Open Hardware solutions for applications in HEP and industry

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Who we are?

Creotech Instruments S.A.:

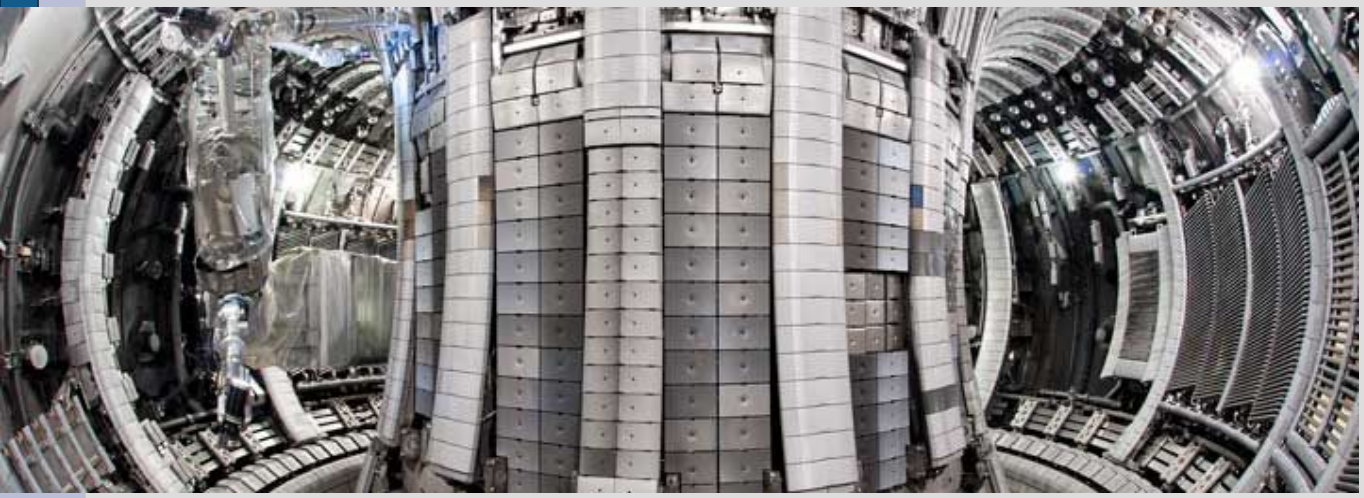
- Creotech Ltd. was founded in 2008 by 3 CERN workers
- 2011 – the joint-stock company Creotech Instruments S.A. was created
- 2012 – two private share emissions, work on ISO9001 started
- 2013 – an investment in a cleanroom facility, start of space technologies projects

  First ASIM (ISS) project completed

- 14 people employed (2 PhD, 12 engineers)

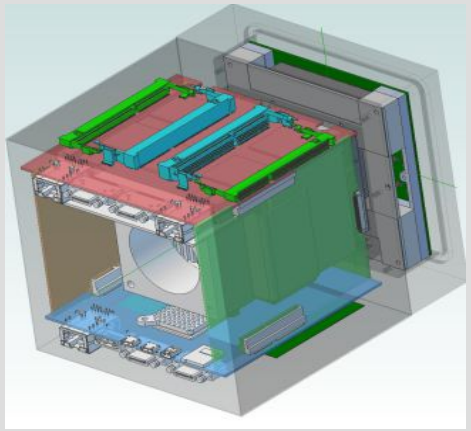
Who we are?

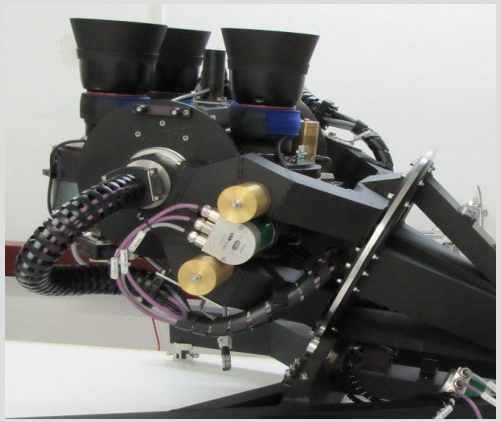
Our proprietary solutions were tested in international research projects

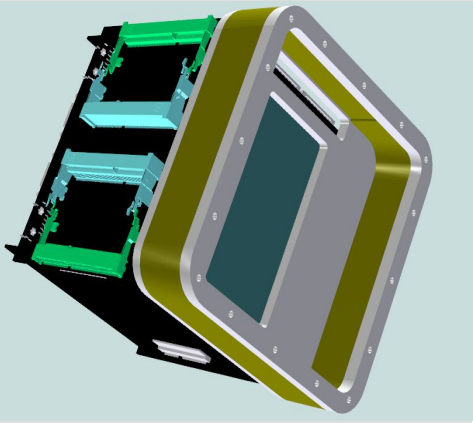


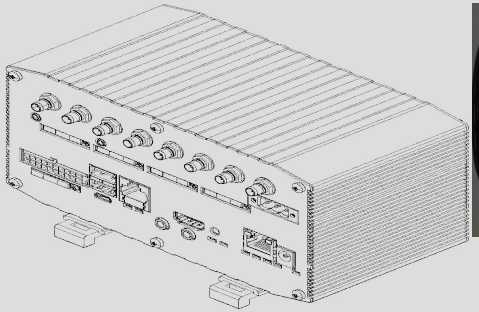
We do not only for science..

But interaction with scientific projects improves our skills and know-how









Open Hardware and Industry

Open Hardware is excellent from the point of view of CERN and experimental physics community:

- it solves certain problems of the community
- the development cost can be drastically reduced
- community is financed from public money so there is expectation that some of scientific and technical achievements are open

Can it be also good for companies ????

Business – is making money not giving things for free !

Why Open Hardware? :

Big Hardware Company

- we will invest 0.1% of our resources (we are big) → not a big cost for us

- we will for sure find some applications of OHW devices in our own hardware designs → sell these complex devices, and make money

- problems that we have/might have will be solved without our investments (someone else will solve it)

- we are following the trends and could react more quickly on demands from this market

OHW could be good for us

Small (not only small) software companies:

- we will invest 80% of our resources → it a big cost for us

- we will understand the hardware that is given for us for free

- we will prepare software solutions for this hardware, software is our own and we have copyrights for it

- we will sell the software+hardware solution and earn money

OHW is good for us

Small hardware companies:

- we will invest 80% of our resources → it a big cost for us

- we will give for free an effect of our work

- someone else will produce it and sell under its brand

OHW – why do we want to take part in that ???

Creotech point of view...

A few words on the Creotech Instruments SA:

- Small company: ~12 engineers + technical staff
- Special equipment for tests + for production of short series of highly sophisticated solutions (i.e. ESA-certified clean-room)
- Close collaboration with WUT
- Company started by post-CERN workers and people connected with other scientific laboratories

Our business model:

- We take orders from scientific institutes and industry, we develop complete systems.
- Orders are for highly sophisticated equipment
- Sophisticated equipment consist of HW, SW and FW
- We publish HW, FW and partially SW, still keeping our experience and knowledge in system integration.
- System integration, SW and support generates most of the income. HW cost covers production, testing, warranty and support

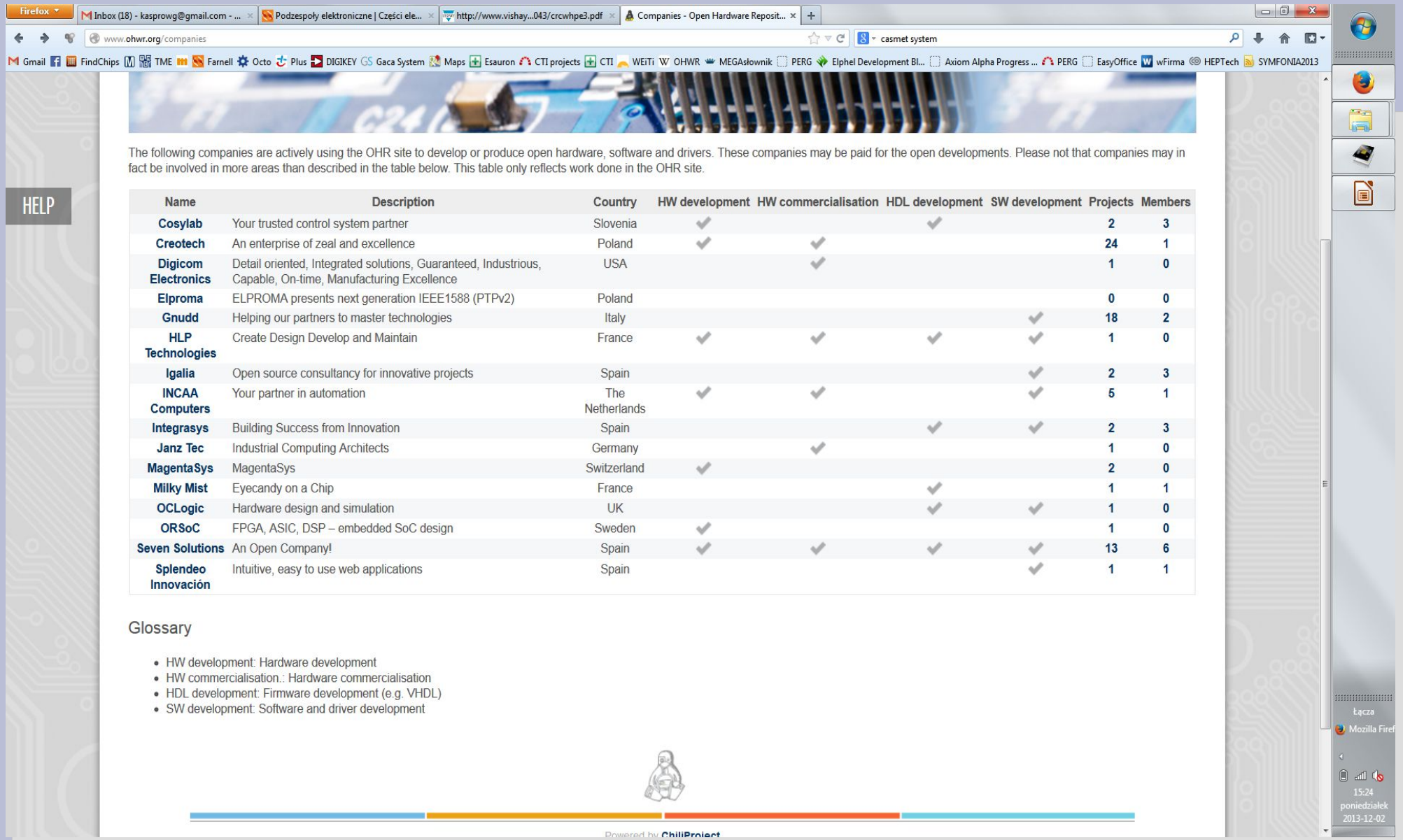
Other institutions notice that our solutions what they need are available as OH, they integrate themselves or, more often, let us do it:

- they risk less, because in the case of lack of the support they can modify and produce the HW themselves
- they have references from other institutions where we integrated it
- they see what exactly will get

How OH gives us business opportunity

- It's great place to advertise company capabilities, skills and expertise and collect more orders
- It's place to exchange ideas, collect feedback and product improvements
- Here the company may show realized projects and get recommendations
- Sharing hardware and firmware files encourages other companies to do the same and lets us gain part of their know-how
- Next products can be created much faster thanks to modification or re-use of existing ones, developed and tested by someone else
- Thanks to opening design files in early stage of product, other engineers may find bugs or suggest modifications which leads to better product
- By sharing own product HW and FW files, company gets vantage over competition – some clients will choose such solution which they can control, modify or repair in the future (after warranty period)
- If you are client and have a choice between OH equipment and proprietary one, providing that they cost the same, what would you choose? Why?

Examples of successful OH projects



www.ohwr.org/companies

HELP

The following companies are actively using the OHR site to develop or produce open hardware, software and drivers. These companies may be paid for the open developments. Please not that companies may in fact be involved in more areas than described in the table below. This table only reflects work done in the OHR site.

Name	Description	Country	HW development	HW commercialisation	HDL development	SW development	Projects	Members
Cosylab	Your trusted control system partner	Slovenia	✓		✓		2	3
Creotech	An enterprise of zeal and excellence	Poland	✓	✓			24	1
Digicom Electronics	Detail oriented, Integrated solutions, Guaranteed, Industrious, Capable, On-time, Manufacturing Excellence	USA		✓			1	0
Elproma	ELPROMA presents next generation IEEE1588 (PTPv2)	Poland					0	0
Gnudd	Helping our partners to master technologies	Italy				✓	18	2
HLP Technologies	Create Design Develop and Maintain	France	✓	✓	✓	✓	1	0
Igalia	Open source consultancy for innovative projects	Spain				✓	2	3
INCAA Computers	Your partner in automation	The Netherlands	✓	✓		✓	5	1
Integrasys	Building Success from Innovation	Spain			✓	✓	2	3
Janz Tec	Industrial Computing Architects	Germany		✓			1	0
MagentaSys	MagentaSys	Switzerland	✓				2	0
Milky Mist	Eyecandy on a Chip	France			✓		1	1
OCLogic	Hardware design and simulation	UK			✓	✓	1	0
ORSoC	FPGA, ASIC, DSP – embedded SoC design	Sweden	✓				1	0
Seven Solutions	An Open Company!	Spain	✓	✓	✓	✓	13	6
Splendeo Innovación	Intuitive, easy to use web applications	Spain				✓	1	1

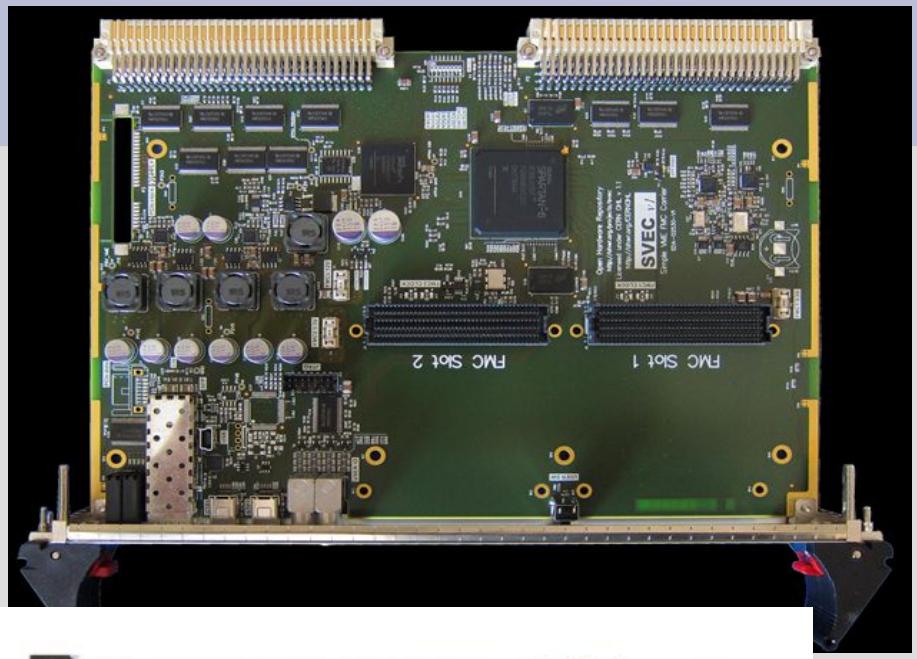
Glossary

- HW development: Hardware development
- HW commercialisation.: Hardware commercialisation
- HDL development: Firmware development (e.g. VHDL)
- SW development: Software and driver development

Powered by ChiliProject

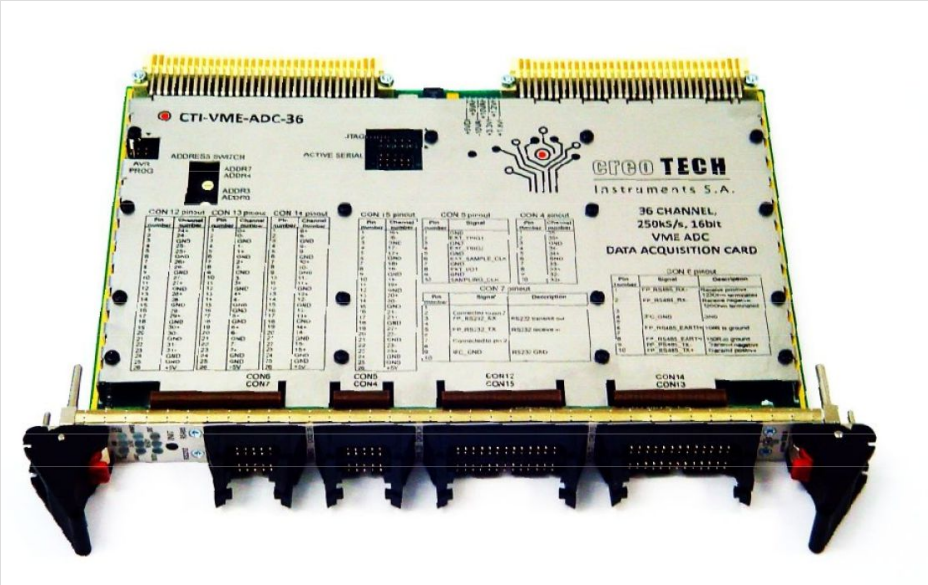
How we started OHWR : SPEC & SVEC

- SPEC, SVEC, FMC DEL were outsourced by CERN to CTI
- Several hundreds pieces produced by 3 companies
- Used worldwide



VME ADC board

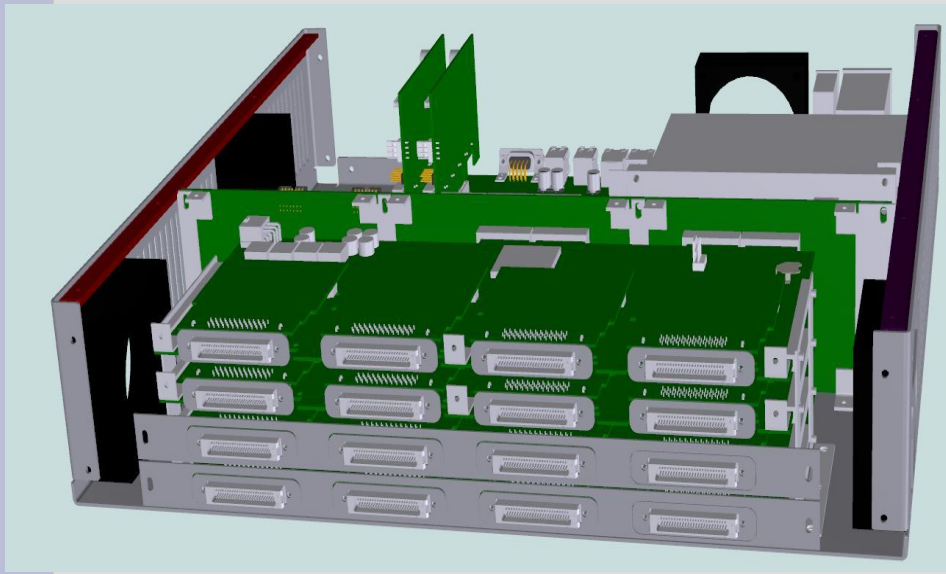
36 ADC channels, simultaneously sampling
16 bits
250kHz
64MB of RAM
MPV901 compatible
Main application: SEM grids
OHWR design

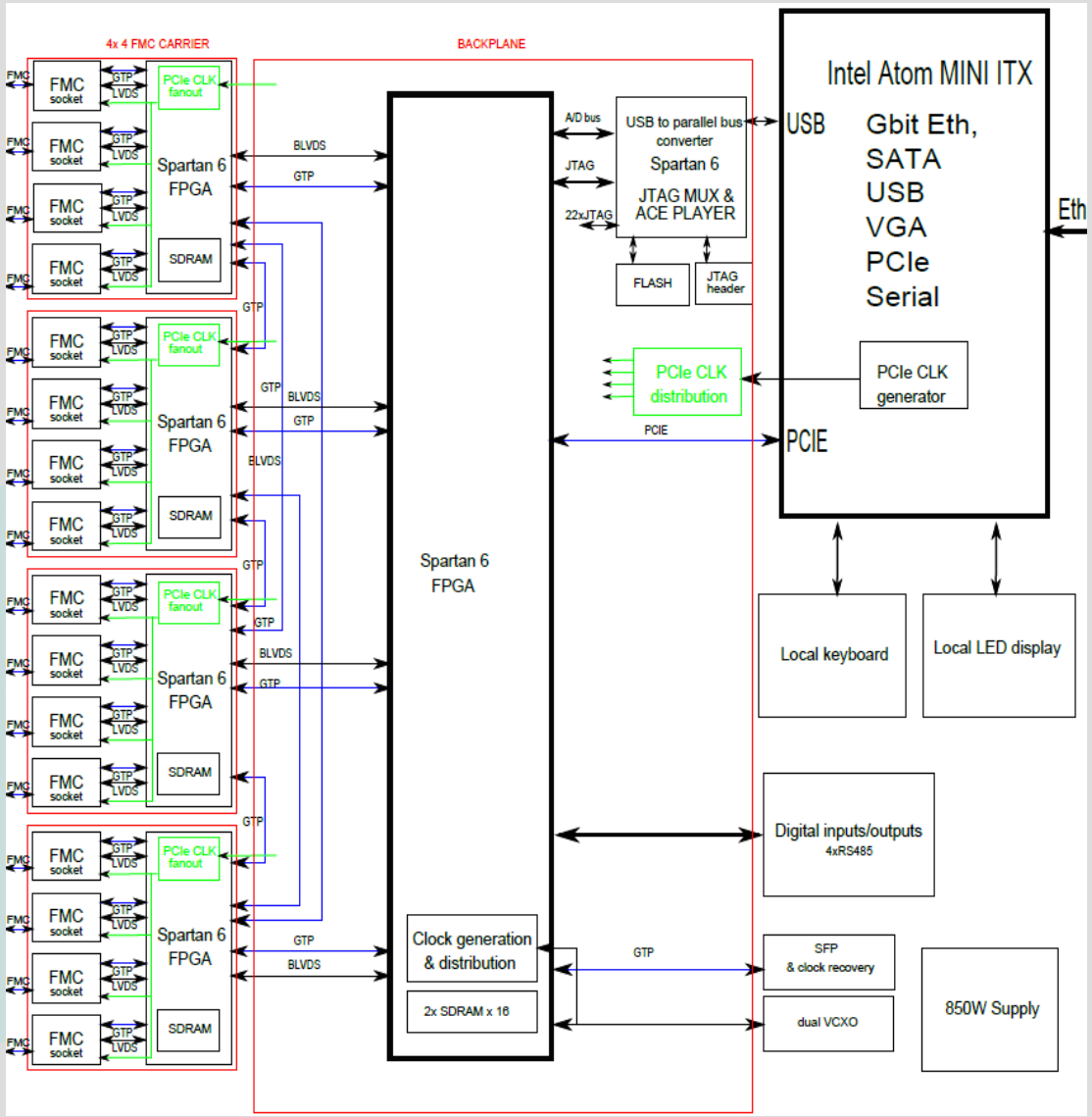


Product developed in close collaboration with CERN,
180 pieces produced
Application: Linac 4 SEM grid readout, DC transformer DAQ
CERN requested OH licensing in call for tender

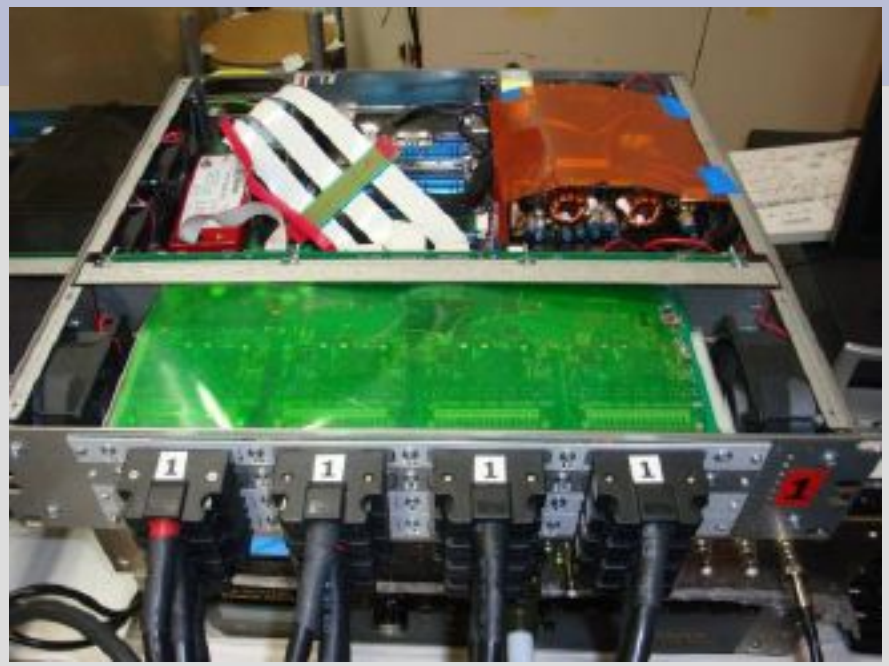
Custom FMC Carrier

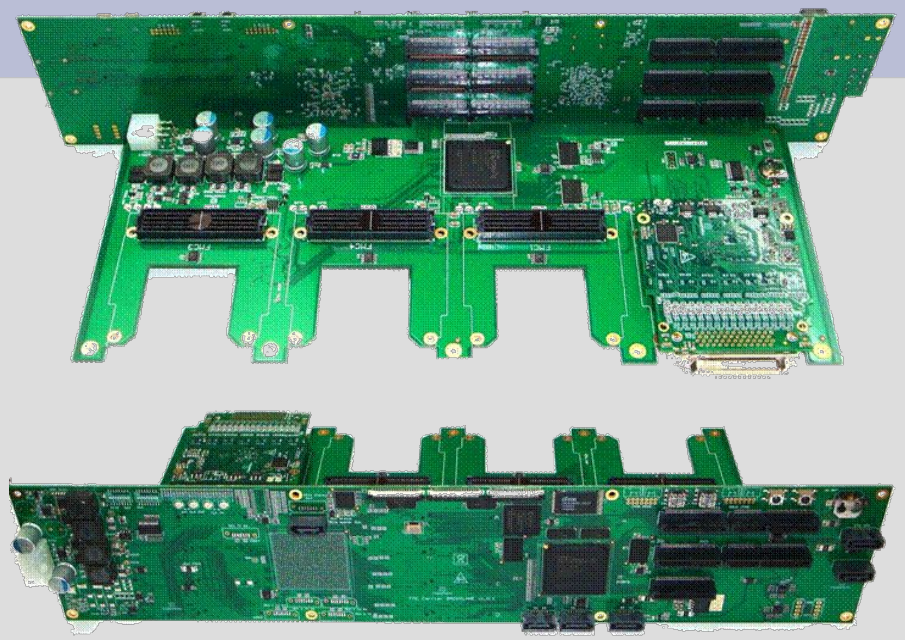
- Up to 36 FMC
- PCIe Gen2 (5gbit/s)
- Global CLK distribution
- White Rabbit/ IEEE1588
- Max 46 FPGAs





Custom FMC Carrier

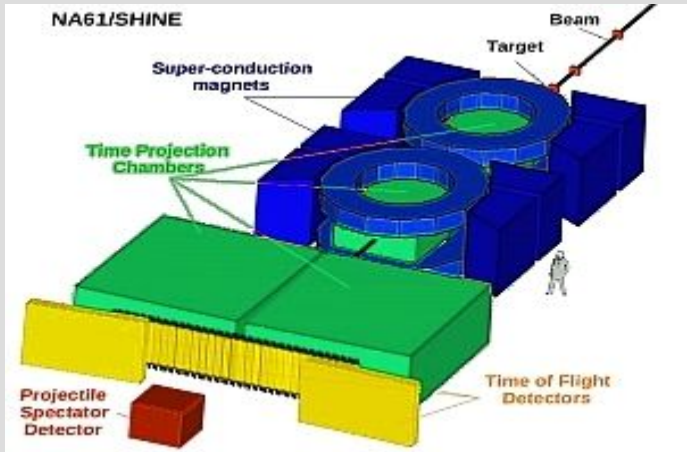


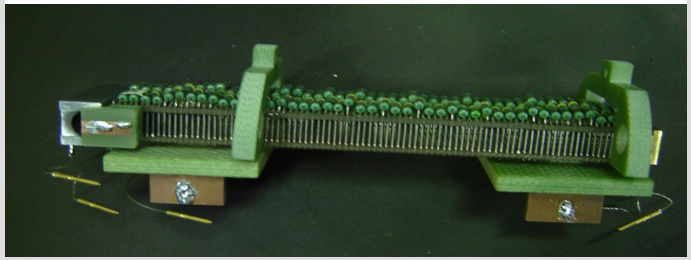


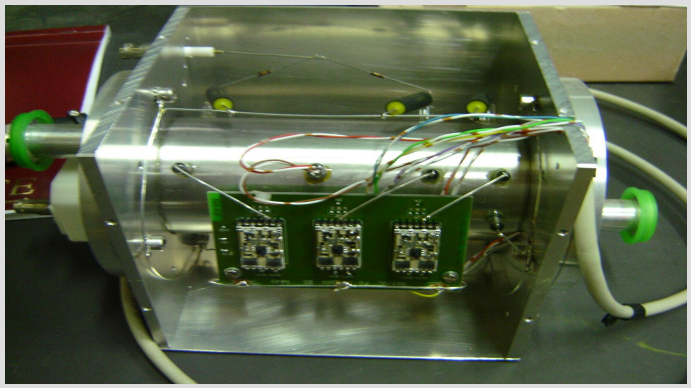
- High speed 18xFMC carrier
- WR enabled, 23 FPGAs
- I7 CPU, 1kW PSU
- Own, dedicated, based on WBgen and HDLmake
  FMC Configuration System that let us build complex systems in days
- Automatic FMC discovery and HDL generation.

CERN SPS NA61 ion velocity monitor

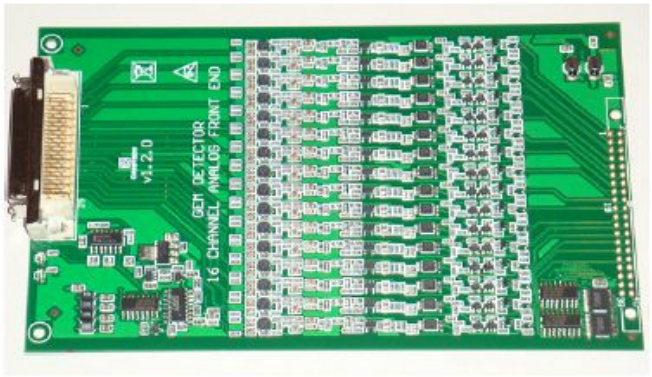
- NA61/SHINE studies hadron production in hadron-nucleus and nucleus-nucleus collisions at the CERN SPS.
- Large acceptance hadron spectometer
- Excellent capabilities for momentum, charge and mass measurements.
- Time Projection Chambers, Time of Flight and Projectile Spectator Detectors
- Reference ion-velocity (in delivered gas) monitoring system is needed
- Measurement of ToF, temperature, pressure, voltage
- Supply of 3 HV electrodes
- Online processing and calculations
- Single GbEth interface

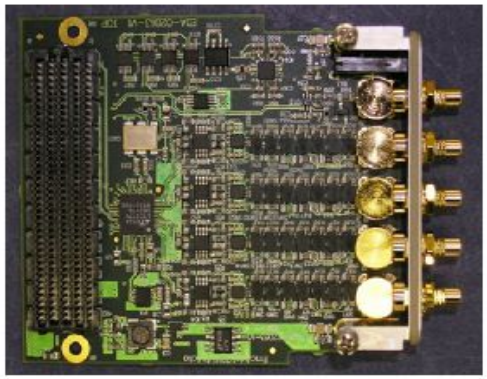


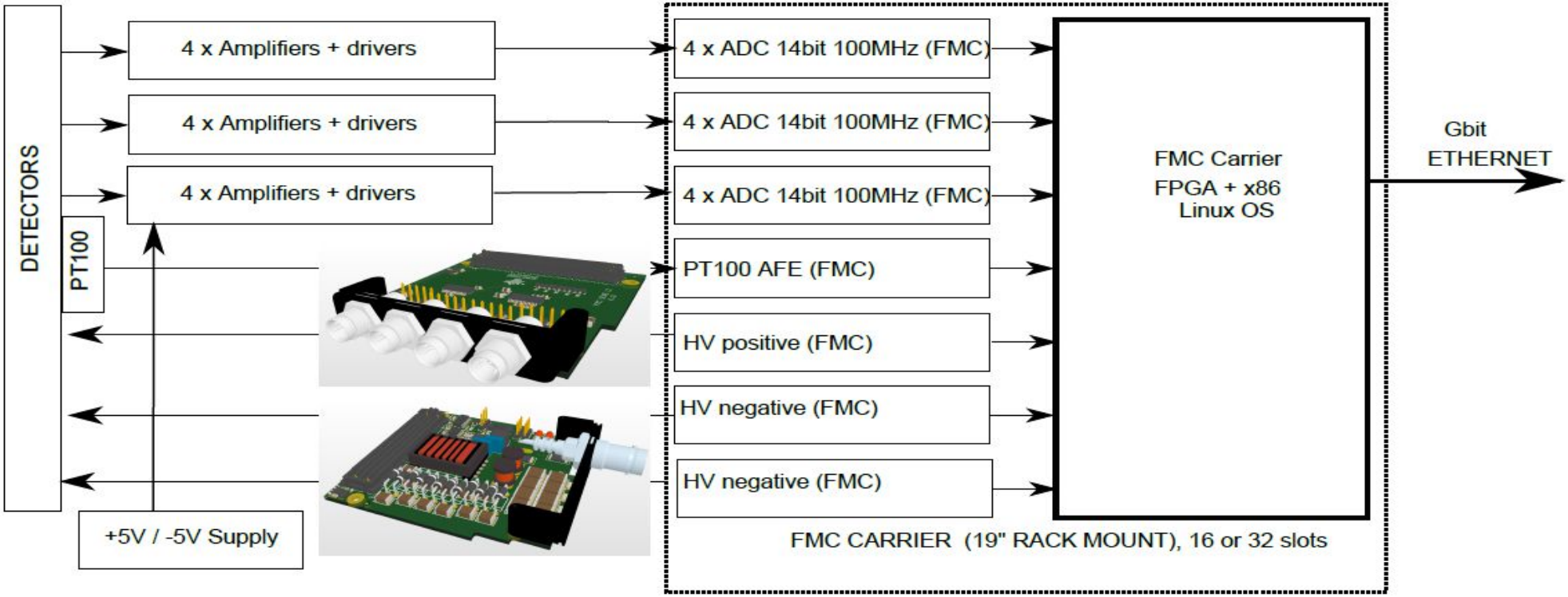




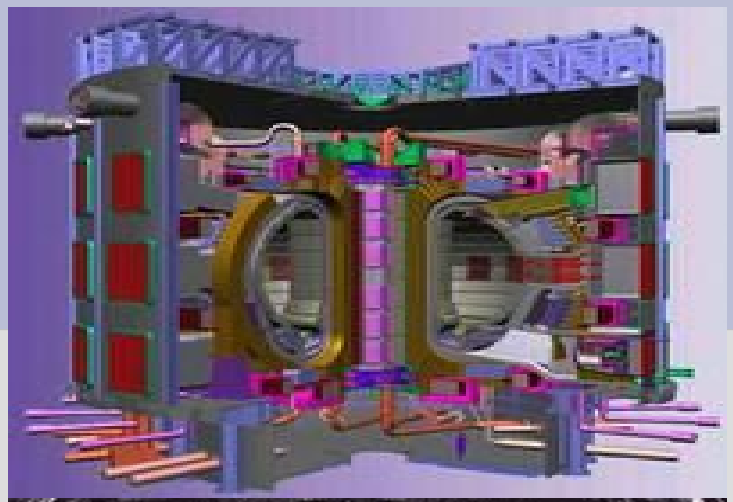
CERN NA61 ion velocity monitor

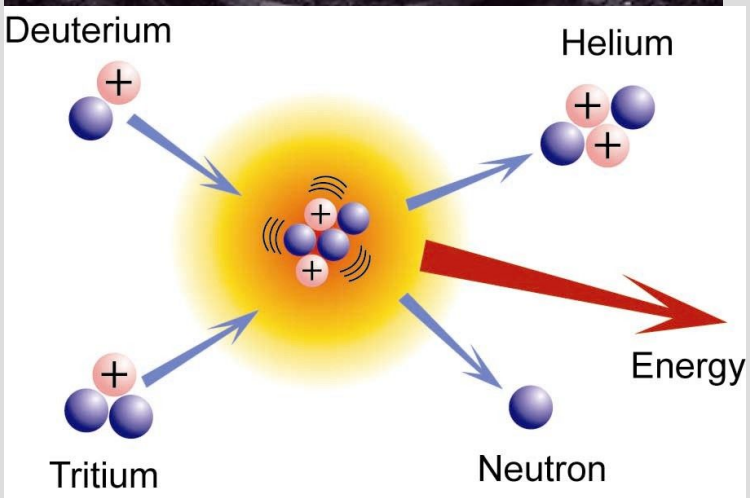






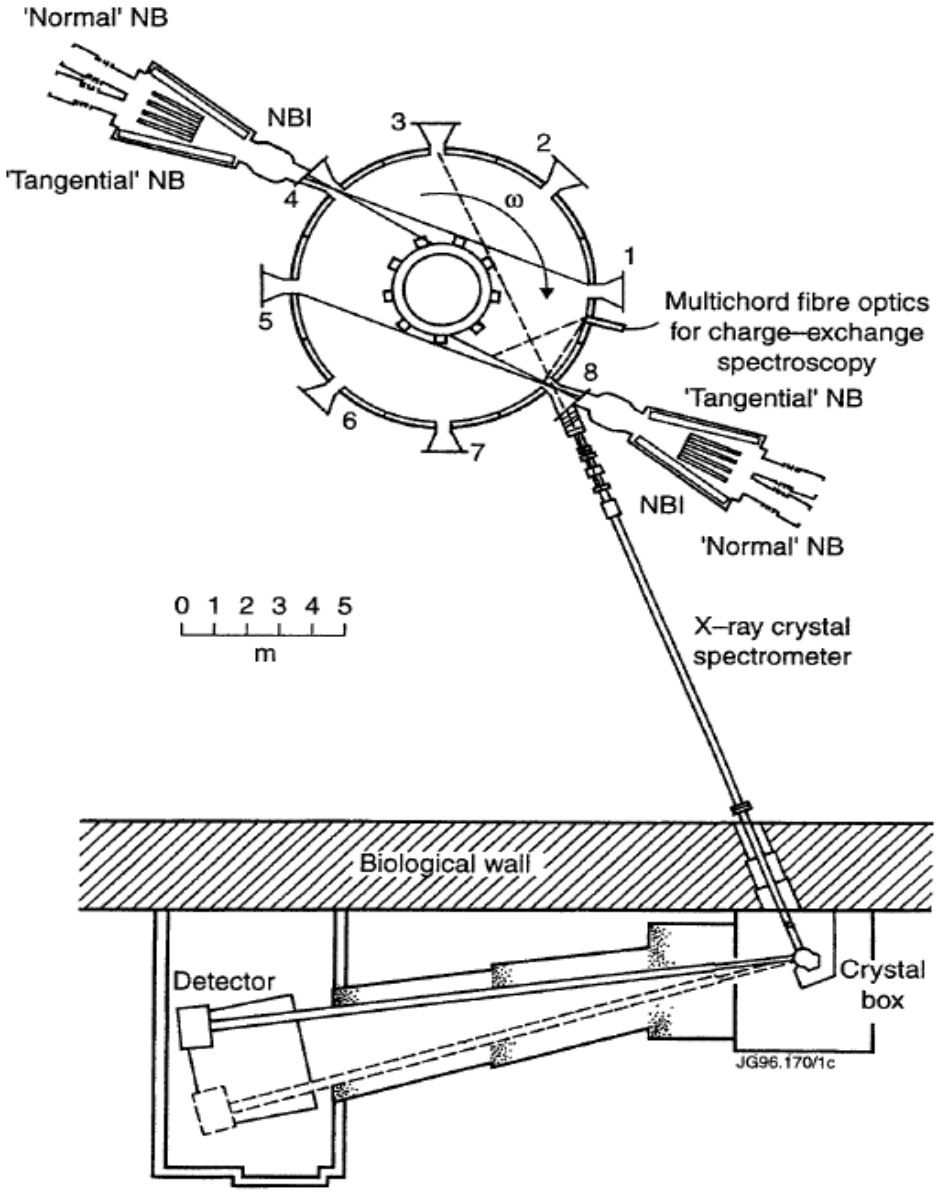
Joint European Torus



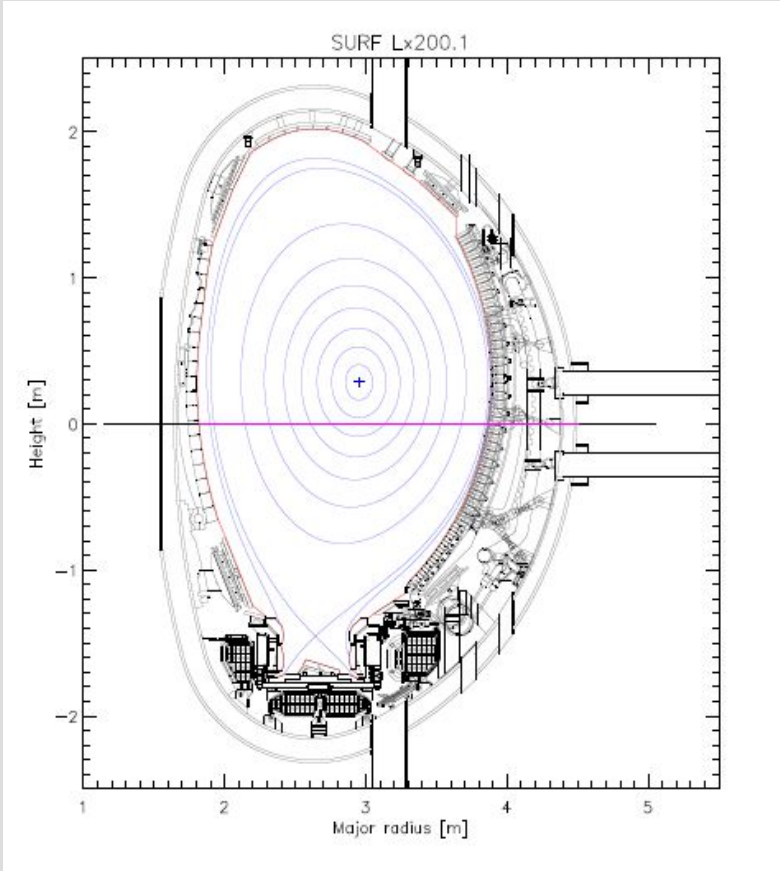


- Nuclear fusion: Deuterium (sea water) + Tritium (Lithium)
- ITER prototype
- Safe operation - reaction requires very specific conditions. Immediate machine stop possible.
- 100mln K - ohmic & microwave heating,
- 1g of fuel = 11T of coal, no emission of wastes or CO2
- 1m^3 of H2O contains 10g of Deuterium – fuel for milions of years
- Difficult to keep the reaction for more than a few second
- Plasma contamination → new wall material research
- Plasma spectrum monitoring required

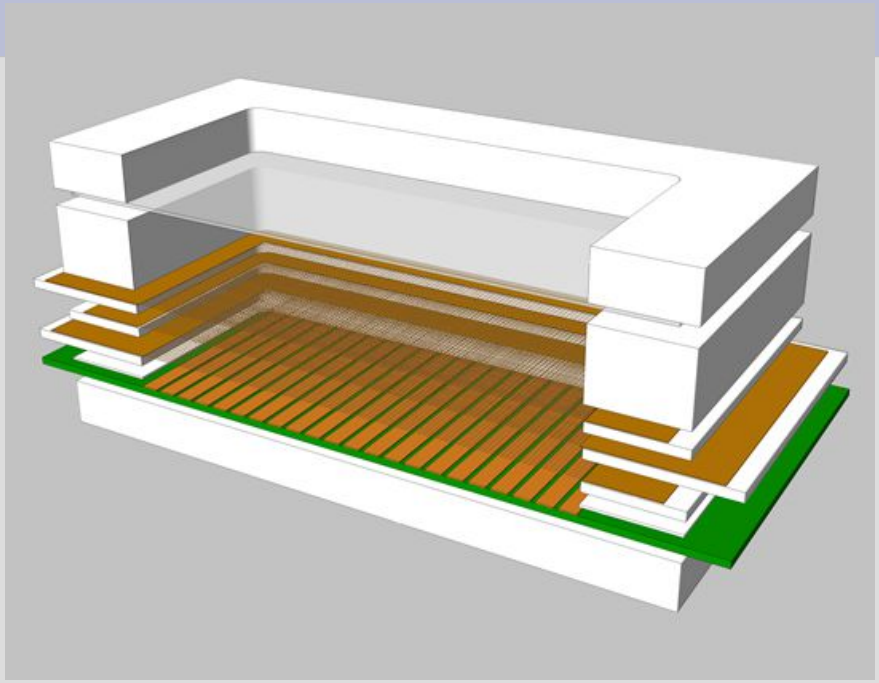
JET X-ray spectrometer

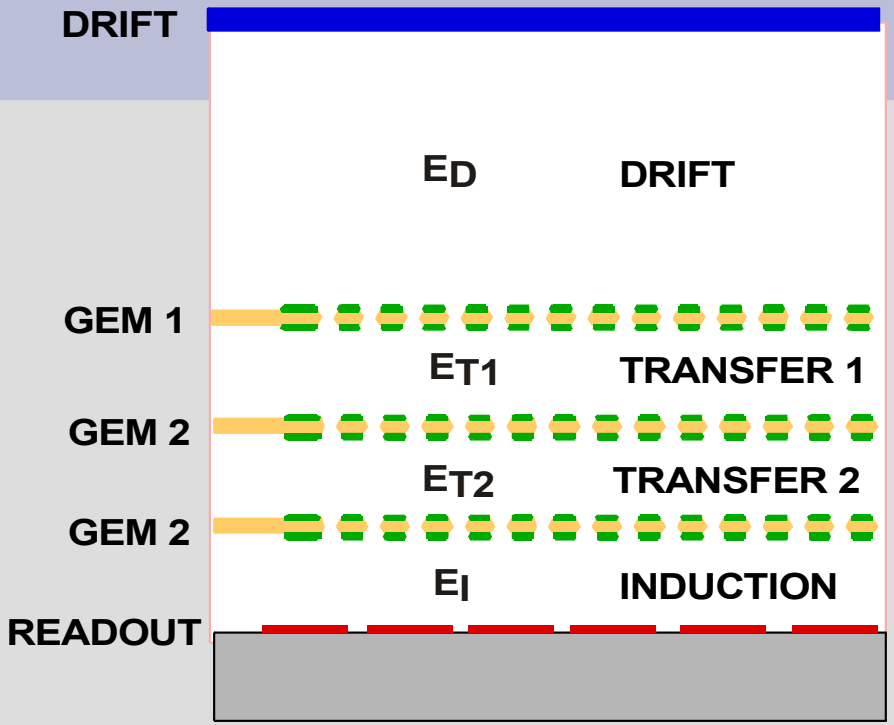


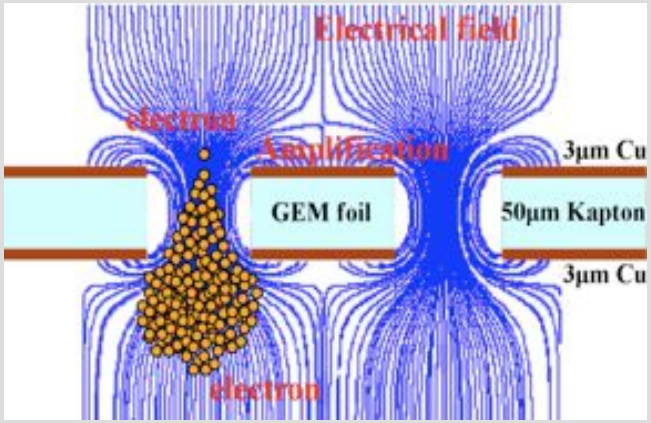
Spectrometer =
crystal + detector

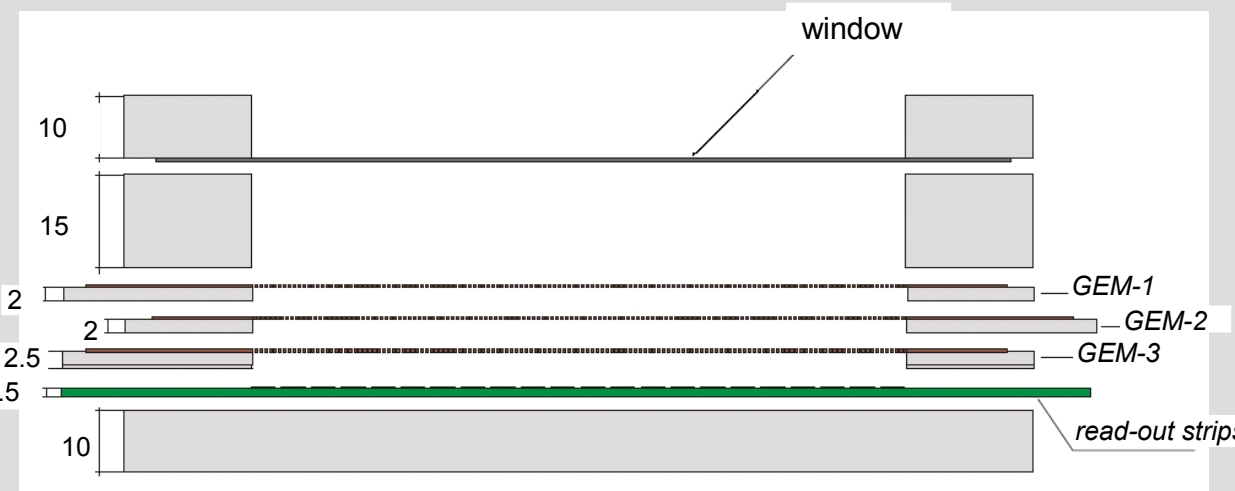


GEM Detector – photon to electron conversion

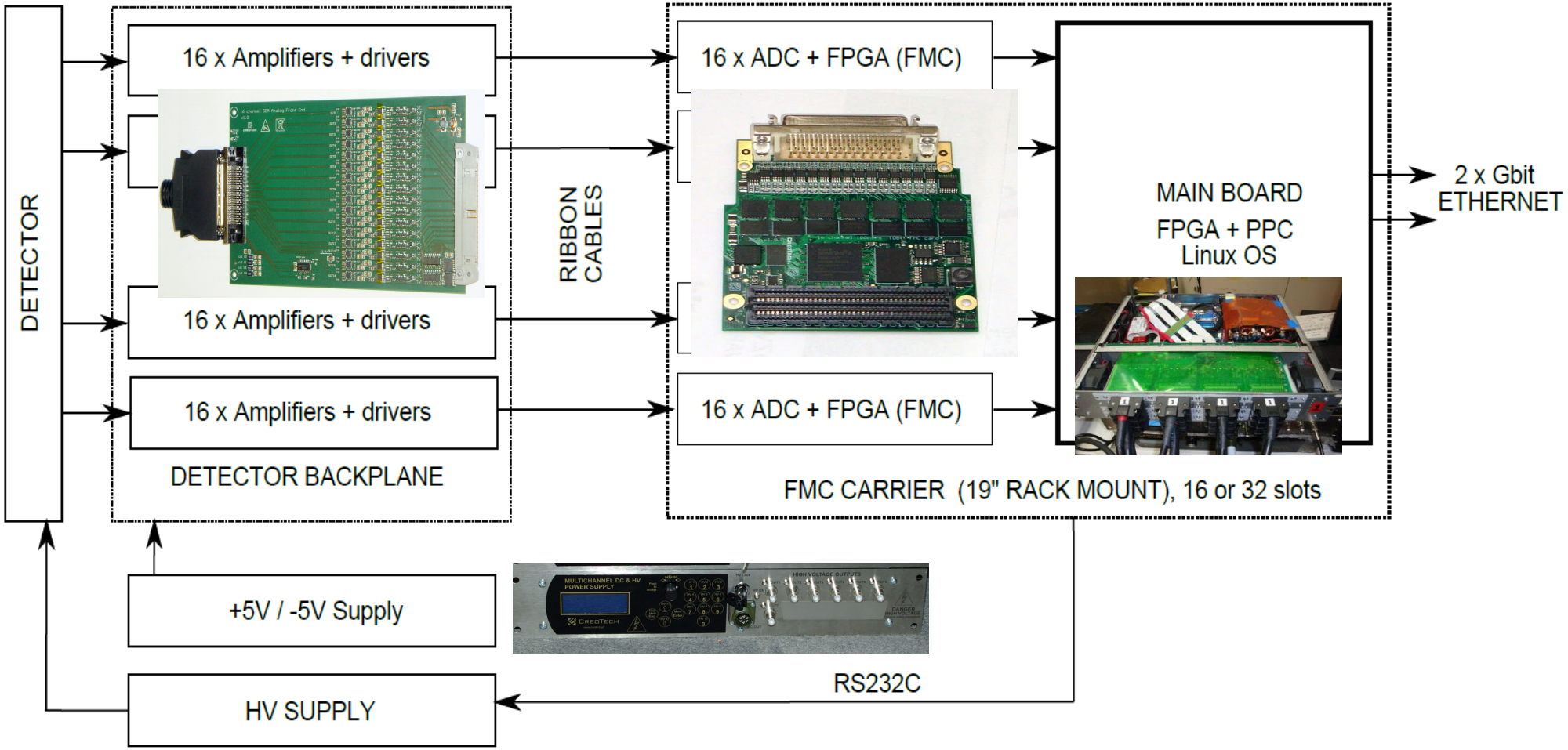






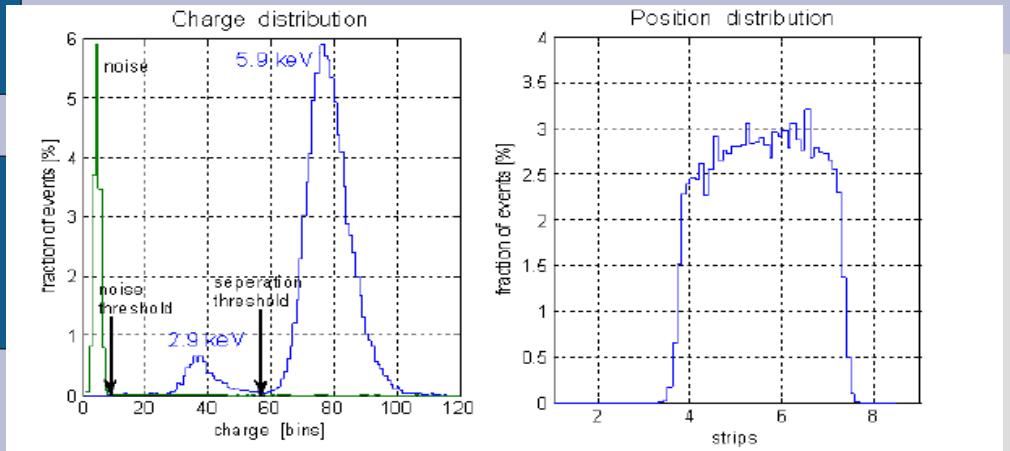


Detector processing electronics



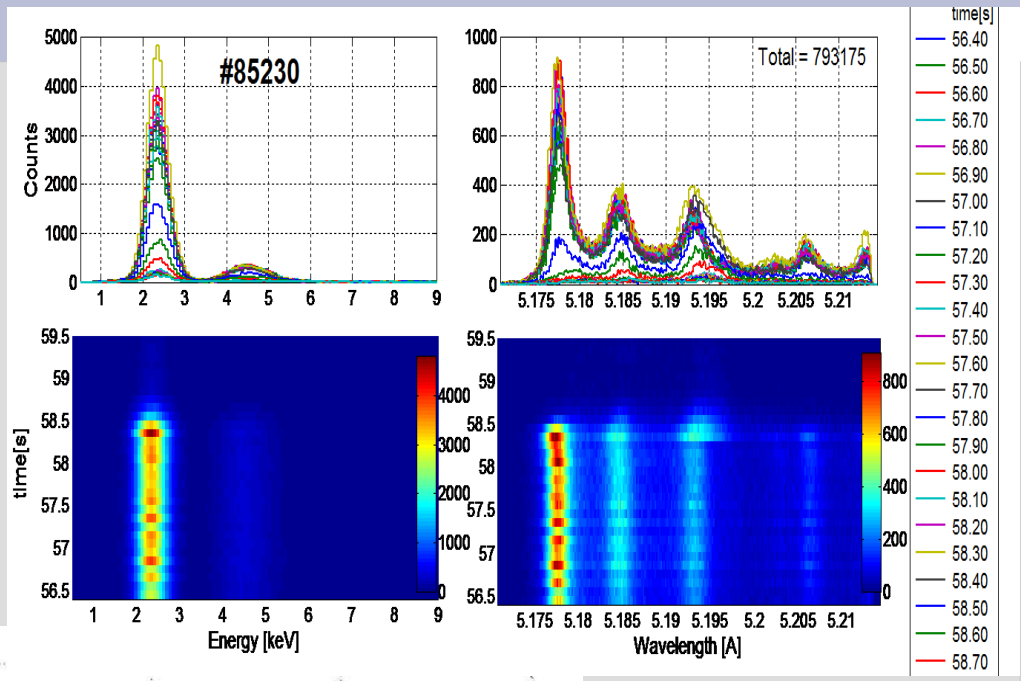
256 strips, charge: 100fC (10uA/10ns)
256 charge amplifiers
256 ADCs, 10bit, 100MS/s
22 FPGA chips

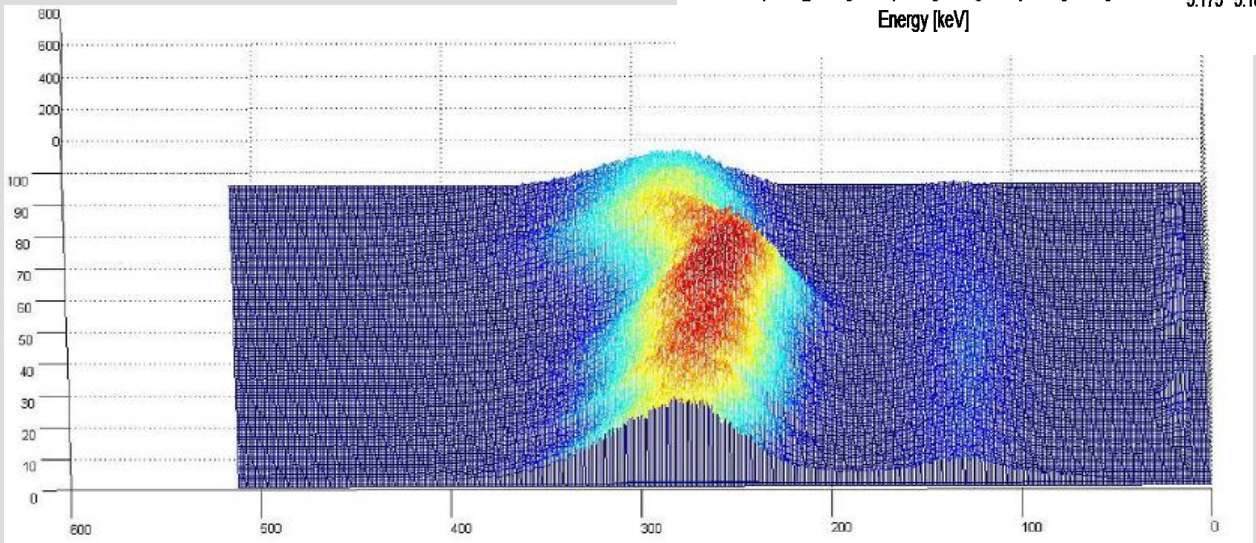
JET Spectrometer results



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

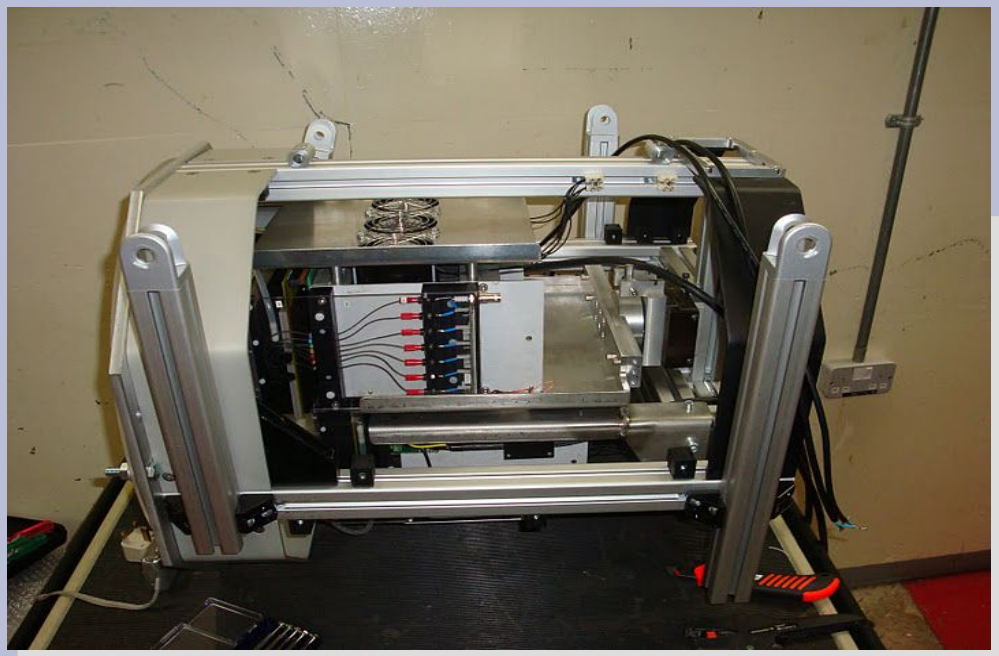
U_{ind} = 1250V, U_{GEMs} = 350, 370, 390V, U_{trans} = 700V, U_{drift} = 1500V

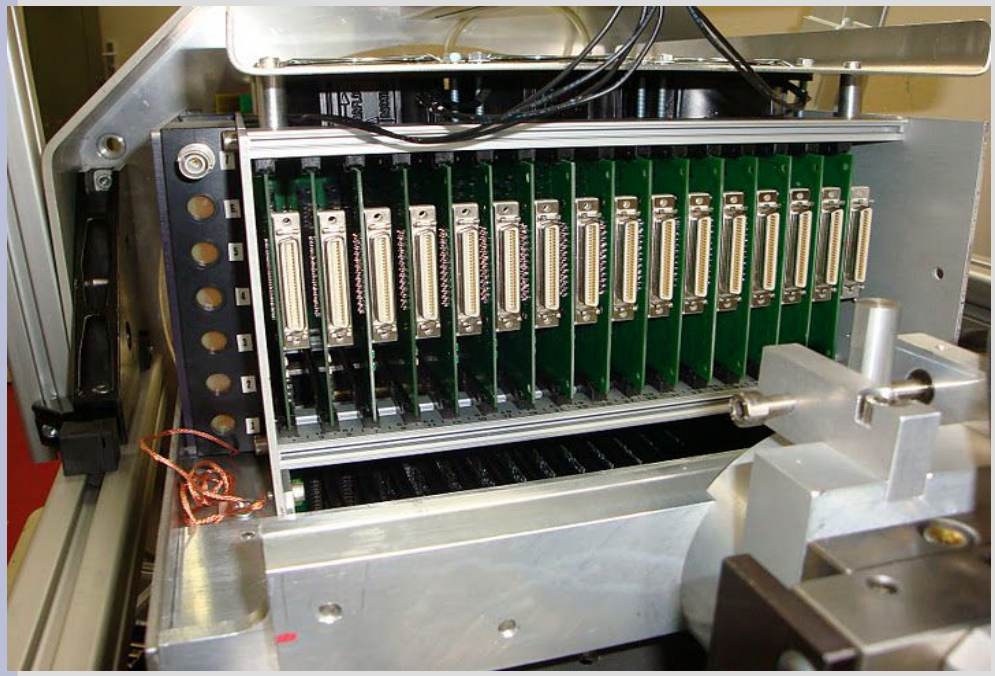




2D map individual histograms for each readout channel for Fe radiation source, HV = 5550 V

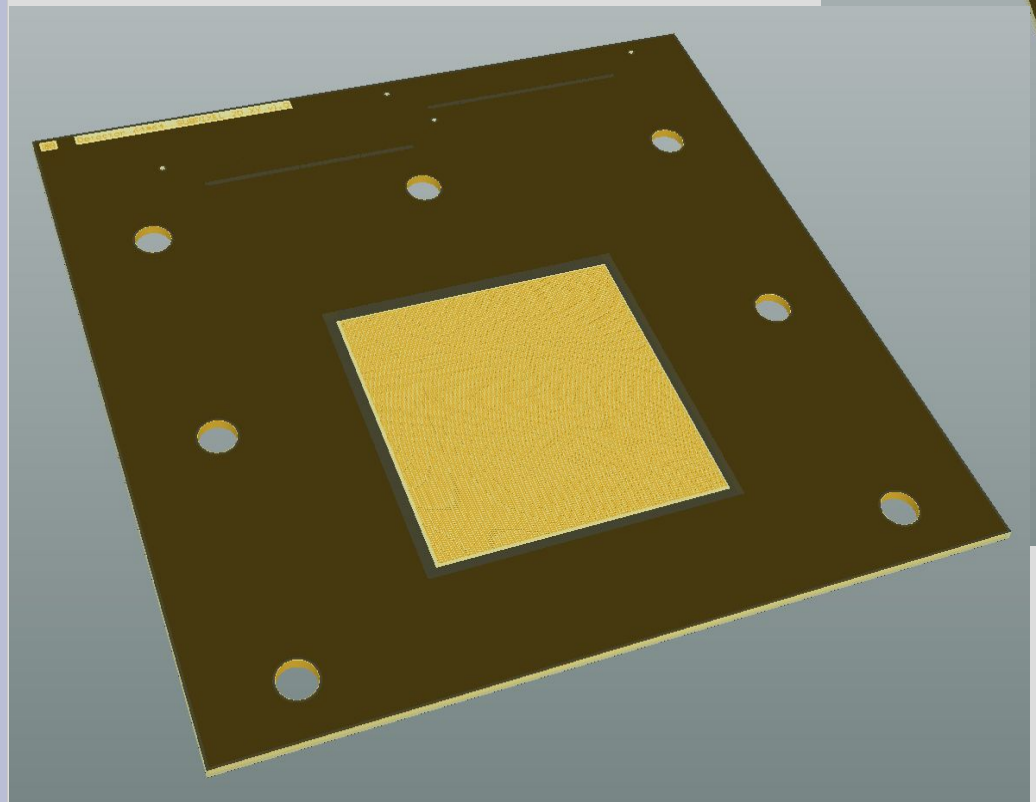
Final detector system

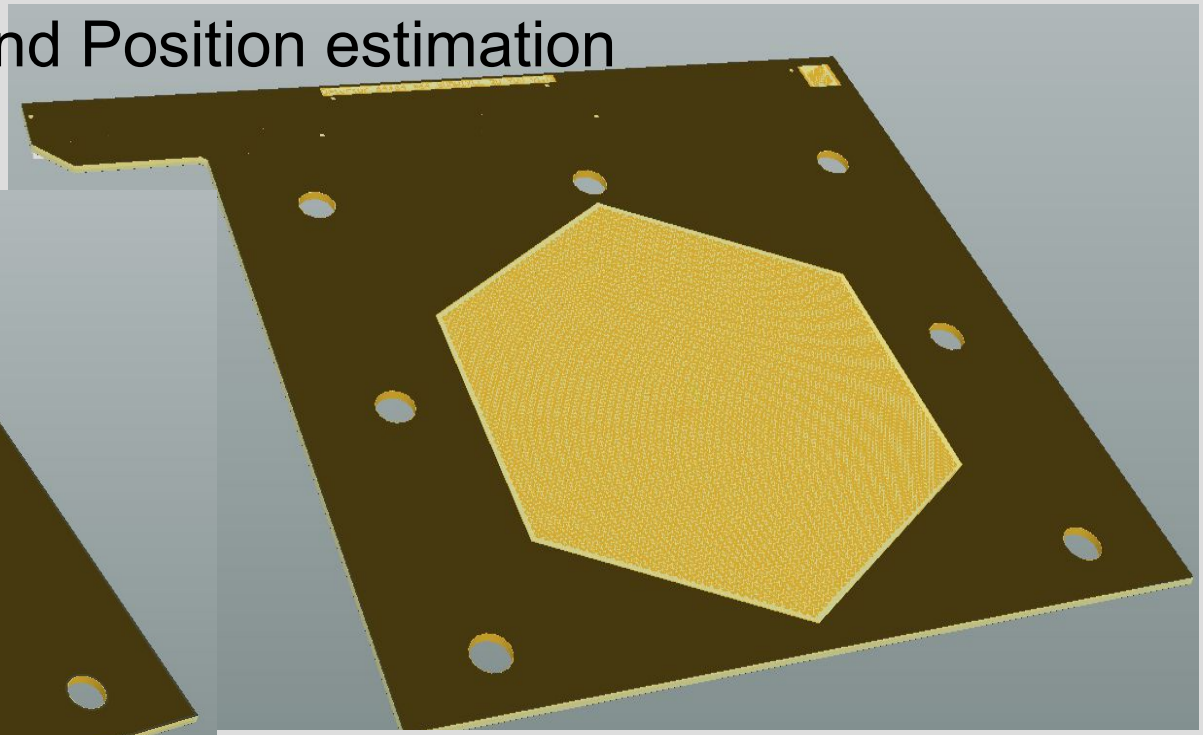




GEM-based large format X-ray camera

- High resolution, 640x640
- 128x128 analogue channels
- 10x10cm imaging area
- Low cost GEM detector
- Single photon Energy and Position estimation





MTCA.4 development at CTI and WUT

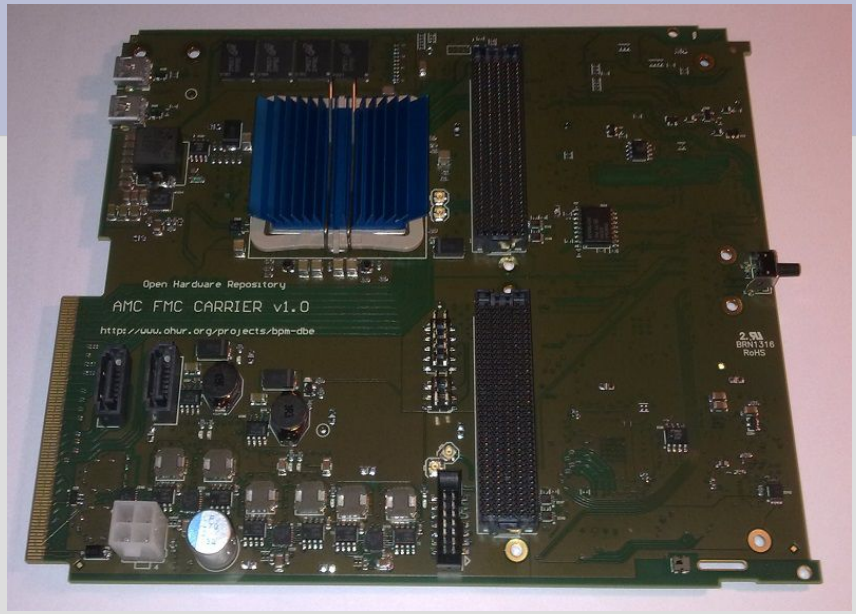
- AMC FMC v2 (Artix 7)
- AMC FMC v3 (Artix 7) with RTM
- FMC FMC with Kintex 7 FPGA *
- AMC QSFP *
- AMC CPU
- RTM SFP
- AMC DSP
- WR MCH + CPU *
- + several compatible FMC extensions

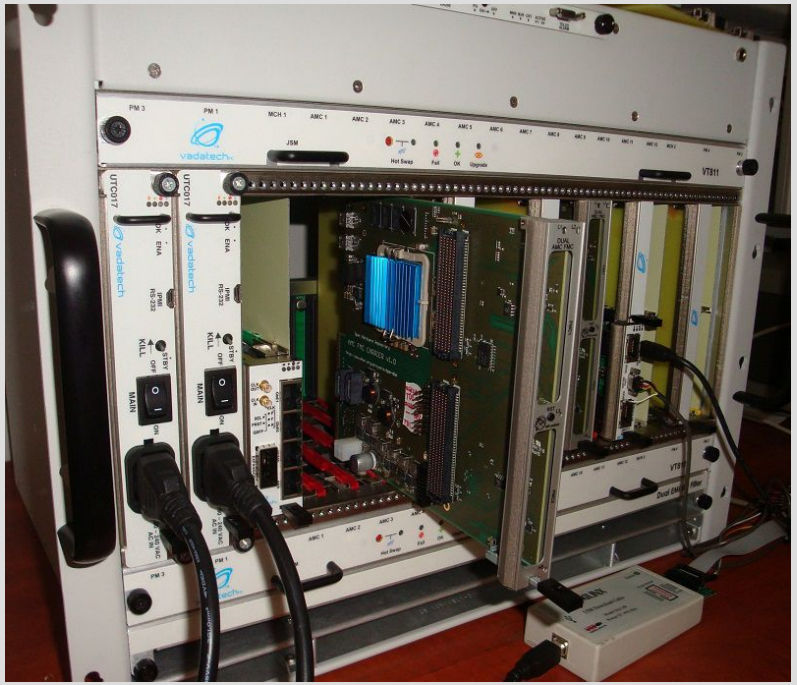
* during development

AMC FMC board

- 7-series FPGA, Artix 200T
- Kintex version available soon
- Dual HPC FMC
- Clock crossbar
- 4Gbit SDRAM
- 2x 256Mbit FLASH
- Custom NXP MCMC
- SCANSTA JTAG switch

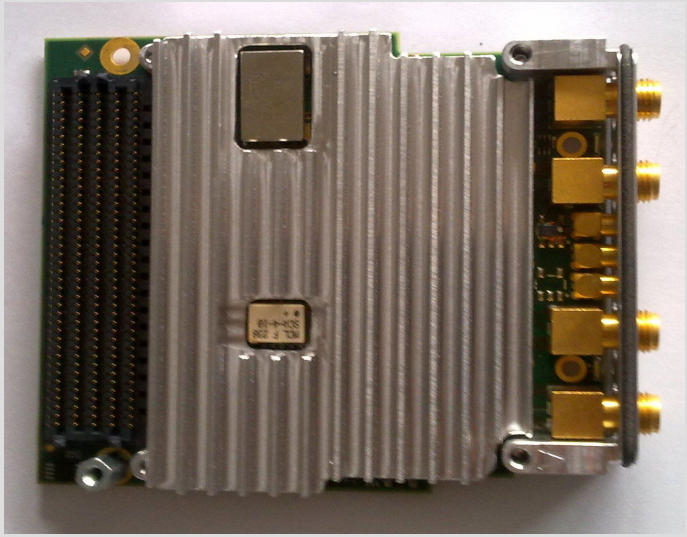
- Fully debugged HW
- Version 3 with RTM
- Used for GSI TMS, LNLS Sirius and others
- SDRAM, PCIe with DMA working
- Custom MCMC working with Vadatech MCH

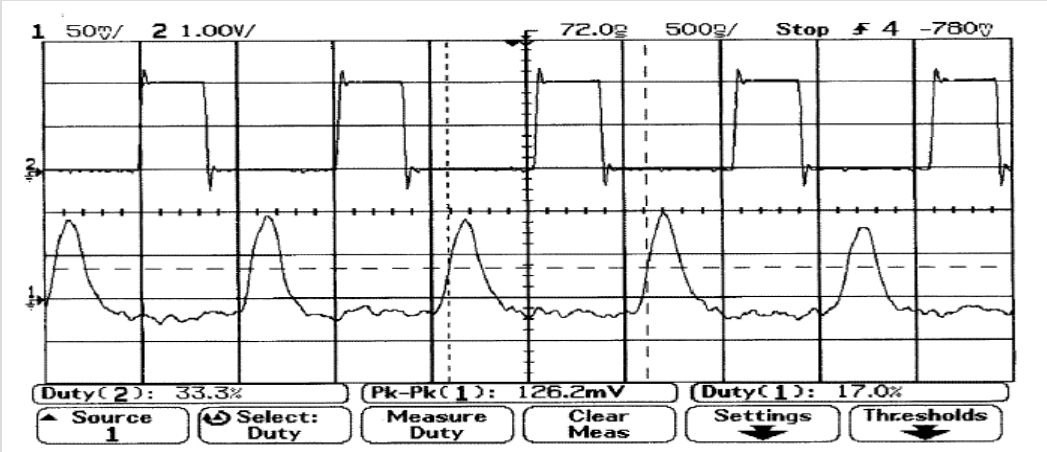


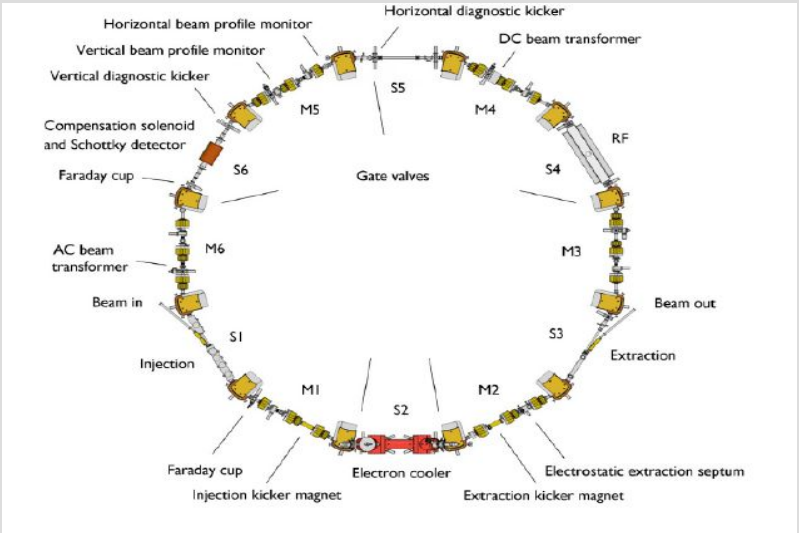


BPM system for Cryring GSI

- 8 PU units
- Trajectory and orbit measurement
- Adaptive PLL algorithm in FPGA
- uTCA system with custom AMC and ADC
- 5 AMC FMC carriers
- 8 quad channel, 250MHz, 16bit FMC cards
- Sub-ns synchronisation, WR-enabled

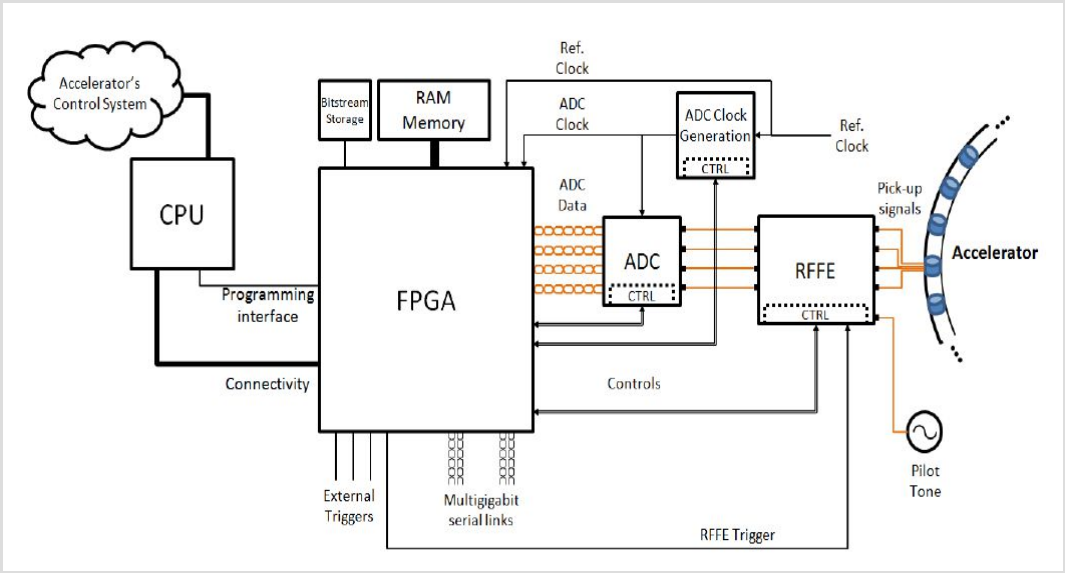


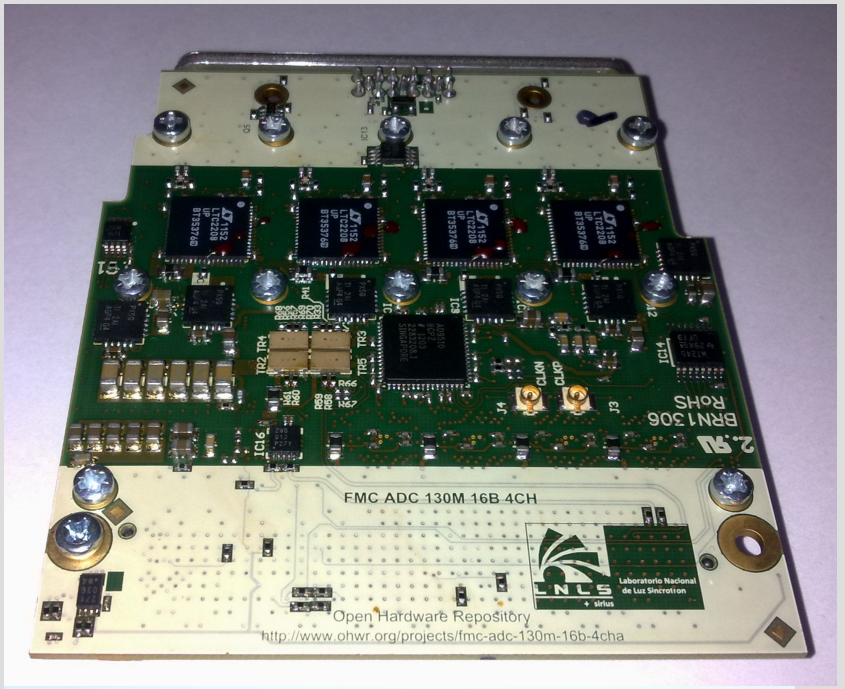


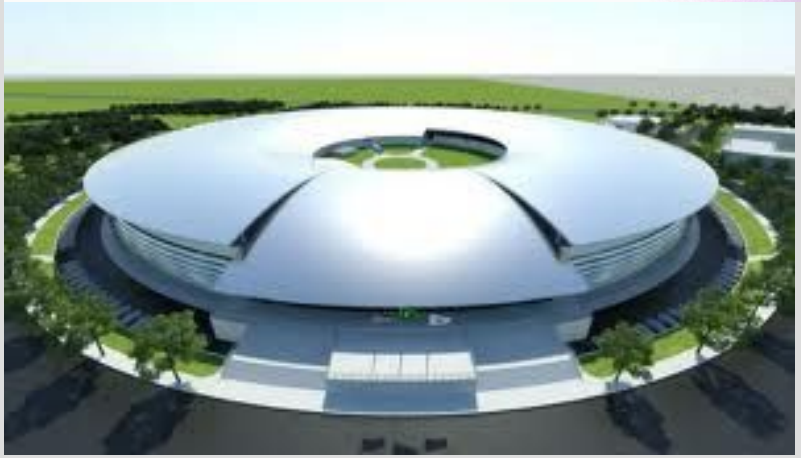


BPM system for Sirius (LNLS)

- 3Gev 3-rd gen light source
- 160 BPM units (640 ADC channels)
- Custom, quad channel 130Mhz, 16bit FMC cards
- Sub-sampling of 480 MHz RF
- On-line processing

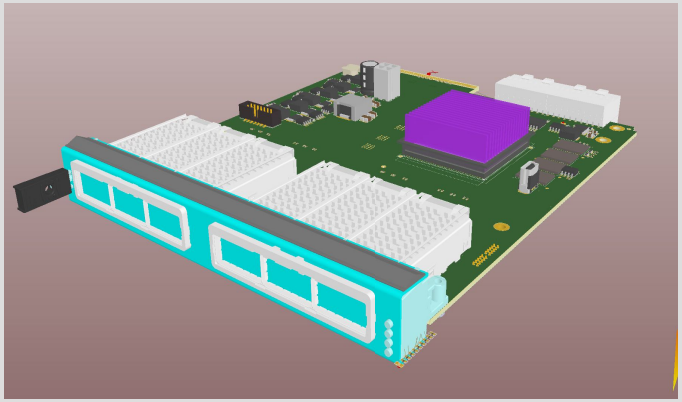






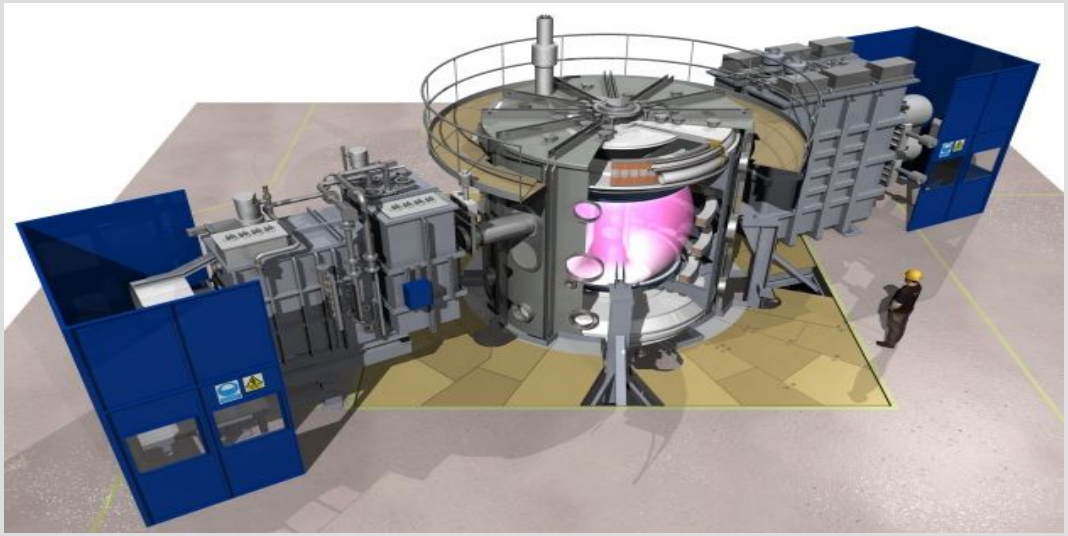
AMC FPGA QSFP board (CBM)

- Kintex 7 FPGA (XC7K420T or XC7K480T), 32 GTX, 760 LC, 34,380 Kb RAM, PCIe Gen 2 core,
- 6 **QSFP**, 24 x10Gbit/s optical links per board
- clock distribution circuit with crosspoint switch, VCXO, WR clock recovery
- QDR RAM, 800MHz, 3 individual controllers
- configuration FLASH. Update via JTAG from MCH2
- 1x GTX (Port0) for Ethernet (MCH1)
- 1x GTX (Port1) for WR (MCH2)
- 4xGTX (FP1) PCIe from MCH1
- 4xGTX (FP2) crossbar from MCH2
- 24xGTX 6xQSFP
- Stand-alone operation possible

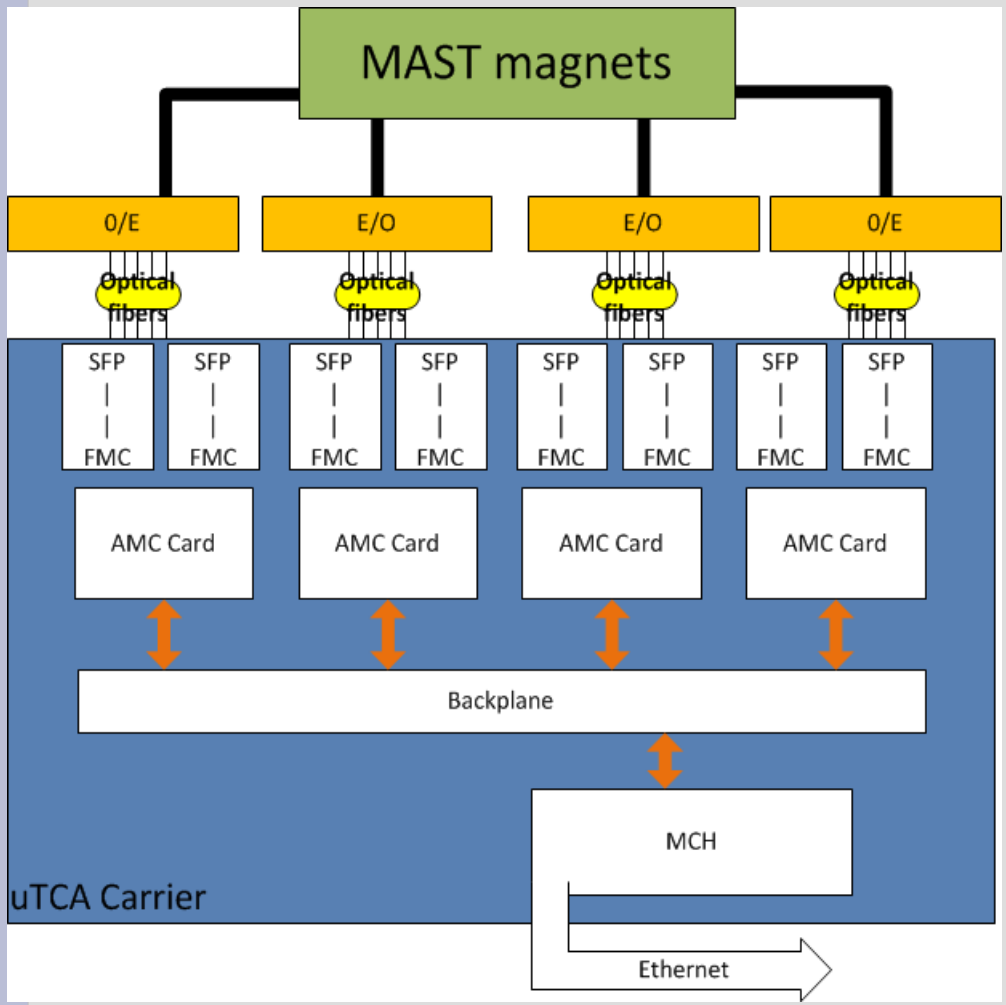


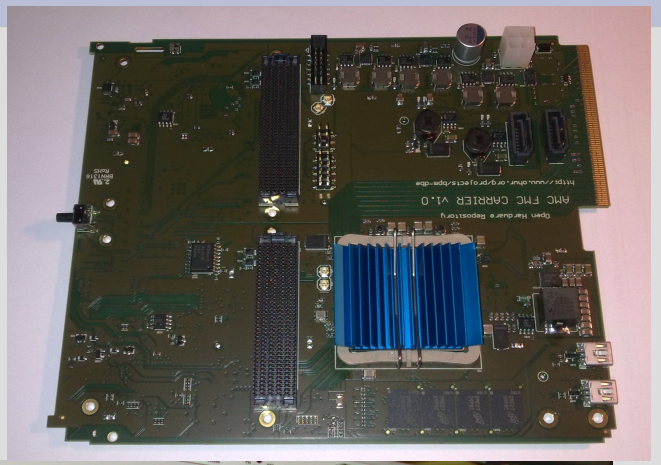
Diagnostic and control system for MAST superconducting divertor magnets

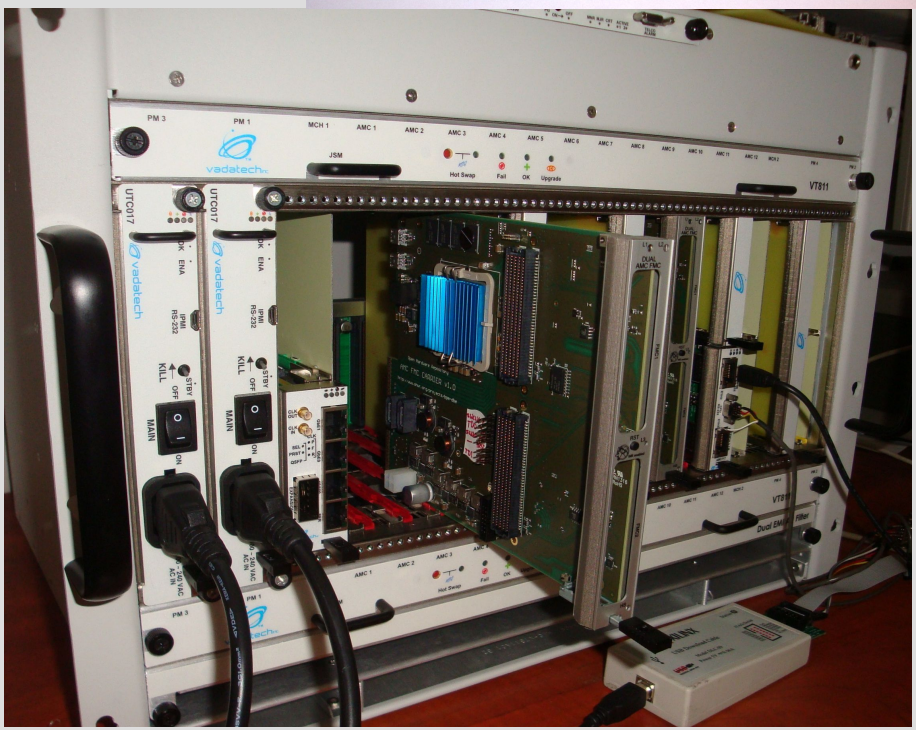
- Control and protection of superconducting magnets
- Isolated voltage and current measurement
- Low reaction time (us)
- Quench detection and brake choppers control
- Recent FPGA technology
- UTCA platform
- SFP fibre isolation
- Remote ADC and DAC



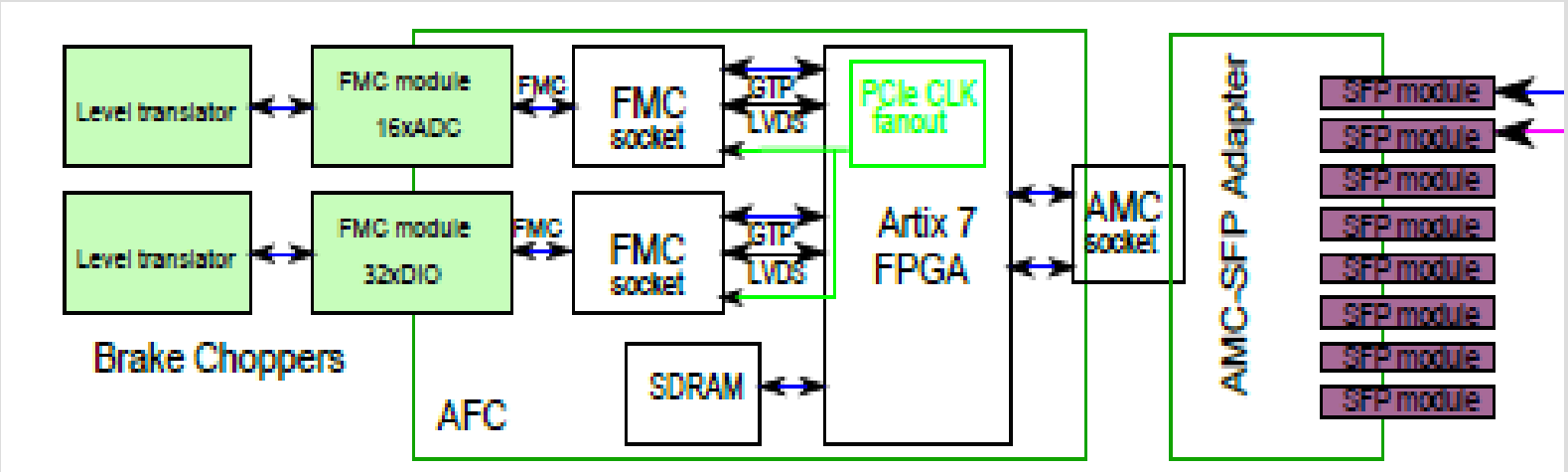
System block diagram



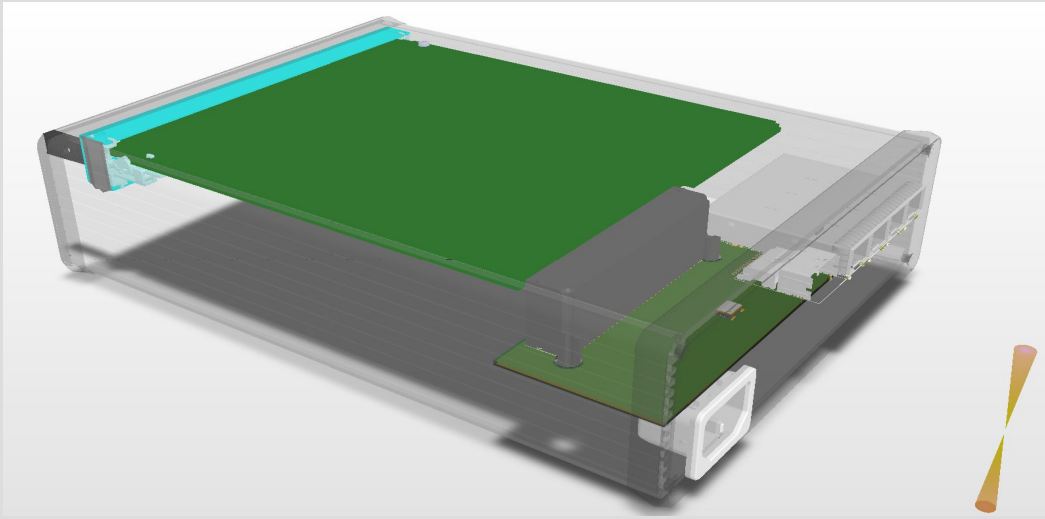




Optical ADC / DAC / DIO – based on AMC FMC + micro backplane

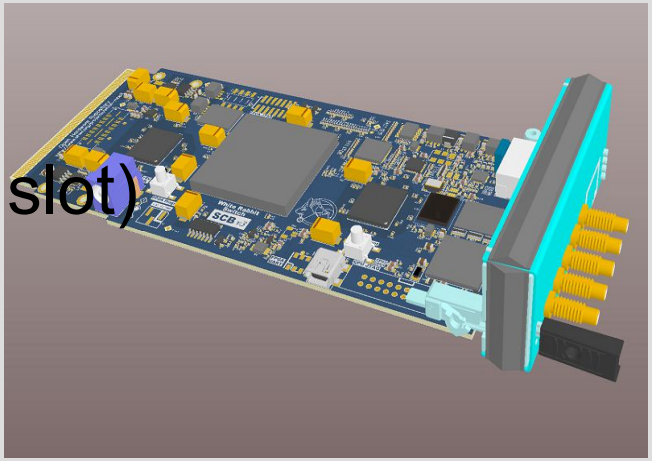


- Stand – alone or remote operation
- Usage of common platform
- Proven operation
- Prototype stage

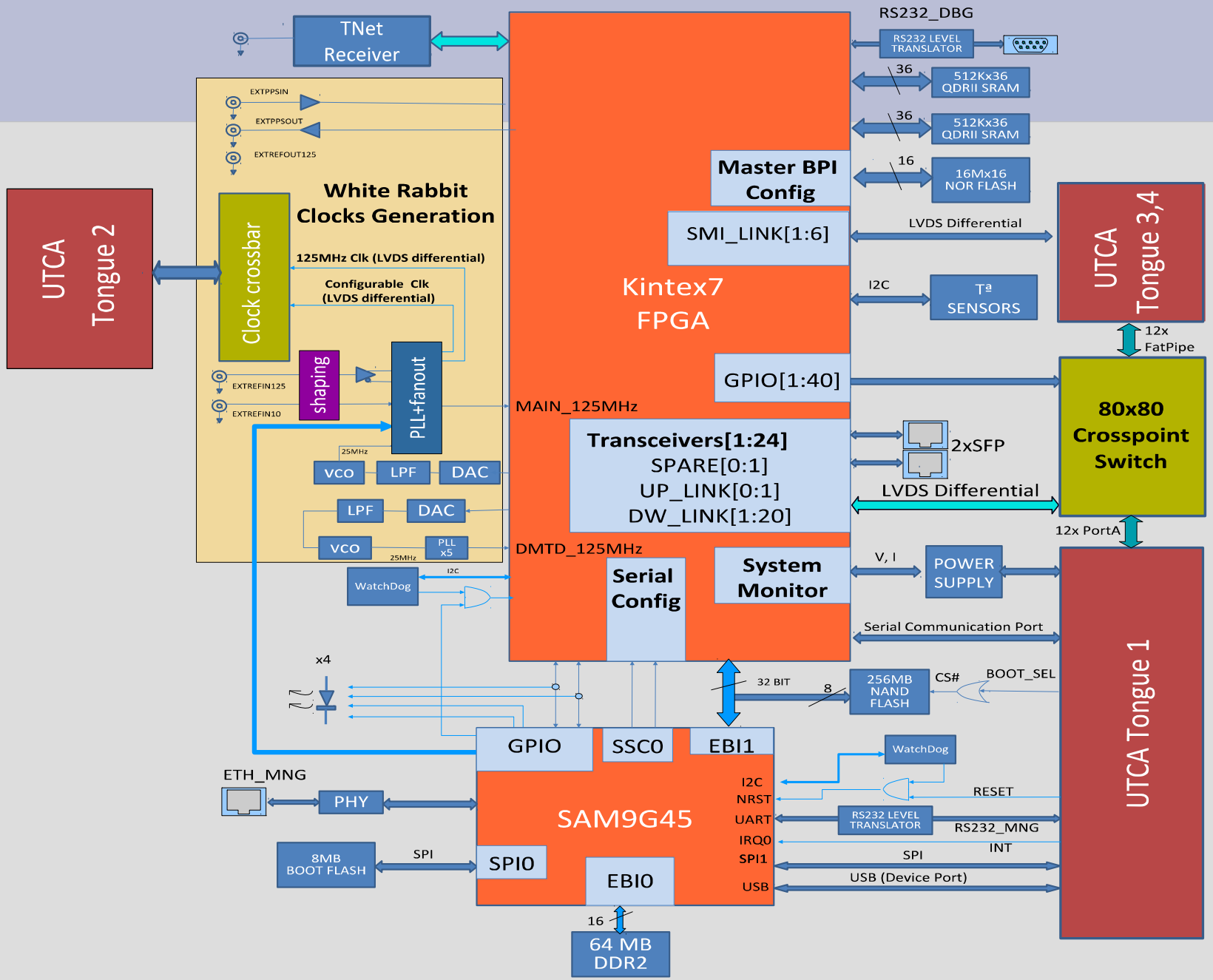


MCH WR timing receiver/switch

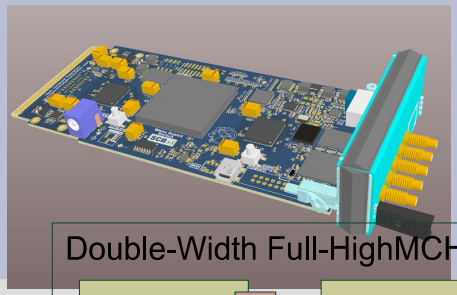
- Modified standard 18 port WR switch from OHWR
- Additional 80x80 4.25Gbit Crosspoint Switch (crossbar)
- All 12 AMC Port1 routed to crossbar
- 24GTX routed to crossbar
- All FP2 routed to crossbar
- The crossbar used to setup p2p and 1-to-all links between all AMCs, up to 5x4.7Gbit/s per link
- Low jitter clock distribution based on crossbar
- Dedicated Tnet receiver
- IPMI
- Optional RTM for CPU (saves one AMC slot)
- GenIII PCIe or crossbar switch options

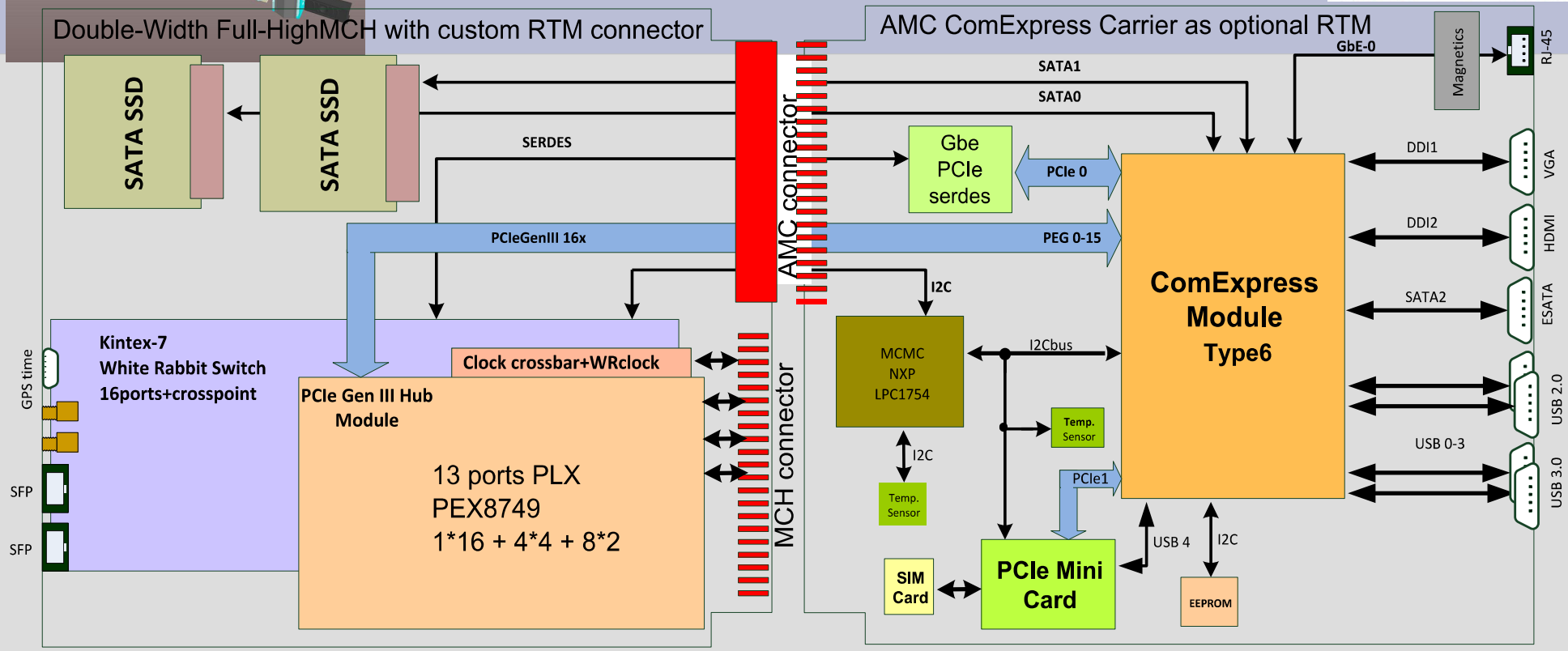


MCH WR timing receiver/switch



MCH WR with slot-saving AMC/RTM CPU





- Saves one AMC slot. 12 AMC slots available!
- Low cost (<1.5k EUR) OH solution. Recent x86 I7 CPU
- Works as main or redundant MCH
- No more troubles with IPMI caused by MCMC!

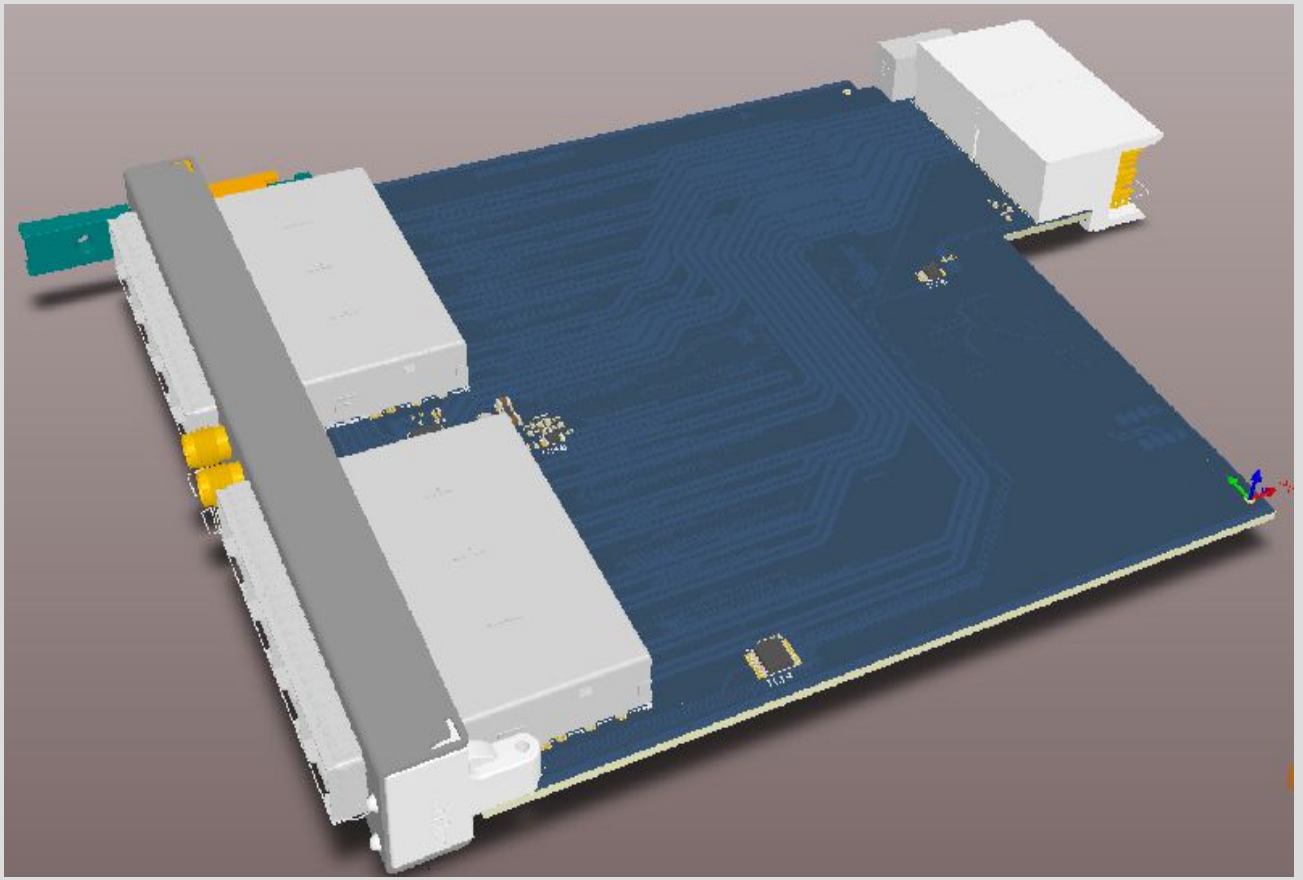
AMC-CPU-COM EXPRESS 6

- Troubles with Concurrent i7 CPU:
- Bugs in BIOS, support not willing to solve them
- Incompatibility with Vadatech crate
- Own AMC-CPU designed.
- No more troubles with IPMI
- Recent I5 & I7 cores
- Supports SSC, FP1, FP2
- Gen 3 PCIe
- FPGA extension module
- Plenty of IO, USB, eSATA, VGA
- mPCIe (WiFI, 3G modem)/ mSATA
- 2 gigabit ports with P0, P1 support
- Low cost, i5 CPU < 2k EUR

RTM-SFP+8

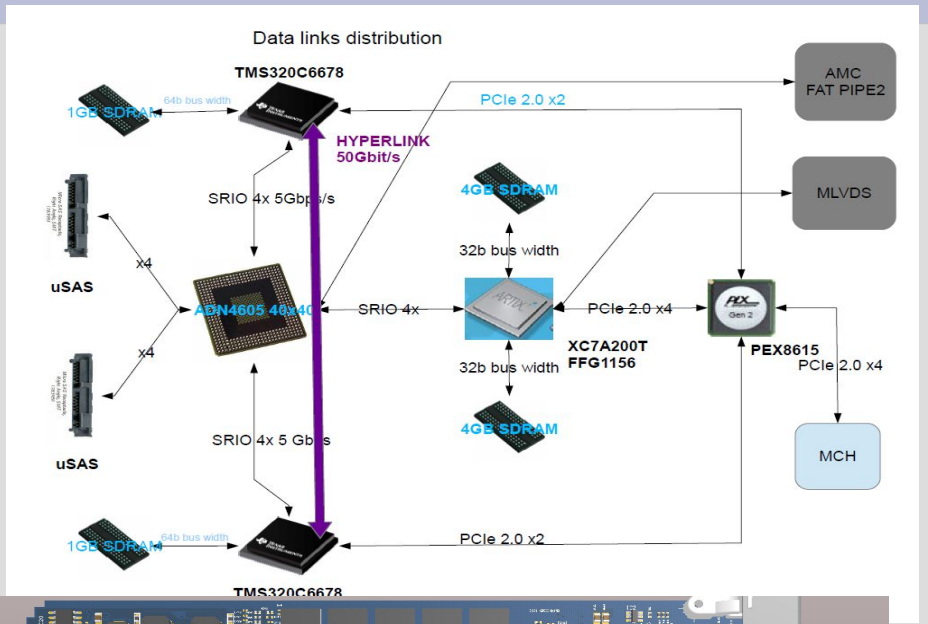
- Compatible with:
- AMC-FMC v3
- AMC-FMC Kintex
- WR-MCH

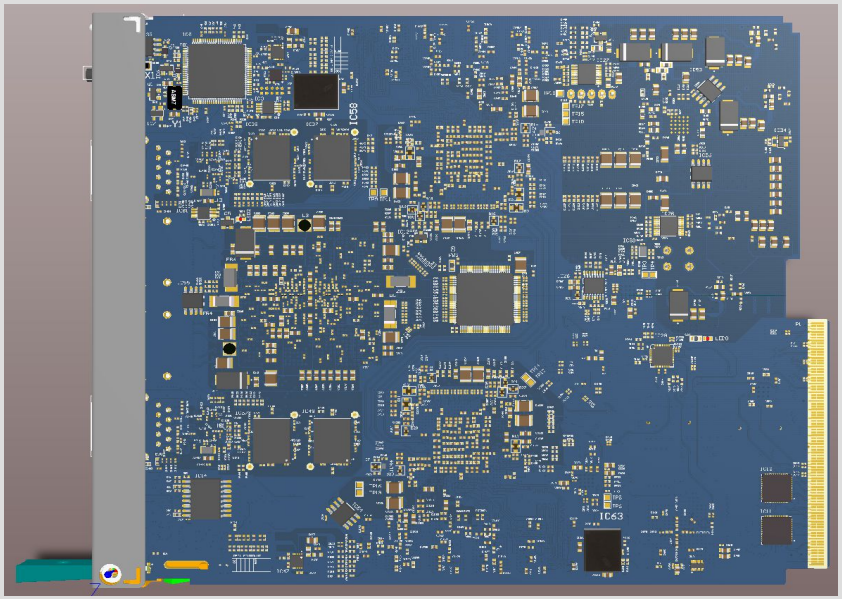
- Prototype stage

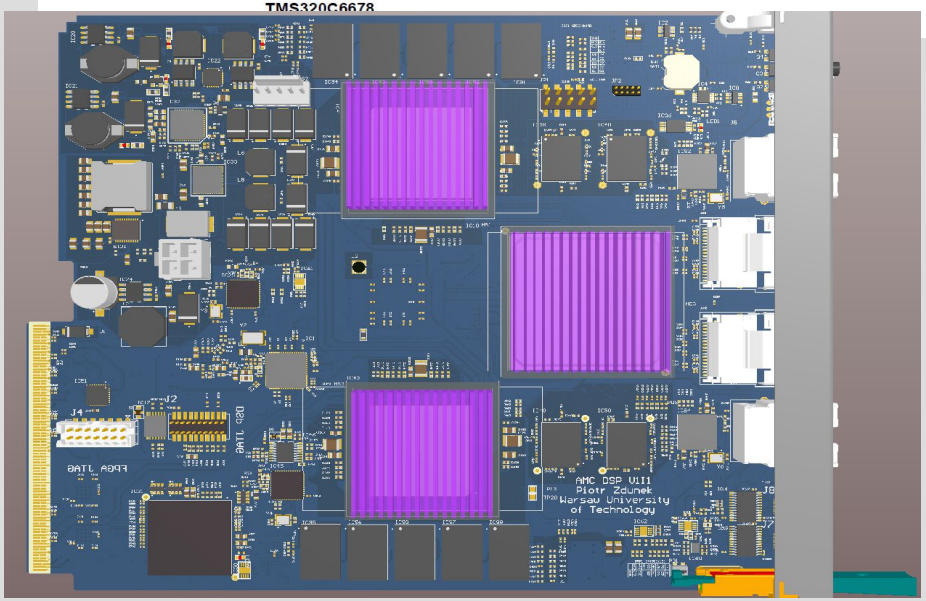


AMC DSP accelerator – 16 cores with flexible crosspoint switch

- 16 DSP TI cores
- Artix FPGA
- Crossbar switch
- 2x 20Gbit quad lane GTP connectors
- 2x Gigabit Ethernet
- Designed for GEM detector signal processing







THANK YOU