Radiation Dosimetry Research at Tyndall National Institute (Experiences of a Lucky Researcher)

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ELICSIR Virtual Summer School
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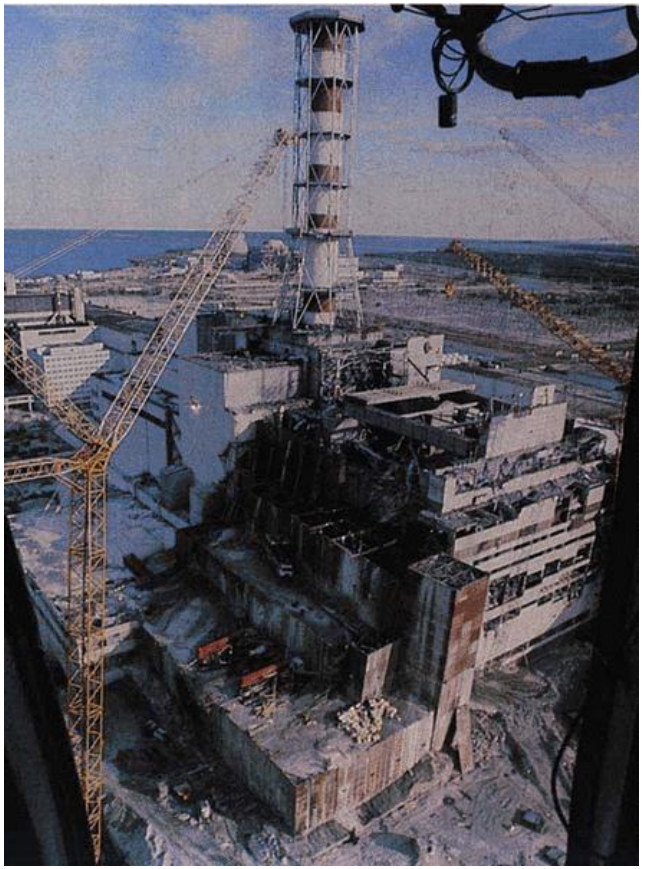
Radiation: useful, but can be dangerous

Injuries during radiotherapy (New York Times, January 2010)



Chernobyl power plant after disaster

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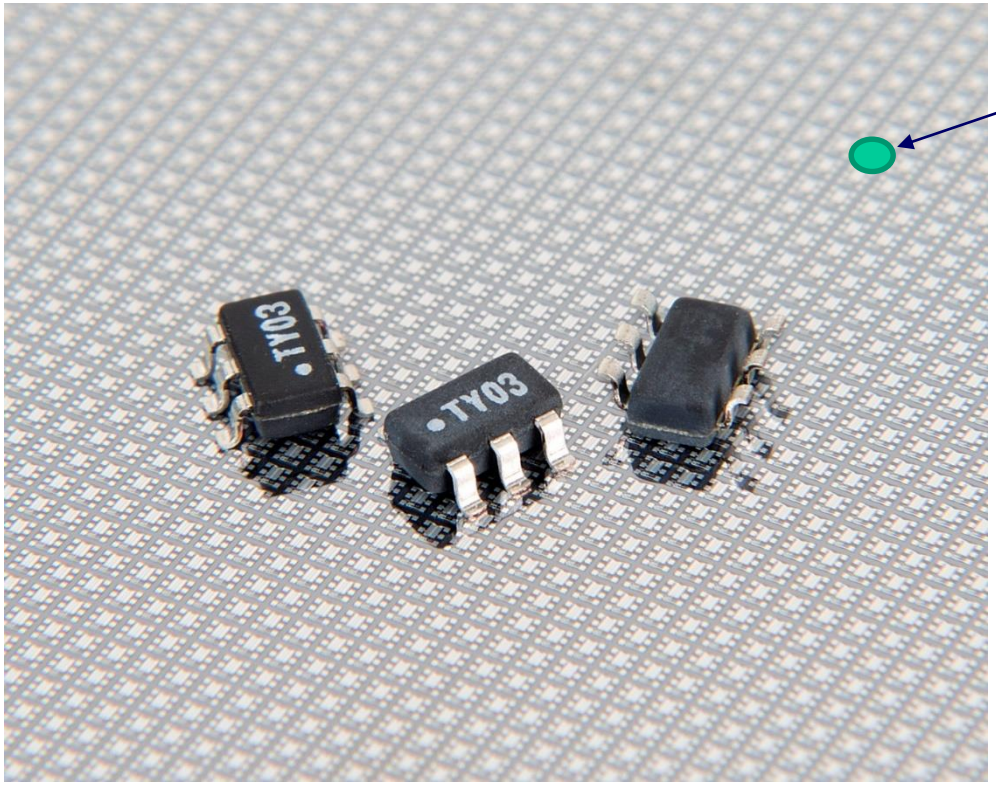
Our solution: RADFET



Packaged RADFETs on a wafer
(up to 25,000 devices on a single wafer)

RAD1 chip (0.5mm x 0.5mm)

Tyndall silicon fab

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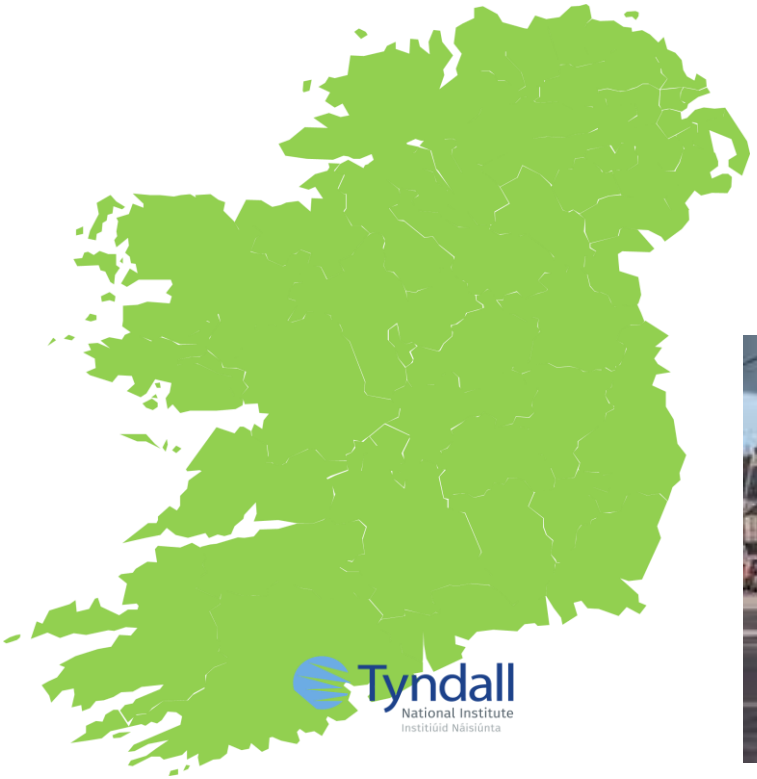
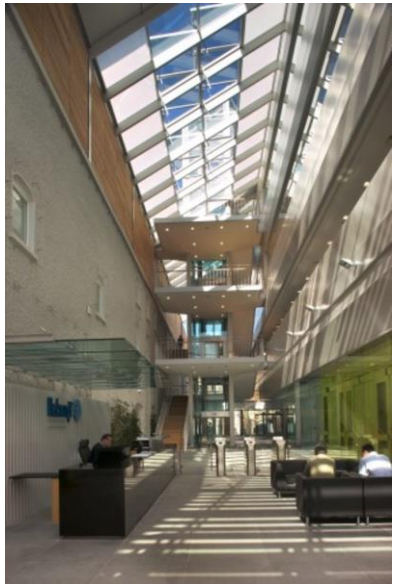
Our core team:

Radiation dosimetry research at Tyndall:

- **RADFETs**
- Special dosimetric diodes
- Scintillator/SPM based detectors

Ireland, Cork, Tyndall:





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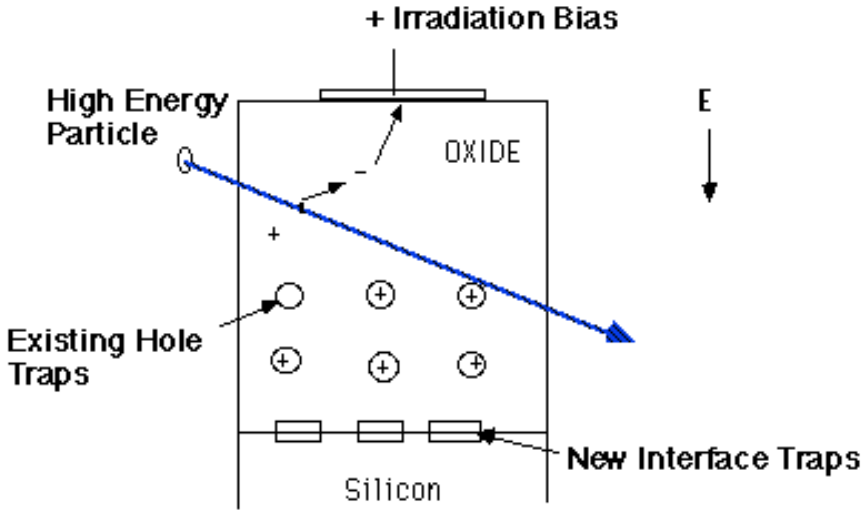
One slide, 20 years:

- RADECS conference (1999)
- Interview in Ireland (2000)
- First commercial orders (2000)
- MED-X-TEST (2000-2003)
- INVORAD (2001-2006)
- ESA BIOPAN (2003)
- Sicel Technologies (2001-2012)
- RADDOS (2008-2012)
- General Atomics / CERN orders (2008-2019)
- EUCPAD (2012-2018)
- ROC/HANDHOLD/ROCSAFE (2010-2019)
- Varadis (2019)

RADFET operating principle:



- Radiation creates electron-hole pairs
- Initial recombination of electrons and holes happens
- Non-recombined electrons leave the oxide;
  holes are trapped in the vicinity of the oxide/silicon interface
- RADFET threshold voltage (V_T) changes ($\Delta V_T \sim$ Dose)

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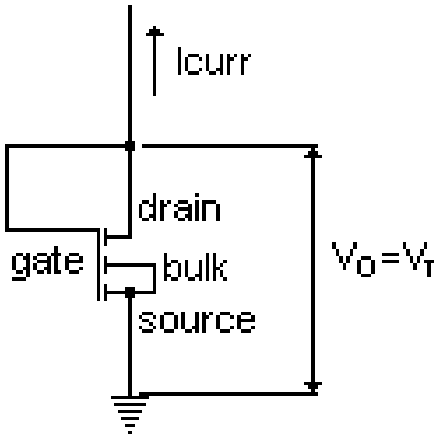
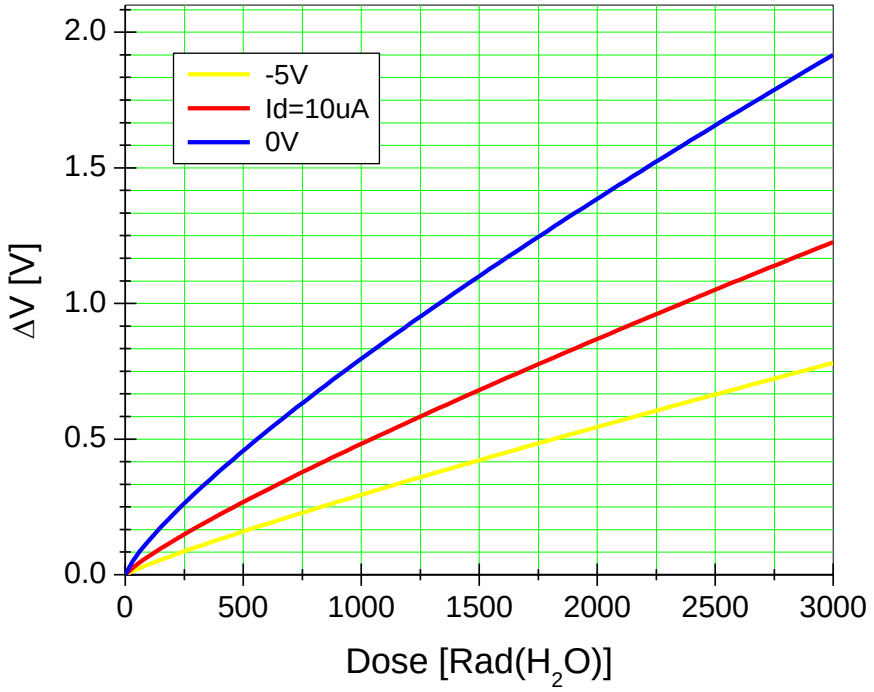
Read-out and calibration curves:





Calibration coefficients

The curve equation is of the form: $\Delta V = a \times Dose^{b}$; ΔV[Volts], Dose[Rad(H_2O)].

Bias	a	b	R-square	SSE
-5V	0.000643	0.8871	0.9999	0.00042
Cont Id=10μA	0.001365	0.8494	0.9994	0.00475
0V	0.003166	0.8001	0.9976	0.04626

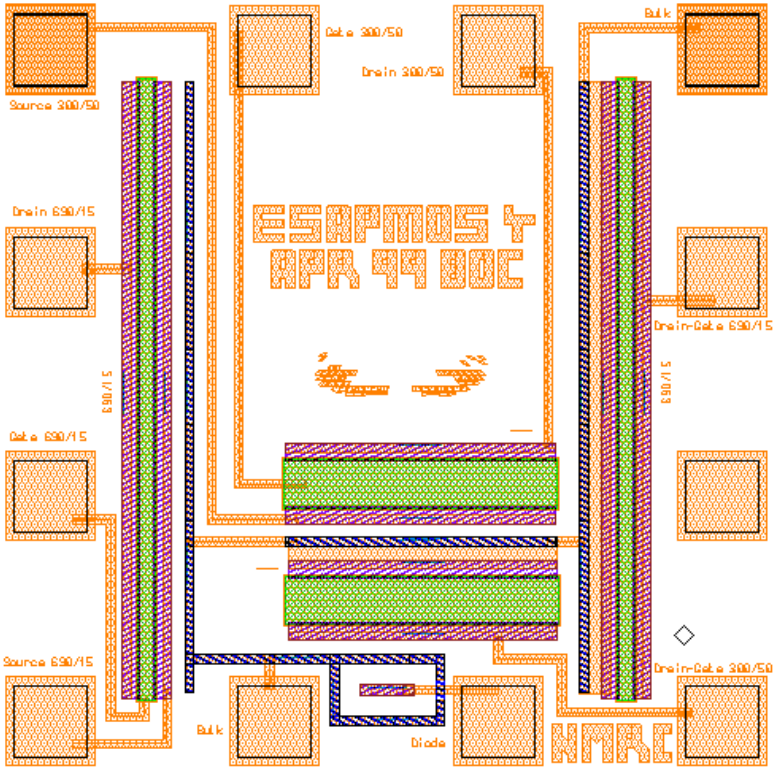
RADFET features:

- Active, integrating dosimeter
- Immediate read-out without destroying the data
- Extremely small sensor chip
- Very low or zero power consumption
- Technology suitable for connection to a microprocessor
- Sensitive to electrons, X-rays, protons

RADFET applications:

- Radiotherapy
- Personal dosimetry (accidental)
- High energy physics laboratories
- Space exploration
- Personal dosimetry (?)

First commercial orders / ESAPMOS4:



- Chip size: 1mm x 1mm
- Contains four RADFETs and one diode
- Chip types (gate oxide):
  - 100 nm
  - 400 nm
  - 400 nm Implanted (IMPL)
  - 1 μm
  - 1 μm Implanted (IMPL)

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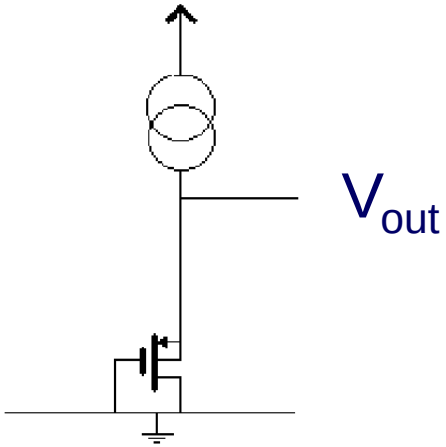
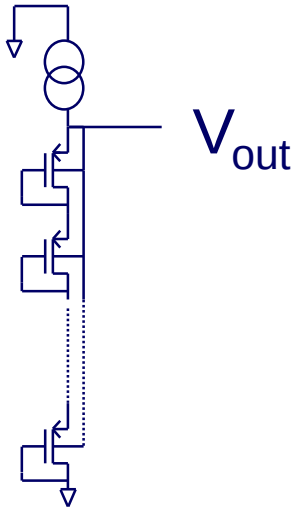
MED-X-Test Project / Stacked RADFET:



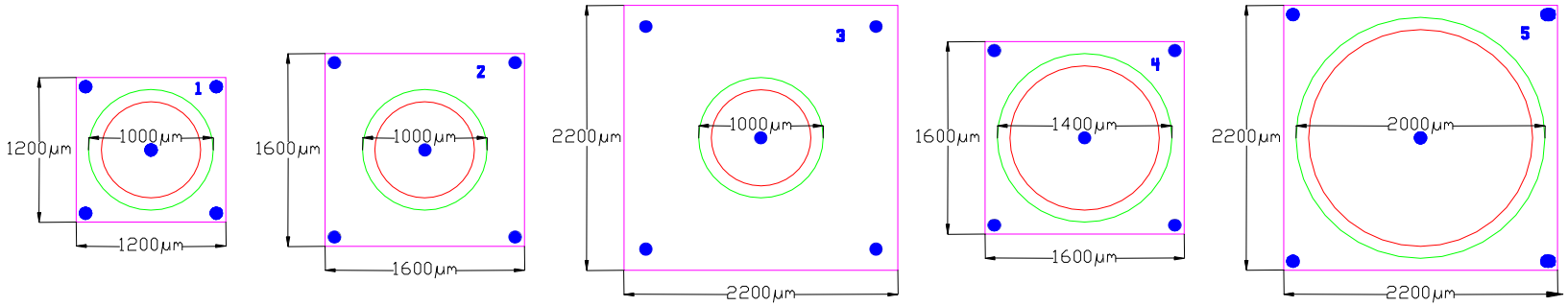
Single



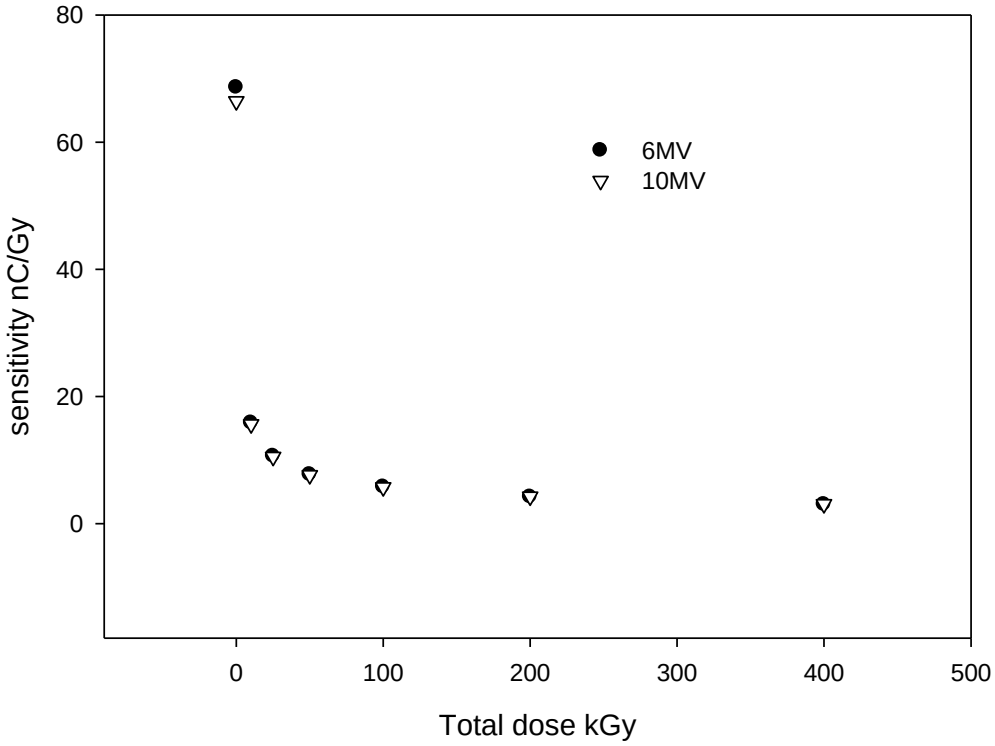
Stacked

- Stacked RADFET applications:
  - Personal dosimetry
  - General low dose applications

INVORAD Project / p-type diodes:



- Highly accurate
- Perfectly linear
- Small active region size
- No need for frequent re-calibration



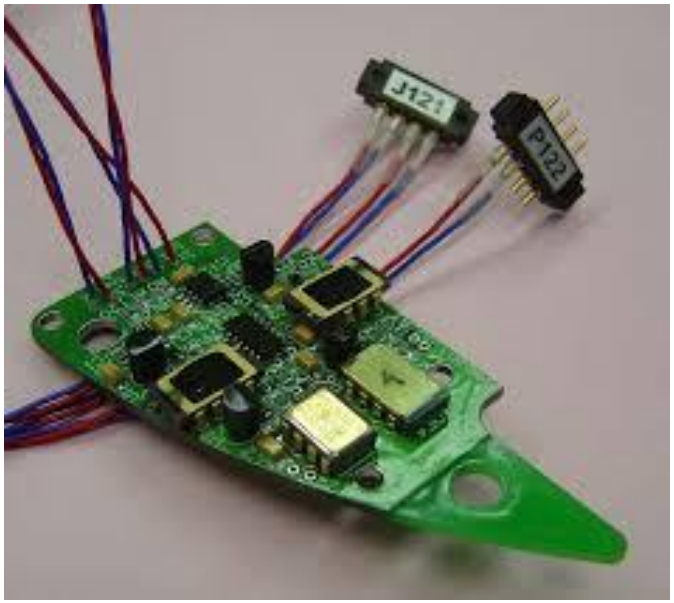
INVORAD final results and lessons:

ScandiDos's Delta4 diode array

RADFET Catheter array

- Be-careful when you choose project partners!
- Don't trust the simulations without experiment

ESA Biopan experiment:



RADFET Biopan Board

Foton 2M spacecraft after landing

Sicel Technologies: OneDose and DVS

Sicel's OneDose system: dosimeter patch and the reader

Sicel's DVS: implantable capsule and wireless reader

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RADDOS:

First RAD Conference, Nis, 2012

Some large orders:

GEASi's accidental dosimeter for first responders

3000 RADFETs installed in the LHC ring at CERN

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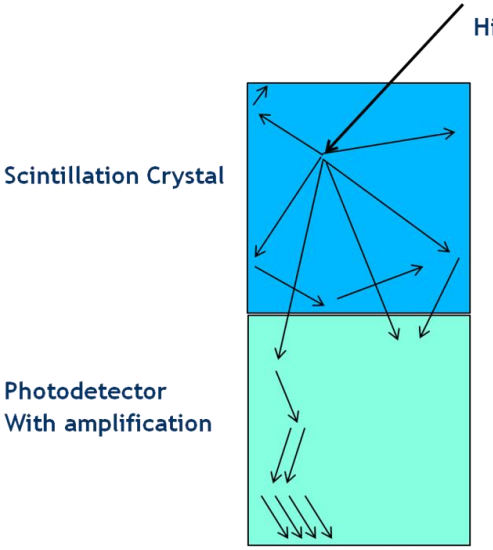
ESA EUCPAD:

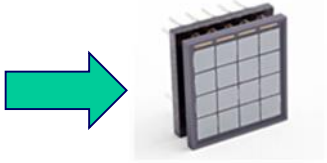
ROC/HANDHOLD/ROCSAFE:



1) Conversion to lower energy visible photons

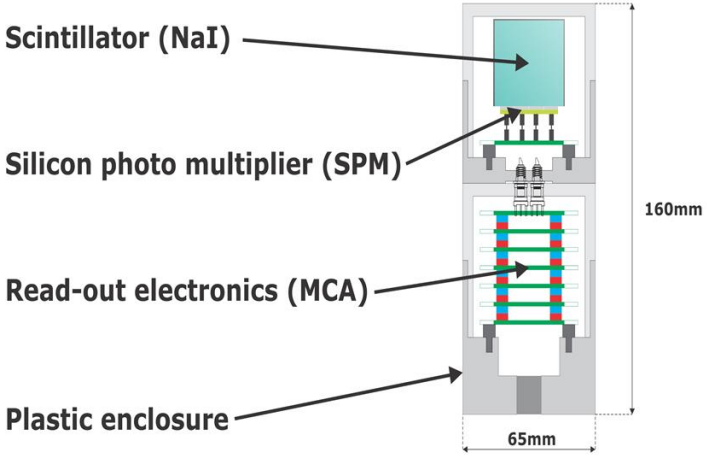
2) Detection and amplification of visible photons

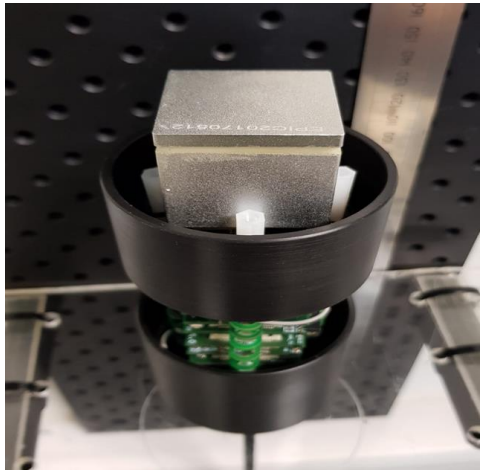
PhotoMultiplier Tube



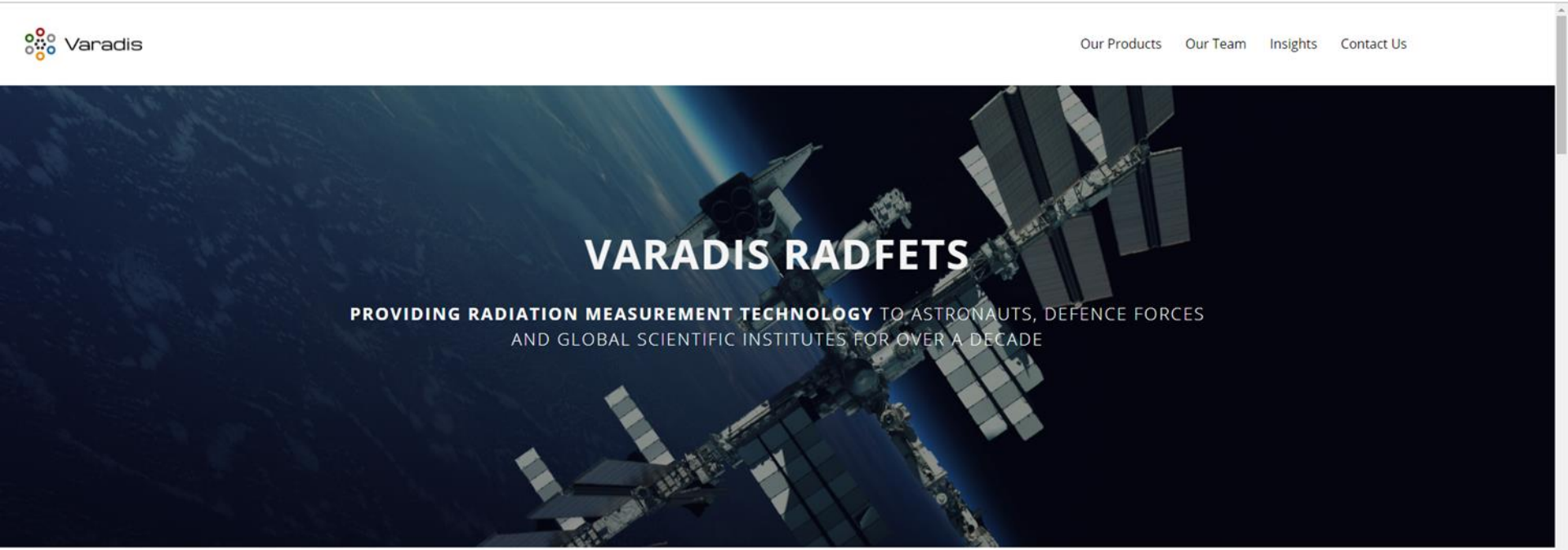
Silicon PhotoMultiplier

Scintillator detection technology





Varadis:



Varadis

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