LHC
General Machine Timing (GMT)

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Some general points on LHC timing

▶ The Basic-Period in the LHC machine is the UTC second. The millisecond modulo represents the millisecond in the UTC second 0..999

▶ LHC Events are sent out on change, the payloads contain machine parameters.

▶ LHC Telegrams are sent out each basic-period, the parameters in the telegram are a snap shot of the LHC machine state already sent out as events with payloads.

Some web addresses

► http://ab-dep-co-ht.web.cern.ch/ab-dep-co-ht/timing/Seq/tgm.htm

- This link shows the current telegram configuration.
- It also has information about the CTR hardware and other useful stuff.

► http://ab-dep-co-ht.web.cern.ch/ab-dep-co-ht/timing/Seq/mtgConfig.htm

- This link shows all defined timing events for the timing cables, and other useful stuff.

Information here generates the timing configuration and is hence the definitive source. The situation is quite volatile, new events and telegram changes often happen.

What is distributed on the LHC timing cable

▶ The LHC telegram

- It's a message sent out each second. Today there are 17 parameters defined in the telegram. Its main function is to continuously retransmit information that has already been transmitted by the first 17 events.

▶ LHC machine events

- An event is sent punctually when something happens that affects the machine state. Some are asynchronous that come from external processes, e.g. post-mortems, while others are produced from timing tables corresponding to running machine processes.

▶ The UTC time of day

- Resolution is 25ns, jitter is less than 10ns peak to peak.

Telegrams and events

► Each telegram parameter contains a header (which telegram parameters it is), and a 16 bit payload (the value of the parameter)

- Telegrams are stored in the timing receiver memory and are activated by a "ready telegram" event 1ms before the PPS (they are a 1S history).

► Each machine events has a header (which event it is) and a 16 bit payload (information relevant to the event)

- Machine events trigger counters to make pulses and provoke bus interrupts for real time tasks. Some of them correspond exactly to the telegram parameters.

Telegram and corresponding machine event parameters

► Injection parameters
- Next injected beam type
- Next injected RF bucket
- Next injected ring

► Energy (point 6) and intensity (point 4). Events transmitted from 1 to 10Hz (not yet decided)
- Energy encoded at 120Mev per bit
- Intensity ring 1 at 10^{10} protons per bit
- Intensity ring 2 at 10^{10} protons per bit

► Beam flags (Events sent at 10Hz [Monostable])
- Safe, Stable, Movable ring 1
- Safe, Stable, Movable ring 2

Some LHC event/telegram parameters (volatile)

```
01 HX.BTNI      0x1401FFFF Next injection beam type
02 HX.BPNM      0x1402FFFF Basic Period Number (Reset at Pre-Inject)
03 HX.BKNI      0x1403FFFF Next injection RF bucket
04 HX.RNGI      0x1404FFFF Next injection ring
05 HX.ENG       0x1405FFFF Beam energy
06 HX.INT1      0x1406FFFF Beam intensity - Ring 1
07 HX.INT2      0x1407FFFF Beam intensity - Ring 2
08 HX.SBF1      0x1408FFFF Safe flags - Ring 1 Safe, Present, Stable, Movable
09 HX.SBF2      0x1409FFFF Safe flags - Ring 2
10 HX.MODE      0x140AFFFF What LSEQ says the LHC is doing
11 HX.FILN      0x140BFFFF Fill number (Incremented at Pre-Inject)
12 HX.BTC1      0x140CFFFF Circulating beam type - Ring 1
13 HX.BTC2      0x140DFFFF Circulating beam type - Ring 2
```

See web page for latest information

Telegram and corresponding machine event parameters

► Beam mode
- Setup, Inject-pilot, Ramp, Stable ......
- Circulating beam type in ring 1
- Circulating beam type in ring 2

► Machine mode
- Access, Shutdown, Cool-down, Checkout ….

► Assorted other stuff
- Fill-number, Power-permit-60-amps, Seconds-since-pre-inject-mode .....

Events alone

▶ Disable/Enable Postmortem

▶ Dump ring 1,2.

▶ Postmortem both rings on one event

   ▪ Can be sent twice if both rings are dumped

▶ Beam was dumped ring 1,2

▶ Start/Stop ramps RF and Power

▶ Injection warnings

▶ System events, ready-telegram, start-basic-period

   …..

LHC Dump and Postmortem events

```
33 HX.DISPM1      0x14210000 Disable Post-Mortem Ring 1
34 HX.DISPM2      0x14220000 Disable Post-Mortem Ring 2
35 HX.ENBPM1      0x14230000 Enable Post-Mortem Ring 1
36 HX.ENBPM2      0x14240000 Enable Post-Mortem Ring 2
37 HX.DUMP1       0x14250000 Dump ring 1
38 HX.DUMP2       0x14260000 Dump ring 2
39 HX.PM1         0x14270000 Postmortem ring 1 or 2
40 HX.PM2         0x14280000 Postmortem for test only

So PM1 gets sent twice in 1ms, if both rings are dumped.


See web page for latest information
```

Some other LHC events

```
41 HIX.FW              0x14290000 Injection forewarning (Currently 1S)
42 HX.SRMP-POW         0x142AFFFF Start ramp power converters
43 HX.ARMP-POW         0x142BFFFF Abort ramp power converters
44 HIX.REQ-RF          0x142CFFFF RF Injection request
45 HX.SFRMP-RF         0x142DFFFF Start frequency ramp RF
46 HX.SVRMP-RF         0x142EFFFF Start voltage ramp RF
47 HIX.STFB-RF         0x142FFFFF Start TFB injection RF
48 HIX.SLFB-RF         0x1430FFFF Start LFB injection RF

49 HX.SYNC-RF    0x1431FFFF Synchronize rings RF
50 HIX.W100      0x1432FFFF Warning injection 100ms (900ms after HIX.FW)
51 HIX.W20       0x1433FFFF Warning injection 20ms  (980ms after HIX.FW)
52 HIX.AMC       0x1434FFFF Injection NOW (Acquisition master C, 1S after HIX.FW)
53 HIX.APOST     0x1435FFFF Injection +10ms (1010 after HIX.FW)
54 HX.RPLS       0x14FE0000 Ready telegram (Each UTC second)
```

See web page for latest information

Distribution

- ► RS-485 copper 500 Kbit giving 8 X 32 bit timing frames per millisecond

- ► Fibers for long distance

- ► Calibrated using our portable Cesium clock

- ► A small number of events and the telegram are distributed over Ethernet as UDP packets

- ► Can subscribe via middleware to any event.

Timing receivers

CTR I=PCI(4) P=PMC(3) V=VME(8) provide

- 1KHz
- PPS
- 40MHz
- Time stamps
  - ► UTC time and machine time, inputs and outputs
- TTL/TTL-Bar Pulses, adjustable width, VME-P2
- Bus interrupts and event payloads
- Telegrams
- 2 External Start inputs & 2 External clock inputs
  - ► Clock rate <= 50MHz

Postmortem Event generation

► There are two Beam-Permit-Flags, one per LHC ring, arriving at the LHC central timing inputs from the Safe-Machine-Parameter-Verifier (SMPV) hardware module (Its part of the BIS).

► There are two Beam-Dump events that may be sent from the LHC central timing to the LHC control system to dump the beam in one or the other ring.

► The specification requires only one PM event for both rings. In some LHC machine modes such as "Inject *& Dump*", sending the PM events will be inhibited.

► When both rings are dumped, the postmortem event is sent twice within 1ms.

Postmortem Event suppression

Two counters are used in the CTR, one per Beam-Permit-Flag (BPF)
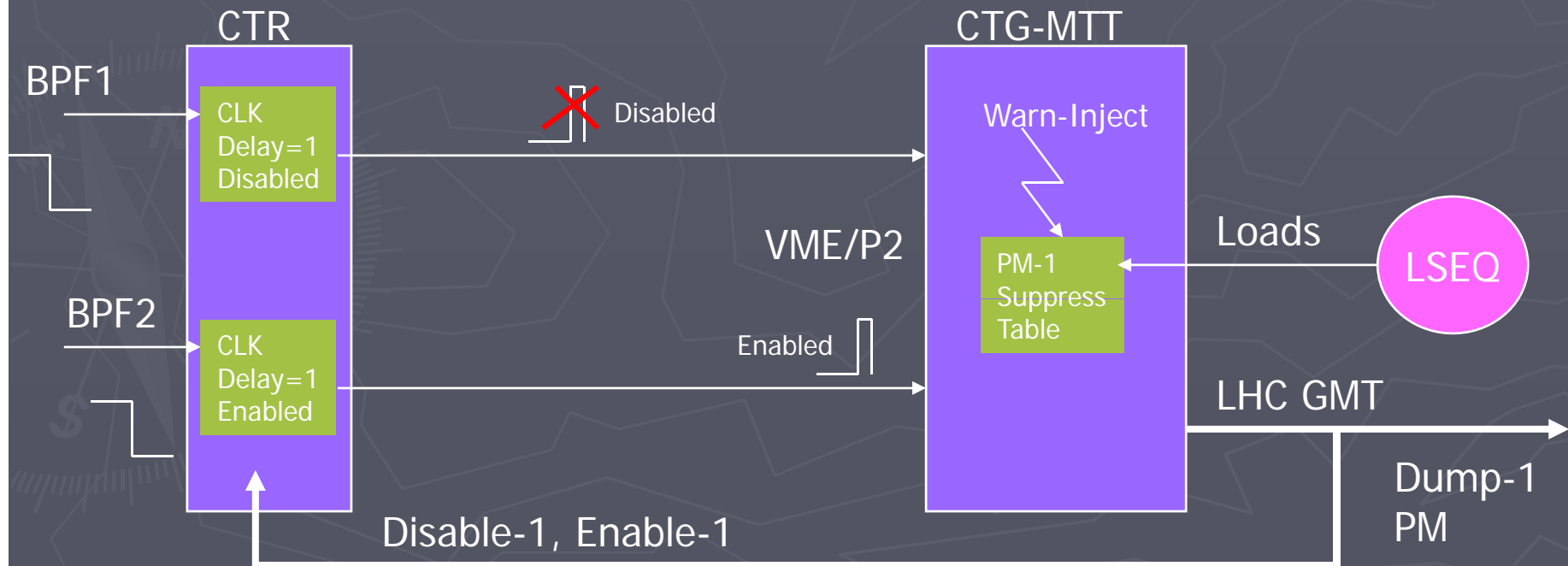Each counter clock is connected to one of the BPF flags
The "Disable Post-Mortem Ring 1" disables the counter connected to BPF-1
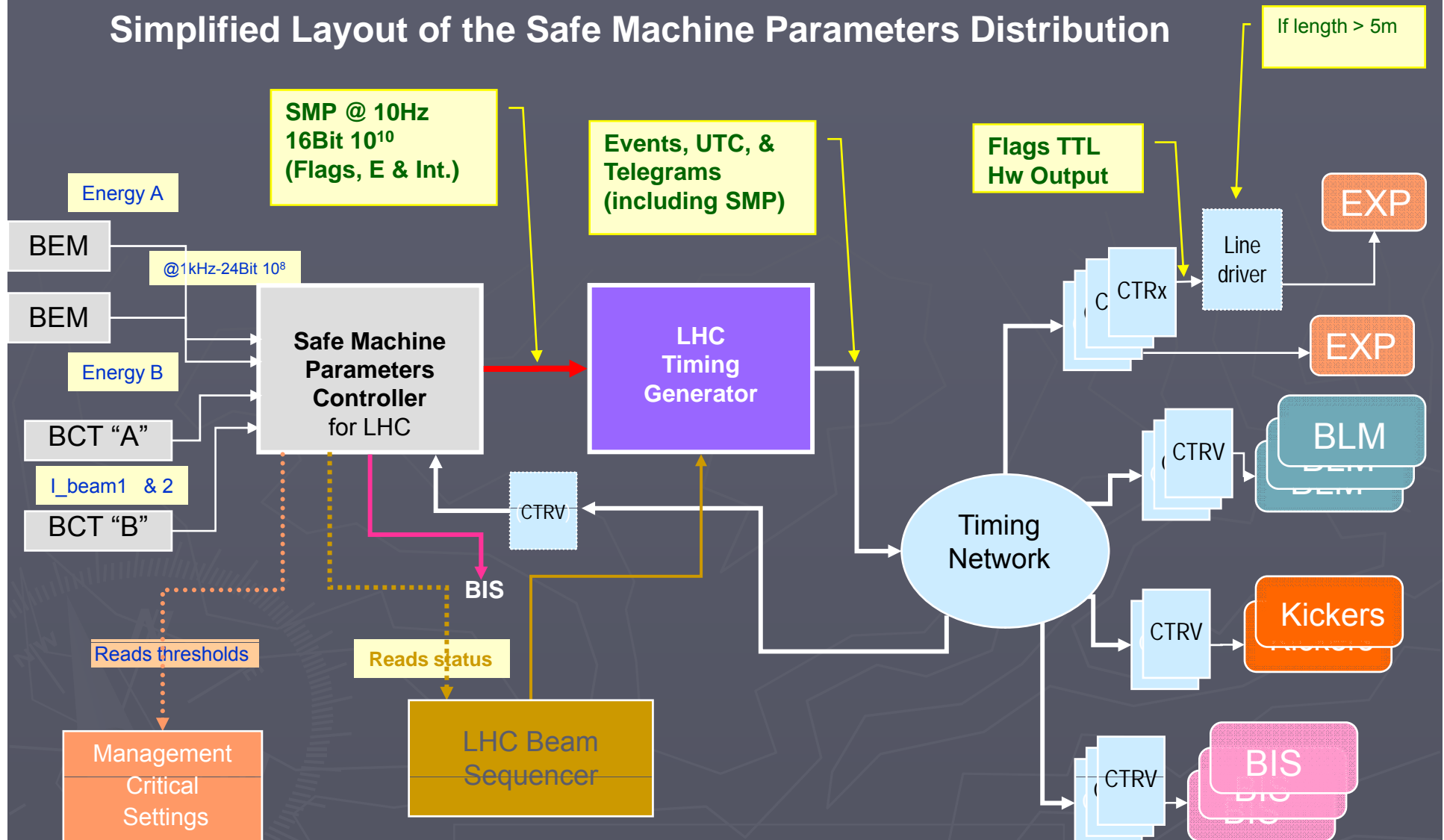The "Enable Post-Mortem 1" enables the counter connected to BPF-1
When the counter is disabled and the BPF goes down nothing happens
When its enabled the counter makes an output triggering the PM event
It will be sent twice if both counters are enabled and both rings are dumped

Simplified Layout of the Safe Machine Parameters Distribution

If length > 5m

SMP @ 10Hz
16Bit 10^{10}
(Flags, E & Int.)

Events, UTC, &
Telegrams
(including SMP)

Flags TTL
Hw Output

Energy A

BEM

@1kHz-24Bit 10^8

BEM

Energy B

BCT "A"

I_beam1 & 2

BCT "B"

Safe Machine
Parameters
Controller
for LHC

LHC
Timing
Generator

Line
driver

EXP

EXP

C CTRx

CTRV

Timing
Network

CTRV

BLM
BLM
BLM

BIS

CTRV

CTRV

Kickers
Kickers

Reads thresholds

Reads status

CTRV
BIS
BIS

Management
Critical
Settings

LHC Beam
Sequencer

main **S**afe **M**achine **P**arameters for LHC:

- Energy

- Safe Beam Flags

- Movable Devices Allowed Flag

- Safe Injection Flags (*new*)

B.P. 23rd Aug.07

Thanks Bruno

CTRV Timing receivers (monostable)