where the Web was born

CERN and the LHC Computing Challenge

by

Wolfgang von Rüden

Head, IT Department

CERN 50th anniversary with openlab partners

19th October 2004

What is CERN?

- CERN is the world's largest particle physics centre

- Particle physics is about:
  - elementary particles, the constituents all matter in the Universe is made of
  - fundamental forces which hold matter together

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

CERN is also:

-2500 staff (physicists, engineers, technicians, …)

*- Some 6500 visiting scientists (half of the world's particle physicists)*

They come from 500 universities representing 80 nationalities.

What is CERN?

- Physicists smash particles into each other to:
  - identify their components
  - create new particles
  - reveal the nature of the interactions between them
  - recreate the environment present at the origin of our Universe (big bang)

- What for? To answer fundamental questions like:
*how did the Universe begin? What is the origin of mass?
What is the nature of antimatter?*
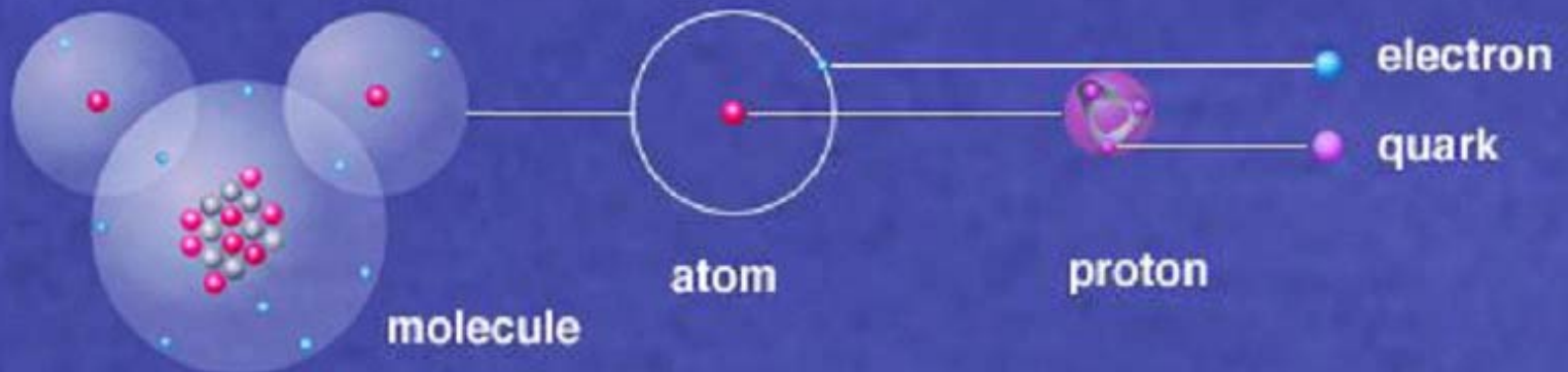
What is CERN?

The special tools for particle physics are:

- ACCELERATORS, huge machines able to speed up particles to very high energies before colliding them into other particles

- DETECTORS, massive instruments which register the particles produced when the accelerated particles collide

- COMPUTING, to re-construct the collisions, to extract the physics data and perform the analysis

The CERN Site

Mont Blanc, 4810 m

Downtown Geneva

LHCb

ATLAS

CMS

CERN sites

ALICE
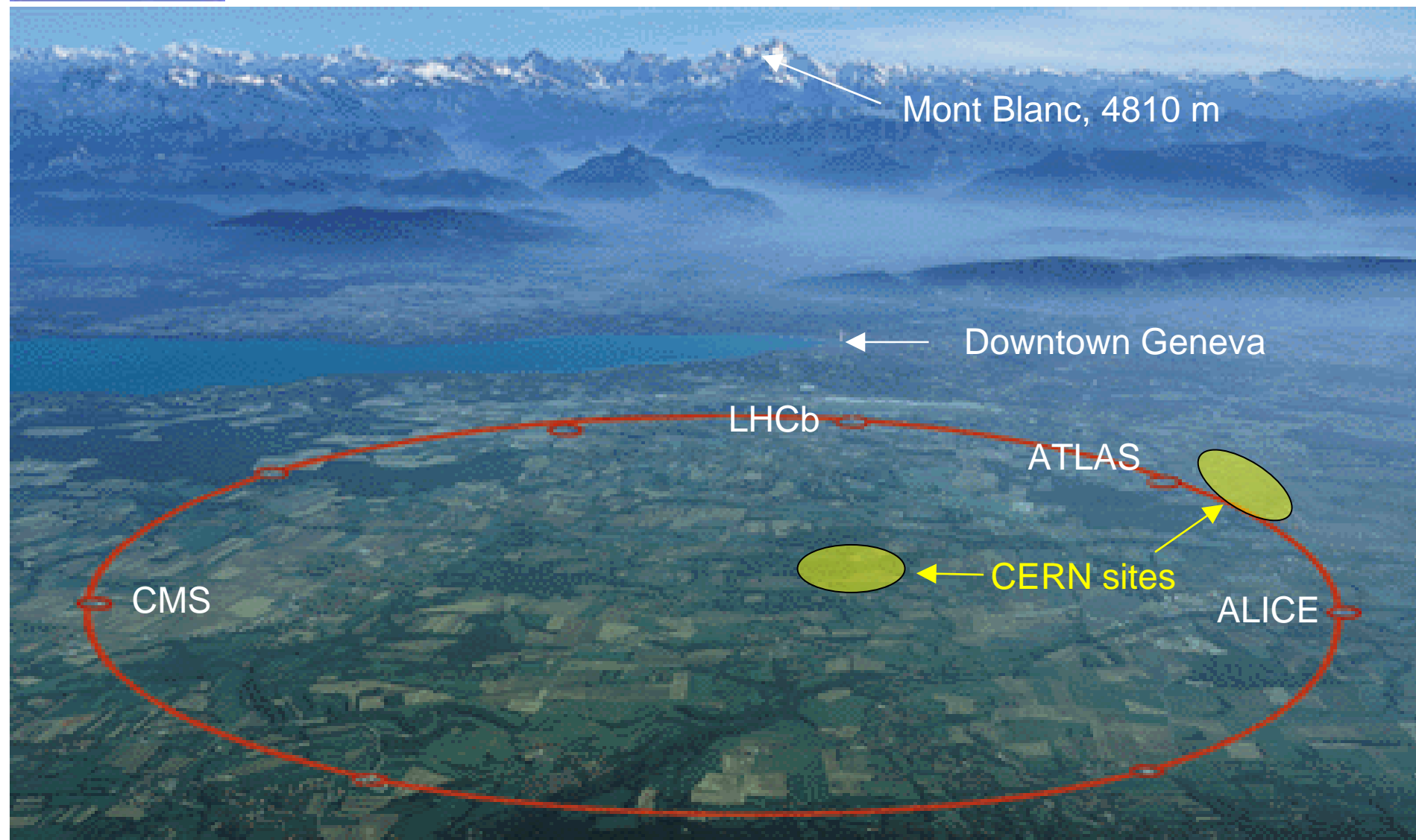
What is LHC?

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

- Using the latest super-conducting technologies, it will operate at about $-270^{\circ}C$, just above the absolute zero of temperature

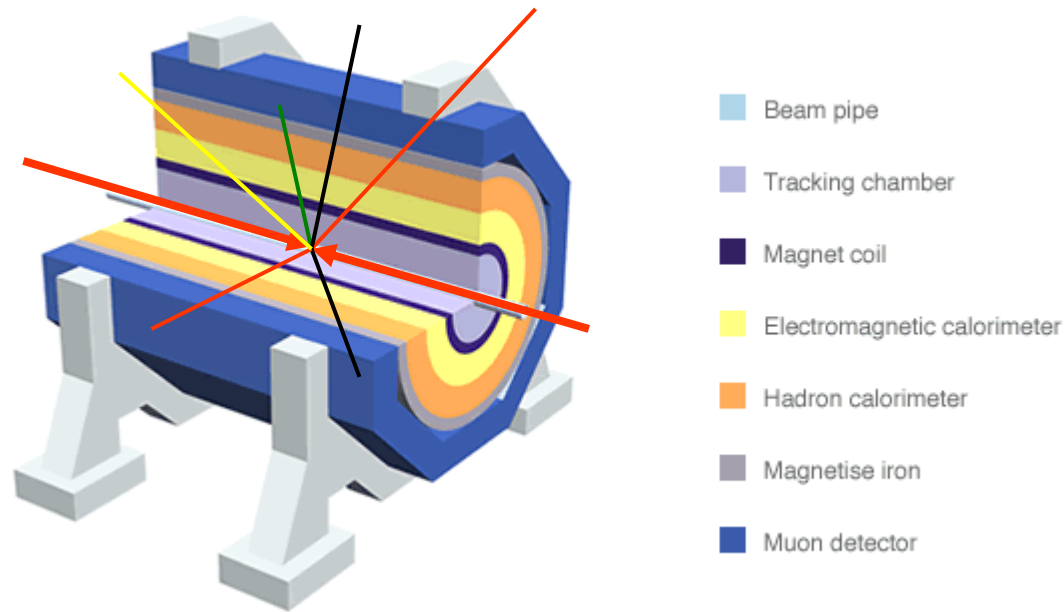- With its 27 km circumference, the accelerator will be the largest superconducting installation in the world.

LHC is due to switch on in 2007

Four experiments, with detectors as 'big as cathedrals':
ALICE
ATLAS
CMS
LHCb

Typical Experiment Layout

Beam pipe

Tracking chamber

Magnet coil

Electromagnetic calorimeter
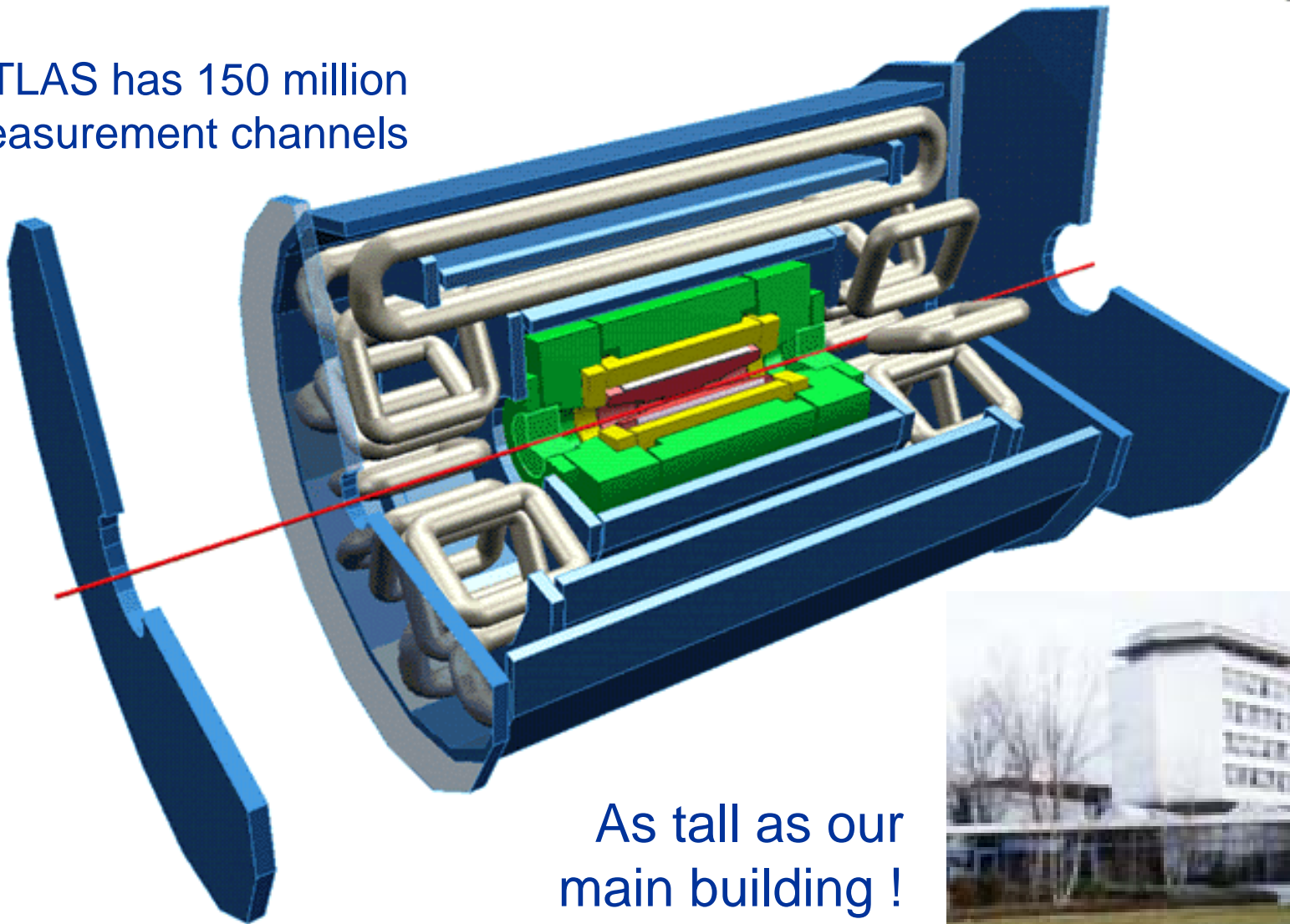
Hadron calorimeter

Magnetise iron

Muon detector

- Complex system of detectors centred around the beam interaction point

ATLAS, one of the four LHC experiments

ATLAS has 150 million measurement channels

As tall as our main building !

![CERN 50 years 1954-2004 logo]

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**
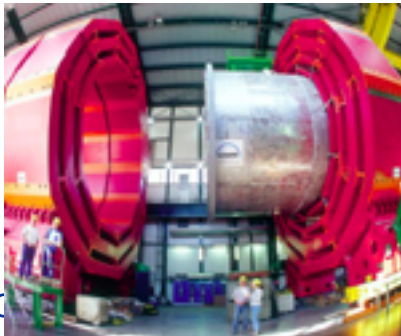
1 Megabyte (1MB)
A digital photo

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)
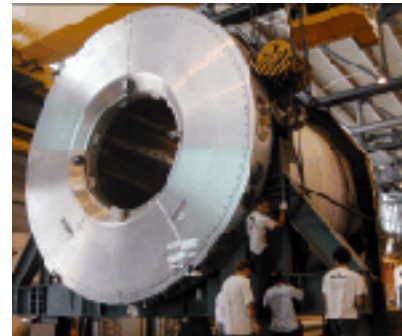*= 1000 PB*
World annual
information production
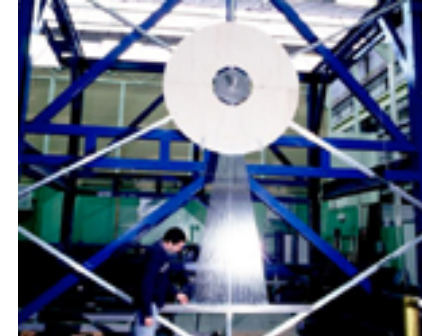
CMS

LHCb

ATLAS

ALICE

The LHC Computing Grid Project

Les Robertson

LCG Project Leader

CERN, IT Department

les.robertson@ cern.ch - www.cern.ch/lcg

LHC Computing Grid Project

Aim of the project

To prepare, deploy and operate the computing environment

    for the experiments to analyse the data from

        the LHC

    detectors

Applications development environment, common tools and frameworks

Build and operate the LHC computing service

The Grid is just a tool towards achieving this goal
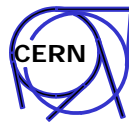
Data Handling and Computation for Physics Analysis

detector

event filter (selection & reconstruction)

reconstruction

event summary data

processed data

raw data

event reprocessing

batch physics analysis

analysis

analysis objects (extracted by physics topic)

event simulation

simulation

interactive physics analysis

les.robert...on.ch
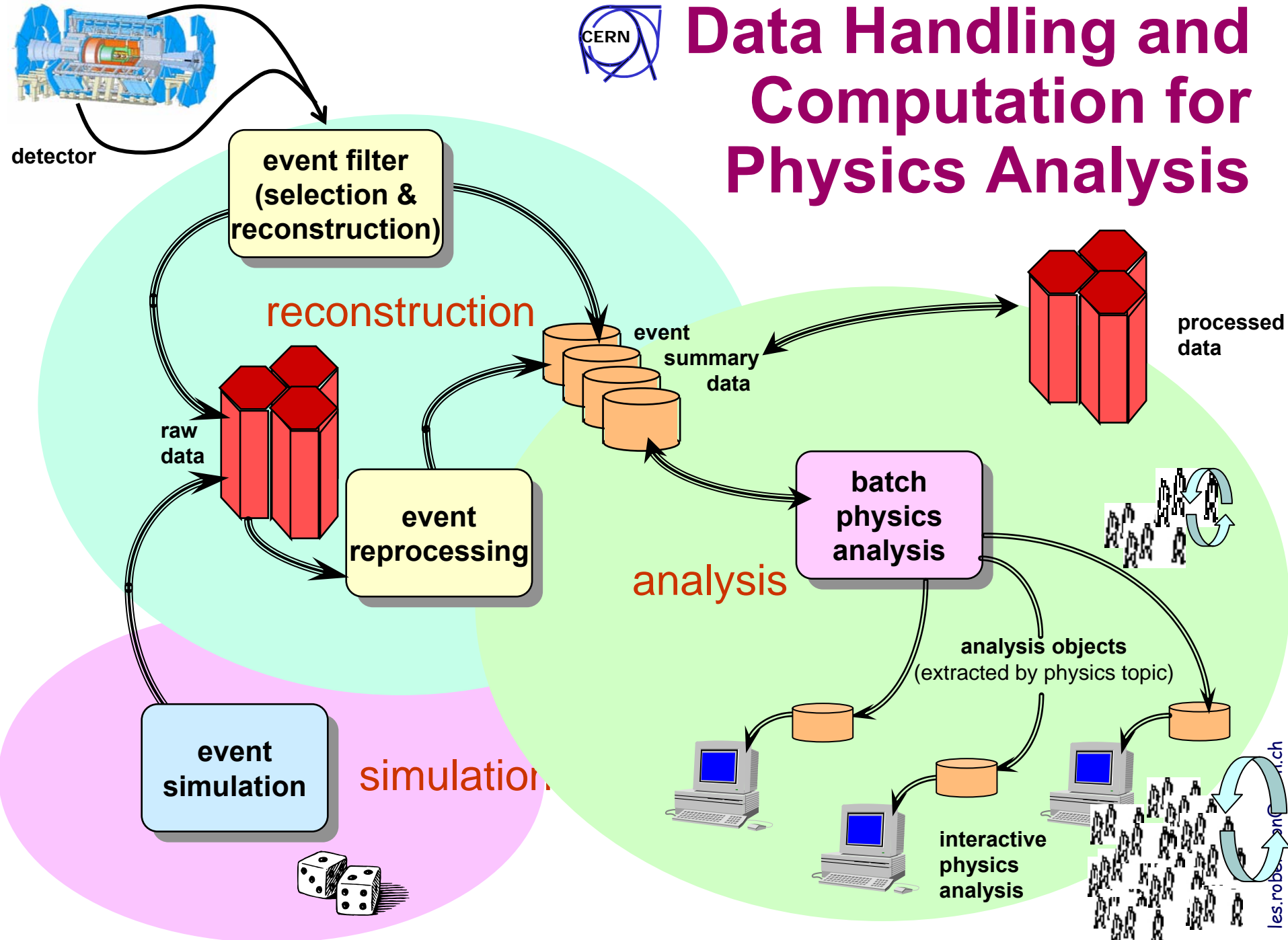
The CERN Community
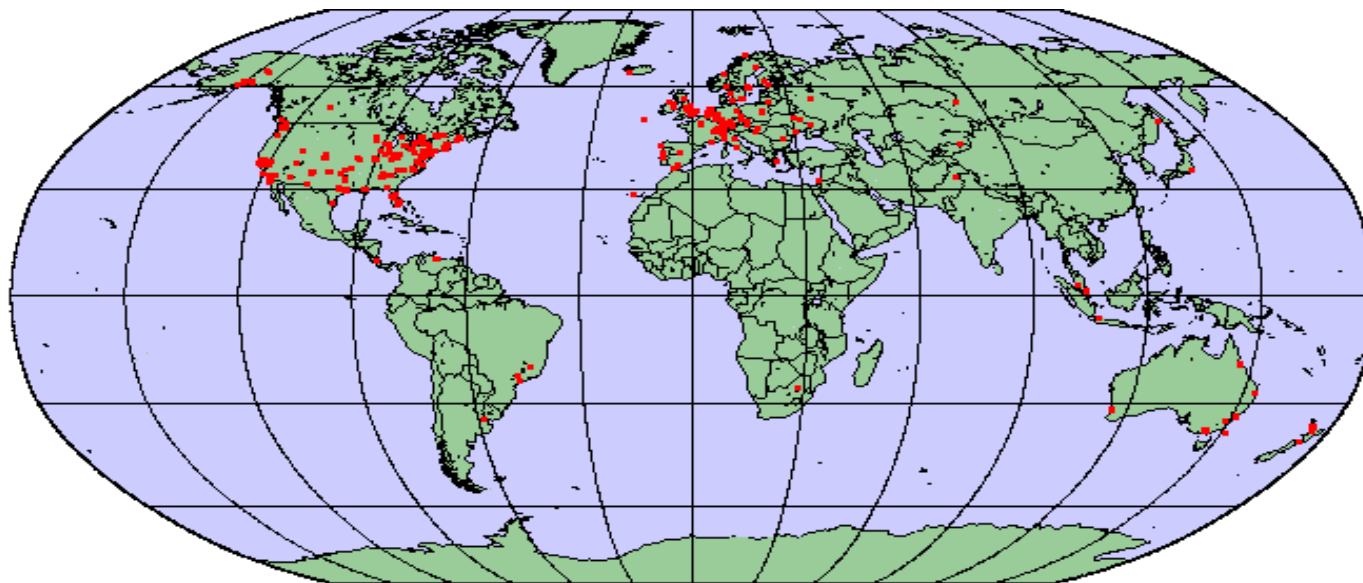
Europe:	*267 institutes*	*4603 users*
Elsewhere:	*208 institutes*	*1632 users*

Tier-2   **Tier-1**

desktops portables

small centres

....   *RAL*

IC   *IN2P3*

IFCA   *FNAL*

UB   *NIKHEF*

Cambridge   *TRIUMF*

Budapest   *CNAF*

Prague   *FZK*

Taipei   *BNL*

LIP   *PIC*   *Nordic*

Legnaro   *ICEPP*

CSCS

IFIC

Rome

CIEMAT   *MSU*   *Krakow*   *USC*   ....

LHC Computing Model (simplified!!)

- **Tier-0 – the accelerator centre**
  - Filter→ *raw data* → reconstruction
    → *event summary data (ESD)*
  - Record and distribute the data
    to Tier-1s

- **Tier-1 –**
  - **Managed Mass Storage –**
    → **grid-enabled data service**
  - Data-heavy, batch analysis
  - National, regional support
  - "online" to the data acquisition process
    high availability, long-term commitment

- **Tier-2 –**
  - Well-managed, grid-enabled disk storage
  - End-user analysis – batch and interactive
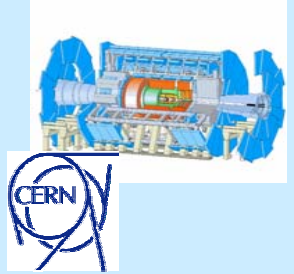 - Simulation

Current estimates of Computing Resources needed at Major LHC Centres

First full year of data - 2008

	Processing M SI2000**	Disk PetaBytes	Mass Storage PetaBytes
CERN	20	5	20
Major data handling centres (Tier 1)	50	22	17
Other large centres (Tier 2)	40	12	5
Totals	**110**	**39**	**42**
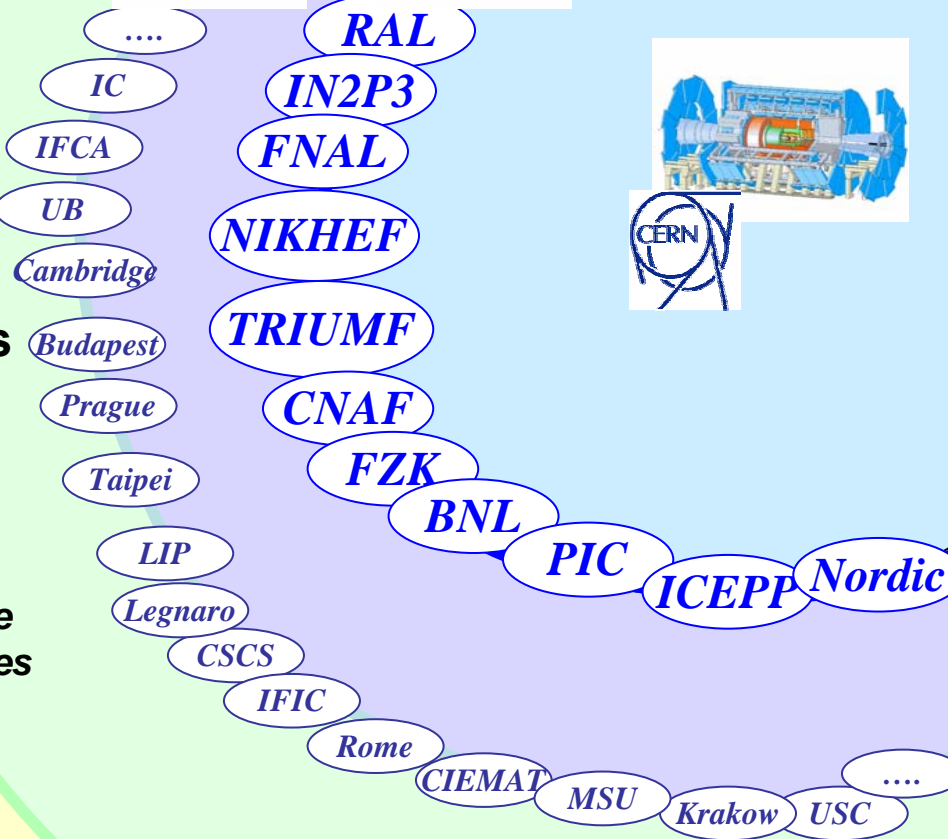
*** Current fast processor ~1K SI2000*

LCG

desktops portables

small centres

Tier-2   **Tier-1**

....
IC
IFCA
UB
Cambridge
Budapest
Prague
Taipei
LIP
Legnaro
CSCS
IFIC
Rome
CIEMAT
MSU
Krakow
USC
....

RAL
IN2P3
FNAL
NIKHEF
TRIUMF
CNAF
FZK
BNL
PIC
ICEPP
Nordic

CERN

LCG LHC Computing Grid Project - a Collaboration

Building and operating the LHC Grid – a collaboration between

- The physicists and computing specialists from the LHC experiments

  Researchers

- The projects in Europe and the US that have been developing Grid middleware

  Computer Scientists & Software Engineers

- The regional and national computing centres that provide resources for LHC

  Service Providers

- The research networks

eGee Enabling Grids for E-science in Europe

DataGRID

the globus alliance

iVD gL

GriPhyN — Data Intensive Science

CERN

Virtual Data Toolkit

egee

Enabling Grids for E-science in Europe

- CERN
- Central Europe (Austria, Czech Republic, Hungary, Poland, Slovakia, Slovenia)
- France
- Germany and Switzerland
- Ireland and UK
- Italy
- Northern Europe (Belgium, Denmark, Estonia, Finland, The Netherlands, Norway, Sweden)
- Russia
- South-East Europe (Bulgaria, Cyprus, Greece, Israel, Romania)
- South-West Europe (Portugal, Spain)

Russia

US

70 institutions in 27 countries

LCG-2
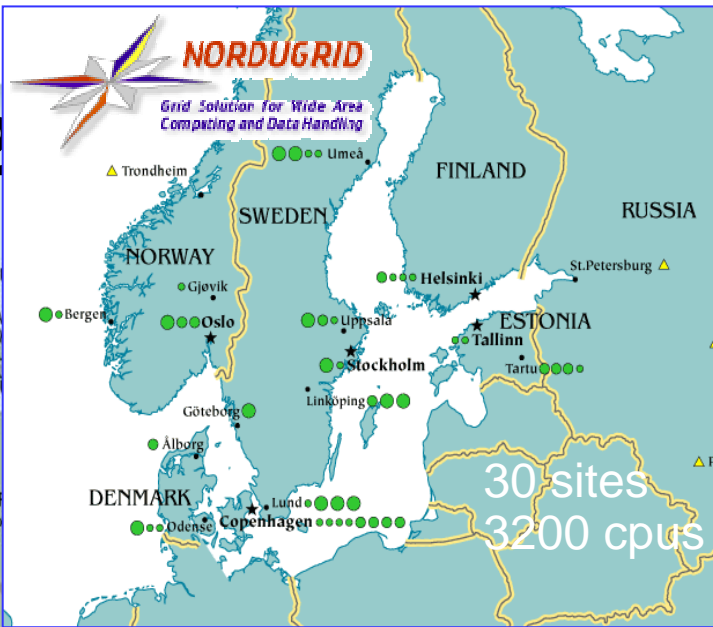
NORDUGRID
Grid Solution for Wide Area
Computing and Data Handling

30 sites
3200 cpus

25 Universities
4 National Labs
2800 CPUs

Total Sites	82
Total CPUs	7269
Total Storage (TB)	6558

Wed September 22 2004

Grid3

Open Science Grid

last update 21/10/2004 13:45
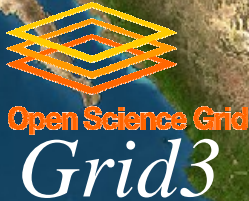
Data Readiness Programme

LCG

1   **Dec04** – Basic data handling verification
CERN + 3 Tier-1s, 500 MB/sec, physics data sets - sustained for two weeks

2   **Mar05** - Reliable file transfer service in operation
mass store (disk) - mass store (disk), CERN+5 sites
500 MB/sec between sites, sustained for one month

3   **Jul05** – Infrastructure verification
CERN + 50% of Tier-1s, sustained operation at 300 MB/sec. including tapes
Nov05 – ATLAS and CMS Tier-0/1 model verification at *half scale*

4   **Apr06** - Infrastructure operational
ALL Tier-1s, 50% of Tier-2s - full target data rates
Aug06 – All experiments - Tier-0/1/2 model verification at *full scale*

5   **Nov 06 Infrastructure Ready**
ALL Tier-1s, most Tier-2s - operating at *twice* target data rates
Feb07 – all experiments - full model in operation

2005   2006   2007

1   *2*   *3*   **3V**   *4*   **4V**   *5*   **5V**   *commissioning*

detectors in partial operation - cosmic rays **First beams**   **Full physics run**

Continuous grid operation for physics simulation, analysis

Summary

- **LCG**
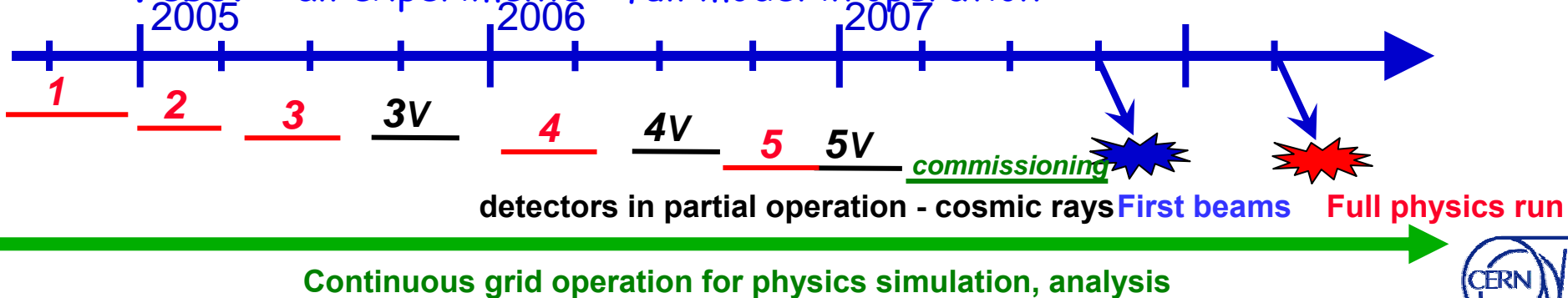
- LHC computing –
  - **Data intensive -** Geographically distributed
  - Independent regional centres

- LHC Grid –
  - Reliable environment for data intensive batch work
  - An early example of a working data-intensive grid
  - Co-existing with multiple grids, other sciences

- Current status
  - Large global grid established – and being used for real work by LHC experiments
  - Middleware – basic functionality, acceptable reliability
  - Beginning now to tackle
    - Operations management
    - Performance
  - Ambitious schedule to achieve required service level by March 2007l
  -

- Long-term expectation –
  - Science grids operated as national/international infrastructure
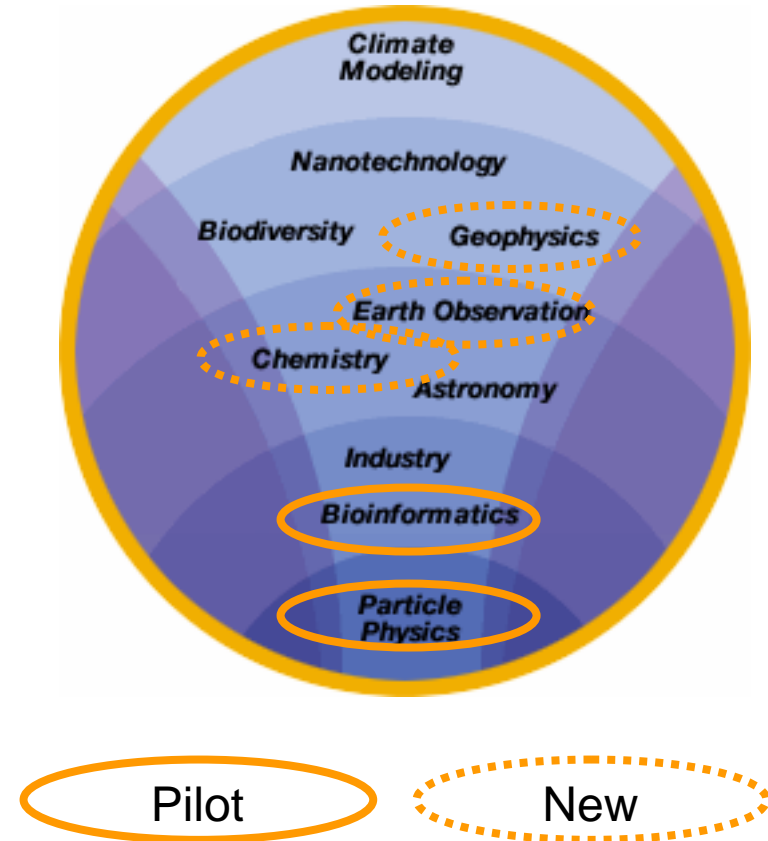
EU EGEE project – status and plans

Bob Jones
EGEE Technical Director
Bob.Jones@cern.ch

In 2 years EGEE will:

- **Establish production quality sustained Grid services**
    - 3000 users from at least 5 disciplines
    - over 8,000 CPU's, 50 sites
    - over 5 Petabytes (10^{15}) storage

- Demonstrate a viable general process to **bring other scientific communities on board**

- **Propose a second phase** in mid 2005 to take over EGEE in early 2006

Climate Modeling
Nanotechnology
Biodiversity   Geophysics
Earth Observation
Chemistry   Astronomy
Industry
Bioinformatics
Particle Physics

Pilot   New

EGEE Activities

32 Million Euros EU funding over 2 years starting 1st April 2004

- **48 % service activities** (Grid Operations, Support and Management, Network Resource Provision)

- **24 % middleware re-engineering** (Quality Assurance, Security, Network Services Development)

- **28 % networking** (Management, Dissemination and Outreach, User Training and Education, Application Identification and Support, Policy and International Cooperation)

24% Joint Research

28% Networking

48% Services

Emphasis in EGEE is on operating a production grid and supporting the end-users

EGEE pilot application: BioMedical

- BioMedical
  - Bioinformatics (gene/proteome databases distributions)
  - Medical applications (screening, epidemiology, image databases distribution, etc.)
  - Interactive application (human supervision or simulation)
  - Security/privacy constraints
    - Heterogeneous data formats - Frequent data updates - Complex data sets - Long term archiving

- BioMed applications deployed and going live in September
  - **GATE -** Geant4 Application for Tomographic Emission
  - **GPS@ -** genomic web portal
  - **CDSS -** Clinical Decision Support System

http://egee-na4.ct.infn.it/biomed/applications.html

Future EGEE Middleware - gLite
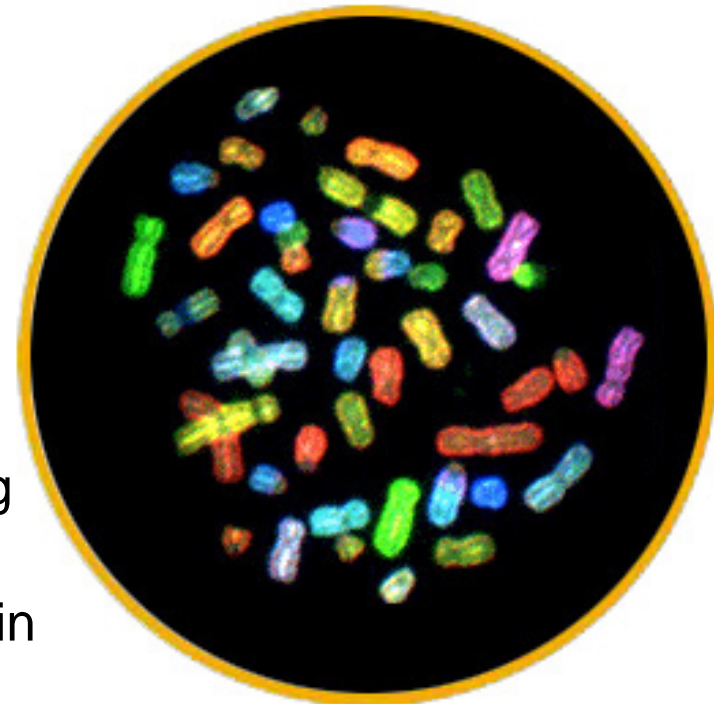
- Intended to replace LCG-2

- Starts with existing components from AliEN, EDG, VDT etc.

- Aims to address LCG-2 shortcoming and advanced needs from applications

- Prototyping short development cycles for fast user feedback

- Initial web-services based prototypes being tested with representatives from the application groups
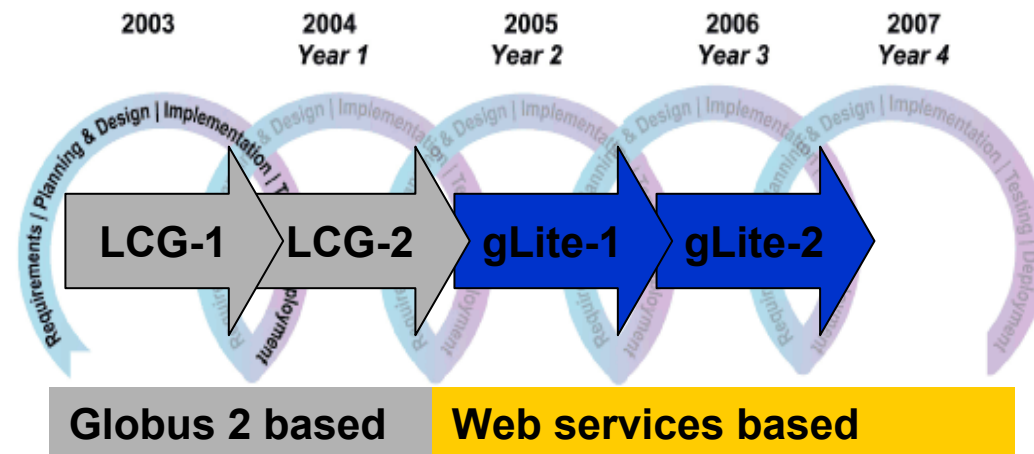
Application requirements http://egee-na4.ct.infn.it/requirements/

Intellectual Property

- The existing EGEE grid middleware (LCG-2) is distributed under an Open Source License developed by EU DataGrid
  - Derived from modified BSD - no restriction on usage (academic or commercial) beyond acknowledgement
  - Same approach for new middleware (gLite)

- Application software maintains its own licensing scheme
  - Sites must obtain appropriate licenses before installation

Who else can benefit from EGEE?

- EGEE Generic Applications Advisory Panel:
  - 4 applications presented
  - 3 applications (comp. chemistry, earth science, astro-particle) recommended for deployment with allocation of NA4 resources
  - EU GRACE project already tested

- EU projects: MammoGrid, Diligent, SEE-GRID …

- Expression of interest: Planck/Gaia (astroparticle), SimDat (drug discovery)

http://agenda.cern.ch/age?a042351

Next meeting at EGEE conference (November)

User training and induction

- Training material and courses from introductory to advanced level

- Train a wide variety of users both internal to the EGEE consortium and external groups from across Europe

- ~20 courses/presentations already held and many more planned (see roadmap)

- Experience with GENIUS portal and GILDA testbed

- Courses inline with the needs of the projects and applications

Training: **http://www.egee.nesc.ac.uk/**
Roadmap: **http://www.egee.nesc.ac.uk/schedreg/index.html**

Dissemination

- ## 1st project conference
  - Over 300 delegates came to the 4 day event during April in Cork Ireland
  - Kick-off meeting bringing together representatives from the 70 partner organisations

- ## 2nd conference scheduled
  - 22-26 November in The Hague
  - http://public.eu-egee.org/conferences/2nd/

- ## Websites, Brochures and press releases
  - For project and general public **www.eu-egee.org**
  - Information packs for the general public, press and industry
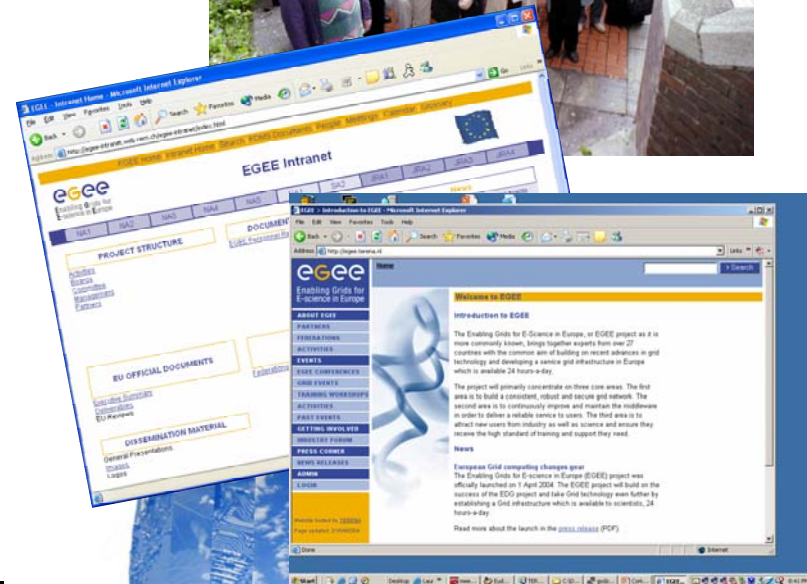
Enabling Grids for
E-science in Europe

- EGEE Industry Forum
  - raise awareness of the project in industry to encourage industrial participation in the project
  - foster direct contact of the project partners with industry
  - ensure that the project can benefit from practical experience of industrial applications

- For more info:

  http://public.eu-egee.org/industry/

- Expect Industry to play an important role in follow-on project
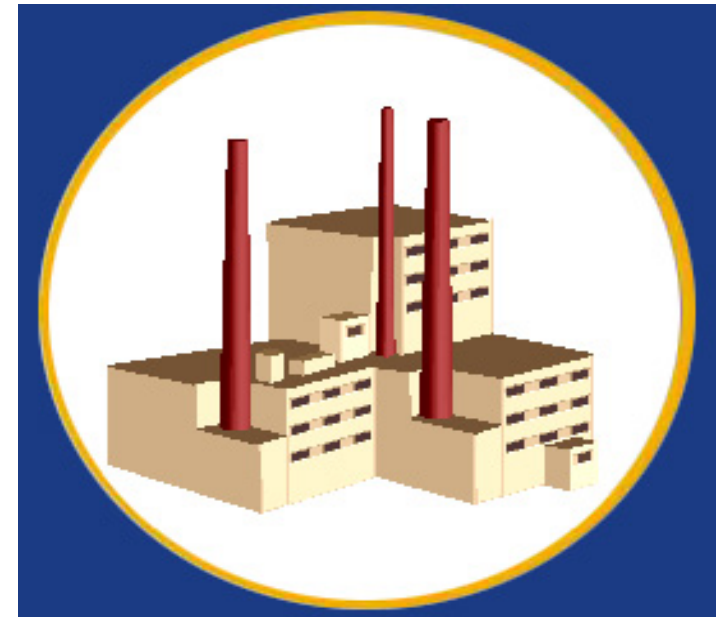
- **EGEE** is the first attempt to build a worldwide Grid infrastructure for data intensive applications from **many scientific domains**

- A **large-scale production grid service** is already deployed and being used for HEP and BioMed applications with new applications being ported

- Resources & user groups will **rapidly expand** during the project

- A process is in place for **migrating new applications** to the EGEE infrastructure

- A **training programme** has started with events already held

- Prototype "*next generation*" middleware is being tested (**gLite**)

- Plans for a **follow-on project** are being discussed

More information: www.eu-egee.org

CERN
openlab for DataGrid applications

*In partnership with
and sponsored by*

IBM

intel.

hp invent

ORACLE

enterasys
Networks that Know

**Wolfgang von Rüden
Head, IT Department**

October 2004

CERN openlab

- **IT Department's main R&D focus**
- **Framework for collaboration with industry**
- **Evaluation, integration, validation**
  - **of cutting-edge technologies that can serve LCG**
- **Initially a 3-year lifetime**
  - **As of 1.1.2003**
  - **Later: Annual prolongations**
- **Slogan: "You make it, we break it".**

LCG

CERN openlab

| 02 | **03** | **04** | **05** | **06** | 07 | 08 |
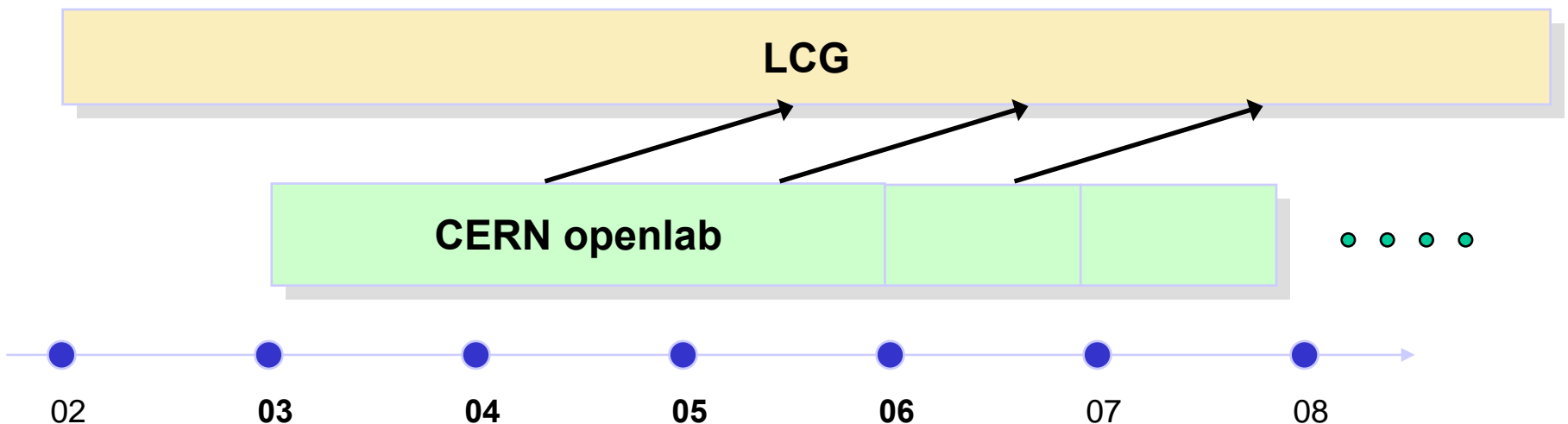
openlab participation

- **Five Partners (contributing ≥ 1.5 M€ over 3 years)**
  - Enterasys:
    - 10 GbE core routers
  - HP:
    - Integrity servers (103 * 2-ways, 2 * 4-ways)
    - Two post-doc positions
  - IBM:
    - Storage Tank file system (SAN FS), currently with 28 TB
  - Intel:
    - Large number of 64-bit Itanium processors & 10 Gbps NICs
    - 64-bit Nocona system w/PCI-Express
  - Oracle:
    - 10g Database software w/add-ons
    - Two post-doc positions
- **One contributor (contributing ≥ 170 k€ for 1 year)**
  - Voltaire
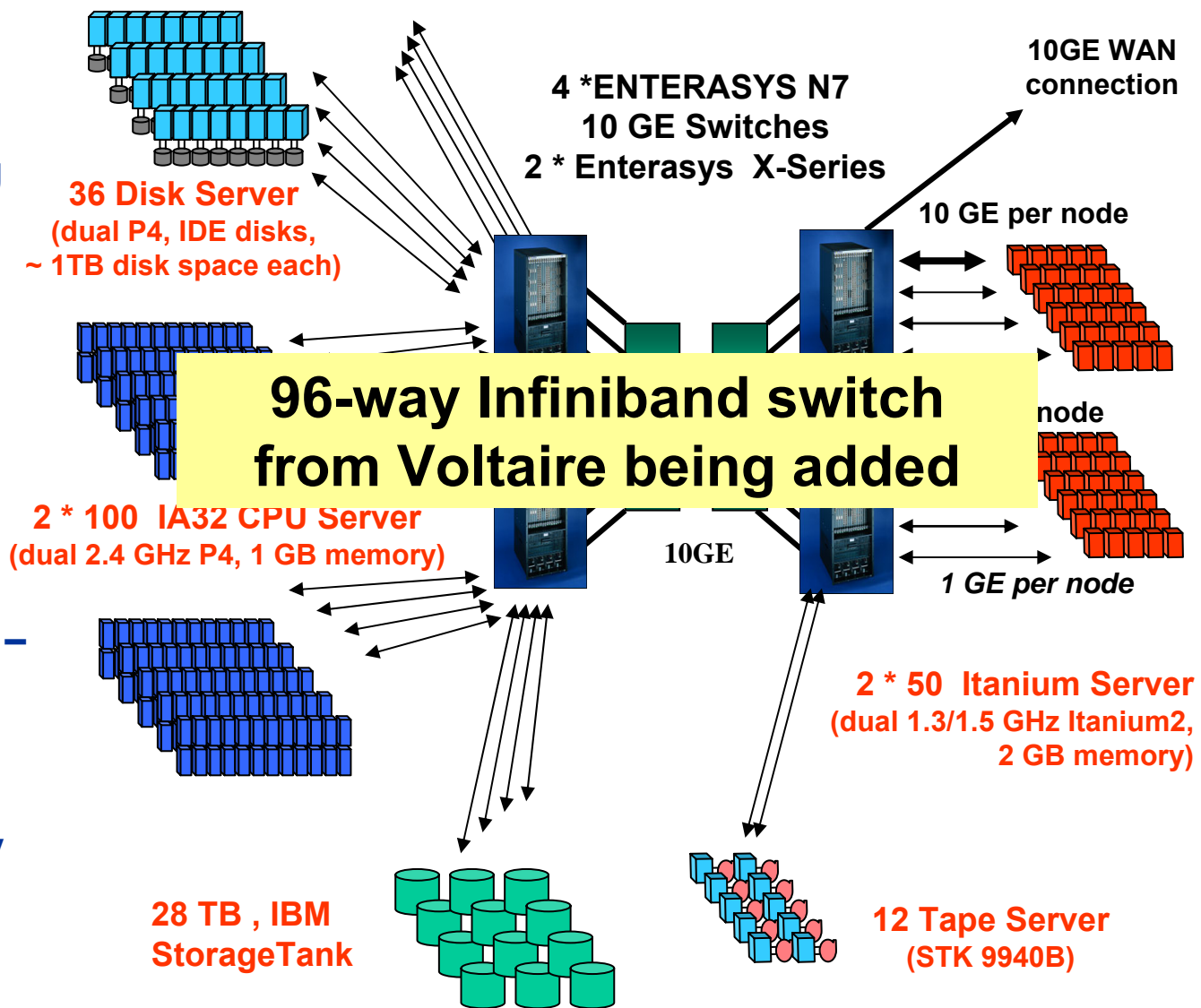   - 96-way Infiniband switch and necessary HCAs

High Throughput Cluster Prototype openlab/LCG

4 * GE connections to the campus backbone

10GE WAN connection

4 *ENTERASYS N7
10 GE Switches
2 * Enterasys X-Series

10 GE per node

36 Disk Server
(dual P4, IDE disks, ~ 1TB disk space each)

node

- **Experience with likely ingredients in LCG:**
  -- 64-bit programming
  -- next generation I/O (10 Gb Ethernet, Infiniband, etc.)

- **High performance cluster used for evaluations, and for data challenges with experiments**

- **Flexible configuration – components moved in and out of production environment**

- **Co-funded by industry and CERN**

96-way Infiniband switch from Voltaire being added

2 * 100 IA32 CPU Server
(dual 2.4 GHz P4, 1 GB memory)

10GE

1 GE per node

2 * 50 Itanium Server
(dual 1.3/1.5 GHz Itanium2, 2 GB memory)

28 TB , IBM StorageTank

12 Tape Server
(STK 9940B)

Next project: security

- **Grid projects (LCG/EGEE) address Grid specific security issues**
- **Site security is not included**
- **No Grid security w/o site security**
- **Proposal:**
  - Address site security globally, including all aspects
  - 25 companies invited, 16 expressed interest and came to the first meeting last Thursday
  - Workshop to refine the project on 18/19 November
  - Still open for others to join

Thank you for your attention

Questions?