

# CERN General Machine Timing System: status and evolution

The title text is overlaid on a row of five circles. The first circle is white with a light blue outline. The second, third, and fourth circles are solid light blue. The fifth circle is white with a light blue outline. Below the title, there are two solid light blue circles on the left and one white circle with a light blue outline on the right.

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15 February 2008



# Outline

- Motivation

- Why timing systems at CERN?
- Types of CERN timing systems.

- The General Machine Timing System

- General topology.
- Sequencing.

- The timing renovation project

- Why?
- How?

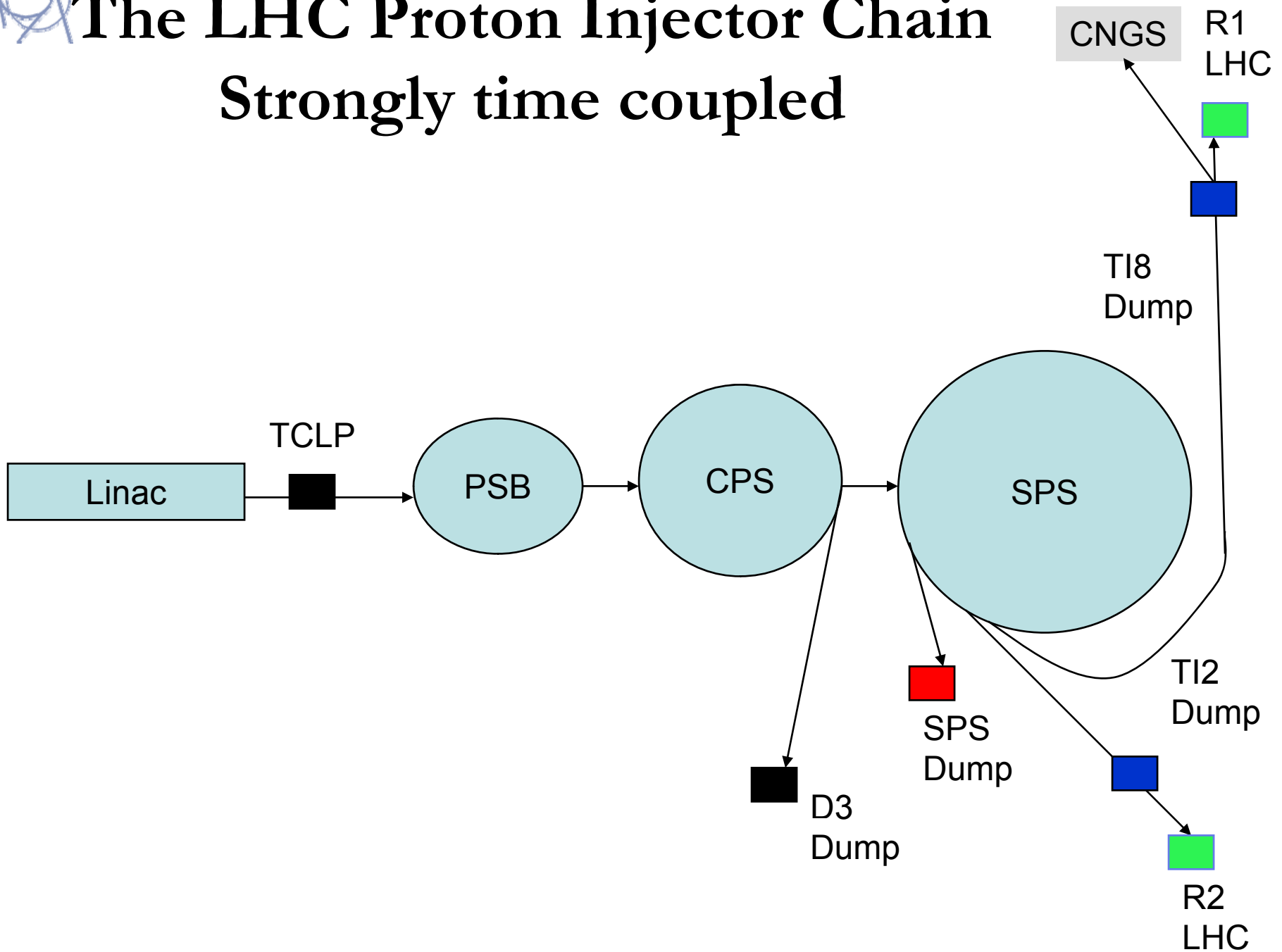
# Why timing systems at CERN?

- CERN is like a factory: its end products are BEAMS.
- Manufacturing a beam requires a series of sequential “cycles” in cascaded accelerators.
- Orchestrating this process we have the Central Beam and Cycle Manager, sending messages out.
- Receivers react on these messages by producing interrupts/front panel pulses.



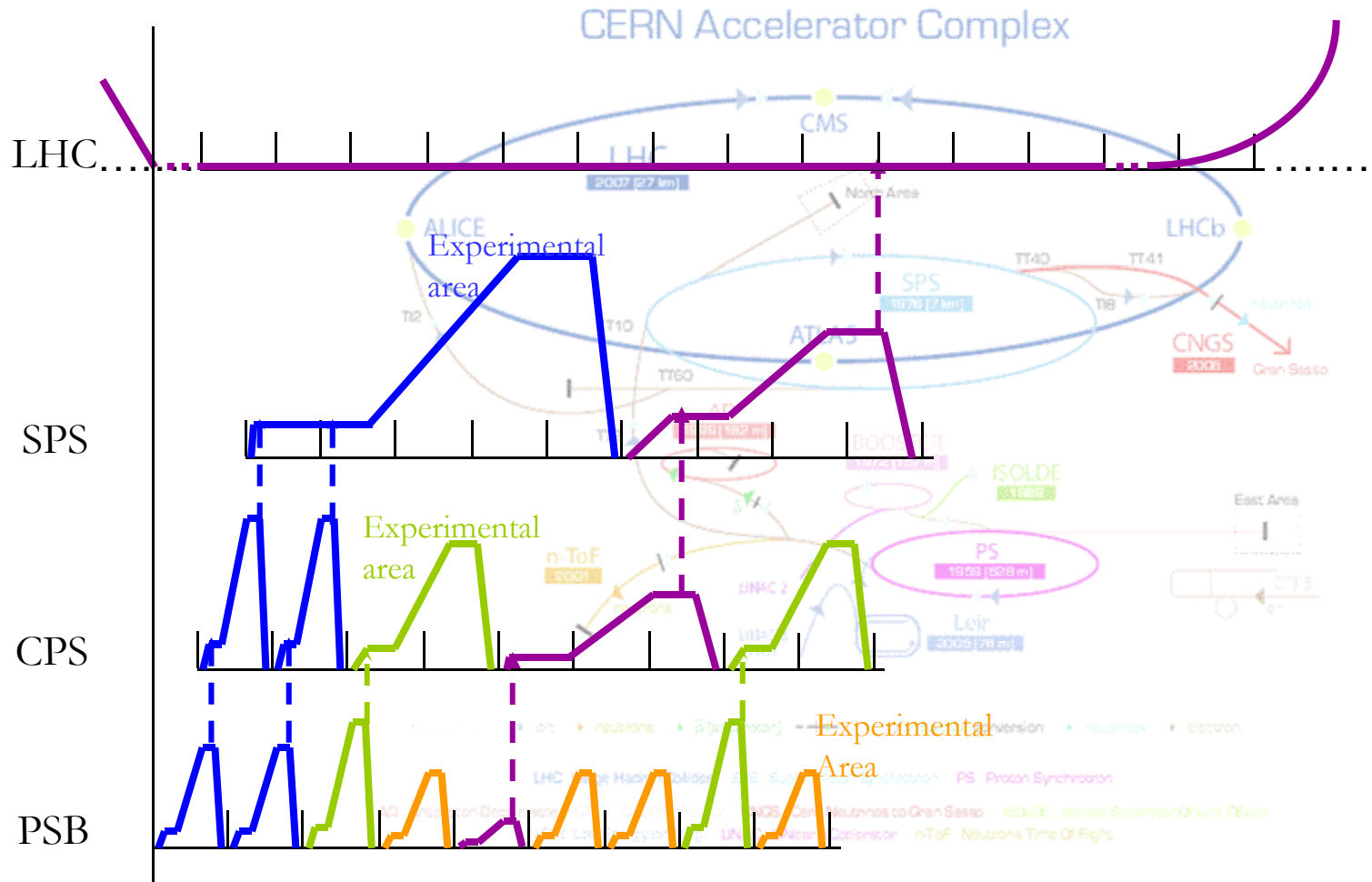
# The LHC Proton Injector Chain

## Strongly time coupled



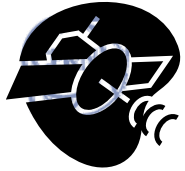


# CERN accelerator network sequenced by central timing generator



# Types of CERN timing systems

- **General Machine Timing (GMT)**
  - Based on UTC-synchronous 40.000 MHz.
  - 500 kbit/s over fiber and twisted pair (RS-422).
  - Granularity: 1 ms.
  - Jitter < 1 ns.
- **Beam Synchronous Timing (BST)**
  - Based on TTC technology (see below).
  - Encodes messages in TTC data channel using bunch crossing frequency for LHC (40.079 MHz). Fiber-based.
  - Granularity: 1 LHC revolution (89  $\mu$ s).
  - Jitter < 1ns.
- **Timing Trigger and Control (TTC)**
  - Technology to multiplex Revolution tick and data in a single stream.
  - Experiments use it without data to have better clock recovery.

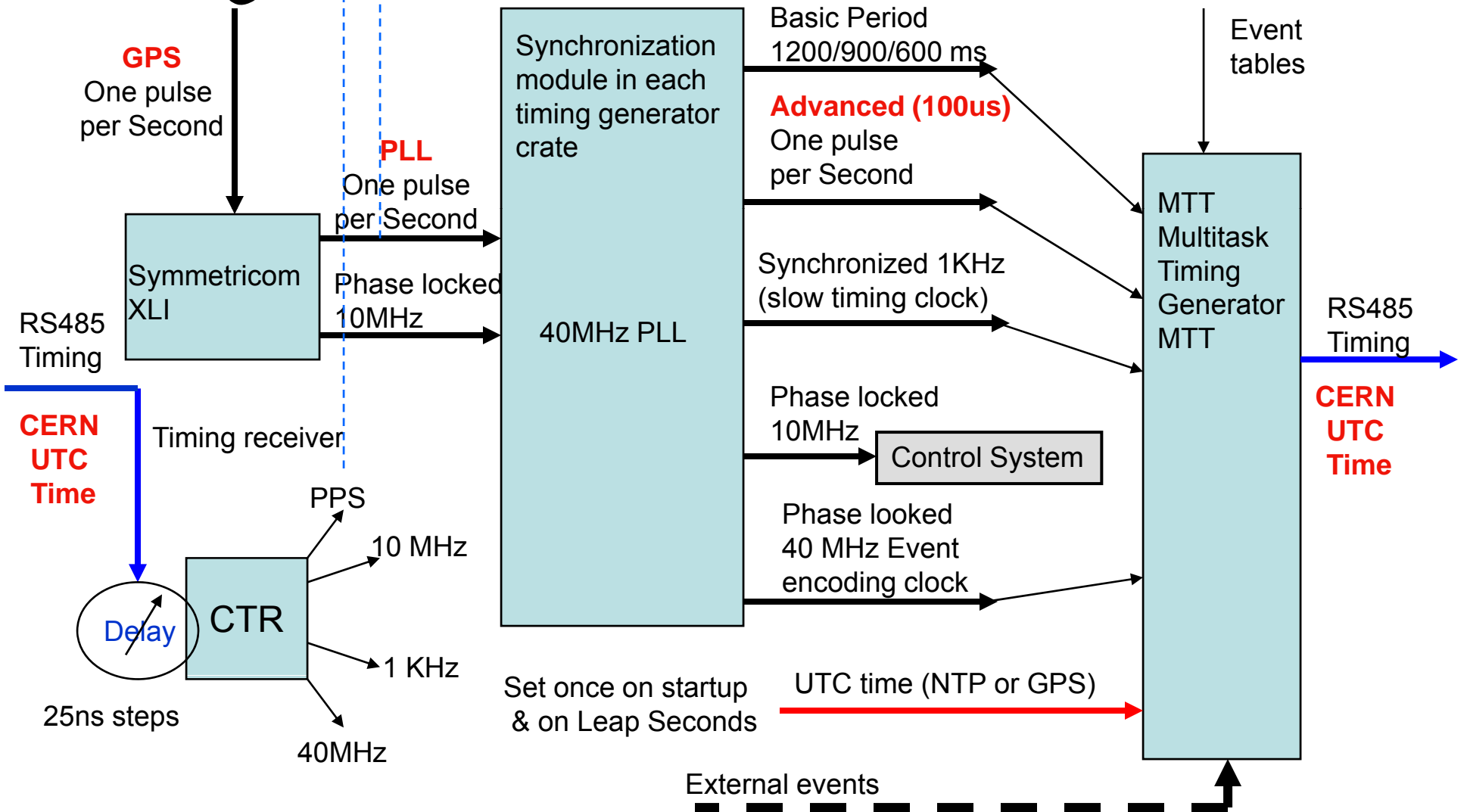


GPS



Symmetricom CS4000 portable Atomic Clock

# UTC Time and GPS





# CBCM Sequence Manager

BEAM COORDINATION DIAGRAM EDITOR: Edit BCD /scrubbing SPS/

File Edit R.Checker Tools Specialist Help

Type

Description Rule violations Selection

General description

Name **scrubbing SPS**

Desc.

Created Mon Jun 02 07:02:20 Updated Wed Jun 11 13:54:16

Other informations

Bcd length **20**

S	<- 4 ->				1	2	3	4	5	6	7	8	9	10	11	12	13	14
P		LHCTEST			LHCTEST			LHCTEST			LHCTEST			ZERO	ZERO			
S		LHCTEST			LHCTEST			LHCTEST			LHCTEST			ZERO	ZERO			
C	<- 1 ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P		LHC			LHC			LHC			LHC			EASTB	TOF	EASTB		
S		ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO
P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	LHC	TSTLHC	ISOGPS	LHC	TSTLHC	ZERO	LHC	TSTLHC	ZERO	LHC	TSTLHC	ZERO	EASTB	ISOGPS	TOF	EASTB	ZERO	TOF
B	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ISOGPS	ZERO	ZERO	ISOGPS	ZERO	ZERO

Fault: Error detected. Can't strip Bcd for machine SPS Exception: cern.ps.cbcm.srvapi.SrvException: Cbcm Server Exception: Can't get parameter SPS.FILLHOLES; nested exception is: Cbcm Context Excepti

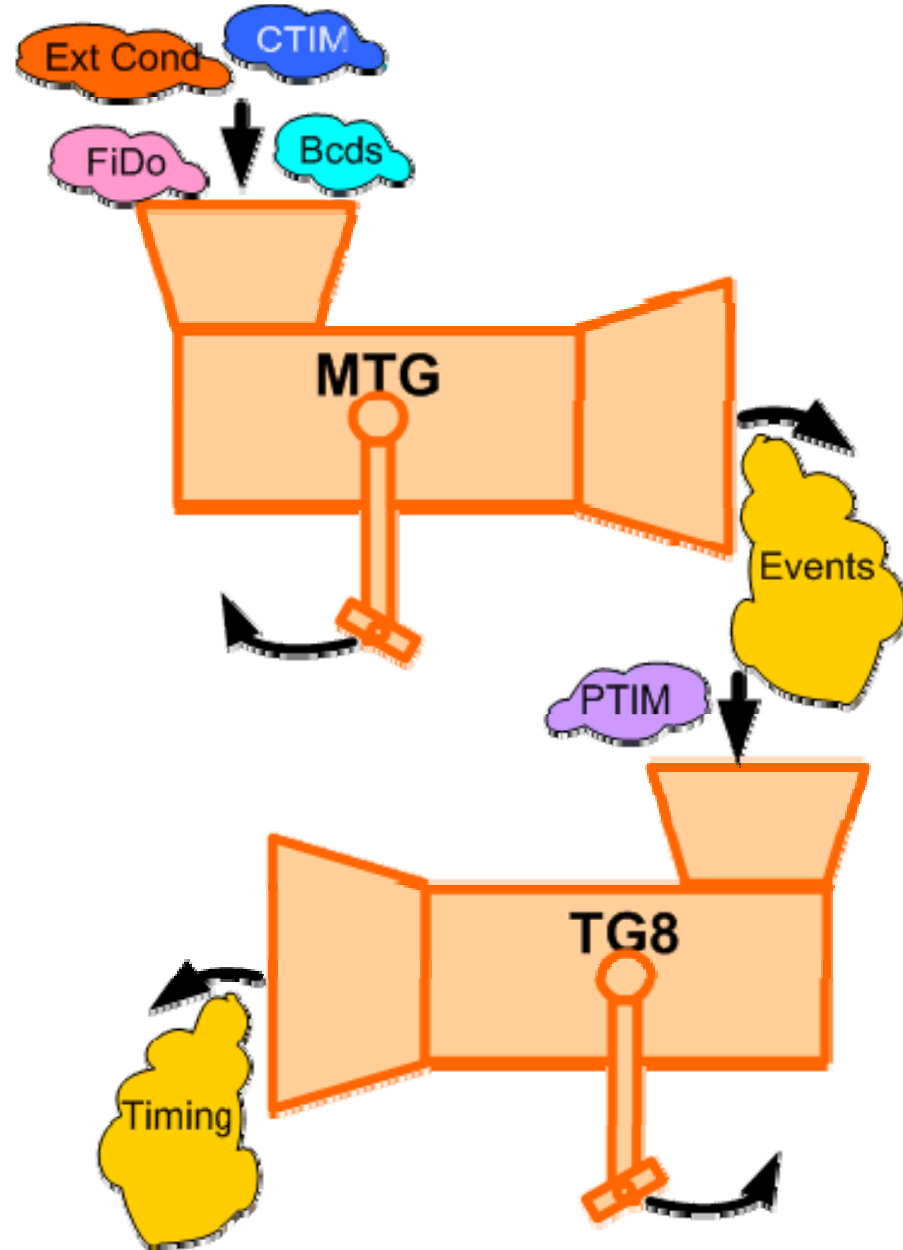
11/Jun/2003 13:54 User CPS.LABO.SUPERUSER RES P8PC8476:BCD editor:LABO.SUPERUSER... RChecker





# The MTG

- Inputs
  - BCDs
  - External conditions
  - Timing description (CTIM)
  - External timings
  - FiDo programs
- Outputs
  - Telegrams events
  - Timing events
  - Time events
  - ...



# The timing renovation project: why?

- Lack of bi-directionality in GMT:
  - Forces us to have a parallel data path (technical network) for control and diagnostics → forces us to support only platforms with an embedded computing engine.
  - Cabling delay compensation cannot be done automatically → need for costly/unreliable measurement campaigns.
- Lack of bandwidth in GMT
  - 500 kb/s current rate was chosen for backwards compatibility.
  - Forces us to have different networks for different accelerators → cabling and software hassle.

# The timing renovation project: how?

- Identify commonalities with other projects, then launch collaborative effort.
- Promising enabling technologies:
  - Ethernet and PTP.
  - Bidirectional optical links, with active or passive fan-outs.
- Boundary conditions:
  - Be as standard as reasonably possible.
  - End up with a completely open source product.
- Open issues:
  - Time scheduled vs. event based systems.
  - Unclear advantages of plain Ethernet + protocol stack.
  - How to mix companies and open source?