Helmholtz-Zentrum Dresden-Rossendorf

Engineering for science

Technologies for Smart Tech Lab

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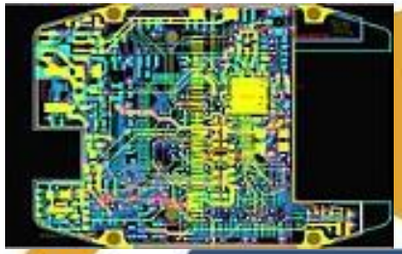
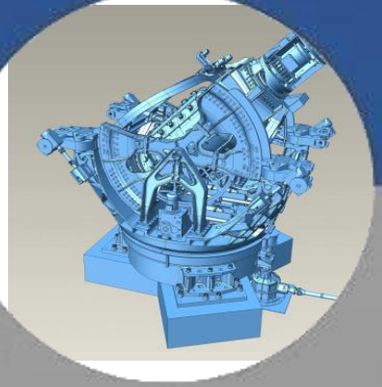
Contributions of Research technology:

- Facilities
- devices
- Components

Electronics

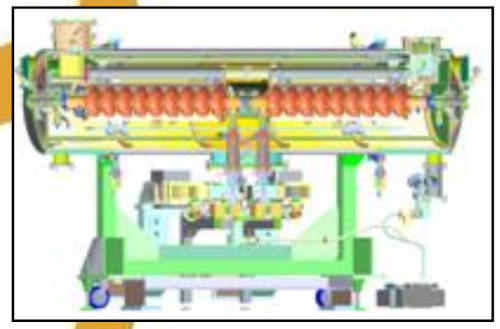


Concept Development

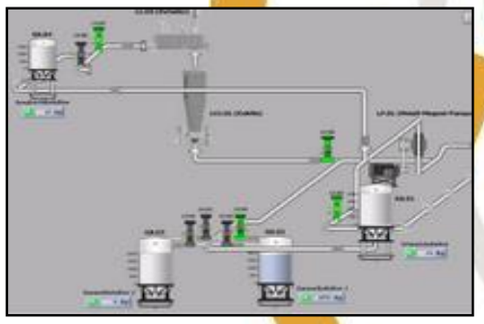


Maintenance Comissioning

Mechanical engineering



Software



- Control systems
- Computer vision & Artificial intelligence

Manufacturing

Control systems: A Muon detector

Muons are part of the ubiquitious cosmic radiation,

interacting with matter to photons (search for coinciding events)

Muon detectors allow for the inspection of massive structures, e.g.:

- **Fukushima reactor**
- **egypt pyramid chamber**

interaction with matter => reconstruction of material structure

Detector elements (event to pulse timing):

Muon converter material (muon => light)

analog electronics for photon detection (light => electric pulse)

FPGA (digital circuits to measure pulse timing in sub-ns-range)

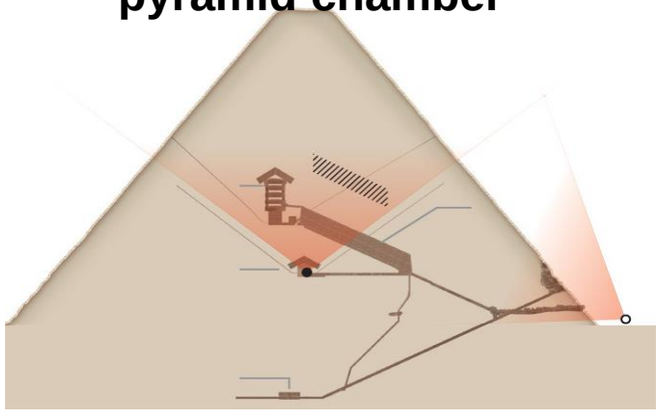
Control system:

- **Collection of large amounts of pulse timing data from detector elements**
- **Scientific image processing**

Fukushima

reactor building

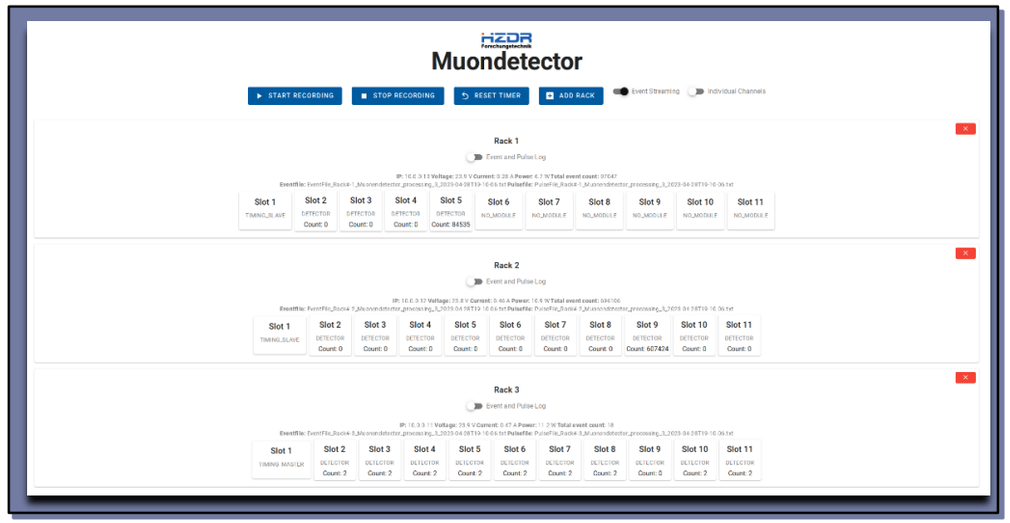
pyramid chamber



Functions of an Ethernet based muon detector:

Control system :

- Parameterization
- event data storage
- Connectivity to racks
- version check, diagnostics
- Ethernet communication with digital IO-hardware

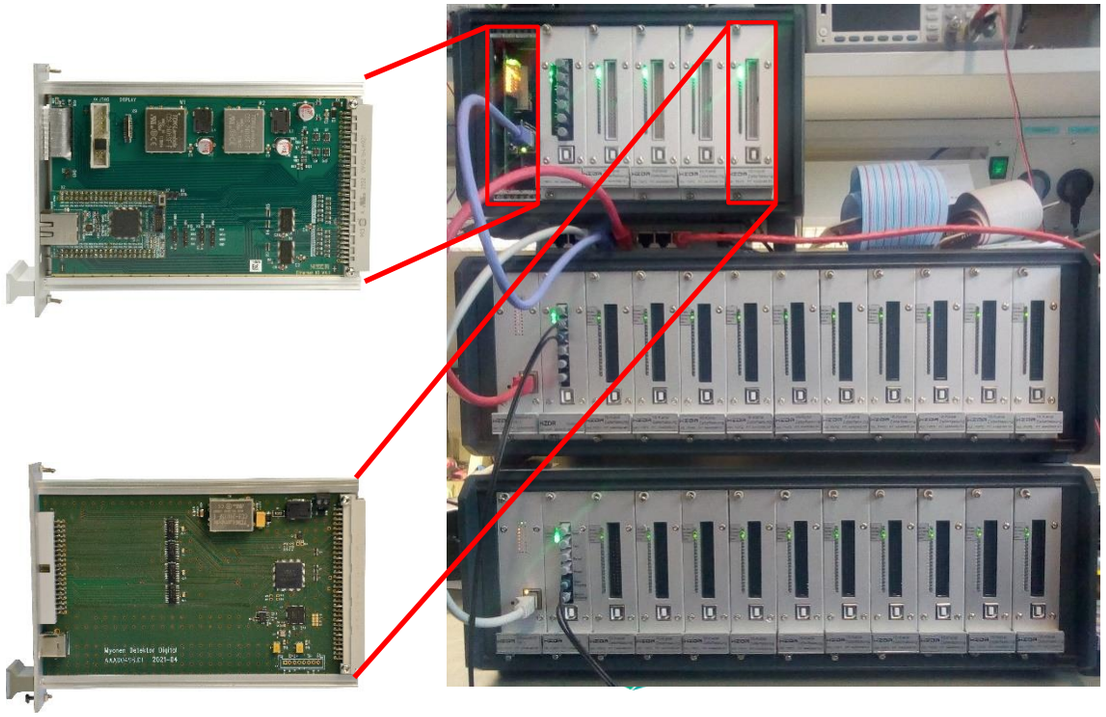


Microcontroller Device (one per rack [160 channels]):

- rack connectivity to control system
- event collection
- parameter handling
- version check (FPGA, firmware)
- Interface to FPGA

FPGA (for 16 channels):

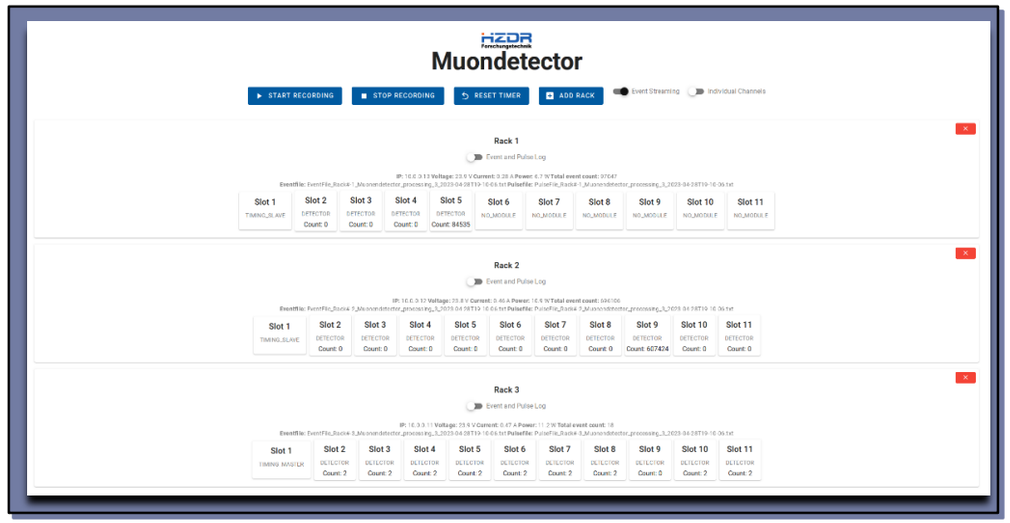
- communication to microcontroller
- timing information (master & slaves)
- digital interface to analog electronics



Applied muon detector technologies:

Control system :

- **Frontend: Webserver (Vue.js, Typescript)**
- **Websocket / QWebChannel communication**
  direct use of Qt Signals (Frontend⇔Backend)
- **Backend: Qt / C++**
- **rack devices with Control wrapper**
- **Ethernet communication with device controller**

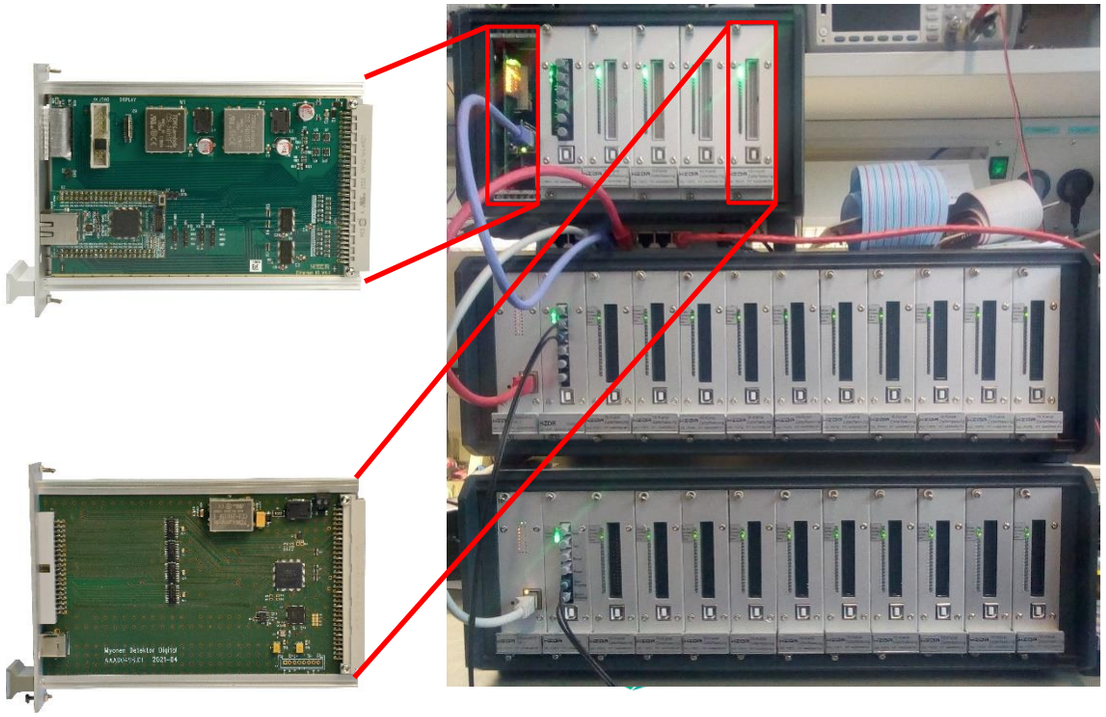


Microcontroller Device (one per rack [160 channels]):

- **Ethernet Protocol stack (UDP / IP / ARP / ICMP)**
- **Servers**
- **Process variables and parameters**
- **state machines, interrupts**
- **Interface to FPGA**

FPGA (for 16 channels):

- **SPI register interface to microcontroller**
- **timing (master & slaves)**
- **digital interface**



Technology map for Smart Tech Lab / control systems

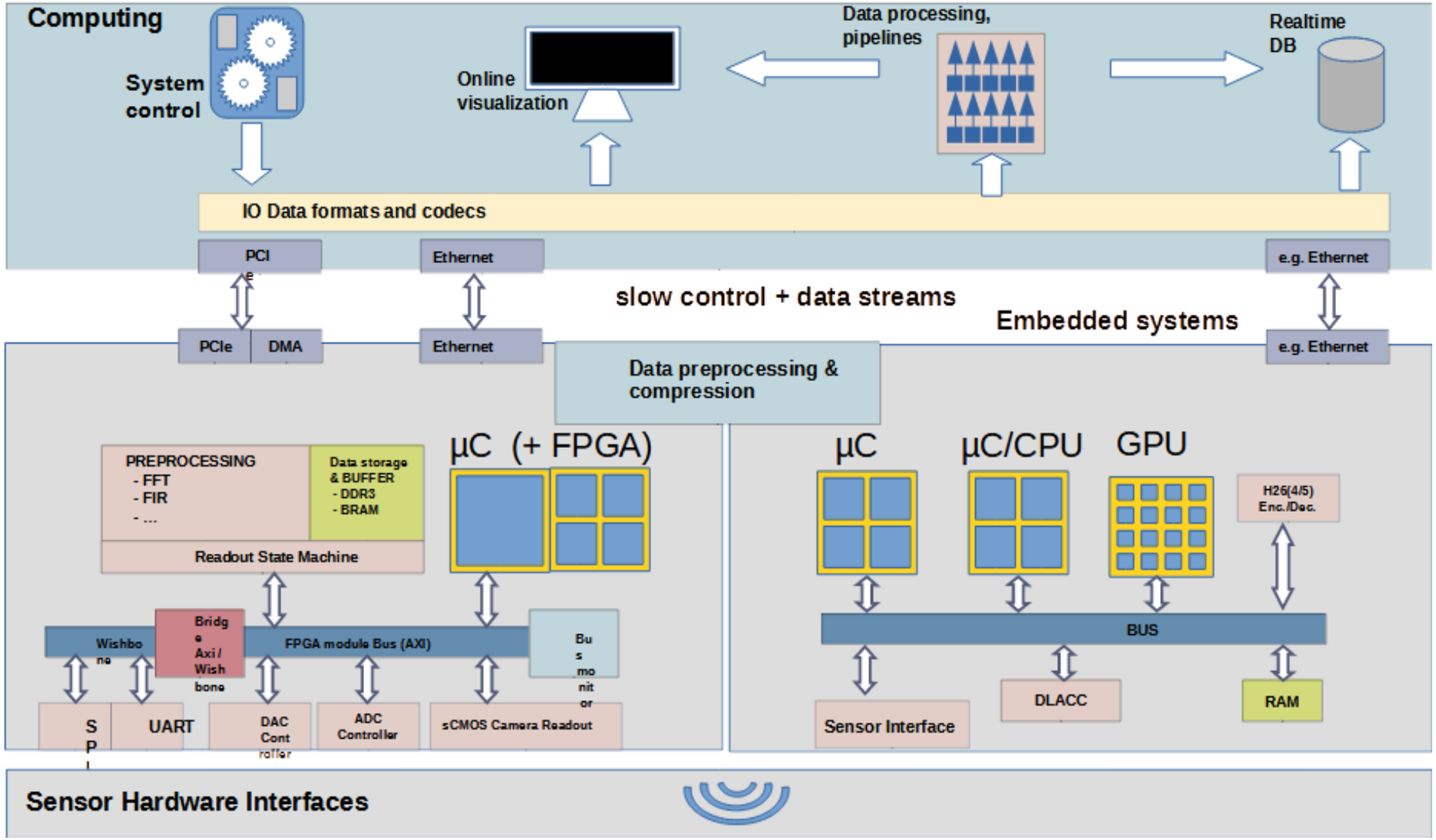
EPICS Qt LabVIEW PLC

Control Systems

Electronics

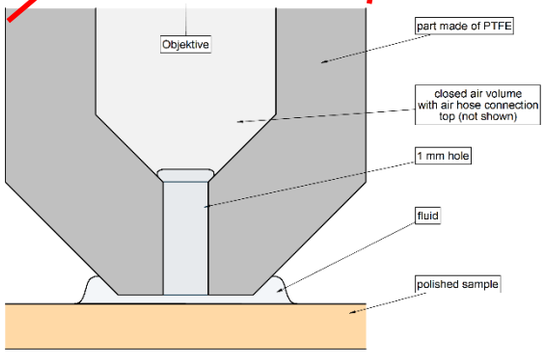
Embedded Device Firmware

Sensors Actors

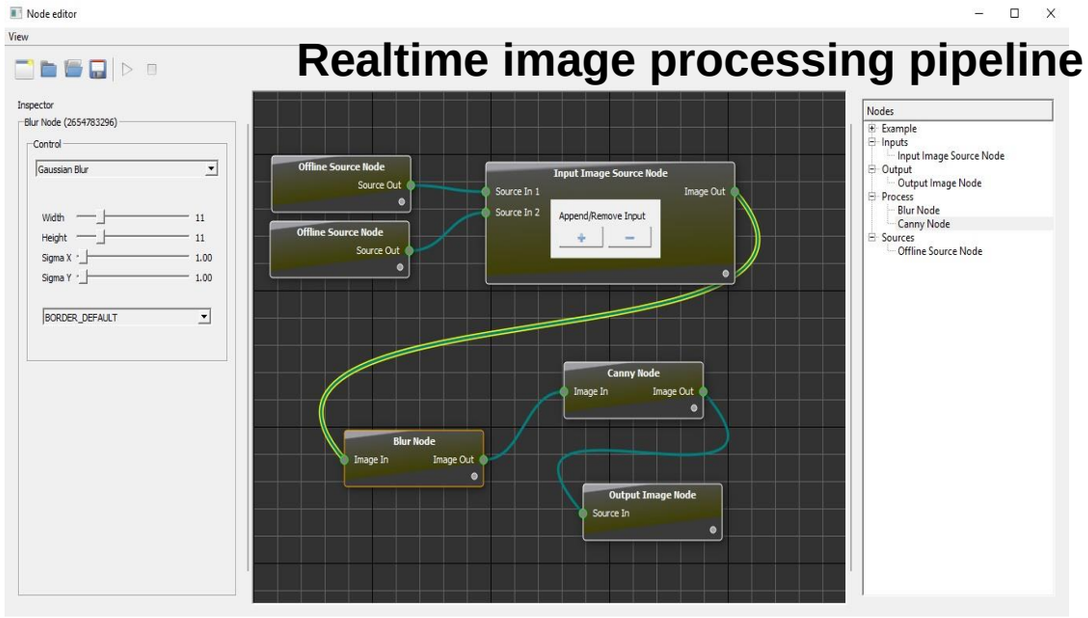


Technology map for Smart Tech Lab / computer graphics and artificial intelligence

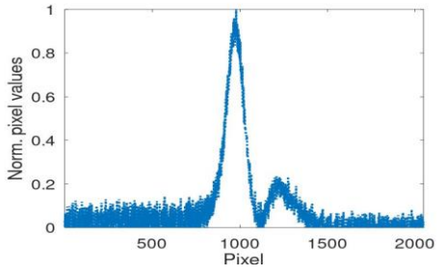
- **Image processing & Artificial Intelligence Lab @HTW Dresden**
- **Camera parameterization and Data akquisition**
- **flexible processing pipeline with AI algorithms**
- **Spectral peak processing @ 50.000 frames/sec**

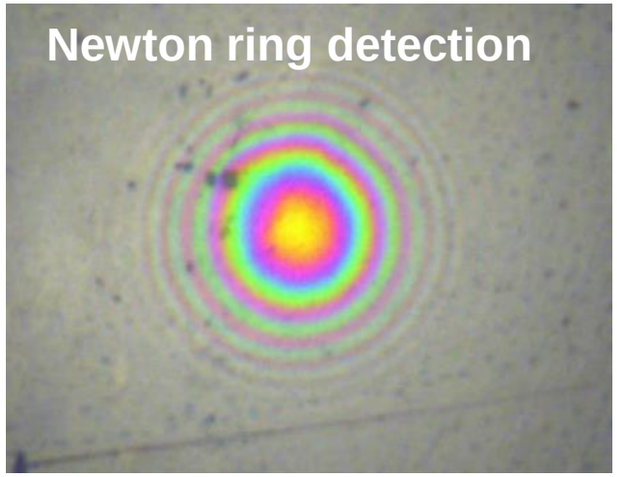


Realtime image processing pipeline



Spectral peak processing





Internship Topics and Tools:

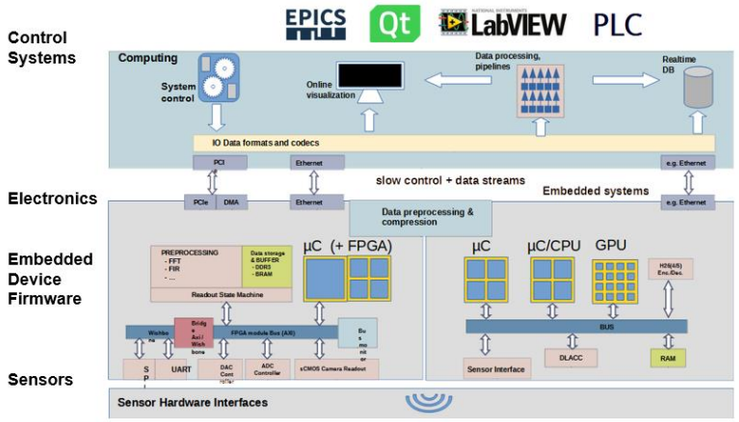
Control systems :

- Qt based techologies
- Webserver-based
- Python interfaces with PyQt

Software development: servers and protocols

- MQTT
- Modbus TCP

- motion profile calculation (numerics)
- analog simulation of motor control circuit hardware
- migration to high performance microcontroller



Computer graphics and artificial intelligence:

- Peak-Detection on GPU with Numba (Python with CUDA support)
- Detection of Newton‘s rings (Python, Numba with CUDA)