Findings

(electronics)

- The front end uses the Penn designed ASDQ ASIC recycled from the CDF Central Outer Tracker (COT).
- Commercial FPGAs are used to perform the time to digital conversion, event buffering, and data transport.
- Some elements of the g-2 ring are potential sources of noise for the straw chamber electronics. These include the injection kickers and electrostatic quadrupoles.

(test beam)

- Results were presented from test beam data collected in June 2015.
- Some of the test beam results indicated good straw chamber performance. For example, the correlation between TDC measurements of overlapping straws in a single view operated with an argon/ethane gas mixture is consistent with expectations, as is the inferred electron drift velocity.

(gas system)

- The g-2 tracker group would like to use the same gas mixture that was used in the CDF COT chamber by adding oxygen to an argon/ethane (50/50) mixture.
- The gas system is being designed to quickly isolate a straw module in case of a leak that would compromise the operation of the electrostatic quadrupoles.
- Tests are planned in the near future to verify that the selected components will perform as required.

(construction)

- All steps for the construction of a tracking module are finalized and the details have been tested by building a full module.
- The gas manifolds will be machined largely from single aluminum pieces; this process has been demonstrated.
- Machined aluminum parts will be coated with chromium to enhance the surface conductivity.
- Methods to pretension the straws and glue the straws in place with conducting glue and regular glue for rigidity have been demonstrated. Some of these glue joints will be exposed to vacuum. Tensioning the wires and straws at the same time is under investigation.
- The construction of one module is expected to take 40 days. The construction plan calls for four modules to be under construction (at different stages) simultaneously.
- Several vacuum test chambers exist or will be built and each module will be vacuum tested at the production site prior to shipping. One of these vacuum chambers will be shipped to Fermilab and used to test each module after it is received.
- Full production of modules is expected to start ~February 1, 2016.
- The first full tracker with 8 modules is expected to be ready by July 2016.

- The first 8-module tracker is expected to be installed in the g-2 ring in March 2017.
- The construction schedule for the front end electronics cards shows delivery to Liverpool also ~February 1, 2016.

Comments

(electronics)

- The ASDQ is a proven device with performance adequate to meet the sensitivity and timing requirements of the tracker.
- The FPGA based TDC has sufficient time resolution to meet the tracker requirements.
- The tracker prototype demonstrates workable solutions to the challenges of signal and high voltage routing and cooling within a very limited space, in a high ambient magnetic field.
- The grounding and shielding appears to have been given careful attention.
- The low voltage power system and all HV choices presented appear adequate to the task.
- We suggest that the TDC be modified to include cable connectors attached to spare FPGA I/O pins through suitable drivers and receivers to allow the system to be debugged with an oscilloscope during operation.

(test beam)

- The test beam results taken as a whole indicate that the straw chamber system did not work well. One example is that, while GARFIELD simulations indicate that the gas gain was ~2E6 during operation with argon-ethane, the measured per straw efficiency was only ~60%, even though the applied threshold was fairly low.
- It is important for the g-2 group to demonstrate to themselves that the straw modules being built will operate as expected. Ideally, this would have been demonstrated by the beam test. However, a sufficient demonstration can be achieved with a combination of radioactive source testing and testing with cosmic rays.
- We strongly suggest that the group modify a module for test purposes to allow the use of at least one ASDQ BLR (analog) output. The analog signal will quickly reveal subtle problems that may exist with the configuration or biasing of the ASDQs.
- We suggest that the group measure the gas gain of a straw tube, preferably using a final-design or near final-design module.
- We suggest that the group use minimum ionizing particles, either from a radioactive source or cosmic rays, to measure the efficiency and TDC distribution of straws in a final-design or near final-design module.

(gas system)

- For CDF, the amount of oxygen added to the gas mixture was increased with the luminosity in order to keep the oxygen level at the exhaust always greater than 50 ppm.
- The CDF COT was always operated with 1.7% isopropyl alcohol, even before oxygen was added to the mixture.
- The vacuum requirement has not yet been translated in a rigorous way into a requirement on either the DC leak rate from a straw module or the amount of outgassing that is acceptable. It would be very desirable to do the engineering necessary to obtain this information.

(construction)

- The interface between the straw and the electronics is established through sockets in a printed circuit board. Due to the rigidity of this connection there is a potential risk to break wires when installing and/or removing this board. Unless testing establishes that this is not a concern, an alternative way of connection is desirable like in the form of conductive elastomer that provides a flexible soft connection or some kind of spring loaded connection that can be engaged/released mechanically all at once for all connections.
- Testing each fully assembled module before shipping to Fermilab with cosmic rays or a radioactive source is desirable. This would add to the time required to produce each module, but if additional manpower is available to do the testing, it could be accomplished in parallel with other module production steps.
- The wire positions could be measured with x-ray photography to high accuracy if need be.
- We suggest that the group perform vacuum tests to measure the outgassing rate from a final-design or near final-design module before starting full production.

<u>Recommendations</u>

- Perform tests to determine impact of kicker firing on the straw system.
- Perform tests using a final-design or near final-design module that demonstrate that the straw modules will operate efficiently.