LHC-ACR-IN in TCC2 area (2002)
Irradiations of Electronic Components

Validation of switching power supplies, diode bridges, and conditioners for pressure sensors

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Radiation test protocol for components of cryogenic systems

- **IN2P3 Orsay, FR**
  - Effects @ cryo Temp.
    Grenoble: SARA cyclotron
    Orleans: CERI cyclotron
    - **Pressure sensors**
      Temp. sensors
- **CERN (LHC/ACR/IN)**
- **UCM, Madrid, Spain**
  - TD effects on COTS
    Lisbon: ITN nuclear reactor
    - **Passives: R, C**
      OPAMPs
      Instrum. opamps
      Voltage references
      Analog switches
      ADCs(14-16bits)

Radiation test protocol for components of cryogenic systems

- IN2P3 Orsay, FR
- CERN (LHC/ACR/IN)
  - SEE tests
    Louvain: UCL cyclotron
    Villigen: PSI cyclotron
    - **Dig. comm. Systems**
    - **Switching power supplies**
    - **A/D signal processing card**
  - Validation of comp. and systems for LHC
    CERN: TCC2
    - **Passives: R, C**
    - **Pressure sensors @300K**
    - **RBFE asic (C4i)**
    - **Power amplifiers**
    - **Power supplies (50-100W)**
    - **FPGA**
    - **Dig. comm. Systems**
    - **Sensor signal conditioners**
- UCM, Madrid, Spain

Why tests in TCC2?

- Radiation spectrum in TCC2 is claimed to be similar to the future LHC machine.
- Different particles (n, p+, gamma, e^-, etc.) at various energies (0-400GeV) are present – mixed radiation field.

- Testing in TCC2 is suitable for final RAD-TOL components validation but does not allow a detailed study of a single damage mechanism.

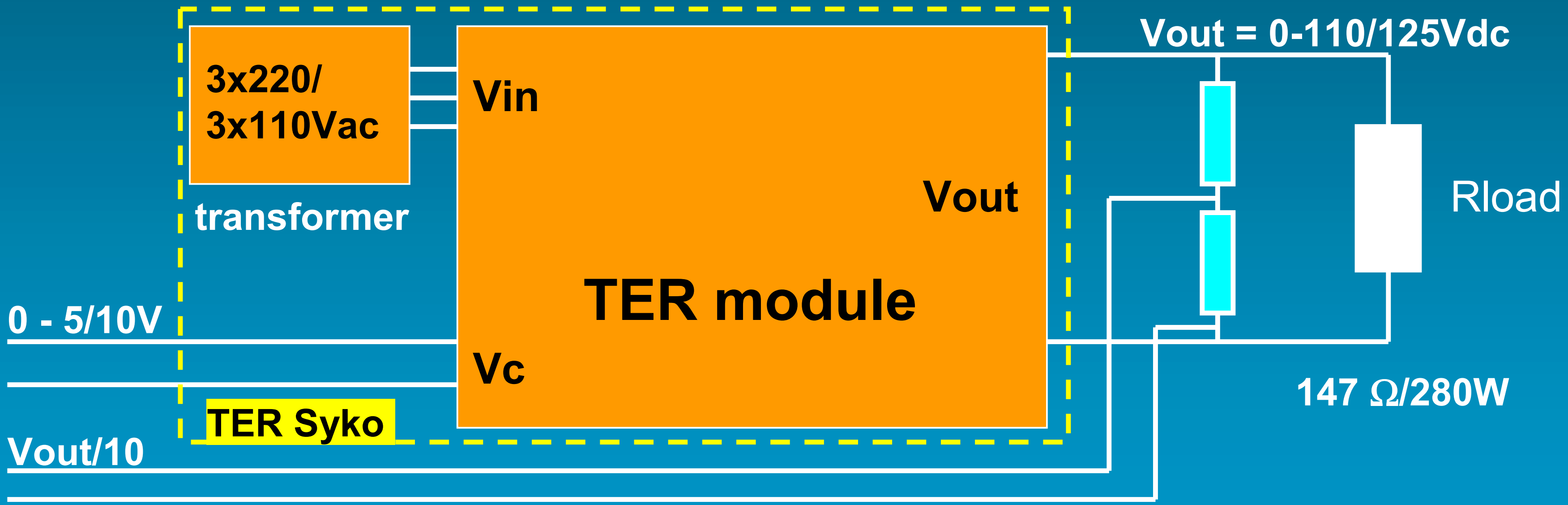
Goals

- Validation of instrumentation electronics for LHC-ACR-IN
- Component selection
- Observation of annealing effects

Table of Contents

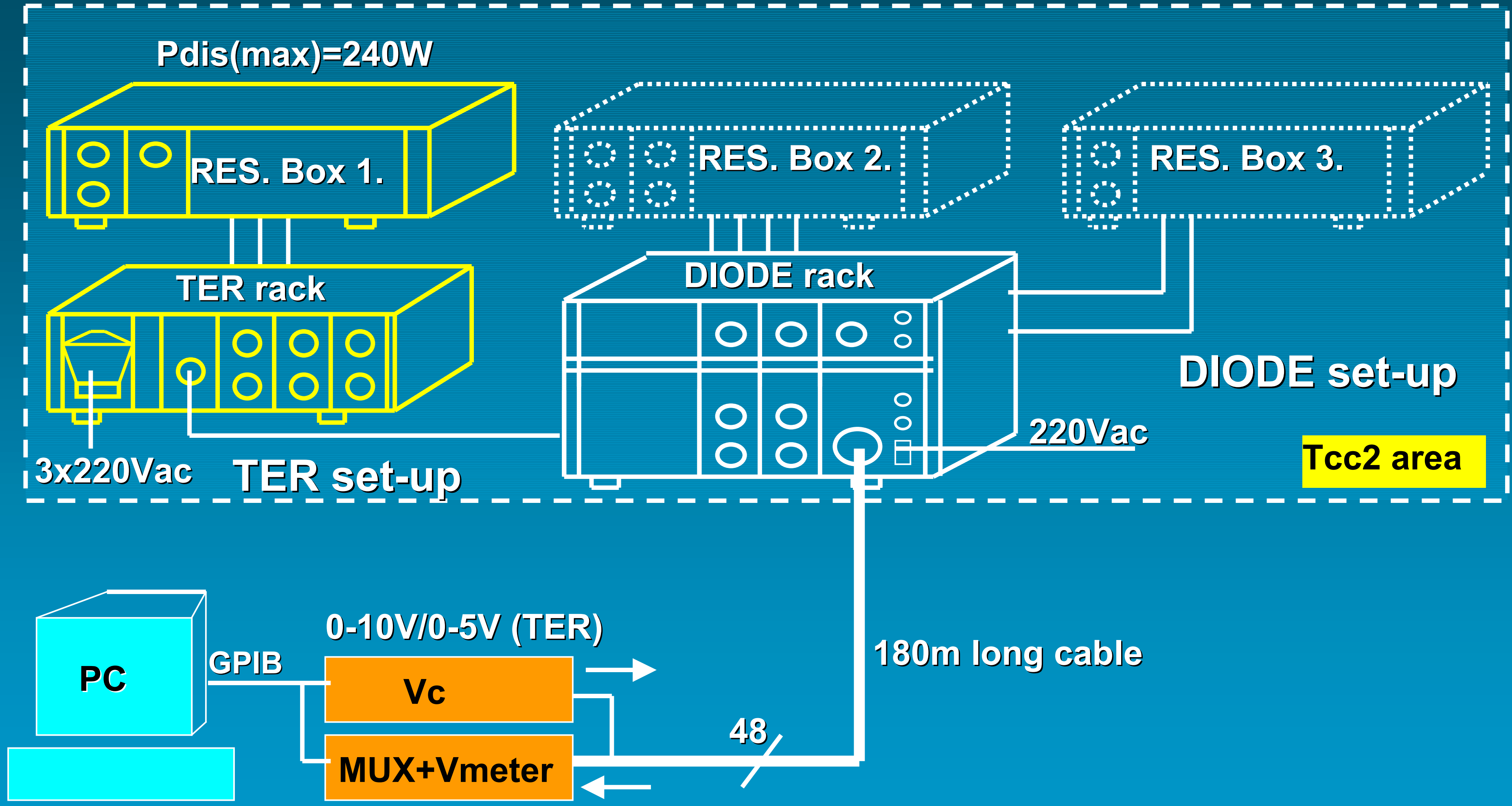
A) Commercial switching power supplies tests

- 3 modules TER, Syko (CH)
  - 1x Vin=3x110Vac, Vout= 0-125Vdc/1A, Vc=0-10V
  - 2x Vin=3x110Vac, Vout= 0-110Vdc/1A, Vc=0-5V
- LHC application: regulated V source for He heaters (50-100W)



One TER module block-scheme

A) Switching power supplies set-up

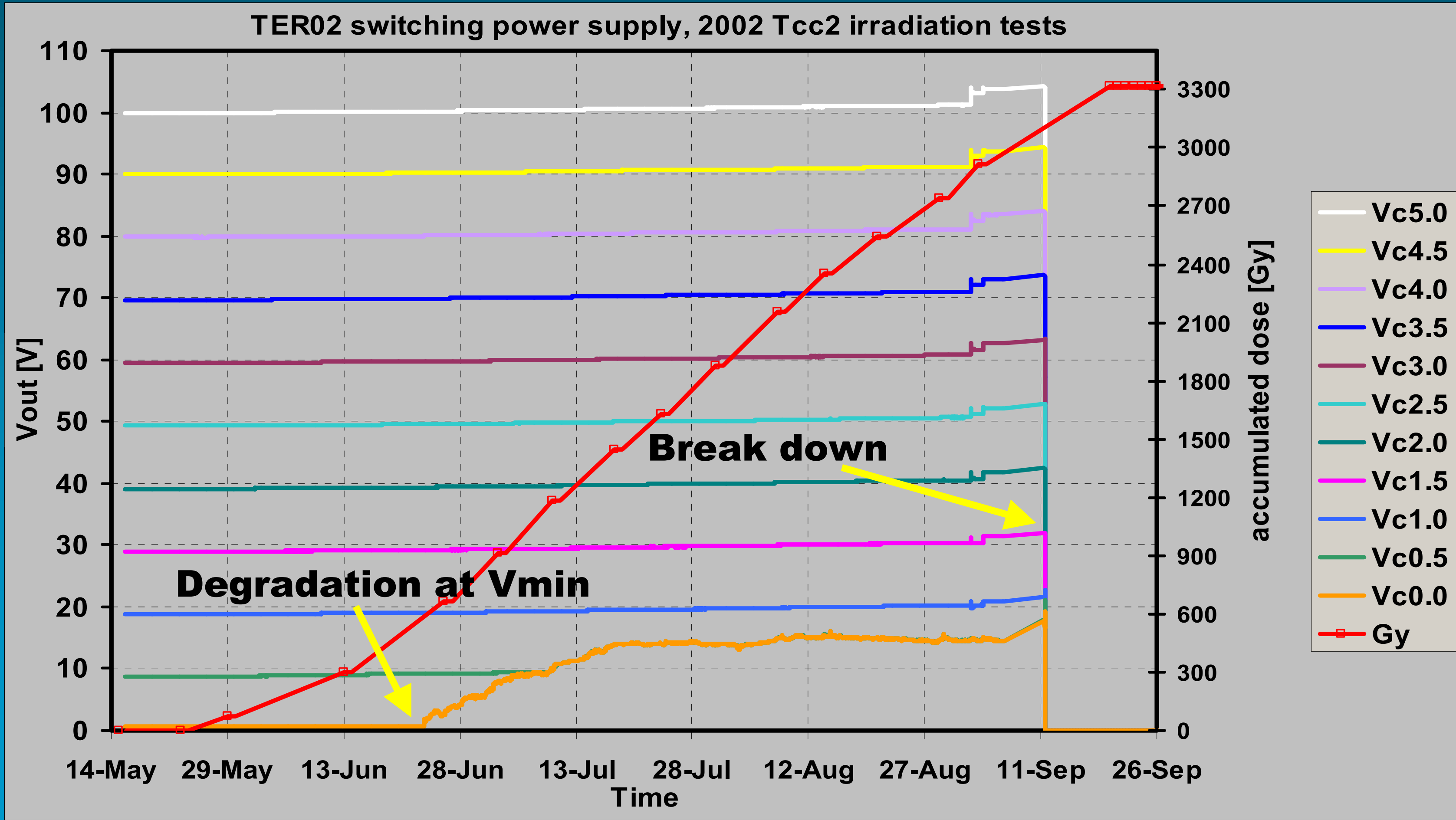


A) Obtained results

TER switching power supplies survive (1%FS Vout error)

1x TER01 1600Gy, degradation at Vout(max)

2x TER02 400Gy, degradation at Vout(min), see Fig. example

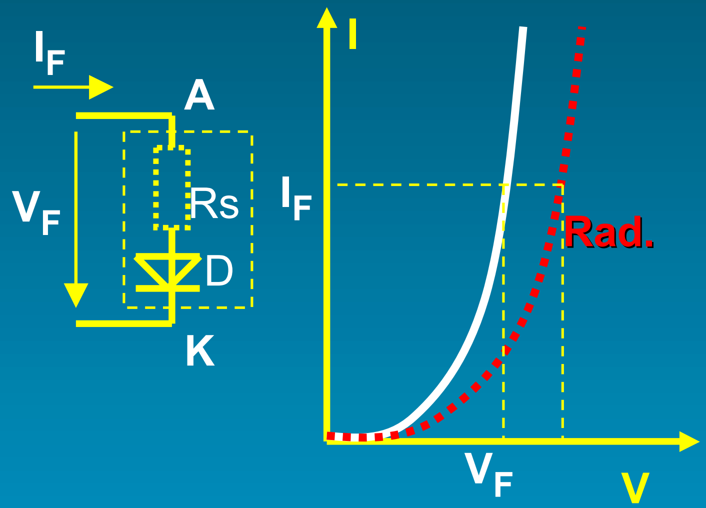


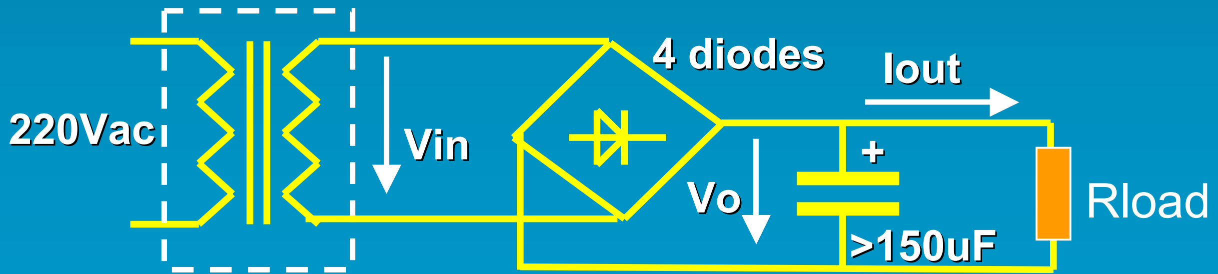
B) Diode bridge rectifiers tests

- 12 x GBU8K bridge rectifiers @ different Vin and Iout
- 2 x DBI6-04 3phase rectifiers @ Vin=72Vac, Iout=0.9A

Qty	Vin(ac)	Iout	Pload	Pbridge
2x	2V	0.16A	0.13W	0.23W
2x	3V	0.19A	0.36W	0.28W
2x	10V	0.19A	2.27W	0.28W
1x	72V	0.9A	81W	1.42W
1x	72V	0.94A	83.06W	1.48W
2x	10V	1.65A	13.61W	2.65W
2x	5V	1.95A	5.70W	3.14W
1x	72V	0.9A	81W	1.45W
1x	72V	0.94A	83.06W	1.51W

I-V diode characteristic



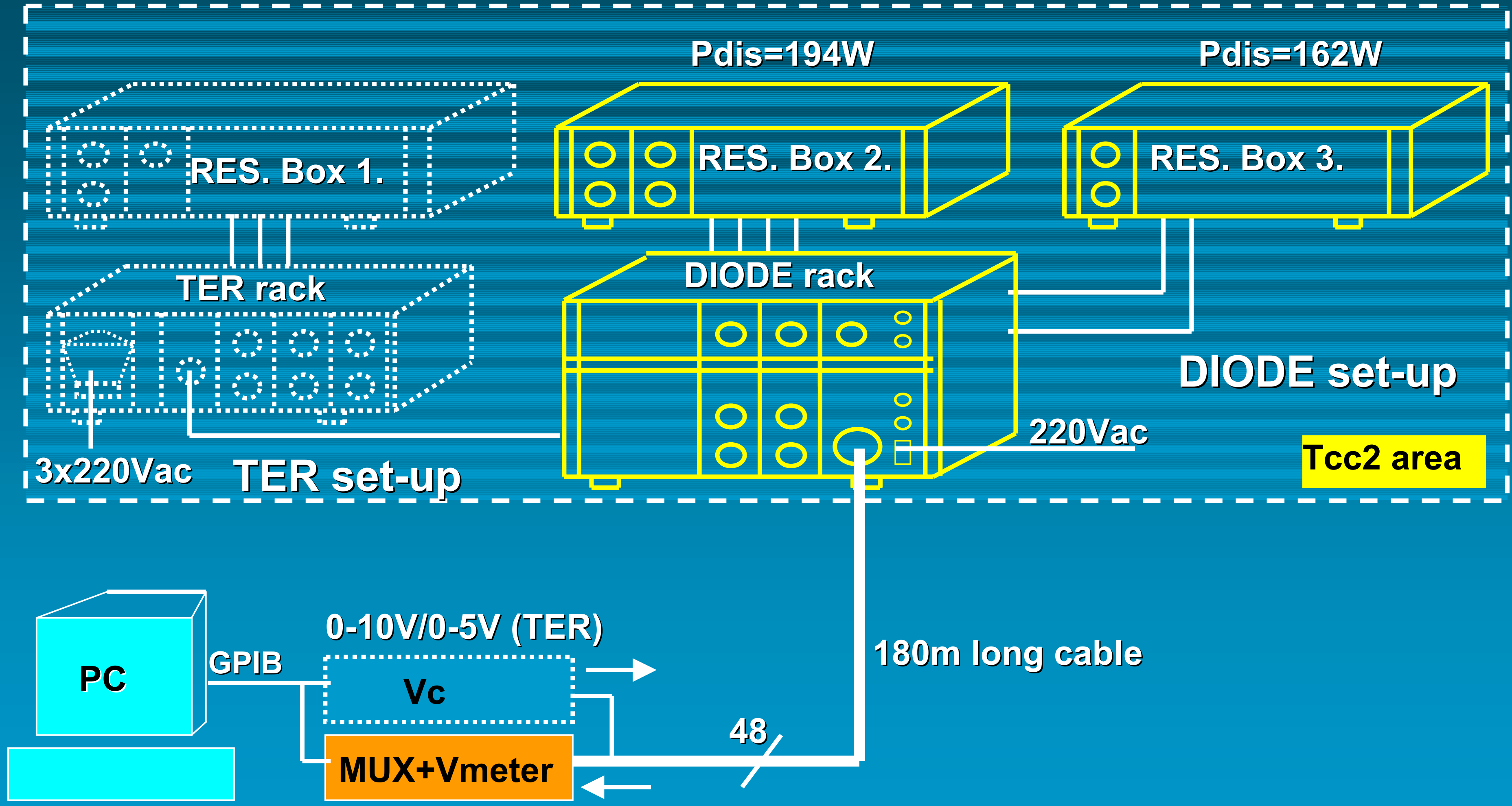


Diode bridge configuration example

Radiation effects on diode

- V_F, P_D increase

B) Diode bridge rectifiers set-up



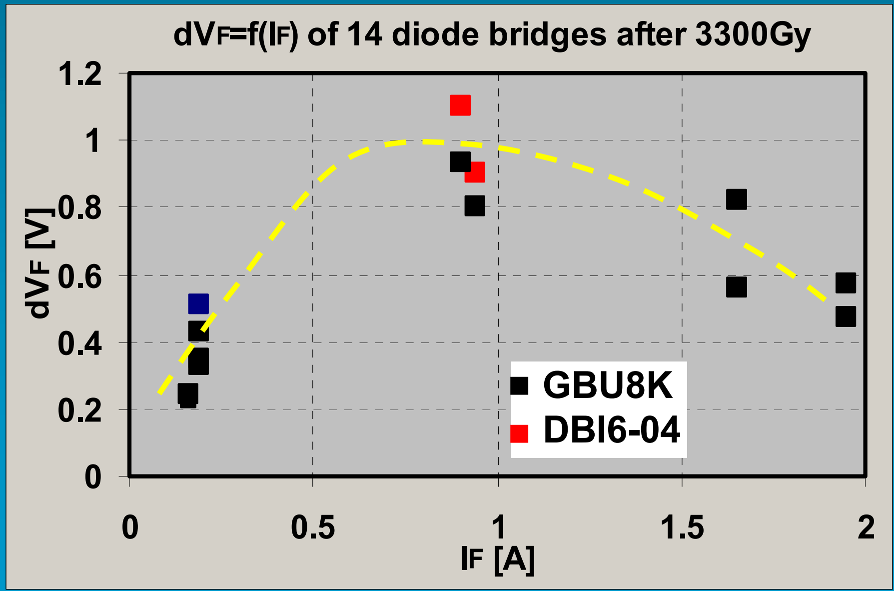
B) Obtained results

Diode bridge rectifiers degradation after 3300Gy - 4.76.10^{13}n/cm^2

- experiment worked all the TCC2 2002 campaign without failure
- 0 - 400Gy : no change, all diode bridges initial behaviour
- 400 - 3300Gy : V_F and P_{bridge} increase due to accumulated TD
- Diodes working at higher currents 1.6 - 1.9A showed smaller V_F rise (see Table and Fig.)

Conclusion: preview necessary cooling fin and V drop for D bridge in the RAD-TOL design

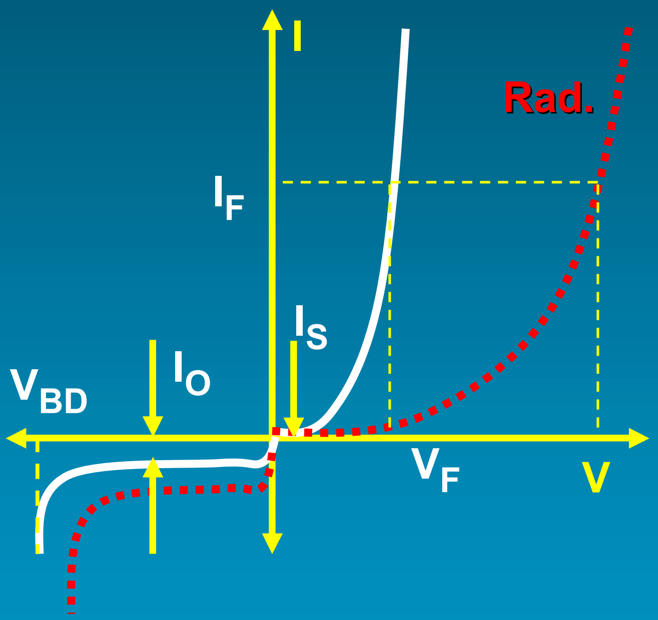
Qty	Vin	I_F(init)	Pbridge	ΔPbridge	ΔV_F
2x	2V	0.16A	0.23W	+0.04W	+0.24V
2x	3V	0.19A	0.28W	+0.09W	+0.35V
2x	10V	0.19A	0.28W	+0.17W	+0.52V
1x	72V	0.90A	1.42W	+1.40W	+0.90V
1x	72V	0.94A	1.48W	+1.35W	+0.80V
2x	10V	1.65A	2.65W	+2.20W	+0.81V
2x	5V	1.95A	3.14W	+1.42W	+0.57V
1x	72V	0.90A	1.45W	+1.80W	+1.10V
1x	72V	0.94A	1.51W	+1.60W	+0.95V

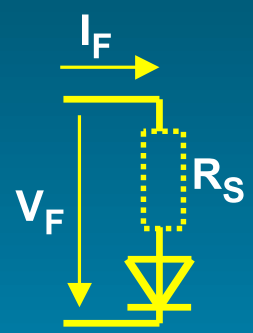


B) GBU8K complementary test results at UCM Madrid

- I_S and R_S measurements of each diode in GBU8K (5 samples)
- total dose 1435Gy, neutron flux max $8.04.10^{13}$ n/cm^2

I-V diode characteristics

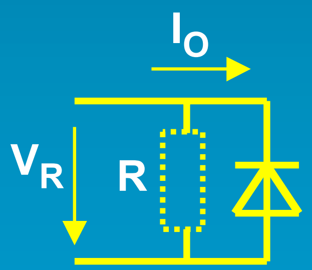




Forward biased region I_F=0.19A

$$I_F = I_S.\exp\left(\frac{V_F - I_F.R_S}{nV_T}\right)$$

I_S(init)[A]	I_S(rad)[A]	R_S(init)	R_S(rad)
3.8e-10	2.8e-7	0.7Ω	120 Ω



Reverse biased region V_R= 5 - 78V

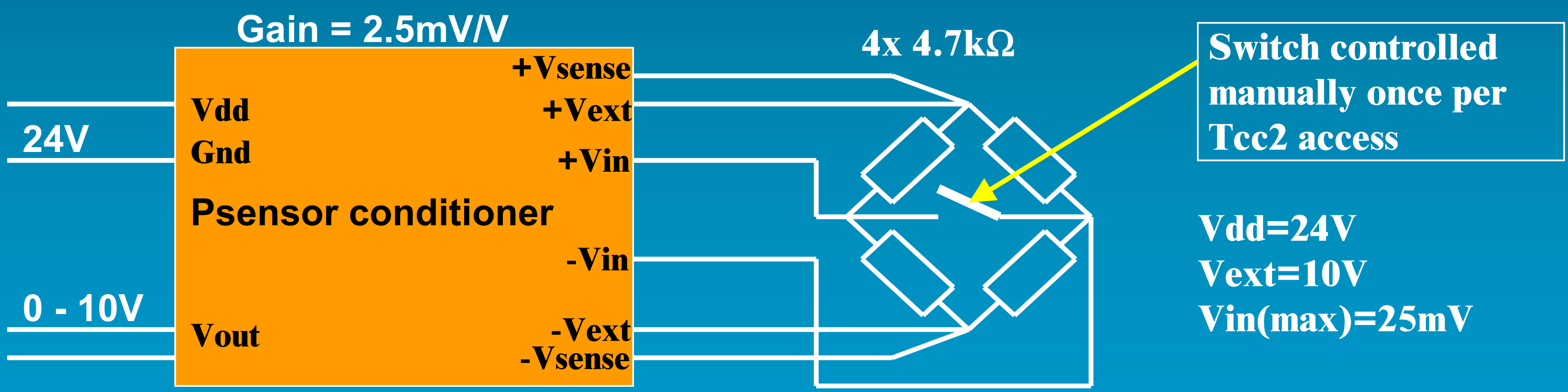
I_O(init)[A]	I_O(rad)[A]	R(init)	R(rad)
9.5e-10	1.5e-7	2.6e10Ω	1.1e7Ω

C) Pressure sensor conditioners

Max drift required: ±0.2%FS

Qty	Model	Company	Init.Drift(%FS)*	Type
3x	9243	MTS (CH)	±0.09%	dumb
3x	SCM90KA	Soclair(CH)	±0.17%	dumb
3x	3310B	Sensorex (FR)	±0.20%	dumb
3x	AE101	HBM (D)	±0.11%	dumb
3x	S7DC	RDP Electrosense(USA)	±0.15%	dumb
3x	PDVD404739	BAUMER (CH)	±0.07%	dumb
2x	2261	PR electronics (DK)	±0.20%	intelligent

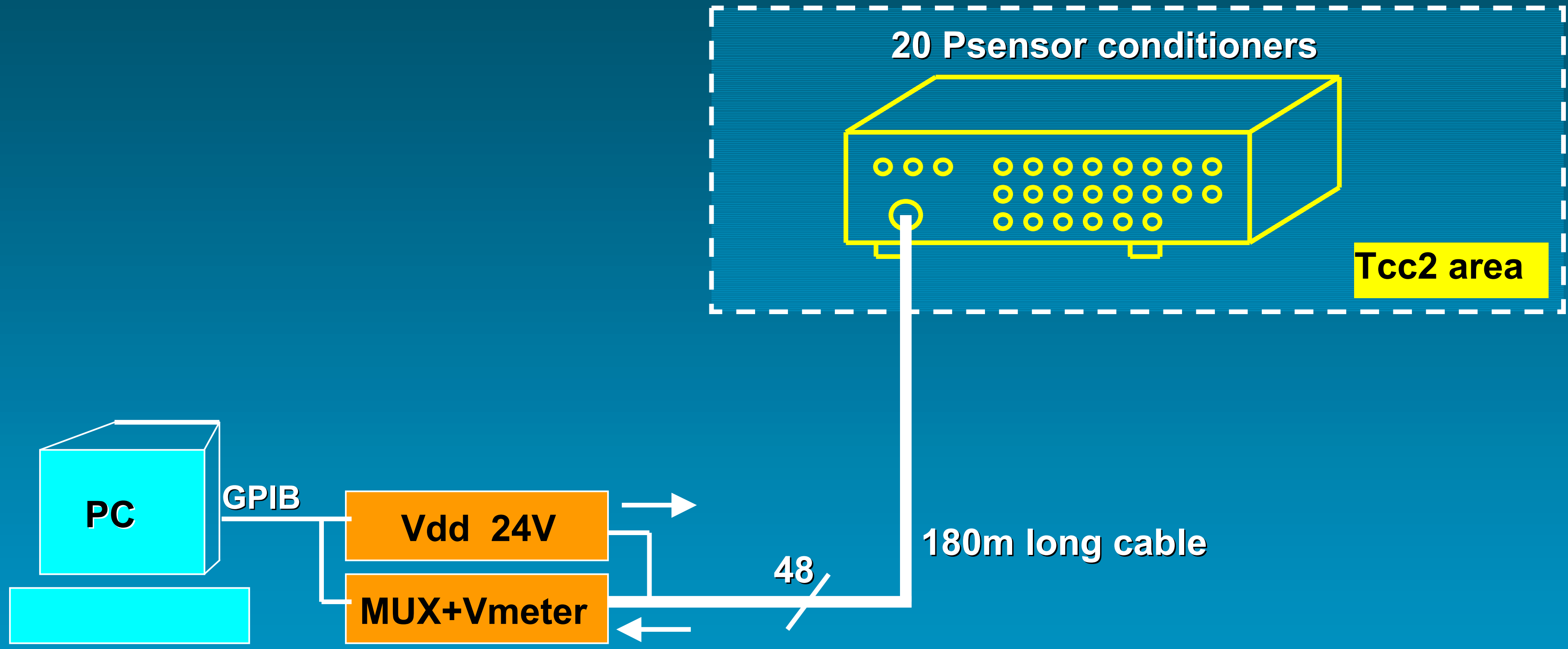
*temp. change of 5°C, 140hours working.



Psensor is simulated by the R bridge.

P sensor conditioner configuration example

C) Pressure sensor conditioners set-up



C) Obtained results

- All pressure sensor conditioners exposed to 3300Gy TD
- Selection of conditioners based on requirement of max ±0.2%FS drift with min 100Gy usable dose range.

Summary of tested pressure sensor conditioners.

Qty	Conditioner	Usable dose range	Failure	Opinion
3x	MTS9243	500Gy	500Gy	Acceptable
3x	Soclair SCM90KA	440Gy	2200Gy	Acceptable
3x	Sensorex 3310B	65Gy	1100Gy	Not good
3x	RDP S7DC	220Gy	2100Gy	Acceptable
3x	PDVD404739	60Gy	750Gy	Not good
2x	PR2261*	120Gy	330Gy	Acceptable

* When power is OFF, it looses calibration data

Conclusion: four possible candidates from 7 commercial conditioners: MTS9243, Soclair SCM90KA, RDP S7DC and PR2261

Final conclusions

Commercial switching power supplies TER

RAD-TOL up to 400Gy (Tcc2 doses)

Diode bridges GBU8K &DBI6

14 D bridges tested up to 3300Gy
Necessary V drop and cooling fin for RAD-TOL power supply design

Pressure sensor conditioners

Four candidates from 7 tested products have sufficiently low radiation induced drift: MTS, Soclair, RDP and PR
Further tests required.