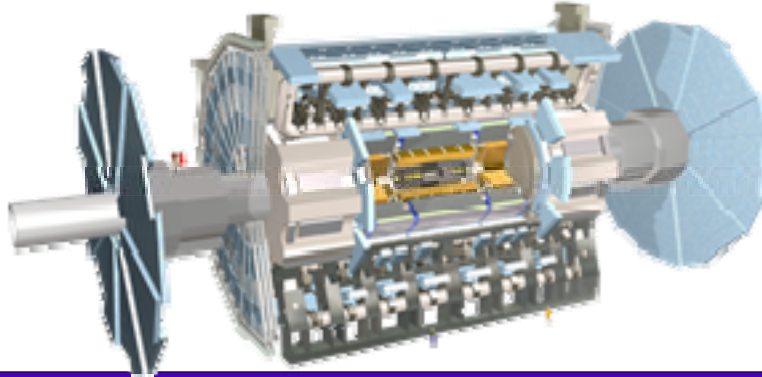


**Australian participation in the world's largest eResearch infrastructure:
the Worldwide LHC Computing Grid and the EGEE Program.**



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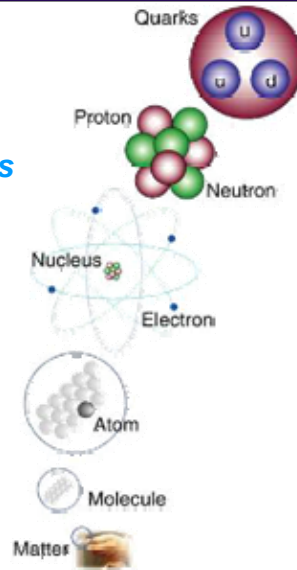
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High Energy Particle Physics

The aim of High Energy Physics is to:

“Understand the *fundamental laws of nature* by *studying elementary particles and fields* and their interactions”



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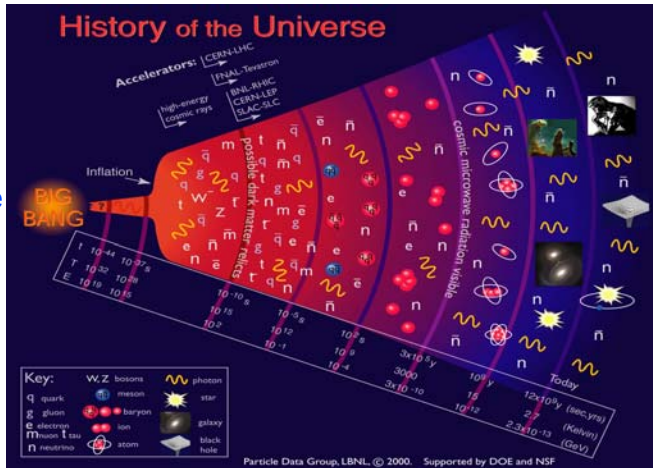
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Peering Back in Time...

Studying matter at high energy densities takes us closer to...

...understanding the physics of the earliest moments of the universe



Colliders shed light on questions of cosmological significance...

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Experimental High Energy Physics in Australia

- **Close collaboration between:**
 - University of Melbourne
 - University of Sydney
 - University of Wollongong
 - *Hold joint Research Grants*
 - a single community of researchers
- **The Physicists:**
 - Academic Staff, Research Fellows, Postgraduate Students, Engineers and Technicians
- **Members of major international HEP experiments...**
 - **ATLAS** at the Large Hadron Collider, CERN, Geneva, Switzerland
 - **Belle** at the KEK laboratory, Tsukuba, Japan

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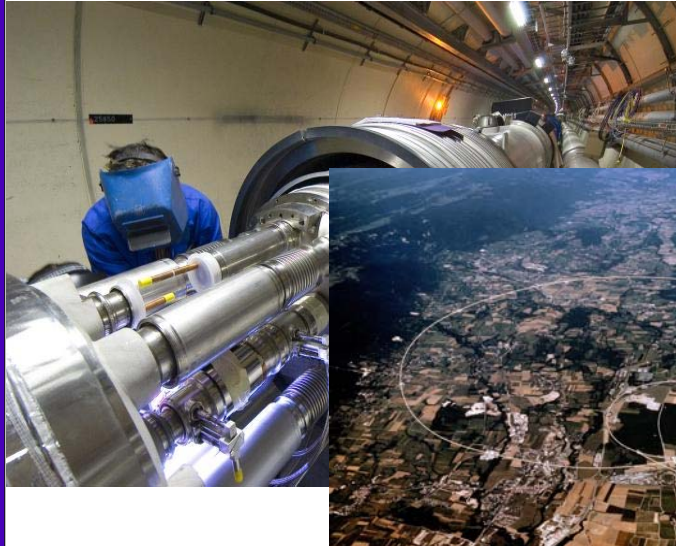
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The Large Hadron Collider, CERN

- *The world's largest scientific instrument...*

Located near
Geneva,
Switzerland



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The Large Hadron Collider, CERN

- The LHC will smash protons together with energies in the Tera electronVolt (TeV) range ...*the energy frontier*



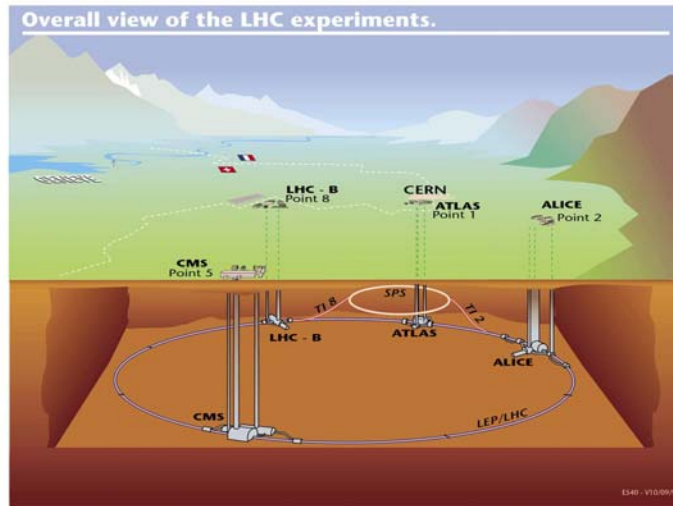
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The LHC Experiments:

- Four experiments: **ATLAS**, **CMS**, **LHCb** and **ALICE**



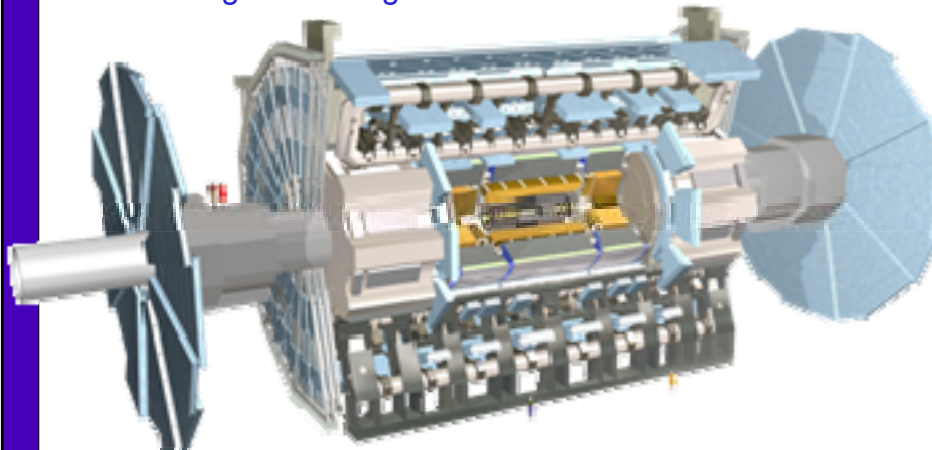
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The ATLAS Experiment

- To investigate the origins of **Mass**

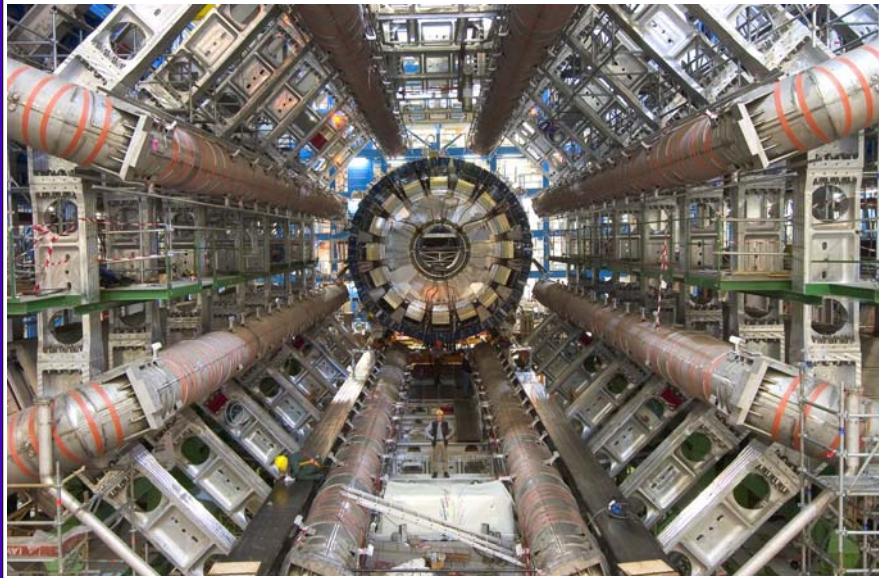


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ATLAS will start taking data in 2008...



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ATLAS Collaboration

35 Countries
161 Institutions
1830 Scientific Authors



Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Ancey, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, Bologna, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, Mannheim, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Ritsumeikan, UFRJ Rio de Janeiro, Rochester, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, Wisconsin, Wuppertal, Yale, Yerevan

Physics at the Tera-Scale

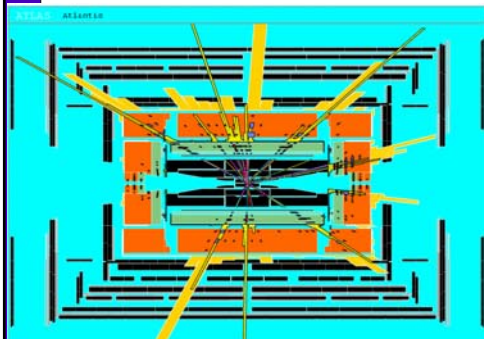
- The LHC is a *frontier machine* – operating in an *unprecedented energy regime: TeV collider*
 - Searching for *New Physics* – beyond the *Standard Model*
 - Enhancing our understanding of the *fundamental structure of matter*
 - ...and throwing a light on the the nature of the universe in the first moments after the *Big Bang*
- *ATLAS will look for:*
 - The elusive *Higgs Boson*: the “*origin of mass*”
 - *Supersymmetry*
 - *Dark Matter, Dark Energy??*
 - *Large Extra Dimensions:*
 - *Microscopic Black Holes*
 - *Exotics: Magnetic monopoles,....*
 - *the Unexpected*

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Black Holes at ATLAS

ATLAS was recently honoured by a visit from Stephen Hawking



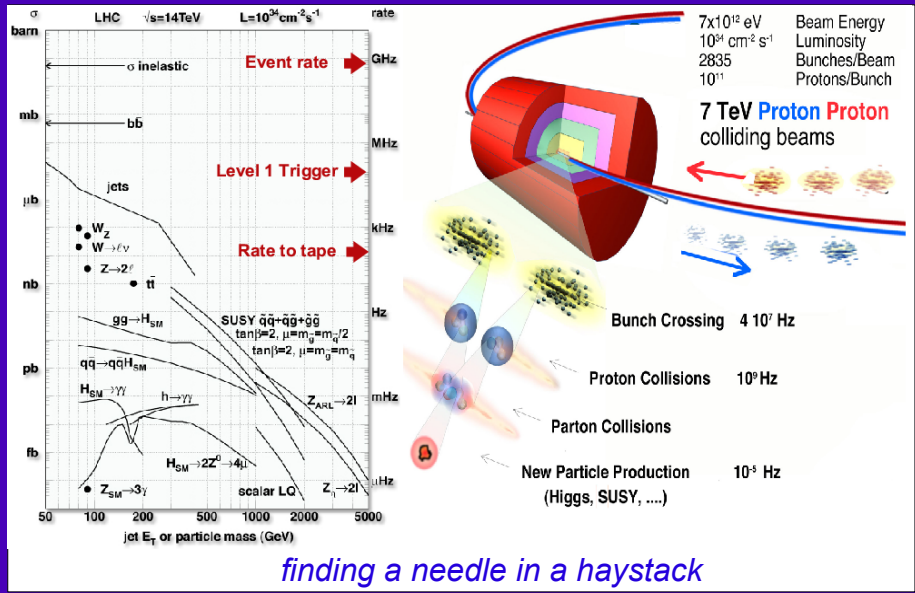
Simulation of a mini black hole event with $M_{BH} \sim 8$ TeV in ATLAS



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Data from an LHC Experiment

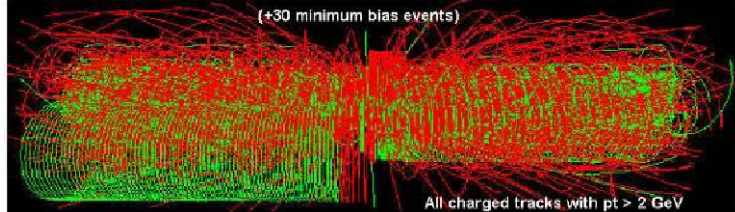


finding a needle in a haystack

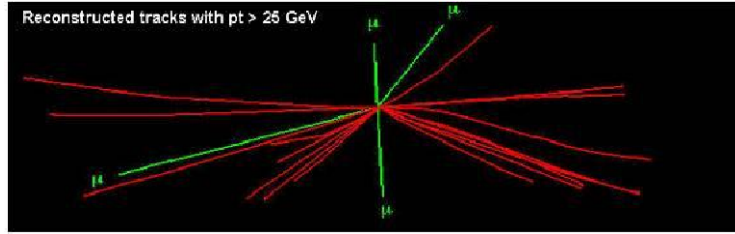
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...finding a needle in a haystack

Each event is really an overlay of many interactions



We are looking for tracks from one interaction in this soup...



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Data Mining

Particle physicists wade through vast collections of events, searching for increasingly rare processes

- *In principle, each physicist, or each team, is looking for something different.*

So, we have thousands of scientists searching through vast collections of data:

- Widely distributed across the Earth
- Each looking for a different type of needle in the haystack

Chaotic data usage patterns!

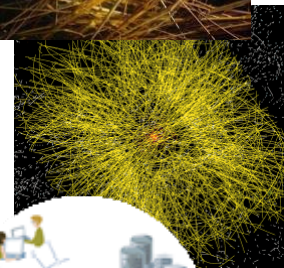
It is essential to deliver high bandwidth data streams to researchers at their home or regional data analysis facilities - a very competitive business

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The LHC Computing Challenge

- **Data volume**
 - High rate x large number of channels x 4 experiments
 - **15 PetaBytes of new data each year**
- **Compute power**
 - Event complexity x Nb. events x thousands users
 - **100,000s of today's fastest CPUs**
- **Worldwide analysis & funding**
 - Computing funding locally in major regions & countries
 - Efficient analysis everywhere
 - *Equity of Access*
 - *Deliver the data to the physicists*
 - **GRID technology**

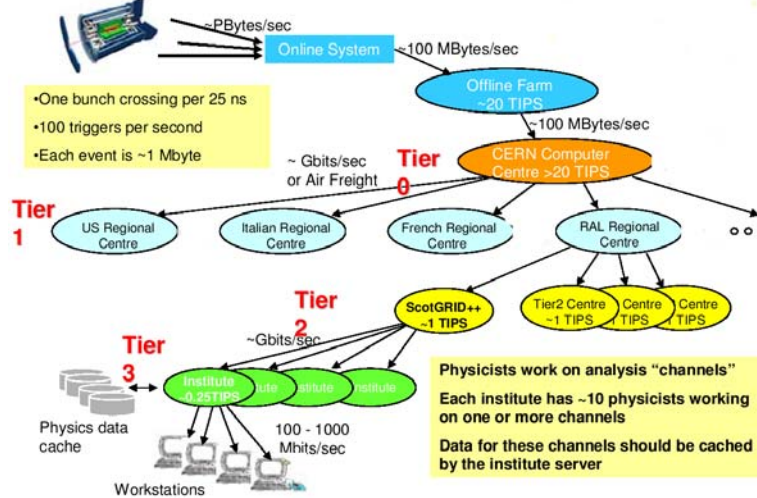


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The LHC Computing Model

- Use distributed resources...
 - Funding, access: Take the data to the physicists!



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The Worldwide LHC Computing Grid

- The EGEE and OSG projects are the basis of the Worldwide LHC Computing Grid Project WLCG



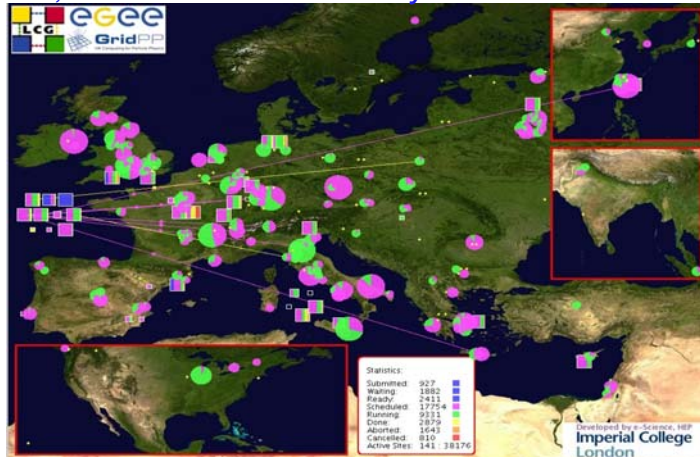
Inter-operation between Grids is working!

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The Worldwide LHC Computing Grid

37,000 CPUs and 13 Petabytes across 240 sites



Up to 98,000 jobs per day: 13,000 non-LHC jobs Other VOs
ATLAS transferring 1000 Terabytes per month

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EGEE: Enabling Grids for Esience

- **Flagship grid infrastructure**
 - co-funded by the European Commission
- **Now in 2nd phase**
 - 91 partners in 32 countries
- **Objectives:**
 - Large scale production quality grid infrastructure for eResearch
 - Attract new resources and users from industry and science
 - Maintain and improve *gLite* grid middleware



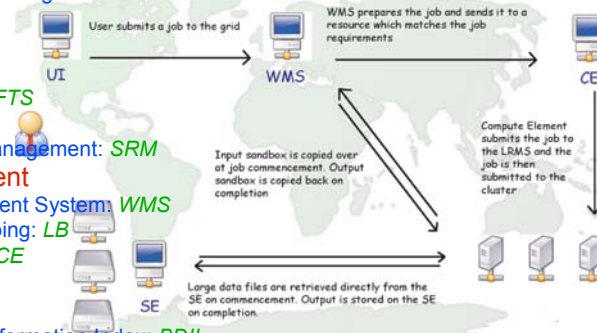
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The EGEE Middleware: *gLite*

- **Security**
 - Virtual Organization Management: *VOMS*
 - MyProxy
- **Data management**
 - File catalogue: *LFC*
 - File transfer service: *FTS*
 - Storage Element: *SE*
 - Storage Resource Management: *SRM*
- **Workload management**
 - Work Load Management System: *WMS*
 - Logging and Bookkeeping: *LB*
 - Computing Element: *CE*
 - Worker Nodes: *WN*
- **Information System**
 - Berkeley Database Information Index: *BDII*
 - Relational Grid Monitoring Architecture: *RGMA*
 - Monitoring & visualization (Griview, Dashboard, etc.)



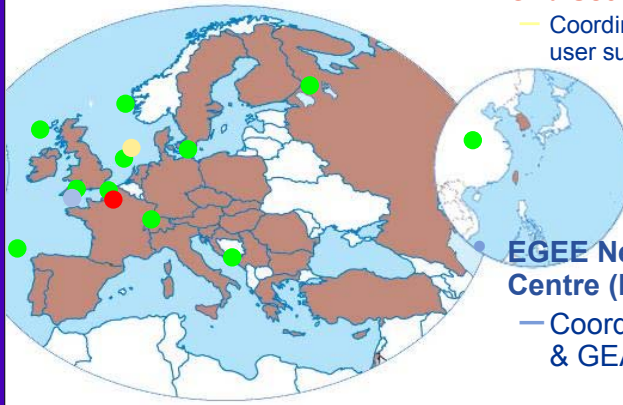
... an infrastructure for eResearch

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EGEE is a *production* infrastructure

- **Operations Coordination Centre**
 - Management, oversight, coordination
- **Regional operations Centres**
 - Core support infrastructure
 - Taipei operates Asia-Pacific ROC
- **Grid User Support (GGUS)**
 - Coordination, management of user support

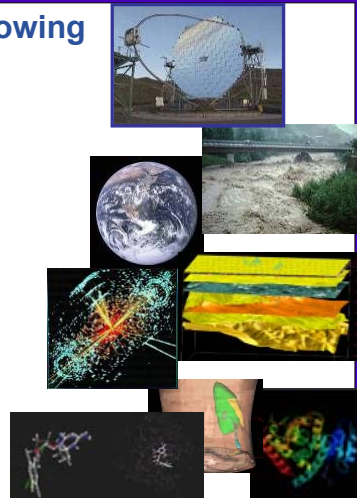


EGEE Network Operations Centre (ENOC)
 - Coordination with NRENs & GEANT2

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Who uses EGEE?

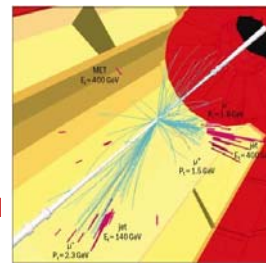
- **Multitude of applications from a growing number of domains**
 - Astrophysics
 - Computational Chemistry
 - Earth Sciences
 - Financial Simulation
 - Fusion
 - Geophysics
 - *High Energy Physics*
 - Life Sciences
 - Multimedia
 - Material Sciences
 -



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High Energy Physics on EGEE

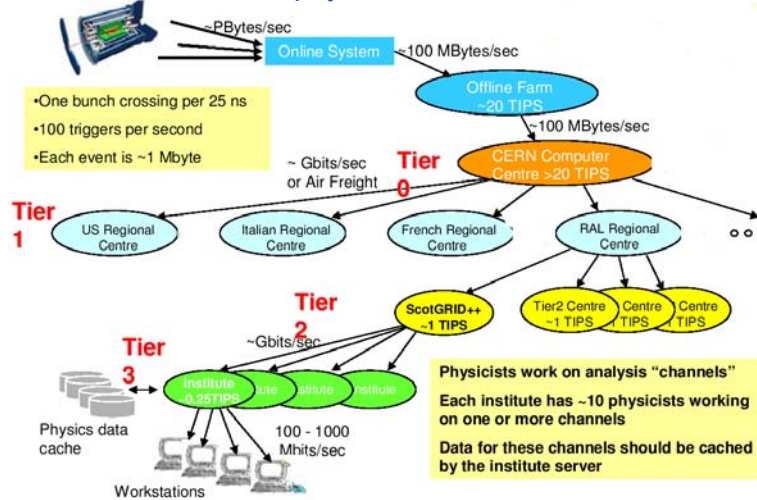
- **Data management:**
 - Demonstrated data transfers at nominal rates: 1.6 GB/s through File Transfer Service (FTS)
 - 1 GB/s with real workloads
 - 2 large experiments transferred >1 PB/month in 2006
- **Workload management**
 - CMS – computing service challenge achieved 50k jobs/day
 - CMS aim this year for 100k jobs/day; ATLAS for 60k
- **Reliability and availability**
 - Significant effort to ensure Tier 1 sites meet MoU commitments – using site and service monitoring
- **Grid is now the primary source of computing resources for experiments at CERN**



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The ATLAS experiment on the WLCG:

- Hierarchical model: Tier 0 at CERN: Regional Tier 1 centres
 - Take the data to the physicists!



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Global ATLAS Computing Resource Requirements

- Worldwide Computing Resources for ATLAS:

	2008	2009	2010
Disk (TB)	30,000	45,000	72,000
Tape (TB)	16,000	29,000	48,000
CPU (Opteron 250)	54,000	88,000	150,000

- Distributed across:
 - Tier 0 (CERN)
 - 10 Tier 1 centres across the world
 - 30 Tier 2 centres
- Australia has deployed a Tier 2 centre at the University of Melbourne
 - Will become a Tier 2 Federation with partner resources at VPAC, AC3, SAPAC...
 - Supported by APAC National Grid program since 2004

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Australian ATLAS Computing Service

- Target Resources for Australian facility:

	2007	2008	2009	2010
Disk (TB)	30	170	280	440
CPU (Opteron 250)	40	200	300	480

- An average Tier 2/3 – to serve Australian ATLAS members
 - Essential to ensure Australian researchers are competitive at the LHC
- Targets will be met by dedicated facility AND shared resources from partners: VPAC, AC3, SAPAC.
- Currently operating a Pilot Tier 2 service:
 - Production Tier 2 Computing Service will be commissioned from July 2007:
- Supported by:
 - ARC, DEST, APAC, Universities of Melbourne and Sydney

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Australia's Pilot ATLAS Computing Service

- Since 2006 we have been operating a Pilot Tier 2 site:
 - For commissioning and participation in Pilot LHC Service
 - 39 CPUs and 8 TB storage
 - Supported by Research Computing Services at the University of Melbourne (Dirk van der Knijff)
 - Certified since July 2006:
 - ATLAS: 15,561 jobs; 38,000 CPU hours
 - BIOMED (Avian Flu): 565 jobs; 9218 CPU hours
- Jobs from across WLCG



A major achievement:

Intensive collaboration:

- Working closely with EGEE, APAC, AARNet, CERN, Taipei, China, Japan - a truly global collaboration

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Australia's ATLAS Computing Service

- **Many challenges to overcome:**
 - gLite Middleware deployment: delivering a reliable service
 - (Marco La Rosa)
 - International long-haul data transfers:
 - Very challenging – International R&E networks
 - Substantial support and expertise from AARNet
 - End-point bottlenecks
- **Regional Operations Centre:**
 - ASGC, Taipei hosts Asia-Pacific ROC and Tier 1
 - Strong collaboration and support
 - Regular meetings



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Australia's ATLAS Computing Service

We are now operating a reliable production facility in the world's largest e-research infrastructure (research e-infrastructure)

- **Now hosting 8 Terabytes of simulated ATLAS data**
 - replicated from ATLAS collaborators across the globe
 - Capacity increasing to 35 Terabytes from July 2007
 - Supporting simulated data production, data analysis and detector calibration
- **Building expertise and capacity:**
 - Major capacity upgrade for 2008
 - We will be ready for first data from the LHC in 2008.

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So, how do researchers use these facilities?

- *EGEE middleware provides:*
 - *storage management protocol (SRM)*
 - *File Transfer Service (FTS) for managed file transfer queues*
 - *File Catalogues (LFC) with file replica management*
 - *Metadata Catalogues for physics-level metadata (AMGA)*
- *ATLAS deploys a Distributed Data Model on top of these services*
 - *Data files are organised into data sets*
 - *We request subscriptions of data sets to our sites.*
 - *DDM system manages subscriptions and files are transferred through a queuing service*
- *Analysis of data “goes to the data set”*
 - *Place the data – then send jobs to it*

Racing to discoveries at the LHC....

Benefits from engagement with EGEE program

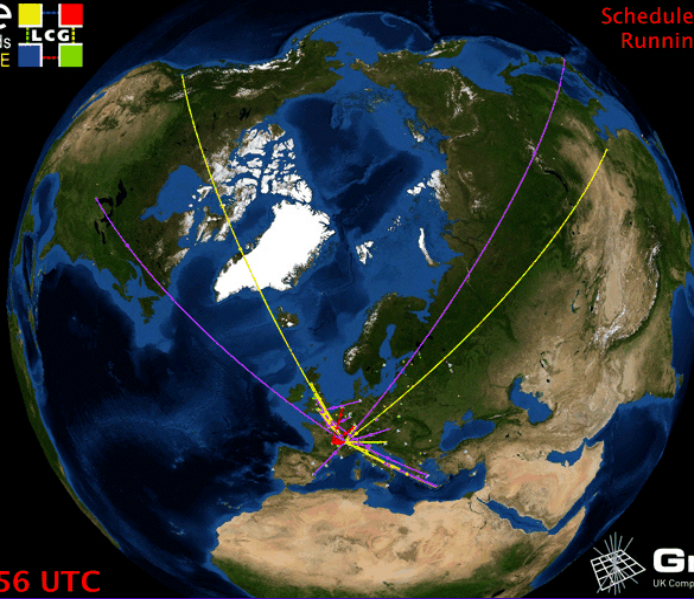
- *Easy to exploit (relatively...)*
 - The real hard work has been done
 - Substantial expertise in Aus HEP group (Marco, Glenn)
 - Major support from EGEE “on-tap”
 - User and operations support, training events
 - Still new developments on the way
 - Exploring the provision of a “gLite service” on the Australian national grid
 - For high energy physics – *and other communities*
 - International interoperation “out of the box”
- *Going further?*
 - We have been invited to join the EGEE-Asia program
 - Working very closely with EGEE partners in Asia-Pacific

Want to know more – see Marco La Rosa's demonstration at the VerSI booth...

EGEE & WLCG: A Truly Global Grid

EGEE 
Enabling Grids
for E-science

Scheduled = 25002
Running = 12614



15:38:56 UTC

 **GridPP**
UK Computing for Particle Physics

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