

# Hadronic Gamma Rays

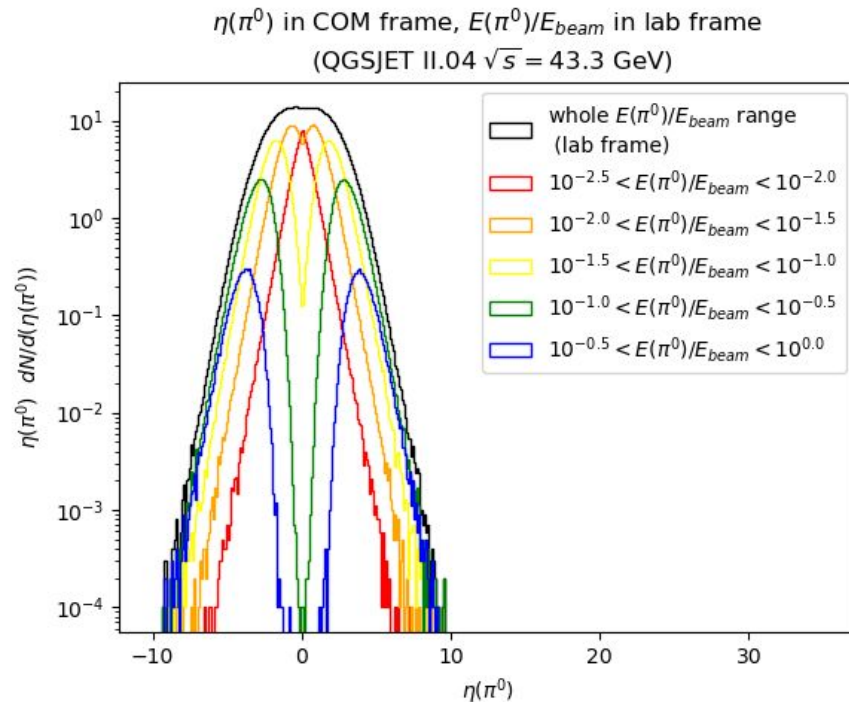
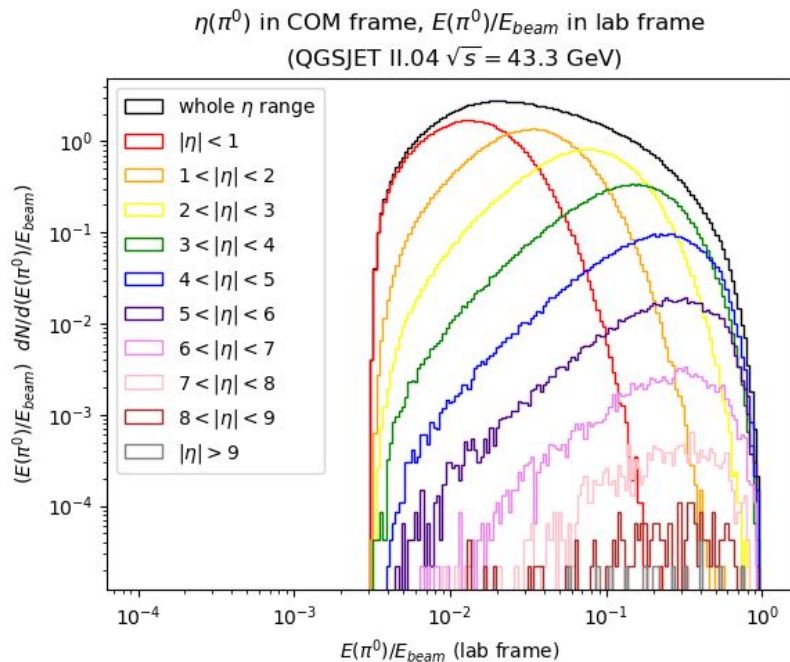
Previously...

- Apply Lorentz boost depending on  $\pi^0$  eta sign in COM
- Could Tevatron data be interesting ([CDF forward detectors](#))?
- Do we have forward 900 GeV data? → only AFP
- Need  $\pi^0$  energy fraction and pT for gamma-like classification

# Link between frames: Lorentz Boost depending on side (QGSJET II-04)

$\eta(\pi^0) < 0$  in COM frame  $\rightarrow$  Lorentz boost to -z

$\eta(\pi^0) > 0$  in COM frame  $\rightarrow$  Lorentz boost to +z

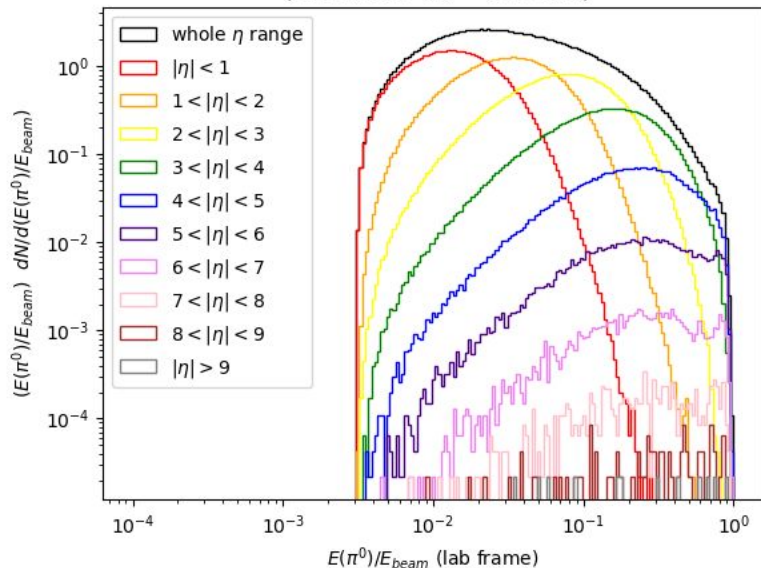


# Link between frames: Lorentz Boost depending on side (PYTHIA 8.3)

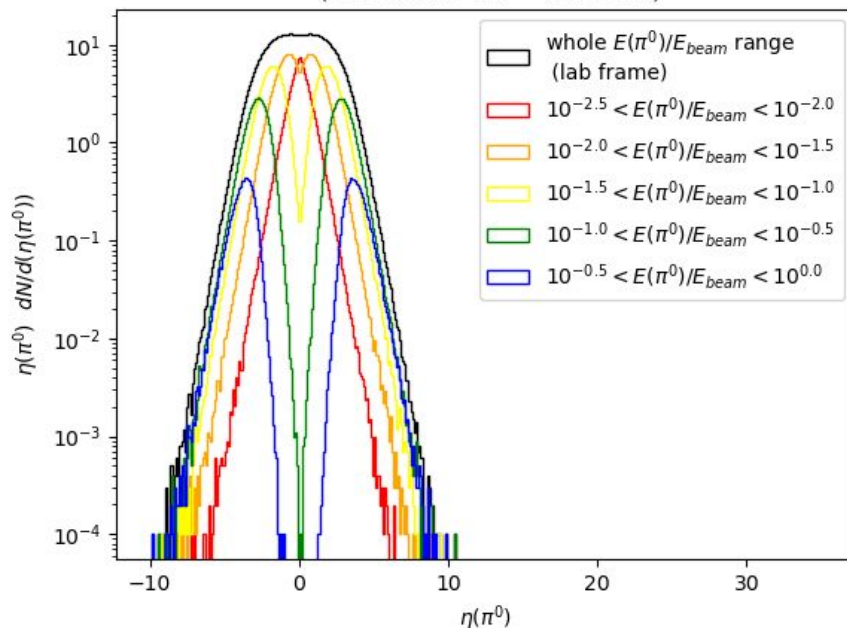
$\eta(\pi^0) < 0$  in COM frame  $\rightarrow$  Lorentz boost to  $-z$

$\eta(\pi^0) > 0$  in COM frame  $\rightarrow$  Lorentz boost to  $+z$

$\eta(\pi^0)$  in COM frame,  $E(\pi^0)/E_{beam}$  in lab frame  
(PYTHIA 8.3  $\sqrt{s} = 43.3$  GeV)



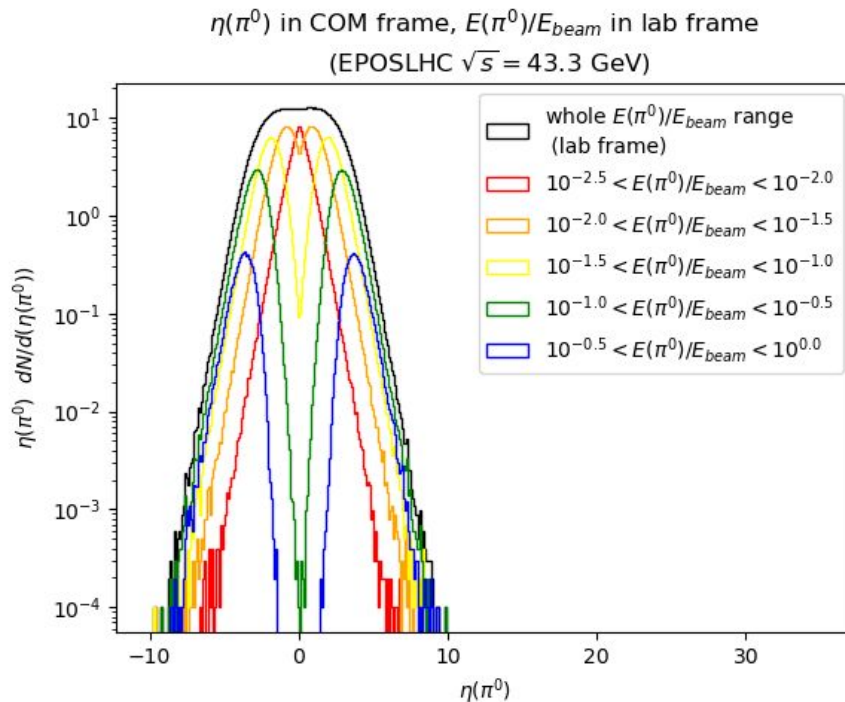
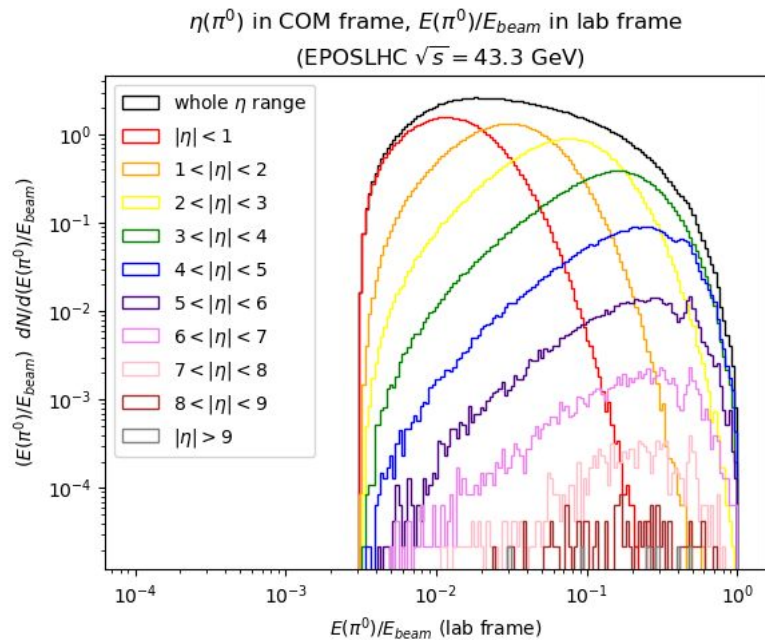
$\eta(\pi^0)$  in COM frame,  $E(\pi^0)/E_{beam}$  in lab frame  
(PYTHIA 8.3  $\sqrt{s} = 43.3$  GeV)



# Link between frames: Lorentz Boost depending on side (EPOS LHC)

$\eta(\pi^0) < 0$  in COM frame  $\rightarrow$  Lorentz boost to  $-z$

$\eta(\pi^0) > 0$  in COM frame  $\rightarrow$  Lorentz boost to  $+z$

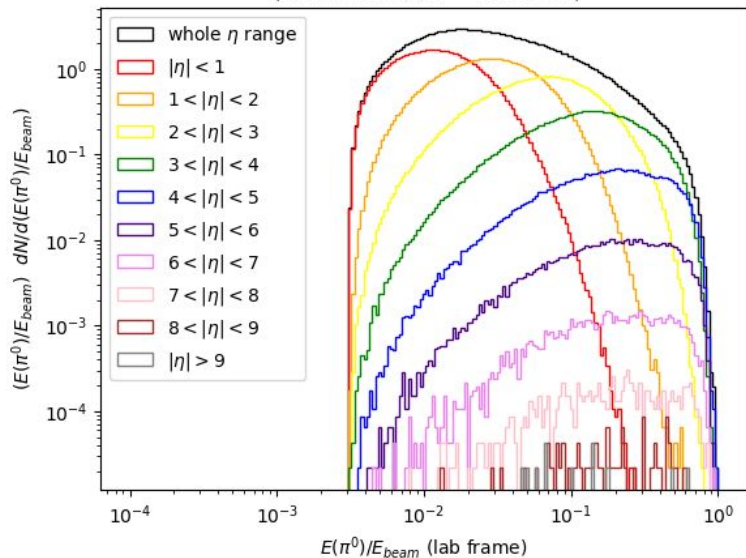


# Link between frames: Lorentz Boost depending on side (SIBYLL 2.3d)

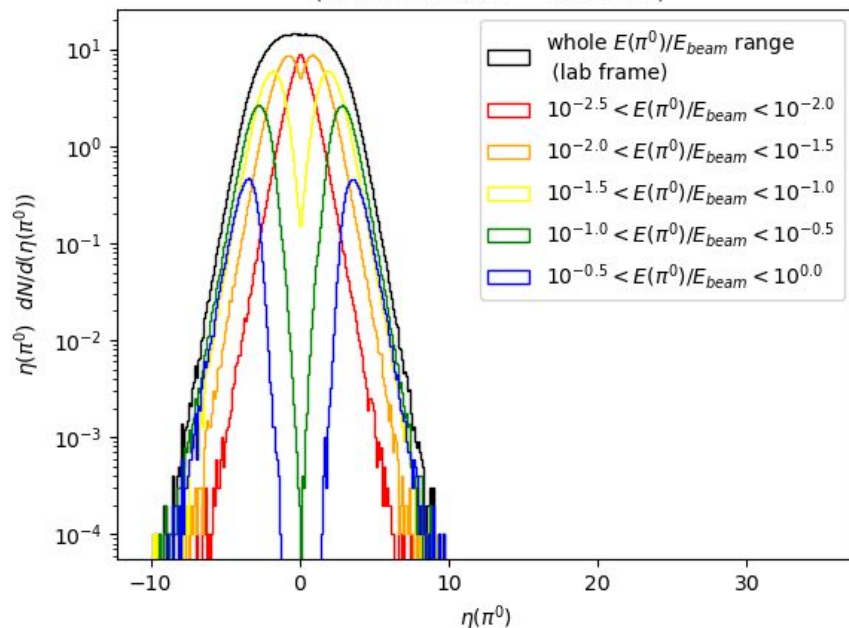
$\eta(\pi^0) < 0$  in COM frame  $\rightarrow$  Lorentz boost to -z

$\eta(\pi^0) > 0$  in COM frame  $\rightarrow$  Lorentz boost to +z

$\eta(\pi^0)$  in COM frame,  $E(\pi^0)/E_{beam}$  in lab frame  
(SIBYLL 2.3d  $\sqrt{s} = 43.3$  GeV)



$\eta(\pi^0)$  in COM frame,  $E(\pi^0)/E_{beam}$  in lab frame  
(SIBYLL 2.3d  $\sqrt{s} = 43.3$  GeV)



# Link Between 2 Energy Scales?

$$\rightarrow \eta_{\text{max}} = 0.5 * \ln( s / m(\pi^0)^2 ) \text{ (} p_{\text{T}} \rightarrow 0 \text{)}$$

$$\rightarrow \eta_{\text{min}} = 0.5 * \ln( 0.9^2 * s / (m(\pi^0)^2 + p_{\text{T}}^2) )$$

$$\text{E.g. } \sqrt{s} = 43.3 \text{ GeV} \rightarrow p_{\text{T}}(\pi^0) \lesssim 1.5 \text{ GeV}$$

(Pythia) for  $E_{\text{lab}}/E_{\text{beam}} > 0.9$

$$\rightarrow 3.15 < |\eta| < 5.77 \text{ (CDF MiniPlug but wrong energy?)}$$

$$\sqrt{s} = 13.6 \text{ TeV} \rightarrow p_{\text{T}}(\pi^0) \lesssim 1.5 \text{ GeV (Pythia) for}$$

$E_{\text{lab}}/E_{\text{beam}} > 0.9$

$$\rightarrow 8.9 < |\eta| < 11.52 \text{ (LHCf coverage!)}$$

$$\sqrt{s} = 900 \text{ GeV} \rightarrow p_{\text{T}}(\pi^0) \lesssim 1.5 \text{ GeV (Pythia) for}$$

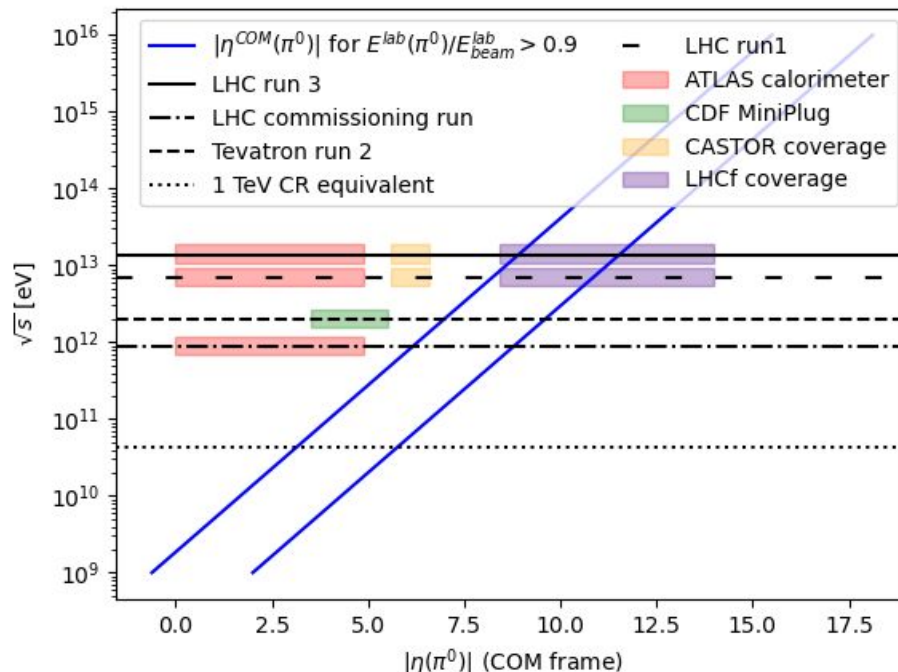
$E_{\text{lab}}/E_{\text{beam}} > 0.9$

$$\rightarrow 6.18 < |\eta| < 8.80 \text{ (maybe CMS CASTOR? - only very small rapidity overlap, } -6.6 < \eta < -5.2 \text{)}$$

$$\sqrt{s} = 1.96 \text{ TeV} \rightarrow p_{\text{T}}(\pi^0) \lesssim 1.5 \text{ GeV (Pythia) for}$$

$E_{\text{lab}}/E_{\text{beam}} > 0.9$

$$\rightarrow 6.96 < |\eta| < 9.58 \text{ (no overlap with any CDF forward detector coverage - see [here](#))}$$

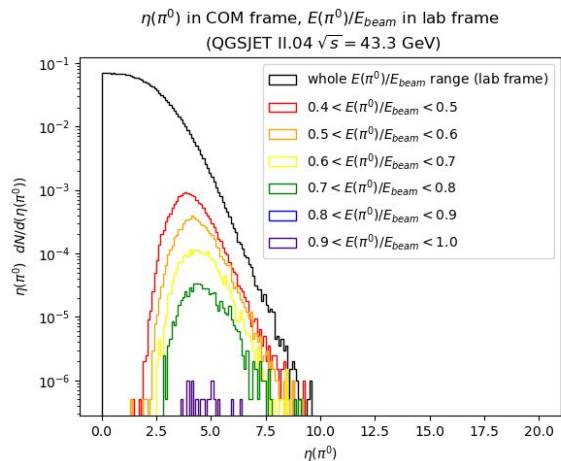


**So far only LHCf data seems to be in right rapidity region.**

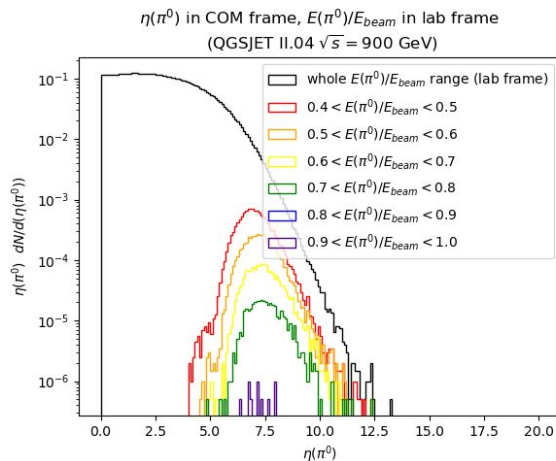


# Link between energy scales: QGSJET II-04

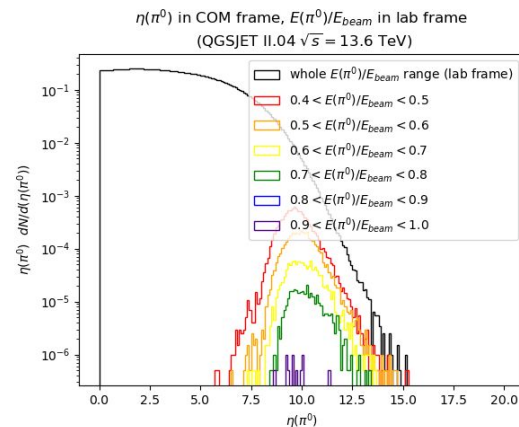
$\sqrt{s} = 43.3 \text{ GeV}$



$\sqrt{s} = 900 \text{ GeV}$



$\sqrt{s} = 13.6 \text{ TeV}$



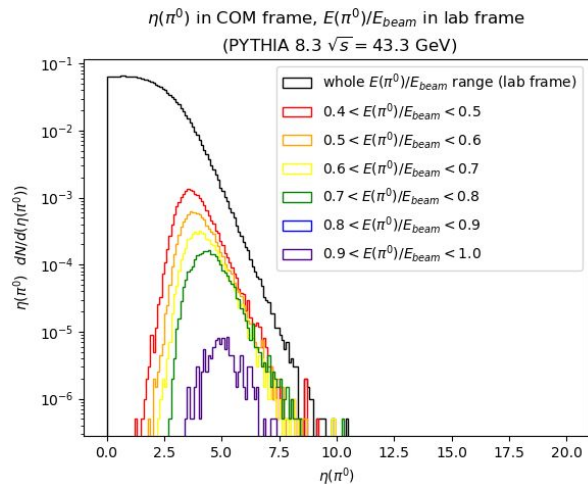
Scaling rel:  $3.15 < |\eta| < 5.77$

$6.18 < |\eta| < 8.80$

$8.9 < |\eta| < 11.52$

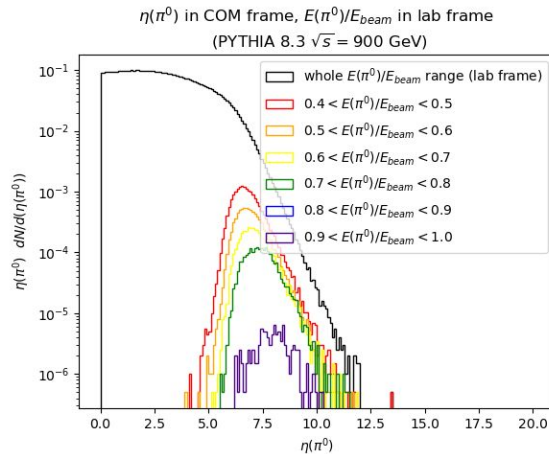
# Link between energy scales: PYTHIA 8.3

$\sqrt{s} = 43.3 \text{ GeV}$



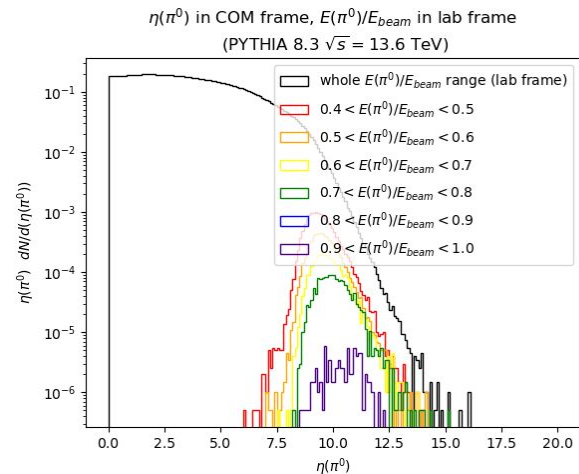
Scaling rel:  $3.15 < |\eta| < 5.77$

$\sqrt{s} = 900 \text{ GeV}$



$6.18 < |\eta| < 8.80$

$\sqrt{s} = 13.6 \text{ TeV}$

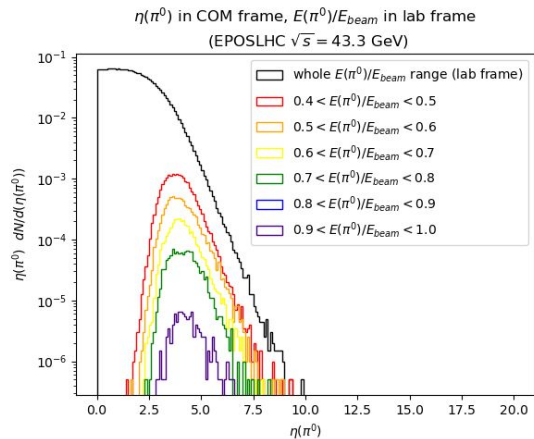


$8.9 < |\eta| < 11.52$

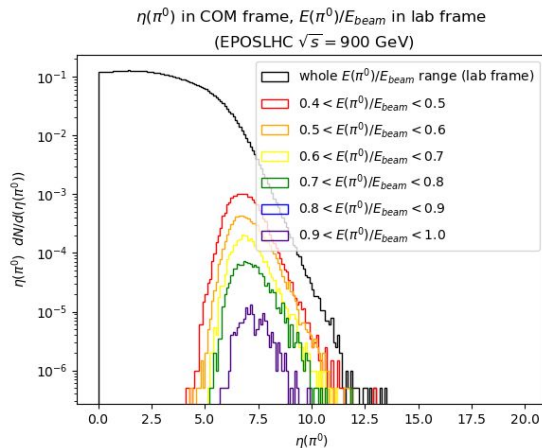


# Link between energy scales: EPOS LHC

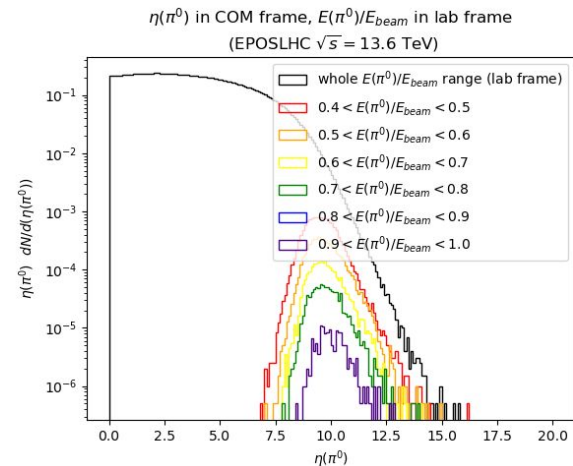
$\sqrt{s} = 43.3 \text{ GeV}$



$\sqrt{s} = 900 \text{ GeV}$



$\sqrt{s} = 13.6 \text{ TeV}$



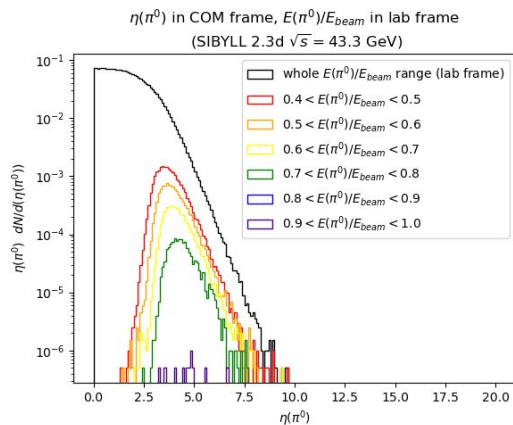
Scaling rel:  $3.15 < |\eta| < 5.77$

$6.18 < |\eta| < 8.80$

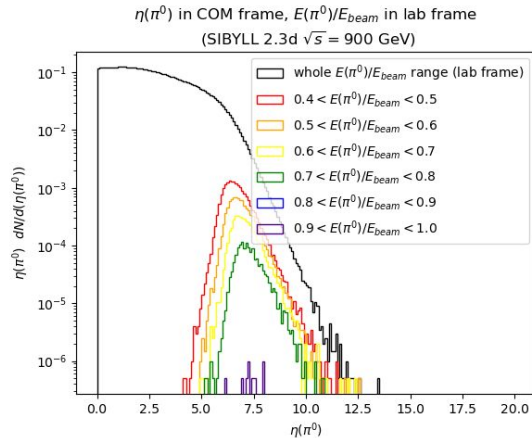
$8.9 < |\eta| < 11.52$

# Link between energy scales: SIBYLL 2.3d

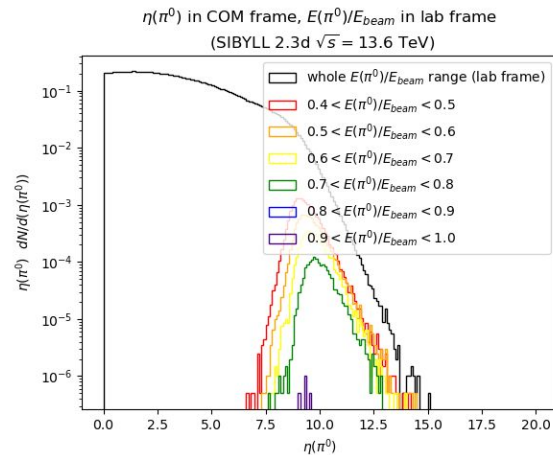
$\sqrt{s} = 43.3 \text{ GeV}$



$\sqrt{s} = 900 \text{ GeV}$



$\sqrt{s} = 13.6 \text{ TeV}$



Scaling rel:  $3.15 < |\eta| < 5.77$

$6.18 < |\eta| < 8.80$

$8.9 < |\eta| < 11.52$

# Current Status

- ✓ All samples for all energies and generators produced
- ✓ Plots for eta in energy bins + energy in eta bins with eta in COM and energy in lab frame for  $\sqrt{s}=43.3\text{GeV}$  and  $13.6\text{TeV}$  for all generators
- ✓ Scaling relation for interesting eta region with  $\sqrt{s}$
- ✓ Lower bound of eta region redefined
- ✓ Plots with  $\sqrt{s}=900\text{GeV}$
- ✗ Need pion energy range for gamma-like shower classification (Jan?) → for plotting and for eta range calculation
- ✗ Need pion pT range for gamma-like shower classification (Jan?) → lower bound of eta range
- ✓ Implemented eta sign dependent Lorentz boost
- ✓ Comparison of interesting eta regions with available experiments/data: LHCf (ZDC) so far only known option
- ✗ Paper draft on overleaf?

**Any other interesting ideas to check for the paper?**