Solid-State Radiation Sensors

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PH-DT2-SD

Outline

- Introduction;
- Sensor Catalogue;
- Dose Sensors (RadFETs);
- Fluence Sensors (p-i-n and detector diodes);
- Readout Circuitry;
- Integration Issues in the Experiments;
- Conclusions.

Introduction

- TS-LEA and PH-DT2 have characterized a set of sensors for IEL (Dose) and NIEL (Φ_{eq}) measurement;
- Survey of cumulated Rad. Damage in detector and elect.;
- Sensors suited for the LHC experiments environment;
- "*Sensor Catalogue*" published;
- R&D on sensors is ongoing: OSL, n_{th} sensors, …
- Integration into the experiments and their readout is not our responsibility!

Sensor Catalogue

Address http://lhc-expt-radmon.web.cern.ch/lhc-expt-radmon/

LHC Experiment Radiation Monitoring (RADMON)

Solid-State Radiation Sensor Group

Publications

Link to LHC Machine (RADWG)

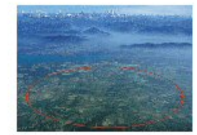
Link to Tevatron (CDF, D0)

Link to HERA (H1, HERMES, ZEUS)

Home

Solid-State

Radiation Sensor Working Group



Sensor Catalogue (PDF)

(DATA COMPILATION OF SOLID-STATE SENSORS FOR RADIATION MONITORING)

by

Federico Ravotti (TS-LEA-RAD), Maurice Glaser and Michael Moll (PH-DT2-SD)

TABLE OF CONTENTS

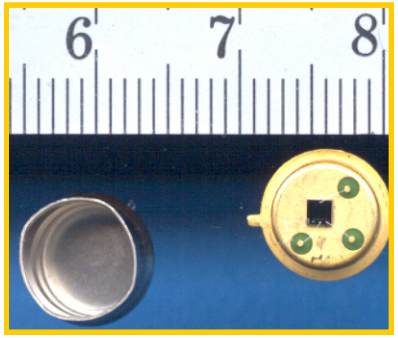
Standard RADMON Integrated Packaging 36LD Chip Carrier

www.cern.ch/lhc-expt-radmon/

TID (Dose) Sensors

RadFETs: Charge built-up in SiO_2 → V_{th} shift proportional to dose

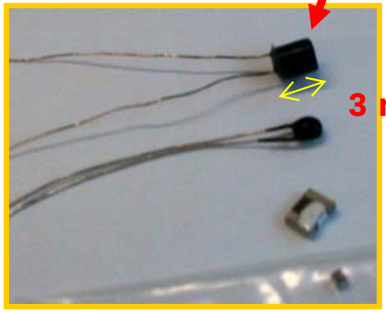
- Thin-Oxide RadFET dies (0.13-0.25 μm):
  - “low” sensitivity (0.1 Gy) – high dynamic range (~ 100 kGy);
  - Minimize SiO_2 recombination effects → mixed-LET particle fields;
  - Suited for dosimetry in inner-detector regions;
  - 850 pcs. at CERN: selection and QA ongoing at CERN.



- Thick-Oxide RadFET dies (1.6 μm):
  - “high” sensitivity (mGy) – low dynamic range (~ 10 Gy);
  - Measurement in “conventional” (γ + n) radiation fields.
  - Suited for dosimetry in outer-detector regions;
  - 100 pcs. at CERN: first 30 to be delivered next week to ATLAS.

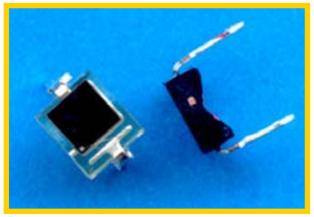
Φ_{eq} (Fluence) Sensors

p-i-n diodes: Bulk damage in Si base → V_F shift proportional to fluence

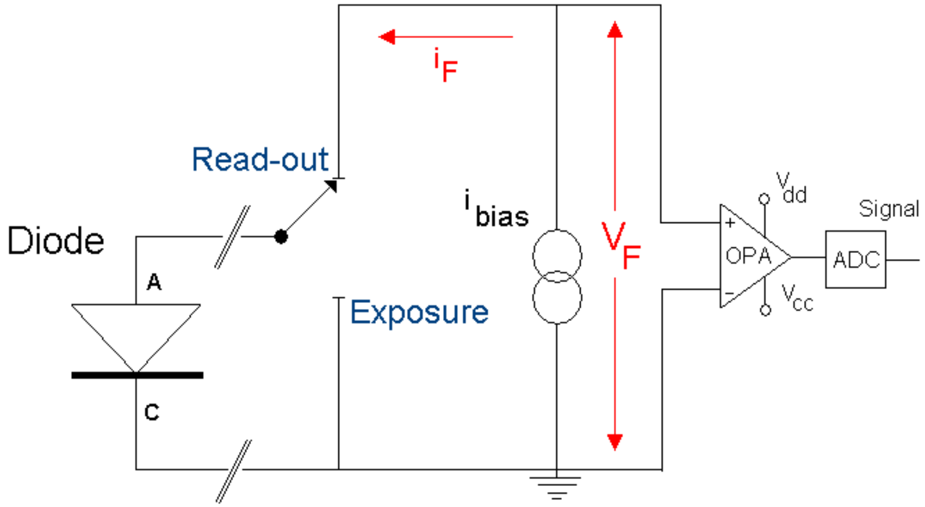


3 mm

- High-Sensitivity diodes:
  - Range: $\Phi_{eq} < 2 \times 10^{12}$ cm^{-2}; Sensitivity: ~ 2×10^{8} cm^{-2}/mV;
  - Packaged or Si Crystal (~ 1 mm^3) for wire-bonding;
  - 100 pcs. at CERN: first 30 to be delivered next week to ATLAS.
- Low-Sensitivity diodes:
  - Range: 2×10^{12} to 4×10^{14} cm^{-2}; Sensitivity: ~ 8×10^{9} cm^{-2}/mV;
  - Commercial Packaging (~ 5 mm^2), no other choices!
  - 160 pcs. at CERN pre-selected to guarantee homogeneity.



Φ_{eq} and TID Readout

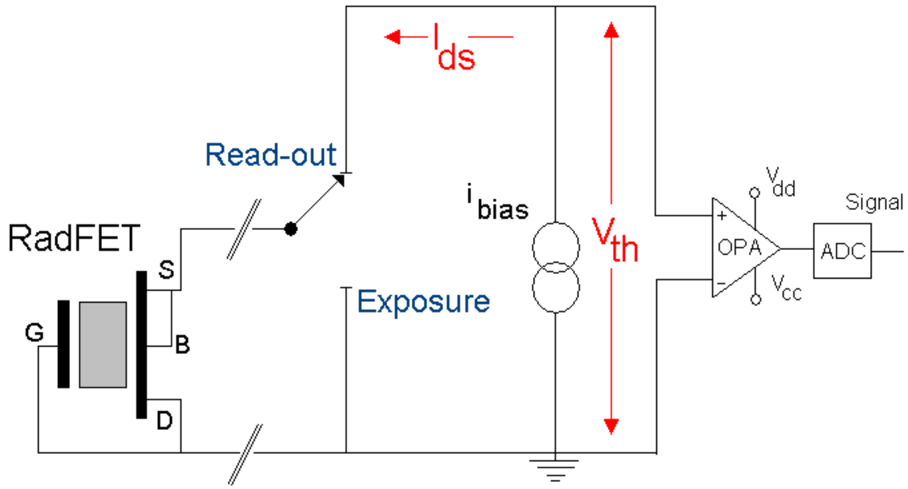


- Currents: 100 μA to 200 μA;
- Time: 5 sec (optimum),

  1 sec (minimum).

- Currents: 1 mA to 25 mA;
- Time: 50 ms (optimum),

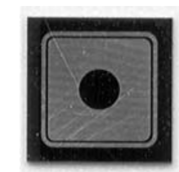
  200 ms (maximum).

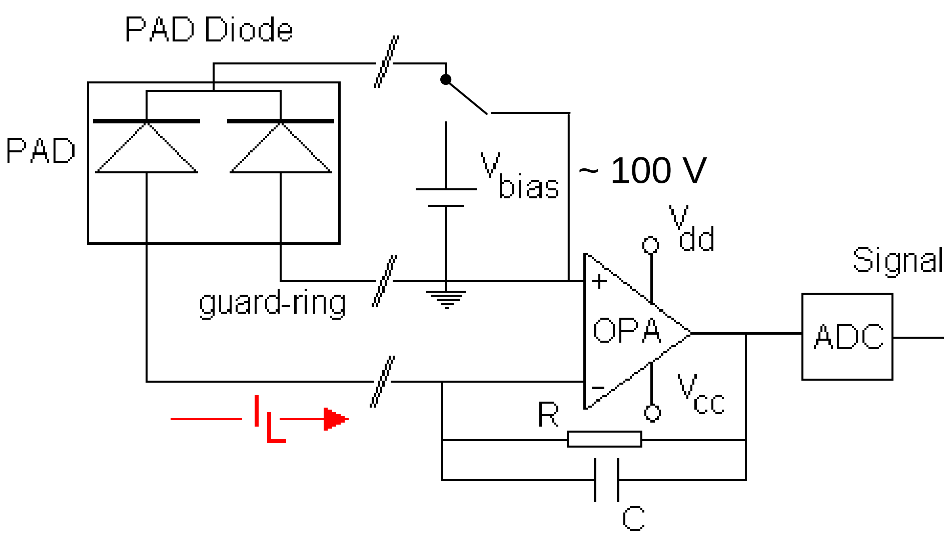


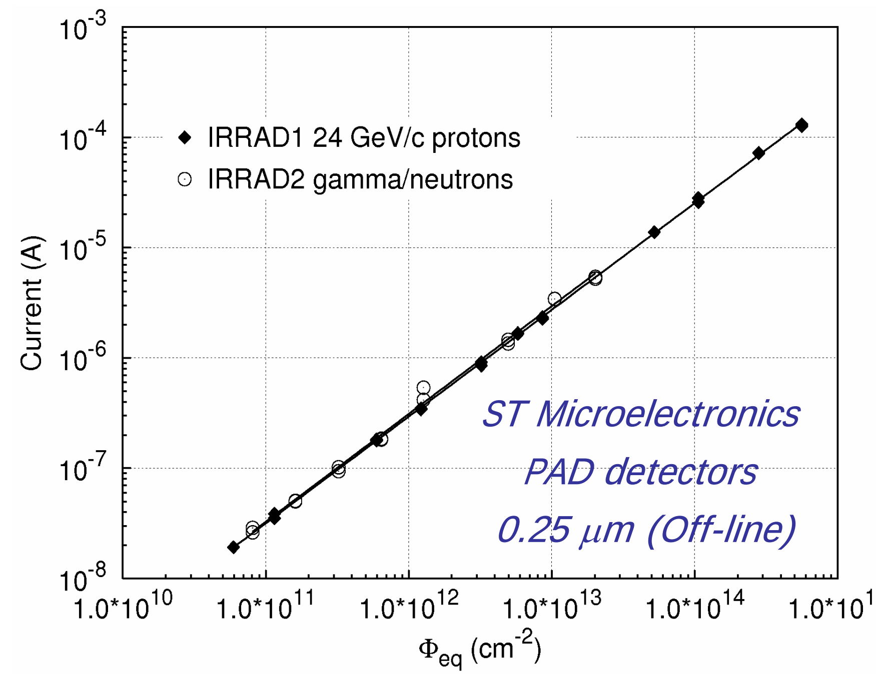
Φ_{eq} (Fluence) Sensors

Detector diodes: Bulk damage in Si base → I_L shift proportional to fluence

- Particle Detector diodes (300 μm):
  - Range: $1x10^{11}$ to $5x10^{14}$ cm^{-2}; Sensitivity: ~ $4x10^{9}$ cm^{-2}/nA;
  - ~ 60 bare samples (7 mm^2) from ST Microelectronics on stock.
  - More complicate readout!

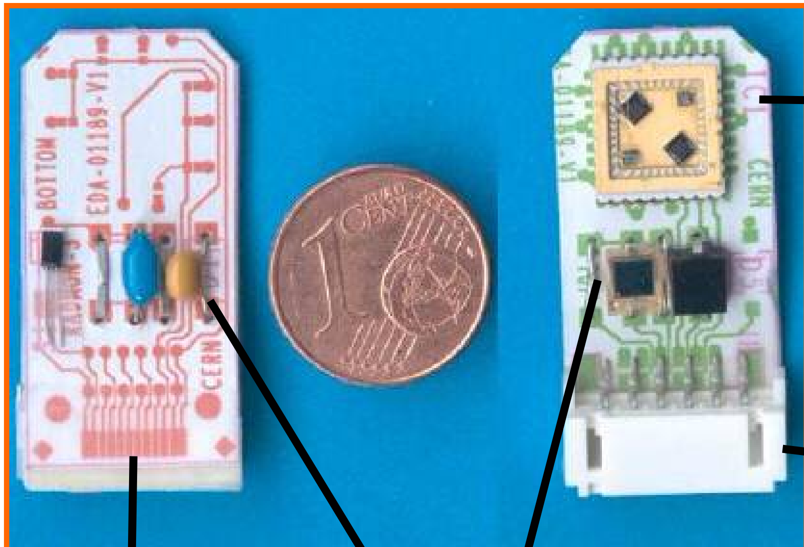


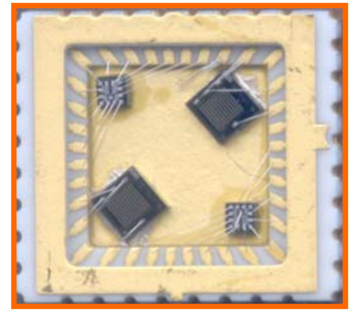




Integration Issues 1/2

about 30 x 15 x 8 mm PCB





TID sensors Package: Integration of several devices!

The TID sensors can be strongly affected by the surrounding materials

standard connector

RADMON BOARD (up to 11 sensors)

Soldering contacts

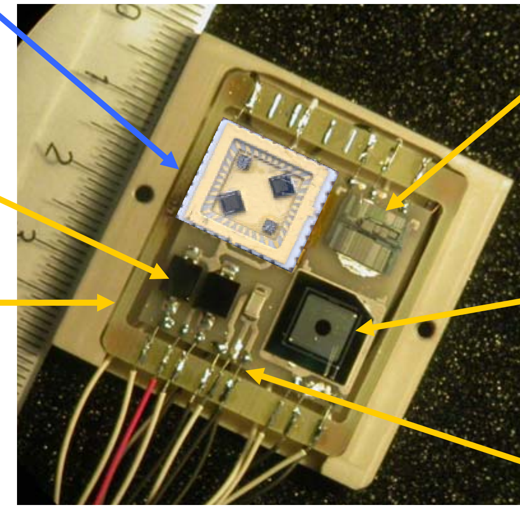
Φ_{eq} Sensors covering 2 dynamic ranges!
+
Temperature sensor

The sensor carrier can be integrated in “on-line” data acquisition systems but can be also removed and used in “off-line” mode on a laboratory test bench.

Integration Issues 2/2

ATLAS ID (RMSB Hybrid)

4 x RADFETs (.. + High Sens. Pin + ..)



DMILL structure (n_{th} damage)

BPW34 diodes

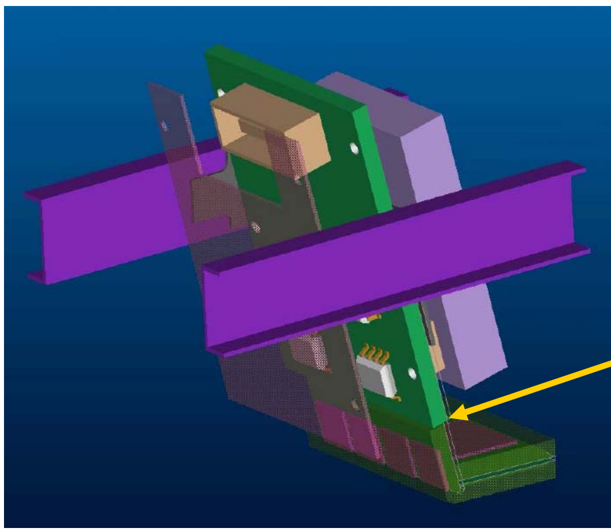
PCB with T control

PAD diode

PT1000

[I. Mandic, JSI]

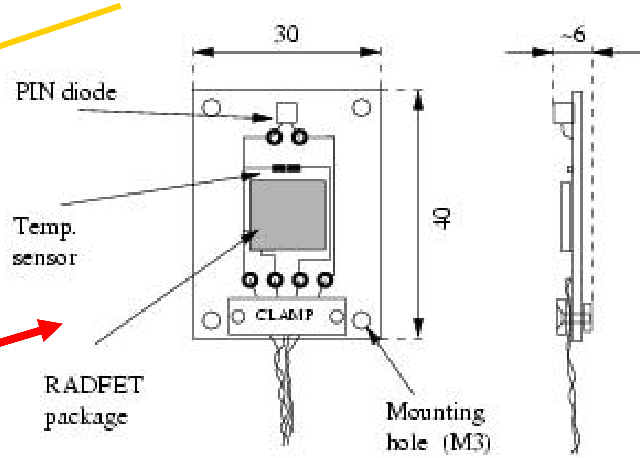
CMS (BCM 1)



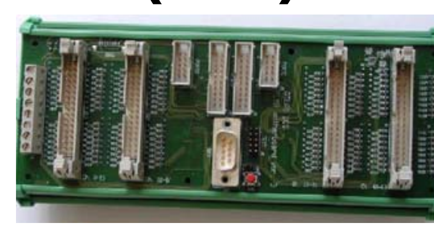
p-i-n diode

[A. Macpherson, CERN]

Rest of ATLAS



ELMB (ADC) + DAQ



General-purpose plug-on I/O module for the monitoring and control of sub-detector front-end equipment

Conclusions

- A set of sensors for the radiation monitoring (IEL and NIEL) in the LHC Experiment environment is available;
- The sensors for the LHC startup have already been procured. The first sensors are delivered to the Experiments;
- The sensor choice has to take into account: expected type of damage, radiation field intensity and composition;
- The integration remain the responsibility of the Experiments.

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www.cern.ch/lhc-expt-radmon/