# Self-healing of the LLRF System at Firmware Level

**IPC Seminar: Speed Talk**

**17.11.2020**

Gianluca Martino

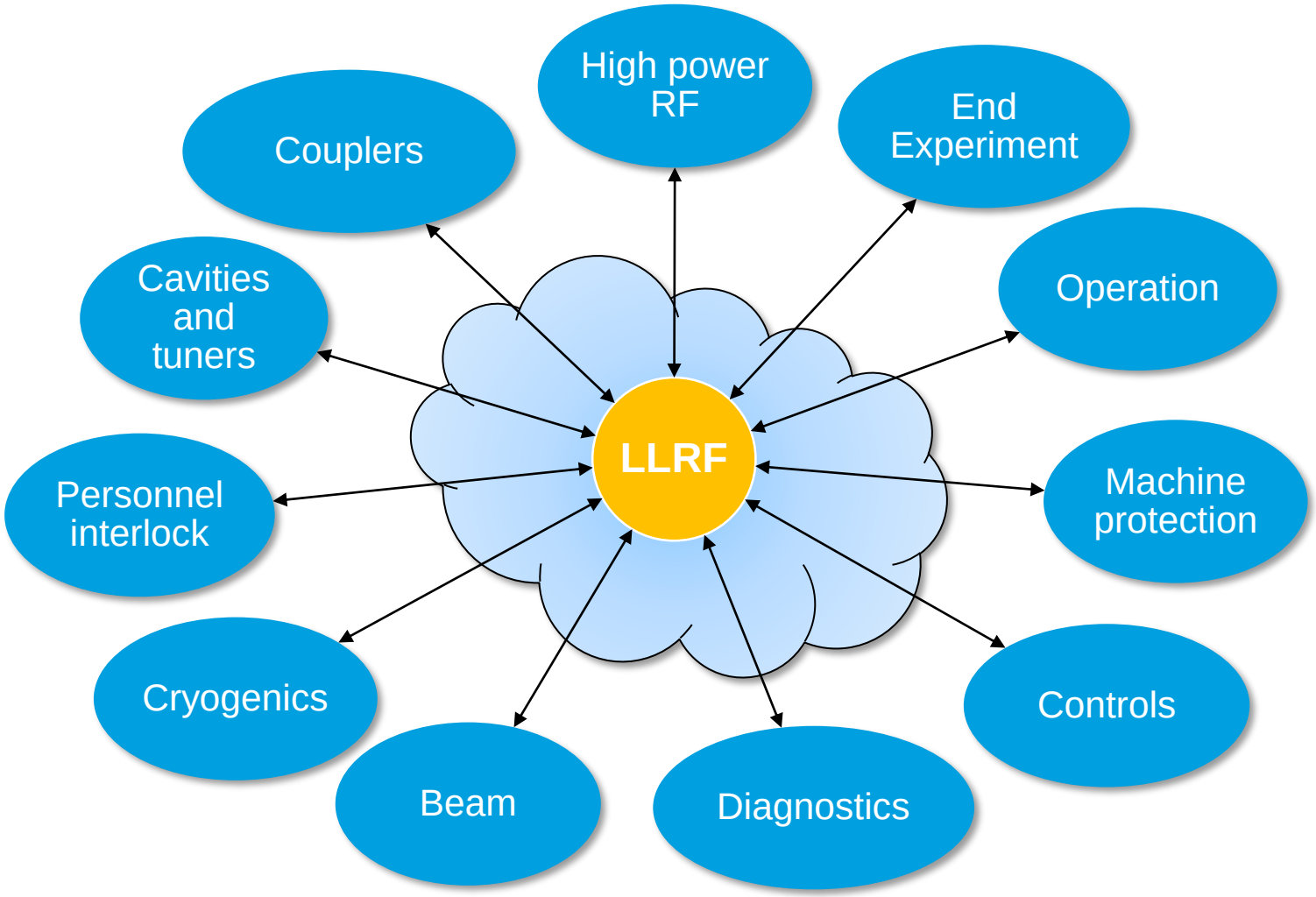
TUHH Technische Universität Hamburg

DESY.

DASHH Data Science in Hamburg HELMHOLTZ Graduate School for the Structure of Matter

# LLRF System

## Where does it start ? Where does it end ?

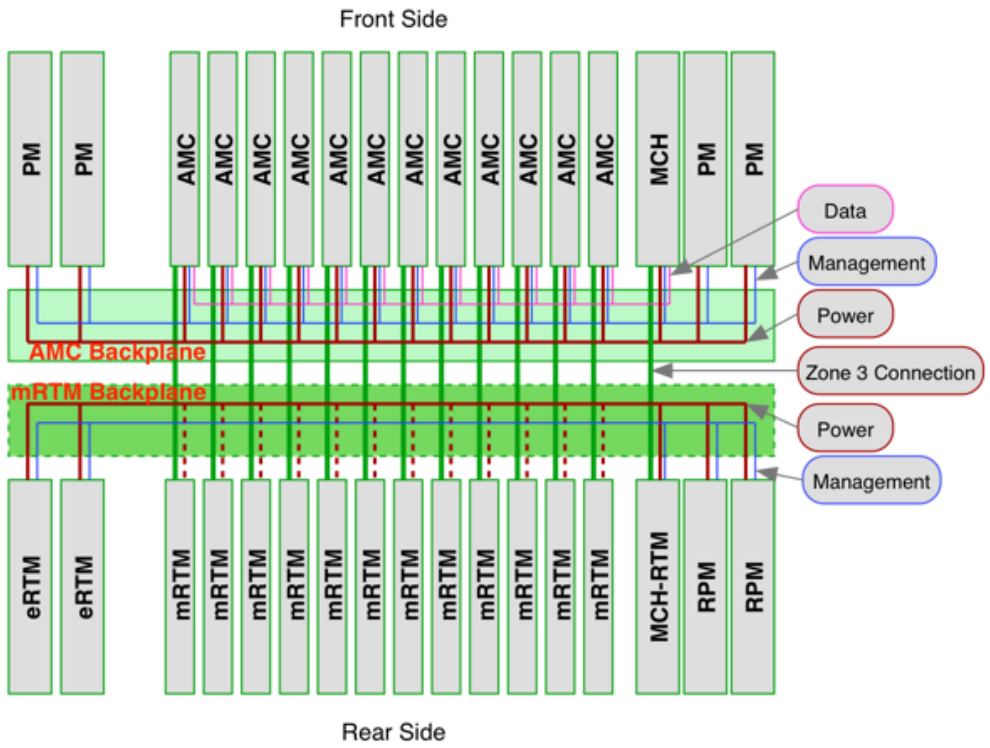





Thanks to Julien Branlard

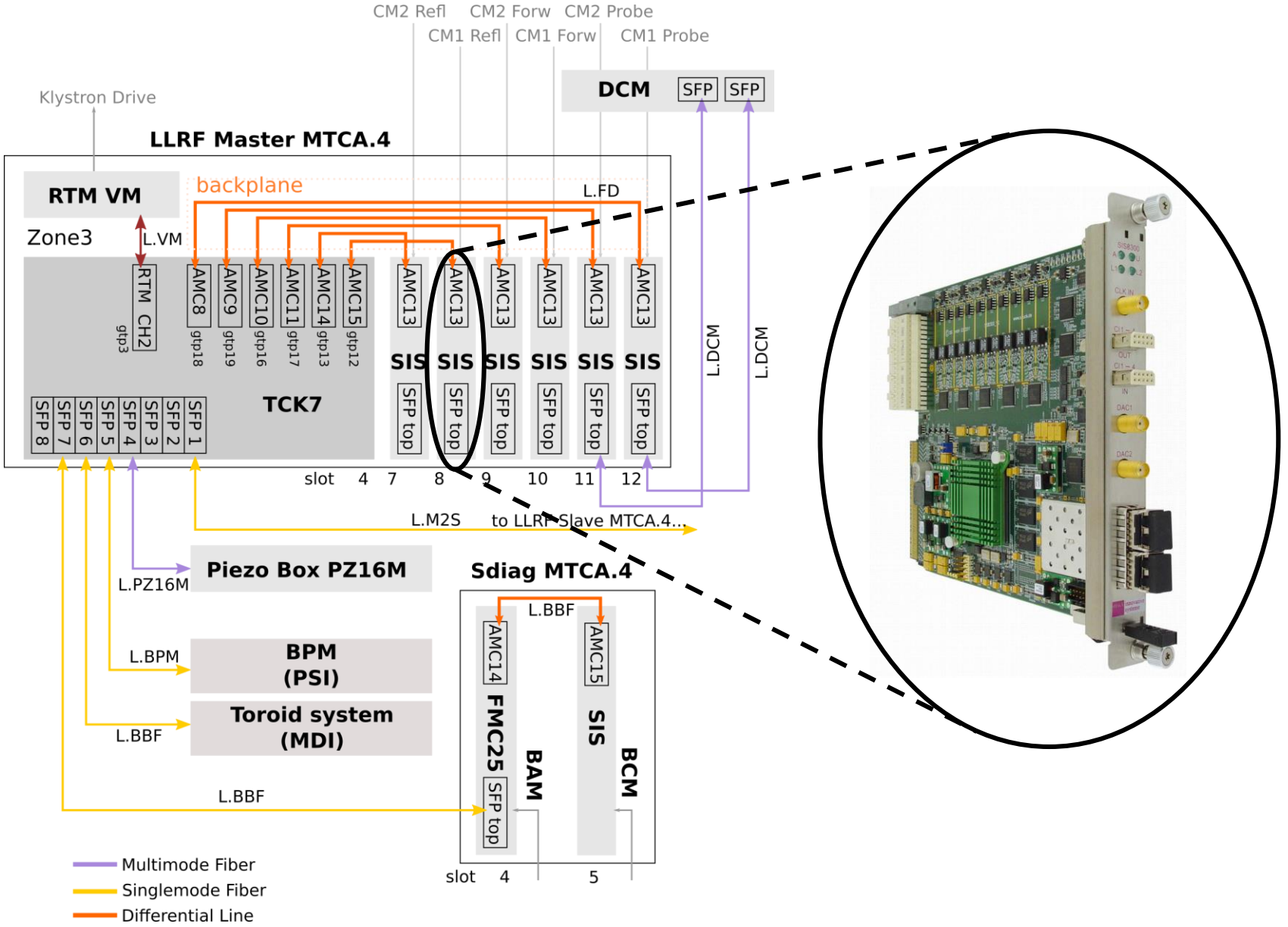
# LLRF System

## MicroTCA.4 crate



# LLRF System

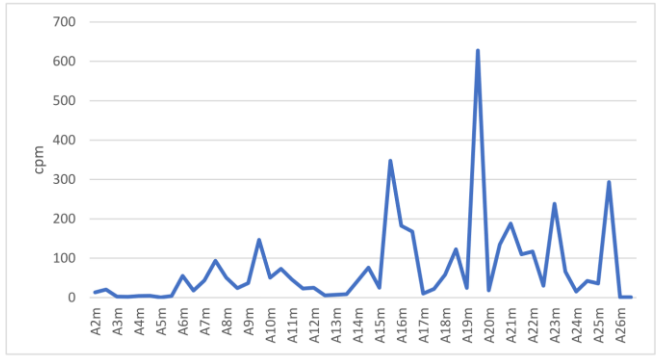
## MicroTCA.4 crate



# LLRF System

## Main issues

### Radiation issues (SEUs)



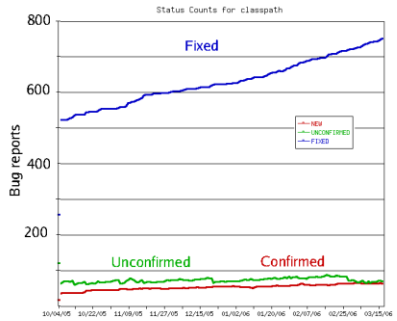

**Bug #6602**

**A1 / AH1 lost PCIe connection**

Added by Julien Branlard about 1 month ago.

| | |
|---|---|
| **Status:** | Closed |
| **Priority:** | Normal |
| **Assignee:** | Julien Branlard |
| **Category:** | MTCA |
| **Target version:** | - |
| **XFEL LLRF station:** | A1.I1, AH1.I1 |

### Software/Firmware bugs




**Bug #5969**

**BLC glitch between bunch trains**

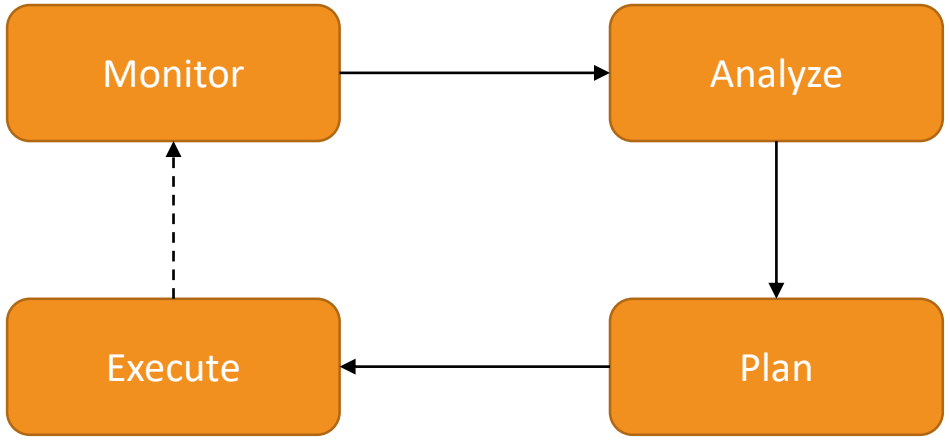
Added by Lukasz Butkowski 7 months ago. Updated 4 months ago.

| | |
|---|---|
| **Status:** | Closed |
| **Priority:** | Normal |
| **Assignee:** | Lukasz Butkowski |
| **Target version:** | r3390 |

# Self-Healing LLRF System

# Self-Healing LLRF System

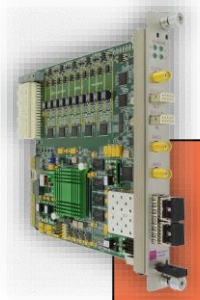
## The MAPE Loop




- **M**onitor: select and elaborate the data in each channel to be analyzed.
- **A**nalyze: depending on the data available and the specific fault, it could be possible to anticipate a fault (predictive-maintenance) or simply detect it when it happens. The result should be the identification of the failing unit.
- **P**lan: for self-healing, the repair action requires that an external system restores the state of the failed unit. Given the information that a unit needs to be restored, multiple approaches can be taken depending on the other components' availability.
- **E**xecute: The system can have a set of hard-coded actions needed to perform the recovery, try to recover by moving predefined "knobs", or a combination of the two approaches.

# Self-Healing LLRF System

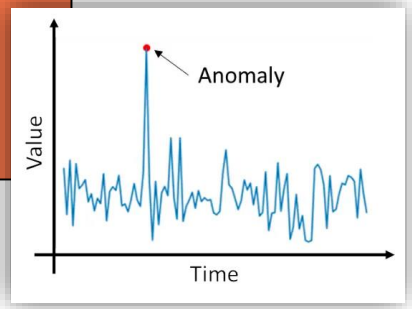
## Distributed monitoring system



Firmware monitoring module

Crate monitoring module

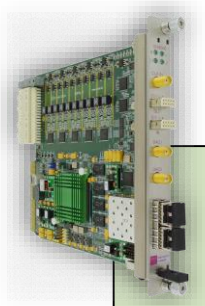
Anomaly detection system




- Pre-processing of data happens at the module e.g., moving average of signals
- The anomaly detection system needs to be based on different techniques, e.g., cluster analysis at system level

# Self-Healing LLRF System

## Safe healing of the system



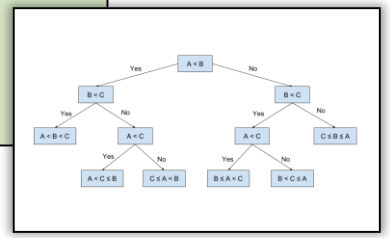
Firmware healing module

Crate healing module

Users

System reporting module

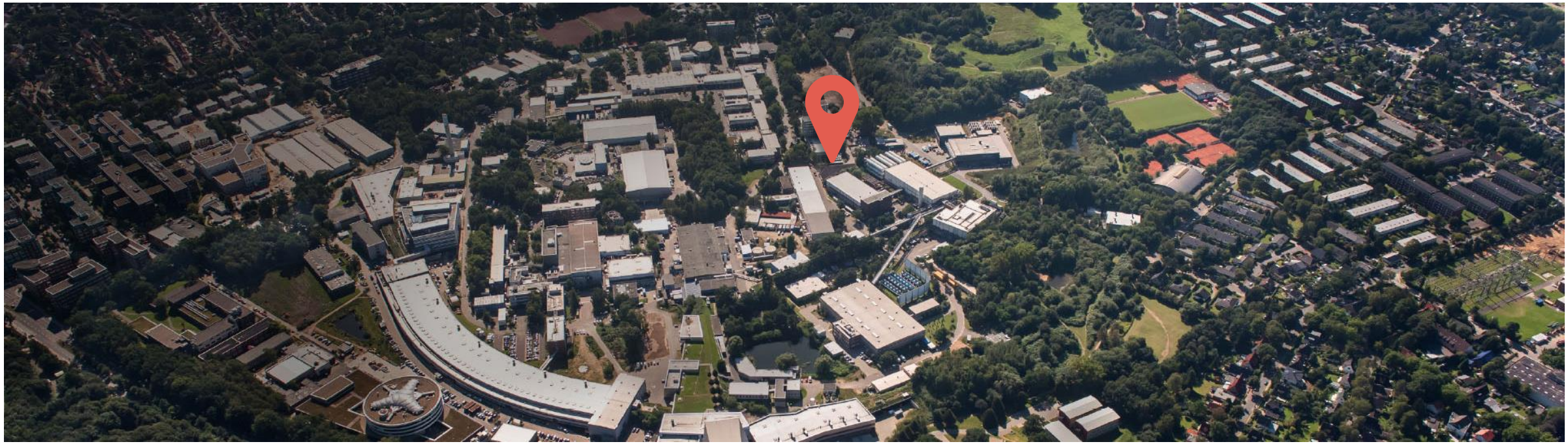
Repair system



- Each module has responsibility over different levels of the hierarchy, e.g., firmware module can change state registers
- The system reporting module will raise a warning in case a repair is not possible

# Thanks for your attention!

Gianluca Martino, Bld. 55A / Room 118



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