Minutes of LHC-CP Link Meeting 9

Subject	:	LHC Controls Project	
Date	:	06 February, 2001	
Place	:	6-2-004	
Participating Groups	:	EST-ISS	Apologies
		LHC-ACR	Apologies
		LHC-ECR	No representative
		LHC-IAS	No representative
		LHC-ICP	Apologies
		LHC-MMS	Wolf, R.
		LHC-MTA	Apologies
		LHC-VAC	Gavaggio, R.
		PS-CO	Serrano J., replacing Di Maio, F.
		SL-AP	Jeanneret, B, replacing Brüning, O.
		SL-BI	Jensen, Lars replacing Gras, J-J.
		SL-BT	Carlier, E.
		SL-CO	Bland, A.
		SL-HRF	Ciapala, E.
		SL-MR	Billen, R.
		SL-MS	No representative
		SL-OP	Lamont, M.
		SL-PO	King, Q.
		ST-MO	No representative
Sub-Project Leaders	:	Alarms	Tyrrell, M.
		LAWG	Lamont, M.
		Components	Apologies
Others	:	Lauckner, R. (chair)	
		Vanden Eynden, M. (Core Team)	
		Mess, K. H..replacing Schmidt, R. (Machine Protection)	
Distribution	:	Via LHC-CP website: **http://cern.ch/lhc-cp**	
		Notification via: **lhc-cp-info@lcern.ch**	

Agenda :

1. Minutes from previous meeting
2. LHC-CP News — R. Lauckner
3. The PS/SPS NAOS System — J. Serrano
4. What data is required to understand failures during LHC operation? — R.Lauckner
5. EDMS Tree for Project Documentation — M. Vanden Eynden
6. AOB

1. Minutes from Previous Meeting

Q. King had contacted K. Kostro to follow up on Middleware Services and Power Converter requirements. He reported that this interface still needed clarification and suggested that String 2 could be used as a test bed for the new Middleware targeting mid 2002.

2. LHC-CP News **R. Lauckner**

R. Lauckner reminded the meeting that the 2nd LHC-CP Workshop will take place on 5/6 April. The program is being clarified but will include progress reports on the goals set last year. Special subjects to be treated this year are being collected and link men should forward suggestions to RL in the next days.

ACTION : all link men

R. Lauckner has discussed progress on SCADA with C.-H. Sicard (representing the LHC-CP in the CERN Working Group), U. Epting (reporting on TCR tests of PVSS) and P. Gayet (chairing the Components Working Group). WinCC has been added to the list of existing systems and it was agreed that the CERN Working Group should be asked to consider what engineering practices should be adhered to in the absence of standards for SCADA.

The Components Working Group had held it's first meeting before Christmas. A review of process control architectures has been initiated. The minutes should be attached to the LHC-CP web site.

ACTION: P. Gayet & N. Boimond

A Controls Board meeting had taken place. The board has decided that CERN contributions to ICALEPCS should be coordinated so that review papers can be added as required and authors presenting contradictory reports can be asked to take contact with each other before the conference.

The schedule and main topics for the next LHC-CP meetings are:

20 Feb	ALARM Sub-Project Report	M. Tyrrell	936 Conference Room
13 Mar	LAWG Sub-Project report	M. Lamont	936 Conference Room
27 Mar	COMPONENTSSub-Project Report	P. Gayet	30-7-012

3. The New Analogue Acquisition System **J. Serrano**

J. Serrano presented the NAOS system (see attached slides) presently deployed in PS and SPS for general purpose digital acquisition and display of signals. He outlined the hardware and software extensions of VME which are defined by the VME eXtension for Instrumentation standard (VXI). This has been used as the hardware bus for the system which collects around 1500 analogue signals in the PS and about 100 signals in the SPS. The PS system employs a large number of dedicated cables as triggers, this part of the system was modified for SPS use where accelerator timing receivers, TG8s are used to generate triggers.

He is currently replacing the VXWorks CPU card with a PowerPC card running LynxOS. This is the first of 3 steps representing possible evolutions for this system. In a second step the current triggering system used in the PS system, which is not scaleable, could be replaced. He is studying a trigger distribution based on optical fibres. The LHC TCC system has been considered but appears too 'heavy'. The TG8 triggers have a jitter of about 500ns while PS requires about 500ps jitter. A possible third step concerns the replacement of VXI, suppliers of the digital scopes have now stopped production.

In future he aims to decouple the 3 basic blocks of the system: trigger, acquisition, and MMI. The final element is based on Motif today and represents a large investment and maintenance burden. Commercial solutions here would be very attractive if available.

E. Ciapala pointed out that PXI and Windows NT is an obvious direction for these systems.

K. H. Mess commented that work at HERA B might be a suitable solution for low jitter triggering.

4. What data is required to understand failures during LHC operation?

R. Lauckner

R. Lauckner reported that a series of meetings had taken place last Autumn to clarify the Post Mortem needs of the LHC involving R. Schmidt, K. H. Mess, J. Wenninger and R. Saban. The work had been reported and written up for the Chamonix workshop.

He explained (see attached slides) that the main motivation behind the Post Mortem is to improve operational efficiency. Rapid diagnostics for operators and the longer term improvement in the methods of operating the machine are important goals. It will be crucial to monitor the operation of the protection systems of the machine and very desirable to be able to provide an explanation if damage occurs.

The ingredients for such a system are:

- A common clock
- Data acquisition equipment
- Common data representation
- Specific and generic Analysis tools
- Efficient data management for alarms, logging, transient recorders and machine settings information.

He outlined a list of information that would be required for the Control Room. Systems break down into services, protection systems, systems that act on the beam and monitors. The protection systems must all be self triggering and must be able to acquire whenever they act, even if this follows a Post Mortem Trigger. Post Mortem data will additionally be required at the experts level to diagnose internal equipment faults.

Analysis of data would in the first instance use the standard application software for understanding machine behaviour. In the case of tougher problems generic analysis techniques would be necessary. These would rely on an agreed method of representing data as well as a common clock. Correlation plots and event sequences could be used to browse data. However there is potentially a large amount of information to search so data reduction and searching techniques will be required.

Work is need now to complete the lists of signals, recording frequencies and depths. Hardware boxes and software interfaces also need study.

Q. King commented that it is better to talk of recording periods and not frequencies to avoid rounding errors.

B. Jeanneret commented that the ionisation monitors on the collimators would be a suitable signal for machine protection and should be acquired for Post Mortem purposes.

E. Carlier asked what degree of reliability needed to be achieved, R. Lauckner replied that this point was still open but reliability should be very high for protection equipment.

The availability of a common clock for all systems has to be followed up with G. Beetham.

5. EDMS Tree for Project Documentation M. Vanden Eynden

M. Vanden Eynden remarked that several participating groups had already defined data trees in EDMS. Nevertheless he proposed (see attached slide and Excel chart) a set of Quality Assurance tools, documentation to described project tools and policies and project documentation structures. These would simply be links to the group sub-trees where appropriate.

Some standard LHC templates were suitable for the project e.g. functional specifications. However some templates were missing such as Use Case capture and software user manuals.

Link men are asked to study the proposal from M. Vanden Eynden and provide him feedback on the structure before the next meeting. They should also present references to information to be catalogued.

ACTION: All

M. Tyrrell asked if training was available for the system . MVDE said his experience so far indicated this was not essential however certain access permissions needed establishing. He invited people about to prepare functional specifications to contact him.

M. Tyrrell also asked where he could access the project planning information. RL said this is currently being compiled, first information on this would be reported at the April workshop.

6. AOB

There was no further business.

Actions	**People**
Establish Real-time sub-projects.	R Lauckner
Set up the LHC Controls Engineering data tree in EDMS	M. Vanden Eynden

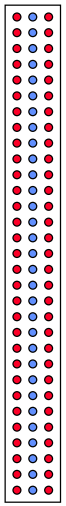
A brief introduction to nAos:

The “new” Analog observation system

Javier Serrano
CERN PS-CO Group - February 2001

Introducing the VXI Bus

On the hardware side

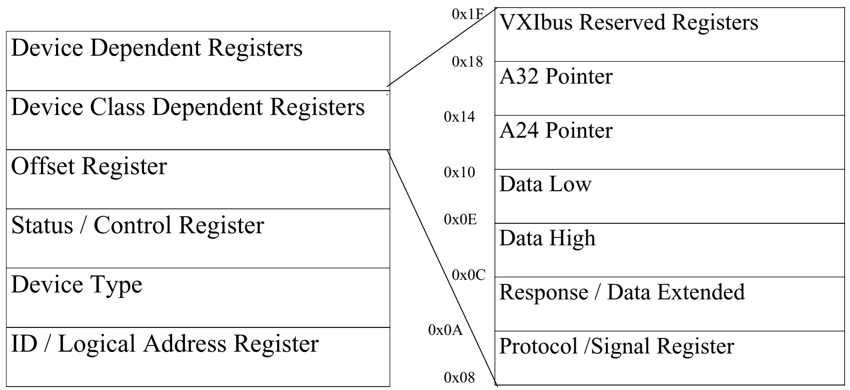


The two outer columns of the P2 connector are undefined in VME. In the VXIbus standard, they include:

- A very stable 10 MHz ECL clock
- ECL and analog supply voltages
- ECL & TTL trigger lines
- An analog summing bus
- The module identification bus
- The local bus (daisy chain structure)

VME/VXI P2 connector

On the software side: VXI Configuration Registers

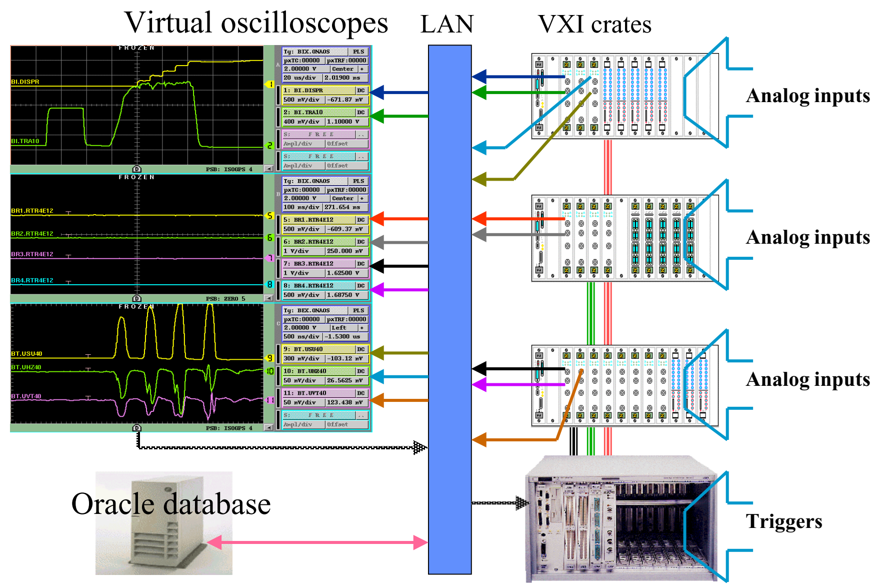


This holds for every VXI device

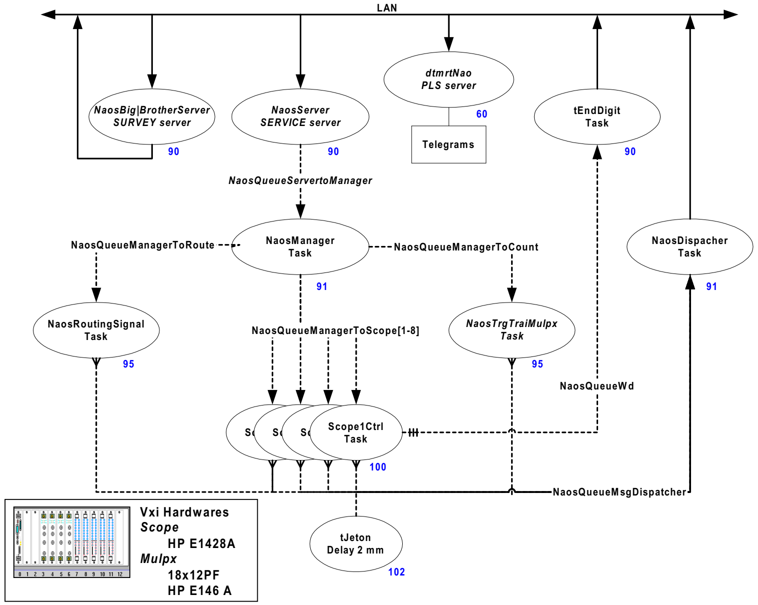
Message-based device

A brief introduction to nAos

The topology



A detailed view of the software



Where we want to go now...

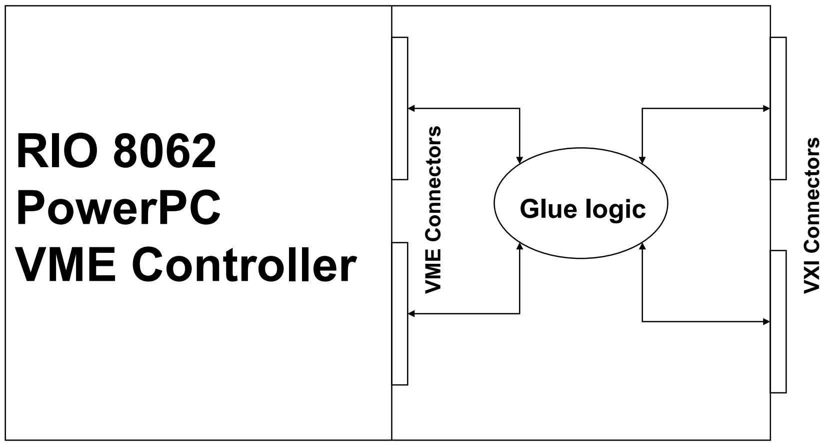
Unfortunately, VXI is almost dead!

- HP and Tektronix stopped production of scopes this year.
- A growing number of users need higher sampling rates and turn to GPIB-based scopes.
- The only crate-based alternative currently available is CompactPCI.
- An open system encompassing industrial PCs, GPIB, compactPCI, and any other standard seems inevitable...

A prioritized list of items

- Make nAos work under LynxOS
- Give users raw access to VXI via a library of C functions (thanks Alain!)
- Split nAos into independent modules to make debugging easier... and assign responsibilities!
- Take advantage of the Middleware Project when its results become available.
- Provide a uniform approach for analog signal acquisition. This one needs further explanation...

Hytec Electronics' VVA4032



The OASIS "concept"

Open
Analog
Signals
Information
System

Operators should be able to build modular solutions for their analog signal acquisition problems.

By providing an open infrastructure with entry points at different levels, OASIS is aimed at saving money and time.

The hot areas for brainstorming are those concerned with synchronization and the coherence of distant acquisitions.

Conclusions

- The nAos application is much appreciated by operators but it needs to become modular to be maintainable.
- Of course an extensive survey is being conducted among our “clients”, i.e. the OP group.
- Once the new system is stable, we can aim at higher goals. A general approach for analog signal acquisition and processing is the next logical step.
- In any case, a good trigger production and distribution system is a prerequisite for success.

What Data Is Required to Understand Failures During LHC Operation?

R. J. Lauckner

What Data is Required to Understand Failures during LHC Operation?

- Purpose of Post Mortem
- Ingredients
- **Data to be Recorded**
- Analysis Tools
- Conclusions

Purpose of Post Mortem

- To improve the operational efficiency of the LHC
  - Provide diagnostics of "incidents" for Control Room. The aim is to quickly identify the origin of failures in order to initiate appropriate actions and restore operation
  - Build long term understanding of accelerator operation. By collecting and managing the hardware and beam performance data
- Ensure comprehensive monitoring of quench detection, machine protection and beam dumping systems
- If damage occurs, to explain the mechanism

To achieve these aims the post mortem data must be *complete* and *coherent* across systems

What is an "Incident"?

- The loss of the Beam Permit Condition ➜ Beam Abort
- The loss of the Power Permit Condition ➜ Power Abort

  Post mortem: diagnose the cause of failure, monitor abort systems
- An unexpected loss of beam
- Other mysterious events

  Post mortem: diagnose the cause of failure

Ingredients

- A common clock to time stamp all data
- Data acquisition hardware
- A trigger to
  - initiate post trigger recordings
  - freeze circular buffers,
  - initiate transfer of the data to the Control Room
- Specific software to analyse system performance
- Connectivity to Logging and Alarm Data
- A common data representation
- Generic tools to access and compare information from all systems

Summary of PCR Post Mortem Data Requirements

System	Transient Recorder	Logging	Alarms	External Trigger	Internal Trigger	Commission Date	
Access System	×	✓	✓	×	×	Sector	
Cooling and Ventilation	×	✓	✓	×	×	Sector	Services
Cryogenics	×	✓	✓	×	×	Sector	
Electrical Network	✓	×	✓	?	×	Sector	
Beam Dump	✓	×	✓	?	✓	Beam	
Beam Loss Monitors	✓	✓	✓	✓	✓	Sector	
Energy Extraction Switches	✓	✓	✓	?	✓	Sector	Protection
Machine Protection	?	✓	✓	×	✓	Sector	
Quench Protection	✓	✓	✓	?	✓	Sector	
Aperture Kickers	✓	×	✓	✓	×	Beam	
Beam Feedback Systems	✓	?	✓	✓	×	Beam	
Collimators	?	✓	✓	?	×	Sector	
Inflector	✓	×	✓	✓	×	Sector	Act on Beam
Power Converters	✓	✓	✓	✓	×	Sector	
RF Power & Low-Level	✓	✓	✓	✓	×	Beam	
Reference Magnet Signals	✓	?	✓	✓	×	Sector	
Transverse Dampers	✓	×	✓	✓	×	Beam	
Vacuum	×	✓	✓	×	×	Sector	
Beam Current Monitors	✓	✓	✓	✓	×	Beam	
Beam Position Monitors	✓	✓	✓	✓	×	Sector	Monitors
Beam Profile Monitors	✓	✓	✓	✓	×	Beam	
Cryostat Instrumentation	?	✓	✓	?	×	Sector	

Explanations

Transient	System required to record fast signals and freeze on trigger
Logging	System required to continuously (on time or on change) record slow or infrequent changes
Alarms	System required to send fault events to the Central Alarm Server, (CAS).
External Trigger	System required to respond to general PM trigger
Internal Trigger	System required to autonomously record all protection actions
Date	Operational for Sector Test or Beam Commissioning

Services Data

Access System Status changes of access chains to be logged.

Cooling and Ventilation Air temperatures in all equipment areas and cooling circuit flows and temperatures to be logged. Expect that the supervisor will extensively log the operational parameters.

Cryogenics Extensive logging of the operational parameters

Electrical Network Transient recording to detect spikes or drops

Safety Systems, Fire, Gas, Red Telephones. Alarms to CAS

Post Mortem ready for Sector Test.

Protection Systems

The correct functioning of all these systems is required to ensure proper protection of equipment.

Beam Dumping System This includes kicker systems, magnets and converters and the absorber block. Transient recordings of the circulating beam, extracted beam, the extraction kick, and profiles to demonstrate correct extraction and dumping are required.

Beam Loss Monitors They are included here as a critical part of the machine protection system, their status should be logged. Beam loss information should be recorded at 100 Hz, depth 20s

Energy Extraction Switches Log status of all switches. Transient recordings of discharge voltages, temperatures and status

Machine Protection Comprehensive status logging.

Quench Protection Transients of active voltage taps and heater systems. Comprehensive status logging.

Systems that act on Beam

Aperture Kickers Transient recording of all discharges

Global Feedback Systems All sensors and actuators should be equipped with a recorders

Collimators Logging of all movements and status

Inflector Transient recording of discharges

Power Converters Transient recording of currents including long decays during energy extraction, recording of the real time input channel, logging of status

RF Power & Low Level Interlocks recorded à la LEP. Transient recording of beam in kicker gap, BI should build the monitor! and of the radial position. The group is considering acquiring many fast signals.

Systems that act on Beam

Reference Magnet Systems Transient recordings of measured and predicted multipoles, recording of the measurement coil signal and a comparison with an independent measurement (hot spare reference?)

Transverse Dampers A recording of the damping of each injection and the wideband pickups around T_0 to check beam stability

Vacuum Logging of status of all valves and pumps. Slow logging of pressures.

Monitors

Beam Current Monitors transient recorders to record bunch intensities and total intensities around T_0

Beam Position Monitors transient recorders for 1000 turn data and closed orbits around T_0

Beam Profile Monitors Transverse profiles before and after T_0. A comparison with earlier performance, possibly from a log.

Cryostat Information All temperatures and pressures to be logged. Bandwidth of the system planned is 1 – 0.1 Hz, String 1 kHz! Status of valves and heaters in the cryostat to be logged.

Some Data Volumes

Cryogenic plant buffering ~ 20000 channels at 0.1 - 1 Hz for 1 hour ~ 1 x 10^7 values. reduction: log on change

Fast kickers 50 channels * 500 MHz * 100µs = 2.5 x 10^6 values

Beam Loss 2000 channels * 100 Hz * 20s = 4 x 10^6 values

Beam Position 2000 channels * 1000 T = 2 x 10^6 values

Quench Protection 10000 channels * 100 Hz * 6s = 6 x 10^6 values, reduction: internal trigger only.

1500 Converters * 2 DCCTs * 1 kHz * 40s = 1 x 10^8! values, reduction: f ↓

Dampers 68 channels * 40 Mhz * 1000 T = 3 x 10^8! values, reduction!

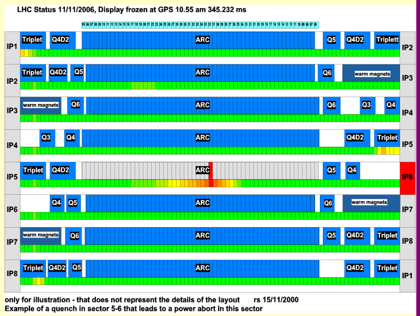
RF System ~ 50 channels * 10000 T = 5 x 10^6 values

A Unique Clock!

- Analysis DEMANDS single clock
- TIM WG has recommended UTC
- It does not include LOCAL TIME
- It does not include DAYLIGHT SAVING
- This is not GPS time Systems that act on Beam
- It does include LEAP SECONDS

Many phenomena are "slow" and do not require highly precise time stamping. Should all systems intercept and time stamp post mortem trigger?

System Analysis



First level analysis must be with system specific tools

These must integrate into PM data management and archiving system

Generic Analysis

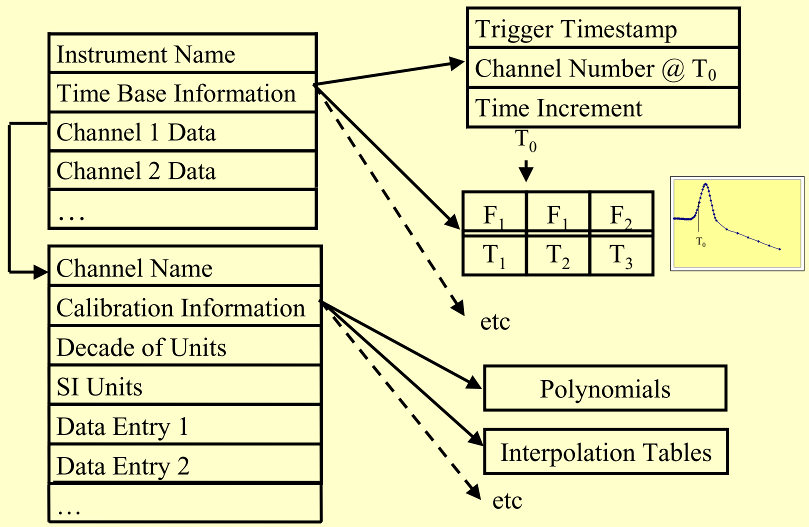
- This combines information from different systems
- Must have same clock
- Must be able to interpret the information
- Closely coupled to the Alarm and Logging Systems

Data Representation

Experts from CERN strings and HERA recommend:

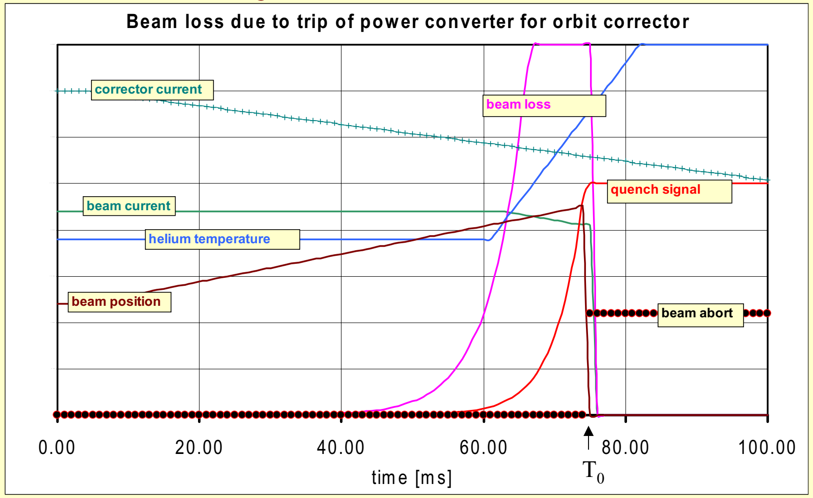
- Data sets must be self-describing
- A data set must only contain data from 1 sensor
- A sensor may only have 1 time base but it may have several channels
- Data will be in ASCII!

Data Representation



Generic Analysis

Correlation Plot, ® Rüdiger S



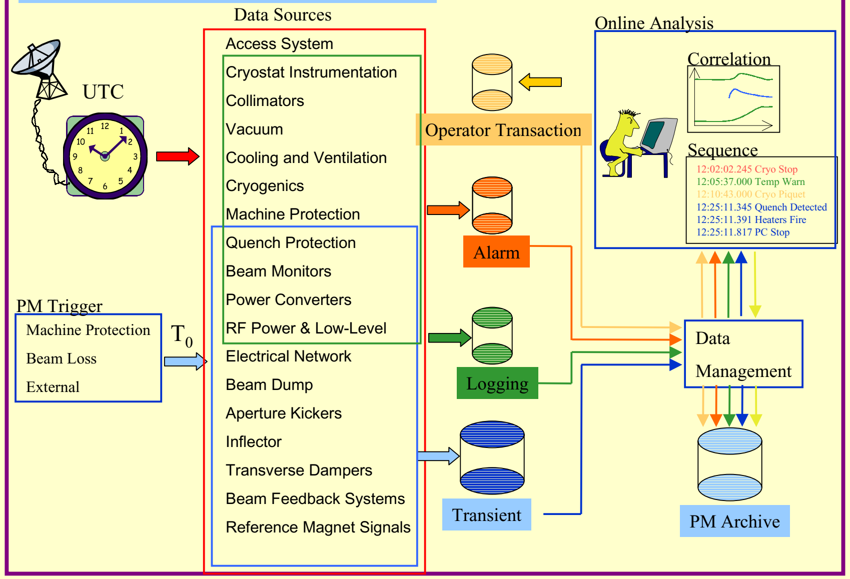
Generic Analysis

Event Sequence

Date	Time	System	Identifier	Event
14/2	03:10:24.530	Quench Detection	MBB.B18.L2	Quench
14/2	03:10:24.531	Quench Detection	MBB.B18.L2	Heaters Fire
14/2	03:10:24.535	Machine Protection	Arc L2	Critical C Fault
14/2	03:10:24.535	Machine Protection	Arc L2	Cryo Power Abort
14/2	03:10:24.535317	Kickers	Beam Dump	Both rings aborted
14/2	03:10:24.535317	Post Mortem	Trigger	Freeze
14/2	03:10:24:545	Kicker	MKP Ring 1	On standby
14/2	03:10:24.560	Converters	RB.A12.UA23	Switch Open Req
14/2	03:10:24.570	Beam Loss	Arc R4	Warning Cleared
14/2	03:10:24.580	Energy Extraction	Arc L2	Opened
14/2	03:10:27.15	Cryostat Instrument	Arc L2	He Pressure High

Schematic! Combines Alarms and Logged Data

POST MORTEM SYSTEM OVERVIEW



Conclusions

- a single and unique clock to timestamp data
- coherent data representation and management
- the system will be in full use during hardware commissioning
- alarms, logging and post mortem closely linked
- work required to refine signal definition, recording frequencies and depths as well as to fix hardware (e.g. time stamping) and software (e.g. data formats) interfaces.

LHC-CP EDMS PROPOSAL

- **Provide a mechanism to handle LHC Controls related documents :**
  - provide a “pragmatic” set of Q&A practices compliant with the overall LHC project
  - provide support to the designers and developers for the specification of their systems (function, interface, design, user manual, troubleshooting, ...)
  - provide information about supported engineering tools and techniques (configuration management, OO A/D, graphics, ...)
  - provide information about policies and guidelines (operator console, control room software, ...)
  - provide a coherent way to document and validate designs and implementations

LHC-CP PROJECT MANAGEMENT

- Project Mandate
- Sub-projects Mandates
  - LHC Analysis Sub-project (LAWG)
  - LHC Alarm Sub-project
  - LHC Real Time Sub-project
  - LHC Industrial Components Sub-project
- Quality Assurance Principles and Guidelines
  - Naming Convention (HW and SW)
  - LHC-CP Document Templates
    - Operational Specification
      - Use Case Document
      - Trouble shooting Document
    - Engineering Specification
      - Functional Specification
      - Interface Specification
      - Design Specification
    - User Manual
      - Software User Manual

LHC-CP PROJECT PLANNING

- QRL Test
- Sector Test
- Commissioning for operation

SOFTWARE ENGINEERING TECHNIQUES, TOOLS AND SUPPORT

- Software Configuration and Management
  - The SCaMS System
  - Software User Manual
- Software Analysis and Design
  - Techniques
  - Supported Tools
    - Rational Rose
- Software Coding and GUI development
  - Standards
  - Supported Tools
    - Jbuilder
    - Jindent
- On-line Data Visualization
  - Supported Tools
    - Jdataviewer

SPS AND LHC CONTROLS INFRASTRUCTURE

- Back End Hardware and Operating System Platform (SL/CO HELIX project)
- Front End Operating System Platform (SL/CO FFEWG)
- Middleware (PS/SL Middleware Project)
- Real Time Communications (LHC-CP Sub-project)
- Industrial Components Usage and Support (LHC-CP sub-project)
- Alarm System (LHC-CP sub-project)
- Fast and Slow Timing

LHC ANALYSIS (LHC-CP LAWG sub-project)

- Monitoring of equipment and activities during shutdown or repairs periods
- Making the LHC safe for operation
- Preparing equipment for operation
- Operation without beam
- Operation with beam
  - Injection
  - Ramp

Recovery and diagnostics after beam or power abort

LHC CONTROL ROOM SOFTWARE

Operator Console

Control Room Software Design Principles

LHC SYSTEMS

LHC Beam Instrumentation

LHC Beam Tranfer

LHC Magnet Factory

LHC Power Systems

LHC Radio Frequency

LHC Magnet Protection System

LHC TECHNICAL SERVICES

LHC Cryogenics

LHC Vacuum

LHC Cooling and Ventilation

LHC INTERLOCKS

LHC POST MORTEM