

# **MPP Workshop**

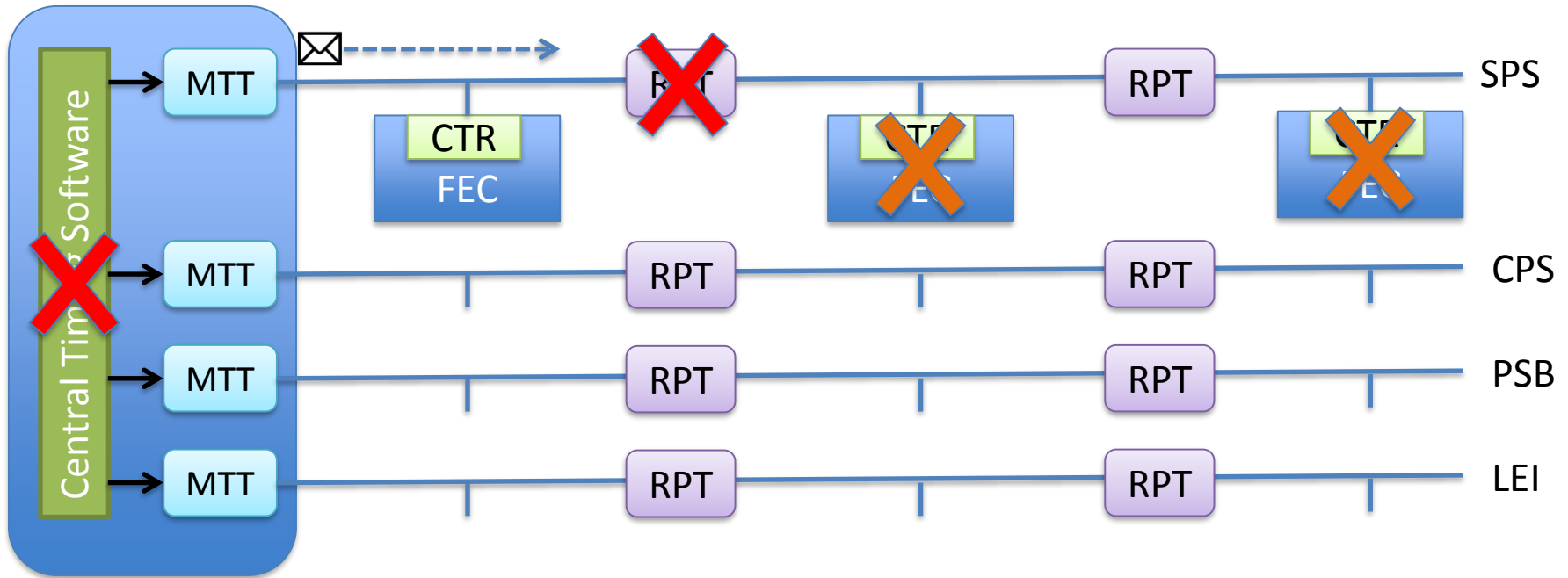
# **LHC Injector Chain (LIC) Timing**






G.Kruk on behalf of the Timing Team

GMT Monitoring

External Conditions, SIS, BIS

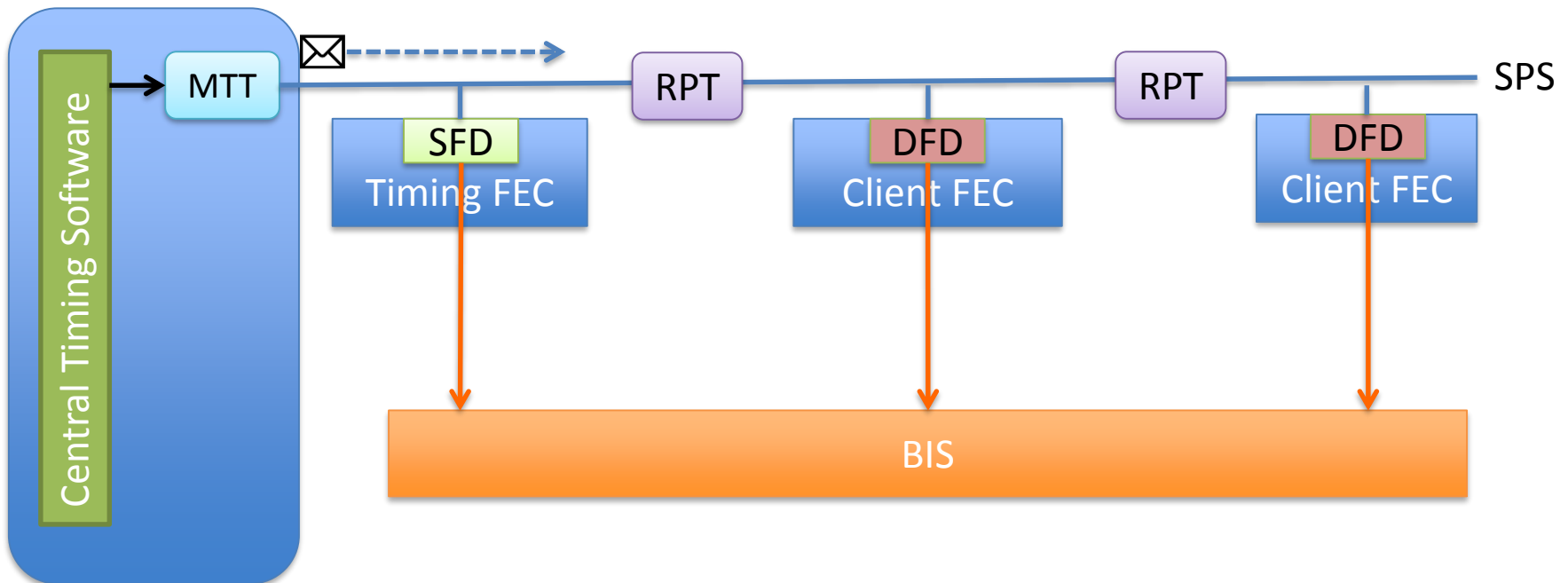
# General Machine Timing (GMT)



-  GMT Cable (fiber, copper)
-  MTT Multitasking Timing Generator
-  RPT GMT Repeater
-  CTR Central Timing Receiver (HW Module)
-  GMT Message  
- events, telegram, UTC, cable ID, ...

# GMT Monitoring

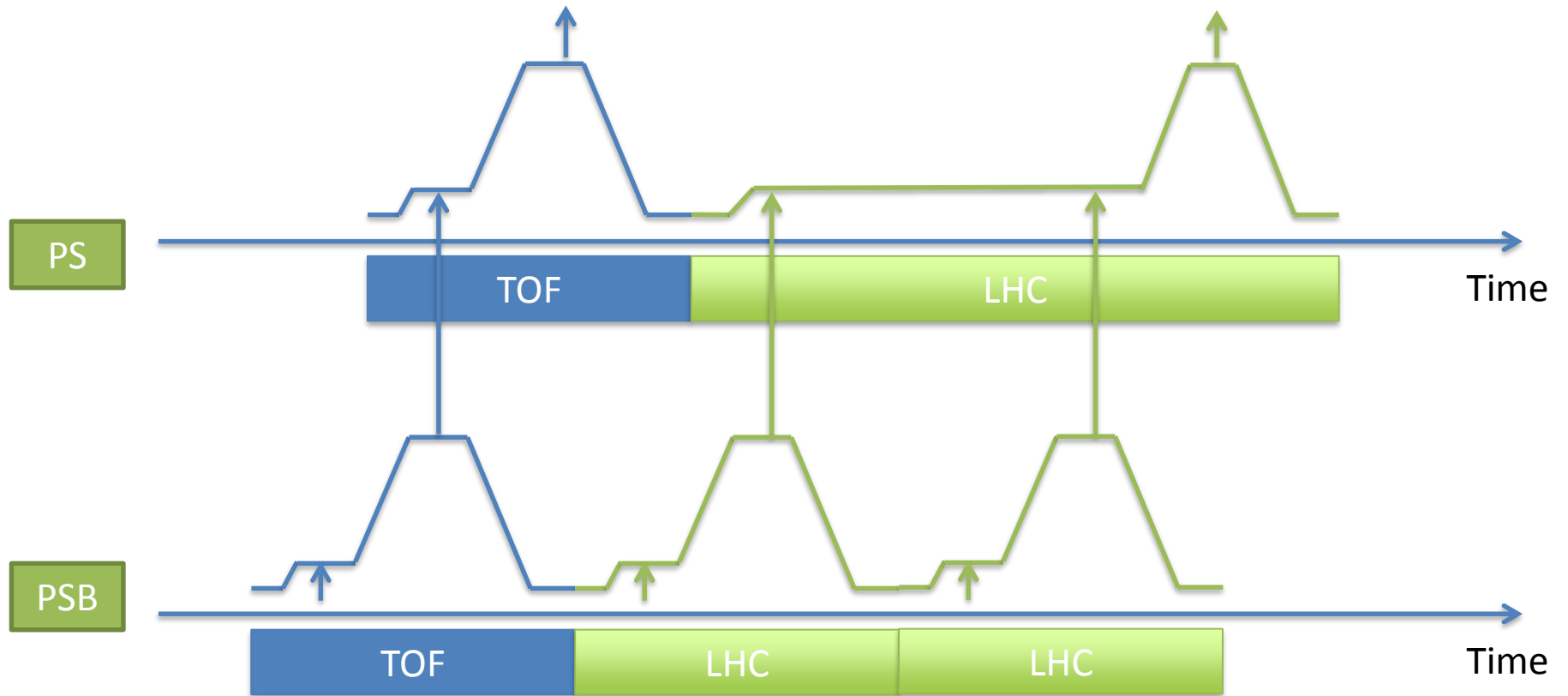
- CT Software Failure Detector SFD
- Distribution Failure Detector DFD



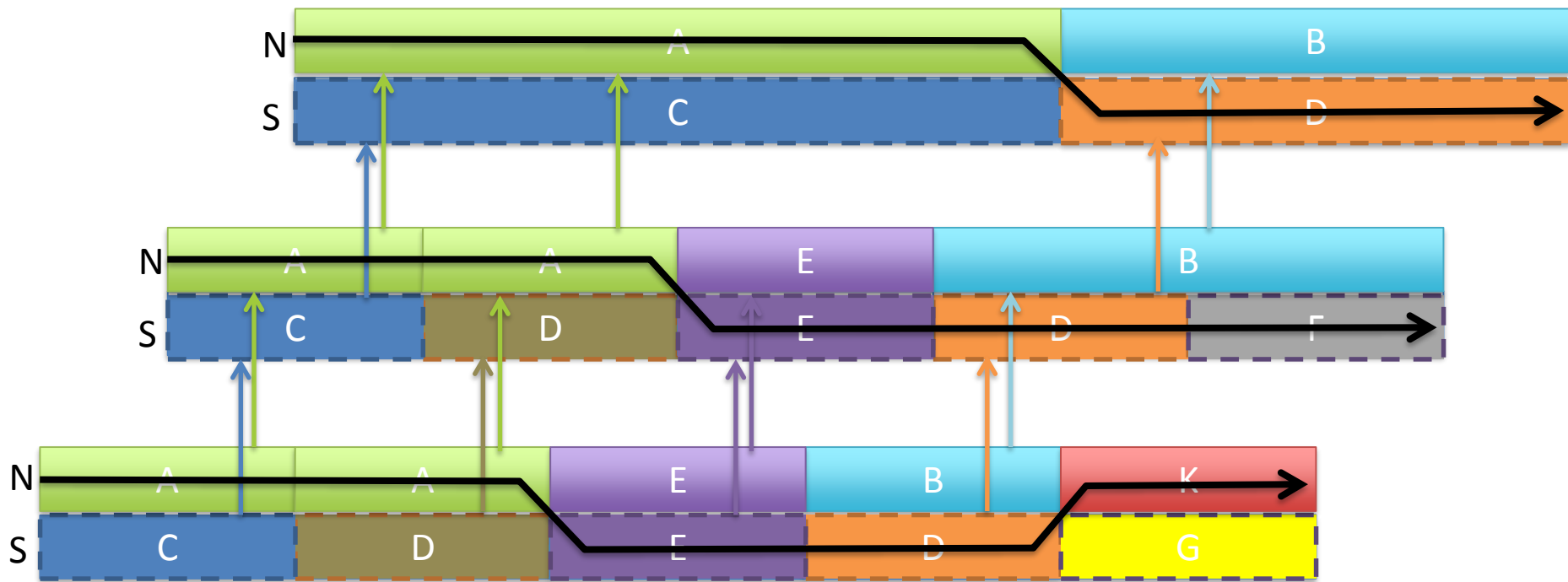
# **EXTERNAL CONDITIONS**

**SITUATION UNTIL LS2**

# Beam



# Spare Beams and Beam Coordination Diagram (BCD)



**Normal or Spare? → External Conditions**

# External Conditions

- Boolean value: GOOD/BAD or ACTIVE/INACTIVE
- Few categories:
  - Equipment problems or bad beam conditions
  - Inhibits
  - Software Interlocks
  - Requests / runtime configuration
- Two ways of signaling:
  - **Hardware:** cable link
  - **Software:** CMW set on MTG\_ExtCond FESA class
- MTG\_ExtCond
  - 1 device per condition
  - Allows changing software conditions and monitor state of all conditions
  - Masking

# Equipment Problems

- As of today 4 providers:
  - Power Converters
  - Kickers
  - EN-STI equipment (beam stoppers, target, ..)
  - Vacuum
- Hardware Conditions
  - Collected in bld 354 (Meyrin)
  - Sent to the CCR



# Inhibits

- Inhibit beams by different criteria
  - Destination, Particle Type, MD cycles
- Buttons in the CCC



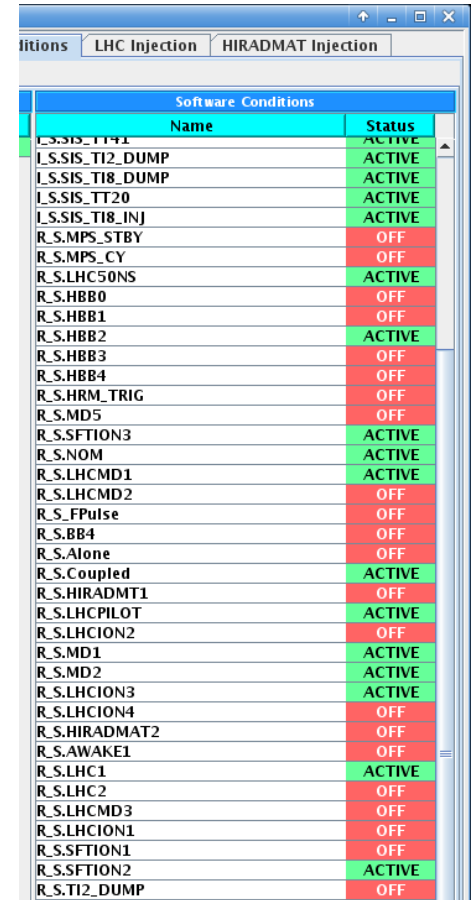
- Hardware Conditions
  - Collected in the CCR

# Software Interlocks

- Problems detected by SIS, concerning specific SPS destinations
  - SPS Ring, TT40, TT41, TT60, TT66,...
- Like inhibits but activated by SIS
- Software Conditions

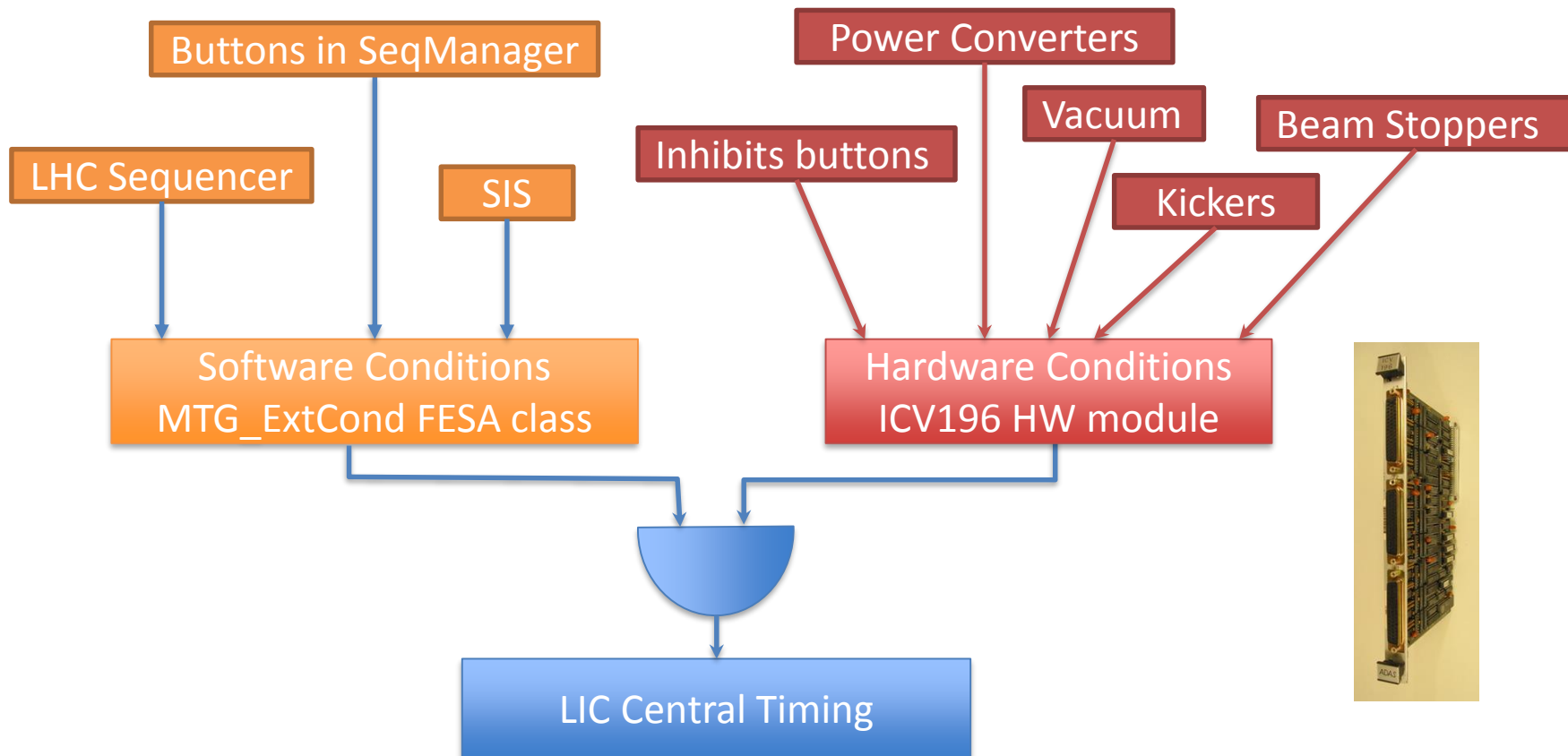
# Requests

- Various requests
  - BCD selection (1-8)
  - Specific cycle (user) requests
  - Beam requests from experiments
  - LHC and HIRADMAT requests
    - Pilot/nominal, ring1/2, nb of batches, ...
  - Enter/exit standalone mode (SPS/LEIR)
  - Enter/exit coast (SPS)
  - ...
- Software Conditions
- Changed by:
  - Operator pressing a button in the SeqManager GUI
  - LHC Sequencer
  - Custom applications



Name	Status
L.S.SIS_T141	ACTIVE
L.S.SIS_T12_DUMP	ACTIVE
L.S.SIS_T18_DUMP	ACTIVE
L.S.SIS_TT20	ACTIVE
L.S.SIS_T18_INJ	ACTIVE
R.S.MPS_STBY	OFF
R.S.MPS_CY	OFF
R.S.LHC50NS	ACTIVE
R.S.HBB0	OFF
R.S.HBB1	OFF
R.S.HBB2	ACTIVE
R.S.HBB3	OFF
R.S.HBB4	OFF
R.S.HRM_TRIG	OFF
R.S.MD5	OFF
R.S.SFTION3	ACTIVE
R.S.NOM	ACTIVE
R.S.LHCMD1	ACTIVE
R.S.LHCMD2	OFF
R.S.FPulse	OFF
R.S.BB4	OFF
R.S.Alone	OFF
R.S.Coupled	ACTIVE
R.S.HIRADMT1	OFF
R.S.LHCPILOT	ACTIVE
R.S.LHCION2	OFF
R.S.MD1	ACTIVE
R.S.MD2	ACTIVE
R.S.LHCION3	ACTIVE
R.S.LHCION4	OFF
R.S.HIRADMAT2	OFF
R.S.AWAKE1	OFF
R.S.LHC1	ACTIVE
R.S.LHC2	OFF
R.S.LHCMD3	OFF
R.S.LHCION1	OFF
R.S.SFTION1	OFF
R.S.SFTION2	ACTIVE
R.S.T12_DUMP	OFF

# External Conditions Summary

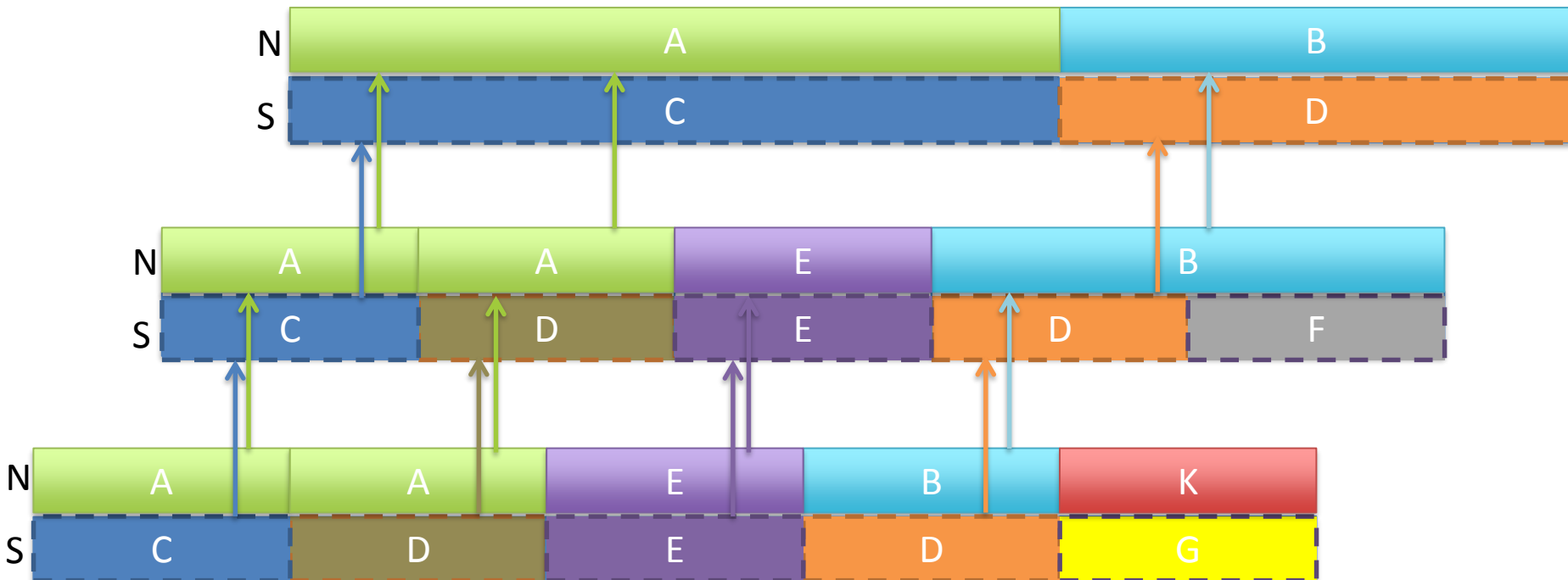


# How Central Timing uses them?

- Make a choice: NORMAL or SPARE
- Decide if should enable tail clipper (cut the beam)
- Decide if should cut particular Booster ring
  
- Select next BCD
- Enter/exit standalone and coast mode
- ...

# NORMAL or SPARE

- External conditions check: beam OK or BAD?
- If normal beam is OK → play it
- If normal beam is BAD → play spare beams
- If spare beam is BAD → play it with tail clipper enabled

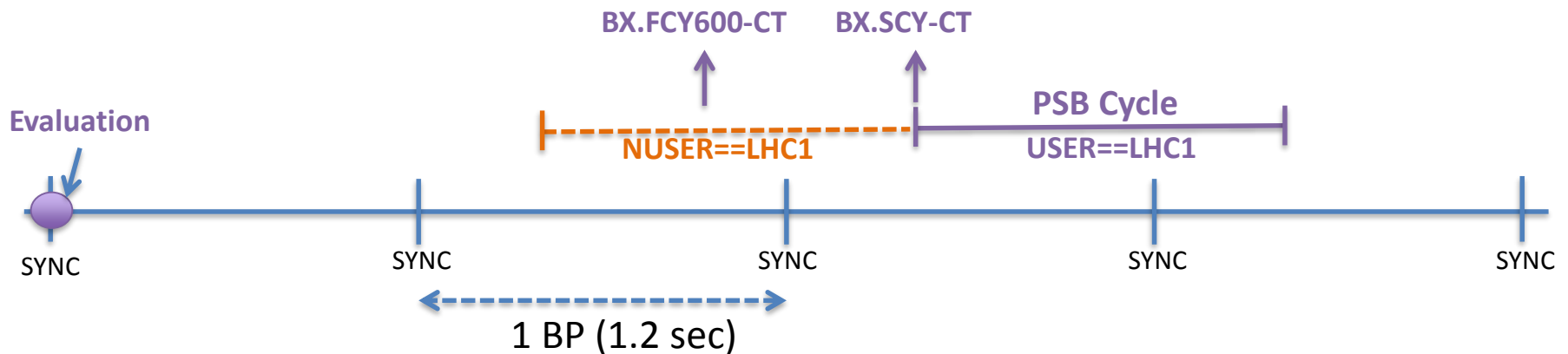


# Examples of rules turning beam to BAD

- General:
  - B\_VV or B\_MPS is BAD
- Destination dependent:
  - PSB dest is PS and BE\_SMH is BAD
  - PS dest is EAST\_N and (I\_P\_EAN is active or (UR\_EA9 and UR\_EA10 and UR\_EA11 are not active))
- Beam type dependent:
  - PSB MD beam and I\_B\_MD is active
  - PARTY is PROTON and I\_P\_PROT is active
  - Beam to LHC but doesn't match the LHC request or LHC doesn't have mastership

# Enabling Tail Clipper

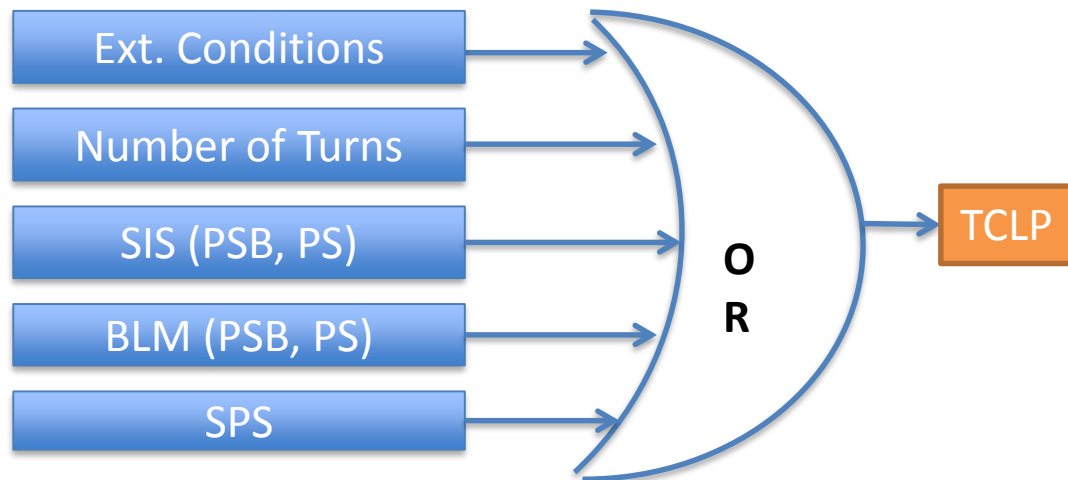
- Conditions evaluated also “*just before*” the PSB cycle is played
  - During calculation of the telegram
  - Additional checks: Requested number of batches, BHZ377 rule violation
  - If conditions are bad → PSB telegram COMLN:TCLP = true
- Possibility to cut a single ring
  - Ring extraction kicker is BAD
  - Ring destination is BAD but destination of another ring is OK (East\_N / nTOF)
  - COMLN:NORING[1-4]





# Enabling Tail Clipper

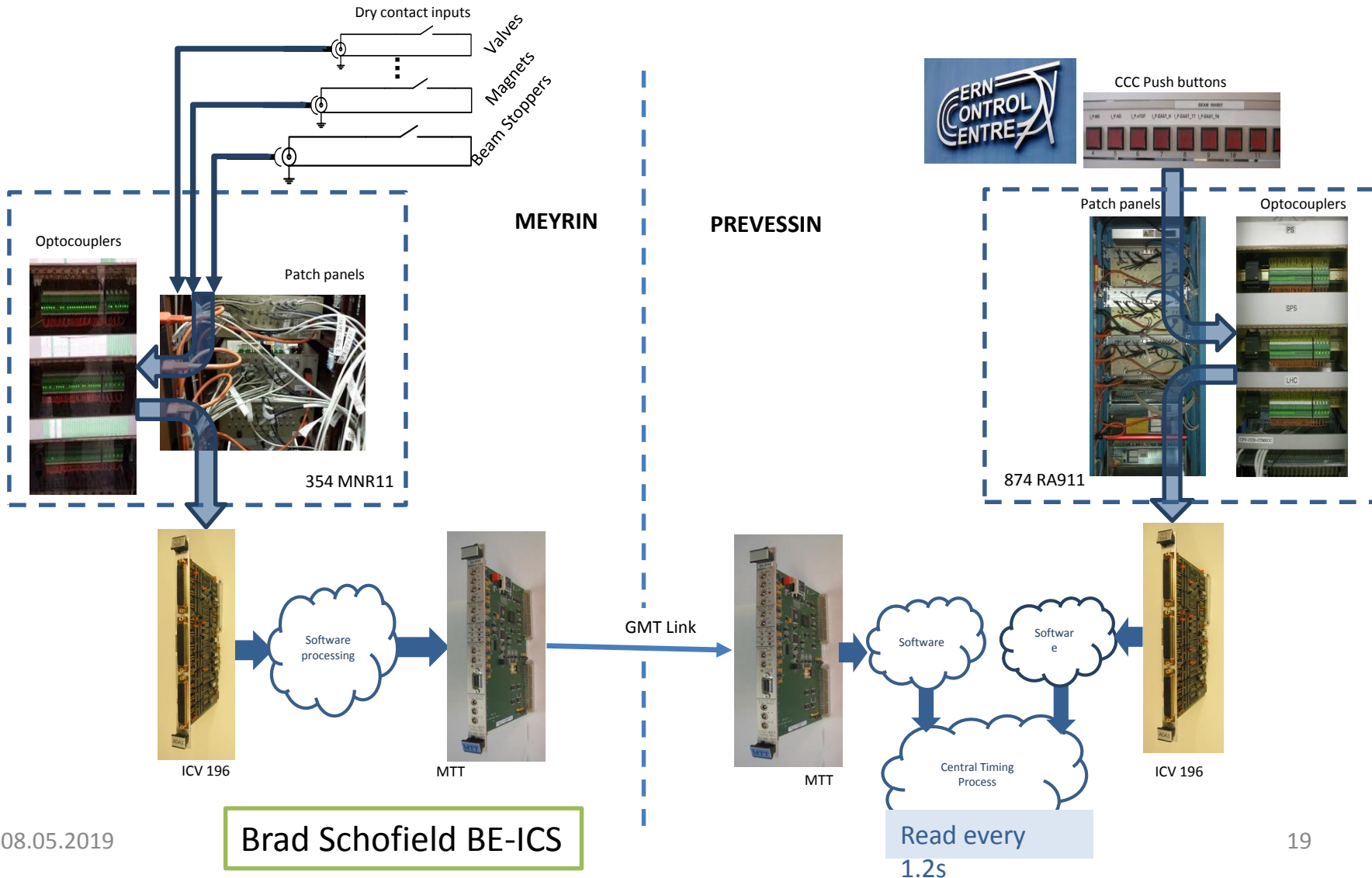
- $\text{COMLN:TCLP}==1 \rightarrow \text{LTIM triggering before inj.}$
- $\text{COMLN:NORING}[1-4] \rightarrow \text{NT}[1-4] = 0$



More in the following talks of Bettina and Klaus

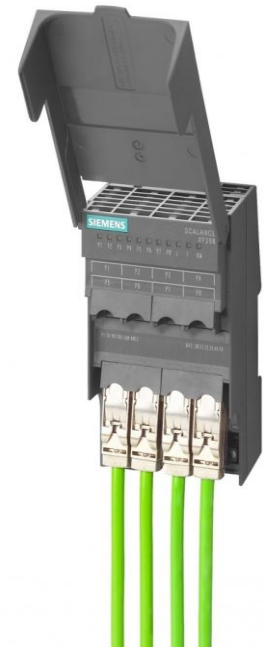
# **EXTERNAL CONDITIONS RENOVATION**

# Current System

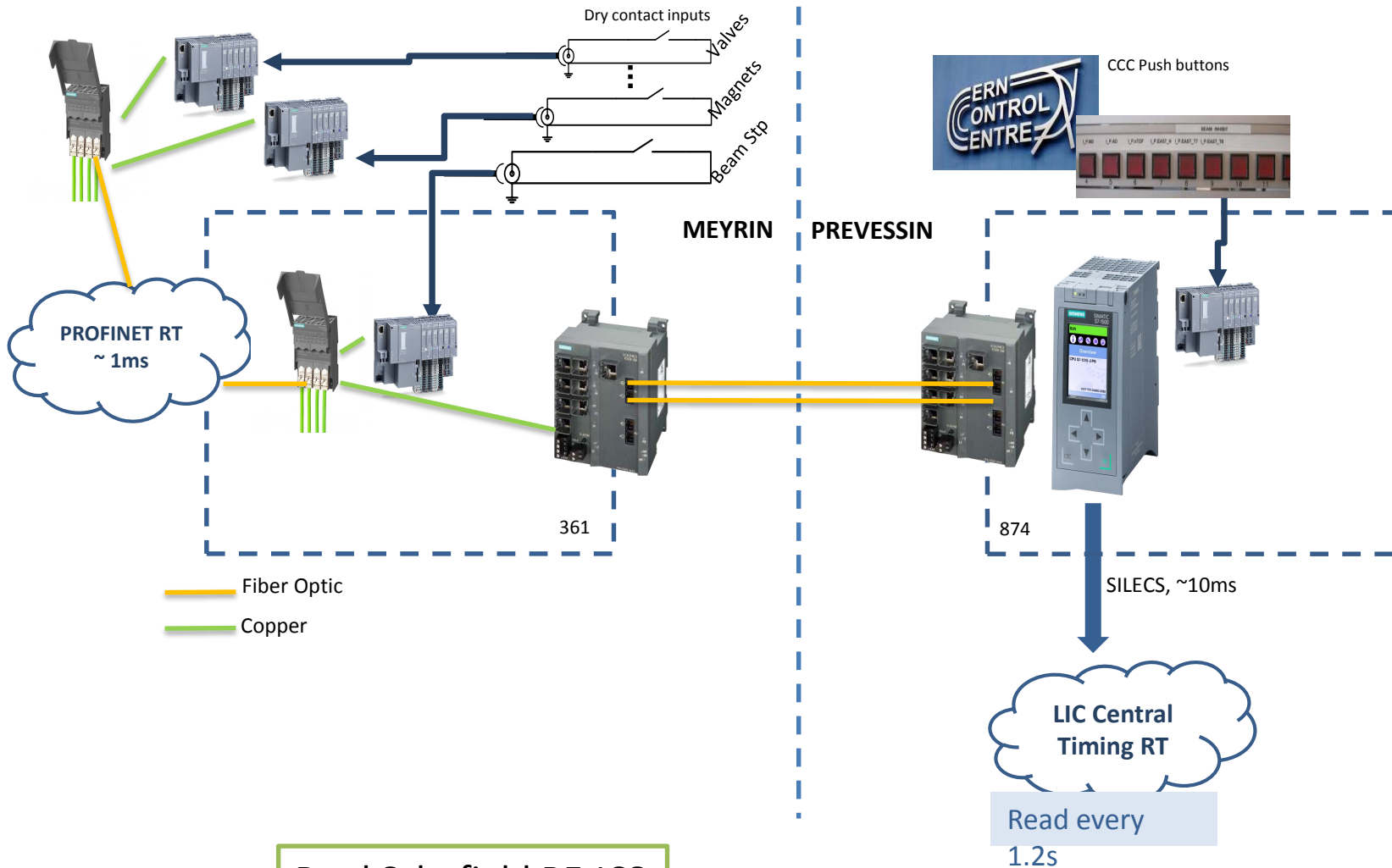


# Proposed Technologies

PLCs and remote IO communicating over Industrial Ethernet (Profinet)



# New System



# Hardware link or JAPC/CMW?

- FGCs
  - After LS2 no HW link for Power Converters
  - Subscribe to a status property published 2Hz (more than just power off)
  - No update for 1 sec → BAD
- Kickers
  - The external condition is PPM (setting-dependent)
  - The HW link converted to non-PPM
  - A non-PPM property could be added
  - Should Central Timing support PPM ECs in the future?
- Beam Stoppers
  - PSBS FESA class publishes state equivalent to the HW link (1Hz)
  - SIS already used for certain beam stoppers (EAST)
- Vacuum
  - No FESA class, only CMW server publishing valves state and pumps pressure
    - Preference for HW link
  - Some HW links connected to the BIS during LS2 (LINAC4, PSB Injection)
  - Plans to connect the remaining ones to the BIS after LS2
- Inhibit buttons
  - PLCs and Profinet - best option

# Hardware link or JAPC/CMW?

- Hardware conditions are not exactly *hardware*
  - Software processes involved
  - Readout via Ethernet (SILECS)
  - Delay of 2-3 BPs before the beam is cut (max 4 shots)
- Ideally same way of accessing all conditions
  - E.g. standard property implemented by all providers
- With EC publication at 1-2Hz the CT reaction time won't change significantly

# LIC CT (ECs) vs. SIS vs. BIS

- LIC Central Timing External Conditions
  - Beam scheduling and slow interlocking (2-3 BPs)
  - PCs, Kickers, Beam Stoppers, Vacuum, Inhibits, Requests
  - Non-PPM but takes into account beam config (dest, MD, particle type, ...)
  - **Operational efficiency**
- SIS
  - Slow interlocking (1-2 BPs)
  - PCs, Kickers, ...
  - PPM or non-PPM, can take into account beam config
  - **Flexible configuration**
- BIS
  - BLMs, PCs, Vacuum, ..
  - Fast interlocking (instant)
  - Non-PPM, doesn't take into account beam config
  - **Safety**



# Summary

- External Conditions:
  - Inputs to the LIC Central Timing used to decide what to do
  - Delivered by HW links, CMW Sets and CMW Subscriptions
- External condition concept must remain → beam time optimization
  - CMW subscriptions sufficient for that
- Infrastructure of collecting HW conditions will be renovated during LS2
  - Inhibit buttons → PLC
  - Vacuum → PLC
  - Power Converters (FGC) → CMW Subscription
  - Beam Stoppers, Kickers → ?
- Three systems interlocking the beam: LIC CT, SIS, BIS

# Points for future discussion

- Should the Central Timing continue playing the role of an interlocking system?
  - Or should it be just aware of interlocks to make an efficient use of the beam time
- Could and should BIS interlock all external conditions?
  - Vacuum (remaining), Kickers, Beam Stoppers, PCs and Inhibits connected to BIS?
  - BIS permit evaluator would have to be aware of beam config
    - What about double destination cycles?
- What should be the role of SIS and how should it act?
  - Today: Source of external conditions, input to the tail clipper, input to the BIS
- LIC CT would still enable the tail clipper in specific cases
  - Disabled batch, BHZ377 rule, cut single ring, ...

**Long term strategy and responsibilities should be clarified**

# SPARE SLIDES

# Software Failure Detector

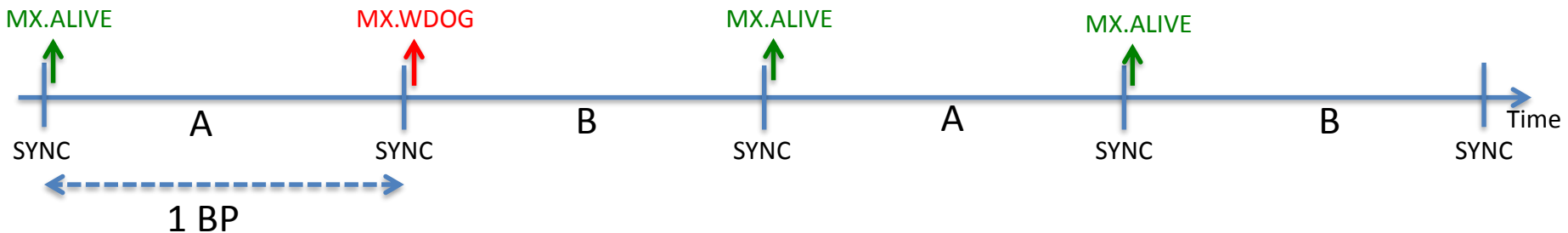
## MTT Programming:

- Two alternated tasks A and B, each one sending messages over 1 BP
- While one is executed, CT software prepares and loads the next one

## MTT task program:

```
wait next SYNC  
send MX.ALIVE  
wait N ms  
send msg1  
wait M ms  
send msg2  
...
```

```
wait 2 SYNC  
send MX.WDOG
```



# Software Failure Detector

- MTT reprogrammed every 1.2 sec
  - MX.ALIVE event sent as first message
  - MX.WDOG sent at the end of the program (normally never executed)
- SFD observes MX.ALIVE and MX.WDOG events and provides permit *level* for the BIS that is dropped in case:
  - MX.ALIVE does not arrive after 1200ms
  - MX.WDOG is received
- Implemented using CTR
- Will be installed in BA5

# GMT Distribution

- GMT cable: RS-485 – 8 frames / ms
  - Millisecond (MS) event + up to 7 other messages

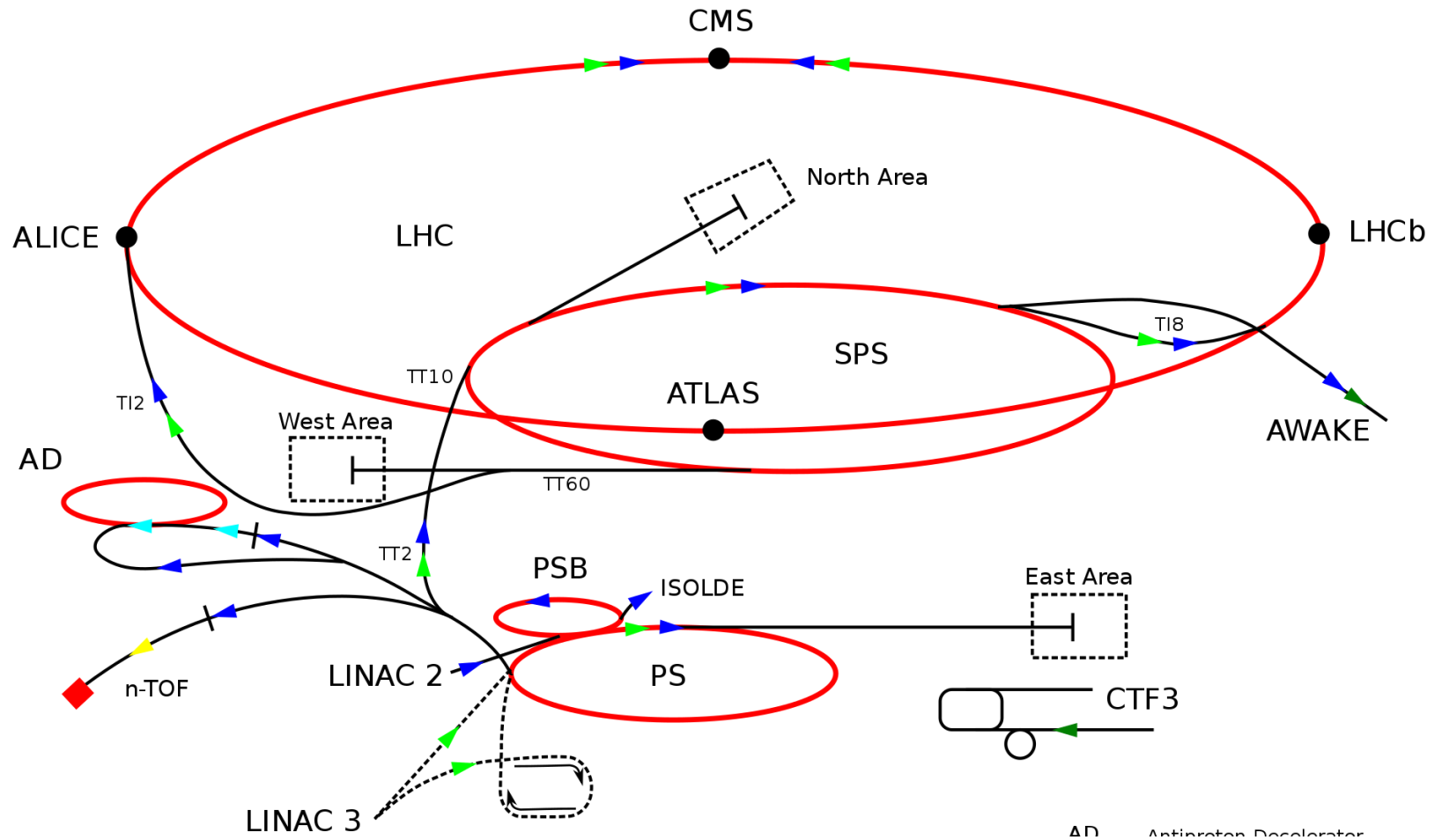


- CTR detects bad and lost GMT transmission
  - Status registers: GMT Error, PLL Error, Lost Frames Cnt

# Distribution Failure Detector (SPS)

- Will be installed in client FECs
  - Beam Dump, MPS, BLMs, Damper
- Drop BIS permit if either:
  - Millisecond event missing
  - CTR status is bad (must be read at 1KHz)
- Implemented using CTR
- The BIS permit is dropped by the existing client software/hardware

# Destinations



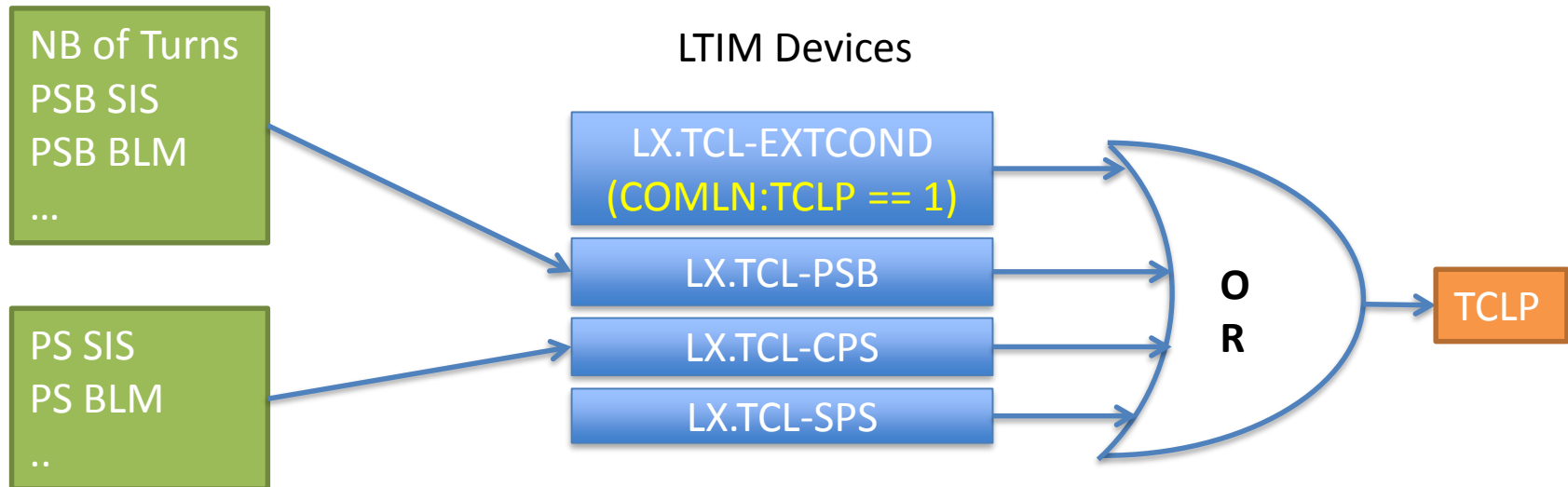


# Examples of rules turning beam to BAD

- B\_VV or B\_MPS is BAD
- PSB dest is PS and BE\_SMH is BAD
- PSB dest is global and dest is PS and nb of good ring ej kickers < 3
- PSB dest is ISOGPS and R\_BY\_GPS is not active
- PSB MD beam and I\_B\_MD is active
- PS dest is EAST\_N and (I\_P\_EAN is active or (UR\_EA9 and UR\_EA10 and UR\_EA11 are not active))
- PARTY is PROTON and I\_P\_PROT is active
- SPS USER is LHC50NS and R\_S\_LHC50NS is not active
- Beam to LHC but LHC doesn't have mastership or requested beam doesn't match the evaluated one

# Enabling Tail Clipper

- $\text{COMLN:TCLP} == 1 \rightarrow$  LTIM triggering before inj.
- $\text{COMLN:NORING}[1-4] \rightarrow \text{NT}[1-4] = 0$



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