PXDHits association issues with K's

(on sensitivity study for TDCPV with $B \rightarrow \phi K^0$)

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Tracking meeting, April 7th 2017

Introduction

- I am working on a sensitivity study of Time Dependent CP Violation of $B^0 \rightarrow \phi K^0$;
- I am considering $\phi \rightarrow K^+K^-$ and $\phi \rightarrow \pi^+\pi^-\pi^0$ decays;
- For the analysis, it is essential to have a precise determination of the decay vertex of my signal B candidate. The vertex is essentially determined by the tracks of the ϕ daughters;
- To ensure optimal vertexing resolution, I require that each track from the ϕ decay has at least one PXDHit associated to it;
- In all the studies I have done in the last ~2 years, I have always observed that the probability for the kaons (from ϕ decay) to have at least on PXDHit associated to it is significantly lower than it is for the π's from ϕ or for the μ's from J/ψ;

- All the results I am presenting today are based on officially produced MC7 samples.

PXDHit association efficiency

- Requiring that both K's (π's) from $\phi \rightarrow K^+K^-$ ($\phi \rightarrow \pi^+\pi^-\pi^0$) decay have at least one PXDHit associated to it (with BGx0 simulation):

	efficiency
$\phi \rightarrow K^+K^-$	83.8%
$\phi \rightarrow \pi^+\pi^-\pi^0$	92.8%

Assuming no correlations:

ε_K(PXDHit > 0) = 91.5%

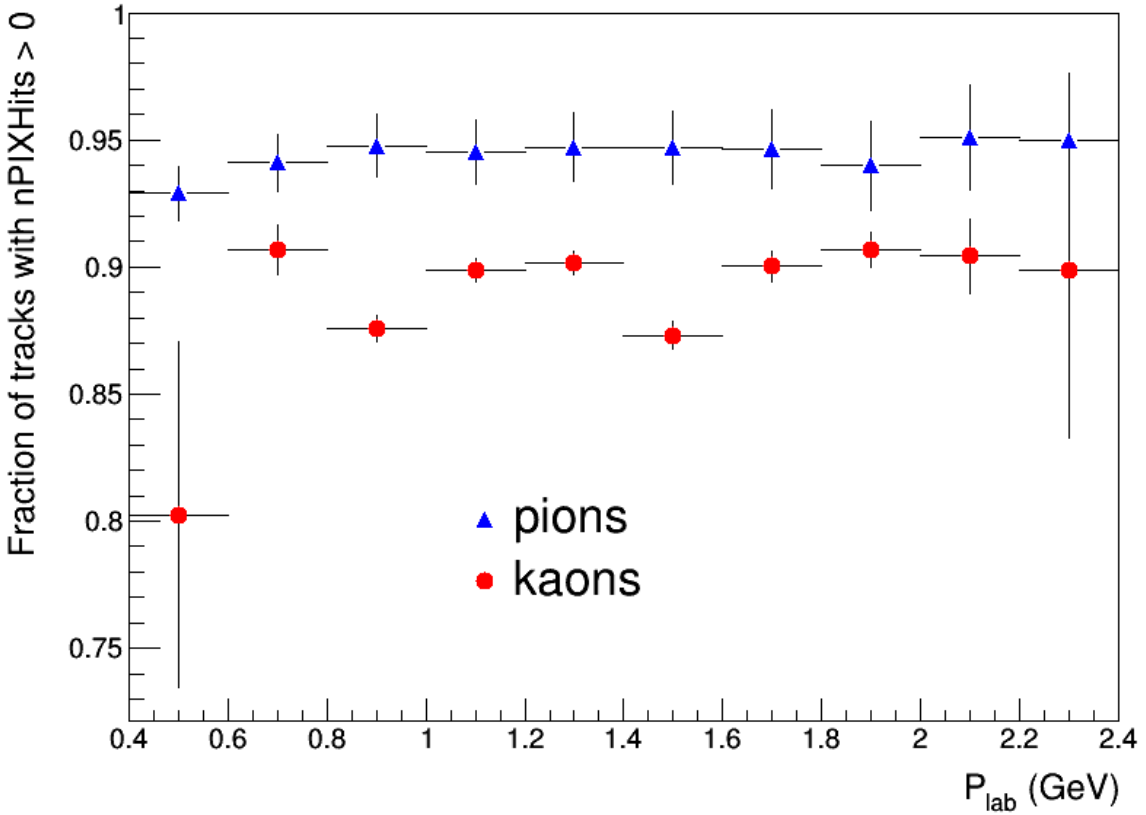
ε_π(PXDHit > 0) = 96.3%

(full breakdown of my selection cuts on backup)

- Experts: there is no reason why the efficiency for the kaons should be lower than for the pions;
- I studied a little bit more the issue, to determine whether this comes to the unfortunate topology of $\phi \rightarrow K^+K^-$ decays or it is actually pointing towards some inefficiency on the tracking side.

Momentum dependence

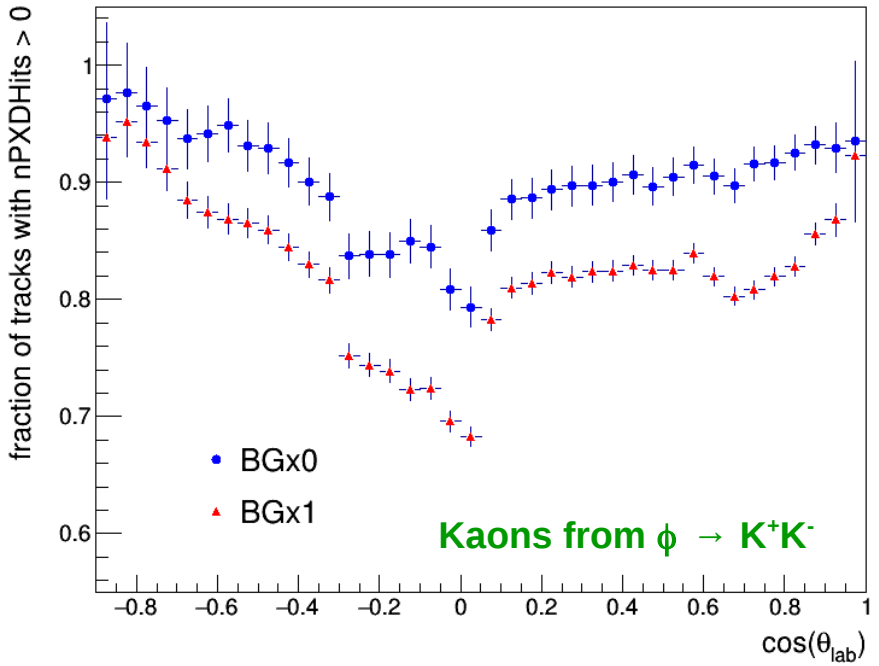
- The ϕ is just above the threshold for decaying to KK, so I was expecting some evident effect when the boost of the ϕ is low (and thus the K's are pretty soft);
- Actually the distribution is more complicated:

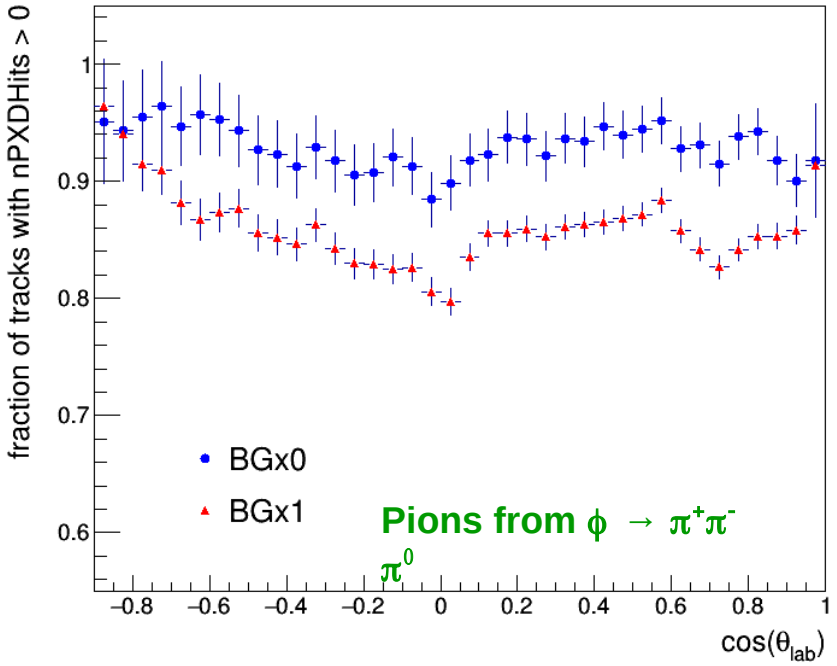


Here and in the following: all the candidates are truth-matched

Dependence on θ_{lab}

- The comparison between $\phi \rightarrow K^+K^-$ and $\phi \rightarrow \pi^+\pi^-\pi^0$ as a function of $\cos\theta_{lab}$ is definitely more interesting: it seems that a large part of the inefficiency comes from the tracks that fly almost at 90 degrees from the beam line:

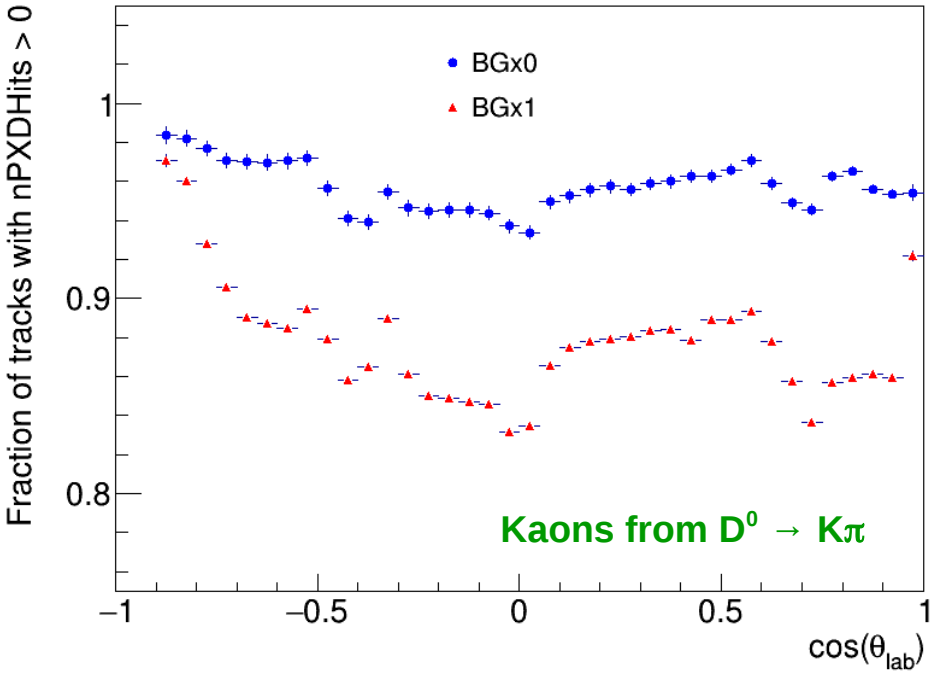


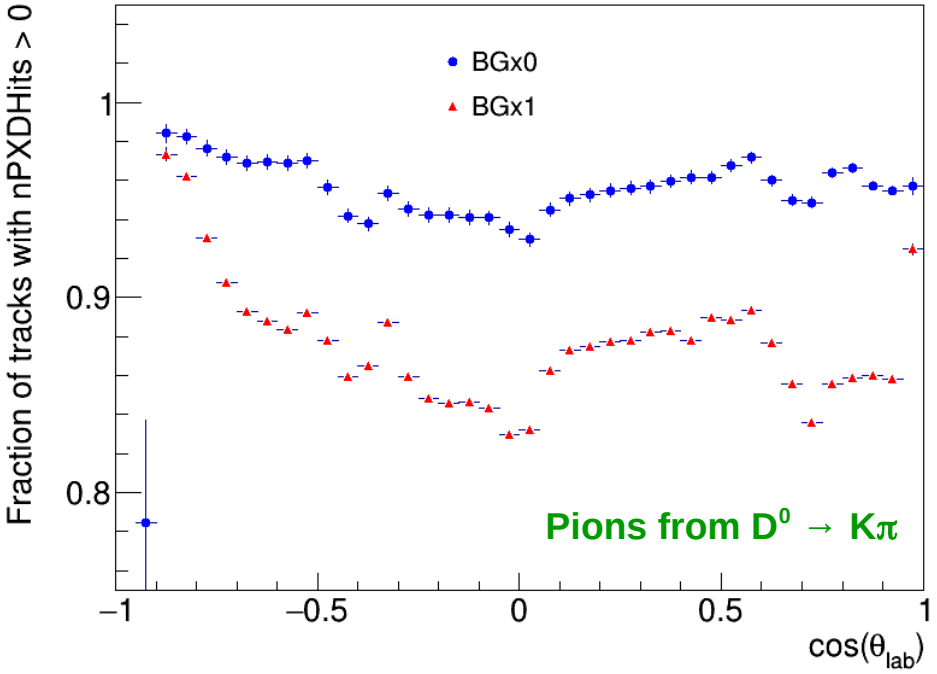


- The very sharp dip at $-0.3 < \cos\theta < 0.1$ looks like a bug to my untrained eye...

Comparing K/π from $D^0 \rightarrow K\pi$

- I took a look at pions and kaons from $D^0 \rightarrow K\pi$, from a MC7 ccbar sample at the Y(4s) energy;

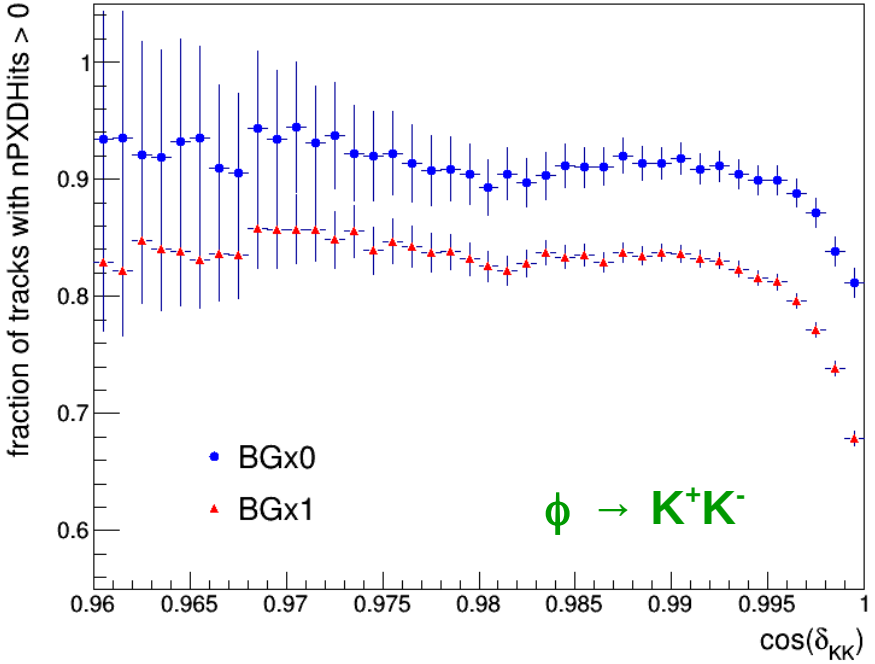


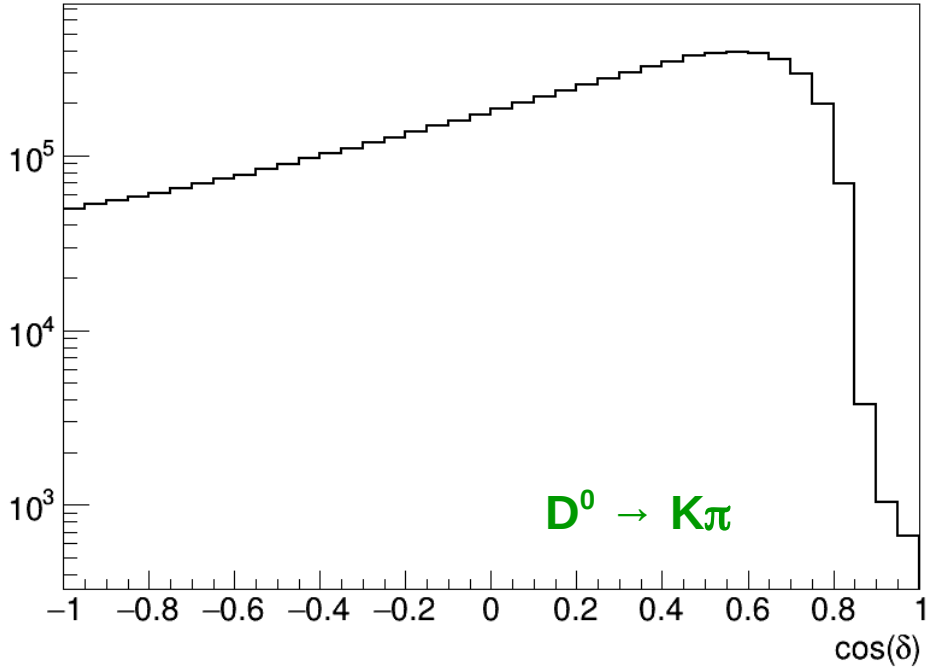


- The distributions are almost identical (with the same kind of dip around $\theta \sim 90$ degrees, although much less evident).

What is specific to $\phi \rightarrow K^+K^-$

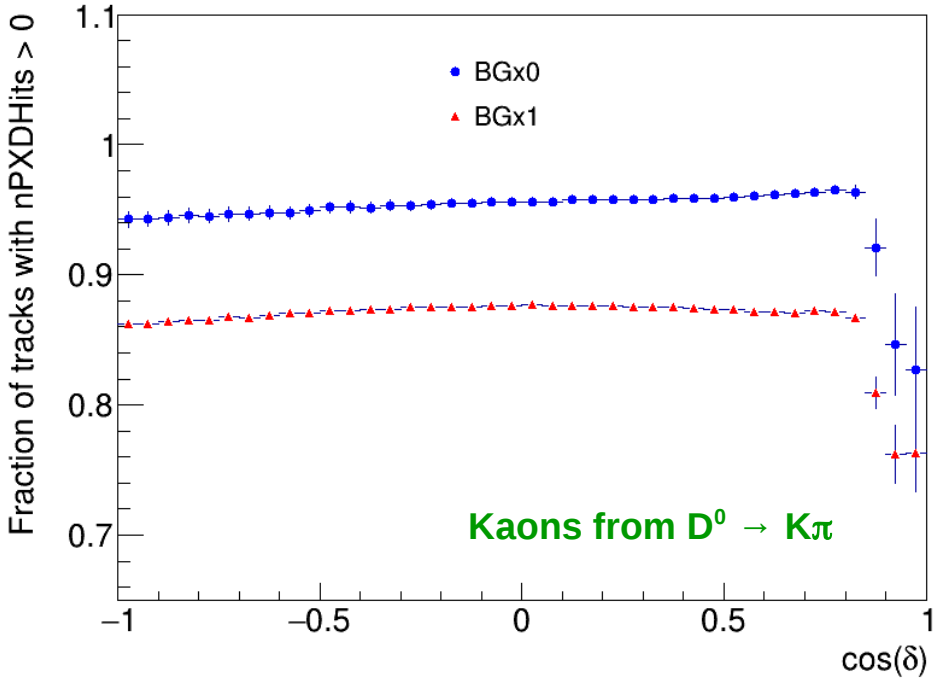
- In the $\phi \rightarrow K^+K^-$ decay, the kaons are almost collinear, so the hits of the two kaons are relatively close to each other;
- As the angle (δ) between the kaons decreases, the efficiency of associating the PXDHits to the track decreases;
- I checked if the same effect is visible also on $D^0 \rightarrow K\pi$; unfortunately the statistic is not great...

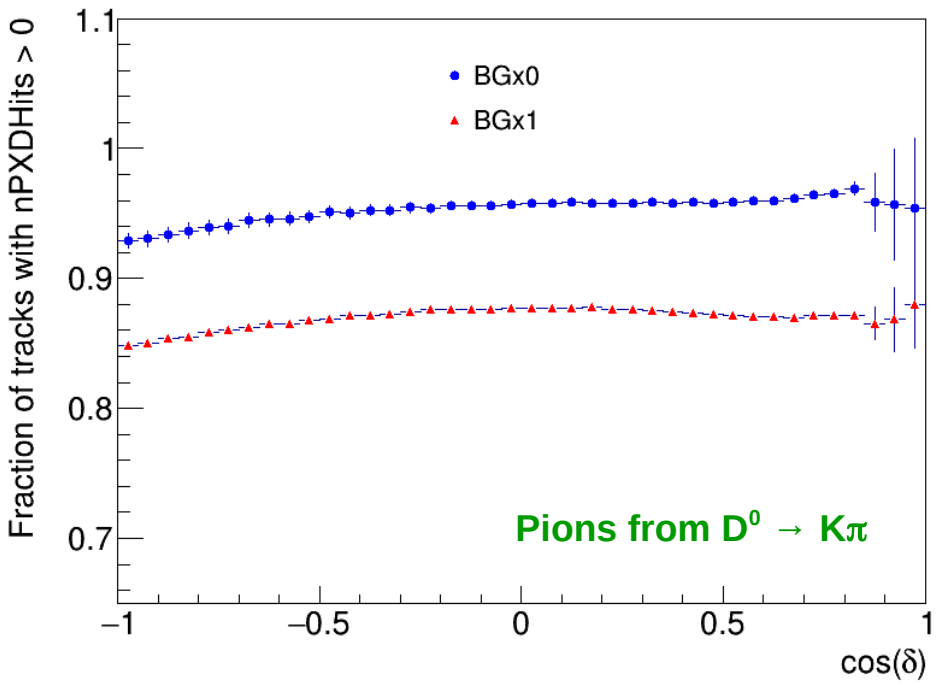




Comparing K/π from $D^0 \rightarrow K\pi$

- The same effect, a drop in the efficiency by ~10% is seen for the kaons… but not for the pions!

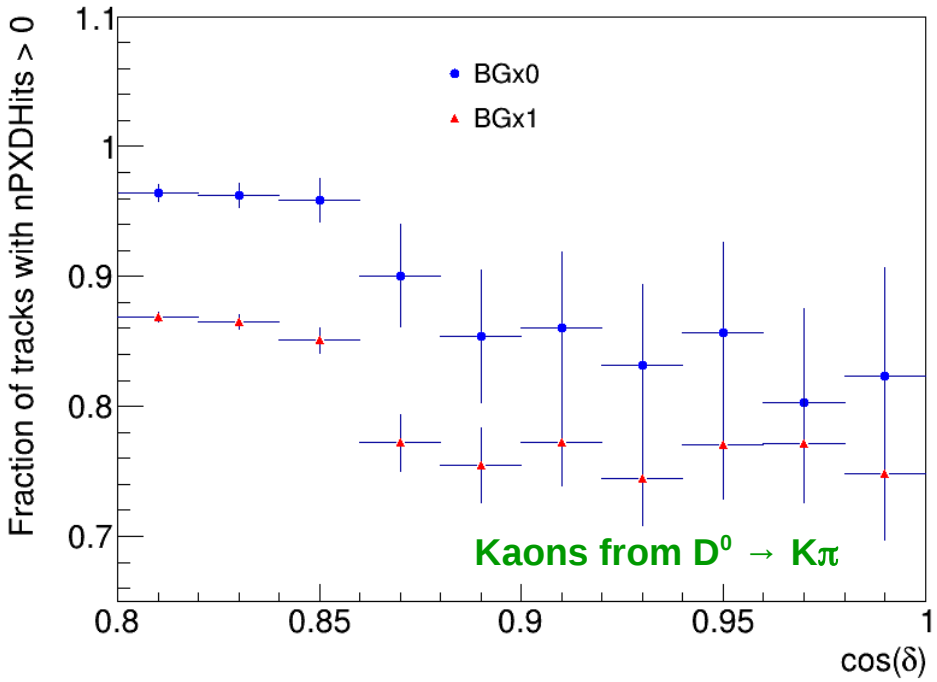


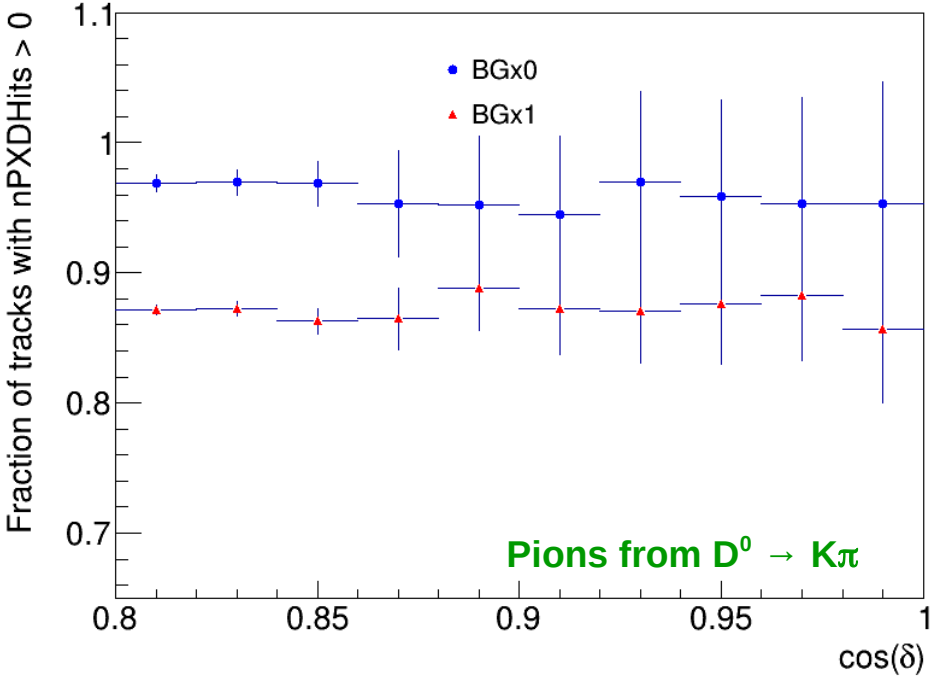


(δ is the angle between the π and K momenta)

Comparing K/π from $D^0 \rightarrow K\pi$

- Zoom in the high cos(δ) region, the effect is definitely statistically significant:





- Comment from Eugenio: when π and K are collinear, they cannot have the same momentum;
- But why is the effect only visible on the K's?

Comments

- I investigated a bit the issue of low PXDHits association efficiency for the K's from ϕ decays;
- Certainly the issue is somewhat related to the unfavorable topology of the $\phi \rightarrow K^+K^-$ decay;
- However, there seem to be two independent problems:

  1) dip around $\cos\theta \sim 0$ (no naive explanation);

  2) drop when another track is close by (seen for the K's but not for the π's);

- Hopefully (part of) these problems can be recovered (?);

- Thank you for your attention, I'd appreciate any insights and your looking into this issue (not sure how much more I can learn from mdst's);
- I'm happy to share my steering files, macros, and rootuples if you want to take a look as well.

Backup Slides

Efficiency breakdown: $\phi(K^+K^-)$ $K_S(\pi^+\pi^-)$

	# events	Efficiency	Rel. efficiency	Cand. multiplicity
Generated	2000000			
Reconstructed ($M_{bc} > 5.25$, $\|\Delta E\| < 0.2$)	1088443	54.4%	54.4%	1.0243
M(ϕ) cut	1045203	52.3%	96.0%	1.0139
d_0(K) cut	1010450	50.5%	96.7%	1.0077
z_0(K) cut	979978	49.0%	96.7%	1.0070
K PXD hits cut	821614	41.1%	83.8%	1.0063
PID(K)	756615	37.8%	92.1%	1.0039
K_S VtxProb	712507	35.6%	94.2%	1.0027
K_S flight length sign.	705888	35.3%	99.1%	1.0023
ϕ VtxProb	687746	34.4%	97.4%	1.0020
B VtxProb	621262	31.1%	90.3%	1.0008

Efficiency breakdown: $\phi(\pi^+\pi^-\pi^0)$ $K_S(\pi^+\pi^-)$

	# events	Efficiency	Rel. efficiency	Cand. multiplicity
Generated	2000000			
Reconstructed (M_{bc} > 5.25, -0.1 <ΔE < 0.2)	588446	29.4%	29.4%	1.343
M(π^0) cut	528893	26.4%	89.9%	1.171
E(π^0) cut	468782	23.4%	88.6%	1.118
M(ϕ) and M(K_S) cut	453176	22.7%	96.7%	1.071
$d_0(\pi)$ cut	439441	22.0%	97.0%	1.058
$z_0(\pi)$ cut	434397	21.7%	98.9%	1.056
π PXD hits cut	402929	20.1%	92.8%	1.055
K_S VtxProb	384214	19.2%	95.4%	1.054
K_S flight length sign.	380784	19.0%	99.1%	1.053
ϕ VtxProb	377025	18.9%	99.0%	1.051
B VtxProb	347526	17.4%	92.2%	1.047