Cherenkov R&D Reprise

D. J. Summers and L. M. Cremaldi

University of Mississippi–Oxford

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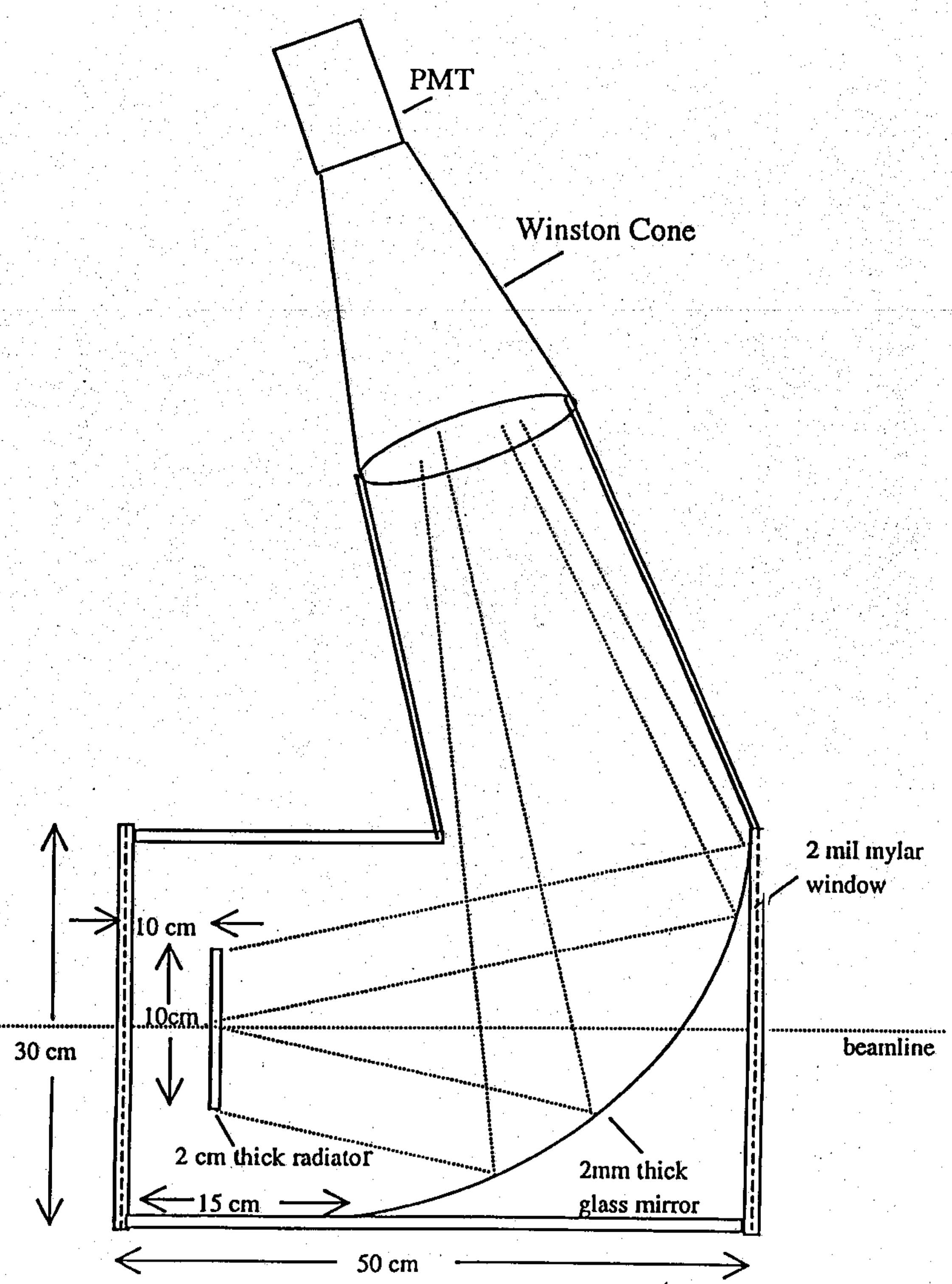
Table 1: Cherenkov thresholds ($p = \gamma\beta m$; $\beta = 1/n$) for electrons, muons, and pions. The refractive indices for C_6F_{14} and C_2F_6 are for 350 nm and are approximations based on linear extrapolations [T. Ypsilantis and J. Seguinot, NIM **A343** (1994) 30]. DELPHI [http://wwwcn.cern.ch/ ~reale/ richmain.html] and SLD use C_6F_{14} as a liquid Cherenkov radiator. BELLE at KEK plans to use silica aerogel [Cantin et al., NIM **118** (1974) 177] .

Material	Boiling Point ^{0}K	Density g/cm^3	X_0 mm	Length mm/15pe	Refractive Index n	Electron MeV/c	Muon MeV/c	Pion MeV/c
Polystyrene		1.03	424	4	1.581	0.42	86	114
Quartz	2500	2.20	123	4	1.458	0.48	99	132
Water	373	1.00	361	5	1.33	0.58	120	159
C_6F_{14}	329	1.68	206	6	1.244	0.69	143	189
C_2F_6	195	1.61	~200	7	1.222	0.73	150	199
LN_2	77	0.81	471	7	1.205	0.76	157	208
LD_2	24	0.18	7540	10	1.128	0.98	202	267
LH_2	20	0.071	8900	12	1.112	1.05	217	287
LNe	27	1.206	240	14	1.092	1.16	241	318
Aerogel	2500	0.30	995	16	1.075	1.30	268	354
Aerogel	2500	0.20	1490	24	1.050	1.60	330	436
Aerogel	2500	0.15	1990	31	1.038	1.84	379	501
Aerogel	2500	0.10	2985	46	1.025	2.27	470	620
Isobutane	261	0.0027	169300	581	1.0019	8.29	1710	2260

PARTICLE ID


PMT
Winston Cone
2 mil mylar window
10 cm
10cm
30 cm
beamline
2 cm thick radiator
2mm thick glass mirror
15 cm
50 cm

NUCLEAR INSTRUMENTS AND METHODS 169 (1980) 397-399; © NORTH-HOLLAND PUBLISHING CO.

FABRICATION AND USE OF LARGE ELLIPSOIDAL MIRRORS IN COLLIDING BEAM CHERENKOV COUNTERS

M. IZEN, R. V. KLINE and E. SADOWSKI

High Energy Physics Laboratory, Harvard University, Cambridge, MA USA

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The construction of Cherenkov counter mirrors with an ellipsoidal shape suitable for the point-to-point focus requirements of a colliding beam detector is described.

1. Introduction

The particle identification system in CLEO, the large magnetic detector for use at the Cornell Electron Storage Rings (CESR), makes use of two high-pressure (6 atm Freon 12) Cherenkov counters. These counters employ large ellipsoidal mirrors to focus Cherenkov light onto five-inch photomultiplier tubes.

The geometry of the mirrors was suggested by the need to focus light from the crossing point of the colliding beams to the photomultiplier tubes. Two differently shaped mirrors, henceforth to be called "inner" and "outer", were needed, because the mirrors were at different distance from the intersection region. The photomultiplier tubes were housed in their own pressure vessels. These pressure vessels were located to the side of the pressure tank enclosing the whole counter in order to minimize the amount of solid angle obstructed. The location of the photomultiplier tube pressure vessels required a left-handed and a right-handed version of each mirror shape so that a total of four mirror types were made. The geometry of the optics is shown in fig. 1.

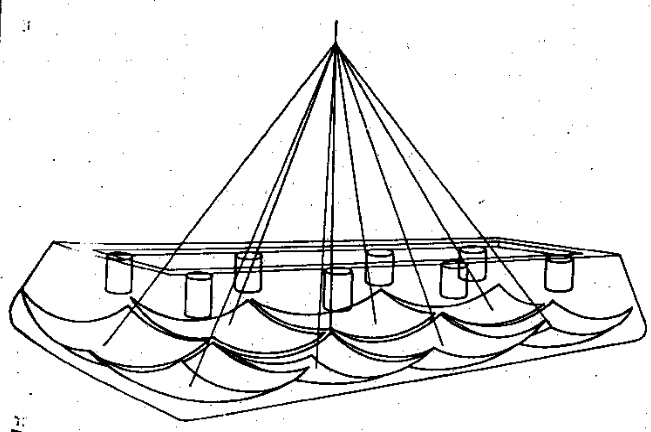

Fig. 1. Isometric of Cherenkov counter optics.

The mirrors were made of aluminized Plexiglas-K® plastic[1]). Plexiglas-K was used because of its superior thermoformability. The mirrors were typically 32 inches square with one focus about 20 inches from the mirror surface.

2. Construction

Concave mirror molds were constructed of cast aluminum[2]) which was ribbed on the rear surface to reduce mass and cost. The raw casting corresponded roughly to the mirror shape on the front surface, with excess material left for final machining. Two molds, again to be called "inner" and "outer" were used to make the four mirror types.

The shape of the optical surface was determined using a Monte Carlo program that modelled the optics of the counter. A function describing the surface was derived and this was input for a five-axis omnimill digital milling machine[3]). The machined surface was left rough (500 micro-inch surface) so that a vacuum could be pulled between the mold and the plastic. Vacuum holes ($\frac{1}{16}$" diameter) were drilled into the mold. These left imprints on the back of the mirror which later served as reference marks when the mirrors were layed out and mounted. A groove was cut around the edge of each mold for a $\frac{1}{4}$" silicone "O"-ring, which was cemented in place with high-temperature adhesive[4]). It was found that on the outer mold two strips of silicone rubber tape[5]) (closed cell) $\frac{1}{2}$" by $\frac{3}{16}$", instead of the "O"-ring, made it easier to seal. After making three mirrors the tape had to be replaced because it took a permanent set and would no longer seal. Shallow grooves radiated from each vacuum hole to insure that a good vacuum was pulled between the mold and mirror. Even though the mold was somewhat porous (sand casting), a vacuum of 6 cm Hg was obtained. Clamps[6]) around the perimeter of each mirror were used to create a

PROGRESS on MC SIMULATION of PID

L.Cremaldi, P.Rubinov, D. Summers
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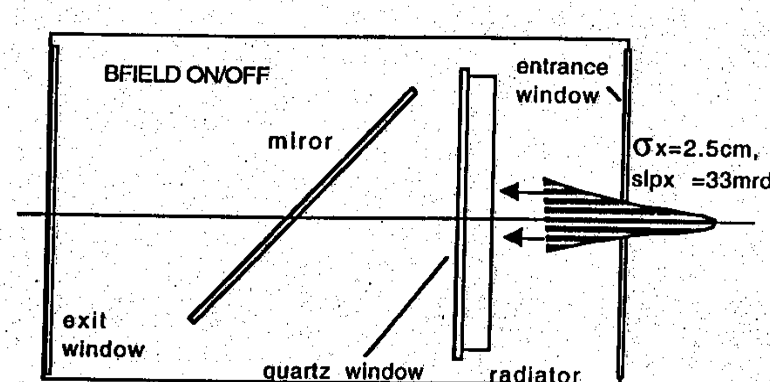
4x

- MUCOOL GEANT PID Simulation

1/2 mm - entrance window
1.00cm - fc-72 Cv radiator
1/2 mm - quartz window
30 cm - He gap
1/2 mm - glass mirror
1/2 mm - exit window



- P_{inc} = 180 MeV π, μ, e (No decays)
- n = 1.244 ΔZ=1CM OF C6F14 (FC72)
- Features:

-$d\lambda/\lambda^2$ spectrum
-chromatic dispersion
-1/2 PE noise
-Q(λ) PMT quantum efficiency
-T(λ) quartz transmission

- <NPe>= 0.5/cm π

<NPe>= 18/cm μ $\varepsilon_\mu \approx .98 \rightarrow r_e^{misid} \approx 4\times10^{-3}$, $r_\pi^{misid} < 10^{-5}$
<NPe>= 45/cm e

- NEAR FUTURE- DECAYS IN FLIGHT
REFINEMENT OF CONSTANTS

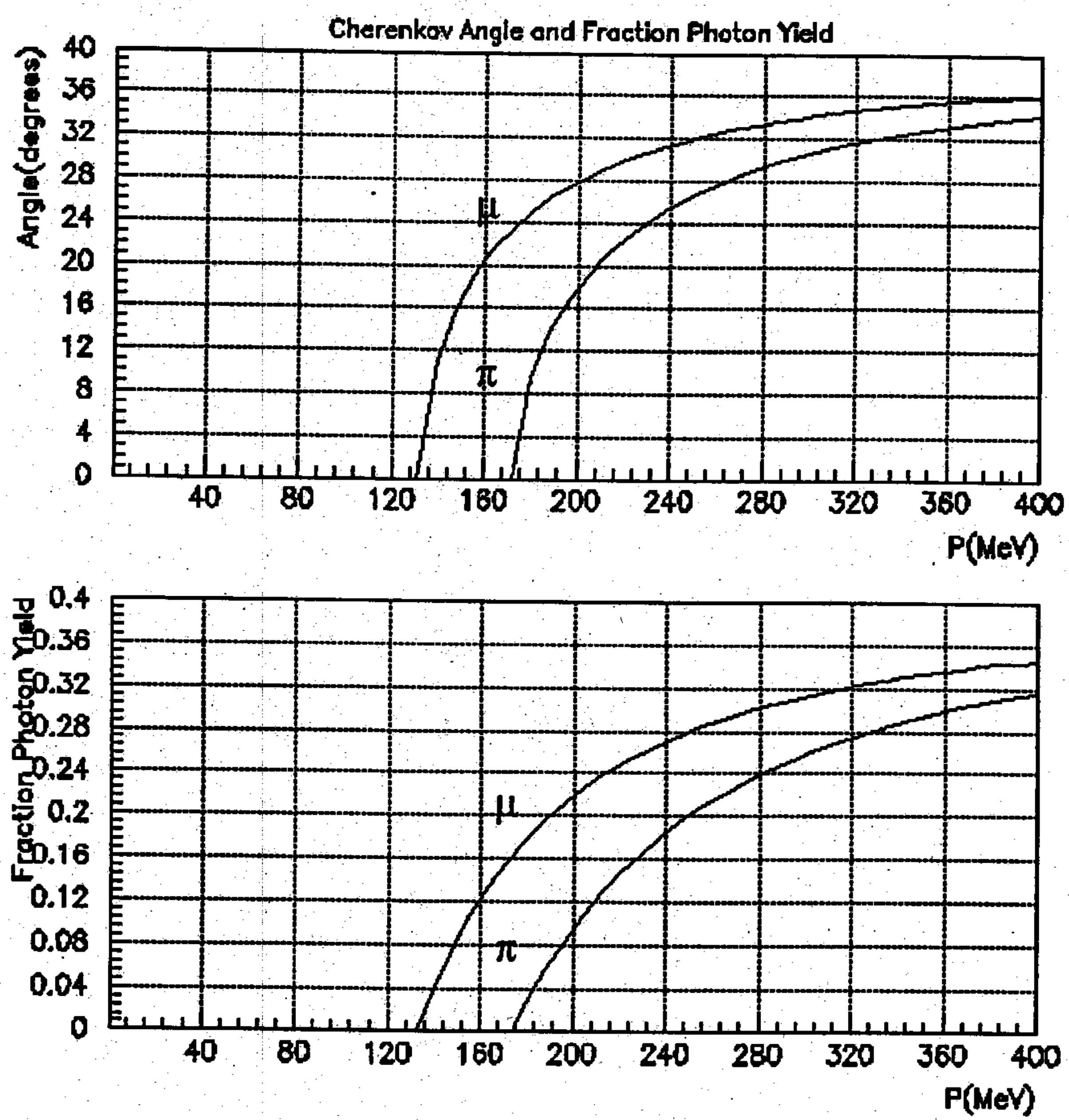


Figure 2: Cerenkov angle and light yield as a function of momentum for C6F14 liquid fluorocarbon radiator for muons and pions.

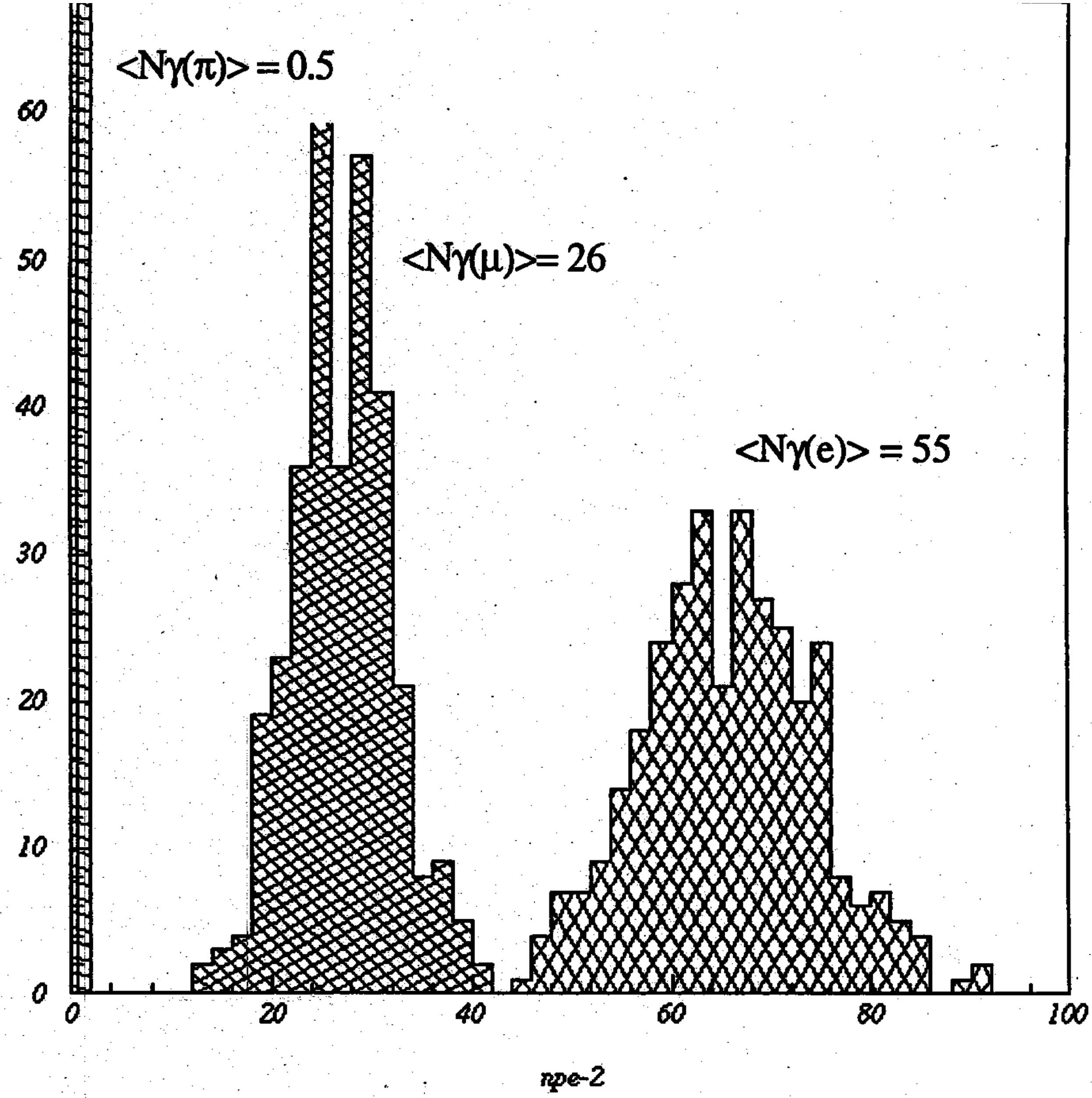
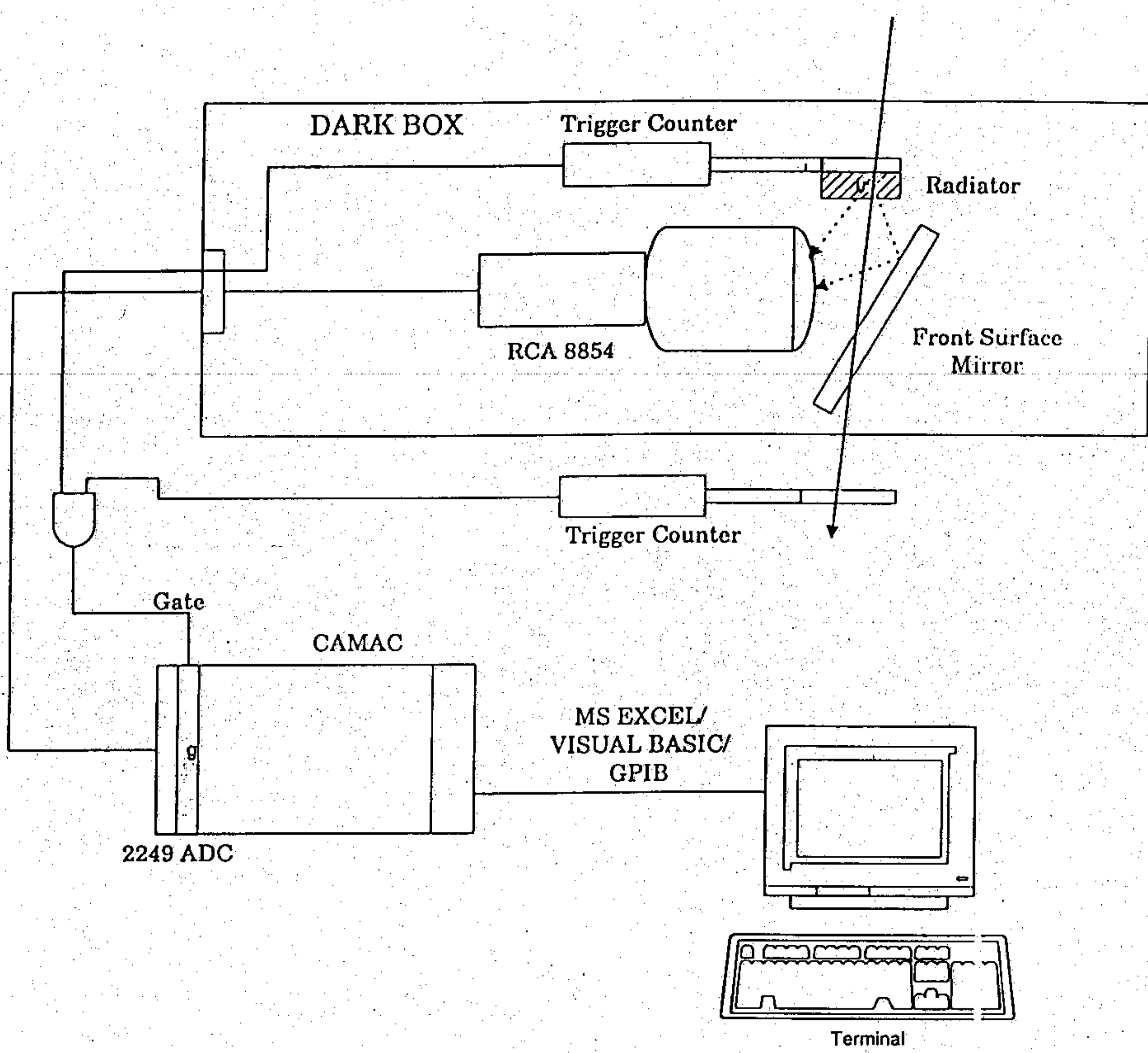


Figure 3: Light collection averages for incident pions, muons, and electrons at Pbeam=180MeV/c, 1cm C6F14.

EXPERIMENTAL SETUP



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form fe off

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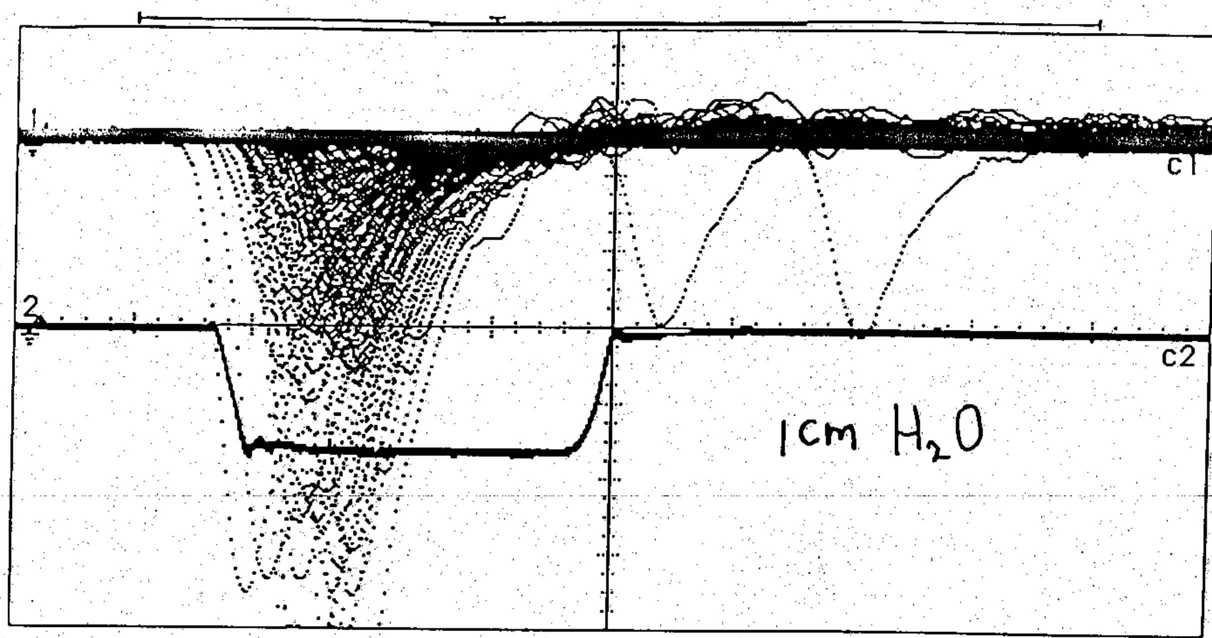

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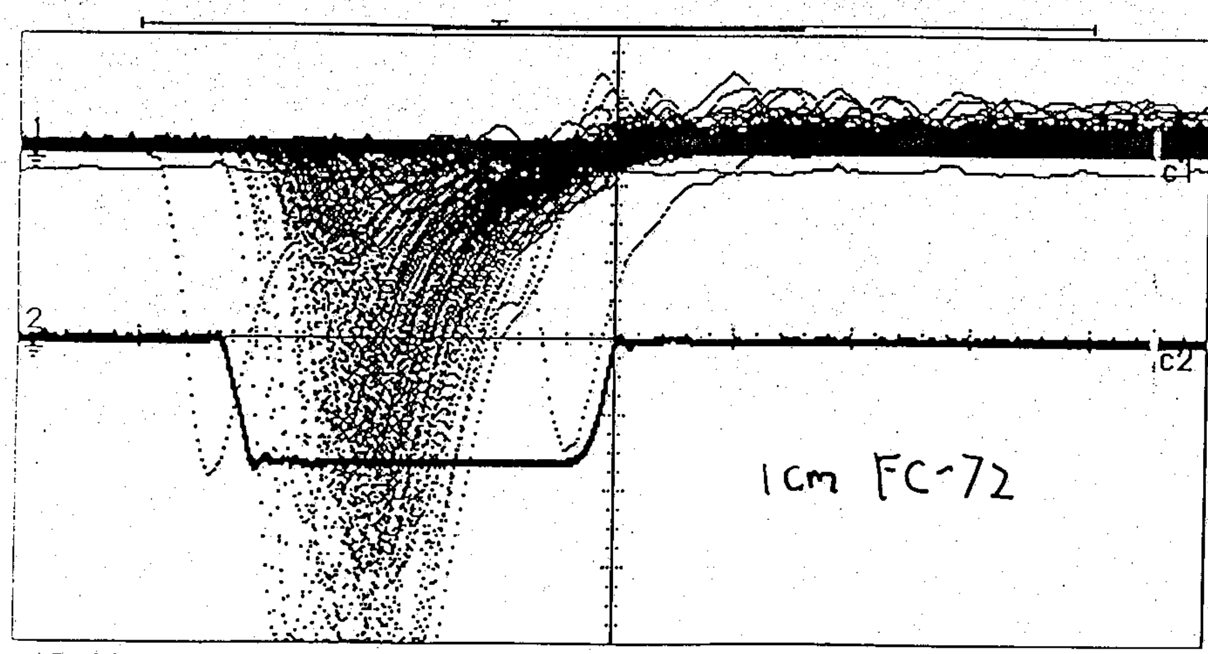


1 10.0 m
pos: -25.
1.000:1 5

2 500 m
pos: 0.0
1.000:1 5

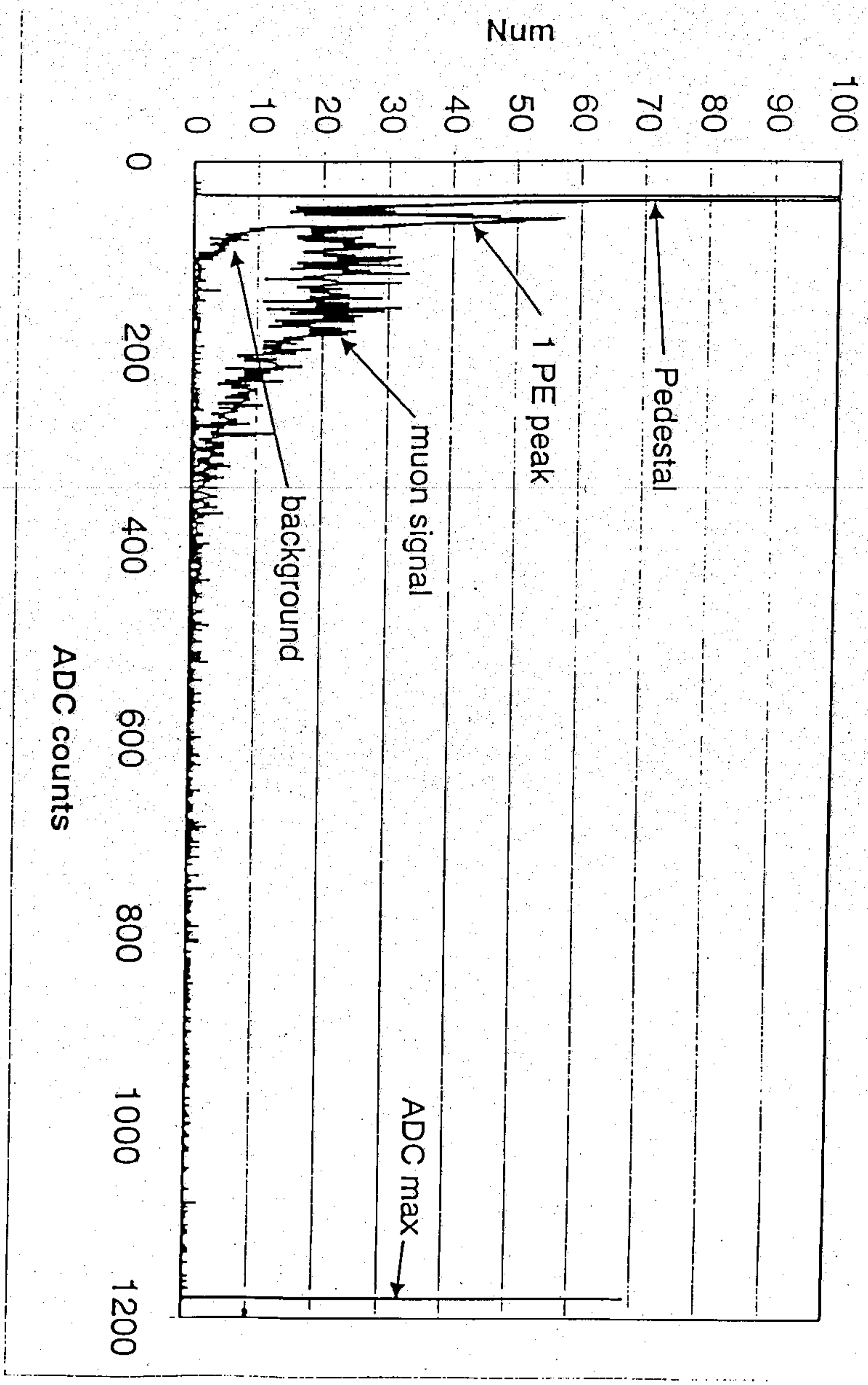
-18.000 ns | 32.000 ns | 82.000 ns

10.0 ns/div

realtime Trigger Mod
Edge

1 10.0 mV/ 2 500 mV/
-25.0000 mV 0.00000 V

Muons through H2O



hep-ex/9707042 31 Jul 1997

Monte-Carlo Simulation for an Aerogel Čerenkov Counter*

R. Suda[a], M. Watanabe[b], R. Enomoto[c†], T. Iijima[c], I. Adachi[c], H. Hattori[d], T. Kuniya[e], T. Ooba[b], T. Sumiyoshi[c], and Y. Yoshida[f]

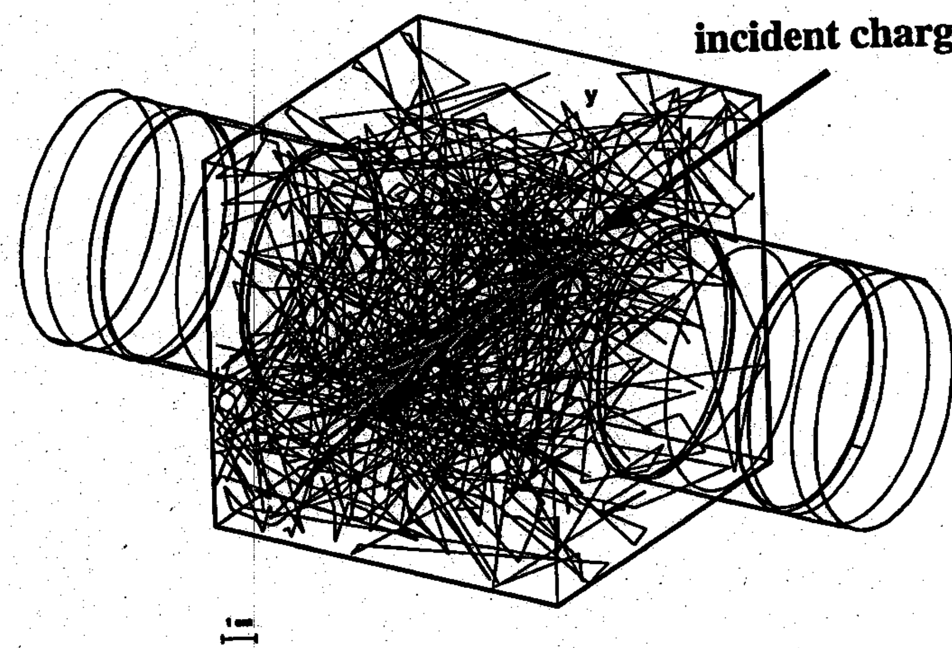


Figure 14: Event display of the Monte-Carlo simulation. The lines are the photon trajectories.

NOTE 0221

MUON COOLING EXPERIMENT-
MC SIMULATION of BEAM PARTICLE ID

L. Cremaldi*, D.Summers
University of Mississippi
Oct 10, 2001

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.

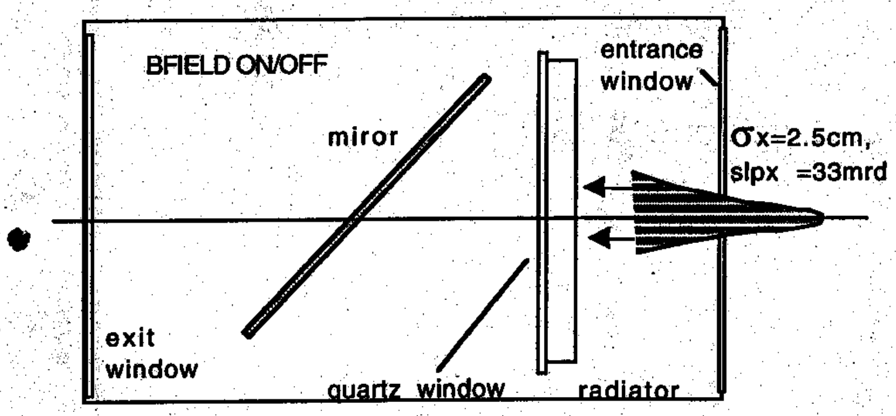


Figure 1: Cerenkov device concept.

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

* cremaldi@phy.olemiss.edu