zhctin
  91:  py-radical-saga    /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/py-radical-saga-1.20.0-opcx7gnnn2tkjw7sbpnxnhbufjz2am3i
  92:  qthreads           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/qthreads-1.18-z7gy4texq5n7viuezu2yslfvua47mrou
  93:  quantum-espresso   /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/quantum-espresso-7.2-6rdjedntmcko2oxu7wakcdcrxh2zx3ie
  94:  raja               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/raja-2022.10.4-f62ixftvvlwygnuw7h3k3mle77l3pwqj
  95:  rempi              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/rempi-1.1.0-w3s4auqcmjuhk4nezr24zppowhoxu6dv
  96:  scr                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/scr-3.0.1-ngtxi6tk5v6eswxthsgq54ilk26mg7bf
  97:  slate              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/slate-2023.08.25-v27dzgdzblfzrbgg7qux5u3odjdp2tq5
  98:  slepc              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/slepc-3.20.0-4u3mo7glxond4wsxod7iimlwk77p2yns
  99:  stc                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/stc-0.9.0-tezaek7xix4c3fp4mwzpeebs27dfcpd3
 100:  strumpack          /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/strumpack-7.2.0-vaaywamkyrq3ejic6bieored6yyphy77
 101:  sundials           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/sundials-6.6.1-7pm7jket35co5lcxctqkksuamhd45n5g
 102:  superlu-dist       /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/superlu-dist-8.1.2-b7owlntmfzxc7rhuzzzrw2olng43idfh
 103:  swig               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/swig-4.1.1-aqoiv4uwzt77yyjnvl4e36d5fqcbecag
 104:  sz3                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/sz3-3.1.7-we6faorx6wtdbij24boo3e6j4cgi4ixu
 105:  tasmanian          /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/tasmanian-8.0-pdayiop7j3c2qcbqvcnhj6k2tnbzyyg7
 106:  tau                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/tau-2.33-su4wnkcus3amzrbsa35s5duaw52rkuvh
 107:  trilinos           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/trilinos-14.4.0-vlnbznuxihnf7wx5vf2rzhva6af5cnnw
 108:  turbine            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/turbine-1.3.0-fvdnkaskt2weryvuzprcs3kxmn72cixm
 109:  umap               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/umap-2.1.0-j7nwvki6jddng6lxkvefw7d5remhp5hr
 110:  umpire             /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/umpire-2022.10.0-izloaumfivkrpw22es2xijlk3jtozcd2
 111:  unifyfs            /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/unifyfs-1.1-uovx3pyemkcfbohtndj6zoe77lkw44iu
 112:  upcxx              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/upcxx-2023.3.0-gjih3of4wpttybtbbpjkkmtm2zbqi6r4
 113:  variorum           /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/variorum-0.7.0-ch6jjcqiihsxvlmlghmazjkl6sievbz3
 114:  veloc              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/veloc-1.7-s26qya7dfrooqpcjgqs6v6jta6bqpk34
 115:  visit              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/visit-3.3.3-pbu6q4bs22pr3hhyh6l4dz5eqv5rc4hx
 116:  vtk-m              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/vtk-m-2.0.0-qphfufzsli67k3qop4ssbzdpzvnavjco
 117:  wannier90          /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/wannier90-3.1.0-nupc7qg4e2opiv7axj4octzfwklcnxot
 118:  warpx              /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/warpx-23.08-2a3phdnxo53nc4v3cgiazb4j7kaa7yvt
 119:  xyce               /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/xyce-7.7.0-cs66kshjz4pwu43vkpor652jixasazoa
 120:  zfp                /spack/opt/spack/linux-ubuntu20.04-x86_64/gcc-11.4.0/zfp-1.0.0-6fg3luiw5e6sudjjsudczx2irdyl3teb
```

Languages:

- Julia with support for MPI, and CUDA
- Python

AI products with GPU support

- Tensorflow
- Pytorch
- JAX
- Horovod

EDA Tools:

- Xyce

3D Visualization

- Paraview
- VisIt
- TAU's paraprof
- Jupyter notebook …

E4S Support for AI/ML frameworks with NVIDIA GPUs

```
$ singularity run --nv e4s-cuda90-x86_64-23.11.sif
Singularity> python
Python 3.8.10 (default, May 26 2023, 14:05:08)
[GCC 9.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import tensorflow
>>> tensorflow.__version__
'2.12.0'
>>> import torch
>>> torch.__version__
'2.0.0'
>>> import jax
>>> jax.__version__
'0.4.13'
>>> import horovod
>>> horovod.__version__
'0.28.1'
>>> torch.cuda.get_device_name(0)
'NVIDIA H100 PCIe'
>>> print(torch.cuda.get_arch_list())
['sm_35', 'sm_70', 'sm_75', 'sm_80', 'sm_90']
>>>
```

E4S 23.11 supports NVIDIA H100 GPUs with TensorFlow 2.12.0 and PyTorch 2.0.0

E4S 23.11 Support for GPUs: NVIDIA

```
Singularity> spack find +cuda
-- linux-ubuntu20.04-x86_64 / gcc@11.4.0 ------------------------
adios2@2.9.1        dealii@9.4.2          hypre@2.29.0           nvcomp@2.2.0       strumpack@7.2.0
amrex@23.11         ecp-data-vis-sdk@1.0  kokkos@4.0.00          omega-h@9.34.13    sundials@6.6.1
arborx@1.4.1        exago@1.6.0           kokkos@4.1.00          papi@6.0.0.1       superlu-dist@8.1.2
blaspp@2023.08.25   flecsi@2.2.1          kokkos@4.1.00          paraview@5.11.2    tasmanian@8.0
bricks@2023.08.25   flux-core@0.55.0      kokkos-kernels@4.0.00  parsec@3.0.2209    tau@2.33
cabana@0.6.0        ginkgo@1.6.0          lammps@20230802        petsc@3.20.1       trilinos@14.4.0
caliper@2.10.0      gloo@2023-05-19       lapackpp@2023.08.25    petsc@3.20.1       umpire@6.0.0
camp@0.2.3          heffte@2.4.0          legion@23.06.0         py-torch@2.1.0     umpire@2022.10.0
camp@2022.10.1      hiop@1.0.0            libpressio@0.95.1      raja@0.14.0        upcxx@2023.3.0
camp@2022.10.1      hpctoolkit@2023.08.1  magma@2.7.2            raja@2022.10.4     vtk-m@2.0.0
chai@2022.03.0      hpx@1.9.1             mfem@4.6.0             slate@2023.08.25   zfp@0.5.5
cusz@0.3.1          hwloc@2.9.1           mgard@2023-03-31       slepc@3.20.0
==> 59 installed packages
```

E4S 23.11 Support for GPUs: AMD

```
Singularity> spack find +rocm
-- linux-ubuntu20.04-x86_64 / gcc@11.4.0 ------------------------
amrex@23.11              exago@1.6.0       hipsolver@5.4.3        magma@2.7.2         sundials@6.6.1
arborx@1.4.1             gasnet@2023.3.0   hipsparse@5.4.3        mfem@4.6.0          superlu-dist@8.1.2
blaspp@2023.08.25        ginkgo@1.6.0      hpctoolkit@2023.08.1   paraview@5.11.2     tasmanian@8.0
cabana@0.6.0             heffte@2.4.0      hpx@1.9.1              petsc@3.20.1        tau@2.33
caliper@2.10.0           hiop@1.0.0        hypre@2.29.0           raja@0.14.0         trilinos@14.4.0
camp@0.2.3               hip@5.4.3         kokkos@3.7.01          raja@2022.10.4      umpire@6.0.0
camp@2022.10.1           hipblas@5.4.3     kokkos@4.1.00          slate@2023.08.25    umpire@2022.10.0
chai@2022.03.0           hipfft@5.4.3      lapackpp@2023.08.25    slepc@3.20.0        upcxx@2023.3.0
ecp-data-vis-sdk@1.0     hiprand@5.4.3     legion@23.06.0         strumpack@7.2.0     vtk-m@2.0.0
==> 45 installed packages
```

E4S 23.11 Support for GPUs: Intel

```
Singularity> H1=$(spack find --format /{hash} +level_zero)
Singularity> H2=$(spack find --format /{hash} +sycl)
Singularity> spack find $H1 $H2
-- linux-ubuntu22.04-x86_64 / oneapi@2023.2.1 --------------------
amrex@23.11   blaspp@2023.08.25  kokkos@4.0.00  kokkos@4.1.00        petsc@3.20.1      sundials@6.6.1
arborx@1.4.1  cabana@0.6.0       kokkos@4.0.00  lapackpp@2023.08.25  slate@2023.08.25  tau@2.33
==> 12 installed packages
Singularity>
```

Use of Intel oneAPI BaseKit and HPCToolkit is subject to acceptance of Intel EULA by the user

23.11 Release: 120+ Official Products + dependencies (gcc, ppc64le)

```
  1: adios2                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/adios2-2.9.1-ihpdzy4dsqrwh7jz7cv4nnht2woncjgd
  2: alquimia              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/alquimia-1.1.0-fsdfwpg7gwg4r773eee5s6j5lpdjksfe
  3: aml                   /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/aml-0.2.1-4uo5m3ex3zgt7osm5cd25syty43d6iaf
  4: amrex                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/amrex-23.11-muif6apkte7iht2fa4qj2rkftndrv2tw
  5: arborx                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/arborx-1.4.1-3sk3esse5cgnblyprb7kaesyszy4azpn
  6: argobots              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/argobots-1.1-ip5ldsfywkffr6mfchrpai5kak2znaht
  7: ascent                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/ascent-0.9.1-4rpesskqcim7kxvy6ejjehrny34lyrkb
  8: axom                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/axom-0.8.1-3mchzrgofobr74n7adxldxkdbyfnwyek
  9: blaspp                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/blaspp-2023.08.25-6xwxtyrqpzbrwa5kqwdo7vgui6kkdaf3
 10: bolt                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/bolt-2.0-xq7q5476o6ffoixuudd2h7hsucba5vle
 11: bricks                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/bricks-2023.08.25-5pil4ub5e3cw77n64shxbpn4r3fiu54h
 12: butterflypack         /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/butterflypack-2.4.0-ztlgxwffmbhkpxbl642mddwaqtoinoum
 13: cabana                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/cabana-0.6.0-etpdjbqaow3w74eh2tsxfhk4omjpm2qa
 14: caliper               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/caliper-2.10.0-rp6dot6ed4qwrzor5pr7q2qdp2l7i47i
 15: camp                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/camp-2022.10.1-nb6dssbn4lmdxjaqu5povmzomrwhss7b
 16: chai                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/chai-2022.03.0-25vuj3egmq5naj7hg7h2kij6cddwgv43
 17: charliecloud          /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/charliecloud-0.34-fbooueqk7fwjiglm2ldwi4jkgua5ldsx
 18: conduit               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/conduit-0.8.8-p4ajqe2l2bazvyiocer43c2ecetikmoj
 19: darshan-runtime       /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/darshan-runtime-3.4.4-is26455r2gn7vmqxlcoqopgd32pilqhh
 20: datatransferkit       /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/datatransferkit-3.1.1-4yehenigkjqmqwai6qunxgjar5gurixt
 21: dyninst               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/dyninst-12.3.0-gwhlxsuoxinwz2nv6qsieh3czg5iv75c
 22: ecp-data-vis-sdk      /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/ecp-data-vis-sdk-1.0-ezt6wvqjrlectlfx2suplxmoarxlfdub
 23: exago                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/exago-1.6.0-fom5b762f3wpjx62nyv5ghsnlp6euvud
 24: exaworks              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/exaworks-0.1.0-74fvnc4jvpcer2n5a3txwoxipafghehx
 25: faodel                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/faodel-1.2108.1-jum3idkeyjgdcmpbtsbiwyfy62tchrxc
 26: flecsi                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/flecsi-2.2.1-ll5al4sxjxllp5wxmmftgw5yac5uezfy
 27: flit                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/flit-2.1.0-s6s4re6ouy7xjh526jz5vjdk3ye4yvdc
 28: flux-core             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/flux-core-0.55.0-uacox6eqswawy73qdft3gnz2a4i2vy56
 29: flux-sched            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/flux-sched-0.28.0-au2cj2blfeoudttsybp5lvlyryfklge7
 30: fortrilinos           /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/fortrilinos-2.3.0-77ggkxmajgcn5ohtsrfunonnmm7g5c5i
 31: gasnet                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/gasnet-2023.3.0-r2ixqqbifetxotbdrok4xmkeizsb3zy4
 32: ginkgo                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/ginkgo-1.6.0-qqevqtav375scruxy53obmkfvt2ejinj
 33: globalarrays          /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/globalarrays-5.8.2-vmnny2lpx7i2cyoew35bb37iz7qtahlp
 34: gotcha                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/gotcha-1.0.4-lvpeg277suxpjvyaprwa3vijksbe6iq4
 35: gptune                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/gptune-4.0.0-woqutsjkz7dsd3gmki7vd7qp7ia543xl
 36: h5bench               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/h5bench-1.4-yso2n36h6w73mijm2dqkxexy4o37ykke
 37: hdf5                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hdf5-1.14.3-ldmeyuivxhhulrvcsxsbpjn5thcq3nlt
 38: hdf5-vol-async        /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hdf5-vol-async-1.7-pztbuunl3kd3jozq64dvjtzkayfj6qik
 39: hdf5-vol-cache        /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hdf5-vol-cache-v1.1-umtyv6b2mm2tjnkkyfzd56kmgffcbcem
 40: hdf5-vol-log          /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hdf5-vol-log-1.4.0-qjvsniaxpzdr47i5fs2ewabvzpxpyxhp
```

GPU runtimes for IBM Power
- CUDA 12.2
- NVHPC 23.9

Languages
- Julia with MPI and CUDA
- Python

EDA Tools
- Xyce

CFD Tools
- OpenFOAM

AI packages for NVIDIA GPU
- TensorFlow
- PyTorch
- LBANN

23.11 Release: 120+ Official Products + dependencies (gcc, ppc64le)

```
41:  heffte              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/heffte-2.4.0-5yjaxnerbmvwzyjycnkna7dm6p5srqv2
42:  hiop                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hiop-1.0.0-gjxeaaxnby4nj4gy6hkhmaipths6rm64
43:  hpctoolkit          /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hpctoolkit-2023.08.1-5ya42md6zqawbfthk3sof3vvqrweblmk
44:  hpx                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hpx-1.9.1-tmndtkm5kv7skzuog4oy6aea6v2cten3
45:  hypre               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/hypre-2.29.0-xafpu6ka5poq2metwdeb3w357mqpcfbl
46:  kokkos              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/kokkos-4.1.00-mdwjeji6t5hmcoecaob3ll7e5on4hbwc
47:  kokkos-kernels      /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/kokkos-kernels-4.0.00-nfzxte7sjifsmn4kmy6uf37556j2557i
48:  lammps              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/lammps-20230802-xjtlwkptplhclcoqvaqbwyesatid6tkl
49:  lapackpp            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/lapackpp-2023.08.25-d66jpyjk2rvmro4yffor5awnwdrd3ih5
50:  lbann               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/lbann-0.102-4pgfuox3kwgntrfafys7zau6l7bjcq2k
51:  legion              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/legion-23.06.0-v6kg226wal2bgajalpzkdm5cjb7qsu7y
52:  libnrm              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/libnrm-0.1.0-gczzg3dnazmhvtx2l7kr3yot5dzwpxmu
53:  libpressio          /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/libpressio-0.95.1-zeq62cksskfbyttrp6m5u6yxqzsmofhz
54:  libquo              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/libquo-1.3.1-noue3szg7ljiv6oxsmlqgltvw76mohbf
55:  loki                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/loki-0.1.7-xjrdr7sdlsw5gkrosqhykqu74zk2lqxn
56:  magma               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/magma-2.7.2-j5knwazdi6mseha3lhxtf3j4peipeqej
57:  mercury             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/mercury-2.3.1-3n56a5fmv2yaks6cj7ntylezjieaeymg
58:  mgard               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/mgard-2023-03-31-tkvarpjfwroxx5jklnji56rpf7efdjxu
59:  metall              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/metall-0.25-ke2rr3b4rv5glcszbrbdyo4ywdrrz3gf
60:  mfem                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/mfem-4.6.0-i4jpse2teo3ft25emlf2tpufzqtpdnlp
61:  mpark-variant       /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/mpark-variant-1.4.0-ririz5ovbtkiyusx6uervst45plz5h5g
62:  mpich               /usr/local/mpich/install/mpich
63:  mpifileutils        /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/mpifileutils-0.11.1-e7ekl6oxoxaa6ggy3zrjure3kmzbe654
64:  nccmp               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/nccmp-1.9.1.0-cd6sctvwy65hlg62ma3drqhzocpysm55
65:  nco                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/nco-5.1.6-lgoywbimatw3lq6piar5wwddo3huupqr
66:  netcdf-c            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/netcdf-c-4.9.2-xkdm6sj7y3uwoxoemxtbxcyhllclmo3v
67:  netlib-scalapack    /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/netlib-scalapack-2.2.0-mgsenm33zlkofr6drz4gcapy2tjehnyf
68:  nrm                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/nrm-0.1.0-jup6rr7vod334xqjaqtcspvgtgbgkfej
69:  omega-h             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/omega-h-9.34.13-5tfq4tc62ngc56a65tn4vnvvgbi3tgqz
70:  openfoam            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/openfoam-2306-ob46pi75qvijibmstxvpw2nibkn2aqvn
71:  openmpi             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/openmpi-4.1.6-w43d6iisjgvncu7xnvpkwuy76xsnmsdn
72:  openpmd-api         /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/openpmd-api-0.15.2-rbnixfbpyhlpc6t7h6juvgwp5gnygzxr
73:  papi                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/papi-6.0.0.1-a5hh5jnbmc7bmsq3ywuqf7mlip5d5qxu
74:  papyrus             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/papyrus-1.0.2-zo2oyva3xhdtnocmwyn7j25kfdcjrgdp
75:  parallel-netcdf     /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/parallel-netcdf-1.12.3-3vrlabot5wa6b3r3v3gdqcp4abr7qlgj
76:  paraview            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/paraview-5.11.2-lhidhoi3xdjealydgpemdnv76wcqa4ig
77:  parsec              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/parsec-3.0.2209-dqdfjlgfv3jf6ntppqdnxumrizrejt4c
78:  pdt                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/pdt-3.25.1-ze6vpcl6vajxvknibsdurnuttu25p7f5
79:  petsc               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/petsc-3.20.1-irydrf4k4nzktzau2xr72m44kefpcrcv
80:  plasma              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/plasma-23.8.2-5vfsp2ia57he7aflv4vyiq5t2t3mrbac
```

23.11 Release: 120+ Official Products + dependencies (gcc, ppc64le)

```
  81:  plumed              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/plumed-2.9.0-jljeadfhqynhlhgrvg5gjecfkllugycx
  82:  precice             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/precice-2.5.0-ed3pisb4lfr4aaweybqaoflx5u5t6u2p
  83:  pruners-ninja       /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/pruners-ninja-1.0.1-znaejqmsz5lo7oqjxqwlwde2wy3ozd5h
  84:  pumi                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/pumi-2.2.8-2claov3kfcx6w54o2oy3zmc2uuxopjns
  85:  py-cinemasci        /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-cinemasci-1.3-n7c3jkmm26fcesiyzhcgdwbui7knm7cq
  86:  py-jupyterhub       /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-jupyterhub-1.4.1-m45rfxh4yshbptjigx7rwu7vpf72suxv
  87:  py-libensemble      /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-libensemble-1.0.0-z73csgy7hvt6bwbgozbrhni7cvf225q6
  88:  py-parsl            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-parsl-2023.08.21-uvudb3nharj6h43g55n4jxcpsxaqzv5d
  89:  py-radical-pilot    /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-radical-pilot-1.20.0-egv7er3kdbjrh7vbgoy2cdd23lpkgtgy
  90:  py-radical-saga     /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/py-radical-saga-1.20.0-6br2l2z6j5nvdice4h5fsoaguwc5adw2
  91:  qthreads            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/qthreads-1.18-vq6ui6c2qiizdf5gl2z4jmqmpdntpxpb
  92:  quantum-espresso    /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/quantum-espresso-7.2-gzgvs5uate7b75e75dzwpcdnfpawogjo
  93:  raja                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/raja-2022.10.4-7ootusdyhsfgiva7fxqtrwd66uvc5xop
  94:  rempi               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/rempi-1.1.0-d35pbskvieefhz7shn7k3evuvvw33cdb
  95:  scr                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/scr-3.0.1-z7ngk3g7fiip7djhlmlm3vxdznwcos6g
  96:  slate               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/slate-2023.08.25-cxyyt5nre5rjb3nptmwktomymjc7fqov
  97:  slepc               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/slepc-3.20.0-dq6rxxwfrcooh53xfhh2kd53ybq4prak
  98:  stc                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/stc-0.9.0-q5h6ac5maywtljun7zimxkyvpxbdkaxg
  99:  strumpack           /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/strumpack-7.2.0-pqdhytlnfut7wrw6yyp7wcy5thbkd6ci
 100:  sundials            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/sundials-6.6.1-uxtnmnmja77hrsnossvwkm5suktyknzt
 101:  superlu             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/superlu-5.3.0-rslxrp6xmbjtm6kvvc7dth64atuyg5mq
 102:  superlu-dist        /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/superlu-dist-8.1.2-3i5373lzamvgaw5us2a54vnzvopo6dco
 103:  swig                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/swig-4.1.1-qljcvrmgm3e5cbti2opgmzzw4kuu7ixr
 104:  sz                  /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/sz-2.1.12.5-6xehslpqqe6ub2o4h6o5y2flwxjhzxpo
 105:  sz3                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/sz3-3.1.7-a7jrbvqxdehj7s3wp43azq5uxvc3j4su
 106:  tasmanian           /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/tasmanian-8.0-lgqssqwxckctz45wc6jb7hhnegzaccvx
 107:  tau                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/tau-2.33-tqv5wr63b2xzxlxc2kiumj23466igje3
 108:  trilinos            /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/trilinos-14.4.0-j7qmkitn4vkzsmvnns6n4y3v6f4atsxx
 109:  turbine             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/turbine-1.3.0-j6syzfwz7ydatc5yngk5yar5fmi4aq7s
 110:  umap                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/umap-2.1.0-ndekgmacnqysxbqiuaj7ajjmudt3aopv
 111:  umpire              /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/umpire-2022.10.0-4mkmdh2xegjoxpzk736krbtplpgwwiyr
 112:  unifyfs             /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/unifyfs-1.1-c3h2bojb2mn6sdliujwgvgoy2zdgdzqa
 113:  upcxx               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/upcxx-2023.3.0-2b6f6lm33c6wyoobvsxzwy744iyfo2i2
 114:  veloc               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/veloc-1.7-q7khqjblg3uy52xm5tol4tchrohvjjr5
 115:  visit               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/visit-3.3.3-ld57dpvltpzua6btm5hcrmqi2vfrlunq
 116:  vtk-m               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/vtk-m-2.0.0-tgnhx43yh6d3wqi4bdptdmomz63ziabe
 117:  wannier90           /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/wannier90-3.1.0-i7j4n7lkhwrvzwqouj3ngss75i4ddc33
 118:  warpx               /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/warpx-23.08-xcmc2moe2hrtmkcel5jlp2mkww3zomvc
 119:  xyce                /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/xyce-7.7.0-als6bbddavc2d2m6alyxsul2b7cd5toe
 120:  zfp                 /spack/opt/spack/linux-ubuntu20.04-ppc64le/gcc-9.4.0/zfp-1.0.0-qsgdtjjrij57atf3ns3elsd3uyj26ez4
```

Supports
IBM Power10 and
Power 9 processors

E4S 23.11 Support for GPUs: NVIDIA CUDA

```
[Singularity> lscpu | grep "Model name"
Model name:                      POWER10 (architected), altivec supported
[Singularity> spack find +cuda
-- linux-ubuntu20.04-ppc64le / gcc@9.4.0 ------------------------
adios2@2.9.1        ecp-data-vis-sdk@1.0  kokkos@4.0.00          paraview@5.11.2     tasmanian@8.0
amrex@23.11         exago@1.6.0           kokkos@4.1.00          parsec@3.0.2209     tau@2.33
arborx@1.4.1        flecsi@2.2.1          kokkos@4.1.00          petsc@3.20.1        trilinos@14.4.0
blaspp@2023.08.25   flux-core@0.55.0      kokkos-kernels@4.0.00  petsc@3.20.1        umpire@6.0.0
bricks@2023.08.25   ginkgo@1.6.0          lapackpp@2023.08.25    raja@0.14.0         umpire@2022.10.0
cabana@0.6.0        heffte@2.4.0          magma@2.7.2            raja@2022.10.4      vtk-m@2.0.0
caliper@2.10.0      hiop@1.0.0            mfem@4.6.0             slate@2023.08.25    zfp@0.5.5
camp@0.2.3          hpctoolkit@2023.08.1  mgard@2023-03-31       slepc@3.20.0
camp@2022.10.1      hpx@1.9.1             nvcomp@2.2.0           strumpack@7.2.0
camp@2022.10.1      hwloc@2.9.1           omega-h@9.34.13        sundials@6.6.1
chai@2022.03.0      hypre@2.29.0          papi@6.0.0.1           superlu-dist@8.1.2
==> 51 installed packages
Singularity>
```

23.11 Release: 120+ Official Products + dependencies (gcc, aarch64)

```
 1:  adios2              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/adios2-2.9.1-uft22g2mrry7ga3uf6ef64qrgi524imh
 2:  alquimia            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/alquimia-1.1.0-2wtbogmb5utr7aobrs4aijy2untp5dr3
 3:  aml                 /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/aml-0.2.1-w7viezgpmbzdtdjfnceskvam2llhd4h6
 4:  amrex               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/amrex-23.11-xrurplfkepihnygqubz5xwj3k76ej5eb
 5:  arborx              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/arborx-1.4.1-5uwyjf2axgvv4t25gpzgbvjb7blz3362
 6:  argobots            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/argobots-1.1-gr47krhthg5yafbughtbvfisn53o6zt7
 7:  ascent              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/ascent-0.9.2-lhsneqzg7vthmcoy4ltmwnlp3ahqsid2
 8:  axom                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/axom-0.8.1-dqb2cku35wdlyifhdgc3doboih5iysny
 9:  blaspp              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/blaspp-2023.08.25-njb5lz7qcsinda7wnelql744jxsegxa6
10:  bolt                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/bolt-2.0-eepeuib5dttu6tnwrkcb6kifv3w7kiqf
11:  bricks              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/bricks-2023.08.25-4pgczi2gqeskz7gx3ijsk4nqkzndo42r
12:  butterflypack       /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/butterflypack-2.4.0-hifvtxgulqlzkrinkadie2m3rlyqrefa
13:  cabana              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/cabana-0.6.0-w7qg5cnaaevjbpeyjopp2k6zwk4arwsb
14:  caliper             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/caliper-2.10.0-jhmmthydhvt4femkmiedm7nyvwmutwn5
15:  camp                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/camp-2022.10.1-oop4gctvzf5rcvxpjglbxjfuzyghsiyz
16:  chai                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/chai-2022.03.0-4xu2qmjt72vrplbjehwrzprmx5t7bld5
17:  charliecloud        /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/charliecloud-0.34-cagxu3tetwr3xkpiln66r2ghzsmpfbl3
18:  conduit             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/conduit-0.8.8-lc56hbwernfuiuzmrkb4ms6jm7lh4c4x
19:  darshan-runtime     /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/darshan-runtime-3.4.4-iwkj3a7xl4pnhwcjbczgcskwxmqohfyo
20:  datatransferkit     /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/datatransferkit-3.1.1-xasaq5tdb6xbwjfugbivue3fdq2blwwk
21:  dealii              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/dealii-9.4.2-ibonlcdumwguc54bqeoejpxpnwkemb2h
22:  dyninst             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/dyninst-12.3.0-qdivrghrm4hn56hkuvzf7mefrlj6loid
23:  ecp-data-vis-sdk    /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/ecp-data-vis-sdk-1.0-agbw2rqivjmfbzji74razmhn7cm6qgjh
24:  exago               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/exago-1.6.0-k33qfrsqklgpzvci647zokzlo7hfprnn
25:  exaworks            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/exaworks-0.1.0-mkgxnddmhxjes2v5ajvilrgh6jfnhcxx
26:  faodel              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/faodel-1.2108.1-svalgqvueeyfvvjswiegrkmbom4zaihz
27:  flecsi              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/flecsi-2.2.1-4bxmrsca3z37qxyeyc6afv6cqz7qvnwo
28:  flit                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/flit-2.1.0-tdnojm5tcfyh7rkb2nhztphqgvdqmdsz
29:  flux-core           /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/flux-core-0.55.0-ouxklx2ef3bj2aclxyjne4nccqyzkyy3
30:  flux-sched          /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/flux-sched-0.28.0-fxsxwujwznwgqiekyniyuihgo7wgs7jl
31:  fortrilinos         /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/fortrilinos-2.3.0-m2i5xmdqxq6oft6bvj5o5mrdikzd4k4f
32:  gasnet              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/gasnet-2023.3.0-wll3acsggquumawdsbprb5cog7l4mkos
33:  ginkgo              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/ginkgo-1.6.0-zww5mpt3axs5xmv2qgbcwroomp3skegg
34:  globalarrays        /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/globalarrays-5.8.2-hbum2e775x4odzjiqjkcaphtf2u5sfww
35:  gotcha              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/gotcha-1.0.4-mr2wu2wyzrnqlywugyeth23epm72htq7
36:  gptune              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/gptune-4.0.0-354tew3jikrmdcs4xholtmr5p7tqj7nb
37:  h5bench             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/h5bench-1.4-qbqzt6mkkt7q3a4trolhb5kh3jl4jz52
38:  hdf5                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hdf5-1.14.3-nguuw5n5vi7vanfpiyiffbrbhnzug6c3
39:  hdf5-vol-async      /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hdf5-vol-async-1.7-f3s4vezg2c3ysz47oadlcaewmwsit3r6
40:  hdf5-vol-cache      /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hdf5-vol-cache-v1.1-cvgviu6sf5hzpmgb7p3winnbahqou4xr
```

GPU runtimes for aarch64

- CUDA 12.2
- NVHPC 23.9

Languages

- Julia with MPI and CUDA
- Python

EDA

- Xyce

AI packages for NVIDIA GPU

- TensorFlow
- PyTorch
- JAX
- Horovod
- LBANN

23.11 Release: 120+ Official Products + dependencies (gcc, aarch64)

41:	hdf5-vol-log	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hdf5-vol-log-1.4.0-askwti2uhmlqciyotwmssu22nd7hfcpe
42:	heffte	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/heffte-2.4.0-nlefprawl2amop2xn5yp76uducmdrgf7
43:	hiop	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hiop-1.0.0-c3pggtagjpkekfjytdyjiaaoliixjftf
44:	hpctoolkit	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hpctoolkit-2023.08.1-r7gu47hjez3dz63gg5kew7xe45r5kwx5
45:	hpx	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hpx-1.9.1-l2osvhqyf57w3zpqfksap5doxgucxegs
46:	hypre	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/hypre-2.29.0-5yaiww5gbyngxdmlzeaoy66hzlcqgkyu
47:	kokkos	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/kokkos-4.1.00-kyfxs4ow7bclk4eftkxxukowvprs6oku
48:	kokkos-kernels	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/kokkos-kernels-4.0.00-bdvu6m3nkkkq2x4g3jigmhhibs4mzaaf
49:	lammps	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/lammps-20230802-zqaokelg4ucinzevltvfa5xubhukxsev
50:	lapackpp	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/lapackpp-2023.08.25-nx5s7h3nofqg5qoqvbkfrp55ezv5piea
51:	lbann	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/lbann-0.102-pvqyvg7f7j5jn6npdwr4o53qucfuwp3k
52:	legion	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/legion-23.06.0-3xud3q7a4cmv25bq62ltc77yrlzul5es
53:	libnrm	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/libnrm-0.1.0-mc566yor3refvyrespcbg2xaewejaplw
54:	libpressio	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/libpressio-0.95.1-dajhp3lomiflm2tlj5wo4e3lcxm26uqm
55:	libquo	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/libquo-1.3.1-qdrq2fnjlyoeietws5hf66i2qm3d5sr7
56:	loki	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/loki-0.1.7-c7vcttrw2dsxbf4lfpgeu3yg2wdra5h4
57:	magma	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/magma-2.7.2-l4qpnzbrbh4q7a6bn6b2imt3iis7babn
58:	mercury	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/mercury-2.3.1-7gi27gfvyfwav3feb6mrdhd6i2ejypa7
59:	metall	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/metall-0.25-oihlh4zpwatnx5kjlch4tupnmphxrtnt
60:	mfem	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/mfem-4.6.0-dzfpk6ksrqqh6rqxchj7fty2r4rxzepm
61:	mgard	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/mgard-2023-03-31-7wmscjugmga3sqfwdjstffyt6eeyccxg
62:	mpark-variant	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/mpark-variant-1.4.0-sjcpjtlkzwjvlfwtc4upb74yp7cjwbcg
63:	mpich	/usr/local/mpich/install/mpich
64:	mpifileutils	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/mpifileutils-0.11.1-l2lodjtmwpu7ucl47jsd4i6al523n7l5
65:	nccmp	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/nccmp-1.9.1.0-krelczi3on2x75qekfvntq3wmnqolhyo
66:	nco	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/nco-5.1.6-jmkhimcj3zn22exemhanqz3qgzom2qjq
67:	netcdf-c	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/netcdf-c-4.9.2-sestahceq42gejet66jxfjyjt775lyd4
68:	netlib-scalapack	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/netlib-scalapack-2.2.0-3jdyuvvzoa5hsxj6fxlx47pcrynf23g5
69:	nrm	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/nrm-0.1.0-ze4bp63qs47yjwle5meg23bnxwm6wcjn
70:	omega-h	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/omega-h-9.34.13-o3hrfhsxjuxxmrazzyusevcwsdgobu3b
71:	openfoam	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/openfoam-2306-svciwdoghv2d3upt6pyvqow5aytjqwny
72:	openmpi	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/openmpi-4.1.6-tokf2wr56b5h7k6wfbwijbkc2detfjov
73:	openpmd-api	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/openpmd-api-0.15.2-43zhb3zsjgx5rdkypc477uemxoloijsk
74:	papi	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/papi-6.0.0.1-xl67muwm32gd7ihffvzhssrz3kmo77is
75:	papyrus	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/papyrus-1.0.2-5seeb4y2ouo33pdlxrykllmacirzqlwv
76:	parallel-netcdf	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/parallel-netcdf-1.12.3-hjrgktmpfarivcjwrqjtaaxt56er625e
77:	paraview	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/paraview-5.11.2-mvx5wfzxurxe4xv6ri7ylvfk3nvvzmxl
78:	parsec	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/parsec-3.0.2209-qbpmkrkwxlwmkga2cvbk3qfh5cfspfqc
79:	pdt	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/pdt-3.25.1-ja6n6kerewjwq5heec2p7haznudx3rta
80:	petsc	/spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/petsc-3.20.1-mfome36qyemllxmz46fl7bpajhnyvcig

23.11 Release: 120+ Official Products + dependencies (gcc, aarch64)

```
  81:  phist              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/phist-1.12.0-sqefaqj3bkvs72vg6y5invdhxzpvnkqj
  82:  plasma             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/plasma-23.8.2-ksrdra6qy5vhl2b2mgyo2cahzmmtgouz
  83:  plumed             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/plumed-2.9.0-edy6dyolgmvpepjtegm46z5bviadig4p
  84:  precice            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/precice-2.5.0-kuyz5ezu2qilbqttqlvrarg73hasfq5l
  85:  pruners-ninja      /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/pruners-ninja-1.0.1-4tcd663wymmdiyijhyvolb4bj4nezrzm
  86:  pumi               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/pumi-2.2.8-66yv6y63cnpeqloq76tucrhold7xdq2f
  87:  py-cinemasci       /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/py-cinemasci-1.3-254yajm7c2ehjphmuhhmphz5q5mrceuw
  88:  py-jupyterhub      /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/py-jupyterhub-1.4.1-tbuic7rvqnic4ahob7gbc32abzofhk5j
  89:  py-libensemble     /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/py-libensemble-1.0.0-xpgmddjq753ldshwq3xcoixvziewgvcd
  90:  py-parsl           /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/py-parsl-2023.08.21-33ccycqjtw6k25vdrehceg3xzbconqnv
  91:  py-radical-saga    /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/py-radical-saga-1.20.0-3jnfljb2jaxel6axgwiclols3an5ry7t
  92:  qthreads           /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/qthreads-1.18-whrpaz7mmgjxripbacnxwki4tl3mz2td
  93:  quantum-espresso   /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/quantum-espresso-7.2-uvm6s4d4zrljbrkb223lblopuulzkv5o
  94:  raja               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/raja-2022.10.4-t5wt2dllepntcgysiqiw7afjnyte5g7o
  95:  rempi              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/rempi-1.1.0-7xeoova2qxwlqxjkawevjgnfsfuiqpzd
  96:  scr                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/scr-3.0.1-ublrmcdmdyycygontq3gsthcaieaptic
  97:  slate              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/slate-2023.08.25-zm6apwmfecfpt4boaua63bweohxosyva
  98:  slepc              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/slepc-3.20.0-hi76rds7khmuxynuiz6nrlqf2gomgt6m
  99:  stc                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/stc-0.9.0-ami5ftjxjg6xfkbvx3ld6fdrd2met4qt
 100:  strumpack          /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/strumpack-7.2.0-y4jcze7od4sgmsnic7uea22r54kfo55d
 101:  sundials           /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/sundials-6.6.1-byxdyutgnn2e6zxut5iw2squba4t42rz
 102:  superlu-dist       /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/superlu-dist-8.1.2-d6ygwr5kf7juhbj4psbpb5nmt6ndzjkx
 103:  swig               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/swig-4.1.1-uxe5rqc6ckx2zskykfxt2jfciqtdldo7
 104:  sz                 /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/sz-2.1.12.5-xnlcrsdqfrc54yqhm3qec6kxz4j4vcvu
 105:  sz3                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/sz3-3.1.7-ru6xv3yvmlhrmtwqzi57dkwkp6jhct45
 106:  tasmanian          /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/tasmanian-8.0-dzigpliqklwf3qifgywjbbodh44rj7bx
 107:  tau                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/tau-2.33-iexs5h7d6fbqokbl4kxfkrj5b3l5wchs
 108:  trilinos           /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/trilinos-14.4.0-llnjmxef27uwjqac57tbxzxq3ogfr3wu
 109:  turbine            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/turbine-1.3.0-lbxcndhw76uy6hf3tjlrxbmr5tisu7uj
 110:  umap               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/umap-2.1.0-fv3b5twed65uguuwl2dslcyilbnb7oop
 111:  umpire             /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/umpire-2022.10.0-j56z2ax27skkexmrfyxsfaazcl4ydqmz
 112:  unifyfs            /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/unifyfs-1.1-exepusu7yo5cnukhq6ngevszojbxismv
 113:  upcxx              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/upcxx-2023.3.0-whffawlrdzubel6qiacindjmp7vktioa
 114:  veloc              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/veloc-1.7-x6zhslhptku6xqixa5c6qe4u6mqhaiw2
 115:  visit              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/visit-3.3.3-ybdrxdnxgwaizyqzftkvd6mhgtjpq27w
 116:  vtk-m              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/vtk-m-2.0.0-3p3w7nrim6n6bo5qwbgc6pvbrueuyjfu
 117:  wannier90          /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/wannier90-3.1.0-bwhu37ygvhbu7x43au7qy3oevetk37su
 118:  warpx              /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/warpx-23.08-3jbeqgufv7bpik7qcbbv5tzsbtdauwtk
 119:  xyce               /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/xyce-7.7.0-3qtj2llp6hmz4xohbjoaiimhlg4m2uup
 120:  zfp                /spack/opt/spack/linux-ubuntu20.04-aarch64/gcc-11.4.0/zfp-1.0.0-r5qrgfqpgtmzvplmtwsnvggwoibe6rso
```

E4S Support for GPUs: CUDA on aarch64

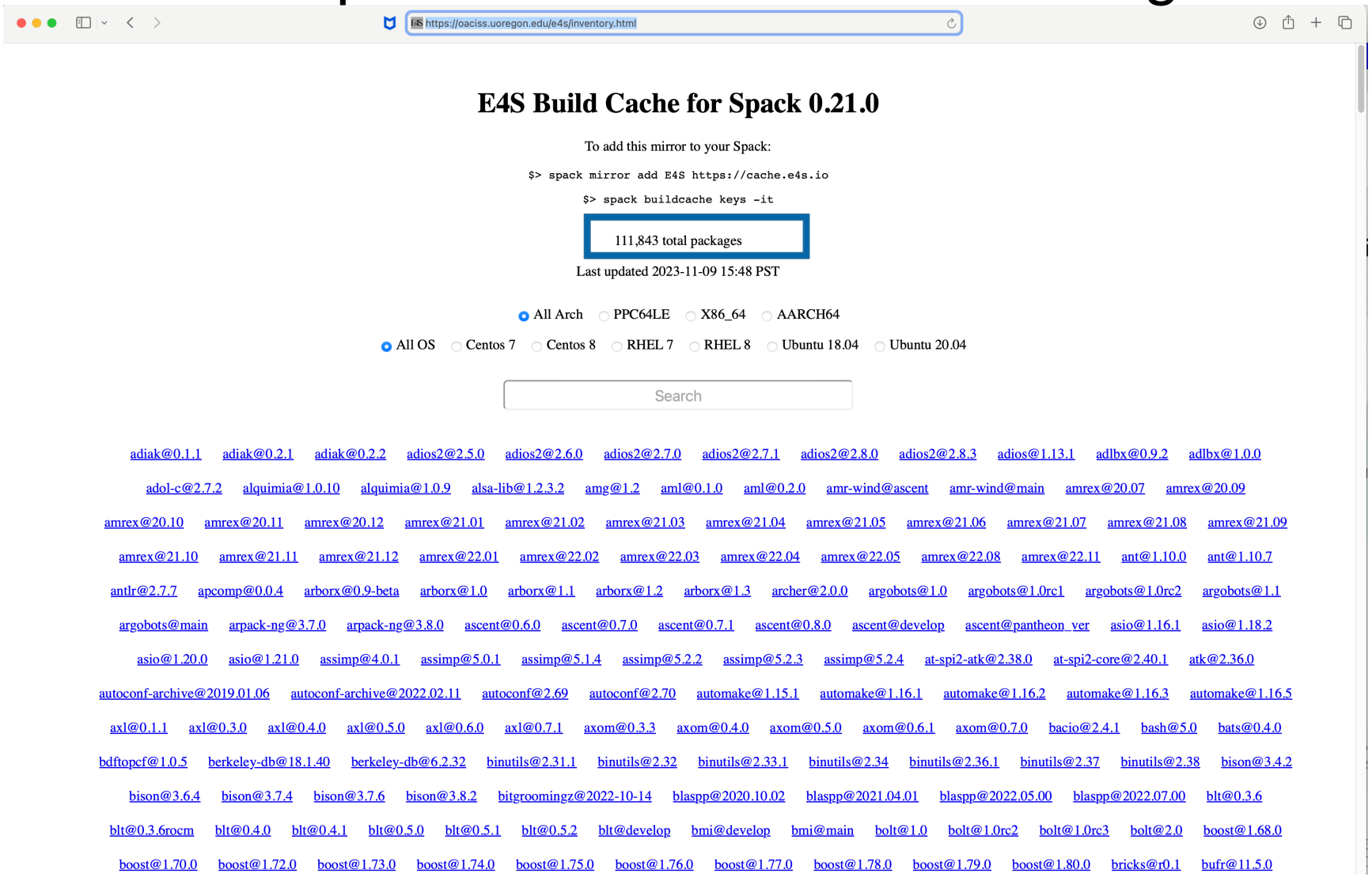
```
Singularity> spack find +cuda
-- linux-ubuntu20.04-aarch64 / gcc@11.4.0 ------------------------
adios2@2.9.1        dealii@9.4.2           kokkos@4.0.00          papi@6.0.0.1         tasmanian@8.0
amrex@23.11         ecp-data-vis-sdk@1.0   kokkos@4.1.00          paraview@5.11.2      tau@2.33
arborx@1.4.1        exago@1.6.0            kokkos@4.1.00          parsec@3.0.2209      trilinos@14.4.0
blaspp@2023.08.25   flecsi@2.2.1           kokkos-kernels@4.0.00  petsc@3.20.1         umpire@6.0.0
bricks@2023.08.25   flux-core@0.55.0       lammps@20230802        petsc@3.20.1         umpire@2022.10.0
cabana@0.6.0        ginkgo@1.6.0           lapackpp@2023.08.25    raja@0.14.0          upcxx@2023.3.0
caliper@2.10.0      heffte@2.4.0           legion@23.06.0         raja@2022.10.4       vtk-m@2.0.0
camp@0.2.3          hiop@1.0.0             magma@2.7.2            slate@2023.08.25     zfp@0.5.5
camp@2022.10.1      hpctoolkit@2023.08.1   mfem@4.6.0             slepc@3.20.0
camp@2022.10.1      hpx@1.9.1              mgard@2023-03-31       strumpack@7.2.0
chai@2022.03.0      hwloc@2.9.1            nvcomp@2.2.0           sundials@6.6.1
cusz@0.3.1          hypre@2.29.0           omega-h@9.34.13        superlu-dist@8.1.2
==> 56 installed packages
```

E4S 23.08 supports CUDA architectures 75 (T4), 80 (A100), as well as 90 (H100)

E4S DOE LLVM Release: x86_64, ppc64le, and aarch64

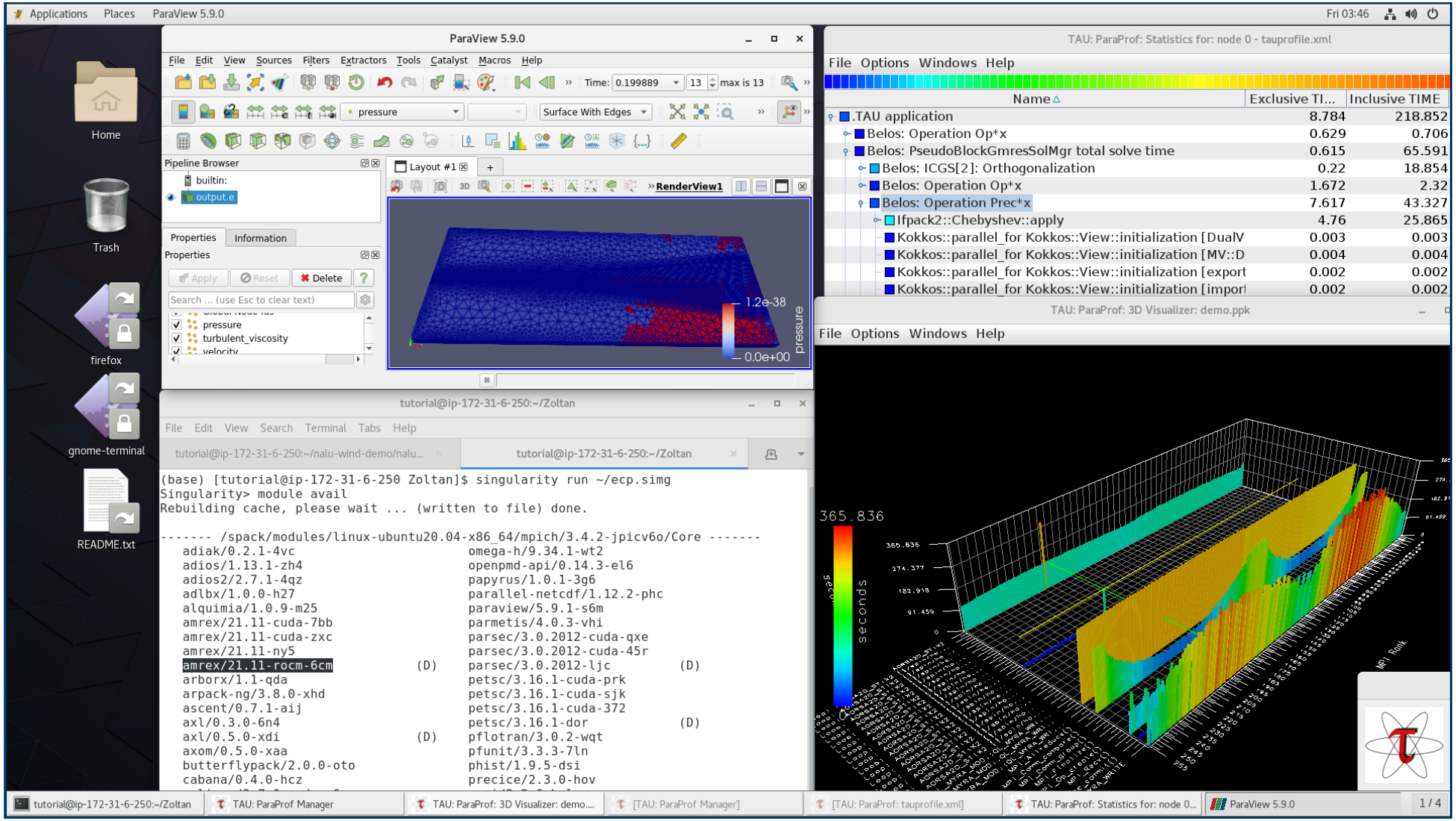
```
Singularity> spack find -x
-- linux-ubuntu20.04-x86_64 / clang@16.0.2 ----------------------
adios@1.13.1  cabana@0.5.0       globalarrays@5.8.2  heffte@2.3.0     mfem@4.5.2           parsec@3.0.2209  sundials@6.5.1      umpire@2022.03.1
aml@0.2.0     chai@2022.03.0     gmp@6.2.1           hypre@2.28.0     mpark-variant@1.4.0  pdt@3.25.1       superlu@5.3.0       upcxx@2023.3.0
amrex@23.05   charliecloud@0.32  gotcha@1.0.4        legion@23.03.0   mpich@4.1.1          plumed@2.8.2     swig@4.0.2-fortran
arborx@1.3    flit@2.1.0         h5bench@1.3         libnrm@0.1.0     nccmp@1.9.0.1        pumi@2.2.7       tasmanian@7.9
argobots@1.1  flux-core@0.49.0   hdf5-vol-async@1.5  libquo@1.3.1     nco@5.1.5            qthreads@1.16    turbine@1.3.0
bolt@2.0      gasnet@2023.3.0    hdf5-vol-log@1.4.0  libunwind@1.6.2  papyrus@1.0.2        stc@0.9.0        umap@2.1.0

-- linux-ubuntu20.04-x86_64 / gcc@11.1.0 ------------------------
cmake@3.26.3  llvm-doe@16.0.2

Singularity> spack find -x
-- linux-ubuntu20.04-ppc64le / clang@16.0.2 ---------------------
adios@1.13.1  cabana@0.5.0       globalarrays@5.8.2  heffte@2.3.0     mfem@4.5.2           parsec@3.0.2209  sundials@6.5.1      umpire@2022.03.1
aml@0.2.0     chai@2022.03.0     gmp@6.2.1           hypre@2.28.0     mpark-variant@1.4.0  pdt@3.25.1       superlu@5.3.0       upcxx@2023.3.0
amrex@23.05   charliecloud@0.32  gotcha@1.0.4        legion@23.03.0   mpich@4.1.1          plumed@2.8.2     swig@4.0.2-fortran
arborx@1.3    flit@2.1.0         h5bench@1.3         libnrm@0.1.0     nccmp@1.9.0.1        pumi@2.2.7       tasmanian@7.9
argobots@1.1  flux-core@0.49.0   hdf5-vol-async@1.5  libquo@1.3.1     nco@5.1.5            qthreads@1.16    turbine@1.3.0
bolt@2.0      gasnet@2023.3.0    hdf5-vol-log@1.4.0  libunwind@1.6.2  papyrus@1.0.2        stc@0.9.0        umap@2.1.0

-- linux-ubuntu20.04-ppc64le / gcc@11.1.0 -----------------------
cmake@3.26.3  llvm-doe@16.0.2

Singularity> spack find -x
-- linux-ubuntu20.04-aarch64 / clang@16.0.2 ---------------------
adios@1.13.1  cabana@0.5.0       globalarrays@5.8.2  heffte@2.3.0     mfem@4.5.2           parsec@3.0.2209  sundials@6.5.1      umpire@2022.03.1
aml@0.2.0     chai@2022.03.0     gmp@6.2.1           hypre@2.28.0     mpark-variant@1.4.0  pdt@3.25.1       superlu@5.3.0       upcxx@2023.3.0
amrex@23.05   charliecloud@0.32  gotcha@1.0.4        legion@23.03.0   mpich@4.1.1          plumed@2.8.2     swig@4.0.2-fortran
arborx@1.3    flit@2.1.0         h5bench@1.3         libnrm@0.1.0     nccmp@1.9.0.1        pumi@2.2.7       tasmanian@7.9
argobots@1.1  flux-core@0.49.0   hdf5-vol-async@1.5  libquo@1.3.1     nco@5.1.5            qthreads@1.16    turbine@1.3.0
bolt@2.0      gasnet@2023.3.0    hdf5-vol-log@1.4.0  libunwind@1.6.2  papyrus@1.0.2        stc@0.9.0        umap@2.1.0

-- linux-ubuntu20.04-aarch64 / gcc@11.1.0 -----------------------
cmake@3.26.3  llvm-doe@16.0.2
```

E4S Build Cache for Spack 0.21.0 hosted at U. Oregon



- Over 110K binaries!
- No need to recompile from source code

E4S 23.11 AWS image: ami-08c2daa0fb4864b90 in US-West-2 (OR)

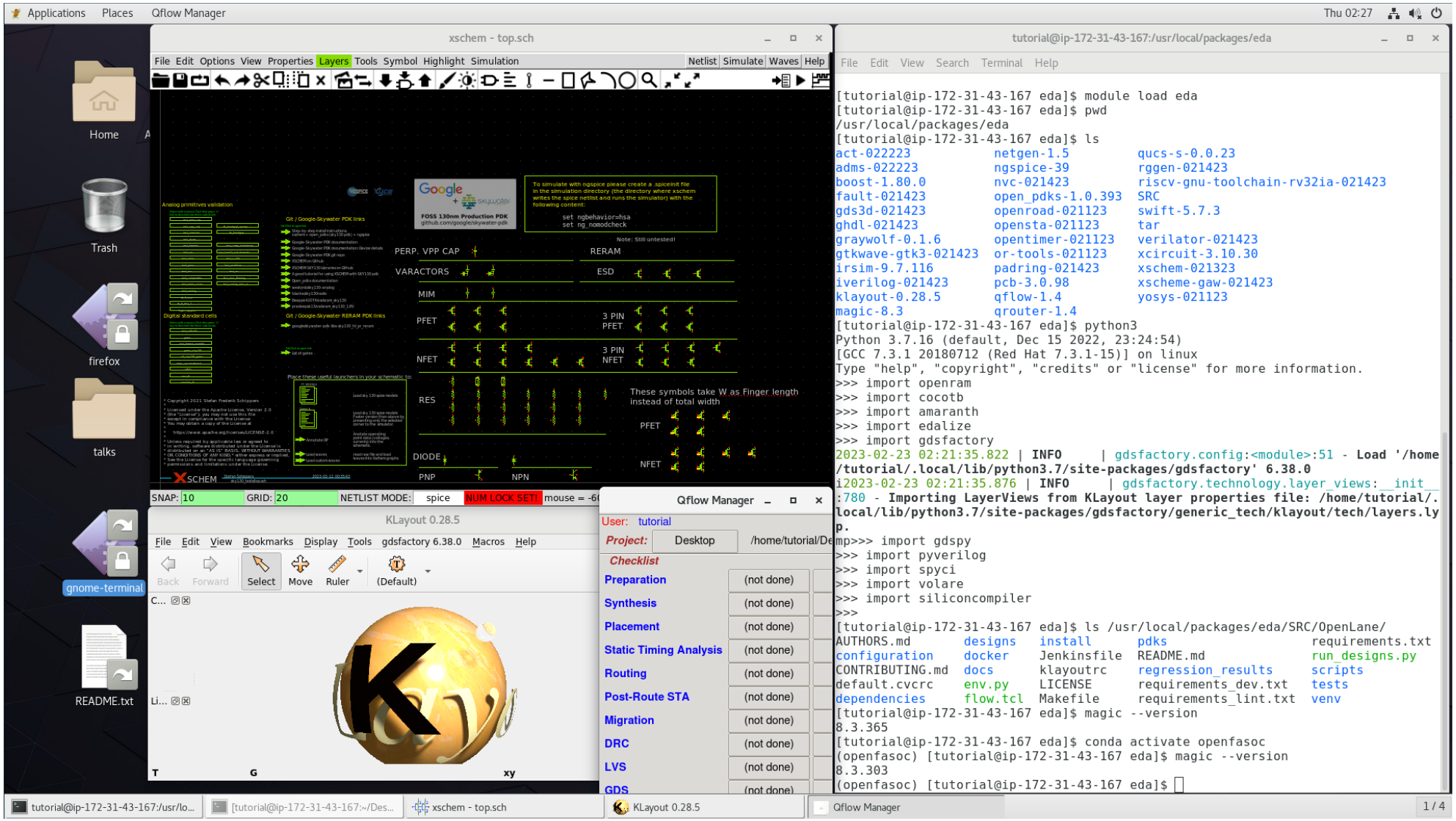


E4S AWS

- Intel oneAPI
- CUDA
- NVHPC
- ROCm
- AWS DCV
- Spack Build Cache
- ECP: Nalu-Wind
- Trilinos
- OpenFOAM
- ParaView
- TAU
- Docker
- Shifter
- Charliecloud
- E4S Singularity…

E4S for Commercial Cloud Platforms for EDA on AWS

- E4S: HPC Software Ecosystem – a curated software portfolio for Electronic Design Automation



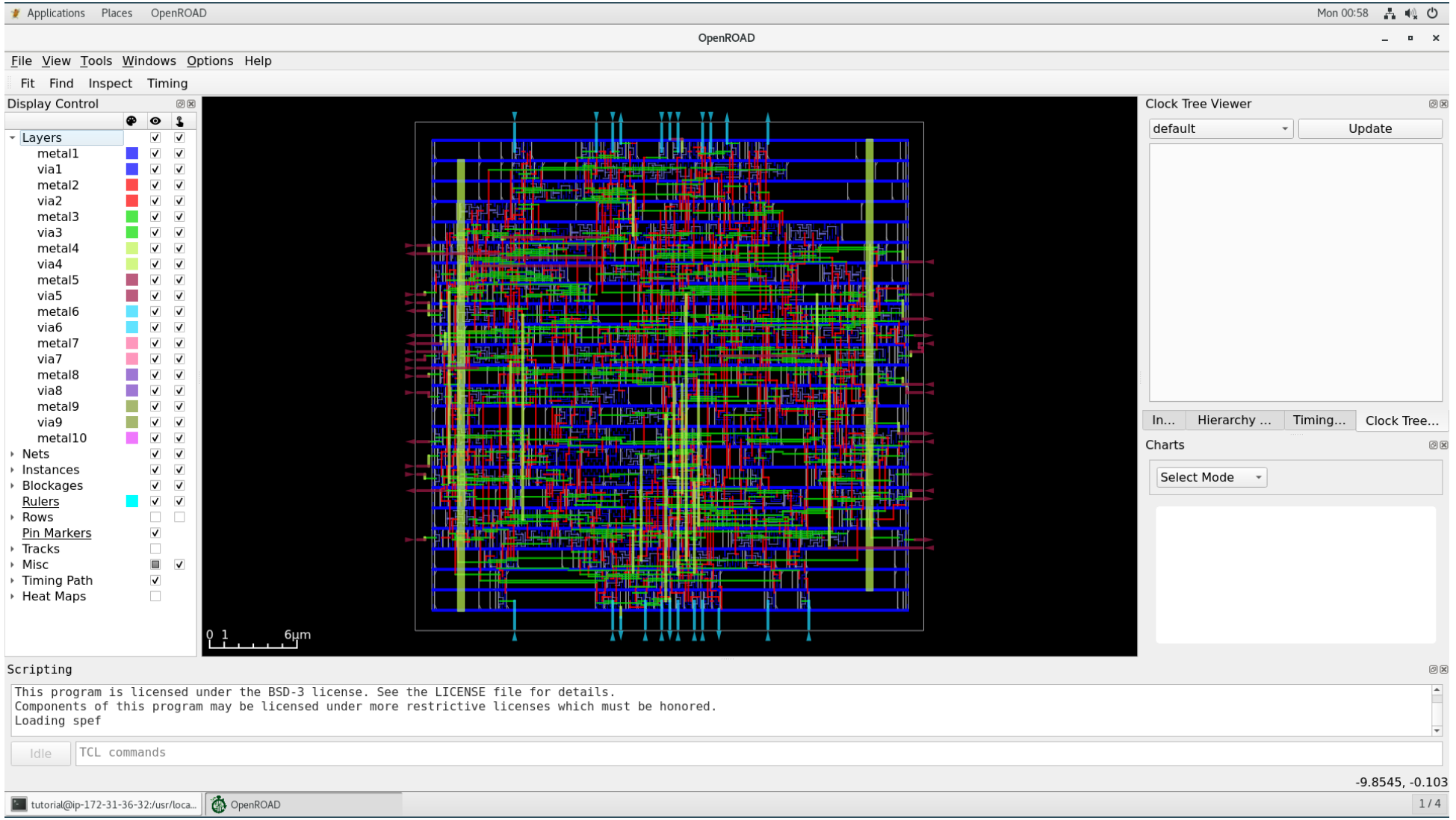
E4S EDA on AWS

- Magic
- ACT
- Klayout
- Qflow
- Xschem
- Xcircuit
- Yosys
- Volator
- OpenROAD
- OpenLane
- iVerilog
- Gtkwave
- Irsim
- Qrouter
- Fault
- GDS3D
- Rggen
- Python tools
  - Cocotb
  - Amaranth
  - Edalize
  - Gdsfactory
  - Gdspy
  - OpenRAM
  - Gdstk
  - Silicon compiler
  - Volare …
- PDKs
  - GF
  - Skywater

https://e4s.io/eda

E4S for Commercial Cloud Platforms for EDA on AWS

- E4S: HPC Software Ecosystem – a curated software portfolio for Electronic Design Automation. Microwatt CPU (IBM) in OpenROAD.



OpenROAD GUI

E4S EDA on AWS

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- OpenROAD
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E4S for Commercial Cloud Platforms for EDA on AWS

- E4S: HPC Software Ecosystem – a curated software portfolio for Electronic Design Automation

#	Packages currently in E4S	URL
1	Magic	http://opencircuitdesign.com/magic/
2	Xyce	https://xyce.sandia.gov
3	NGSPICE	https://ngspice.sourceforge.io
4	KLayout	https://www.klayout.de
5	Qflow	http://opencircuitdesign.com/qflow
6	OR-Tools	https://developers.google.com/optimization
7	IRSIM	http://opencircuitdesign.com/irsim/
8	OpenROAD	https://github.com/The-OpenROAD-Project/OpenROAD
9	OpenLane	https://openlane.readthedocs.io/
10	OpenFASOC	https://openfasoc.readthedocs.io/
11	Open_PDKs	http://opencircuitdesign.com/open_pdks/
12	Netgen	http://opencircuitdesign.com/netgen/

#	Packages currently in E4S	URL
13	Yosys	https://github.com/YosysHQ/yosys
14	Xcircuit	http://opencircuitdesign.com/xcircuit/
15	Graywolf	https://github.com/rubund/graywolf
16	OpenSTA	https://github.com/The-OpenROAD-Project/OpenSTA
17	OpenTimer	https://github.com/OpenTimer/OpenTimer
18	Qrouter	http://opencircuitdesign.com/qrouter/
19	Xschem	https://github.com/silicon-vlsi-org/eda-xschem
20	RISC-V GNU Toolchain	https://github.com/riscv-collab/riscv-gnu-toolchain
21	Fault: Design for Test	https://github.com/AUCOHL/Fault
22	NVC	https://github.com/nickg/nvc
23	Amaranth	https://github.com/amaranth-lang/amaranth
24	Cocotb	https://github.com/cocotb/cocotb

https://e4s.io/eda

E4S for Commercial Cloud Platforms for EDA on AWS

- E4S: HPC Software Ecosystem – a curated software portfolio for Electronic Design Automation

#	Packages currently in E4S	URL
25	Covered	https://github.com/hpretl/verilog-covered
26	Edalize	https://github.com/olofk/edalize
27	Gaw3-xschem	https://github.com/StefanSchippers/xschem-gaw.git
28	GDSFactory	https://github.com/gdsfactory/gdsfactory
29	GDSPy	https://github.com/heitzmann/gdspy
30	GDS3D	https://github.com/trilomix/GDS3D
31	Ghdl	https://github.com/ghdl/ghdl
32	Gtkwave	https://github.com/gtkwave/gtkwave
33	iic-osic	https://github.com/hpretl/iic-osic.git
34	Iverilog	https://github.com/steveicarus/iverilog.git
35	Netlistsvg	https://github.com/nturley/netlistsvg
36	Ngspyce	https://github.com/ignamv/ngspyce

#	Packages currently in E4S	URL
37	Padring	https://github.com/donn/padring
38	Pyverilog	https://github.com/PyHDI/Pyverilog
39	OpenRAM	https://github.com/VLSIDA/OpenRAM
40	Rggen	https://github.com/rggen/rggen
41	Spyci	https://github.com/gmagno/spyci
42	Volare	https://github.com/efabless/volare
43	Siliconcompiler	https://github.com/siliconcompiler/siliconcompiler
44	Verilator	https://github.com/verilator/verilator
45	Sky130	SkyWater Technologies 130nm CMOS PDK
46	Actflow	https://github.com/asyncvlsi/actflow.git
47	Qucs-s	https://github.com/Qucs
48	ADMS	https://github.com/Qucs/ADMS.git
49	Gdstk	https://heitzmann.github.io/gdstk/
50	xcell	https://github.com/asyncvlsi/xcell.git

https://e4s.io/eda

e4s-cl: A tool to simplify the launch of MPI jobs in E4S containers

- E4S containers support replacement of MPI libraries using MPICH ABI compatibility layer and Wi4MPI [CEA] for OpenMPI replacement.
- Applications binaries built using E4S can be launched with Singularity using MPI library substitution for efficient inter-node communications.
- e4s-cl is a new tool that simplifies the launch and MPI replacement.
  - e4s-cl init --backend [singularity|shifter|docker] --image <file> --source <startup_cmds.sh>
  - e4s-cl mpirun -np <N> <command>

- Usage:

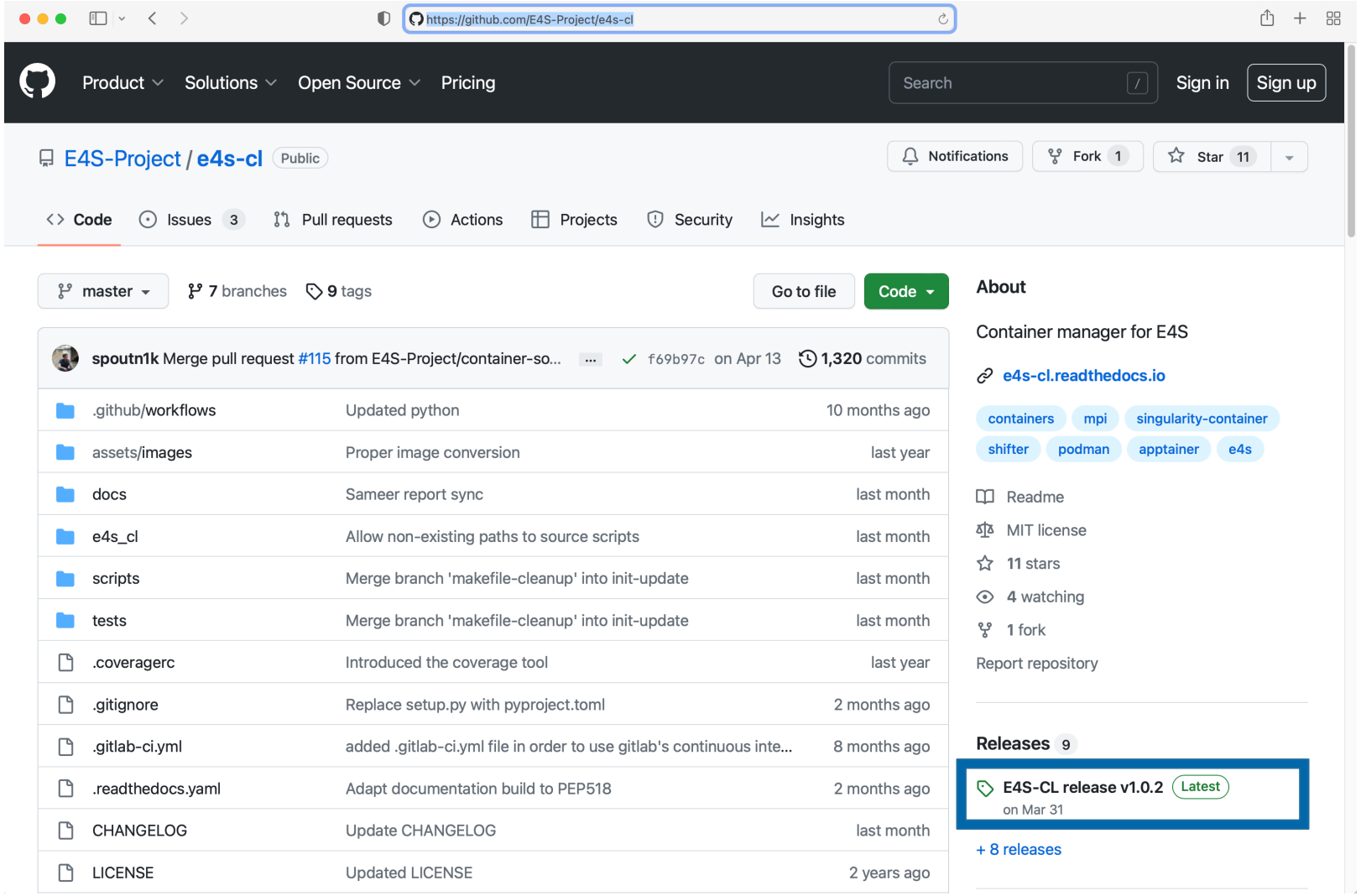
```
% e4s-cl init --backend singularity --image ~/images/e4s-gpu-x86.sif --source ~/source.sh

% cat ~/source.sh
   . /spack/share/spack/setup-env.sh
   spack load trilinos+cuda cuda_arch=80

% e4s-cl mpirun -np 4 ./a.out
```

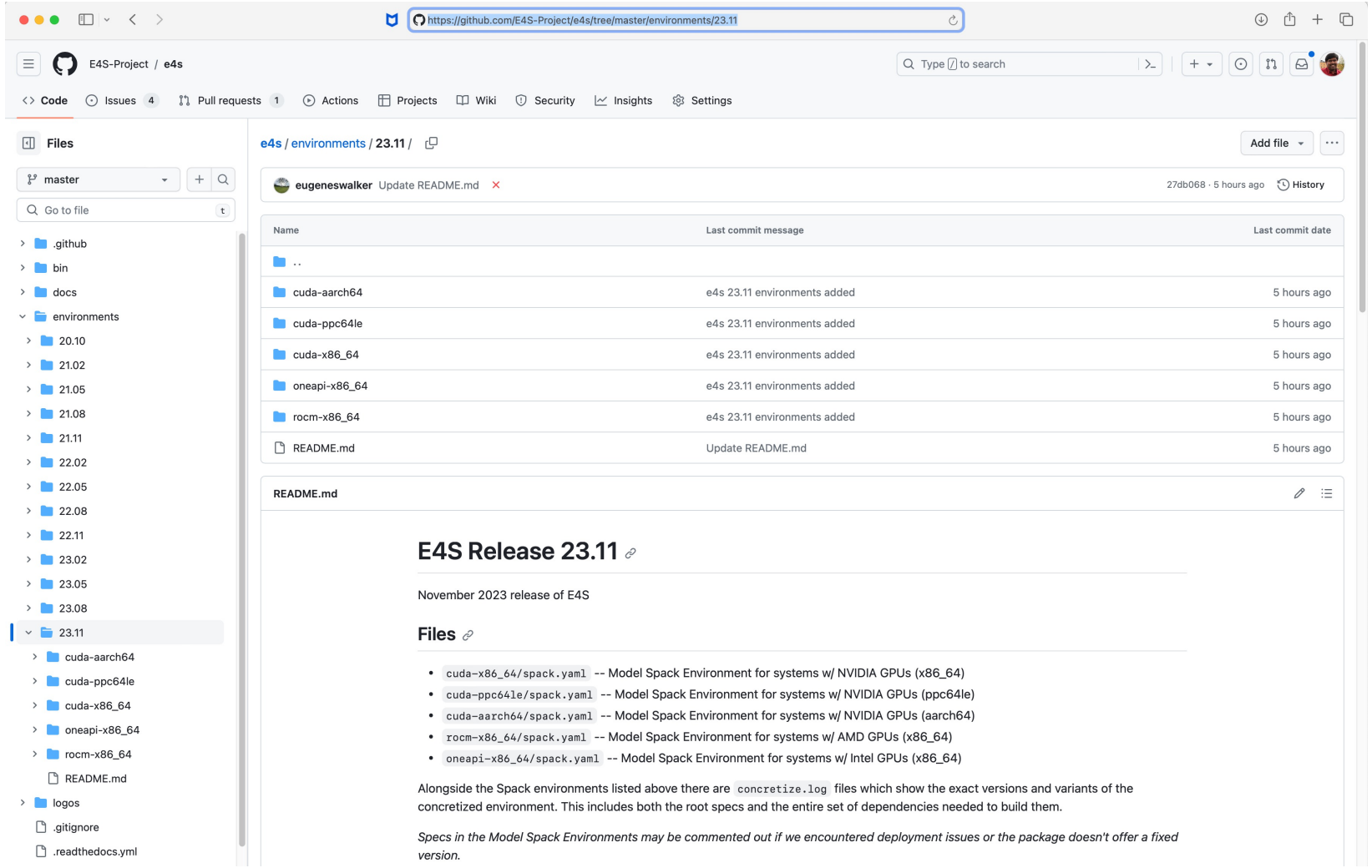
https://github.com/E4S-Project/e4s-cl

New release of e4s-cl on GitHub



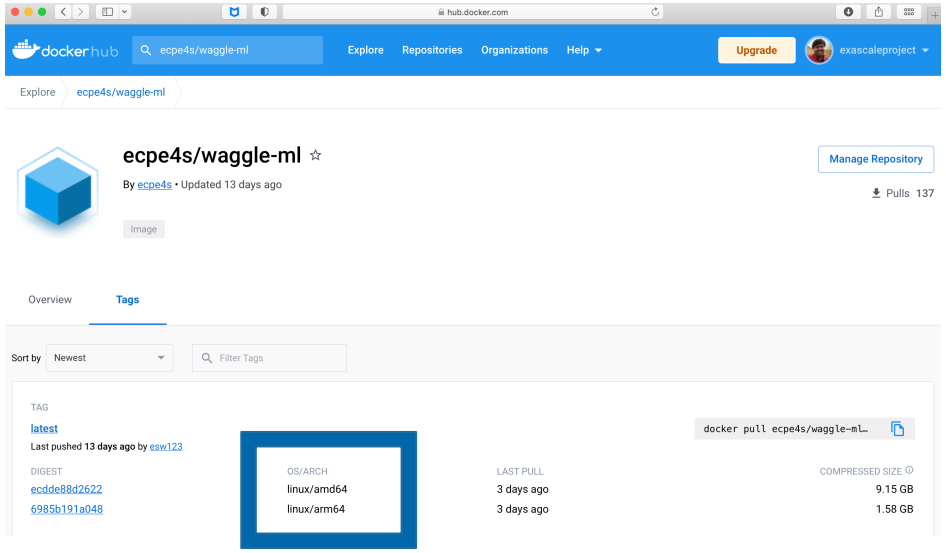
https://github.com/E4S-Project/e4s-cl

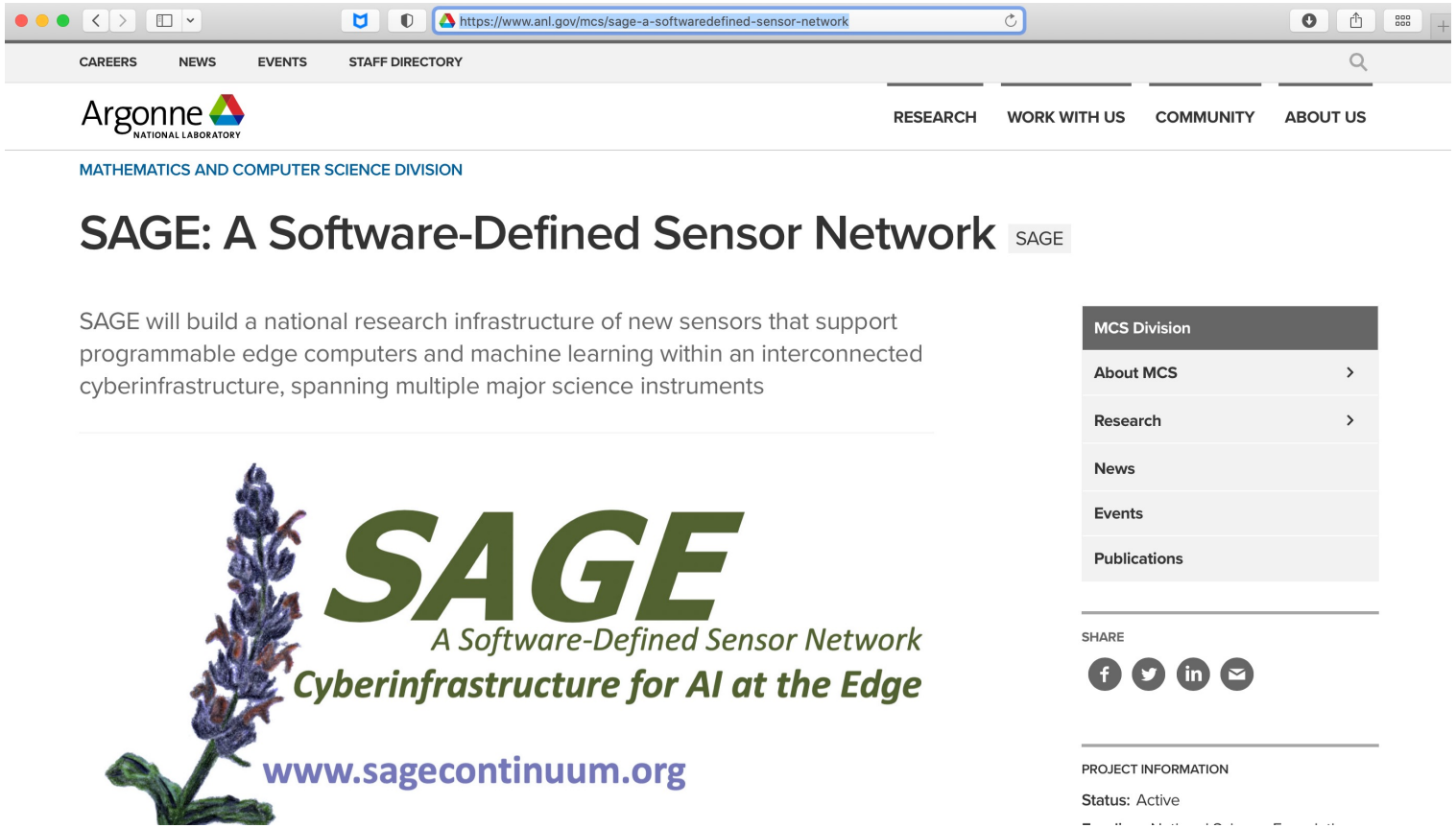
E4S: Open Source Development on GitHub



https://github.com/E4S-Project

Release of custom E4S images: Waggle and SAGE projects





% docker pull ecpe4s/waggle-ml

Thank you

https://www.exascaleproject.org

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.

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.