CMS
Compact Muon Solenoid

New Dosimeter Equipment

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- A Radiation Monitoring System for CMS: why? how?
- RadFETs and neutron diodes: operating principle
- Test beam results
- Conclusions

The Radiation Monitoring System for CMS

CMS radiation environment: mixed radiation field (IEL, NIEL)

Purpose of the system

1) Mapping of dose and fluence in each sub-detector: independent measurement of dose and fluence to cross-check for calibration, etc.
2) Studies of machine related backgrounds
3) Measurement of activation levels: planning of shutdown activities

Main characteristics of the system

1) Real-time online dosimetry: no need to access the experiment first
2) Separation between Ionising Energy Loss (dose) and Non-Ioning Energy Loss (fluence)

Beam-abort system: to protect against beam-losses (not looked into it yet)

The dosimeters

All dosimeters selected are commercially available, but some R&D in collaboration with the producers may be required.

Dose measurements (IEL)
MOSFET transistors called RadFETs (Radiation sensitive MOSFETs)
Producers: NMRC in Ireland
REM in UK
Thomson and Nielsen in Canada
Possible R&D: change in gate oxide thickness

Fluence measurements (NIEL)
$p^+/n/n^+$ diodes called neutron diodes
Producer: University of Wollongong in Australia
Possible R&D: change in base width

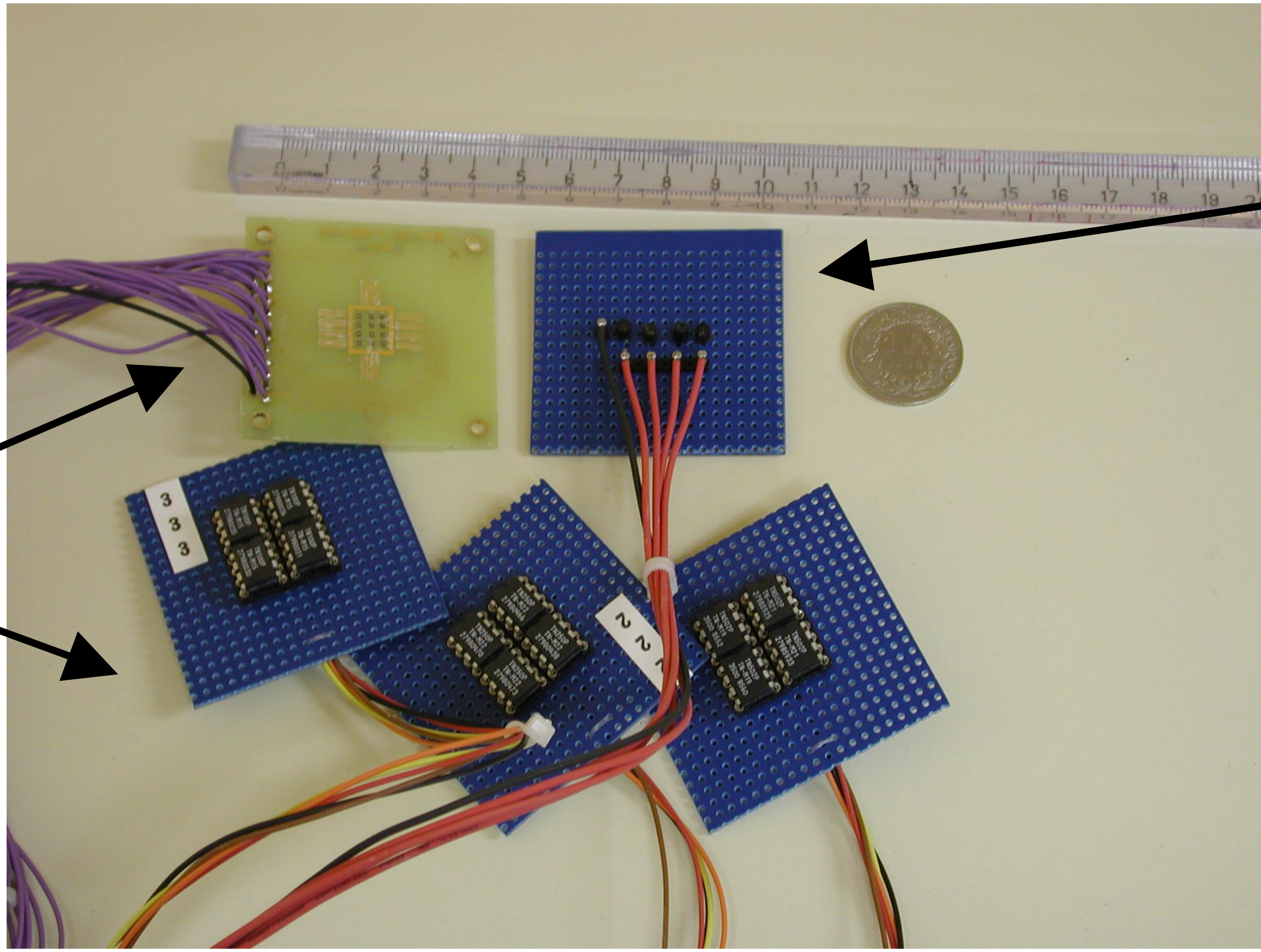
The dosimeters: operating principle

RadFETs

p-channel MOSFET transistors with calibrated sensitivity to ionising radiation
Electron-hole pair production in the gate oxide by charged particle
Positive space charge creation at the interface by hole trapping
Negative charge induced in the substrate
Increase in drop of voltage, V_{th}, across the transistor when biased with a constant current

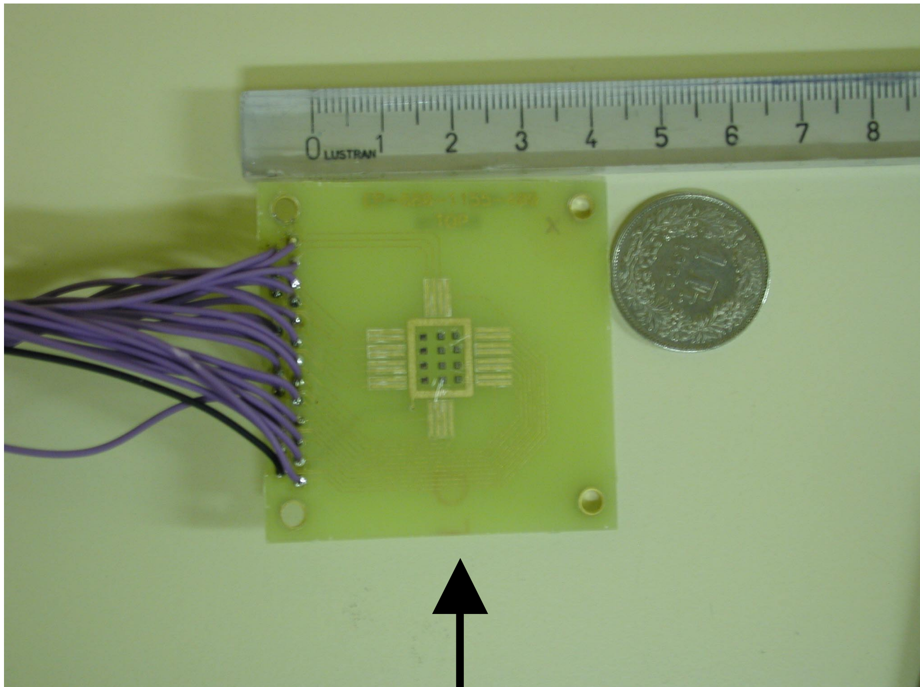
Neutron diodes

$p^+/n/n^+$ diodes with calibrated sensitivity to non-ionising radiation
Bulk damage created in the intrinsic region by neutrons and other particles (p, π, e, etc.)
New traps creation
Decrease in minority carrier lifetime
Change in voltage, V_F, across the diode when biased forward with a constant current



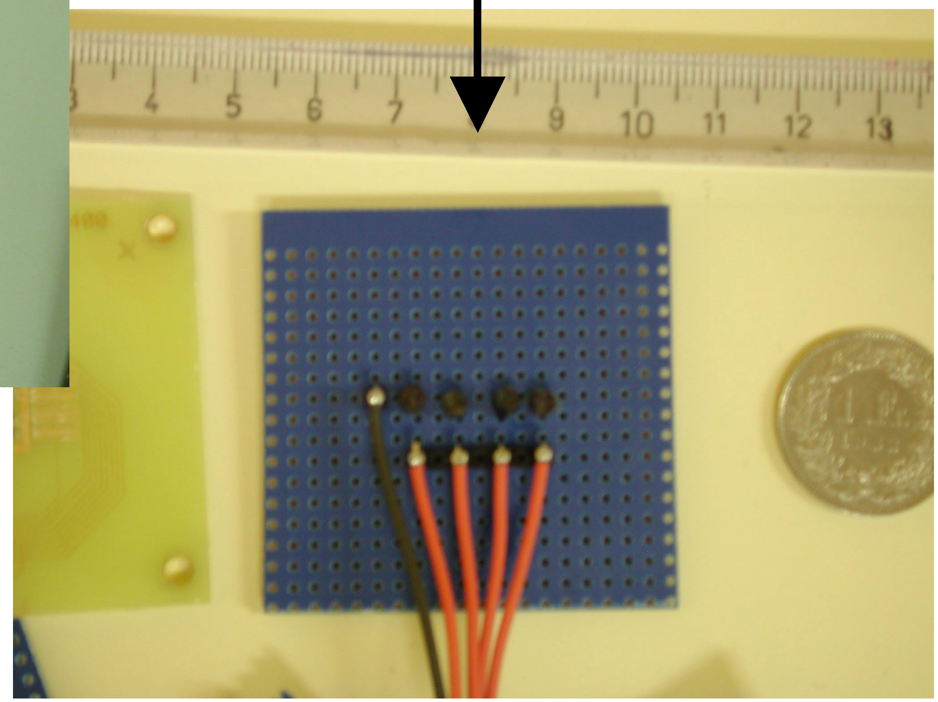
Neutron diodes

RadFETs



RadFETs

Neutron diodes



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2000 / 2001 test-beam program

Irradiations

2000: 192 MeV π^- (PSI) up to 1×10^{14} π/cm^2, 500 MeV e^- (LIL) up to $4\text{-}7 \times 10^{14}$ e/cm^2

23 GeV p (IRRAD1) up to 0.5×10^{14} p/cm^2, n (IRRAD2) up to 2.4×10^{14} n/cm^2,

3.6 GeV π^- (T11) up to 2×10^{10} π/cm^2

2001: 23 GeV p (IRRAD1) up to 1×10^{14} p/cm^2, n (IRRAD2) up to 0.6×10^{14} n/cm^2, TCC2

Measurement protocol

All terminals shorted during irradiation

Readings taken with beam on and off

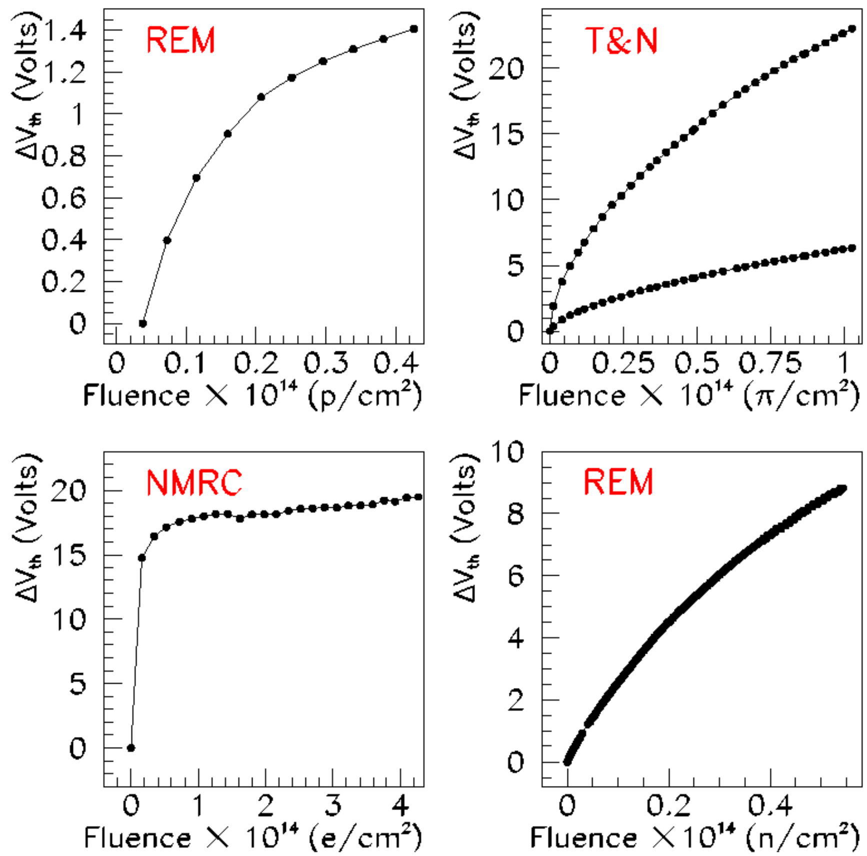
Injection of constant current: 10 µA, 100 µA, 160 µA for RadFETs,
1 mA for neutron diodes

Readout of voltage: 2-5 times at few second interval for RadFETs
1 time after 180 ms for neutron diodes

RadFETs: typical response curves

23 GeV p (IRRAD1)

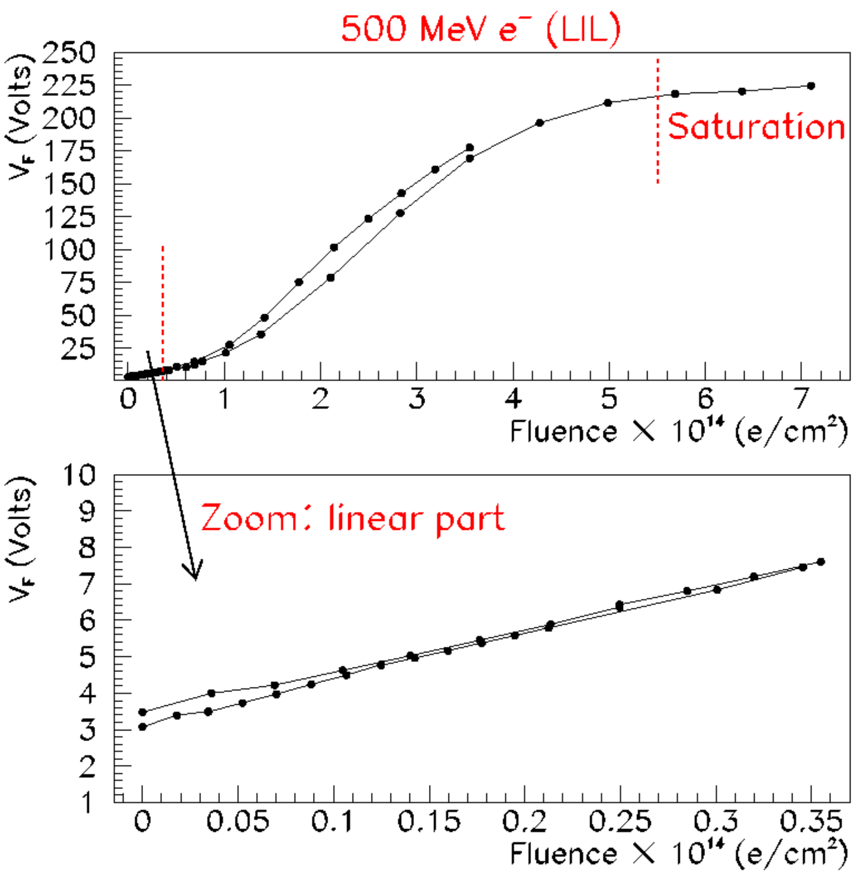
192 MeV π⁻ (PSI)



500 MeV e^- (LIL)

n (IRRAD2)

Diodes: typical response curve



Saturation = 5.5×10^{14} e/cm^2

Slope = 12.14 +/- 0.66 mV/(10^{11} e/cm^2)

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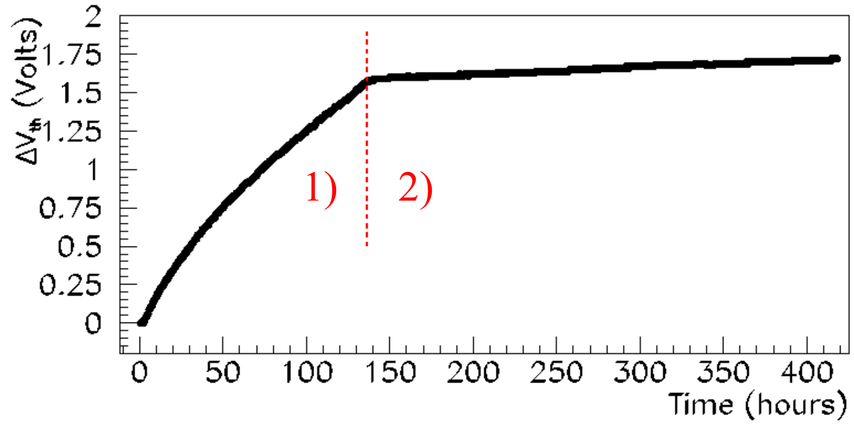
TCC2: preliminary results

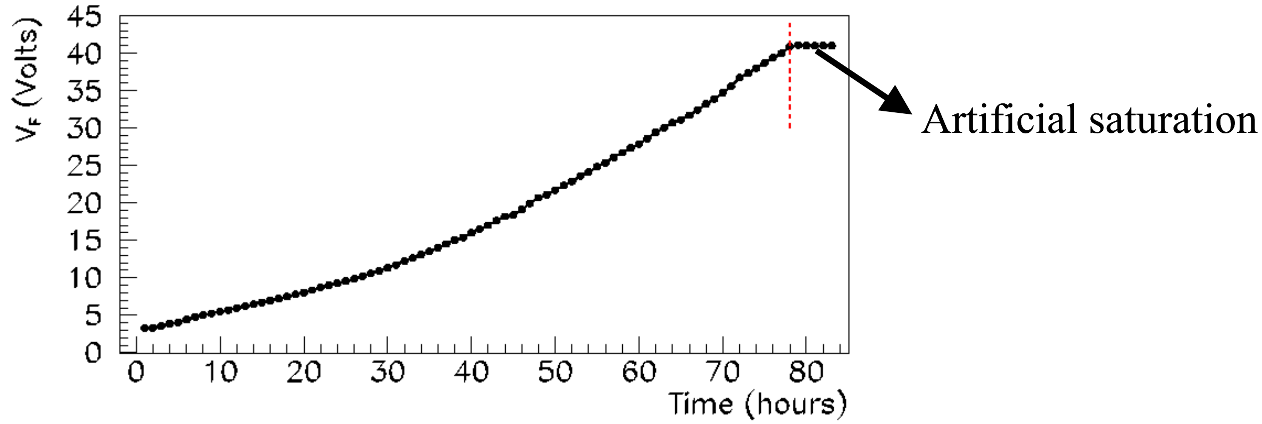
RadFET (T&N):



1) = High intensity run

2) = Low intensity run

Neutron diode:



170m of readout cable!

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Conclusions

- A CMS Radiation Monitoring System is under development:
  - real-time online readout
  - separation IEL/NIEL

- Technologies for such system are available:
  - RadFETs for IEL
  - Neutron diodes for NIEL

  as proved in test-beams last and this year.

- First irradiation in TCC2 performed this year: the dosimeters worked well in such environment.

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From CMS:
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