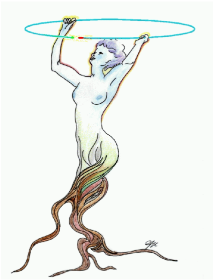

The LHC Computing Grid Project (LCG) and ROOT

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http://cern.ch/lcg/peb/applications

ROOT Workshop, CERN

October 16, 2002

Outline

- Introduction to LCG
- Applications Architecture Blueprint RTAG
  - LCG software architecture blueprint
  - Use of ROOT
- Concluding remarks

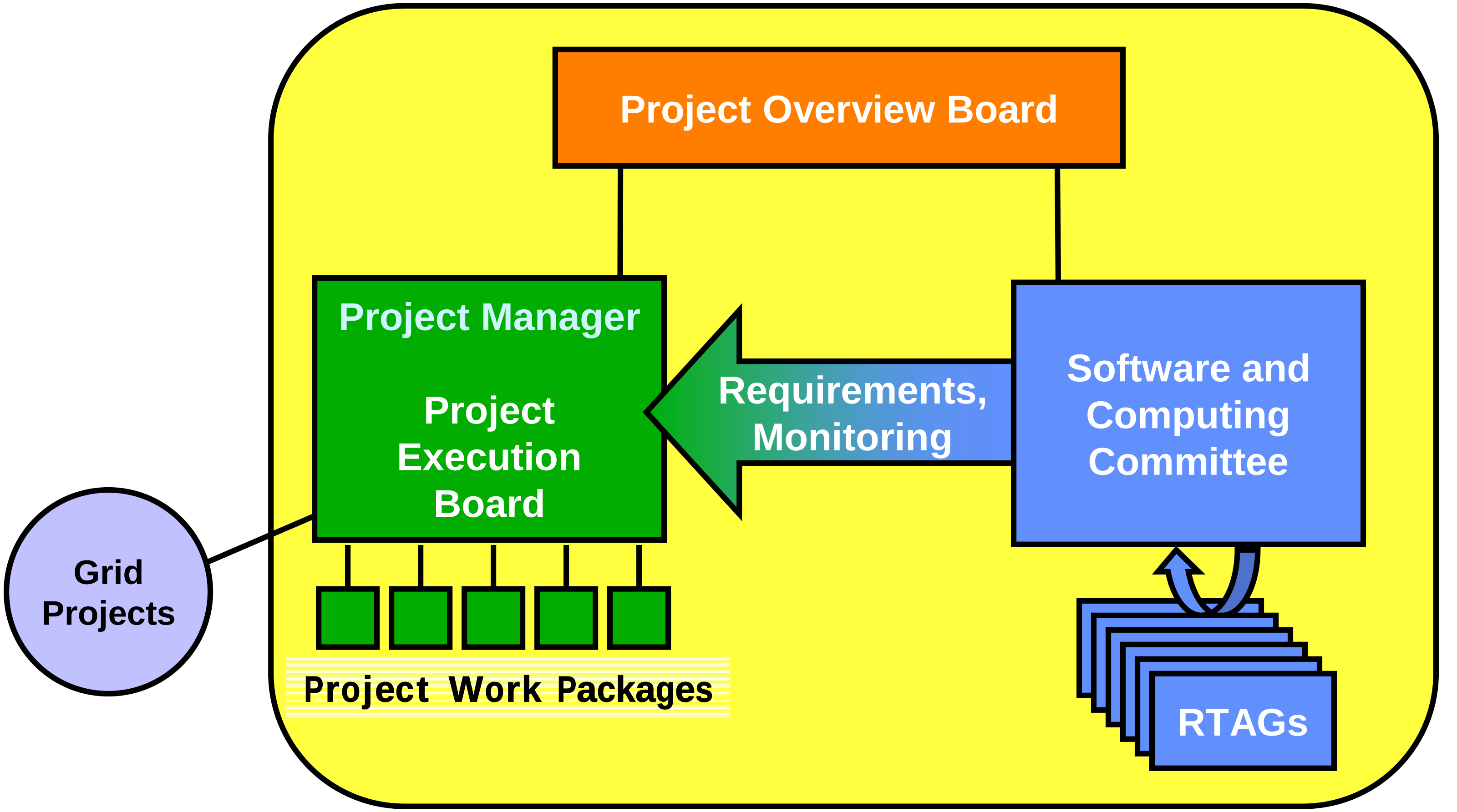
The LHC Computing Grid (LCG) Project

Goal – Prepare and deploy the LHC computing environment

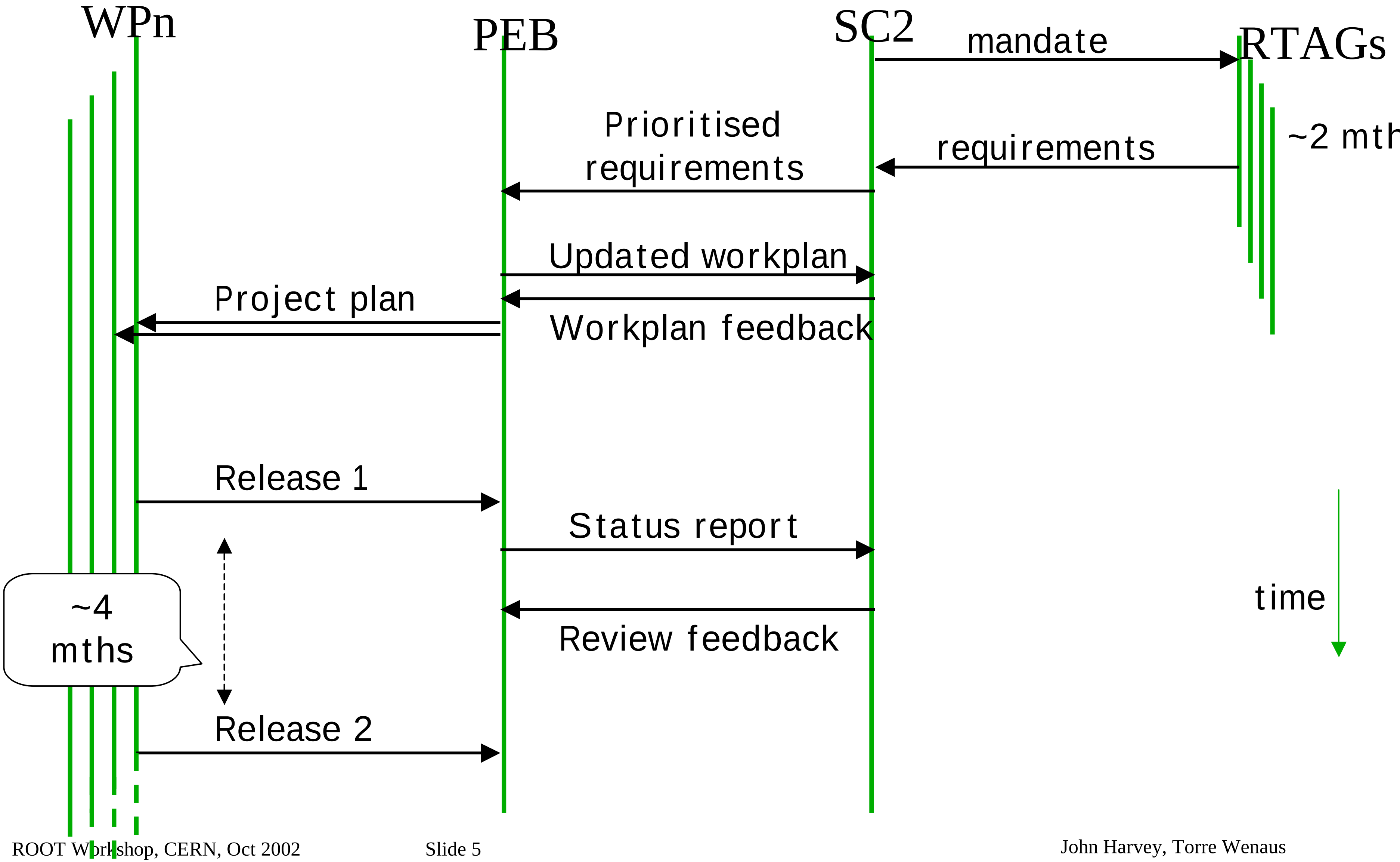
- Approved (3 years) by CERN Council, September 2001
  - meanwhile extended by 1 year due to LHC delay
- Injecting substantial new facilities and personnel resources
- Scope:
  - Common software for physics applications
    - Tools, frameworks, analysis environment
  - Computing for the LHC
    - Computing facilities (fabrics)
    - Grid middleware, deployment

  → Global analysis environment

The LHC Computing Grid Project Structure



LCG Workflow



LCG Areas of Work

Computing System

- Physics Data Management
- Fabric Management
- Physics Data Storage
- LAN Management
- Wide-area Networking
- Security
- Internet Services

Grid Technology

- Grid middleware
- Standard application services layer
- Inter-project coherence/compatibility

Applications Support & Coordination

- Application Software Infrastructure – libraries, tools
- Object persistency, data management tools
- Common Frameworks – Simulation, Analysis, ..
- Adaptation of Physics Applications to Grid environment
- Grid interfaces, Portals

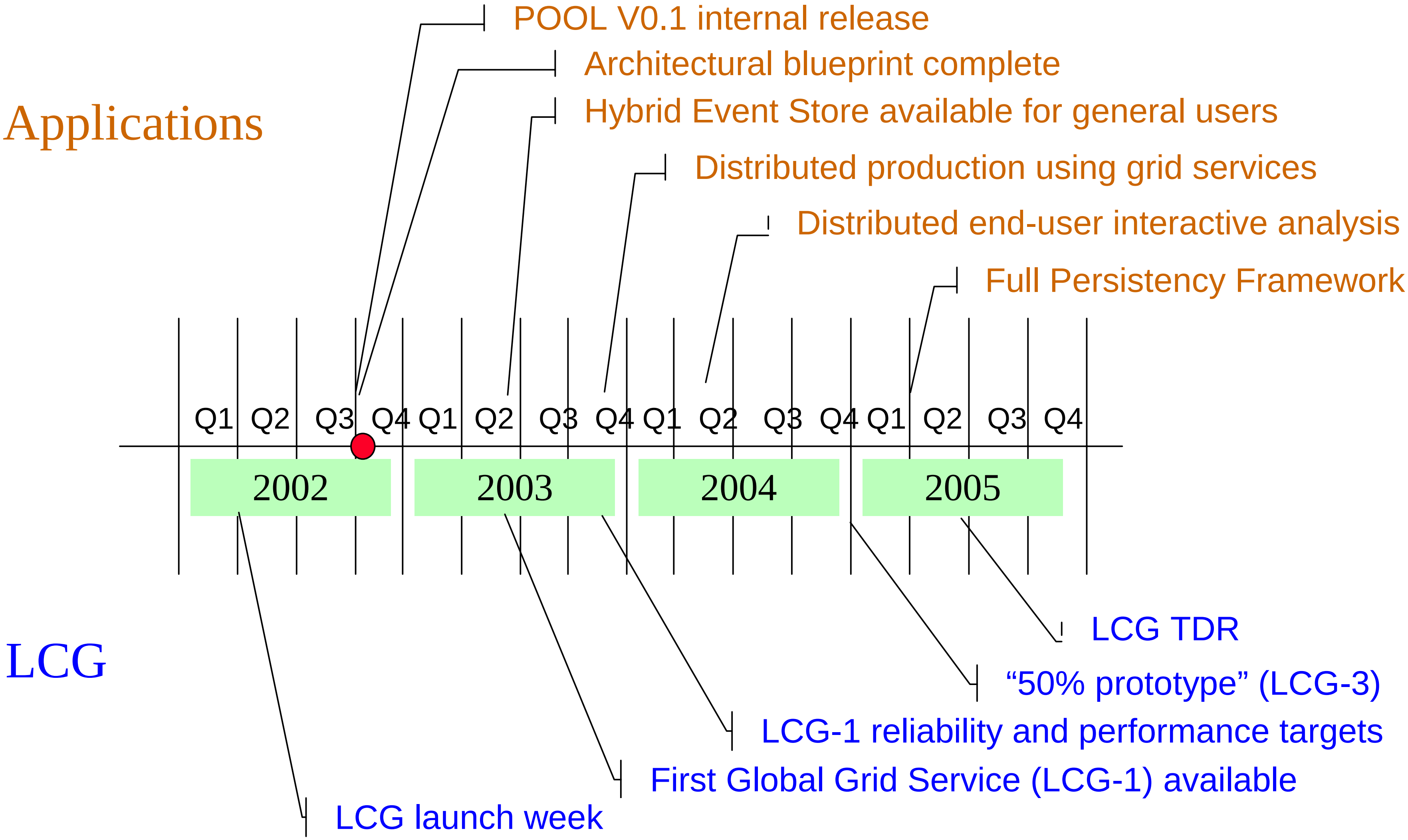
Grid Deployment

- Data Challenges
- Grid Operations
- Network Planning
- Regional Centre Coordination
- Security & access policy

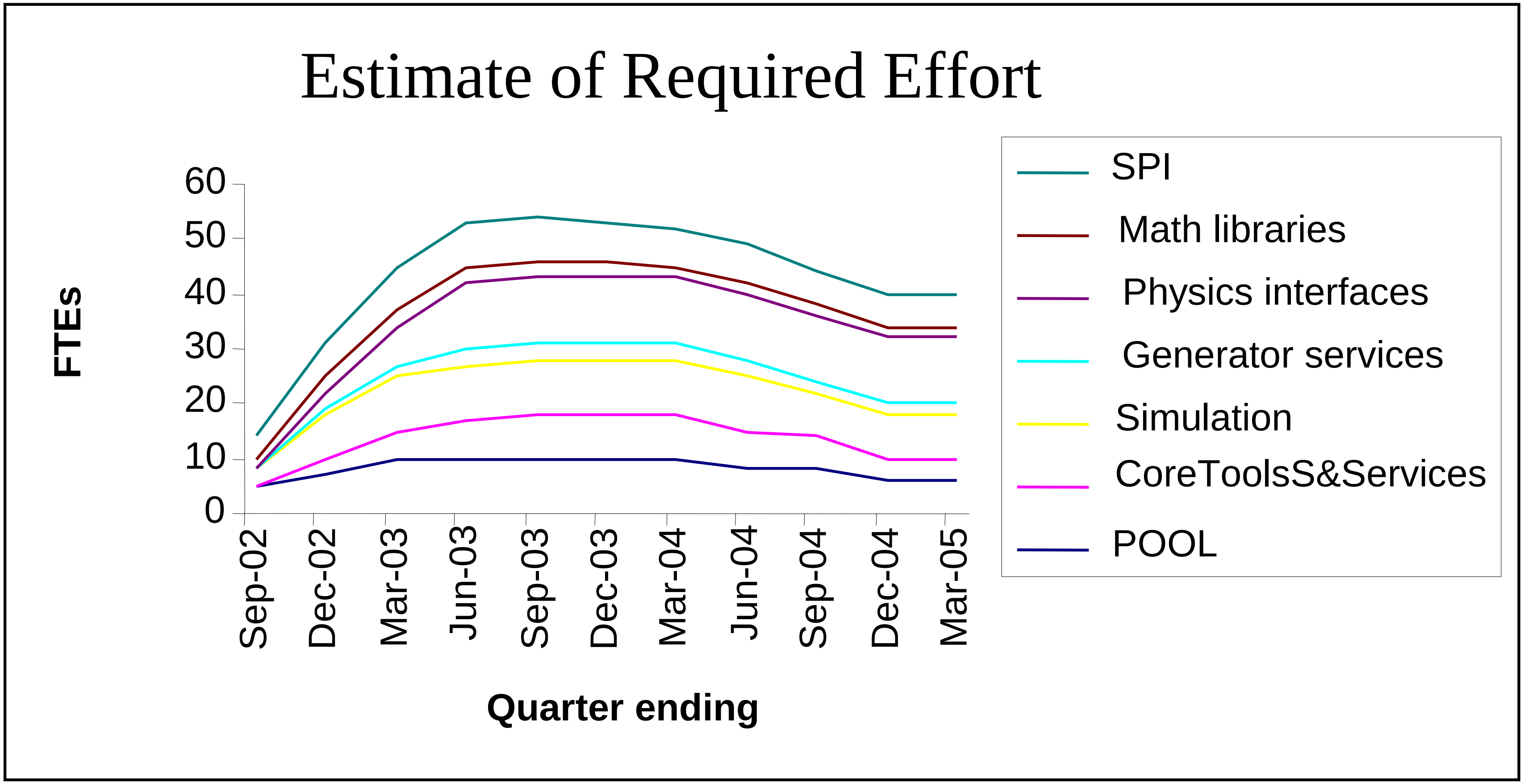
Applications Area Projects

- Software Process and Infrastructure *(operating)*
  - Librarian, QA, testing, developer tools, documentation, training, …
- Persistency Framework (*operating)*
  - POOL hybrid ROOT/relational data store
- Mathematical libraries *(operating)*
  - Math and statistics libraries; GSL etc. as NAGC replacement
- Core Tools and Services *(being initiated)*
  - Foundation and utility libraries, basic framework services, system services, object dictionary and whiteboard, grid enabled services
- Physics Interfaces *(being initiated)*
  - Interfaces and tools by which physicists directly use the software. Interactive (distributed) analysis, visualization, grid portals
- Simulation *(coming soon)*
  - Geant4, FLUKA, virtual simulation, geometry description & model, …
- Generator Services *(coming soon)*
  - Generator librarian, support, tool development

LCG Applications Area Timeline Highlights



Personnel resources



Available resources from all sources (CERN, LCG, experiments) satisfy this profile

FTEs today: 12 LCG hires, ~10 CERN IT, ~7 CERN EP + experiments

Software Architecture Blueprint RTAG

- **Goals**
  - integration of LCG and non LCG software to build coherent applications
  - provide the specifications of an architectural model that allows this i.e. a ‘blueprint’
- **Mandate**
  - define the main domains and identify the principal components
    - For example: Simulation is such an architectural domain; Detector Description is a component which figures in several domains.
    - result is a set of ‘collaborating frameworks’, one per domain
  - Define the **architectural relationships** between these ‘frameworks’ and components, identify the main requirements for their **inter-communication**, and suggest possible **first implementations.**
    - The focus here is on the architecture of how major ‘domains’ fit together, and not detailed architecture within a domain.

Architecture Blueprint RTAG Report

- Executive summary
- Response of the RTAG to the mandate
- Blueprint scope
- **Requirements**
- **Use of ROOT**
- **Blueprint architecture design precepts**
  - High level architectural issues, approaches
- **Blueprint architectural elements**
  - Specific architectural elements, suggested patterns, examples
- **Domain decomposition**
- **Schedule and resources**
- **Recommendations**

After 14 RTAG meetings,
several with external experts,
end-user readers from experiments,
much email...
A 36-page final report
Accepted by SC2 October 11

John Apostolakis, Guy Barrand, Rene Brun,
Predrag Buncic, Vincenzo Innocente, Pere Mato,
Andreas Pfeiffer, David Quarrie, Fons Rademakers,
Lucas Taylor, Craig Tull, Torre Wenaus (Chair)

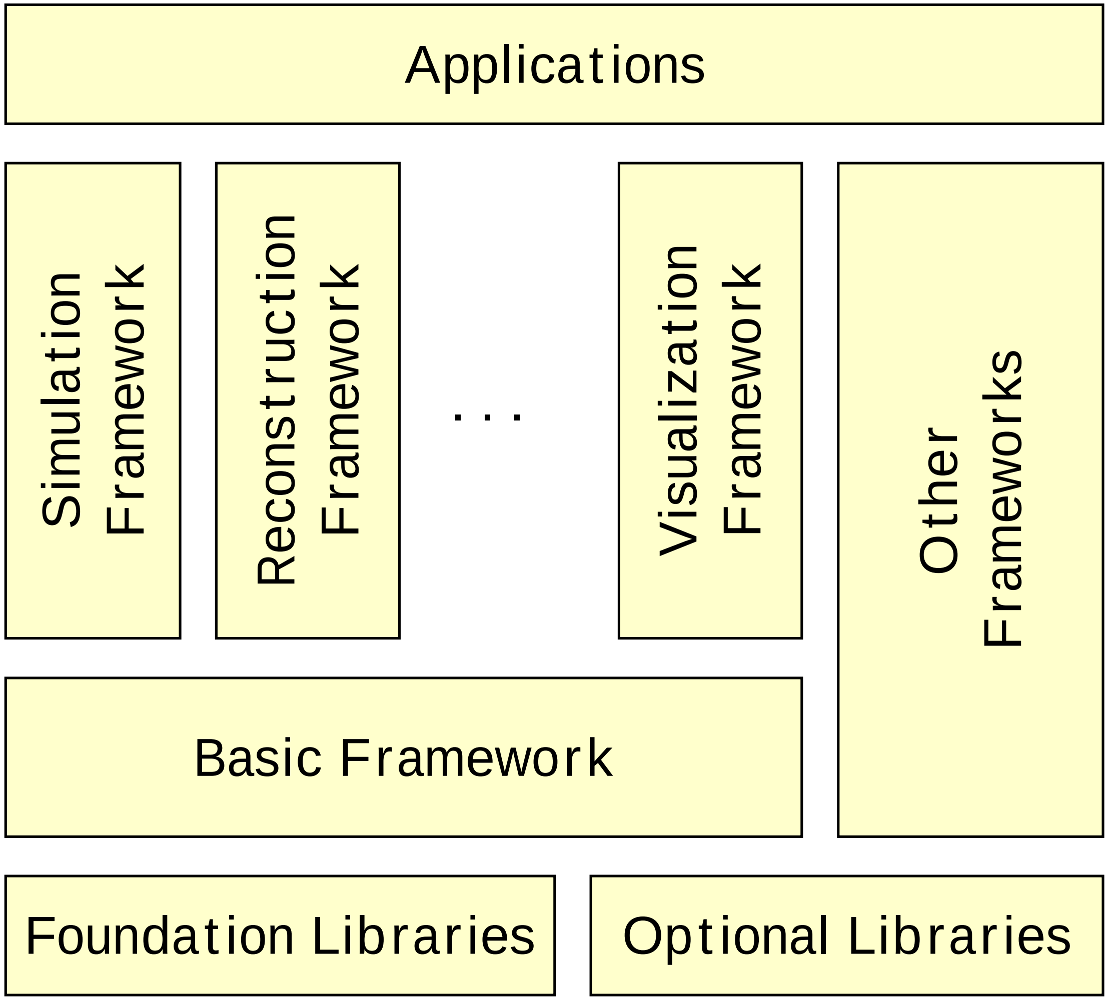
http://lcgapp.cern.ch/project/blueprint/BlueprintReport-final.doc
http://lcgapp.cern.ch/project/blueprint/BlueprintPlan.xls

Requirements

- **Long lifetime: technology evolution**
- Languages: C++ today; allow multi-language and evolution
- Distributed applications
- TGV and airplane work
- **Modularity of components**
- **Component communication via public interfaces**
- **Interchangeability of implementations**
- **Integration into coherent framework**
- Design for end-user's convenience more than the developer's
- **Re-use existing implementations**
- Software quality at least as good as any LHC experiment
- Meet performance, quality requirements of trigger/DAQ software
- Platforms

Bold: bearing strongly on architecture and ROOT role

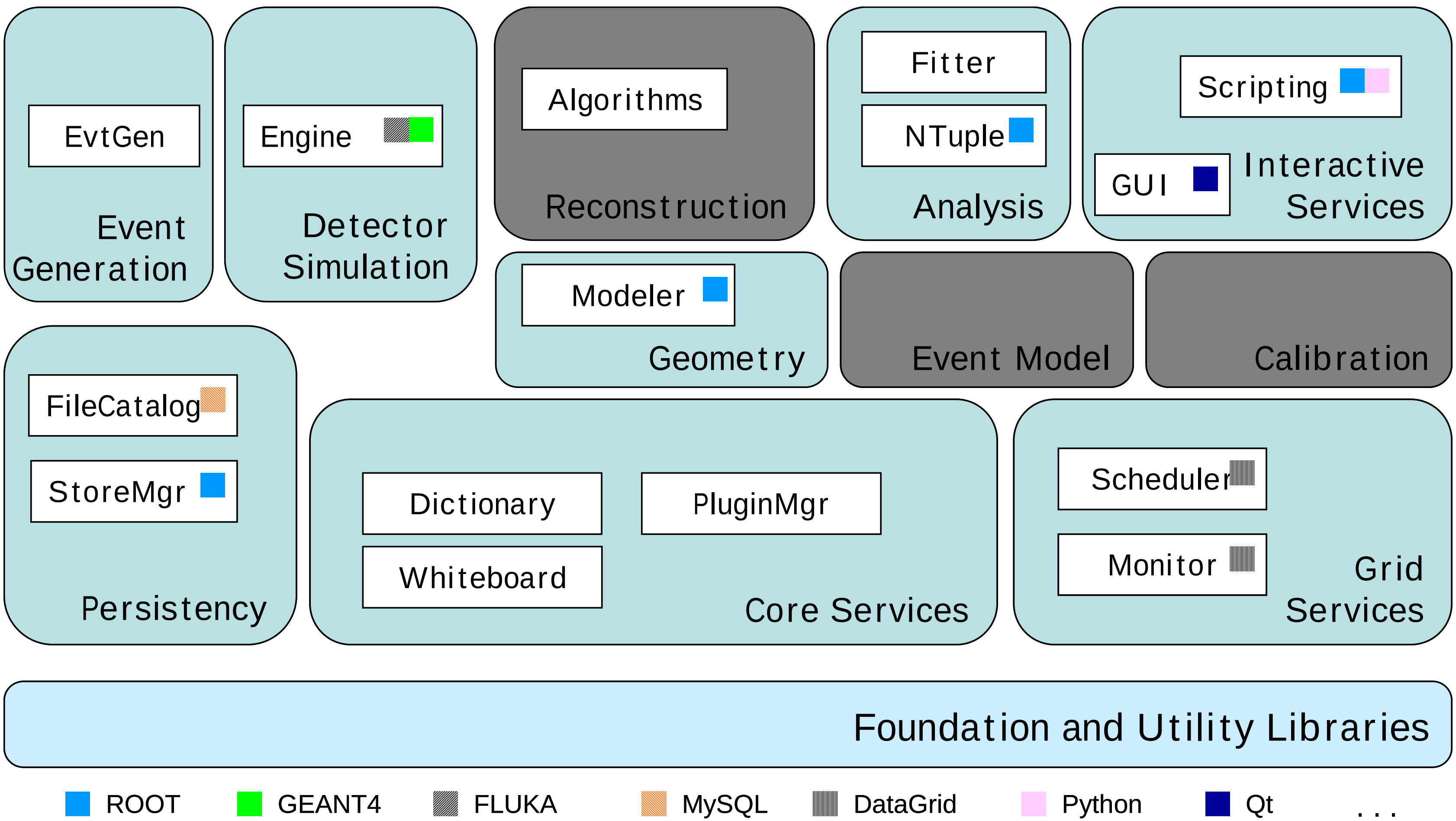
Software Structure



Blueprint Architectural Elements

- Object dictionary
- Standard component interfaces (e.g. for discovery, creation, destruction, etc.)
- Scripting language (ROOTCINT and Python both available)
- Component configuration – uniform approach
- Basic framework services
  - Framework infrastructures: creation of objects (factories), reference counting, communication & discovery (eg. registries), ….
  - Core services: ‘event’ management, monitoring & reporting, exception handling, etc.
  - System services : platform support
- Foundation and utility libraries
  - clhep, STL, Boost, etc.

Domain Decomposition



Products mentioned are examples; not a comprehensive list

Use of ROOT in LCG Software

- Among the LHC experiments
  - ALICE has based its applications directly on ROOT
  - The 3 others base their applications on components with implementation-independent interfaces
    - look for software that can be encapsulated into these components
- All experiments agree that ROOT is an important element of LHC software
  - Leverage existing software effectively and do not unnecessarily reinvent wheels
- Therefore the blueprint establishes a **user/provider relationship** between the LCG applications area and ROOT

ROOT in the LCG Blueprint Architecture

- User/provider relationship should allow experiments to take full advantage of the capabilities of ROOT
  - Implementation technology choices will be made on case by case basis
- It can be expected that LCG software may place architectural, organizational or other demands on ROOT
  - e.g. to ensure no interference between components used in different domains
- For specific components can expect that different implementations will be made available
  - e.g. CINT and python will both be available

RTAG Conclusions and Recommendations

- **Use of ROOT** is described and aspects of ROOT development of expected importance for LCG outlined
- **Start common project on core tools and services**
- **Start common project on physics interfaces**
- **Start RTAG on analysis**, including distributed aspects
- Tool/technology recommendations
  - CLHEP, CINT, Python, Qt, AIDA, …
- Develop a clear process for adopting third party software

ROOT Development Areas of LCG Interest

- Support for ‘foreign classes’ in ROOT I/O
- Relocatable persistent references
- Expanding support for STL
- Convenient external access to CINT dictionary (feed/retrieve info)
- Eventual migration to a standard C++ introspection interface
- Support for automatic schema evolution
- PROOF and grid interfacing
- Interfaces to Python and Java
- Qt based GUI
- Histogramming, fitting, n-tuples, trees
- Interface to GSL

Concluding Remarks

- The LCG project acts as a forum between the 4 experiments and other computing providers to maximise cooperation in the development of the LHC computing infrastructure, and in particular in the common components of software applications
- The Architecture RTAG has established requirements for defining a ‘blueprint’ for the way LCG software should be developed to facilitate integration of components developed by the different parties
- Strong commitment from all four experiments to use of ROOT
- Strong CERN support for ROOT
  - ROOT section in new LCG-focused EP/SFT group
  - ROOT personnel requests addressed by CERN and LCG
- Two LCG seminars coming in early November (6/7- to be confirmed):
  - The LCG software architecture blueprint
  - Rene’s personal vision for ROOT and LHC software
- First LCG product deliverable, POOL, is on schedule, and is a good example of the LCG/ROOT ‘working relationship’ in action