# Hadronic Gamma Rays

Previously...

- Modify summary plot of existing datasets wrt eta region
- Reproduce photon energy plot with LHCf data (as Marcel did)

## Link Between Energy Scales?

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

E.g.  $\sqrt{s}$  = 43.3 GeV  $\rightarrow$ p T( $\pi$ 0)  $\lesssim$  1.5 GeV (Pythia) for E lab/E beam > 0.9 $\rightarrow$  3.15 <  $|\eta|$  < 5.77 (CDF MiniPlug but wrong energy?)

 $\sqrt{s}$  = 13.6TeV  $\rightarrow$ p T( $\pi$ 0)  $\lesssim$  1.5 GeV (Pythia) for E lab/E beam > 0.9 $\rightarrow$  8.9 <  $|\eta|$  < 11.52 (LHCf coverage!)

 $\sqrt{s} = 900 \text{GeV} \rightarrow p \text{T}(\pi 0) \leq 1.5 \text{ GeV}$  (Pythia) for E lab/E beam > 0.9 $\rightarrow$  6.18 <  $|\eta|$  < 8.80 (maybe CMS CASTOR? only very small rapidity overlap, -6.6 <  $\eta$  < -5.2)

 $\sqrt{s} = 1.96 \text{ TeV} \rightarrow p \text{ T}(\pi 0) \leq 1.5 \text{ GeV}$  (Pythia) for E lab/E beam > 0.9 $\rightarrow$  6.96 <  $|\eta|$  < 9.58 (no overlap with any CDF

forward detector coverage - see here)



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



- LHCf has analyzed data in our region of interest, but unfortunately only π0 pT, not energy
- Only photon energy spectra from run 2 (8.81 <  $\eta$  < 8.99,  $\eta$ >10.94)

https://arxiv.org/pdf/1703.07678.pdf https://www.hepdata.net/record/ins1518782





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https://arxiv.org/pdf/1703.07678.pdf https://www.hepdata.net/record/ins1518782 Seems to agree with original LHCf publication but larger differences between models and data in Marcel's plot?



## What do we still need for the paper?

Overleaf: https://www.overleaf.com/project/64b0fee99c5f0c061eb1005b

- Pion energy range (+ pT range) for gamma-like CR-EAS
  - Update eta range (and data summary plot) accordingly
- We need to actually write the paper:
  - Structure
  - Final plots
  - References
  - o ...?
- Anything else?

# Hadronic Gamma Rays

Previously...

- Apply Lorentz boost depending on pi0 eta sign in COM
- Could Tevatron data be interesting (<u>CDF forward detectors</u>)?
- Do we have forward 900 GeV data?  $\rightarrow$  only AFP
- Need pi0 energy fraction and pT for gamma-like classification

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



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



Link between frames: Lorentz Boost depending on side (EPOSLHC)



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



## Link Between 2 Energy Scales?

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

E.g.  $\sqrt{s} = 43.3 \text{ GeV} \rightarrow p_T(\pi 0) \leq 1.5 \text{ GeV}$ (Pythia) for E\_lab/E\_beam > 0.9  $\rightarrow 3.15 < |\eta| < 5.77$  (CDF MiniPlug but wrong energy?)

 $\sqrt{s}$  = 13.6TeV →p\_T( $\pi$ 0)  $\lesssim$  1.5 GeV (Pythia) for E\_lab/E\_beam > 0.9 → 8.9 <  $|\eta|$  < 11.52 (LHCf coverage!)

 $\sqrt{s} = 900 \text{GeV} \rightarrow p_T(\pi 0) \le 1.5 \text{ GeV}$  (Pythia) for E\_lab/E\_beam > 0.9  $\rightarrow 6.18 < |\eta| < 8.80$  (maybe CMS CASTOR? only very small rapidity overlap, -6.6 <  $\eta$  < -5.2)

 $\sqrt{s} = 1.96 \text{ TeV} \rightarrow p_T(\pi 0) \le 1.5 \text{ GeV}$  (Pythia) for E\_lab/E\_beam > 0.9

 $\rightarrow$  6.96 <  $|\eta|$  < 9.58 (no overlap with any CDF forward detector coverage - see <u>here</u>)



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

## Link between energy scales: QGSJET II-04

#### √s = 13.6 TeV



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

6.18 < |η| < 8.80

8.9 < |η| < 11.52

## Link between energy scales: PYTHIA 8.3

√s = 43.3 GeV

√s = 900 GeV

√s = 13.6 TeV



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

6.18 < |η| < 8.80

8.9 < |η| < 11.52

## Link between energy scales: EPOSLHC

√s = 43.3 GeV

√s = 900 GeV



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

6.18 < |η| < 8.80

8.9 < |η| < 11.52

## Link between energy scales: SIBYLL 2.3d

√s = 43.3 GeV

√s = 900 GeV



Scaling rel:

3.15 < |η| < 5.77

6.18 < |η| < 8.80

8.9 < |η| < 11.52

√s = 13.6 TeV

## **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)=43.3GeV and 13.6TeV for all generators
- Scaling relation for interesting eta region with sqrt(s)
- Lower bound of eta region redefined
- Plots with sqrt(s)=900GeV
- 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?)  $\rightarrow$  lower bound of eta range
- Manual Sector 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?