Computer Physics Communications

Summary of session 4: Classical aging

Andreas S. Schwarz*

DESY, Notkestr.85, D-22607 Hamburg, Germany

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Abstract

A short summary of the session "Classical Aging" is given. The session consisted of 10 talks covering the results of radiation-induced aging tests for central tracking chambers (open geometry drift chambers, straw type, honeycomb type, Microstrip Gas Chambers) as well as muon chambers.

1. Introduction

Because the individual talks presented in this session have been written up as separate contributions to these proceedings, the details will not be repeated here. Instead, an attempt will be made to collect the lessons that have been learned in the course of performing the various aging tests. Not all the results of the various presentations can fit into a brief summary of this sort, and any omissions in this respect are regretted.

2. General comments

Some general observations can be made:

- All devices under discussion are either brand new tracking detectors that have just come into operation or detectors that are intended for use in the next generation of experiments
- Contrary to past practices, all detectors under scrutiny have been submitted to serious aging tests **prior** to mass production of the full system
- Muon chamber systems, so far known for their small occupancies and negligible irradiation doses,

* Corresponding author. Tel.: +0-49-40-89982524; fax: +0-49-40-89984018; e-mail: andreas.schwarz@desy.de.

now join the league of tracking devices that have to survive large irradiation loads.

3. Expected irradiation doses, gases used, effects observed

The expected accumulated charge for central tracking detectors ranges from a few mC/cm (BaBar) to O(500-1000 mC/cm) (HERA-B, CMS, ATLAS) per year of running.

Typical gases that the experiments have settled on are Ar(Xe)/CF_4/CO_2 for HERA-B (ATLAS), He-Isobutane for BaBar, and Ar-DME or Ne-DME for the MSGCs originally intended for use in the CMS experiment.

For muon detectors, typically expected radiation doses range from between 10 mC/cm (CMS) to 300 mC/cm (COMPASS, high-gain option).

A wide variety of effects has been observed in the course of the irradiation tests:

- Malter effect
- permanent dark currents
- anode etching
- anode "swelling"
- Silicon polymerization
- effects from electronegative radicals

Most of the effects have been overcome through design changes, and some appear only at very high doses. A few investigations are still in progress. Radiation hardness exceeding 2,000 mC/cm has been achieved with Ar(Xe)/CF_4/CO_2-based gases (ATLAS, HERA-B, CMS).

4. Observations/Results

(a) Global

- aging effects can depend on
  - the collected charge
  - the gas gain
  - the type of irradiation (hadrons, heavily ionizing particles, electrons, photons)
  - the area of irradiation
  - the mode of irradiation (high vs. low radiation dose)
  - the gas flow vs. irradiation mode

(b) Specific

- Using CH_4 in a gas mixture (HERA-B) can lead to strong polymerization on the anode wire. Therefore, this type of mixture should be avoided.
- Silicon should be avoided at all costs (ATLAS).
- H_2O, Methylal, 2-Propanol all help as classical remedies to cure Malter effects (BaBar). This can be dangerous, however, for high-irradiation environments (see below).
- Water content in CF_4-based gases should be kept below 1000 ppm (ATLAS) (500 ppm, HERA-B).
- An Ar/CO_2 (30:70) mixture already shows strong aging after 250 mC/cm (CMS). This is not due to the base gas Ar/CO_2 composition, but rather to other external factors. In contrast, an Ar/CO_2 (93:7) mixture seems fine up to 1,300 mC/cm, and an Ar/CO_2 (90:10) mixture survives 600 mC/cm (ATLAS).
- Gases that have been 'engineered' for optimal properties not related to aging hardness (e.g. a very linear drift-time relation) unfortunately tend to fail when tested under irradiation (an example is the Ar/CH_4/N_2/O_2 mixture originally intended for use in the ATLAS muon drift tubes).

5. Lessons

- Former remedies can be current enemies: any ad hoc admixture to the chosen gas to cure aging problems "on the fly" MUST be avoided! If you find yourself forced to take such an action, it is probably too late. (For example: H_2O helps cure the Malter effect in a low-irradiation environment but can cause wire breakage in CF_4-based gases in a high-irradiation environment.)
- **Therefore, put aging hardness on top of the list of requirements for your gas choice.**
- Avoid surfaces with undefined/unknown properties (ATLAS, HERA-B).

- Severely restrict/avoid unknown materials (ATLAS, HERA-B).
- Once a chamber system is polluted, it is likely to remain so indefinitely! A few exceptions, though, are possible:
    - The rejuvenation of an aged BaBar test chamber using O_2 as a "healing gas".
    - The removal of CH_4 polymerizations on the anode wire with a CF_4-based gas under irradiation (HERA-B).
- Perform aging tests with a particle mix as close as possible to the one expected (HERA-B).

6. Conclusion

Since irradiation results depend on so many variables, it is virtually impossible to design a radiation-hard chamber system from first principles. The "lever arm" for extrapolation from test results to the final chamber system will remain large. To play it safe, one should cover as much of the possible parameter space as feasible during the testing phase and try to bracket the extremes. There is no alternative for guiding the design of a radiation-resistant chamber system but through tests, tests, tests.