Controls for LHCb experiment

Pere Mato, CERN
on behalf of the LHCb collaboration
JCOP Workshop II, 6-8 September 1999
Outline

- LHCb Experiment
  - Goals, LHCb in numbers, Overall planning
- LHCb Computing Organization
  - Goals, Structure, Planning
- Update on requirements for controls
- Program of work and priorities
- Position of the experiment on what has been presented
- Conclusions
LHCb

- LHCb is a dedicated experiment at the LHC collider for precision measurements of CP-violation and rare decays
- Single-arm spectrometer with forward angular coverage from ~10 mrad to ~300(250) mrad
  - Vertex detector
  - Tracking system
  - RICH system
  - Calorimeter system
  - Muon system
LHCb in numbers

- Collaboration: ~45 Institutes, ~350 participants
- Cost of the experiment: 86 MCHF
- Electronics: ~10^6 readout channels
- Trigger System: 4 Levels. 40 MHz → 1 MHz → 40 kHz → 5 kHz → 200 Hz
- Data Acquisition: 100 kB/event. 2-4 GB/s → 20 MB/s. 1.5 10^6 MIPs
- Status of the Experiment:
  - Technical proposal submitted in February 1998
  - Approved in September 1998
  - R&D phase for ~2 years
LHCb Computing: Goals

- Need to focus on **quality** but at the same time be **efficient** in use of resources

- **Quality**
  - by designing quality architectures
  - by building or acquiring quality components

- **Efficiency**
  - by re-using components
  - by avoiding duplications
# LHCb Computing: Project Organization

## Steering Group
- Coordination, Planning, Resources

### Computing Facilities
- Farms
- Desktop
- Storage
- Network
- Operating System

### Reconstruction
- Level 2
- Level 3
- Prompt Rec.
- Full Rec.
- Calibration

### Analysis
- Framework
- Tools

### Simulation
- GEANT4 Framework
- Tools
- Production

### DAQ
- Event Builder
- Readout Network
- Interfaces
- Links
- Crates
- DAQware

### Controls
- DCS
- LHC
- Safety
- Run Control

### Control Room
- Operations
- Consoles
- Shift Crew Environment

### Software Engineering Group
- Methods
- Tools
- Code Management
- Quality
- Document
- Training
- Licenses
- Collab.
- Tools

### Re-usable Components
- Data Management: Event Store, Geometry, Database Utilities, ODBMS
- Architecture: Frameworks, Component model, Distributed system
- Toolkits: GUI, Histograms, Communications
- Utilities: data quality monitoring, event display, bookkeeping

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# LHCb DAQ/Controls Project: Planning

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<th>ID</th>
<th>Task Name</th>
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<td>1</td>
<td>Detectors</td>
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<td>R&amp;D and prototypes</td>
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<td>Control system (DCS)</td>
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<td>UR (sub-detectors,infrastructure)</td>
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<td>Architecture/Evaluations/R&amp;D</td>
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<td>Interface recommendations</td>
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<td>Interim develop/test beam</td>
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<td>Final Technology/Product choice</td>
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<td>System Installation/Integration</td>
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<td>LHCb startup</td>
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LHCb logo

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Update in Requirements
The ECS will be used to monitor and control the operational state of the LHCb detector, of the data acquisition and of the associated experimental infrastructures.

Typical sub-systems are:
- Environmental parameters (temperature, pressure, etc.)
- Equipment Safety
- High and Low voltages
- Read-out electronics (front-end and read-out network)
- Gas systems
- Cooling and ventilation
Controls: Scope

Trigger & Data Acquisition system

Trigger Level 2 & 3 Event Filter

Variable latency
L2 ~10 ms
L3 ~200 ms

Storage

Sub-farm controllers

Read-out Network

Read-out units

Front-End Electronics

LHC-B Detector

VDET TRACK ECAL HCAL MUON RICH

Control & Monitoring

LAN

Data rates

40 TB/s

1 TB/s

4 GB/s

2-4 GB/s

20 MB/s

Trigger & Data Acquisition system

Level 0 Trigger

Level 1 Trigger

Timing & Fast Control

40 MHz

1 MHz

40 kHz

1 MHz

Variable latency
L2 ~10 ms
L3 ~200 ms

Trigger Level 2 & 3 Event Filter

Read-out units

Read-out Network

Sub-farm controllers

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Read-out units

Read-out Network

Sub-farm controllers

Control & Monitoring

LAN

Data rates

40 TB/s

1 TB/s

4 GB/s

2-4 GB/s

20 MB/s

Trigger & Data Acquisition system
## DAQ Configuration Parameters

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<th>Element</th>
<th>#Units</th>
<th>#Parameters</th>
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<td>1'000</td>
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<td>Front-End Multiplexers</td>
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<tr>
<td>Readout Units</td>
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<tr>
<td>Sub-Farm Controllers</td>
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<tr>
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<tr>
<td>Level 1 Trigger</td>
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<tr>
<td>Level 2/3 Farm Processors*</td>
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<td>n00000</td>
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<tr>
<td><strong>Totals</strong></td>
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</table>

Read/Write frequency of Configuration Parameters: every run, fill, error recovery
Monitoring frequency of Alarm/Monitoring Items: every 1 minute

(*) same parameter set will be loaded into ~2000 processors
DAQ configuration

◆ Observations
  – The number of different **device types** is of the order of a dozen
  – The number of **devices** is of the order of 17’000
  – The number of **parameters** is of the order of $n \cdot 10^6$
  – The number of monitored quantities is of the order of $n \cdot 10^5$

◆ Implications
  – A tag-oriented system is unrealistic if each parameter is an entry.
  – We need a namespace hierarchy (Device->Parameters).
  – For highly repetitive items (e.g. individual detector channels in an electronics board) arrays are needed (don’t want to name each of them).
Program of work and Priorities
Control/Monitoring structure

- Configuration DB, Archives, Logfiles, etc.
- Experimental equipment
- Storage
- Other systems (LHC, Safety, ...)
- Controller/PLC
- FieldBus
- VME
- Supervision
- Process Management
- Field Management
- Technologies
  - SCADA
  - OPC
  - Communication Protocols
  - PLC
  - Field buses
  - Sensors/devices

SCADA = supervisory control and data acquisition
OPC = OLE for process control
PLC = Programmable logic controller
Field buses = CAN, ProfiBus, WorldFip, ...
Decisions for the lower layers need to be taken sooner.

Studies need to be completed before making informed choices.

Logically, our priority is in the lower layers.
  – Viewpoint not shared by JCOP

Milestone for recommended hardware interfaces: end of the year.

SCADA low priority.
Need for an Architecture

- We continue to be convinced of the importance of defining an architecture.
  - We need to decompose the system into components/layers with well defined interfaces.
  - Specific functionality should be assigned to each component or layer.
  - Needs to be documented and adopted
- Aspects like “partitioning” need to be studied
  - Use cases
- This has very high priority for LHCb.
Areas where LHCb is active

- Field buses (with IT-CO)
  - Need to provide guidelines to designers of read-out electronics.
  - Study the goodies of each solution. Survey market. Provide practical advice. Chip-sets, evaluation boards,…

- OPC (within JCOP)
  - Evaluation of OPC standard
  - Practical experience developing OPC servers
  - Answer the question: Can we standardize on it?

- SCADA Evaluation (within JCOP)
  - Follow the SCADA evaluation in order to have an opinion.
Position of the experiment on what has been presented
Field buses

- We need to consider other candidate buses (bandwidth, addressability,…)
  - Maybe the 3 CERN standard field buses are not sufficient
  - Specially for the needs of DAQ control

- Standard solutions for:
  - Adapter to I²C, JTAG,…
  - Bus controllers (chipsets, daughter boards, programming)
  - PCI/VME interfaces
PLCs

◆ Our vision:
  – We will use a mixture of “traditional” processors (probably PC based) and PLCs in our control system.
  – PLCs will be used in specialized domains:
    » Well defined process control (gas systems, magnet,…)
    » If safety is required
  – Traditional processors will be used for the rest:
    » Cheaper solution
    » Program flexibility. Programmed eventually by end users.
    » SoftPLC?

◆ We think there is sufficient expertise on PLCs at CERN and JCOP.
**OPC**

- OPC is a good standard
  - Well designed
  - Adopted by many vendors. Strong industry support
  - Performance seems adequate

- Known problems
  - Security
  - Basically NT based. Difficulty to communicate to UNIX world.

- JCOP should recommend OPC.
The SCADA evaluation has been extremely useful as information gathering

- We know what commercial systems can provide
- We know better the goodies and badies of industrial systems
- We know better the companies. Links and contacts.

Very rapidly changing domain

- New products and new versions appearing continuously
- For how long the information obtained will still be valid?
Is one of the SCADA systems likely to be acceptable?

- Mandatory Features:
  - **Support for devices.** To handle the complexity and scale of our problem.
  - **Support for arrays.** To handle highly repetitive items.
  - **Openness.** To extern its functionality and interface with existing systems

- The only exiting candidate is XXXXX
  - With the next two announced versions, all the mandatory features will be available.
  - Problems encountered have prevented the completion of the evaluation.
Time scale for an eventual decision

- LHCb do not need to take a decision on the SCADA product before end 2001.
- Taking a final decision too early on this kind of products is very risky. Rapid evolution.
- We think it is not needed to tender now. LHCb will not know what to do with the licenses!
- If the majority of JCOP collaborators decides with an earlier date, then LHCb will go along with it. Provided it can be used!
What can we do for the next 2 years?

- Architecture
  - Collect use cases.
- Focus on the low level stuff (field buses, …)
- Study experiment configuration database issues
- Use the most promising (XXXXXX) SCADA product to build realistic prototype systems
  - Run control type of application, test beam, etc.
  - Only few licenses needed
  - Start the engineering activity
- Continue technology watch. Investigate alternatives.
Summary

◆ The LHCb approach to controls have not changed since last year: Integrated ECS.
◆ LHCb priority is currently in the lower level stuff and architecture.
◆ Position of LHCb on what has been presented:
  – Field buses: Open the scope of applicability and investigate standard solutions.
  – PLCs: Well covered in general.
  – OPC: Should be recommended by JCOP.
  – SCADA evaluation: Very successful. At least one usable product.
◆ LHCb needs a decision on the supervisory software by end 2001. No need for tendering now.