Tracking and PXDHits association issues with K's

(VXDTF1 vs VXDTF2 performance)

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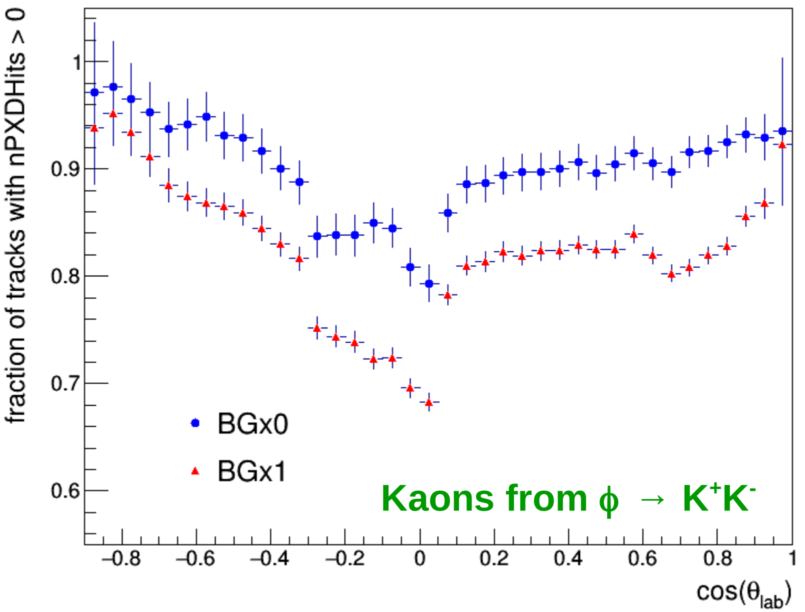
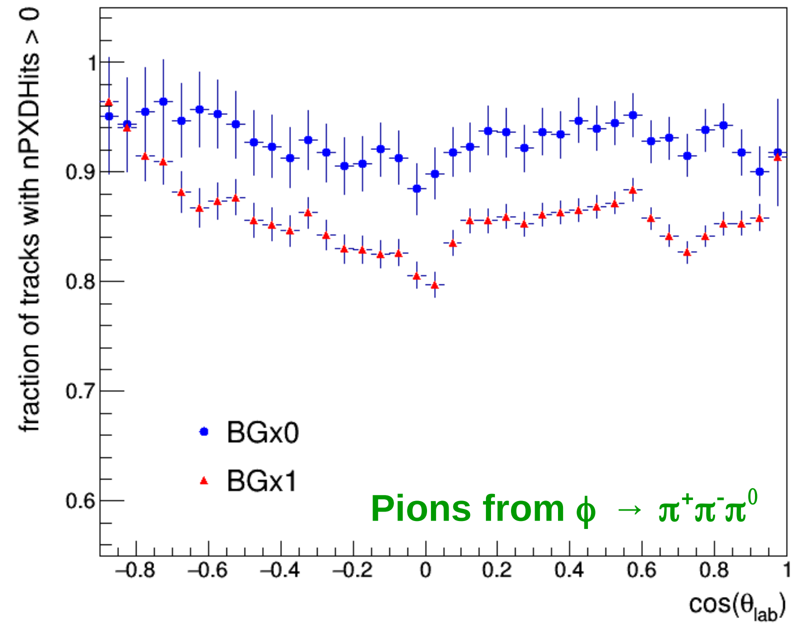
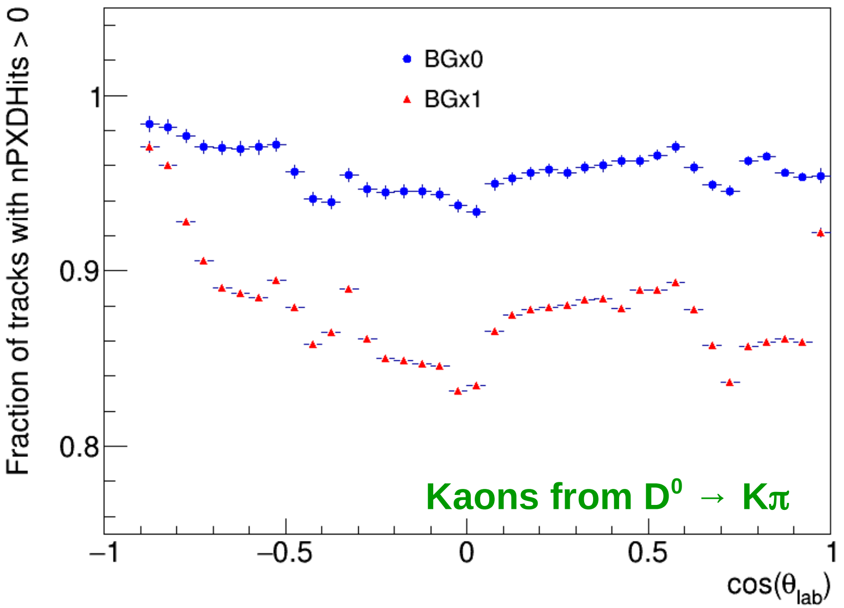
Introduction

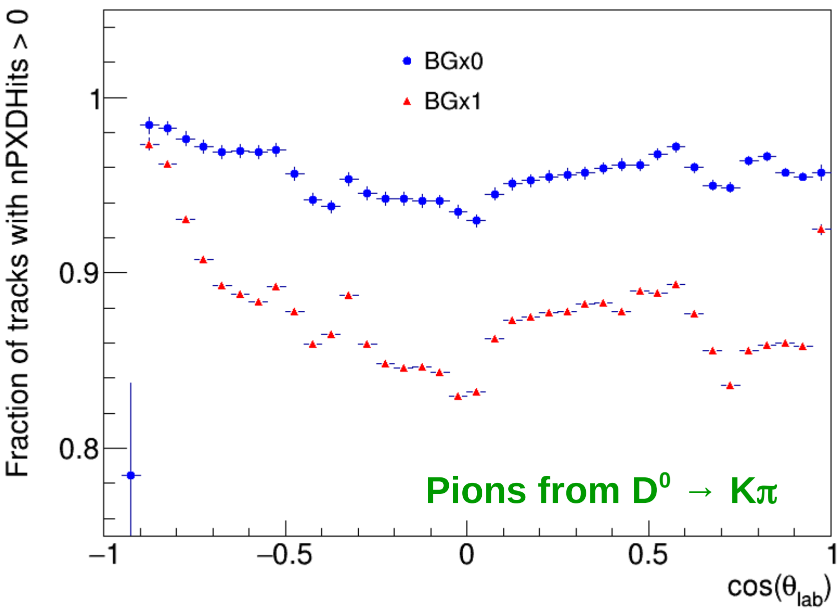
- I am working on a sensitivity study of TDCPV of $B^0 \rightarrow \phi K^0$;
- I am considering both $\phi \rightarrow K^+K^-$ and $\phi \rightarrow \pi^+\pi^-\pi^0$ decays;
- For the analysis, it is essential to have a precise determination of the decay vertex of my signal B candidate. The vertex is 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;
- Last April I gave a presentation based on MC7 samples;
- Today I will show some more results based on recently produced MC9 samples, comparing the performance of VXDTF1/2.

Reminder, MC7 results



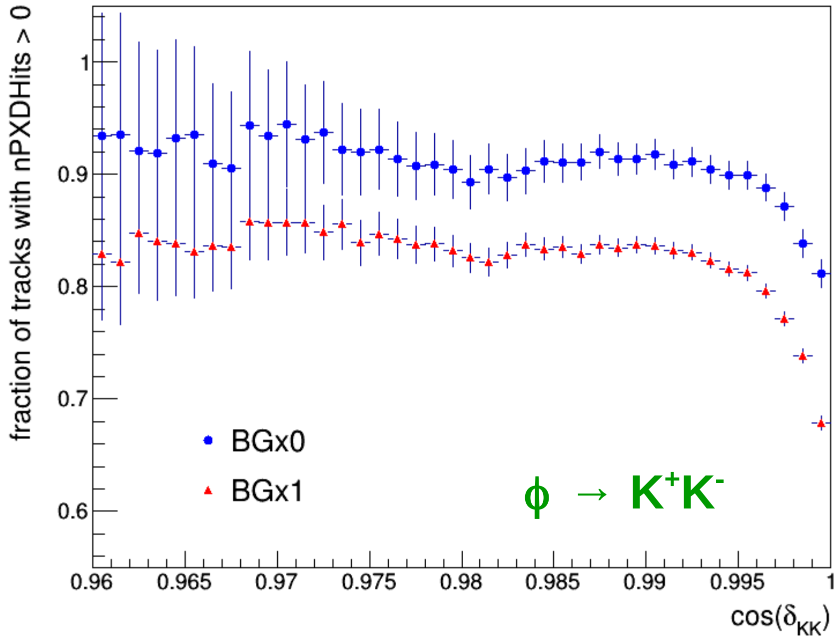




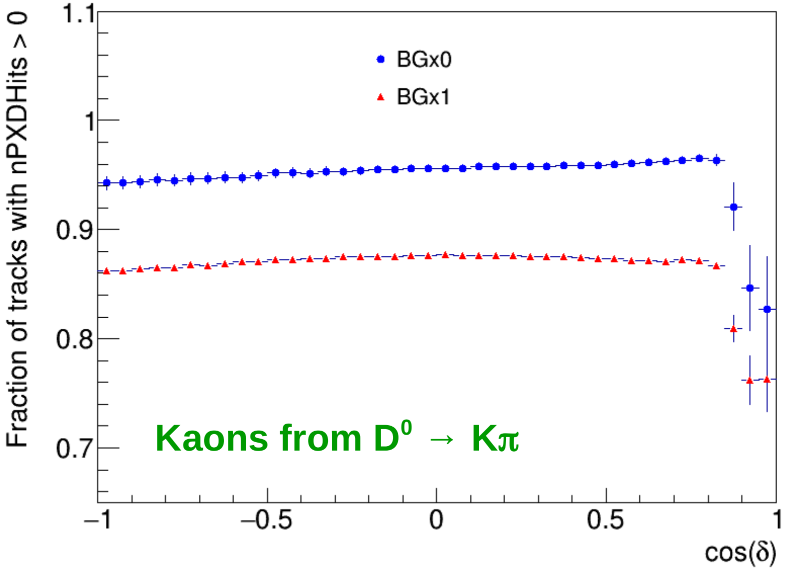


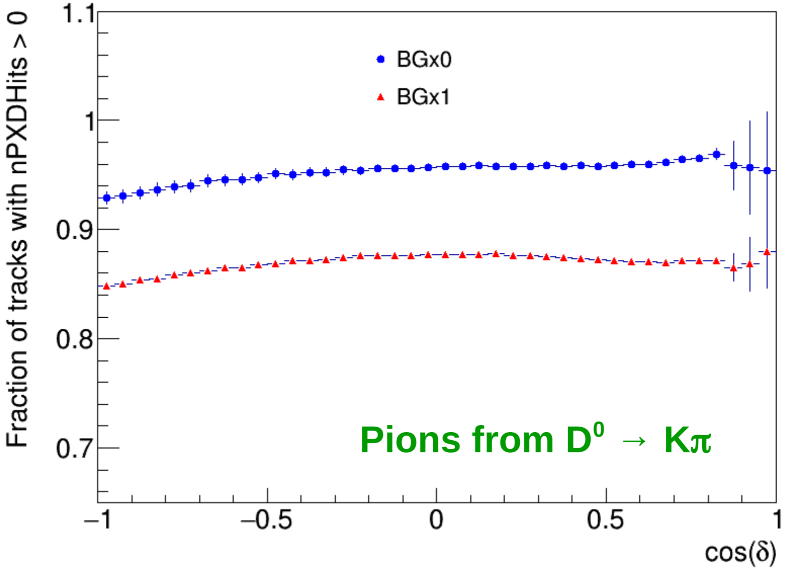
Reminder, MC7 results

- 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.



The same effect is seen on the kaons from $D^0 \rightarrow K\pi$
(but not on the π's?)





MC9 samples

- To test the newly developed VXDTF2 and compare its performance against VXDTF1 (as much as possible in an "apples to apples" way) the following samples have been generated:

Decay	VXDTF version	Beam background	Status
$\phi[K^+K^-]\ K_S[\pi^+\pi^-]$	1	x0	**Done**
$\phi[K^+K^-]\ K_S[\pi^+\pi^-]$	1	x1	**Pending**
$\phi[K^+K^-]\ K_S[\pi^+\pi^-]$	2	x0	**Done**
$\phi[K^+K^-]\ K_S[\pi^+\pi^-]$	2	x1	**Pending**
$\phi[\pi^+\pi^-\pi^0]\ K_S[\pi^+\pi^-]$	1	x0	**Done**
$\phi[\pi^+\pi^-\pi^0]\ K_S[\pi^+\pi^-]$	1	x1	**Pending**
$\phi[\pi^+\pi^-\pi^0]\ K_S[\pi^+\pi^-]$	2	x0	**Done**
$\phi[\pi^+\pi^-\pi^0]\ K_S[\pi^+\pi^-]$	2	x1	**Pending**

Many thanks to Jake Bennett for pushing these through with high priority

- Each sample contains 1M events.

$\phi[K^+K^-]\ K_S[\pi^+\pi^-]$ efficiency breakdown

BGx0 **VXDTF1** **VXDTF2**

	VXDTF1 Efficiency	VXDTF1 Rel. efficiency	VXDTF2 Efficiency	VXDTF2 Rel. efficiency
Reconstructed (M_{bc} > 5.25, $\|\Delta E\|$ < 0.2)	47.5%	47.5%	49.9%	49.9%
$M(\phi)$ cut	45.7%	96.1%	47.9%	96.1%
$d_0(K)$ cut	43.3%	97.0%	46.4%	96.9%
$z_0(K)$ cut	44.3%	97.7%	45.5%	98.1%
PID(k)	39.0%	90.2%	41.1%	90.3%
K PXD hits cut	26.8%	68.6%	33.7%	82.0%
K_S VtxProb	26.4%	98.5%	33.2%	98.6%
ϕ VtxProb	25.9%	98.3%	32.8%	98.6%
B VtxProb	24.0%	92.6%	30.1%	91.8%

$\phi[\pi^+\pi^-\pi^0]$ $K_S[\pi^+\pi^-]$ efficiency breakdown

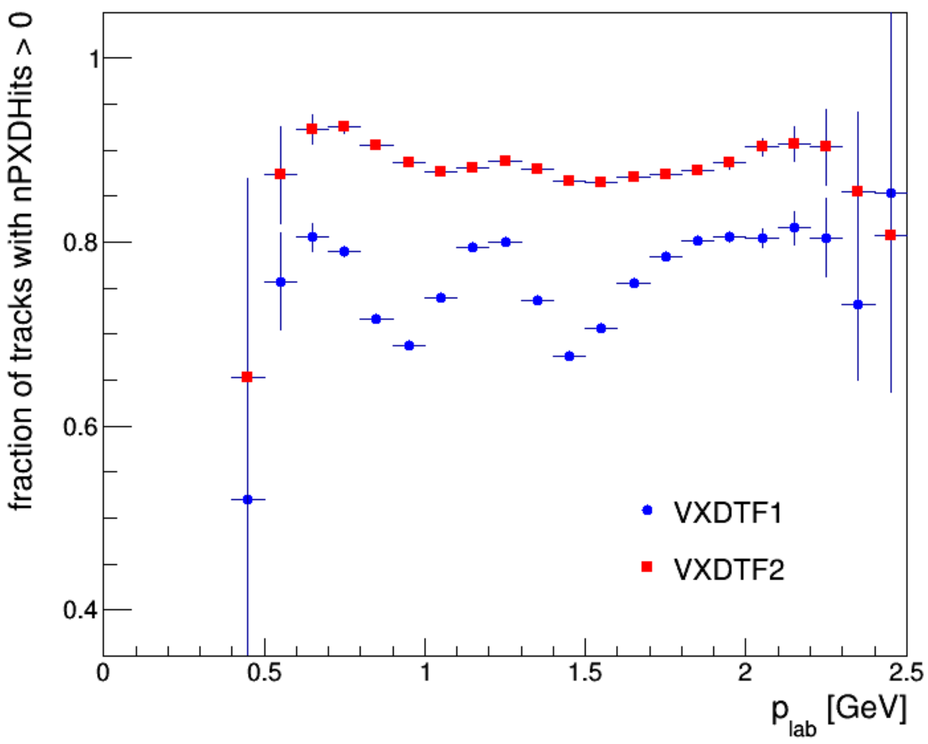
BGx0 **VXDTF1** **VXDTF2**

	VXDTF1 Efficiency	VXDTF1 Rel. efficiency	VXDTF2 Efficiency	VXDTF2 Rel. efficiency
Reconstructed (M_{bc} > 5.25, -0.1 < ΔE < 0.2)	30.9%	30.9%	31.8%	31.8%
$M(\pi^0)$ cut	30.2%	97.5%	31.0%	97.5%
$E(\pi^0)$ cut	27.1%	90.0%	27.8%	89.7%
$M(\phi)$ and $M(K_S)$ cut	25.6%	94.3%	26.3%	94.5%
$d_0(\pi)$ cut	24.3%	94.8%	25.1%	95.5%
$z_0(\pi)$ cut	23.9%	98.4%	24.8%	98.8%
π PXD hits cut	18.8%	78.9%	23.0%	92.7%
K_S VtxProb	18.5%	98.3%	22.6%	98.4%
ϕ VtxProb	18.4%	99.3%	22.5%	99.9%
B VtxProb	18.1%	98.3%	22.0%	98.0%

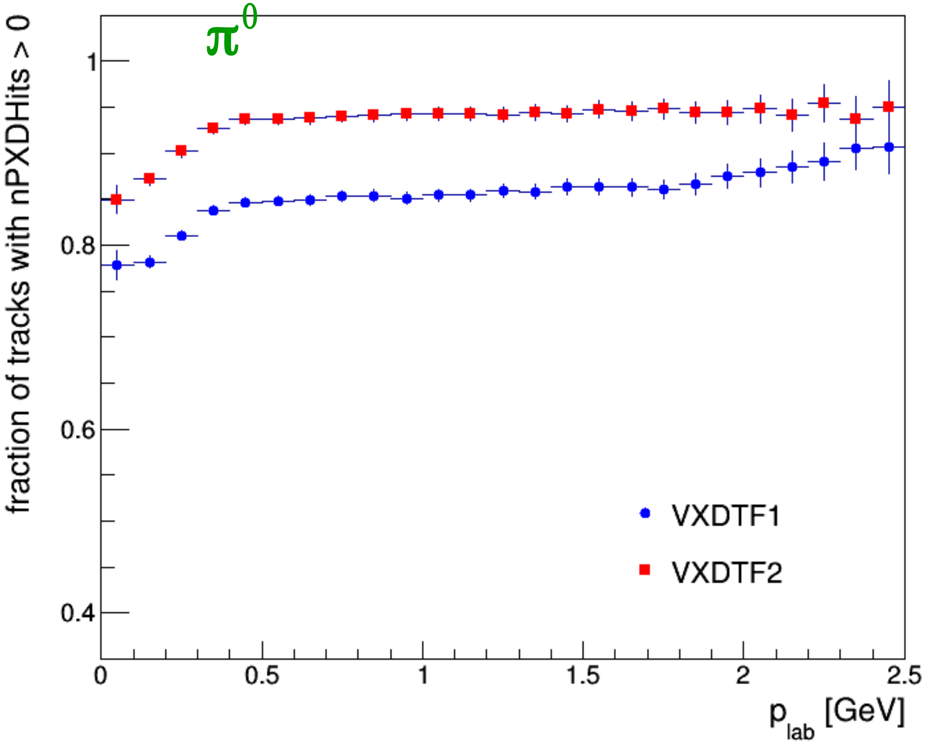
Momentum dependence

- Plotting the fraction of tracks with at least one PXDHit associated to it as a function of the momentum, some features appear…;
- We still see very significant differences between K's and π's:

Kaons from $\phi \rightarrow K^+K^-$



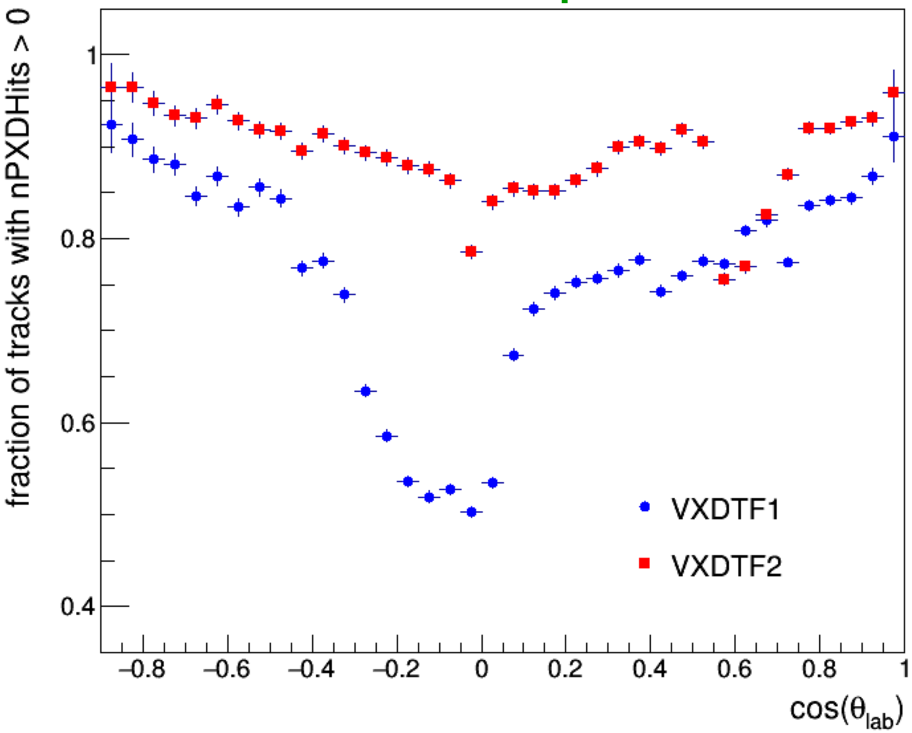
Pions from $\phi \rightarrow \pi^+\pi^-\pi^0$



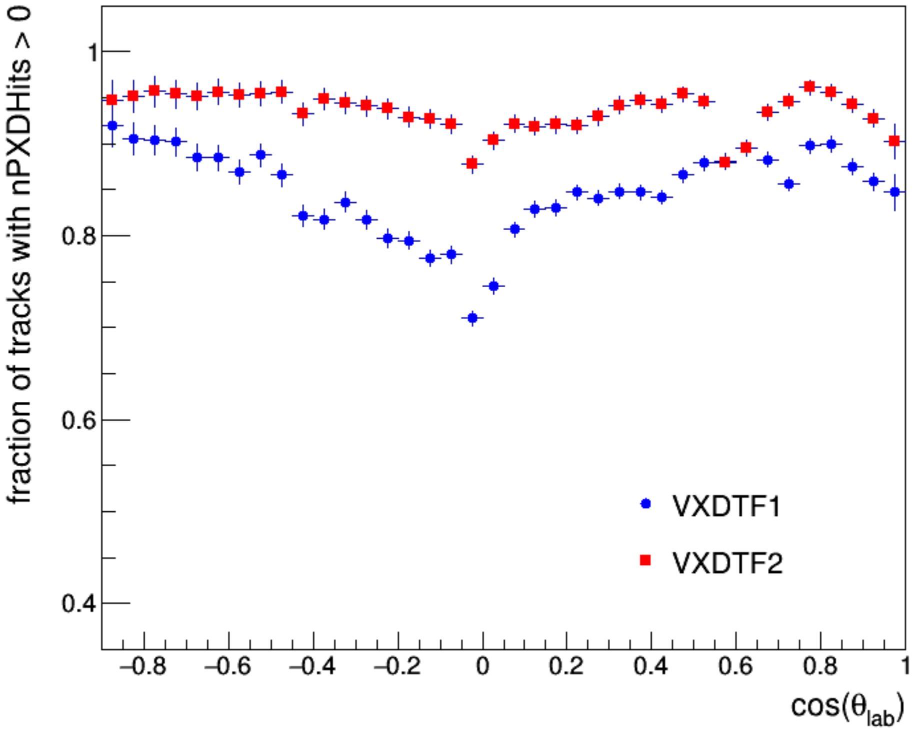
Polar angle dependence

- Plotting the PXDHit association efficiency as a function of the polar angle, the structures become more clear;
- Good news: the large dip at cosθ ~ 0 in the kaons plot almost disappears with VXDTF2;
- Bad news: another dip (visible also with the π's) appears at cosθ ~ 0.6.

Kaons from $\phi \rightarrow K^+K^-$



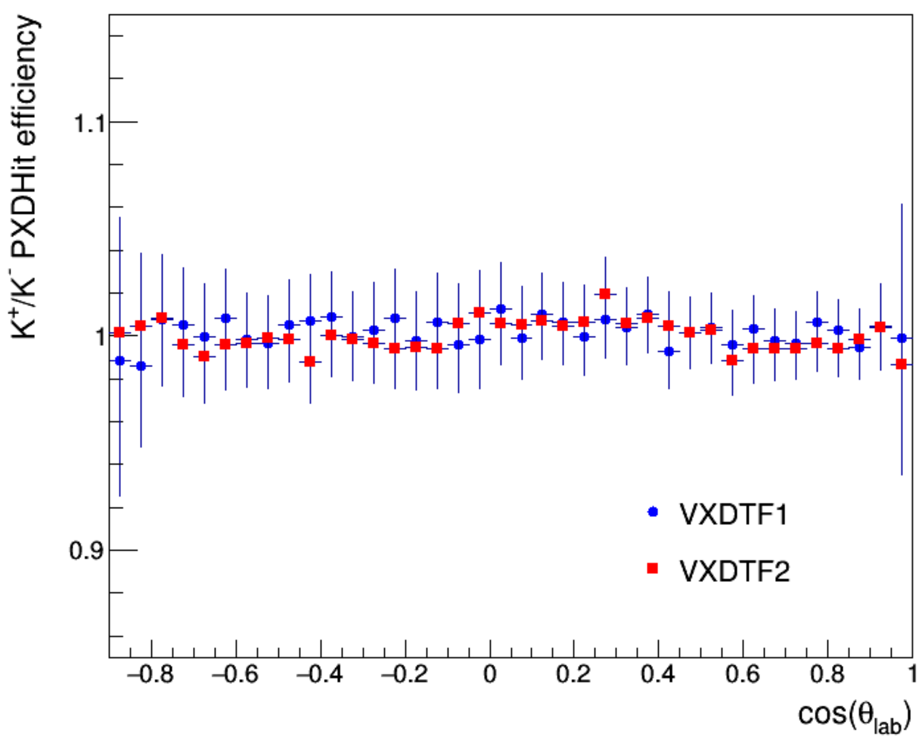
Pions from $\phi \rightarrow \pi^+\pi^-\pi^0$



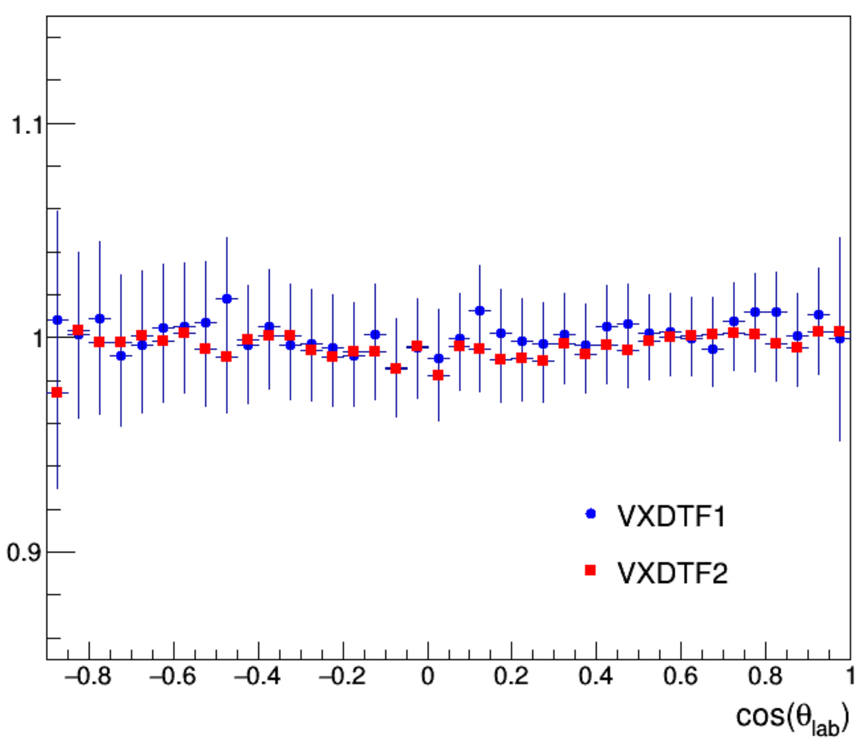
Charge asymmetry

- Here I am plotting the ratio of K^+/K^- (π^+/π^-) PXDHit association efficiency as a function of the cosine of the polar angle;
- No significant charge asymmetry is observed.

Kaons from $\phi \rightarrow K^+K^-$



Pions from $\phi \rightarrow \pi^+\pi^-\pi^0$



Comments

- I compared the performance of VXDTF1/2 on samples of MC9 $\phi \rightarrow K^+K^-$ and $\pi^+\pi^-\pi^0$ decays;
- There is a clear increase of performance using the new VXDTF2…
- … however the overall performance is similar to that of VXDTF1 on MC7 (see backup for details);
- We still have very relevant differences between K's and π's;

- Today's results are based on BGx0 MC, I will analyze the BGx1 samples as soon as they become available;
- I am at your disposal to perform any other kind of checks you consider interesting.

Backup Slides

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

	# events	Efficiency	Rel. efficiency	Cand. multiplicity
Generated	2000000			
Reconstructed (M_{bc} > 5.25, $\lvert\Delta E\rvert$ < 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

MC7

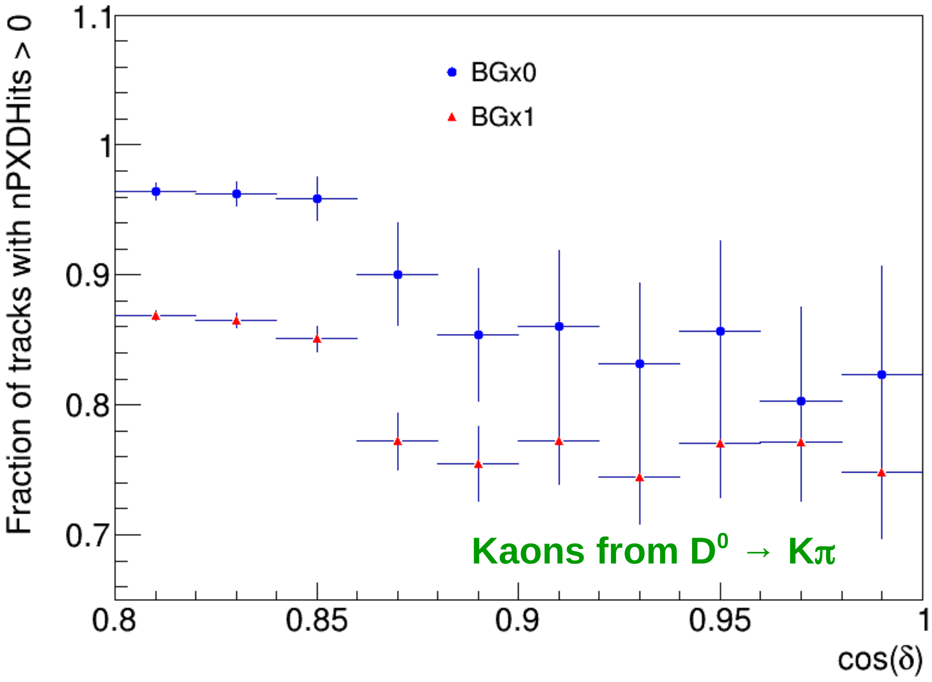
Efficiency breakdown: $\phi(\pi^+\pi^-\pi^0)\ K_S(\pi^+\pi^-)$

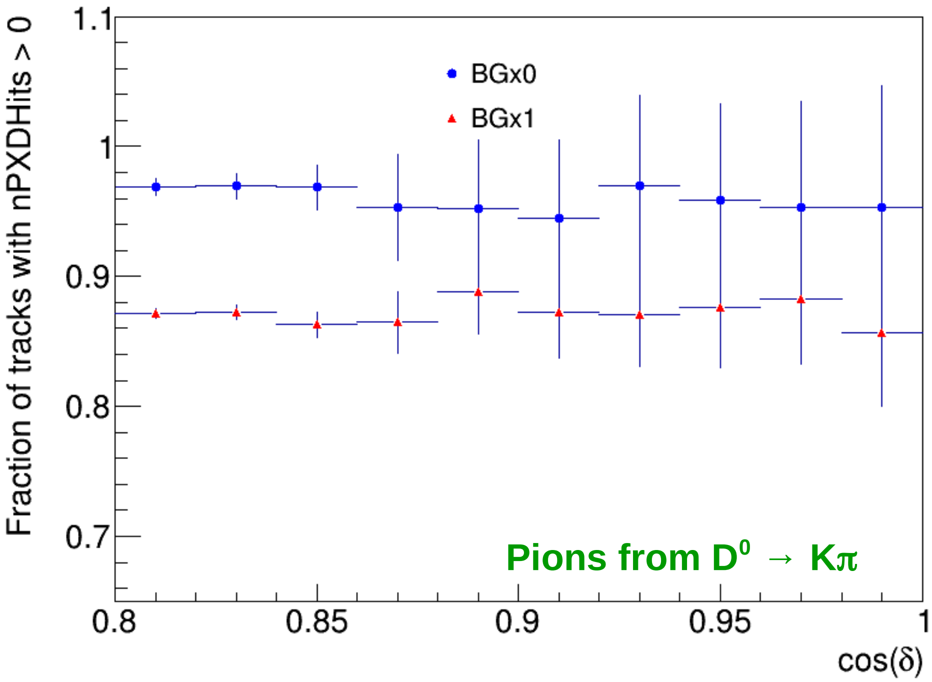
	# events	Efficiency	Rel. efficiency	Cand. multiplicity
Generated	2000000			
Reconstructed ($M_{bc} > 5.25$, $-0.1 < \Delta E < 0.2$)	588446	29.4%	29.4%	1.343
$M(\pi^0)$ cut	528893	26.4%	89.9%	1.171
$E(\pi^0)$ cut	468782	23.4%	88.6%	1.118
$M(\phi)$ and $M(K_S)$ cut	453176	22.7%	96.7%	1.071
$d_0(\pi)$ 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

MC7

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?

MC7

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: