



# **DUNE - Identification of Interactions not covered by external data in PPFX**

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PPFX Meeting

# Goal of this Project :

- Identifying interactions where we need new hadron production data.
- Identify events in PPFX that are not covered by data and quantity their breakdown in terms of parent/child hadrons (e.g.,  $p \rightarrow \pi$ ,  $\pi \rightarrow K$ , etc),
- For each of the major processes in that list, plot the  $p$ - $\theta$ ,  $x_f$ - $p_T$  distribution of those events. This will help hadron production experiments know where measurements are most needed.

# From Leo's Thesis

## Thin Target Data

These are experiments that use monochromatic beams on targets of a few percents of interaction lengths. They measure:

- The inelastic and absorption cross-section. Some of the datasets found are:
  - Belletini et. al. [64], Denisov et al. [65], etc. : proton, pions and kaons on carbon, aluminum, etc. in a wide energy range.
  - NA49 ([66]): proton on carbon at 158 GeV.
  - NA61 ([40]): proton on carbon at 31 GeV.
- Hadron Production. Some of the datasets found are:
  - Barton et. al [56]:  $pC \rightarrow \pi^\pm X$  at 100 GeV for  $x_F > 0.3$ .
  - NA49 ([66]):  $pC \rightarrow \pi^\pm X$  at 158 GeV for  $x_F < 0.5$ .
  - NA49 ([67]):  $pC \rightarrow n(p)X$  at 158 GeV for  $x_F < 0.95$ .
  - NA49 ([68]):  $pC \rightarrow K^\pm X$  at 158 GeV for  $x_F < 0.2$ .
  - NA61 ([40]):  $pC \rightarrow \pi^\pm X$  at 31 GeV.

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<sup>4</sup>These data were not used in this thesis but it could be used as a cross check in the future.

- MIPP [69]:  $\pi/K$  from  $pC$  at 120 GeV for 20 GeV/c.

All this data is stored in the xml files in PPFX repositories

# How it is done ?

dk2nu tuple



Categorize Interactions based on available data in xml files



Interactions covered by data

Interactions not covered by data



Make plots – hadron kinematics

# Statistics Used:

- Total POT ~ 24M
- Version – v3r5p7
- External data Used :

## ThinTarget and Barton

- ThinTarget\_K\_PI\_Bins.xml
- ThinTarget\_material\_scaling\_Bins.xml
- ThinTarget\_pC\_n\_Bins.xml
- ThinTarget\_pC\_pi\_Bins.xml
- ThinTargetBarton\_pC\_pi\_Bins.xml
- ThinTargetLowxF\_pC\_k\_Bins.xml
- ThinTarget\_MesonIncident.xml
- ThinTarget\_pC\_p\_Bins.xml

## MIPP

- MIPPNumiData\_K\_PI\_Bins.xml
- MIPPNumiData\_PIP\_Bins.xml

# Particle Information

Particles info for maps :

$$= \{p, \pi^+, \pi^-, k^+, k^-, n, k^l, k^s, \eta\}$$

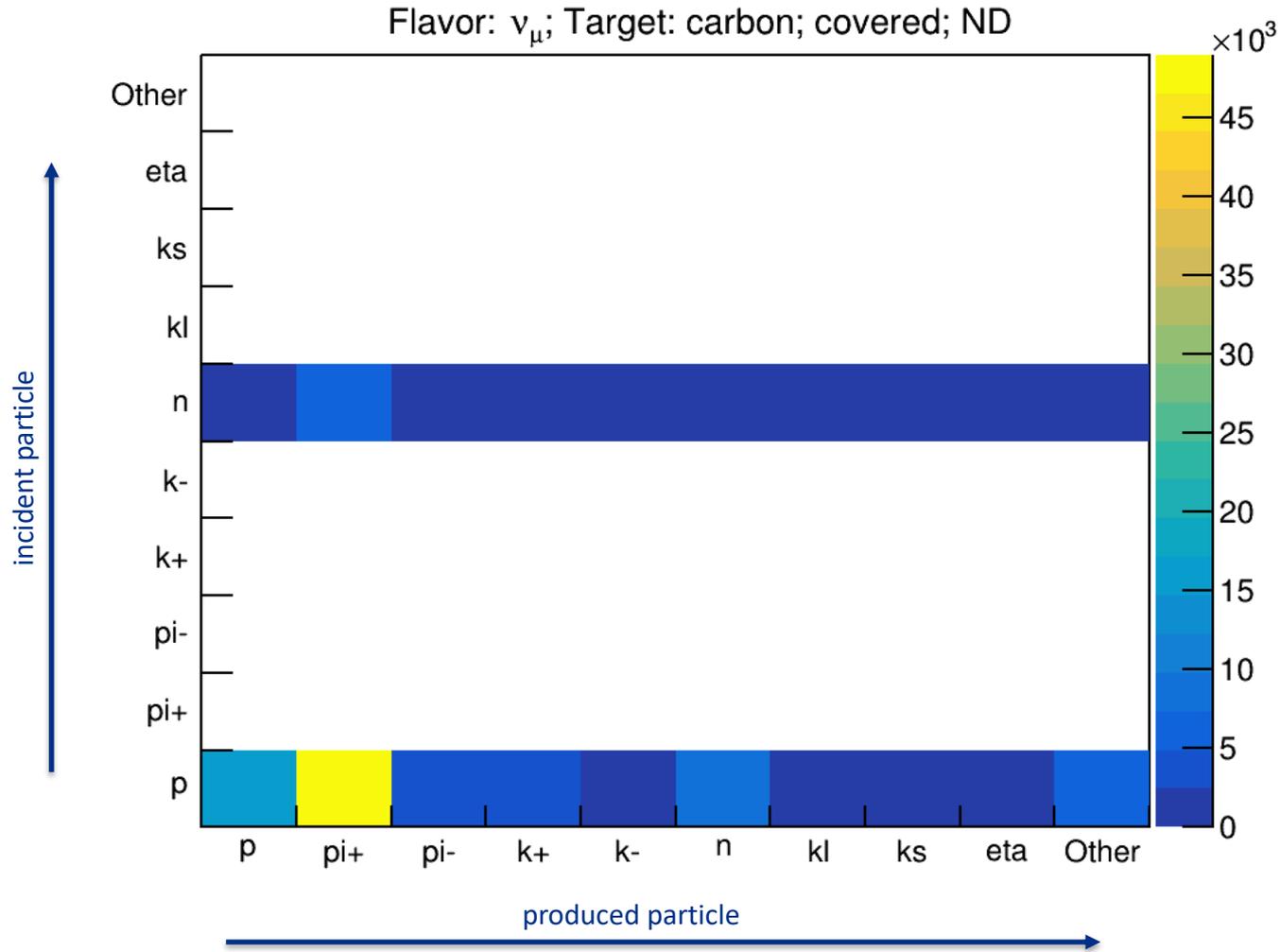
Today I will show :

Incident =  $\pi^+$  and  $\pi^-$

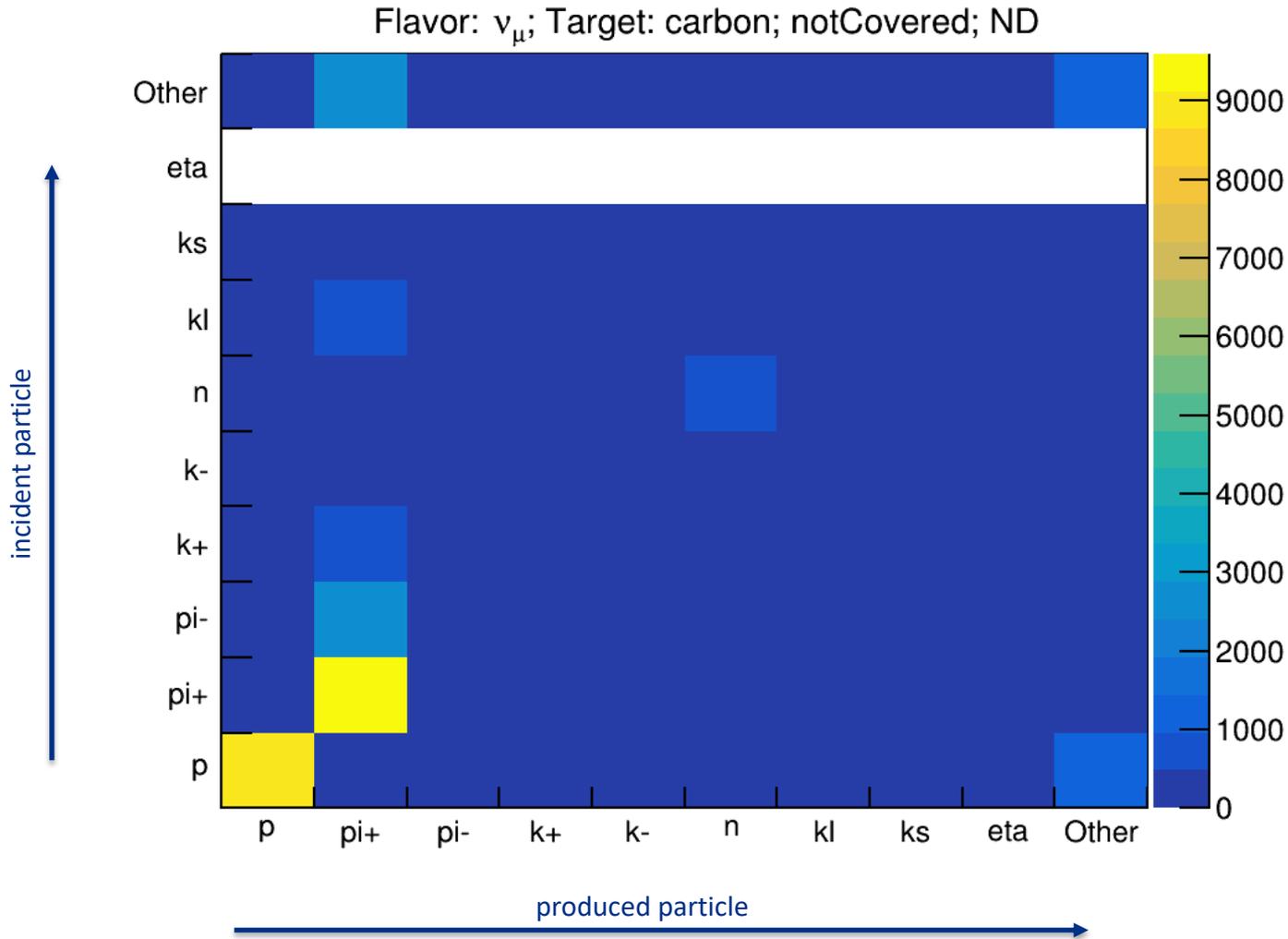
Produced =  $\{p, \pi^+, \pi^-, k^+, k^-, n, k^l, k^s, \eta\}$

Other = not having any of these particle combinations.

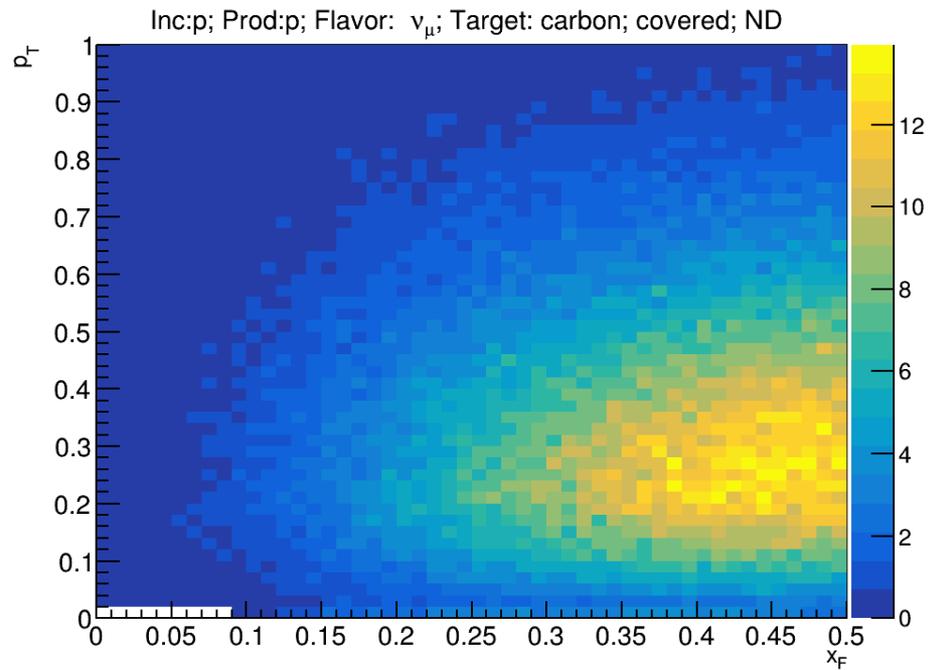
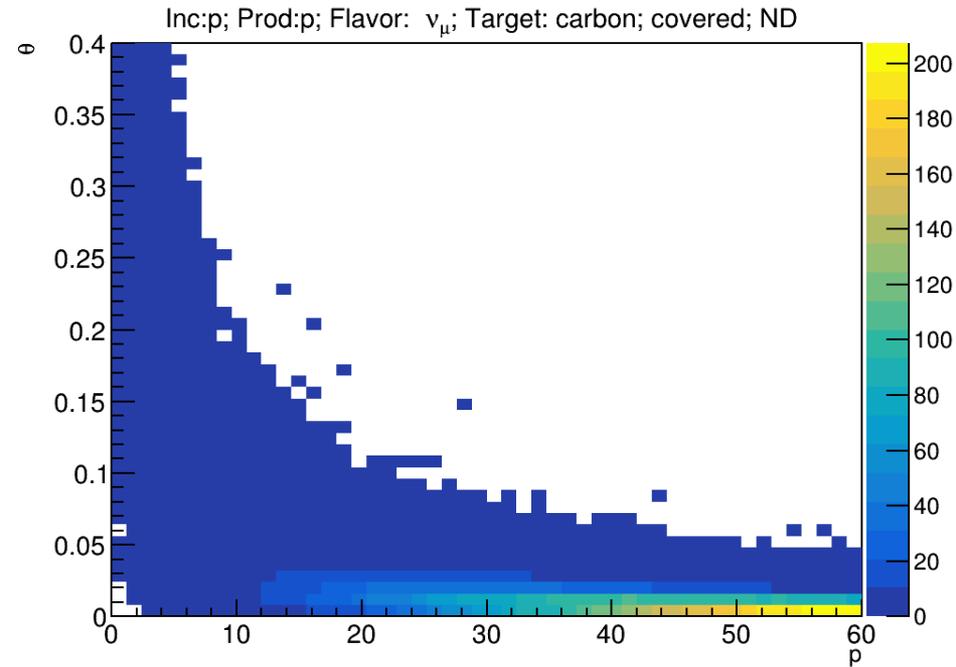
# Particle Map - covered



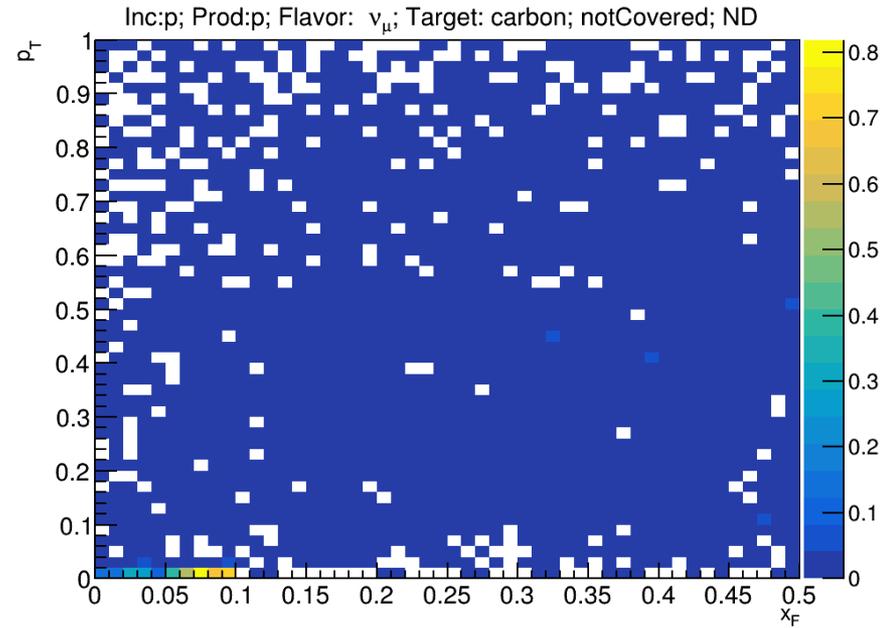
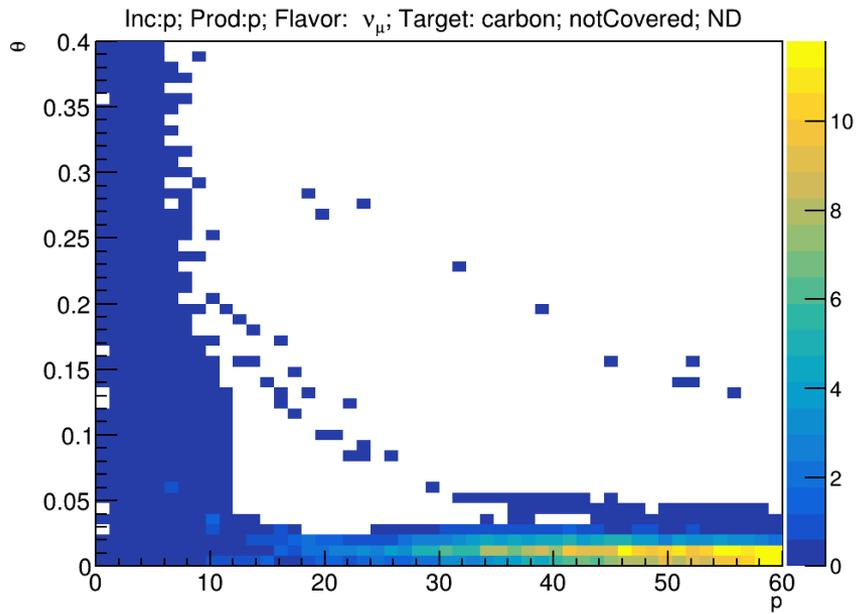
# Particle Map – Not Covered



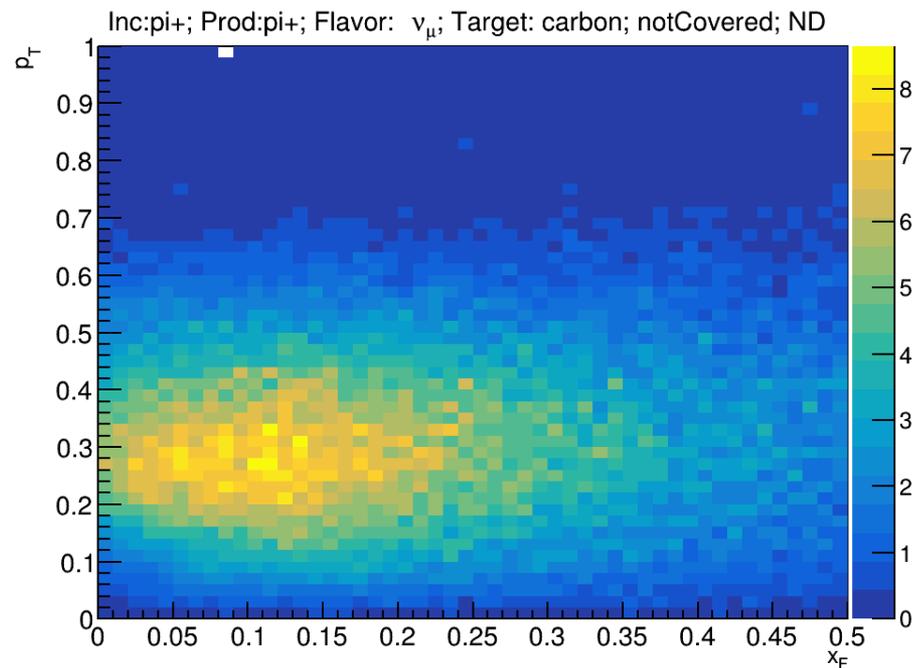
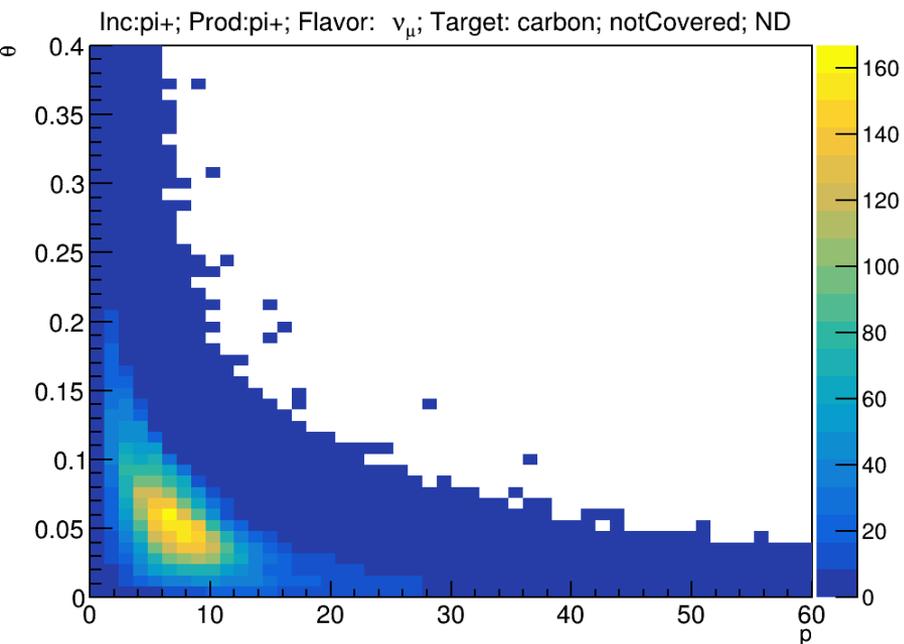
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $p \rightarrow p$ covered



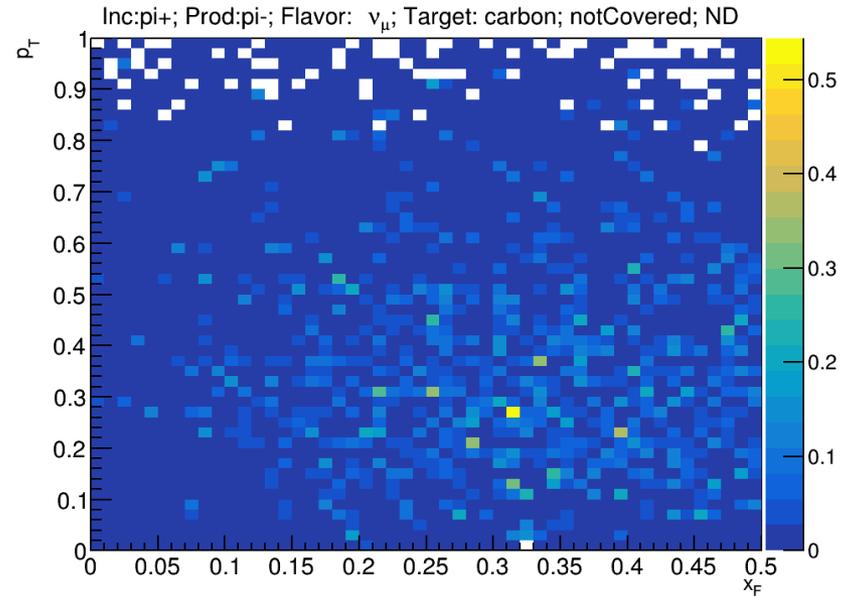
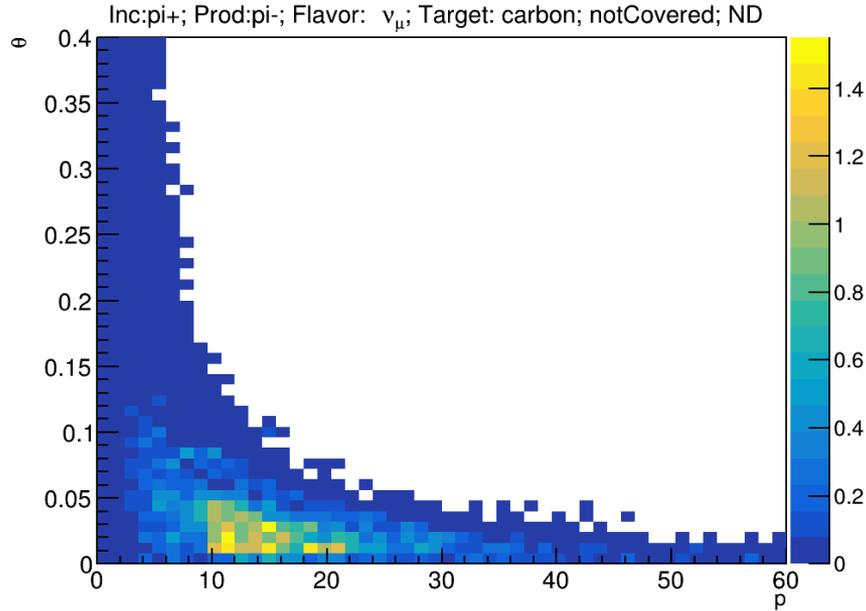
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $p \rightarrow p$ not covered



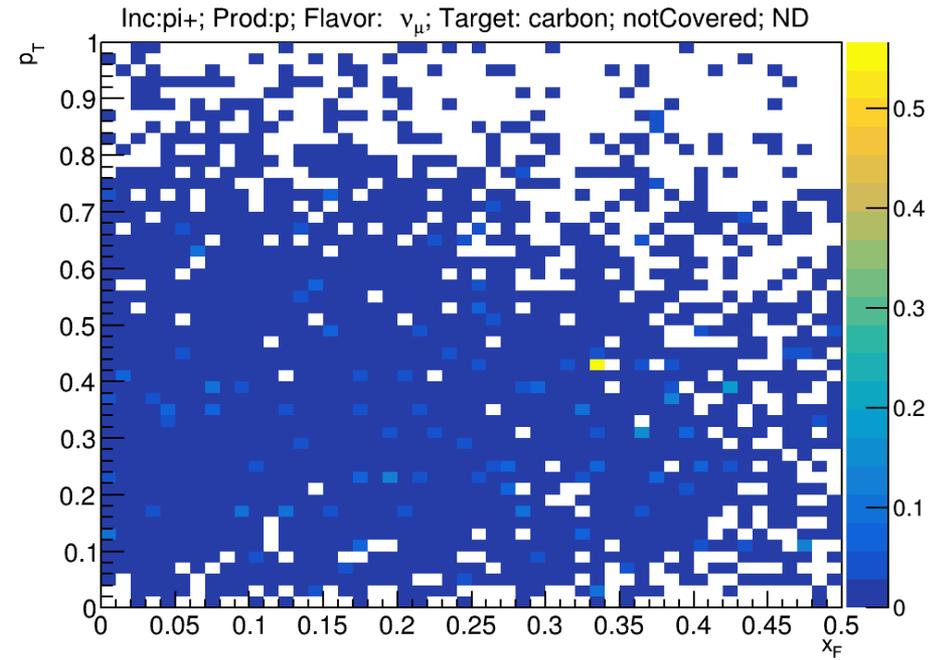
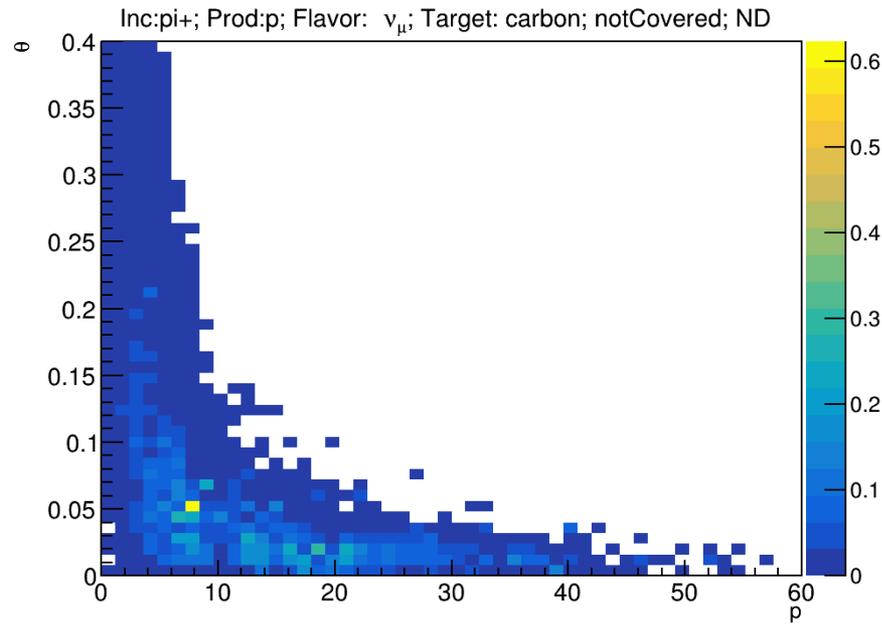
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow \pi^+$



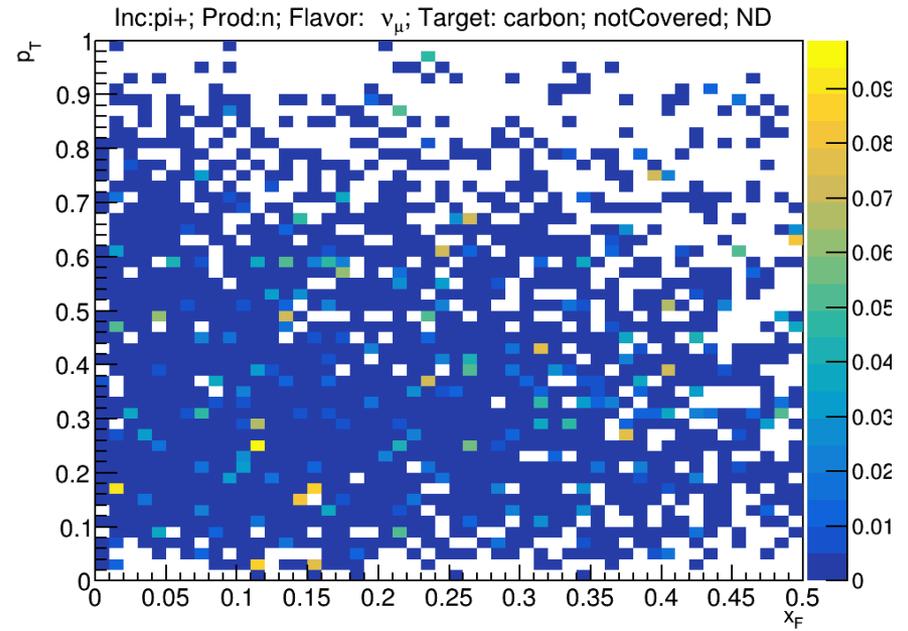
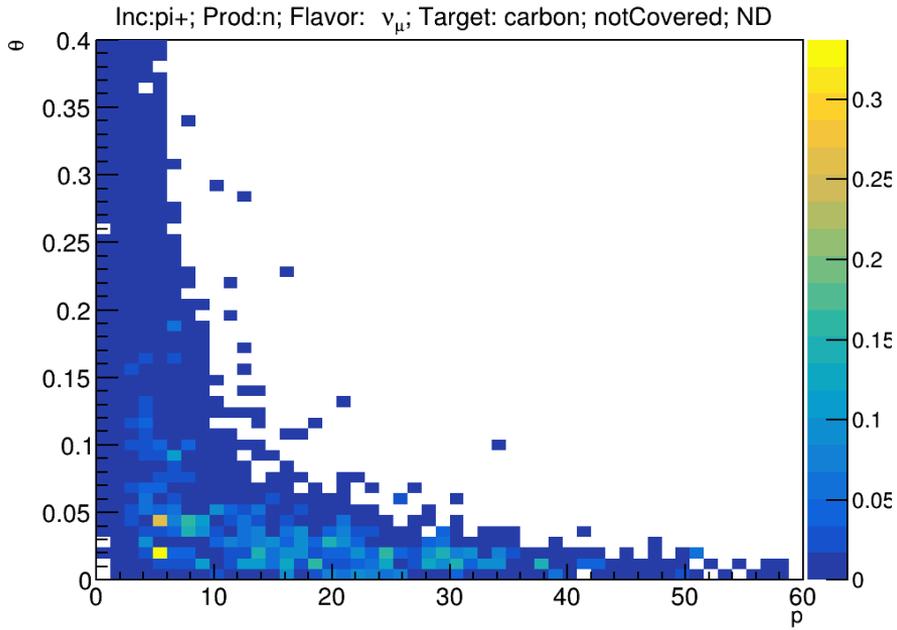
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow \pi^-$



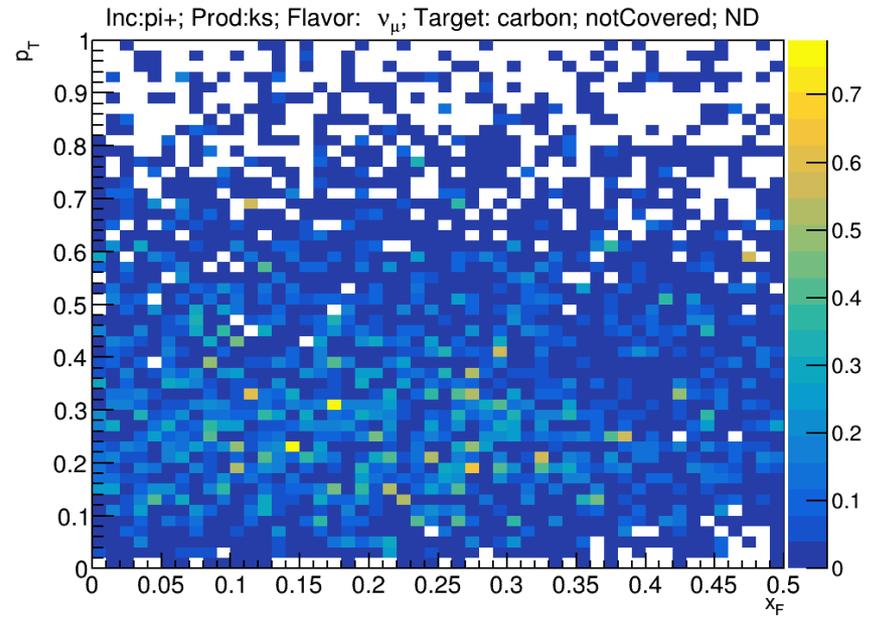
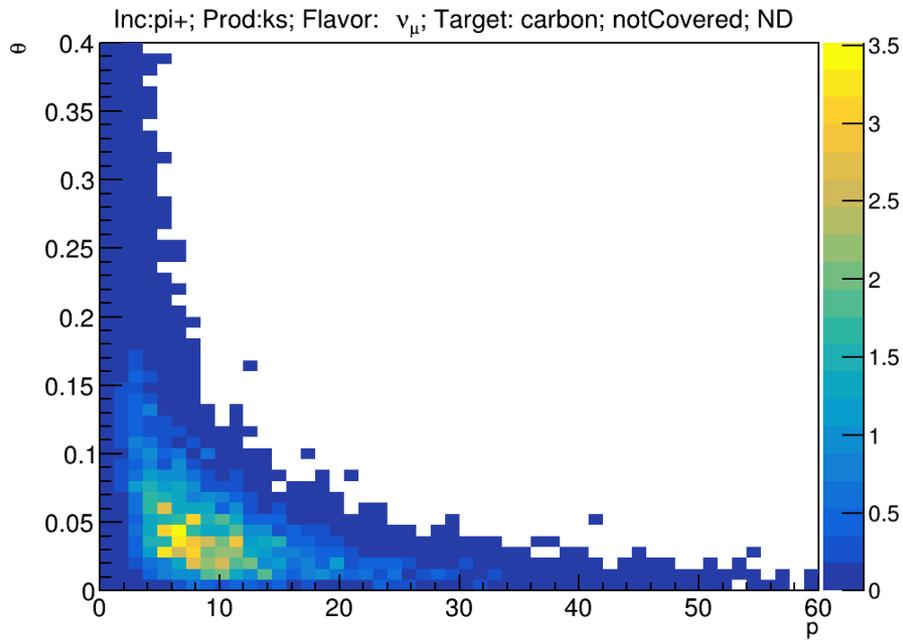
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow p$



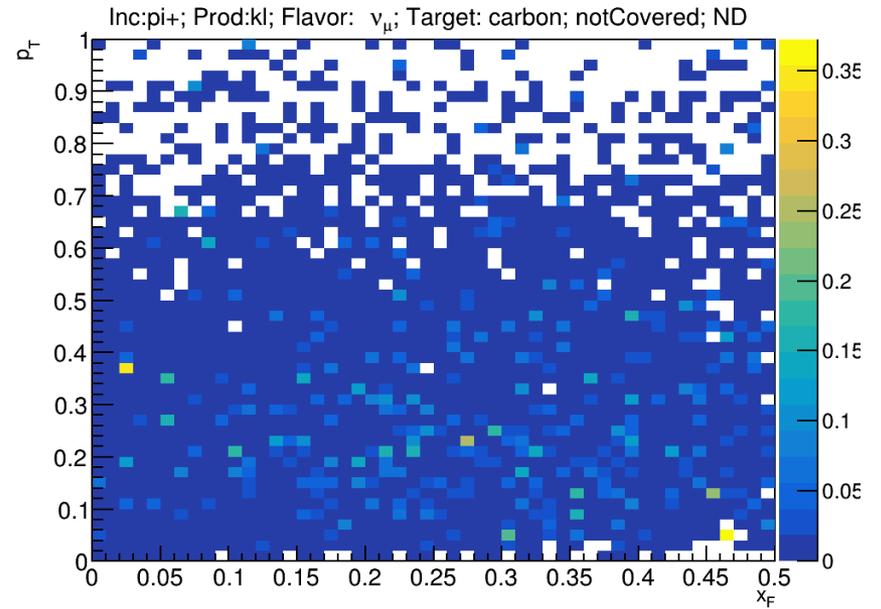
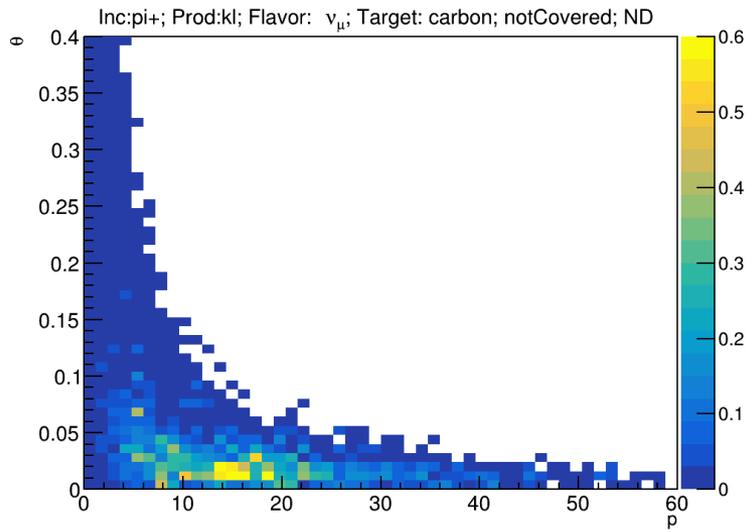
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow n$



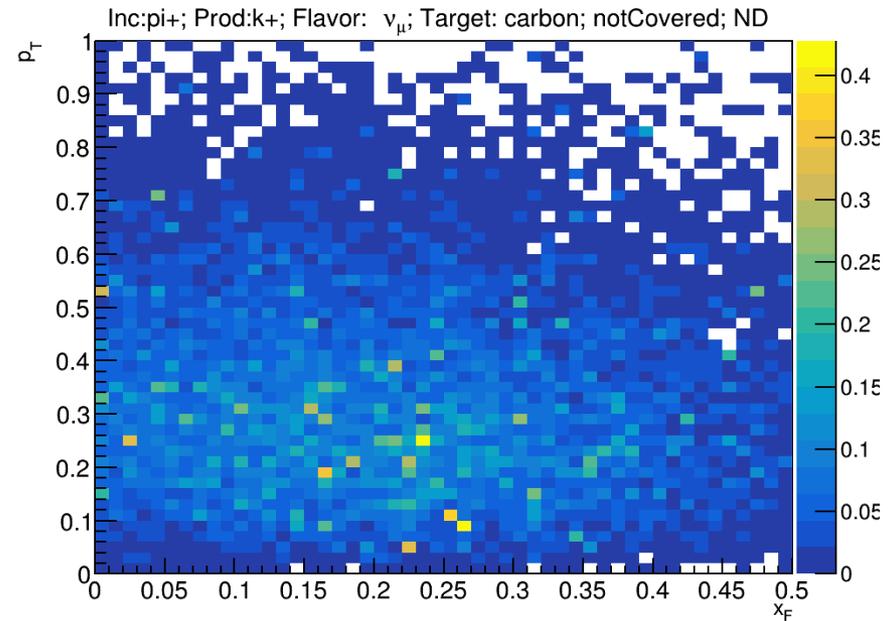
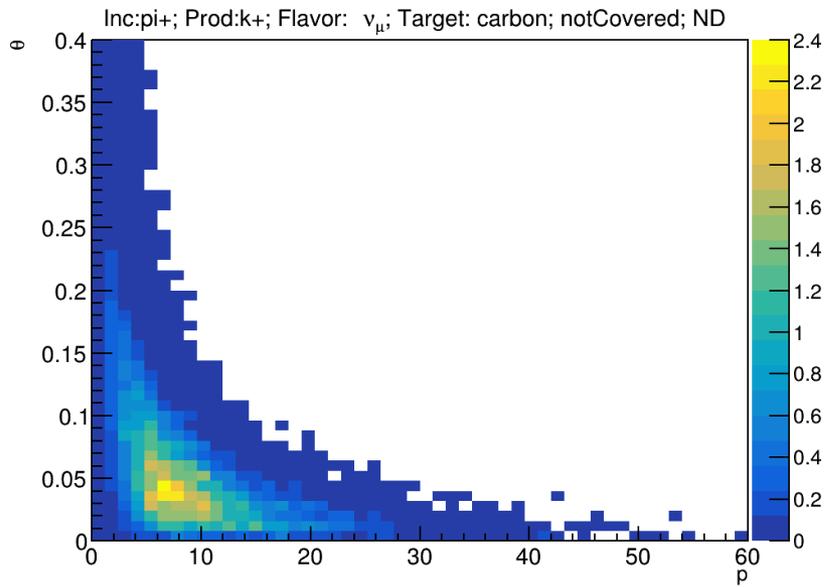
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow k_s$



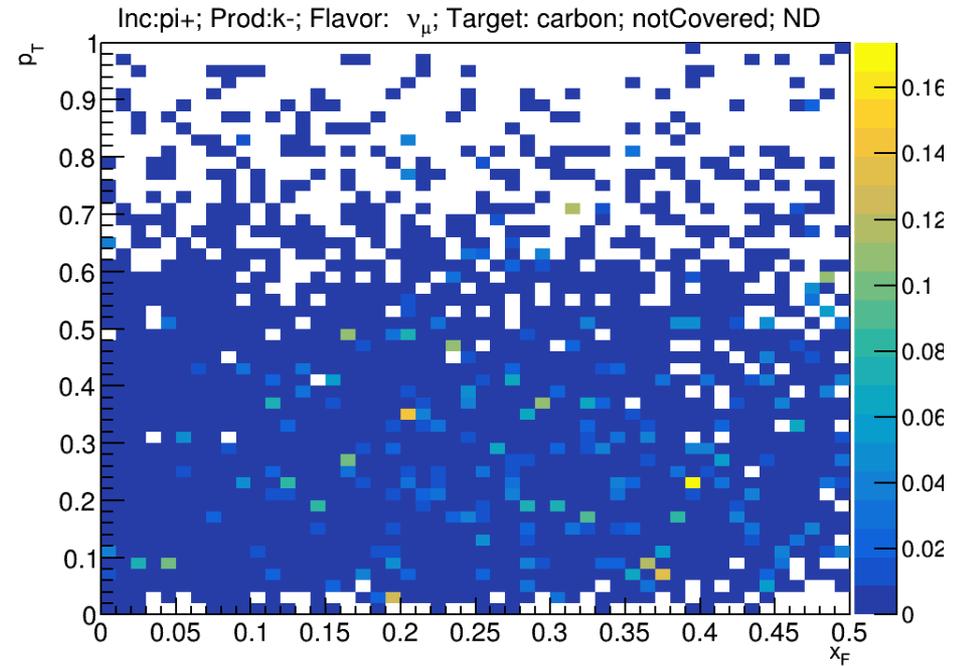
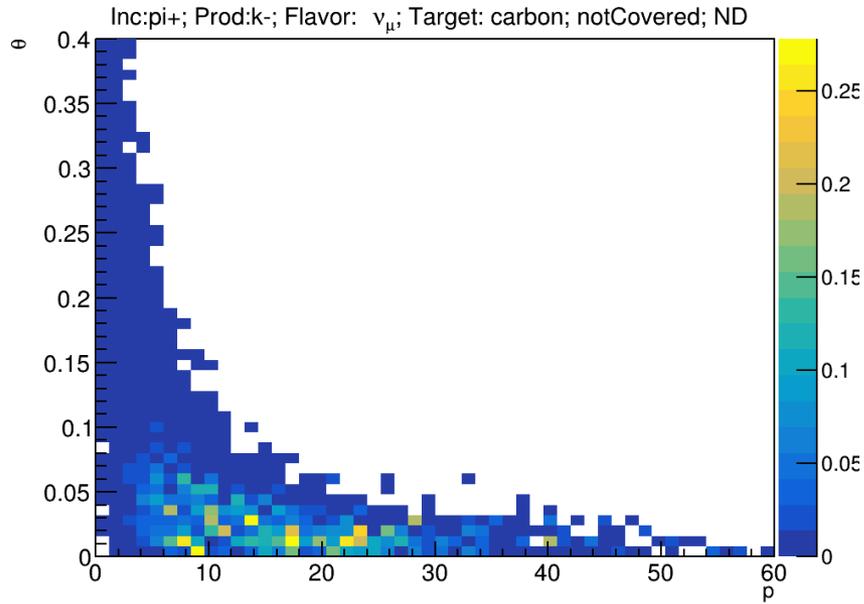
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow k_l$



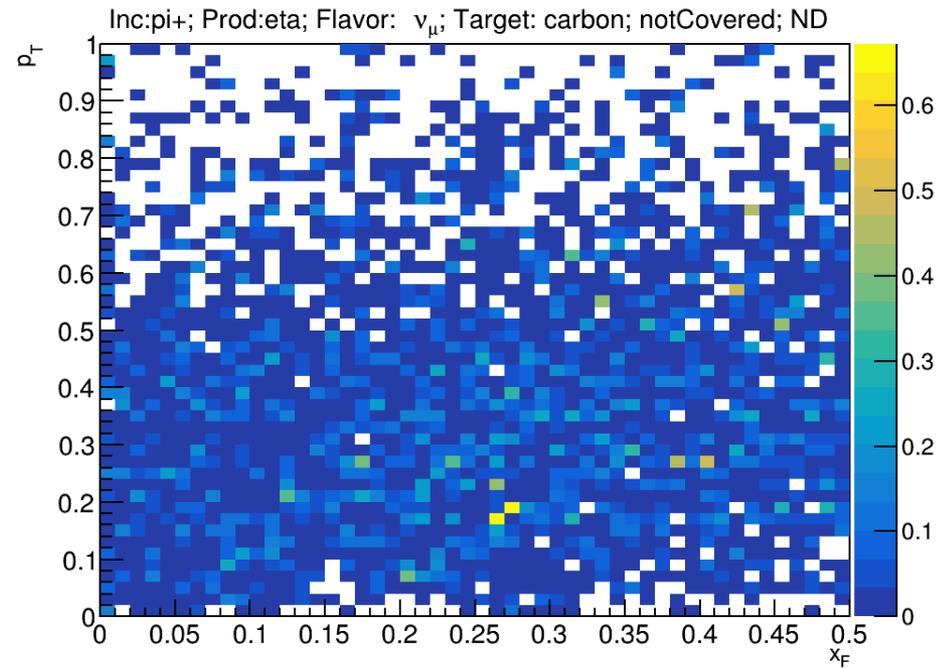
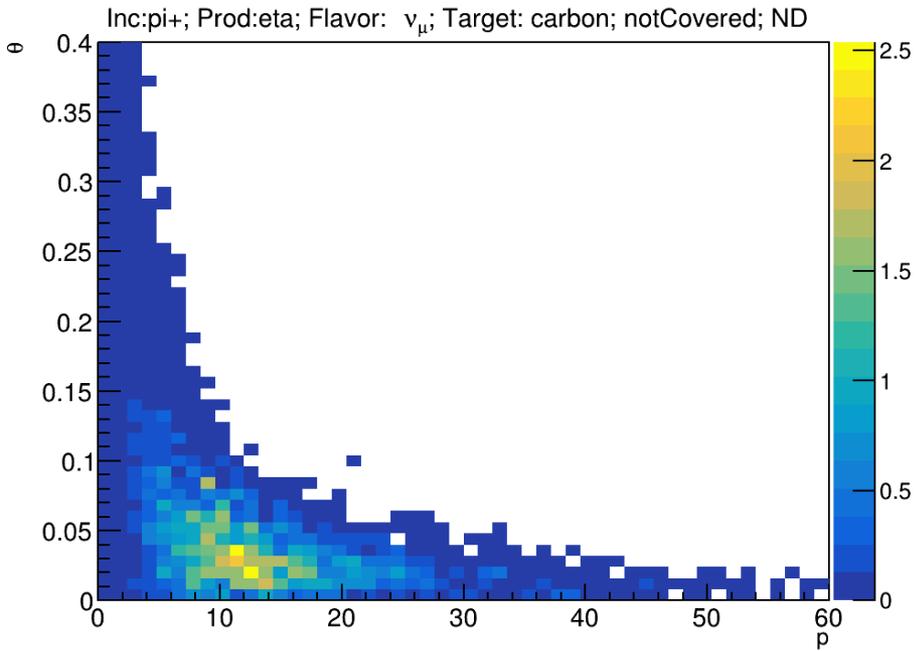
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow k^+$



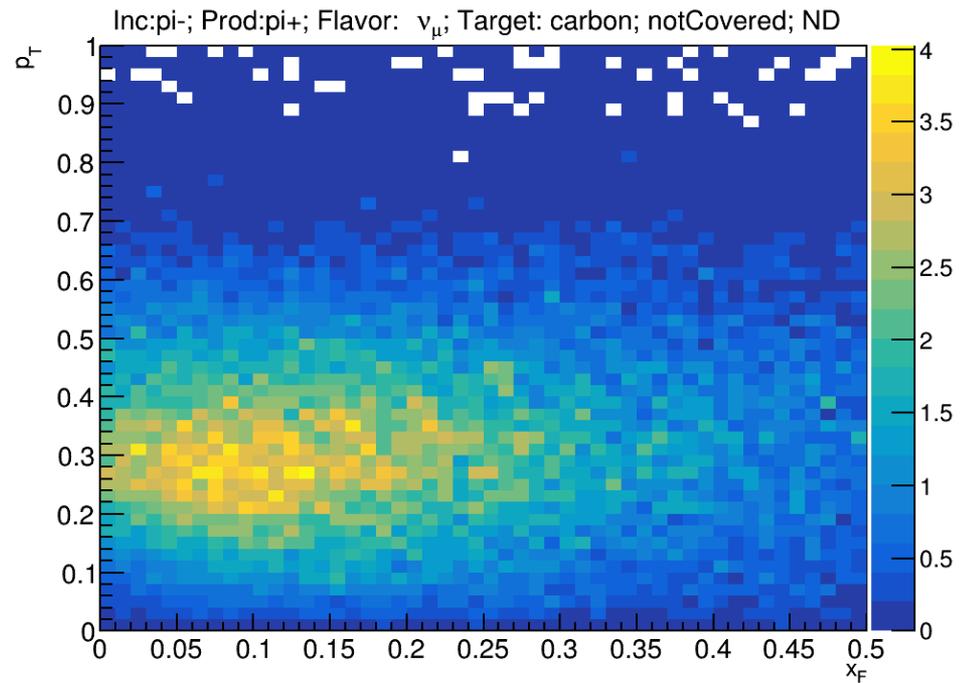
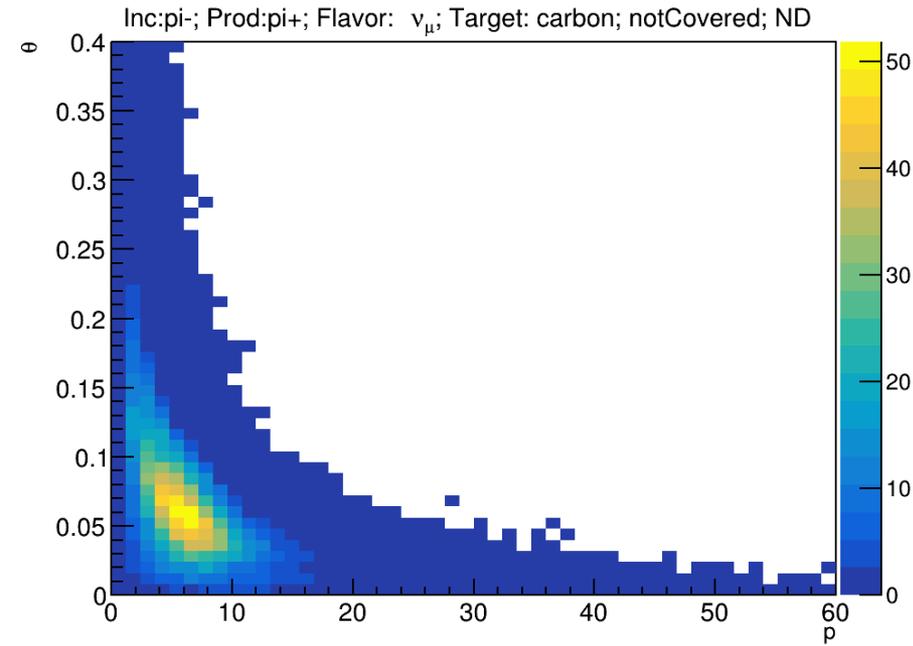
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow k^-$



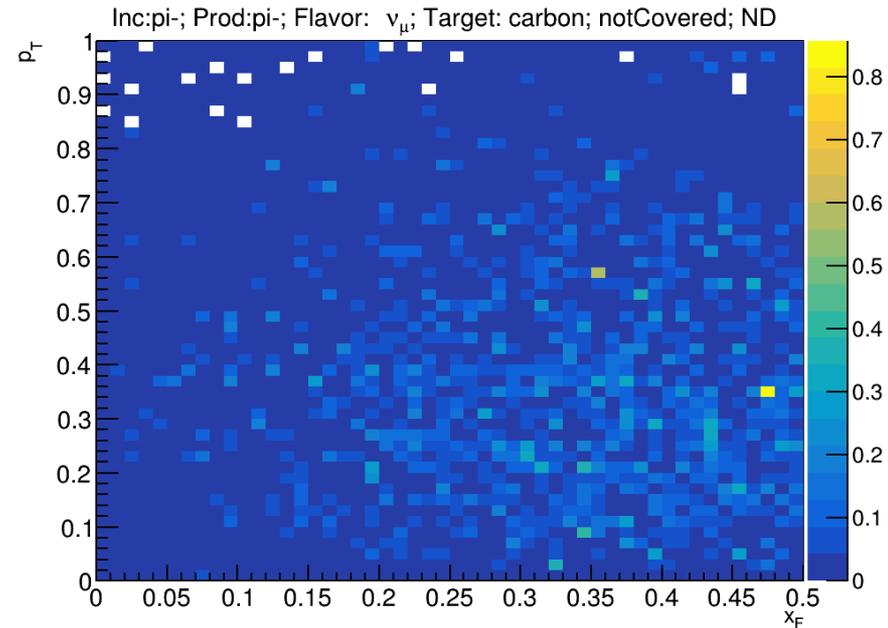
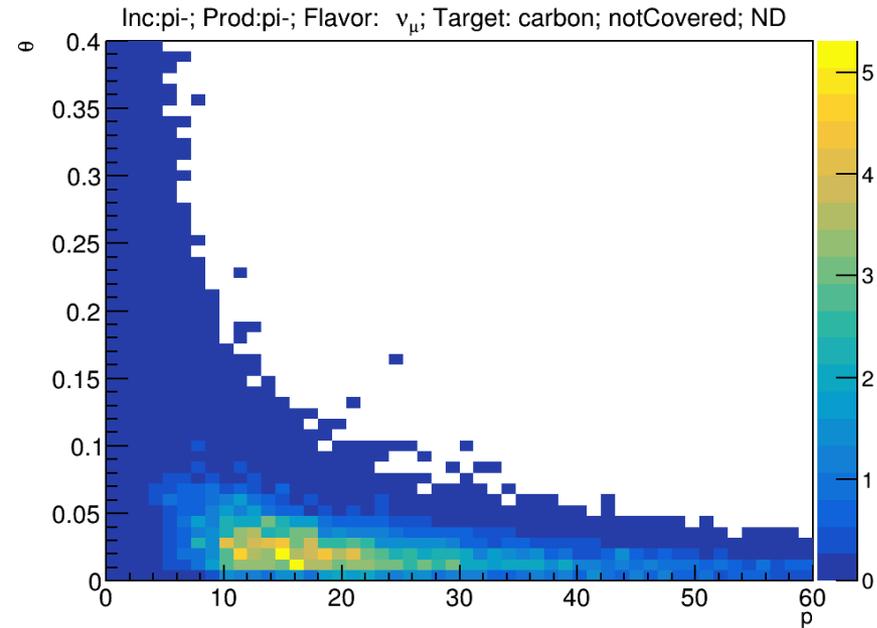
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^+ \rightarrow \eta$



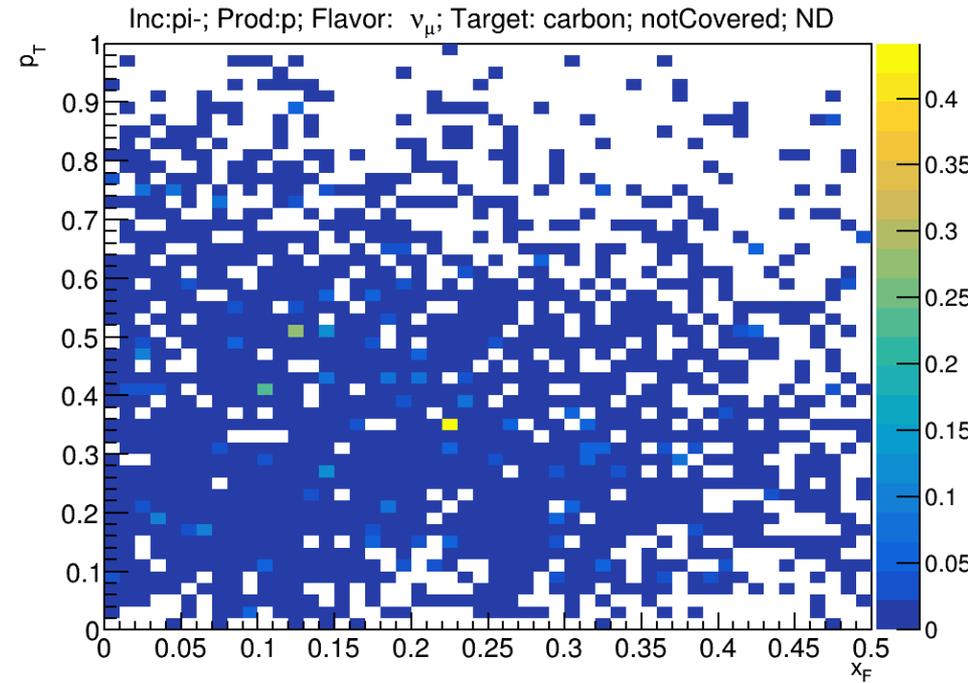
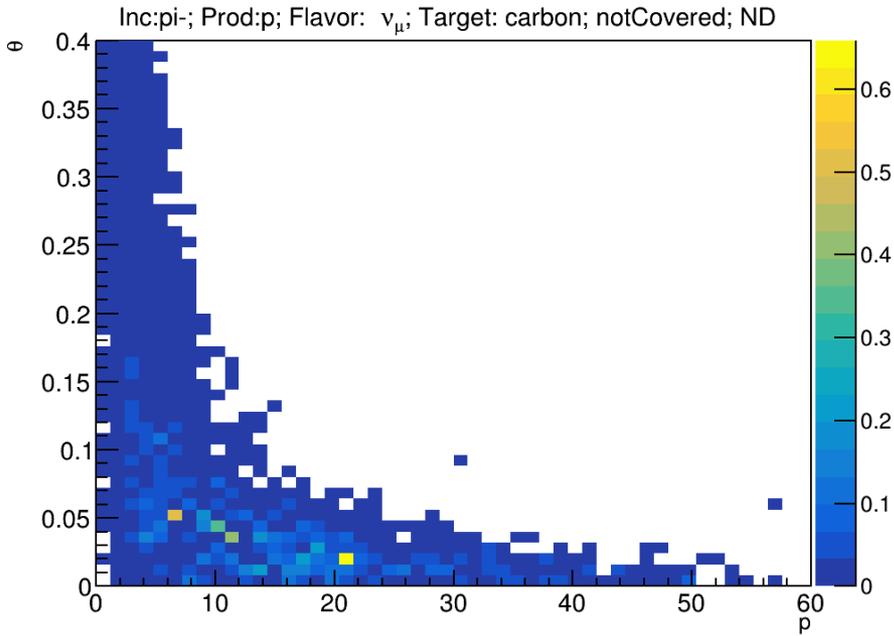
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow \pi^+$



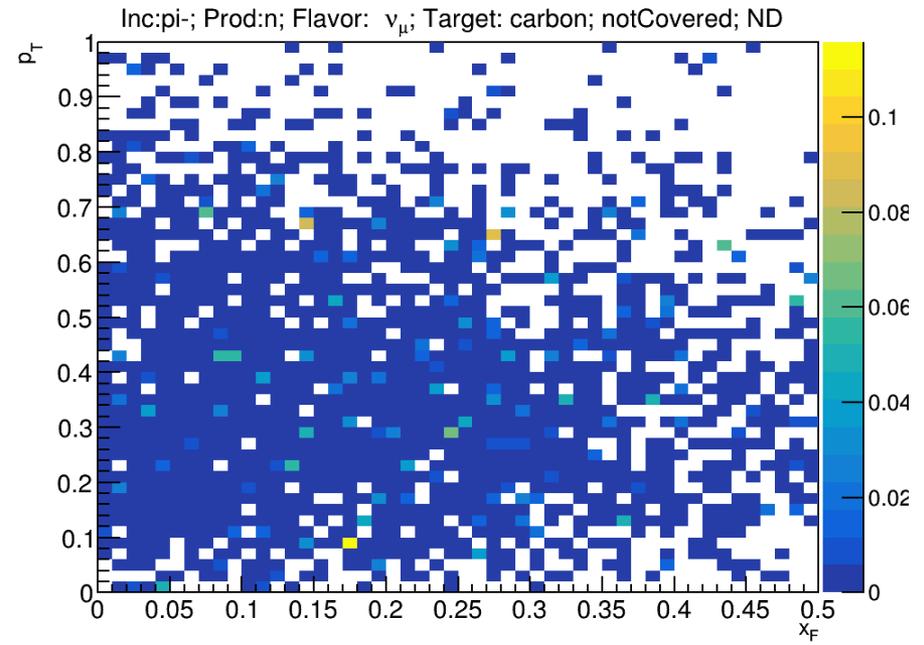
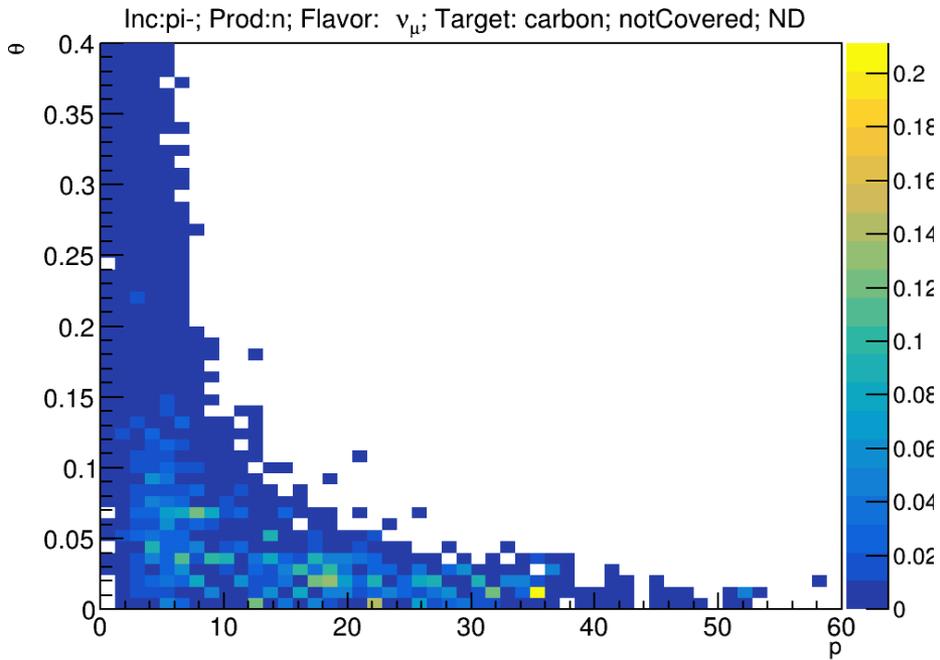
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow \pi^-$



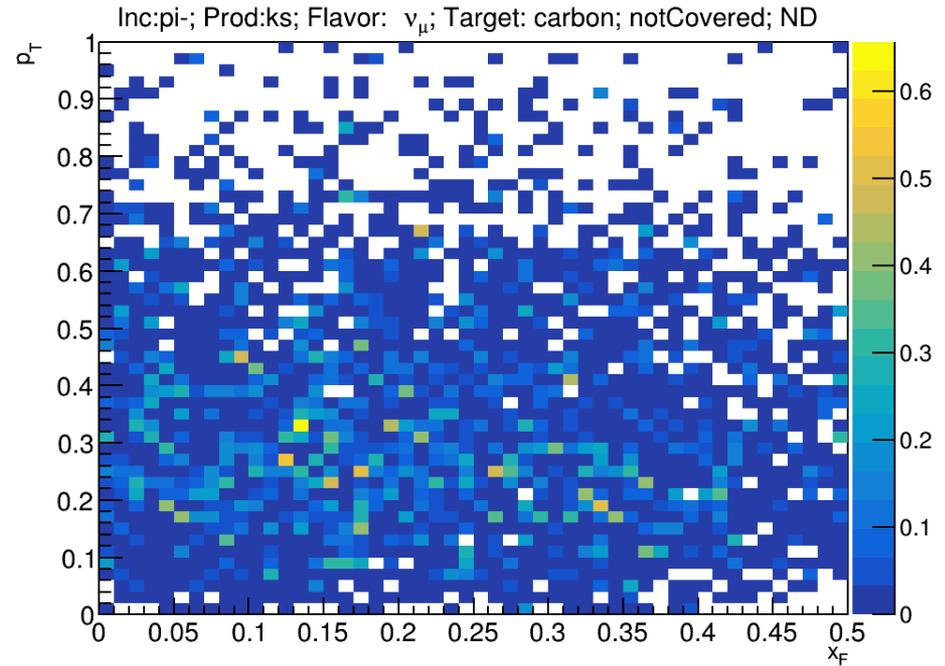
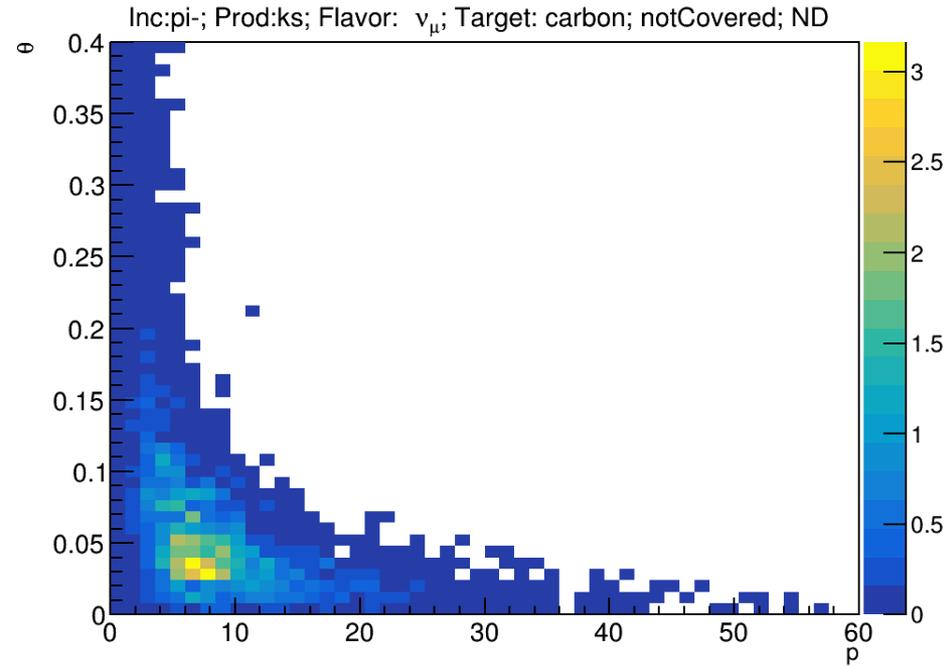
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow p$



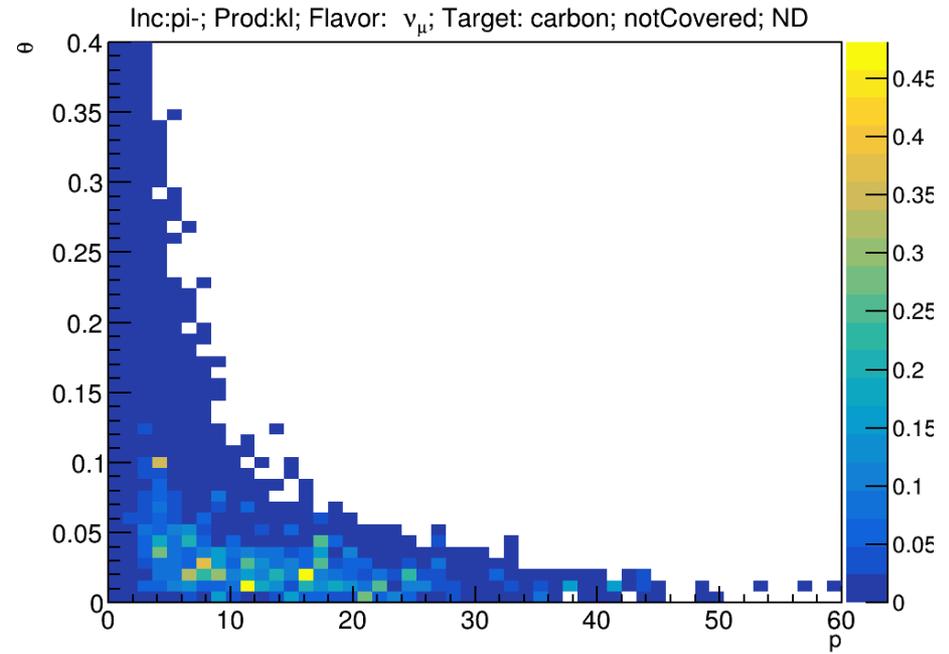
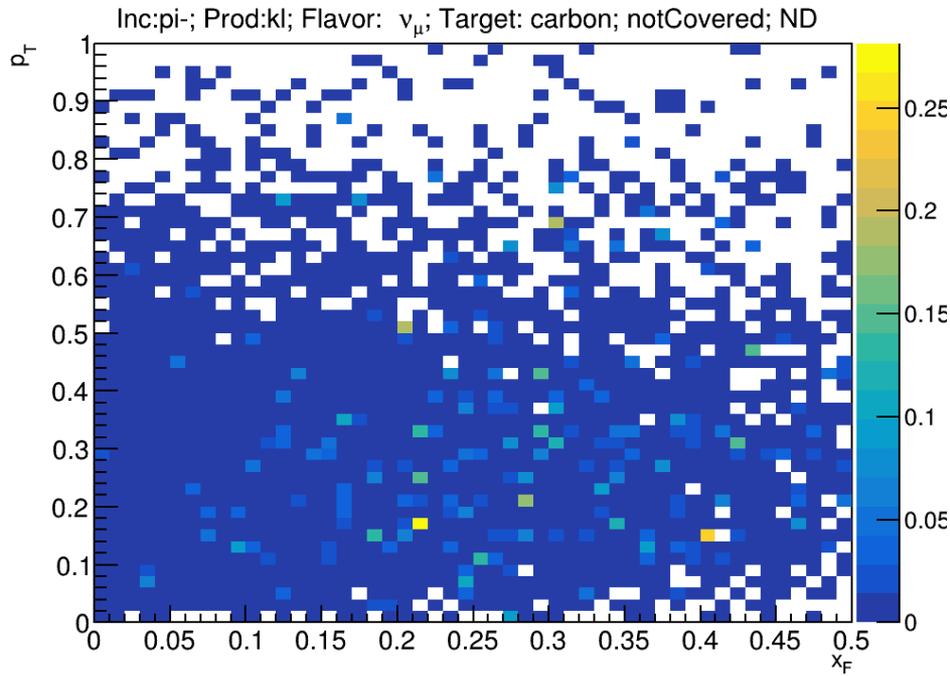
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow n$



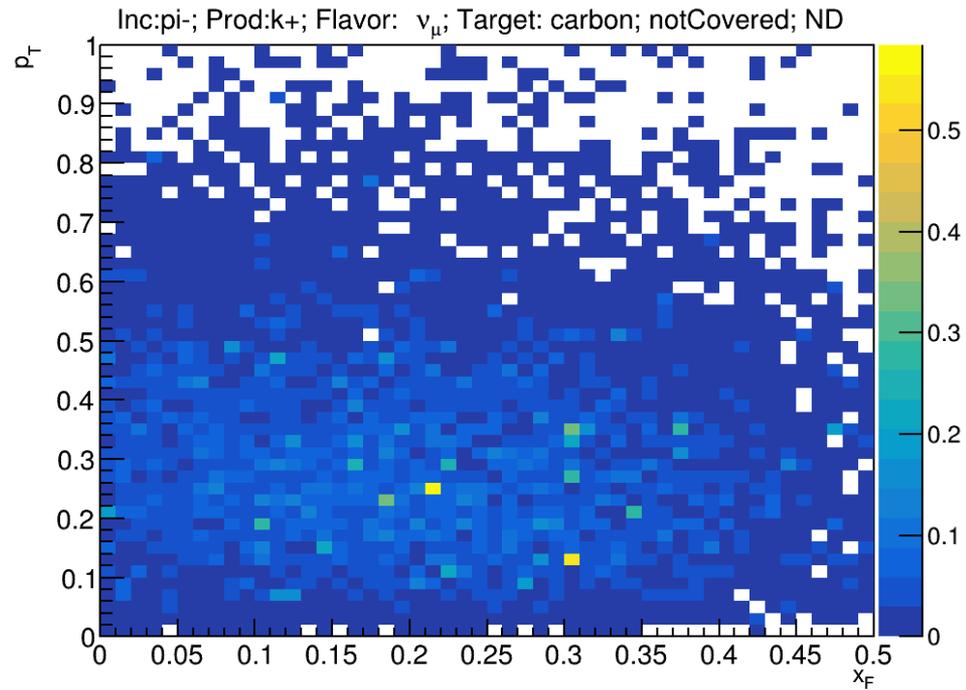
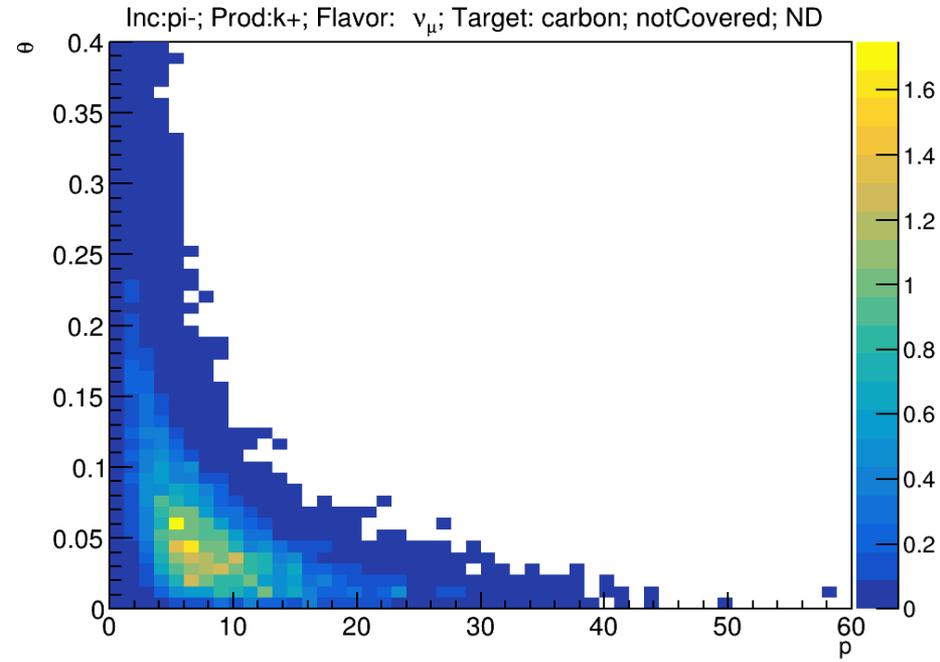
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow k_s$



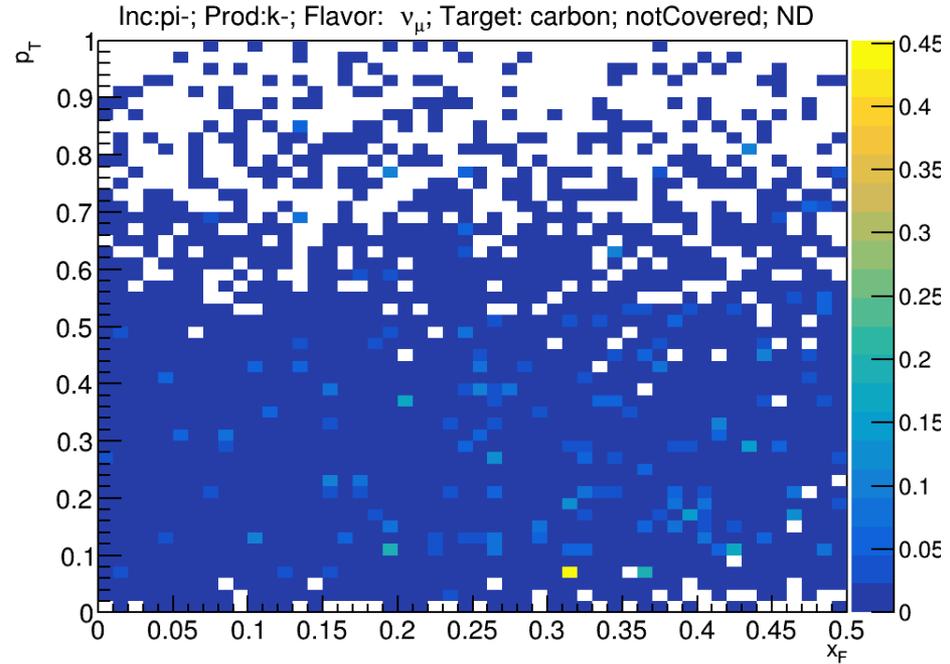
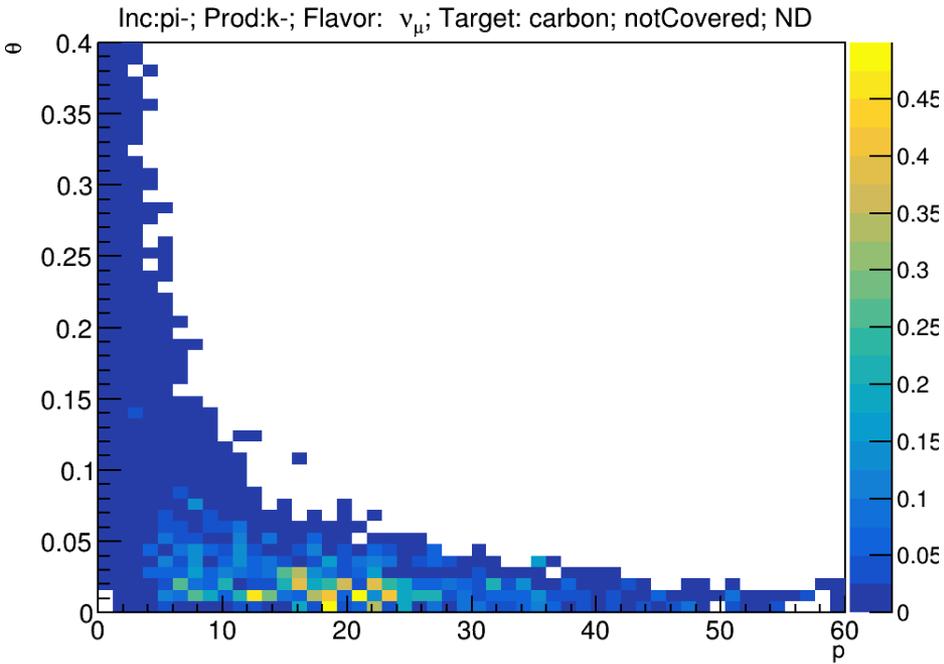
# $p$ vs $\theta$ and $x_F$ vs $p_T$ : $\pi^- \rightarrow k_1$



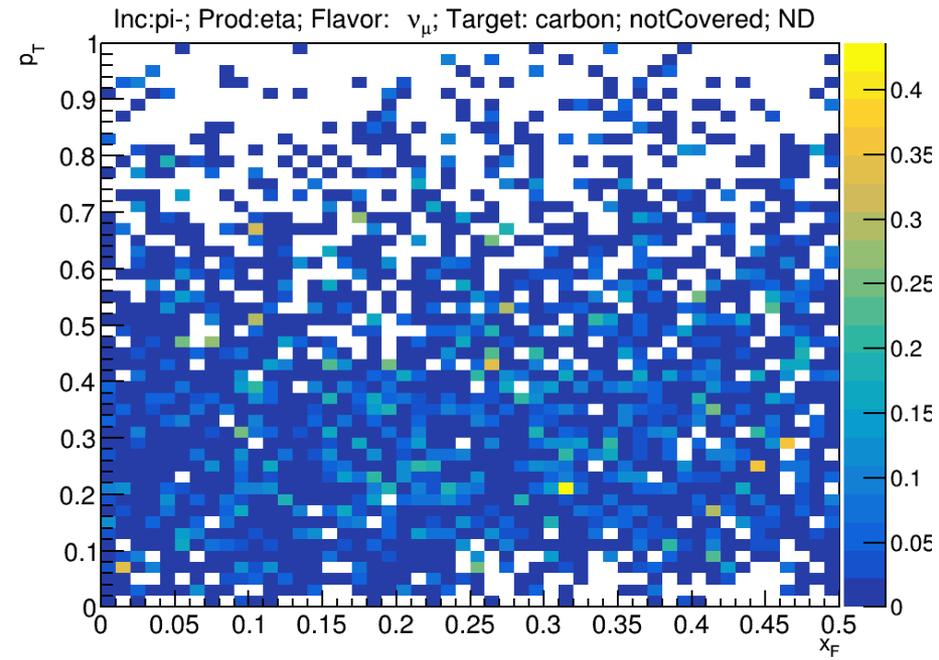
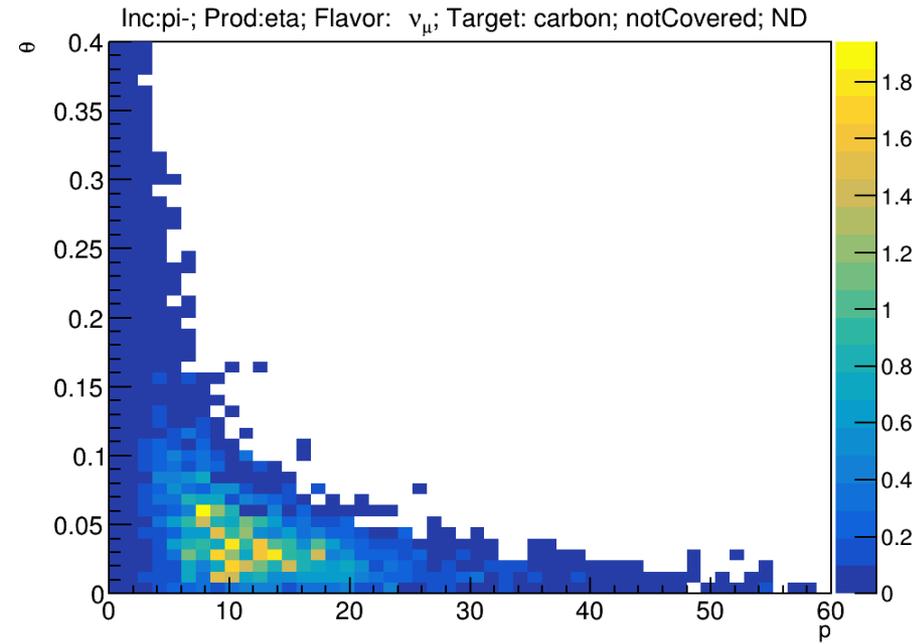
# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow k^+$



# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow k^-$

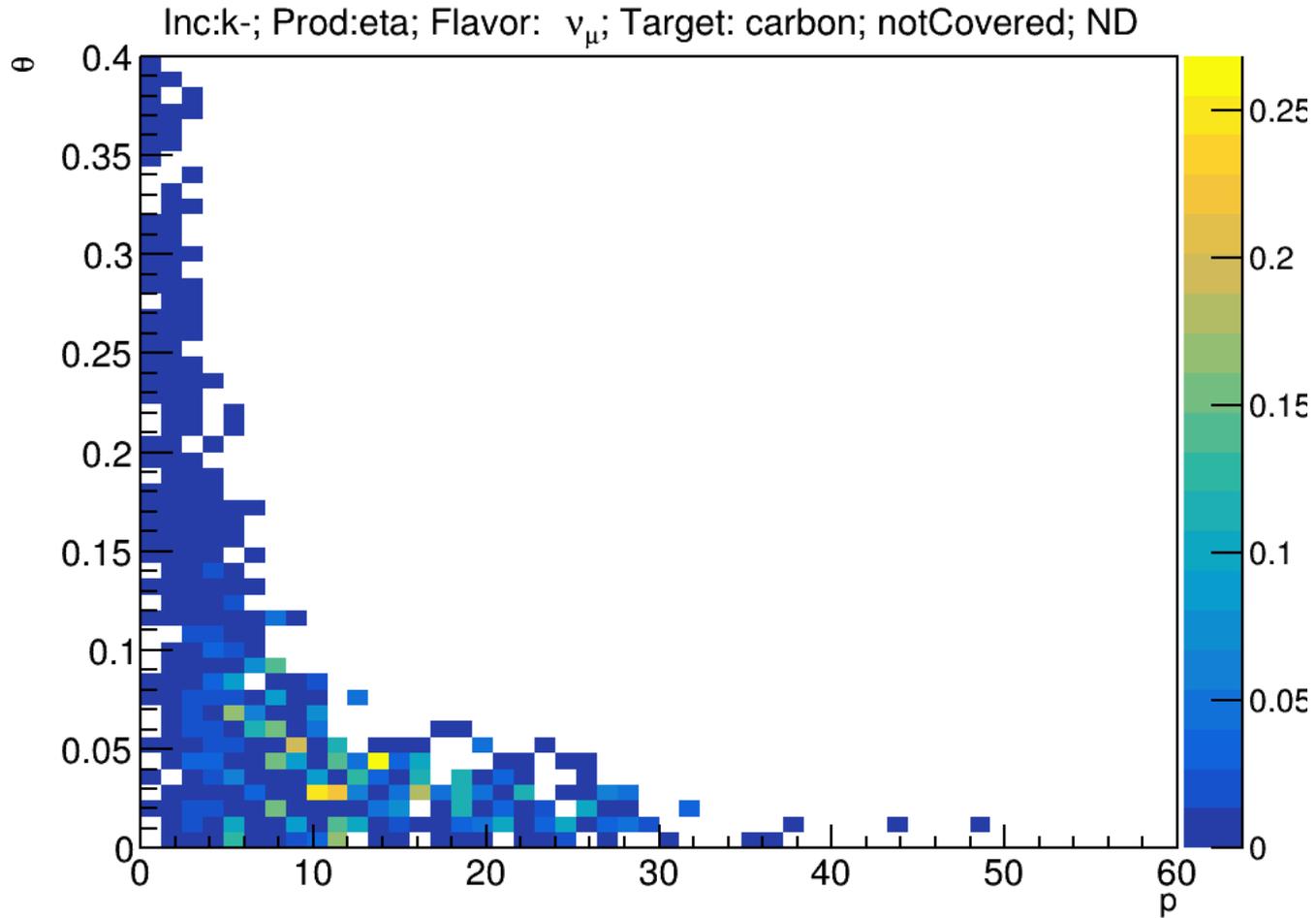


# $p$ vs $\theta$ and $x_F$ vs $p_t$ : $\pi^- \rightarrow \eta$



# BACKUP

# P-theta distributions



- `inc_E_lab = TMath::Sqrt(inc_P*inc_P + inc_mass*inc_mass);`
- `int inc_bin = findParticleIndex(inc_pdg);`
- `int prod_bin = findParticleIndex(prod_pdg);`
- `double xF = PL*2./Ecm;`
- `double pT = sqrt(prod.startpx*prod.startpx+prod.startpy*prod.startpy);`
- `double prod_P =`  
`TMath::Sqrt(prod.startpx*prod.startpx+prod.startpy*prod.startpy+prod.startpz*prod.startpz);`
- `double prod_theta = TMath::ACos(prod.startpz/prod_P);`

- `particle_maps[map_index]-`  
`>Fill(prod_bin,inc_bin,importance_weight*location_weight);`
- `incident_energies[map_index][kinematic_plot_index]-`  
`>Fill(inc_E_lab,importance_weight*location_weight);`
- `produced_xfpt[map_index][kinematic_plot_index]-`  
`>Fill(xF,pT,importance_weight*location_weight);`
- `produced_pth[map_index][kinematic_plot_index]-`  
`>Fill(prod_P,prod_theta,importance_weight*location_weight);`