ATLAS Radiation Monitor

- ***integrating monitor***

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Integrating part of the *ATLAS Radiation Monitor* will measure

–Total Ionization Dose - TID

–Non-Ionizing Energy Loss – (bulk damage in silicon)

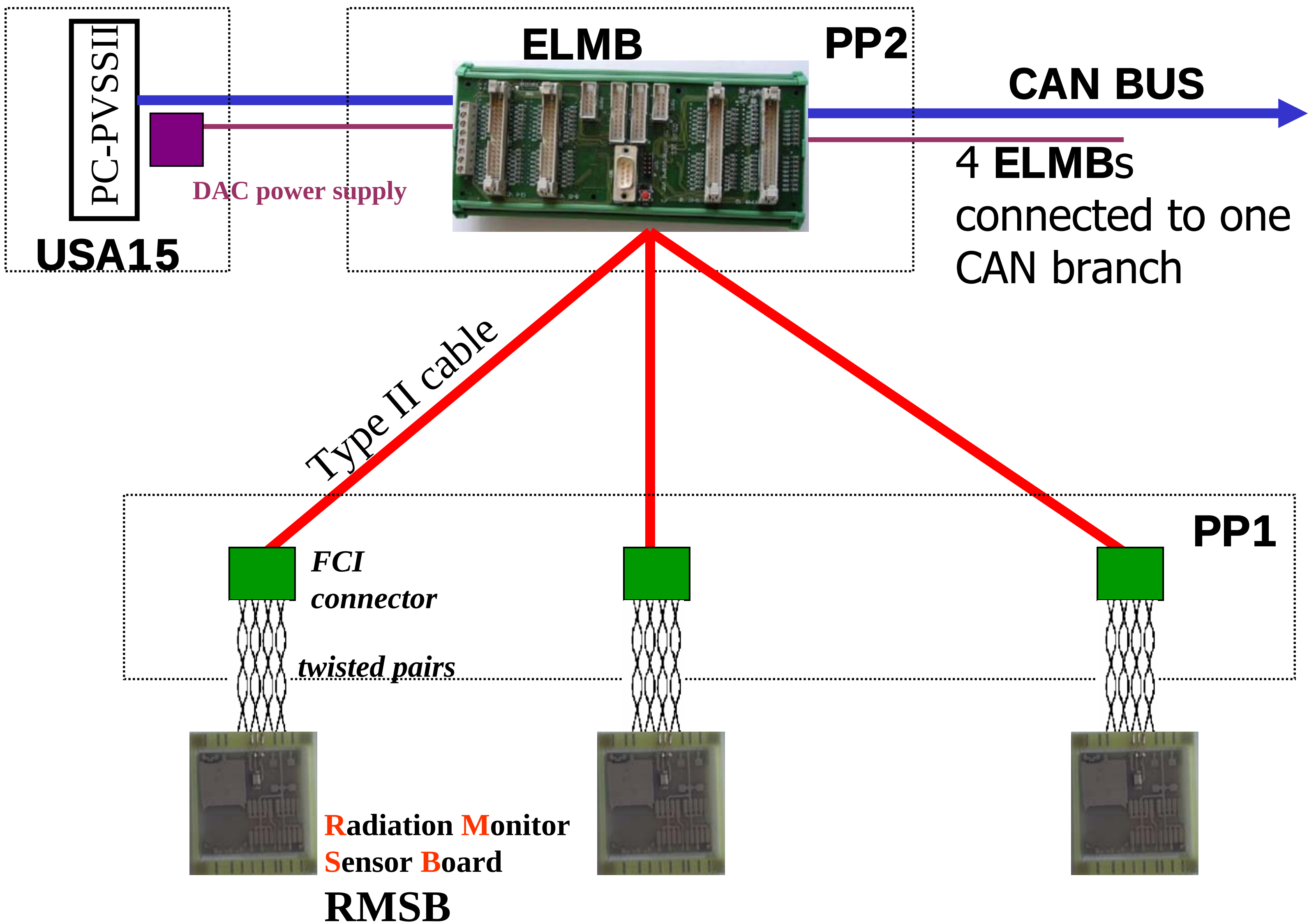
–Thermal Neutron Fluence

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

- more information in:
  - **EDMS document: *ATL-IC-ES-0017***
  - G. Kramberger's transparencies from November 04 RADMON meeting

(look at http://lhc-expt-radmon.web.cern.ch/lhc-expt-radmon/meetings.htm)

REMINDER: schematic view of the on-line monitor



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 boards will be produced soon
  4 boards (16 channels each) per ELMB

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)

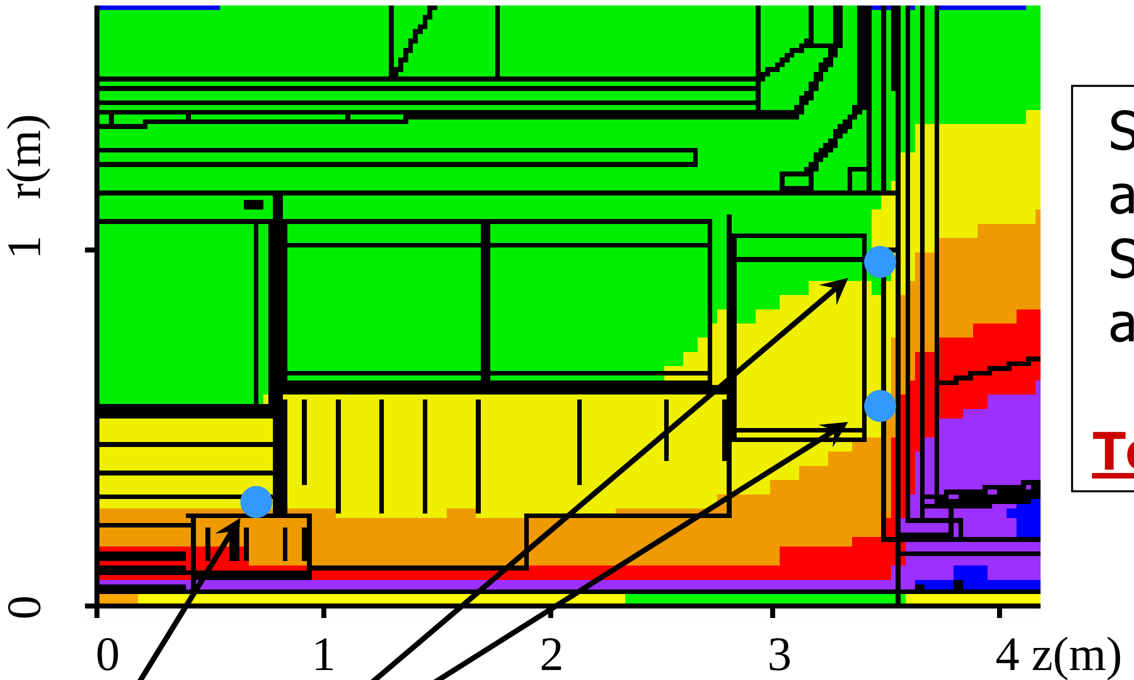
EPI: current (DAC) converted to voltage (resistor) –
voltage drop on resistor due to leakage current measured (ADC)

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

Maximum voltage of DAC limited to 28 V!

HEATER: 3-5 DAC channels connected together
or use the LHC4913 voltage regulator controlled by 1 DAC channel
if more heating power needed.

NEW: positions of RMSB in the ID

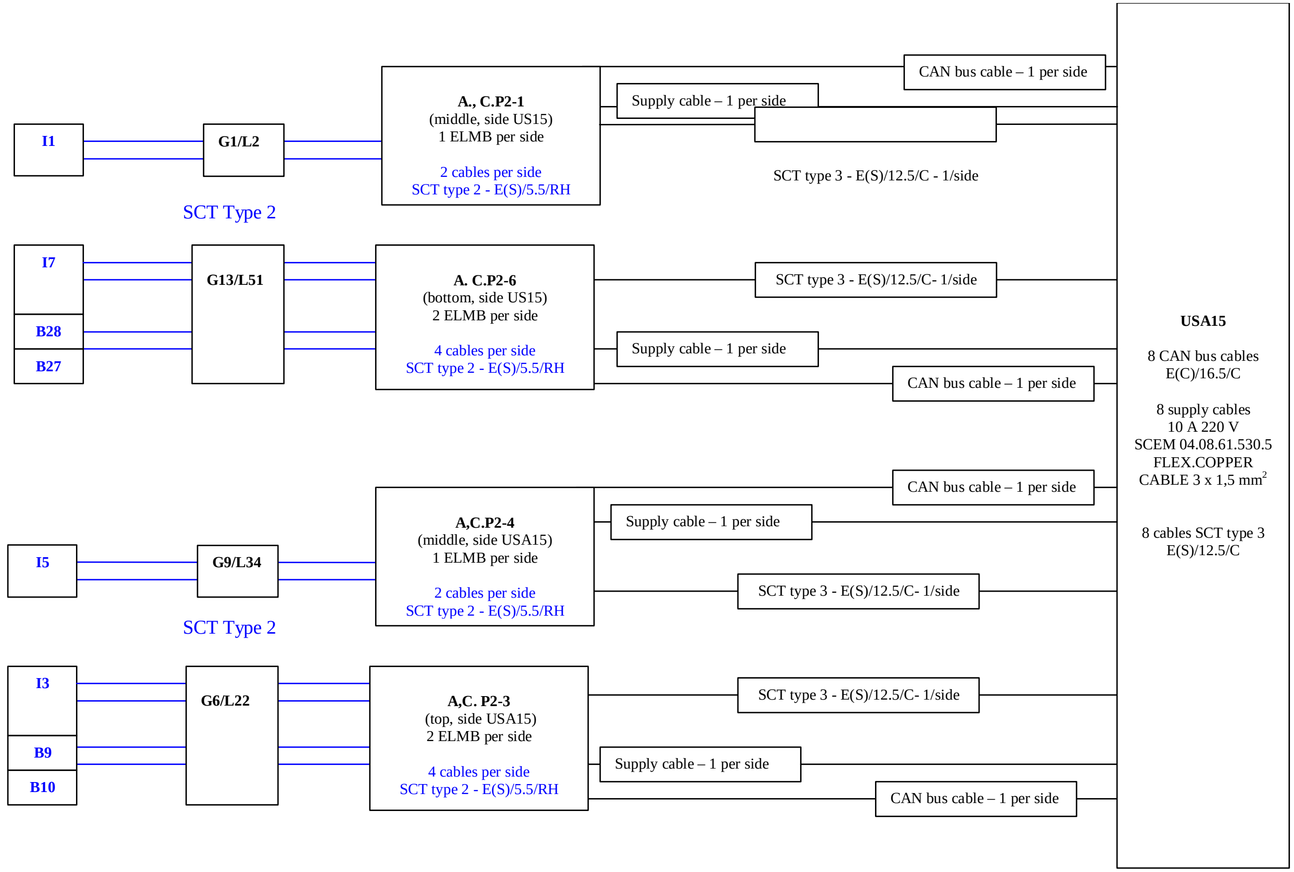


Side A (z>0):
at Φ = 0° and 180°
Side B (z<0):
at Φ = 90° and 270°

Total of 12 in the ID

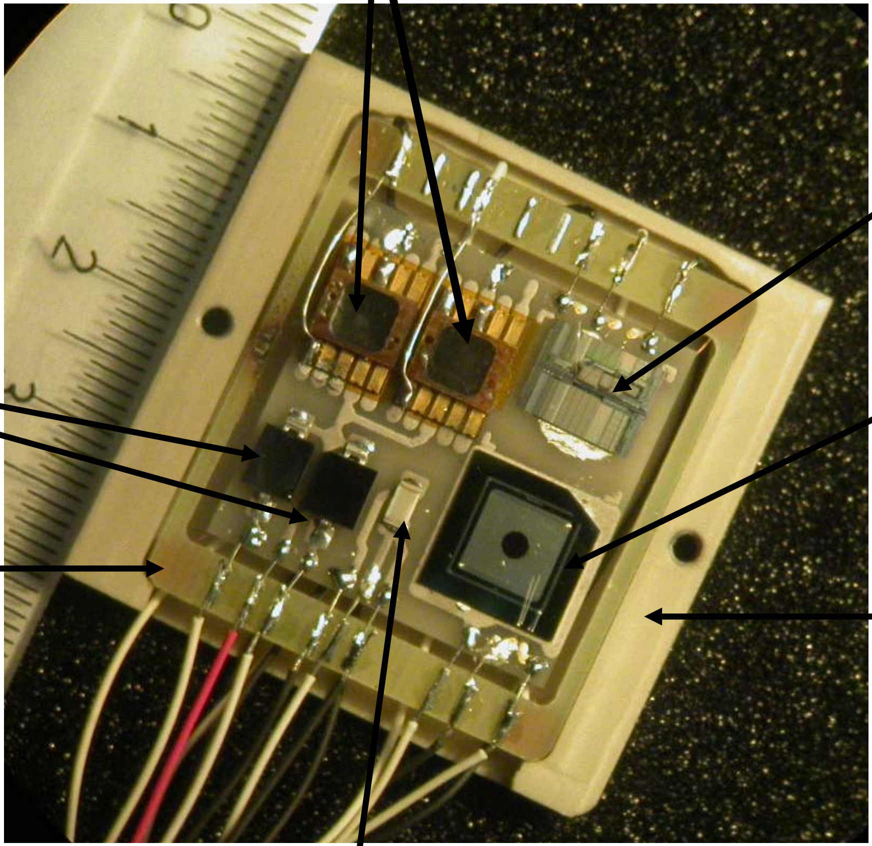
r[cm]	z [cm]	Φ_{eq} [$10^{14}/m^2$]	Φ(E >20 MeV) [$10^{14}/cm^2$]	TID[10^4 Gy]
20-30	80-90	2.33	2.2	14
40-50	340-350	2.35	1.25	6.7
80-90	340-350	1.06	0.41	1.91

Cabling and locations of ELMB boards and patch pannels was defined for the system with 24 RMSBs. Will be downgraded to 12 RMSBs.

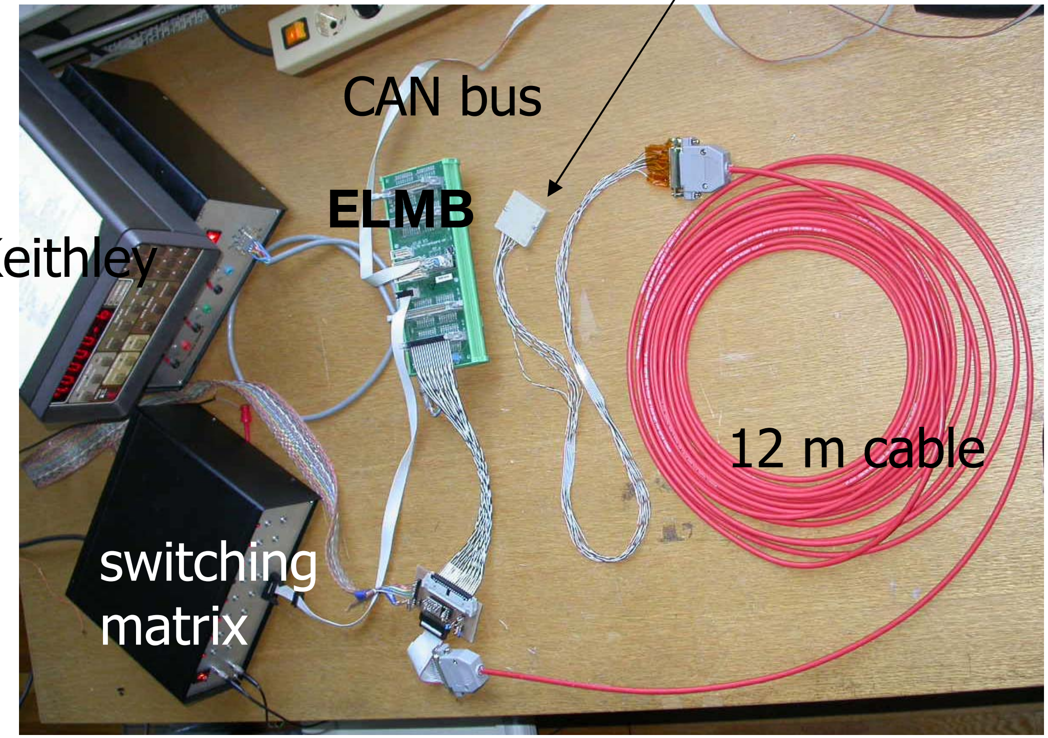


RM Cabling Schematic – draft 0.1, 17/11/2004 M.Mikuž, adapted from drawing by M. Stodulski
Routing gaps, PP2 positions subject to change
If rerouting of I1, I5 to I3, I7 on ID plate possible, reduce all services from PP2 – USA15 by ½, ELBM 3 to 2/side

Prototype ceramic hybrid populated



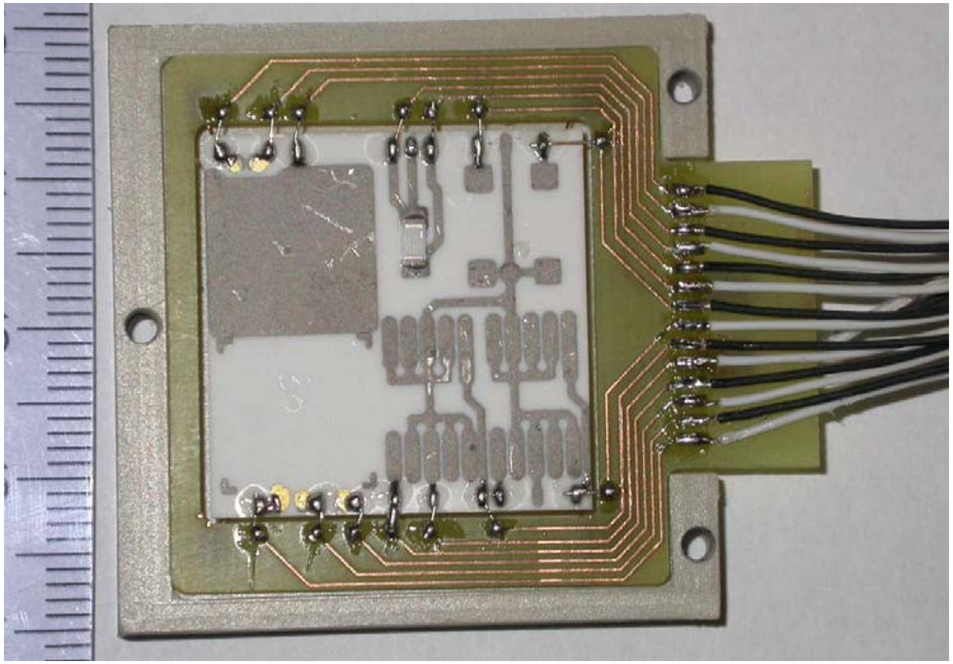
- Sensors succesfuly read out with ELMB over CAN-BUS using CANopen OPC server.
- Keithley 220 and switching matrix was used as current sources for sensors instead of ELMB DACs.
- DACs should be ready for testing soon (delays with with delivery of components)



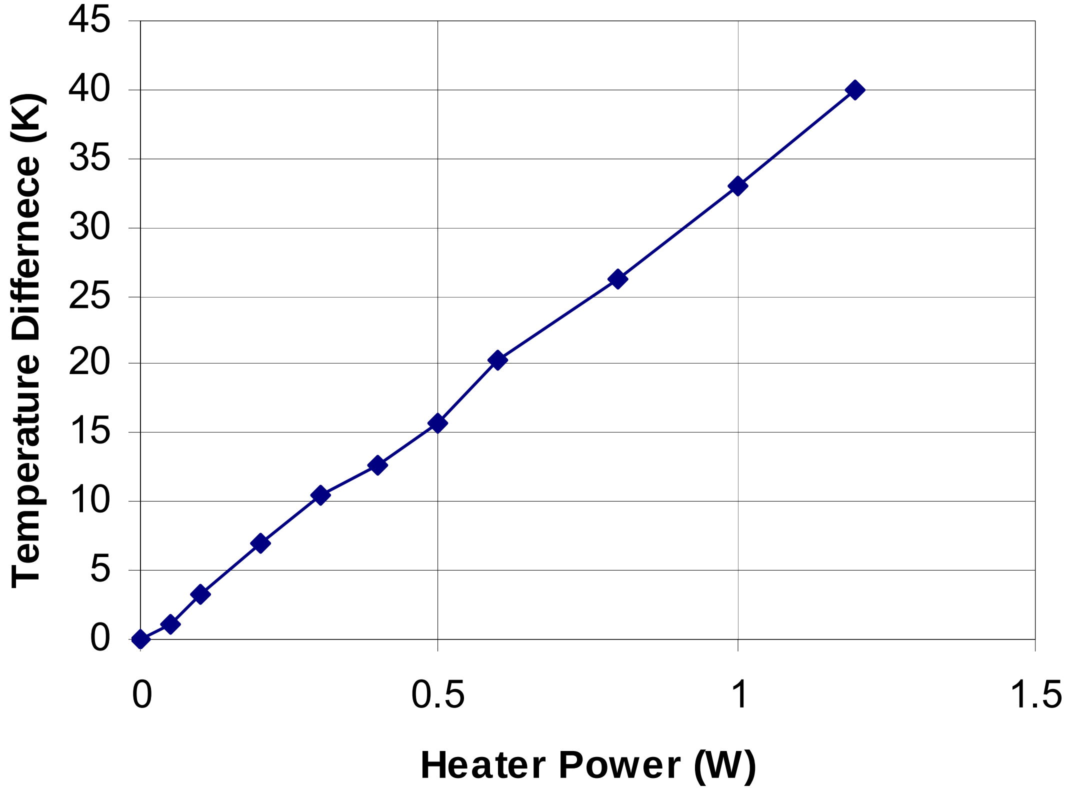
Al_2O_3 instead of AlN will be used as hybrid naterial:

- better adhesion of conductor
- lower cost
- thermal conductivity good enough for our application

New design of the PCB frame and housing:



Thermal test: 40° of temperature difference can be maintained with 1.2 W of heater power → not too bad
(temperature on the pixel support tube can be between –20° and +20° C)



Selection of sensors

Number of sensors that can be put on the final board is limited

- by the number of wires in the Type II conection cable (16 wires)

- by the size of components (the maximum dimension of the box is 4x4x0.8 cm^3)

With 16 wires the following configuration can be made:

- 2 RADFETs sensitive to 15 Mrad (thin oxide)
- 1 RADFET with higher sensitivity for TID measurements in low-luminosity years
- 1 BPW34 diode NIEL
- 1 epi-silicon diode
- 1 CMRP diode for NIEL measurements in the low-luminosity years
- 2 DMILL test structures

Expected doses in the inner detector:

r[cm]	z [cm]	$\Phi_{eq}[10^{14}/cm^2]$ (Per LL year)	TID[10^4 Gy] (per LL year in Gy)
40-50	340-350	2.35 (3.3e12)	6.7 (940)
80-90	340-350	1.06 (1.5e12)	1.91 (266)
20-30	80-90	2.33 (3.2e12)	14 (2000)

- REM K radfets (oxide thickness 0.25 μm) from the ***Sensor Catalogue:***

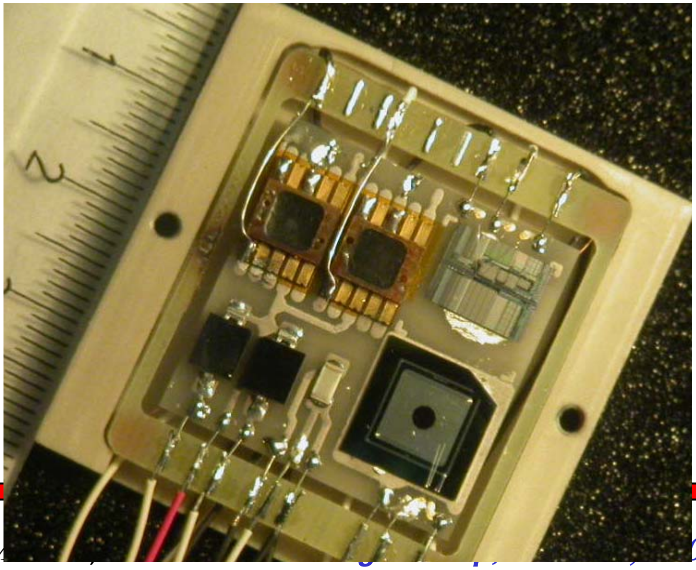
  - in the first year ΔV = ~ 2 V to ~ 15 V
  - end of life (**when voltage > 28 V)** at the hotest location reached in the first high luminosity year
  - these radfets can be used as the high sensitivity devices in the inner detector

- **we need radfets for measurements of higher doses:**
  the REM K radfets with 0.13 μm oxide would be OK
  → **but need calibration**

- **or: read out the 0.25 μm radfets at lower drain current to reduce the voltage → calibration needed**

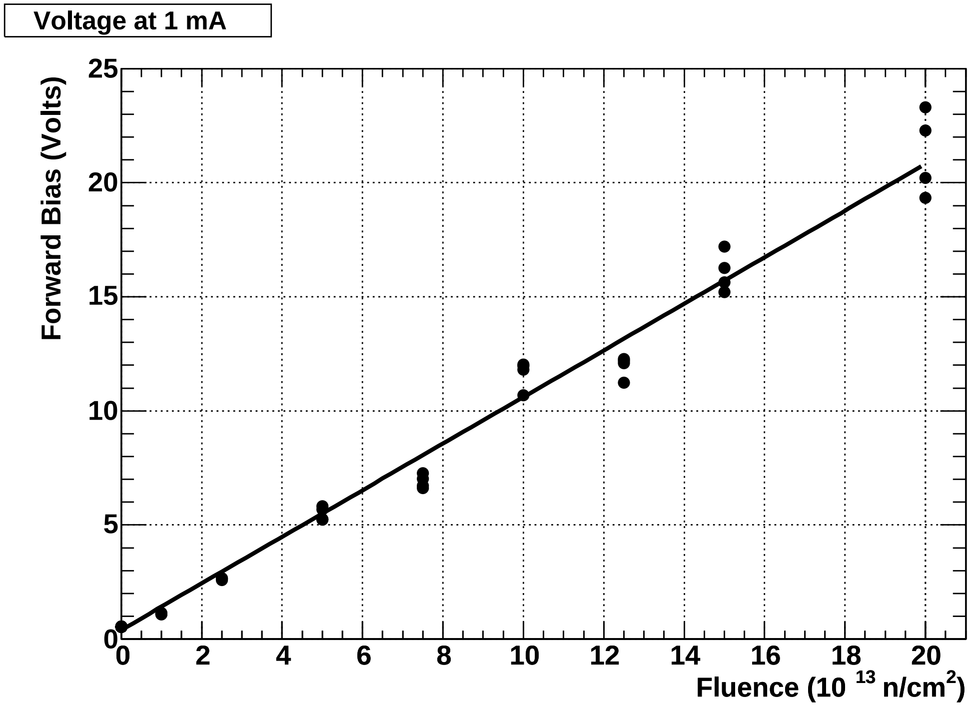
Enough space on the hybrid for 2 CC6 packages:

- if we want to have 3 radfets then 2 must be put in one package
  or bare chips must be mounted on the hybrid
  → is it posible to have 2 radfets (on separate chips) in one CC6 package?



- **CMRP diodes will be at the end of life after the first year of low-luminosity running → OK**
  micro-polymeric carrier would fit better than the standard package

- BPW34 will cover the fluences after 10 years of running



Cost estimate for the 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

Rest of ATLAS (outside of the ID)

- radiation monitoring system with online readout using ELMB could be used also for locations outside of the Inner Detector.

- estimates of doses and voltage shifts are given in the table below
  - locations of the system electronics (*ATLAS Policy on Radiation Hard Electronics* ATC-TE-QA-0001 form year 2000)
  - voltages (ΔV) from the *Sensor Catalogue* for LAAS thick oxide RADFET (TID) and CMRP diodes (NIEL)

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	0-0.02	0.1-1	1.5e10-2.3e11	2.1e8-3.2e9	0-0.02	0.08-1
MuonCSC	15-520	0.21-7.28	0.1-0.9	3.-5.	1.0e12-5.0e12	1.4e10-7.0e10	0.05-0.3	4.0-25
MuonRPC	1.3-3.0	0.02-0.04	0.01-0.02	0.5-1.5	2.1e10-2.8e10	2.9e8-3.9e8	0	0.1-0.15
MuonTGC	2.3-2.5	0.04	0.02	0.8-1.	1.4e10-2.6e10	2e8-3.6e8	0	0.07-0.12
MuonMDT	1.3-6.4	0.02-0.09	0.01-0.04	0.6-2.5	1.8e10-2.9e11	2.5e8-4.1e9	0-0.02	0.08-1.3

- ΔV small even after 10 years of running

- we must check what can we measure with our system at such low dose rate:
  - how well can we correct for temperature variations (we did not plan to have temperature controlled boards outside of the ID)
  - check the stability with time, noise, annealing...

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
ELMB	:0.25x200 CHF = 50
DAC	: 4x22 CHF = 88
RMSB-ELMB connect	:0.25x170 CHF = 43
Housing	:0.25x100 CHF = 25
board	:0.25x200 CHF = 50

TOTAL 446 CHF

Conclusions

- **Inner Detector**

Progress since the last meeting:

- locations of RMSBs redefined
- cables, locations of ELMBs and patch pannels defined
- prototype board populated, readout tested
- choose Al_2O_3 , as the hybrid material
- new PCB frame and housing box designed
- thermal properties tested

No major problem in the design of the system found so far

Needs to be done:

- produce and test the ELMB DACs
- solution for measurements of high doses with RADFETs must be found
- decision about packaging of RADFETs must be made

RMSBs for the ID must be ready by the end of this year!

- **Rest of ATLAS**
  - **CMRP diodes and LAAS radfets are the sensor candiates**
  - **sensitivity of the system must be determined**
  - **locations for monitoring boards should be defined**