



# PS and Machine Protection

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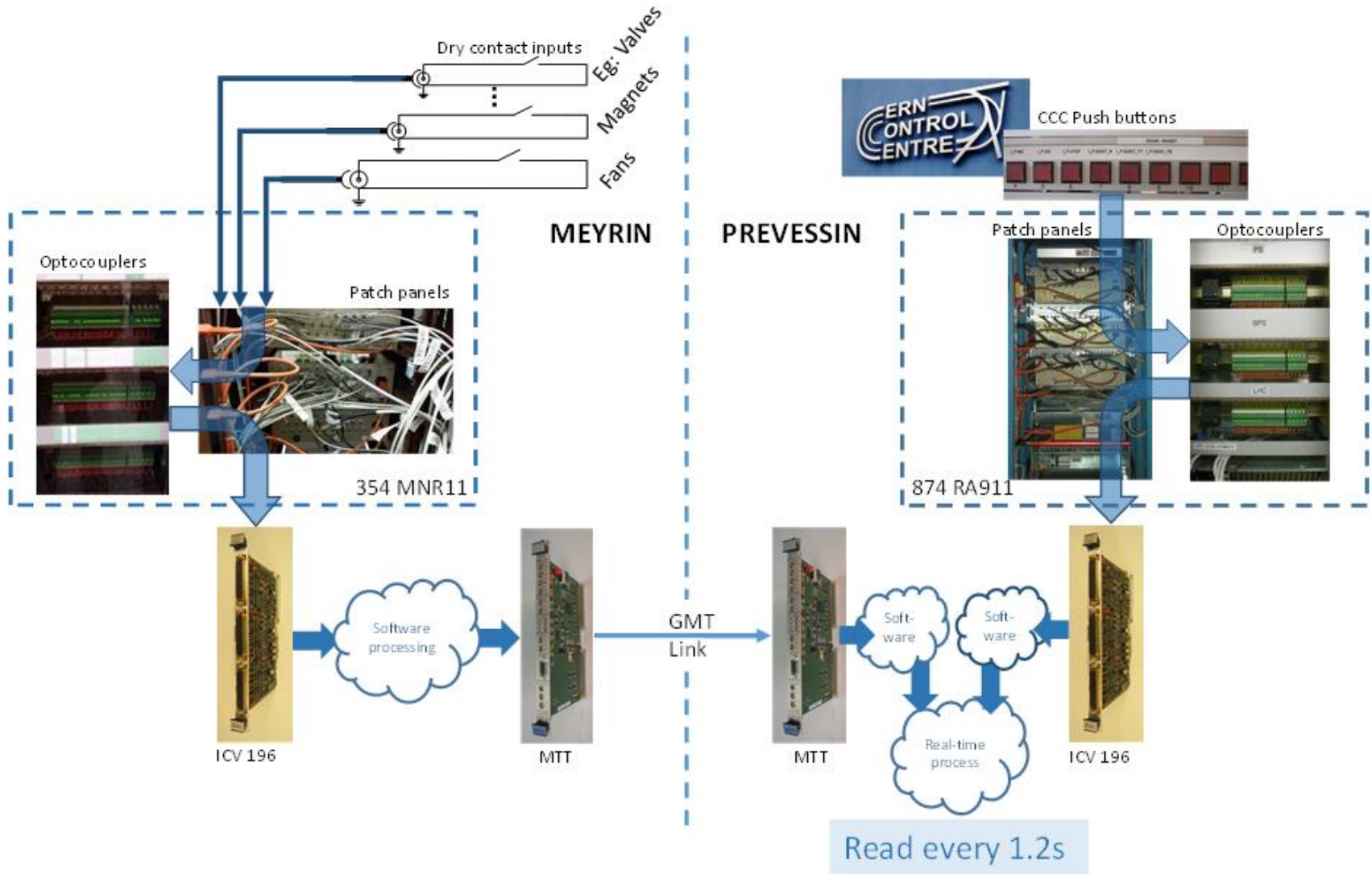
# Outline

- Present situation
  - Features of the present system and experience with (pre-LS2) protection
  
- Mid-term strategy
  - LS2 changes and run 3
  
- Long-term strategy
  - LS3 and beyond

# Interlocks in the PS: Present Situation

- **External Conditions EC:**
  - Presently main system
  - Hw system
  - Reaction time up to 4 cycles (in the worst case)
  
- **Software Interlock System SIS:**
  - Additional monitoring
  - Not fail safe
  - Reaction time 2-3 pulses
  
- **BLMs**
  - Cutting Linac2 timing

# External Conditions

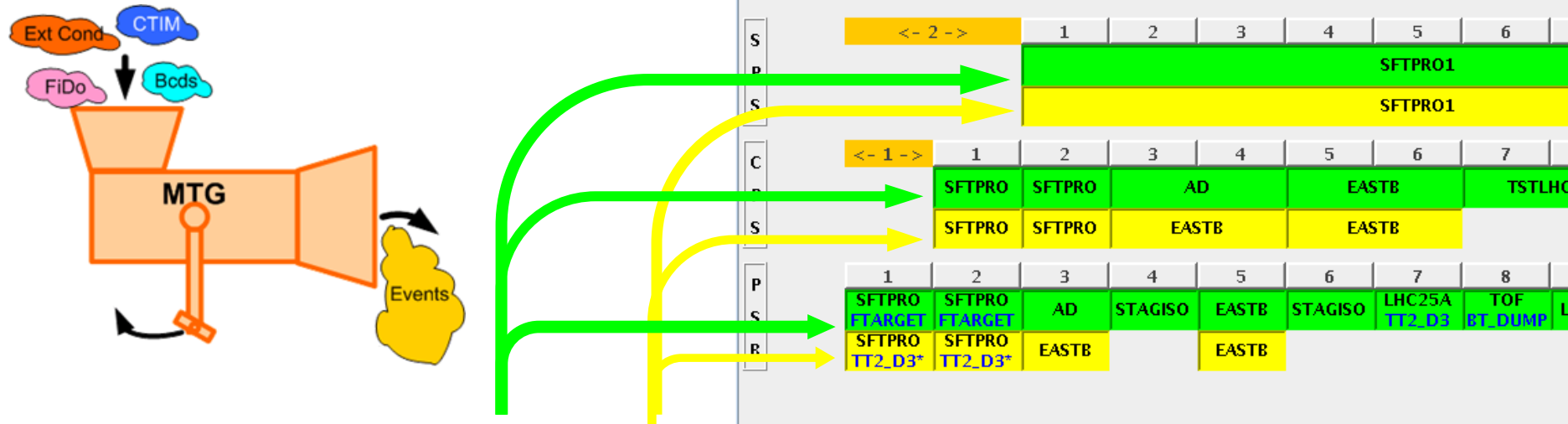


# External Conditions

Hardware Conditions		Hard/Soft Conditions			Software Conditions	
Name	Status	Name	Priority	Status	Name	Status
PLSMH42	BAD	PE.F61BHZ01_DMP	SOFT	OK	NEW_GDT	OFF
PLKFA45	BAD	PE.BSW61	SOFT	OK	R.P.EAST_N	ACTIVE
PESTP152	BAD	PE.F61BHZ01_EA	SOFT	OK	R.P.EAST_T7	ACTIVE
PESTP176	BAD				R.P.EAST_T8	ACTIVE
P.MMON	OK				R.P.MERIT	OFF
PE.BHZ327	BAD				R.P.AD	ACTIVE
PE.BTI247	BAD				R.P.LHC25	OFF
PE.BHZ377	BAD				R.P.EASTA	ACTIVE
PESMH16	BAD				R.P.EASTB	OFF
PESMH57	OK				R.P.LHCION	ACTIVE
PESMH61	BAD				R.P.SFTPRO	OFF
PE.KFA71	BAD				R.P.MD3	ACTIVE
PE.BFA	BAD				R.P.MD4	ACTIVE
P.VV	BAD				R.P.MD2	OFF
PE.VVD3	BAD				R.P.EASTC	ACTIVE
PE.VVFTA	BAD				R.P.MDION	ACTIVE
PE.VVSPS	BAD				R.P.LHCPILOT	ACTIVE
PE.VVFTN	BAD				R.P.MD1	ACTIVE
PESTPFTN	BAD				R.P.MDPRO	ACTIVE
I.PS	BAD				R.P.MDPS	OFF
I.P.PROT	BAD				R.P.LHC75	OFF
I.P.ION	BAD				R.P.TSTLHC75	OFF
I.P.EAST_N	BAD				R.P.LHCINDIV	OFF
I.P.EAST_T7	BAD				R.P.TOF	OFF
I.P.EAST_T8	BAD				R.P.TSTLHC25	ACTIVE
					R.P.CNGS	OFF
					R.P.TSTPS	OFF
					R.P.LHCPROBE	OFF
					NEW_UMAT	OFF
					NEW_CHS	OFF



# External Conditions



The EC give us the flexibility to select nominal and spare cycles depending on the ECs

# External Conditions

Equipment	Details	Comments
<b>TE-EPC</b> - power supplies	hardware EC mixed solution SOFT-EC + SIS	POPS (hw) FGCs (mixed)
<b>TE-STI</b> - beam stoppers, internal dump, “ralentisseur”	hardware EC	internal dump with (BIC + SIS + EC)
<b>TE-VSC</b> - valves	hardware EC	possible candidate for future BIS
<b>TE-ABT</b> - kickers, BFA	hardware EC	

# External Conditions: EPC

Equipment	Details	Comments
P.MMON (EIS)	main power supply ON only FGC with hardware EC	POPS - FGC53
PE.SMH16 (EIS)	extraction septum with HW EC renovation post-LS2	POWM1553
PI.SMH42, PE.SMH57(EIS), PE.SMH61  <u>TT2</u> : PE.BTI247(EIS), PE.BHZ377/8(EIS), FTN.BHZ403 (EIS)	renovation foreseen during LS2 with FGC control type; agreement of a mixed solution SOFT-EC + SIS	EC in TT2 to be renamed with correct prefix F16 BHZ377/8 will be powered with two separate circuits
2 new external conditions for EAST Area	agreement of a mixed solution SOFT-EC + SIS	F61.MBXHD025 F63.MBXHD001 (name tbc)



# External Conditions: STI

Equipment	Details	Comments
PE.STP152 (EIS) PE.STP176 (EIS)	renovation during LS2, keep hardware EC	prefix to be renamed (F16) 2+1 Stoppers
FTN.TARGET	renovation during LS2, keep hardware EC	
PE.STPFTN (EIS)	renovation foreseen post-LS2, hardware EC	Prefix to be renamed (FTN)
PE.STPFTA (EIS)	renovation foreseen post-LS2, hardware EC	Prefix to be renamed (FTA)
PE.STPF61 (EIS) PE.STPZT8 (EIS)	renovation during LS2, keep hardware EC	Sum of 5 Stoppers in F61 (1 EC) Sum of 5 Stoppers in T8 (1 EC) 1 in T9, 1 in T10, 1 in T11 (no EC)
PR.TDI47 PR.TDI48	new equipment	1 (or 2) EC in parallel with BIC + SIS EDMS 1977845
PR.RAL12	new equipment interlock with SEMGrid position	1 EC for maximum threshold for beam impact (could be software or SIS) to be defined

# External Conditions: VSC

Equipment	Details	Comments
P.VV	keep hardware EC vacuum valves in PS Ring	possible client for future BIC (LS3)
PE.VVD3	keep hardware EC FT16.VVS10 + FT16VVS20 + FT16VVS30	possible client for future BIC (LS3)
PE.VVFTA	keep hardware EC vacuum valves in FTA	possible client for future BIC (LS3)
PE.VVFTN	keep hardware EC vacuum valves in FTN	possible client for future BIC(LS3) in PS
PE.VVSPS	keep hardware EC FTS.VVS10	possible client for future BIC(LS3) in PS or to be linked to SPS BIC -> BHZ377/378 to 0A

# External Conditions: ABT

Equipment	Details	Comment
PI.KFA45	switch to sw solution	
PE.BFA_CT	to be removed (pedestal + staircase)	
PE.KFA13-21	renovation during LS2 keep existing hardware EC	act only on MTE type beam
PE.KFA4	renovation during LS2 keep existing hardware EC	act only on MTE type beam
PE.BFA_MTE	keep existing hardware EC (pedestal 9 only)	could be remove in case we allow MTE beam in degraded mode
PE.KFA71-79	switch to sw solution	successful test performed in order to replace EC with a PPM interlock + SIS in 2018

# SIS: Existing Situation (until 2018)

- Monitor power converter status for critical circuits (PFWs)
- Monitor power converter status of 8 Low Energy Quadrupoles equipped with thermal switches in order to switch off all power supplies powering the same quadrupole family
- Stop TOF beam in case the maximum proton flux to nTOF target is exceeded
- Dump beams with destination SPS in case of absence of TFID
- Cut predefined users in case the KFA71 ppm interlock is present
- Protect EAST Area from a bad setting of F61 switching magnet
- Handle beam request and beam stopper position for EAST users

# LS2 Modifications

- **External Conditions**
  - Need to be modified (“software” ECs)
- **Beam Interlock System BIS:**
  - not used in the PS for the moment (two devices will be connected to the BIS of other machines)
  - acts shot to shot
  - hw system
- **Warm Interlock System WIC**
  - new in PS
- **Timings:**
  - BLMs cut beam in Linac4

## EC: Post-LS2 Situation

- External conditions cannot be included as before with the new power converters
- For the FGCs a pure hw solution for the ECs is not possible any more after LS2
- As a compromise we will need to implement ECs as “sw” ECs
- Note: already before LS2, ECs were not “fully” hw; there was always sw involved

# BIS: Post-LS2 Situation

There will be no BIS in the PS after LS2 (no risk of damage of equipment)

In two cases PS equipment will be linked to the BIS of other machines (where shot-to-shot reaction and fail safety is mandatory):

- Interlocks from both PS internal dumps in case of bad position of the dump core → will act on the Booster extraction BIS + EC
- Interlock from SPS BIS in case of wrong condition in TT10 → will act on switching magnet F16.BHZ377/378 at the end of TT2 in order to send the beam to D3

# WIC: Post-LS2 Situation

New system being implemented during LS2 dedicated to the protection of the auxiliary magnets from overheating by switching off the power converter

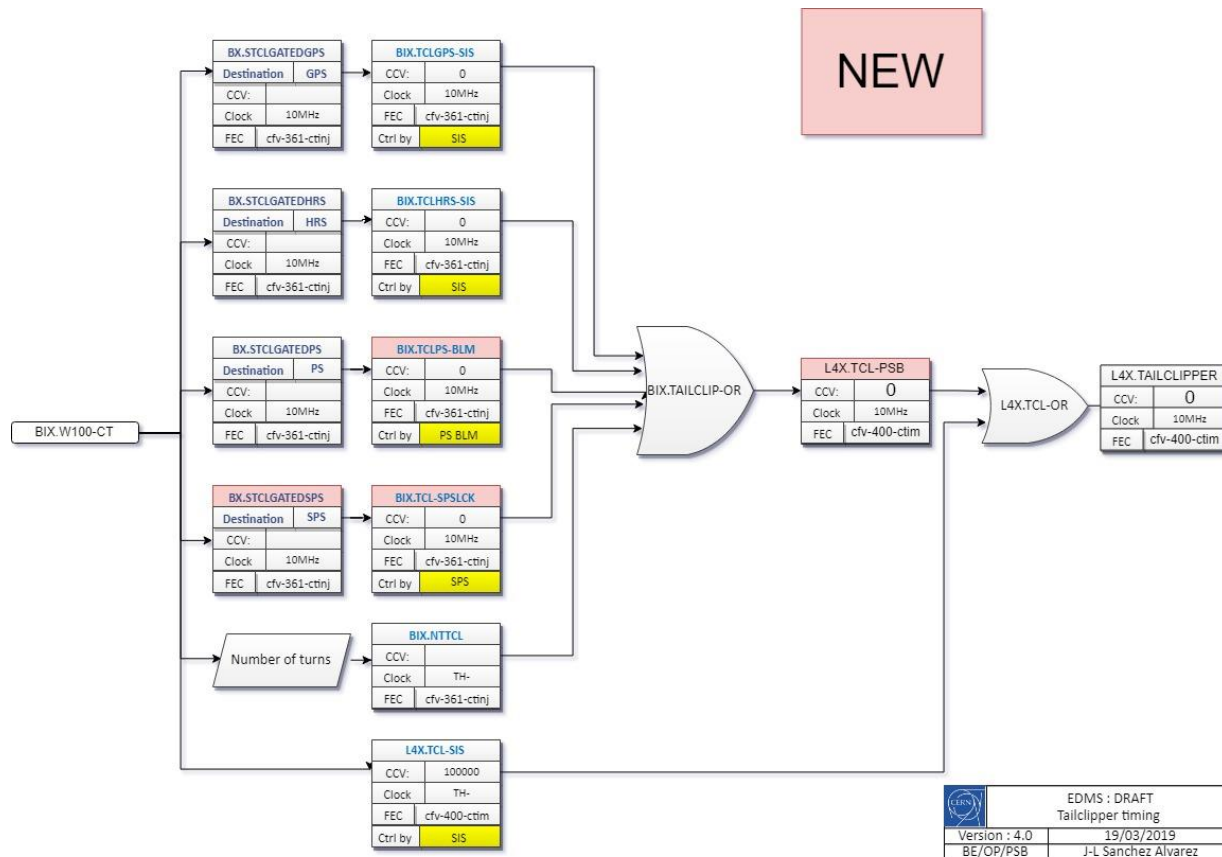
- Concerns all auxiliary magnets in the PS Ring except the Low Energy Quads (EDMS1701483)
- Concerns extraction lines F16 & FTN (EDMS1701477); not FTA
- Concerns all magnets in the EAST AREA extraction lines F61, F62, F63, T8, T9, T10, T11 (EDMS 2037701, under approval)



# Timings for BLMs: Post-LS2 Situation

Stop the beam in case of beam loss in the PS Ring or TT2

- Act on Linac4 Pre-Chopper timing L4X.TAILCLIPPER
- Triggered by the new BE-BI FESA class for BLM
- BLMs in EAST AREA (F61,F62, F63 and T8) will not be interlocked



EDMS : DRAFT  
Tailclipper timing  
Version : 4.0  
19/03/2019  
BE/OP/PSB  
J-L Sanchez Alvarez

# Internal Dump TDI47/48

Condition to trigger the internal dump

- Protection against possible high intensity beam:
  - Protect EAST Area from erratic extraction of parasitic TOF bunch
  - Equipment protection
- Dump satellite bunches a few milliseconds after extraction (LHC type beams)
- Dump the full beam just before extraction in case of absence of TFID
- On purpose for Machine Development or setting-up



# Post-LS2 Modifications

- **WIC further implementation (EDMS1836387)**
  - Main magnets during YETS22-23
  - Low Energy Quads to be equipped during LS3
  - PFW? Today only B8L is equipped with a thermal switch on the reference magnet
  
- **BIC**
  - Implementation of a BIC for the PS under discussion; could replace external conditions
  - Could be envisaged for LS3 to ensure same strategy across the machines and would coincide with new BIS version

# Overview of the three Main Protection Systems

System	Reaction time	Main feature	Up to LS2	Post LS2	Post LS3
External Conditions	max 4 pulses (typically 2-3)		hw; main system	“soft” ECs will remain main system	
SIS	2 – 3 pulses	high flexibility!	used to complement ECs	continue to use	continue to use
BIC	pulse to pulse	fail safe	no BIC	no BIC but use of PSB and SPS BICs in two cases	could be envisaged

# Summary

- The present machine protection in the PS is widely based on External Conditions complemented by SIS
- The external conditions will be modified during LS2 (“soft-ECs”)
- Post LS2 we will have additional machine protection systems: WIC, BLMs acting on Linac4; there will be no BIS for the time being
- In the long term one could think of a BIS for the PS, in order to harmonise with the other machines and in order to have a fast and fail safe system
- There are very few (if any) cases where equipment can be damaged in the PS, even with LIU beams
- The goal of machine protection is therefore to avoid long term activation
- We must preserve the flexibility and efficiency of the PS