

Kaon Identification at NA62

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Abstract. The NA62 experiment at the CERN SPS aims to measure the branching ratio of the very rare kaon decay $K^+ \rightarrow \pi^+ \nu \bar{\nu}$, collecting $\mathcal{O}(100)$ events with a 10% background in 2 years of data taking. A modified CEDAR (Cherenkov Detector with Achromatic Ring focus), named KTAG (Kaon TAGger), will be used to positively identify kaons in the beam, to reduce the background from scattered pions.

1 The NA62 Experiment

The NA62 experiment is a kaon decay in flight experiment at CERN which will begin taking data in October 2014. The primary aim is to measure the branching ratio of the very rare decay $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ which, in the Standard Model, is predicted to be $BR(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (7.81 \pm 0.75 \pm 0.29) \times 10^{-11}$ [1]. High momentum (75 GeV/c) kaons will be obtained by impinging protons from the CERN SPS accelerator onto a target to produce an unseparated beam of protons (22%), pions (72%), and kaons (6%) [2], which will be allowed to decay in vacuum. Since the experimental signature of the signal decay is a single pion and no other detected particles, there is a potential background from beam pions interacting with the residual gas in the vacuum tank. NA62 will use an upgraded CEDAR detector, called KTAG, to positively identify kaons in the beam, relaxing the requirements on the vacuum purity which would otherwise be required.

The specifications of KTAG are driven by the properties of the beam and the background rejection requirements of the NA62 experimental strategy. KTAG must reject pions with a mistagging rate below 10^{-4} , while maintaining a kaon tagging efficiency above 95%. Since the total rate of beam particles is 750 MHz, the kaon crossing time must be measured with a resolution better than 100 ps.

2 Operation of CEDAR and KTAG

When particles travel through a gas at a velocity greater than the local speed of light, they emit Cherenkov radiation at an angle which is a function only of the particle velocity and the refractive index of the medium. In the NA62 beam which has a fixed momentum, a particle's velocity depends only on its mass, and at fixed temperature, the refractive index of a gas depends only on the pressure and the wavelength of light passing through it. The CEDAR detector (Cherenkov Detector with Achromatic Ring focus [3]), uses a chromatic corrector lens to compensate for the wavelength dependence, so that, at a given pressure, light from particles passing through it can be focussed on a ring whose opening angle is determined almost completely by the particle mass.

¹ On behalf of the NA62 Collaboration: Birmingham, Bratislava, Bristol, Bucharest, CERN, Dubna, Fairfax, Ferrara, Florence, Frascati, Glasgow, Liverpool, Louvain, Mainz, Merced, Moscow, Naples, Perugia, Pisa, Prague, Protvino, Rome I, Rome II, San Luis Potosí, Stanford, Sofia, Turin



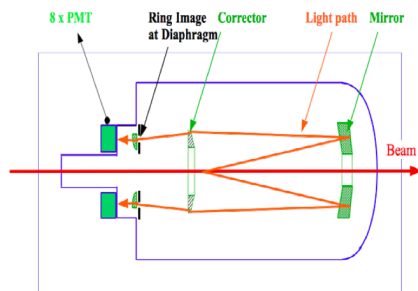


Figure 1: Light path through the CEDAR detector

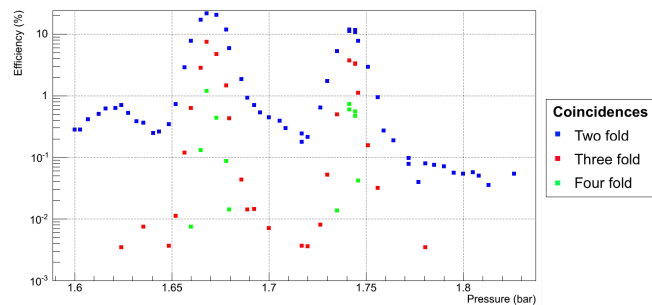


Figure 2: Pressure scan from the 2012 Technical Run showing peaks due to pions (left) and kaons (right)

Figure 1 shows the layout of the CEDAR detector. The beam passes through a steel vessel, 4.5 m long and filled with compressed nitrogen. Cherenkov photons emitted in the gas are reflected at the downstream end of the vessel before passing through a chromatic corrector. The light is focussed on a ring at the upstream end of the detector, whose width (due to chromatic dispersion) is $\Delta r = 2$ mm. A diaphragm of variable annular aperture allows selection of light at a fixed radius – corresponding to particles of a fixed mass, determined by the gas pressure.

In the original CEDAR design, Cherenkov light was detected by 8 photomultiplier tubes (PMTs) at the upstream end of the detector. The high rate expected at NA62 (50 MHz of kaons) would correspond to an unmanageably high flux of 250 MHz of photons per PMT, so a new system has been designed using more PMTs. Light from each of the 8 windows is reflected radially outward by a spherical mirror, spreading the photons evenly over an array of 48 PMTs. The rate of photons on an individual PMT is then reduced to 5 MHz, which can be read out and digitized with a custom electronics chain.

The partially instrumented KTAG was tested in a Technical Run in 2012 [4] and performed as expected. Figure 2 shows the results of scanning the gas pressure to identify light from both pions and kaons.

3 Conclusion

The kaon tagging requirements of NA62 have been met by upgrading the CEDAR detector to perform in a high rate environment. The detector is expected to meet all performance requirements and will begin taking data in October 2014.

4 References

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