… where the Web was born

CERN and the LHC data challenge

Wolfgang von Rüden, IT Department Head

IBM Study Tour, March 2004, Geneva

What is CERN?

- CERN is the world's largest particle physics centre funded by 20 European member states

- Particle physics is about:

  - elementary particles of which all matter in the universe is made

  - fundamental forces which hold matter together

- Particles physics requires:
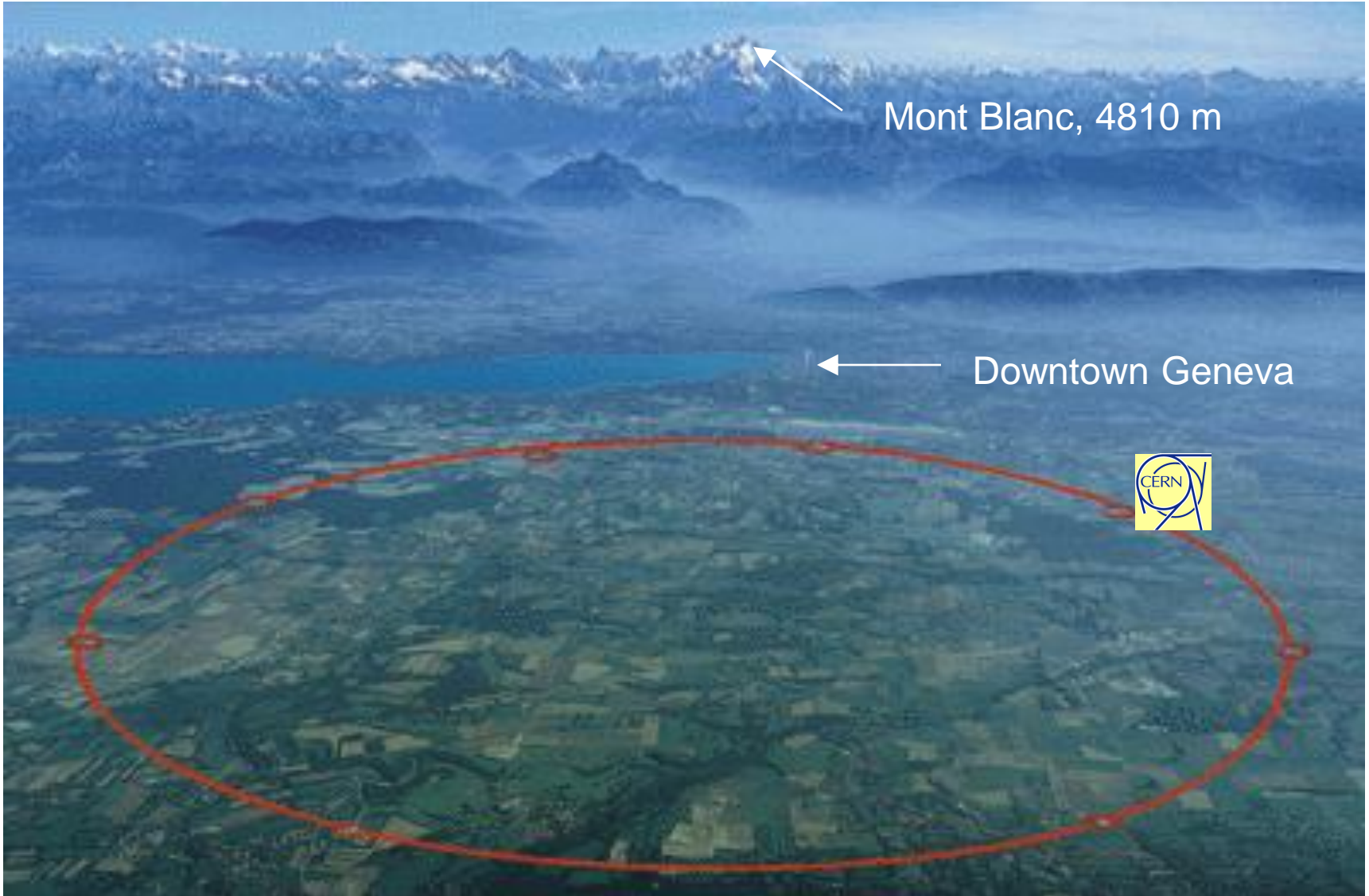
  - special tools to create and study new particles

... is located in Geneva, Switzerland

Mont Blanc, 4810 m

Downtown Geneva

CERN's special tools are:

- **ACCELERATORS**
  Huge machines able to speed up particles to very high energies before colliding them with other particles

- **DETECTORS**
  Massive instruments which register the particles produced when the accelerated particles collide

- **COMPUTERS**
  Large clusters in a world-wide grid infrastructure

What is LHC?

- LHC will collide beams of protons at an energy of 14 TeV

- Using the latest super-conducting technologies, it will operate at about -270^0C, just above absolute zero of temperature.

- With its 27 km circumference, the accelerator will be the largest superconducting installation in the world.
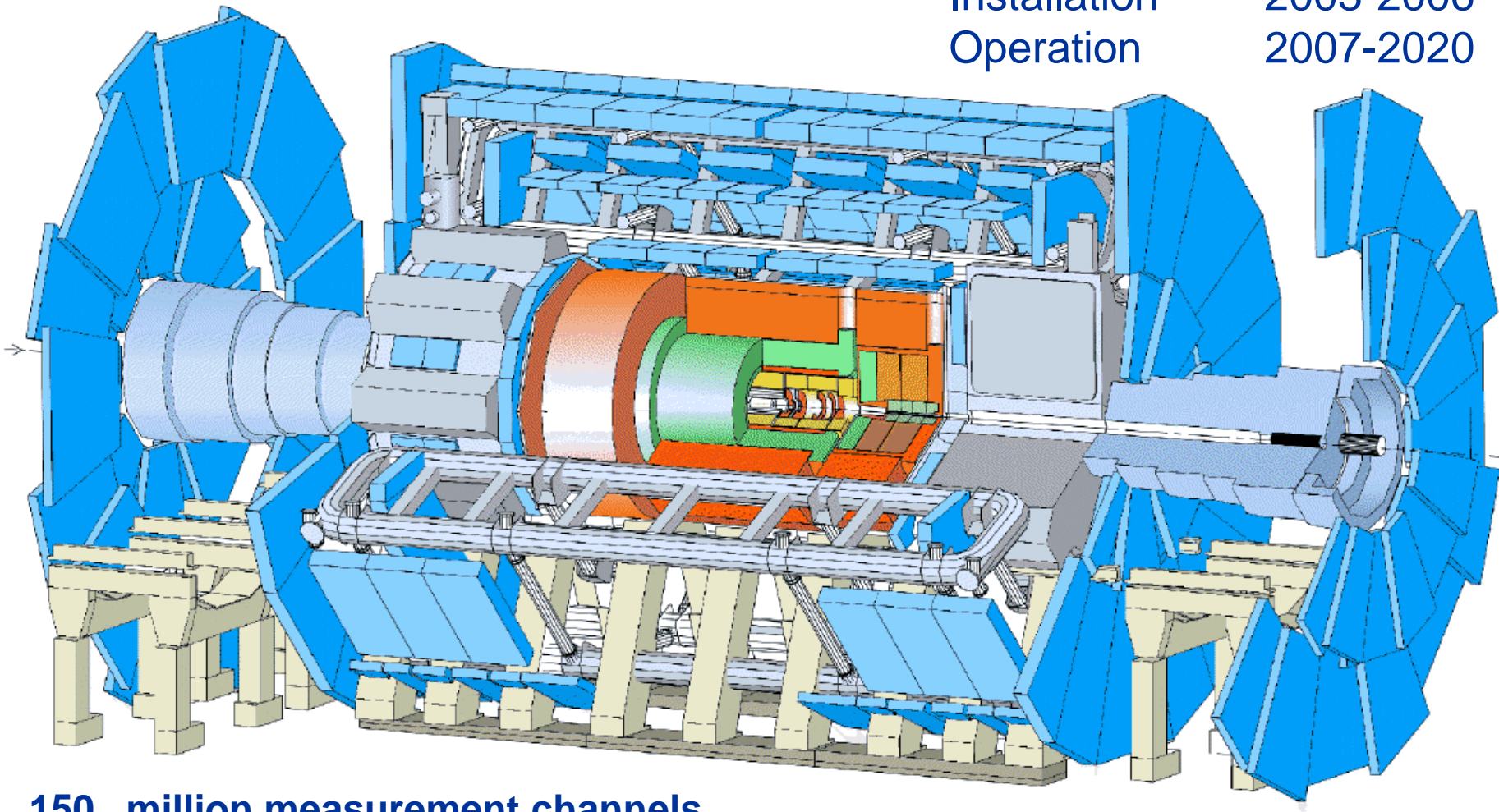
LHC is due to switch on in 2007

Four experiments, with detectors as 'big as cathedrals':

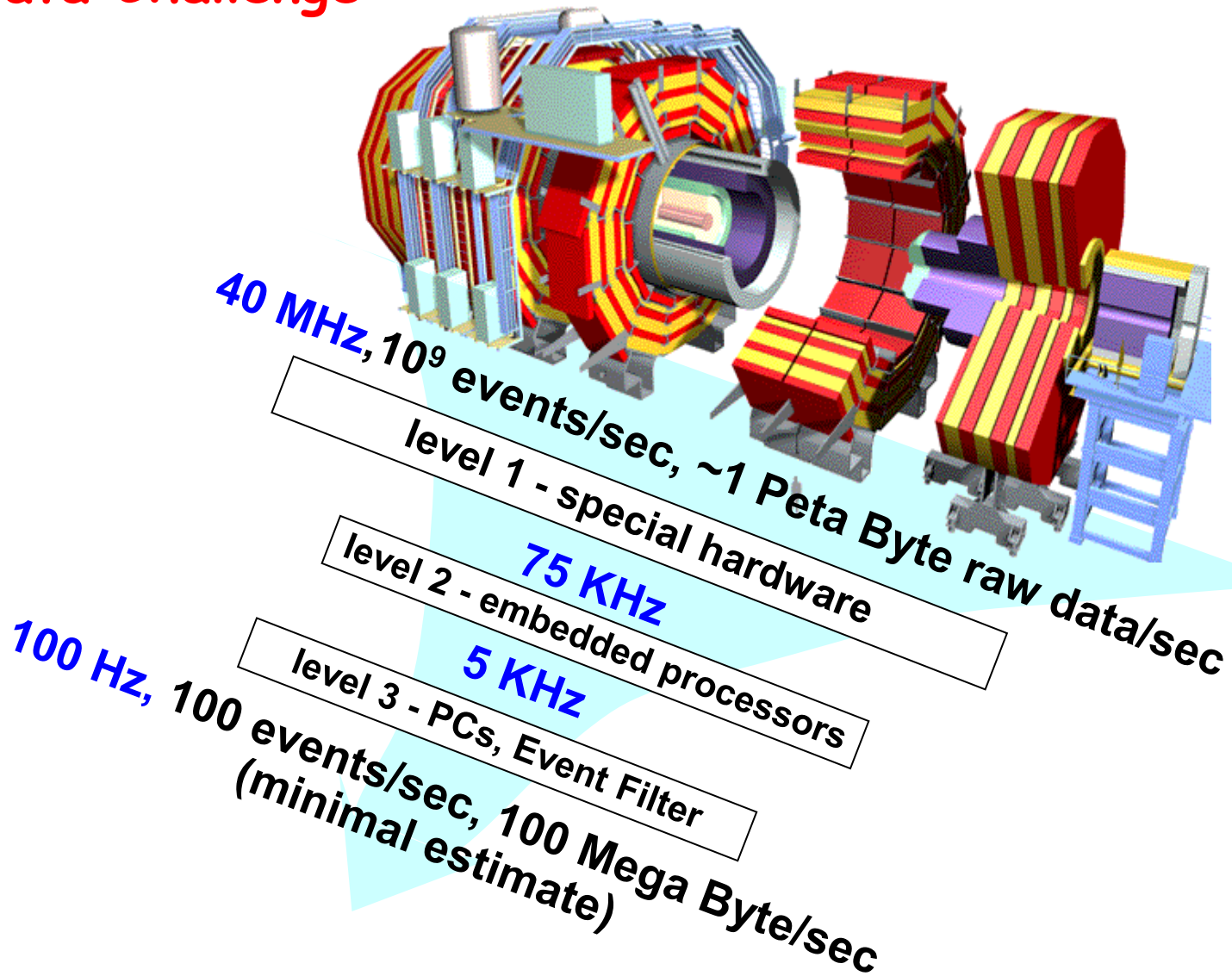*ALICE*
ATLAS
CMS
LHCb

ATLAS Detector

R&D	1988-1995
Proposal	1994
Approval	1996
Installation	2003-2006
Operation	2007-2020

150 million measurement channels
1 million control points
1 million lines of code

> 500 MCHF, CERN: 15%

CMS
Compact Muon Solenoid

LHC Data Challenge

40 MHz, 10^9 events/sec, ~1 Peta Byte raw data/sec

level 1 - special hardware

75 KHz

level 2 - embedded processors

5 KHz

level 3 - PCs, Event Filter

100 Hz, 100 events/sec, 100 Mega Byte/sec (minimal estimate)

LHC data (simplified)

Per experiment:

- 40 million collisions per second

- After filtering, 100 collisions of interest per second

- A Megabyte of digitised information for each collision = recording rate of 0.1 Gigabytes/sec

- 1 billion collisions recorded = 1 Petabyte/year

Total: ~10.000.000.000.000.000 = **1% of**

1 Megabyte (1MB)
A digital photo

1 Gigabyte (1GB)
= 1000MB
A DVD movie

1 Terabyte (1TB)
= 1000GB
World annual book production

1 Petabyte (1PB)
= 1000TB
10% of the annual production by LHC experiments

1 Exabyte (1EB)
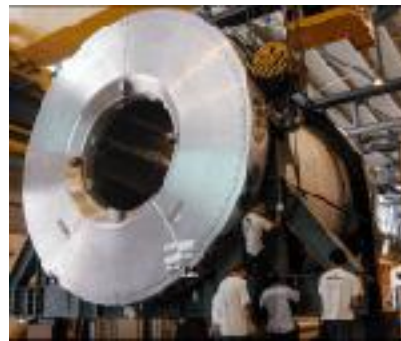*= 1000 PB*
World annual information production
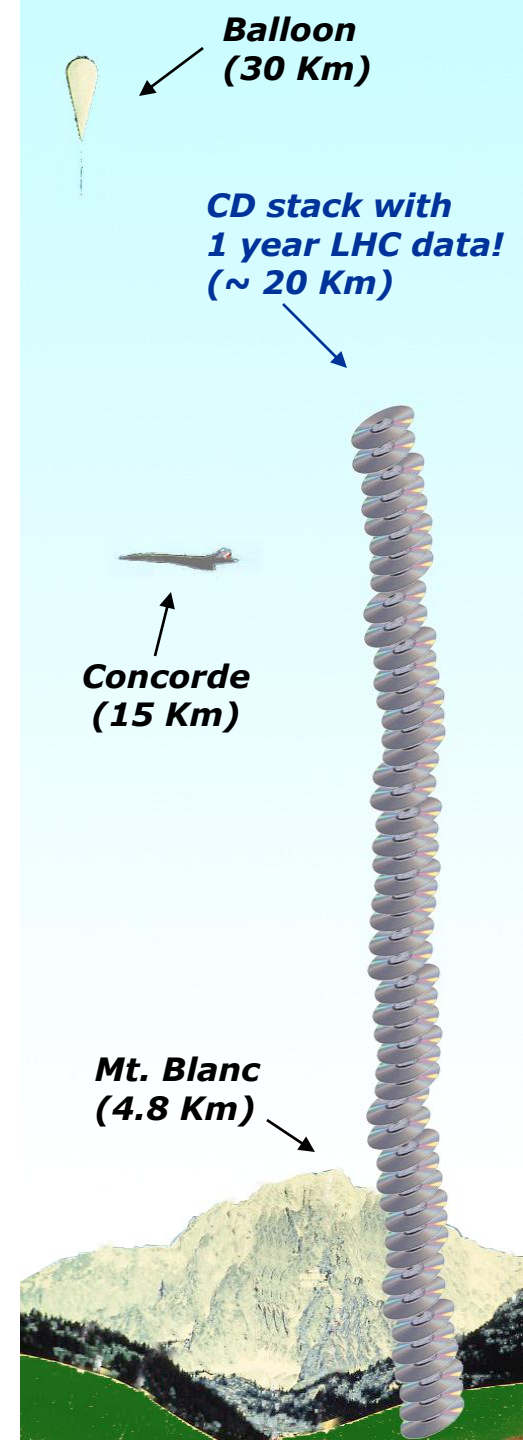
CMS

LHCb

ATLAS

ALICE

LHC data

**LHC data correspond to about 20 million CDs each year**

Where will the experiments store all of these data?

Balloon (30 Km)

CD stack with 1 year LHC data! (~ 20 Km)

*Concorde (15 Km)*

Mt. Blanc (4.8 Km)

The LHC Data Challenge

- A particle collision = an event

- Provides trivial parallelism, hence usage of simple farms

- Physicist's goal is to count, trace and characterize all the particles produced and fully reconstruct the process.

- Among all tracks, the presence of "special shapes" is the sign for the occurrence of interesting interactions.
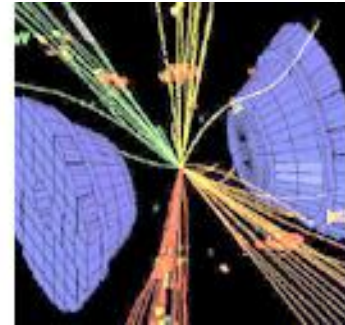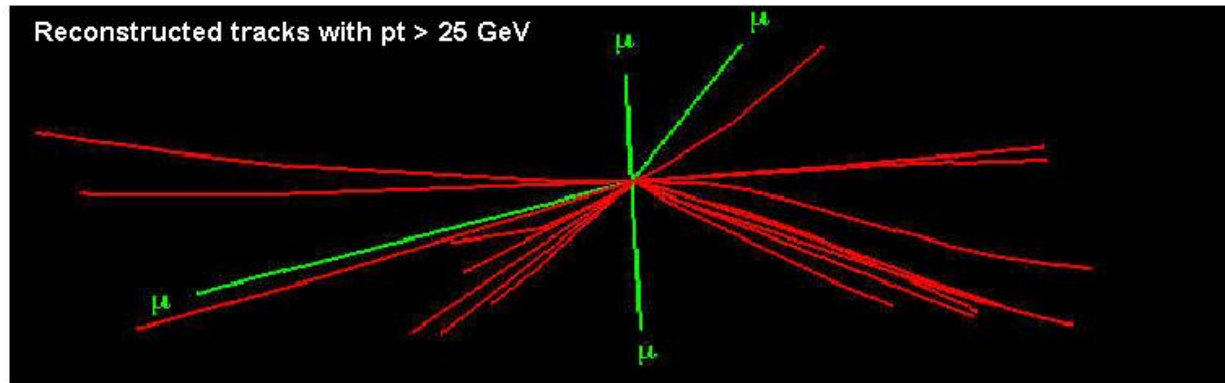
The LHC Data Challenge

Starting from this event…

(+30 minimum bias events)

All charged tracks with pt > 2 GeV
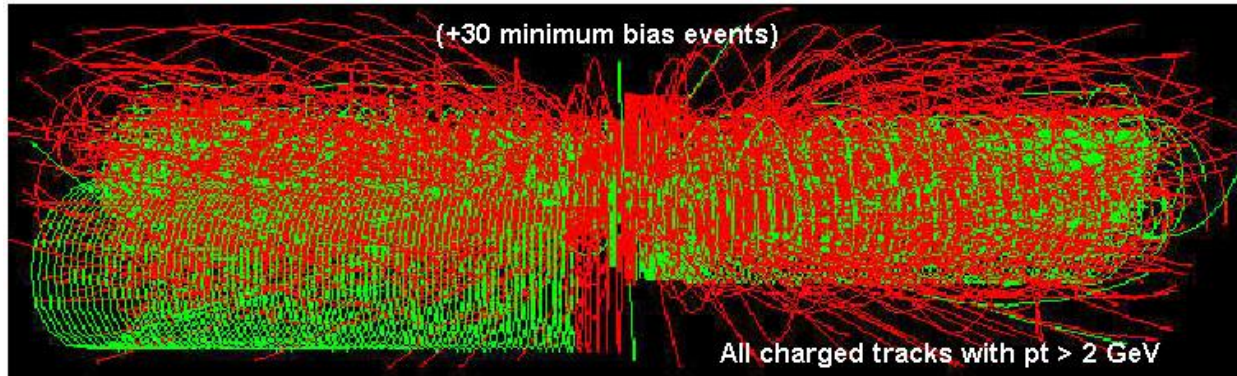
Selectivity: 1 in 10^{13}

Like looking for 1 person in a thousand world populations!

Or for a needle in 20 million haystacks!
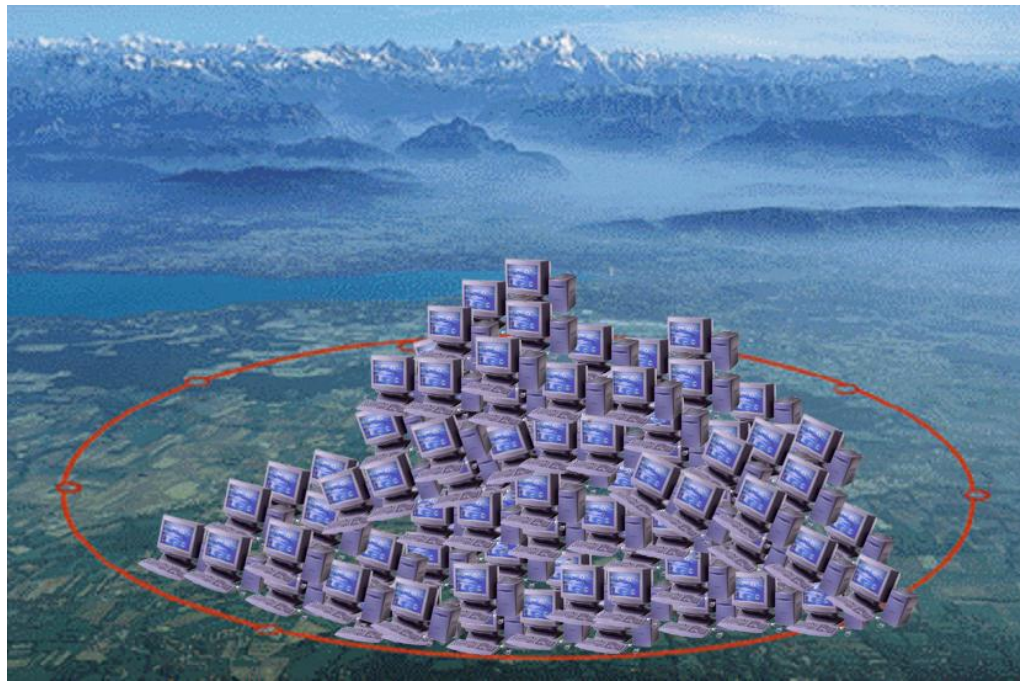
You are looking for this "signature"

Reconstructed tracks with pt > 25 GeV

LHC data processing

LHC data analysis requires a computing power equivalent to ~ 70,000 of today's fastest PC processors
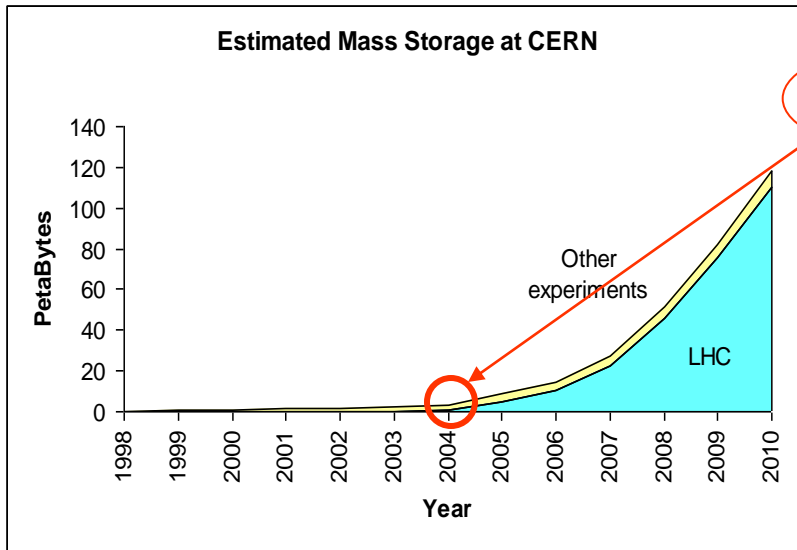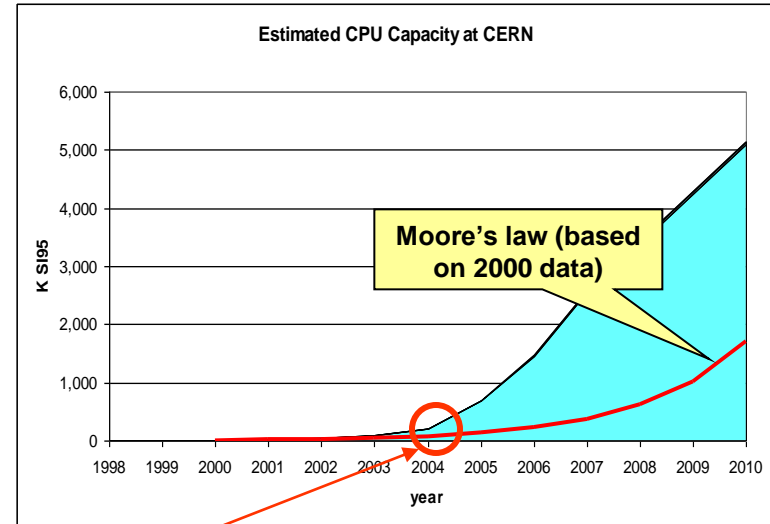
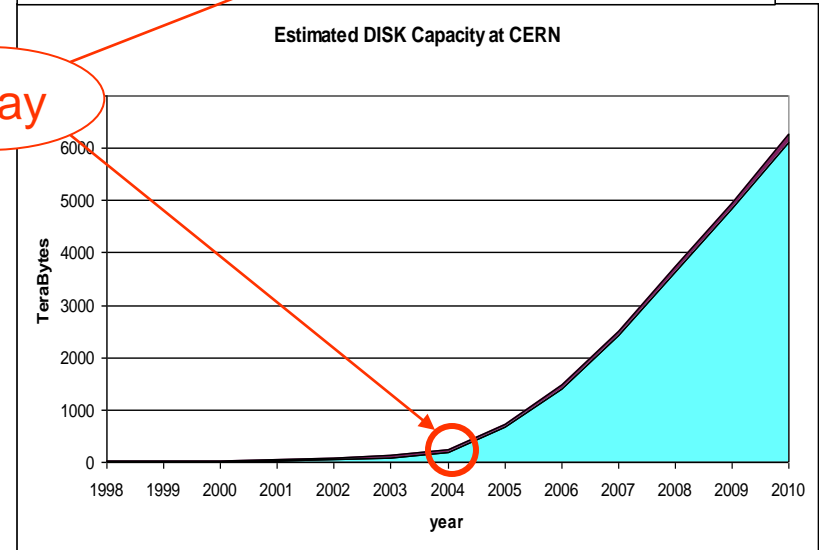**Where will the experiments find such a computing power?**

Expected LHC computing needs

Networking:
10 – 40 Gb/s to all big centres
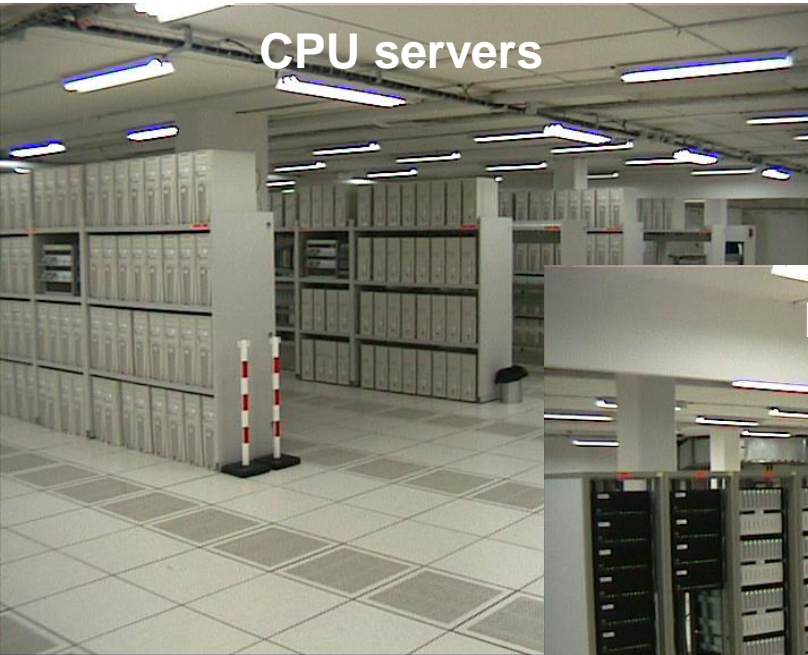
Computing at CERN today

- High-throughput computing based on reliable "commodity" technology
- More than 1500 dual processor PCs
- More than 3 Petabyte of data on disk (10%) and tapes (90%)

Nowhere near enough!

Computing at CERN today

CPU servers

Disk servers

Tape silos and servers

The new computer room is being populated…

…while the existing computer centre is being cleared for renovation…

…and an upgrade of the power supply from 0.5MW to 2.5MW is underway.
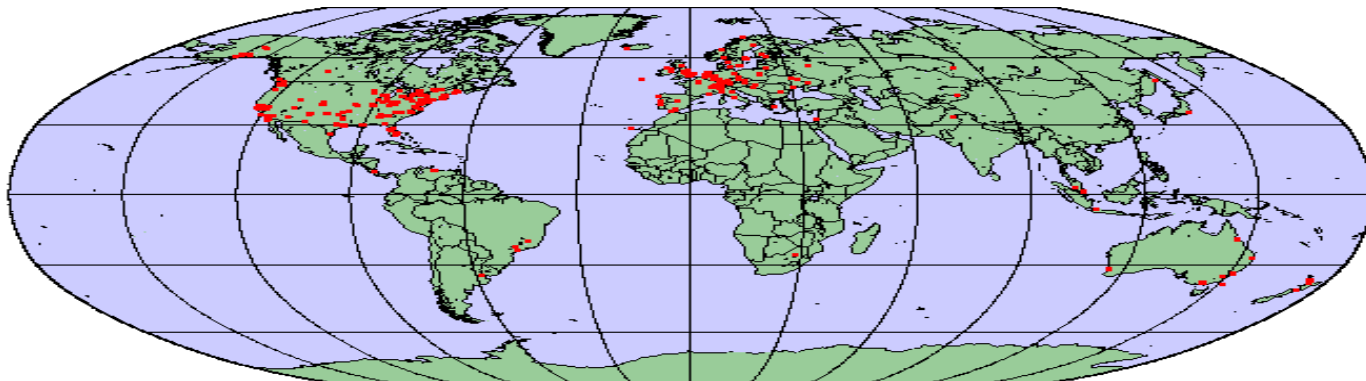
…and the services continue to run…

Computing for LHC

- **Problem:** even with computer centre upgrade, CERN can only provide a fraction of the necessary resources

- **Solution:** computing centres, which were isolated in the past, will now be connected, **uniting the computing resources of particle physicists in the world using GRID technologies!**
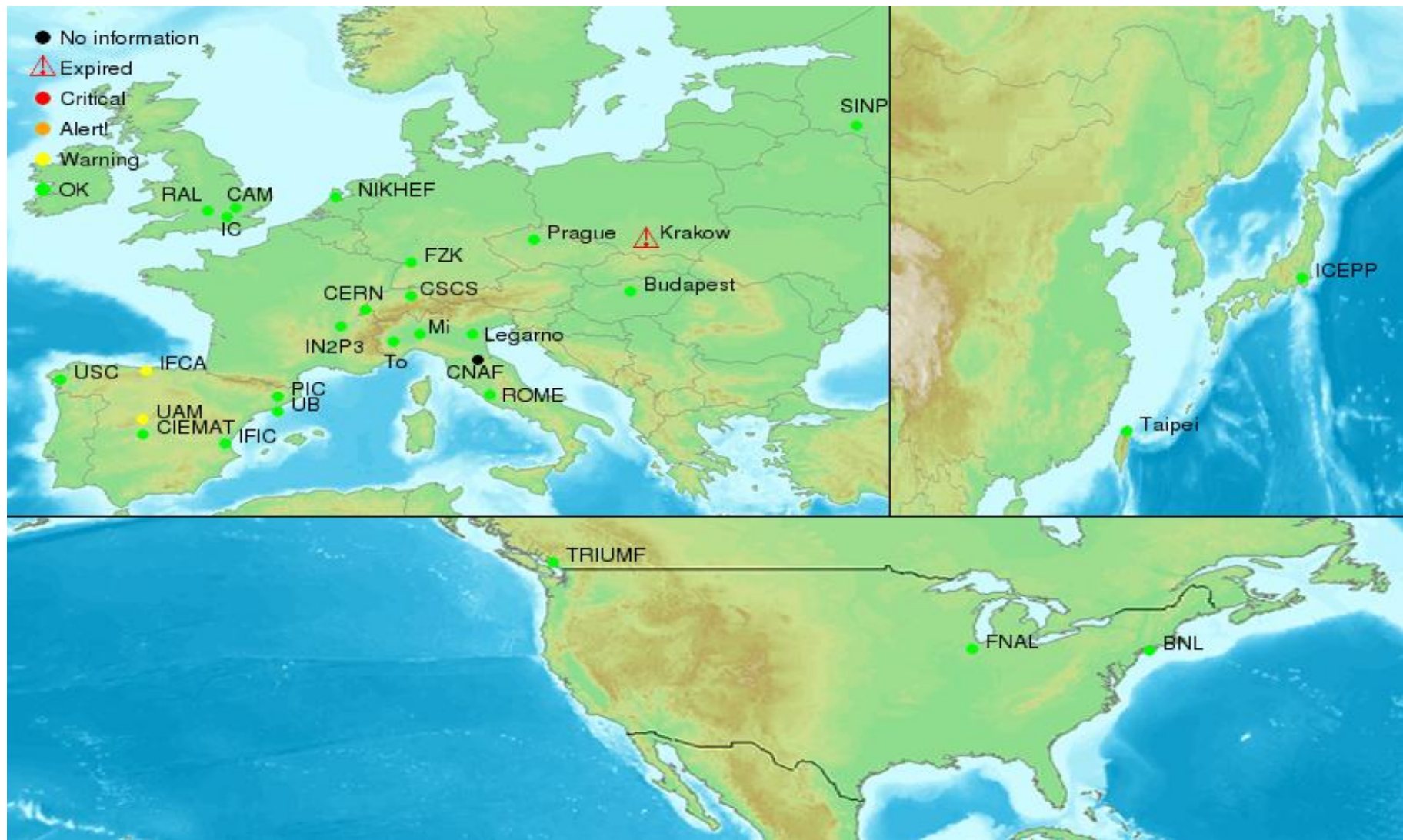
Grid @ CERN

- CERN projects:
  LHC Computing Grid (LCG)

- EC funded projects led by CERN:
  European DataGrid (EDG), terminates 3/04
  European DataTAG (EDT), terminates 3/04
  Enabling Grids for E-Science in Europe (EGEE), starts 4/04

- Industry funded projects:
  CERN openlab for DataGrid applications

LHC Computing Grid (LCG)

CERN

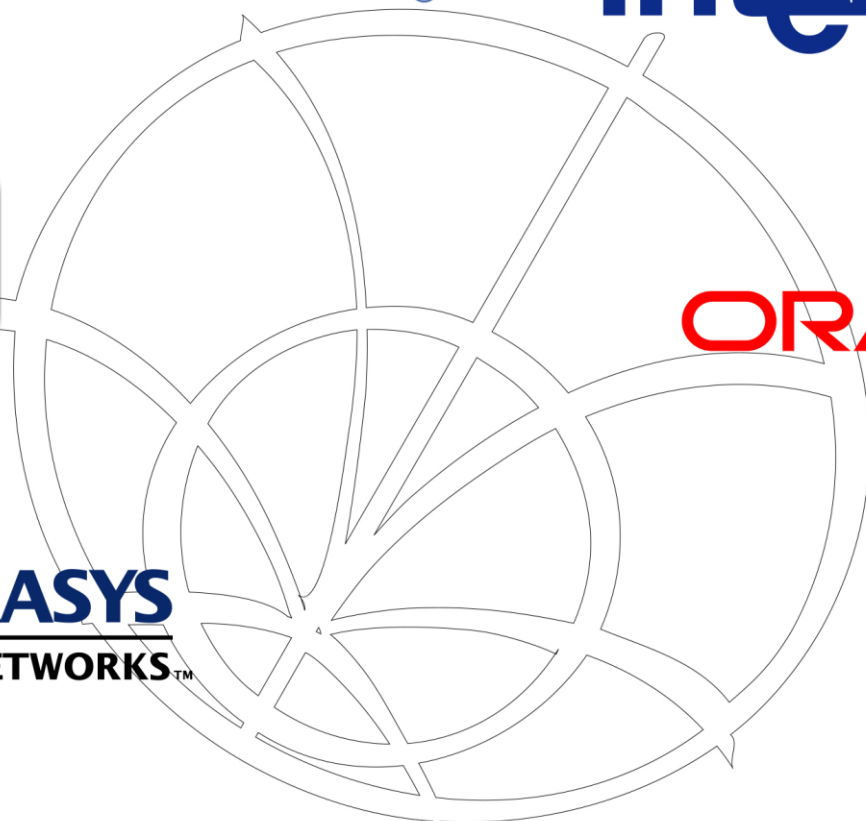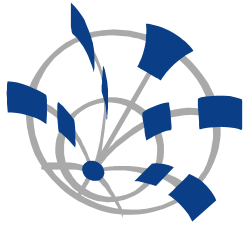openlab for DataGrid applications

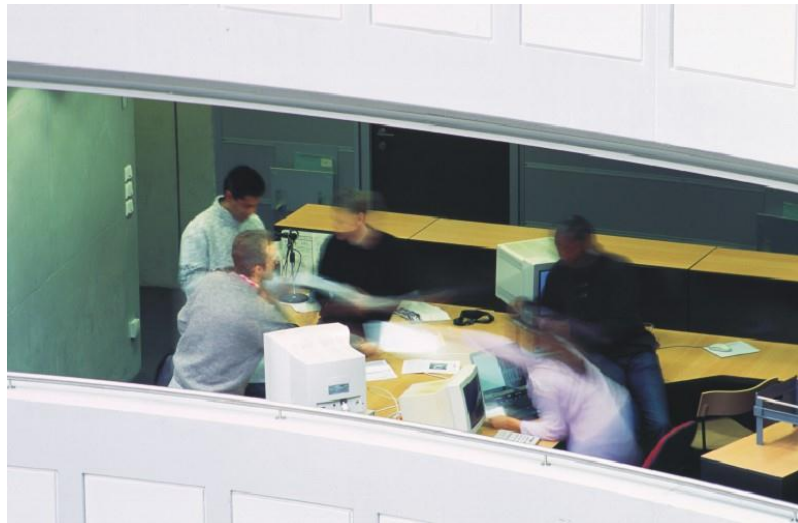*sponsored by*

IBM

intel®

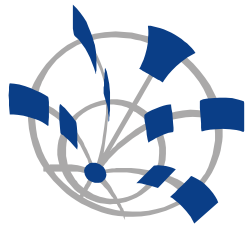hp invent

ORACLE®

ENTERASYS NETWORKS™

Mission of CERN openlab

- **Testbed** for cutting edge hardware and Grid software

- **Industry consortium** for Grid-related technologies of common interest

- **Training ground** for a new generation of engineers to learn about Grid
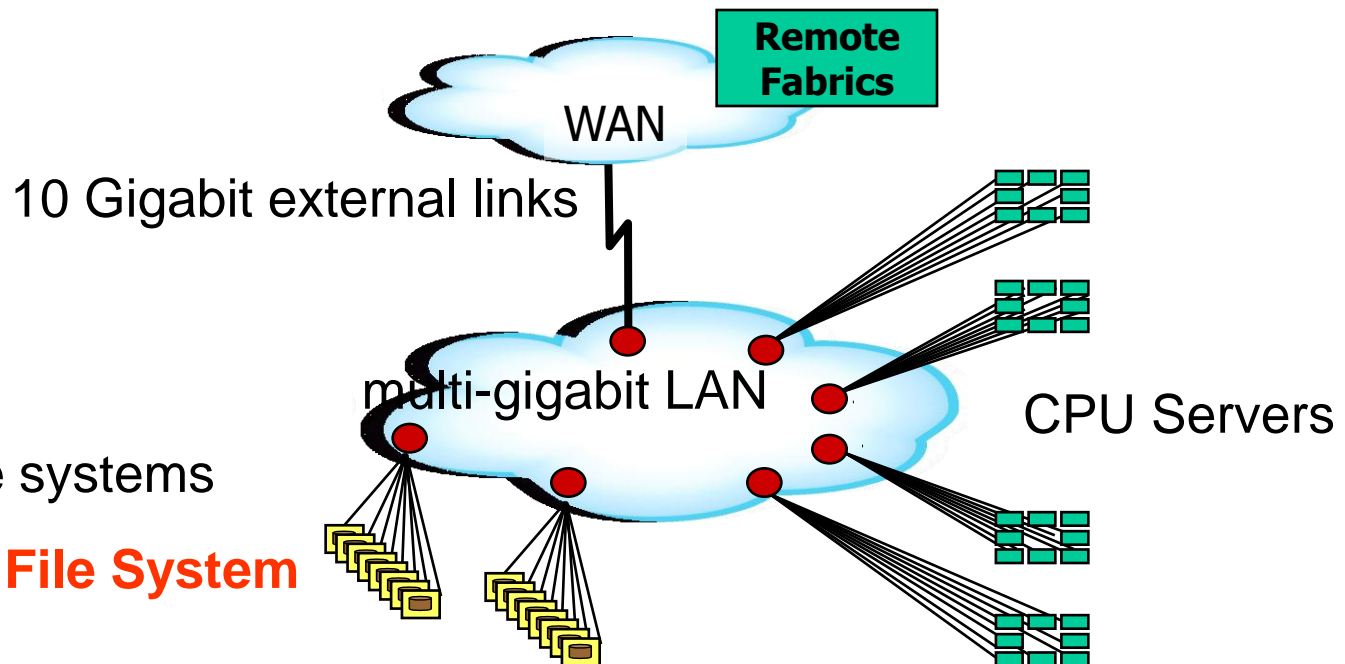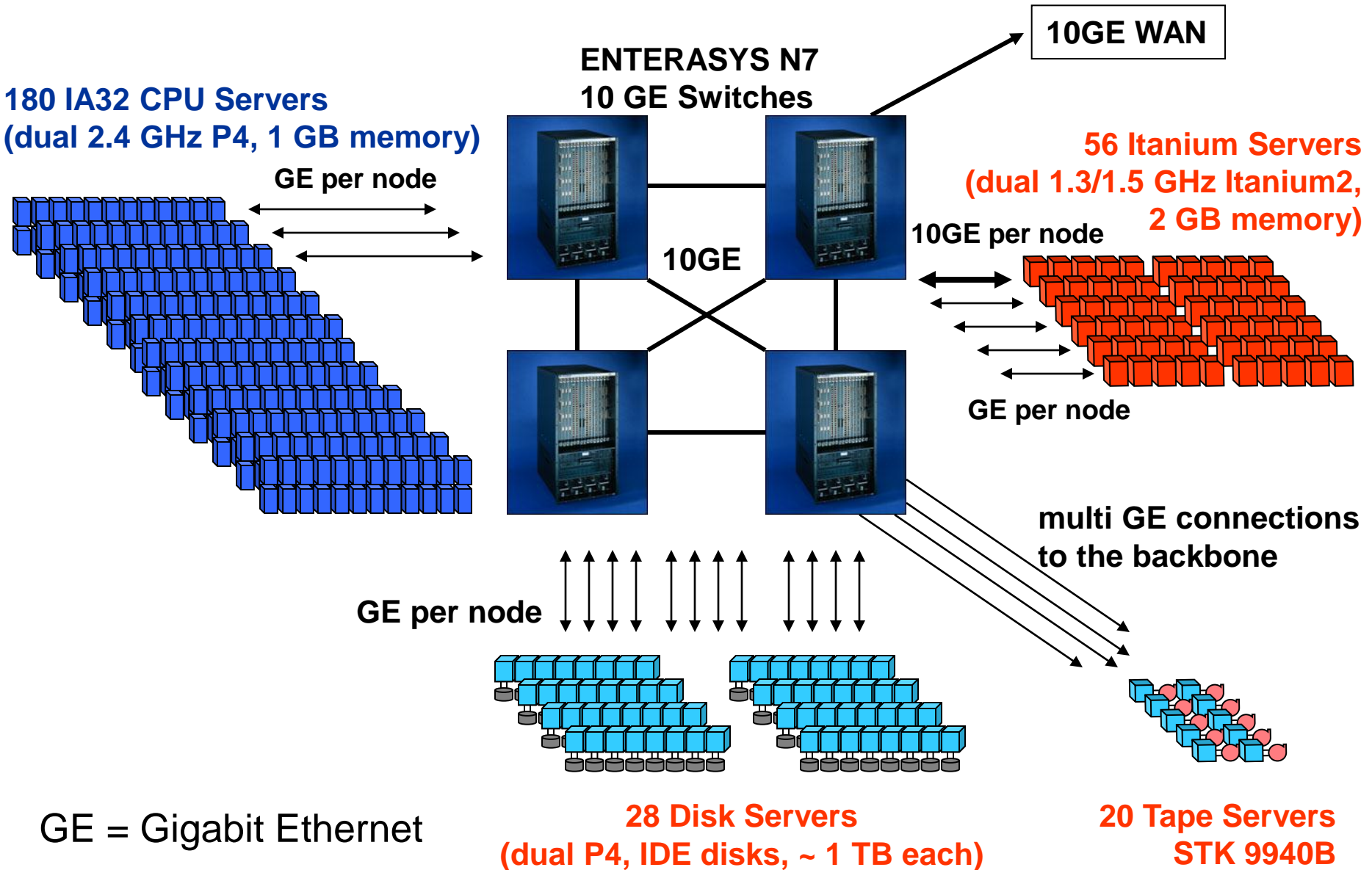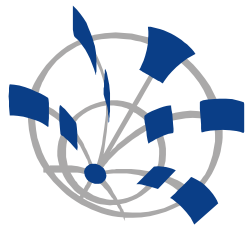
The CERN opencluster

Objectives

- Build an ultrahigh performance computer cluster

- Link it to the DataGrid and test its performance

- Evaluate potential of new technologies for LCG

- Port Grid software and physics applications to new environment

Remote Fabrics

WAN

10 Gigabit external links

multi-gigabit LAN

CPU Servers

CERN storage systems

and **IBM SAN File System**

High Throughput Prototype (openlab + LCG prototype)

10GE WAN

**ENTERASYS N7
10 GE Switches**

**180 IA32 CPU Servers
(dual 2.4 GHz P4, 1 GB memory)**

GE per node

10GE

10GE per node

**56 Itanium Servers
(dual 1.3/1.5 GHz Itanium2,
2 GB memory)**

GE per node

GE per node

**multi GE connections
to the backbone**

GE = Gigabit Ethernet

**28 Disk Servers
(dual P4, IDE disks, ~ 1 TB each)**

**20 Tape Servers
STK 9940B**

The CERN opencluster

Sponsorship so far

- 120 **Intel** Itanium™ processors (64-bit technology) and network cards
- **HP** servers for 60-node cluster
- Three 10-Gbit/s switches from **Enterasys** Networks, recently replaced by four large N7-type switches
- 28TB SAN File System System from **IBM**
- **Oracle** joined recently, Oracle 10g now under evaluation
- Dedicated R&D staff from industrial partners
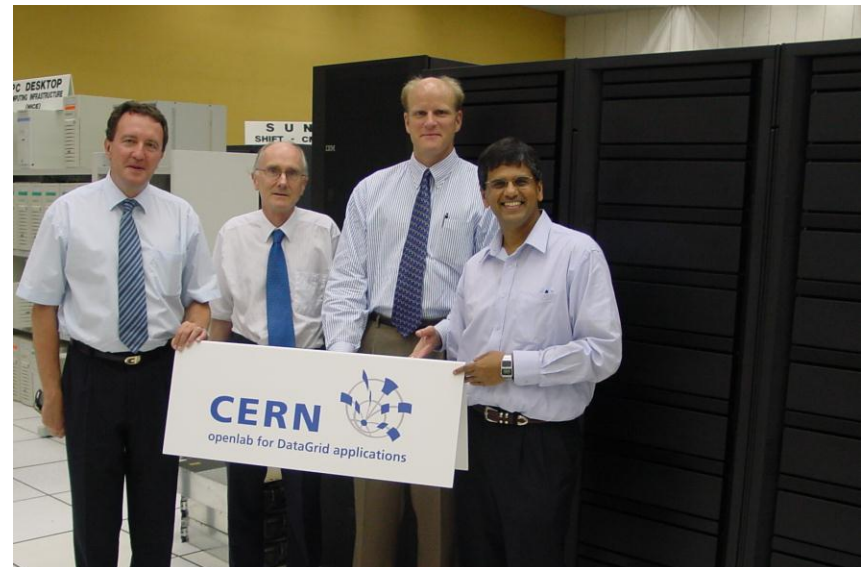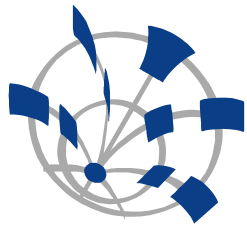- Funding for four CERN fellows (postdocs) (**HP** & **Oracle**)

The CERN opencluster

IBM's contribution

- **IBM joined the CERN openlab in April**

- **Sponsors SAN File System with**

  - **28TB of iSCSI storage**

  - **6 node SAN server cluster**

- **A key feature of the CERN installation is the use of iSCSI with Linux clients**

IBM delegation at openlab annual
sponsors meeting, June 2003
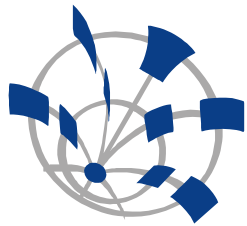
The CERN opencluster

SAN File System status

- **Equipment installed over summer 2003**

- **80 Linux clients connected**

- **Reliability and performance tests currently being run**

Medium-term goals

- **Test SAN File System in CERN environment (very heterogeneous)**

- **Link to opencluster and DataGrid with Distributed SAN File System**

- **Integrate existing disk-servers during 2004**

Preliminary results & goals

- **iSCSI is a brand-new extension to SAN File System. Initial tests gave promising results, but performance was not sufficient**
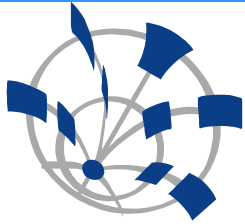
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- **ST over long-distance networks**

- **Find cost-effective solutions matching the needs of LHC**

Remember:

This is still an advance development project, not a final product !

Conclusions

- **CERN's LHC experiments have enormous computing needs**

- **The LCG/EGEE projects are the major driving force for Grid technology developments in the scientific arena**

- **CERN is leading some of the most ambitious data-intensive Grid projects worldwide**

- **CERN is collaborating with leading IT partners via the CERN openlab**

- **IBM is providing key storage technology to the partnership**