FDC Test Plan GlueX-doc-1306-v1

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1 Introduction

The test of the front drift chamber (FDC) full scale prototype will be done in the EEL building in room 126. It can be subdivided into several phases. A short outline of these phases is given below.

1. Mechanical and Electrical Test
   - Test wires and strips for shorts to ground
   - Test wires and strips for shorts to neighboring channels
   - Check HV boards and preamplifier card connections
   - Check HV system: connectors, cables etc.
   - Check gas handling system and controls
   - Flush chamber with gas
   - Test gas leakage
   - Electrical test of wires at low voltage
2. Wire conditioning
   - Increase HV on wires in steps an monitor current (¡10μA !)
   - Check electrostatic stability
   - Record analog signals of wires and strips, determine noise level for various wire and strip length
3. Test with Sr90 source and Fe55
   - Tests with Sr90 source. Do HV scan, determine plateau and operating HV and determine efficiencies of wires and strips at operating parameters.
   - Record and document response of wires and strips at nominal operating parameters as determined in cosmic ray test and/or the Sr90 source.
   - Determine response of wires and strips with Fe55 source
   - Record response for different wire and trip length

- Verify response with Garfield calculation
- Test HV dependence of the response

4. Cosmic Ray tests

   - HV scan: determine HV plateau for different gas mixtures (as with Sr90 source)
     the nominal gas mixture is 40% Ar and 60% CO_2
   - Determine efficiencies for wires and strips
   - Determine and record signal noise for wires and strips
   - Determine response in the central region where wires are deaden

1.1 FDC Prototype Hardware

The prototype has three wire planes each with two cathode planes. This constitutes half the size of a full FDC package. Each wire plane has 96 sense wires and 97 field wires each wire type with a pitch of 10 mm. Each cathode plane has 216 strips, 5 mm wide and 1mm gap between strips. The angular orientation between wires and strips is $\pm 75^{\circ}$. The distance between wire planes and cathode planes is 5mm resulting in a detection cell of 1 cm^2. The channels from wire plane and cathode plane are capacitively coupled to preamplifier-shaper cards with 24 channel capacity. The wire channels are then connected to F1TDCs to measure the drift time while the cathode strip channels are read out by fADC125 flash-ADCs operating at 125 MHz. The total number of TDC channels needed to fully equip the prototype is 288 while the total number of fADC125 channels is 1296. This translates into 18 FADC125 modules, 9 F1TDCs modules and 66 preamplifier-shaper cards that are required for a fully equipped detector readout. Positive high voltage will be applied to the sens wire and negative high voltage to the field wires. The cathode planes will be at ground. With a nominal operating gas mixture of 40% Ar and 60% CO_2 a voltage difference between the sens and field wire of about 3000 V is expected while the field wires are operating at about -500 V. The maximum voltage applied to the sens wire should not exceed +2550 V the maximum field wire voltage should not exceed -750V while the total voltage difference should not exceed 3300 V.

1.2 Cosmic test stand

Two layers of 6 scintillator paddles are available to form a cosmic ray trigger stand where tracking chambers can be positioned between these two scintillator planes. Each paddle is 0.5 inch thick with a length of 49 inches and a width of 8 inches. The paddles is read out on both sides with XP2261 PMTs. The trigger is formed as a coincidence between the top and bottom plane formed by the paddles as indicated in figure 1 The electronics required to setup the trigger is as follows: While the scalers are not necessary a few visual scalers can be of great help during operation for monitoring purposes and on-line estimations of efficiencies. The timing of the left right coincidence for each paddle is set such that the right signals arrive about 10 ns later than the left signals at the coincidence input. The coincidence between top and bottom plane is set such that the signal from the bottom plane arrives about 10 ns later then the signal from the top plane. This ensures that the timing of the trigger is determined by the bottom plane right PMTs. The left-right coincidence is established with a Camac module 4516 from LeCroy. It has 3 times 16 input channels and is set to AND and OR for the three inputs. Two rear pannel outputs provide the OR for the first and second group of 8 output

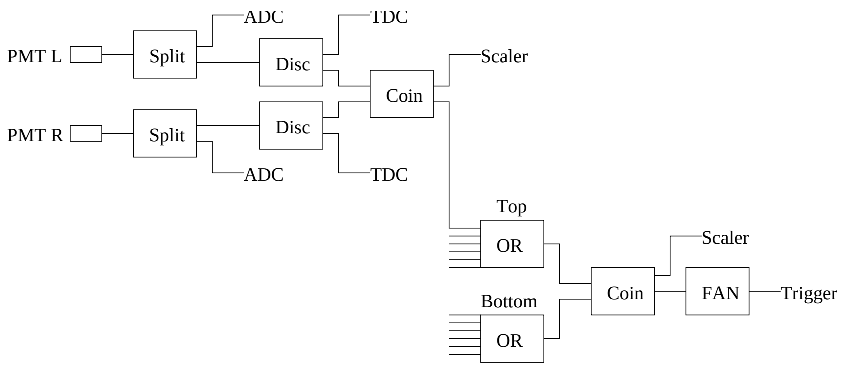

Figure 1: Electronic sketch of the cosmic ray trigger electronics using the scintillator paddle signals.

Table 1: Electronics required for cosmic trigger

Modules	channels
Splitter/Fan-out	24
Discriminator	24
Coincidence	13
6-fold OR	2
ADC	24
TDC	27
Scalers	39

channel coincidences. The channel configuration is such that the first 6 of 8 channels correspond to the top scintillator paddles while the bottom scintillator paddles occupy channel 9 to 14.

2 Mechanical and Electrical tests.

After completion of the prototype chamber the mechanical and electrical integrity of the detector system has to be verified. In order to ensure safe operation of the chamber it is necessary to first verify that the chamber is mechanically stable and mounted to a frame. The flatness of the full chamber assembly needs to be determined and any deformation recorded. Using a digital volt meter all wires need to be tested for any shorts to ground or between wires. Note that several wires are connected through the same high voltage (HV) channel. Similar test need to be done for the cathode strips.
The chamber needs to be connected to the gas handling system and flushed with the operating gas mixture. The amount of gas flushing through the system should be the equivalent of at least two times the chamber volume before applying any HV to the detector. At this point a second electrical test at a low HV setting of about +200 V is performed thereby identifying potential malfunctions of electric and electronic components. The chamber needs to be tested for potential gas leaks. Measurements will be conducted in addition on the amount of gas entering the chamber and leaving the chamber. If available a gas analyzer can be connected to the chamber exhaust to monitor the gas types exiting the chamber. After these tests the HV is increased in steps while monitoring the wire currents. This procedure is referred to as conditioning. Currents on the wires should not exceed 10 μA. A successful conditioning will reach HV settings beyond the anticipated

+2450 V but no further than +2600 V. The limits on HV and current on the power supply needs to be set accordingly to prevent any potential damage to the chamber. These numbers apply to the nominal 40/60% Ar/CO_2 mixture gas mixture.

2.1 Gas System

It is foreseen to operate the chamber with Ar gas and a 60% CO_2 admixture. The mixing has to be done on-line using either vernier style manual flow meter or automatic remote controlled flow controllers. A mineral oil bubbler needs to be introduced at the exhaust of the chamber to monitor gas flow. If available a gas spectrograph will be used to monitor the exhaust gas from the chamber.

3 Tests with Sr90 and Fe55 sources

The Sr90 source provides electrons with sufficient energy to pass through the full detector package and trigger a scintillator detector positioned behind the chamber. The maximum electron energy is about 2.5 MeV. Tests with a Sr90 source and kapton foil with 5 μm copper coating show that about 30% of the initial electrons will pass through 24 layers of this foil and generate a trigger in a plastic scintillator detector. This material is equivalent to 1.05% of one radiation length and is considerably more than the total thickness of one full FDC detector package built from 2 μm thick copper strip kapton foils which amounts to 0.73% of one radiation length. Following this approach to test the prototype chamber allows the operation of the chamber in same vertical orientation as in the final installation.

3.1 Sr90 Setup

The collimated Sr90 source is mounted on a U-shaped jig on one end of the U-tip while the scintillator detector is mounted on the other end of the U-tip aligned with the Sr90 source. The depth of the U-jig is large enough to position the source anywhere on the active surface of the chamber. The signal of the trigger scintillator is multiplexed and connected to a discriminator to generate a trigger signal for the data acquisition system (DAQ). The analog signal is recorded by an ADC while the timing of the trigger is recorded by the F1TDC. At the same time the signals from the chamber wires and cathode strips are recorded by the F1TDC and the fADC125. From this data the detection efficiency of individual wires can be tested as a function of HV, wire length and wire position. The wires in the central area of the wire chamber have been coated with copper to render them insensitive at this location. This can also be tested with this setup.

3.2 HV scans

Data needs to be recorded with the Sr90 at different operating parameters of the chamber. For different gas mixtures HV scans need to be done to investigate the properties and performance of the chamber. These data can be compared to Garfield simulations to verify the expected behavior. The scan of the sense wire HV should be performed for various settings of the field wire HV (e.g. -500 V, -600 V, -700 V). The rates and efficiency of these scans should be plotted as a function of the Voltage difference between sens and field wire. Based on the results from these tests the basic nominal operating parameters of the chamber will be determined (HV, Gas mixture). Operating the chamber at these determined parameters will then provide data to determine the efficiency of the wires as function of position along the wire and of different wire length. Similar the performance of the strips will be tested and documented.

3.3 Gas Gain tests with Fe55

The Fe55 radioactive source provides 5.9 keV γ- rays and can be used to determined the gas gain. The sense wire triggers the DAQ and the mean charge of the events can be determined using a charge integrating ADC or using the data from the fADC125. The gain is then the charge divided by the electric charge e and the mean number of electrons liberated by a γ ray which depends on the gas mixture. Typical values are 200 to 250.

3.4 Noise Studies

Electronic noise on the wire and cathode strip signals need to be determined and minimized. Most likely causes for noise are missing or inadequate electric shielding and grounding. The electronics in particular the preamplifier cards need to be shielded. Usually these electronic parts are contained completely within copper casings where small slits allow for the flat ribbon cables to pass through. In this particular case due to material budget consideration there is no copper casing, however the electronics is located between the chamber frames that provide some shielding. The noise needs to be recorded and possible steps to minimize the noise investigated. Noise rates as function of threshold needs to be determined.

4 Cosmic ray test stand

In order to determine the resolution of the prototype chamber it is necessary to have a calibrated tracking detector system in combination with a particle source. A cosmic ray test stand as described above with tracking chambers provides such a test environment. The tracking chambers to be used to provide tracked cosmic rays for testing the prototype chamber are extruded aluminum chambers from Fermilab. These chambers are operated with 90% Ar 10% CO_2 gas mixture. The gas handling system has the capability to use an alcohol bubbler in combination with a refrigerator to treat the gas mixture for the Fermilab chambers. The operating HV for these chambers is about +2100V. Each individual chamber has two staggered rows of

8 and 7 cells respectively. Two planes of these chambers oriented at 90 degree to each other provide a space point. Two such space points one above the prototype chamber and one below the prototype chamber define a track through the prototype chamber.Such a setup allows the determination of the position resolution of the prototype chamber given the knowledge of the resolution of the Fermilab chambers.