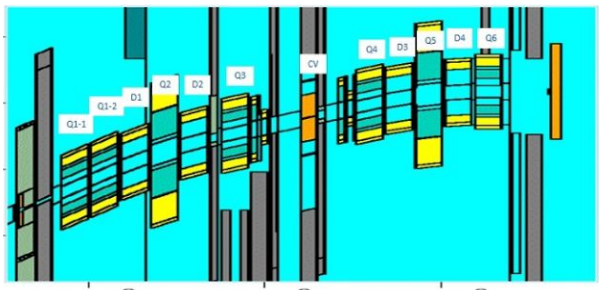
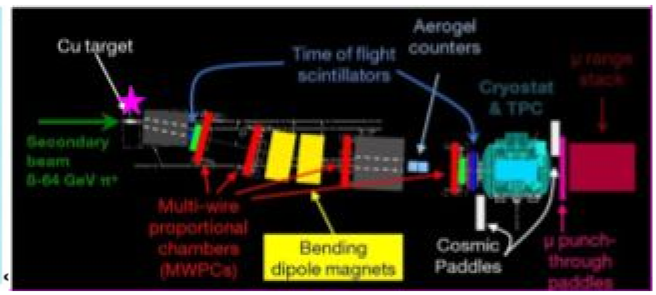
Nintey Degree Target Monitor to Center MCenter secondary beam on Target.
Kathleen Murphy

Intro

A new detector was placed into the MCenter Tunnel. It is located just northwest of the beamline at the secondary target. The goal of this detector is to measure the particle flux at a 90 degree production angle off LArIAT's secondary target. This detector will be used to improve the beam alignment on the target. Below are schematics of the secondary(left) and tertiary(right) beamlines referred to in this paper. The detector is located at the pink star on the tertiary beamline schematic.





Planning and Simulation

G4 Beamline was used to simulate the beam on the target. The code for the beam and target along with a visualization of the final setup is below:

```
physics QGSP_BIC
beam gaussian particle=pi+ meanMomentum=64000 nEvents=200000

#  Cu int. length.  135 g/Cm^2;  density = 9; so int length = 3.9 cm ( 39mm )
# Target is a right parallelogramatic prism 1.25" = 31.75 mm high and
#wide, measured transverse to incoming beam.
# 31.75 mm / (5 tan (16 deg)) = 22.145 mm
# 31.75 mm / (5 tan (13 deg)) = 27.5048 mm (if we make a new one)

# target:
extrusion                    Target                    length=31.75
vertexes='0,0;109.728,31.75;321.056,31.75;     211.328,0;'     material=Cu
color=1,0,1

place Target z=500 y=-31.75/2 rotation=Y90
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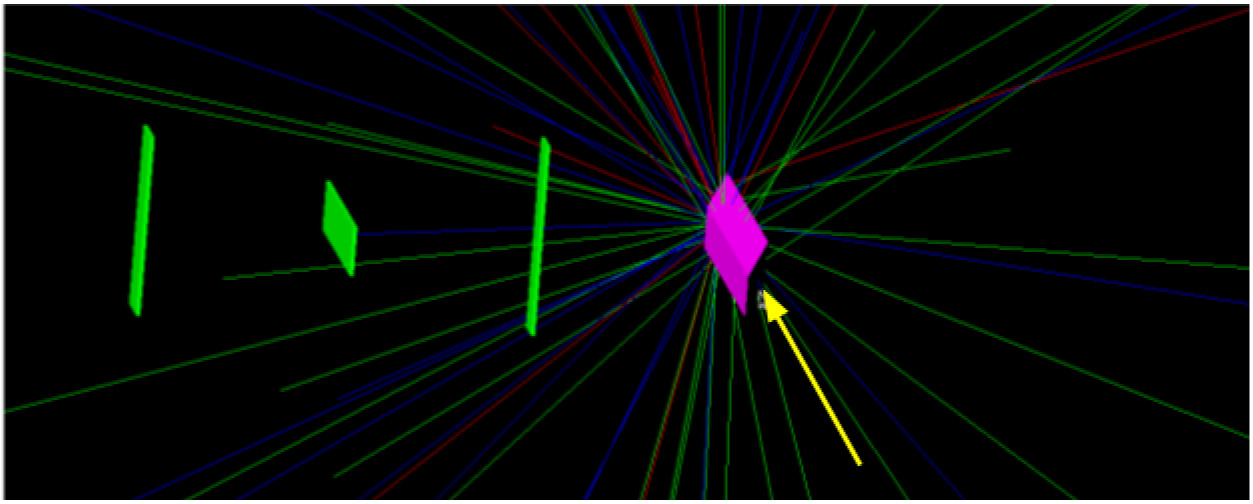


Above: Visualization of one event in G4 Beamline, the magenta prism is the target, the yellow arrow is the incoming beam, the green prisms represent the scintillators, green blue and red lines are neutral, positive and negative particles respectively.

This simulation was tested with a variety of detector setups to optimize detector position.

Design

It was decided that the most practical and effective setup would be three detectors which would line up horizontally and perpendicular to the beamline.The horizontal acces was choesen to decrease noise from cosmics and to simplify building of the stand. By monitoring the particle that come off the target at ninety degrees eliminates signals from muons coming off upstream targets. The coincidence of these three detectors is the indicator of beam on the target. The detectors used were Photomultiplier tubes(PMT) with scintillator put together by interns at the Test Beam Facility. The PMTs were previously used by the test beam facility but were not being used at the time this detector was made. The lengths of the closest scintillator(90° SC1) and the furthest scintillator(90° SC3) are perpendicular to the length of the middle scintillator(90° SC2) and parallel to the beamline. This arrangement is to decrease the solid angle of the coincidence of the three detectors and therefore decrease the signal noise from the primary beam. Steel shielding surrounds the target. A small hole (~1/2in diameter) in these shielding bricks allows particles scattering ninety degrees off the target to come through the shielding and hit the detector.

The Stand

The three scintillators are on a stand made out of 80/20 aluminum channel strut. The heights of the PMTs are easily adjusted with an allen wrench. The PMTs are each held on the stand with 2 hose clamps which can be loosened, to exchange PMTs, using a large flat head screwdriver.

Wiring

The Three PMTs are connected to the patch panel channels MC/HV 30, 31 and 32 and MT/MC 54, 55, and 56 respectively. The patch panel in the tunnel is located just upstream of the stand which delivers signals to a patch panel located in the MCenter control room on rack 1RR12F. All three PMTs are powered by one high voltage source and operate at 1800 V. The three analog signals are converted to digital signals by a quad discriminator which are then fed into a 4-fold logic unit which ultimately outputs the coincidence signal which is counted in a scaler module. This scaler module is an input into Acnet and seen as Acnet parameter F:MC7SC4.

Testing

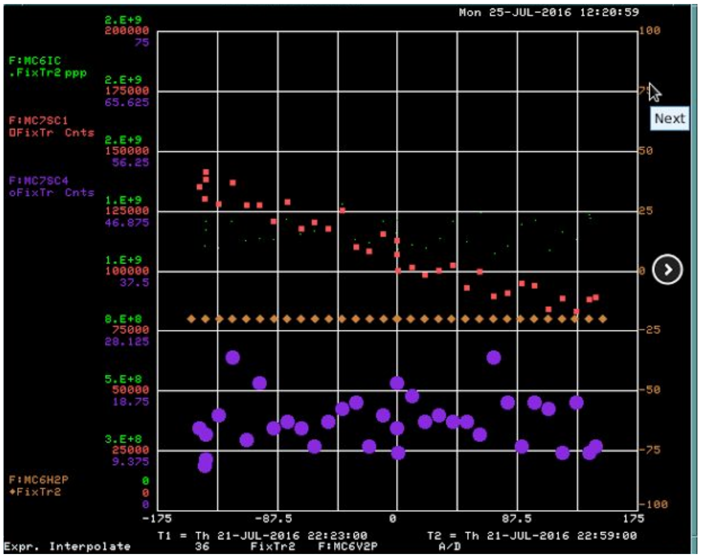
When the beam is off there are very few coincidence hits, about 1 every 2 hours, this establishes the background signals. The detector was then tested with the beam on. The parameter for the detector was plotted in the fast time plotter along with MC6IC and MC7SC1. MC6IC is the signal from an ion chamber that measures primary beam intensity and MC7SC1's signal comes from a scintillator right before the secondary target. The graph below shows one supercycle. It is clear that the counts in the detector increase as the beam hits the target. At typical beam intensities, ~1.0e9 counts in MC6IC, the detector normally sees less than 20 counts per spill. But at higher beam intensities, ~1.0e10 counts in MC6IC, the detector saw 100 to 200 counts.

F:MC7SC4 is the 90 Degree Monitor shown here with primary and secondary beam counters

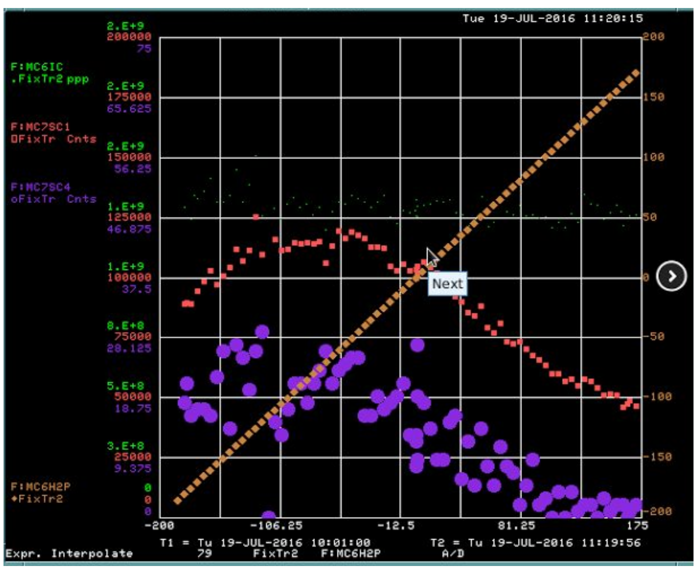
Target Scan

Using Acnet, horizontal and vertical target scans were performed. In the horizontal scan, F:MC6H2, which controls a trim dipole magnet current, was varied from -200 A to 175 A in 5 A intervals. This scanned the beam horizontally across the target. When the beam was bent completely to the Southeast our counter saw no hits indicating the beam was completely off target. As the bend in the beam lessened the counts increased indicating more of the beam began to hit the target. As the beam bent to the northwest side of the target it was not ever clear that the beam was completely off target. This may be caused by the fact that the detector is located on that side and as the beam bent towards it particles from the beam and particles from the beam hitting the shielding were also going through the detector. The peak of the F:MC7SC4 graph is centered around -60 A which shows that the beam is centered on the target when the voltage on trim is set at -60 A. It was previously operated at 0 A.
The vertical scan was not conclusive. The graph below shows there was no clear correlation between the number of hits the detector saw and the current of the vertical trim F:MC6V2. This is most likely because the profile of the beam in the vertical direction is much wider than it is in the horizontal direction. Momentum selection occurs in the Vertical plane, so as the current on the vertical trim changes the target sees a different momentum spread. This could explain why the number of counts in the 90 degree monitor does not seem to vary.

Possible Improvements
The number of counts on the detector is relatively low which makes the uncertainty on our target scan high. Scans were performed one time in each direction and both were relatively fast, 5 A increments per supercycle in the trims current in order to not interfere as much with experimental data. More scans would improve uncertainty.



Vertical Target Scan



Horizontal Target Scan