ATLAS Radiation Monitoring Meeting

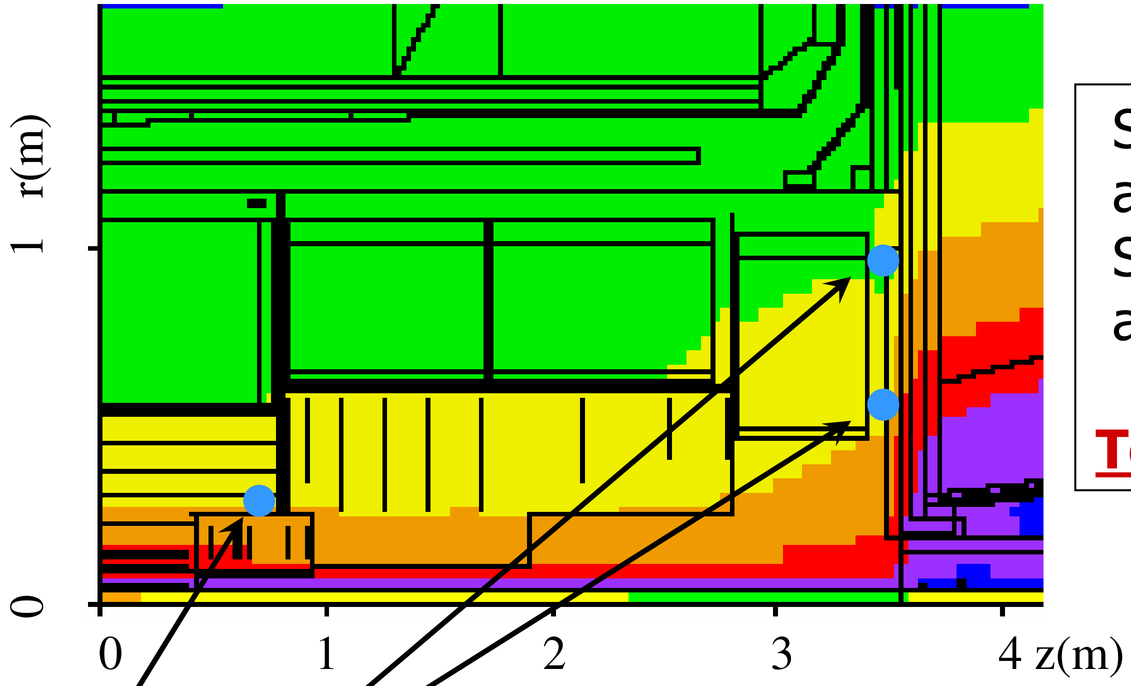
Integrating part of the *ATLAS Radiation Monitor* will measure

- –Total Ionization Dose - TID
- –Non-Ionizing Energy Loss – (bulk damage in silicon)
- –Thermal Neutron Fluence (in the ID)

Design of the integrating monitor in the ATLAS Inner Detector well advanced

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

Positions of RMSBs in the ID



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

Total of 12 in the ID

r[cm]	z [cm]	Φ_{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)

Sensors planned to be used on ID RMSB

Monitor Total Ionizing Dose (TID):

- RADFET's (threshold voltage increase)

Monitor NIEL:

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

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

- DMILL bipolar transistor from ATMEL (measure decrease of common-emitter current gain (increase of base current at given collector current)

Temperature control

Temperature should be stable to simplify analysis (annealing...)
Stabilization achieved by heating sensor boards made of ceramics to few degrees above environment temperature of ~20^{o}C.

Read-out

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

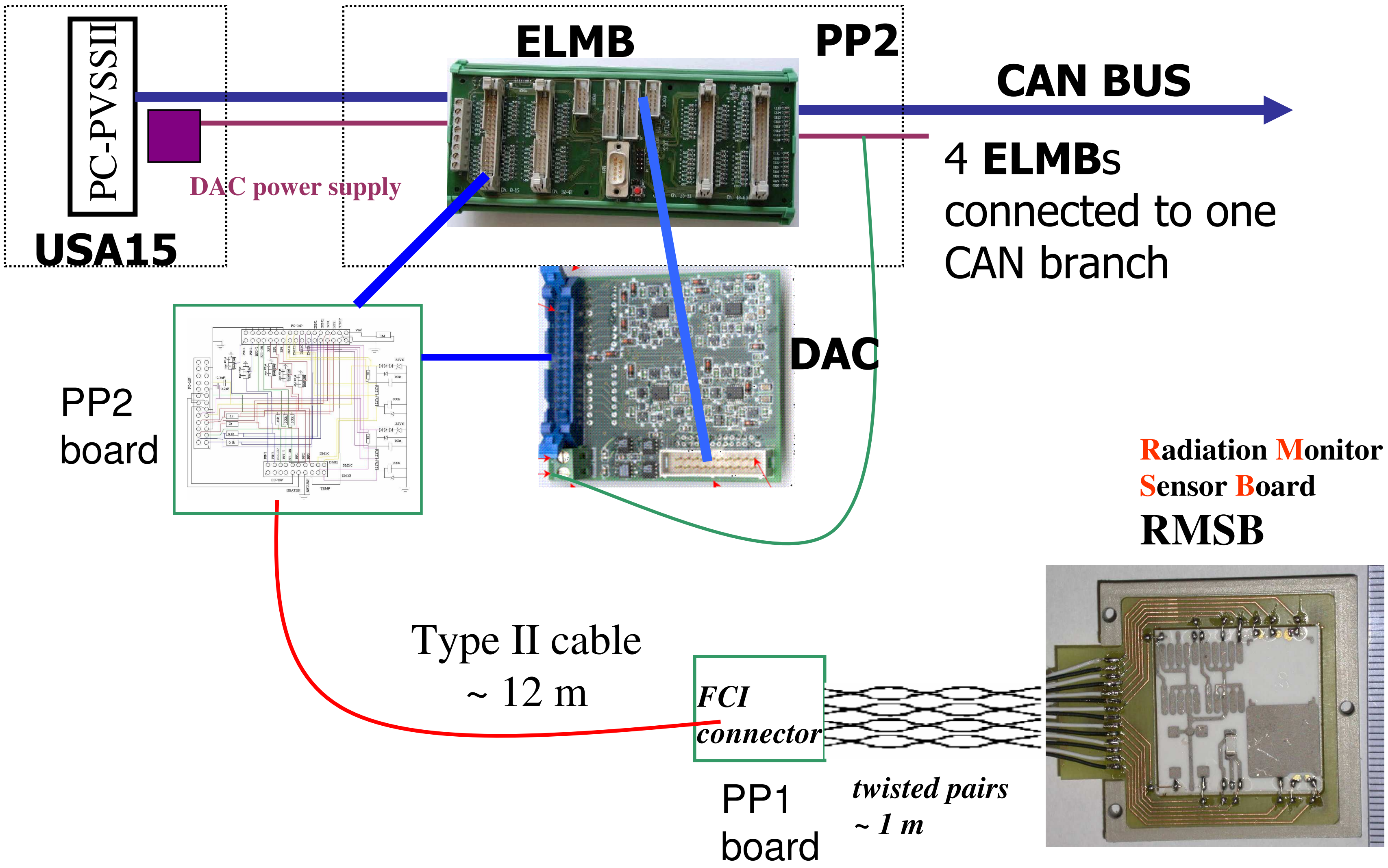
<u>Readout principles</u>

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)

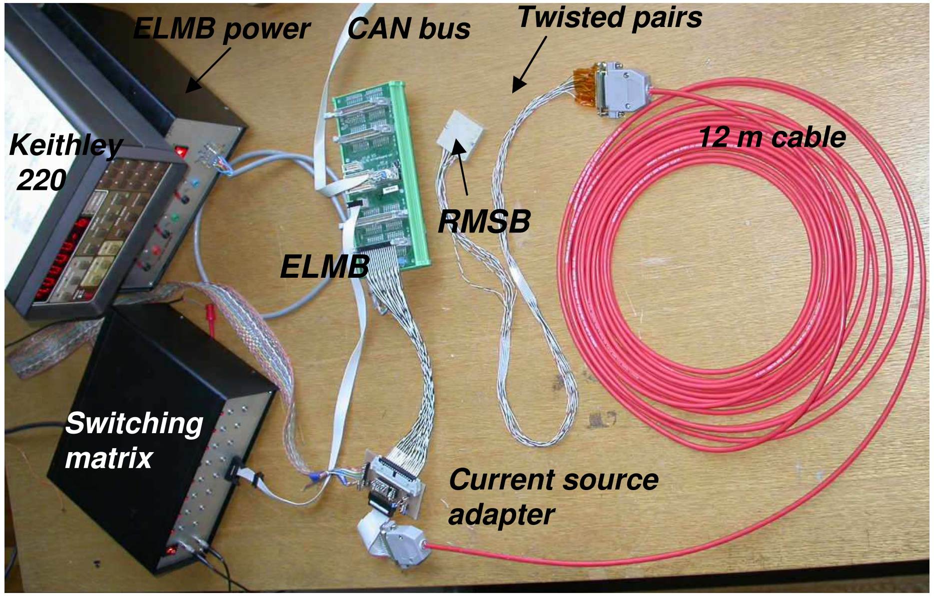
Maximum voltage of DAC limited to 28 V!

HEATER: 4 or more DAC channels connected together

Schematic view of the Inner Detector monitor



System test



Aim: determin the sensitivity of the system

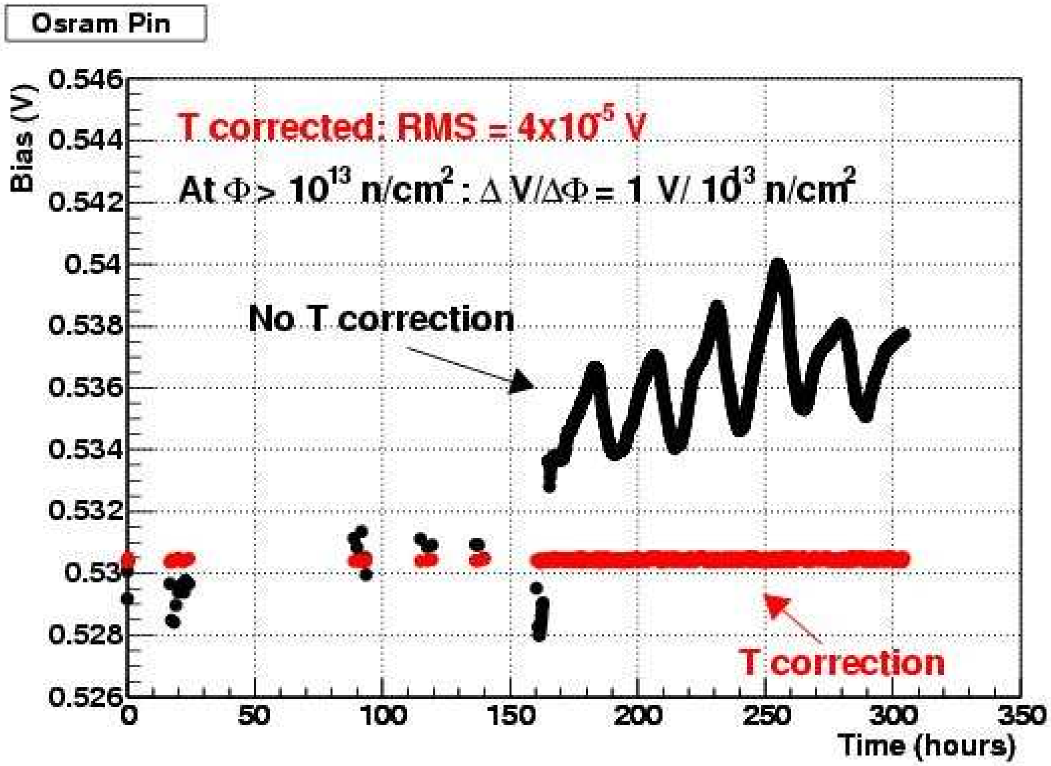
- read sensors in certain time intervals time
- after 150 hours RMSB exposed to ^{22}Na source (D/t ~ 20 µSv/h)

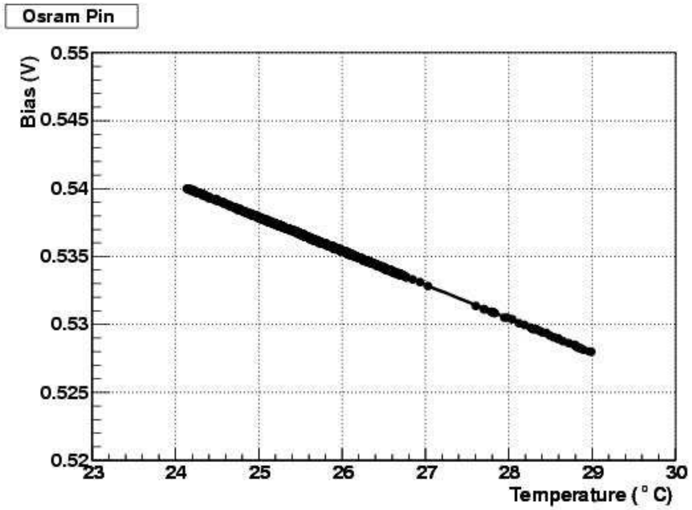
Osram BPW34F pin diode

Temperature of the RMSB not stabilized

→ correct for temperature variations offline:

Measure bias voltage at forward current I_f = 1 mA





Sensitiviy:

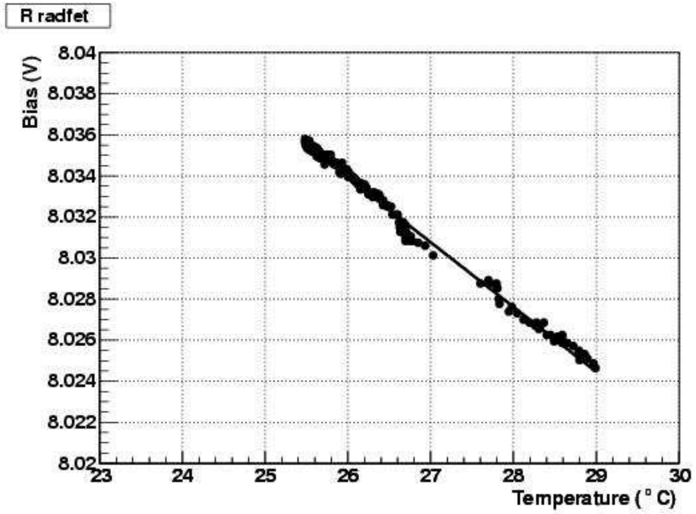
BPW34F ($\Delta V/\Delta\Phi$ = 1 V/10^{13} n/cm^2)
→ better than 10^{10} n/cm^2

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

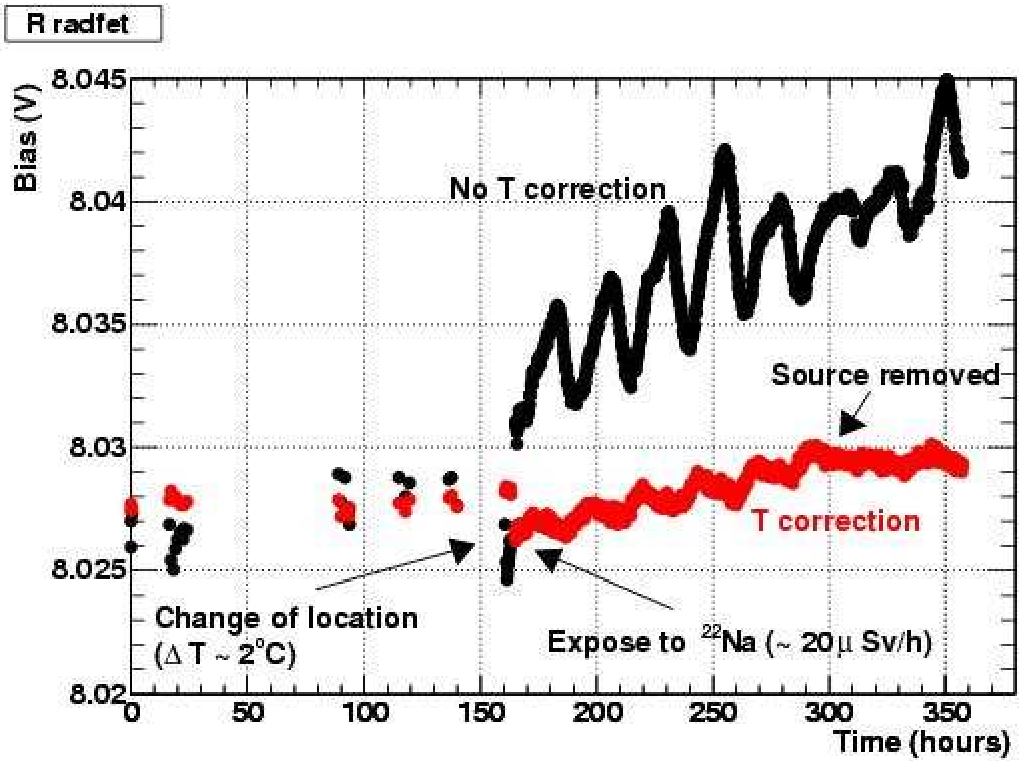
REM thick oxide RADFET

Temperature of the RMSB not stabilized

→ correct for temperature variations offline:



Measure gate voltage at drain current I_d = 160 µA



Detectable: ΔV ~ 2 mV

LAAS radfets (ΔV/ΔD ~ 0.5 V/Gy) will be used in ATLAS:

Sensitivity ~ 4 mGy

Inner Detecotr Sensor board

(sesnor prices from the *Catalogue*, one configuration, no overhead)

1. epi-diode 1x 25 CHF = 25 CHF
2. BPW34F PIN diode 2x 5 CHF = 10 CHF
3. CMRP PIN diode 1x 120 CHF = 120 CHF
4. thin oxide radfet 2x 50 CHF = 100 CHF (assumed price of the 0.25 μm REM radfet)
5. thick oxide radfet 1x 60 CHF = 60 CHF
6. DMILL transistor 2x 25 CHF = 50 CHF
7. NTC 1x 10 CHF = 10 CHF
8. Ceramic hybrid 1x 200 CHF = 200 CHF
9. PEEK housing 1x 100 CHF = 100 CHF
10. ELMB 0.5x 200 CHF = 100 CHF
11. DAC 16x 22 CHF = 352 CHF
12. RMSB-PP2 connect 1x 170 CHF = 170 CHF

TOTAL: 1300 CHF

Monitors for Locations Outside of the Inner Detector

- simpler sensor boards:
  - → LAAS radfet + CMRP diode + temperature sensor
  - → no temperature stabilization
  - → RMSB can be a simple ~ 2x2 cm^2 PCB
  - → no unprotected wire bonds → no need for housing

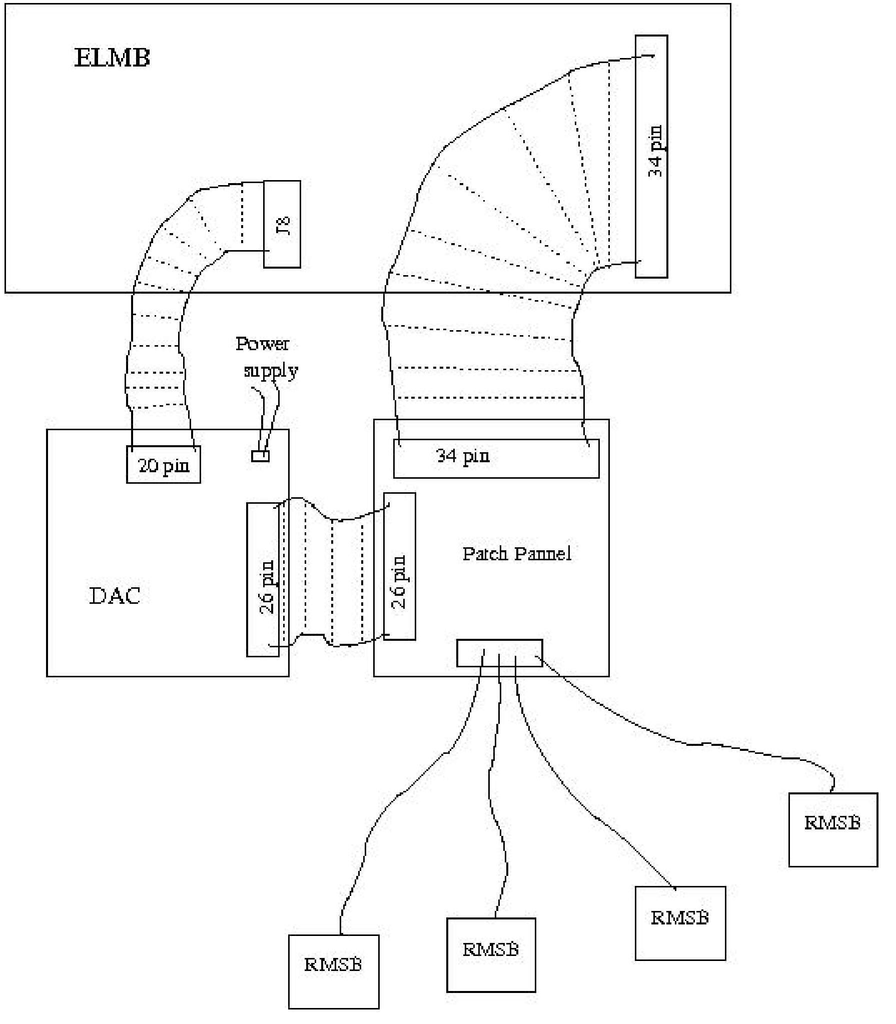
- use free channels on existing subdetector's ELMBs

Cost estimate for the simplified radiation sensor board:

thick oxide radfet	: 1x 60 CHF	= 60
CMRP PIN diode	: 1x120 CHF	= 120
Temperature sensor	: 1x 10 CHF	= 10
DAC (minimum cost)	: 2x22 CHF	= 44 (depends on number of RMSBs per DAC board)
board	: 1x10 CHF	= 10
TOTAL		= 244 CHF

Scheme of Connections

- use ELMB power lines (12 V) to power DAC → to get ~ 10 V at DAC output
- up to 8 RMSBs can be connected to one DAC board
- each RMSB needs at least 3 ADC channels (max. 5 if DAC output is also monitored)



Conclusion

- Ljubljana can produce:
  - RMSB boards
  - DAC boards
  - patch pannel boards

- Subdetectors must take care of
  - cabling
  - finding free ELMB channels
  - providing the number of RMSB, DAC and patch-pannel boards as soon as possible