



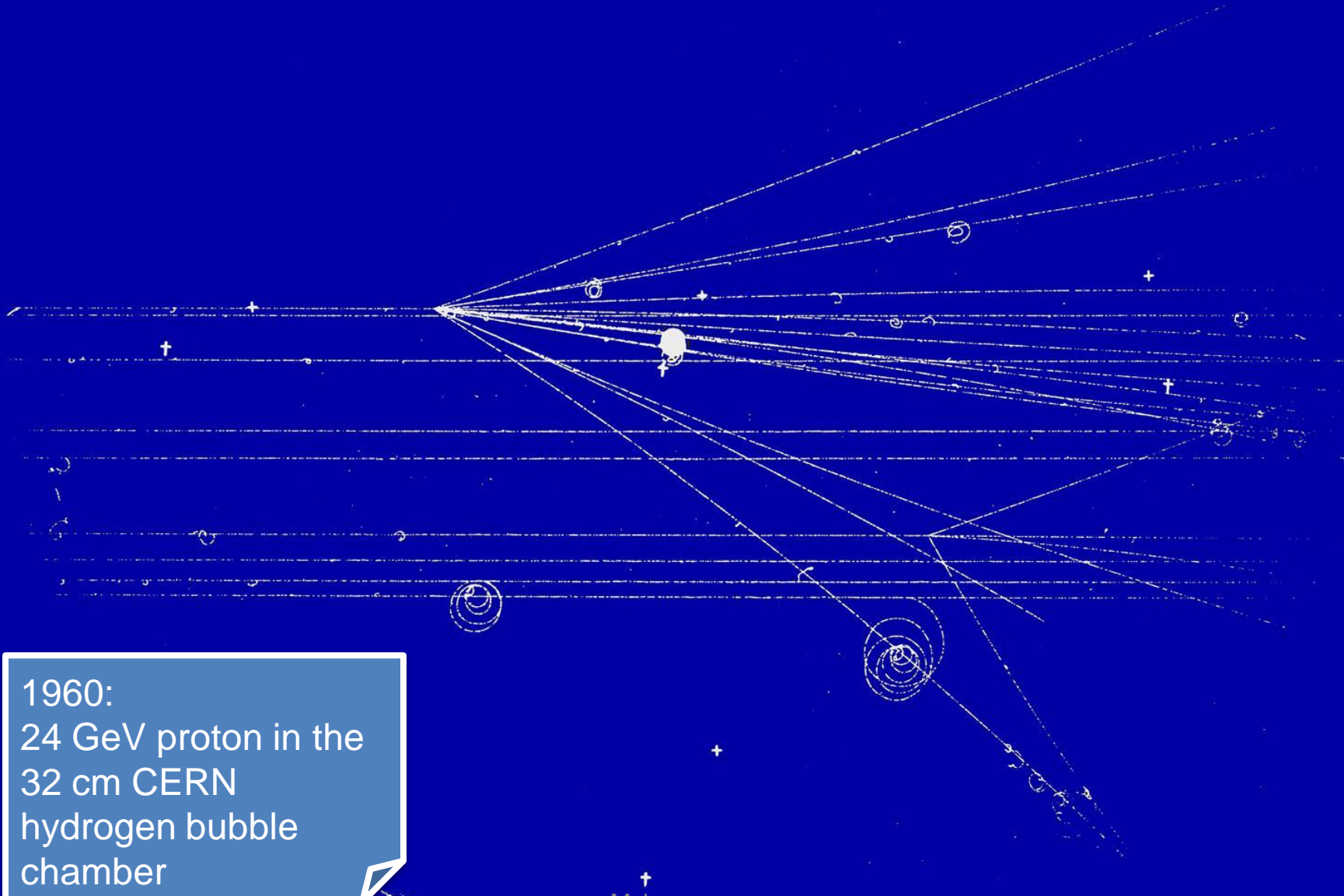
# LHC Grid computing



Massimo Lamanna

CERN

Information Technology Department  
Grid Support Group



1960:  
24 GeV proton in the  
32 cm CERN  
hydrogen bubble  
chamber

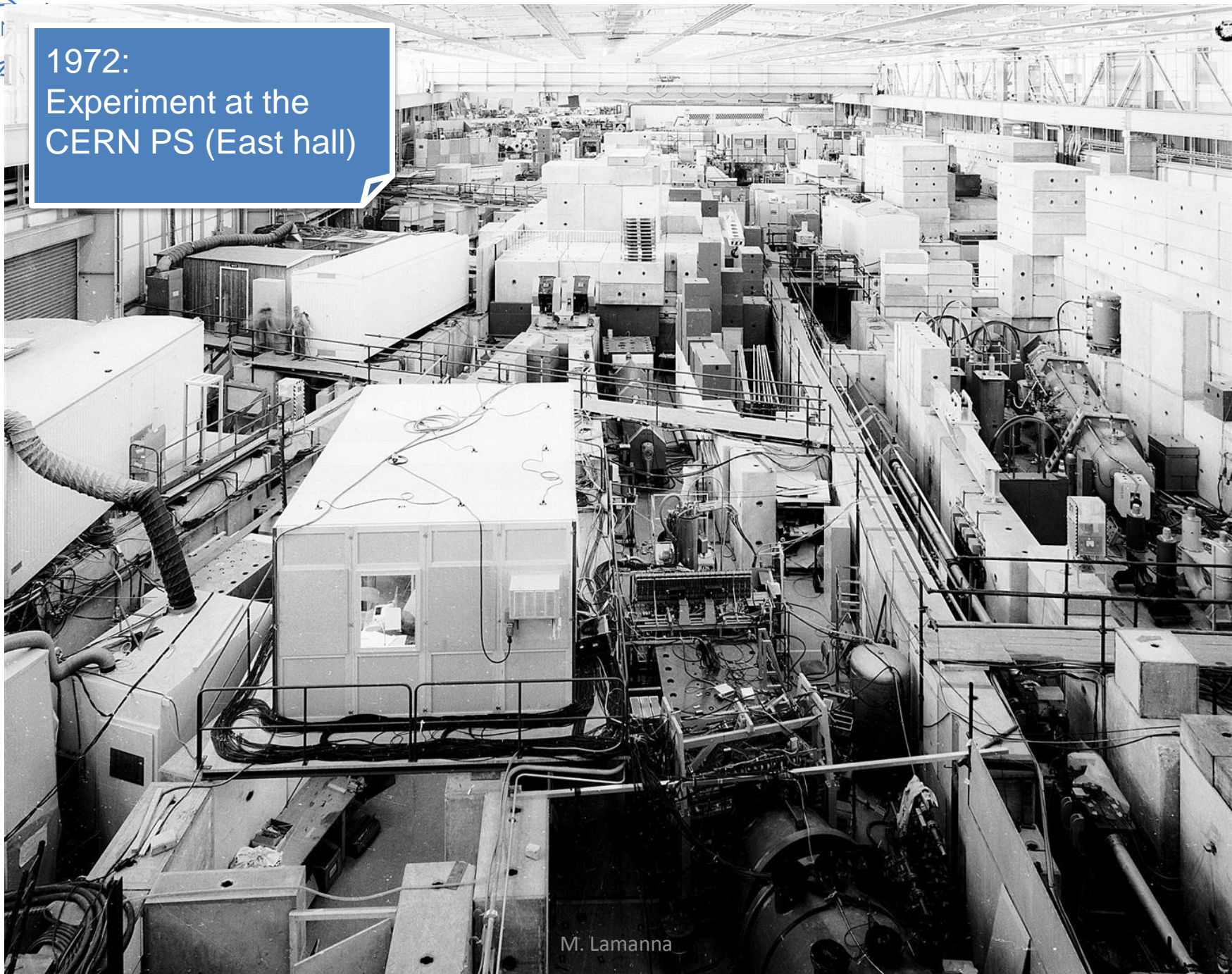
†  
M. Lamanna



1960:  
IBM 709 at Geneva  
airport



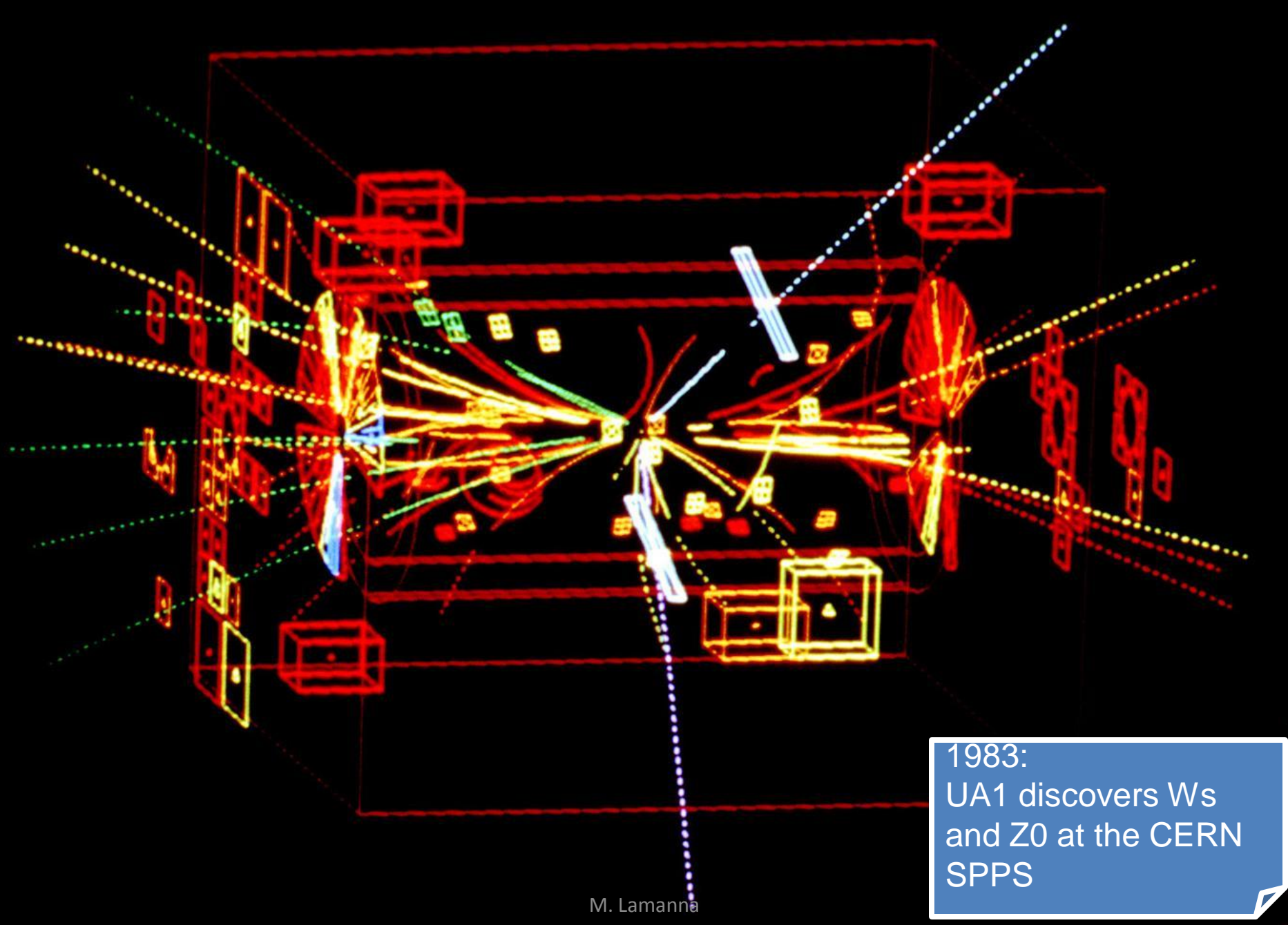
1972:  
Experiment at the  
CERN PS (East hall)



M. Lamanna

1972:  
Installation of the  
CDC 7600  
(Bd 513)

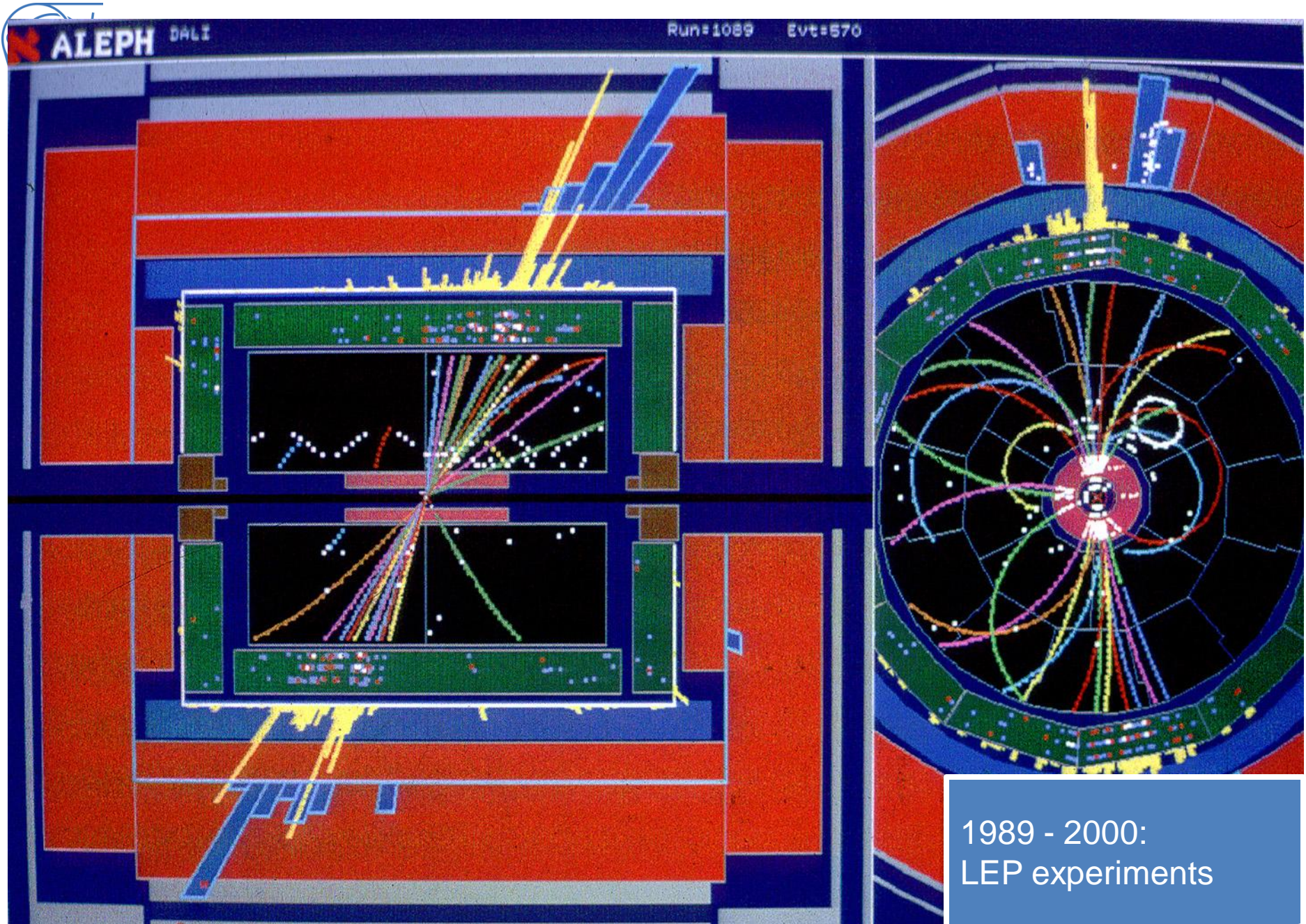




1983:  
UA1 discovers Ws  
and Z0 at the CERN  
SPPS



1983:  
Computer centre mainframes (IBM,  
Siemens, CDC)  
(Bd 513)



1989 - 2000:  
LEP experiments



1990:  
The first web server: this machine was used by Tim Berners-Lee in 1990 to develop and run the first WWW server, multi-media browser and web editor.

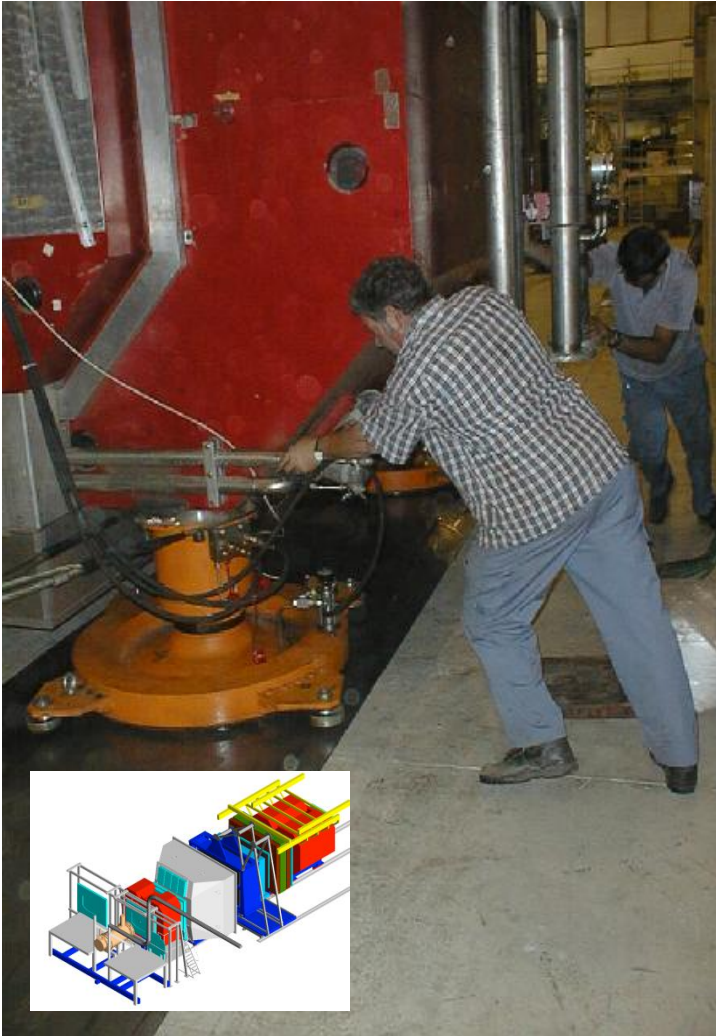


M. Lamanna

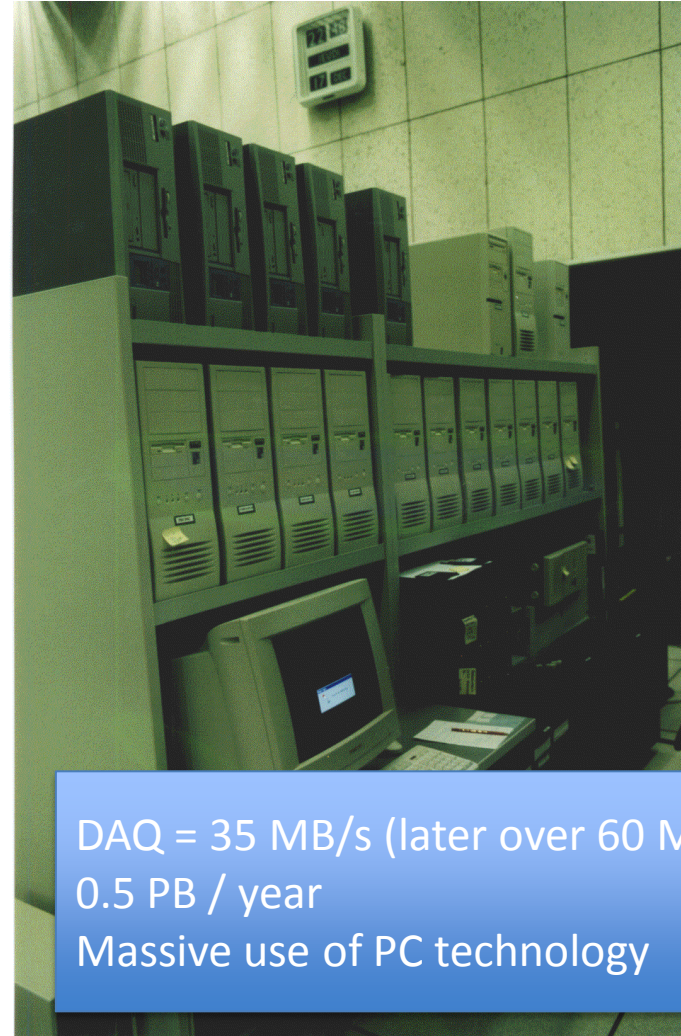
# Early days of COMPASS (1998)

A new experiment being built...

... with new computing challenges



The SM2 magnet...



DAQ = 35 MB/s (later over 60 MB/s)  
0.5 PB / year  
Massive use of PC technology

The COMPASS Computing Farm...



# COMPASS Event Display

CEDRIC Event Display mDST-63041-1-7.root

File View Navigator Options Help

Zoom Rotate Select Ruler Orthographic Side Top Front Home Link 0.00 /500300

Setup

- Detectors
  - Scintillating Fibres
  - Veto Trigger
  - Veto Outer
  - Silicon
  - Micromegas SciFi
  - Drift Chamber
  - GEM Detectors
  - Straw Tube Chambers
  - MWPCA
  - RICH Wall
  - MWPCA
  - Myon Wall 1
  - Outer Hodoscope
  - DW 45
  - Inner Hodoscope
  - Middle Trigger Hodosc...
  - Ladder
  - MWPC Typ B
- Calorimeters
  - EC01P1
  - EC02P1
  - HC01P1
  - HC02P1
- RICH
- Magnets
  - SM 1
  - SM 2
- Target

Transparency

Navigator

Immerse MaxDelta Color Stress

Ready

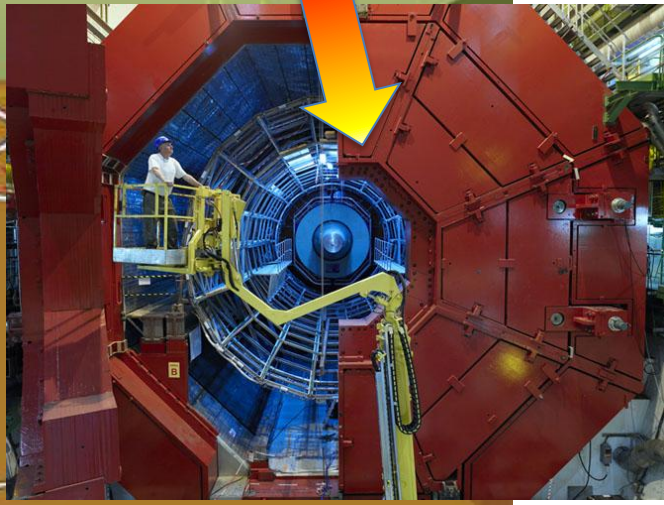
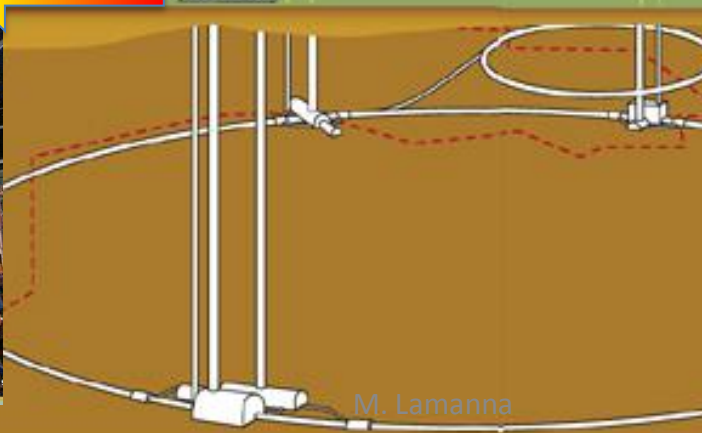
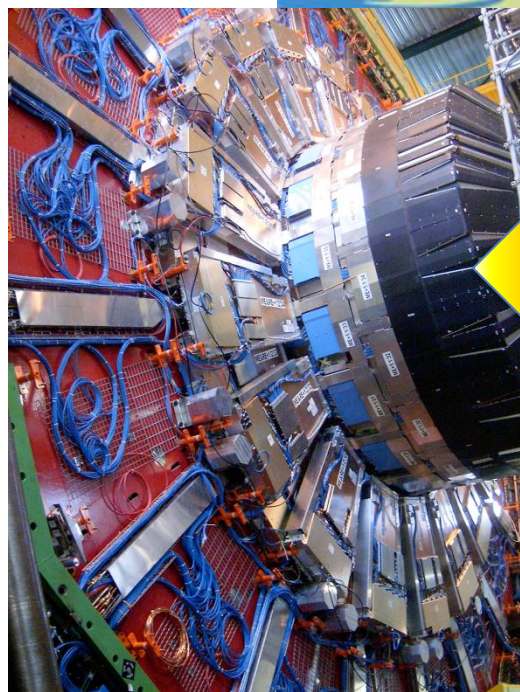
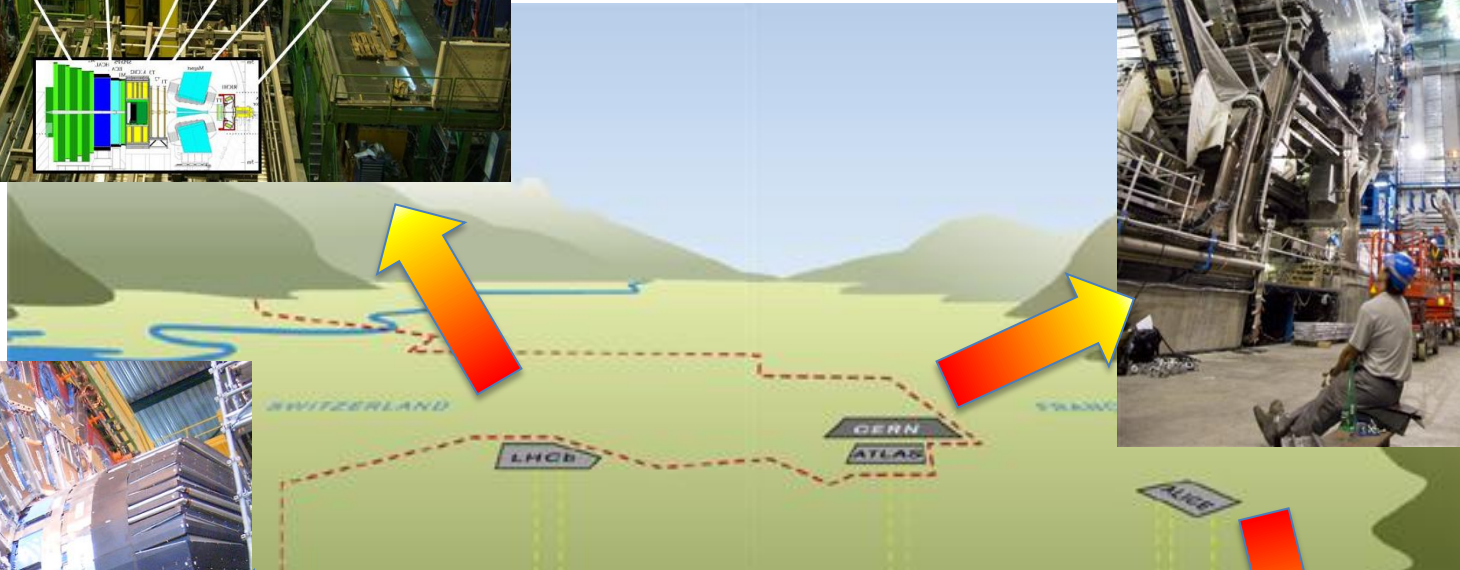
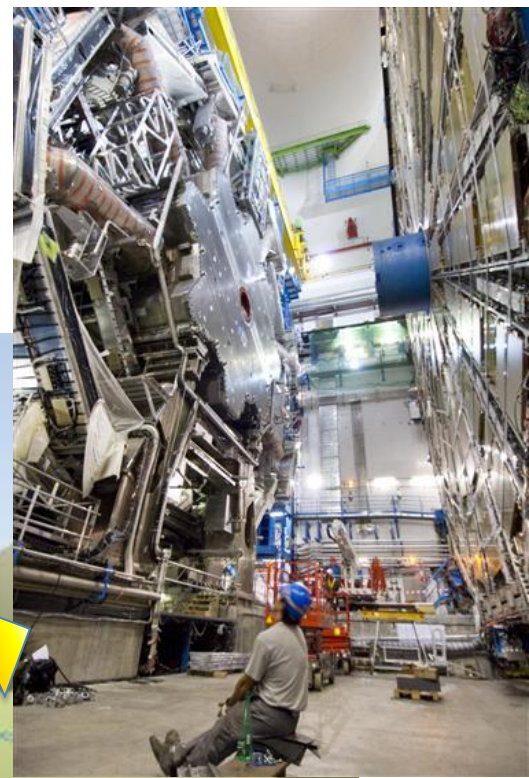
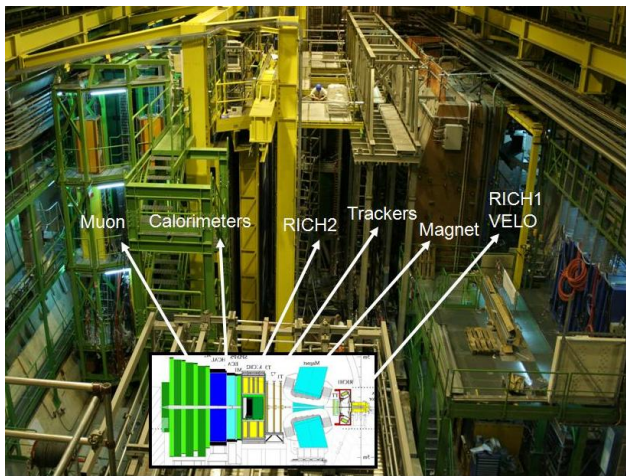
Particles

| Index | Color | Charge [e] | Momentum [GeV] | RichInfo? | Max.Likelihood | Mass [MeV] | Particle | Vertices | CaloRefs | PID    | Beam? | Mu Prim? | ZFirst [cm] | ZLast [cm] | Length [cm] | NHits | Chi2Tot | MeanTime [ns] |
|-------|-------|------------|----------------|-----------|----------------|------------|----------|----------|----------|--------|-------|----------|-------------|------------|-------------|-------|---------|---------------|
| 0     | #e... | 1          | 153.474        | no        |                |            | 0        | 1        | 0        |        | yes   | no       | -270.6      | -270.6     | 0           | 16    | 3.40751 | 0.548429      |
| 1     | #e... | 1          | 7.25104        | yes       | Pion           | 139.347*   | 1        | 1        | 1        |        | no    | no       | 140.901     | 1023.46    | 882.554     | 54    | 62.7637 | 2.19898       |
| 2     | #e... | 1          | 10.1625        | yes       | Kaon           | 492.182*   | 2        | 1        | 1        |        | no    | no       | 140.901     | 554.073    | 413.172     | 38    | 67.789  | -7.75175      |
| 3     | #e... | 1          | 1.5873         | yes       |                |            | 3        | 1        | 2        |        | no    | no       | 140.901     | 1028.42    | 887.514     | 47    | 82.2656 | 6.48206       |
| 4     | #e... | -1         | 5.28156        | yes       | Pion           | 141.362*   | 4        | 1        | 1        |        | no    | no       | 140.901     | 1023.46    | 882.554     | 46    | 59.1349 | -807.268      |
| 5     | #e... | 1          | 2.77329        | yes       | Pion           | 141.704*   | 5        | 2        | 1        |        | no    | no       | 140.901     | 1028.42    | 887.514     | 38    | 76.9424 | 2.79923       |
| 7     | #0... | 1          | 85.4293        | yes       |                | nan*       | 6        | 1        | 1        | Muon + | no    | yes      | 131.5       | 4784.4     | 4652.9      | 77    | 72.6842 | -0.0441936    |
| 14    | #e... |            |                | no        |                |            | 7        | 0        | 1        |        | no    | no       | 2589.36     | 3134.24    | 544.875     | 19    | 25.1346 | -0.445051     |
| 15    | #e... |            |                | no        |                |            | 8        | 0        | 1        |        | no    | no       | 2800.03     | 3132.24    | 332.21      | 14    | 18.5613 | 2.30524       |

Run 63041 | File /home/mhermann/mdst/mDST-63041-1-7.root



# LHC



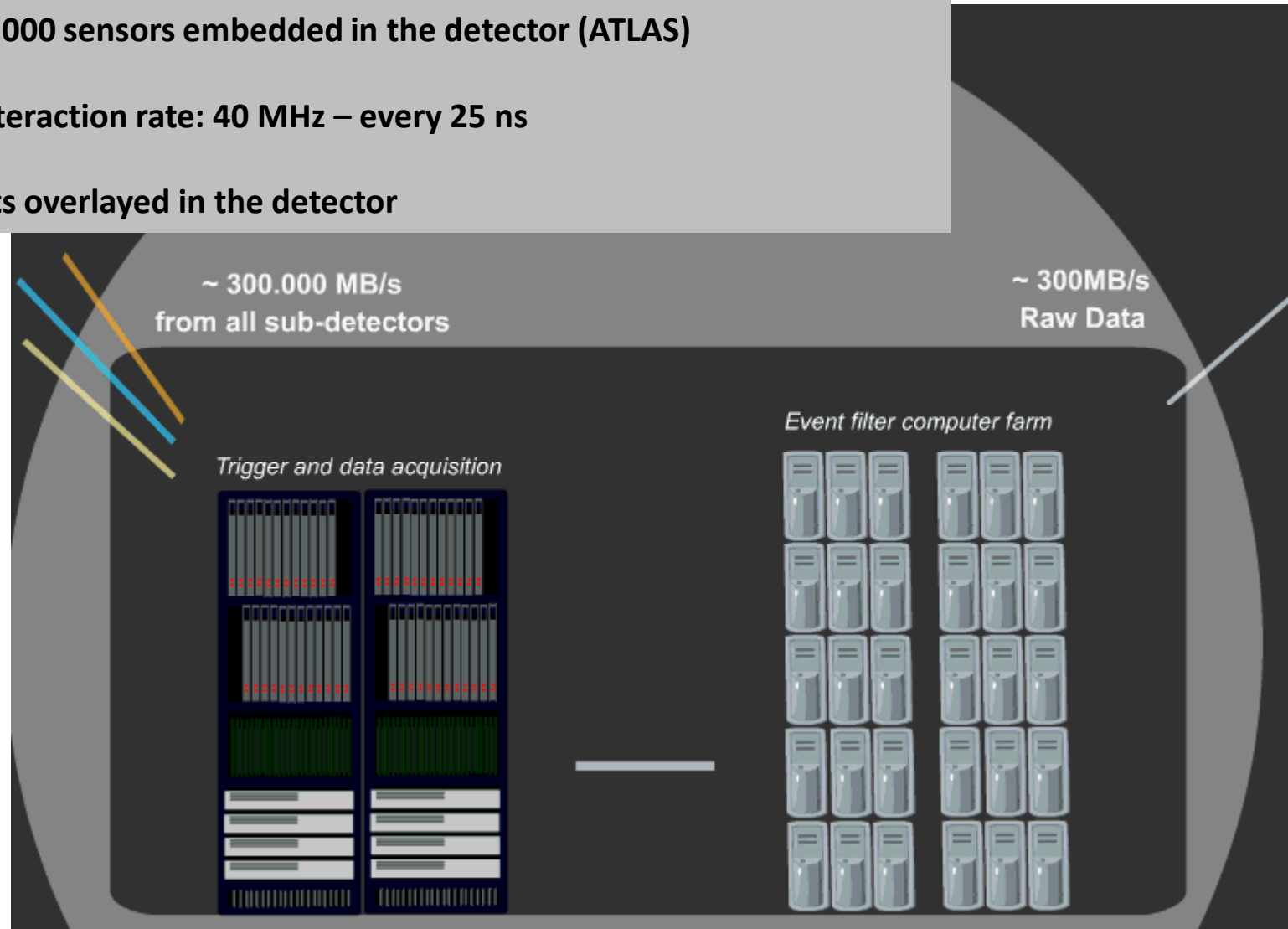


# Trigger & Data Acquisition

150,000,000 sensors embedded in the detector (ATLAS)

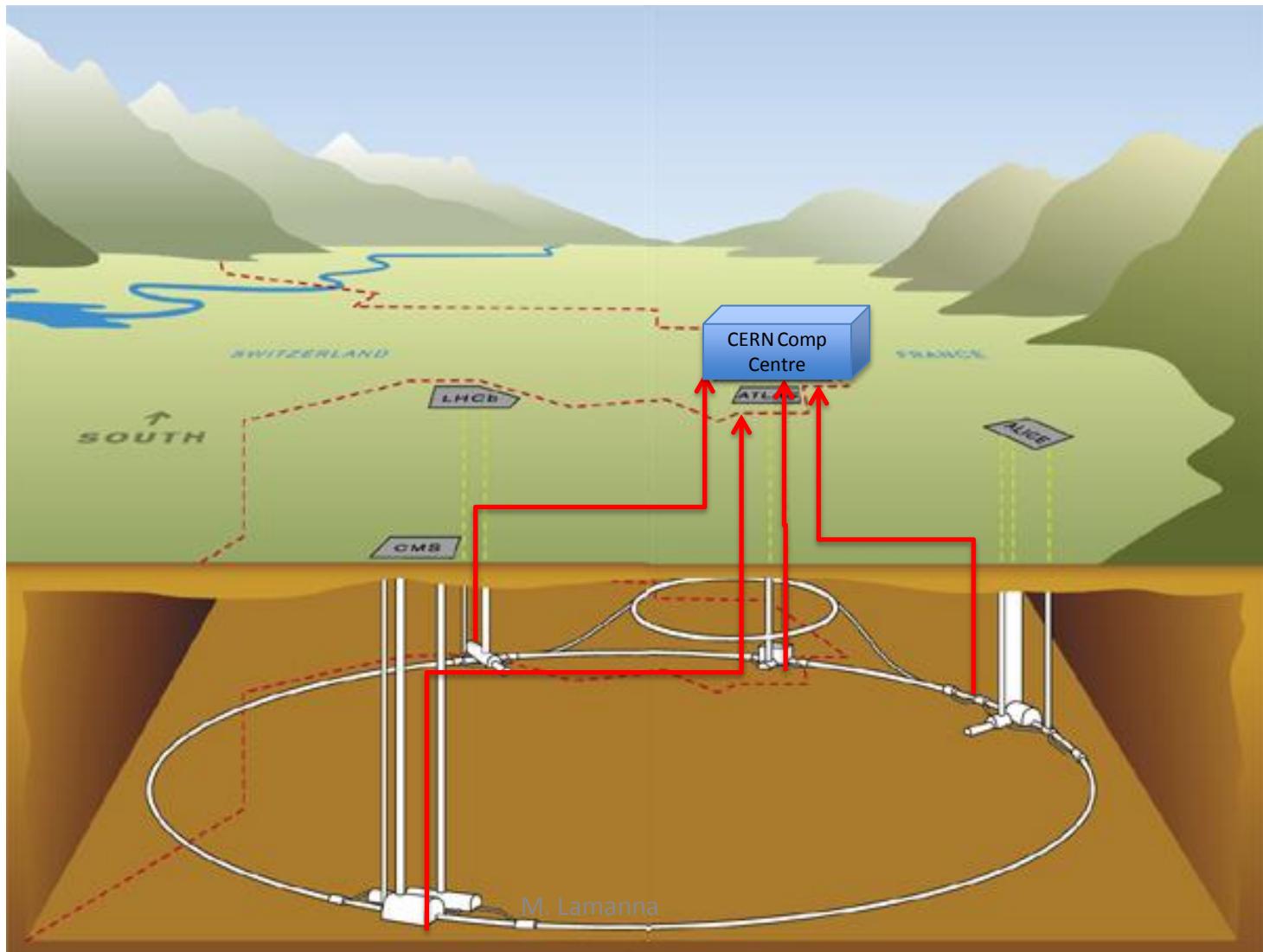
Beam interaction rate: 40 MHz – every 25 ns

20 events overlaid in the detector





# Data to the CERN COMPUTER CENTRE

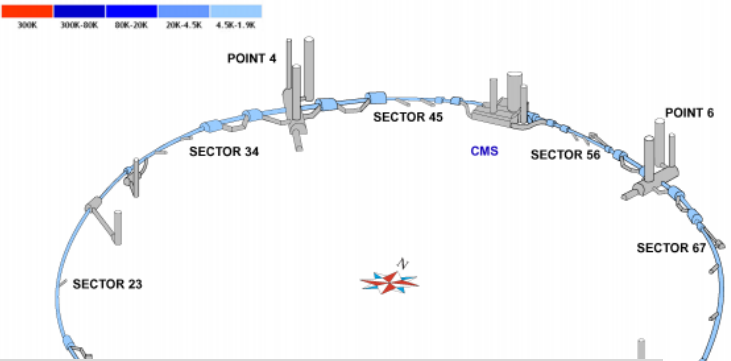




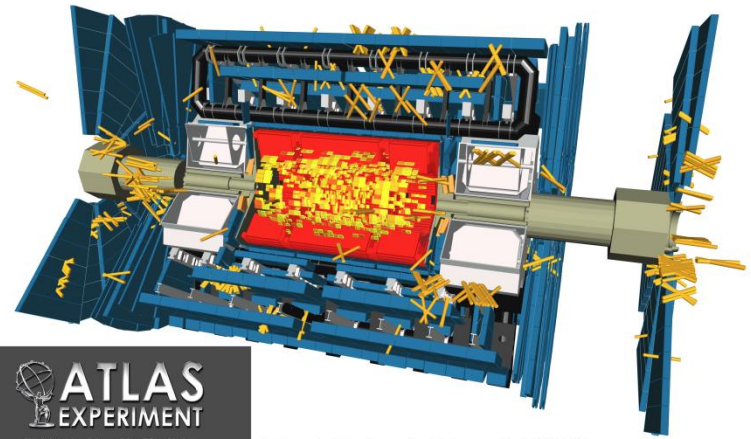
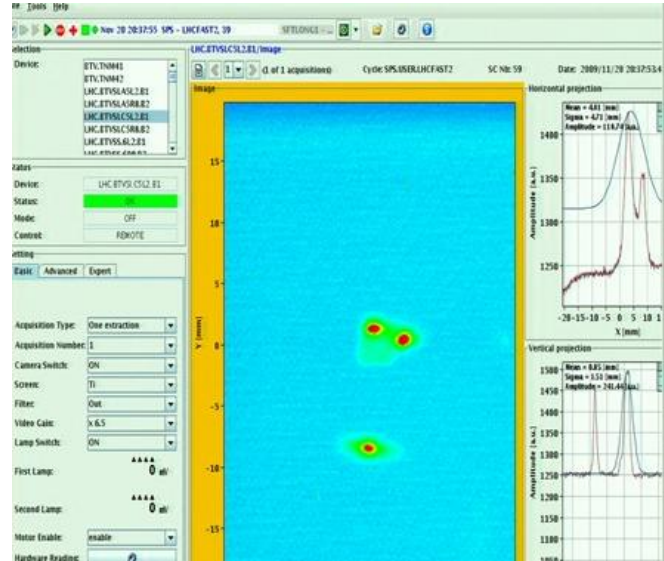
# Data, data, Data!



# 20<sup>th</sup> of November 2009



27 km tunnel (2000+ superconductive dipoles)  
 450 GeV injection energy  
 7 TeV max beam energy  
 3.5+3.5 TeV (March the 30<sup>th</sup> world record)

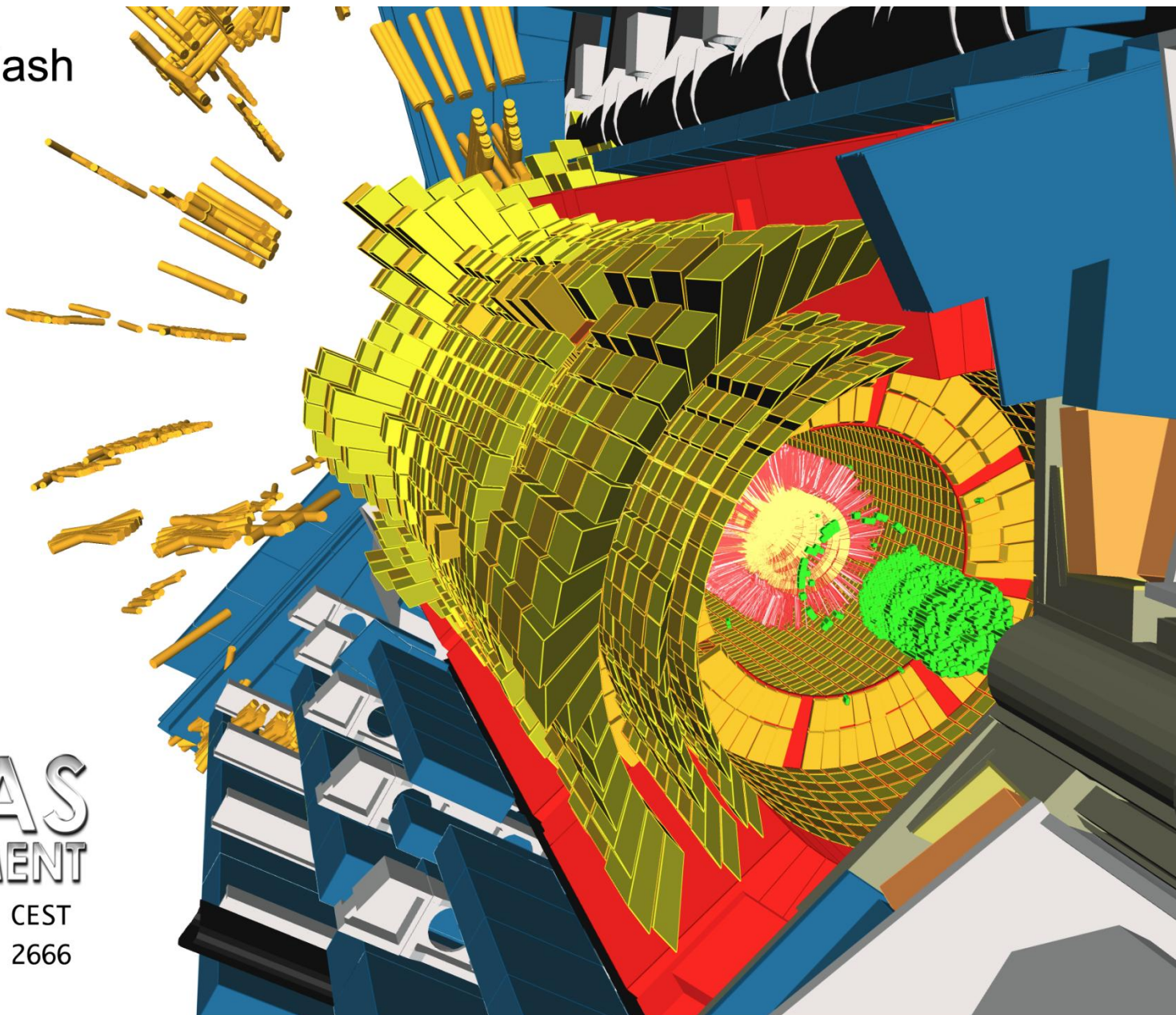


**ATLAS**  
 EXPERIMENT  
 2009-11-20, 20:33 CEST  
 Run 140370, Event: 2154

First Splash Event 2009

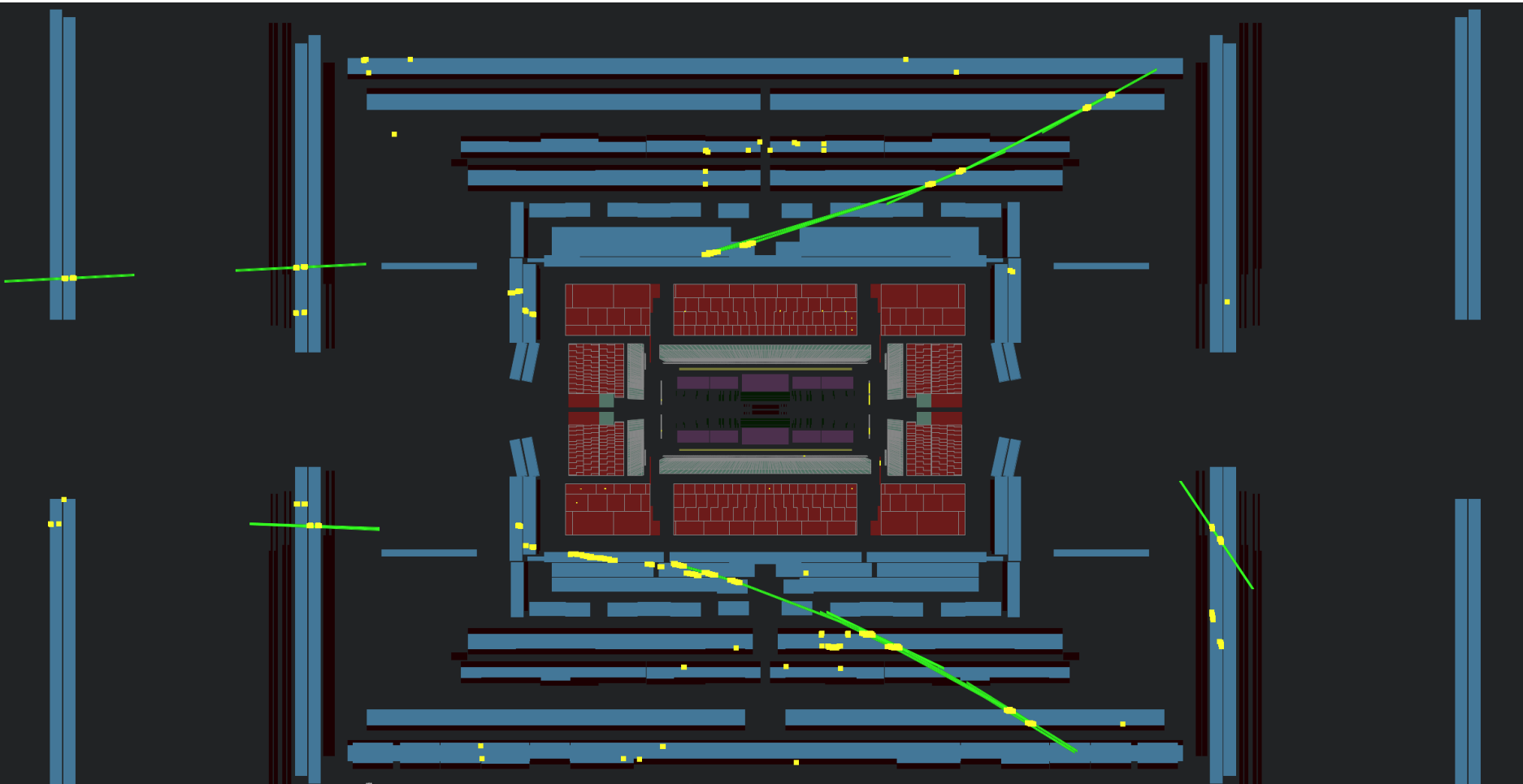


# 1st Beam Splash from Beam-2



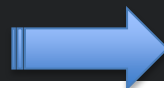
 **ATLAS**  
EXPERIMENT

2009-11-20, 23:32 CEST  
Run 140370, Event 2666

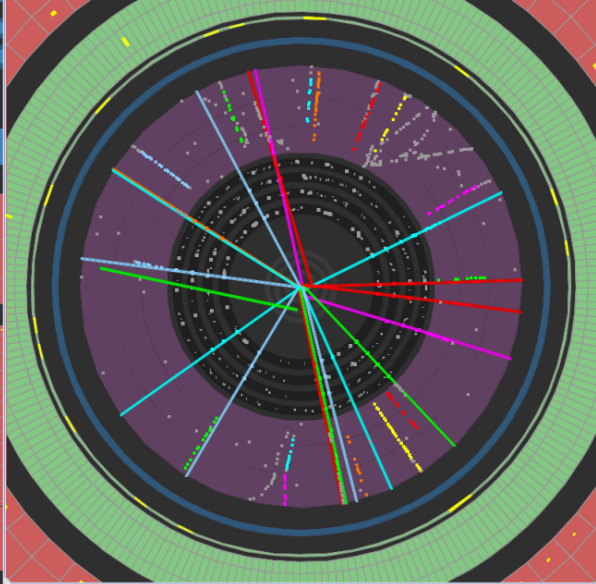
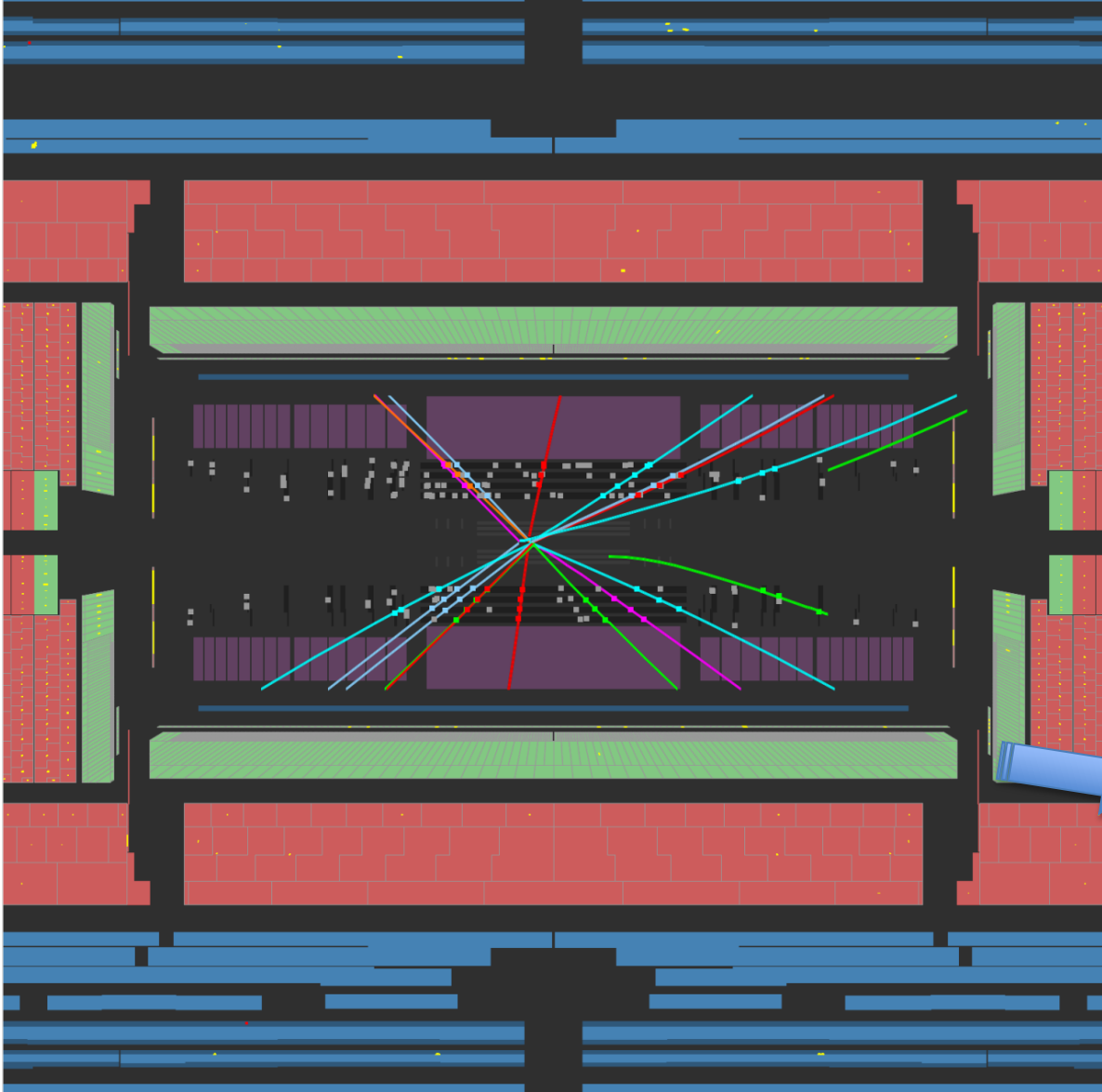


**ATLAS**  
EXPERIMENT

**Beam Halo Event**



2009-11-21, 00:17 CEST



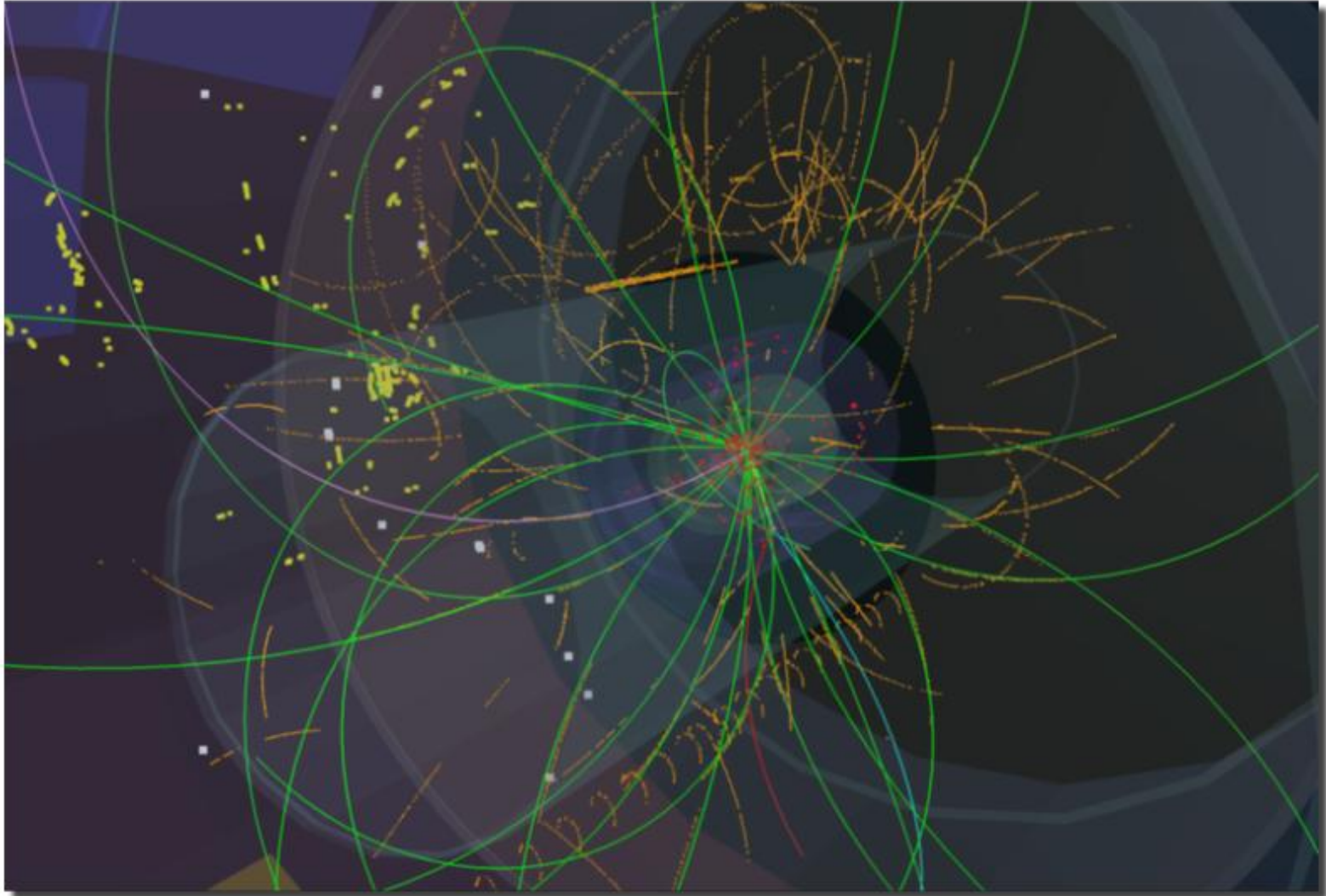
**ATLAS**  
**EXPERIMENT**

2009-11-23, 14:22 CET  
Run 140541, Event 171897

Candidate  
Collision Event

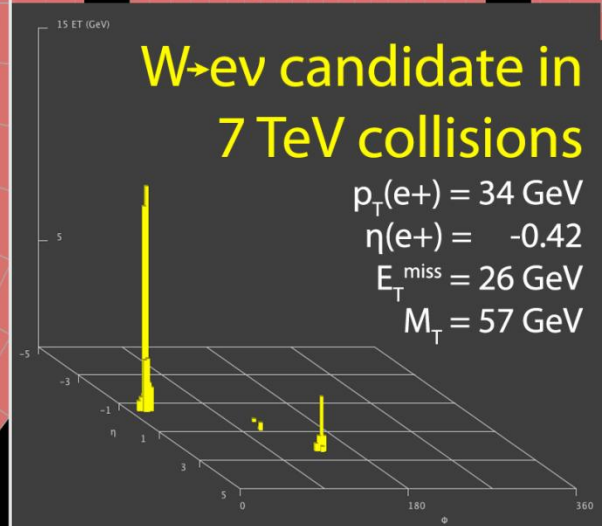
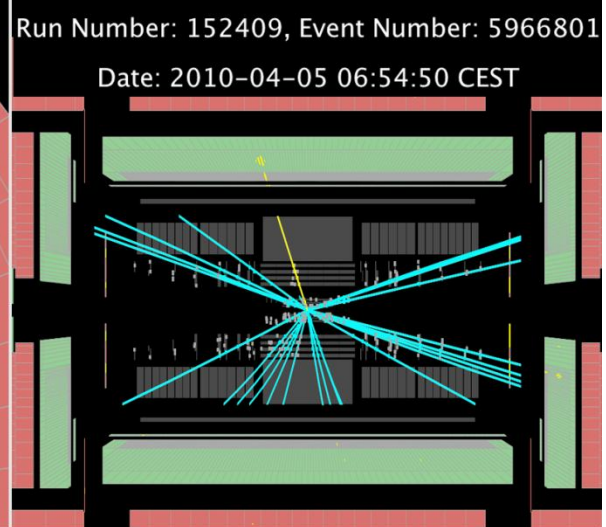
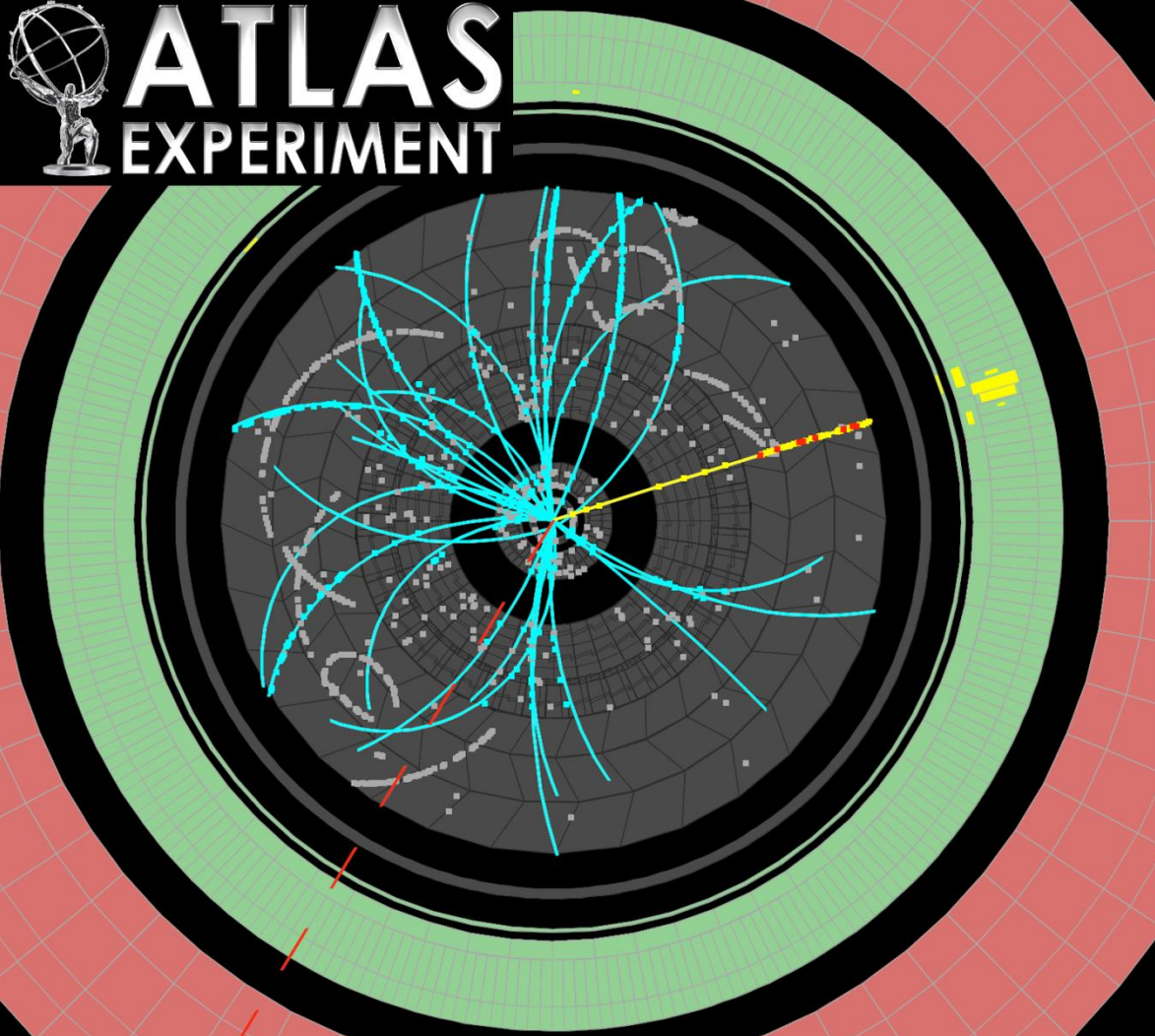
# 3.5 TeV + 3.5 TeV collisions

# ALICE event

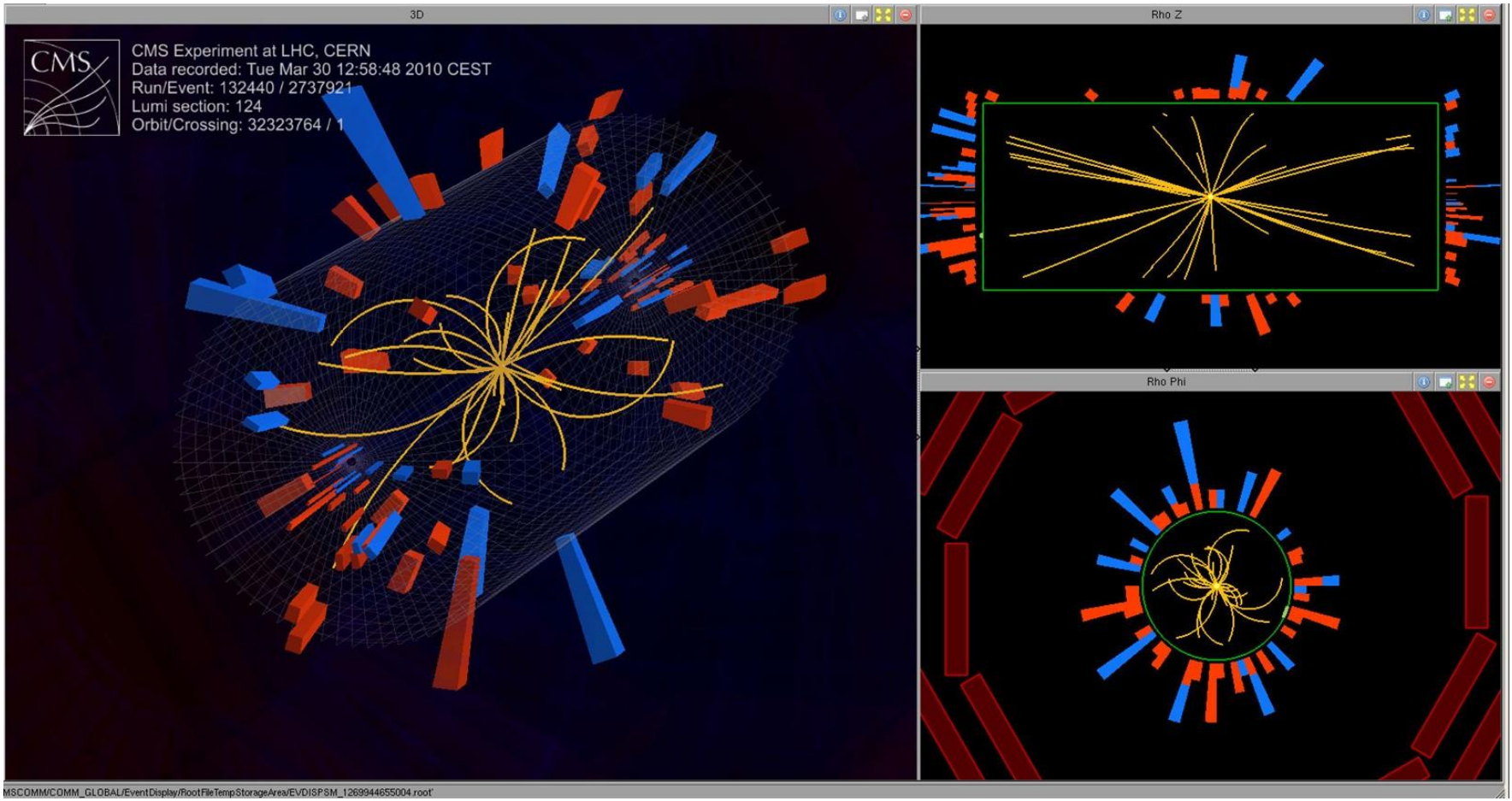




# Very recent LHC pp collisions!

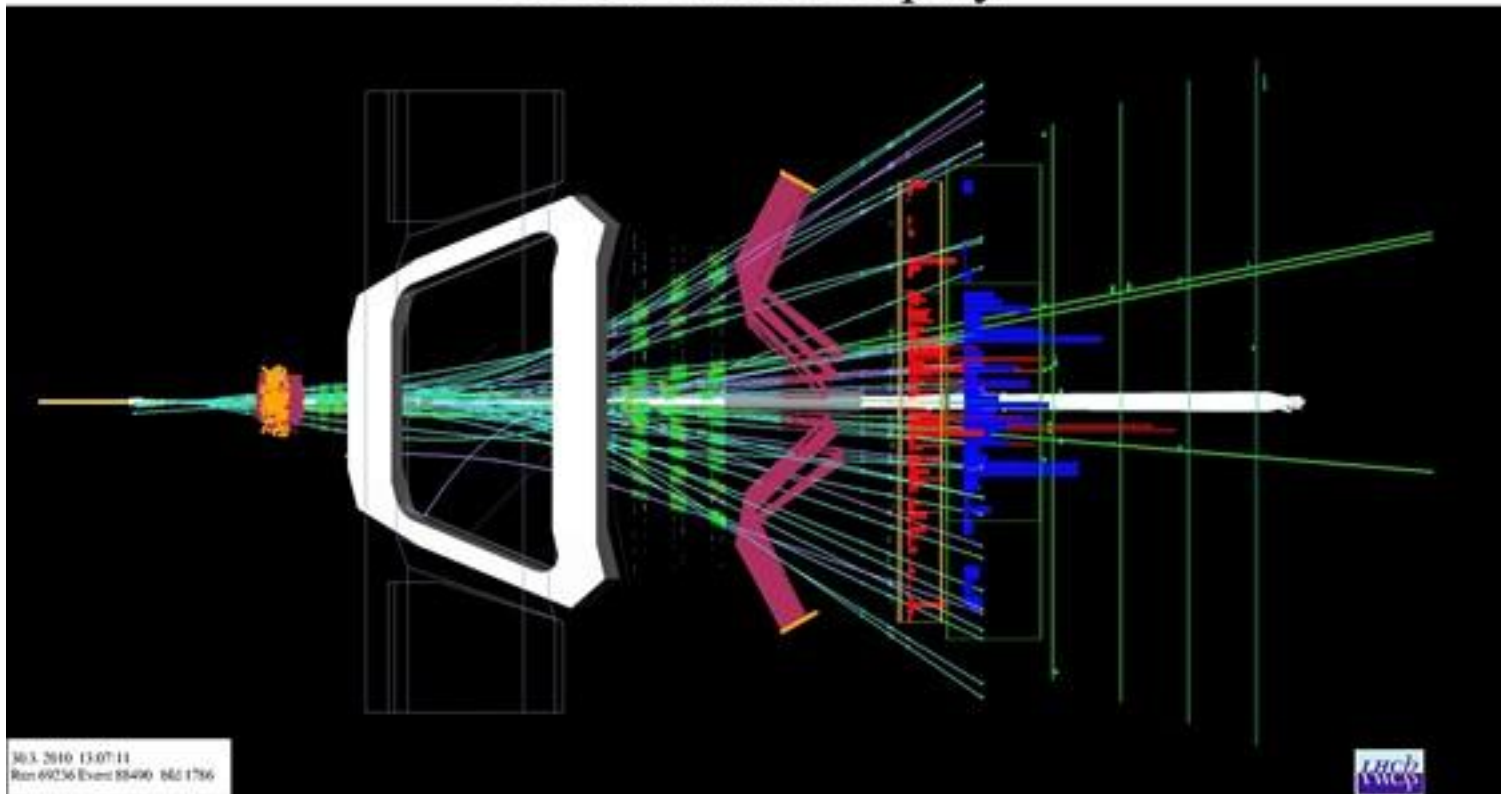


# Collisions in CMS



# Collisions in LHCb

## LHCb Event Display

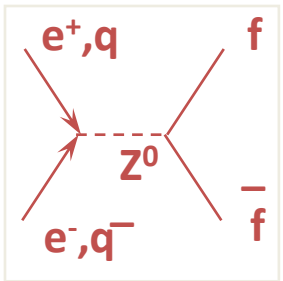




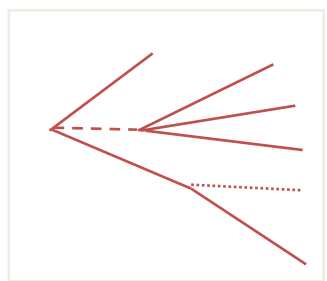


# WHY COMPUTING?

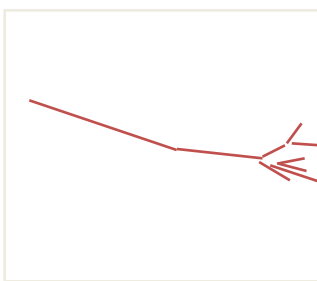
# From Physics to Raw Data



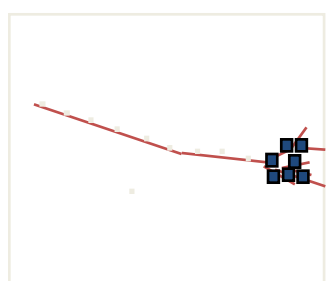
Basic physics



Fragmentation, Decay



Interaction with detector material  
Multiple scattering, interactions

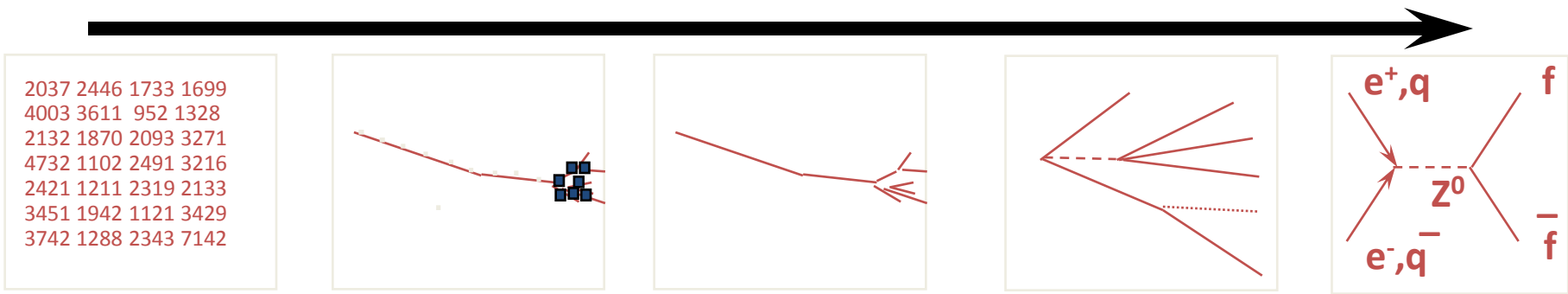


Detector response  
Noise, pile-up, cross-talk, inefficiency, ambiguity, resolution, response function, alignment, temperature

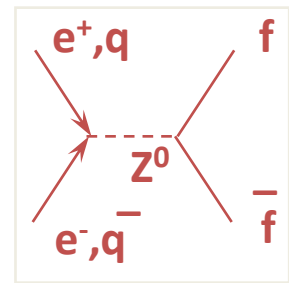
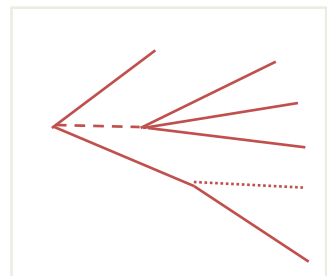
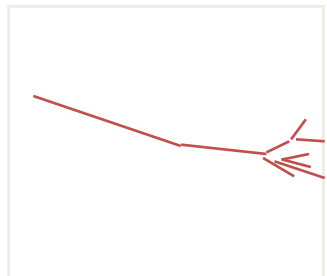
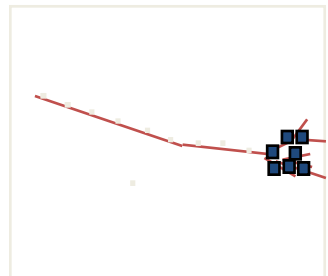
```
2037 2446 1733 1699
4003 3611 952 1328
2132 1870 2093 3271
4732 1102 2491 3216
2421 1211 2319 2133
3451 1942 1121 3429
3742 1288 2343 7142
```

Raw data (Bytes)  
Read-out addresses, ADC, TDC values, Bit patterns

# From Raw Data to Physics



2037 2446 1733 1699  
4003 3611 952 1328  
2132 1870 2093 3271  
4732 1102 2491 3216  
2421 1211 2319 2133  
3451 1942 1121 3429  
3742 1288 2343 7142



**Raw data**  
Convert to physics quantities

**Detector response**  
apply calibration, alignment,

**Interaction with detector material**  
Pattern, recognition, Particle identification

**Fragmentation, Decay**  
Physics analysis

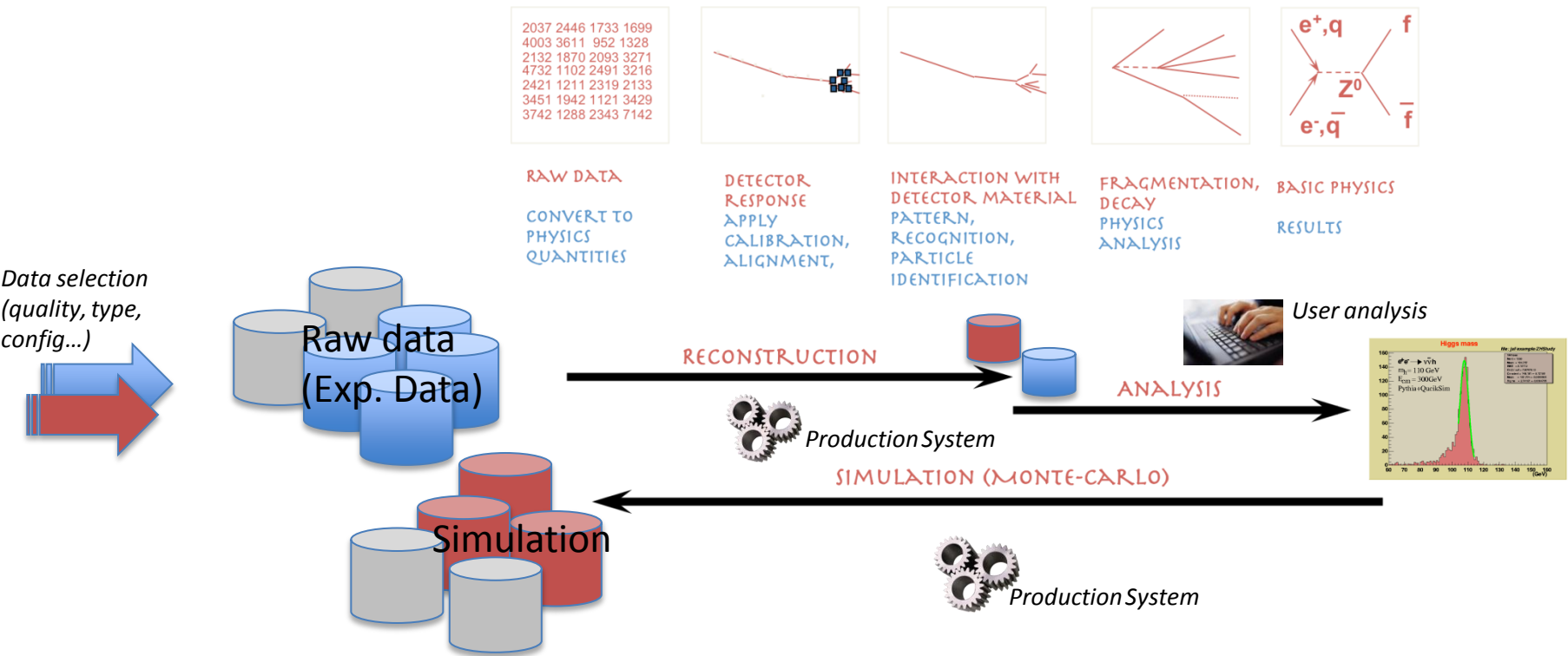
**Basic physics**  
Results

**Reconstruction**

**Analysis**

**Simulation (Monte-Carlo)**

# Analysis flow (user view)



But how this is done *in practice*? Of course we need CPUs, disks, networks etc..  
We cannot rush to the solution yet...

Dataset concept = collection of files. Only a small fraction of data in real DBs (e.g. calibrations)

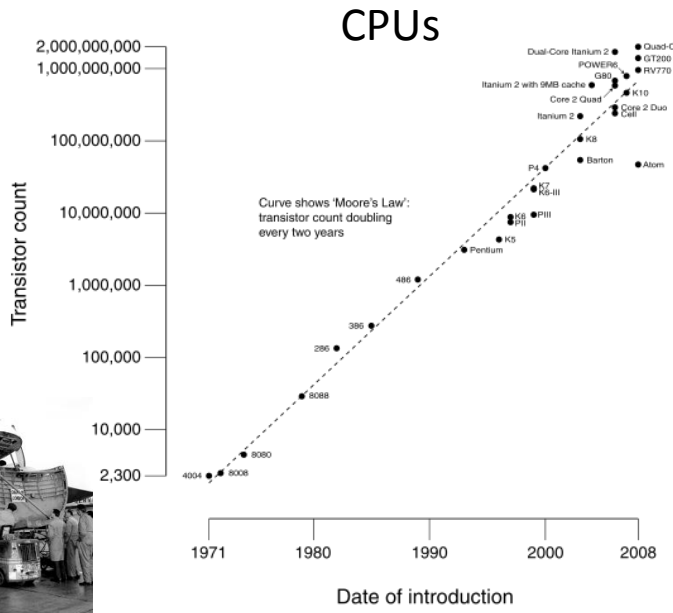


# HOW COMPUTING?

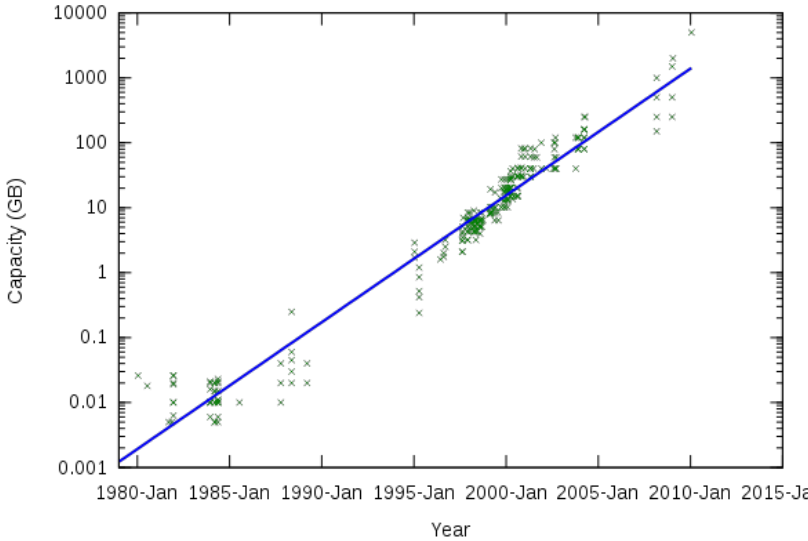


# Moore law (mass-market dynamics)

CPU Transistor Counts 1971-2008 & Moore's Law



## Hard Disks



A nice way to express it is that in 2 years your next PC will cost the same but it will be twice as fast (and have twice as much disk space etc...)

[http://en.wikipedia.org/wiki/Moore%27s\\_law](http://en.wikipedia.org/wiki/Moore%27s_law)

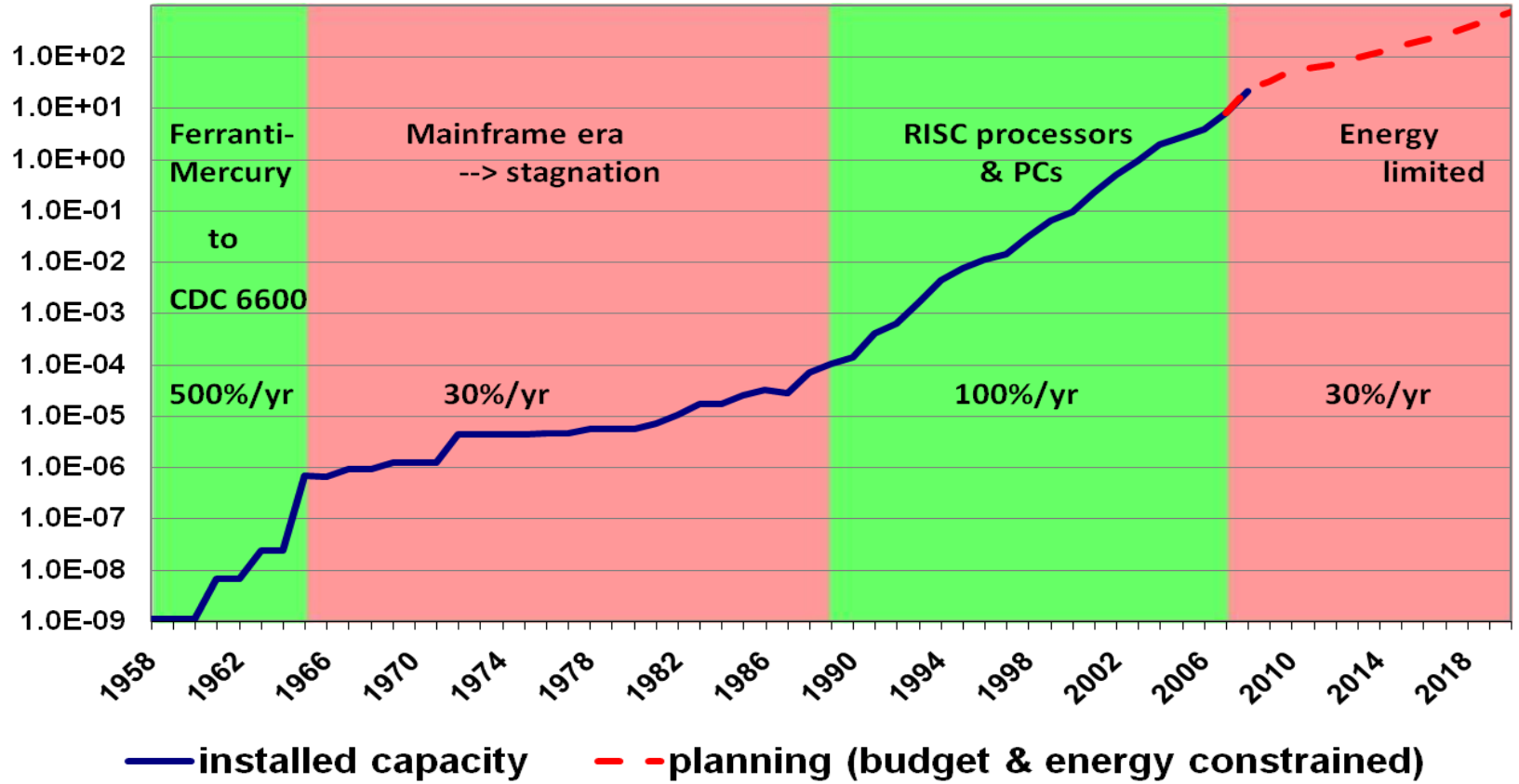
# Commodity computing



- Commodity hardware challenging the mainframe computing
  - Instead of an expensive supercomputer, buy lots of relatively inexpensive PCs
  - Total cost-of-ownership is an issue
  - On the other hand, your farm will be
    - Upgradable (buy more PCs if needed)
    - Evolutionary (change old out-of-guarantee PCs with new -more performing- ones)
    - Cost-effective (buy the "cheapest" SPEC. No vendor lock!)
- The only way to cope with the CPU (and data storage!) request from new generation experiments
  - Late '90: NA48 and COMPASS at CERN, several other experiments at FNAL, SLAC, DESY...
  - Nowadays: LHC experiments
- Limiting factors:
  - PC market evolution
    - Desktop vs laptops or other commodity devices
    - Multicore architectures
  - Power (includes cooling...) consumption




# Evolution of CERN Computing Processing Capacity in MSI2K

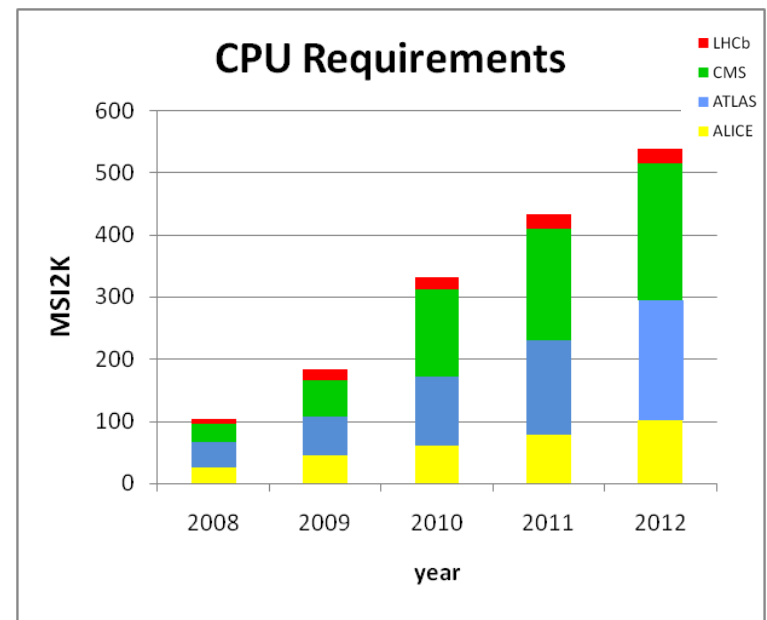


1.0E-03 MSI2K = 1,000 kSPEC INT 2000 ~ Pentium4 @ 3GHz (~3GFlops)



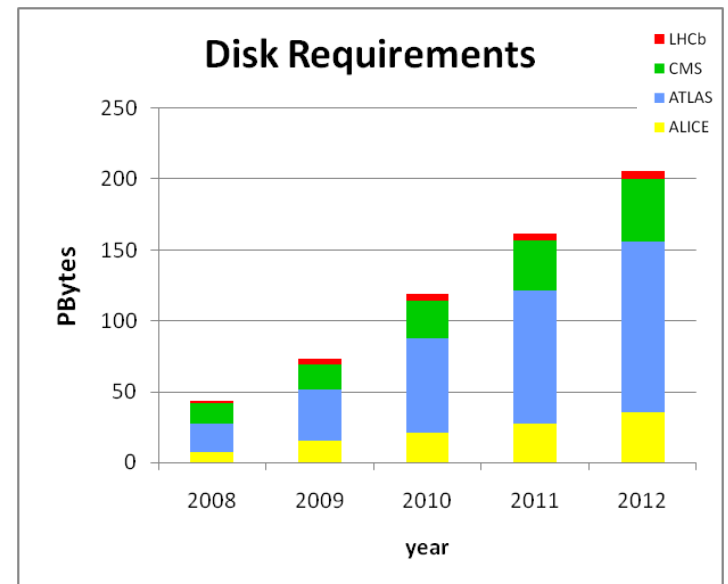
# CPU

- “Number crunching” boxes
  - No resident scientific data
  - Shared facility for all CERN users (basically every physicists participating in an experiment at CERN)
- Faster PC means more SPECs per box 
  - 1,000 SI2K ~ Pentium4 @ 3GHz (~3GFlops)
- Mass-market driven
  - MP3 encoding, Digital images processing, heavy office suites...



# DISKS

- “Staging” area: they keep “hot” data
- Access to these disks is managed by dedicated PCs (serving/receiving data to the PC crunching numbers)
- Moore’s law at work here!
  - Less expensive
    - GB/\$ goes up
  - More compact
    - GB/cm<sup>3</sup> goes up
  - Mass-market items!
    - Technology drive by you(storing digital-camera pics, MP3, etc...)



# Tapes

- Data custodial
  - We build accelerator and experiments to collect scientific data
- Write-once / Read-many
  - At variance with backups (Write-once / Read-never)
- Evolving (a' la Moore's law) but more "gently" than PCs
  - No surprise, none of us has a tape library at home, I guess 😊
  - No mass-market as for CPU, RAMs and Disks
  
- Expect to store 40 PB (40,000 TB) of data per year
  - Scientific data, corresponding derived data (reconstruction, analysis), simulation data





# Interesting facts (CERN Computer centre)

- **Number of machines**
  - About 4,500 batch (18,000 CPUs)
  - About 3,000 disk servers (50,000 hard drives)
  - Several hundred tape servers, console head-nodes, database and Grid servers etc.
- **Storage Capacity**
  - 5+ PB disk
  - 25+ PB tape (IBM and Sun/StorageTek)
  - There will be an additional 15 PB each year needed for the LHC data ( $3 \cdot 10^6$  DVDs!)
- **Network Capacity**
  - Connection at 10 gigabits/second to each Tier 1, plus backup, plus regular (firewalled etc) internet
  - Speed record: 1.1 TB in less than half hour (CERN-CalTech)
- **Number of staff**
  - CERN: ~2700 ; IT department (computing) ~250 and ~200 on shorter-term Grid projects

| Service/Activity                       | Description   | Data  |
|--|---|---|
| <b>Disk and Tape</b>                   | Provide storage capabilities                                | 1500 disk servers<br><br>5 PB disk space,<br><br>16 PB tape storage   |
| <b>Network Campus</b>                  | Provide local CERN area network service                     | The Network core has a capacity of 4.8 Tbps<br>The total number of network ports is:<br>>1000 10 Gigabit ports<br>>70000 Gigabit ports<br>feeding 34000 hosts   |
| <b>External Networking</b>             | Provide connectivity and infrastructure with other 11 T1s   | Out-coming Internet Back bone up to 60GB/s to 11 centers<br>Speed record:1.1 TB transferred in less than half hour (Caltech-CERN)   |
| <b>NICE PC</b>                         | PC cluster  | 5,500 active NICE PCs<br>1,500 Macs<br>1,100 CMF packages   |
| <b>Computing Facility</b>              | Provide local & Grid Computing Power                        | 4500 nodes installed<br>16K CPUs available<br>Up to 10K concurrent jobs   |
| <b>Computing Center cooling system</b> | The system to cool the centre                               | more than 500,000 m <sup>3</sup> /h cold air to cool PCs<br>three 1.5 MW chillers   |
| <b>CVS</b>                             | Concurrent Version System                                   | over 300 Software Projects<br>and over 3000 users   |
| <b>Messaging services</b>              | Email, Ldap, Listbox, News, Fax, Antispam                   | 17,015 mailboxes<br>7000 lists<br>2.8TB data<br>2.5 Million messages/day<br>(~98% SPAM)<br>- 8852 sites<br>- including 930 sharepoint sites<br>- 6 million hits per day<br>- Bandwith 2 Tbyte per day |
| <b>Web Services</b>                    | Web Services , Search Engine, Verisign                      |   |
| <b>WLCG</b>                            | Coordinating and operating WLCG grid activities             | 30,000 simultaneously<br>1 PB /month each ATLAS, CMS<br>1 GB/s (1.6 GB/s peak) to 12 sites<br>160 VOs   |
| <b>AFS</b>                             | Andrew File System (distributed file system for CERN users) | 15,000 users<br>27,000 volumes<br>25TB allocated  |



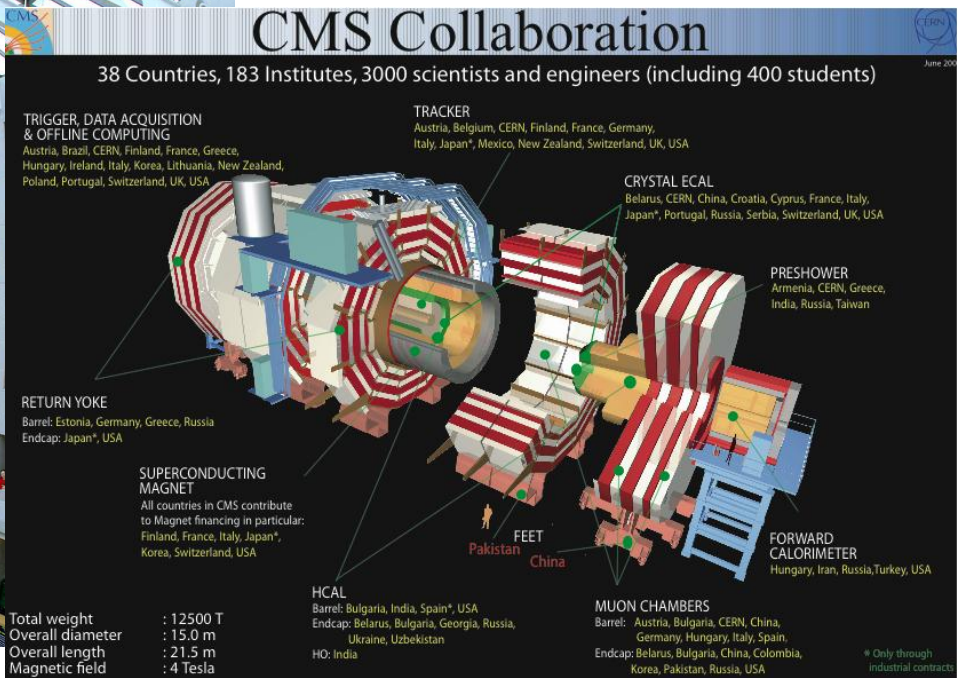
# WHERE COMPUTING?



# Another view of LHC experiments



ATLAS is more than 2,500 collaborators  
 From 169 universities from 37 countries  
 700 students!!!  
 CMS has a similar size. ALICE and LHCb collaborations are a bit smaller



# But do not be surprised if...

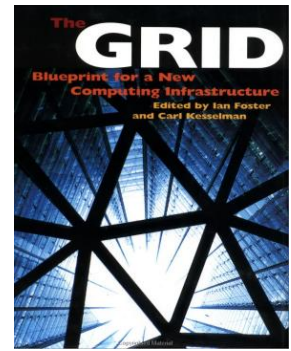


Computing goes worldwide...  
...after all, we all got networks!  
... and we invented the Web!!  
... and now we play with Grids!!!



# The Promise of Grid Technology

*Ian Foster & Carl Kesselman - 1999*



- The **Grid** – a virtual computing service **uniting the world wide computing resources** of particle physics
- The **Grid** provides the end-user with **seamless access** to computing power, data storage, specialised services
- The **Grid** provides the **computer service operation** with the tools to manage the resources, move the data around, monitor the behaviour of the services, alert operators to attend to potential problems



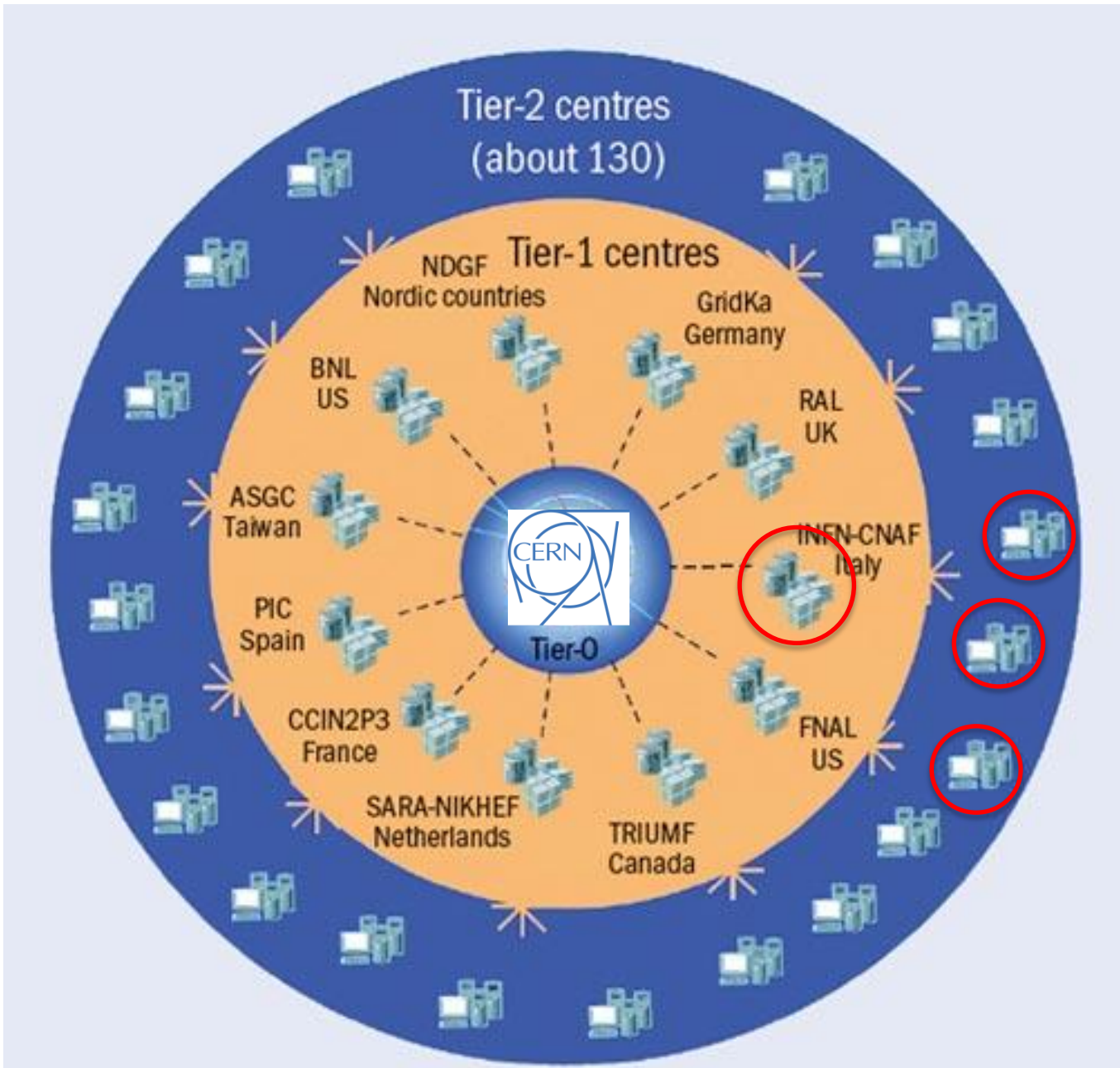
Sounds good!

Although very complicated ☺



# How does it work?

- **ATLAS**
  - Not substantially different for the other 3 LHC experiments
  - Heavily simplified...
- **What do we want to achieve**
  - The user wants to specify a subset of the data and run applications on it (chain of programs reading intermediate outputs)
  - Only at the end of the chain data sizes and computational complexity this can be (possibly) done on a laptop
    - 1000+ of physicists worldwide after the same data





# Behind the scenes...



User sitting "anywhere"

Dataset  $\rightarrow \{f1, f2, \dots, fn\}$



DDM

Dataset  $\rightarrow \{site1, site2, \dots, sitek\}$

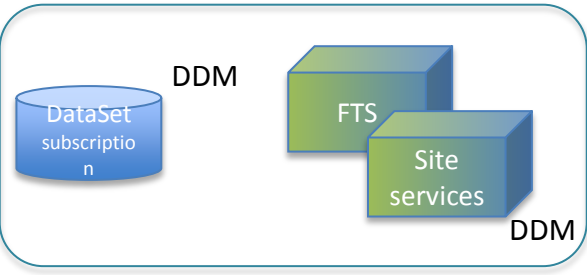


DDM

myprogram fj

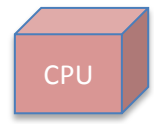


PanDA



Data distribution (asynchronous)

Payload transfer



CE+Batch system

fj  $\rightarrow$  //fj.dat

open/read/write/copy



LFC



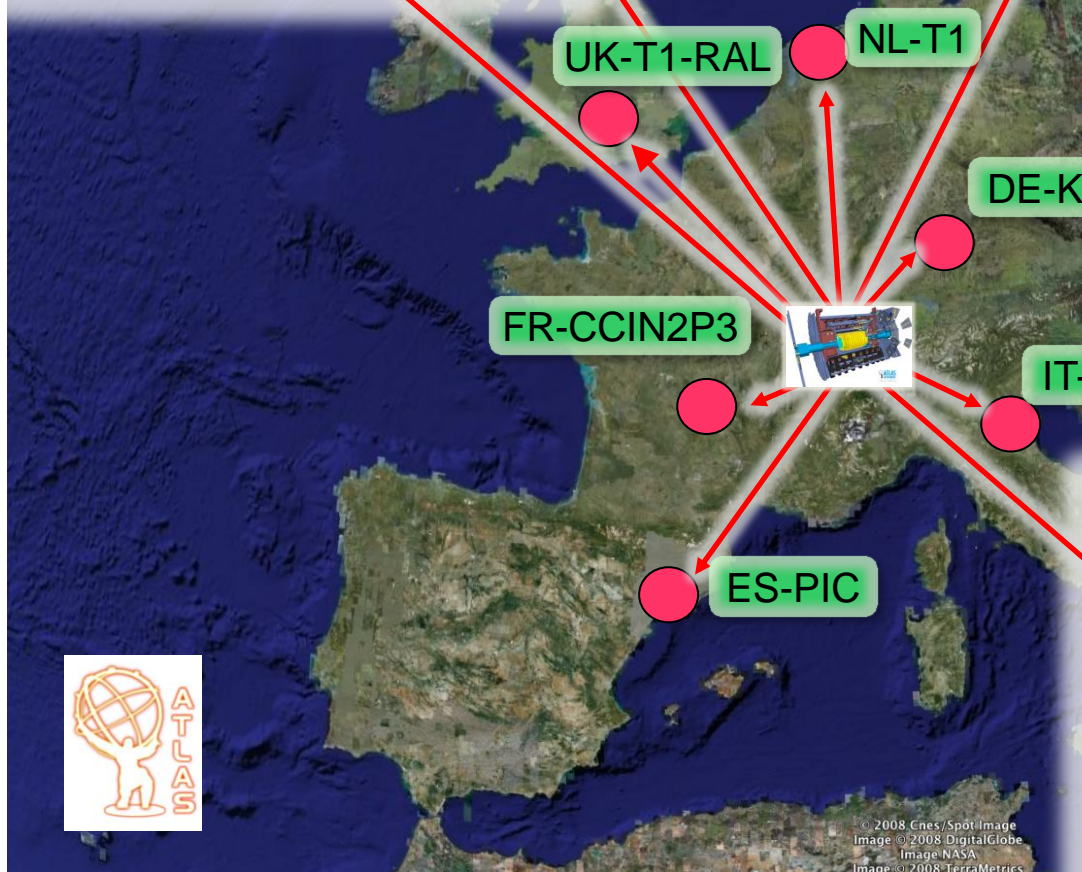
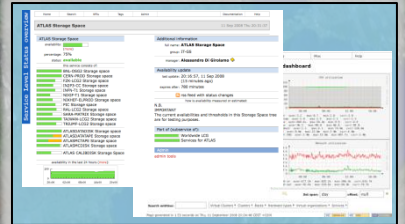
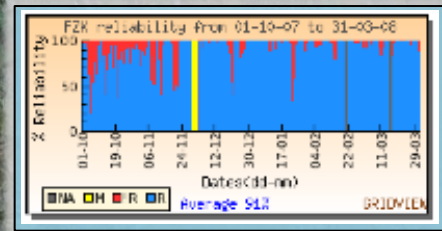
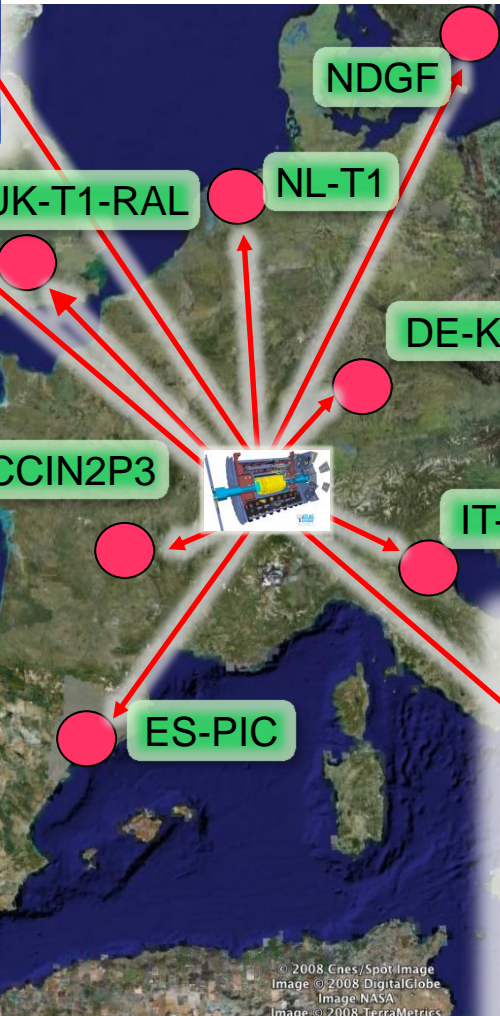
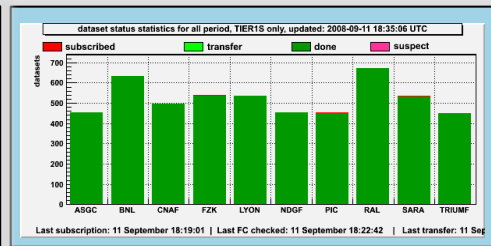
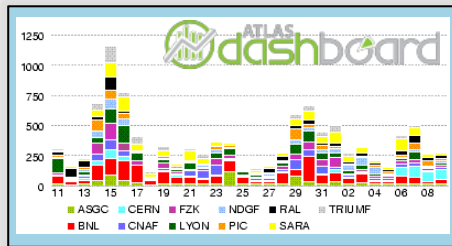
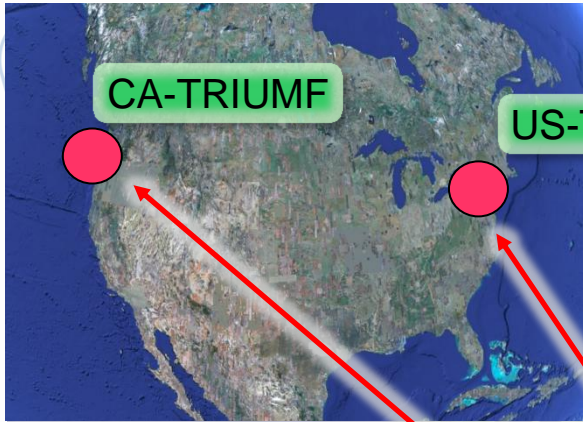
SRM



Monitoring (Dashboard)



Simplified  
One job executed in one cloud



© 2008 Cnes/Spot Image  
 Image © 2008 DigitalGlobe  
 Image NASA  
 Image © 2008 TerraMetrics

10 clouds  
 Only the Tier1 centre are shown  
 About 100 Tier2s in total

M. Lamanna



# Powered by *middleware* !

- *Globus, Condor and EDG* as starting point
  - Evolution lead by Europe (EDG → EGEE)
  - Other projects competing/collaborating
    - ARC, Unicore etc...
  - Large contribution from LHC community
    - And to a lesser extend from other users communities
    - "High-level" services
- **Security**
  - X509 infrastructure
  - Certificates → Proxies

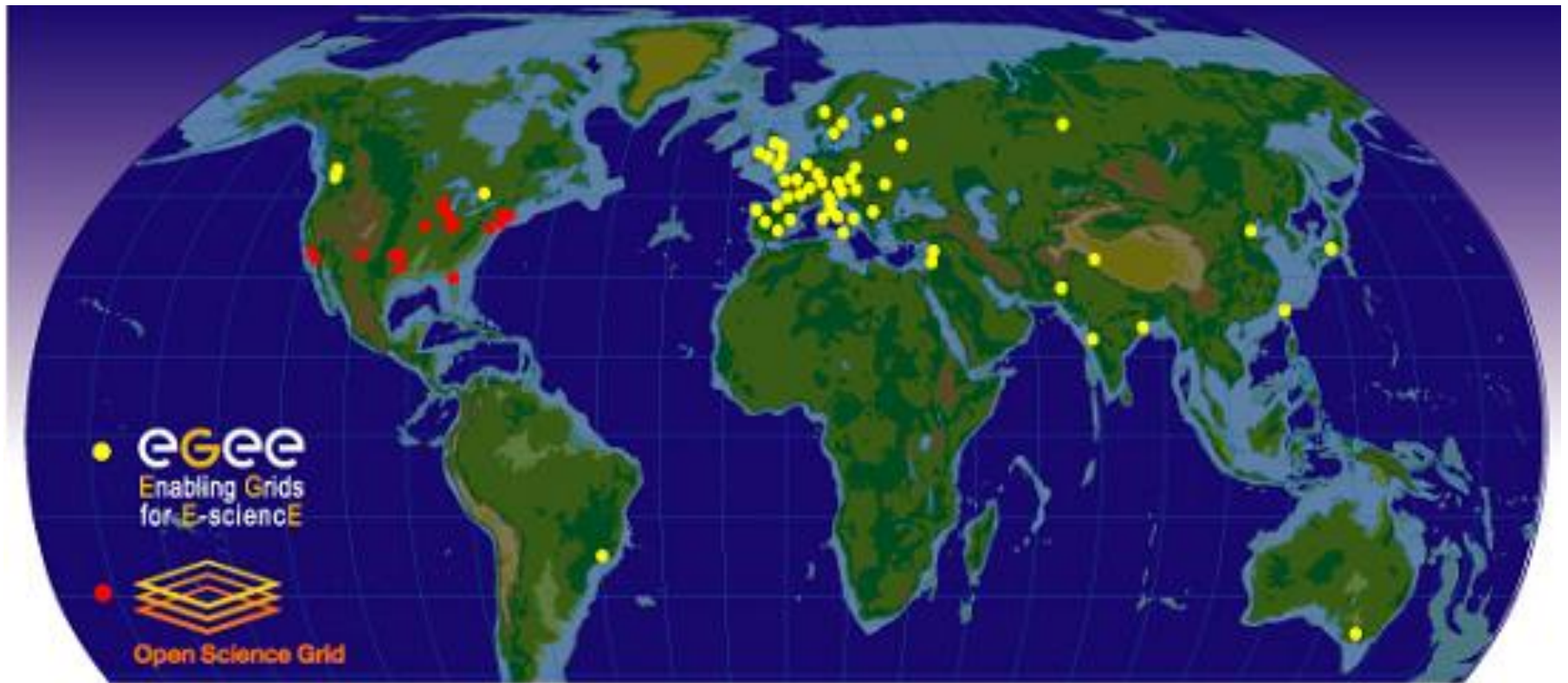
# Examples

- **Computing Element (CE)**
  - Gateway to CPU resources (typically a batch farm)
  - Examples: LCG-CE (LCG), CREAM (EGEE/INFN)
- **Data transfer**
  - Layer on top of gridFTP
  - Example: FTS (LCG/CERN)
- **Workload Management System**
  - CPU allocation for workload execution
  - Examples: gLite WMS (EGEE/INFN), glideinWMS (CMS), DIRAC (LHCb), PanDA (ATLAS), ALIen (ALICE), etc...
- **Storage Element (SE)**
  - Layer on top of storage solutions (Distr. FileSystem, Disk-Tape HSM-SAN, etc..)
  - SRM (Storage Resource Manager)
- **Other services: information systems, catalogues, etc...**



# LHC Computing GRID

Worldwide infrastructure  
(EGEE + OSG + NDGF)

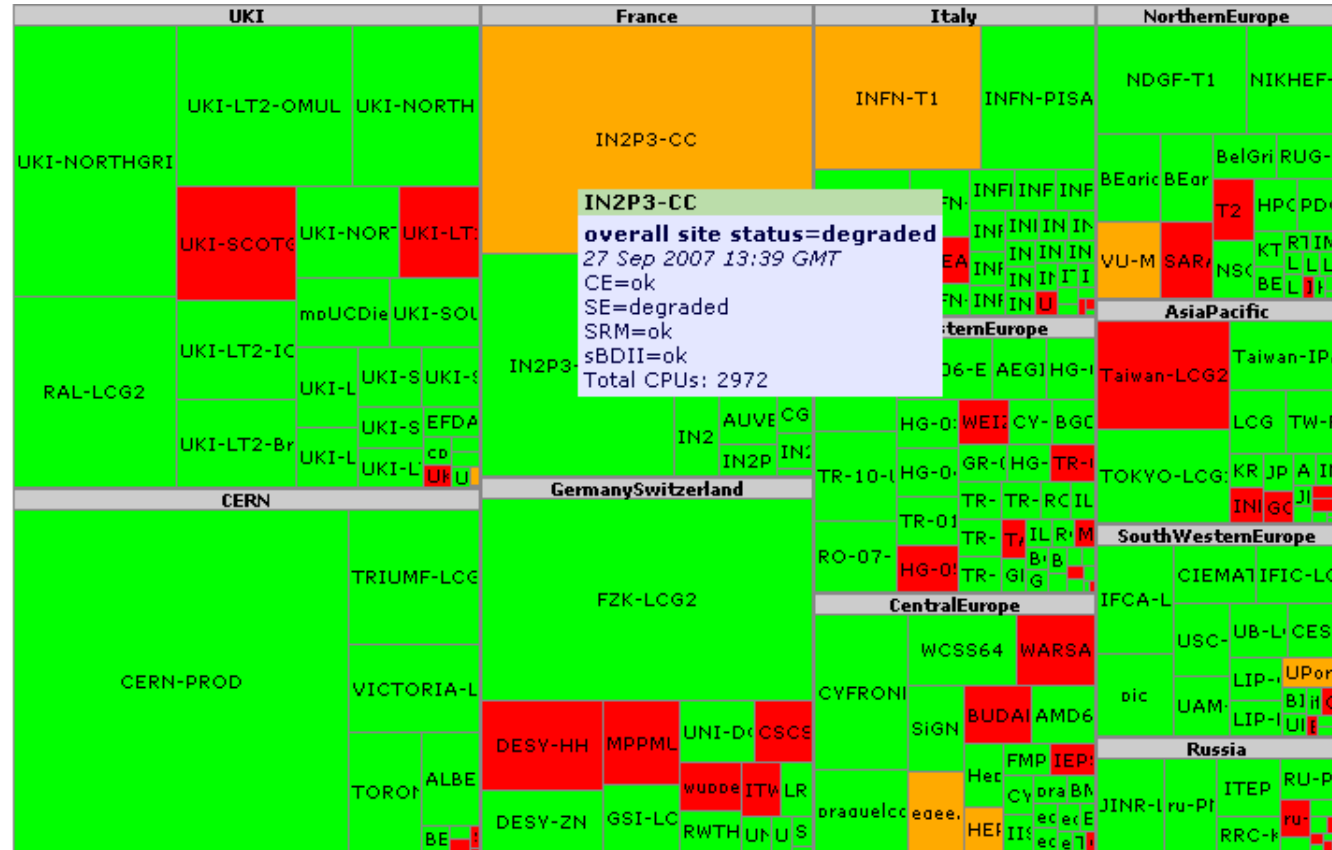






# All together now...

- CPUs, disk and tapes from more than 200 sites
- Sharing hardware
  - Share CPUs
  - Replicate data across different sites (performance and data preservation)
- Collaborative effort
  - Complex operations
  - Share responsibilities
  - Solve problems together



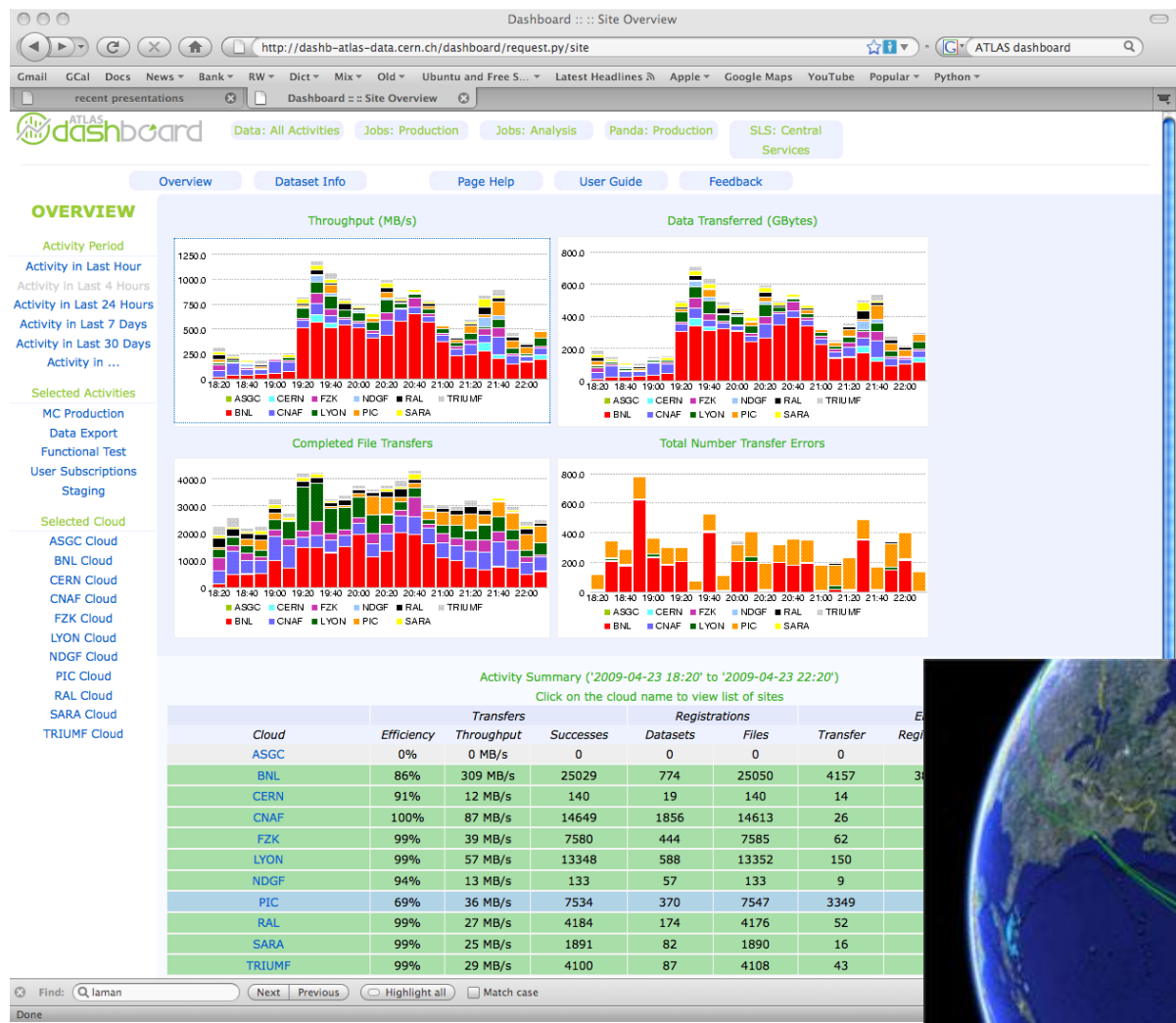
Latest SAM results, Site Status, for 'OPS' VO, 27 Sep 2007 13:39 GMT.  
 Size of site rectangles is number of CPUs from BDII.  
 Certified Production sites, grouped by regions.



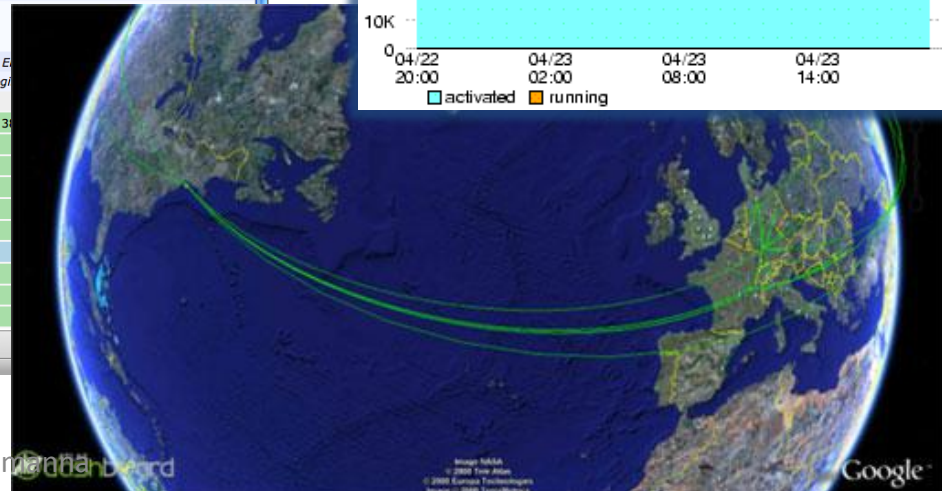
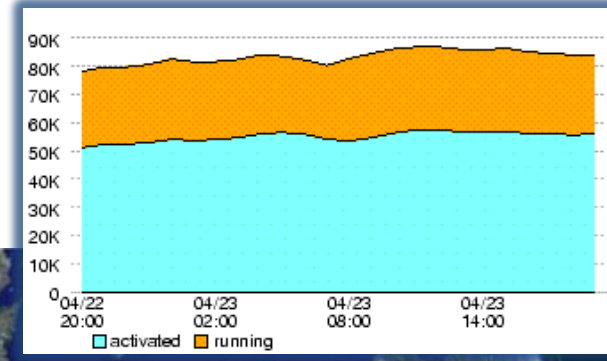
© CERN openlab / EDS



# ATLAS ON THE GRID



- Data distribution (left)
- Job distribution (bottom)



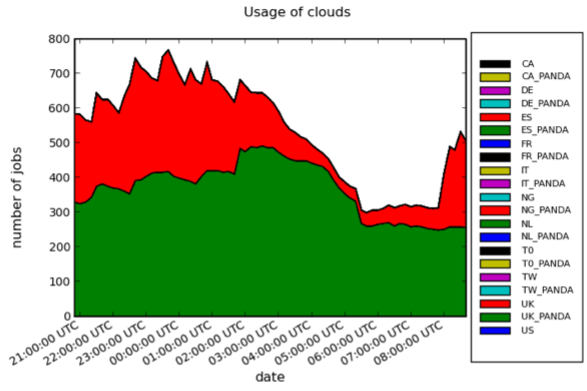


# HammerCloud



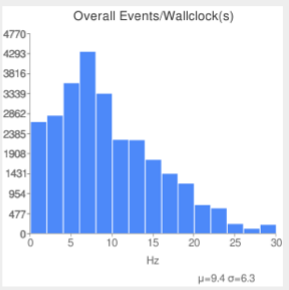
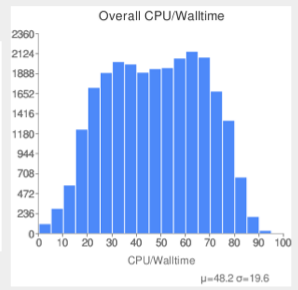
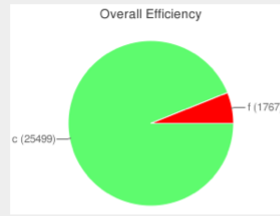
## Hammercloud

- Home
- Clouds
- Tests
- Last Tests
- Time
- HC Stats
- Administration



| Running and Scheduled Tests |     |                   |                     |                     |          |  |
|-----------------------------|-----|-------------------|---------------------|---------------------|----------|--|
| state                       | id  | host              | start time (CET)    | end time (CET)      | clouds   | sites  |
| running                     | 879 | voatlas49.cern.ch | 2009-11-20 15:01:00 | 2009-11-21 18:00:00 | IT       | INFN-MILANO-ATLASC_MCDISK                            |
| running                     | 878 | voatlas73.cern.ch | 2009-11-20 15:00:00 | 2009-11-21 18:00:00 | IT_PANDA | ANALY_INFN-MILANO-ATLASC                             |
| running                     | 874 | voatlas49.cern.ch | 2009-11-20 11:00:00 | 2009-11-21 11:00:00 | NL       | CSTCDIE_MCDISK, JINR-LCG2_MCDISK, RU-PNPI 4 more...  |
| running                     | 868 | voatlas73.cern.ch | 2009-11-19 11:05:00 | 2009-11-21 11:00:00 | ES       | IFAE_MCDISK, IFIC-LCG2_MCDISK, LIP-COIMBRA 5 more... |

Input DS Patterns: mc08.\*merge.AOD.e\*\_s\*\_r6\*tid\*  
 Ganga Job Template: /data/gangarobot/hammercloud/inputfiles/muon1531/muon1531\_panda.tpl  
 Athena User Area: /data/gangarobot/hammercloud/inputfiles/muon1531/source.1531.tar.gz  
 Athena Option file: /data/gangarobot/hammercloud/inputfiles/muon1531/MuonTriggerAnalysis.py  
[View Test Directory \(for debugging\)](#)



M. Palladin Università Udine – CERN OpenLab

| Site              | Submitted jobs | Running jobs | Completed jobs | Failed jobs | Num datasets per bulk | Min queue depth | Max running jobs | Resubmit enabled | Resubmit force |
|-------------------|----------------|--------------|----------------|-------------|-----------------------|-----------------|------------------|------------------|----------------|
| ANALY_LYON_DCACHE | 344            | 25           | 2811           | 209         | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_LPC         | 139            | 175          | 2884           | 38          | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_LYON        | 208            | 331          | 1401           | 96          | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_LAPP        | 101            | 45           | 1673           | 7           | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_BEIJING     | 284            | 115          | 2548           | 27          | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_ROMANIA02   | 0              | 0            | 0              | 0           | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_TOKYO       | 109            | 360          | 6266           | 155         | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_GRIF-IRFU   | 219            | 0            | 0              | 0           | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_LPSC        | 193            | 52           | 385            | 84          | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_GRIF-LPNHE  | 261            | 124          | 2207           | 9           | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_ROMANIA07   | 40             | 50           | 57             | 131         | 50                    | 50              | 1000000          | yes              | no             |
| ANALY_CPPM        | 134            | 0            | 161            | 3           | 50                    | 100             | 1000000          | yes              | no             |
| ANALY_GRIF-LAL    | 200            | 537          | 5106           | 1008        | 50                    | 100             | 1000000          | yes              | no             |
| <b>Total</b>      | <b>2232</b>    | <b>1814</b>  | <b>25499</b>   | <b>1767</b> |                       |                 |                  |                  |                |



# Oct. 30 @ midnight

**Panda Analysis Dashboard - Mozilla Firefox**

File Edit View History Bookmarks Yahoo! Tools Help

http://panda.cern.ch:25980/server/pandamon/query?dash=analysis

Most Visited Getting Started Latest Headlines Customize Links Free Hotmail Windows Marketplace Windows Media Windows

Search Web Mail Shopping Personals My My Yahoo! News Games Travel Finance Answers Sports Sign In

**Status of pathena analysis queues:** See the wiki page [PathenaAnalysisQueues](#)

**Analysis jobs:** [Listing of analysis jobs](#). To look up a particular Panda job by ID use the quick search at left or click a PandaID in the job listing.

**Analysis users:** [User list](#) (also linked at top right, or above if you've logged in) shows analysis usage, ordered by most recent. From there you can go to your page (you're on the list if you've run a Panda job); if you 'log in' you'll get easier access to your page from a new menu at the top of the page.

**Groups:** [~11k Panda jobs](#) by role, physics working groups etc. and support collaborative work, accounting rights etc. (Not much used yet.)

**Data:** [above](#) for information on data location, requesting replication of data, and staging data from tape to disk.

**Analysis Summary By Cloud**

World Wide - analy\_runni

Jobs: 0 to 12 k

Legend: CA, US, DE, ES, FR, UK, TW, NL, IT, CERN

Generated by TRIUMF-LCG2 (times in UTC)

**Summary By Site**

US - running - day

Jobs: 0.0 to 3.0 k

Legend: BNL, ANALY\_SWT2\_CPB, ANALY\_OU\_OCHEP\_SWT2, ANALY\_NET2, ANALY\_MWT2, ANALY\_AGLT2, ANALY\_SLAC, ANALY\_GLOW-ATLAS

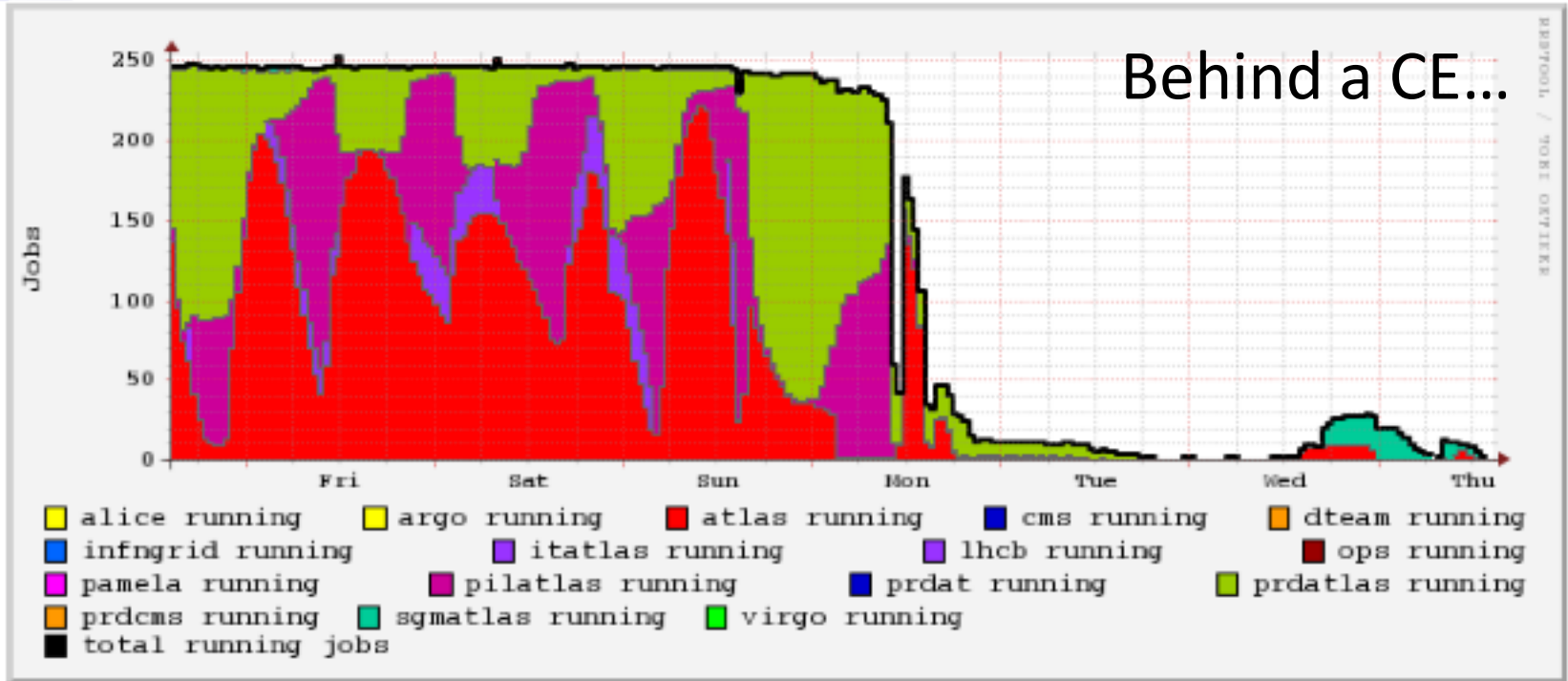
Generated by TRIUMF-LCG2 (times in UTC)

**Analysis job summary, last 24 hours** (Details: [errors](#), [nodes](#)) [pathena analysis queue status](#)

Cloud Information Job Latest Pilot defined assigned waiting activated sent running holding transferring finished failed tot trf other

start Panda Analysis Dash... 12:02 AM

# Balancing within activities



## INFN-NAPOLI

- Green = production (PanDA production)
- Red = WMS analysis
- Purple = Pilot (PanDA analysis)
- Blue = WMS local share

# Grid is about cooperation

- “Obviously” all computing centres cooperate!
- An interesting dimension is cooperation (sharing, exchange of information,...) across different scientific and technical communities
  - Because of **experience** (*long history of high performance innovative computing*), **present situation** (*we have to cope with LHC physics requirements*) and **culture** (*large international collaborations*) HEP can help and collaborate with other sciences!
- This is very actually concrete!
  - Grid (projects) is an ideal playground for this
    - CERN is the lead partner of the largest Grid infrastructure (EGEE - EU funded)
    - EGEE is a multi-science grid project (It contributes to LCG but supports several other communities, like biomedical, earth sciences, nuclear fusion, astrophysics etc...)



# ITU conference (2006)

The problem:  
Assign frequencies for digital radio and television (international treaty)

Critical point:  
Need on dependability:  
verify (iteratively)  
the compatibility between radio stations

Solution:  
Use the EGEE grid + a system used in ATLAS and LHCb to increase the reliability of the Grid

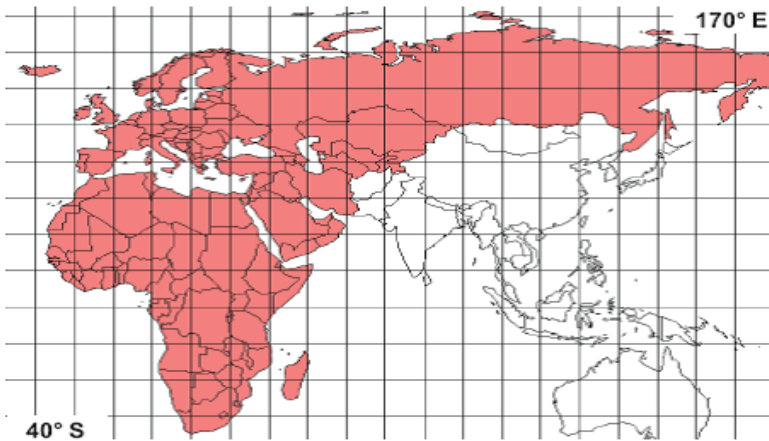
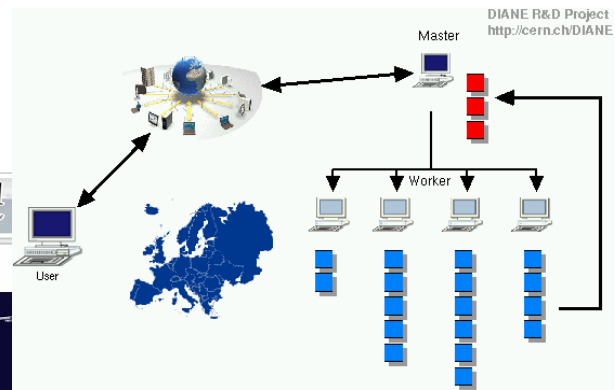
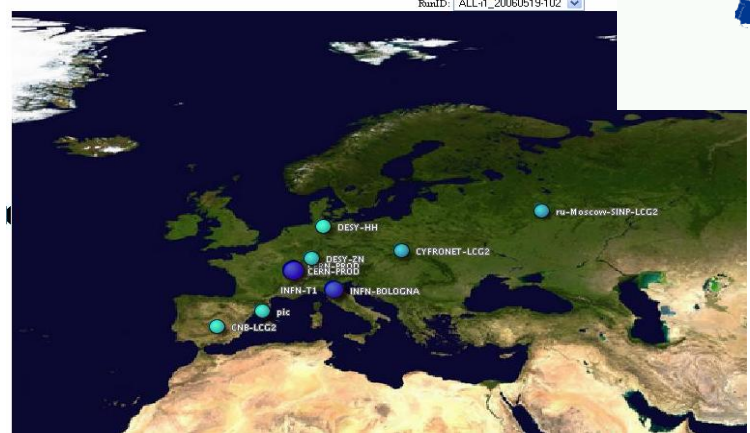


Figure 1  
The extent of the planning area for the RRC-06



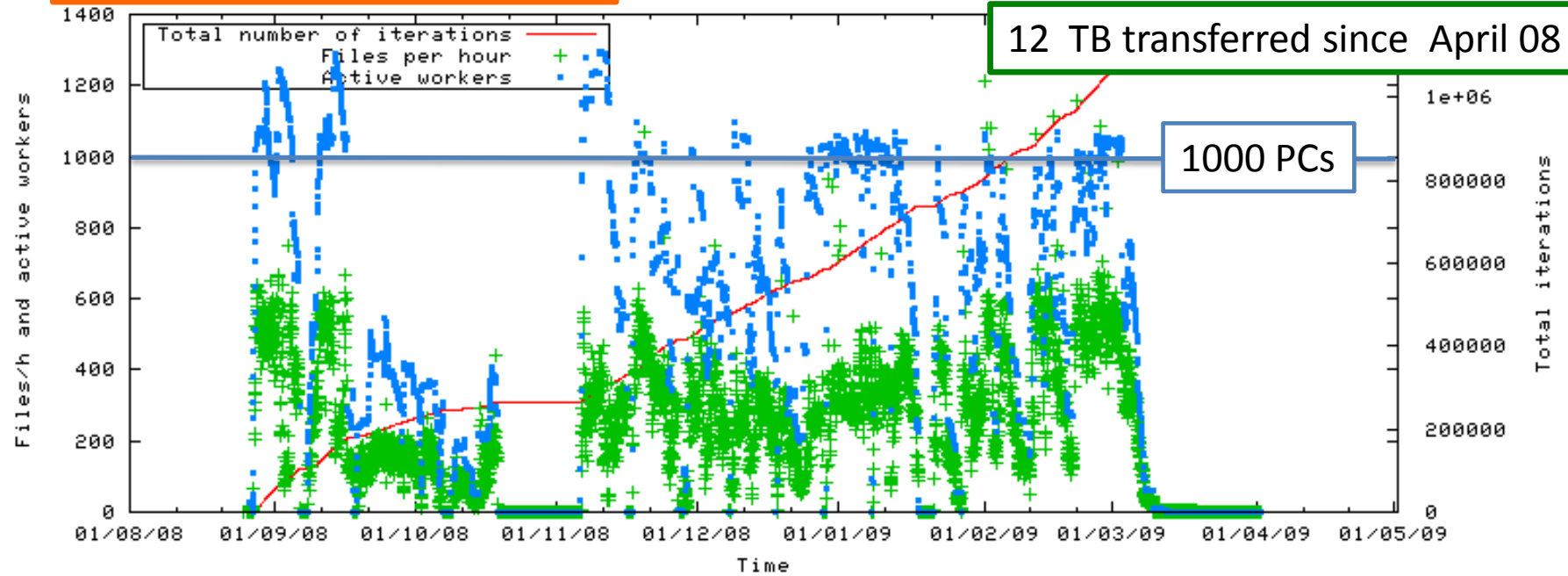


# QCD on the Grid

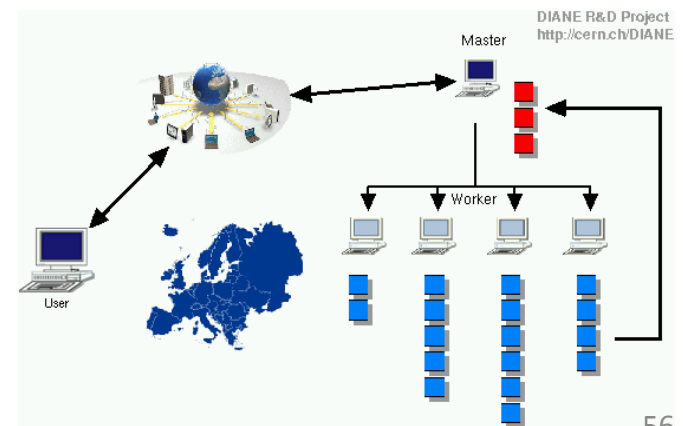
600+ CPU•years since April 08

un (plot created Fri Apr 3 11:40:58 2009)

12 TB transferred since April 08



- Several day in 2007 (first campaign)
- 12 months of running in 2008/9
  - second campaign, several periods, graph Sep08-Mar09
- Results regularly presented to leading conferences:
  - Lattice Conference -- Ph. De Forcrand (ETH and CERN)









# “Interactions” with computer science (PhD students)

**EGEE** Enabling Grids for E-science

## Design of an Expert System for Enhancing Grid Fault Detection based on Grid Monitoring Data

Gerhild Maier  
March 2<sup>nd</sup> 2009

www.eu-egee.org

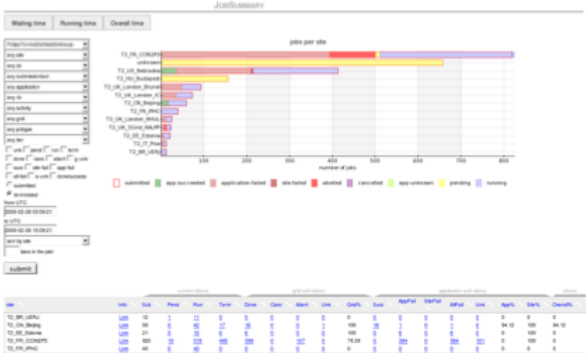



EGEE-III INFSD-RI-222667 EGEE and gLite are registered trademarks

**EGEE** Enabling Grids for E-science

## Output Verification (1/2)

one user has problems on different sites




EGEE-III INFSD-RI-222667 Mining Job Monitoring Data Gerhild Maier 12

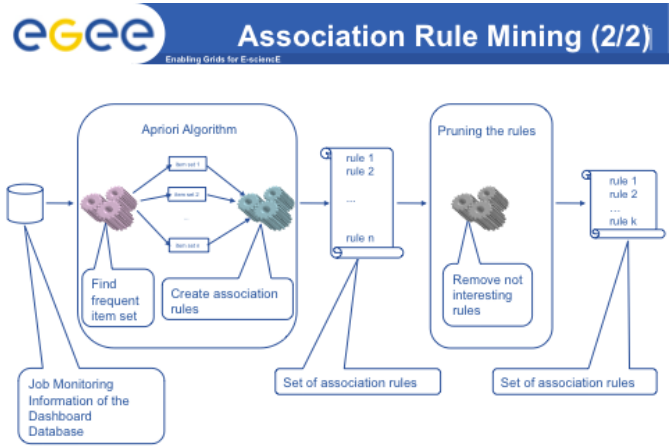
**EGEE** Enabling Grids for E-science

## Output Verification (2/2)

one user has problems with different datasets

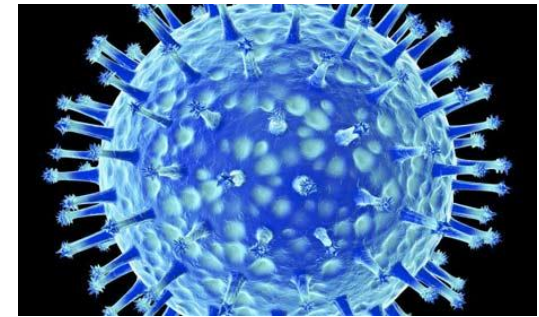


EGEE-III INFSD-RI-222667 Mining Job Monitoring Data Gerhild Maier 13

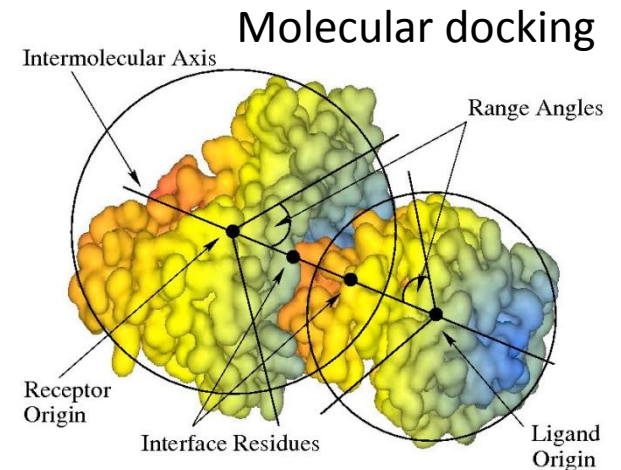


EGEE-III INFSD-RI-222667 Mining Job Monitoring Data Gerhild Maier 6

# Bird Flu



- Basic idea:
  - Compute how a given chemical interacts with a protein (e.g. belonging to a virus)
  - High affinity means the chemical is a potential drug against the virus
- In silico (i.e. use your PC):
  - Scan millions of chemicals ( $\sim 10^3$  s per chemical-protein pair)
    - With 1,000 PCs, 1 docking per second
  - Good candidate given to biologist (verification longer -and more expensive- than in silico docking)
    - In practice, you enrich the initial sample saving time (and money)
    - Essential to fight to pandemic (H5N1) or neglected diseases (like Malaria)
- WISDOM collaboration
  - Malaria
  - H5N1 (Bird Flu)





# ...More communities sharing tools designed for LHC and being useful in other domains!



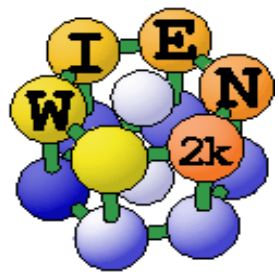
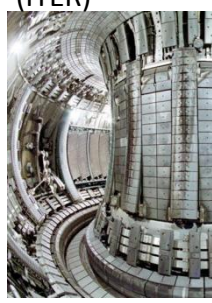
## Geant 4



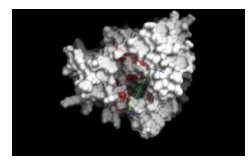
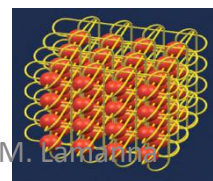
## Garfield



Nuclear fusion (ITER)



Lattice QCD



Academia Sinica Genomics Research Center



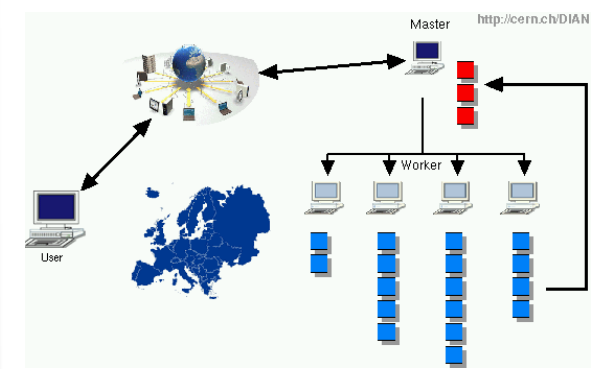
## HARP



<http://cern.ch/ganga>

Always reuse the same pattern:

1. Divide the problem in small task that can be distributed independently
2. Distribute these tasks to "dumb" workers (Grid processes)
3. Recollect the results



<http://cern.ch/DIAN>

CERN e-Recruitment Home Page

https://ert.cern.ch/browse\_wd\_wd\_pds?p\_web\_site\_id=1

twiki computer centri

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 Intranet  
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 By Reference  
 Employment Conditions  
 Information for  
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 Fellows  
 Associates  
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 FAQ

CERN is the European Organization for Nuclear Research, based on the Franco-Swiss border near Geneva (more...).

We are at the forefront of technologies in many fields, and there are opportunities for both working and learning at CERN, including student and graduate programmes, as well as vacancies in many domains such as electricity, mechanics, electronics and computing, etc.

Please use the left-hand menu to search and apply for our current opportunities or look for further information on our recruitment conditions and programmes, recruitment events or to contact us.

Cliquez ici pour une explication en français

News

Welcome to our e-Recruitment website! We rely on your feedback to continue improving this site. Problems can be reported by mail.

CERN staff please click on "Internal posts" in the menu to access internal vacancy notices (AIS login required)! (more info)

Important technical information.

Deadlines

|                               |           |
|-------------------------------|-----------|
| Technical & Doctoral Students | 07-AUG-09 |
| Fellows                       | 07-SEP-09 |
| Scientific Associates         | 19-MAR-09 |

Do not wait until the last day to send your application as additional information will be requested by CERN once your application form has been received! More Info...

Focus on...

Are you an undergraduate student of a CERN Member State nationality in a technical field looking for a practical training period or a place to do your final project? CERN has a Technical Student programme that could interest you. If you have completed at least 18 months of your technical undergraduate studies, and your course requires a practical training period of 6 to 12 months, which you wish to spend at CERN, apply to the Technical Student Programme. Note that students of theoretical and experimental



## CERN options for students

- University level (BS/Master)
  - Summer student
  - OpenLab summer students
- Master thesis
  - Technical student (non physicist)
- PhD students
  - Doctoral students
- Young scientists/engineers
  - Fellowship
  - Other programmes



# Questions?

**ANGELS & DEMONS**  
IN THEATERS MAY 2009

*Audio Off* [icon]

I. ROBERT LANGDON   II. VATICAN CITY   III. THE CRISIS   IV. A HIDDEN THREAT

← BACK TO THE CRISIS

## CERN

Based near Geneva, CERN is one of the world's premiere scientific research laboratories. Created in 1954, it houses the world's largest particle physics facility where scientists and engineers seek to understand the Laws of Nature.

CERN grabbed headlines in September 2008 with the first tests of its Large Hadron Collider, an underground tunnel spanning more than 17 miles under Switzerland and France. Once fully operational, CERN will be able to replicate the moment of Creation or what's referred to as the 'big bang.' While proponents of CERN see this

← BACK   NEXT →

COLLISION EVENT DETECTION IMAGING CORE

XTR CODE BASE

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