The Machine Protection System for PETRA III

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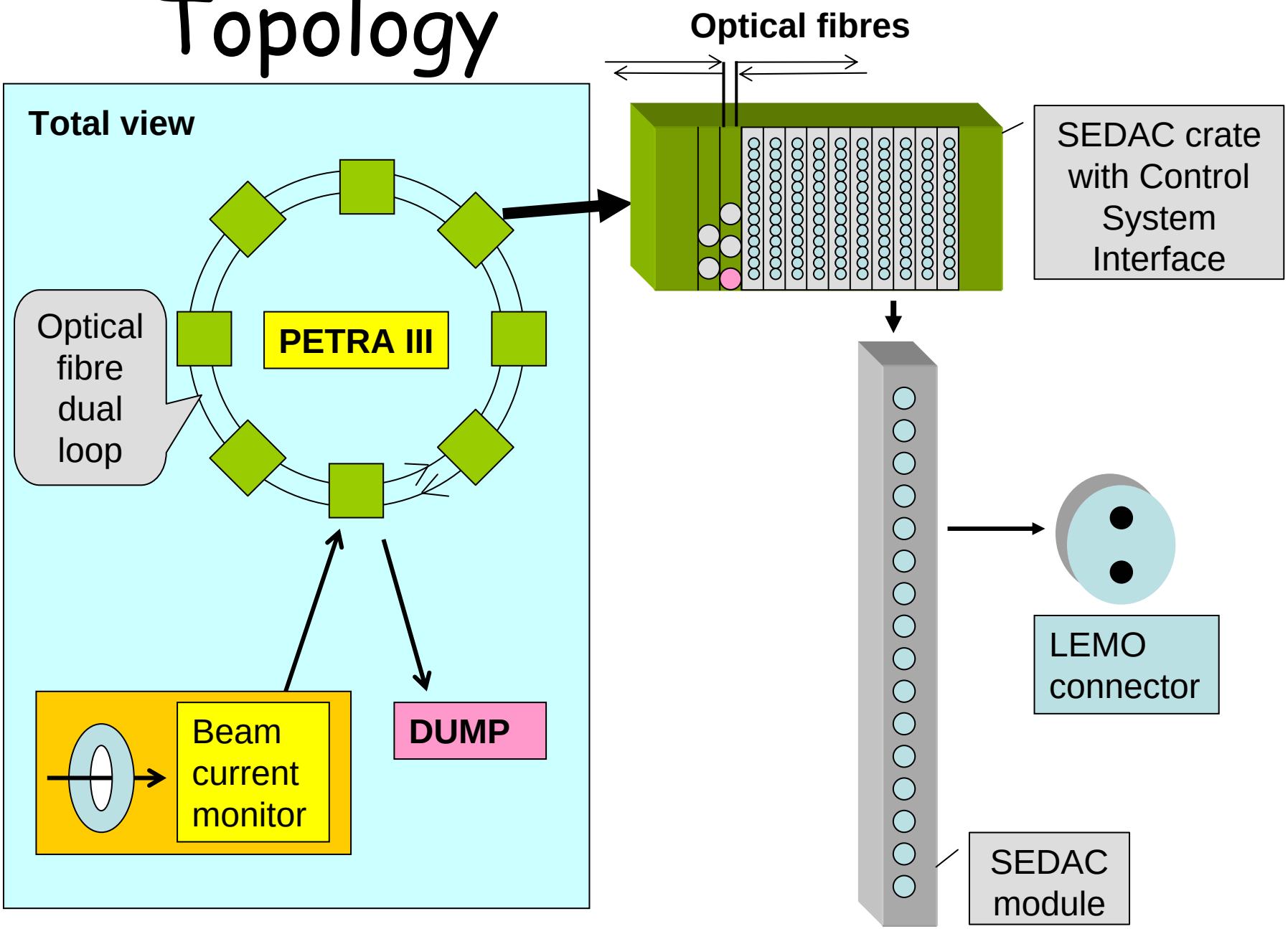
DESY
FLS 2006

Topology


Total view
PETRA III
Optical fibre dual loop
Beam current monitor
DUMP
Optical fibres
SEDAC crate with Control System Interface
LEMO connector
SEDAC module

Specifications

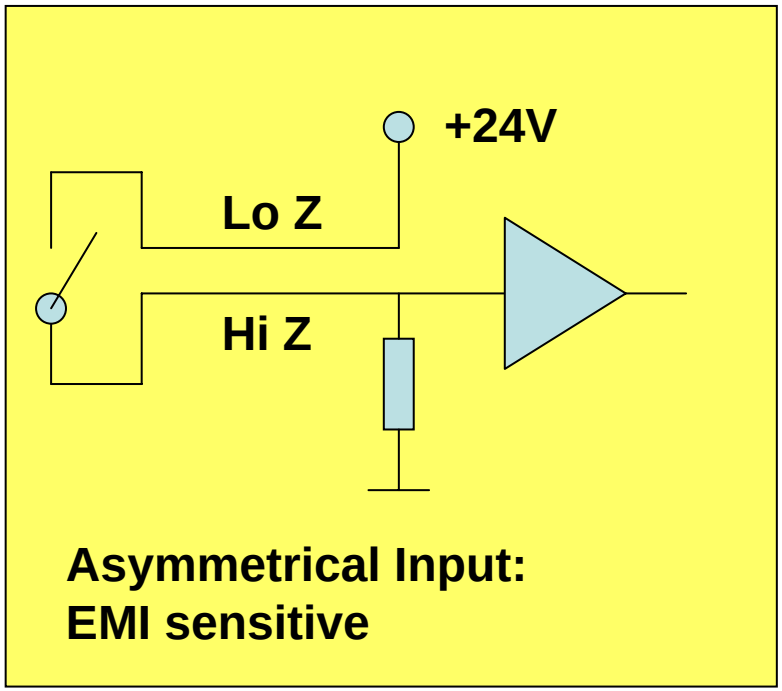
- **Several 100 alarm inputs** distributed over 8 halls
- **Reaction time** < 100 us
- Alarms indicated by **ground-free switches or optocouplers** (switch open = alarm)
- **Logical combination** of alarm signals
- Individual **masking** dependent on beam current
- Synchronous **Post Mortem** output
- Recognition of **first alarm**
- **High availability** and **high reliability**
- Connection to Control System
- Commissioning in 2008

Alarm sources

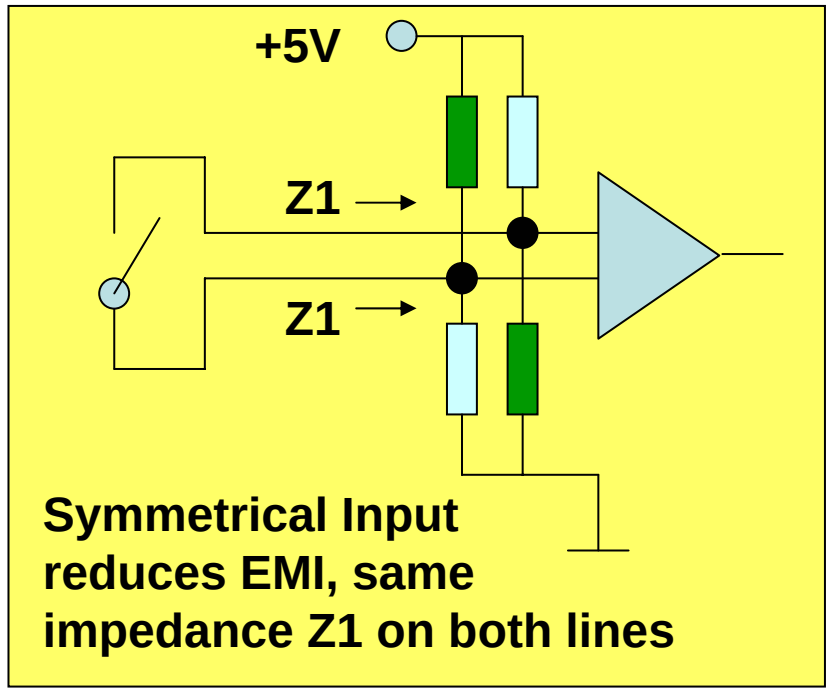
- Beam position monitors (BPMs)
- Photon BPMs
- Temperature sensors
- Personal interlock
- Magnets
- RF
- Vacuum valves, Fast shutters
- Wigglers, Undulators („gap closed“ used as alarm enable signal for Photon BPMs and Fast shutters)

Improving EMI immunity

- EMI: Electro-Magnetic Interference
- Optical fibre link between crates: EMI-resistant
- Symmetrical alarm inputs avoid spurious dumps



worse



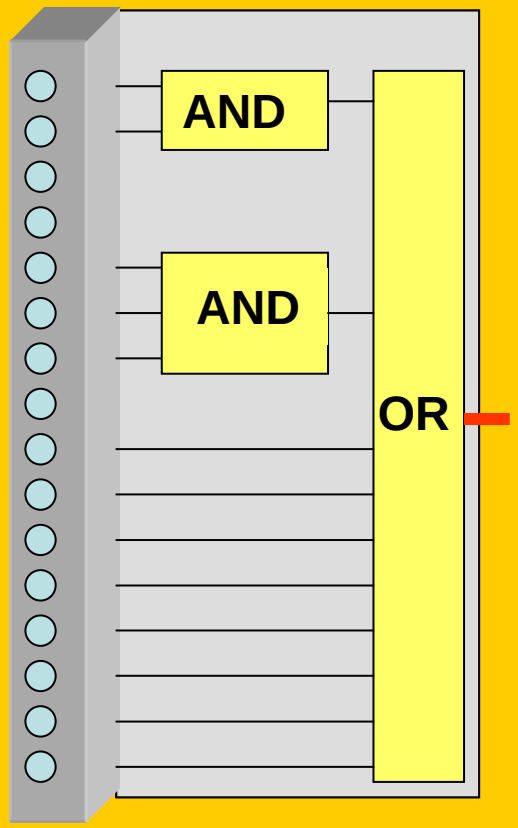
better

Flexible alarm combinations

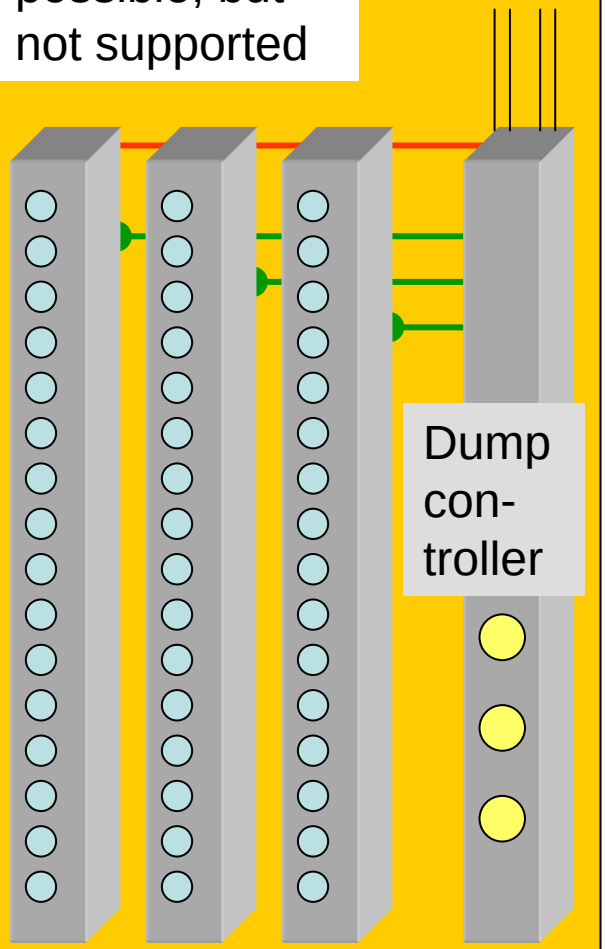
- **All alarm inputs of a module** (max. 16) can be combined in a user programmable AND – OR matrix by the FPGA in the module)
- Option: **all alarms of a crate** (max. 160) can be combined inside the „Dump Controller“ using the dedicated serial links between modules and Dump Controller (latency < 3us)
- Option: **all alarms of the system** (max. 1280) can be combined using the optical fibre links (latency < 20us for less than 100 combined inputs)

Scope of alarm combinations

Module scope:
Supported by user interface

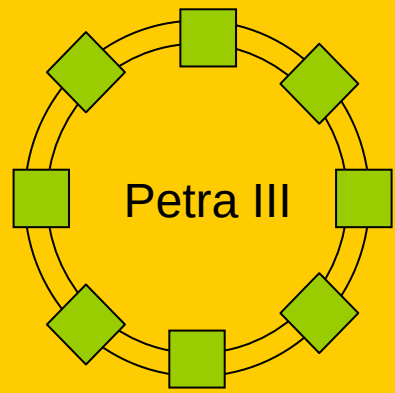


Crate scope:
possible, but not supported

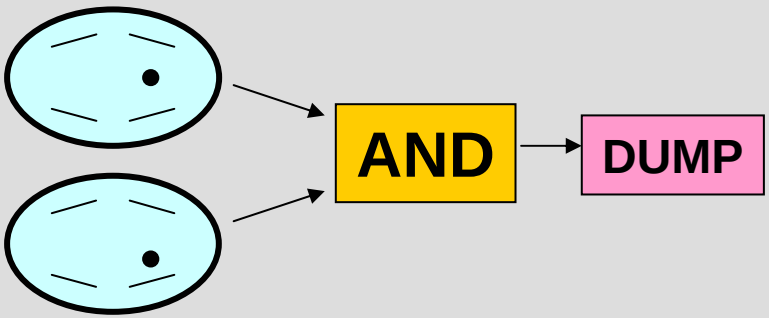


System scope:
possible but not supported

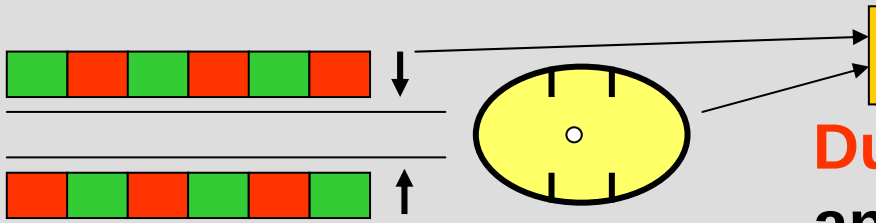
Alarm distribution via optical link



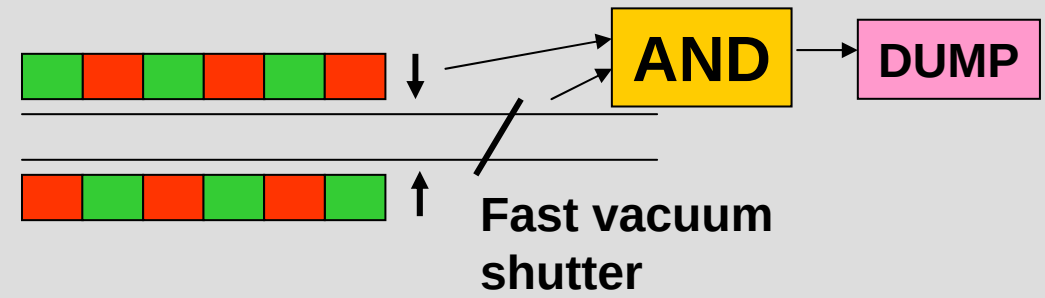
3 Examples for alarm combinations



Dump only if 2 BPMs show alarm to increase machine availability



Dump if photon BPM alarm and undulator closed

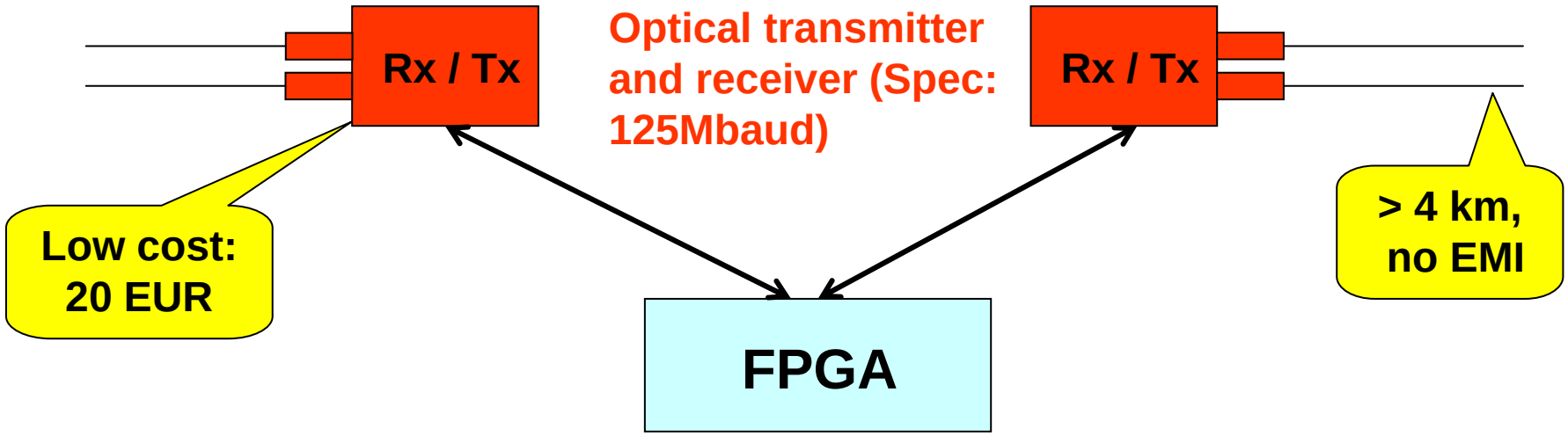


Dump if Fast Shutter closed AND undulator closed

Optical Link between crates

- Two optical fibre rings operated in opposite direction (redundancy to increase reliability)
- Information to be transmitted:
  - Dump trigger (short latency)
  - Post mortem trigger
  - Beam current
  - Time synchronisation
  - Optional: alarm flags for system-wide alarm combinations
- **Data and dump trigger will be transmitted in the same bit stream over the same optical fibre!**

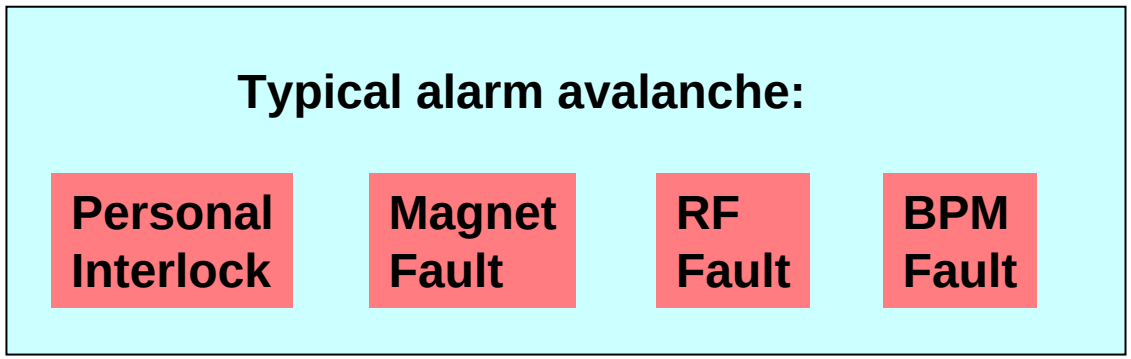
Optical fibre link between crates



- Use self defined protocol:
  - Biphase-Mark-Code, e.g. 10 Mbps (frames→words→bits)
  - Constant frame length (different from Gbit Ethernet)
  - Dump latency < 3us by dump bit in every word
  - Robust against transmission errors
  - Re-Synchronisation time < 30us

Operator support

- Find out the cause for an alarm avalanche:
  - Alarm hierarchy analysis (what can cause what?): software implementation
  - First alarm recognition (who came first?): hardware implementation

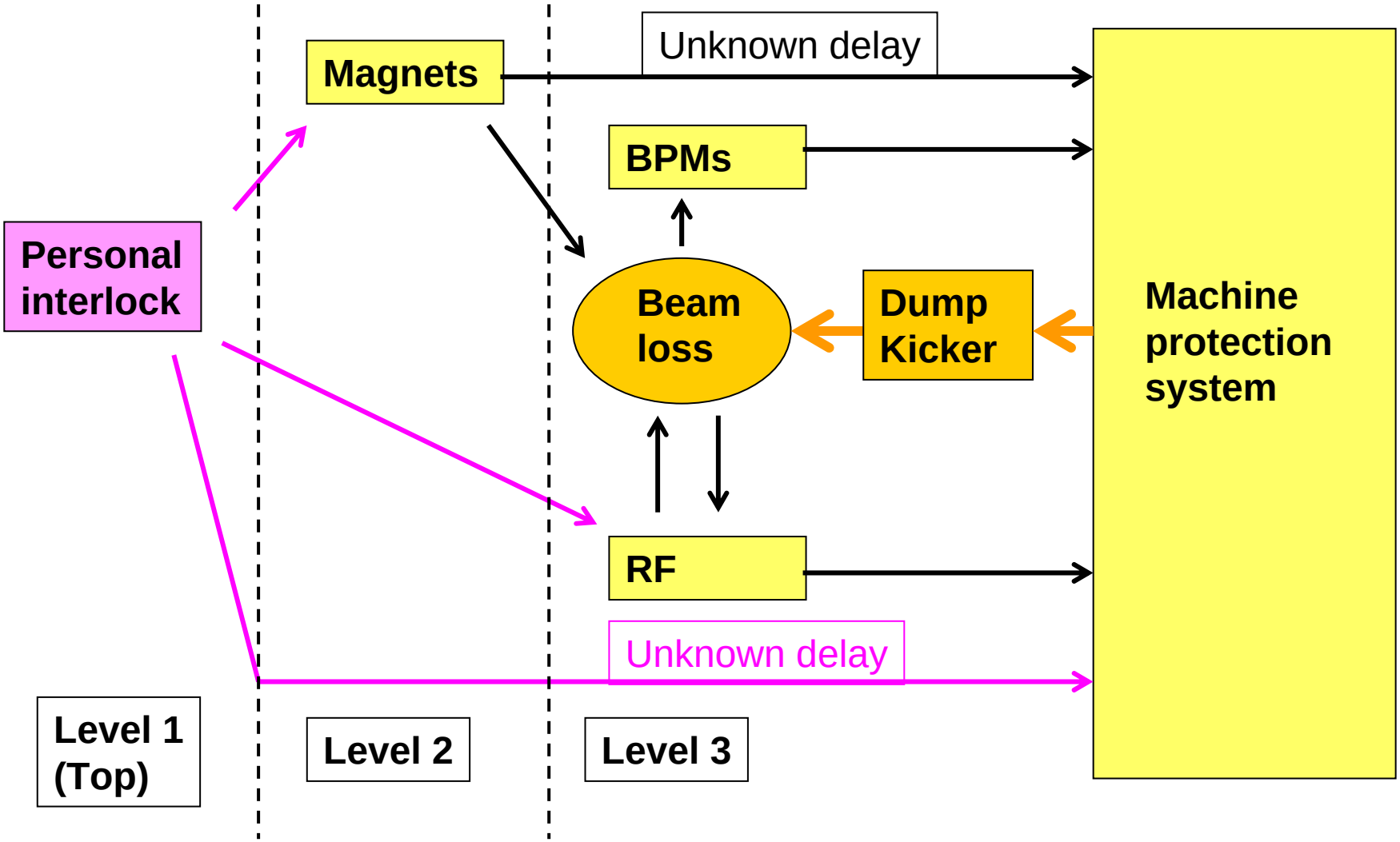


„First alarm" recognition

- Every module contains a **time counter**, all time counters of the system are synchronized via the optical link and the backplane
- Every alarm is time-stamped individually to discover the first alarm
- Useful to decide quickly if e.g.
  - BPM alarm → beam dump → RF fault

    OR
  - RF fault → beam dump → BPM alarm

Alarm hierarchy analysis



The End

Thank you for your attention!