Reconstruction and Analysis Software Environment of LHCb

- LHCb reconstruction and analysis
- Software Architecture “Gaudi”
- Some Examples:
  - High-Level Trigger
  - Event Display
  - Interactive Analysis

Patrick Koppenburg
CERN / PH

On behalf of the LHCb collaboration
Software Environment of LHCb

- LHCb reconstruction and analysis
- Software Architecture “Gaudi”
- Some Examples:
  - High-Level Trigger
  - Event Display
  - Interactive Analysis

Patrick Koppenburg
CERN / PH

On behalf of the LHCb collaboration
$\mathcal{L} = 2 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$

$\sigma_{b\bar{b}} = 500 \mu\text{b} \text{ at } 14 \text{ TeV}$

$10^{12} \text{ b}\bar{b}/\text{year}$

See S. Barsuk’s talk on Tuesday.

Tracking system: See M. Needham’s talk on Thursday.

Trigger: 40 MHz $\rightarrow$ 1 MHz (hard) $\rightarrow$ 2 kHz (software)

See F. Teubert’s talk on Wednesday.
LHCb Software strategy

Structure: Develop an Architecture ("blueprint") and a Framework (real code) to be used at all stages of LHCb data processing

- Software triggers, simulation, reconstruction, analysis, visualization...
- One single framework used by all members of the collaboration for all code

→ Gaudi

Development: Avoid duplication of computing effort

- Develop simple components that can be used in any environment
- Use common interfaces to allow easy "plug-and-play" switching of tools. Ex: Vertex Fitters, Cuts...

Applications are developed by customizing the framework.
• Separation of “data” and “algorithms”: Write 00 code, but profit from decades of HEP experience
• Separation of “transient” and “persistent” data
• Physicist code encapsulated in specific places (Algorithms)
The same architecture is used online in the software triggers.

→ The same algorithms are used
Example: High-Level Trigger

Reconstruction, Generic HLT

\[ \gamma, e \]

\[ K, \pi \]

Muons

Inclusive B

Dimuons

Loose Dimuons

\[ D^0 \rightarrow hh \]

\[ D^0 \rightarrow K\pi \]

\[ D^0 \rightarrow K\pi \]

\[ \phi \rightarrow K\pi \]

\[ D_s \rightarrow K\pi \]

\[ D^* \rightarrow D^0\pi \]

\[ B \rightarrow hh \]

\[ B^0 \rightarrow D^*\pi \]

\[ B^0 \rightarrow D^0K^* \]

\[ B_s \rightarrow \phi\gamma \]

\[ B_s \rightarrow \phi\phi \]

\[ B_s \rightarrow D_s h \]

\[ B^0 \rightarrow K^*\mu\mu \]

\[ B \rightarrow J/\psi X \]
Example: High-Level Trigger

- Same code used:
  1. online in the High-Level-Trigger
  2. offline in the stripping ( = “skimming”)
  3. May be used for final selection

... With increasingly hard cuts

→ Maximal correlations of selections
Applications

**Gauss:** Simulation. Uses generators and **Geant 4**.

**Boole:** Digitization. Simulates detector response and transforms to “raw” data format.

**Brunel:** Reconstruction. Full pattern recognition and PID.

**DaVinci:** Analysis. Deals with “Particles” and “Vertices”. Final event selection.

**Euler:** L1 Trigger. For on- and offline use.

**Moore:** High-Level Trigger. For on- and offline use.

**Panoramix:** Visualization.

**Bender:** Interactive Analysis in **python**.
Data Production Flow

Gaudi-Applications

Gauss (simulation)
Boole (digitization)
Brunel (reconstruction)
DaVinci (analysis)

Data
sim
digi/raw
dst
dst

~ 400 million events produced during 2004 data challenge
Example: Panoramix Display

- Visualization application based on Gaudi, OnX and OpenInventor
- Scripting based on python
- Allows to (re-)process everything

P. Koppenburg
**Example: Interactive analysis**

- **Bender** combines a python-wrapping of the DaVinci tools, the LHCb Event Model and the Gaudi framework.
- It allows to perform interactive physics analysis...
- ...and access to many external tools.

---

P. Koppenburg
Example: Interactive analysis

HippoDraw
Panoramix
PI/ROOT
ROOT
Bender Prompt
Conclusion

- A well defined structure for 500 users
- One framework for 8 applications:
  - Data production
  - Analysis
  - Trigger
  - Interactivity
- Facilitates migration of algorithms between applications
- Encourages optimal usage of the code
- Helps to minimize inefficiencies
- Allows analysis in C++ or python