Catalogue of Solid-State Radiation Sensors and Summary of User Requirements

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This presentation will be focused mainly on Procurement details.

For more technical details see RADMON webpage

Recent Work ...

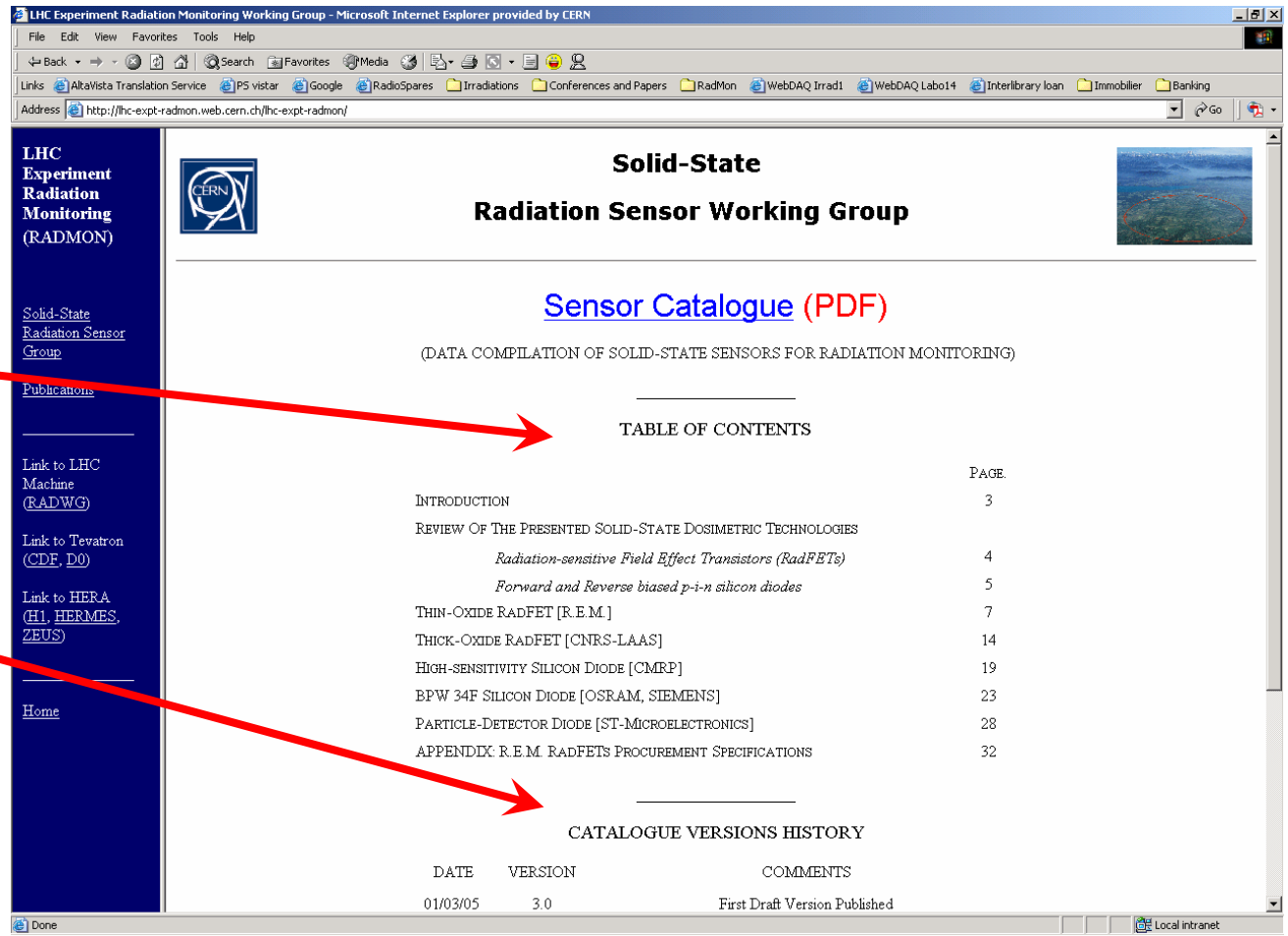
- Aug. 2004 - Low-rate irradiation in mixed field and long-term annealing in PS-T7 area;
- Nov. 2004 - Presentation of sensors selected and available for LHC startup;
- Dec. 2004 – work on packaging intensified;
- Jan/Feb. 2005 – Procurement details clarified;
- Mar. 2005 - Sensor Catalogue distributed.

Sensor Catalogue

http://lhc-expt-radmon.web.cern.ch/lhc-expt-radmon/

Index of available sensors

Catalogue Updates (last 15/3/05)



Sensor Catalogue

http://lhc-expt-radmon.web.cern.ch/lhc-expt-radmon/

For each listed sensor:

1. Physical / geometrical data (connectivity);
2. Readout details (schematic examples);
3. Pre- and after- irradiation characteristics;
4. Radiation responses;
5. Handling and operation precautions (temperature, magnetic field)
6. Packaging options and commercial details.

→ Appendices with **Technical Specifications for Procurement.**

RadFET Sensors

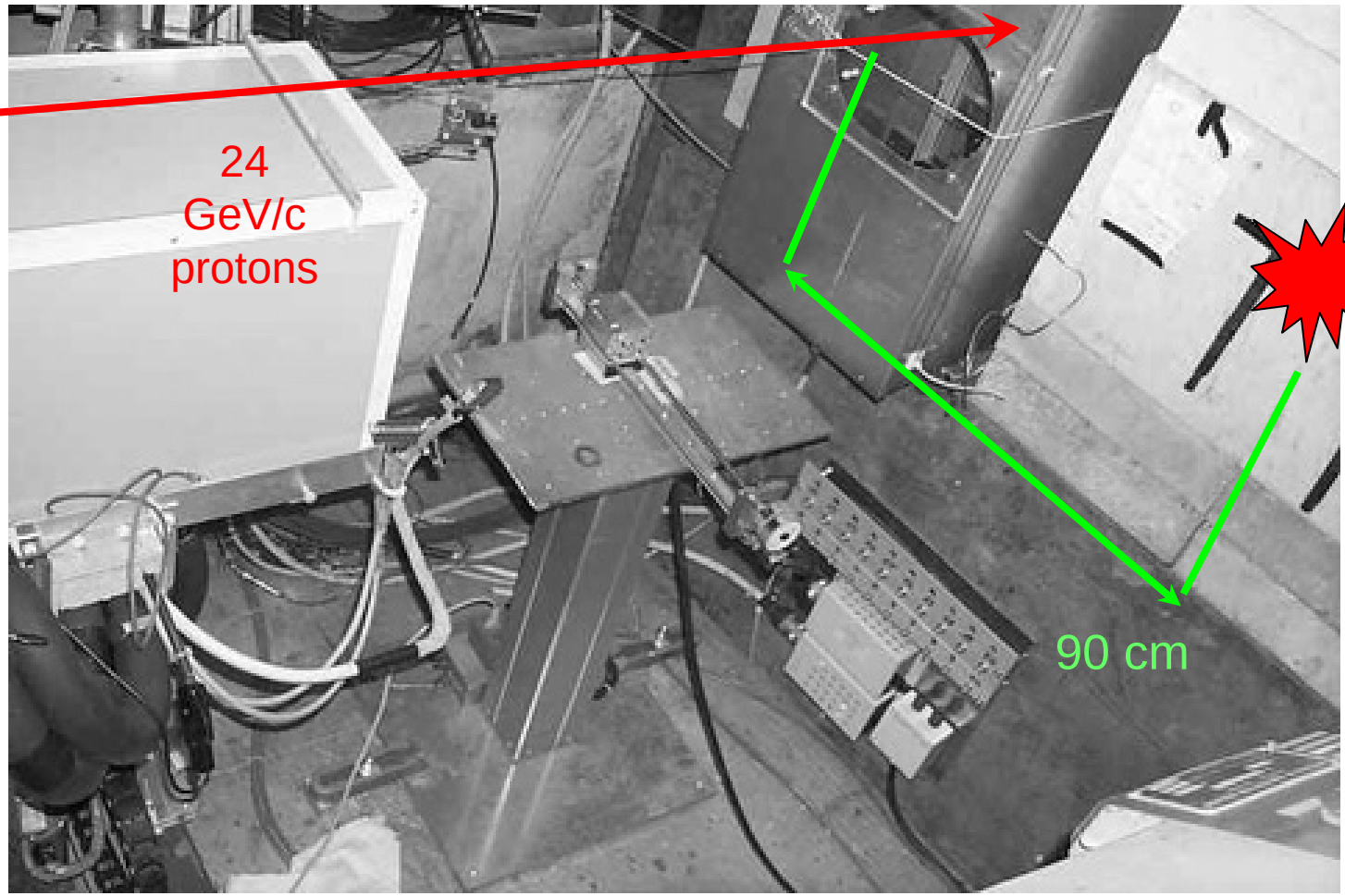
Nine products were evaluated to suit <u>experiments requirements</u>:

- Thin-Oxide RadFET dies (0.25 μm):
  - "low" sensitivity – high dynamic range;
  - Minimize SiO_2 recombination effects → mixed-LET particle fields;
  - Suited for dosimetry in inner-detector regions.

- Thick-Oxide RadFET dies (1.6 μm):
  - "high" sensitivity – low dynamic range;
  - Measurement in "conventional" (γ + n) radiation fields.
  - Suited for dosimetry in outer-detector regions;

RadFETs: a real application ...

MONITORING OF THE PRIMARY AREA PS-T7 29/9/04 – 18/3/05



Monitoring Location RadFETs + ALANINE

γ (>100 keV):
16 ÷ 560 mGy/h

on average:

n (<50 keV):
3.2×10^{10} cm^{-2} h^{-1}

HEP (>100 MeV):
3.1×10^{7} cm^{-2} h^{-1}

RadFETs: Calibration

- At the "90 cm location" alanine should be a good benchmark:

$$d_{n,LE} < 1\ \%\ d_{TOT}$$

$$d_{Alanine} = d_{\gamma,HE} + (\sim 0.1) \times K_{n,LE} \times \Phi_{n,LE} + K_{HEP} \times \Phi_{HEP} \qquad (K^{I}_{n,LE} << K_{n,LE})$$

$$d_{RadFET} = d_{\gamma,HE} + (\sim 0.6) \times K^{I}_{n,LE} \times \Phi_{n,LE} + K^{I}_{HEP} \times \Phi_{HEP} \qquad (K^{I}_{HEP} \sim K_{HEP})$$

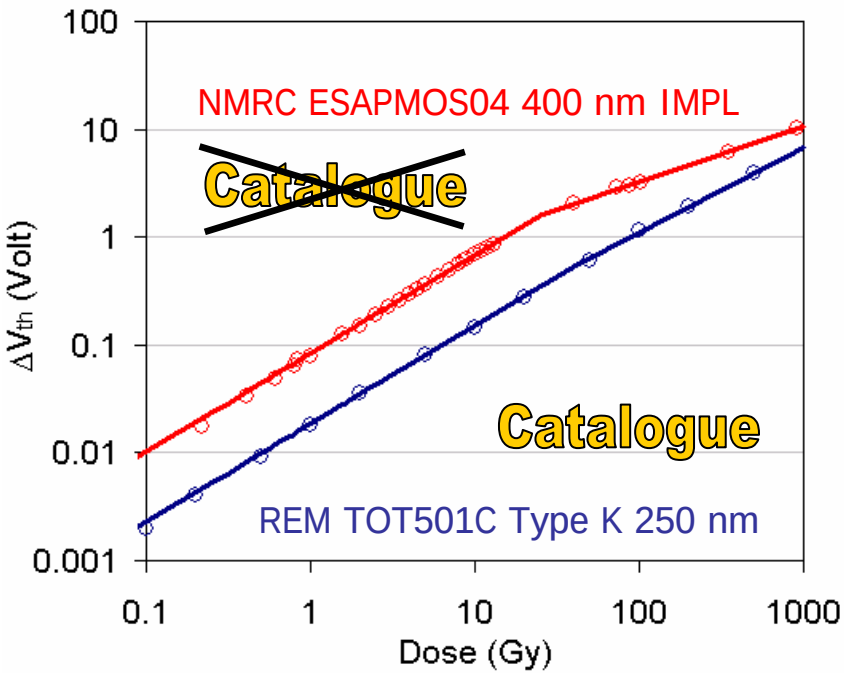
- RadFETs Signal-to-Dose Conversion:

γ-Calibration based on CERN, ESTEC and suppliers to obtain the parameters a_n, b_n

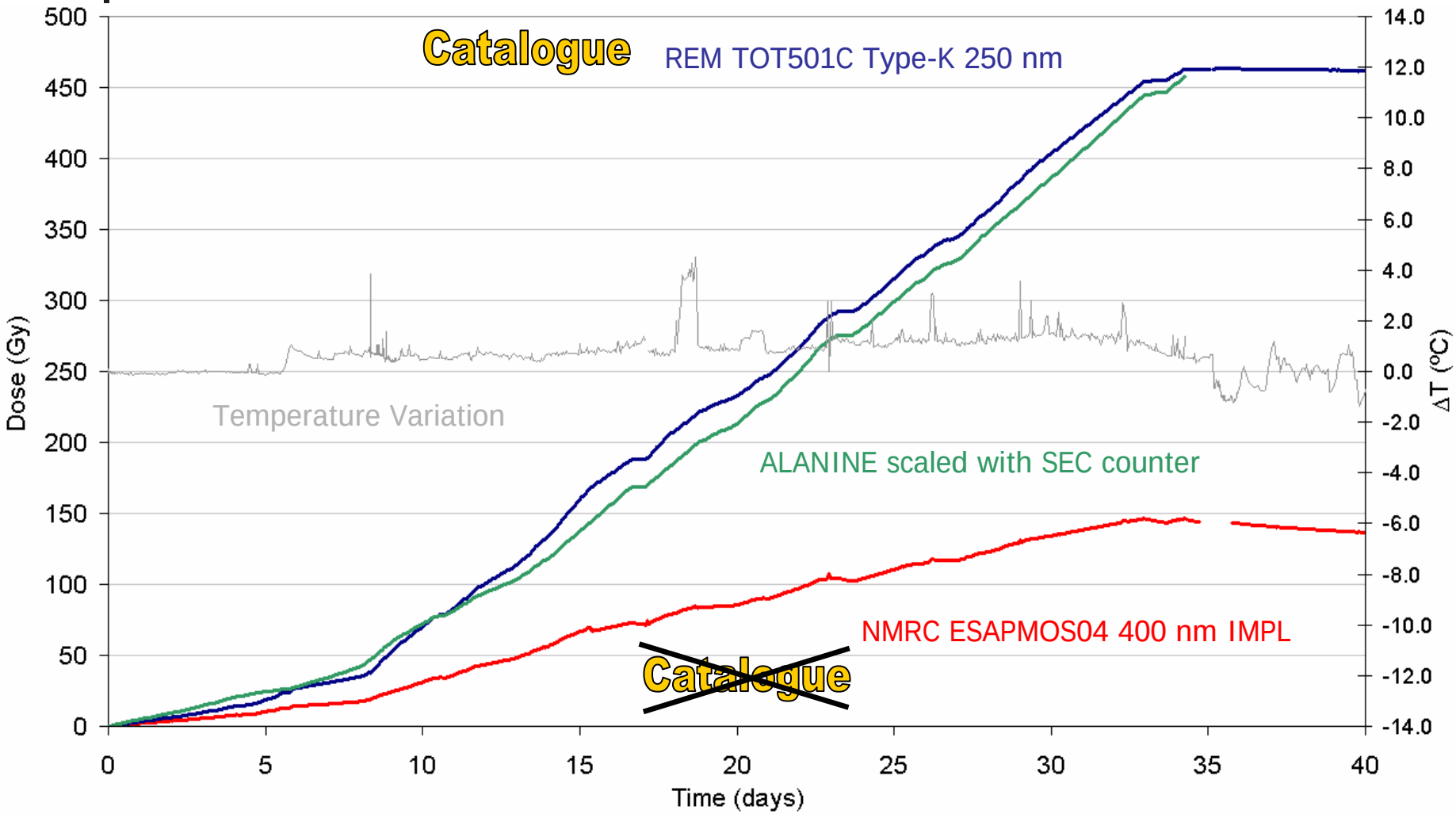
$$Dose = C_1 \times \{[\Delta V_{th}(T) / a_1]^{1/b1}\} + + C_2 \times \{[\Delta V_{th}(T) / a_2]^{1/b2}\}.$$

$C_1 = 1$ and $C_2 = 0$ for $\Delta V_{th} \le V_0$

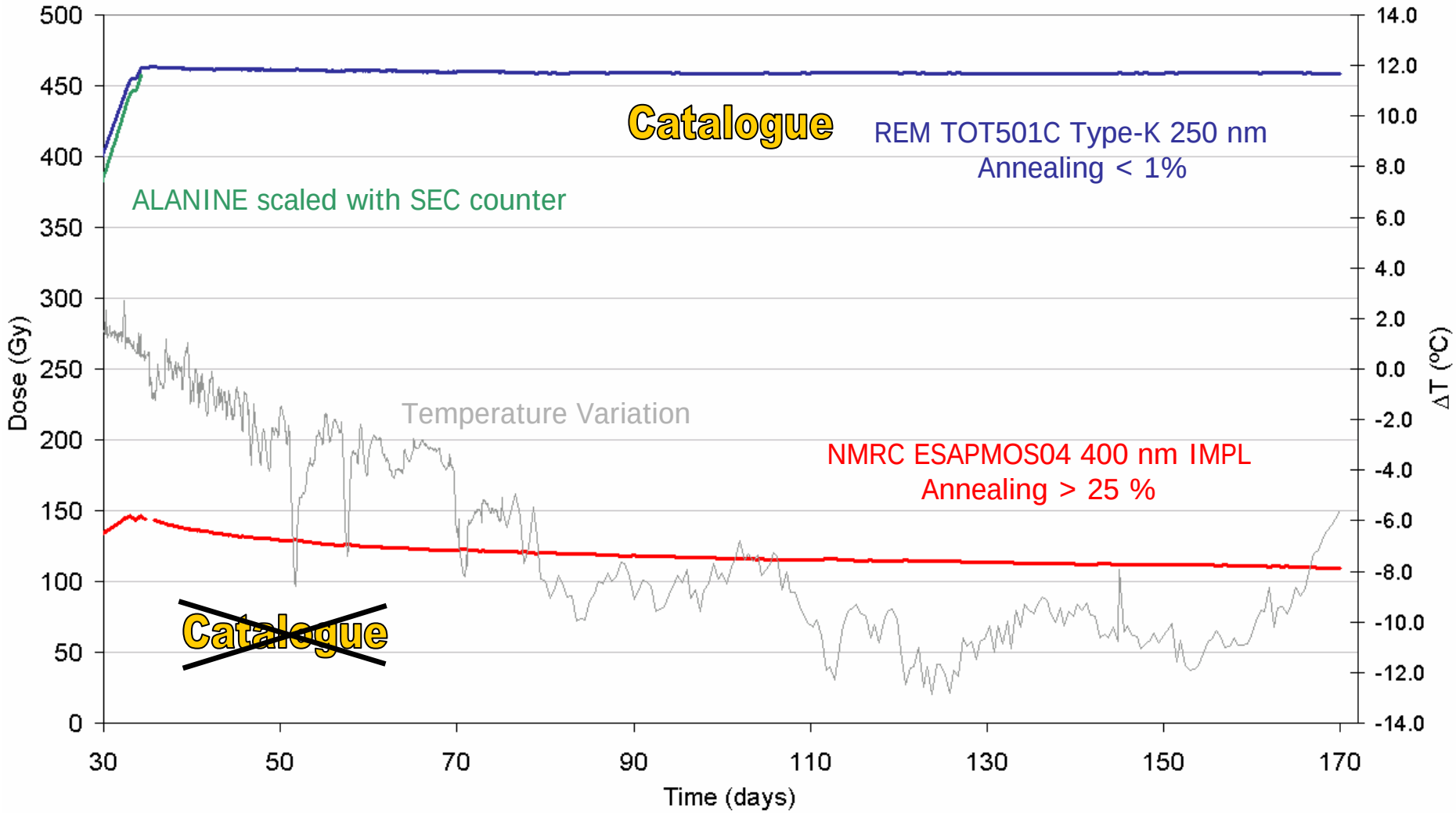
$C_1 = 0$ and $C_2 = 1$ for $\Delta V_{th} > V_0$



RadFETs: Irradiation



RadFETs: Shutdown



RadFETs: Comments

Origin of the presented mismatch for some types of RadFETs:

a. Some oxides show saturation phenomena in hadron fields;

b. Strong RT annealing plays a substantial role over long times;

Additional data-treatment could be a “work-around” to scale the data, however ….

a. The understanding and the evaluation of scaling factors is still an open issue (Nowadays data match only up to low doses/short times!)

b. Fading correction must be implemented (very complex! unreliable?).

Easy and Reliable measurements over long-times can be performed up to high doses in LHC experiments if devices are carefully selected!

RadFETs: Quotes

- Thin-Oxide RadFET dies (0.25 μm):
  - Purchase of remaining 600 samples of the REM TOT501C wafer;
  - Unselected stock of diced devices → Appropriate **packaging** needed!
  - CERN accurate selection procedure and QA needed;
  - ~ 60 CHF/pc. (working device: quantity/yield dependence).
- Thick-Oxide RadFET dies (1.6 μm):
  - Purchase of 100 samples of the LAAS 1600 MOSFET wafer;
  - Selected stock of diced (TO-5) devices → Appropriate **packaging** needed!
  - 60 CHF/pc.
  - Prompt delivery for 100 pcs reserved;

RadFETs: Packaging

Commercial Packaging (i.e. TO-5) cannot satisfy all Experiment Requirements (dimensions/materials)

Development by External Company

If ~ 1k pcs needed
1st quote ~ 60 CHF/pc.

Development in-house at CERN

Design Study

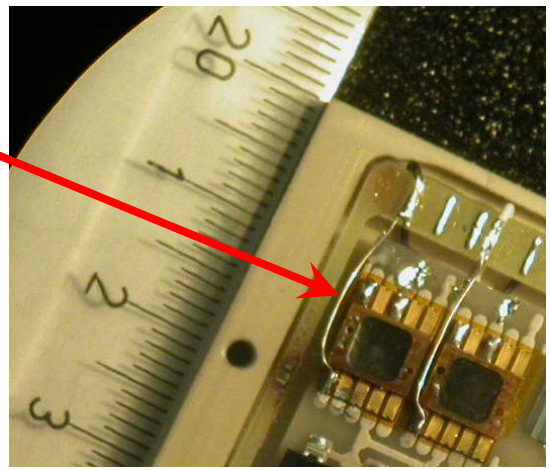
Prototyping

Production

Assembly

Start Device Selection!

R.E.M. CC-6 SMD-like carrier mounted on the prototype of the ATLAS Hybrid
(carrier now discontinued!)



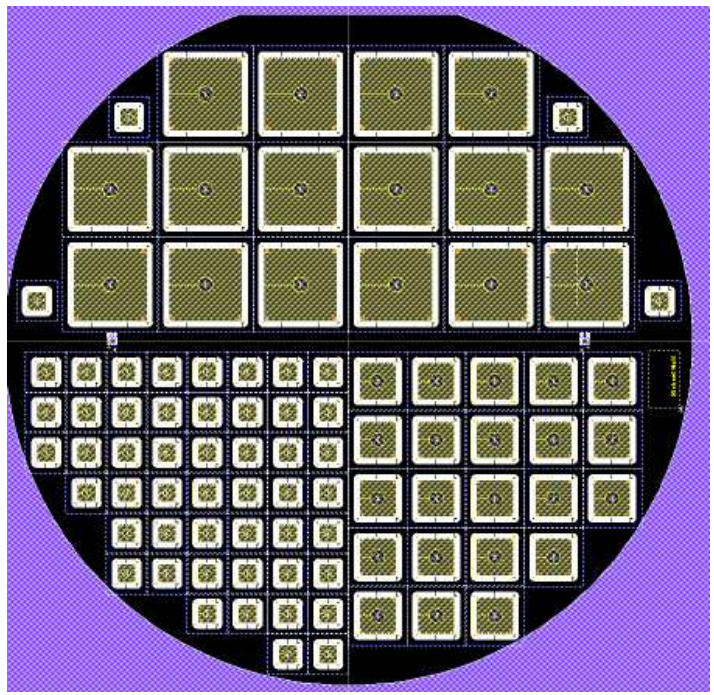
Courtesy of I. Mandic (JSI)

p-i-n Si-diodes

- High-Sensitivity [$\Phi_{eq} < 2x10^{12}$ cm^{-2}] Si-diode **(Forward)**:
  - Low-rate data analysis ongoing: no problem at the moment!
  - Purchase of 100 samples in prompt delivery;
  - Selected stock of packaged devices (∅ 3 mm × 3 mm);
  - 100 USD/pc (117 CHF/pc).
- BPW 34F Si-diode [$\Phi_{eq} > 2x10^{12}$ cm^{-2}] **(Forward)**:
  - Readout protocol under definition;
  - pre-irradiation seems the solution to go for lower fluences!
  - More annealing studies are ongoing;
  - A coordinate purchase may avoid in homogeneity problems.
  - ~ 2 CHF/pc.

p-i-n Si-diodes

- Particle Detector diode **(Reverse)**:
  - ~ 200 bare samples from ST Microelectronics on stock.
  - Unselected stock of diced devices: selection procedure and QA needed;
  - 30 CHF/pc.



- New Particle Detector structure **(Reverse)**:

A sensor mask has already been designed.

3 detector sizes: from 2.5 to 10 mm^2

Experiments Sensor-Requirements

	Status	Thin Oxide FETs	Thick Oxide FETs	High Sensitivity p-i-n	BPW 34 p-i-n	Si-Detector p-i-n
ALICE	March 2005	10	20	30	0	0
ATLAS	February 2005	36 [ID] (18+18)	100 [RoA]	36 [ID] 100 [RoA]	20 [ID]	0
CMS	March 2005	a few ?	a few ?	a few ?	/	/
LHCb	March 2005	30	30	50	30	0
TOTEM	March 2005	A contact-person is going to be appointed				

[ID] = Inner Detector; [RoA] = Rest of Atlas

Conclusion & Future Steps

→ First version of “Sensor Catalogue” has been presented containing devices available for LHC startup:

- 2 x RadFETs dosimeters;
- 2 x p-i-n diodes (Forward operation);
- 1 x p-i-n diodes (Reverse operation).

→ In contact with all suppliers: preliminary offers received, prices will depend on quantities;

→ Working on packaging options started: needs input from experiments!

→ **We are going to order devices by middle of April 2005.**