



LHC Machine Protection Considerations in UPS Replacement Project

LHC Machine Protection Panel

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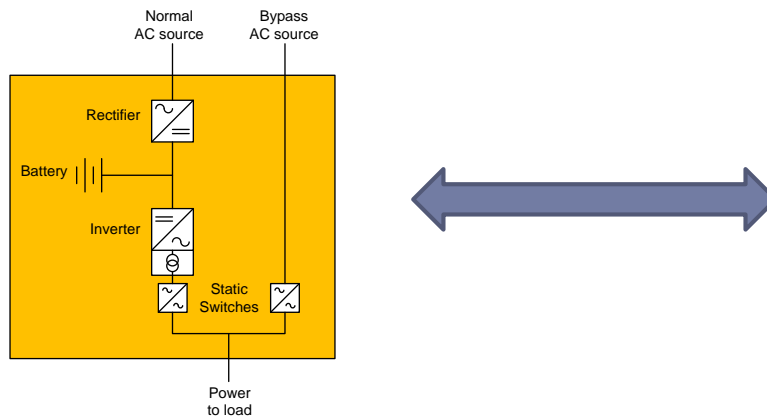


Outline

- ▶ Introduction: LHC UPS replacement project
- ▶ Existing and new UPS system topology
- ▶ Basic requirement for QPS power supply: distribution in the tunnel
- ▶ Existing UPS configuration in the RE zones
- ▶ Analysis of an UPS failure in the existing configuration
- ▶ New UPS configuration in the RE zones
- ▶ Analysis of UPS failure scenarios
- ▶ UPS configuration and distribution in UA and US zones
- ▶ Analysis of an UPS failure in UA and US zones
- ▶ Conclusion
- ▶ Remarks

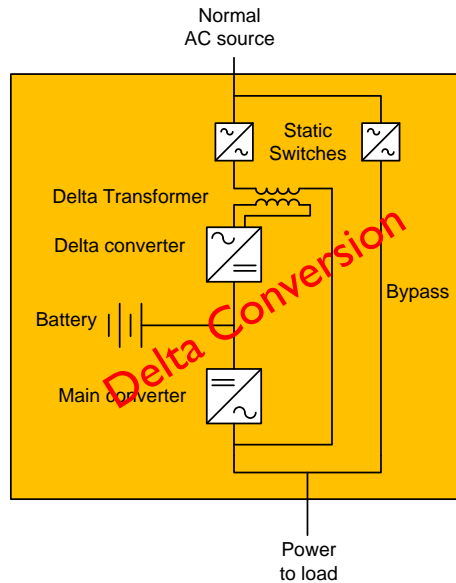
LHC UPS Systems Replacement Project

- ▶ 64 UPS systems for supplying the Quench Protection Systems of the 1706 LHC magnets



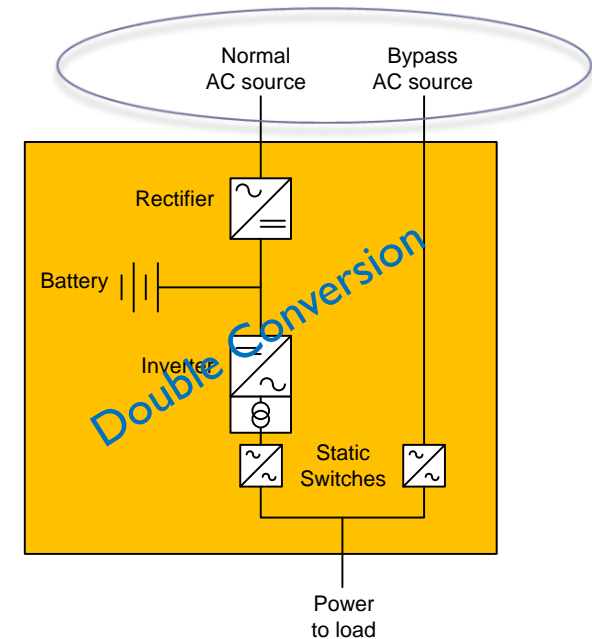
- ▶ Replacement of the existing APC Silcon UPS systems during LSI
- ▶ Project motivations:
 - ▶ Improve the reliability
 - ▶ Decrease the failure rate
 - ▶ Minimize LHC run time losses
- ▶ EN-EL project approved: see EDMS I151991

New UPS System Topology



- ▶ Parameters of the existing UPS systems:
 - ▶ Type = APC Silcon UPS
 - ▶ Topology = delta conversion
 - ▶ Rated power = 80 kVA
 - ▶ Backup time = 10 min

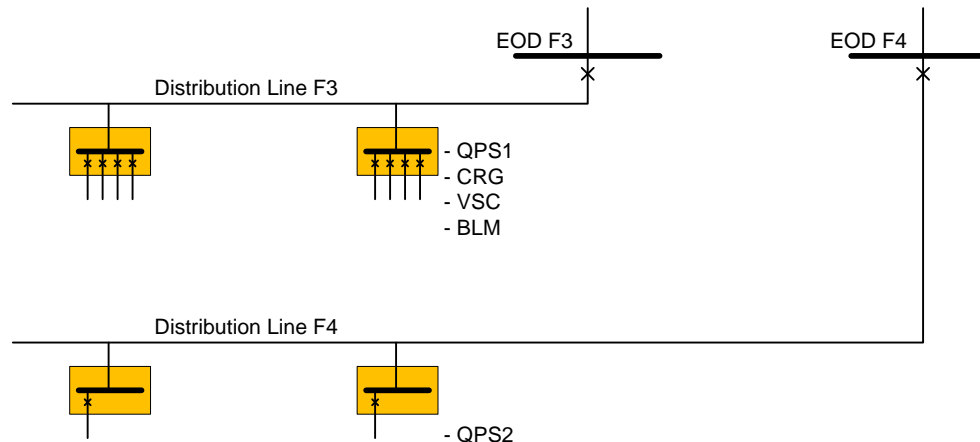
- ▶ Parameters of the new UPS systems:
 - ▶ Topology = double conversion with isolation transformer
 - ▶ Rated power = 100 kVA (battery 40 kW)
 - ▶ Backup time = 10 min





Basic Requirement for the QPS Power Supply

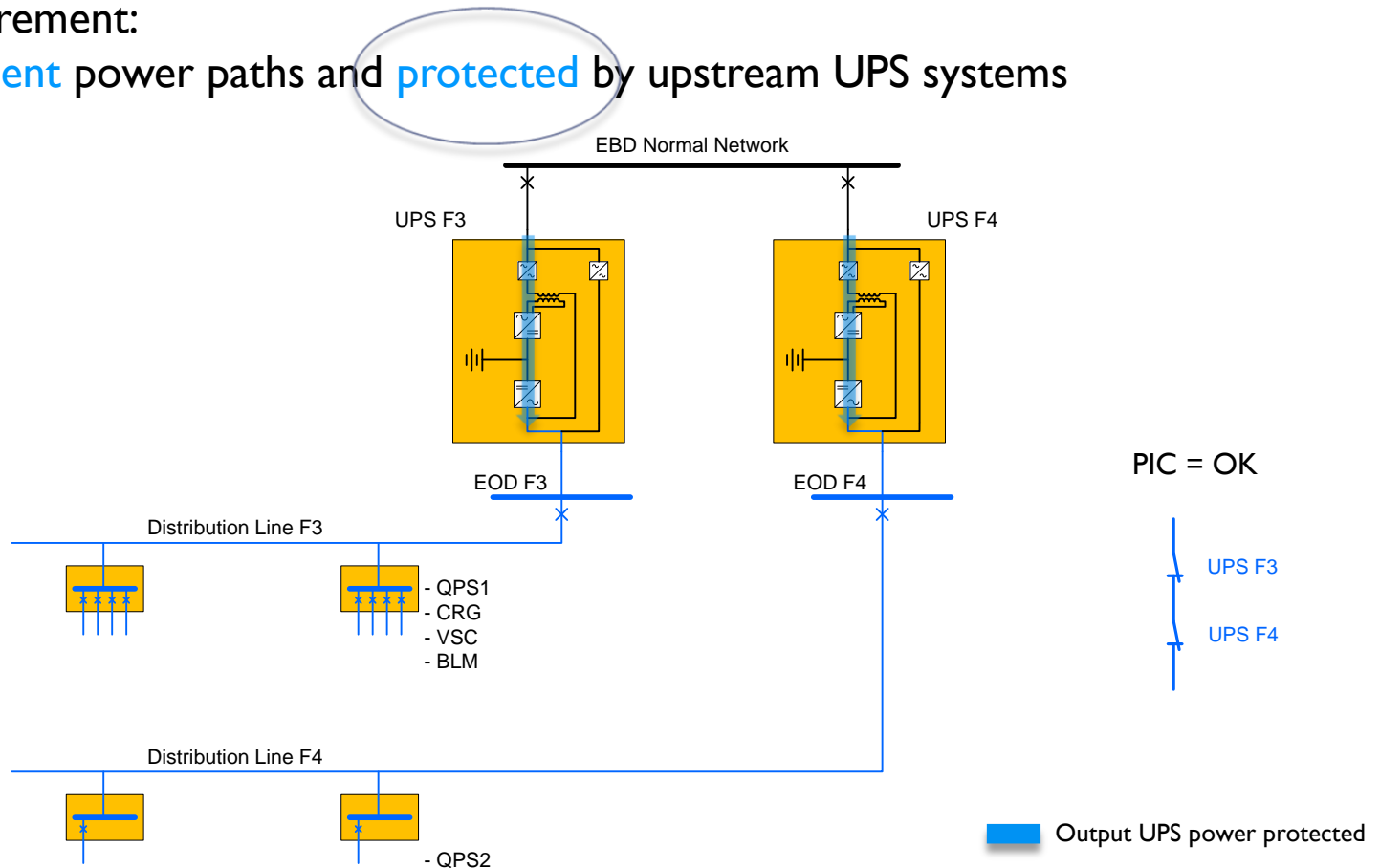
- Basic requirement:
2 independent power paths and protected by upstream UPS systems





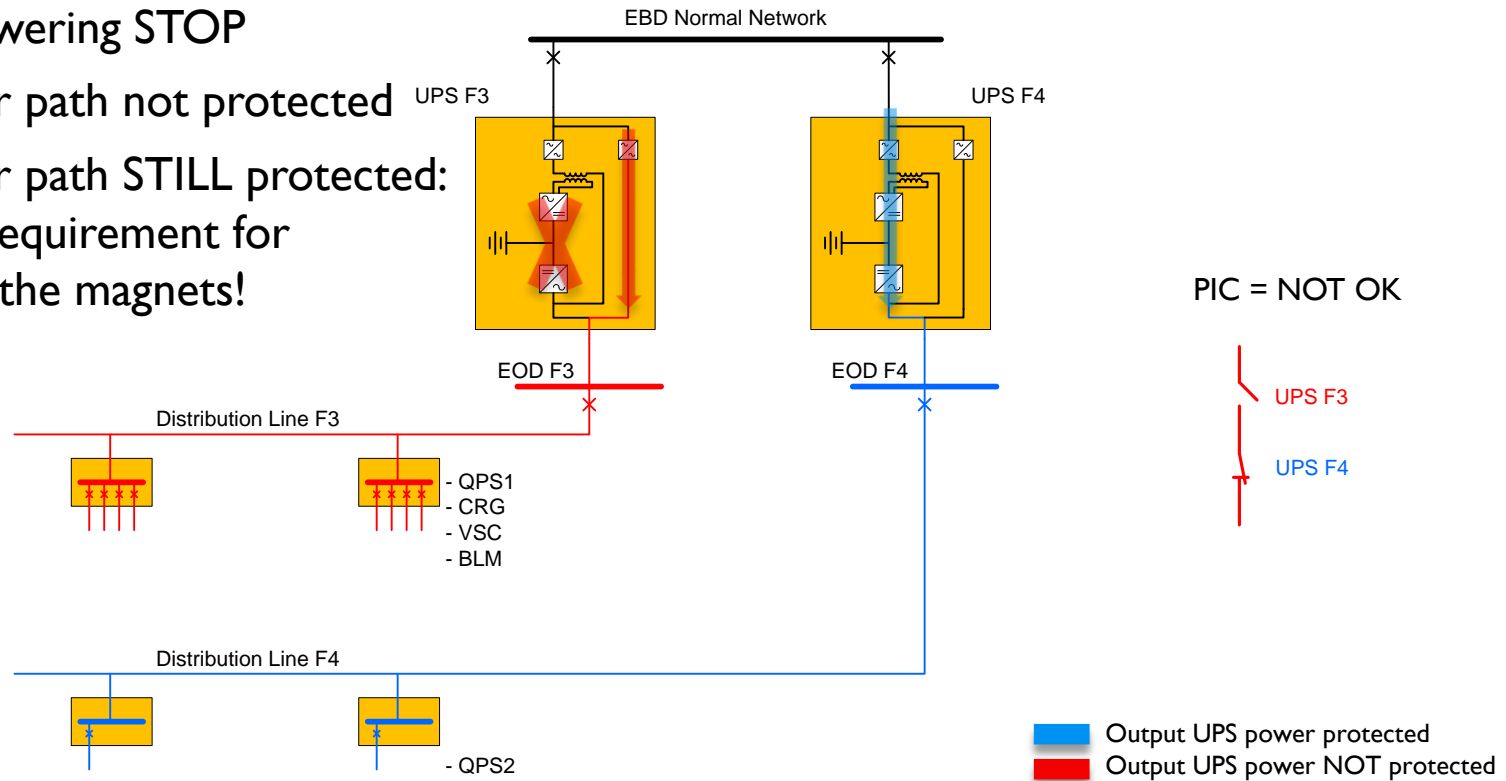
Existing UPS Configuration in the RE Zones

- Basic requirement:
2 independent power paths and **protected** by upstream UPS systems



UPS Failure in the Existing Configuration

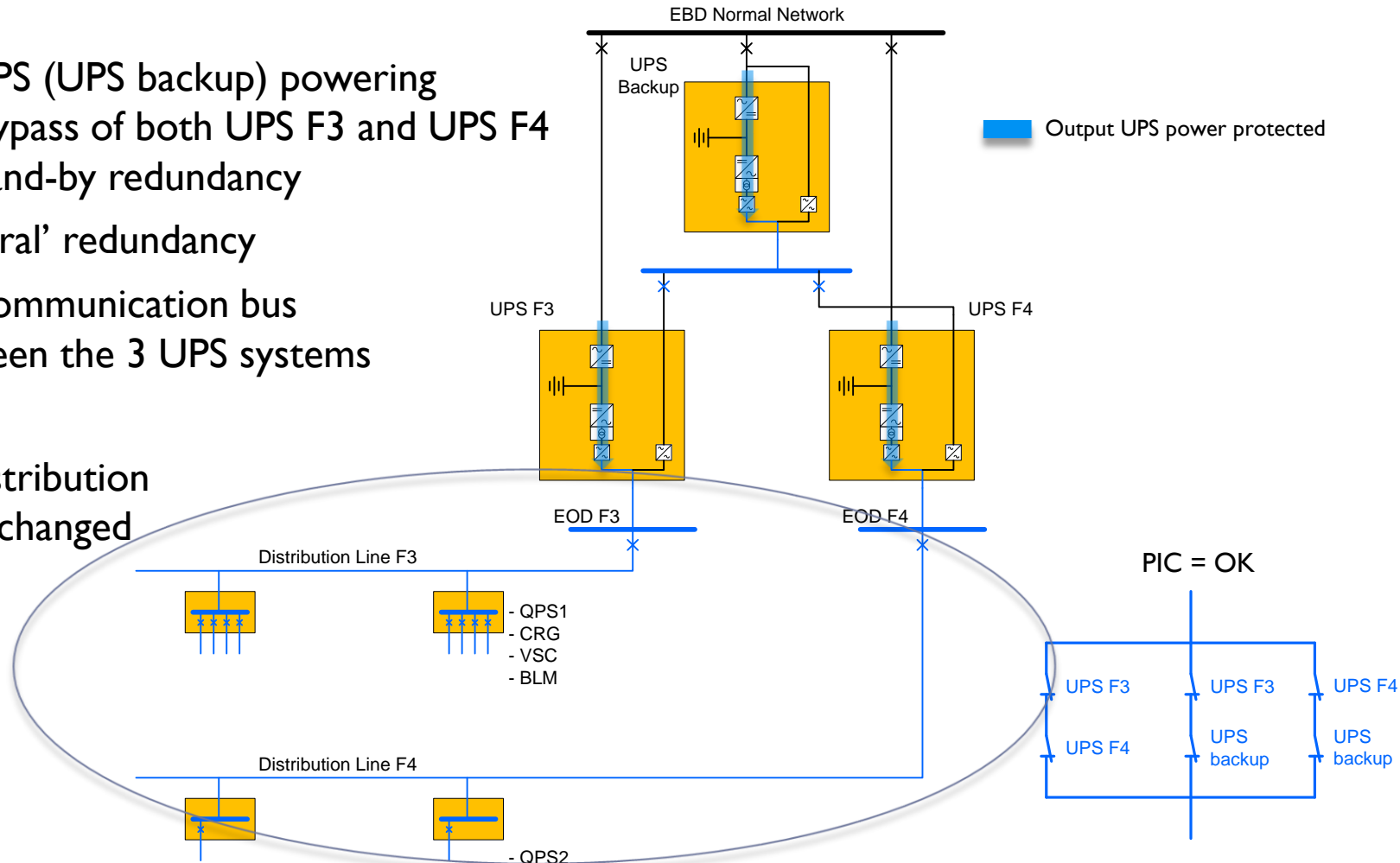
- ▶ Failure of one UPS = transfer of the load to bypass
- ▶ PIC triggered
- ▶ Magnet powering STOP
- ▶ One power path not protected
- ▶ One power path STILL protected: minimum requirement for protecting the magnets!



New UPS Configuration in the RE Zones

- ▶ 3rd UPS (UPS backup) powering the bypass of both UPS F3 and UPS F4 = Stand-by redundancy
- ▶ 'Natural' redundancy
- ▶ No communication bus between the 3 UPS systems

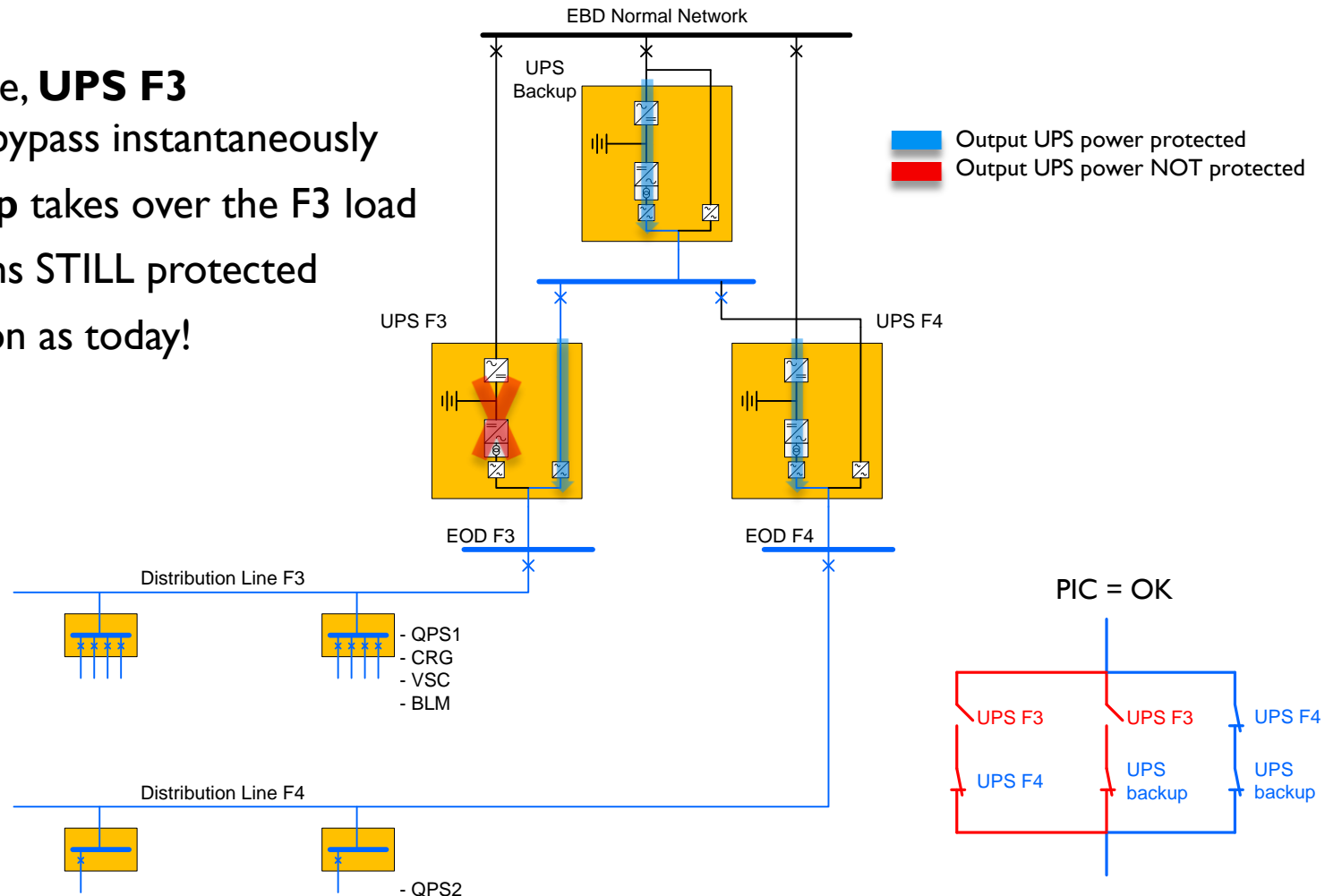
Distribution Unchanged





Scenario I: UPS F3 Failure

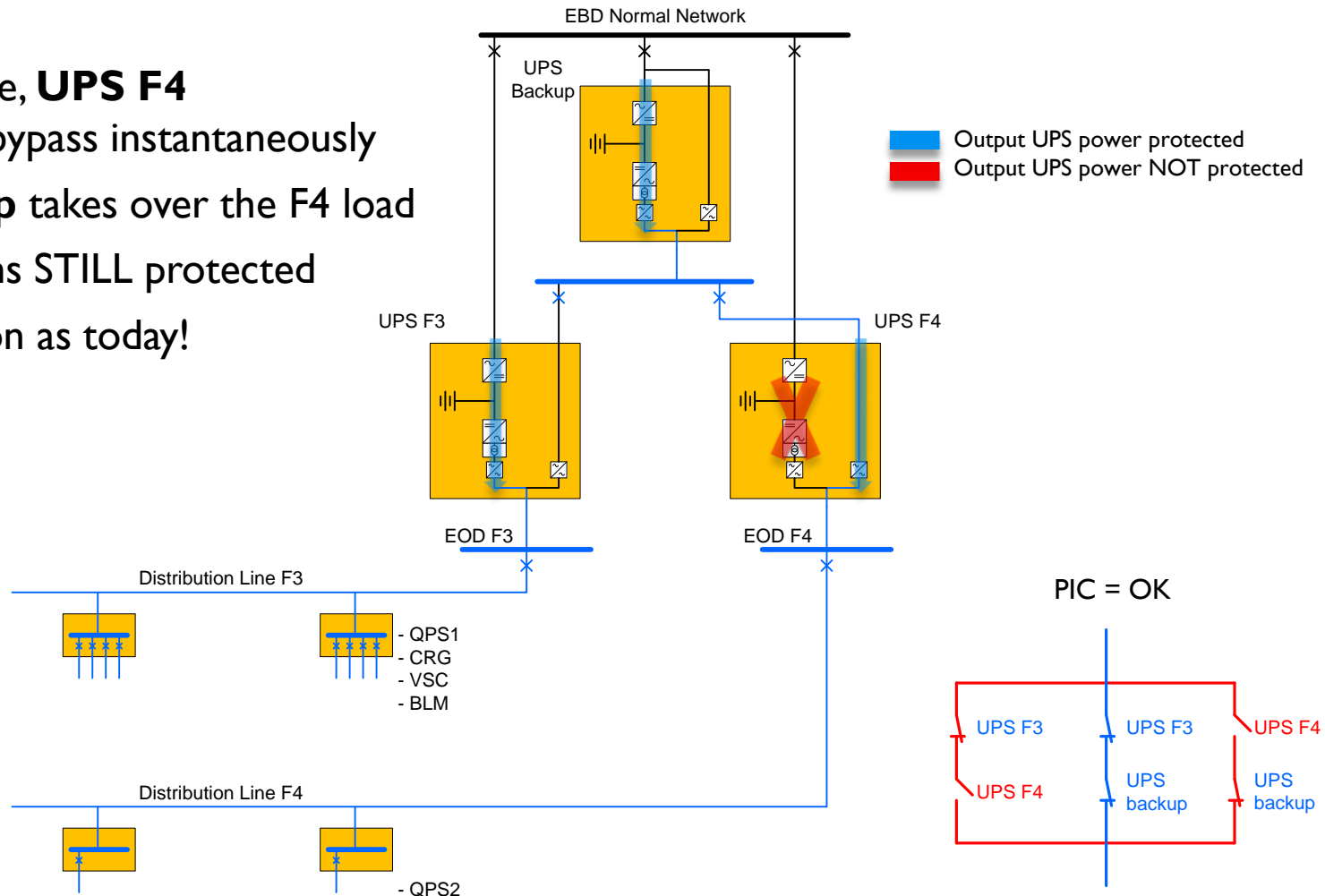
- ▶ Upon a failure, **UPS F3** transfers to bypass instantaneously
- ▶ **UPS backup** takes over the F3 load
- ▶ 2 power paths **STILL** protected
- ▶ Same situation as today!





Scenario 2: UPS F4 Failure

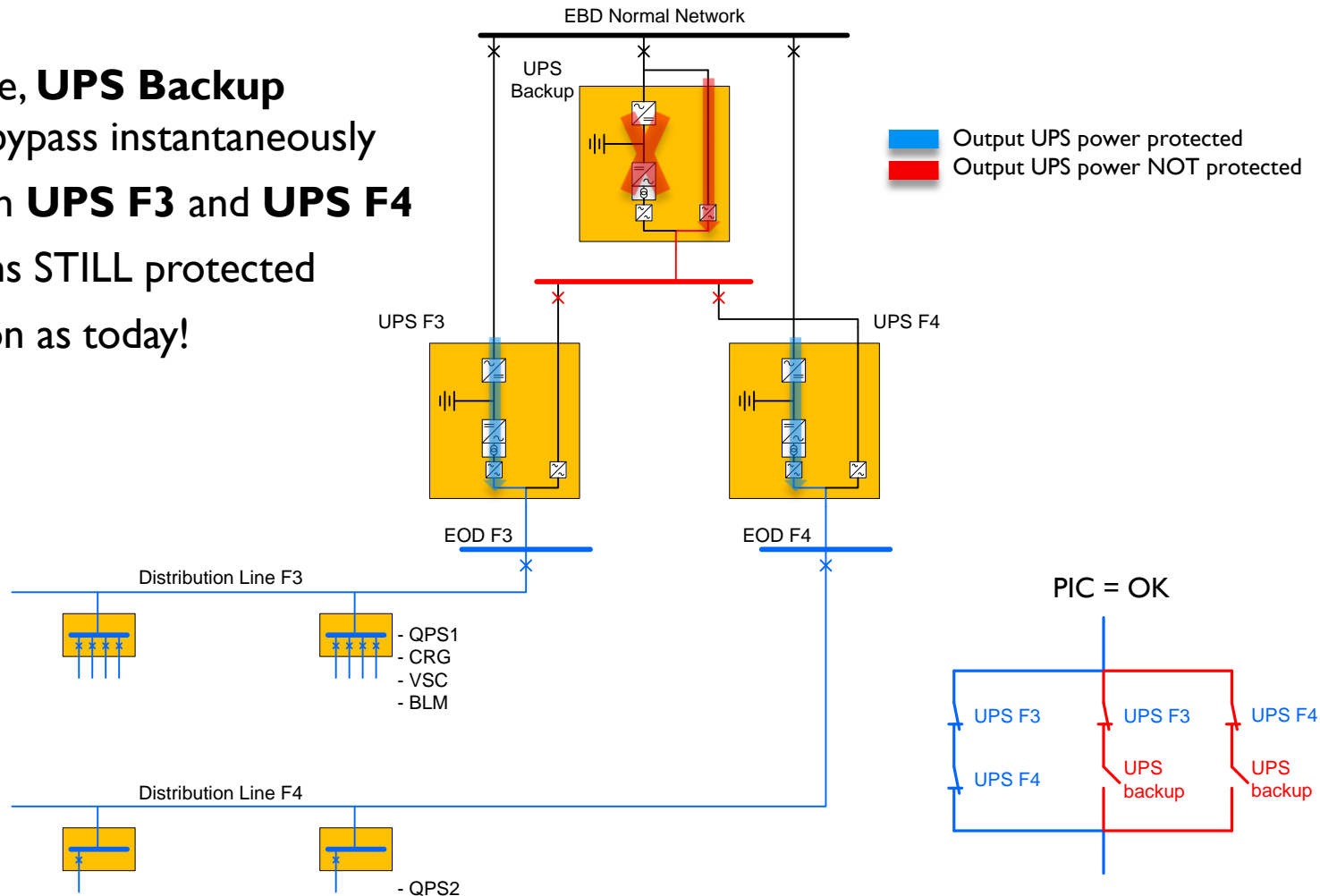
- ▶ Upon a failure, **UPS F4** transfers to bypass instantaneously
- ▶ **UPS backup** takes over the F4 load
- ▶ 2 power paths **STILL** protected
- ▶ Same situation as today!





Scenario 3: UPS Backup Failure

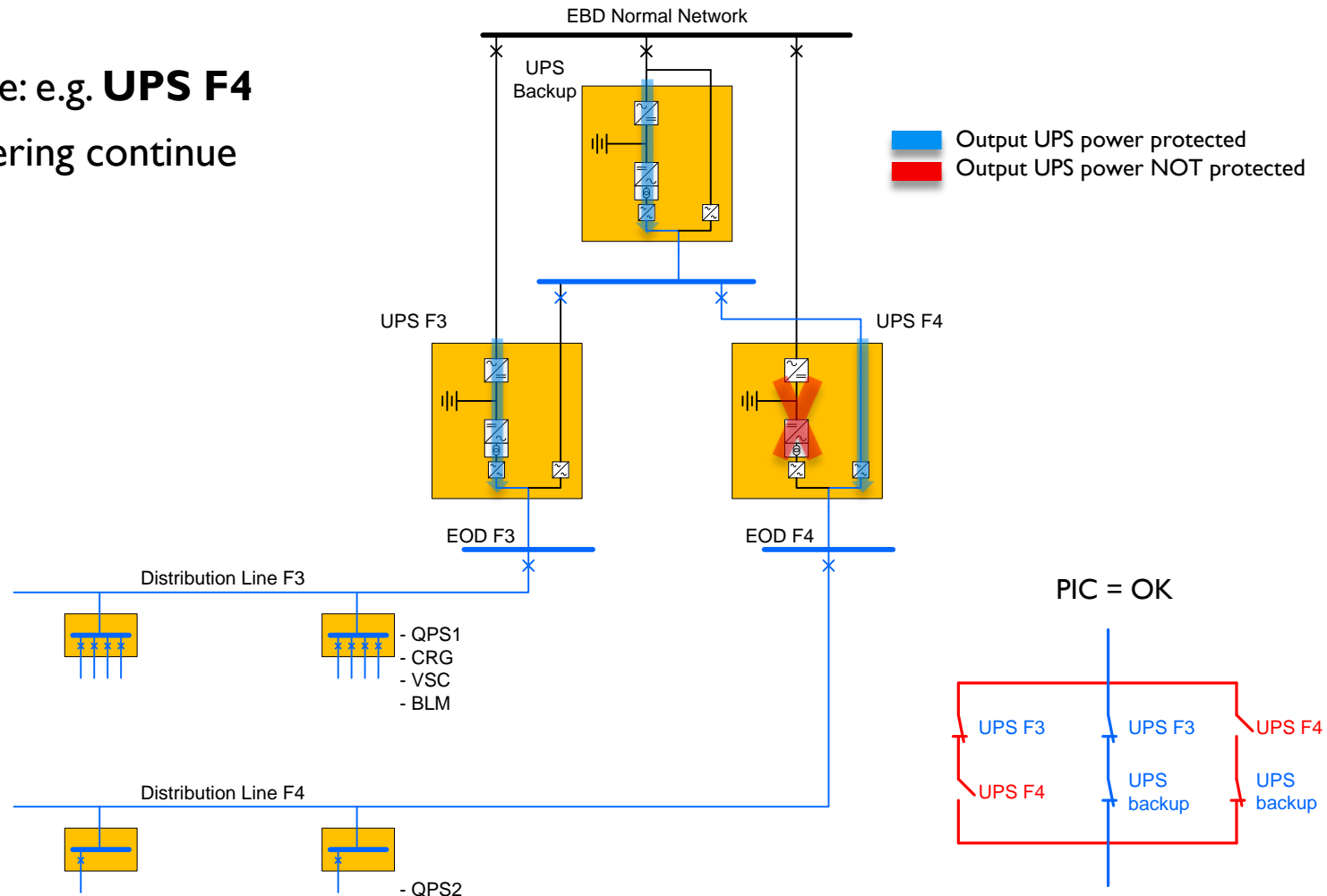
- ▶ Upon a failure, **UPS Backup** transfers to bypass instantaneously
- ▶ No impact on **UPS F3** and **UPS F4**
- ▶ 2 power paths **STILL** protected
- ▶ Same situation as today!





Scenario 4: Double UPS Failures

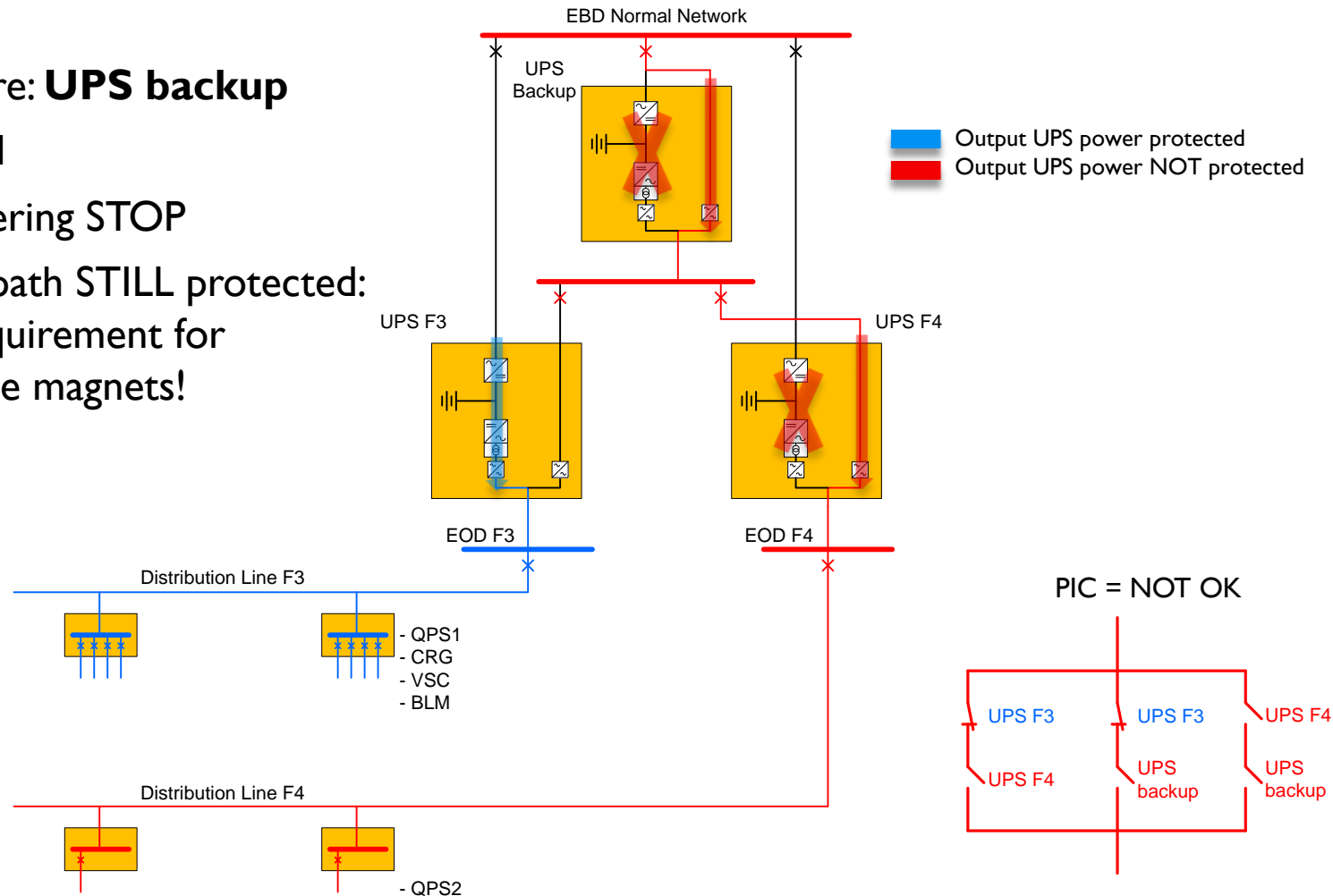
- ▶ 1st UPS failure: e.g. **UPS F4**
- ▶ Magnet powering continue





Scenario 4: Double UPS Failures

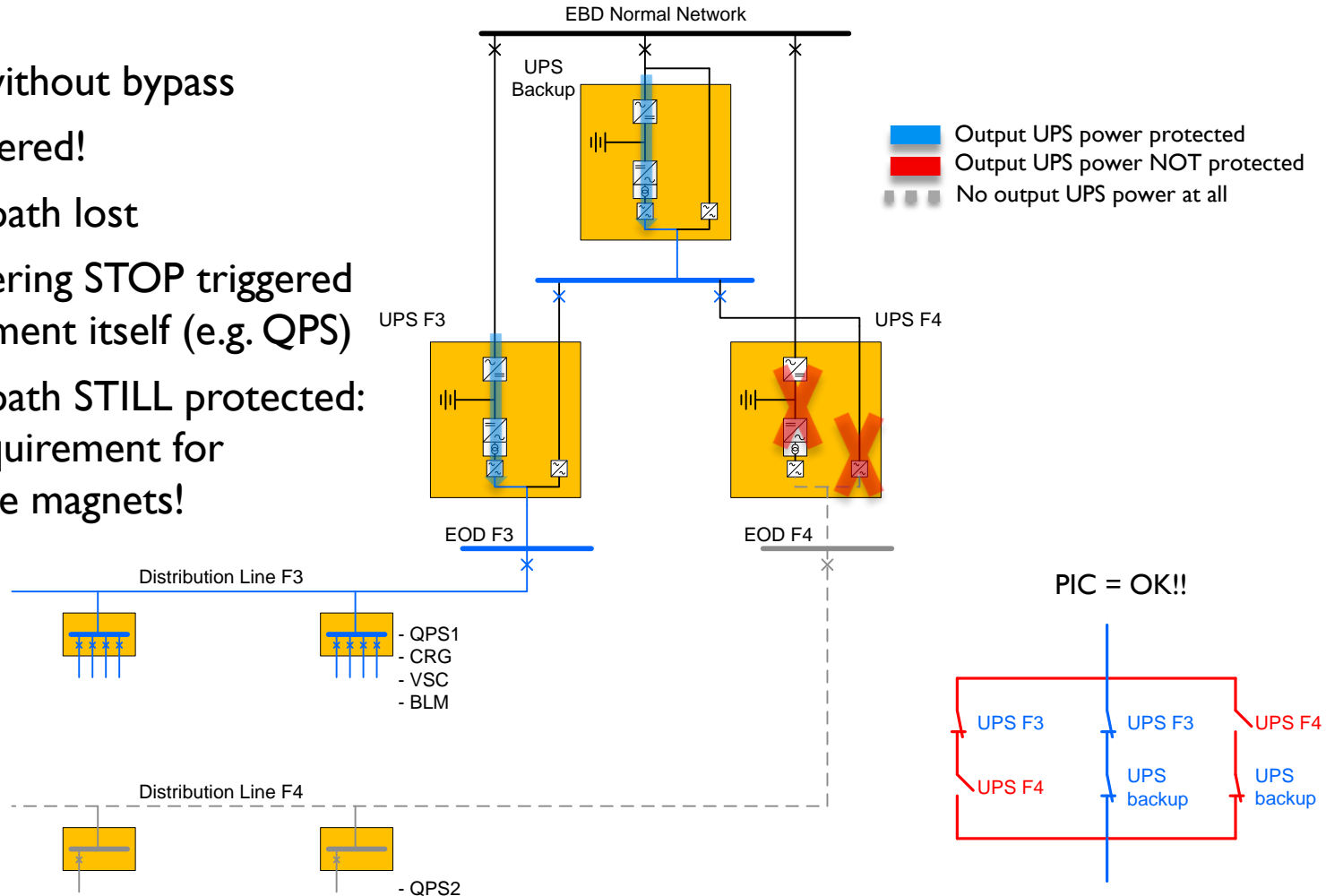
- ▶ 2nd UPS failure: **UPS backup**
- ▶ PIC triggered
- ▶ Magnet powering STOP
- ▶ One power path **STILL** protected: minimum requirement for protecting the magnets!





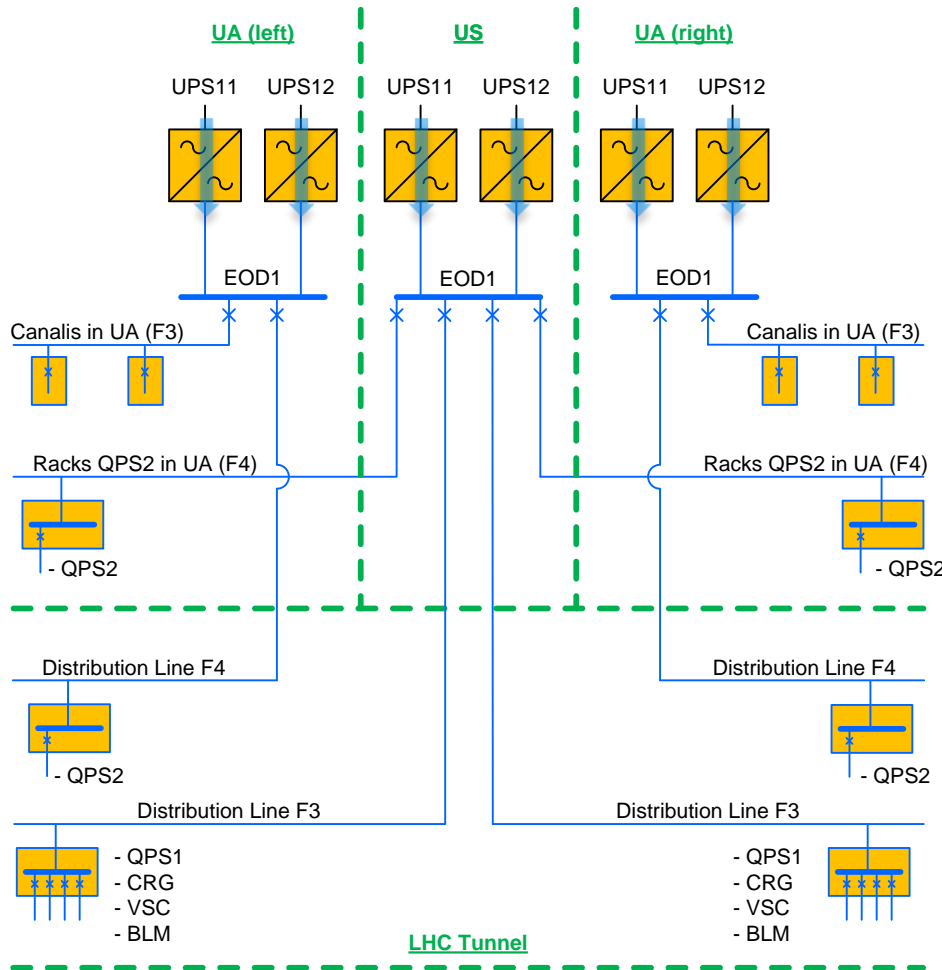
Worst Scenario: UPS Output Power Cut

- ▶ UPS failure without bypass
- ▶ PIC not triggered!
- ▶ One power path lost
- ▶ Magnet powering STOP triggered by the equipment itself (e.g. QPS)
- ▶ One power path **STILL** protected: minimum requirement for protecting the magnets!



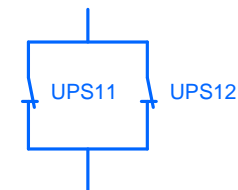


UPS Configuration and Distribution in UA and US zones



- ▶ Parallel-redundant UPS systems in each zone
- ▶ F3 and F4 lines always powered from 2 different redundant UPS configurations (one in US, one in UA)
- ▶ One-to-one replacement of the UPS systems
- ▶ UPS configuration and distribution preserved

PIC = OK

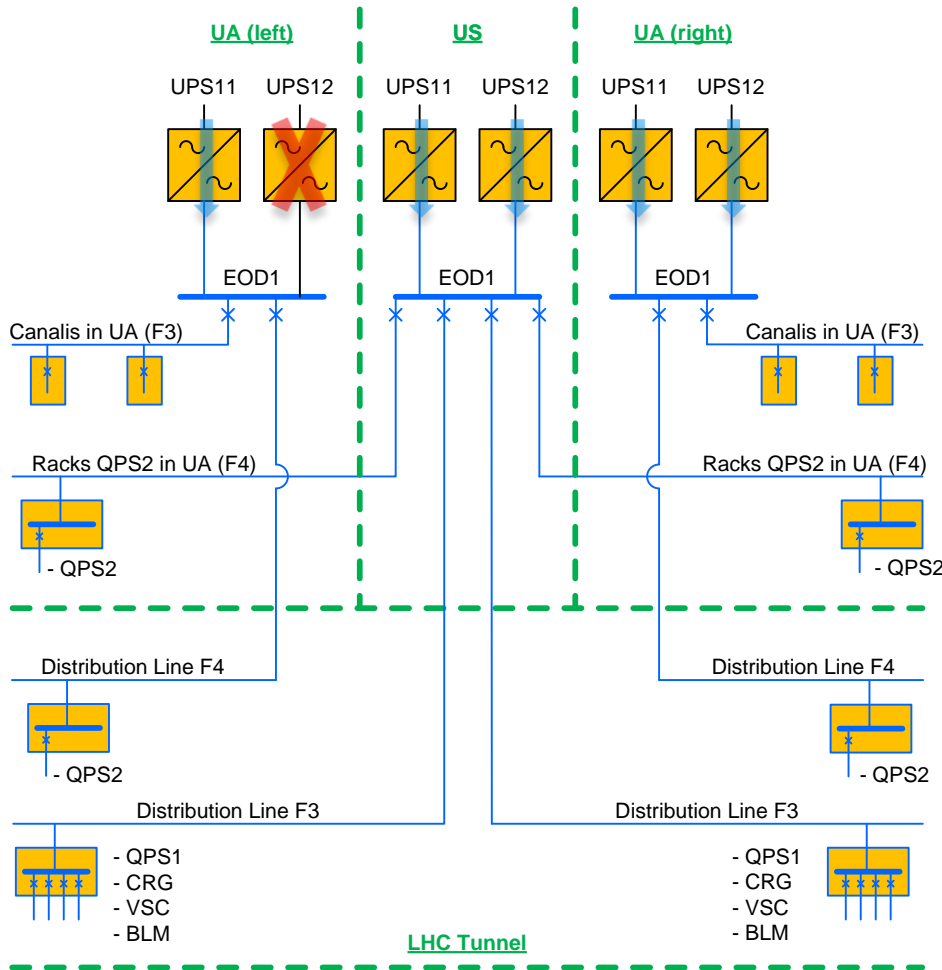


 Output UPS power protected

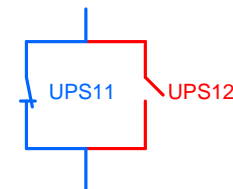


UPS Failure in UA and US zones

- ▶ Failure of one UPS system in a redundant UPS configuration
- ▶ Automatic stop of the faulty UPS
- ▶ Automatic transfer of the full load to the remaining UPS system
- ▶ F3 and F4 distribution lines fully protected



PIC = OK



Output UPS power protected



Conclusion

- ▶ One single UPS failure = 2 power paths still protected = No PIC triggered
- ▶ Benefits of this new PIC logic:
 - ▶ Magnet powering can continue upon one single UPS failure
 - ▶ Machine can start with 2 UPS systems out of 3 in the RE zones and LHC odd points
 - ▶ Machine can start with one UPS system out of 2 in the UA and US zones
- ▶ This UPS distribution allows to wait for the next technical stop for repairing an UPS failure
- ▶ This gives time for preparing and optimizing the intervention



Remarks

- ▶ Power increase for the next 10 years is needed
- ▶ UPS F3 and UPS F4 strongly unbalanced in terms of load
- ▶ Are other clients allowed to be powered from the F4 lines (initially reserved for QPS)?
- ▶ Some clients with redundant and critical equipment for machine protection:
 - ▶ Beam interlock system
 - ▶ Beam dumping system
 - ▶ Others not yet identified?