

# Data Grid for High Energy Physics

Glenn Moloney  
University of Melbourne

June 21, 2004

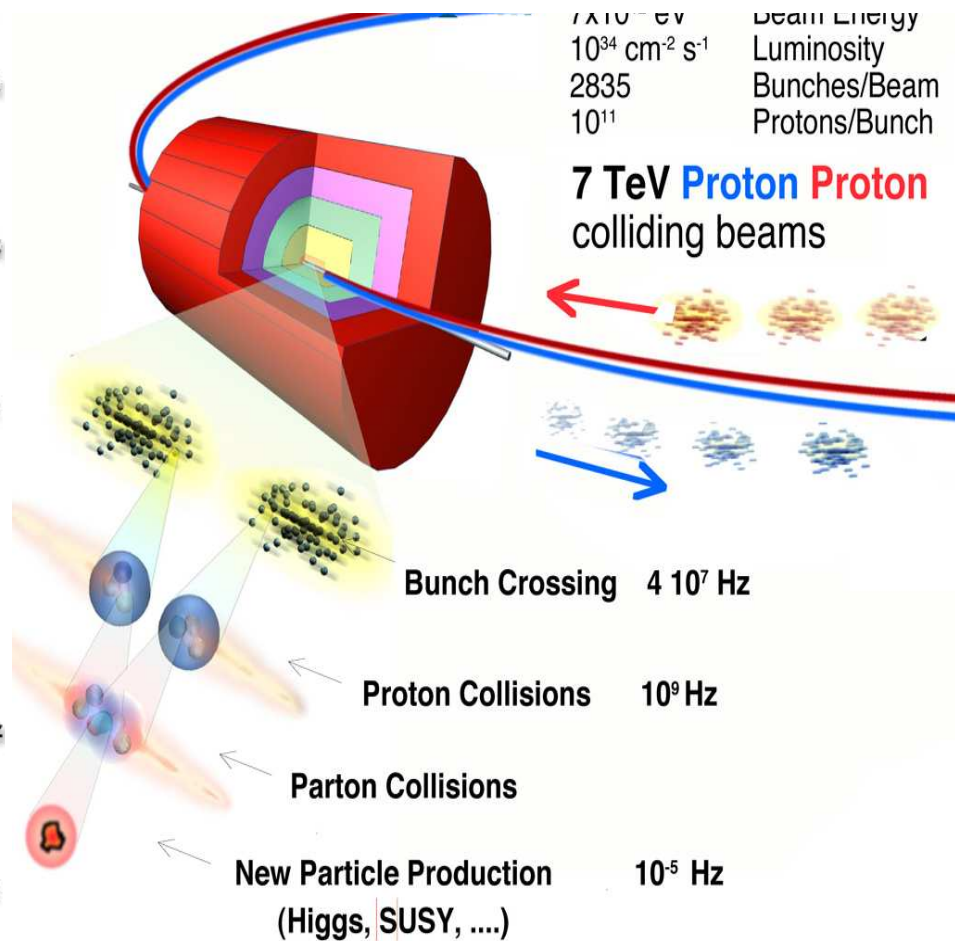
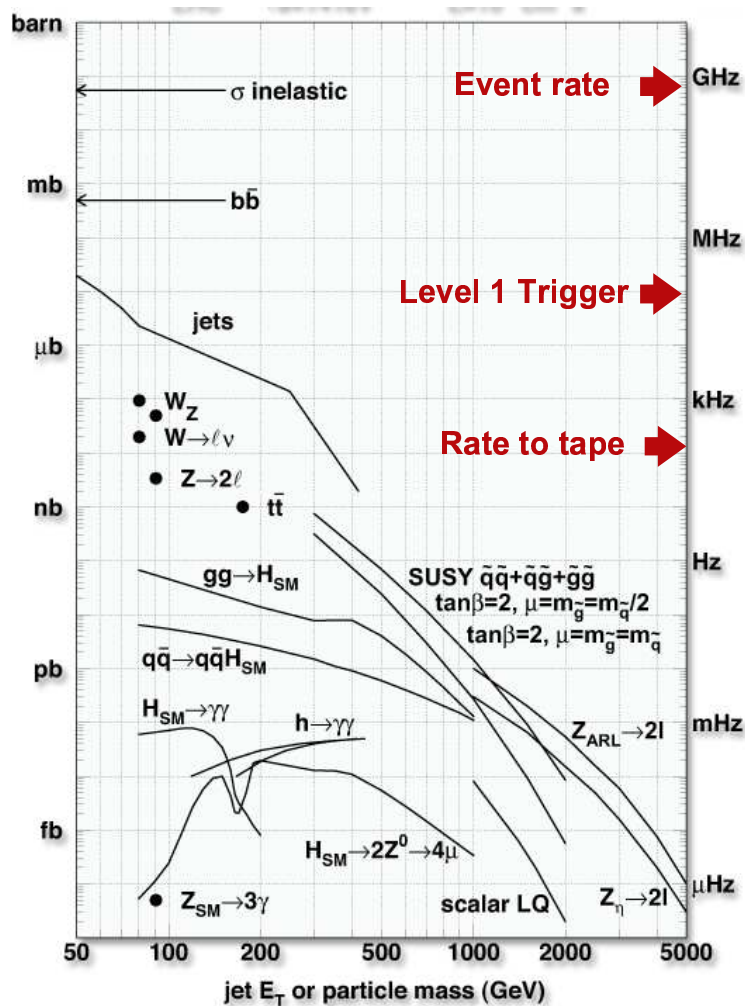
# The Challenges of *Bigger HEP Experiments*

- The Nomad experiment: Shutdown in  $\approx 1996$ 
  - Accumulated  $O(\text{Terabytes})$
- The Belle experiment: Commenced data taking in 1999
  - Has accumulated  $O(1 \text{ Petabyte})$
- The Large Hadron Collider experiments: Commence data taking in 2007
  - Will accumulate  $O(10 \text{ Petabytes/year})$

*Also:*

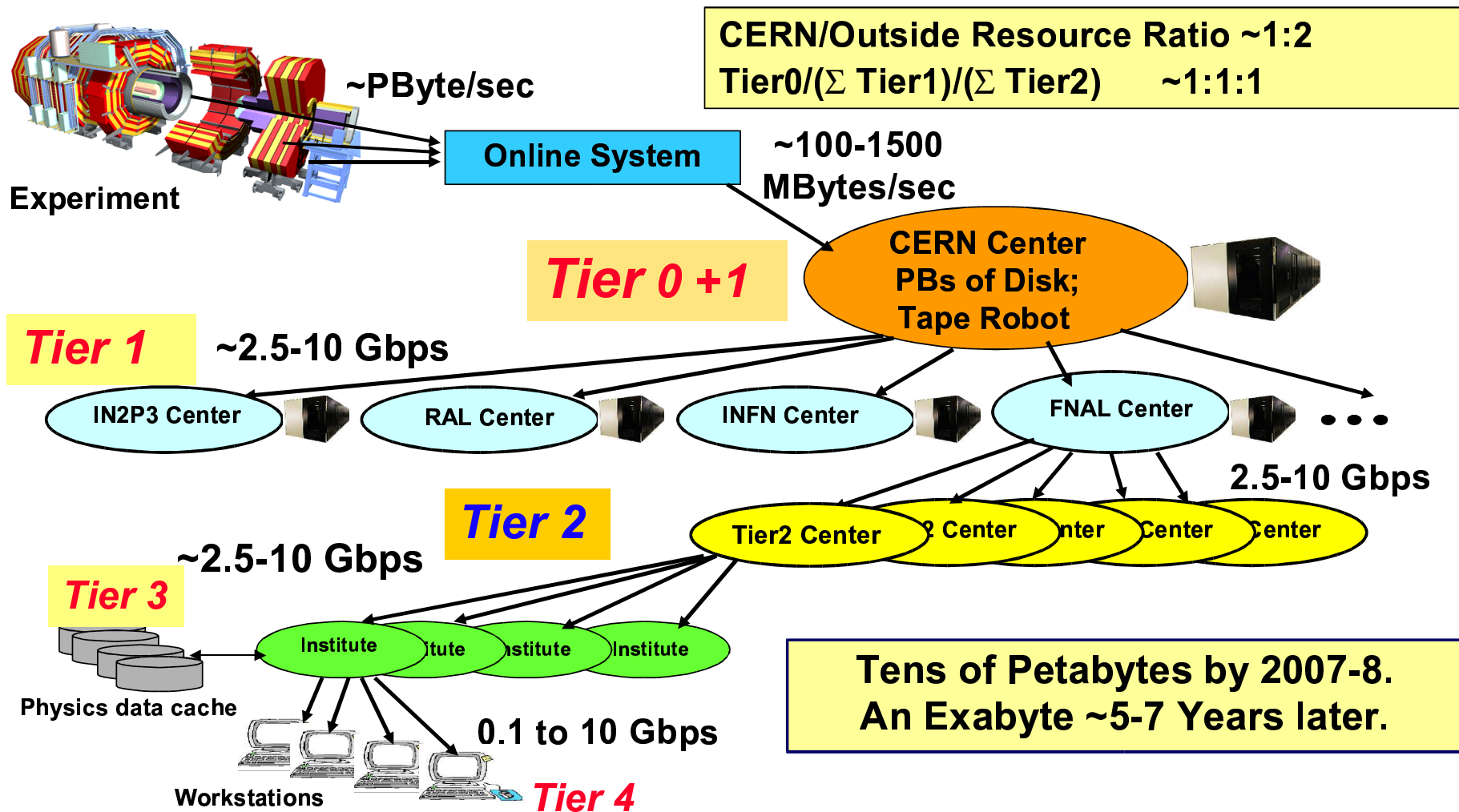
- More physicists and more geographically dispersed

# Data from an LHC Experiment



# A Distributed Data Processing Model

- Large processing requirements: Use *distributed* resources
  - Funding, Access, Taking the data to the physicists, ...



# Enter the Grid

## What is the grid?

- A *cluster of clusters*
- A *virtual community* sharing distributed resources (Ian Foster)
- One true grid — Or:
  - Many communities - many grids
- Ubiquitous, commodity computing:
  - Peer to Peer computing
  - Seti@Home

## So what is it *really*?

- A distributed collection of computers or computer clusters tied together by:
  - networks, software and a desire/will to share.
- Grid *middleware* software provides:
  - Secure, convenient access to computers
  - Resource discovery
  - Reading and writing of data between computers on the grid

# Data Grids

## The dream of the Computing Grid:

- Scientist asks for jobs to be run
- Don't care where - and on which resources
- *The grid* decides how to use the resources efficiently

## For HEP the data sets are enormous:

- We need a computing grid *with data management:*  
*The Data Grid*
- Data grids are more complicated than compute grids
- Data grids need to manage:
  - data replication and caching, metadata, scheduling, bandwidth, . . .

*The LHC places enormous demands on the scalability of data grid  
middleware*

# The LHC Computing Grid: *LCG*

## The LCG toolkit:

- Provides data grid *middleware*:
  - The *fabric* of the data grid
- Integrates data grid component software from:
  - Globus, European DataGrid (EDG), US Virtual Data Toolkit (PPDG, iVDGL, GriPhyN)
  - Also working with EGEE to deploy a robust European data grid.

## The LCG is also responsible for other non-grid software for the LHC:

- Infrastructure for developers
- Application support software: POOL, ROOT, GEANT4, SEAL, ...

# LHC Computing Grid Status

- LCG-1 toolkit released mid-2003
- LHC Computing Grid established with >30 sites
  - Used for CMS event production in 2003
- LCG-2 toolkit released in February 2004
  - Aimed at 2004 Data Challenges: CMS, ATLAS, ALICE, LHCb
- Issues being targeted in 2004:
  - File catalogue
  - Replica management
  - Database access
  - Mass storage management

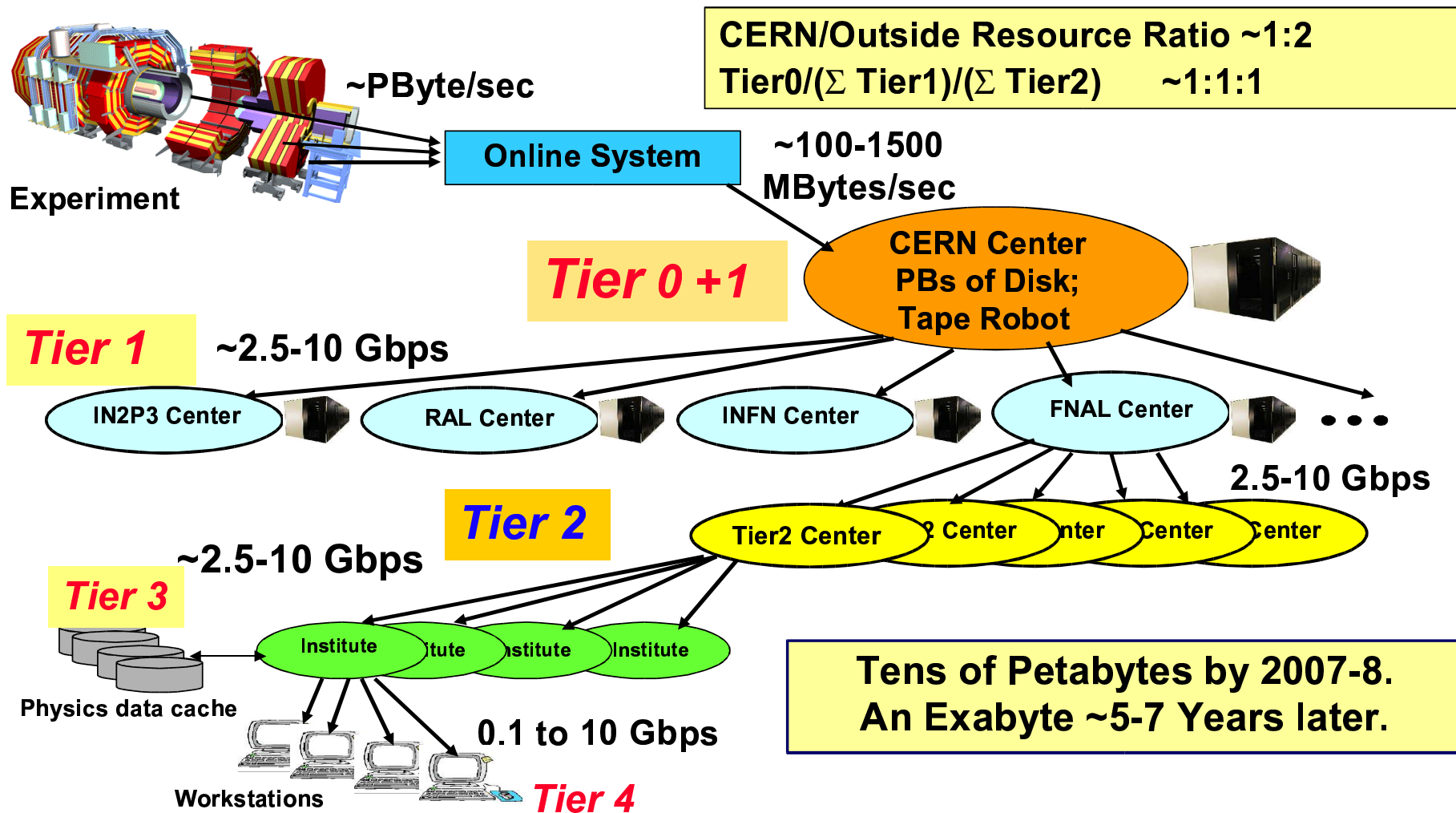
The 2004 data challenges are also using resources from:

- Grid3:
  - US – setup for SuperComputing-2003
- Nordugrid:
  - Nordic countries . . . *and Australia!!*



# Remember the Tiered Processing Model

- Large processing requirements: Use *distributed* resources
  - Funding, Access, Taking the data to the physicists, ...



# ATLAS requirements

- Tier 0 (CERN):
  - Raw Data: 100%
  - Event Summary Data (ESD): 100%
  - Analysis Object Data (AOD): 0%
  - First pass event *reconstruction*
  - 7000 Terabytes Tape, 800 Terabytes Disk, 2500 3GHz Pentium4
- Tier 1: 7 regional centres
  - Event Summary Data (ESD): 33%
  - Analysis Object Data (AOD): 100%
  - Simulation and Analysis
  - 230 Terabytes Tape, 420 Terabytes Disk, 1000 3GHz Pentium4
- Tier 2: National/Institutional centre
  - Event Summary Data (ESD): 33%
  - Analysis Object Data (AOD): 100%
  - Simulation and Analysis
  - 78 Terabytes Tape, 102 Terabytes Disk, 500 3GHz Pentium4

# How will Australia get a tier 2? - NZ?

For Australia:

- Tier with Tokyo or US?
- Beginning collaboration with KEK Atlas and Todai
- Bandwidth b/n Australia, NZ, TransPORT SX
- Collaboration on funding/people
- Can Australia and NZ collaborate?
  - Some differences - ATLAS/CMS

# The Australian HEP Data Grid Team

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- *Physicists:*

- Experimental Particle Physics:
- Falkiner High Energy Physics:

University of Melbourne  
University of Sydney

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- *Physicists:*

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- *Computer Scientists:*

- GRIDS Lab:
- Computer Science:

University of Melbourne  
University of Adelaide

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## Who are we?

- *Physicists:*
  - Experimental Particle Physics: University of Melbourne
  - Falkiner High Energy Physics: University of Sydney
- *Computer Scientists:*
  - GRIDS Lab: University of Melbourne
  - Computer Science: University of Adelaide
- *High Performance Computing:*
  - MARCCentre (HPC): University of Melbourne
  - Internet Futures Group: Australian National University
  - Australian Partnership for Advanced Computing (APAC)
  - Victorian Partnership for Advanced Computing (VPAC)
  - GrangeNet: Australian 10Gb Academic Research Network
  - IBM Singapore

# Australian HEP Grid Activities?

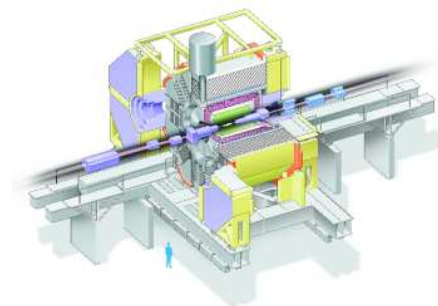
## Atlas

- Participate in the deployment of the LCG tools across APAC grid facilities in Australia.
  - *LCG-2 toolkit*
  - *ATLAS application layer.*
- Implement an LCG Tier 2 in Australia



## Belle

- Introducing Grid techniques to:
  - Belle physics analysis
  - Monte Carlo generation



Funded by Australian Research Council, Australian Partnership for Advanced Computing and Victorian Partnership for Advanced Computing  
*Support from APAC Information Infrastructure Project*



# Australian Belle Data Grid Testbed

- “*Simple*” Data Grid tools could provide real benefits for physicists *now*:
  - Data Catalogue (Replica Catalogue)
  - *Network-aware* scheduler

Initially, we aimed to:

- Use standard middleware products wherever possible
- Develop simple tools to fill the gaps
- Start *real* data analysis ASAP.

Then move on to:

- Trial and incorporate more sophisticated tools for:
  - Scheduling
  - Data Replication and Caching
    - *EDG, LCG, SRB, ...*
  - Monitoring and Simulation  
(*In collaboration with CS colleagues*)

# What have we got to work with?

## Network Infrastructure in Australia:

- Australian Academic Research Network (AARNET)
- GrangeNet: Multi-gigabit network to support grid and advanced research projects

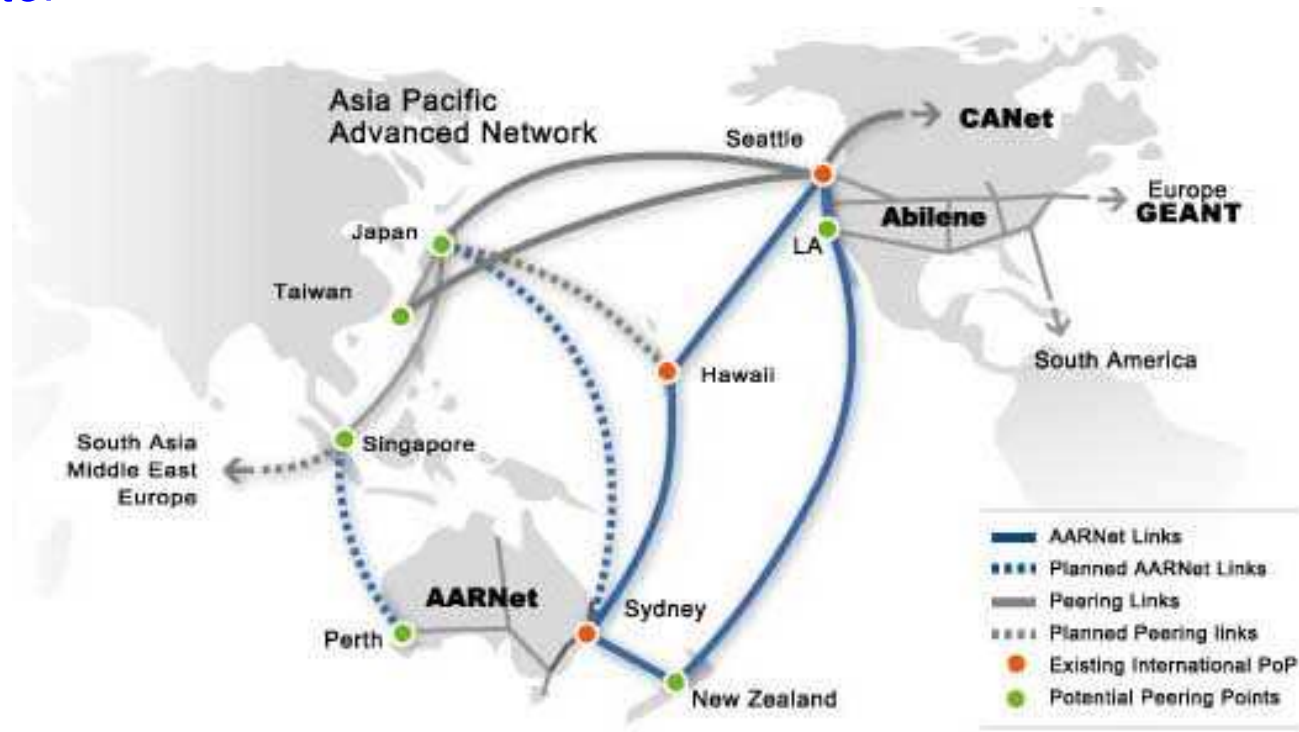


- Active 2003
- 10 Gigabit backbone between:
  - Melbourne
  - Sydney
  - Canberra
  - Brisbane

# Future Upgrades to International Links

## Planned upgrades to international research and education links

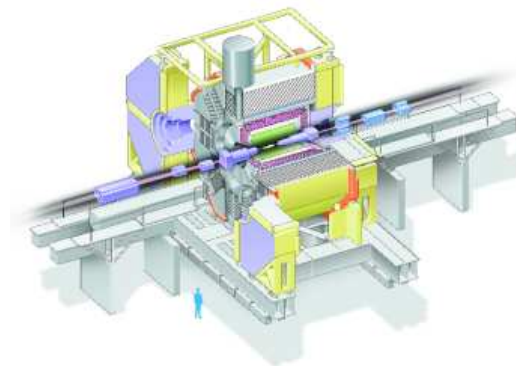
- 10Gb to US
  - *within 2 months*
- 2Gb to Japan ??
  - *Later*
- 100Mb to Singapore
  - Installed now



# Current Belle Activities

## Australian Belle Data Grid Testbed:

- “Simple” Data Grid tools could provide real benefits for physicists *now*:
  - Data Catalogue (Replica Catalogue)
  - *Network-aware* scheduler



## Initially (3 years ago), we aimed to:

- Use standard middleware products wherever possible
- Develop simple tools to fill the gaps
- Start *real* data analysis ASAP.

## The Belle Analysis Software: *BASF*

- Enable BASF to read and write Grid URIs directly
  - Able to *stream* data across network
  - A *simple* solution which reduces need to stage data

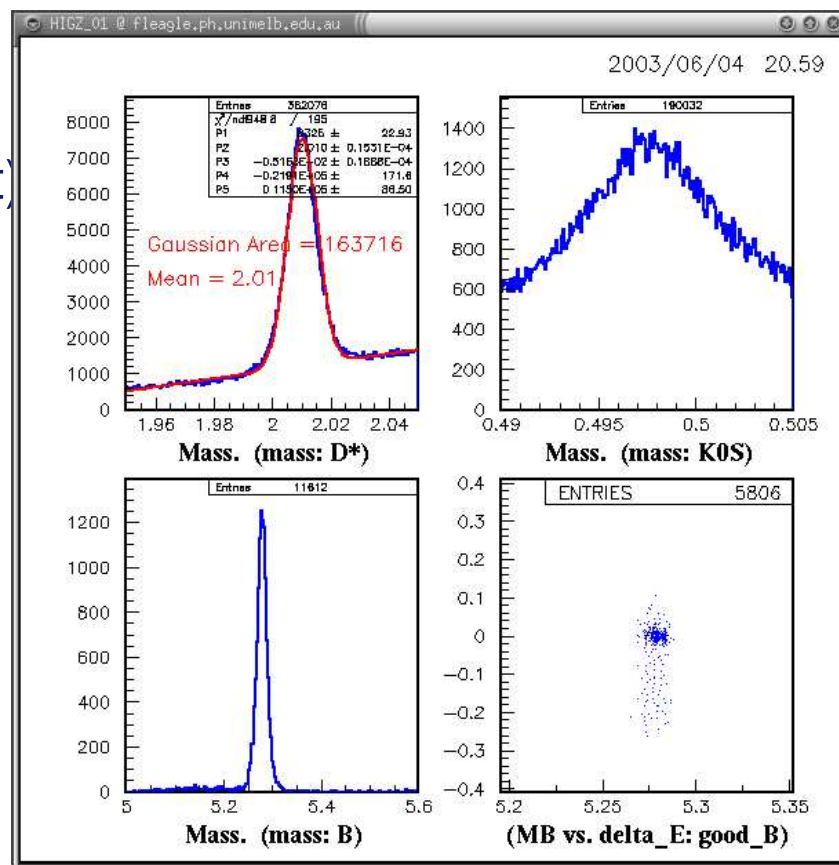
Lyle Winton

# Belle data analysis demonstration at SC2003

## The Global Data-Intensive Grid Collaboration

<http://gridbus.cs.mu.oz.au/sc2003/>

- 1,000,000 events analysed using Grid-enabled BASF
  - Gridbus broker discovered the catalogued data  
(lfn:/users/winton/fsimddks/\*.mdst)  
and:
    - decomposed into 100 Grid jobs
    - nodes in Australia and Japan.
  - Optimised job assignment to minimise:
    - data transmission time *and*
    - computation time.
- Completed in 20 minutes.



# Collaboration with Belle and KEK laboratory

- Recent collaboration between UoM, ANU SF, KEK Computing Research Centre, and Belle collaboration:
  - Use Storage Resource Broker (SRB) for Belle data management
  - Federation between SRB servers at KEK and ANU SF.
  - Distribution of input and output data for current Belle mass simulated data production.
  - Utilising computing resource from APAC, VPAC, AC3, UoM, ANU SF.
- We will use this as the base for grid based data processing of Belle data.
  - Collaboration with Bristol UK e-science group:
    - GMCat — RLS interface
- Development of SRB-aware grid scheduler.
  - Identify location of resources, replicas
  - Despatch jobs according to static network model.

*Running Belle data simulation production now.*

# Future of Australia HEP Data Grid

- Deploy Belle Monte Carlo production across APAC Data Grid
- Support deployment of Belle Analysis Data Grid across Belle collaboration.
- Build partnership to establish LCG Tier 2 site
- Participate in ATLAS DC 2005

*Be ready for 2007!*