

# Probing PDFs via Neutrino Scattering with FASER $\nu$

**Jason Arakawa**

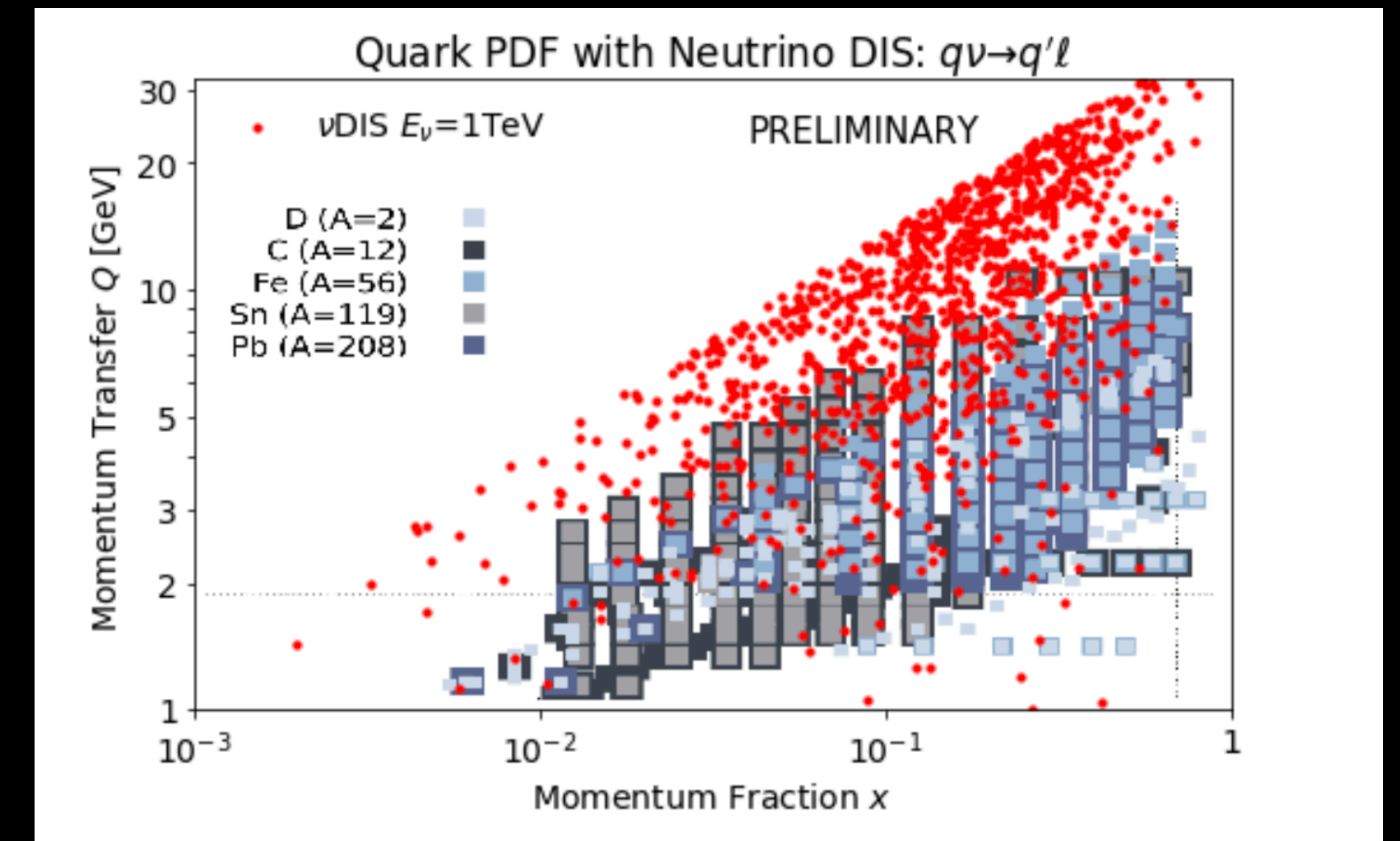
**2nd Forward Physics Facility Meeting**

**With Felix Kling, Tyler Smith, Tim Tait, and Michael Waterbury**

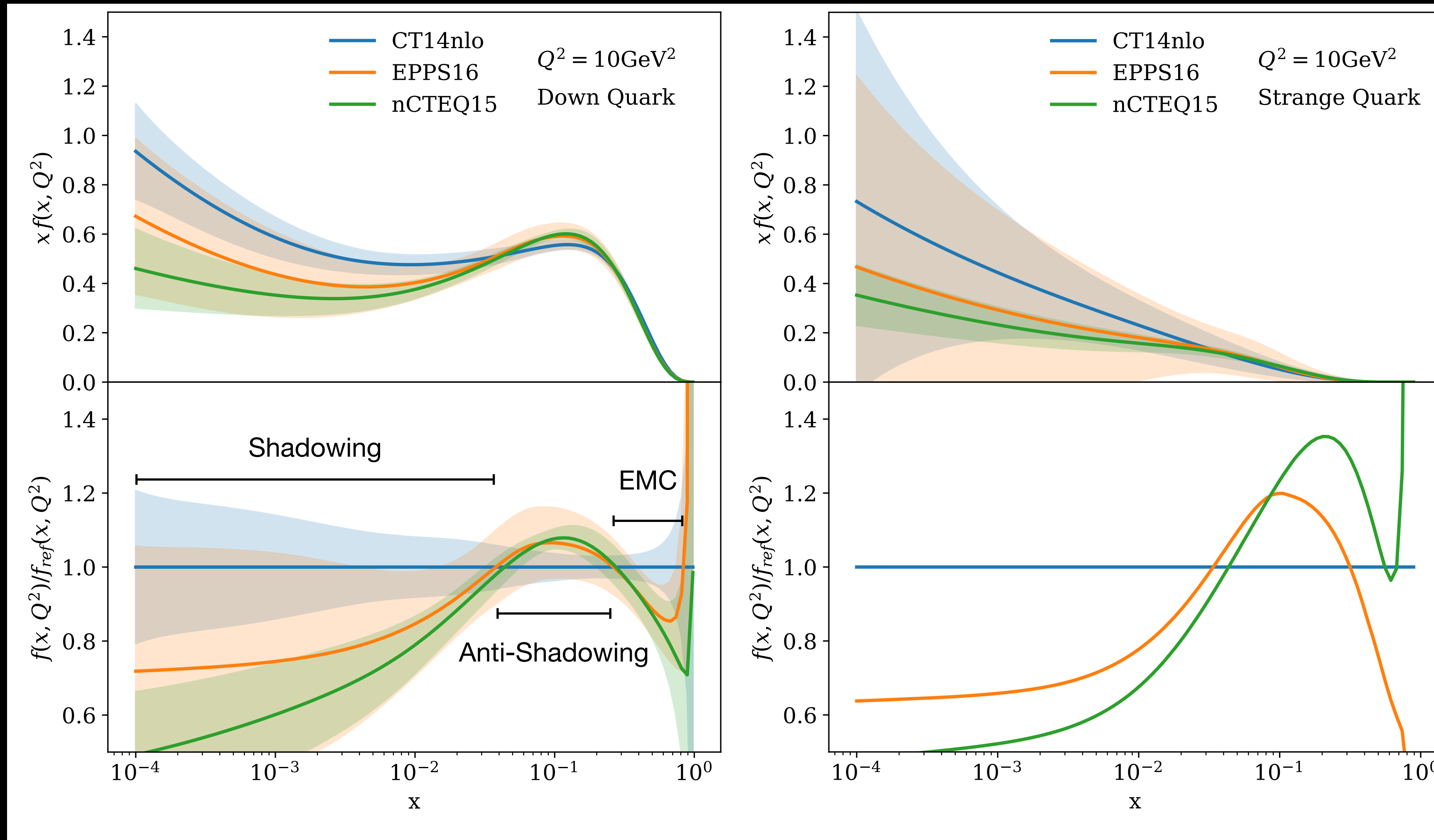


# Motivation

- Neutrino DIS has previously been used to constrain PDFs
- But, the LHC provides access to higher energy neutrinos  $\longrightarrow$  broader range of parameter space for PDFs!
- Could constrain nuclear PDFs (Tungsten in FASER  $\nu$ , but other targets could be possible in the future)
- Could also constrain the strange/anti-strange PDF, which are poorly constrained



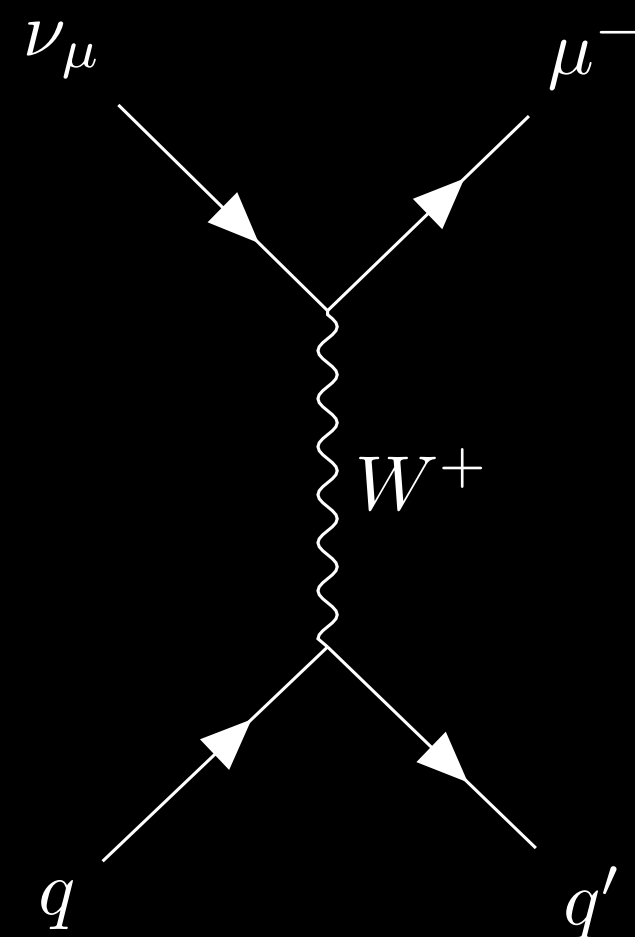
# Aim to reduce uncertainties, especially at low x!



# General Setup: Neutrino DIS

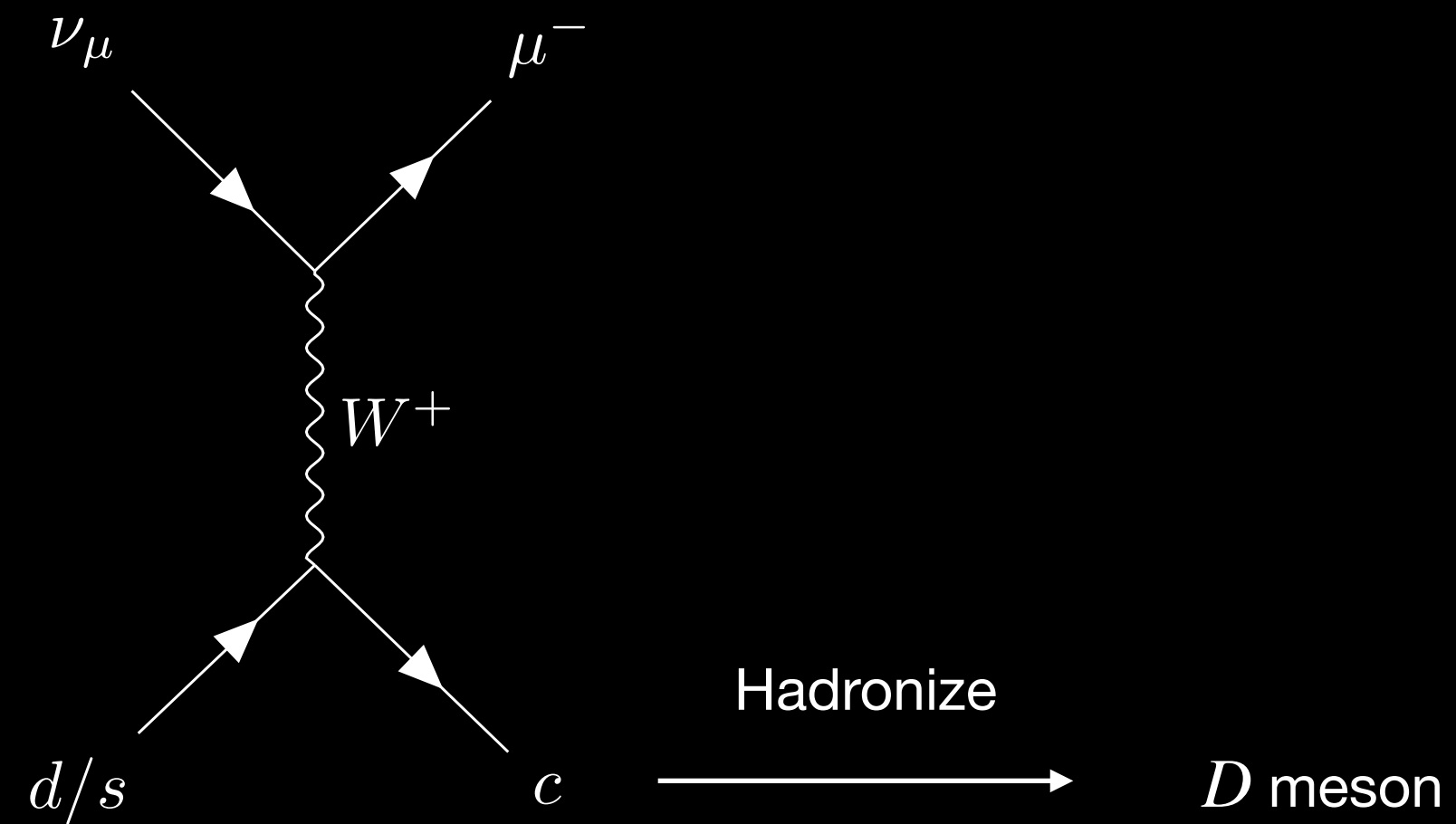
Inclusive

$$\nu_{\mu} q \rightarrow \mu^{-} q'$$



Charm Exclusive

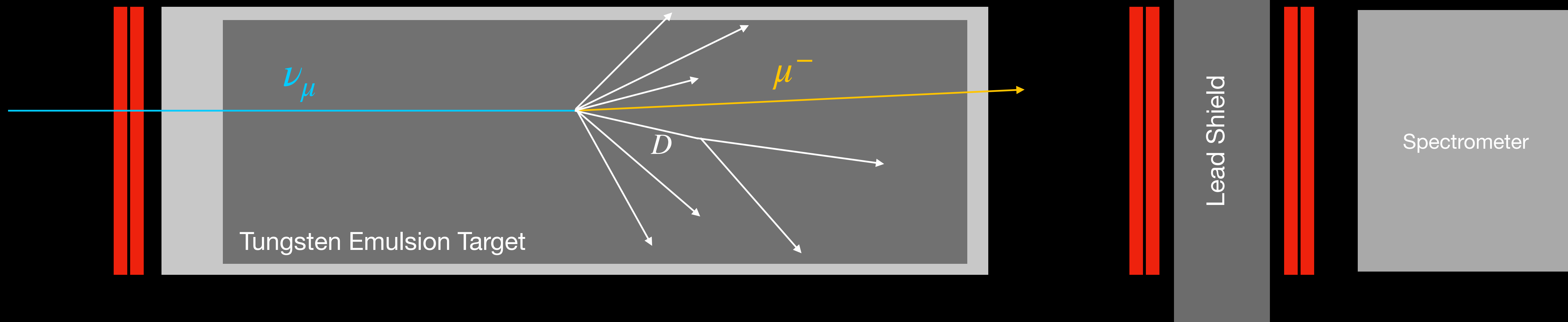
$$\nu_{\mu} s \rightarrow \mu^{-} c, \quad \nu_{\mu} d \rightarrow \mu^{-} c$$



Can be identified using displaced decay signature, leading to a kink signature

# FASER $\nu$ Target: Tungsten

Want to probe neutrino DIS  $\longrightarrow$  Can construct  $x, y, Q^2$  from  $E_{\mu^-}$ ,  $p_{\mu^-}^T$ , and  $E_\nu$



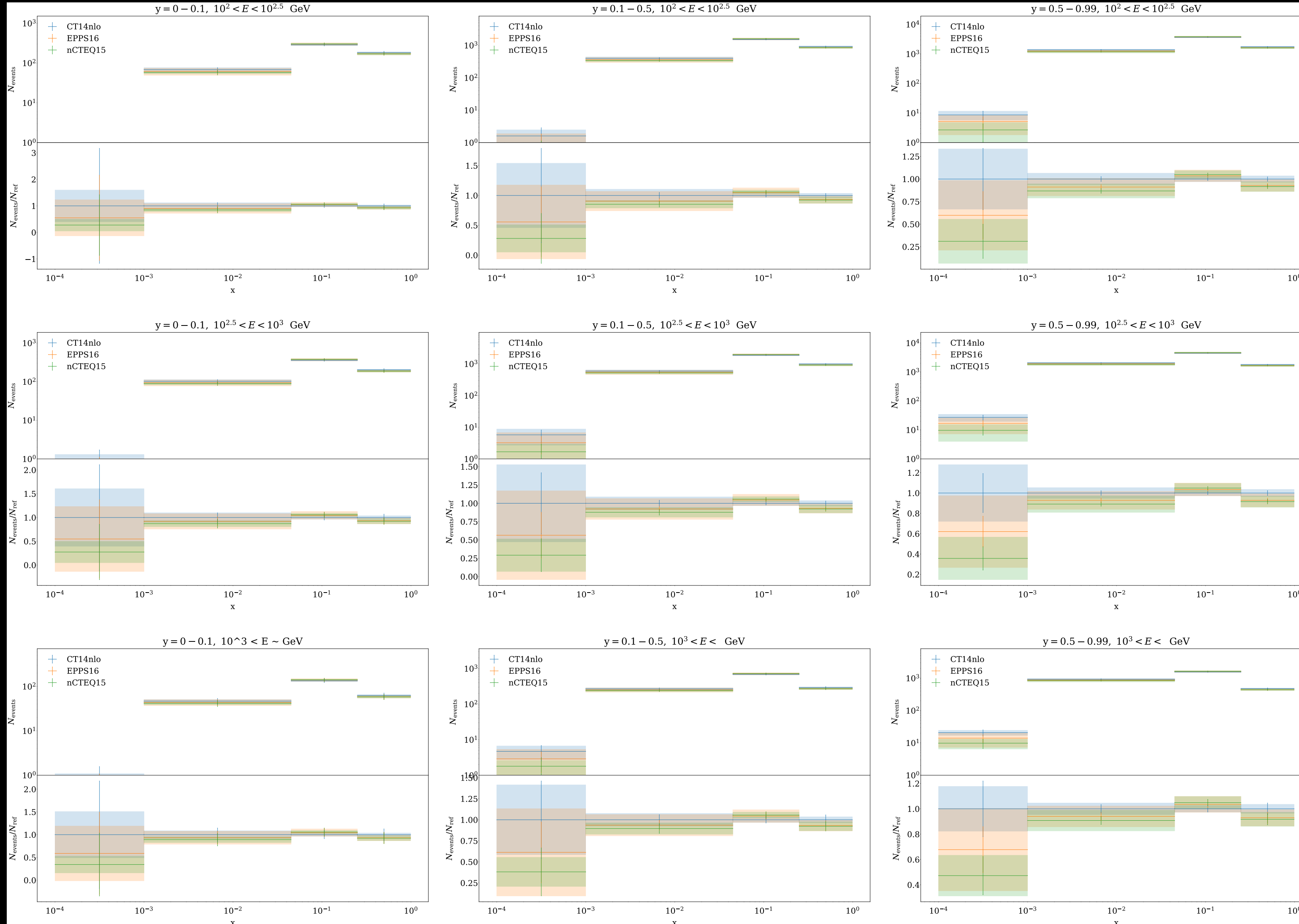
# Event Generation and PDFs

- Generate expected number of events in different bins of  $x$ ,  $y$ , and  $E$ , using the LO cross sections and Pythia, to guide our expectations.
- Plan to replace this with a N(N)LO calculation later.
- Input our pseudo data into ePump to make a forecast of how FASER $\nu$  could update the PDFs, especially at lower  $x$ .

# Neutrino Scattering:

## Inclusive event rate in bins of $x$ , $y$ , and $E$

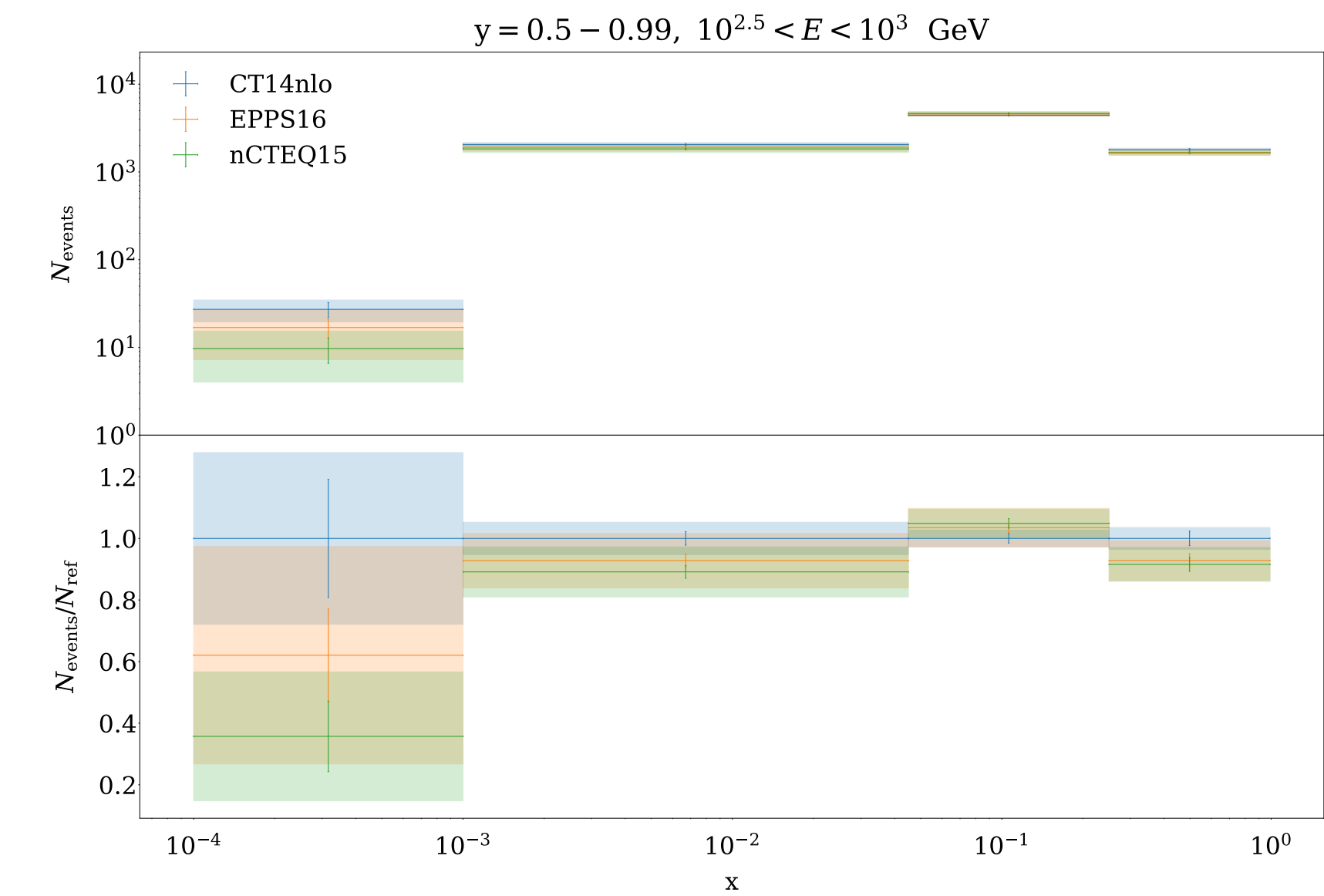
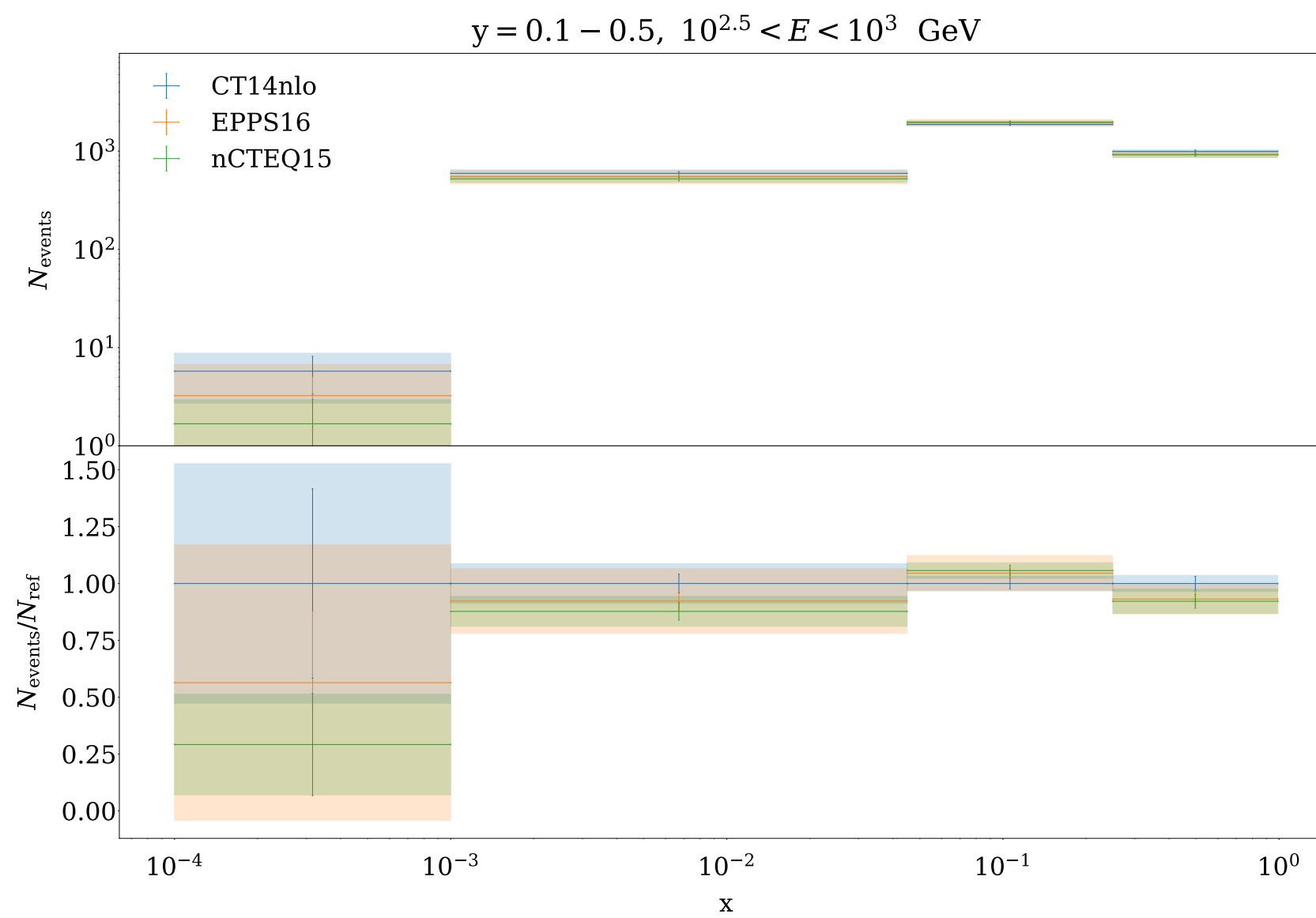
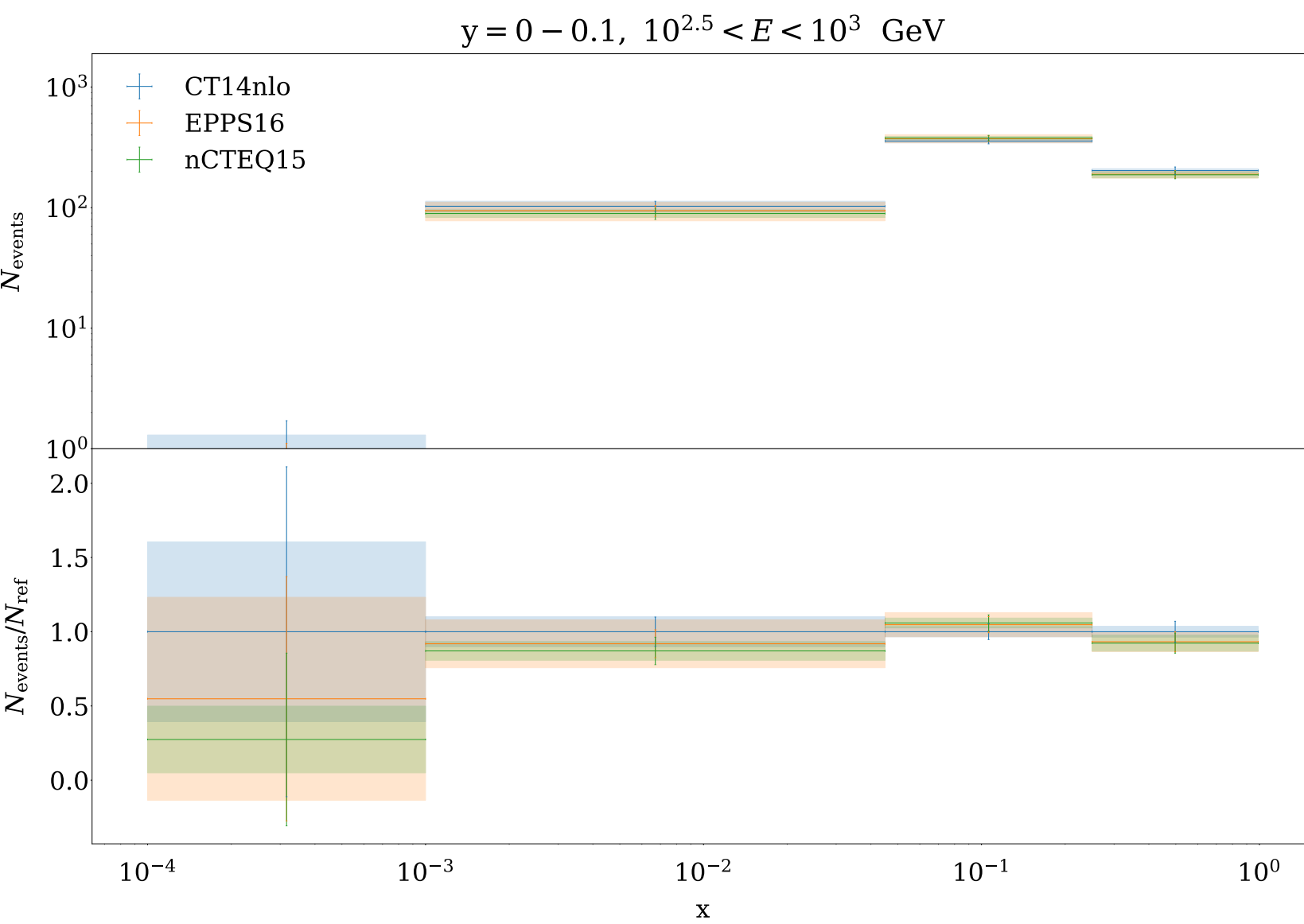
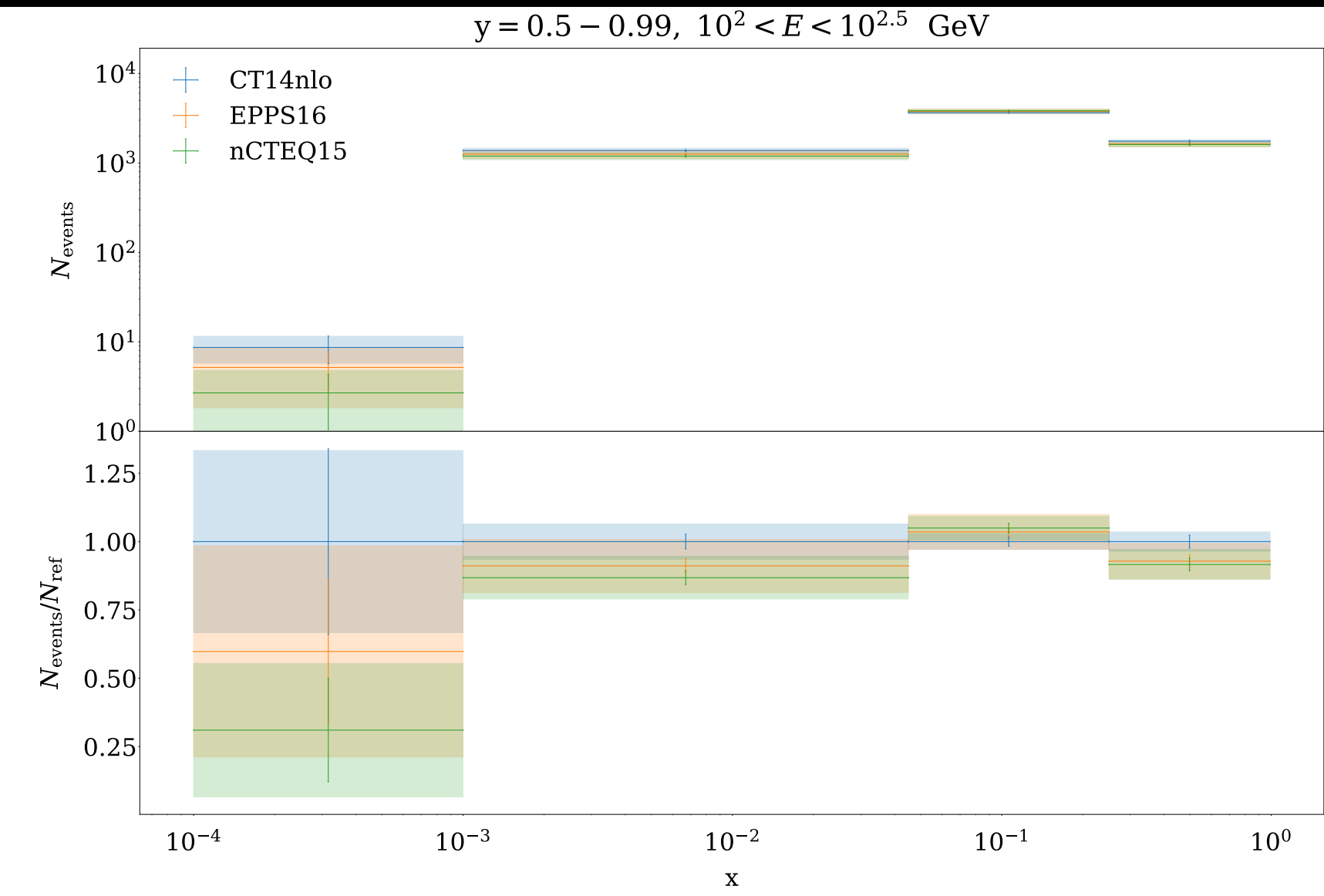
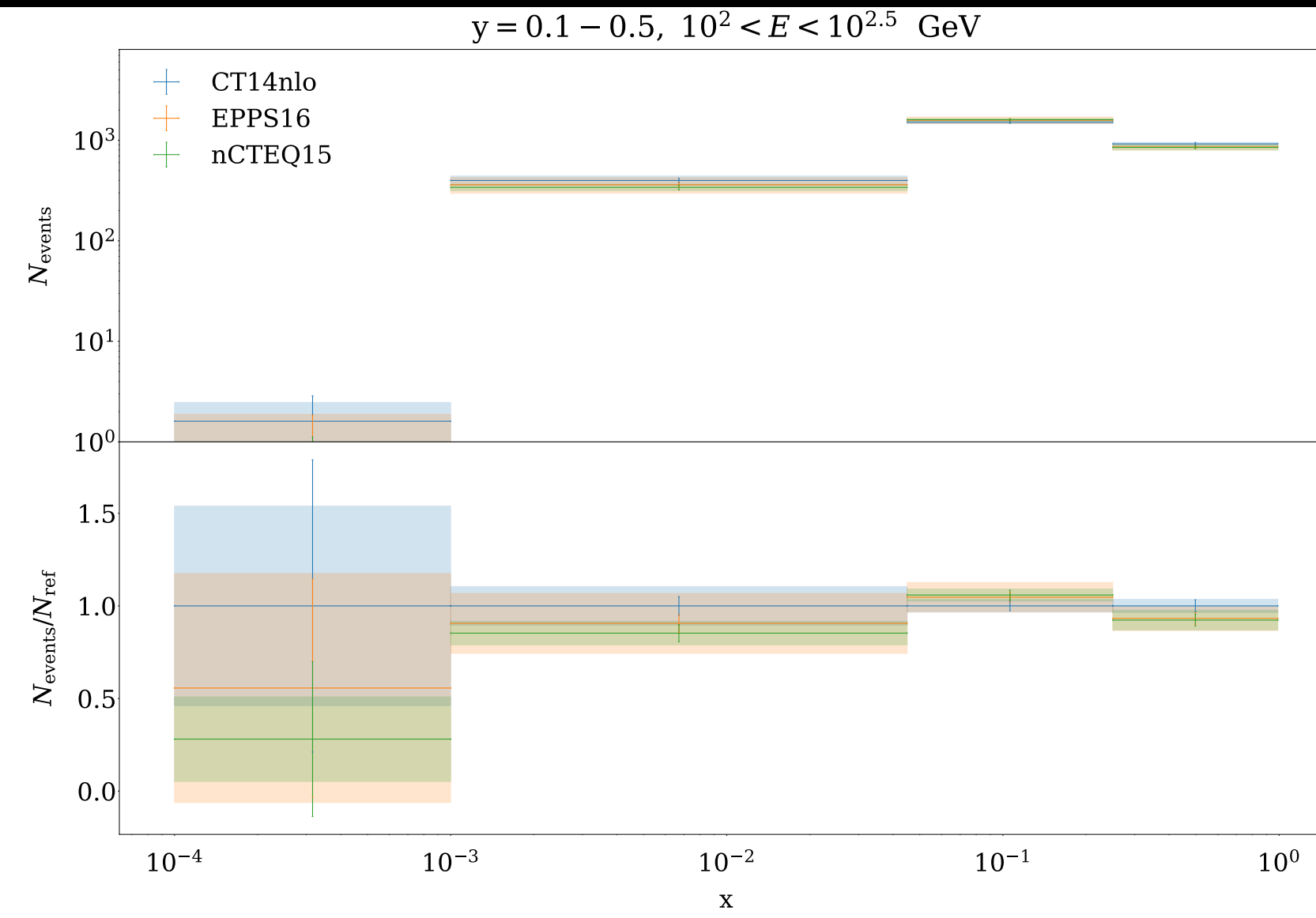
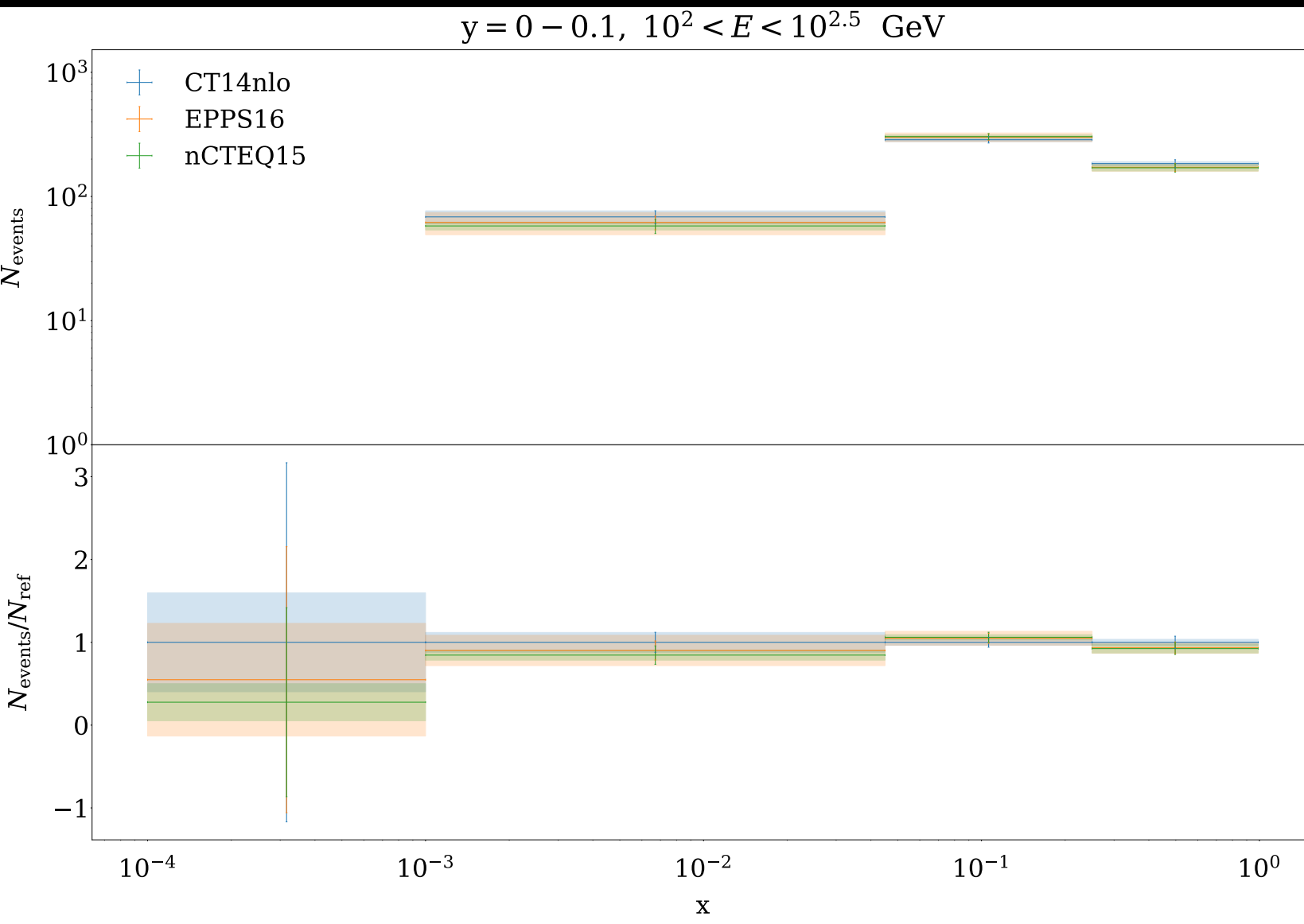
Error Bars: Statistical Uncertainty  
Shaded Regions: PDF Uncertainty



# Neutrino Scattering:

Inclusive event rate in bins of  $x$ ,  $y$ , and  $E$

Error Bars: Statistical Uncertainty  
Shaded Regions: PDF Uncertainty

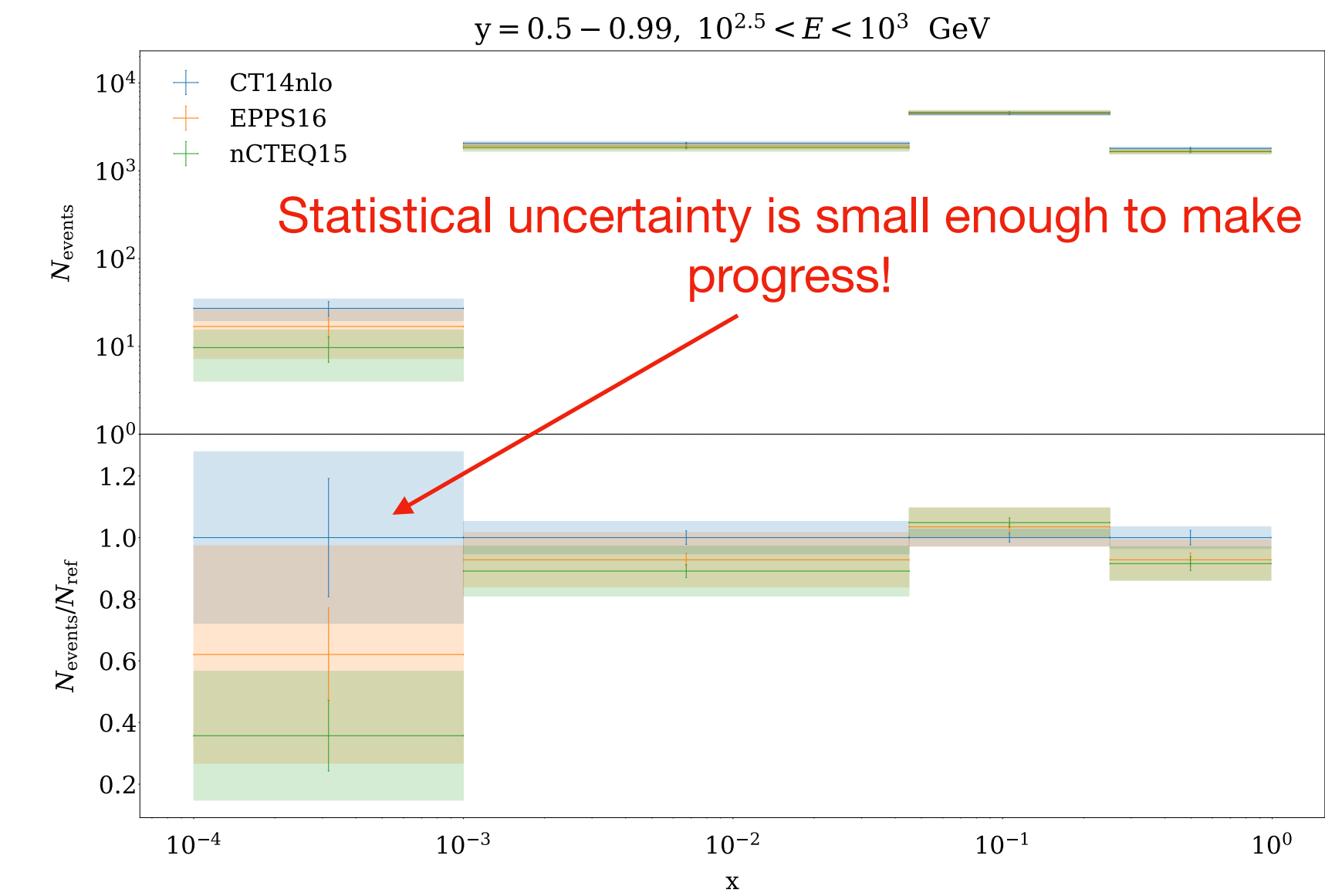
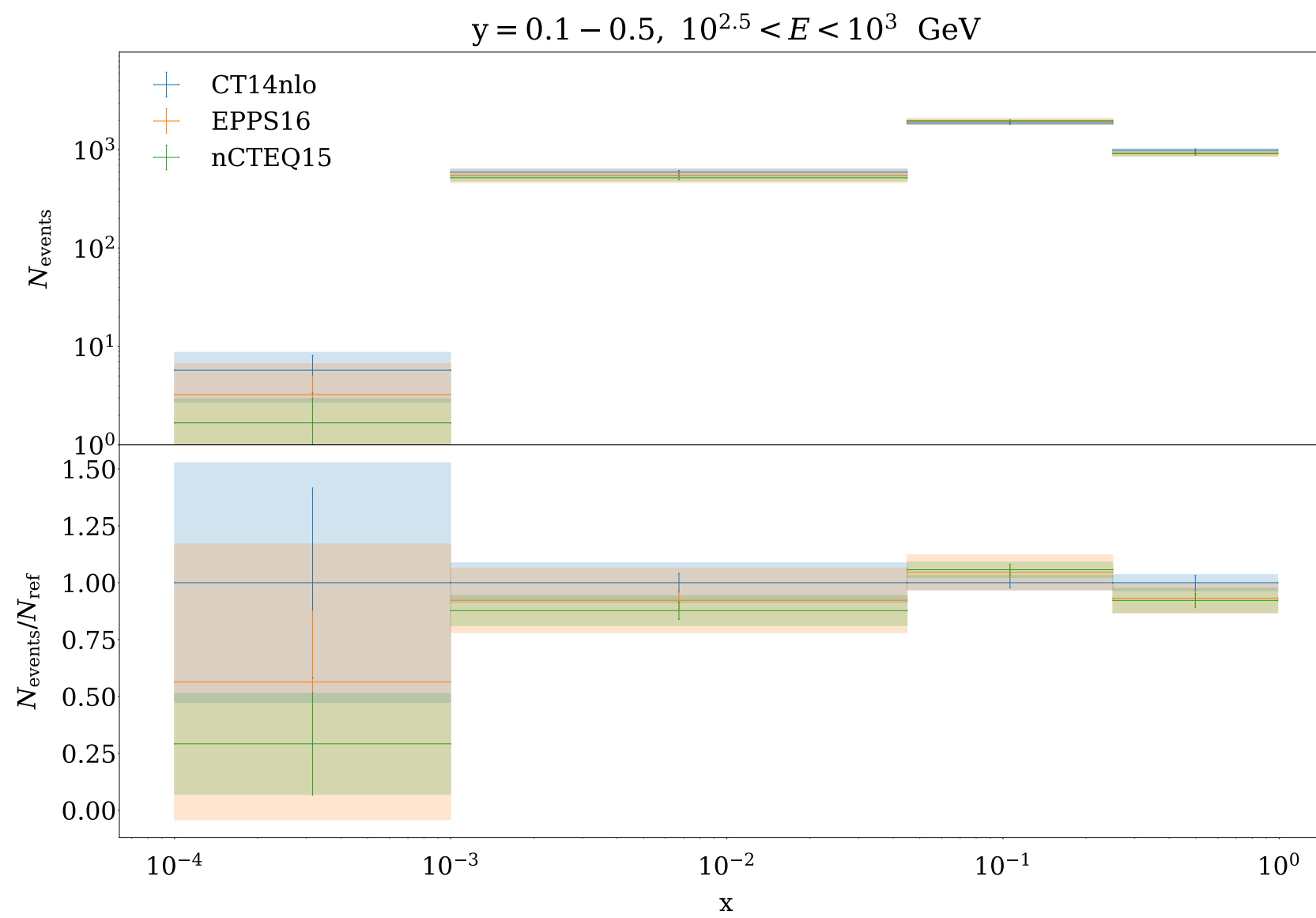
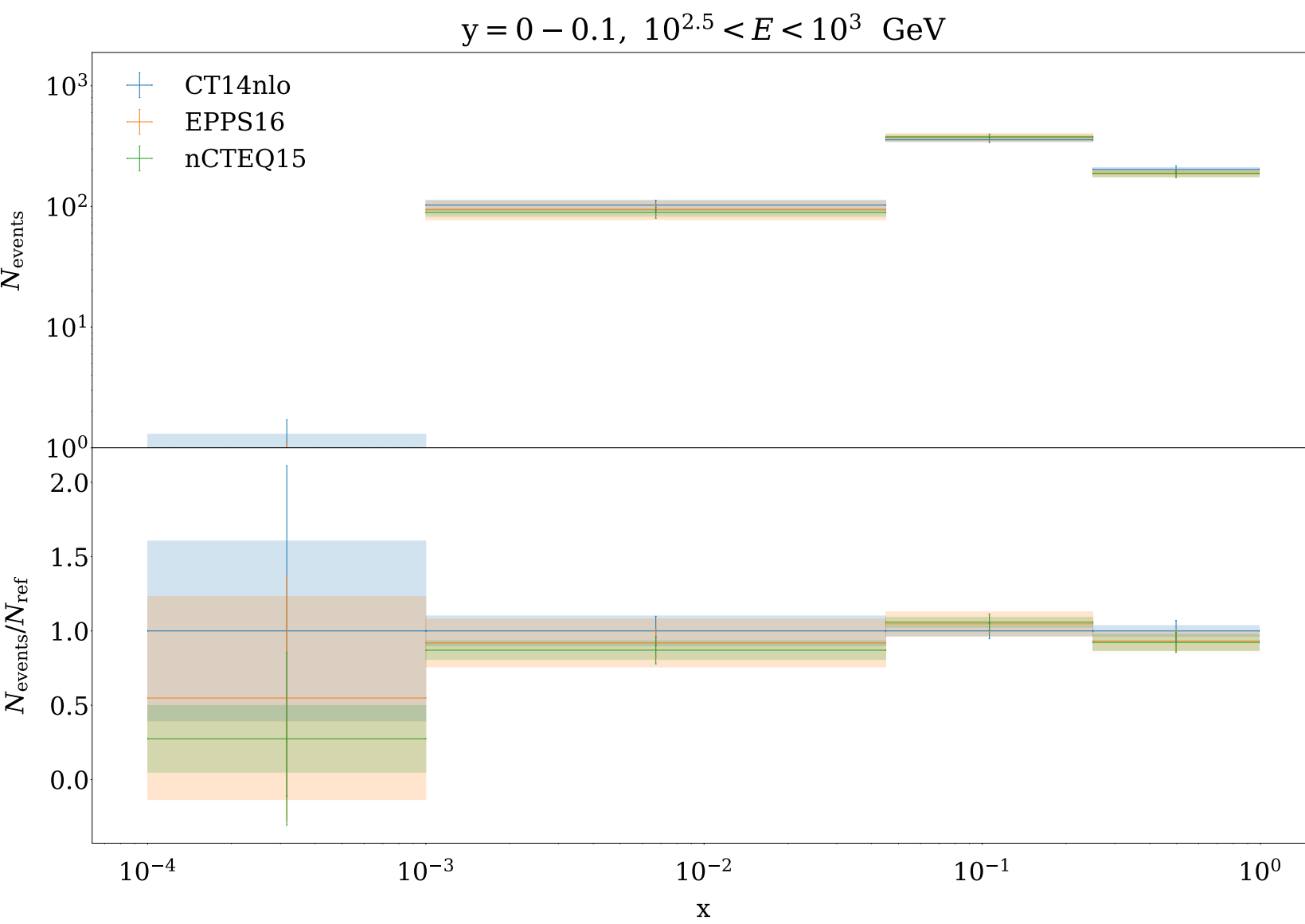
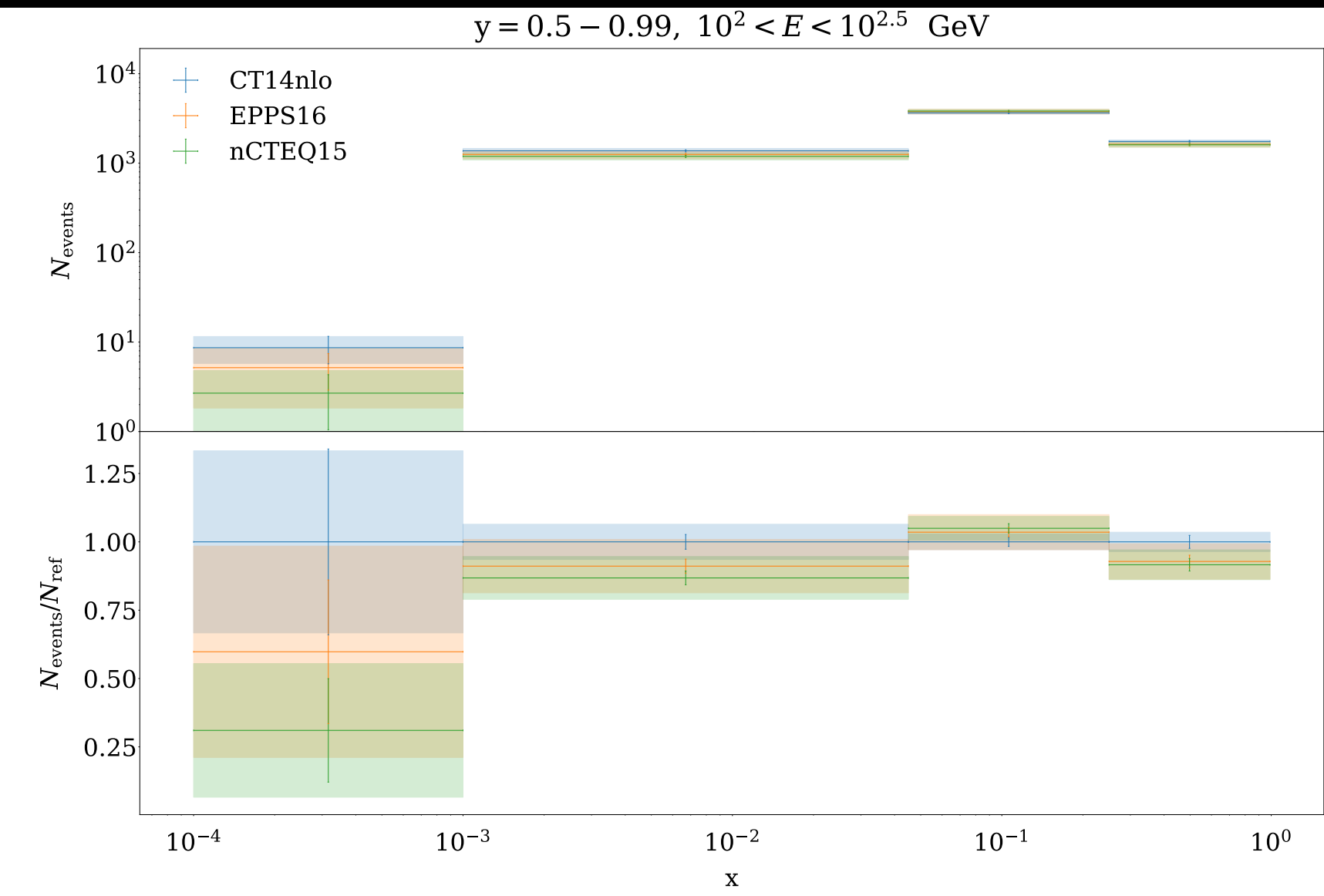
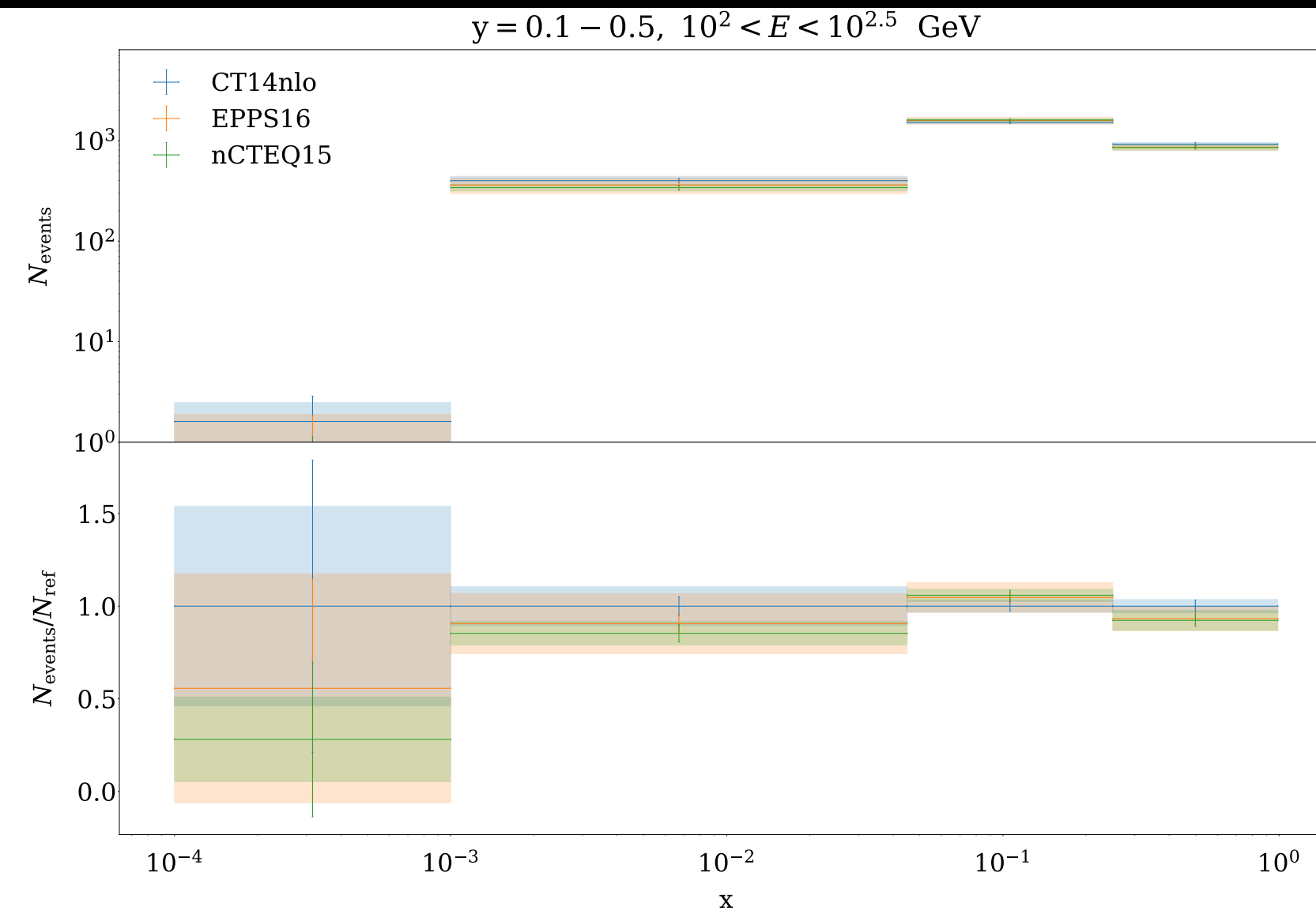
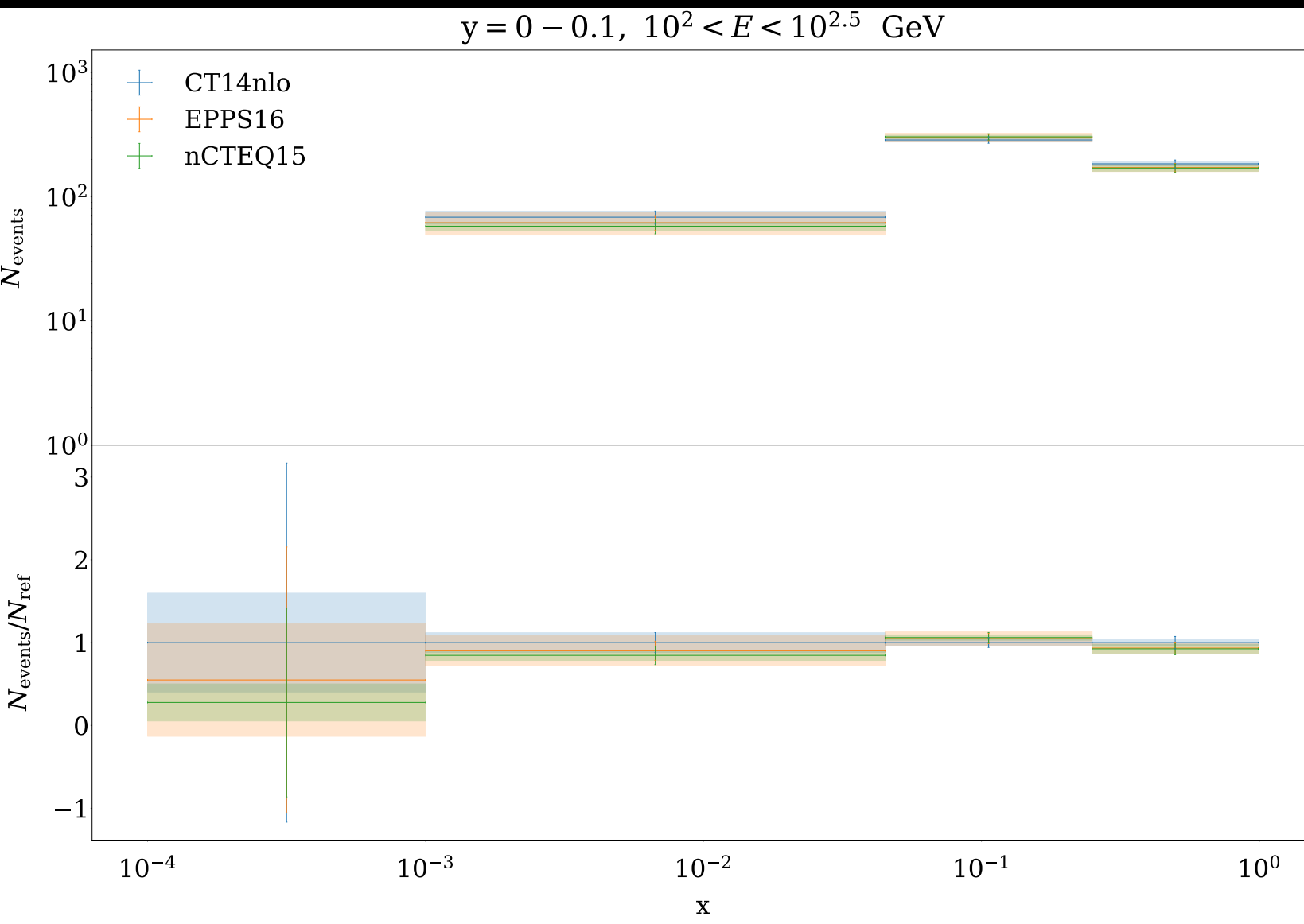




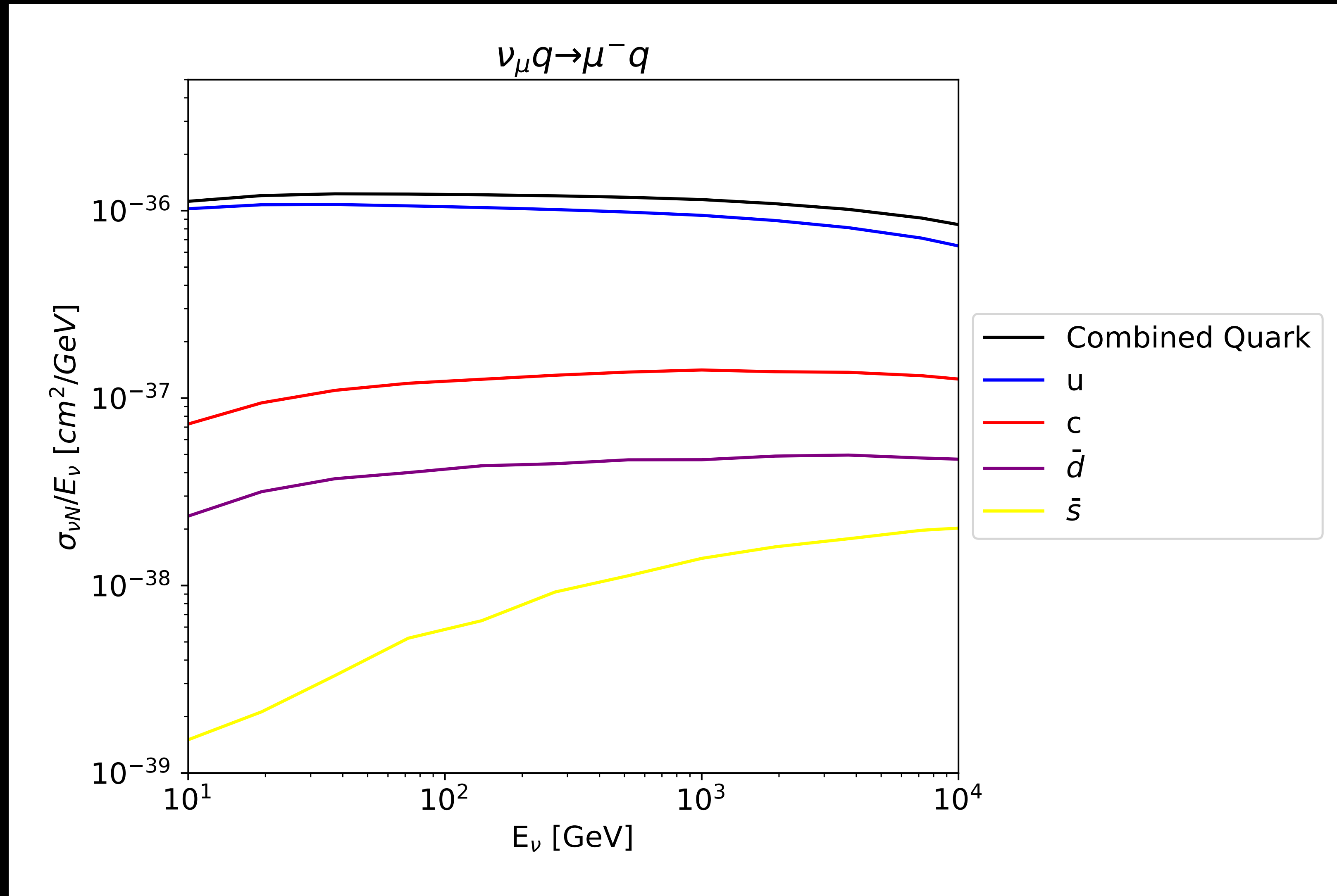
# Neutrino Scattering:

Inclusive event rate in bins of  $x$ ,  $y$ , and  $E$

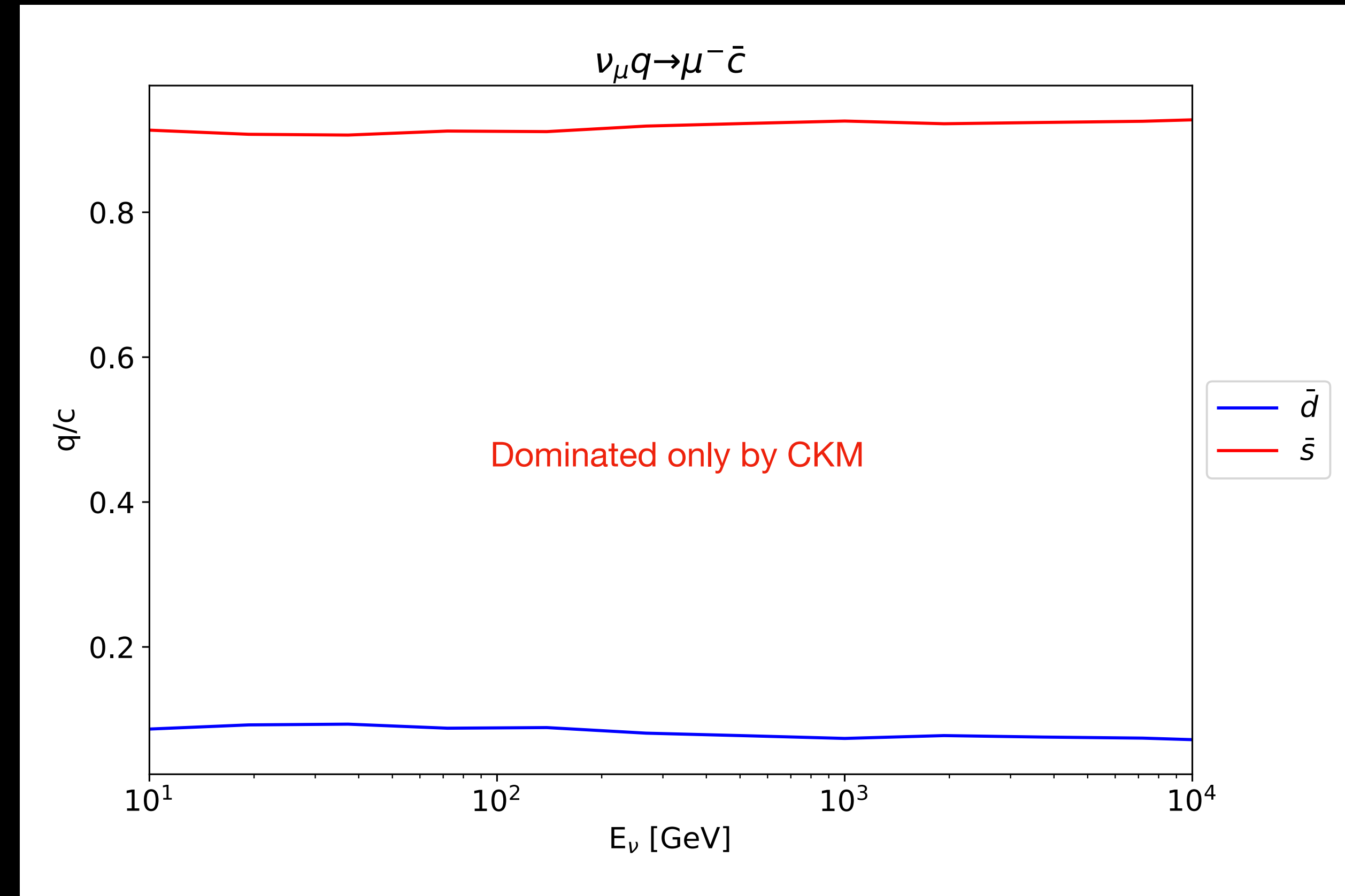
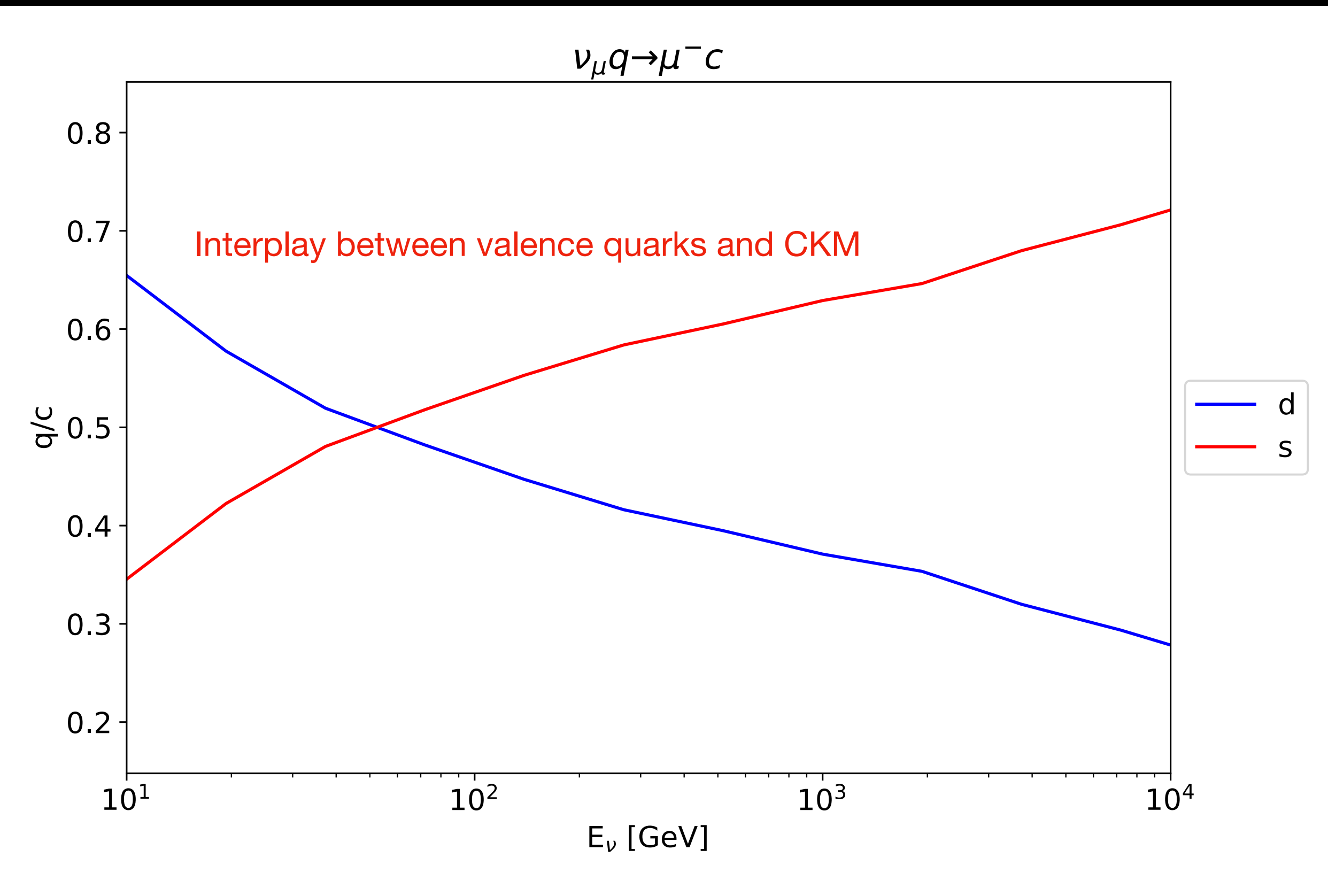
Error Bars: Statistical Uncertainty  
Shaded Regions: PDF Uncertainty



# Generating events with Pythia



# Constraining the down vs strange PDF

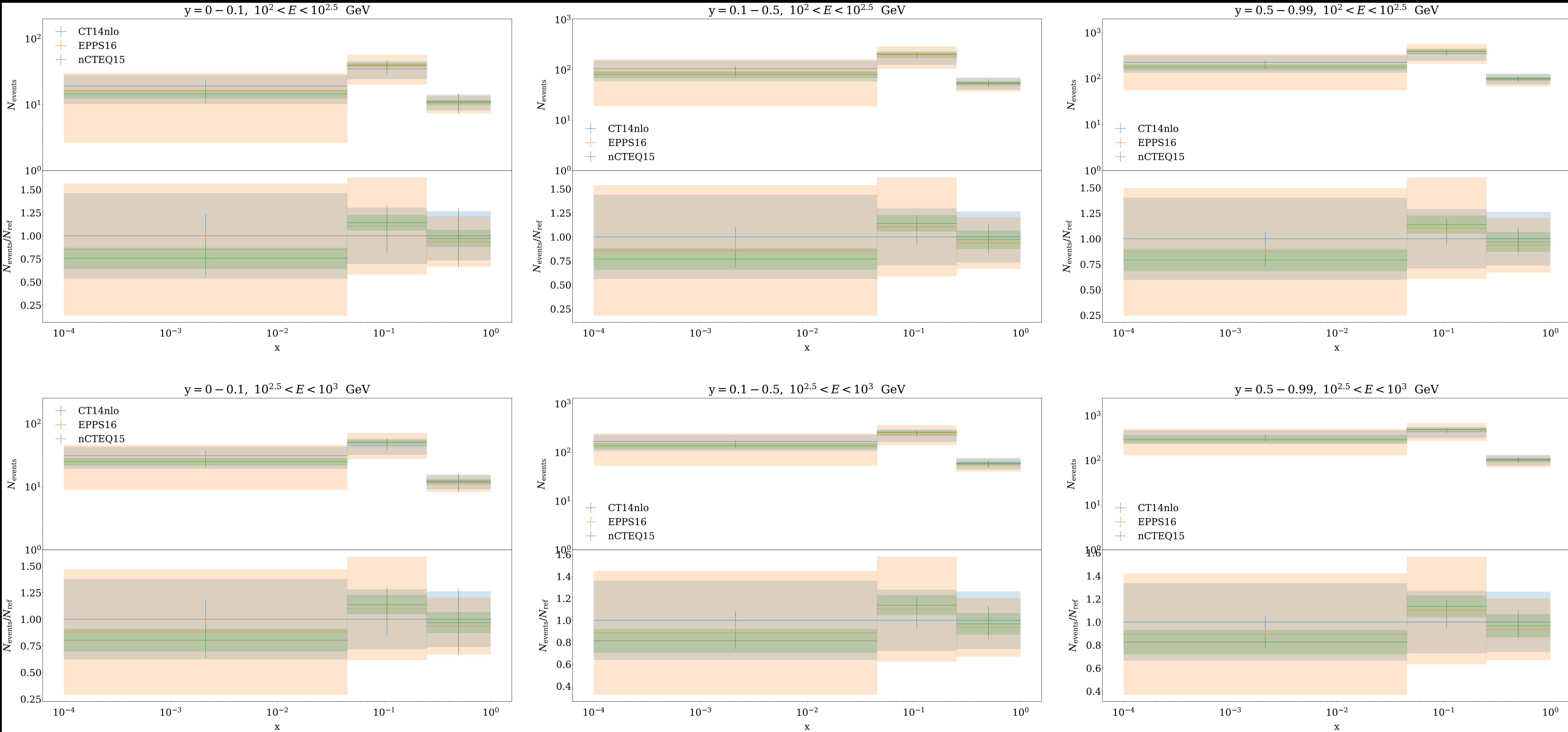


At  $E_\nu \sim \text{TeV}$ , we're primarily probing the strange PDF

Neutrino Scattering:

Charm exclusive event rate  
in bins of  $x$ ,  $y$ , and  $E$

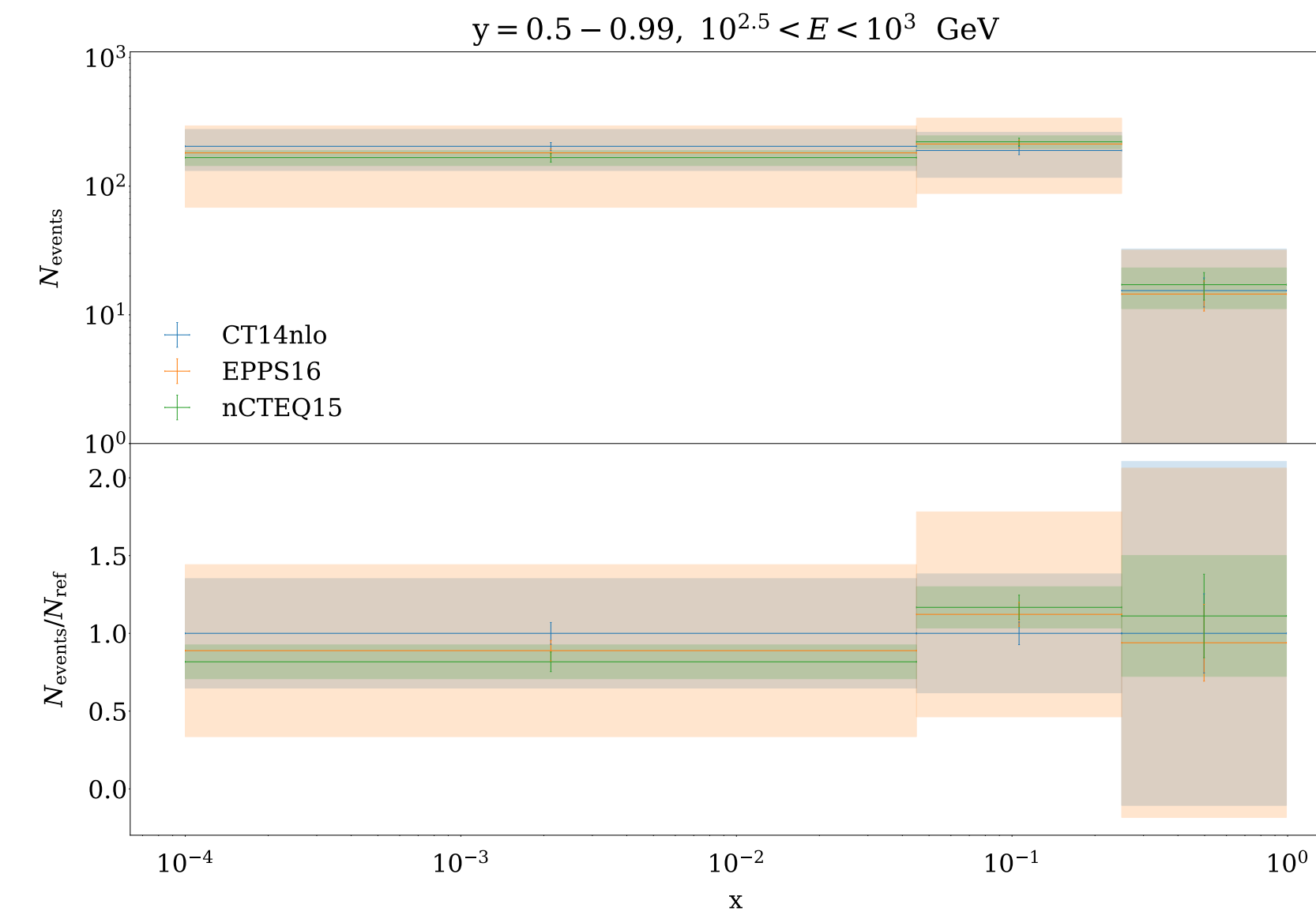
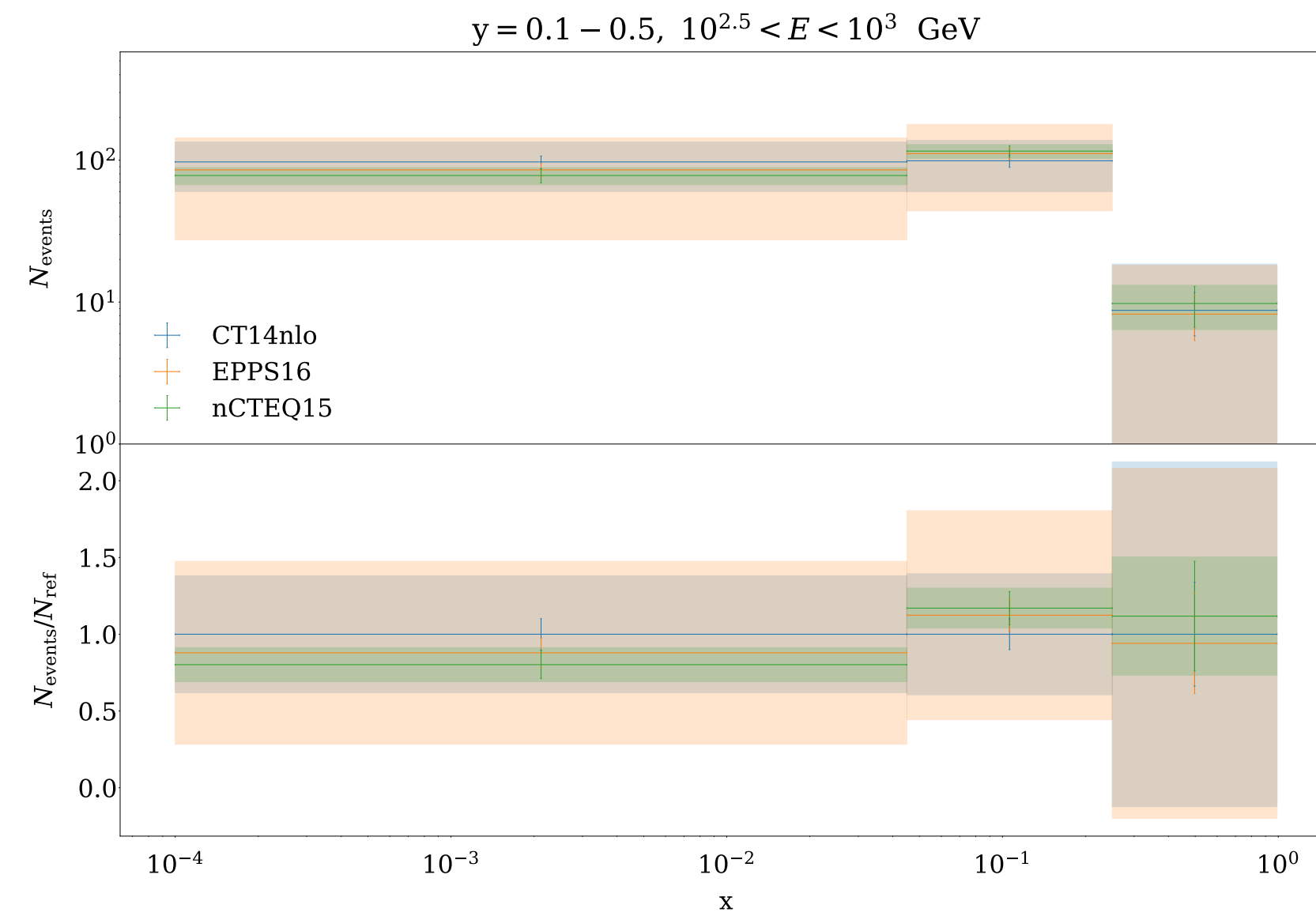
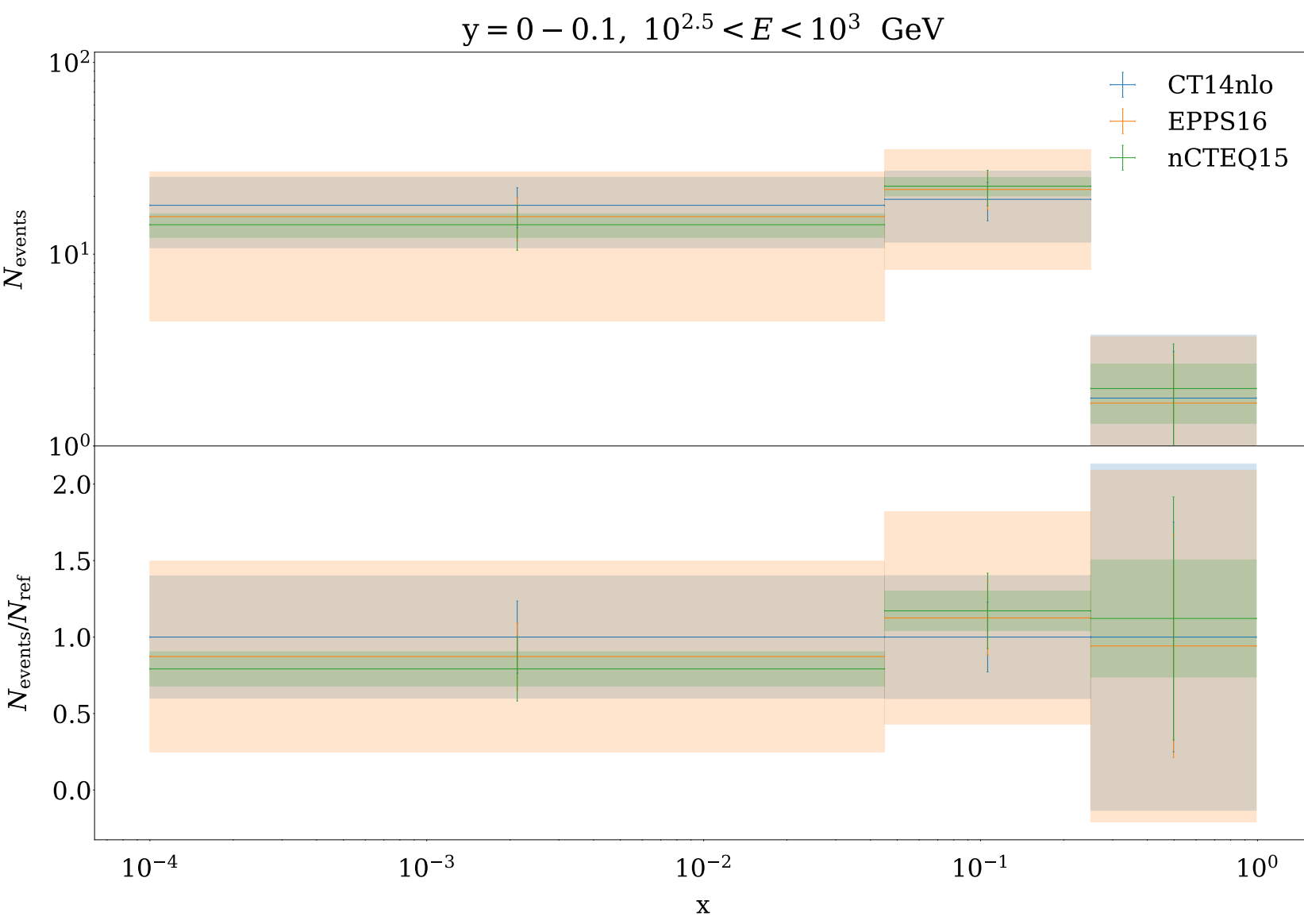
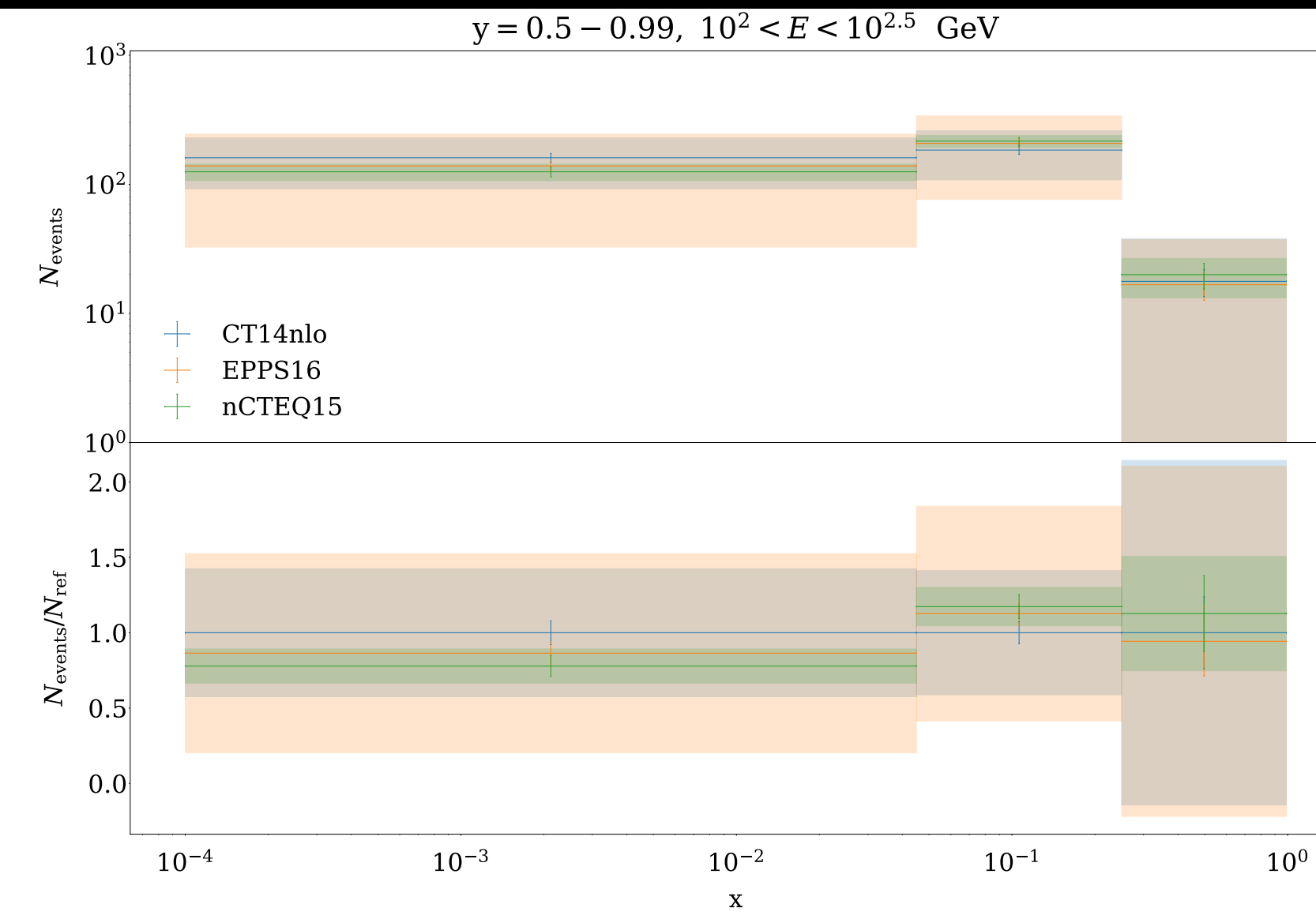
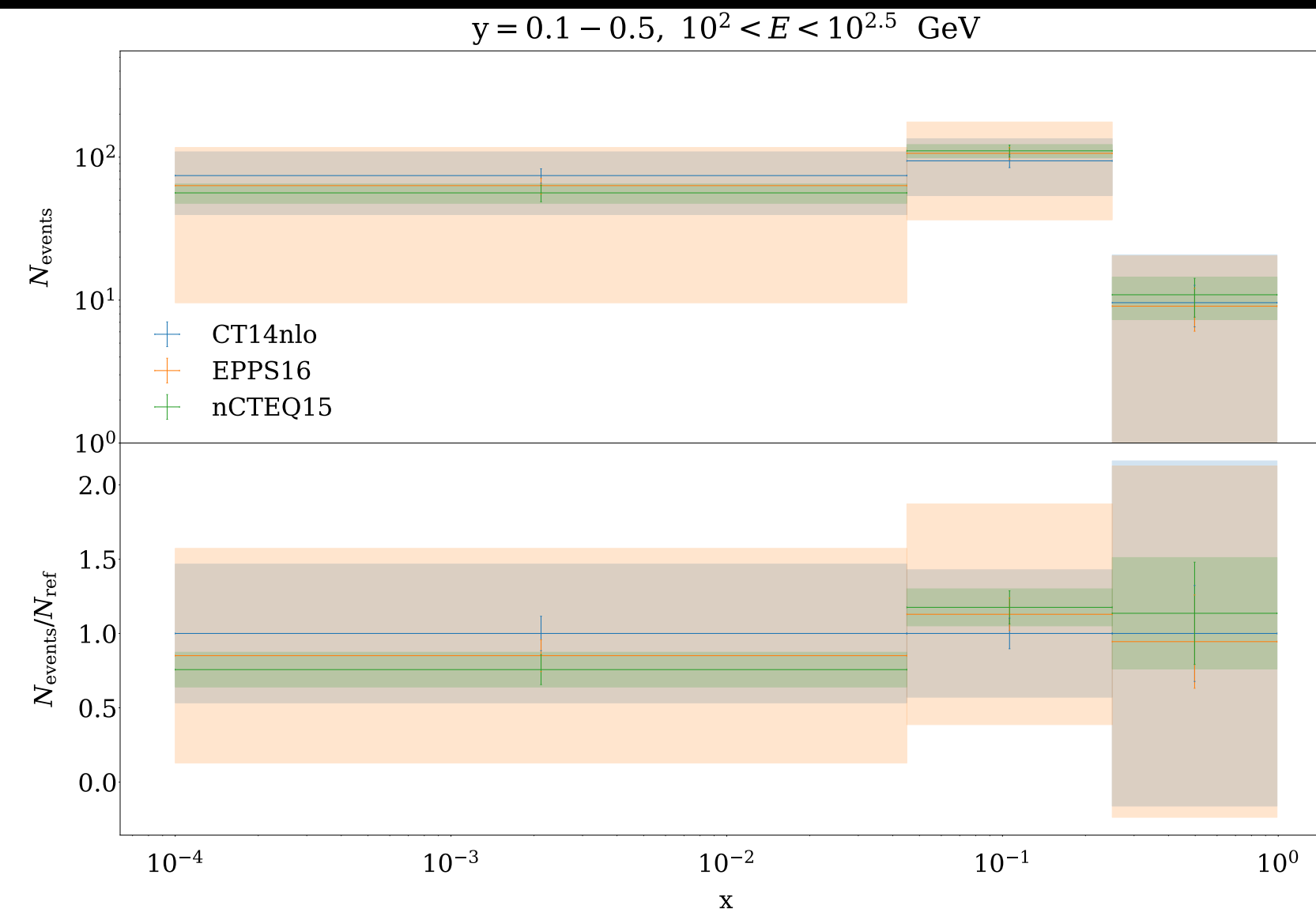
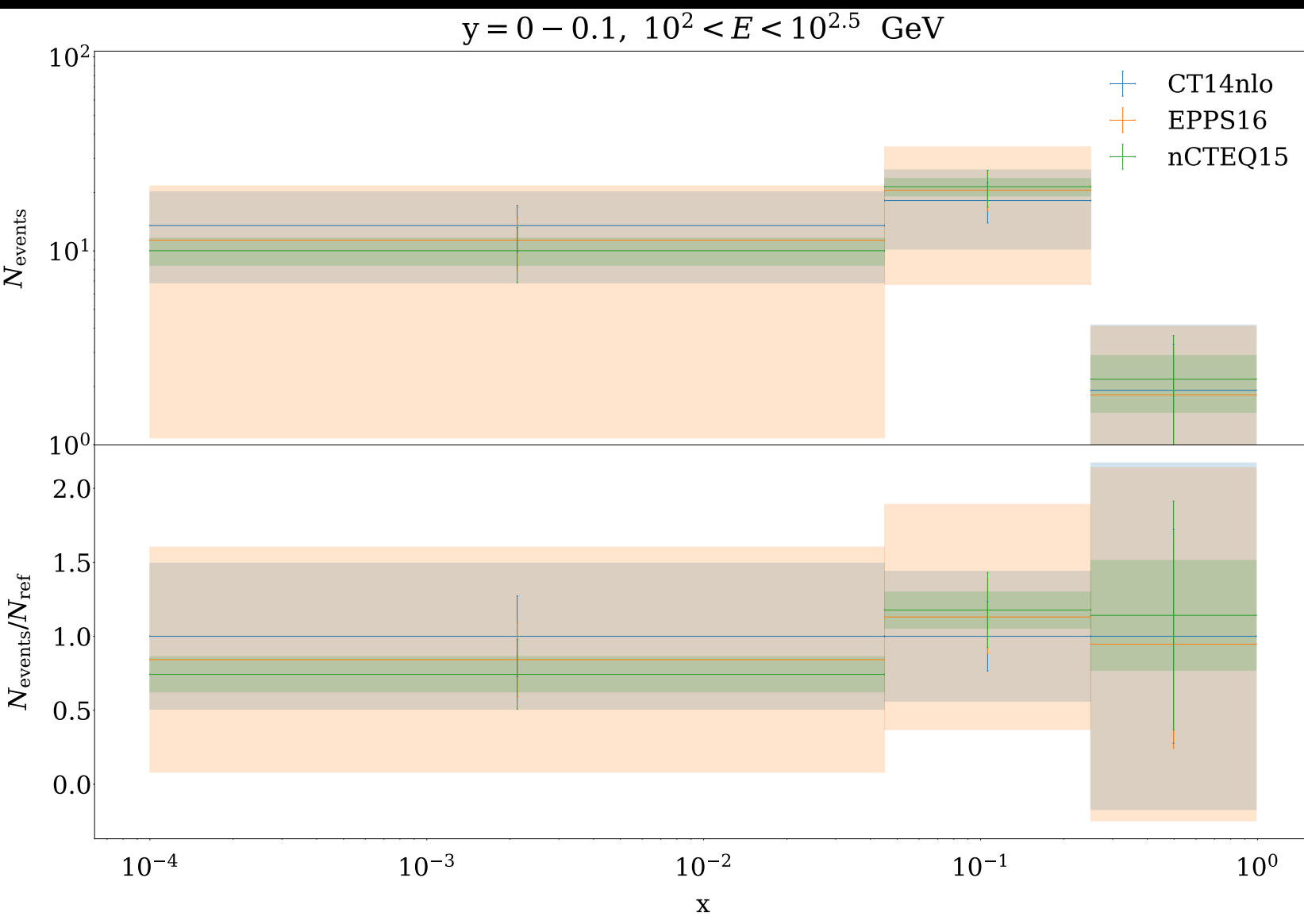
Error Bars: Statistical Uncertainty  
Shaded Regions: PDF Uncertainty



# Anti-Neutrino Scattering:

## Charm exclusive event rate in bins of $x$ , $y$ , and $E$

Error Bars: Statistical Uncertainty  
Shaded Regions: PDF Uncertainty



**Thank you!**