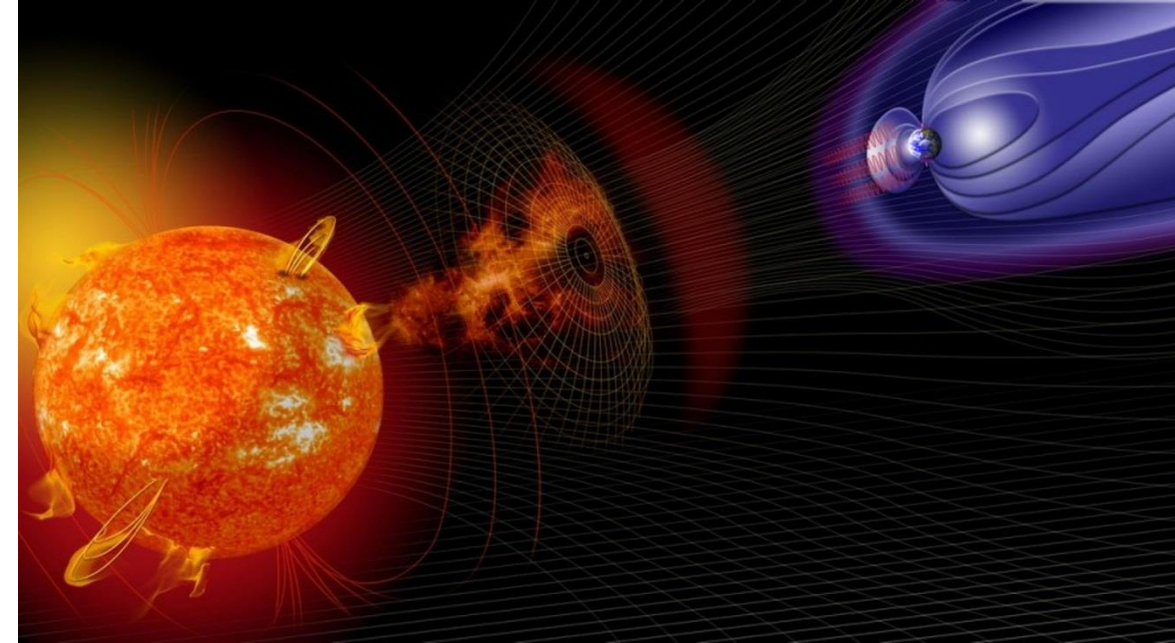


Miniaturised Readout Solutions for Spaceborne Ionising Radiation Detectors



[NASA]

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SPACEMON workshop, ESTEC, The Netherlands, 2017-12-14



UiO : Universitetet i Oslo



Integrated Detector Electronics AS (IDEAS)

- Privately owned Norwegian company.
- History: Founded in 1992 as a spin-off from Norway's high-energy physics activities at CERN.
- Purpose:
 - Integrated circuits for radiation detection, infrared, X-rays, gamma rays and (charged) particles.
 - Systems used in industrial and scientific applications including space missions.
- More than ASIC development: physics + engineering design, test and verification.



HQ: Gjerdrums vei 19, 0484 Oslo, Norway
Resellers in China and Korea
www.ideas.no

Goal: Enable instrumentation for constellations

Reduce overall complexity & cost:

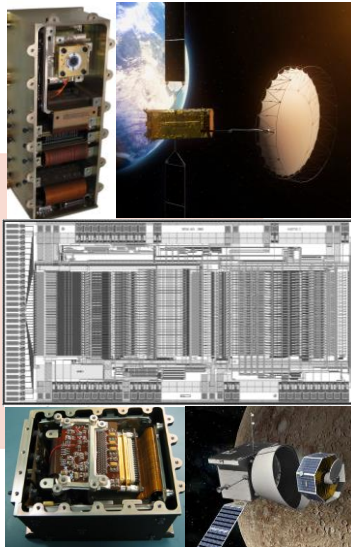
- Miniaturisation
- High degree of integration
- Leveraging on existing parts both COTS / HIREL -> lower unit cost, size, mass.
- New Space approach (CubeSats & cheaper launchers, hybrid approach – retain reasonable reliability)
- Standardisation: simplifying proper component- & instrument-level calibration

Inexpensive, compact radiation monitors enable space weather constellations – increasing relevant data & forecasting capability.

IDEAS space heritage

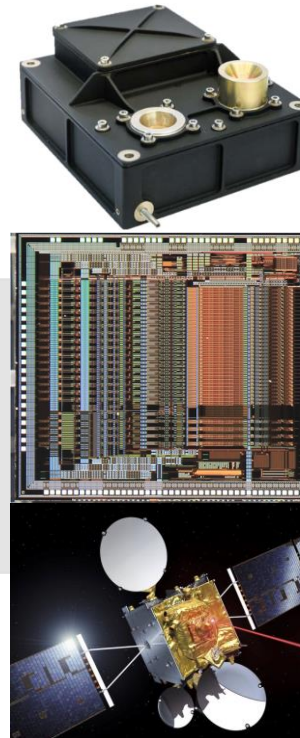
Recent instruments using IDEAS radhard IC readout solutions for silicon diode stacks:

MFS – Alphasat
BERM –
BepiColombo
VA32TA2.2



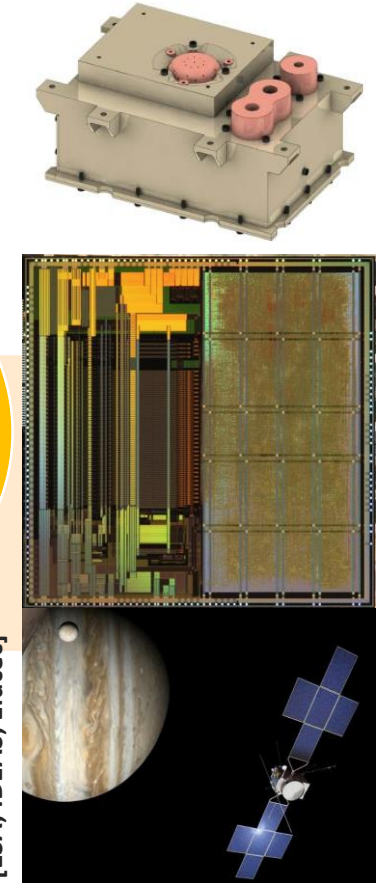
[Efacec; ESA; IDEAS; Efacec; ESA]

NGRM –
EDRS-C etc.
IDE3465



[RUAG / Thales; IDEAS; ESA]

RADEM –
JUICE
IDE3466



[ESA; IDEAS; Efacec]

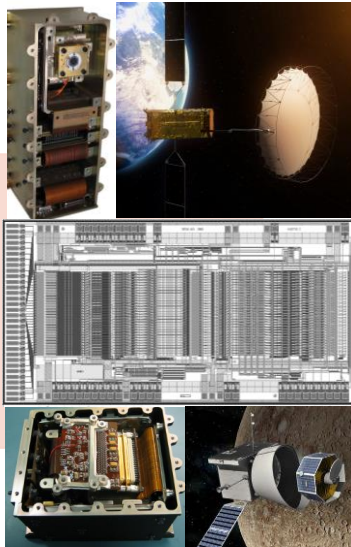
Additional missions: Polar [CN], STEREO [USA], Pamela [IT]
and many more for other instrument types.

IDEAS provides the readout solution
for many instruments.

IDEAS space heritage

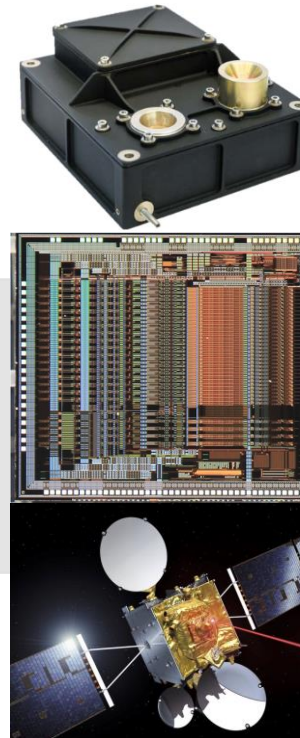
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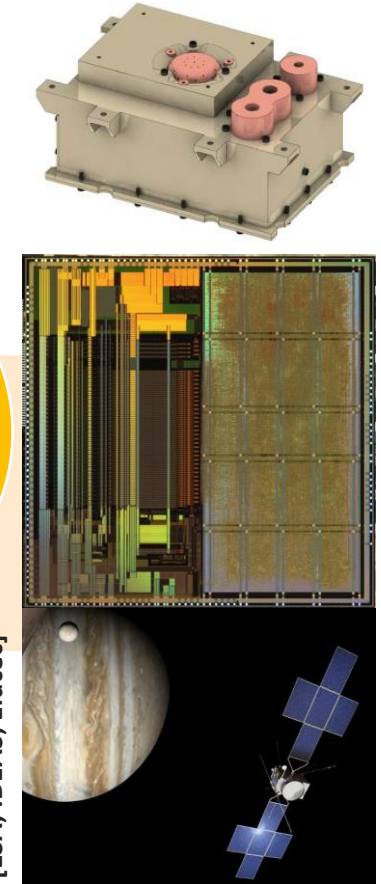
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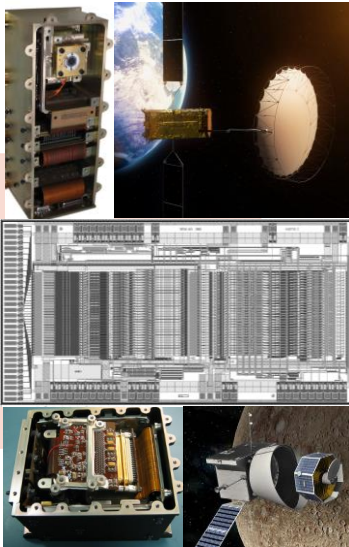
IDEAS space heritage

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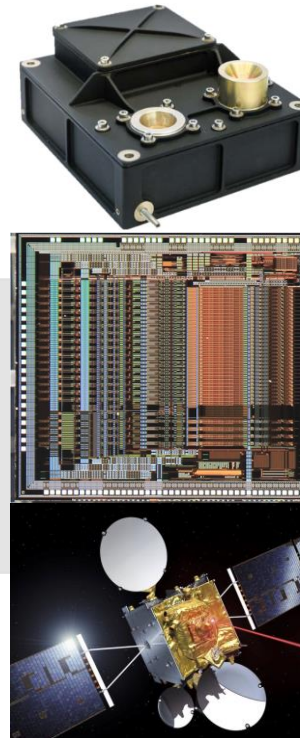
None of the instruments fit onto a CubeSat or usable as compact smallsat bus add-on!

MFS – Alphasat
BERM –
BepiColombo
VA32TA2.2



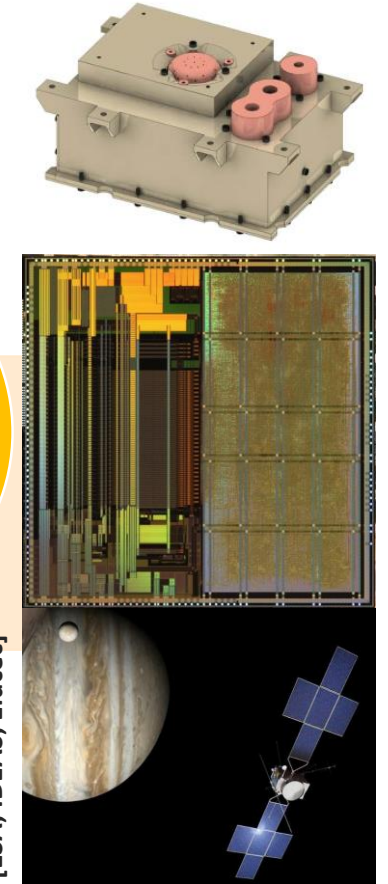
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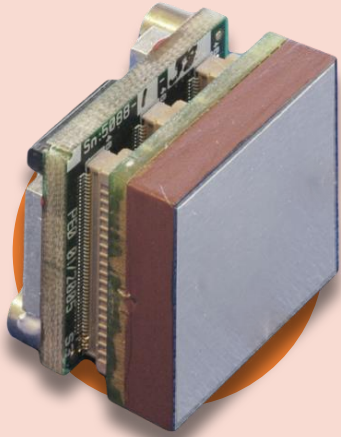
RADEM –
JUICE
IDE3466



[ESA; IDEAS; Efacec]

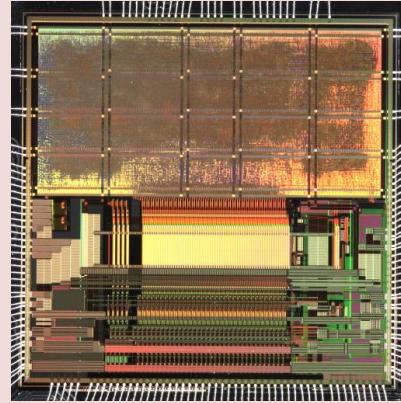
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IDEAS ICs & modules relevant for SpWx Cube/SmallSat missions



Gamma / X-rays

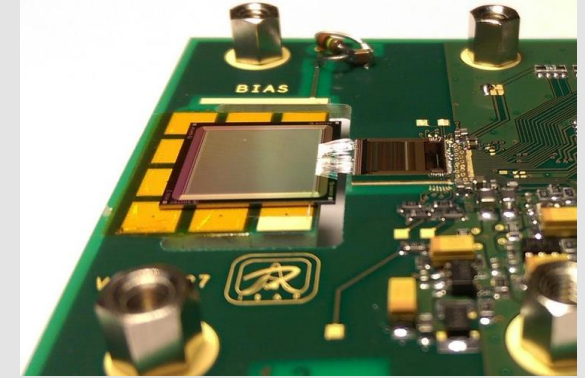
- IDE3380 SiPM [EIRSAT-1]
- IDEAS CZT modules
SRE4001 [ASIM@ISS]
- VATA45x/VATA46x series
[DSSDs@Astro-H]
- IDE4281
- NIRCA for CMOS readout



Charged Particles

- IDE3466 [RADEM, ...]
- IDE3465 [NGRM]
- IDE1180
- ROSMAP module + IC ...

Most IDEAS ICs & modules are available with an evaluation kit,
greatly reducing time to functioning prototype.
IDEAS also offers FPA readout for SWIR and thermal cameras.

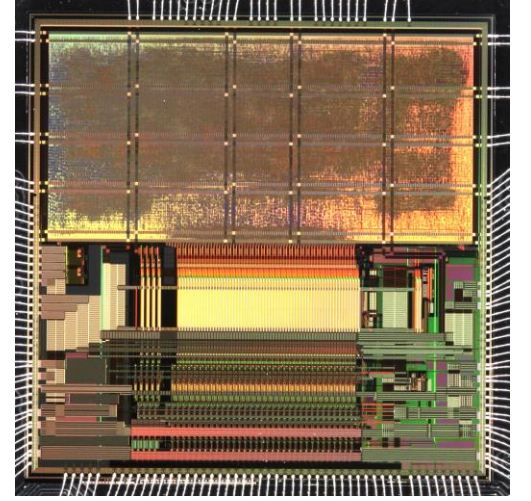


Neutrons

- VATAGP8 [AD-BANG]
- IDE1180
- ROSMAP module + IC ...

Readout ICs for X-rays, Gamma-rays, and Elementary Particles

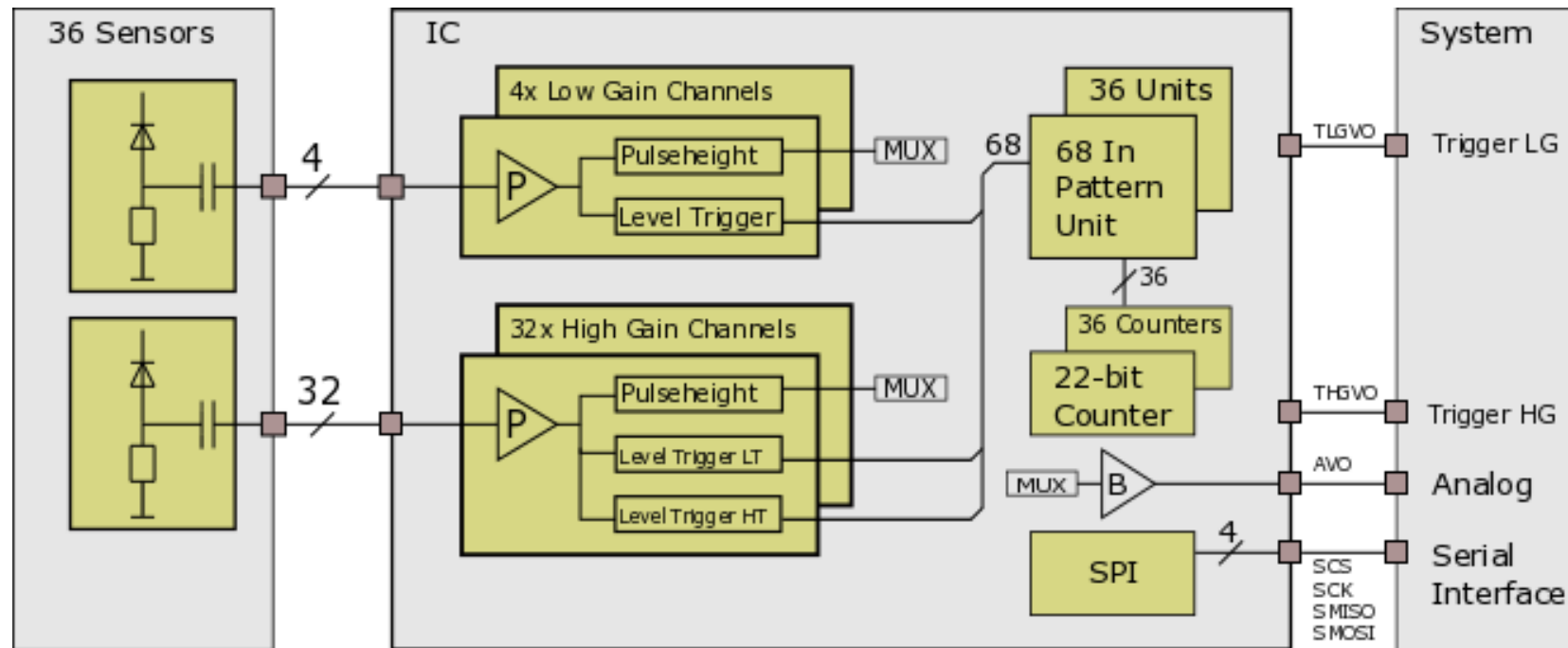
www.ideas.no



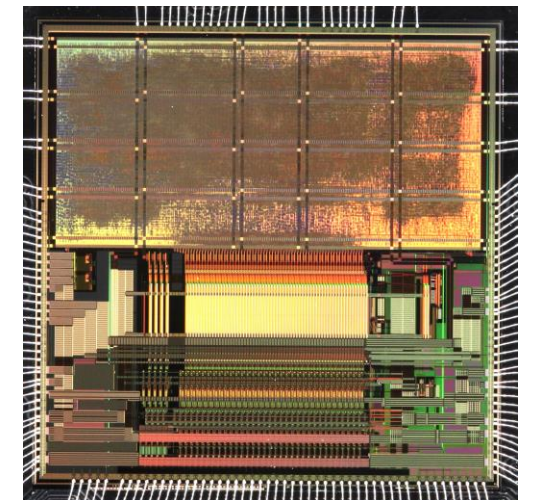
Multi-channel Si-diode readout

Applications: particle telescopes for SpWx rad. monitors + directional detectors
or crude dosimetry.

IDEAS IDE3466

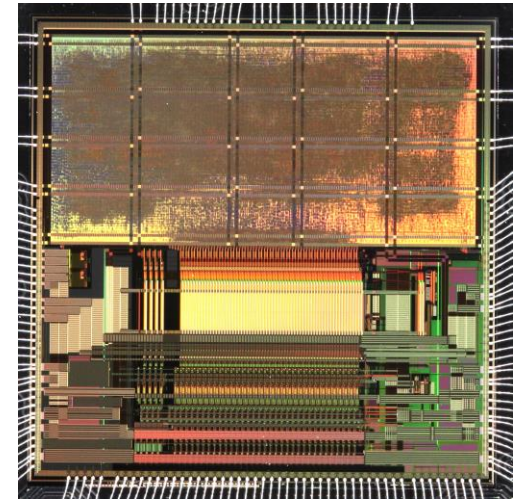
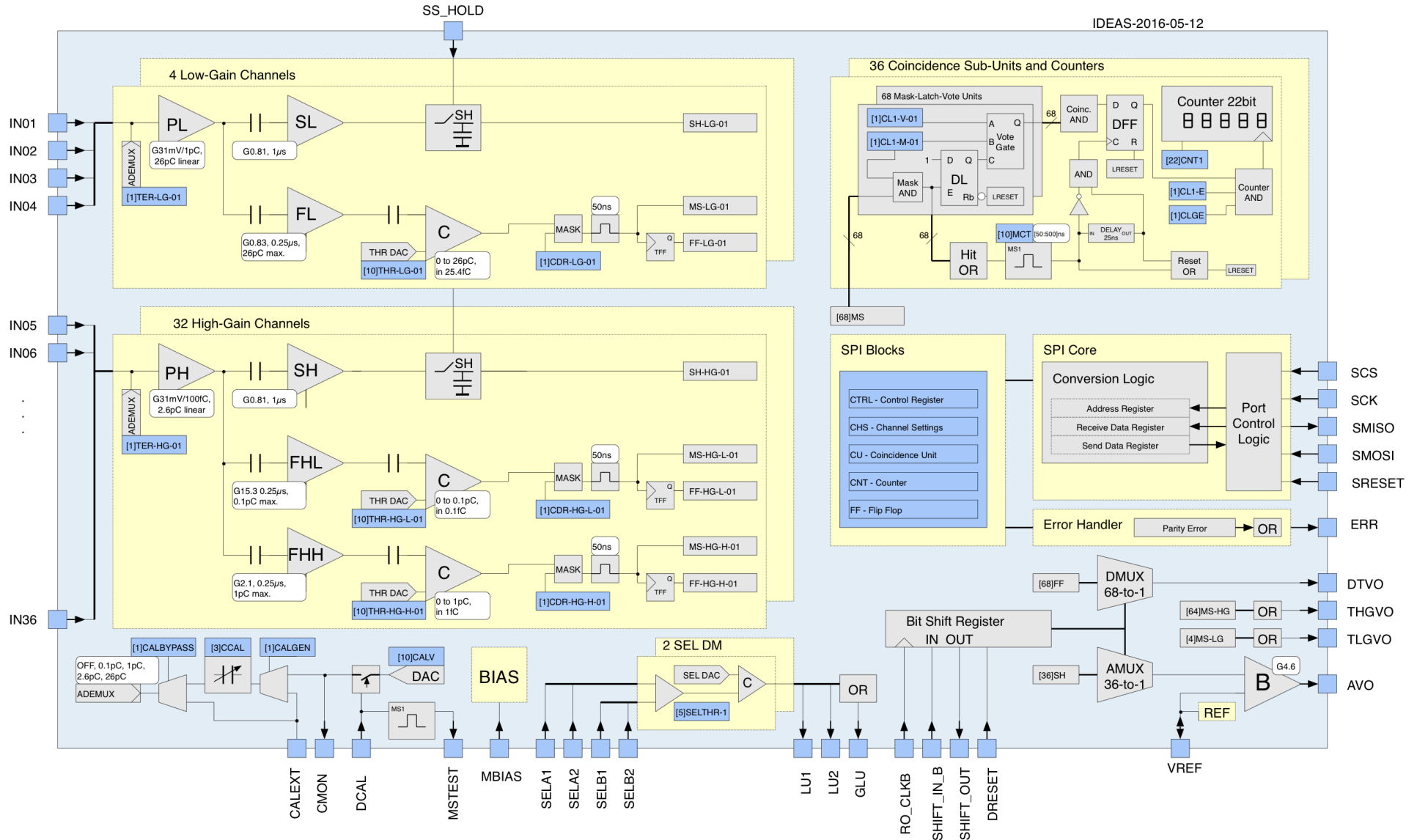


Simplified block diagram of the IC IDEAS IDE3466
omitting SEL detection capability



Photograph of the IDEAS
IC IDE3466

IDEAS IDE3466 Block diagram



Photograph of the IDEAS IC IDE3466

IDEAS IDE3466

4 low-gain channels (LG), charge-sensitive inputs Spectroscopy up to +20.8 pC, $ENC \approx 33000\text{ e} + 3\text{ e/pF}$ 1 threshold, 10-bit linear prg. from 260 fC to +22.8 pC, 260 fC lowest threshold above noise 1 trigger logic OR digital output
32 high-gain channels (HG), charge-sensitive inputs Spectroscopy up to +2.2 pC, $ENC \approx 3320\text{ e} + 9\text{ e/pF}$ 1 low threshold (HGLT), 10-bit linear prg. from 1.2 fC to +0.1 pC, 2.2 fC lowest threshold above noise 1 high threshold (HGHT), 10-bit linear prg. from 15 fC to +1 pC, 15 fC lowest threshold above noise 1 trigger logic OR digital output
Energy-resolved counting 36 digital counters read out via serial peripheral interface (SPI) 22-bit Gray code counters 1 Mcps / HG-channel count rate for 600 fC input charge 100 kcps / LG-channel count rate for 10 pC input charge 68-to-1 programmable coincidence pattern logic for every counter
Pulse-height (charge) spectroscopy Analogue mux. output from all channels
150 mW power typical operation, 240 mW power worst-case register settings
SEL/SEU radiation hardened (triple-modular redundant, parity check, enclosed layout structures)

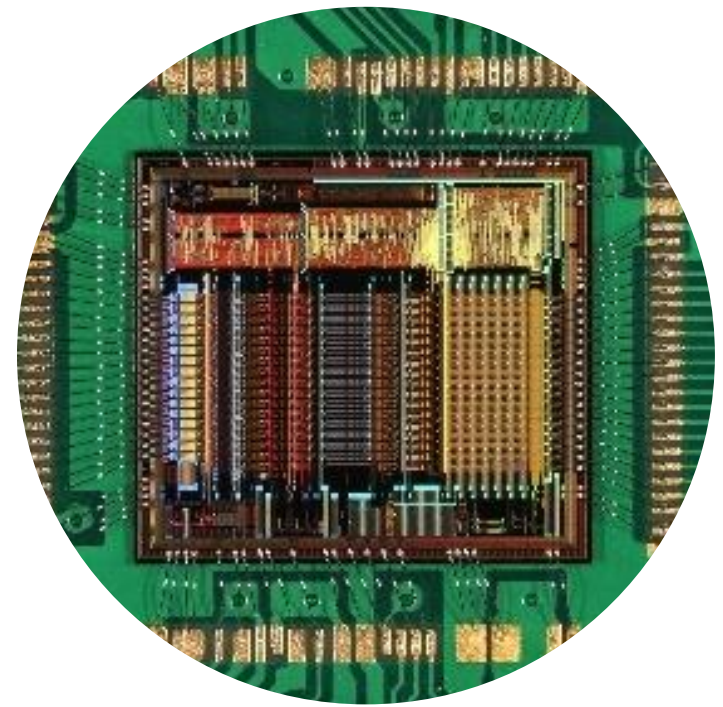
More information:

+ T. A. Stein et al.: “Front-end readout ASIC for charged particle counting with the RADEM instrument on the ESA JUICE mission”, Proc. SPIE 9905, (July 2016).

DOI: 10.1117/12.2231901.

+ Final electronics characterisation results to be published Q1/2018.

+ SEE/TID testing foreseen Q3/2018.

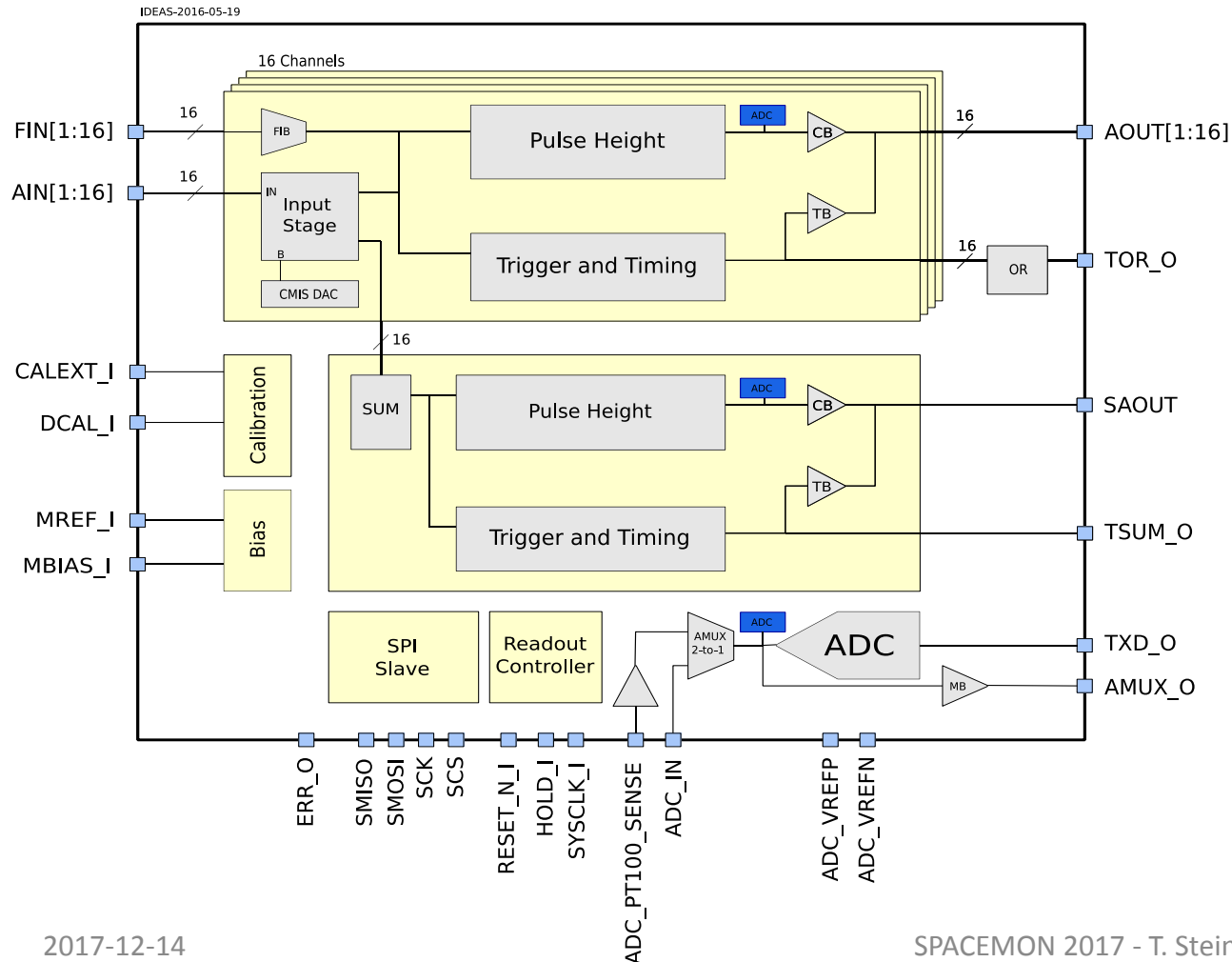


Multi-channel SiPM readout

Applications: Lunar + asteroid prospecting, neutron detection, gamma spectroscopy.

IDE3380 Features & Sketch

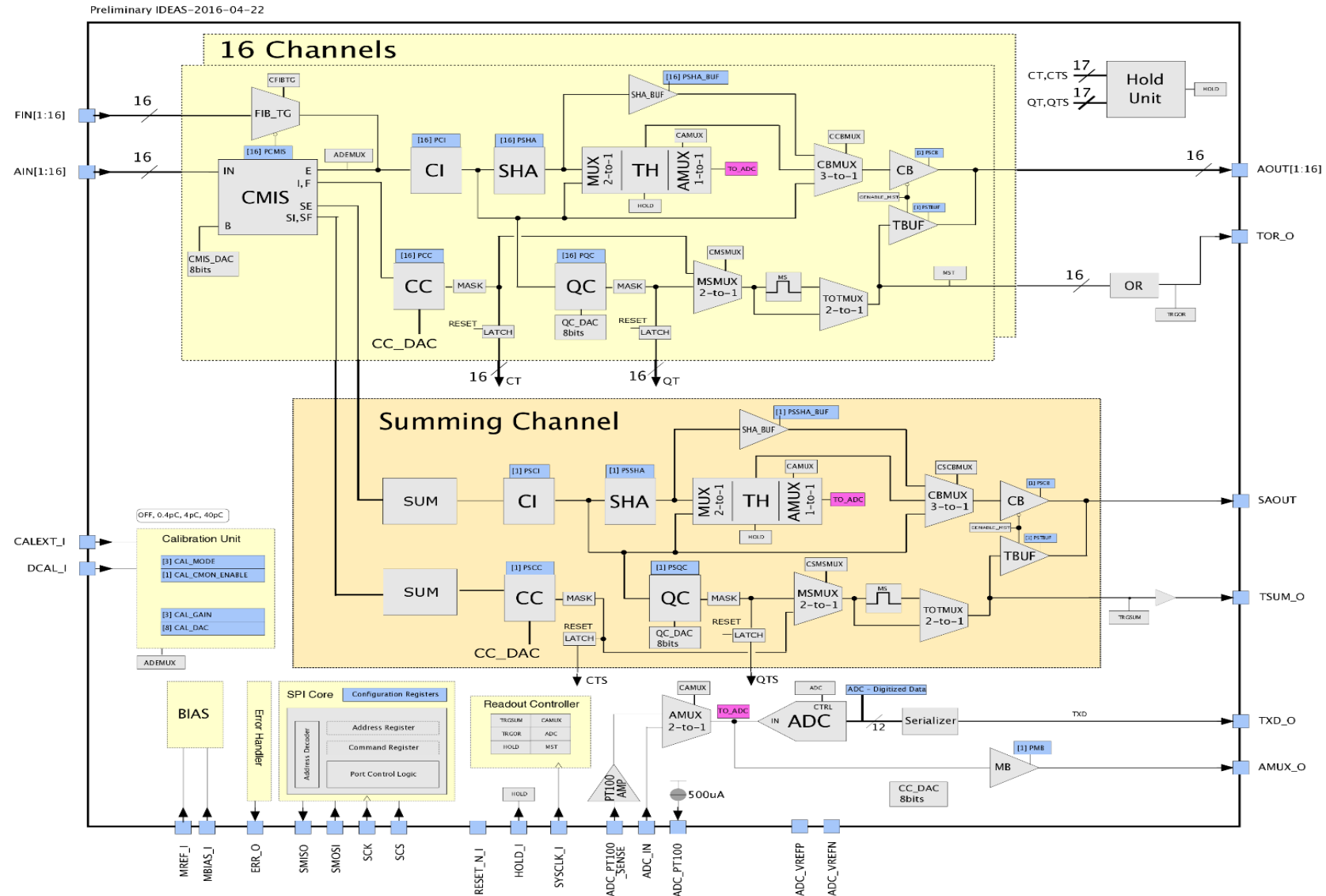
The IDE3380 will be flight tested aboard
EIRSAT-1 – Ireland's first CubeSat.

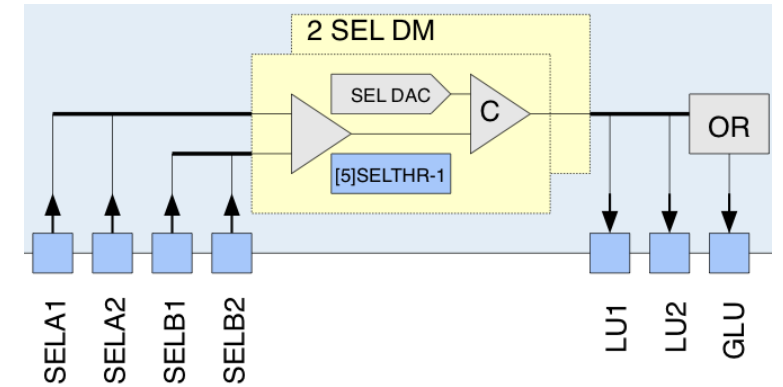


IDE3380 SIPHRA Features

16 channels for SiPM/PMT readout 16 current sensitive inputs (≤ 16 nC) 1 summing channel
Programmable attenuation to handle charge up to -16 nC, -8 nC, -4 nC, -400 pC at AIN inputs, or +40 pC, +4 pC, +0.4 pC at FIN inputs
Programmable shaping time 200 ns, 400 ns, 800 ns, 1600 ns
16 inputs (AIN) with programmable offset voltage
Pulse height spectroscopy 16 shapers followed by track-and-hold Programmable hold timing 12-bit SAR ADC digital and/or analogue readout 3 ksps/channel max.
Trigger generation Internal from charge discriminator via programmable threshold in every channel External (trigger on input, trigger on sum)
Power 15 mW without CMIS, 30 mW with CMIS active Flexible power down scheme of channels or functions
SEL/SEU radiation hardened
SPI Interface

IDE3380 Architecture





Latch-up Detection & Handling

IDEAS investigates the design of a monolithic latch-up detection & handling unit.

Such device allows for “reasonable” use of COTS parts in your design.

Community input is kindly requested!

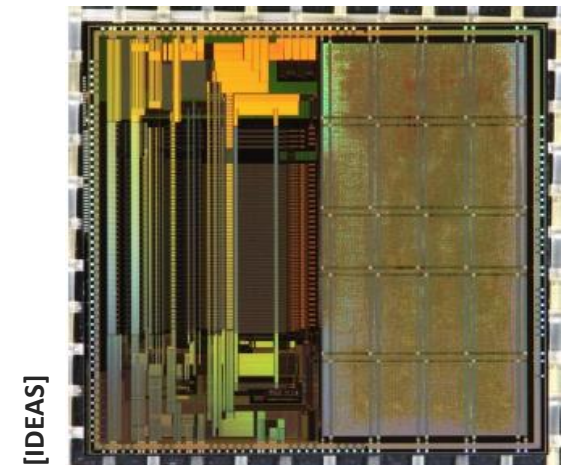
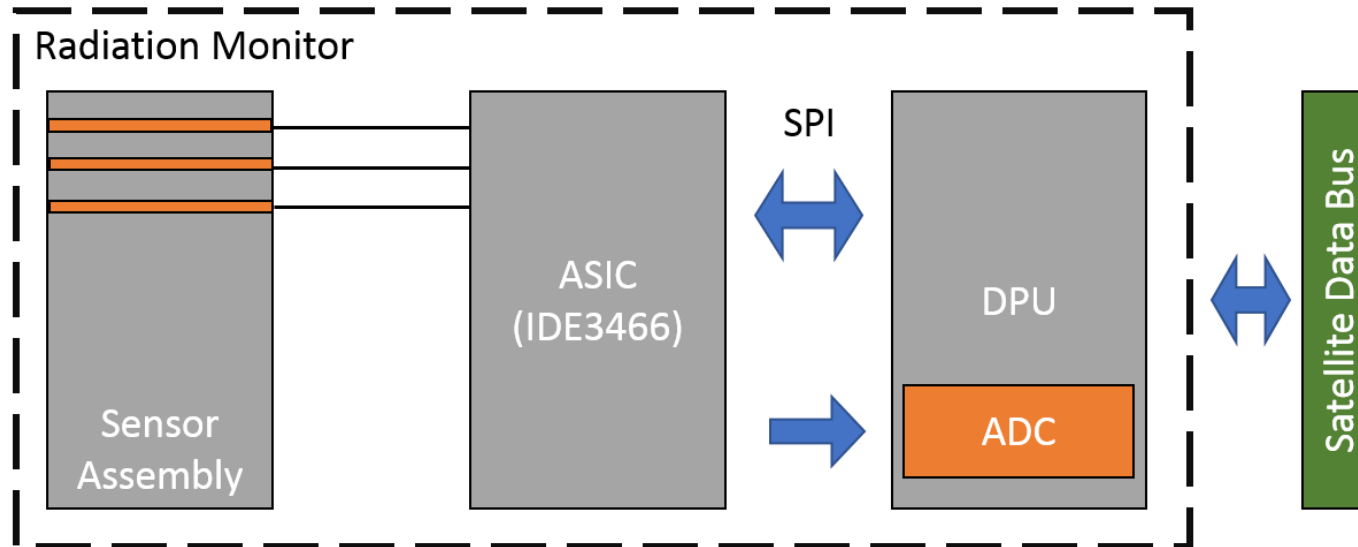
NORM: Proof of concept towards a CubeSat-ready radiation monitor

- Milestone for future instruments such as the Belgian-Norwegian mEPT [cf. S. Benck et al.].
- Industrial-PhD project with University of Oslo and IDEAS with support by the Norwegian Research Council (contract nr.: 254678) – 2016-2018.
- ESA NPI (ref.: NPI 502-2016) – 2017/18.

Norwegian Radiation Monitor_proto (NORM)

Goal: Lab prototype by Q3/2018 demonstrating mEPT-style device.

- Silicon diode particle telescope (dE/E).
- IDEAS IDE3466 IC & Si diodes.
- Microcontroller-based C/DH; no FPGA req.
- Energy spectroscopy capability.
- CubeSat-ready (1U).
- SEL-protect. built-in, hybrid approach.
- Other sensor-heads possible
-> other rad. environments.



Summary

IDEAS radhard IC readout solutions are widely used, proven & enable compact rad. monitors.

IDEAS readout technology is mostly generic to the underlying instrument type.

Constellations require miniaturised & inexpensive radiation monitors.

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Thanks for your attention. Get in touch and let's cooperate!

Timo Stein, timo.stein@ideas.no