FLASH2 and XFEL

Machine Protection System – MPS

µTCA-based

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Concept – Experience

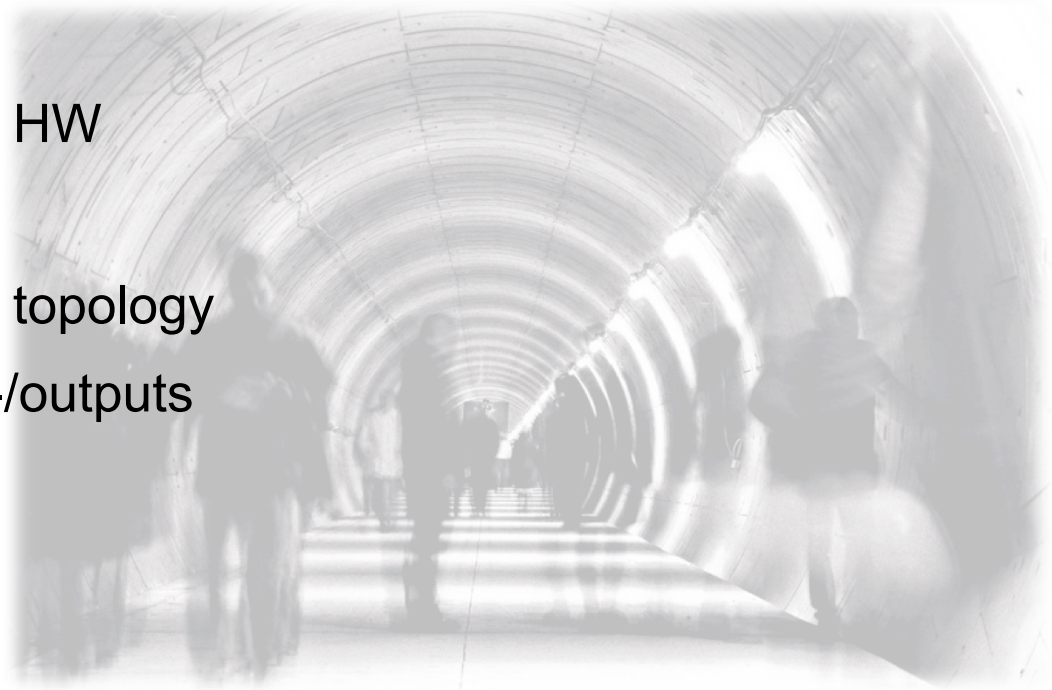
3rd MicroTCA Workshop – 11th-Dec-2014

HELMHOLTZ ASSOCIATION

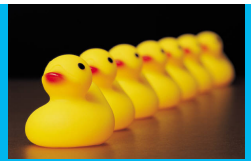
DESY

Outline

1. Purpose of MPS
2. Overall requirements
3. Chosen HW
4. Requirements fulfilled by this HW
5. Installation experience
6. MPS-internal communication topology
7. MPS-external interfaces – in-/outputs
8. Cooperation concept



Purpose



- MPS **protects** the accelerator from damage
  - esp. caused by heavy impacts of electron bunches
  - e.g. if beam is misaligned
  - e.g. if subsystem trade fails
  - e.g. during diagnostic routines or beam commissioning if inappropriate beam mode has been chosen
    - ✓ e.g. during wire scanning, OTR-screen movement, TDS-activity, collimator repositioning
    - ✓ e.g. in gun mode or analysis mode

- MPS **detects** that indirectly through a whole lot of alarm, error, interlock and status signals from a multitude of (diagnostic) systems
- MPS **reacts** appropriately by stopping or limiting the electron beam

How, when and by means of will be shown later

Overall Requirements

- MPS must be **bullet-proved**
  - XFEL benefits from FLASH2 as the new µTCA-based MPS is used there first
  - where it is running smoothly with only minor issues for several months
- MPS shall be as **invisible** as possible
- MPS' alarm-responses shall be **well-balanced**
  - protection shall be as sensitive as necessary, but also as tolerant as reasonable possible to still enable a properly operable system

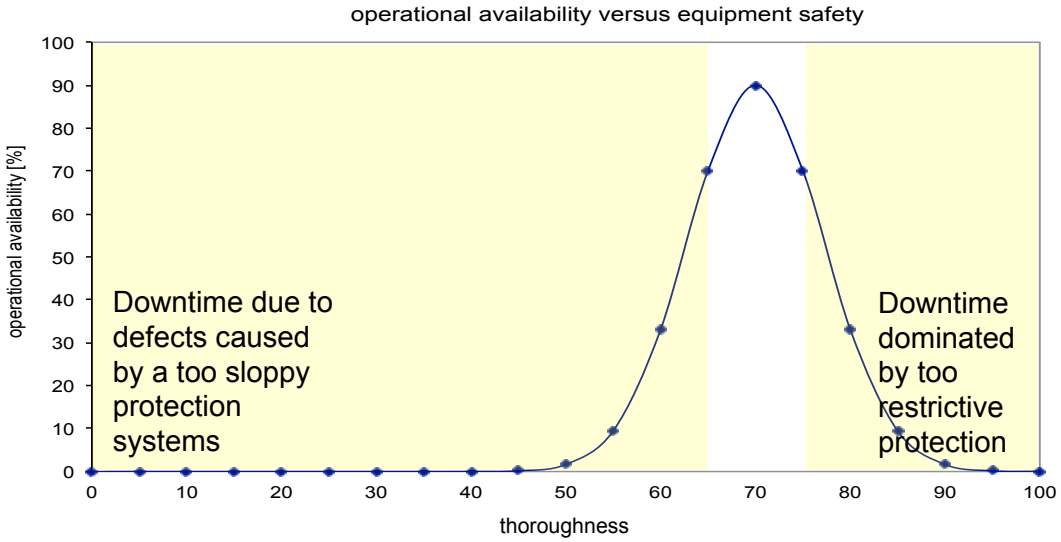
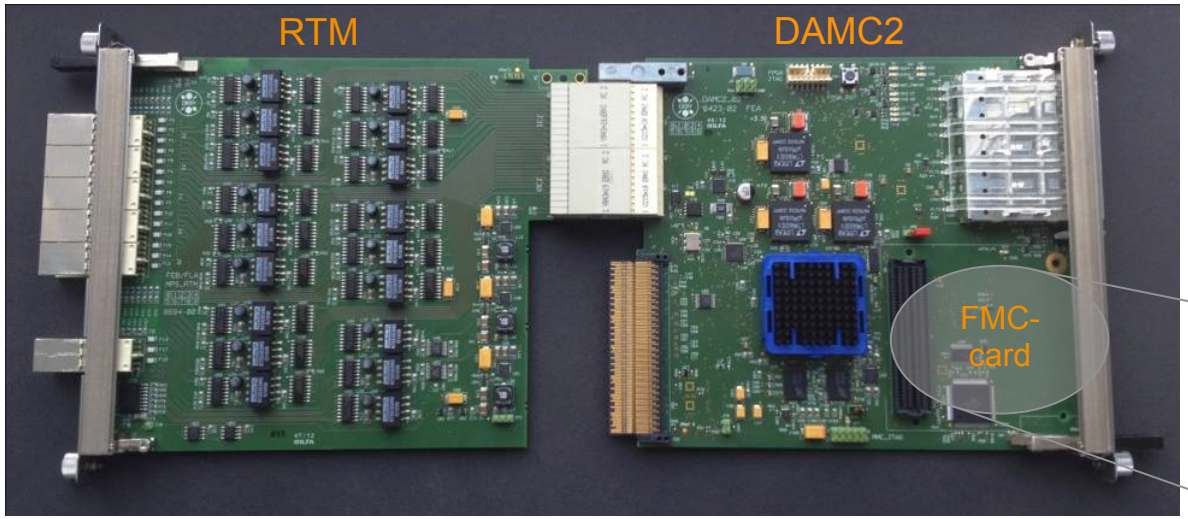
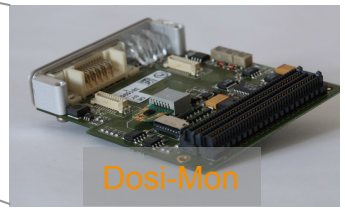


Figure by courtesy of CERN

Chosen Hardware – DAMC2-board – MTCA.4

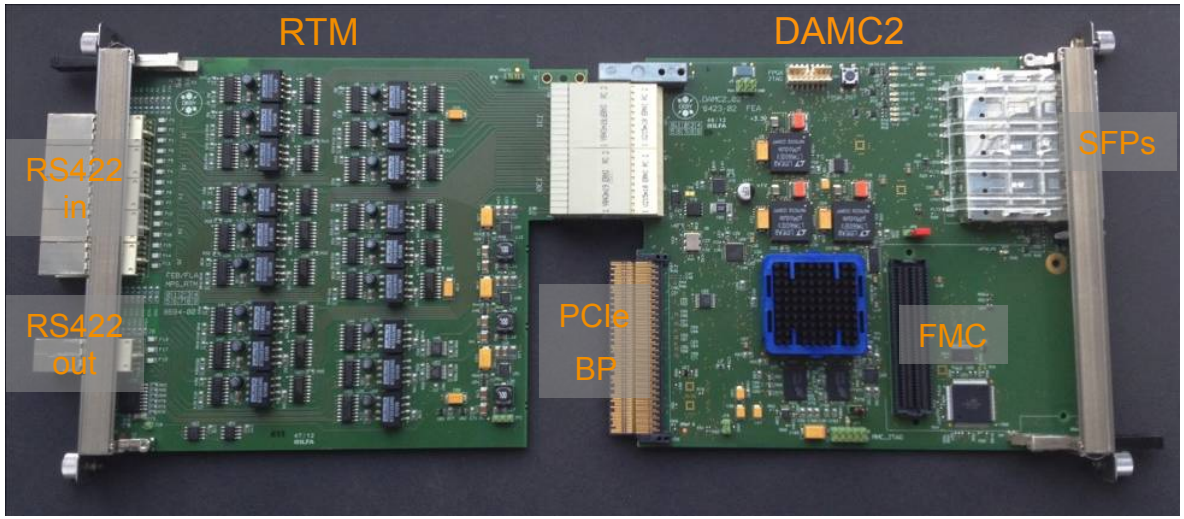


- XILINX Virtex-5 FPGA
- MMC support
- onboard flash-memory
- 1 Gbit SDRAM
- optional dosimetry FMC-card



- DAMC2 has been developed at FE
  - Besides MPS, other groups have developed firmware for their projects, e.g. BLM-controller
  - 25 MPS-boards in use, 100 ordered for the beginning of 2015, further will follow
- Interface RTM has been developed at FLA and FEB
  - Besides MPS, it also used by other systems, e.g. laser controller
  - 18 MPS-RTMs in use, 100 delivered and under final assembly, further will follow
- Radiation dosimetry monitoring FMC-card is currently under development at MDI

Requirements Fulfilled by the Chosen Hardware



- 4 double-fibred bi-directional optical links (SFPs)
- 45 digital inputs (RS422)
- 7 digital outputs (RS422)
- 3 input lines from backplane
- 2 output lines to backplane
- 3 digital inputs from FMC-card
- I^2C-bus to FMC-card
- PCIe-bus to all FPGA-registers
- IPMI for firmware updates

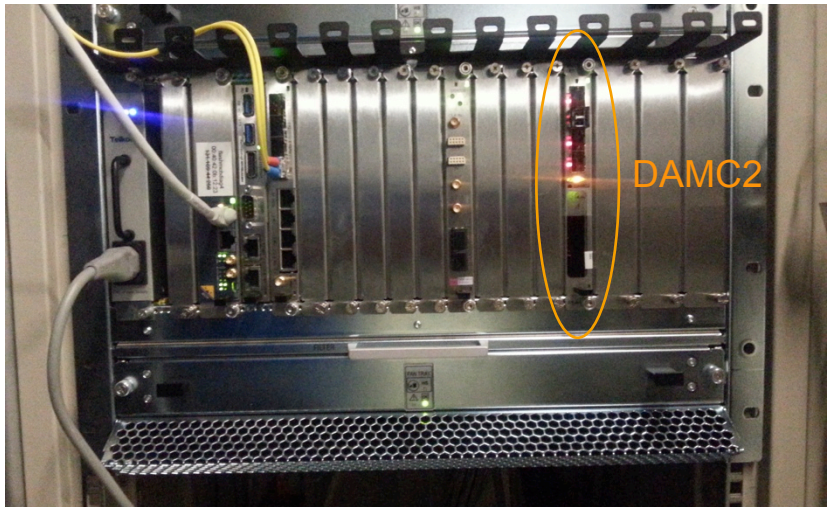
✓ Safety & availability & timeliness

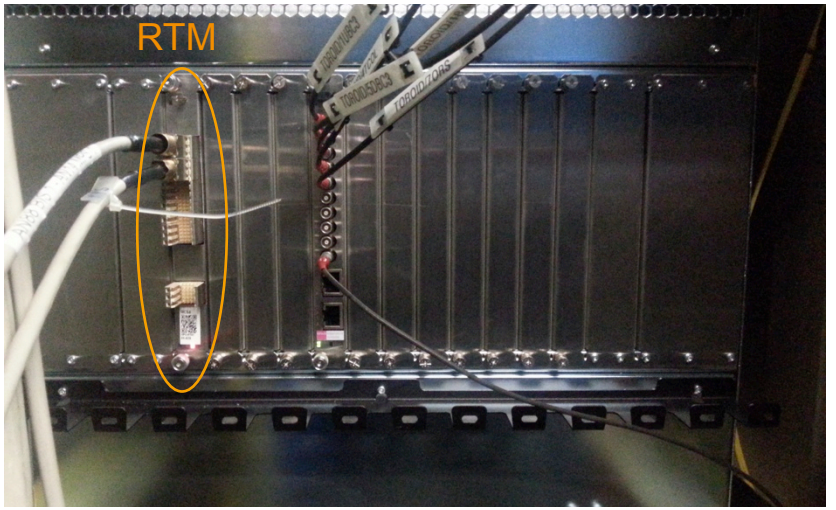
- all **machine safety-relevant** functions are realized within FPGA logic (~42 ns latency)
- to be **independent** from the availability of network, operating system, DOOCS-servers, PCIe-device drivers …

✓ Maintainability & scalability

- MPS architecture can be extended by utilizing the cascaded communication topology
- same firmware on every board, same DOOCS-server on every crate
- all alarm-responses can be configured through DOOCS/JDDD even during machine run
- boards and RTMs are hot-swappable

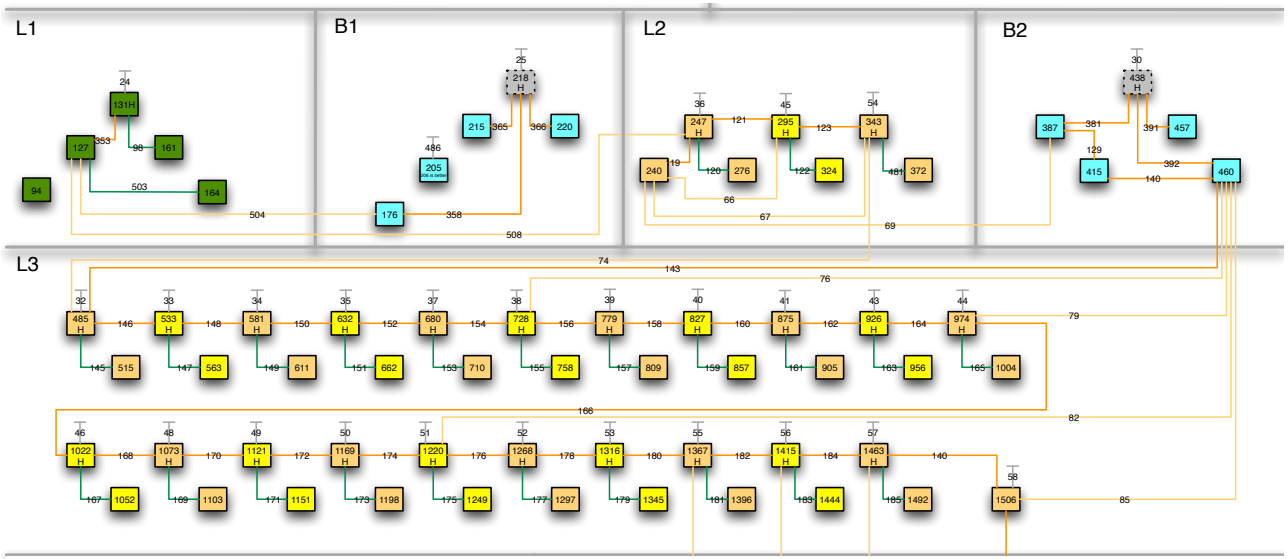
Installation Experience

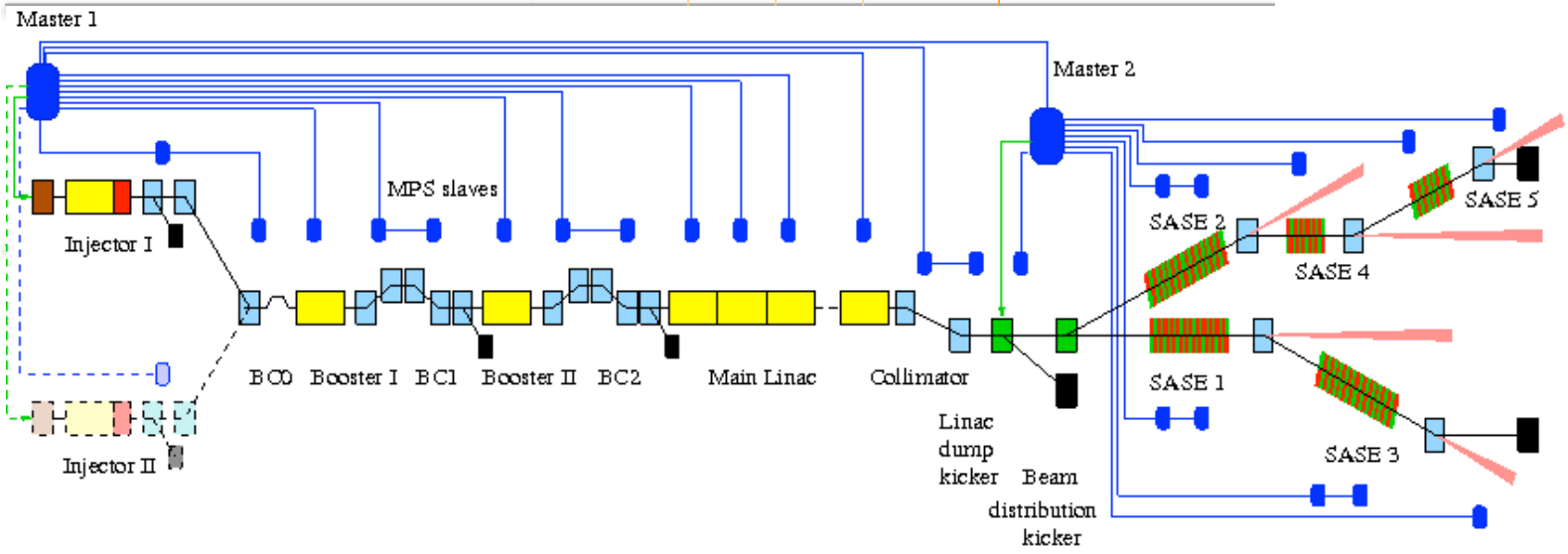




- ✓ Already installed boards (to be grown quickly)
  - 6 boards for **operational FLASH2:** injector hutch, cryo annex, extraction area & supply system aisle
  - 3 boards for **XFEL gun test**: 7th basement of the XFEL tunnel
  - 3 boards for **LLRF tests** at 3 test-stands in the AMTF-hall
  - 13 boards for development at several DESY laboratories
- > Reasons of the few anomalies at FLASH2
  - mostly: cable contact problems
  - once after firmware update: misconfigured operation mode setting

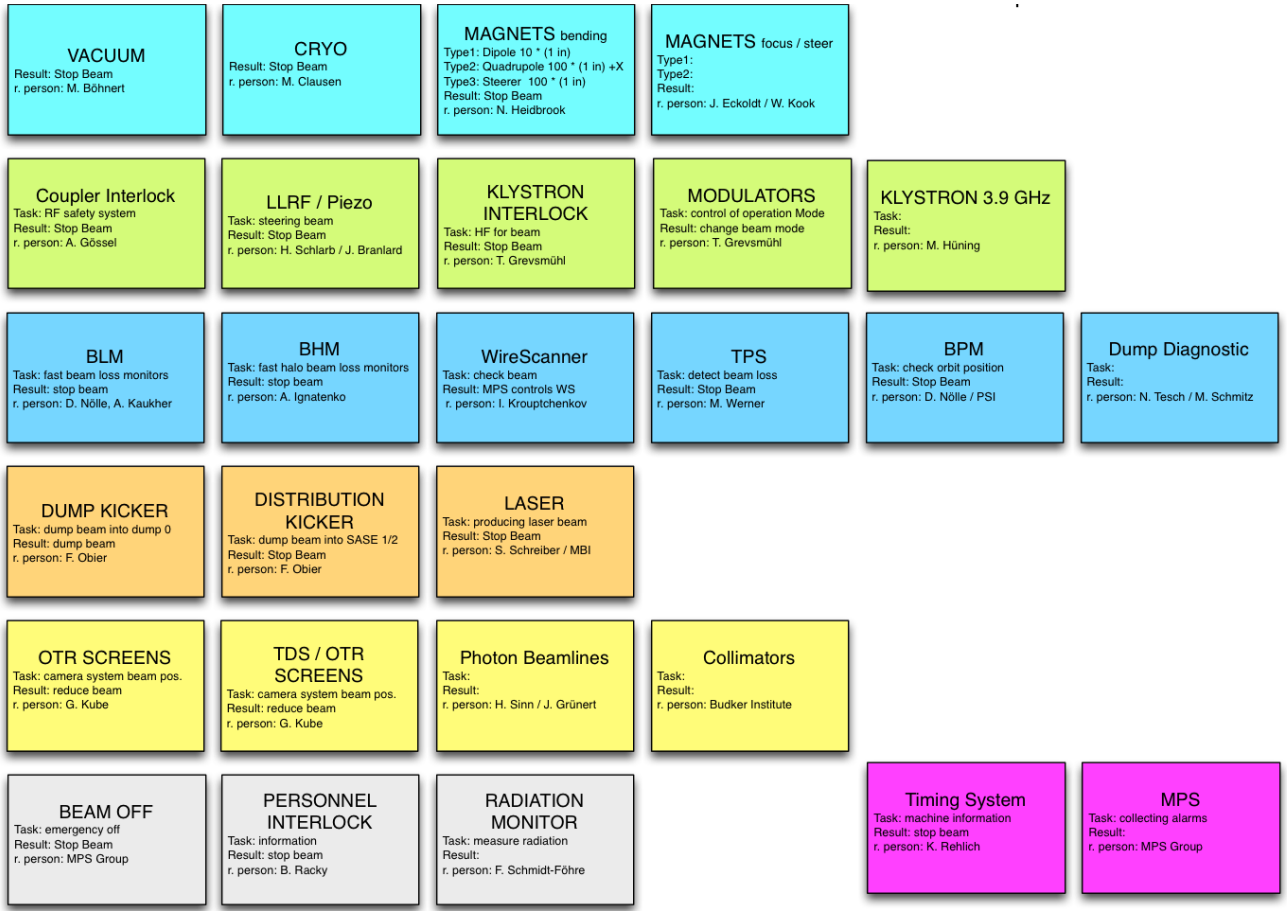
MPS-internal Communication Topology





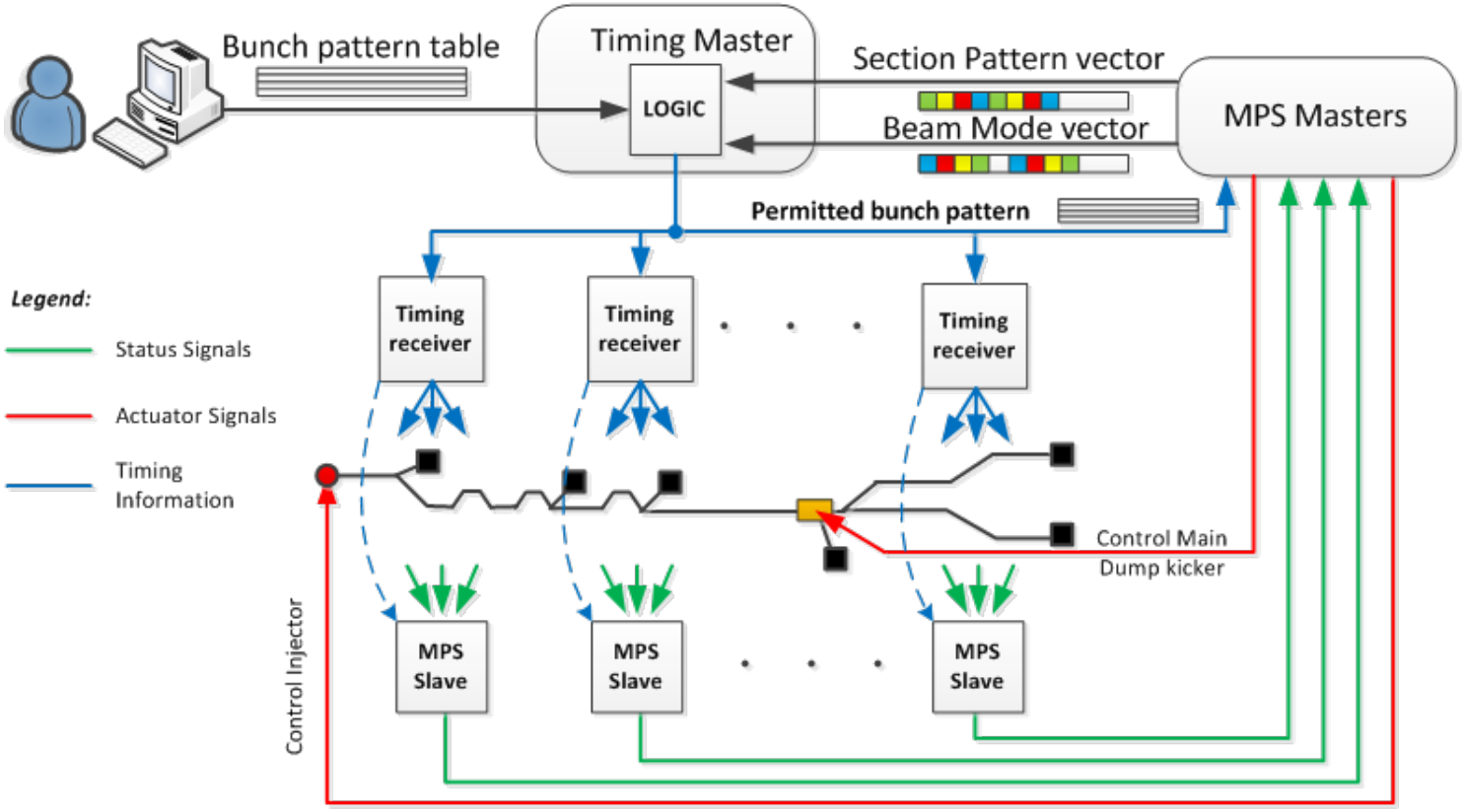
- In XFEL 150 MPS-boards will be installed
- MPS-boards inter-communicate via **fiber optics**
  - i.e. telegrams with laser inhibits, beam limits, section availabilities and operation modes

MPS Inputs – Systems Providing Alarms to MPS



- In XFEL MPS will receive ~2000 interlock, alarm, error and status signals from ~27 types of systems
- Alarm signals were provided via **RS422**-conforming twisted-pair copper wires
- Alarm providing (diagnostic) systems strongly varies in their complexity

Cooperation Concept with Timing System



- The operator tells the timing system his/her demanded beam parameters (top left)
- MPS collects all alarms signals from providing (diagnostic) systems (green lines)
- MPS evaluates the alarms against current operation modes and sends the appropriate beam limits to the timing system
- Timing system combines wishes and limits and sends it as bunch pattern tables and triggers, e.g. to laser controller (blue)
- MPS is also able to bypass the timing system temporarily and control laser and kicker directly (red)

Q&A

Thank you for your attention!

Questions and comments are welcome