Progress Report of the TimWG

- Members
- Objectives (Mandate)
- Meetings
- List of Consultants
- Signals Identified
- Overall Pictorial Presentation
- Topics to be Resolved
- Tests in Progress (Including Timescales)
- Conclusions (TimWG + PLC)

TimWG Members

Gary Beetham	SL/CO	Chairman
Philippe Baudrenghien	SL/HRF	
Etienne Carlier	SL/BT	Secretary
Michel Jonker	SL/CO + SL/OP	
Julian Lewis	PS/CO	
John Pett	SL/PO	
Adriaan Rijllart	LHC/IAS + IWG	
Jean-Jacques Savioz	SL/BI	

TimWG Mandate (April 1999)

"Synchronisation and timing is required for various systems in the LHC accelerator. The WG should 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 summary of the WG should be documented as a functional specification, for the end of September 1999.

Timing and synchronisation includes domains such as:

Beam synchronous timing for injection and extraction, experiments, RF, beam instrumentation and other accelerators in the injector chain.

"Cycle" timing for synchronisation of settings for distributed machine components such as cavity voltages and magnet currents.

Synchronisation of data acquisition systems for post-mortem analysis after a beam dump or equipment fault. This includes the magnet protection system, the cryogenic system, the vacuum system, power converters and possibly other systems to be identified.

Timing references for the archiving and tagging of data.

For each domain the clients, their requirements (as an example, the precision of the timing) and their geographical location should be identified.

The WG should formulate recommendations in order to avoid unnecessary divergence between solutions for the different systems.

The working group will report to PLC, and keep both TCC and MARIC informed whenever appropriate."

Objectives

- Determine all potential clients for LHC timing, including transfer line users
- Identify all their timing requirements
- Specify the precision required and the geographical location for each signal
- But not to propose solutions (yet)
- Avoid unnecessary divergence
- Post-mortem data acquisition analysis
- “Establish a clear philosophy for the timing associated with LHC”

TimWG MEETINGS			
Meeting	**Date 1999**	**Speaker**	**Subject/Requirements**
1	15 April	P. Proudlock	Introductory remarks
		R. Lauckner	Mandate
		All	TimWG members timing interests
2	30 April	E. Carlier	Web page
		J. Pett	SL/PO timing
		E. Carlier	SL/BT timing
3	12 May	E. Tsesmelis	CMS test beams
		M. Jonker	SPS + LEP Timing
4	28 May	P. Baudrenghien	SL/HRF LHC timing
		A. Rijllart	LHC equipment group's timing
5	11 June	J-J Savioz	Beam instrumentation fast and slow timing
		J. Lewis	PS involvement in LHC timing
6	25 June	A. Swift	Timing policy for electricity control
		G. Baribaud	SPS experimental areas in the LHC era
7	9 July	Q. King	SL/PO WorldFIP timing
		R. Brun	SL/LRF WorldFIP timing
8	20 August	Q. King	LHC timing events based on absolute time
9	27 August	M. Jonker, M. Lamont	Timing requirements for machine operation
		P. Anderssen	NTP computer synchronisation
10	24 September	B. Taylor	Timing, Trigger & Control (TTC) for LHC Detectors

http://hpslweb.cern.ch/slbt/tim.html

TIMING CONSULTANTS		
NAME	GROUP	TOPIC
Guy Baribaud	SL/BI	SPS Experimental Areas
Philippe Baudrenghien	SL/HRF	SL/LHC RF
Gary Beetham	SL/CO	Machine Timing, GPS
Thomas Bohl	SL/HRF	SPS Hadron RF
Luca Bottura	LHC/MTA	Magnet Tests, String 2
Raymond Brun	SL/LRF	WorldFIP
Etienne Carlier	SL/BT	Injectors, Kickers, Q Measurements
Juan Casas	LHC/ACR	Cryogenics
Jose Luis Gomez Costa	LHC/ICP	Magnet Protection
Quentin King	SL/PO	Power Converters, WorldFIP
Michel Jonker	SL/CO	SL Machine Timing
Mike Lamont	SL/OP	SPS + LEP Operations
Robin Lauckner	SL/CO	Machine Controls
Julian Lewis	PS/CO	PS Machine Timing
Rolf Lindner	EP/LHB	LHC-B Test Beam Coordinator
John Pett	SL/PO	Power Converters, WorldFIP
Soren Poulsen	ST/EL	Electricity Control
Adriaan Rijllart	LHC/IAS	String 1/2 Acquisition, IWG
Shaun Roe	EP/ATT	ATLAS Tracking
Felix Rodriguez Mateo	LHC/ICP	Magnet Protection
Jean-Jacques Savioz	SL/BI	Beam Instrumentation
Rudiger Schmidt	LHC/ICP	LHC Philosophy
Pierre Strubin	LHC/VAC	CERN Vacuum
Arthur Swift	ST/EL	Electricity Control
Bruce Taylor	EP/CMD	TTC*
Emmanuael Tsesmelis	EST/LEA	CMS Beam Coordinator

* Timing, Trigger and Control (TTC) Systems for LHC Detectors – RD12

Signals Identified

- **FAST PULSED SIGNALS**
  - LHC Injection Pre-pulse
  - LHC Radio Frequency (RF)
  - LHC Bunch Frequency
  - LHC Revolution Frequency (Rev)
  - CERN 10 MHz
- **SLOW ENCODED SIGNALS**
  - 1ms Clock + Event Codes
  - Time of Day

LHC FAST INJECTION PREPULSE				
GROUP	CONTACT	PRECISION	LOCATION	COMMENTS
SL/HRF	P. Baudrenghien	<250ps	BA3 and SR4	Distributed from PCR
SL/BT	E. Carlier	1ns	UA23 + SR2	LHC Injection MK12
"	"	1ns	SPS – BA6	SPS Extraction MKE6
"	"	1ns	UA87 + SR8	Injection MK18
"	"	1ns	SPS – BA4	SPS Extraction MKE4
SL/BI	J-J. Savioz	1us	PCR	BST Master

An Injection Pre-pulse is generated at a fixed delay before the transfer of each "batch" from the SPS into LHC. One batch contains
243 SPS bunches and 12 batches are required to fill LHC. To compensate for the rise time of the LHC injection kicker, the last batch
contains less bunches, resulting in a total of 2835. The Injection Pre-pulses are generated in the SPS BA3 Faraday Cage.

LHC 400MHz RF				
GROUP	CONTACT	PRECISION	LOCATION	COMMENTS
SL/HRF	P. Baudrenghien	<250ps	BA3, SR4, UA43,UA47*	PCR Distribution
SL/BI	J-J. Savioz	100ps	LHC – Point 4	Q Meter, BCT
EST/LEA	E. Tsesmelis	?	LHC – Point 1	ATLAS
EST/LEA	E. Tsesmelis	?	LHC – Point 2	ALICE
EST/LEA	E. Tsesmelis	?	LHC – Point 5	CMS
EST/LEA	E. Tsesmelis	?	LHC – Point 8	LHC-B

LHC Radio Frequency (RF). 400.789 MHz at 450 GeV injection energy and 400.790 MHz at 7 TeV collision energy.
Generated in the LHC Faraday Cage and distributed from the PCR.
* UA43 and UA47 are klystron galleries at LEP point 4

LHC BUNCH FREQUENCY				
GROUP	CONTACT	PRECISION	LOCATION	COMMENTS
SL/HRF	P. Baudrenghien	<250ps	SR4, UA43, UA47*	Distribution from PCR
SL/BI	J-J. Savioz	1ns	All pits + alcoves + PCR	BST Connection?
EST/LEA	E. Tsesmelis	?	LHC - Point 1	ATLAS
EST/LEA	E. Tsesmelis	?	LHC - Point 5	CMS
EST/LEA	E. Tsesmelis	?	LHC - Point 2	ALICE
EST/LEA	E. Tsesmelis	?	LHC - Point 8	LHC-B

Bunch Frequency = 1/10 of Radio Frequency, i.e. 40.079 MHz. Bunch spacing is 24.95 ns.
Generated in LHC Faraday Cage and distributed from PCR.

LHC REVOLUTION FREQUENCY				
GROUP	CONTACT	PRECISION	LOCATION	COMMENTS
SL/HRF	P. Baudrenghien	<250ps	BA3, SR4, UA43, UA47	Distributed from PCR
SL/BI	J-J. Savioz	1ns	All pits+alcoves+PCR	Local resync BST
SL/BT	E. Carlier	5ns	SR6 + UA63 + UA67	MKA,B,D,QH/V. Redundant
EST/LEA	E. Tsesmelis	?	LHC - Point 1	ATLAS
EST/LEA	E. Tsesmelis	?	LHC - Point 5	CMS
EST/LEA	E. Tsesmelis	?	LHC - Point 2	ALICE
EST/LEA	E. Tsesmelis	?	LHC - Point 8	LHC-B

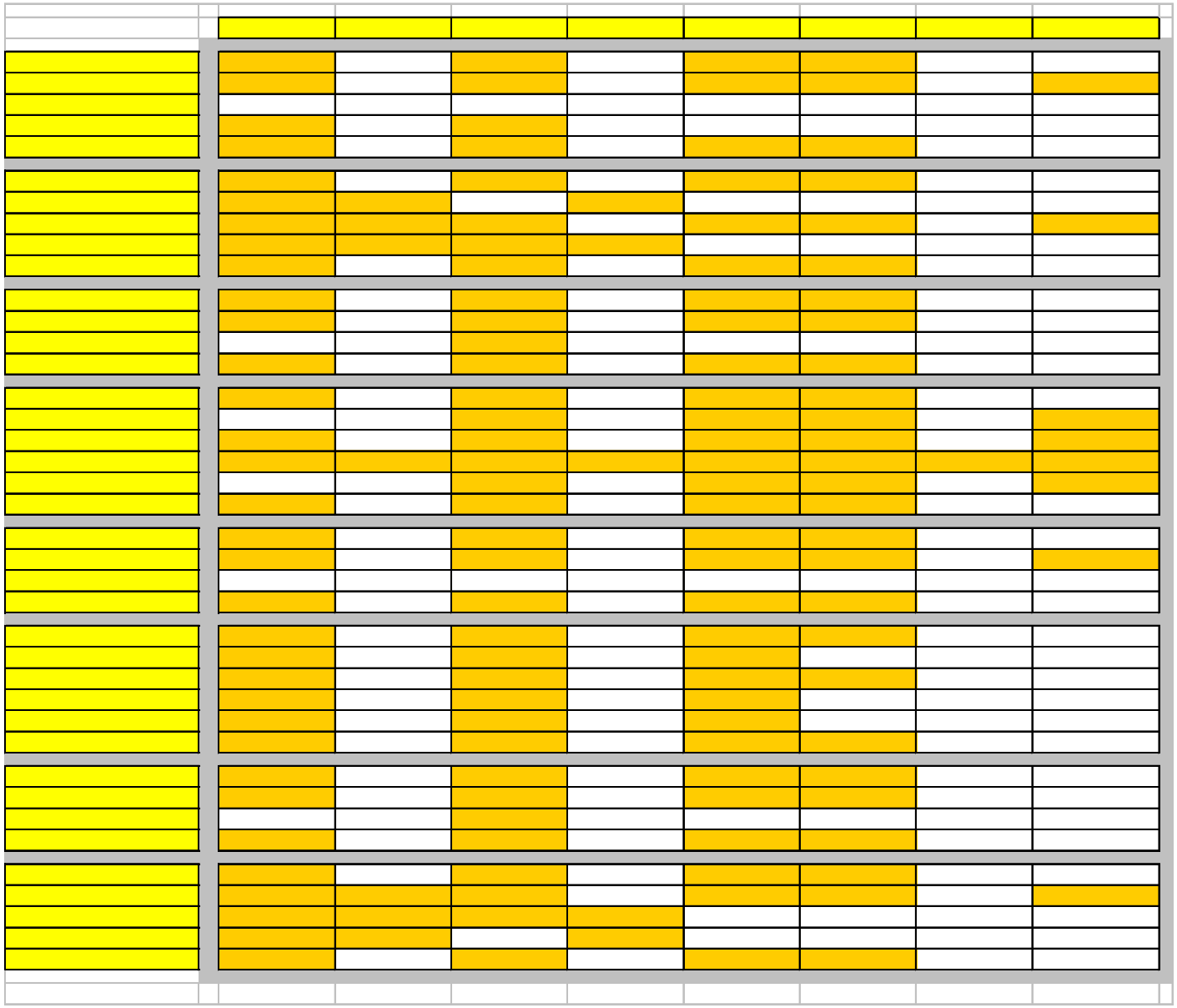
The Revolution Frequency is defined as the time it takes a bunch to complete one turn of the LHC circumference.
It is defined as Rev = RF/35640 where 35640 is the “Harmonic number” of the LHC. At injection, the frequency is 11.245kHz and at collision it is 11.246kHz. Generated in LHC Faraday Cage and distributed from PCR.
*UA43 and UA47 are the klystron galleries at LEP Point 4.

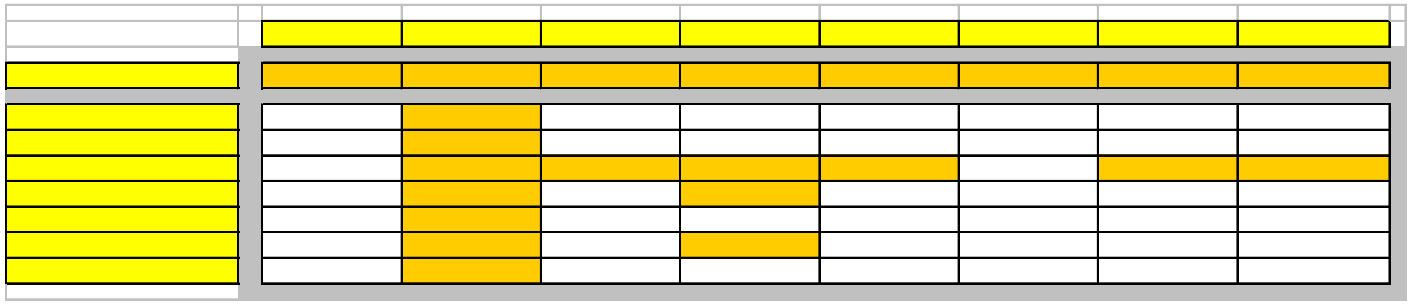
10 MHz				
Group	Contact	Precision	Location	Comments
PS/CO	J. Lewis	1 in 10-11	PS MNR/RA04	GPS Referenced
SL/HRF	P. Baudrenghien	<250ps	SPS BA3 Faraday Cage	
“	“	<250ps	PCR	
“	“	<250ps	LHC SR4 Faraday Cage	

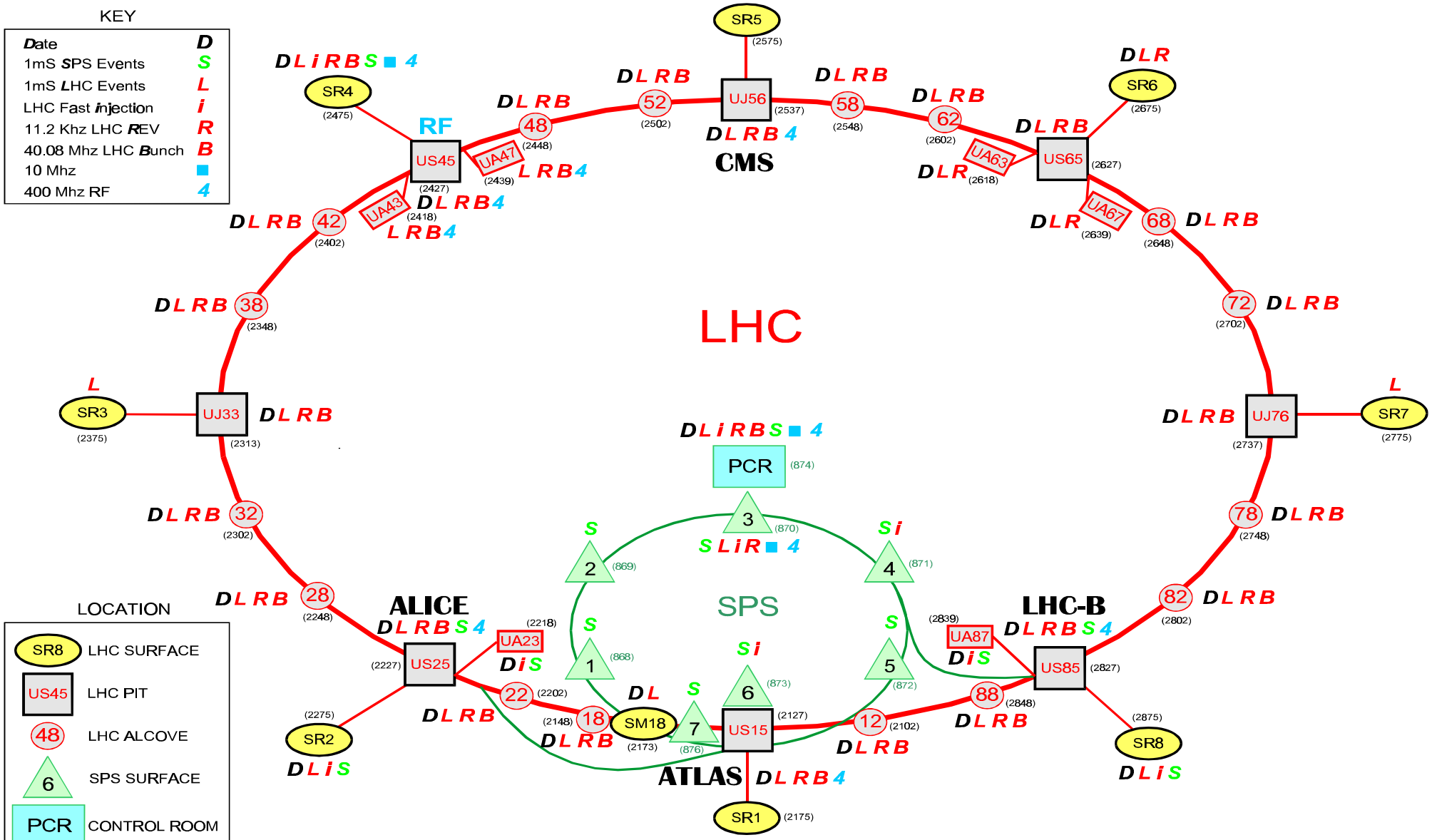
It will provide a common reference clock for all the CERN wide RF counters and generators.

LHC SLOW TIMING REQUIREMENTS							
GROUP	CONTACT	TYPE	PRECISION	RE-SYNC*	PROTOCOL+	LOCATION	COMMENTS
SL/PO	J. Pett	Date + LHC Events	15us	10ms	WorldFIP	Alcoves + pits + SM18	Referenced to GPS
SL/BT	E. Carlier	Date + SPS Events	10us	1ms	?	UA23 + SR2	Injection MK12
“	“	Date + SPS Events	10us	1ms	?	UA87 + SR8	Injection MK18
“	“	Date + LHC Events	10us	1ms	?	UA63/7 + SR6	Extraction MKB/D
“	“	Date + LHC Events	10us	1ms	?	UA63/7 + SR6	Aperture MKAH/V
“	“	Date + LHC Events	10us	1ms	?	UA63/7 + SR6	Q Meas. MKQH/V
SL/HRF	P. Baudrenghien	SPS Events	1us	1ms	?	BA3 and SR4	SPS Timing
“	“	LHC Events	1us	1ms	?	BA3, SR4,UA43,UA47	LHC Timing
SL/LRF	R. Brun	Date + LHC Events	15us	5ms	WorldFIP	Pt.4 pit + SR4	
LHC/ICP	F. Rodriguez	Date	1ms	1 Hour	WorldFIP	Alcoves + pits	AMC
LHC/MTA	L. Bottura	Date	1-10ms	1-10Hours	Ethernet	SM18	String 2
LHC/ACR	J. Casas	Date	1s	1 Day	Ethernet	Alcoves + pits	
LHC/VAC	P. Strubin	Date	1s	1 Day	Ethernet	Alcoves + pits	
ST/EL	A. Swift	Pulse	1ms	1 minute	Hardwired	Principle Electrical Substations (>150)	GPS referenced throughout system
SL/BI	G. Baribaud	SPS Events	10us	1ms	?	Experimental Areas	SPS Timing
“	J-J. Savioz	Date + LHC Events	15us	1ms	WorldFIP	Alcoves + pits + PCR	

* RE-SYNC is the maximum time between consecutive synchronisation actions.
+ It is not yet clear what will replace the MIL1553 Command/Response bus.







LHC TIMING REQUIREMENTS

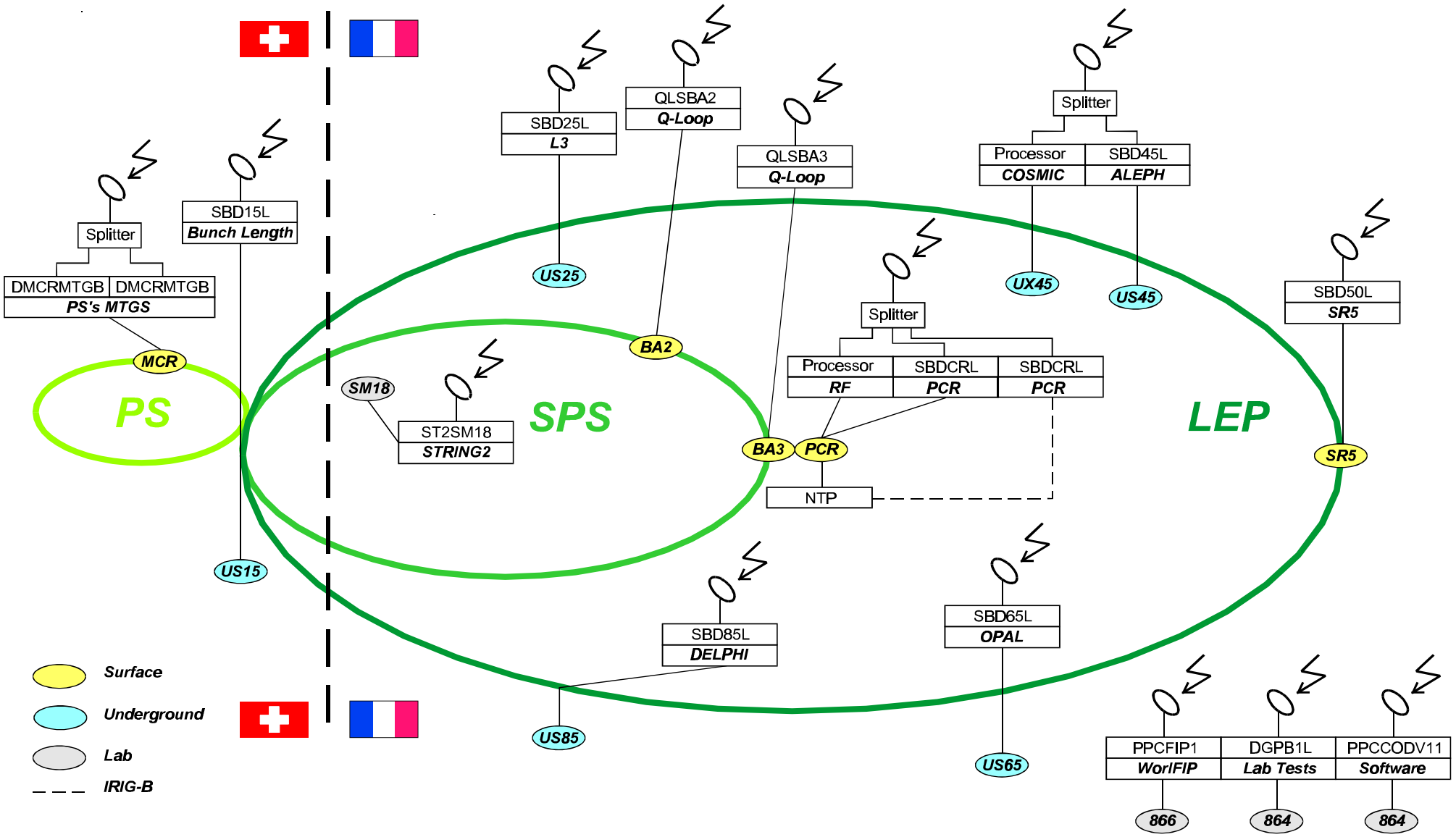
Topics to be Resolved

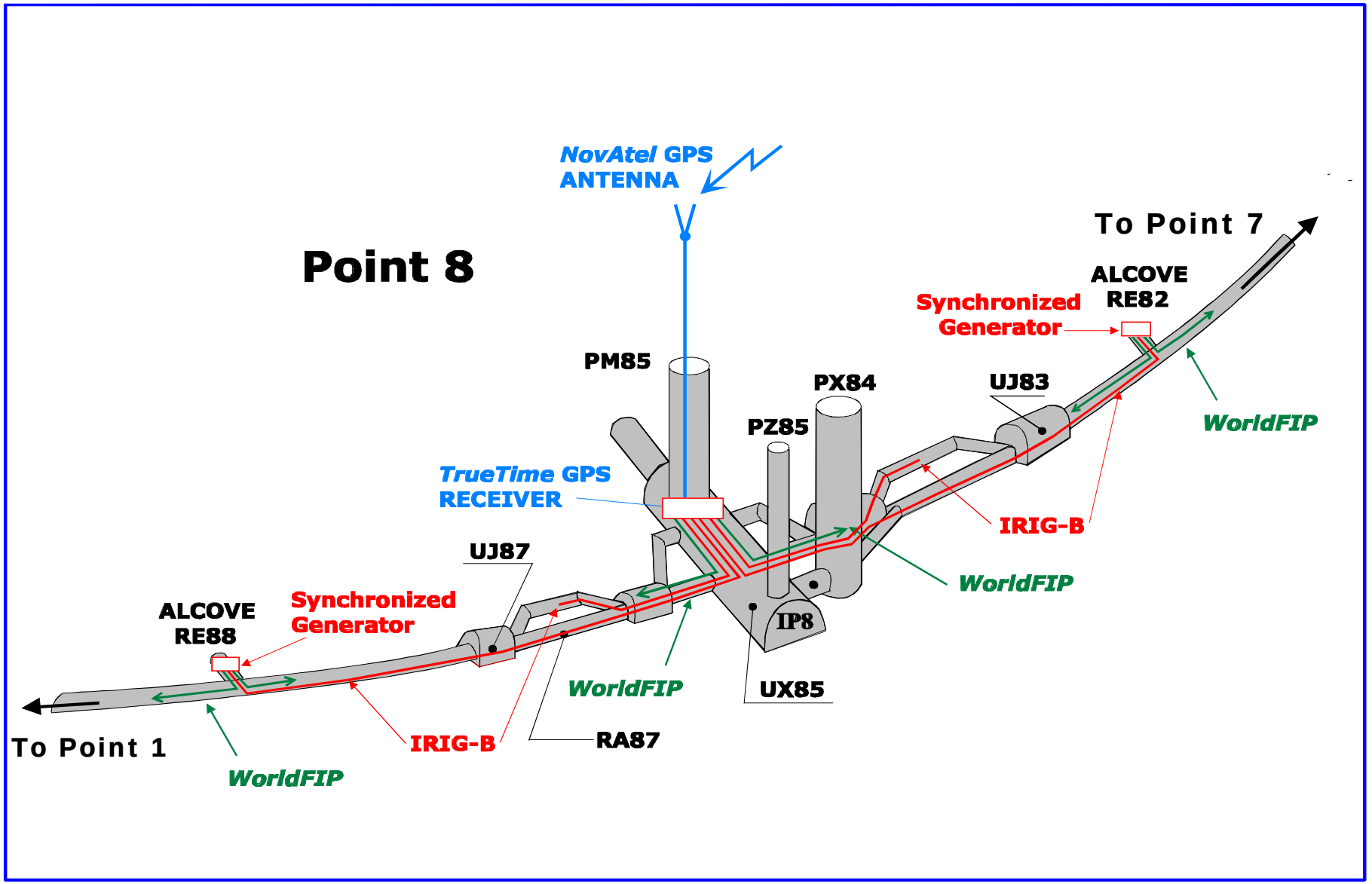
- Do we require a separate timing channel if we use events based on real-time?
- <20 us jitter, ref. to GPS, for WorldFIP cycles
- Can the IRIG-B Standard transmit GPS date time to the alcoves, using copper cable? (radiation)
- A unified time format for archiving and data tagging? At LEP, BCD, Unix, POSIX, NTP, are all used.
- Do we use an updated LEP type BST or a TTC system for LHC beam instrumentation?
- Will there be a TG8 replacement?
- Redundancy, reliability, determinism, monitoring
- Will there be two sets of RF signals?

Tests in Progress

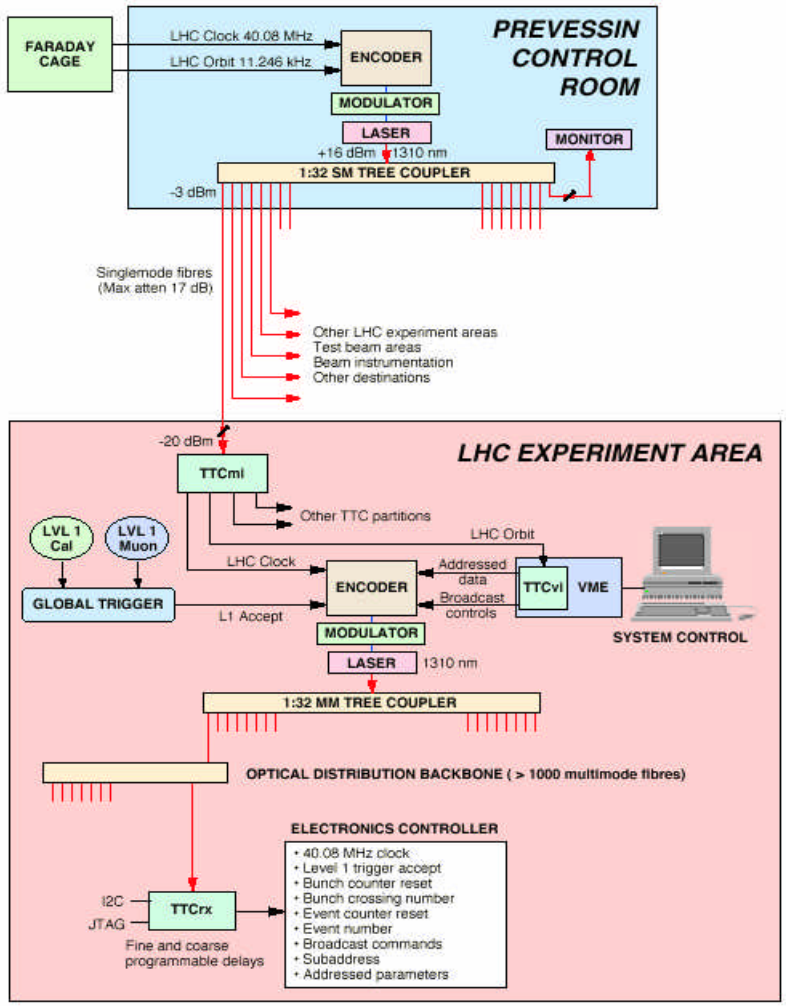
- **SHORT TERM (This year, early next year)**
  - GPS time synchronisation measurements
  - IRIG-B date transmission tests
  - LEP RF post mortem
  - PowerPC, GPS, WorldFIP communication
  - WorldFIP cycle jitter referenced to GPS
- **MEDIUM TERM (Next year)**
  - Connection of GPS time to PROFIBUS
  - String2 tests in SM18
  - CMS, ATLAS, LHC-B, beam tests + BST Transmission tests with TTC System
  - 10MHz

GPS INSTALLATIONS AT CERN




Point 8
NovAtel GPS
ANTENNA
To Point 7
ALCOVE
RE82
Synchronized
Generator
PM85
PX84
UJ83
PZ85
WorldFIP
TrueTime GPS
RECEIVER
IRIG-B
UJ87
WorldFIP
ALCOVE
RE88
Synchronized
Generator
IP8
WorldFIP
UX85
IRIG-B
RA87
To Point 1
WorldFIP

Overall TTC Distribution



Conclusions (TimWG)

- The TimWG has achieved many of the initial objectives.
- The short / mid term tests, should be monitored and their results presented to the TimWG.
- The periodicity of the TimWG meetings will be aligned with the test results
- To avoid divergence, aim for one “fast” plus one “slow” timing system for all LHC equipment
- It was considered too early to define the overall timing philosophy, PS<>SPS<>LHC, require input from operations and the CO-OP forum.

Conclusions (PLC)

- **"The TimWG should continue its work with the objective of producing a final definition of the timing before the end of 2000"**