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EARLY π° PARTICLE PRODUCTION SURVEY WITH THE GAS JET TARGET

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ABSTRACT

We wish to measure the photon yield from the gas target to be situated at the Co straight section. Several angles will be surveyed using existing lead glass counters. This information will be used for comparison with production models for π^0 mesons making possible an early estimate of the low energy neutrino yield for a broad band neutrino beam. In addition K meson yield measurements will be attempted by looking at downstream γ sources. The photon yield will also be intrinsically interesting for computing the theoretical yield of electromagnetic processes in the neutrino shield.

Physics Justification

At the earliest possible time after protons are accelerated in the machine it will be important to determine the meson production yields. Such a determination may have an important effect on the early physics program at NAL as well as stimulating the invention of 'clever' experiments. In many ways the easiest spectrum to measure is the π° spectrum using the γ decay spectrum. As a practical technique the π° spectrum might be unfolded by first using existing particle production models such as CKP or Hagedorn and Ranft and comparing the calculated and the measured γ yield. If no existing model works then the π° spectrum could still be unfolded at the expense of more computer time.

Independent of the interest in determining the π° yield it will be of great interest to search for unexpected structure in the photon energy spectrum or the transverse momentum distribution of the photons. For example the production of a high mass W° boson which could decay by the $\gamma + \gamma$ or $\gamma + \pi^\circ$ mode would result in high transverse momentum photons ($P_\perp \sim M_{W/2}$). For a W° mass of 5-20 GeV the $P_\perp$ spectrum would show structure in the vicinity of $M_{W/2}$, at a $P_\perp$ that is highly unlikely for π° production (for $P_\perp \sim 4$ GeV/c^2, the π° production would be down by $\sim e^{-15} \sim 10^{-5}$).

The production of $K^\pm$, K°, Λ, Σ°, Ξ^c and Ω^- particles can give rise to a photon source that is spatially well removed from the gas target. In this case the $P_\perp$ spectrum of the γ's have well defined limits. Except for Ω^- and Ξ decays, the $K^\pm \to \pi^\pm\pi^\circ$ and $K_S^\circ \to \pi^\circ\pi^\circ$ decays give the largest transverse momentum for photons. Table 1 gives the maximum $P_\perp$ of the photons for different particles. The expected yields of $\Xi\Omega^-$'s should be very small compared to K° and K^+ mesons and can be neglected to first order. A measure of energy and angular distributions of the photons coming from a source that is several meters from the target can be used to infer the yield of K_s mesons (the decay length of a 100 GeV/c K meson is ∿ 5 meters). In addition the production of heavy stable particles that live 10^{-10} or longer and decay into high transverse momentum photons might be detected.

The electromagnetic production of various kinds of particles in the ν shield or other targets may be of interest in future experiments. For example heavy lepton pairs can be produced by high energy photons. To estimate the yield of such lepton it will be necessary to know the γ yield. The Ξ° and Ω^- particles should be separable from K°s because of the large

Table 1

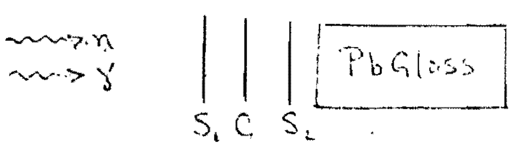
Mode	$P_\perp$ Max. of Photons	
$K^\pm \to \pi^\pm\pi^\circ$	205 MeV/c	
$K_s^\circ \to \pi^\circ\pi^\circ$	209 MeV/c	
$\Lambda \to \pi^\circ n$	104 MeV/c	
$\Sigma^\circ \to \gamma\Lambda$	75 MeV/c	
$\Sigma^+ \to p\pi^\circ$	189 MeV/c	
$\Xi^\circ \to \Lambda\pi^\circ$	135 MeV/c	
$\hookrightarrow n\pi^\circ$	239 MeV/c	
$\to n\pi^\circ$	299 MeV/c	(a forbidden ΔS = 2 transition)
$\Omega^- \to \Xi^-\pi^\circ$	289 MeV/c	
$\to \pi^\circ\Lambda$	424 MeV/c	
$\to \pi^\circ n$	528 MeV/c	

transverse momenta available for these decays. (See Table 1)

Experimental Arrangements

The beam survey suggested here is a 'table top' experiment with an extremely simple apparatus. We intend to use several Pb glass counters that have been recently used by two of us (CR, JP.) in a measurement of $K^\circ_L \to \pi^\circ\pi^\circ$ at CERN. The energy resolution of the counters is expected to be $\sim$ (2-3)% for photon energies above 20 BeV. The diameter of the counters are 10 cm. Placing the counters 5 m downstream of the target gives $\Delta\theta/\theta \sim$ 10mr. The electronic circuits for the experiment are all standard and the data will be recorded by a standard multichannel pulse height analyser. To change the photon angle the table is 'rolled' to another position in the tunnel.

The counter arrangement will be as follows



where S_1 is used to veto charged particles, C is a thin radiator to convert the photons, S_2 and the Pb glass counter are put in coincidence. This scheme separates neutron interactions from photons.* A check on the cleanliness of the photon detection is provided by changing the thickness of the radiator and observing a linear change in the yield. Three to six such counters will be used. We have these counters in hand at present.

The equipment will be entirely tested before putting it into the ring either at the ZGS or at one of the electron machines. We estimate that several days of running with $\sim 10^9$ interactions in the gas jet per machine pulse should be sufficient to obtain reliable yield estimates with which to make first estimates of the neutrino yields at NAL.

* By changing the ratio of absorption to radiation length of the converter.

We want to emphasize that this beam survey will in no way slow up the installation of E1A and in fact may provide important imput for that experiment if the yield measurements are made early enough.

Two of the ~~three~~ four proponents are now in quasi permanent residence at NAL.

We believe that the beam survey proposed here can run simultaneously with the pp scattering experiment. We do not intend to ask for any NAL support for this experiment.