Post-mortem acquisition triggering

A post-mortem timing event distributed by the LHC machine timing system is used to freeze the PM buffers of a large fraction of the LHC equipment.

This event must be generated automatically whenever the BIS is issuing a beam dump request by changing the state of the beam permit signal.

This presentation outlines the present ideas on how to generate the PM timing event. The issue of PM event suppression in the case of single beam dumps or special operation modes like 'inject and dump' will be addressed.

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Some initial observations

- 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.
- Even though the specification requires only one PM event for both rings, two PM events are defined in the central timing !

Some initial observations

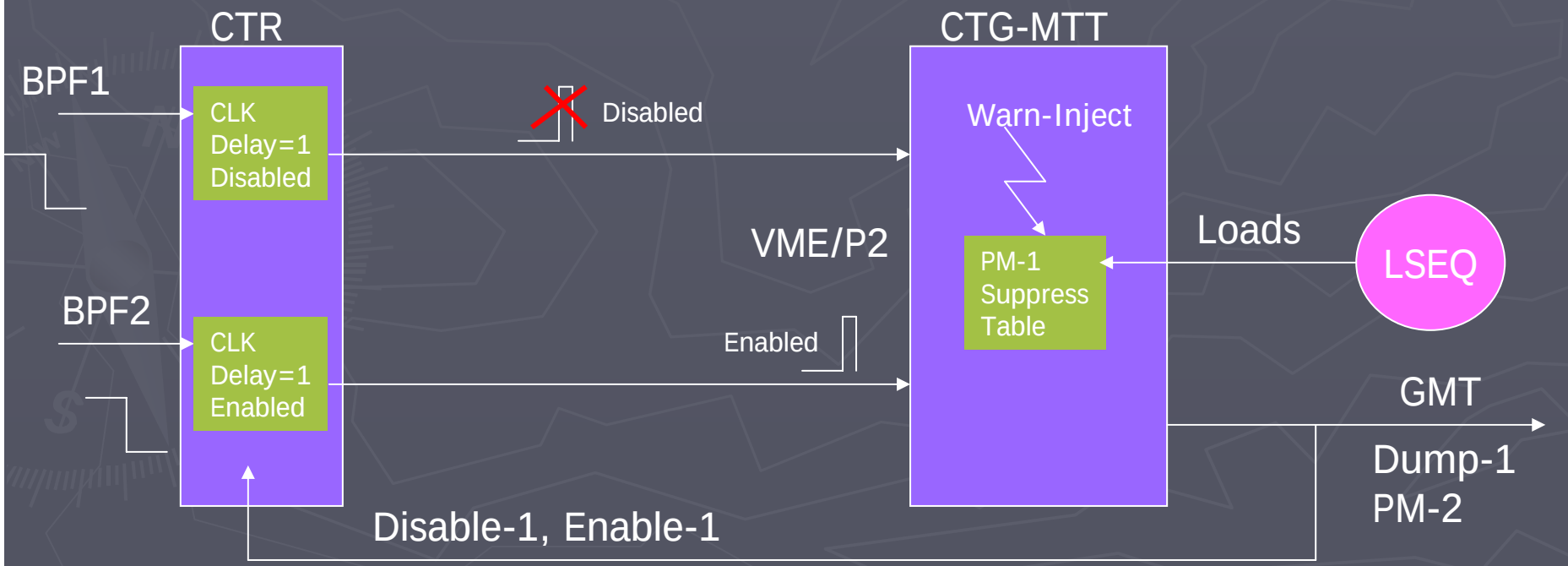
- Post-mortem events are just part of the general Safe-Beam (SB) parameter distribution over the LHC General-Machine-Timing (GMT) network.
- In some LHC machine modes such as “Inject *& Dump”* , sending the PM events will be inhibited.
- Some SB parameters are monitored directly by the SMPV and CTR hardware to ensure high reliability.

Postmortem Event generation

- The LHC central timing reacts to falling edges on the Beam-Permit flags for ring 1 and ring 2. When enabled, then on a falling edge, a PM event is generated and sent within 1ms.
- This mechanism can be enabled or disabled via events for each LHC ring.
- LSEQ will load an event table triggered from an LHC injection warning event that disables and then re-enables the PM response ...

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 corresponding PM event



Postmortem Event suppression table loaded by LSEQ

- Wait for LHC Injection forewarning
- Wait some time in milliseconds to the moment you want
- Send event "Disable Post-Mortem Ring 1"
- Wait 1 ms
- Send event "Dump Ring 1"
- Wait 2 ms for dump to complete and BPF1 to go down
- Send event "Enable Post-Mortem 1"
- Halt

Concerning Energy and Intensity

- The measuring systems in point 6 (Energy) and point 4 (Intensity 1&2) will provide measurements encoded as described at a frequency of 10Hz (100ms). These values are forwarded by the MTG with modified headers over the LHC GMT.
- For each complete measurement triplet the Beam-Present and Safe-Beam flags are calculated for each ring and sent out over the GMT, hence also at 10Hz.
- Any missing measurement from the triplet results in the Safe-Beam flag (s) being set to zero (Dangerous), and the Beam-Present set to one (Present).

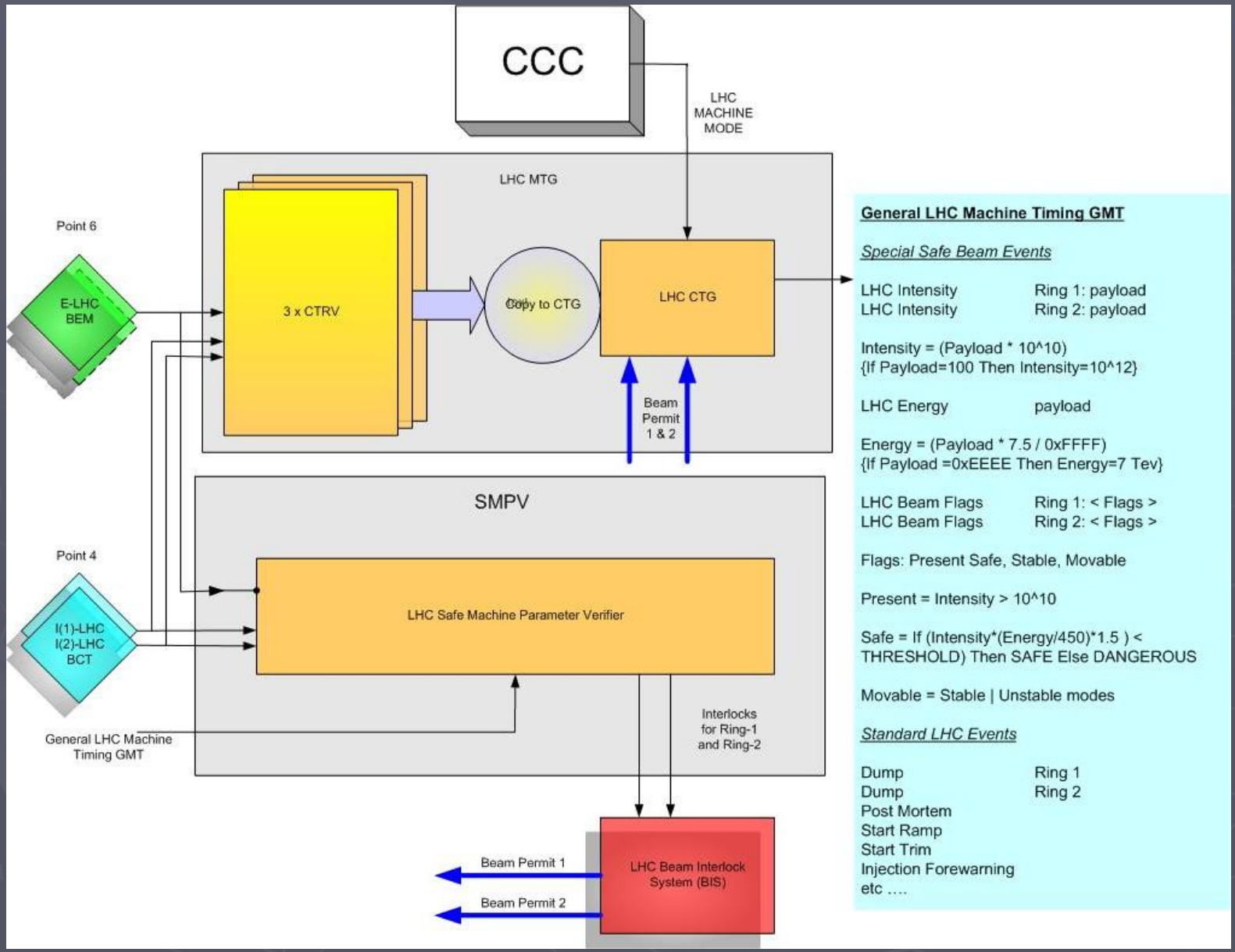
I1, I2, Eng, SBF Algorithm

- On error (Timeout is 200ms)
  - SBF1&2=0, I1&2=0xFFFF, Eng1&2=0xFFFF
- Eng arrives
  - Eng1&2=F(payload) ;Make two copies !
- I-x arrives where x=1 or 2
  - I-x = F(payload) ;Get I-x from payload
  - SBF-x = F(I-x, Eng-x) ;Calculate flag-x
  - I-x = Eng-x = 0xFFFF ;Values have been used

Conclusion:

The Energy value must arrive at least as often as the Intensity values to keep the SBF value SAFE

Safe machine parameter verification



Calculating flags

Energy = (Payload*7.5/0xFFFF) {If Payload=0xEEEE Then Energy=7}
Intensity = (Payload * 10^10) {If Payload=100 Then Intensity=10^12}
Safe-Threshold = 10^12
Present-Threshold = 10^10

Safe-Beam = If (Intensity*(Energy/450)*1.5) < Safe-Threshold)
Then SAFE (1)
Else DANGEROUS (0)

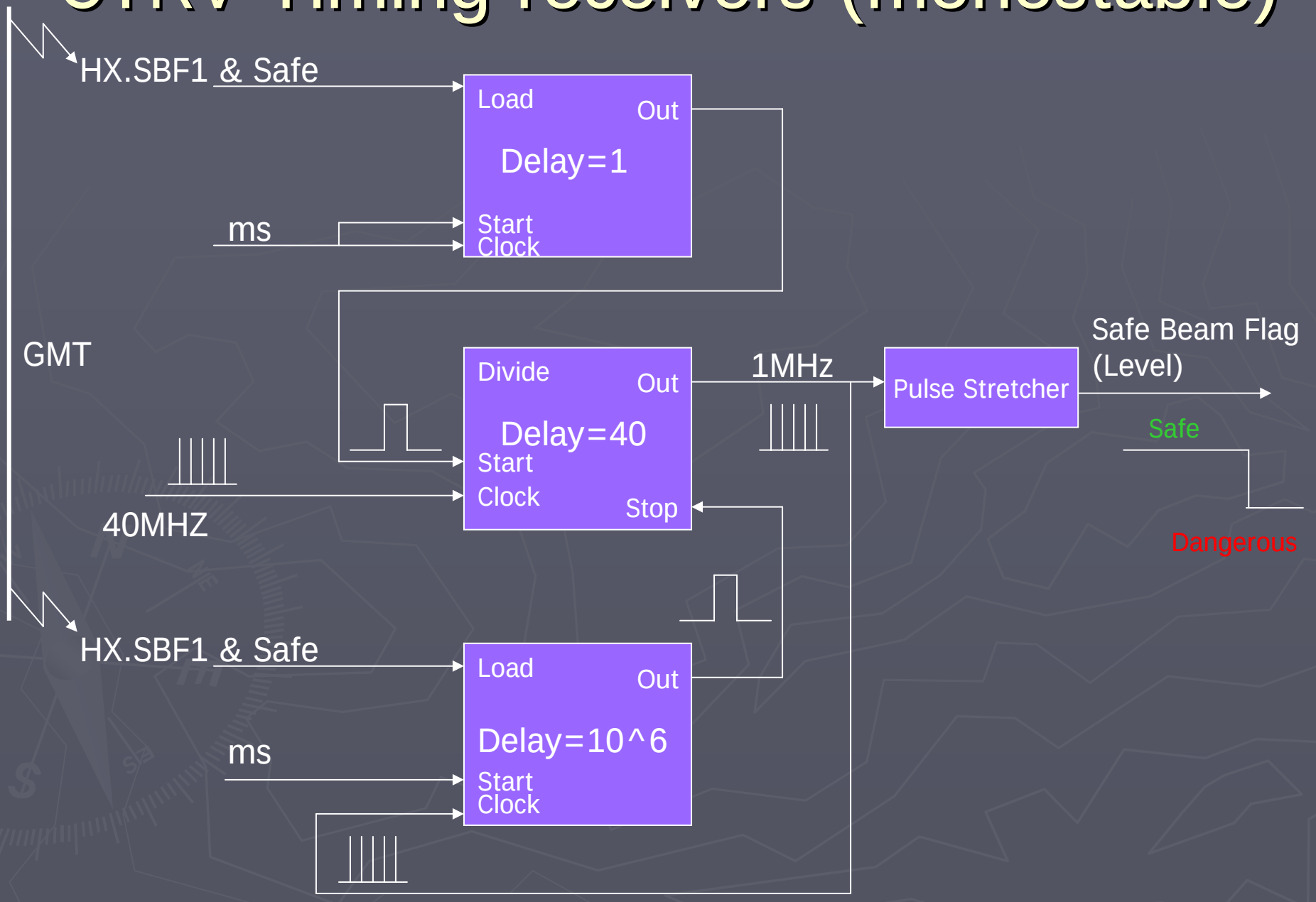
Beam-Present = If (intensity < Present-Threshold)
Then NOT_PRESENT (0)
Else PRESENT (1)

Stable-Beam = If (MODE=“Stable-Beam”)
Then STABLE (1)
Else UNSTABLE (0)

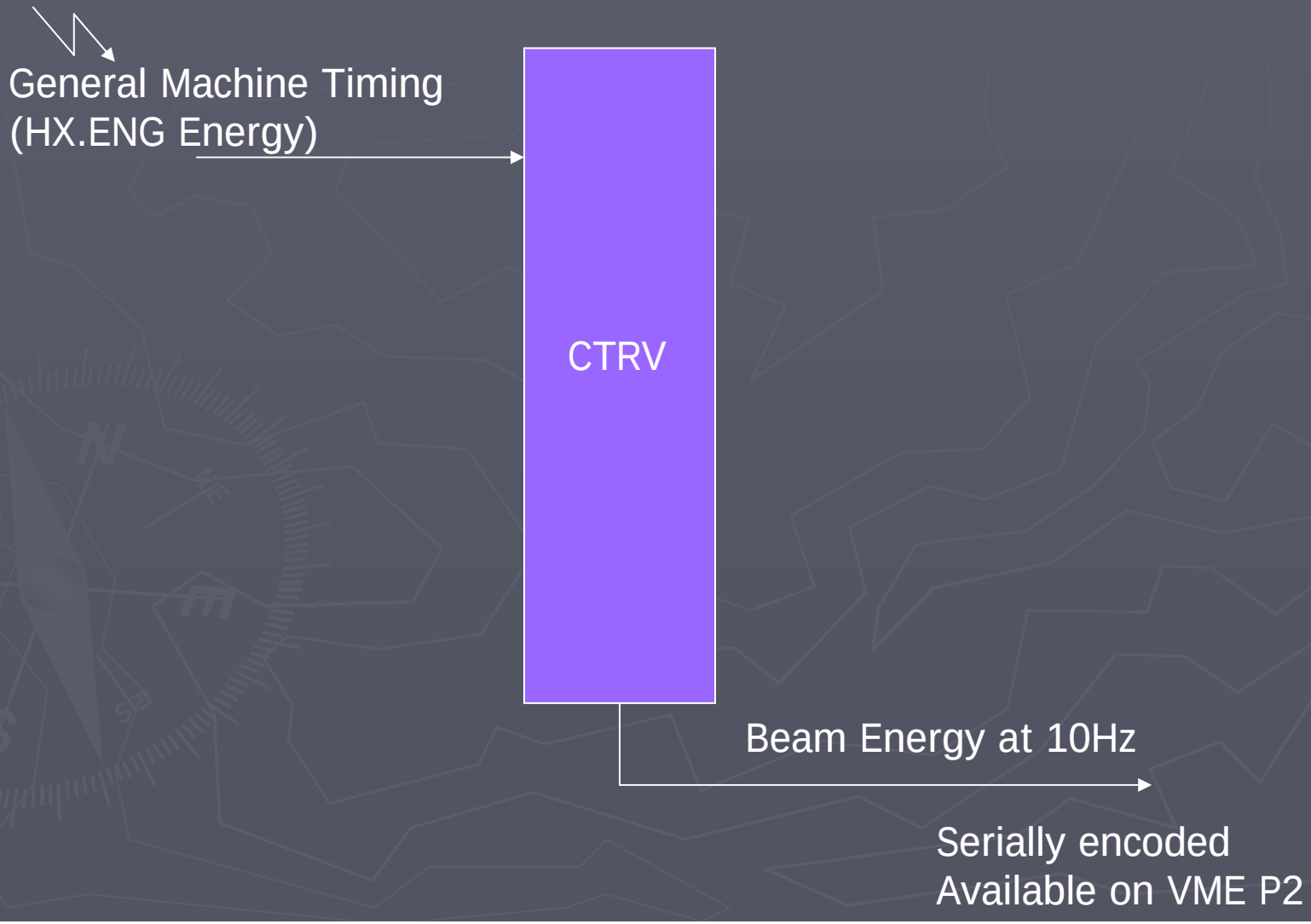
Movable-Flag = If ((MODE = “Stable-Beam”) OR (MODE= “Unstable-Beam”))
Then ALLOWED (1)
Else NOT_ALLOWED (0)

Safe value
Default value

CTRV Timing receivers (monostable)



CTRV Energy via P2



Concerning Safe Machine Parameter verification

- The MTG calculates the Safe, Present, Stable, and Movable flags based on the Energy, Intensity 1&2, the threshold and the machine mode and sends these 4 flags in two events (one per ring) each with 4 bits (Positive Logic, True=1, False=0).
- The SMPV module performs the same calculation, and also checks the GMT Energy/Intensity values against the original data.

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.

The LHC event/telegram parameters

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
14 HX.THRS	0x140EFFFF	Safe beam flag threshold **

** SMPV Needs this to follow threshold changes

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
40 HX.PM2	0x14280000	Postmortem ring 1

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)
911 MX.CTRIG 0x0100FFFF The millisecond event

60 HX.OPEN-WIN 0x14360000 Open inject batch window (SPS Beam Out)
61 HX.CLOS-WIN 0x14370000 Close inject batch window (Warn start PSB super-cycle)
62 HX.REQB-CLR 0x14380000 Clear inject batch request (Last inject batch extracted)