The LHCb Software and Computing

NSS/IEEE workshop
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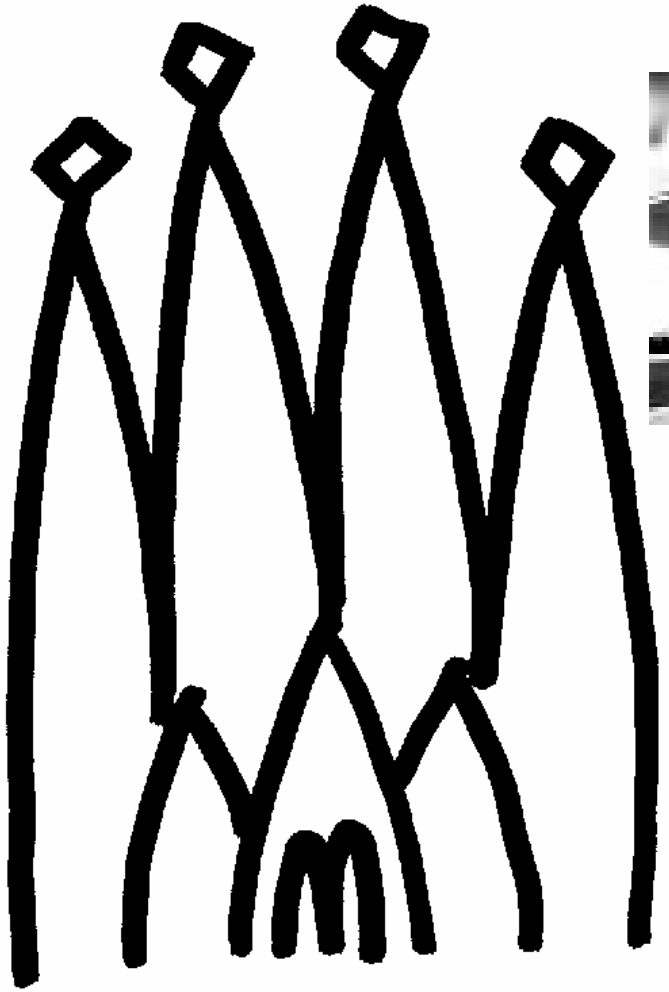

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

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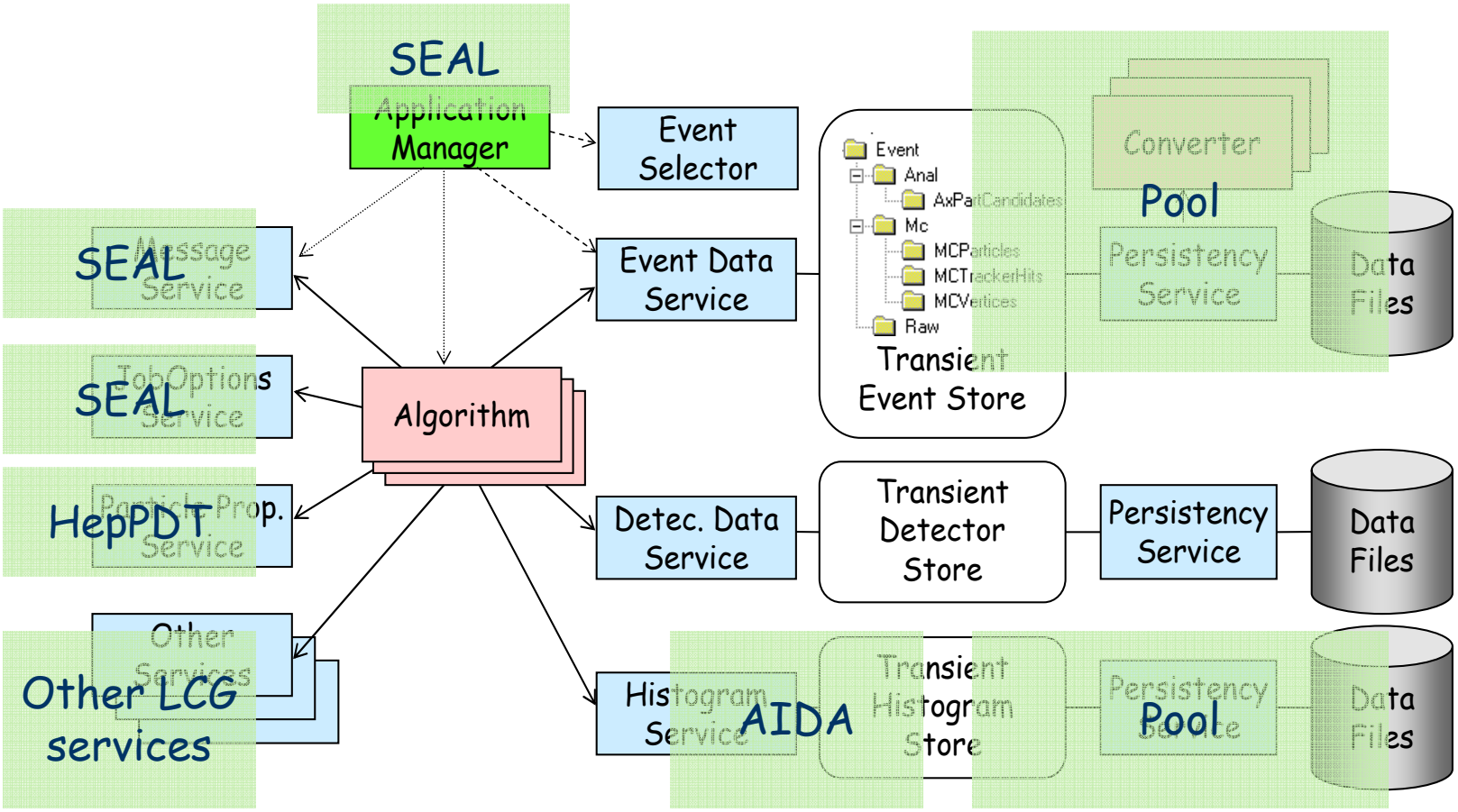
Outline

- Core software
- LHCb Applications
- Production and Analysis tools
- Computing Model and Data Challenges
- Summary

Software Strategy

- Develop an Architecture ('blueprint') and a Framework (real code) to be used at all stages of LHCb data processing
  - high level triggers, simulation, reconstruction, analysis
  - a single framework used by all members of the collaboration
- Avoid fragmentation and duplication of computing efforts
  - common vocabulary, better understanding of the system
  - better specifications of what needs to be done
  - identify and build common components
    - guidelines and coordination for SD groups
- Transparent use of third-party components wherever possible
  - Leverage from LCG applications area software
  - GUI, persistency, simulation….
- Applications are developed by customizing the Framework

Gaudi Architecture and Framework



Applications and datasets

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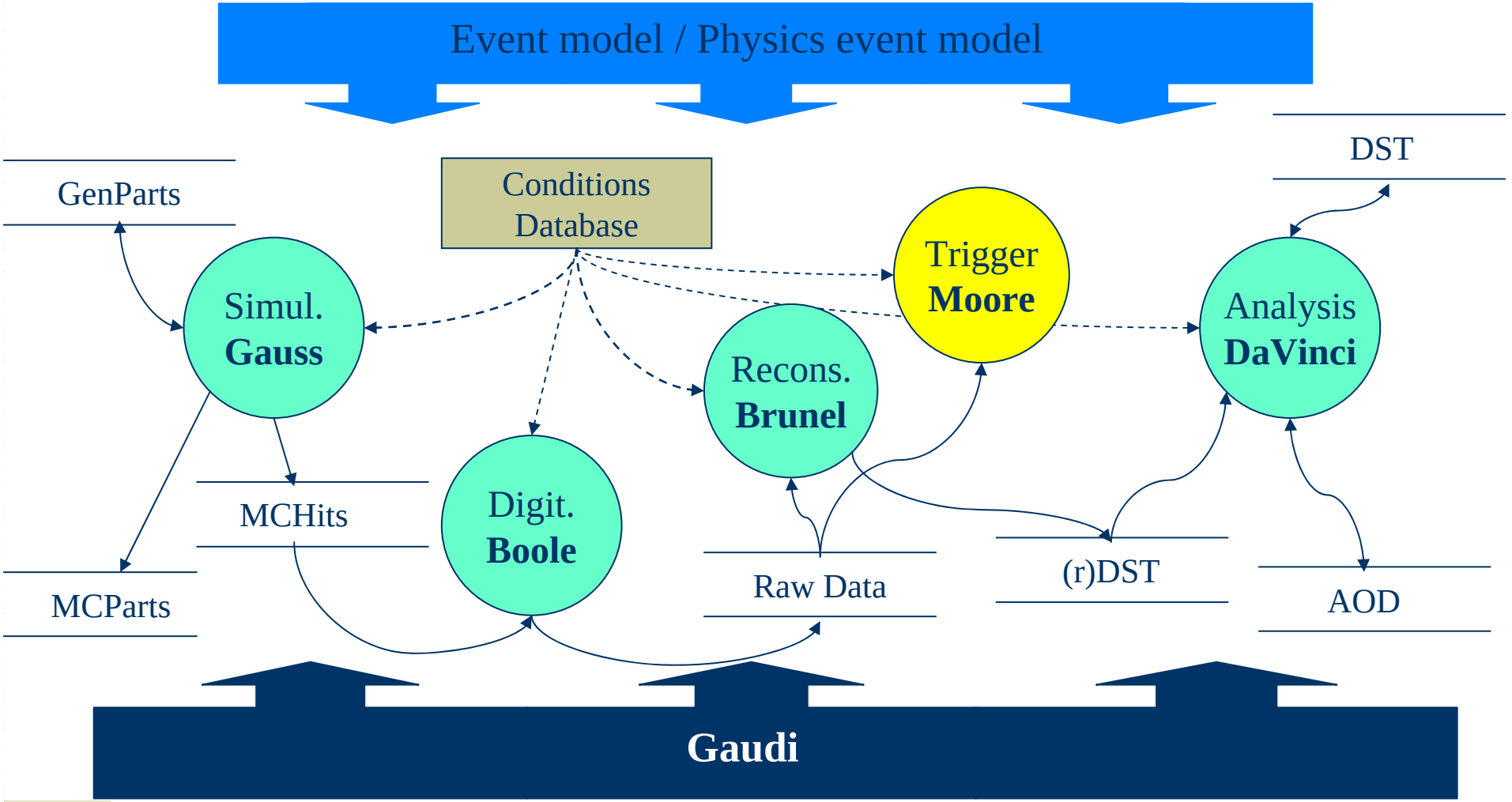


Gauss - Geant4-based simulation application

- Gaudi application
- Uses
  - Pythia (Herwig being included) and EVTGEN (Babar) for event generation
  - HepMC as exchange model
  - Geant4 as simulation engine
- Simulation framework within Gaudi: GiGa
  - Converts HepMC to Geant4 input
  - Interfaces with all Gaudi services (geometry, magnetic field…)
  - Converts Geant4 trajectories to **LHCb event model** (MCHits, MCParticles and MCVertices)

Boole & Brunel
Digitisation and reconstruction

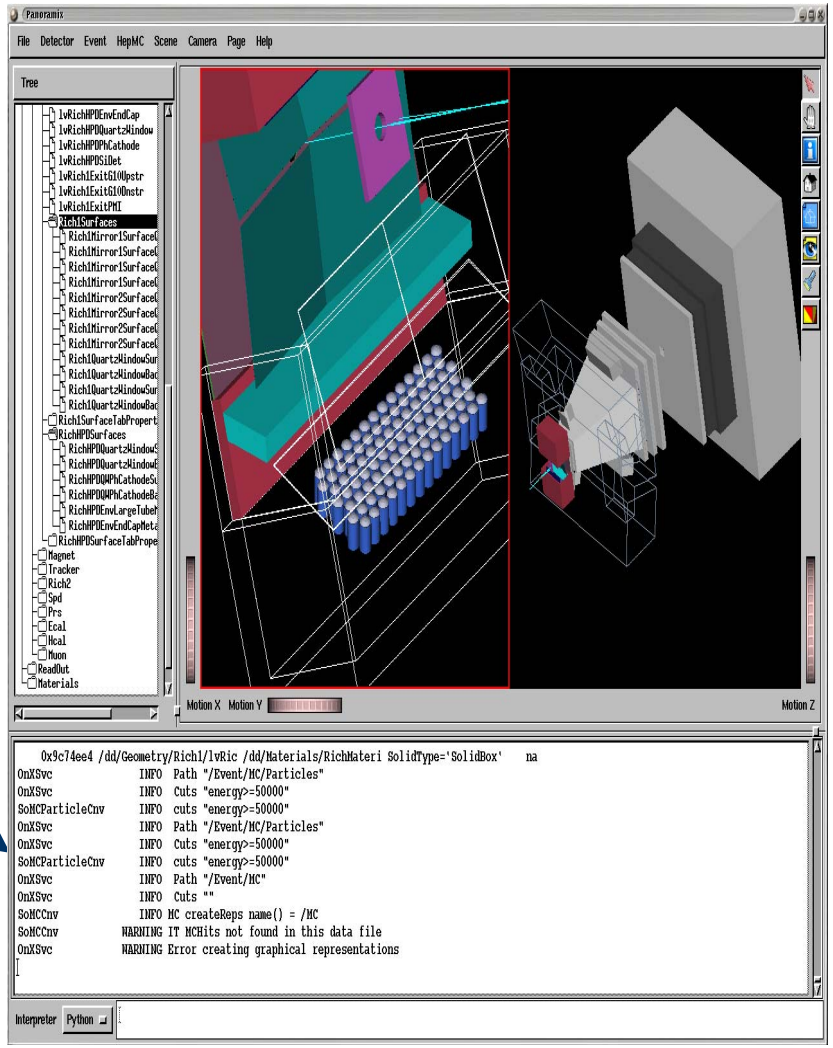
- Boole
  - From MCHits to Digits (Raw buffer format)
  - [Running trigger algorithms]
  - Output: Raw buffer & MC truth (+relations)
- Brunel
  - From Raw buffer to DST
  - Complete pattern recognition
  - Charged tracks: long, upstream, downstream
  - Calorimeter clusters & electromagnetic particle identification
  - RICH particle identification
  - Muon particle identification
  - Output: [r]DST format based on the **LHCb event model**

DaVinci - The LHCb Analysis Framework

- Gaudi application
  - Facilitates migration of algorithms from analysis to reconstruction
  - Interactive analysis through Python scripting
- Physicists only manipulate abstract objects (particles and vertices)
  - Concentrate on functionality rather than on technicality
- Manipulation and analysis tools for general use
- Physics event model for describing all physics-related objects produced by the analysis algorithms
  - Keep loose connection to reconstruction entities (tracks, clusters)

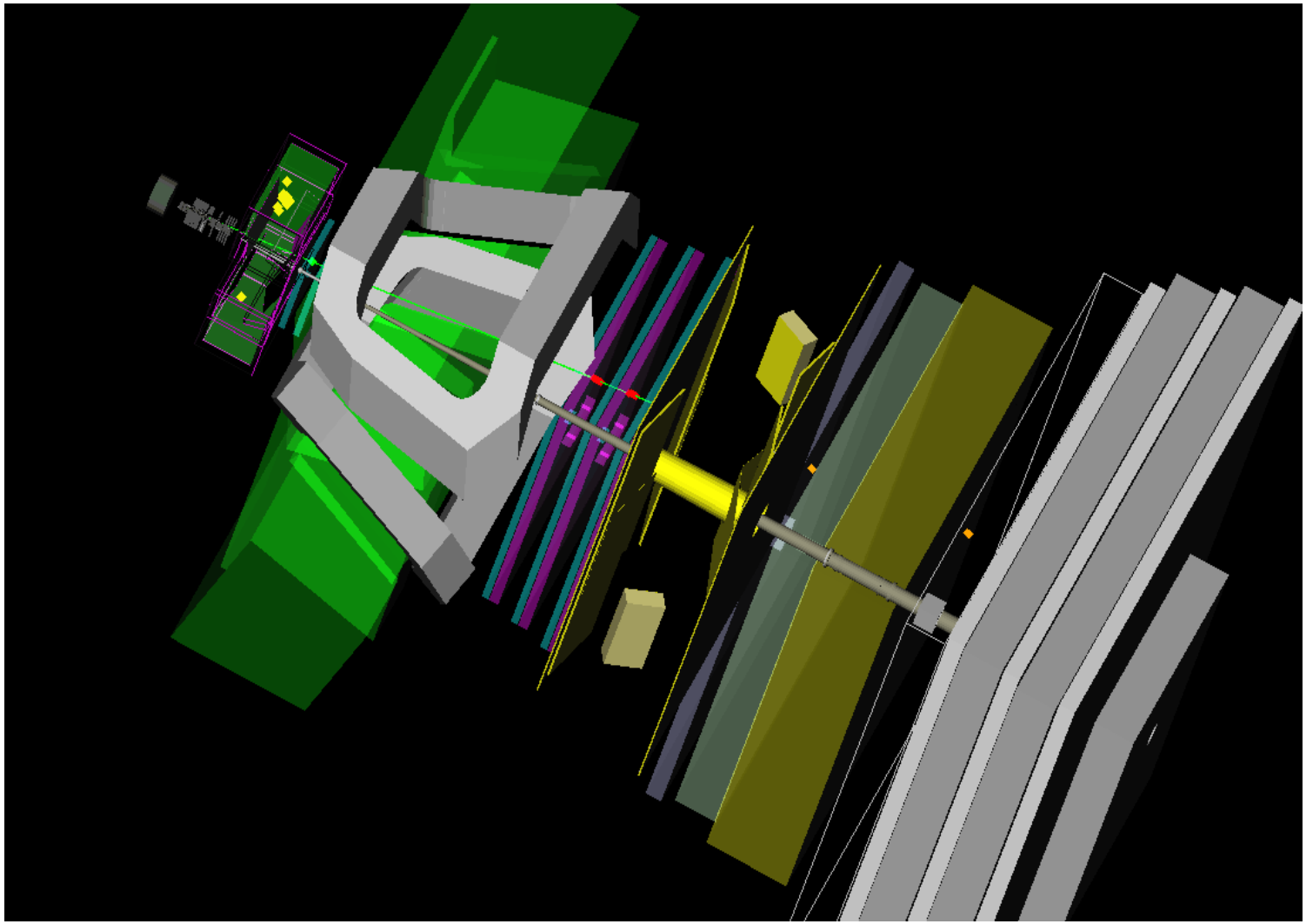
Panoramix - Event & Geometry Display

- Panoramix package based on OpenInventor
- Is able to display:
  - Geometry from XML files
  - MC data objects
  - Reconstruction objects
- Scripting based on python
- Gaudi application, hence can be integrated with e.g. DaVinci algorithms



Event Viewing

QuickTime™ et un décompresseur TIFF (LZW) sont requis pour visionner cette image.



Dirac
Workload and Data Management Software

User interfaces

DIRAC services

DIRAC resources

Job monitor

Production manager

GANGA UI

User CLI

BK query webpage

FileCatalog browser

JobMonitorSvc

JobAccountingSvc

AccountingDB

DIRAC Job Management Service

BookkeepingSvc

FileCatalogSvc

ConfigurationSvc

FileCatalog

Agent

Resource Broker

LCG

CE 3

Agent

CE 1

CE 2

I am a pilot-agent!

Storage

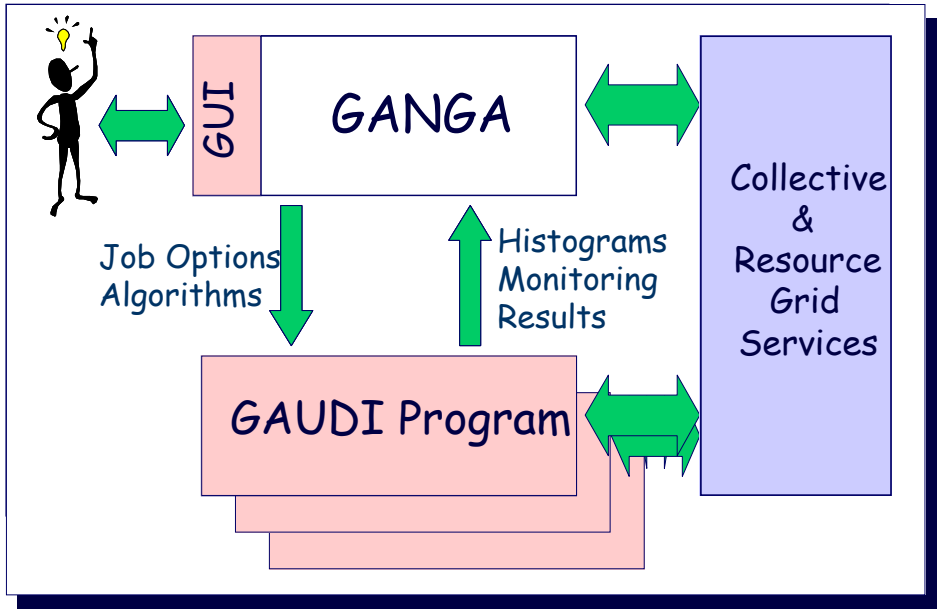
ftp

FTS

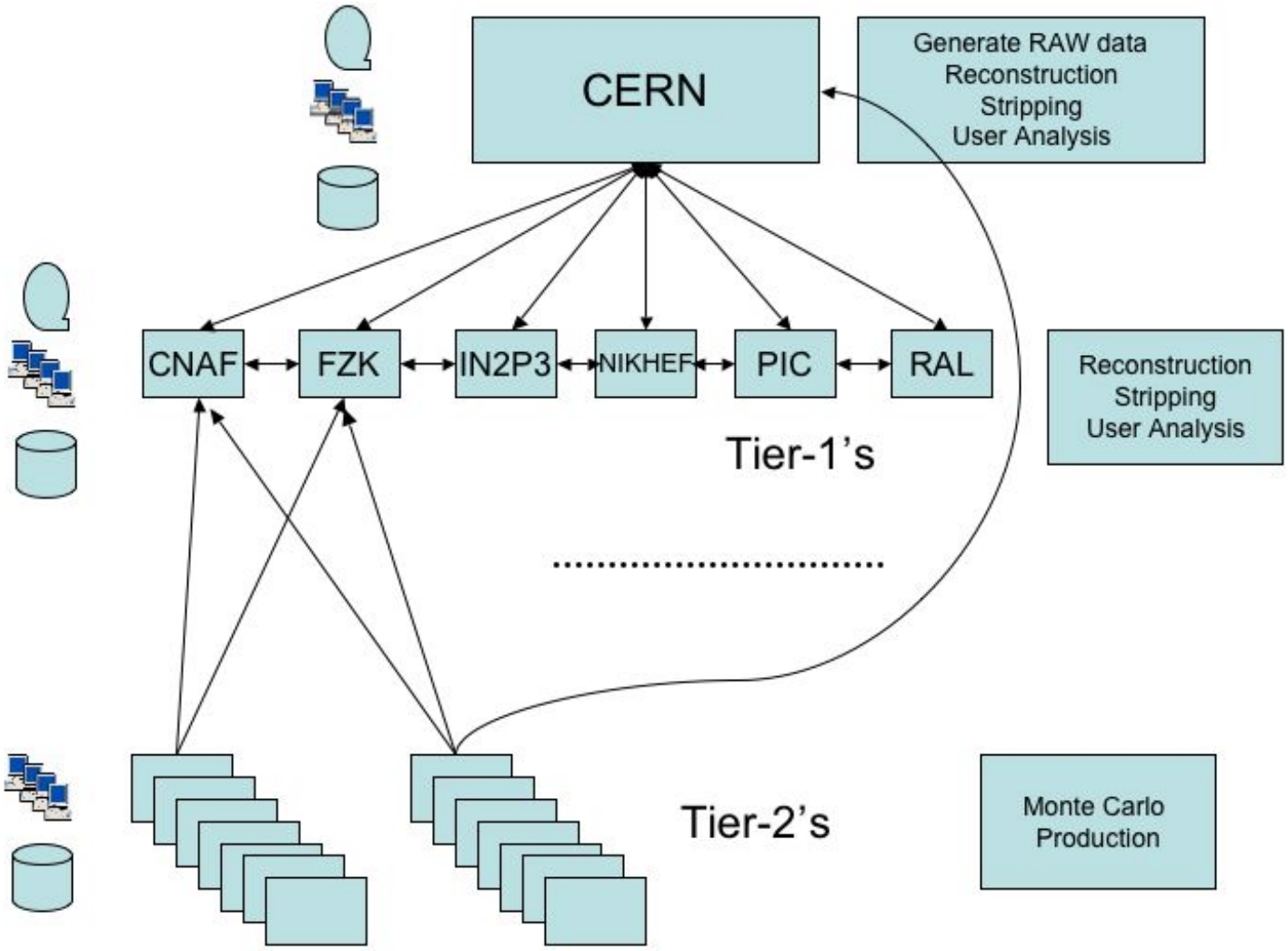
DiskFile

Ganga - The job wizard

- Goal
  - Simplify the management of analysis and production jobs for end-user physicists by developing a tool for accessing Grid services with built-in knowledge of how Gaudi works
- Required functionality
  - Job preparation and configuration
  - Job submission, monitoring and control
  - Resource browsing, booking, etc.
- Done in collaboration with ATLAS
- Back-end for LHCb analysis: **Dirac**
- Status: starts being used at Tier-1 sites



LHCb Computing Model

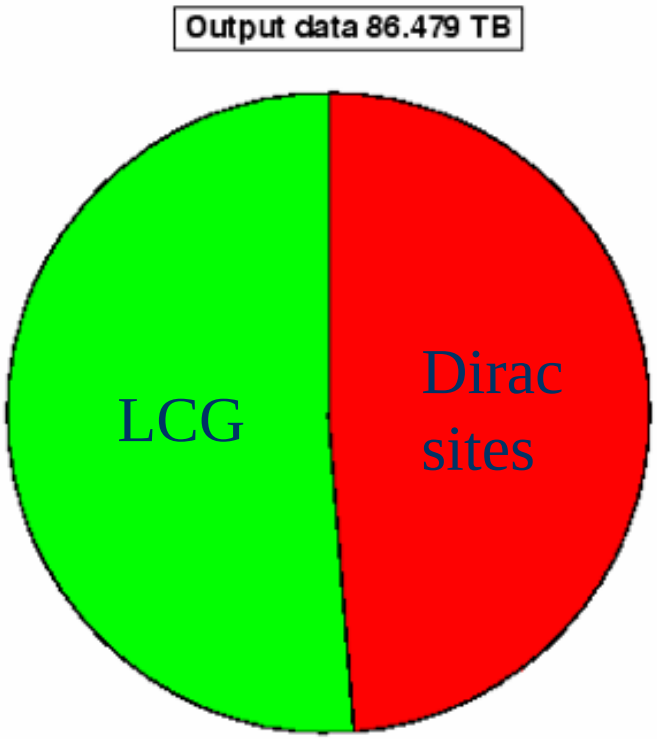


Data Challenges

- Series of Data Challenges
  - measure quality (# crashes / # events) and performance of software
  - scalability tests for simulation, reconstruction and analysis
  - production tests over grid using all LHCb regional centres

DC'03	TDR production	5. 10^7 Events (2%) 1 crash in < 20k events	Feb-April 2003
DC'04	LCG2 functionality test	300. 10^6 Events (10%) 1 crash in < 200k events	May-August 2004
SC3	LCG Service Challenge	Large data transfers (up to 10 Tbytes) to Tier-1s	October-Nov 2005
DC'06	Large scale test over fully deployed grid Testing Computing Model	~300. 10^6 Events (~10%) 1 crash in < 20M events	May-August 2006

Data Challenge '04



DIRAC.Barcelona.es	1.41%	LCG.Ferrara.it	0.27%
DIRAC.Bologna-T2.it	0.23%	LCG.GRNET.gr	0.45%
DIRAC.Bologna.it	6.18%	LCG.IN2P3.fr	0.68%
DIRAC.CERN.ch	14.81%	LCG.IPP.bg	0.00%
DIRAC.CracowAgu.pl	0.40%	LCG.ITEP.ru	0.61%
DIRAC.IF-UFRJ.br	0.13%	LCG.Imperial.uk	1.72%
DIRAC.IHEP-Protvino.ru	0.66%	LCG.Iowa.us	0.00%
DIRAC.IHEP2-Protvino.ru	0.47%	LCG.JINR.ru	0.19%
DIRAC.ITEP-Moscow.ru	2.90%	LCG.KFKI.hu	0.93%
DIRAC.ITEP.ru	0.08%	LCG.Krakow.pl	0.13%
DIRAC.Imperial.uk	2.22%	LCG.Lancashire.uk	0.37%
DIRAC.JINR-Dubna.ru	0.40%	LCG.Legnaro.it	2.11%
DIRAC.Karlsruhe.de	3.48%	LCG.Liverpool.uk	0.00%
DIRAC.LHCBONLINE.ch	1.33%	LCG.Manchester.uk	0.82%
DIRAC.Liverpool.uk	1.20%	LCG.Milano.it	0.28%
DIRAC.Lpool.uk	0.20%	LCG.Montreal.ca	0.04%
DIRAC.Lyon.fr	4.02%	LCG.NCU.tw	0.15%
DIRAC.Manno.ch	0.04%	LCG.NIKHEF.nl	3.28%
DIRAC.Oxford.uk	0.12%	LCG.Napoli.it	0.05%
DIRAC.RAL.uk	0.11%	LCG.Oxford.uk	0.75%
DIRAC.Santiago.es	3.07%	LCG.PIC.es	2.57%
DIRAC.ScotGrid.uk	8.00%	LCG.Padova.it	0.61%
DIRAC.Zurich.ch	0.69%	LCG.QMUL.uk	1.52%
LCG.BHAM-HEP.uk	0.55%	LCG.RAL-HEP.uk	0.86%
LCG.Barcelona.es	0.28%	LCG.RAL.uk	5.37%
LCG.Bari.it	0.31%	LCG.RHUL.uk	0.86%
LCG.CERN.ch	9.02%	LCG.Roma.it	0.04%
LCG.CESGA.es	0.01%	LCG.SARA.nl	0.68%
LCG.CGG.fr	0.12%	LCG.SINP.ru	0.07%
LCG.CNAF.it	4.59%	LCG.Sheffield.uk	0.37%
LCG.CNB.es	0.12%	LCG.Test.uk	0.00%
LCG.CSCS.ch	0.01%	LCG.Torino.it	0.77%
LCG.Cagliari.it	0.11%	LCG.Toronto.ca	0.26%
LCG.Cambridge.uk	0.25%	LCG.Triumf.ca	0.17%
LCG.Carleton.ca	0.27%	LCG.UCL-CCC.uk	2.18%
LCG.Catania.it	0.10%	LCG.USC.es	0.64%
LCG.FNAL.us	0.03%	LCG.WEIZMANN.il	0.06%
LCG.FZK.de	2.23%		

Summary

- A software framework (Gaudi) with full set of services has been developed for use in all event processing applications
- Common set of high level components developed
  - e.g. detector geometry, conditions DB, event model, interactive/visualization tools
  - provides guidelines and minimizes work for physicists developing detector and physics algorithms
- The production of large datasets of ~300 M events was a success (DC04)
  - Production architecture (DIRAC) and toolset
  - Dirac using LCG2 in place and running (~50% of processing power)
- Data management challenge (SC3) ongoing
- Distributed Analysis (Ganga + Dirac) starting now at Tier-1's
- DC06 planned for testing the Computing Model