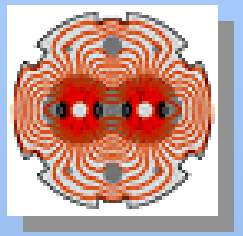
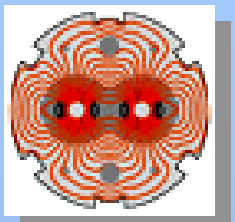


QUENCH PROTECTION SYSTEM

QUENCH DETECTION
QUENCH HEATER POWERING
ACQUISITION & MONITORING

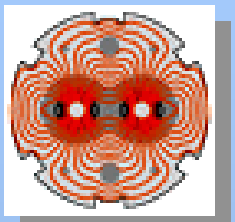
R. Denz LHC/ICP

QPS & radiation tolerance

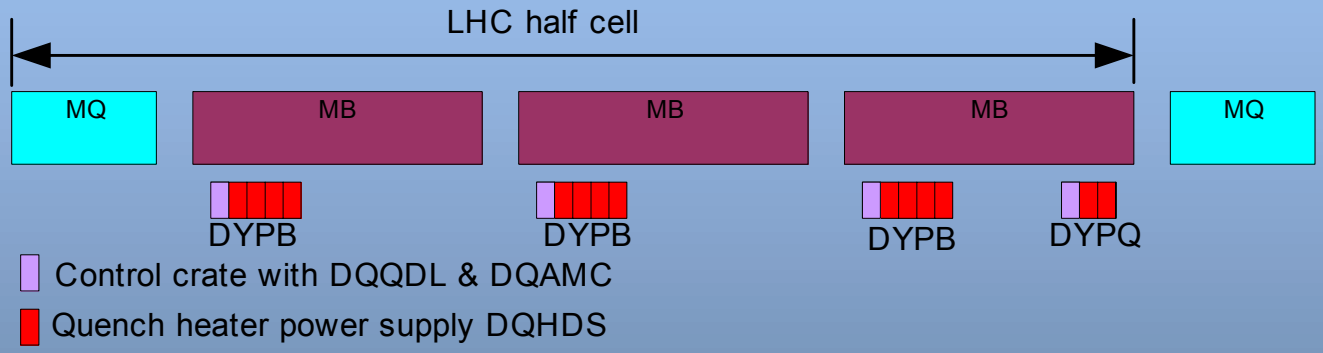


- **TID: 200 Gy Fluence: 2 x 10^{12} ncm^{-2} SEU free**
  - Valid for QPS locations in the arc and in the DS
  - Safety margin included
  - Qualification in TCC2 mandatory
- **Affected QPS equipment**
  - 6076 quench heater discharge power supplies
  - 2016 local quench detectors
  - 1624 acquisition & monitoring controllers
  - Equipment in the RR's
  - Energy extraction systems
- **In-house designs**
  - Radiation taken into account as engineering constraint

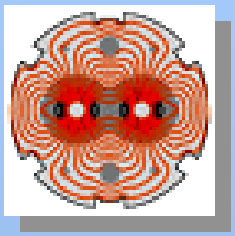
Location of radiation tolerant QPS equipment



Not to forget the RR's …

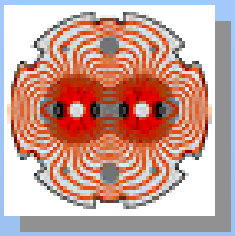


Devices under test in 2002



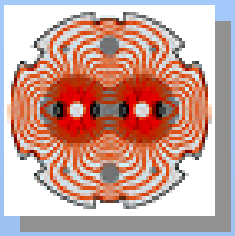
- DQHDS quench heater power supply (5)
- TRIVOLT power supply (3)
- THI0511 DC/DC converter (1)
- INA105 unity gain amplifier (8)
- INA141 instrumentation amplifier (8)
- ISO150 digital isolator (8)
- ADuC812 + VY27257 MicroFip (1)
- DSP test board (1)
- Energy extraction system (1)

Quench heater power supply DQHDS



- Energizes quench heater strips in case of a magnet quench
- In house design using COTS
- 4 units per MB, 2 units per MQ, 6076 in LHC
- ~ 200 close to hot spots in the dispersion suppressor areas
- Series production starts in 2003
- Radiation tests since 99, “mass” testing since 2001
- Thyristors are most vulnerable part with respect to radiation tolerance
- One thyristor type with acceptable performance identified: SEMIKRON SKT80/18E

Quench heater discharge power supply DQHDS



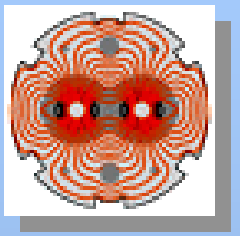
TID [Gy]

Year	Thyristors under test	Minimum	Average	Maximum
2000	2	380	380	380
2001	8	151	230	405
2002	26	218	283	368

Fluence [ncm^{-2}]

Year	Thyristors under test	Minimum	Average	Maximum
2000	2	3.9e12	3.9e12	3.9e12
2001	8	1.5e12	2.3e12	4.1e12
2002	26	2.0e12	2.6e12	3.2e12

Quench heater discharge power supply DQHDS

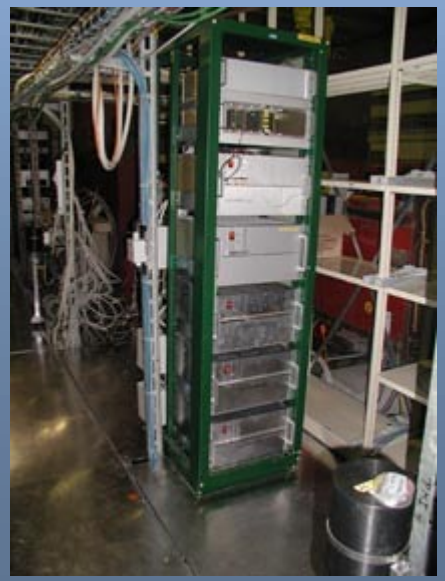


Year	Total dose [Gy]
2000	1123
2001	463
2002	675
Σ	2261

Year	Total dose [Gy]
2001	501
2002	895
Σ	1396

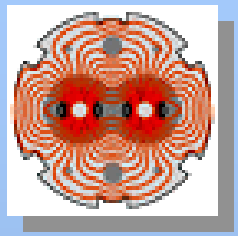
Year	Total dose [Gy]
2001	563
2002	1135
Σ	1698

Year	Total dose [Gy]
2001	210
2002	1135
Σ	1345



Year	Total dose [Gy]
2001	507
2002	895
Σ	1402

TRIVOLT power supplies

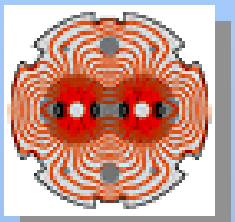


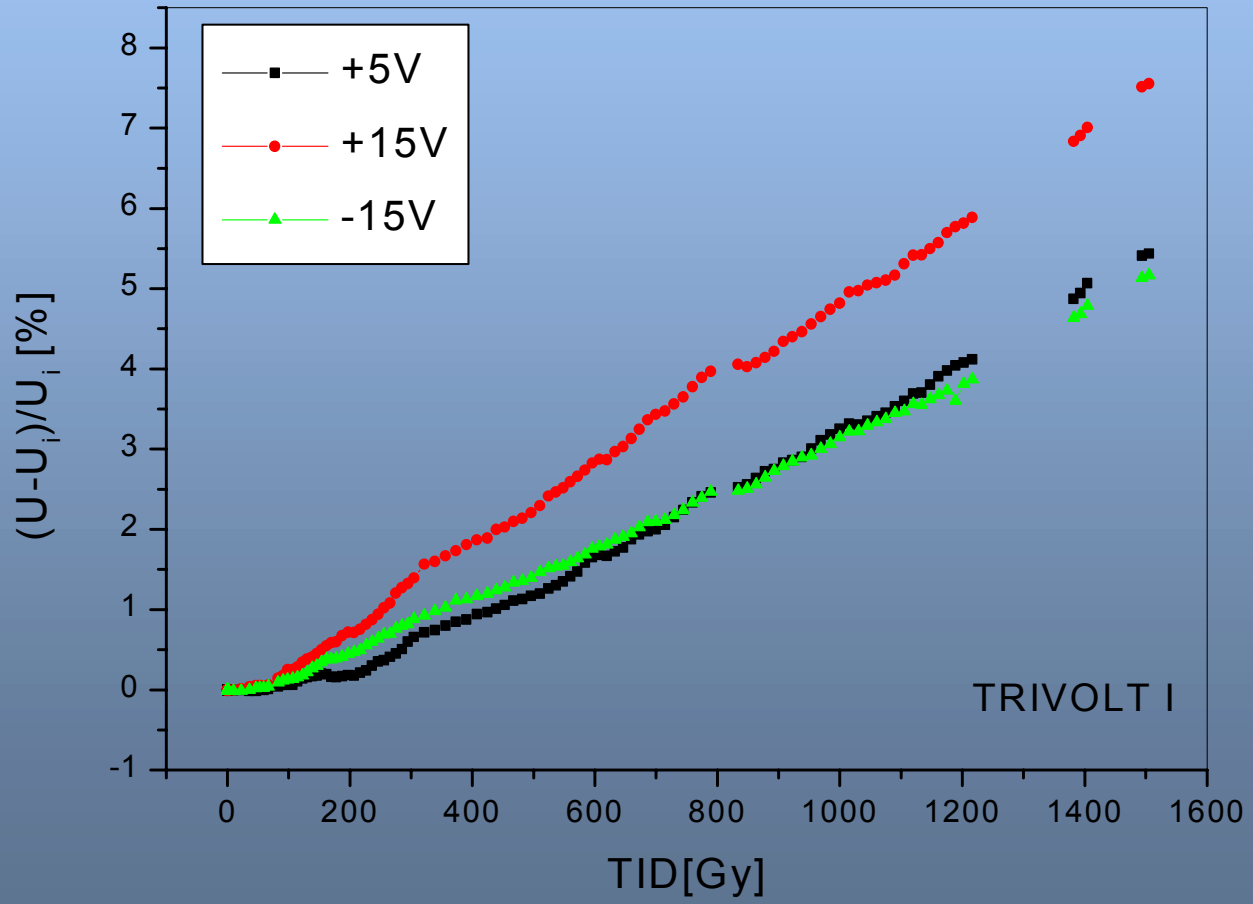
- Commercial device, partly hardened by manufacturer (MOSFET)
- 3 devices under test in 2002 up to 1.5 kGy / 12.6 x 10^{12} ncm^{-2}
- Annealing observed after the end of the irradiation
- Devices from various manufacturers already qualified in 2001

Name	Dose [Gy]	Fluence [$10^{12}$$ncm^{-2}$]
TRIVOLT I	No failure, increased output voltage	
TRIVOLT II	1130	9.3
TRIVOLT III	1150	9.4

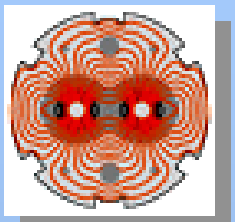
	Average output voltage drift (linear fit)
+5 V	0.17 mV/Gy
+15 V	0.69 mV/Gy
-15 V	-0.69 mV/Gy

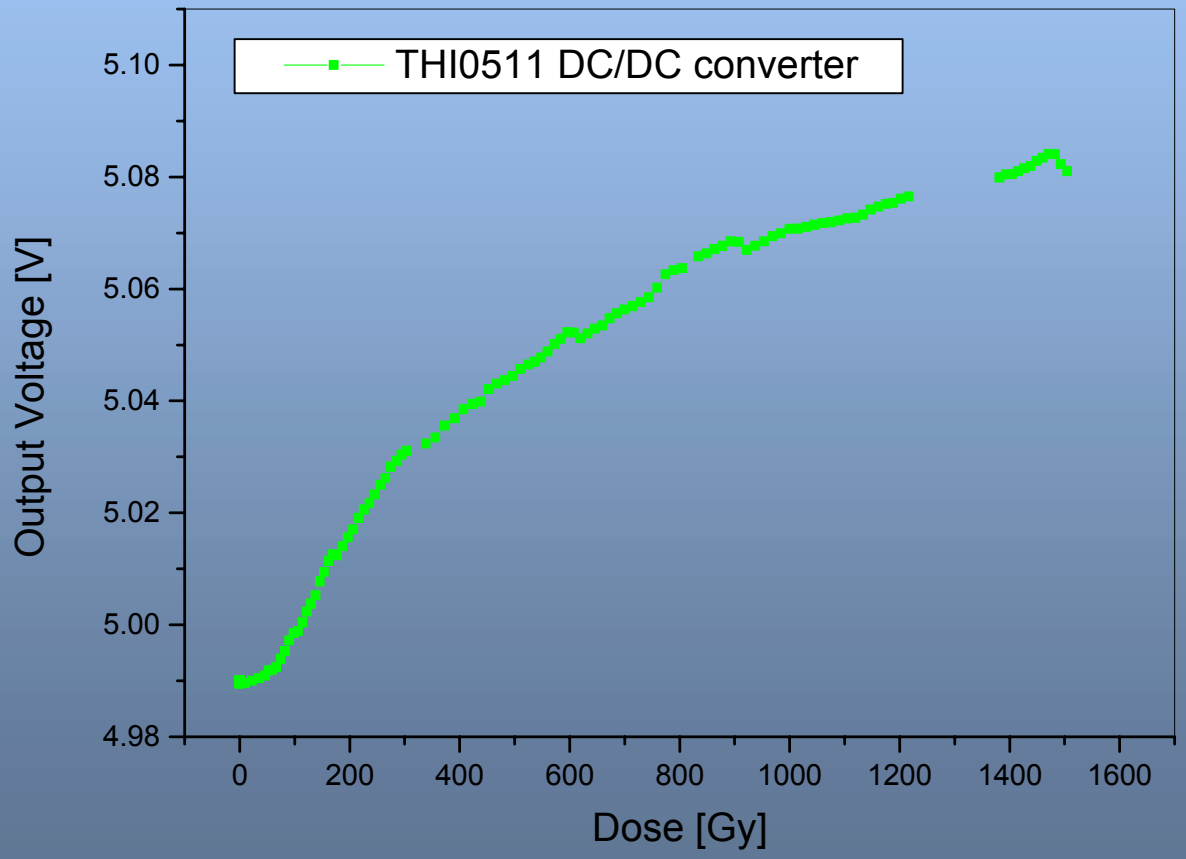
TRIVOLT power supplies



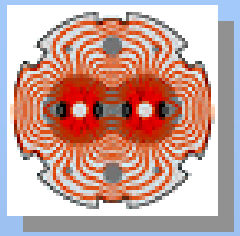


THI0511 DC/DC converter

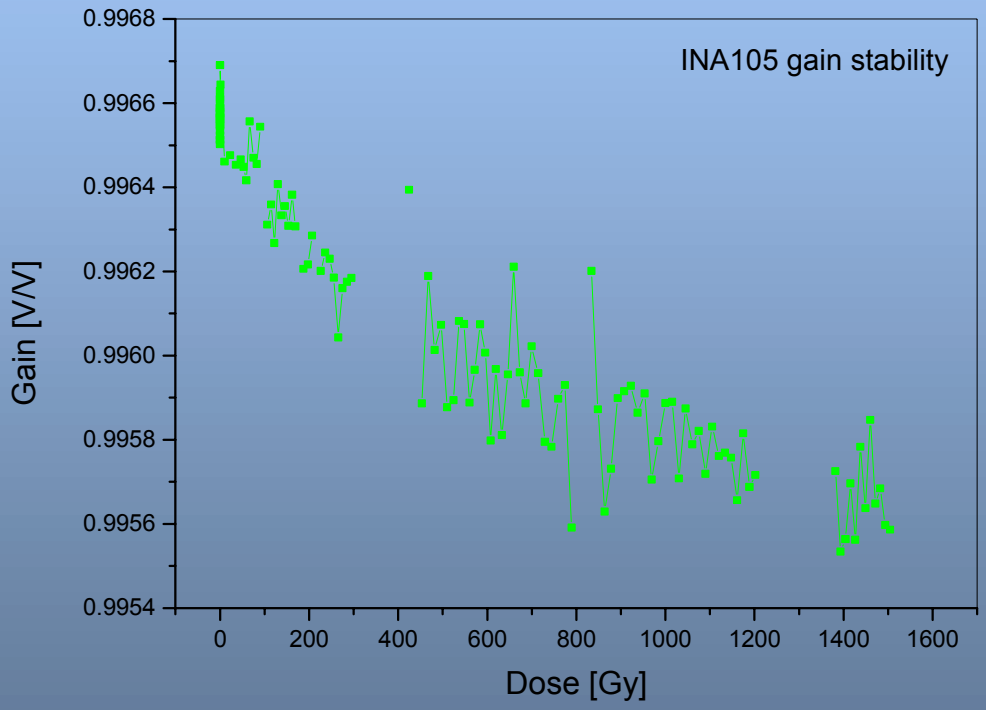




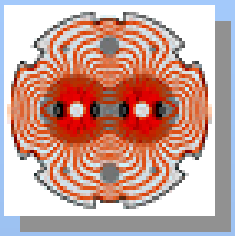
INA105 differential amplifiers



- Used in various quench detector designs as:
  - Unity gain precision inverter
  - Precision level shifter
- 8 units under test
- Gain stability and offset verified
- All devices passed the test

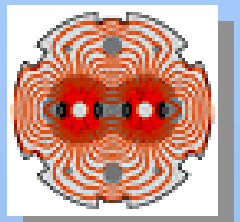


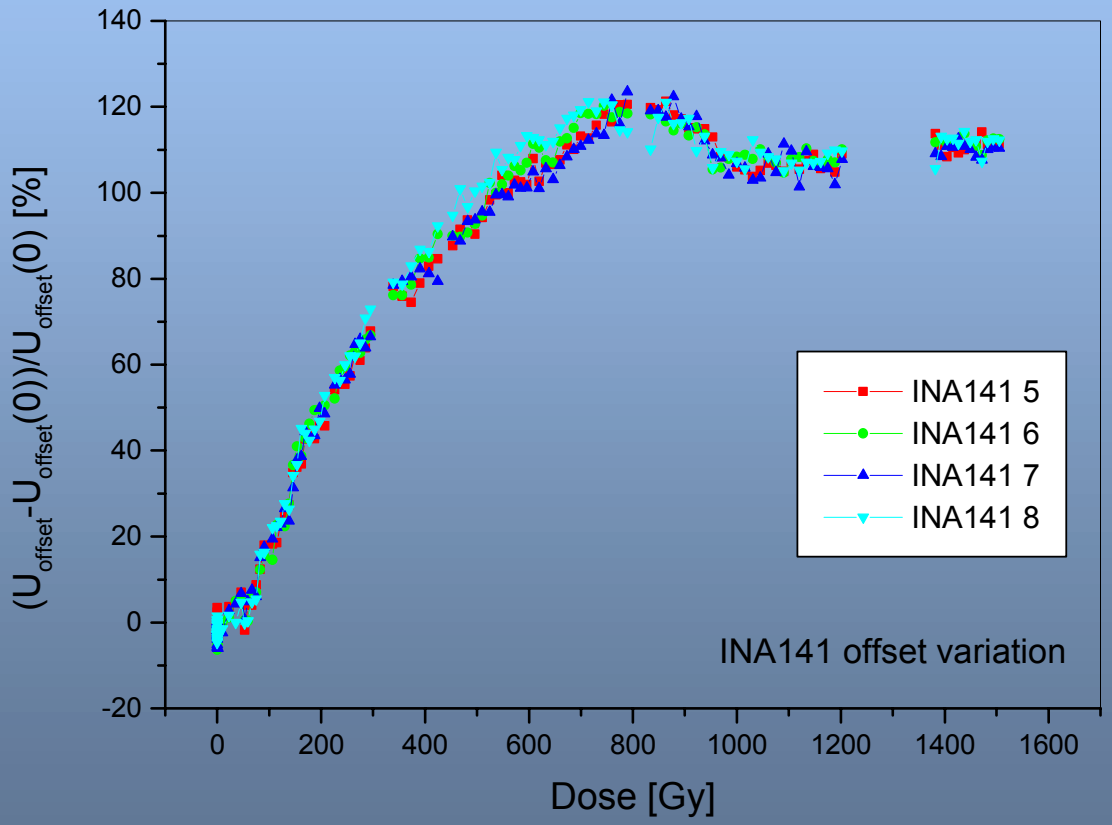
INA141 instrumentation amplifiers



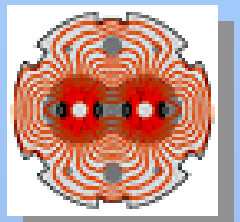
- Fixed gain (10 / 100) precision instrumentation amplifier
- Analog input stage of almost all quench detector designs (also in “radiation free” areas)
- 8 units under test (4 already irradiated during 2001 campaign)
- Gain stability and offset verified
- Drift of parameters observed but all components passed the test with respect to QPS qualification criteria.
- Severe degradation starts at about 1.3 kGy

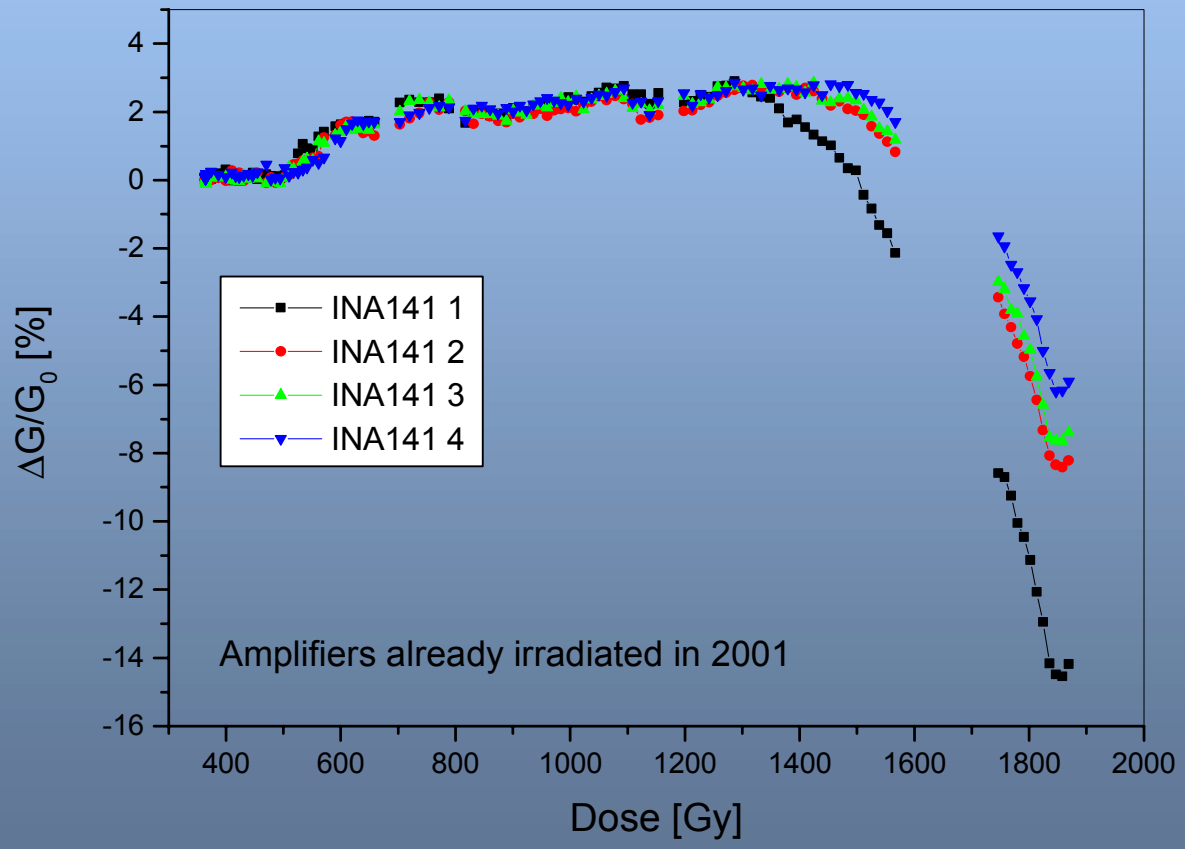
INA141 instrumentation amplifiers



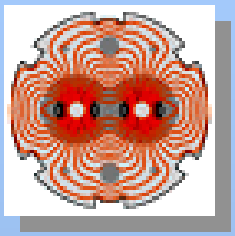


INA141 instrumentation amplifiers



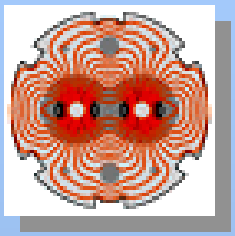


Functional test of a 13kA energy extraction system



- System's responsible: K. Dahlerup-Petersen
- Functional test required due to installation constraints in LHC point 3
- Control electronics in "safe " area
- Device exposed to 800 Gy / 5.9 x 10^{12} ncm^{-2}
- Functional test successfully passed

Conclusions & Outlook



- Installation of quench protection electronics in the LHC tunnel is fully feasible
- Design phase finished and radiation tolerance validated
- Radiation tests to be continued in 2003 for qualification of pre-series devices
- TCC2 test area still required
- Participation in SEE tests