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Beam Lost in TI2

Event Analysis and Proposed Mitigations

SPS and LHC MPP

https://indico.cern.ch/event/516263/

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on behalf of EPC

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SPS Interlock System

SPS Interlock comprises:

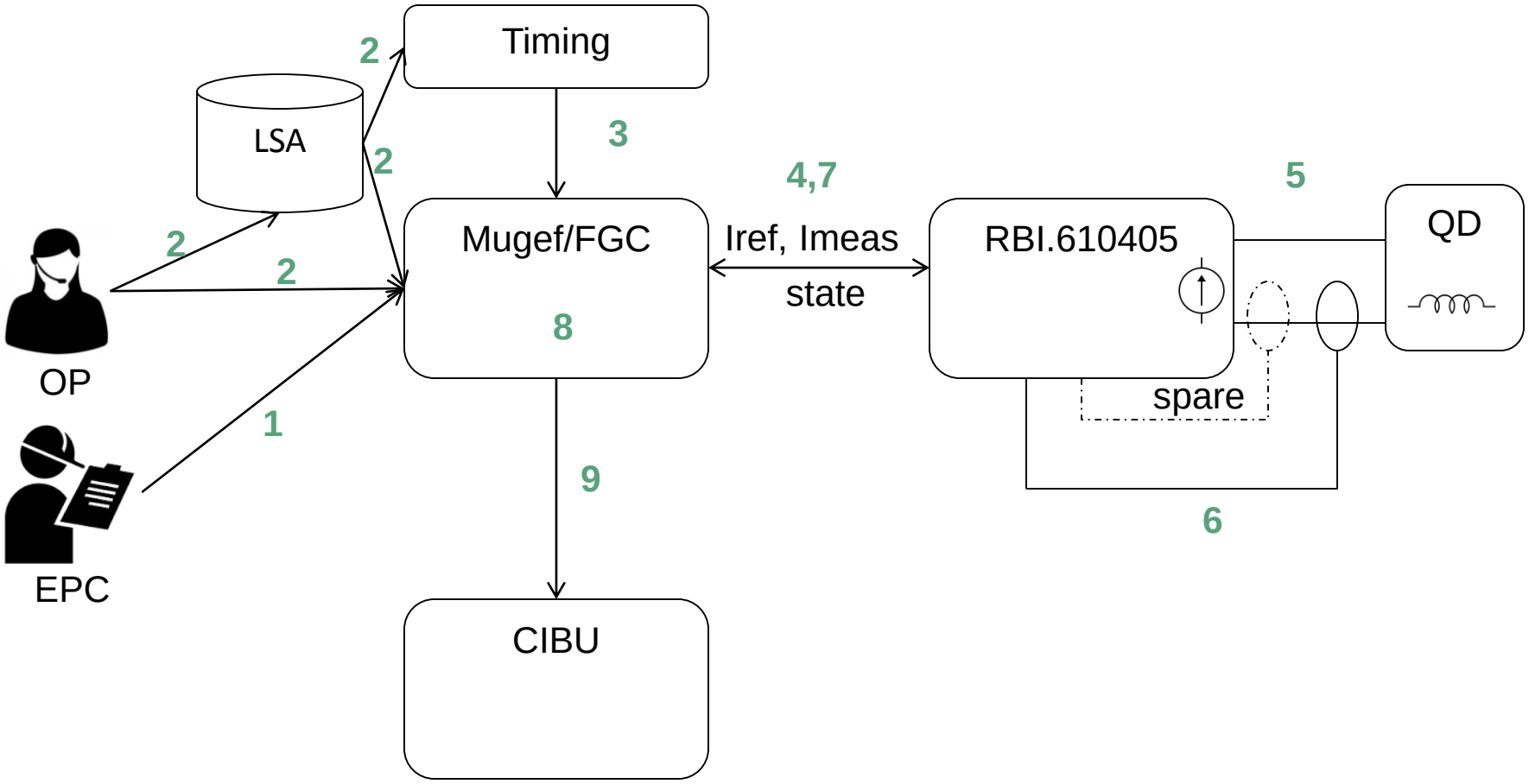
- Beam and Energy Tracking
- SPS Software Interlock System
- Beam Position and Losses
- Vacuum
- 18 kV
- Power Converter state and current
- … and people, procedures, training

Power Converter Interlocks

Power Converter Interlocks:

- Belong to the Beam and Extraction Interlock Sub-systems
- Software (Converter -> Fieldbus -> Software -> FEI Card -> CIBU)
- Two types:
  - Beam Dump Interlock, Δt~150ms
  - Fast Extraction Interlock Permit, Δt~1ms, tolerance 0.1% to 10%

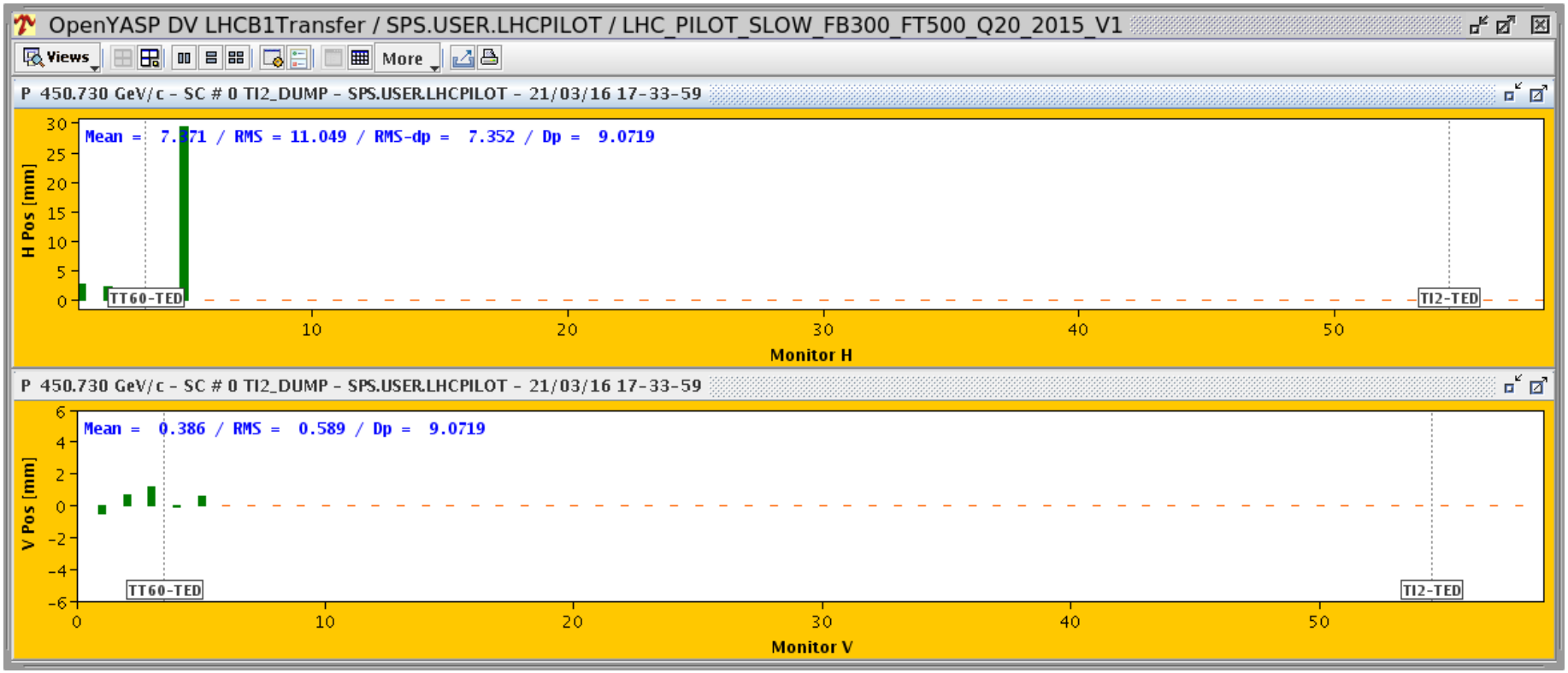
Power Converter Interlocks



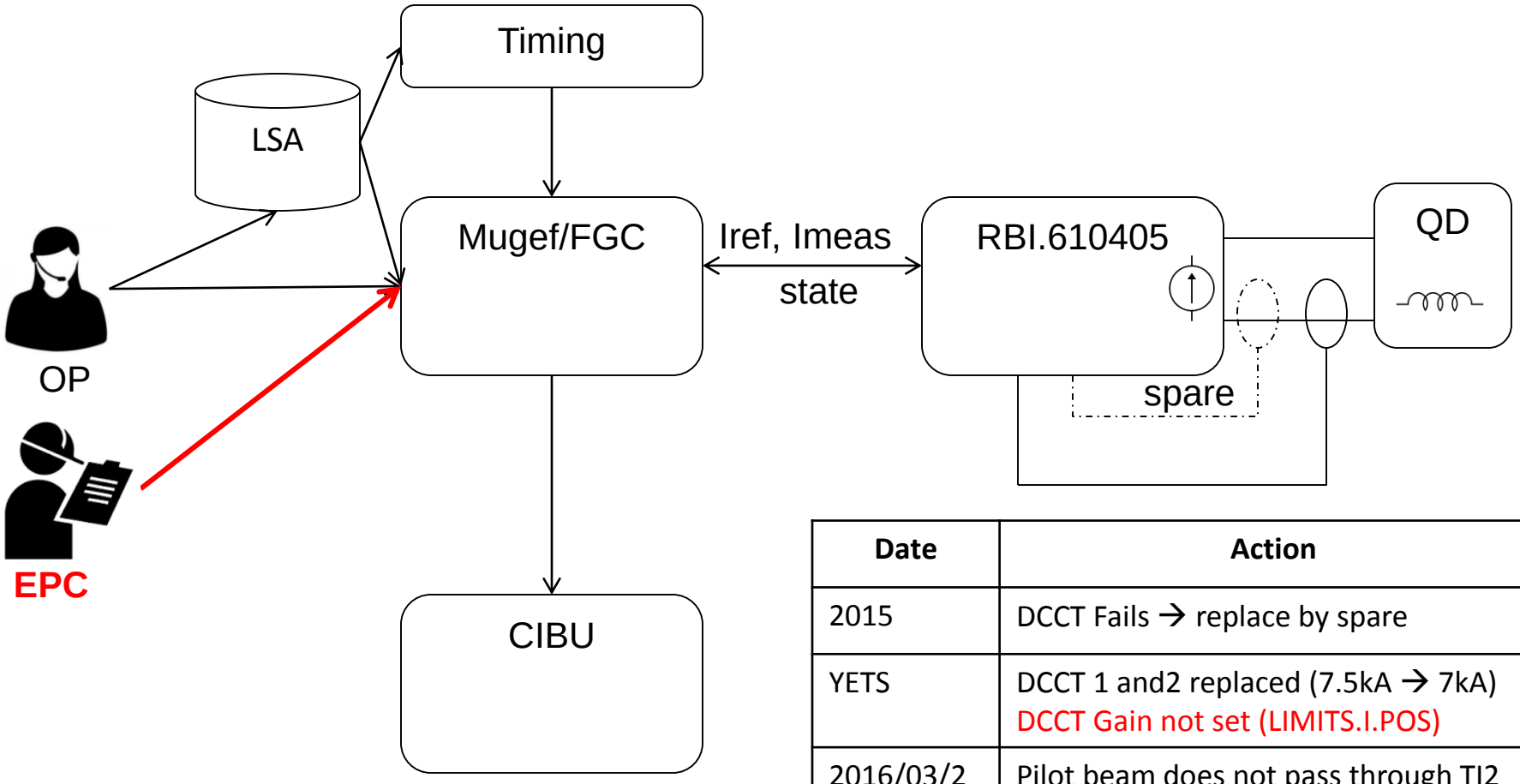
What failed on TT60 (1/3)?

Pilot beam lost in TI2, all the systems looked ok…

- S. Cettour local measurement of currents gave a hint
- Failure in the dipole is easier to diagnose



What failed on TT60 (2/3)?



Date	Action
2015	DCCT Fails → replace by spare
YETS	DCCT 1 and2 replaced (7.5kA → 7kA) DCCT Gain not set (LIMITS.I.POS)
2016/03/21	Pilot beam does not pass through TI2

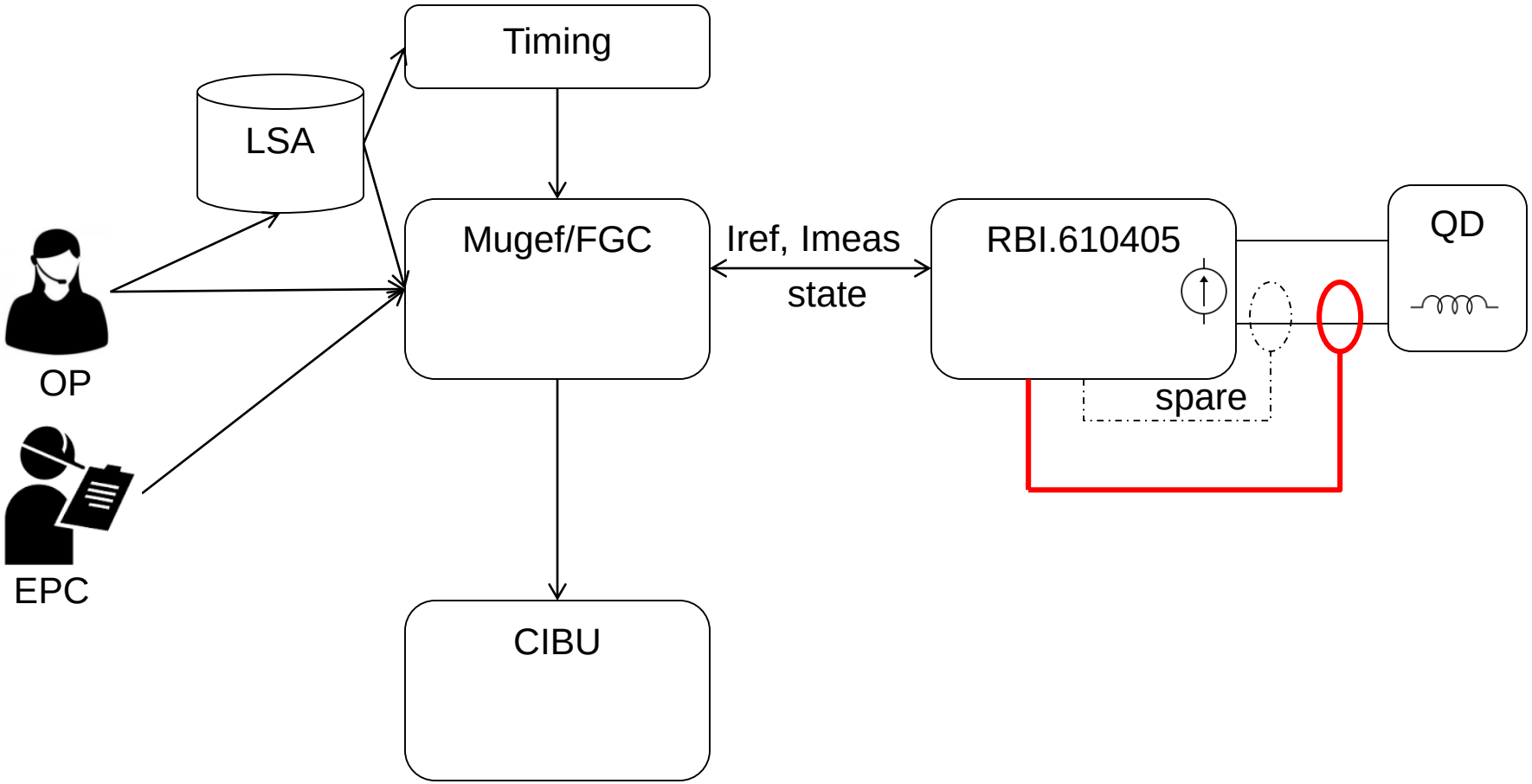
What failed on TT60 (3/3)?

Notes:

- Pilot beam was being used
- SPS/TI2 not at risk
- Main issue was the diagnostic difficulty
- Higher safety risk during high intensity operations
- More difficult to diagnose for quads
- SPS converters use one DCCT
- The converter is not meant to assure the safety of SPS

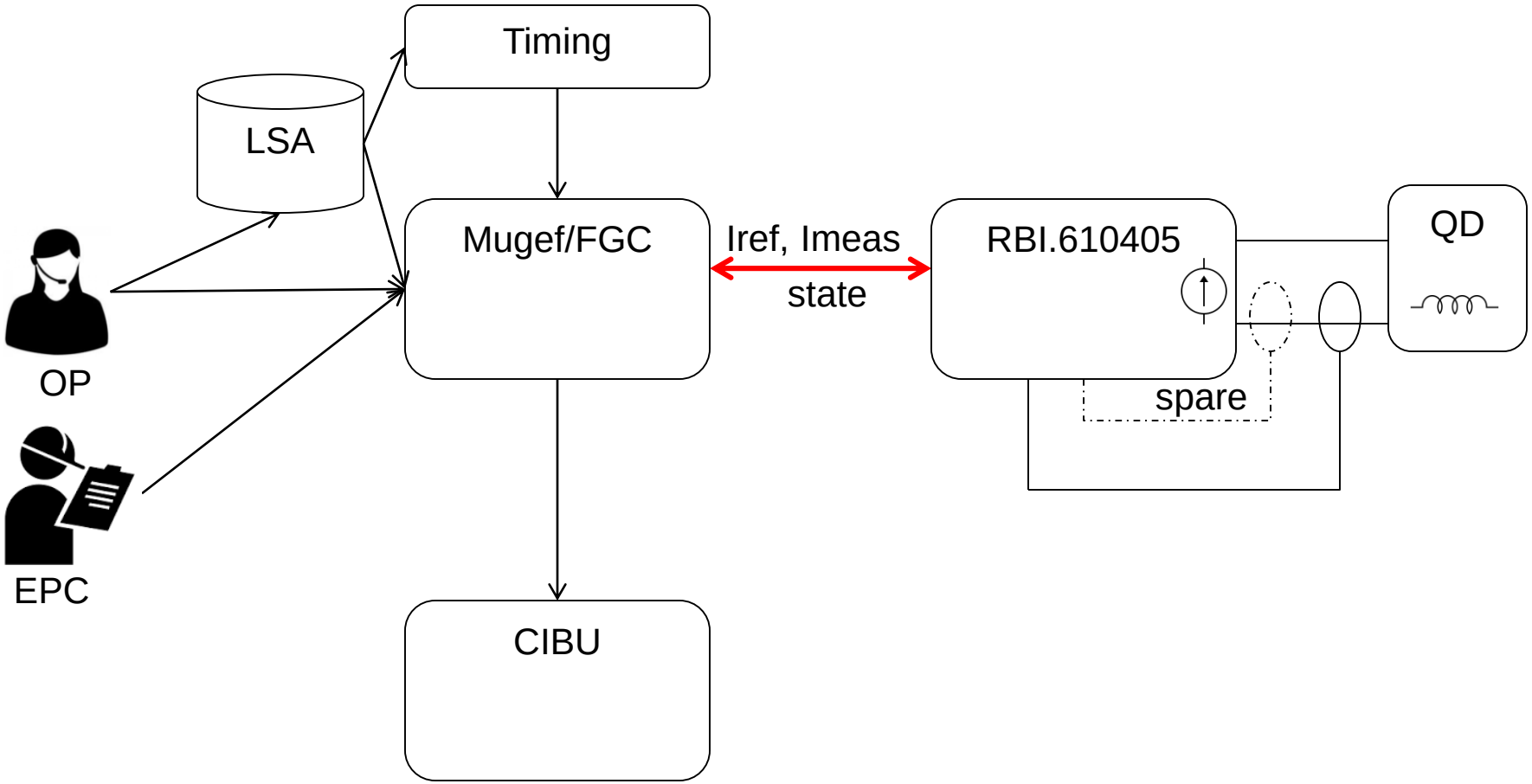
What else can fail (1/6)?

DCCT fails (or wrongly replaced)



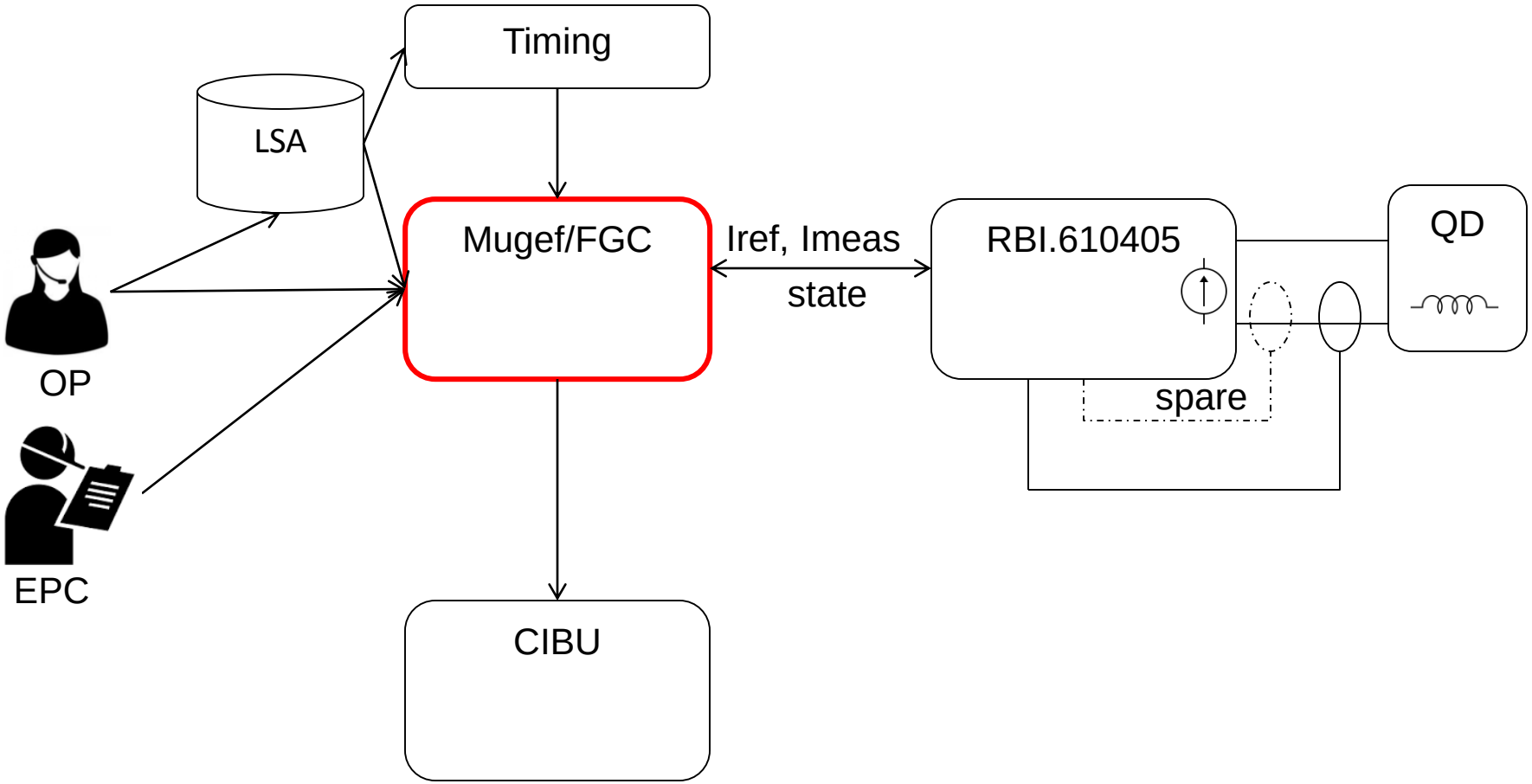
What else can fail (2/6)?

Fieldbus failure



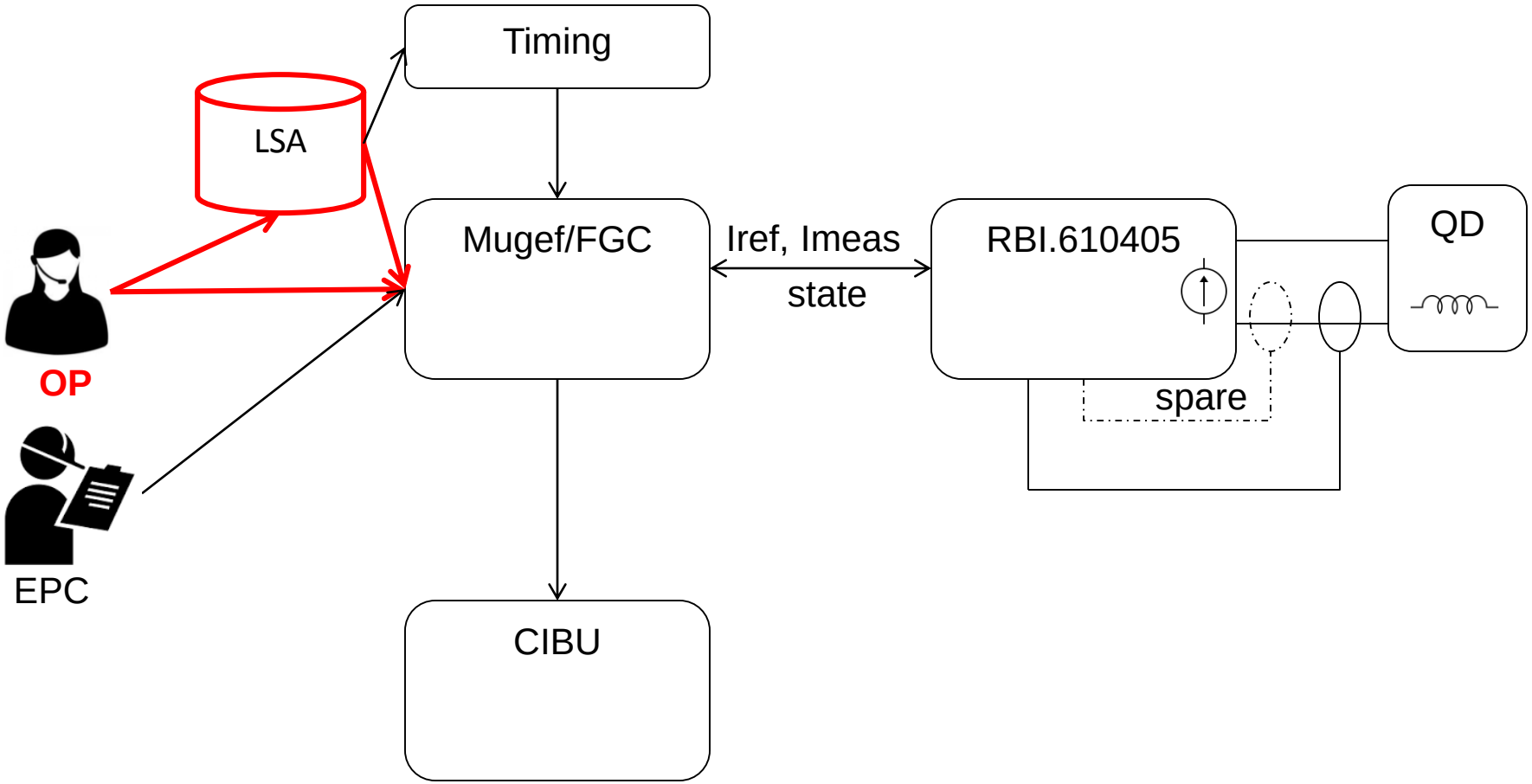
What else can fail (3/6)?

Software regression



What else can fail (5/6)?

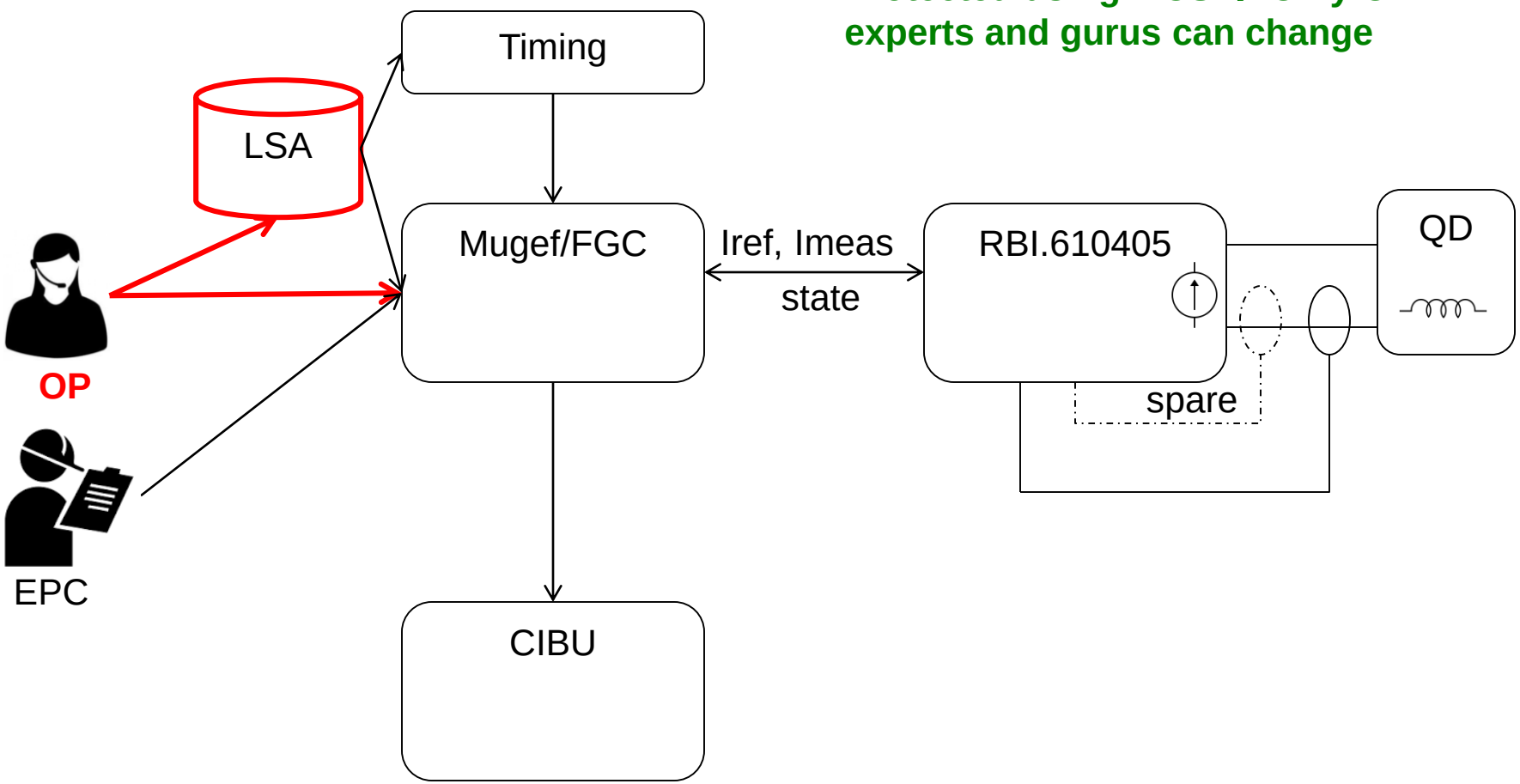
LSA and Mugef/FGC thresholds do not match



What else can fail (4/6)?

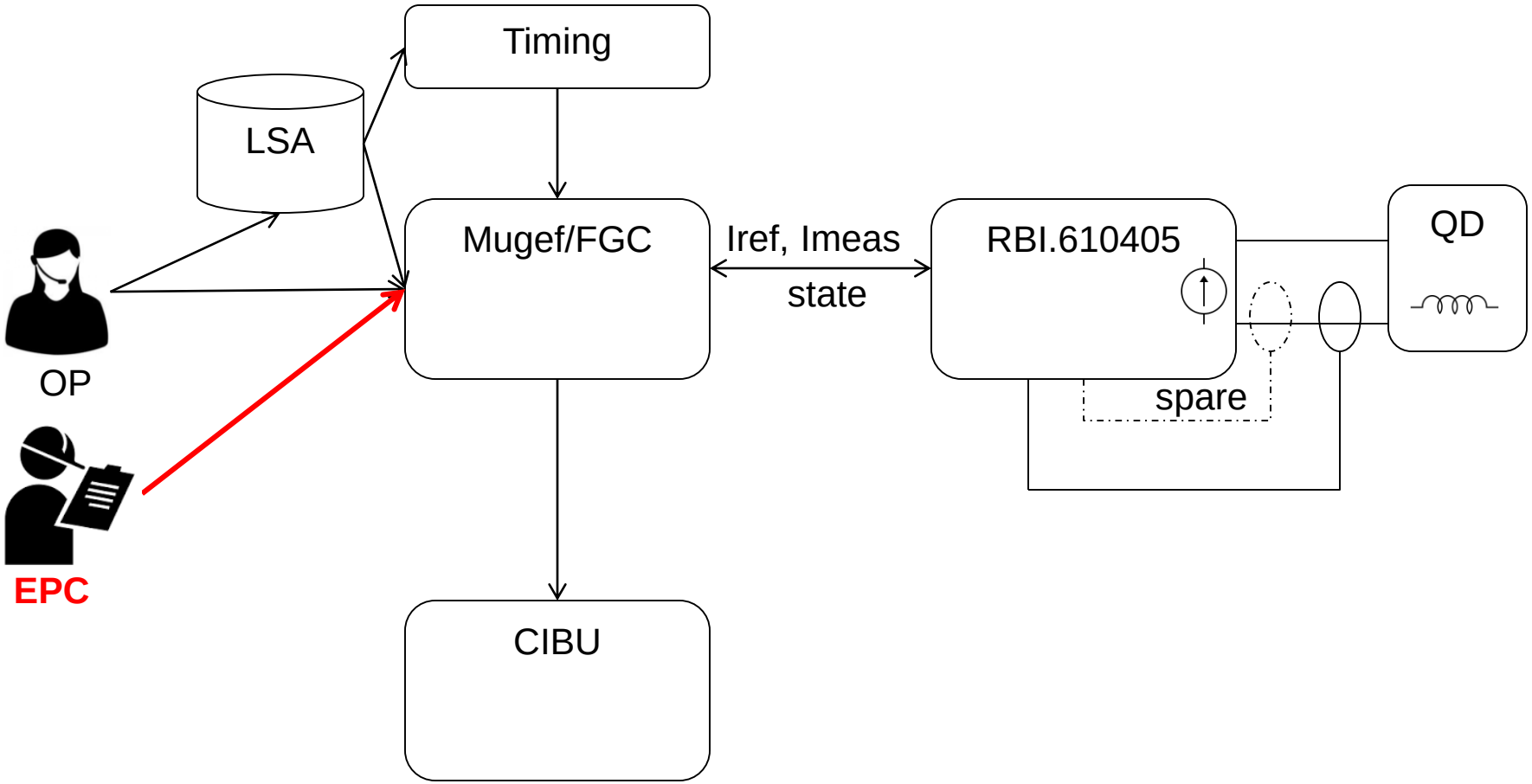
Wrong LSA thresholds

Protected using MCS → Only OP experts and gurus can change



What else can fail (6/6)?

EPC incorrectly changing DCCT gain



Context of Possible Improvements

SPS EPC Consolidation Schedule:

- EYETS: Digital regulation of the SPS Main bending current
- LS2: Replacement of Orbit Correctors with FGC3s
- LS2: Replacement of TI2/TI8 controls by FGC3 (tentative)
- LS2: Replacement of SPS Mains control electronics
- LS3: Replacement of AuxPS controls by FGC3
- LS3: Mugef End Of Life

Why?

- Converter electronics are old and difficult to maintain
- Possible problems with spares
- DCCT redundancy + automatic equipment settings

Possible improvements

Short-term (before LS2)

- SPS OP: Use Pilot Beam after each intervention
- EPC: Label all Mugef Transfer Line converters indicating new procedure
- EPC discussion and documentation
- Software Regression → Add specific tests during development
- LSA vs FGC/Mugef thresholds → Periodic check

Long-term (LS2 and LS3, FGC3)

- EPC incorrectly changing gain → Automatic equipment settings
- DCCT Fails → Redundant measurement system

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References

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