My research career – interesting anecdotes and useful tips

Aleksandar Jaksic

2nd ELICSIR Training School
22 April 2021

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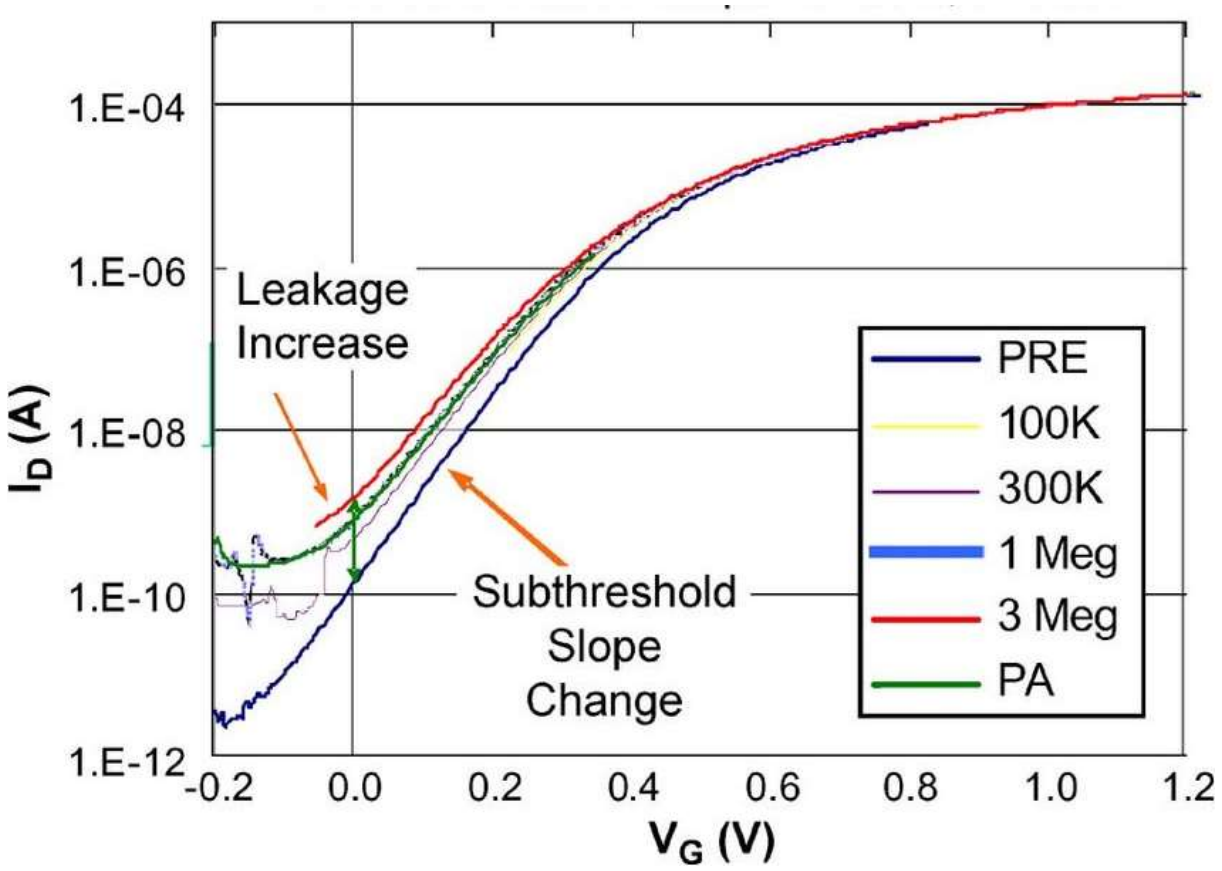
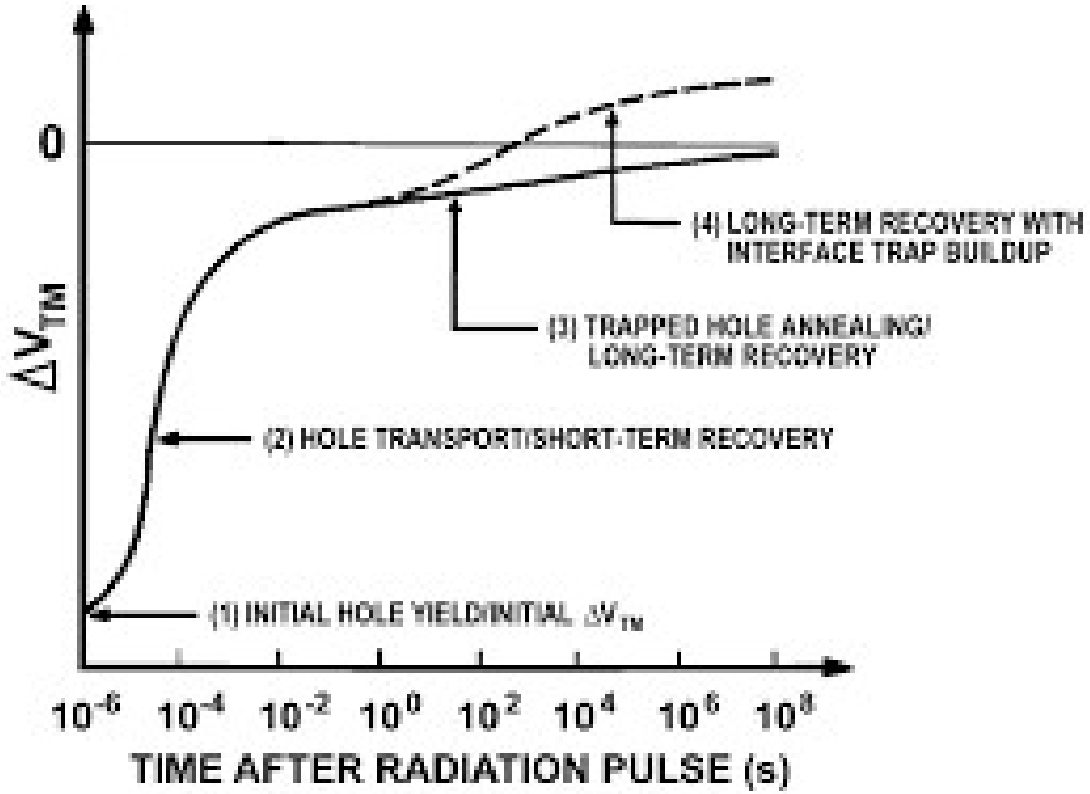
My very short CV:

- Undergraduate studies (1988 – 1993, Nis, Serbia)
- Post graduate research (1994 – 2000, Nis, Serbia)
- Tyndall National Institute (2000 – 2021, Cork, Ireland)
- Private consultant (2021 - ?, ?)

Radiation effects in MOSFETs:



Rebound effect:



My first paper:

electron stress in reoxidized nitrided gate oxide MOSFET's', *IEEE Electron Device Lett.*, 1992, **13**, pp. 47–49

9 GRUNTHANER, F.J., GRUNTHANER, P.J., and MASERJIAN, J.: 'Radiation-induced defects in SiO_2 as determined with XPS', *IEEE Trans.*, 1982, **NS-29**, pp. 1462–1466

10 SHIH, D.K., KWONG, D.L., and LEE, S.: 'Study of the SiO_2/Si interface endurance property during rapid thermal nitridation and reoxidation processing', *Appl. Phys. Lett.*, 1989, **54**, pp. 822–824

10 APTE, P.P., and SARASWAT, K.C.: 'SiO_2 degradation with charge injection polarity', *IEEE Electron Device Lett.*, 1993, **14**, pp. 512–514

11 VASQUEZ, R.P., and MADHUKAR, A.: 'Strain-dependent defect formation kinetics and a correlation between flatband voltage and nitrogen distribution in thermally nitrided SiO_xN_y/Si structures', *Appl. Phys. Lett.*, 1985, **47**, pp. 998–1000

12 FUKUDA, H., UCHIYAMA, A., KURAMOCHI, T., HAYASHI, T., IWABUCHI, T., ONO, T., and TAKAYASHI, T.: 'High-performance scaled flash-type EEPROMs with heavily oxynitrided tunnel oxide films'. IEDM Tech. Dig., 1992, pp. 465–468

Rebound effect in power VDMOSFETs due to latent interface-trap generation

A. Jakšić, G. Ristić and M. Pejović

Indexing terms: Power MOSFETs, Radiation effects

The rebound effect, observed in commercial *n*-channel power VDMOSFETs during biased thermal annealing, following γ-radiation exposure, is analysed. Rebound is caused predominantly by 'latent' interface-trap generation, which occurs in transistors irradiated and annealed with positive bias applied to the gate, after initial apparent saturation of the interface-trap density. Latent, interface-trap buildup may cause difficulties in predicting device response in low dose rate environments, such as space.

plays a secondary role. We discuss the implications of latent buildup for rebound prediction and minimisation.

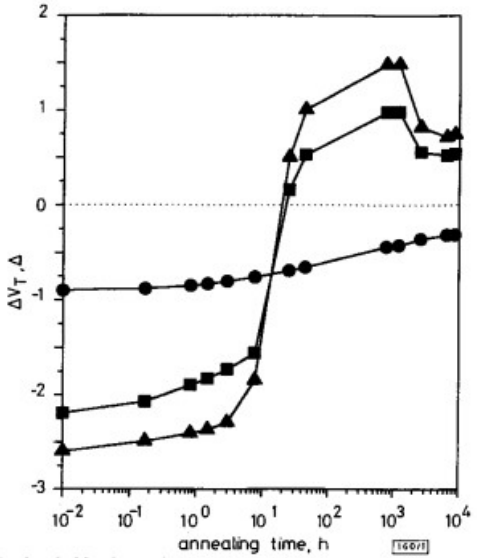


Fig. 1 *Threshold voltage shift during annealing*

● V_{GS} = 0V
■ V_{GS} = 5V
▲ V_{GS} = 10V

The devices used in the experiment were *n*-channel enhancement-mode power VDMOSFETs EFL1N10, fabricated in a standard Si-gate process, with a nominal gate oxide thickness of 100 nm. Since it is established that laboratory irradiation at a small dose rate, followed by high temperature postirradiation annealing,

Latent interface trap buildup:

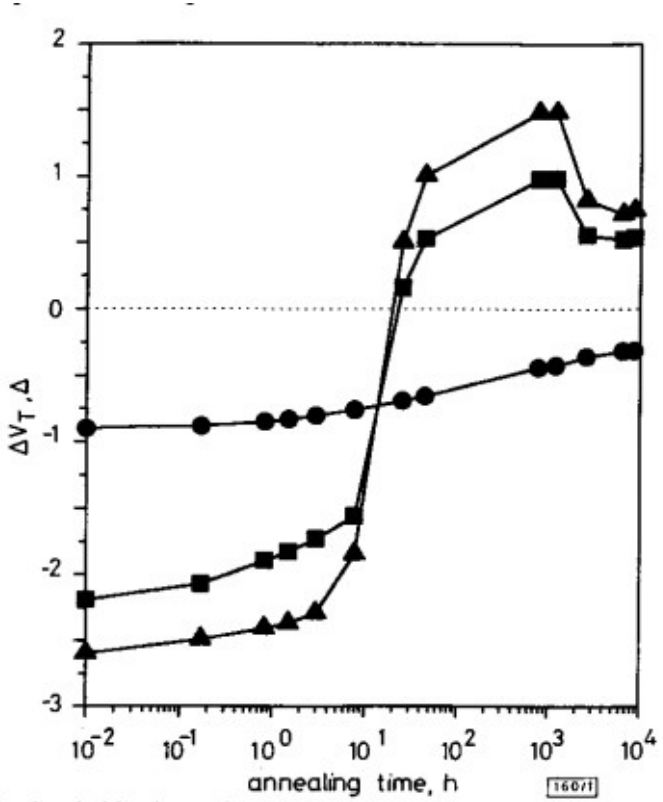


Fig. 1 *Threshold voltage shift during annealing*

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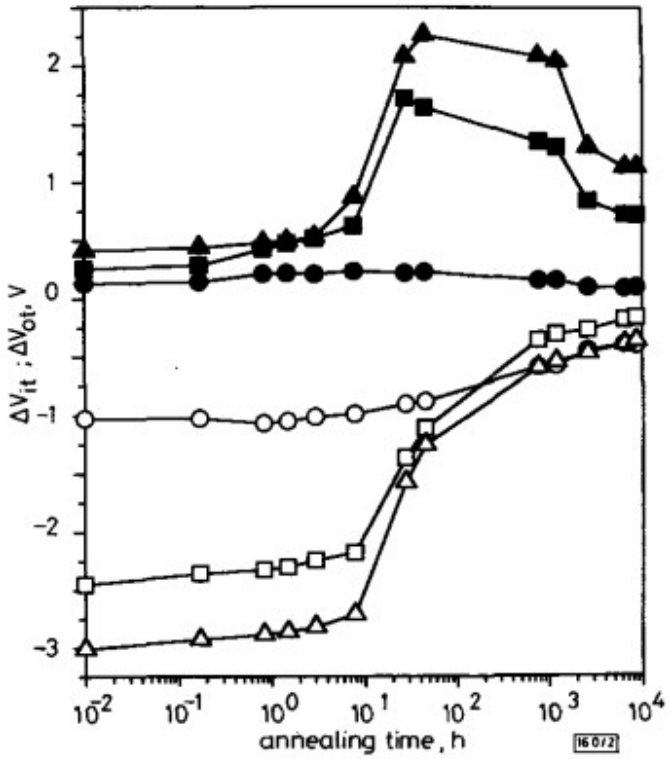

Fig. 2 *Contributions to threshold voltage shift due to oxide-trap charge and interface traps during annealing*

—○— ΔV_{it} —●— ΔV_{ot}: V_{GS} = 0V
—□— ΔV_{it} —■— ΔV_{ot}: V_{GS} = 5V
—△— ΔV_{it} —▲— ΔV_{ot}: V_{GS} = 10V

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)

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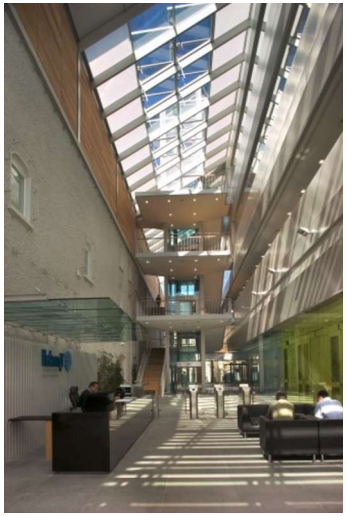
Ireland, Cork, Tyndall:



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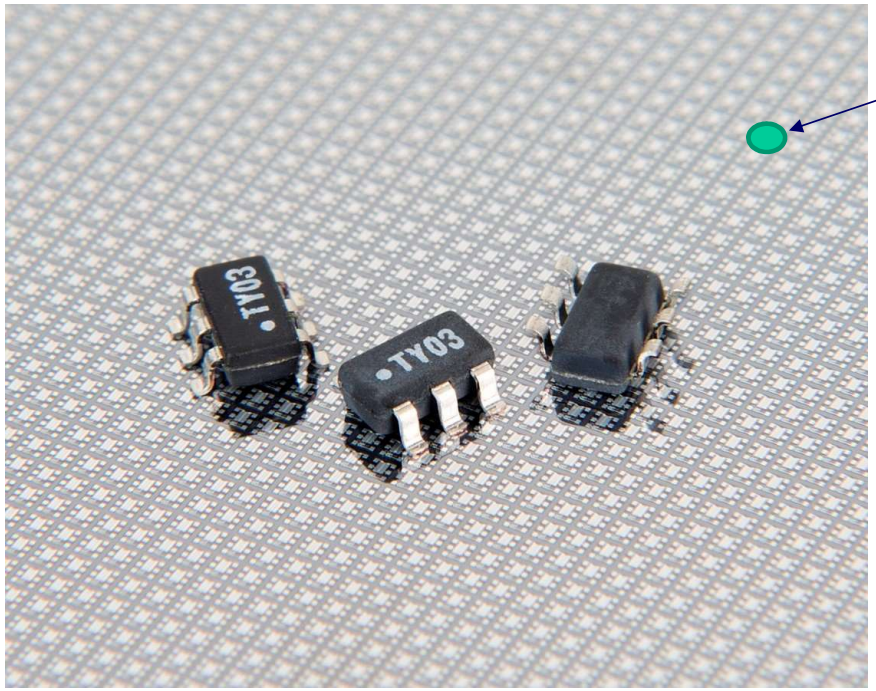
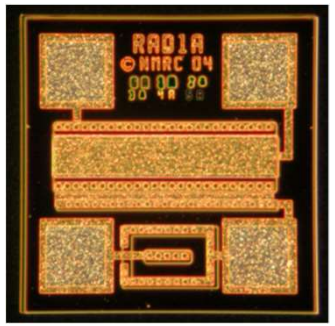
RADFET:



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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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

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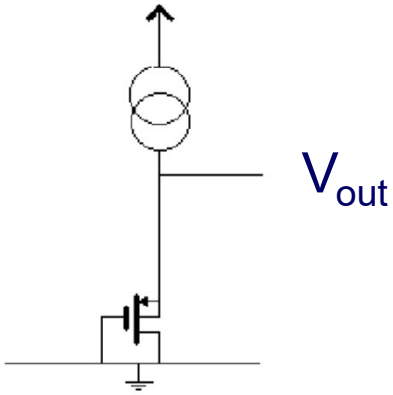
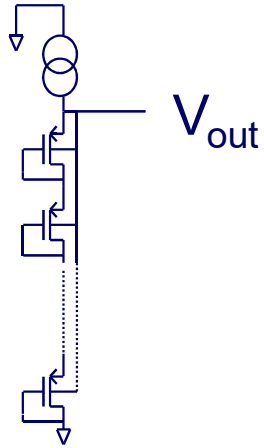
RADFET applications:

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

MED-X-Test Project / Stacked RADFET:



Single



Stacked

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

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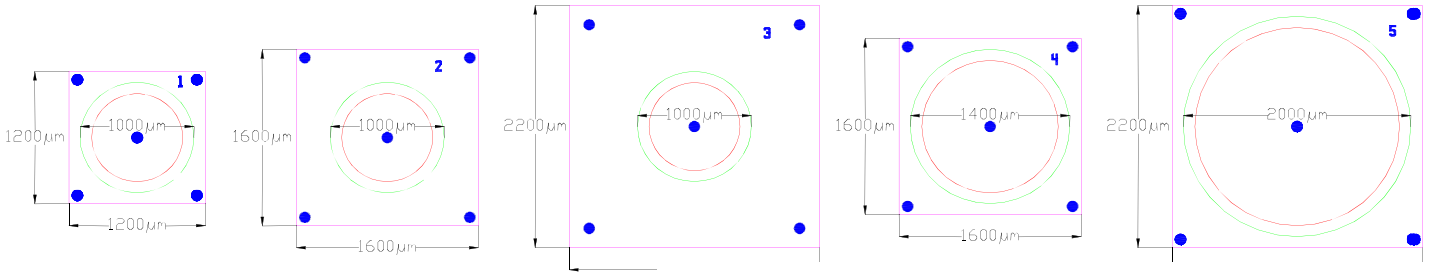
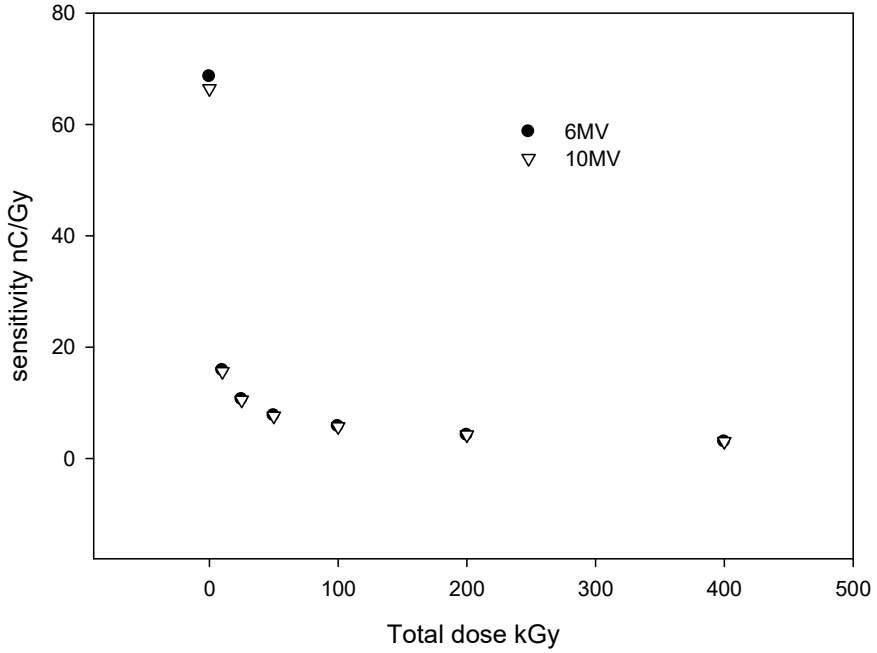
INVORAD Project / p-type diodes:



- 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!!!

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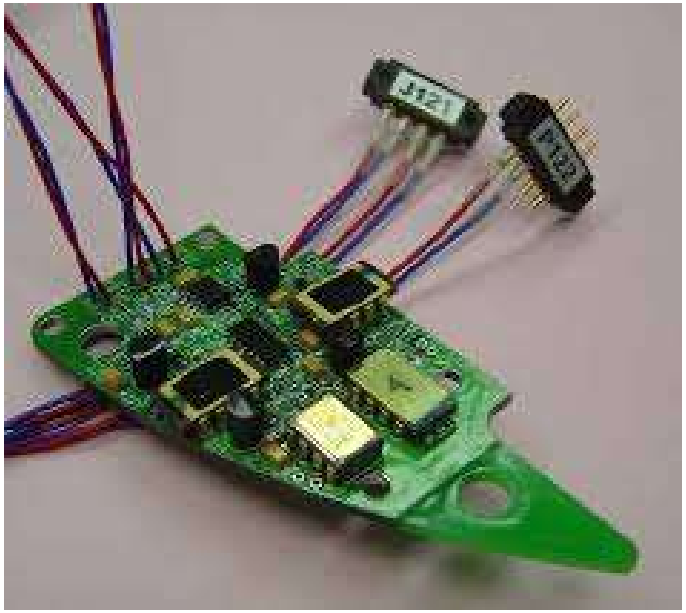
ESA Biopan experiment:



RADFET Biopan Board

Foton 2M spacecraft after landing

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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

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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:

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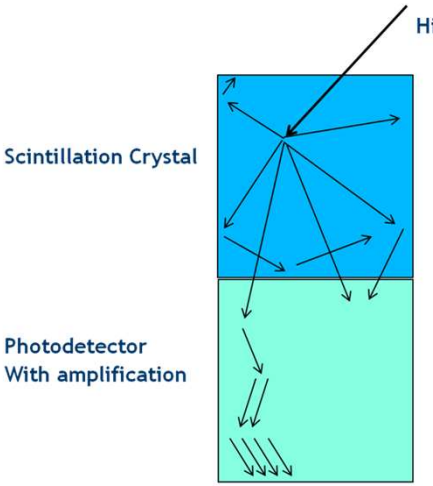
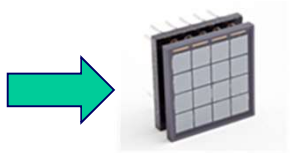
ROC/HANDHOLD/ROCSAFE:



1) Conversion to lower energy visible photons

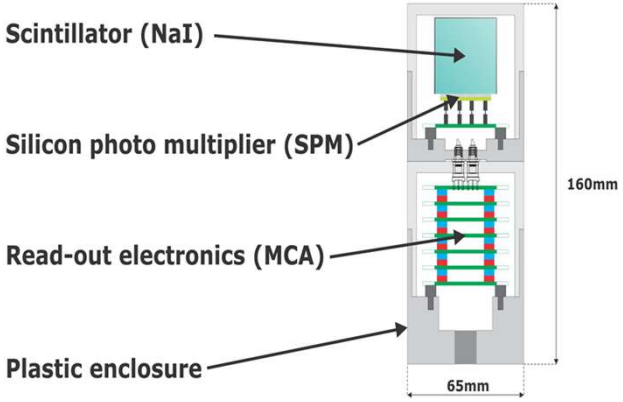
2) Detection and amplification of visible photons

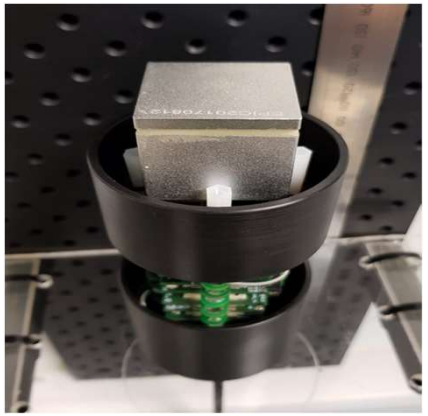
PhotoMultiplier Tube



Silicon PhotoMultiplier

Scintillator detection technology





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VARADIS:

Varadis

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