Requirements for the LHCb Controls

JCOP Workshop

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P. Mato, CERN

for the LHCb Collaboration

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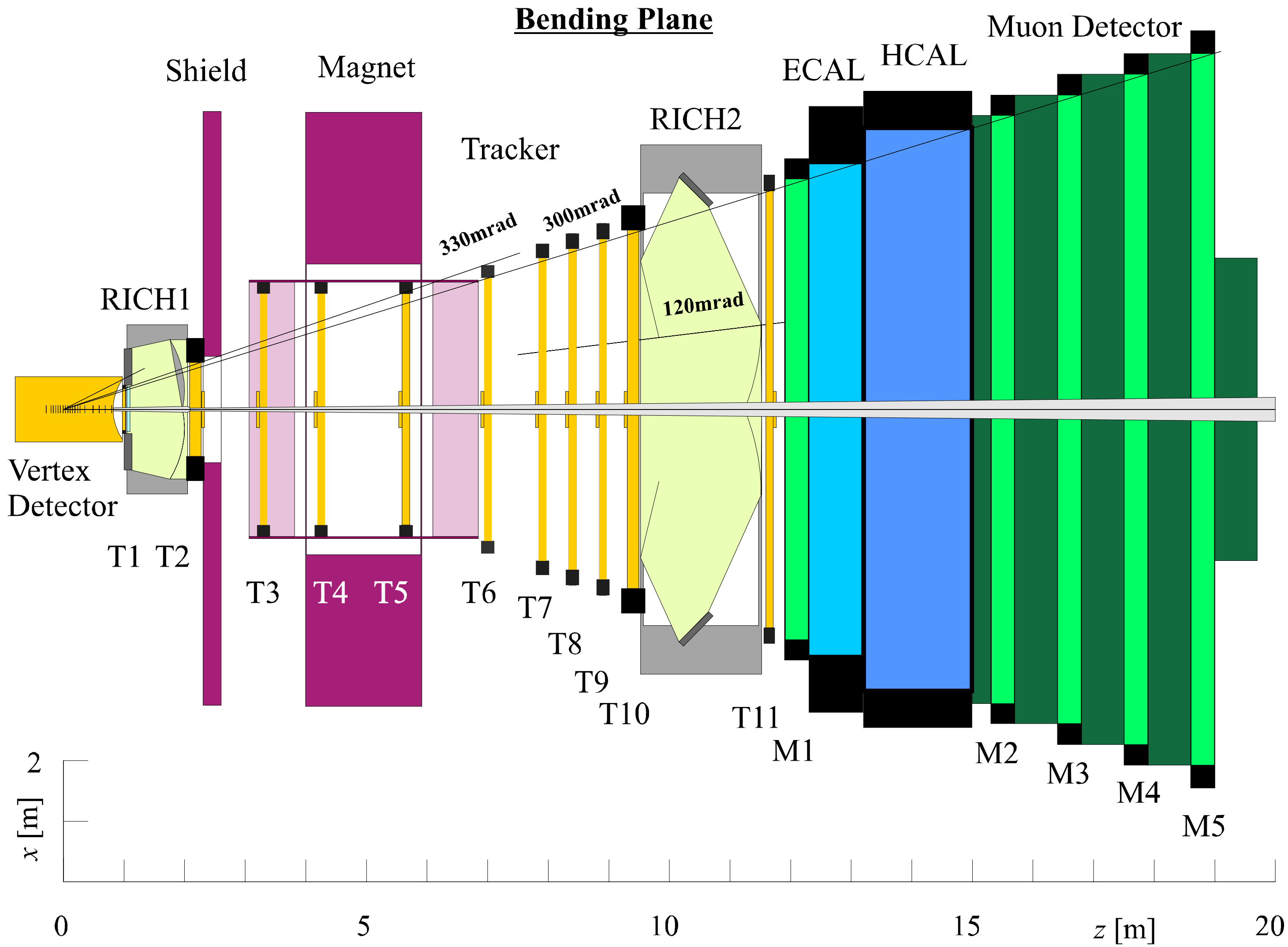
LHCb: Physics Goals

- LHCb is a dedicated experiment at LHC collider for precision measurements of CP-violation and rare decays
  - CP violation currently observed in kaon decays is consistent with Standard Model, but cannot exclude that CP violation is partly or even entirely due to new physics.
  - Cosmology (baryon genesis) suggests that an additional source of CP violation other than the Standard Model is needed.
- LHC is an ideal place to produce lots of B_d and B_s
- All interesting decay channels have 10^{-5} visible branching fractions.

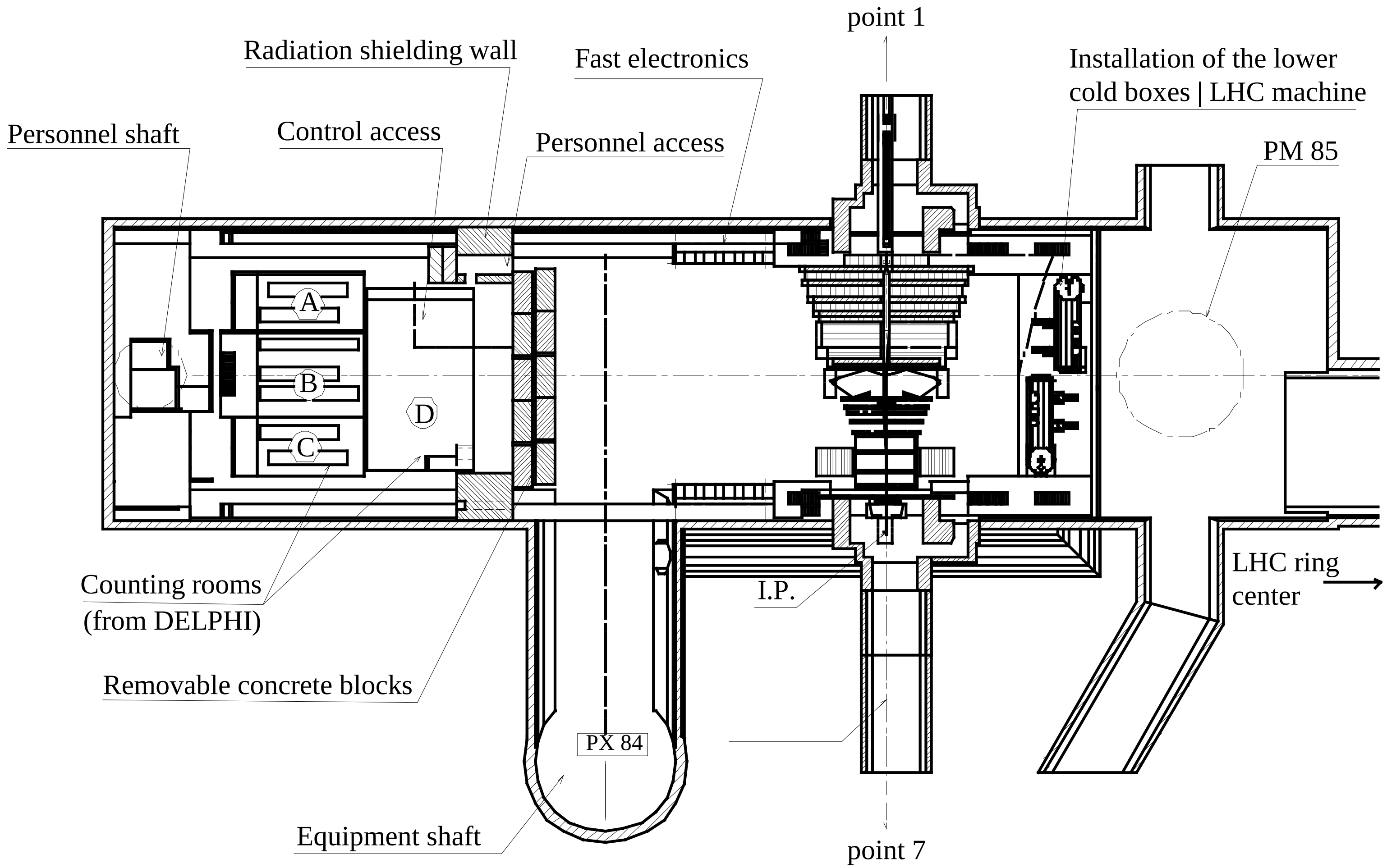
LHCb: The Detector



LHCb: The Detector

- Single-arm spectrometer with forward angular coverage from ~10 mrad to ~300(250) mrad.
  - Vertex detector
    - » Si r-ϕ strip detector, single-sided 150 μm
  - Tracking system
    - » Outer: drift chamber honeycomb. Inner: MSGC with GEM or MCSC
  - RICH system
    - » RICH1: Aerogel + C_4F_{10}. RICH2: CF_4
  - Calorimeter system
    - » Preshower: single layer Pb/Si. ECAL: Shashilik. HCAL: Atlas Tile Cal.
  - Muon system
    - » Multi-gap RPC and CPC

Experimental Zone

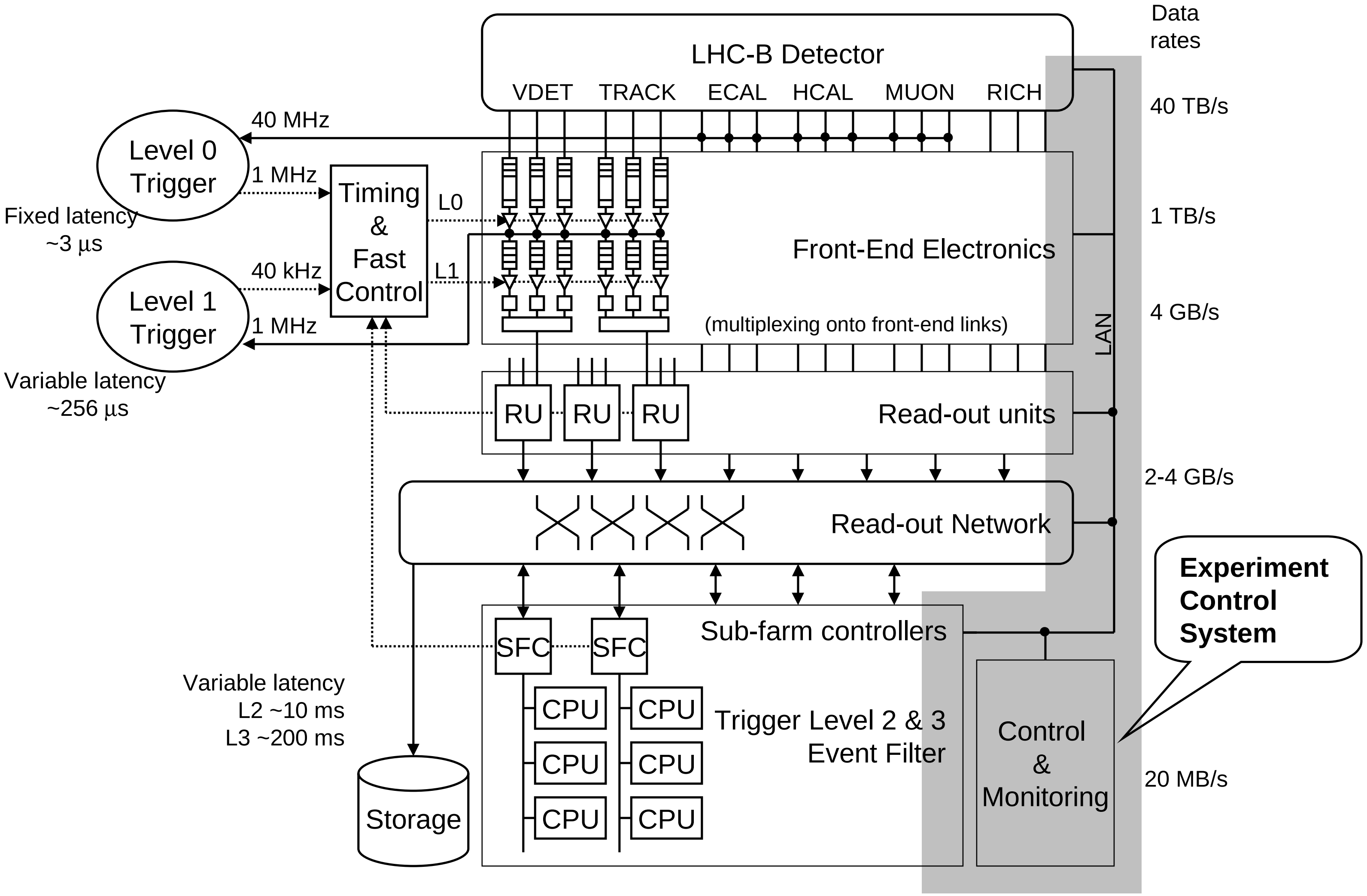


LHCb in numbers

- Collaboration: 42 Institutes, 336 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: 70 kB/event. 2-4 GB/s →20 MB/s. 1.5 10^6 MIPs
- Status of the Experiment:
  - Feb 98 Technical Proposal submitted
  - We hope Jul 98 recommendation by LHCC and Sep 98 approval by Research Board.

➔ LHCb is a smaller and newer collaboration than ATLAS or CMS. Comparable to the size of a LEP experiment. Less advanced (TP now, TDRs by 2000). But, it needs to be ready at the same time.

LHCb: Trigger & DAQ system



Requirements

The Experiment Control System

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

General System Requirements

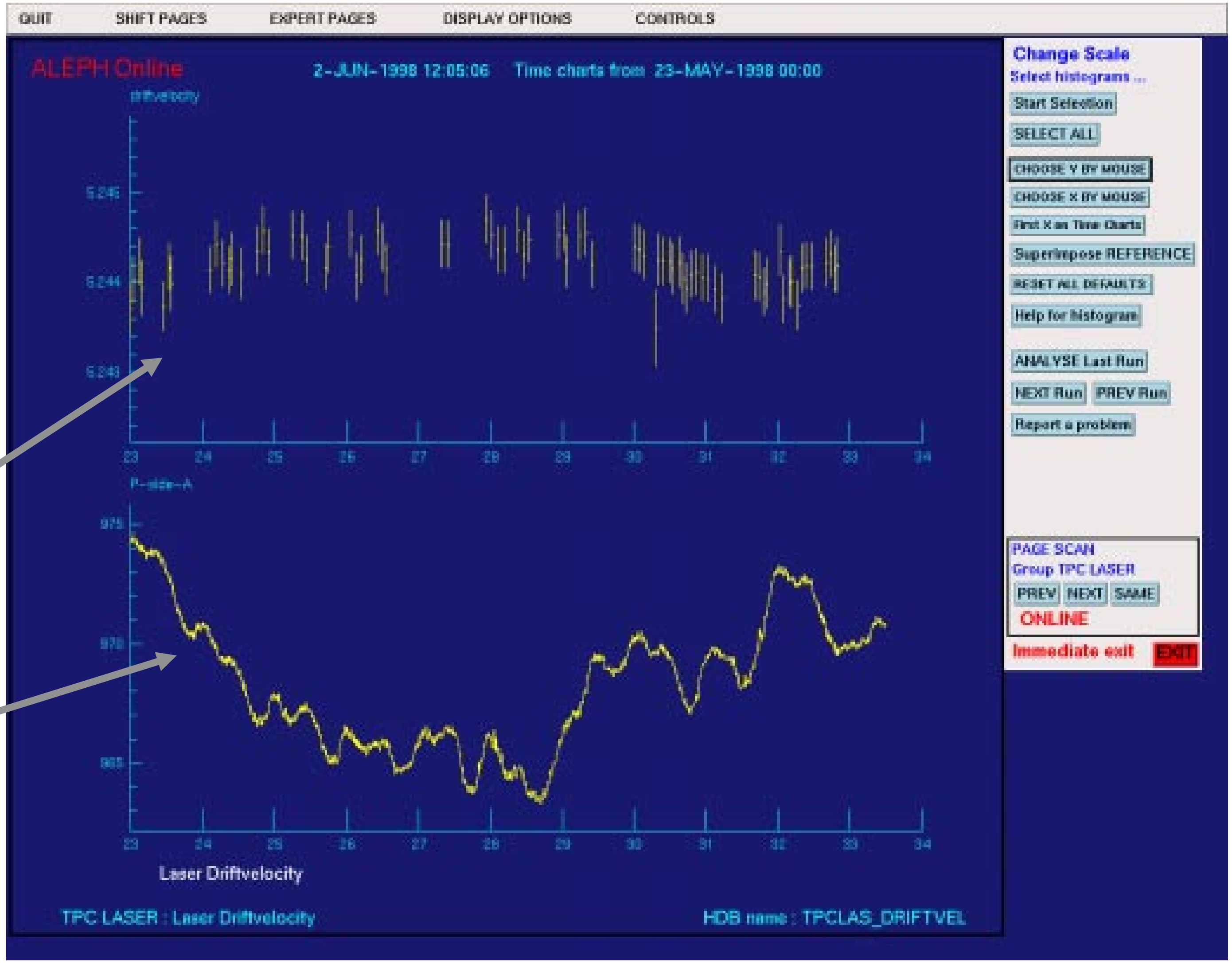
- Common control services across experiment:
  - Distributed information system. Control data archival and retrieval.
  - System configuration services. Coherent information in database.
  - Error reporting and alarm handling.
  - Data presentation: Status displays, trending tools, etc.
  - Expert System to assist shift crew.
- Objectives
  - Easy to operate: 2-3 people to run the complete experiment.
  - Easy to adapt to new conditions and requirements.
- Integration of DCS with the control of DAQ and Data Quality.

Integrated System: Example (a)

- ALEPH Presenter

DAQ

Slow Control



Integrated System: Example (b)

- ALEPH Error Logger
  - The operator running the experiment needs only to interact with a single error display to deal with all problems.

ALEPH error logger, ERRORS + MONITOR + ALARM

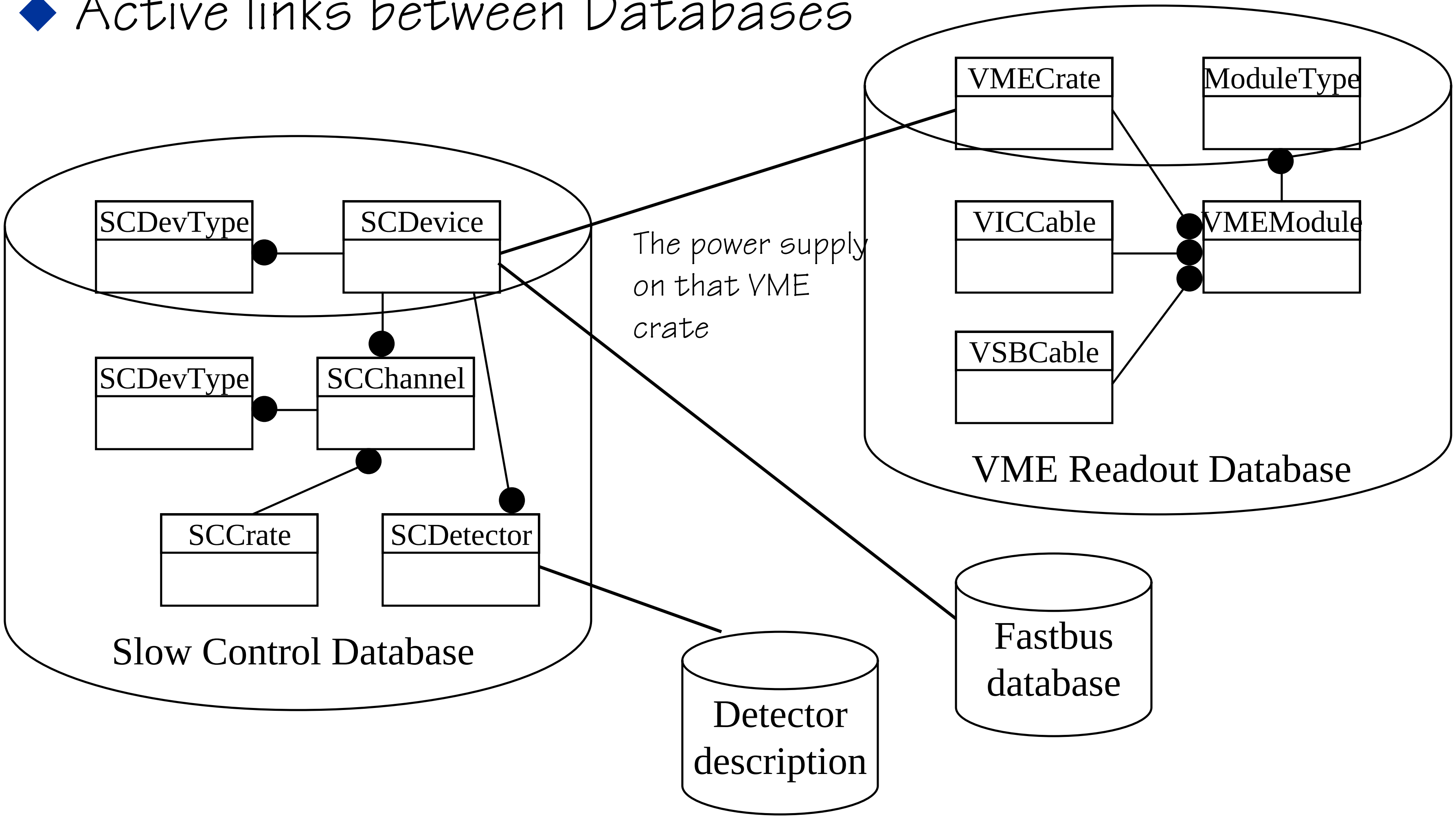
DAQ →

```
2-JUN 11:30 ALEP R_ALEP_0 RUNC_DAQ     ALEPH>> DAQ Error
2-JUN 11:30 ALEP TPEBAL   MISS_SOURCE  TPRP13 <1_missing_Source(s)>
2-JUN 11:30 ALEP TS       TRIGGERERROR Trigger protocol error(TMO_Wait_No_Busy)
2-JUN 11:30 TPC  SLOWCNTR SECTR_VME    VME CRATE fault in: SideA Low
```

Slow Control →

Integrated System: Example (c)

- Active links between Databases



Integrated System

- Different components which can communicate easily with each other by sharing services. (example: MS Office)
- Integrated ≠ Monolithic
- Advantages:
  - Same look-and-feel in all applications. Easier to learn.
  - Re-use. Better quality and easy maintenance.
  - Facilitates trouble-shooting.

System partitioning

- We would like to build a single control system which can be partitioned instead of building n independent systems.
- Partitioning would allow:
  - Independent development of the controls for the sub-systems or sub-detectors and later integration.
  - Allow various sub-detectors to run independently and concurrently while minimizing possible interference (test, commissioning, calibration, etc.)

Specific Requirements

- Detector Control

	GAS	HV	LV	Align.	Calib.	Environ.
Vertex		✓	✓	✓		✓
Inner Tracking	✓	✓	✓	✓		✓
Outer Tracking	✓	✓	✓	✓		✓
RICH 1 & 2	✓	✓	✓	✓		✓
Preshower		✓	✓		✓	✓
ECAL		✓	✓		✓	✓
HCAL		✓	✓		✓	✓
Muon	✓	✓	✓	✓		✓
DAQ			✓			✓

- Infrastructure (cooling, ventilation, magnet, power, LHC...)
  - Monitoring and Error/Alarm handling.
- Front-end electronics
  - Configuration, parameter downloading (thresholds, gains, timing, operation mode, etc.)

Specific Requirements (2)

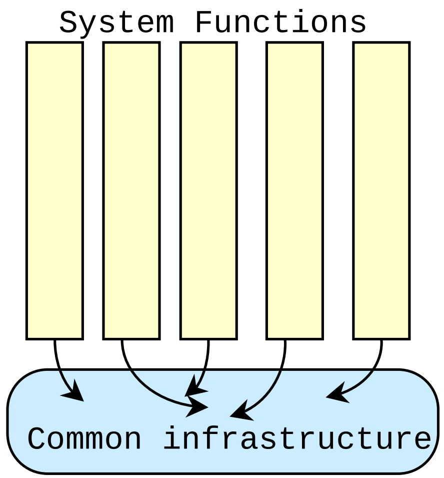
- Trigger system
  - Configuration: Program activation and parameter downloading.
  - Commands: Enable/disable.
  - Monitoring and Alarm handling.
- Read-out units and read-out network
  - Configuration: Network configuration, parameter downloading.
  - Run time backpressure (trigger throttle).
  - Monitoring and Alarm handling.
- Event Filter farm
  - Configuration: Program activation and parameter downloading.
  - Monitoring and Alarm handling.

Specific Requirements (3)

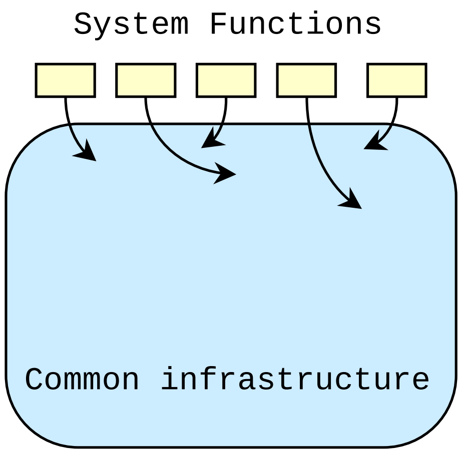
- Scale of the LHCb Control system
  - Detector Control: $O(10^5)$ parameters
  - FE electronics: Few parameters x 10^6 readout channels
  - Trigger & DAQ: $O(10^3)$ DAQ objects x $O(10^2)$ parameters
- Environmental constraints:
  - Radiation:
    - » $L = 2 \times 10^{32}$ $cm^{-2}s^{-1}$. At distance > 4 m (1krad in 10 years) standard electronics. Inside detector, radiation-hard or tolerant.
  - Accessibility:
    - » Open geometry. Easy access if LHC not running.

Architecture-driven

- We are convinced of the importance of having a good architecture:
  - Maximize common infrastructure, more re-usable components.
  - Technology changes. Evolution.
  - Better quality.
- Creation of a framework that satisfies all known hard requirements and is able to adapt to those requirements that are not yet known or well understood.



Requirement-driven project



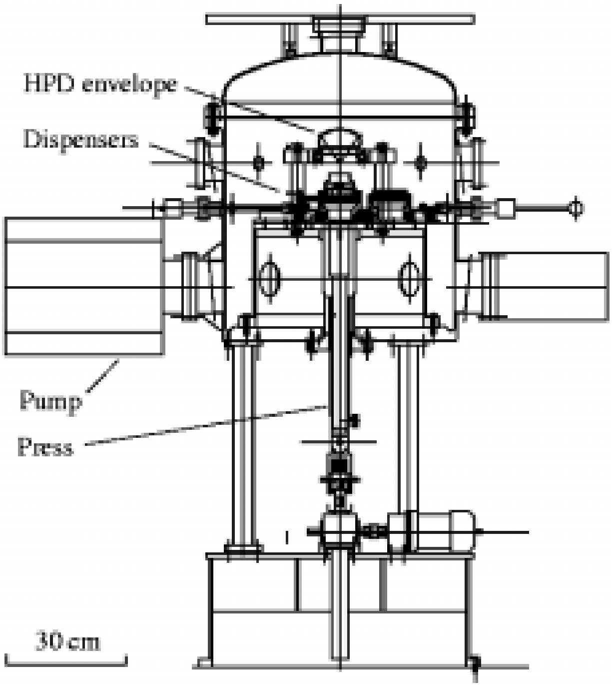
Architecture-driven project

Immediate needs

- We have and will have control needs in labs, test beams, production sites, etc.
  - We do not want to compromise the final system to satisfy the immediate needs.
  - Ad hoc and interim solutions will be provided. The requirements of these solutions are different from those of the final system.
  - A migration path from the interim solutions to the final system is envisaged.
- Current immediate needs:
  - Test beams: Not yet big enough to require a control system.
  - Laboratory: The Hybrid Photodiode (HPD) laboratory example.

Immediate needs: HPD Laboratory

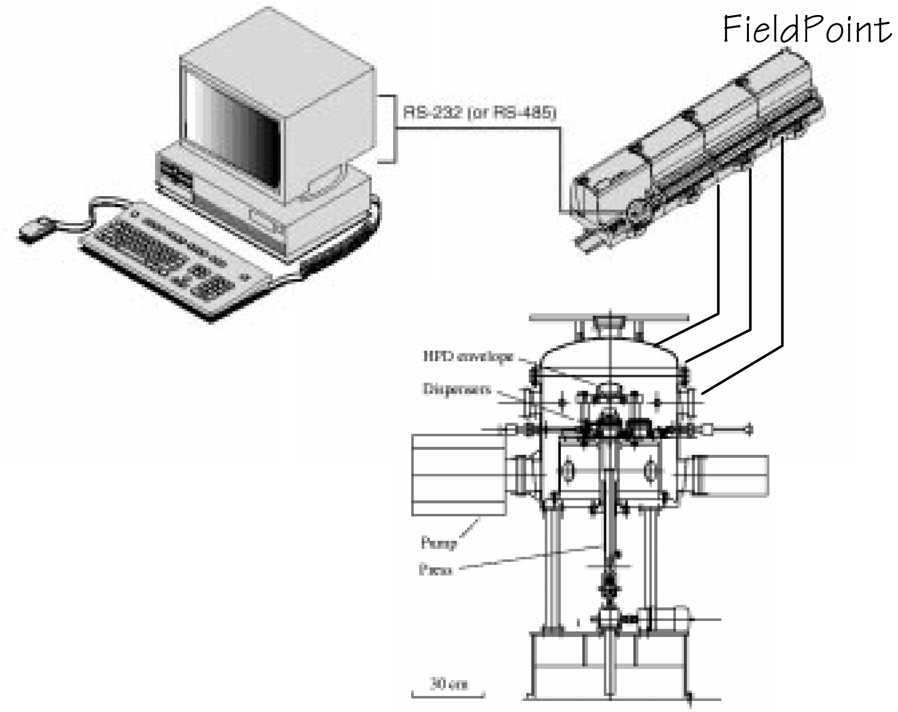
- HPD Photocathode Deposition (A. Go et al.)
  - To monitor and control photocathode deposition process for the fabrication of Hybrid Photodiodes.
  - Two monitor and DAQ rates:
    - » Slow Rate: During the vacuum bake-out process (~72hrs), the temperature and pressure of the deposition chamber are monitored.
    - » Fast Rate: During the deposition process (~20min.), the deposition current, substrate temperature and thickness are controlled. The photocathode current, temperature and pressure are monitored.
  - Control needs:
    - » 4 Output parameters (3 analog and 1 digital)
    - » 8 Input parameters (analog)



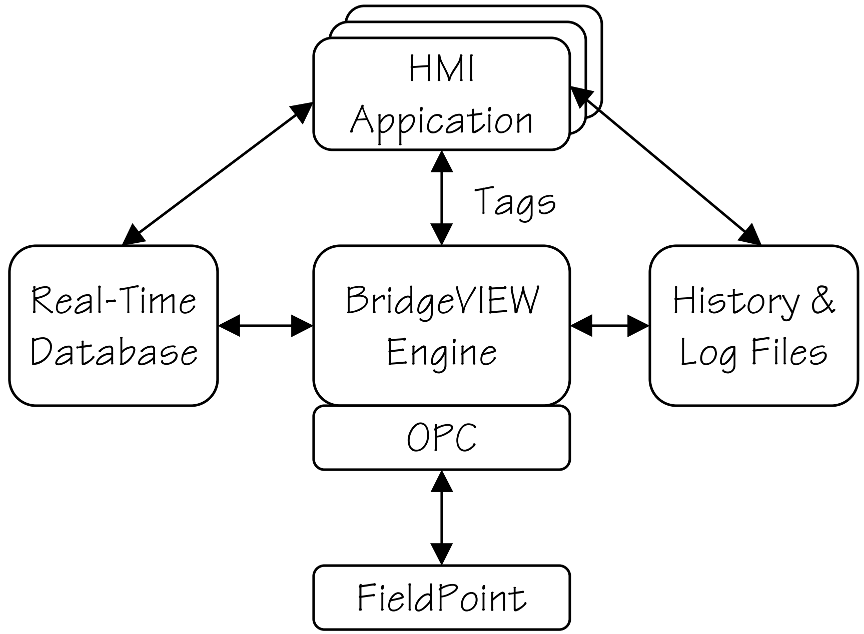
Immediate needs: HPD Laboratory (2)

Based on OPC server/client model:

- FieldPoint distributed I/O system connected to PC via RS-232 port.



- BridgeVIEW Process control software



OPC = OLE for Process Control

Project Organization and Planning

Project Organization

- The LHCb Controls Project is part of the overall Computing Project which includes the on-line and off-line computing activities and covers both hardware and software.
- A dedicated team will be responsible for the LHCb common control infrastructure. The sub-detector teams will be in charge of adapting/developing sub-detector specific applications.
- Active participation in the LHC Joint Controls Project. We relay heavily on the positive outcome.

Project Organization (2)

Steering Group

- Coordination, Planning, Resources

Computing Facilities

- Farms
- Desktop
- Storage
- Network
- Operating System

Recon-struction

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

Analysis

- Framewk
- Tools

Simulation

- GEANT4 Framewk
- Tools
- Production

DAQ

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

Controls

- DCS
- LHC
- Safety
- Run Control

Control Room

- Operations
- Consoles
- Shift Crew Enviroment

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

Software Engineering Group

- Methods
- Tools
- Code Management
- Quality
- Document.
- Training
- Licenses
- Collab. Tools

Project Planning

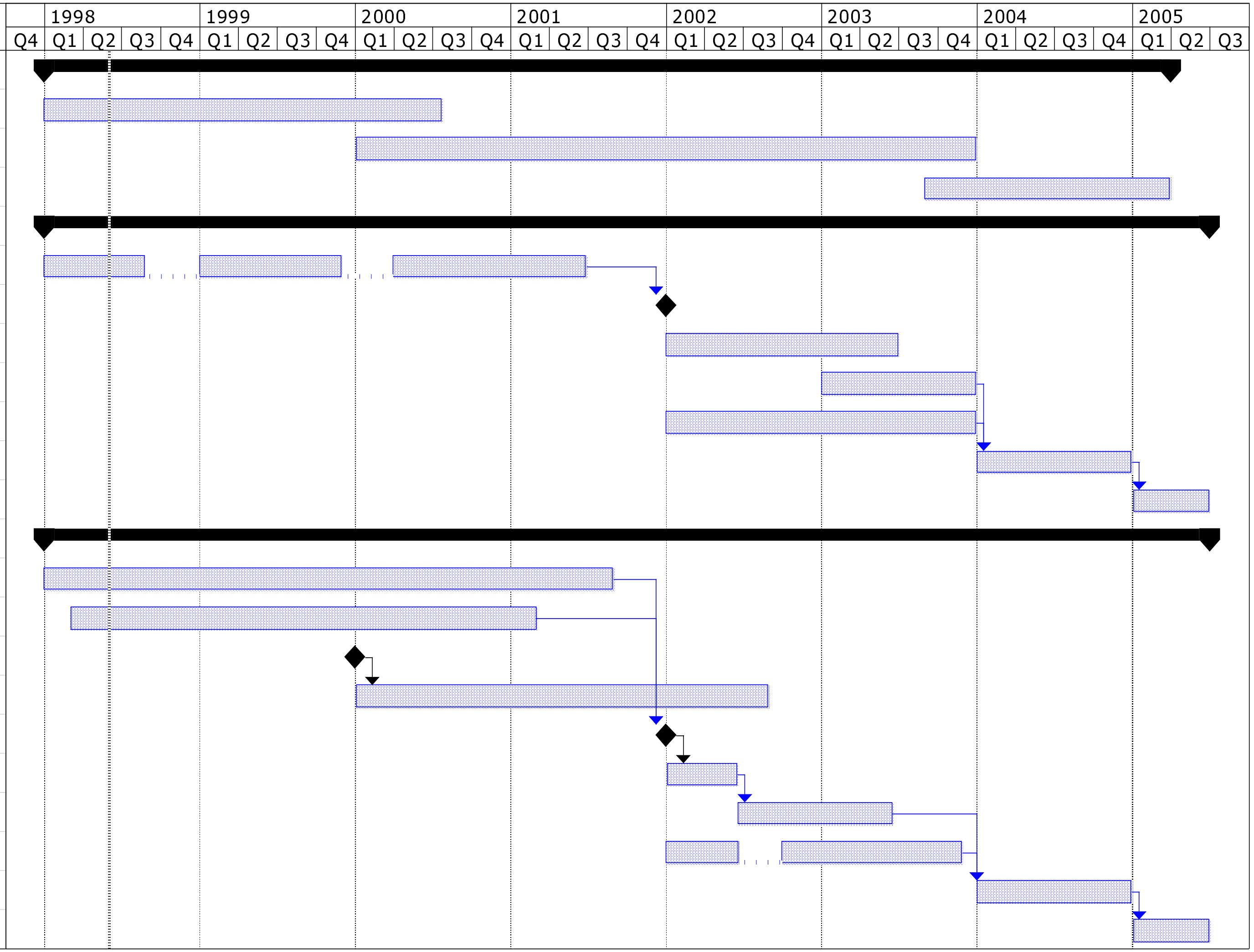
- Main Milestones:
  - Choice of technology for the hardware interfaces: Jan 2000
  - Choice of final product/technology: Jan 2002
  - Installation/integration & commissioning during 2004
  - Operational system in 2005
- From now to Jan 2002
  - Understanding requirements. Architecture design.
  - Coordination.
  - Evaluations of products and technologies.
  - R&D. Prototypes. Interim solutions.

Evaluations, Prototypes and R&D

- Gathering knowledge for final product/technology choice.
- Activities which are interesting from our point of view:
  - Field buses: Understanding them. Hands-on practice. Limitations. Software protocols. Hardware interfaces.
  - PLCs: Understanding them. Hands-on practice. Limitations.
  - OPC standard: Understanding the standard. Test various configurations. Survey market.
  - Integration technologies: Understanding them. Building systems out of software components (componentware). Prototypes.

Project Planning (2)

ID	Task Name
1	**Detectors**
2	R&D and prototypes
3	Construction
4	Installation
5	**DAQ system**
6	Architecture/Protocols/R&D
7	Technology choices
8	Hardware Development
9	Production/Purchase
10	Software Development
11	System Installation/Integration/test
12	LHCb startup
13	**Control system (DCS)**
14	UR (sub-detectors, hall infrastructure)
15	Architecture/Evaluations/R&D
16	Interface technology recommendations
17	Interim development/Test beams/Production
18	Final Technology/Product choice
19	Purchase
20	Common infrastructure development
21	Subdetector systems development
22	System Installation/Integration
23	LHCb startup



Conclusions

- We try to apply lessons learned from LEP experiments.
  - Global computing approach (reduce on-line & off-line barriers)
  - Promote re-usable components which provide services across applications.
  - Integrated Experiment Control System.
  - Avoid duplication inside same experiment.
- The diversity in control entities in LHCb is similar to other LHC experiments. Therefore, equivalent complexity.
- We are in an R&D phase for the next 2 years.
- LHCb is fully committed to the LHC Joint Controls Project.