



# Recent IDEAS ASICs for Radiation Detection and Imaging

Application Specific Integrated Circuits and Systems for Radiation Detection and Imaging

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# IDEAS Facts

## Business

## Radiation Detection and Imaging

## Products

ASICs full-custom mixed mode design, chips/wafers

## Markets

Astrophysics, Space, Nuclear Science, Medical, Environmental Monitoring, Security

## Model

Fabless Semiconductors

Integrated Detector Electronics AS (IDEAS) is located at Fornebu near Oslo, Norway

Founded in 1992 under the name IDE AS

Year 2013: 100% privately owned, revenues €2m, staff of 17 from 8 countries

Degrees in electrical engineering, applied physics, and business administration

Devoted to developments for radiation detectors and imaging systems



# Location at Fornebu near Oslo



40min. by train to Oslo airport Gardemoen



# IDEAS Faces



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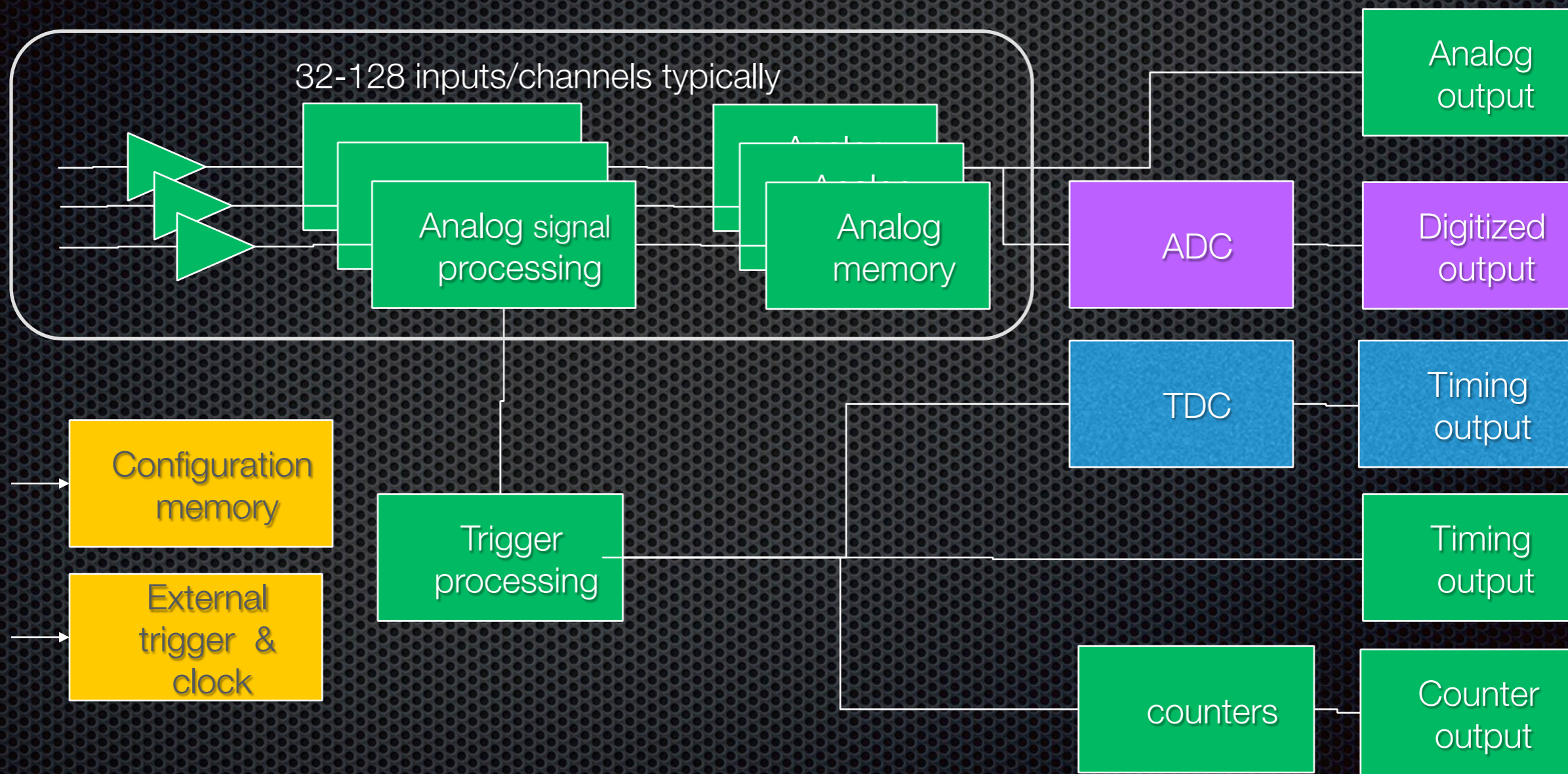


Dirk Meier, Dr. rer.nat., Dipl. Phys.,  
Product Manager,  
dirk.meier@@ideas.no

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# Classical ROIC/ASIC Architecture – Front-end Electronics for Radiation Detectors



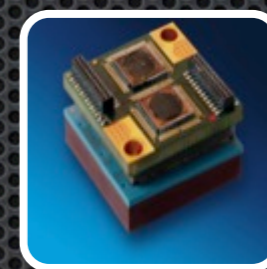
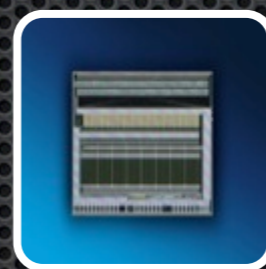
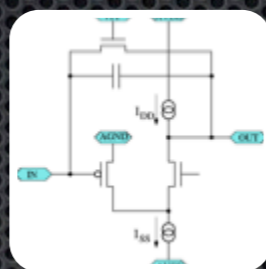
# Other ASIC Architectures

Ongoing activities with non-ionizing radiation:

1. Near Infrared Readout and Controller ASIC for Focal Plane Array MCT
2. FE ASIC for mm-wave imaging
3. Energy harvesting with MEMS



# ASIC Development Process



**KO - Project Kick-Off**

- Contract,
- Statement of Work

**SRR - System Requirements Specification**

- ASIC Development Plan,
- ASIC Requirements Specification,
- Feasibility and Risk Analysis

**PDR – Preliminary Design Review**

- ASIC Preliminary Datasheet,
- ASIC Verification Plan

**CDR – Critical Design Review**

- ASIC Design Validation Plan,
- ASIC Updated Datasheet

**TRR – ASIC Test Readiness Review**

- ASIC engineering samples,
- ASIC test system hardware

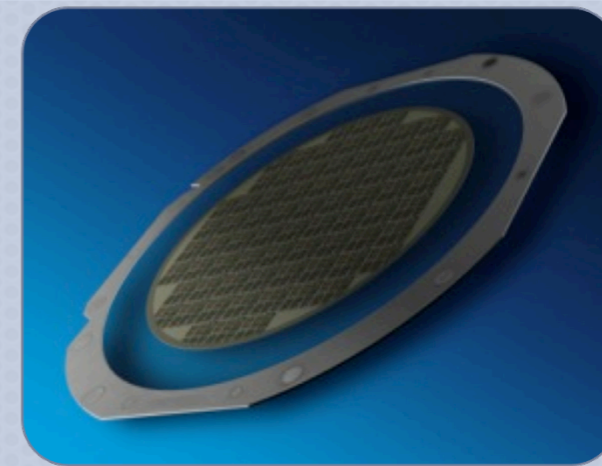
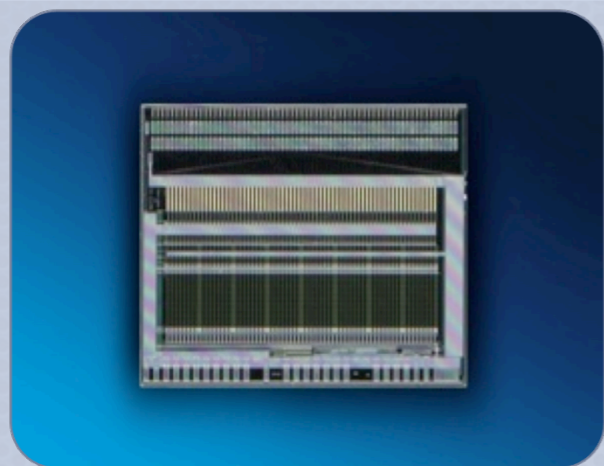
**QR/AR – Quality and Acceptance Review**

- ASIC Design Validation Report
- ASIC Final Datasheet

ECSS-Q-ST-60-02 ASIC/FPGA development, and other standards of the European Corporation for Space Standardization



# ASIC Design, Prototyping, Qualification, Manufacture



IDEAS does full-custom mixed mode, analogue and digital IC design.

Analogue ASIC design: schematic capture, circuit simulation, process corners (PVT), layout, physical verification (LVS, DRC)

Digital ASIC design: VHDL/Verilog, behavior simulation, synthesis, scan insertion, P&R, extraction, verification

IDEAS compliant ECSS-Q-ST-60-02 ASIC/FPGA development, ECSS-M-ST-10 Project planning and implementation, IEC 60601 Medical electrical safety and performance

IDEAS performs ASIC design validation and qualification.

IDEAS designs prototype systems, does verification of the ASIC functional and performance requirements, if needed with ionizing radiation.

IDEAS does verification and validation of physical and environmental requirements specifications.

MIL-STD 883 Test method standard for microcircuits, radiation effects characterization (SEE, TID)

IDEAS directly work with the wafer foundry (AMS, XFAB, Tower, TSMC) on wafer processing and ASIC manufacture. IDEAS specifies engineering services, if needed (process options, dicing, thinning)

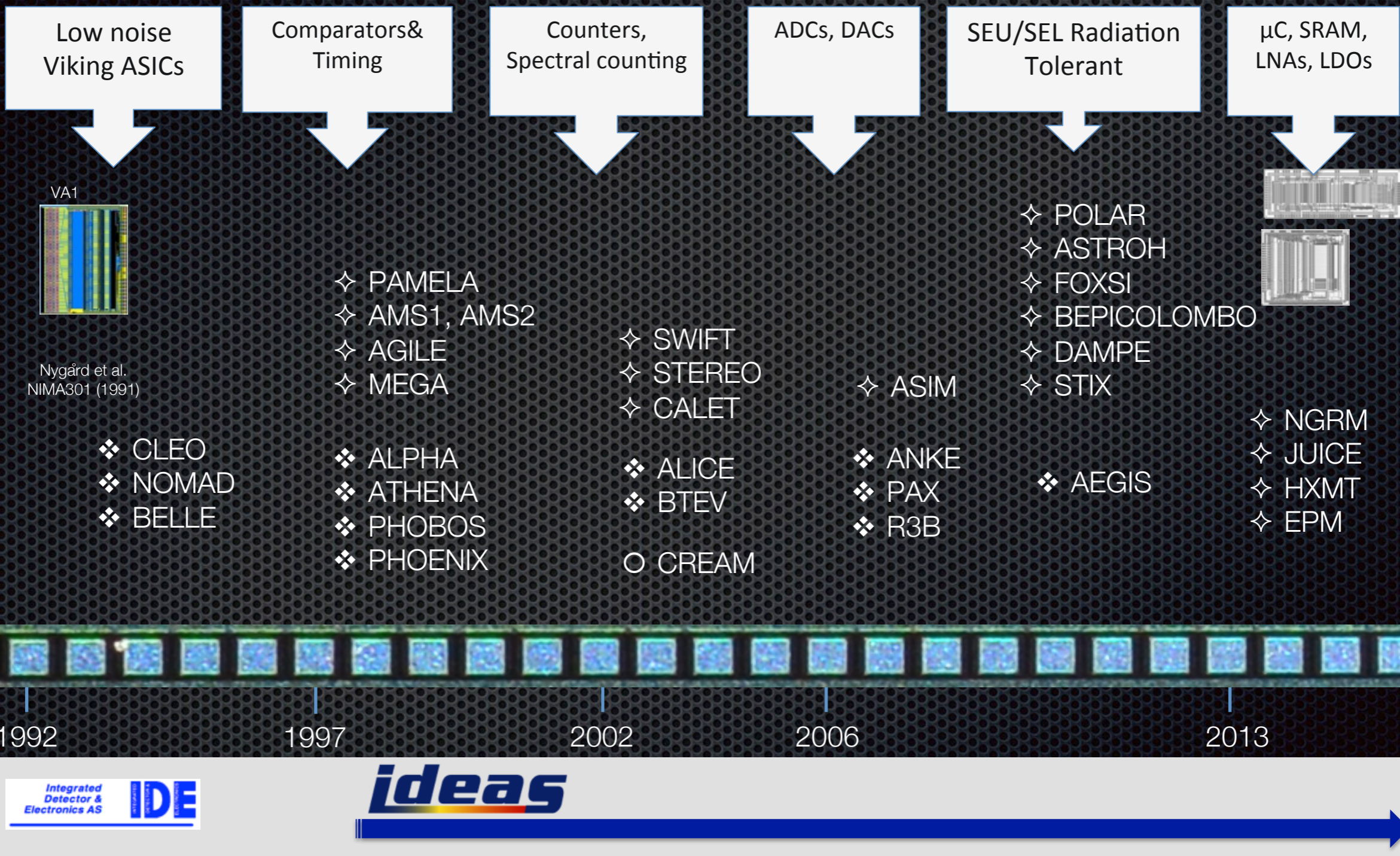
IDEAS specifies and sub-contracts lot acceptance tests (LAT), wafer level probe testing, packaging services

AMS design and production is ISO/TS 16949:2009 and ISO 14001:2004/Cor 1:2009





# Heritage of IDEAS ASICs for HEP & Astronomy



# Medical Imaging

We have worked with medical companies on ASICs and imaging sub-systems for SPECT, PET, CT for medical applications.

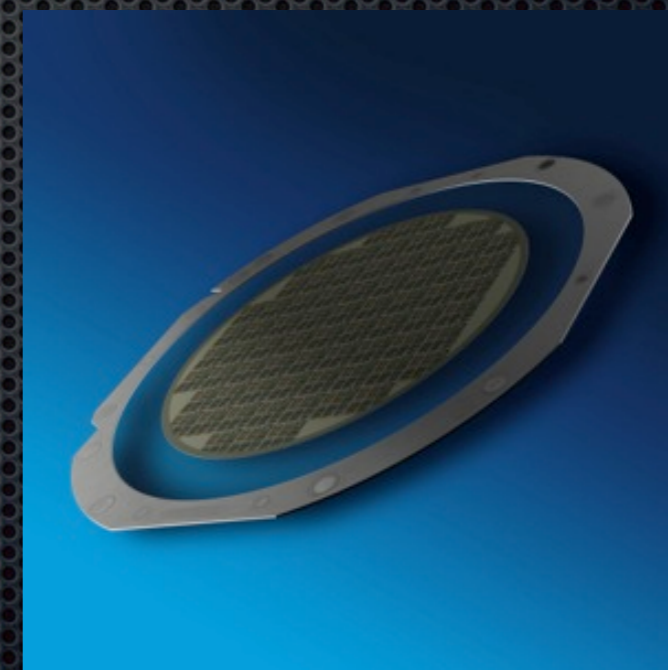
Recently



LumaGEM MBI



$\mu$ SPECT, SPECT/MRI,  
Color CT



# Astronomy / Astrophysics

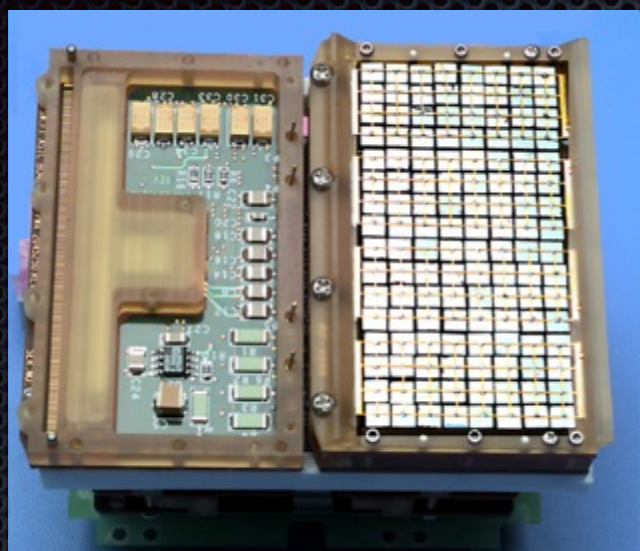
## Ongoing ASIC developments for Astrophysics

Experiment	ASIC and Detector	ASIC Development Phase
CAS/DAMPE, Dark Matter Particle Explorer	<b>IDE3160</b> and <b>IDE1140</b> , CSA/Triggers for PMT and silicon readout	Validation and Qualification
ESA/NGRM, Next Generation Radiation Monitor	<b>IDE3465</b> , CSA/Triggers for charged particle counting in silicon	Validation and Qualification
ESA/RADEM, Radiation Hard Electron Monitor for JUICE	<b>IDE3466</b> , CSA/Coincidence Counters for charged particles in silicon	Design
BSSL	<b>IDE1180</b> , CSA for MCP anode strip readout	Design
ESA/NIRCA, Near Infrared Readout and Controller ASIC in Space	<b>NIRCA</b> with MCT FPA, LNAs, SAR ADC, LDOs, $\mu$ C, SRAM, FSM, SPI	Manufacture
ESA/SiPM, Readout for Silicon Photomultipliers in Space	<b>ASIC</b> for SiPM, pulse height spectroscopy and timing CSA, CC, TAC, ADC, SPI	Design



# High Z Materials

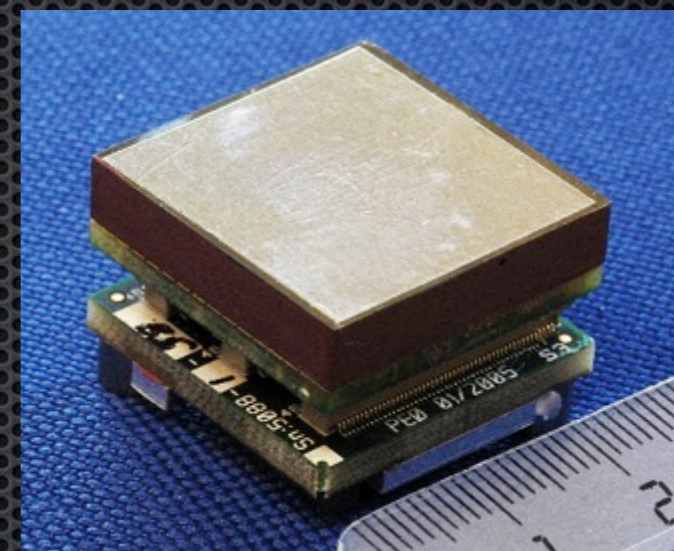
eV CZT



SWIFT/BAT

Our customers use many high-Z materials:

- CZT
- CdTe
- TlBr
- Ge
- HgI
- MCT



ACRORAD CdTe



Castilla, et al., "Development of a 24x24 CZT-FEE pixel detector block for the CSTD project", Nucl. Sci. Symp. IEEE, 2008.



Mikkelsen, Meier, Maehlum, et al., "An ASIC for multi-energy x-ray counting", Nucl. Sci. Symp. IEEE, 2008.

# Environmental Radiation Monitoring

Experiment/Facility	ASIC and Detector	ASIC Development Phase
GammaVision/IDEAS	<b>IDE3421</b> , 128+2 channel CSA for CZT	Prototype hardware, uses "GammaPipe"
UoM/H3D/Polaris	<b>VASTAT</b> , 121+2 channel CSA for CZT	Demonstrator hardware
AstroCAM/JAXA	<b>VATA450</b> , 32 channel CSA for CZT	Demonstrator hardware
Advanced Detectors for Better Awareness of Neutrons in the Environment	<b>VATAGP7.1</b> , CSA with trigger for silicon sensors with converter material	Design, and Prototype hardware
Portable x-ray dose meter	<b>IDE4281</b> , 16 channel CSA for CZT or n-side readout of silicon diodes	Potential idea



Image: JAXA

Real-time imaging of visible light and  $\gamma$ -radiation sources and isotope identification.

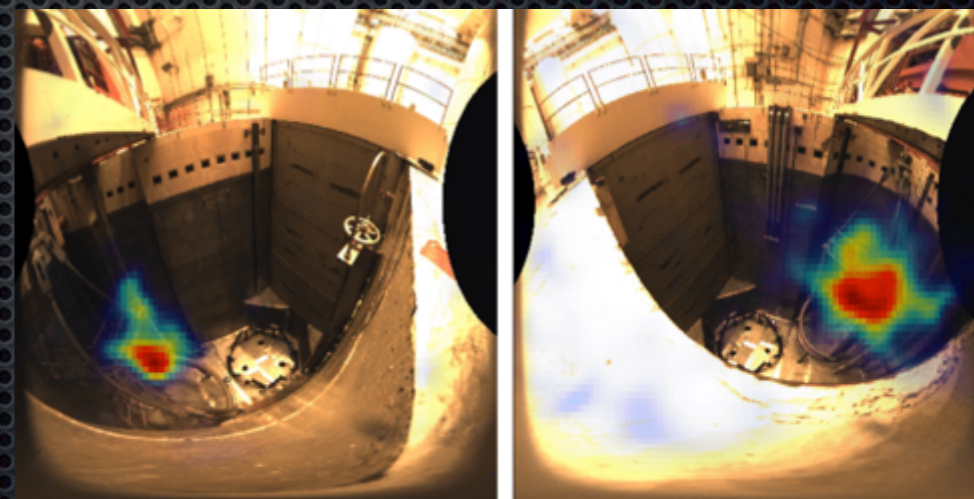
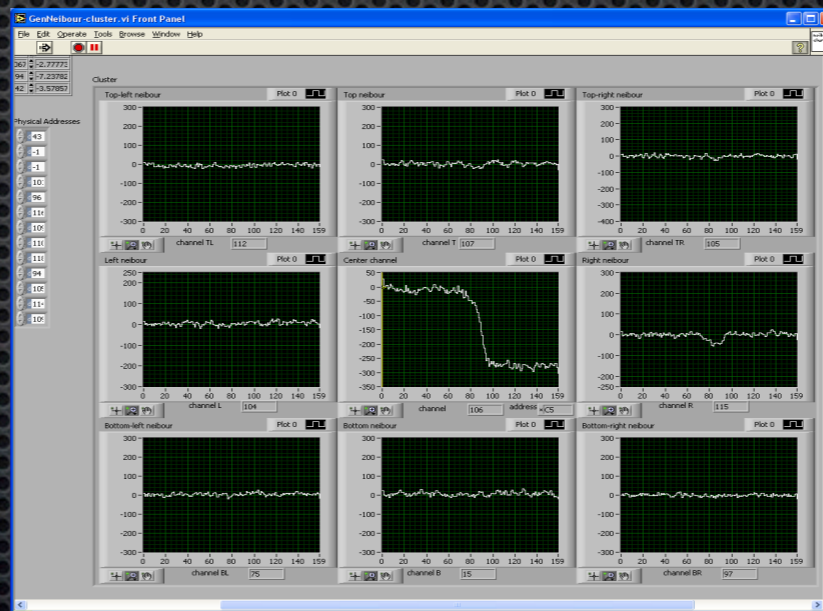
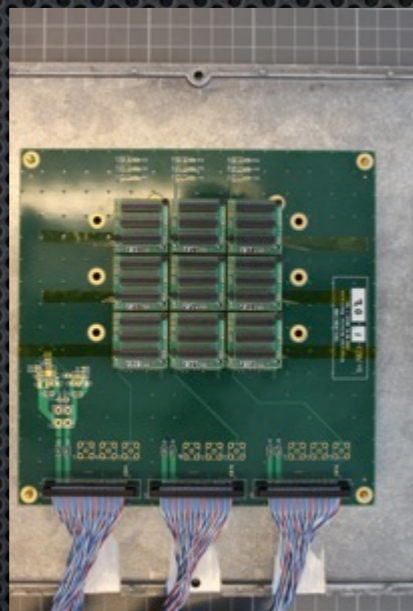
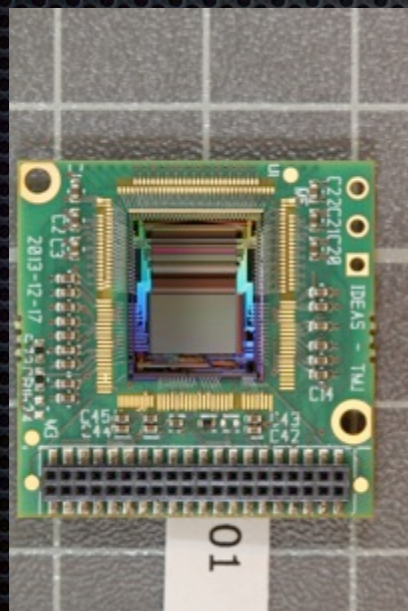
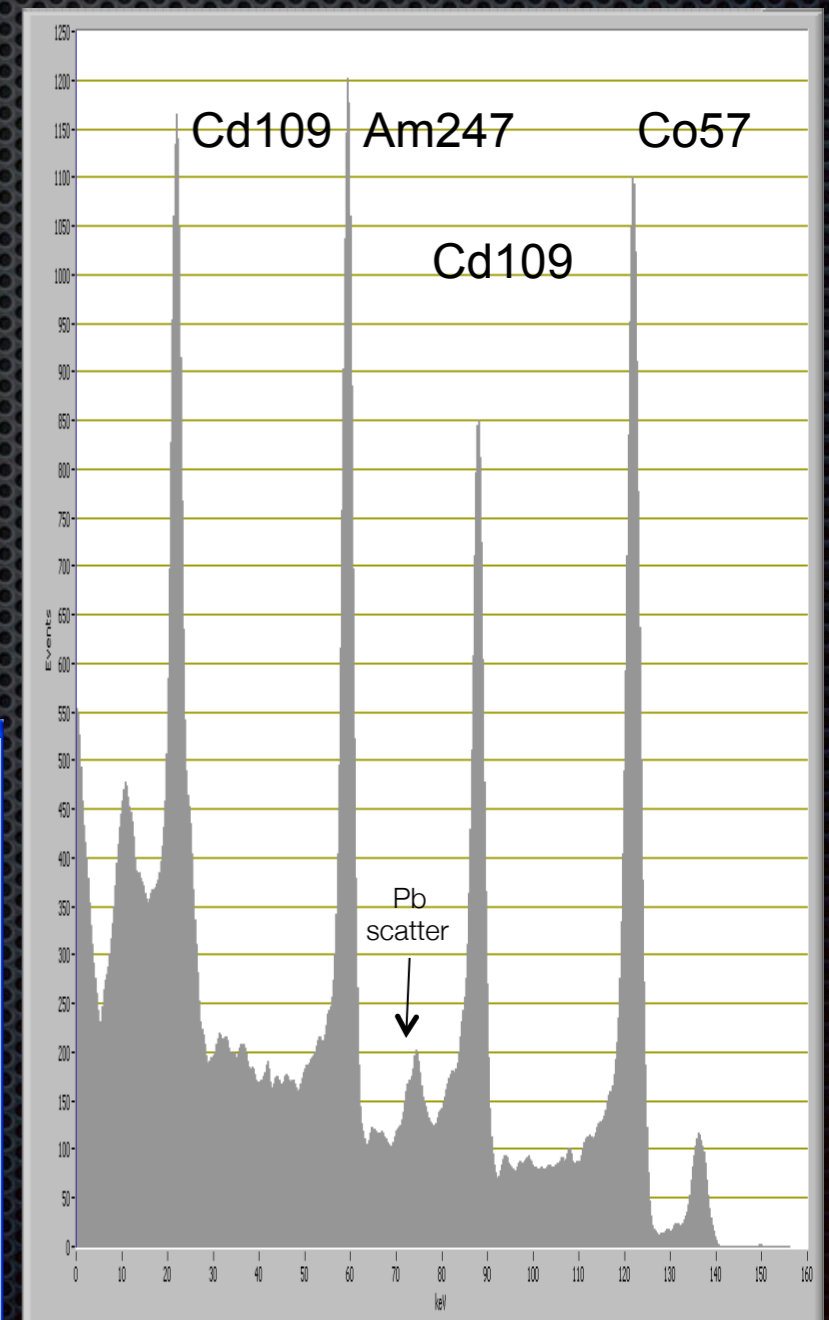


Image: H3D



# GammaPipe Readout

- Readout and control of pixelated CZT up to 9 MeV
- 9 CZT crystals read by 9 ASICs
- 11 x 11 anode pixels per CZT crystal
- 2 cathode per CZT crystal
- Pre-amp output waveform sampling in all pixels
- PC connection via Ethernet TCP/UDP



# Hadron Therapy

Experiment	ASIC and Detector	ASIC Development Phase
In-vivo dosimetry with a gamma camera based on the Compton scatter principle	<b>IDE3421</b> , 128+2 CSA waveform sampling in CZT	Validation and qualification, design iterations, hardware and software prototype available



# Neutron Facilities

Experiment/Facility	ASIC and Detector	ASIC Development Phase
ESS	<b>VA32TAP3</b> , CSA for MAPMT for counting in FPGA	Demonstrator hardware, SoNDe – Solid State Neutron Detector H2020-INFRADEV proposal
?	<b>IDE1180</b> , CSA with MCP with boron or gadolinium, high rate (5Mcps/channel)	Idea for discussion
?	Pixelated ASICs, <b>IDE3241</b> type ASIC with 3D integration / direct attach to a pixelated neutron detector array	Idea for discussion





# MA PMT Readout

Charge measurement up to 20 pC

Trigger from PMT dynode signal

Read out rate 1kHz

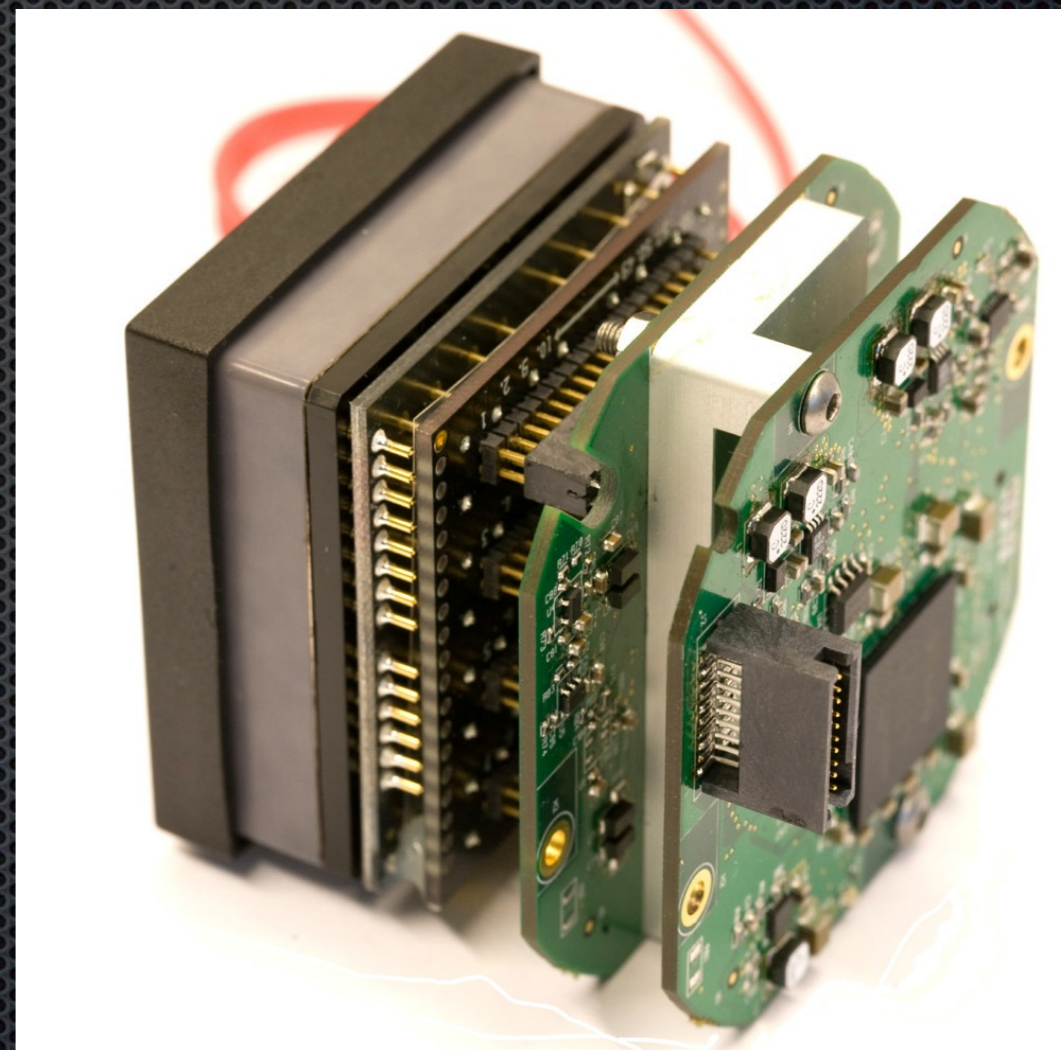
8-bit resolution

3V to 5V supply voltage

2W power consumption (w.o. tube)

Spectroscopy and counting

Available with short delivery time, samples  
from stock



# Commercial Off-the-Shelf COTS ASICs

ASIC ID	Description	Lead time (weeks)
IDE3464, IDE3465	16+4 channel RO for silicon radiation monitor	2
IDE1140	128 channel RO for silicon particle tracking	2
IDE1160, IDE2160, IDE3160	32 channel RO for PMTs anode and dynodes	2
IDE3450, IDE3460	32 and 64 channel RO with ADC in each channel for CdTe and APDs	2
VATA64HDR16	64 channel RO for SiPMs	2
IDE4184	128 channel RO for CZT	2
CA3	32/64 channel multi-energy counting with CdTe/CZT	2
VASCM3	128 channel readout for silicon in switched current mode with CDS	2
NIRCA	Near infrared controller ASIC, engineering model	Year 2015
IDE3466	32+4 channel CSA with coincidence counters	Year 2015
IDE1180	16 channel CSA for MCP	Year 2015
SIPHRA	16 channel CSA for SiPM with TAC and ADC	Year 2016



# Recent Publications

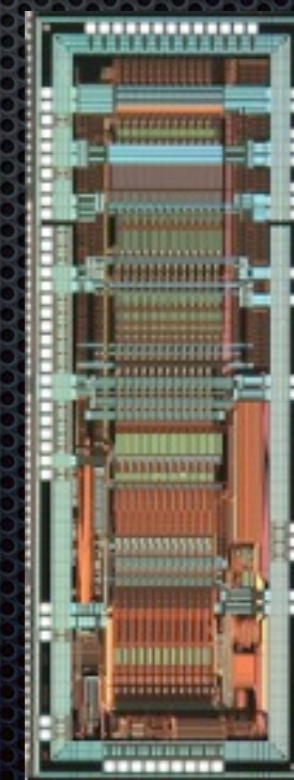
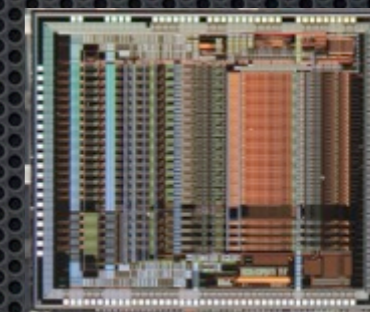
Meier/IDEAS, et al. (2014) Development of an ASIC for the Readout and Control of Near-Infrared Large Array Detectors. Proc SPIE Astronomical Telescopes and Instrumentation.

Meier/IDEAS, et al. (2013) Development of an ASIC for Charged Particle Counting with Silicon Radiation Detectors. Proc IEEE Nuclear Science Symposium.

Meier/IDEAS, et al. (2013) Development of an ASIC for the Readout of CdTe Radiation Detectors in Space. Proc IEEE Nuclear Science Symposium.

Wang, Meier/IDEAS, et al. (2011) Material Separation in X-ray CT with Energy Resolved Photon-Counting Detectors. Med Phys 38:1534-46.

Meier/IDEAS, et al. (2011) A SPECT Camera for Combined MRI and SPECT for Small Animals. Nucl Instrum Methods 652:731–734.



# Thank you

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