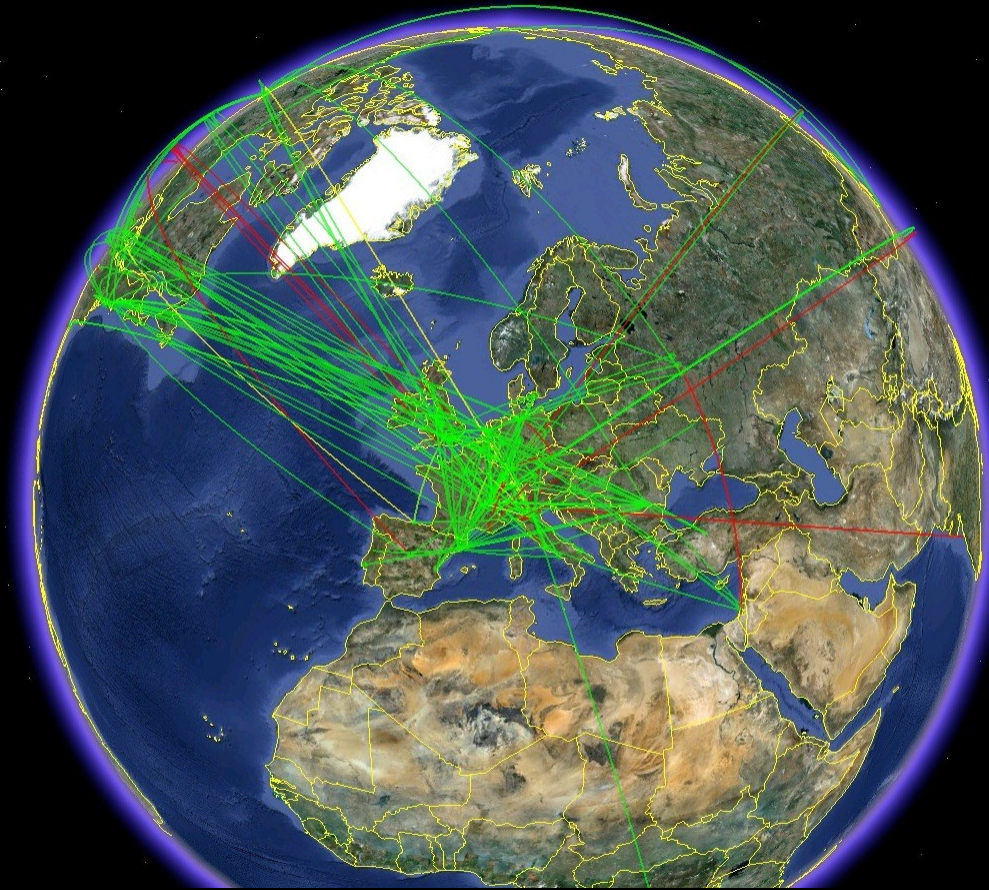


The Worldwide LHC Computing Grid

8/2/2012 8:21:32 am

Running jobs: 261027
Transfer rate: 12.33 GiB/sec

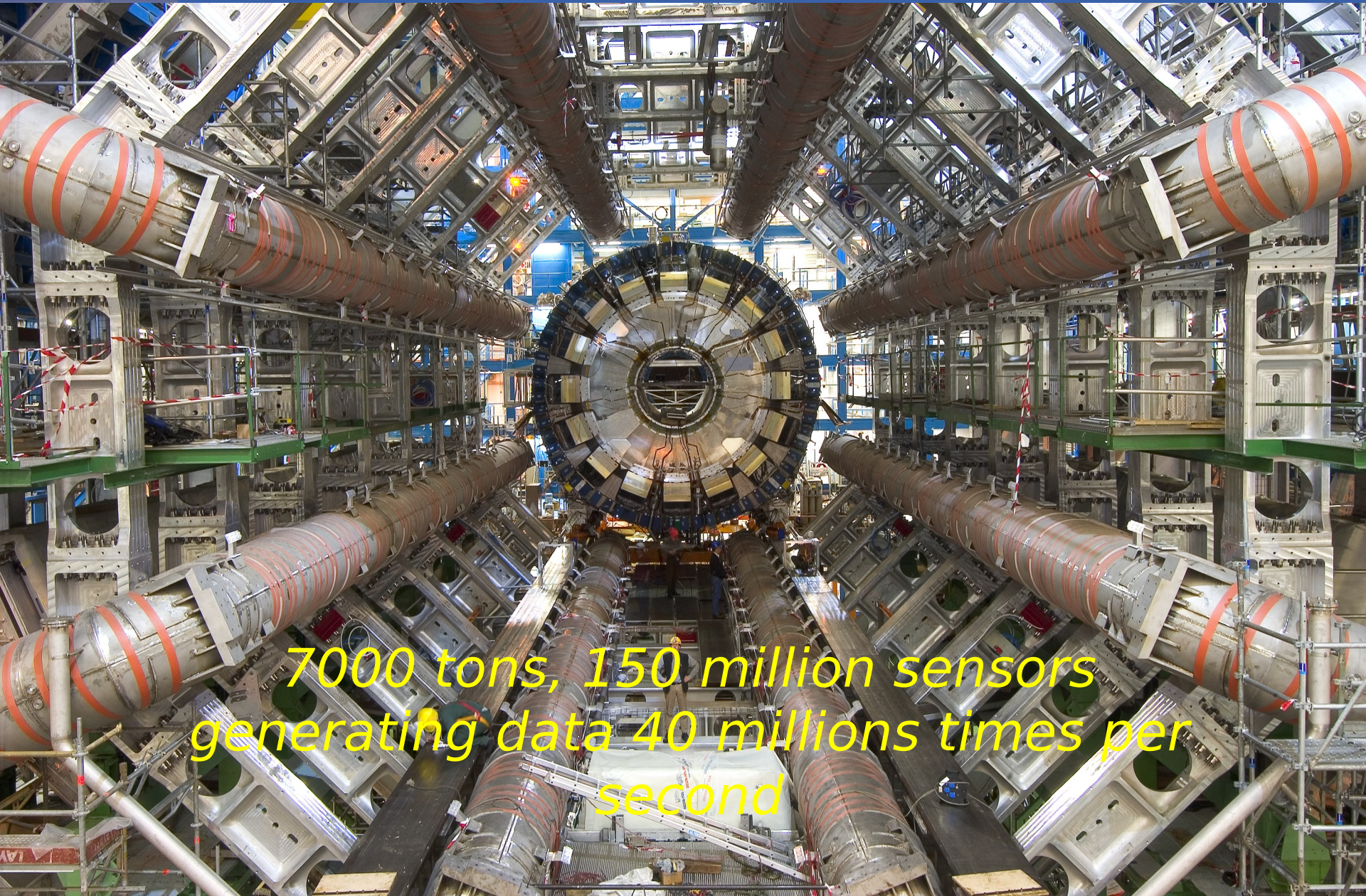


dashboard

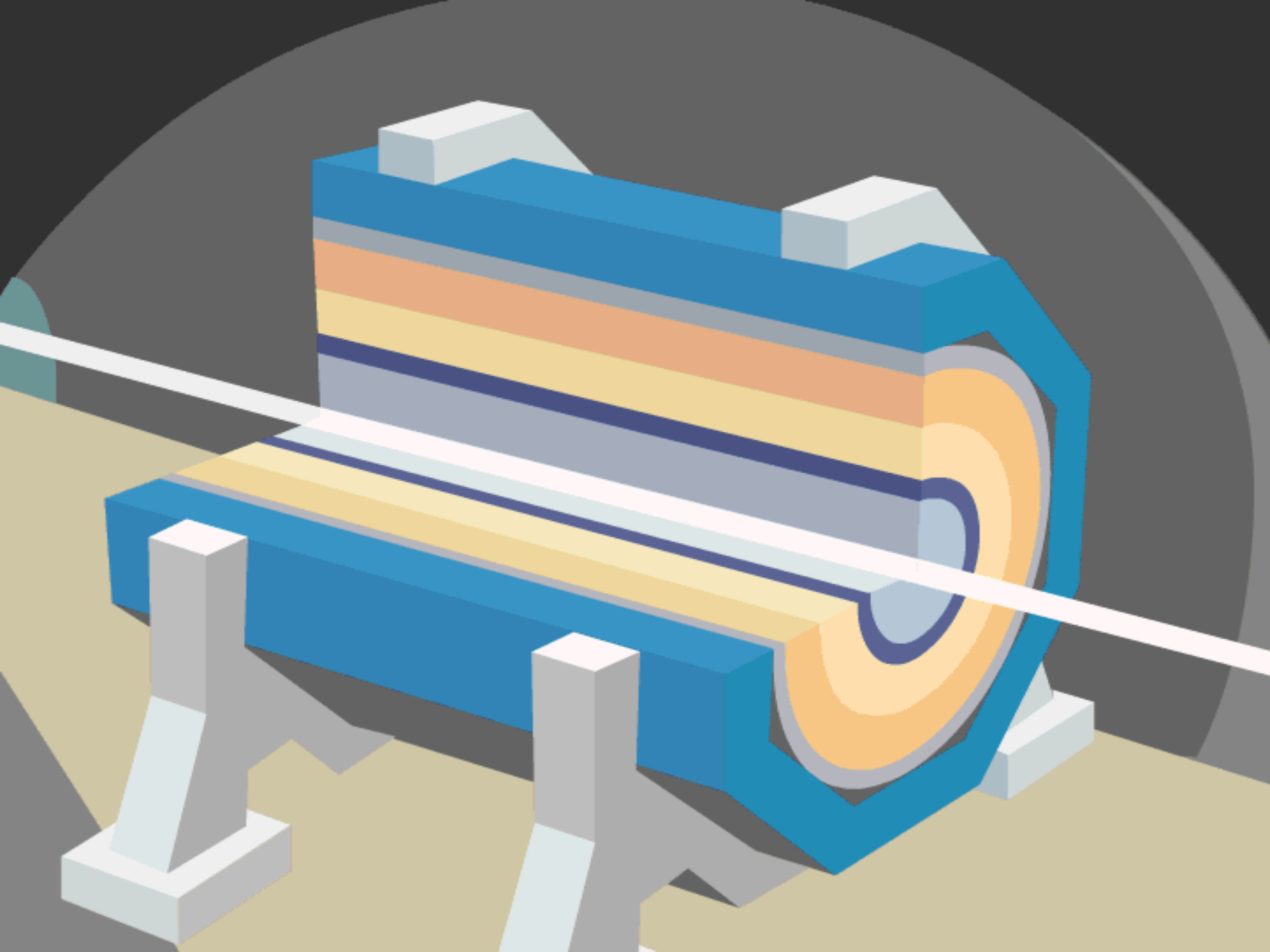
Nils Høimyr
IT Department

The ATLAS experiment

CERN
IT
Department



7000 tons, 150 million sensors
generating data 40 millions times per
second



~ 300.000 MB/s
from all sub-detectors

~ 300MB/s
Raw Data

Trigger and data acquisition

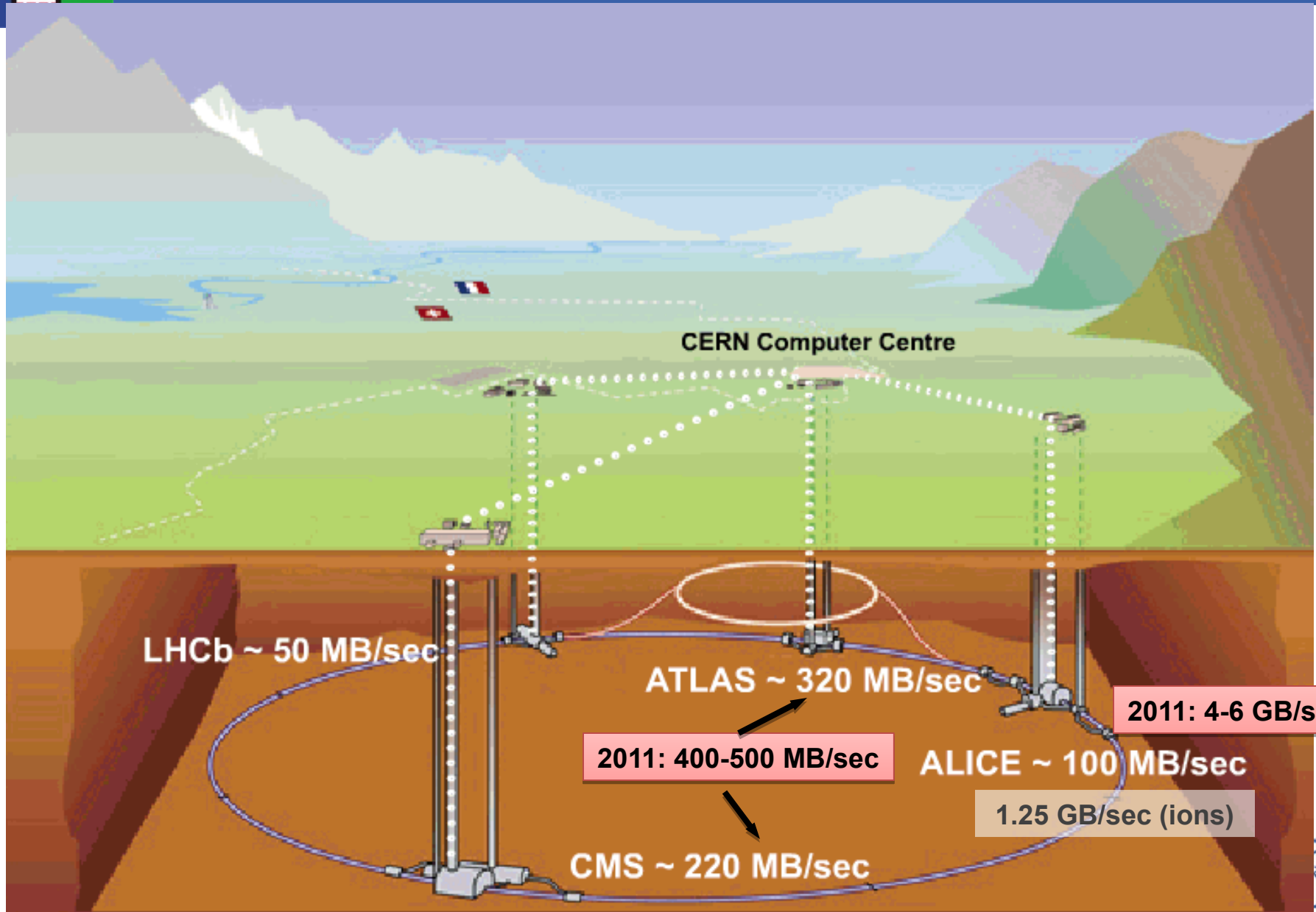


Event filter computer farm





Tier 0 at CERN: Acquisition, First pass reconstruction, **Storage & Distribution**



The CERN Data Centre in Numbers

- Data Centre Operations (Tier 0)
 - 24x7 operator support and System Administration services to support 24x7 operation of all IT services.
 - Hardware installation & retirement
 - ~7,000 hardware movements/year; ~1800 disk failures/year
 - Management and Automation framework for large scale Linux clusters

CERN Computer Centre (B513)

- ~10 000 servers
- ~90 000 processor cores
- About 100 Pb of storage
- 3500 kW power

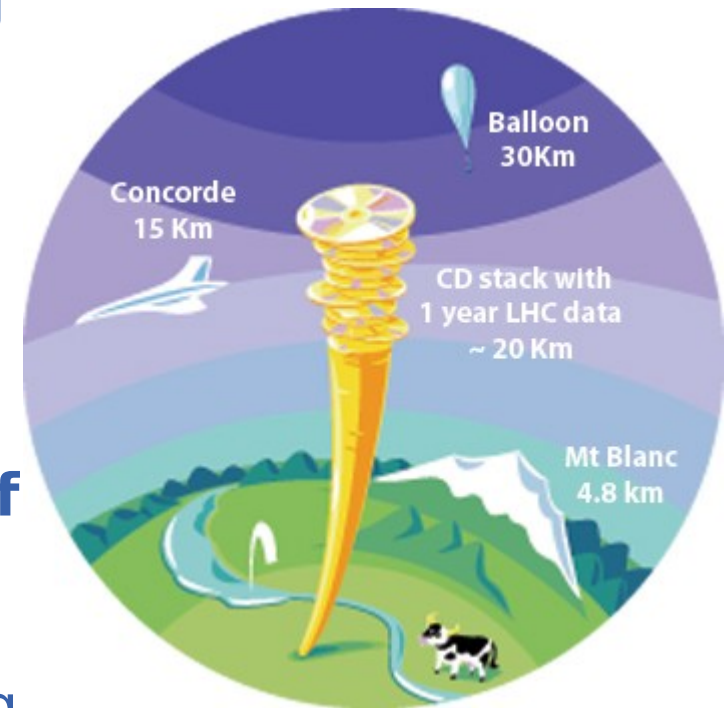
Details on hardware:

- <http://hwcollect.cern.ch/>



The LHC Data Challenge

- The accelerator will run for 20 years
- Experiments are producing about **25 Million Gigabytes** of data each year (about 3 million DVDs – 850 years of movies!)
- LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**
- Requires many cooperating computer centres, as CERN can **only** provide **~20% of the capacity**



Solution: the Grid

- Use the Grid to unite computing resources of particle physics institutes around the world

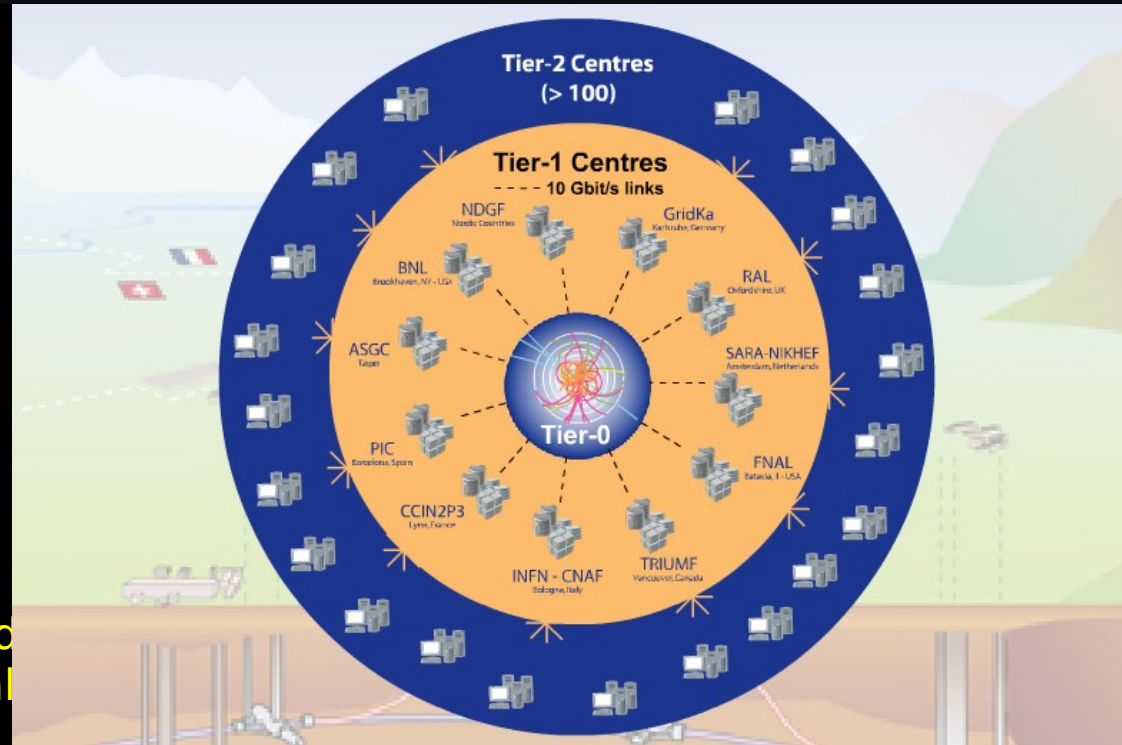
The **World Wide Web** provides seamless access to information that is stored in many millions of different geographical locations

The **Grid** is an infrastructure that provides seamless access to computing power and data storage capacity distributed over the globe



WLCG - what and why?

- A distributed computing infrastructure to provide the production and analysis environments for the LHC experiments
- Managed and operated by a worldwide collaboration between the experiments and the participating computer centres
- The resources are distributed – for funding and sociological reasons
- Our task was to make use of the resources available to us – no matter where they are located



Tier-0 (CERN):

- Data recording
- Initial data reconstruction
- Data distribution

Tier-1 (11 centres):

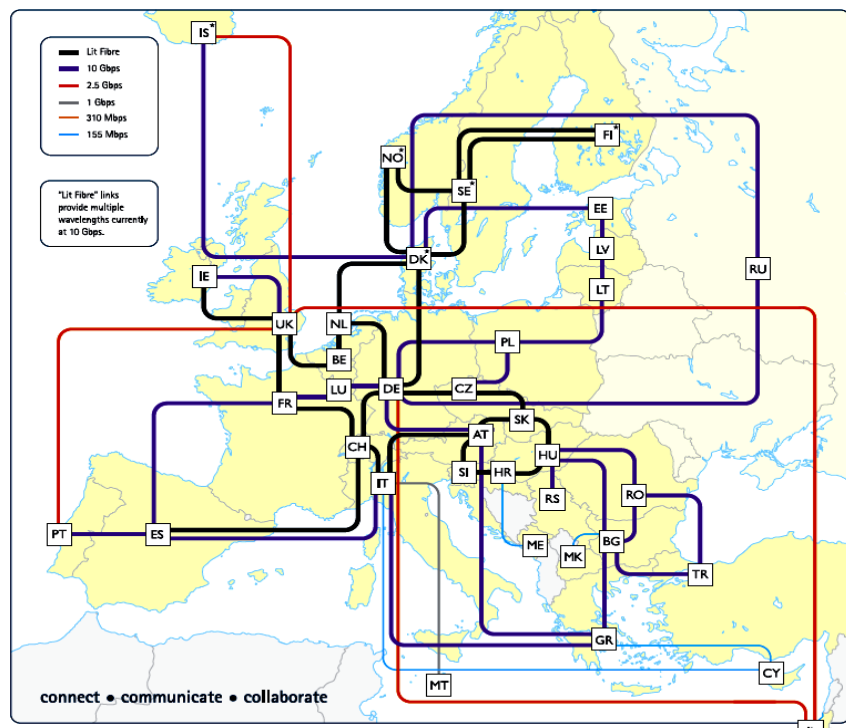
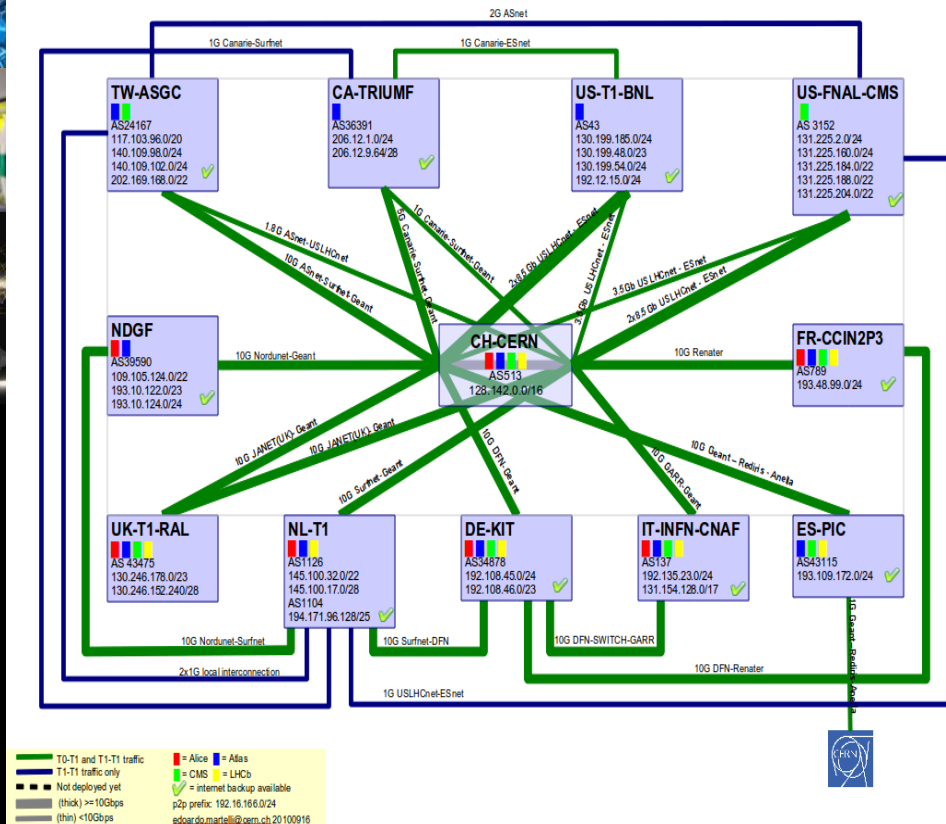
- Permanent storage
- Re-processing
- Analysis

Tier-2 (~130 centres):

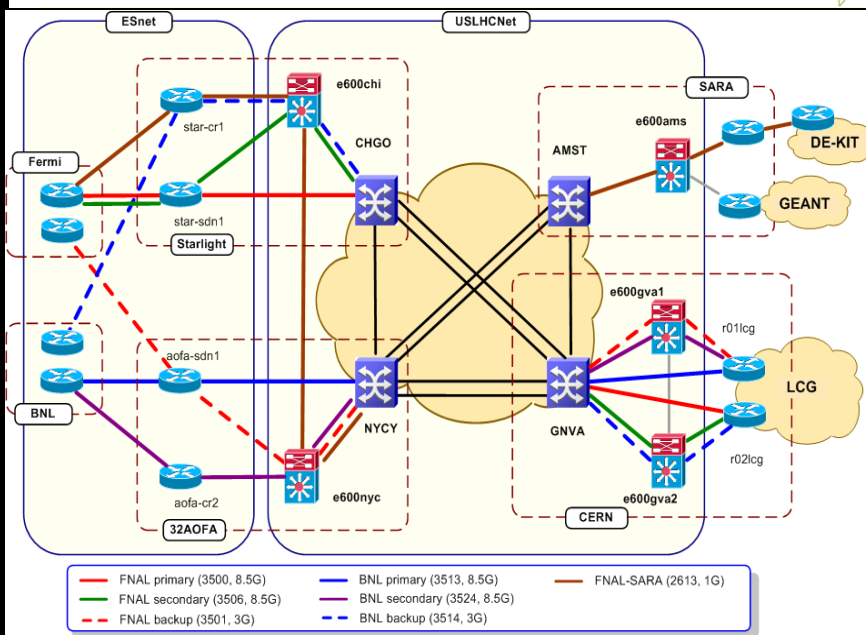
- Simulation
- End-user analysis

LHC Networking

LHCOPN

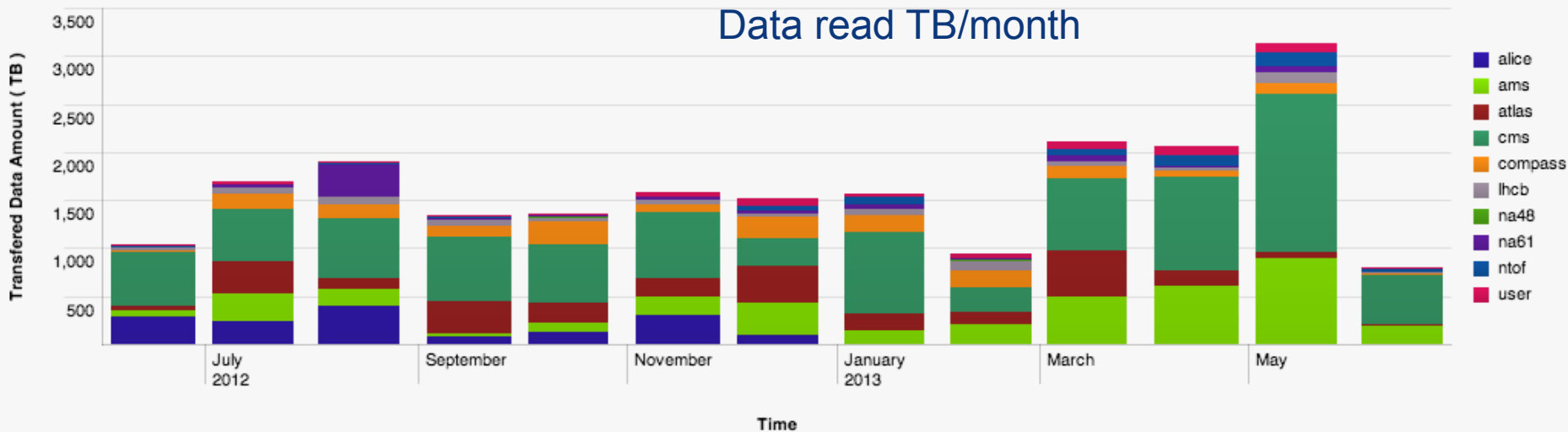
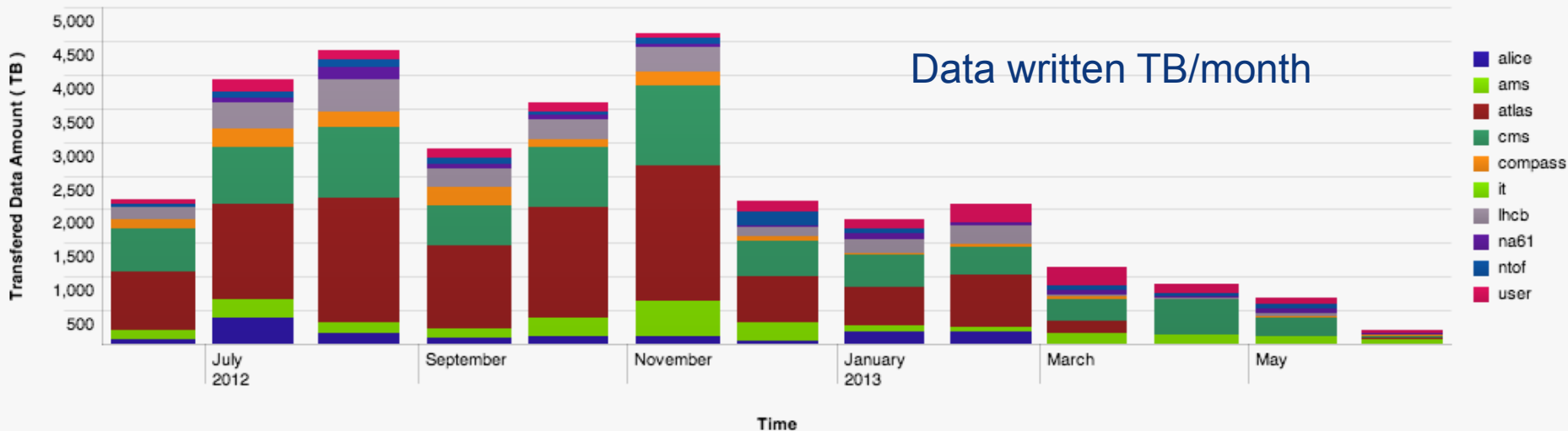


Planned Backbone Topology by the end of 2010. GÉANT is operated by DANTE on behalf of Europe's NRENs.

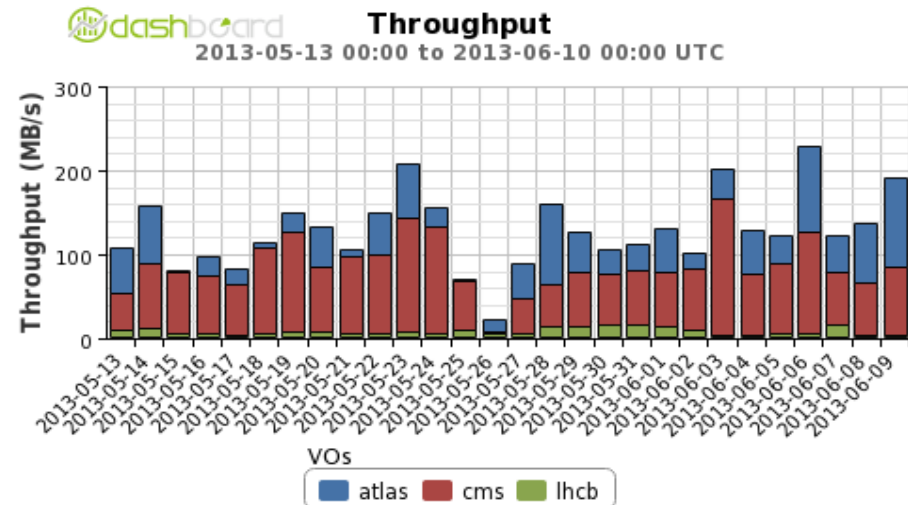
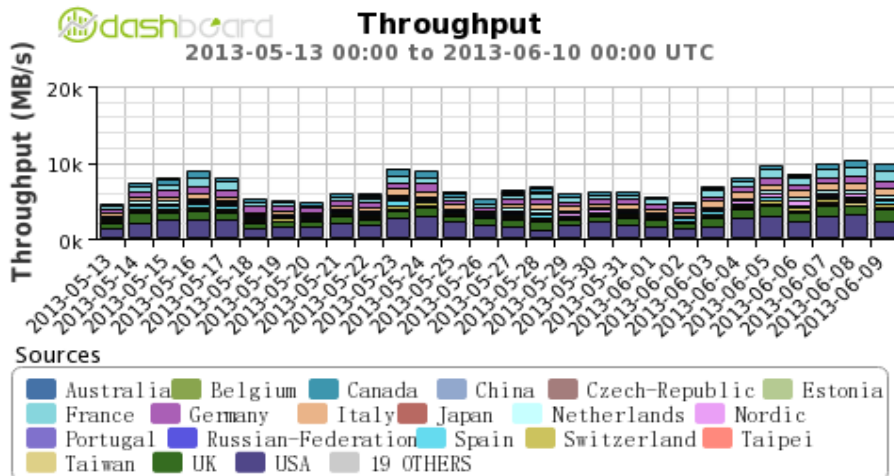
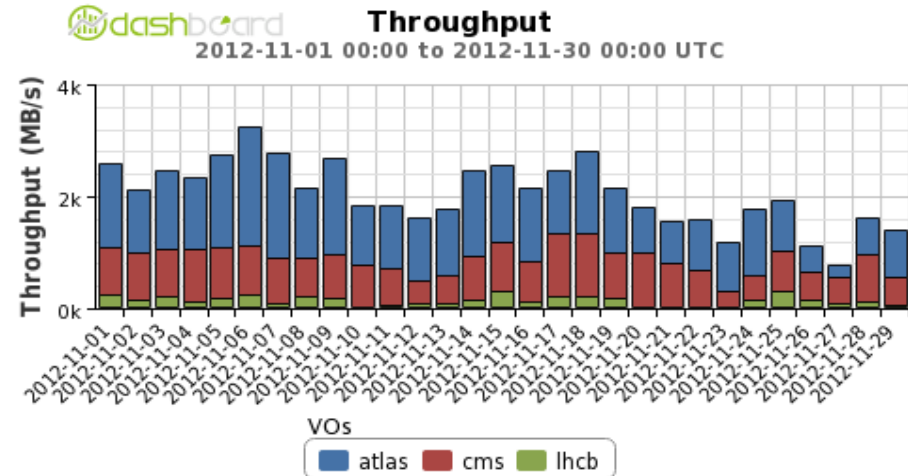
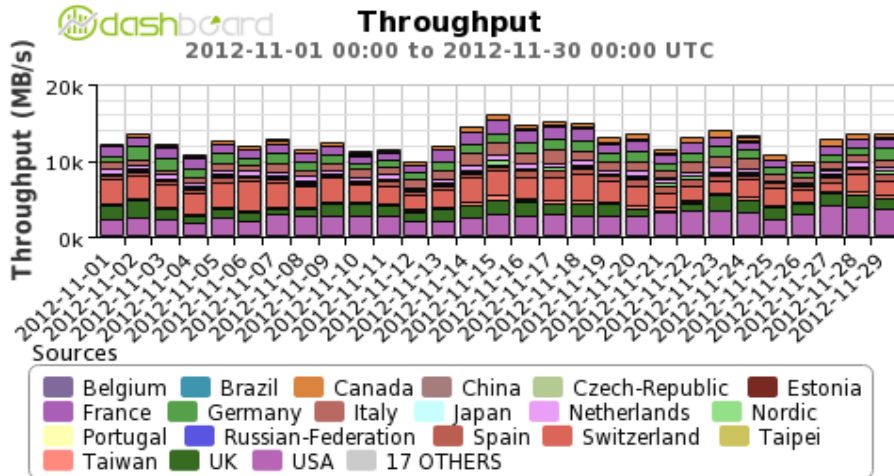


- Relies on
 - OPN, GEANT, US-LHCNet
 - NRENs & other national & international providers

Mass storage access

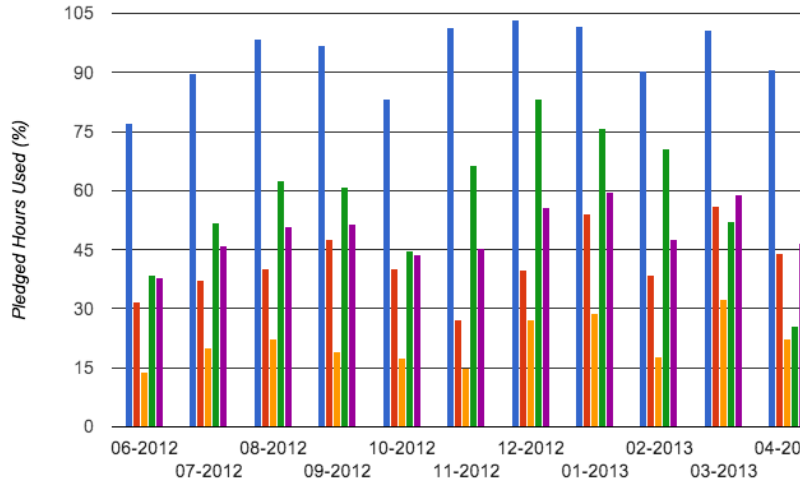


Data transfers

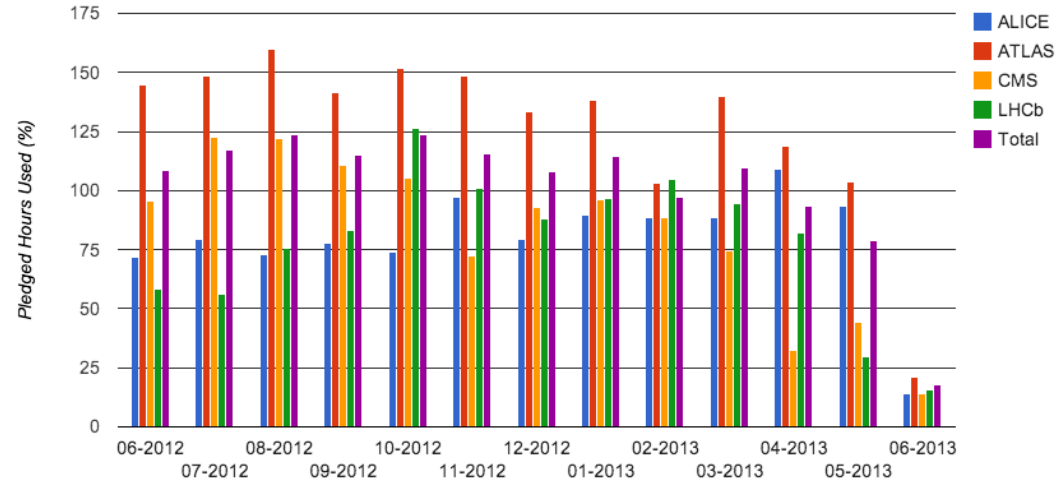


Resource use

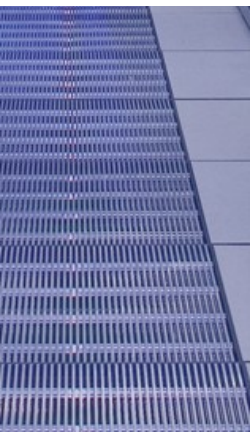
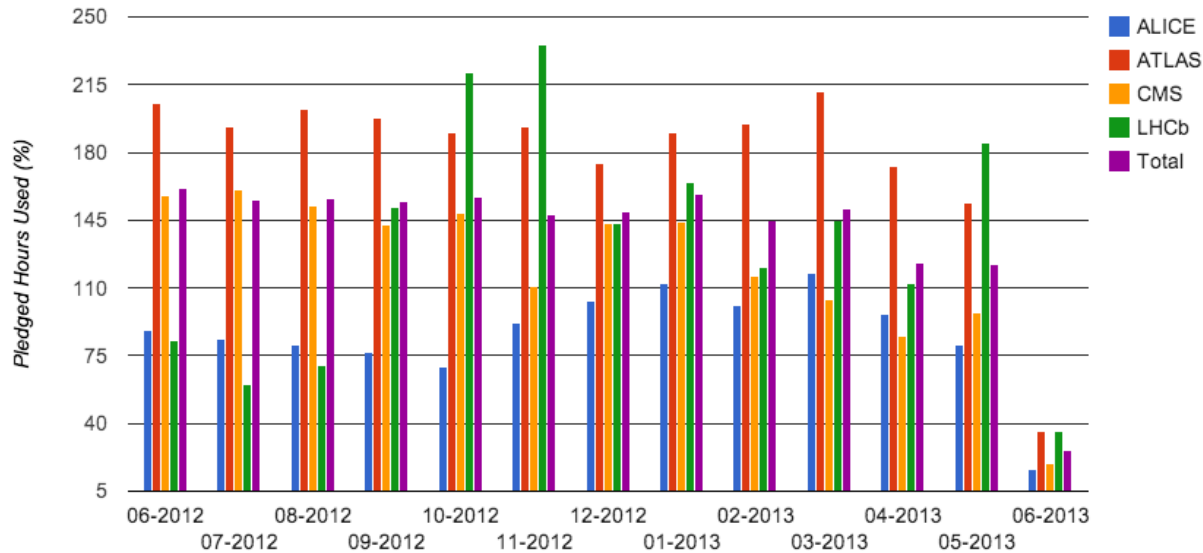
Pledged Hours Used: CH-CERN



Pledged Hours Used: All Tier-1 Sites

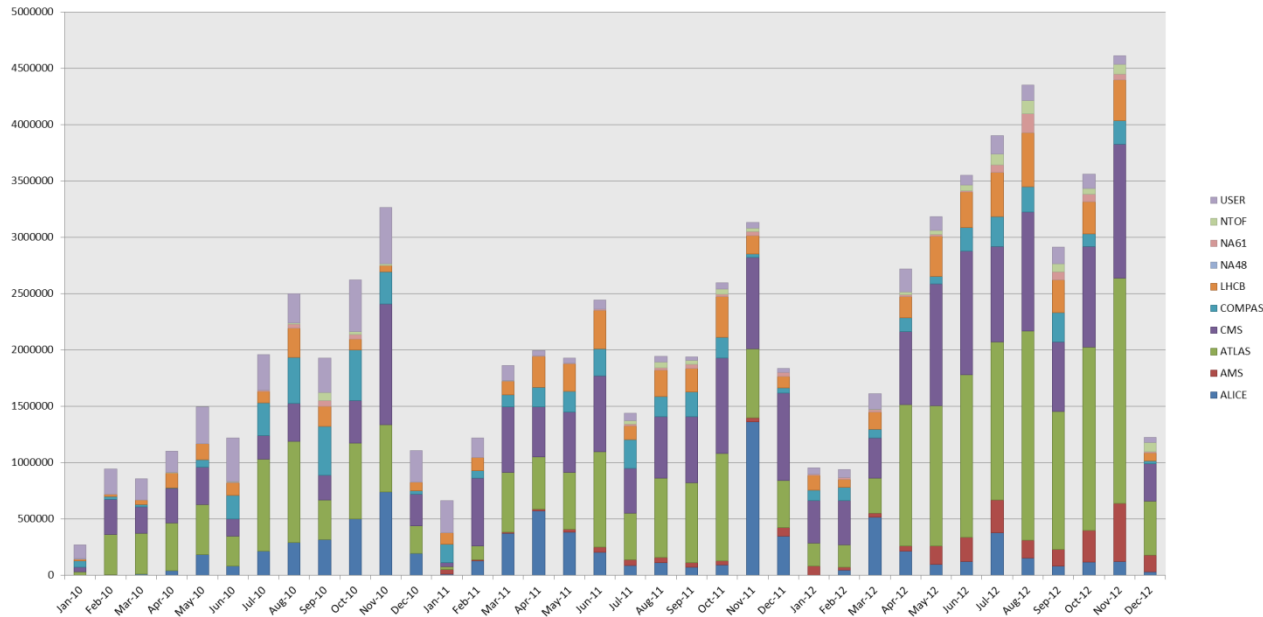


Pledged Hours Used: All Countries (Tier-2 Sites)



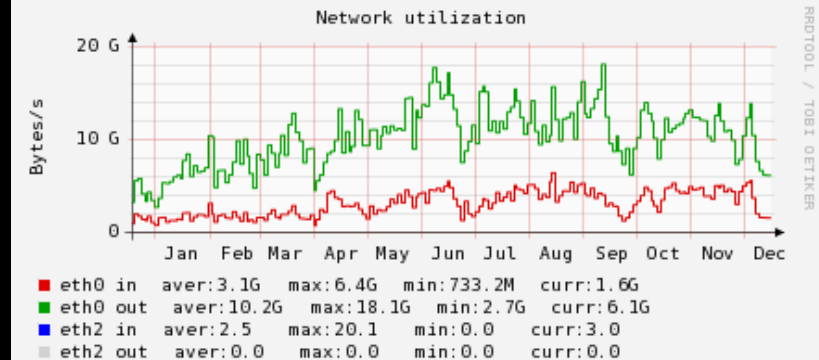
CERN: Data written 2010-12

CASTOR data written, 01/01/2010 to 9/12/2012 (in GB)



2010-2012
Data
written:
Total ~30 PB
in 2012
Close to 3-4
PB/month

Data rates increased
 3-4 GB/s input
 ~15 GB/s output



Broader Impact of the LHC Computing Grid

WLCG has been leveraged on both sides of the Atlantic, to benefit the wider scientific community

Europe:

Enabling Grids for E-science
(EGEE) 2004-2010

European Grid Infrastructure
(EGI) 2010--

Nordugrid in the Nordic countries

USA:

Open Science Grid (OSG)
2006-2012 (+ extension?)

Many scientific applications \equiv

Archeology
Astronomy
Astrophysics
Civil Protection
Comp. Chemistry
Earth Sciences
Finance
Fusion
Geophysics
High Energy Physics
Life Sciences
Multimedia
Material Sciences

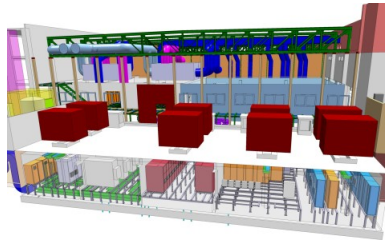
...



Scaling CERN Data Center(s) to anticipated Physics needs

CERN Data Center dates back to the 70's

- Upgraded in 2005 to support LHC (2.9 MW)
- Still optimizing the current facility (cooling automation, temperatures, infrastructure)



Renovation of the “barn” for accommodating 450 KW of “critical” IT loads (increasing 513 total to 3.5 MW)

Exploitation of 100 KW of remote facility down town

- Understanding costs, remote dynamic management, ensure business continuity



Exploitation of a remote Data center in Hungary

- Max. 2.7 MW (N+1 redundancy)
 - Business continuity
- 100 Gbps connections

2 networks to Wigner

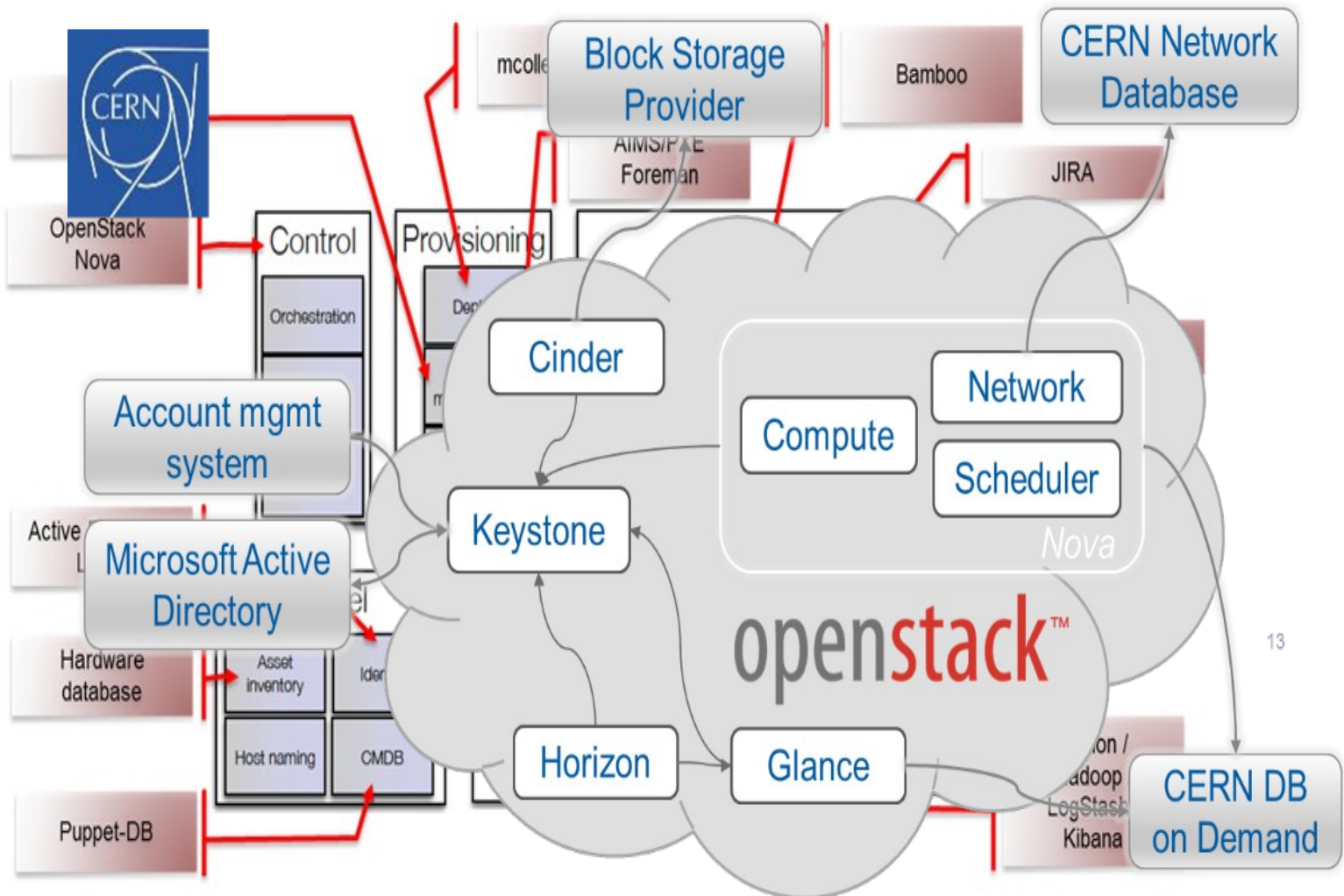


GRID vs Cloud

- “Cloud computing” is becoming the standard
 - Web based solutions (http/https and RES)
 - Virtualization, upload machine images to remote sites
- GRID has mainly a scientific user base
 - Complex applications running across multiple sites, but works like a cluster batch system for the end user
 - Mainly suitable for parallel computing and massive data processing
- Technologies converging
 - “Internal Cloud” at CERN – Ixcloud, now OpenStack
 - CernVM – virtual machine running e.g. at Amazon
 - “Volunteer Cloud” - [LHC@home 2.0](#)



Cloud Infrastructure



13



LHC@home

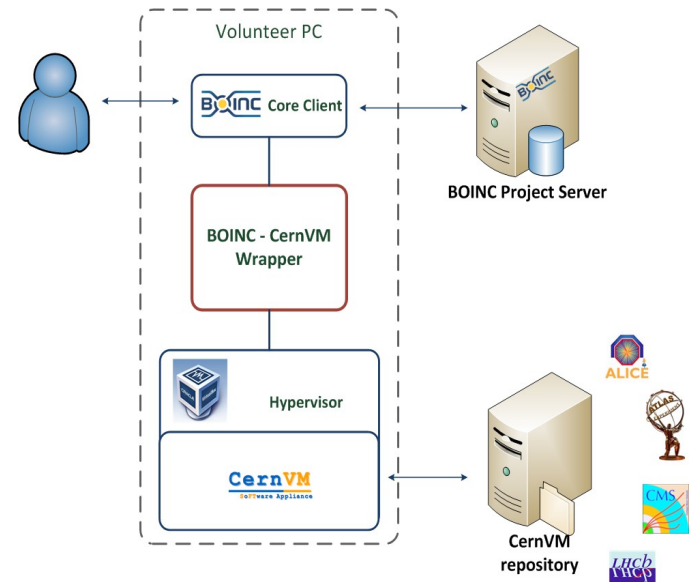
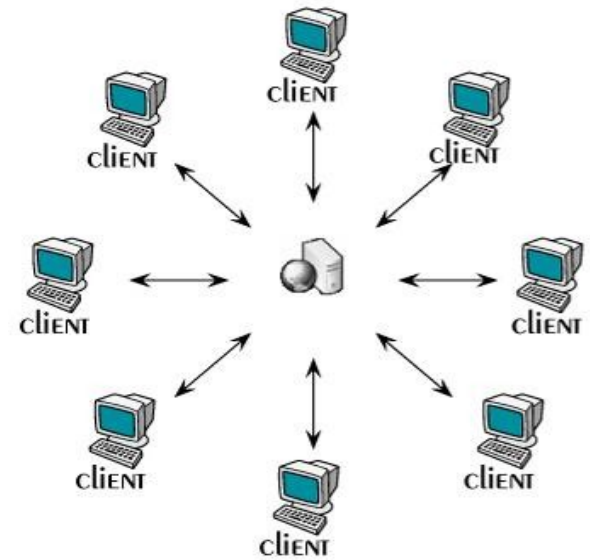


- **LHC volunteer computing**

- Allows us to get additional computing resources for e.g. accelerator physics and theory simulations

- **Based on BOINC**

- “**Berkeley Open Infrastructure for Network Computing**”
- Software platform for distributed computing using volunteered computer resources
- Uses a volunteer PC’s unused CPU cycles to analyse scientific data
- Virtualization support - **CernVM**
- Other well known projects
 - **SETI@Home**
 - **Climateprediction.net**
 - **Einstein@Home**



International Scientific Collaborations



- Many scientific projects are global collaborations of 100s of partners
- Efficient computing and data infrastructures have become critical as the quantity, variety and rates of data generation keep increasing
- Funding does not scale in the same way
 - Optimization and sharing of resources
- Collaboration with commercial IT companies increasingly important
 - Requirements are not unique anymore



CERN Biomedical Facility



CERN openlab in a nutshell

- A science – industry partnership to drive R&D and innovation with over a decade of success
- Evaluate state-of-the-art technologies in a challenging environment and improve them
- Test in a research environment today what will be used in many business sectors tomorrow
- Train next generation of engineers/employees
- Disseminate results and outreach to new audiences

PARTNERS



ORACLE

SIEMENS

CONTRIBUTOR



ASSOCIATE

Yandex

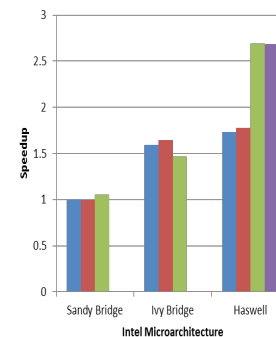
Multi-Core Platforms



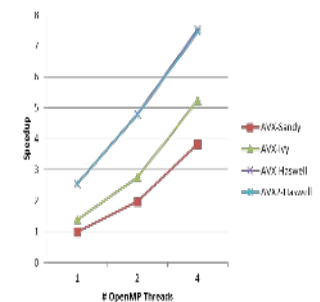
- Very high-level of parallelism, both online and offline
- Parallelism exploited sending multiple independent computational jobs on separate physical or virtual nodes
- Multiple physical cores partitioned across virtual machines
- Current software not written to exploit multi-cores
- Very important issue with detector simulations, very CPU intensive tasks

- CERN is CPU based, GPUs little used
- Project to exploit multi-core platforms using vectorization techniques
- Build experience with data and task parallelism using Cilk and Haswell (CilkPlus and GCC)
- Requires rewriting the software: Geant 5

Speedup 500,000 events #1Thread



AVX Comparison

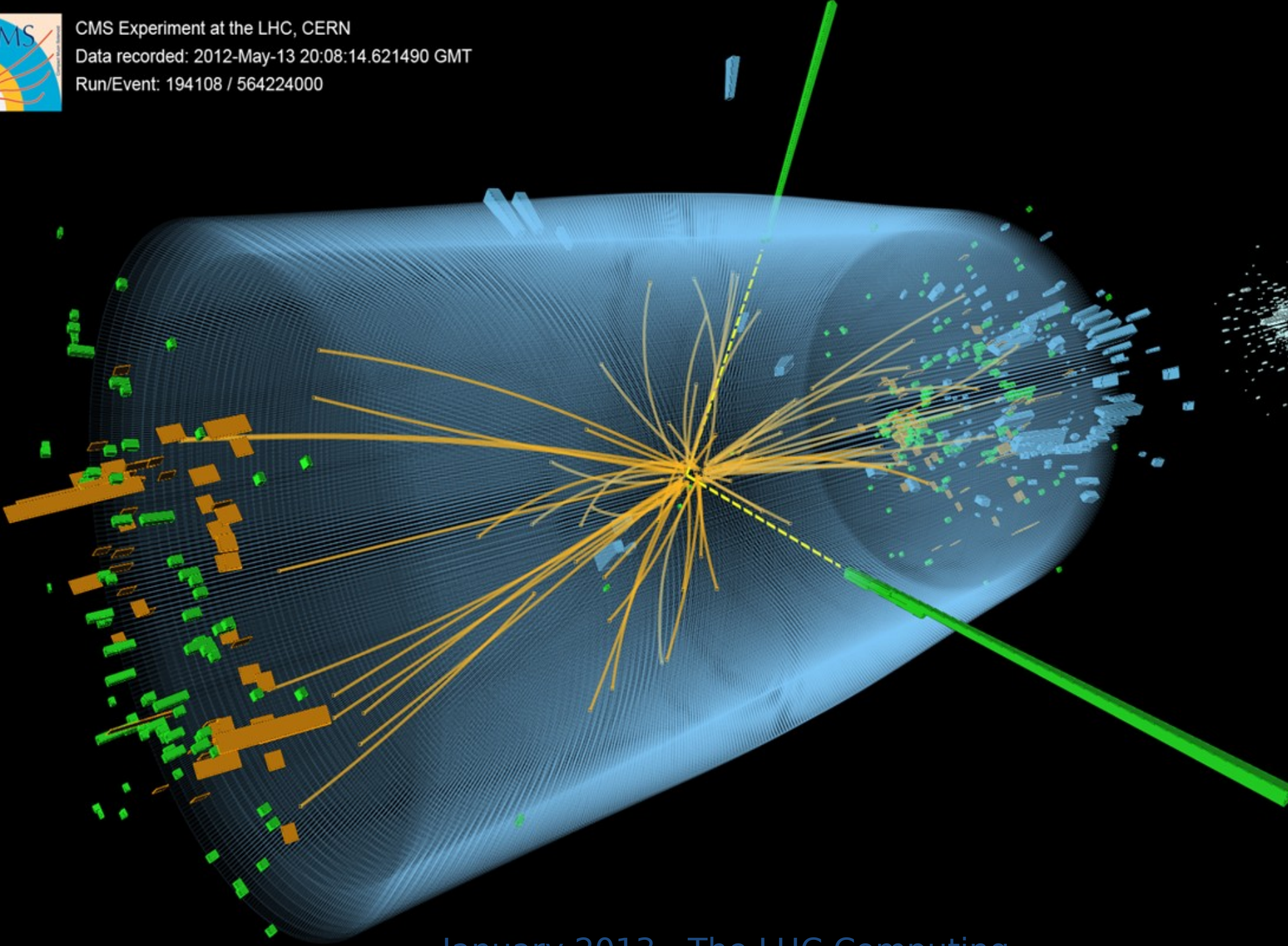




CMS Experiment at the LHC, CERN

Data recorded: 2012-May-13 20:08:14.621490 GMT

Run/Event: 194108 / 564224000



January 2013 - The LHC Computing

- **Physics computing – Grids (this talk!)**
- **Administrative information systems**
 - Financial and administrative management systems, e-business...
- **Desktop and office computing**
 - Windows, Linux and Web infrastructure for day to day use
- **Engineering applications and databases**
 - CAD/CAM/CAE (Autocad, Catia, Cadence, Ansys etc)
 - A number of technical information systems based on Oracle, MySQL
- **Controls systems**
 - Process control of accelerators, experiments and infrastructure
- **Networks and telecom**
 - European IP hub, security, voice over IP...

More information: <http://cern.ch/it>



Thank You!

More information



www.cern.ch/openlab



WLCG
Worldwide LHC Computing Grid

www.cern.ch/lcg



www.nordugrid.org



www.eu-egi.org/



lhcat.home.cern.ch