NAL PROPOSAL No. 325

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STUDY OF DI-MUON PRODUCTION AT HIGH TRANSVERSE MOMENTA

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ADDENDUM TO NAL PROPOSAL 325

THE MULTI-HOLE SPECTROMETER (MHS)

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We have given further consideration to the study of high mass dimuon events. In the original Proposal 325 (E-300 Addendum), we suggested using the east end of the pit being built for Adair (E-48). (We assume the reader has also read the E-300 Addendum). At the time of writing this note (August 1, 1974), the exact location of the pit is still uncertain. In addition, we have done more detailed calculations on muon background and find that a wide detector transverse to the muon direction is far from optimum. For the small angle muons there is insufficient thickness to suppress the μ background from π and K decay, while at larger angles, the desired muons do not have sufficient range. Thus,in this note we propose an alternative scheme which, on the one hand, is an escalation, but, on the other hand, is far superior and sensibly designed.

One should recall that E-100 was the first experiment at FNAL to successfully measure direct muons. Our results are now published (Phys. Rev. Letters 33, 114, 1974). We are most eager to continue this work in a modest but significant way. We realize that there are many muon experiments approved or proposed. We are still behaving as scientists, trying to follow up on a discovery with a reasonable next step, given the limitations of our location and apparatus.

It is well known that the invariant π and K production cross sections are functions only of $p_{\perp}$ in the central region (x = 0.) Thus, if one builds a detector parallel to the proton beam, the decay muons must penetrate a fixed amount of transverse shielding independent of angle with respect to the incident beam. We have designed a detector which has a fixed $p_{\perp}$ = 1.5 GeV/c cutoff for muons.

The detector is a set of 10 6' x 4' x 1' liquid scintillation counters, each placed in a 4' diameter 17' deep hole. The 10 holes are placed along a line 19' displaced from the incident beam direction. One has 15' of transverse earth shielding which corresponds to a 1.5 GeV/c cutoff in transverse momentum. The holes, which begin at 140' from the target, increase in distances from another in geometric progression with a factor 1.166 in distance from one to another.

Figure 1 shows a layout of this "Multi-Hole Spectrometer" (MHS). The spacing of the detectors is such that each has a 1' overlap with its neighbors for muons that travel in a straight line from the target. This overlap assures that no muon can scatter around a detector. In the center of mass of a 300 GeV pp collision, the detector subtends a polar angle of 45° to 120°. It subtends an azimuthal angle of 18°.

As in our previous proposal, we plan to interrogate the multi-hole spectrometer each time a direct muon is detected in our E-100 spectrometer. Given a direct muon in the spectrometer from parton-anti-parton annihilation, we expect to observe the other muon in the MHS with a probability of 0.8 or greater.

We are also eager to operate such a detector in coincidence with identified hadrons in the spectrometer. We would be eager to find out if direct muons are produced in coincidence with hadrons. In particular, people speculate these days that charmed particles might be produced in pairs in ordinary collisions. They are expected to have a finite branching ratio to $K\mu\nu$. Hence, one might observe K,μ coincidences--the K coming from one charmed particle in the pair and the muon from the other of the pair.

Such a device cannot measure the $\mu\mu$ mass accurately. It can however measure the minimum mass which is given by $M_{\mu\mu} \gtrsim (p_{\perp}^{s} + 1.5)$ GeV/c^2 where $p_{\perp}^{s}$ is the transverse momentum setting of the spectrometer and 1.5 is the transverse momentum cutoff of the MHS. If the RMS transverse momentum of $M_{\mu\mu}$ is less than .5 GeV/c, then the dimuon mass resolution is $\Delta M_{\mu\mu}/M_{\mu\mu} \sim 0.1$.

A steel hadron absorber 6" wide and 72" long is placed on the west side of the beam. Figure 2 shows the arrangement of the absorber close to the target. It moves in a transverse direction to the beam for a distance between 0.5" and 2" from the beam. This varies the decay distance for π's and K's by a factor 4. For μ's at .040 mrad the distance varies between (12.5" + λ) and (50" + λ) where λ is the attenuation length in steel measured to be 6.8" in the last experiment. For μ's at .150 mrad the decay distance varies between (3.3" + λ) and (13.3" + λ).

We have calculated the singles rates in the detectors for the absorber close position using the measured invariant cross sections on a heavy target. The rates from π and K decay are found to be $\sim$ 500 μ's/ft^2/10^{12} interacting protons. This is, then, 1.2×10^4 μ's/pulse for one detector and 1.2×10^5 for the entire system. Assuming a 500 msec effective spill, the chance coincidence probability for the entire system is 4×10^{-3}, and 5×10^{-4} for a given detector. This sets a limit on the sensitivity of the apparatus. One notes that the insertion of 12" additional transverse shielding will increase the sensitivity by a factor 5. This could easily be done by inserting a solid steel drawer in position 2D of the target box.

We have consulted a contractor (Case, Roselle, Ill.) for the price of holes. The contractor stated $1500/per hole for 10 4' diameter 17' deep holes lined with corregated steel. The additional cost to place a cover on each hole and a Sears-Roebuck sump inside may cost NAL $500/hole. Our detector cost is estimated to be $1000 each (4 665PM's, 24 cu. ft. liquid scintillator, and a rough aluminum tank.)

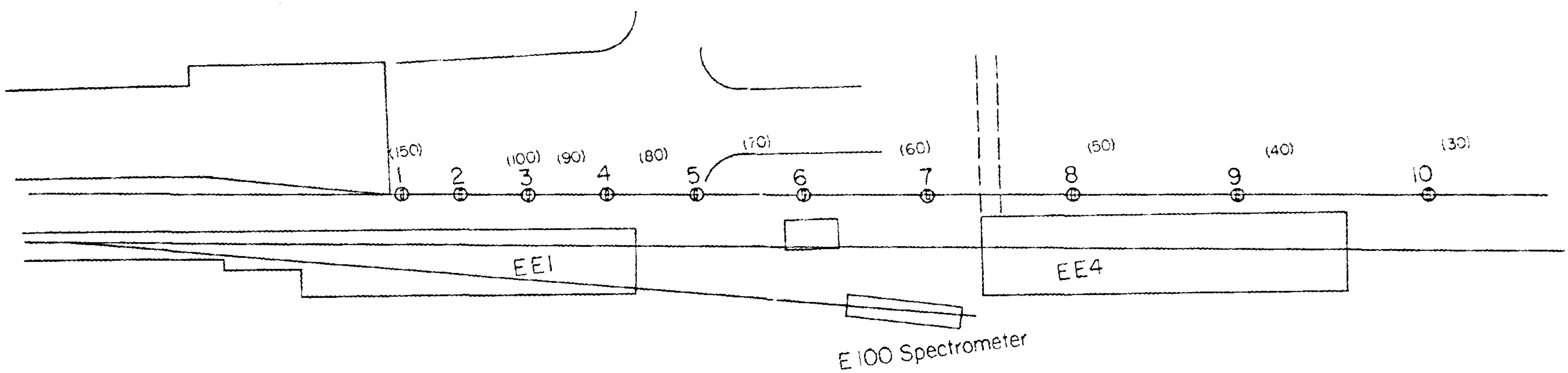
In order to make the MHS less unsightly, we have considered more decorative covers which may enhance the beauty of the site. Figure 3 shows several disguises which might be appropriate.

FIGURE CAPTIONS

Figure 1. The experimental layout. The numbers in parenthesis are angles measured from the beam line in milliradians.

Figure 2. The moveable shutter for the second arm.

Figure 3. Possible decorative covers to the MHS.


(150)
1
2
(100)
3
(90)
4
(80)
5
(70)
6
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7
(50)
8
(40)
9
(30)
10
EE1
EE4
E 100 Spectrometer

Figure 1

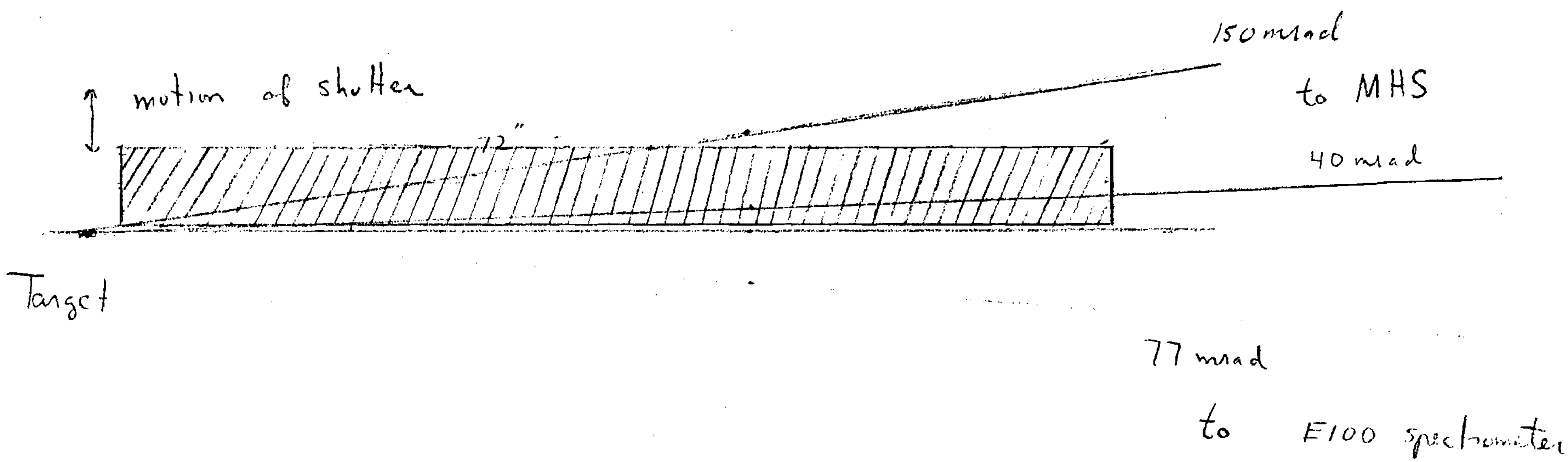
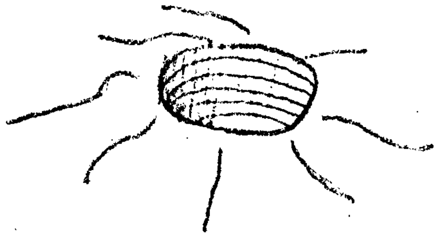
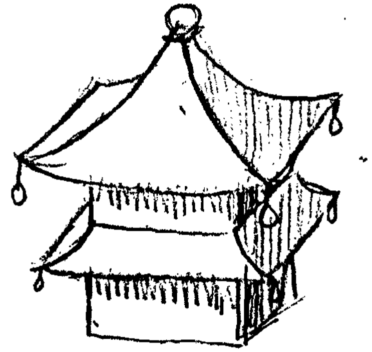

150 mrad
to MHS
motion of shutter
12"
40 mrad
Target
77 mrad
to E100 spectrometer

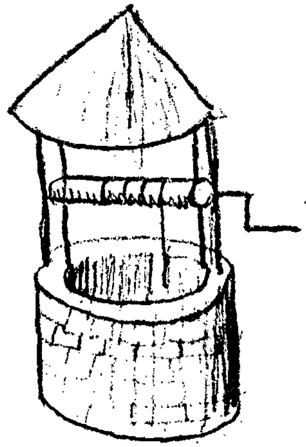
Fig 2



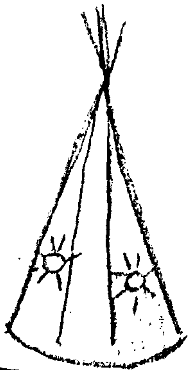
Ugly Exposed Hole



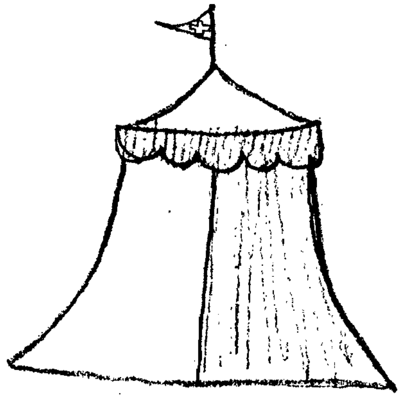
Chinese Pagoda



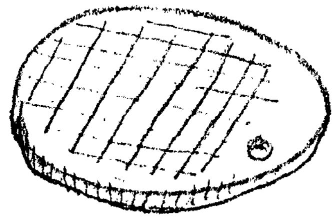
Wishing Well



Tepee



Jousting Tent



Manhole

or Missle silo

Fig 3