NOTE 0221

MUON COOLING EXPERIMENT-
MC SIMULATION of BEAM PARTICLE ID

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I. INTRODUCTION

In future tests of a muon cooling channel e,μ.π beam tagging is most effectively accomplished with a threshold cerenkov devise capable of single photoelectron measurement [1]. It would be easy to place a low-mass system forward in the cooling channel to tag incoming beam particles and the again at the rear . Sub-ns timing in such a system can be achieved, limited by PMT response. The essential features of such a system is shown below in figure 1.

1- The entrance window must accommodate a beam spread of spread of σ~2.5cm
2- A solid or liquid radiator can be enveloped by a thin quartz window achieving sensitivity to the near-UV cerenkov photon spectrum.
3- A front surface mirror can reflect light in to a PMT which resides in a field-free region.
4- Possible He filled volume with low mass entrance/exit window.

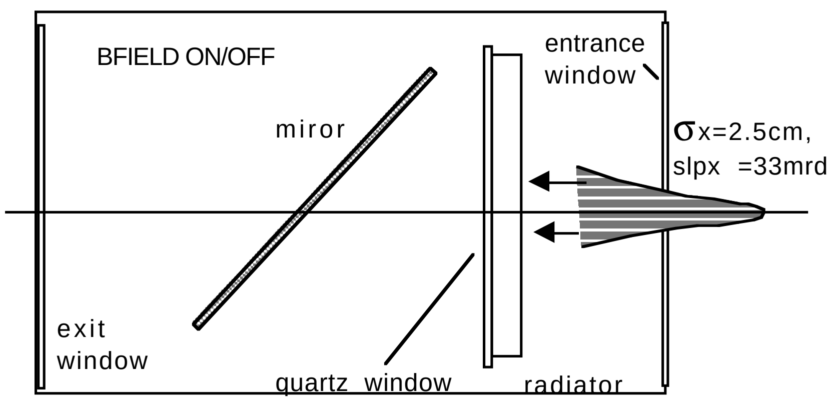

Figure 1: Cerenkov device concept.

II. RADIATORS and LIGHT YIELDS

We have focused on radiators available in the momentum range (180-200) MeV/c. This led to selection of a fluorocarbon such as C6F14 with index of refraction of n=1.244. The light yield and cerenkov angle for C6F14 is shown below , figure 2, as a function of beam momentum. We see it is feasible to use both light yield and angle for particle i.d. discrimination in the broader momentum range 120GeV/c<P<240GeV/c. Other radiators

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can also be useful in this momentum region. In particular water and Teflon-AF. The momentum thresholds can also be extended higher with aerogels n=1.005 – 1.050

Radiator	n	Pe	Pμ	Pπ
C6F14	1.24	.069 KeV/c	143 MeV/c	189 MeV/c
Teflon-AF	1.30	.062 KeV/c	128 MeV/c	167 MeV/c
H2O	1.33	.058 KeV/c	121 MeV/c	159 MeV/c

Table 1: Useful radiators and associated momentum thresholds.

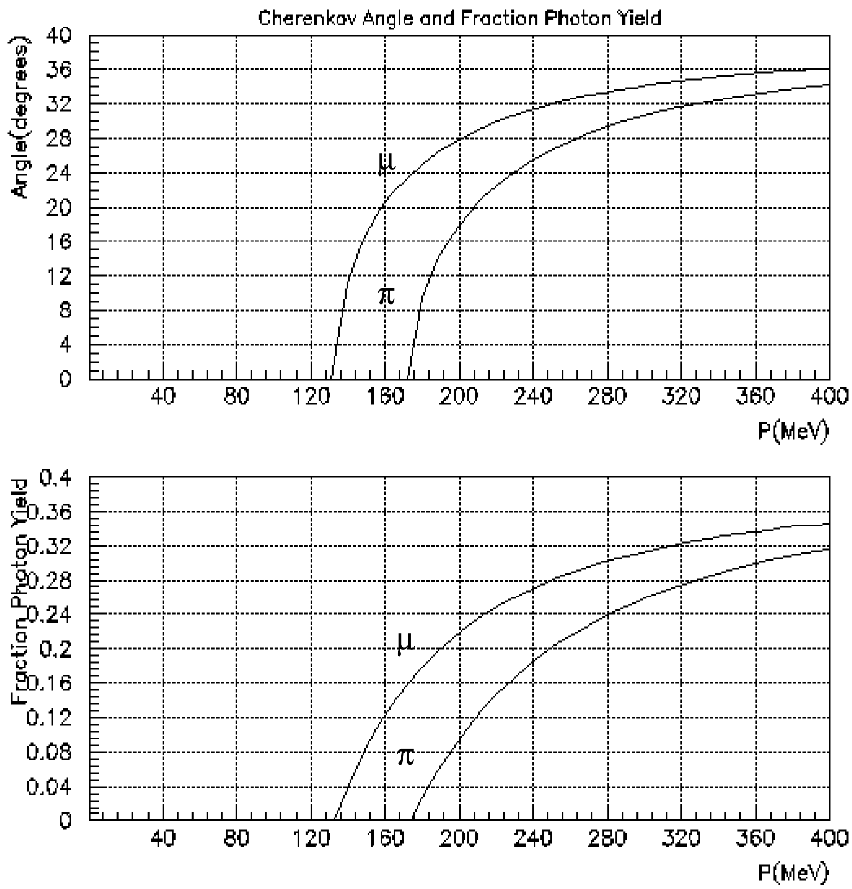

Figure 2: Cerenkov angle and light yield as a function of momentum for C6F14 liquid fluorocarbon radiator for muons and pions.

In figure 3 we simulate a muon beam at Pμ=180.0 MeV/c with 1cm of C6F14 radiator. About 1500 primary photons are released in the range (200-600)nm. After accounting for quantum efficiency losses, window losses, reflectivity loses, 1/2 p.e noise, and 5% beam momentum spread, the light collection yield for electrons, muons, pions is shown.

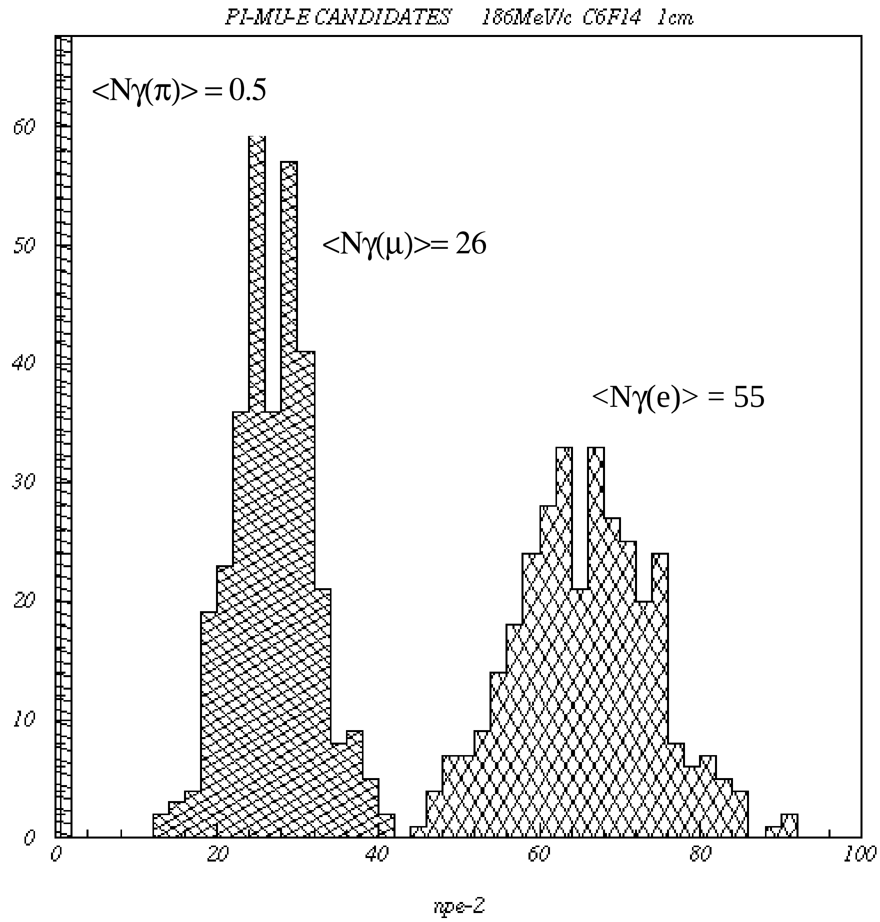

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Figure 3: Light collection averages for incident pions, muons, and electrons at Pbeam=180MeV/c, 1cm C6F14.

III. SEGMENTED READOUT

As previously mentioned one can segment the readout and possibly use the angular ring information to further reduce background, out of time, interacting beam particles, and off-axis events. Such a system is depicted in figure 4. Here a petal-ring of mirrors is used to lightly focus cerenkov light on to a bank of PMTs surrounding the light box. In figure 5 we show the cerenkov light rings (~19cm) projected on to an 8-segment mirror array in front view. The central mirror size is defined by the overlap of the outer ring and can be adjusted. In this model we attempted to balance the photoelectron count in the 8 mirrors. A beam spread of +-2.5cm was used.

A GEANT simulation of muons taking in to account mutliple scattering, energy loss, delta rays, in addition to light light collection has been performed. Beam pions and muons are tagged with good efficiency $\varepsilon_\mu = .98$, and very low mis-id rates $<10^{-5}$.

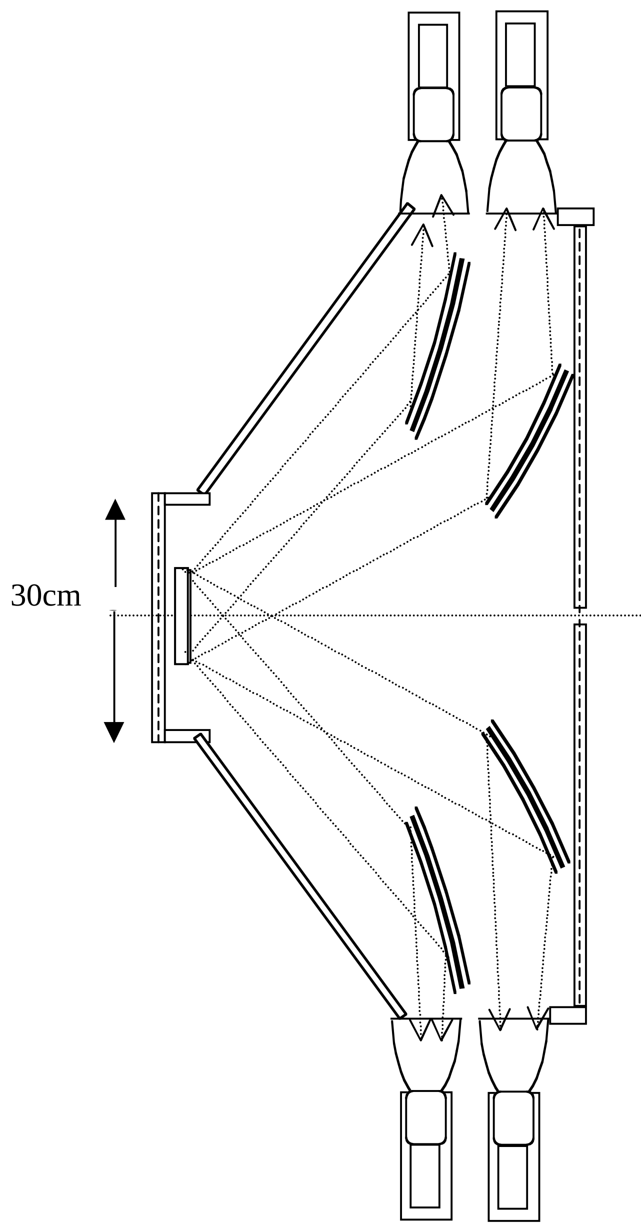

Figure 4: An 8- segmented mirror array surrounding the beam. The radiator measures about 15cm in diameter . The outer mirror array extends to +-40cm.

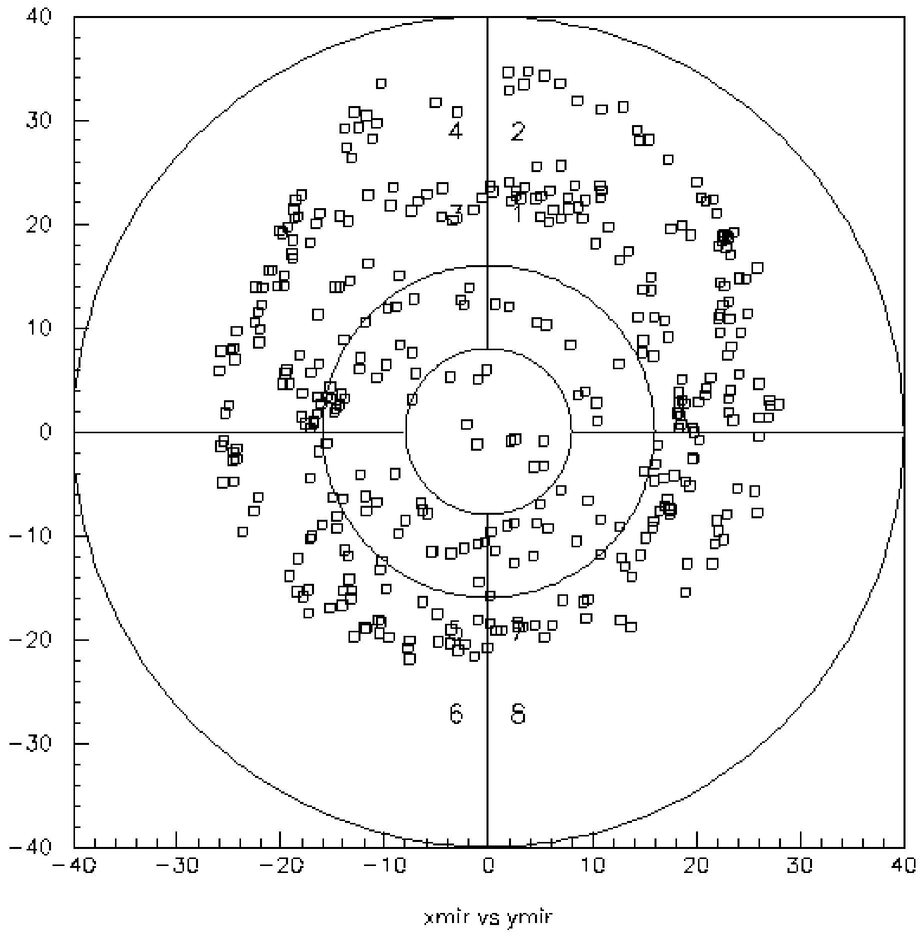

Figure 5: Photoelectrons projected on to the 8-segment mirror array. About 26 photoelectrons per ring are distributed. Here we shown 10 overlapped events with a gaussian beam spread of +-2.5cm.

IV. SUMMARY

With a simple threshold cerenkov device we believe we can discriminate between beam pions, muons, and electrons over a wide range of beam energies with simple radiators. A segmented device might aide in the vetoing of false events. A GEANT simulation is currently available to look at design issues.

REFERENCE

[1] D. Bartlett et al. “Performance of the Cherenkov Counters in the Fermilab Tagged Photon Spectrometer Facility”, Nucl. Instr. Meth. A260 (1987) 55-75