

# DESY Machine Protection and Fast interlock systems

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ESS, Lund

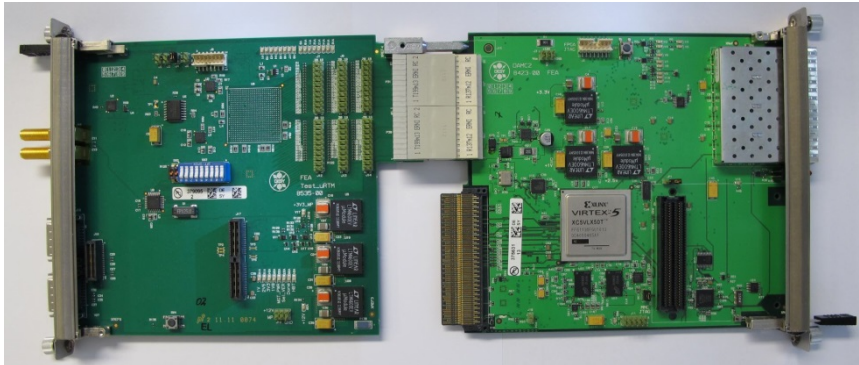
# Overview

- $\mu$ TCA for physics
  - Crate, AMC + RTM, Backplane, Frameworks
  - General purpose modules: DAMC-2 and SIS8300
  - $\mu$ TCA based systems at Desy
  - In detail: TPS (Toroid protection system) for EXFEL
- Some FPGA High Reliability Considerations

# $\mu$ TCA for Physics

RTM

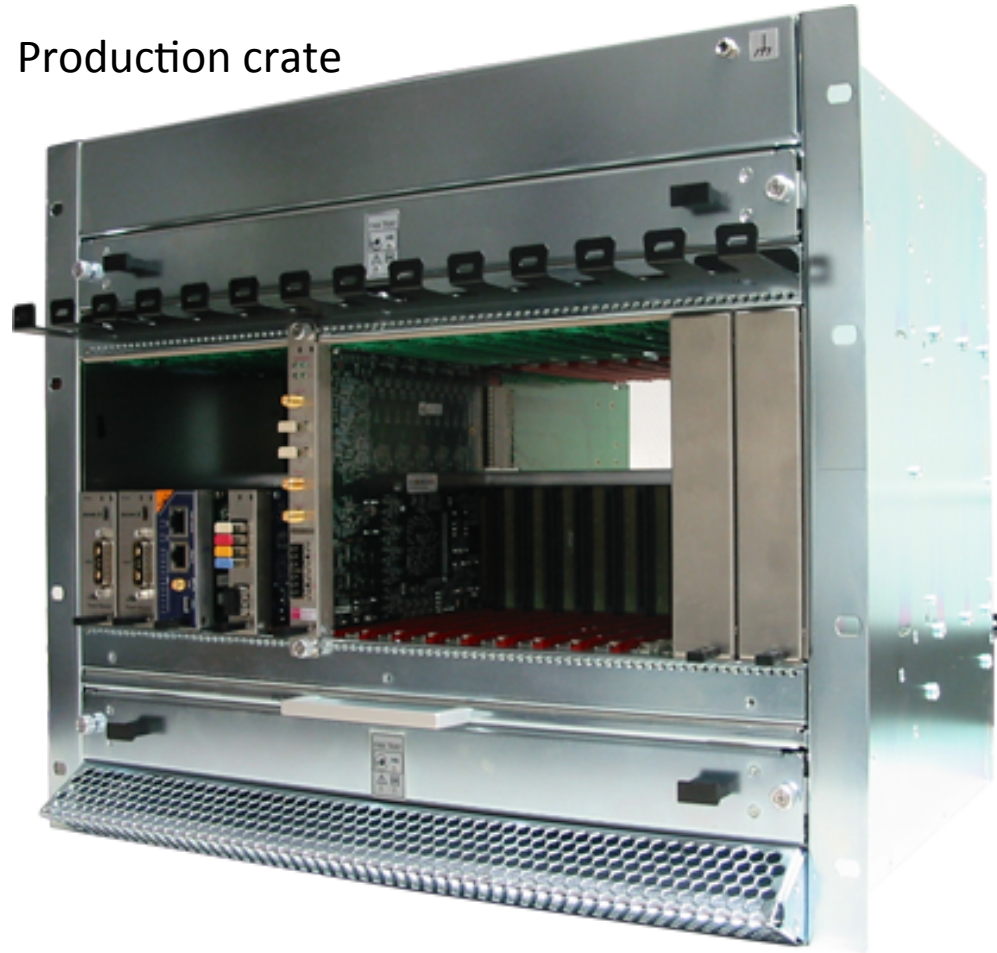
AMC



(Test adapter)

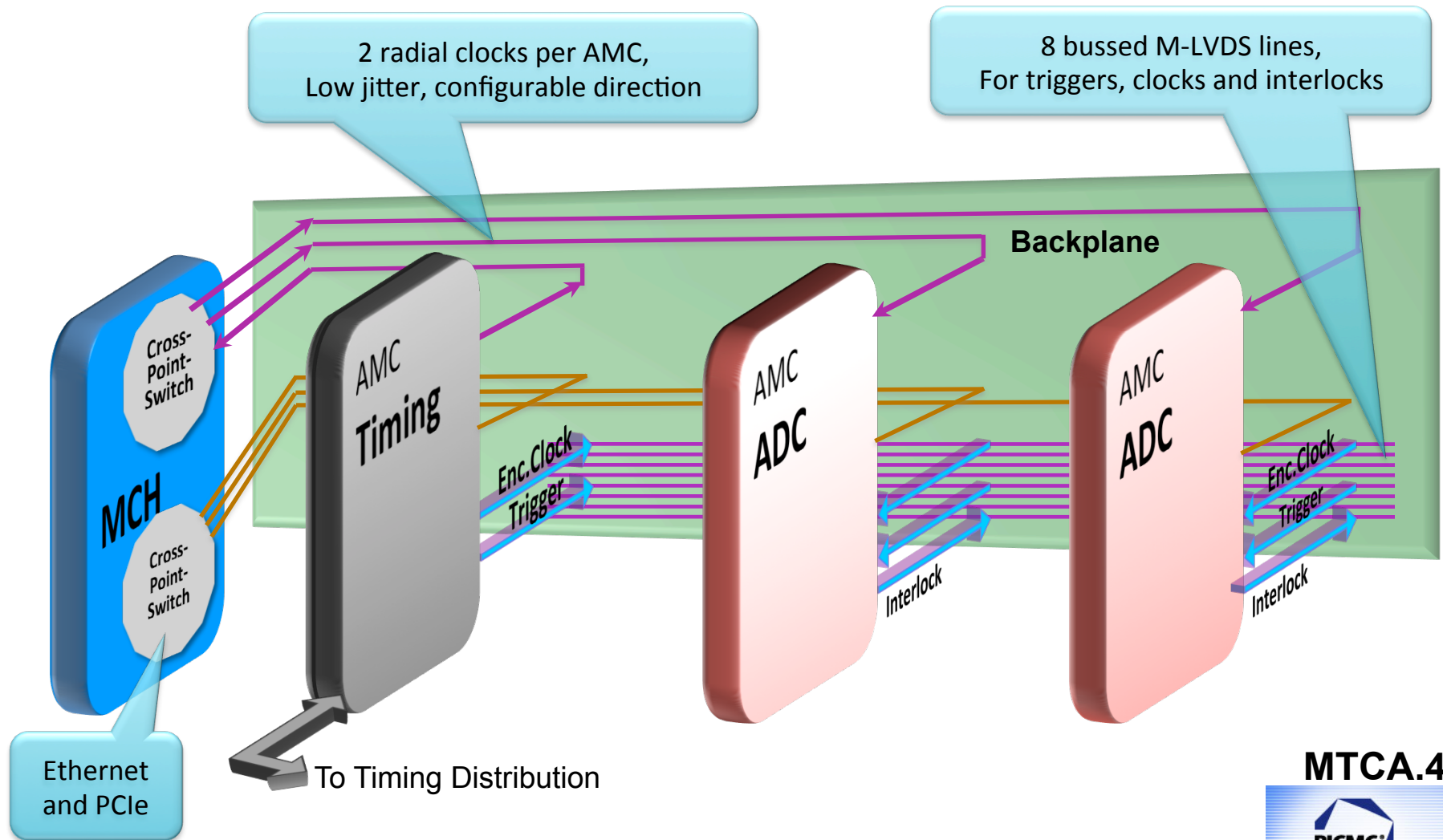
(DAMC-2)

Production crate



Courtesy: Kay Rehlich

# $\mu$ TCA: Clocks, Triggers and Interlocks



Courtesy: Kay Rehlich

**MTCA.4**

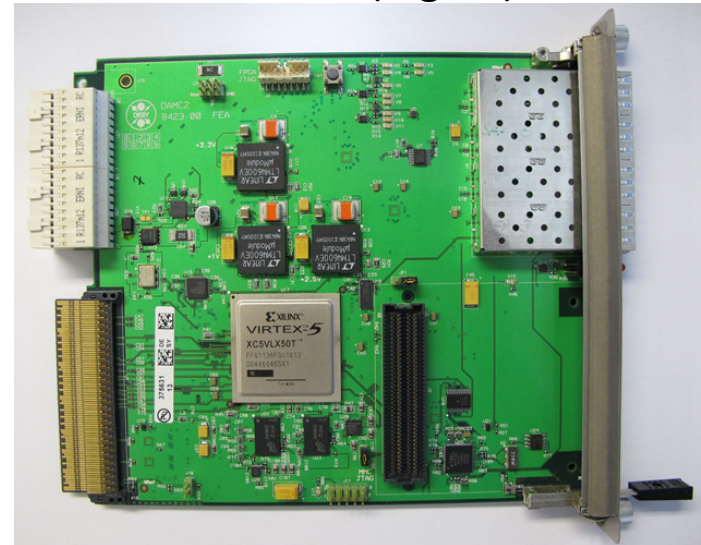


# $\mu$ TCA „Hardware Framework“

Development crate with CPU, MCH and power supply



DAMC-2 (digital)



SIS8300 (analog)





# „DAMC-2“

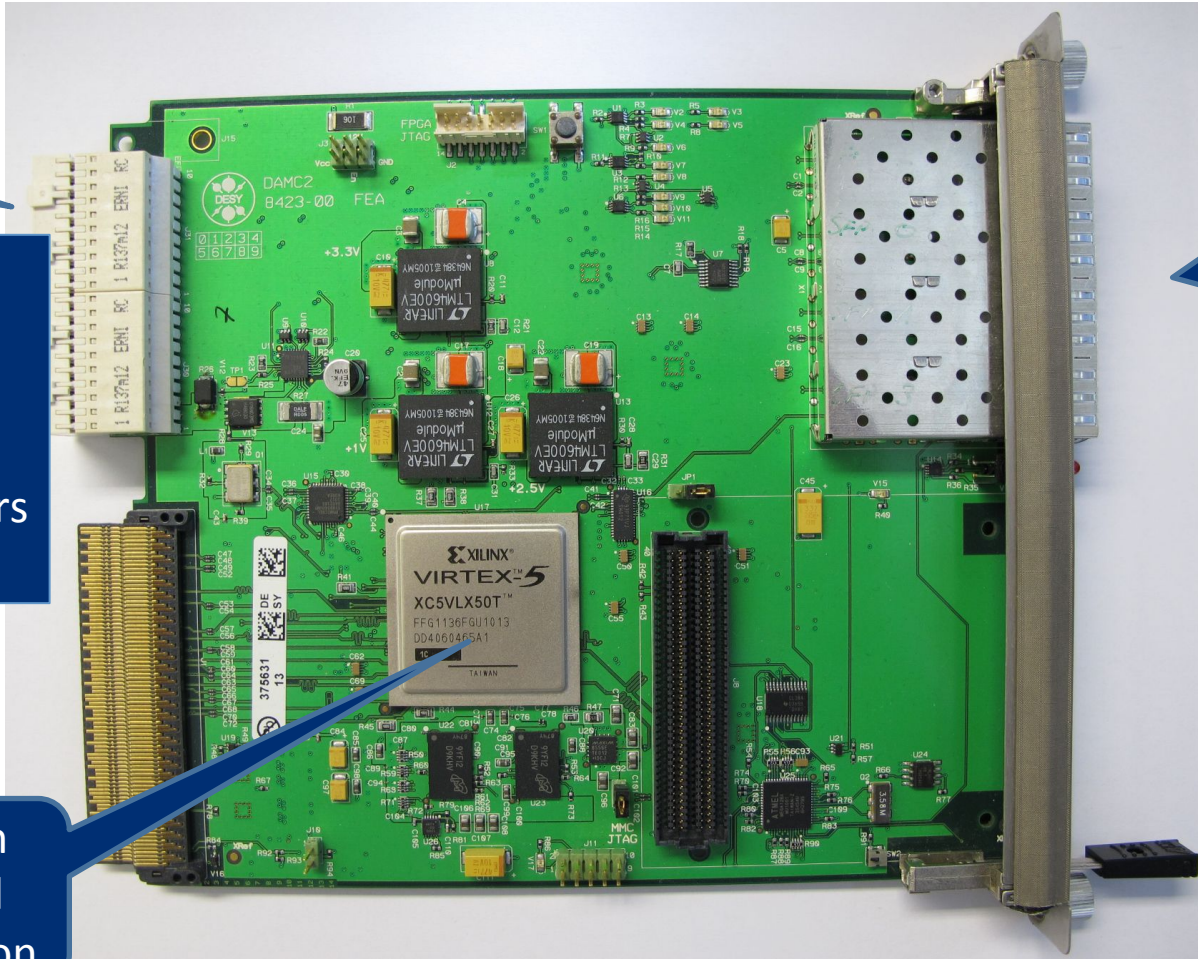
General purpose high performance digital I/O module,  
developed at DESY (group FEB)

53 LVDS  
I/O pairs

To RTM:  
MPS  
Toroids  
BLMs  
Wireshanners  
others ...

FPGA with  
dedicated  
configuration

4 bidirectional  
Gigabit Links



# SIS8300

**General purpose Fast ADC / DAC module:**

10 ch ADC 16 bit 125 MSPS, 2 ch DAC 16 bit 125 MSPS

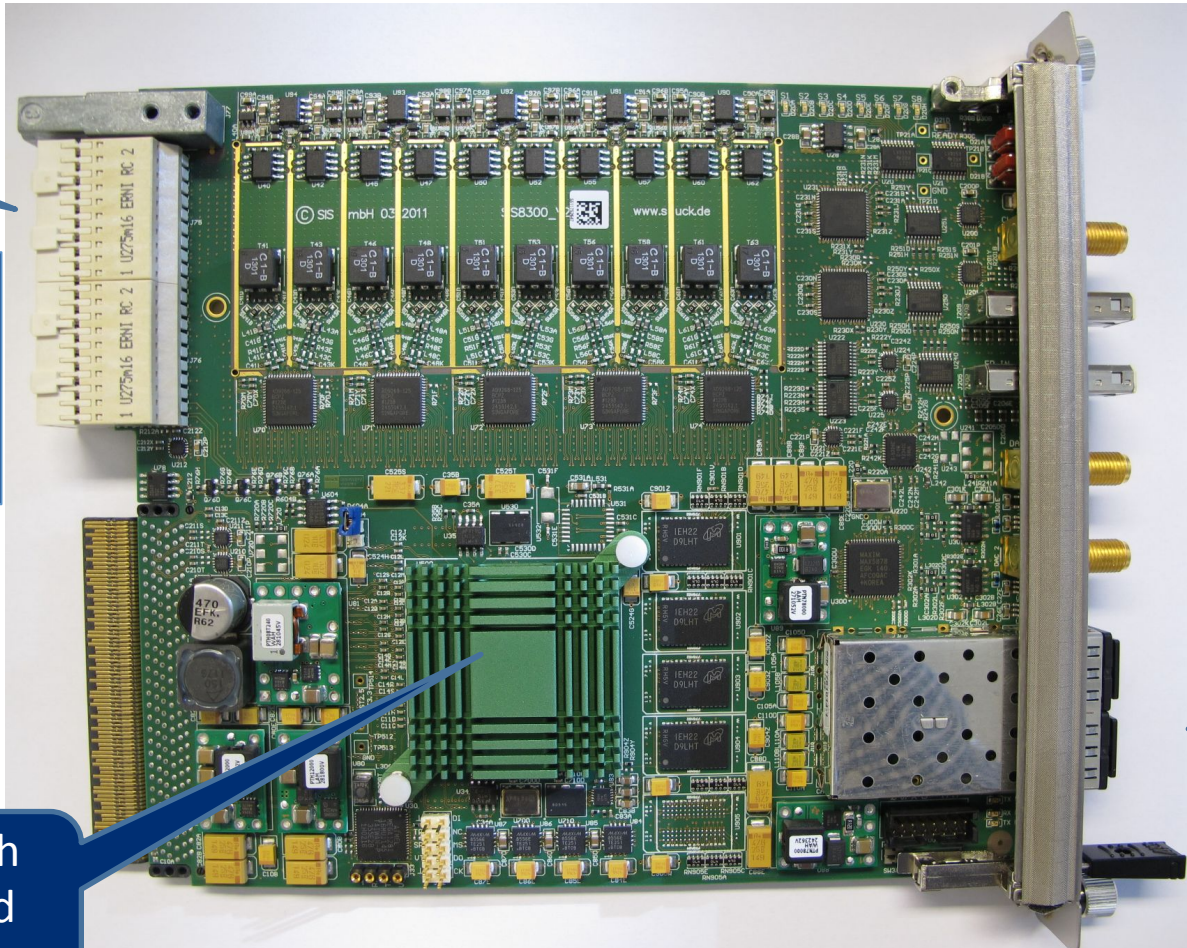
Commercial product (Struck company)

10 ADC  
inputs

To RTM:  
BPMs  
LLRF  
others ...

FPGA with  
dedicated  
configuration

2 bidirectional  
Gigabit Links



# μTCA Software and Firmware Framework

- Software Framework (Linux C applications and drivers, DOOCS control system)
- Firmware Framework: „Startup project“ for implementation of user specific firmware into DAMC-2 (digital) or SIS8300 (analog), using the ISE development kit for XILINX FPGAs
- FPGA language: VHDL



# Some $\mu$ TCA based systems at DESY

(Already presented by Dirk Nölle in the ESS diagnostics mini workshop in March 2012):

MPS systems:

- MPS backbone system: prototype existing
- BLM system: prototype existing
- Toroid protection system: under development

Other diagnostics systems:

- Wirescanner system: prototype existing (no slides)
- BPM system: prototype existing (no slides)

# MPS for EXFEL

- Fast FPGA based interlock
- → see presentation of Sven Karstensen

Alarm I/Os

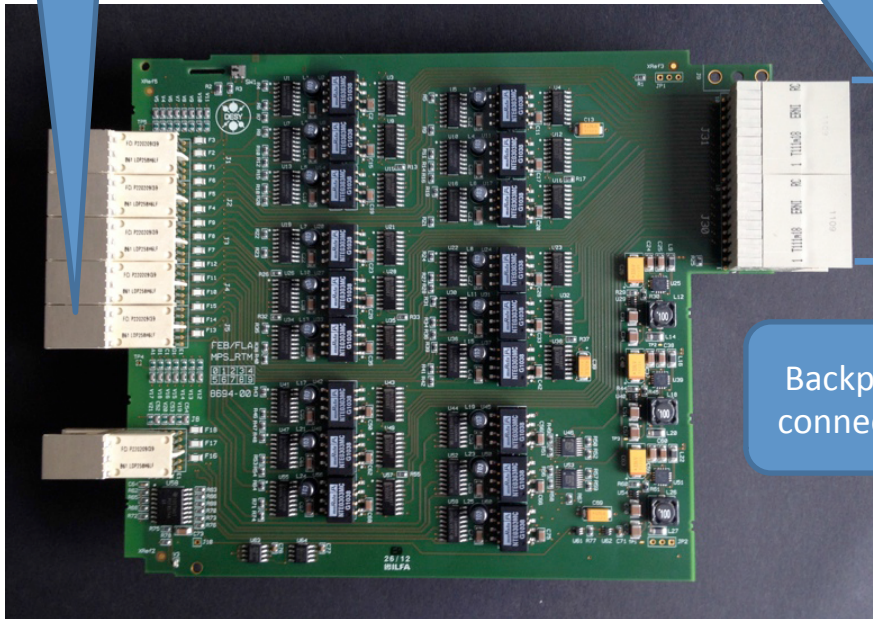
MPS-RTM

Digital I/Os

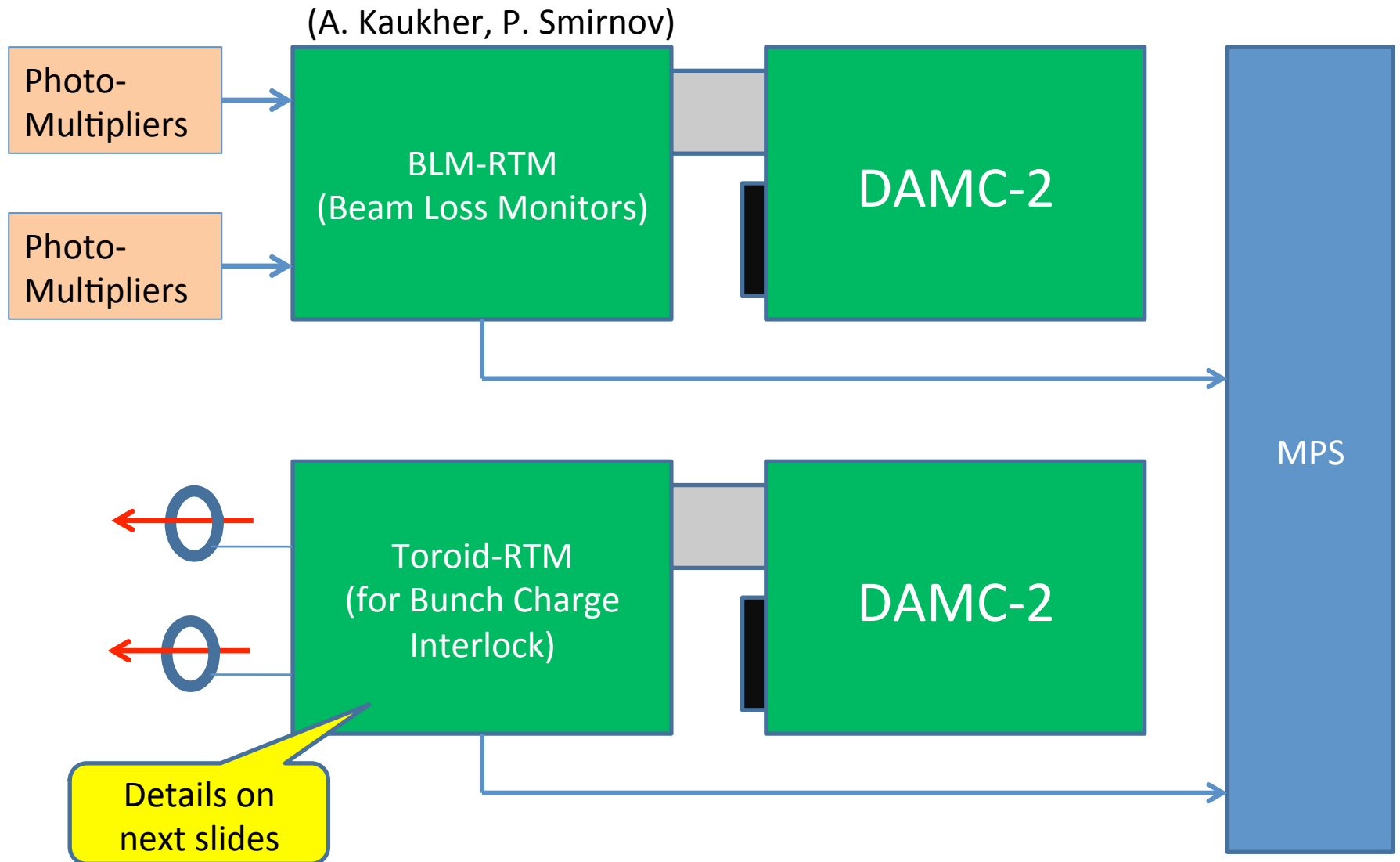
Backplane connection

DAMC-2

Gigabit connection

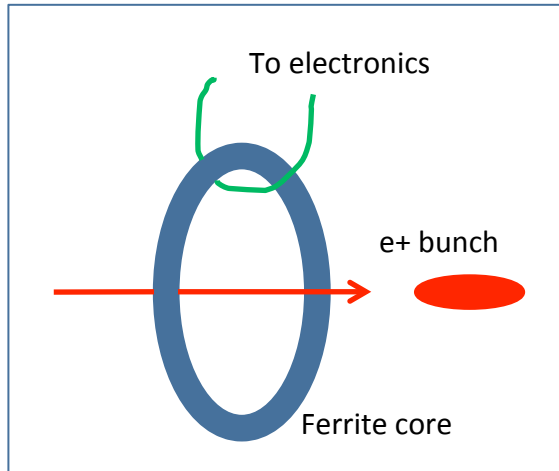


# More $\mu$ TCA based MPS for EXFEL



# „Toroid“: Beam current transformer

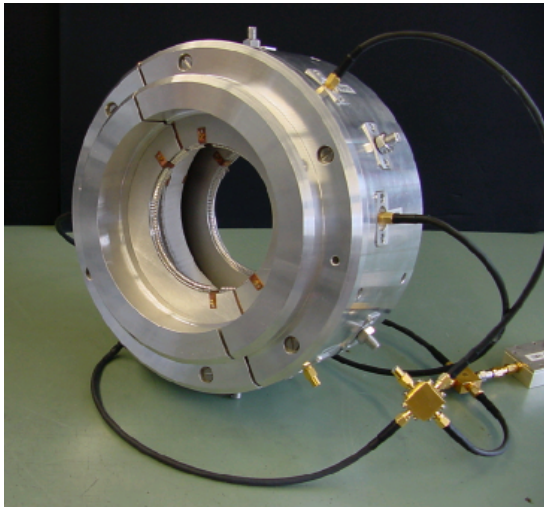
Principle



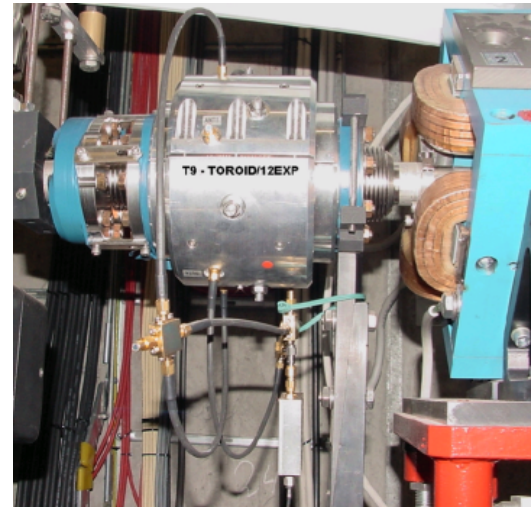
A beam current transformer (often called „toroid“) is a transformer with a toroidal ferrite core where the primary coil is represented by the beam.

The bandwidth can range from kHz to GHz, so the device can be used to measure bunch charges individually.  $\leftrightarrow$  DCCT !

Device not yet installed



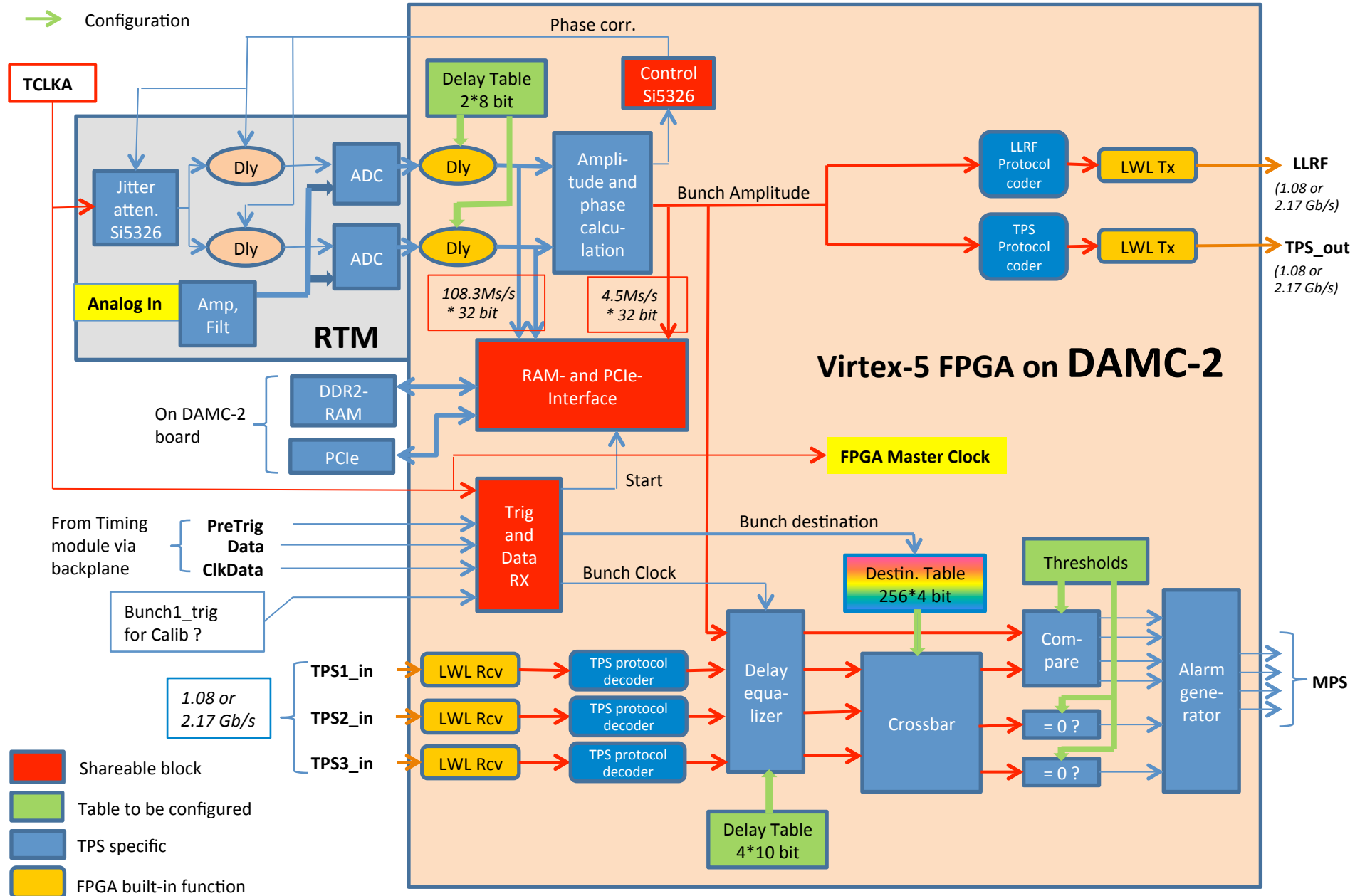
Installed in FLASH



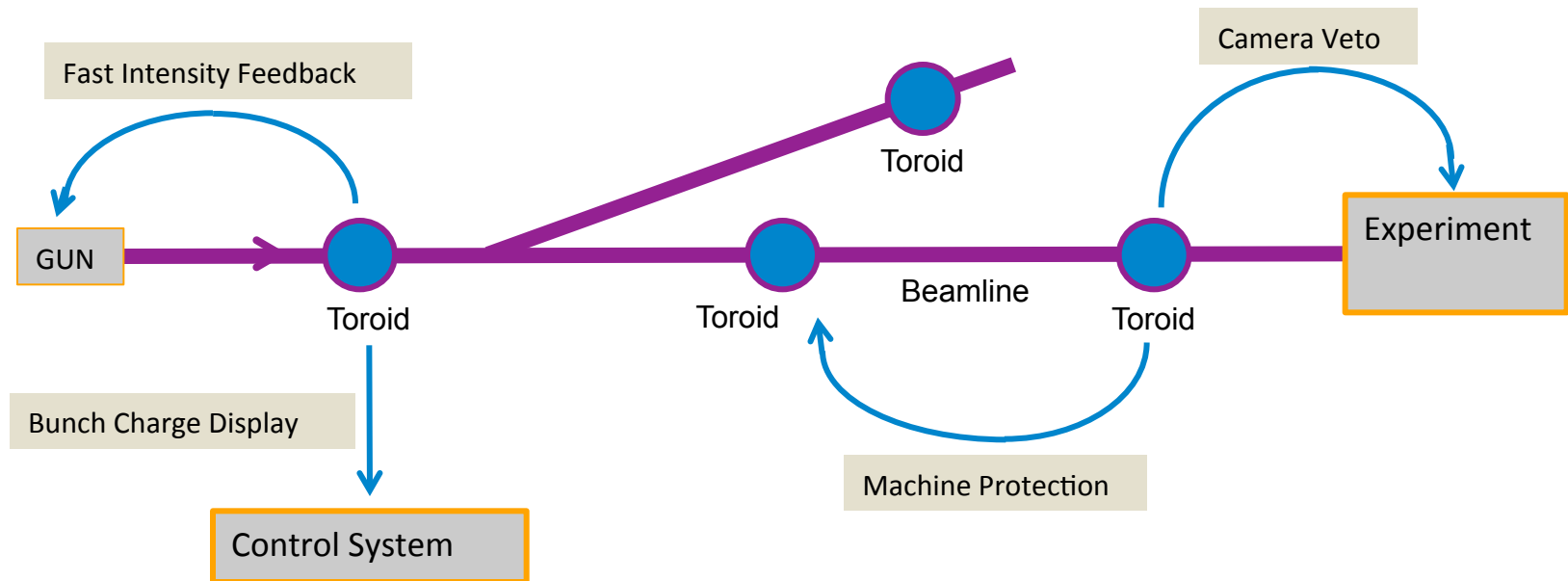


# Toroid System: FPGA and RTM (version 1)

- Optical fibre
- Bunch by bunch amplitude
- Configuration



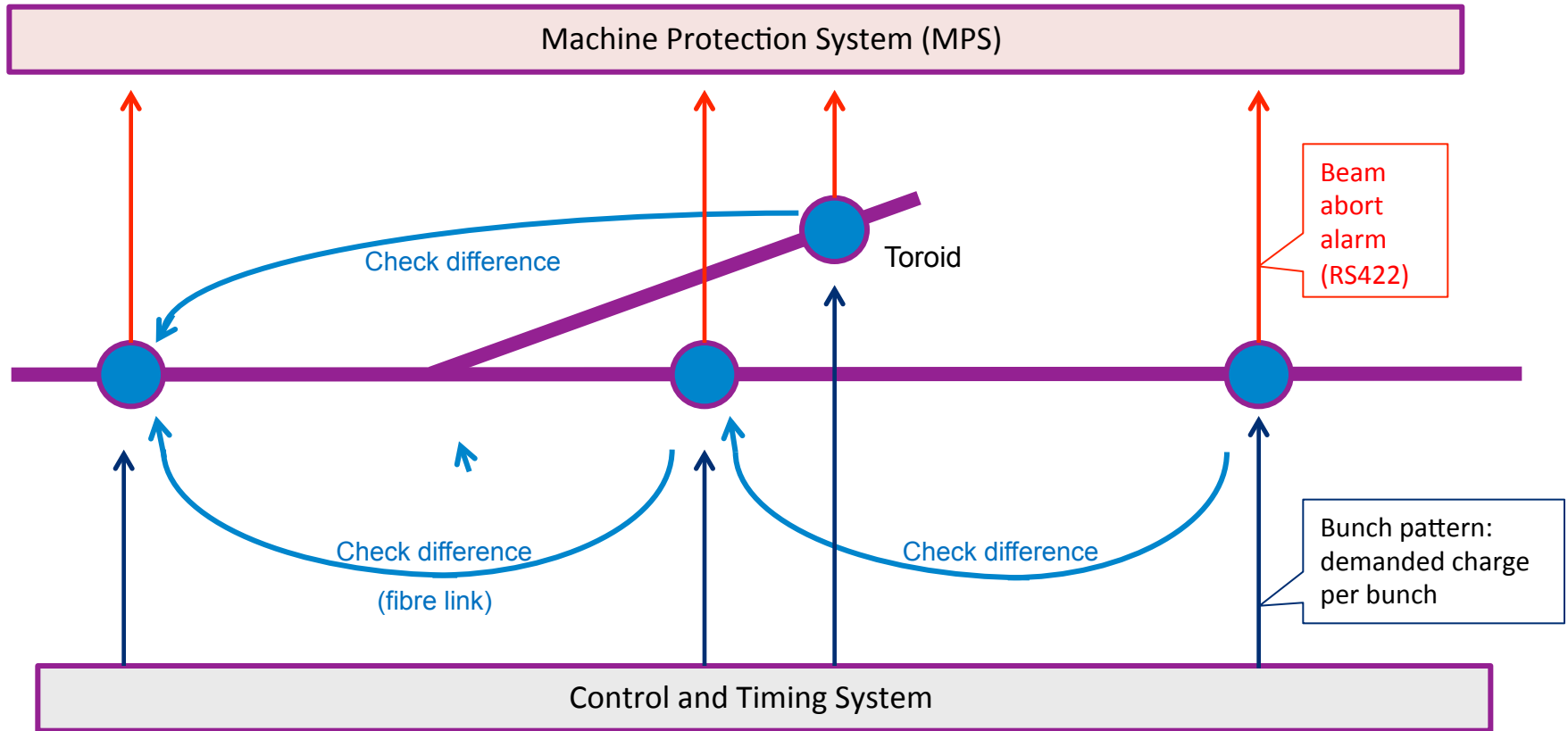
# Toroid System: Applications



Applications of the Toroid system (measuring bunch charge):

- Fast beam intensity feedback
- Bunch by bunch Charge Display (for Diagnostics)
- **Machine Protection: TPS functionality**
- Camera Veto to experiments

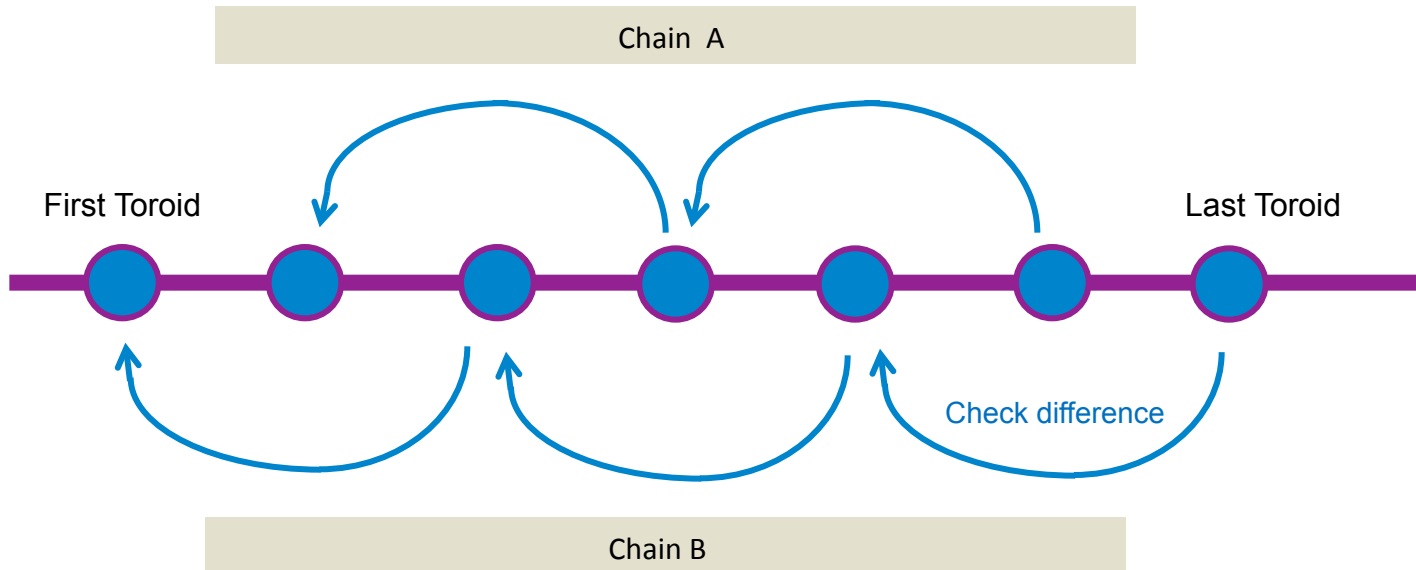
# Toroid System: TPS principle



“Toroid Protection System” (TPS) is one application of the Toroid system:

- Compare charge (bunch by bunch) of neighbored Toroids: abort beam if difference is too large
- Compare beam intensity with requirements from control system: abort beam if charge too high or too low (too low can mean beam loss at previous section)

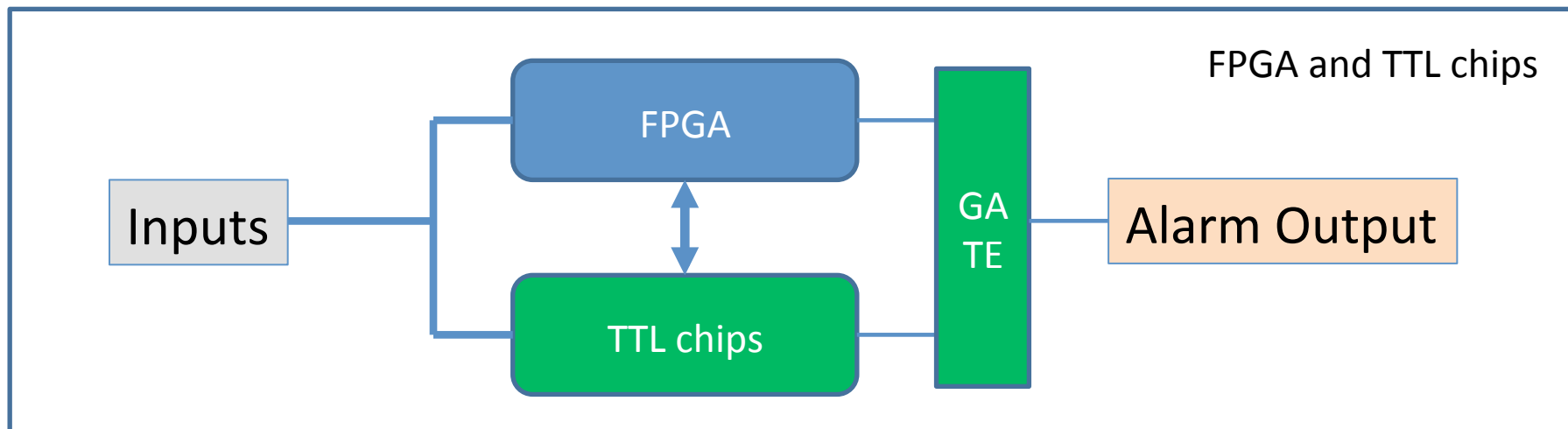
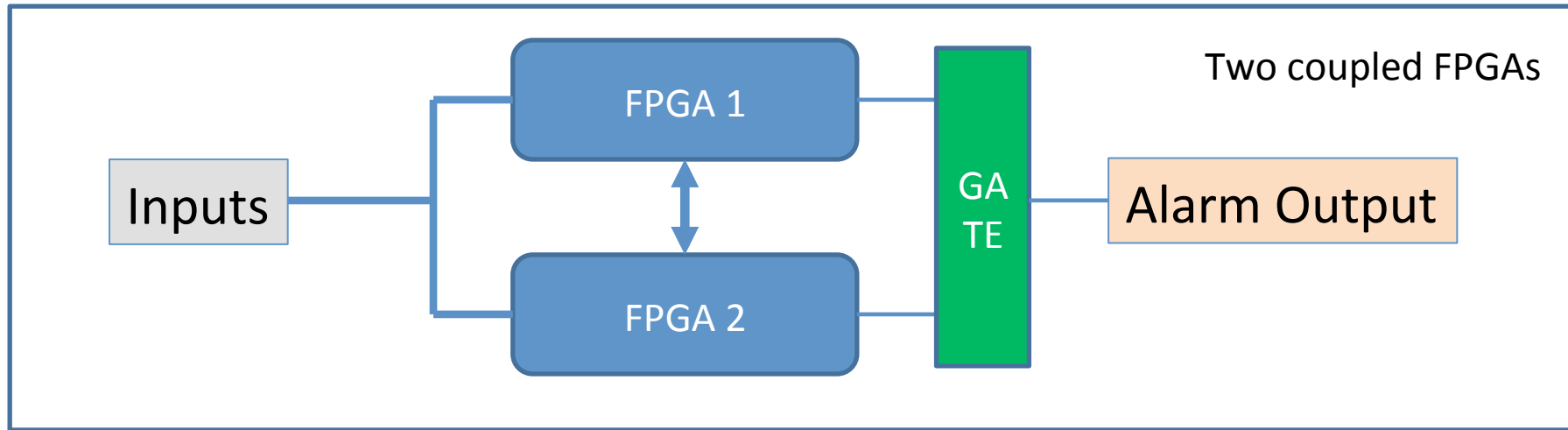
# Toroid system: Redundancy, Availability



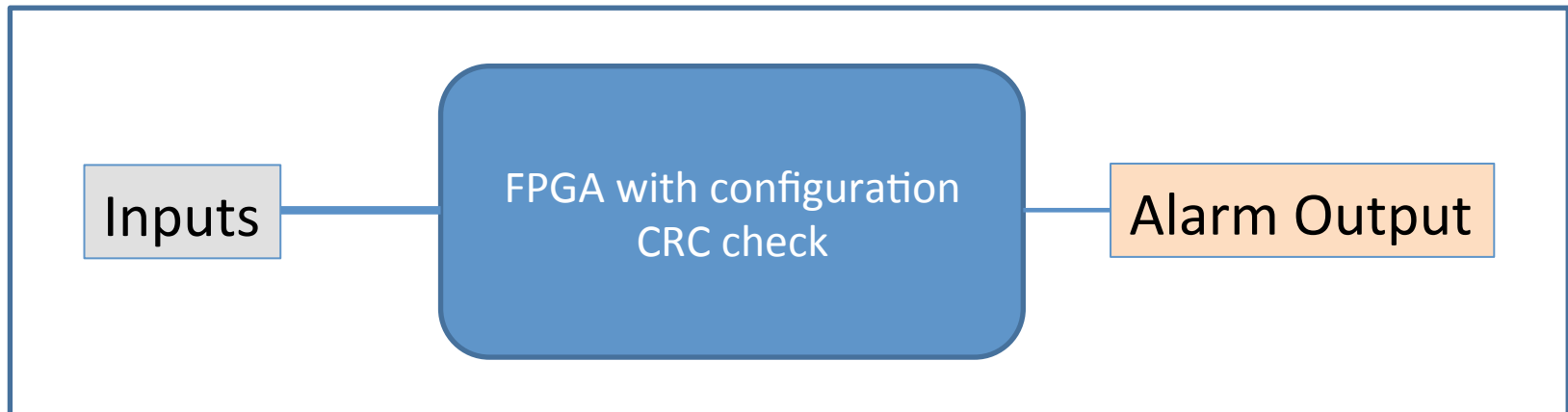
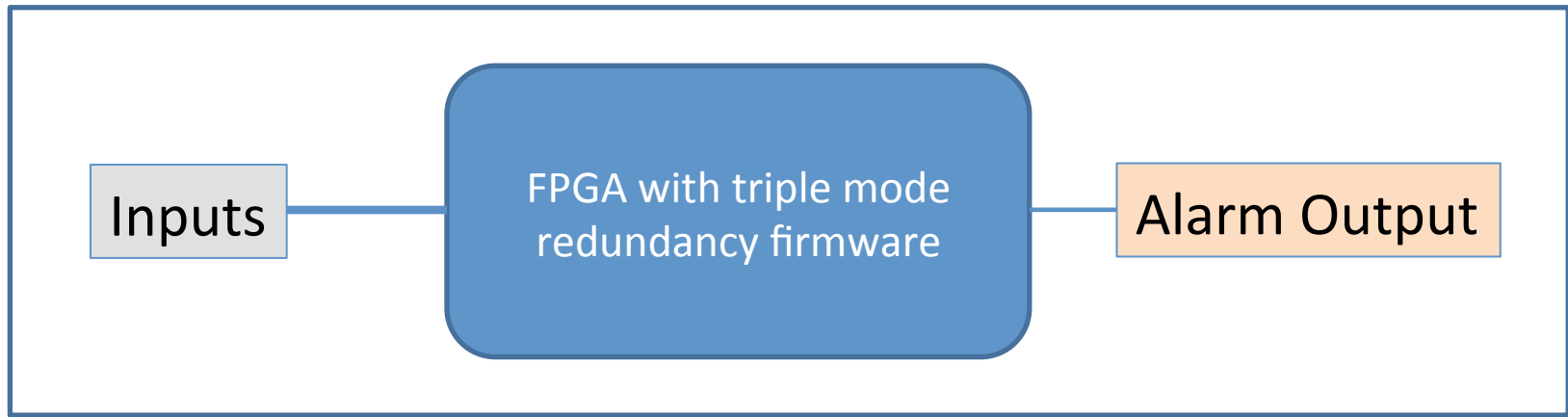
Redundancy for the TPS functionality is added by interleaved fibre chains. If one Toroid fails (except the very first or very last device), the accelerator can still be operated with full TPS protection. This results in high availability.



# Redundant MPS topologies



# More ways for high reliability



# Thanks to:

- Timmy Lensch
- Sven Karstensen
- Dirk Nölle (Coordinator EXFEL diagnostics)
- Kay Wittenburg (Group leader diagnostics)
- Kay Rehlich (Developed and introduced uTCA for physics at DESY)
- Holger Schlarb (Group leader MSK)
- Petr Vetrov (Designer of DAMC-2 board)
- And many others ...

Thank you!

Questions?