CSCS
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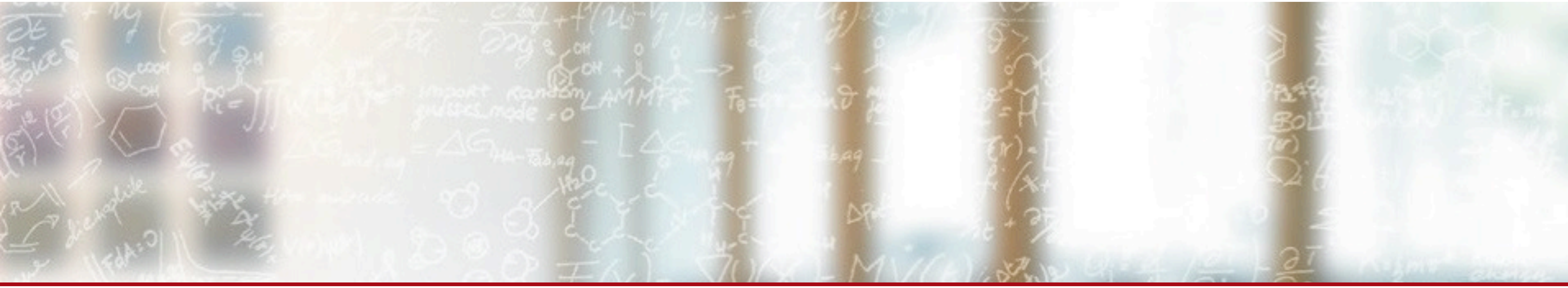
Swiss National Supercomputing Centre

ETH zürich



The WLCG Journey at CSCS: from Piz Daint to Alps

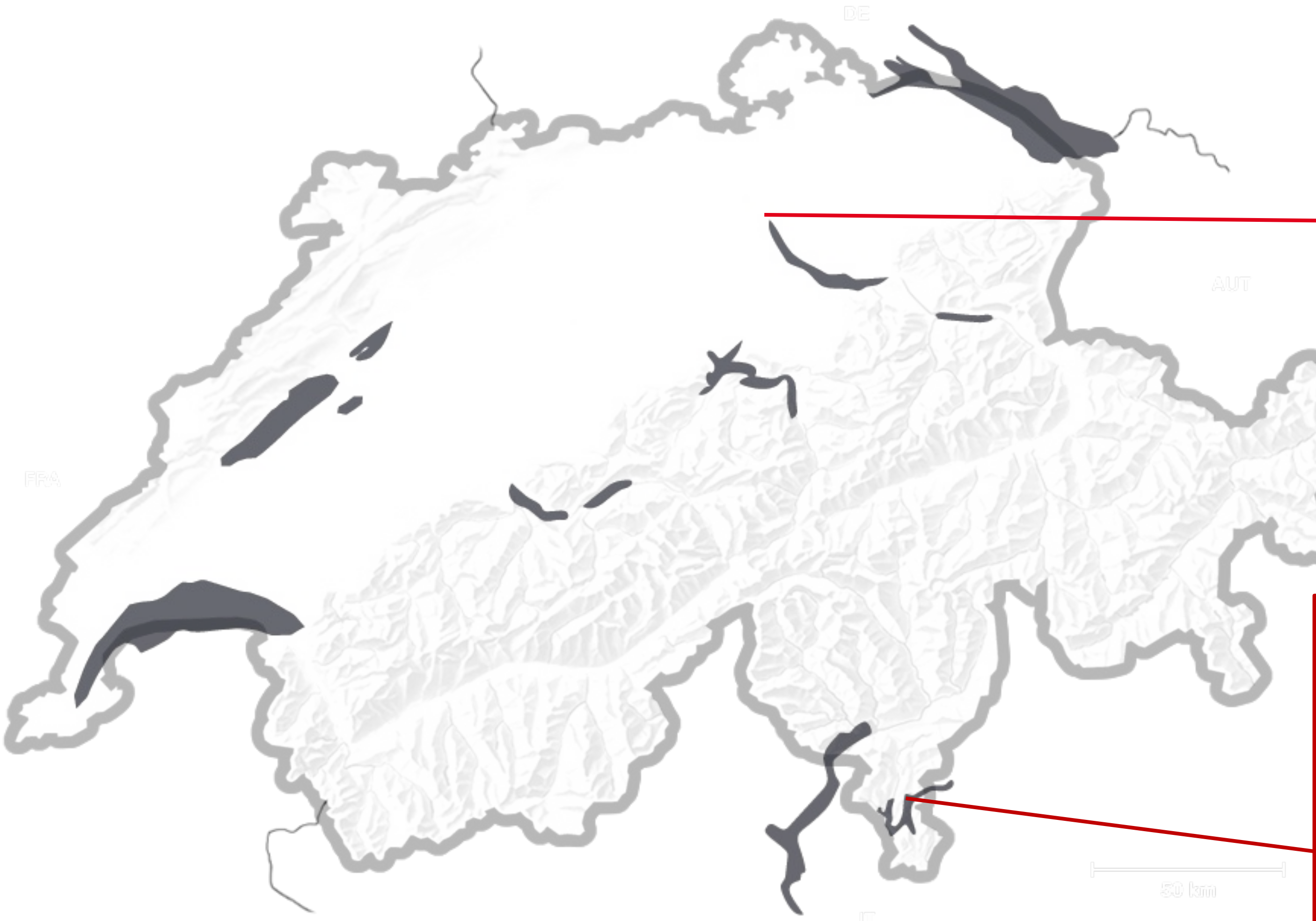
Dr. Riccardo Di Maria (ETH Zurich – CSCS)

HEPiX Spring 2023 Workshop – ASGC, Taipei, Taiwan
March 28th, 2023

Alps and Kubernetes at CSCS

Disclaimer:

The ***Swiss National Supercomputing Centre,*** located in Lugano, is a unit of the ***Swiss Federal Institute of Technology*** *in Zurich* (ETH Zurich)



ETH Zurich

CSCS Lugano

Different infrastructure, different workloads, and different requirements

The challenge of multiple customers

- Different Infrastructure
  - Flagship - CPU/GPU
  - Clusters - Customer Specific
    - WLCG
    - MeteoSwiss
    - CTA and SKA
    - …
  - OpenStack IaaS
  - Experimental Hardware

Piz Daint

- Different Workloads
  - Classic HPC
    - SSH to login nodes
    - Submit jobs to Slurm
    - Wait for results
    - Repeat
  - Grid Computing
    - WLCG
  - Interactive Computing
    - Jupyter Notebooks
    - Remote Visualization
  - IaaS

Alps

Successor to Piz Daint

Alps

- Alps at CSCS
  - HPE Cray EX (AMD Rome and Milan, ARM Grace, NVIDIA A100, etc.)
    → Shasta architecture and Slingshot
  - ***Infrastructure as Code***
    → designed from ground up for programmability of resources for workflows
    → multi-tenancy paradigm
    → Slurm/HPC and K8s/Cloud vClusters: persistent, on-demand, and/or elastic
  - Continued support for classic supercomputing use cases
  - Additional support for AI, ML and data-driven workflows
  - Phased installation/expansion (10-15% March 2023 == ~1200 nodes)

Virtual/Versatile/Volatile Cluster Configuration at CSCS

Views:

HPC User

- ❑ SSH to machine
- ❑ Compile and build
- ❑ Submit jobs
- ❑ Stage data in-out

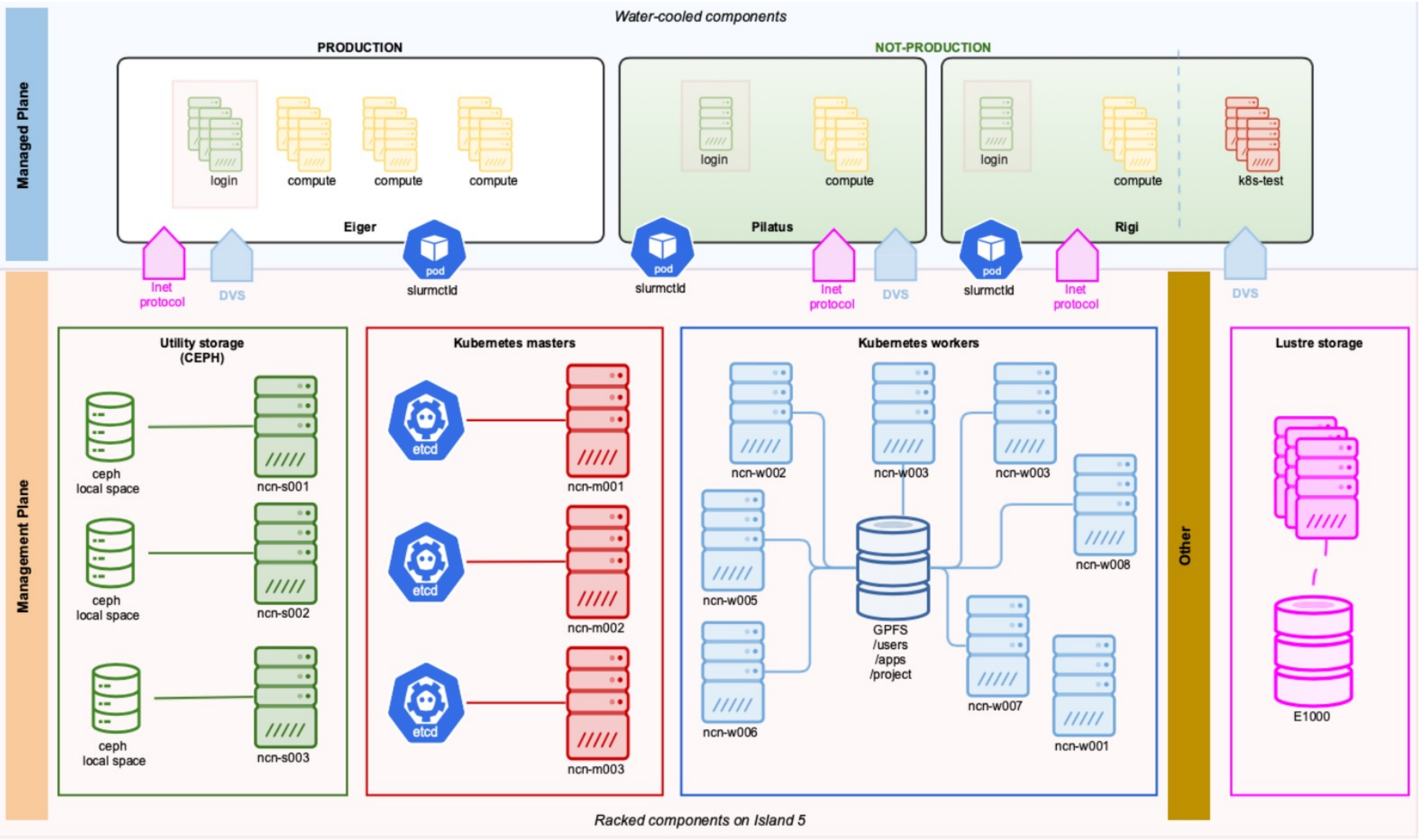
Cluster Admin

- ❑ Slurm config
- ❑ Storage config
- ❑ Login config
- ❑ Image config
- ❑ IAM config

Infrastructure Admin

- ❑ Hardware provisioning
- ❑ Hardware config
- ❑ Capacity management
- ❑ Monitoring and logging
- ❑ Access controls

CSCS



WLCG @ CSCS

Tier-2 for ATLAS, CMS, and LHCb under CHiPP Federation

2022

- ATLAS
  - 89 kHS06
  - 3.7 PB
- CMS
  - 77 kHS06
  - 2.8 PB
- LHCb
  - 56 kHS06
  - 2.5 PB

2023

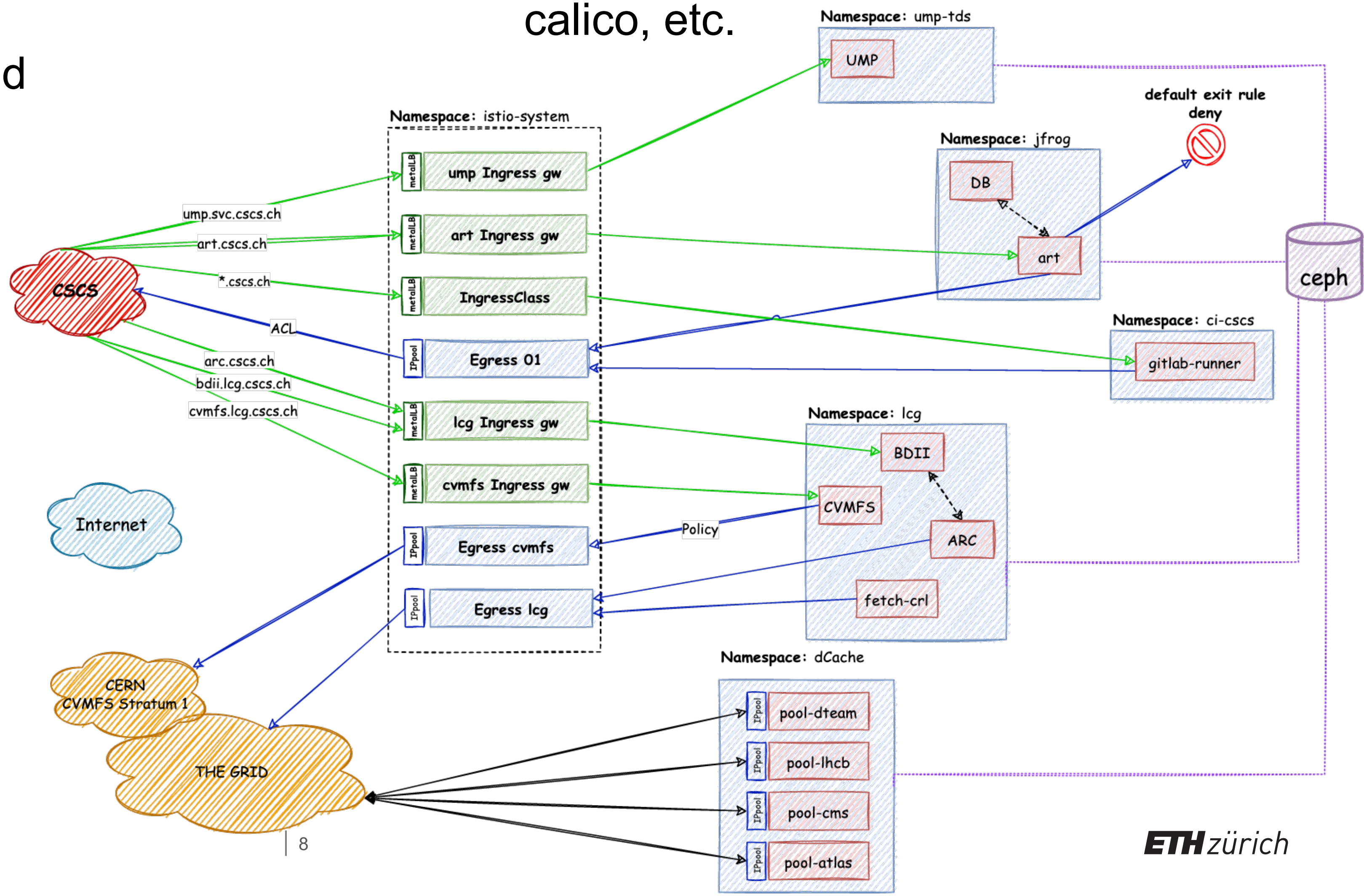
- ATLAS
  - 112 kHS06
  - 4.4 PB
- CMS
  - 92 kHS06
  - 3.4 PB
- LHCb
  - 70 kHS06
  - 3.0 PB

- ~15 PB dCache on Ceph
- 100 AMD EPYC Rome nodes
  - 128 cores (256 CPUs), 256 GB RAM
  - “Mont Fort” cluster
  - 4 ARC-CEs
- +4 nodes for dev/tds instance
  - “Mont Gele” cluster, 1 ARC-CE
- Production CE
  - 300 TB shared CephFS NVMe
  - 4 TB local RBD NVMe per node
  - 64 GB CVMFS cache RBD NVMe per node

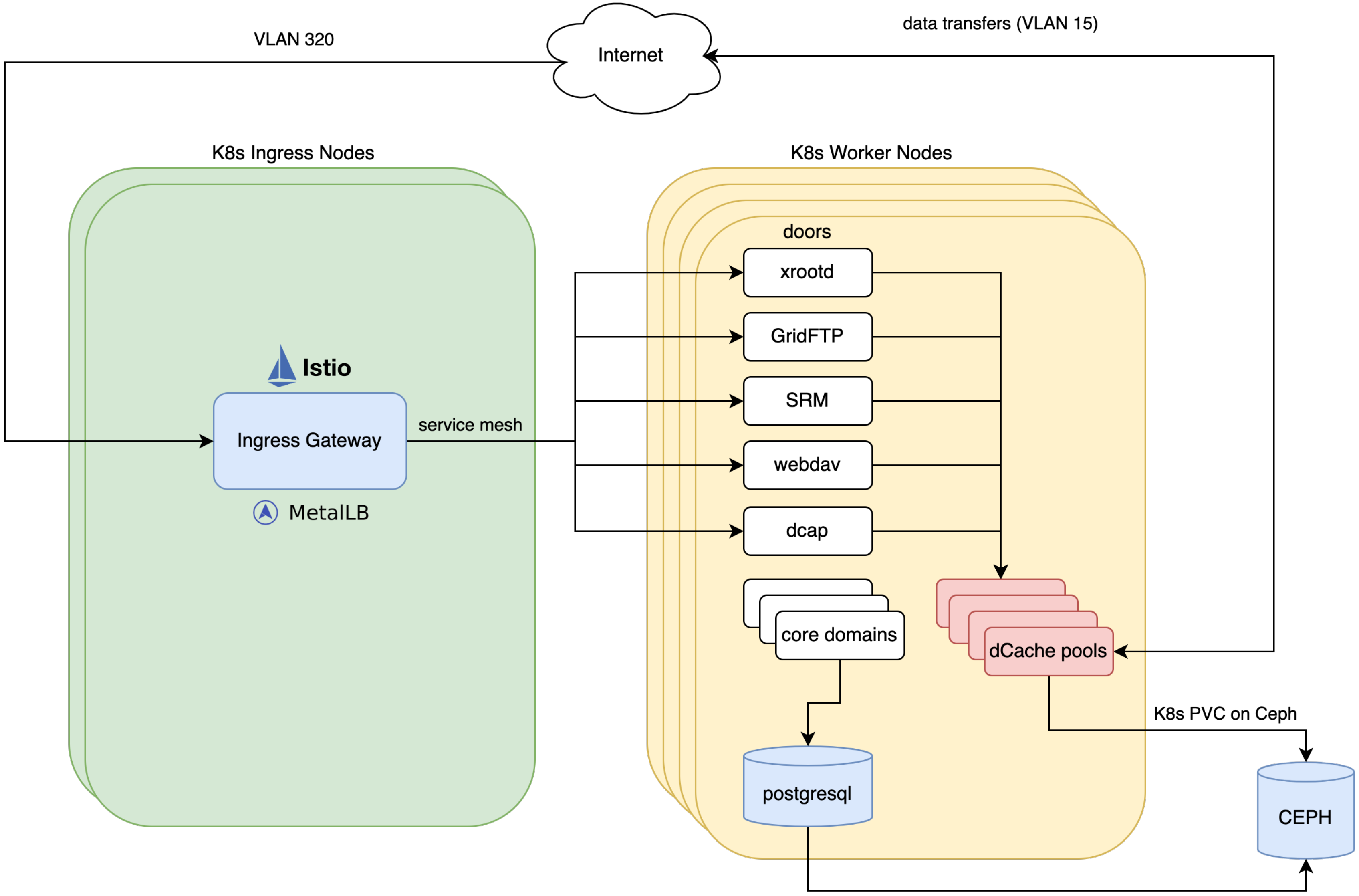
Kubernetes at CSCS (v1.0)

- Kubernetes Clusters at CSCS
  - shared internal CSCS-managed services (Fulen)
  - shared external user-managed (Combin)
  - dedicated for specific needs
- Based on community “vanilla” Kubernetes
- The “Fulen case”
  - **dCache**
  - WLCG Services
    - **ARC-CE**, CVMFS, BDII, VO Boxes, etc
  - …

- Key features
  - metalLB, istio, cert manager, OIDC, calico, etc.

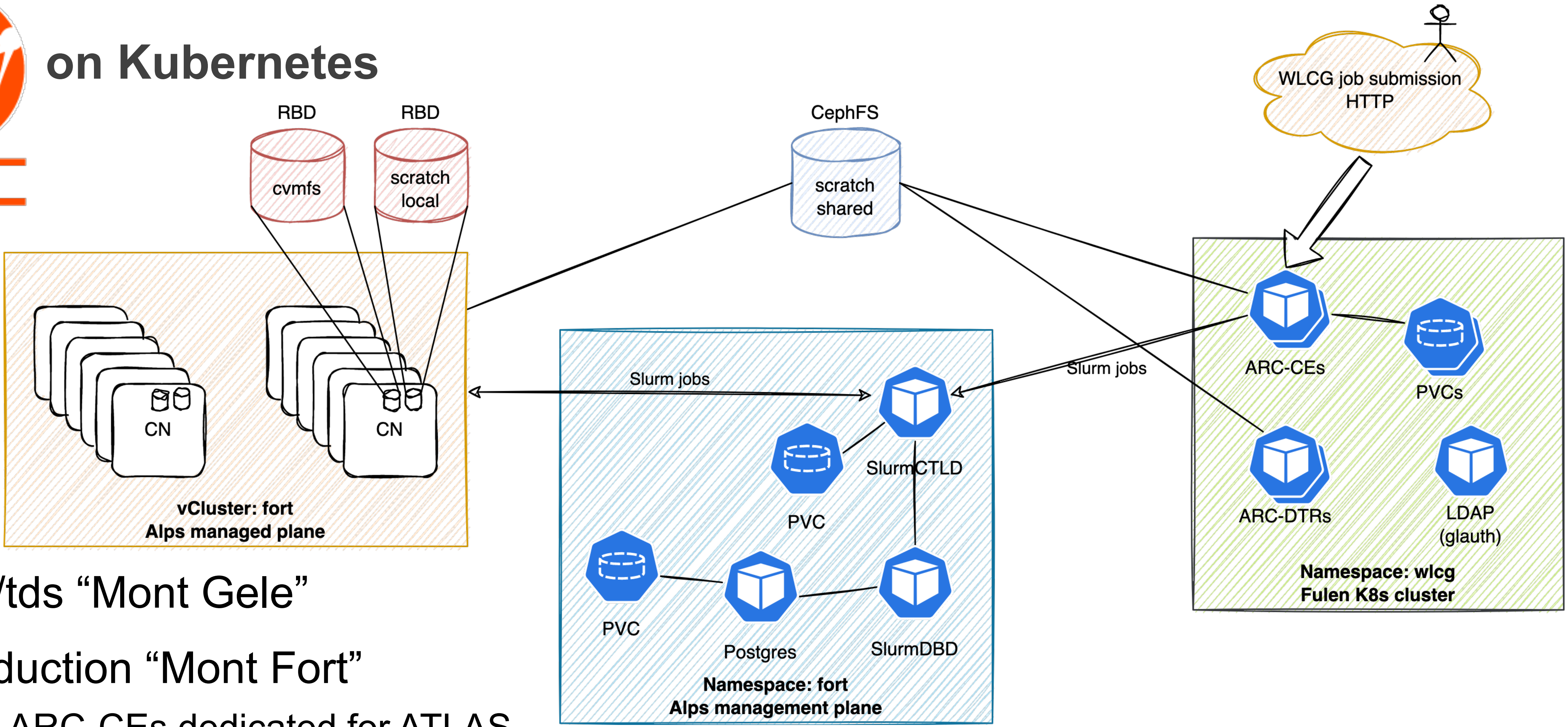


dCache on Kubernetes



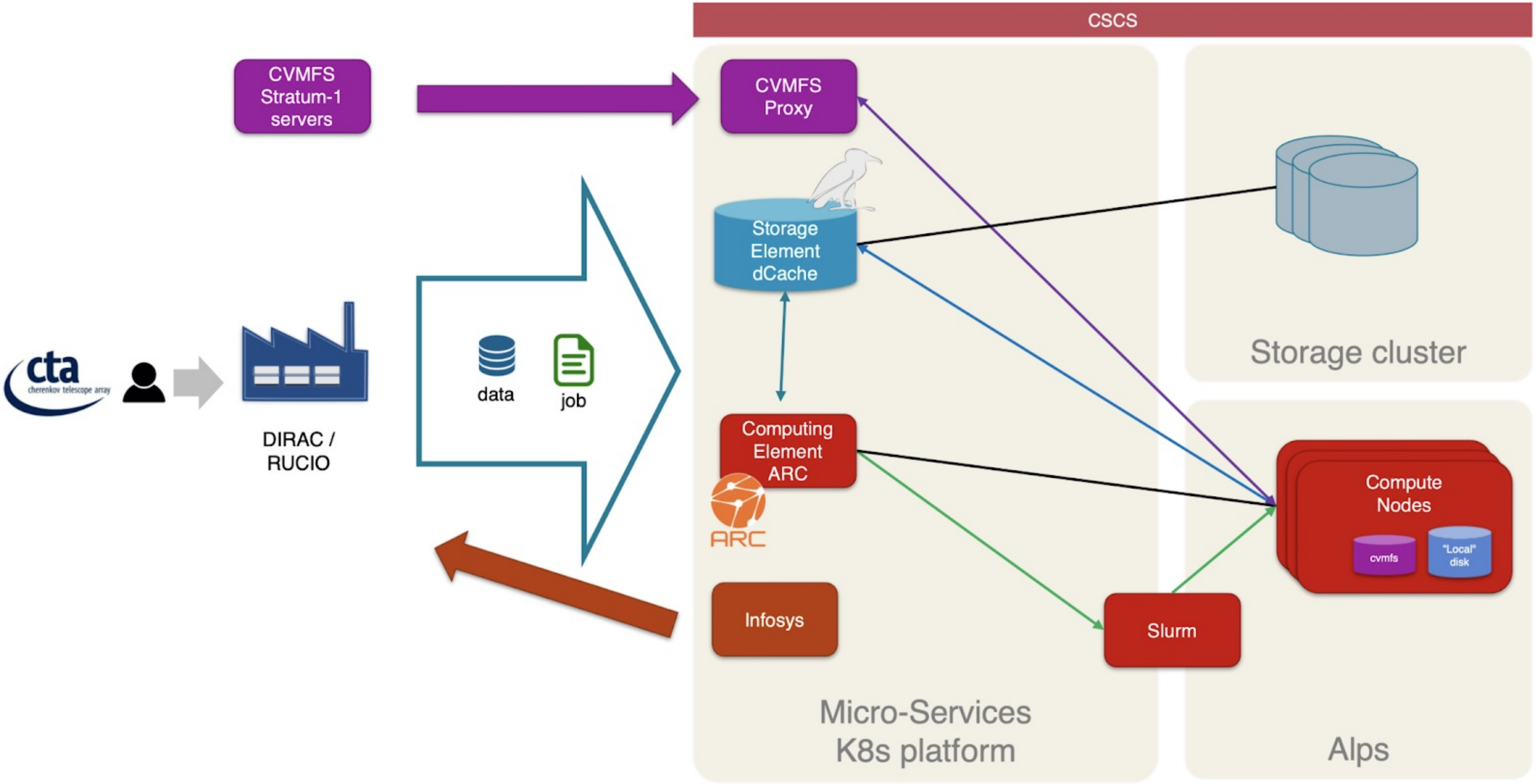
- K8s came after WLCG and CTA requirements were set
- ~1 year in production
- dCache pool services run as K8s pods
- Pods mount Ceph RBD volumes through Kubernetes CSI

ARC on Kubernetes



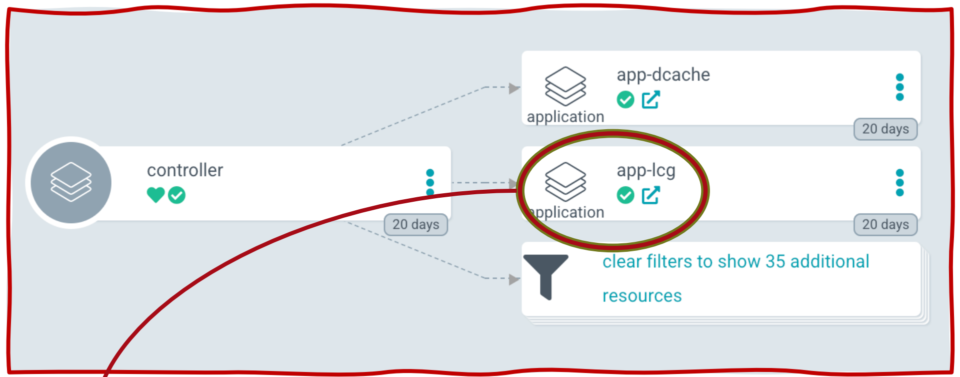
- dev/tds "Mont Gele"
- Production "Mont Fort"
  - 2 ARC-CEs dedicated for ATLAS
  - 2 ARC-Ces dedicated for CMS and LHCb
  - Common Slurm queue

WLCG and CTA Workflows at CSCS



The Fulen Cluster and ArgoCD

CI/CD for ARC-CE on Kubernetes

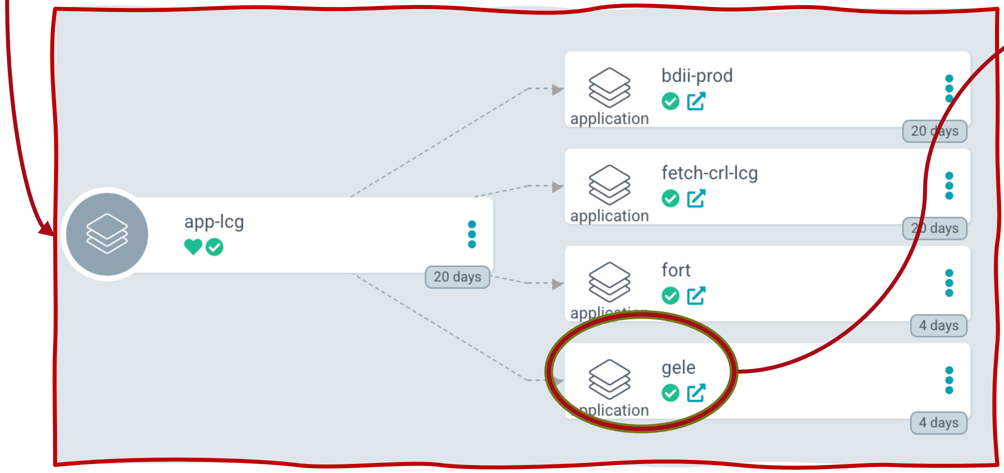


controller ♥✓ 20 days

app-dcache application ✓ 20 days

app-lcg application ✓ 20 days

clear filters to show 35 additional resources



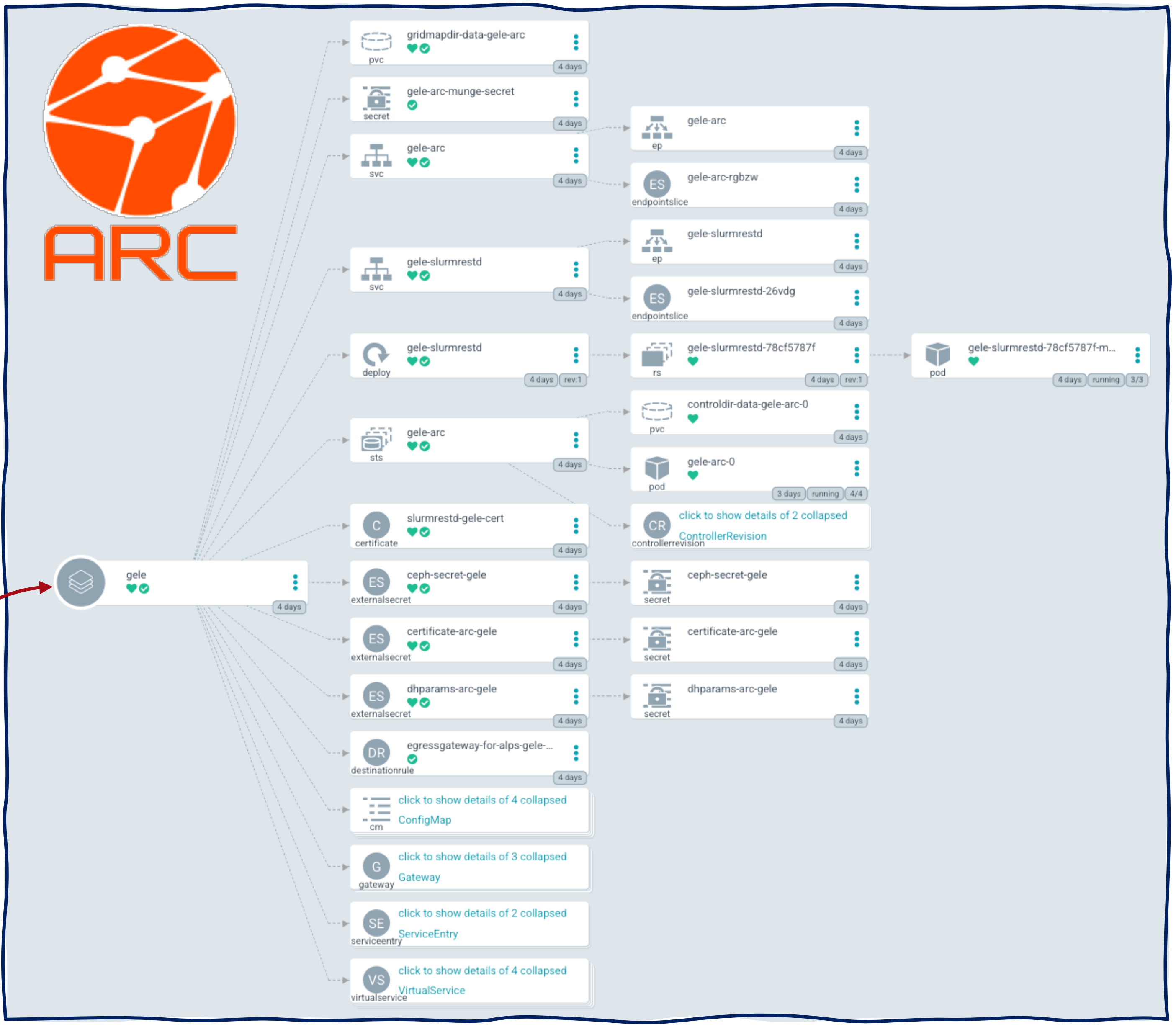
app-lcg ♥✓ 20 days

bdii-prod application ✓ 20 days

fetch-crl-lcg application ✓ 20 days

fort application ✓ 4 days

gele application ✓ 4 days



gele ♥✓ 4 days

gridmapdir-data-gele-arc pvc ♥✓ 4 days

gele-arc-munge-secret secret ✓ 4 days

gele-arc svc ♥✓ 4 days

gele-arc ep 4 days

gele-arc-rgbzw endpointslice 4 days

gele-slurmrestd ep 4 days

gele-slurmrestd svc ♥✓ 4 days

gele-slurmrestd-26vdg endpointslice 4 days

gele-slurmrestd deploy ♥✓ 4 days rev:1

gele-slurmrestd-78cf5787f rs ♥ 4 days rev:1

gele-slurmrestd-78cf5787f-m... pod ♥ 4 days running 3/3

controldir-data-gele-arc-0 pvc ♥ 4 days

gele-arc sts ♥✓ 4 days

gele-arc-0 pod ♥ 3 days running 4/4

slurmrestd-gele-cert certificate ♥✓ 4 days

click to show details of 2 collapsed ControllerRevision controllerrevision

ceph-secret-gele externalsecret ♥✓ 4 days

ceph-secret-gele secret 4 days

certificate-arc-gele externalsecret ♥✓ 4 days

certificate-arc-gele secret 4 days

dhparams-arc-gele externalsecret ♥✓ 4 days

dhparams-arc-gele secret 4 days

egressgateway-for-alps-gele-... destinationrule ✓ 4 days

click to show details of 4 collapsed ConfigMap cm

click to show details of 3 collapsed Gateway gateway

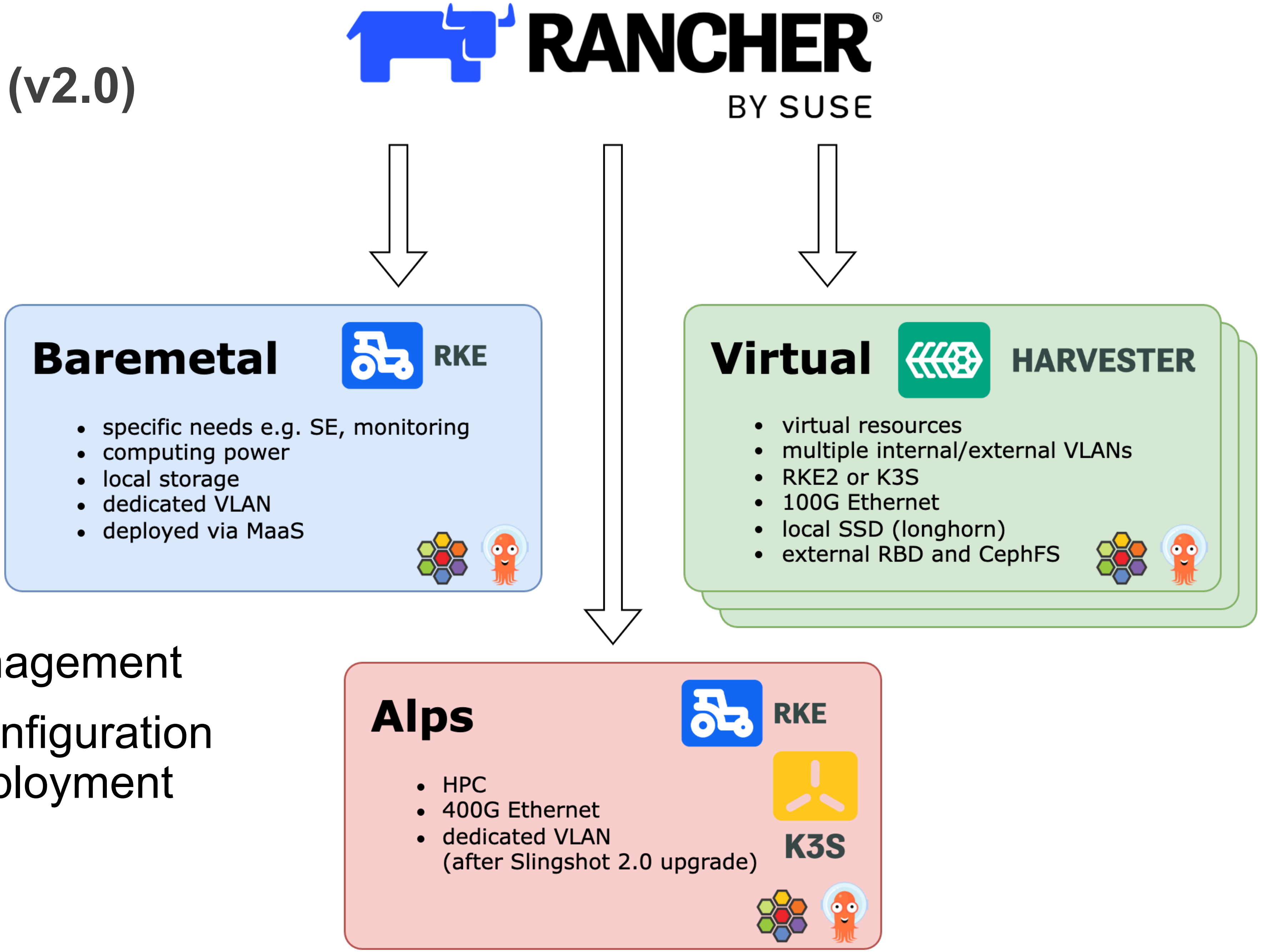
click to show details of 2 collapsed ServiceEntry serviceentry

click to show details of 4 collapsed VirtualService virtualservice

argo autopilot *(mmh, not quite!)*

Kubernetes at CSCS (v2.0)

- On-demand K8s clusters for clients and customers with different needs and requirements
- K3S/RKE2 spawned clusters with tagged VLAN isolation
  → improved istio management
- ArgoCD for cluster configuration and/or application deployment
- Cilium as K8s CNI



Baremetal RKE

- specific needs e.g. SE, monitoring
- computing power
- local storage
- dedicated VLAN
- deployed via MaaS

Virtual HARVESTER

- virtual resources
- multiple internal/external VLANs
- RKE2 or K3S
- 100G Ethernet
- local SSD (longhorn)
- external RBD and CephFS

Alps RKE K3S

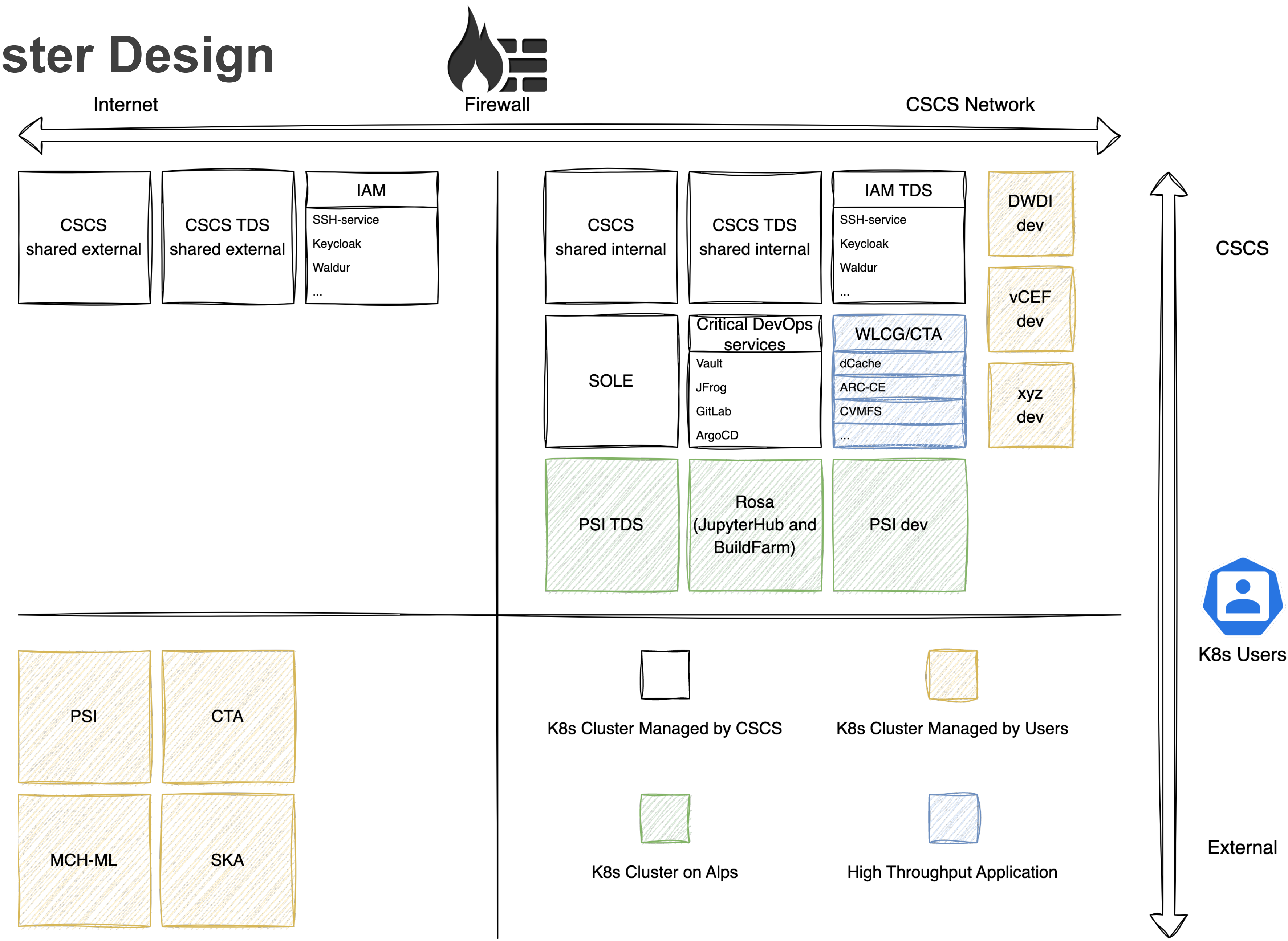
- HPC
- 400G Ethernet
- dedicated VLAN (after Slingshot 2.0 upgrade)

Kubernetes at CSCS (v2.0)

- Baremetal
  - e.g. monitoring/ECK → Dino Conciatore "*Dynamic Deployment of Data Collection and Analysis Stacks at CSCS*", HEPiX 2023
  - on-going WLCG and CTA dCache instances migration
- Alps
  - challenges:
    - cluster persistency and CI/CD
    - admin privileges for customers → Slingshot 2.0 upgrade on-going → dedicated VLANs to be tested
  - PoC/MVP for PSI
- Virtual
  - *quite a few…*

Kubernetes Multi-Cluster Design

- Cluster for client:
  - etcd cluster S3-backup
  - CSI CephFS and RBD
  - velero
  - beats
  - ingress nginx
  - metalLB
  - external-DNS
  - cert-manager
- External-secrets
- Vault
- ArgoCD



Internet | Firewall | CSCS Network

CSCS | External

K8s Users

CSCS shared external

CSCS TDS shared external

IAM: SSH-service, Keycloak, Waldur, …

PSI

CTA

MCH-ML

SKA

CSCS shared internal

CSCS TDS shared internal

IAM TDS: SSH-service, Keycloak, Waldur, …

DWDI dev

vCEF dev

xyz dev

SOLE

Critical DevOps services: Vault, JFrog, GitLab, ArgoCD

WLCG/CTA: dCache, ARC-CE, CVMFS, …

PSI TDS

Rosa (JupyterHub and BuildFarm)

PSI dev

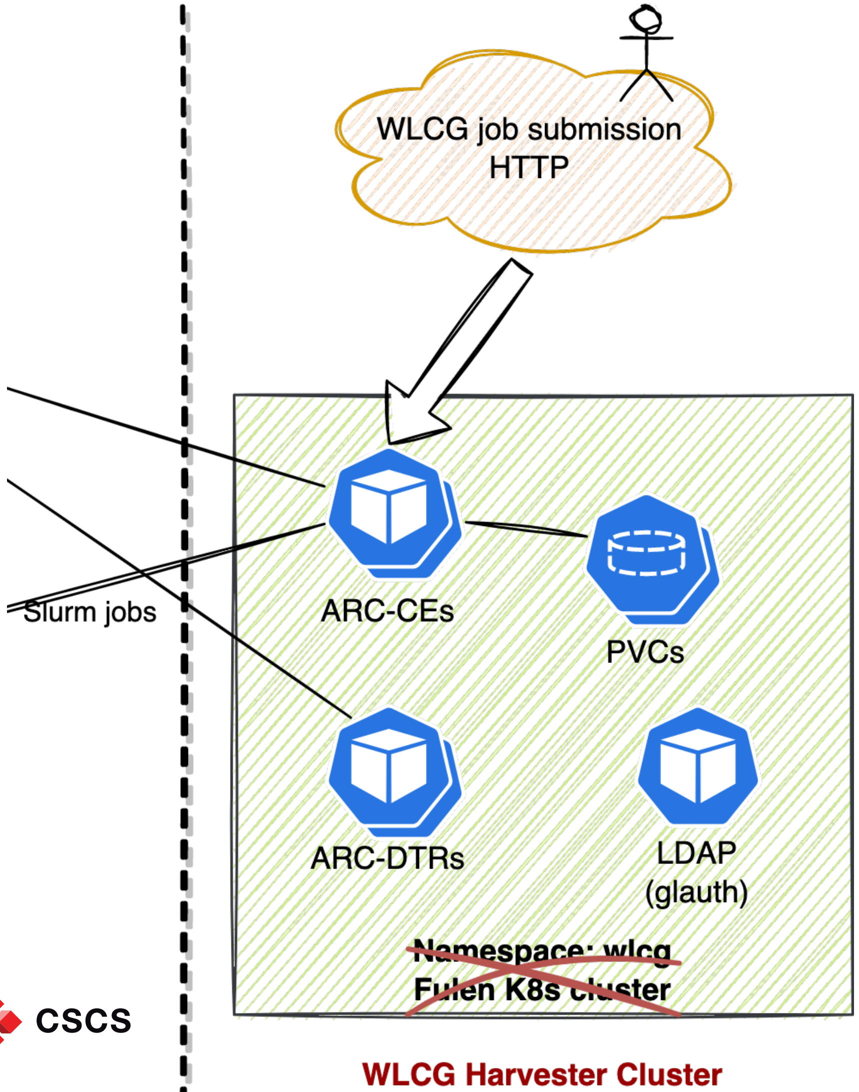
□ K8s Cluster Managed by CSCS

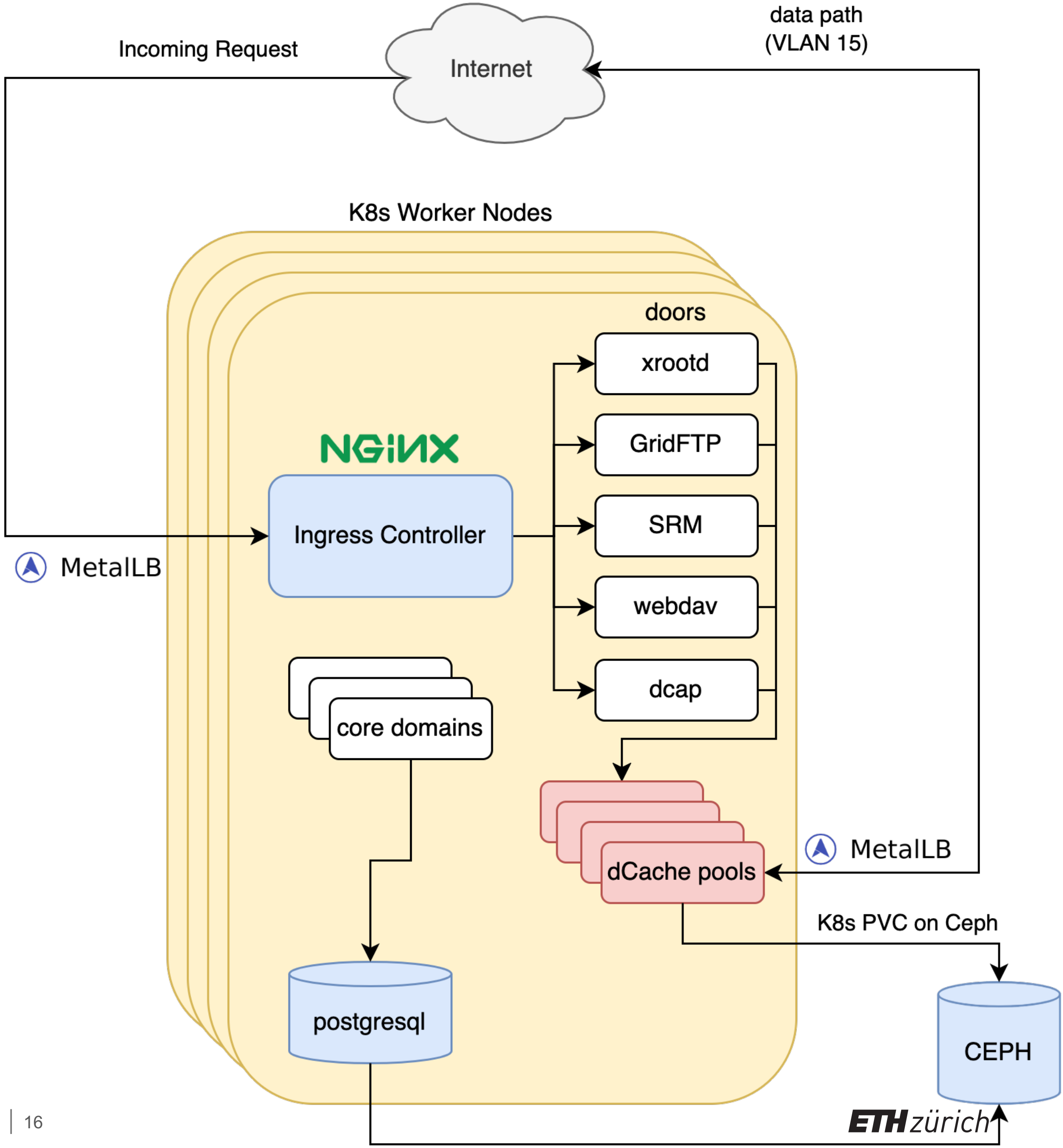
▨ K8s Cluster Managed by Users

🟩 K8s Cluster on Alps

▨ High Throughput Application

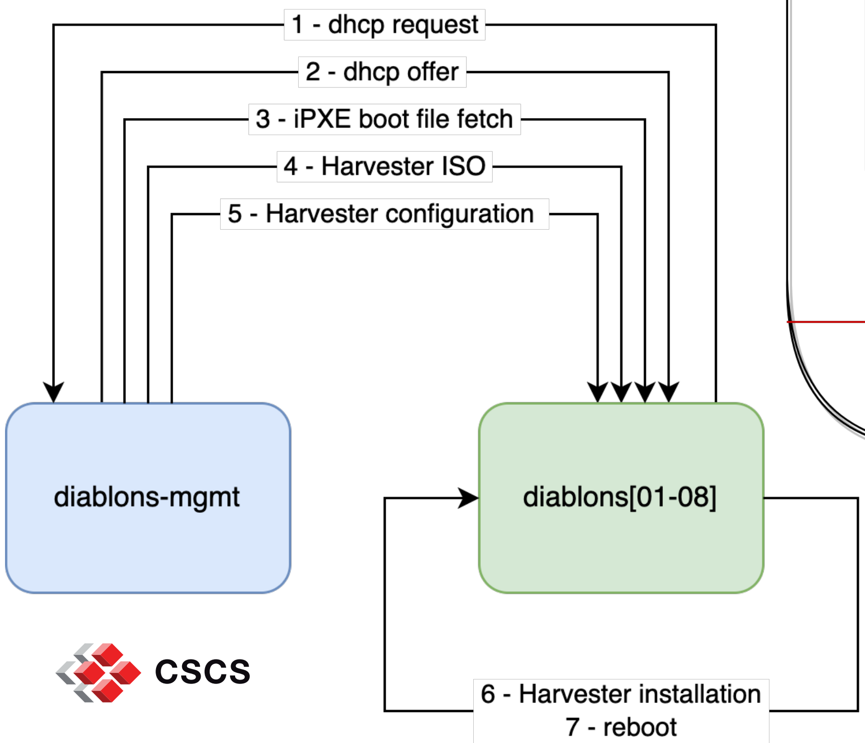
ARC and dCache (v2.0)

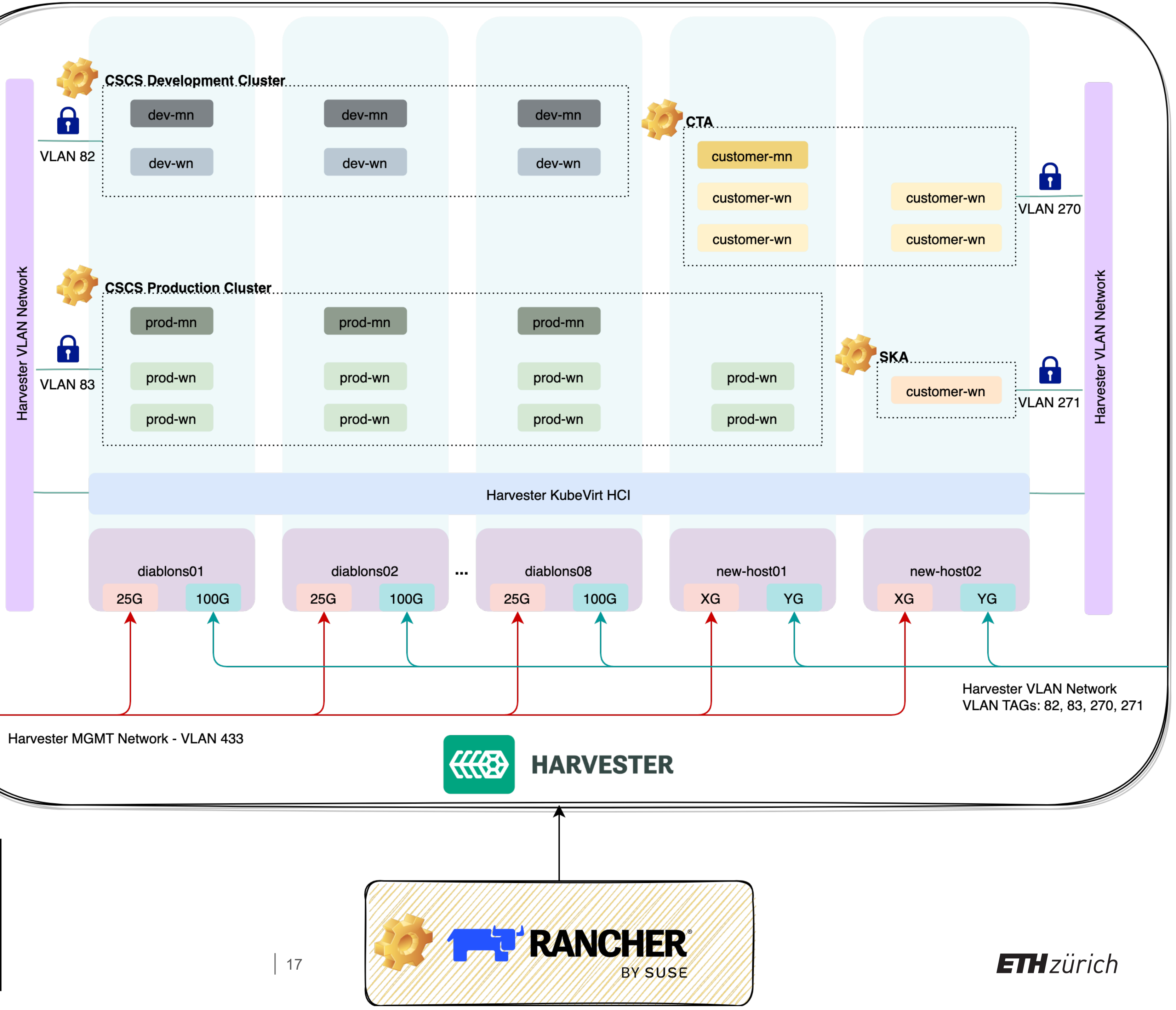




Harvester at CSCS

- Cluster deployment →
- Harvester deployment:

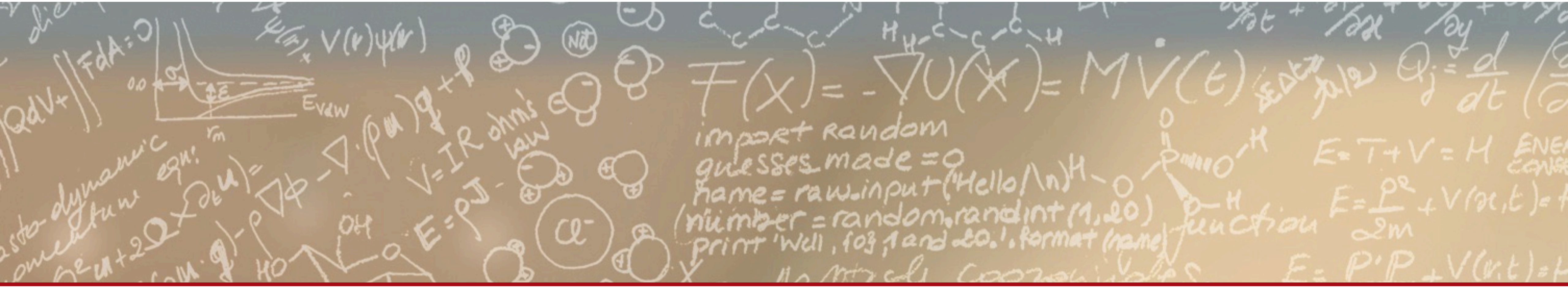




Why are we moving services to Kubernetes?

What’s the point of using Kubernetes?

- Main advantages
  - Load balancing
  - Storage orchestration
  - Automated rollouts and rollbacks
  - Automatic bin packing
  - Self-healing
  - Secret and configuration management
  - Observability and traffic management
  - **Disaster recovery management and one-button deployment**
- Main challenges
  - Additional “moving parts” and complexity layer
    - Networking: Cilium vs. Calico, and service mesh
  - Security
    - Additional configuration and additional MAC (mandatory access control) configuration

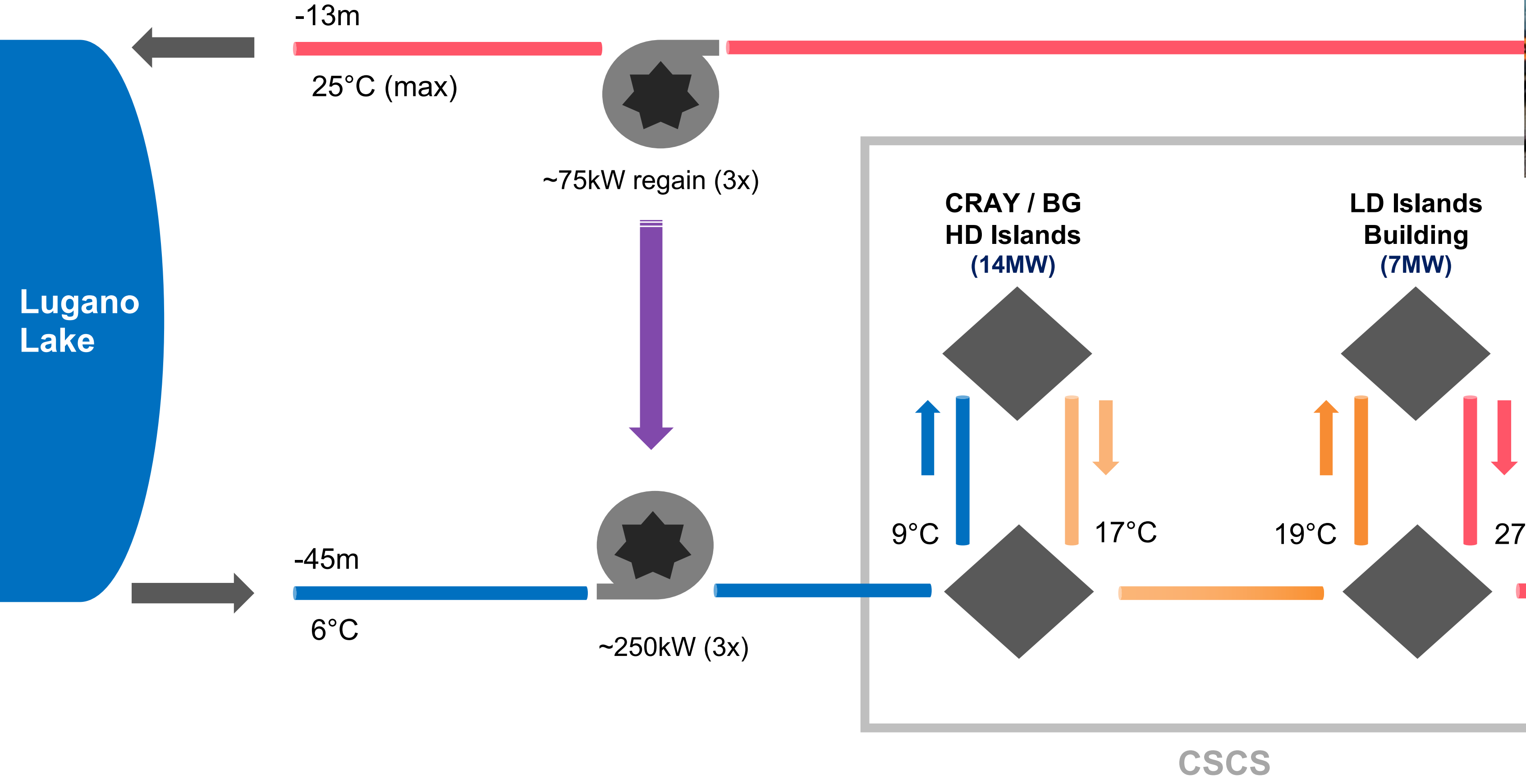


Thank you for your attention.

Questions?

Contact: riccardo.dimaria@cscs.ch

CSCS Facility – Water cooling system

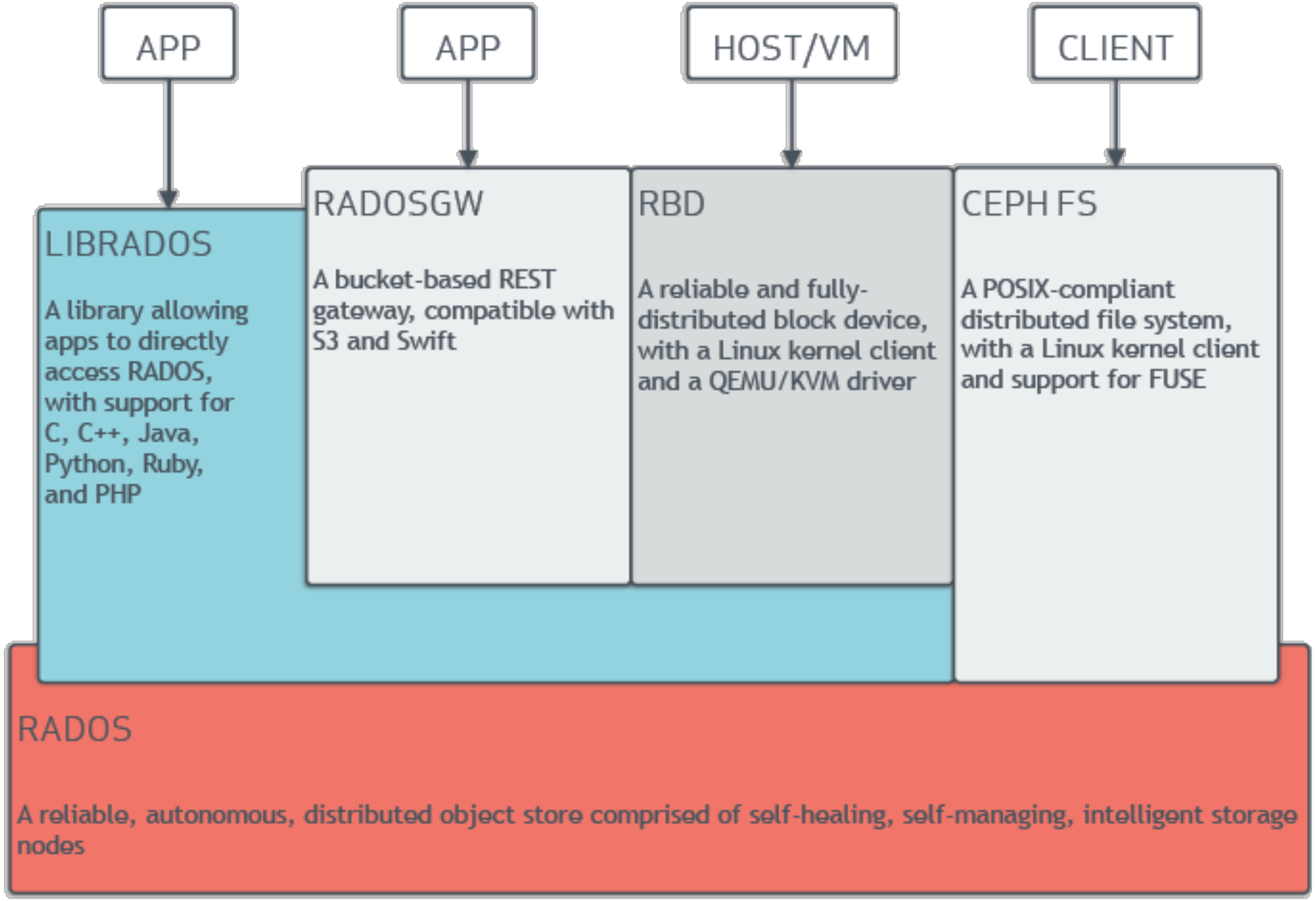


- Pipeline length: 2.8 km
- height: 30 m
- Max. flow rate: 760 l/s

Ceph at CSCS

WORK IN PROGRESS

- Existing implementation
  - NVMe (~300TB)
  - HDD (~11PB)
- Expansion phase ahead
- On-going:
  - Rucio backend integration with S3



A library allowing apps to directly access RADOS, with support for C, C++, Java, Python, Ruby, and PHP

A bucket-based REST gateway, compatible with S3 and Swift

A reliable and fully-distributed block device, with a Linux kernel client and a QEMU/KVM driver

A POSIX-compliant distributed file system, with a Linux kernel client and support for FUSE

A reliable, autonomous, distributed object store comprised of self-healing, self-managing, intelligent storage nodes