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A BARREL IFR INSTRUMENTED WITH LIMITED STREAMER TUBES FOR BABAR EXPERIMENT

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The new barrel Instrumented Flux Return (IFR) of BABAR detector will be reported here. Limited Stramer Tubes (LSTs) have been chosen to replace the existing RPCs as active elements of the barrel IFR. The layout of the new detector will be discussed: in particular, a cell bigger than the standard one has been used to improve efficiency and reliability. The extruded profile is coated with a resistive layer of graphite having a typical surface resistivity between 0.2 and 0.4 MOhm/square. The tubes are assembled in modules and installed in 12 active layers of each sextant of the IFR detector. R&D studies which have been done to choose the final design will be discussed, as well as the Quality Control procedure adopted during the tube production to assure high performances of the detector.

1. The flux return geometry

As originally built, the muon and K_L^0 detection system for BABAR consisted of 19 layers of resistive plate chambers (RPCs) interleaved with the flux return iron in the barrel region and 18 layers in the forward and backward endcaps. Each detector gap contained a single layer of RPCs based on a bakelite and linseed oil design. During initial BABAR operations, the temperature in the iron increased to as much as 30^oC. Since that time efficiencies have continued to decline at the rate of appoximately 1.2% per month. Efforts to reverse or halt the underlying decline in efficiency have not been successful. All the chambers in the forward endcap were replaced in the summer and fall of 2002 with RPCs built with more stringent quality control (the upgrade project foresaw also the replacement of 5 active layers with 2.5 cm thick brass plates to improve the pion rejection. In December 2002 BABAR it has been decided to replace RPCs with limited streamer tubes (LSTs) for the barrel upgrade.

2. The LST Concept

A "standard" LST configuration [1] consists of a silver plated wire 100 μm in diameter, located at the center of a cell of 9x9 mm^2 section. A plastic (PVC) extruded structure, or profile, contains 8 such cells, open on one side (Fig. 1). The profile is coated with a resistive layer of graphite, having a typical surface resistivity between 0.1 and 1 MOhm/square. The profiles, coated with graphite and strung with wires,

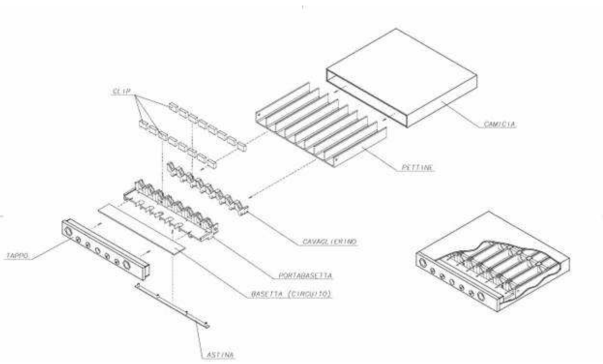

Fig. 1. Schematic of the “standard” Limited Streamer Tube configuration.

are inserted in plastic tubes (“sleeves”) of matching dimensions for gas containment. The signals for the measurement of one coordinate can be read directly either from the wires or from external strip planes attached on both side of the sleeve.

3. Design and Performance

The LST tubes are somewhat fragile mechanically so careful design, handling, and operation are of paramount importance in preventing failures. The “mortality” of the LSTs depends on the cell size, on the care and attention given during construction and installation, and on the strictness of the acceptance tests. Given these constraints to build a highly efficient detector means:

- Reduce tube mortality and/or introduce redundancy to decrease its effect on detector efficiency. For this reason it has been chosen a 15x17 mm^2 cell design.
- Arrange tubes into modules that can be extracted and replaced and to minimize the dead space.
- Feed each tube with one or more independent HV channels.
- Locate HV distribution boxes and front end electronics on the outside of the detector.

Such indications led us to a 15x17 mm^2 cell design (which is more reliable and efficient) where each tube is composed by 7 or 8 cells and assembled in modules. We use wire readout for the azimuthal coordinate, ϕ, and strips plans for the z coordinate (along the beam direction).

4. R&D Studies

More than one year of R&D studies have been done before choosing the final LST design. Our R&D program has been concentrated on several critical issues like: selection of safe gas mixture, rate capability, wire surface quality and uniformity, aging test and performance of the prototypes. For brevity only the most relevant results will be reported [2].

Aging test. Aging tests have shown that the performance of PVC tubes is still satisfactory after operation with an irradiation well above what can be expected from an upgrade of the machine. No big drop of signal charge or self-sustaining discharge has occurred. We have therefore decided to use PVC because it is cheap, and easier to extrude than other plastics: standard-cell tubes made of PVC have been coated with the water-based carbon paint with good result: average resistivity has been within the desired range, and there is no evidence of “bald spots”, which cause tube failure.

Gas mixture. A gas mixture with 3% Argon, 89% CO_2 and 8% Isobutane has been selected to operate the LSTs. This gas mixture is certified to be safe (i.e. not flammable) and guarantee good performances for the detector: the single rate plateau region is about 500V large, the operating point is around 5500V while the tube efficiency is around 92% [a] [3].

5. LST production and quality control

The LST production has been commissioned to an external firm, the Pol. Hi. Tech (PHT), which also assembled all the prototype used for R&D.
We worked together with PHT to improve the cleanliness of the tubes and to setup a system of stringent quality (QC) control to guarantee the high performance of the product. This include:

- Mechanical inspection of profiles
- Graphite coating
- Resistivity measurement
- Inspection of the small parts and wire check
- Gas tightness (leak test)
- HV conditioning and plateau measurement
- Source scan test
- Long range tests

The main tests of the QC system will be describeed in the following.

Graphite coating. After coating, all profiles have been visually checked. Big defects have been corrected, smaller, acceptable defects have been recorded together with their position along the tube.

Resistivity measurement. The surface resistivity was monitored by measuring the resistance between a pair of appropriate electrodes. The resistivity have been

[a]The inefficiency is mainly due to the geometrical acceptance of the LSTs design.

measured in an automatized way at 50 cm intervals along the tube's length, for each of the 8 cells, on the bottom of the cell. The average surface resistivity is between 0.2 and 0.4 MOhm/square. In addition, we also measured, manually, the resistivity of the side walls.

Electrical conditioning and Plateau measurement. An electrical conditioning was performed for each tube for a minimum of 7 days (even if the drawn current became acceptable in less than 7 days). A current limiting power supply has been used. The tubes have been fluxed with a ternary gas mixture (89 % CO_2, 8% Isobutane, 3% Argon).
For each tube the plateau has been measured using the ternary gas mixture. We required the single rate plateau to be at least 300V. Tubes failing this test were rejected.

Source scan test. Each tube has been scanned with a Sr90 radioactive source to look for surface defects of the graphite coating not observed by the operator. Tubes which presented self-sustaining discharge have been rejected.

Long Range Tests. Each tube has been kept at the maximum operating voltage (as resulting from the plateau curve) for a period of thirty days, during which the current drawn by the tube must not exceed 200 nA for more than 5% of the time it is monitored. In addition no observed activity allowed in the second half of the history.

6. Installation into BaBar

Installation plans foresaw the insertion and the commissioning of the first 2 sextants during summer 2004. While the remaining four will be installed in the 2005 shutdown. Installation began with the insertion into each gap of a strip plane covering an entire gap. These strips have been attached to the iron and supported by gravity. Then the modules were brought onto a supporting structure and inserted into the gap on top of the strip layer. The full installation and commissioning of the two sector took less than 2 months and has been completed on schedule. QC tests after installation certify the proper working of the apparatus.

References

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