Analog Acquisition - Infrastructure

General Purpose Analog Signal Observation in LHC

- Signal Types and Numbers - RF & BT
- LHC Era - Common solutions across equipment, PS SPS and LHC
  - Analog signal transmission equipment (Fibres)
  - Acquisition systems : Summary of discussions:
    - Existing nAos system
    - Requirements
    - hardware,
    - Software
    - Timing
    - Post mortem
- SPS Extraction (TT40) Requirements (E. Carlier)
- How to proceed?

Analog Signals - LHC Extraction Kicker MKD (Dump)

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

Analog Signals - 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 - LHC 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 - LHC 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**			

Numbers of Analog Signals - BT and RF

Frequencies => DC to RF in 3 Ranges:

Signal		BT (LHC)	RF (All)
0 - 10 kHz	DC		224
0 - 50 MHz	HF	242	232
10MHz - 1GHz	RF	34	26
Totals		276	482

Analog Signal Monitoring

- Direct 'real time' via cables or fibre optic links

  (From underground areas to equipment control areas)

- Some commercial equipment, from different manufacturers has been evaluated RF, BI, BT.

  For use in the frequency ranges of interest:

  - RF links to 2 GHz
  - HF link to 10 MHz
  - (LF multiplexed links 0 to 10 kHz)

Analog Acquisition systems

Want common solution in PS, SPS & LHC - across equipment

=> Various discussions with specialists and users in PS SL LHC on requirements and solutions *"Brainstorming Session"* (write-up on Web)

* nAos system
* Acquisition hardware choice
* Timing requirements
* Software implementations - choices
* Post Mortem
* How to proceed ?

nAos System

- General Purpose Observation System
  => Signal selection, trigger selection, visualization, archiving

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- PS 25 VXI crates with HP ‘scopes & 2 types of multiplexer modules
- SPS 4 crates monitoring over 100 signals from RF damper and kickers
- VxWorks in acquisition crates, Client ‘Virtual Scope’ developed in Motif and runs on Linux
- System appreciated by all its users
- However
  - Lack of modularity in the software is a problem (=>OASIS)
  - Main problem is obsolescence of VXI hardware
- Solutions needed urgently (LEIR, SPS extraction TT40)

Analog acquisition - Hardware

- Acquisition Modules
  Slow systems: Many suppliers
  Fast systems: Acquiris, (Widely used at CERN) PS-BD, SL-RF, SL-BT
  GaGe - recent presentation of future products

- Platforms

VME	Widely used at CERN- very long term commercial future ?
VXI	(Becoming) Extinct - Main problem for nAos
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 but fits in 6U CPCI)

! **General agreement that CPCI is the best choice** !

Analog acquisition - Timing

- Development of common hardware in CPCI

- TG1 timing module in PS-CO
- RF timing module in SL-HRF
- Time-stamping hardware ?
- Other for synchronization, delays ??

Analog Acquisition - Software

LabVIEW =>

- Quick realization of stand-alone system, using graphic building blocks (Vis)
- Standard signal treatment tools, Easy hardware debugging etc,

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- Heavy in larger systems.=> VIs increase rapidly in numbers
- Problems with integration with other systems,

- Need special implementation of external functions - e.g. equipment setting, timing control

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LHC Analog Signals - Software

Custom =>

Still Using COTS Solutions (Commercial/CERN) as far as possible

3 Layers:

- Local acquisition server
  - LabVIEW, 'C', Windows …
- Remote clients (Data Presentation)
  - LabVIEW
  - Own GUI & Dataviewer
- Communication / Middleware
  - CMW OPC

Choice of OS =>

Windows - better COTS support ?

Linux - CERN expertise stronger ?

! General agreement more difficult to reach !

General Purpose Observation and PM systems

Post Mortem: - Buffer freeze on timing event

- Same hardware - Do both PM and observation with the same ?

BUT

- PM Settings must remain fixed, although probably automatically updated for best observation
- Use of common equipment for PM and observation would need case by case study.
  - Data could be systematically stored in separate buffers
  - Should provide PM trigger (and others + Time-stamping) for 'unanticipated' needs - Allowing observation system to behave as PM if needed
- Should make PM acquisition data available on any trigger request

SPS Extraction (TT40) Requirements (E. Carlier)

	SPS Extraction MKE TT60 TT40	LHC Injection MKT TI8 TI2	LHC Extraction MKD RA63 RA 67
Observation	√	√	√
Post-mortem (incl. Previous pulse)	√	√	√
Equipment control		√	√

- Observation
  - Triggering via fast prepulses conditioned by timing
  - Multiplexing of signals
- Post Mortem
  - Visualisation of previous pulse, logging
- Equipment Control Functionality
  - Pulse to pulse regulation

How to proceed ?

- Close collaboration on urgent projects

1. PS LEIR acquisition system
2. SPS RF Fast Mountain Range Display
3. SPS extraction (EA and LHC) - TT40

⇒ Coordination of software developments
=> common solutions

- Analysis of individual systems
  - Observation, control, post mortem, acquisition points
- Agreement on standard acquisition hardware modules / multiplexers

The End

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 satisfy all requirements with above ?