Minutes of LHC-CP Link Meeting 21

Subject	:	LHC Controls Project	
Date	:	18 December, 2001	
Place	:	936-R-030	
Participating Groups	:	EST-ISS	P. Martel,
		LHC-ACR	no representative,
		LHC-ECR	no representative,
		LHC-IAS	J. Brahy,
		LHC-ICP	F. Rodriguez -Mateos,
		LHC-MMS	no representative,
		LHC-MTA	no representative,
		LHC-VAC	I. Laugier, R. Gavaggio,
		PS-CO	F. DiMaio,
		SL-AP	E. Wildner,
		SL-BI	J-J Gras,
		SL-BT	E. Carlier,
		SL-CO	A. Bland,
		SL-HRF	E. Ciapala,
		SL-MR	R. Billen,
		SL-MS	no representative,
		SL-OP	M. Lamont,
		SL-PO	apologies,
		ST-MO	R. Bartholomé replacing P. Solander.

Others : R. Lauckner (Chair),
B. Puccio (Machine Protection),
J. Serrano (PS-CO)
M. Tyrrell (Alarm Project),
M. Vanden Eynden (Core Team).

Distribution : Via LHC-CP website: **http://cern.ch/lhc-cp**
Notification via: **lhc-cp-info@cern.ch**

Agenda :

1. Matters arising from Previous Meeting	
2. LHC-CP News	R. Lauckner
3. Func Spec for LHC Front Ends	M. Vanden Eynden
4. Requirements for Analogue Signals	E. Ciapala
5. AOB	

1. Matters arising from Previous Meeting

As P. Gayet was absent no report was available on the urgent actions from October 9th concerning fieldbus cables and ergonomics for the vacuum supervision.

ACTION: P. GAYET

2. LHC-CP News R. Lauckner

R. Lauckner reported that the planning meetings concerning the sector test were continuing. A review of the situation for the BT group had taken place (5/12) and raised several open issues including beam interlocks for the SPS, beam energy distribution, software API and support for analogue signals, operational data requirements for the sector test.

A review of the Quench Protection System had taken place 5 – 12 December. The String 2 QPS controls, see LHC-CP 15, is considered exotic and a more standard solution needs to be found. H. Milcent (LHC-IAS) and F. Rodriguez-Mateos are looking into this.

The contract extension with ETM is still being finalized following requests for clarification from ST and LHC Cryogenics.

The Controls IWG of Task Force 5 is discussing with equipment groups in all accelerator divisions. R. Lauckner emphasised that anybody who would like to inject ideas or opinions to the IWG should contact him, input is very welcome at this stage.

3. Functional Specification for LHC Front Ends M. Vanden Eynden

M. Vanden Eynden described the work going on to produce the Engineering Specification for the LHC Front End Platform. Recalling that there are around 300 FE systems installed at SL today the investment in resources both money and manpower for the future systems at LHC is expected to be large and the systems will have a lifetime of many years. His FE section in the SL Controls Groups provides operational and development support covering hardware, software, administration and monitoring. Resources are already stretched to provide this service. It is imperative to actively upgrade these systems as CERN relies on maintenance and support from the Single Board Computer (SBC) supplier who requires operating system upgrades to be applied.

At LEP all Front End equipment was connected to the control system through generic front ends. At the LHC there will be major deviations from this approach with custom industrial systems for the technical services and also for some beam related systems eg kickers and warm magnets.

In addition several equipment groups are investigating alternative technologies for front ends including cPCI hardware, embedded Windows. However he said that choices must be made bearing in mind the resources available to support these systems over many years and the essential requirement to integrate accelerator sub-systems.

The Front End engineering specification must clarify and concentrate choices. It is currently in a second draft version and requirements and constraints are being added from the SL PO, BT, RF and BI groups.

It is anticipated that LHC systems will require an SBC in VME and that volumes will exceed the Finance Committee limits. Therefore the FE section is collaborating with Atlas who have recently launched a market survey for such systems. This imposes a milestone for the finalisation of the Specification for February 2002. Tenders will be launched in June 2002 and following the principle that prototypes are required 1 year before beam BI have requested first systems by the end of 2002. Purchases will extend through 2005 so an upgrade policy for these systems is essential.

He insisted on the need to limit the number of choices and to assess technological strategies through prototypes, in collaboration with the equipment groups. The support of any new technology includes the necessary tools to integrate Front End systems for accelerator operation.

F. Rodriguez-Mateos and R. Lauckner pointed out that the QPS and the Multipole Factory are potential clients for these systems. They should discuss their requirements and constraints with the Front End team.

ACTION, L. DENIAU, F. RODRIGUEZ- MATEOS

A. Bland recalled that financial constraints should also be examined. The size of the support team means that either an economical solution i.e. Linux PC or a more robust solution i.e. Lynx O/S VME can be supported but not both.

F. di Maio recalled that at present SL and PS are employing the same contract with a single SBC supplier, a situation he would like to maintain. M. Vanden Eynden replied that CERN's purchasing rules oblige him to launch tenders for the LHC requirement but PS-CO have received the drafts of the Engineering Specification and are invited to join in the new purchasing exercise.

J.J. Gras reported that the BI group were against extending the collaboration with Atlas to the purchase of VME crates. This would entail necessary modifications to an expensive solution. He also wanted to know what type of crates would be available for the new transfer lines.

ACTION: M. VANDEN EYNDEN

4. Requirements for Analogue Signals E. Ciapala

Ed Ciapala introduced this topic with a caution that he could only provide an introduction to this topic based on discussions in SL; he acknowledged that J. Serrano of the PS is also active in this area, see LHC-CP 9. The BT and RF groups have identified several hundred analogue signal sources which are to be sampled at rates from 1 kHz up to a few GHz.

He divided the subject into 2 main topics, digital acquisition and analogue monitoring. The latter involves direct transmission of signals from areas where access is restricted to instruments such as oscilloscopes and is the first priority as cable requirements must be known. Signals for analogue transmission cover a wide range of frequencies from DC to the GHz range. Transmission by cable is limited by attenuation at high frequencies and the cables are expensive. Commercial solutions are available employing optical fibres covering frequencies from DC to 1 GHz. and it is possible to multiplex from 8 – 16 low frequency channels on the same fibre. The dynamic range is limited for RF signals. Both BT and RF groups are testing commercial fibre based systems.

Turning to the second topic, digital acquisition, he reviewed the various buses in used and recommended that cPCI was perhaps the best candidate for LHC requirements. A variety of triggers are required in the accelerator environment and it is important to verify that all requirements have been identified. Several issues need to be addressed concerning software for these systems: crate O/S, communication software, operator GUI tools.

As a next step more input is needed from operations, equipment groups and the controls group on a range of topics.

ACTION: E. CIAPALA

J. Serrano said that the PS team are in a similar position in their work to upgrade NAOS. He agreed that PCI and cPCI were good candidates for cheap and fast systems. He also pointed out the importance of multiplexers that are used at the PS but limit bandwidths to about 40 MHz.

J.J. Gras reported that BI use GPIB based instruments connected to their VME crates. Displays are based on the DataViewer that gives fully satisfactory results. NAOS could not meet the BI requirements as it was limited by the flexibility of the triggers. In the LHC the BST will be available.

5. AOB

There was no further business.

Long-Term Actions	**People**
Underground Control Rooms requested	R. Lauckner
Establish Post Mortem sub-project	R. Lauckner
Clarify Middleware Services to be used by LHC-CP	Core Team

Reported by R. Lauckner

Front End Platform for the LHC Control System

Front End Platform for the LHC Control System

Engineering Specification

Front End Platform for the LHC Control System

Agenda

- Front Ends Today
  - Installation
  - Operational and development support
  - Short term plans
- LHC : New Context, New Trends
  - Growing interest for Industrial Controls and Automation solutions
  - Emergence of specific (different) requirements in various domains
  - Need for Engineering Specification
- Engineering Specification
- Next Milestones
- Open Issues

Front End Platform for the LHC Control System

Front Ends Today (I)

- Installation : About 300 Systems

Type	Operational	Development
PowerPC Lynx/OS 2.5.1	**148** *SPS Ring* *LEP services*	**69**
PC Lynx/OS 2.5.0	**25** *SPS Experimental Areas*	**20**
M68K OS/9	**15** *SPS Beam Instrumentation*	**15**

Front End Platform for the LHC Control System

Front Ends Today (II)

- Operational and Development Support
  - Hardware
    - VMEbus crates and SBC purchasing, testing and installation
  - Software
    - Network bootable operating system kernel
    - NFS, SNMP, compilers, …
    - Device drivers (Jbus, Equipment bus, TG8, MIL-1553, GPIB, WorldFip, Camac, GPS, …)
  - Administration and Monitoring
    - Remote Software monitoring (daemons, interfaces)
    - Remote HW reboot facility
    - Front line support (HW and SW)

Front Ends Today (III)

Front End Platform for the LHC Control System

- Short term plans (Q1 2002)
  - Upgrade (as much as we can ...) PPC Lynx/OS 2.5.1 systems to Lynx/OS 3.1.0.A
    - Stay close with Lynx/OS product line
    - Keep good support from our SBC supplier
    - Allow deployment of PS/SL middleware
  - Prepare engineering specification for the LHC front ends (more on this later)

LHC :New Context, New Trends (I)

Front End Platform for the LHC Control System

- Growing interest for Industrial Controls and Automation solutions
  - Most of the LHC technical services and several beam related systems will be designed using PLCs and industrial fieldbuses (Profibus, WorldFip)
    - Cooling and Ventilation, Electricity, Vacuum, Cryogenics, Level3 Alarms, etc.

    But also :
    - Some parts of the LHC beam transfer systems (MKD,MKI), transfer lines warm magnets, interlocks (?), some parts of the RF system, etc.

LHC : New Context, New Trends (II)

Front End Platform for the LHC Control System

- Emergence of specialized (different) requirements in various domains
  - Real Time (BI, PC)
    - Real Time O/S and RT Ethernet connections (orbit, tune, chromaticity control)
    - Deterministic fieldbus : WorldFip
  - Data Acquisition and Triggers (BT, RF)
    - Specific trigger synchronization requirements
    - Analog signals acquisition, treatment and display

LHC : New Context, New Trends (III)

Front End Platform for the LHC Control System

☛ Need for Engineering Specification :

- The definition of “front ends” has to be seriously re-considered in the light of the **LHC requirements**
- Alternative technologies are currently investigated in several equipment groups :
  - cPCI/PXI Hardware
  - Embedded O/S (Windows, National Instruments)
- Technical **choices** have to be made, resources have to committed and **support** must be organized for **many years** (Responsibility? Cost considerations ?)
- In addition to platform considerations, a coherent strategy must exist to **interface** the potential different approaches (PLCs, VMEbus, etc) to the control system :
  - RT API
  - Middleware API

Engineering Specification

- Table of Contents

Engineering Specification

Front Ends in the LHC control System

- Describe the intended usage of front ends for the various LHC sub-systems :
  - Architecture
  - Requirements (HW,SW)
  - Constraints (cost, experience, performance)
  - Location
  - Procurement dates
- Systems currently considered :
  - Power Converters (~100 systems)
  - Beam Instrumentation (~180 systems)
  - Beam Transfer
  - Radio Frequency
  - RT Feedback Loops
- Summary (requirements, constraints, procurement)

Engineering Specification

Technical Specification (VMEbus)

- Processor Board (SBC)
  - Family (PPC, Intel Pentium)
  - Performance (clock)
  - Memory (user available, flash)
  - Backplane (VMEbus64)
  - PCI bridge, PMCs, RS-232 ports, reset lines
  - Network Interface
- Operating System and Device Drivers
  - Lynx/OS 3.1.0 or >
  - Drivers for TG8 (or equivalent), WorldFip

Engineering Specification

Technical Specification (VMEbus)

- Real Time Suppport
  - Low latency IRQs
  - Maskable strategies for IRQs
  - Fine grain timers
  - Support for interrupting DMAs
- System level libraries
  - VMEbus and PCI bus access library
  - WorldFip Application Programming Interface (Fip Device Manager)
- Diagnostic and Management Software
  - Terminal server
  - Remote SYSRESET facility (HW + SW)
  - SNMP daemon
  - Remote monitoring and administration tool (equivalent to clic/xcluc)

Engineering Specification

Technical Specification (Communication Interface)

- Middleware Communication Interface
  - Basic Principles
  - Interface Specifcation for VMEbus
    - » APIs, language bindings, etc
  - Interface Specification for PLCs
- Real Time Communication Interface
  - Basic Principles
  - APIs, language bindings, etc

Engineering Specification

Support

- Procurement (SBCs, Crates, SW licenses)
  - Market Survey, technical Specification, call for tender
  - Upgrade policy
- Technical Support
  - Hardware integration
  - Hw diagnostics and repair
  - Software development environments procurement and support
  - Slow control middleware
  - RT interface
- Operational Support
  - operational systems monitoring
  - First line support
  - interventions that will be under the responsibility of each group

Next Milestones

- Procedures
  - SL/CO has joined the "VME Task Force" and participates, with the ATLAS experiment, in the market survey, technical specification and call for tender procedure for the VMEbus systems (SBCs for ATLAS Read Out Driver System and for the LHC Machine)
    - Call for tender in June 2002
  - The LHC Front Ends Engineering Specification (V1.2 today) is a <u>mandatory input to this process</u>
    - Feb 2002
  - First systems required by SL/BI for fall 2002 (in general : prototypes required 1 year before installation in the machine)

Open Issues

- Some investments have started in technologies not currently supported by SL/CO (cPCI/PXI with Embedded Windows or National Instruments products)
- There is a vast choice of combinations (HW platform + O/S) (and opinions ...)
- What are the cost boundaries ?
- Requirements Vs constraints is a key point
- Number of choices <u>must</u> be limited and all forces must be concentrated on :
  - technology assessment through prototypes and
  - common design decisions (not the case today)

Analog Signal Requirements

General Purpose Observation in LHC

- **Types of signals**
- **Analog signal transmission**
- **Acquisition systems**
- **Timing**
- **Remote data display (archiving)**
- **Relation to Post Mortem?**
- **Requirements**
- **Pilot project(s) – aims & needs**

Input from:

Etienne Carlier
Jean-Jacques Gras
Luca Arnaudon
Felix Rodriguez-Mateos

Signal Monitoring

a) Digital Acquisition:

- **Local acquisition – transmission of data via the network, data display on console**

b) Analog 'real time' monitoring:

- **Direct transmission of DC or HF signals from machine to surface or PCR installed instrumentation.**

First priority – cabling requirements etc.

LHC Extraction Kicker MKD

LHC Extraction Kicker - MKD - Analog Signals Summary - 18/12/01

#	Source	Function	Physical Quantity	Name	Sensor Type	Magnitude Scale (V)	Bandwidth (MHz)	Sampling Rate (Ms/s)		Qty. per Unit	Qty. per Kicker
1	Generator	Diag.	Current (princ.)	Ip	CT		50	200		2	30
2	Generator	Diag.	Current (comp.)	Ic	CT		50	200		2	30
	Generator	Diag.	Current (free wheel)		CT		50	200		2	30
3	Generator	Diag.	Voltage (princ.)		VD 1:1000		20	100		2	30
4	Generator	Diag.	Voltage (comp)		VD 1:100		20	100		2	30
5	Re-trigger	Intl.	Pulse				50	200		4	60
10											
11	Magnet	Diag.	Current		CT		200	500		2	30
12									**Total**		**240**
13											
14											
15	General trigger	Trigger	Voltage							2	2
16	Trigger pulse	Trigger	Voltage							2	60
17									**Total**		**62**

LHC Injection Kicker MKI

LHC Injection Kicker - MKI - Analog Signals Summary - 14/08/01

#	Source	Function	Physical Quantity	Name	Sensor Type	Magnitude Scale (V)	Bandwidth (MHz)	Sampling Rate (Ms/s)	Qty. per RCPS	Qty. per PFN	Qty. per Kicker
1	RCPS	Diag.	Voltage (Primary)	U_p	VD 1:300	10V=>3KV	50	200	1		2
2	RCPS	Diag.	Current (Primary)	I_p	CT	5mV/A	50	200	1		2
3	RCPS	Diag.	Uanode Thy.		VD 1:300		15	100	1		2
4	RCPS	Diag.	Ucathode Thy.		VD 1:300		15	100	1		2
5	Dump Switch	Diag.	Voltage (PFN)	U_{pfn}	VD 1:6000	10V=>60KV	50	200		1	4
6	Dump Switch	Diag.	Current (Thyratron)	I_{thy}	CT		50	200		1	4
7	TDR	Diag.	Voltage	U_{tdr}	VD 1:x	15V=>30KV	50	200		1	4
8	Main Switch	Diag.	Current (Thyratron)	I_{thy}	CT		50	200		1	4
9	TMR	Diag.	Voltage	U_{tmr}	VD 1:x	15V=>30KV	200	500		1	4
10											
11	Magnet	Diagnose	Voltage		PU Capa.					2	8
12									**Total**		**36**
13											
14											
15	Fast prepulse	Trigger	Voltage								1
16	RC Thy. Trigger	Trigger	Voltage							1	2
17	Dump Thy.Trigger	Trigger	Voltage							1	4
18	Main Thy. Trigger	Trigger	Voltage							1	4
19	Main Thy.Trigger	Trigger	Voltage							1	4
20									**Total**		**15**

Analog Signals – RF Systems

	Frequency range			Digital Acquisition		
	DC to	DC to	0.5/1.0	Sampling	Recording	Treatment
Beam Control	10 kHz	40 MHz	GHz		Depth	
Detected Total Accelerating voltage amplitude	1			1 turn		
Total 200 Mhz voltage amplitude/phase	2			1 turn		
Total 400 Mhz voltage amplitude/phase	2			1 turn		
Measured RF frequency (Digital)				1 turn		
Phase loop phase discriminator	1			1 turn		
Synchro loop phase discriminator	1			1 turn		
Radial position	1			1 turn		
Wideband longitudinal pickup (I bunch profile)			1	4 Gs/s		
Total Beam Control	***8***		***1***			
ACS Cavities:						
Cavity Antenna RF			8	2 Gs/s		
Cavity Antenna - Fast Detector (Tbunch)		8		25 ns		
Cavity Antenna - Slow Detector	8			1 ms		
Waveguide coupler - for/ref		16		25 ns		
Cavity voltage (vector demod: I and Q)		16		25 ns		
Drive in: (vector demod: I and Q)		16		25 ns		
Circulator in forward power	8			1 ms		
Cavity in forward power	8			1 ms		
Cavity in reverse power	8			1 ms		
Tuner position	8			1 ms		
Coupler position (400 MHz)	8			1 ms		
HOM coupler fundamental	32			1 ms		
Totals ACS	***80***	***56***	***8***			

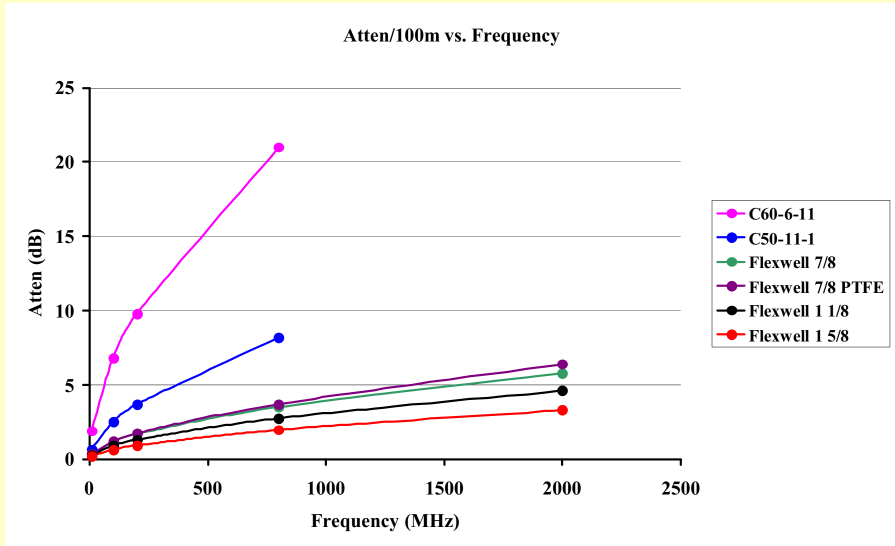
Analog Signals – RF Systems Contd.

Cavity Antenna RF			4	2 Gs/s		
Cavity Antenna - Fast Detector (Tbunch)		4		25 ns		
Cavity Antenna - Slow Detector	4			1 ms		
Waveguide coupler - for/ref		8				
Cavity voltage (vector demod: I and Q)		8		25 ns		
Drive in: (vector demod: I and Q)		8		25 ns		
Circulator in forward power	4			1 ms		
Cavity in forward power	4			1 ms		
Cavity in reverse power	4			1 ms		
Tuner position	4			1 ms		
Damping loop position (200 MHz)	4			1 ms		
Total ACN	***24***	***28***	***4***			
Transverse Dampers:						
Kicker Voltages		8		40 MHz	1000 turns	
Driver Voltages		16		40 MHz	1000 turns	
Output from Digital Processing		4		40 MHz	1000 turns	
Pick-up		4		40 MHz	1000 turns	
Total Dampers		***32***				
Totals per Ring	112	116	13			
Total overall	224	232	26			

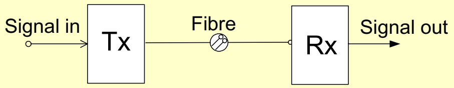
Analog 'real time' monitoring

- **Frequencies => DC to RF in 3 Ranges:**
  1) 0 - 10 kHz = DC
  2) 0 - 50 MHz = HF
  3) 10MHz – 1GHz = RF
- **Signal distribution**
  – Cable characteristics/costs
  – Optical fibre based links

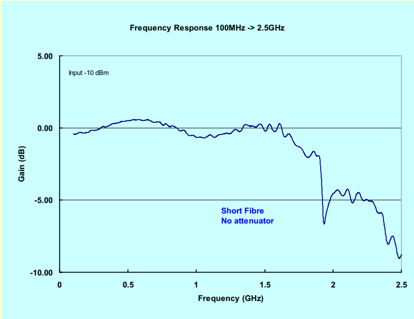
Coaxial Cable - Attenuation Characteristics

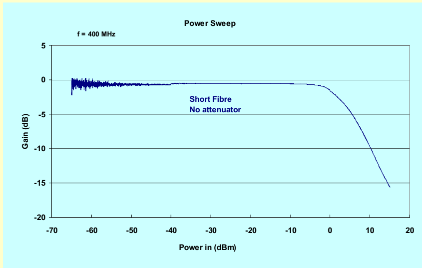


Fibre Optic Links



- Range of frequencies available – DC to several GHz.
- Low frequency systems DC to several kHz
  These usually multiplex several channels
- RF links - Dynamic range generally limited to 40 dB for wideband applications





Commercial Equipment

0 to 5 Mhz link on test in SL BT Etienne Carlier

Tests on RF modules 100 kHz to 1.5 GHz by Philippe Baudrenghein/Donat Stellfeld

Local Digital Acquisition – Hardware

- **Instruments** (GPIB, Ethernet)
- **Acquisition Modules**

Slow systems: Many suppliers

Fast systems: Acquiris, used by PS-BD, SL-RF, SL-BT
GaGe – recent presentation of future products

VME	Widely used at CERN– very long term commercial future ?
VXI	(Becoming) Extinct
PCI	Most widely used, size & connectivity are problems ?
CPCI	Good size (3U/6U) & connectics, software compatible with PCI
PXI	NI (LabVIEW) CPCI with extensions (3U height only)

GP Signal Acquisition
Triggering, Timing and Synchronization

Triggering:

GM Timing
Event driven
Hard-Wired input – as Beam or Power Permit for Post Mortem
BST message ?

Fast Timing - if needed

RF bucket timing (400 & 200MHz)
BST (40MHz)

Synchronization:

GPS - (IRIG-B) => several µs

Can above satisfy all requirements ?

Local Digital Acquisition: Software – 3 levels

1. **Local acquisition server:**
   - LabVIEW, ‘C’, + Windows, Linux …
2. **Remote clients:**
   Data Presentation
   - LabVIEW’
   - Own’ GUI (using toolkit?)
3. **Communication / Middleware**

LabVIEW =>

- Quick realization of stand-alone system, easy hardware debugging etc.
- Complex in larger systems.
  - storage & treatment of data, coordination with other systems?

General Purpose Systems

- Need
  - Input from future LHC-OP group and LHC-CP on what signals are needed in PCR and other areas.
  - Definition of respective roles of GP observation, Post Mortem, Logging systems
  - Equipment groups
    - Agreement on hardware standards ?
    - Also on local Operating System and Software
  - Support from CO group on software, middleware, GUI, database etc. Standard data formats?

General Purpose observation and PM systems

Can the functionality be shared ?

- Only if acquisition settings are maintained and just the recovered data is manipulated

  => Leads to severe restrictions ?

On the other hand:

- PM could provide data for general purposes
- Frequently observed data is inevitably part of PM

?

Proposed test system in SPS RF.

Longitudinal profile of single bunch over a number of revolutions (Mountain Range)

- Fast 2/4 GS/s sampling unit
- Local data buffer
- Fast Bucket Timing – bucket selection, repeating at revolution frequency/N
- Acquisition trigger (GM Timing)
- GPS Timing to identify revolution ?
  - Also triggered by bucket selection signal
- On line analysis of data – e.g. bunch length

- Control Software ?
- Data recovery and display ?
- Database Storage ?

Middleware
GUI
Data Formats