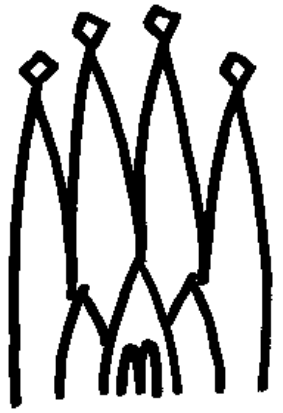
GAUDI - The Software Architecture and Framework for building LHCb data processing applications



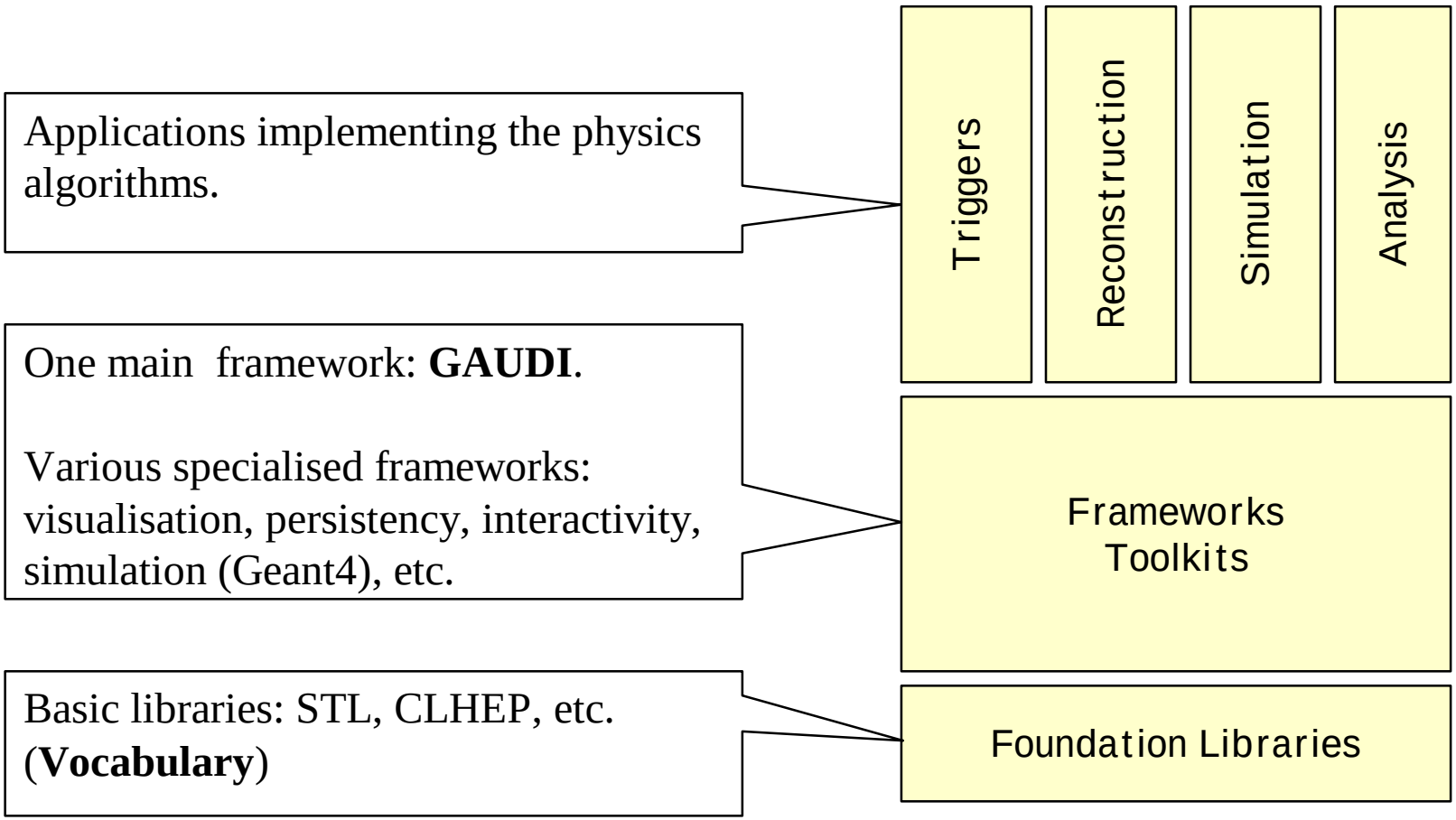
Marco Cattaneo, CERN

February 2000

Outline

- Introduction
- Design choices
- GAUDI Architecture overview
- Status
- Conclusions

Software Structure



GAUDI project goals

- **Develop an *Architecture* and a *Framework* to be used at all stages of LHCb data analysis**
  - Trigger levels 2 and 3, simulation, reconstruction, analysis
- **Avoid fragmentation and duplication of computing effort**
  - **Single development team across online and offline domains**
    - Identify common components, re-use
  - **Give users (physicists) a framework within which to develop applications**
    - Rapid transition away from FORTRAN to minimise legacy code
    - A single framework used by all members of the collaboration
- **Transparent use of third-party components wherever possible or necessary**
  - GUI, persistency, simulation....

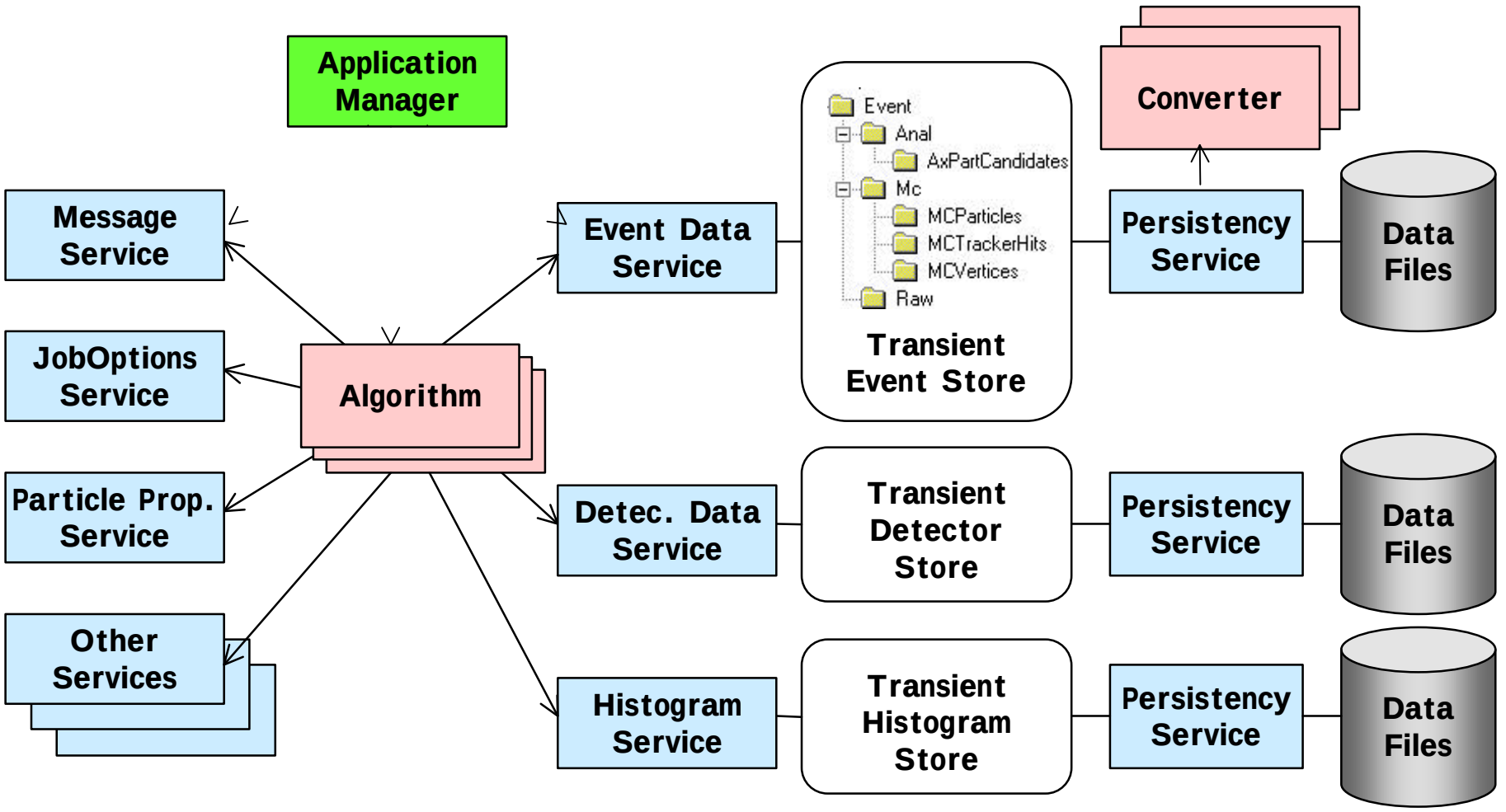

Software development strategy

- **Start with small design team of 6-8 people**
  - **architect, librarian, domain specialists with design/programming experience**
- **Collect User Requirements and use-cases**
- **Establish basic criteria for the overall design**
- **Make technology choices for implementation of initial prototypes**
- **Incremental approach to development.**
  - **Release every ~4 months.**
  - **Releases accompanied by complete documentation**
  - **Development cycle driven by the users: priorities, feedback, etc.**
- **Strategic decisions after thorough design review (~1/year)**

Principal design choices

- **Separation between *"data"* and *"algorithms"***
  - Data objects primarily carry data, have only basic methods
    - e.g. Tracking hits
  - Algorithm objects primarily manipulate data
    - e.g. Track fitter
- **Three basic categories of data:**
  - *"event data"* (obtained from particle collisions, real or simulated)
  - *"detector data"* (structure, geometry, calibration, alignment, ...)
  - *"statistical data"* (histograms, ...)
- **Separation between *"transient"* and *"persistent"* data.**
  - Isolate user code from persistency technology .
  - Different optimisation criteria.
  - Transient as a bridge between independent representations.

GAUDI object diagram

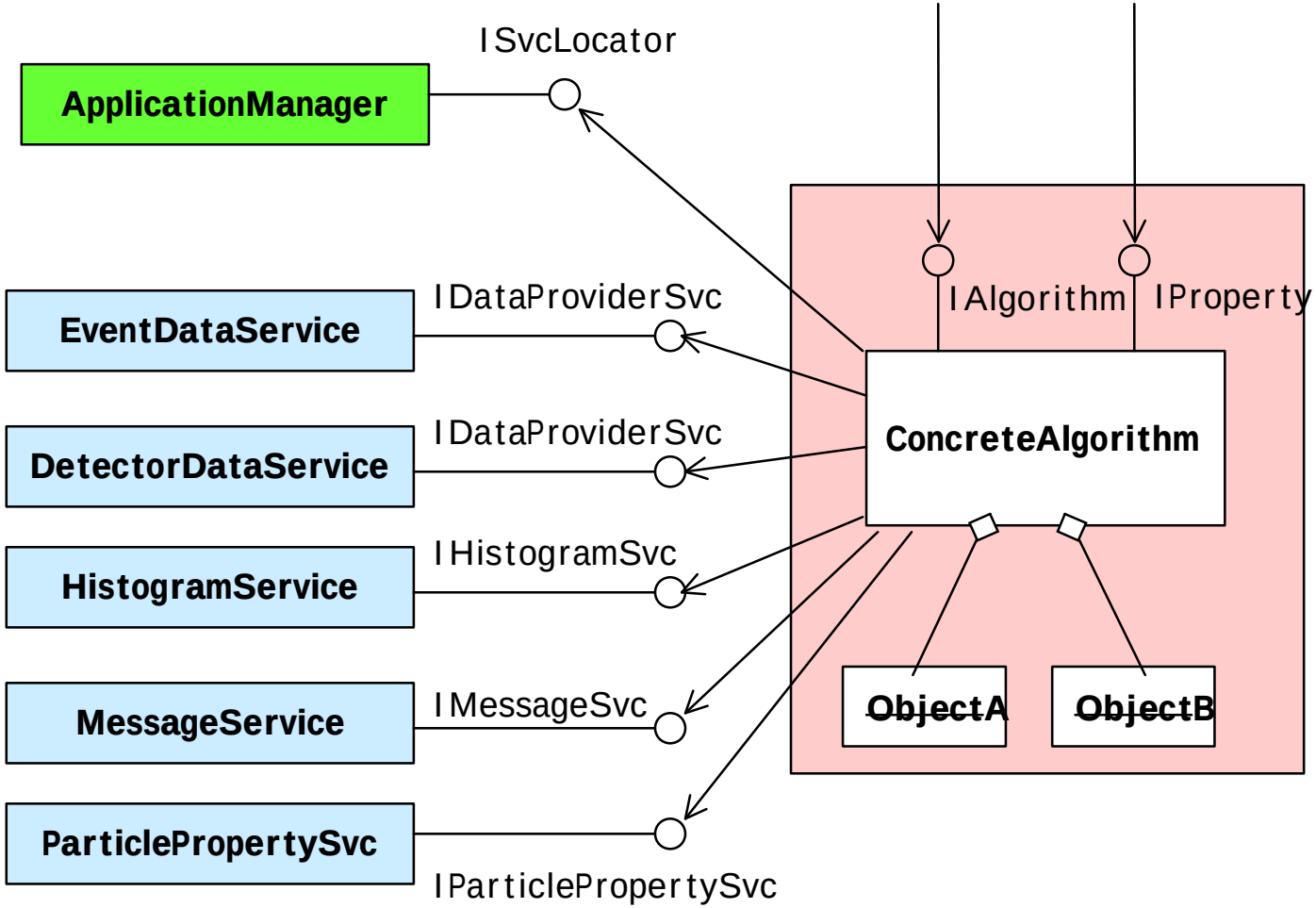


Principal design choices (2)

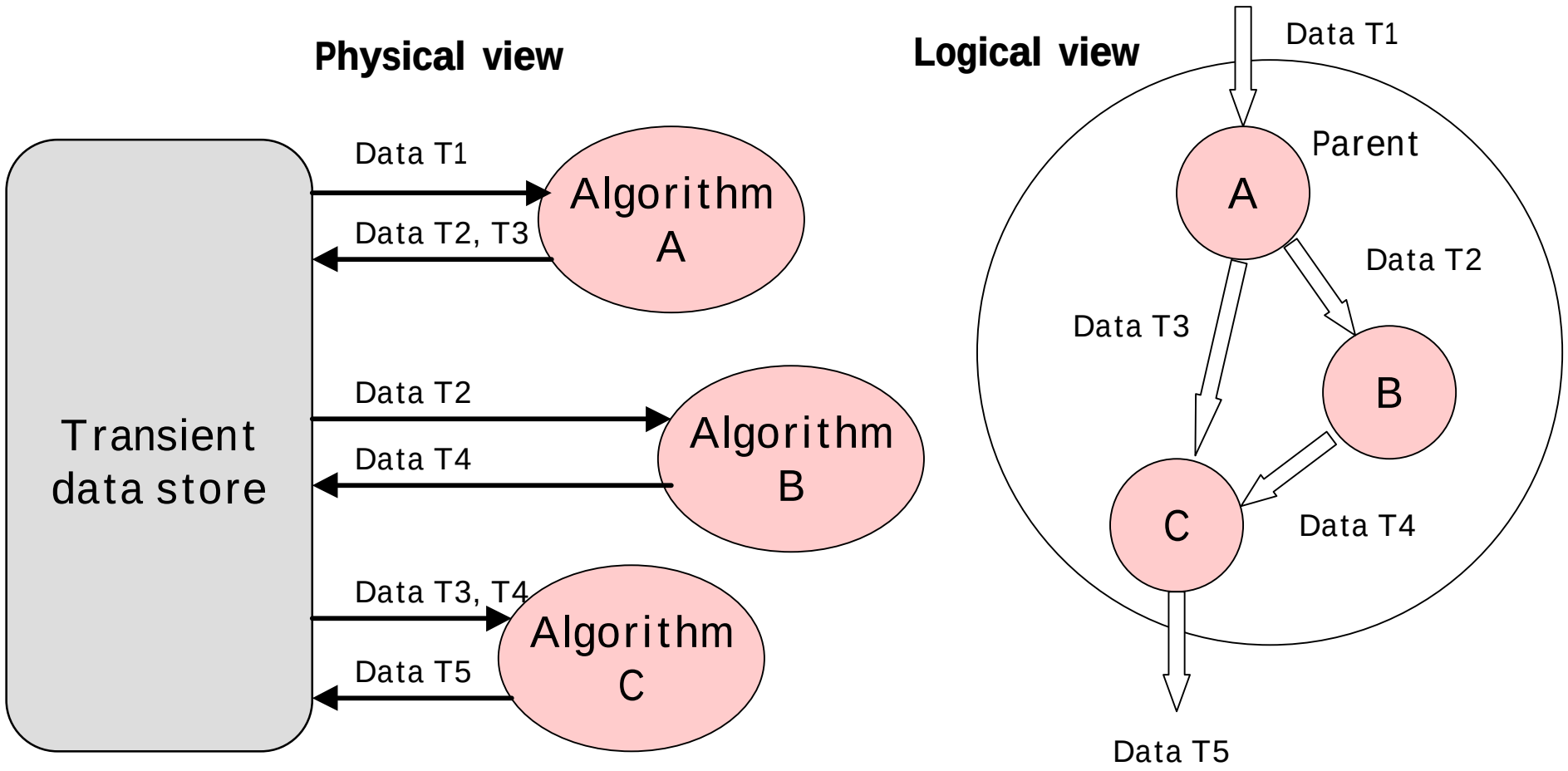
- **Data store -centred (*"blackboard"*) architectural style.**
  - ***Algorithms* as producers and consumers of *data* objects**
  - **Minimal coupling between algorithms, allows independent development.**
- ***"User code"* encapsulated in a few specific places:**
  - ***"Algorithms"*: physics code**
  - ***"Converters"*: convert data objects between representations**
- **Well defined component *"interfaces"*, as *"generic"* as possible.**
  - **Stable, shield clients from the (changing) implementation**
  - **In C++, pure abstract class**

Interfaces

- Each component **implements** one or more interfaces
- Each component **uses** one or more interfaces of other components
- An **Algorithm** uses many **Services**



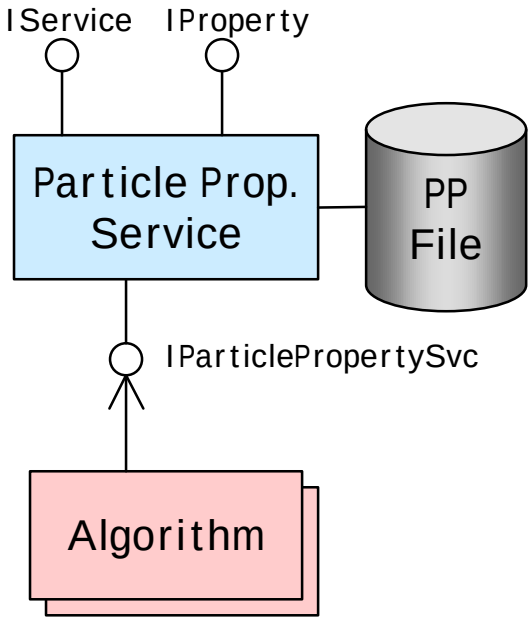
Algorithms



- An Algorithm knows only which data (type and name) it uses as input and produces as output.
- The only coupling between algorithms is via the data.
- The execution order of the sub-algorithms is the responsibility of the parent algorithm.

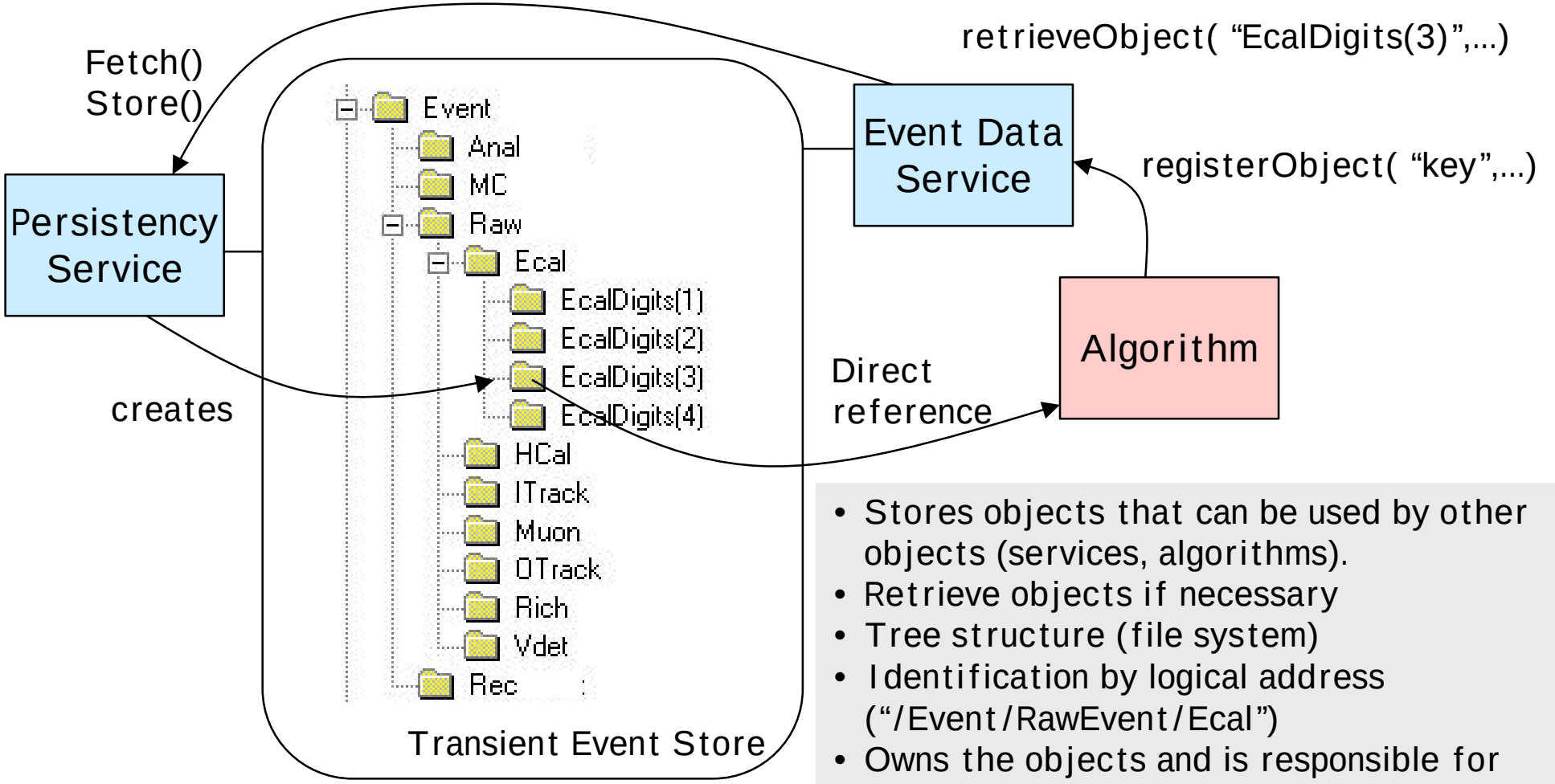
Services

- **Various *services* are provided to *algorithms***
- **Examples:**
  - **Job Options service (configuration "card" files)**
  - **Message reporting service**
  - **Event/Detector/Histogram data service**
  - **Event Selector**
  - **Persistency and Conversion services**
  - **User Interface (GUI)**
  - **Particle property service**
  - **...**



Event Data Store

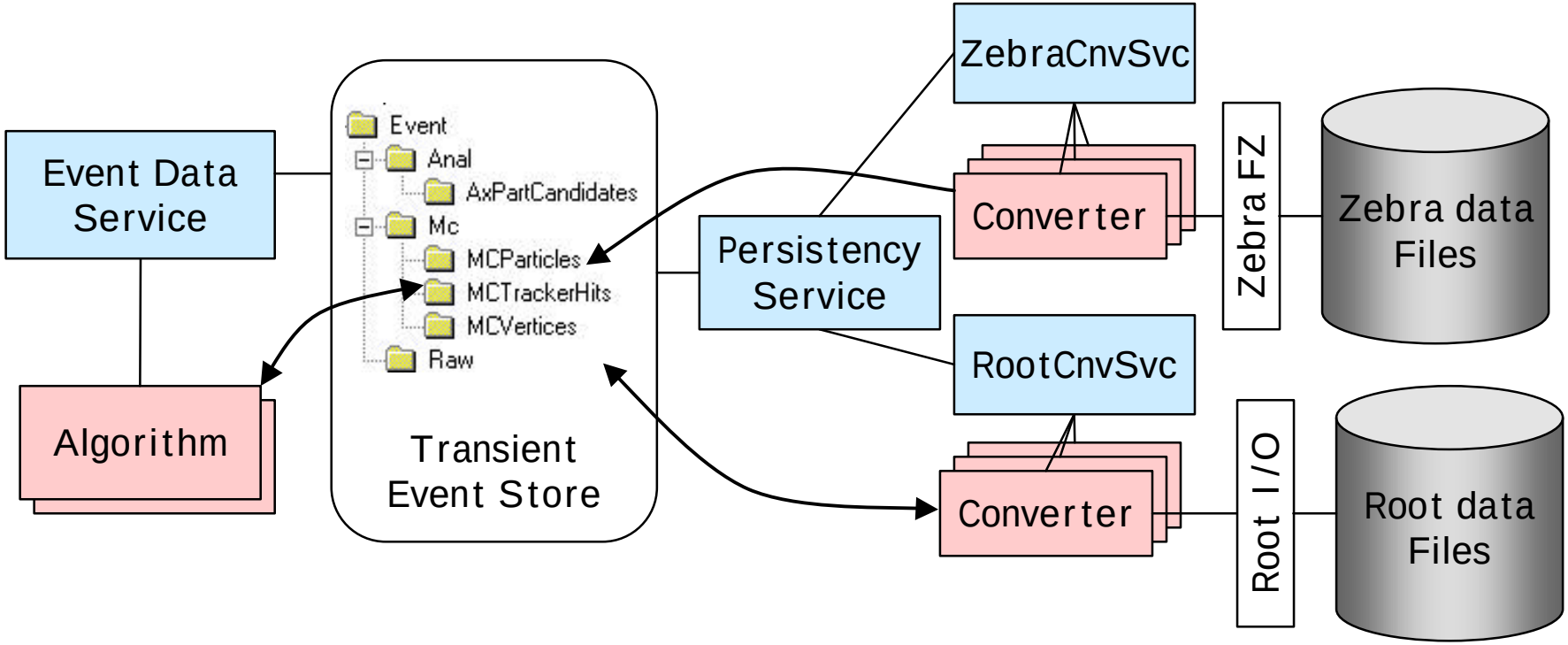
(See Markus Frank's talk, C153)



- Stores objects that can be used by other objects (services, algorithms).
- Retrieve objects if necessary
- Tree structure (file system)
- Identification by logical address ("/Event/RawEvent/Ecal")
- Owns the objects and is responsible for their clean-up.

Persistency

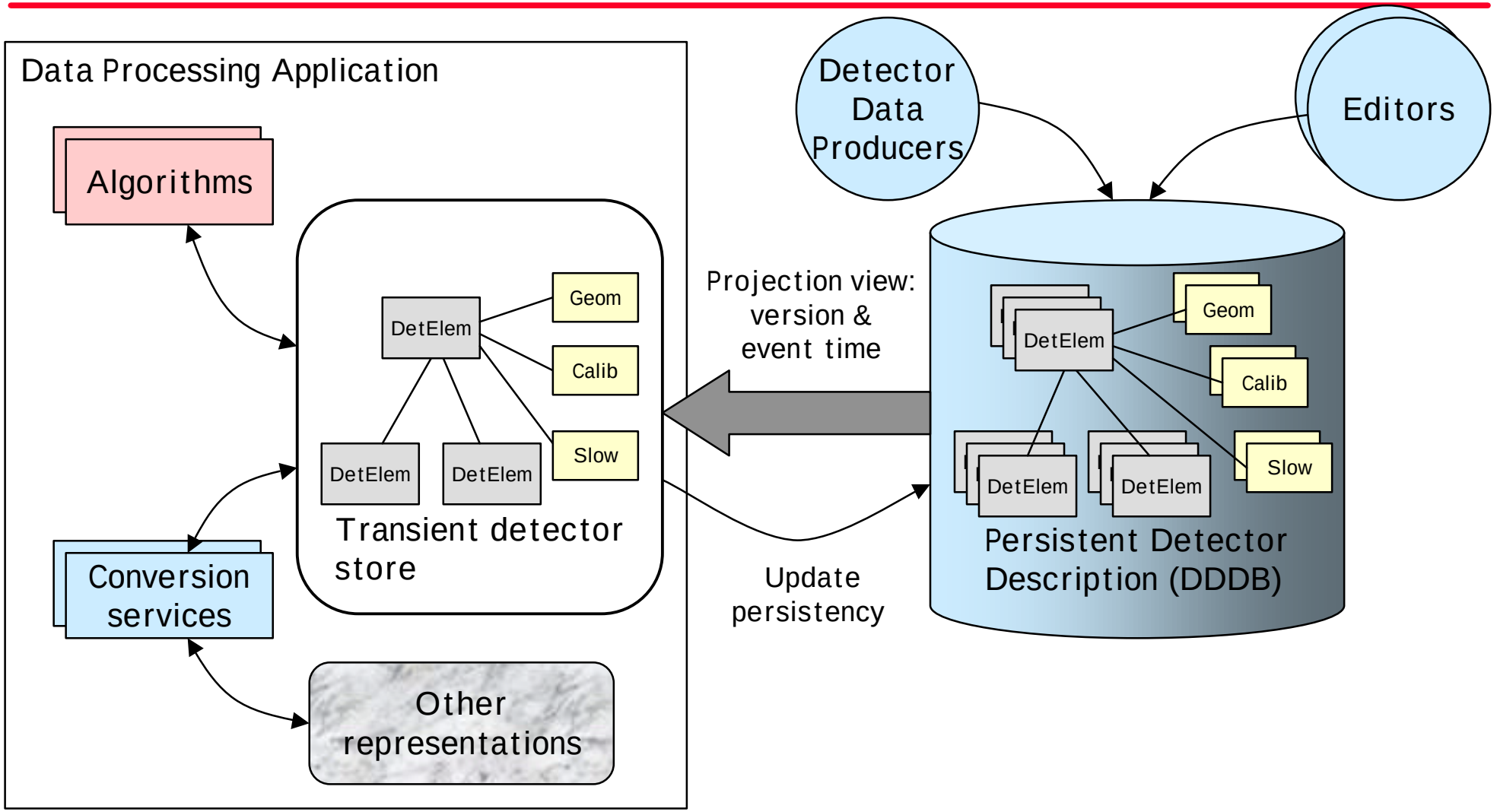
(See Markus Frank's talk, C153)



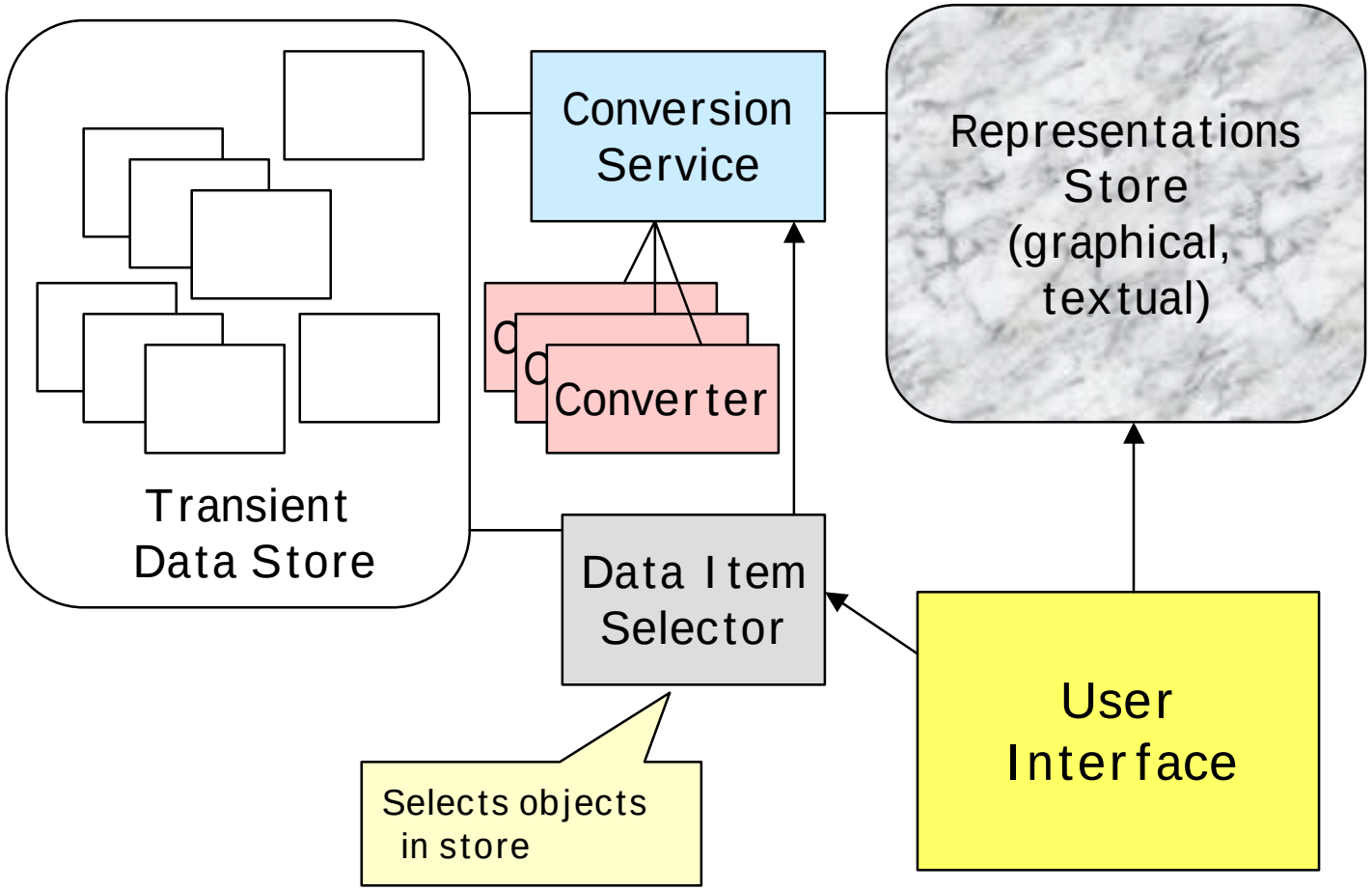
- Various technologies available in the same program: Objy, Root, Zebra,...
- **Converters** transform objects from one representation to another.

Detector Description

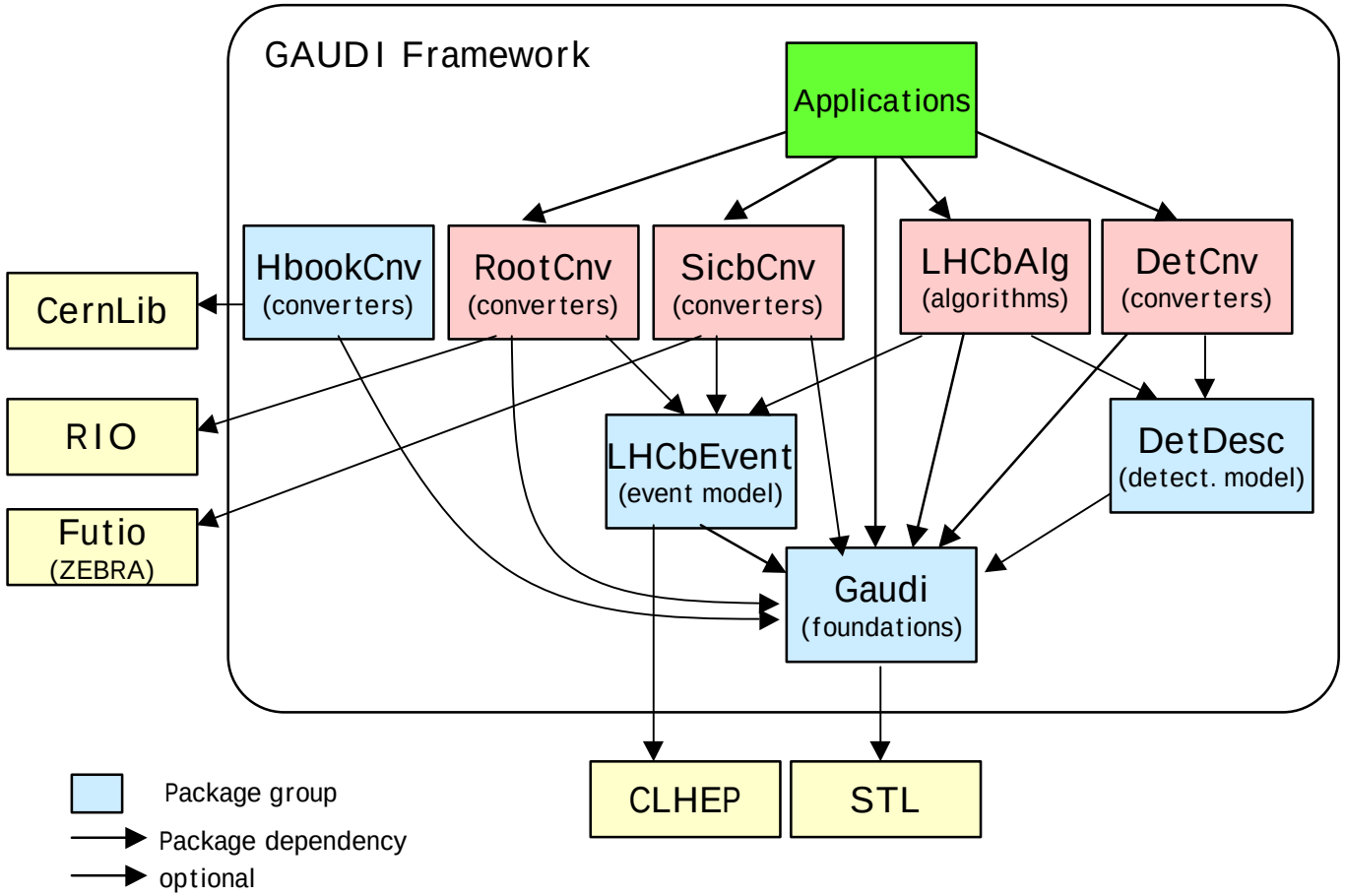
(See Radovan Chytracek's talk, A155)



Visualisation



Packages



- Sub-division into **packages** is an architectural problem.
- Important consequences for:
  - compilation time
  - link dependencies
  - configuration management
  - executable size
  - ...
- Dependencies between packages must be approved by the architect
- Avoid circular dependencies

Implementation

(see Florence Ranjard's talk, F151)

- **Platforms:**
  - **WNT, Linux,** IBM AIX, HP-UX
- **Tools and Libraries:**

Design tools	Visual Thought, Rational Rose
Coding rules	Interim LHCb coding conventions
Code Management	CVS
Configuration Management	CMT
Problem tracking	Plan to use Remedy
Compilers/Debuggers	Visual C++, GNU EGCS, ddd
Libraries	STL, CLHEP, NAG C, HTL, RIO
Documentation	FrameMaker, Visual Source Safe
Source code documentation	Object Outline

Work in progress:

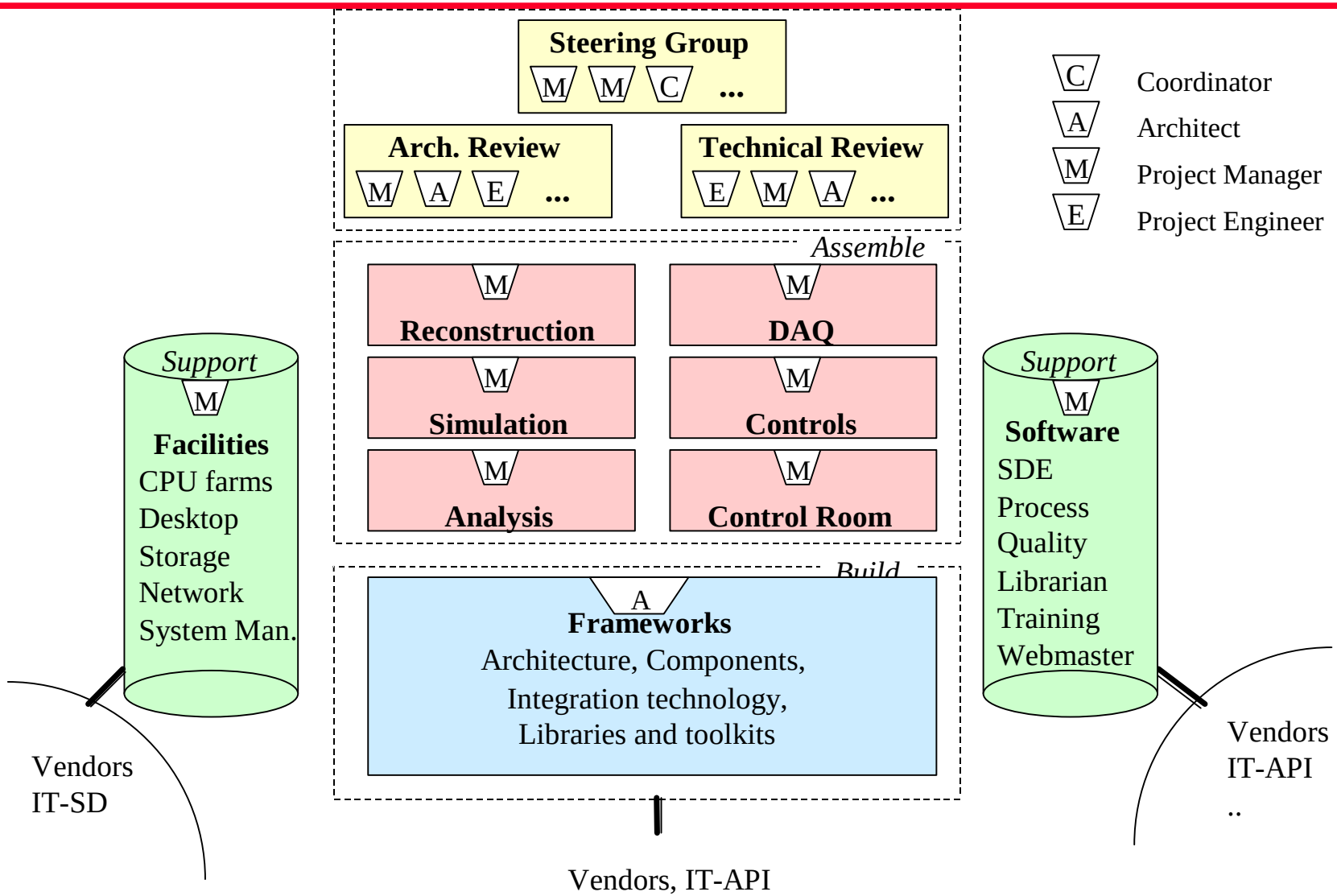
- Integration of GEANT4
- Visualisation, event display
- Algorithms and tools for data analysis
- Java evaluation
- Collaboration with AIDA (see Andreas Pfeiffer's presentation, F82)
  - Definition of interfaces
- Ongoing discussions with other experiments
- Deployment for physics applications:
  - migration of reconstruction
  - test beam analysis
  - tracking, RICH pattern recognition
  - ECAL geometry
  - etc.

Conclusions

- **We believe it is fundamental to define an architecture**
  - And to provide a framework which implements the architecture
  - Ensures adaptability, maintainability and resilience against change.
  - GAUDI is the LHCb architecture and framework
- **Physicists have started to enjoy the pain!**
  - Many new development activities entirely within Gaudi
  - Ongoing migration of existing code to Gaudi framework
- **We welcome advice, criticism, collaboration**

http://lhcb.cern.ch/computing/Components/html/GaudiMain.html

Software Project Organisation



Project history

- Sep '98 - architect appointed, design team (6 people) constituted
- Nov 25 '98 - external architecture review
  - objectives, architecture design document, URD, scenarios

- Feb 8 '99 - first GAUDI release
  - first software week, presentations, tutorials
  - plan second release (together with users)
  - expand GAUDI team

- May 30 '99 - second GAUDI release
  - second software week, plan third release with users, expand team.

- Nov 23 '99 - third GAUDI release and software week
  - plan deployment for production applications
- Spring '00 - second external review

Migration Strategy

- **Objective: all applications exclusively in OO**
- **Transition phase**
  - **Incorporate existing reconstruction and analysis programs in GAUDI** (wrap FORTRAN)
    - **Split existing program into independent algorithms**
    - **Develop an OO event model, write converters to populate it from the FORTRAN banks**
  - **Incorporate new OO algorithms developed exclusively in GAUDI**
    - **e.g. Tracking pattern recognition**
    - **Write converters to make the results available to the FORTRAN world**
  - **Many converters in both directions, COMMON blocks etc.**
- **Hybrid phase**
  - **C++ and FORTRAN coexist in a single reconstruction program**
    - **Two detector descriptions, two cards files, doubled memory use, which output format?**
  - **Gradually replace FORTRAN**