



**Radiations tests made for**

**SIEMENS Remote I/Os**

**used for the protection of the**

**WARM Magnets**



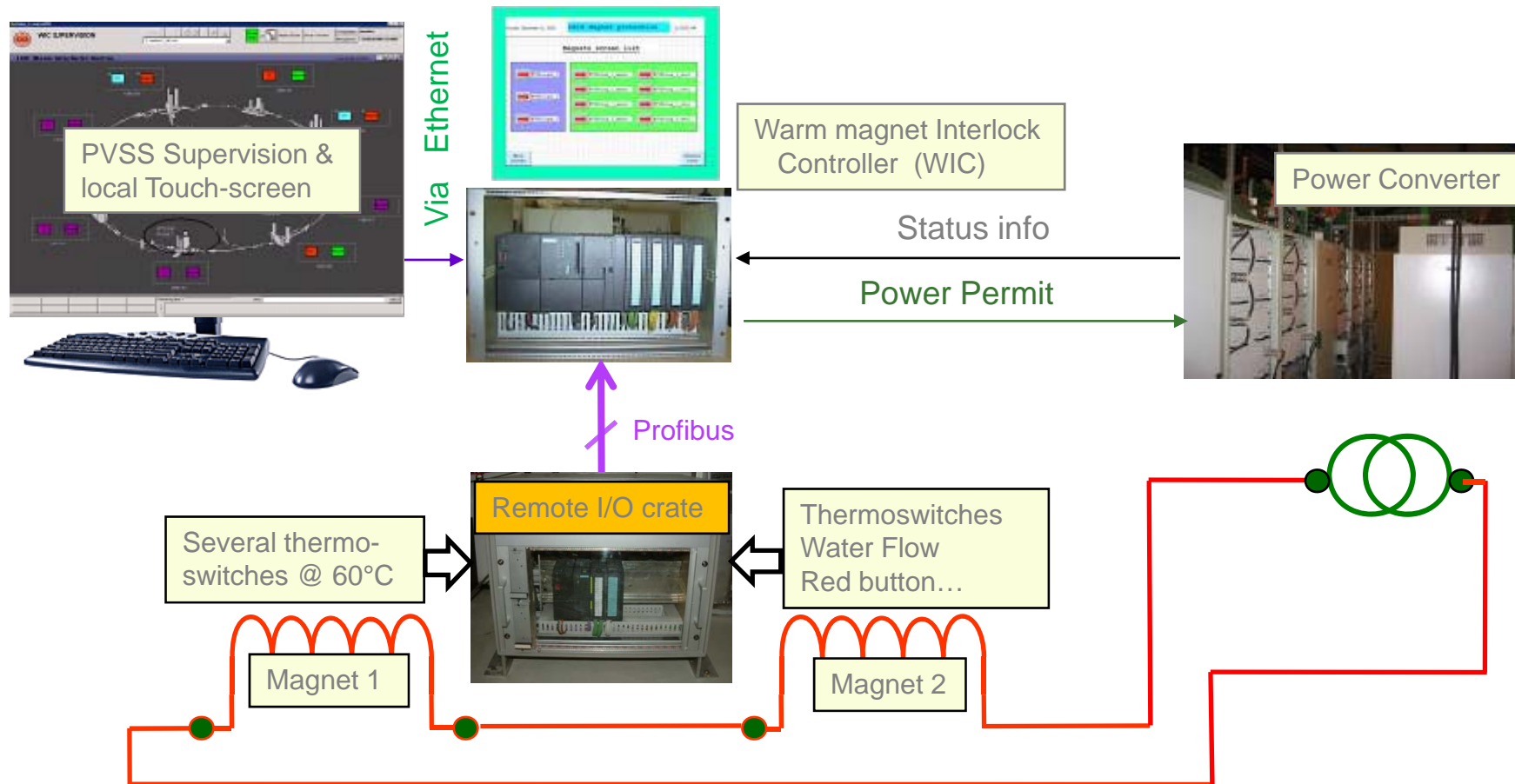
# Summary



- Principle of the Warm magnet Interlock Controller (WIC)
- The Remote I/Os (composition & location)
- The Radiations tests made at CERN in 2002/2003
- The additional Radiations tests at PSI-Villingen
- Complementary tests made at Saclay on elements used in LHC-WIC



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Remote I/Os collect the information coming from the magnets and are connected to the WIC through Profibus.

WIC is installed in LHC, Transfert Lines (TL) SPS – LHC & LEIR.



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The Remote I/Os crate is made up of:

- 24V Power Supply - (from EXISTA)

- SIEMENS Modules:

- PROFIBUS INTERFACE IM 153-1 - ET200M  
6ES7 153-1AA03-0XB0
- 32 DIGITAL INPUT SM 321 – 6ES7 321-1BL00-0AA0
- RS485 REPEATER – 6ES7 972-0AA01-0XA0





## Location of the Remote I/Os crates

The Remote I/Os are installed under Dipoles or the vacuum pipe but far from the quadrupoles



## Number of Remote I/Os crates used in the TL

- 18 Remote I/Os for TI2 controlling 300 magnets
- 20 Remote I/Os for TI8 controlling 403 magnets
- 6 Remote I/Os for TT41 (CNGS) controlling 145 magnets



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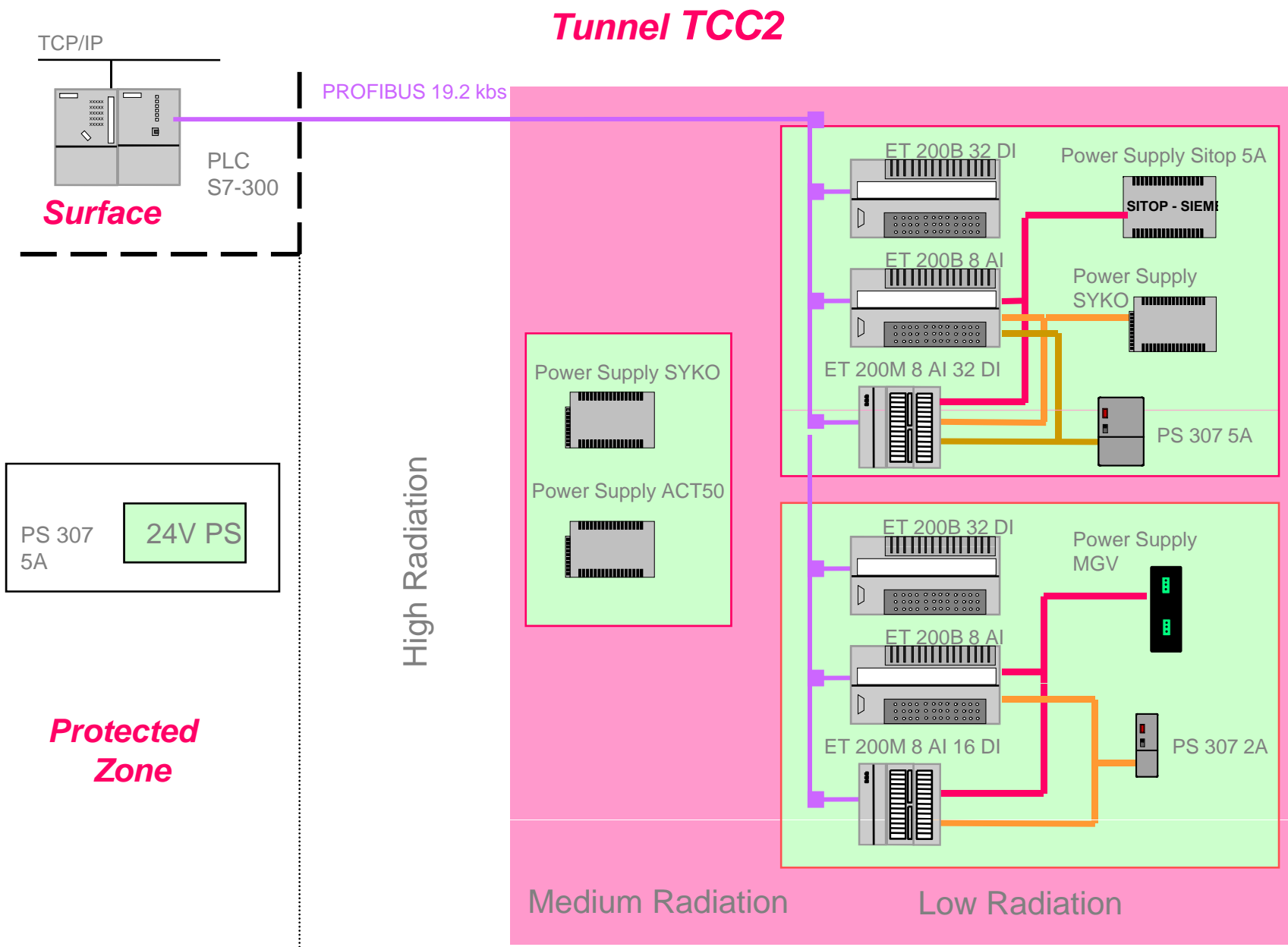




## Reasons for these Tests



- To qualify the Siemens modules we have to install in the Transfer lines SPS–LHC-CNGS
- To know which type of module we can use in a radioactive area
- To know how these modules react in a radioactive area
- To know the maximum dose these modules can receive







## Siemens I/Os modules + Power-supplies + Repeaters radiation tests in TCC2 - May 23 to September 20, 2002 -



Module	Type	Serial N°	Dose (Gray)	SEE ( n/cm <sup>2</sup> x10 <sup>12</sup> )	Duration (weeks/days)
ET 200 M	6ES7 153-1AA03-0XB0	S C-NNE79333	277	1,87	6 w
ET 200 M	6ES7 153-1AA03-0XB0	S C-P3F0623	280	1,96	5 w
ET 200 M	6ES7 153-1AA03-0XB0	S C-P3F41194	210	1,57	4 w
SM 321 16DI (ET 200M)	6ES7 321-1BH02-0AA0	S C-NNF16364	136	0,97	4 w
SM 321 32DI (ET 200M)	6ES7321-1BL00-0AA0	S C-P3F64025	500	3,69	9 w
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0	S C-NNG50644	43	0,40	2 w
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0	S C-P3E30770	60	0,65	12 d
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0	S C-P5C15342	28	0,34	5 d
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0	S C-NNG 50364	5	0,05	1 d
ET 200B 32 DI (Module)	6ES7 131-0BL00-0XB0	S C-NNC18601	80	0,67	3 w
ET 200B 32 DI (Module)	6ES7 131-0BL00-0XB0	S C-NNC18596	340	2,44	6 w
ET 200B 32 DI (Module)	6ES7 131-0BL00-0XB0	S C-P3E02968	61	0,32	11 d
ET 200B 32 DI (Module)	6ES7 131-0BL00-0XB0	S C-P3E 02962	510	3,66	9 w
ET 200B 32 DI (Socket)	6ES7 193-0CB10-0XA0	S C-NNA28144	601	4,33	12 w
ET 200B 32 DI (Socket)	6ES7 193-0CB10-0XA0	S C-NNE50566	550	4,01	10 w
ET 200B 8AI (Module)	6ES7 134-0KH01-0XB0	S C-N0A24 755	20	0,13	5 d
ET 200B 8AI (Module)	6ES7 134-0KH01-0XB0	S C-P2B72516	27	0,18	5 d
ET 200B 8AI (Module)	6ES7 134-0KH01-0XB0	S C-P2B72527	25	0,18	5 d
ET 200B 8AI (Socket)	6ES7 193-0CD40-0XA0	S C-NNC 46087	95	0,67	23 d
ET 200B 8AI (Socket)	6ES7 193-0CD40-0XA0	S C-P3D28352	80	0,38	15 d
PS 307 5A	6ES7 307-1EA00-0AA0	S Q6NN350341	13	0,04	2 d
PS 307 5A	6ES7 307-1EA00-0AA0	S Q6P3336437	3	0,01	0.5 d
PS 307 2A	6ES7 307-1BA00-0AA0	S Q6P5320969	5	0,05	1 d
PS MGV	PH70-2403	00BC151387	41	0,13	1 w
PS Syko	7.55.233.001.0	2,06007	550	4,01	10 w
PS Syko	7.55.233.001.0	2,06006	942	8,02	17 w
PS ACT 50	ACT50	4000,1270	942	8,02	17 w
PS Sitop 5A	6EP1333-1AL11	Q6NN367122	80	0,65	2 w
PS Sitop 5A	6EP1333-1AL11	S Q6P4389091	317	2,23	5 w
Profibus Repeater	6ES7 972-0AA01-0XA0	S C-P5C65251	268	2,05	5 w





# Siemens PLC modules & Power-supplies

## Radiations test in TT60 – Run 2002



Module	Type	Serial N°	Dose (Gray)	SEE ( n/cm <sup>2</sup> x10 <sup>12</sup> )	Duration (weeks)
ET 200 M	6ES7 153-1AA03-0XB0		22	5,82	17
SM 321 32DI (ET 200M)	6ES7321-1BL00-0AA0		22	5,82	17
SM 321 16DI (ET 200M)	6ES7 321-1BH02-0AA0		22	5,82	17
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0	S C-NNG50364	5,63	0,76	5
SM 331 8AI (ET 200M)	6ES7 331-7KF02-0AB0		16,6	0,76	12
ET 200B 8AI (Module)	6ES7 134-0KH01-0XB0		15	1,20	13
ET 200B 8AI (Socket)	6ES7 193-0CD40-0XA0		15	1,20	13
ET 200B 16 DI (Module)	6ES7131-0BH00-0XB0		22	5,82	17
ET 200B 16 DI (Socket)	6ES7193-0CA10-0XA0		22	5,82	17
PS 307 2A	6ES7 307-1BA00-0AA0		22	5,82	17
PS ACT 50			22	5,82	17
PS Syko			22	5,82	17
PS Syko			22	5,82	17
PS MGV	PH70-2403		22	5,82	17
PS Sitop 5A	6EP1333-1AL11		22	5,82	17
Profibus Repeater	6ES7 972-0AA01-0XA0	S C-P5C65550	8,1	4,68	5



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# Siemens I/Os modules - radiation tests in TCC2 - Run 2003



Module	Type	Serial N°	Indice	Dose in 2002 (Gray)	Dose in 2003 (Gray)	Total Dose
ET 200 M	6ES7 153-1AA03-0XB0	S C-R2D89243	6		100 Gy	100 Gy
		S C-R2D90385	6		129 Gy	129 Gy
<b>Modules Siemens 32 DI pour ET 200 M</b>						
SM 321 32 DI	6ES7 321-1BL00-0AA0	S C-P9B51289	4		129 Gy	129 Gy
		S C-R1G72304	4		129 Gy	129 Gy
<b>Modules Siemens 8 AI pour ET 200 M</b>						
SM 331 8AI - 14 bits	6ES7 331-7KF02-0AB0	S C-R2E59970	2		31 Gy	31 Gy
		S C-R2E59972	2		38 Gy	38 Gy
<b>Modules Siemens 8 AI pour ET 200 M</b>						
SM 331 8AI - 13 bits	6ES7 331-1KF00-0AB0	S C-R7G42827	2		60 Gy	60 Gy
		S C-R7G34156	2		54 Gy	54 Gy
<b>Modules Siemens : Repeteur</b>						
Repeteur	6ES7 972-0AA01-0XA0	S C-P5C65251	4	268 Gy	32 Gy	300 Gy
		S C-NND98373	3		57 Gy	57 Gy
		S C-R2B29941	4		38 Gy	38 Gy





# POWER-SUPPLIES - radiation tests in TCC2 - Run 2003

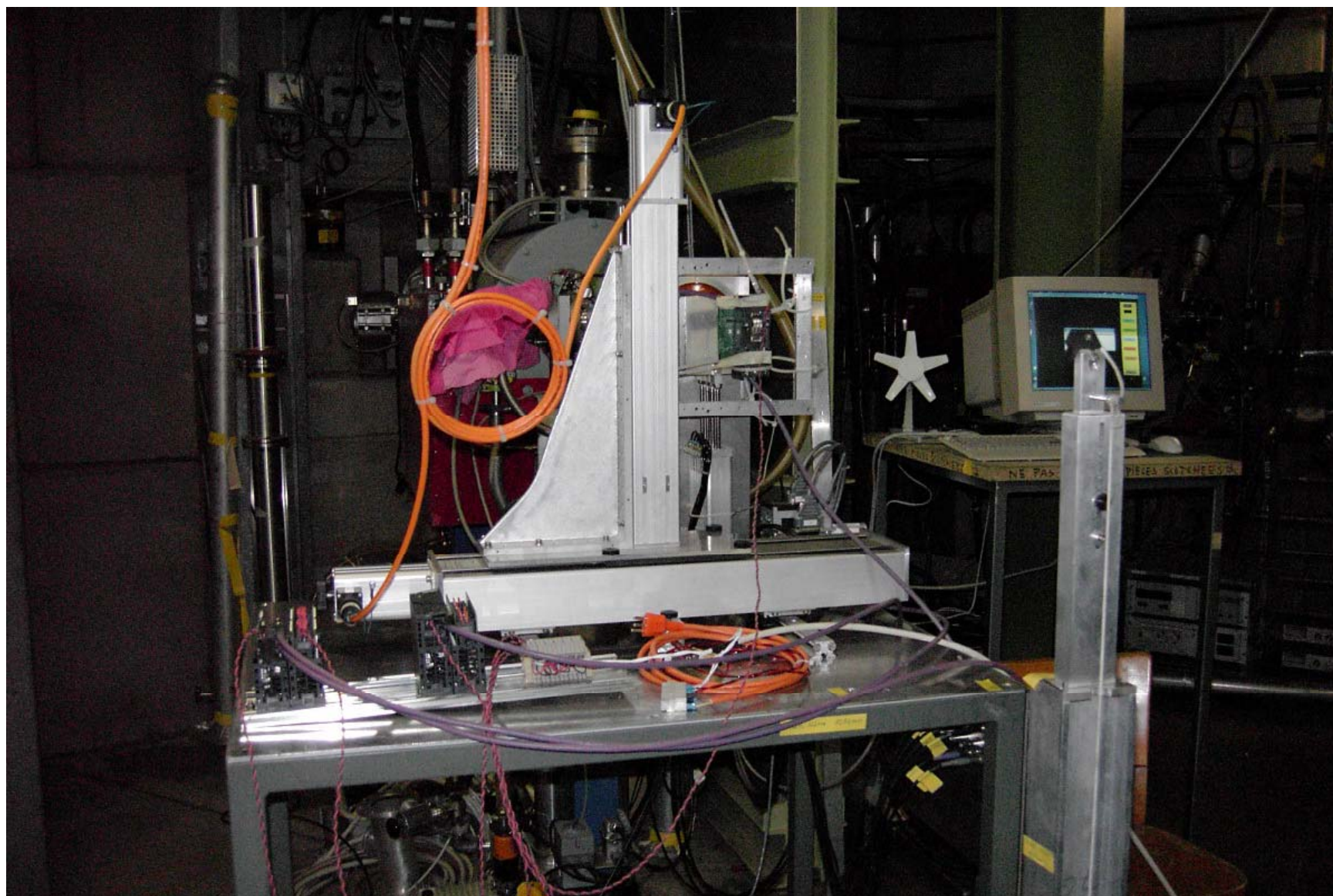


<u>Module</u>	<u>Type</u>	<u>No de serie</u>	<u>Indice</u>	<u>Radiation recu en 2002</u>	<u>Radiation recu en 2003</u>	<u>Radiation total recu</u>
<b>Alimentations Siemens PS 307 2A</b>						
Alim. Siemens PS307 2A Standard		S Q6PD342917	4		11 Gy	11 Gy
		S A6PN399972	4		27 Gy	27 Gy
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386477	3		1 Gy	1 Gy
<i>(Alim. modifiee par Siemens: Secondary voltage regulator replaced by a zener diode)</i>						
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386489	3		8 Gy	8 Gy
<i>(Alim. modifiee par Siemens: Primary control IC N3 is wrapped in copper foil)</i>						
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386485	3		10 Gy	10 Gy
<i>(Alim. modifiee par Siemens: Photocoupler U1 &amp; U2 replaced by CNY65)</i>						
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386481	3		12 Gy	12 Gy
<i>(Alim. modifiee par Siemens: Photocoupler U1 &amp; U2 replaced by CNY17-F3)</i>						
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386490	3		38 Gy	38 Gy
<i>(Alim. modifiee par Siemens: Mofset V7 changed to 25K1358/ Toshiba 900V/9A)</i>						
<b>Alimentations Siemens Sitop 5A</b>						
Alim. Siemens Sitop 5A	6EP 1333 - 1AL11	S Q6P4388995	3		68 Gy	68 Gy
<b>Alimentations MGV</b>						
Alimentations MGV	PH70-2403	15.8242.900			6 Gy	6 Gy
<b>Alimentations Exista Blue Line</b>						
Alimentations Exista Blue Line	??	<b>TCC2</b>			98 Gy	98 Gy
<b>Alimentations ACT50 1 x 24 V</b>						
Alimentations ACT50 1x24V	??	<b>TCC2</b>			129 Gy	129 Gy
<b>Alimentations ACT50 2 x 24 V</b>						
Alimentations ACT50 2x24V	ACT50	4000, 1270 (TCC2)		942 Gy	129 Gy	1071 Gy
<b>Alimentations Syko 2 x 24 V</b>						
Alimentations Syko 2x24V	7.55.233.001.0	2.06007 (TCC2)		550 Gy	129 Gy	679 Gy
		2.06006 (TCC2)		942 Gy	129 Gy	1071 Gy



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**In order to have a better precision**





# Material tested at PSI on the 22th of november 2003



Material tested	Type	Indice	Maximal dose (Gray)	Comments
Slave Module ET 200 M (Siemens)	6ES7 972-OAA01 0XA0	7	280	* During irradiation several voluntary power supply "on/off" without problem. *After 70 grays of irradiation - module down but comes "ok" without any action
Digital Module 32 DI (Siemens)	6ES7 972-OAA01 0XA0	4	190	* During irradiation several voluntary power supply "on/off" without problem.
Analog Module 8AI 13 bits (Siemens)	6ES7 972-OAA01 0XA0	1	75	* After 15 Grays - module down after "on/off" module ok - * During irradiation several inputs are down but comes "ok" without any action
Répéteur Profibus (Siemens)	6ES7 972-OAA01 0XA0	6	89	30mm collimator on DRASIC -ST 03333 KU 002 circuit
		6	110	no collimator - irradiation on the power circuits
Switching Power supply (Exista)	ASC 50 24 V		370	Starting voltage = 24,598 V - current = 246,33mA End voltage = 25,51 V - current = 247,158mA

140 Gy=1\*10<sup>E11</sup> protons à 60 MEV

Nb de protons: 450 / (140 \* 10<sup>E11</sup>) = **3.21429 E+11**

Durée d'exposition: (3.21429 E+11 / 1\* 10<sup>E+8</sup>) / 60 = 54 minutes



## Material tested at PSI on the 16<sup>th</sup> of February 2007



Material tested	Type	Indice	Maximal dose (Gray)	Comments
Digital Module 32 DO (Siemens)	6ES7 322-1BL00-0AA0	6	105	Irradiation in vertical position and after 66 Gy in horizontal position
		6	64	Irradiation in vertical position only
8DI / 8DO Module (Siemens)	6ES7 323-1BH01-0AA0	4	276	Irradiation in vertical position only
		4	284	Irradiation in vertical position only
Digital Module 32 DI (Siemens)	6ES7 321-1BL00-0AA0	4	175	Irradiation in vertical position only - same results as in 2003

140 Gy=1\*10<sup>E11</sup> protons à 60 MEV



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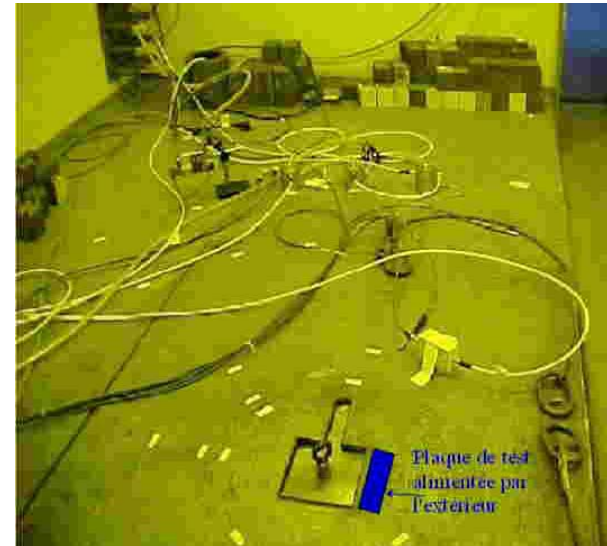
**Thermoswitch - ELMWOOD Type 3106 – T117**



**Magnet Interlock Box where a relay is installed to simulate the opening of a thermoswitch**

Note: Only the Magnet Interlock Boxes are installed in the LHC tunnel (I/O crates are installed in US/UJ/TZ areas)

The goal of this irradiation test was to apply an amount "Gamma" radiation to various elements which will be installed on the Warm magnets in LHC tunnel and in particular at points 3 & 7, area of collimation and "cleaning" of the beam where the amount of radiation will be near 1MGy/year



Installation PAGURE - Source 60Co



Central Pot





# Material tested - CEA / SACLAY - November 2005



Number	Material tested	Maximal dose (KGy)	Comments
1	Miniature Relay for printed board - FINDER : type 30 : 24V – 2 A	74	} Installed on a test board near the source - After irradiation <b>OK</b>
1	Miniature Relay for printed circuit - FINDER : type 32 : 24V – 6 A	74	
1	Miniature Relay for printed board - FINDER : type 34 : 24V – 6 A	74	
1	Miniature Relay for printed board - FINDER : type 36 : 24V – 10 A	74	
1	Air & watertight Relay for printed board - HONGFA HF 9313: 12V - 2A	74	
2	Miniature Relay for printed board - FINDER : type 30 : 24V – 2 A	987	} Installed inside the pot - After irradiation <b>OK</b>
2	Miniature Relay for printed circuit - FINDER : type 32 : 24V – 6 A	987	
2	Miniature Relay for printed board - FINDER : type 34 : 24V – 6 A	987	
2	Miniature Relay for printed board - FINDER : type 36 : 24V – 10 A	987	
1	Air & watertight Relay for printed board - HONGFA HF 9313: 24V - 2A	987	
2	Thermoswitch ELMWOOD : type : 3106 - T116 - 65°C	987	
2	Thermoswitch ELMWOOD : type : 3106 - T117 - 65°C	987	
2	Push Bouton SECME C4	987	
2	BURNDY connectors 4BPM	987	
1	Cable 2 x 0.5 mm <sup>2</sup> / L=0.5m - Kapton / fiber glass	987	



# Conclusion



- Various radiation tests campaigns have been performed for validating the different WIC elements (I/O modules, PS and Profibus repeater):
  - @TCC2: first results => preliminary choices  
But lack of precision
  - in TT60: more realistic regarding the final installation  
Less radiation dose and still lack of precision
  - @PSI: previous results validated  
Doses limits better defined and more precise  
➔ Confirmation that chosen material will meet the expected radiation level.
- Complementary tests for specific LHC-WIC elements (e.g. Magnet Interlock boxes) have given very good results and have confirmed that they could be installed in the corresponding LHC areas.



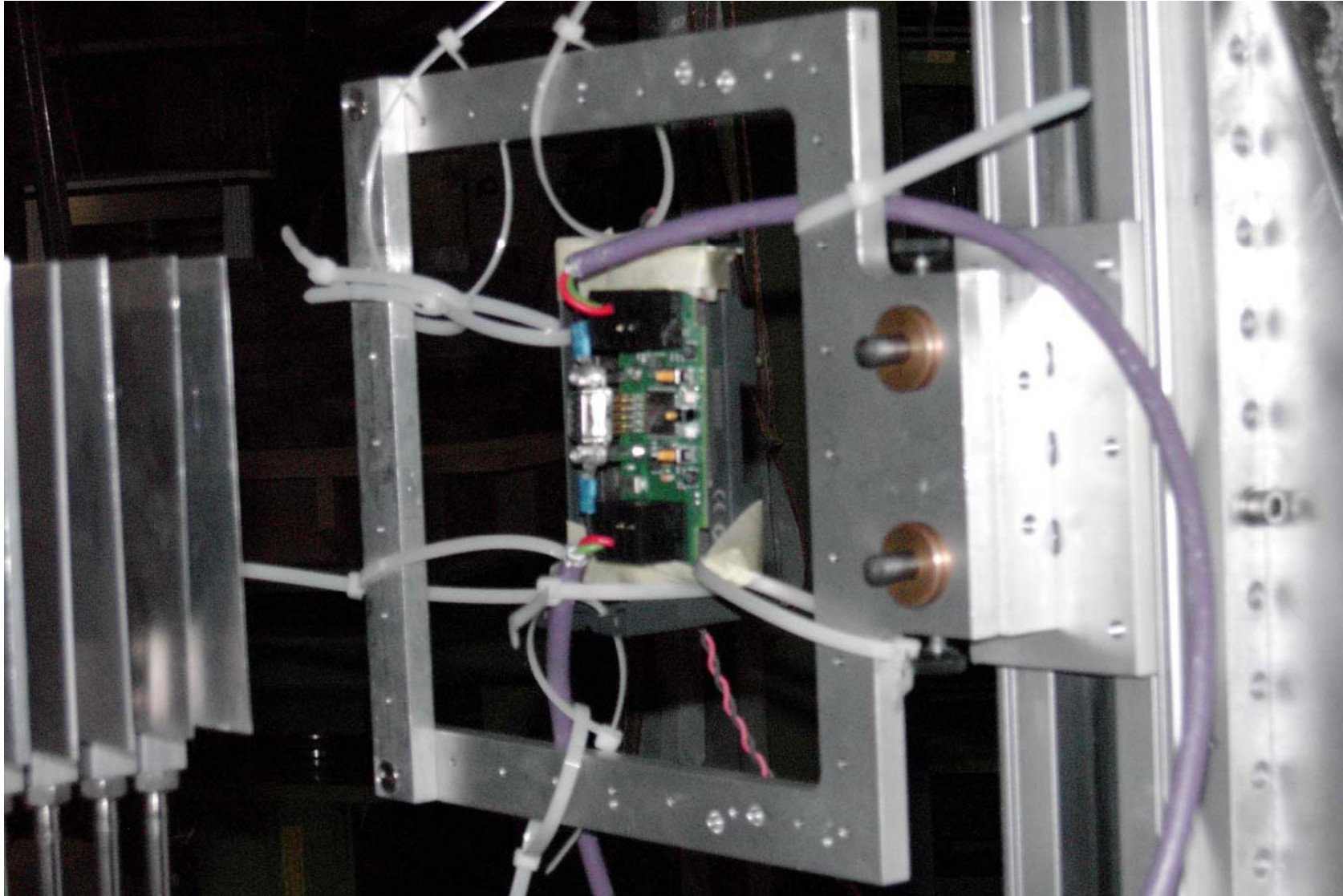
# Thank you very much for your attention

Thanks to: B. PUCCIO, B. TODD, T. WJNANDS for their help

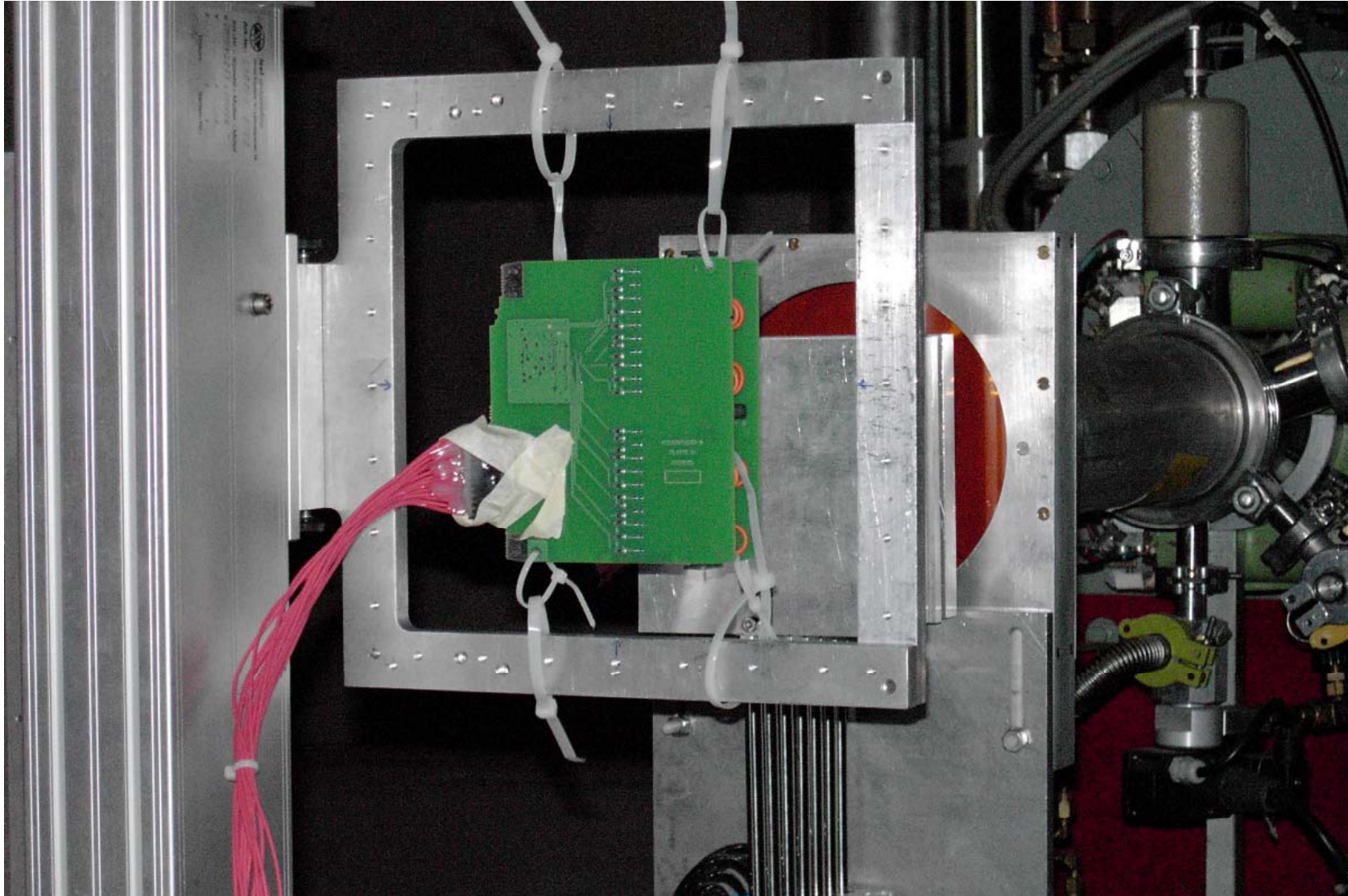


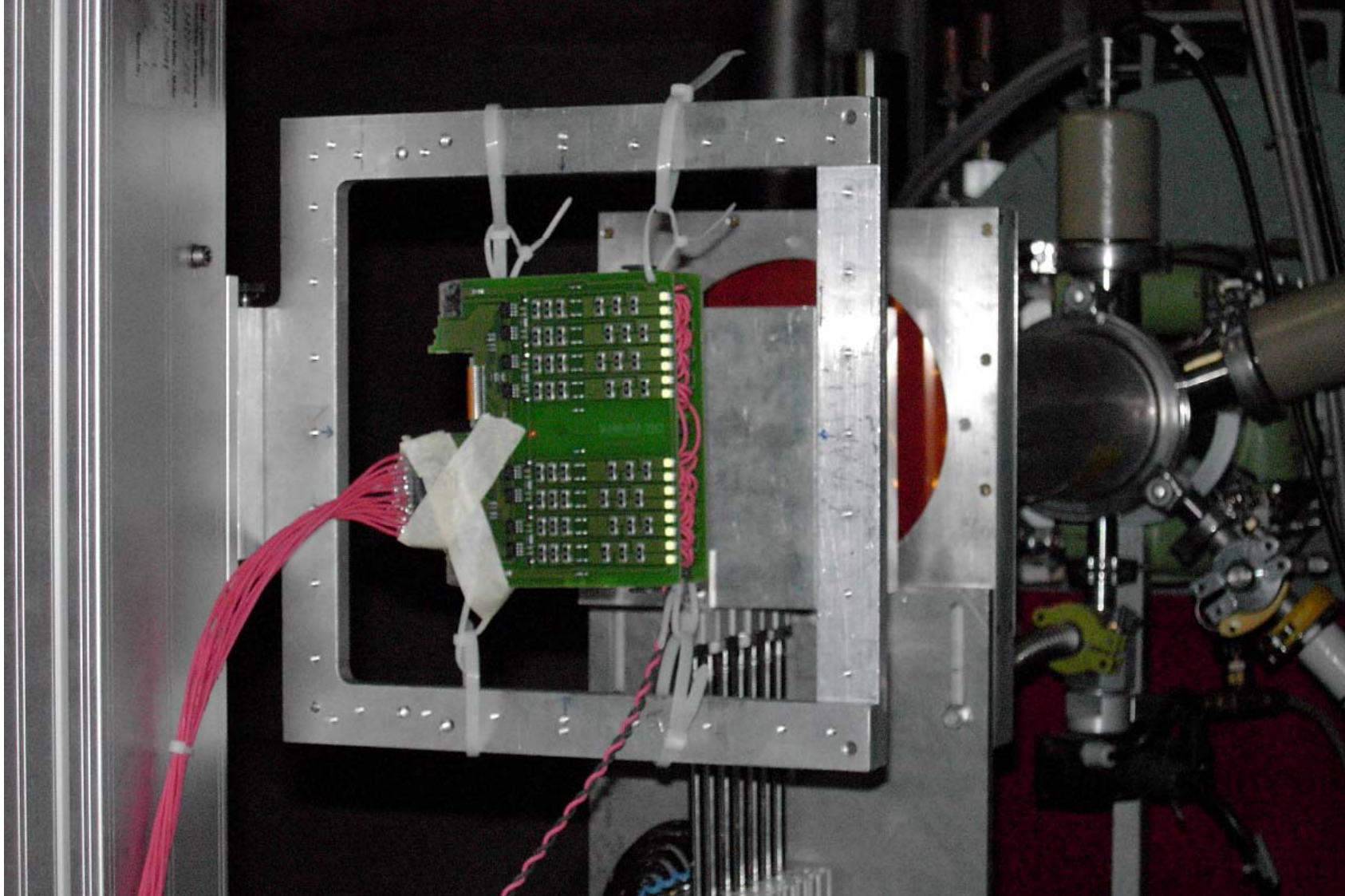
# Additional slides

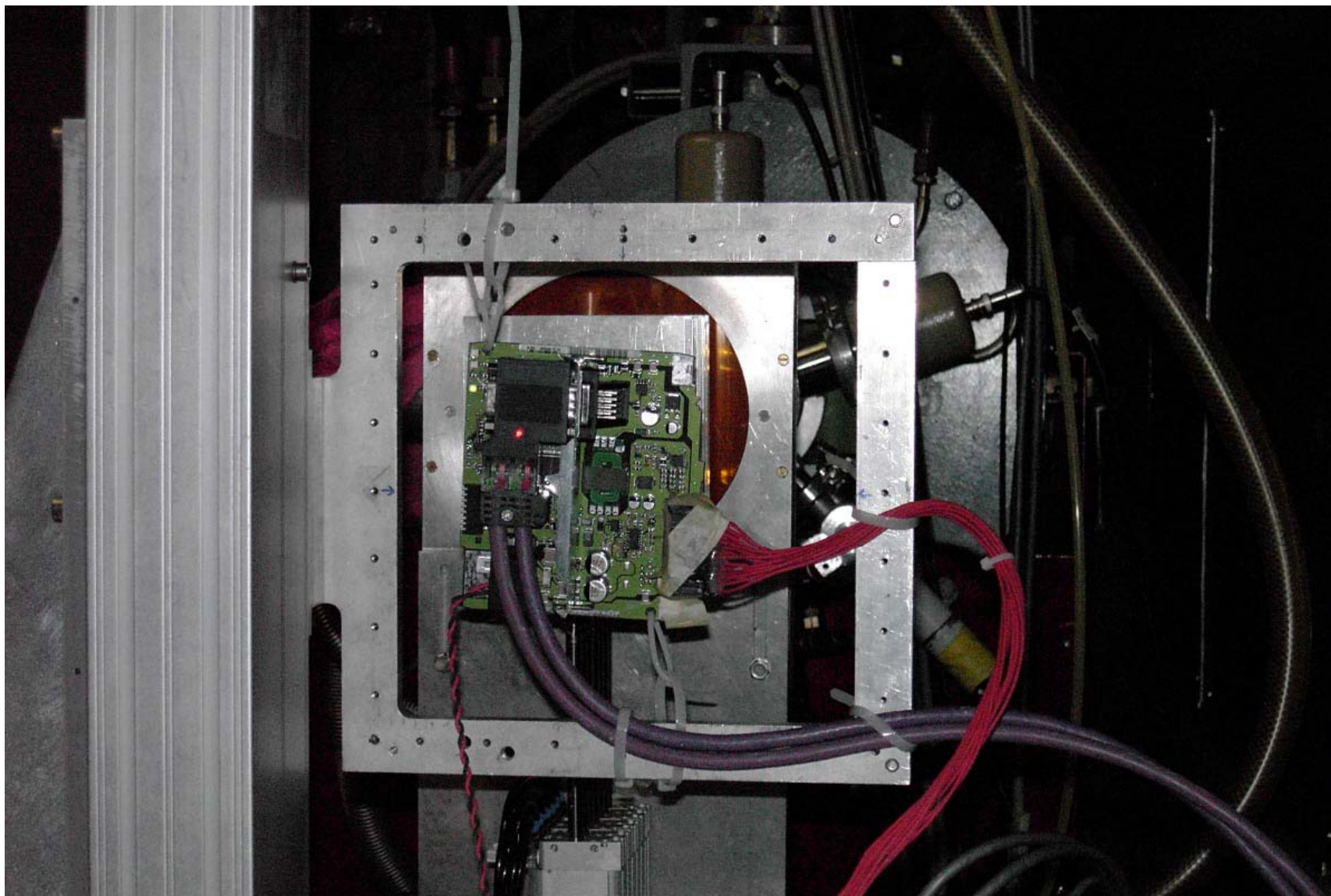
# Profibus repeater



# Analog module 8AI – 13bits

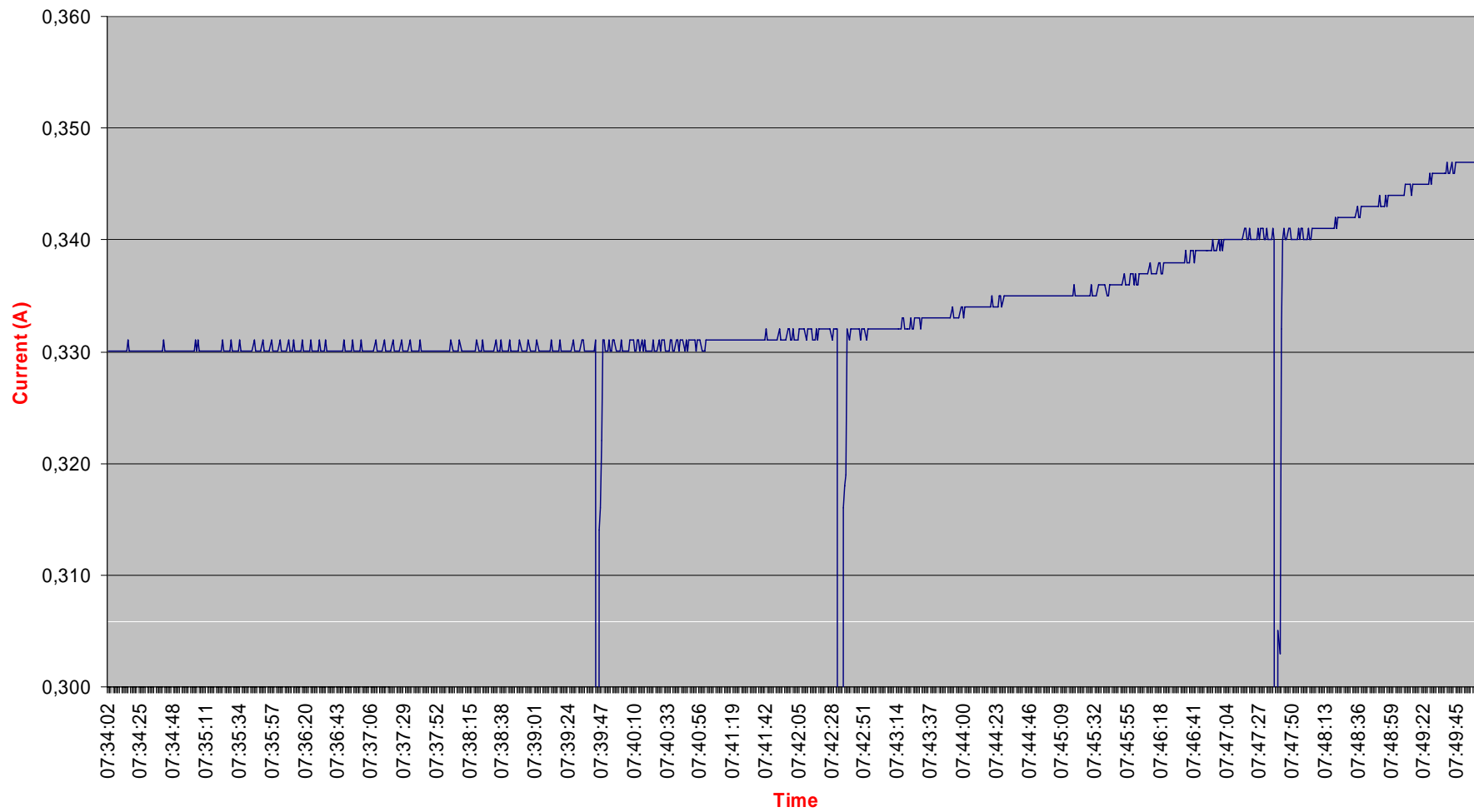








### Digital module SM321 - 32DI



### Slave module ET200M

