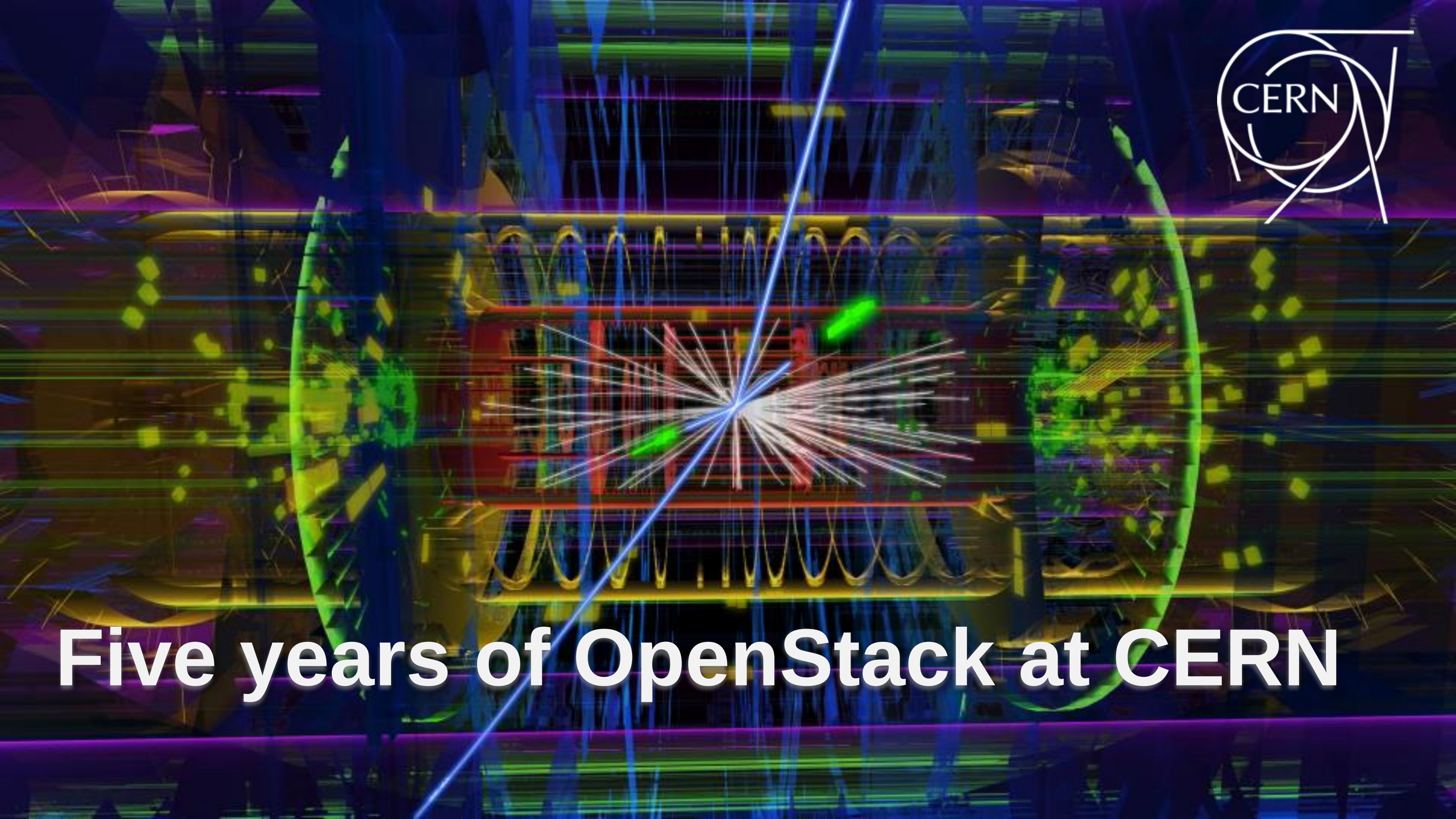


Five years of OpenStack at CERN

CERN: founded in 1954: 12 European States

"Science for Peace"

Today: 22 Member States

~ 2300 staff
~ 1400 other paid personnel
~ 12500 scientific users

Budget (2017) ~1000 MCHF

Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

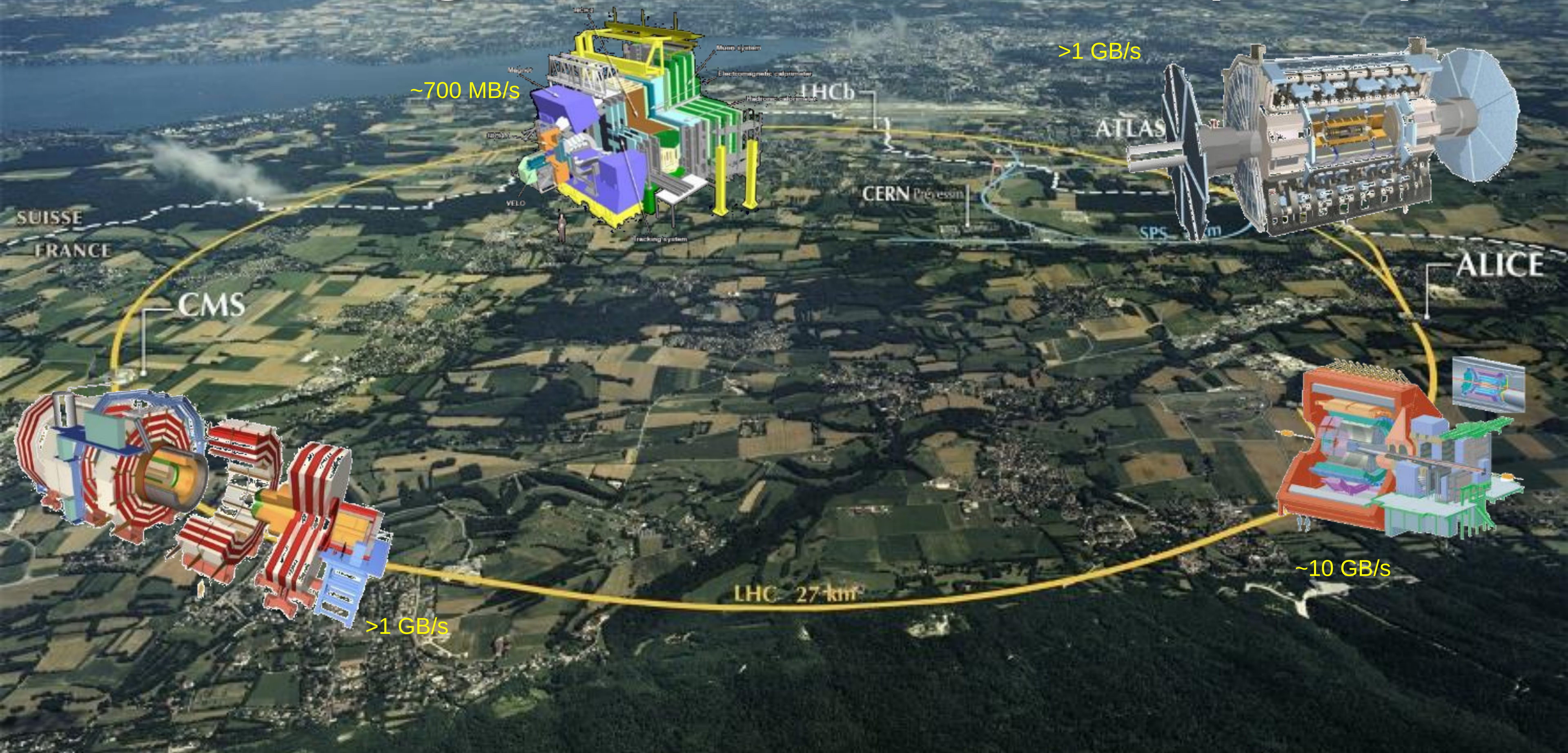
Associate Member States: Pakistan, India, Ukraine, Turkey

States in accession to Membership: Cyprus, Serbia

Applications for Membership or Associate Membership: Brazil, Croatia, Lithuania, Russia, Slovenia

Observers to Council: India, Japan, Russia, United States of America; European Union, JINR and UNESCO

The Large Hadron Collider (LHC)



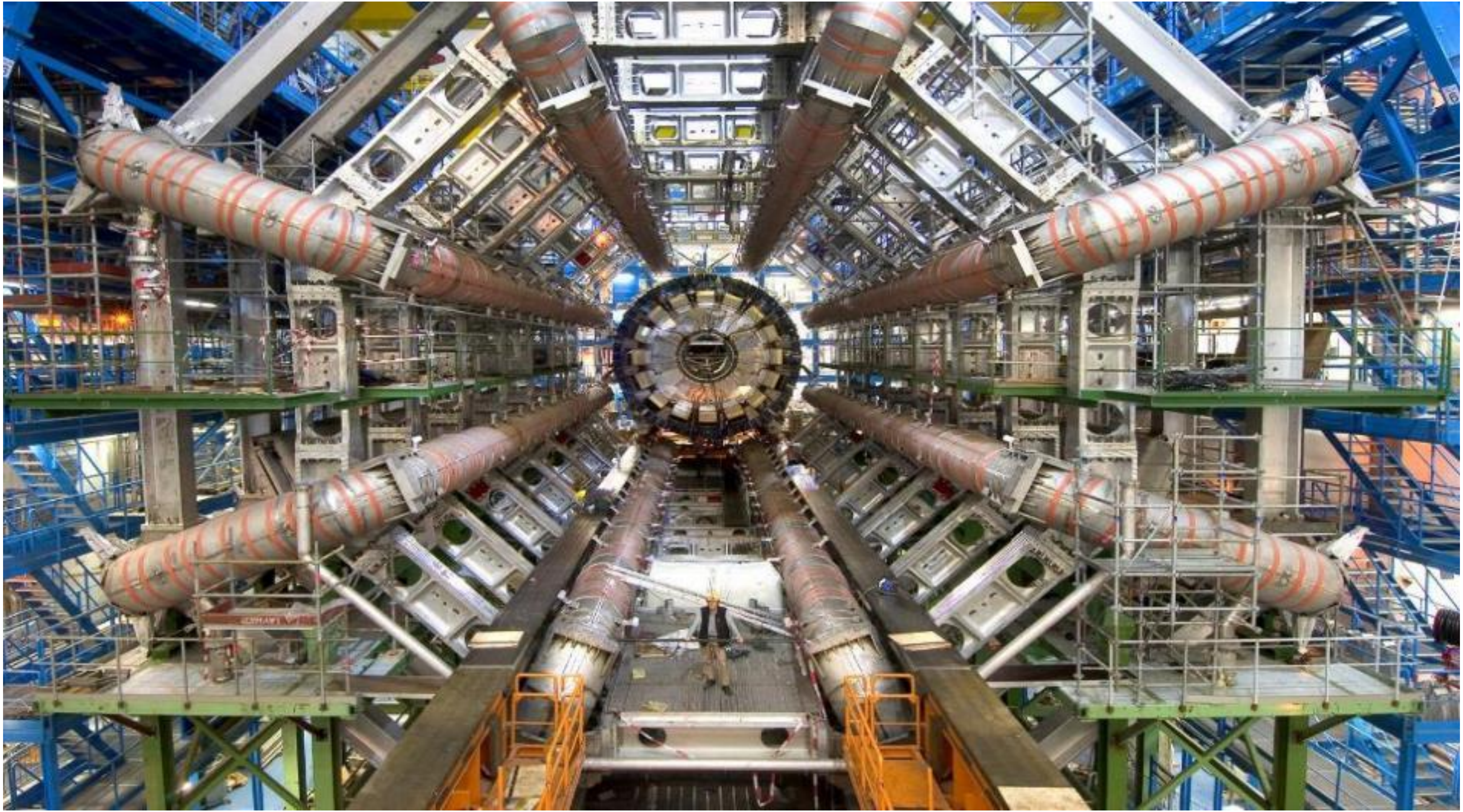
~700 MB/s

>1 GB/s

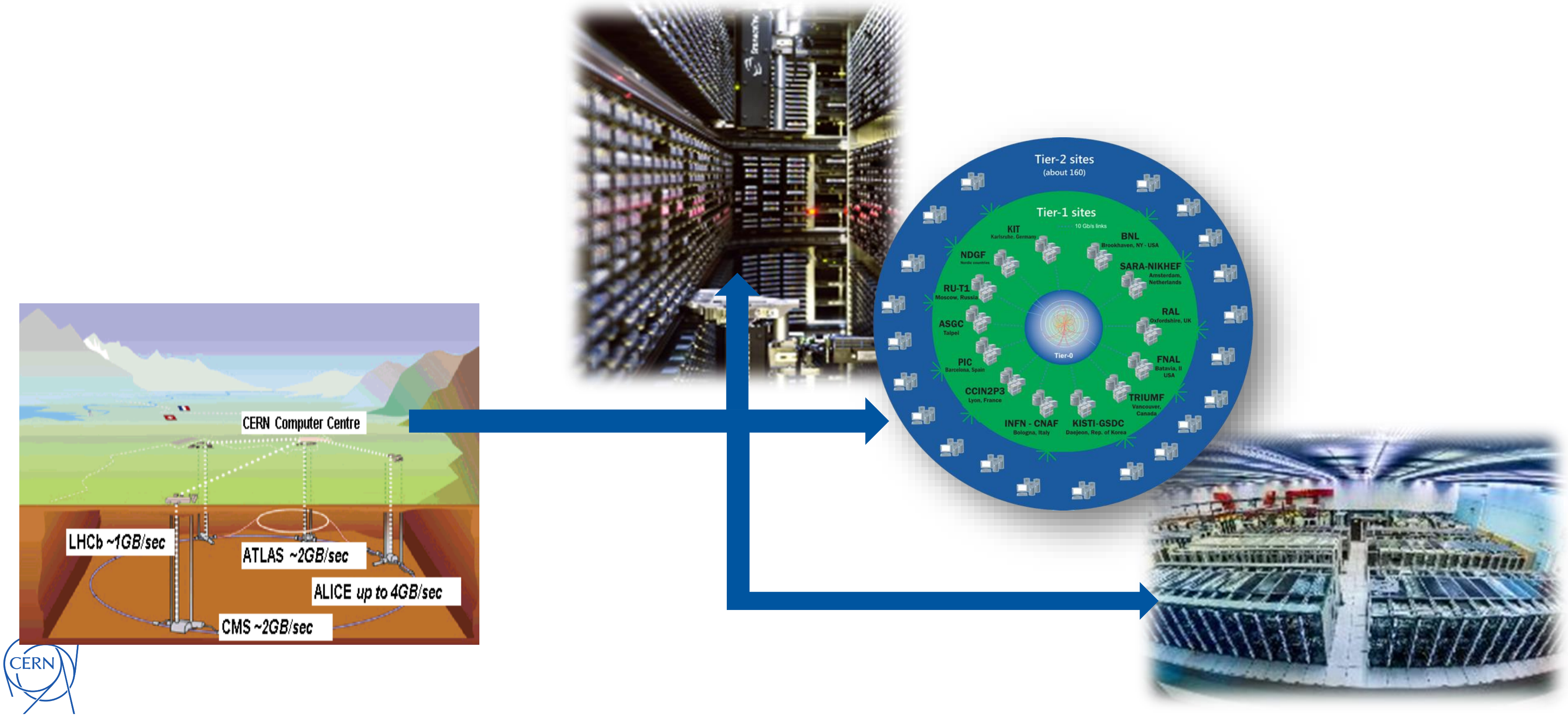
~10 GB/s

>1 GB/s

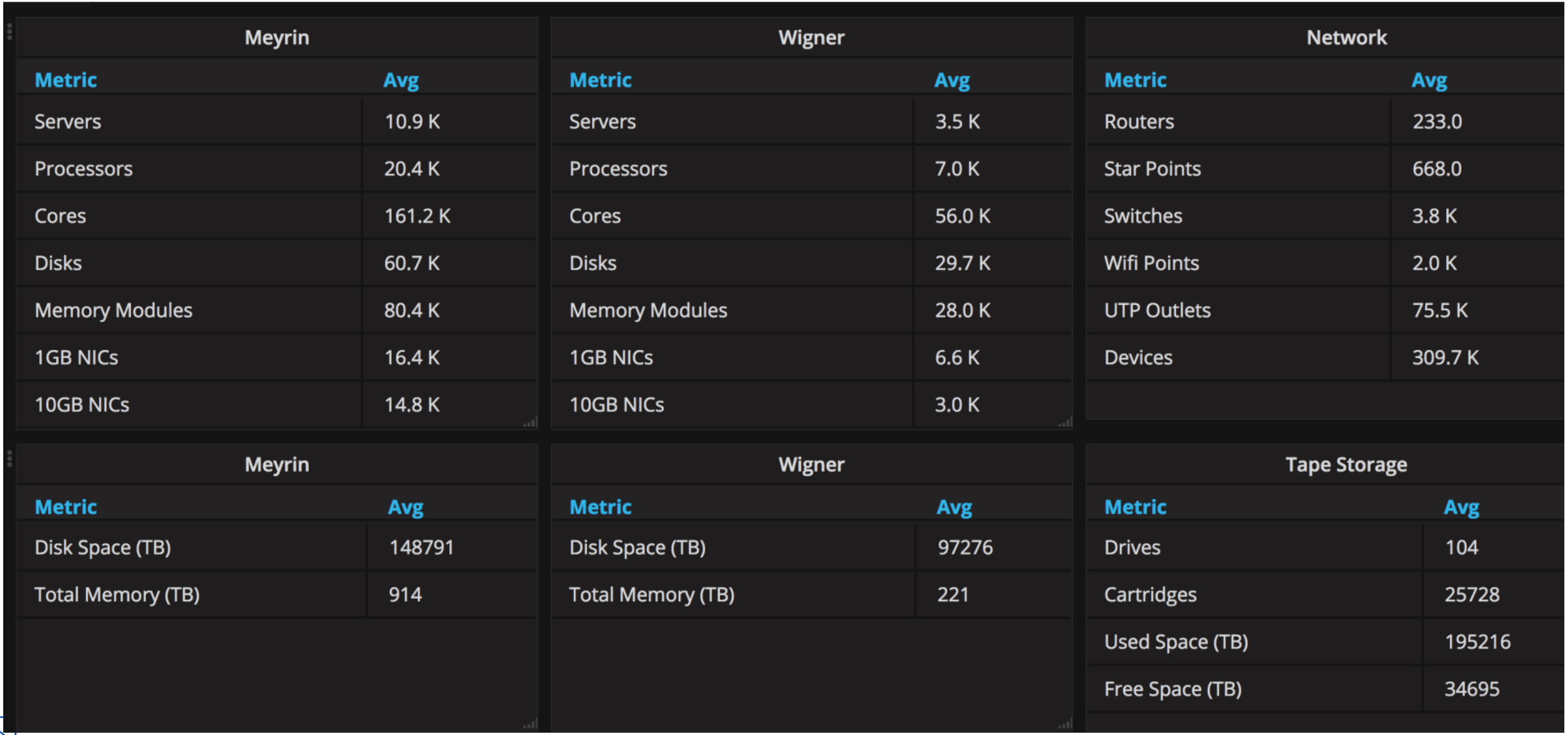
1213



2016: 50 PB recorded on tape!



Data Centres by Numbers



Meyrin

Metric	Avg
Servers	10.9 K
Processors	20.4 K
Cores	161.2 K
Disks	60.7 K
Memory Modules	80.4 K
1GB NICs	16.4 K
10GB NICs	14.8 K

Wigner

Metric	Avg
Servers	3.5 K
Processors	7.0 K
Cores	56.0 K
Disks	29.7 K
Memory Modules	28.0 K
1GB NICs	6.6 K
10GB NICs	3.0 K

Network

Metric	Avg
Routers	233.0
Star Points	668.0
Switches	3.8 K
Wifi Points	2.0 K
UTP Outlets	75.5 K
Devices	309.7 K

Meyrin

Metric	Avg
Disk Space (TB)	148791
Total Memory (TB)	914

Wigner

Metric	Avg
Disk Space (TB)	97276
Total Memory (TB)	221

Tape Storage

Metric	Avg
Drives	104
Cartridges	25728
Used Space (TB)	195216
Free Space (TB)	34695

Managing all this became…

…very…

…very…

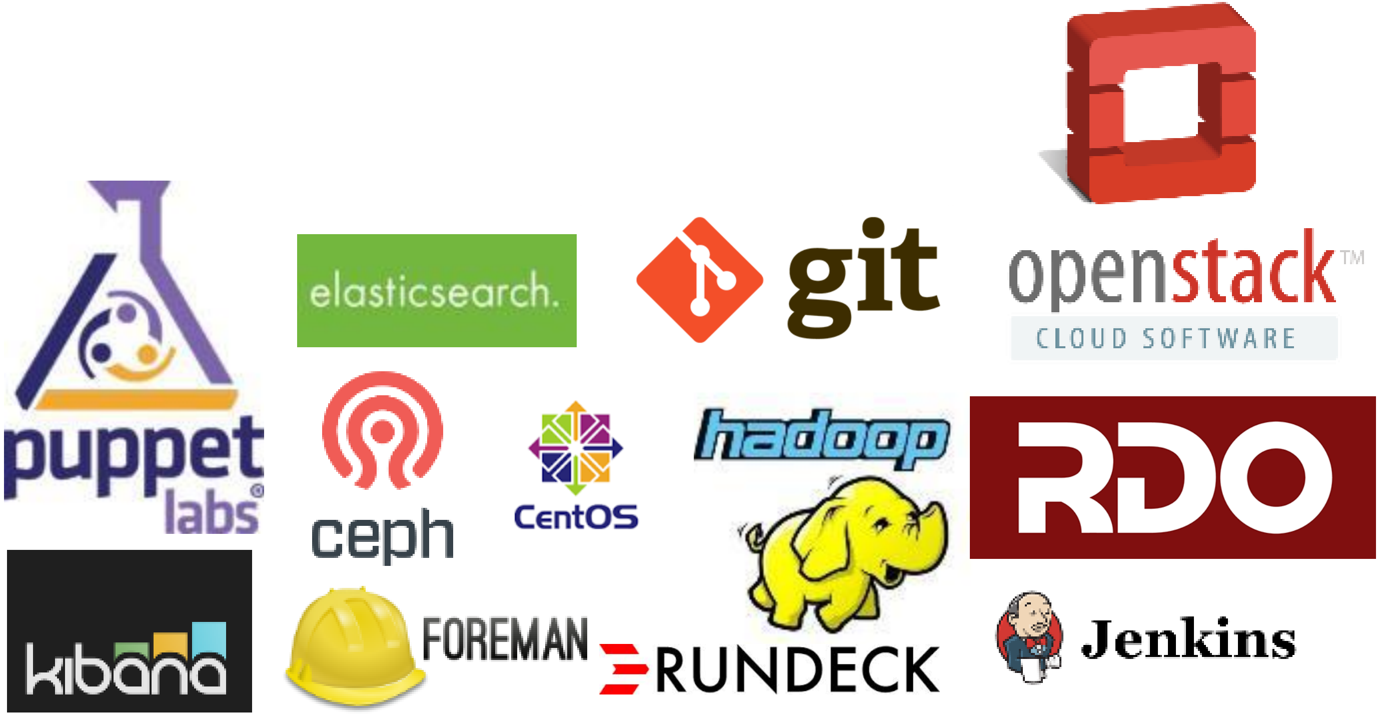
…very…

…tricky…

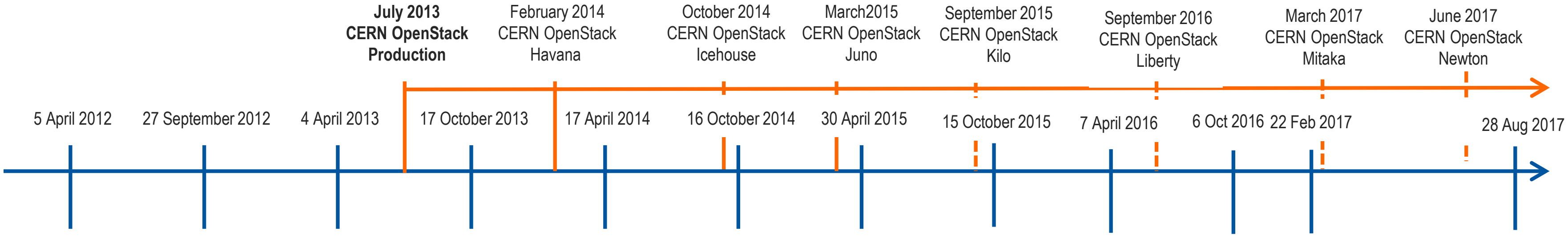
2012: Agile Infrastructure project

- Provisioning + Configuration + Monitoring
- Aim: virtualize all the machines
  - Unless really, really, really not possible
- Offer Cloud endpoints to users
- Scale horizontally
- Consolidate server provisioning
  - Yes, we use the private cloud for server consolidation usecases as well

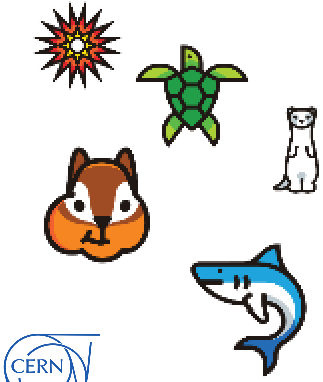
CERN Tool Chain



CERN OpenStack Service Timeline

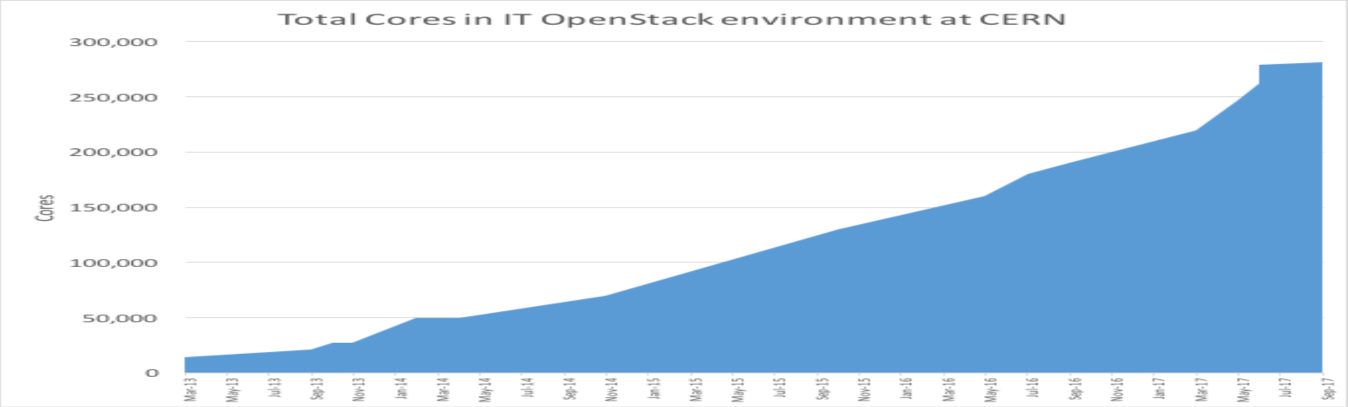


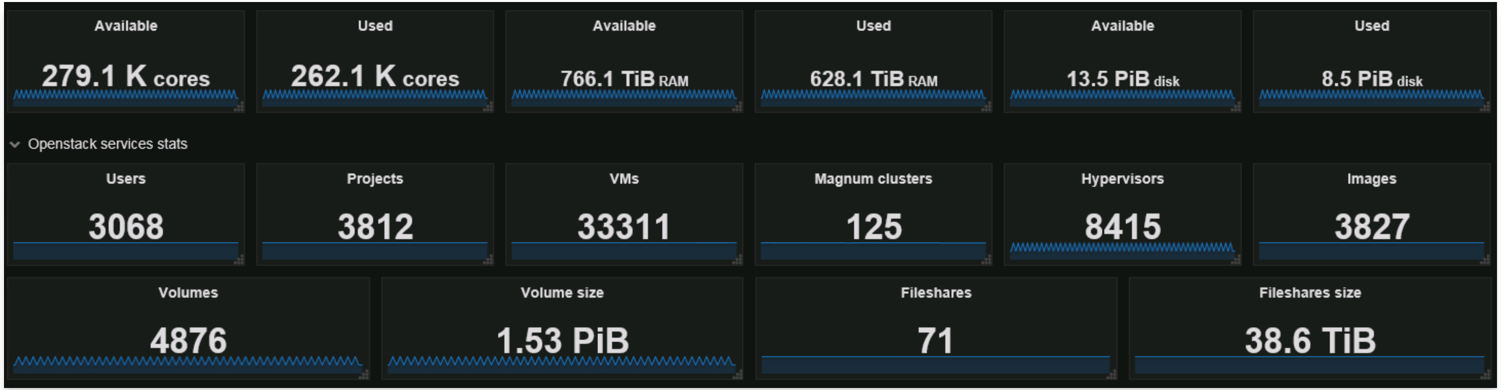
ESSEX	FOLSOM	GRIZZLY	HAVANA	ICEHOUSE	JUNO	KILO	LIBERTY	MITAKA	NEWTON	OCATA	PIKE
Nova (*)	Nova (*)	Nova	Nova	Nova	Nova	Nova	Nova	Nova	Nova	Nova	Nova
Glance (*)	Glance (*)	Glance	Glance	Glance	Glance	Glance	Glance	Glance	Glance	Glance	Glance
Horizon (*)	Horizon (*)	Horizon	Horizon	Horizon	Horizon	Horizon	Horizon	Horizon	Horizon	Horizon	Horizon
Keystone (*)	Keystone (*)	Keystone	Keystone	Keystone	Keystone	Keystone	Keystone	Keystone	Keystone	Keystone	Keystone
	Quantum	Quantum	Neutron	Neutron	Neutron	Neutron	Neutron (*)	Neutron	Neutron	Neutron	Neutron
	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder	Cinder
		Ceilometer (*)	Ceilometer (*)	Ceilometer	Ceilometer	Ceilometer	Ceilometer	~~Ceilometer~~	~~Ceilometer~~	~~Ceilometer~~	~~Ceilometer~~
			Heat	Heat	Heat (*)	Heat	Heat	Heat	Heat	Heat	Heat
				~~Ironic~~	Rally (*)	Rally	Rally	Rally	Rally	Rally	Rally
				~~Trove~~		~~Manila~~	EC2API	EC2API	EC2API	EC2API	EC2API
							Magnum (*)	Magnum	Magnum	Magnum	Magnum
							Barbican (*)	Barbican	Barbican	Barbican	Barbican
								Ironic (?)	Ironic (?)	Ironic (?)	Ironic (*)
								Mistral (?)	Mistral (?)	Mistral (?)	Mistral (*)
								Manila (?)	Manila (?)	Manila (*)	Manila (*)



(*) Pilot (?) Trial ~~Retired~~

CERN OpenStack cloud in numbers





Available
279.1 K cores

Used
262.1 K cores

Available
766.1 TiB RAM

Used
628.1 TiB RAM

Available
13.5 PiB disk

Used
8.5 PiB disk

Openstack services stats

Users
3068

Projects
3812

VMs
33311

Magnum clusters
125

Hypervisors
8415

Images
3827

Volumes
4876

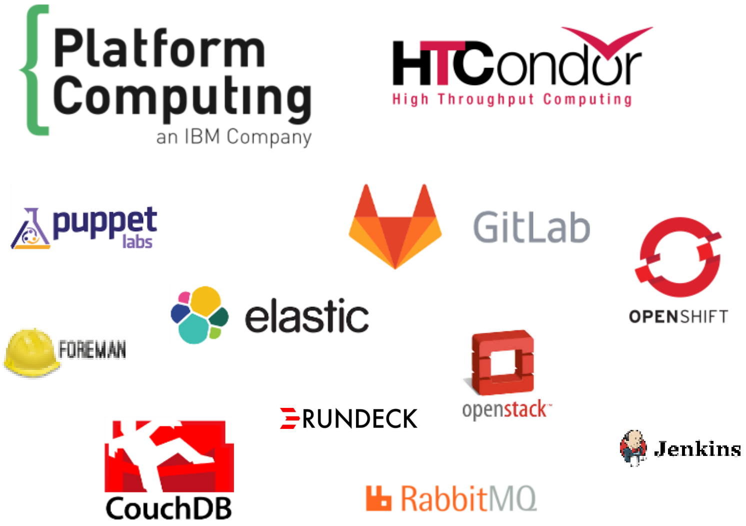
Volume size
1.53 PiB

Fileshares
71

Fileshares size
38.6 TiB

Rich Usage Spectrum …

- ❑ Batch service
  - Physics data analysis
- ❑ IT Services
  - Sometimes built on top of other virtualised services
- ❑ Experiment services
  - E.g. build machines
- ❑ Engineering services
  - E.g. micro-electronics/chip design
- ❑ Infrastructure services
  - E.g. hostel booking, car rental, …
- ❑ Personal VMs
  - Development



… rich requirement spectrum!

Scaling Nova

Top level cell

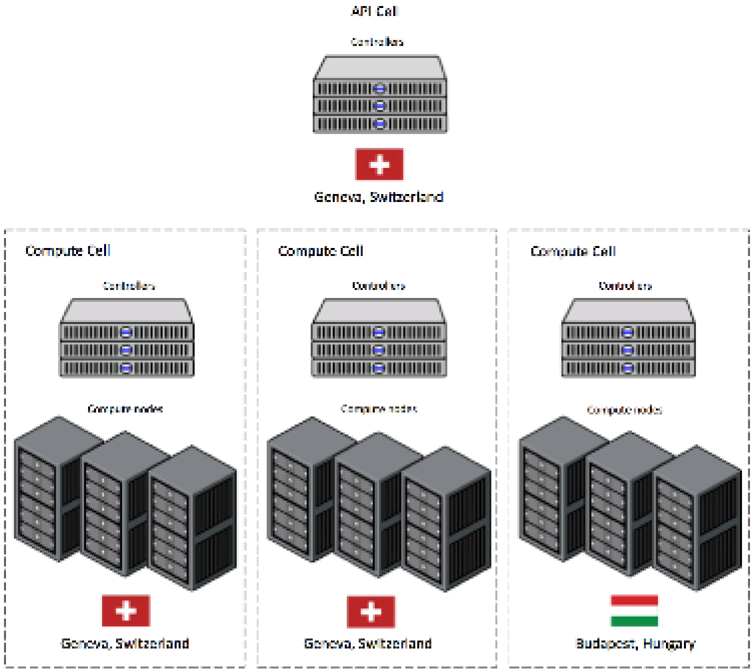
- Runs API service
- Top cell scheduler

>50 child cells run

- Compute nodes
- Scheduler
- Conductor

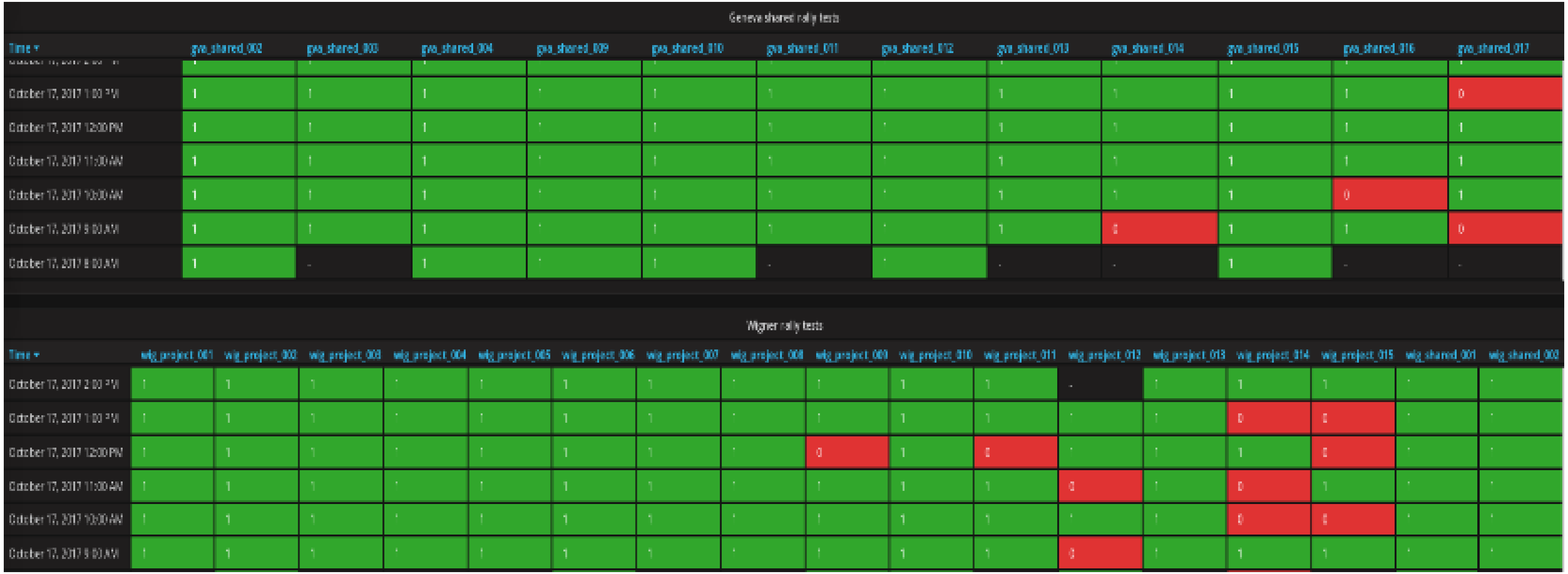
Cells v2 coming

- Default for all



Rally

RALLY
an OpenStack Community Project



Geneva shared rally tests

Time ▾	gva_shared_002	gva_shared_003	gva_shared_004	gva_shared_009	gva_shared_010	gva_shared_011	gva_shared_012	gva_shared_013	gva_shared_014	gva_shared_015	gva_shared_016	gva_shared_017
October 17, 2017 1:00 PM	1	1	1	1	1	1	1	1	1	1	1	0
October 17, 2017 12:00 PM	1	1	1	1	1	1	1	1	1	1	1	1
October 17, 2017 11:00 AM	1	1	1	1	1	1	1	1	1	1	1	1
October 17, 2017 10:00 AM	1	1	1	1	1	1	1	1	1	1	0	1
October 17, 2017 9:00 AM	1	1	1	1	1	1	1	1	0	1	1	0
October 17, 2017 8:00 AM	1	-	1	1	1	-	1	-	-	1	-	-

Wigner rally tests

Time ▾	wig_project_001	wig_project_002	wig_project_003	wig_project_004	wig_project_005	wig_project_006	wig_project_007	wig_project_008	wig_project_009	wig_project_010	wig_project_011	wig_project_012	wig_project_013	wig_project_014	wig_project_015	wig_shared_001	wig_shared_002
October 17, 2017 2:00 PM	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1
October 17, 2017 1:00 PM	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1
October 17, 2017 12:00 PM	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1
October 17, 2017 11:00 AM	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1
October 17, 2017 10:00 AM	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1
October 17, 2017 9:00 AM	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1

Magnum

- Container Engine as a Service
  - Kubernetes, Docker, Mesos, DCOS…
  - 120 clusters, 700 nodes

```
$ magnum cluster-create --name myswarmcluster --cluster-template swarm --node-count 100

$ magnum cluster-list
+------+----------------+------------+--------------+-----------------+
| uuid | name           | node_count | master_count | status          |
+------+----------------+------------+--------------+-----------------+
| .... | myswarmcluster | 100        | 1            | CREATE_COMPLETE |
+------+----------------+------------+--------------+-----------------+

$ $(magnum cluster-config myswarmcluster --dir magnum/myswarmcluster)

$ docker info / ps / ...
$ docker run --volume-driver cvmfs -v atlas.cern.ch:/cvmfs/atlas -it centos /bin/bash
[root@32f4cf39128d /]#
```

MAGNUM
an OpenStack Community Project

CERN openlab

rackspace®

CERN

What’s new? Mistral

- Workflow-as-a-Service used for multi-step actions, triggered by users or events
- Horizon dashboard for visualising results
- Examples
  - Expire personal resources after 6 months
  - Multi-step project creation
  - Scheduled snapshot of VMs
- Code at https://gitlab.cern.ch/cloud-infrastructure/mistral-workflows
- Some more complex cases coming in the pipeline

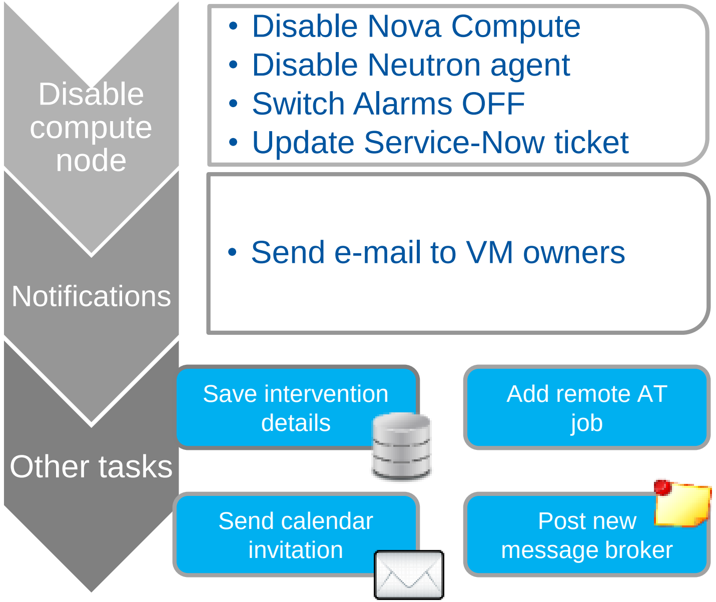
Automate provisioning

Automate routine procedures

- Common place for workflows
- Clean web interface
- Scheduled jobs, cron-style
- Traceability and auditing
- Fine-grained access control
- …

Procedures for

- OpenStack project creation
- OpenStack quota changes
- Notifications of VM owners
- Usage and health reports
- …



Disable compute node

- Disable Nova Compute
- Disable Neutron agent
- Switch Alarms OFF
- Update Service-Now ticket

Notifications

- Send e-mail to VM owners

Other tasks

Save intervention details

Add remote AT job

Send calendar invitation

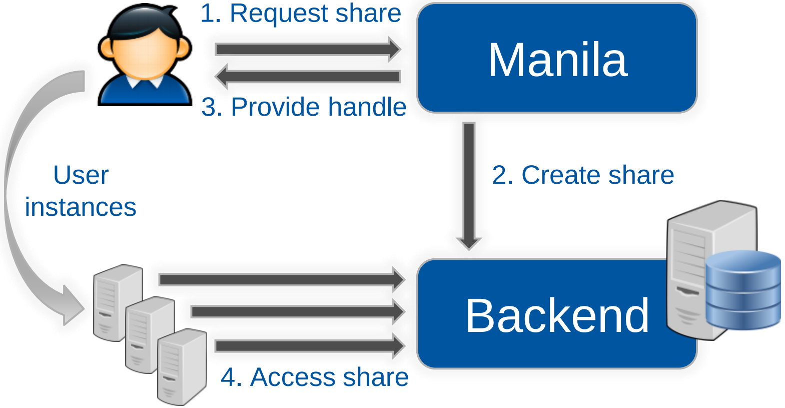
Post new message broker

Manila: Overview

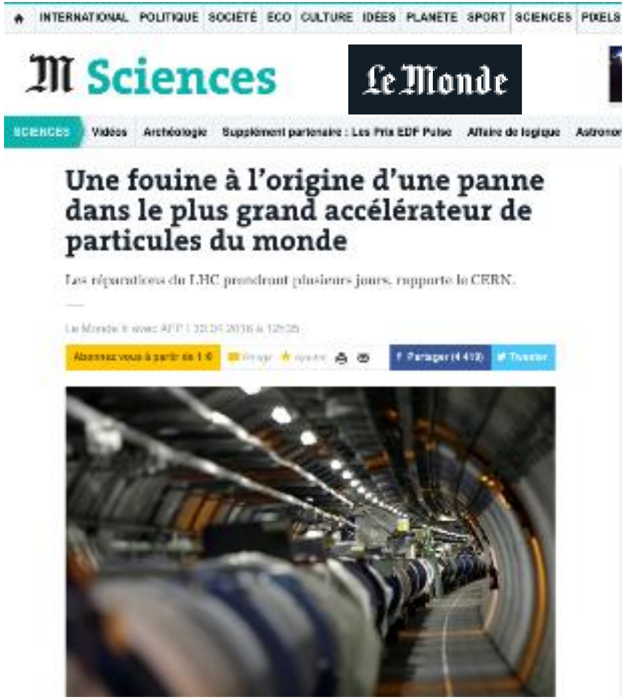
- File Share Project in OpenStack
  - Provisioning of shared file systems to VMs
  - ‘Cinder for file shares’
- APIs for tenants to request shares
  - Fulfilled by backend drivers
  - Accessed from instances
- Support for variety of NAS protocols
  - NFS, CIFS, MapR-FS, GlusterFS, **CephFS**, …
- Supports the notion of share types
  - Map features to backends

MANILA

an OpenStack Community Project



LHC Incident in April 2016

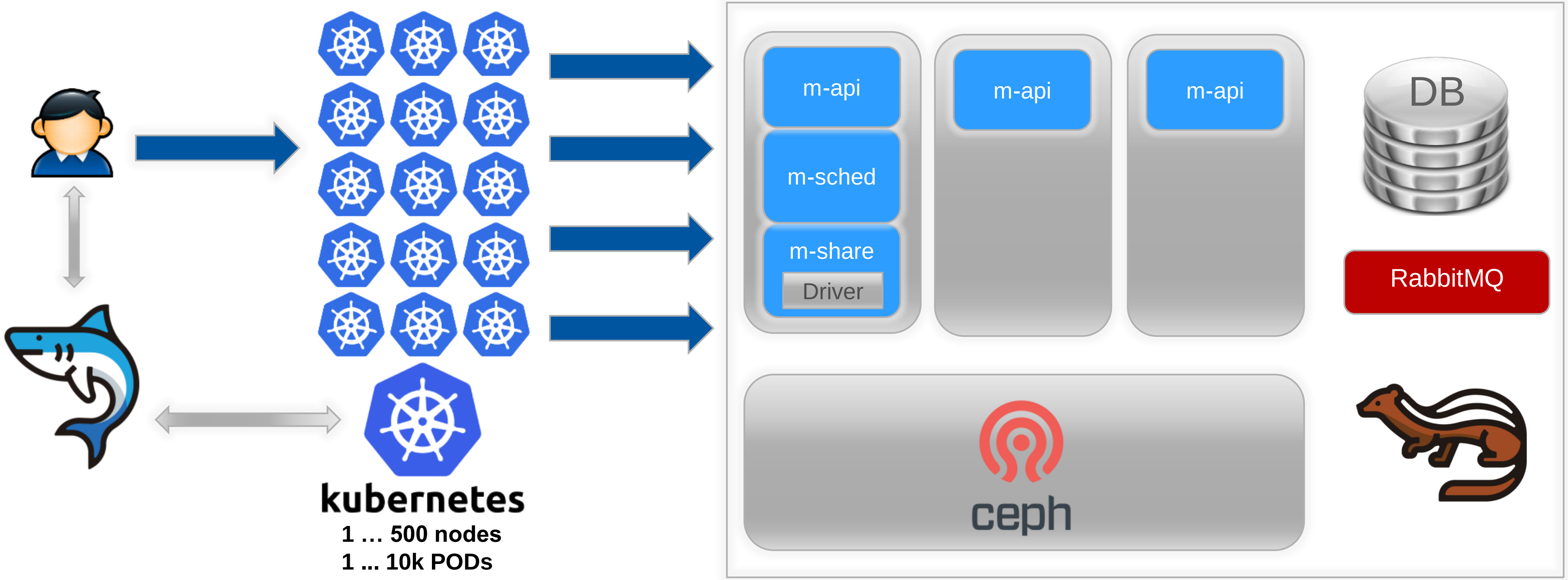


Une fouine à l'origine d'une panne dans le plus grand accélérateur de particules du monde

Les réparations du LHC prendront plusieurs jours, rapporte le CERN.

Le Monde.fr avec AFP | 30.04.2016 à 12h35

Manila testing: #fouinehammer



Operations areas going forward

- Further automate migrations
  - Around 5,000 VMs / year
  - First campaign in 2016 needed some additional scripting such as pausing very active VMs
  - Newton live migration includes most use cases
- Software Defined Networking
  - Nova network to Neutron migration to be completed
  - In addition to flat network in use currently
  - Introduce higher level functions such as LBaaS

Development areas going forward

- Nova Pre-emptible VMs
- Nova Cells V2
- **M**agnum rolling upgrades

- Collaborations with Industry

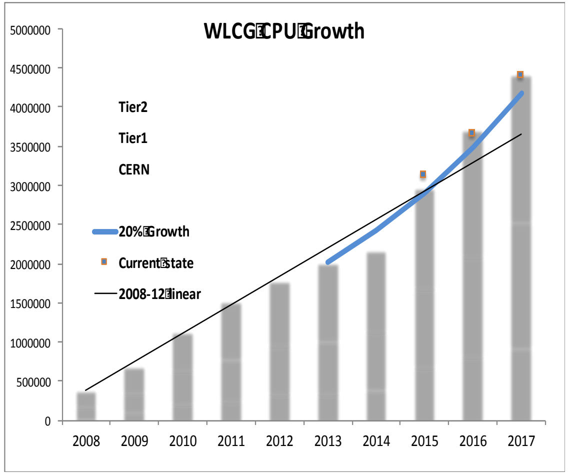
HUAWEI

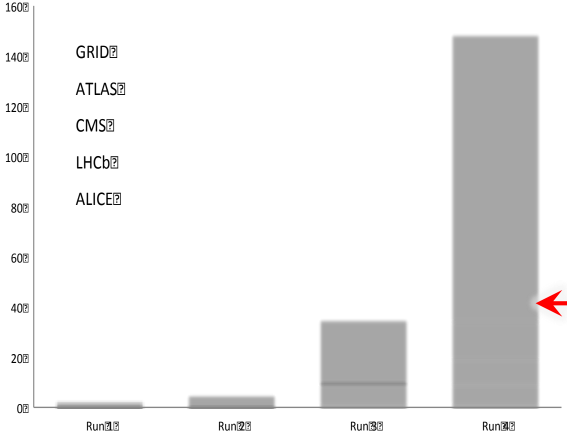
CERN openlab

rackspace®
*the #1 **managed cloud** company*

Compute needs growing…

- With the needs of LHC computing in future years, efficient and flexible delivery of compute resources will be key
  - Computing needs in 2023 estimated at 60x the current capacity (HL-LHC)

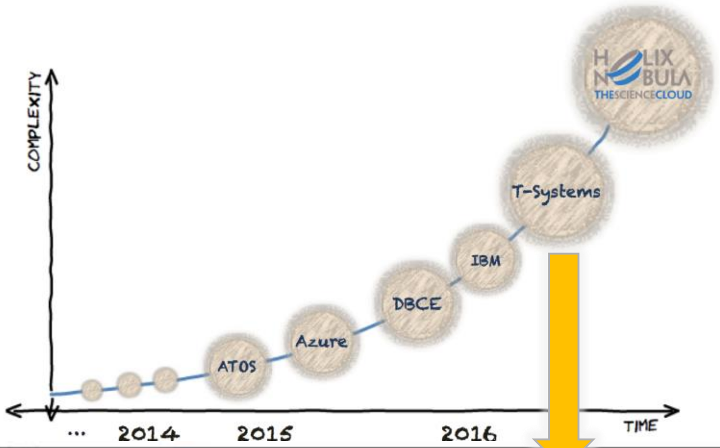


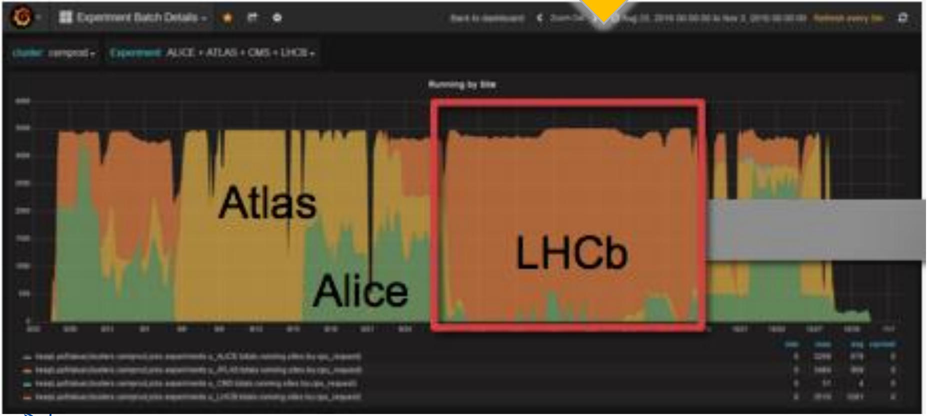


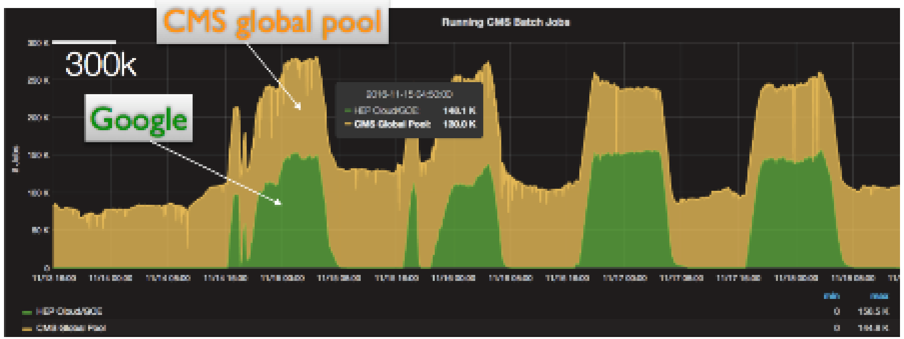
Compute: Growth > x60

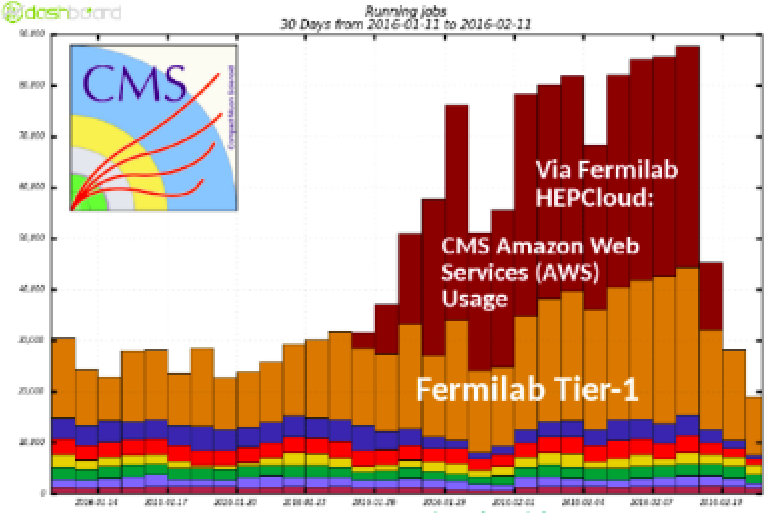
What we think is affordable unless we do something differently

Commercial Clouds









Summary

❑ OpenStack has provided a strong base for scaling resources over the past 5 years

❑ Additional functionality on top of pure Infrastructure-as-a-Service is now coming to production

❑ Community and industry collaboration has been productive and inspirational for the CERN team

❑ Some big computing challenges up ahead…

Thank you!

Further Information

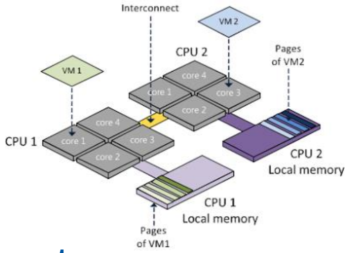
Technical details on the CERN cloud at http://openstack-in-production.blogspot.fr

Custom CERN code is at https://github.com/cernops

Scientific Working Group at https://wiki.openstack.org/wiki/Scientific_working_group

Helix Nebula details at http://www.helix-nebula.eu/

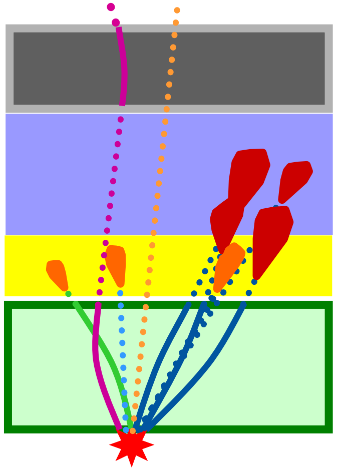
Tuning



- ❑ Many hypervisors are configured for compute optimisation
  - CPU Passthrough so VM sees identical CPU
  - Extended Page Tables so memory page mapping is done in hardware
  - Core pinning so scheduler keeps the cores on the underlying physical cores
  - Huge pages to improve memory page cache utilisation
  - Flavors are set to be NUMA aware
- ❑ Improvements of up to 20% in performance
- ❑ Impact is that the VMs cannot be live migrated so service machines are not configured this way

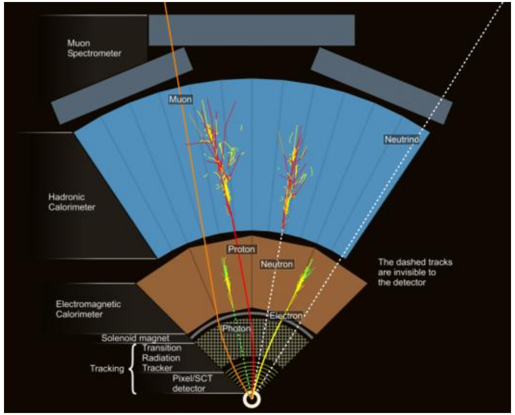
Pick the interesting events

- 40 million per second
  - Fast, simple information
  - Hardware trigger in a few micro seconds
- 100 thousand per second
  - Fast algorithms in local computer farm
  - Software trigger in <1 second
- Few 100 per second
  - Recorded for study



Muon tracks

Energy deposits


Muon Spectrometer
Muon
Neutrino
Hadronic Calorimeter
Proton
Neutron
The dashed tracks are invisible to the detector
Electromagnetic Calorimeter
Electron
Photon
Solenoid magnet
Tracking
Transition Radiation Tracker
Pixel/SCT detector