Zurich University
of Applied Sciences

School of
Engineering

IAMP Institute of Applied
Mathematics and Physics

FBIS ConOps

14.05.2017

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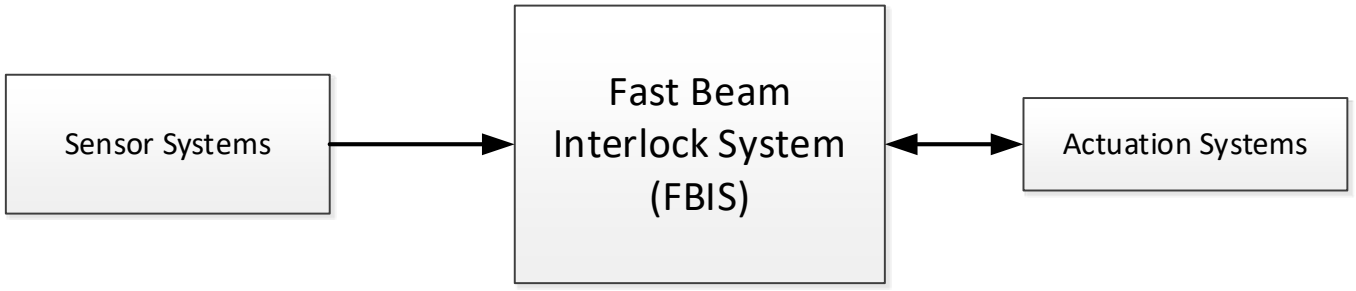
FBIS Role

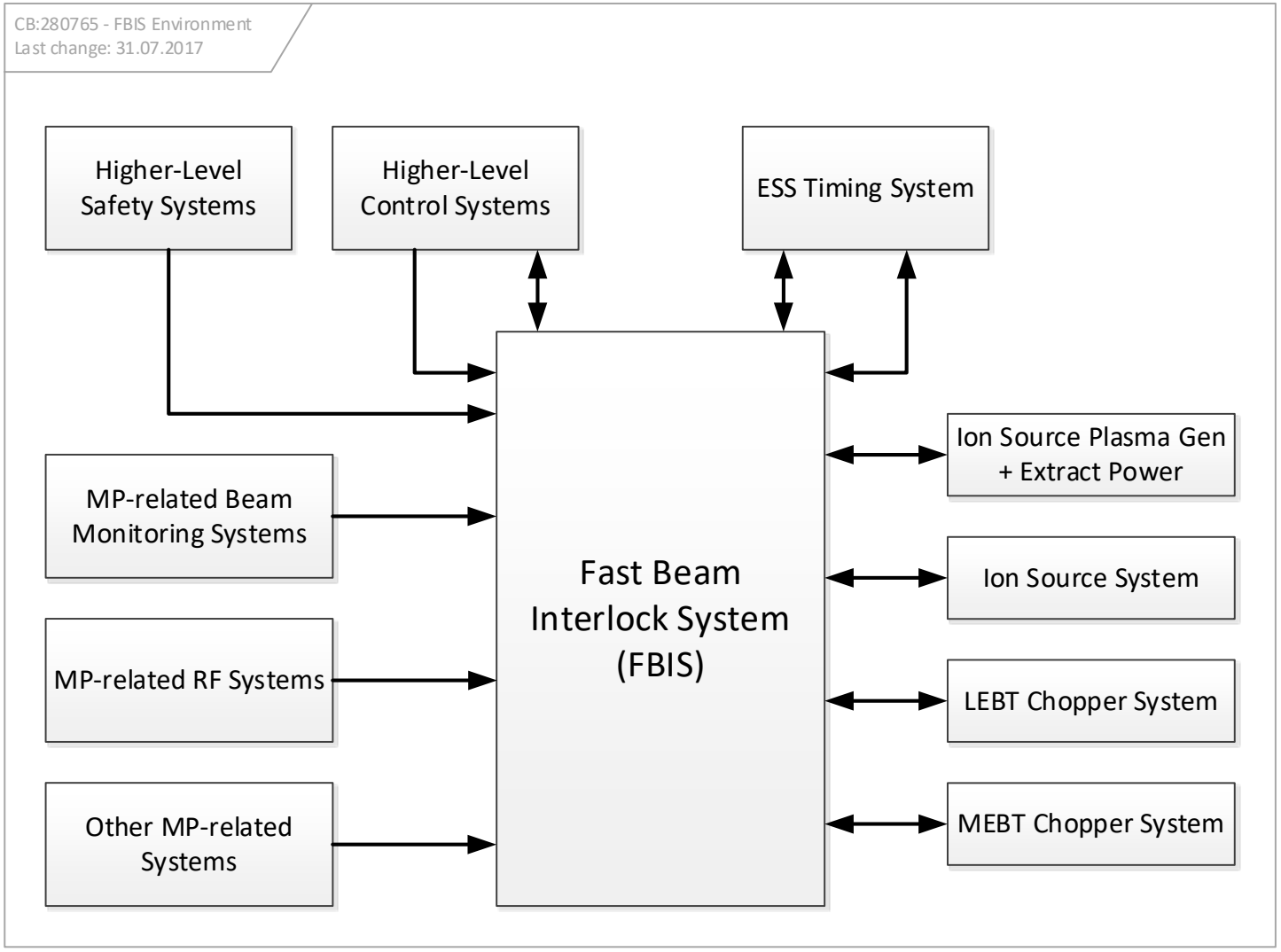
- In Essence: FBIS constitutes the final link between the many MP-related systems and the MP-related Actuation Systems.
- “Safe” in the context of MP.



FBIS Role

- FBIS controls the MP-related Actuation Systems to achieve and maintain a safe state based on:
  - BEAM-PERMIT signals;
  - READY signals;
  - Proton Beam Destination and Proton Beam Mode of the machine;
  - “Mode” configuration of all relevant MP-related;
  - “No-beam detected” information from beam instrumentation systems;
  - Faraday-Cup and Emittance-Measurement-Unit positions,
  - Operational status and health status;

FBIS Role


CB:280765 - FBIS Environment
Last change: 31.07.2017
Higher-Level Safety Systems
Higher-Level Control Systems
ESS Timing System
MP-related Beam Monitoring Systems
MP-related RF Systems
Other MP-related Systems
Fast Beam Interlock System (FBIS)
Ion Source Plasma Gen + Extract Power
Ion Source System
LEBT Chopper System
MEBT Chopper System

Approach

- Why a FBIS ConOps?

- ESS Hazard and Risk Analysis and definition of Protection Functions still under development
- No «formal User Requirements Specification» for the FBIS (Lastenheft)

- FBIS development guided by:
  - Benchmark Use Cases
  - Driving Requirements
  - Concept of Operation

General FBIS Behavior

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Reaction of FBIS depends:

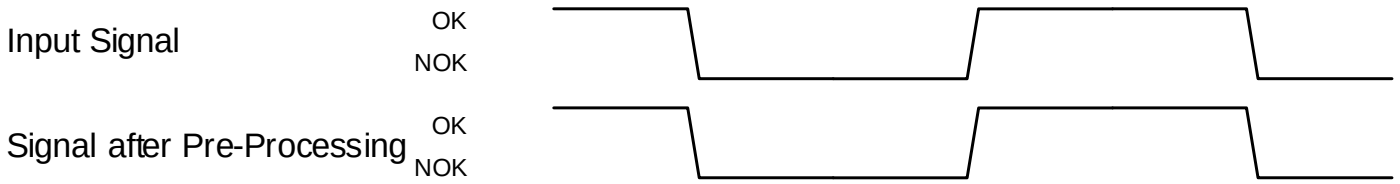
a) on the configuration of the respective FBIS input

b) on the status of the proton beam

Input Signal Latching

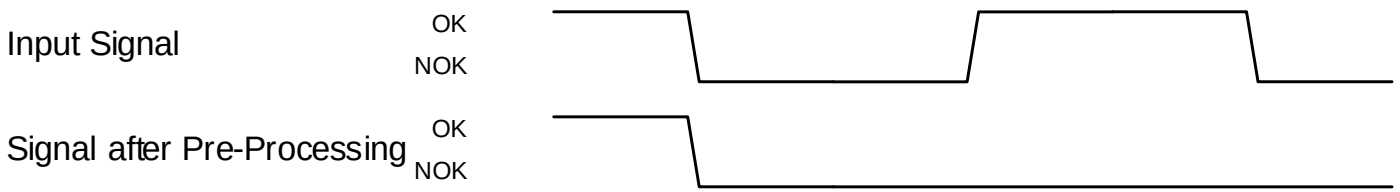
- FBIS Input can be configured to:
  - «no latching»: the signal is processed as detected at the FBIS input

An FBIS input is configured to **No Latching**:



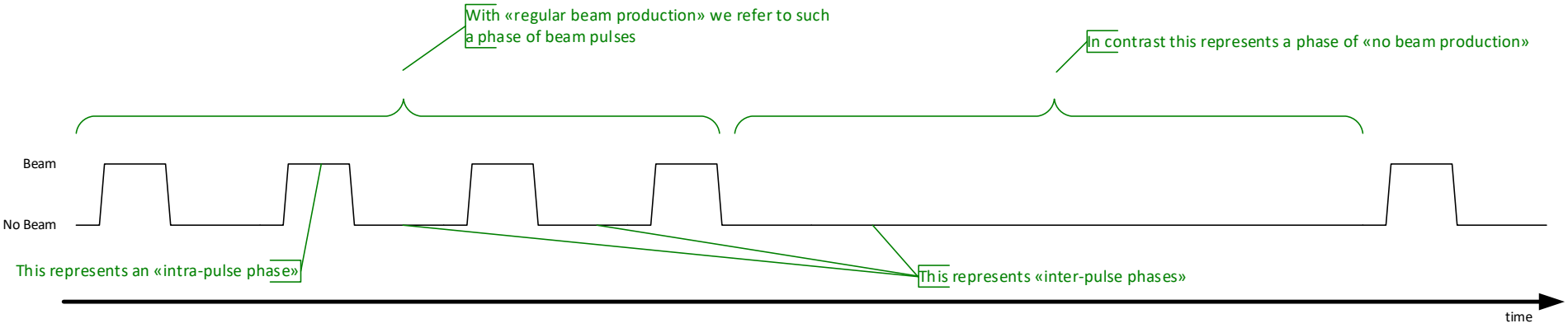
  - «latch NOK»: a NOK state is latched until an explicit reset occurs

An FBIS input is configured to **Latch NOK**:



Beam Pulse Phase

- The FBIS differentiates two beam pulse phase states:
  - Beam is Off (e.g. in between beam pulses) aka «inter-pulse phase»
  - Beam is On aka «intra-pulse phase»



General FBIS Behavior

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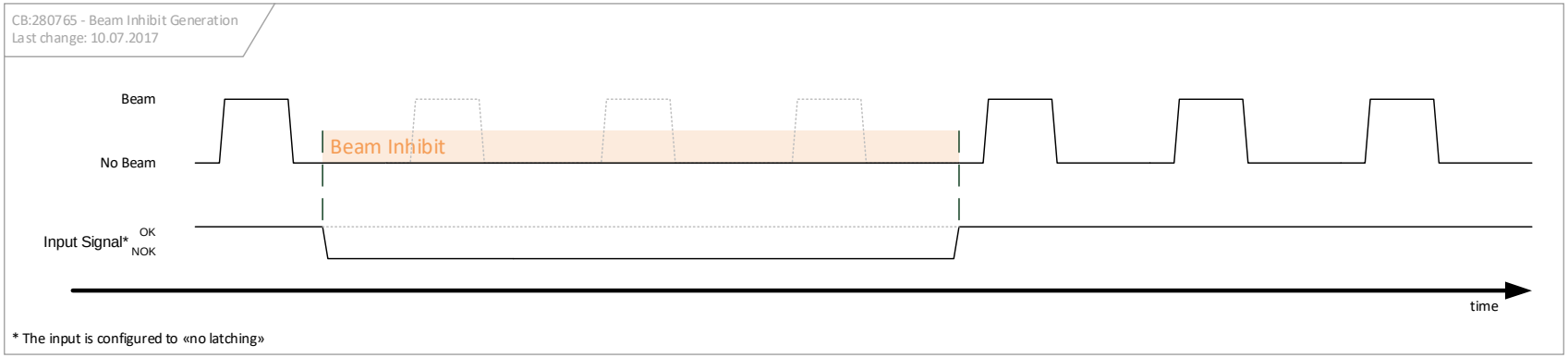
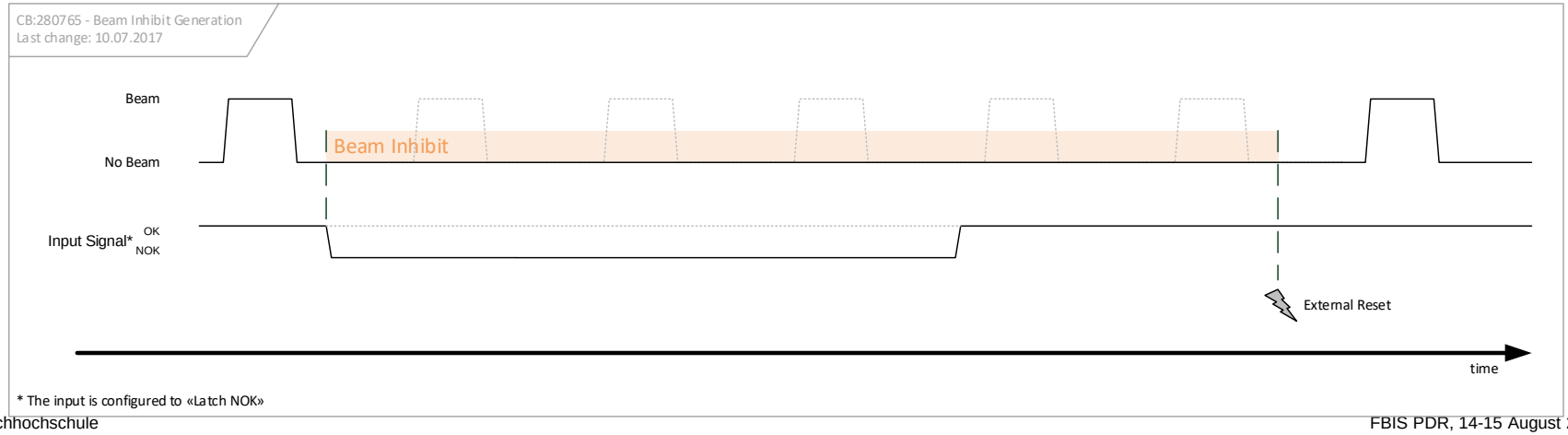
Proton Beam state	Configuration of the FBIS input	FBIS reaction to an Input signal in state NOK
Inter-Pulse phase	No Latching (READY signal)	The FBIS carries out a “Beam Inhibit”. The “Beam Inhibit” is not latched.
	Latch NOK (BEAM-PERMIT signal)	The FBIS carries out a “Beam Inhibit”. The “Beam Inhibit” is latched. The FBIS informs the ESS Timing System that the Beam Inhibit is latched.
Intra-Pulse Phase	No Latching (READY signal)	The FBIS carries out a “Regular Beam Interlock“. The “Regular Beam Interlock” is latched.
	Latch NOK (BEAM-PERMIT signal)	The FBIS informs the ESS Timing System that the Regular Beam Interlock is latched.

Beam Inhibit

- OK→NOK transition of input configured to «no latching» when there is no beam:



- OK→NOK transition of input configured to «latch NOK» when there is no beam:



Regular Beam Interlock

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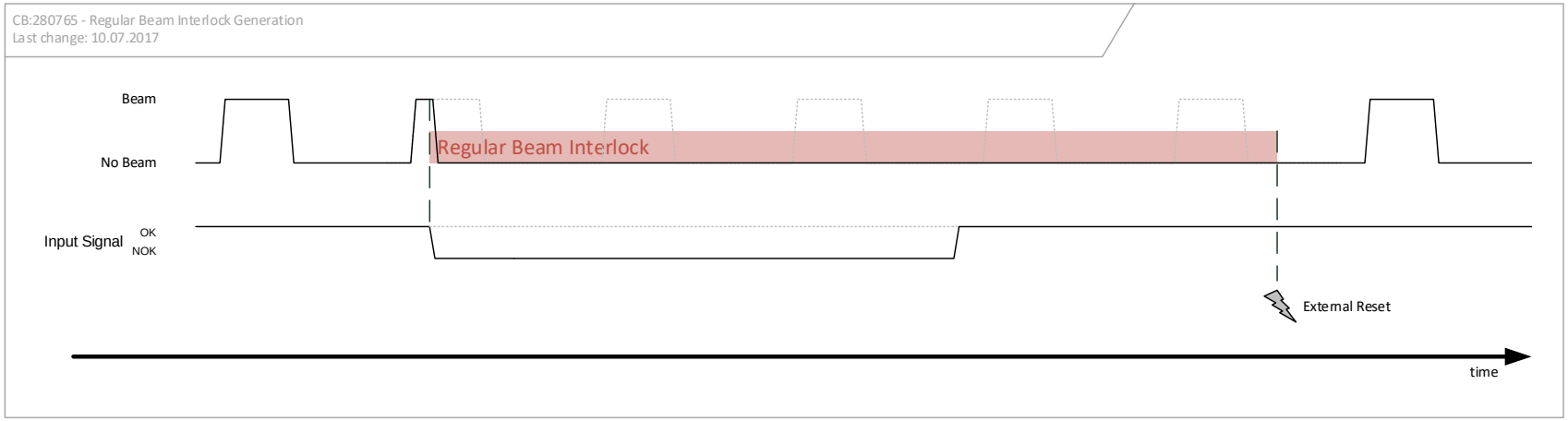
- OK→NOK transition of input configured to «no latching» when there is beam:
- OK→NOK transition of input configured to «latch NOK» when there is beam:



Beam Inhibit Function

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- When carrying out a “Beam Inhibit” the FBIS performs the following actions:
  - it inhibits the generation of further beam pulses by acting on the ESS Timing System;
  - it interrupts proton beam extraction by “interlocking” the proton source through a dedicated input of the Proton Source System.
  - in addition, it activates the LEBT and MEBT choppers as precaution, should the inhibit via ESS Timing System and proton source fail.

Regular and Emergency Beam Interlock

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- When carrying out a “Regular Beam Interlock” (RBI) the FBIS performs the following actions:
  - it inhibits the generation of further beam pulses by acting on the ESS Timing System;
  - it interrupts proton beam extraction by “interlocking” the proton source through a dedicated input of the Proton Source System.
  - causes the proton beam to be dumped by activating the LEBT and MEBT choppers;
- When escalated to an “Emergency Beam Interlock” (EBI) the FBIS performs additionally the following actions:
  - cutting the power to the plasma generator of the Proton Source System and
  - cutting the power to the extraction system of the Proton Source System.

Checks and Escalation

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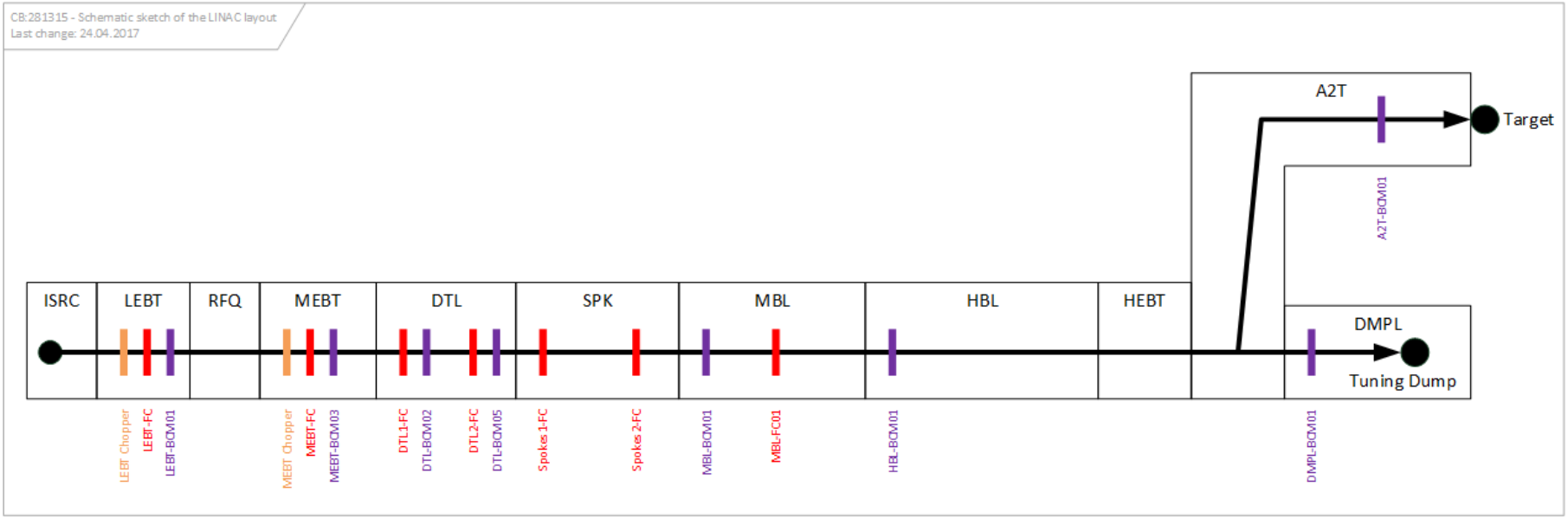
- FBIS checks for beam while in inter-pulse phase → RBI
- FBIS checks for beam downstream of intermediate beam destinations → RBI

- FBIS checks if Beam Inhibit / Regular Beam Interlock was successful.
  - Based on beam presence information from BI
  - Based on status feedback of Actuation Systems
- → EBI

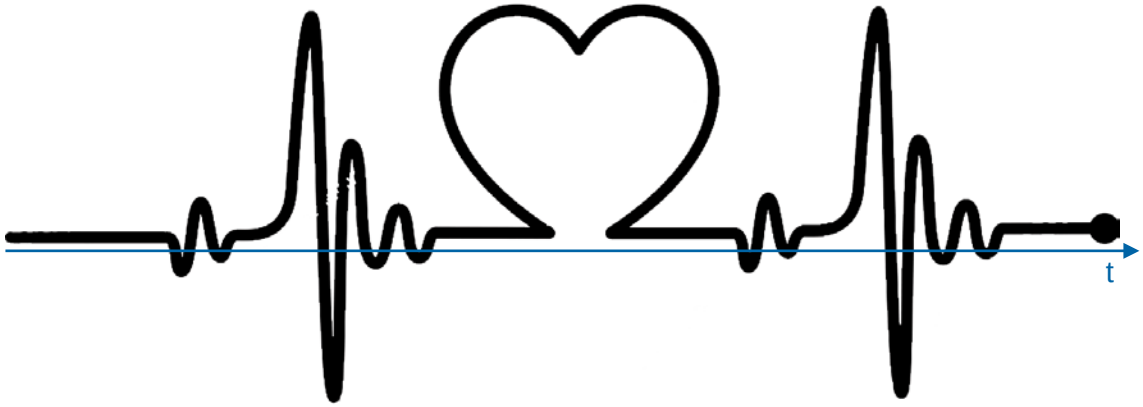
Configuration Confusion

- Configuration confusion considered to be big risk!
- ESS operation based on two «principal modes»
  - Proton Beam Destination



Configuration Confusion

- Configuration confusion considered to be big risk!
- ESS operation based on two «principal modes»
  - Proton Beam Destination
  - Proton Beam Mode



Enforced Proton Beam Destination

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- We assume
  - FBIS knows Requested Proton Beam Destination from TS and Higher-Level Control System
  - FBIS knows from all relevant MP-related Systems which proton beam destination they enforce (LPSID, LPS-A2T, LPS-RF, …)
- FBIS deduces «Enforced Proton Beam Destination»
- FBIS requests beam switch-off in case of missmatch

Enforced Proton Beam Mode

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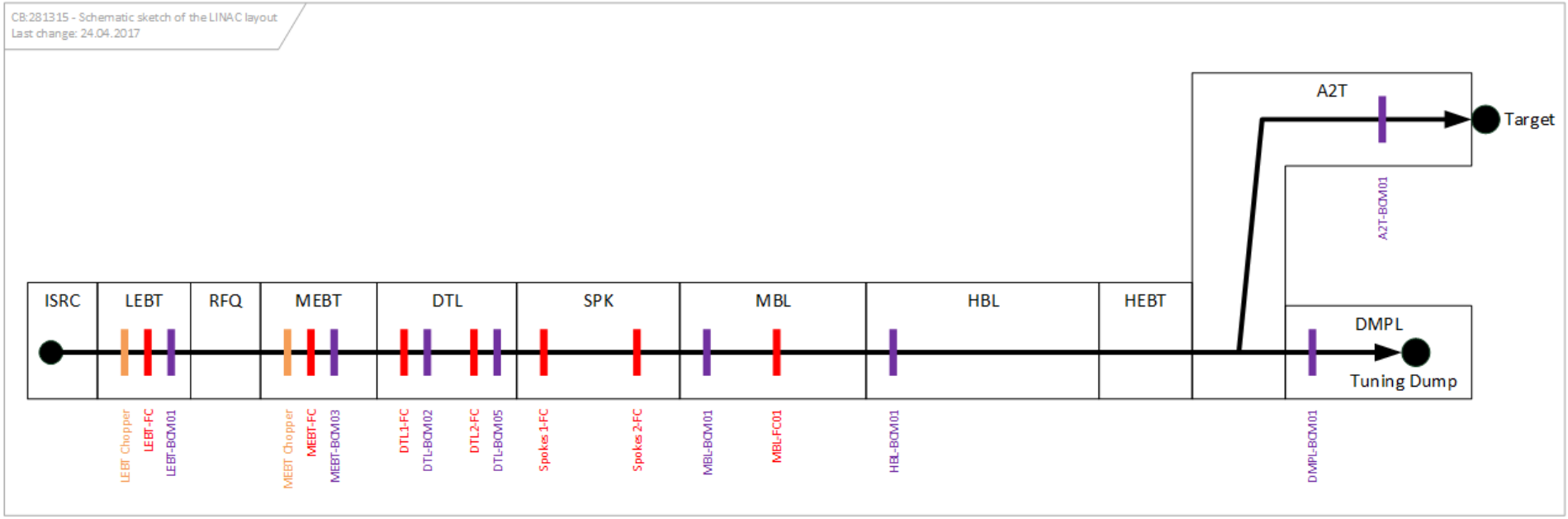
- We assume
  - FBIS knows Requested Proton Beam Mode from TS and Higher-Level Control System
  - FBIS knows from all relevant MP-related Systems which proton beam mode they are configured for (they enforce)
- FBIS deduces «Enforced Proton Beam Mode»
- FBIS requests beam switch-off in case of missmatch

FBIS Decision Logic is more than an AND

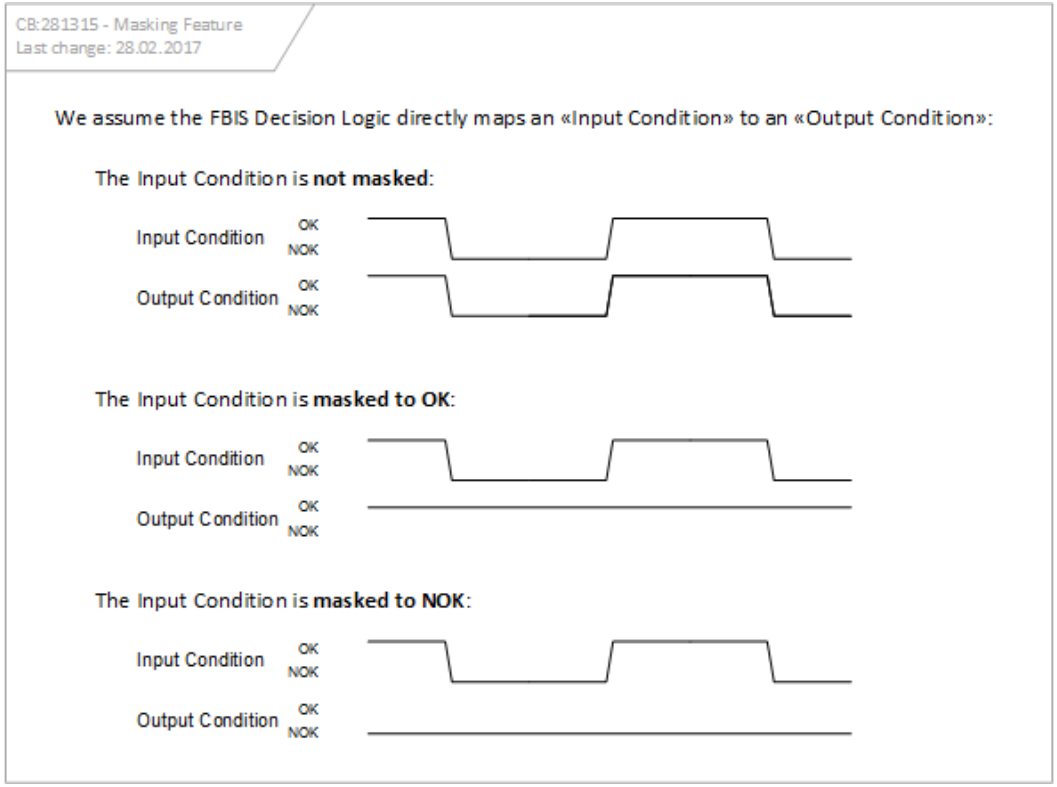
- Logic is Proton Beam Destination dependent



However, logic is not changed based on “sensor information” only!

Masking Feature

- FBIS inputs can be masked:



Masking depends on rulesets

Convenience Functions

FBIS features «convenienve functions»

- Status and Diagnostic information
- Event Logging
- Software Beam-Permits
- …

- Running in «Degraded Mode»

Use Case:
Change Beam Destination from LEBT-FC to DTL-FC

Use Case

Status at start of use-case:

- beam is on and is captured by LEBT-01:PBI-FC-01 (in the use case referred to as LEBT-FC)
- Insert and extract permit for all ID's is NOK (no ID is moving)
- Gate Valves between LEBT-FC and DTL-FC are closed

Expected status at end of use case:

- beam is on and is captured by DTL-04:PBI-FC-01 (in the use case referred to as DTL-FC)

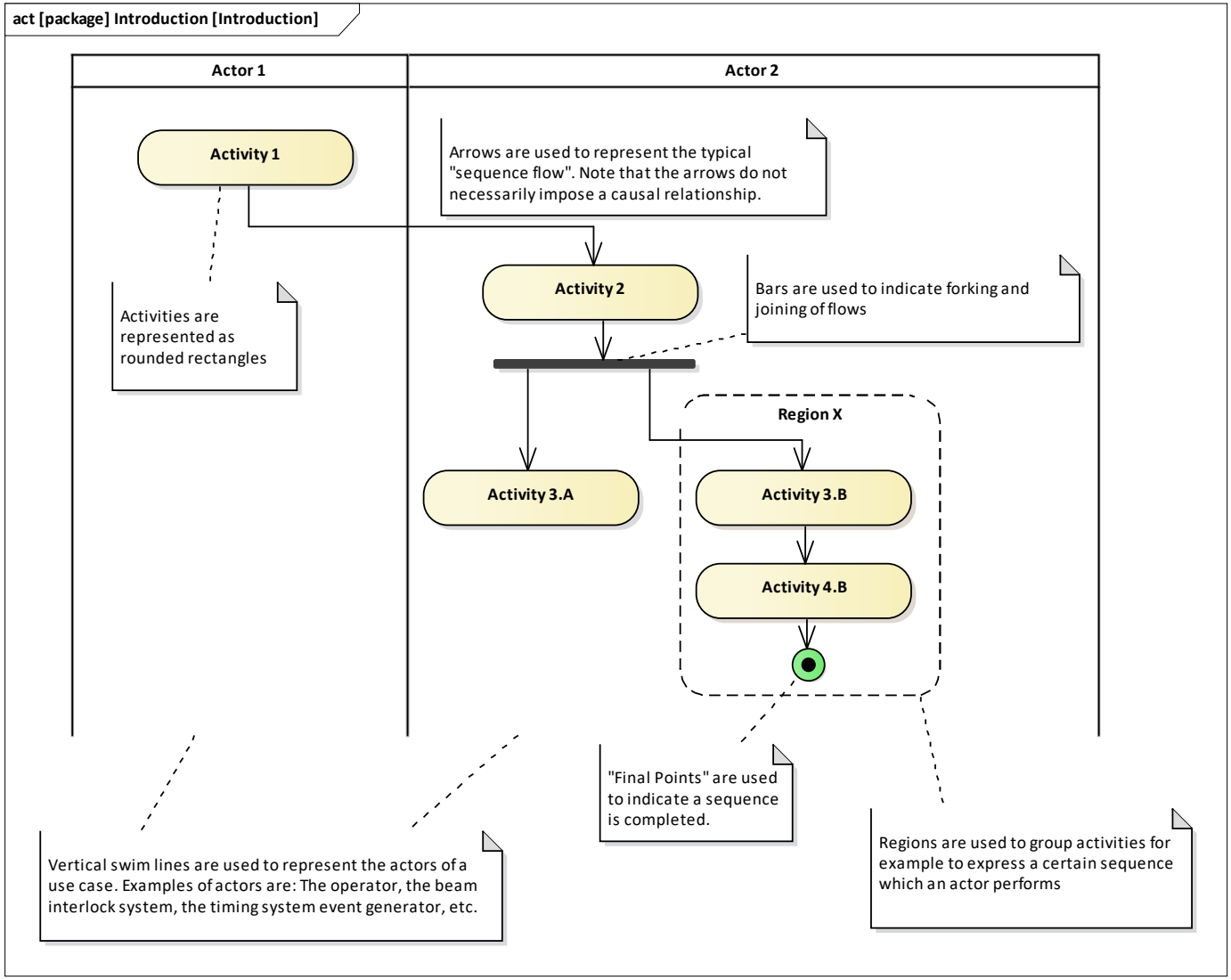
Assumptions:

- Handshaking between the Control System Sequencer and other systems is not explicitly modeled in this use case

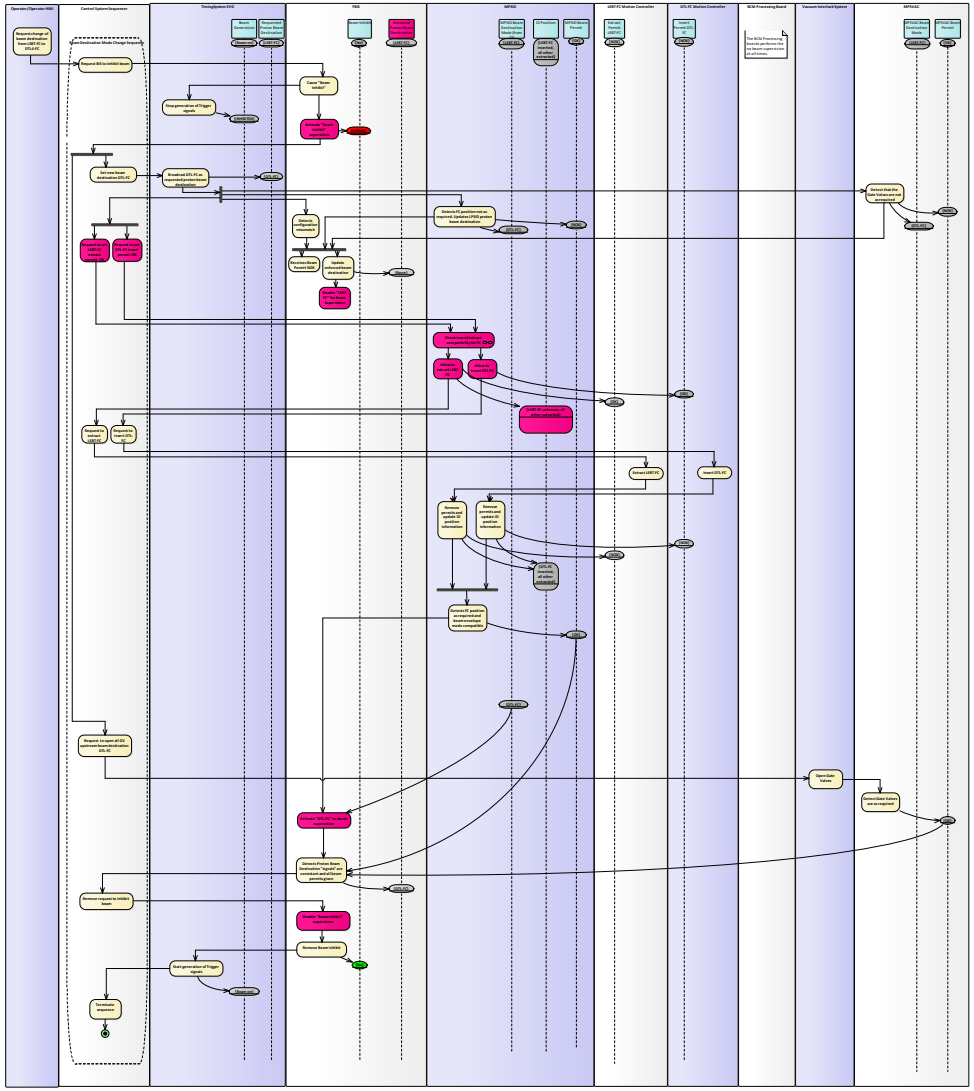
Use Case - Actors

- Operator/Operator HMI
- Control System Sequencer
- Timing System EVG
- FBIS
- MPSID
- LEBT-FC Motion Controller
- BCM Processing Board
- Vacuum Interlock System (actually more a control system)
- MPSVAC

Use Case – Graphical Representation



Use Case



For more information see document:

FBIS_ConceptOfOperation

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