Status of the Radiation Monitors for the LHC Experiments

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Outline

- Sensors delivery/procurement status;
- Sensors Calibration data sets;
- Integrated Sensor PCB;
- BPW34 and LBSD diodes;
- GEANT4 modeling of the RadFET packaging;
- Conclusions

Sensor delivery

	Status	Thin Oxide FETs	Thick Oxide FETs	High Sensitivity p-i-n	BPW34F p-i-n	PCB
ALICE	11/2006	0	12	12	0	YES
ATLAS	11/2006	20+20(*) [ID]	20 [ID] 50**+15** [RoA]	20 [ID] 50**+10** [RoA]	20 [ID]	NO
CMS	9/2005	0 (?)	0 (?)	0 (?)	0 (?)	NO
LHCb	2/2006	~ 30 (?)	~ 30 (?)	~ 30 (?)	~ 30 (?)	YES (?)
TOTEM	7/2006	~ 24 (?)	~ 24 (?)	~ 24 (?)	~ 24 (?)	YES

[ID] = Inner Detector; [RoA] = Rest of Atlas; TOTEM = Estimation based on 24 full boards;

(*) Ultra-thin oxide FETs

Sensors Procurement

Thin Oxide FETs (0.25 μm)	Ultra-thin Oxide FETs (0.13 μm) (ATLAS request)	Thick Oxide FETs	High Sensitivity p-i-n	BPW34F p-i-n
393 (74%) LHC *477 (90%) OK!*	*150*	*120*	*100*	*160 DIL* *50 SMD*
373 left [*]	130 left [*]	23 left [*]	8 left [*]	160 DIL left 20 SMD left [*]
0 ordered	0 ordered	300 ordered (new wafer)	40 ordered (same batch)	0 bought
40 CHF/die	23 CHF/die	70 CHF/die	120 CHF/unit	8 CHF/unit

[*] Procured Sensors – delivered to ATLAS – in delivery to ALICE

Price Estimation for the **sensor carrier PCB** ~ 65 CHF including mounting of components.

Total received at CERN end of 2006: 823 components

Calibration curves

- SENSOR CATALOGUE DEVICES -

BPW/CMRP *p-i-n* diodes: $\Delta V = c \times \Phi_{eq}$

BPW34: $1/c = 9.1 \times 10^9$ cm^2/mV $\pm$ 20 % (annealing correction !!)

CMRP: $1/c = 1.7 \times 10^8$ cm^2/mV $\pm$ 13 %

LAAS/REM RadFETs: $\Delta V = a \times D^b$

$$a = 0.01854\ V/Gy \quad b = 0.91072$$
$$for\ 10^{-1}\ Gy < D < 40\ Gy \quad (0 < \Delta V_{th} < 0.5343)$$

DOSE RANGE

$$a = 0.02921\ V/Gy \quad b = 0.78778$$
$$for\ 40\ Gy < D < 2 \times 10^3\ Gy$$

DOSE RANGE

Proposed FIT is in $\pm$ 10 % agreement with experimental data

→ availability for the LHC Experiments of raw data calibration files (ongoing)

Calibration curves

- REM (Thin Oxide) DEVICES -

- We bought remnant stocks of devices produced in the ’80 and employed since then in space/military/medical applications;
- Broadening of the calibration sets for the REM devices 0.25 μm and 0.13 μm with independent data owned by the producer:

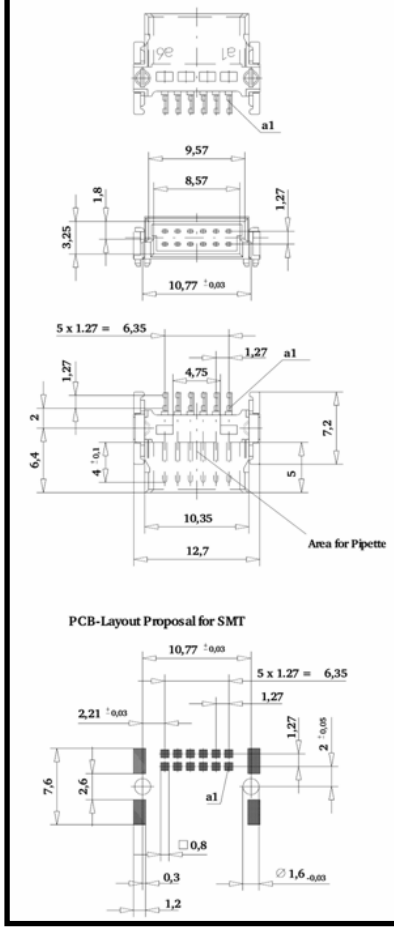
  → Holmes-Siedle, Ravotti, Glaser: NSREC 2007 Data Workshop.

- Complementary data from gamma-ray, MV and KV X-ray, electrons will be added.

Further Details: Ravotti’s PhD Thesis, “Development and Characterisation of Radiation Monitoring Sensors for the High Energy Physics Experiments of the CERN LHC Accelerator” (**CERN-THESIS-2007-013**, 17/11/2006)

Integrated Sensor PCB

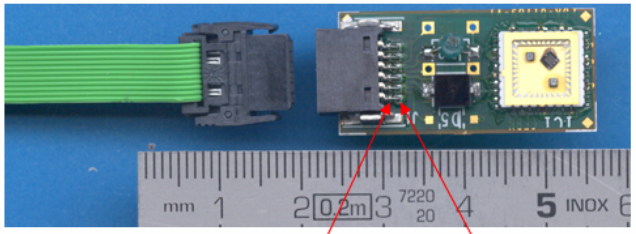
INTEGRATED SENSOR PCB
Connections Layout



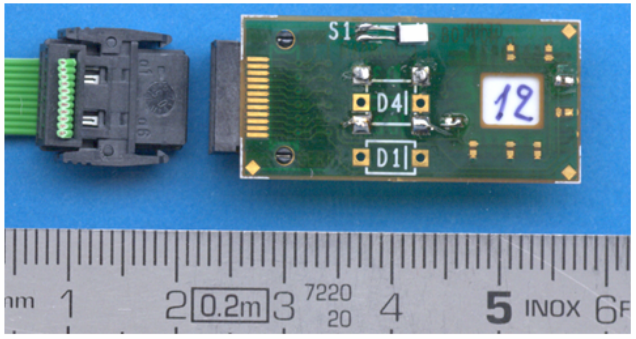
pin-out ERNI
Male Connector
SMC-B 12 contacts
(model: 054594)

ERNI	PCB	Device
a1	gnd	
a2	D5	pin diode
a3	D3	pin diode
a4	D4	pin diode
a5	D1	pin diode
a6	IC1	C3 (REM)
b1	S1	T. probe
b2	IC1	C4 (LAAS)
b3	n.c.	free
b4	D2	pin diode
b5	IC1	C1 (REM)
b6	IC1	C2 (LAAS)

FRONT



BACK



NOTE: Devices to be supplied with negative currents !

F.Ravotti, M.Glaser (72058)
CERN - August 2006

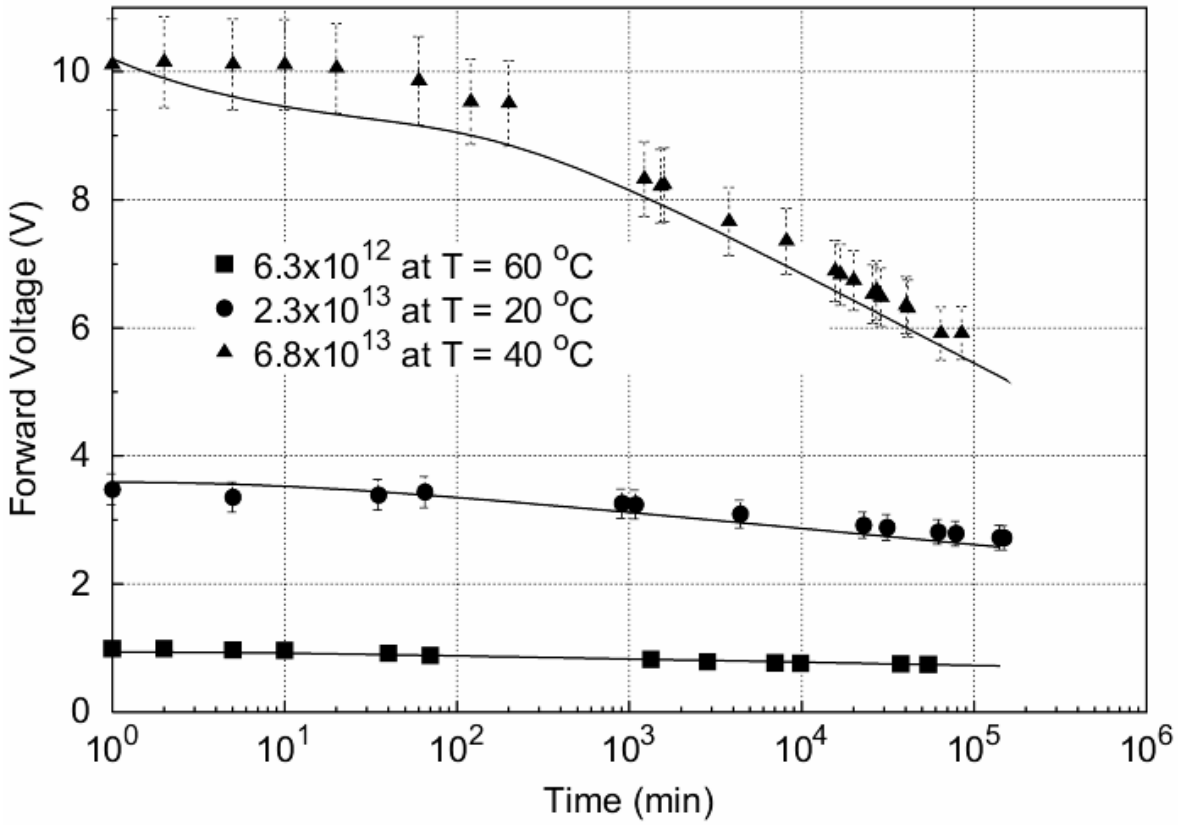
Detailed connections layout are available on the RADMON webpage

- sensor-catalogue section -

BPW34 Annealing

Parametrization of the phenomenon:

T_{range}: 20°C - 60°C and $\Phi_{eq,\ range}$: $2x10^{12}$ cm^{-2} – $1x10^{14}$ cm^{-2}

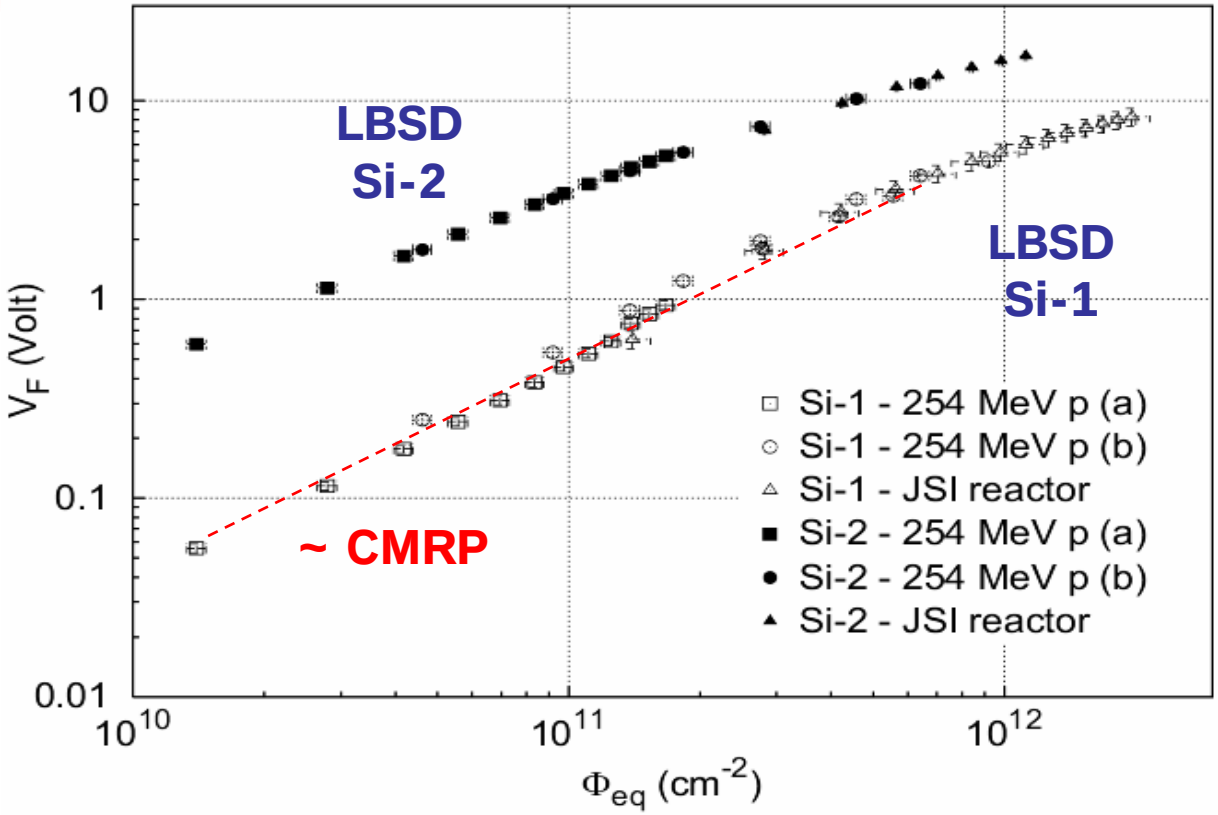


Equations available in: CERN-THESIS-2007-13;

In low dose-rate field the present correction guarantees ± 20 % accuracy;

All data been validated over 3-4 months time.

LBSD diodes

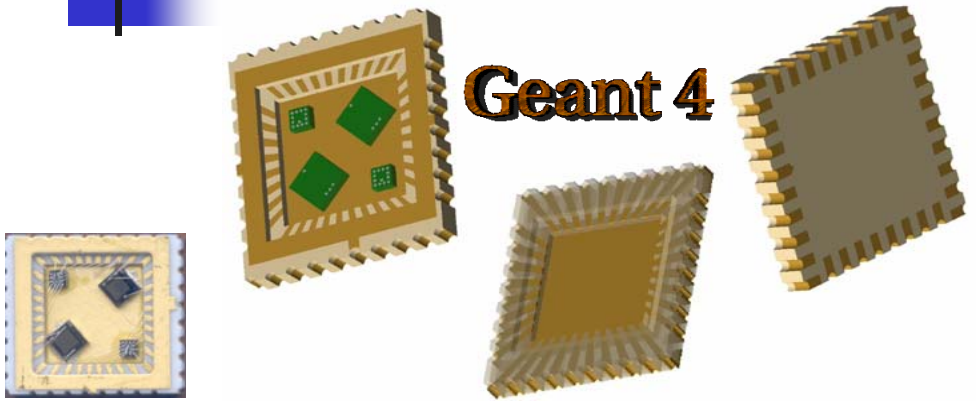


First Irradiation tests on Czech diodes proven their suitability for LHC experiments needs at an higher injection level (25 mA):

Study of their response at 1 mA is needed.

Diode type	Sensitivity	Maximum Φ_{eq} range	Annealing	
CMRP	$1.7\times10^{8}\ cm^{-2}/mV \pm 13\%$	$2\times10^{12}\ cm^{-2}$	< 15 % after 1800 h.	@ I_F = 1 mA
LBSD Si-1	$1.6\times10^{8}\ cm^{-2}/mV \pm 15\%$	$\sim 1\times10^{12}\ cm^{-2}$	~ 10 % after 200 h.	@ I_F = 25 mA
LBSD Si-2	$2.7\times10^{7}\ cm^{-2}/mV \pm 15\%$	$\sim 2\times10^{11}\ cm^{-2}$	~ 10 % after 200 h.	@ I_F = 25 mA

RadFET Package Model



– MODEL VALIDATION:
  – Proton data: statistical analysis completed, the model can be used in "predictive" mode.
  – Gamma-neutron data: folding of gamma simulation with neutron simulations that uses *"standard neutron-physics models".* Running simulations with other *"(HP) neutron-physics models"* and comparison with experimental data.

– MODEL APPLICATION:
  – PH/DT2 (J. Mekki) is starting the packaging optimization.

Conclusions

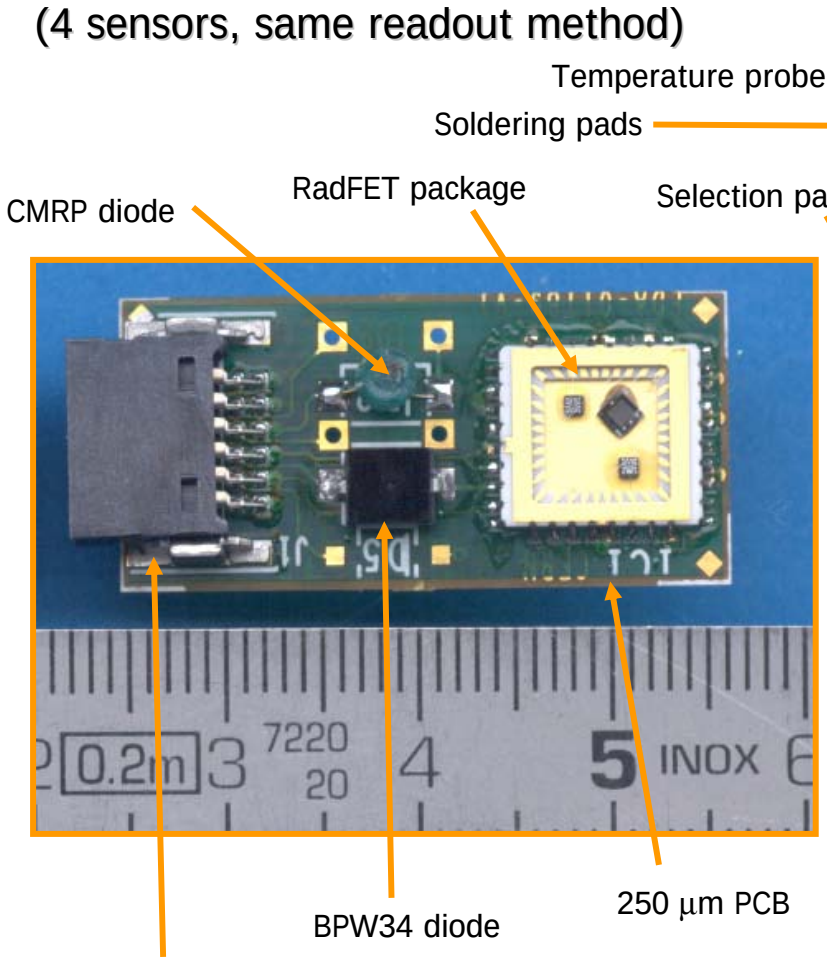
- Sensors procurement continue to satisfy LHC experiments needs;
- First samples of Integrates sensor PCB have been delivered to the Experiments (ALICE/LHCb) for testing;
- Set of calibration data ready for all sensors:
  - REM devices: set extension with independent data;
  - Annealing correction of BPW34 validated over a few months
    - → useful to verify/improve the model over year time-scale;
- GEANT4 Modeling of RadFET Packaging: Focusing on γ/n experimental data validation and in the model applicability;
- Study of LBSD devices at lower injection level (1 mA) to be done.

  (300 parts of LBSD Si-1 and 200 parts of LBSD Si-2 ordered end of 2006)

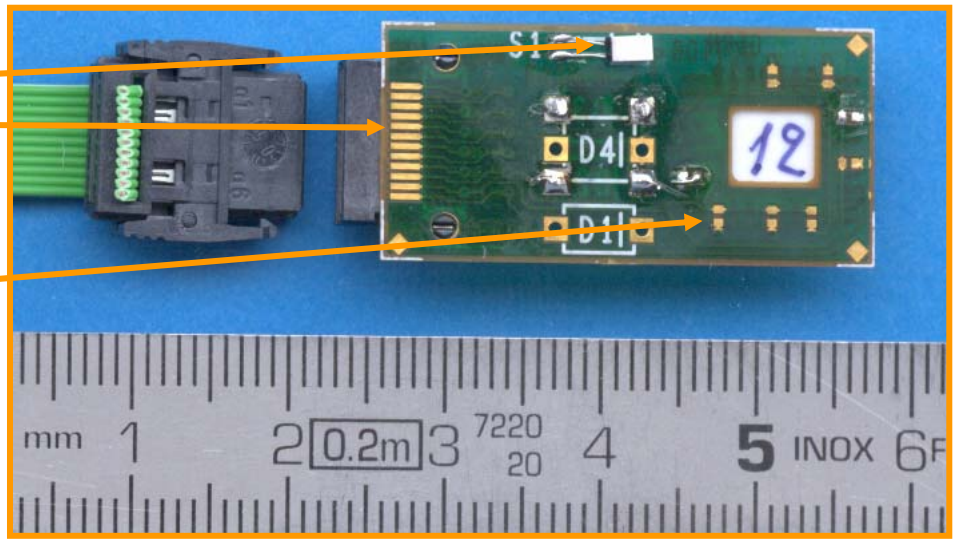
BACKUP SLIDES

Integrated sensor carrier

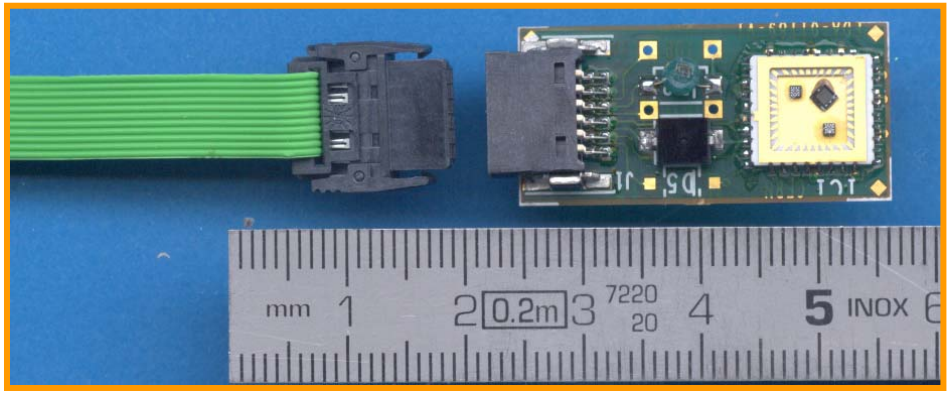
INTEGRATED SENSOR CARRIER
(4 sensors, same readout method)



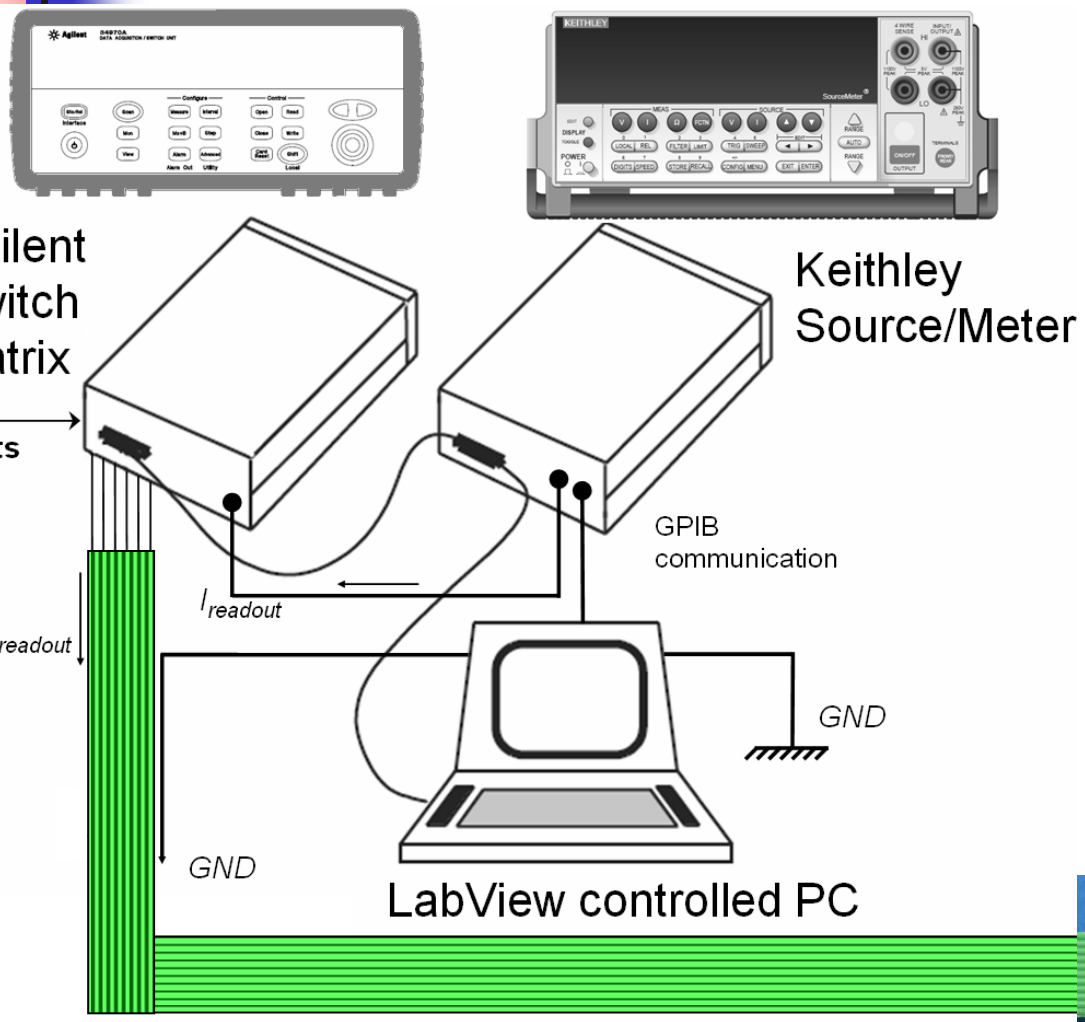
➢ Back-Side



➢ Front-Side



Integrated sensor carrier



INTEGRATED SENSOR CARRIER

Tested during several irradiation campaigns in 2005