PID Acceptance Using TOF, Cerenkov, and Kinematic Fitting

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The HDFAST monte carlo code was used to estimate the acceptance of the Hall D spectrometer for the reaction $\gamma p \rightarrow Mp \rightarrow K^*K^*p \rightarrow K^+K^-\pi^+\pi^-p$ with a 9 GeV photon beam. All events were for a single resonance, M, with a mass of 2.0 GeV and width of 300 MeV, as in the previous simulations. The goal of this study was to determine if kinematic fitting of kaon events would compensate sufficiently for incomplete particle identification to allow one to determine exclusive events with large acceptance. Two atmospheric-pressure Cerenkov detectors were considered, one with an aerogel radiator (n=1.008) and one with C_4F_{10} gas.

Three detector systems were included in the simulation, time-of-flight from the barrel calorimeter (sigma = 250 ps), time-of-flight from the downstream hodoscope (sigma = 80 ps), and threshold momenta for the Cerenkov detector. Proton identification was assumed to be 100 percent efficient. Smeared flight times, momenta and path lengths were used in the calculations (see Fig.1). With the exception of the Cerenkov detector, the geometry of all elements was determined by HDFAST. An additional dead region near the beam was incorporated into the Cerenkov detector. Tracks hitting the detector within 10cm of the beam were not counted.

The tof acceptance for charged tracks was determined by flagging events for which the calculated difference in tof between a pion and kaon of equal momenta was less than three times the resolution of the detector. This three-sigma limit will suppress pion contamination in the kaon signal by about a factor of 25. Three different values were tried for the resolution of the downstream hodoscope: 70, 80, and 90 ps.

The Cerenkov detector was incorporated with sharp thresholds for pion and kaon identification. Since the precise response of the detector is not yet known, the threshold was incorporated at a fixed spacing (100 MeV/c) above the calculated threshold for each particle type to emit Cerenkov light. This produces a momentum window for each radiator for which the detector can identify kaons. The aerogel radiator functions between 1.2 and 4.0 GeV/c, and the gas discriminates at a higher range, 2.8 to 10.0 GeV/c. Table 1 summarizes the detector response when the hodoscope resolution was set to 80 ps.

Table 1: Fraction of events with N ambiguous hits, in percent.

	N=0	N=1	N=2	N=3	N=4
aerogel	15	39	33	11	1
gas	26	43	25	5	1

The results indicate that neither Cerenkov radiator is able to unambiguously identify a large fraction of the events. In principle those events with only one ambiguous meson can be recovered by requiring strangeness conservation. The price one pays is an increased sensitivity to pion contamination. In this report we consider a second approach; events with ambiguous hits were fitted to all available hypotheses and the best fit was chosen. Using this in conjunction with strangeness conservation should yield high acceptance and good background rejection.

The 3-momenta of all tracks were varied in the fit, with constraints provided by energy and momentum conservation. The error matrix from HDFAST was used for each track. For those events having two ambiguous hits, only hypotheses consistent with

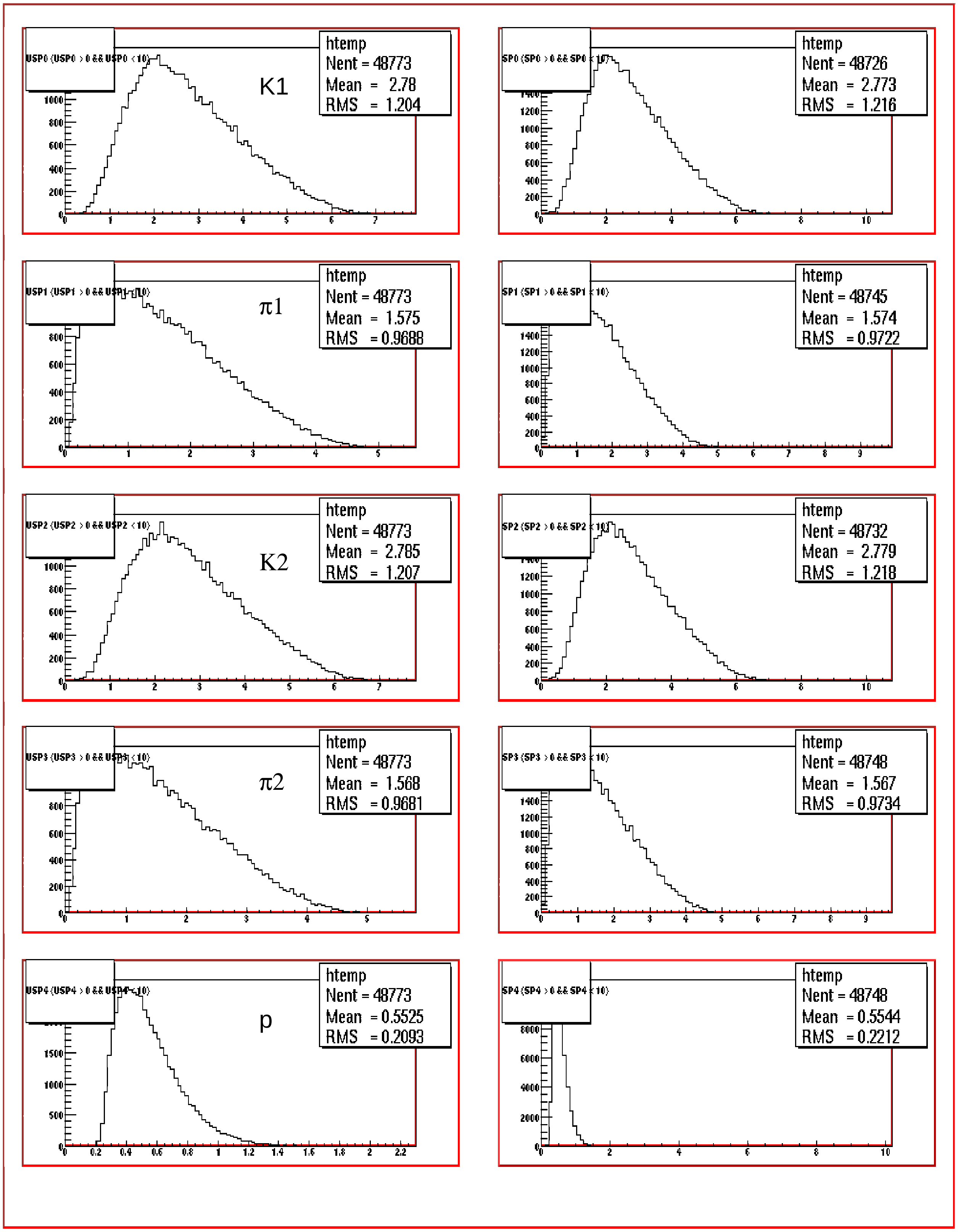

Fig. 1 - Unsmeared (left) and smeared (right) momentum distributions.

strangeness conservation were tested. Table 2 shows the fraction of events that was correctly identified by the kinematic fitting test. These results show that kinematic fitting

Table 2: Acceptance (in percent) when events with N ambiguous hits are fitted.

	N=0	N=0+1	N=0+1+2
aerogel	15	52	83
gas	26	66	88

is an effective method for extending the range of either Cerenkov radiator. The largest losses came from events where one pion and one kaon were ambiguous before the fit. Fig. 2 characterizes the events that were missidentified. The variation of acceptance with TOF resolution is shown in Fig. 3.

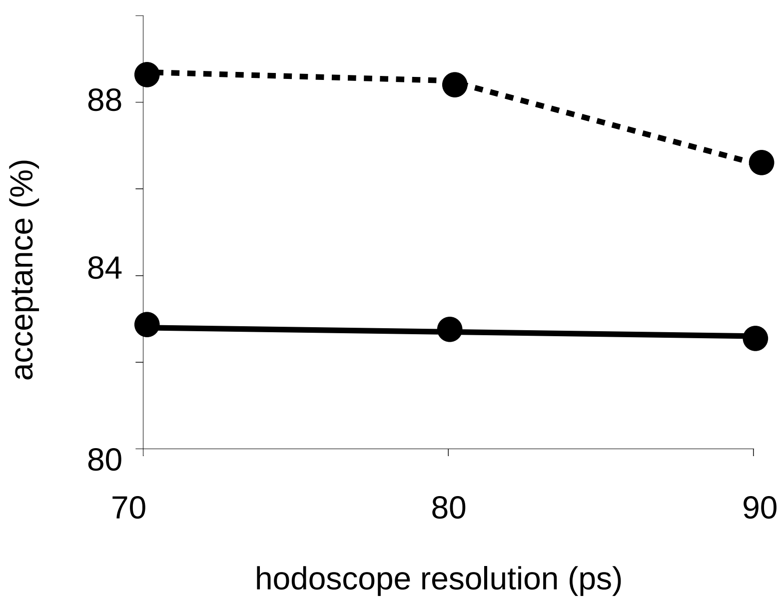

Fig. 3 - PID acceptance for hodoscope resolution equal to 70, 80, or 90 ps.

Studies are now underway to determine the PID acceptance for a reaction with fewer particles, $\gamma p \rightarrow Mp \rightarrow K^*Kp \rightarrow K^+K^-\pi^0 p \rightarrow K^+K^-\gamma\gamma p$. This reaction necessitates the use of the LGD in the kinematic fit and hence may result in lower resolution for particle mass. Also, with only three mesons in the final state one can anticipate that the average momenum of each particle will be shifted higher than for the present case, resulting in a larger difference between the gas and aerogel acceptances. This consideration and the fact that the gas results in a slightly higher acceptance (Table 2) leads us to conclude that a gas Cerenkov is favored over an aerogel radiator.

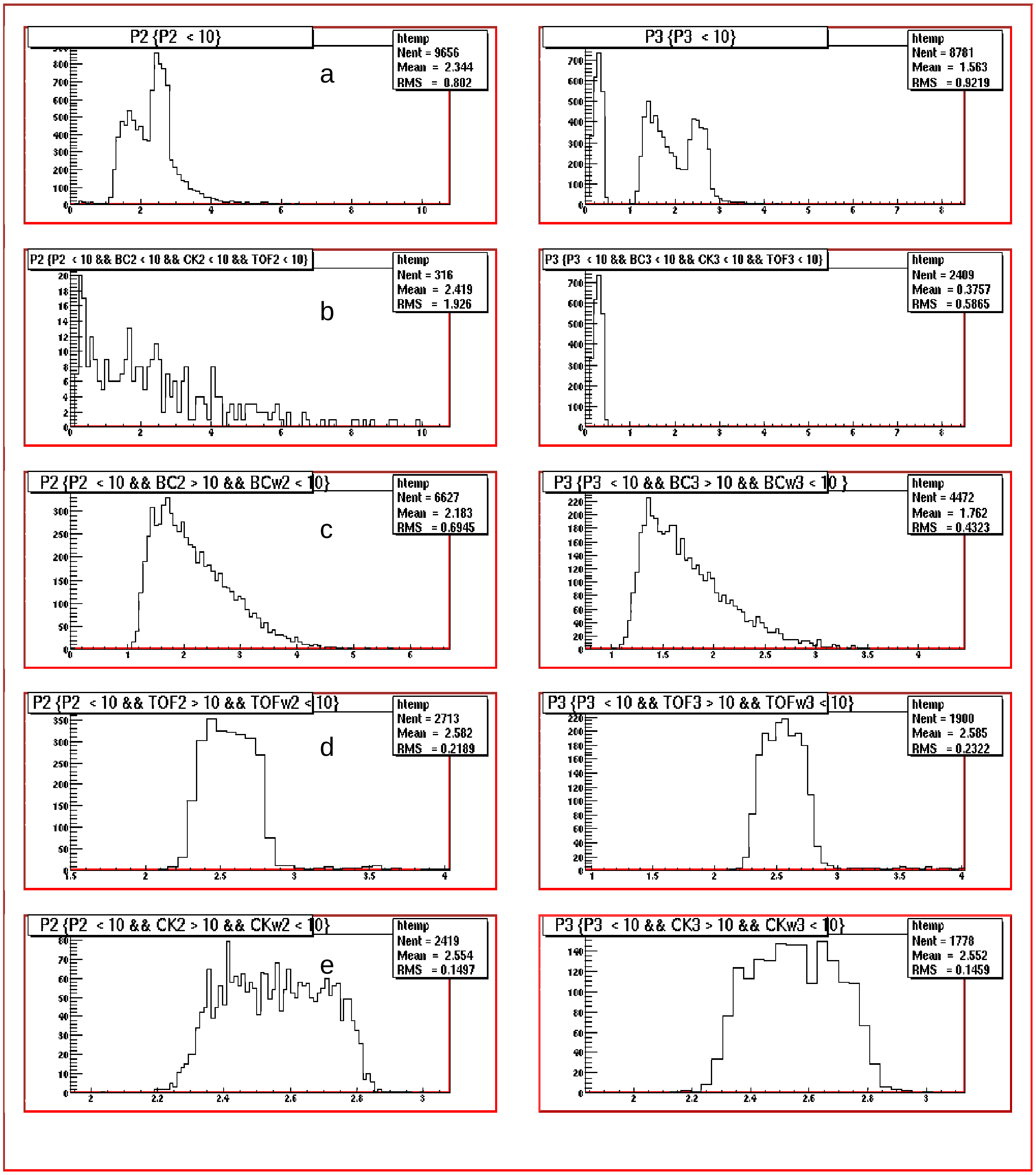

Fig. 2 - Kaon (left) and pion (right) momentum spectra for unrecoverable events having one ambiguous hit. The events are sorted by (a) all events, (b) events that missed BC, TOF, and CC, (c) events that hit BC but were unresolved, (d) events that hit the TOF but were unresolved, and (e) events which hit CC but were not identified (gas radiator).