Test Experience and Future Needs of European SEE accelerators for the LHC project at CERN

7 March 2005 : First LHC dipole installed

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Recall

- ***Radiation testing of LHC accelerator equipment started in 1998, electronic engineers with little or no experience in the field***
- ***Radiation testing for the LHC experiments had started years before, mainly for central part of detectors because radiation levels high and it was already clear that radiation damage would be an issue***

Single Events :

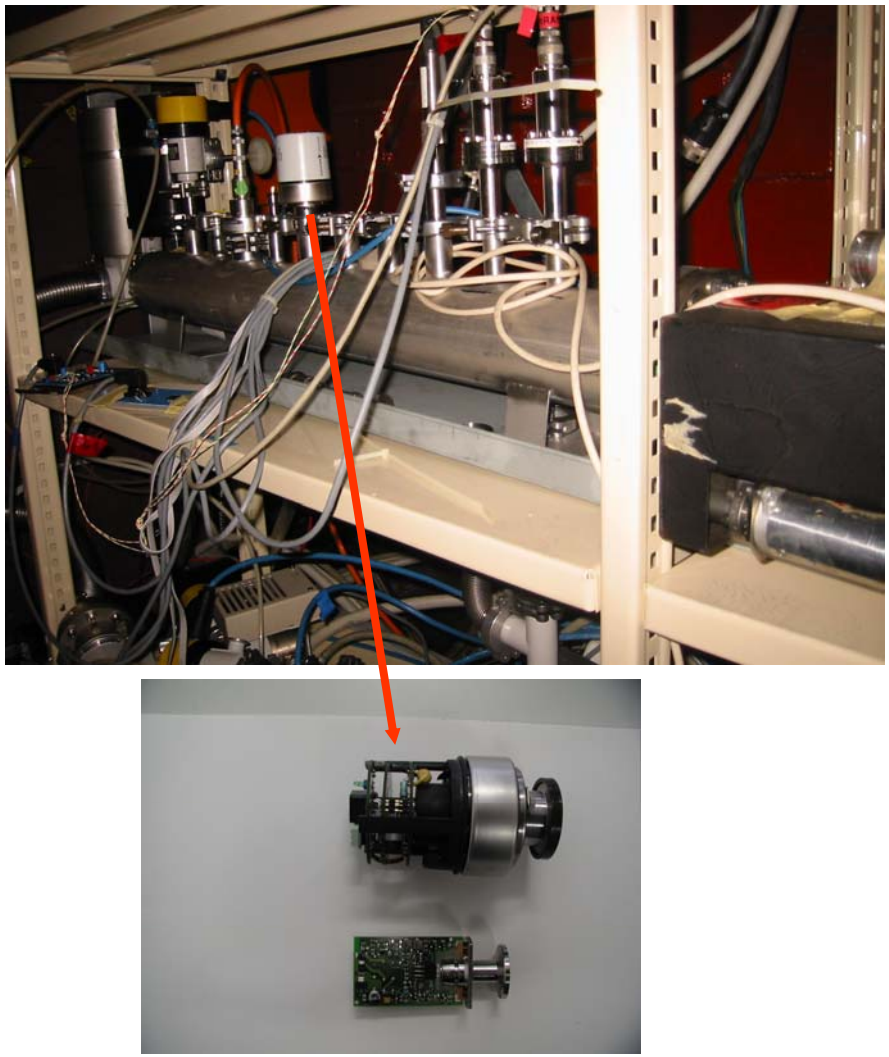
- ***SEE Recognized as a major issue rather late in the LHC project***
- ***Established a radiation tolerance assurance procedure***
- ***Shielding added to LHC baseline (but is very difficult !)***
- ***Modified electronics integration taking rad levels into account***
- ***Sharp increase in SEE radiation testing***
- ***Start design of a radiation monitoring system***

LHC radiation test facility – SPS North Area

First Radiation test in LHC Radiation test facility

- **LHC radiation test facility was initially only intended for the LHC machine equipment**
- **LHC experiments used facility at a later stage when characterization of the area had finished**
- **Extremely convenient for “trial and error” tests because facility is at CERN site**

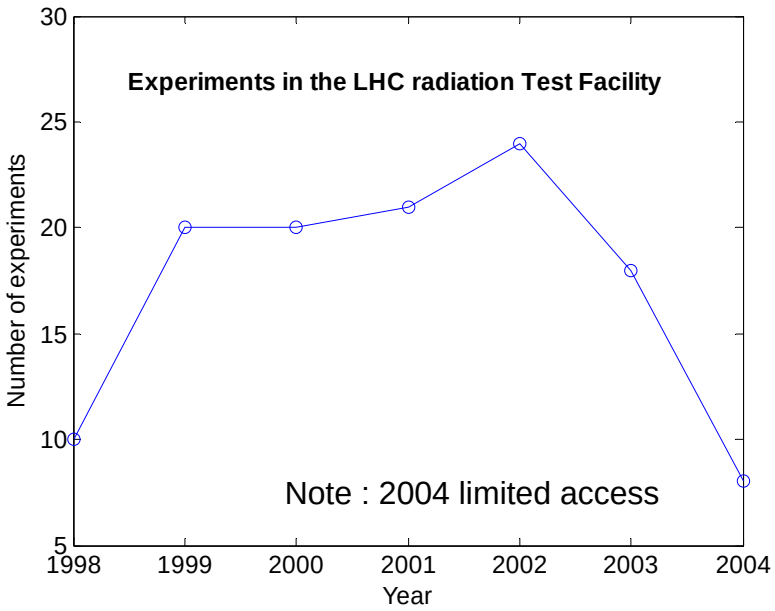
LHC Radiation test facility



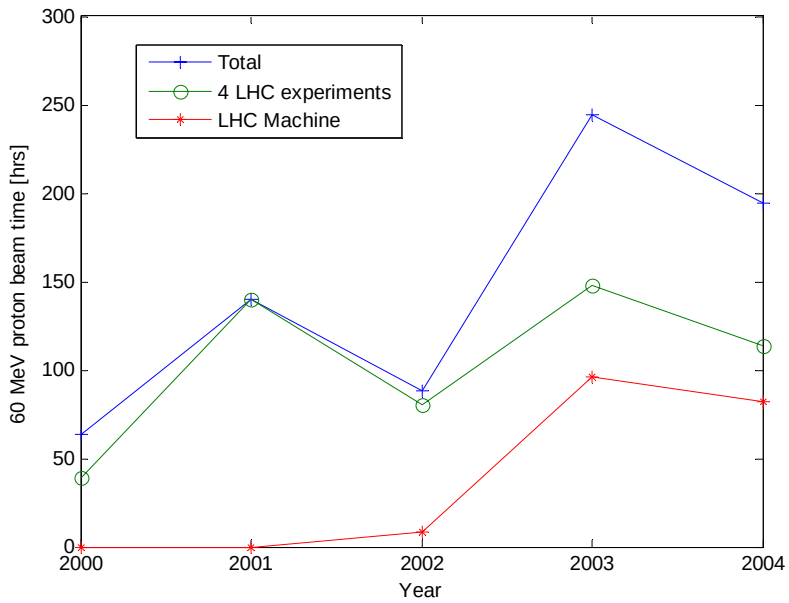
Example : Test of LHC pressure sensors

Radiation testing Experiments/ Machine – statistics

Radiation Tests at CERN



Proton beam time used at UCL/PSI

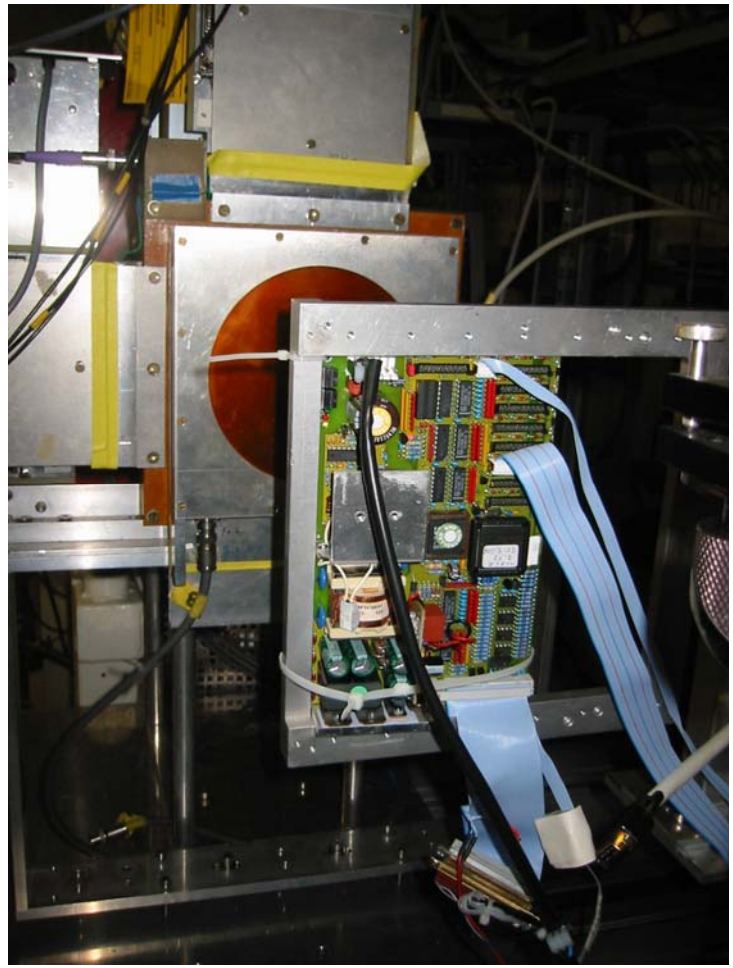


Note : in 2005 16 hours to date

- **Radiation Testing is reduced as the installation of LHC equipment is at full swing**
- **SEE test Requests continue (some groups are late) but are significantly reduced**
- **Some groups are preparing backup solutions**

SEE test with protons : what have we learned ?

- Education of experimenters crucial
- Preparation has to be impeccable
- At least 2 people for each test
- 8 hrs sessions – not more
- 1 hour overlap with previous group
- Debriefing and data analysis imposed
  - Informal discussions
  - CERN Rad Tol Database
  - Annual CERN Radiation Workshop
- Labor intensive & time consuming
- One 8 hrs session is almost never enough

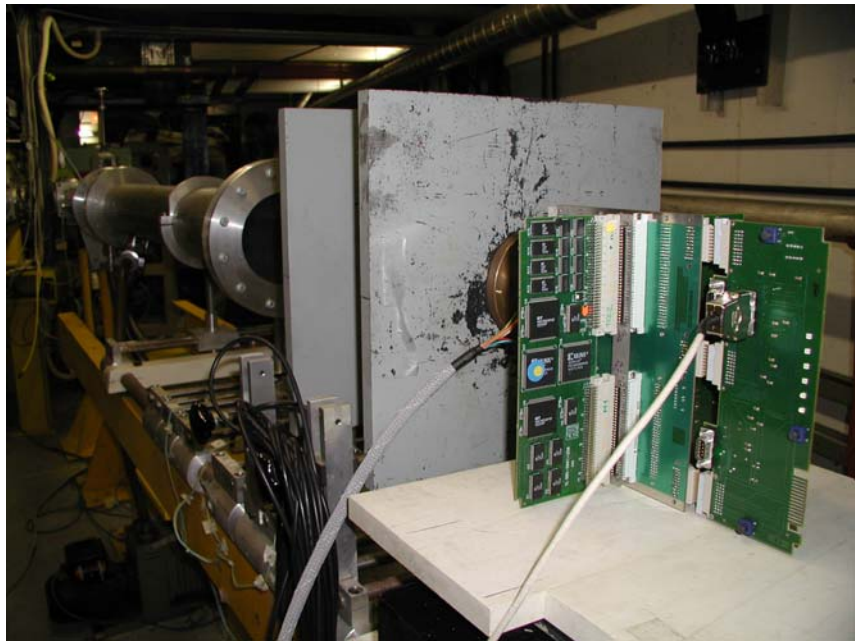


60 MeV proton beam test at PSI

Common user problems encountered at PSI and UCL

- Bad adjustment of flux w.r.t. available beam time and fluence required
- SEE appear where not expected
- Access time not taken into account (example : no remote reset build in)
- RP issues
  - CERN RP rules not respected
  - PSI/UCL RP rules not respected
  - Material irradiated unintentionally

    (ex: cable connectors)
- Shipped equipment did not arrive
- Equipment does not work before test
- …



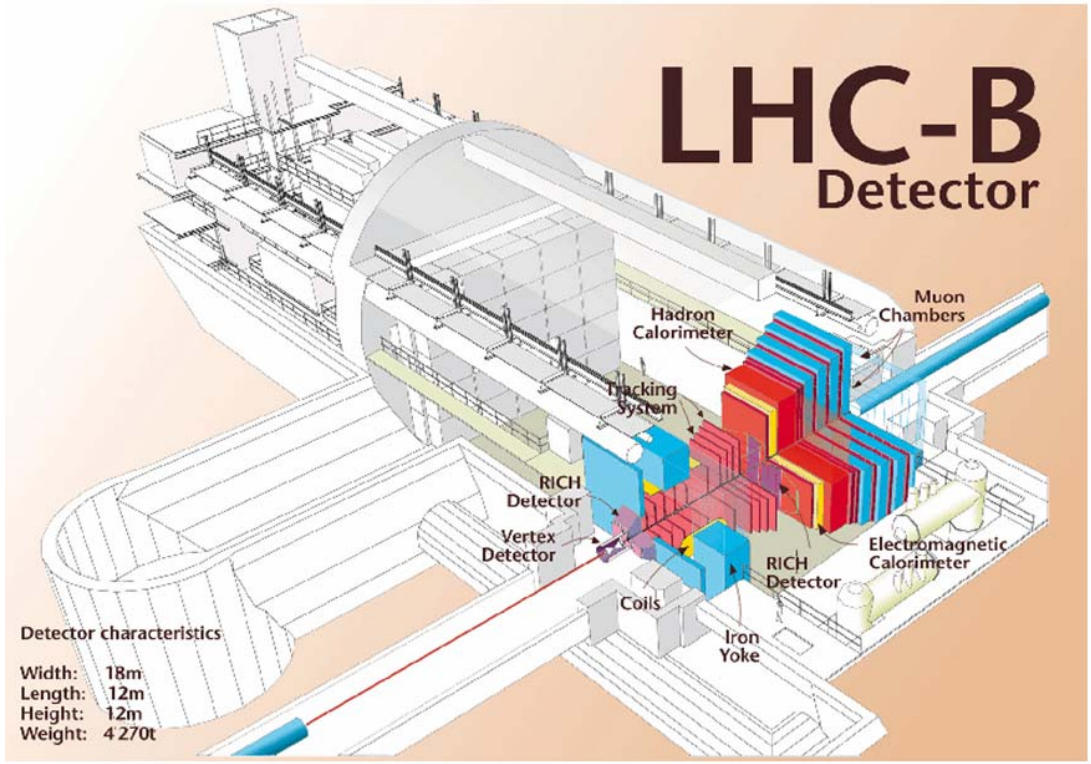
60 MeV proton beam test at UCL

Risk equipment failure from SEE has been reduced

.. but a considerable amount uncertainty remains

- ➔ **Accuracy simulated radiation levels ?**
- ➔ **New radiation physics at 7 TeV ?**
- ➔ **Shielding efficiency ?**
- ➔ **Accelerator operating modes ?**
- ➔ **30 % of equipment not tested ?**
- ➔ **Vacuum conditions ?**
- ➔ **Collimation efficiency ?**
- ➔ **…**

Collaboration between Fermilab and CERN started earlier this year on this subject

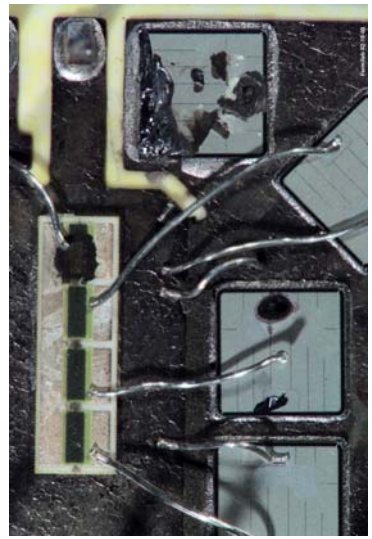


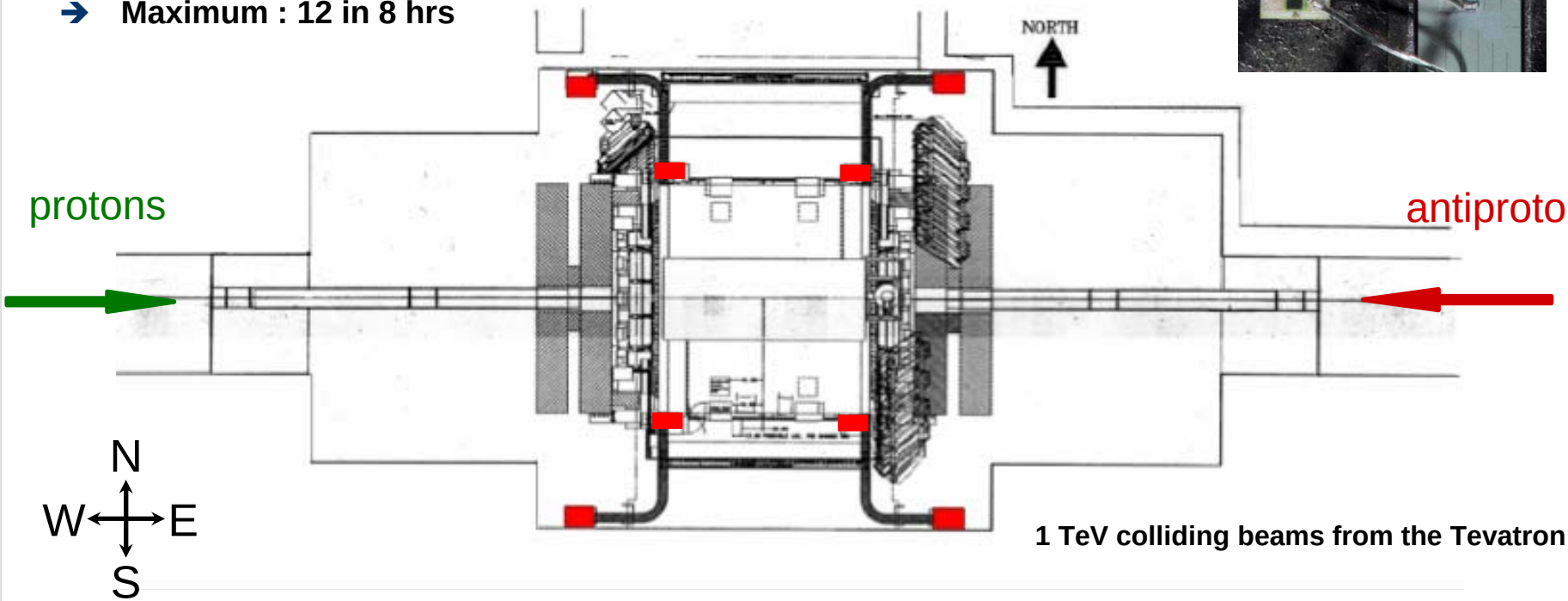
Experience from CDF detector at the Tevatron

Ex : Power Supply failures at CDF

- ➔ **Position and beam dependent**
- ➔ **Catastrophic (SEB)**
- ➔ **Only switched mode power supplies**
- ➔ **Average failure rate : 3/week**
- ➔ **Maximum : 12 in 8 hrs**

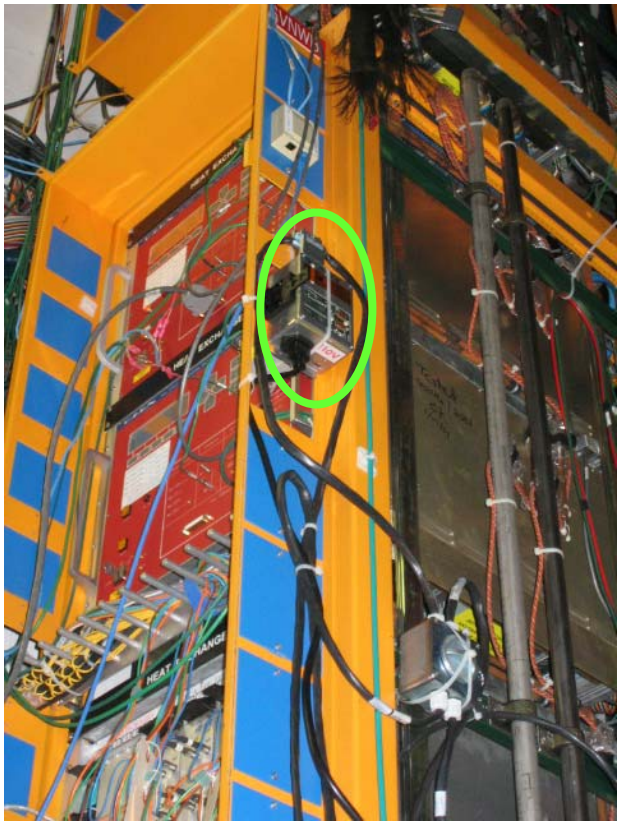
silicon in MOSFET sublimated during discharge through single component

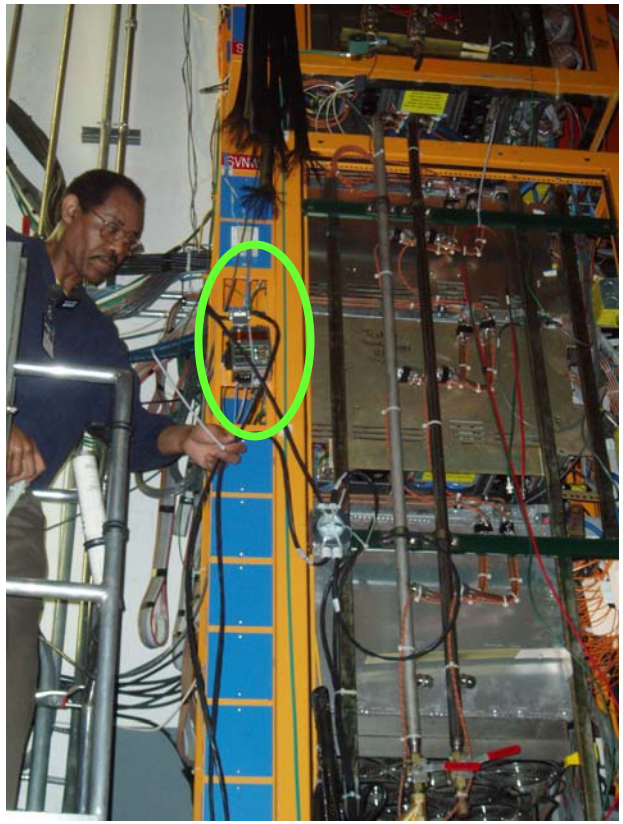


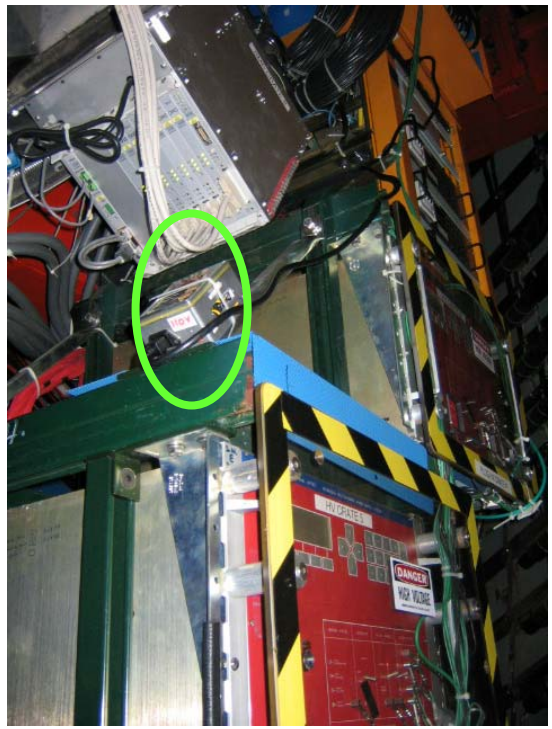


1 TeV colliding beams from the Tevatron

CERN radiation monitors in CDF collision hall



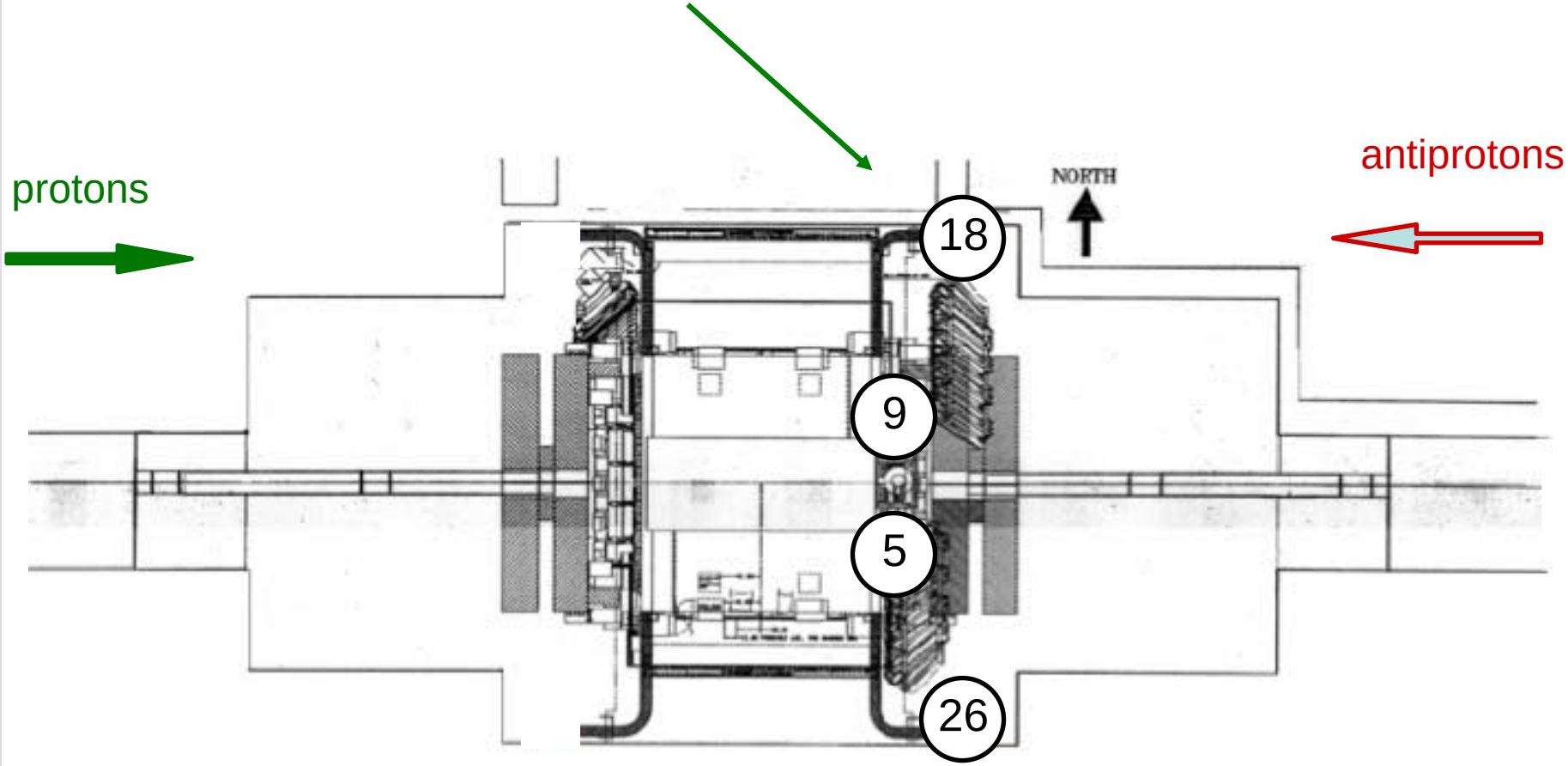




http://agenda.cern.ch/fullAgenda.php?ida=a044378

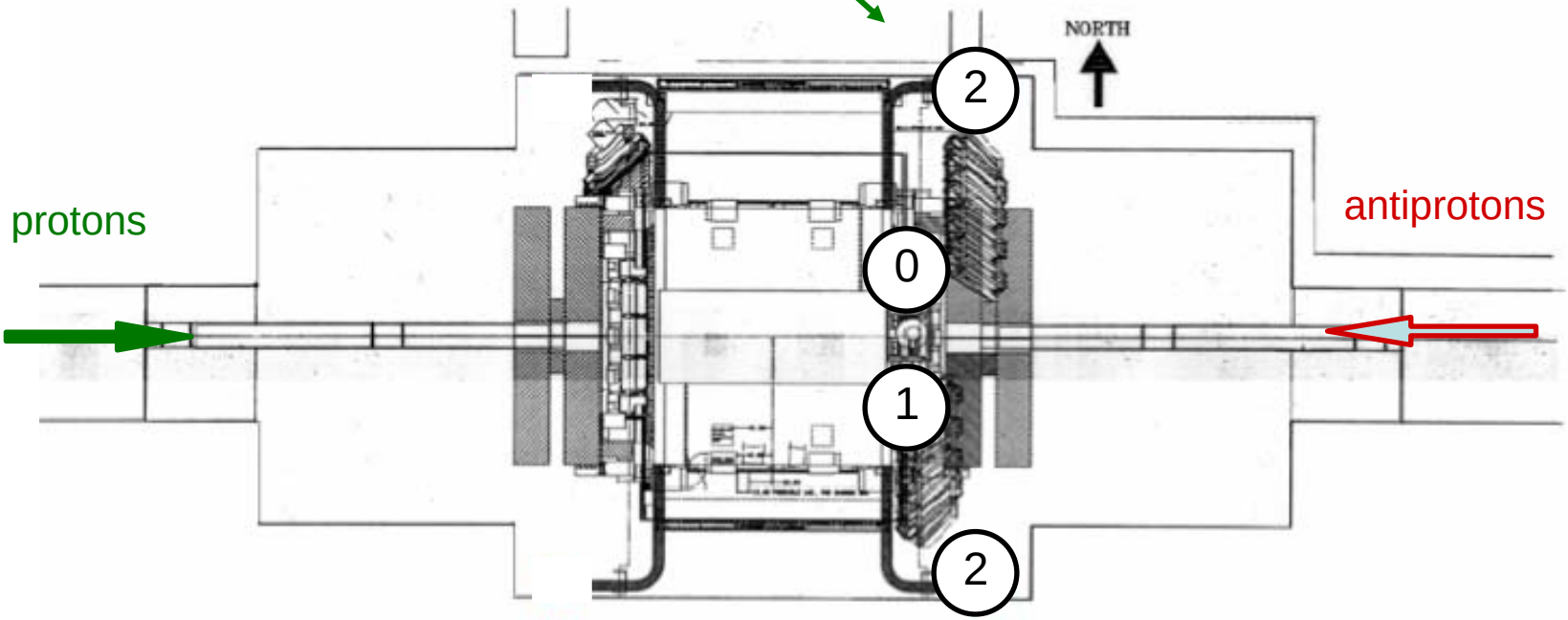
Preliminary data from CDF collision hall

SEU counter after 3 weeks



8 x 10^8 hadrons/cm^2 per year which is similar to LHC

Dose (rad) after 3 weeks



~30 rad per year - TID damage really not an issue !

Conclusions

- ***SEE* remain a *major concern for LHC equipment* despite efforts so far**
- ***Many uncertainties and risk areas remain***
- ***60 MeV Proton beams are adequate for testing of LHC equipment***
- ***UCL and PSI are excellent facilities and cover our needs***
- ***Beam time requests are now *reduced* but may well *increase after 2007***
- ***CERN is looking forward to continue using these SEE facilities***

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