Grid Computing
23. April 2009
Slovak teachers at CERN

Marian Babik
CERN, IT/FIO

Web of Today!

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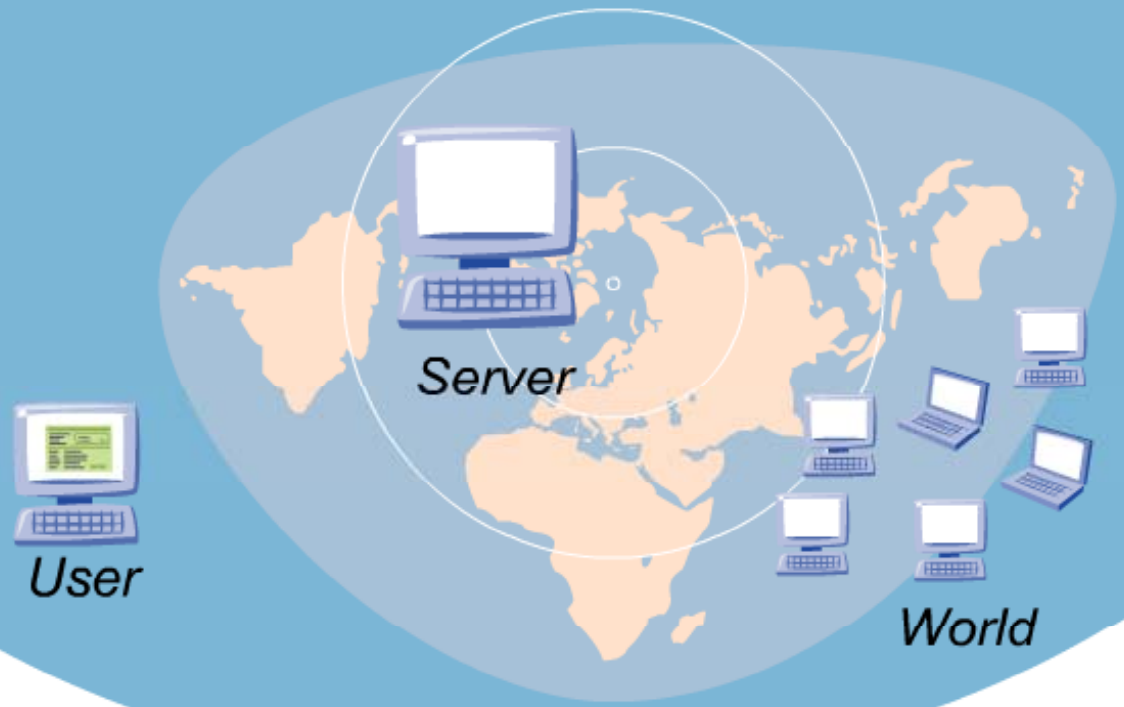
Golfe du Mexique: l'ouragan Ike menace les USA
L´ouragan Ike, balayant les eaux du Golfe du Mexique, poursuivait lentement sa route mercredi vers les Etats-Unis et les côtes du Texas. A Cuba, les intempéries ont entraîné l´évacuation de 2,6 millions de personnes et fait quatre morts. | Suite
Edipresse: bénéfice en hausse de 10% au 1er semestre
Edipresse a vu son bénéfice net progresser de 10% à 24 millions de francs au premier semestre. En revanche, les revenus de l´éditeur vaudois ont reculé dans les mêmes proportions, à 385,3 millions de francs. | Suite
Vidéo
© keystone
COLLISIONNEUR DU CERN
RSS
Mise en route réussie du LHC: ce n'est pas la fin du monde!
Le CERN a procédé avec succès ce matin au démarrage du plus grand accélérateur de particules au monde, le Grand collisionneur de hadrons (LHC). A 09h33, le faisceau de protons était injecté dans l´anneau de 27 kilomètres et à 10h25, le tour complet était réalisé pour la première fois. Suivez l'expérience en direct sur le matin.ch | Suite
Le Matin Online 69 commentaires
Dossier
› Le CERN et la fin du monde

What is the Web?



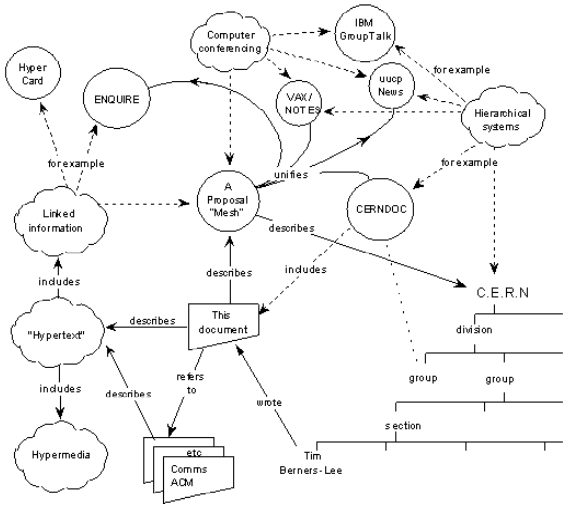
GridCafé
www.gridcafe.org

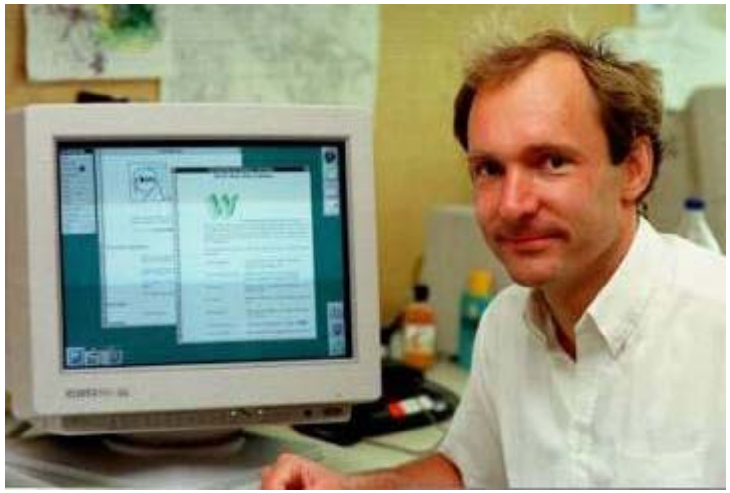
Why was the Web invented at CERN?

- Science depends on free **access to information** and exchange of ideas. CERN is the hub of a worldwide community of **6500 scientists** in **80 countries.**
- CERN has a long history of being at the forefront of **scientific computing** and **networking** (first lab on Internet outside the US).
- During the preparation of the previous large project LEP, the need to share documents in a global way became vital.

How did it start?

- 1989: **Tim Berners-Lee** circulates “Information Management: A proposal” to help with future Large Hadron Collider project.
- 1991: Early **www system released** to high energy physics via the CERN program library. First web servers located in European physics laboratories.
- 1993: First Mosaic browser; web reaches 500 servers and 1% of Internet traffic; CERN places **WWW in the public domain**.





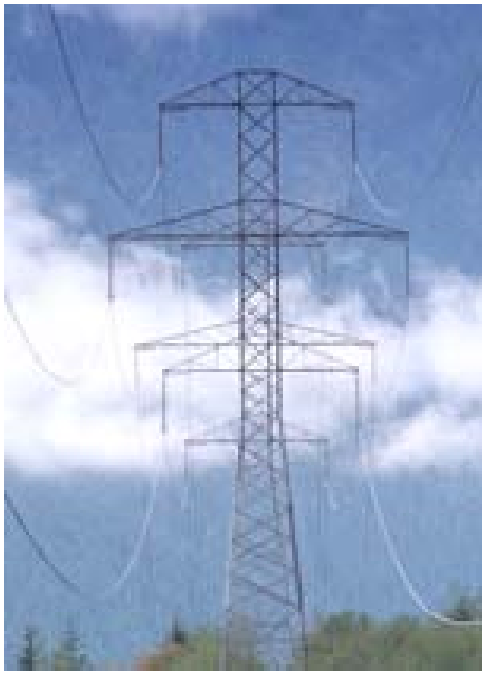
What is the Grid?

The **World Wide Web** provides seamless access to information that is stored in many millions of different geographical locations

The **Grid** is an infrastructure that provides seamless access to computing power and data storage capacity distributed over the globe

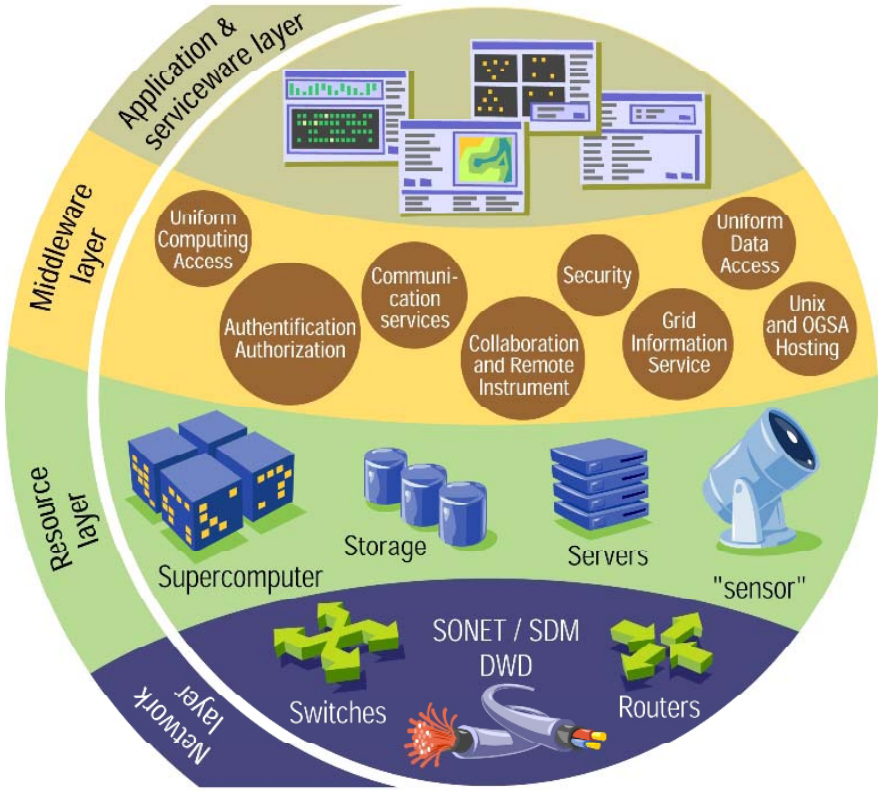
Grid history

- Name “Grid” chosen by analogy with electric power grid (Foster and Kesselman 1997)
- Vision: plug-in computer for processing power just like plugging in toaster for electricity.
- Concept has been around for decades (distributed computing, metacomputing)
- Key difference with the Grid is to realise the vision on a global scale.



How does the Grid work?

- It relies on advanced software, called **middleware**.
- Middleware automatically finds the **data** the scientist needs, and the **computing power** to analyse it.
- Middleware balances the load on different resources. It also handles **security, accounting, monitoring** and much more.



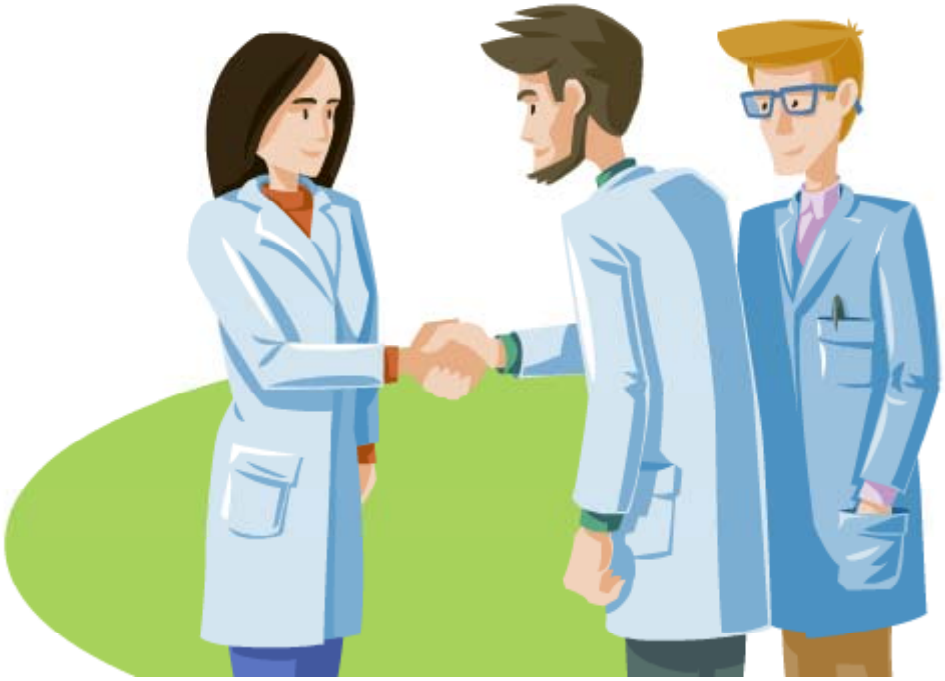
Virtual Organization

High Energy Physics, Earth Observation and Biology are examples of communities made up of several institutions and individuals sharing the same interests and the same scientific goals. They greatly benefit from putting together their computing resources, data and scientific instruments.

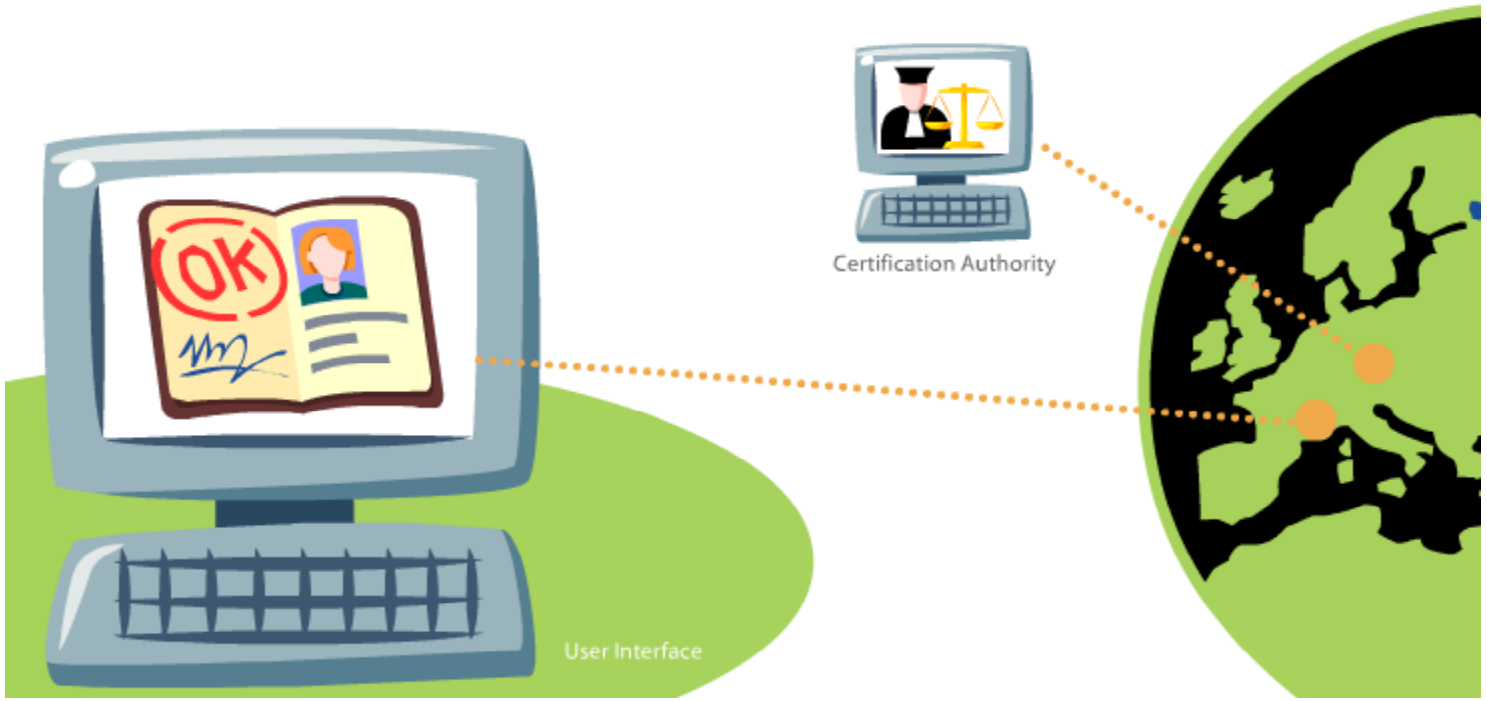
Such distributed communities are called ***Virtual Organisations***.

Step 1: Join Virtual Organization

To have access to the Grid facility, you need to join a *Virtual Organisation*.



Step 3: Get a permission



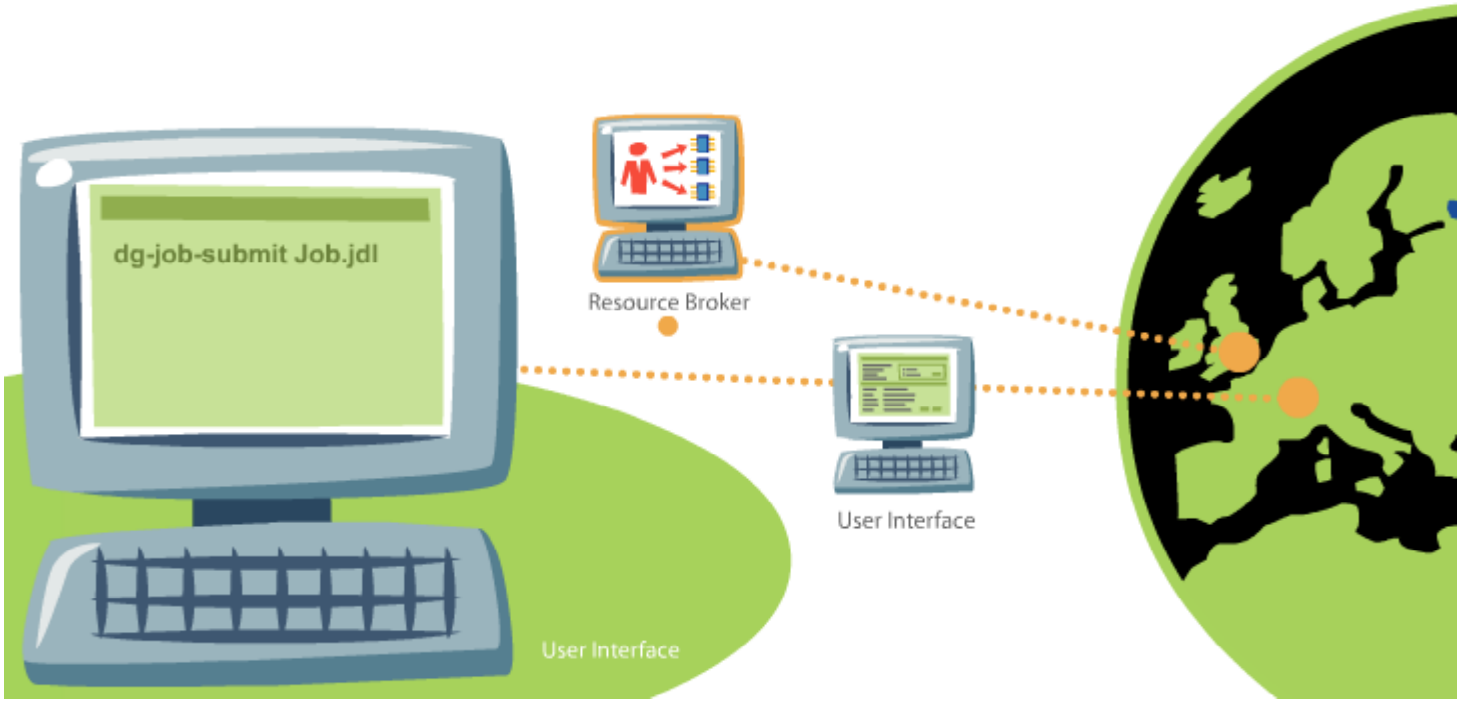
Step 4: Write a file describing your job

To run a job on the LCG/EGEE Grid Facility, you have to describe it in the ***Job Description Language*** (***JDL***).

JDL specifies job characteristics such as the application to use, the input data, the required resources, etc.

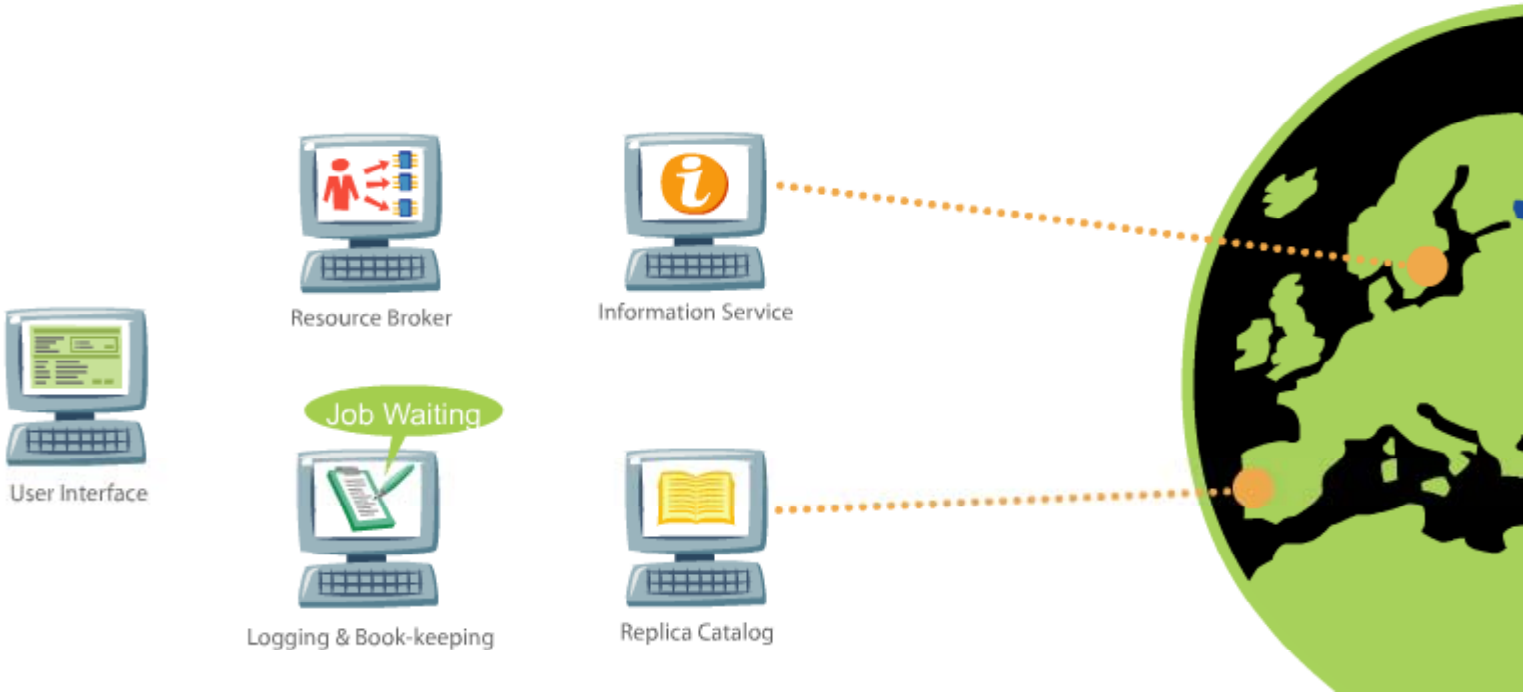
Step 5: Submit your job to the resource broker

Once you have the jdl file for your job, you can submit it to the ***Resource Broker***.



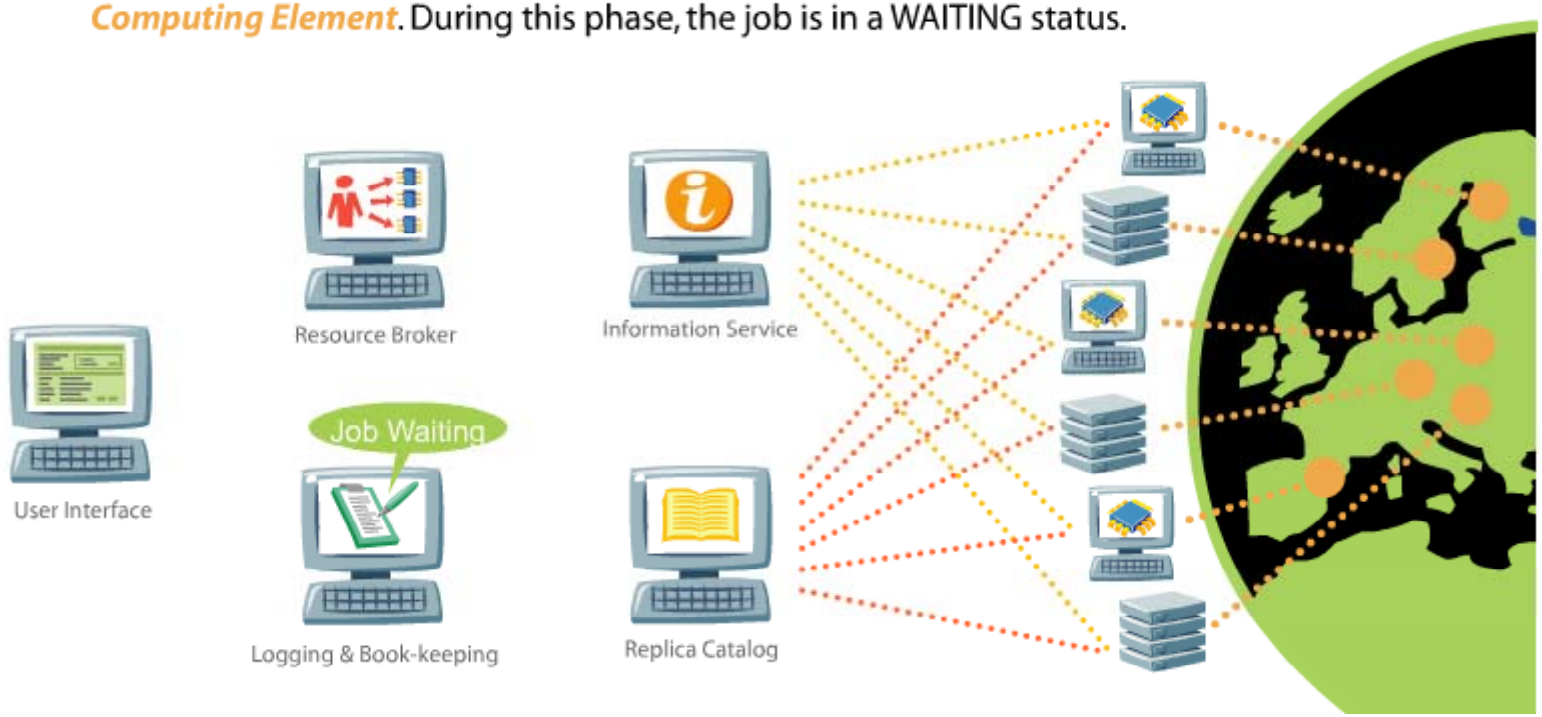
Step 5: Submit your job to the resource broker

Based on the information given in the JDL file, the *Resource Broker* queries the *Information Service* and the *Replica Catalog* to check resources.



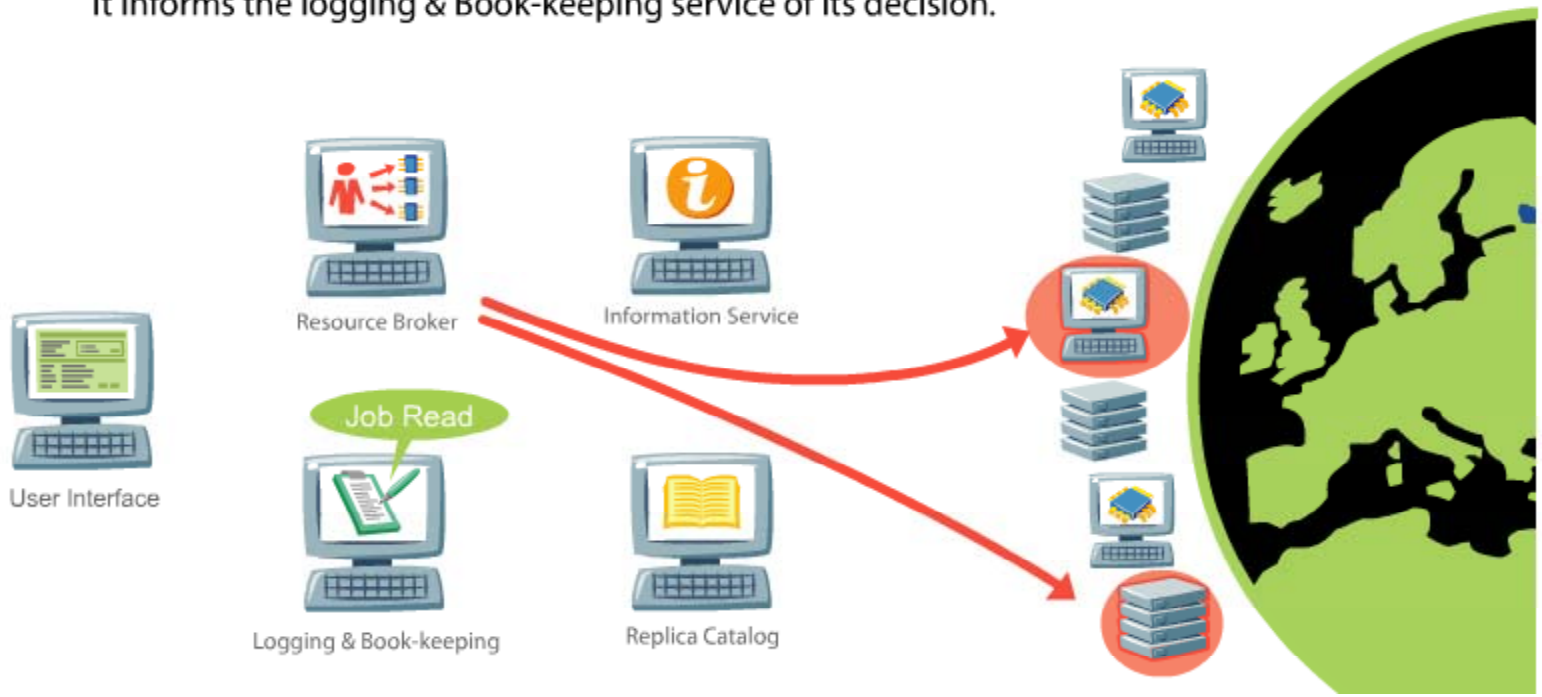
Step 5: Submit your job to the resource broker

The ***Replica Catalog*** and the ***Information Service*** hold information on the current status of all the sites. The Resource Broker uses this info to match the job to a suitable ***Computing Element***. During this phase, the job is in a WAITING status.



Step 5: Submit your job to the resource broker

The Resource Broker ***makes its choice***. It has found a suitable Computing Element and the Storage Element with the necessary data.
It informs the logging & Book-keeping service of its decision.

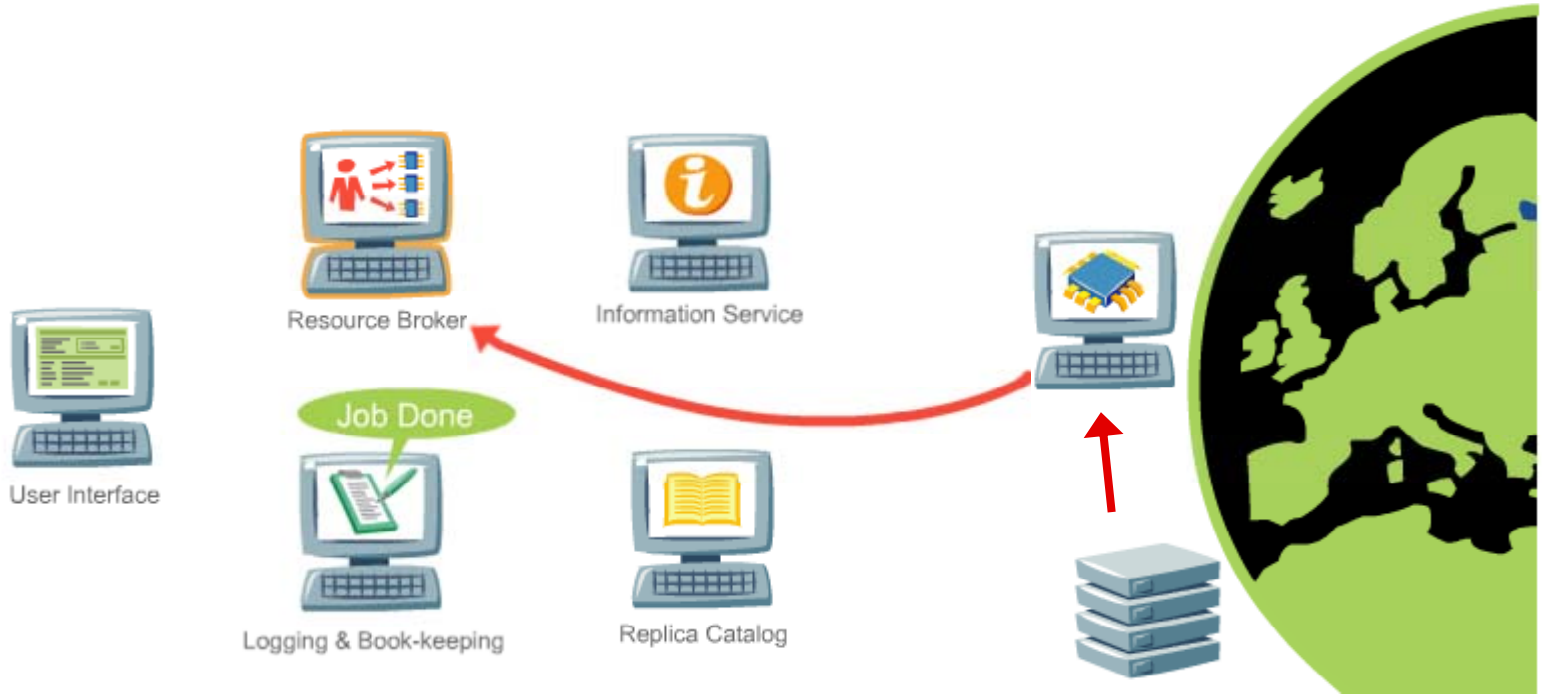


Step 6: Check the status of your job

During all this process, you can check the status of your job by contacting the ***Logging & Book-keeping Service***.

Step 6: Check the status of your job

The execution of the job has completed on the Computing Element.
The ***Computing Element transfers the output to the Resource Broker***.

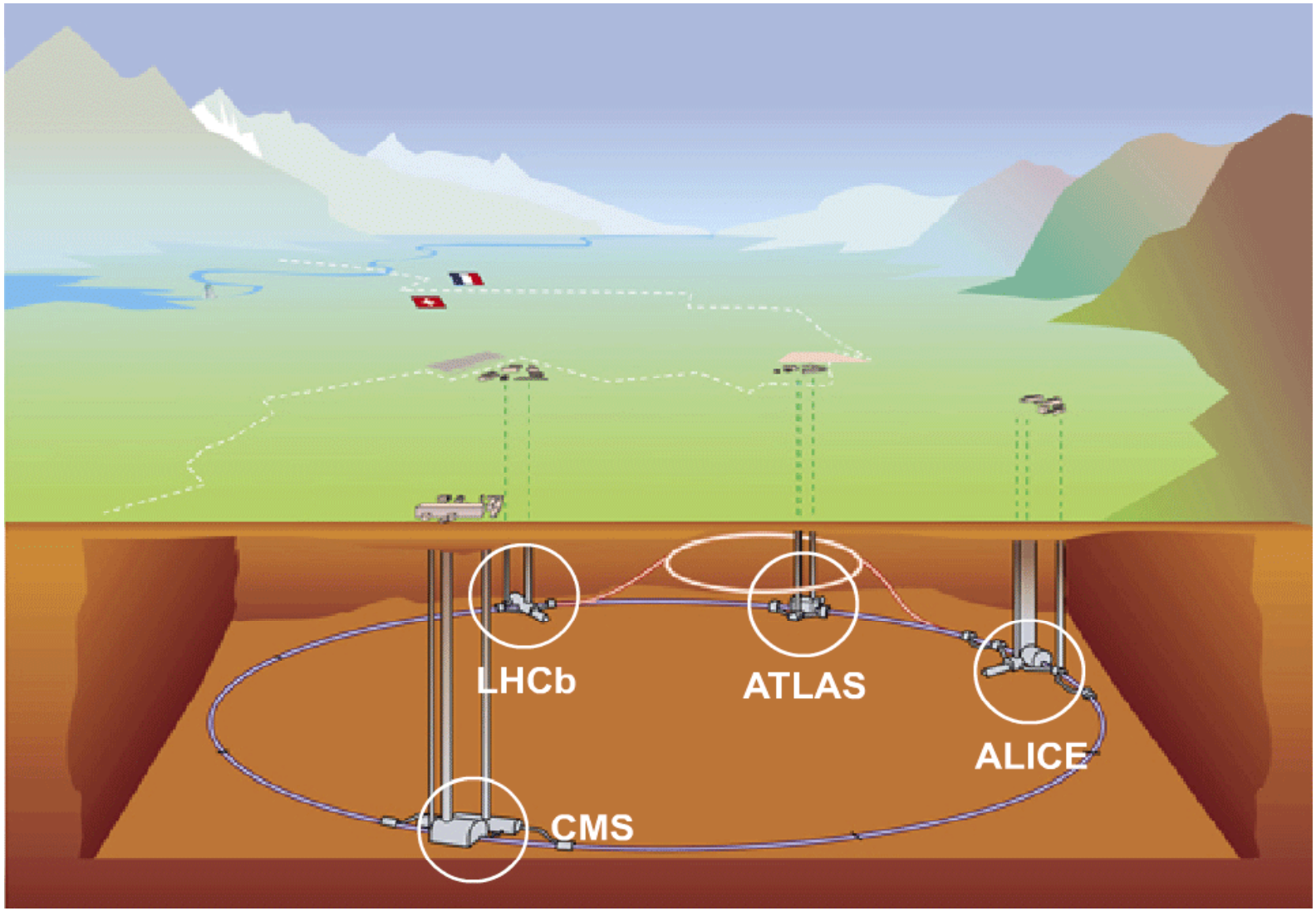


Step 7: Get the results

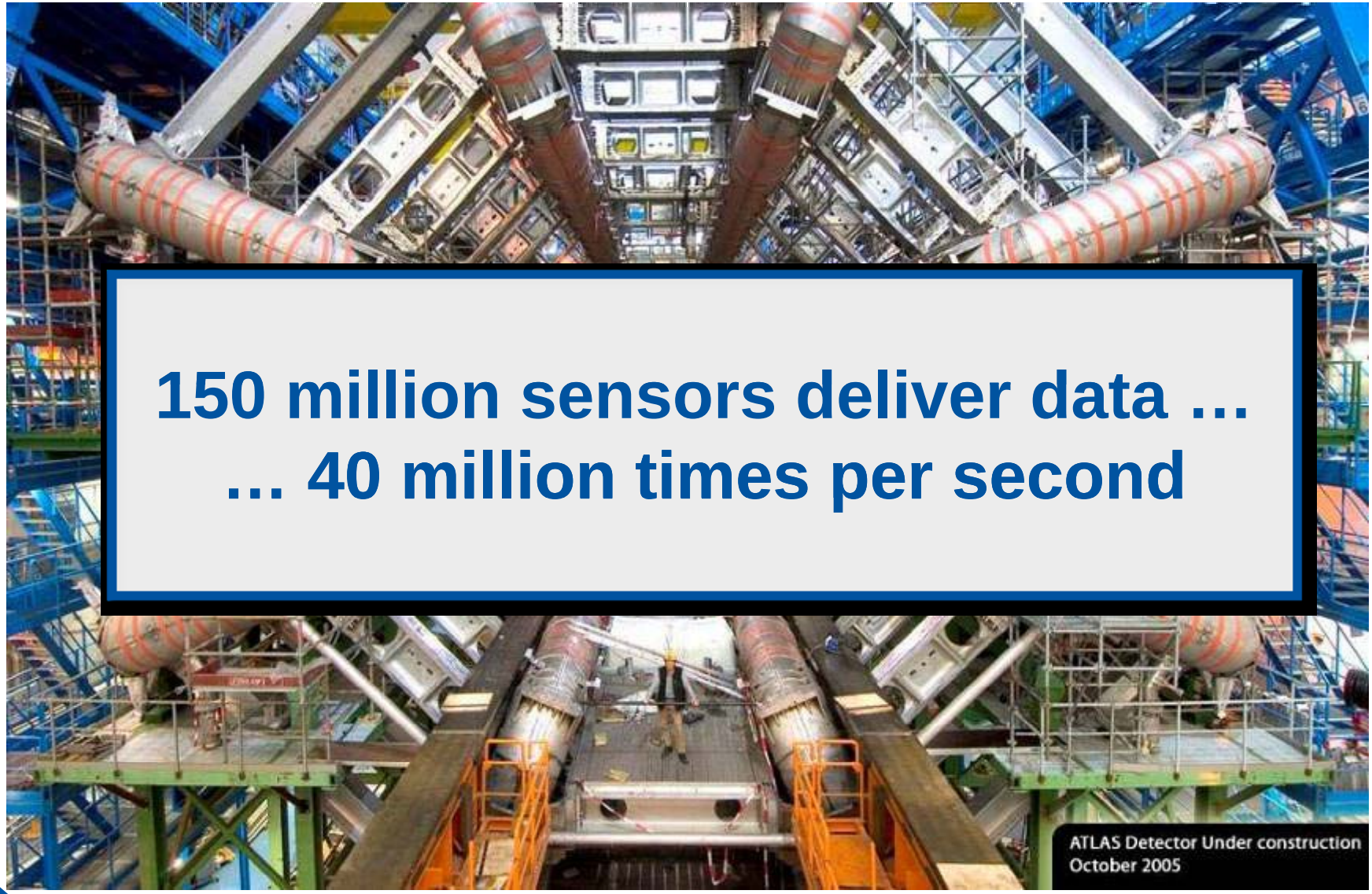
You can now retrieve your Output from the Resource Broker.
When finished, book-keeping ***information is purged***.

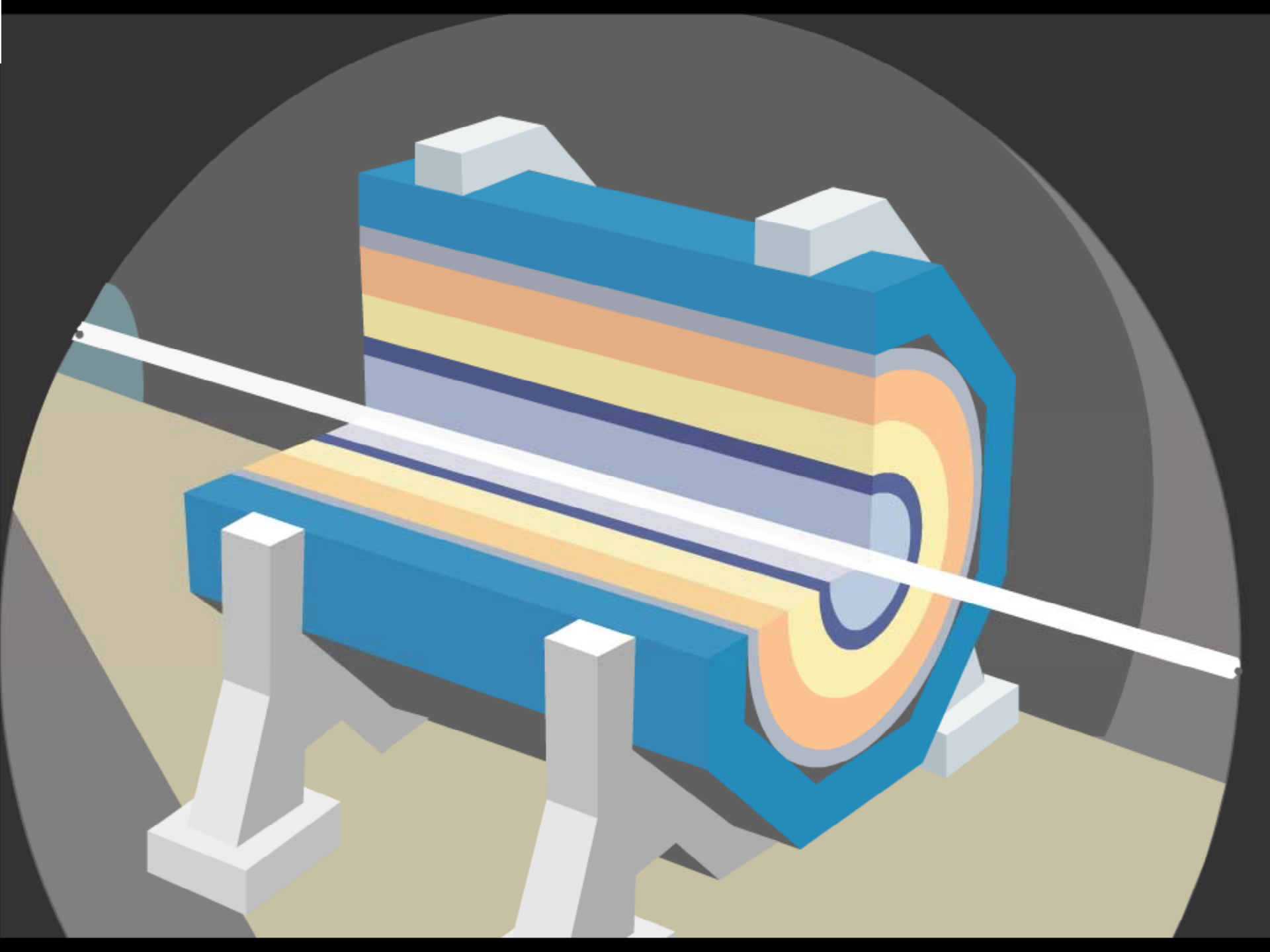
Why the Grid at CERN?

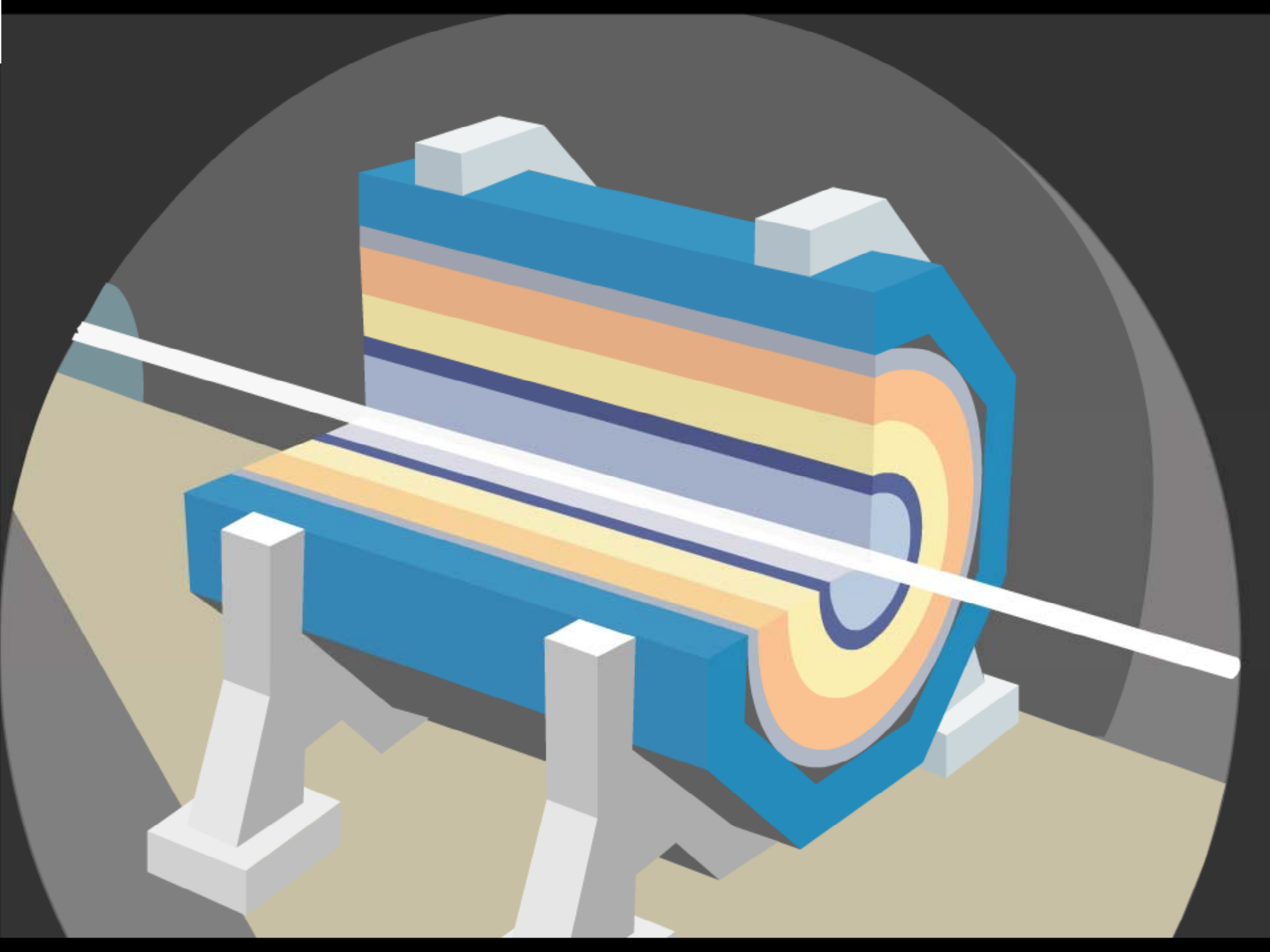
The LHC accelerator and the 4 experiments

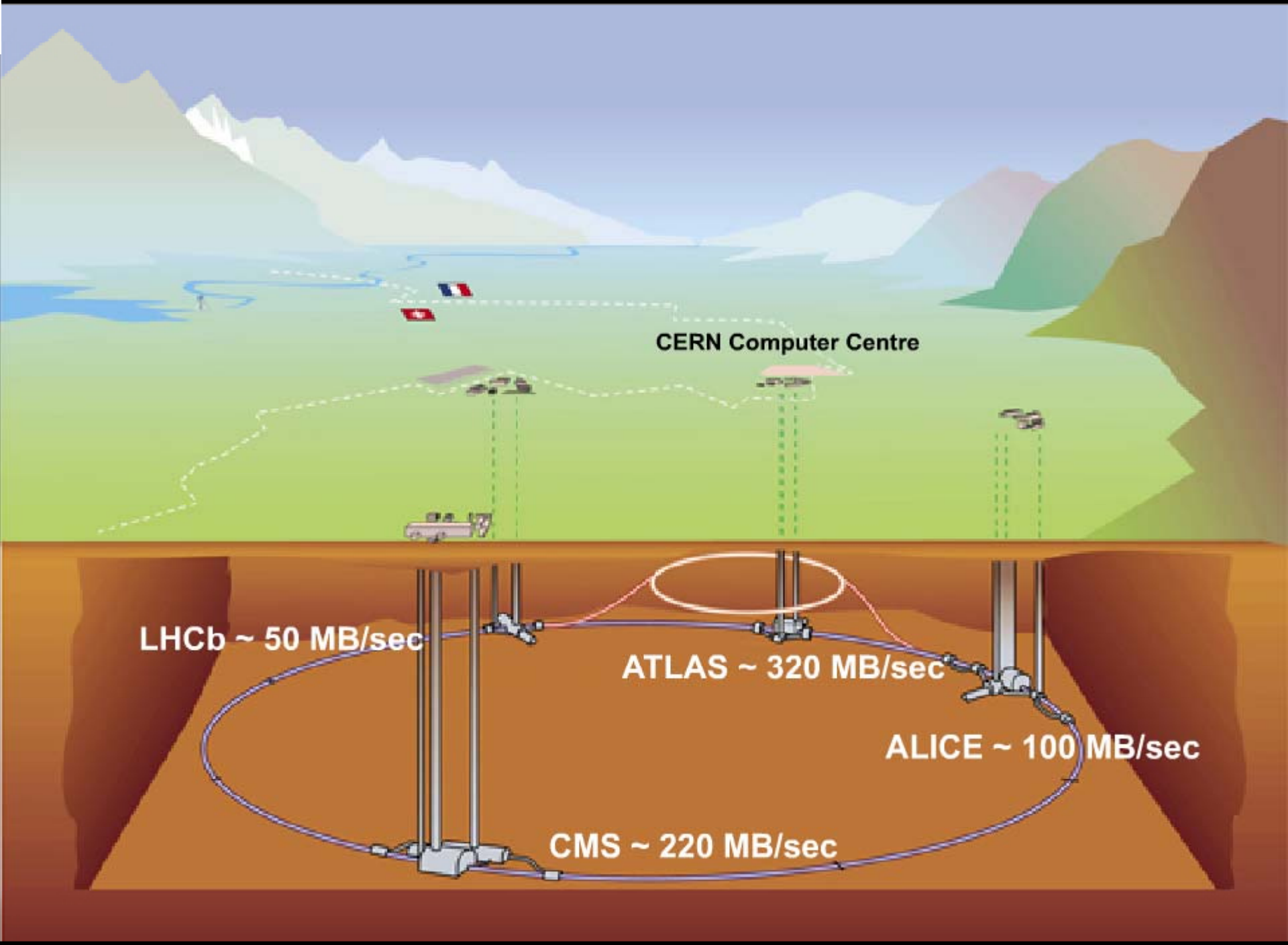


View of the ATLAS detector (under construction)





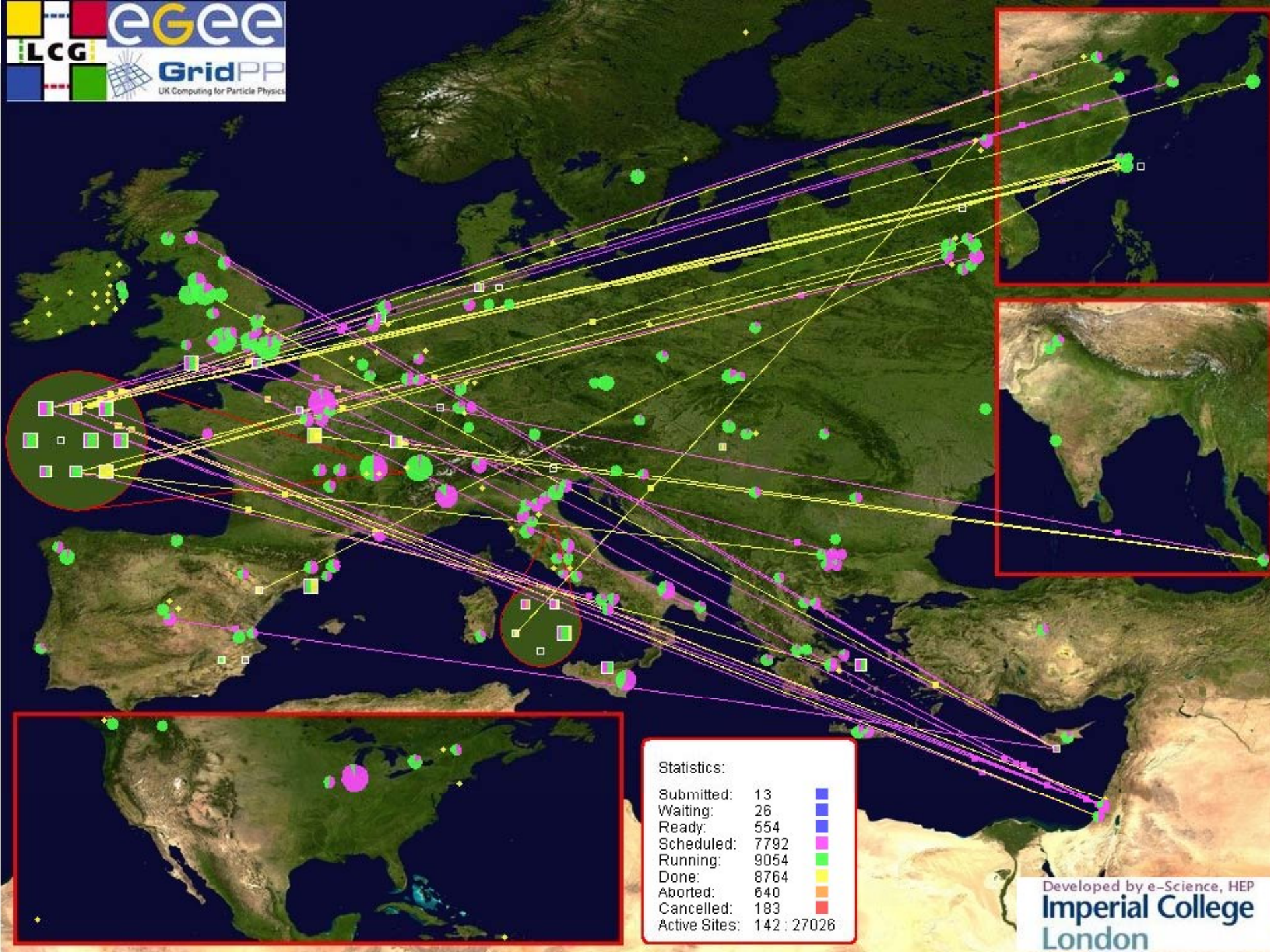



CERN Computer Centre
LHCb ~ 50 MB/sec
ATLAS ~ 320 MB/sec
ALICE ~ 100 MB/sec
CMS ~ 220 MB/sec

The LHC Data Challenge

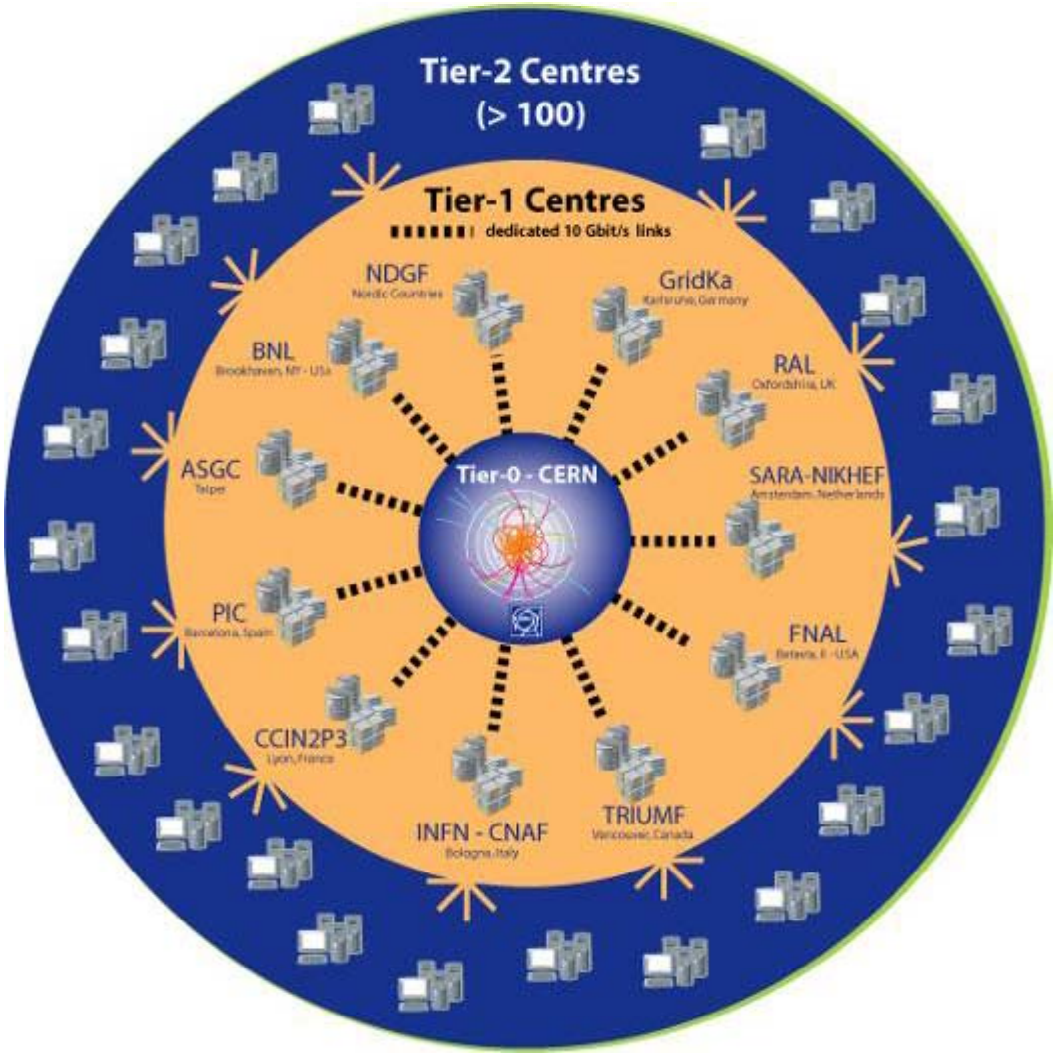
- The accelerator has been completed this year and will run for 10-15 years
- Experiments will produce about **15 Million Gigabytes** of data each year (about 20 million CDs!)
- LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**
- Requires many cooperating computer centres, as CERN can only provide ~20% of the capacity

10 Gbit/s link

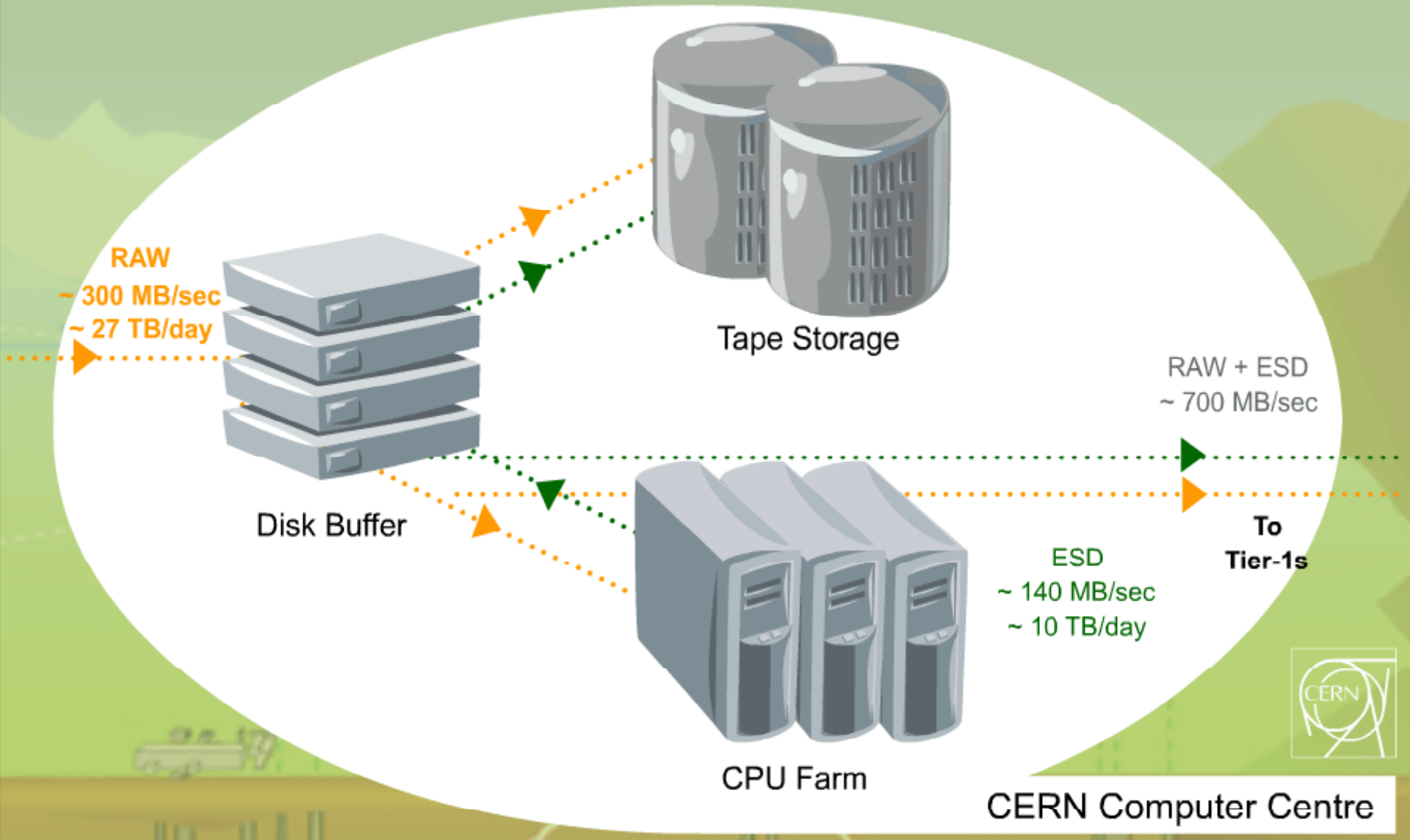

LCG
eGee
GridPP
UK Computing for Particle Physics
Statistics:
Submitted: 13
Waiting: 26
Ready: 554
Scheduled: 7792
Running: 9054
Done: 8764
Aborted: 640
Cancelled: 183
Active Sites: 142 : 27026
Developed by e-Science, HEP
Imperial College
London

LHC Computing Grid project (LCG)

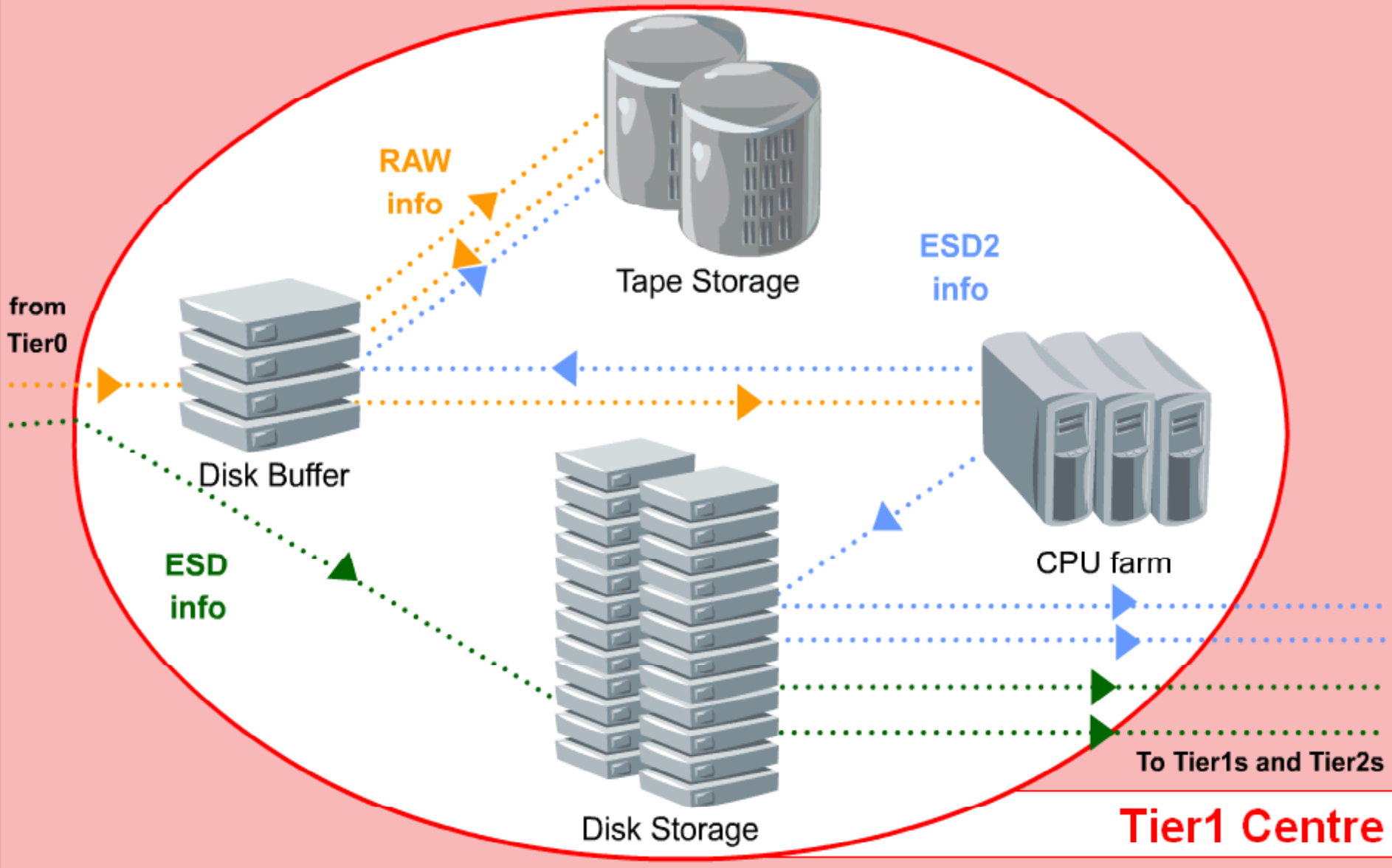
- More than 140 computing centres
- 12 large centres for primary data management: CERN (Tier-0) and eleven Tier-1s
- 38 federations of smaller Tier-2 centres
- 35 countries involved



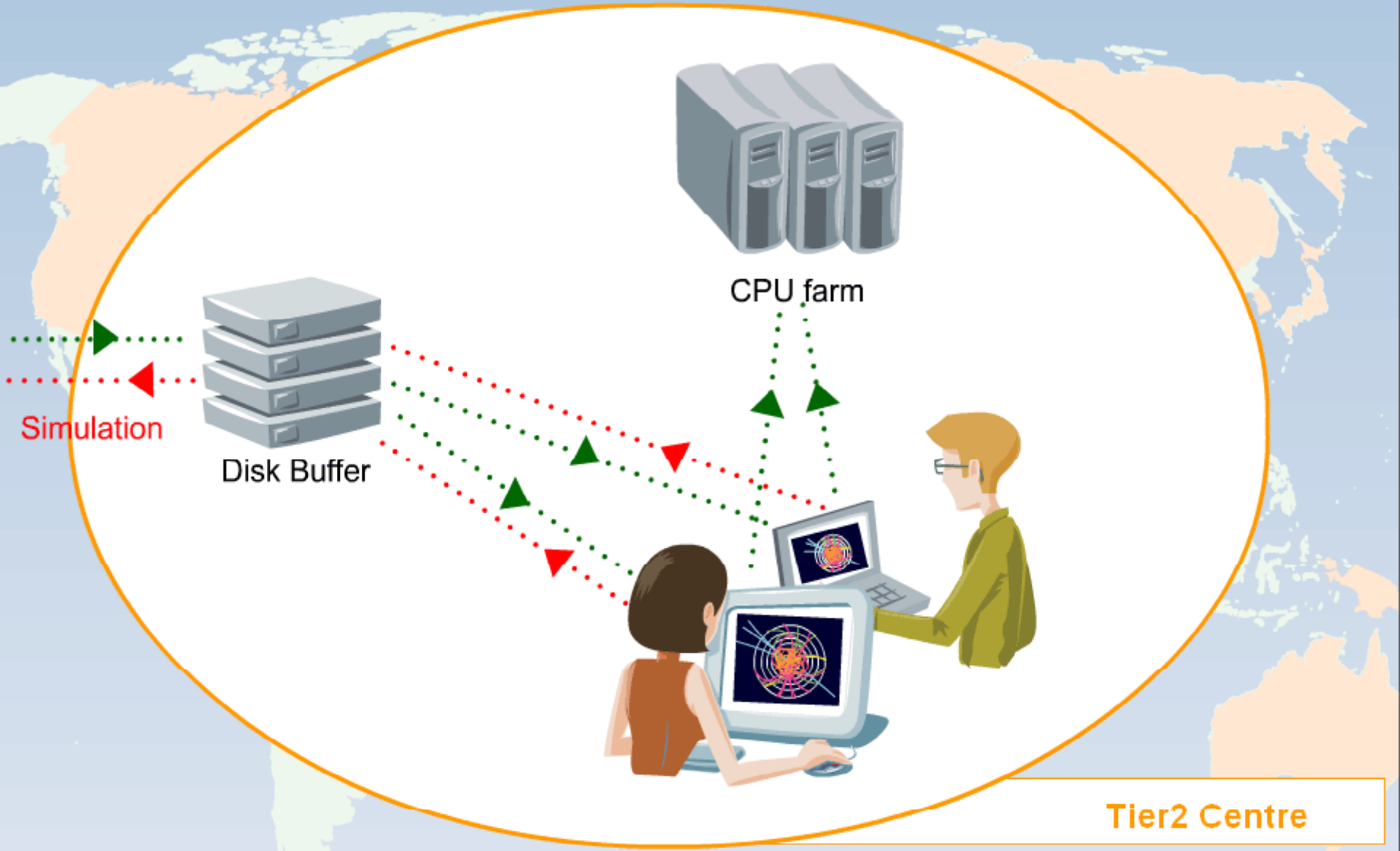
One Tier0 Centre (CERN)



Eleven Tier1 Centres



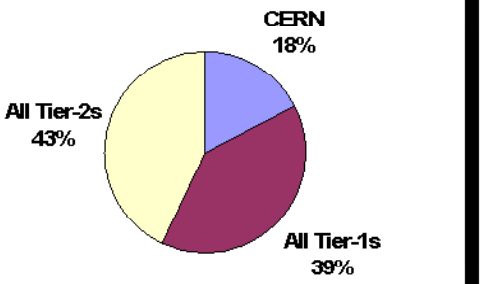
>100 Tier2 Centres



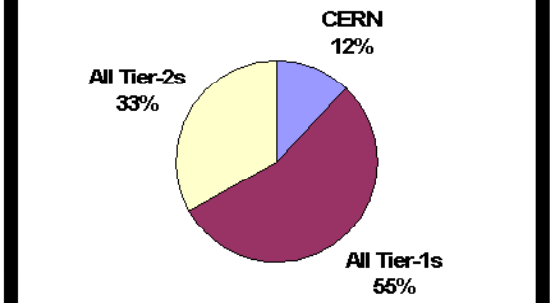
Resources needed for the LHC computing

[redacted]

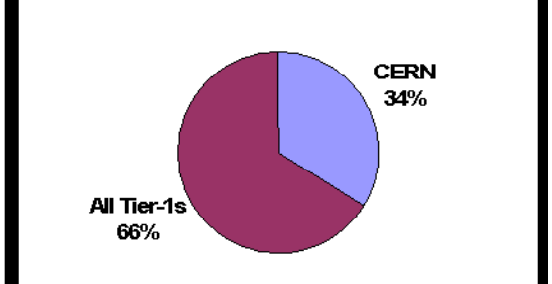
CPU



Disk



Tape



WLCG: Worldwide LHC Computing Grid

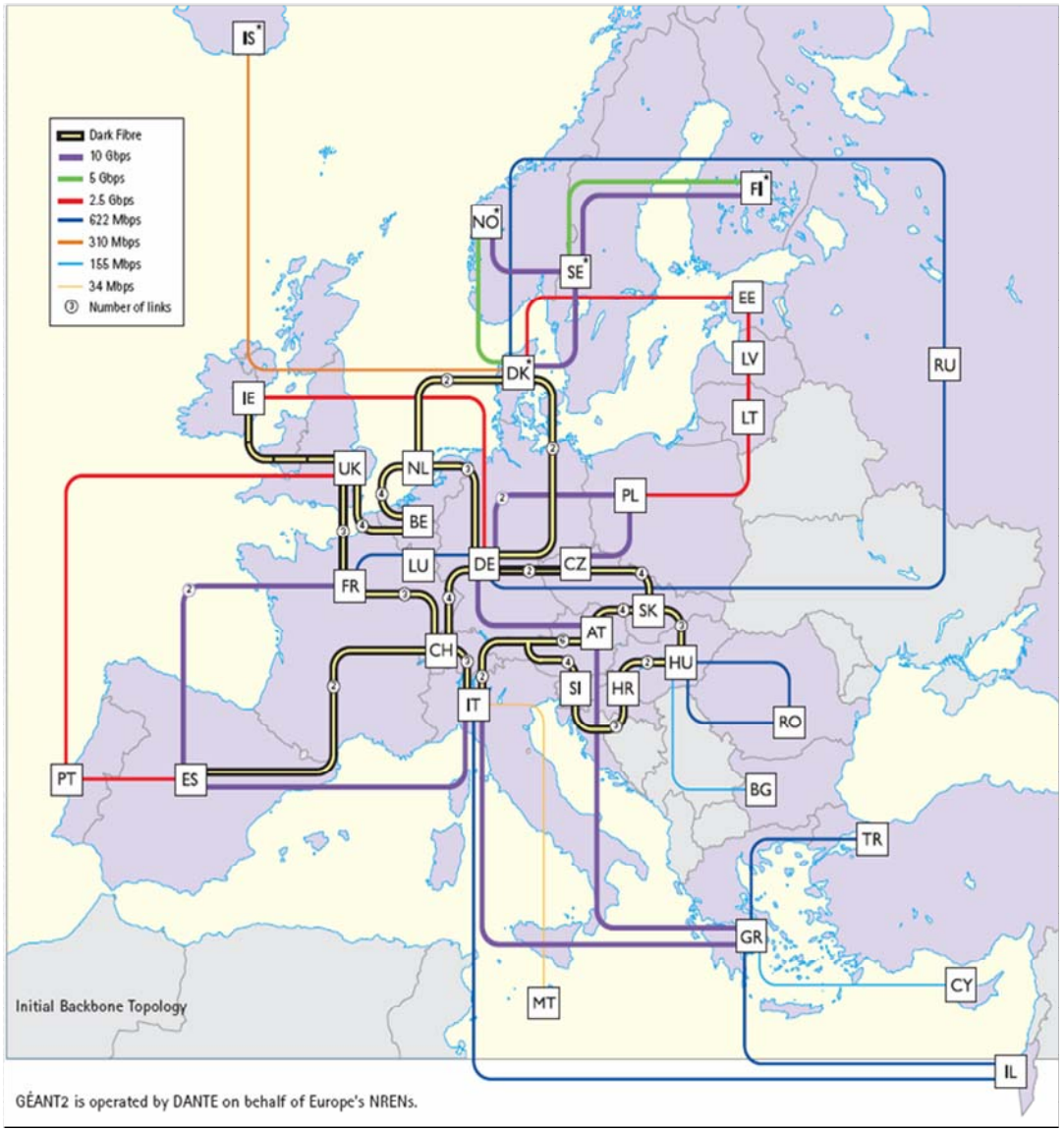
- Project to build and maintain data storage and computing infrastructure for LHC
- Uses infrastructure of several Grid organizations where 2 the biggest ones are
  - EGEE (founded by EC)
  - OSG (founded by US)

GridPP
UK Computing for Particle Physics

NORDUGRID
Grid Solution for Wide Area Computing and Data Handling

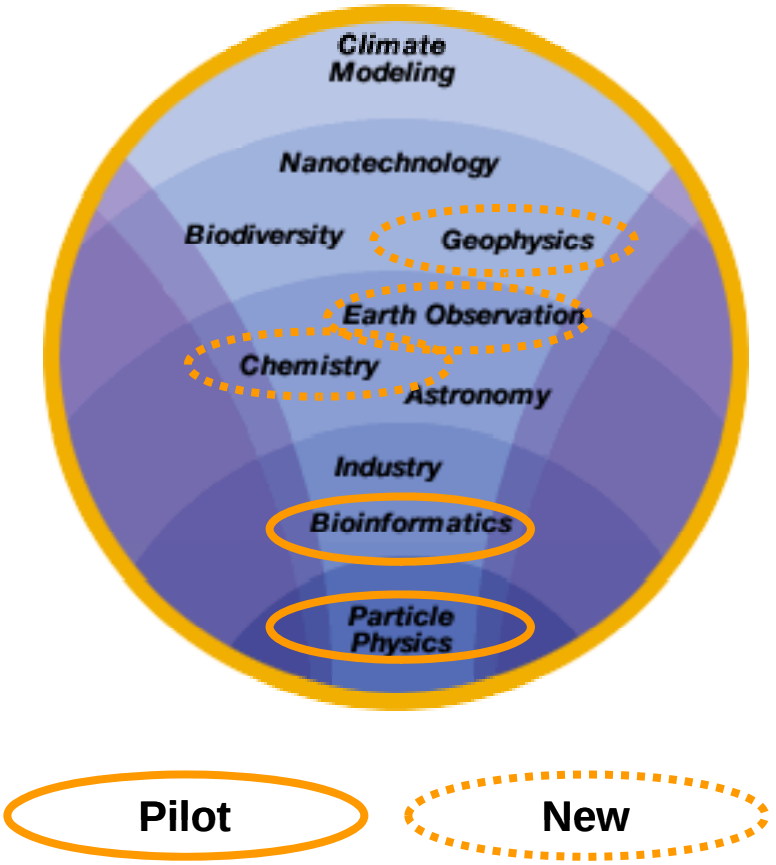
The Géant Research Network

- General purpose network connecting national research and education nets (NREN)
- For LHC in addition: Optical Private Network with 10Gb/s links over dark fibres



Enabling Grids for e-Science (EGEE)

- EGEE Scope : ALL-Inclusive for academic applications (open to industrial and socio-economic world as well)
- LCG has been the driving force for the European multi-science Grid EGEE (Enabling Grids for E-sciencE)
- EGEE is now a global effort, and the largest Grid infrastructure worldwide
  - Used by 10,000 users from at least 15 disciplines
  - Provided by 259 sites from 52 countries
  - over 72,000 CPU's
  - over 20 Petabytes (10^{15}) HDD storage
  - massive data transfer: 1.5 GB/s
  - between 30K and 150K jobs/day



EGEE Status July 2008

- **Infrastructure**
  - Number of sites connected to the EGEE infrastructure: 259
  - Number of countries connected to the EGEE infrastructure: 52
  - Number of CPUs available to users 24/7: ~ 72,000
  - Storage capacity available: ~ 20 PB disk + tape MSS
- **Users**
  - Number of Virtual Organisations using the EGEE infrastructure: > 200
    (this number is according to gstat)
  - Number of registered Virtual Organisations: >130
  - Number of registered users: >7500
  - Number of people benefiting from the existence of the EGEE infrastructure: ~14000
  - Number of jobs: >150k jobs/day
  - Number of application domains making use of the EGEE infrastructure: more than 15
    - Archeology
    - Astronomy & Astrophysics
    - Civil Protection
    - Computational Chemistry
    - Computational Fluid Dynamics
    - Computer Science/Tools
    - Condensed Matter Physics
    - Earth Sciences
    - Finance (through the Industry Task Force)
    - Fusion
    - Geophysics
    - High-Energy Physics
    - Life Sciences
    - Multimedia
    - Material Sciences
    - ... ***Further applications under evaluation***

Project

Duration: 24 months
European Commission contribution: 32,000,000 euro
Total budget: cca. 47,150,000 euro, with a further estimated 50,000,000 euro worth of computing resources contributed by the partners.
Total manpower: 9,010 Person Months, of which over 4,500 Person Months contributed by the partners from their own funding sources.

For the overall project metrics, please also refer to the Quality Assurance section.

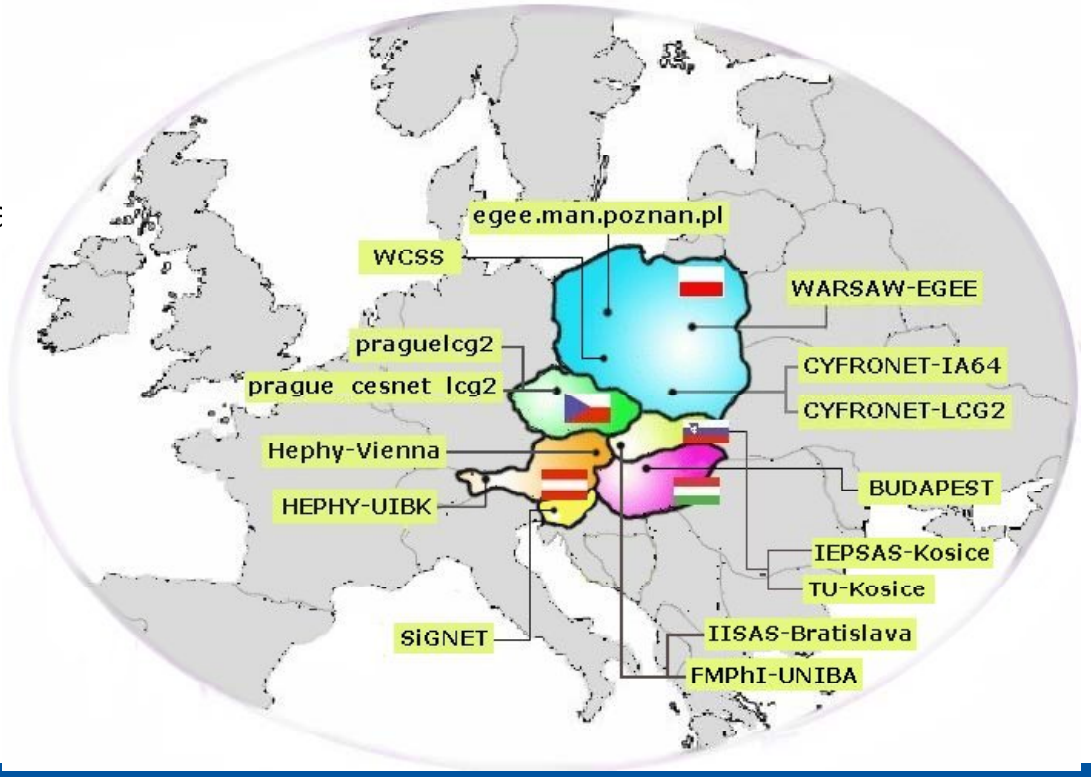
Problems suitable for grid computing

- Easy to divide into many sub-problems which can be solved asynchronously (parallelism)
  - Most of the grid applications are “embarrassingly parallel”
- Problems which involve a simple tasks which has to be repeated many times
  - E.g. all Monte Carlo simulations
- Requires large amount of data which follows the job
- Involves data which need to be shared

Central European Grid

- Central European (CE) Federation is one of 12 federations in EGEE project
- seven countries: Austria, Croatia, Czech Republic, Hungary, Poland, Slovakia and Slovenia.
- 10 EGEE-approved virtual organizations (VOs)
- Sites, around 10 000 CPUs
- 850 TBs

Source: http://goc.grid.sinica.edu.tw/gsta

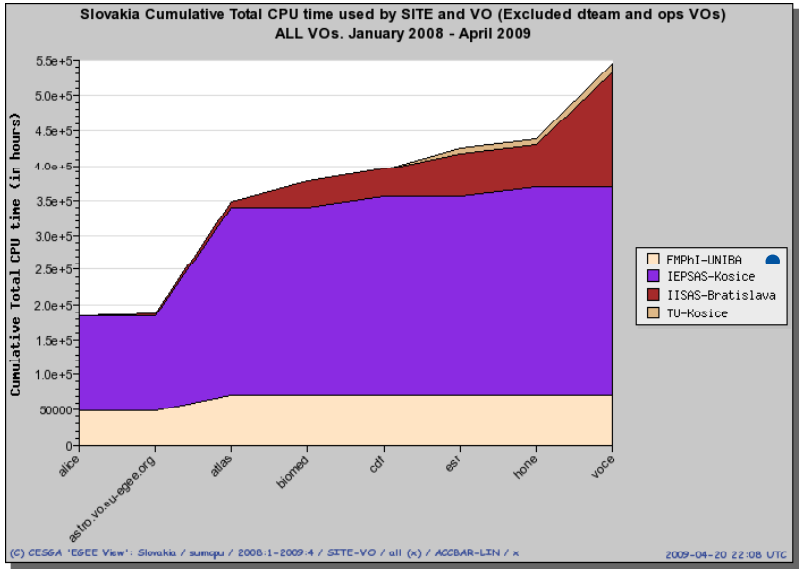


Slovak Grid infrastructure

- Slovakia is a federated Tier-2/3 HEP community
- Slovak Grid Initiative / www.slovakgrid.sk
- But there are also general purpose sites with wide VO support

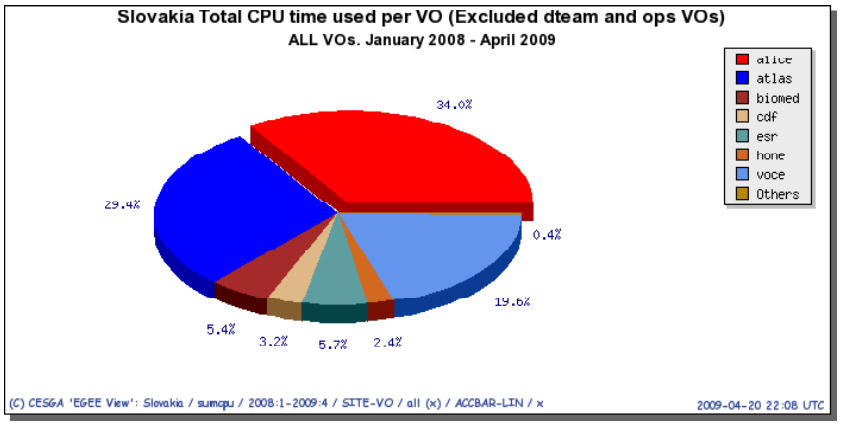
- FMPHI-UNIBA – ATLAS, ALICE
- IEPSAS-Kosice – ATLAS, ALICE, CDF, H1
- TU-Kosice – VOCE, BIOMED
- IISAS-Bratislava – ESR, VOCE, BIOMED

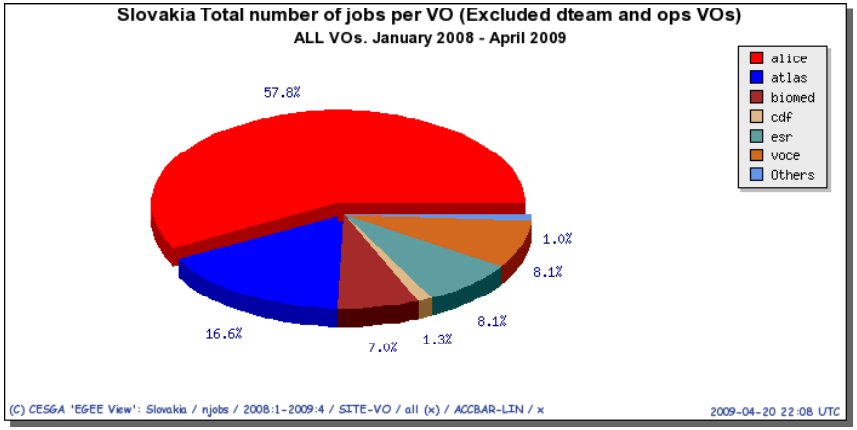
Slovak Grid activity



WLCG ran ~ 250k jobs in 2008 – workload has continued to increase

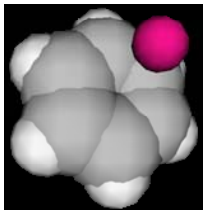
Main focus in supporting EGEE, LHC Grid (Alice, Atlas, ESR, Biomed)

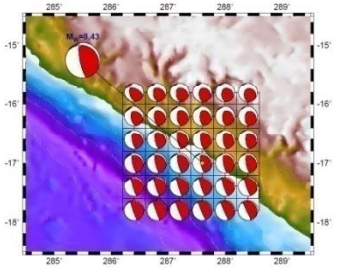


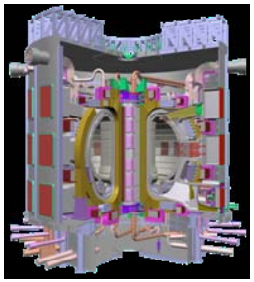


EGEE: Scientific disciplines

- Growth and diversification of applications.
- Reported apps. only ⇒ *underestimate!*





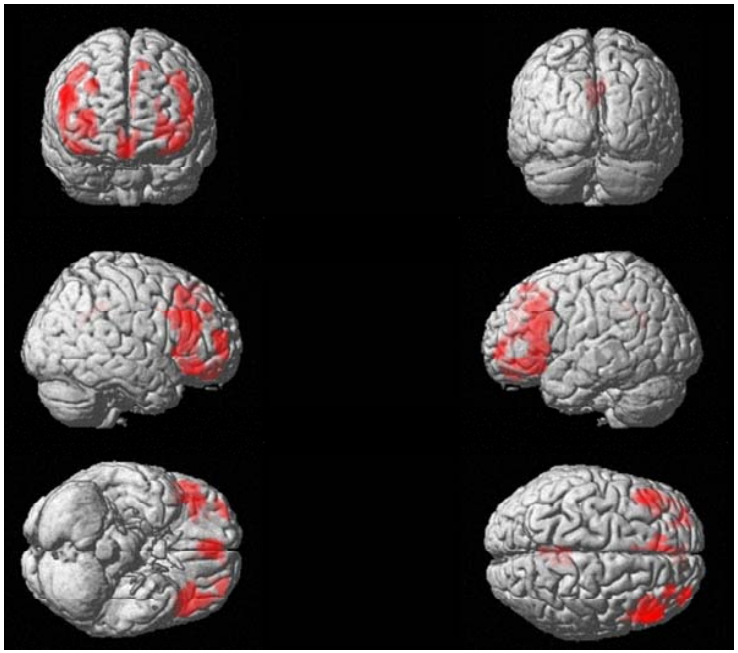


	6/2006	2/2007	1/2008
Astron. & Astrophysics	2	8	9
Computational Chemistry	6	27	21
Earth Science	16	16	18
Fusion	2	3	4
High-Energy Physics	9	11	7
Life Sciences	23	39	37
Others	4	14	21
Total	62	118	117

Condensed Matter Physics
Comp. Fluid Dynamics
Computer Science/Tools
Civil Protection
Finance

SPM: Alzheimer's disease evaluation

- Statistical Parametric Mapping (SPM) – powerful but difficult to use
  - Need of huge amount of data –> sharing instead of building own repositories
  - Computational power needed to achieve results fast enough

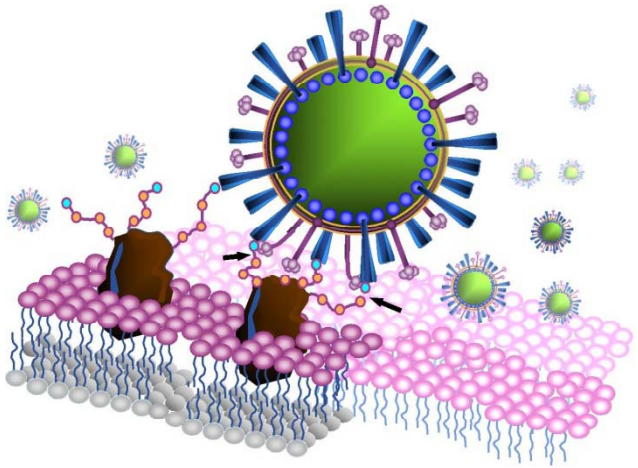


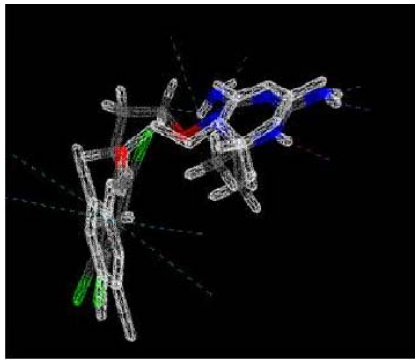
WISDOM: In silico drug discovery

April 2006, Asian and European labs analysed 300K possible drug components against the H5N1 virus using EGEE infrastructure

- 2000 computers for 4 weeks
- (equivalent of 100 years on a single computer)

Preparation for the second run are ongoing





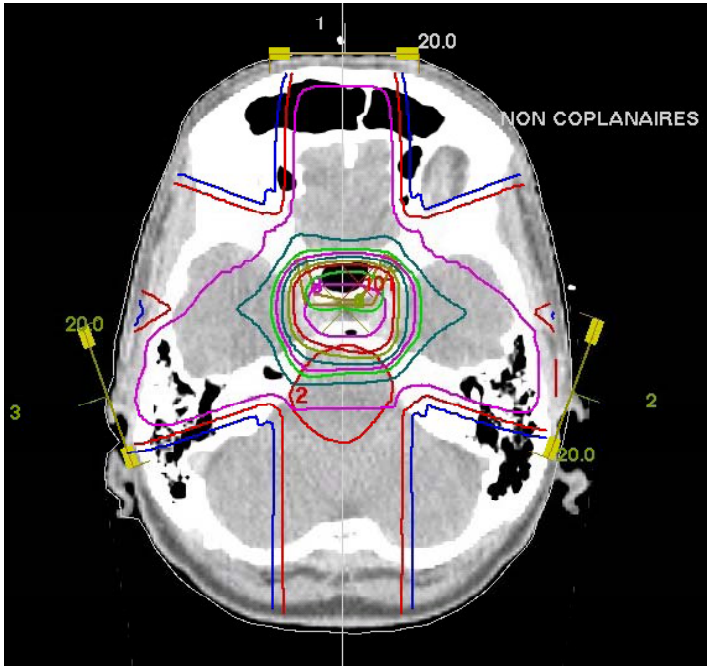
October 2006 – January 2007, the same analysis for malaria resulted in 140 million dockings (80 000 per hour)

- 5000 computers for 2.5 month (equivalent of 420 years on a single computer)

WISDOM
Initiative for grid-enabled drug discovery against neglected and emergent diseases

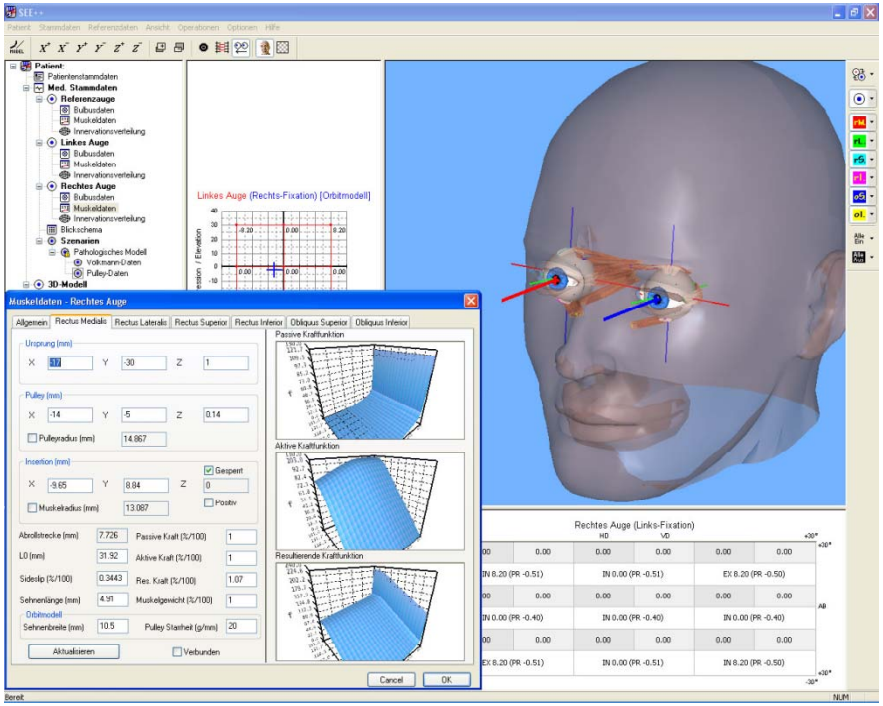
GATE: radiotherapy planning

- Goal is to improve accuracy of the treatment of cancer by ionizing radiations of the tumours
- Therapy planning is computed from the MR (Magnetic Resonance) scans
  - Tumours are accurately located in 3D
  - Radiation doses needed to be applied are computed
- Due to the Monte Carlo approach – very easy to divide in the parallel



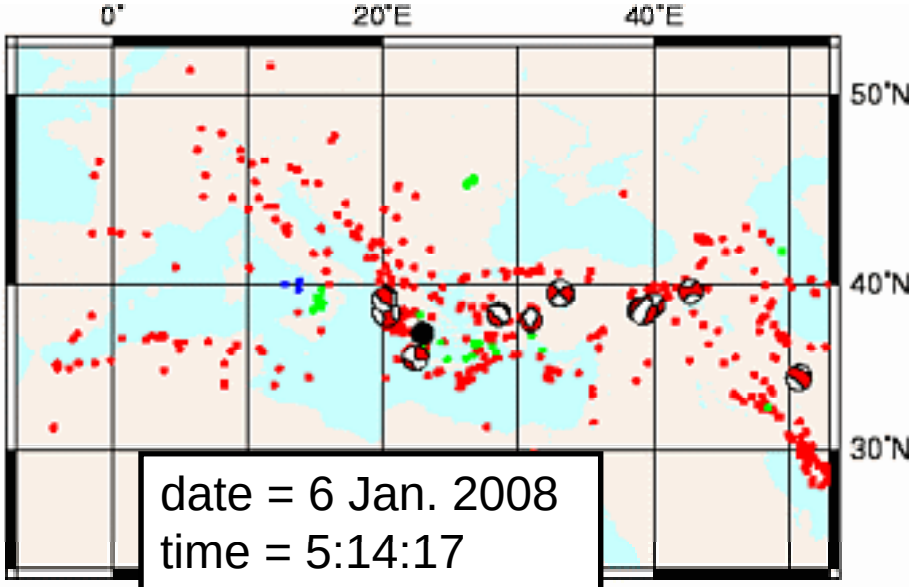
SEE++: Virtual Eye Surgery

- Simulation system that aims at the forecast of clinical operation results
- Used to simulate pathologies and evaluate possible treatments
- User presentation on the client -> computation in the Grid

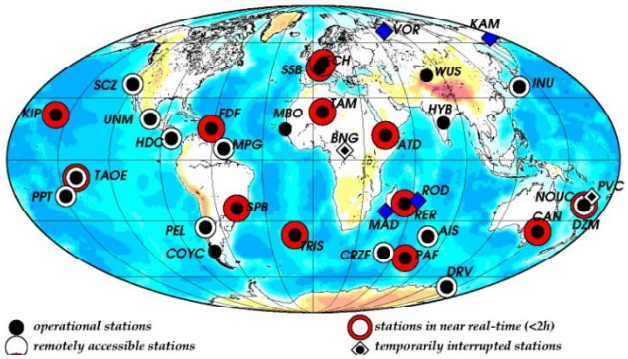


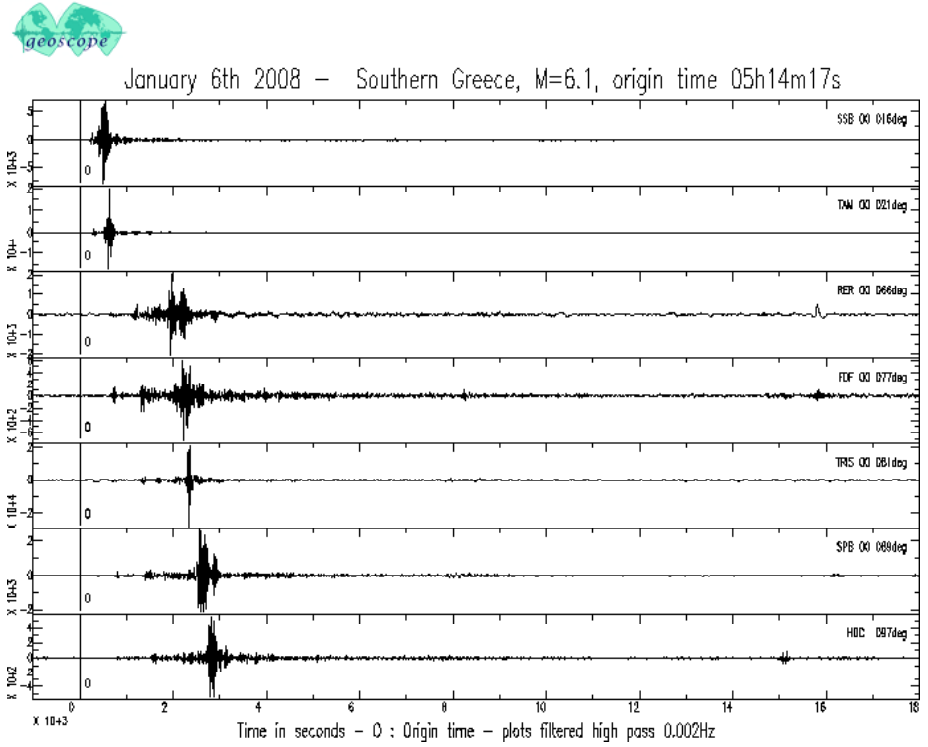
GEOSCOPE: determine the earthquake source

- Localization of earthquakes
- Determination of rupture modes of the faults
- Results within a few hours of major earthquakes



date = 6 Jan. 2008
time = 5:14:17
depth = 50.9 km
magnitude = 6.1
latitude = 37.150°
longitude = 22.934°





The Grid = SETI@HOME ???

- The GRID
  - Reliable computer centres
  - Hardware and software
    - Dedicated,
    - Static,
    - Fully controlled
  - costs
- SETI@HOME
  - Home PCs
  - Hardware and software
    - Heterogeneous
    - Shared
    - Dynamic
  - “for free”

Who pays for the grid?

- Grid is like World Wide Web
  - created for scientific purpose
  - subsidized by the institutions that use it
- There is a sophisticated accounting software which tracks resource usage in the Grid
  - But it is used rather to track kind of bartering – I let you use my resources if you let me use yours
  - But money is a simple way to track bartering deals, so probably one will pay real money to use grid in the future!

Commercial Software

- Gaussian
  - http://www.gaussian.com/
  - Predicts the energies, vibrational freq., … of molecular systems.
  - VO-based licensing model, actually in use in gaussian VO.
- MathWorks
  - http://www.mathworks.com/
  - Integrate MATLAB & Distributed Computing Engine with EGEE.
  - Both client and server are licensed in this model.
- Interactive Supercomputing
  - http://www.interactivesupercomputing.com/
  - Similar to DCE; used from multiple clients (MATLAB, Python, R)
  - Server licensed, some clients licensed

More information about the Grid:

- GridCafe (www.gridcafe.org)
- EGEE (www.ce-egee.org), LHC Grid (www.cern.ch/lhc)
- Slovak Grid (www.slovakgrid.sk)
- Cloud computing
- Amazon EC2, Google Web Apps, etc.

More information about the Web:

- Wolfram alpha project
- Semantic Web
  - Linked Data

Spongecell
Jyla
kiko
Trumba
eskobo
mayomi
Pageflakes
vimeo
skobee
shadows
grovee
YouTube
Zimbra
LookSmart FURL | Your Personal Web File
smugmug
newsgator
Blogniscient
TiNFINGER
shutterfly
feedia
PodDater
Feedster
favoor
Planzo.com
ZAZZLE
Tailrank
TagWorld
nuvvo
dogear
yakalike
grouper
ODDPOST
QOOP
iNods
Lulu
BR
blish
flagr
FireAnt
simplyhired
veoh
theadcloud
rbloc.com
gather
Agatra
browsr
oyogi
cafepress
Renkoo
standpoint
pixagogo
meebo
EXTRA TASTY!
last.fm
Jotspot
Frappr!
jeteye
dabble
YEDDA
Writeboard
SHOUTWIRE
iKarma
RaNOODLE
AirSet
techmemeorandum
CalendarHub
Suprglu
PIECING YOUR WEB TOGETHER
pando
zigtag
Findory
backfence
clipmarks
wayfaring
gOFFICE
AllPeers
Rallypoint
Zoozio
blogbeat
Ziggs
zoto
vSocial
Boltfolio
wink
riya
Audible Wordcast
Opinity
reddit
measuremap
gumshoo
bluepulse
STREAMLOAD
Ta-da Lists
FeedSky
jellyBarn.INC
nativetext
CONGOO
PODZINGER
RSS MAD
FeedTier
phanfare
Fruitcast
PubSub
dPolls
flickr
Ning
Ookles
Strongspace
zoominfo
CASTPOST
WIKIPEDIA
yubnub
AC
BLOOP
ProjectSpaces
FeedBurner
Bloglines
purevolume.com
FOTOLOG
ourmedia
gabbr.com
Gcast
blinkx
openomy
riffs
ajchat
Yub.com
Spot Runner
myspace
NewsAlloy
Allmydata.com
chatsum
PANDORA
looklater
jambo
PROTOPAGE
ROLLYO
ClipShack
squishr
WebJay
PLAZES
Noodly
30 BETA
wondir
diigo
box
Jots
Xdrive
vizu
digg
del.icio.us
omni drive
AlmondRocks
Tagyu
30GIGS
writely
Simpy
Gtalkr
TRUVEO
egoSurf
mozy
Quimble
pegasus
remember the milk
SQUIDOO
picturecloud
newsvine
Clipfire
Basecamp
Netvibes
gOOwy
My Videokaraoke
Lexxe alpha
powered by advanced natural language technology
OOKSTER
PXN8
measuremap
facebook
43 Things
Technorati
Platial
Backpack
Gmail
yelp
Smarkets
inform
filangy
magnolia
ShoZu
wrickr.com
feedmarker
mercora MusicSearch
Meet With Approval.com
HOMEPORTALS
Spin spy (beta)

Summary

- World Wide Web – born at CERN - elaborate set of interlinked documents accessible over the Internet
- Grid computing
  - infrastructure that provides seamless access to computing power and data storage
  - Suitable for problems that need huge/shared data, must run in parallel or need to be run frequently
- EGEE – largest existing Grid infrastructure (academic)
- Slovak Grid Initiative
- Many existing applications besides high energy physics