Charged particle spectra at 13TeV

Unfolding

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Responce Matrices

- Matching Reco-Gen
  - pT: $\Delta R = \sqrt{(\Delta\eta^2 + \Delta\varphi^2)} < 0.04$
  - Eta: $\Delta R = \sqrt{(\Delta p_T^2 + \Delta\varphi^2)} < 0.07$
  - Multiplicity: Same event selection

Events must have the same event selection at Gen and Detector level.

Initial binning:

- p_T [0.5, 50] GeV with 0.1 bin width
- η [-2.4, 2.4] with 0.2 bin width
- Multiplicity [1, 100] with 1 bin width

Rebinning

For each distributions there are several RM's involved for its unfolding and Systematic uncertainties determination.

- Nominal Selection (exactly 1 vertex and HFcut 5GeV) ------ (1)

- For HF (event selection) systematics:
  - Variation UP (HFcut 6GeV) ---------- (2)
  - Variation DOWN (HFcut 4GeV) ---------- (3)

- For PU systematics:
  - At Least 1 vertex ---------- (4)

Rebinning

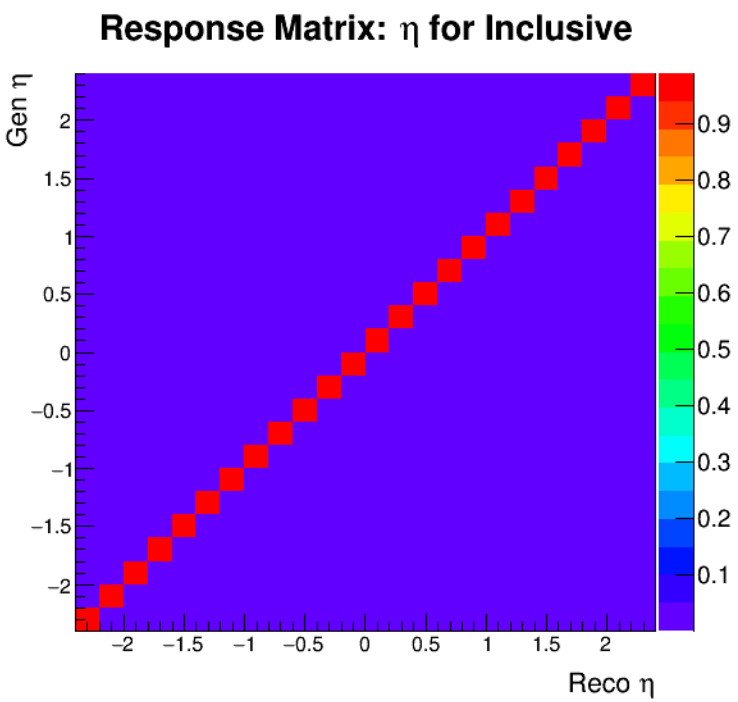
They have to be populated enough along the full phase space for the Unfolding procedure.

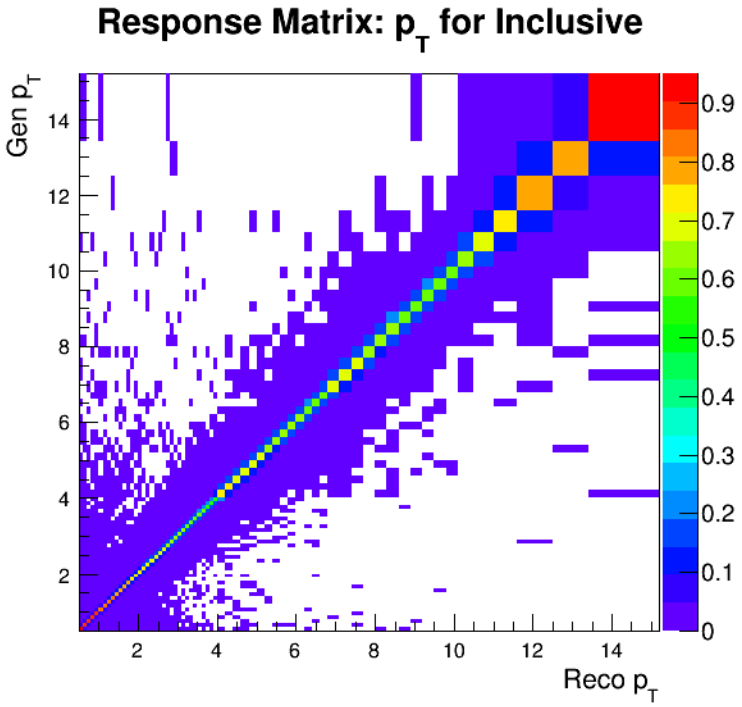
Condition: to have at least certain number of entries along each Gen bin

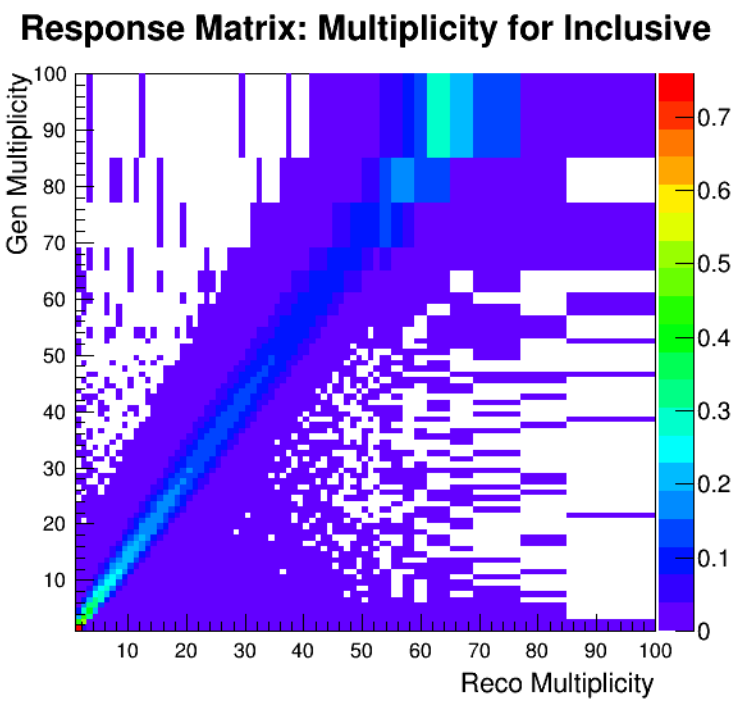
All the RM's are scanned simultaneously and the **maximum common value** of all RM's with the Initial Binning is kept and from that value the rest of the RM is rebinned doubling the last bin binwidth.

The process is **repeated iteratively** until covering all the populated phase space.

RM normalised by rows -> fraction Gen particles(per bin) in Reco bins







η is completely diagonal
Unfolding is not needed

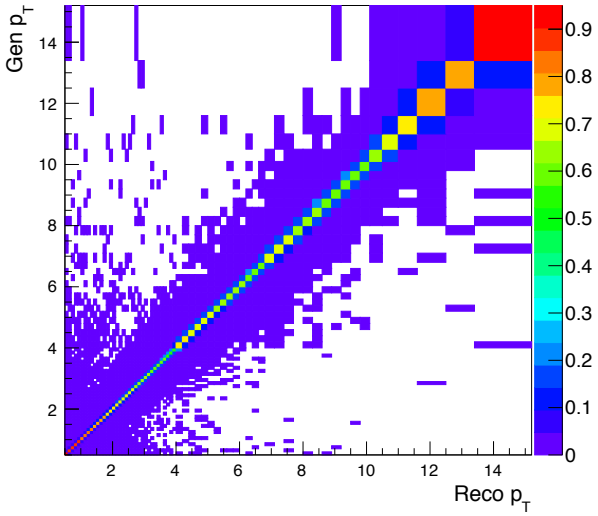
p_T is diagonal
Above 70% stays
in the diagonal

Big migration from
High M -> Low M

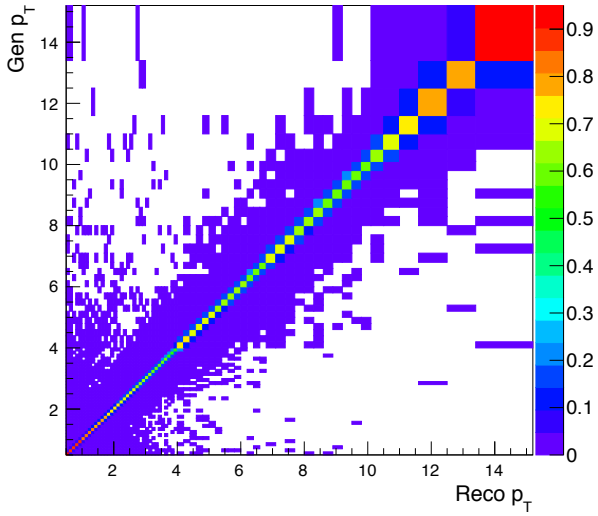
RM for transverse momentum distributions in different event selections

CUETP8M1

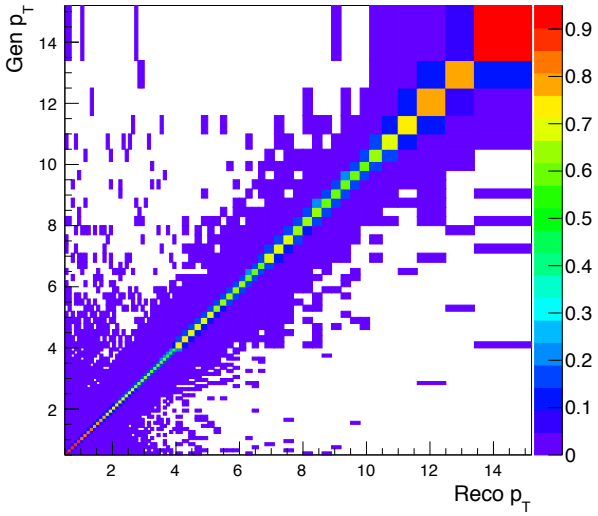
Response Matrix: p_T for Inclusive



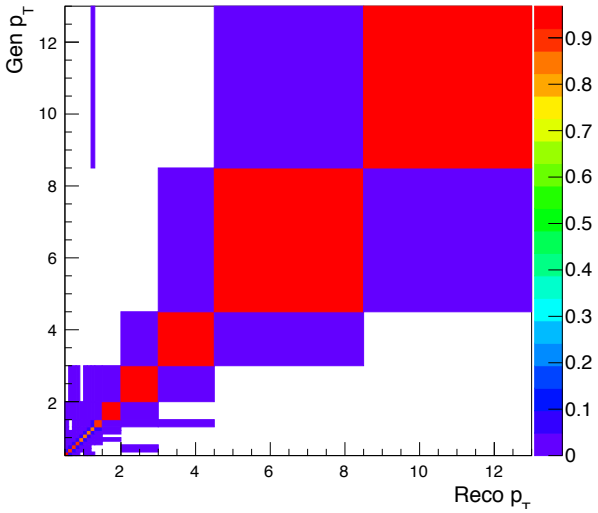
Response Matrix: p_T for Inelastic



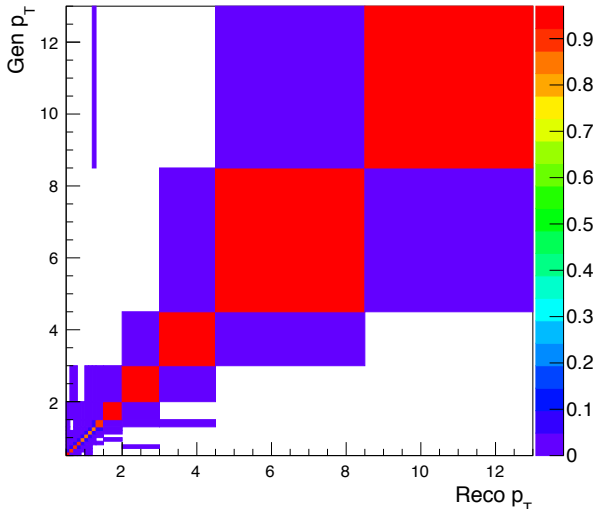
Response Matrix: p_T for NSD



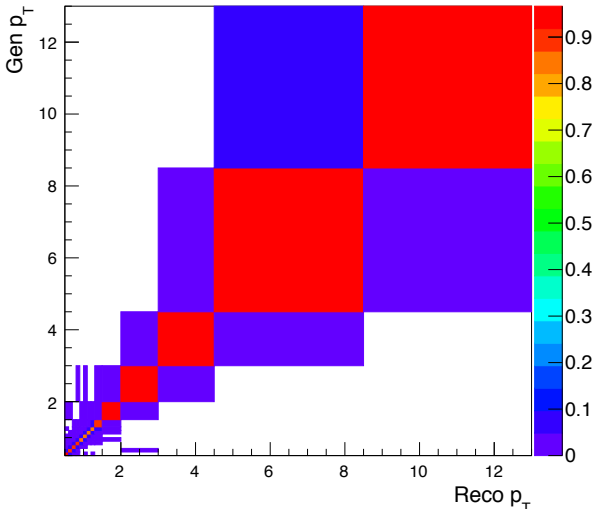
Response Matrix: p_T for SD



Response Matrix: p_T for SD minus

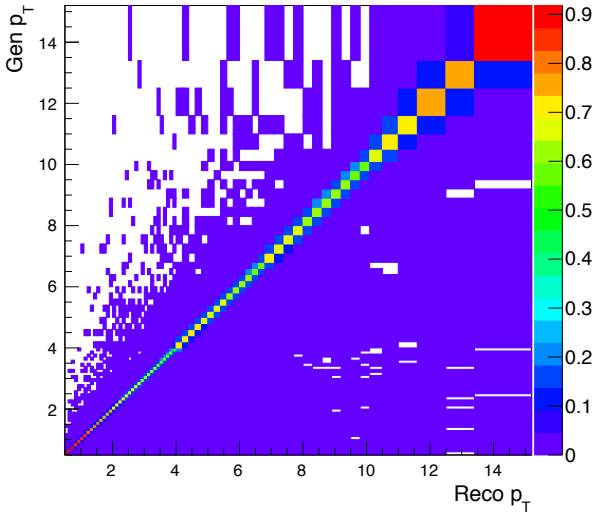


Response Matrix: p_T for SD plus

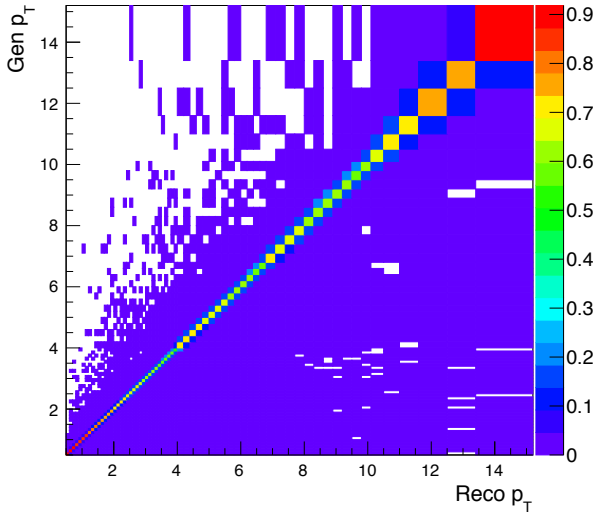


RM for Leading transverse momentum distributions in different event selections **CUETP8M1**

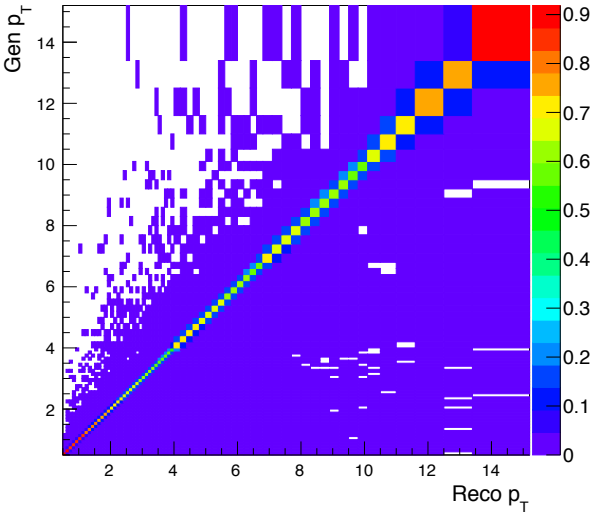
Response Matrix: p_T for Inclusive (leading)



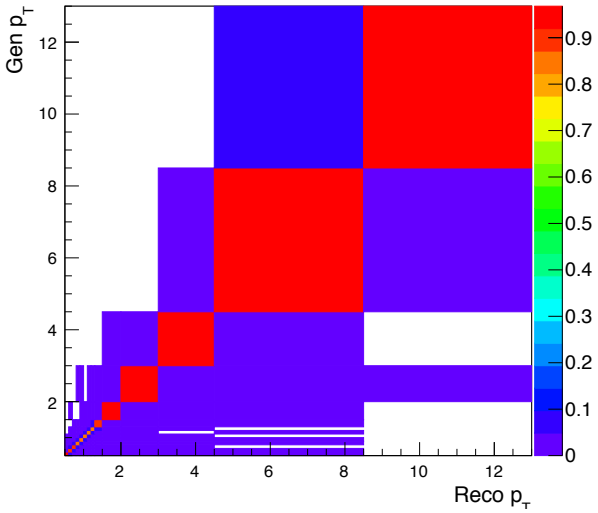
Response Matrix: p_T for Inelastic (leading)



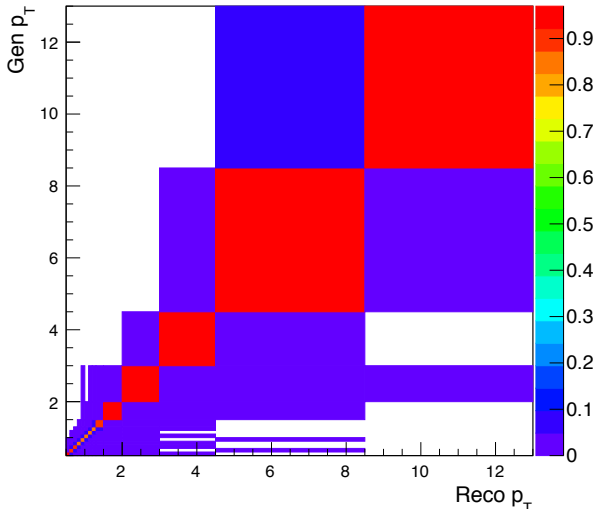
Response Matrix: p_T for NSD (leading)



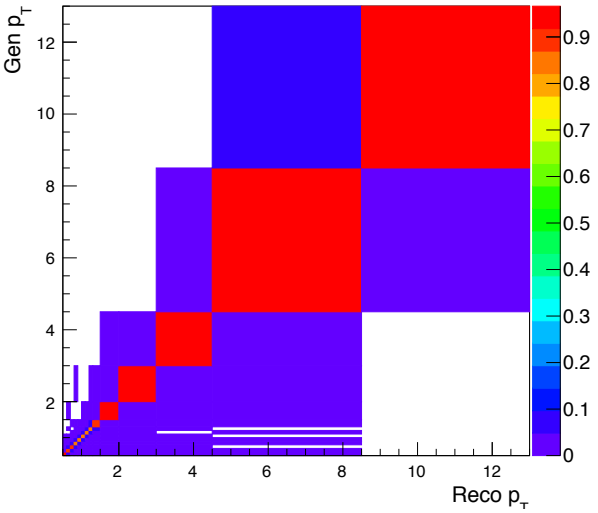
Response Matrix: p_T for SD (leading)



Response Matrix: p_T for SD minus (leading)



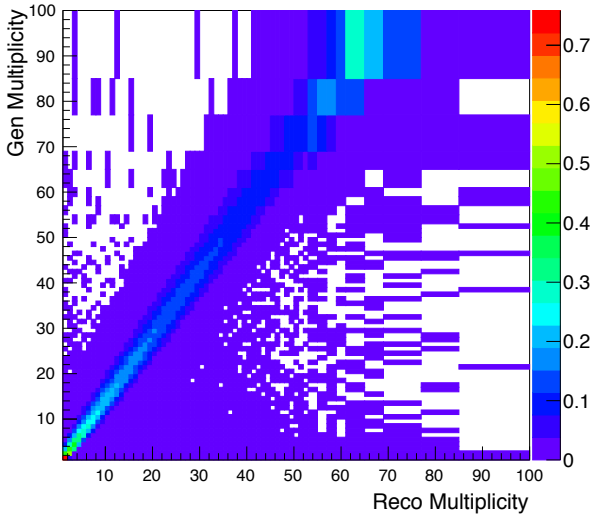
Response Matrix: p_T for SD plus (leading)



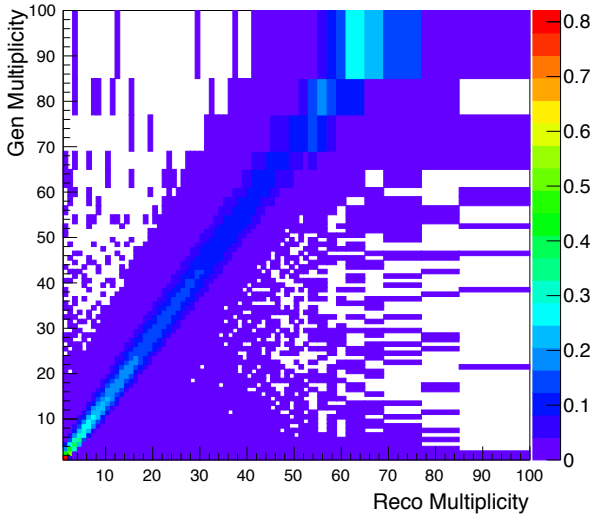
RM for Multiplicity distributions in different event selections

CUETP8M1

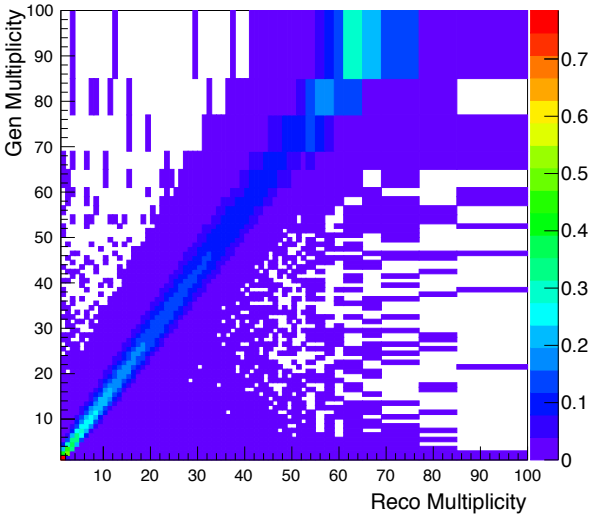
Response Matrix: Multiplicity for Inclusive



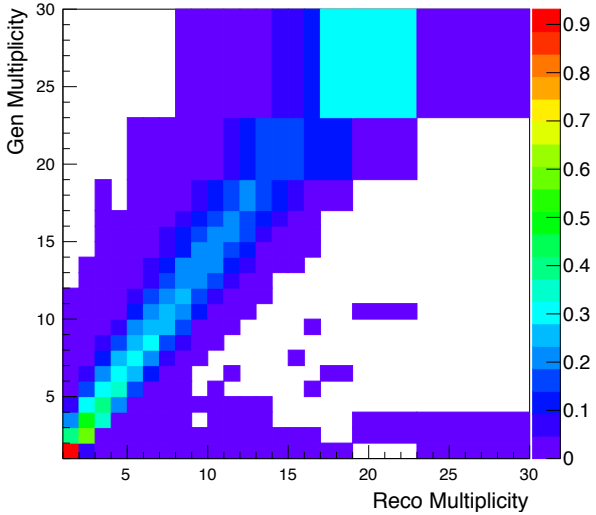
Response Matrix: Multiplicity for Inelastic



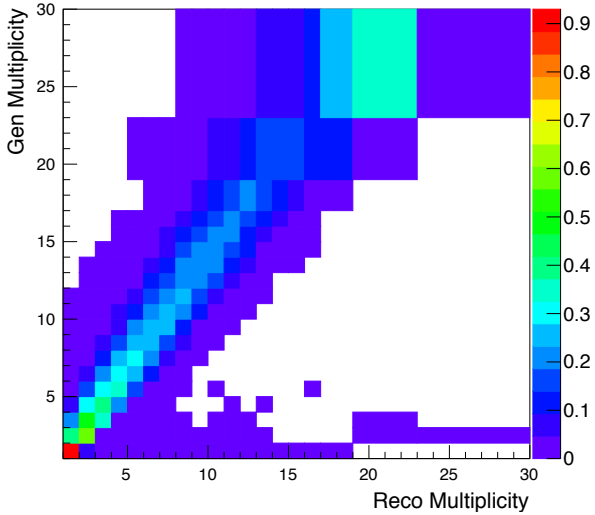
Response Matrix: Multiplicity for NSD



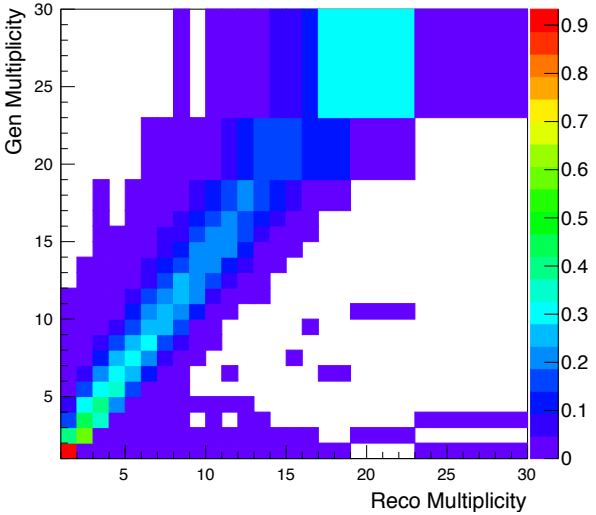
Response Matrix: Multiplicity for SD



Response Matrix: Multiplicity for SD minus

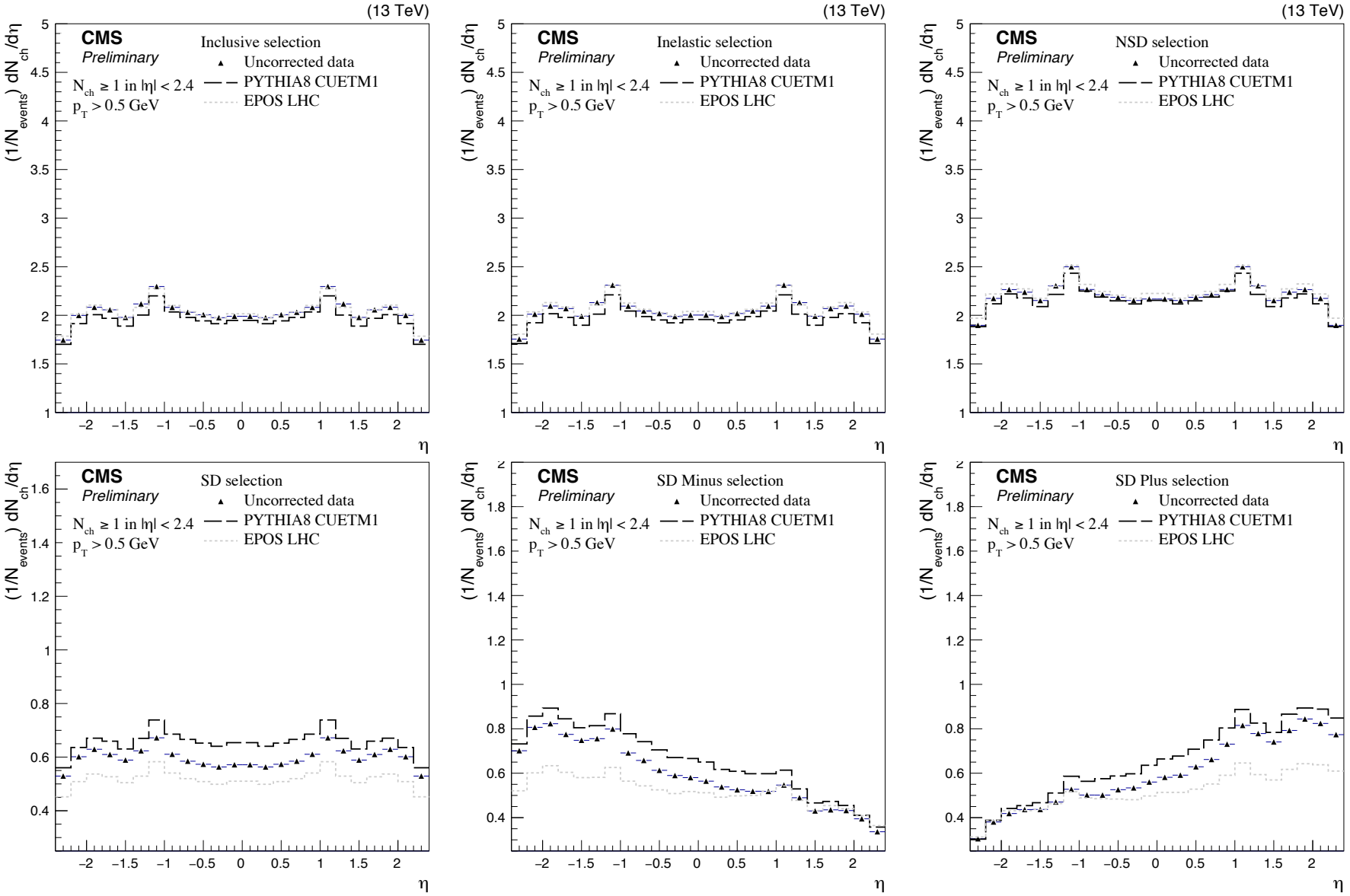


Response Matrix: Multiplicity for SD plus

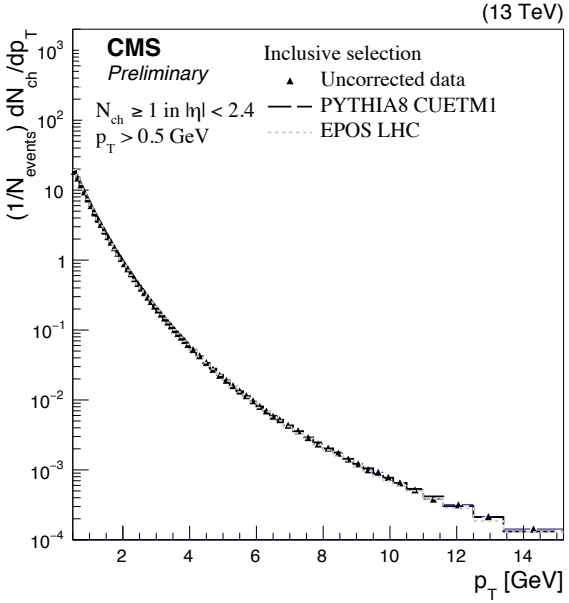


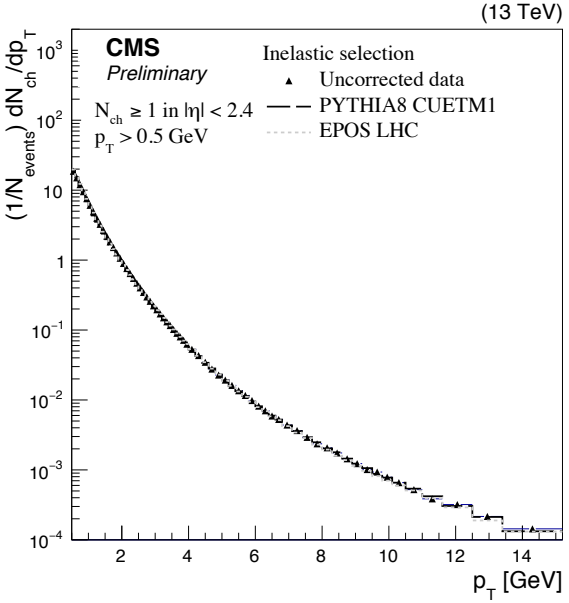
Comparison at detector level

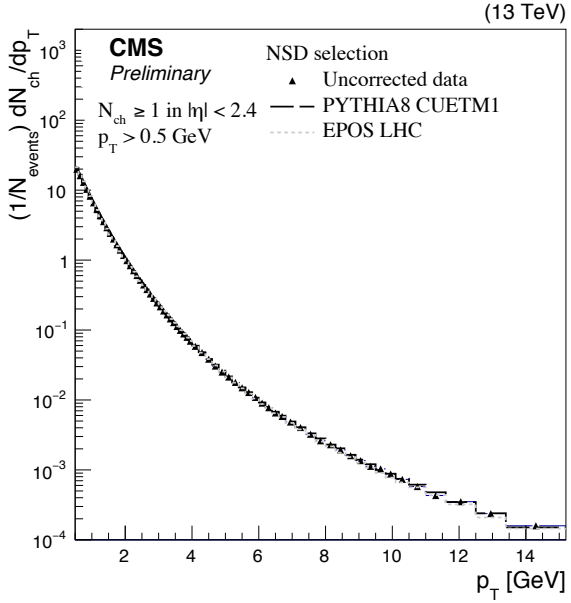
Pseudorapidity

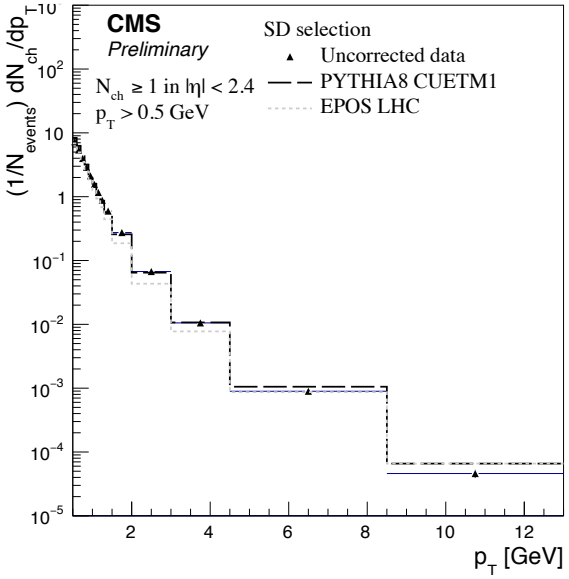


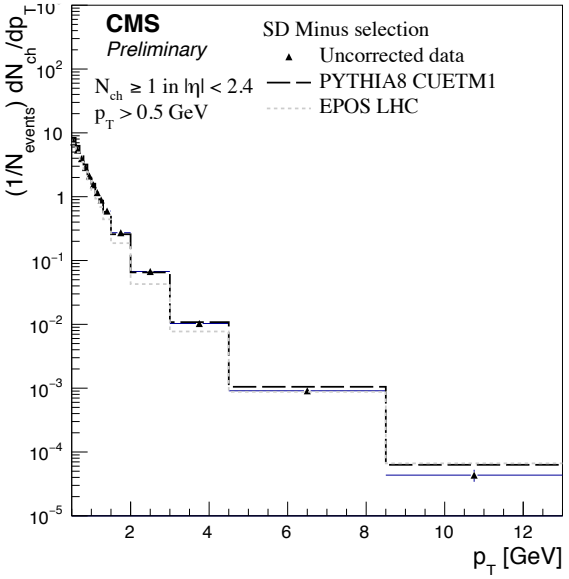
Transverse momentum (Log scale)

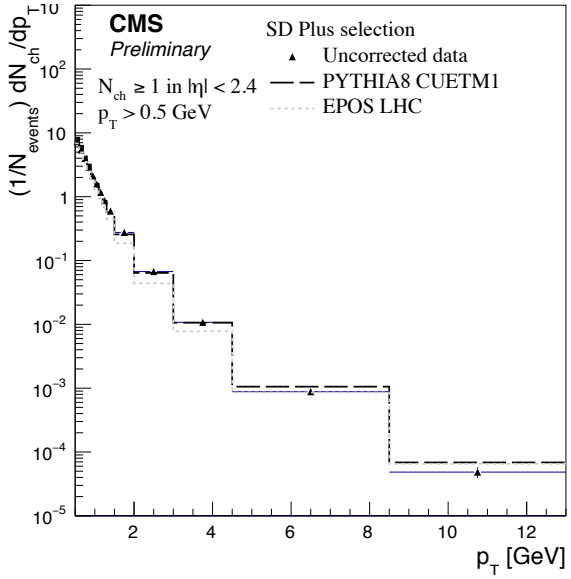




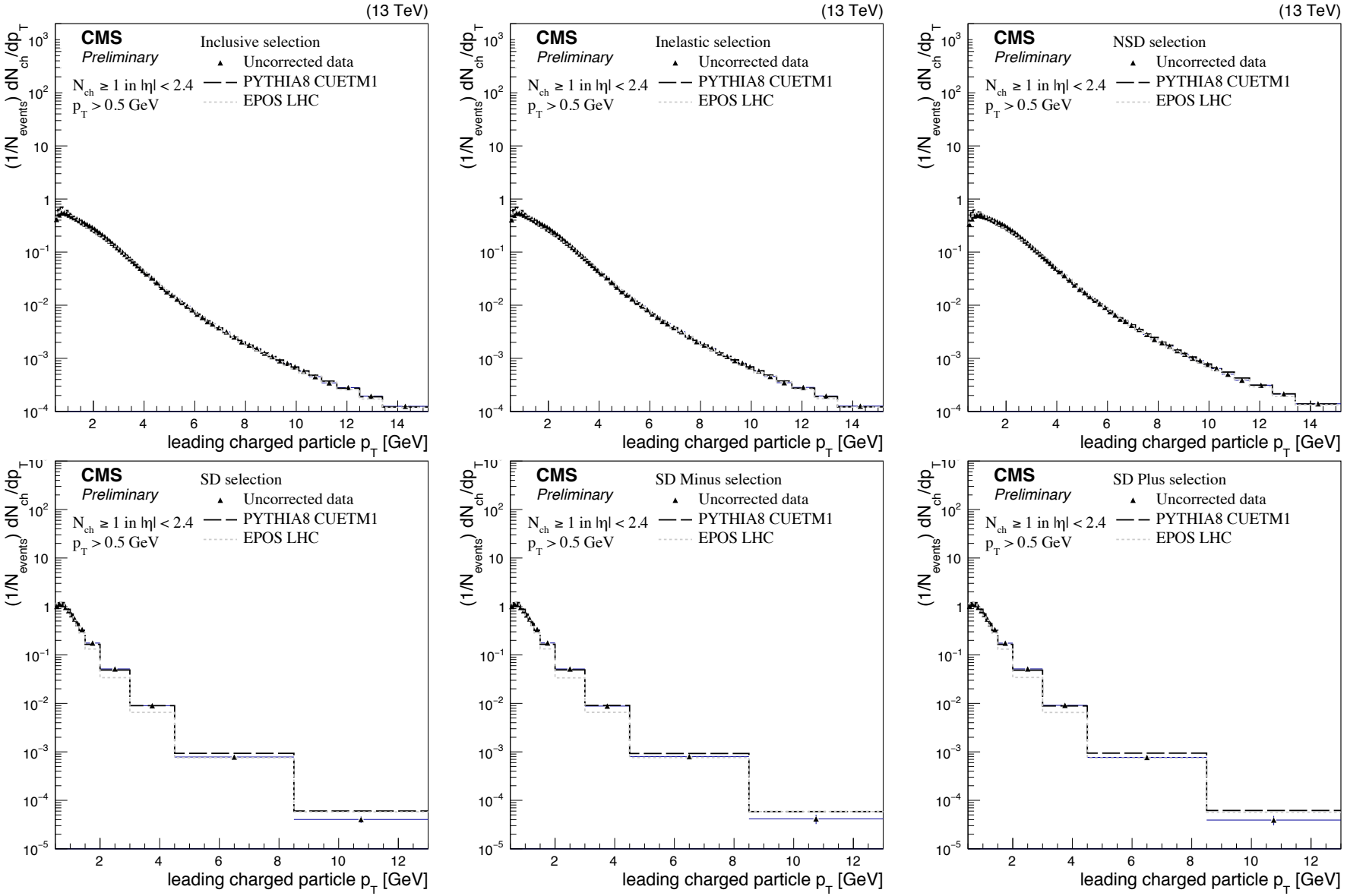




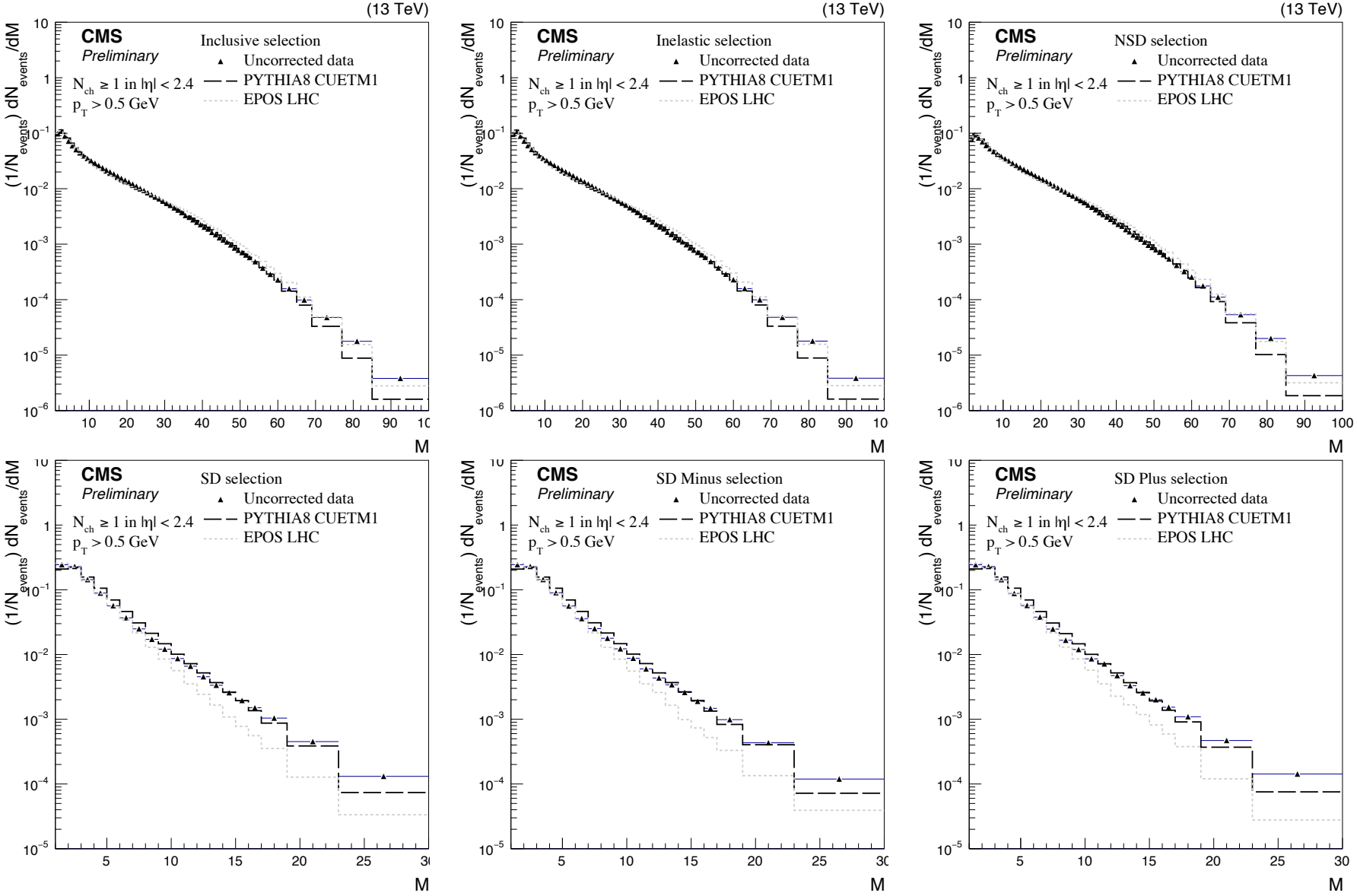




Leading transverse momentum (Log scale)



Multiplicity distributions (Log scale)



Iterations of unfolding
and
Folding Back

Folding Back

$$N^i_{det} = \sum_{j=1}^{N_{bins}} \frac{P^{ij} \cdot N^j_{unfold} \cdot (1 - Miss)}{1 - Fake^i}$$

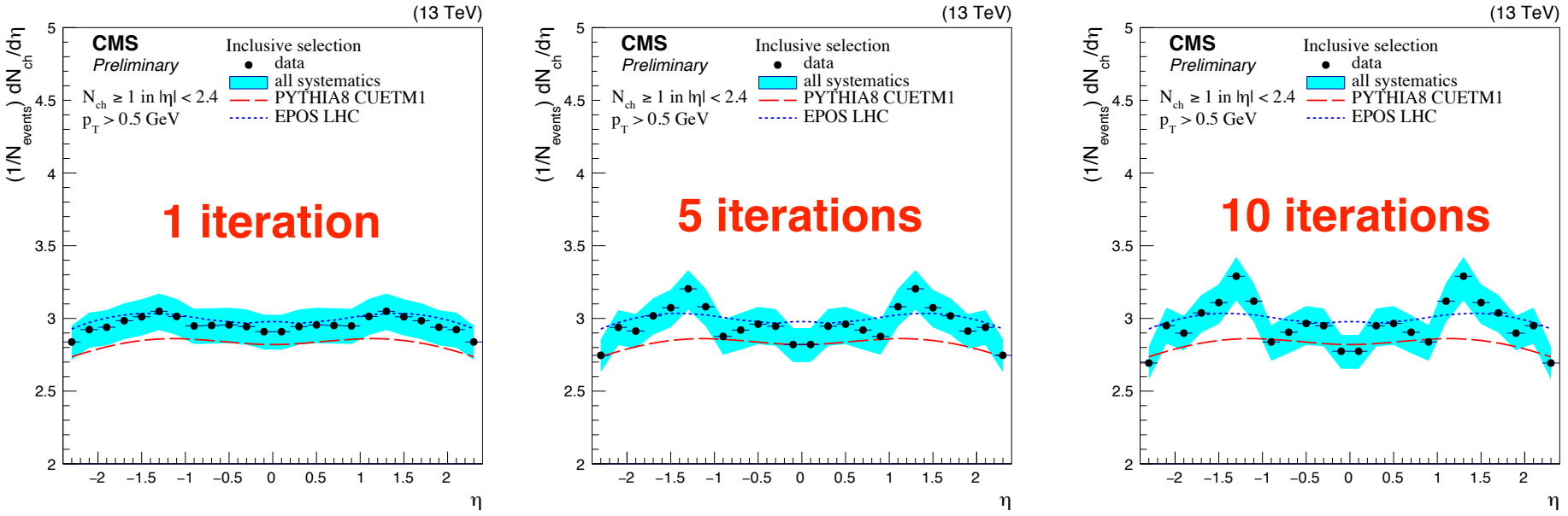
The quality of the backfolding is estimated by evaluating:

$$\chi^2 = \sum_{i=1}^{Nbins} \left(\frac{X_{det} - X_{fold}}{\sqrt{\sigma^2_{det} + \sigma^2_{fold}}} \right)^2$$

*** DAS school: Inclusive Jets Exercise**

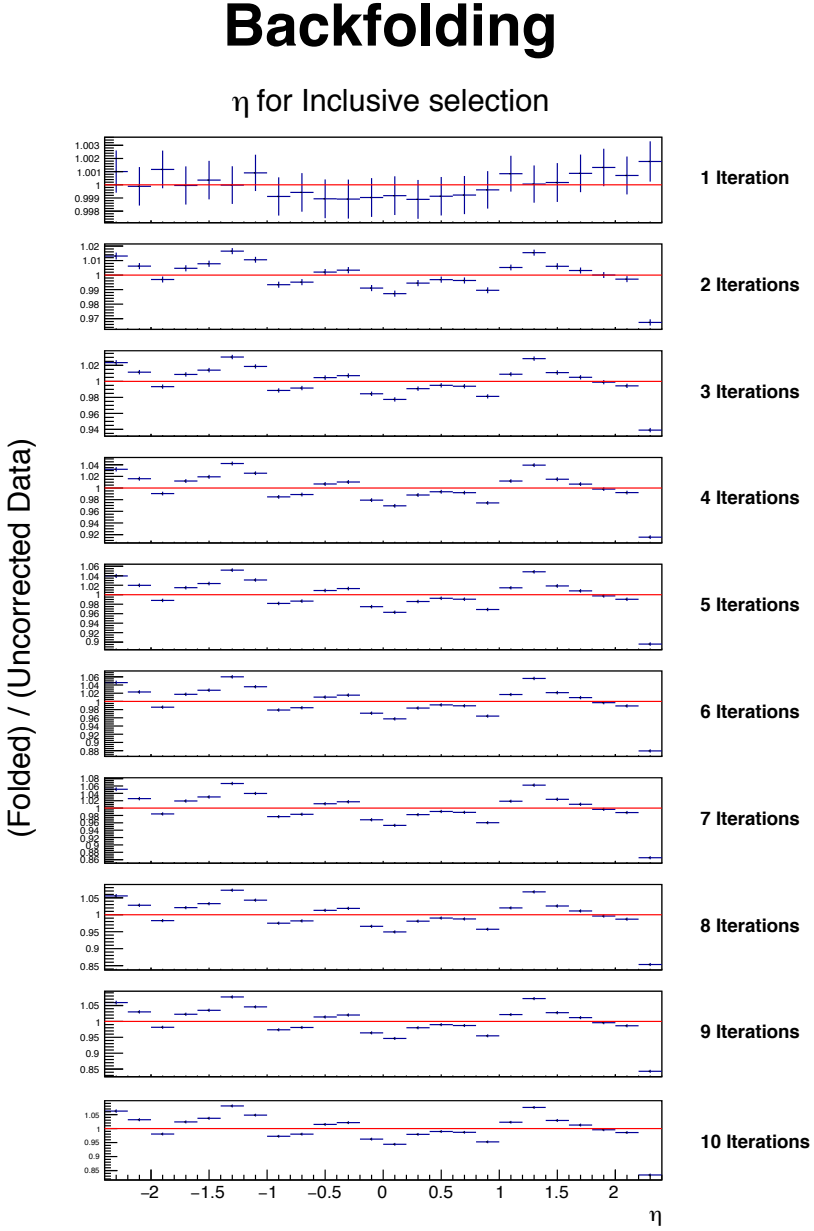
Pseudorapidity (Inclusive event selection)

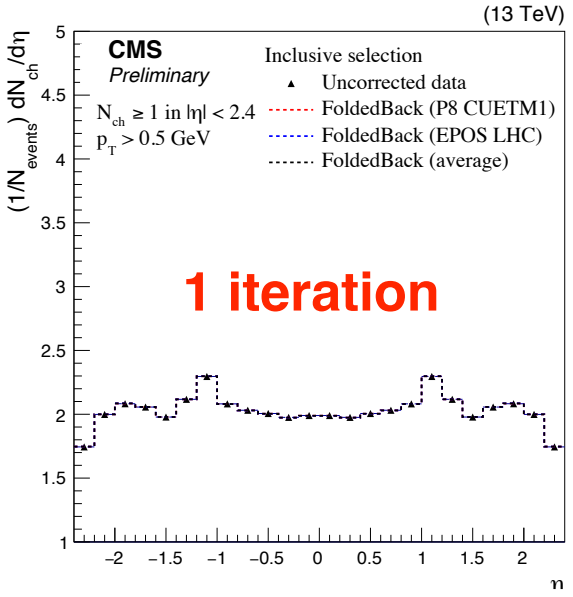
Unfolded distributions

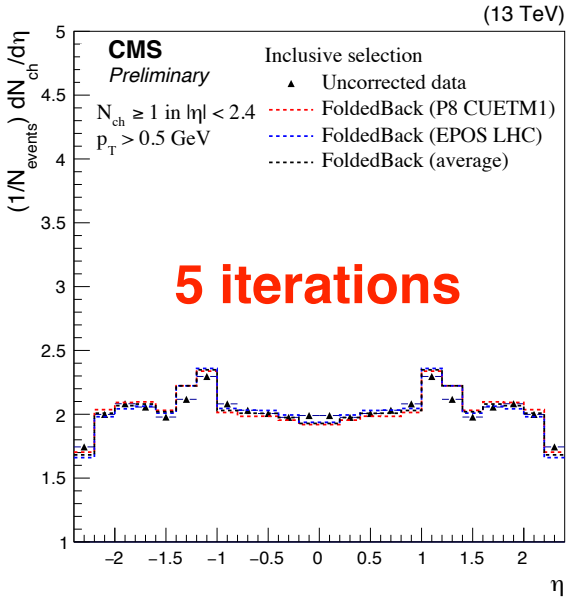


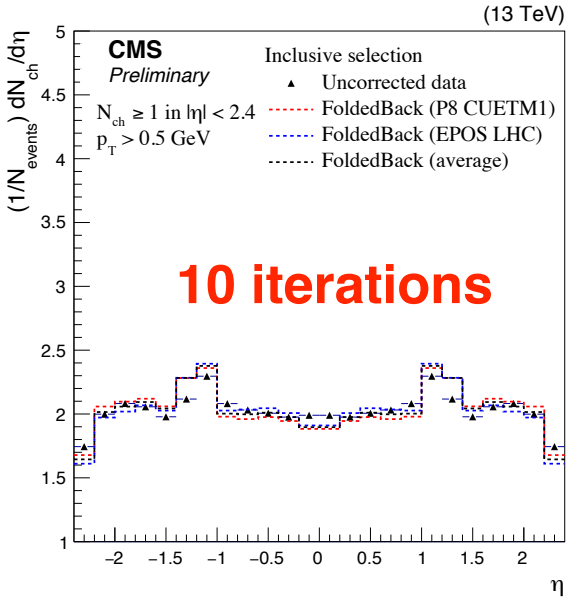
Unfolding starts to degenerate with the number of iterations for highly diagonal RMs

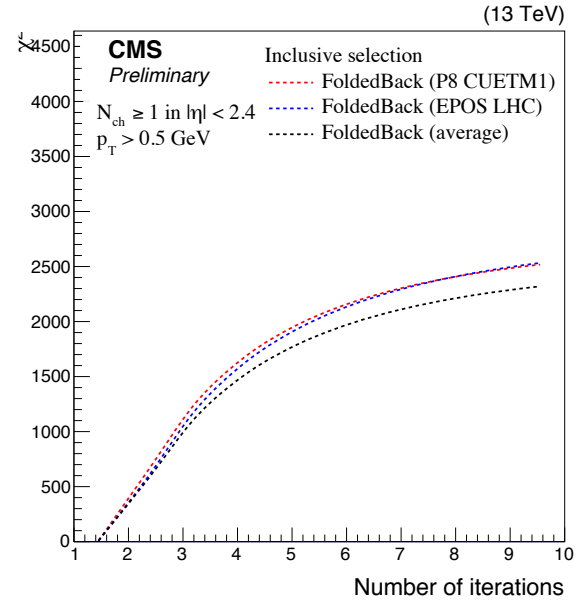
Backfolding





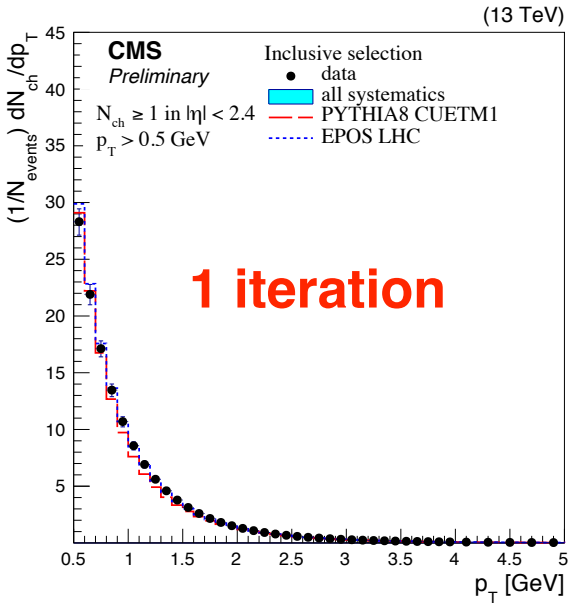


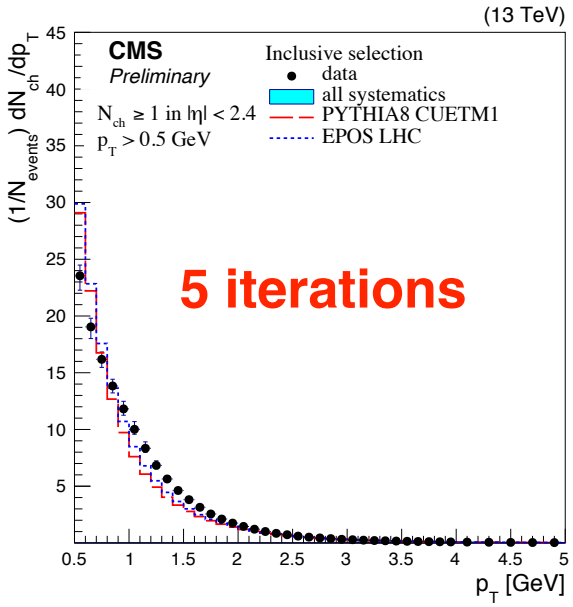


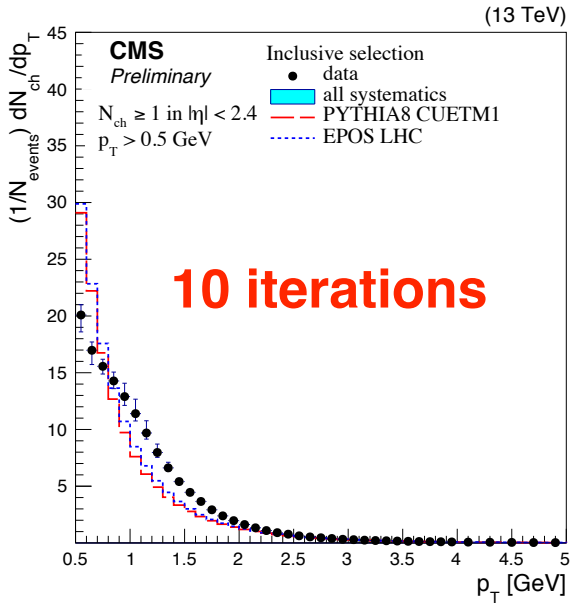


Transverse momentum (Inclusive event selection)

Unfolded distributions

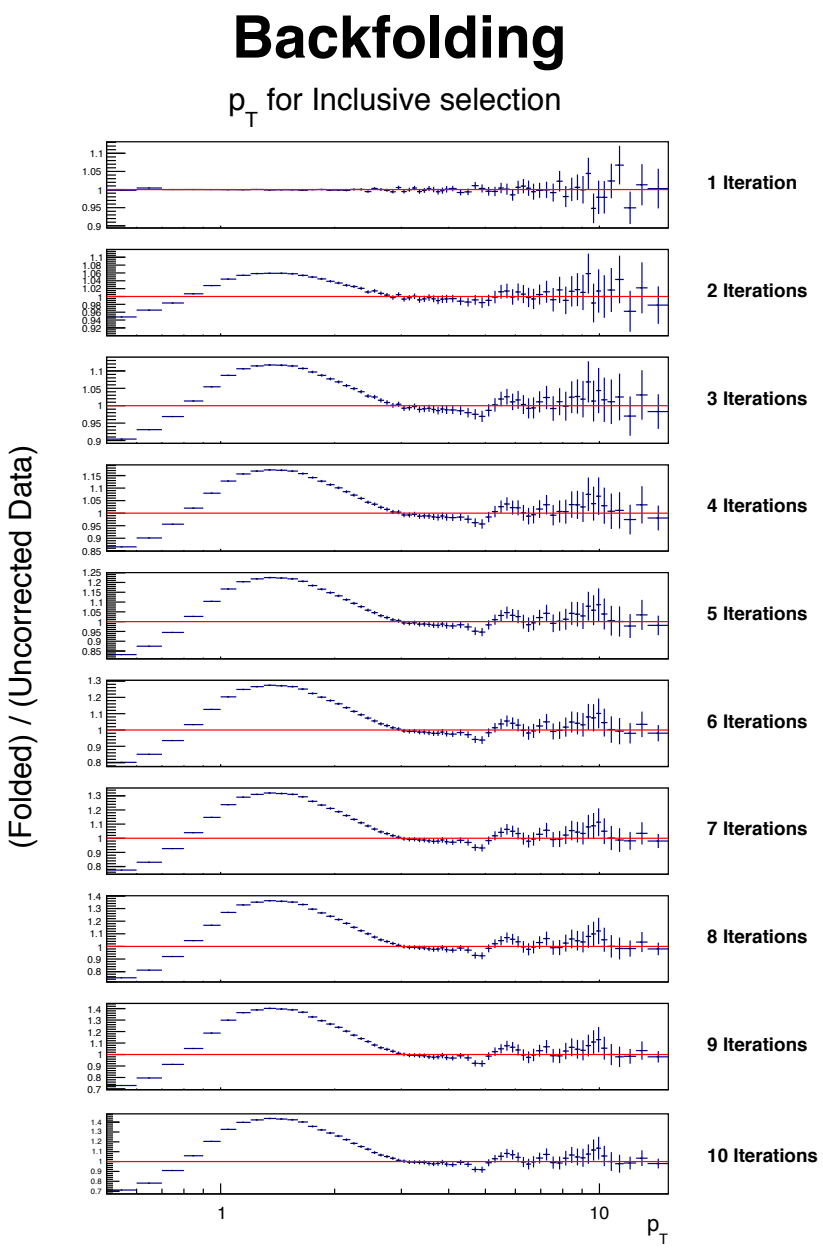


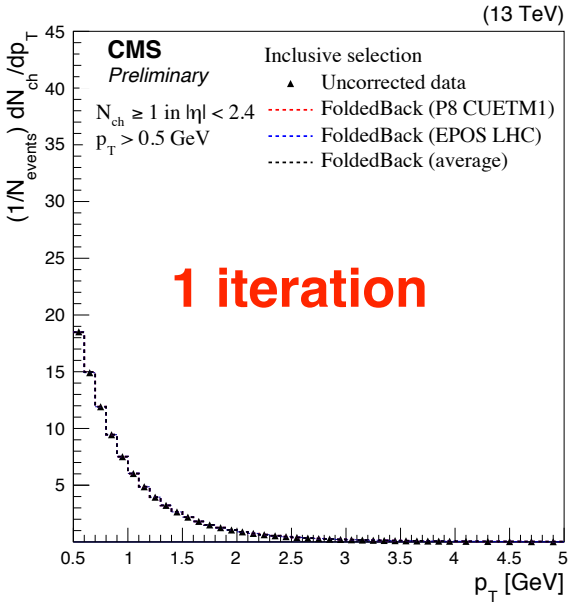


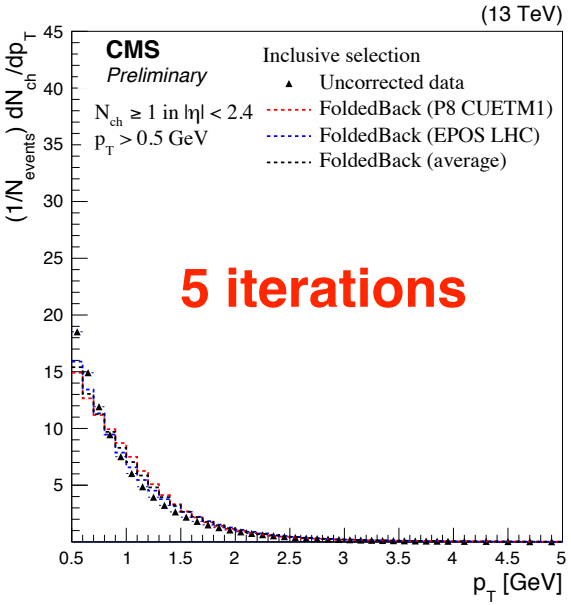


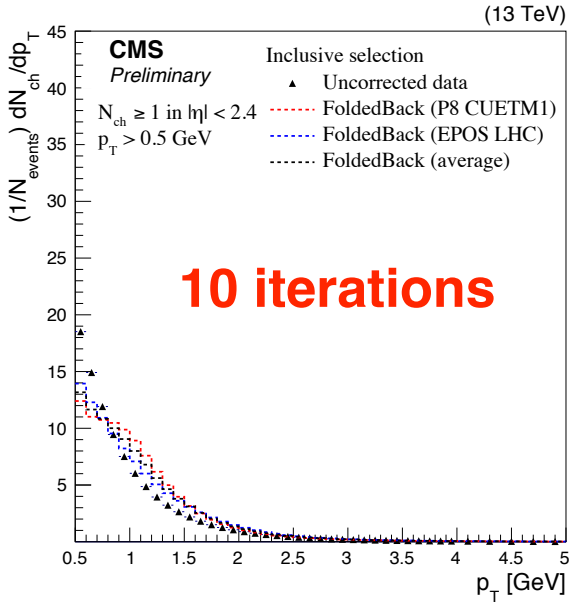
Degeneration as increasing number of iterations

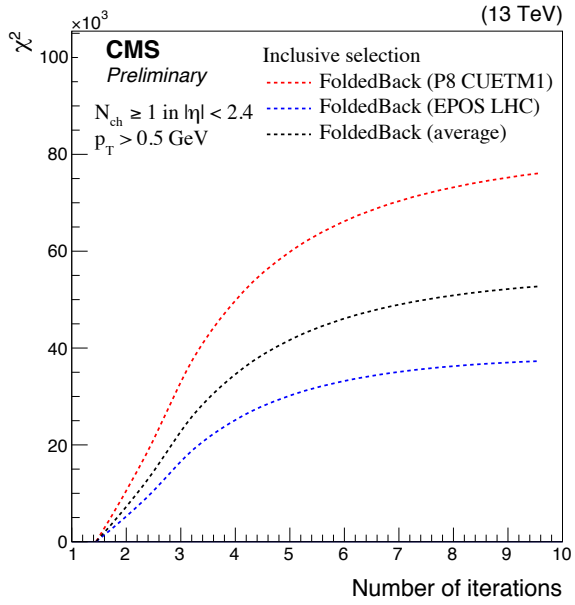
Backfolding





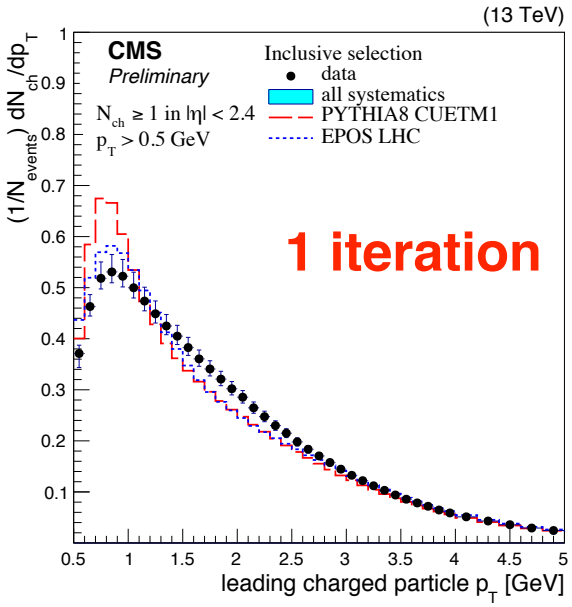


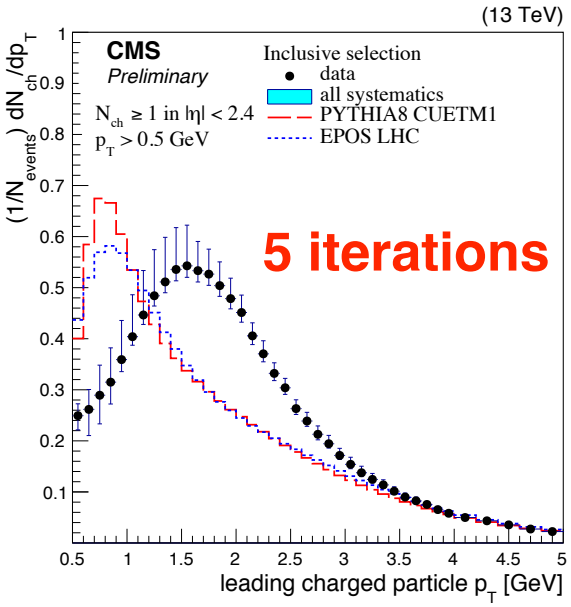


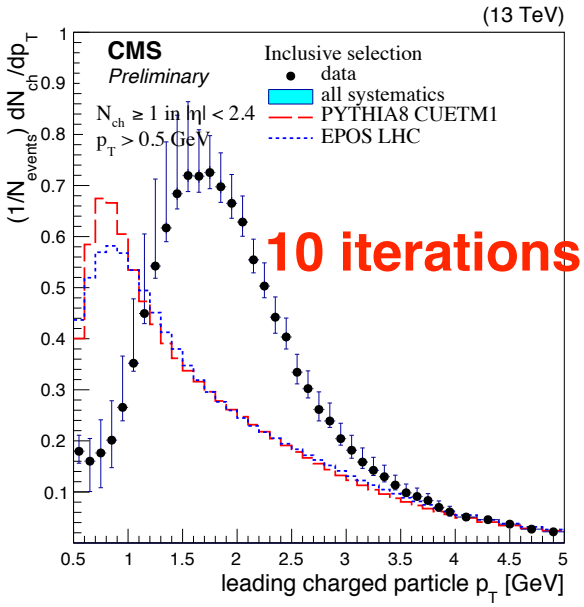


Leading transverse momentum (Inclusive event selection)

Unfolded distributions



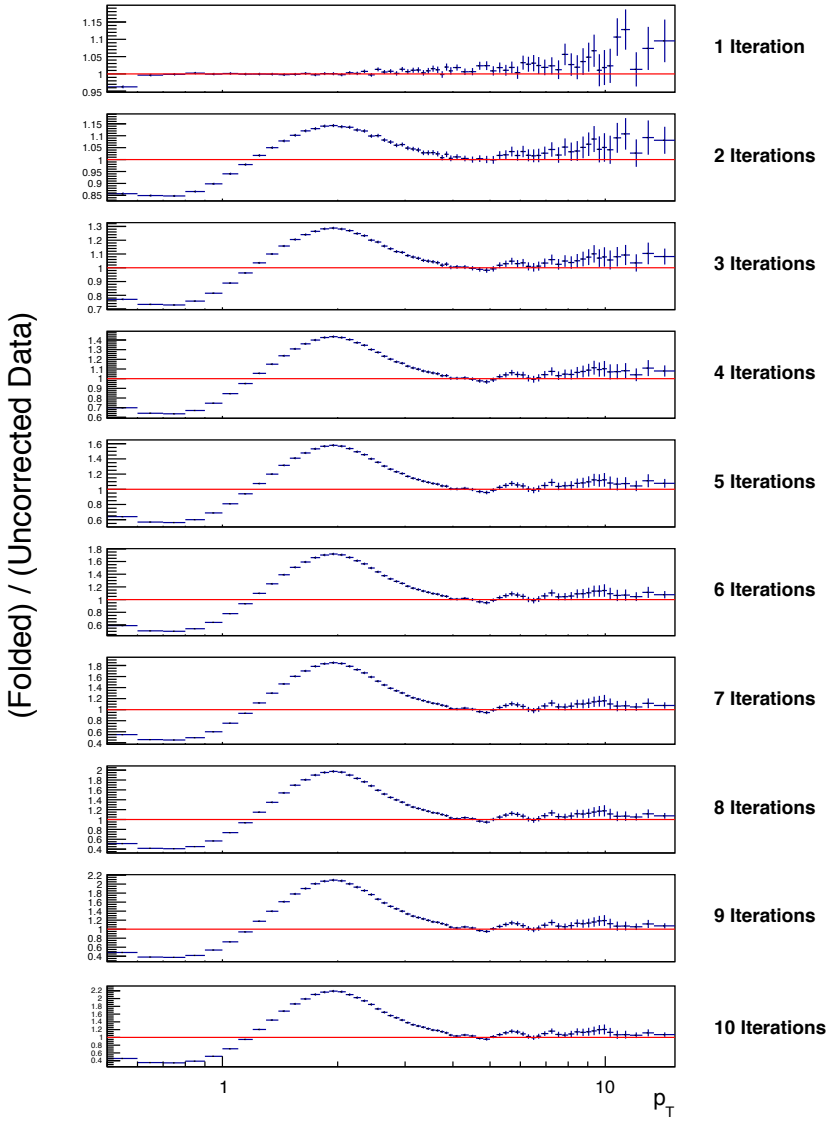


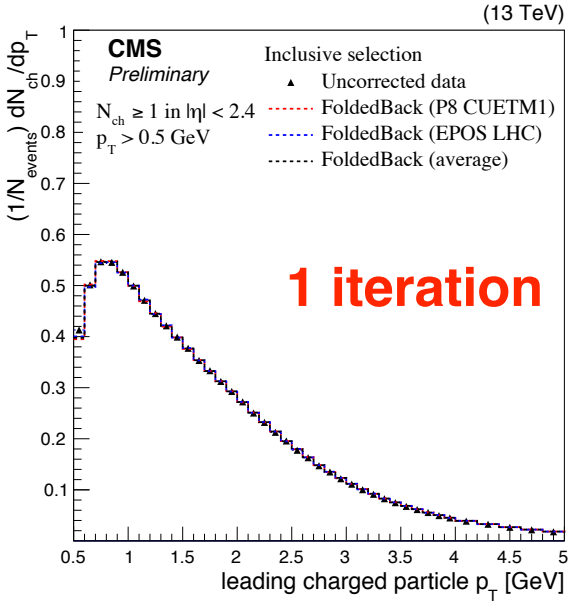


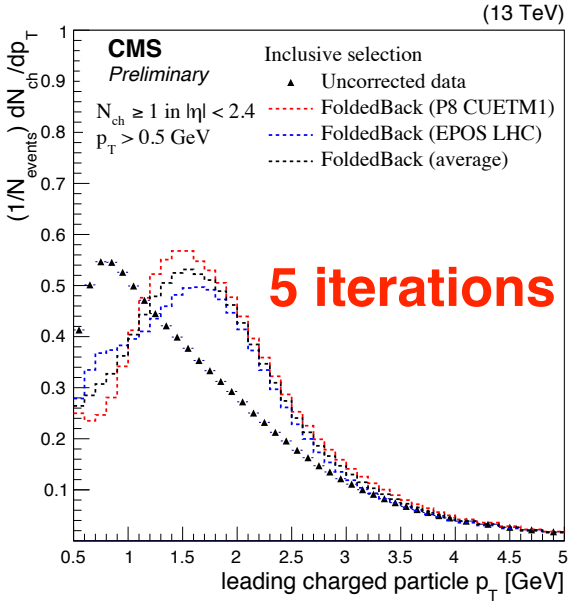
Degeneration as increasing number of iterations

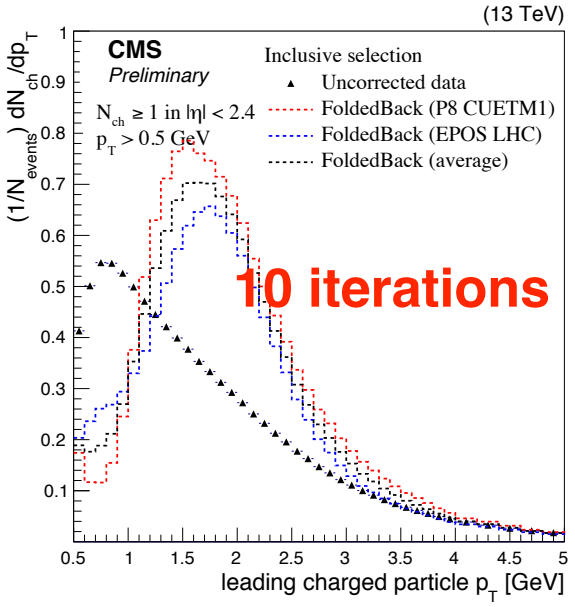
Backfolding

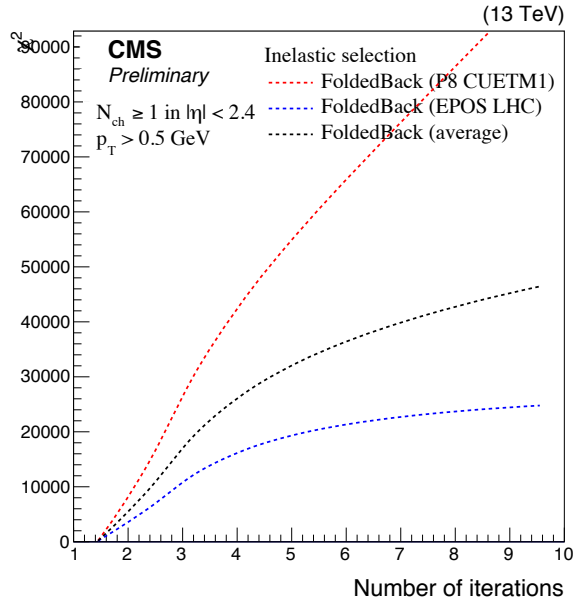
p_T for Inclusive selection (leading)







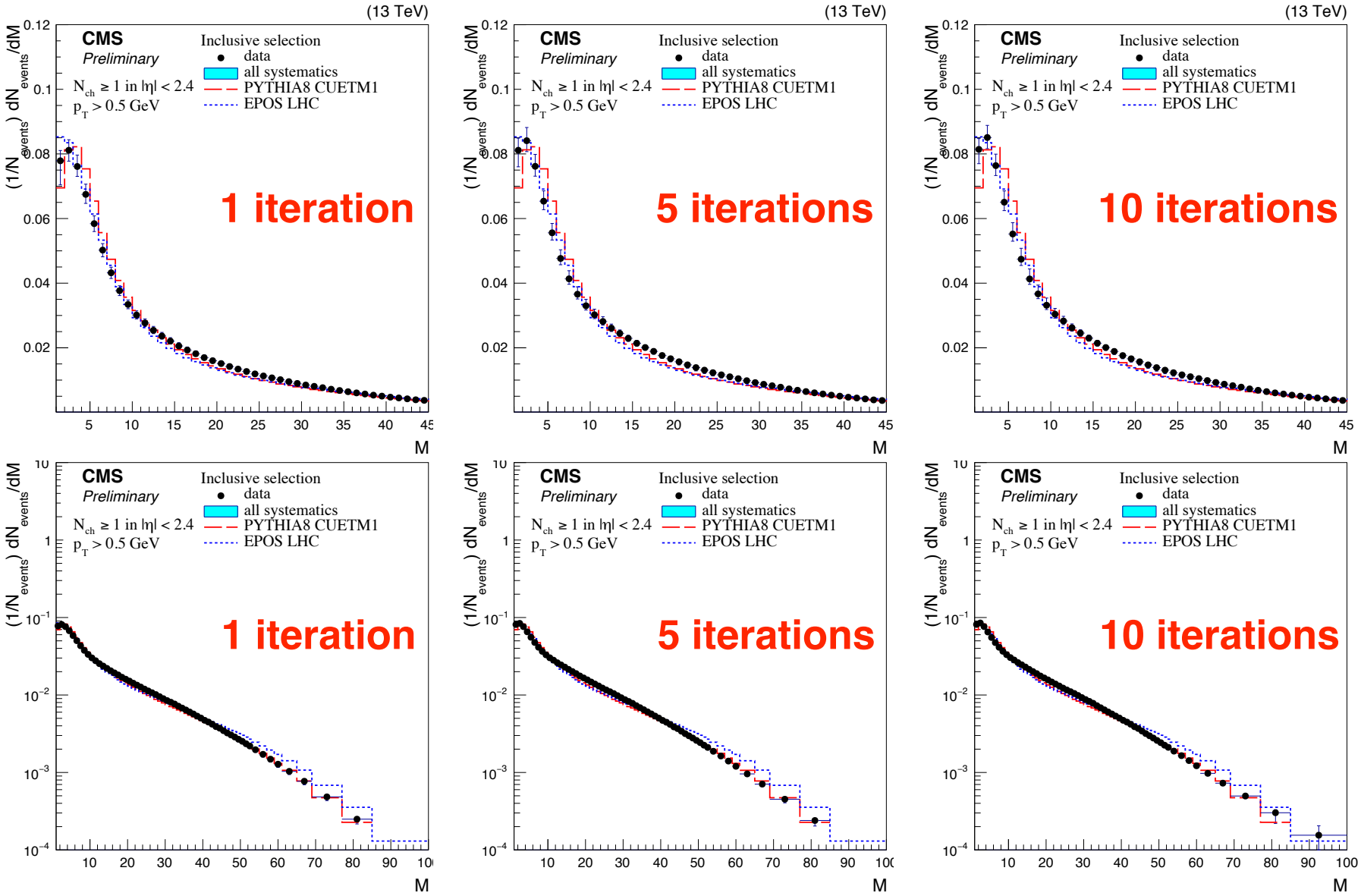




Multiplicity distributions (Inclusive event selection)

Unfolded distributions

Looks more stable as number of iterations increase



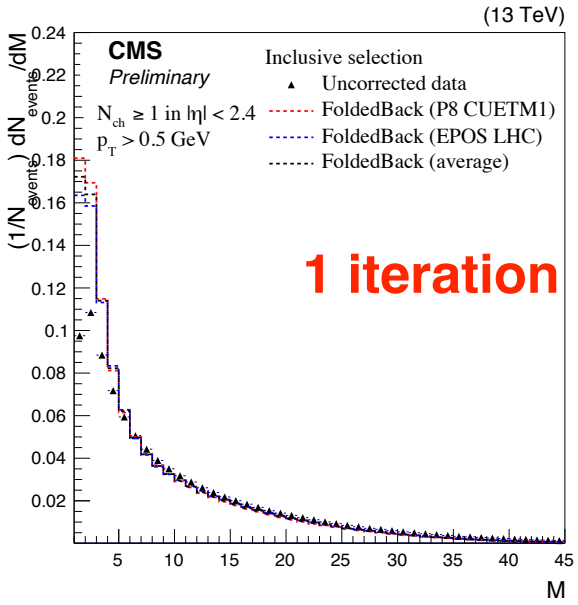
Multiplicity distributions (Inclusive event selection)

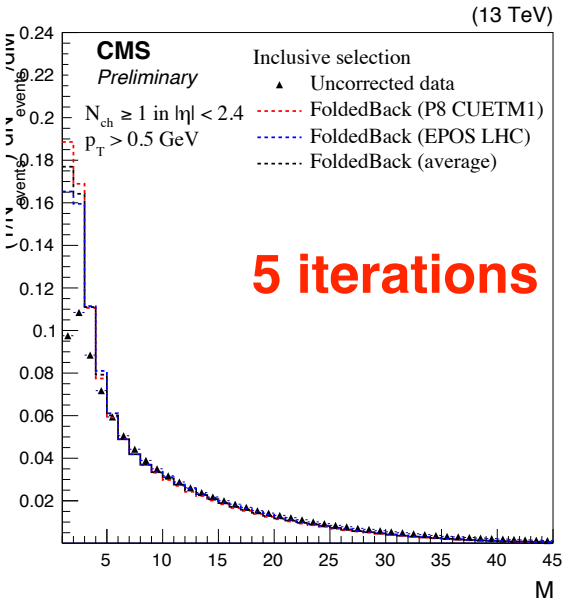
Backfolding

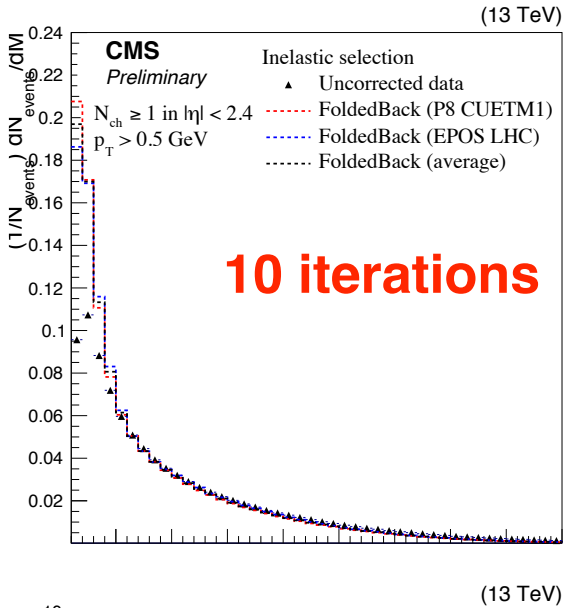
Stable but not good

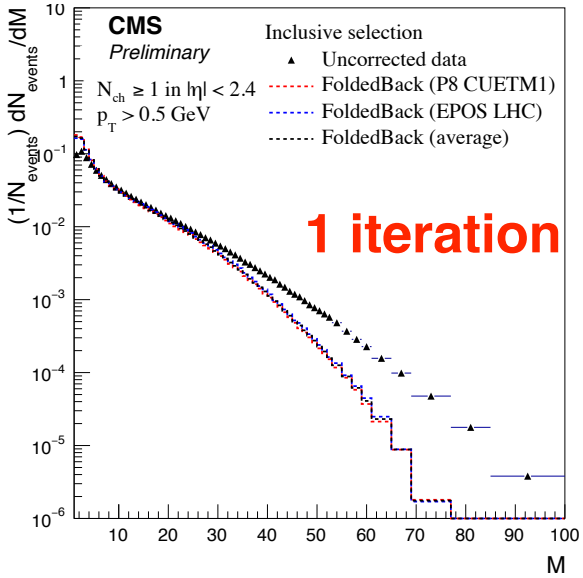
Merge high multiplicity bins?

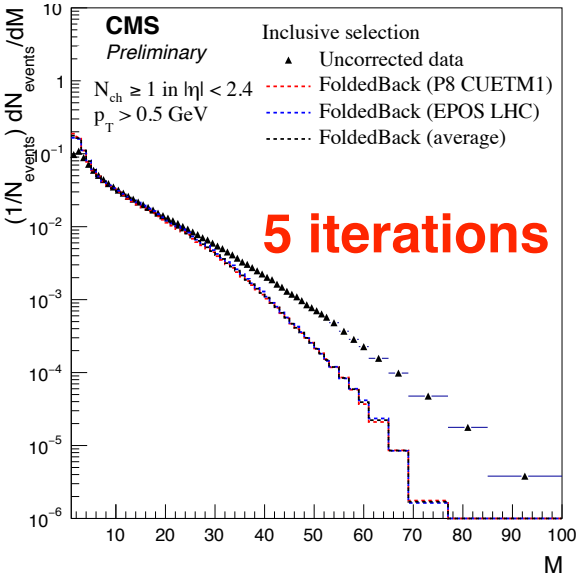
What about low multiplicity bins?

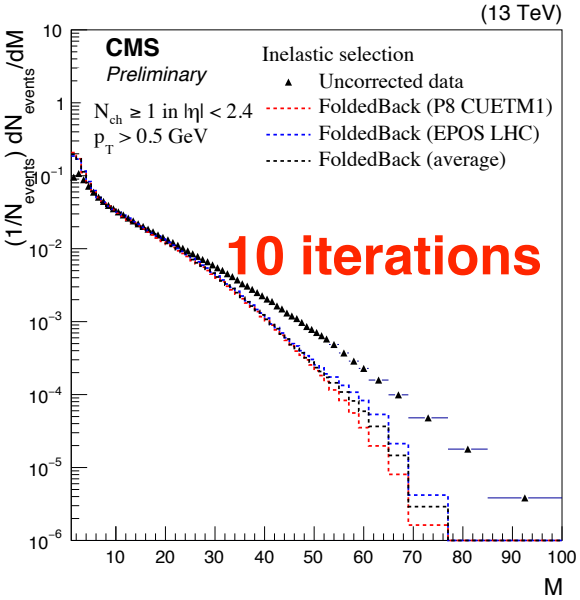




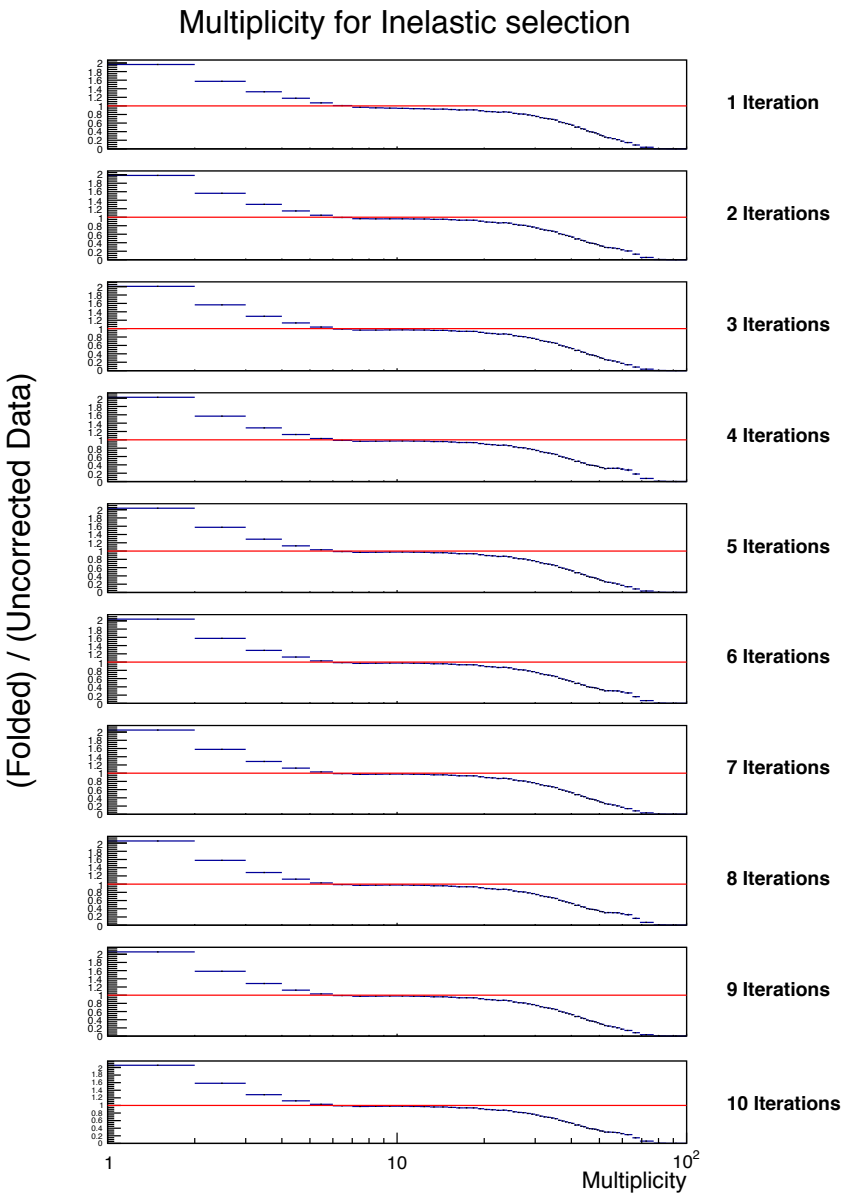


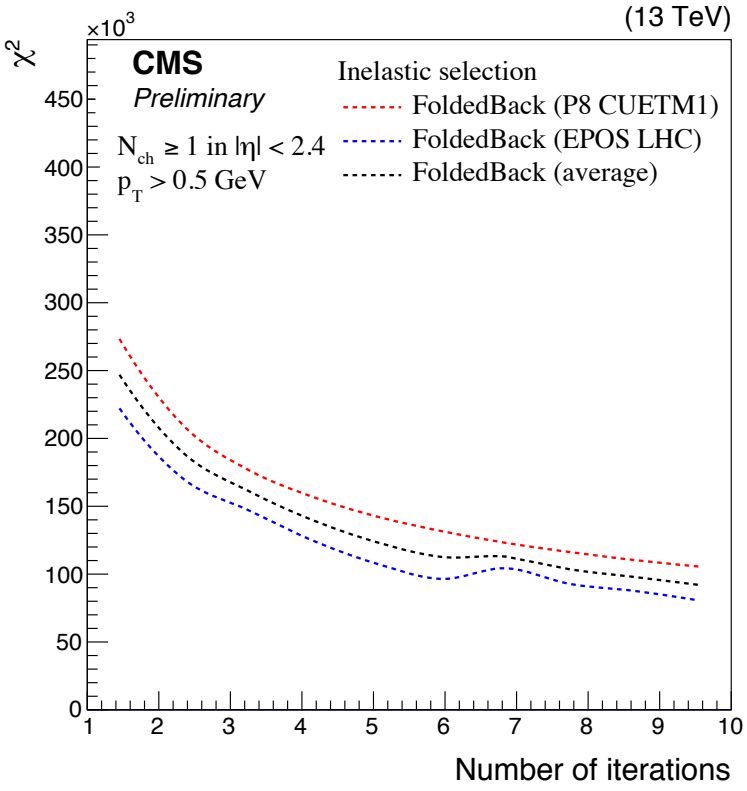


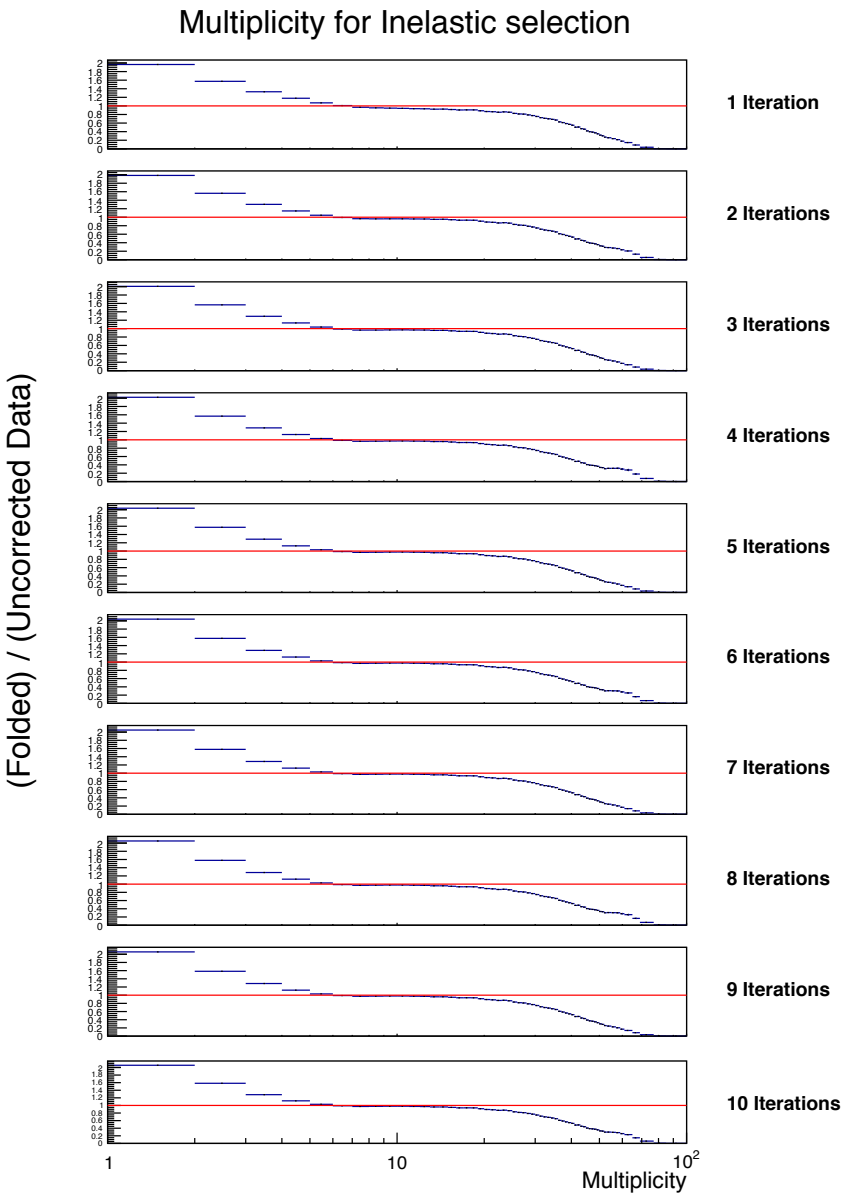




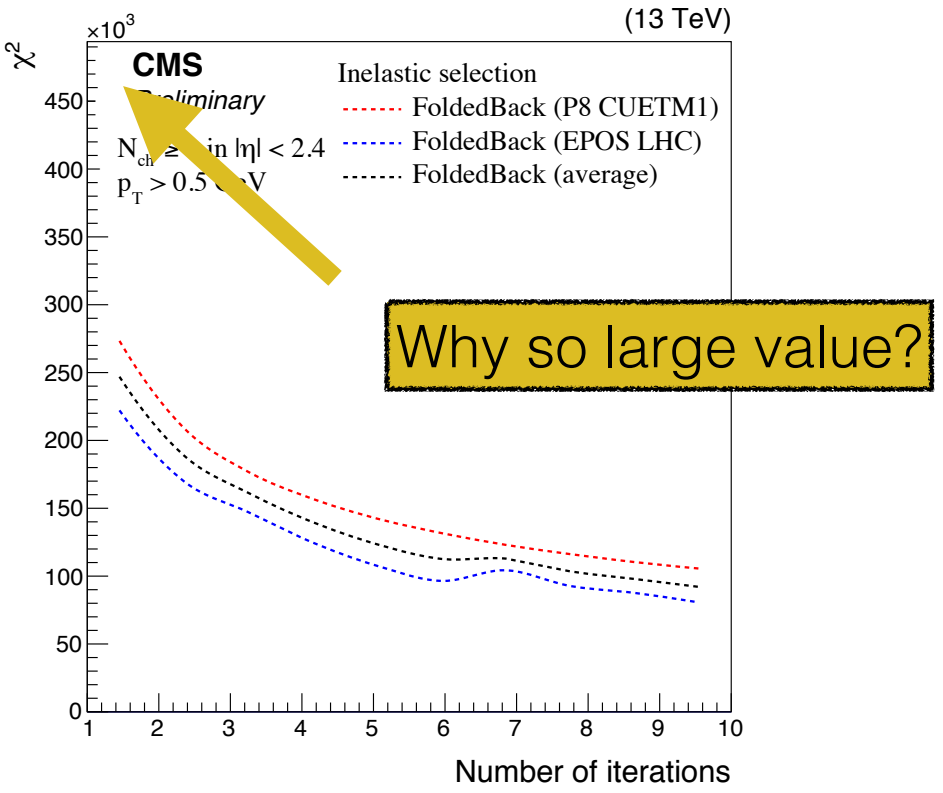
Backfolding





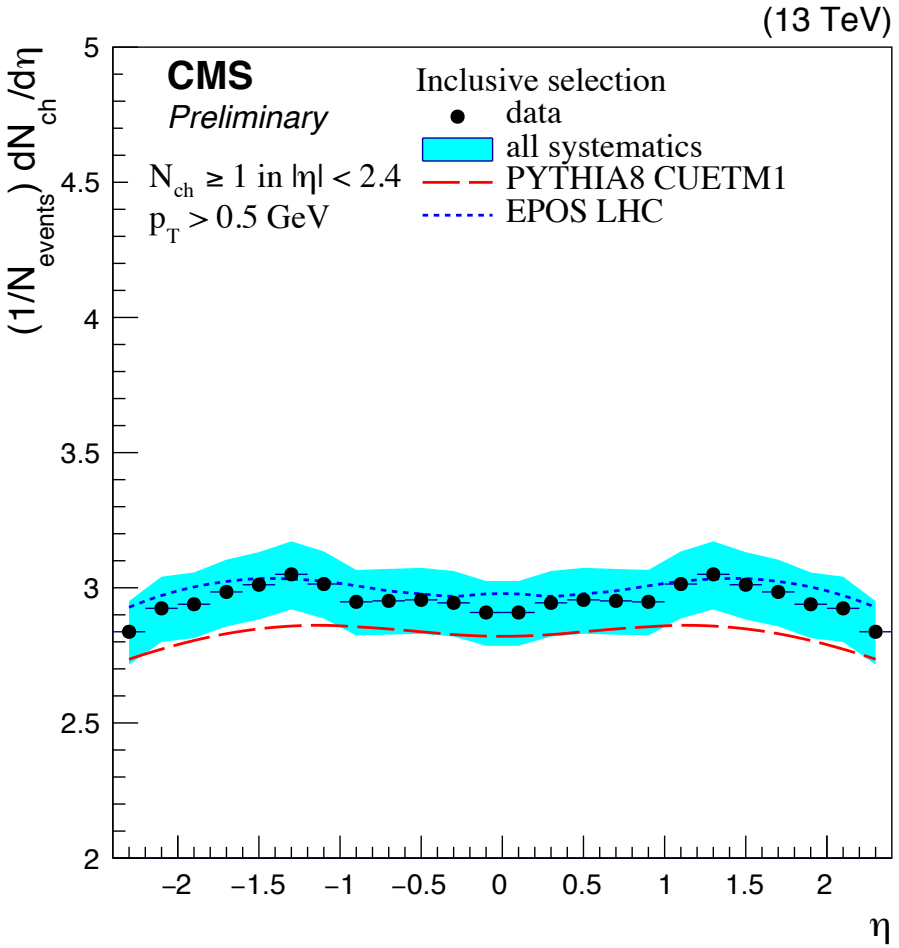


Backfolding

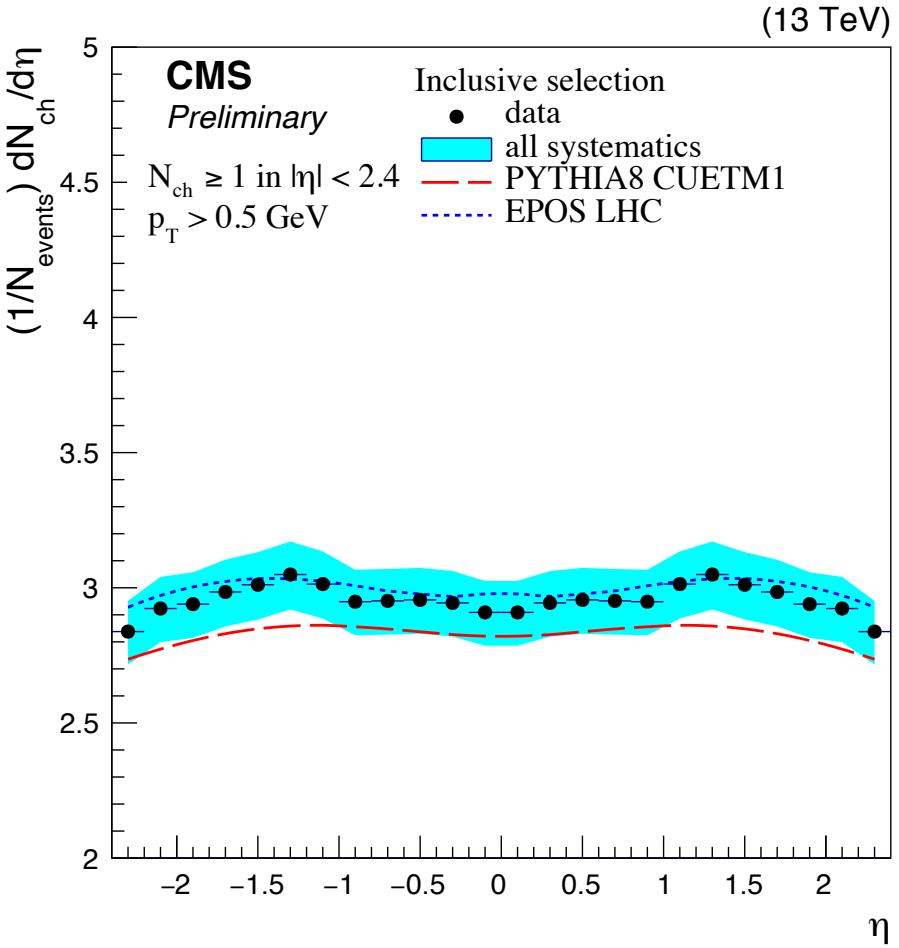


Comparison
Bin-By-Bin vs Unfolding

Pseudorapidity



Bin by Bin

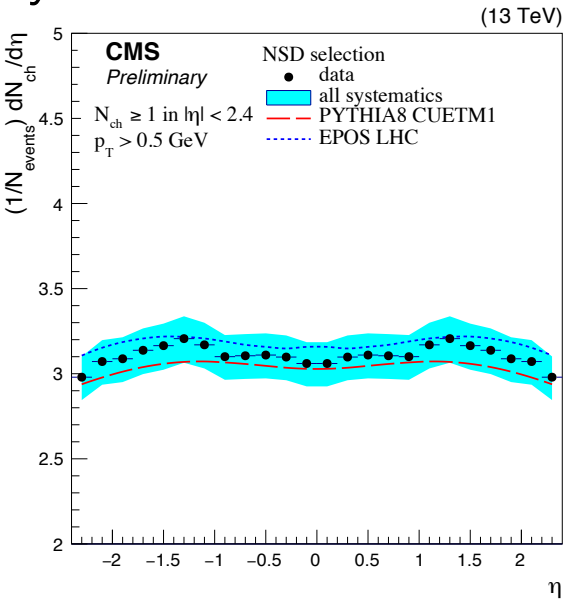


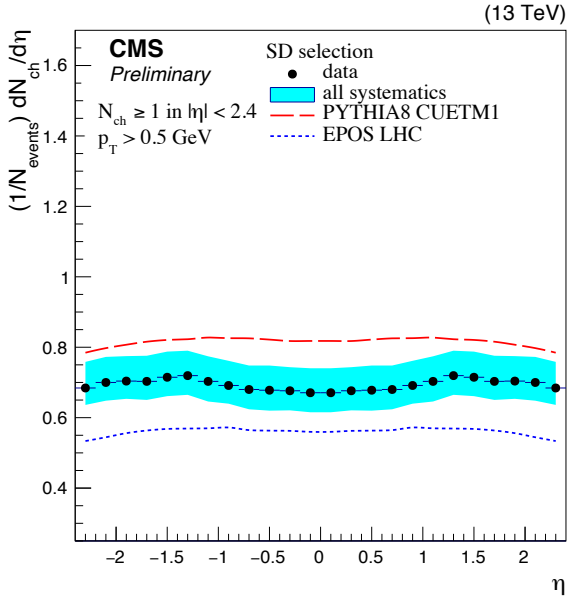
Unfolding 1 iteration

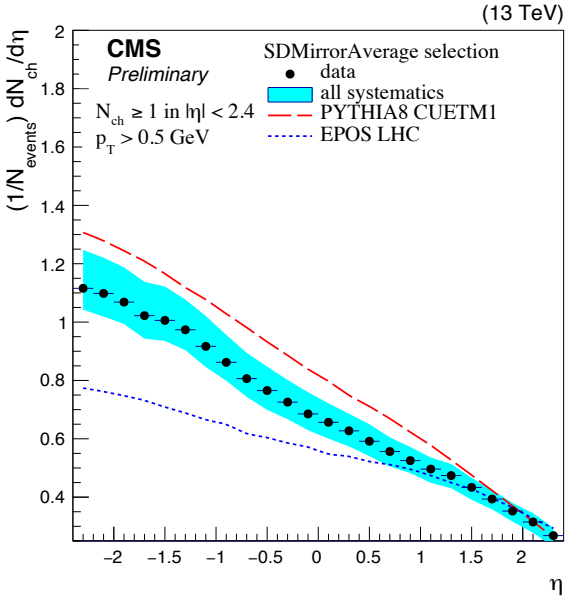
Pseudorapidity

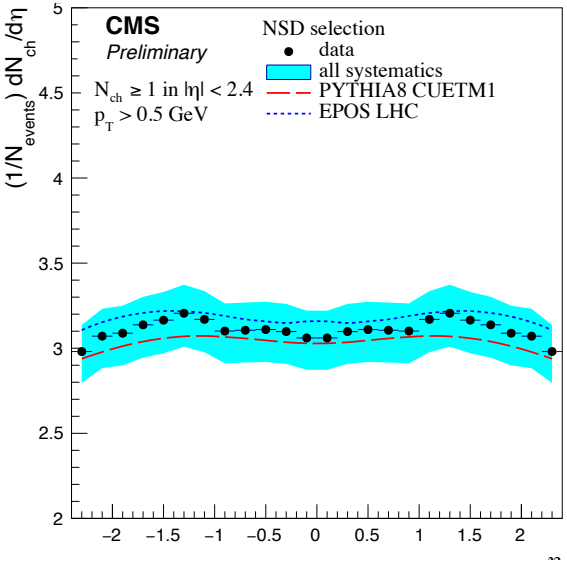
Bin By Bin

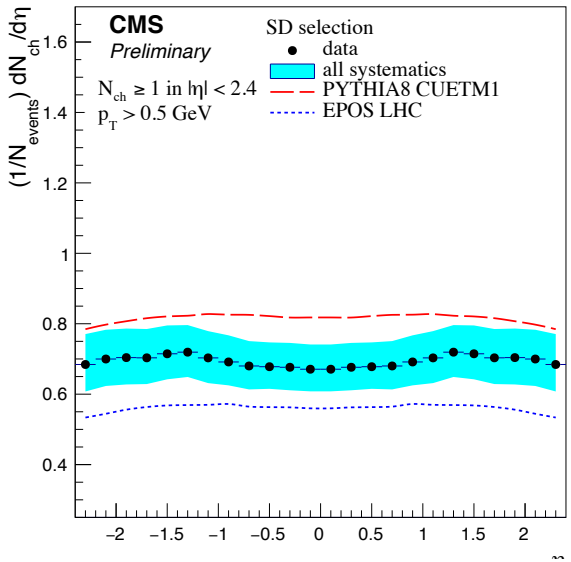
Unfolding 1 iteration

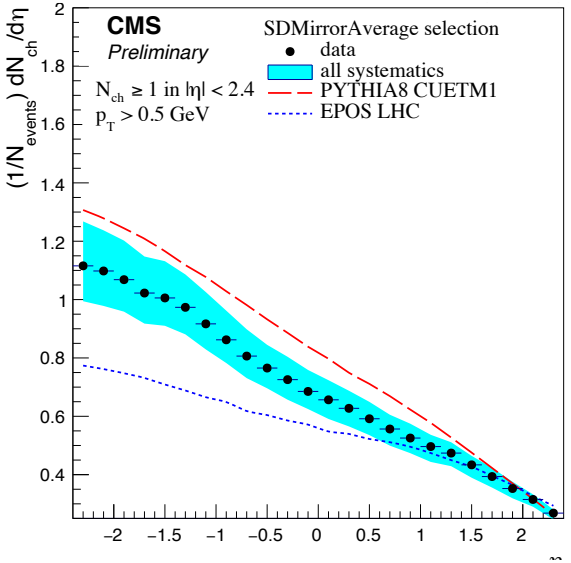








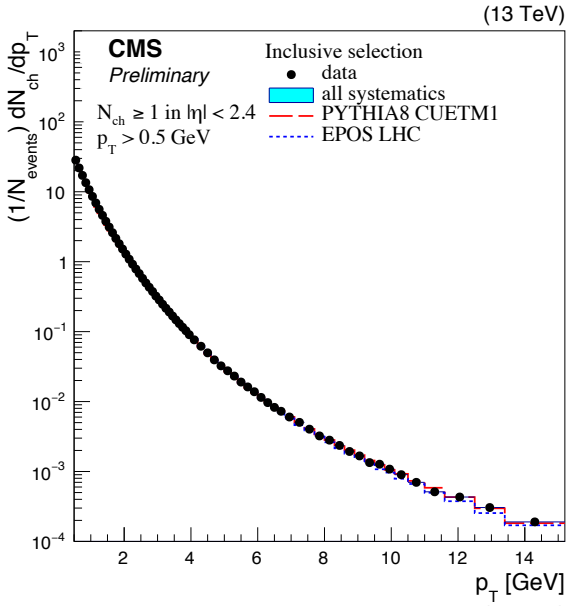


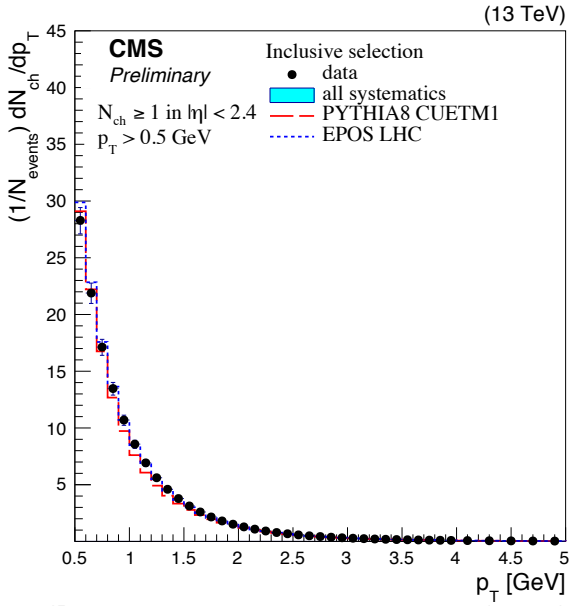


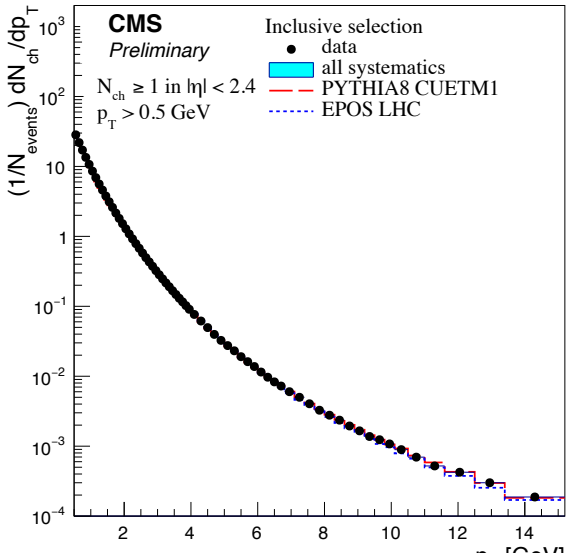
Transverse momentum

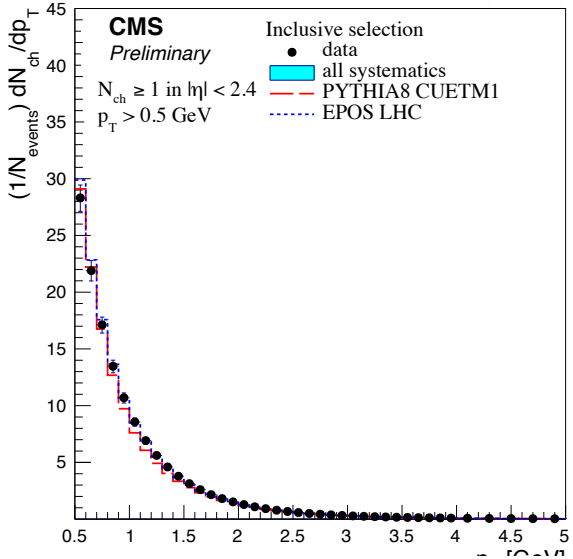
Bin By Bin

Unfolding
1 iteration





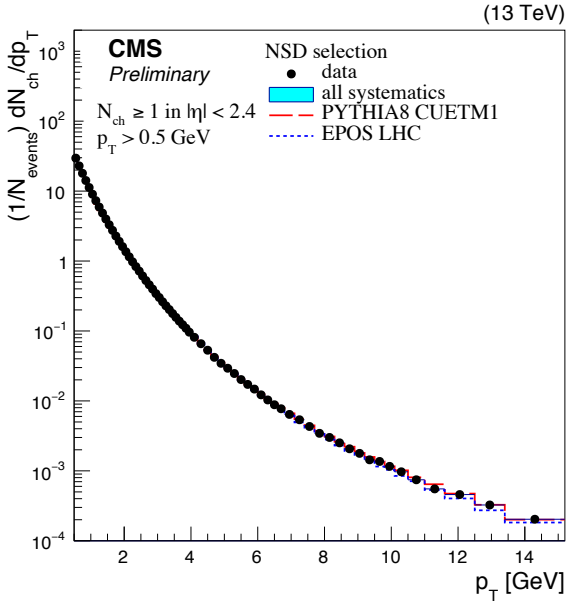


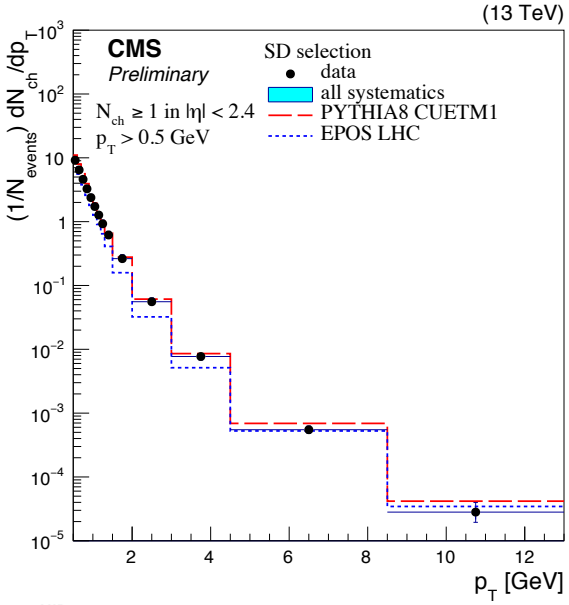


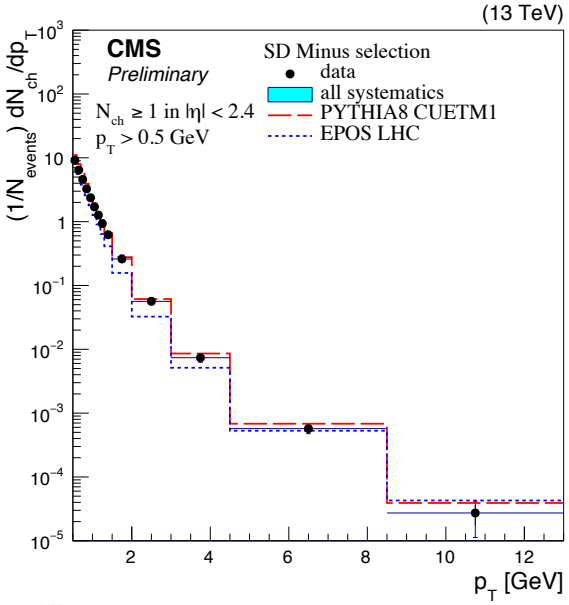
Transverse momentum (Log scale)

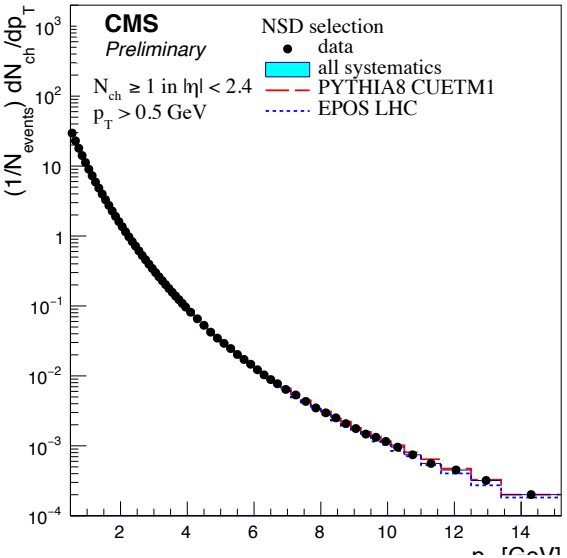
Bin By Bin

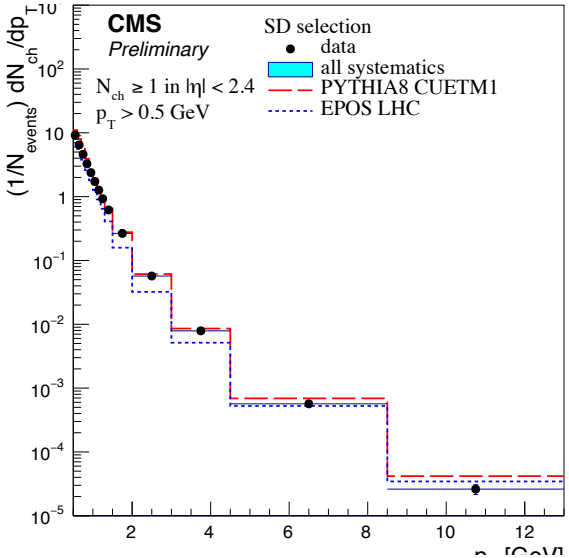
Unfolding 1 iteration

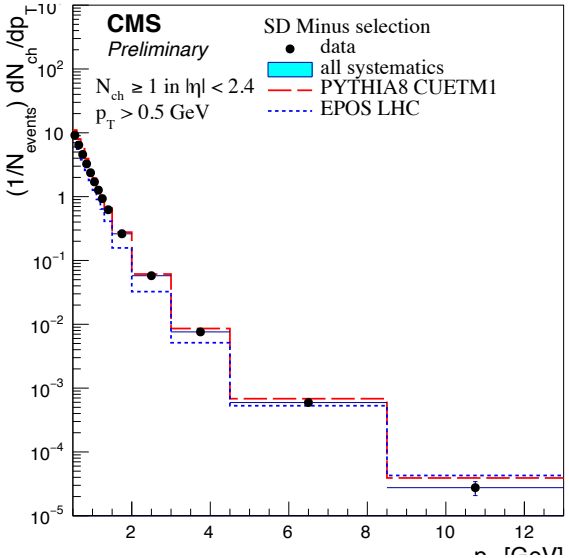








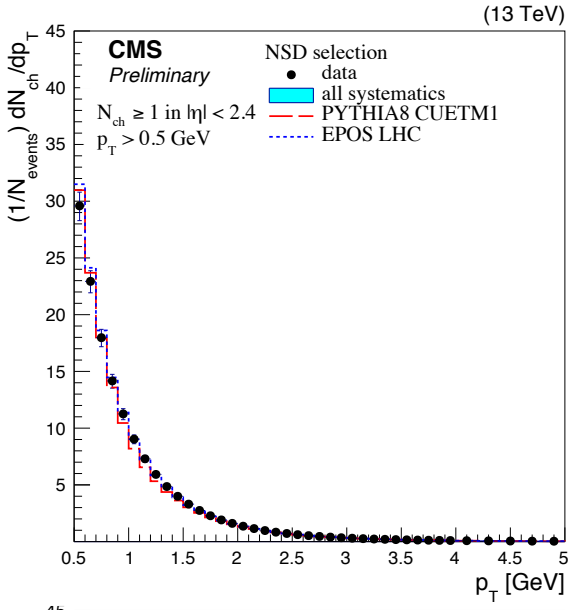


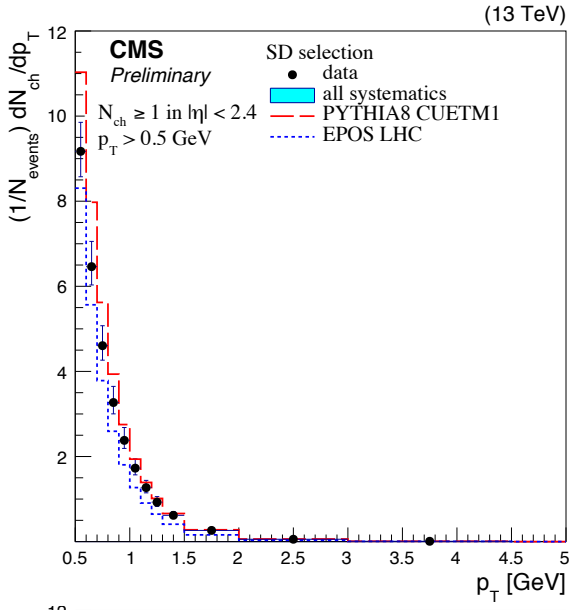


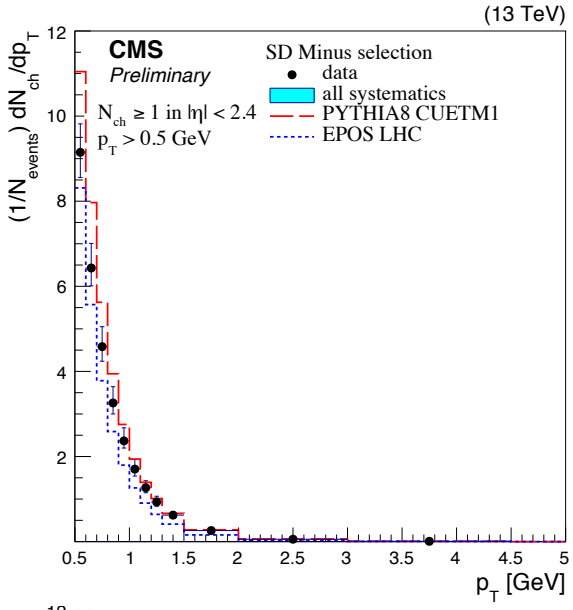
Transverse momentum (Liner scale)

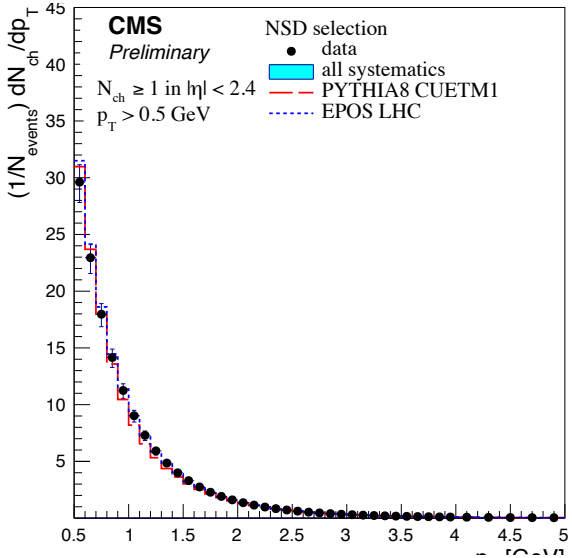
Bin By Bin

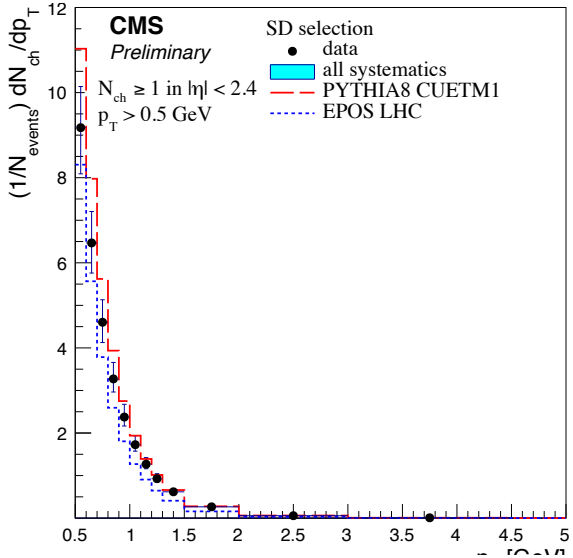
Unfolding 1 iteration

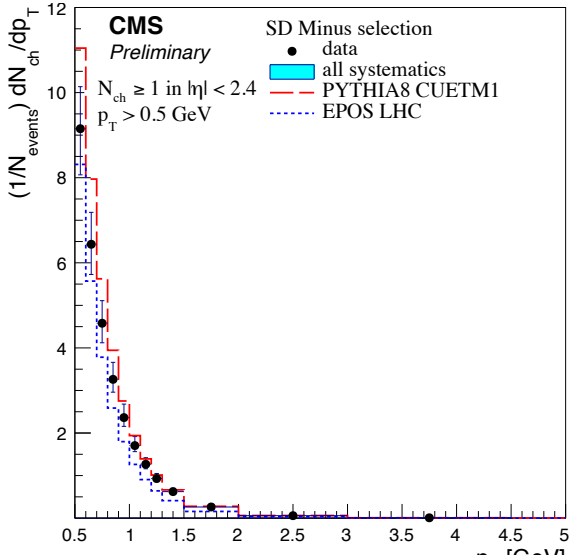








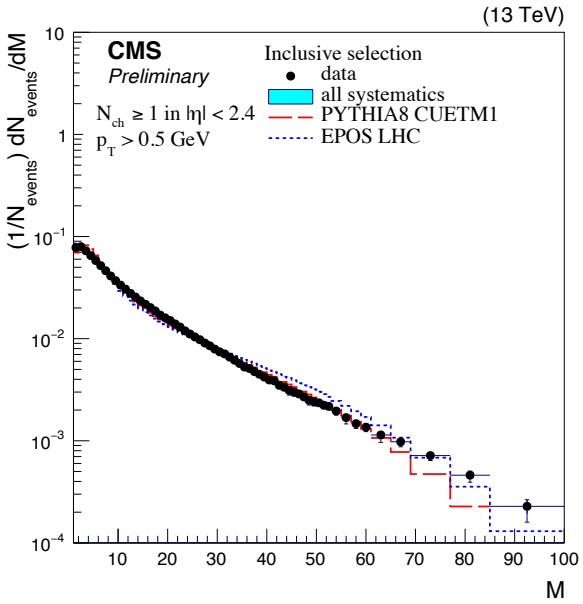


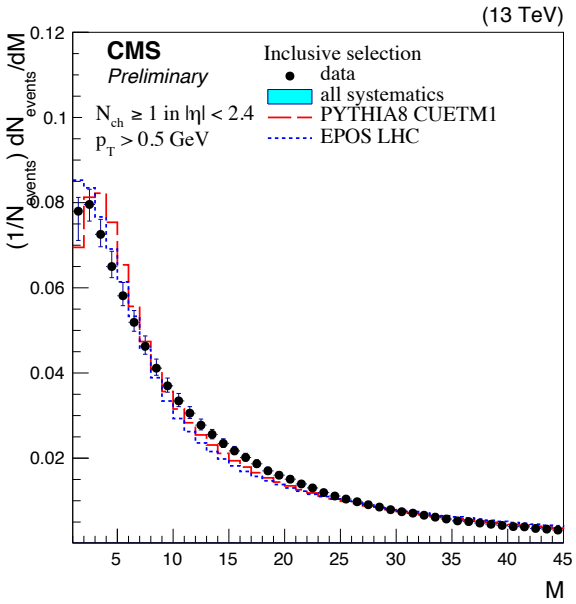


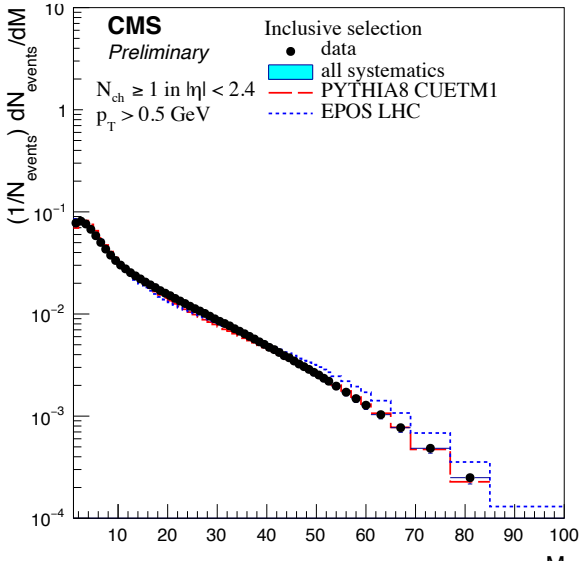
Multiplicity distributions

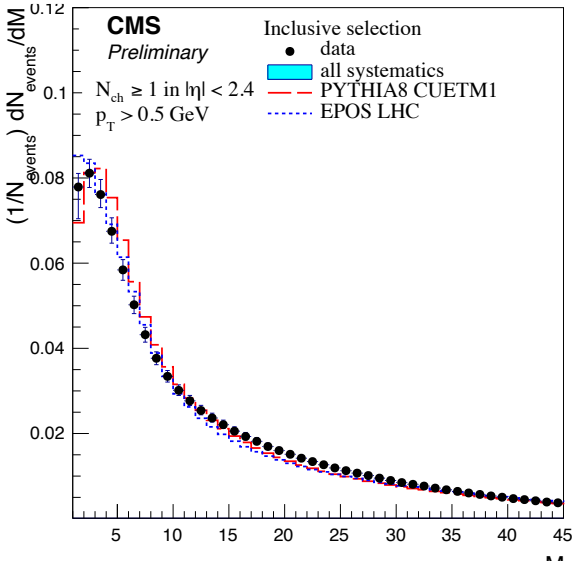
Bin By Bin

Unfolding
1 iteration





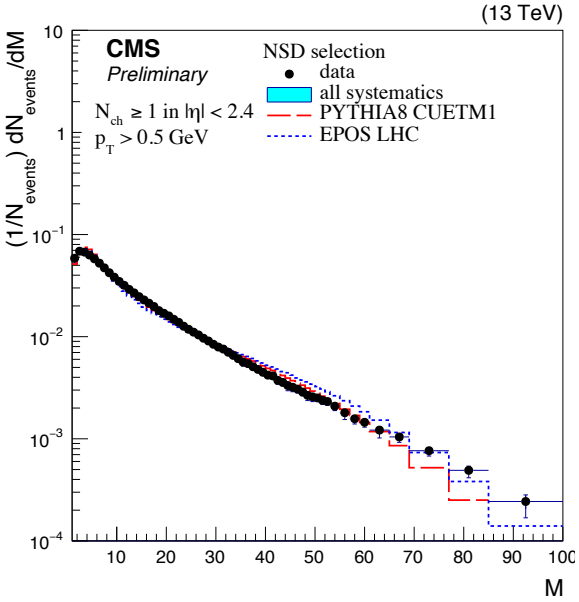


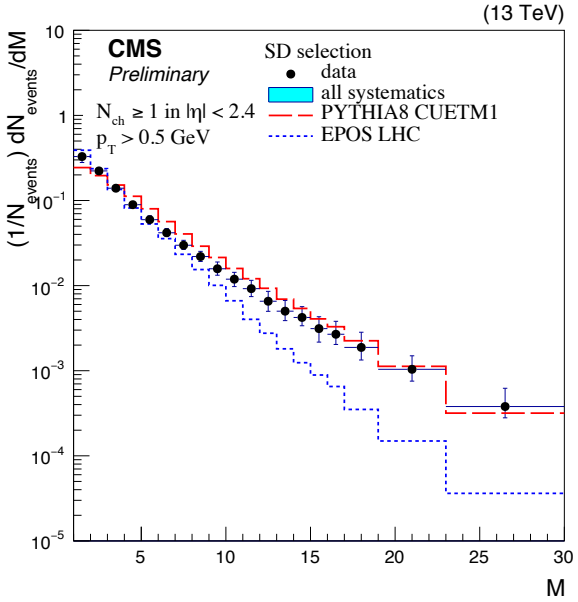


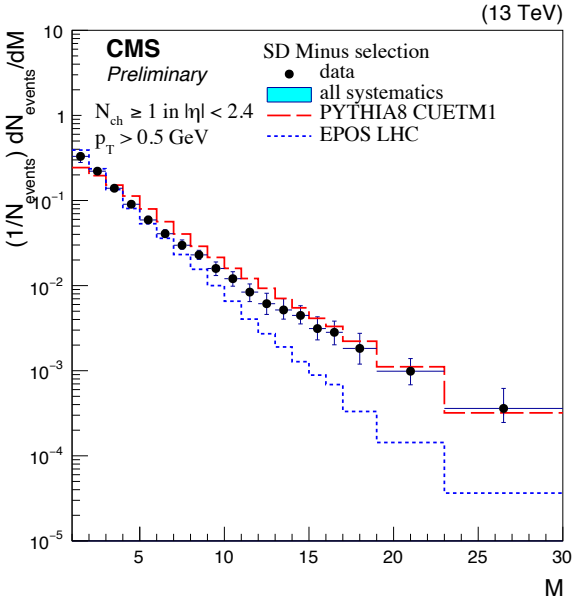
Multiplicity distributions (Log scale)

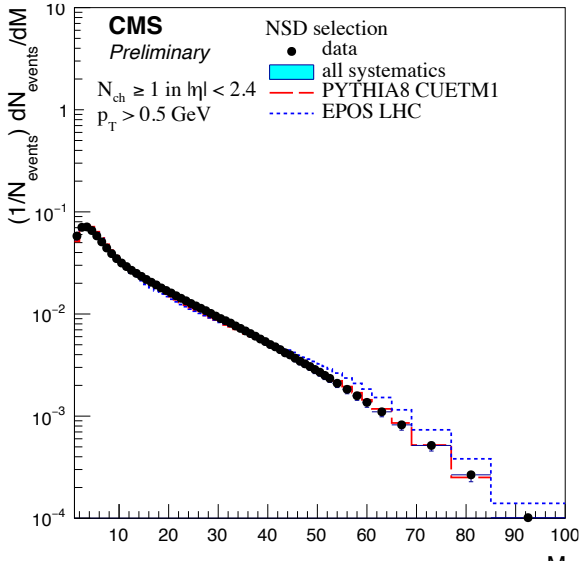
Bin By Bin

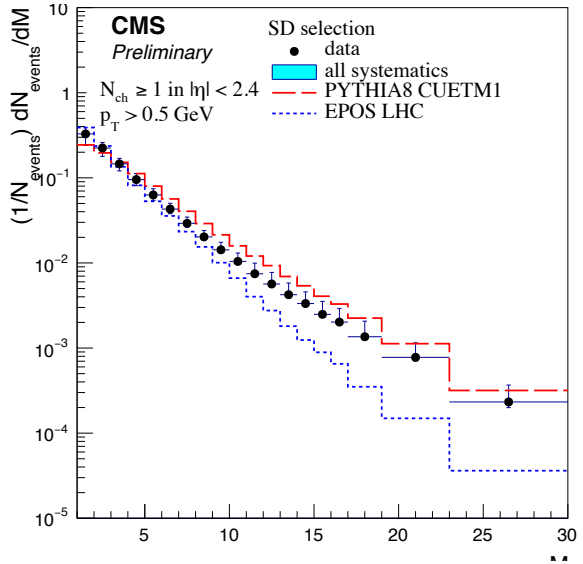
Unfolding 1 iteration

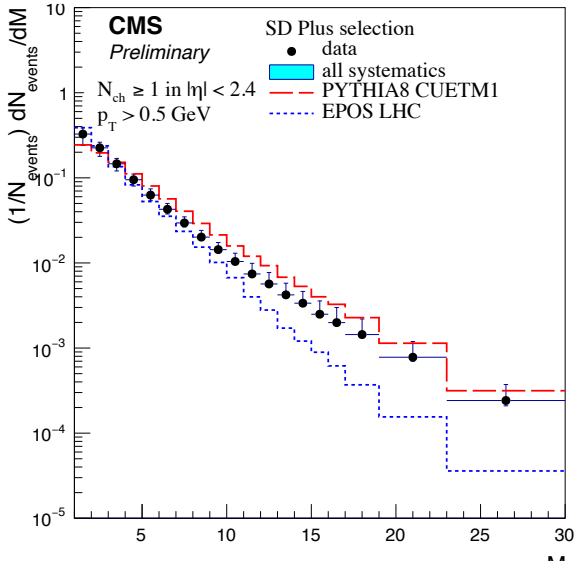








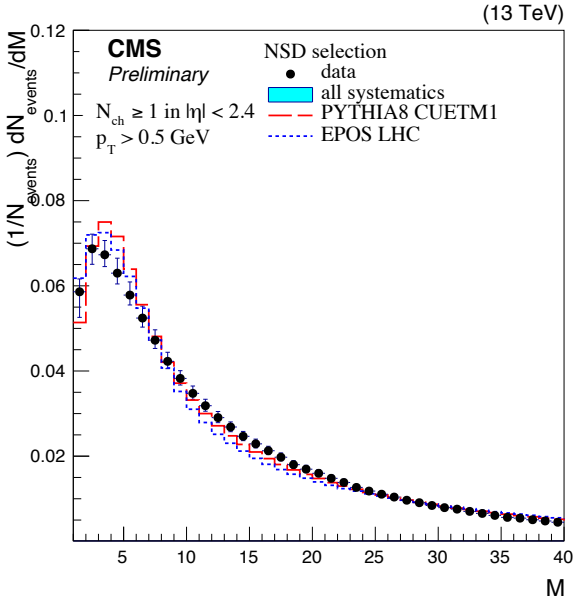


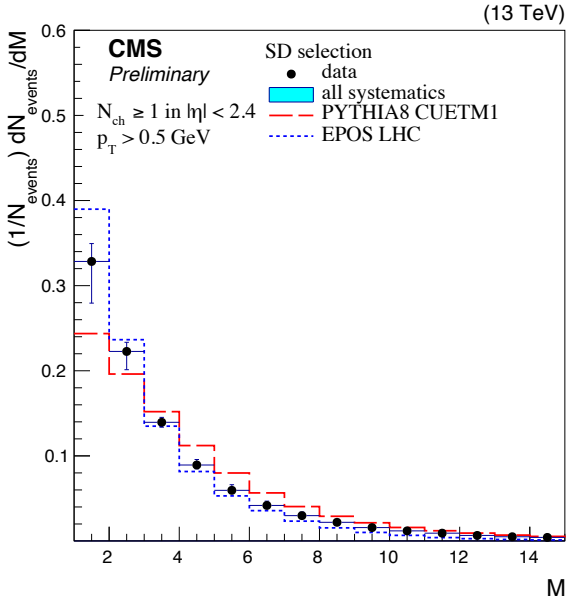


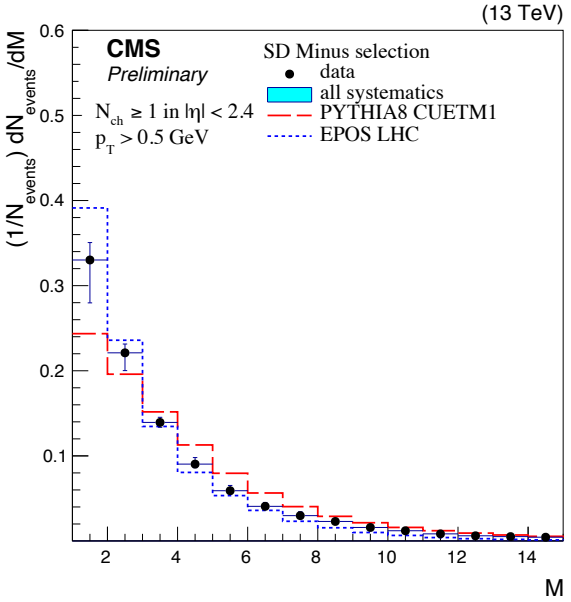
Multiplicity distributions (Linear scale)

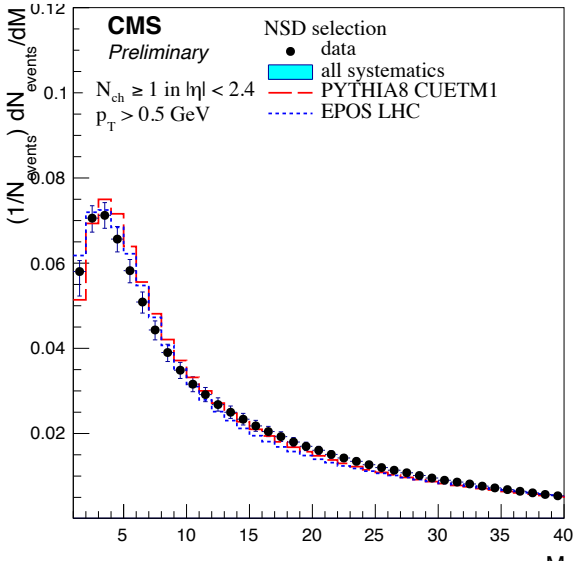
Bin By Bin

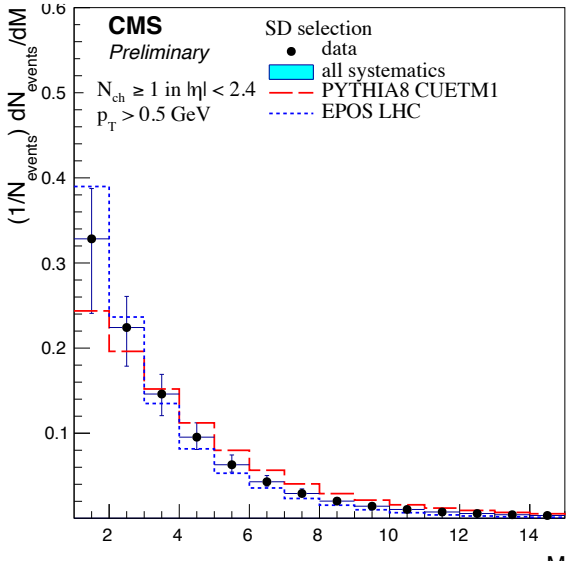
Unfolding 1 iteration

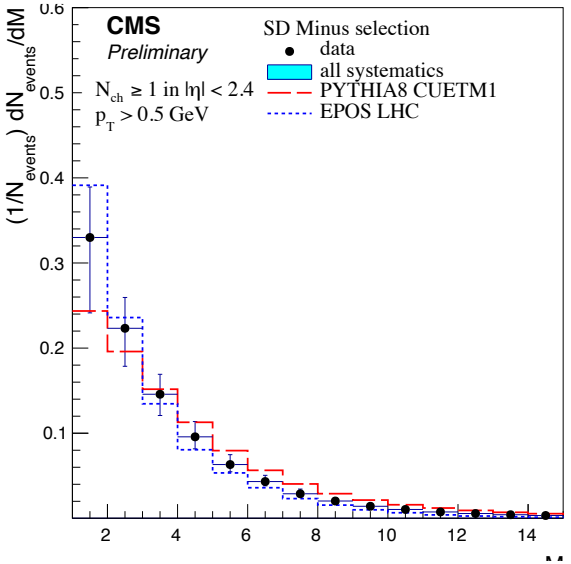










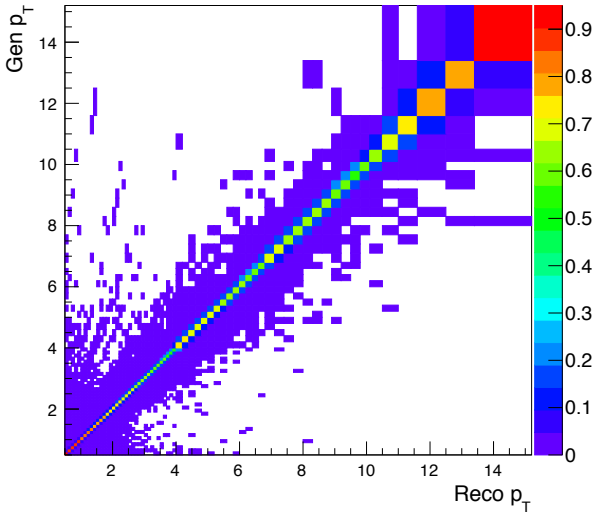


Additional Material

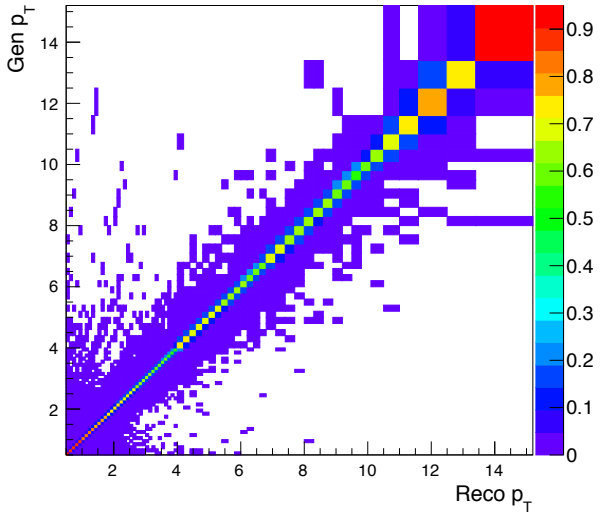
RM for transverse momentum distributions in different event selections

EPOS

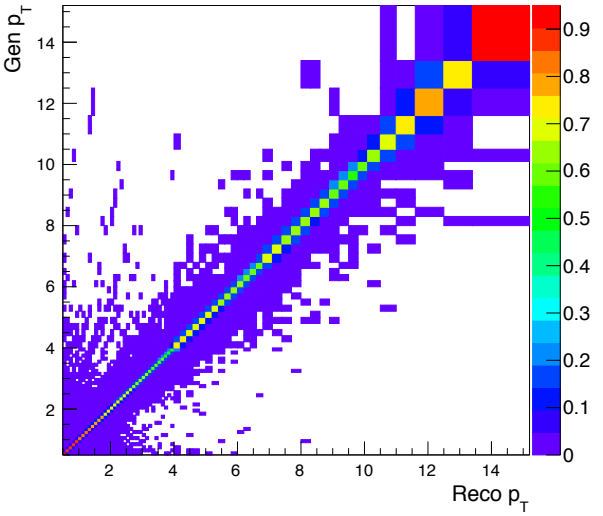
Response Matrix: p_T for Inclusive



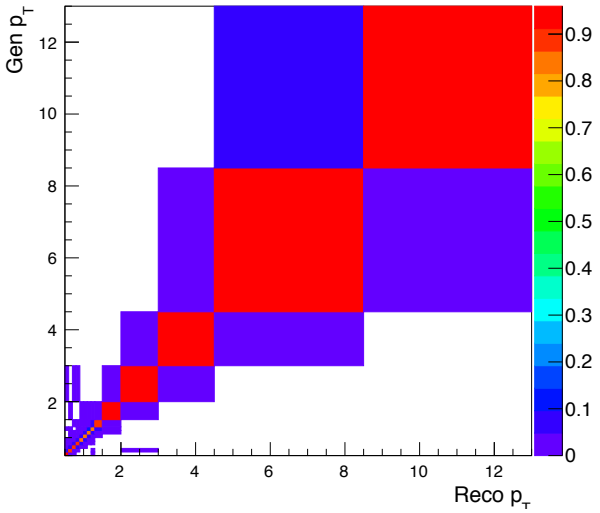
Response Matrix: p_T for Inelastic



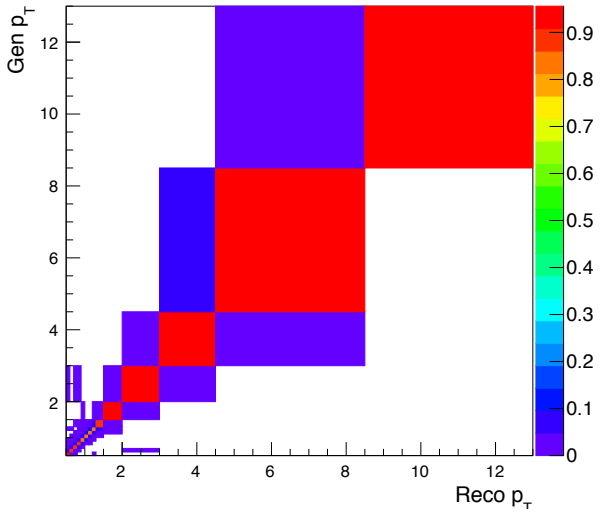
Response Matrix: p_T for NSD



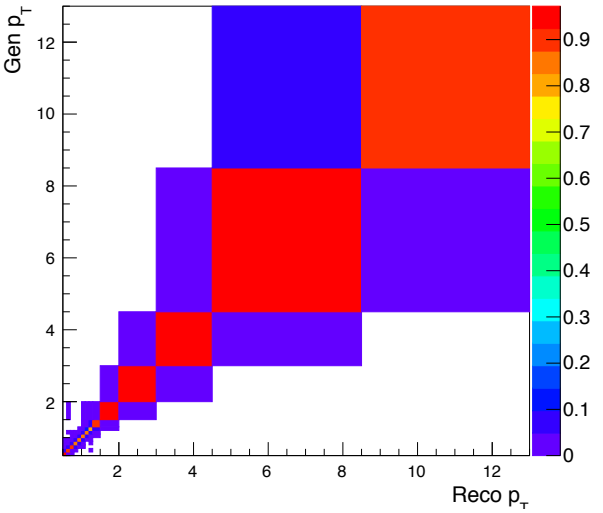
Response Matrix: p_T for SD



Response Matrix: p_T for SD minus



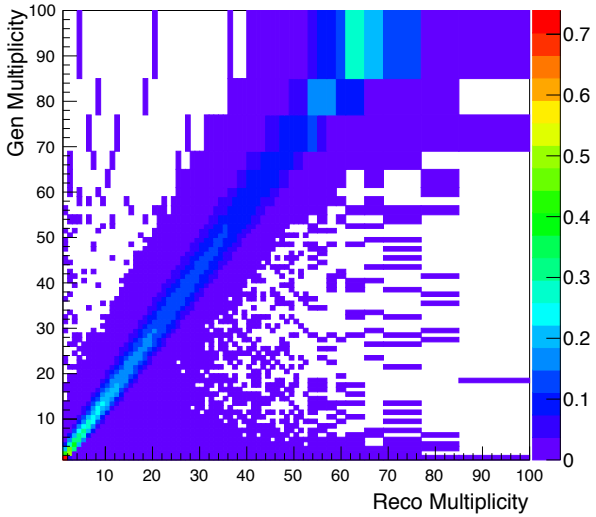
Response Matrix: p_T for SD plus



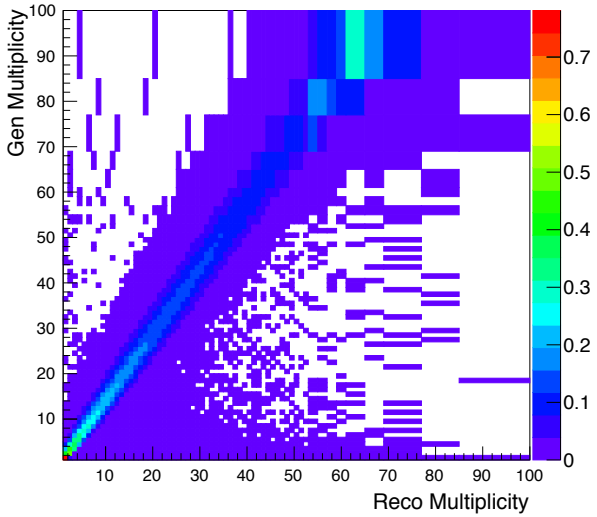
RM for Multiplicity distributions in different event selections

EPOS

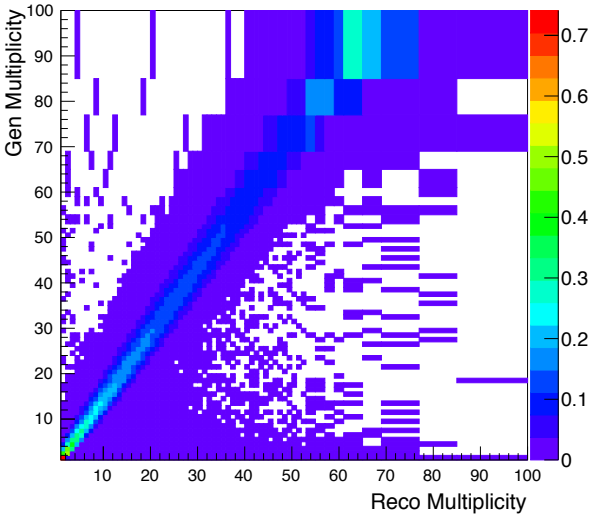
Response Matrix: Multiplicity for Inclusive



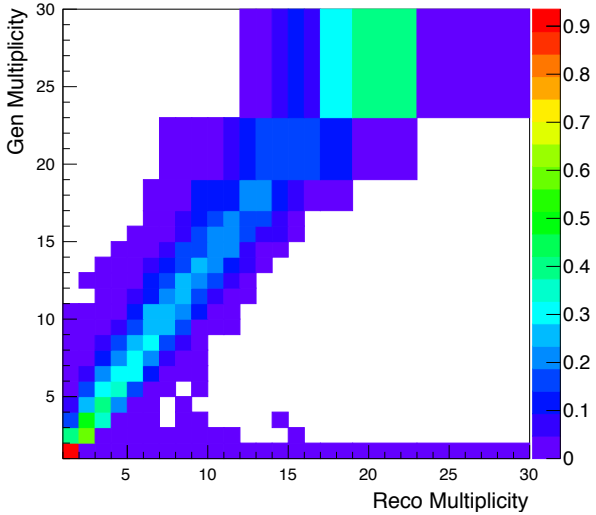
Response Matrix: Multiplicity for Inelastic



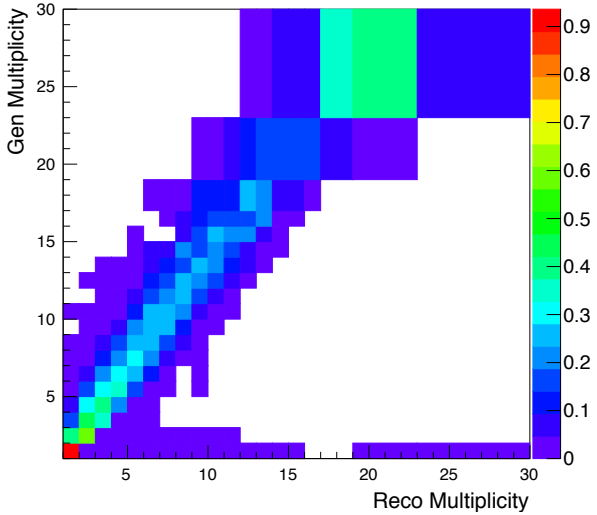
Response Matrix: Multiplicity for NSD



Response Matrix: Multiplicity for SD



Response Matrix: Multiplicity for SD minus



Response Matrix: Multiplicity for SD plus