Tracking and PXDHits association issues with K's

Ale Gaz,
KMI, Nagoya University

Tracking meeting, January 12th 2018

Introduction

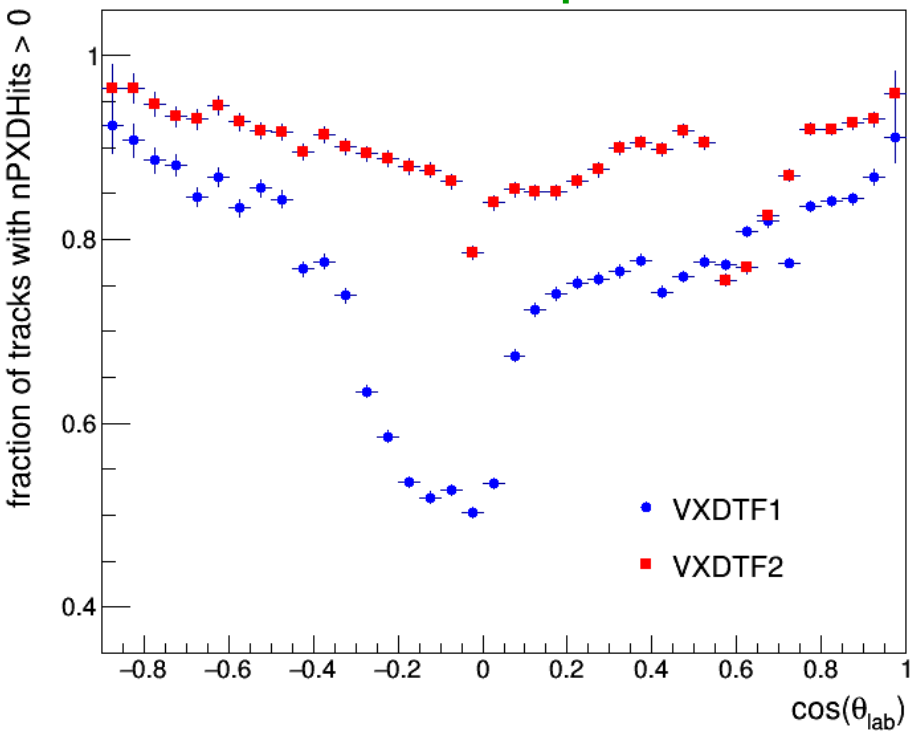
- I am working on a sensitivity study of TDCPV of $B^0 \to \phi K^0$;
- I am considering both $\phi \to K^+K^-$ and $\phi \to \pi^+\pi^-\pi^0$ decays;
- For the analysis, it is essential to have a precise determination of the decay vertex of my signal B candidate. The vertex is essentially determined 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;
- I have consistently observed two kinds of problems:
  1) the probability of associating at least one PXDHit to a kaon track is lower than for a pion track;
  2) there are weird structures in the distribution of this probability as a function of the polar angle;

- Today I will give you an update of my studies, based on `release-01` Monte Carlo.

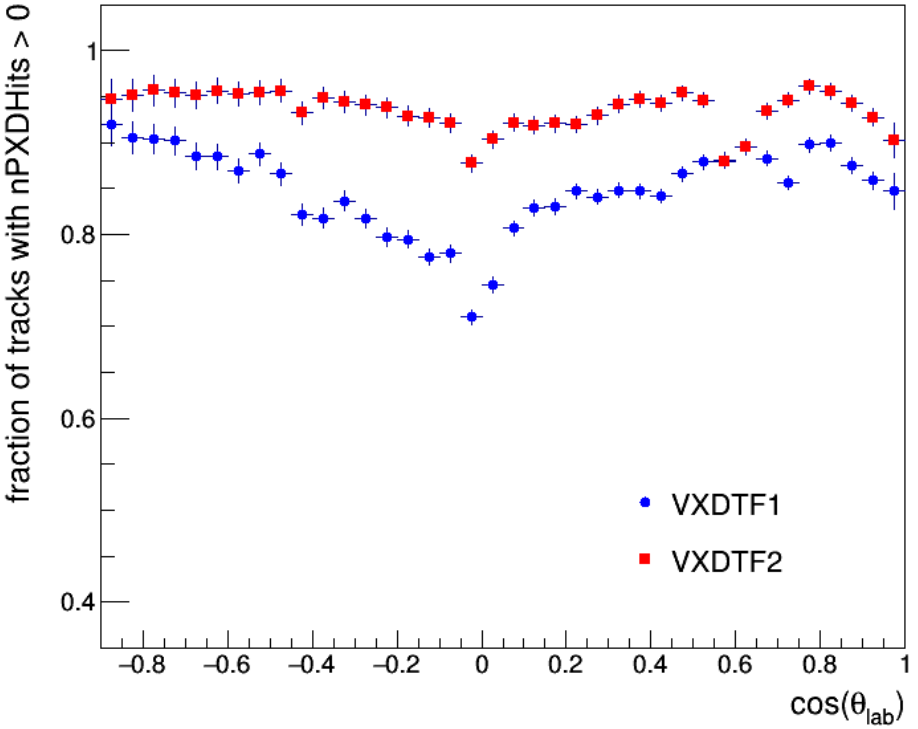
Reminder of previous results

MC9, BGx0

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



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

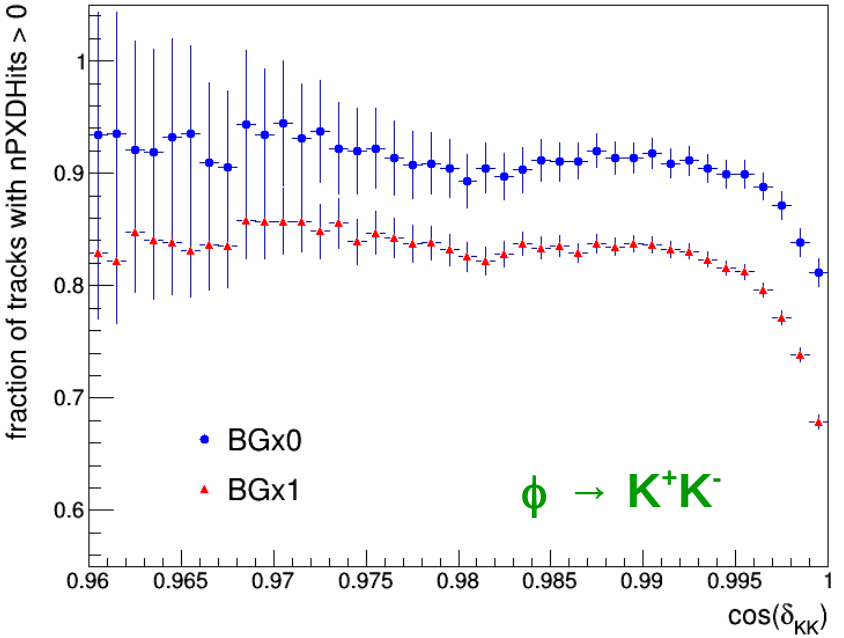


- With the introduction of VXDTF2, things improve a lot, but there are some dips at particular values of $\cos\theta_{lab}$ that cannot be explained;

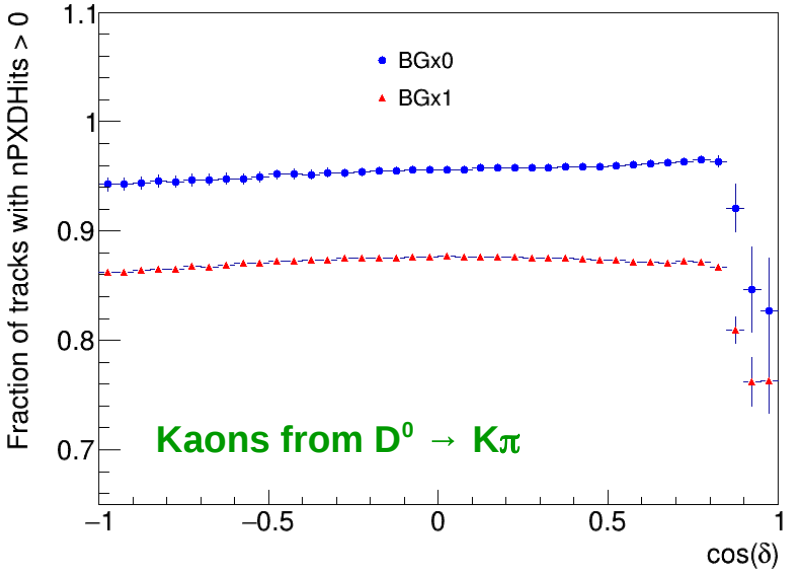
The same kind of plots for MC7 are in the backup slides.

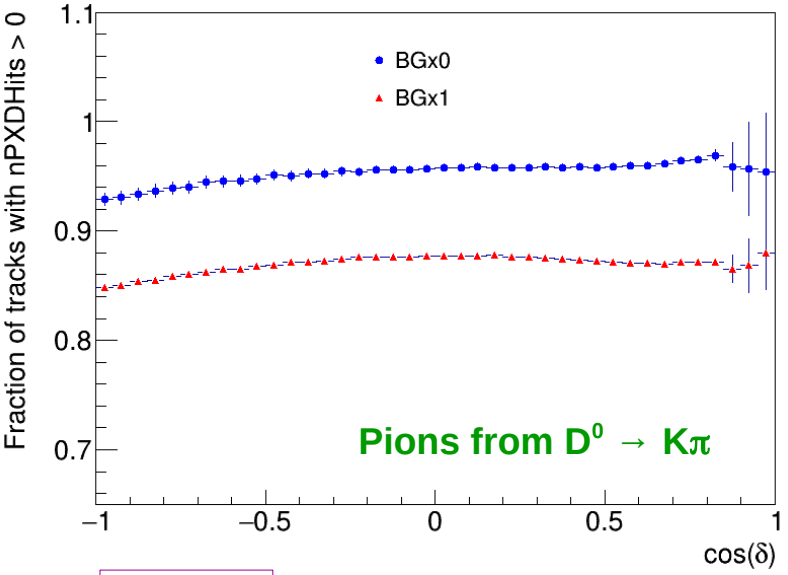
What's specific about $\phi \rightarrow K^+K^-$

- 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.



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





MC7

Samples

- I have samples of 1 million events for each $\phi[K^+K^-]\ K_S[\pi^+\pi^-]$ and $\phi[\pi^+\pi^-\pi^0]\ K_S[\pi^+\pi^-]$ for the following cases:

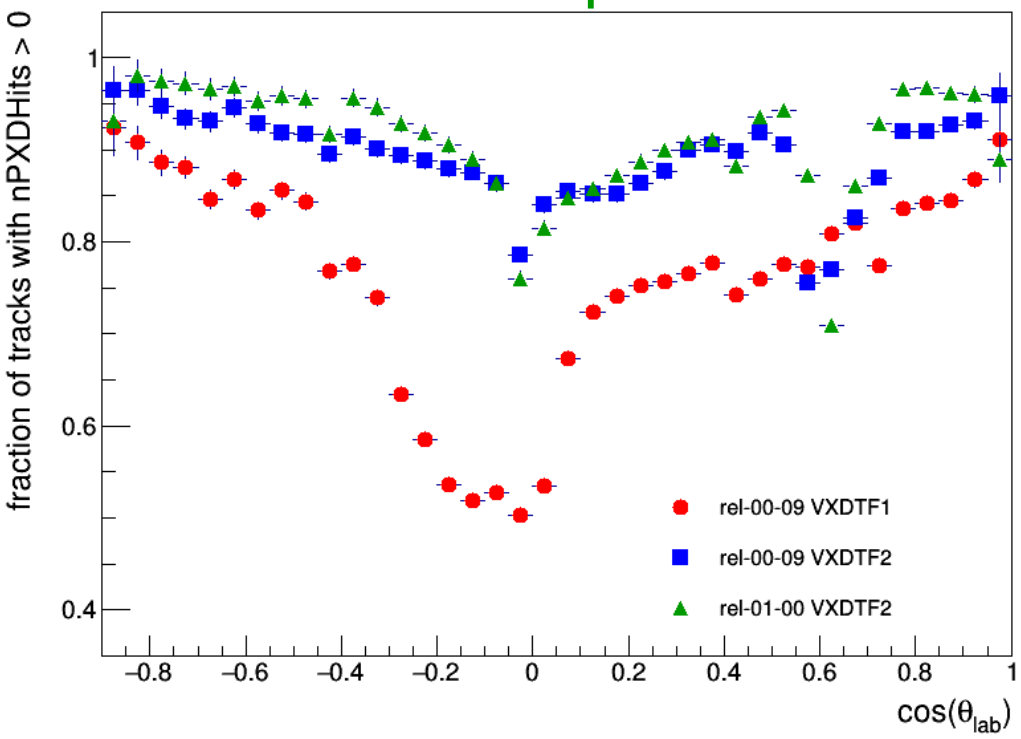
Release	Algorithm	Beam background
release-00-09-00	VXDTF1	x0
release-00-09-00	VXDTF1	x1
release-00-09-00	VXDTF2	x0
release-00-09-00	VXDTF2	x1
prerelease-01-00-00c	VXDTF2	x0
prerelease-01-00-00c	VXDTF2	x1

This was not produced eventually, because samples with relatively high multiplicity ran out of computing resources

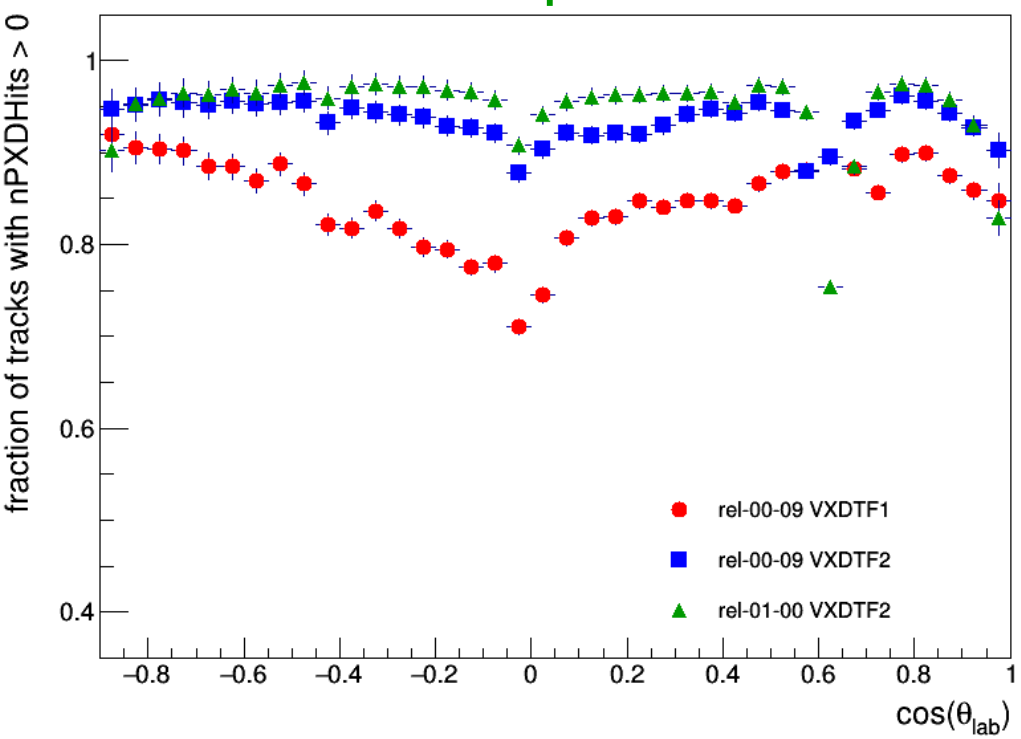
These samples have been produced privately by Jake and are available on disk at KEKCC

Comparison of BGx0 samples

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



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

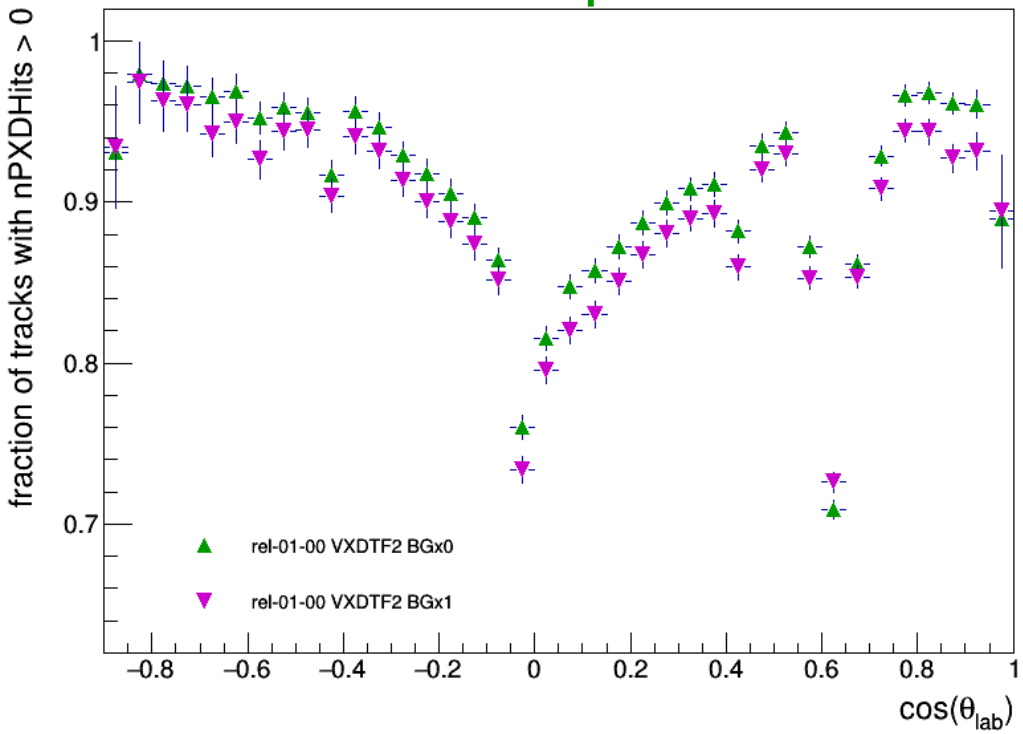


- Overall there is some improvement from `release-00-09` (VXDTF2) to `release-01-00`, but the dips at cosθ ~-0.4, ~0.0, ~0.65 become more visible;
- Still sizable difference between kaons and pions.

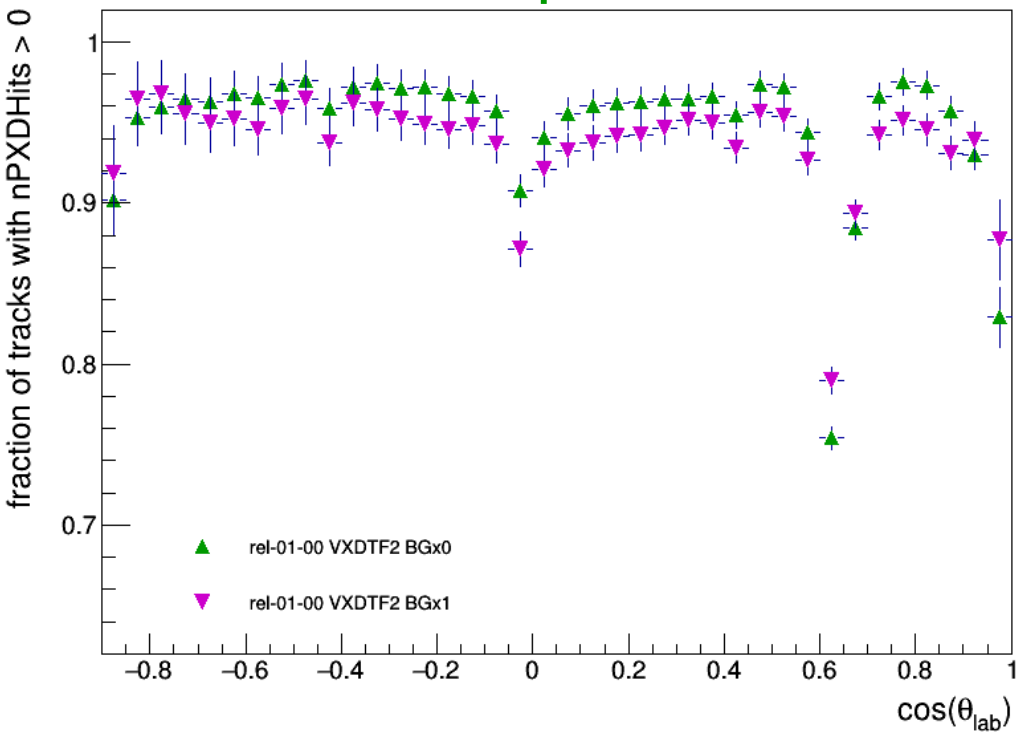
Impact of beam background

- With `release-01-00`, the impact on the PXD hit association efficiency seems to be relatively small;
- Most of the effect of the beam background is on the overall tracking efficiency (efficiency breakdown is in the backup slides).

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

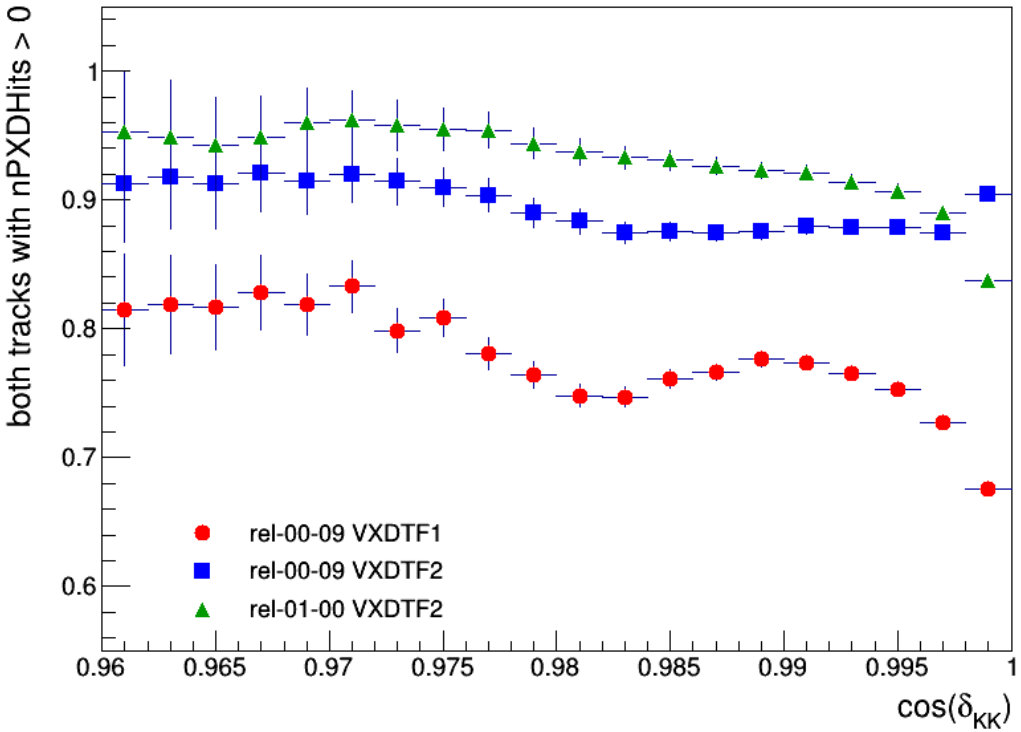


Pions from $\phi \rightarrow \pi^+\pi^-\pi^0$

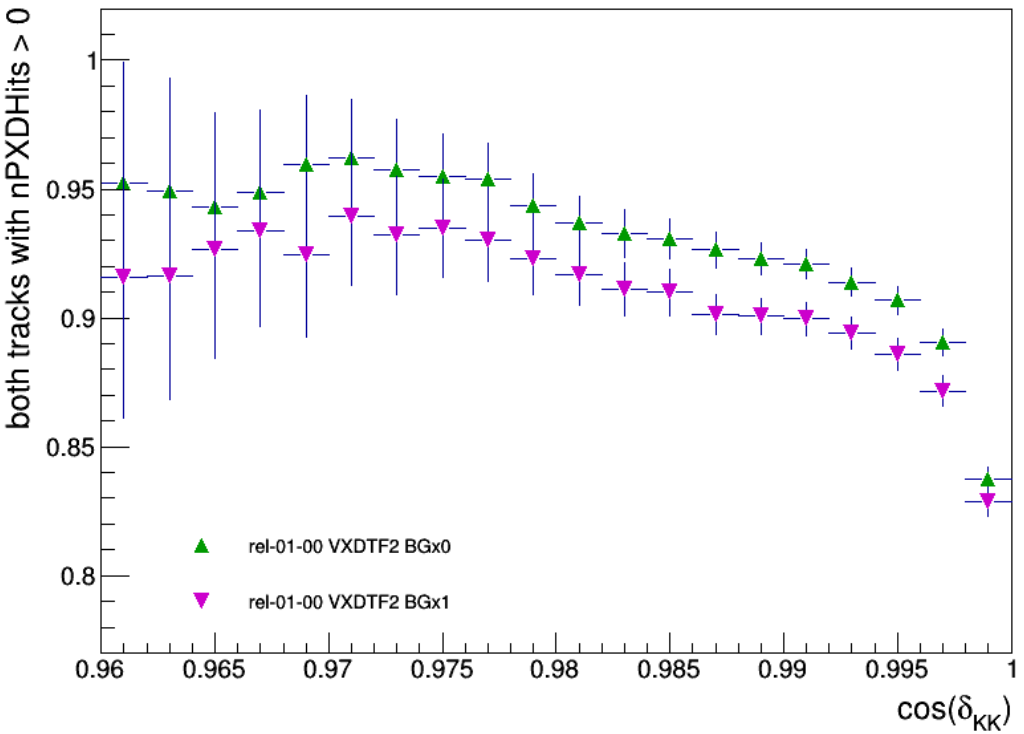


Dependence on $\cos(\delta_{KK})$

- I checked again the dependence of the PXDHit association efficiency (I require that both tracks have at least one PXDHit) as a function of the angle between the momenta of the two kaons $\cos(\delta_{KK})$;
- We see the drop for release-00-09 VXDTF1 and release-01-00 VXDTF2, but curiously not for release-00-09 VXDTF2;



BGx0 samples



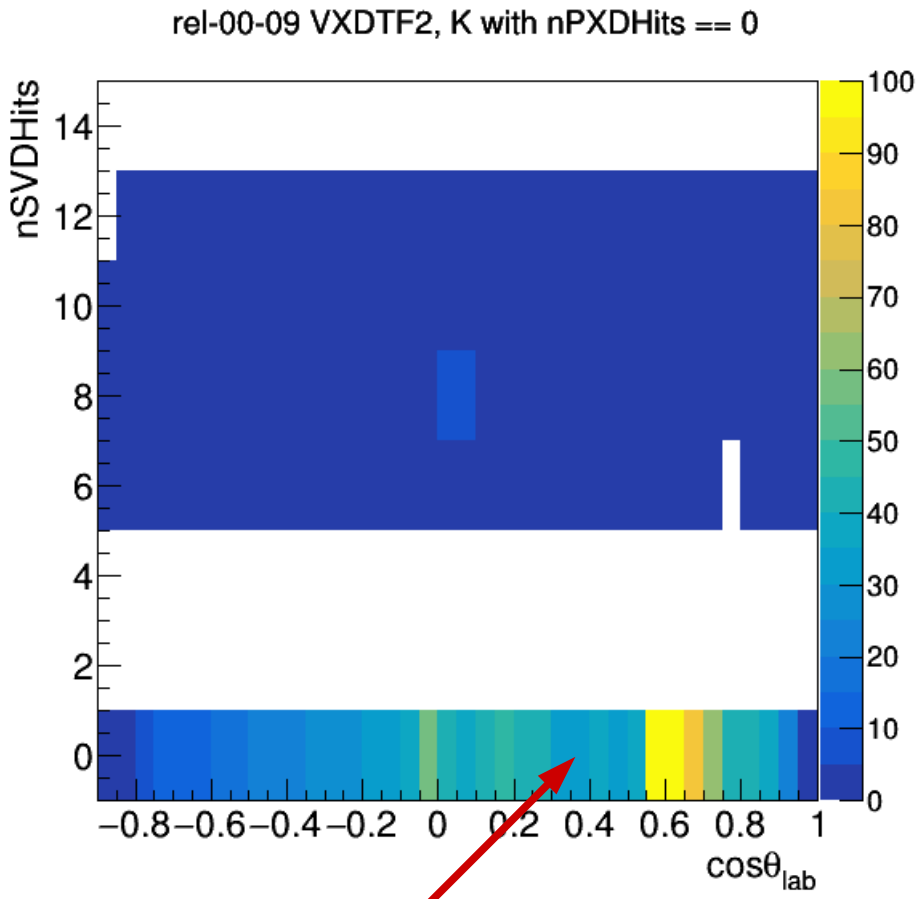
release-01-00 samples

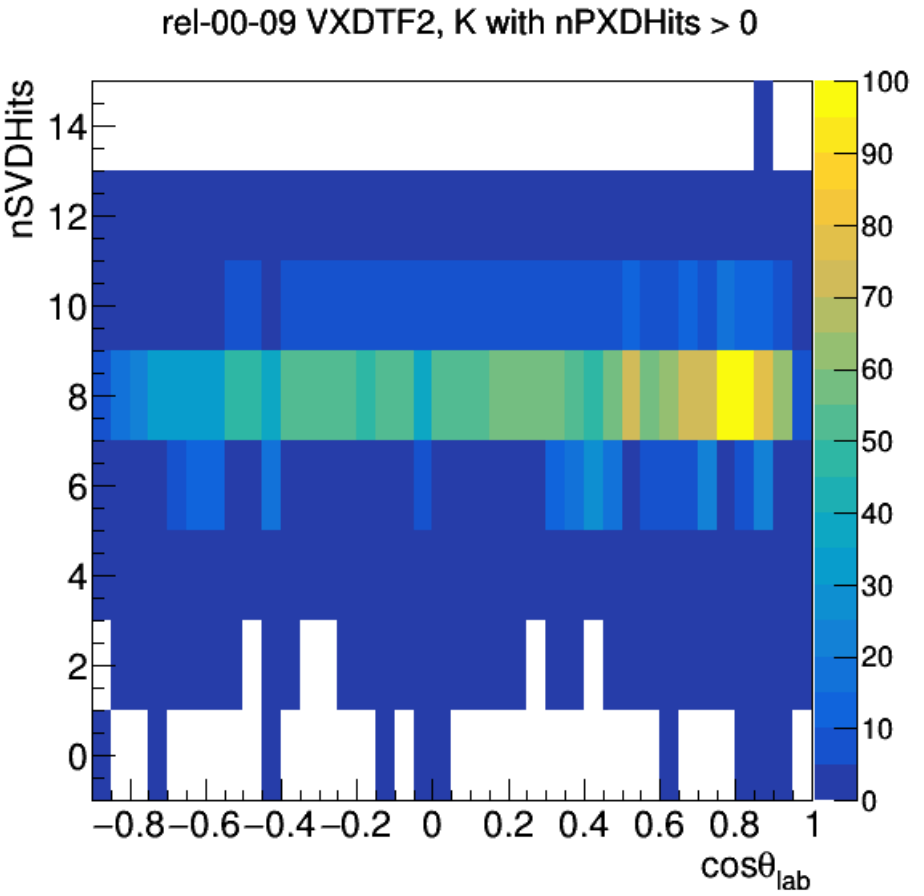
Correlation #PXDHits vs #SVDHits

- In the next slides I am going to check for the correlation between #SVDHits and #PXDHits (as a function of the interesting variable $\cos\theta_{lab}$);
- I plot the number of SVDHits as a function of the polar angle for each K (π) track in two cases:
  1) no PXDHits are associated to the track (left plot);
  2) at least one PXDHit is associated to the track (right);

- The plots are normalized so that the maximum is at 100.

release-00-09 VXDTF2 - Kaons

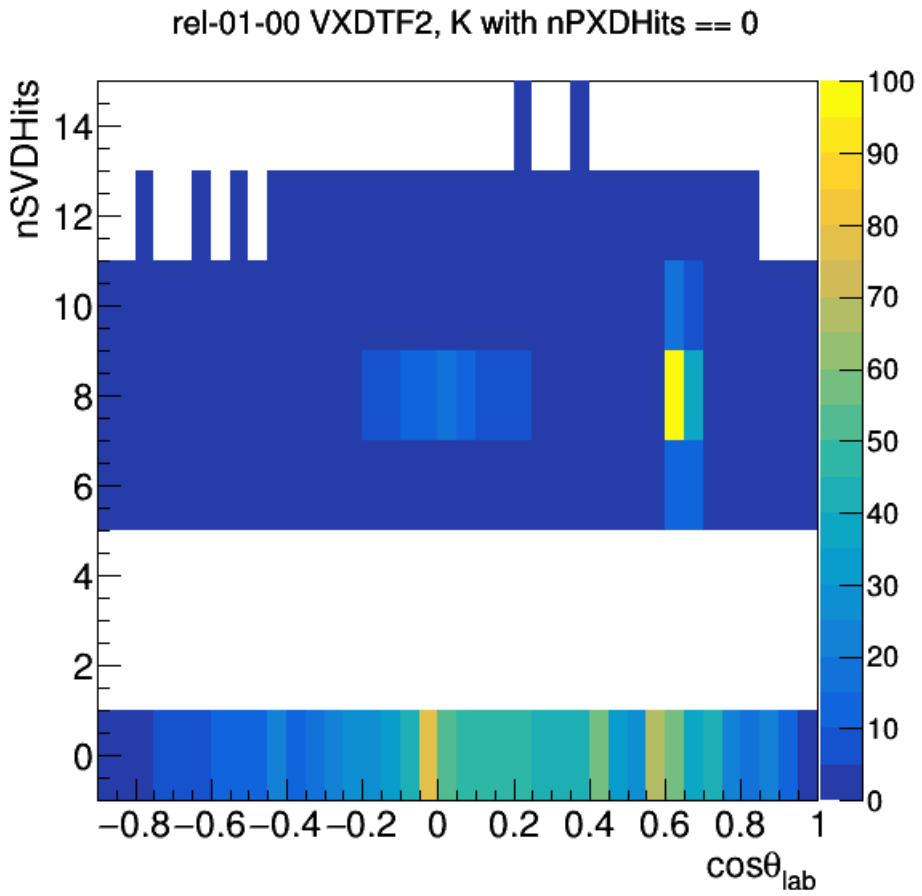


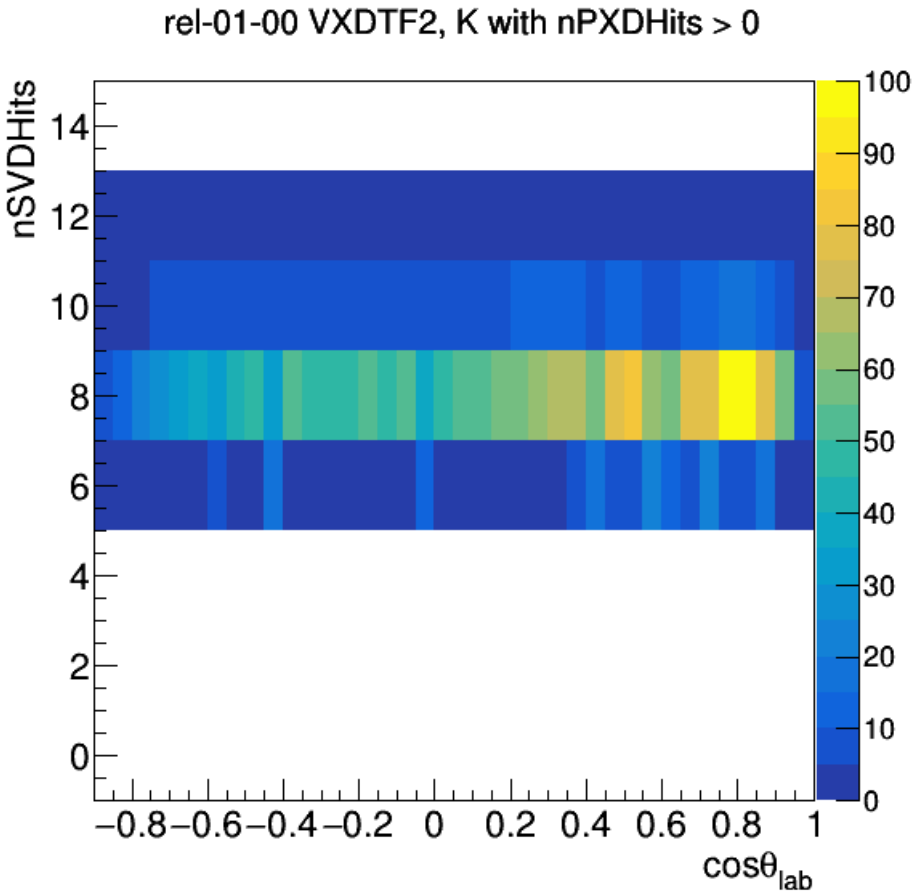


This band represents CDC-only tracks (!?)

There is clearly a large correlation between the SVD and PXD hit multiplicities.

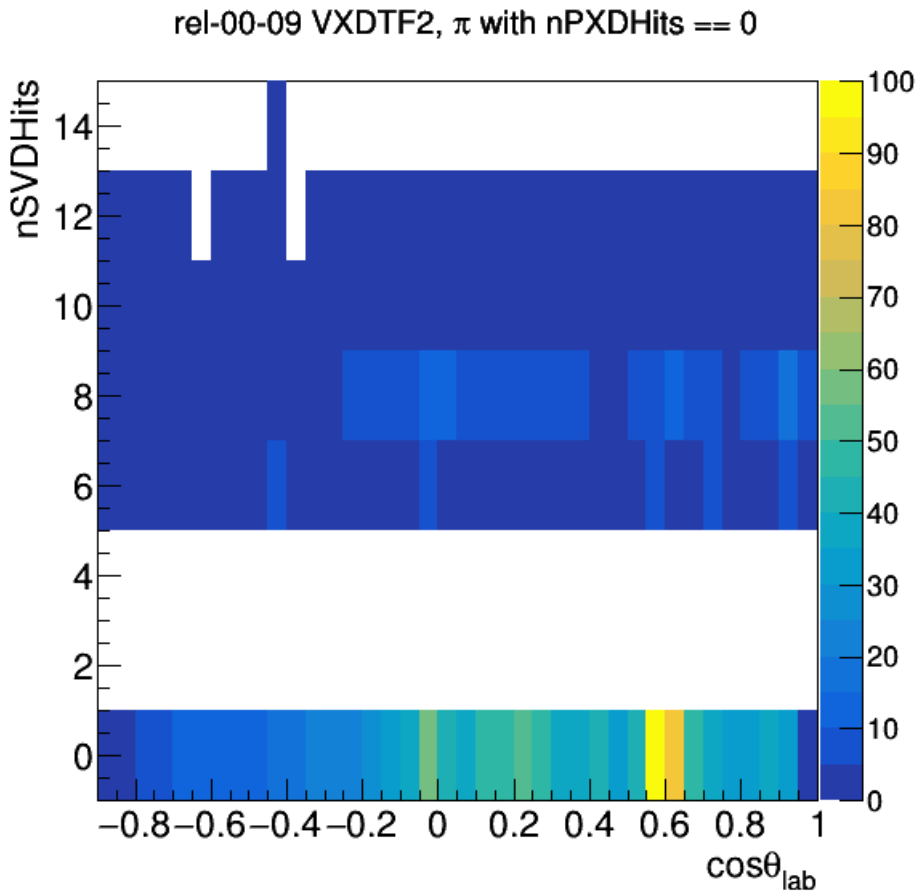
release-01-00 VXDTF2 - Kaons

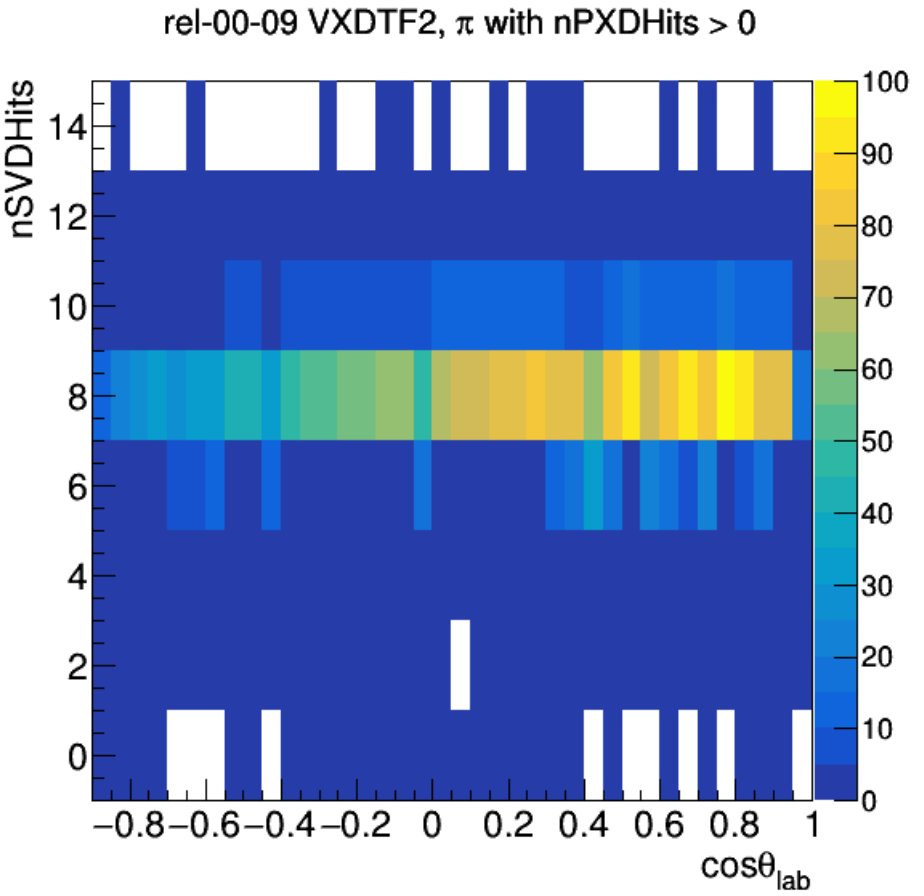




The situation improves, but there is still a large correlation between SVD and PXD hits.

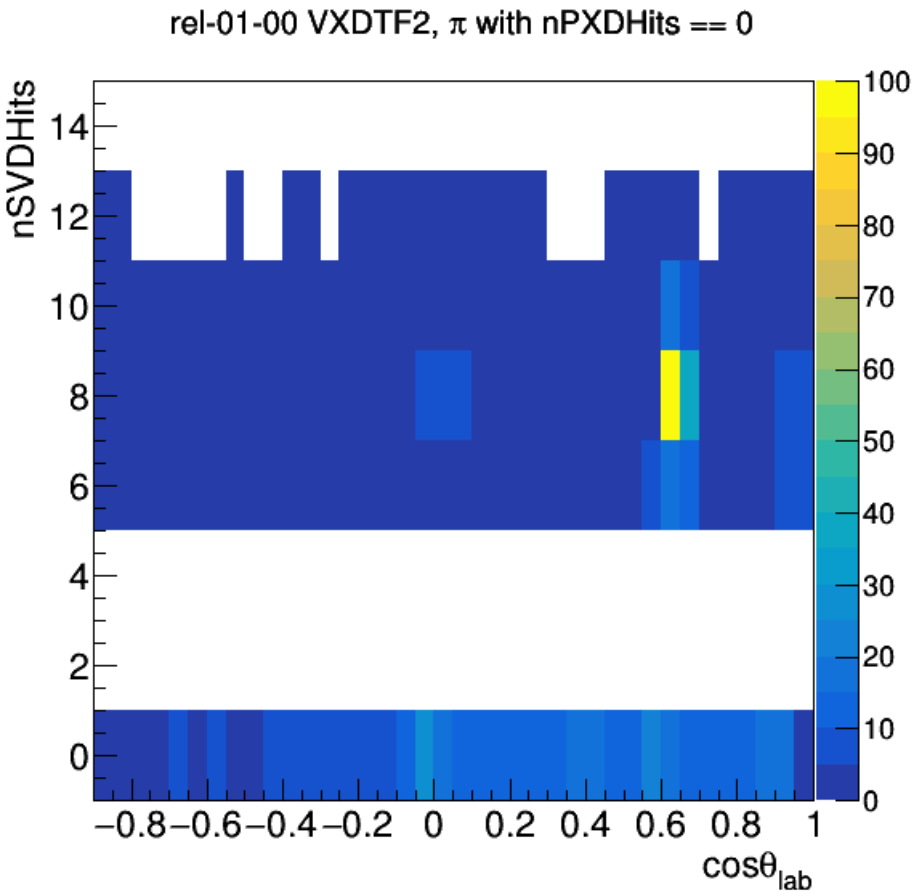
release-00-09 VXDTF2 - Pions

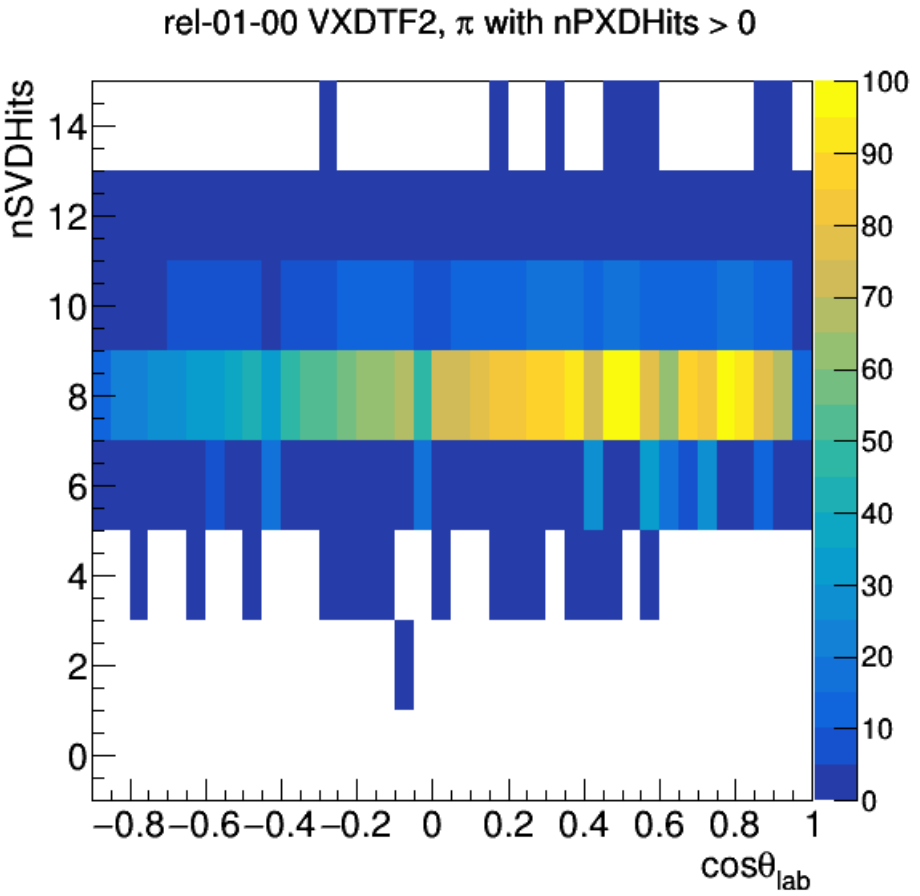




Similar considerations can be made for pions also.

release-01-00 VXDTF2 - Pions





Similar considerations can be made for pions also.

Comments

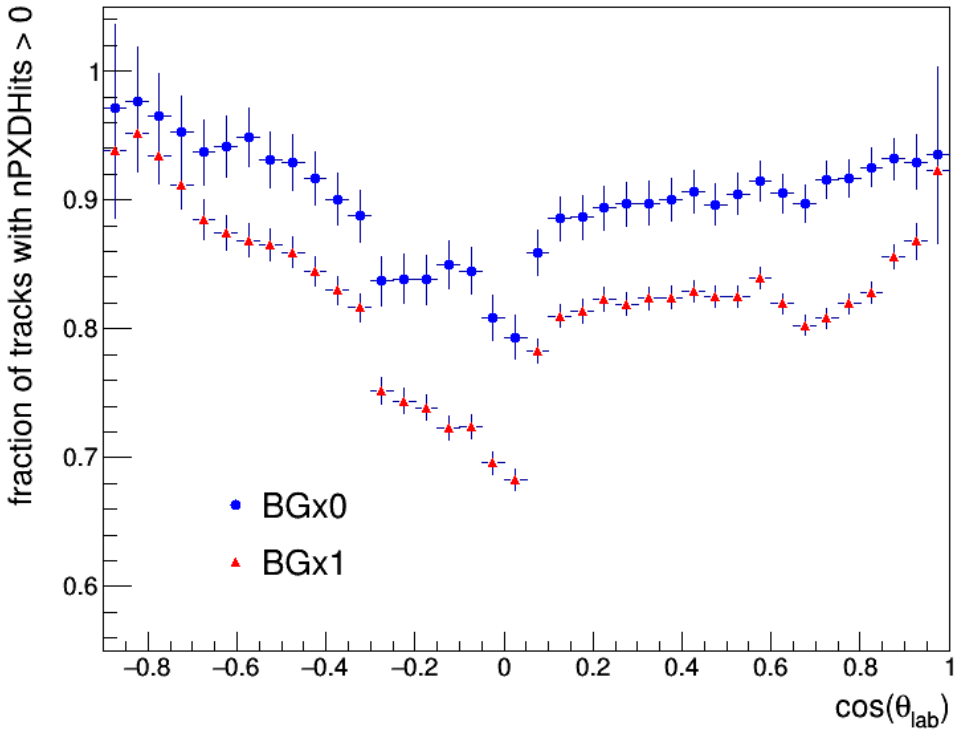
- I repeated my checks with release-01-00 signal Monte Carlo (many thanks to Jake Bennet for producing the samples so quickly);
- The numbers improved significantly, but the main features of the issue basically remained there;
- I am happy if you can provide feedback or suggest further checks that I can make.

Backup Slides

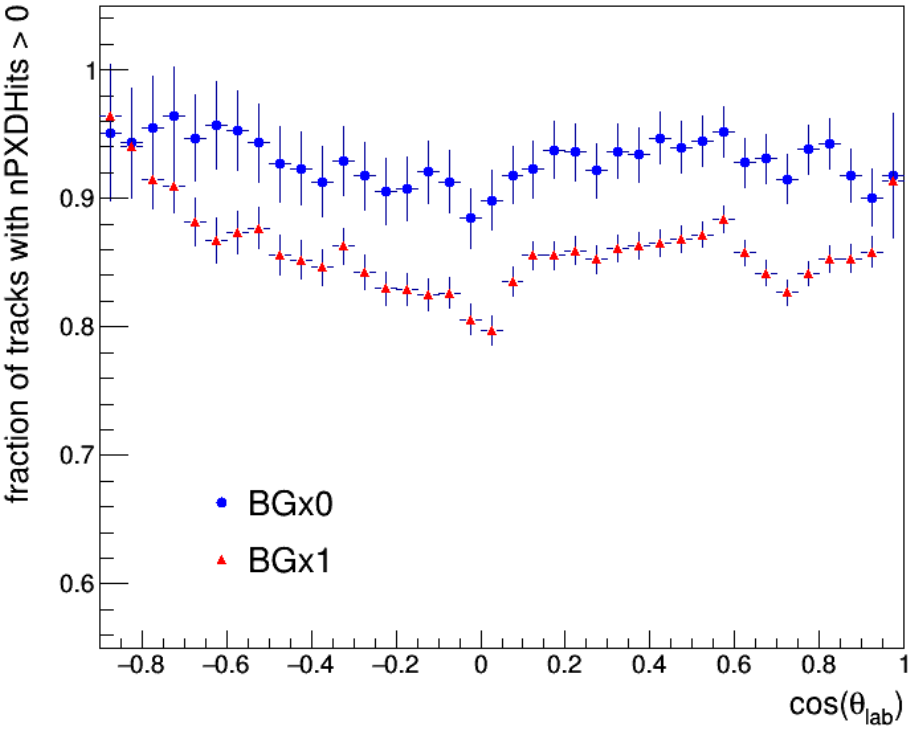
Reminder of previous results

MC7

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



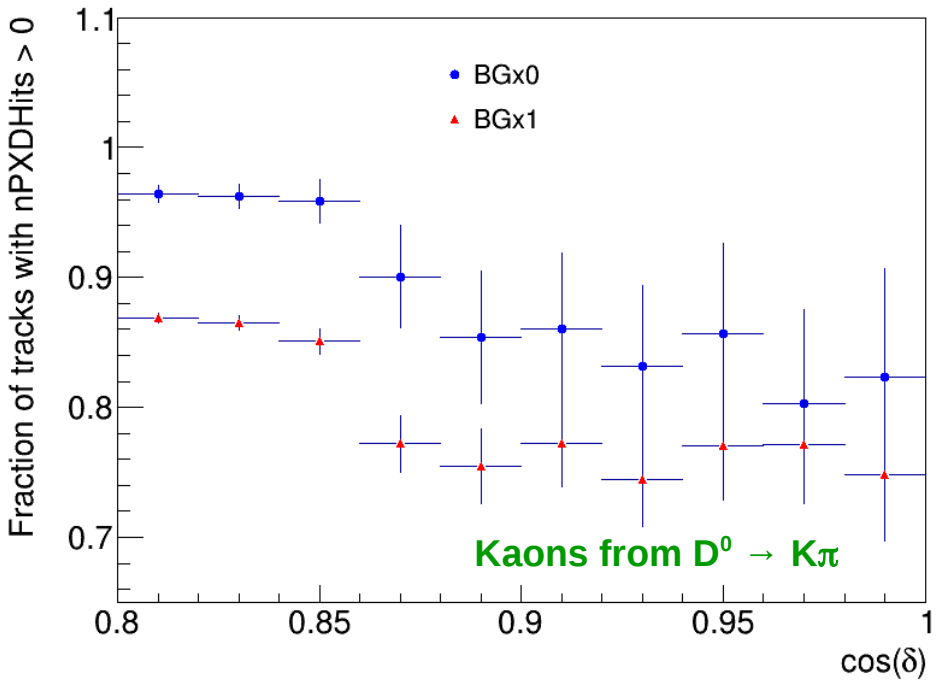
Pions from $\phi \rightarrow \pi^+\pi^-\pi^0$

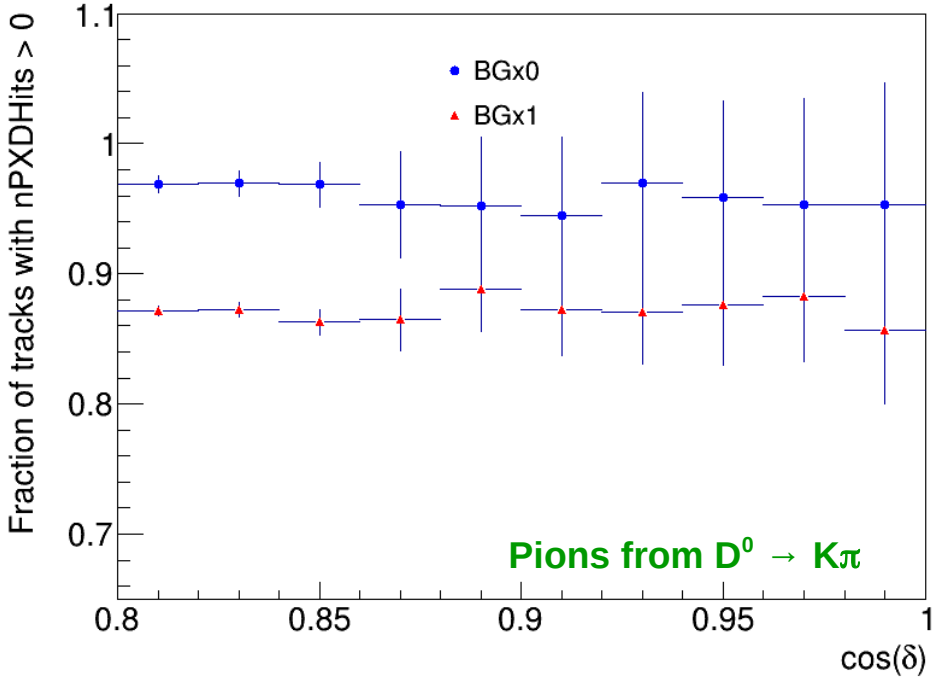


Comparing K/π from $D^0 \rightarrow K\pi$

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

MC7





- 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?

Efficiency breakdown – $\phi[K^+K^-]$

		BGx0		BGx1
	rel-00-09 VXDTF1	**rel-00-09 VXDTF2**	**rel-01-00 VXDTF2**	**rel-01-00 VXDTF2**
Reconstructed ($M_{bc} > 5.25$, $\|\Delta E\| < 0.2$)	47.5%	49.9%	50.7%	37.7%
M(ϕ) cut	96.1%	96.1%	96.2%	96.2%
d_0(K) cut	97.0%	96.9%	98.4%	97.8%
z_0(K) cut	97.7%	98.1%	98.6%	97.1%
PID(K)	90.2%	90.3%	90.5%	90.2%
K PXDHit cut	68.6%	82.0%	86.4%	75.9%
K_S VtxProb	98.5%	98.6%	98.3%	97.1%
ϕ VtxProb	98.3%	98.6%	98.9%	98.7%
B VtxProb	92.6%	91.8%	88.8%	85.0%
Total efficiency:	24.0%	30.1%	32.0%	21.3%

Efficiency breakdown – $\phi[\pi^+\pi^-\pi^0]$

		BGx0		BGx1
	rel-00-09 VXDTF1	**rel-00-09 VXDTF2**	**rel-01-00 VXDTF2**	**rel-01-00 VXDTF2**
Reconstructed ($M_{bc} > 5.25$, $-0.1 < \Delta E < 0.2$)	30.9%	31.8%	32.3%	24.4%
$M(\pi^0)$ cut	97.5%	97.5%	97.2%	96.2%
$E(\pi^0)$ cut	90.0%	89.7%	88.1%	88.5%
$M(\phi)$ cut	94.3%	94.5%	95.1%	90.5%
$d_0(\pi)$ cut	94.8%	95.5%	96.6%	94.6%
$z_0(\pi)$ cut	98.4%	98.8%	99.2%	97.9%
π PXD hits cut	78.9%	92.7%	94.1%	92.7%
K_S VtxProb	98.3%	98.4%	98.2%	96.7%
ϕ VtxProb	99.3%	99.4%	99.4%	98.9%
B VtxProb	98.3%	98.0%	91.0%	87.4%
Total efficiency:	18.1%	22.0%	21.0%	13.5%