Why we dare to go without DARE (library)

Innovation for life

TNO | Knowledge for business

ESA AMICSA workshop

TNO is active in five core areas

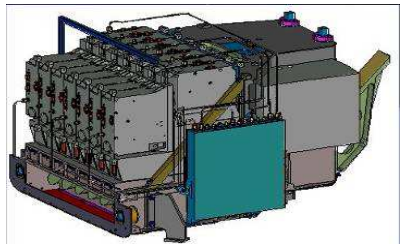
- Quality of Life
- Defence, Security & Safety
- Science & Industry
- Built Environment & Geosciences
- Information & Communication Technology





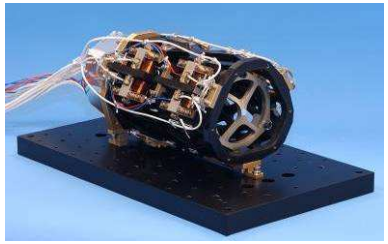
Activities in Opto-Mechanical Instrumentation for Space Applications

- **Scientific payload instrumentation, such as spectrometers**
  - S59 UV stellar spectrometer
  - ISO Short wave Spectrometer (5-15 microns)
  - Herschel HIFI design and production support
  - Herschel HIFI cryogenic alignment camera system



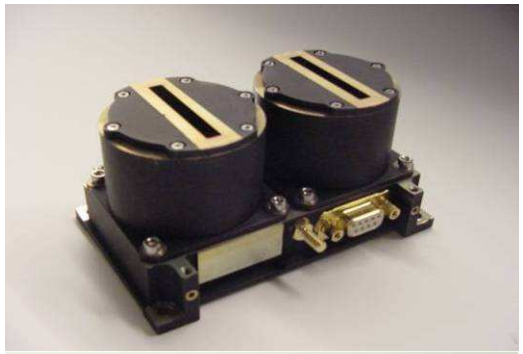
- **Earth-observation payload instrumentation & calibration**
  - GOME, SCIAMACHY, OMI design, production & calibration
  - Diffuser design, production and calibration
  - Optical Ground Support Equipment (GOME, SCIA, IASI)
  - Multi-spectral imaging spectrometer (Earthcare)

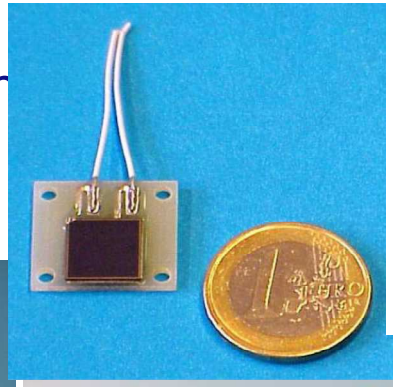
- **Precision Mechanics**
  - Refocussing mechanisms for MSG
  - Optical Delay-Lines (Darwin technology development)
  - Achromatic Phase Shifters, Nulling technology (Darwin)
  - GAIA basic angle monitoring; Wave Front Sensor; Test eqpt

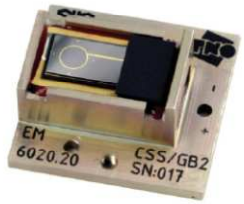


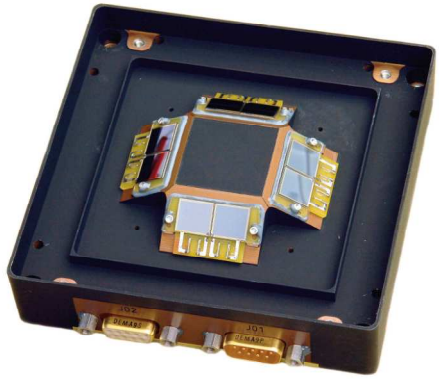
- **Avionics Equipment and Other business**
  - **Sun sensors**
  - Precision Optical Metrology sensors for Formation Flying
  - Fibre-Bragg grating for in-situ measurement of stress, deformation etc

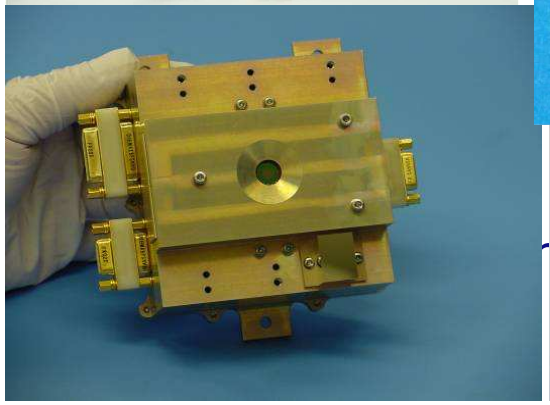
TNO's current portfolio

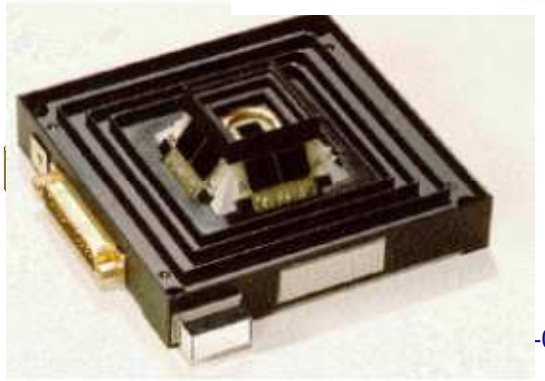




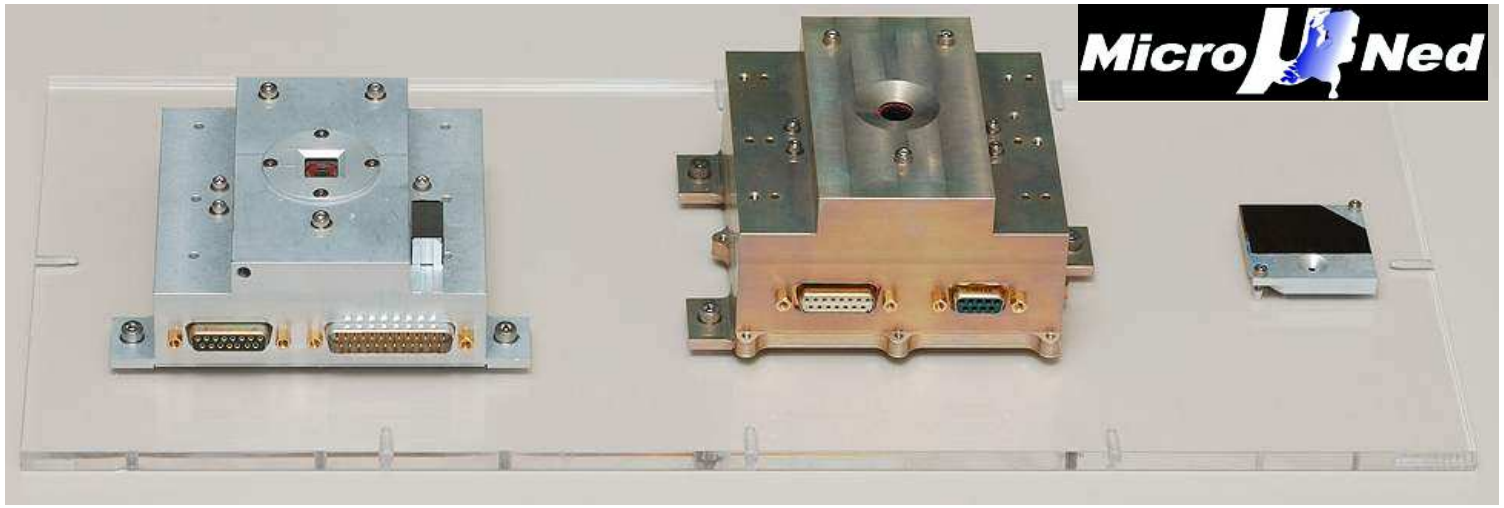




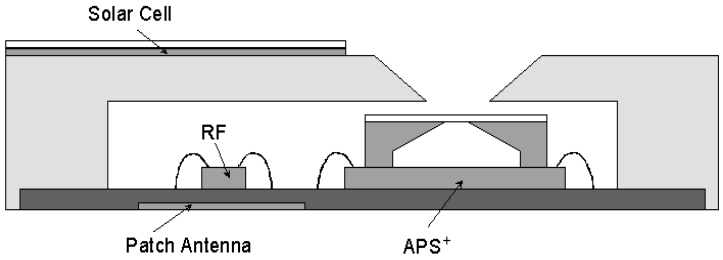




Start of the miniaturisation within Microned

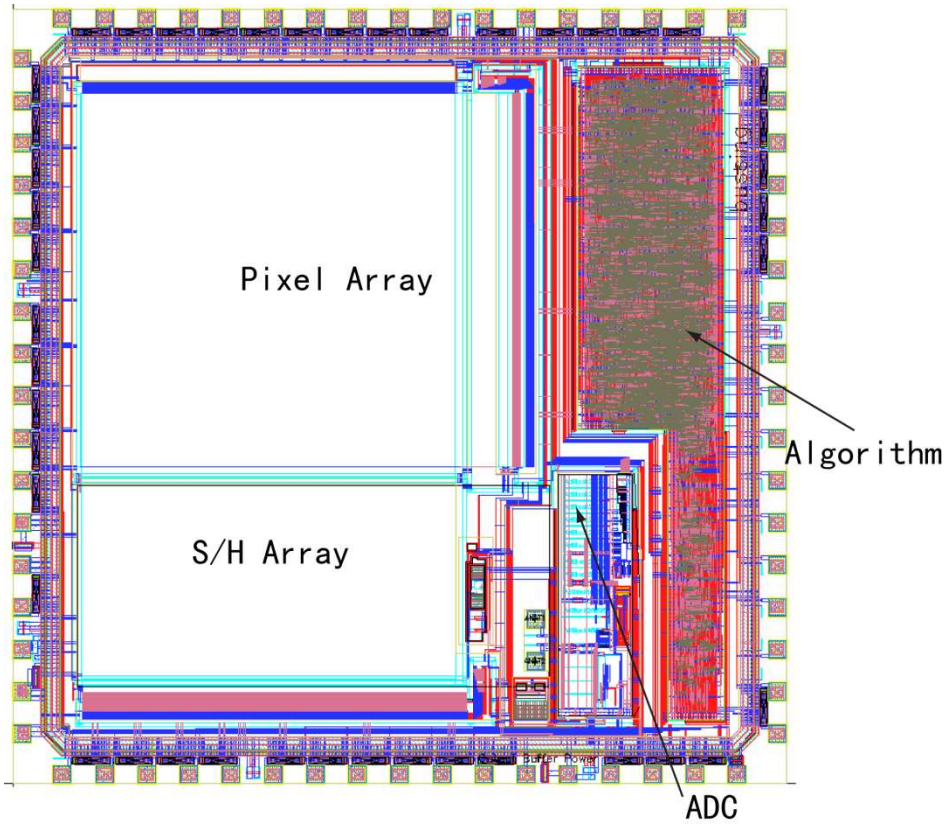


- Autonomous micro-digital sunsensor
  - Autonomous power
  - Wireless link
  - MEMS based



Main deliverable **APS+ chip**

- Single chip sunsensor
- Optimised for low power
- TSMC 0.18 micron process
- Last spin-out 5th May
- Chips received 23th of june
- Standard design library
- Several circuit design modifications to avoid SEL and SEU related issues.



Key personel

Albert Theuwissen

harvest imaging

Ning Xie

TU Delft

Delft University of Technology

Key personel

Murat Durkut

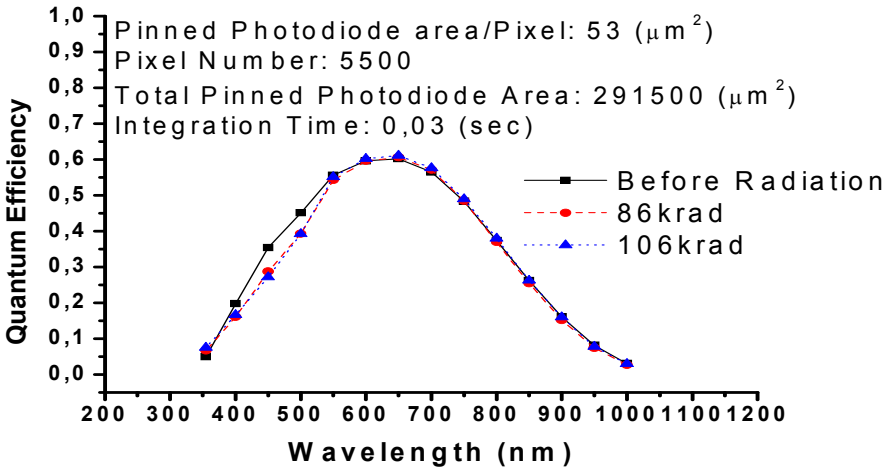
Johan Leijtens

Henk Hakkesteegt

Henk Jansen

Total dose radiation tolerance

- 0.18 micron CMOS TSMC
- Pixels tested up to 100 krad
- No significant impact observed
- Using DARE library would increase power consumption by factor of 2



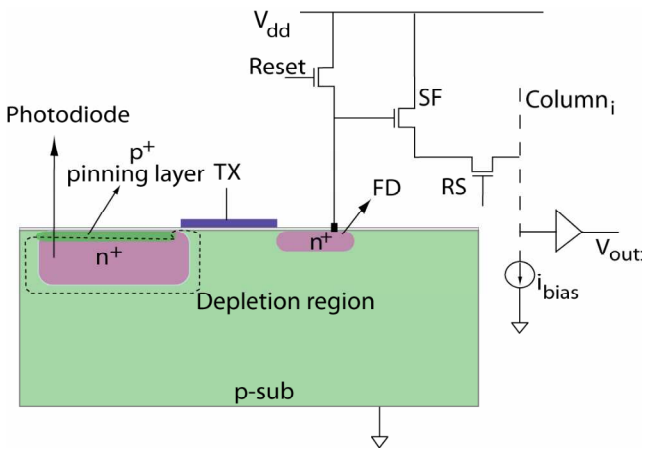
- Low power was the main requirement
- 20krad is sufficient for majority of applications
- For small systems extra shielding has less impact

↓

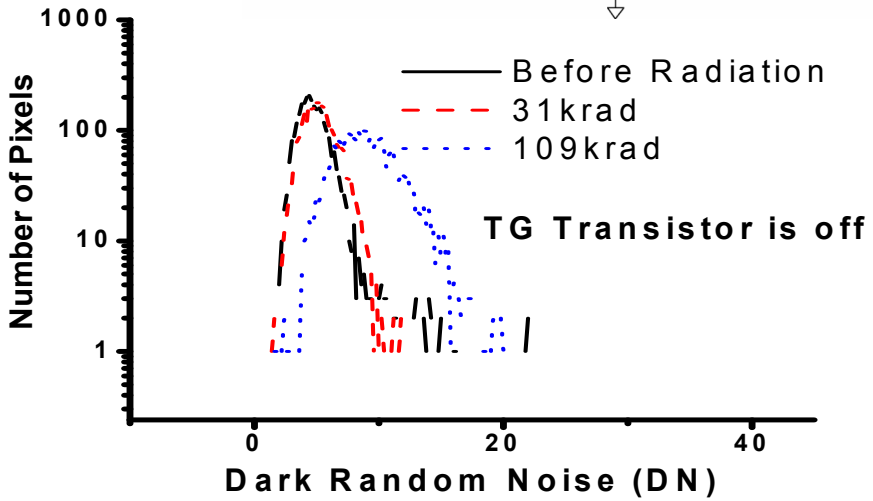
- No DARE library was used

Radiation tolerance tested with gated pixel

- total ionizing dose (TID) level of 31krad, 86krad, 106krad, 109krad and 137krad with an average energy of 46.2keV



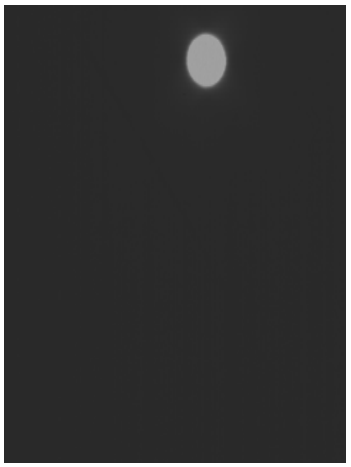
- No significant decrease in quantum efficiency
- No appreciable increase in dark current for 30krad

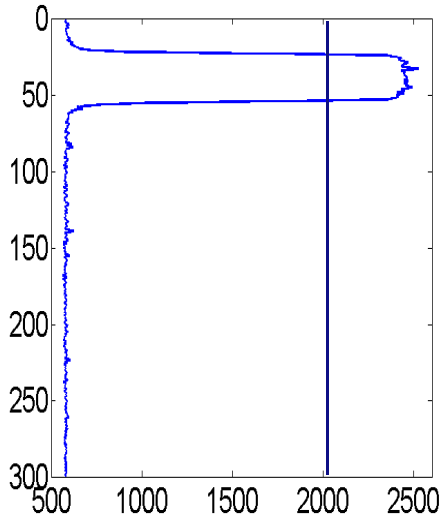


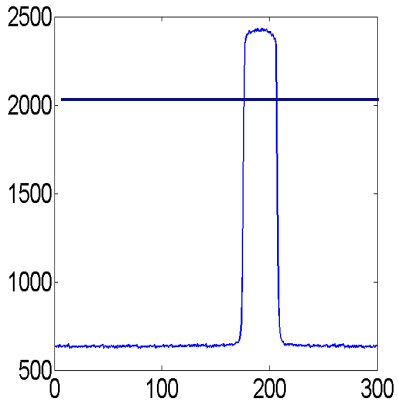
Ref:

Increased darkcurrent not significant.

- Significantly lower then threshold
- Noise on reading less then 0.004 degrees for ±47 degree system



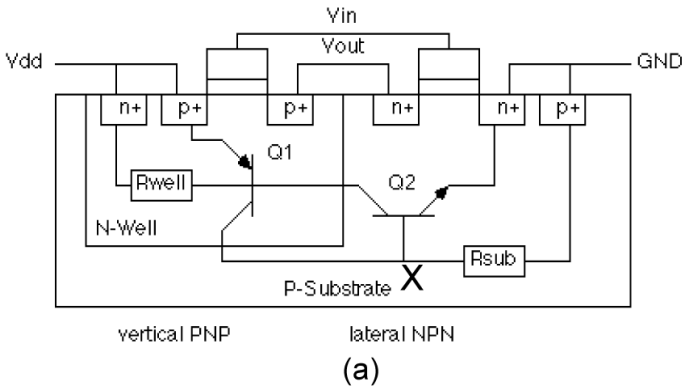




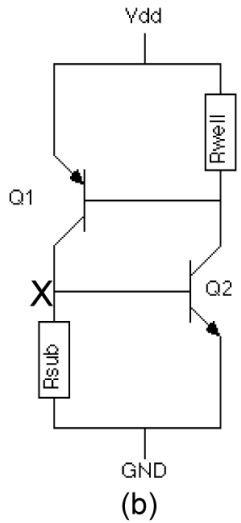
Single Event Latch-up in CMOS

- Parasitic SCR (through substrate)
- SEL if gain >1
- SEU if gain <1

- Latch up can destroy the circuit



(a)

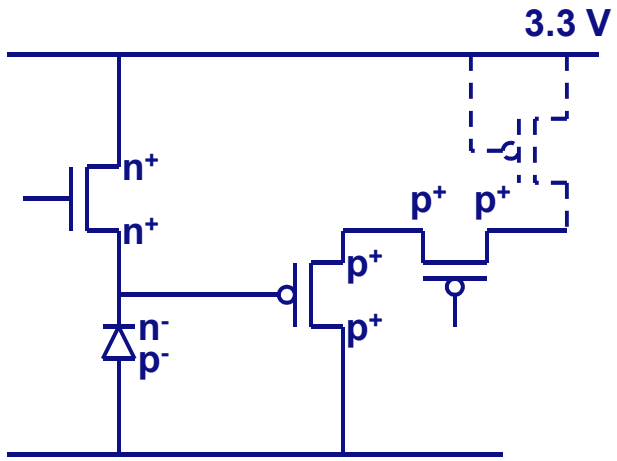


(b)

N.B. Significant current can only flow if both N+ and P+ terminals are connected to low impedance, and substrate resistance is high enough

SEL hardened pixel design
Winner takes all 3T pixel design

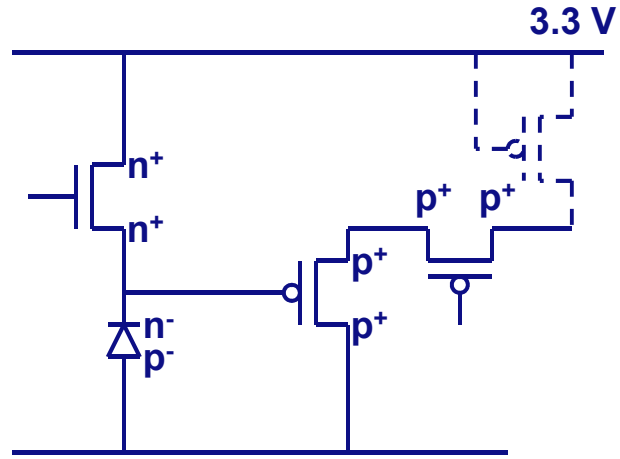
- Parasitic SCR through NMOS reset transistor and PMOS source follower
- Reduced QE due to N well for PMOS transistor

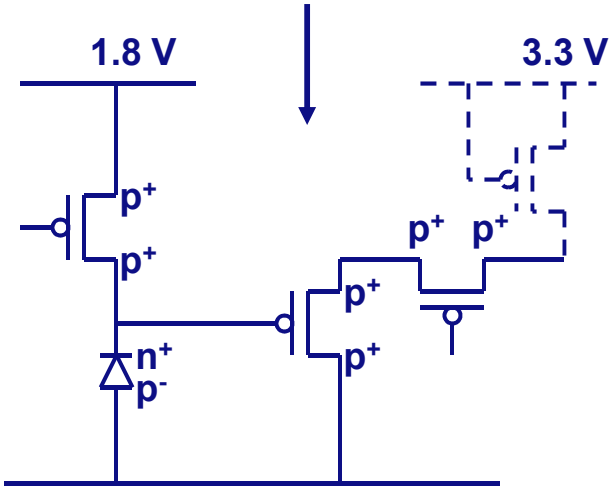


N.B. Reduced QE not important for this application, because there is an abundance of light.

SEL hardened winner takes all pixel design

- All PMOS design
- PMOS reset transistor is not significantly reducing QE any further
- Extra ground connection per pixel to reduce substrate resistance.(decreases the effect of any SEU)

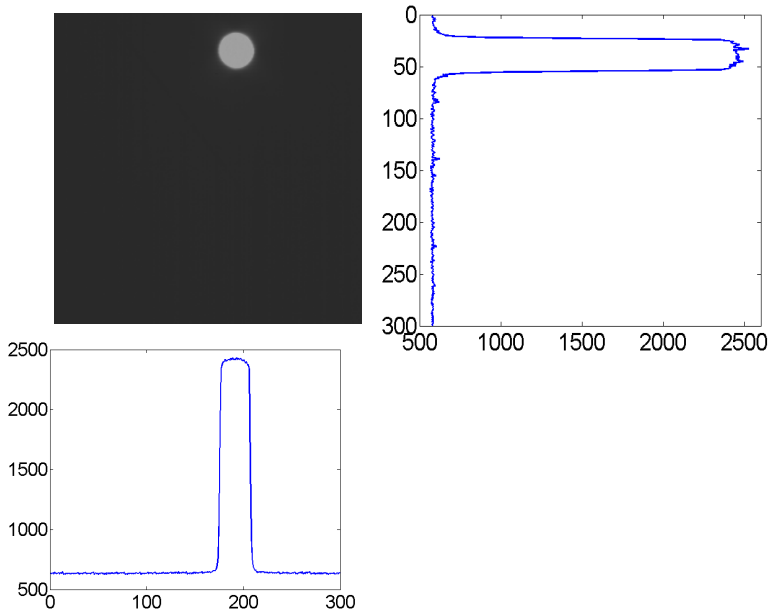




No SCR no SEL

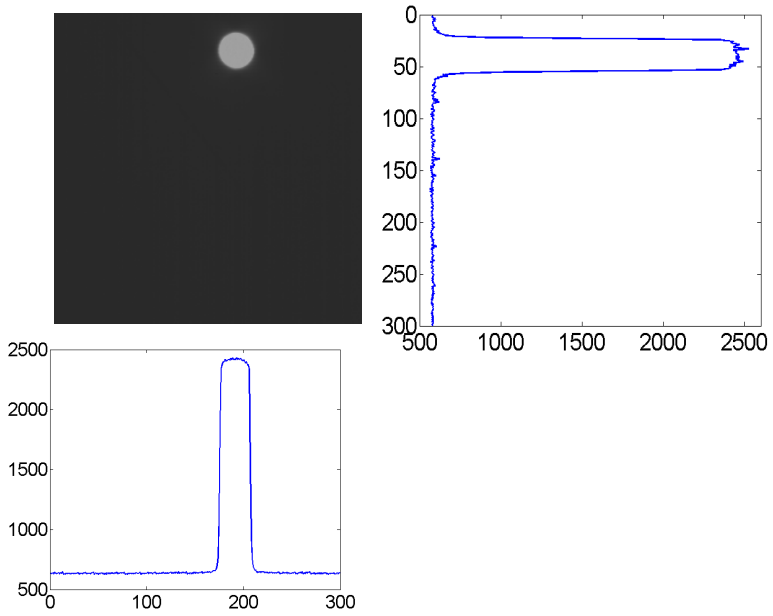
Ten pixel pin-hole

- No false detection of the sun-spot due to bad pixels or SEU
- Replace affected pixels by the average of neighbouring pixels
- Automatic compensation of SEE



Single cycle acquisition through winner takes all hardware.

- No forbidden states in the internal state machines.
- Hard wired configuration straps
- Automatic switchback to acquisition mode at SEU



Loss of accuracy for a single cycle due to SEU is the worst consequence

Conclusions

- Power consumption is our main driver
- Total dose radiation tolerance is sufficient for most sunsensor applications
- SEL/SEU effects are deemed more critical and tackled through several design decisions (DARE)

That's why we dare to go without DARE libraries

But we don't dare to go without DARE

Thank you for your attention.

For further information

Johan Leijtens

+31 15 269 2191

Johan.leijtens@tno.nl