



# Applications and the Grid

**The European  
DataGrid Project Team**

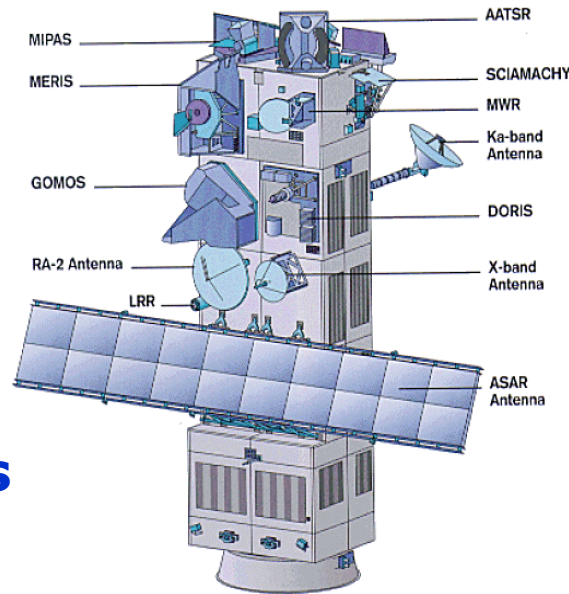
<http://www.eu-datagrid.org>



# EDG Application Areas

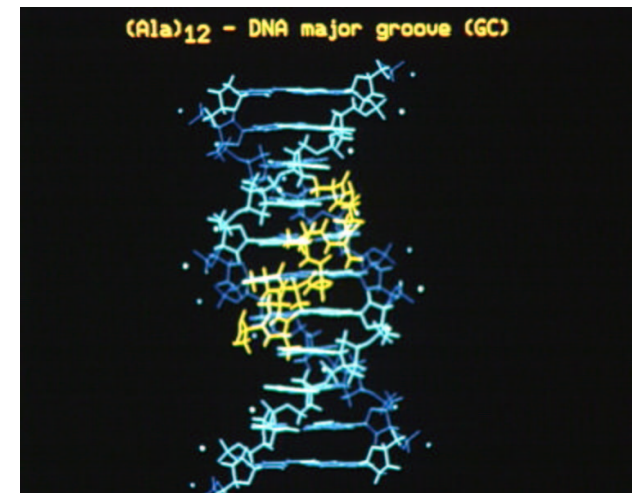


## Earth Observation Science Applications



## High Energy Physics

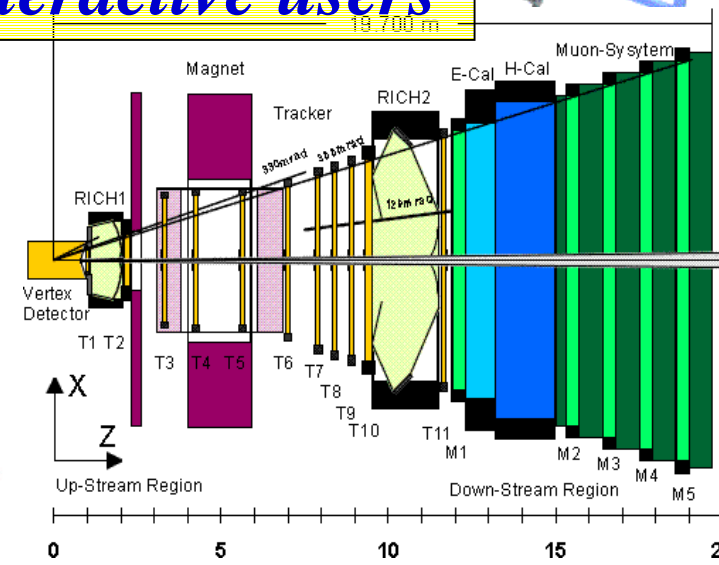
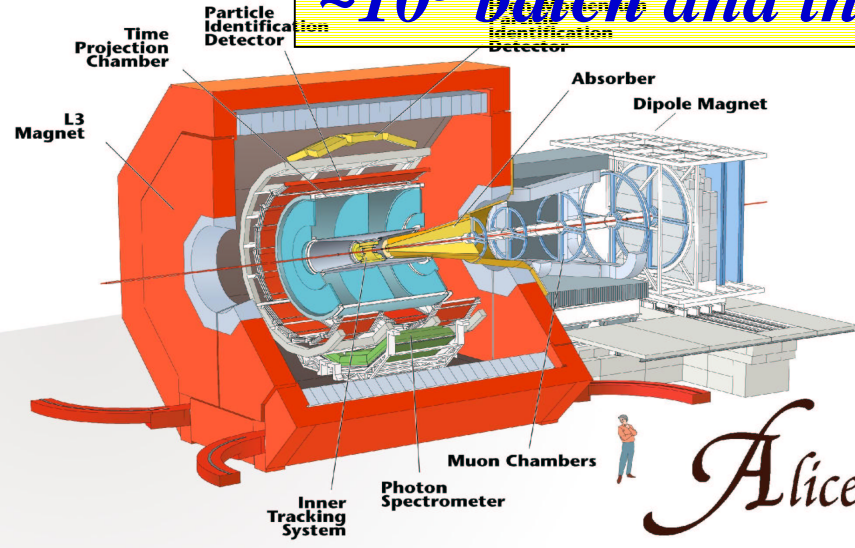
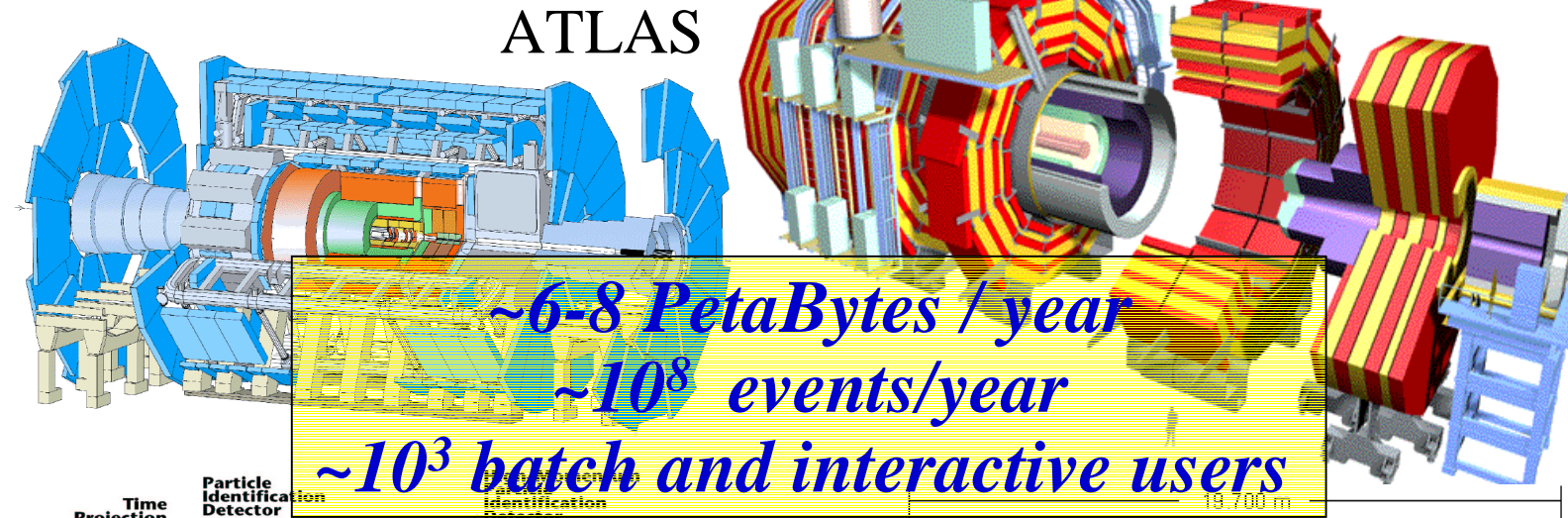
## Biomedical Applications



# High Energy Physics



## 4 Experiments on LHC

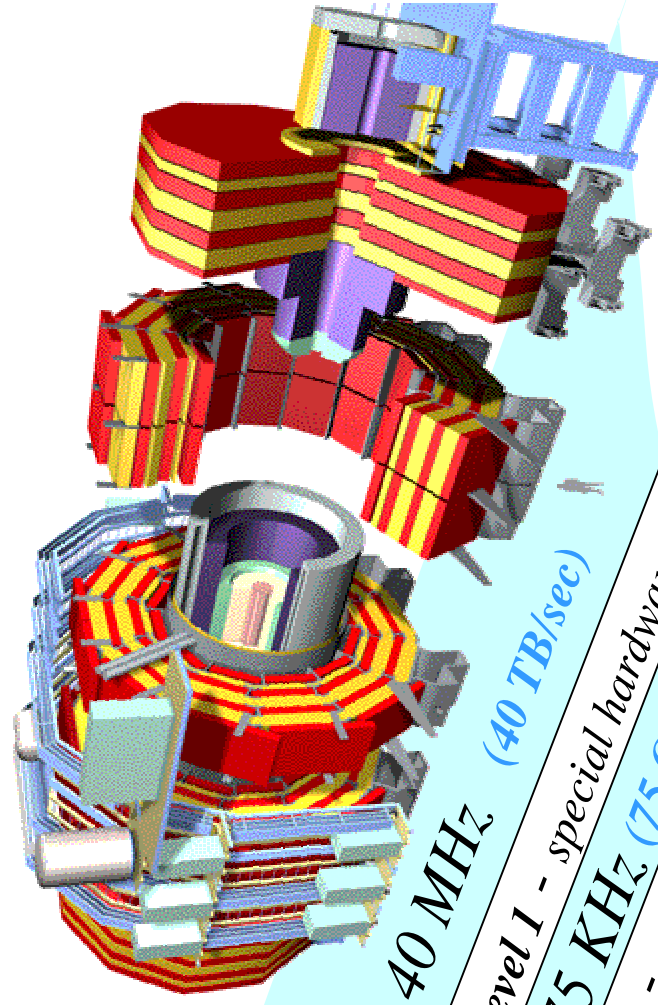


LHCb





**CMS**  
Compact Muon Solenoid



**online system**  
multi-level trigger  
filter out background  
reduce data volume

40 MHz (40 TB/sec)

level 1 - special hardware

75 KHz (75 GB/sec)

level 2 - embedded processors

5 KHz (5 GB/sec)

level 3 - PCs

100 Hz  
(100 MB/sec)

data recording &  
offline analysis

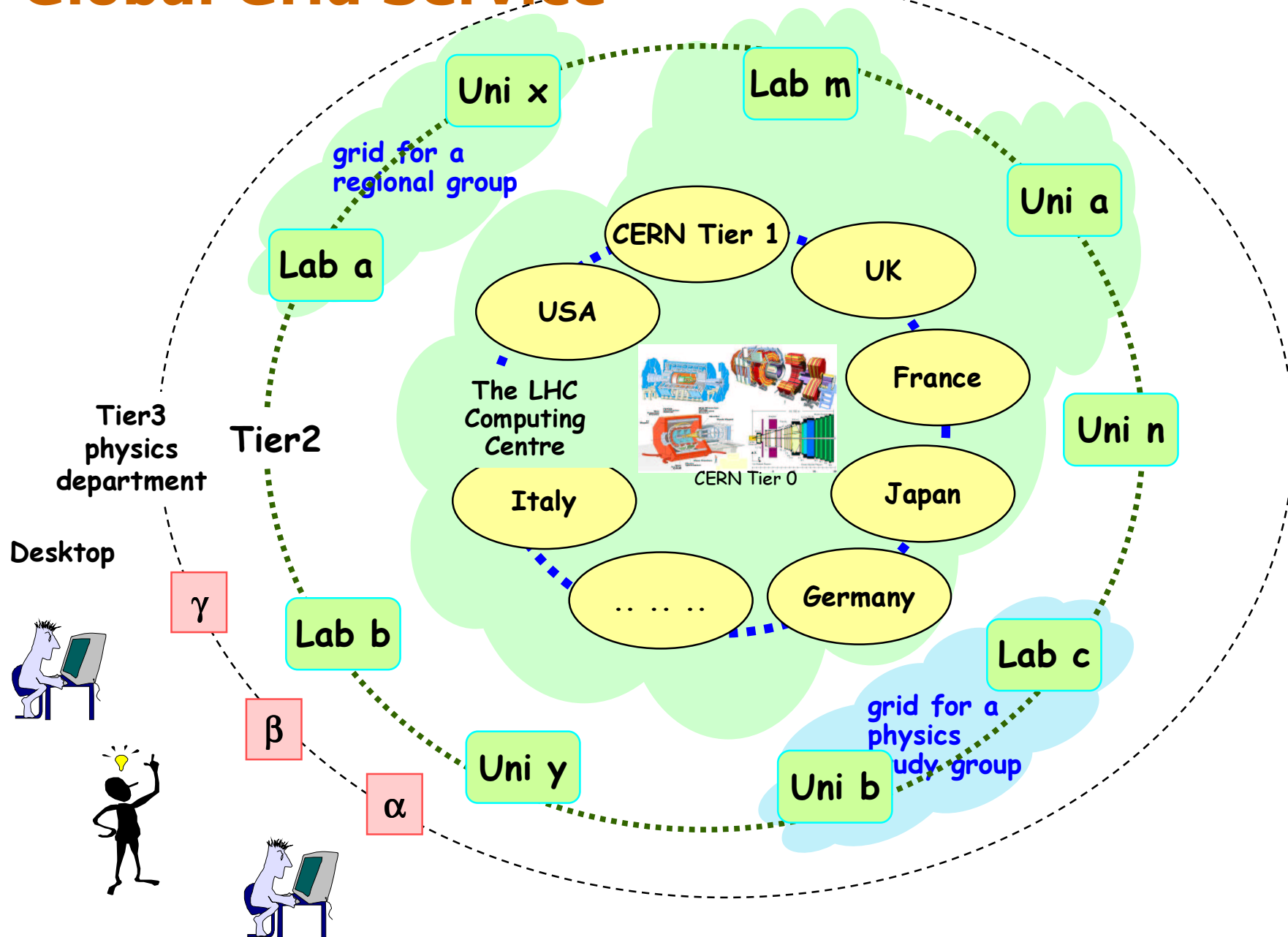
les.robertson@cern.ch

# CERN's Network in the World

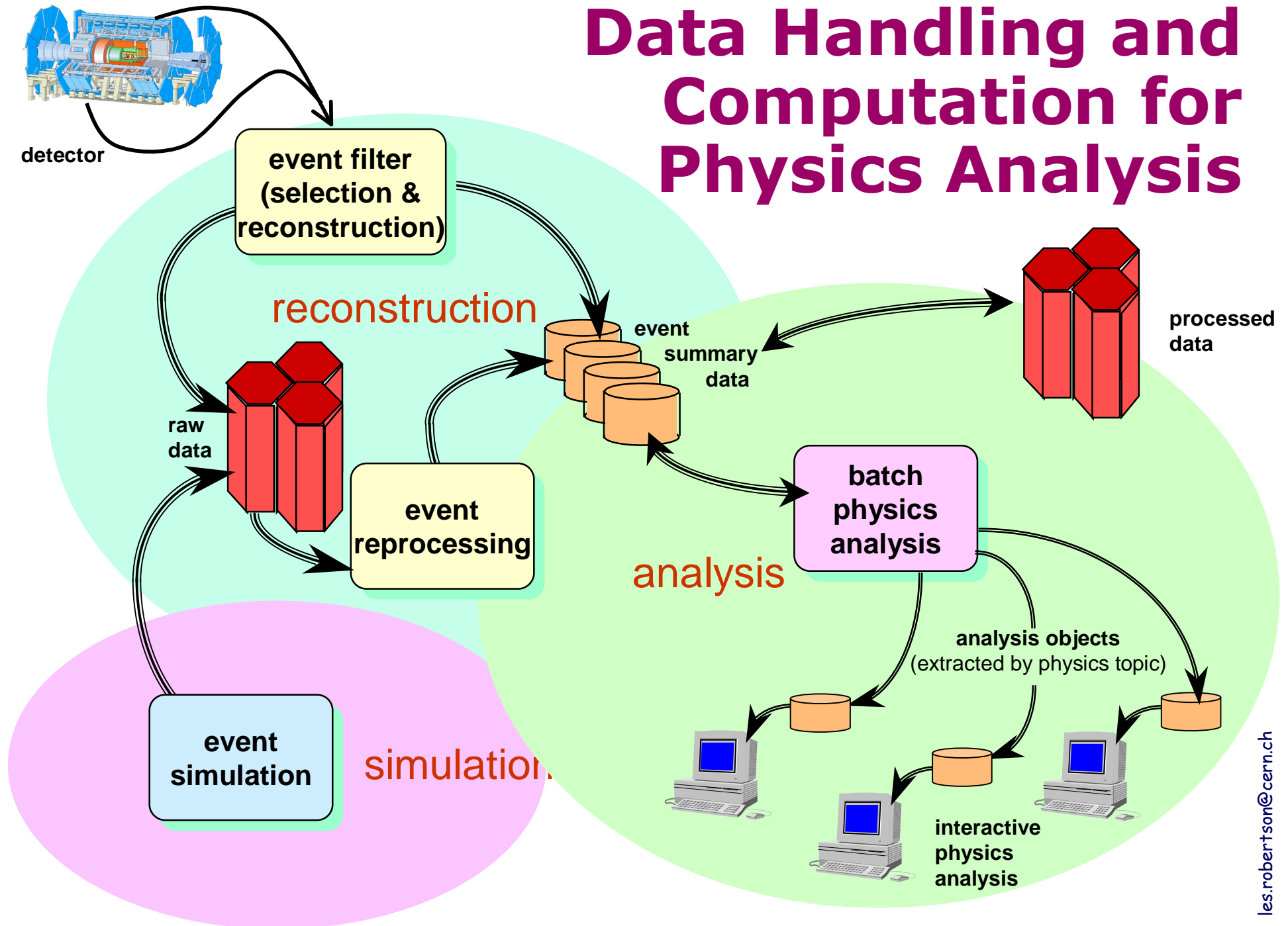


**Europe: 267 institutes, 4603 users**  
**Elsewhere: 208 institutes, 1632 users**

# Deploying the LHC Global Grid Service



# Data Handling and Computation for Physics Analysis







## Earth Observation applications

- **Global Ozone (GOME) Satellite Data Processing and Validation by KNMI, IPSL and ESA**
- The **DataGrid testbed** provides a **collaborative processing environment** for 3 geographically distributed **EO** sites (Holland, France, Italy)

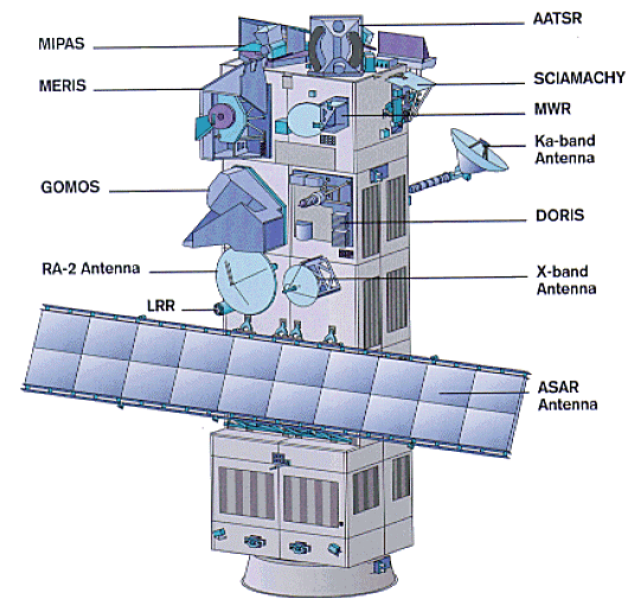


# Earth Observation

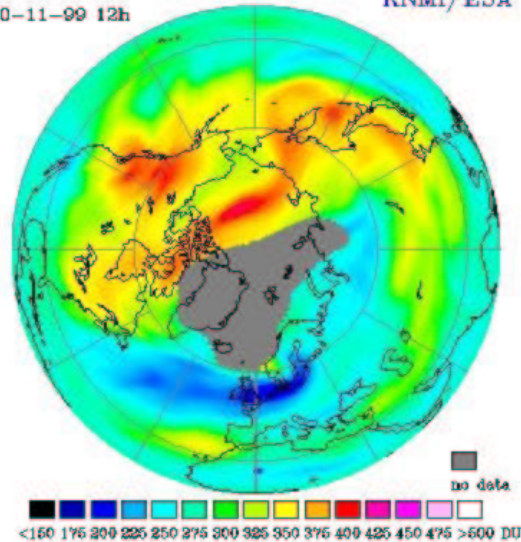


## ESA missions:

- about 100 Gbytes of data per day (ERS 1/2)
- 500 Gbytes, for the next ENVISAT mission (2002).



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



## DataGrid contribute 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 ...)

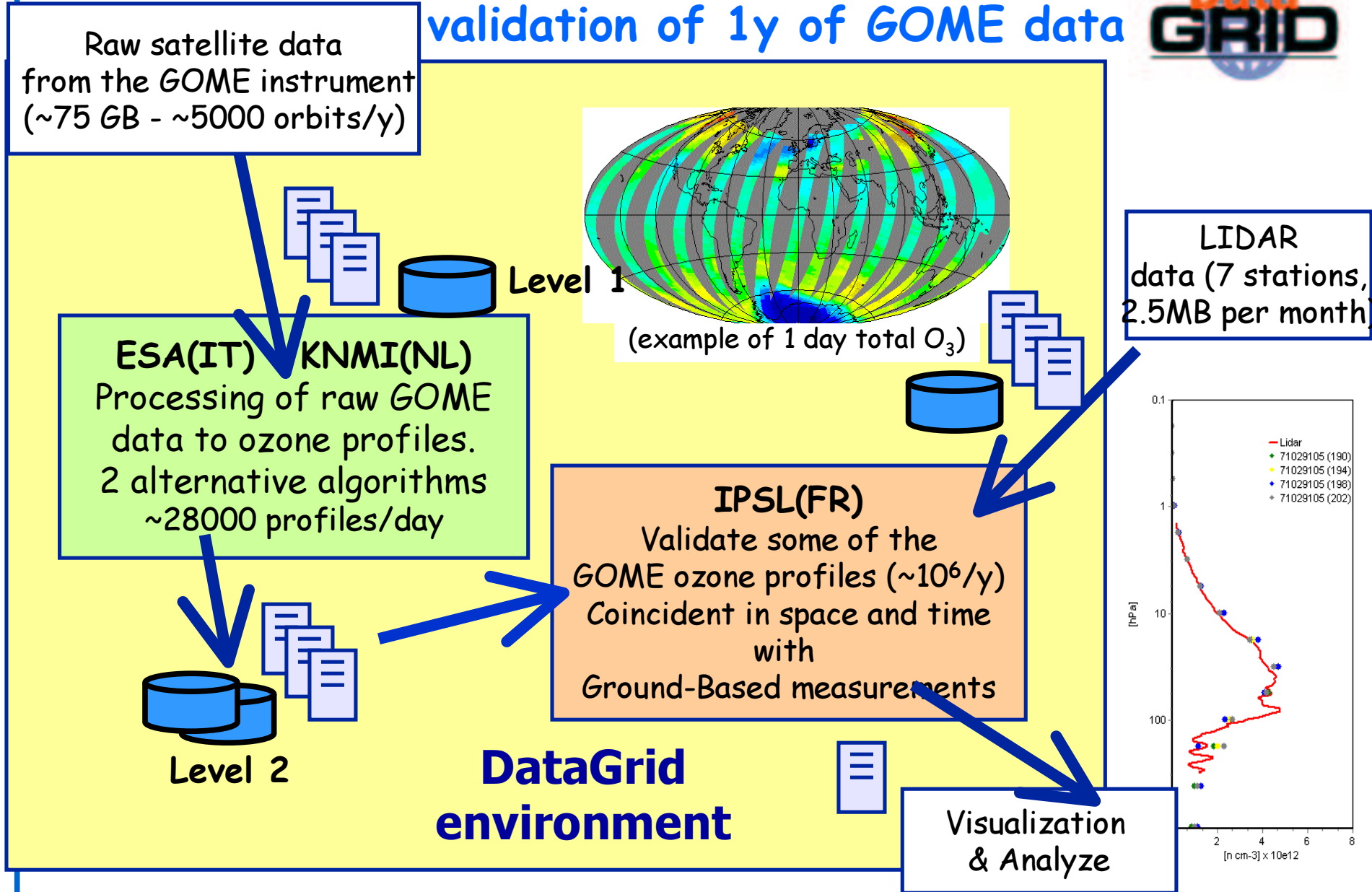
Source: L. Fusco, June 2001

A photograph of the Earth Observing Satellite (ENVISAT) in orbit above the Earth. The satellite is a complex, gold-colored structure with various instruments and antennas. A long, thin solar panel array extends from the main body of the satellite. The Earth's surface is visible below, showing blue oceans, white clouds, and brown landmasses. The background is the blackness of space.

# ENVISAT

- 3500 Meuro programme cost
- Launched on February 28, 2002
- 10 instruments on board
- 200 Mbps data rate to ground
- 400 Tbytes data archived/year
- ~100 'standard' products
- 10+ dedicated facilities in Europe
  
- ~700 approved science user projects

# EDG EO challenge: Processing / validation of 1y of GOME data





# EO WebMap Portal

ESA - GRID on demand - Microsoft Internet Explorer

Address: <http://giserver.esrin.esa.int/grid-demo/>

**esa** GRID on-Demand Ozone Application **Data GRID** Work Package 9  
European Space Agency

Start Date (1997): October 01  
End Date (1997): October 03  
Dataset: ERS/GOME LVL11  
ESA Catalogue Server: ODISSEO  
Select GRID: Local GRID

Query Restart

[acknowledgments]

**LIDAR stations**

ESA Storage(AMS)	GRID Storage	Processed Files	Web Mapping
71003124.LV1	71003124.LV1	71003124	71003124
71001121.LV1	71001121.LV1	71001121	71002114
71002114.LV1	71002114.LV1	71002114	71003092
71003111.LV1	71003111.LV1	71003111	71003111
71001102.LV1	71003092.LV1	71003092	

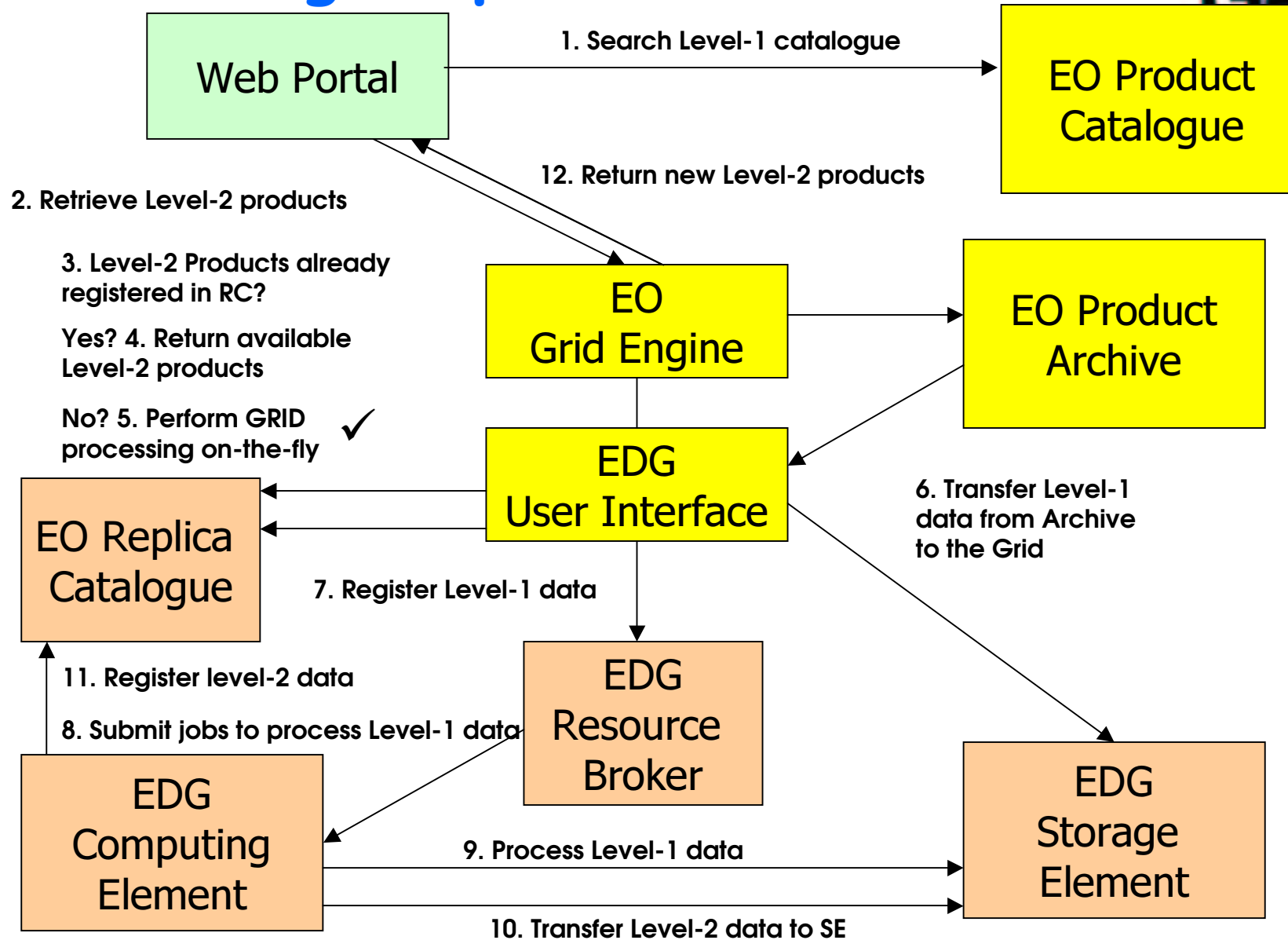
Preview Retrieve Process View Delete

ATSR/2 (Orbit 12831...)

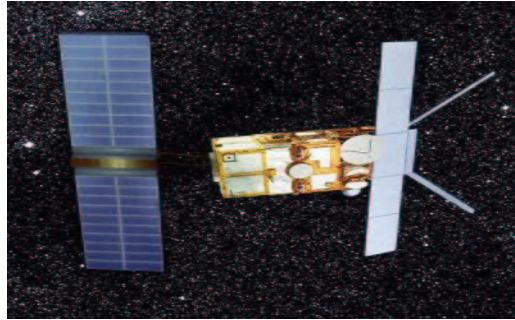
FileName = 71003111.LV1  
Orbit = 12831  
StartDate = 1997-10-03  
StartTime = 11:09:59.99  
EndDate = 1997-10-03  
EndTime = 12:00:17.99

71002114.LV1,12817,1997-10-02,11:39:59.99,1997-10-02,12:30:17.99

# Processing Sequence

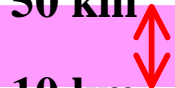


# GOME Ozone Profile Validation



ERS/GOME satellite

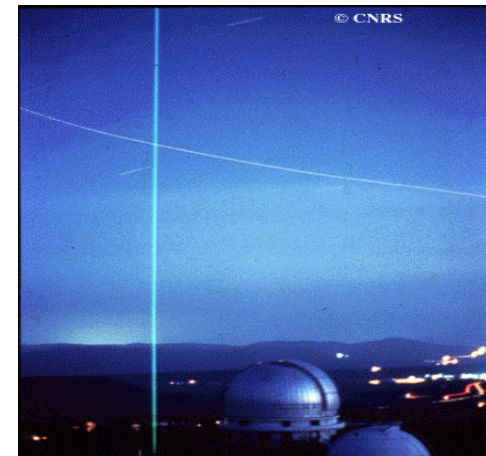
50 km



10 km

OZONE LAYER

- ✓ Goals of the DataGrid application
  - validate satellite data with all ground based data available in an easy way:
    - Comparison of ozone profiles provided by satellite with lidar data in different locations and times (see the web portal)
    - Statistical comparison and analysis in order to improve algorithms.



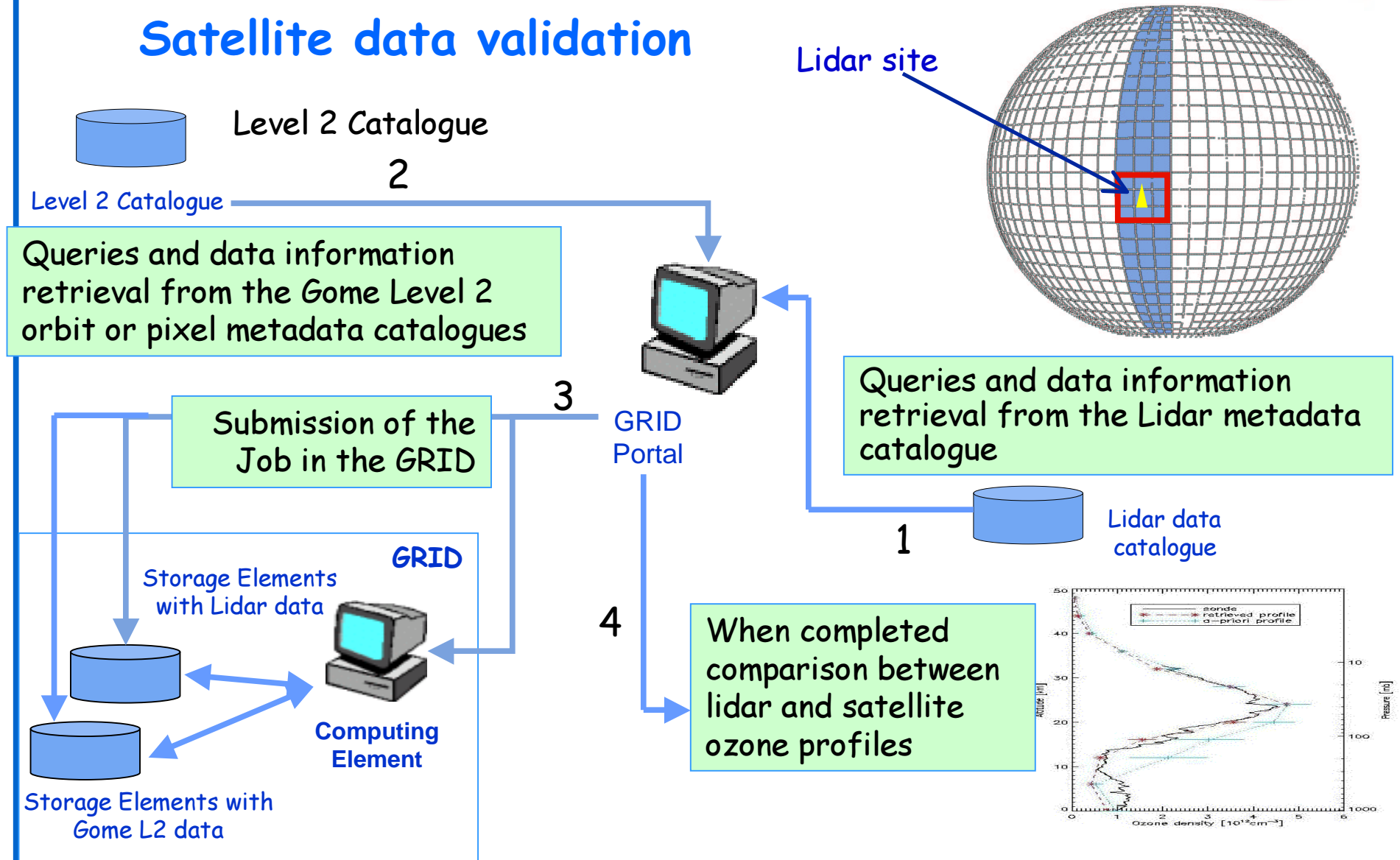
Lidar at the Haute Provence Observatory



# Validation Processing Sequence



## Satellite data validation



# Validation Output

Figure 1:

Estimation of the bias between Gome and Lidar using one month of data.

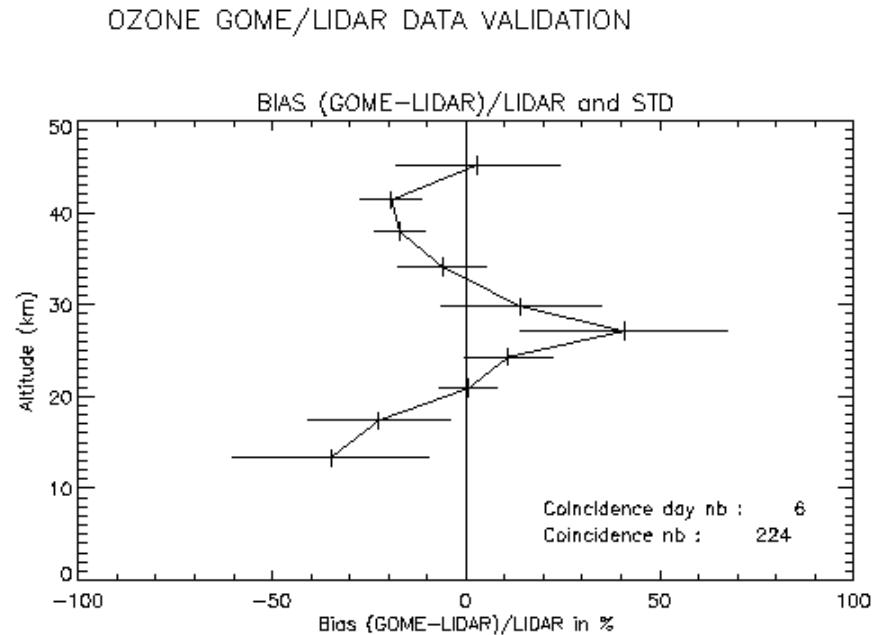
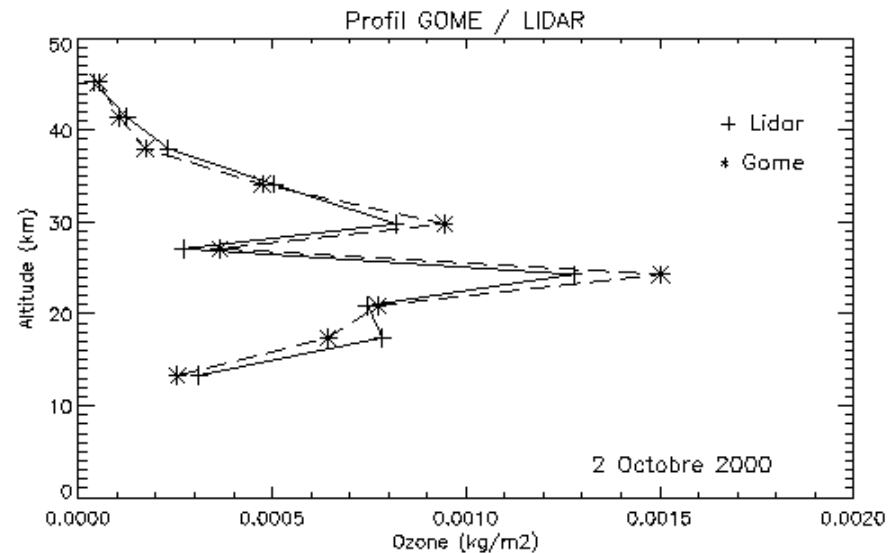


Figure 2 :

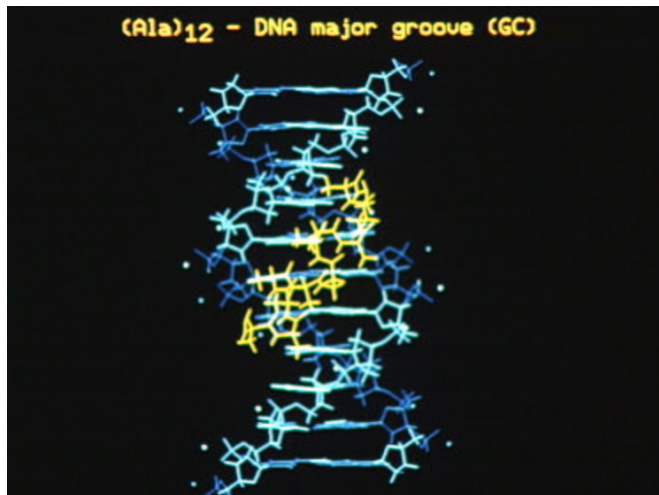
example of 2 profiles :  
Comparison between Gome profile and lidar profile for the 2nd October 2000.



# Biomedical Applications

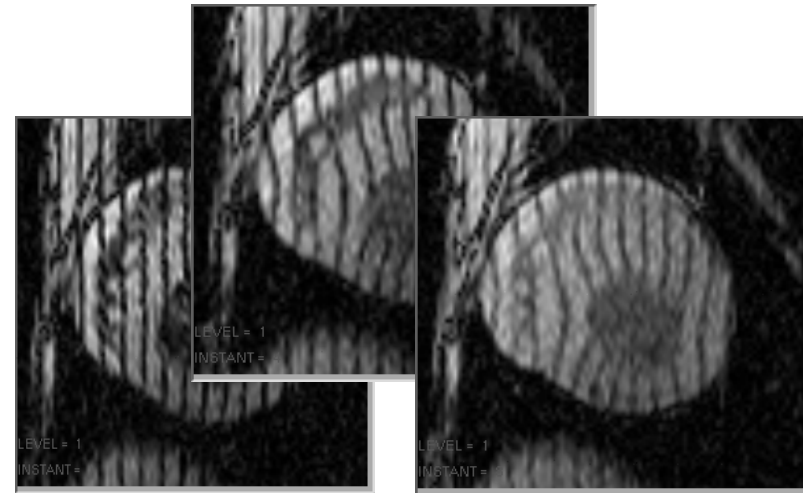


Genomics, post-genomics,  
and proteomics



Explore strategies that facilitate the sharing of genomic databases and test grid-aware algorithms for comparative genomics

Medical images  
analysis



Process the huge amount of data produced by digital imagers in hospitals.



# Biomedical Applications



## ◆ Bio-informatics

- Applications deployed
  - Applications tested on EDG
  - Applications under preparation
- **Phylogenetics : BBE Lyon (T. Sylvestre)**
  - **Search for primers : Centrale Paris (K. Kurata)**
  - **Statistical genetics : CNG Evry (N. Margetic)**
  - **Bio-informatics web portal : IBCP (C. Blanchet)**
  - **Parasitology : LBP Clermont, Univ B. Pascal (N. Jacq)**
  - **Data-mining on DNA chips : Karolinska (R. Médina, R. Martinez)**
  - **Geometrical protein comparison : Univ. Padova (C. Ferrari)**

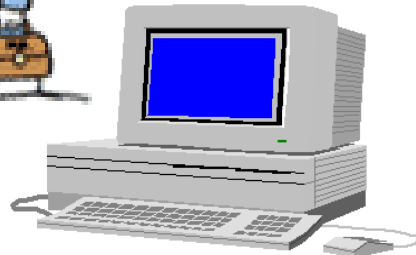
## ◆ Medical imaging

- **MR image simulation : CREATIS (H. Benoit-Cattin)**
- **Medical data and metadata management : CREATIS (J. Montagnat)**
- **Mammographies analysis ERIC/Lyon 2 (S. Miguet, T. Tweed)**
- **Simulation platform for PET/SPECT based on Geant4 : GATE collaboration (L. Maigne)**

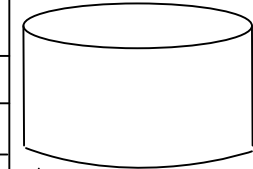
# Medical Imaging



H



LFN	image	patient	hospital	...

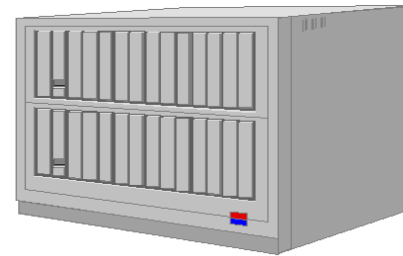


Medical images

1. query  
2. visualisation

5. best results visualisation

3. similarity search  
4. scores



# Graphic layer



Job	Status	Target
27499 (similarity)	Terminated	localhost:0/queue
27503 (similarity)	Terminated	localhost:0/queue
27507 (similarity)	Terminated	localhost:0/queue
27511 (similarity)	Terminated	localhost:0/queue
27515 (similarity)	Terminated	localhost:0/queue
27520 (similarity)	Terminated	localhost:0/queue
27524 (similarity)	Terminated	localhost:0/queue
27528 (similarity)	Terminated	localhost:0/queue
27532 (similarity)	Terminated	localhost:0/queue
27536 (similarity)	Terminated	localhost:0/queue
27540 (similarity)	Terminated	localhost:0/queue
27544 (similarity)	Terminated	localhost:0/queue
27548 (similarity)	Terminated	localhost:0/queue
27552 (similarity)	Terminated	localhost:0/queue
27556 (similarity)	Terminated	localhost:0/queue
27560 (similarity)	Output ready	localhost:0/queue
27564 (similarity)	Running	localhost:0/queue
27568 (similarity)	Submitted	localhost:0/queue
27572 (similarity)	Submitted	localhost:0/queue
New similarity	Sending to UI	

Job Monitoring

Path: /medical/thorax

- 0000.inr
- 00001.inr
- 00002.inr
- 00003.inr
- 00004.inr
- 00005.inr

Create Remove Delete View

Target SE: No default SE selected  
localhost

Grid File Browsing

Path: /home/johan/RM/medical/heart

- 002.inr
- 003.inr
- 004.inr
- 005.inr
- 006.inr
- 007.inr
- 008.inr
- 009.inr
- 010.inr
- 011.inr
- 012.inr
- 013.inr
- 014.inr
- 015.inr

Path: /medical

- brain
- heart
- thorax

Target SE: gppse05.gridpp.rl.ac.uk  
grid005.pd.infn.it  
grid007g.cnaf.infn.it

Cancel

File registration and retrieval



# Graphical Interfaces



## Image registration

Path: /home/johan/RM/medical/heart

- 002.inr
- 003.inr
- 004.inr
- 005.inr
- 006.inr
- 007.inr
- 008.inr
- 009.inr
- 010.inr
- 011.inr
- 012.inr
- 013.inr
- 014.inr
- 015.inr
- 016.inr
- 017.inr
- 018.inr

Path: /medical

- ..
- brain
- heart
- thorax

Target SE:

- gppse05.gridpp.rl.ac.uk
- grid005.pd.infn.it
- grid007g.cnaf.infn.it

Cancel

Source file: /home/johan/RM/medical/heart/237.inr  
 Destination: grid005.pd.infn.it/medical/237.inr  
 Type: 8 bits unsigned, Vectorial dim: 1  
 Size: 256 x 256 x 1 x 1  
 Voxels Size: 1.000 x 1.000 x 1.000 x 1.000

Patient name: Dupont Françoise  
 Sexe: Female Birth date: 21/03/1964

Hospital: Lyon Cardiology Hospital Radiologist: Dr André Dussolie  
 Acquisition date: 16/10/1999

Modality: MRI Region: Heart  
 Orientation:   
 Diagnosis:

Random Register Cancel

Local files

Grid files

Metadata



## Image retrieval

Patient name: Dupont  
 Sexe: Birth date:  
 Hospital: Radiologist:  
 Acquisition date:  
 Modality: MRI Region:  
 Orientation:

Query Select all Cancel

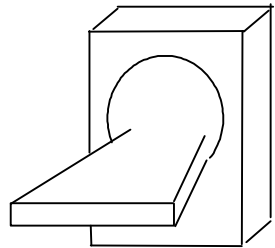
Patient	Medical	Hospital	Diagnosis	Image
Family name	First name	Sexe	Birth date	
Dupont	Peter	M	1944-03-12	
Dupont	Denise	F	1970-12-04	
Dupont	John	M	1966-11-18	
Dupont	Marc	M	1975-12-25	
Dupont	Denise	F	1970-12-04	
Dupont	Denise	F	1970-12-04	
Dupont	Denise	F	1970-12-04	
Dupont	Marc	M	1975-12-25	
Dupont	Marc	M	1975-12-25	
Dupont	Peter	M	1944-03-12	
Dupont	Jean	M	1978-06-02	
Dupont	Sandra	F	1962-12-27	
Dupont	Denise	F	1970-12-04	

View Dismiss

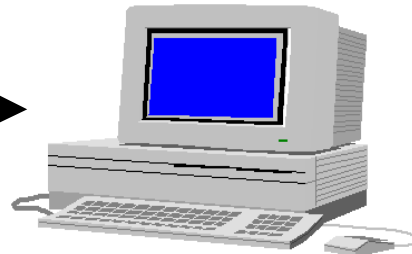
Query over metadata

Query result

# Image Registration



Imager



Source file: /home/johan/RM/medical/heart/237.inr  
 Destination: grid005.pd.infn.it/medical/237.inr  
 Type: 8 bits unsigned, Vectorial dim: 1  
 Size: 256 x 256 x 1 x 1  
 Voxels Size: 1.000 x 1.000 x 1.000 x 1.000

Patient name: Dupond Françoise  
 Sexe: Female Birth date: 21/03/1964  
 Hospital: Lyon Cardiology Hospital Radiologist: Dr André Dussole  
 Acquisition date: 16/10/1999

Modality: MRI Region: Heart  
 Orientation:   
 Diagnosis:   
 Random Register Cancel

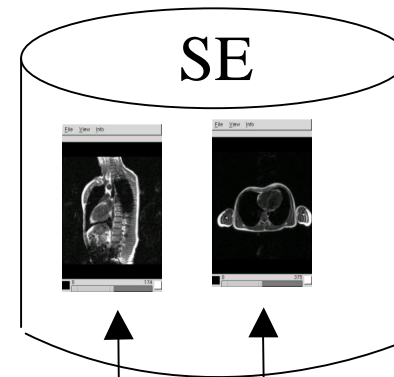
Path: /home/johan/RM/medical/heart  
 Path: /medical

002.inr	
003.inr	
004.inr	
005.inr	
006.inr	
007.inr	
008.inr	
009.inr	
010.inr	
011.inr	
012.inr	
013.inr	
014.inr	
015.inr	
016.inr	
017.inr	
018.inr	

Target SE:  
 gppse05.gridpp.rl.ac.uk  
 grid005.pd.infn.it  
 grid007g.cnat.infn.it

Cancel

LFN	image	patient	hospital	...



# Similarity search

## Similarity computation



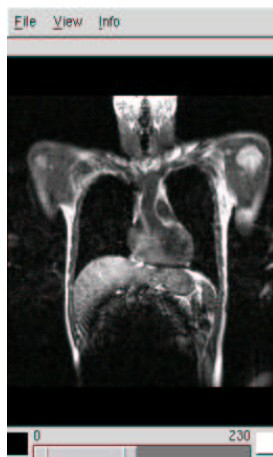
Job	Status	Target
27499 (similarity)	Terminated	localhost:0/noqueue
27503 (similarity)	Terminated	localhost:0/noqueue
27507 (similarity)	Terminated	localhost:0/noqueue
27511 (similarity)	Terminated	localhost:0/noqueue
27515 (similarity)	Terminated	localhost:0/noqueue
27520 (similarity)	Terminated	localhost:0/noqueue
27524 (similarity)	Terminated	localhost:0/noqueue
27528 (similarity)	Terminated	localhost:0/noqueue
27532 (similarity)	Terminated	localhost:0/noqueue
27536 (similarity)	Terminated	localhost:0/noqueue
27540 (similarity)	Terminated	localhost:0/noqueue
27544 (similarity)	Terminated	localhost:0/noqueue
27548 (similarity)	Terminated	localhost:0/noqueue
27552 (similarity)	Terminated	localhost:0/noqueue
27556 (similarity)	Terminated	localhost:0/noqueue
27560 (similarity)	Output ready	localhost:0/noqueue
27564 (similarity)	Running	localhost:0/noqueue
27568 (similarity)	Submitted	localhost:0/noqueue
27572 (similarity)	Submitted	localhost:0/noqueue
New similarity	Sending to UI	

Job monitoring

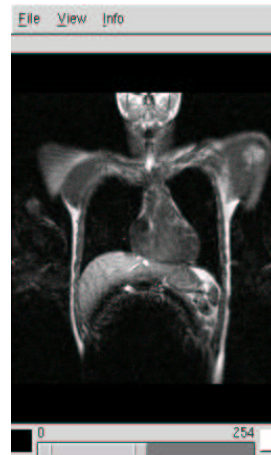
File	Similarity	About
Source image: Jones Jean    Cardiology Center of Monaco    Dr Jina Carlson    1997-11-18		
Results:		
0.904684	Durand Jean	Lyon Cardiology Hospital    Dr Alain Deloin    2002-02-21
0.743148	Dupont Marc	Cardiology Center of Monaco    Dr Francis Black    1998-01-18
0.219426	Durand Jean	Cardiology Center of Monaco    Dr Jina Carlson    2000-10-08
0.217490	Jones Linda	Montreal Neurological Institut    Dr Fany Anderson    2000-12-21
0.193847	Jones Sandra	Cardiology Center of Monaco    Dr Francis Black    2000-12-25
0.003237	Dupont Denise	Montreal Neurological Institut    Dr Norbert White    1998-10-22
0.003084	Dupont John	Montreal Neurological Institut    Dr Norbert White    1998-04-22
0.002636	Smith Marc	Cardiology Center of Monaco    Dr Jina Carlson    1997-04-04
0.001778	Durand Sylvie	Lyon Neurology Hospital    Dr Martine Foliet    2001-02-14
0.001515	Smith Marc	Montreal Neurological Institut    Dr Norbert White    2001-02-09
0.001023	Durand Jean	Cardiology Center of Monaco    Dr Jina Carlson    2000-02-24

Ranked list of images

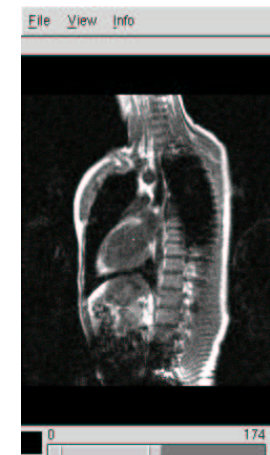
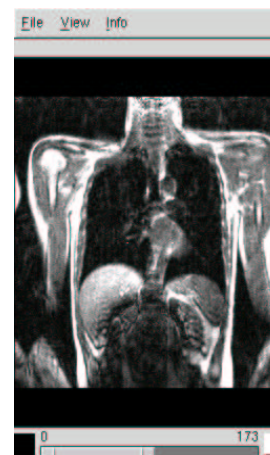
## Results visualization



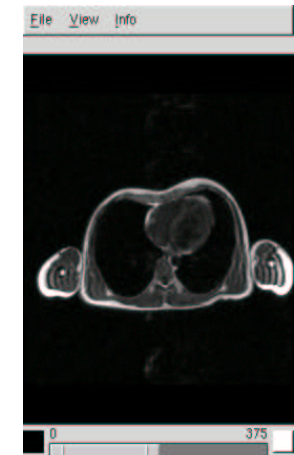
Source image



Most similar images

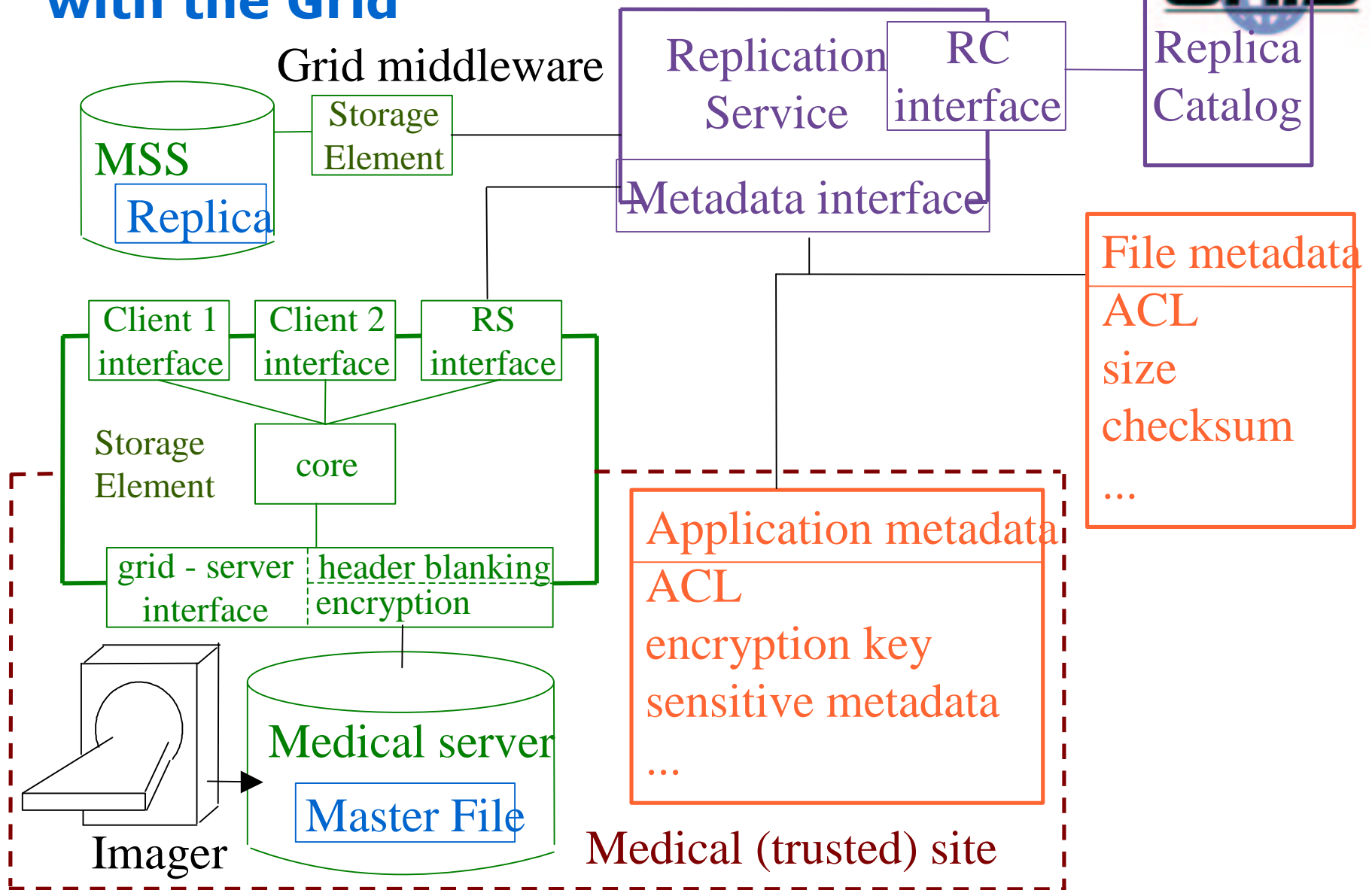


Low score images





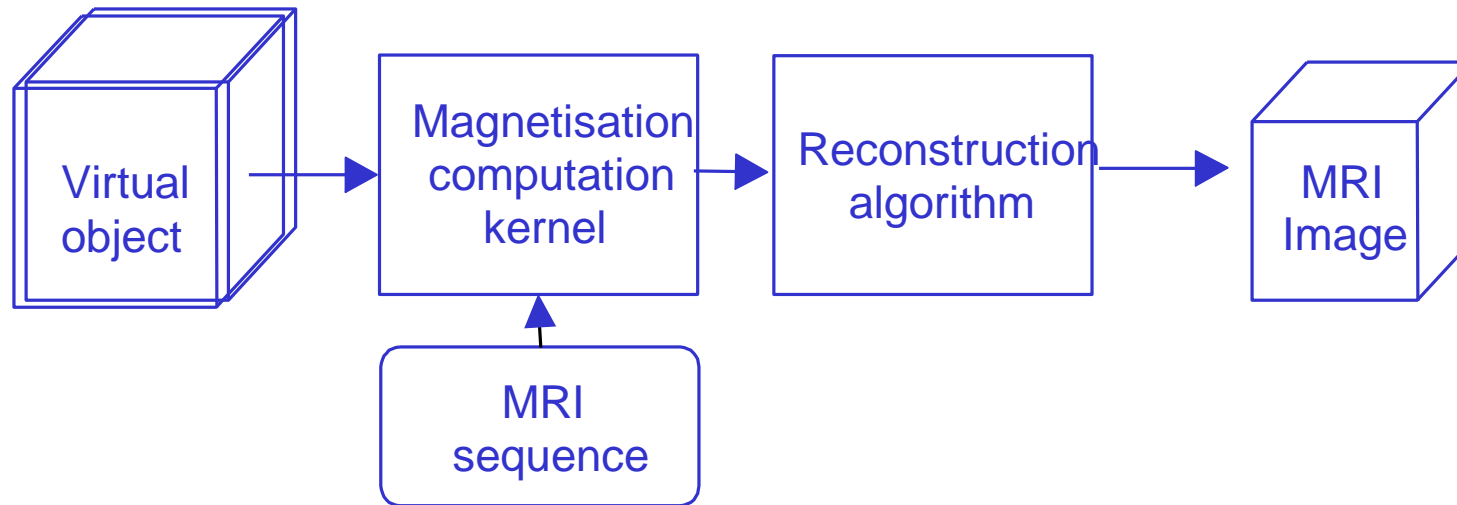
# Future: Interfacing medical data with the Grid



# Parallel Processing



- Magnetic Resonance Images simulation using the grid



- 3 levels of parallelism:
  - Parallel isochromat computations
  - Multi-slice MRI computation
  - Parallel magnetization kernel

# Summary



- ◆ Use Cases
  - High Energy Physics
  - Earth Observation
  - Biomedical Applications



## Further Information

- ◆ High Energy Physics

<http://datagrid-wp8.web.cern.ch/DataGrid-WP8/>

- ◆ Bio-Informatics

<http://marianne.in2p3.fr/datagrid/wp10/index.html>

- ◆ Earth Observation

<http://styx.esrin.esa.it/grid/>