AIM AND STEPS OF ANALYSIS

Manmohan Dash

Virginia Tech

(23 June 2004)

1.Aim of Analysis

2.Steps of Analysis

Aim of Analysis

- Definition of asymmetry

$\langle A \rangle = \frac{N^{phys}_{K_L\pi} - N^{phys}_{K_S\pi}}{N^{phys}_{K_L\pi} + N^{phys}_{K_S\pi}}$

asymmetry in $D^0 \to K_L\pi$ and $D^0 \to K_S\pi$ from CF, DCS interference

$N^{phys}_{K\pi} = \int_a^b \eta^{rec}_{K\pi}(p)/\epsilon_{K\pi}(p)\, dp \;, p \equiv p^{lab}_{K^0}$

$\eta^{rec}_{K\pi}(p)$: number density of reconstructed $D^0 \to K\pi$ events in data

$\epsilon_{K\pi}(p)$: reconstruction efficiency of $D^0 \to K\pi$

$[a, b]$: limits on p where similar $[K\pi]$, $[K\pi\pi]$ spectrum expected

- How to extract reconstruction efficiency $\epsilon_{K_L\pi}(p)$ and $\epsilon_{K_S\pi}(p)$

We make 2 assumptions

$D^0 \to K^{*-}(K_L\pi^-)\pi^+ \; and \; D^0 \to K^{*-}(K_S\pi^-)\pi^+$ are generated 1:1

reconstruction efficiencies can be factorised as follows

$\epsilon_{K_L\pi}(p) = \epsilon_{K_L}(p) \times \epsilon_\pi(p) \, , \epsilon_{K_S\pi}(p) = \epsilon_{K_S}(p) \times \epsilon_\pi(p)$

$\epsilon_{K_L\pi\pi}(p) = \epsilon_{K_L}(p) \times \epsilon_\pi(p) \times \epsilon_\pi(p) \, , \epsilon_{K_S\pi\pi}(p) = \epsilon_{K_S}(p) \times \epsilon_\pi(p) \times \epsilon_\pi(p)$

it follows that

$r(p) \equiv \frac{\epsilon_{K_L\pi}(p)}{\epsilon_{K_S\pi}(p)} \equiv \frac{\epsilon_{K_L\pi\pi}(p)}{\epsilon_{K_S\pi\pi}(p)} = \frac{\eta^{rec}_{K_L\pi\pi}(p)}{\eta^{rec}_{K_S\pi\pi}(p)}$: (K_L/K_S) relative efficiency

Aim of Analysis

- Extracting the asymmetry

We measure the following asymmetries

$$\langle A\rangle = \frac{\int_a^b 1/\epsilon_{K_S\pi}(p)[\eta^{rec}_{K_L\pi}(p)/r(p) - \eta^{rec}_{K_S\pi}(p)]\,dp}{\int_a^b 1/\epsilon_{K_S\pi}(p)[\eta^{rec}_{K_L\pi}(p)/r(p) + \eta^{rec}_{K_S\pi}(p)]\,dp}$$, averaged over $p^{lab}_{K^0}$

$$A(p) = \frac{\eta^{rec}_{K_L\pi}(p) - r(p)\times\eta^{rec}_{K_S\pi}(p)}{\eta^{rec}_{K_L\pi}(p) + r(p)\times\eta^{rec}_{K_S\pi}(p)}$$, in bins of $p^{lab}_{K^0}$

We extract the asymmetry from the following quantities

Monte Carlo : $\epsilon^{MC}_{K_S\pi}(p) = \frac{\eta^{recMC}_{K_S\pi}(p)}{\eta^{genMC}_{K_S\pi}(p)}$

Data : $[a,b]\,,\eta^{rec}_{K_L\pi}(p)\,,\eta^{rec}_{K_S\pi}(p)\,,r(p) = \frac{\eta^{rec}_{K_L\pi\pi}(p)}{\eta^{rec}_{K_S\pi\pi}(p)}$

Steps of Analysis

- Why do I do what I do?

  How can I use signal Monte Carlo
  i)Build and test codes, devise preliminary selection cuts
  ii)preliminary measurement of limits on momentum $[a, b]$
  iii)test the assumption of factorisability
  iv)test dependence of relative efficiency r on different variables

  Why to study Background Monte Carlo
  i)study potential sources of background
  ii)refine and optimise the cuts from signal MC study

  Data
  skim data and extract all required functions
  Systematics
  need careful attention to this aspect as we need calibration better than 5 %

Signal Monte Carlo

- Building and testing the codes

  Building the codes

  π^0 : mdst-pi0

  $\pi^{\pm}$: mdst-charged

  $K^0_S : mdst - vee2 \, , dr > 0.25mm \, , zdist < 1cm \, , d\phi < 0.1$

  $dr \rightarrow$ vertex and IP separation in plane perpendicular to beam

  $zdist \rightarrow$ distance between $\pi^{\pm}$ tracks at K^0_S vertex

  $d\phi \rightarrow$ angle between assumed and reconstructed K^0_S direction in transverse projection to beam

  K^0_L : $D^0 \, , K^0_L$ mass fixed at PDG value, minimum ionisation cut

  D^0 : $-0.95 < cos(\theta_{DK}) < 0.2$???is it θ_{DK^*} for $K\pi\pi$ modes???

  $\theta_{DK} \rightarrow K^0$ flight angle wrt D^0 boost

  D^{*+} tag,cut on $\delta M = (D^{*+} - D^0)$ mass, $p_{D^{*+}}$ = reconstructed scaled momentum cut

  Inv. mass cuts on $K^0_S \, , K^{*-} \, , D^0(K_s\pi/K_s\pi\pi) \, , \pi^+\pi^-(K\pi\pi) \, system$

  Testing the codes

  look at $D^{*+} \, mass \, , \delta M$, generated vs reconstructed momentum of $D^{*+} \, , D^0 \, , K^0_L \, , K^0_S \, , K^{*-}$

Signal Monte Carlo

- Preliminary measurement of $[a, b]$
  reconstruct $D^0 \to K^0_S \pi \, and \, D^0 \to (K^0_S \pi)\pi$
  plot reconstructed $p^{lab}_{K^0}$ and obtain $\eta^{recMC}_{K_S\pi}(p) \, and \, \eta^{recMC}_{K_S\pi\pi}(p)$
  take the ratio of $\eta^{recMC}_{K_S\pi}(p) \, and \, \eta^{recMC}_{K_S\pi\pi}(p)$ and find $[a, b]$

- Factorisability of efficiencies, test $\epsilon_{K_S\pi\pi}(p) = \epsilon_{K_S}(p) \times \epsilon_\pi(p) \times \epsilon_\pi(p)$
  etc

  reconstruct $D^0 \to (K^0_S \pi)\pi$
  plot reconstructed and generated $p^{lab}_{K^0}$
  obtain $\epsilon_{K_S\pi\pi}(p) = \eta^{recMC}_{K_S\pi\pi}(p)/\eta^{genMC}_{K_S\pi\pi}(p)$
  plot reconstructed and generated momentum of K^0_L candidates
  obtain $\epsilon_{K_S}(p) = \eta^{recMC}_{K_S}(p)/\eta^{genMC}_{K_S}(p)$
  similarly obtain $\epsilon_{\pi^\pm}(p) = \eta^{recMC}_{\pi^\pm}(p)/\eta^{genMC}_{\pi^\pm}(p)$
  similarly for facorisability in other modes
  ??? We don't rely on MC for K_L simulation, yet study this in MC ???
  ??? different momentum space for $K_S\pi\pi \, , K_S \, and \, \pi^\pm$???

Signal Monte Carlo

- Dependence of r on different variables

  plot $r = \eta^{recMC}_{K_L\pi\pi}(p)/\eta^{recMC}_{K_S\pi\pi}$ in bins of different variables
  e.g. reconstructed $p^{lab}_{K^0}$ and θ_{K^0}

Background Study and skimming data set

- charm background first(skim by using cuts from signal MC)
  reconstruct $D^0 \to K_L\pi$ with a wide D^{*+} mass scale
  tag decays in evtgen for entire event set
  investigate any other potential background source
  plot reconstructed D^{*+} mass
  for each decay(background)see the number appearing on the D^{*+} mass scale
  refine cuts from signal MC study and optimise cuts
  do for other decay modes
- extend to uds,charge,mixed background sample
  anti-continuum suppression and further refinement of cuts
  extract $\epsilon_{K_S\pi}\, and\, [a,b]$ again
- skim data set
  extract $\eta^{rec}_{K_L\pi}(p)\, ,\eta^{rec}_{K_S\pi}(p)\, ,\eta^{rec}_{K_L\pi\pi}(p)\, ,\eta^{rec}_{K_S\pi\pi}(p)\, and\, [a,b]$

Systematics

- residual difference in $p_{K^0}^{lab}$ spectra leads to bias if ϵ_{K_L} depends strongly on momentum
  introduce momentum dependent efficiency for $K_S\pi$ and $K_S\pi\pi$ modes
  weight changes linearly from 0 at 'a' to 1 at 'b'
  calculate change in ratio of yield, gives estimation of systematics