Radiation testing of the anode ASIC
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($www-hep.phys.cmu.edu/cms/RAD\_HARD/2000/rad\_test.html$)

- **Introduction**
- **Static parameters vs total dose**
- **Dynamic parameters vs total dose**
- **Conclusion**

Introduction

- **The radiation levels in the EMU region (ME1/1)**
  - the 10-year period of LHC operation with a peak luminosity of 10^{34} cm^{-2}s^{-1}
  - up to 1.78 krad of total ionizing dose (TID)
  - up to 0.62 x 10^{12} n/cm^2 of neutron fluence
  - the goal to test front-end electronics up to level of 3 times doses above (safety factor)

- **What to look for (see T.Y.'s test plan)**
  - Single Event Effects (Latch-Up) and performance degradation (Qthr, gain, noise, offset, timing) vs TID in 63 MeV p beam at UC Davis
  - performance degradation due to displacement effects in 1 MeV neutron flux at OSU

- **Test procedures**
  - in 63 MeV proton beam:
    powered board, current and voltage monitoring during succesive exposures;
    performance test between exposures
    with use of ASIC test stand from Fermilab
  - in neutron flux:
    boards without power;
    one exposure with total dose;
    boards tested at Fermilab 2-3 weeks later

Static parameters monitoring

- **Static parameters in 63 MeV p beam:**
  - total current I;
  - discriminator voltage Vd;
  - amplifier voltage Vd;
  - power regulator voltage Vc.

- **ASIC chips CMP16E (1.2μ technology)**
  - six chips (previous submission, Nov. 99)
  - irradiated in March-April 2000
  - doses of 12,30,60,180,300 and 600 krad
  - no latch-ups have been seen
  - the most sensitive is current draw I (starting to raise after 5 krad)
  - the first indication of peak is at 70 krad
  - chips died at TID of 200 krad (Fig.1)

- **ASIC chips CMP16F (1.5μ technology)**
  - four chips (latest submission, Jan. 2000)
  - irradiated in June 2000
  - doses of 14,14,74 and 80 krad
  - no latch-ups or spikes have been seen
  - no changes in static parameters

Performance test

- Chips CMP16F in 63 MeV p beam:
  - Qthr, noise,gain, discriminator offset and slewing time measured between 1-2 min exposures with use of precision pulser (ASIC test stand)
  - 14,14,74 and 80 krad doses
  - all channels in two chips failed after TID of 65-70 krad (but were back to life a month later)
  - Qthr decreased by 15% at TID of 60 krad due to changes in the gain and discriminator offset (Fig.2)
  - no change in time resolution
  - slewing time increases by almost 40% at TID of 40 krad but no change up to TID of 5 krad (Fig.3)

- Irradiation by neutrons at OSU
  - three chips CMP16E after 63 Mev proton radiation
  - four chips CMP16F
  - only two chips (CMP16F) survived

Table. Doses for chips. Note that the neutron fluence is $0.6{\cdot}10^{12}$ n/cm^2 and TID = 1.78 krad for 10 years of LHC operation.

Board #	**Neutron dose (10^{12} n/cm^2)**	**γ dose (krad)**	**Comment**
2	**1.2**	**30.8**	**CMP16F**
3	**1.8**	**46.3**	**CMP16F**
4*	**3.0**	**77.1**	**CMP16F**
18*	**6.0**	**154.3**	**CMP16F**
21*	**1.2**	**30.8**	**CMP16E after proton TID of 60 krad**
23*	**1.8**	**46.3**	**CMP16E after proton TID of 30 krad**
26*	**3.0**	**77.1**	**CMP16E after proton TID of 13 krad**

The chips marked with * did not work after neutron irradiation.

Table above was modified after presentation.

- Dynamic parameters after irradiation by neutrons for boards ## 2,3
  - gain is up by 40%
  - offset goes down by 75 mV
  - Qthr is up by 4% only, thanks to opposite contributions of the gain and discr. offset
  - no change in time resolution

- Conclusion
  - **- anode front end survives the TID up to 65-70 krad and up to 1.8 x 10^{12} n/cm^2 of neutron fluence**
  - **- no latch-up or spikes have been observed**
  - **- dynamic parameters are much more sensitive than static**
  - **- they are not affected by the TID of 5 krad and beyond**
  - **- γ contribution to the neutron irradiation should be taken into account**
  - **- more boards (6) will be tested for TID of 5 krad in the p beam and for dose of 1.8 x 10^{12} n/cm^2**