

# Study of tracking performance for soft particles in SpdRoot

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# Event samples

- 4 samples:  $\pi^+$ ,  $K^+$ , p, d
- 400 000 primary particles in each sample
- Uniformly distributed in momentum magnitude  $p_0$  from 0.005 to 0.995 GeV/c with step = 0.01 GeV/c.
- Isotropically distributed in angle [i.e. uniformly in  $\cos(\theta)$  and  $\varphi$ ].
- The primary vertex coordinates has a gaussian smearing with  $\sigma_z = 30$  cm,  $\sigma_x = \sigma_y = 0.1$  cm.
- The last commit in the SpdRoot master branch (16.03.2023).
- Standard geometry with DSSD option for the vertex detector (3 layers, endcaps present).

# Track quality cuts

- How do these cuts affect:
  - efficiency at different momenta and angles
  - number of hits
  - reconstructed momentum vs MC momentum

```
//-----  
inline Bool_t SpdTrackFitPar::GetIsGood() const  
{  
    if (fErrorFlag != 0) return false;  
    if (HasErrorMesg()) return false;  
    //if (fNFailedHits > 0) return false;  
    if (fConvergencyGF != 1) return false;  
    return true;  
}  
  
//-----  
inline Bool_t SpdTrackFitPar::GetIsAcceptable() const  
{  
    if (fErrorFlag != 0) return false;  
    if (HasErrorMesg()) return false;  
    //if (fNFailedHits > 0) return false;  
    if (fNDF < 3) return false;  
    if (GetChi2overNDF() < 2) return true;  
    return false;  
}
```

# SpdMCTrackFinder

Makes tracks (SpdTrackMC) from particles (SpdMCParticle).

Default cuts:

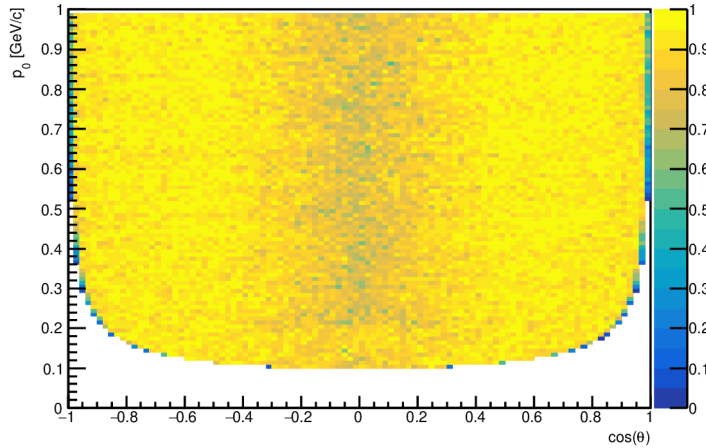
Variable	Min. value	Comment
Transverse momentum $p_T$	0.1 GeV/c	
Momentum $p$	0.004 GeV/c	GF requirement
$\beta\gamma$	0.05	GF requirement (Corresponding momentum: $\pi$ : 0.007 GeV/c, K: 0.025 GeV/c, p: 0.047 GeV/c, d: 0.094 GeV/c)
Hits in ITS	1	
Hits in ITS + TS	3	



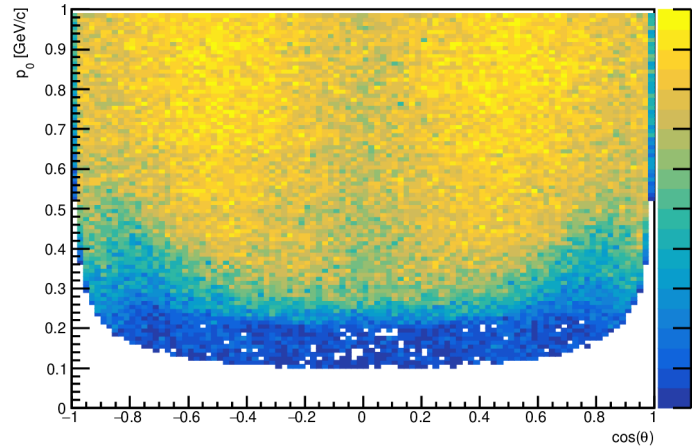
# Pions

# Pions: Efficiency ( $p_0 : \cos \theta$ )

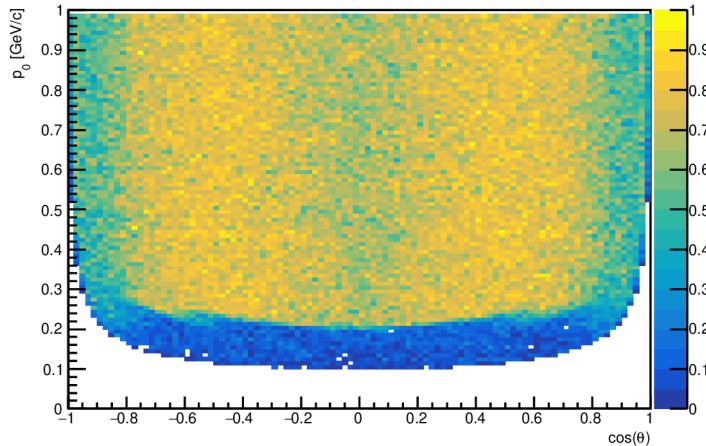
efficiency



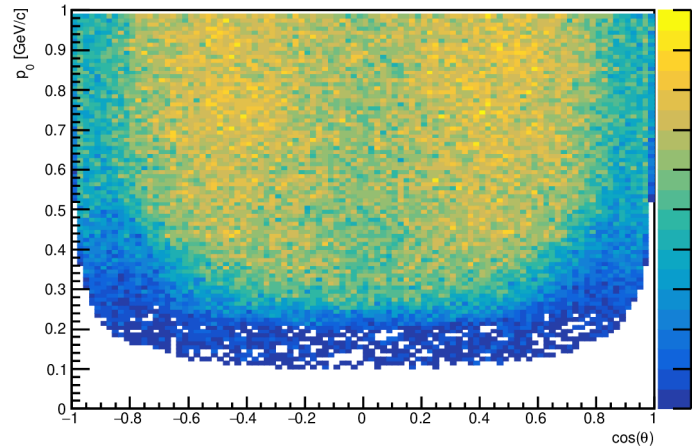
efficiency [GetIsGood()]



efficiency [GetIsAcceptable()]



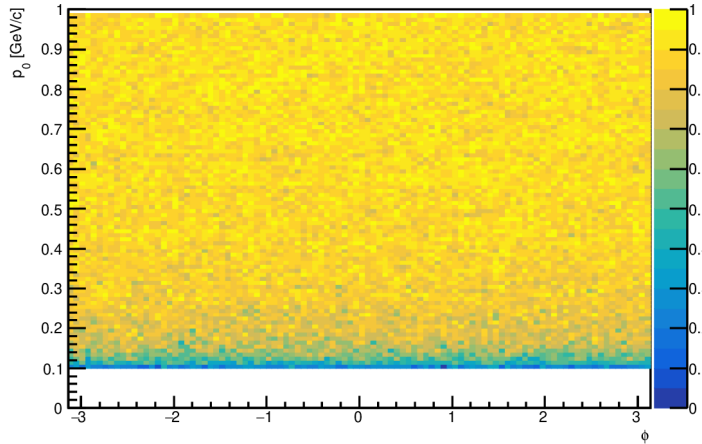
efficiency [GetIsGood() && GetIsAcceptable()]



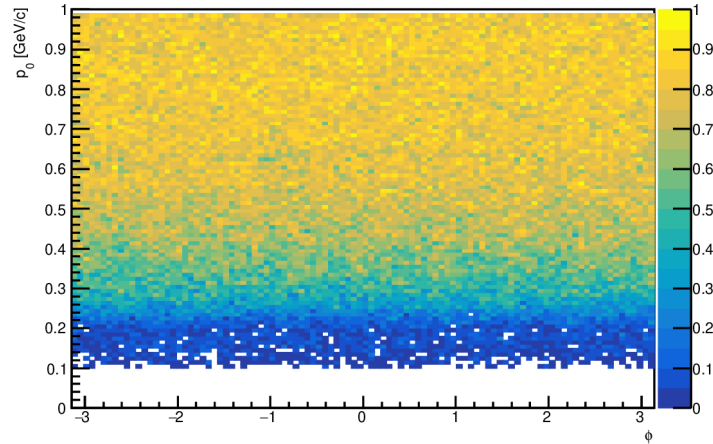
- Why there is a drop in efficiency for  $\theta \approx 90^\circ$ , even for large momenta?
- Particles with  $p \lesssim 0.2$  GeV are mostly rejected by the fit quality cuts. They have trajectories inside the straw tracker region.

# Pions: Efficiency ( $p_0 : \phi$ )

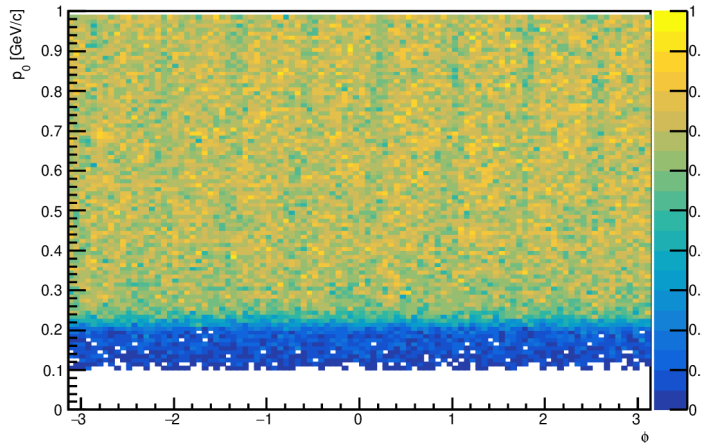
efficiency



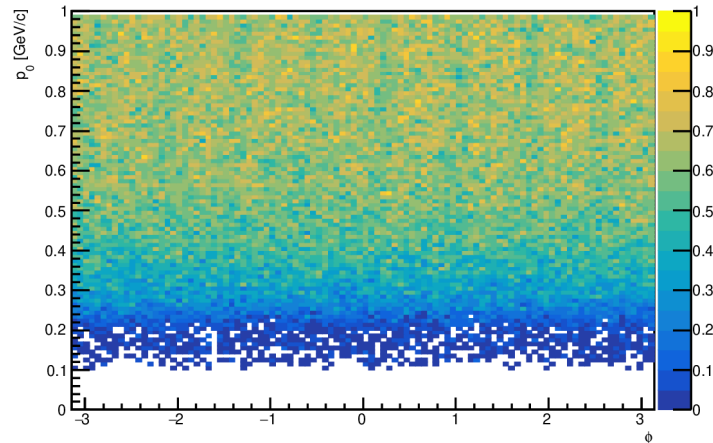
efficiency [GetIsGood()]



efficiency [GetIsAcceptable()]

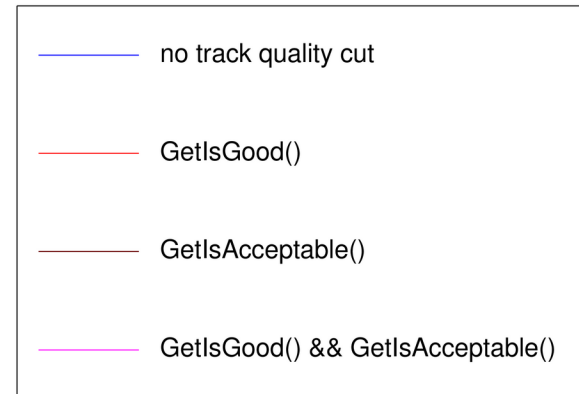
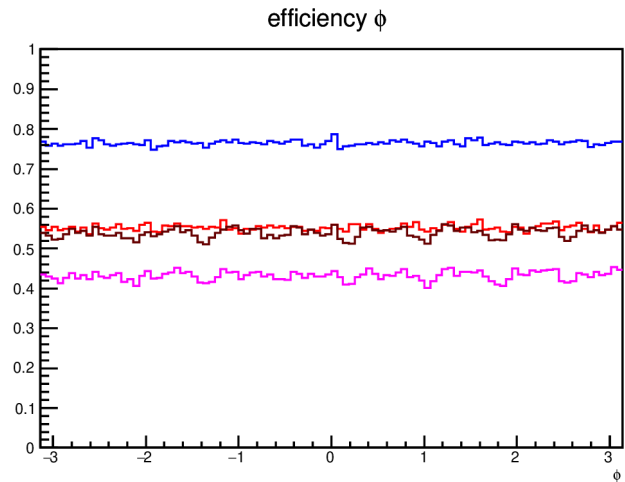
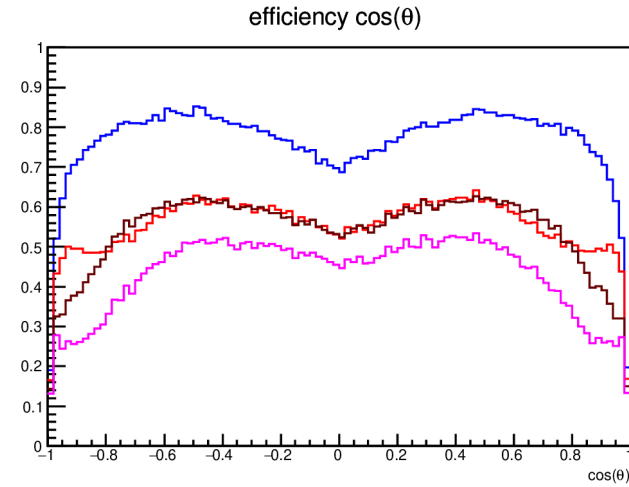
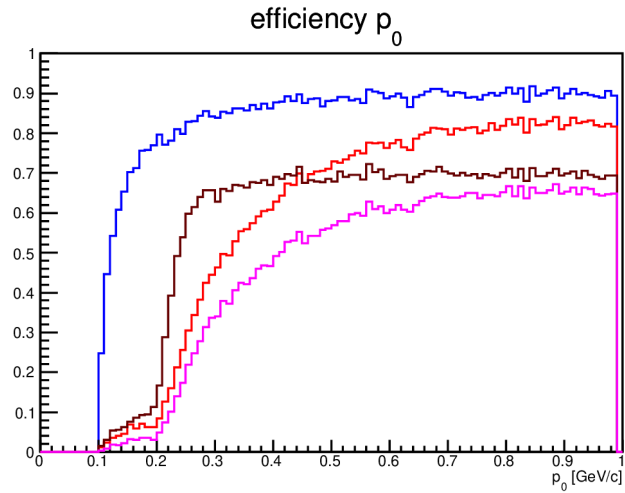


efficiency [GetIsGood() && GetIsAcceptable()]

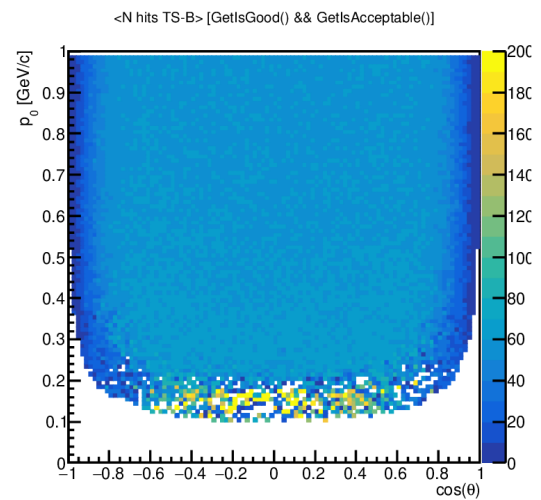
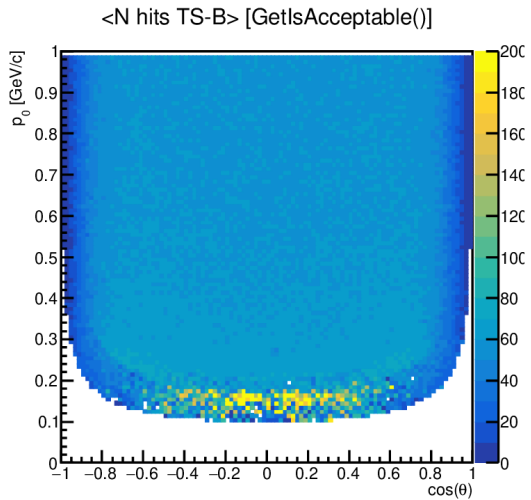
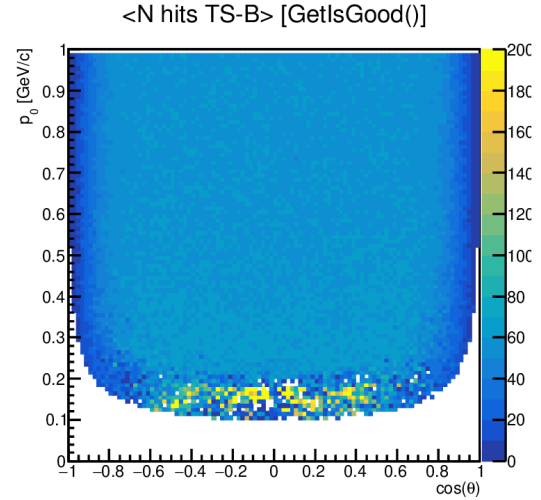
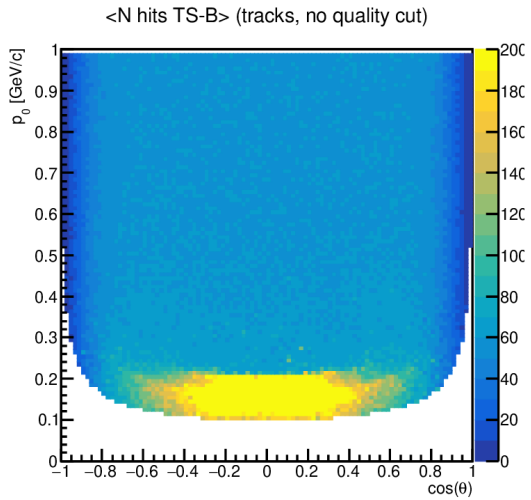
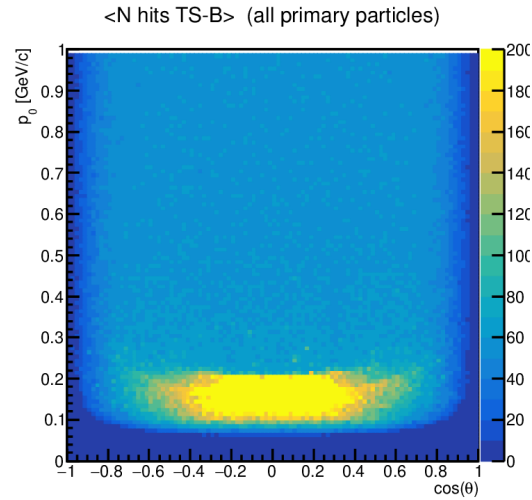


- There is a small drop in efficiency due to gaps between the octants of the TS.

# Pions: Efficiency 1D ( $p_0$ , $\theta$ , $\phi$ )

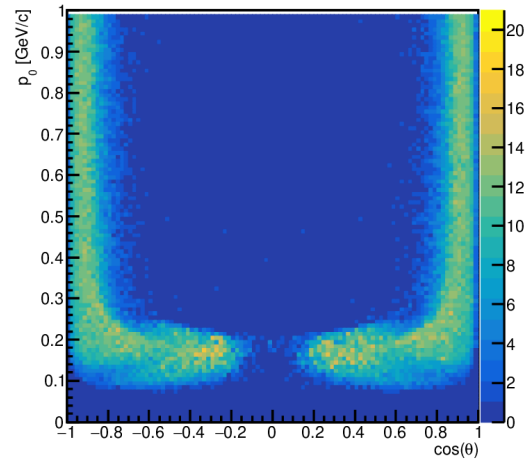


# Pions: Mean number of hits in TS barrel ( $p_0 : \cos \theta$ )

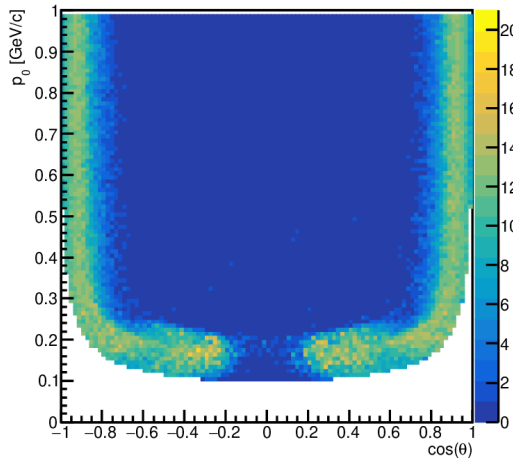


# Pions: Mean number of hits in TS endcaps ( $p_0 : \cos \theta$ )

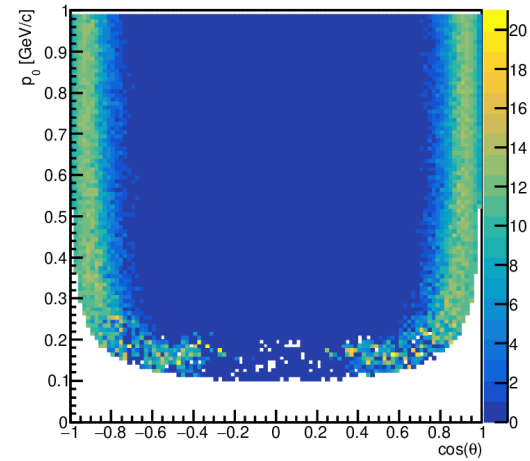
<N hits TS-EC> (all primary particles)



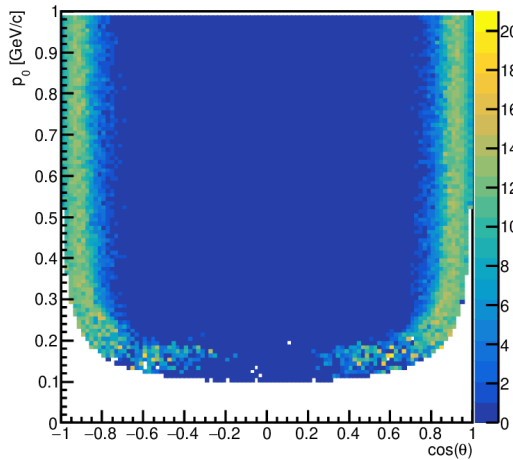
<N hits TS-EC> (tracks, no quality cut)



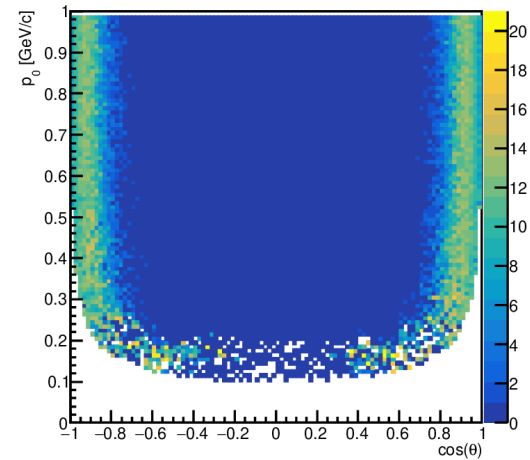
<N hits TS-EC> [GetIsGood()]



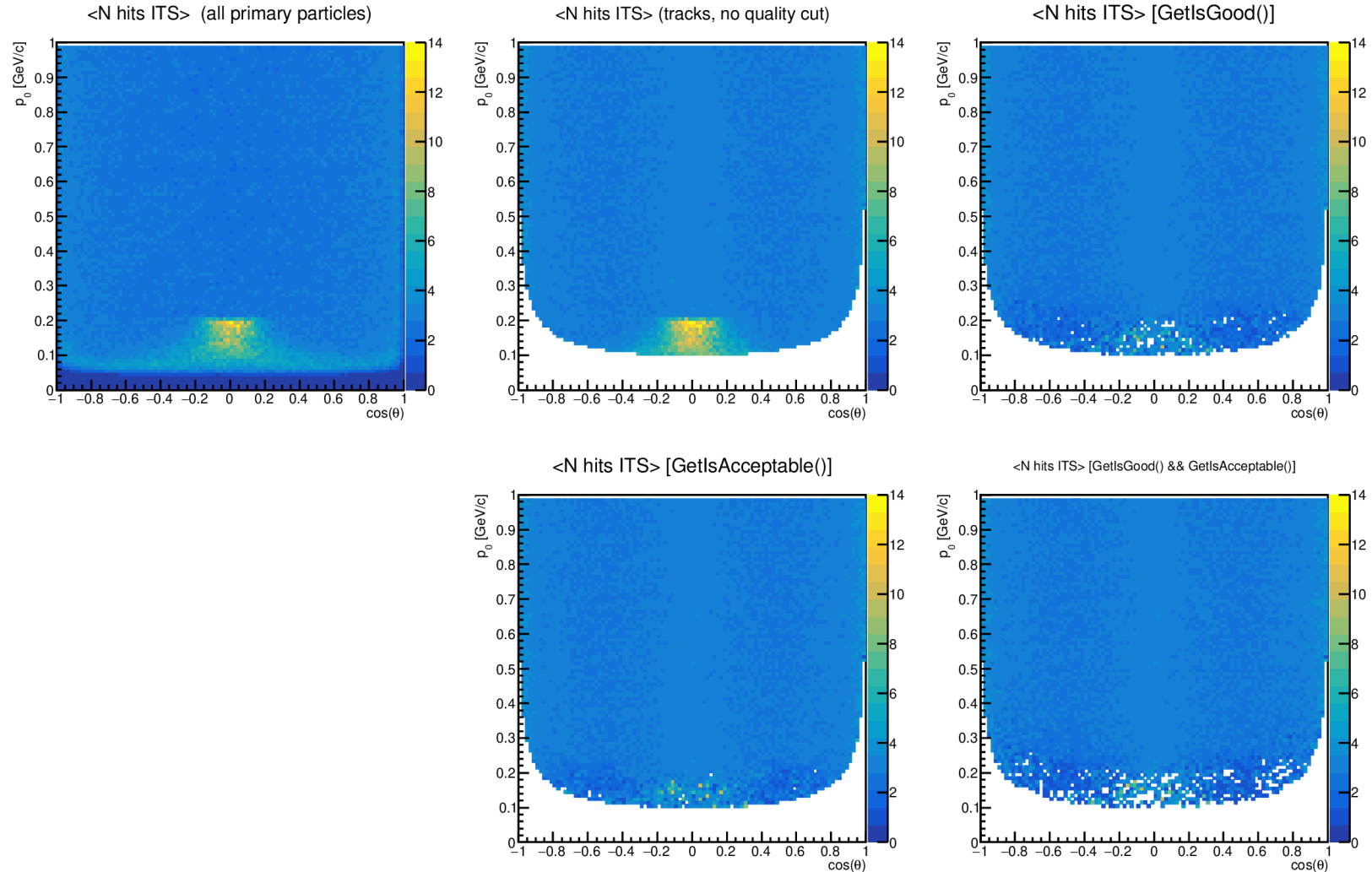
<N hits TS-EC> [GetIsAcceptable()]



<N hits TS-EC> [GetIsGood() && GetIsAcceptable()]

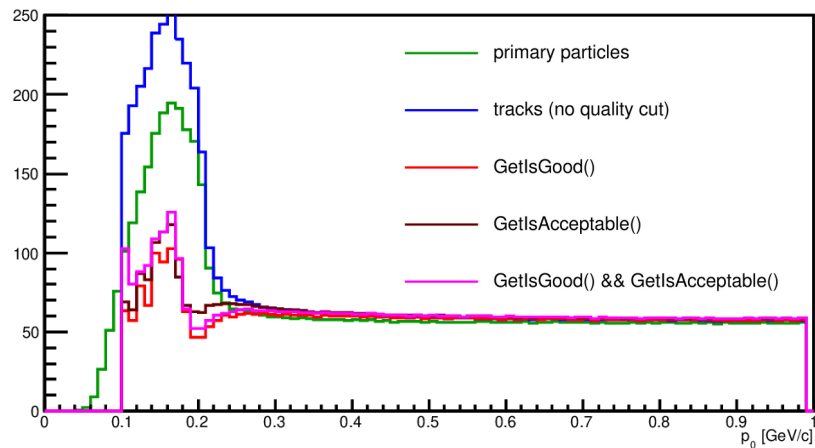


# Pions: Mean number of hits in ITS ( $p_0 : \cos \theta$ )

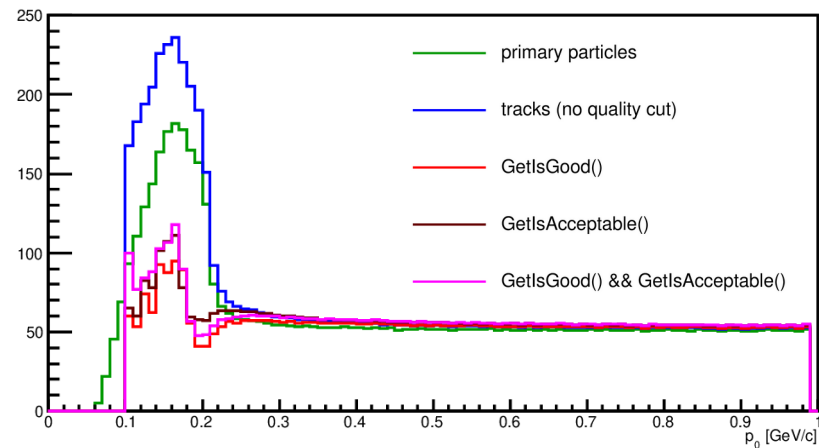


# Pions: Mean number of hits ( $p_0$ )

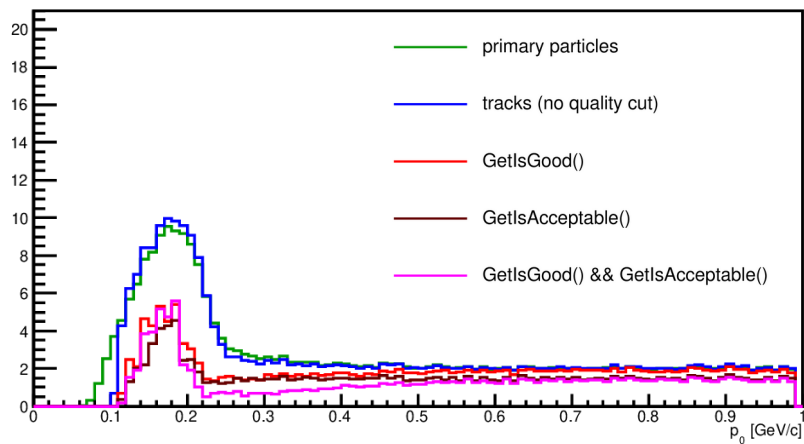
<N hits >



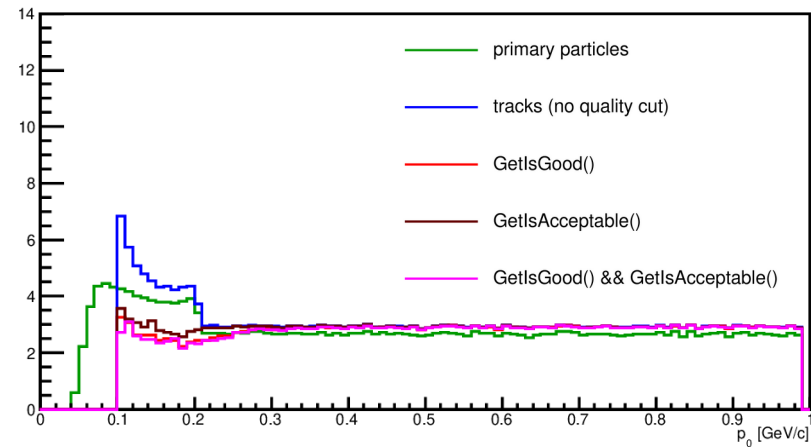
<N hits TS-B>



<N hits TS-EC>



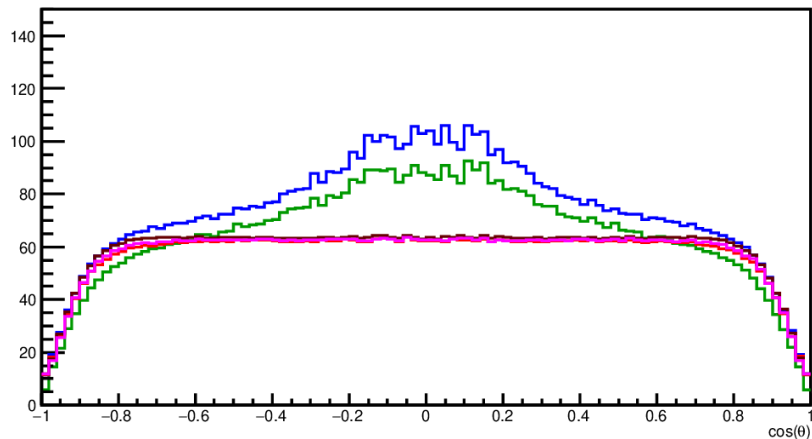
<N hits ITS>



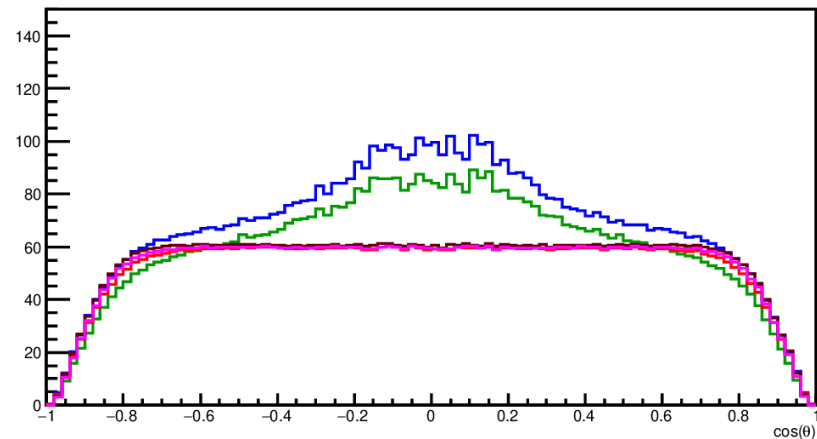


# Pions: Mean number of hits ( $\cos \theta$ )

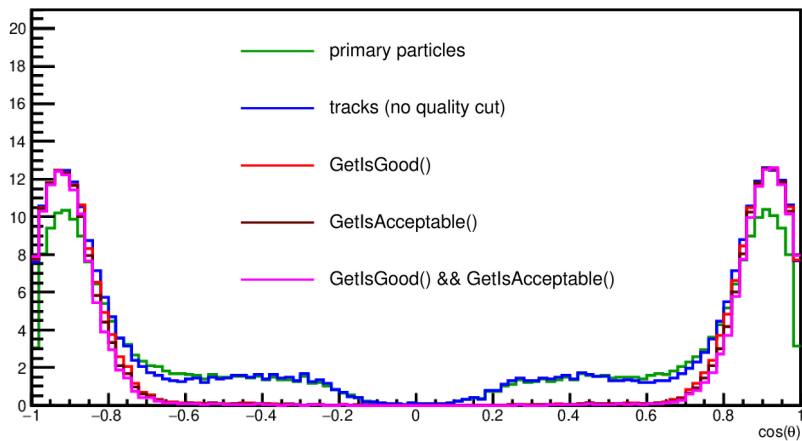
$\langle N \text{ hits} \rangle$



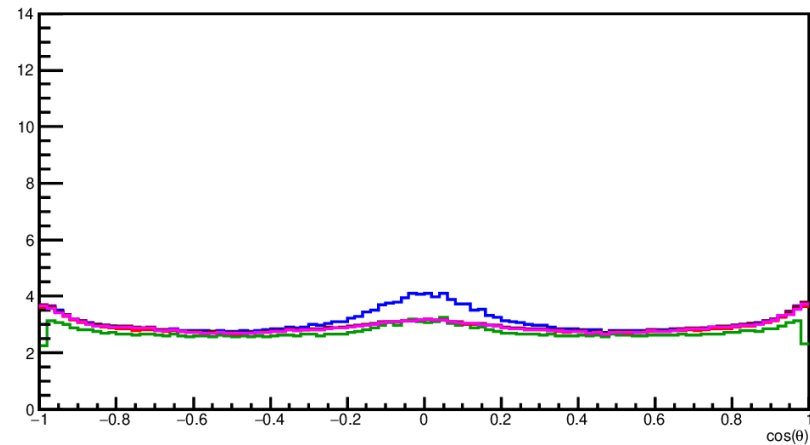
$\langle N \text{ hits TS-B} \rangle$



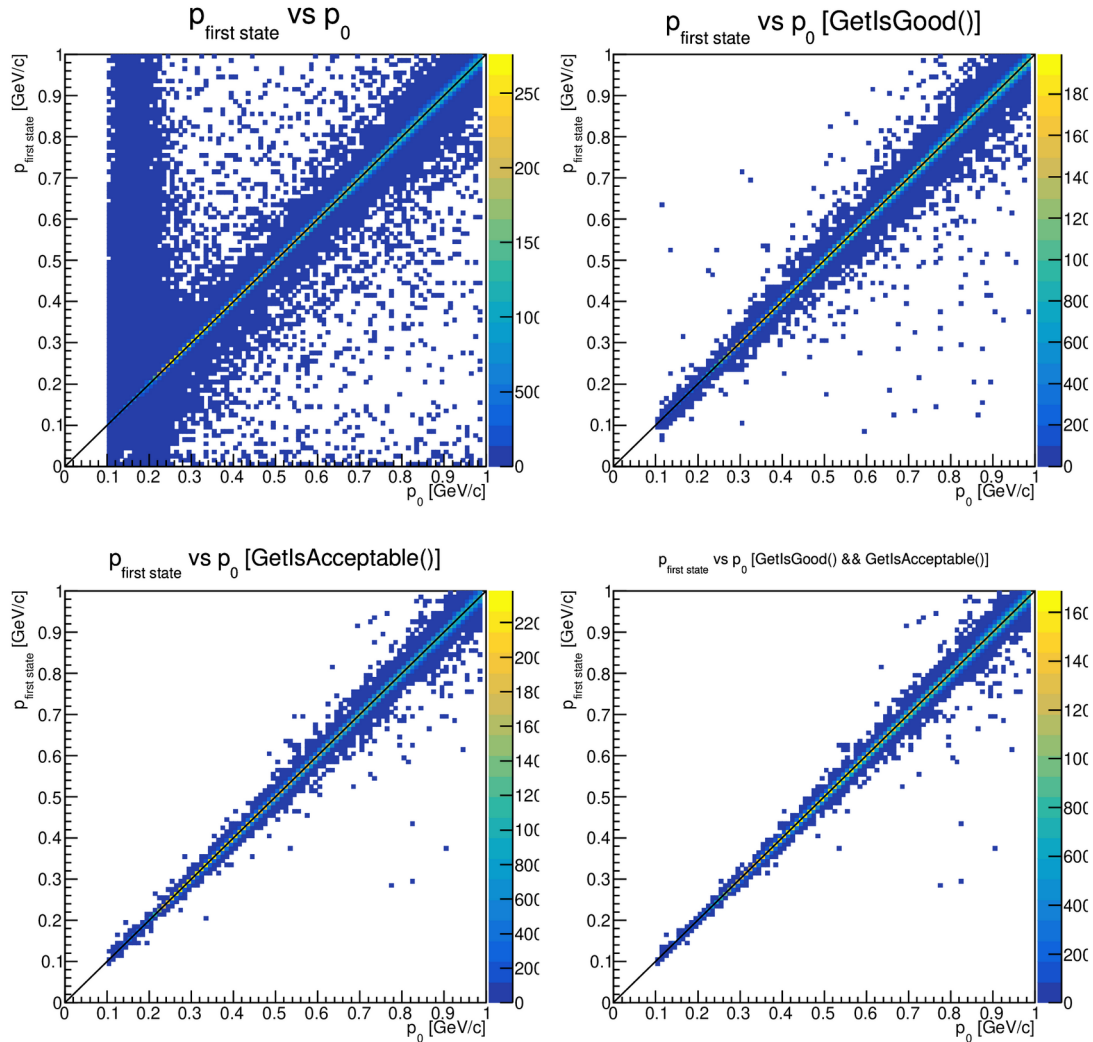
$\langle N \text{ hits TS-EC} \rangle$



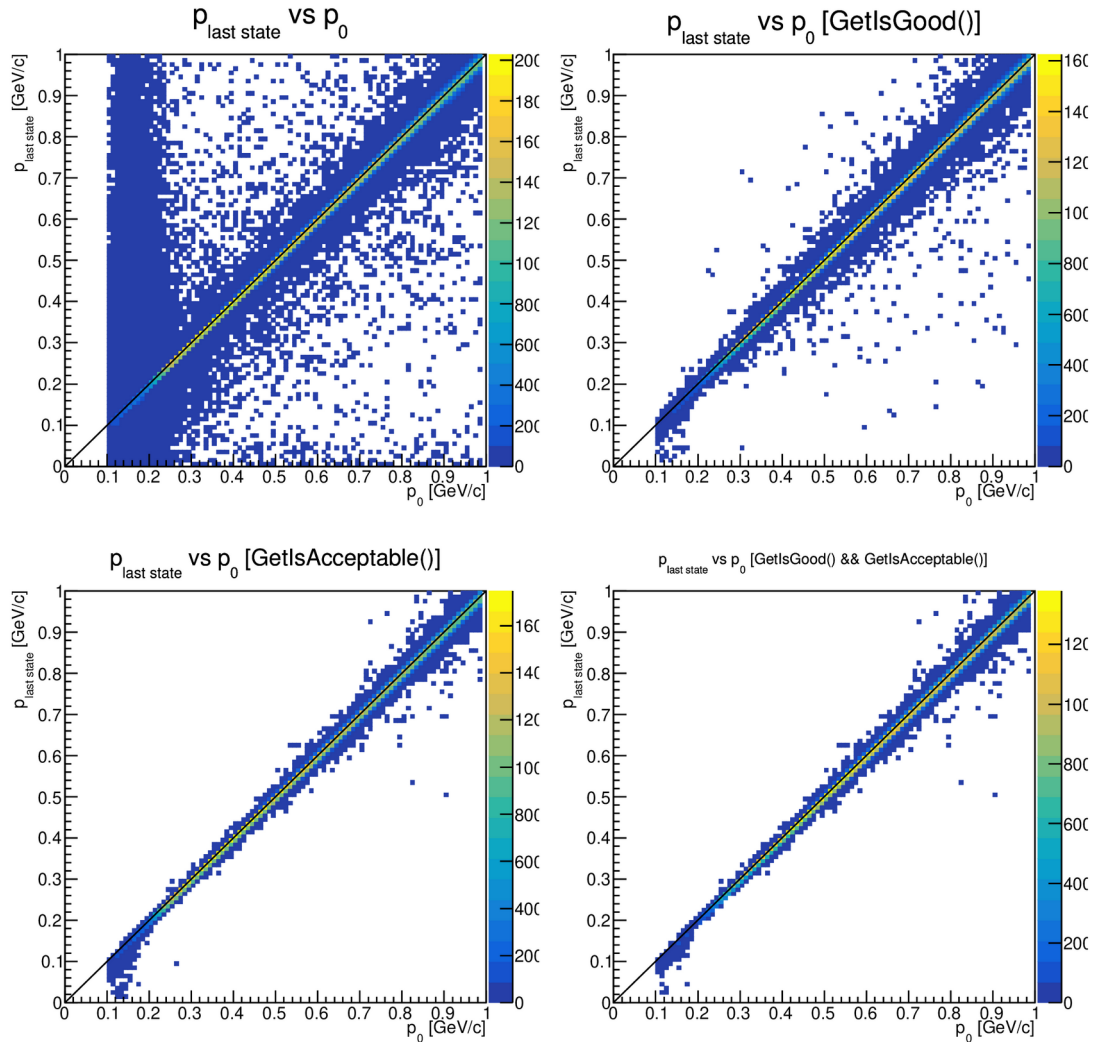
$\langle N \text{ hits ITS} \rangle$



# Pions: Momentum in the first point vs $p_0$

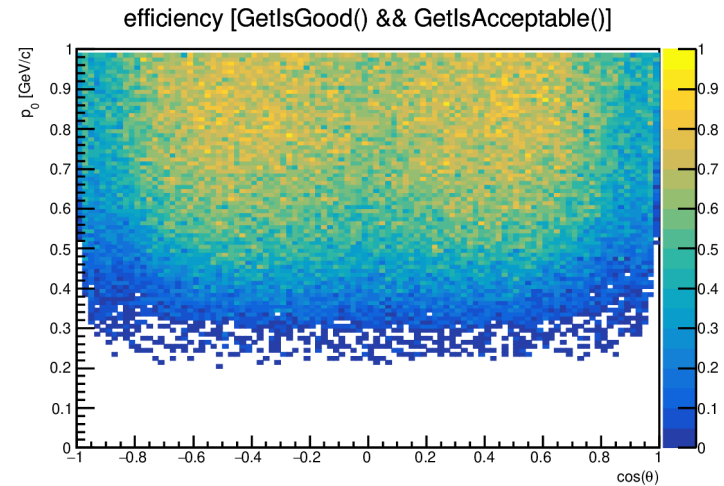
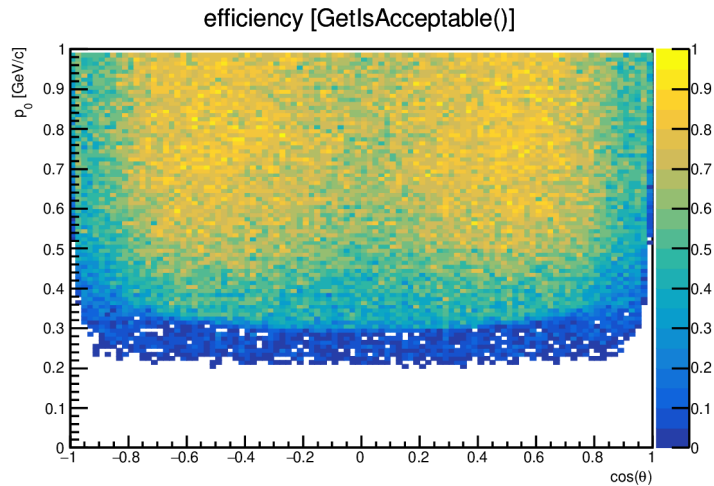
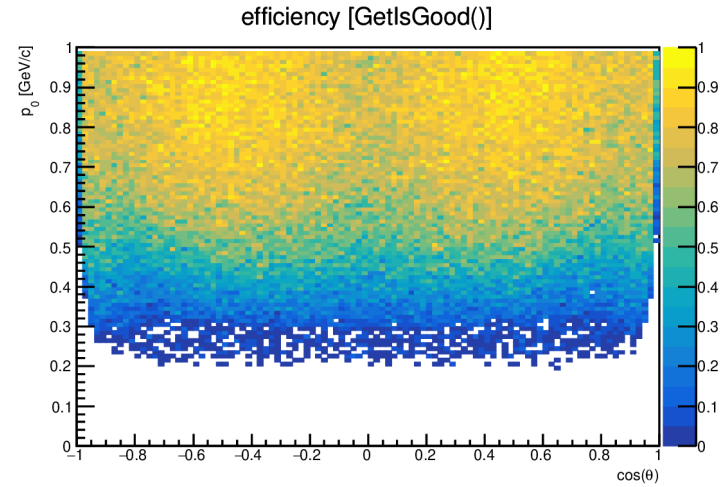
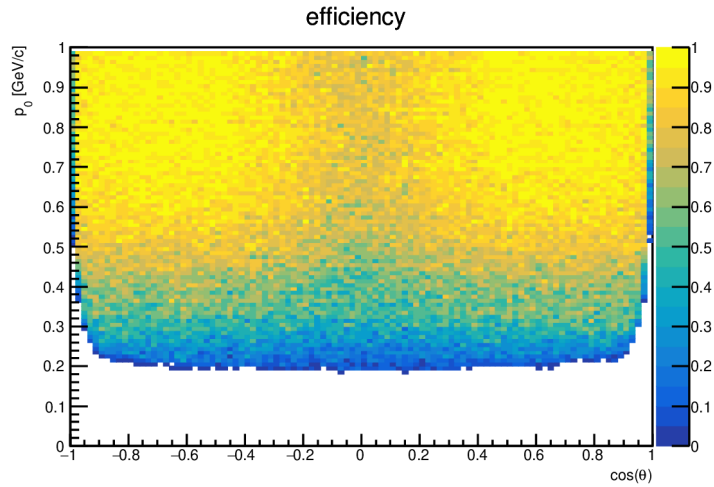


# Pions: Momentum in the last point vs $p_0$

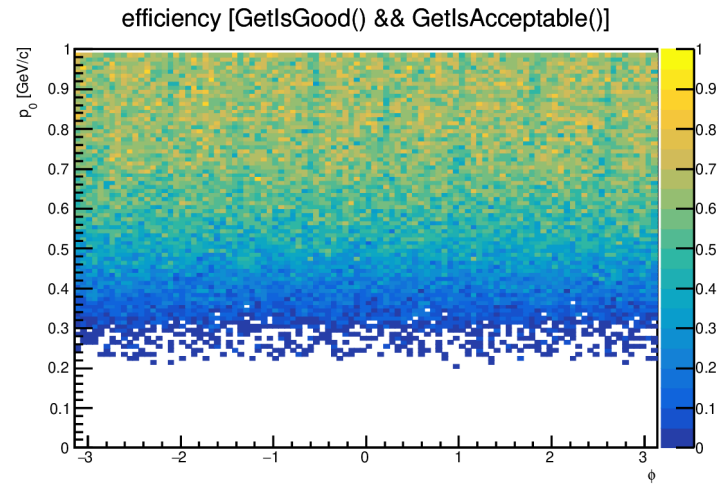
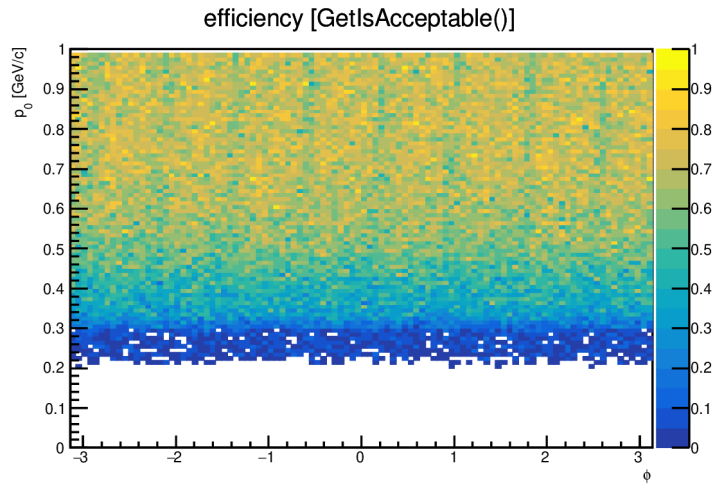
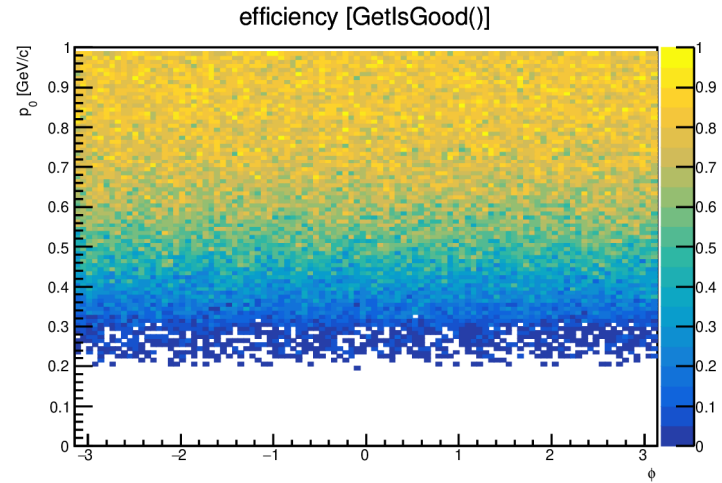
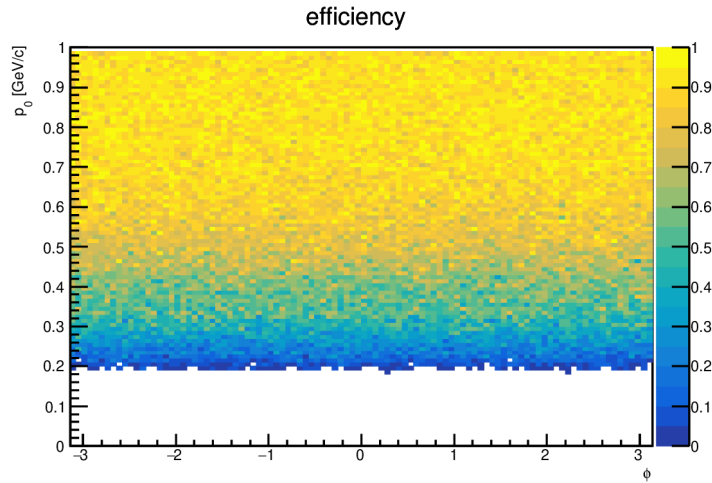


# Protons

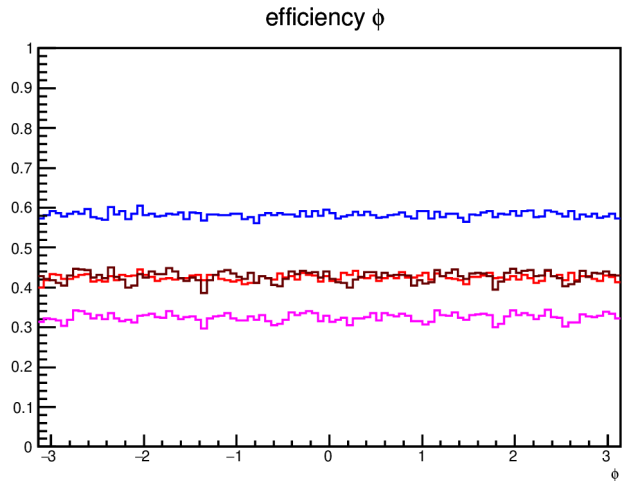
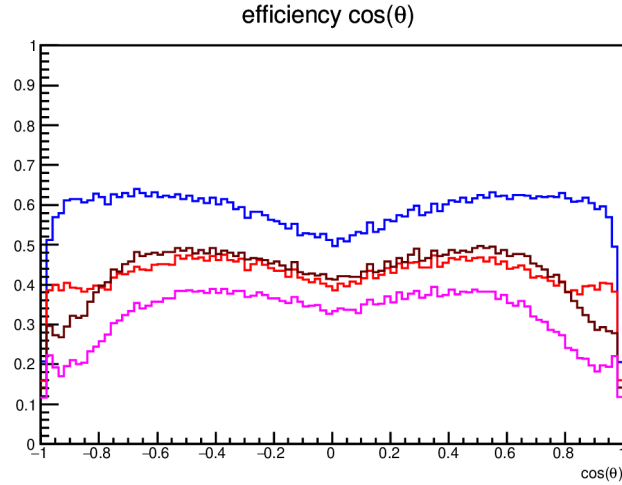
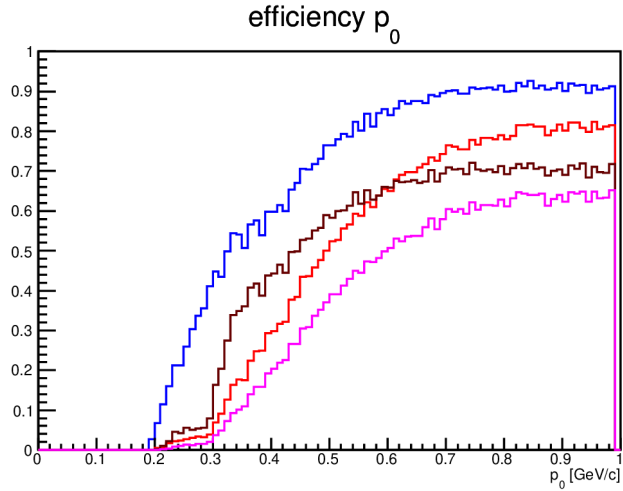
# Protons: Efficiency ( $p_0 : \cos \theta$ )



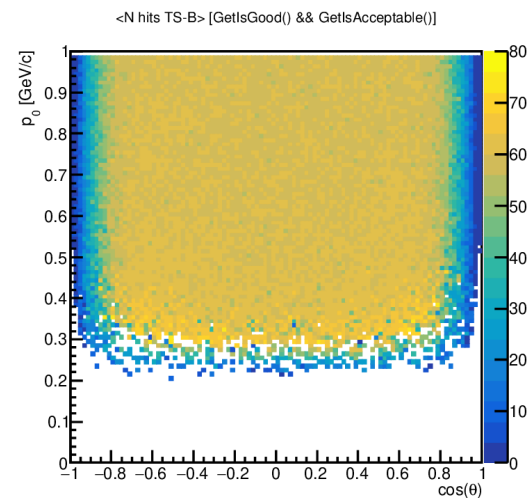
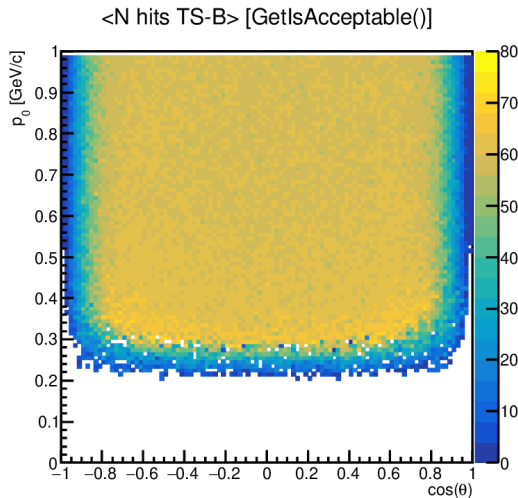
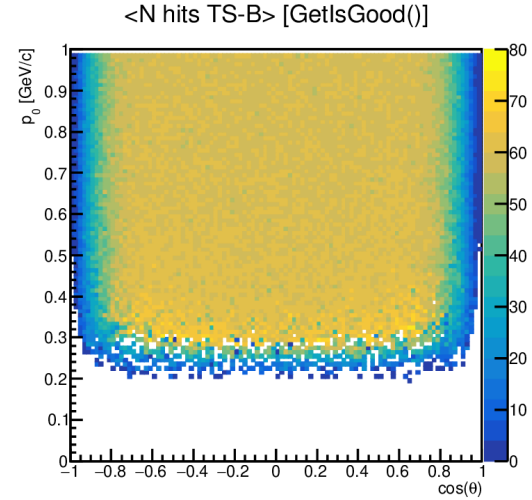
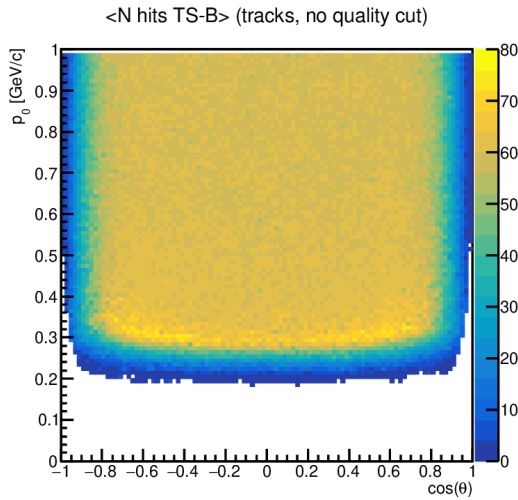
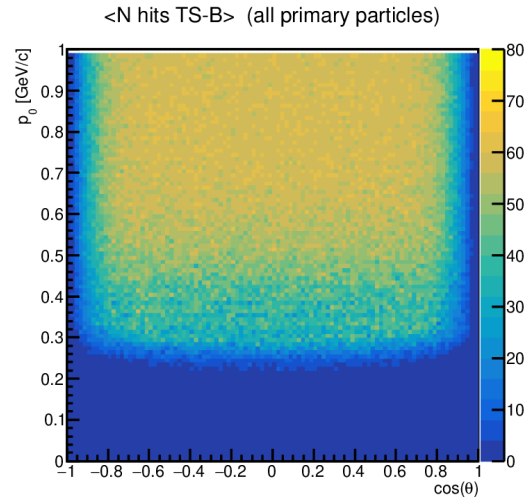
# Protons: Efficiency ( $p_0 : \phi$ )



# Protons: Efficiency 1D ( $p_0$ , $\theta$ , $\phi$ )



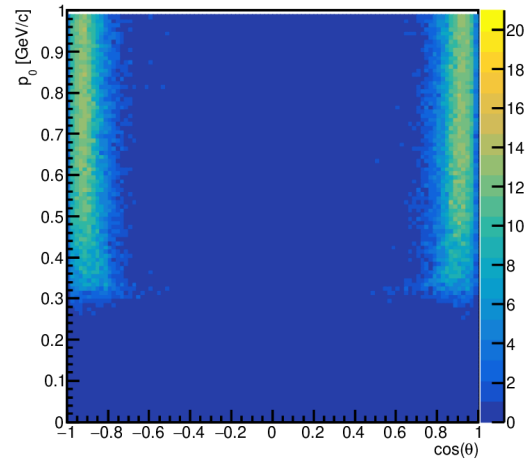
# Protons: Mean number of hits in TS barrel ( $p_0 : \cos \theta$ )



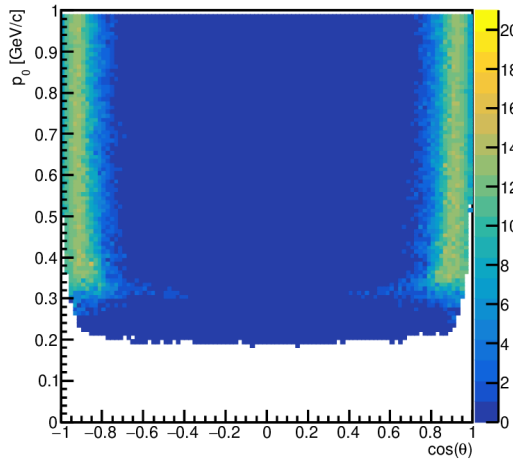


# Protons: Mean number of hits in TS endcaps ( $p_0 : \cos \theta$ )

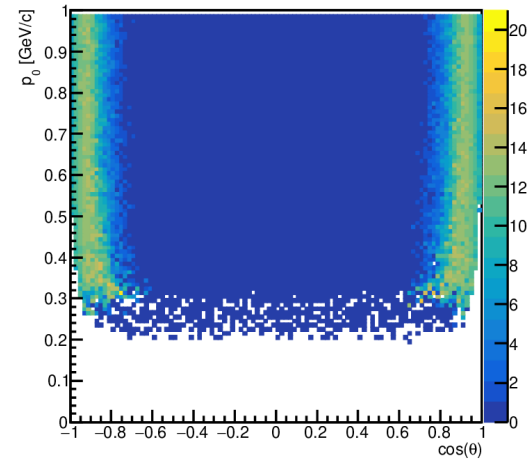
<N hits TS-EC> (all primary particles)



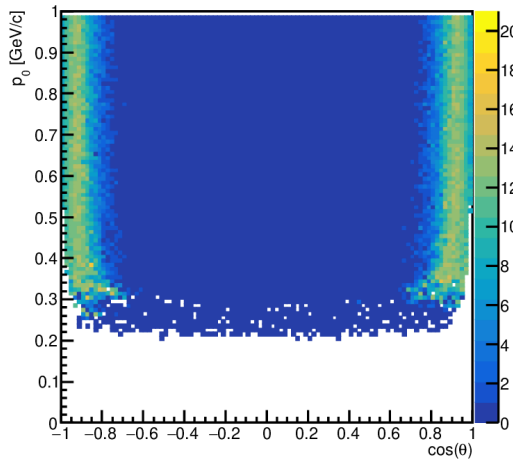
<N hits TS-EC> (tracks, no quality cut)



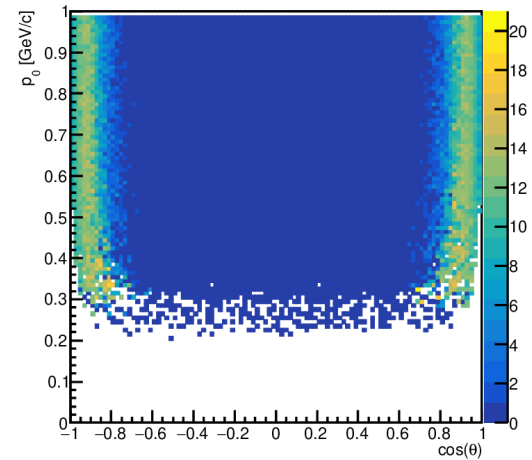
<N hits TS-EC> [GetIsGood()]



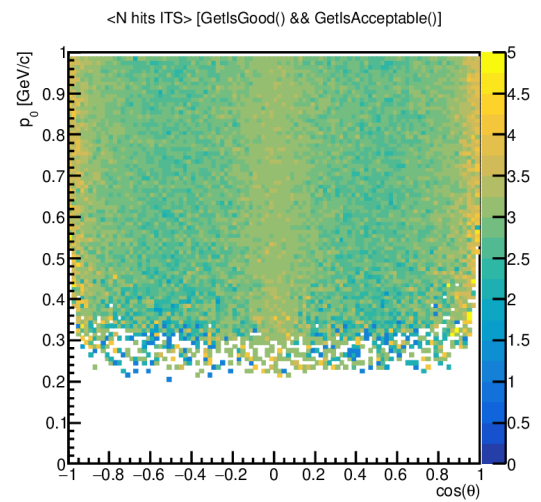
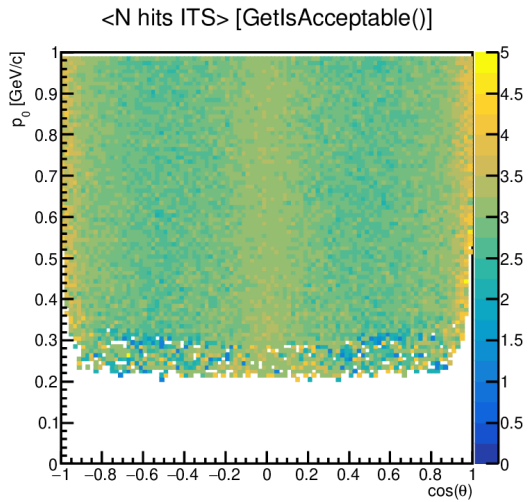
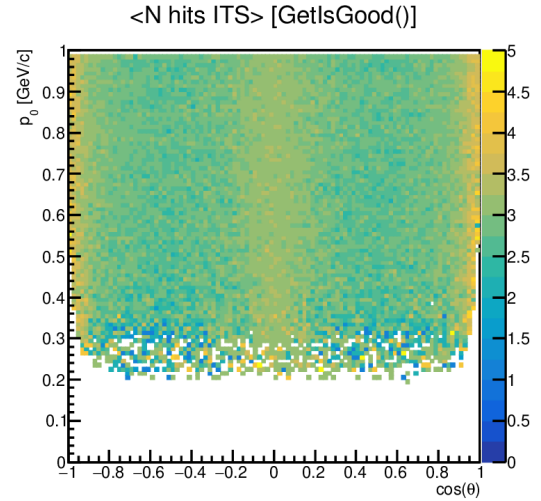
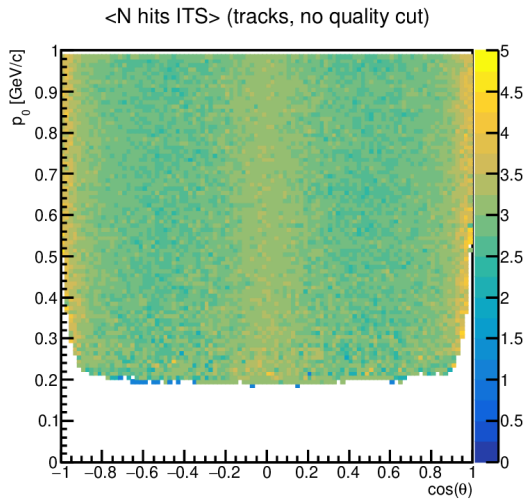
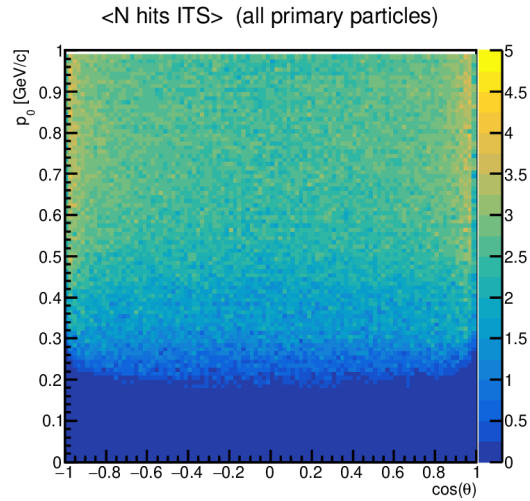
<N hits TS-EC> [GetIsAcceptable()]



<N hits TS-EC> [GetIsGood() && GetIsAcceptable()]

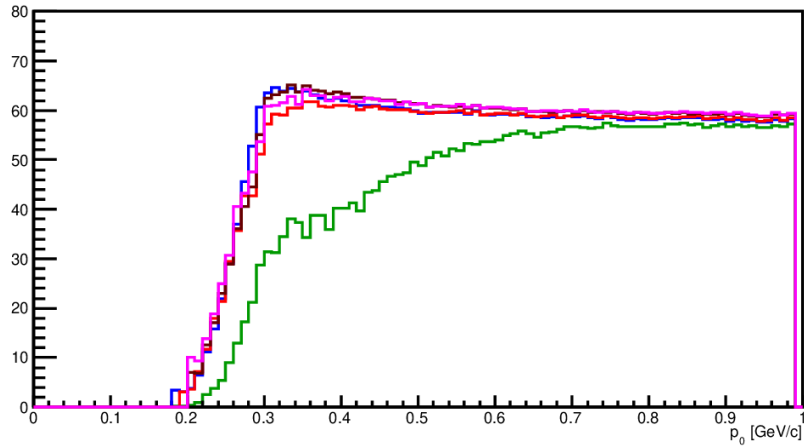


# Protons: Mean number of hits in ITS ( $p_0 : \cos \theta$ )

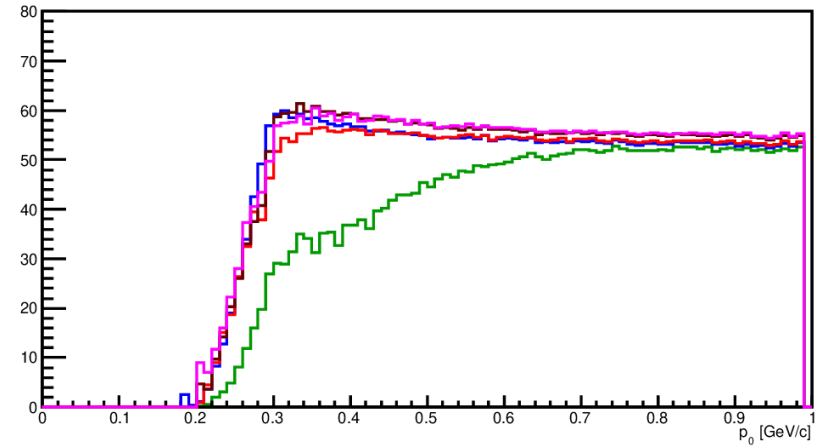


# Protons: Mean number of hits ( $p_0$ )

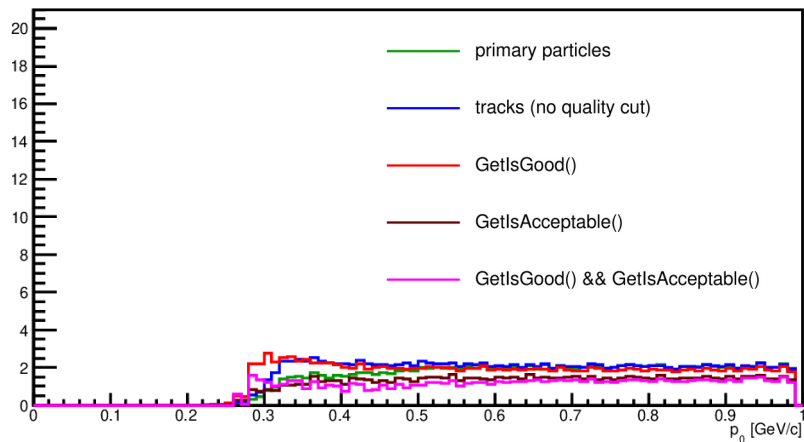
<N hits >



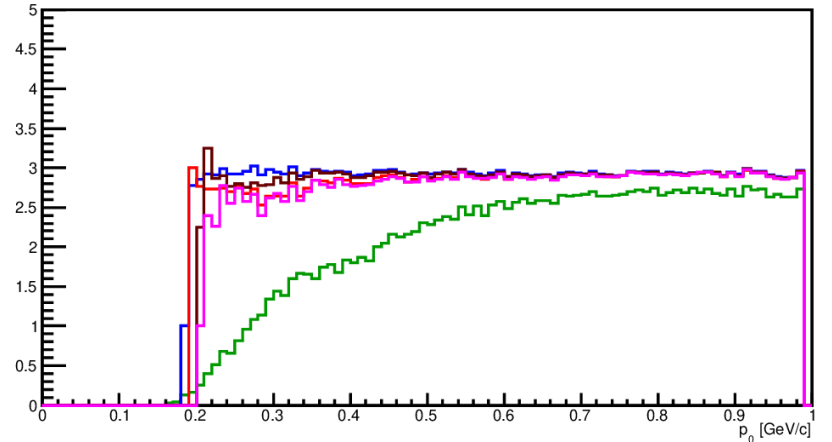
<N hits TS-B>



<N hits TS-EC>

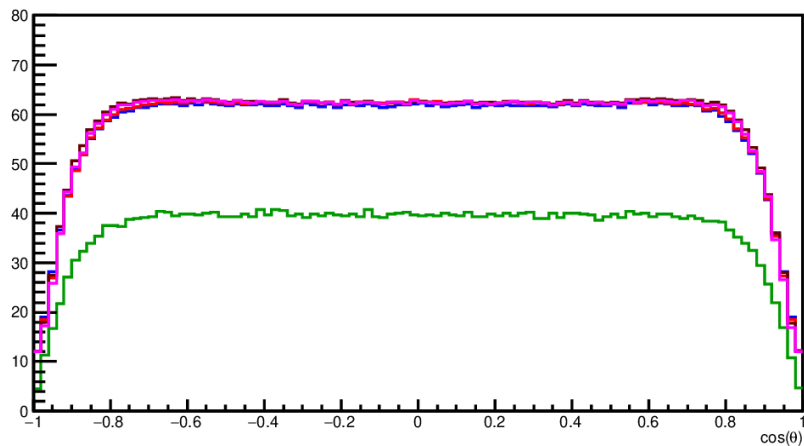


<N hits ITS>

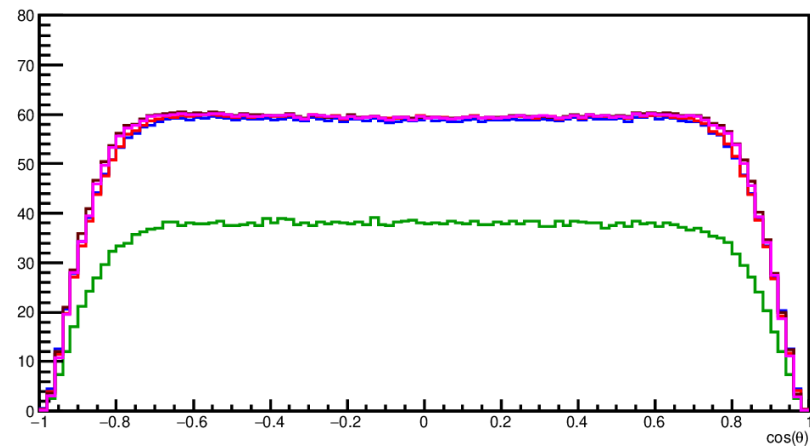


# Protons: Mean number of hits ( $\cos \theta$ )

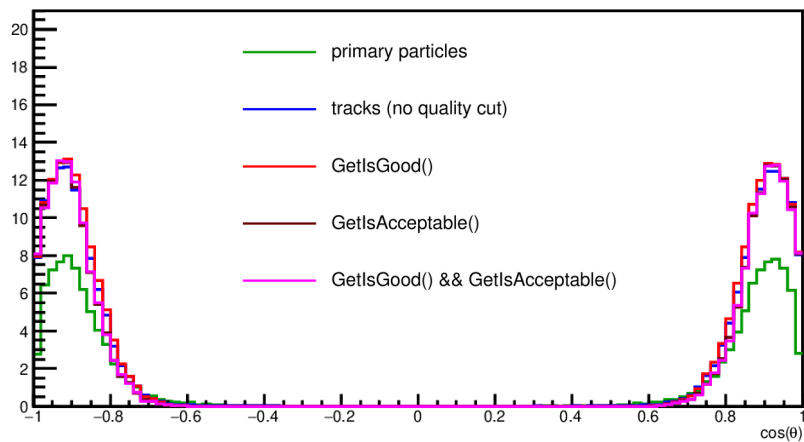
<N hits >



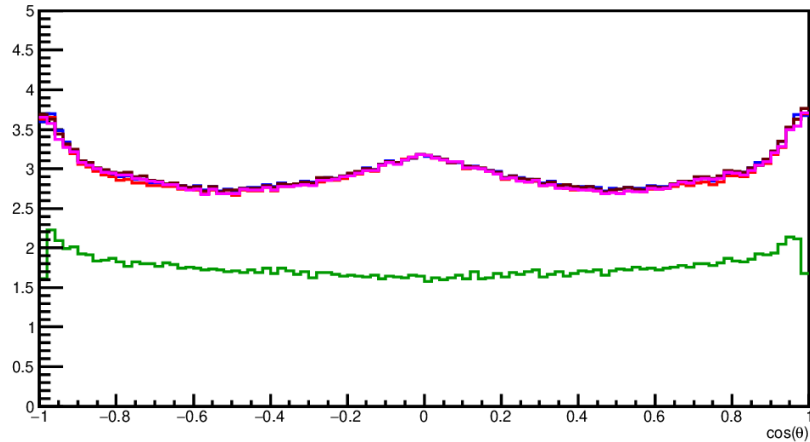
<N hits TS-B>



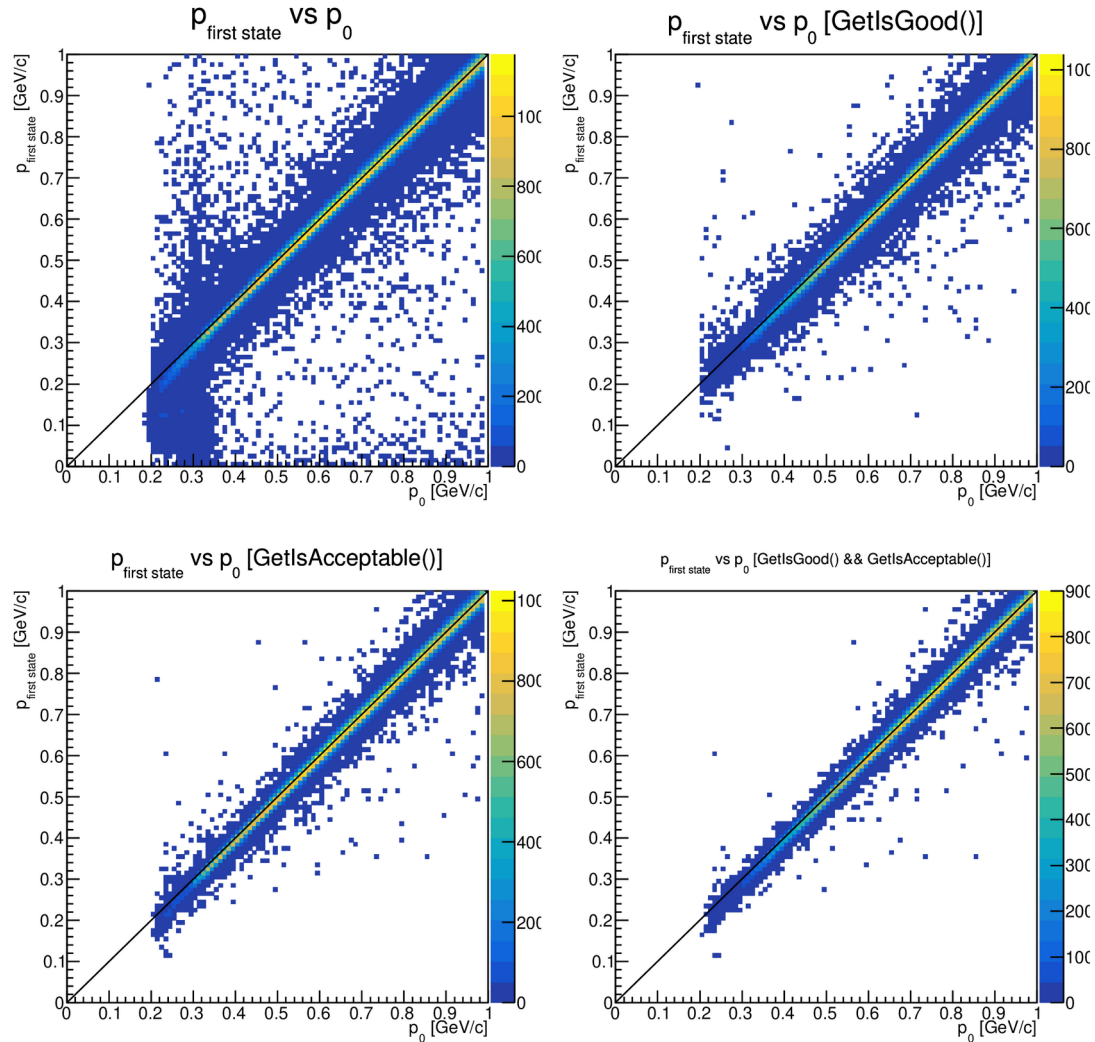
<N hits TS-EC>



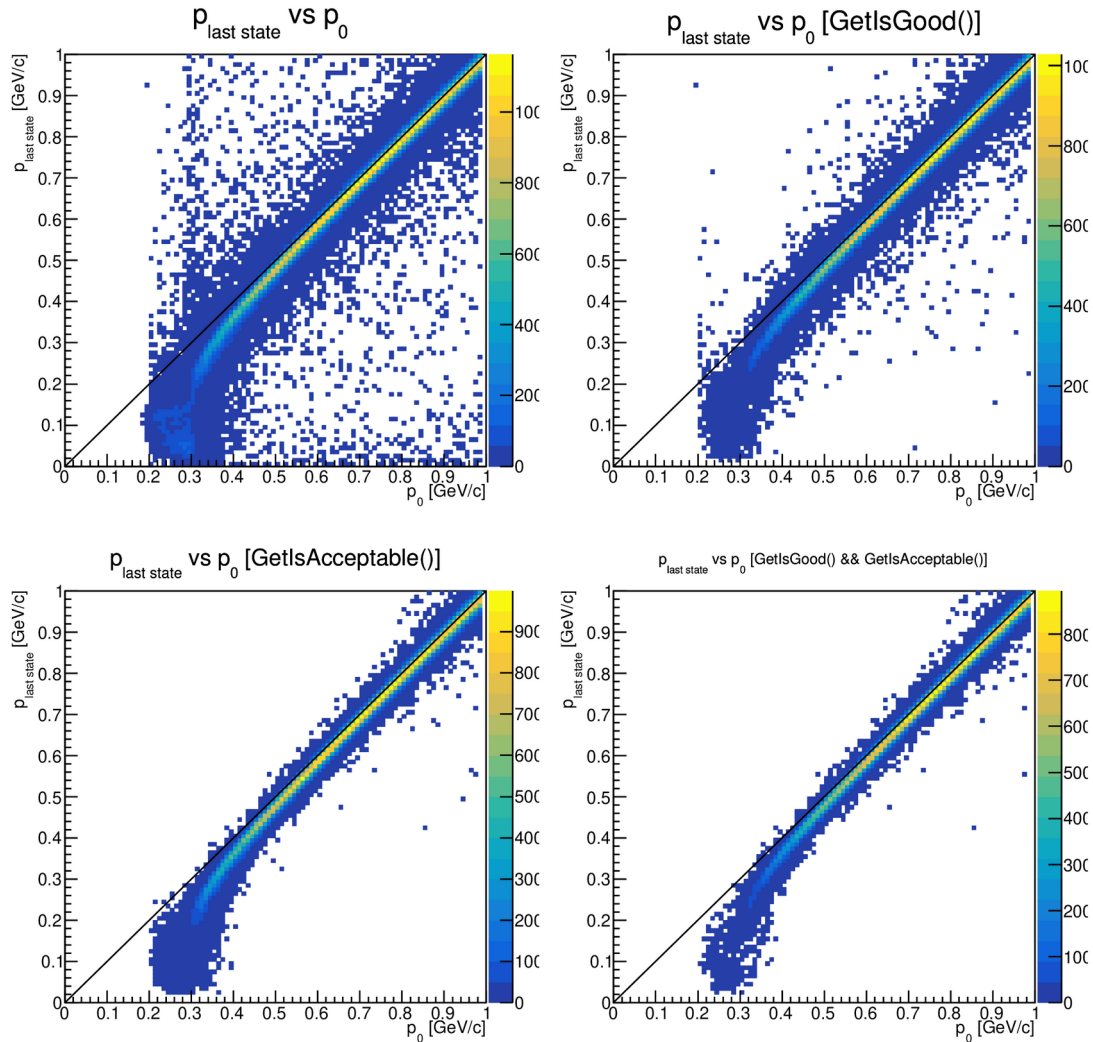
<N hits ITS>



# Protons: Momentum in the first point vs $p_0$



# Protons: Momentum in the last point vs $p_0$



# Conclusions

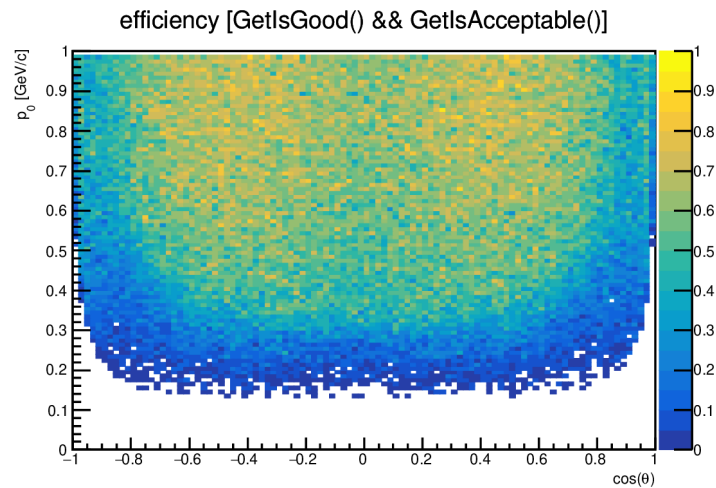
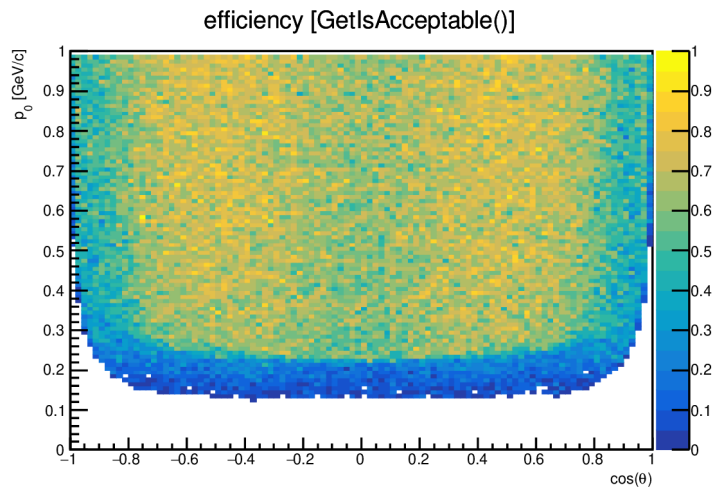
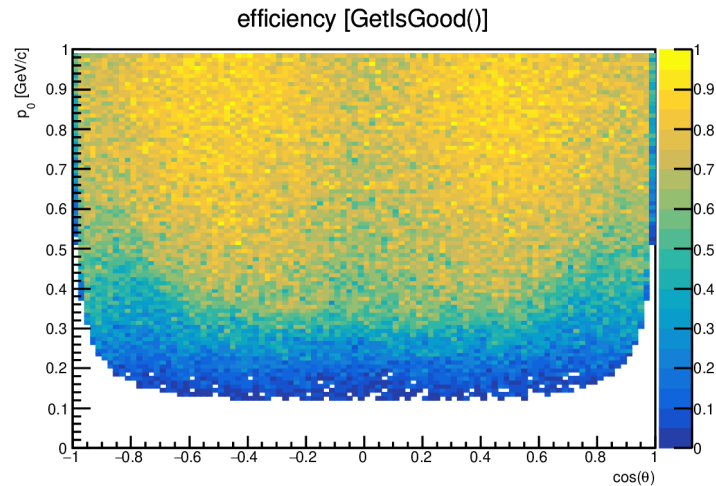
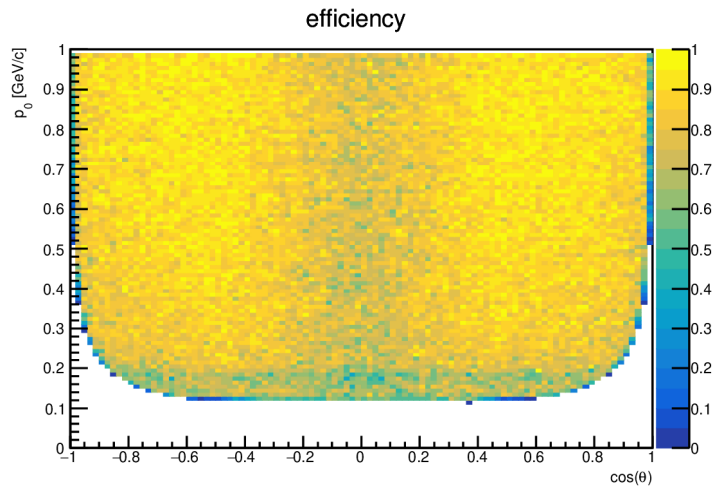
- `GetIsGood()` and `GetIsAcceptable()` cuts increase the quality of tracks, but significantly reduce the number of particles.
- Soft particles, which are spiraling inside the straw tracker region, are mostly rejected.
- It is not clear why we have drop in efficiency for  $\theta \approx 90^\circ$ .

*Additional slides*

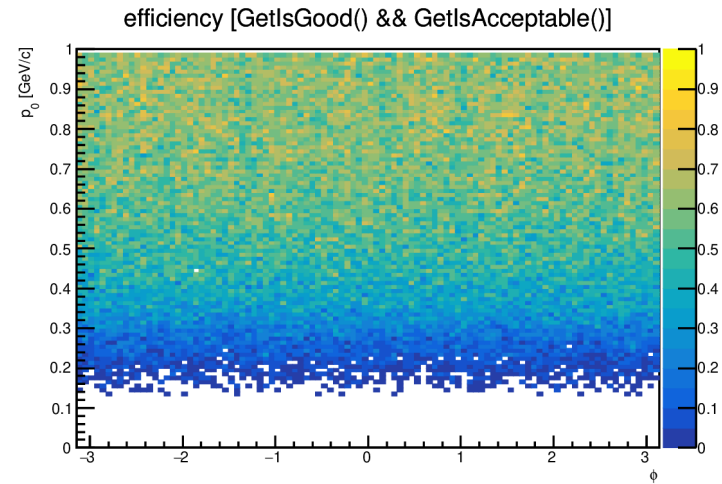
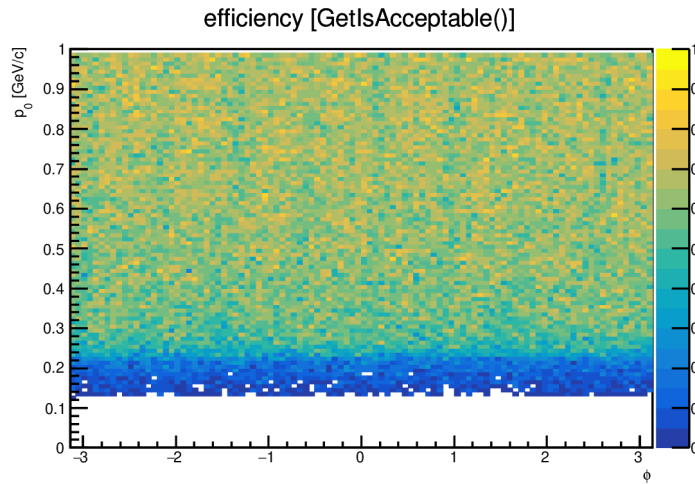
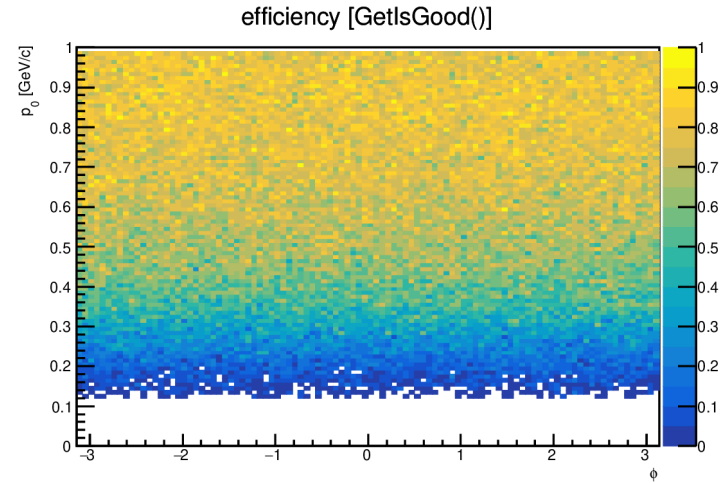
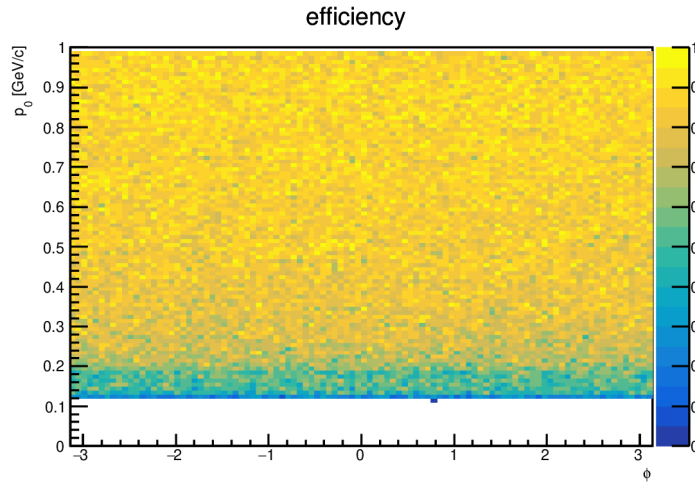


Kaons

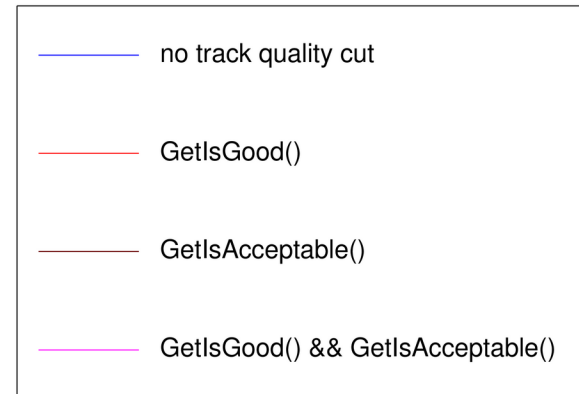
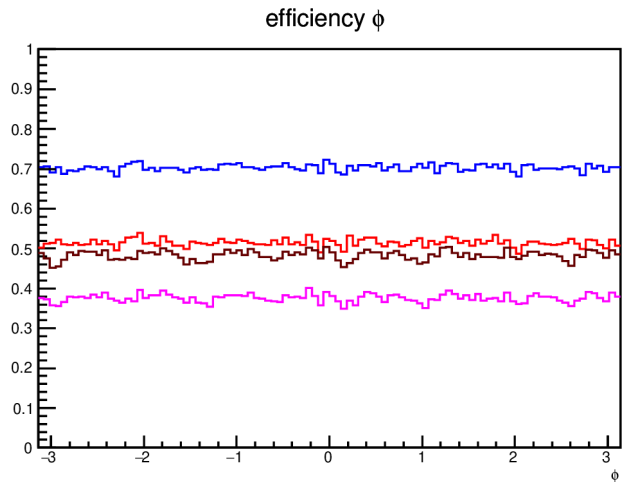
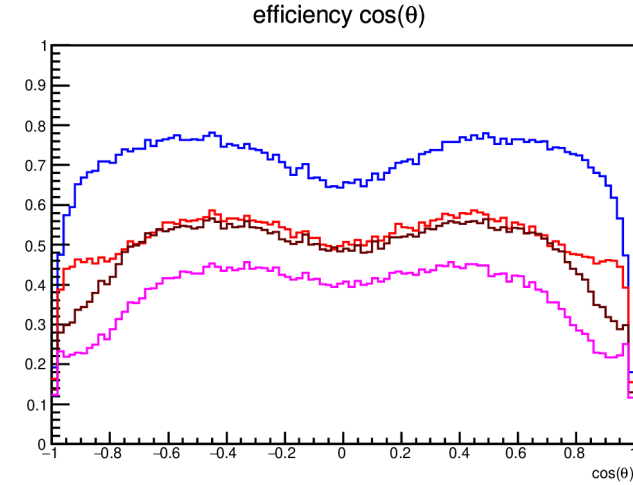
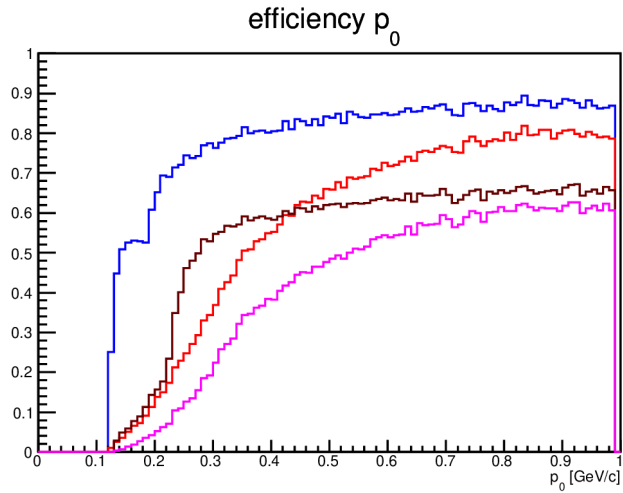
# Kaons: Efficiency ( $p_0 : \cos \theta$ )



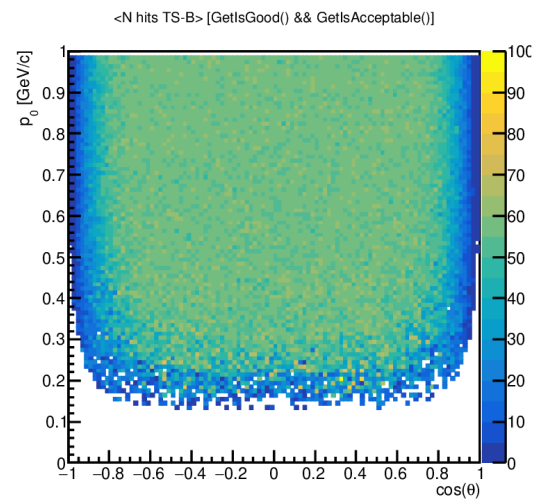
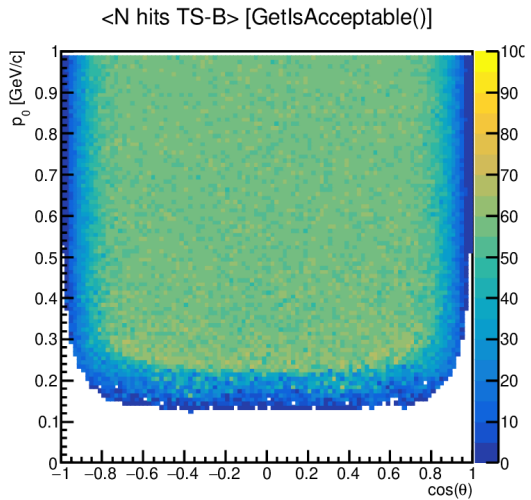
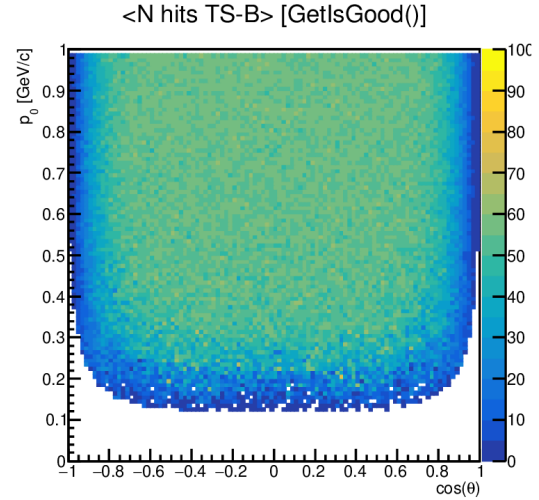
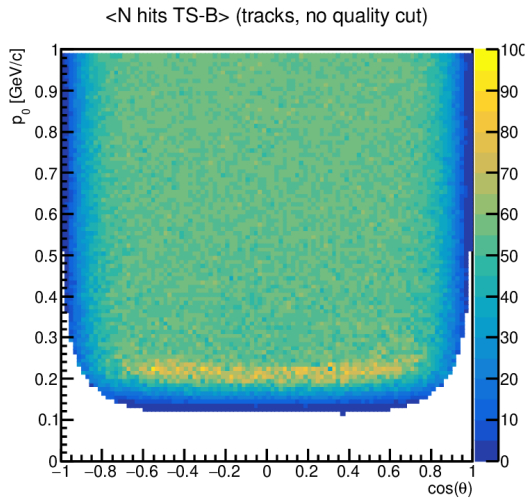
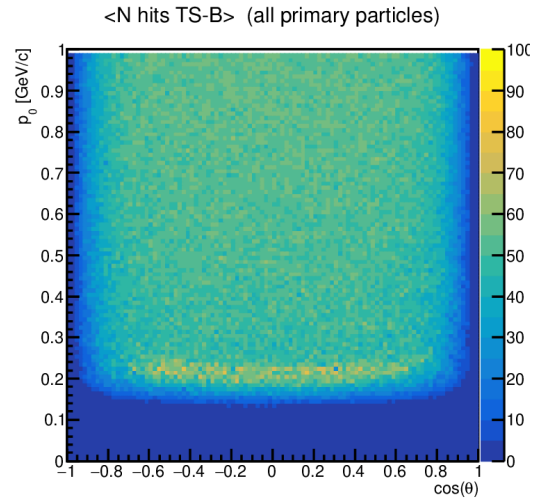
# Pions: Efficiency ( $p_0 : \phi$ )



# Kaons: Efficiency 1D ( $p_0$ , $\theta$ , $\phi$ )

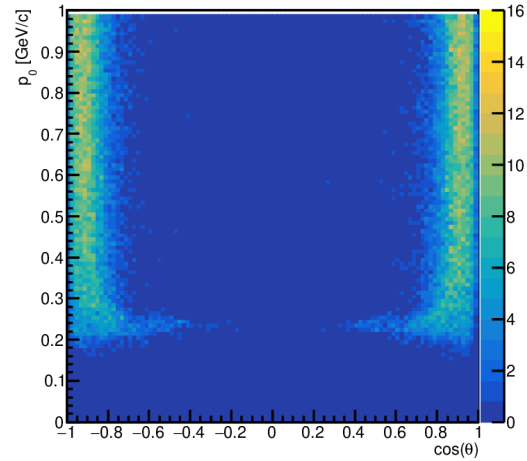


# Kaons: Mean number of hits in TS barrel ( $p_0 : \cos \theta$ )

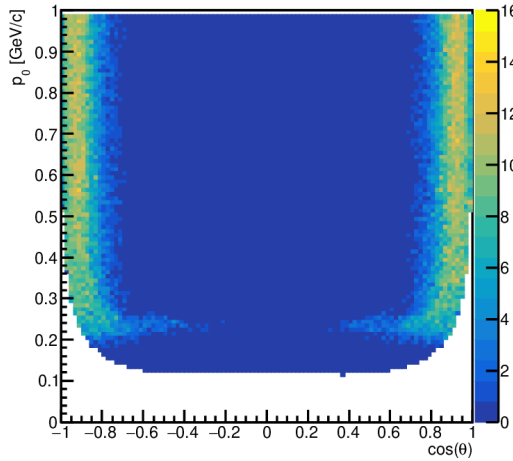


# Kaons: Mean number of hits in TS endcaps ( $p_0 : \cos \theta$ )

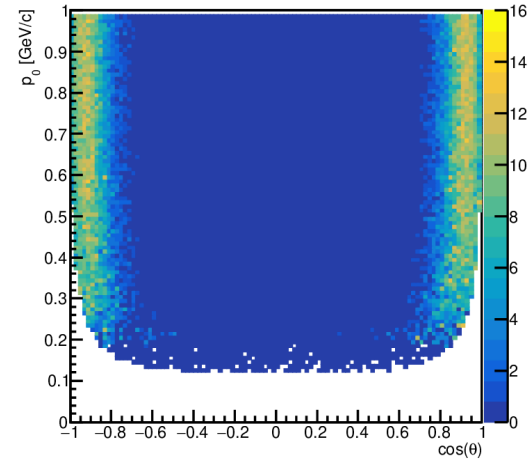
<N hits TS-EC> (all primary particles)



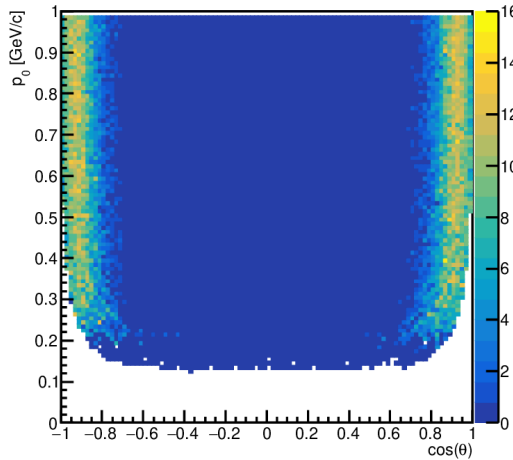
<N hits TS-EC> (tracks, no quality cut)



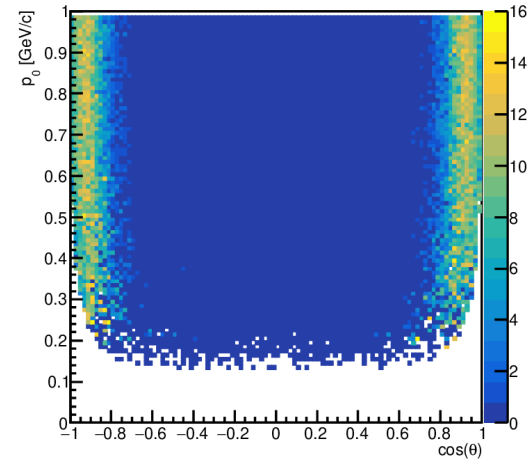
<N hits TS-EC> [GetIsGood()]



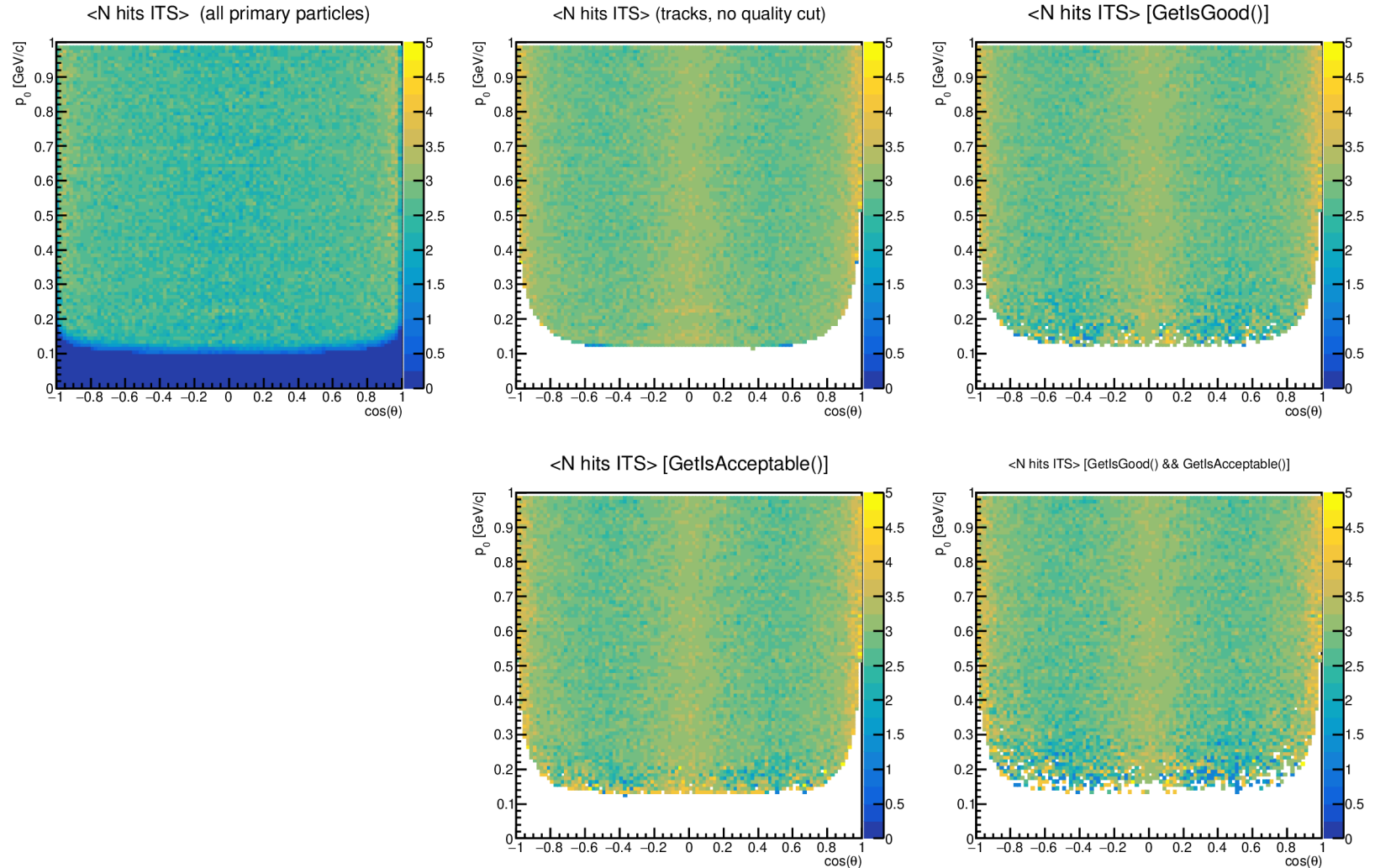
<N hits TS-EC> [GetIsAcceptable()]



<N hits TS-EC> [GetIsGood() && GetIsAcceptable()]

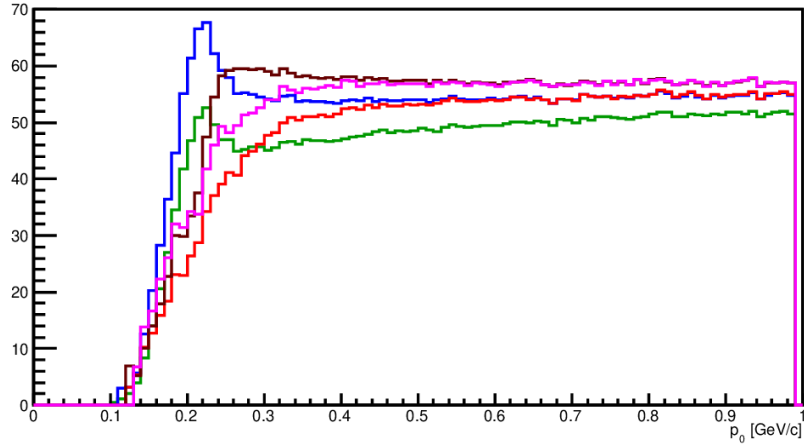


# Kaons: Mean number of hits in ITS ( $p_0 : \cos \theta$ )

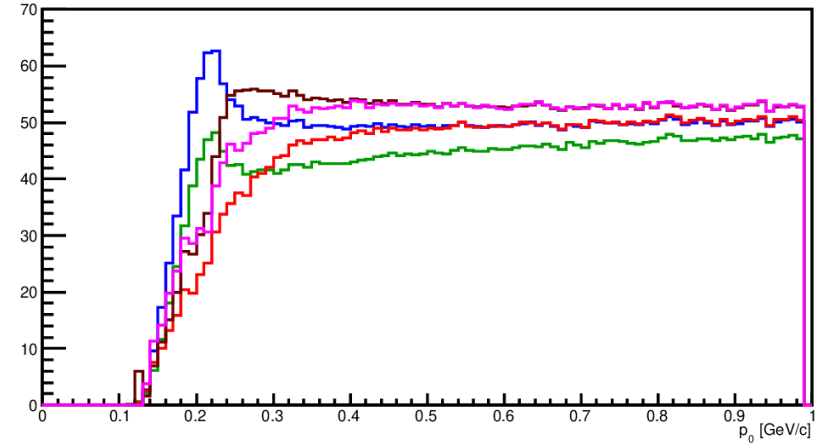


# Kaons: Mean number of hits ( $p_0$ )

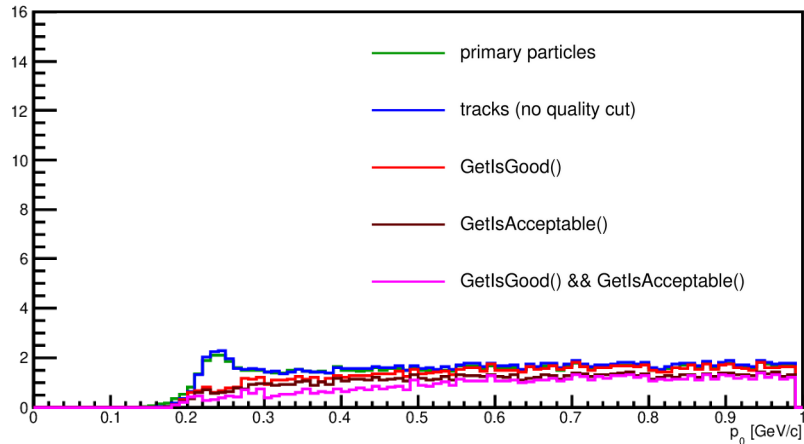
<N hits >



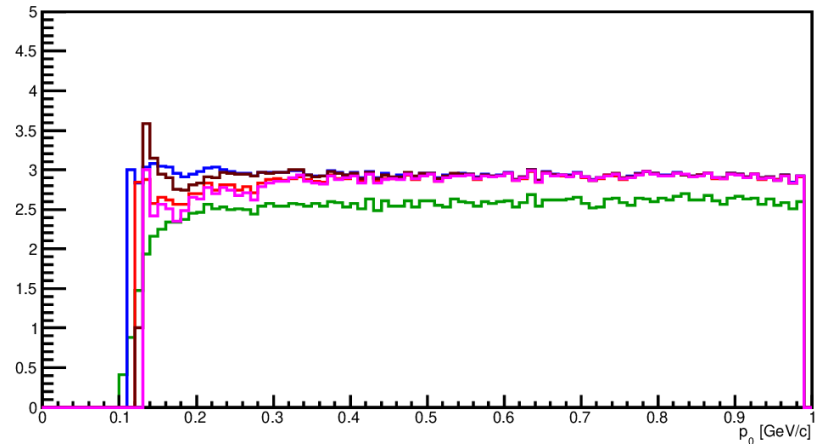
<N hits TS-B>



<N hits TS-EC>



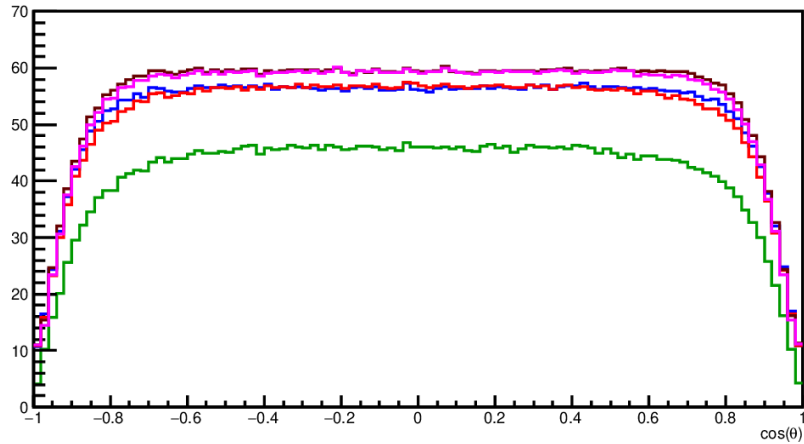
<N hits ITS>



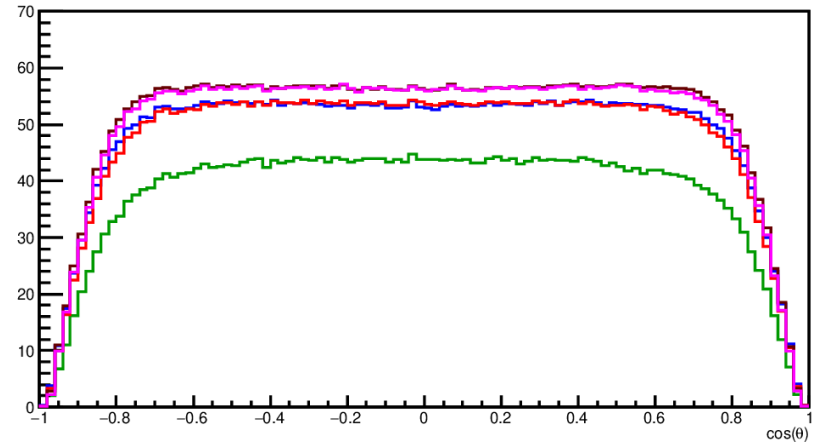


# Kaons: Mean number of hits ( $\cos \theta$ )

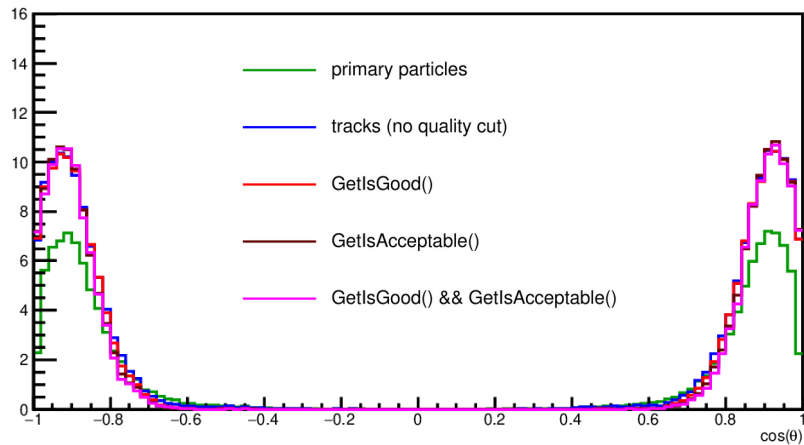
<N hits >



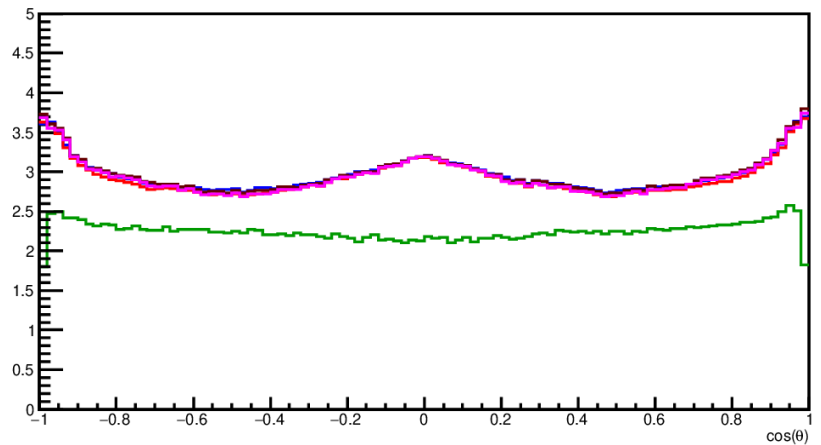
<N hits TS-B>



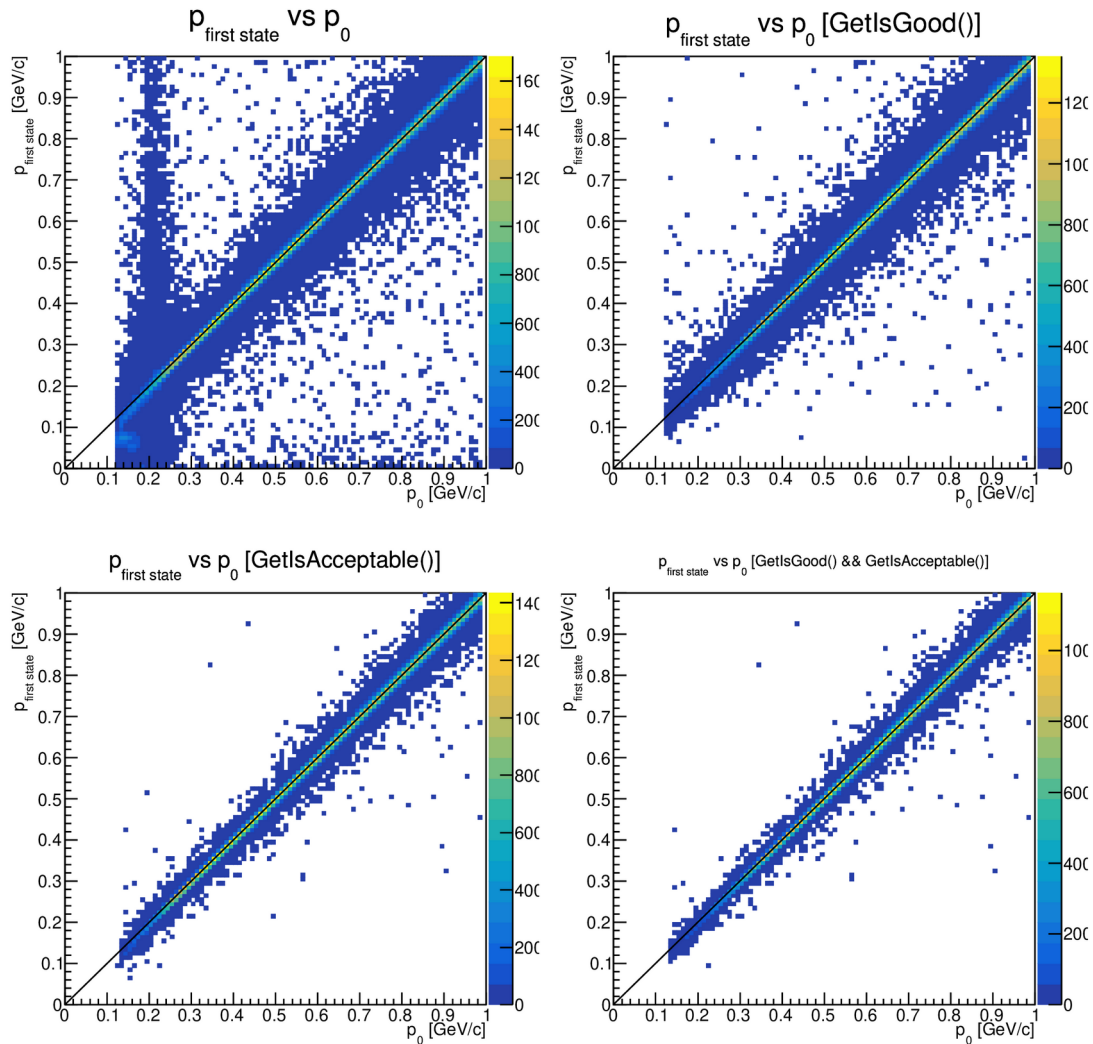
<N hits TS-EC>



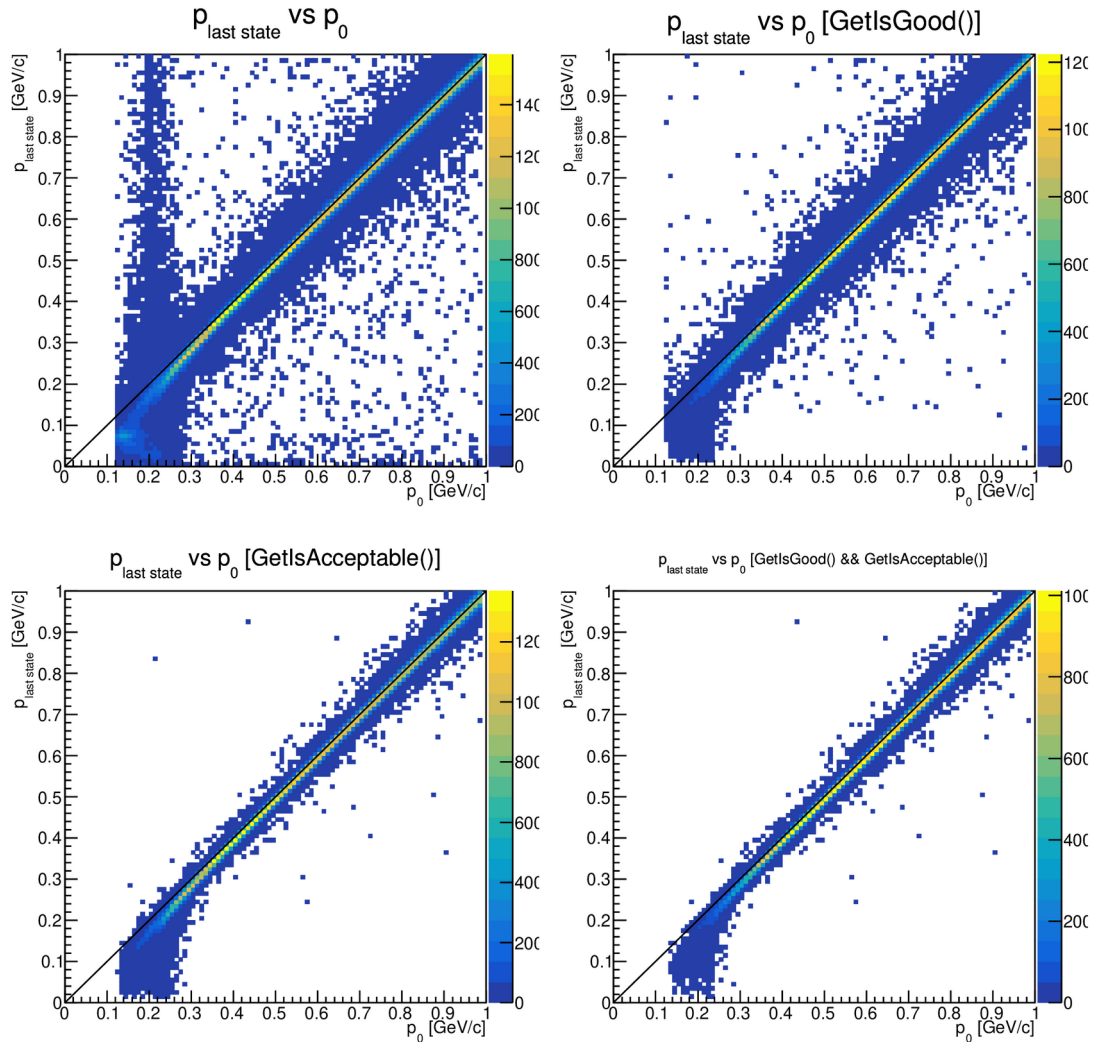
<N hits ITS>



# Kaons: Momentum in the first point vs $p_0$

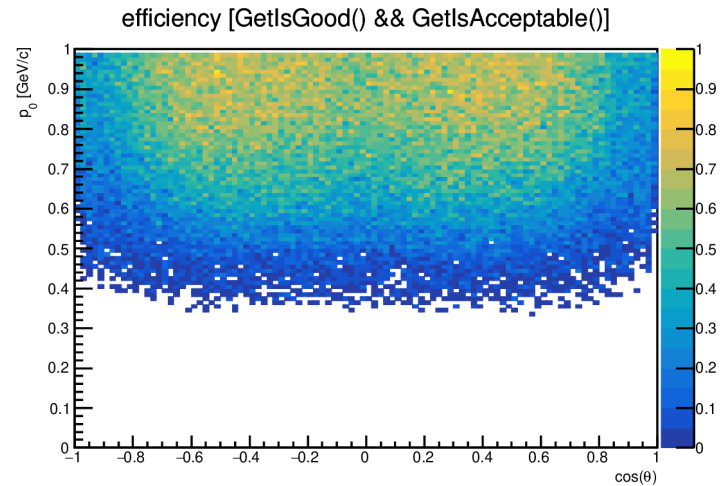
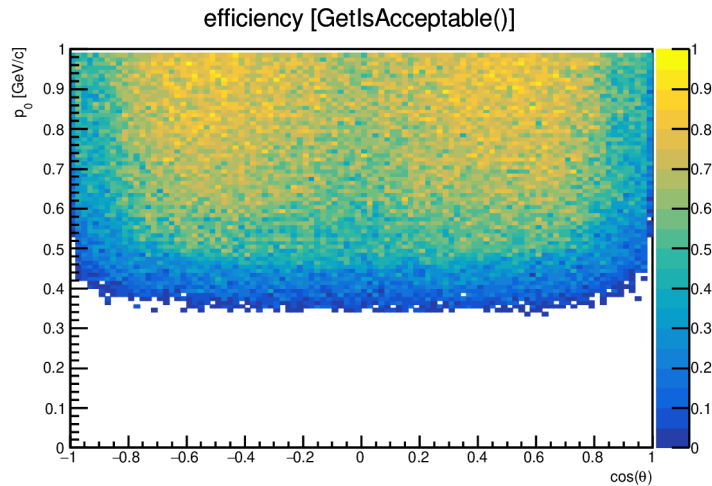
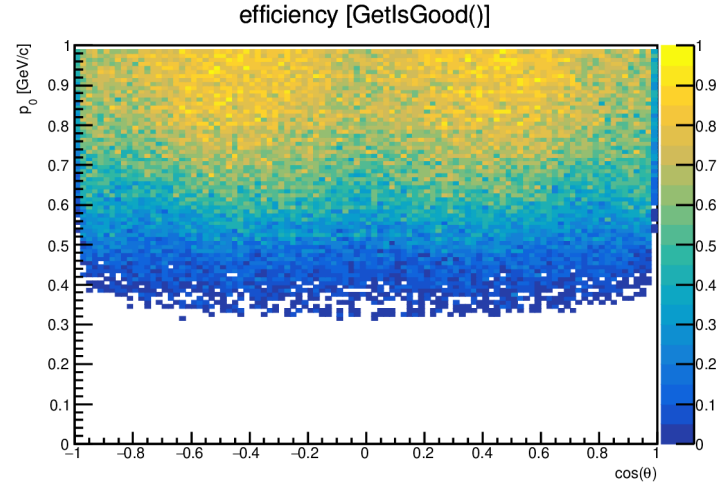
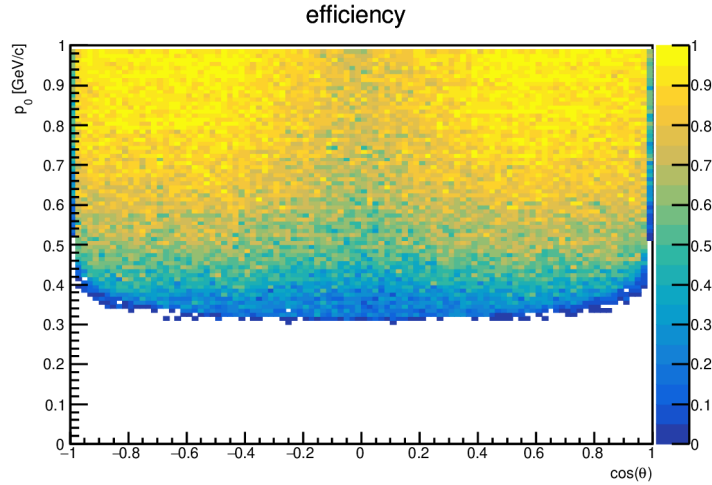


# Kaons: Momentum in the last point vs $p_0$

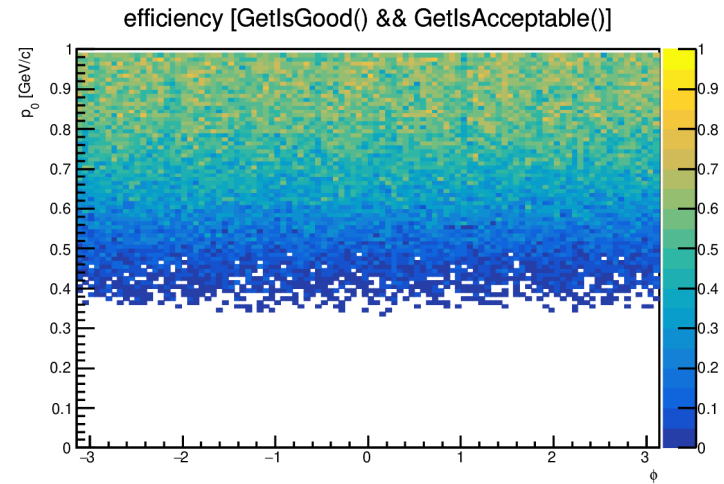
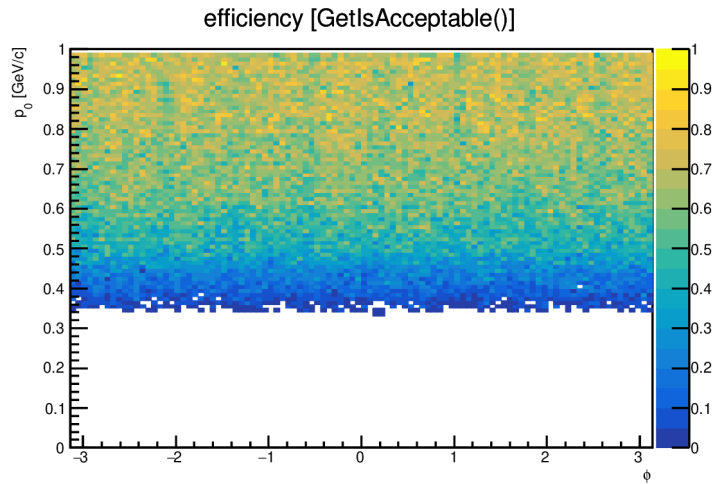
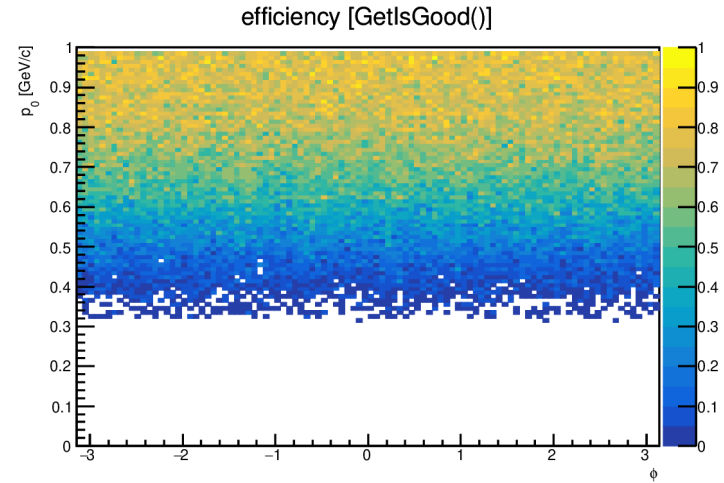
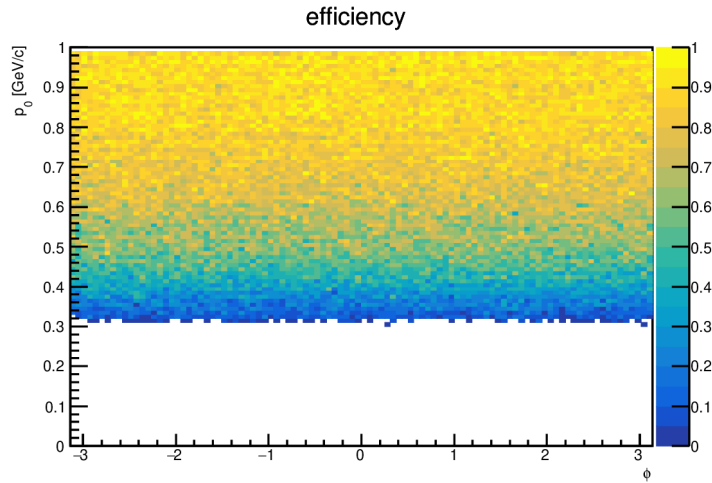


# Deuterons

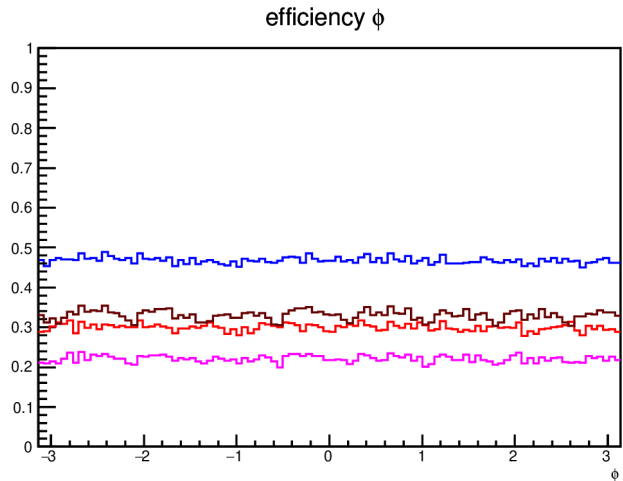
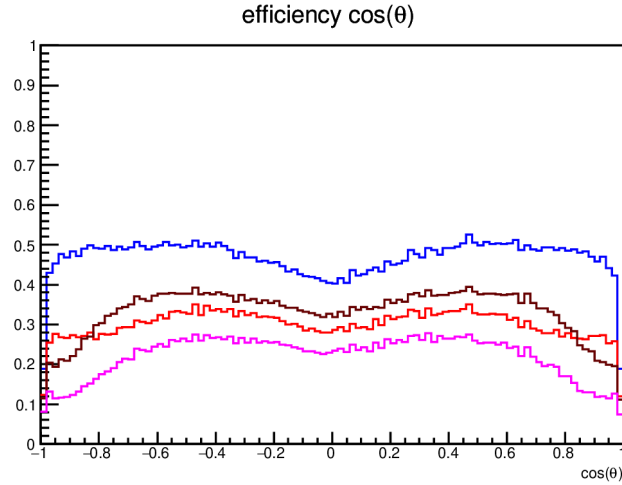
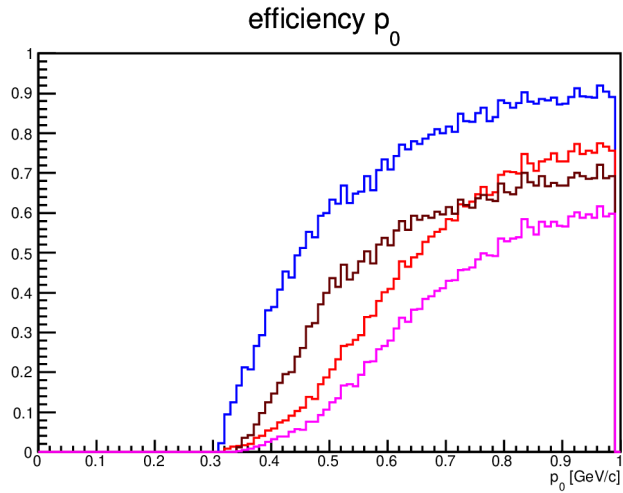
# Deuterons: Efficiency ( $p_0 : \cos \theta$ )



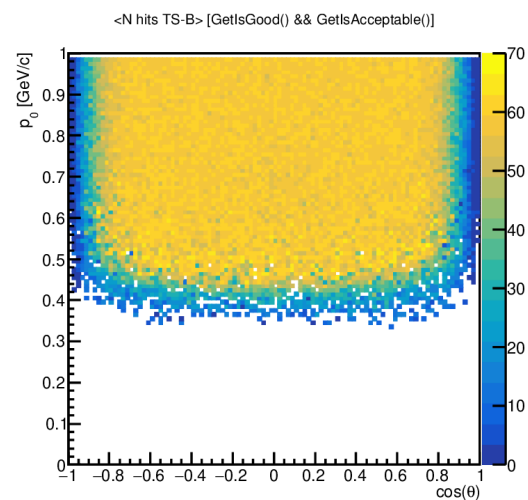
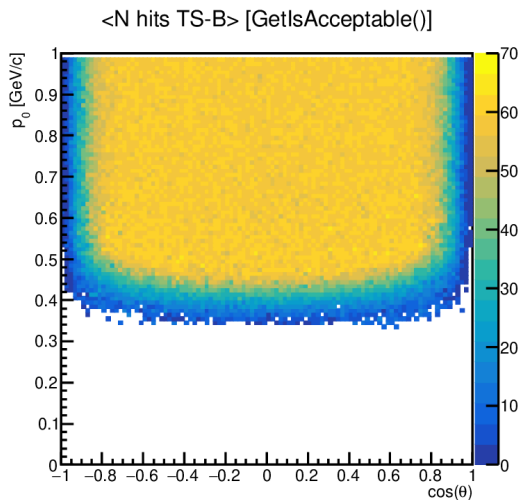
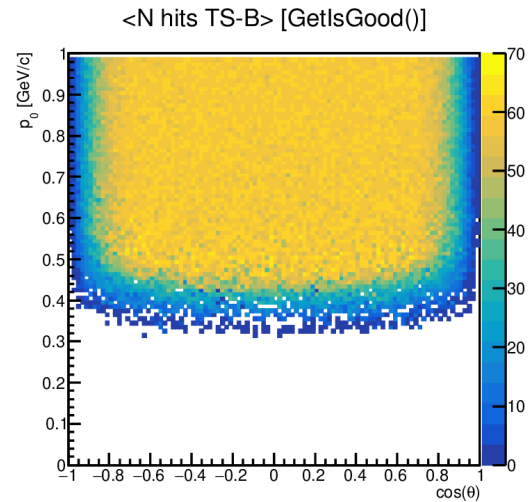
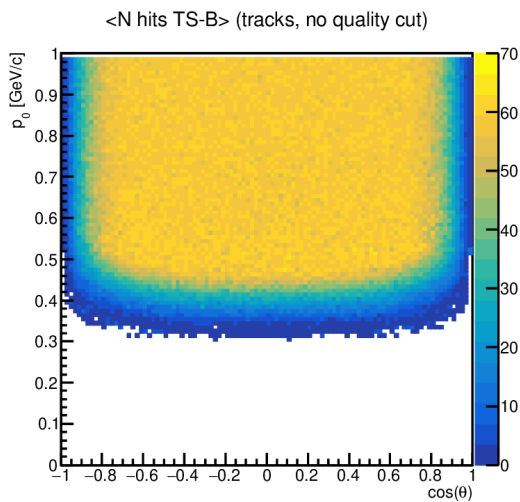
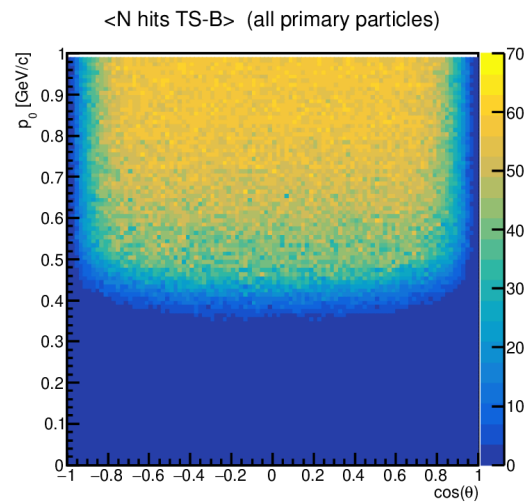
# Deuterons: Efficiency ( $p_0 : \phi$ )



# Deuterons: Efficiency 1D ( $p_0$ , $\theta$ , $\phi$ )

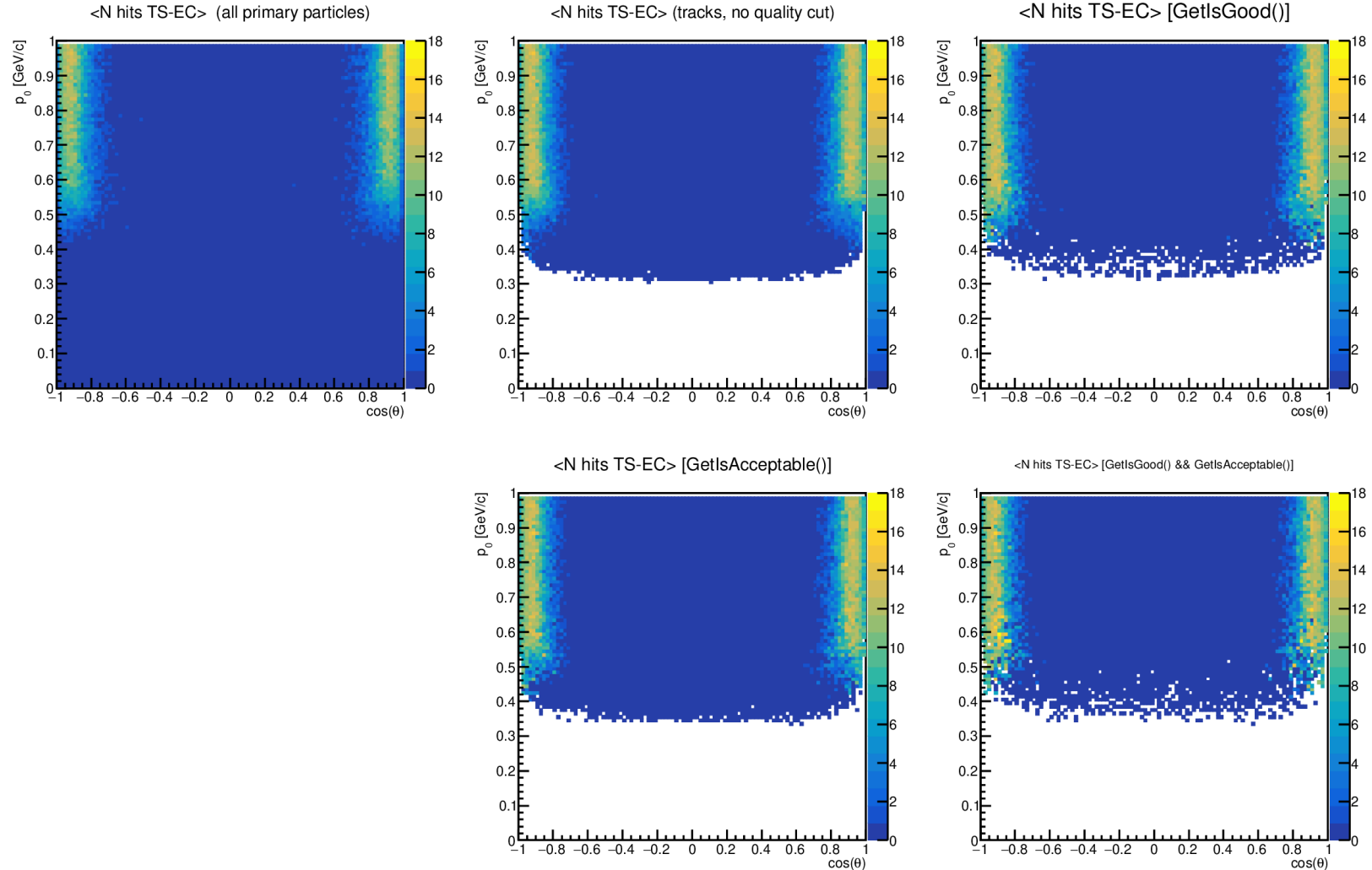


# Deuterons: Mean number of hits in TS barrel ( $p_0 : \cos \theta$ )

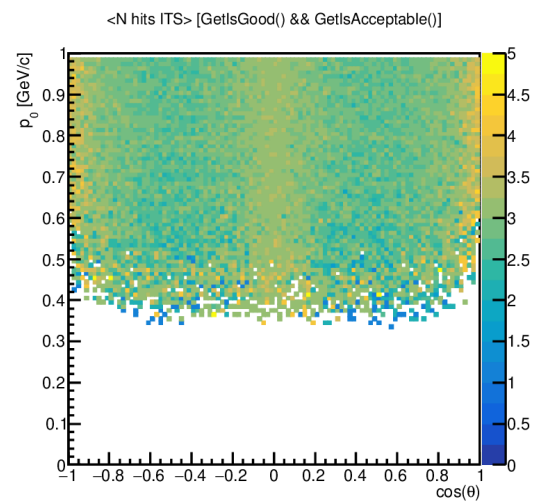
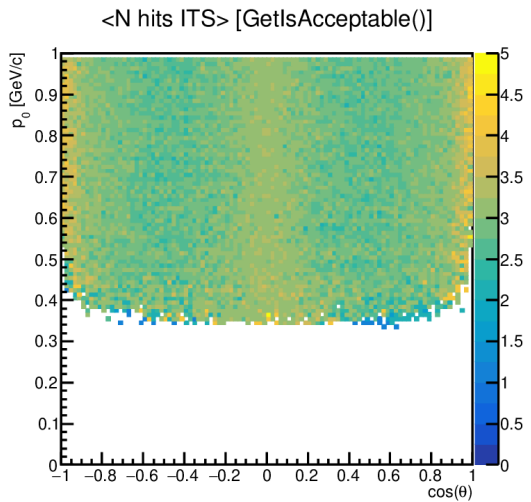
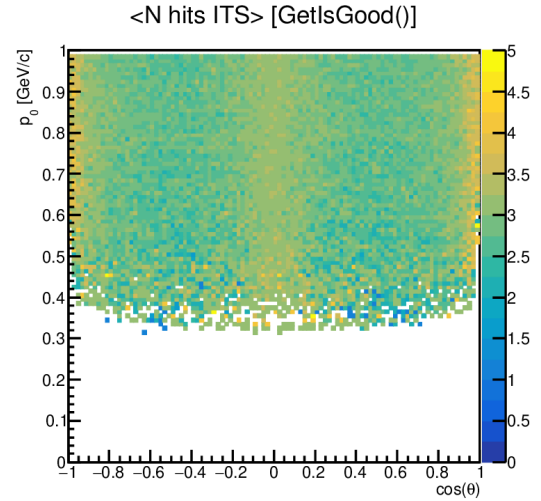
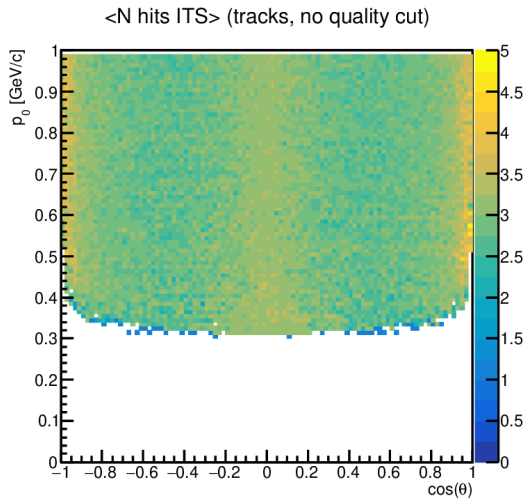
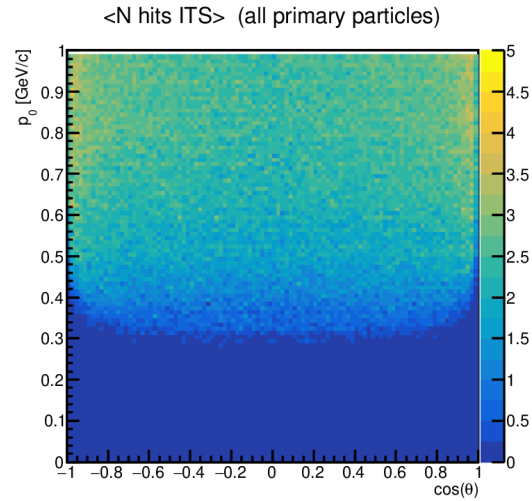




# Deuterons: Mean number of hits in TS endcaps ( $p_0 : \cos \theta$ )

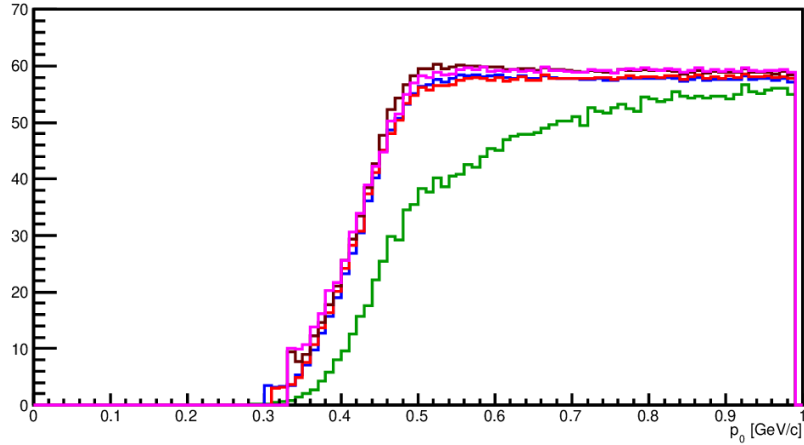


# Deuterons: Mean number of hits in ITS ( $p_0 : \cos \theta$ )

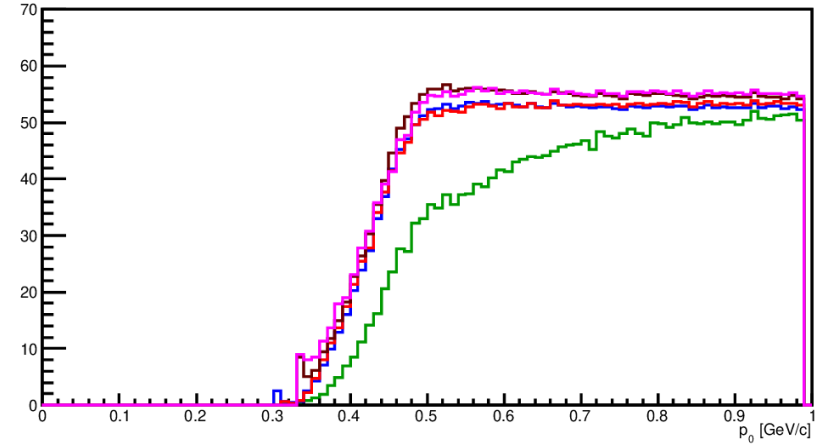


# Deuterons: Mean number of hits ( $p_0$ )

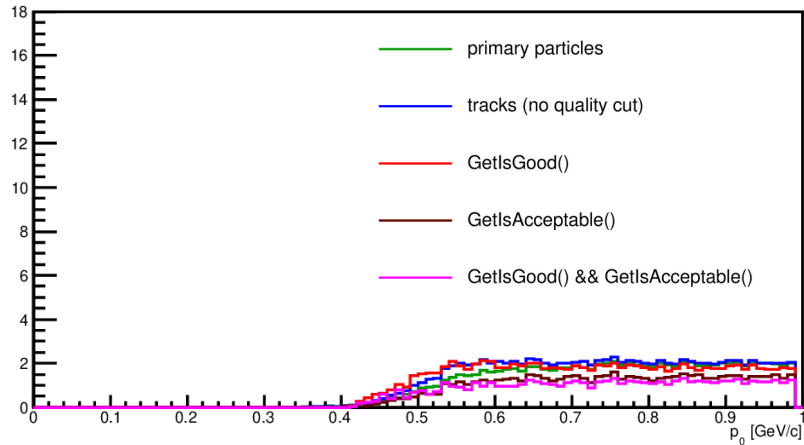
<N hits >



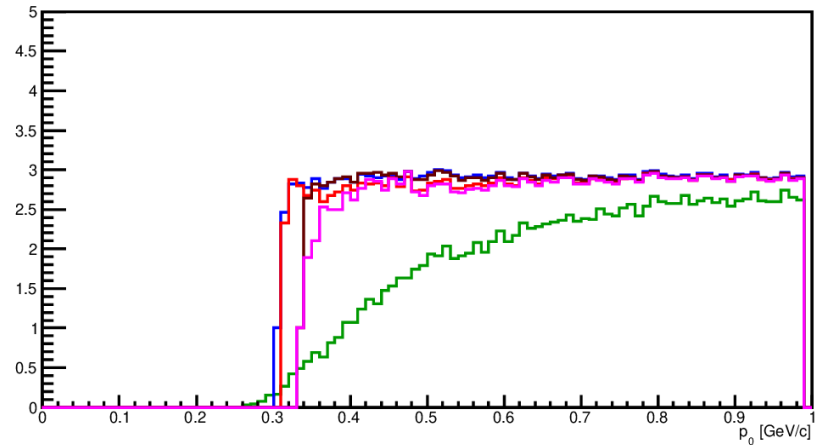
<N hits TS-B>



<N hits TS-EC>

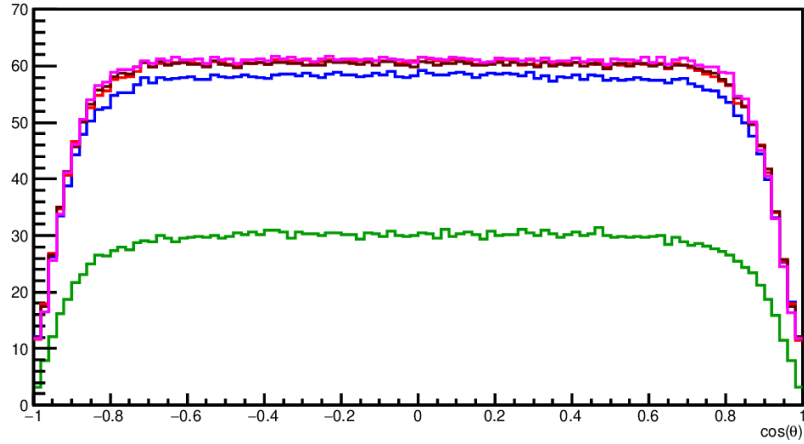


<N hits ITS>

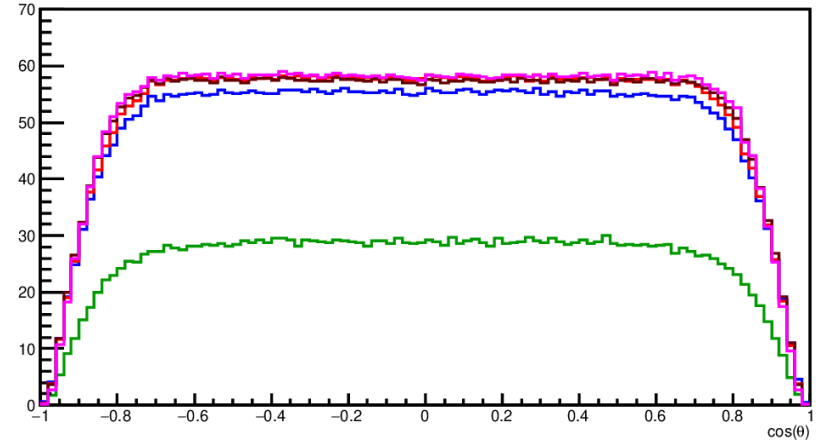


# Deuterons: Mean number of hits ( $\cos \theta$ )

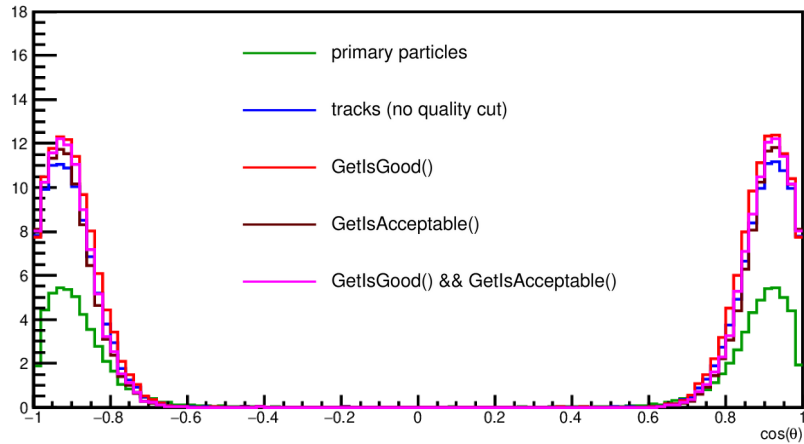
$\langle N \text{ hits} \rangle$



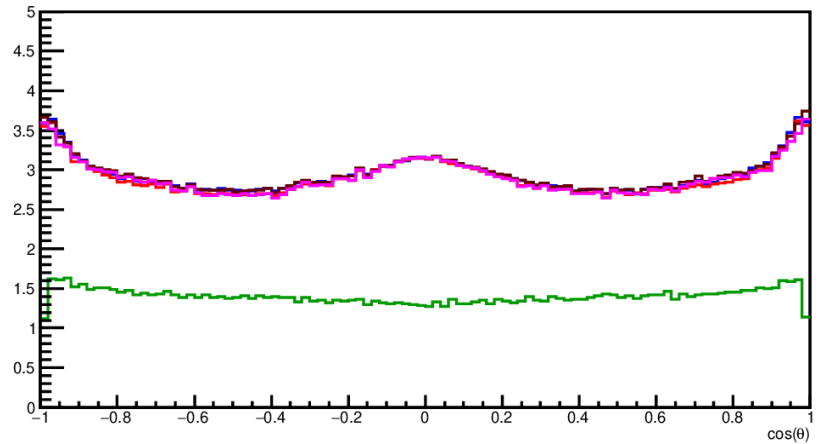
$\langle N \text{ hits TS-B} \rangle$



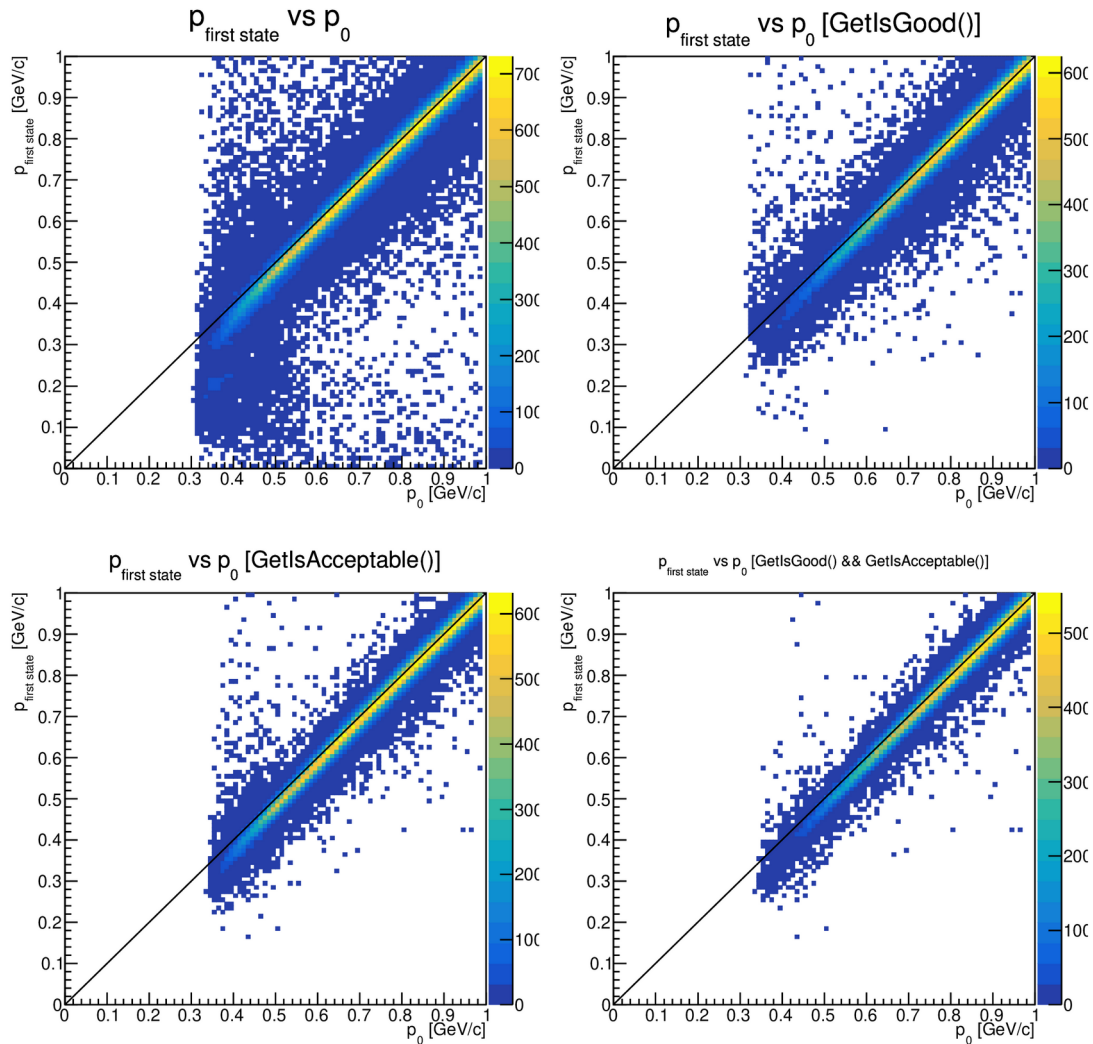
$\langle N \text{ hits TS-EC} \rangle$



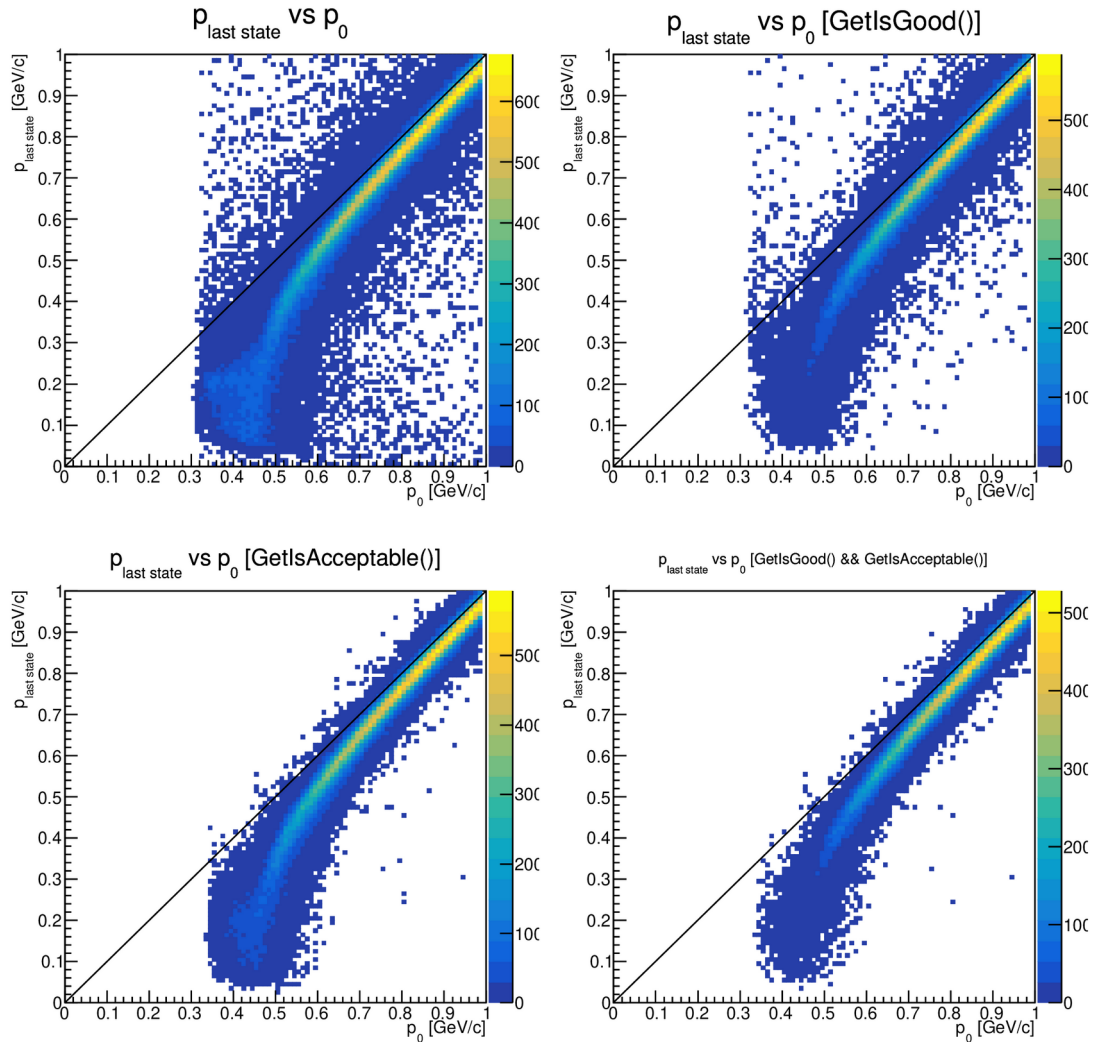
$\langle N \text{ hits ITS} \rangle$



# Deuterons: Momentum in the first point vs $p_0$

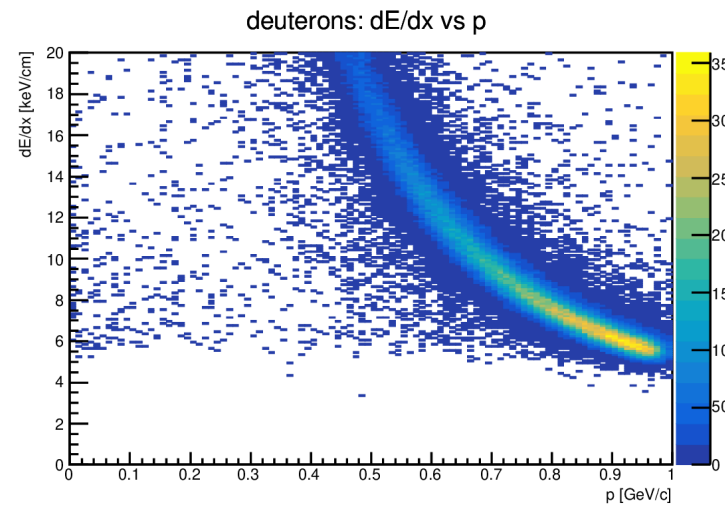
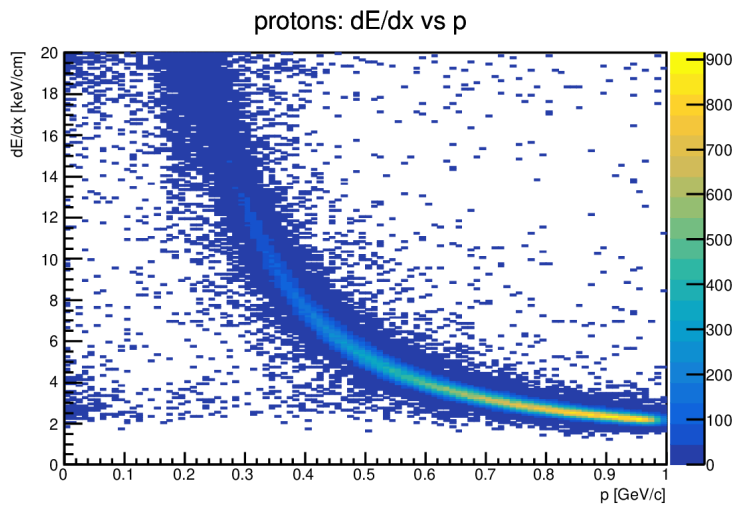
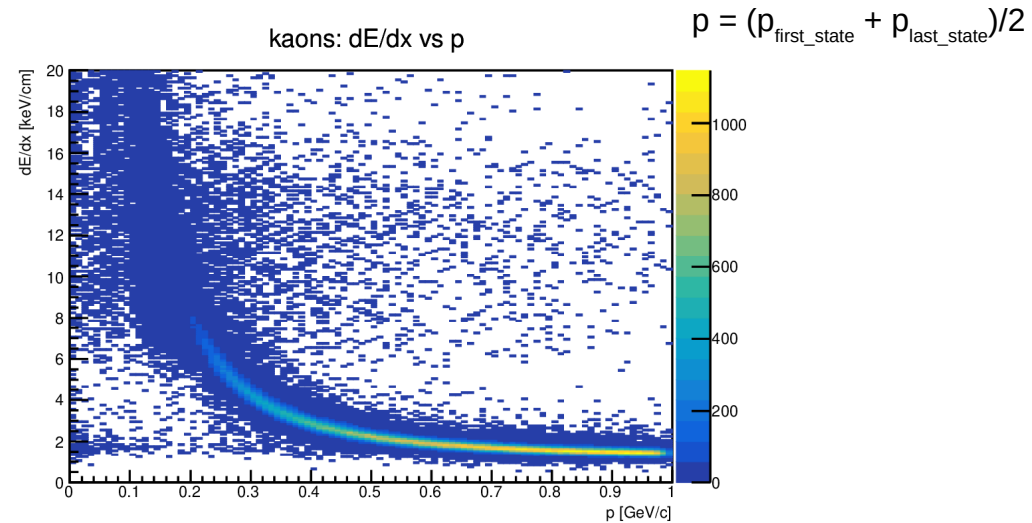
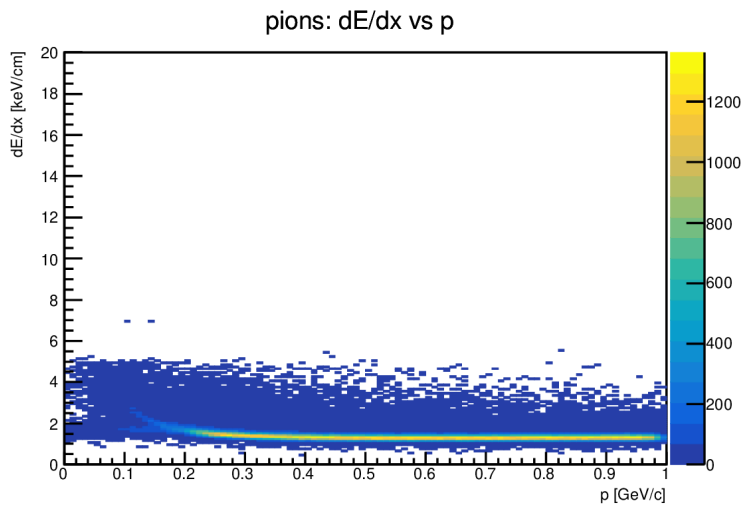


# Deuterons: Momentum in the last point vs $p_0$



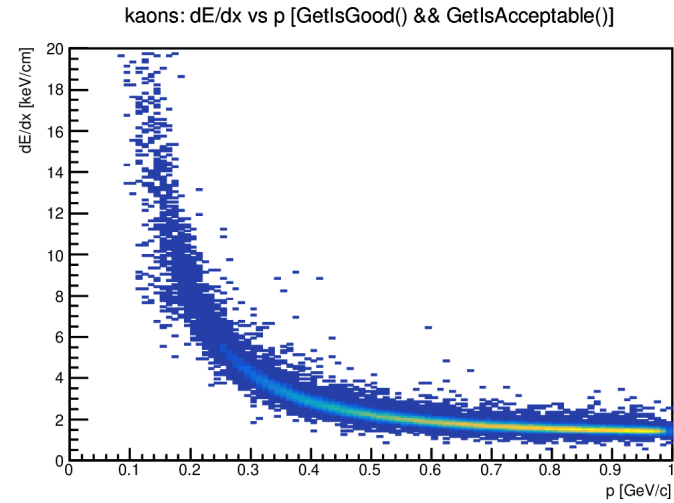
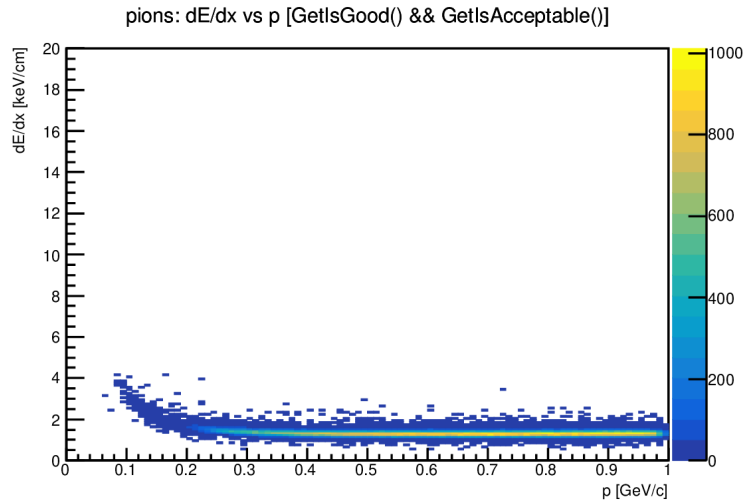
$dE/dx$  vs  $p$

# Truncated mean dE/dx vs p distributions





# Truncated mean dE/dx vs p distributions



$$p = (p_{\text{first\_state}} + p_{\text{last\_state}})/2$$

