

A flexible evaluation platform for a novel X-ray detector

September 26th 2019
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bruco
INTEGRATED CIRCUITS



BRUCO INTEGRATED CIRCUITS

Short overview

- ✦ Independent, privately owned fab-less IC design center
- ✦ Founded in 1988 – 31 years of Innovation!
- ✦ Turn key solutions and design services with own validation lab
- ✦ Customers from large multinational to **technology startups**
- ✦ End markets: Consumer Electronics, Industrial, and Automotive
- ✦ Design centers in Borne and Nijmegen
- ✦ Sales office in Taiwan
- ✦ Part of Dieco Electronics holding, ~50 highly educated and enthusiastic people



Core competences



RF



Analog / Mixed-Signal





OUR SERVICES

Designing, verifying and validating IC's

**IC Design
services**

**Production
Services**



**Application
Development**

The logo for G-ray Medical, featuring the text "G-ray" in a bold, sans-serif font with a horizontal line through the "y", and the word "Medical" in a smaller font to the right, all enclosed in a rectangular border with a color gradient from red to purple.



OUR CUSTOMERS

We have designed IC's and application boards among others for the following companies

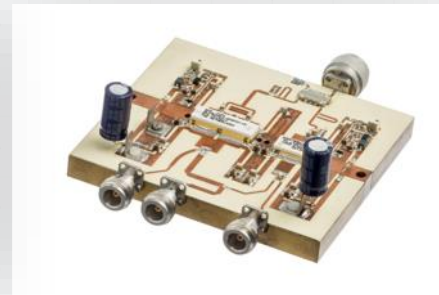
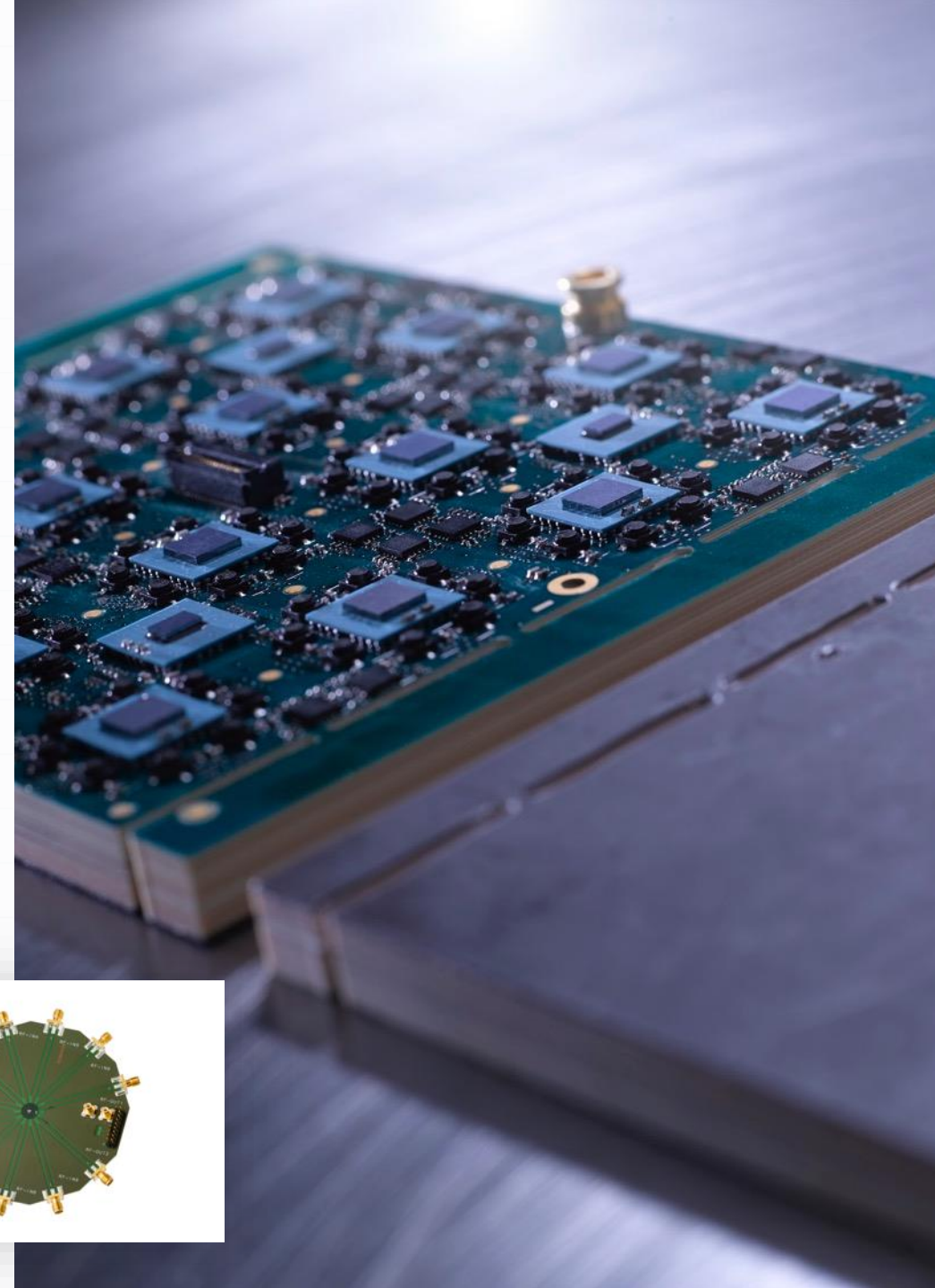




OUR BUSINESS

Consumer, RF

- ◆ Switches & LNAs for WLAN, LTE, 5G high-end cell phones
- ◆ Beam-forming Phased Array systems for satellite reception, Ku band 11-13 GHz RF front-end
- ◆ PLL for satellite receivers ~15 GHz
- ◆ PAs including power and, bias circuitry 400 MHz- 2.7 GHz
- ◆ Discrete, High-Power Doherty PA modules for Base Stations

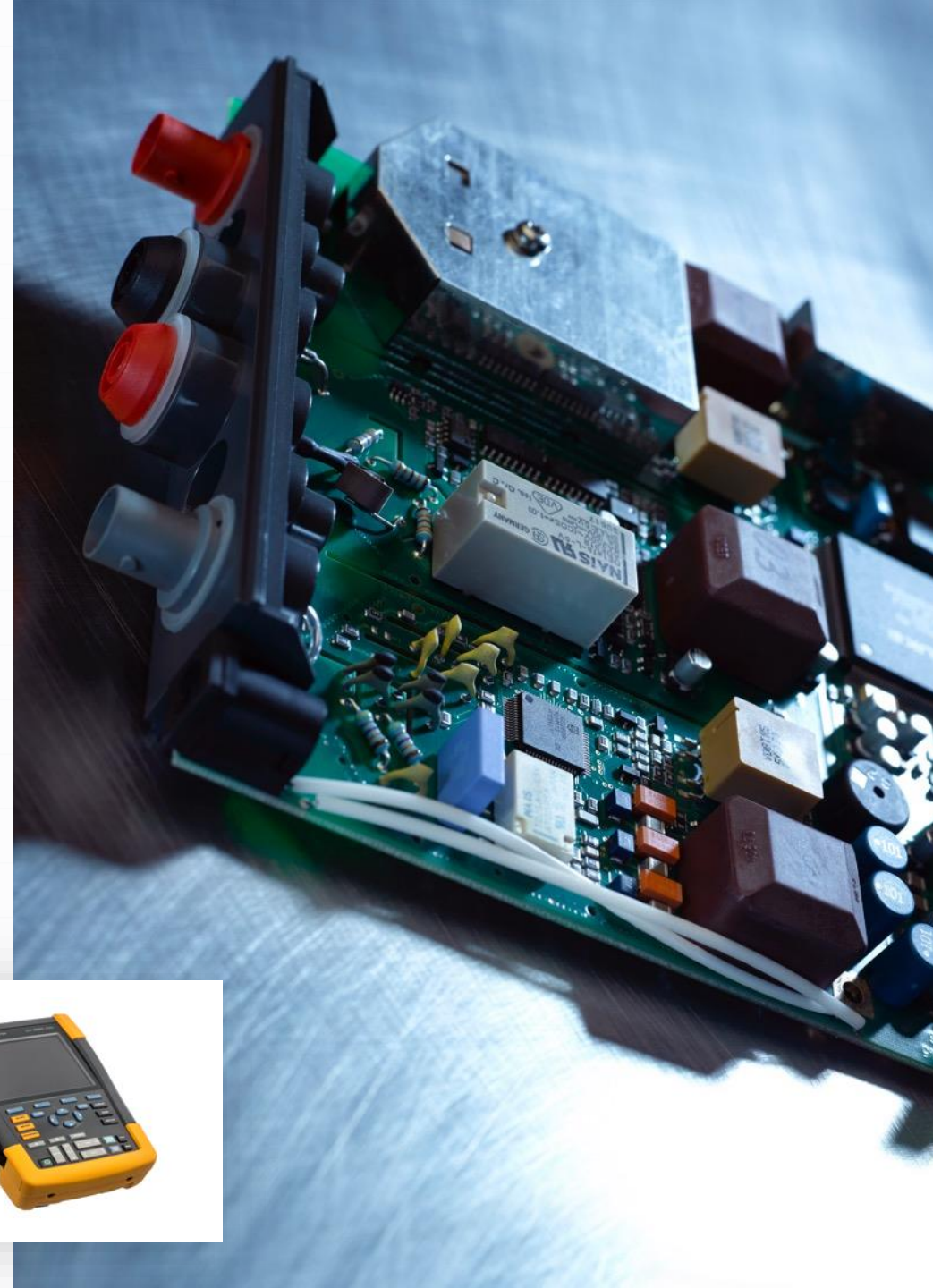


OUR BUSINESS

Industrial With SALLAND
Engineering

- ◆ Flexible power convertor controllers for LED and QL Lighting
- ◆ Motor driver IC's
- ◆ High-side and low-side Driver IC's

- ◆ High-voltage, dual-axis MEMS mirror array driver IC
- ◆ Analog front-end for a handheld Scope Meter
- ◆ Earth-fault circuit breaker

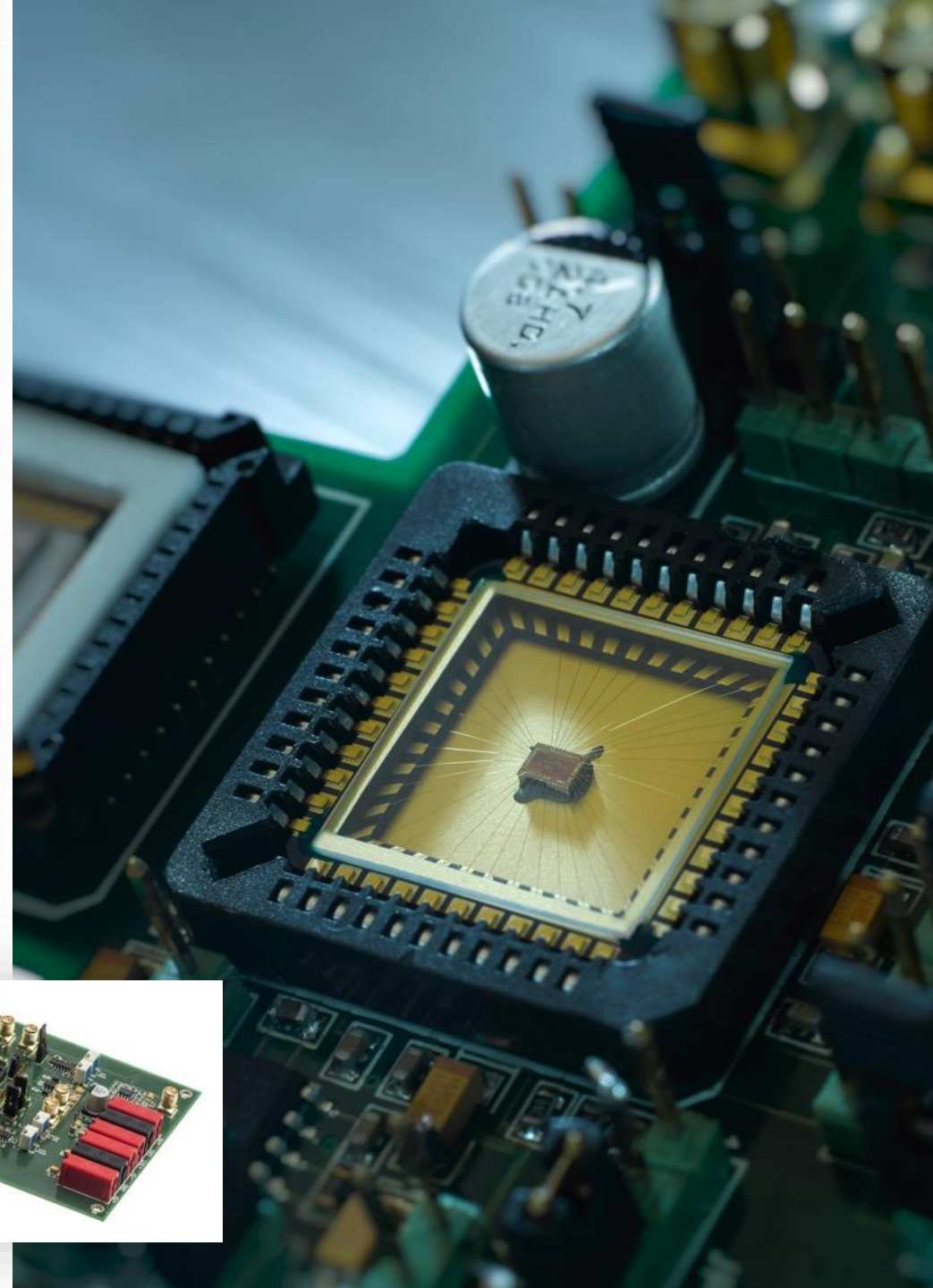




OUR BUSINESS

Automotive

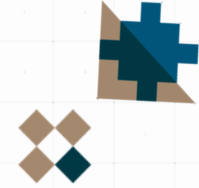
- ◆ Smart power MOSFET and gate drivers
- ◆ Alternator Voltage Regulator (Chinese customer)
- ◆ Versatile Body Control
- ◆ Resonating mirror driver @ 80V with accurate position detection system (IP sold to Infineon)





OUR BUSINESS

EDA Tools, Technology and Foundries



Match technical and commercial requirements

- ✦ Mostly 180-130 nm
- ✦ CMOS
- ✦ BiCMOS
- ✦ SiGE (RF)
- ✦ SOI (RF)
- ✦ BCD (HV)

Foundries

Analog, Mixed-Signal, HV

- ✦ UMC
- ✦ TSMC
- ✦ X-Fab
- ✦ Tower-Jazz
- ✦ SSMC

RF

- ✦ NXP
- ✦ GlobalFoundries

RFwave

EDA Tools

- ✦ Cadence
- ✦ Synopsys
- ✦ ADS
- ✦ LabView
- ✦ Altium Designer



OUR BUSINESS

Evaluation, Qualification and Production Test

Evaluation

- ◆ Own lab facilities including:
 - ◆ Dedicated RF measurement equipment
 - ◆ Thermo streamer
- ◆ Automated evaluation set-ups mostly LabView based
- ◆ Create Application / Evaluation PCB's for Lab measurements

Qualification & Production Test

- ◆ 3rd parties




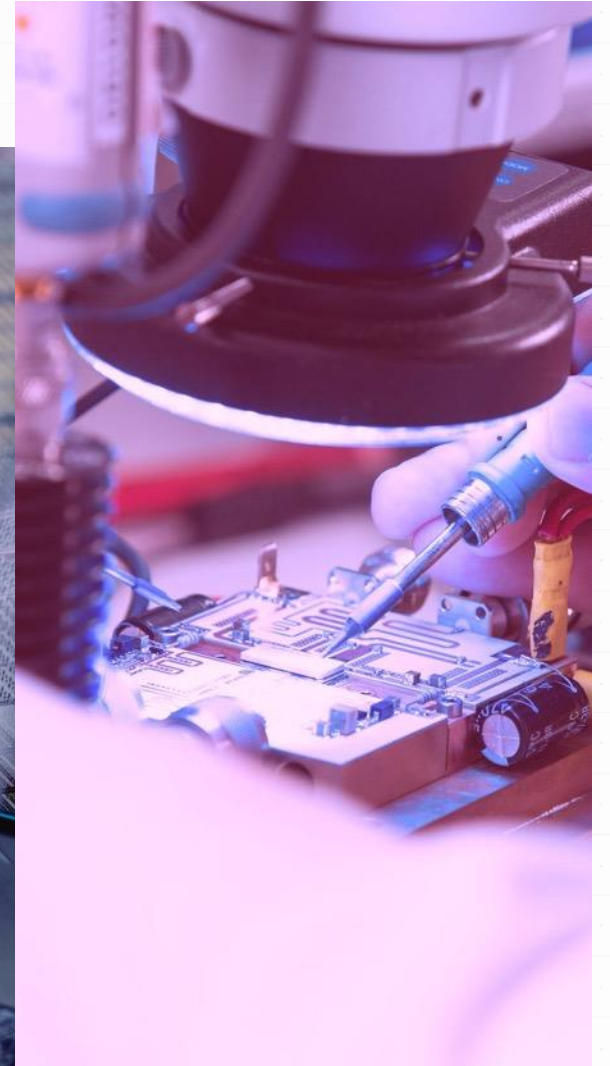
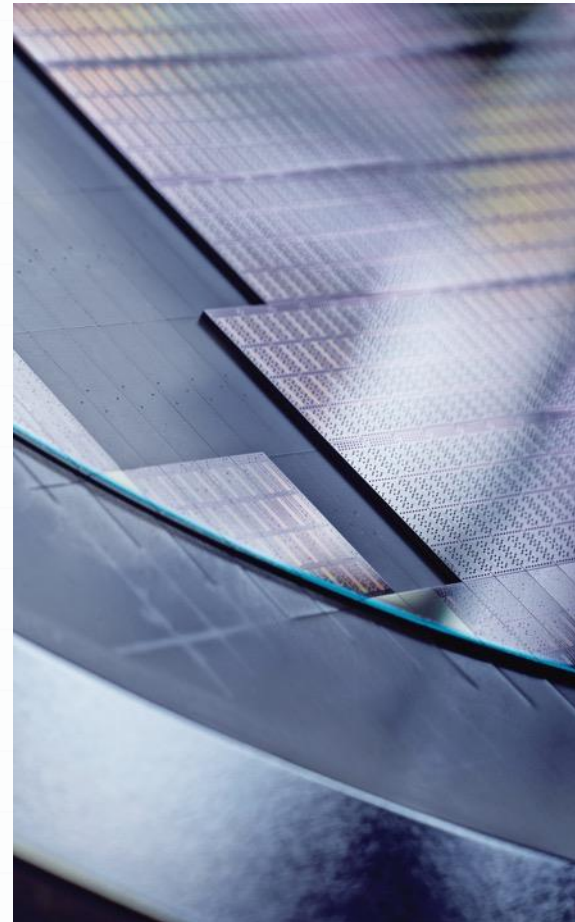
SALLAND
Engineering



OUR BUSINESS COMPONENTS

Production and Supply

- ✦ Complete supply chain
 - ✦ Forecast
 - ✦ Packaging
 - ✦ Testing e.g.  SALLAND Engineering
 - ✦ Shipment (in split lots if needed)
- ✦ Wafer and component storage
in Nitrogen environment > 10 years
- ✦ Separated storage locations for safety reasons



Why work with start-ups?

The fun and the challenges



Only **3%** of start-ups go on to scale up, but they are **Europe's job creation champions**

By creating the right conditions, we can see **more scale-ups, more jobs, more prosperity**



- Endless Can-Do-Mentality & big ego's
- Coming from another field of expertise
- Build up knowledge about other domains
- Ever changing requirements and application
- No clue about electronics or IC
- Typically no SemiCon business experience
- Build trust – focus on the right stuff
- Getting money – Stop-and-Go



a Swiss start-up

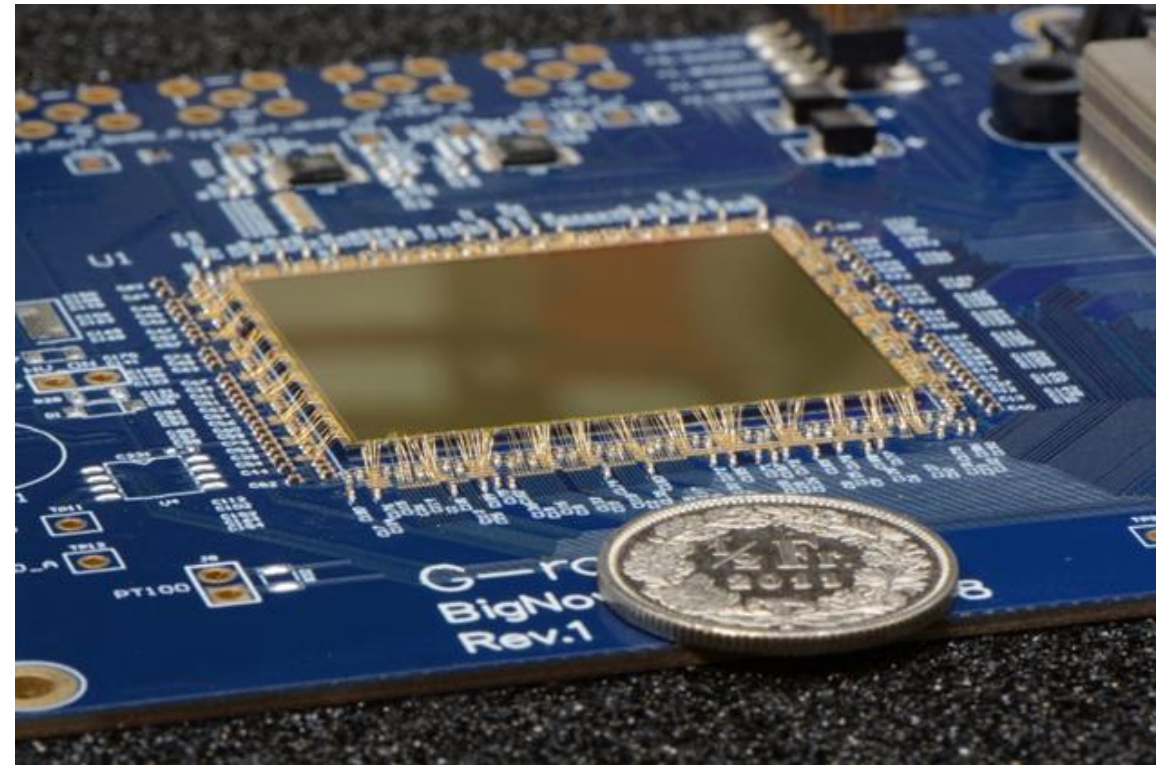


- Build large, novel X-ray detector for mammography
- Low-temperature covalent wafer bonding
 - Realized at a 200 mm wafer scale
- Absorber materials
 - Si, GaAs, CdTe, epitaxial SiGe
- Advantages
 - CMOS compatible
 - X-ray direct conversion
 - Photon counting capability
 - Large-area detectors
 - No bump bonding
- Applications
 - Scientific, industrial, medical
- Needed
 - 2 new technological processes
 - X-ray sensor array
 - Readout electronics for the X-ray sensor

Sensor specification



- 2.4 x 3.0 cm² active area
- 100 μm pixel pitch
- 240 x 300 pixel array: 72'000 pixels
- Dark current compensation up to 1μA / pixel
- 2 discriminators with 12-bit counters per pixel
- Programmable charge amplifier sensitivity
- Parallel 12-bit interface for data readout
- Programmable region-of-interest for readout
- Sequential acquisition/ readout with 2 thresholds or continuous mode with 1 threshold
- 1.8V single power supply
- 587 wire bond pads
- Programmable shaping time: 40/70 ns
- 6-bit in-pixel DAC for threshold calibration



Readout Electronics

High Level Requirements



Customer

- Programmable – requirements change over time (typical for a start-up)
- Flexible – different sensors (absorbers)
- Demonstrator for customers (fool proof, easy to use)

Bruco

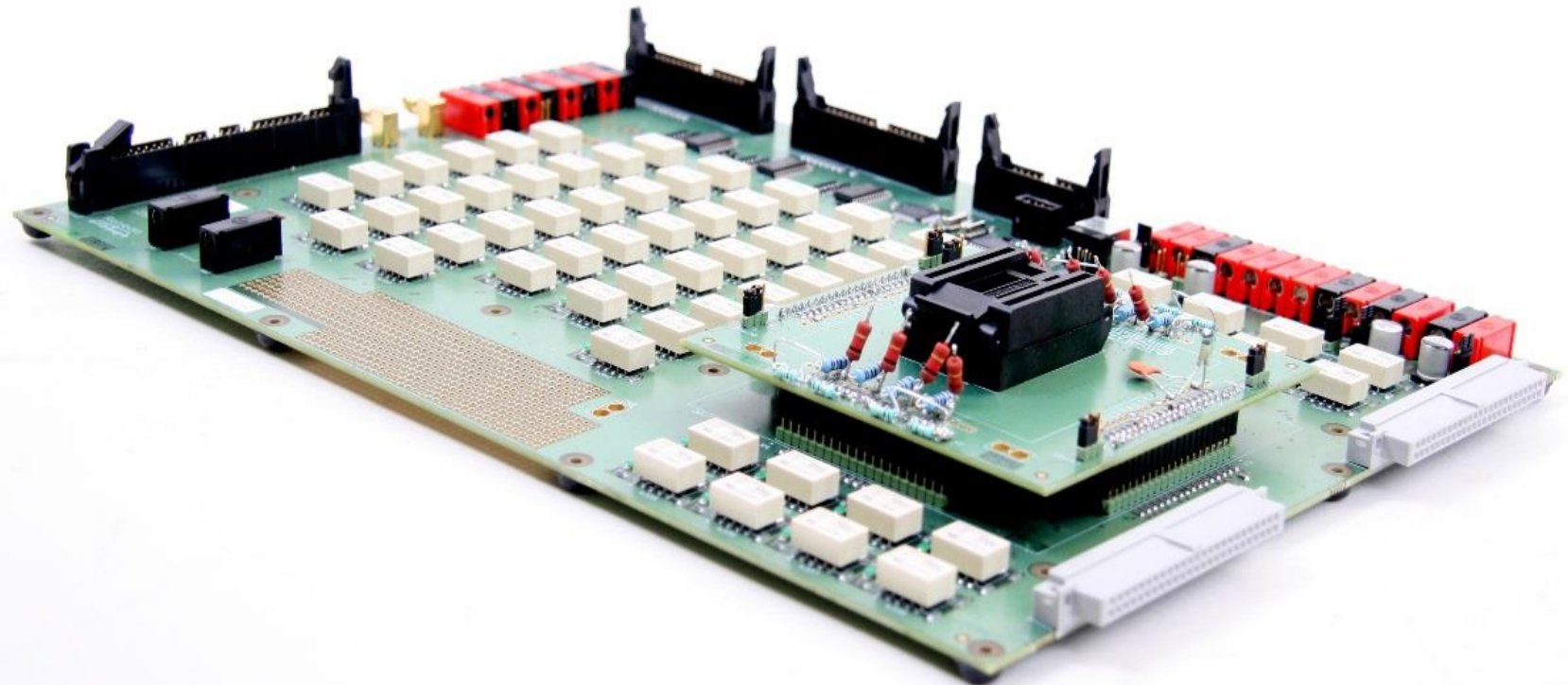
- Build re-usable evaluation platform



Evaluation boards 1

2006 – Versatile Body Controller IC

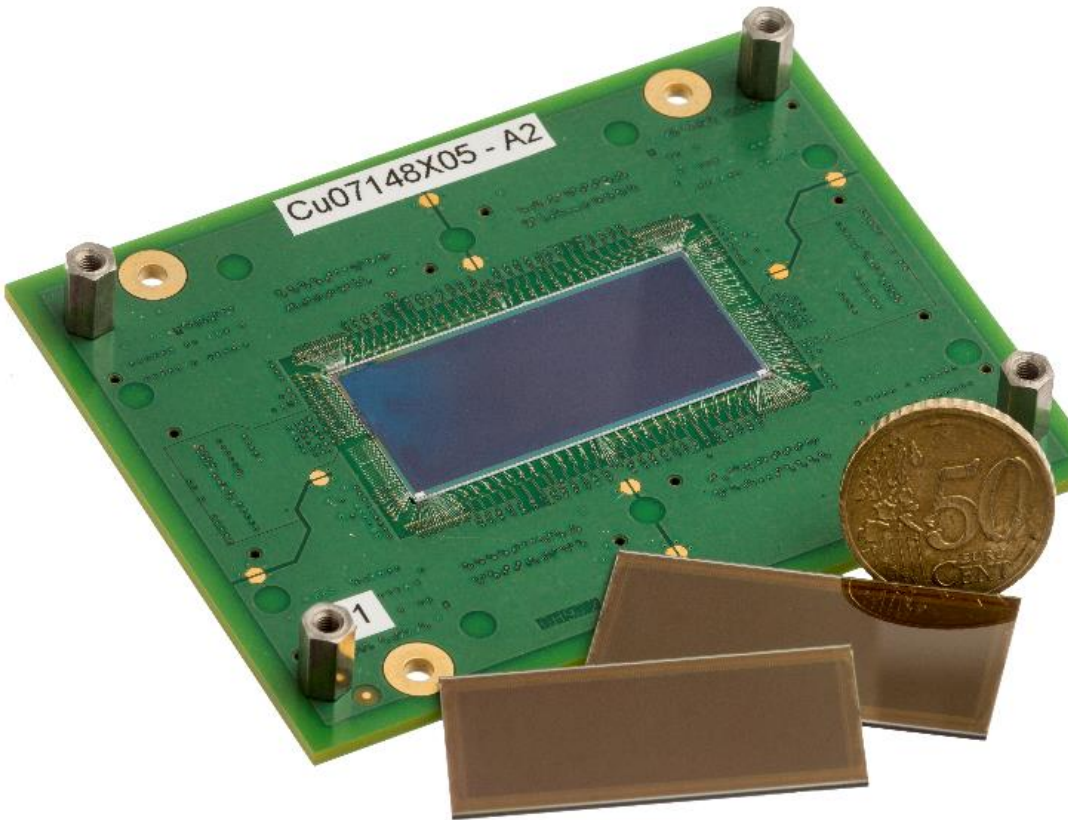
- Flexibility via relays and GPIB controlled instruments
- Test program and results via Labview
- Daughter board with test socket



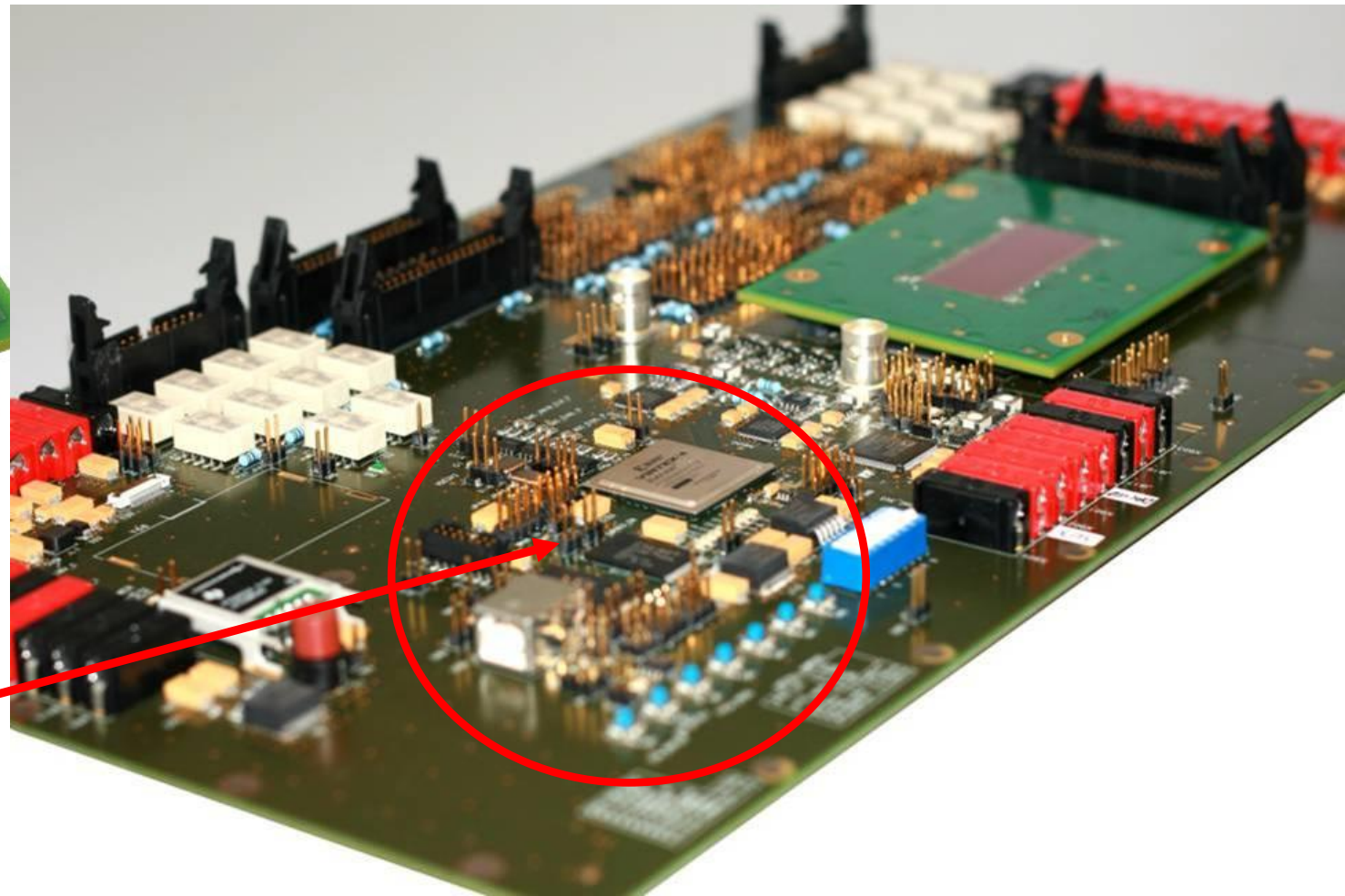
Evaluation boards 2



2007 – 11M MEMS mirror array, 5.0x2.5 cm single die



FPGA with USB-IF



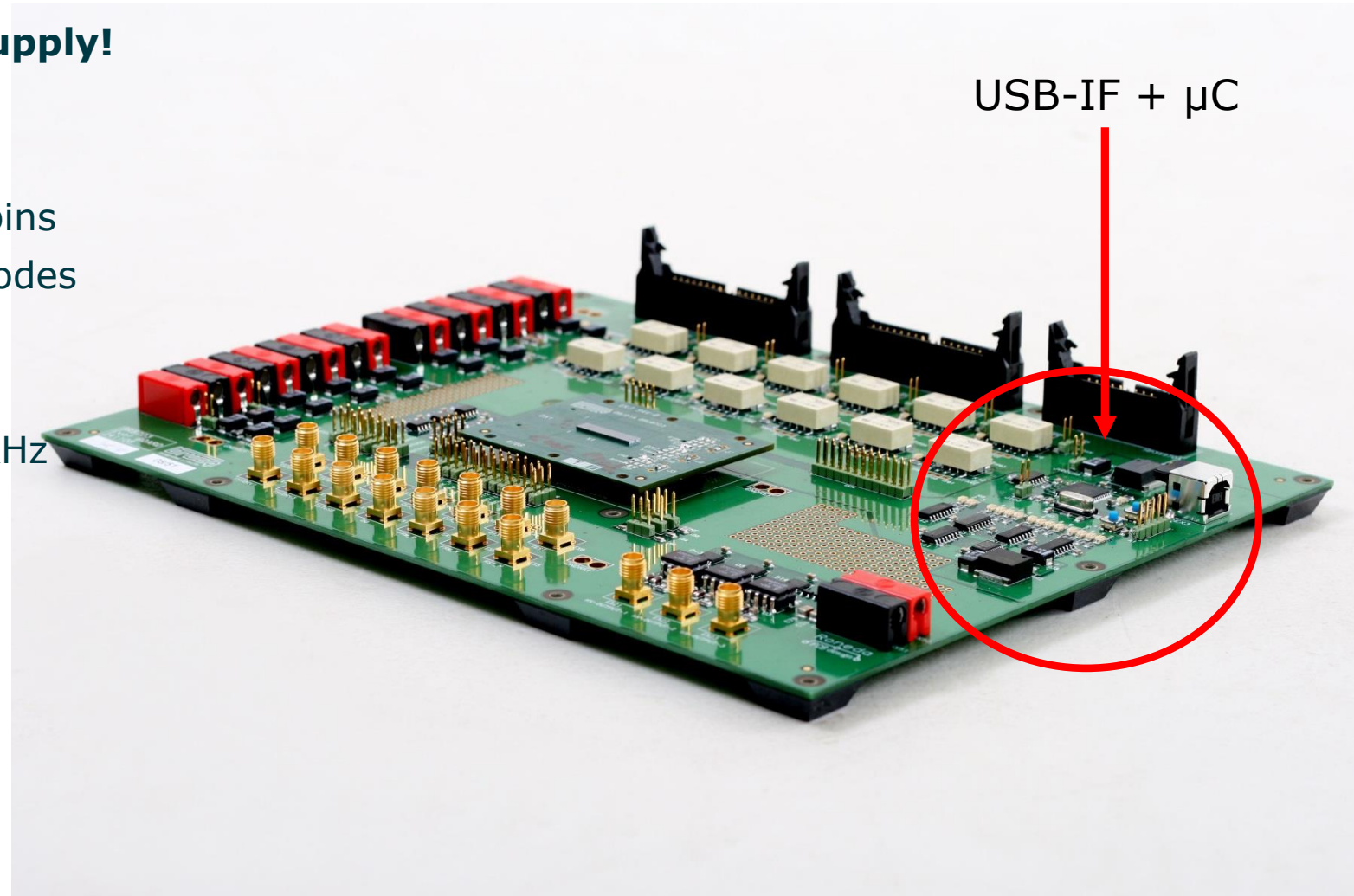
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Evaluation boards 3

2007 – 2-axis mirror array driver



- **From system spec. to supply!**
- **BCD technology**
- 200k gates on die
- Flip-chip, naked die, 254 pins
- 64 mirror drivers, 3 electrodes
- Operating @ 55V
- Die 19x4 mm
- 128 DACs, 12 bits @ 1.5 kHz
- Automated test set-up

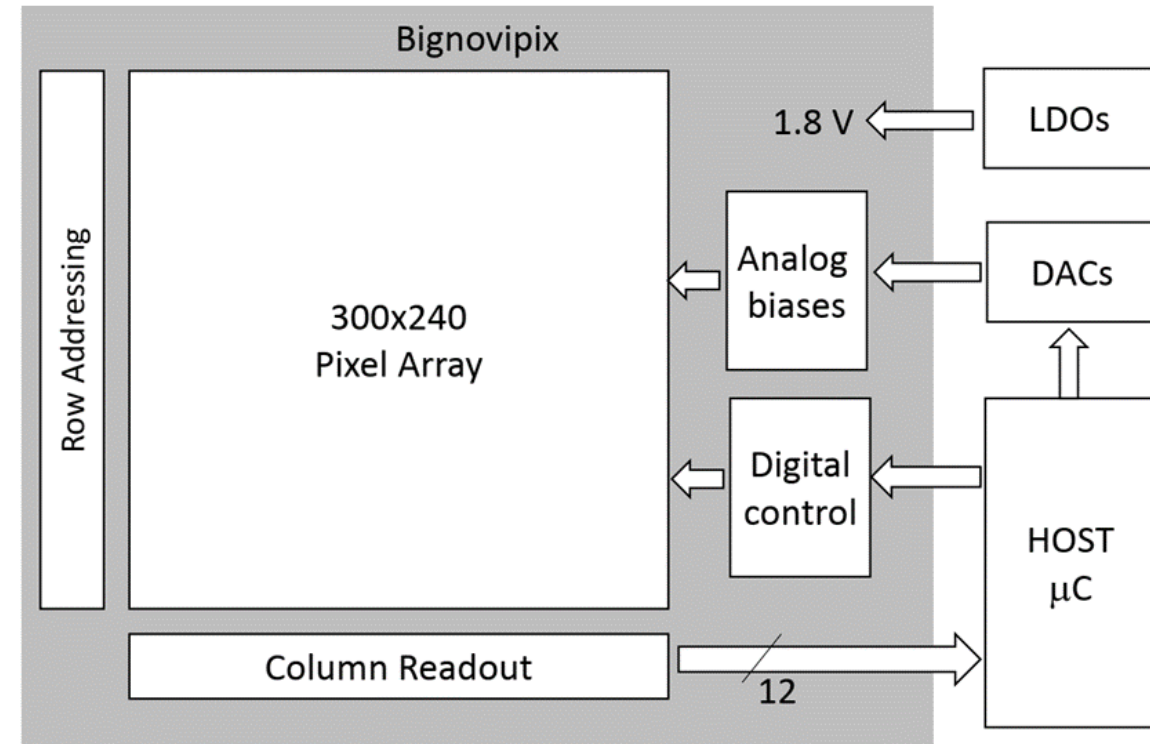




Readout system

More detailed requirements

- 4x Controllable Power Supplies, 1.2 – 2.5V, two with remote voltage sensing
 - 1x High voltage, low-current Power Supply, 4W: 0 - 1kV
 - 8x Controllable reference current 0-5 mA, 0.1% full-scale
 - External, isolated 12V Power Supply
 - Power Supply monitoring on the sensor board
-
- 8 temperature and humidity sensors close to the X-ray sensor
 - I²C EEPROM unique ID + calibration info



The resulting system

What we designed



Hardware:

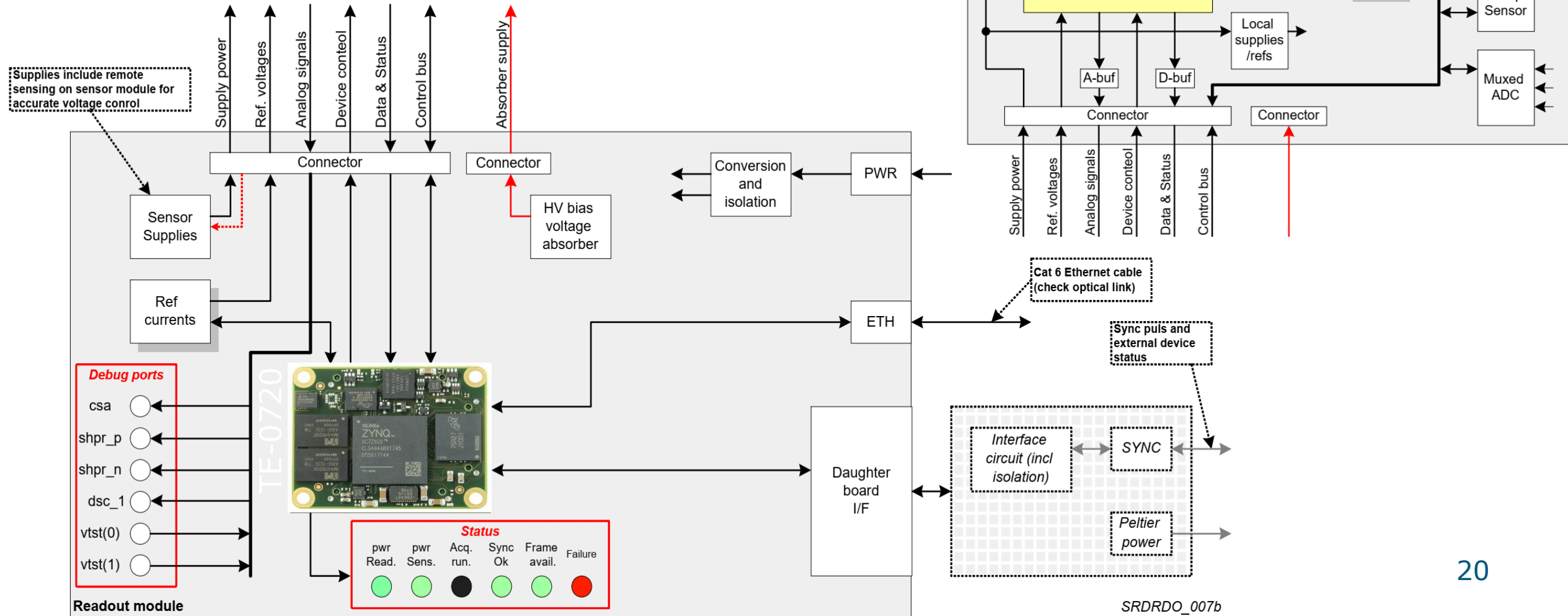
- Use of standard Trenz module, TE0720 with Xilinx ZYNQ SoC featuring integrated FPGA + ARM core and 1GB ethernet
- Autonomous sensor acquisition
- Frame rate, acquisition window, shutter programmable
- Timing crystal based (RTC disabled)
- 120 pins IF between sensor and FPGA
- Hardware controls the Power Supplies based on sensor ID
- Defined our own interface between CPU and FPGA

Software:

- CPU: Application, command line
- Compiled PetaLinux (Xilinx) to run on the ARM core
- SFTP to read sensor images and to upload command scripts
- SSH for command handling – parallel sessions tested
- Virtual serial port via USB (PuTTY) – Service interface (log information)

Readout system

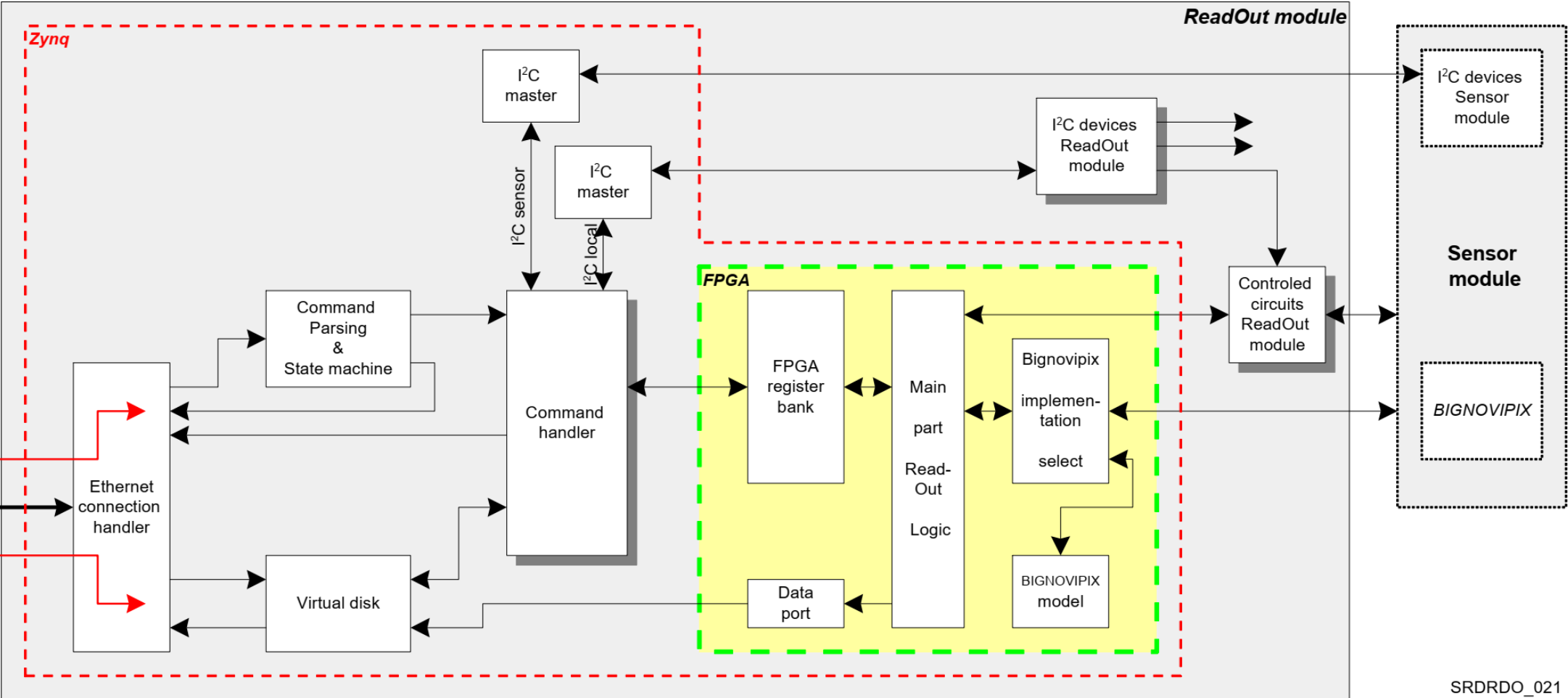
Functional overview





Readout system

Software/ hardware partitioning



Personal delivery...

... and a happily smiling customer



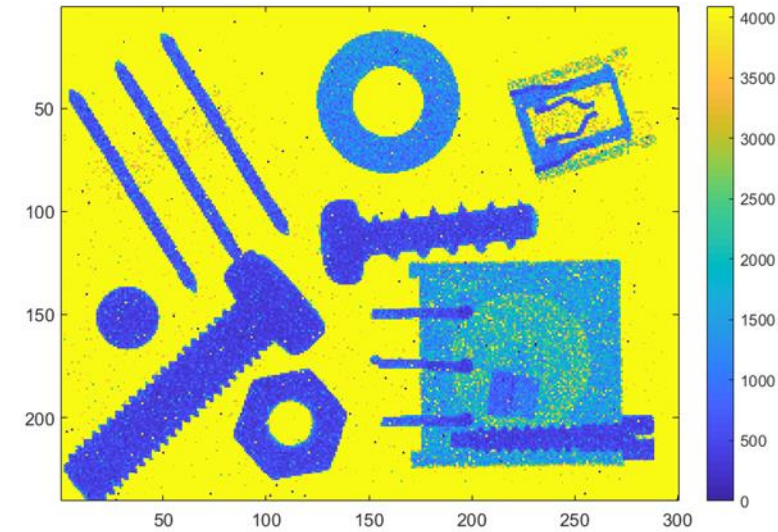
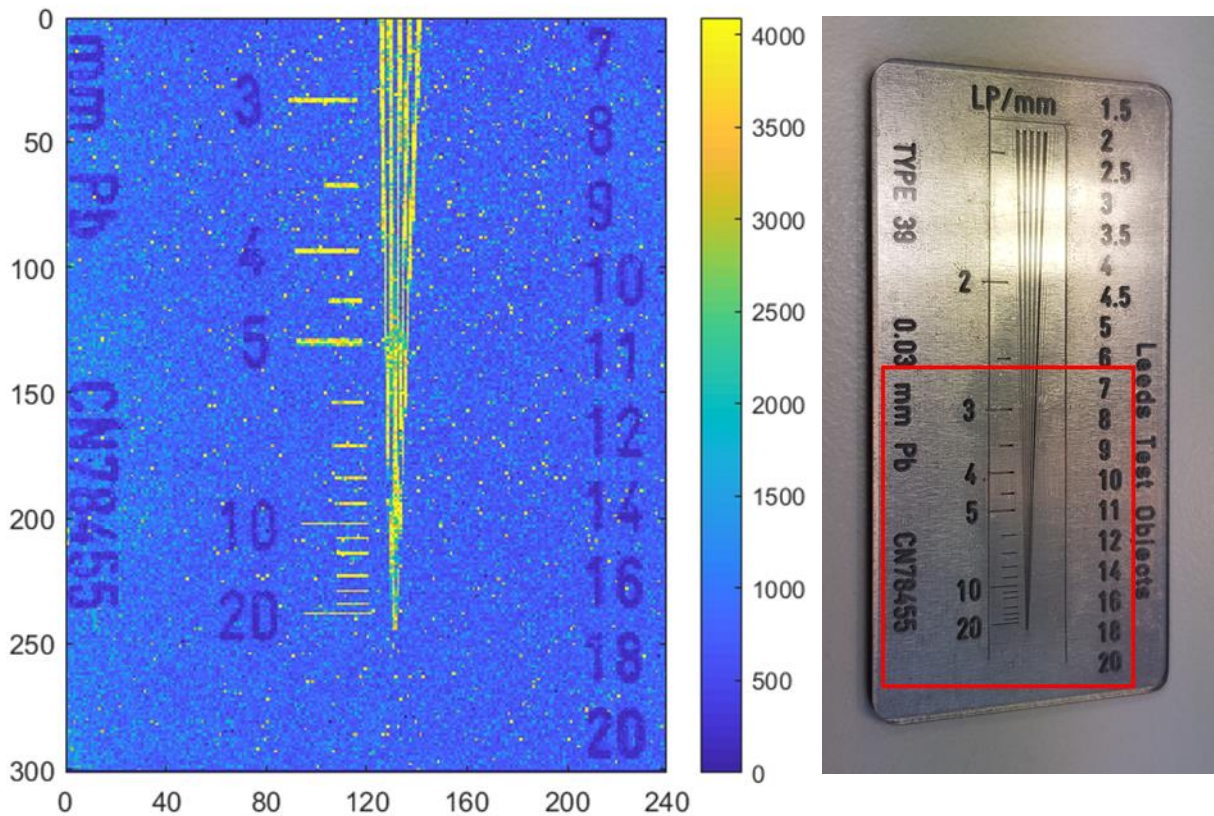
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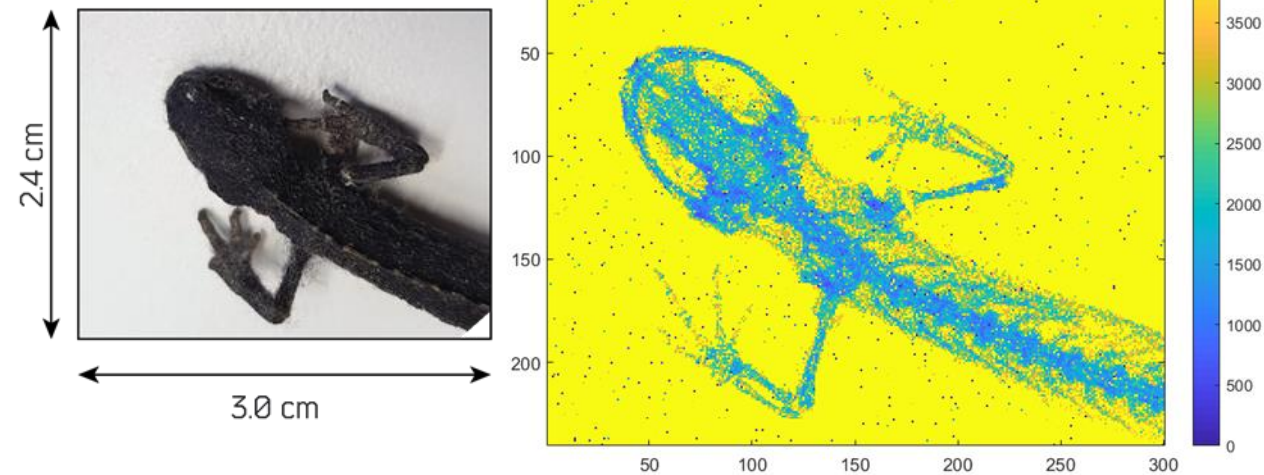
The results

X-ray Detector characterization

Pb-phantom with diverging lines: 5 lines/mm resolved



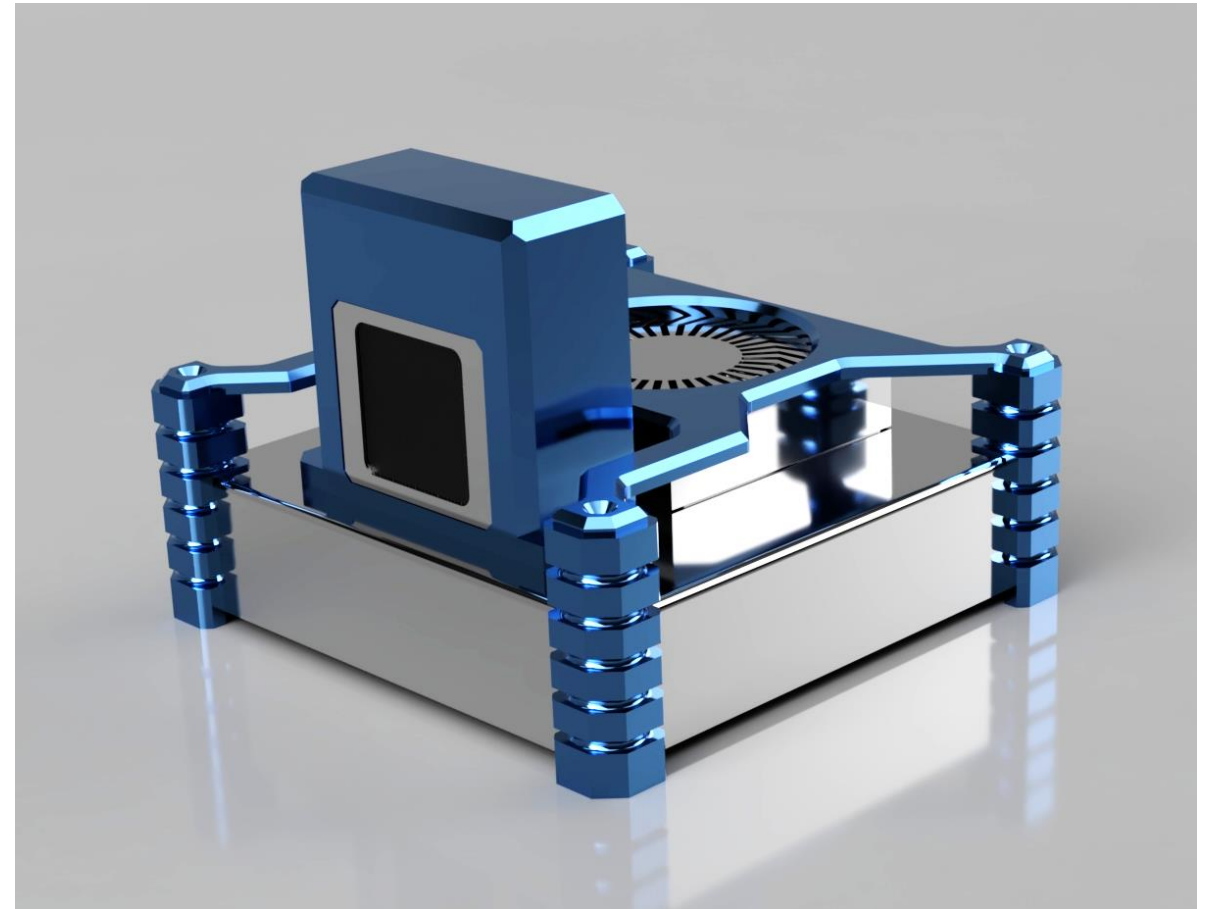
Petrified salamander sample



What is next?



- G-ray to sell the demonstrator kit to it's customers
- Develop bigger sensors with new readout electronics
- Get onboard with IC Development
- Re-use the developed evaluation platform for other Bruco customers and applications



Thank you for your attention

Questions?



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