Radiations to Electronics
Chamonix 2010

Radiation 2 Electronics

Session 6 - 27th January 2010

Need substantial manpower in 2010 for "integration" studies

Outline of presentations

Review of critical radiation areas for LHC Electronics and mitigation actions. Radiation monitoring and first results. — **M. Brugger / EN-STI**

Review of exposed equipment in the LHC: a global view. — **T. Wijnands / EN-STI**

LHC Power Converters, the proposed approach. — **Y. Thurel / TE-EPC**

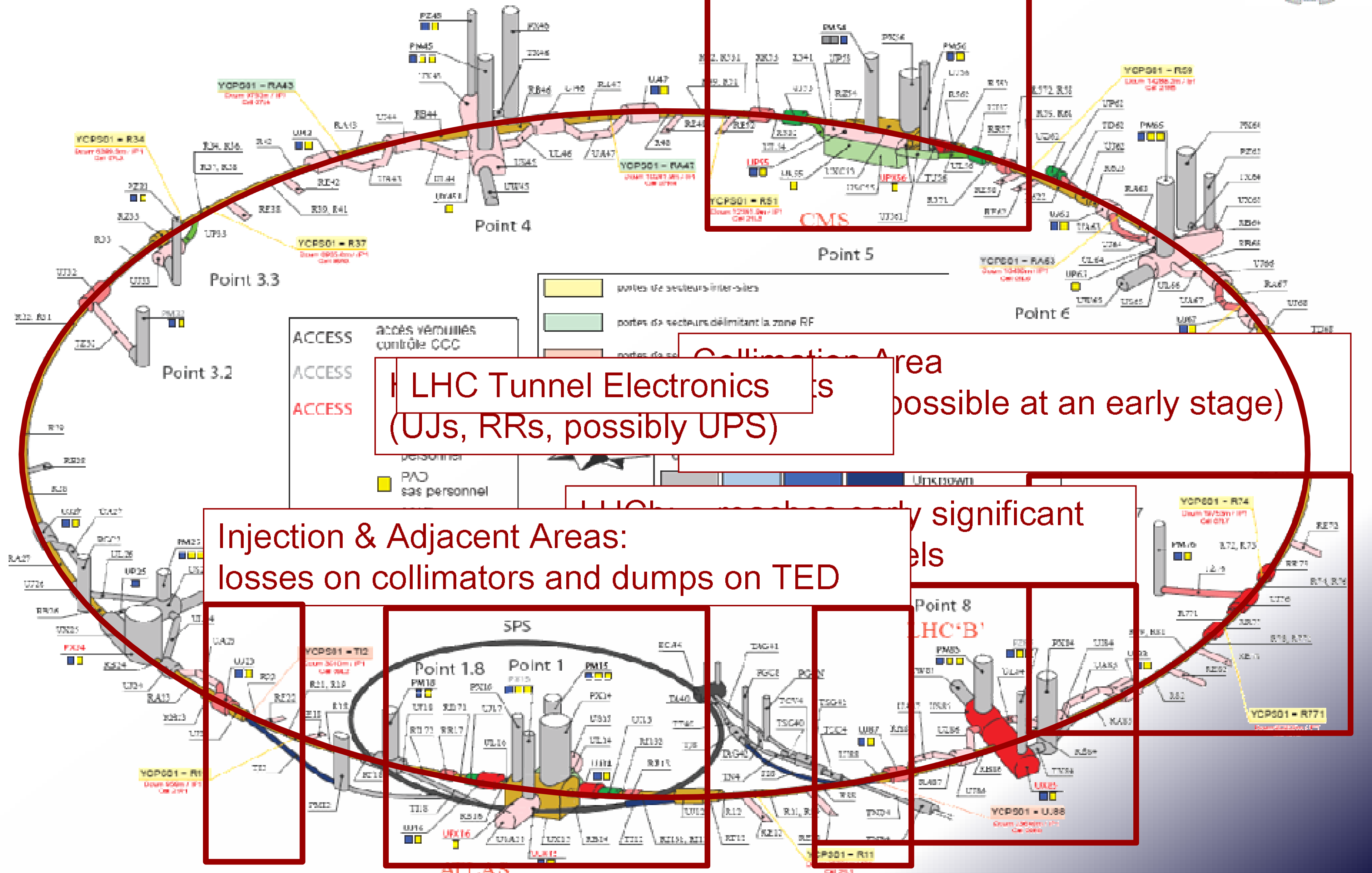
Is the WorldFIP a reliable Rad-hard Fieldbus on long term? — **J. Serrano / BE-CO**

Summary of the 2009 irradiation tests and perspectives for future tests and facilities. — **D. Kramer / EN-STI**

Experience with the ATLAS radiation policy: can we say we are safe? — **Ph. Farthouat / PH-ESE**

Where are we with the Long-term plans and the CERN-wide radiation Policy. — **R. Losito / EN-STI**

Critical Area Overview



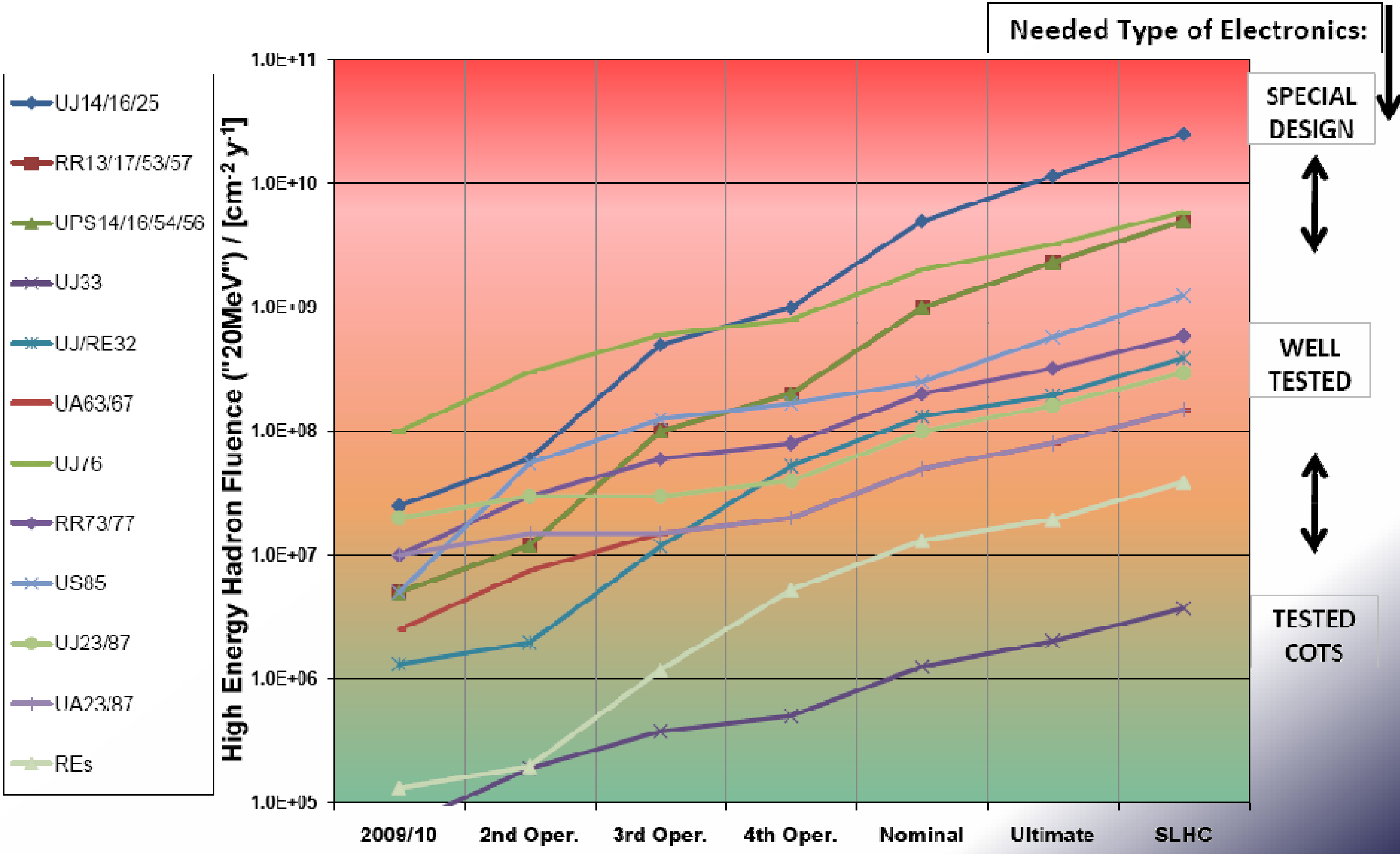
Collimation Area
possible at an early stage)

LHC Tunnel Electronics
(UJs, RRs, possibly UPS)

LHCb: ... early significant
...els

Injection & Adjacent Areas:
losses on collimators and dumps on TED

Summary Of Areas



Options

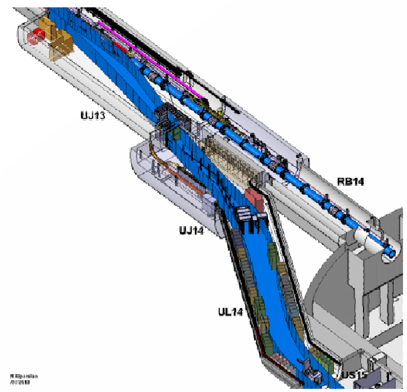
Mitigation Options

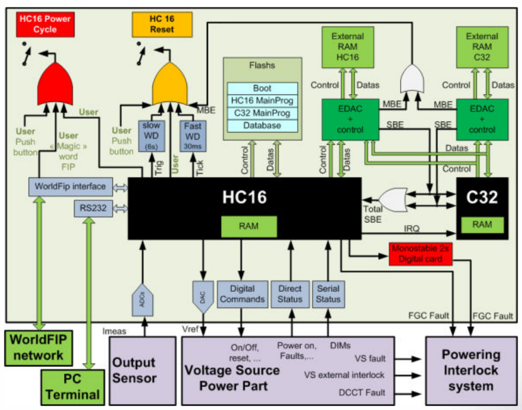
- EARLY RELOCATION
- RELOCATION
- SHIELDING
- RAD-TOL DESIGN
- CIVIL ENGINEERING
- OTHER

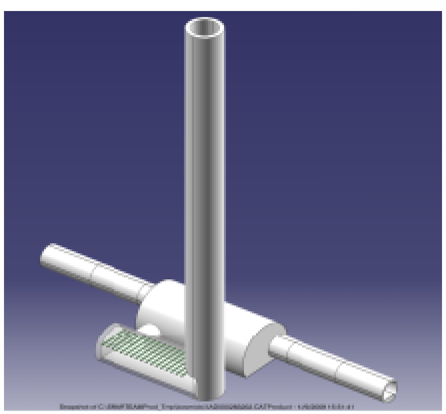
Mitigation

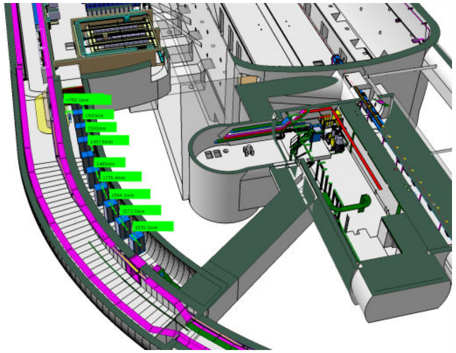
Possible means of mitigation:

- Shielding (easy + complex) [UJ87/88, UJ14/16, UJ56, …]
- Relocation of equipment [UJ14/16, UJ56 upgrade studies]
- Radiation-hard design [NanoFIP, Power Converters]
- Civil engineering









NanoFIP Project

Power Converters

Point 1 & Point 5 [301 converters]
LHC120A-10V (87) LHC600A-10V (80) LHC4..8kA-08V (66)

- **LHC60A-08V:** **SAFE & under control**
- **LHC120A-10V:** **UNSAFE but limited action can/will correct CERN design**
- **LHC600A-10V:** **UNKNOWN and potentially CRITICAL**
  - Complete redesign: possible ➔ Inner Triplet Upgrade
  - Possible relocation has to deal with cables voltage drop
- **LHC600A-40V:** **SAFE by relocation (action already launched)**
- **LHC4..8kA-08V:** **UNKNOWN and potentially CRITICAL**
  - Surely the most critical item (LHC need it 100%)
  - Redesign is far from EPC Manpower & Plans
  - Action Possible: Card analysis ➔ card redesign & test
  - Relocation OK if cryo line added (Cable Voltage drop)
  - Inner Triplet Upgrade does not solve RR1&5 situation

TE-EPC position and recommendations

We could "survive" 3-4 years, waiting for a civil engineering work upgrade if chosen.

Our actual power converters should not be placed in areas more than 2-3 Gy/year. UJ56 is announced at 5 Gy/year, which means majority of our equipments are dead after only 8-10 years.

[However SEE induced errors are still uncertain.]

Biggest fear is that troubles arrive in some years only (high luminosity) and could make LHC not useable for years!!! (crash program = long reaction time). In case converter redesign options are chosen, reaction time is around 4 years.

Relocation options must accommodate cost increase if voltage drop exceeds rating of existing power converters.

WorldFIP and NanoFIP

WorldFIP usage in the LHC:

- Over 450 km of cables
- More than 12'000 nodes
- Used in many critical LHC subsystems: Cryo, QPS, Power Converters, BI, RF, RadMon

New generation of MicroFip from Alstom chips is much less tolerant to radiations

CERN decided to buy the design from Alstom and start an insourcing effort: a rad-hard alternative to MicroFIP in FPGA technology

[BE-CO, with participation from EN-STI, TE-CRG, TE-EPC, TE-MPE]

The NanoFIP Project

NanoFIP project delayed due to LHC startup pressure (other FIP users could not provide help). Will get more priority in 2010

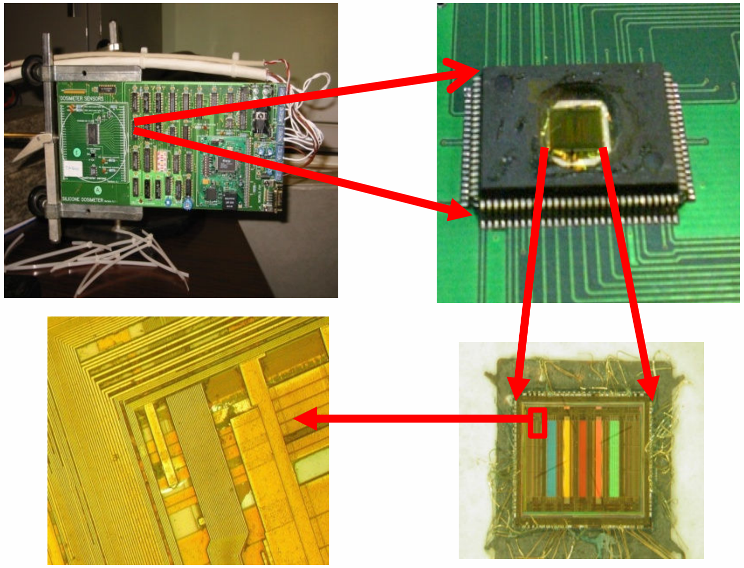
Strategic decision to be taken on MicroFIP3 (ASIC design)

Needs strong collaboration with PH-ESE and clarification of responsibilities

Review of exposed equipment

- **Single Events**
  - Soft Errors (recoverable)
    - Single Event Upset (SEU)
    - Multiple Bit Upset (MBU)
    - Single Event Transient (SET)
    - Single Event functional Interrupt (SEFI)
  - Hard Errors (non recoverable)
    - Single Event Latch-up (SEL)
    - Single Event Gate Rupture (SEGR)
    - Single Event Burn-out (SEB)
- **Total Dose**
- **Displacement damage**

Example : SEL



Equipment inventory done by Priority [full list available in talk]:

Priority 1: Personnel and Machine safety
Priority 2: Long downtime
Priority 3: Beam quality degradation
Priority 4:Monitoring or no immediate impact on the machine

In most cases a question of relocation and shielding, plus partial redesign

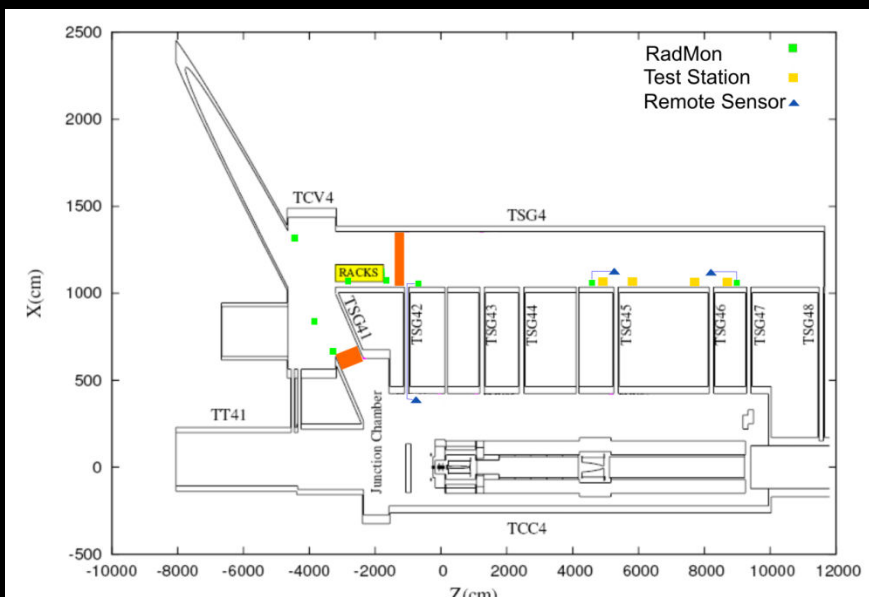
CNGS Test Facility- TSG4 side gallery

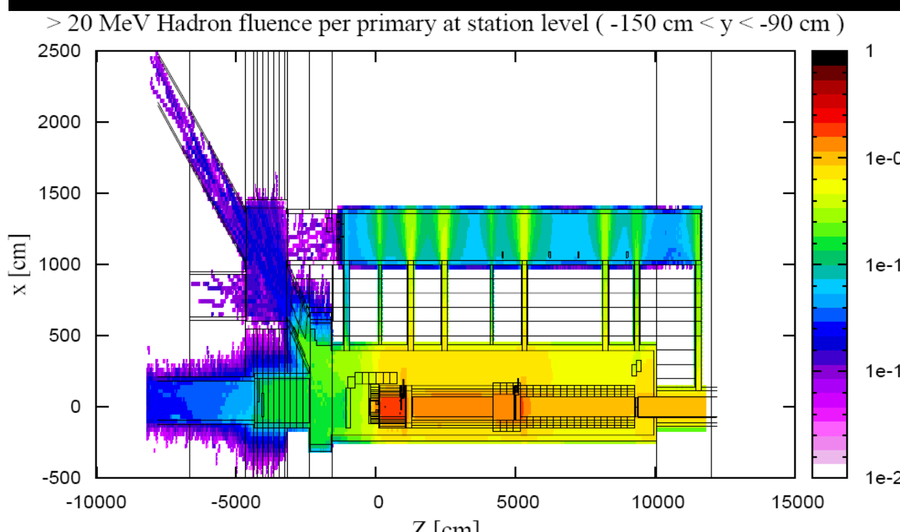
Measured quantities:

- **Dose (SiO2)**
- **Hadron >20 MeV fluence**
- **1 MeV n eq. fluence**

1 week ~ 1 e18 pot

Hottest test area in TSG45:
1 week ~ 3 years (10Gy/y) in LHC arcs





Irradiation tests

Most of the equipments installed in LHC tunnel have been tested in CNGS. ***[Equipment in critical areas need more dedicated tests]***
In most cases solved by HW/FW modifications, shielding

Cryo:	ok, with soft reset and shielding
BIC/PIC:	ok, shielding and relocation
BLM:	ok
BPM:	ok with mitigation
QPS:	not ok, but with reset of WorldFIP
CL heaters:	not critical, shielding will help
Survey:	ok
WorldFIP:	development of NanoFIP
Power Conv:	some critical

Other test facilities:

PSI [p, 60/250 MeV], CEA [n], UCL [Heavy Ions], NRI [Thermal n], IRA [Co60]

Remark on COTS and elements testing

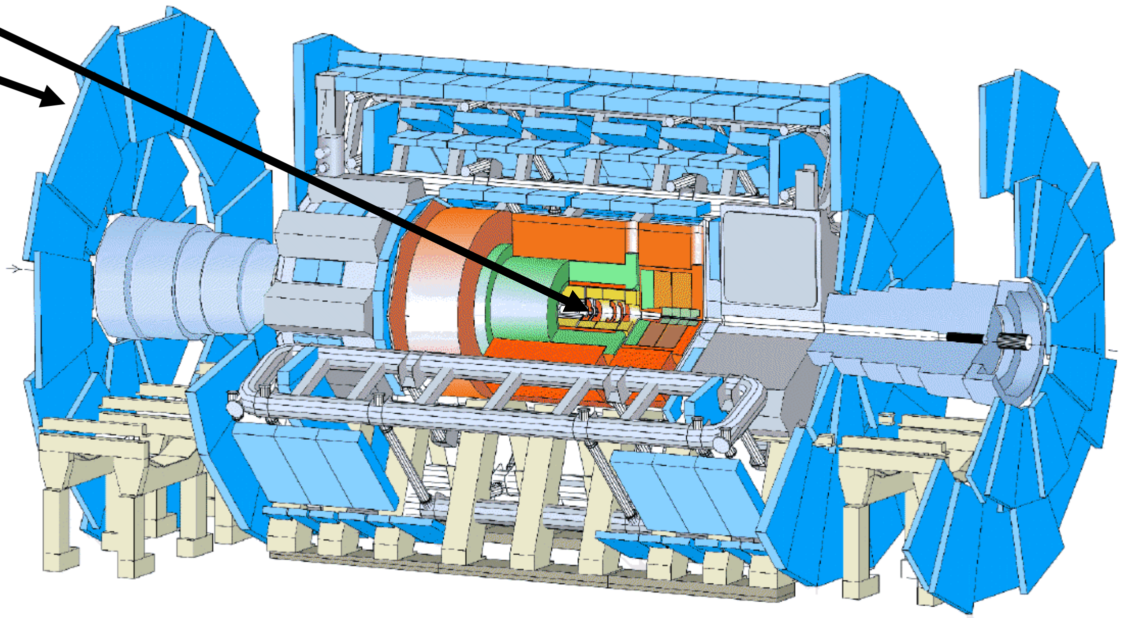
A request was mentioned to reinforce the section / service for testing COTS and components for all CERN users ?

It could then provide:

- **Optimization of the resources**
- **Larger effectiveness than having plenty of people trying to do it from their own**
- **Provide recommended components**

Radiation constraints in ATLAS

- **TID (10 years)**
  - 1 MGy (Pixels)
  - 7 Gy (Cavern)
- **NIEL (10 years)**
  - 2 10^{15} n.cm^{-2} (Pixels)
  - 2 10^{10} n.cm^{-2} (Cavern)
- **SEE (10 years)**
  - h > 20 MeV
  - 2 10^{14} h.cm^{-2} (Pixels)
  - 2 10^{9} h.cm^{-2} (Cavern)



- ***Simulated levels***

ATLAS Radiation Tolerance Policy

- **ATLAS introduced a formal policy on radiation tolerant electronics**
  - Defined tests procedures
  - Defined procurement procedures (ASIC's, COTS)

- **To enforce it**
  - One person in charge with some executive power
  - Strong support from the management
  - Tutorial on radiation effects (also with RD49)
  - Clear definition of the radiation tolerance criteria's
  - Help for testing organisation (often with RD49)
  - Specifically addressed during design reviews
  - Data base of tested components: not a big success and proven to be difficult to maintain

Long-term strategy [1]

Strategy (comparable to ATLAS strategy):

- **Environment must be known**

  Need of at least:
  - TID: Dose (Gray/year in silicon)
  - NIEL: 1MeV eq. Neutron fluence. **But Thermal neutrons ?**
  - SEU: >20 MeV fluence

  We need to specify a parameter for thermal neutrons

- **Simulate critical areas**

- **Have a repository for the project**

- **Select components compatible with radiation level**
  - Designers shall have to select components compatible with the expected level of radiation
  - Test procedures and reports adapted to the fluence/dose
  - Tests need to be performed for every new batch
  - While a central database may be established, this is not felt fundamental by users: It quickly gets obsolete…
  - A central procurement of rad-tolerant components might be more useful

Long-term strategy [2]

- **Tests in similar environment as final, keep results**
- **For critical systems: design reviews**
  - Equipment critical for personnel safety and machine/experiment protection should not be installed underground if possible
  - If not, they have to undergo a strict procedure of design review and test to ensure a minimum risk of failure.
  - Systems responsible for relevant beam downtime should undergo design reviews as well.
  - Monitoring: only on request of its owner
- **Relocation, shielding but safe solution:**
- **Invest in infrastructure with new shafts and electronic cavern**

A workshop will be organized in May to consolidate the information

It is necessary to invest substantial manpower in 2010 for integration studies

Conclusions

Big efforts have been realized in:

- **Simulation of dose and fluence**
- **Integration studies in LHC tunnel**
- **Shielding**
- **Relocation**
- **Testing**

www.cern.ch/r2e
reference site

Remain critical:

- **US85/UJ76 risk with 1000 pb-1**
- **Development of NanoFIP**
- **Complete strategy for Power Converters**

Still open questions:

- **Implementation of a long-term strategy**
- **Civil engineering pits and caverns**