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The NA62 RICH detector

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The CERN NA62 experiment aims to measure the ultra-rare (BR ~ 10E-10) charged kaon decay K+−>pi+ nu nubar with a 10% accuracy. The experiment will use part of the existing NA48 infrastructure, but new detectors will be built in order to match the requirements for the novel measurement. The main background, the decay K+−>mu+ nu (BR ~ 63%), must be suppressed by a rejection factor of 4x10E-13. This can be accomplished using a combination of kinematical cuts (8x10E-6), the different power of penetration through matter of pions and muons (10E-5) and a further 5x10E-3 suppression factor can be provided by a RICH detector, in a momentum range between 15 and 35 GeV/c.
To provide such a very demanding task a RICH detector filled with Neon at atmospheric pressure, 18 m long and equipped with 2000 photomultipliers has been proposed. The RICH detector must also provide the pion crossing time with a resolution of the order of 100 ps to minimize wrong matching with the mother particle measured by an upstream detector.
The details of the RICH project will be described. A RICH prototype of the same length of the final detector, equipped with 96 PM's has been built and tested on a pion beam at CERN in the 2007 fall: the results of this test beam as well as results from a second test performed in 2009 using a larger number of PM's and several beams will be presented. The final RICH detector is supposed to be completed in time for the NA62 commissioning run foreseen in 2011.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

The NA62 RICH must identify pions and muons in the momentum range 15 GeV/c to 35 GeV/c with a muon suppression factor better that 10E-2. In order to achieve the required pi/mu separation, the NA62 RICH must have a Cherenkov angle resolution better than 80 μrad. Moreover, it must provide the crossing time of the pion produced in the K+ decay with a resolution of less than 100 ps, useful to suppress accidental coincidences with an upstream beam detector. In order to have full efficiency for a 15 GeV/c momentum pion, the Cherenkov threshold should be about 20% smaller or 12.5 GeV/c, corresponding to (n-1) ≈ 60 × 10E-6. Neon gas at atmospheric pressure fulfils this requirement; it also guarantees a small dispersion. However, the smallness of (n-1) implies a low emission of Cherenkov photons per unit length which should be compensated with a long radiator. The NA62 RICH will make use of the maximum space available along the beam line, i.e. about 18 m. A stainless steel cylindrical vessel is foreseen, about 3.7 m in diameter and 18 m long, with the beam pipe passing through. It will be filled with Neon gas at atmospheric pressure, corresponding to 5.6% radiation lengths. In order to achieve full acceptance coverage for the Cherenkov photons emitted by pions and muons, the total surface of the mirrors will have a diameter of about 3 m. A mosaic given by 20 hexagonal mirrors with 17 m focal length, made of 2.5 cm thick glass, each one inscribed inside a 70 cm diameter circle, will be used. To avoid the beam pipe shadow on the reflected Cherenkov photons, one half of the mirrors will be oriented towards the right side of the beam pipe and one half towards the left one, thus defining two regions in the focal plane to be equipped with photomultipliers, out of the detector acceptance. The centre of each PM region is about 1 m far from the beam pipe axis. Hamamatsu R7400-U03 photomultipliers have been chosen as photo detectors. They are metal packaged single-anode PM with 8 stages, with typical rise time of 0.78 ns, transit time of 5.4 ns and transit time jitter of 0.28 ns (FWHM). The wavelength sensitivity ranges between 185 nm and 650 nm, with maximum response at 420 nm and quantum efficiency of about 20%. Winston cones covered with aluminized mylar will be used as Cherenkov light guides toward the active area of the PM. The PM signal is sent to custom-made current amplifiers with differential output. The amplifiers feed NINO chips used as discriminators operating in time-over-threshold mode. The RICH readout consists of custom made TDC boards (TDCB), equipped with 128 TDC channels based on HPTDC chips. The NINO output signals are sent to FPGA based TELL1 mother boards housing 4 TDCB (512 channels) each. A fast simulation of the NA62 RICH detector as well as a full GEANT4 based Monte Carlo have been developed.

A RICH prototype has been constructed and tested. It consists of a full longitudinal scale (18 m) stainless vessel filled with Neon gas at roughly atmospheric pressure. The diameter is about 60 cm and a single spherical glass mirror, 2.5 cm thick, 50 cm diameter and 17 m focal length, is used, without a beam pipe. In the first test beam, performed in October 2007 at CERN SPS along the K12 beam line, the RICH was equipped with only 96 PM (budget limited). The aim of the test was to measure the number of photoelectrons in each event

and the Cherenkov angle and time resolutions. The average number of PM hits per events was found to be 17 for a pion. The ring centre position was fitted with a resolution of 1.9 mm (RMS) on each coordinate. The pion Cherenkov angle resolution and the average event time (RMS) were measured to be ˜50 μrad and 65 ps, respectively. All results are in good agreement with the expectations of the Monte Carlo simulation.
An improved prototype with 414 photomultipliers and new readout electronics has been tested in May-June 2009. The main purpose of this test was to validate the pi/mu separation and the final readout electronics design, based on TELL1 boards and TDCB cards. The prototype performances have been tested under several conditions: beam momenta (10 to 75 GeV/c), mirror orientation, rates, TELL1 firmware versions, gas contamination (adding air and CO2 to the Neon). The measurements have been repeated with a new mirror, similar to the final ones.
The data analysis is in progress; preliminary results look very promising.

Primary author: Prof. ANZIVINO, Giuseppina (University of Perugia and INFN)

Presenter: Prof. ANZIVINO, Giuseppina (University of Perugia and INFN)

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