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Aerogel Cherenkov counters for high momentum proton identification

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Abstract

Results from ultrarelativistic heavy ion collisions at RHIC indicate that the identification of protons in a large momentum range until 10 or more GeV/c is crucial for the understanding of the underlying processes that govern the production of high momentum baryons in general, and specifically the protons. We have investigated the possibilities to enlarge the present identification of protons from about 5 to $10-12\,\mathrm{GeV}/c$ using aerogel counters in threshold mode. We present here the simulations for a setup with aerogel cells using one photomultiplier to collect the light emitted and the experimental results for another setup which collects the light via a wavelength shifter foil.

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1. Introduction

One of the most striking observations in the central heavy ion collisions at the Relativistic Heavy Ion Collider (RHIC) is the large enhancement of baryons and antibaryons relative to pions at intermediate $p_T \approx 2-5\,\mathrm{GeV}/c$ [1,2], while the neutral pions and inclusive charged hadrons are strongly suppressed at those p_T. The (anti)proton to pion ratio is enhanced by almost a factor of three when one compares peripheral reactions to the most central Au + Au reactions, as measured

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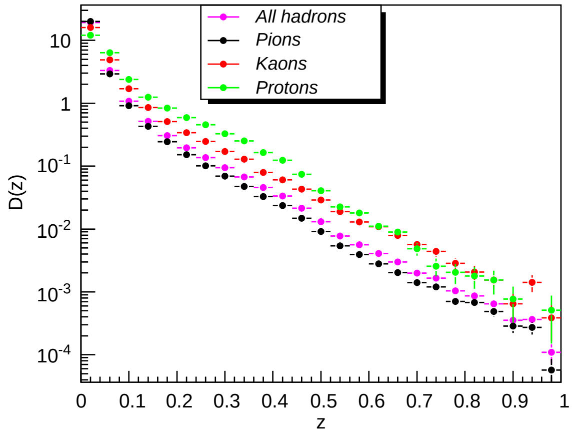

Fig. 1. Normalized fragmentation functions for pions, kaons and protons obtained with a Pythia simulation for an initial parton of 30 GeV.

by PHENIX at RHIC [1,2], hence the large baryon fraction observed by all the RHIC experiments comes as a surprise.

Since it is expected that at momenta of $6-8\,\mathrm{GeV}/c$ the difference in the attenuation of protons will disappear, it would be crucial to measure the protons and the pions in this range. On the other hand, if one looks at fragmentation functions of different hadron species in jets one observes that the different species do have rather different fragmentation functions. In Fig. 1 we show the fragmentation function for a 30 GeV parton. It may therefore be important to be able to identify particles up to higher momenta than anticipated earlier.

In the present work we present two different approaches to the use of aerogel detectors in a heavy ion experiment with little room for the installation. To guide our thoughts we have used the ALICE experiment although no plans to install a very high momentum PID exists at the time of the writing of the article.

2. Threshold aerogel detectors

The technology of aerogel production has reached a level where industrial production of aerogels of indices of refraction ranging from 1.005 till 1.05 is possible with a relatively high

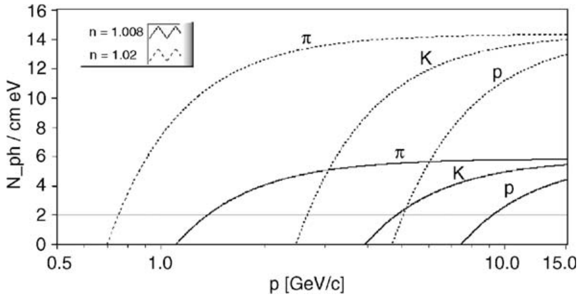

Fig. 2. Photon yield per unit length due to pions, kaons and protons. Two sets of curves corresponding to radiators of indices of refraction 1.008 (solid lines) and 1.02 (dashed lines) are shown.

Rayleigh scattering length. The existing space and the presence of high magnetic fields (0.5 T) preclude the use of aerogel detectors in an imaging mode like in Ref. [3]. We have therefore limited our studies to the use of aerogel in the threshold mode. Before entering in the details of the tested and simulated configurations we present in Fig. 2 the dependence of the yield of Cherenkov photons for two different indices of refraction. We are considering two possible configurations:

(1) two superimposed tiles of aerogel with indices of refraction of 1.008 and 1.02, respectively,
(2) two tiles of 1.005 and 1.02.

In the figure we show the yields of photons ($\mathrm{cm}^{-1}\,\mathrm{eV}^{-1}$) of aerogel material for the case 1. In the same figure we also show the effect of a minimum experimental momentum threshold of 2 photoelectrons on the effective threshold one may reach. The effective thresholds are shown in Table 1.

In the experiment we will use the following information: signal/no signal in one or both detectors, and the momentum information from tracking. In Table 2 we show the ranges of identification for different species. In the case of only one aerogel tiles, which may be necessary for questions of cost, the identification is limited to pions in the range up to $1.4\,\mathrm{GeV}/c$ and protons up to $9\,\mathrm{GeV}/c$ using aerogel of $n = 1.008$. For completeness we also show in Table 2 the ranges of identification using, as the second tile, aerogel of $n = 1.005$.