Research activities in Electronics for High Energy Physics (ELHEP) Group

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Electronics for High Energy Physics Laboratory (ELHEP Laboratory)

Staff:

- Krzysztof Poźniak, DsC, PhD – head of laboratory, FPGA firmware, HEP metrology
- Ryszard Romaniuk, DsC, PhD – photonics expert
- Maciej Linczuk, PhD – DSP algorithms
- Wojciech Zabołotny, PhD – FPGA & DSP implementation
- Grzegorz Kasprowicz, PhD – fast & multichannel hardware designer, project manager
- Andrzej Wojenski , PhD – FPGA, embedded systems specialist
- Rafał Krawczyk , PhD – DSP specialist, high performance computing
- Radosław Cieszewski, FPGA, C/C++ specialist
- 13 PhD students, >30 BSc and MSc students

Electronics for High Energy Physics Laboratory (ELHEP Laboratory)

Scientific activities:

- 1991 – 2002: ZEUS, HERA DESY, Hamburg, Germany
- 2002 – 2007: TESLA, Desy, Accelerators, Free Electron Laser
- 1995 – now: CMS, LHC CERN, Geneva, Switzerland
- 2002 – now: FP6 / FP7 - CARE (Coordinated Accelerator Research in Europe)
- 2001 – now: ASTROPHYSICS - PI of the sky scientific project
- 2009 – 2016: EFDA JET (ITER prototype) Nuclear Synthesis Reactor (UK)
- 2012 – now: CBM,GSI (Germany)
- 2012 – 2016: LNLS(Brasil)
- 2014 – 2016: MAST upgrade (UK), WEST
- 2014 – now: Electronic equipment for Optogenetics
- 2014 – now: EUROFUSION – WEST tokamak SXR diagnostics -plasma tomography
- 2015 – now: Hardware and DSP(FPGA) for passive radars
- 2016 – now: ARTIQ - Advanced Real-Time Infrastructure for Quantum physics
- 2017 – now: HyperSat – modular, versatile satellite platform

Electronics for High Energy Physics Laboratory (ELHEP Laboratory)

Commercial activities:

- Several successful projects with companies

- space
- passive radars
- scientific instrumentation
- surveillance
- dependable computing
- high speed FPGA – based DSP
- data acquisition
- industrial measurement and control
- time synchronisation

Electronics for High Energy Physics Laboratory (ELHEP Laboratory)

ELHEP team skills and area of interest

- **Optoelectronic terabit technologies**
  – very fast & synchronous data transmission
- **Photonics**

- high speed, scientific grade CCD cameras with online processing

- **FPGA technologies**
  – hardware & firmware design, multi-FPGA systems, radiation tollerant
- **DSP technologies**
  – DSP processors & DSP in FPGA designs, real-time algorithms
- **PCB design (multi GHz)**
  – multilayer EMC/SI verified and tested
- **Testing**
  – EMC/SI simulation and measurements
  – HW & software, dependable computing
- **Space projects** – nanosatellites, onboard computers, star trackers, multispectral & hyperspectral imaging. Cooperation with PWSAT2 team and CBK. Several space-related Thesis ongoing.

Electronics for High Energy Physics Laboratory (ELHEP Laboratory)

Technical equipment:

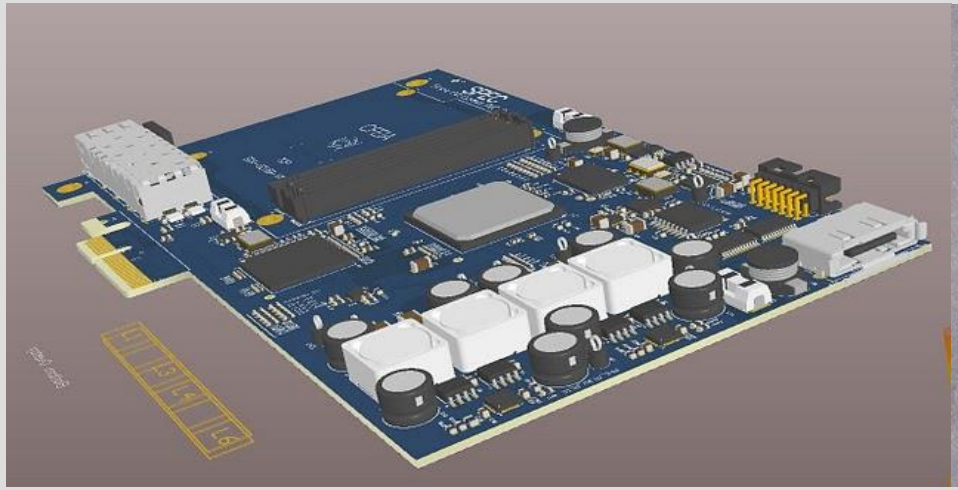
- **2012-2016 hardware investment: over 1 MEUR**
- **FPGA developing hardware**
  - Evaluation Boards with FPGAs & DSP processors including recent technologies
  - NanoBoard modules for FPGA prototyping
- **Scopes**
  - several 60, 20, 5, 1GHz, Analogue and Mixed Signal
- **SI laboratory**
  - CS8200 analyser (70GHz Main-Frame) + modules
- **EMC lab**

- Emtest equipment

- **Generators**
  - arbitrary Analogue and Mixed Signal, RF up to 3GHz
- Other tools: bench supplies, programmers, VNA,
- **Solder & assembly**
  - Pick and Place, 4-zone reflow oven
- **Software**
  - CAD software (Code Composer, Matlab, ISE, Quartus II, Questa, Vivado)
  - PCB design software (Altium Designer,Hyper Lynx, Expedition PCB)

Selected, space related, ELHEP Group Activities

- Photonics – CCD detectors (Pi of the Sky)
- Accelerators diagnostic and control (CERN, LNLS, GSI)
- Detectors (CMS, CBM)
- Tokamaks (JET, MAST, ToreSupra (WEST))
- Embedded systems (DSP, ARM CPU, FPGA)
- Time synchronisation (WR)

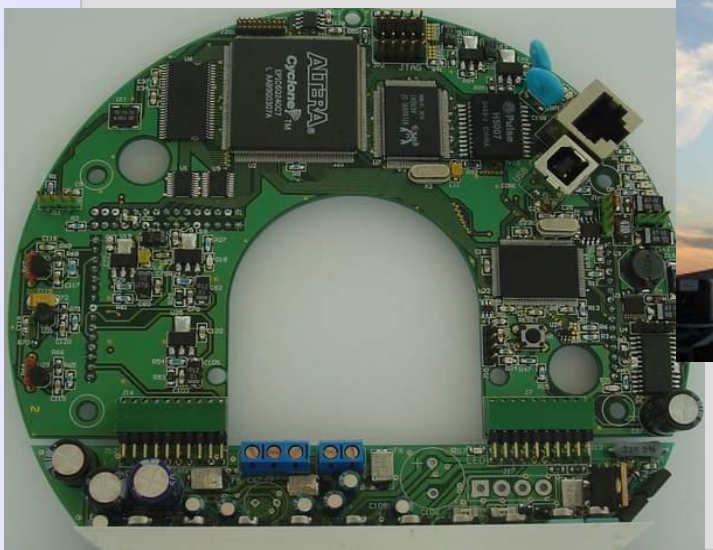


ELHEP laboratory equipment

PCB and Hardware development

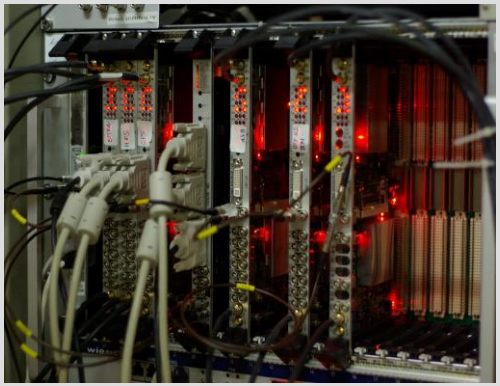
CCD cameras for Pi of the Sky project

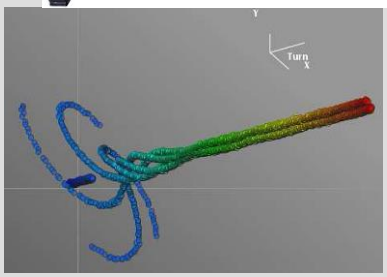
Search for GRB events
All visible sky
On-line analysis
Leading project of polish science
Publication in Nature (2008)

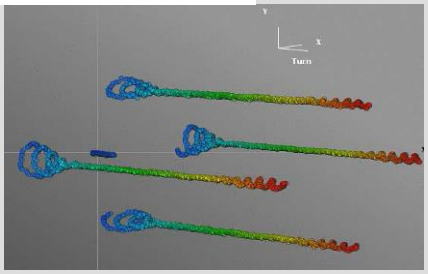


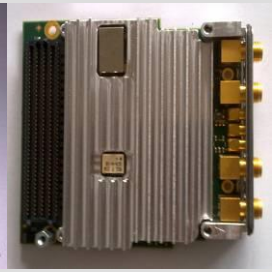
MTCA electronics for accelerators diagnostics

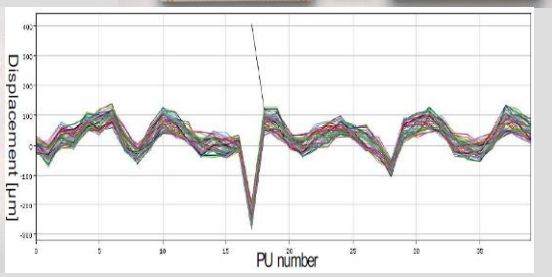
- Beam position, orbit and detector processing systems for :
- CERN PS, CMS (Switzerland),
- GSI Cryring, CBM (Germany)
- LNLS Sirius (Brasil)
- **Development of MTCA standard for LLRF, high performance computing and precision timing**





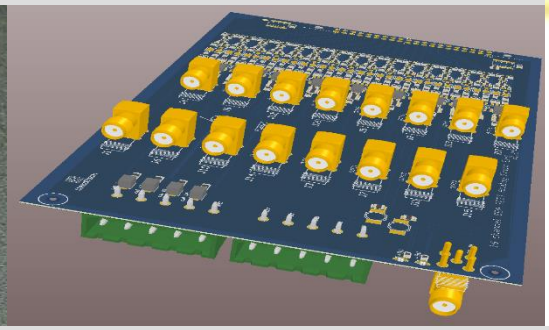


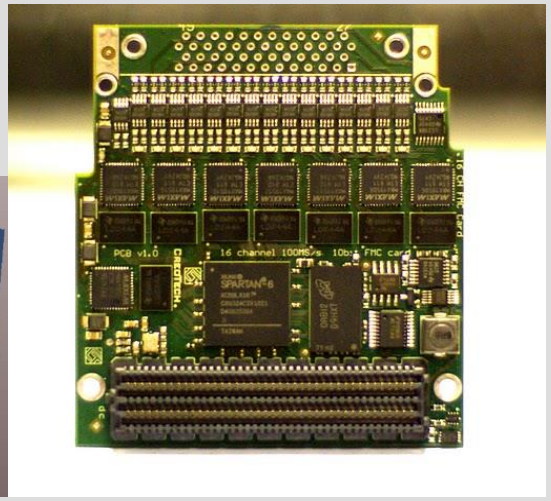




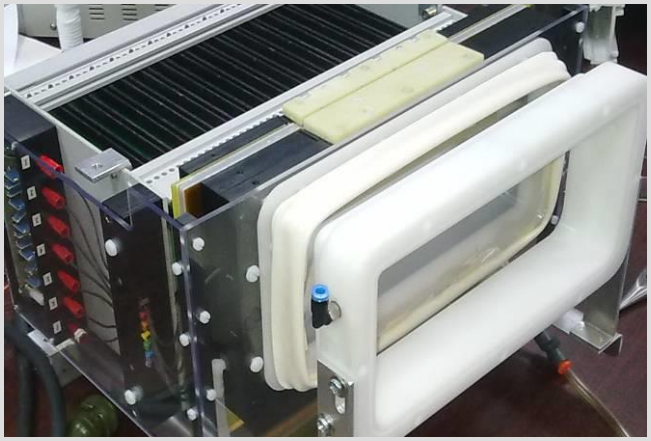
Detector and electronic systems for Tokamaks

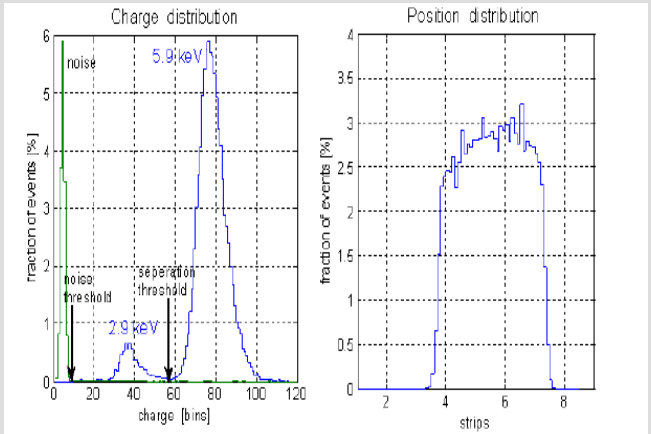
- EFDA JET Tokamak plasma inpurity measurement system – X-ray spectrometer for W(Tungsten) and Ni (Nickel) energy ranges (2.4keV, 7.8 keV). 512 channel, 100MS/s measurement system for GEM detectors
- ToreSupra 2D and 3D (future) high intensity plasma X-ray tomography
- MAST (Mega Ampere Spherical Tokamak) upgrade – control and monitoring of superconductor magnets
- 2D high definition, GEM-based large-format X-ray camera
- Possible applciations in space – i.e. SOLPEX polarimeter





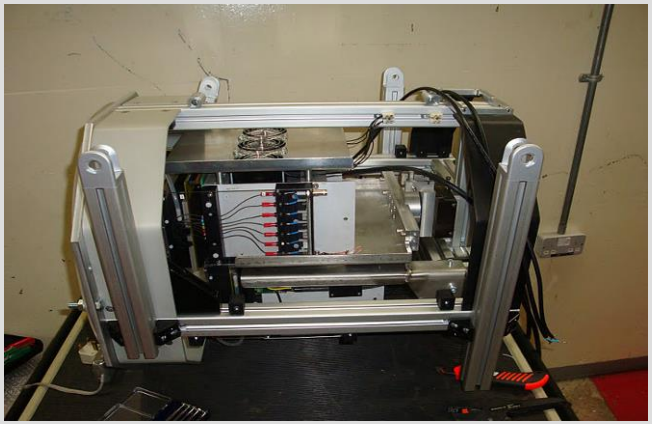
GEM Detectors – SXR spectrometer at JET

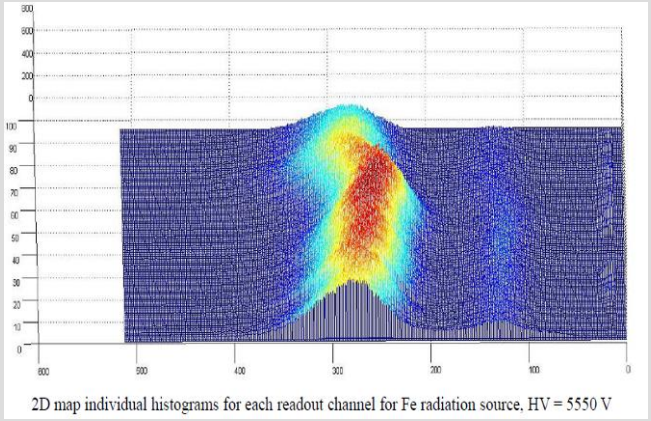




Collected charge distribution (left) and reconstructed position distribution within anode strips (right)

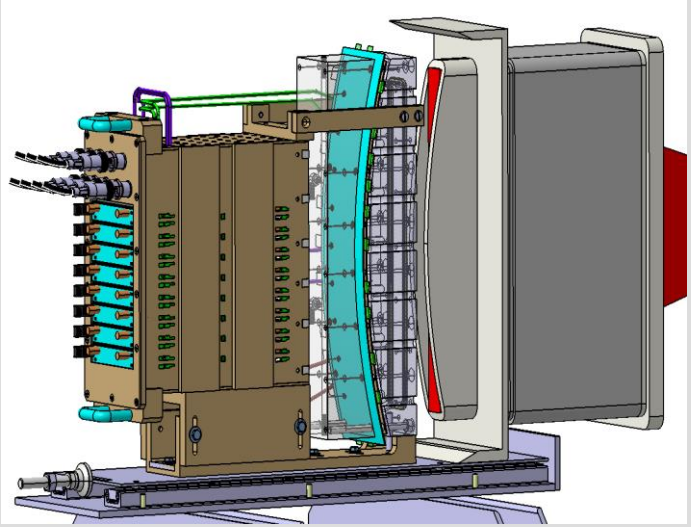
U_{ind} = 1250V, U_{GEMs} = 350, 370, 390V, U_{trans} = 700V, U_{drift} = 1500V

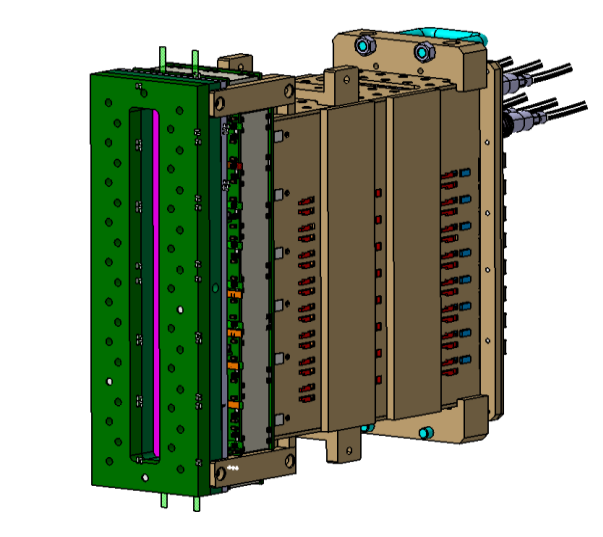


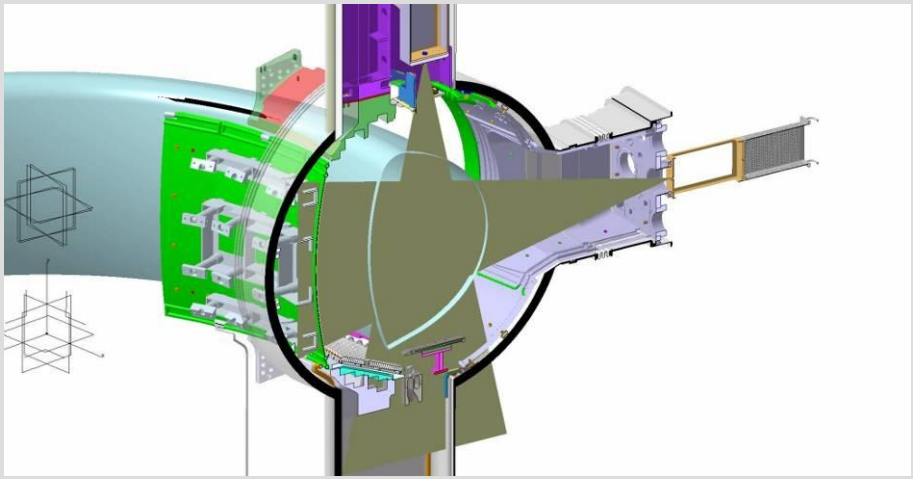


2D map individual histograms for each readout channel for Fe radiation source, HV = 5550 V

GEM-based large format X-ray detectors for plasma tomography





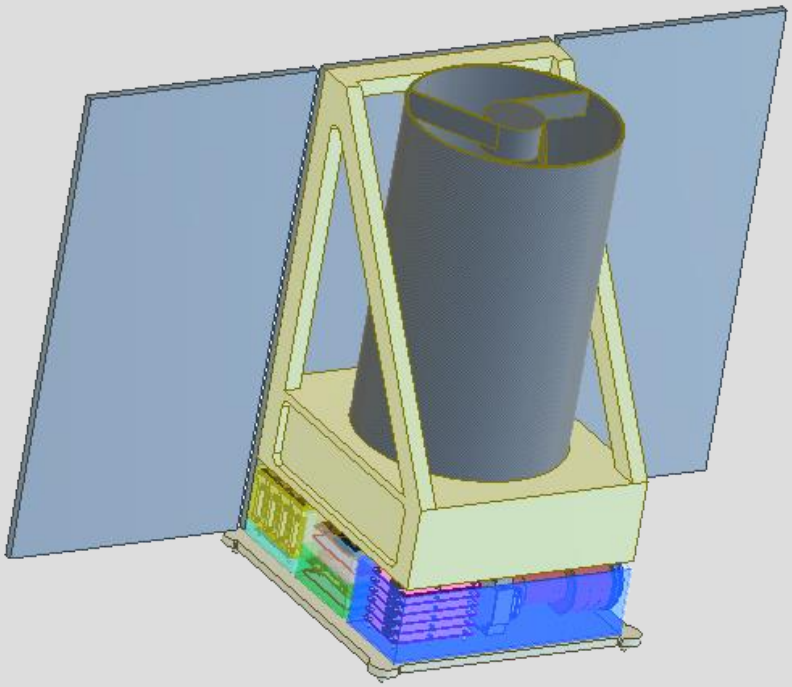


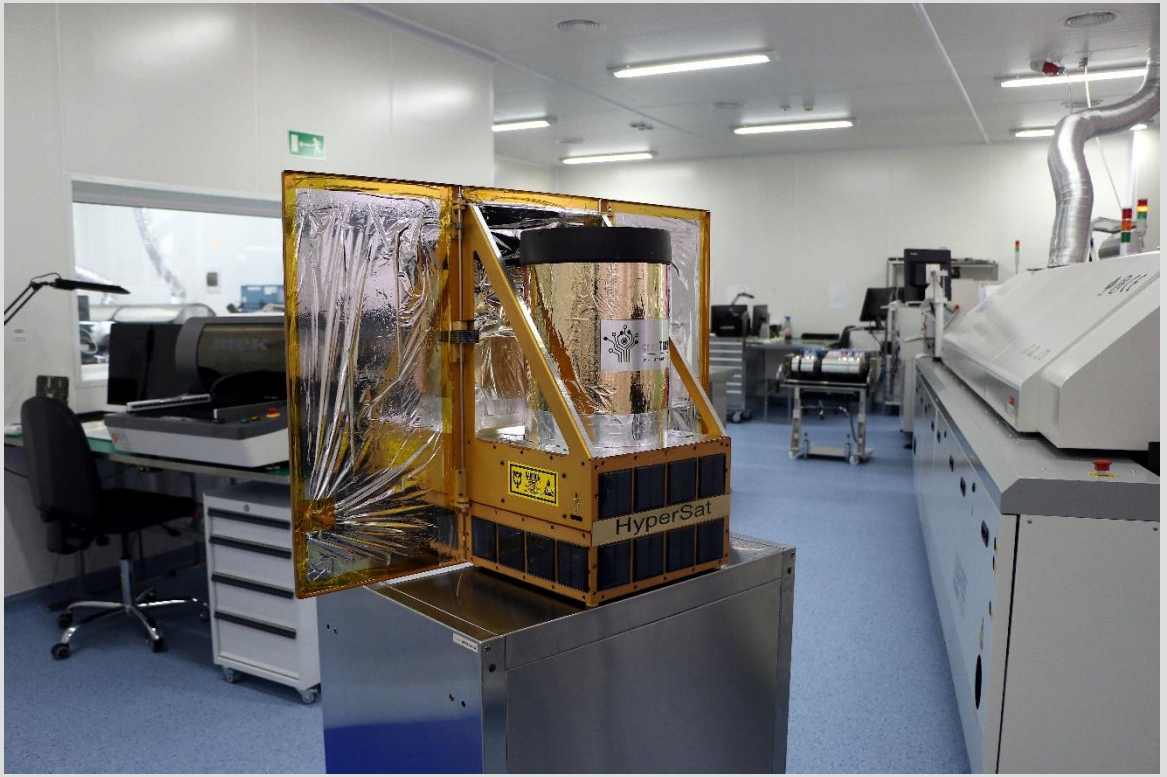
White Rabbit development

- Extensible measurement and control platform based on Gigabit Ethernet, SyncE and IEEE1588 protocol
- Provides sub-nanosecond synchronisation
- Developed with CERN and also several companies and scientific organisations
- Precise frequency distribution with <20ps jitter
- Less than 1 frame per year lost
- Deterministic timing
- Reliability, redundancy
- Up to 2000 nodes
- WR-SYNTEF project for ESA with CTI

White Rabbit development

HyperSat platform

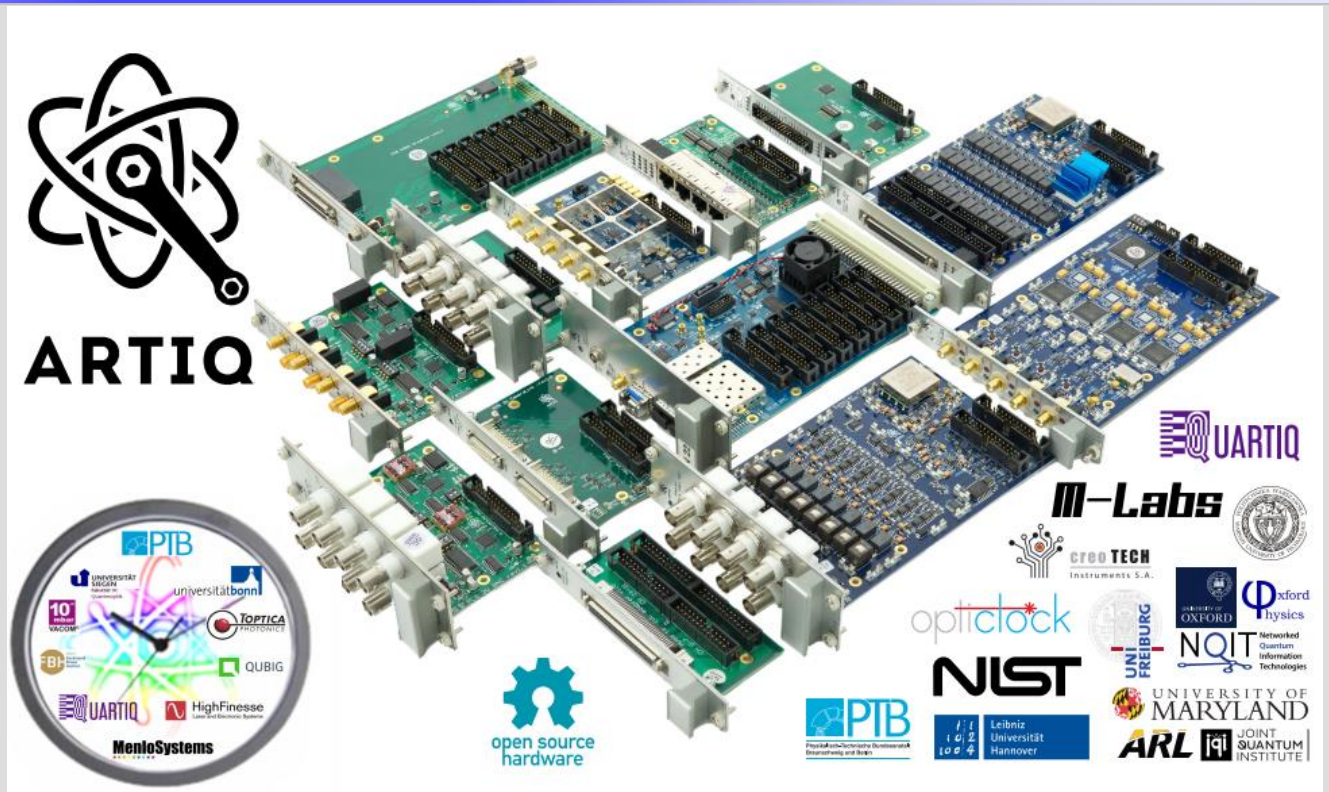


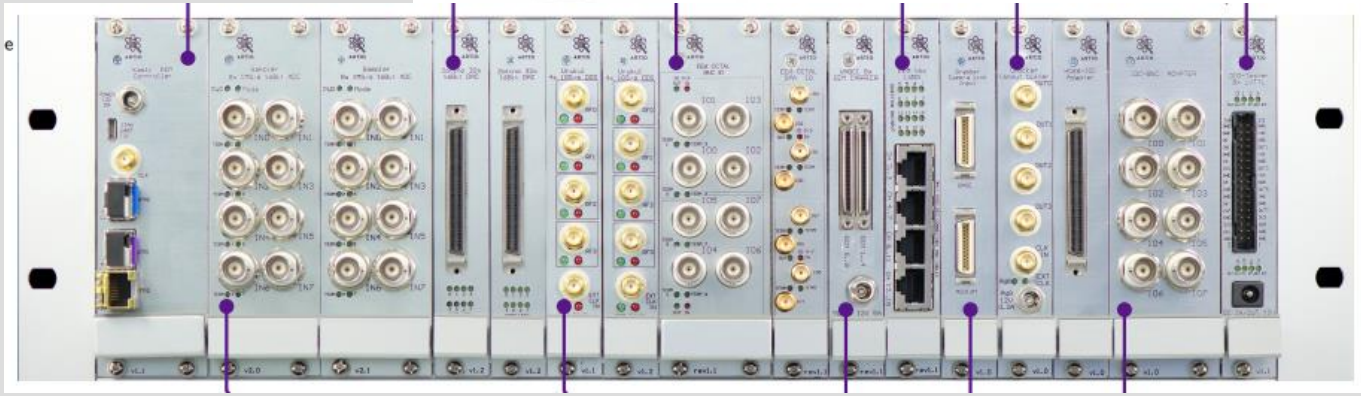


- Modular, versatile platform for specialized instruments.
- For pico and nano-satelites called CubeSat.
- Size: from 30x30x10cm to 30x30x60cm. Weight: 10-60kg.

ARTIQ and Sinara

- Advanced Real-Time Infrastructure for Quantum Physics.
- SINARA – open hardware ecosystem.





Summary

ELHEP laboratory provides complete design services:

- system conception
- algorithm evaluation
- hardware design
- FPGA and DSP implementation
- software coding
- professional HW production (cooperation with external companies)
- hardware commissioning
- intense in-field testing
- documentation

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