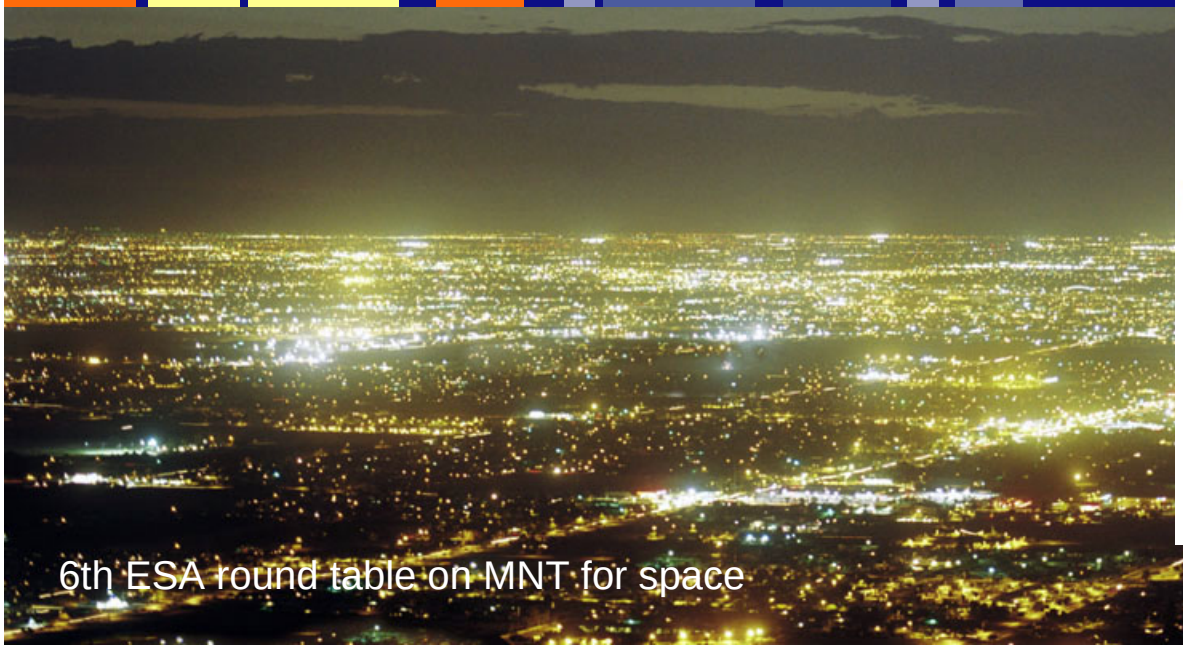
Evolution or revolution

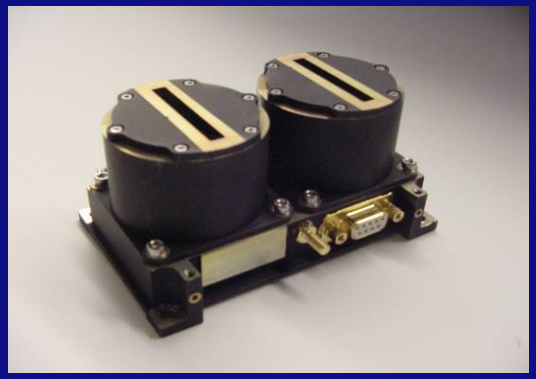
MICRO SUNSENSORS

TNO | Knowledge for business



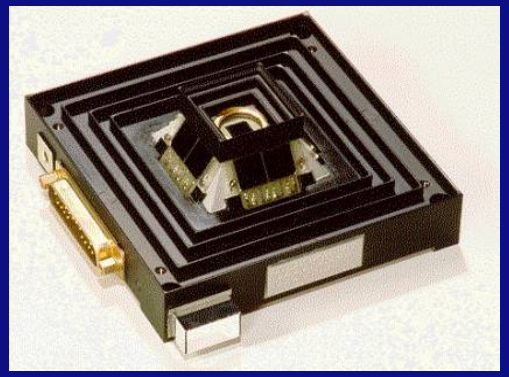
6th ESA round table on MNT for space

TNO: 30 years of heritage in sunsensors

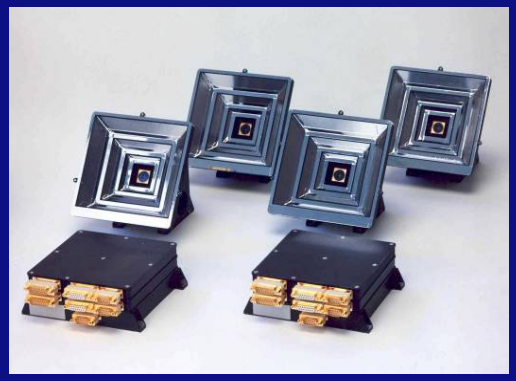


Attitude Anomaly Detector (AAD)
(1986- ….)

Sun Acquisition Sensor (SAS)
(1975- ….)

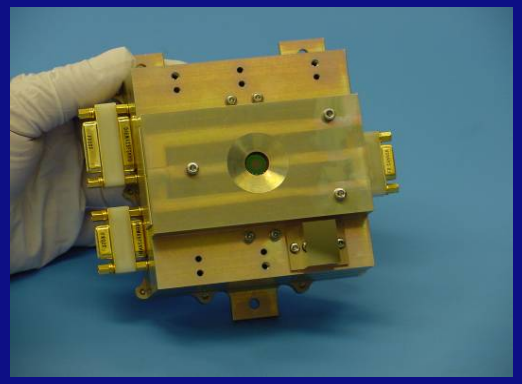


Quadrant + SAS (QSAS)
(1996- ….)



Quadrant Sun Sensor (QSS)
(1988- 1994)

Analog Fine Sun Sensor (FSS)
(2006- ….)



Digital Sun Sensor (DSS)
(2004- ….)

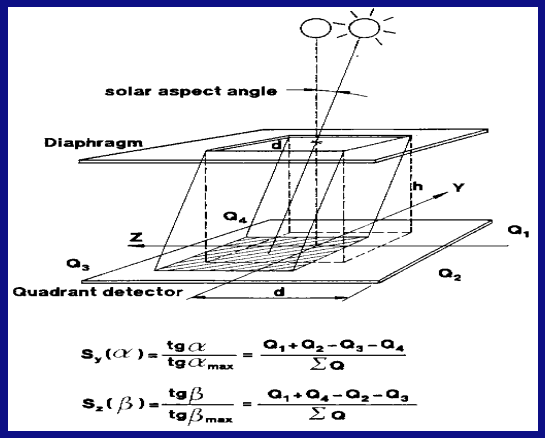
Past projects

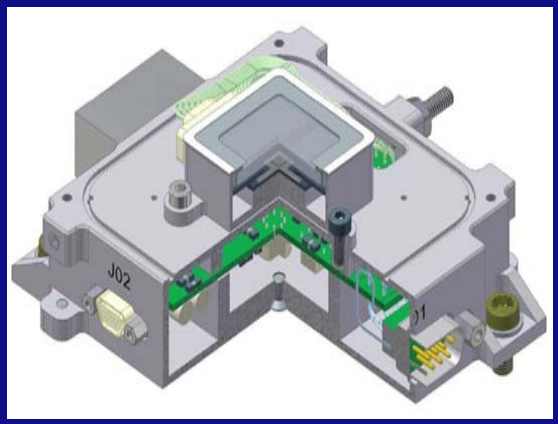
- Small series (per satellite)
- Conventional manufacturing methods
- Per project (expensive) tailoring
- Recurring qualification

Current projects

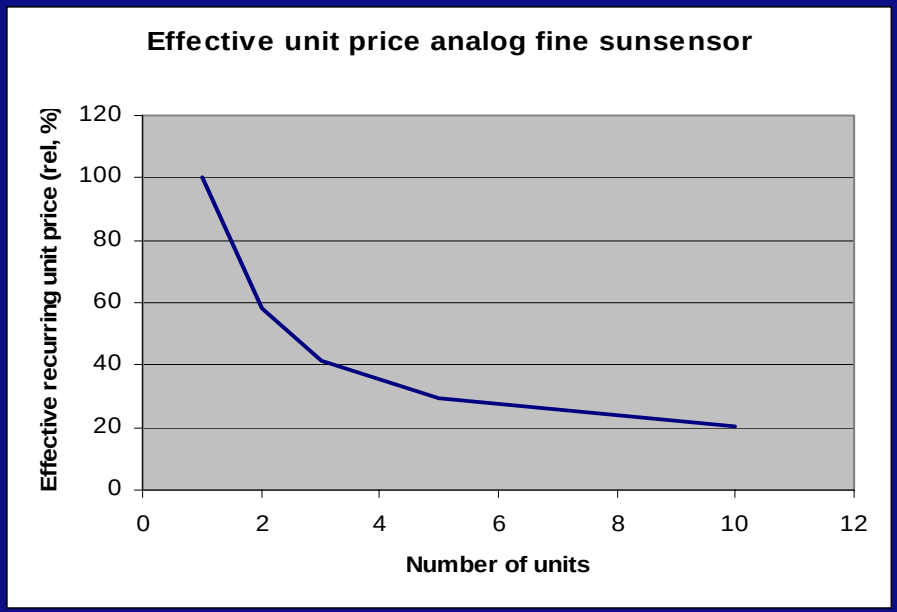
- Larger quantities (constellations and standard platforms)
- Conventional manufacturing methods
- Per project (expensive) tailoring
- Less frequently Recurring qualification
- Delta qualifications

Standardisation: example analog FSS





- Cost reduction through volume production
  - Galileosat navigation
  - Globalstar LEO telecom



Future projects

- Miniaturisation
- Application of MEMS technology
- Extreme specifications
- Generic qualification
- COTS delivery
- MOQ (minimum order Quantity)
- Less paperwork

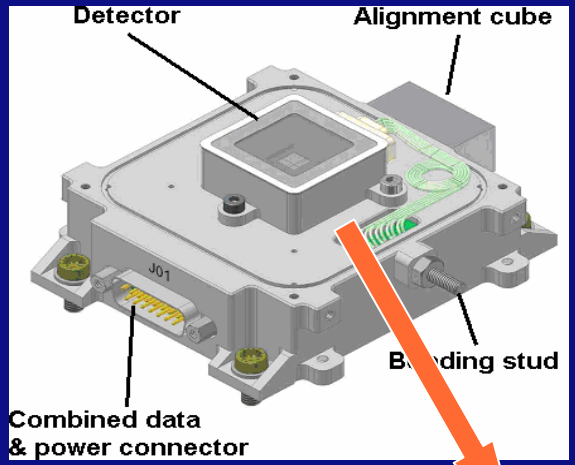
➢ Significant cost reduction

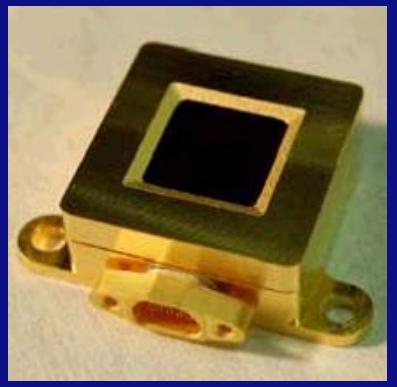
➢ Modifications will be relatively expensive

Miniaturization: example mini- FSS

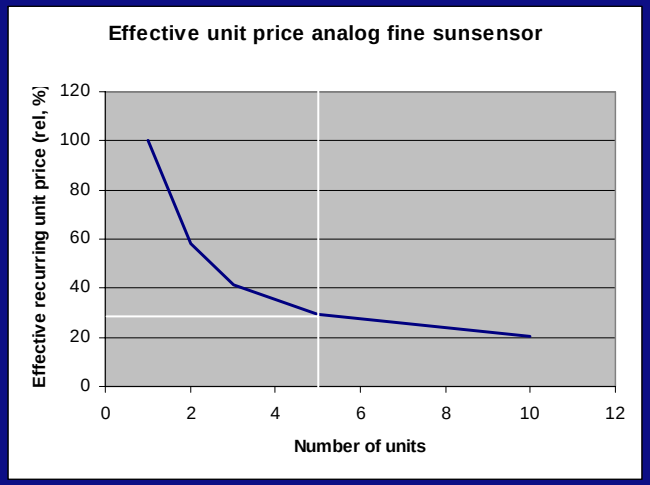
- Function integration in a single package (chip, mask, rad shielding)
- Microconnector I/F

- COTS
- 15 k€ each @ 5 pcs

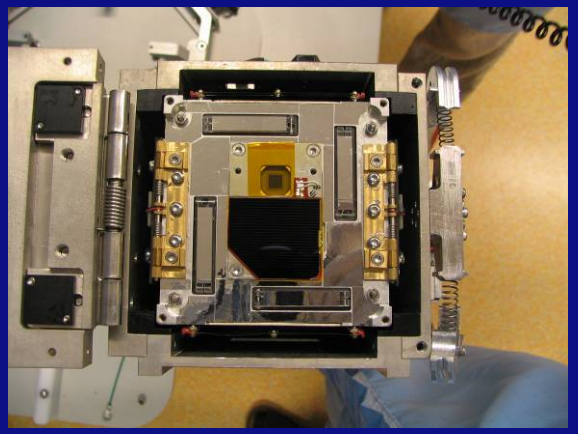




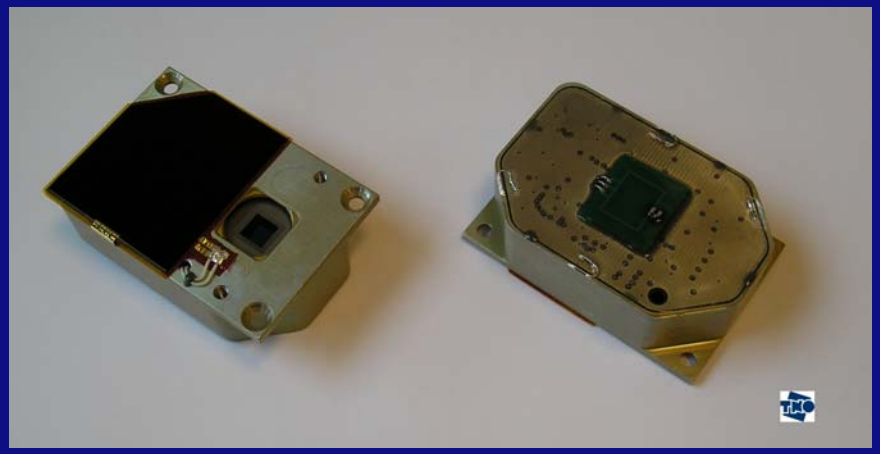
FOV 128 x 128 ,
mass 60 grams,
Size: 30x30 x17 mm



Autonomous wireless sunsensor (AWSS)



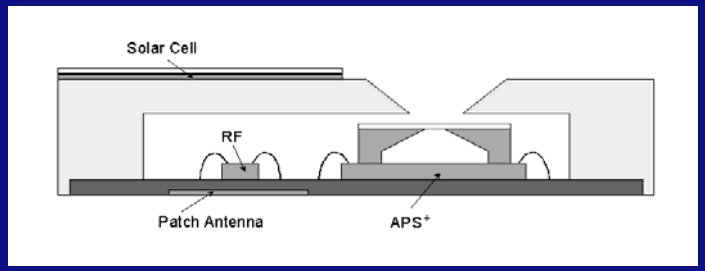
- Separate RF IO circuit
- Patch antenna
- Aluminium housing
- Dedicated solarcell power supply
- Launch with Delfi-C3 Dec 2007
- Not for sale (conventional detector)

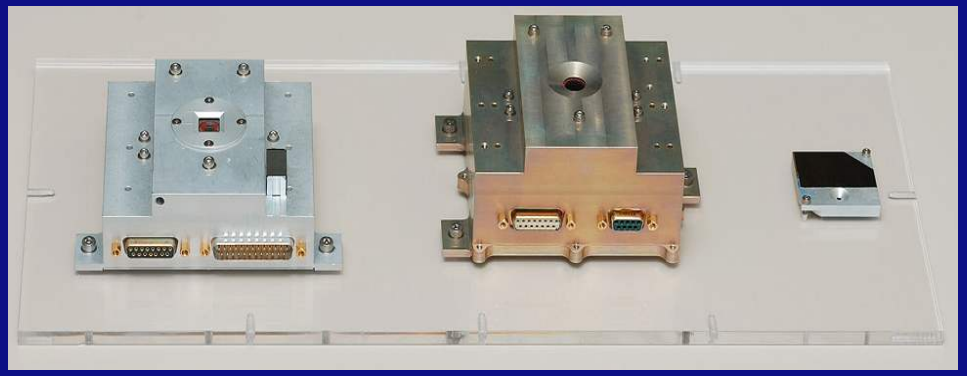


Tests performed

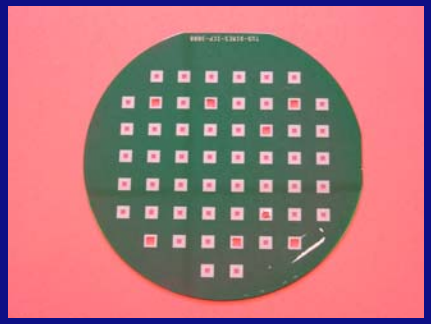
- Temperature
- Vibration
- Vacuum
- EMC

Example: Micro Digital sunsensor

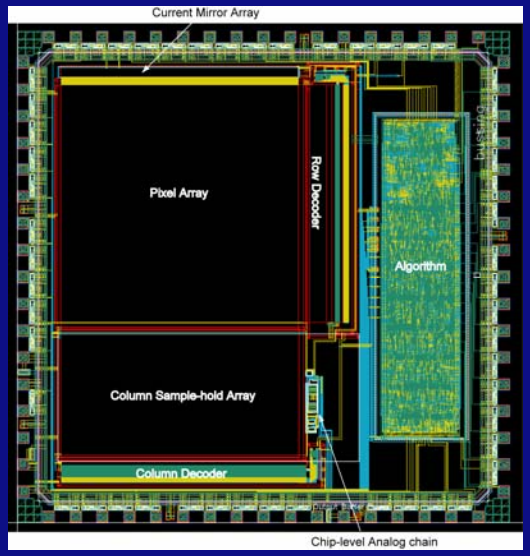




- Active pixel sensor including signal processing (APS+)
- Waferscale membrane
- Wafer to wafer bonding
- Separate RF IO circuit
- Patch antenna
- Aluminium housing
- Dedicated solarcell power supply

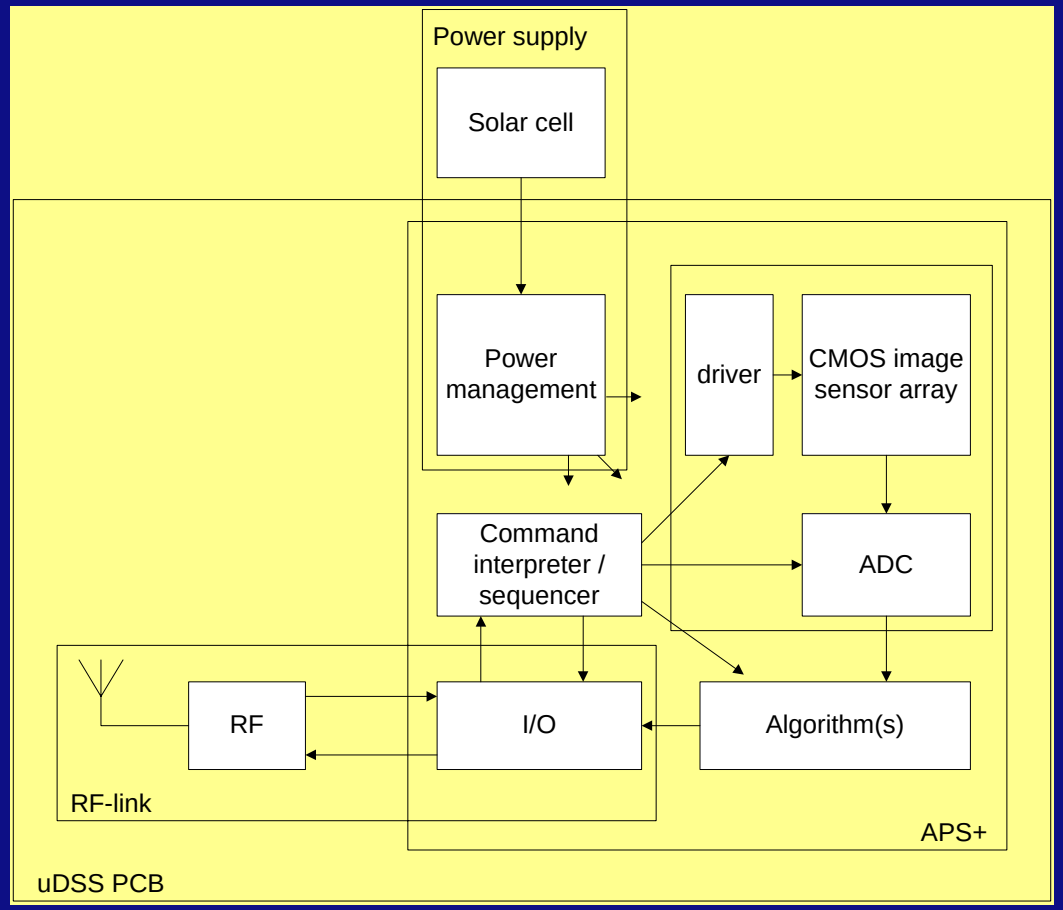


Membrane wafer

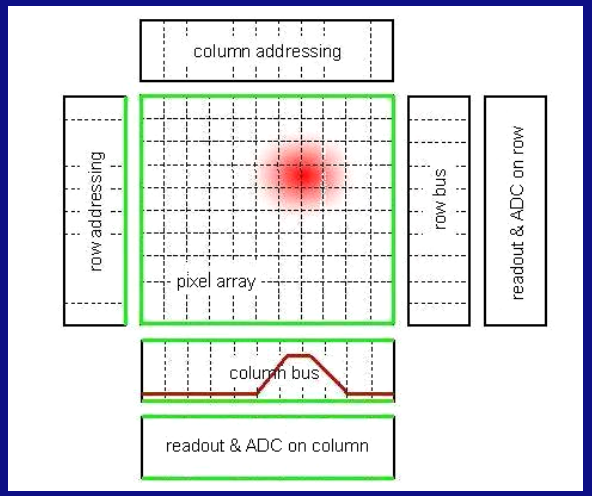


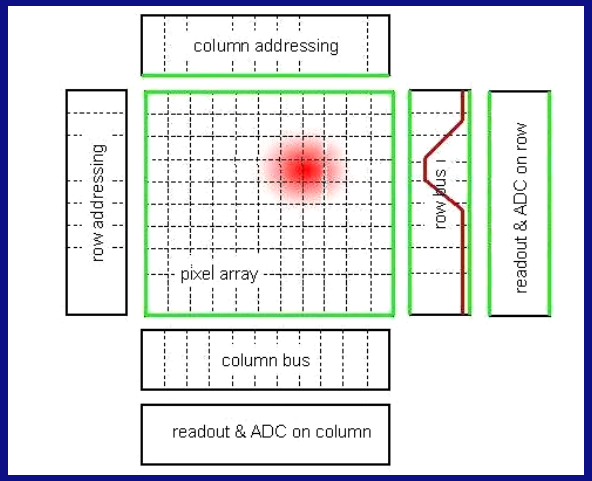
APS + functionality
General layout

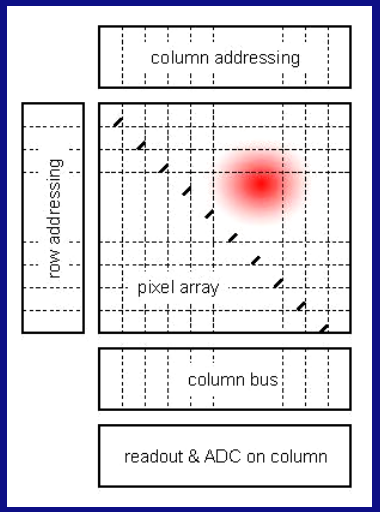
- APS
- ADC
- Control
- Centroïding
- I/O
- Power conditioning



APS + functionality
acquisition mode (winner takes all)

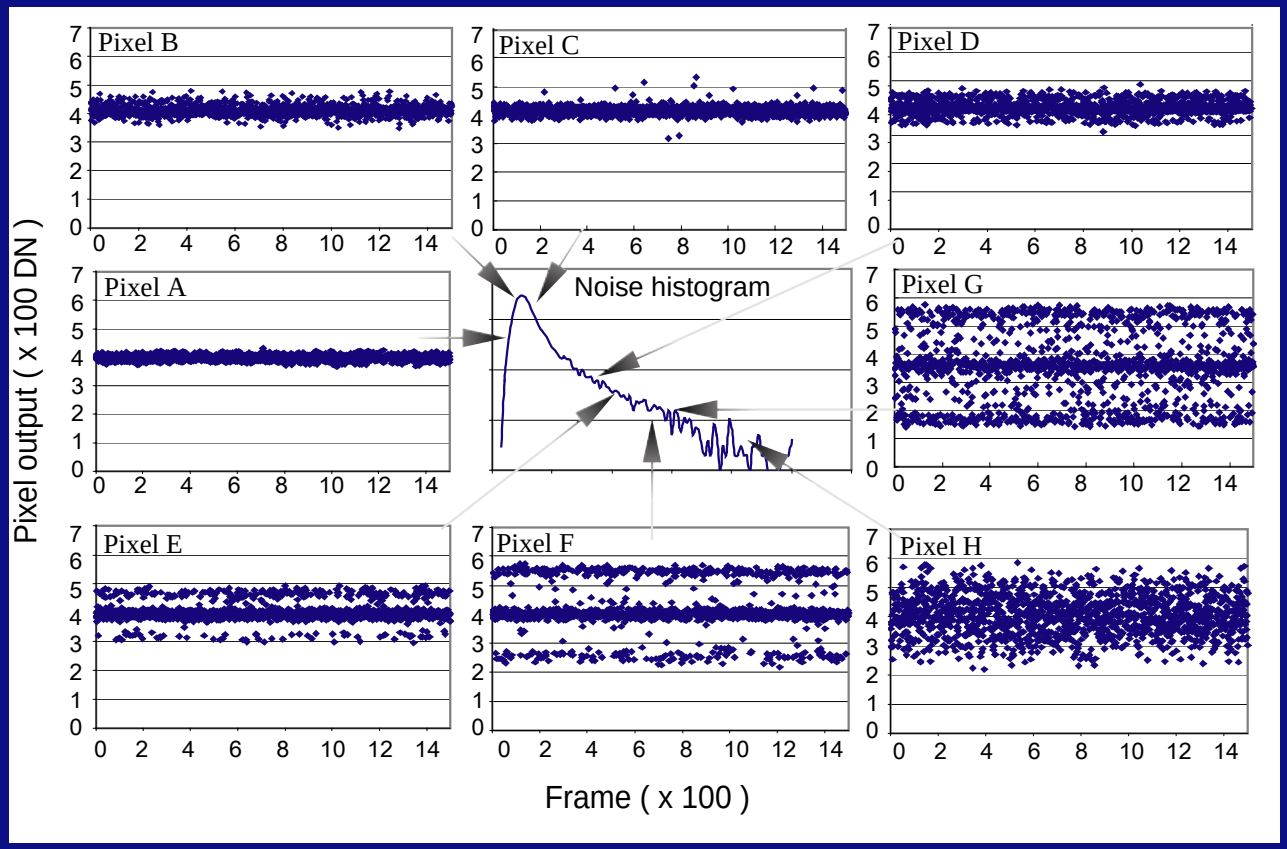






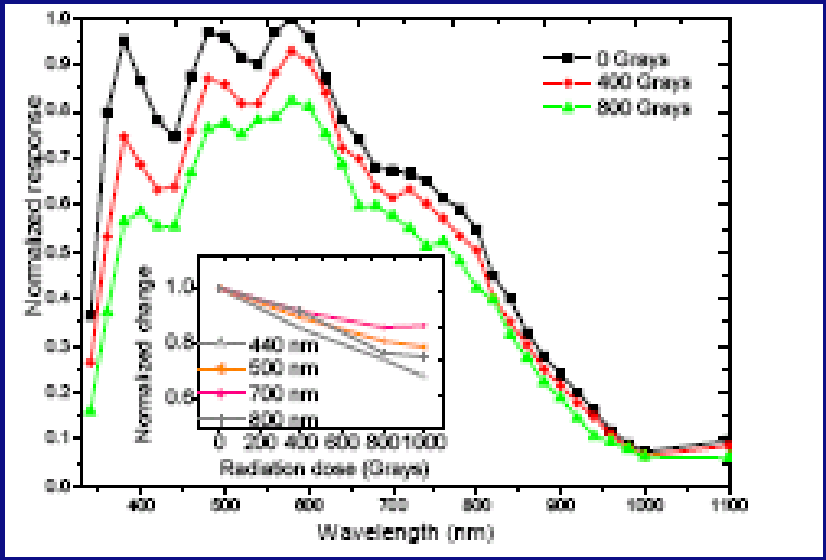
- Winner takes all circuit in hardware
- Extra switches added to save row bus and row ADC
- Fast profiling of bright spots within field of view
- Saves power during acquisition allowing for minimum solarcell size

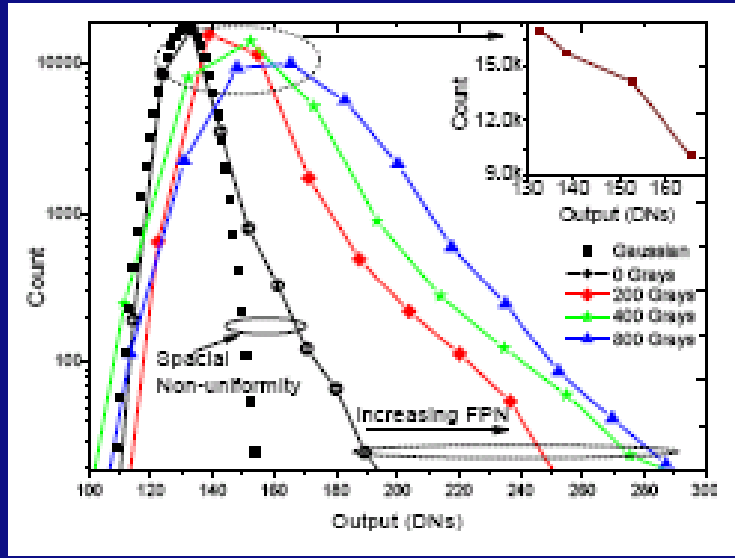
0.18 micron CMOS properties
noise results



- **Discrete noise levels for noisy pixels**

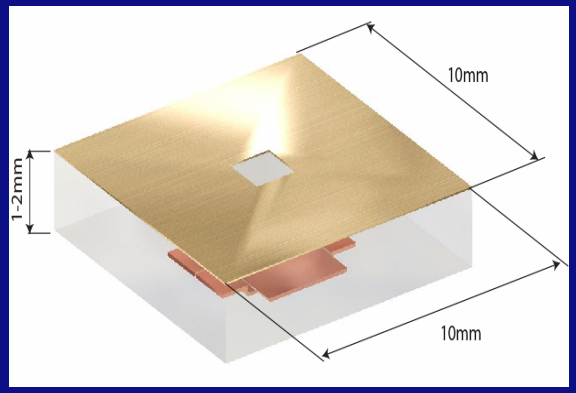
0.18 micron CMOS properties
Radiation tollerance

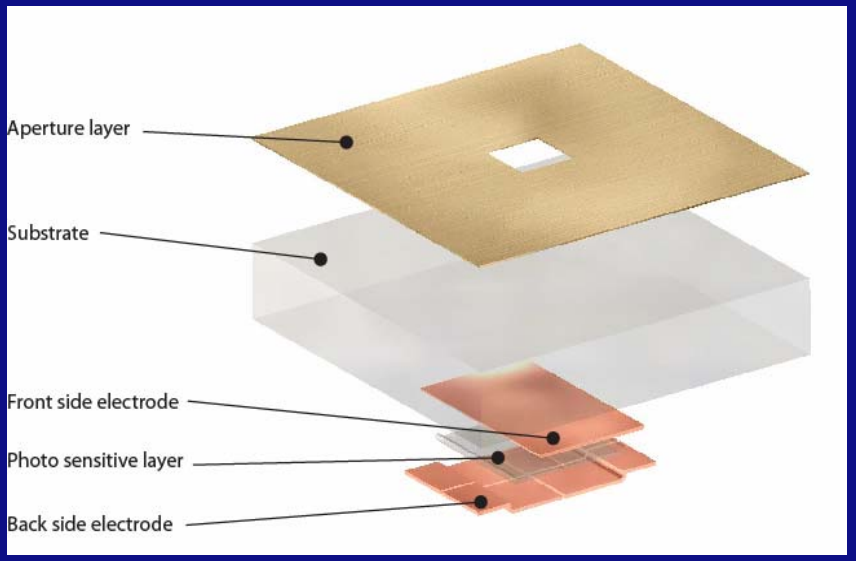




- **Near linear decrease in performance**
- **Radiation tolerant to at least several 10's of kilo rads.**

Example: immersed sunsensor (ISS)





- Rad hard glass carrier (“wafer”)
- Solar cell power generator
- Aperture in solarcell
- Detector & Electronics on backside
- Robust, suitable for mass production
- FOV 128 x 128, accuracy: <1°, (goal 0,2°)

Conclusions:

Miniaturisation leads to several characteristics

- **Smaller**
- **More robust**
  - Mechanical
  - Temperature
  - EMC
  - Radiation
- **Cheaper to produce in large volume**

This + high level of NRE costs lead to:

- **Severe specifications**
- **Recurring production**
- **COTS approach**
- **New applications (growing market)**

Thank you for your attention.

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