The supercomputer for particle physics at the ULB-VUB computing center

P. Vanlaer
Université Libre de Bruxelles
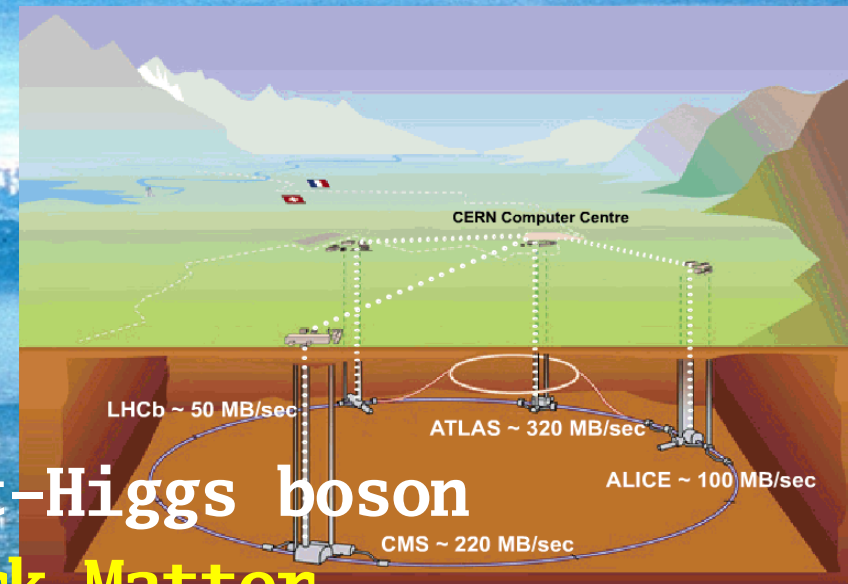**Interuniversity Institute for High Energies (ULB-VUB)**

Tier-2 cluster inauguration
ULB, May 8, 2009

The Large Hadron Collider at CERN

- Search for the Brout-Englert-Higgs boson
- Search for the nature of Dark Matter
  - Supersymmetry?
- Search for clues of unification of gravity and the other interactions
  - Extra space dimensions? Micro black holes?
- ...
- Made possible by unique accelerator characteristics
  - Factor >5 jump in collision energy
  - Factor 100 jump in beam luminosity

The Large Hadron Collider at CERN
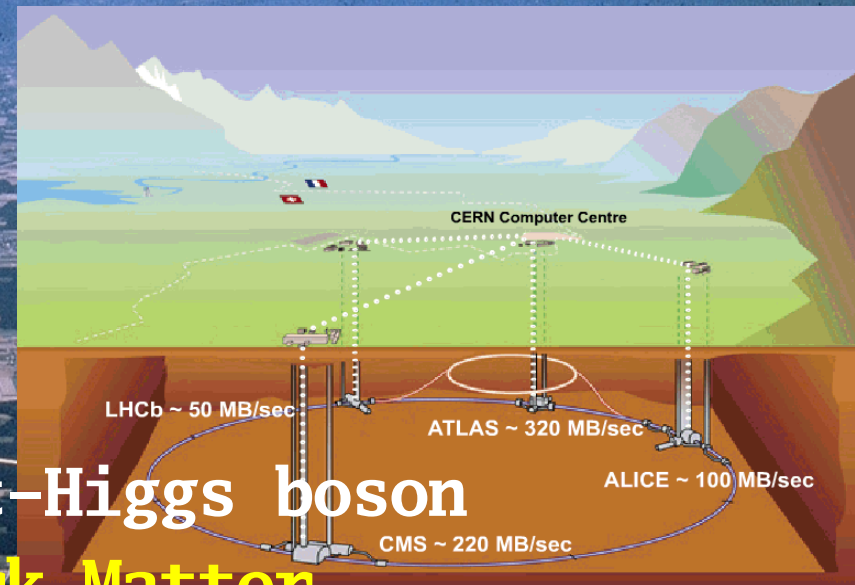
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The Compact Muon Solenoid (CMS)
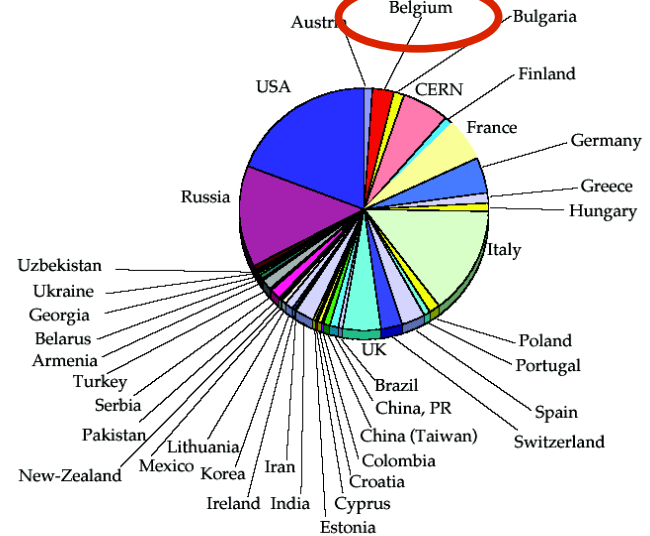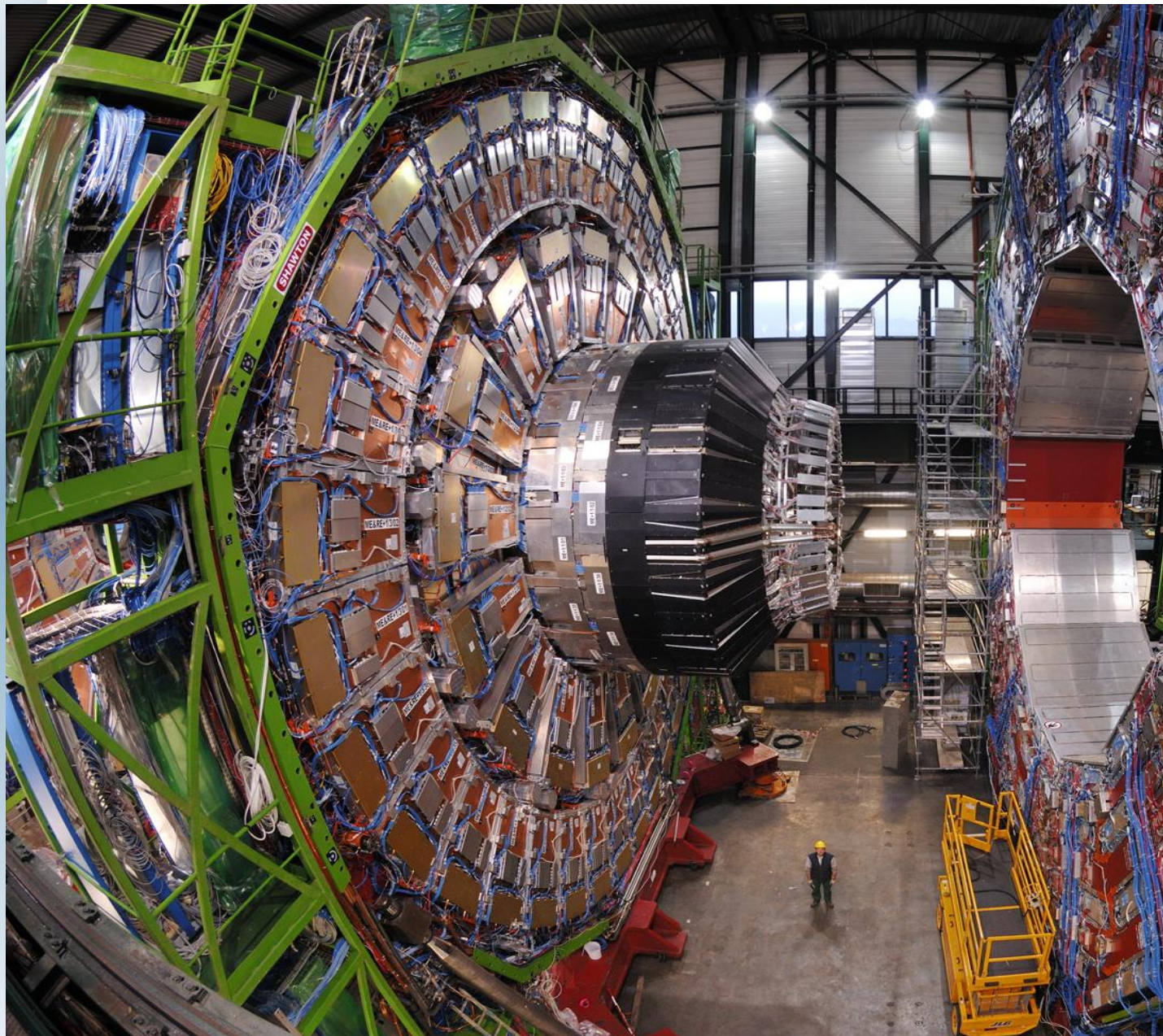
2310 Scientific Authors
38 Countries
175 Institutions

Contributions of ULB-VUB

- **Interuniversity Institute for High Energies (ULB-VUB together with U.Antwerpen) contributes**
  - To central tracker (>200 m^2 of silicon sensors) since 1992
  - To muon system (resistive plate chambers) since 2000

1800 silicon detectors assembled in Brussels (15.000 in total)

Silicon tracker endcap
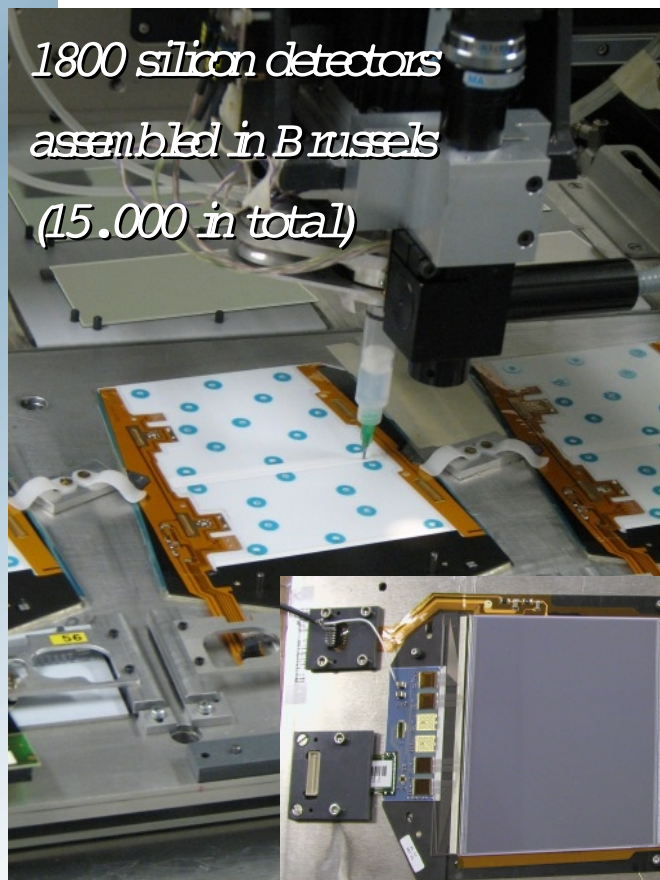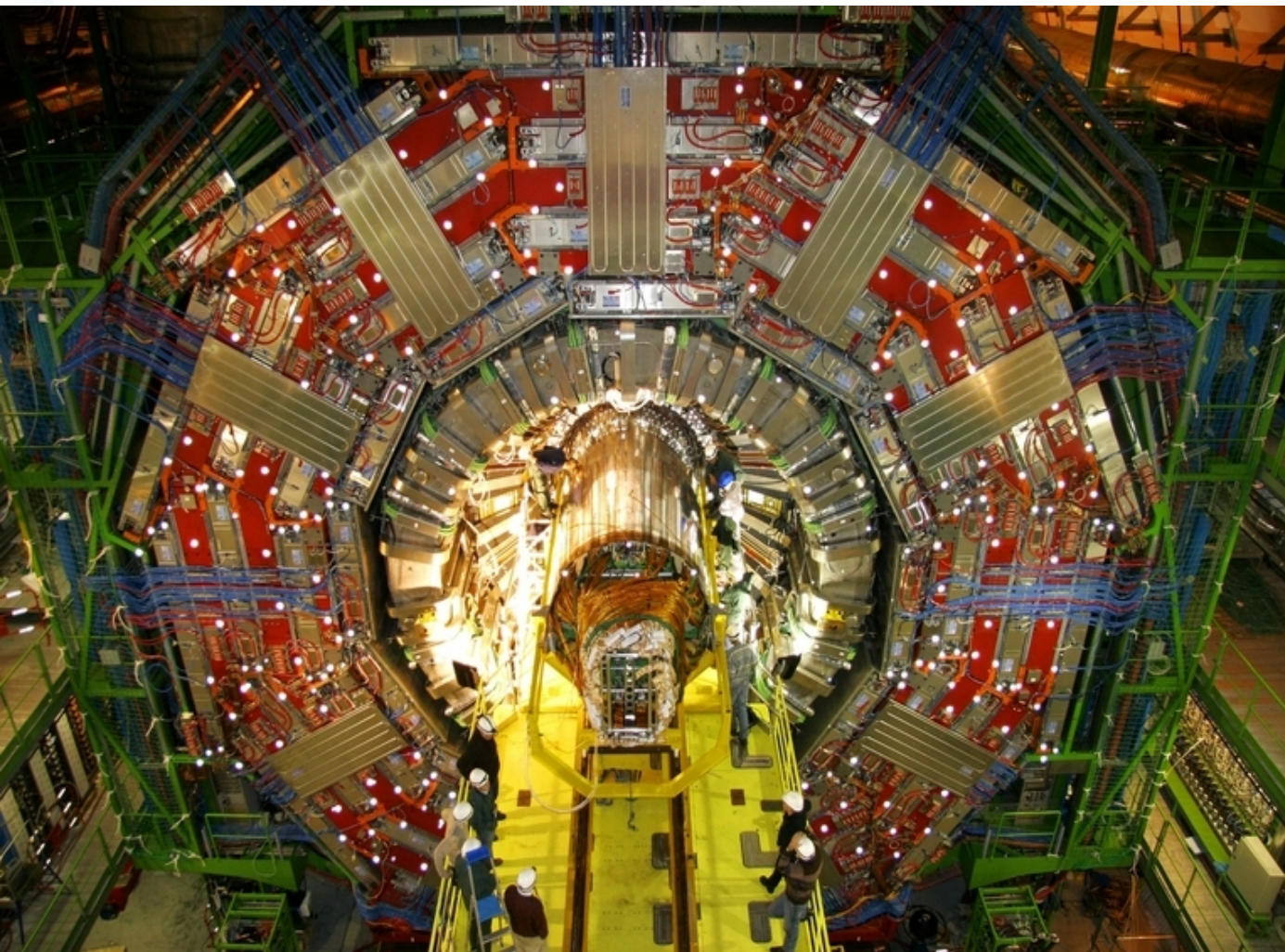
Insertion of central tracker in CMS, December 2007
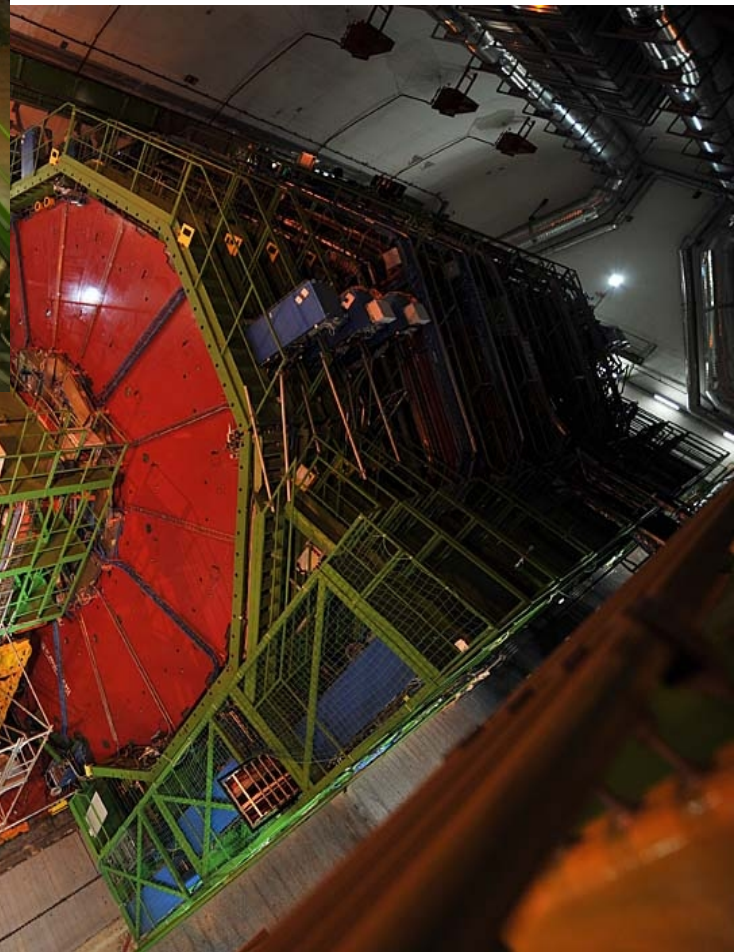
CMS closed and ready for beam, September 3, 2008

P. Vanlaer (ULB)   Tie

CMS in operation

Cosmic rays

$600 . 10^6$ collected

Run 66748, Event 8860756, LS 160, Orbit 1667

Muons from beam dump

Run 62063, Event 1534

CMS
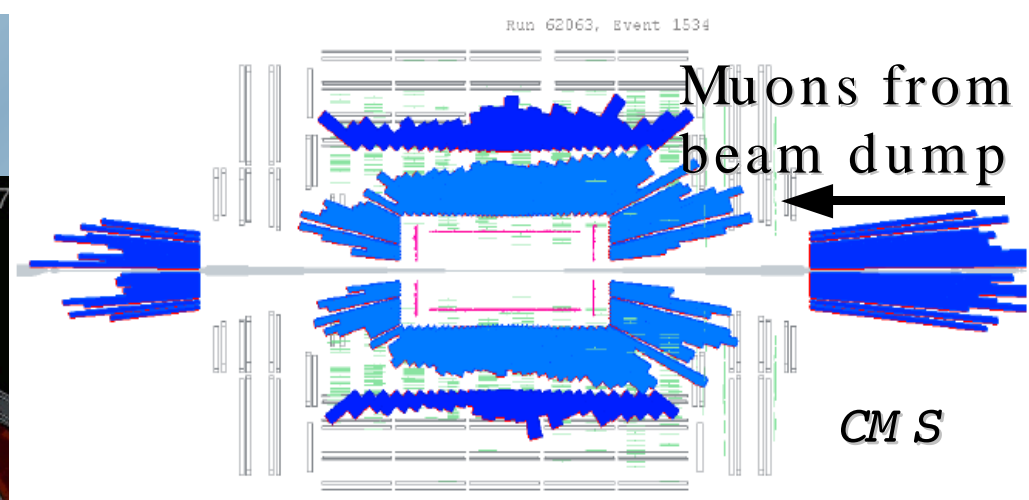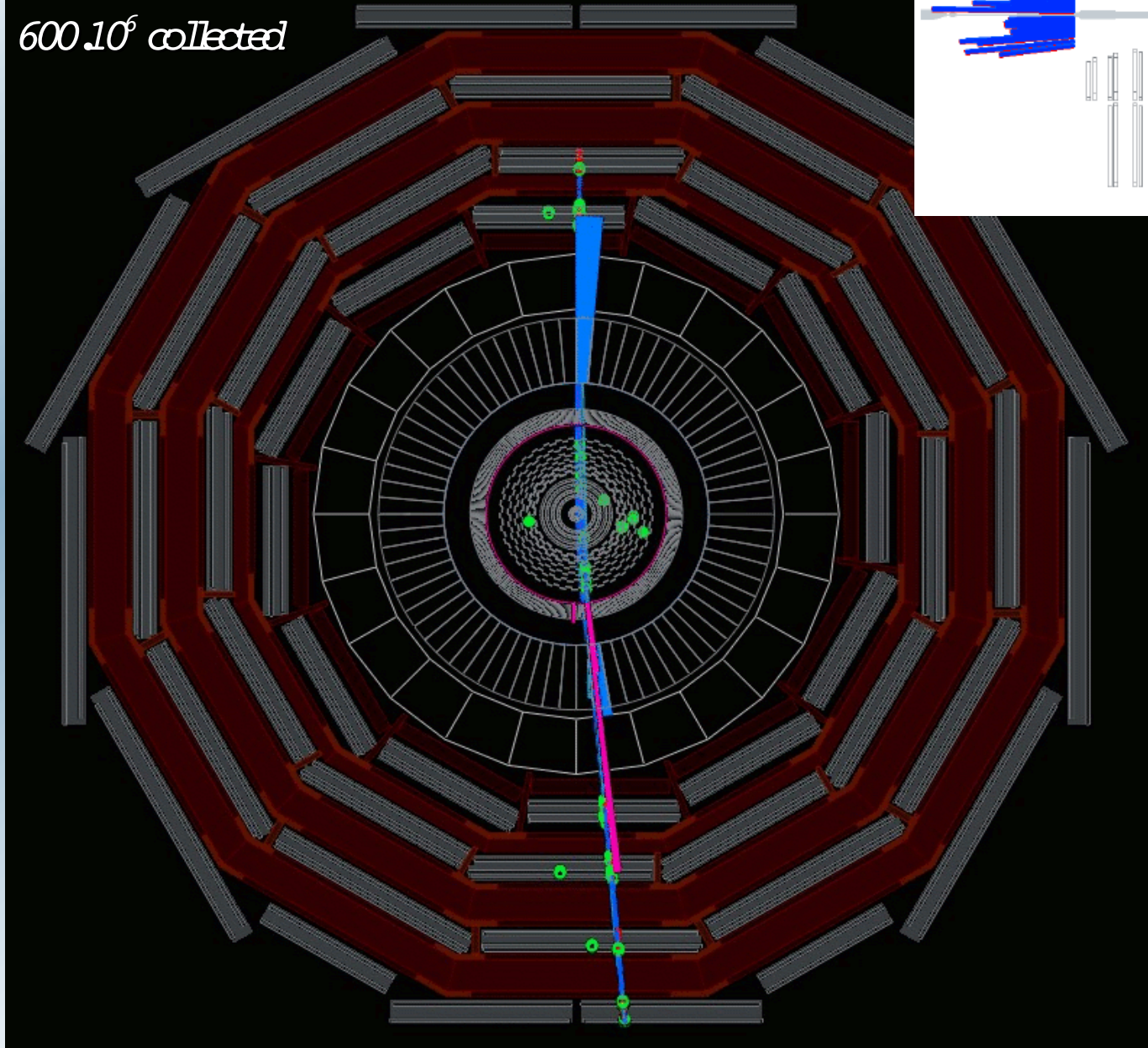
First LHC beam, September 10

ATLAS

event 2627

LHC-b

Alice
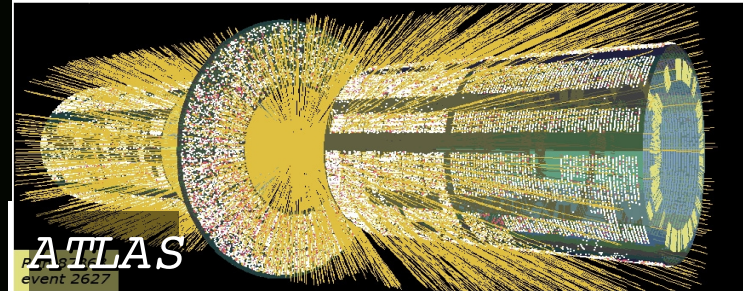
P. Vanlaer (ULB)   Tier-2 cluster inauguration, ULB,
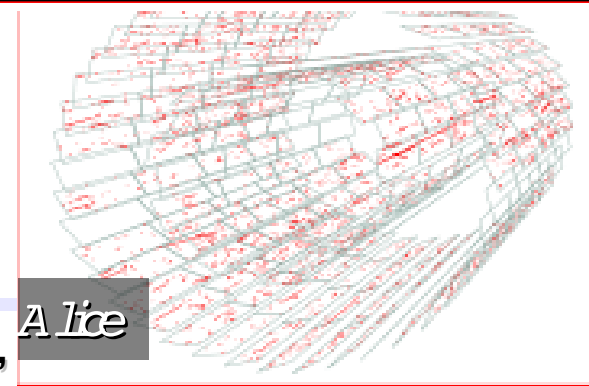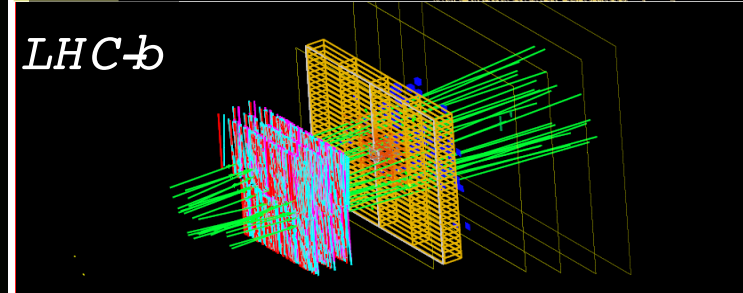
Worldwide LHC Computing Grid (W-LCG)

- **LHC data processing is a challenge**
  - 10^9 events/year/experiment
  - 100,000 processors
  - 15 million Gigabytes of disk/year
  - 20% resources provided by CERN
- **The Grid is an infrastructure that provides seamless access to computing power and data storage capacity distributed over the globe**
  - As the World Wide Web provides seamless access to information stored in million different locations
- **Distributed, heterogeneous resources connected by the Internet are put in common**
  - Through a software interface
    - Grid middleware
  - Transparent for the users
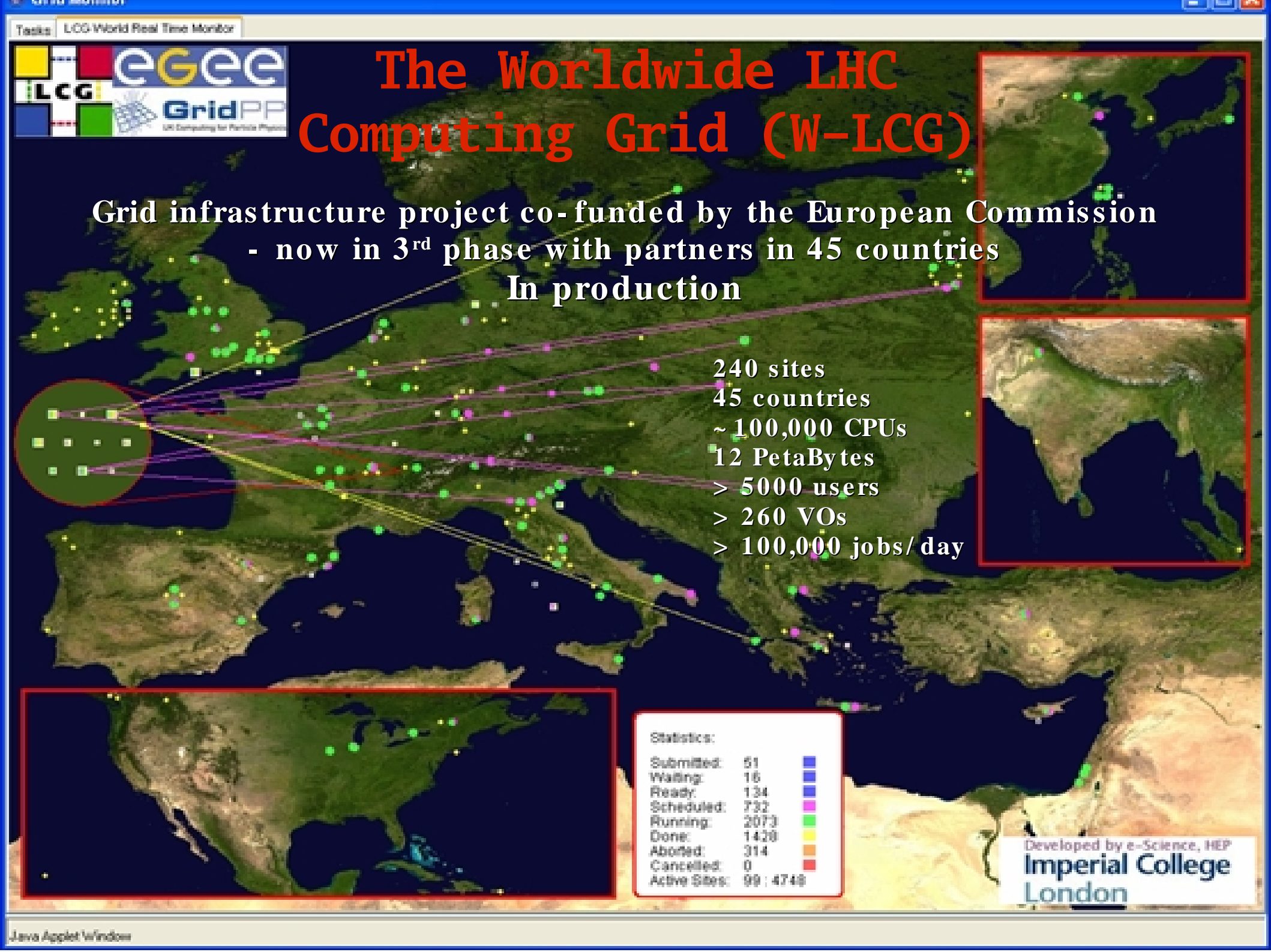
The Worldwide LHC Computing Grid (W-LCG)

Grid infrastructure project co-funded by the European Commission
- now in 3rd phase with partners in 45 countries
In production

240 sites
45 countries
~ 100,000 CPUs
12 PetaBytes
> 5000 users
> 260 VOs
> 100,000 jobs/day

Statistics:

Submitted:	51	
Waiting:	16	
Ready:	134	
Scheduled:	732	
Running:	2073	
Done:	1428	
Aborted:	314	
Cancelled:	0	
Active Sites:	99 : 4748	

Developed by e-Science, HEP
Imperial College
London

CMS hierarchy of computing centers

Prompt processing

CERN
TIER-0

CERN
Analysis
Facility
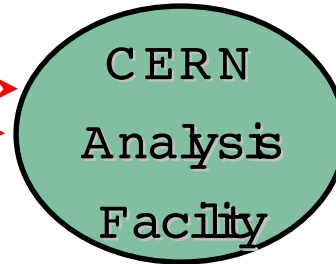
Calibration
Data Quality
Monitoring

600MB/s

50-500MB/s

TIER-1
Germany

TIER-1
Italy

TIER-1
France

Reprocessing,
Subsamples
for analyses

50-500MB/s

TIE TIE TIE
TIER-2
Belgium

Simulations
Analysis

CMS Preliminary
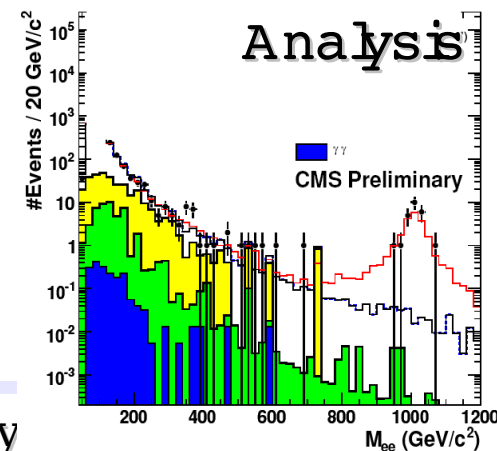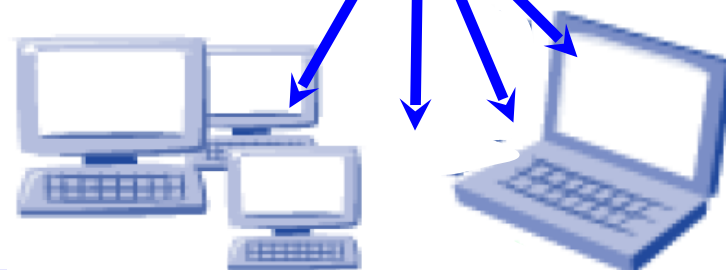
The Belgian Tier-2

- Joint project of particle physics groups from **ULB, VUB, UA, UMH, UCL, UGent**
- Funded by **F.R.S.-FNRS, FWO, Vlaams gemeenschap and ULB for a total budget of 1.5 MEuros**
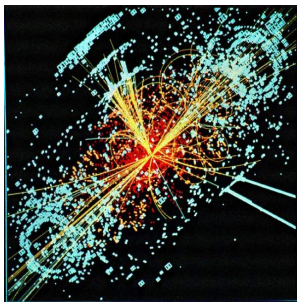- Federation with 2 sites
  - ULB-VUB Computing Center
  - CISM (Louvain-la-Neuve)
- Serving ~70 physicists in Belgium
- Staff at IIHE:
  - 3 persons (2 FTE) at ULB-VUB: Shkelzen Rugovac, Stephane Gerard (ULB), Olivier Devroede (VUB)
  - Key contributions also from:
    - Othmane Bouhali (ULB), on leave of absence for computing center of University of Qatar
    - Stijn De Weirdt, now at the Vlaams Supercomputing Center

The IIHE cluster

CPU:
- 148 cores from BEgrid in 32 physical nodes for 1.3 Tflops
- 276 cores from CMS in 47 physical nodes for 2.6 Tflops
- 424 cores in total in 79 physical nodes for 3.9 Tflops

Disk:
- 260 TB for CMS

**Will increase by factor 4 until 2011
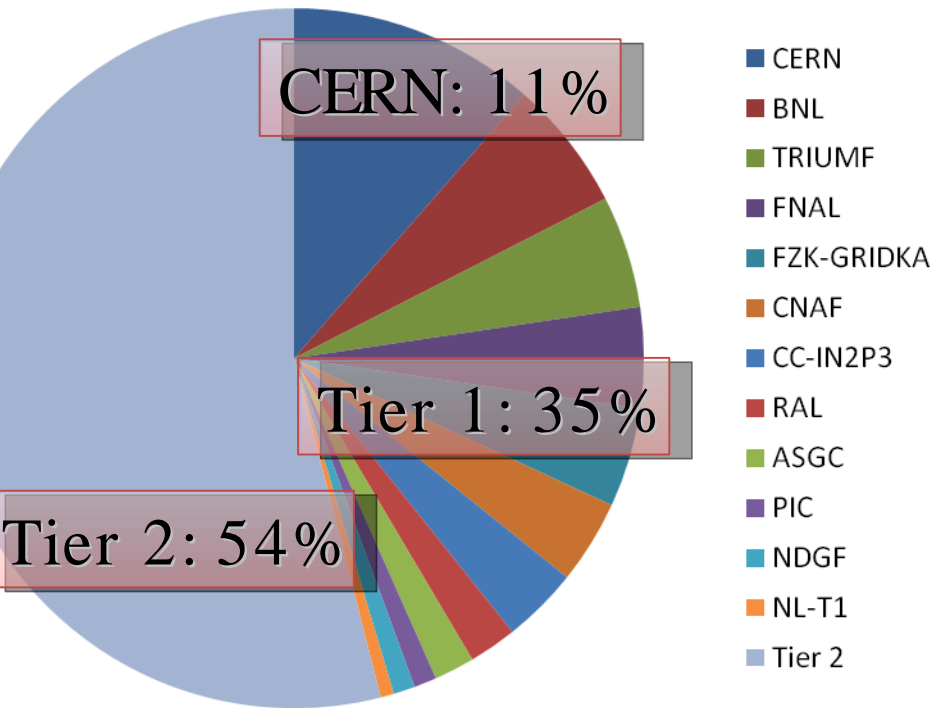(full LHC intensity)**

Partnership with BELNET Grid project BEgrid

Picture of cluster

Implantation at the ULB-VUB computing center

- **Critical infrastructures were available**
  - High bandwidth to GEANT research network
    - 1 Gb/s to CERN and other Tier-1 centers
  - Cooling and air conditioning
    - Expected heat dissipation ~40kW in 2011
  - High power electric lines
  - Protection against power glitches
- **Scale savings**
  - Use of spare cooling power at ULB-VUB computing center
  - Common investment in larger power glitch protection (UPS)
- **Sharing of responsibilities**
  - Computing Center: infrastructures, firewall
  - IIHE: cluster deployment, software deployment, user support

The LHC Grid at work

CPU Usage Early 2008

- CERN: 11%
- Tier 1: 35%
- Tier 2: 54%

Legend:
- CERN
- BNL
- TRIUMF
- FNAL
- FZK-GRIDKA
- CNAF
- CC-IN2P3
- RAL
- ASGC
- PIC
- NDGF
- NL-T1
- Tier 2

Average data transfer volume

[courtesy of L. Tuura]

Required burst level 1st year

2007 2008

Terabytes per day

10.0

1.0

0.1

2004-01   2005-01   2006-01   2007-01   2008-01

■ DC04 ■ SC2 ■ SC3 ■ SC4 ■ CSA06 □ Debug ■ Load test ■ General

3%of world grid resources at ULB- VUB

BEgrid-ULB-VUB

overall site status	ok
29 Apr 2009 14:53 GMT	
CE	ok
SRMv2	ok
sBDII	ok
Total CPUs:	372

UKI · NorthernEurope · Italy · CERN · SouthEasternEurope · GermanySwitzerland · France · AsiaPacific · SouthWesternEurope · Russia

Latest SAM results, Site Status, for 'OPS' VO, 29 Apr 2009 14:53 GMT.

Maint · Down · Degraded · Ok
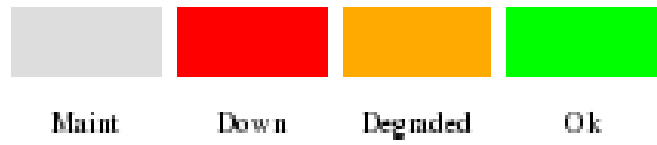
Performance of IIHE cluster

jobs per activity

~ 45.000 jobs per month

iihe Traffic

Gbit/s inbound and outbound

Inbound	Outbound
Peak Inbound	Peak Outbound

Inbound : Max 47.6 M 5% — Avg 2.7 M 1% — Last 279.0
Outbound : Max 989.0 M 99% — Avg 107.3 M 11% — Last 12.5

100% Bandwidth (1000 Mb/s)

Quality Ranking for T2 Site Readiness last 30 days
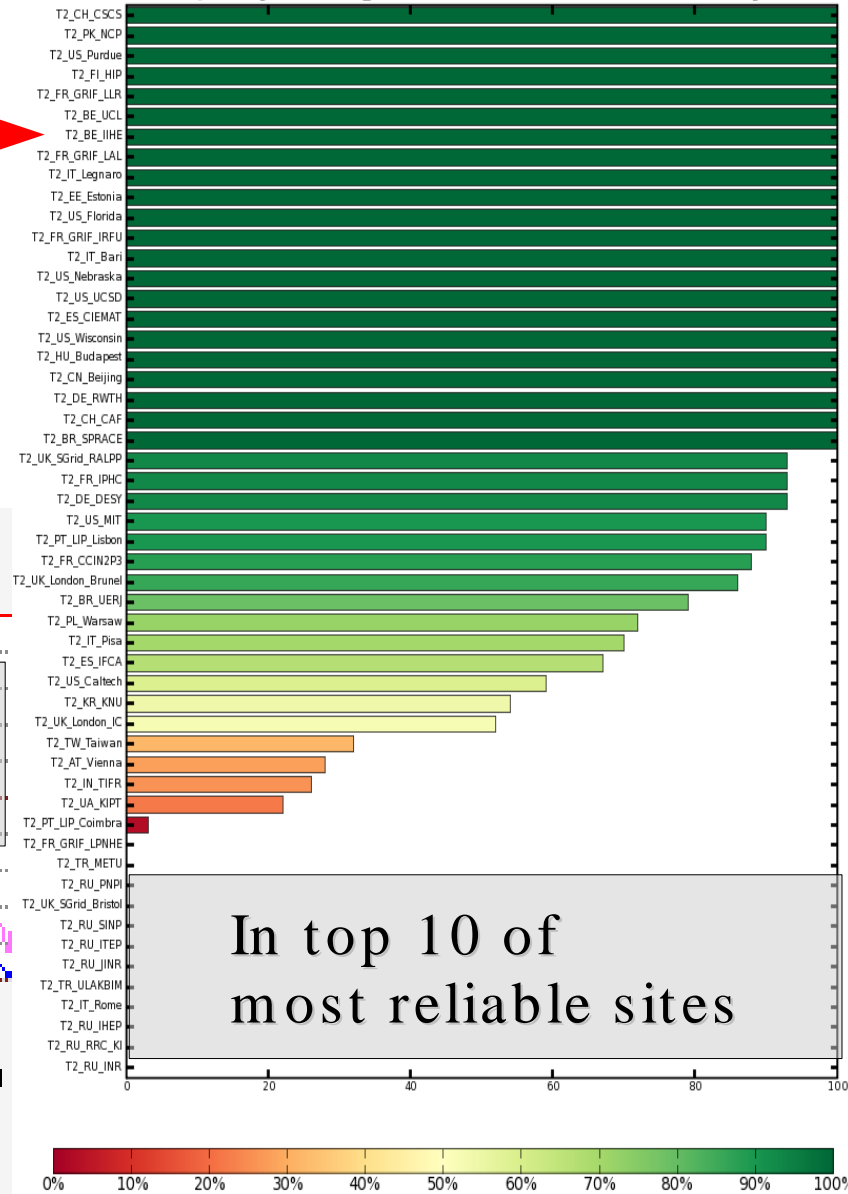
In top 10 of most reliable sites
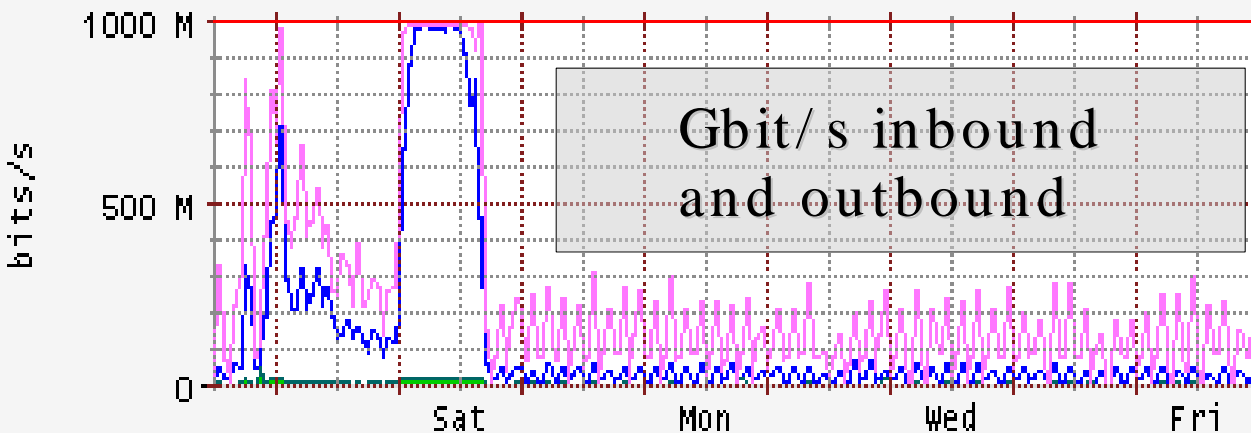
Use of cluster beyond particle physics

- **10% of CPU freely accessible to owners of Grid account**

- **Accounts are managed centrally**
  - Certification Authority: BELNET
    - Delegates to Registration Authorities (1 per University)

- **Access rights and priorities are managed per research project**
  - Virtual Organizations (VO's)
  - Generic VO "beapps" for BELNET users, supported on IIHE cluster

- **Share per VO in 2008:**
  - CMS: 83%
  - Beapps: 12.2%
    - Ice^3 experiment, mostly
  - Betest: 1.7%

Grid use per domain

Source: EGEE accounting portal
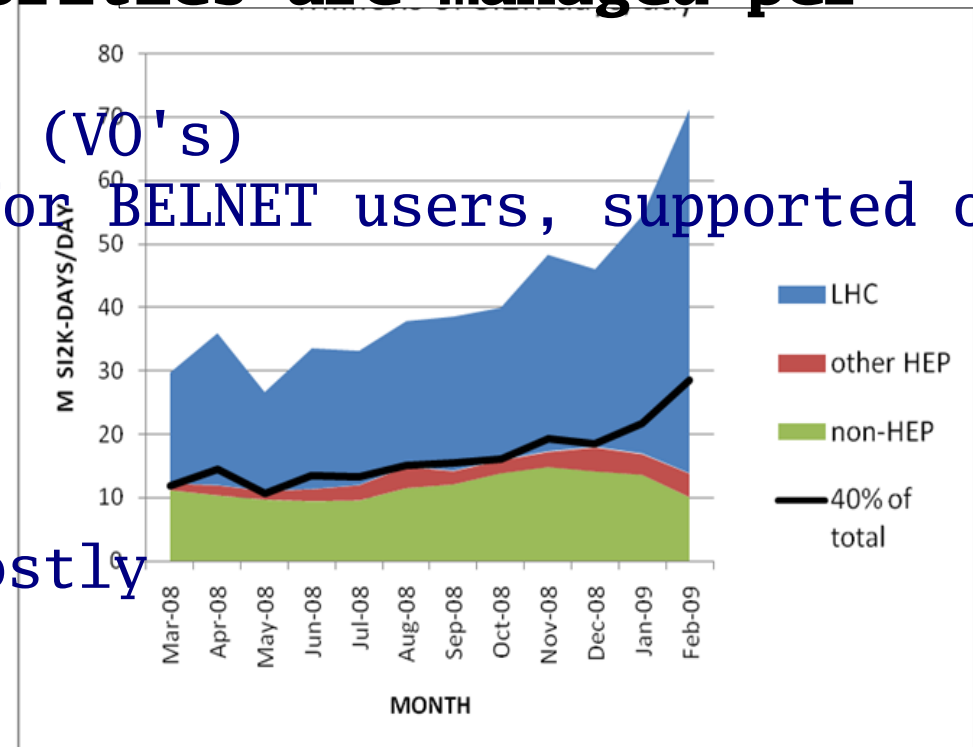
Other achievements last 5 years

- **11 Master theses**
  - 4 with the Faculties of Sciences and of Applied Sciences
  - 7 in collaboration with Morocco
- **15 talks at international conferences**
- **CMS Monte-Carlo production team in 2007**
  - Management of 20% of simulated samples for the collaboration
- **CMS software deployment team**
- **Seminars and tutorials with Belnet**

Thanks

- **Technical teams of IIHE and of Computing Center**
  - Shkelzen, Olivier, Stephane, Stijn, Othmane, Abdel, Georges, Edwin
  - Simone De Brouwer, Andre Schierlinckx, Paul Raeymaekers
- **Funding agencies**
  - FRS-FNRS, FWO, Vlaams gemeenschap, ULB
- **ULB-VUB authorities**
  - Support in installing cluster at computing center premisses
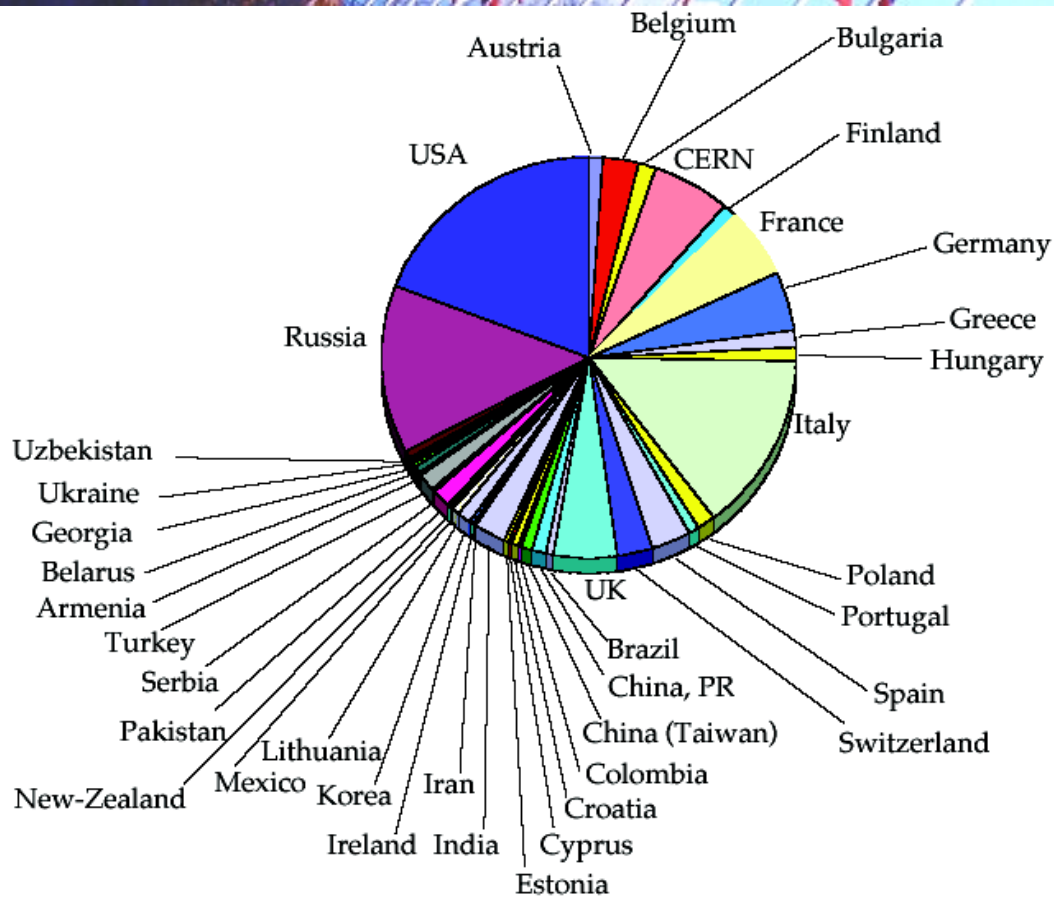
Backup

The LHC computing challenge

- 10^9 events/year/experiment
- ~100,000 processors required
- 15 million Gigabytes of disk per year
- Funding raised locally
  - CERN provides 20% of resources
- Efficient analysis worldwide
  - → **Grid technologies**

$H \rightarrow \gamma\gamma$

Higgs signal
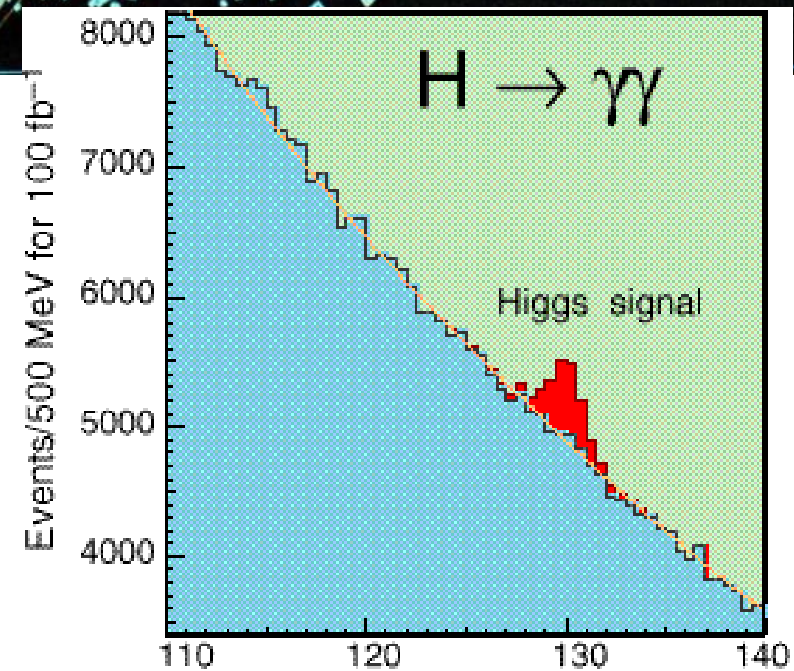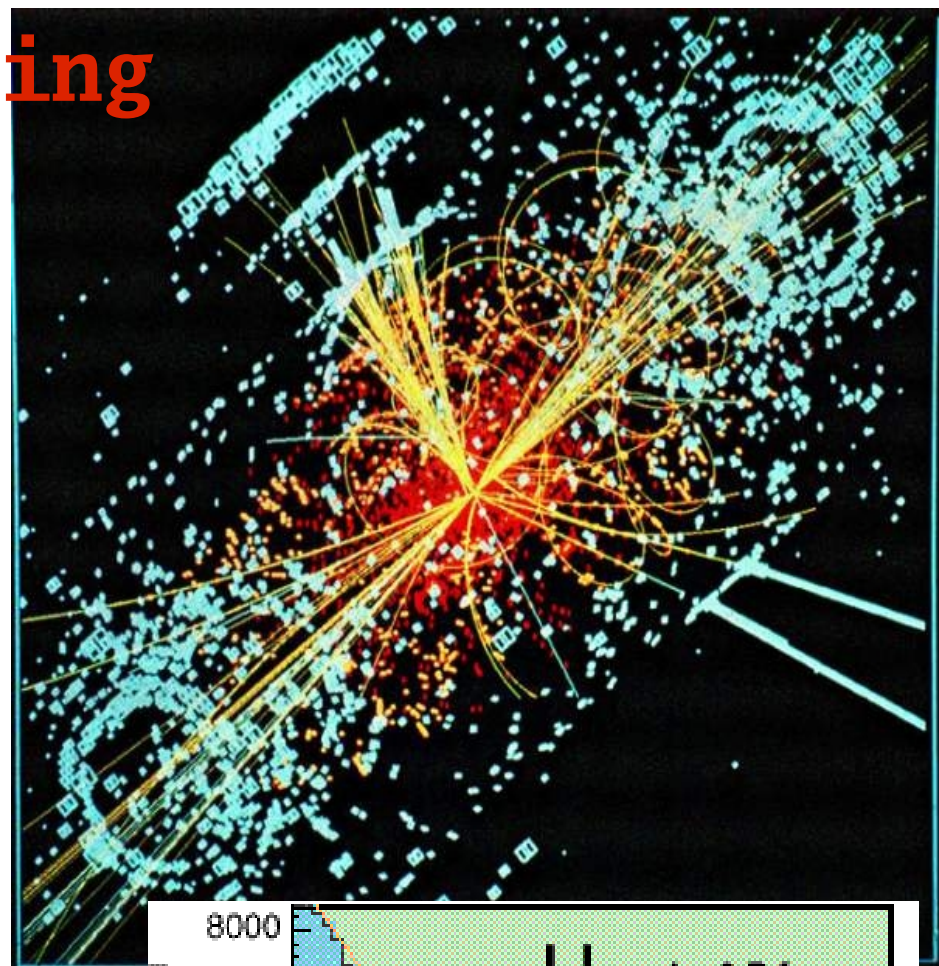
The CMS collaboration

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