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The HERMES dual radiator RICH—Performance and impact

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On behalf of the HERMES Collaboration

Abstract

The HERMES RICH is a novel dual radiator detector which provides clean particle identification of pions, kaons, and protons over the traditionally difficult momentum region of 2–15 GeV/c. Extensive operating experience acquired since installation at HERA confirms stable operation at design levels. Particle identification with this instrument has proven to be essential for almost all recent HERMES physics studies. Typical physics results obtained are discussed together with options for improving the RICH performance.
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1. Introduction

Semi-inclusive deep-inelastic scattering in which a hadron is detected in coincidence with a lepton scattered from the incident beam is the primary reaction studied in the HERMES experiment. The detection of an identified coincident hadron provides an added dimension for probing experimentally the flavor structure of elementary particles and related phenomena. For the kinematics characteristic of the HERMES beam energy of 27.5 GeV, 95% of the hadrons produced are in the momentum range of 2–15 GeV/c, a range in which clean particle identification using ring-imaging Cherenkov (RICH) detectors has been very difficult. Liquid radiators are usually employed only for momenta <2 GeV/c while gas radiators become operative for momenta typically >10 GeV/c. However, with the development of clear hydrophobic aerogels [1,2] with indices of refraction in the range 1.01–1.05, for the first time RICH technology can conveniently span this kinematic region.

The HERMES collaboration exploited this development in 1998, and installed a novel dual radiator RICH detector which used the clear aerogel in combination with a heavy gas, C_4F_{10},

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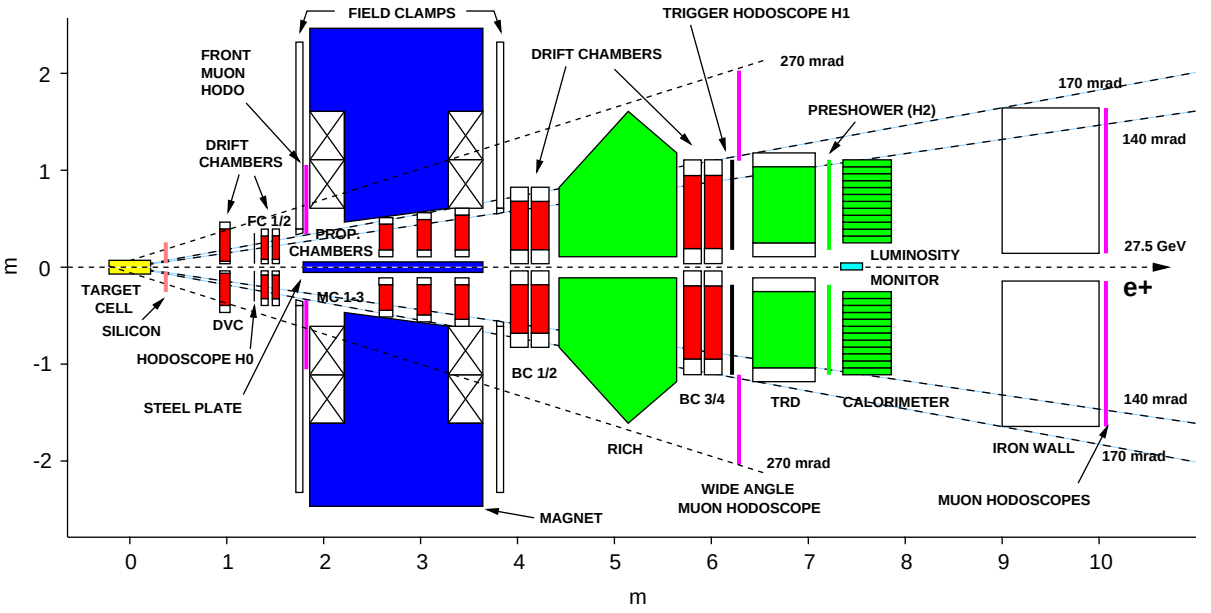

Fig. 1. Side view of the HERMES spectrometer. The lepton beam enters from the left. The spectrometer is split into two halves, one below and one above the beam, by a flux exclusion plate that shields the beams from the magnetic field.

to provide clean separation of pions, kaons, and protons over most of the acceptance of the HERMES experiment. The instrument has functioned reliably without detectable degradation in performance since that time. The general features of the design, its operation, recent physics results obtained with its use, as well as possibilities for improving its performance are discussed in the following sections.

2. Detector design

The HERMES spectrometer, shown in Fig. 1, is a forward spectrometer designed to detect a scattered electron/positron as well as hadrons in coincidence. The RICH detector consists of two symmetric RICH modules shown in Fig. 2, which are positioned between the two rear tracking chambers. The aerogel radiator is a wall of tiles configured to fill the entrance of the detector with an aerogel thickness of 5 cm. The unoccupied space of the detector behind the aerogel is filled with the gas radiator, C_4F_{10}. A spherical mirror array located at the rear of the radiator box images

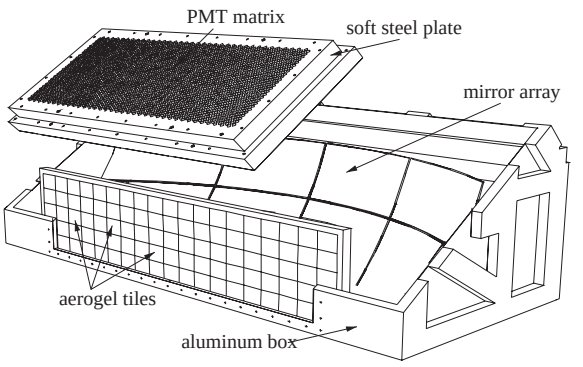

Fig. 2. A cutaway schematic view of the (top) RICH counter.

the Cherenkov light on a focal surface located above (below) the active volume. The mirror array is a graphite fiber composite structure with a radius of curvature of 220 cm. The photon detector is a hexagonal close-packed matrix of 1934 Photonis XP1911/uv green enhanced photomultipliers (PMTs). These $\frac{3}{4}$ in. photomultiplier tubes give a pixel size of 23.3 mm and a corresponding single photon angular resolution of $\approx 6\,mr$. A