HPC-BP Webinar: Extreme-scale Scientific Software Stack (E4S)

Wednesday, January 13th, 2021, 10am – 10:30am PT

ECP HPC-BP Webinar
https://exascaleproject.zoomgov.com/j/1616523770

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https://e4s.io

ECP EXASCALE COMPUTING PROJECT
NNSA National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY | Office of Science

Challenges

- As our software gets more complex, it is getting harder to install tools and libraries correctly in an integrated and interoperable software stack.

E4S: Extreme-scale Scientific Software Stack

- Curated, Spack based software distribution
- Spack binary build caches for bare-metal installs
  - x86_64, ppc64le (IBM Power 9), and aarch64 (ARM64)
- Container images on DockerHub and E4S website of pre-built binaries of ECP ST products
- Base images and full featured containers (with GPU support)
- GitHub recipes for creating custom images from base images
- GitLab integration for building E4S images
- E4S validation test suite on GitHub
- E4S VirtualBox image with support for container runtimes
  - Docker
  - Singularity
  - Shifter
  - Charliecloud
- AWS and GCP images to deploy E4S

https://e4s.io

Extreme-scale Scientific Software Stack (E4S)

- E4S: A Spack-based distribution of ECP ST and related and dependent software tested for interoperability and portability to multiple architectures
- Provides distinction between SDK usability / general quality / community and deployment / testing goals
- Will leverage and enhance SDK interoperability thrust

https://e4s.io

- 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
- Jan 2020: E4S 1.1 – ppc64le and x86_64 release with 50 full (x86_64), 46 full (ppc64le) release products.
- Nov. 2020: E4S 1.2 – ppc64le and x86_64 release each with 67 full release products.

Spack is a flexible package manager for HPC

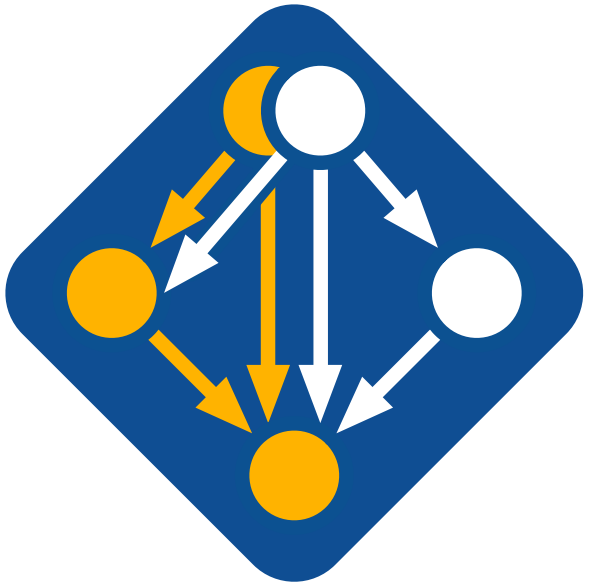
- How to install Spack (works out of the box):

```
$ git clone https://github.com/spack/spack
$ . spack/share/spack/setup-env.sh
```

- How to install a package:

```
$ spack install tau
```

- TAU and its dependencies are installed within the Spack directory.
- Unlike typical package managers, Spack can also install many variants of the same build.
  - Different compilers
  - Different MPI implementations
  - Different build options



Visit spack.io

github.com/spack/spack

@spackpm

Spack provides the *spec* syntax to describe custom configurations

```
$ spack install tau                                                  unconstrained
$ spack install tau@2.29                                             @ custom version
$ spack install tau@2.29 %gcc@7.3.0                                  % custom compiler
$ spack install tau@2.29 %gcc@7.3.0 +mpi+python+pthreads             +/- build option
$ spack install tau@2.29 %gcc@7.3.0 +mpi ^mvapich2@2.3~wrapperrpath ^ dependency information
```

- Each expression is a ***spec*** for a particular configuration
  - Each clause adds a constraint to the spec
  - Constraints are optional – specify only what you need.
  - Customize install on the command line!
- Spec syntax is recursive
  - Full control over the combinatorial build space

`spack find` shows what is installed

```
Singularity> spack find
==> 319 installed packages
-- linux-ubuntu18.04-power9le / gcc@7.3.0 ------------------------
autoconf@2.69    diffutils@3.7    libiconv@1.16      m4@1.4.18      ncurses@6.2             openssl@1.1.1g      texinfo@6.5
automake@1.16.2  findutils@4.6.0  libpciaccess@0.16  matio@1.5.17   netcdf-c@4.7.4          parmetis@4.0.3      trilinos@13.0.0
boost@1.74.0     glm@0.9.7.1      libsigsegv@2.12    metis@5.1.0    netlib-scalapack@2.1.0  perl@5.26.1         util-macros@1.19.1
bzip2@1.0.8      hdf5@1.10.7      libtool@2.4.6      mpich@3.2.1    omega-h@9.29.0          pkgconf@1.7.3       xz@5.2.5
cmake@3.18.4     hypre@2.20.0     libxml2@2.9.10     mumps@5.3.3    openblas@0.3.10         suite-sparse@5.7.2  zlib@1.2.11

-- linux-ubuntu18.04-ppc64le / gcc@7.3.0 ------------------------
adiak@0.1.1                 flit@2.1.0                  libpfm4@4.11.0              papyrus@develop                 py-more-itertools@7.2.0     qthreads@1.14
adios@1.13.1                gasnet@2020.3.0             libpng@1.6.37               parallel-netcdf@1.12.1          py-mpi4py@3.0.3             raja@0.12.1
adios2@2.6.0                gasnet@2020.3.0             libpthread-stubs@0.4        parmetis@4.0.3                  py-nbclient@0.5.0           rankstr@0.0.2
adlbx@0.9.2                 gdbm@1.18.1                 libquo@1.3.1                pcre@8.44                       py-nbconvert@6.0.1          readline@8.0
aml@0.1.0                   gettext@0.20.2              libsigsegv@2.12             pcre2@10.35                     py-nbformat@5.0.7           redset@0.0.3
amrex@20.10                 gettext@0.21                libsodium@1.0.18            pdsh@2.31                       py-nest-asyncio@1.4.0       rempi@1.1.0
arborx@0.9-beta             ginkgo@1.3.0                libtool@2.4.6               pdt@3.25.1                      py-notebook@6.1.4           scr@2.0.0
argobots@1.0                git@2.28.0                  libunistring@0.9.10         perl@5.26.1                     py-numpy@1.19.2             shuffile@0.0.3
arpack-ng@3.7.0             git@2.28.0                  libunwind@1.4.0             petsc@3.13.6                    py-oauthlib@3.1.0           slate@develop
ascent@develop              glm@0.9.7.1                 libunwind@1.4.0             petsc@3.14.0                    py-pamela@1.0.0             slepc@3.14.0
autoconf@2.69               globalarrays@5.7            libuuid@1.0.3               pkgconf@1.7.3                   py-pandocfilters@1.4.2      snappy@1.1.8
automake@1.16.2             gmake@4.2.1                 libxml2@2.9.10              plasma@20.9.20                  py-parso@0.6.1              sqlite@3.31.1
axl@0.3.0                   gmp@6.1.2                   libyogrt@1.24               precice@2.1.1                   py-petsc4py@3.13.0          strumpack@5.0.0
axom@0.3.3                  googletest@1.10.0           libzmq@4.3.2                pumi@2.2.2                      py-pexpect@4.7.0            suite-sparse@5.7.2
bash@5.0                    gotcha@0.0.2                lmod@8.3                    py-alembic@1.0.7                py-pickleshare@0.7.5        sundials@5.4.0
binutils@2.33.1             gotcha@1.0.3                lua@5.3.5                   py-argon2-cffi@20.1.0           py-prometheus-client@0.7.1  superlu@5.2.1
bmi@develop                 gperftools@2.7              lua-luafilesystem@1_7_0_2   py-asn1crypto@0.24.0            py-prompt-toolkit@2.0.9     superlu-dist@6.3.0
bolt@1.0                    hdf5@1.8.21                 lua-luaposix@33.4.0         py-async-generator@1.10         py-psutil@5.7.2             superlu-dist@6.3.1
boost@1.73.0                hdf5@1.8.21                 lwgrp@1.0.3                 py-attrs@19.3.0                 py-ptyprocess@0.6.0         swig@4.0.2
boost@1.73.0                hdf5@1.10.6                 lz4@1.9.2                   py-babel@2.7.0                  py-py@1.8.0                 sz@1.4.12.3
boost@1.73.0                hdf5@1.10.6                 lzo@2.10                    py-backcall@0.1.0               py-pycparser@2.20           sz@2.0.2.0
boost@1.73.0                hpctoolkit@2020.08.03       m4@1.4.18                   py-bleach@3.1.0                 py-pyelftools@0.26          sz@2.1.10
butterflypack@1.2.0         hpx@1.5.1                   magma@2.5.4                 py-blinker@1.4                  py-pygments@2.6.1           tar@1.32
bzip2@1.0.8                 hwloc@1.11.11               margo@0.4.3                 py-certifi@2020.6.20            py-pyjwt@1.7.1              tasmanian@7.3
c-blosc@1.17.0              hwloc@2.2.0                 matio@1.5.17                py-certipy@0.1.3                py-pyopenssl@19.0.0         tau@2.29
caliper@2.4.0               hypre@2.18.2                mbedtls@2.16.7              py-cffi@1.14.3                  py-pyrsistent@0.15.7        tcl@8.6.10
cinch@master                hypre@2.20.0                mercury@1.0.1               py-chardet@3.0.4                py-pytest-runner@5.1        texinfo@6.5
cmake@3.17.3                intel-tbb@2020.3            mercury@1.0.1               py-cryptography@2.7             py-python-dateutil@2.8.0    turbine@1.2.3
conduit@master              kokkos@3.2.00               metis@5.1.0                 py-cython@0.29.21               py-python-editor@1.0.4      umap@2.1.0
conduit@master              kokkos-kernels@3.2.00       mfem@4.1.0                  py-decorator@4.4.2              py-python-oauth2@1.1.1      umpire@4.0.1
cuda@10.2.89                kvtree@1.0.2                mpark-variant@1.4.0         py-defusedxml@0.6.0             py-pytz@2020.1              umpire@4.0.1
curl@7.72.0                 legion@20.03.0              mpich@3.2.1                 py-entrypoints@0.3              py-pyzmq@18.1.0             unifyfs@0.9.0
darshan-runtime@3.2.1       leveldb@1.22                mpifileutils@develop        py-idna@2.8                     py-requests@2.24.0          unzip@6.0
da                3.2.1     libarchive@3.4.1            mumps@5.3.3                 py-importlib-metadata@2.0.0     py-send2trash@1.5.0         upcxx@2020.3.0
di                          libbsd@0.10.0               ncurses@6.2                 py-ipykernel@5.3.4              py-setuptools@50.1.0        util-macros@1.19.1
```

Snapz Pro X

All the versions coexist!

- Multiple versions of same package are ok.

Packages are installed to automatically find correct dependencies.

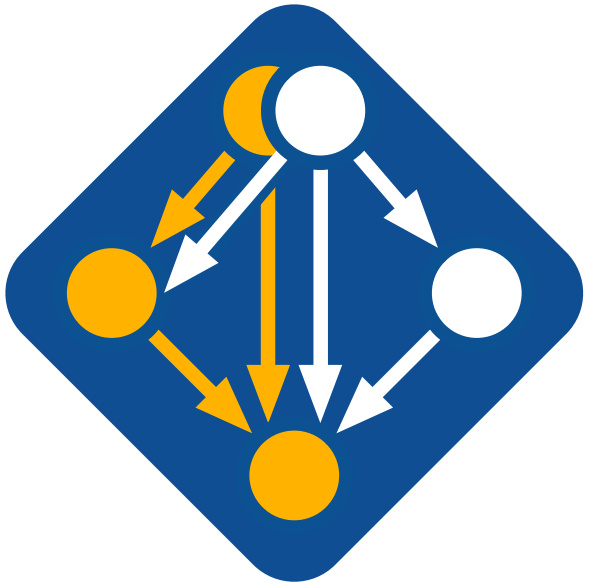
Binaries work *regardless of user's environment*.

Spack also generates module files.

- Don't *have* to use them.

The Spack community is growing rapidly

- **Spack simplifies HPC software for:**
  - Users
  - Developers
  - Cluster installations
  - The largest HPC facilities
- **Spack is central to ECP's software strategy**
  - Enable software reuse for developers and users
  - Allow the facilities to consume the entire ECP stack
- **The roadmap is packed with new features:**
  - Building the ECP software distribution
  - Better workflows for building containers
  - Stacks for facilities
  - Chains for rapid dev workflow
  - Optimized binaries
  - Better dependency resolution

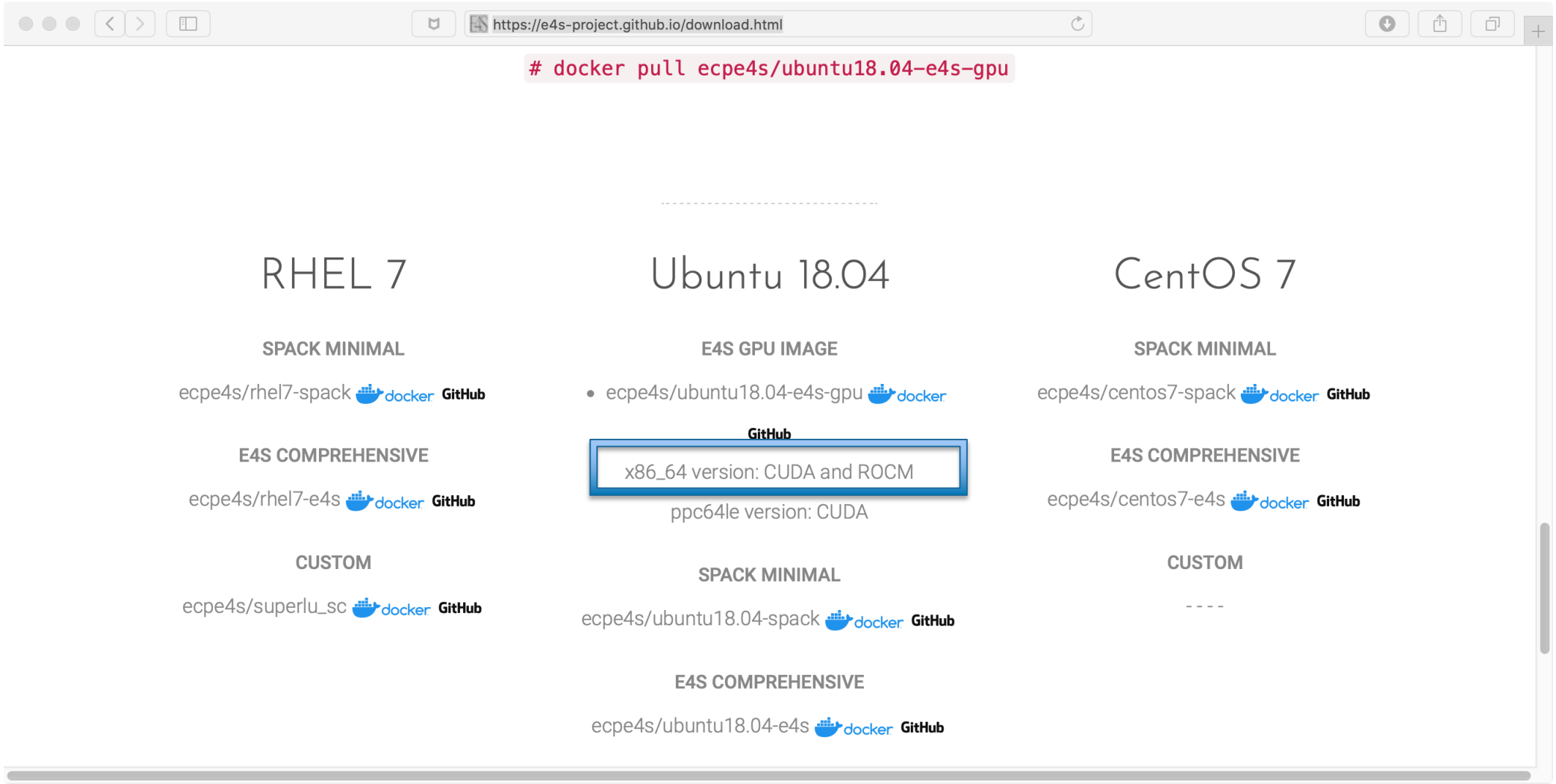


Visit spack.io

github.com/spack/spack

@spackpm

Download E4S v1.2 GPU Container Image



https://e4s.io

E4S v1.2 GPU Release for x86_64

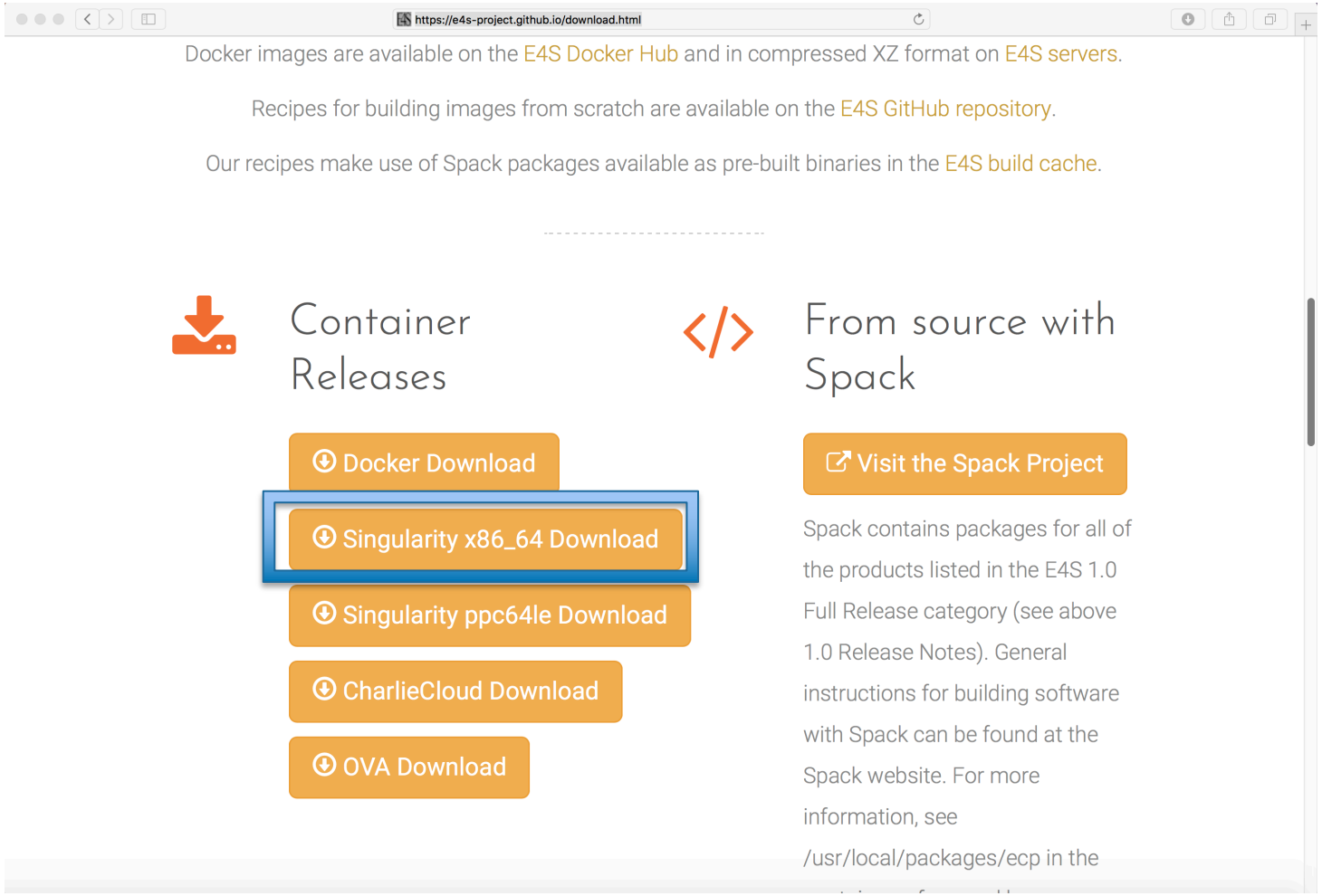
```
1: adios2       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/adios2-2.6.0-nkp24j7enorn3dt7626chuqm3pbkrvfe
2: aml  /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/aml-0.1.0-3mwyb6cf6ervfnruqb5u33v46buyuqth
3: arborx       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/arborx-0.9-beta-qjzxlkcgplto6pnpjwejoh5xpoik3adr
4: argobots     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/argobots-1.0-yoafg2slps7kp4dkmb6pzu5z2a37sgs4
5: ascent       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/ascent-develop-ciwqg6lh6unww3hjsnu47wr7cpqptqgy
6: axom         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/axom-0.3.3-tzyejxpy3p3ekaev35k2bhpkr74cnuhh
7: bolt         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/bolt-1.0-uxku5w5qdfnpa4atgzcbraq7wop7lunc
8: caliper      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/caliper-2.4.0-lfdx3gc6qodg2abbpovib3thdsmsamnn
9: darshan-runtime      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/darshan-runtime-3.2.1-jqugqxx2uunyaduoe3owhd2snves6mlr
10: dyninst     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/dyninst-10.2.1-xad3v6rvosm6qfai5fc7d4nn33svtzzf
11: faodel      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/faodel-1.1906.1-ijilel2vjionmj56mscqkw2hpecfsuym
12: flecsi      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/flecsi-1-c7sevlnc2ak4pf2jgq6wh3mwictch5l2
13: flit        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/flit-2.1.0-yvvog7kmax22ei2yyrwfxj3heinmz5am
14: gasnet      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/gasnet-2020.3.0-ufrq5hym67eq3jsg4jtttjjqgo4i6hnq
15: ginkgo      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/ginkgo-1.2.0-r6lorgchpr5qrcwyqqxtewqdhtpi4rmt
16: globalarrays        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/globalarrays-5.7-bow6d32j63j6gusotzjuityznwqvv64b
17: gotcha      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/gotcha-1.0.3-7n7bjnzsnf5w5tnihiok3otbaewdhjmu
18: hdf5        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/hdf5-1.10.6-k74avubedd5knvlc73dr3ib5oyw6bcwn
19: hpctoolkit  /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/hpctoolkit-2020.08.03-wck4g3h3jhfvzvxorelxqunbe3xsesry
20: hpx         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/hpx-1.5.0-pynmocntkmuwkowyo5jxtycvg34w6kue
21: hypre       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/hypre-2.19.0-vqo72wn6ei7ruitpg7drkje2rdbdfguo
22: kokkos      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/kokkos-3.2.00-pqv3uugd6cv3qftyur3rx6dm2gao2tg3
23: kokkos-kernels      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/kokkos-kernels-3.1.00-y4veufypftworlbehxusg4yzh6n7anhp
24: legion      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/legion-20.03.0-zkbz7h2wuze4dgbwcbo4w5fvqltugmog
25: libnrm      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/libnrm-0.1.0-kp5jb7o4kow25rnggiditwtmdbeebojs
26: libquo      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/libquo-1.3.1-w45wcw6dqbiajeeauj3ryaeskqu7bzx6
27: magma       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/magma-2.5.3-yksxthffslhjrhzwgcx7smz2tca6ojfn
28: mercury     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/mercury-1.0.1-ppledsr3drk2upciytfsuawfxrtjp73q
29: mfem        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/mfem-4.1.0-kivaike2qintplgufwp5yf2mj3n36ay3
30: mpich       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/mpich-3.2.1-kgwtpelzobpkrvg24ct6padfbhw7nene
31: mpifileutils        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/mpifileutils-develop-djje5g7ts55g3yic3bms426c2zi7gqsj
32: ninja       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/ninja-1.10.1-7zbbtuslw25nmqo4ur6abyyf3tchnqvv
33: omega-h     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/omega-h-9.29.0-eln73w7ytpvgqtkmkqyjm4gsabsu2w4p
```

- 67 ECP ST products
- Ubuntu v18.04 x86_64
- AI/ML package support
  - TensorFlow 2.3.5
  - PyTorch 1.8
  - Horovod
- Support for GPUs
  - AMD ROCm 3.8
  - NVIDIA CUDA 10.2, 11
- Kokkos with support for AMD GPUs!

E4S v1.2 GPU Release for x86_64

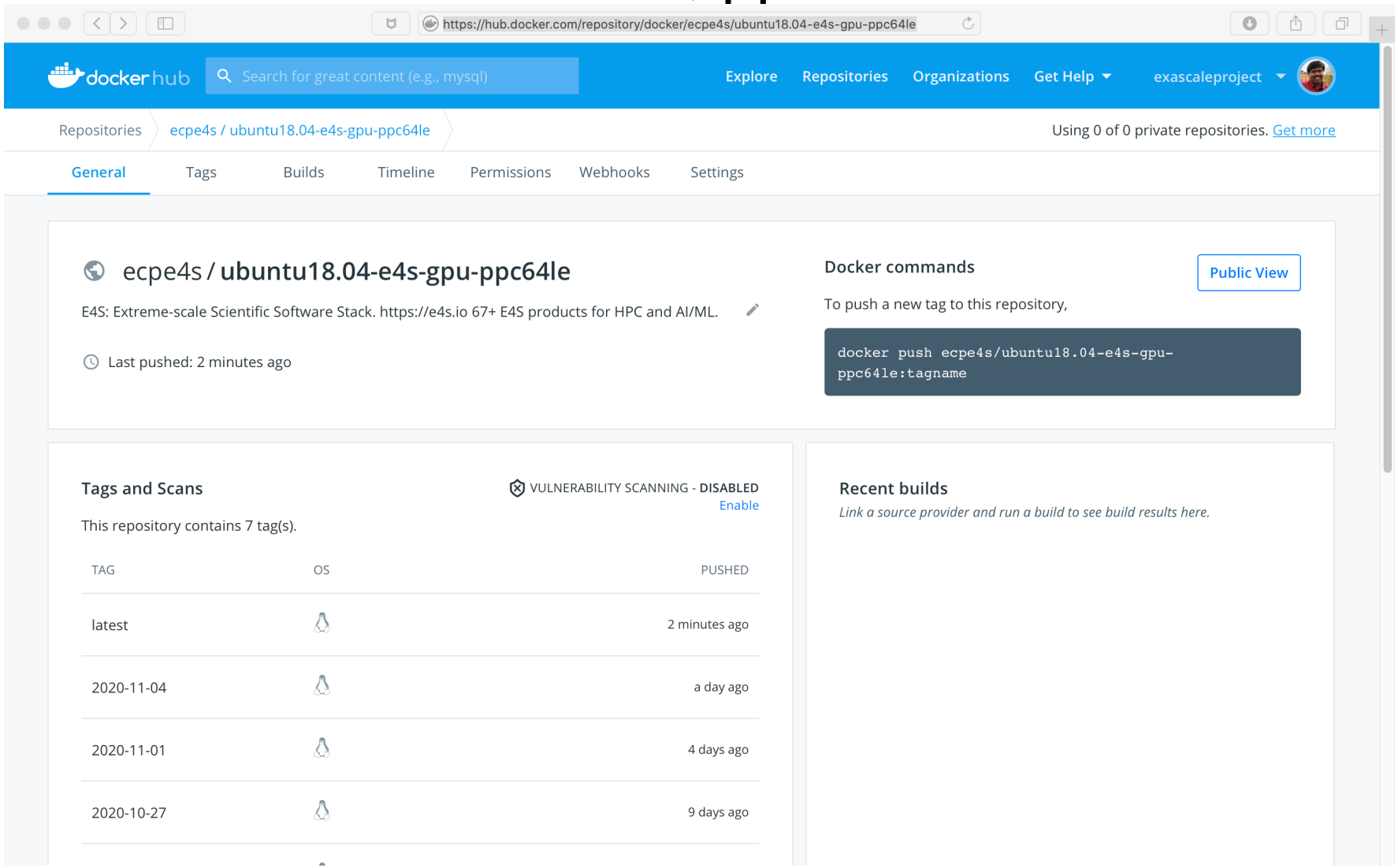
```
34: openpmd-api         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/openpmd-api-0.12.0-4myph6pbjnupgupxdlvbxvqqeqx6atyp
35: openmpi     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/openmpi-3.1.6-6yqtoym56as6xso2pdgkmn4bcsoyufku
36: papi        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/papi-6.0.0.1-gorrfrvrik575lldzgq46qmmu63kxl7x
37: papyrus     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/papyrus-develop-iu3dgpmwwyykgv5mpw2dwcrol4wbwbai
38: parallel-netcdf     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/parallel-netcdf-1.12.1-tmmkzibn43xr7su76msxxusyzrphdtn5
39: pdt         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/pdt-3.25.1-kvi5wuu5y72fypijti3nxqvdn7zpj6ni
40: petsc       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/petsc-3.13.4-llg3u4rrt5axrqlim75tt73epewxu4fb
41: plasma      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/plasma-19.8.1-tji7bojb5ne5hqj2mwn5bqq2tfkm23ke
42: precice     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/precice-2.1.0-ozdmbat2hlivccha3nklbeahikgynewu
43: pumi        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/pumi-2.2.2-52czzdbxeg7pmjkd55nub5jgxzodcprh
44: py-jupyterhub       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/py-jupyterhub-1.0.0-tr3wcolaij3kbzb6xm4mbbvakcstwsw3
45: py-libensemble      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/py-libensemble-0.7.0-mxvqxhiiblqnmhlfepbxboyiskqyvbej
46: qthreads    /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/qthreads-1.14-neshsclplh7ttkebm34grztaijqohnxt
47: raja        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/raja-0.11.0-w25bj2dys6cjqn7isgcjfyvte3tuulev
48: rempi       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/rempi-1.1.0-sideqdbiik2yseshs3loh4sictbis3t6
49: scr         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/scr-2.0.0-yh3chyq5gayuk6r4juejjiye6zg3rh3u
50: slate       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/slate-develop-jnysy2rh5vxhwua5ubtvq4bsfd3py7d5
51: slepc       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/slepc-3.13.4-q3lalpbqoshiyvjjgrnhb2iqiisvnfrp
52: strumpack   /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/strumpack-4.0.0-rlbti5eqc5rjhfisxv2uxevj6m3fn5gg
53: sundials    /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/sundials-5.3.0-3g52gh4a6h4ohucqart5i4m6pi66woj6
54: superlu-dist        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/superlu-dist-6.3.1-o2hkund66coxn2rrbtlalda2vq35uu7j
55: stc         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/stc-0.8.3-oxfik7nsmgufoqyy7xilzsrct7it63ej
56: swig        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/swig-4.0.1-htxmzjd5sed5yfibw6j7jn5cx6p7g72x
57: sz  /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/sz-2.1.9-tcatyiuzh6quctrgd2g3dcli7xa7gvtj
58: tasmanian   /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/tasmanian-7.1-quo3grs5kb2xrvjufpi7vn66cpjfnadv
59: tau         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/tau-2.29-ijw2nbphmlfkt42ubwz7g5a5yru22ikn
60: trilinos    /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/trilinos-13.0.0-6xfnp44g5xm7gpn2en6gkwzfceykfd3x
61: turbine     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/turbine-1.2.3-q4qjvgxjl3cbuyquo6zrurb4mwfn6wkp
62: umap        /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/umap-2.0.0-5tob3exzrmwoitudu5pstbb2dms3xnto
63: umpire      /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/umpire-3.0.0-6woo2uuvazcucxikc6xad6g3zksu2ygi
64: unifyfs     /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/unifyfs-0.9.0-be7mqbng7kdeewdlgvlhdm4jkxnquiil
65: upcxx       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/upcxx-2020.3.0-pshe62qyvmnrvesqa4pkj6bdq3fxxucf
66: veloc       /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/veloc-1.4-gk3iwfjhmgkwlawp7rmxf2eh37rqpqm2
67: zfp         /opt/spack/opt/spack/linux-ubuntu18.04-x86_64/gcc-7.5.0/zfp-0.5.5-6r6yaco7gga5w4gbuvid3zt2iohrnepj
```

E4S Support for Singularity Container Runtime [Sylabs.io]



- wget http://tau.uoregon.edu/ecp.simg
- singularity exec ecp.simg /bin/bash --rcfile /etc/bashrc
- spack find

E4S v1.2 Release: GPU, ppc64le for Docker Containers



- 67 ECP Products
- Support for GPUs
  - NVIDIA (CUDA 10.2)
  - ppc64le and x86_64

% docker pull ecpe4s/ubuntu18.04-e4s-gpu

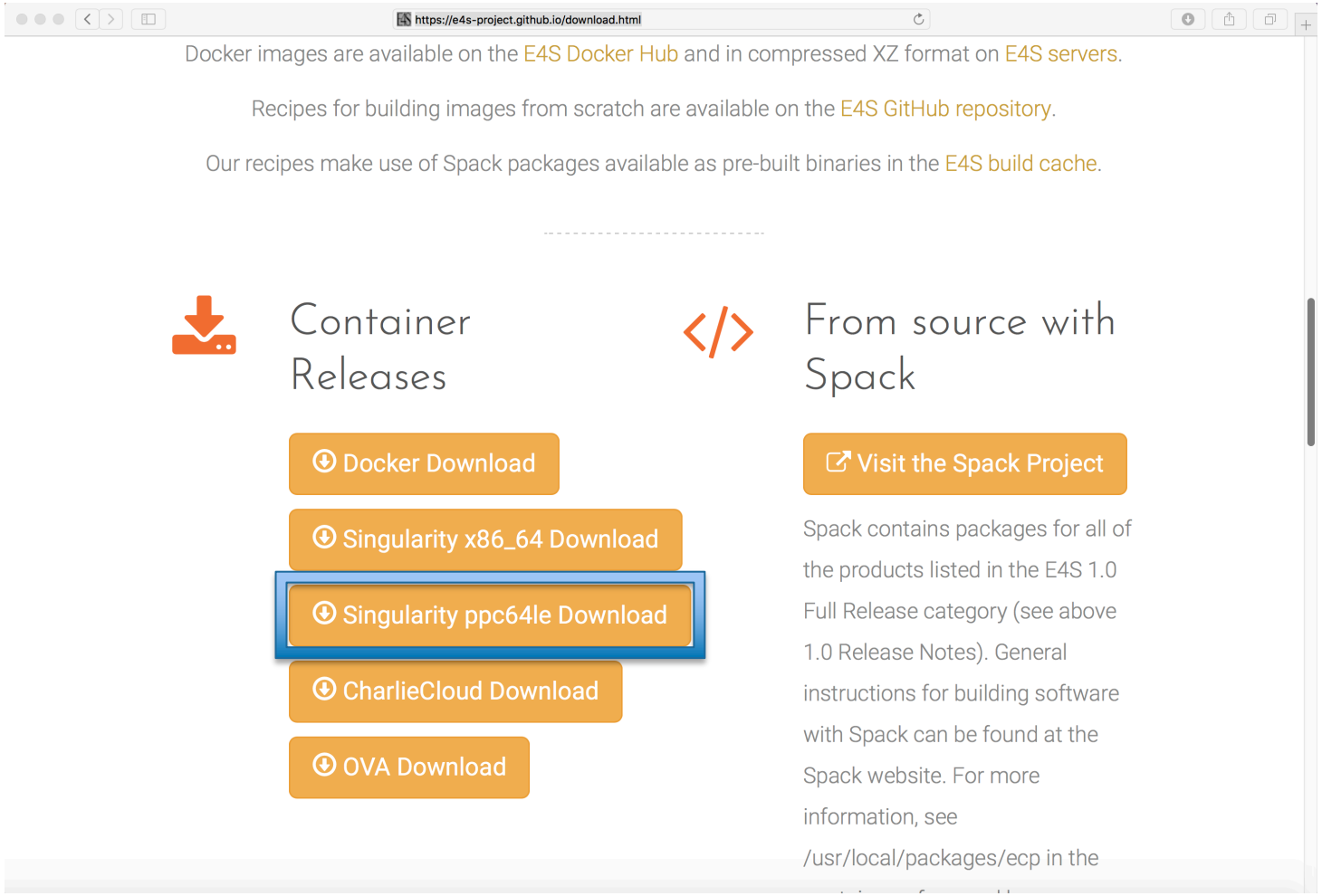
E4S v1.2 GPU Release: 67 E4S Products (ppc64le)

```
1: adios2       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/adios2-2.6.0-veoqi5iqkx4kbeddhxoroggvxqqbtvos
2: aml  /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/aml-0.1.0-ftizegmvpbweuyzg75g3ndzhdyjx37op
3: amrex        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/amrex-20.10-4z5quvlqt3fbzv5n6rrjv5byq7472emy
4: arborx       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/arborx-0.9-beta-p7lw7eobsrdpqwhb7ispxgphng2tn4nt
5: ascent       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/ascent-develop-7ktzsmvluqvd4xzoop7hjwddyjetn2ai
6: axom         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/axom-0.3.3-zfgqs6qa6vxlodjnaojeffmyl26czmp5
7: argobots     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/argobots-1.0-qra2gqxuisqqlbdfrhwm5mvq2iga3l3l
8: bolt         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/bolt-1.0-ojy67rk47pcbqpcvuq6a4c7g7qysvndv
9: caliper      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/caliper-2.4.0-6xzehuxs2updvdrl2tdvcym3n6nf3y3l
10: darshan-runtime     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/darshan-runtime-3.2.1-6uzihv7v75yu47c2jca4qpxqdtgptn2g
11: dyninst     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/dyninst-10.2.1-jvqx4j3ehuh73pp67b4vdy4co3kivma5
12: faodel      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/faodel-1.1906.1-r77asm5xkb256omn4trg5hnxc3e376uy
13: flecsi      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/flecsi-1-2kxukdrijujvbmsabmmj3um54ukhrayk
14: flit        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/flit-2.1.0-tepzltg6kmefdg4eo2rbzwmjeca56bmc
15: gasnet      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/gasnet-2020.3.0-uynuhs6itzczkfpgbnlm2xgotvqmmeb6
16: ginkgo      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/ginkgo-1.3.0-dodvdbixjpdg5ci5xrgomjeqybiob33i
17: globalarrays        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/globalarrays-5.7-3zbsvrakwto5jc454jl3l36rpvray25h
18: gotcha      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/gotcha-1.0.3-pvjdzcg3fggpagjcsorwidsllflmomnz
19: hdf5        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/hdf5-1.10.6-arkkhmy4auglzqndt7xraupyvgkrpv7o
20: hpctoolkit  /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/hpctoolkit-2020.08.03-yqayfprp2aleaxtzq543c75lcvcviso7
21: hpx         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/hpx-1.5.1-tzfs3nkglsacequjxflokigwgjzabybk
22: hypre       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/hypre-2.20.0-ewmv445dkzmju4upg4rregq7apgkcdbu
23: kokkos      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/kokkos-3.2.00-3qzjrzoxl5lpqgtaq4atid6ylgkko3uk
24: kokkos-kernels      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/kokkos-kernels-3.2.00-n4trpqubmexqahdy4tolj6nhfml5j4v6
25: legion      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/legion-20.03.0-xsotehq7eg77hcguvqx5qymfhimgtuic
26: libnrm      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/libnrm-0.1.0-q67khfosljacbl3djdg5jeh4thsl5p5f
27: libquo      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/libquo-1.3.1-syjf6c3adia34wlwneacynrwkhh72i3u
28: magma       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/magma-2.5.4-fzeektdrkybbuo6i6niikzglcwlnt2jx
29: mercury     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/mercury-1.0.1-ufxkkvb7osjnwgbfevdhtrmtuoj6dfbz
30: mfem        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/mfem-4.1.0-qrepufdzopbphsyuyc6npn7k2tpprd5w
31: mpich       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/mpich-3.2.1-5m7ofmtvtov45hcudrm3qvd2dyheunyv
32: mpifileutils        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/mpifileutils-develop-rd5xj2pmx5vdd7fddrhbrvn2uykg4uay
33: ninja       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/ninja-1.10.1-cr2ada5fjgvkvdtmxel4zj6venfiif5e
```

E4S v1.2 GPU Release: 67 E4S Products (ppc64le)

```
34: omega-h     /opt/spack/opt/spack/linux-ubuntu18.04-power9le/gcc-7.3.0/omega-h-9.29.0-ziz55mnp5r7l4kuhx4zqmjp2imjdvrk5
35: openmpi     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/openmpi-3.1.6-utceq6uech6rgnabxevau4lhtzrwbaol
36: openpmd-api         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/openpmd-api-0.12.0-szt65gmfb76iwdbcfkhryfztg5jwjd7g
37: papi        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/papi-6.0.0.1-xu35qtffffq2ofyjic3fafmj6yeijoih
38: papyrus     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/papyrus-develop-2zopf6p3ha4v7ijxslxskrf2qyhpt3py
39: parallel-netcdf     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/parallel-netcdf-1.12.1-svuejkorgi2bzvhgq4wts72bcjfn426r
40: pdt         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/pdt-3.25.1-opxwliyf5vqgt3hbla7qspf3laaqbt74
41: petsc       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/petsc-3.14.0-phaqc52ryvhcib37qqjg2lmqdebql2uo
42: plasma      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/plasma-20.9.20-vc4olrzgwsvqx7mevom2j7mhsgb6ynam
43: precice     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/precice-2.1.1-qlitin5qdhtz3n7rg4jjzxkdss4qocvn
44: pumi        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/pumi-2.2.2-m4uipa7yh632dftix4kzyxcz3pm3fasv
45: py-jupyterhub       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/py-jupyterhub-1.0.0-gzzlya6f4gr2xgsgpndmbp2pkffm3tuc
46: py-libensemble      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/py-libensemble-0.7.1-oee4zlxigkjc5nnkr6fyu7thzsnftvvu
47: py-petsc4py         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/py-petsc4py-3.13.0-g2rp2v37qbpx5fo5fmg6c4xtrj6shsbz
48: qthreads    /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/qthreads-1.14-bdxplr2gf7knpek4vo5sjvzh5py5fdaf
49: raja        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/raja-0.12.1-q32nuxmeowavkwzmoiwx6f5md246tw66
50: rempi       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/rempi-1.1.0-h3x5q2rwwsv34v7e4ricjw65wcd5mvkg
51: scr         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/scr-2.0.0-2okrlxki5b63gzakjy2x4sbovrmegmcx
52: slate       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/slate-develop-2jp7v35nifhyucbf4vmi3mjsernm5t26
53: slepc       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/slepc-3.14.0-7qn6k5qxzf32tc2cnuk2mknlvqvv6hfw
54: strumpack   /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/strumpack-5.0.0-gy5opc36suubh6uoiqy4l223psdyrilg
55: sundials    /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/sundials-5.4.0-wonraynurs6xhyv6m6bc7o4grlwchlnp
56: superlu-dist        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/superlu-dist-6.3.1-poufv43kq7tw2rw6upldbpcpabkpbdta
57: swig        /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/swig-4.0.2-3bddrfojvkrowa43v5so3ongbmhzxx5s
58: sz  /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/sz-2.1.10-fld5xazn2spjg46yaaaam5gftgyb5loa
59: tasmanian   /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/tasmanian-7.3-zbz26kn2yabritfi2wsbqv5raexgi4p3
60: tau         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/tau-2.29-zqbkmoraislptbdny6fw4pakoipm3cbv
61: trilinos    /opt/spack/opt/spack/linux-ubuntu18.04-power9le/gcc-7.3.0/trilinos-13.0.0-olf4mdmym4sjbgue66gx42k7dbeb6z27
62: turbine     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/turbine-1.2.3-jy42tjmn7rd2ofwwb3jaanlri2hnte65
63: umpire      /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/umpire-4.0.1-ynagdhefpcujnpeybxtasoqecr2p7bxj
64: unifyfs     /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/unifyfs-0.9.0-sxswh3b5upcys4bxc5wdzczvwxvn6emg
65: upcxx       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/upcxx-2020.3.0-i6hf7mat23um3fz5wexqswvn6mm4o7zp
66: veloc       /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/veloc-1.4-7ygadmpwv2zr26ec6opicysts4mxkwym
67: zfp         /opt/spack/opt/spack/linux-ubuntu18.04-ppc64le/gcc-7.3.0/zfp-0.5.5-3r4a4s3qdeqbdabvlwlswrgig62yc6yj
```

E4S Support for Singularity Container Runtime [Sylabs.io]

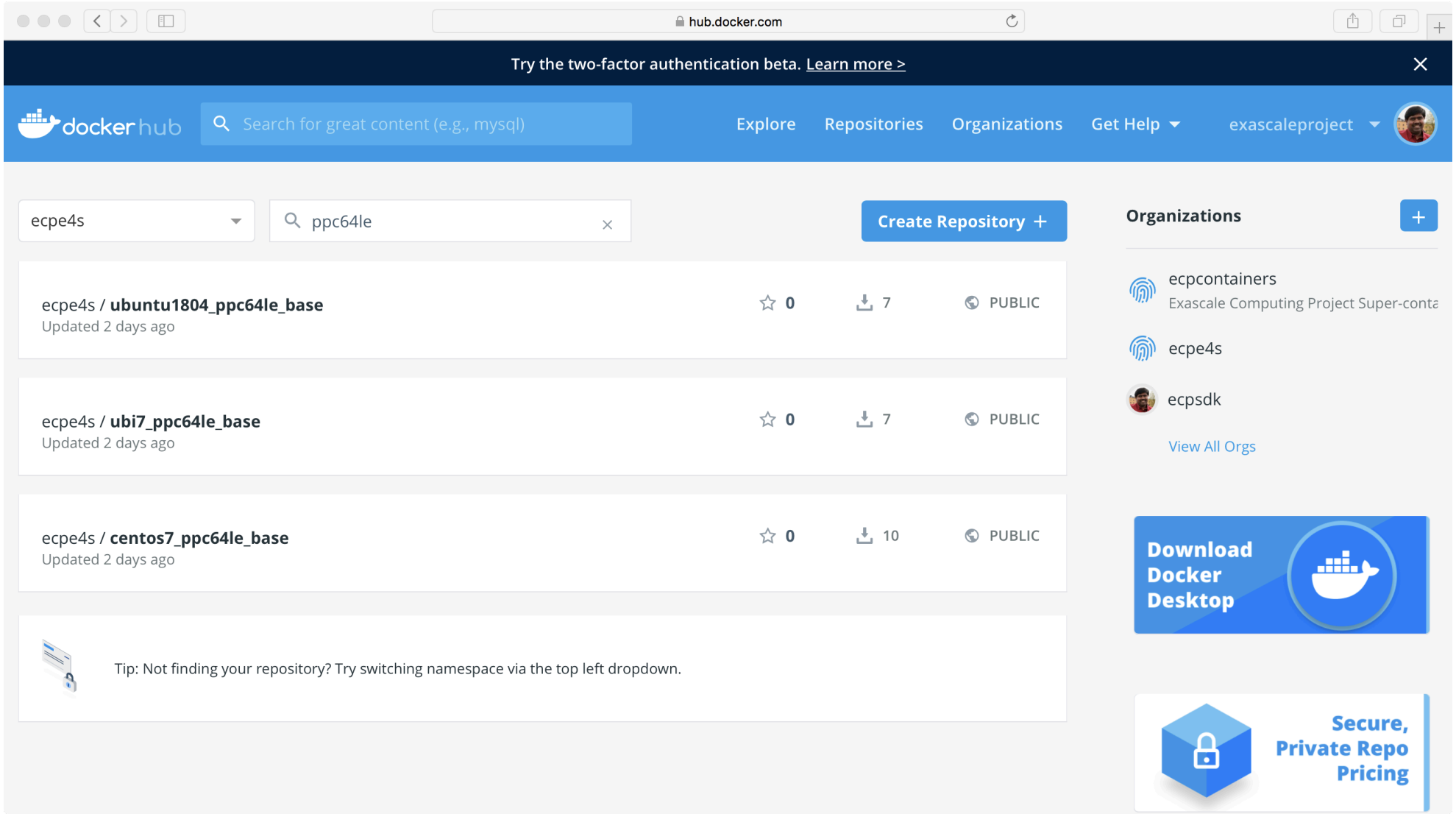


- wget http://oaciss.uoregon.edu/e4s/images/ubuntu18.04-e4s-gpu-ppc64le_1.2.simg
- singularity exec --nv ubuntu18.04-e4s-gpu-ppc64le_1.2.simg /bin/bash --rcfile /etc/bashrc
- spack find; module avail

E4S v1.2 GPU Support

```
alias runsi='singularity exec --nv /home/users/sameer/images/ubuntu18.04-e4s-gpu-ppc64le_1.2.simg /bin/bash --rcfile /etc/bashrc'
[sameer@gorgon ~]$ runsi
Singularity> python
Python 3.6.10 |Anaconda, Inc.| (default, Jan  7 2020, 21:47:07)
[GCC 7.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import tensorflow
>>> import torch
>>> import cv2
>>> import matplotlib
>>> import numpy
>>> tensorflow.test.is_gpu_available()
2020-11-05 17:09:35.705979: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1433] Found device 0 with properties:
name: Tesla V100-SXM2-32GB major: 7 minor: 0 memoryClockRate(GHz): 1.53
pciBusID: 0004:04:00.0
totalMemory: 31.75GiB freeMemory: 12.35GiB
2020-11-05 17:09:35.778351: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1433] Found device 1 with properties:
name: Tesla V100-SXM2-32GB major: 7 minor: 0 memoryClockRate(GHz): 1.53
pciBusID: 0004:05:00.0
totalMemory: 31.75GiB freeMemory: 31.44GiB
2020-11-05 17:09:35.907371: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1433] Found device 2 with properties:
name: Tesla V100-SXM2-32GB major: 7 minor: 0 memoryClockRate(GHz): 1.53
pciBusID: 0035:03:00.0
totalMemory: 31.75GiB freeMemory: 883.50MiB
2020-11-05 17:09:35.989499: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1433] Found device 3 with properties:
name: Tesla V100-SXM2-32GB major: 7 minor: 0 memoryClockRate(GHz): 1.53
pciBusID: 0035:04:00.0
totalMemory: 31.75GiB freeMemory: 31.44GiB
2020-11-05 17:09:35.989594: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1512] Adding visible gpu devices: 0, 1, 2, 3
2020-11-05 17:09:45.948104: I tensorflow/core/common_runtime/gpu/gpu_device.cc:984] Device interconnect StreamExecutor with strength 1 ed
ge matrix:
2020-11-05 17:09:45.948182: I tensorflow/core/common_runtime/gpu/gpu_device.cc:990]      0 1 2 3
2020-11-05 17:09:45.948199: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1003] 0:   N Y Y Y
2020-11-05 17:09:45.948210: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1003] 1:   Y N Y Y
2020-11-05 17:09:45.948222: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1003] 2:   Y Y N Y
2020-11-05 17:09:45.948232: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1003] 3:   Y Y Y N
2020-11-05 17:09:45.950552: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1115] Created TensorFlow device (/device:GPU:0 with 11587
MB Snapz Pro X  physical GPU (device: 0, name: Tesla V100-SXM2-32GB, pci bus id: 0004:04:00.0, compute capability: 7.0)
```

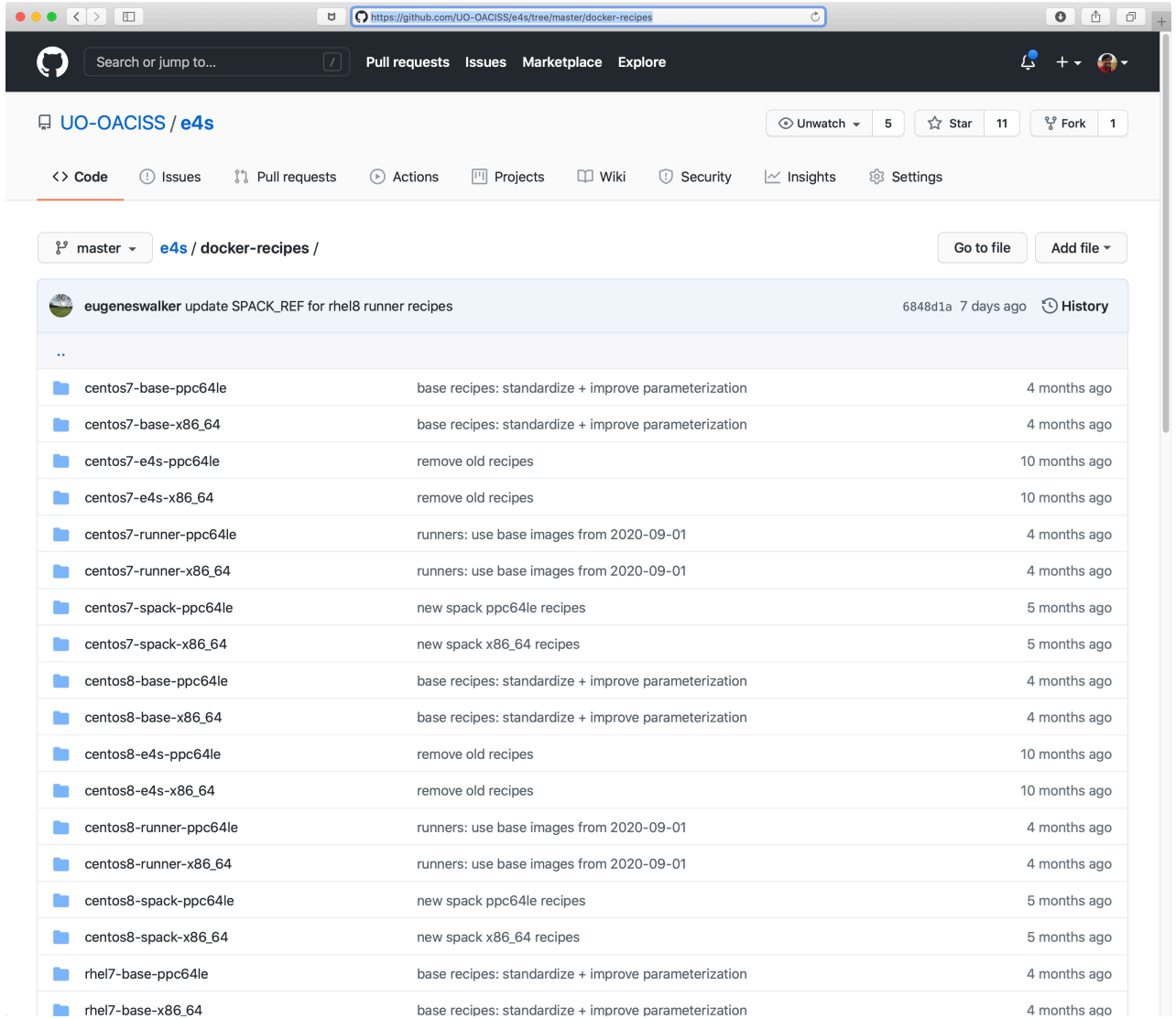
E4S: ppc64le Base Container Images



- Hub.docker.com
- ecpe4s

- Ubuntu 18.04
- RHEL/UBI 7.6
- Centos 7.6

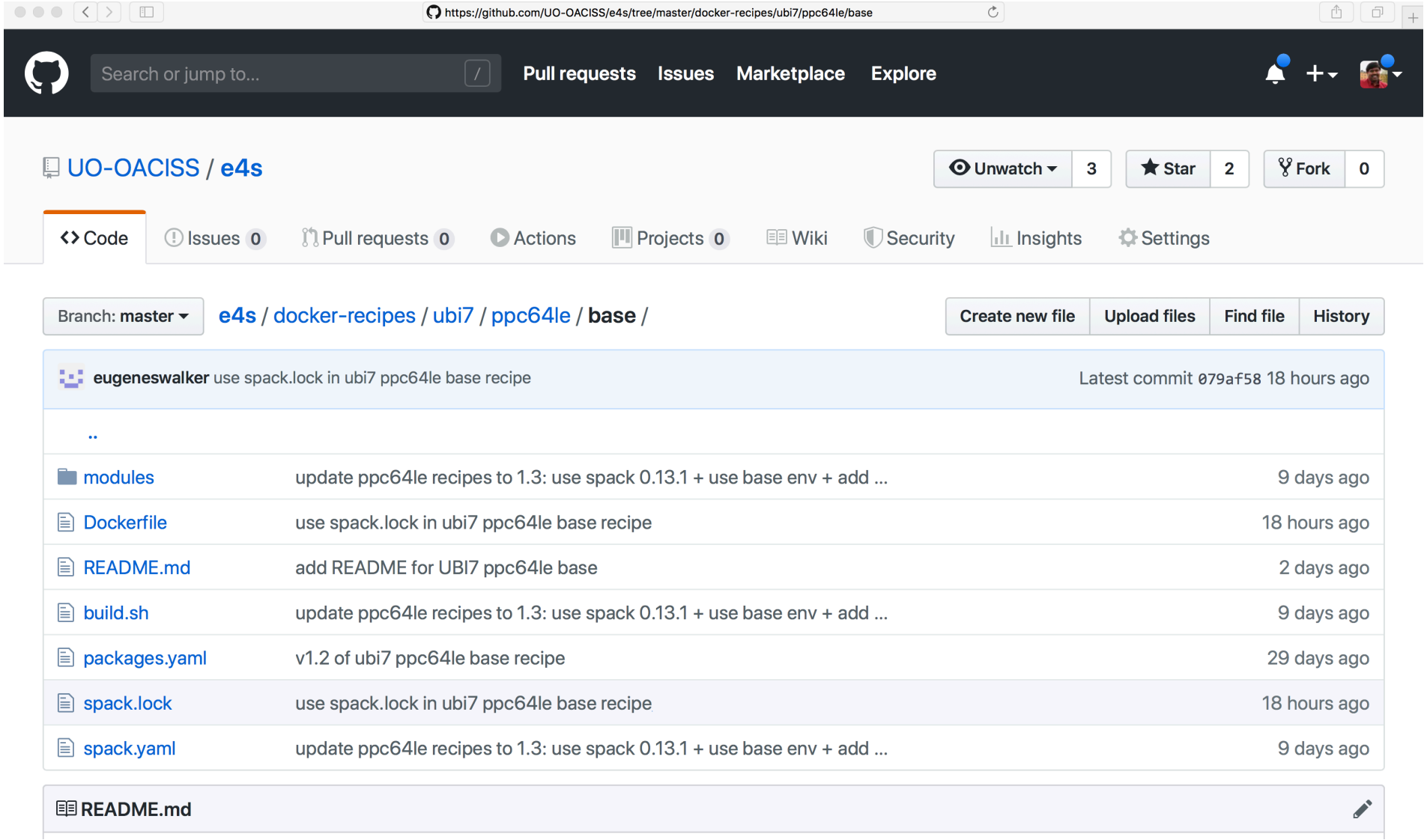
Multi-platform E4S Docker Recipes



10 lines (6 sloc) | 178 Bytes

```
1  FROM ecpe4s/ubuntu18.04-spack-x86_64:0.14.1
2
3  WORKDIR /e4s-env
4
5  COPY /spack.yaml .
6
7  RUN spack install --cache-only \
8   && spack clean -a && rm -rf /tmp/root/spack-stage
9
10 WORKDIR /
```

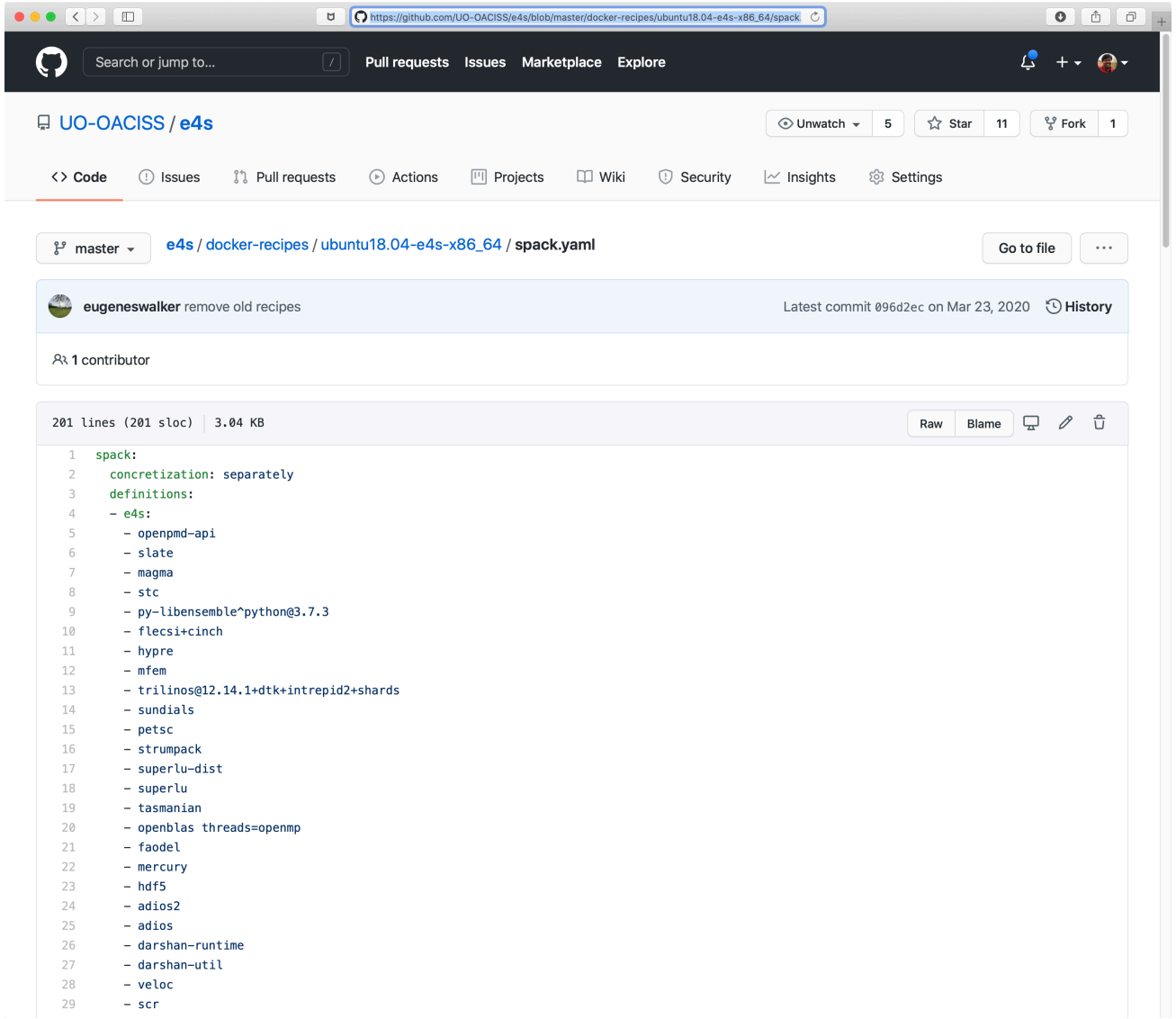
E4S: Multi-platform Reproducible Docker Recipes



E4S
- x86_64
- ppc64le
- aarch64

https://e4s.io

E4S Spack environment spack.yaml

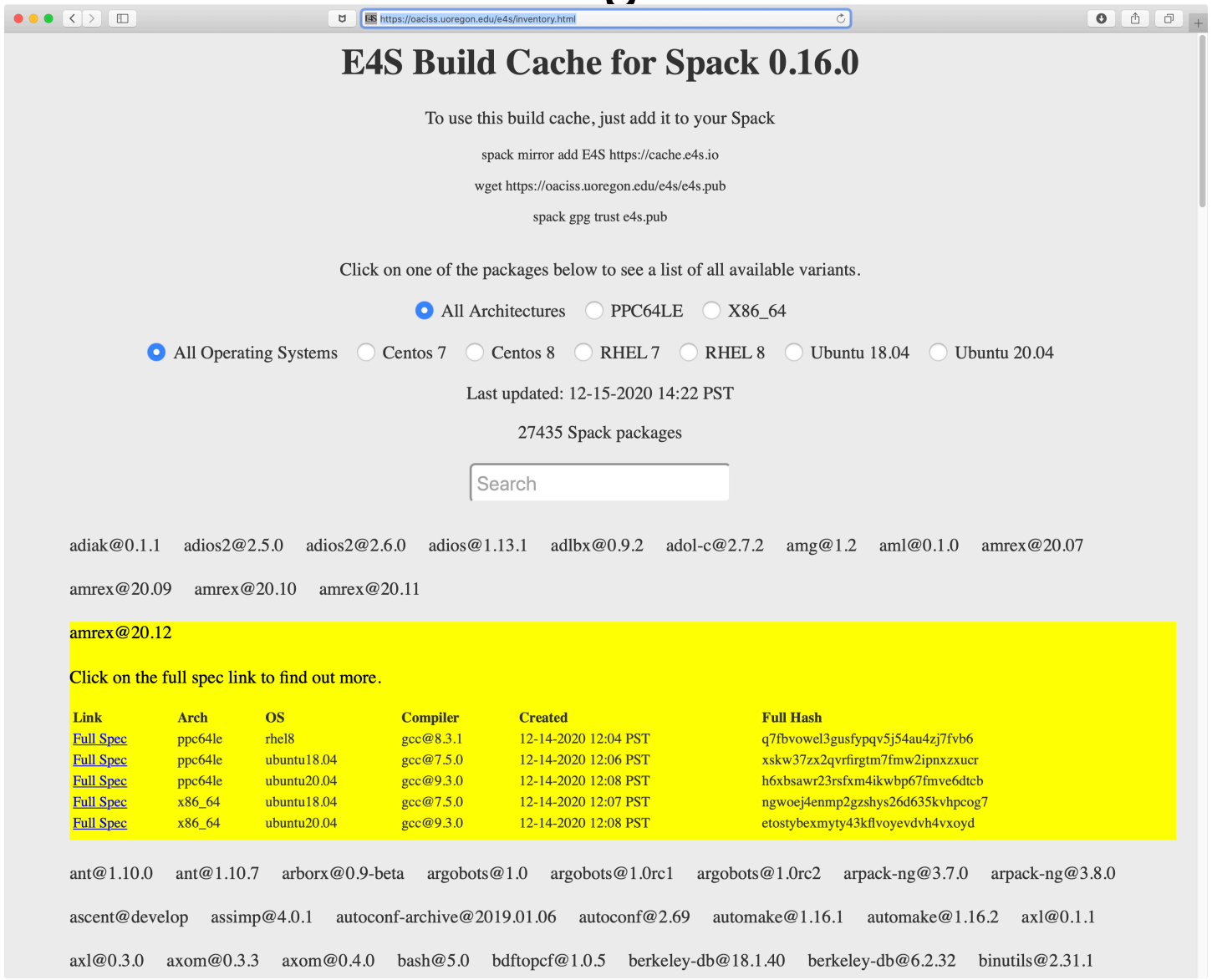


- Bare-metal install
  % cat spack.yaml
  % spack -e . install
- Docker build:

Executable File | 2 lines (2 sloc) | 78 Bytes

```
#!/bin/bash -x
docker build --no-cache -t ecpe4s/ubuntu18.04-e4s-x86_64:1.2 .
```

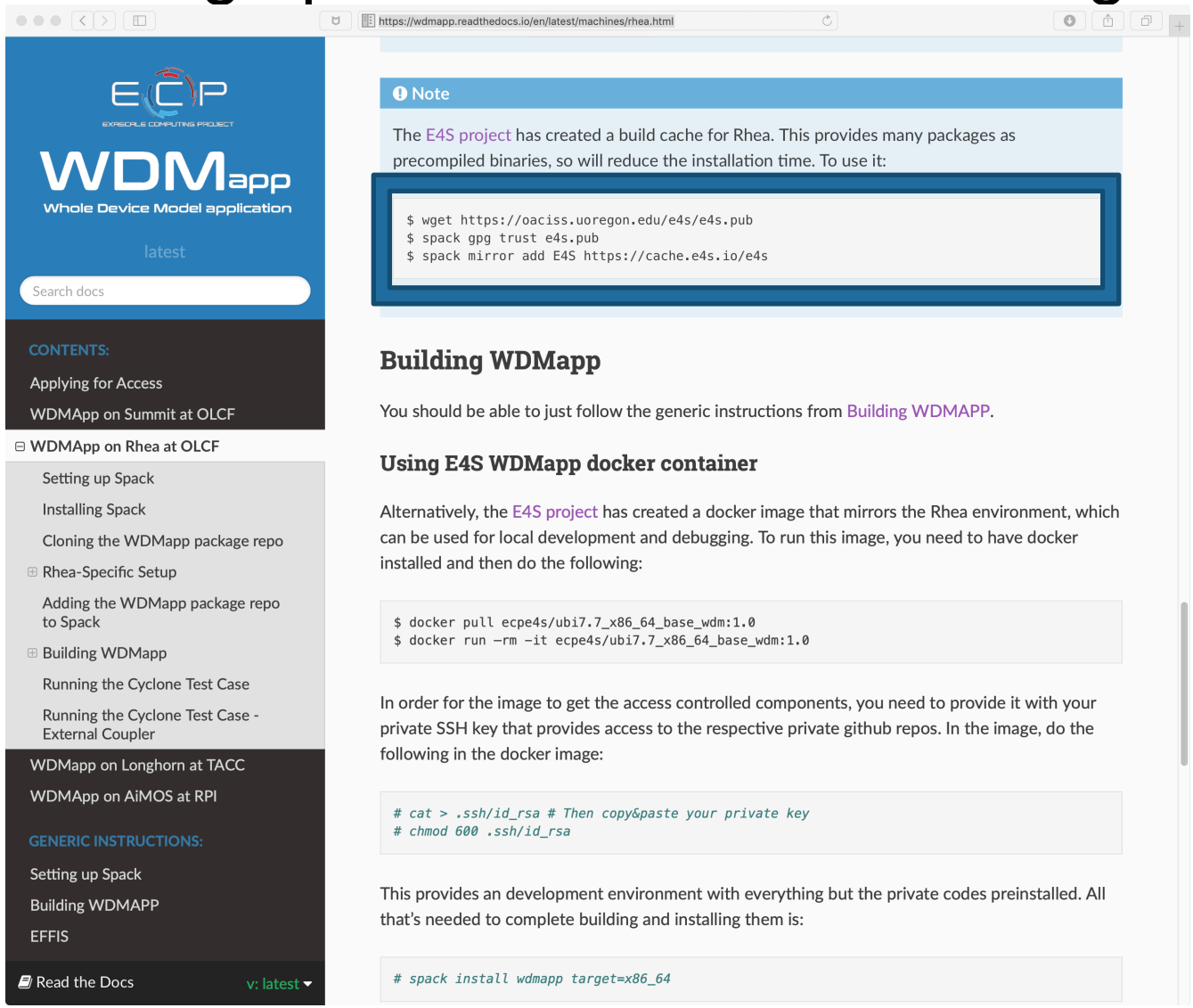
E4S: Spack Build Cache at U. Oregon



- 27,000+ binaries
- S3 mirror
- No need to build from source code!

- https://oaciss.uoregon.edu/e4s/inventory.html

WDMApp: Speeding up bare-metal installs using E4S build cache



- E4S Spack build cache
- Adding E4S mirror
- WDMApp install speeds up!

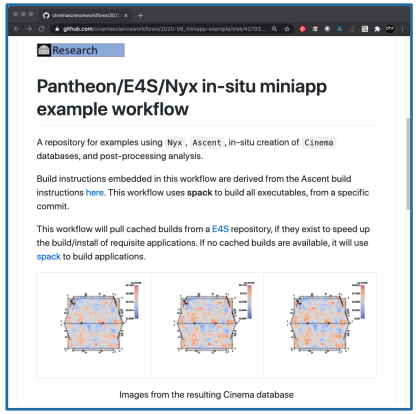
Pantheon and E4S build cache support end-to-end ECP examples

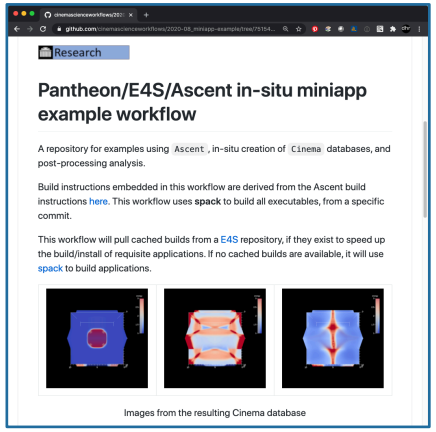
Overview: The Exascale Computing Project (ECP) is a complex undertaking, involving a myriad of technologies working together. An outstanding need is a way to capture, curate, communicate and validate workflows that cross all of these boundaries.

The **Pantheon** and **E4S** projects are collaborating to advance the integration and testing of capabilities, and to promote understanding of the complex workflows required by the ECP project. Utilizing a host of ECP technologies (spack, Ascent, Cinema, among others), this collaboration brings curated workflows to the fingertips of ECP researchers.

Contributions

- Curated end-to-end application/in-situ analysis examples can be run quickly by anyone on Summit. (https://github.com/pantheonscience/ECP-E4S-Examples)
- Pantheon/E4S integration speeds up build/setup times over source builds due to cached binaries (approx.10x speed up).





Instructions page for (top) Nyx, Ascent and Cinema workflow repository, and (bottom) Cloverleaf3d, Ascent, Cinema workflow. These curated workflows use Pantheon, E4S and spack to provide curated workflows for ECP.

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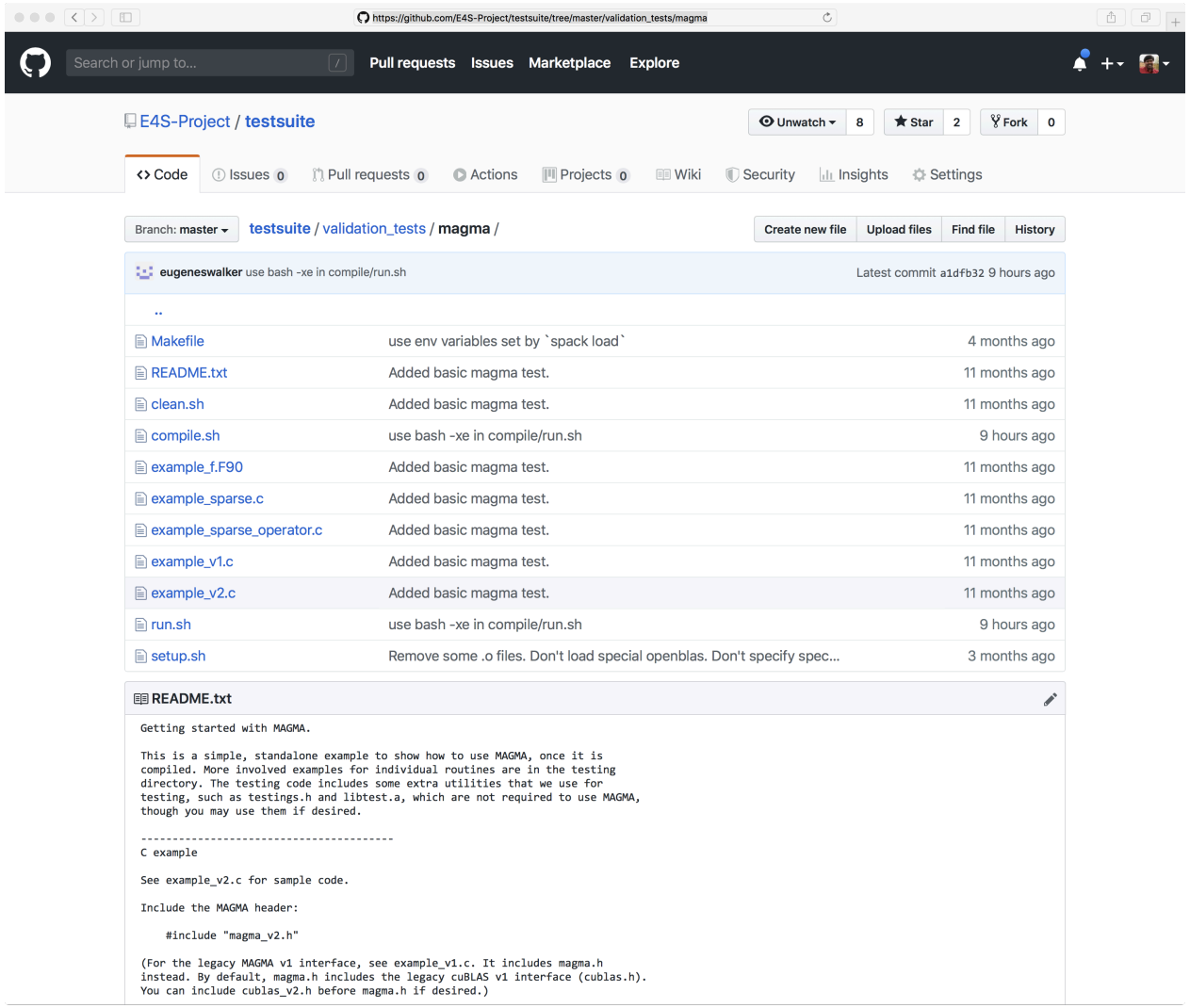
E4S Validation Test Suite

- Provides automated build and run tests
- Validate container environments and products
- New LLVM validation test suite for DOE LLVM



- git clone https://github.com/E4S-Project/testsuite.git

Reproducible Container Builds using E4S Base Images

UO-OACISS / e4s

Unwatch 3 | Star 0 | Fork 0

Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Security | Insights | Settings

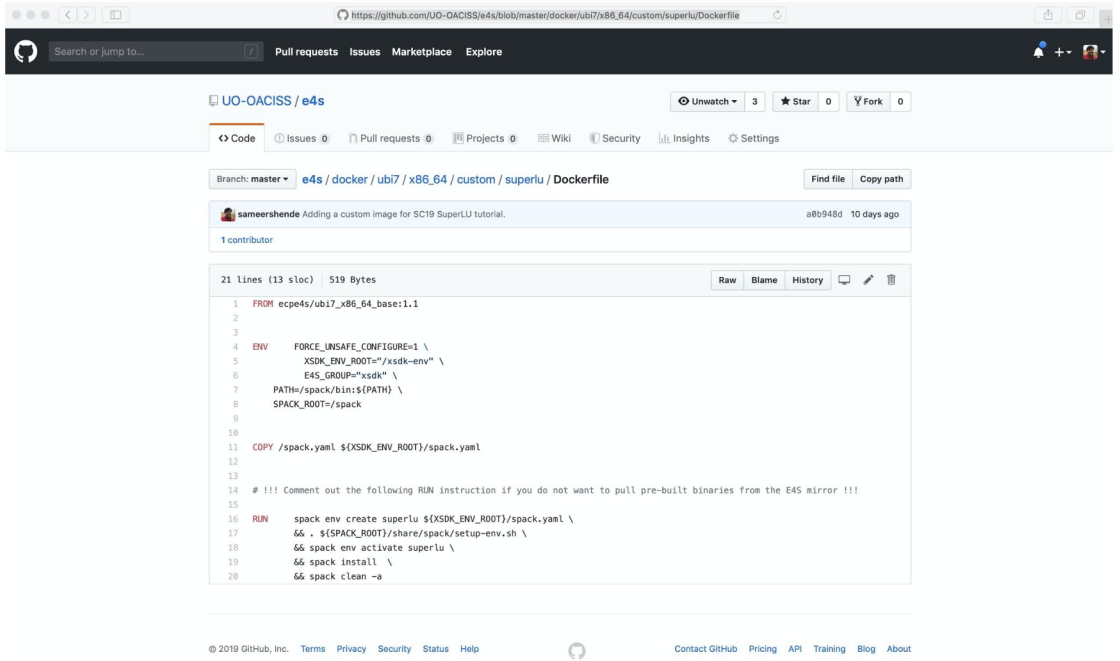
Branch: master — e4s / docker / ubi7 / x86_64 / custom / superlu / spack.yaml — Find file | Copy path

sameershende Adding a custom image for SC19 SuperLU tutorial. a0b948d 10 days ago

1 contributor

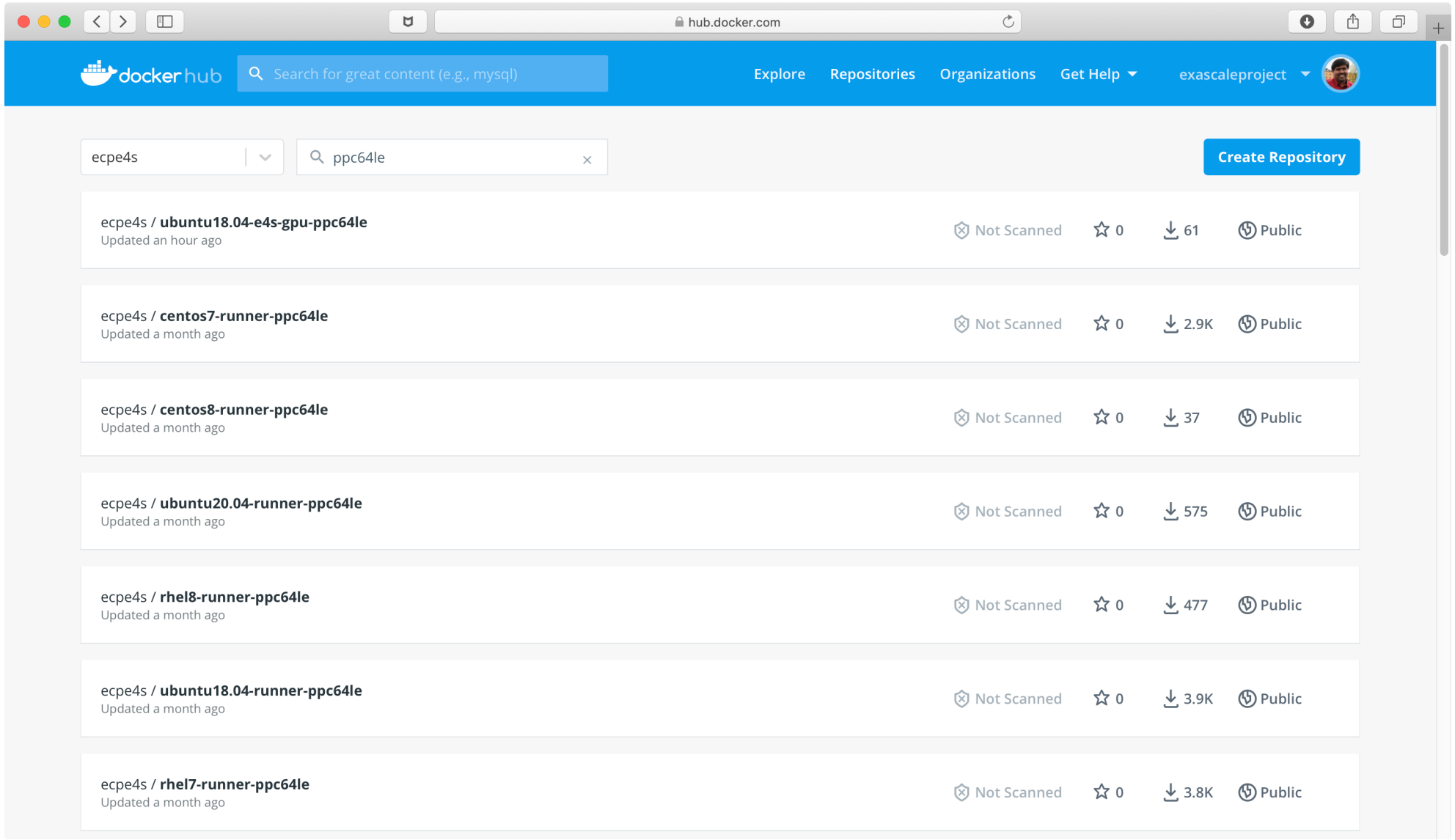
35 lines (34 sloc) | 579 Bytes — Raw | Blame | History

```
spack:
  packages:
    all:
      compiler: [gcc@7.3.0]
      variants: +mpi
      providers:
        mpi: [mpich]
      buildable: true
      version: []
      paths: {}
      modules: {}
    mpich:
      version: [3.2.1]
      variants: ~wrapperrpath
      buildable: true
      providers: {}
      paths: {}
      modules: {}
      compiler: []
    gcc:
      version: [7.3.0]
      buildable: true
      providers: {}
      paths: {}
      modules: {}
      compiler: []
  specs:
  - superlu-dist
  - petsc
  - mfem
  - strumpack
  - butterflypack
  - openblas
  view: false
```



- PMR SDK base image has Spack build cache mirror and GPG key installed.
- Base image has GCC and MPICH configured for MPICH ABI level replacement (with system MPI).
- Customized container build using binaries from E4S Spack build cache for fast deployment.
- No need to rebuild packages from the source code.
- Same recipe for container and native bare-metal builds with Spack!

E4S: GitLab Runner Images

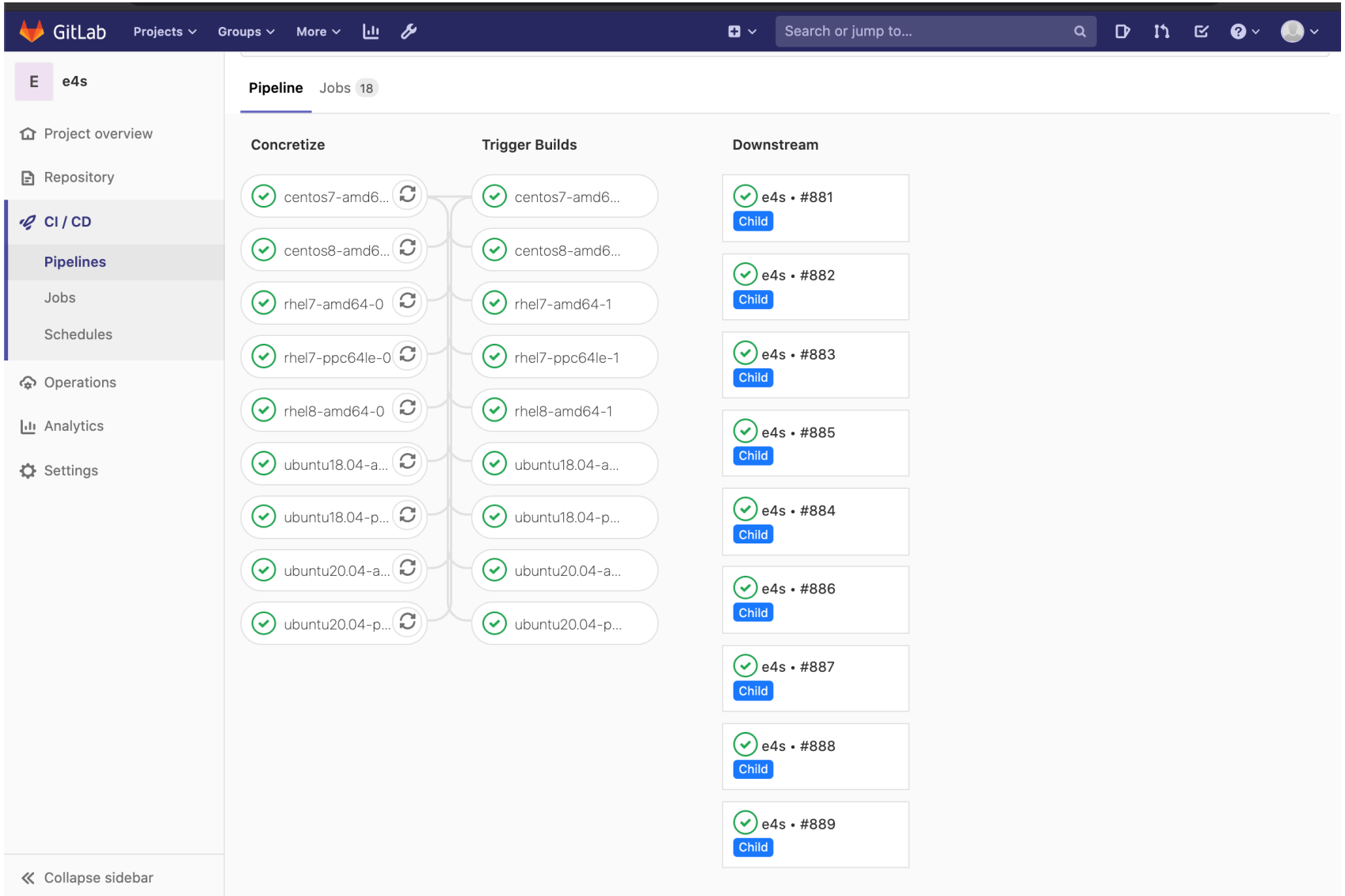


- Dockerhub
- Bare-bones
- Multi-platfrom
- Build E4S

University of Oregon GitLab CI

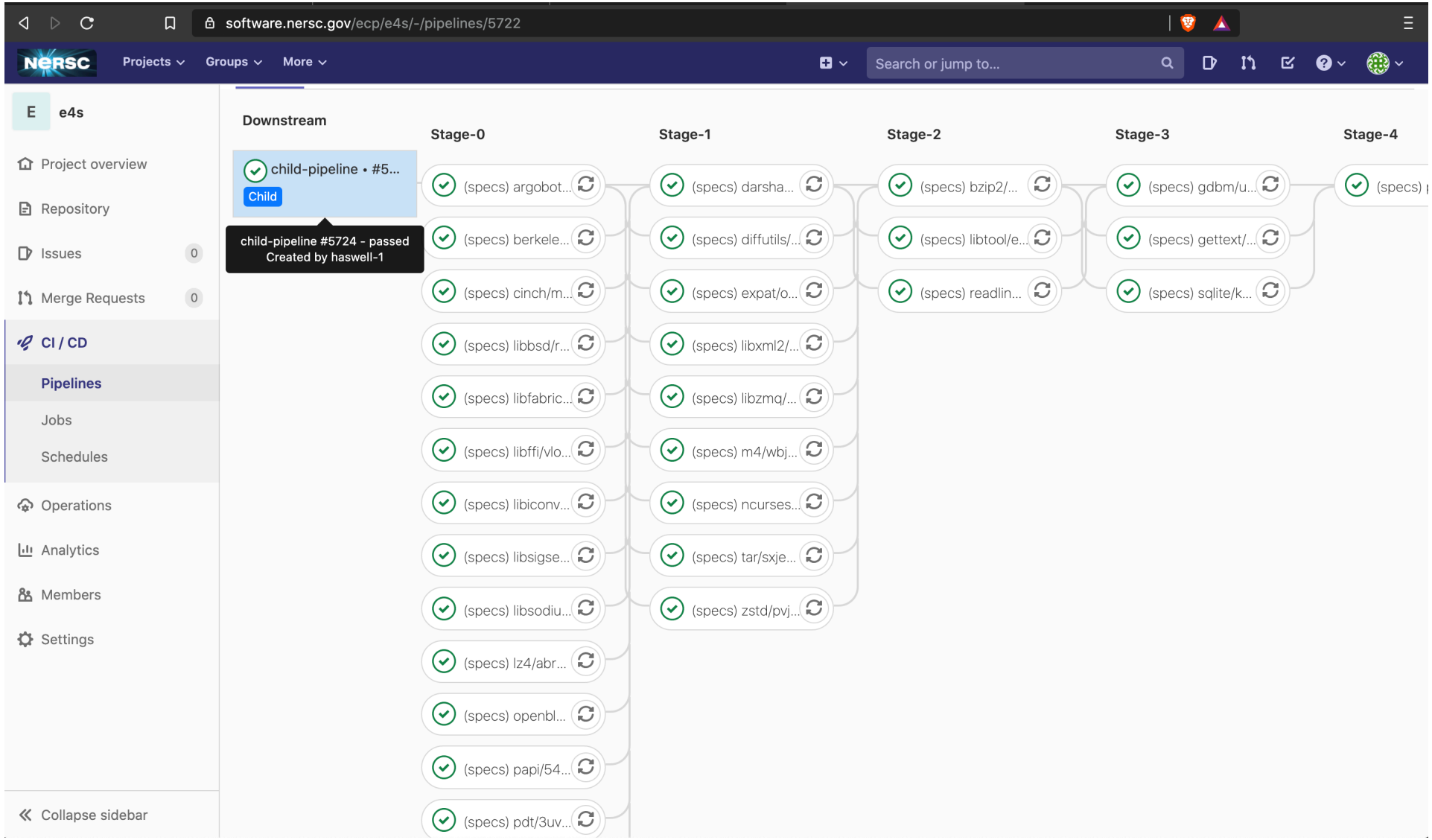
E4S Builds:
- Ubuntu 18.04
- Ubuntu 20.04
- RHEL 7.6
- RHEL 8
- CentOS 7
- CentOS 8

Architectures:
ppc64le and x86_64

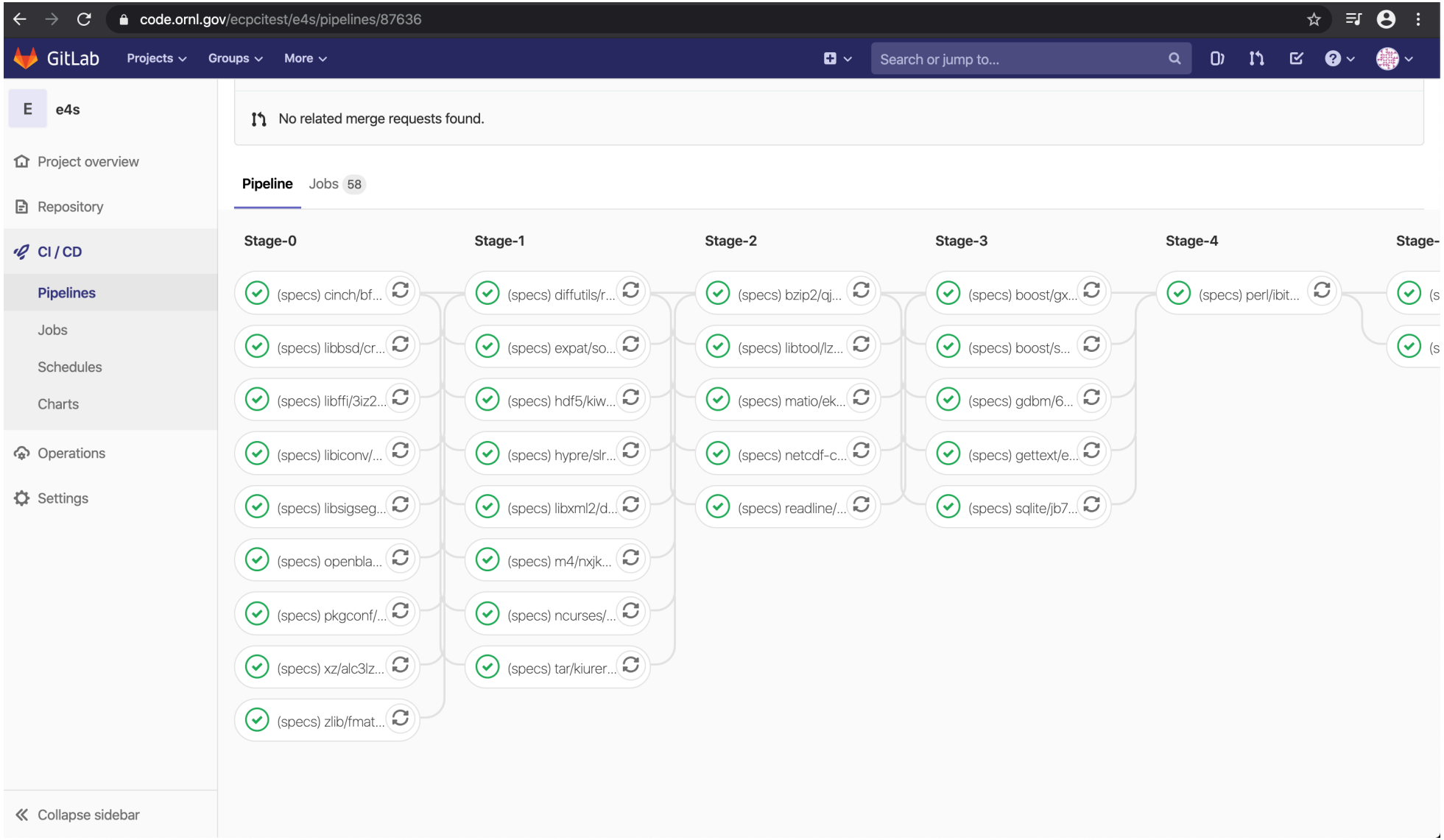


- https://gitlab.e4s.io

Multi-stage E4S CI Build Pipeline on Cori, NERSC



ORNL GitLab Build Pipeline for E4S Spack Build Cache

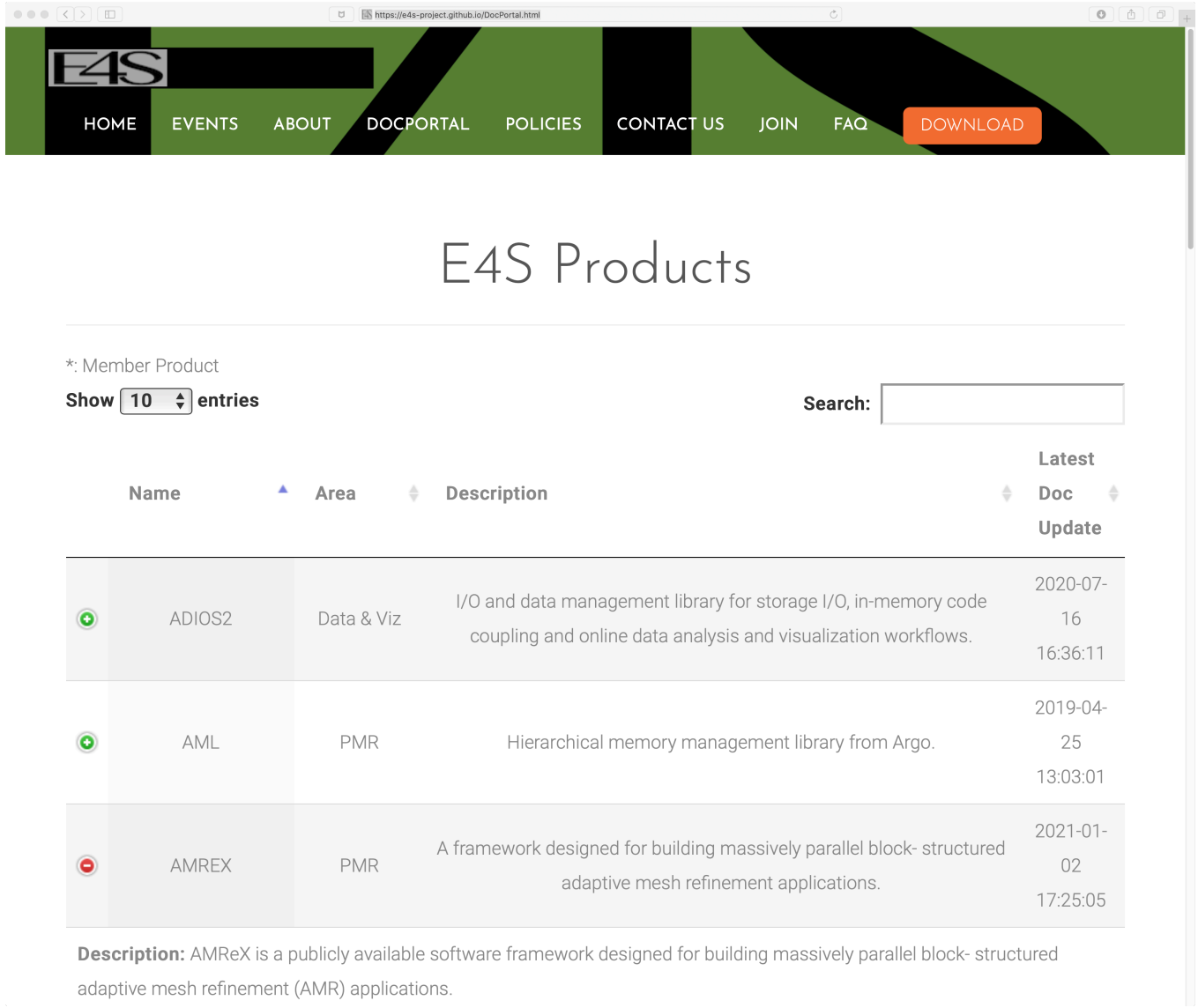


- ppc64le (Ascent @ ORNL)
- Reproducible container builds

E4S DocPortal

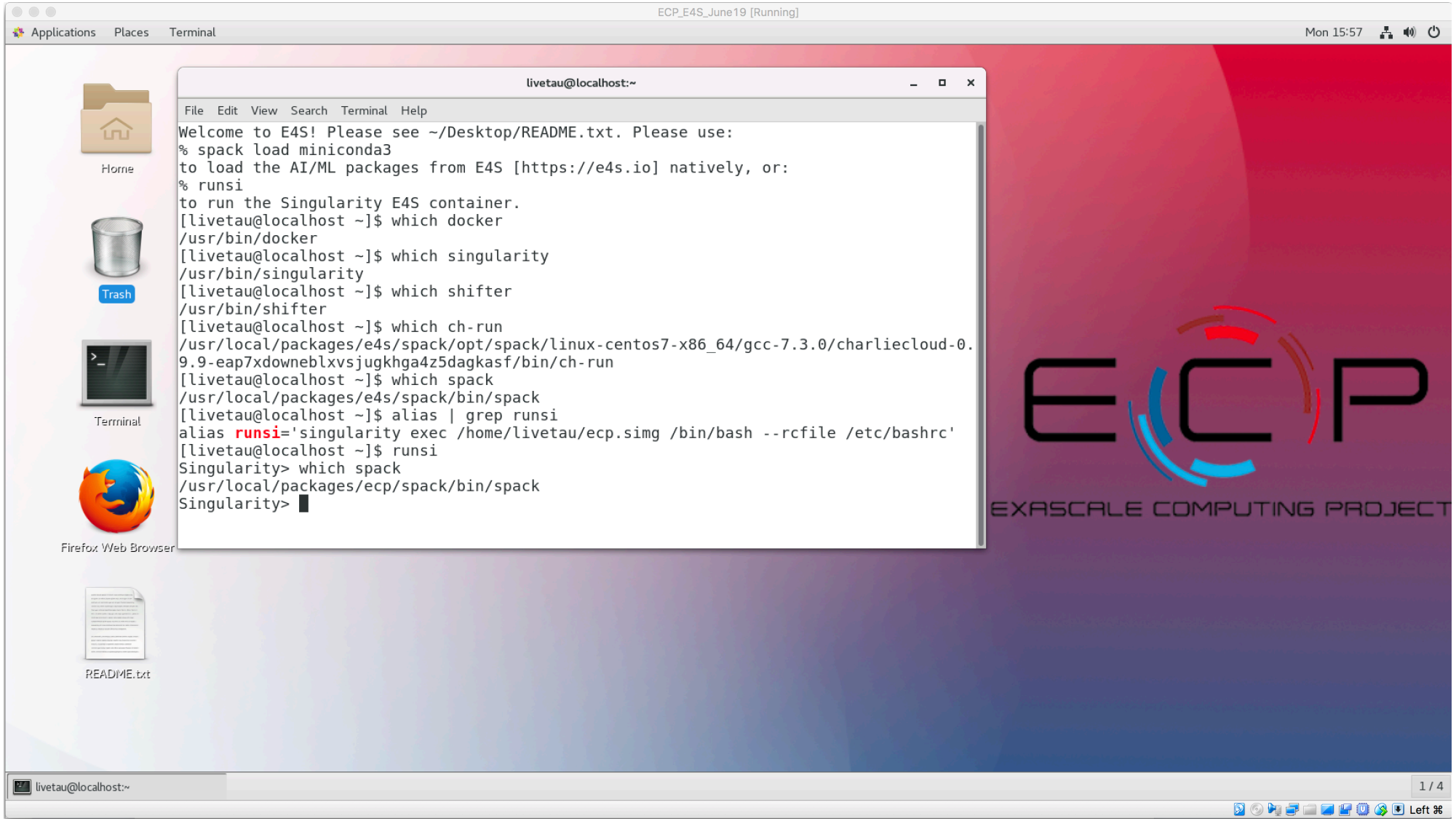
- Provide a single online location for *accurate* product descriptions for ECP software products.
- Derived requirements:
  - Sustainable: Must be integrated into software team workflows.
  - Incremental: Must build on community approaches to providing this kind of information.
  - Extensible: Must be usable by any open source software team.
- Strategy:
  - Use the open source community approach of specially-name files in software repositories.
  - Adopt commonly used file names when available.
  - Identify new information items not already being requested.
  - Develop new special file names for information beyond what is already captured.
  - Create web-based raking tool to capture information from product repositories and present in summary form on a webpage.
  - Aggregates and summarizes documentation and metadata for E4S products
  - Regularly updates information directly from product repositories
  - Prototype: https://e4s-project.github.io/DocPortal.html

E4S DocPortal



https://e4s-project.github.io/DocPortal.html

E4S VirtualBox Image



Container Runtimes

- Docker
- Shifter
- Singularity
- Charliecloud

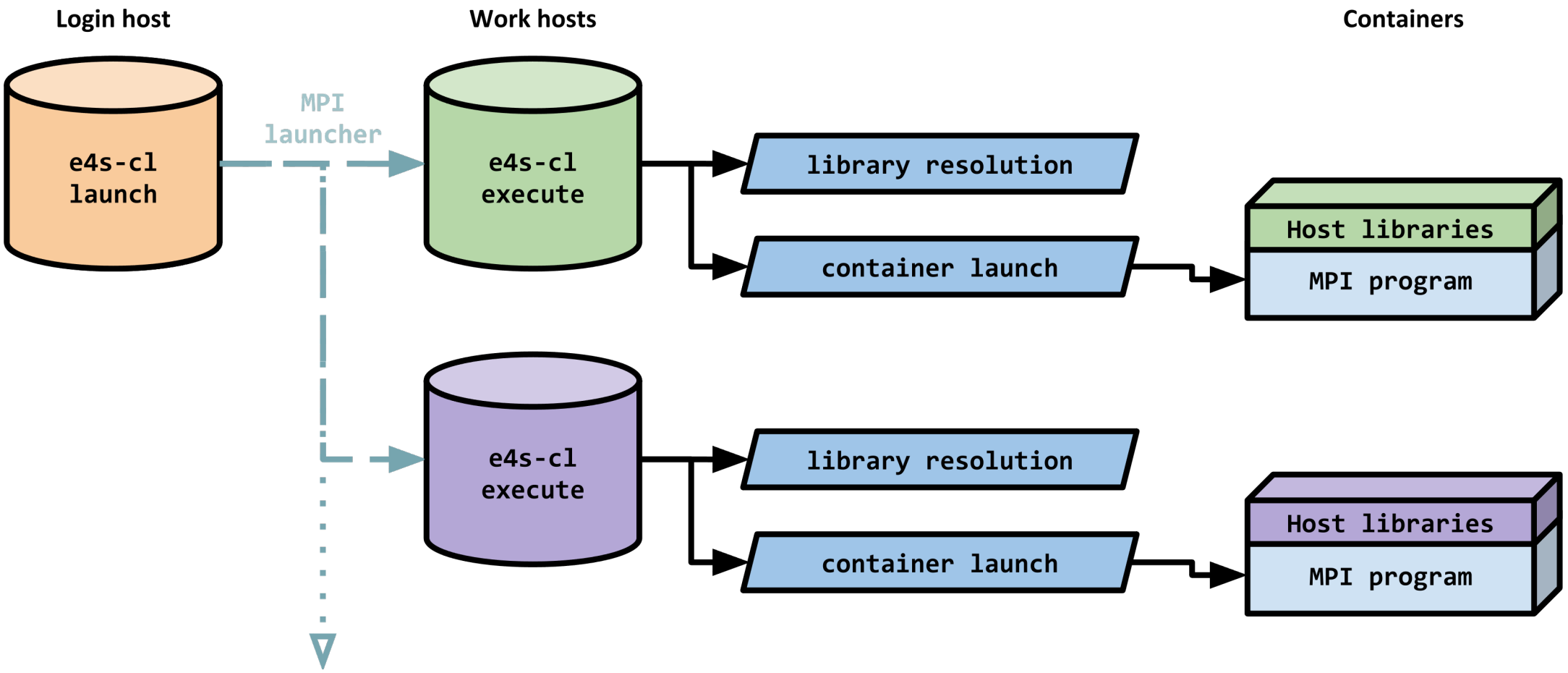
https://e4s.io

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.
- 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.
- Under development. Usage:

```
1. e4s-cl profile detect -o <profile> <MPI executable>
2. e4s-cl profile select <profile>
3. e4s-cl launch mpirun -np <> -hosts <> <command>
```

e4s-cl Container Launcher



https://e4s.io

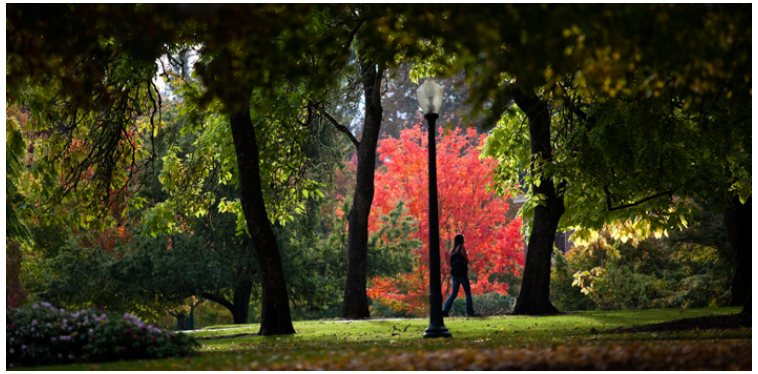
E4S Summary

What E4S is not	What E4S is
A closed system taking contributions only from DOE software development teams.	Extensible, open architecture software ecosystem accepting contributions from US and international teams. Framework for collaborative open-source product integration.
A monolithic, take-it-or-leave-it software behemoth.	A full collection of compatible software capabilities **and** A manifest of a la carte selectable software capabilities.
A commercial product.	Vehicle for delivering high-quality reusable software products in collaboration with others.
A simple packaging of existing software.	The conduit for future leading edge HPC software targeting scalable next-generation computing platforms. A hierarchical software framework to enhance (via SDKs) software interoperability and quality expectations.

Future work, issues…

- Improved support for GPUs and visualization tools
- DOE LLVM
- Addition of CI testing
- Facility deployment
- Scalable startup with full-featured “Supercontainers”
- Improving the launch of MPI applications
- From-source builds assisted by a binary build cache or containers
- Docker and Singularity images are available for download
  - https://e4s.io

Performance Research Laboratory, University of Oregon, Eugene



www.uoregon.edu

Acknowledgment

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