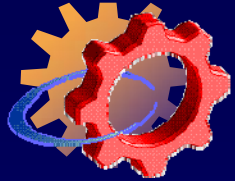


Machine - Experiments Data Exchange

Detlef Swoboda

26 January 2007

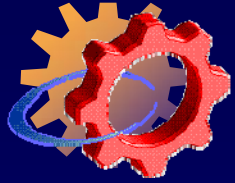
LumiWS



LHC systems and project engineers

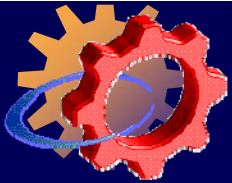
System	CERN Group	Person Responsible
BIS (Beam Interlock System)	AB-CO	B. Puccio
BPTX (Beam position monitors)	AB-BI	R. Jones
BRAN (collision rate monitors*)	AB-BI	E. Bravin
BST (Beam Synchronous Timing)	AB-BI	R. Jones
Experiment Magnets control and interlocks	PH-DT1	E. Sbrissa
GMT (Safe LHC Parameters)	AB-CO	J. Serrano / M. Eynden
TTC (Timing, Trigger and Control)	PH-ESS	S. Baron

*** Installation, control and monitoring of the collision rate monitors (BRANs) is the responsibility of the AB-BI group.**

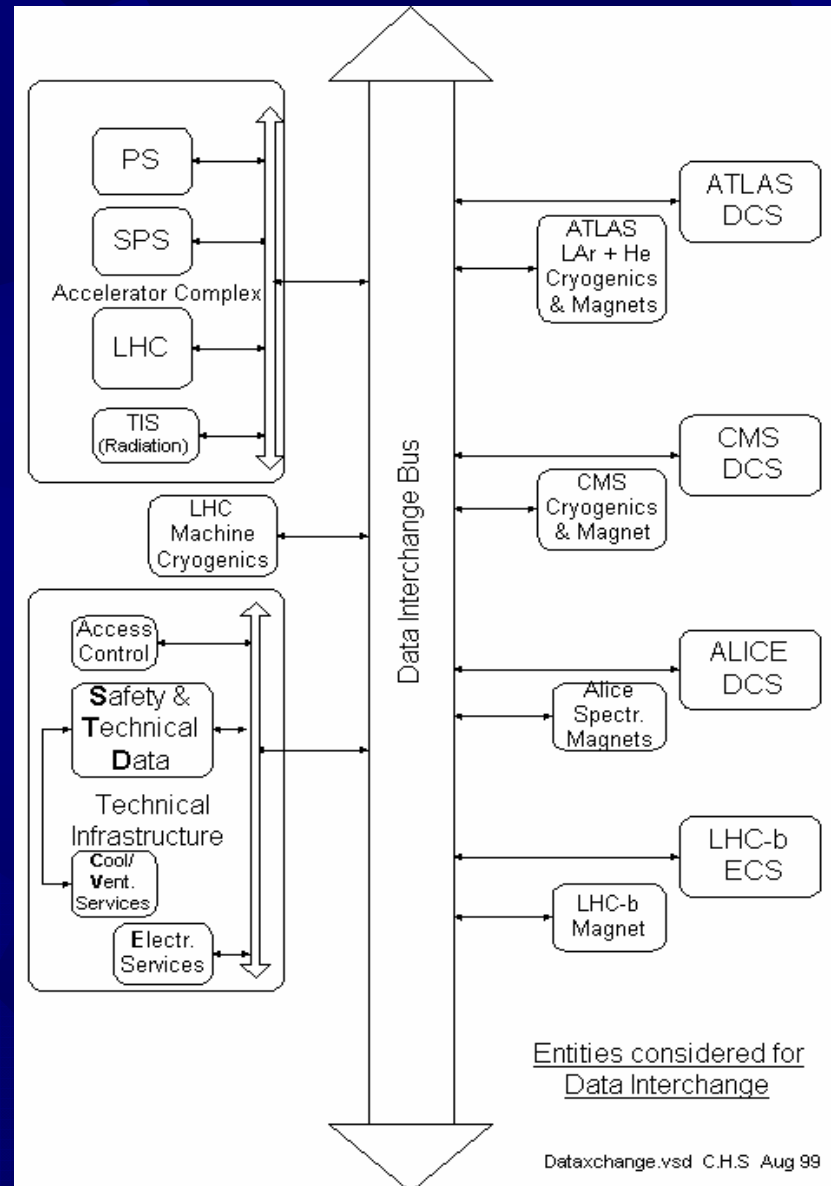


Reference Documents

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- E. Tsesmelis, Data and Signals to be Exchanged between the LHC Machine and Experiments. EDMS 701510 (2006).
- Wayne Salter et al., LHC Data Interchange Protocol (DIP) Definition. EDMS 457113.
- CERN DIP support web page: <http://itcofe.web.cern.ch/itcofe/Services/DIP/welcome.html>
- LHC Experiment Accelerator Data Exchange Working Group (LEADE).
- <http://lhc-data-exchange.web.cern.ch/lhc-data-exchange/>
- Leade Twiki web page: <https://uimon.cern.ch/twiki/bin/view/Leade/WebHome>
- TTC system web page. <http://ttc.web.cern.ch/TTC/intro.html>
- S. Baron, TTC upgrade project. <http://ttc-upgrade.web.cern.ch/ttc-upgrade/Default.htm>
- Jean-Jaques Savioz. The Beam Synchronous Timing Receiver Interface For The Beam Observation System. EDMS 406137.
- R. Schmidt AB/CO, Safe Lhc Parameters Generation And Transmission (SLPT) LHC-CI-ES-0004 rev 0.1 EDMS 810607
- <HTTP://LHC-DATA-EXCHANGE.WEB.CERN.CH/LHC-DATA-EXCHANGE/>
- D. Macina, W.H. Smith, J. Wenninger. LHC Experiments Beam Interlocking, EDMS 653932 (1995).
- B. Todd. CIBU: Realisation of The Beam Interlock System User Interface.
- EDMS 762173
- B. Puccio et al., User Interface to the Beam Interlock System, EDMS 636589
- R. Jones. The LHC Beam Position System, Presentation At The Leade Working Group Meeting, 26th March 2002. <HTTP://LHC-DATA-EXCHANGE.WEB.CERN.CH/LHC-DATA-EXCHANGE/>
- Z. Guzik, R. Jacobsson, Proposal for a Beam Phase and Intensity Monitor for the LHCb Experiment, LHCb 2006 - 055

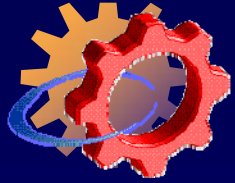


LHC Data Exchange Concept



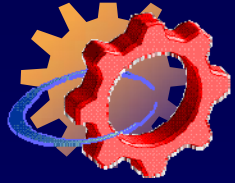
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LumiWS



Data Exchange Key features

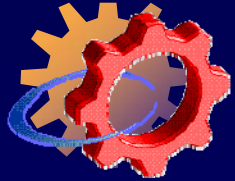
- ✦ Data transmission using the DIM/DIP protocol and a publish/subscribe paradigm.
- ✦ All data are sent with a UTC time stamp and a data quality indicator.
- ✦ The amount of data sent will be about 250 kB/sec (~ 100 messages/sec). The typical latency is about one second although some messages will have longer latencies.



Machine to experiments

★ <https://twiki.cern.ch/twiki/bin/view/Leade/WebHome>

<u>Measurement</u>	<u>DIP item name</u>	<u>Publication contact</u>	<u>Data contact</u>	<u>Volume Bytes</u>	<u>Freq</u>	<u>Estimated availability</u>
Total beam intensity	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	8	1 sec	Jan 2007
Individual bunch intensities	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	28 512	1 min	Jan 2007
Average 2D beam size	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	1	1 sec	
Average bunch length	dip/ACC/Class/Property/Device	K. Kostro	AB/RF	8	1 min	
Luminosity	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	28 512	10 sec	
Average Beam Loss	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	16	10 sec	
HOR & VER Positions	dip/ACC/Class/Property/Device	K. Kostro	AB/BI	128	1 sec	
Total longitudinal distribution	<i>obsolete</i>					

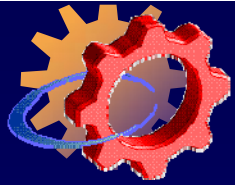


Additional GMT data from LHC machine to Experiments

<https://uimon.cern.ch/twiki/bin/view/Leade/WebHome>

Producer	Measurement	Data type	Production volume (Bytes)	Production frequency
AB-BI	Machine Mode		small	On change
AB-BI	Beam Type		small	On change
AB-BI	Beam Energy	GeV/c ?	small	10 Hz
AB-BI	Safe Beam Flag		small	10 Hz

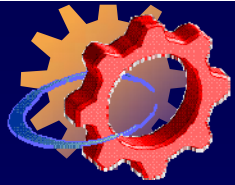
- The AB-BI group intend to publish some dummy data in DIP from January 2007. This will enable the DCS team to test their software.
- Dummy LHC parameters will be transmitted as of 2Q 2007.



Data published by Experiments via the DIP

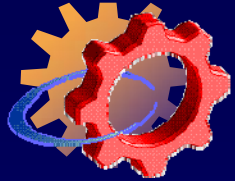
Measurement	Units	Production Volume (Bytes)	Production Interval (sec)	Data Rate (Bytes/sec)
Total luminosity Expmt/Beam/Lumi_Total	$\text{cm}^{-2}\text{s}^{-1}$	4	1	4
Average rates Expmt/Beam/Lumi_Rate_Avg	Hz	12	1	12
Luminosity per bunch Expmt/Beam/Lumi_Bunch	$\text{cm}^{-2}\text{s}^{-1}$	14256	60	238
Rates for individual bunches Expmt/Beam/Lumi_Rate_Bunch	Hz	42768	60	713
Position and size of luminous region (average over all bunches) Expmt/Beam/LumRegion/Pos Expmt/Beam/LumRegion/Size	cm	24	600	0.04

In addition publish information on beam condition (BCM) - (e.g. a number between 1 and 5 where 5 causes a beam dump).



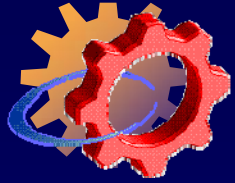
Handshakes between Experiments and CCC

Signal	Client	Publisher
Adjust-Request	Experiment DCS	CCC
Ready-For-Adjust	CERN Control Centre (CCC)	Experiment DCS
Beam-Dump-Request	Experiment DCS	CCC
Ready-For-Beam-Dump	CERN Control Centre (CCC)	Experiment DCS
Inject Inhibit / Permit	Injection Interlock system	Experiment DCS



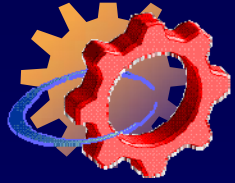
Hardware Beam Interlocks

- ***The Beam Interlock System (BIS) of the LHC, the LHC Injection Interlock System, and the SPS Extraction Interlock System.***
- Each Experiment must provide ***USER_PERMIT signals*** that are collected by the BIS through the local Beam Interlock Controller (BIC) modules
- Interface between Experiment and BIC is via 19-inch 2U modules (***CIBU***) modules, which can be connected directly or through patch panels in case the generation of the USER_PERMIT signal is at more than 4 m distance from the interface rack.
- **Beam Dump Requests**
 - provides a hardware link from a user system to the LHC Beam Dumping system
 - BIS permits injection into the LHC when all systems connected to it are ready for beam. With beams circulating in the LHC, the system transmits beam dump requests from connected systems to the LHC Beam Dumping System.
- **Injection Inhibit**
 - Inject inhibit hardware interlock would require major cabling work since the corresponding BIC are located close to the injection regions. The Injection Inhibit interlock, set by the experiments, will therefore be a software signal.
 - In order to protect experiments from signal transmission failure, due to network problems, a timeout will be applied and the Injection-Permit will be assumed to be false after timeout.
 - The exact details of this software injection inhibit are still to be decided but it is likely to be transmitted using DIP.
- **Limit of Supply**
 - AB-CO group is responsible for cabling from the CIBU/patch panel in Experiment rack to the local BIC modules in the LHC tunnel; they will also provide the necessary CIBU modules.
 - It is the responsibility of each Experiment to provide the input signals to the CIBU modules.



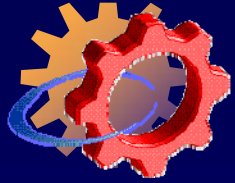
BPTX

- ✦ Each experiment has a beam position monitor about 150 metres either side of their interaction points.
- ✦ Each monitor consists of four button electrostatic pickups in order to detect the vertical and horizontal position of the beams.
- ✦ **Information**
 - Relative timing between signals from the BPTXs, on either side of the IP, can be used to establish an approximate location of the interaction point
 - monitor the phase of the LHC clock locally in order to determine whether the TTC is synchronised with the actual arrival of the bunch.
 - Signals can also be used to identify the location of the bunch train gaps.
- ✦ **Limit of Supply**
 - cables be installed from each BPTX to rack in Experiment.
 - LHCb have developed a VME module to read the BPTX signals and automatically calculate timing differences. Details of this module will be presented at the next LEADE meeting.



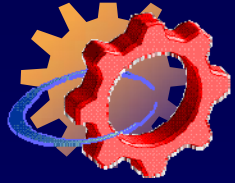
BRAN (Lumino meter)

- ✦ Neutral particles @ 150 m from IP ~ L.
- ✦ Numbers between ATLAS/CMS and ALICE/LHCb (~10⁴ : 1)
- ✦ 2 technologies:
 - ATLAS and CMS → fast ionization chamber, from Berkeley lab
 - ALICE and LHC-B → based on solid state polycrystalline Cadmium-Telluride (CdTe) sensors from CSA-LETI Grenoble
- ✦ **Limit of Supply**
 - Published via DIP



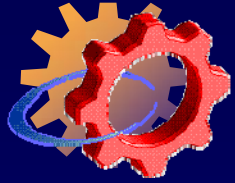
BST (Beam Synchronous Timing)

- ✦ The BST uses TTC technology to send messages over channel B of the TTC system.
- ✦ **Limit of Supply**
 - AB-BI group is responsible for sending the BST data to the experiments, via dedicated TTC optical fibres.
 - Responsibility of the experiments to develop their own hardware in order to read and decode the data.
 - BOBR receiver card developed by the AB-BI group can be used as interface.
 - Part of the BST data is also transmitted to experiments via DIM/DIP.



GMT (General Machine Timing)

- ✦ For the safe operation of the LHC and experiments, a number of systems require machine parameters that must be generated and distributed around the LHC.
- ✦ The Safe LHC Parameters (SLP) are part of the GMT telegram.
- ✦ The system is designed to generate and distribute these parameters in a highly reliable way.
- ✦ The interface with experiments is achieved through a dedicated VME crate including timing trigger outputs which is connected to the General Machine Timing (GMT) system.
- ✦ Values of parameters are supplied as TTL voltage levels on the front connections.
- ✦ Experiments requiring the 40 MHz clock or a TTL level trigger (for hardwired safety interlocks) will want to install the GMT system.



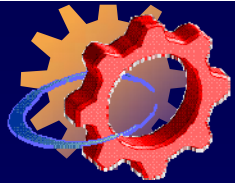
GMT features

GMT exclusive parameters:

- ✦ Circulating beam type/ring
- ✦ RF parameters
- ✦ Next injection parameters
- ✦ Safe Beam Parameters
 - Beam energy/ring
 - Beam present flag/ring
 - Safe Beam flag/ring
 - Safe collimator flag
- ✦ Post mortem
- ✦ 40 MHz PLL clock

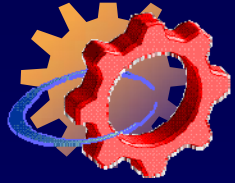
GMT parameters also included in BST frame:

- Beam intensity/ring
- LHC machine mode
- ✦ Fill number
- ✦ Particle type/ring



GMT safe beam flag

- ★ The experiments have requested to get the following signals from the GMT system:
 - ★ - safe "*STABLE BEAM*" flag
 - ★ - safe "*MOVABLE DETECTOR IN ALLOWED*" flag. This flag is TRUE if either the "*STABLE BEAM*" mode OR "*UNSTABLE BEAM*" mode is TRUE.
- ★ The flag is set at a high level in the GMT system.
- ★ "*MOVABLE DETECTOR IN ALLOWED*" flag = FALSE will be used to dump the beam
- ★ "*MOVABLE DETECTOR IN ALLOWED*" = TRUE AND "*STABLE BEAM*" flag = FALSE will be used to retract the movable detectors when necessary.



GMT Limit of Supply

1. AB-CO takes responsibility for the installation and maintenance of the GMT distribution for the 4 LHC experiments. Each of these 4 installations will consist of:

1 3U timing reception and fan-out crate

1 VME 21 slot crate

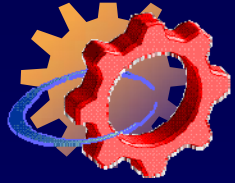
1 PowerPC single Board Computer

n x CTR-P or V timing modules, depending on the number of H/W trigger signals the experiments will need

Total cost estimate per experiment is about 20 KCHF.

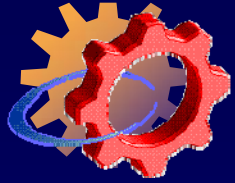
2. Concerning the practical GMT installation work:

- Each experiment should send to the AB-CO-FE (M. vanden Eynden) the date at which GMT should be made available, along with a list of the first timing triggers they want to receive (in order for us to know how many CTR-V to install). The AB-CO-FE will then proceed with the GMT infrastructure installation
- GMT trigger signals have to be declared in the GMT system (in order to activate the CTR-X outputs). Experiments are invited to contact AB-CO-HT (J.Serrano) in order to define these triggers in the GMT system.
- AB-CO responsibility and diagnostic tools stop at the front panel of CTR-x modules.
- The local cabling and signal integrity between the CTR-x modules and the experiments electronics remains under their responsibility.
- In case experiments would need dedicated timing receiver modules (CTR-x) inside their crates (for decoding of GMT telegram for example), CO would charge them 1000 CHF/each.



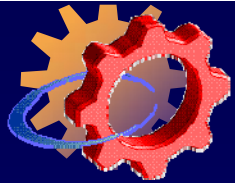
Trigger Timing & Control (TTC)

- The TTC system was designed for LHC experiments and provides for the distribution of synchronous timing, level-1 trigger, and individually addressed control signals, to electronics controllers with the appropriate phase relative to the LHC bunch structure, taking account of the different delays due to particle time-of-flight and signal propagation.
- Within each trigger distribution zone, the signals can be broadcasted from a single laser source to several hundred destinations over a passive network composed of a hierarchy of optical tree couplers.
- **Limit of Supply and Planning**
 - The optical fibres carrying the TTC clock and orbit signals arrive in the dedicated Experiment rack at an optical patch-panel.
 - Experiments must specify their needs for RF2TTC modules.
 - TTC group will provide a rented VME crate (from the CERN Electronics Pool) for the TTC interface modules.
 - Rx/Tx-modules (A & D) validated by AB/RF Production Apr07
 - RF2TTC proto-module under test (Dec 06) Production Feb07
 - C library under development 1Q07
 - Central system installation in summer 2007.
 - The transmission can then be commissioned in Sept 2007.
 - Modules are equipped with diagnostics and PH will make these diagnostics "readable" by AB/OP and AB/RF.



Conclusions

- ✦ The implementation of calculating rates and luminosity per bunch is still under discussion but needs to be finalized in the near future.
- ✦ Cabling between instrumentation and experiment areas is progressing satisfactorily.
- ✦ Testing and commissioning needs still to be organized.

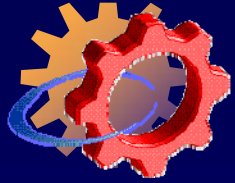


Status of data exchange systems

System	Instrumentation	Eqmt. LHC side	Eqmt. EXP Side	Application LHC side	Application EXP Side	cabling
TTC	- Rx/Tx-modules (A & D) validated by AB/RF ^[1] AB/RF → procurement Prod. Apr07 RF2TTC proto-module under test (Dec 06) Prod. Feb07	~ 90 D links ~ 10 A links	RF2TTC proto ≥ Beg07 Fanout avail.	C library now dvpmt 1Q07	Charge of EXP C library now dvpmt	requested fibres installed except SR4, reserved by TS/EL team patch ≥ Beg07
BST	available	Included in TTC		end 06	Charge of EXP	Included in TTC
GMT	Available		VME (CRTV)	available	TTL trigger signals	requested
BPTX	Available		Pt8 ok Pt1 L ok follows LHC installation	none	Analog signal BPIM ^[2] /3B09	Under way
BRAN	In production		Pt 1,5 1st Q07 Pt 2,8 2nd Q07	DIP	DIP	done
BIS	1st H 07	1st H 07	1st H 07		Charge of EXP	Under way
MCS/MSS	1st H 07	1st H 07	1st H 07		Under way	Under way

[1] http://ttc-upgrade.web.cern.ch/ttc-upgrade/New_system/TTCupgrade_System_Test_report.pdf

[2] Proposal for a Beam Phase and Intensity Monitor (LHCb 2006-055)



DIP naming scheme *

Semantics: <LHC entity>.<LHC entity code>.<location>.<function>:<value>

BCT.B1:INTENSITY Beam intensity from DC beam current transformer
BCTDC

BCT.B1:INTENSITY_BUNCHES

Bunch intensities from fast beam current
transformer BCTFR

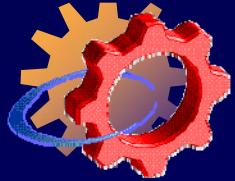
BPMI.86505:POSITION_H

Beam position horizontal in T18

BQM.B2:TUNE_V

Beam tune vertical from tune measurement

* EDMS 473091 and EDMS 473086



Beam Condition Monitors (BCM)

STATUS	
Type of Data Exchange	Interlocks
Person responsible	
ALICE person responsible	Marc Tavlet
Hardware to be installed	Diamond detectors and electronics, interface with CIBU.
Location of Hardware interface	Rack C28 for Beam dump CIBU
Current Status	Still much to do. Diamond detectors irradiation test 8 Feb. 2007. Acquisition chain defined up to TELL1 board.
Action Needed	BCM sensor integration (mounting, co-existence with bake-out). Distance between sensors and FEE. Wired logic to generate Beam permit Signal for CIBU. Dose simulation.
Cost to ALICE	Cost of diamond detectors and electronics unknown.
Comments	