



... where the Web was born ...

CERN and the Challenges of LHC Computing

Introductory Talk at the CERN School of Computing 2003

25 August 2003, Krems

Wolfgang von Rden
CERN, IT Division Leader

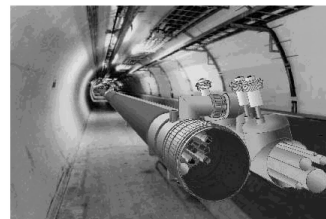
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What is CERN ?

- **European Centre for Nuclear Research**
(European Laboratory for Particle Physics)
 - Frontier of Human Scientific Knowledge
 - Creation of 'Big bang' like conditions
 - Accelerators with latest super-conducting technologies
 - Tunnel is 27 km in circumference
 - Large Electron/Positron Ring (used until 2000)
 - Large Hadron Collider (LHC) as of 2007
 - Detectors as 'big as cathedrals'
 - Four projects: ALICE, ATLAS, CMS, LHCb
- **World-wide participation**
 - Europe, plus USA, Canada, Brazil, Japan, China, Russia, Israel, etc.



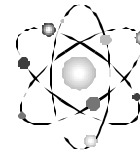
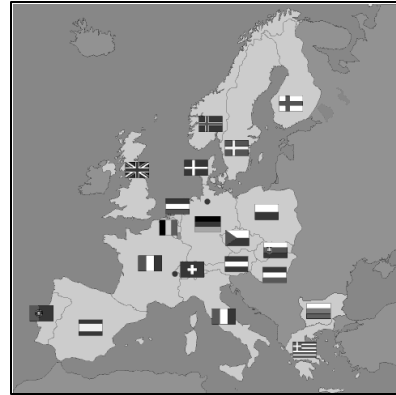
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CERN Member States

- **20 countries**
 - Initially Western Europe, from Norway to Greece
 - In recent years:
 - Poland, Czech Republic, Slovakia, Hungary, and Bulgaria
- **Founded in 1954**

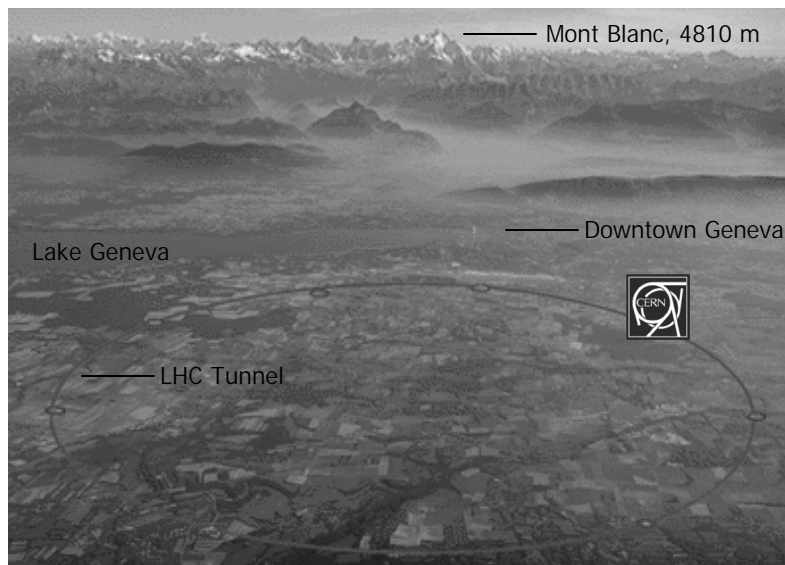


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The CERN site



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CERN in more detail

- **Organisation with:**
 - 2400 staff, plus 6000 visitors (per year)
- **Inventor of the World-Wide Web**
 - Tim Berners-Lee's vision:
 - "Tie all the physicists together – no matter where they are"
- **CERN's Budget**
 - 1000 MCHF (~685 M€/US\$)
 - ~50-50 material/personnel
 - **Budget of IT Division**
 - ~25 MCHF for material, ~35 MCHF for personnel
 - Additional funding via EU projects
 - Desktop/Departmental computing in addition



Some Generalities on Computing



Services provided by IT Division (1)

- **Basic Services**
 - Campus and external Networking, Internet Exchange Point
 - Productivity tools (Windows, Linux, Mac, exchange, office tools, other applications)
 - PC-shop, Printing, backups, phones, faxes
 - Security, user support
- **Engineering Support**
 - Databases (Oracle), EDMS, math tools
 - Electrical and mechanical engineering
 - Simulation



Services provided by IT Division (2)

- **Computing for Physics**
 - Software process support, database applications
 - Interactive and batch services (Linux & Solaris)
 - Central data recording, mass storage
 - Linux support, system management
 - Control systems (SCADA, PLCs, Fieldbuses, ...)
- **Major projects: LCG, EDG, EDT, EGEE, openlab**
 - Tier0/Tier1 centre at CERN
 - Data challenges, grid deployment & operations, middleware
 - Advanced high-speed networks, transatlantic connections
 - Collaboration with industry



CERN's Computer Environment (today)



CERN's Computing: Storage

Today:

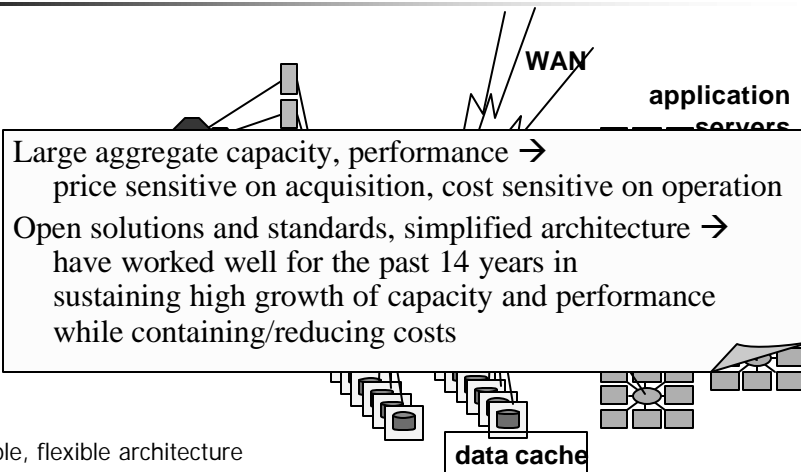
**~ 300 TB of
disk**

**Several PB
on tape
located in
10 tape
silos
(robots) in
two
buildings**





High Throughput Computing



simple, flexible architecture

- easy to integrate mass market components
- easy evolution to new technologies

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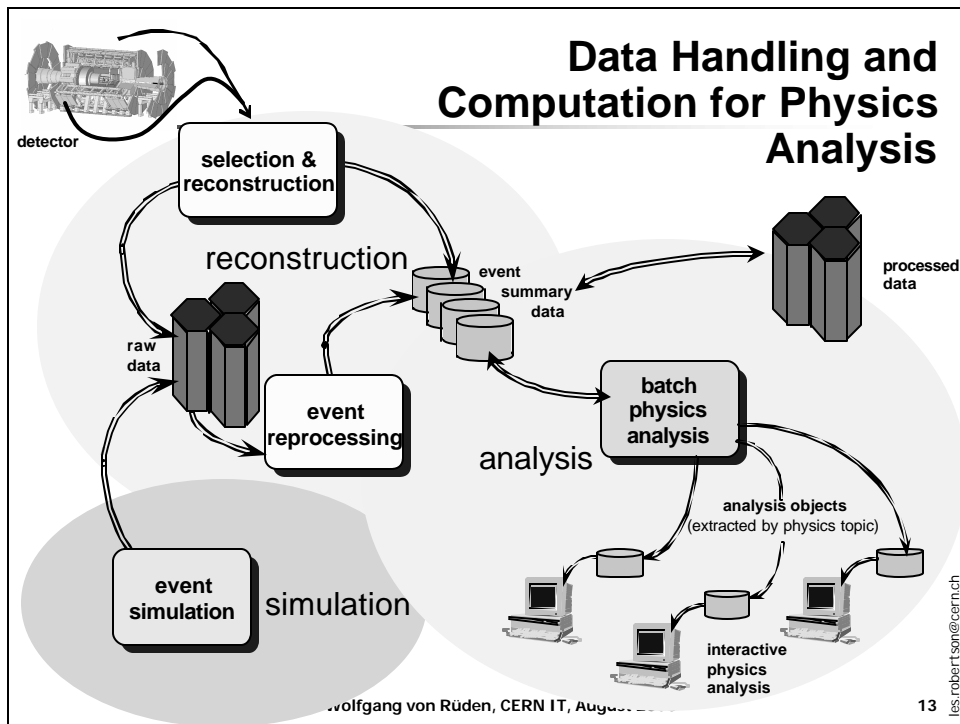
Offline HEP characteristics

- ☺ **Integer processor performance (rather than floating point)**
→ good fit to mass market PCs
- ☺ **independent events**
→ easy parallel processing
- ☺ **bulk of the data is read-only**
→ new versions of master files rather than dynamically updated databases
- ☹ **very large aggregate requirements** - computation, data, i/o
- ☹ **no defined limit to the analysis requirements**

and unpredictable usage patterns → chaotic system load
the real boundary condition is cost -
maximising the amount of resources within the budget envelope

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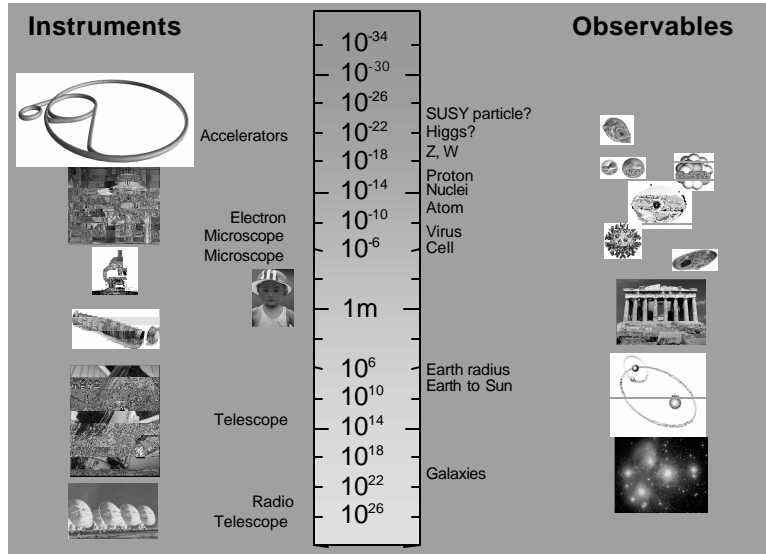
What will happen at LHC ?

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The size of the things



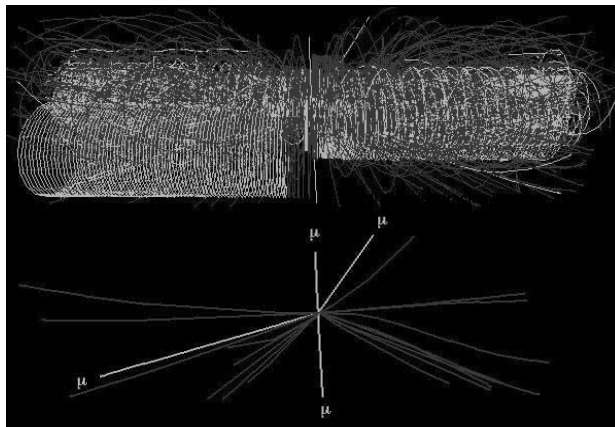
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The goal is ...

Find the Higgs particle and get the Nobel price !



selectivity: 1 in 10^{13} - 1 person in a thousand world populations
- 1 needle in 20 million haystacks

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The Large Hadron Collider - 4 detectors

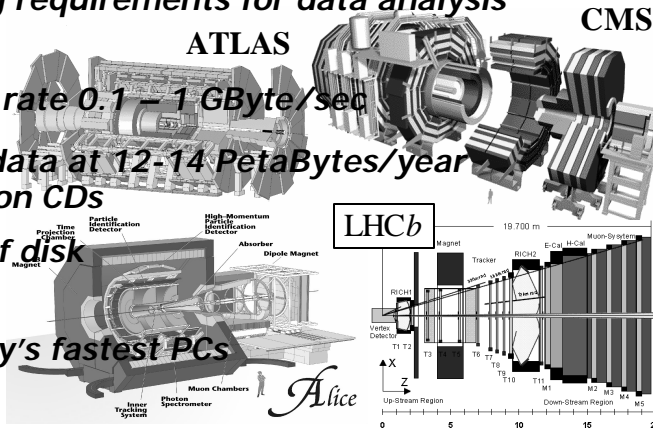
Huge computing requirements for data analysis

Storage –
Raw recording rate 0.1 – 1 GByte/sec

Accumulating data at 12-14 PetaBytes/year
i.e. > 20 million CDs

10 PetaBytes of disk

Processing –
70,000 of today's fastest PCs



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Atlas detector

Data Acquisition

- Multi-level *trigger*
- Filters out background
- Reduces data volume

- Record data 24 hours a day, 7 days a week
- Equivalent to writing a CD every 2 seconds

40 MHz interaction rate
equivalent to 2 PetaBytes/sec
(3 million CDs per second)

Level 1 - Special Hardware

Level 2 - Embedded Processors

Level 3 - Giant PC Cluster

160 HZ (320 MB/sec)
Data Recording & Offline Analysis

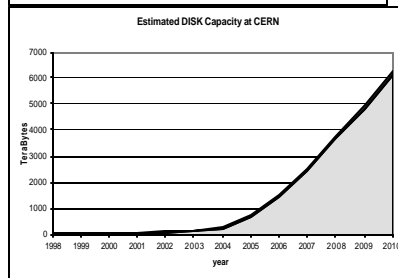
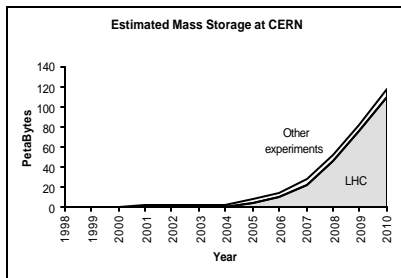
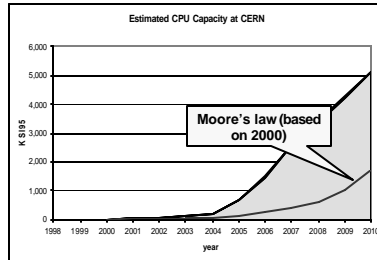
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Expected LHC computing needs

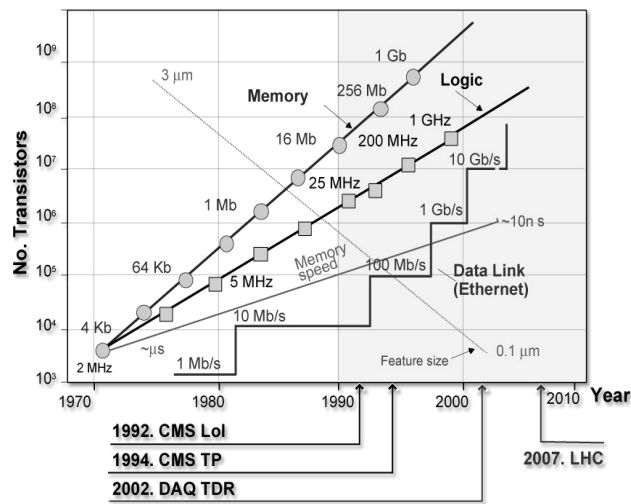
Networking:
10 – 40 GB/s to all big centres



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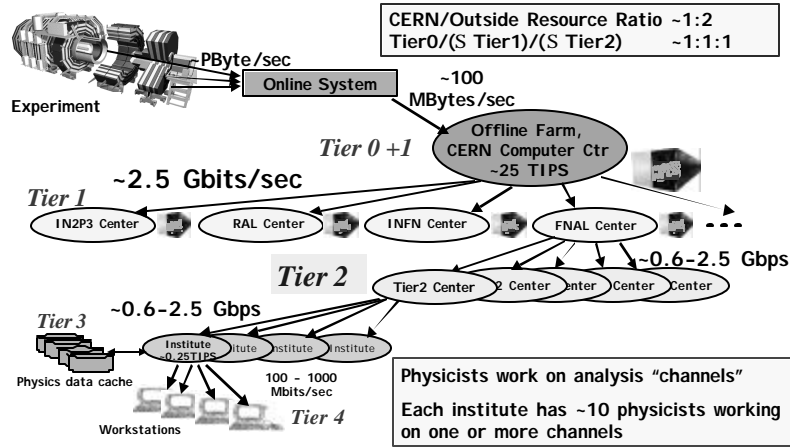
Computing and communication trends



Courtesy of Sergio Cittolin, CMS experiment

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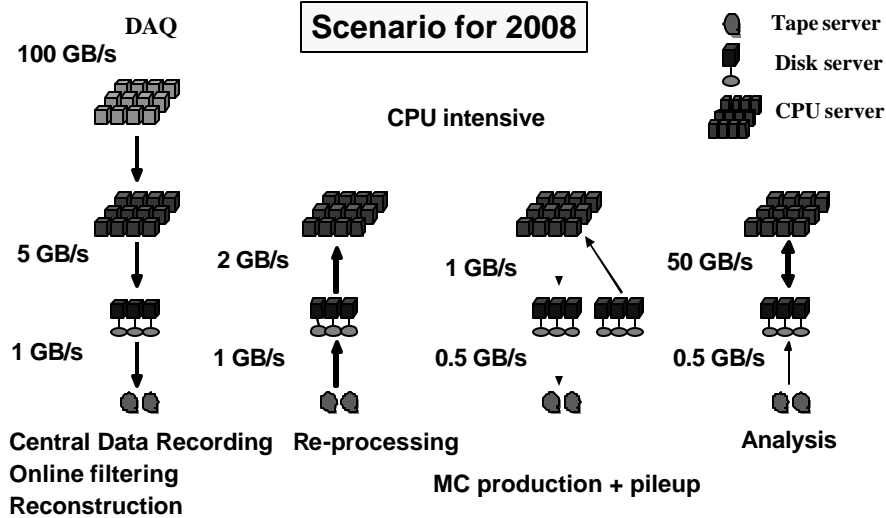
The LHC Data Grid Hierarchy



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Aggregate Data Rates

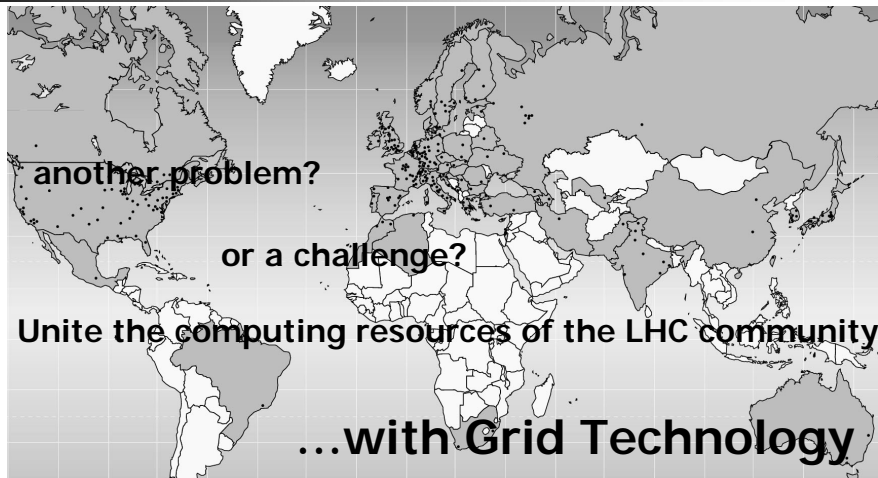


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CERN's Users and Collaborating Institutes



Europe: 267 institutes, 4603 users
Elsewhere: 208 institutes, 1632 users

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How will we address the LHC Computing Challenge?

**Answer:
The LHC Computing Grid
Project - LCG**



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Goal of the LCG Project

LCG: LHC Computing Grid Project

- To prepare and deploy the computing environment to help the experiments analyse the data from the LHC detectors
- **Phase 1 – 2002-05**
Development of common applications, libraries, frameworks, prototyping of the environment, operation of a pilot computing service based on Grid technology
- **Phase 2 – 2006-08**
Acquire, build and operate the LHC computing service



LCG Areas of Work

Physics Applications Software

- Application Software
Infrastructure – libraries, tools
- Data management tools
- Common Frameworks –
Simulation, Analysis, ..
- Adaptation of Physics
Applications to Grid environment
- Grid tools, Portals

Grid Deployment

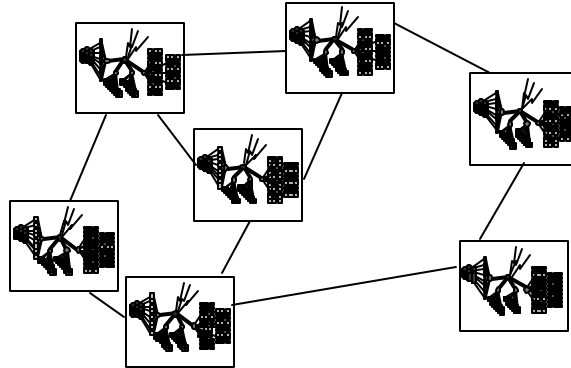
- Grid planning and resource management
- Regional Centre Coordination
- Security & access policies
- Grid Operations

Grid Technology

- Provision of Grid middleware
- Standard application services layer
- Convergence towards standards

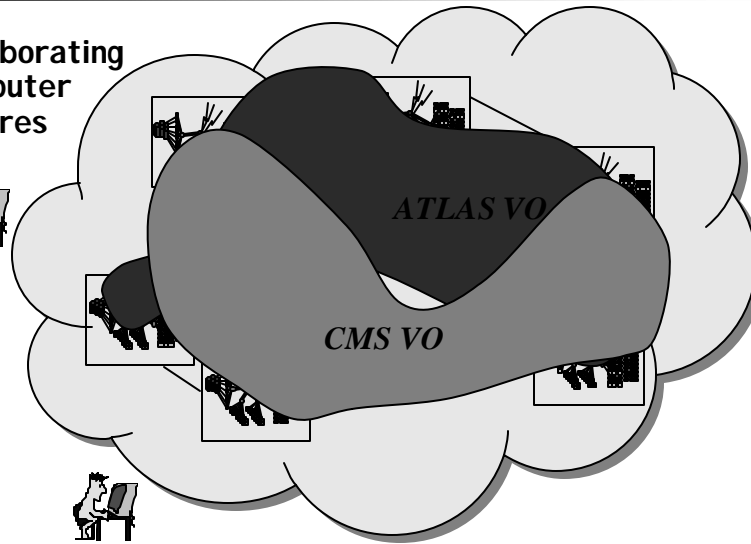
CERN Fabric (and others)

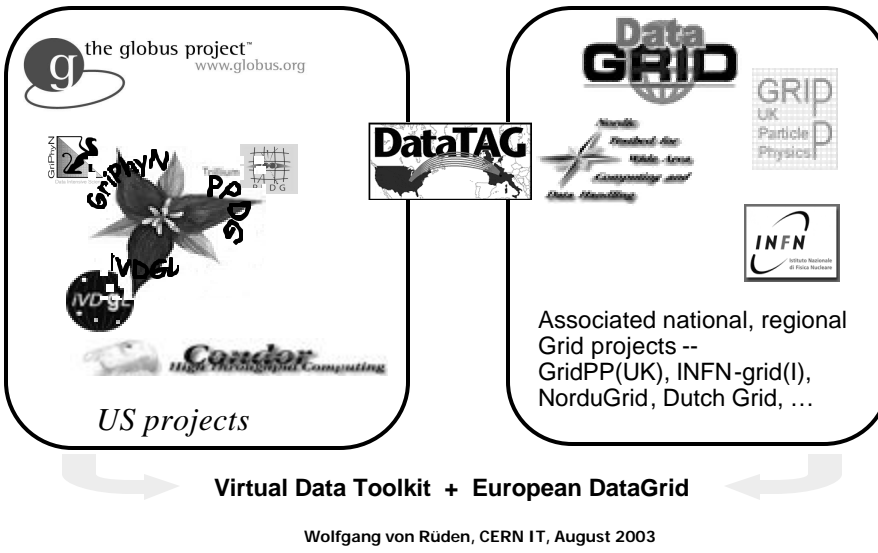
- Automated fabric management
- Physics Data Storage
- LAN Management
- Wide-area Networking
- Data Challenges



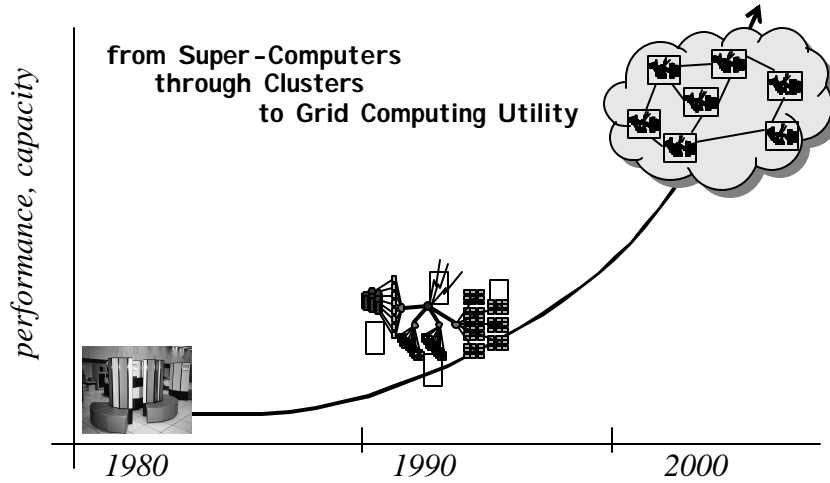
Collaborating Computer Centres advertise their services and resources
Users submit work to Resource Brokers - that match the resource request to what is available

Collaborating
Computer
Centres





- **Middleware:**
 - Integration, testing and certification
 - Packaging, configuration, distribution and site validation
 - Support – problem determination and resolution; feedback to middleware developers
- **Operations:**
 - Grid infrastructure services
 - Operations centres – trouble and performance monitoring, problem resolution – 24x7 globally
 - Integration of independently managed production services
- **Support:**
 - Experiment integration, virtual organisation administration
 - User support – call centres/helpdesk – global coverage; documentation; training
- **Grid Coordination**
 - Policy and strategy – security, resource scheduling, accounting & reporting
 - Data distribution, migration



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The next major step is EGEE

Enabling Grids for E-science in Europe

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EGEE vision:

■ Goal

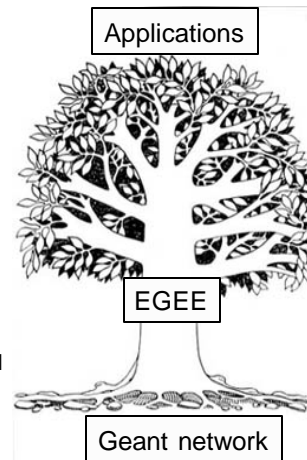
- Create a Europe-wide production quality Grid infrastructure on top of present and future EU Research Network infrastructure

■ Build on

- EU and EU member states major investments in Grid Technology
- International connections (US and AP)
- Several pioneering prototype results
- Large Grid development team
- Major EU funding

■ Approach

- Leverage current and planned national and regional Grid programmes (e.g. LCG)
- Work closely with relevant industrial Grid developers, NRENs and US-AP projects



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Why EGEE? The Historical Analogy

- Prior to the **EU Geant** programme, Europe had a multitude of exploratory projects in networking technology. Geant was truly production oriented, and brought European telecom operators actively into the picture
- In a similar way, **EGEE** can ensure preservation of current investments in European Grid R&D, extending the present infrastructure and focussing all activities towards establishing a production quality Grid



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EGEE Approach

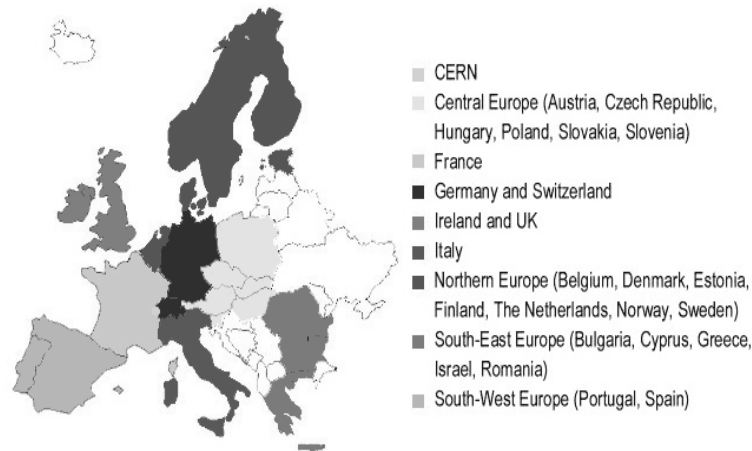
- Most of partners built national and regional Grid federations to participate in EGEE
- Condition to participate in EGEE is to have already an established Grid activity or be an established Grid technology centre
- EU FP6 Communication Network Development Call opened on 17 December 2002, proposal submitted on 6 May.
- Consortium is now invited to negotiate the detailed contract with a maximum funding of 32 M€
- Funding is for manpower and overhead, needs to be matched by partners. Overall funding is for >300 FTEs!!
- Project starts on 1 April 2004 and runs for 2 years.
- Many job opportunities – stay tuned.

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The EGEE consortium of Grid Federations



Total of 70 full partners covering entire EU and beyond

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EGEE and LCG

- Both projects will be tightly coupled
- EGEE provides middleware for LCG
- LCG provides and operates the Grid infrastructure for EGEE
- Both projects will cover Europe, the US and Asia-Pacific
- The Project Leaders will become members of the Oversight Board of both projects



CERN School of Computing 2003

- **Welcome to all**
- **Try to learn as much as you can, go after the lectures if needed**
- **Big thanks to lecturers, track coordinators and organizers, in particular to our Hosts here in Krems**
- **Thanks also to the Sponsors**
- **Enjoy your stay, make friends and have fun**



I declare the
CERN School of Computing 2003
to be open

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