



Enabling Grids for E-scienceE

# Grid-enabled Application Examples

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*Nicosia, April 23<sup>rd</sup>, 2007*

[www.eu-egee.org](http://www.eu-egee.org)





## Grid Projects Collaborating in LHC Computing Grid



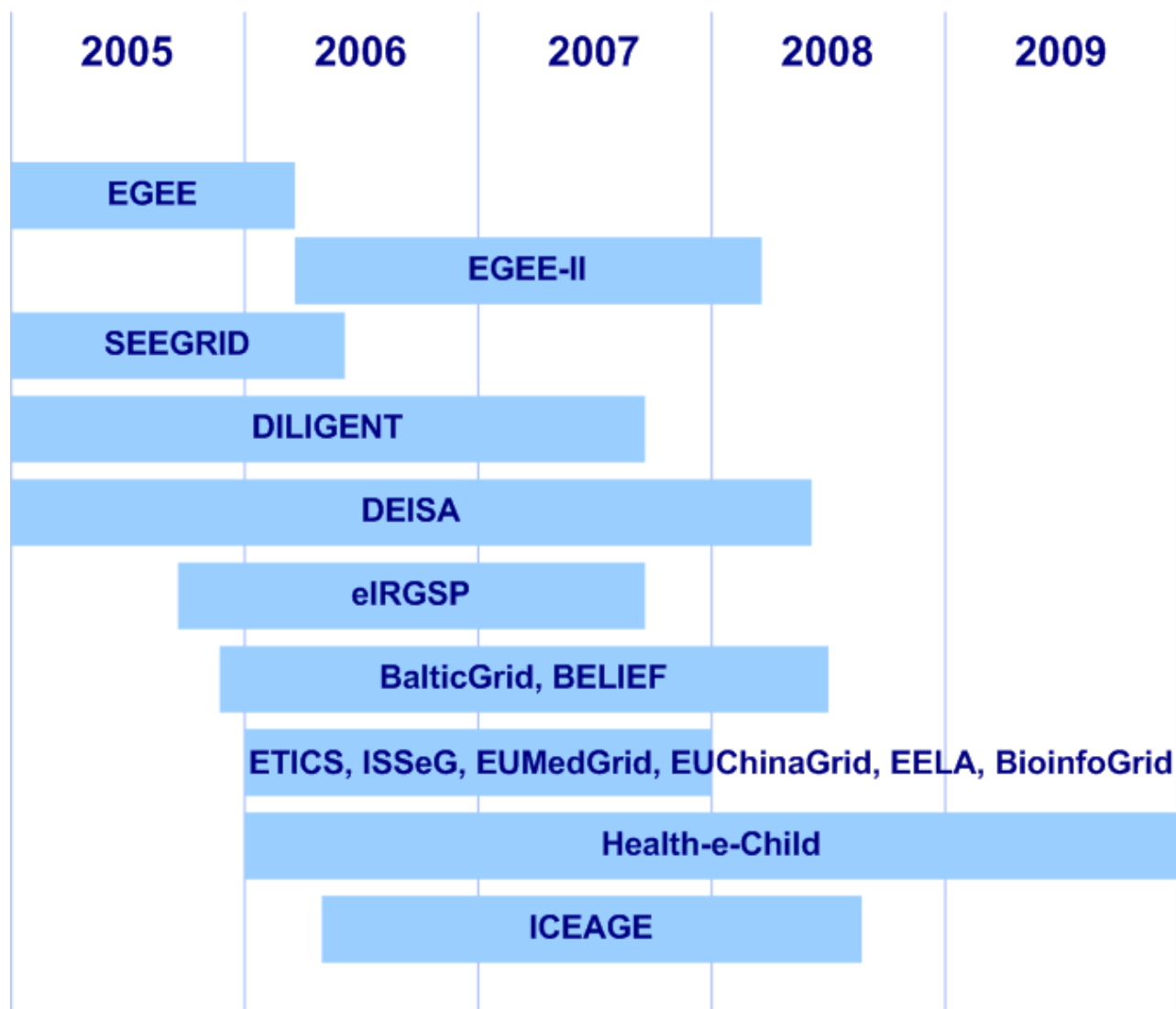
Open Science Grid



EGEE Operations Information	
Active Sites	>200
Available CPU	>30000
Available Storage (TB)	>10PBytes



Mon Feb 20 10:18:10 EST 2006



- ▶ **Science is becoming increasingly digital and needs to deal with increasing amounts of data**
- ▶ **Simulations get ever more detailed:**
  - Nanotechnology – design of new materials from the molecular scale
  - Modelling and predicting complex systems (weather forecasting, floods, earthquakes)
  - Decoding the human genome
- ▶ **Experimental Science uses ever more sophisticated sensors to make precise measurements**
  - Need high statistics
  - Huge amounts of data
  - Serves user communities around the world

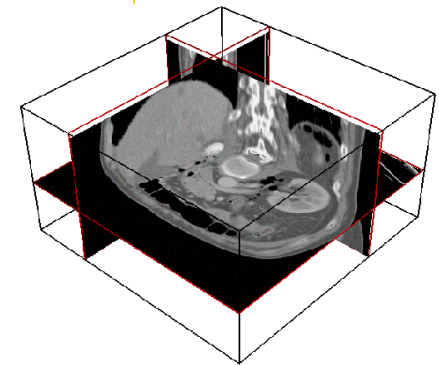
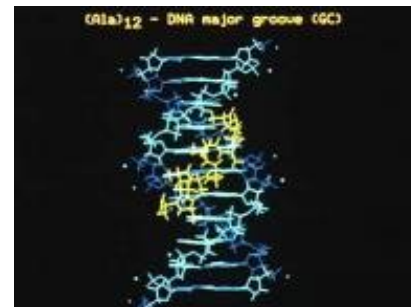
## ▶ High-Energy Physics (HEP)

- Requires computing infrastructure (LCG)
- Challenging:
  - thousands of processors world-wide
  - generating petabytes of data
  - ‘chaotic’ use of grid with individual user analysis (thousands of users interactively operating within experiment VOs)

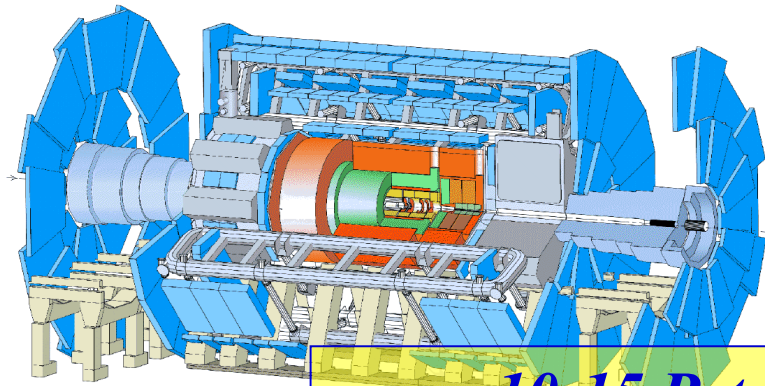


## ▶ Biomedical Applications

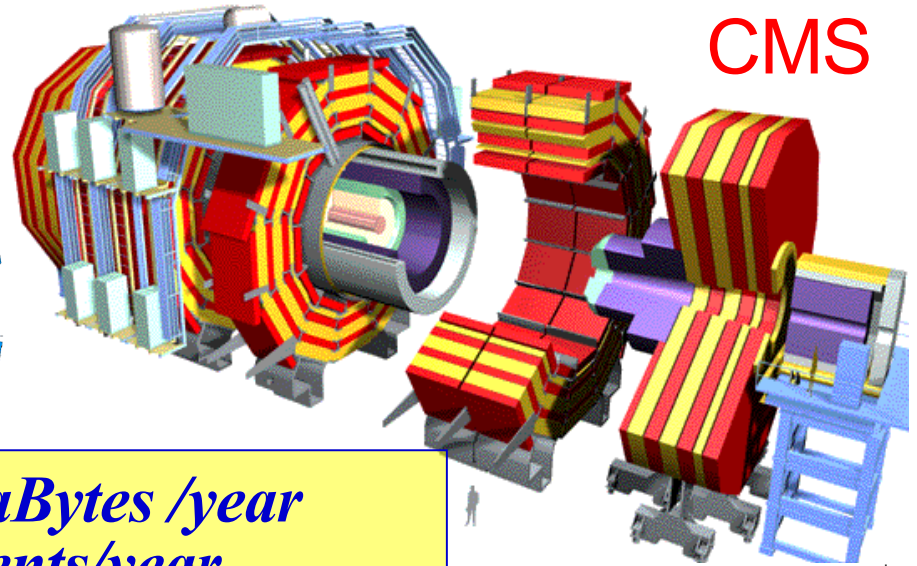
- Similar computing and data storage requirements
- Major additional challenge: **security & privacy**



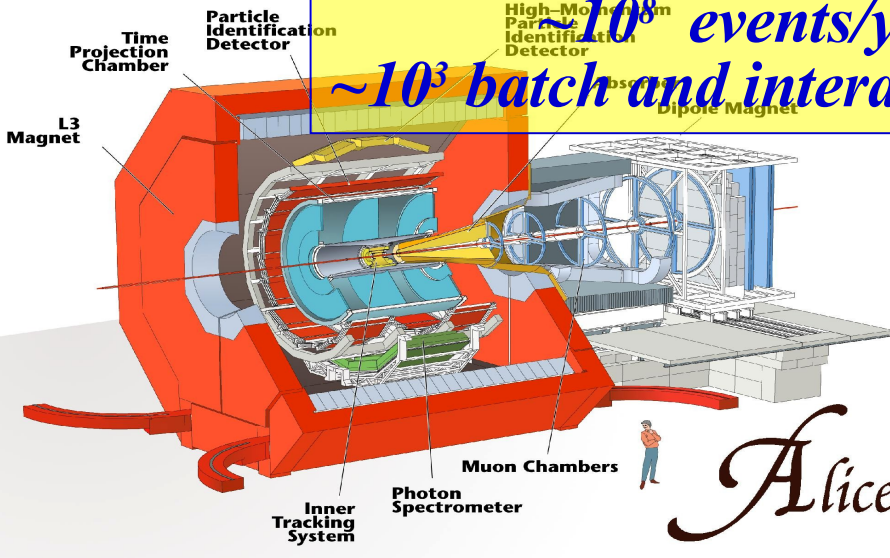
## ATLAS



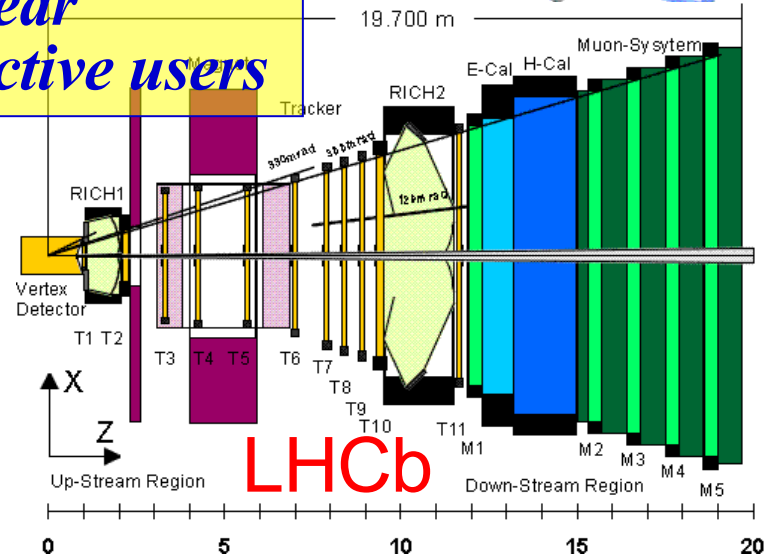
## CMS



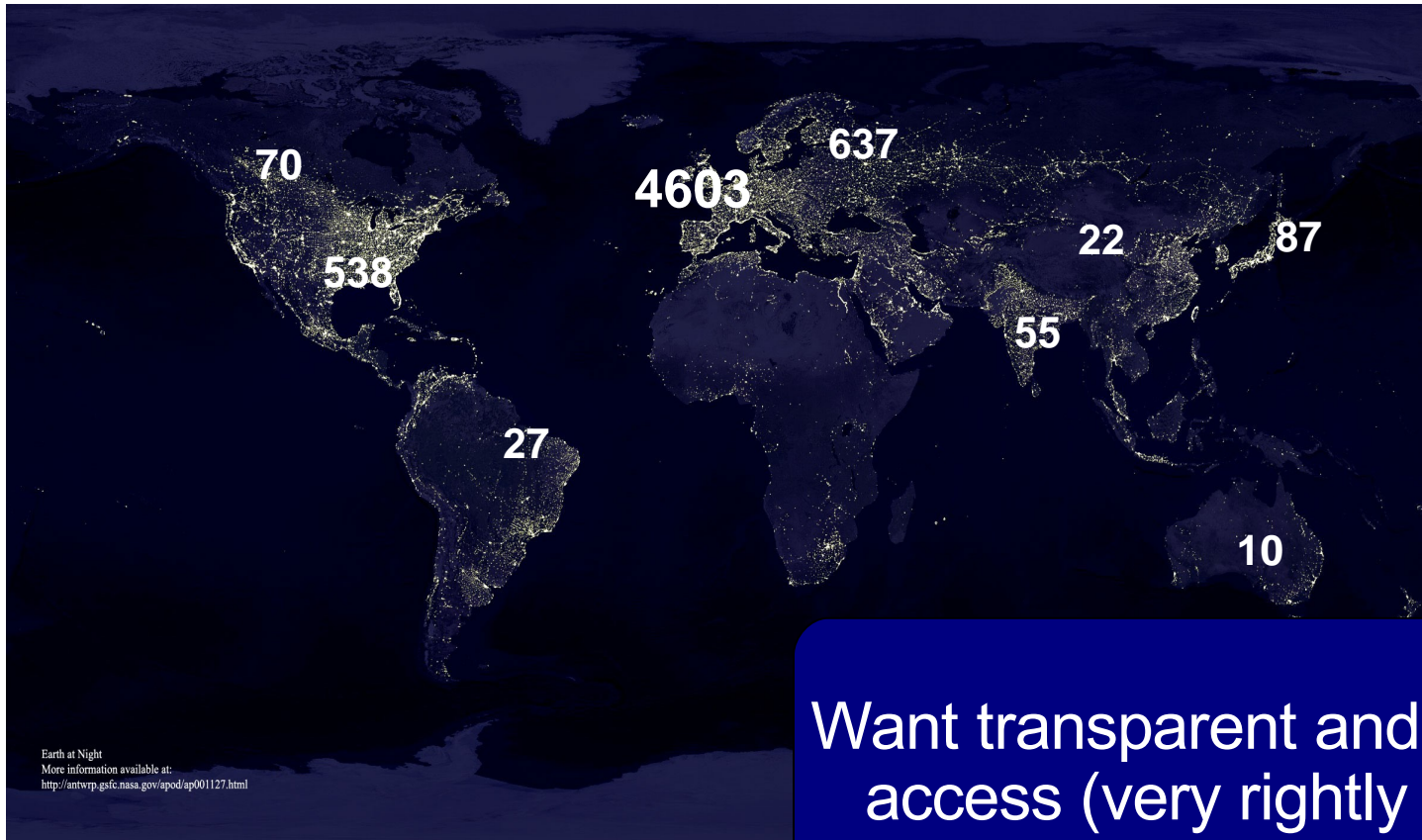
*~10-15 PetaBytes /year*  
*~10<sup>8</sup> events/year*  
*~10<sup>3</sup> batch and interactive users*



*Alice*



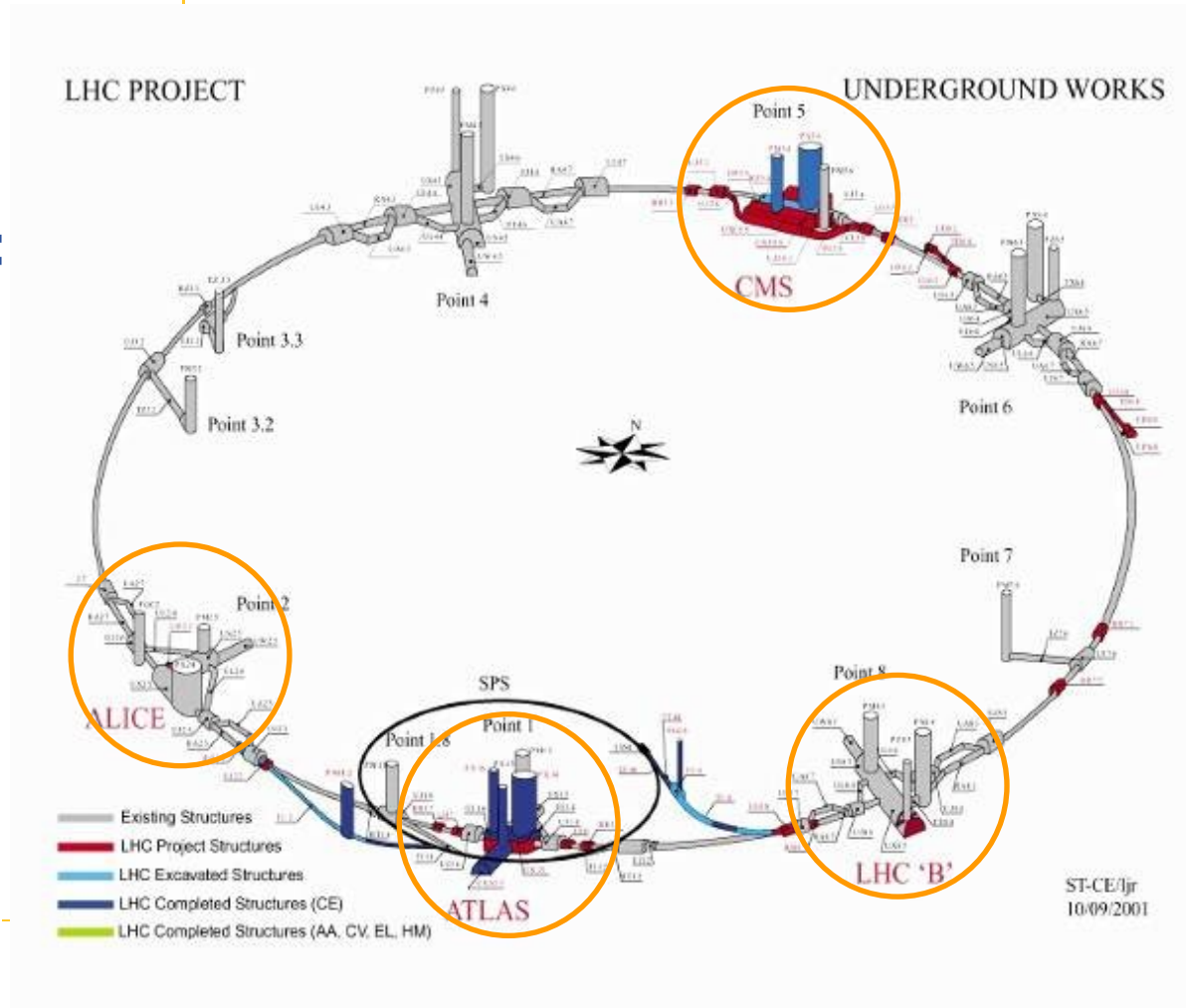
Over 6000 LHC Scientists world wide



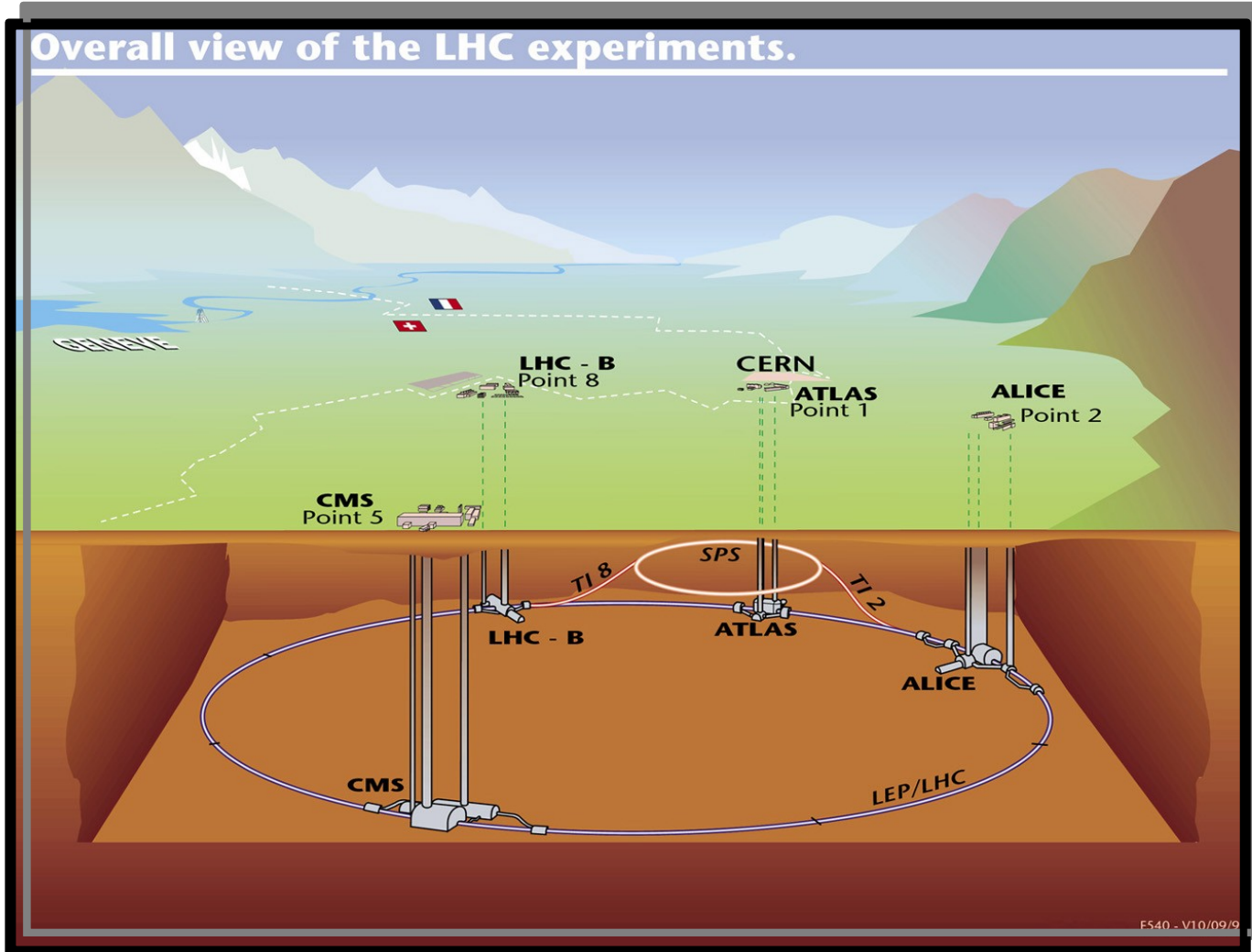
Europe: 267 Institutes, 4603 Users  
 Other: 208 Institutes, 1632 Users

Want transparent and quick access (very rightly so). Interested more in physics results, than computing revolutions

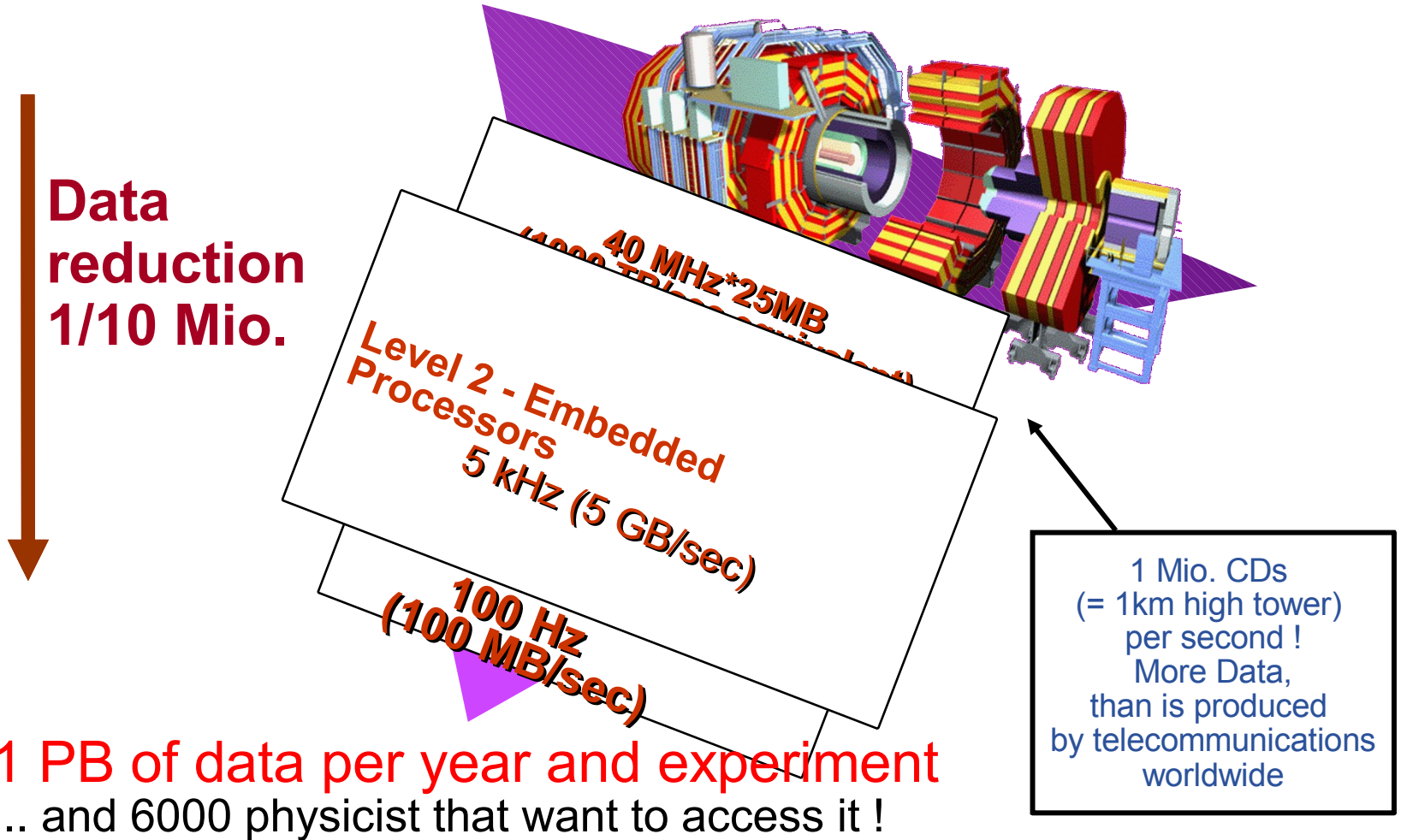
- ▶ **Large Hadron Collider:**
  - four experiments:
    - ALICE
    - ATLAS
    - CMS
    - LHCb
  - 27 km tunnel
  - Start-up in 2007



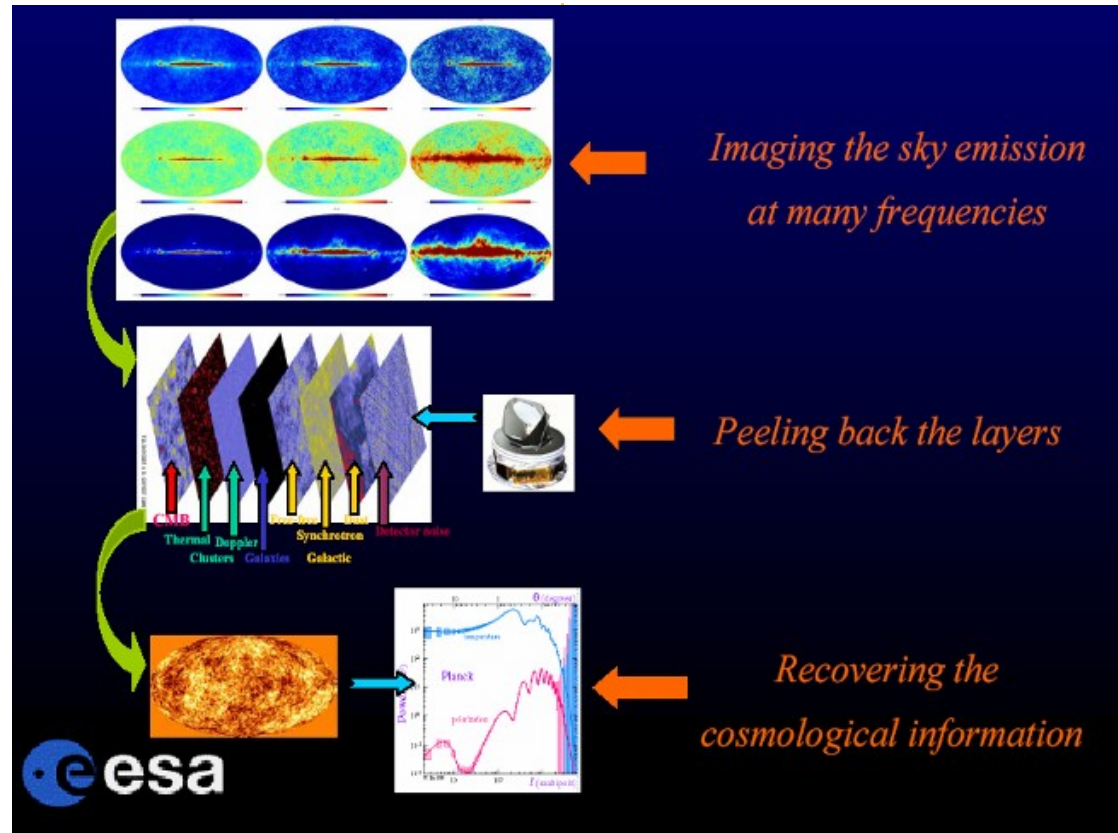




## LHC, the CMS detector

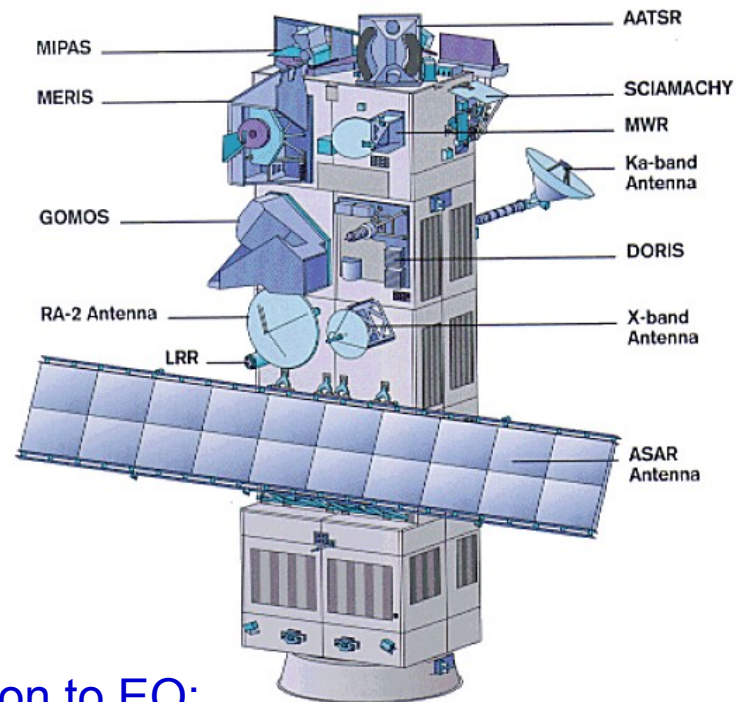
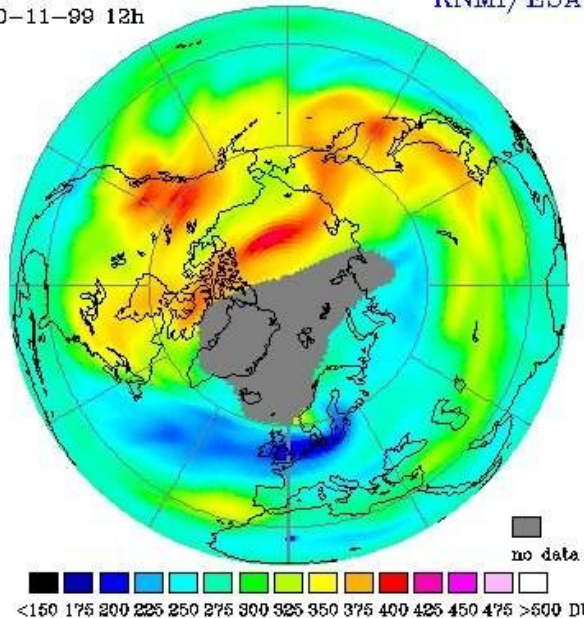


- ▶ **On the Grid:**
  - > 12 time faster
  - (only ~5% failures)
  
- ▶ **Complex data structure**
  - data handling important
  
- ▶ **The Grid as**
  - Collaboration tool
  - common user-interface
  - flexible environment
  - new approach to data and S/W sharing



ESA missions:  
100's of Gbytes of data per day

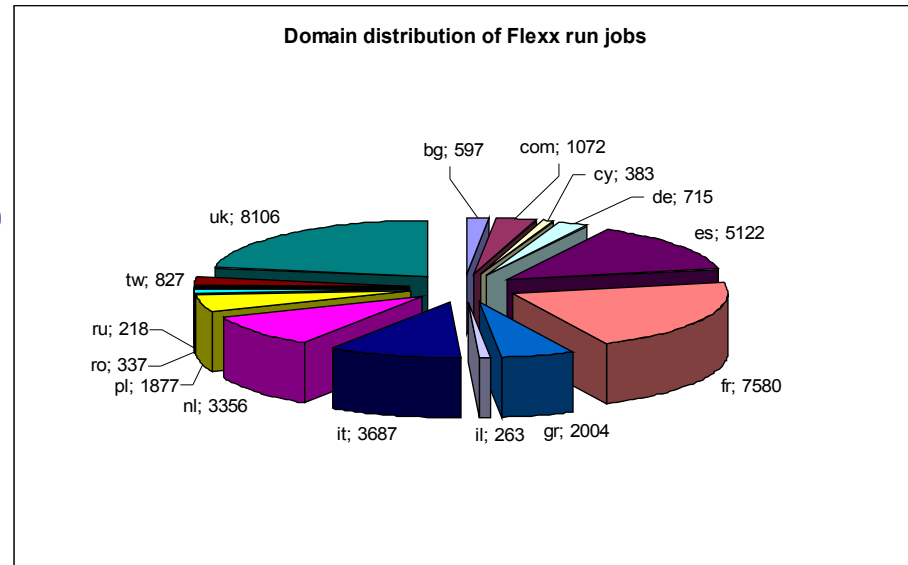
Assimilated GOME total ozone  
30-11-99 12h  
KNMI/ESA



Grid contribution to EO:  
Enhance the ability to access high level products  
Allow reprocessing of large historical archives  
Improve Earth science complex applications  
(data fusion, data mining, modelling ...)

Federico.Carminati , EU review presentation, 1 March 2002

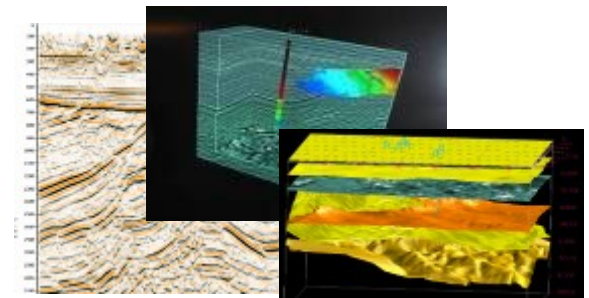
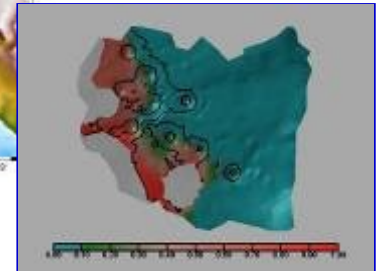
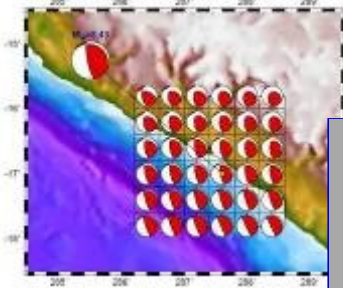
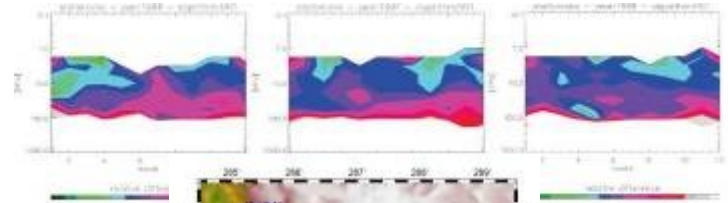
- ▶ Significant biological parameters
  - two different molecular docking applications (Autodock & FlexX)
  - about one million virtual ligands selected
  - target proteins from the parasite responsible for malaria
  
- ▶ Significant numbers
  - Total of about 46 million ligands docked in 6 weeks
  - 1TB of data produced
  - Up 1000 computers in 15 countries used simultaneously corresponding to about 80 CPU years
  
- ▶ **Next case: SARS/H5N1 on the grid!**



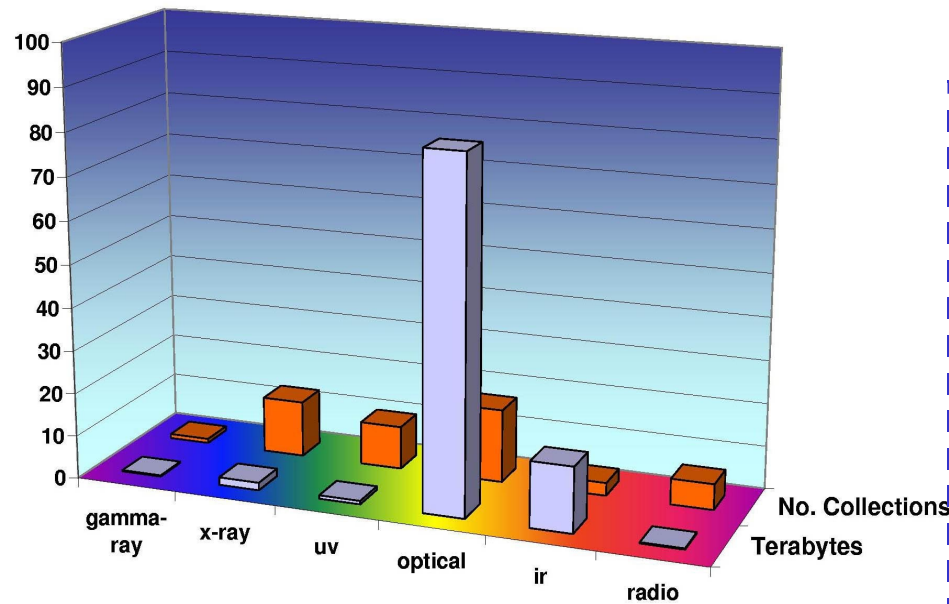
**WISDOM open day**  
**December 16th, 2005, Bonn (Germany)**

**Discuss Data Challenge results**  
**Prepare next steps towards a malaria Grid (EGEE-II, Embrace, Bioinfogrid)**  
**Information: <http://wisdom.eu-egEE.fr>**

- ▶ **Earth Observations by Satellite**
  - Ozone profiles
- ▶ **Solid Earth Physics**
  - Fast Determination of mechanisms of important earthquakes
- ▶ **Hydrology**
  - Management of water resources in Mediterranean area (SWIMED)
- ▶ **Geology**
  - Geocluster: R&D initiative of the Compagnie Générale de Géophysique



- **A large variety of applications ported on EGEE which incites new users**
- **Interactive Collaboration of the teams around a project**



**No. & sizes of data sets as of mid-2002, grouped by wavelength**

12 waveband coverage of large areas of the sky

Total about 200 TB data

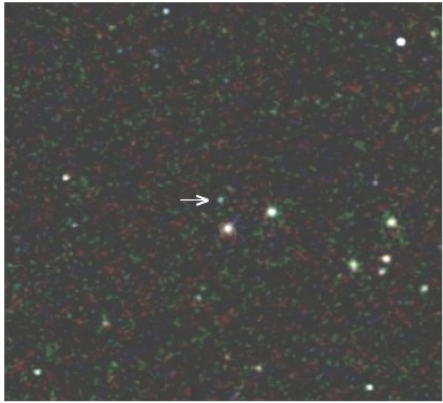
Doubling every 12 months

Largest catalogues near 1B objects

### 2MASSW J1217-03

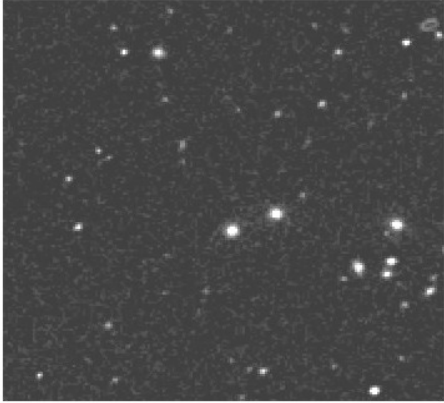
A methane (T-type) dwarf in the constellation Virgo

The near-infrared view




2MASS Composite JHK<sub>s</sub> Atlas Image

The optical view



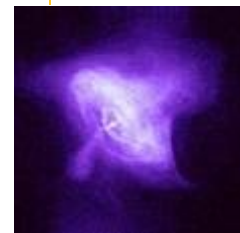
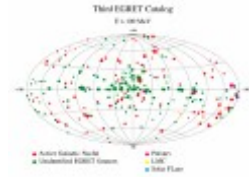
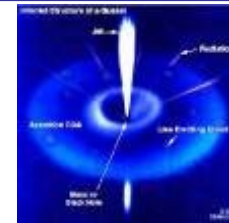
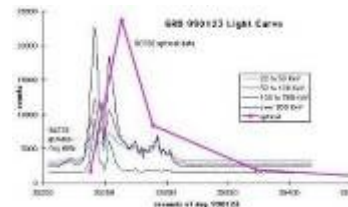
Palomar Digitized Sky Survey



A.J.Burgasser (Caltech), J.D.Kirkpatrick (IPAC/Caltech), M.E.Brown (Caltech),  
I.N.Reid (U.Penn), J.E.Gizis (U.Mass), C.C.Dahn & D.G.Monet (USNO, Flagstaff),  
C.A.Beichman (JPL), J.Liebert (Arizona), R.M.Cutri (IPAC/Caltech), M.F.Skrutskie (U.Mass)  
The 2MASS Project is a collaboration between the University of Massachusetts and IPAC

Data and images courtesy Alex Szalay, John Hopkins University

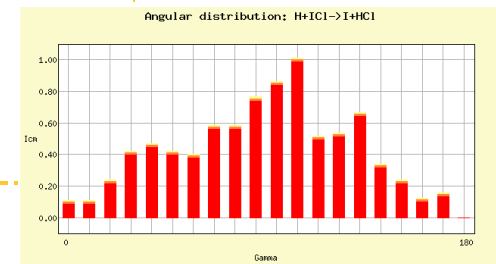
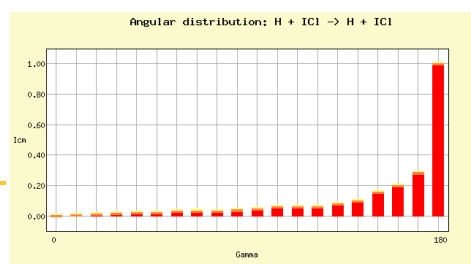
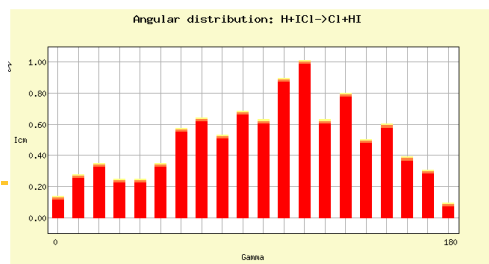
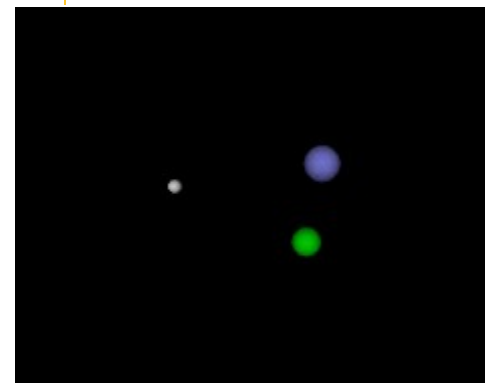
- ▶ **Ground based Air Cerenkov Telescope 17 m diameter**
- ▶ **Physics Goals:**
  - Origin of VHE Gamma rays
  - Active Galactic Nuclei
  - Supernova Remnants
  - Unidentified EGRET sources
  - Gamma Ray Burst
- ▶ **MAGIC II will come 2007**
- ▶ **Grid added value**
  - Enable “(e-)scientific” collaboration between partners
  - Enable the cooperation between different experiments
  - Enable the participation on Virtual Observatories





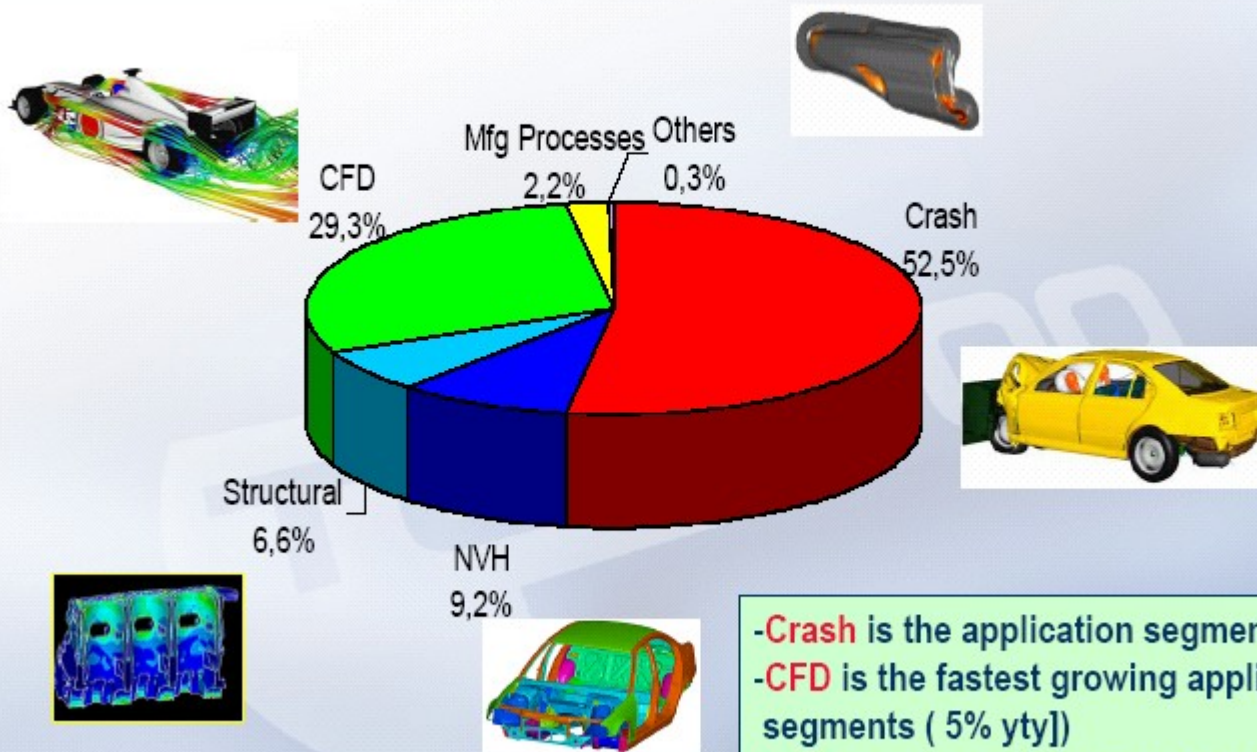
## ► The Grid Enabled Molecular Simulator (GEMS)

- Motivation:
  - Modern computer simulations of biomolecular systems produce an abundance of data, which could be reused several times by different researchers.
    - data must be catalogued and searchable
- GEMS database and toolkit:
  - autonomous storage resources
  - metadata specification
  - automatic storage allocation and replication policies
  - interface for distributed computation



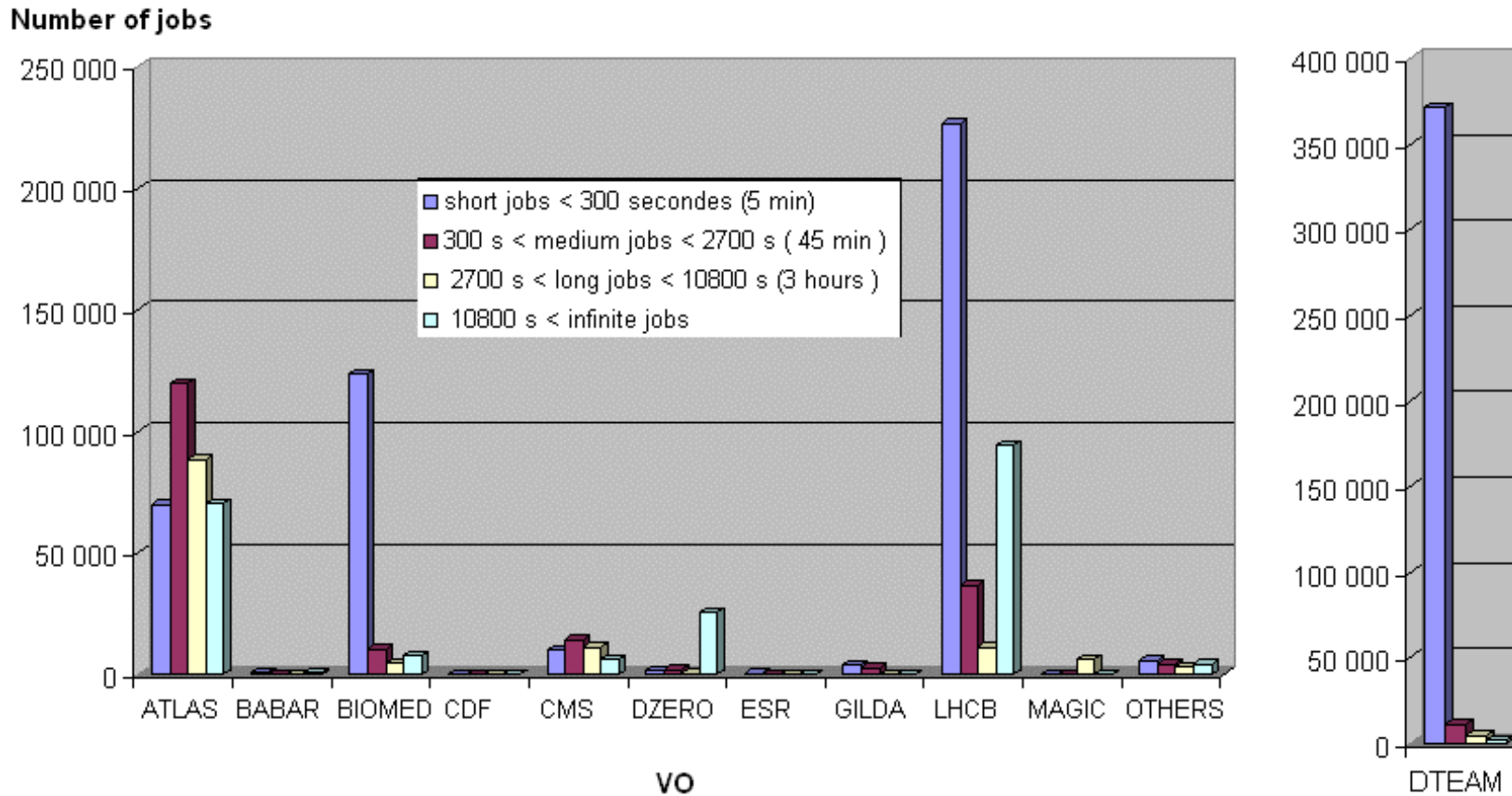


## HPC Application Segments in Automotive



- Crash is the application segment #1
- CFD is the fastest growing application segments ( 5% yty])
- NVH the most demanding in terms of memory and IO bandwidth.

## ▶ Average job duration January 2005 – June 2005 for ten major VOs

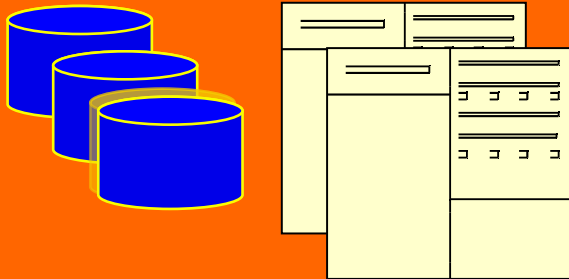


Application

Application  
toolkits, standards

Middleware:  
“collective services”

Basic Grid services:  
AA, job submission, info, ...



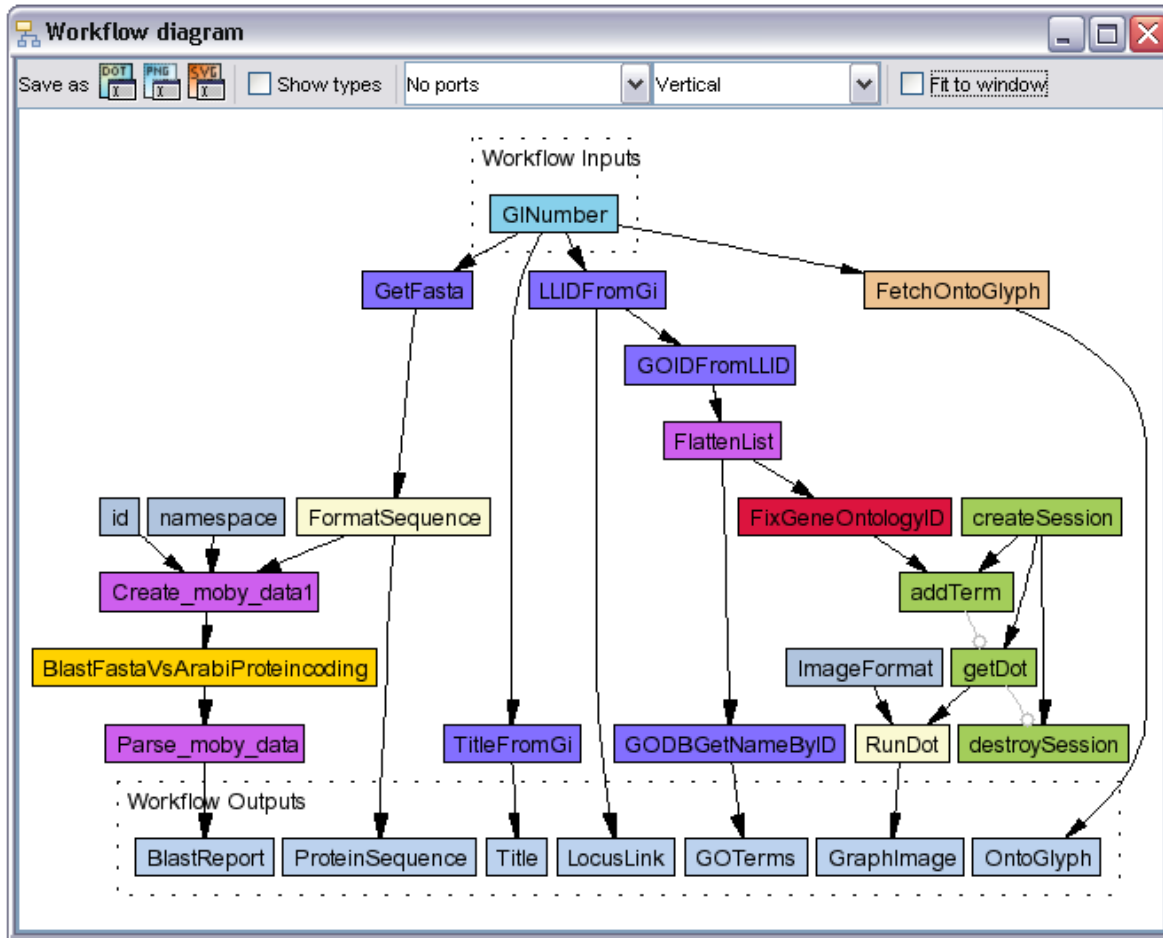
## VO-specific developments:

- ▶ Portals
- ▶ Virtual Research Environments
- ▶ Semantics, ontologies
- ▶ Workflow
- ▶ Registries of VO services

Production grids provide these services.

Develop above these to empower non-UNIX specialists!

- ▶ Taverna in MyGrid <http://www.mygrid.org.uk/>
- ▶ “allows the e-Scientist to describe and enact their experimental processes in a structured, repeatable and verifiable way”
- ▶ GUI
- ▶ Workflow language
- ▶ Enactment engine





CroGrid



- ▶ We live in a time where the computing infrastructure makes **distributed computation more attractive** than centralised computation – at least for some applications
- ▶ Many scientific disciplines, application areas and organisation types create a **demand for a global computing infrastructure**
- ▶ **Grid Computing has gained a lot of momentum**, its meaning has started to change
- ▶ As explained, this gain in momentum stems from the drastically **increased hardware capabilities and new application types**
- ▶ The **theoretical groundwork** for a distributed computing infrastructure has been available since long time – distributed computing and Grid computing is not really a new phenomenon (**only the name is new, plus a couple of facilities**)
- ▶ **The challenge in building this infrastructure lies in the large scale and in the need for standardisation and bridge building**



If "The Grid"  
vision leads us  
here...

... then where are  
we now?



