Total Dose Tests of Technical Equipment for the LHC

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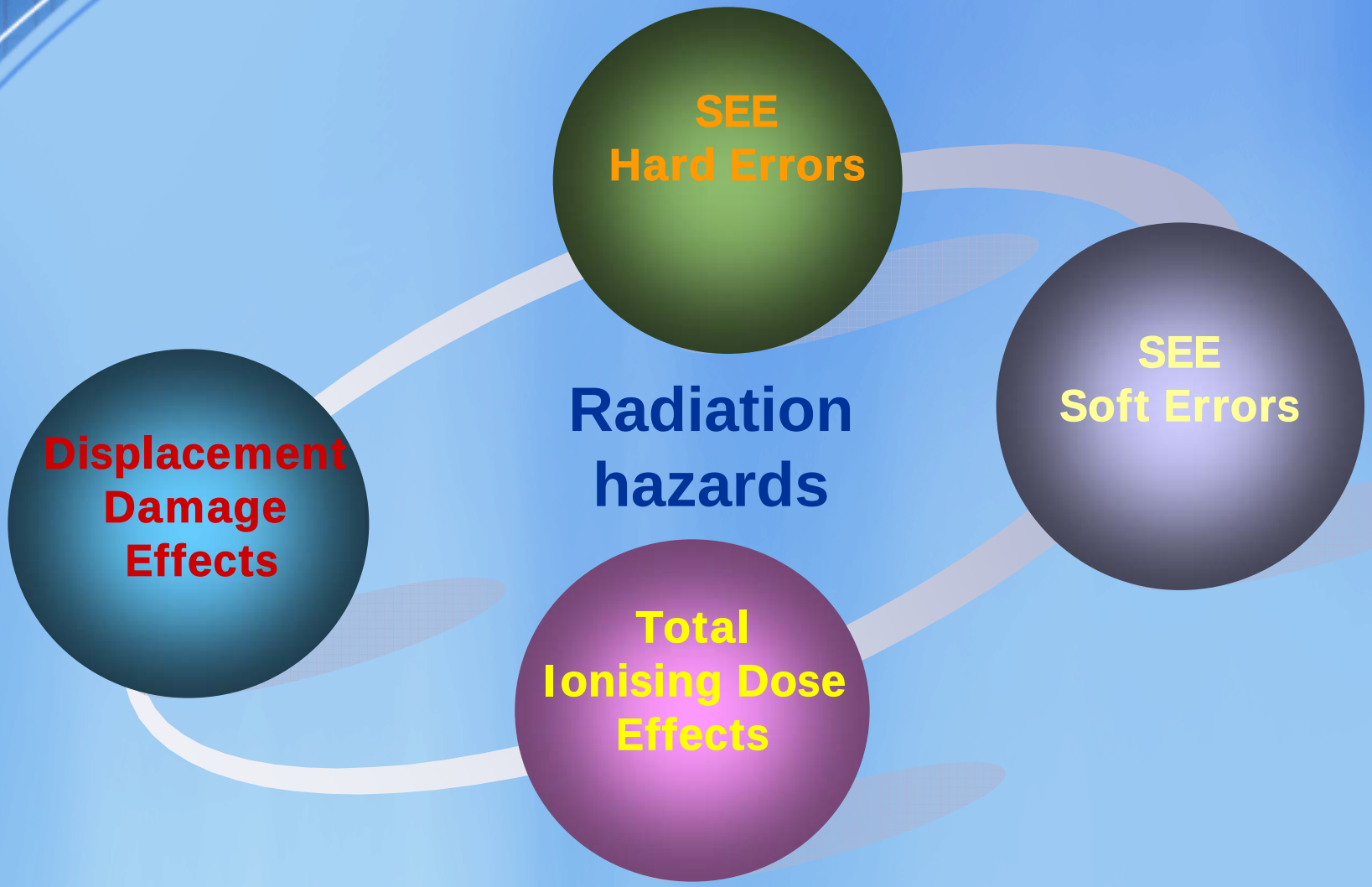
Introduction

- The equipment in the LHC tunnel will be irradiated in a very hostile radiation environment
- Many different kind of particles at energies ranging from eV to hundreds of GeV
- The **radiation tolerance** and reliability of equipment (particularly electronics) are important issues


SEE
Hard Errors
SEE
Soft Errors
Radiation
hazards
Displacement
Damage
Effects
Total
Ionising Dose
Effects

TOTAL IONISING DOSE TESTS

Gamma (^{60}Co) facility, CIS-BIO International CEA Saclay

PAGURE irradiator: (activity ~14 kCi)

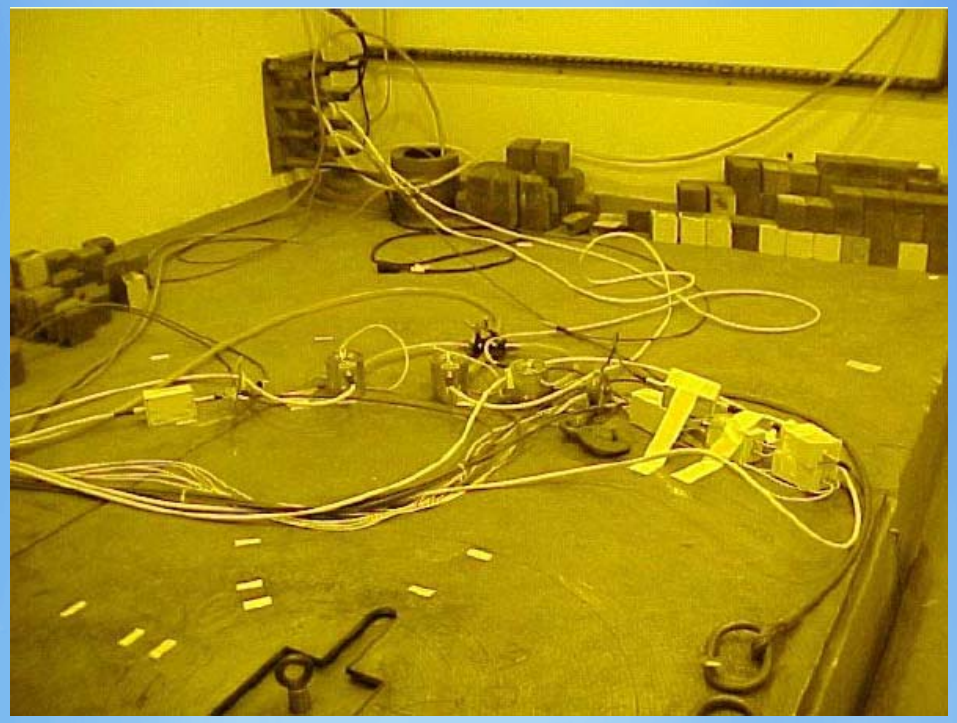
Dose rates:

- **30 Gy/hr to 1 kGy/hr (large volumes)**
- **30 Gy/hr to 20 kGy/hr (small volumes)**

POSEIDON irradiator: (activity ~1 MCi)

Dose rates:

- **~ 2 kGy/hr**



TID tests at CEA- Saclay

Group	Responsible of equipment	Equipment irradiated	Additional info on equipment
TS/CSE	R.Nunes & D. Raffourt	Fire and smoke detectors Conventional alarm lights	
TS/CSE	L. Scibile	RFID	Memory chips for the access control of LHC and for RAMSES
TS/CV	J. Inigo- Golfin & F. Josa	PT-100	Water sensor
		HYGRODAT 100	Temperature & relative humidity sensors
		TR-200	Temperature & relative humidity sensors
TS/EL	S. Casenove	Optic fibers	
TS/LEA	F. Ravotti	RADFETs	RADMON
TS/LEA	T. Wijnands & C. Pignard	RADFETs	RADMON
TS/SU	A. Marin & H. Mainaud Durand	HLS sensors	Hydrostatic leveling system for the alignment of the low beta quadrupoles
AB/CO	R. Brun	repeaters	WorlFIP control (Fieldbus)
AB/CO	P. Dahlen	Several types swithes	Control of normal magnets
AT/ECR	F. Haug	Cooling pipes & Peltier item	Cooling of TOTEM detectors
SC/RP	H. Vincke	PAD & RPL	Polymer Alanine & Radio – Photo- Luminescent dosimeters

TS/CSE
(Controls, Safety and Engineering Databases Group)

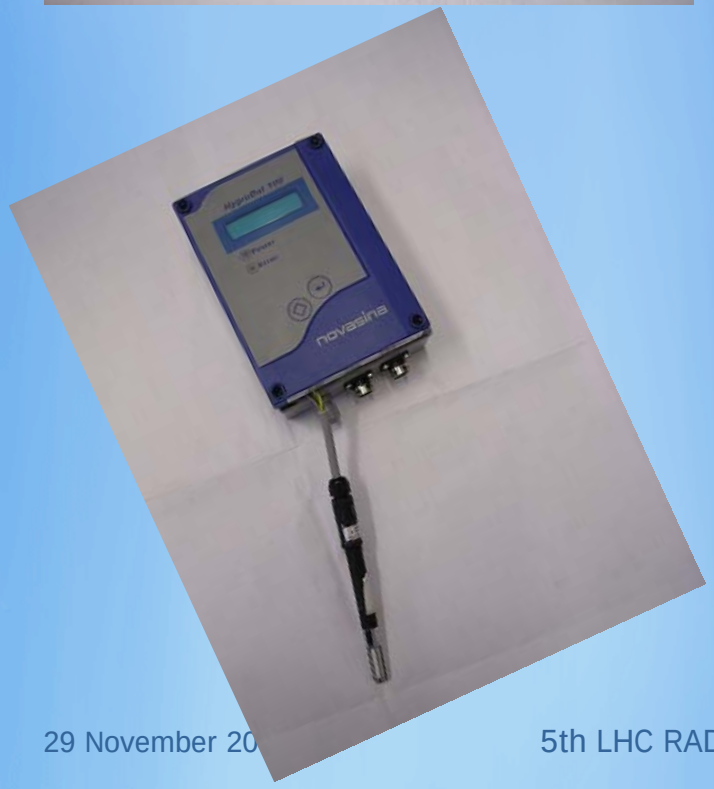
Fire and smoke detectors & conventional alarm lights

+

RFID memory chips for the access control and for RAMSES

TS/CV
(Cooling & Ventilation Group)

- Water sensors
- Temperature and humidity sensors (HYGRODAT 100 and TR-200)



TS/EL
(Electrical Engineering Group)

Tests of optic fibers

- ✓ **Radiation induced attenuation**
- ✓ **Replace the optic fibers from polyamid tubes after some years of operation**

AB/CO (Controls)

WorldFIP network

Magnet protection, Power converters, Beam instrumentation, Radio frequency, Cryogenics…

+

AT/ECR

(Cryogenics for Experiments)

Cooling pipes for the TOTEM RP

Switches on the normal magnets of the LHC (IR3 & IR7). (Thermoswitchs ELMWOOD 3106 – T117 - buttons SECME C4, connectors BURNDY 4BPM, Kapton cables)

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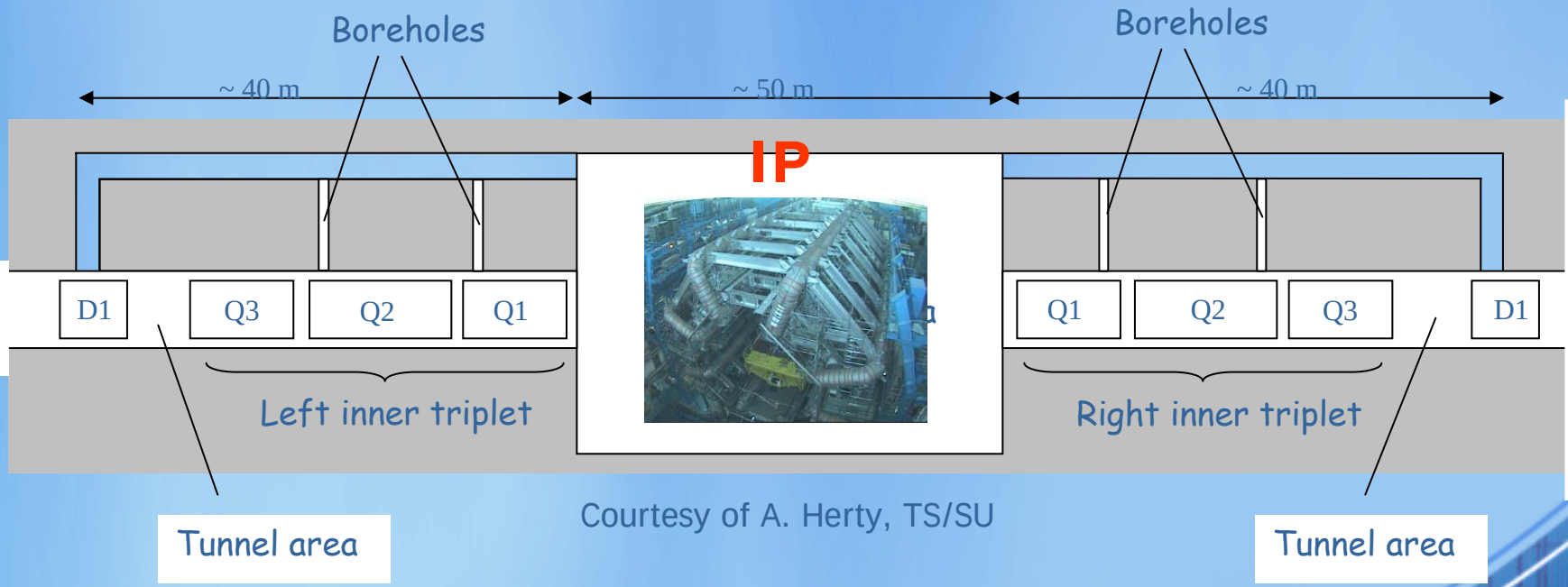
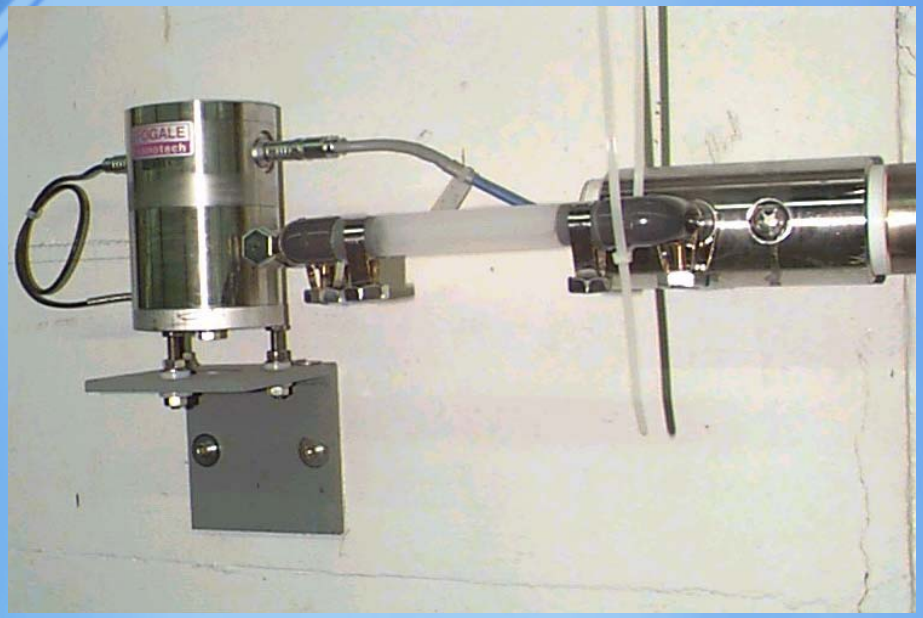
Dose rate effects on the sensors of the Hydrostatic Leveling System (HLS) for the LHC low beta quadrupoles

Q1, Q2 and Q3 : Inner triplet on left and right side of each experiment.
The HLS System designed to provide relative measurement of the magnet position, vertically and transverse tilt.
Alignment tolerances: Positioning of one inner triplet : ± 0.5 mm
One quadrupole inside its triplet: a few um



Courtesy of A. Herty, TS/SU

The HLS unit

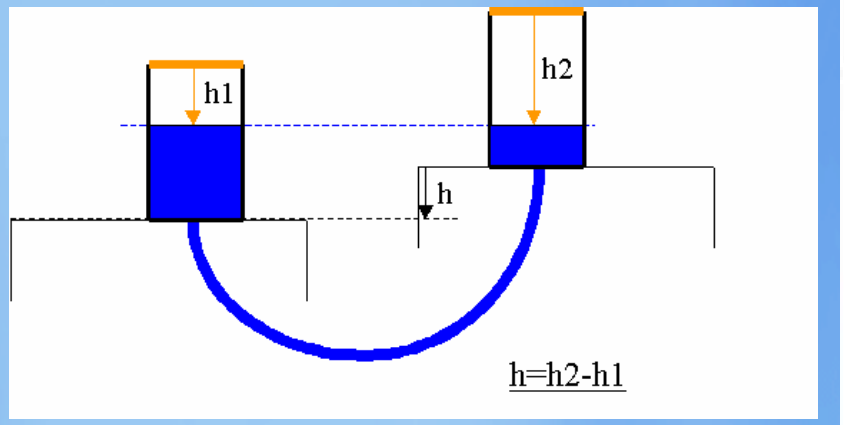


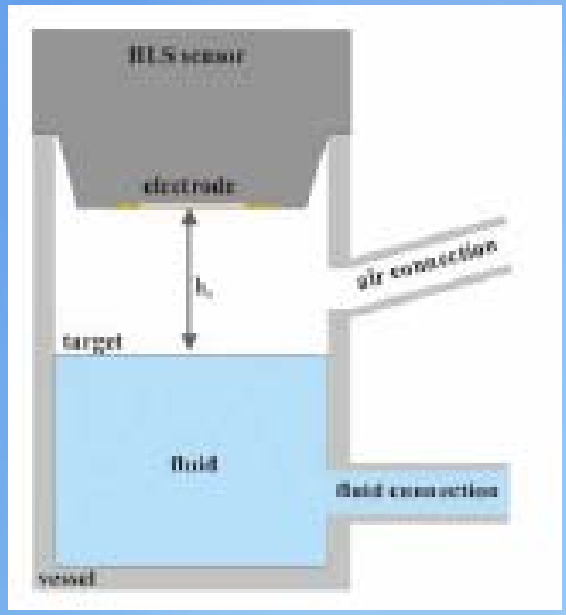
HLS resolution: less than 1um

Precision depends on the configuration of the network

(distance between HLS sensors, type of hydraulic network, type of pipes, diameter of pipes, environment etc)

Basic principle :
the principle of communicating vessels

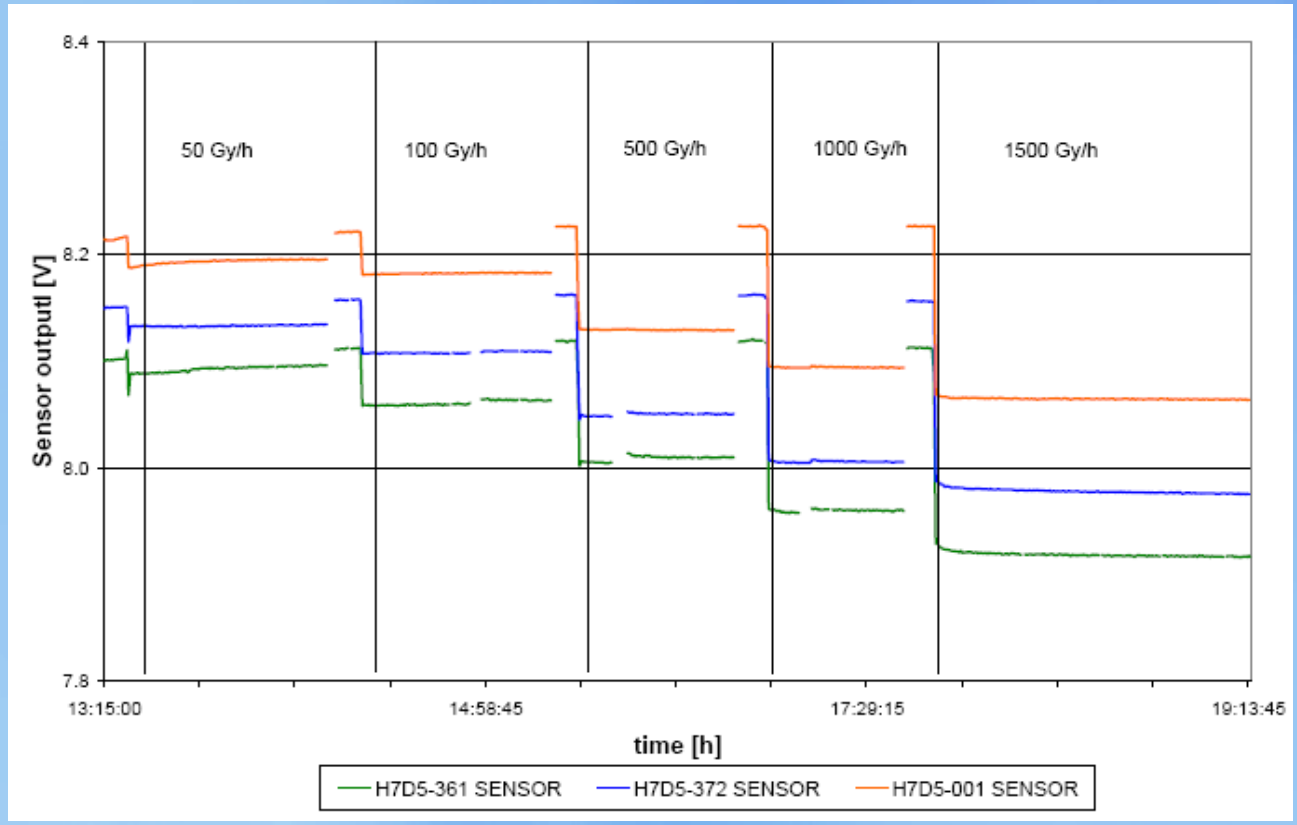




Continuous monitoring of the relative position performed by the sensor's surface (electrode) and the water surface (target).
Capacitive measurements determine the distance to the target.

$$\Delta C = \frac{\varepsilon_0 \cdot \varepsilon_r \cdot S}{\Delta h}$$

The offset signal of the HLS due to radiation



From measurements performed in CEA Saclay (PAGURE facility), March 2005

Radiation induced effects

Physical process inside the sensor similar to condenser type ionization chamber

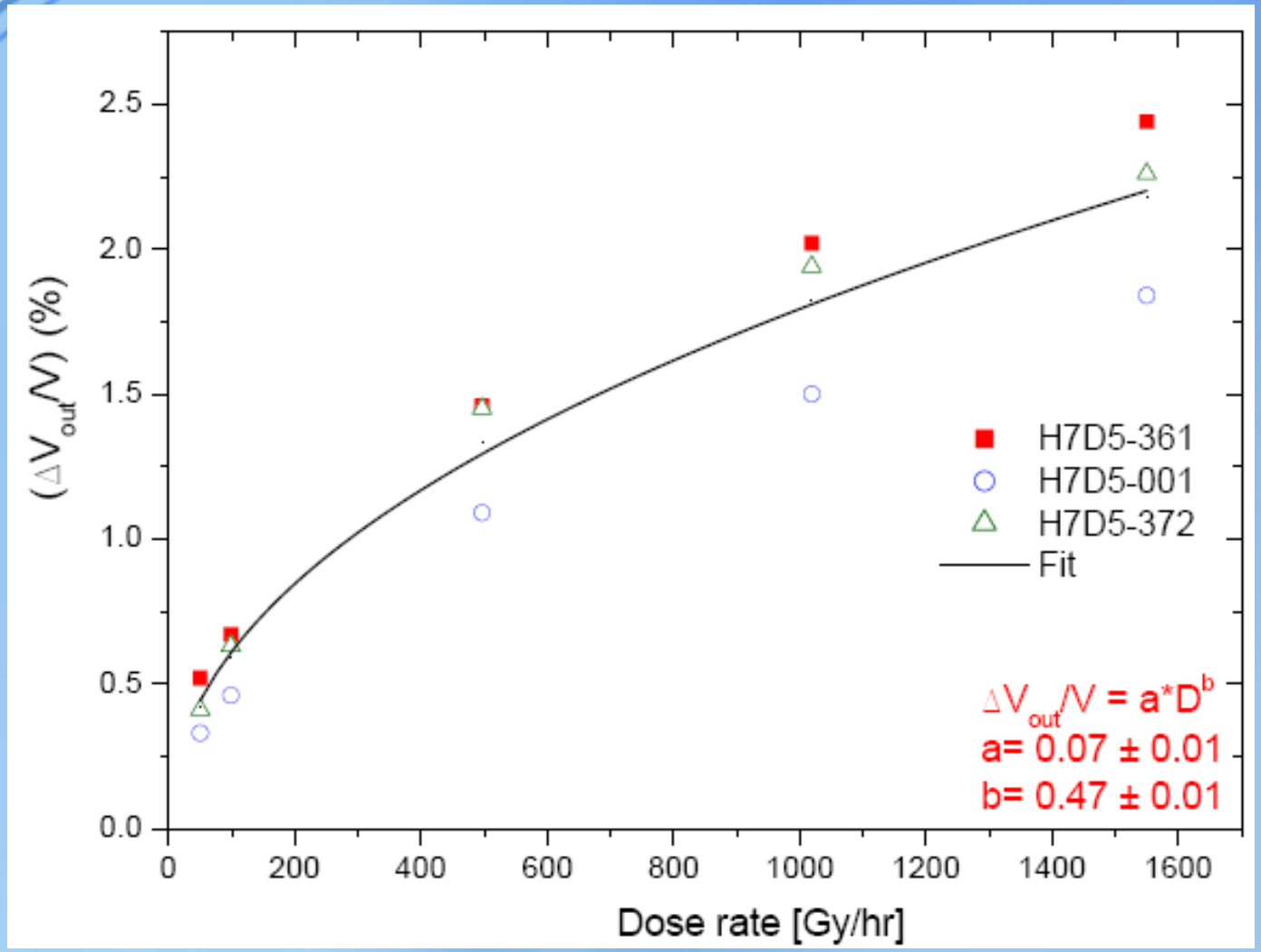
Bragg Gray principle

$$I_{ion} = \frac{D \cdot m \cdot S_g}{W \cdot S_W}$$

Ionizing radiation creates ions and electrons in the air cavity
→Due to applied potential difference ions and electrons move in opposite directions
→Charge deposited on the target plate changes the electric field and varies the excitation voltage

At low dose rates, low number of electron-ion pairs produced

At high dose rates, more recombination →HLS signal saturates



The measured voltage offset for all sensors and the average variation (in black)

Conclusions

- **HLS signal modified when exposed to ionizing radiation- during LHC operation the radiation induced offsets will be ~ a few microns**
- **The signal of the HLS can be corrected with the proposed model (a condenser ionization chamber)**

  TS/SU (Large scale metrology) group is working on the solution
- **Radiation tolerance of HLS electronic readout is ~200 Gy Total Ionising Dose**

For more info on the HLS please have a look at: **TS-Note-2005-052 (EDMS No 629483)**

General remarks

- TS/LEA- RAD provides a service to

  ALL LHC equipment groups

- In depth studies when needed
- Organisation of TID tests at least twice per year

  (March and November)

Maybe we can help YOU !


THANK YOU
FOR
YOUR ATTENTION!!!