Fermi Large Area Telescope:
Science Analysis Software’s
Use of Gaudi

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Ancient History: 1995-1999

- Software effort adopted C++ with a handful of developers with varying amounts of C++ experience.
- Development and support on Windows using Microsoft Visual C++, including Visual SourceSafe as code repository.
- By 1999, we had
  - Detailed Monte Carlo simulation with hard-coded geometry description
  - Prototype reconstruction code
  - Output to ASCII ntuples
- This was before the proposal
- 2000 Richard Dubois takes the software reins.
Why Use a Framework?

• By 1999, we had plenty of code
  - but it was a maintenance nightmare
    • Needed organization and clear lines of division between components.
• Our MC generator was custom built
  - Planned move to Geant4
  - Looked to re-use existing code where possible
    • HEP offered a number of packages: CLHEP, G4
• Provide **one** code system for simulation, test data analysis, and flight operations.
• Flexible & Extensible
Object Oriented C++ Framework

“The implementation of an architecture which defines a structure flexible enough to support all types of physics data processing needs...from simulation to analysis to visualization.”

Promotes the creation of small maintainable components which can be loaded at runtime
- Components = algorithms, services, I/O, etc

Division of data from algorithms

Supports Linux and Windows
• **Standard interfaces for components**
  Algorithms, Services have defined interfaces
  Can extend and create additional interfaces as needed.

• **Gaudi provides a number of basic services:**
  - Event Data Service, Transient Data Store (TDS)
  - Messaging and Logging Services
  - Persistency Service
    - I/O where various output formats may be supported

• **Provides standard event loop**

• **JobOptionsSvc**
  Job parameters are handled via an input ASCII file or optional Python interface.
Example JobOptions

ApplicationMgr.DLLs = {"GaudiAlg", "GaudiAud", "GlastSvc", "HelloWorldGaudi"};

ApplicationMgr.ExtSvc ={ "EventSelector/EventSelector","EventLoopSvc" };

ApplicationMgr.Runable= "EventLoopSvc";

AuditorSvc.Auditors = { "ChronoAuditor" };

ApplicationMgr.TopAlg ={ "HelloWorld" };

// Set output level threshold (2=DEBUG, 3=INFO, 4=WARNING, 5=ERROR, 6=FATAL )
MessageSvc.OutputLevel = 3;

ApplicationMgr.EvtMax = 10; // events to be processed
EventPersistencySvc.CnvServices ={"EventCnvSvc"};
Migration

- Took a few months to get our code working within the Gaudi framework
- Most of the work involved using the TDS.
  - Had to extract the data that was embedded in our existing algorithm classes,
  - And figure out how to use the TDS and Event Data Service correctly
- Skipped using the PersistencySvc, in favor algorithms for ROOT I/O
By 2005...

- ~25 developers distributed across 9 time zones
- Support Windows & Red Hat Linux using Code Management Tool (CMT) as our build system
- ~35 MB (169 MB by 2010) of source code for:
  - Detailed Monte Carlo Simulation using Geant4
  - Reconstruction and Calibration algorithms
  - I/O infrastructure for MC as well as test data to ROOT ntuples and full MC, digitization, and reconstruction data.
Gleam Data Flow using Gaudi

Notes:
- All Doxygen links in this illustration are for the latest GlastRelease.
- Engineering Models 1 and 2 (Em1, Em2), and Latintegration applications are similar to GLEAM.

LEGEND:
- *** Uses ROOT Library
- OLAST's Gaudi Framework
- ROOT Output Files
- Optional ROOT Output Files
- Monte Carlo (MC) Data
- Real Data
- Note: All ROOT output files are available for analysis using ROOT.
How does Gaudi Play with Geant4?

- Both have event loops, and we need to utilize Gaudi’s event loop.
- We usurp G4’s RunManager, and ask for one event at a time through our G4Generator algorithm.
Fermi uses Core Packages of Gaudi

- **GaudiKernel** – defines basic interfaces
- **GaudiSvc** – basic services including event loop and TDS
- **GaudiUtil** – helpful utilities for loading libs at runtime
- **GaudiAlg** – defines Gaudi Algorithms
- **GaudiAud** – auditors, such as ChronoSvc
- May be adding GaudiPython soon
- **Gaudi v21r7**, includes and binaries ~350 MB not counting their ROOT external
Gaudi Has Many Externals

We use these externals.

Gaudi provides many interfaces, but Fermi does not need them.

In the interest of simplifying building Gaudi, we limit what externals we use.
Native Gaudì Components We Use

- **Event Data Store (EDS)**
- **Detector Data Store (DDS), for our calibration data**
- **ChronoSvc**
  - monitors the cpu usage for all algorithms and provides a report at the end of the job
- **JobOptionsSvc**
  - setting of runtime parameters for all components as well as determining the sequence of execution.
- **MessageSvc**
  - **Logging**
    - `log << MSG::INFO << "Hello World!" << endreq;`
Fermi-Defined Gaudi Components

- **G4Generator** - interface to Geant4
- **Monte Carlo and digitization algorithms**
- **GlastDetSvc** - service providing detector geometry description where details are stored in XML
- **CalibSvc** - calibrations
- **GlastRandomSvc** - handles initialization of random number seeds
- **AcdRecon, TkrRecon, CalRecon** - Reconstruction algorithms
- **ntupleWriterSvc** - ROOT ntuple
- **ROOT I/O algorithms**
- **LDFConverter** - Flight and test data input
Advantages and Disadvantages

ADVANTAGES

• Provides standardized, general interfaces
• Free, source code available
• Pick and Choose Components
• Python Interface
• Object Oriented
• Longevity

DISADVANTAGES

• Not well documented
  Most docs from 2000
• Steep learning curve for development
• Slow start up during loading
• Requires use of DataObject interface
Current Plans

• Migrating to Gaudi v21r7 from v18r4
  – Closer relationship to ROOT
    • Uses rootmaps on windows to dynamic load libs
  – Looking for VC++ 2008 and gcc 4 support

• Fermi is moving from CMT to SCons
  – We’ll continue to use CMT to build Gaudi as one of our ext. libs
References

• Fermi Workbook
  - http://glast-ground.slac.stanford.edu/workbook/instrAnalysis_home.htm

• Gaudi Home Page
  - http://proj-gaudi.web.cern.ch/proj-gaudi

• BNL Gaudi Mailing List