Minutes of LHC-CP Link Meeting 29

Subject	:	LHC Controls Project	
Date	:	22nd October, 2002	
Place	:	SL auditorium	
Participating Groups	:	LHC-ACR	no representative,
		LHC-ECR	no representative,
		LHC-IAS	A. Rijllart , H.Milcent,
		LHC-ICP	F. Rodriguez-Mateos, A. Hilaire,
		LHC-MMS	no representative,
		LHC-MTA	no representative,
		LHC-VAC	R. Gavaggio,
		PS-CO	B. Frammery, J. Lewis, J. Serrano, W. Heinze, F. Di Maio,
		SL-AP	no representative,
		SL-BI	J-J Gras,
		SL-BT	E. Carlier, H. Verhagen,
		SL-CO	A. Bland, E. Hatziangeli, M. Jonker, P. Charrue, G. Beetham, P. Nouchi, J. Andersson, K. Kostro,
		SL-HRF	A. Butterworth, E. Ciapala,
		SL-MR	R. Billen,
		SL-MS	no representative,
		SL-OP	J. Wenninger,
		SL-PO	Q. King,
		ST-MA	apologies.
Others	:	A. Daneels (Planning), R. Lauckner (Chair), M.E. Angoletta (Scientific Secretary), B. Puccio, R. Schmidt (Machine Protection), M. Tyrrell (Alarm Sub-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 Meetings. 2. Accelerator timing strategy proposal (J. Lewis).	

1. **Matters arising from Previous Meeting**

   There are matters arising from previous meetings. However, the discussion is postponed to a future meeting.

2. **Accelerator timing strategy proposal.**

   R. Lauckner recalled briefly how the timing strategy proposal came about. In 1999 the Timing Working Group (TIMWG) was created, with the mandate to "take into account the requirements from accelerator operation and the needs of the users to establish a clear philosophy for timing associated with LHC". The TIMWG identified several functional requirements for LHC Timing. Julian Lewis (PS/CO) proposed a new strategy for their implementation to the SPS-LHC Technical Committee (SLTC) of July 2, 2002. For details on this proposal, see the PS/CO/Note 2002-167 (Tech), "LHC Timing Strategy", September 2002. The SLTC concluded that the AB-CO Group and the LHC-CP should undertake a review of all possible options for LHC Timing and report back with a firm proposal has been reached, including a cost estimate and installation schedule.

   Julian Lewis presented an updated view of his proposal in a talk to the LHC-CP entitled "A proposal for a CERN accelerator Timing Strategy". There were several motivations for the proposed timing strategy. Julian underlined how the merging of PS and SL Control Groups stimulated the need of a common timing structure, with the aim to reduce development and maintenance costs by standardising the approach. In addition, this would allow a better usage of CERN accelerators, providing more flexibility, one interface only (in the common control room) and new features such as SPS as a multicycling machine. Another aim of the proposal is to isolate the timing client from the implementation details, therefore allowing changing or upgrading the implementation without affecting existing clients. The proposed Timing Structure would also allow deploying a simpler user interface.

   The Timing System is configured by the Oracle Database according to pre-determined configuration data. It receives interlocks events and clocks as inputs and gives pulses as outputs. The Timing System interfaces with two software layers: Front-End systems and machine operator applications. Applications interface with the Timing System via the operations interface tools and the middleware. Front-End systems interface via the Timing API (Application Programming Interface) provided by CO and receive interrupts for synchronisation. Julian underlined that developers should use only the provided interface to access the Timing System and that any attempt to directly access it is unsupported.

   There are two different types of timings: the ones directly generated by the Central Beam and Cycle Management (CBCM) system and those locally generated by a timing receiver. Some of the characteristics defining a timing are declared as static variables in the Oracle Database, others as dynamic (run-time). The user can change the run-time characteristics by using the Middleware. The timing name is an example of a static variable. For a locally generated timing, a static variable is the central timing triggering it, while another indicates in which Device Stub Controller (DSC, PS jargon indicating a VME crate) it is located. Examples of the dynamic variables are the cycle ID, the operating mode and a variable indicating whether the timing is enabled or not.

   The Master Timing Generator (MTG) is the main "actor" needed to generate a timing pulse. Several inputs are taken by the MTG, such as Beam Coordination Diagrams (BCDs, up to 32 or other small integer will be loaded in each MTG), external timing and conditions (such as interlocks, requests, inhibits) and Timings descriptions (CTIM). These inputs are then elaborated with a "logic glue" to provide Events and PTIMs, which in turn are used by the Timing Receiver module (TG8) to produce telegrams and timing events.

There are two interfaces to the MTG from an operator viewpoint, depending on whether the timing for the considered accelerator is strongly coupled with the injector chain or is independent, i.e. loosely coupled. The PSB, CPS and SPS machines are strongly coupled with each other. The LHC machine is strongly coupled during the filling process and loosely coupled during the collision mode.

Jean-Claude Bau wrote the Strong Coupling BCD editor. Spare cycles (indicated in yellow in the slides) will replace the operational ones, in case these are not possible.

The Antiproton Decelerator (AD) is a machine very similar to LHC concerning timing requirements. It is strongly coupled at injection and loosely coupled during the cycle, which lasts approximately 90 seconds at least and can be much longer, depending on the setup.

The CBCM clock is indirectly generated from the Global Positioning System (GPS) timing by using the outputs of a HP5853A Frequency Reference Generator, namely a 10 MHz and a synthetic One Pulse Per Second (1 PPS) signals.

CBCM inputs include the two signals generated by the HP Frequency Generator, a 40 MHz signal obtained by multiplying by 4 the 10 MHz signal in a PLL, a 1 KHz event clock and the 1.2 seconds synchronisation clock. CBCM inputs also include beam parameters such as beam energy and intensity, which are critical safety factors. B. Puccio asked what happens from a safety point of view if, for instance, the Power Supply is down. Julian answered that of course the system crashes. He underlined also that the MTG system will include masters and slaves, with no automatic switch between them. However, for maintenance purposes it is possible to carry out some intervention on a slave, then seamlessly switch the control from master to slave and carry out interventions on the former. Julian added then that from a reliability point of view, having just one MTG is the best solution. Having two MTGs instead of one in fact means doubling the probability that something goes wrong. Other CBCM inputs are external conditions and interlocks, the fourth harmonic of the revolution frequency and the bunch clock. The Coordinated Universal Time (UTC) will also be one input; it is not yet clear whether it will be carried via Network Time Protocol (NTP) or other means.

Concerning CBCM outputs, the CBCM might drive the Beam Synchronous Timing (BST) systems, with 4 signals named *LHC BST Ring-1*, *LHC BST Ring-2*, *LHC BST Expmt*, *LHC BST 23 μs.* At the time of the presentation this was not confirmed, yet.

The CBCM will also drive the General Machine Timings (GMT) systems for AD, CPS, PSB, SPS and LHC. For SPS a legacy signal (*SPS GMT Legacy*) will also be available, to provide compatibility with the slow four-events-per-millisecond mode. M. Jonker then proposed a technical discussion on the need to provide two parallel systems. He proposed to combine the SPS legacy cable with the SPS one. Julian answered that the cable bandwidth is not sufficient to have them both in the same cable.

The main difference between the SL and the PS approach to timing is that in SL the basic concept is the “Event”, while in PS it is the “Telegram”. The PS approach is the one envisaged for LHC. Telegrams are sets of named values for an accelerator. They describe the present and the next 1.2 seconds basic periods. Telegrams carry information about machine parameters such as bunch number, ring, intensity per ring, operation mode. They carry also information useful to the control system, such as tagging information and time stamps. For instance, the Beam ID is a tagging information that allows tracking back to the beam injector in case of malfunction.

A telegram describing the current basic period is sent together with the one describing the next basic period. They are stored in a buffer located in the receiver and the telegram describing the current period is the active telegram. A Ready Event telegram is used to specify when the telegram describing the next period can become the active one. Answering a question from R. Schmidt, Julian specified that there is one Ready Telegram Event for each machine.

In a telegram, 2 bytes are reserved to specify the value of a parameter. Q. King underlined that 16 bits might not be enough for beam parameters in a high precision machine like LHC. Julian answered that it is not defined what information needs to be transmitted and that in the future CO might provide more bits to be allocated to the transfer of beam parameter values.

Several hardware modules are envisaged for the LHC timing implementation. See the slides for a detailed description.

The Control Timing Generator (CTG) module pilots the timing distribution network. It is a VME card that accepts as inputs all 4 signals generated by the CBCM clock (see above) and 2 BST clocks. It pilots a GMT network for each accelerator and could pilot a BST network. Each MTG will include as many as 10 such modules.

The Timing Receiver CTX1 module is a VME module that incorporates a digital PLL. Thanks to this PLL, CTX1 can for instance continue driving the magnets even if the corresponding MTG stops functioning. The first version of CTX1 is currently running in the CO lab.

The Timing, Trigger and Control Beam Instrumentation (TTCbi) receiver is a PMC module that decodes and stores BST messages and triggers BST equipments. It provides telegram data to Real Time Tasks (RTTs) and, as an extension of the original specifications, it can also receive telegrams through the BST network.

The Timing Receiver CTX8 module takes care of the high precision timing for LHC and will replace the TG8 for new developments. It will come in two formats: VME and PMC. The latter will have a limited functionality. The CTX8 will probably not replace the CTX1, a discussion currently is going on with Q. King concerning this.

Julian then listed the timing distribution networks and the media used for carrying the signals (see slides). K. Kostro expressed his concern about not having enough bandwidth in the cables.

Julian concluded his presentation with the foreseen developments timescale. BTS studies will be done next year, to assess whether the BST can be driven from the CBCM module. Any requirements for that should be expressed now. The CBCM will be installed in the Prevessin Control Room (PCR) because in PS there are no critical requirements and also because the fibre optic cables are already available in the PCR. Meanwhile, CO needs precise definitions of LHC injection scenarios and operations during physics. Furthermore, they need requirements for interlocks, events from Power Supply and RF functions, in order to allocate resources and responsibilities.

The long (1 ½ hour) and thorough presentation ended with several questions.

F. Di Maio asked about the TG8 backwards compatibility. Julian answered that both generators and receivers will be backwards compatible.

G. Beetham enquired about the meaning of the term “precise” about the definition of LHC injection in Julian’s last slide. Julian answered that the word “precise” doesn’t mean “frozen”, and that it would be too limiting to freeze anything at this stage.

P. Charrues enquired about what software actions have to be done to move the front-end software to the new timing. Julian said that probably all synchronisation parts in the applications should be re-done. CO will maintain the legacy part until all software applications are upgraded. In the worst case, two systems will have to be maintained in parallel. R. Lauckner suggested that such discussion should be continued somewhere else.

M. Jonker and R. Schmidt expressed their concern about the reliability of the whole system. In particular, M. Jonker said that the hardware proposed was fine, but not the way to use it. Julian answered that nothing is frozen yet, but one should say also why we should select a system different from the one used in PS. In fact, the PS timing system could control SPS, and the SPS one could not control PS.

F. Rodriguez-Mateos asked whom exactly one should contact to specify requirements or other capabilities. For instance, A. Bland remarked that the post-mortem capabilities had not been mentioned in the talk. Julian answered that the best strategy is to contact both himself and G. Beetham.

Outstanding Points

Does the proposed system offer sufficient reliability?

Ensure that the TIMWG conclusions have been addressed

Ensure proposal meets LHC filling requirements

Provide a migration strategy for current SL Users (Smart Timing)

Long-Term Actions	**People**
Common power circuit database requirements	R. Schmidt
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 M. E. Angoletta

A Proposal for a CERN accelerator Timing Strategy

AB/CO/HT October 2002

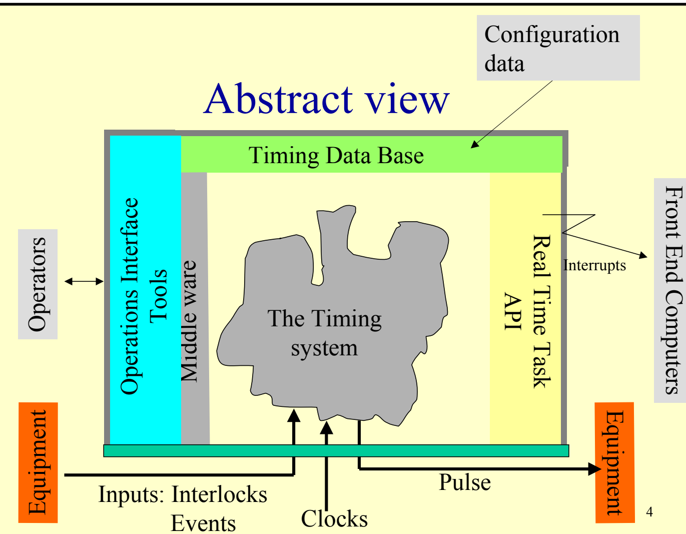
Motivation

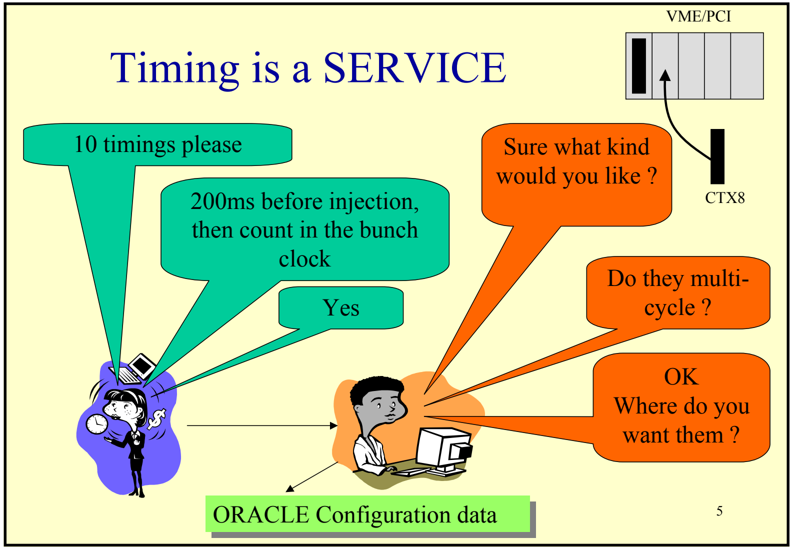
- PS and SL division merger to form AB
- Reduce costs and maintenance
  - Make it as simple as possible, reduce diversity, reliable
  - Standardization of approach, reusability
  - Better maintenance and exploitation
  - Abstraction layers hide implementation details
- Better usage of CERN accelerators, LHC Injectors
  - Flexibility
  - Automation
  - Improvements through modern technology
  - SPS Multi-Cycling
- Improved operational tools
  - Simplification of user interface
  - One model for all
- LHC Timing

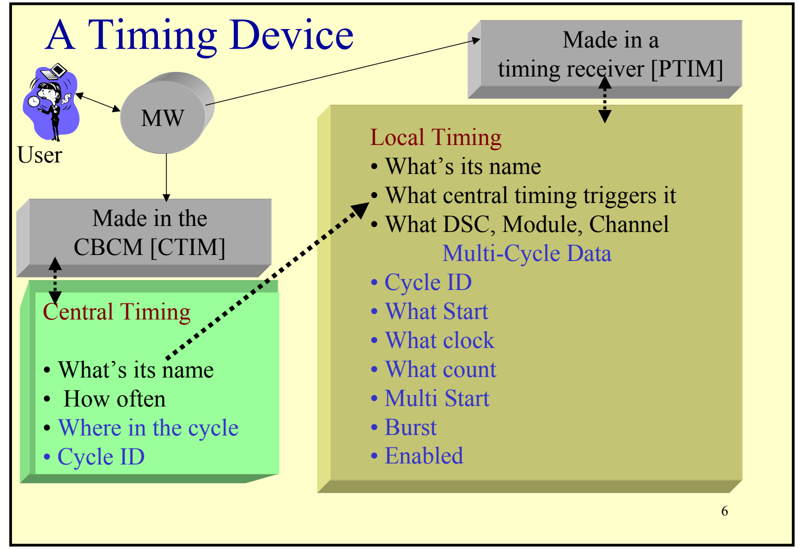
Overview

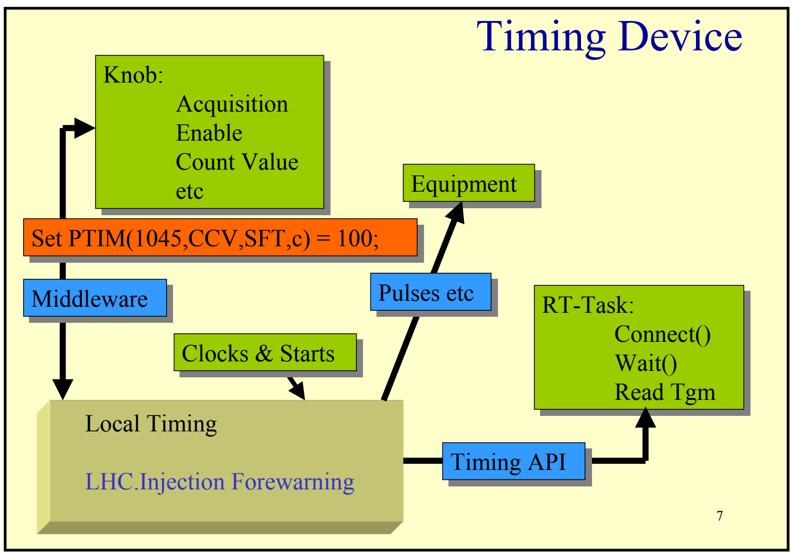
- Concepts
- Central cycle management and Sequencing
- The timing system interfaces
- Distribution
- Keeping time with UTC
- What will be distributed, and how
- Hardware modules

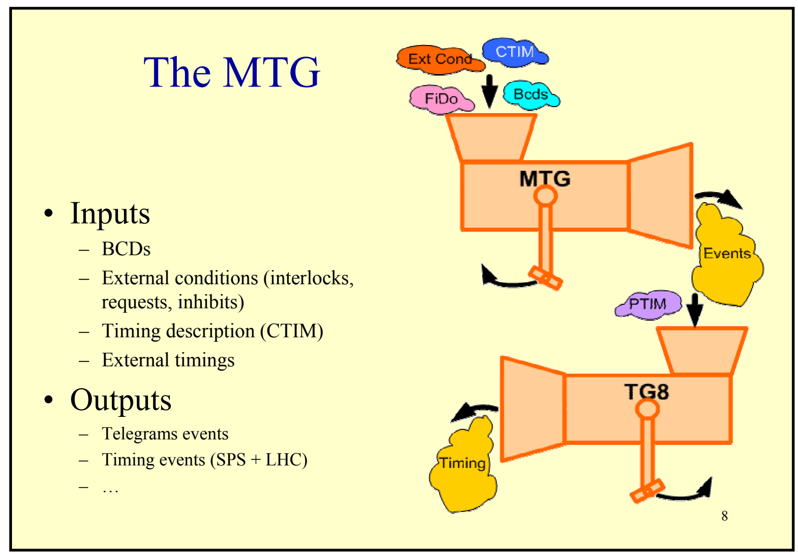
Abstract view



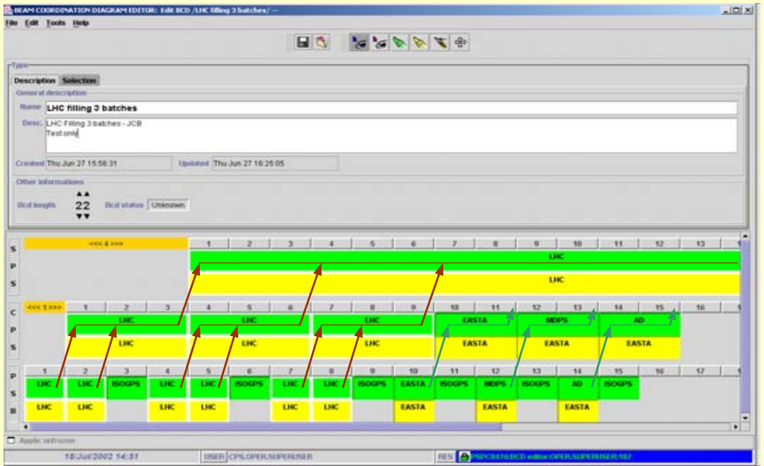

Timing is a SERVICE
VME/PCI
CTX8
10 timings please
200ms before injection, then count in the bunch clock
Yes
Sure what kind would you like ?
Do they multi-cycle ?
OK Where do you want them ?
ORACLE Configuration data
5


A Timing Device
User
MW
Made in a timing receiver [PTIM]
Made in the CBCM [CTIM]
Central Timing
• What's its name
• How often
• Where in the cycle
• Cycle ID
Local Timing
• What's its name
• What central timing triggers it
• What DSC, Module, Channel
Multi-Cycle Data
• Cycle ID
• What Start
• What clock
• What count
• Multi Start
• Burst
• Enabled
6

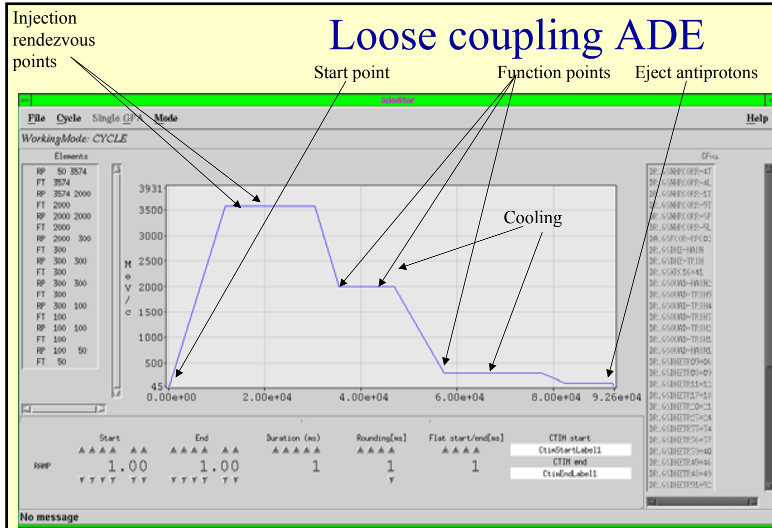

Timing Device
Knob:
Acquisition
Enable
Count Value
etc
Set PTIM(1045,CCV,SFT,c) = 100;
Equipment
Middleware
Pulses etc
RT-Task:
Connect()
Wait()
Read Tgm
Clocks & Starts
Local Timing
LHC.Injection Forewarning
Timing API
7


The MTG
Ext Cond
CTIM
FiDo
Bcds
MTG
Events
PTIM
TG8
Timing
• Inputs
– BCDs
– External conditions (interlocks, requests, inhibits)
– Timing description (CTIM)
– External timings
• Outputs
– Telegrams events
– Timing events (SPS + LHC)
– …
8

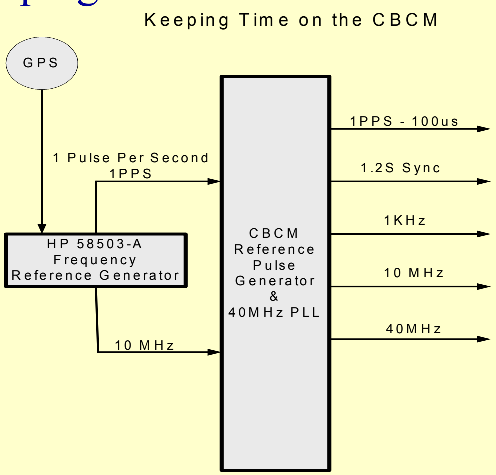
Strong Coupling BCD Editor



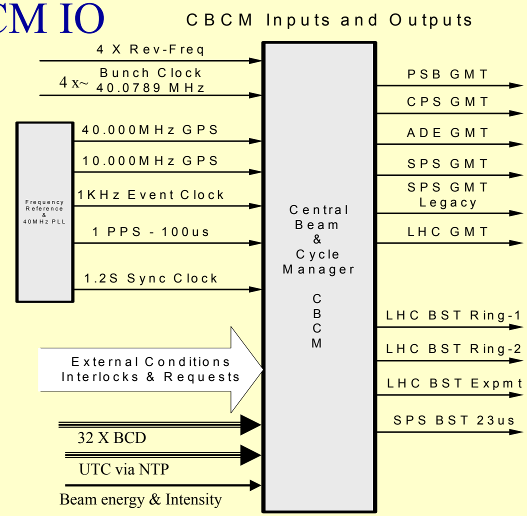
Loose coupling ADE



Keeping Time with UTC



CBCM IO



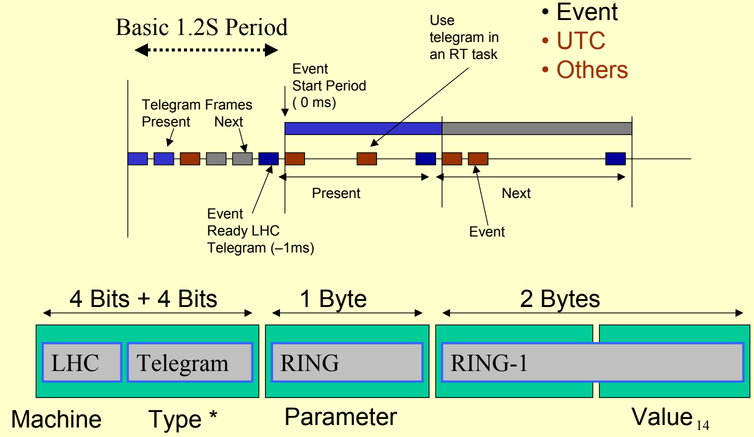
What exactly are Telegrams ?

- A Telegram is a set of named values for an accelerator. One per machine
- Telegrams describe the present and next 1.2S basic periods
- Telegrams have validity periods (N x 1.2S)
- Telegrams and events together coordinate multi-cycling and sequence changes. (PPM)
- Telegrams can be accessed at any time by clients.
- Telegrams are not part of the timing frames

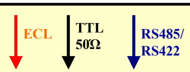
Bunch Number, Ring, SPS Beam intensity, LHC Beam Energy,
Intensity per Ring, Operation mode,
Controls information for tagging data, Cycle ID, Beam ID,
Whatever else the clients need.

Telegrams

- Present Telegram
- Next Telegram
- Event
- UTC
- Others

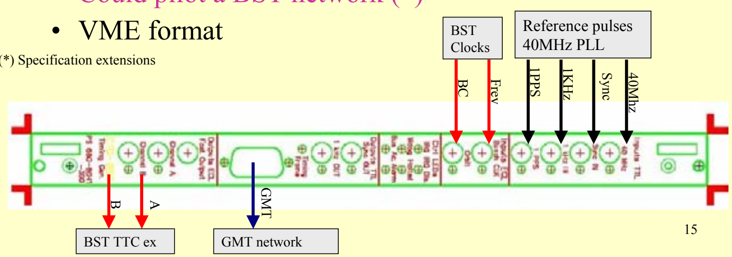


The CTG module



- Encodes with 40.000 MHz, or …
- Can accept a 40.0789 MHz Encoding clock
- Accepts SYNC inputs, 1PPS, 1.2s, FREV
- Keeps UTC with 25ns precision
- Pilots a GMT network for each accelerator
- Could pilot a BST network (*)
- VME format

(*) Specification extensions



The CTX1

- Receives the GMT network
- Incorporates a digital PLL
- Receives telegrams (*)
- Provides bus interrupts from timing frames (*)
- Receives UTC time
- Provides output pulse and ETO interrupt
- Drives gateways even when GMT broken
- VME format

(*) Specification extensions

TTCbi

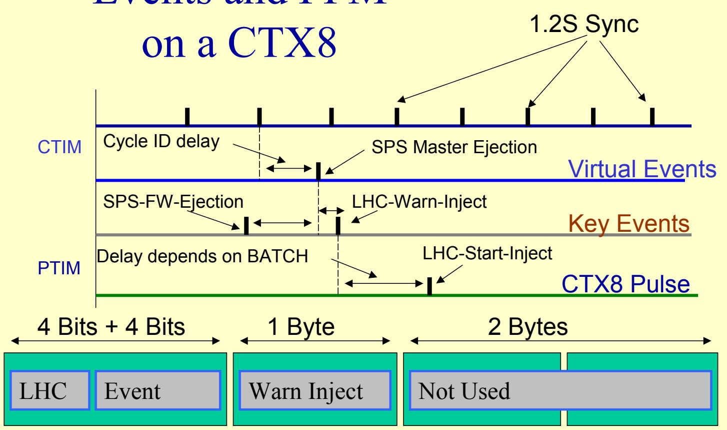
- Receives BST timing
- Triggers BST equipment
- Provides Bunch Clock and FREV
- Can provide telegram data to RT tasks
- PMC format
- Receives telegrams (*)

(*) Specification extensions

The CTX8 module

- Replaces the TG8 for new developments
- Receives the GMT
- Provides the 40.000 & **10.000 MHz** (PP < 1ns)
- 8 X 50MHz configurable counters
- Autonomous driving of PPM timings
- High precision TDC on board (100ps)
- Provides telegrams to RT tasks
- Supports UTC time
- VME and PMC format (PMC reduced function)

Events and PPM on a CTX8



Timing Distribution & media

- TTC => Data, Bunch Clock, Frev (PP~1ns)
- BST => Over TTC, Data is BST message
- GMT=> Events, 40MHz, Telegrams (PP~1ns)
- Optical Fibers => Long haul, Fast stuff
- Copper => Short distances, RS422
- Ethernet => Telegrams, and sync data

What Next: Finalized proposal

- Finish off the CTX1, December 2002.
- Finish off the CTG, March 2003, BST Studies and requirements needed now.
- Complete the PMC version of the CTX8 August 2003, then the VME version.
- Install a CBCM behind the PCR, shutdown 2003.
  - Pilot SPS legacy and New AB/CO GMTs and the SPS BST
  - Pilot the LHC GMT and BSTs
  - Pilot all PS complex, Linacs, PSB, Isolde, CPS and ADE
- Meanwhile be smart when doing SPS timing installations (TI8: SPS Ejection towards LHC)

Meanwhile we need

- A precise definition of LHC injection scenarios and its operation during physics: Dump, Pause etc.
- CBCM interlocks and events from SPS and LHC, Power converters and RF functions
- Requirements for timings cables, progressing well
- Then, we can provide detailed cable layouts
- To determine responsibilities, progressing well
- To allocate resources, especially cabling
- Rendezvous with rest of AB/CO Dec 2002 for …
  - A clear proposal for what an LHC/SPS front-end is, what CO support it has, libraries, COSCOTO, etc
  - Task synchronization management API
  - Middleware
  - Multi-cycling (Contracts vs. GM)