# ATLAS Radiation Monitor

- ***integrating monitor***

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- Integrating part of the *ATLAS Radiation Monitor* will measure online:
  - –Total Ionization Dose - TID
  - –Non-Ionizing Energy Loss – (bulk damage in silicon)
  - –Thermal Neutron Fluence (in the ID)

- more information in:
  - EDMS document: *ATL-IC-ES-0017*
  - http://www-f9.ijs.si/~mandic/RADMON/atlas_radiation_monitor.htm

# Sensors for online radiation monitoring

Total Ionizing Dose (TID):

- RADFET's (threshold voltage increase)

  - thick oxide LAAS (for low doses), thin oxide REM (for high doses)

NIEL:

- PIN diodes under forward bias (resistivity increase with NIEL)

  - CMRP low fluences ($< 10^{12}$ n/cm$^2$ ), BPW34F high fluences ($> 10^{12}$ n/cm$^2$)

- EPI PIN-diodes (leakage current increase with NIEL)

  → Will be used only in the Inner Detector

Thermal neutrons (and monitor the damage of ABCD3T input transistor):

- DMILL bipolar transistor from ATMEL (increase of base current at given collector current)

  → Will be used only in the Inner Detector

# Read-out

**ELMB + ELMB DAC boards:**

- ELMB available, 64 ADC channels
- DAC board (16 channels) produced and tested

Fully compatible with ATLAS DCS (CAN bus communication)

Compliant with radiation tolerance requirements

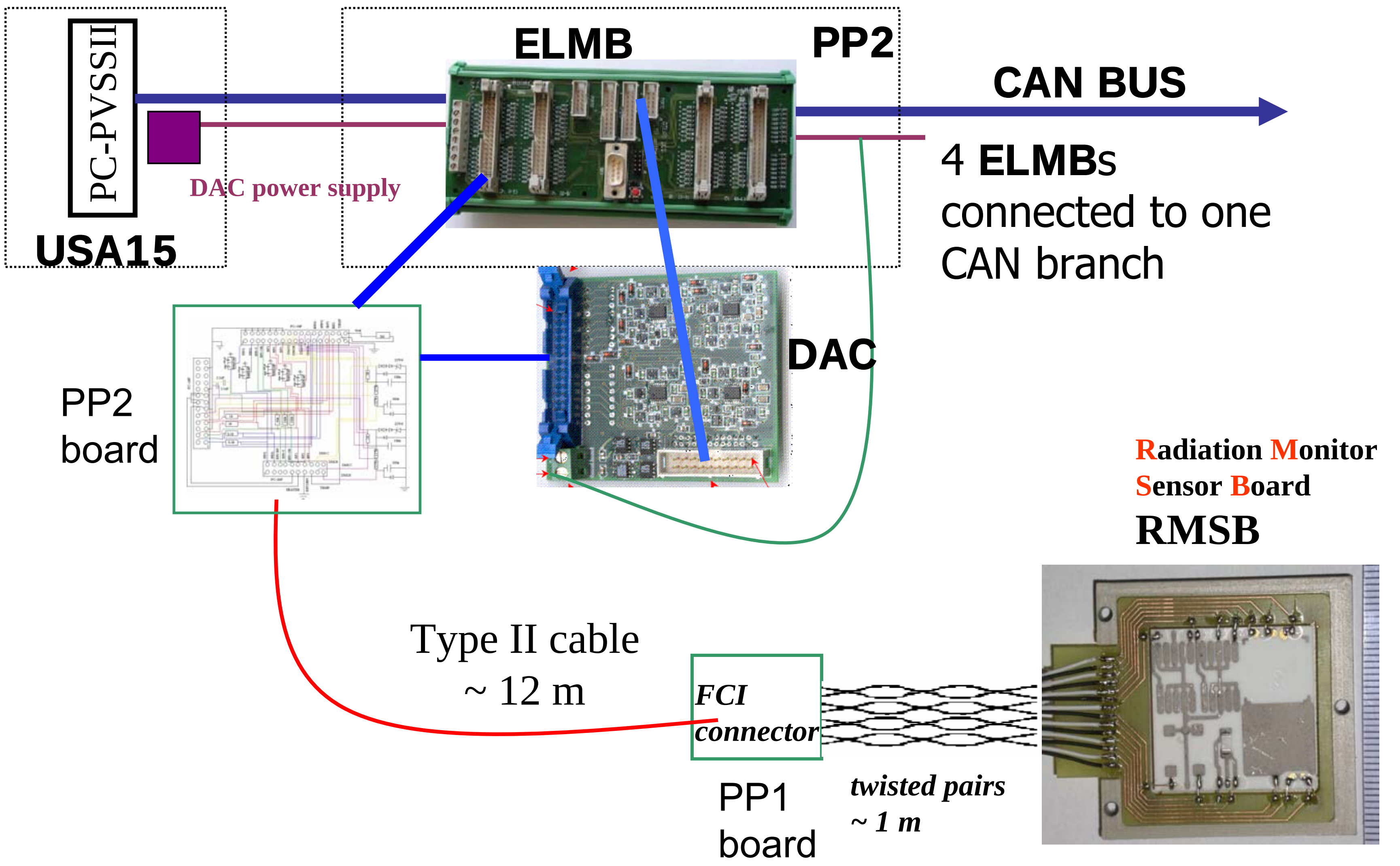
Readout principles

**RADFET,PIN:** current enforced (DAC)-voltage measured (ADC)

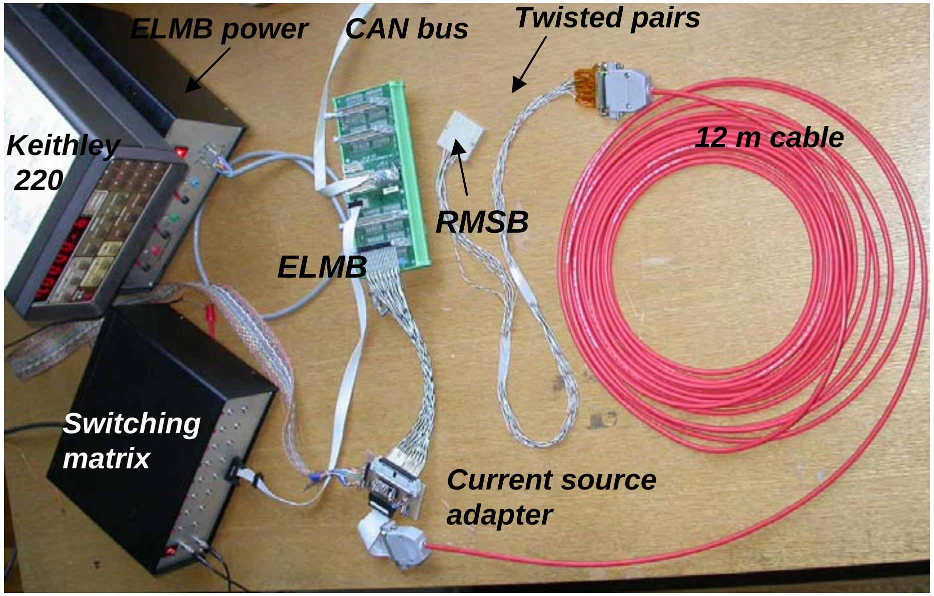
**EPI:** current (DAC) converted to voltage (resistor) –
voltage drop on resistor due to leakage current measured (ADC)

**DMILL:** collector current enforced (DAC) –
voltage drop on resistor due to base current measured (ADC)

# Schematic view of the Inner Detector monitor



# System test

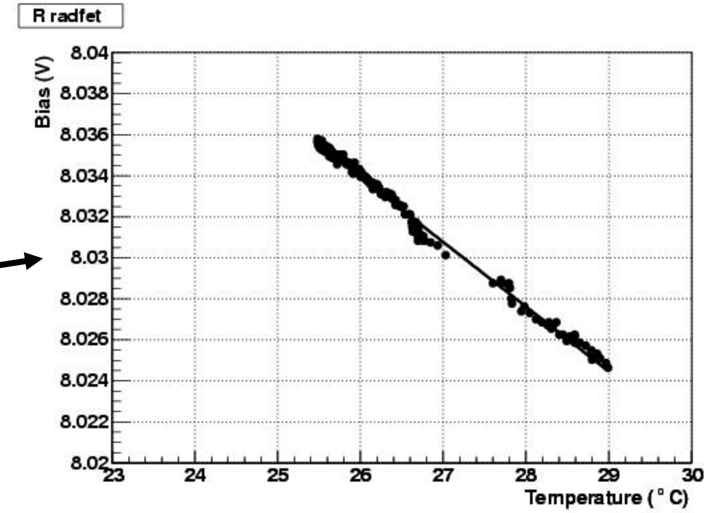



Aim: determine the sensitivity of the system

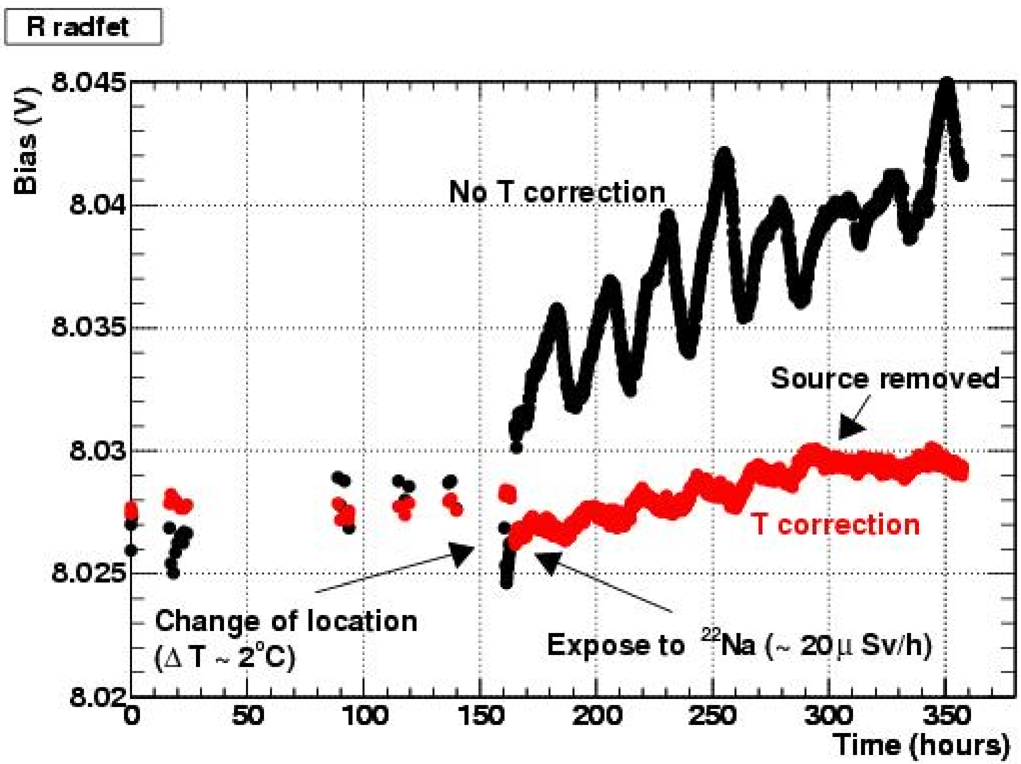
- read sensors in certain time intervals time
- after 150 hours RMSB exposed to $^{22}$Na source ( D/t ~ 20 μSv/h)

# REM thick oxide RADFET

Measure gate voltage at drain current $I_d$ = 160 μA




Temperature of the RMSB not stabilized
➔ correct for temperature variations offline



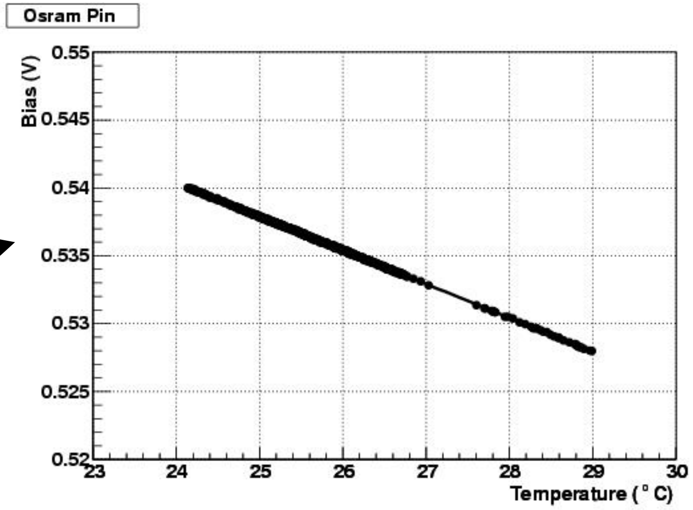

Detectable: ΔV ~ 2 mV

LAAS radfets (ΔV/ΔD ~ 0.5 V/Gy):

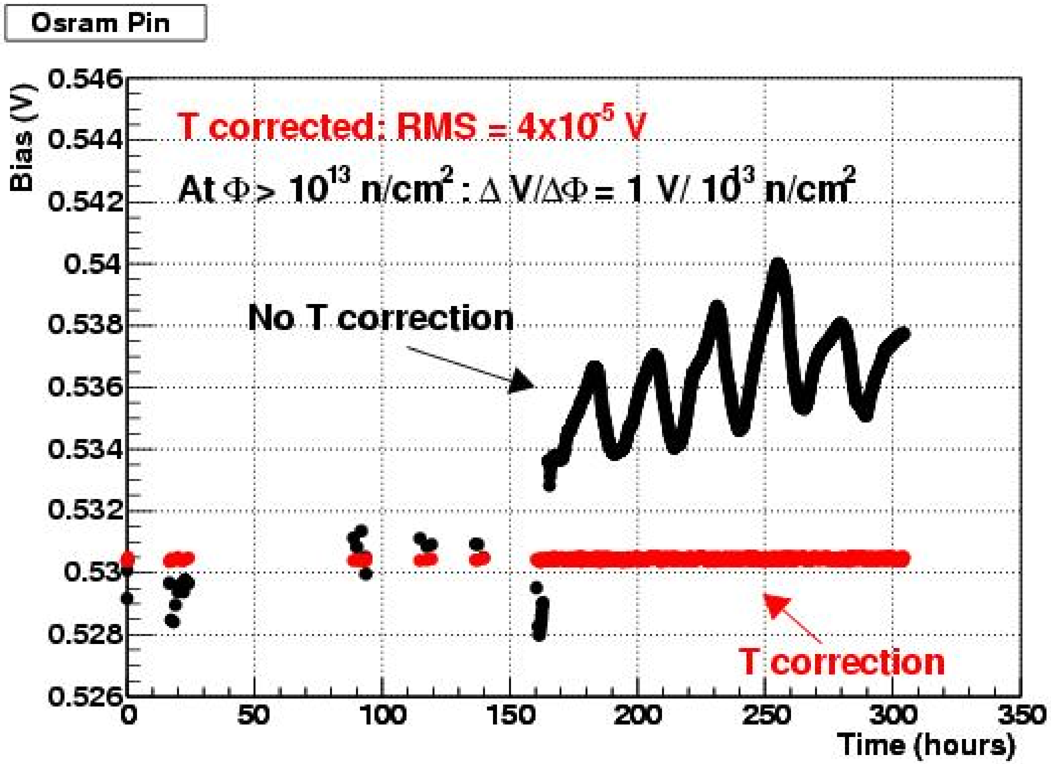
Sensitivity ~ 4 mGy

# Osram BPW34F pin diode

Measure bias voltage at forward current $I_f$ = 1 mA




Temperature of the RMSB not stabilized
→ correct for temperature variations offline:




Sensitivity:

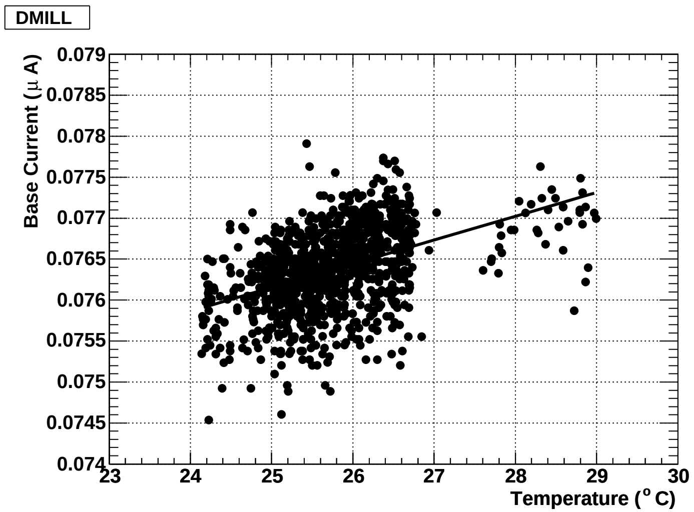
BPW34F ($\Delta V/\Delta\Phi = 1\ V/10^{13}\ n/cm^2$)
→ better than $10^{10}\ n/cm^2$
(but at $\Phi > 10^{10}\ n/cm^2$)

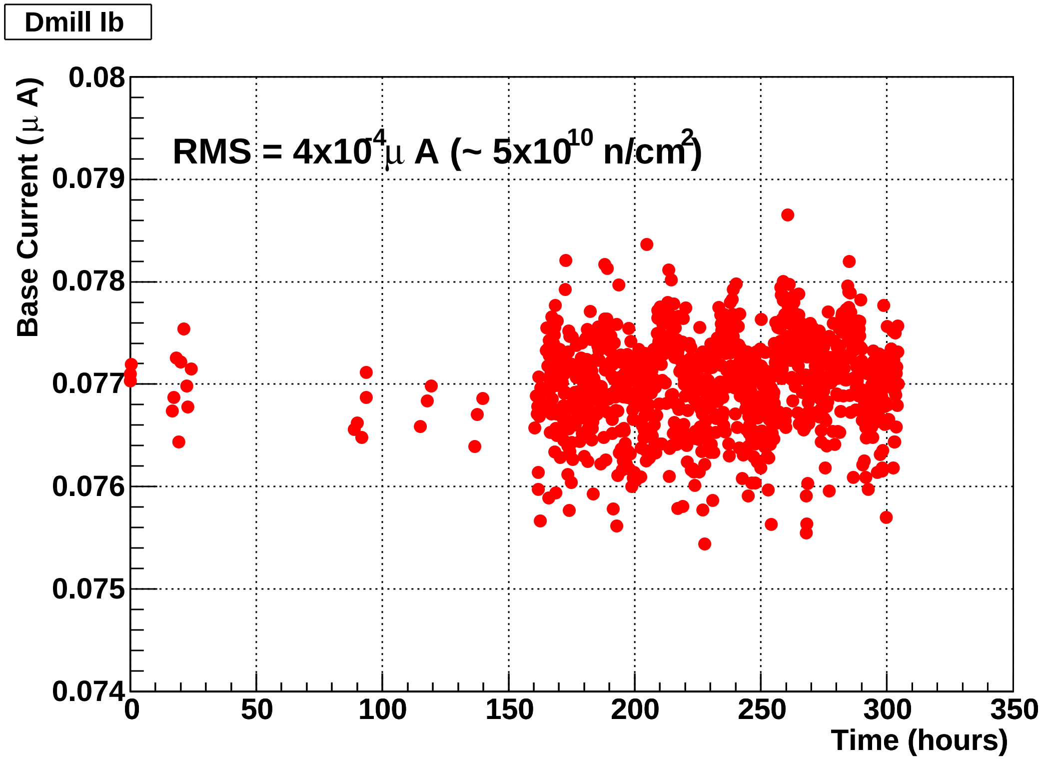
CMRP ($\Delta V/\Delta\Phi = 1\ V/10^{11}\ n/cm^2$)
→ better than $10^{8}\ n/cm^2$

# DMILL transistor:

Measure base current at collector current $I_c$ = 10 μA

Temperature of the RMSB not stabilized
→ correct for temperature variations offline:




Sensitivity:

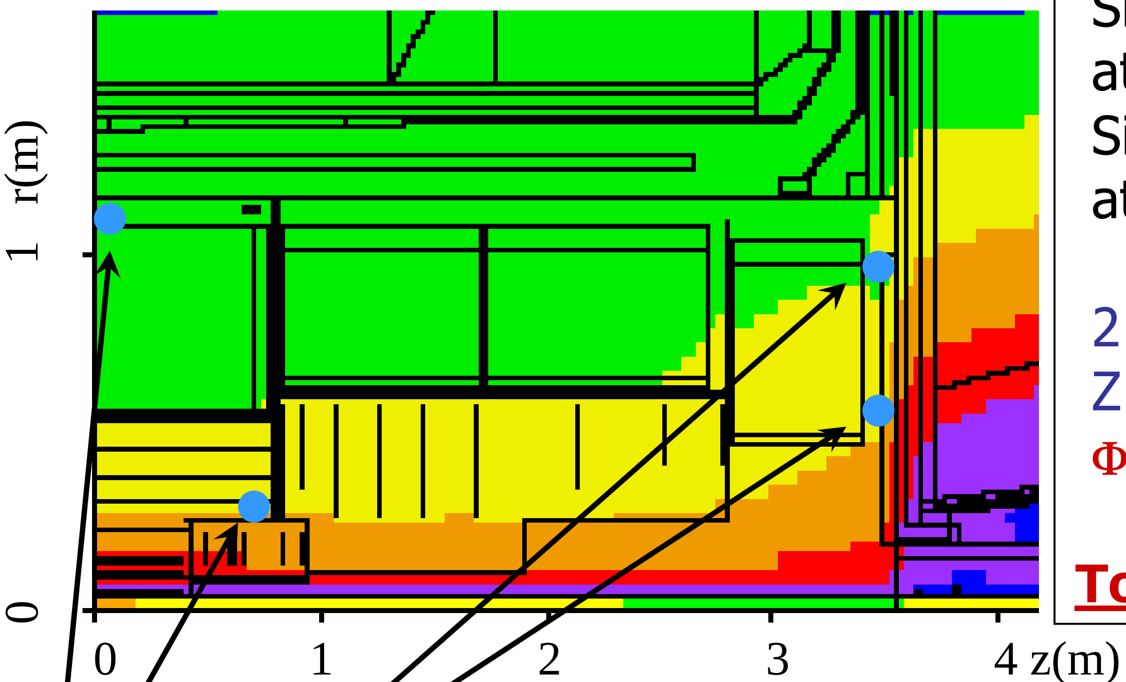
Can detect fluences higher than ~5x10$^{10}$ n/cm$^2$

- Sensitivity: 4 mGy with LAAS radfets and $10^8$ n/cm$^2$ with CMRP diodes is sufficient also for low luminosity years for most of subdetectors

➔ important to get early information to compare with simulations

- Inner Detector: need more sensors per location to cover larger range of doses and to have higher level of redundancy because of very limited access.

# Positions of RMSBs in the ID



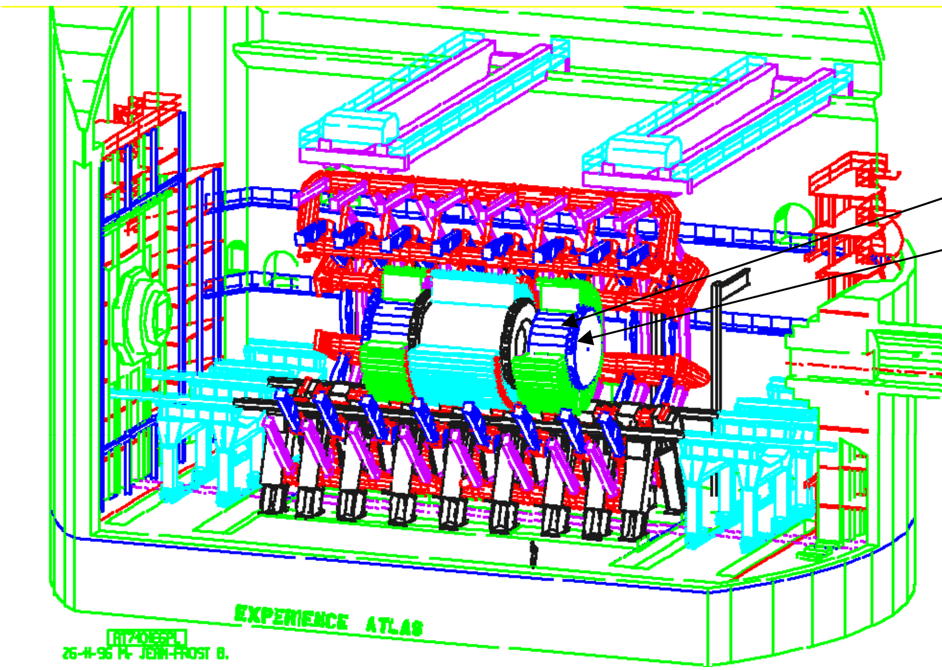

Side A (z>0):
at **Φ = 0° and 180°**
Side C (z<0):
at **Φ = 90° and 270°**

2 positions at
Z=0, R=110,
**Φ = 0° and 180°**

**Total of 14 in the ID**

| r[cm] | z [cm] | $\Phi_{eq}$ [$10^{14}$/m$^2$] 10 y (LL y) | Φ(E >20 MeV) [$10^{14}$/cm$^2$] | TID[$10^4$ Gy] 10 y (LL y) |
|---|---|---|---|---|
| 20-30 | 80-90 | 2.33 (0.03) | 2.2 | 14 (0.2) |
| 40-50 | 340-350 | 2.35 (0.03) | 1.25 | 6.7 (0.09) |
| 80-90 | 340-350 | 1.06 (0.01) | 0.41 | 1.91 (0.03) |
| 100-110 | 0-10 | 0.51 (<0.01) | 0.15 | 0.76 (0.01) |

# RMSBs in calorimeters




6 locations in Tiles

18 locations in LAr

LAAS radfets and CMRP diodes

| System | TID (Gy/10y) | TID (Gy/LL year) | ΔV in the first year (V) | ΔV (10y) | NIEL (n/cm2/10y) | NIEL (n/cm2/frist y) | ΔV first year (V) | ΔV (10y) |
|---|---|---|---|---|---|---|---|---|
| Lar: | 5.7-50 | 0.08-0.7 | 0.04-0.3 | 2.-5. | 1.5e11-1.5e12 | 2.1e9-2.1e10 | 0.01-0.1 | 0.7-7 |
| TILE: | 0.2-2.5 | 0.003-0.035 | 0.002-0.02 | 0.1-1 | 1.5e10-2.3e11 | 2.1e8-3.2e9 | 0.002-0.02 | 0.08-1 |

- waiting for number of locations in muon detector

# Software

- programming of processor on ELMB board:

➔ sensor readout process controlled by ELMB (e.g.):
  - set DAC channel on
  - wait
  - read ADC channel
  - set DAC channel off

➔ temperature stabilization of Inner Detector monitor boards controlled by ELMB

➔ much simpler to use, less trafic on CAN BUS, less dependent on computer status

## Status of monitor for Inner Detector:

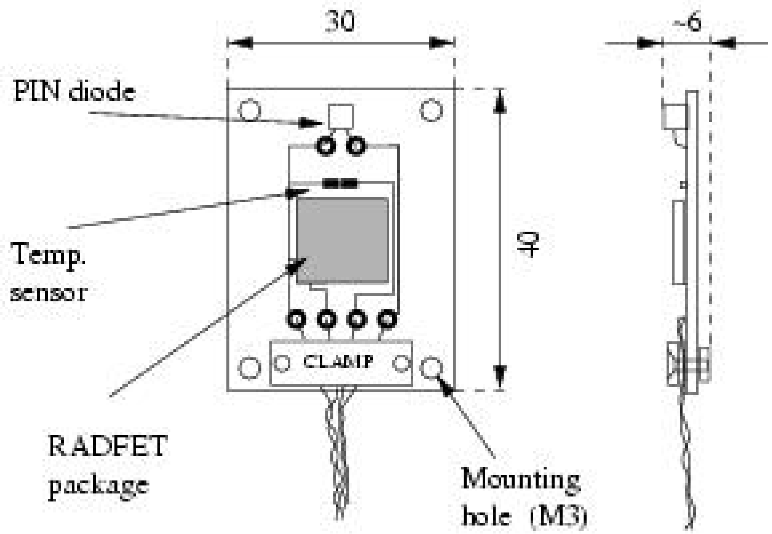
- prototype produced and tested
- DACs, connection board, ceramic hybrid, housing designed and in production
- cabling defined, space for patch panels and ELMBs reserved
- software (programming of processor on ELMB board ) written
- sensors (RADFETs, CMRP, BPW34F) should be available soon

➔ whole system can be ready for installation by the end of the year

# Status of Monitors for Locations Outside of the Inner Detector

- simplified version of ID system :

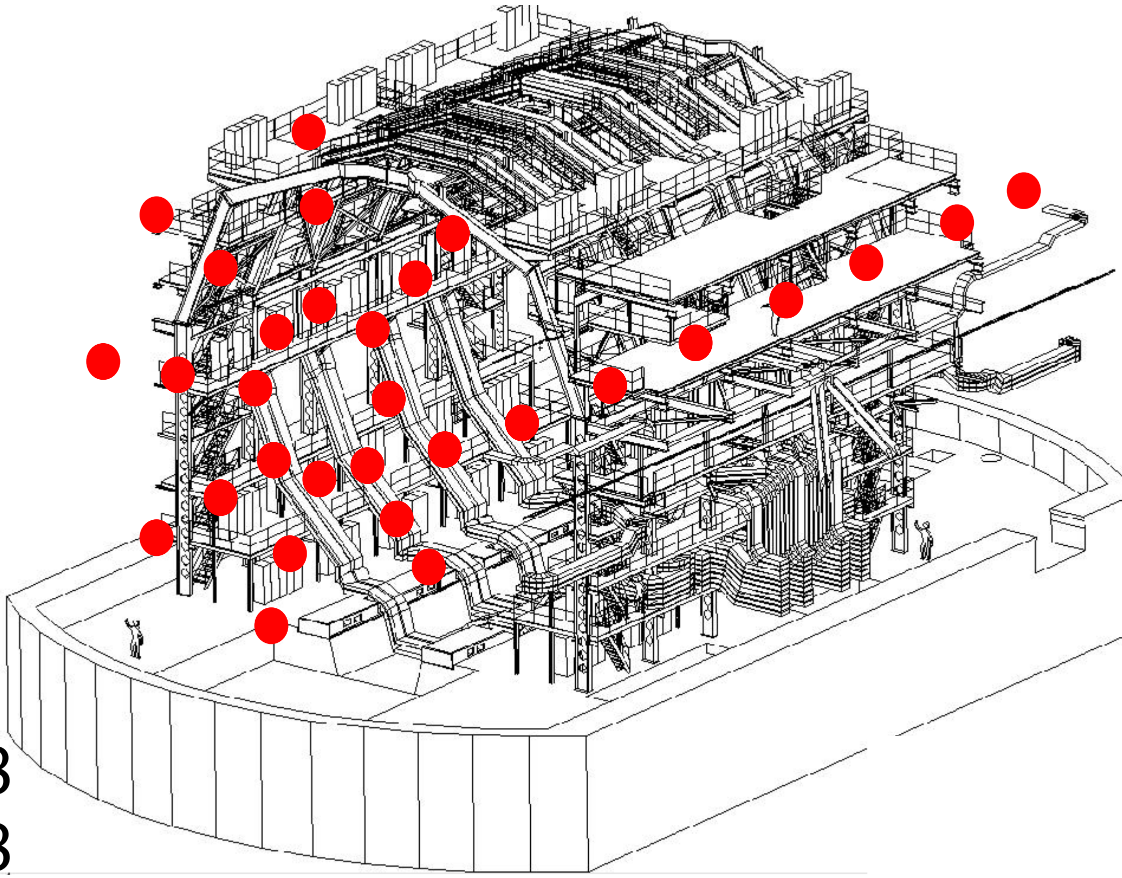
→ LAAS radfet + CMRP diode + temperature sensor
→ no temperature stabilization
→ sensor board is a simple PCB
→ can be delivered (board with pig-tail) soon after sensors are ready




→ waiting for number of locations in muon detector
→ waiting for number of DAC boards needed by calorimeters

## Proposal for locations of passive monitors (TLDs) made

- 154 racks
  - All types



2 PHI planes with 3x8
5 PHI planes with 1x8
Total 88

F. Anfhinolfi, ATLAS RADMON meeting, 27/6/05
http://agenda.cern.ch/fullAgenda.php?ida=a054176#2005-06-27

# New development by Muon System

M. Shupe, ATLAS RADMON meeting, 27/6/2005:
http://agenda.cern.ch/fullAgenda.php?ida=a054176#2005-06-27

➔ Measuring Atlas Radiation  Backgrounds in the Muon System at Startup

➔ Monitor neutron, photon, and charged particle fluxes/spectra in pulsed mode for sensitivity at low luminosity.  Compare measured fluxes to FLUKA and GCALOR to "recalibrate" simulations.

# Conclusion

- radiation sensors selected, packaging defined
- prototypes made and tested
- all components for readout designed, production of components for Inner Detector started
- ELMB software written
- PCBs for sensor boards for Tile and LAr produced

➔ Waiting for information from Tile and LAr about cabling to start production of DAC and patch panel boards

➔ waiting for number of locations for muon subdetector system

- locations of passive dosimeters defined