# Computing at CERN

→Hannah Short,
Computer Security

# Hello!

## My name's Hannah

*CERN Fellow in Computer Security, Brit/Irish, Scientific Computing Enthusiast!*

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@hannah.short08

+ 10 years! =

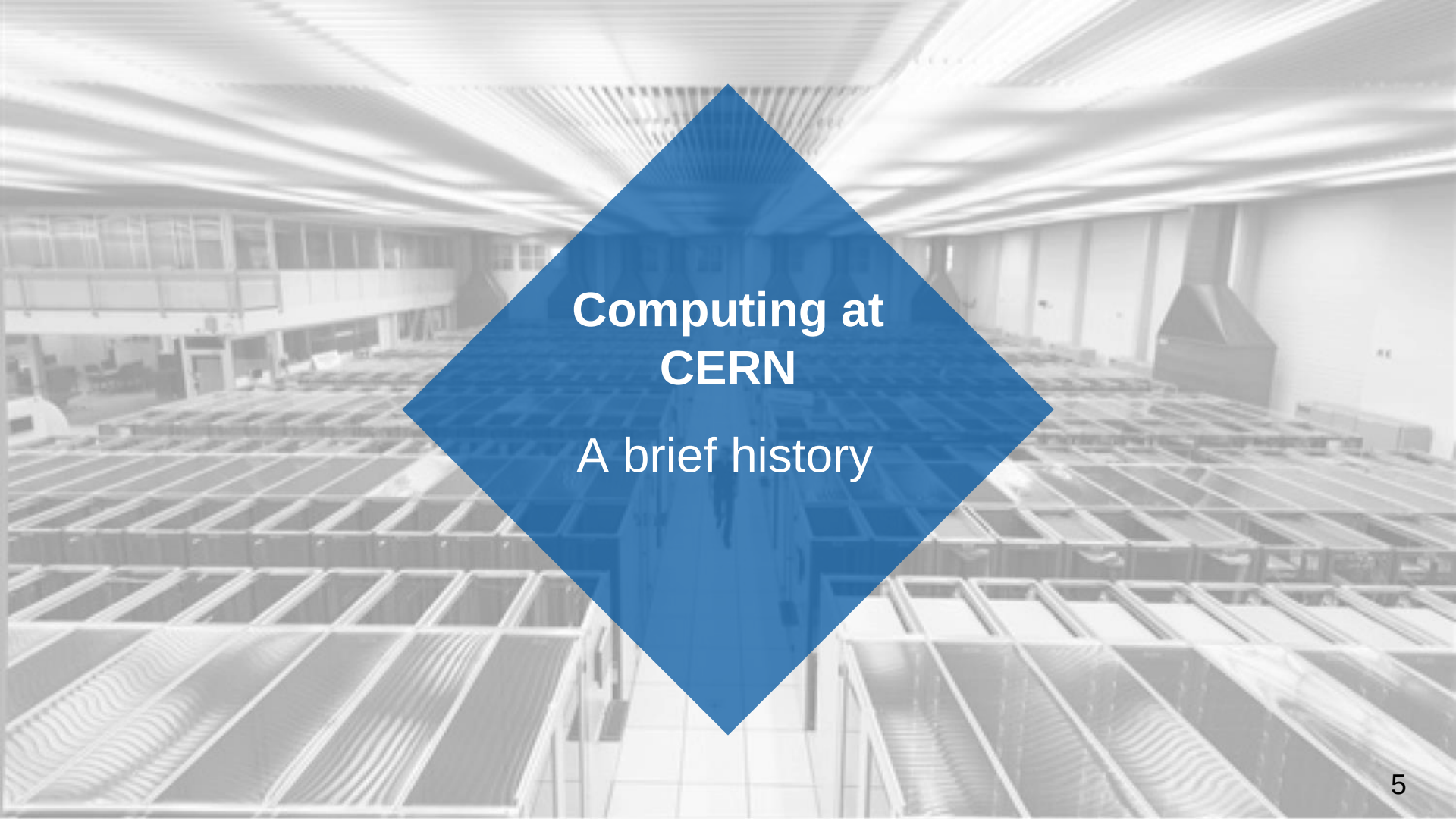
## What will I talk about?

A brief history of Computing at CERN

The IT department (a small selection!)

- WLCG
- Innovation
- Collaborative tools

Born and bred at CERN



# Computing at CERN

A brief history

## computing, *n.*

**Pronunciation:**

Brit. /kəmˈpjuːtɪŋ/ , U.S. /kəmˈpjudɪŋ/

**1.** The action or an instance of calculating or counting; = computation *n.* 1a.

**2.** The action or practice of using computers, esp. as a professional or expert; the activity or operation of an electronic computer; (also) = computer science *n.*

Credit to Tim Smith

## An Early “Computer”

→Wim Klein

→Calculating the 73rd root of a 500 digit number took less than 3 minutes…

→Not the first CERN Computer! Two female computers were already working with mechanical calculators

https://home.cern/cern-people/updates/2012/12/remembering-wim-klein

# 1958, The Ferranti Mercury arrived

# C E R N  C O M P U T E R  N E W S L E T T E R

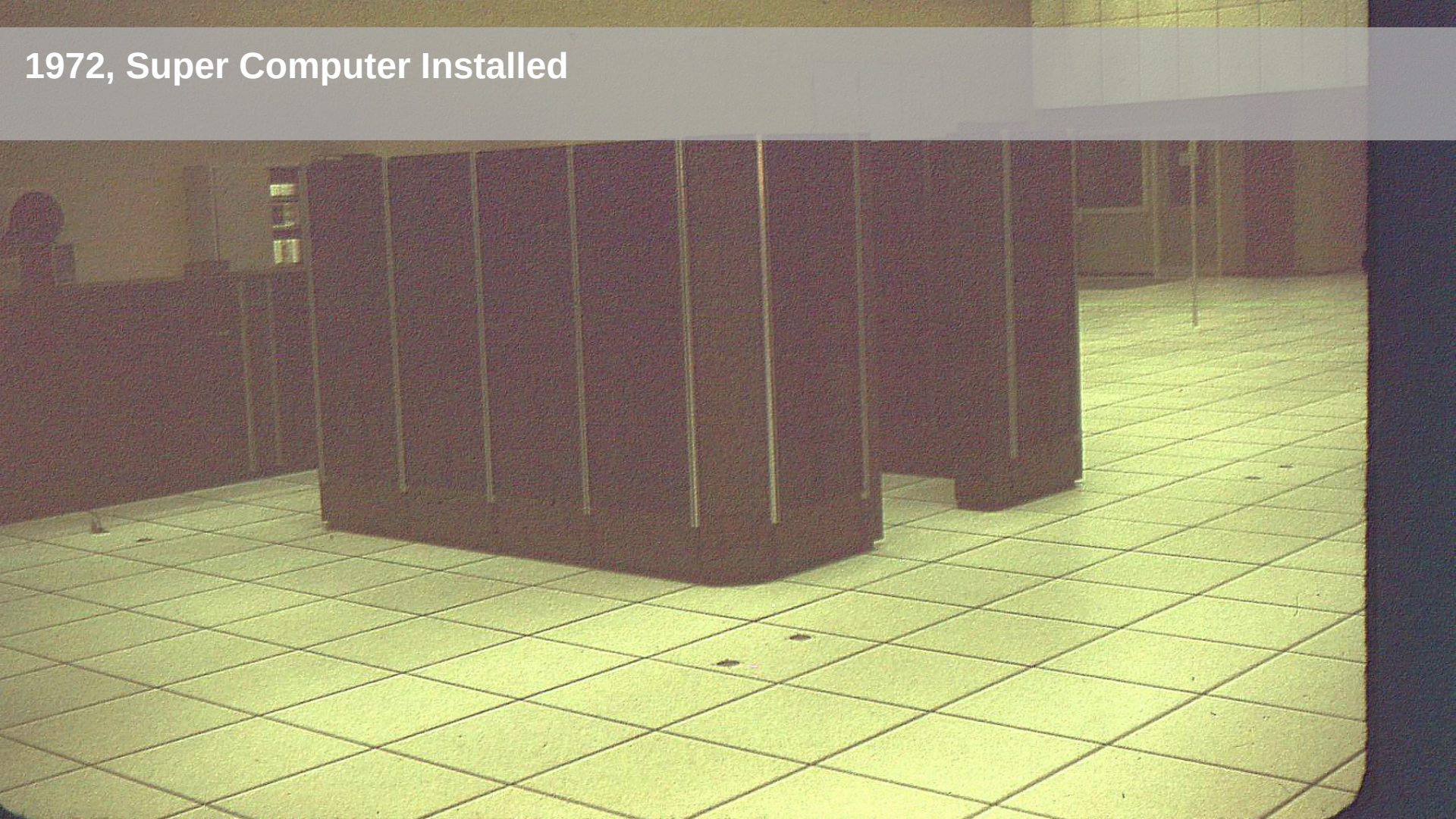
Number 1

15 February 1966

## Introduction

As computing becomes a more and more widespread and complex activity in the laboratory, the need will increase for a means to have a wider general circulation of background information about different aspects of computing activities than is possible with the present system of Computer Notices. I therefore make no apology for introducing yet another circular which will find its way on to CERN desks. Rather I would express the hope that this newsletter will prove to be a useful source of general information on computer use and performance, programming developments and the requirements of different kinds of computer users, as well as on future plans for computers, programming and computer uses in the laboratory. The newsletter will be

# 1972, Super Computer Installed



# Tapes being sent up from B513 basement

# 2016, Today's Data Centre

# The IT Department

# The IT Department

Department Infrastructure

WLCG

openlab

Security

EC Projects

Collaboration, Devices & Applications

Storage

Databases

Compute & Monitoring

Communication Systems

Computing Facilities

# The IT Department

Department Infrastructure

WLCG

openlab

Security

E

We are responsible for Computer Security across CERN… pretty good idea of what is going on!

Collaboration, Devices & Applications

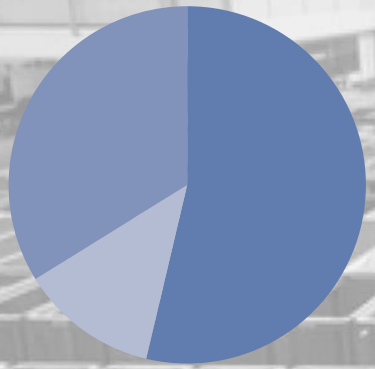
Storage

Compute & Monitoring

Communication Systems

Computing Facilities

## Who are we?




→~400 people in IT
→+ Many computing experts in other departments

https://cds.cern.ch/record/2265782/files/CERN-HR-STAFF-STAT-2016.pdf

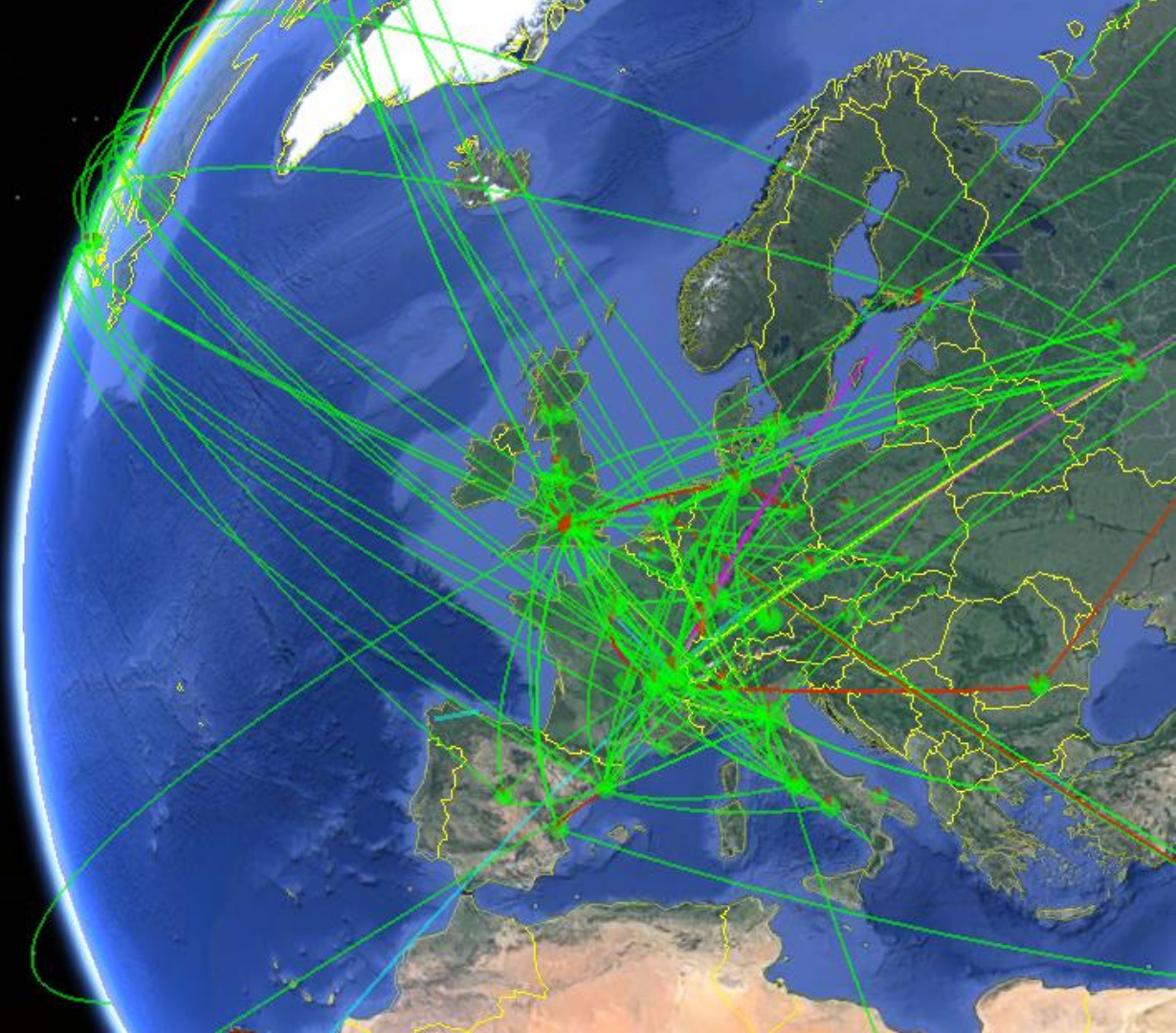
*The role of the IT Department is to keep providing an excellent level of services while scaling up to the foreseen resource levels at an affordable cost*

# WLCG

## WLCG… back in early 2000s

We're building huge physics experiments but we can't store all the data coming from them! What can we do??

# WLCG: The Worldwide LHC Computing Grid



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# Data Volumes

## Mega

10^6

A high resolution photo

This presentation = 85MB

## Giga

10^9

My Mac = 250GB

## Tera

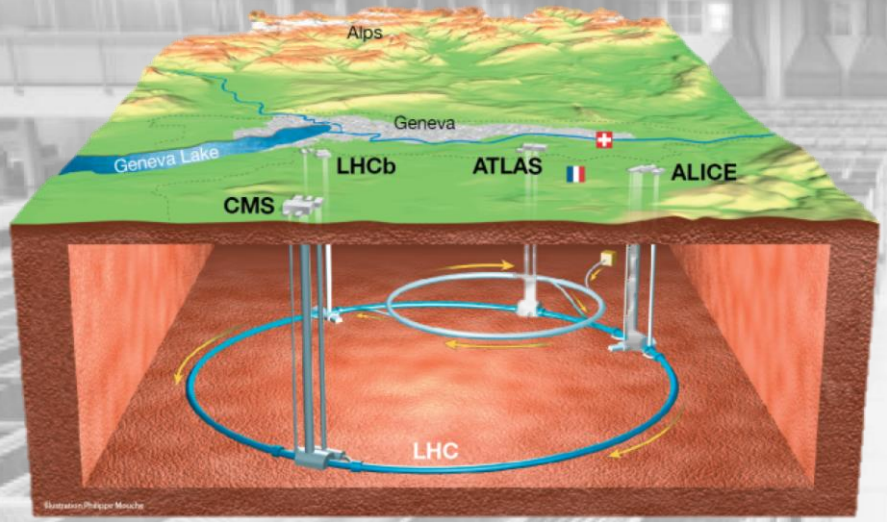
10^12

Good external hard drive

## Peta

10^15

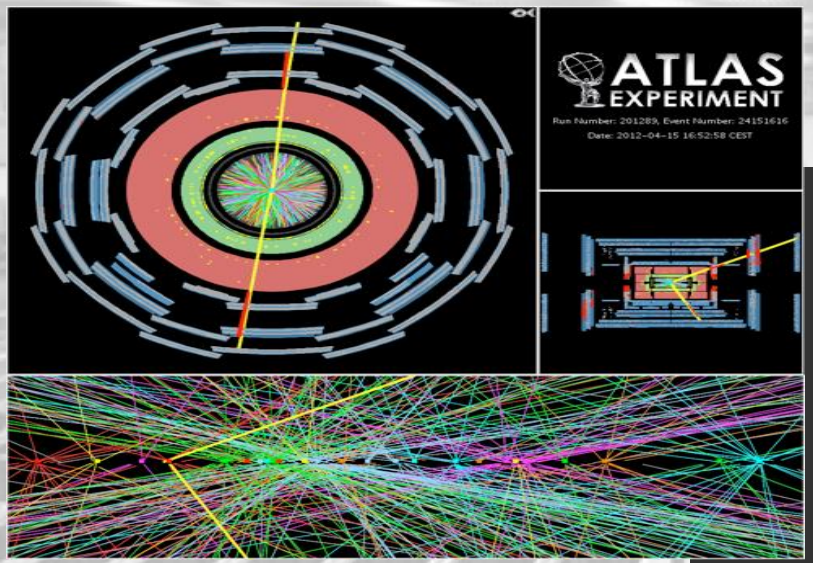
LHC Data Volumes!

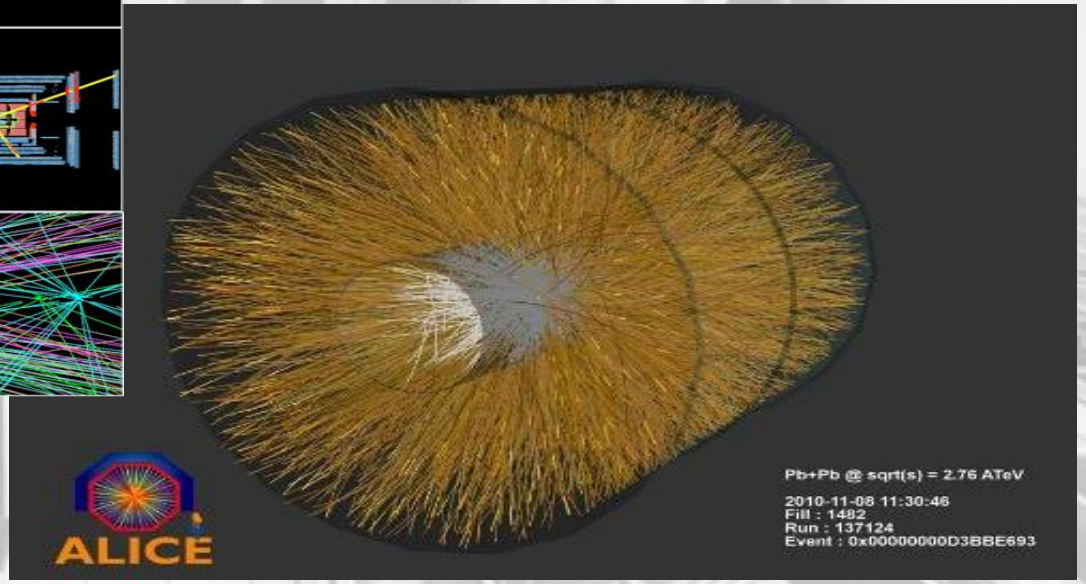



## Where does the data come from?

→Large Hadron Collider
→(Mostly) 4 Experiments, ATLAS, ALICE, LHCb and CMS

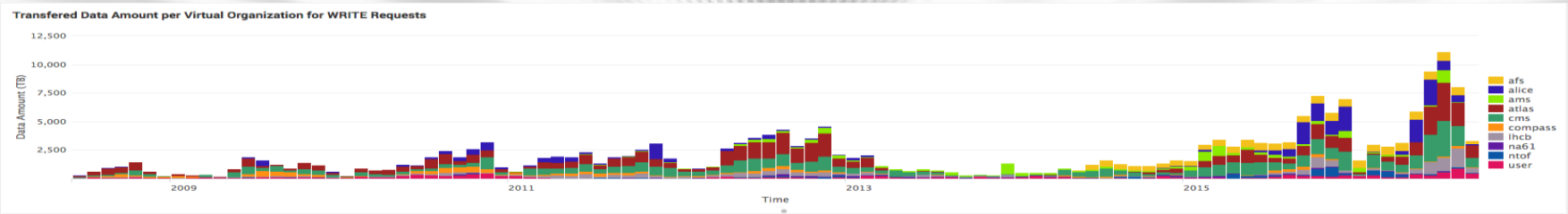
# 1PB/Second!

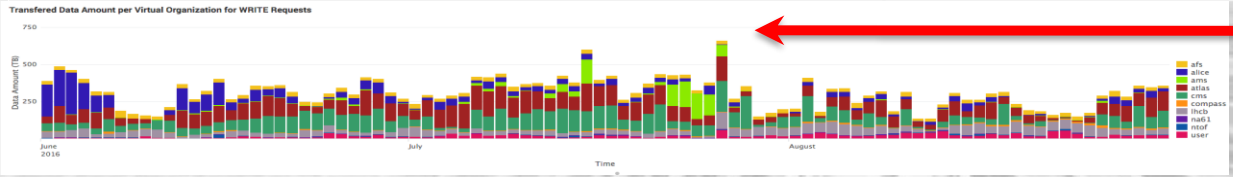



Credit to Lorena Lobato

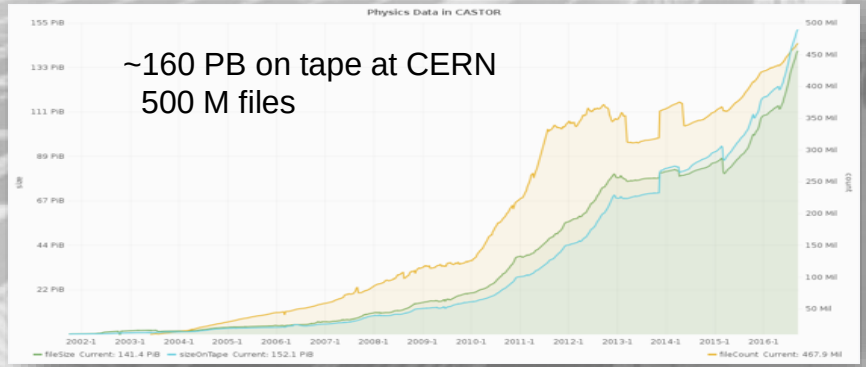
# 2016 LHC Data




June-Aug 2016 >500 TB / day

(Run 1 peak for HI was 220 TB)

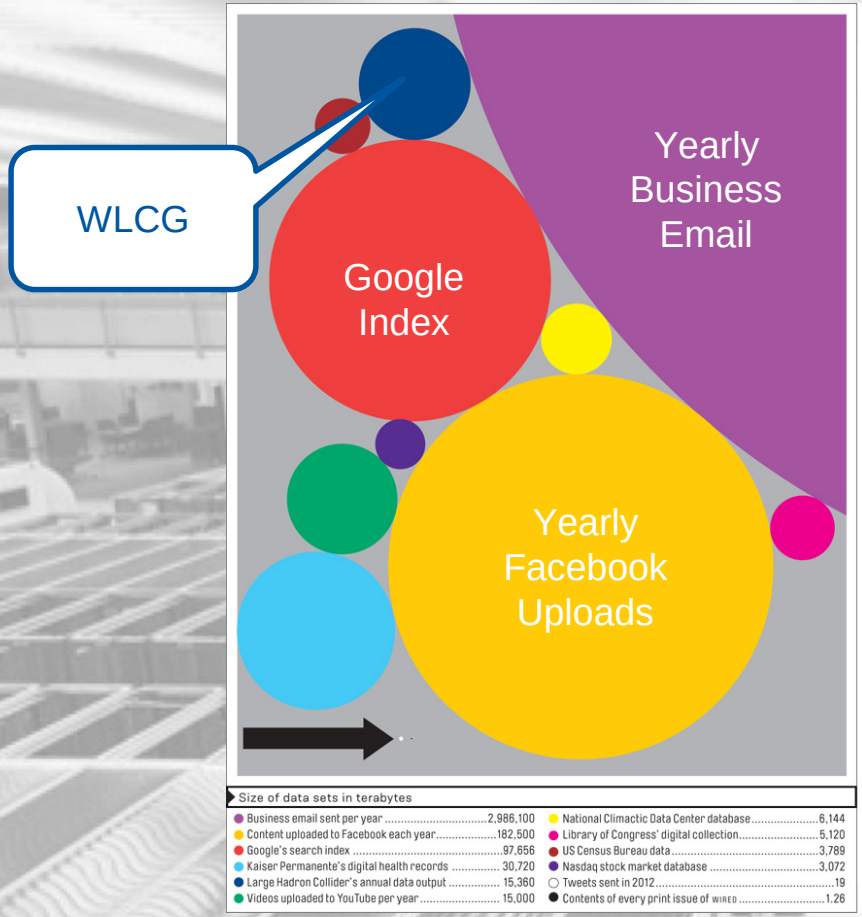



~160 PB on tape at CERN
500 M files

LHC data – Continue to break records:
10.7 PB recorded in July 2016

Credit to Lorena Lobato

# Breaking News!




## How much data are we talking? (2012)

→2012, 15 PB
→2017 estimates 50 PB, equivalent to a 12km high stack of DVDs
→CERN can only provide 20%-30% storage and CPU

https://www.wired.com/2013/04/bigdata/

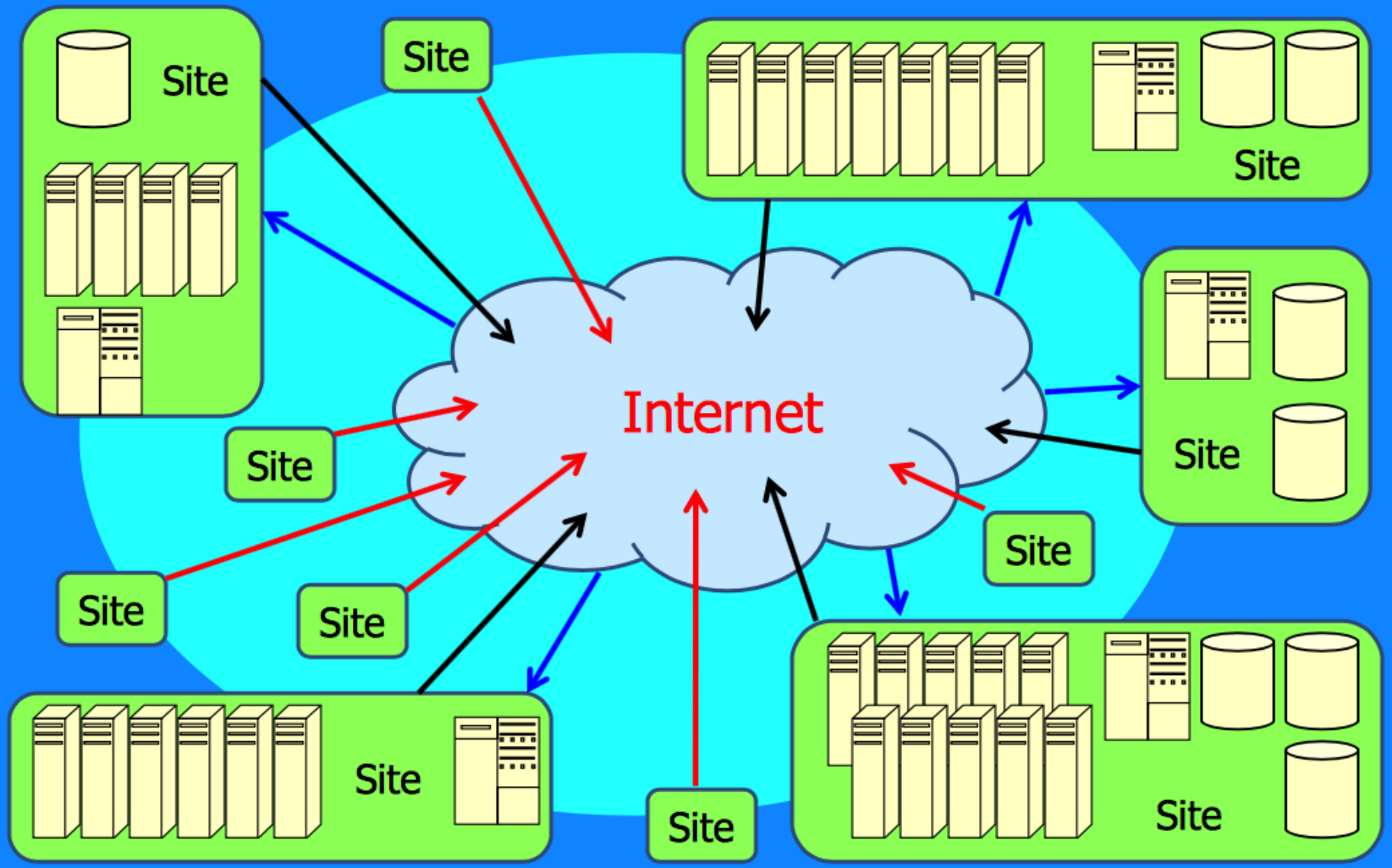
## Distributed Computing

- ➔Collection of independent computers
- ➔Appear as a single system
- ➔Benefits
  - ✓ Continuous availability
  - ✓ Scalability

## What is a grid?

→*“A grid gives selected user communities uniform access to distributed resources with independent administrations”*
→Like a power grid, you don’t need to know where the power comes from!
→Don’t need to know where your computing is done
→Don’t need to know where your data is stored

https://espace.cern.ch/cern-guides/Documents/WLCG-intro.pdf


Site
Site
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Internet
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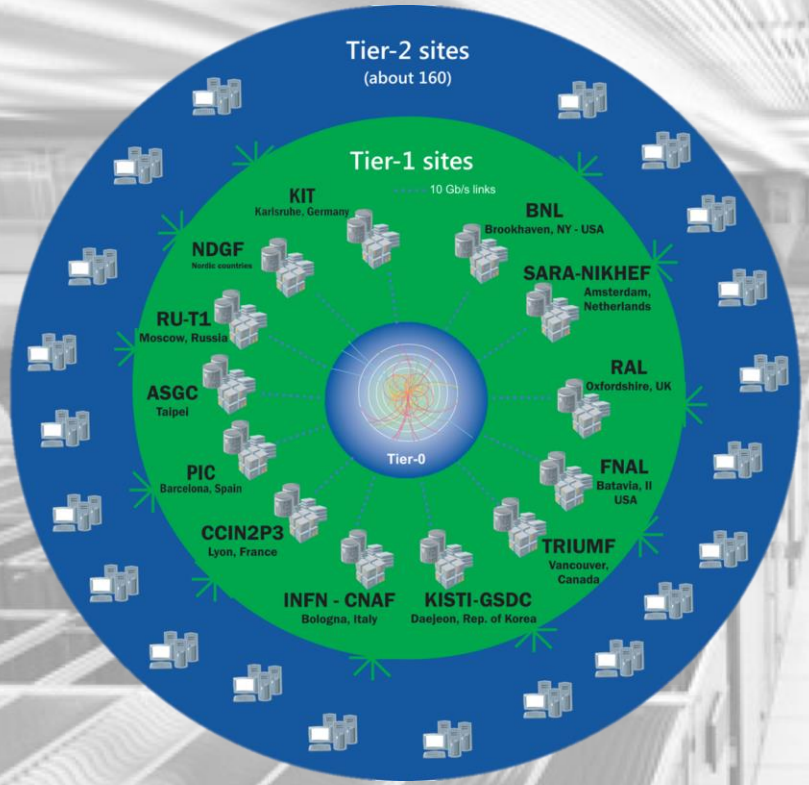
Site

## Isn’t this like a cloud?

Cloud
→On Demand
→Dynamically provisioned & metered by e.g. Amazon, Microsoft Azure

Grid
→Fixed size
→Collaborative, run by community




## Where is the data stored?

➔Tier 0
CERN & Budapest
➔Tier 1
13 large centres
24/7 Support
➔Tier 2
~160 smaller universities and institutes
➔Tier 3
Individuals, accessing the grid

# CERN Meyrin Data Centre

http://goo.gl/maps/K5SoG

Credit to Lorena Lobato

# Wigner Data Centre, Budapest



Credit to Lorena Lobato

# 3 100GB/s Connections


Credit to Lorena Lobato

## What has WLCG achieved?

→Unprecedented **speed and volume** of data processing

→Analysis of **billions of collisions within weeks** to find the Higgs signal (Nobel Prize 2013)

→Successful **collaboration** of diverse countries, organisations and people! 42 countries and 2 million jobs per day

# Innovation

## Collaborative tools

Physics is constantly pushing the boundaries of computing… how can we meet those needs?

## Innovation

→We need to be at the edge of commercial and academic developments!
→Openlab = Commercial Innovation
→EC Project = Research & Education Community Innovation

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## Openlab

→*“CERN openlab is a unique **public-private** partnership that accelerates the development of cutting-edge solutions for the worldwide LHC community and wider scientific research.”*

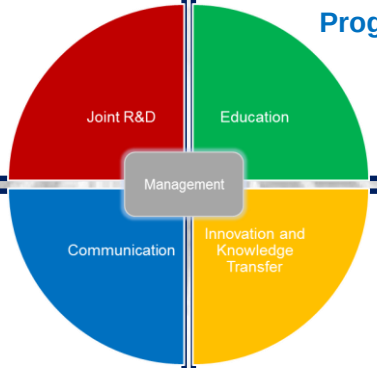
→Testing software and hardware

→Large student internship programme

# Openlab R&D and Innovation

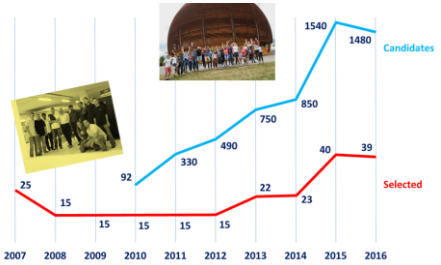
intel ORACLE SIEMENS IDT rackspace BROCADE
SEAGATE Yandex HUAWEI COMTRADE

CERNopenlab




Seminars, training courses, academic training

**CERN openlab Summer Students Programme**

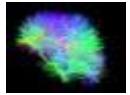



- 200+ press cuttings
- 150,000 visits to our website
- 50+ events, visits, lectures
- 100+ presentations
- 50+ news articles, press releases, case studies

15 years CERNopenlab




Innovation & Entrepreneurship



BioDynaMo
The Biology Dynamic Modeller

GeneROOT

Applications to cross-disciplinary research

# European Commission projects

## On-going

HELIX NEBULA THESCIENCECLOUD

egi

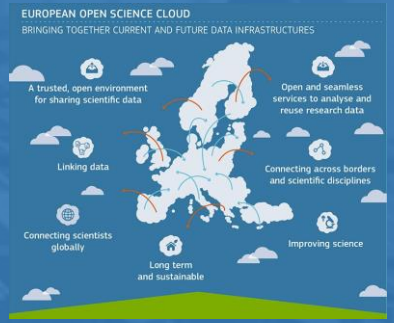
EUDAT

INDIGO DataCloud

AARC

OpenAIRE

## Future




*Bridging the gap between schools and universities through informal education*

UP2U

https://up2university.eu

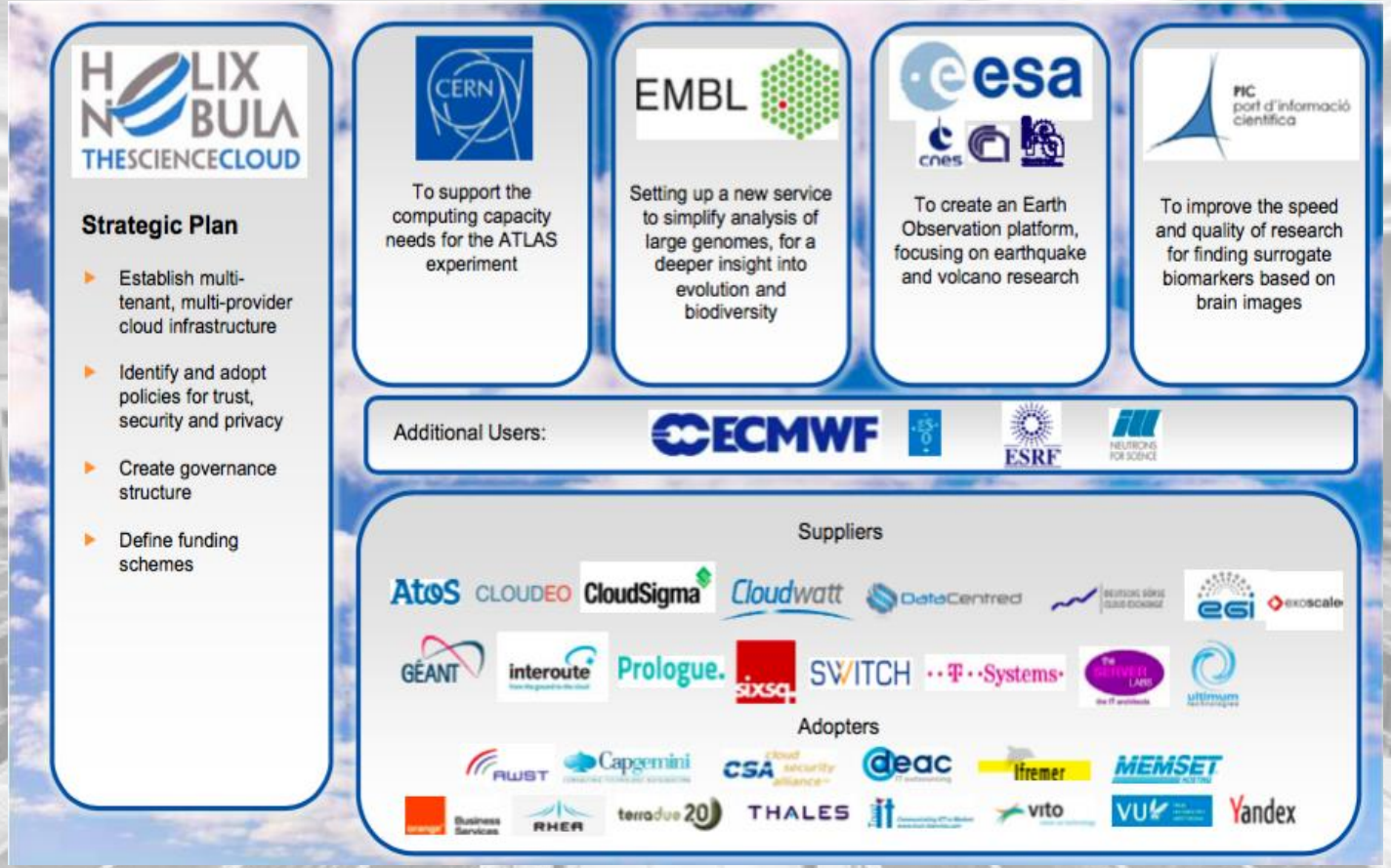
## Challenges in EC Projects

Some of the many themes address:

→On-Premise Vs. Public Clouds

→Supporting the Long Tail of Science (LTOS)

→Trust and collaboration




# The HNSci Cloud public-private partnership

# Open Science: Zenodo

Visitors from ~ all Countries
- Including
  - Antarctica
  - Vatican City
- 56% from Europe

57k Records
- 11k Software
- 3k Datasets

700 Communities
- Projects
- Institutes
- Subjects
- Conferences
- Publishers

→Infrastructure
Runs on 30 VMs in CERN Cloud

→Impact
Biggest issuer of DOIs for SW in world
Reference material for publications
F1000, Wiley, eLife, PLoS, Elsevier, Nature, etc
Recommended by EC and National programmes

→Supports LTOS & large groups

## What’s next?

Growing interest in the community for new models and tools. For example:
→Applications of Machine Learning; impact on computing resources?
→Applications of IoT-like infrastructures; impact on network and security?

# Collaborative Tools

## Collaborative tools

There are ~15,000 people working at CERN… how can we all work together effectively and efficiently?

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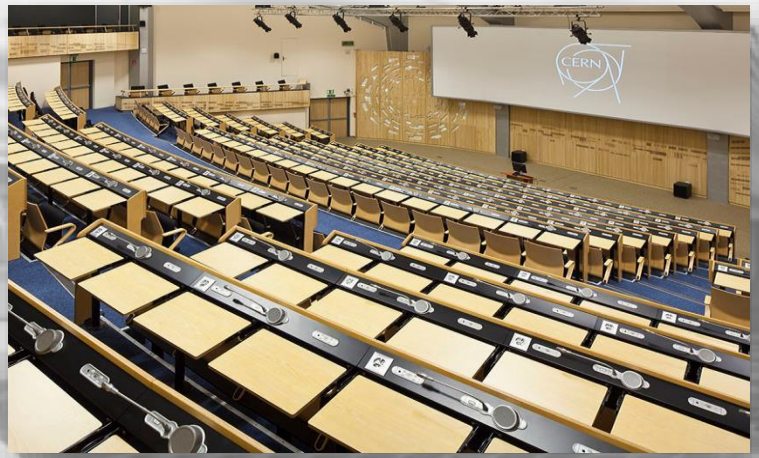


## Videoconference

→250 meeting rooms of all sizes on site

100 equipped for video conference

Legacy + VidyoPanorama

16 equipped for VC + Webcast

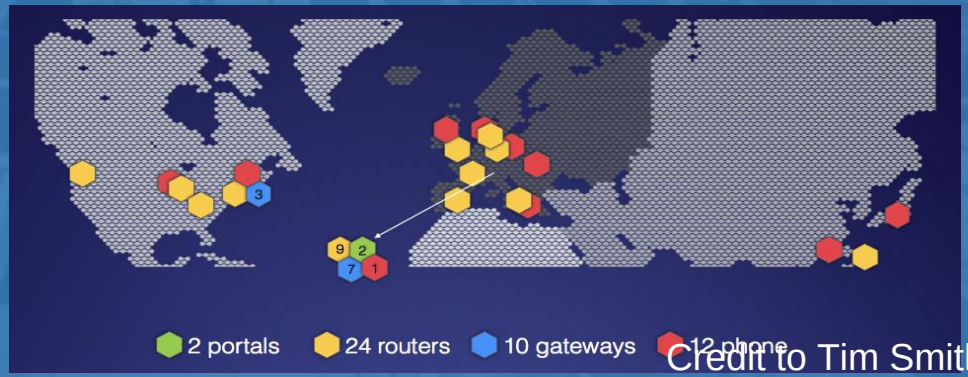
→500 legacy endpoints worldwide

Non centrally managed

Credit to Tim Smith

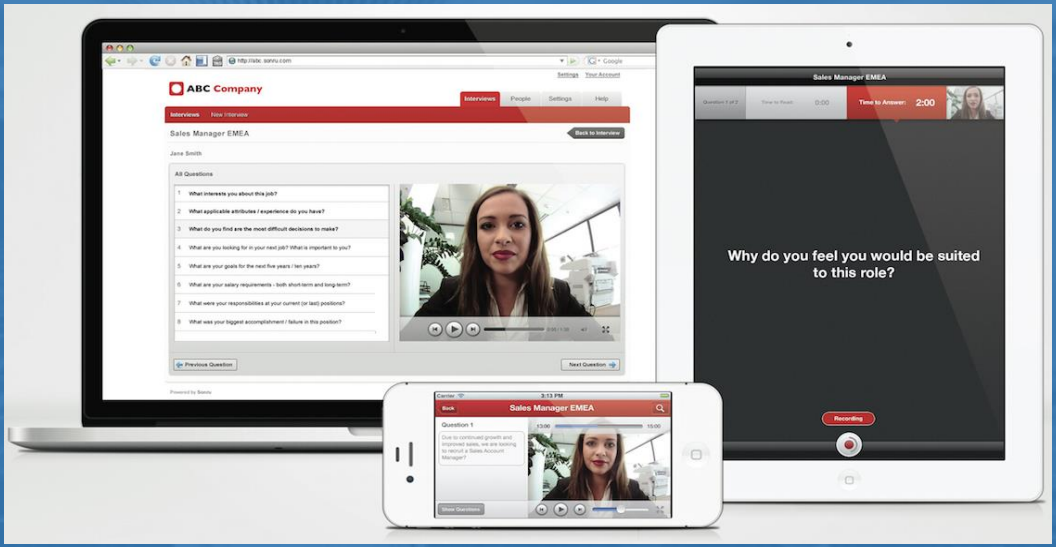
# CERN Vidyo Worldwide Service Topology

→8184 meetings/month
→941 simultaneous connections
→252 in one meeting
→50M minutes last year / 40k downloads




Credit to Tim Smith

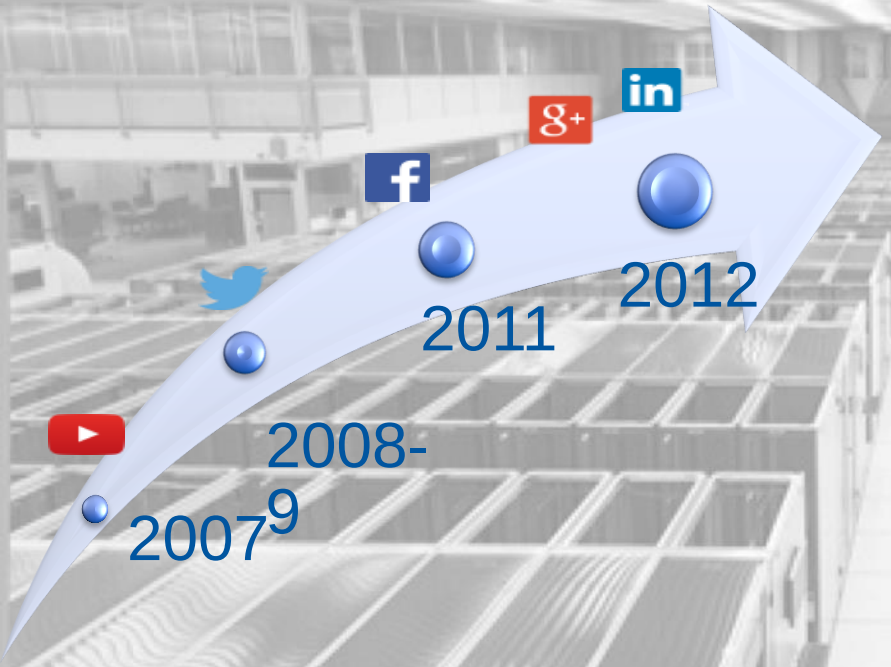
# Recruitment




→Asynchronous video screening
→Cost savings in bringing people to interview
→Multi-lingual – recruit from over 20 countries

Credit to Tim Smith

# CERN's social media



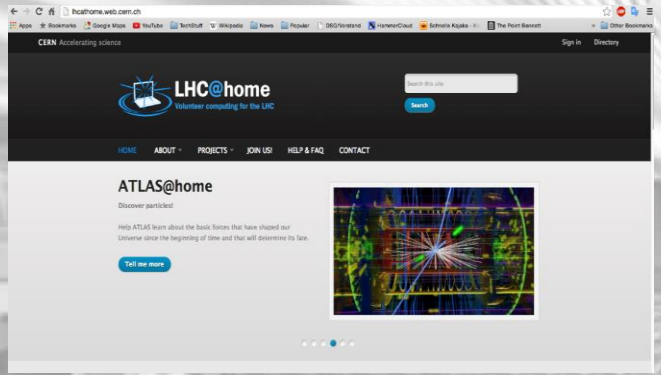

975K
309K
92K
40K
20K
12K

Credit to Tim Smith

# Impact


Courtesy of Twiplomacy, November 2013

Credit to Tim Smith




# Volunteer Computing

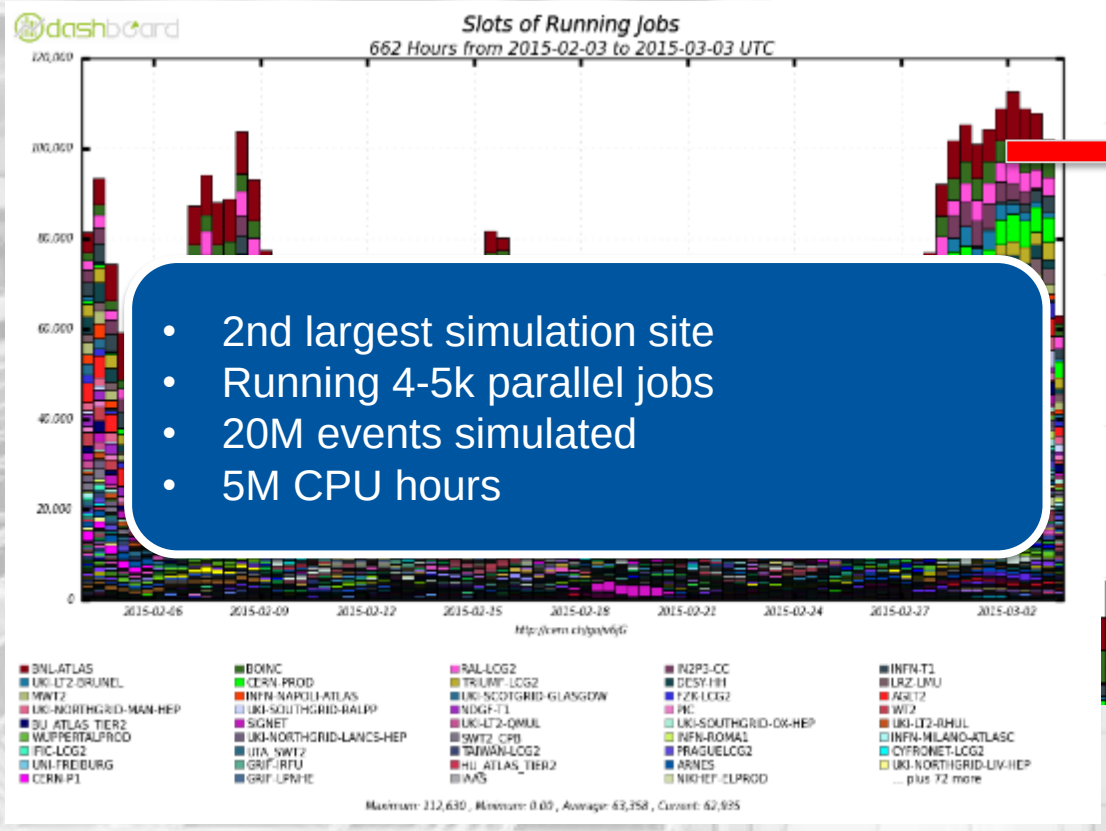
Scavenged resources
→Volunteers (e.g. home PCs)
→Institute desktops
→Even mobile phones!

Unpredictable but significant resources
→Target CPU bound simulations (not data intensive)
→Over 50% of LHC compute is simulation!

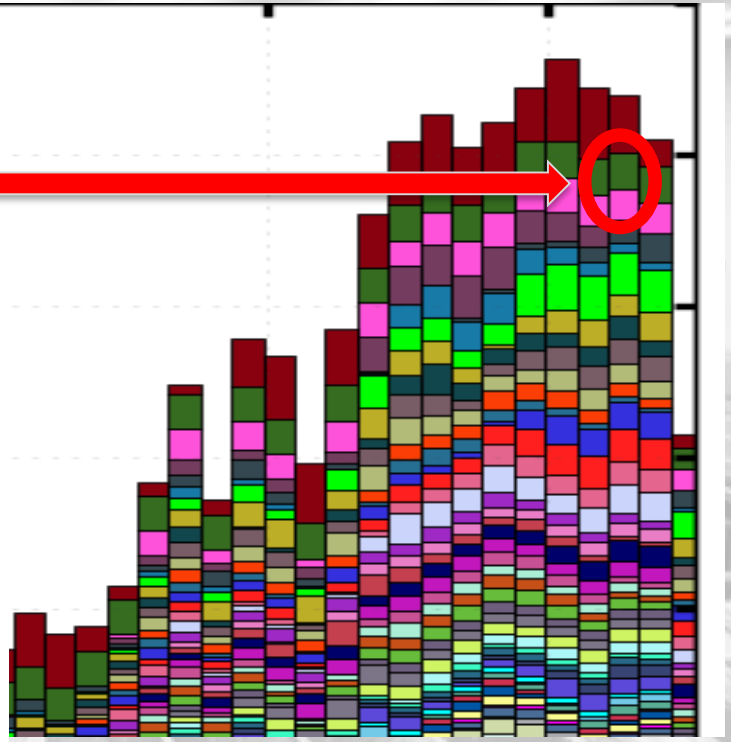
Outreach benefits, LHC@Home

http://lhcathome.web.cern.ch

# Volunteer Computing




- 2nd largest simulation site
- Running 4-5k parallel jobs
- 20M events simulated
- 5M CPU hours



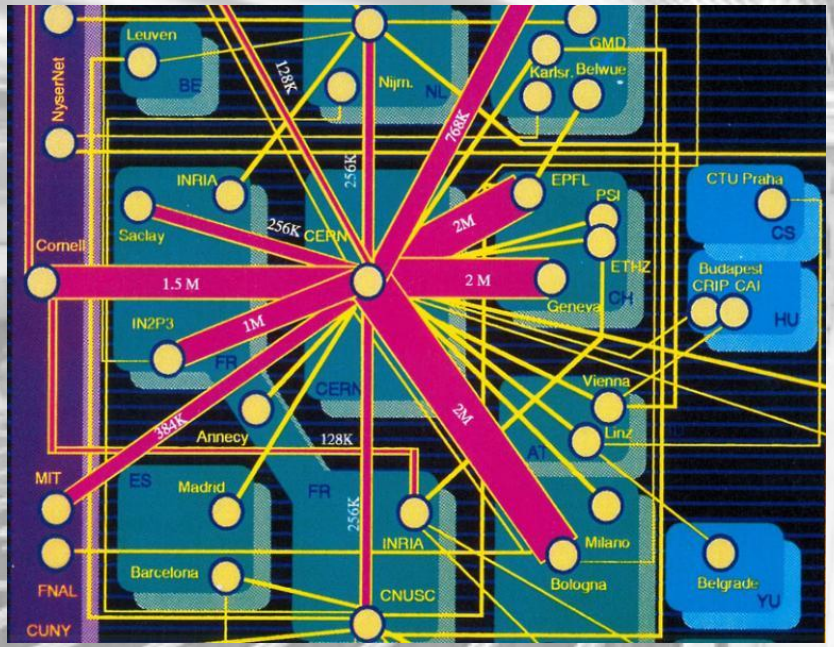
# Born and bred at CERN

## Technical Advances

## CERN's influence in computing

→Several inventions directly from CERN
→Several evolved at CERN
→Direction of scientific computing strongly influenced and continues to be so!

## The Internet

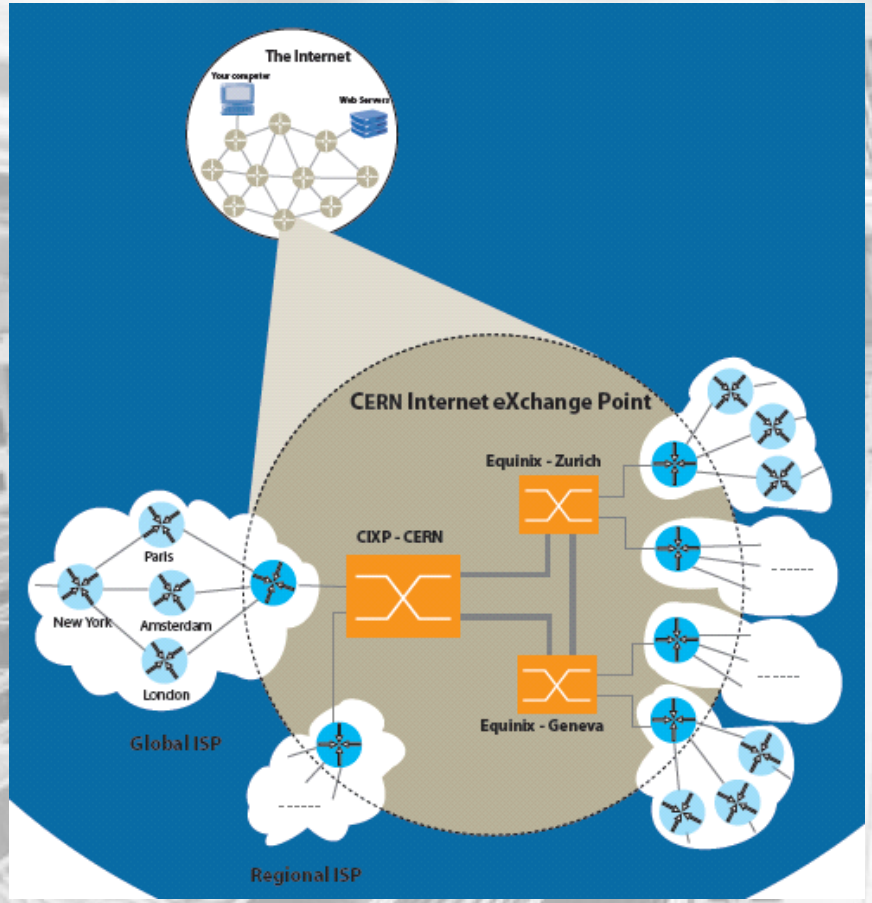



→CERN was one of the early European adopters of the internet

→1991 80% of internet capacity in Europe!

→CERN contributed to standardization

http://home.cern/cern-people/opinion/2013/06/how-internet-came-cern




# The Internet

→HEP centres set up links to enable data sharing
→Data exchange across the iron curtain
→1988 first data connection between China and scientific world – IHEP to CERN

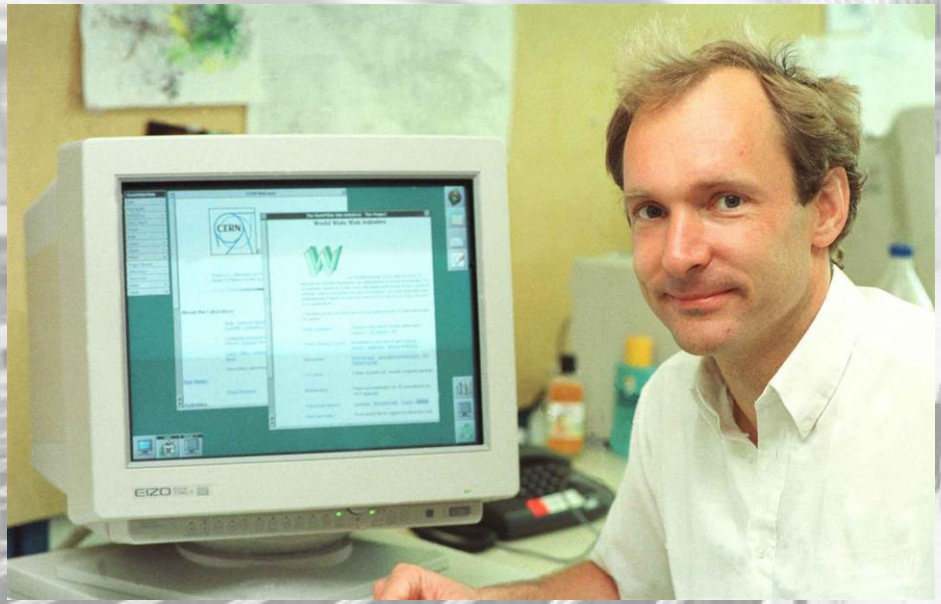
Credit to Tim Smith

## Touch Screens


- ➜Whilst not strictly an invention of the IT Department…
- ➜Super Proton Synchrotron control system required complex controls
- ➜Developed capacitive touch screen
- ➜Based on open standards and moved into industry

http://cerncourier.com/cws/article/cern/42092

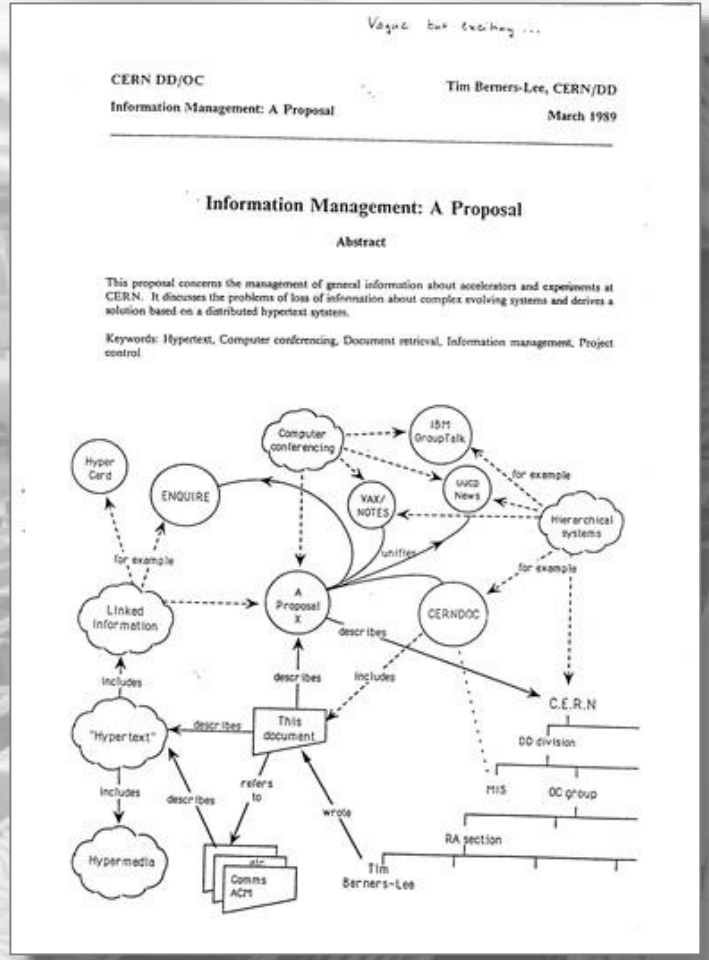
# www




→Tim Berners Lee found a solution to the information sharing backlog

→In 1993, software was made public and quickly changed our lives!

http://home.cern/topics/birth-web



Vague but exciting ...

CERN DD/OC

Information Management: A Proposal

Tim Berners-Lee, CERN/DD

March 1989

## Information Management: A Proposal

**Abstract**

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext system.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control



# www

→"Vague but exciting"
→Not hierarchical, or centrally controlled
→Experts store locally, update independently
→Community is distributed: remote access

Credit to Tim Smith

# Thanks!

## Any questions?

You can find me at:
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hannah.short@cern.ch

# CREDITS

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