Single Event Effects in

Warm magnet Interlock Controller (WIC)

during Ti8 tests

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

- The Event during Ti8 tests

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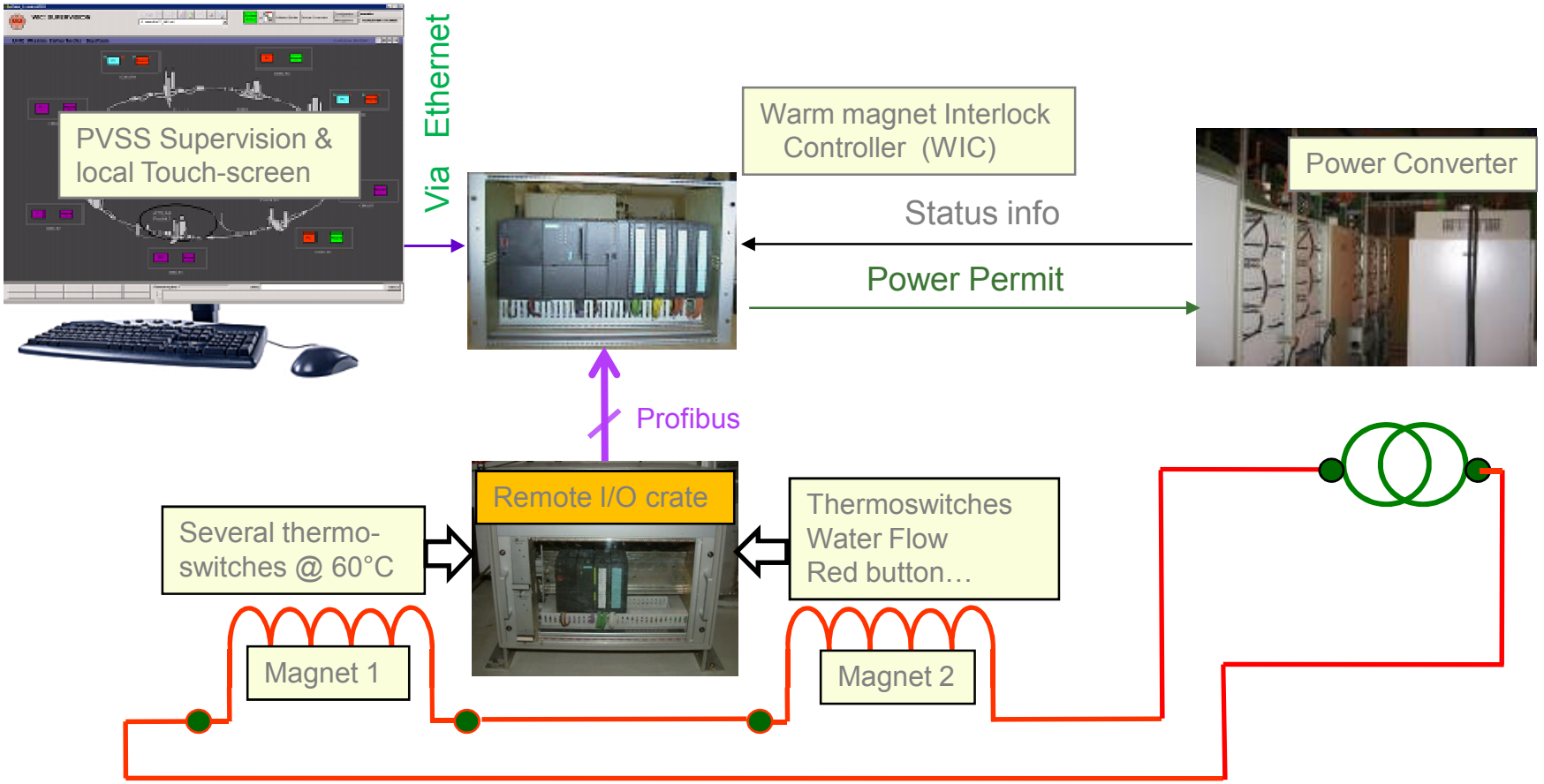
WIC Principle (Warm magnet Interlock Controller)



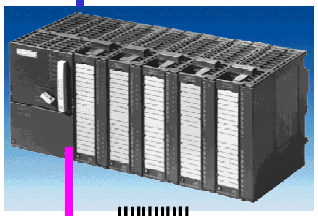
Remote I/Os collect the information coming from the magnets and are connected to the WIC through Profibus.
WIC is installed in LHC, Transfer Lines (TL) SPS – LHC, LEIR & LINAC3

WIC in the Transfer Lines

Ethernet

Building

BA4 / BA7
& BB4



PLC S7-300 (Master)

Ti2 → 1 PLC in BA7

Ti8 → 1 PLC in BA4

TT41 → 1 PLC in BB4

Magnets Interlock Ti2 / Ti8 & TT41(CNGS) Based on S7-300 PLC (Siemens) with SIMATIC ET 200M Periphery

To Power Converter control

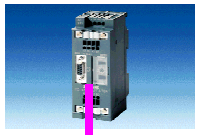
Underground

Tunnel Ti2 / Ti8
& TT41(CNGS)

Profibus DP

Fieldbus

Repeater



ET 200 Periphery is based on:

- Digital modules
- Analogic modules

ET 200 Periphery

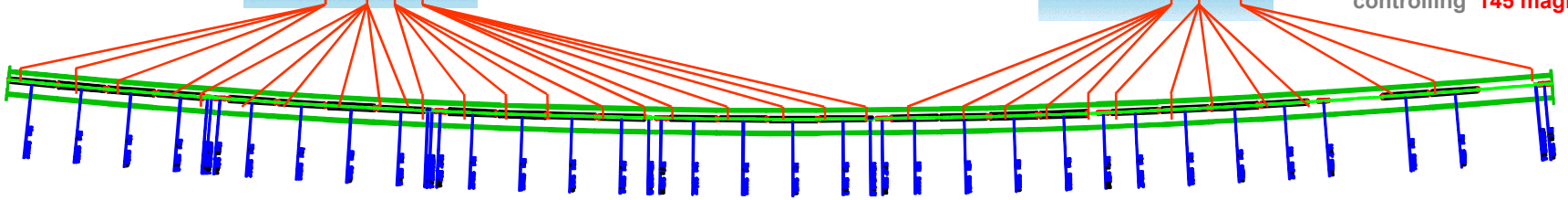
ET 200 Periphery

ET 200 Periphery are installed under Dipole magnet every **120 m**

18 Peripheries for Ti2 tunnel controlling **300 magnets**

20 Peripheries for Ti8 tunnel controlling **403 magnets**

6 Peripheries for TT41(CNGS) tunnel controlling **145 magnets**



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Composition of Remote I/Os crate

The Remote I/Os crates consist 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 & number of Remote I/Os crates

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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Tests performed in TCC2 & TT60 - Run 2002 & 2003

Tests Installation in TCC2

Additional tests performed in TT60

➔ **beginning of the Ti2 line**

Siemens *I/Os modules + Power-supplies + Repeaters* *Radiation tests* - May 23 to September 20, 2002

TCC2 Tests Results

Module	Type	Serial Nº	Dose (Gray)	SEE (n/cm ^{2} x10 ^{12})	Duration (weeks/days)
ET 200 M ET 200 M ET 200 M	6ES7 153-1AA03-0XB0 6ES7 153-1AA03-0XB0 6ES7 153-1AA03-0XB0	S C-NNE79333 S C-P3F0623 S C-P3F41194	277 280 210	1,87 1,96 1,57	6 w 5 w 4 w
SM 321 16DI (ET 200M) SM 321 32DI (ET 200M)	6ES7 321-1BH02-0AA0 6ES7321-1BL00-0AA0	S C-NNF16364 S C-P3F64025	136 500	0,97 3,69	4 w 9 w
PS ACT 50	ACT50	4000,1270	942	8,02	17 w
Profibus Repeater	6ES7 972-0AA01-0XA0	S C-P5C65251	268	2,05	5 w

TT60 Tests Results

Module	Type	Serial Nº	Dose (Gray)	SEE (n/cm^2 x10^{12})	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
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 Sitop 5A	6EP1333-1AL11		22	5,82	17
Profibus Repeater	6ES7 972-0AA01-0XA0	S C-P5C65550	8,1	4,68	5

Siemens *I/Os modules + Power-supplies + Repeaters*
Radiation tests in TCC2 - Run 2003

Module	Type	Serial Nº	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
SM 321 32 DI	6ES7 321-1BL00-0AA0	S C-P9B51289	4		129 Gy	129 Gy
		S C-R1G72304	4		129 Gy	129 Gy
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

Module	Type	No de serie	Indice	Radiation recu en 2002	Radiation recu en 2003	Radiation total recu
Alim. Siemens PS307 2A Modifie	6ES7 307-1BA00-0AA0	S Q6P4386490	3		38 Gy	38 Gy
(Alim. modifiee par Siemens: Mofset V7 changed to 25K1358/ Toshiba 900V/9A)						
Alim. Siemens Sitop 5A	6EP 1333 - 1AL11	S Q6P4388995	3		68 Gy	68 Gy
Alimentations ACT50 1x24V	??	***TCC2***			129 Gy	129 Gy
Alimentations ACT50 2x24V	ACT50	4000, 1270 (TCC2)		942 Gy	129 Gy	1071 Gy
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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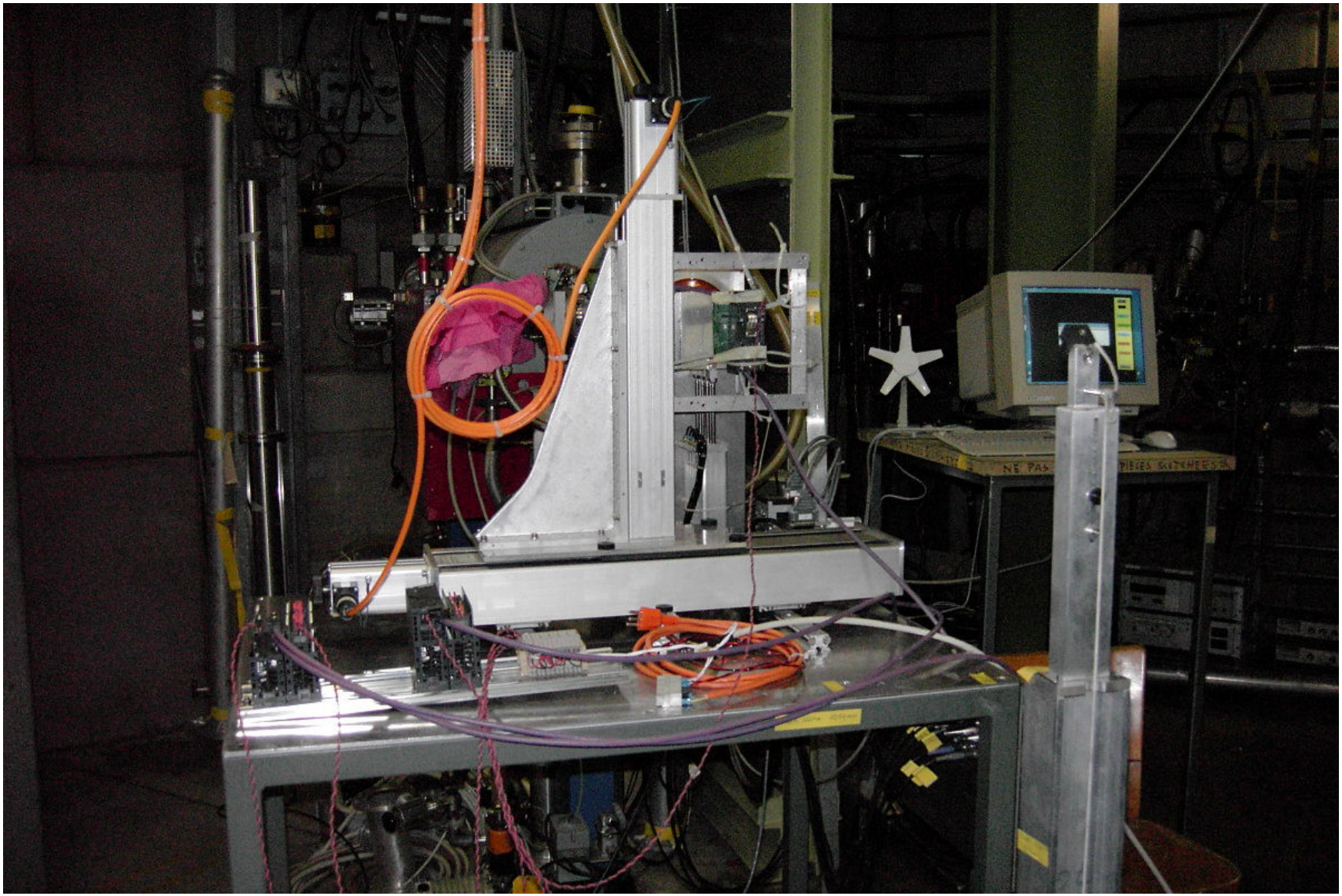
In order to have a better precision

- The Event during Ti8 tests

Irradiation facility– OPTIS – PSI / Villingen



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 153-1AA03-0XB0	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 321-1BL00-0AA0	4	190	* During irradiation several voluntary power supply "on/off" without problem.
Répéteur Profibus (Siemens)	6ES7 972-0AA01-0XA0	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^{E}11 protons à 60 MEV
Nb de protons: 450 / (140 * 10^{E}11) = **3.21429 E+11**
Durée d'exposition: (3.21429 E+11 / 1* 10^{E+8}) / 60 = 54 minutes

Material tested at PSI on the 26th of March 2009

Material tested	Type	Indice	Maximal dose (Gray)	Comments
Digital Module 24 DI Safety (Siemens)	6ES7 326-1BK01-0AB0	2	20	We had to perform a reset during each irradiation (11 in total)
		2	19.5	
Slave Interface ET200M (Siemens)	6ES7 153-1AA03-0XB0	16	226	During irradiation the Profibus address was several times corrupted after a new Profibus cycle or reset module was OK
		16	200	
Digital Output Module DOx8 AC230V/5A Relay (Siemens)	6ES7 322-1HF10-0AA0	2	500	Irradiation was stopped after 500Gy only the output LEDS were broken

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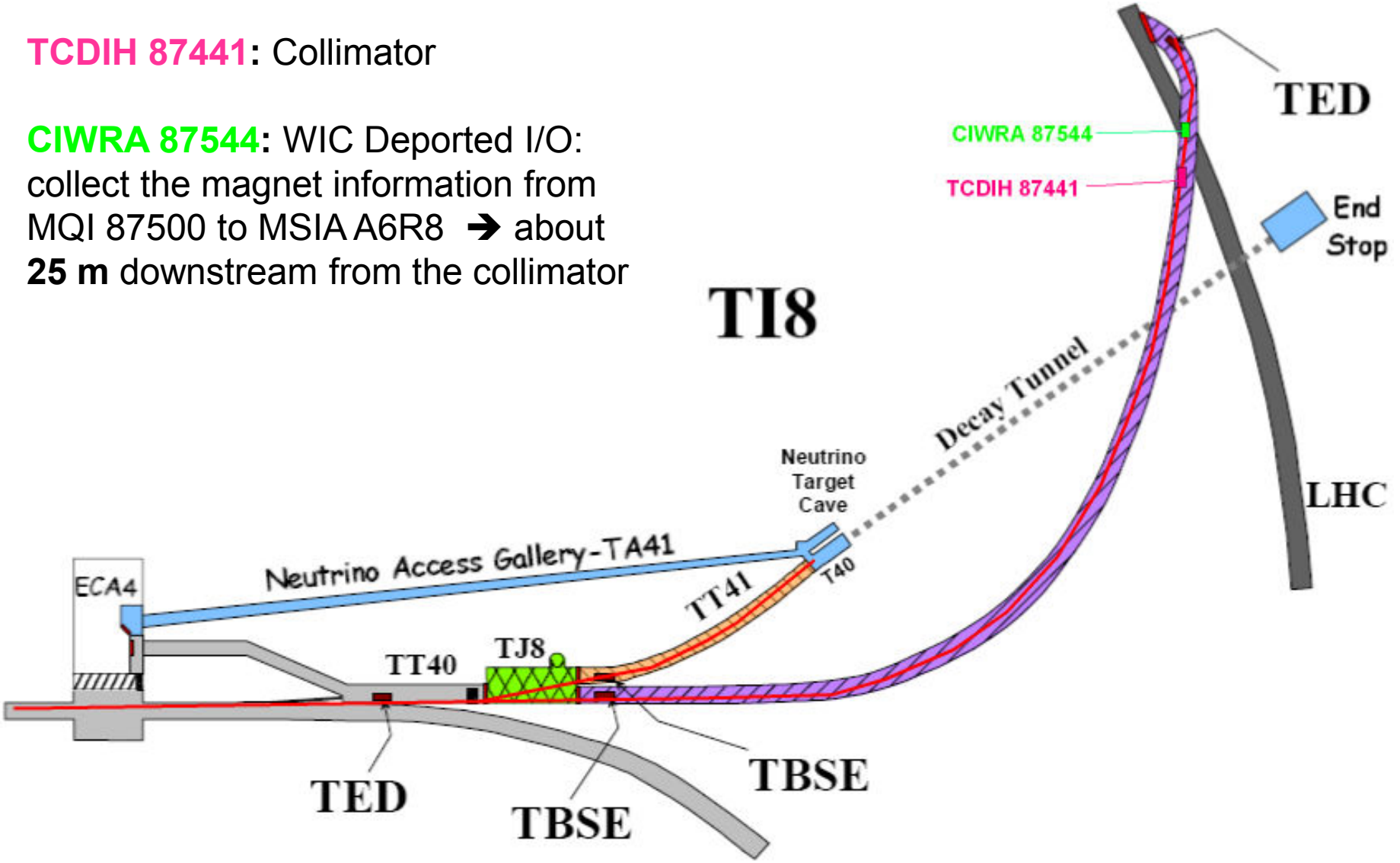
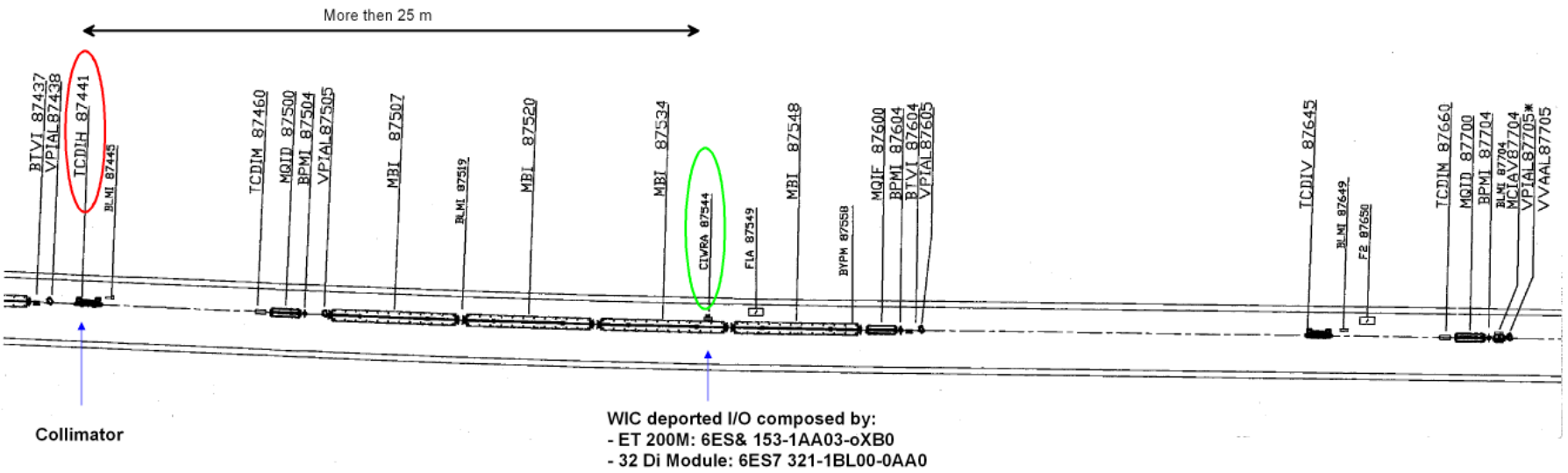
Collimator & Deported I/O position

TCDIH 87441: Collimator

CIWRA 87544: WIC Deported I/O: collect the magnet information from MQI 87500 to MSIA A6R8 ➔ about **25 m** downstream from the collimator



Situation in Ti8 tunnel



What happened before/during the incident:

- When closing the collimator jaws, this has generated a shower of particles which (most likely) corrupted the ET 200M memory

- The remote IO module lost its Profibus address and the Power-Converters which supply the magnets connected to this crate were cut off (expected fail-safe behaviour !)

- After a reset of this crate (24V Power Supply ON/OFF – remotely) the module in question was again operational

Conclusion and solutions to be considered

Conclusion:

- Incident most likely linked to (accidental) particle shower generated by upstream collimator

-The ET 200M module has reacted as foreseen (ie fail-safe switched off converters)

- Remote reset sufficient to make the system again operational

- This kind of problem was never observed during previous operation of the TL with beam, even for (higher intensity) CNGS beam in TT40

- The preliminary design of this TL (at which locations of remote IOs had to be defined) did not include collimators at this location

- Initial radiation estimates of these TL predicted (very) low doses for the remote IO locations

Possible Solutions which could help to limit future impact:

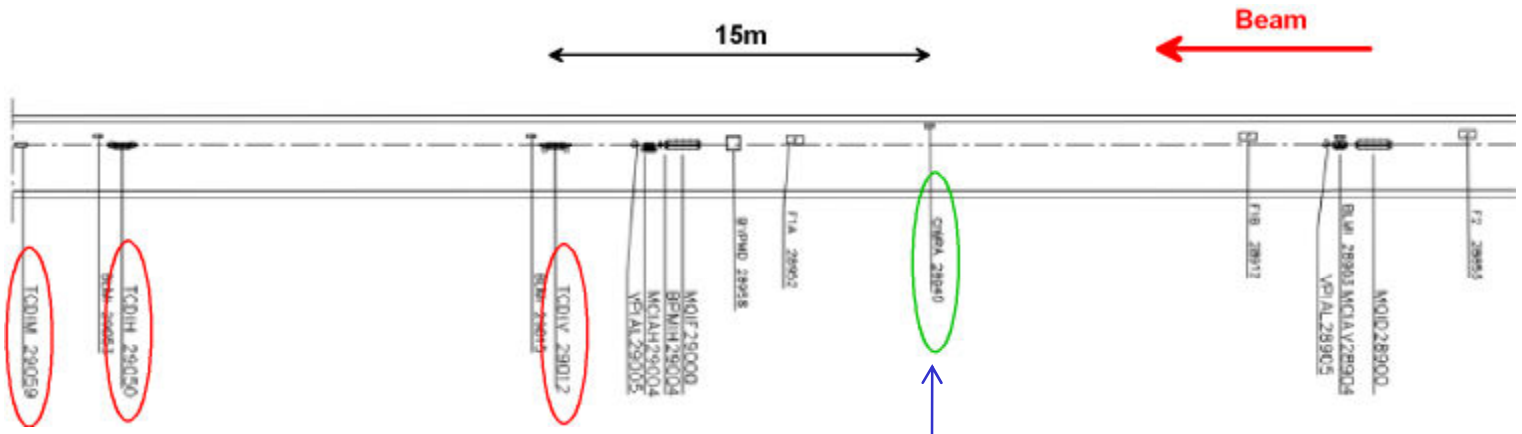
If such collimator adjustments have to be done :

- If sufficient, add additional shielding for this remote I/O crate?

- Move the I/O crate in question 40 m upstream, but this implies a cost and an extended intervention

- Move only the inputs for the main dipole magnets to the upstream I/O crate, thus avoiding to perturb CNGS operation (less cabling, but reconfiguration and re-testing needed)

Next injection test in Ti2



1st Collimator
Position: 29012

Last WIC deported I/O in Ti2 –
Position: 28940