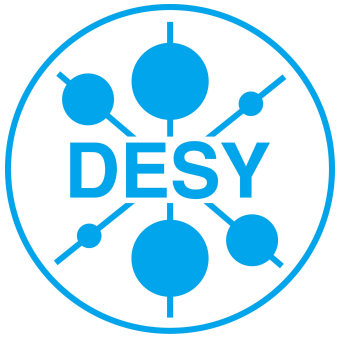
Pseudorapidity spectra in different final states at 13TeV



Juan Manuel Grados Luyando

on behalf of the CMS Collaboration

Deutsches Elektronen-Synchrotron (DESY), Hamburg

DIS 2016: XXIV International Workshop on Deep-Inelastic Scattering and Related Subjects

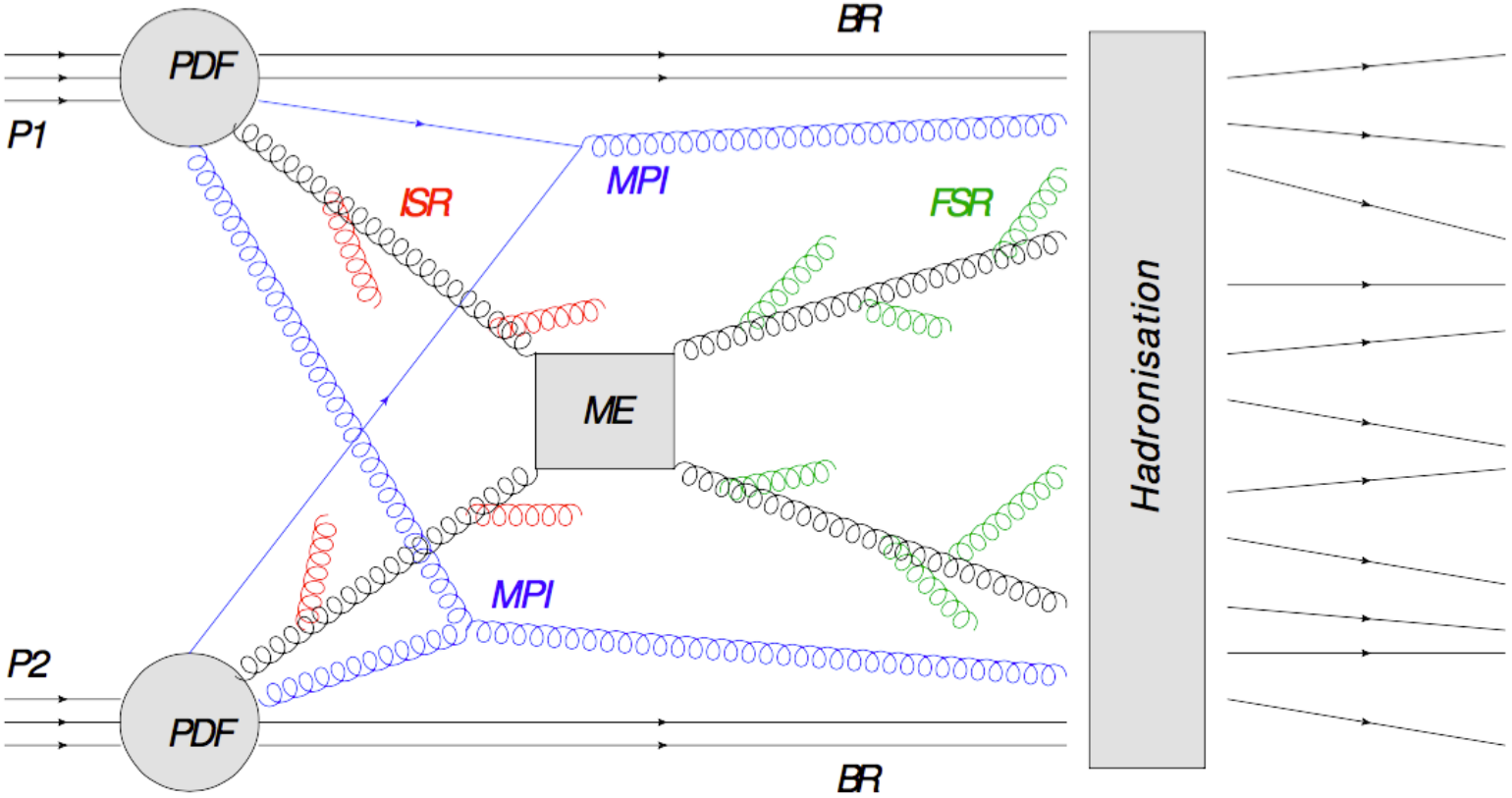
Hamburg, Germany

HELMHOLTZ GEMEINSCHAFT

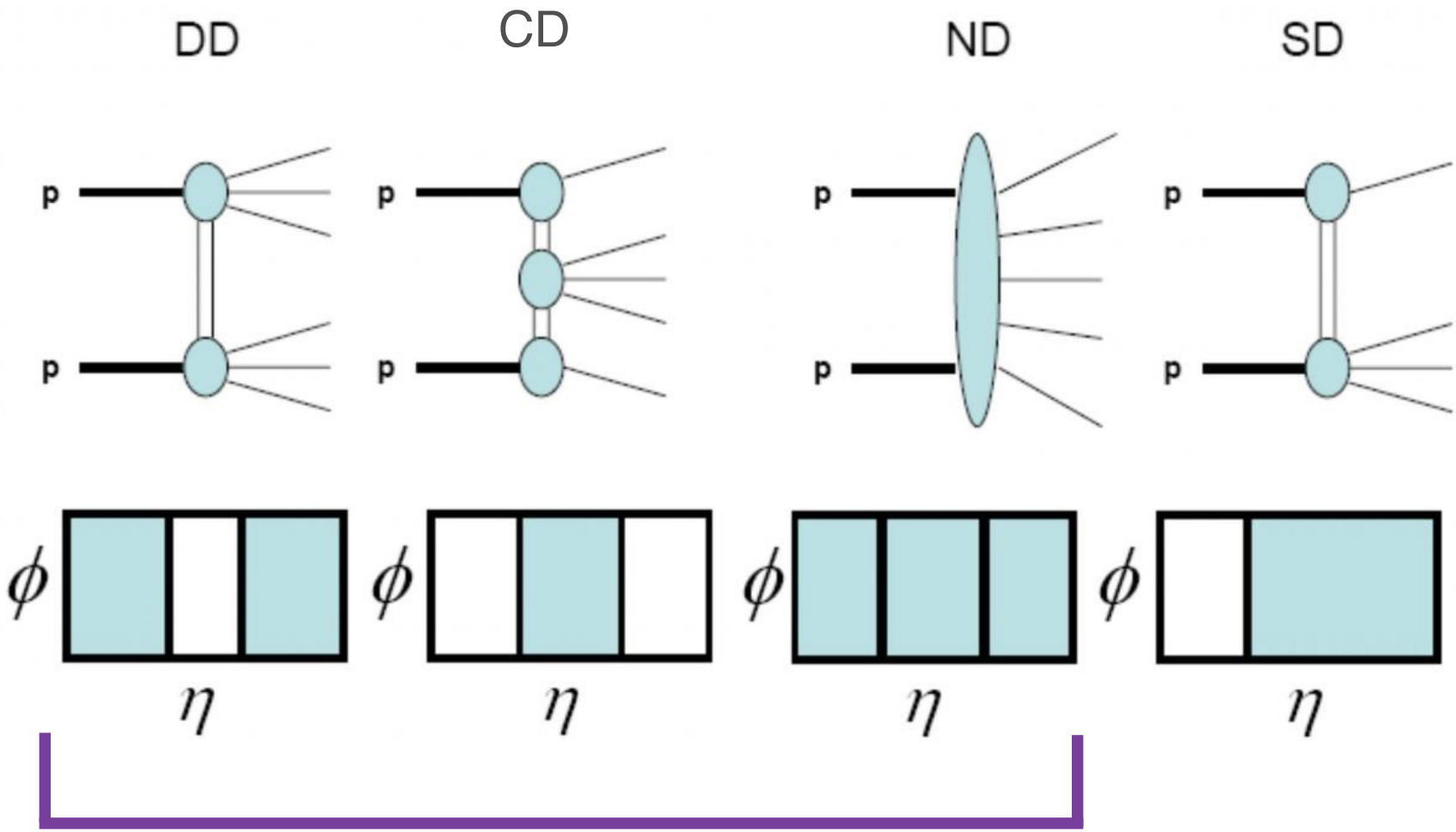
CMS PAS FSQ-15-008

Motivation

- Study the different components of particle production
- Constrain and tune the models
- Study transition from perturbative to non-perturbative region



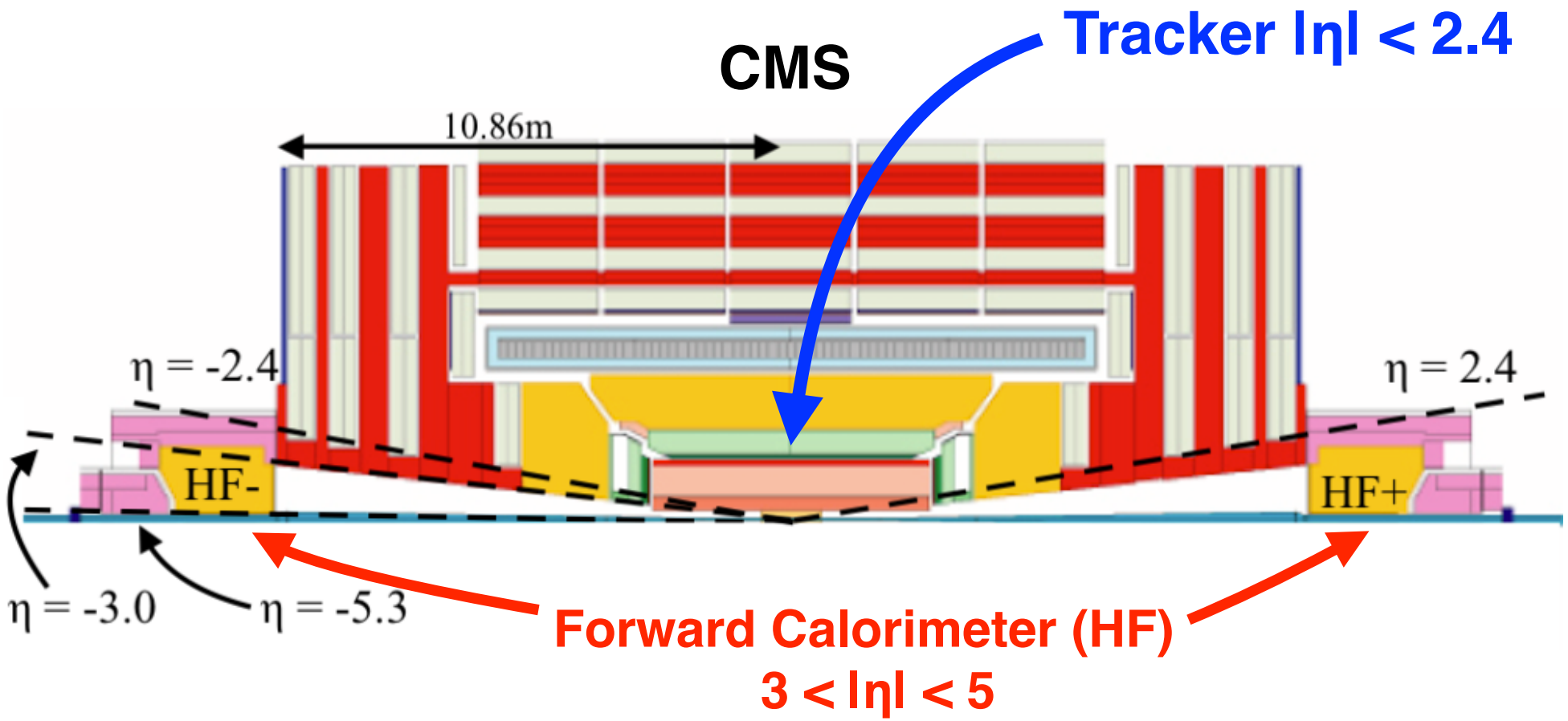
Inelastic components



Non-Single Diffractive (NSD)

Measure average number of particles per pseudorapidity unit

The Compact Muon Solenoid (CMS) detector



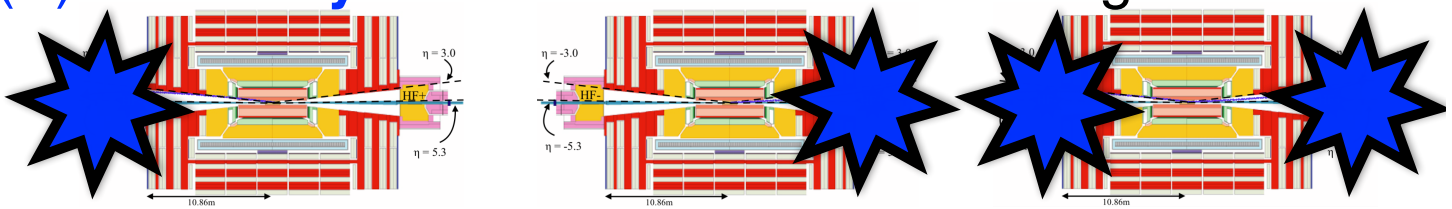
- Trigger: **both** beams crossing at the Interaction Point (IP)
- Activity in the **Forward Regions** (HF)

Phase space definition at stable particle level

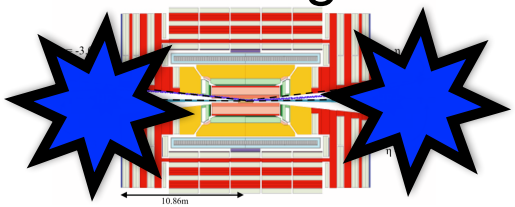
(A) At least 1 charged particle $\begin{cases} p_T > 0.5 \text{ GeV} \\ |\eta| < 2.4 \end{cases}$

- ✦ **Activity**: at least 1 particle with E > 5 GeV
- ✦ **Veto**: no particle with E > 5 GeV

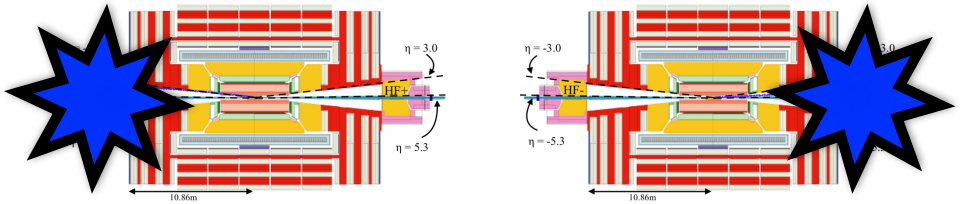
- **Inclusive**: (A)
- **Inelastic enhanced**: (A) **+ Activity** in **at least one** Forward Region



- **NSD enhanced**: (A) **+ Activity** in **both** Forward Regions

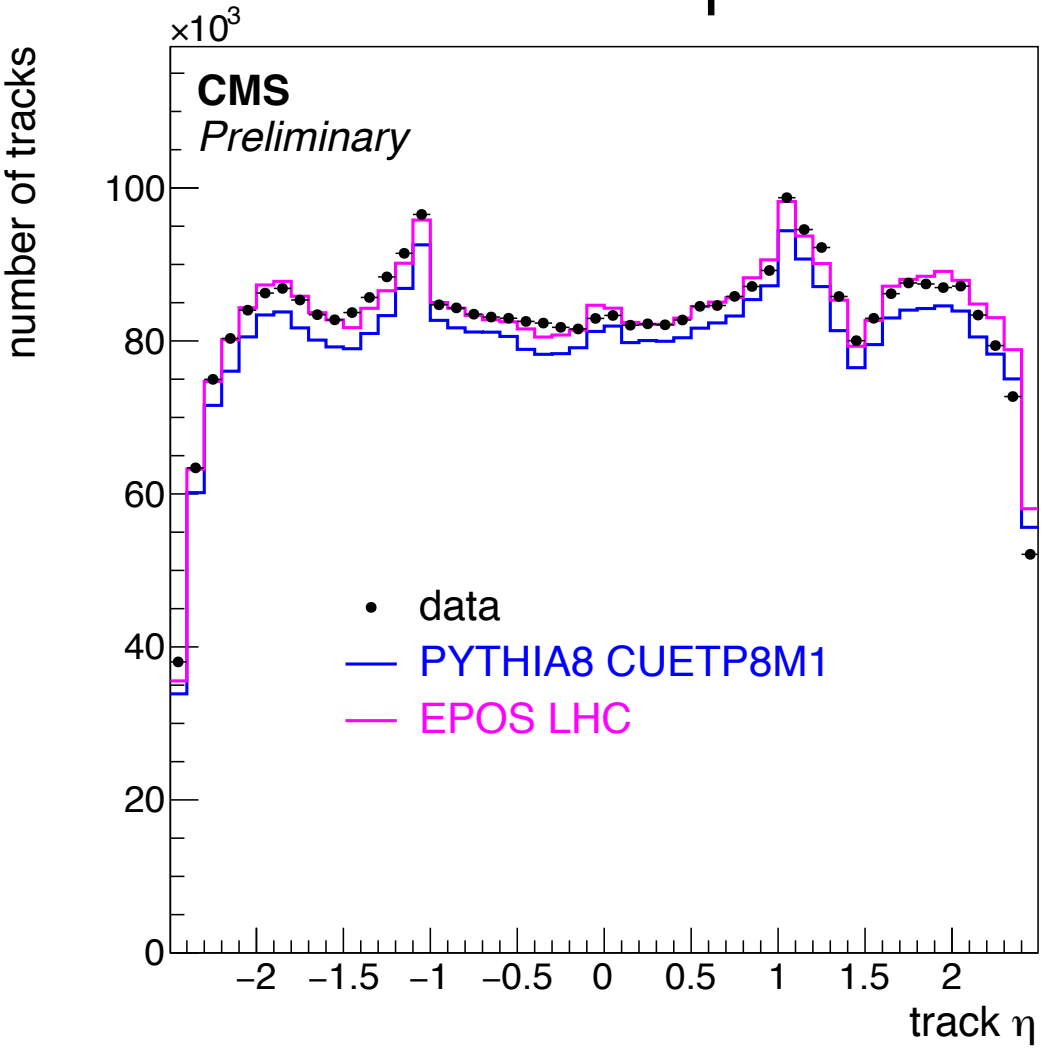


- **SD enhanced**: (A) + **Activity** in one Forward Region **and Veto** in the other side

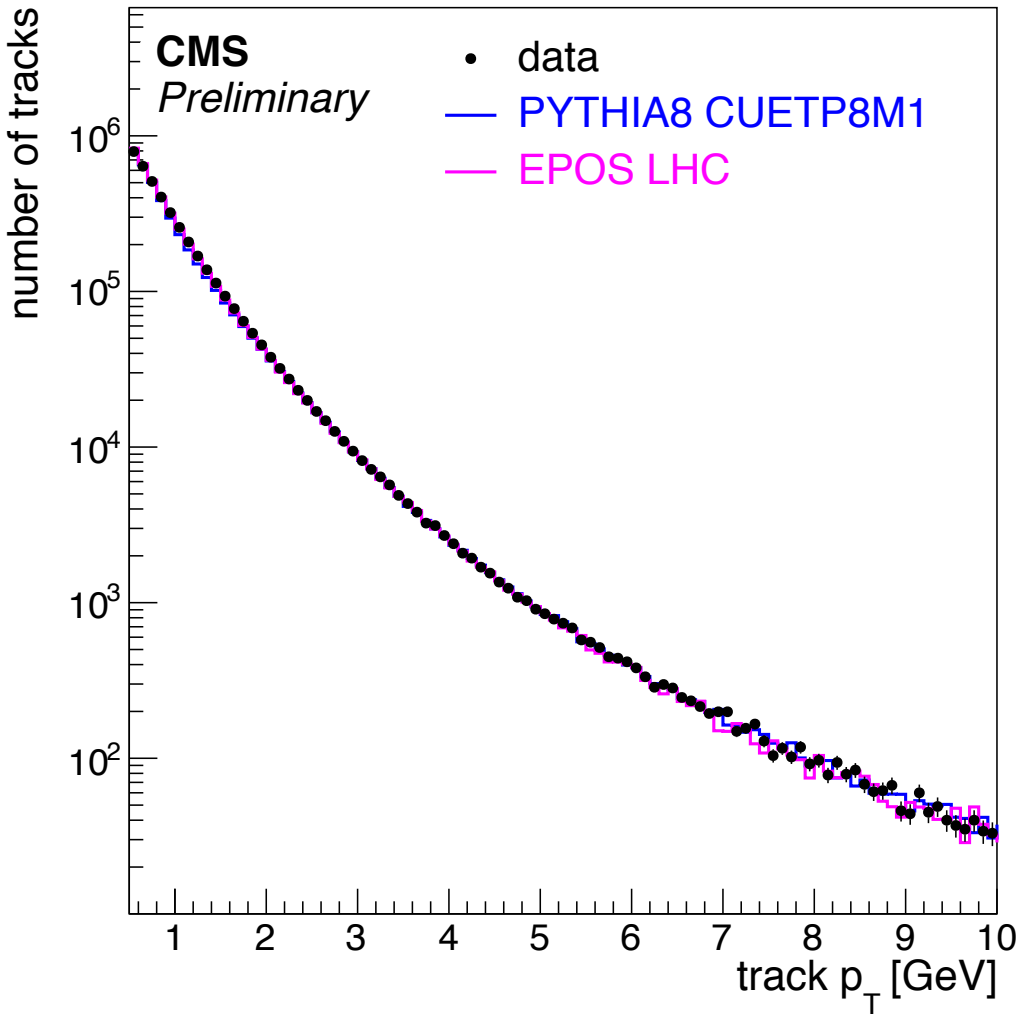


Control distributions: Tracking

Track η



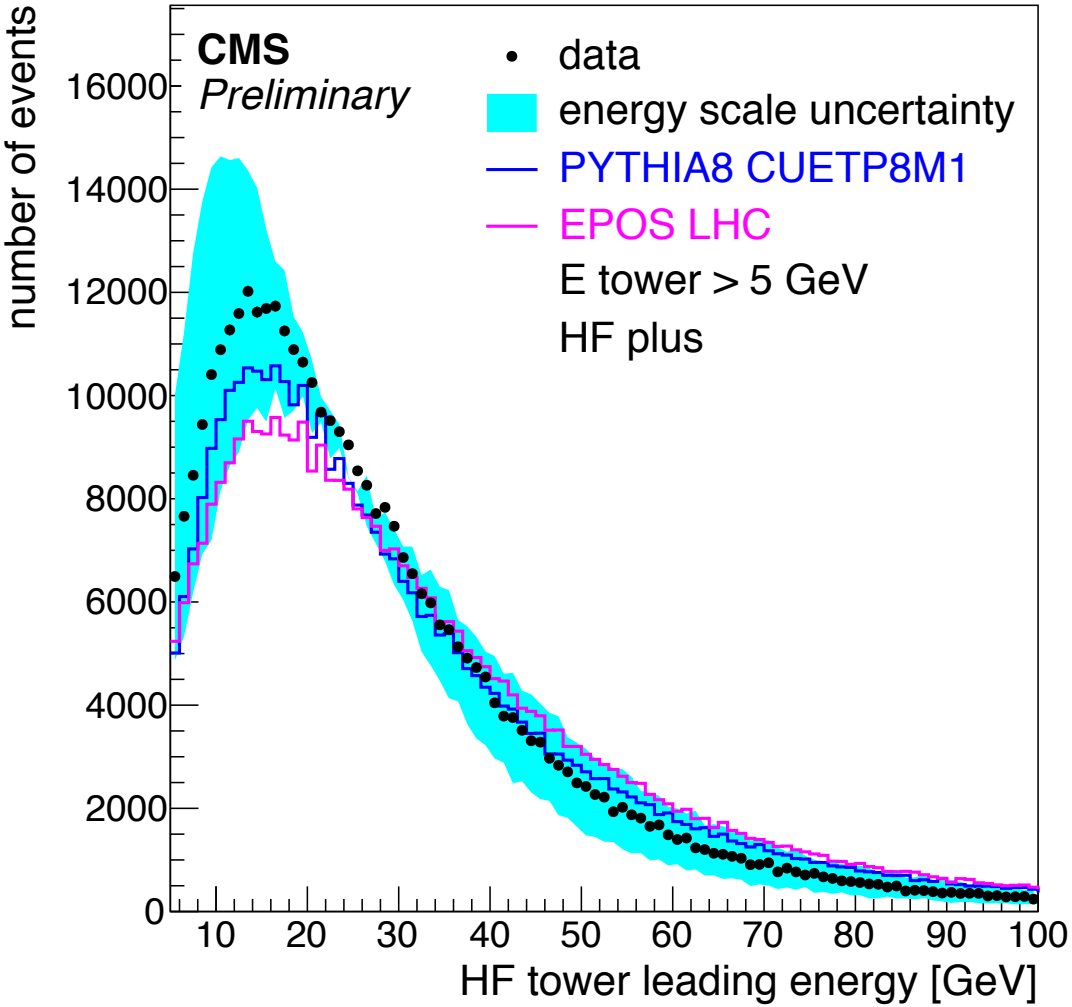
Track p_T

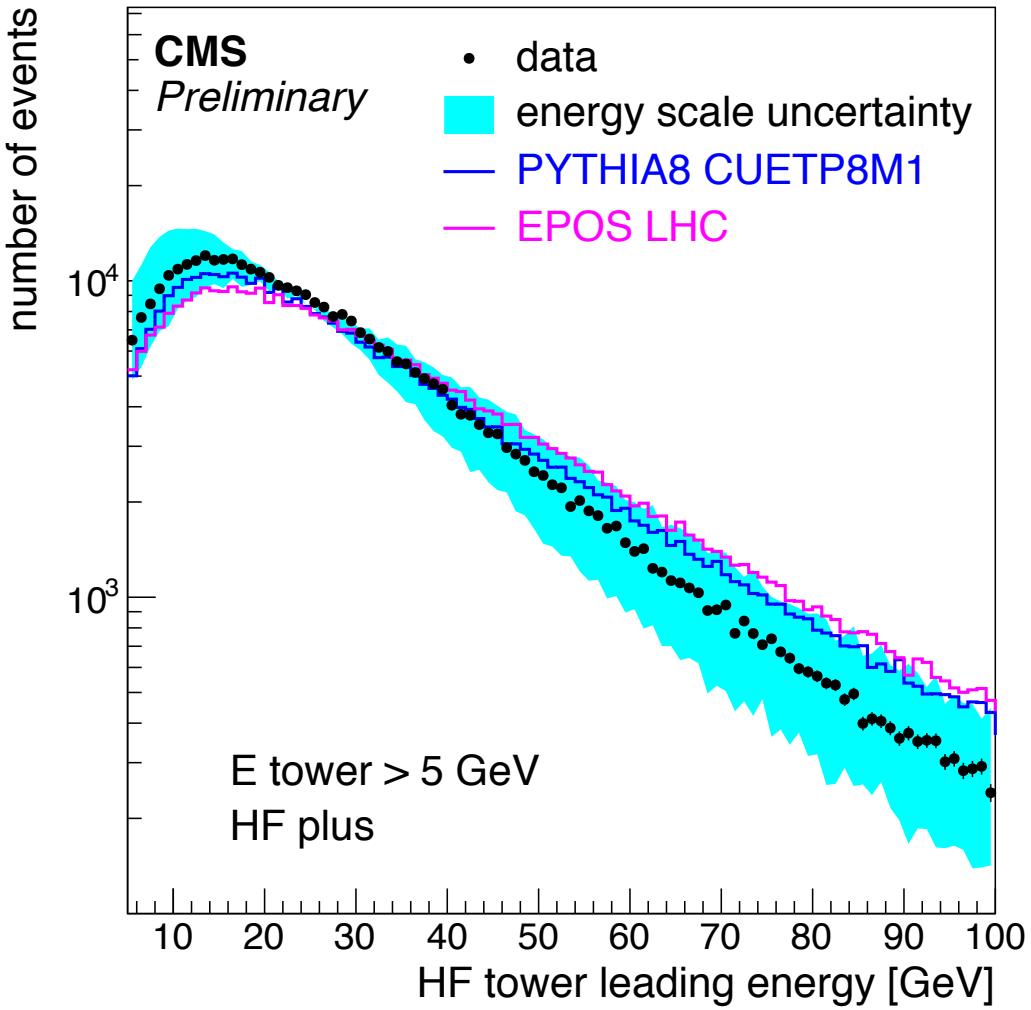


Good description of the data at detector level

Control distributions: Forward calorimeter

Leading tower energy spectrum





An agreement is observed at the 10 % level in the low energy region

Correction Factors

$$\frac{1}{N_{evt}}\frac{dN_{ch}}{d\eta} = C(\eta) \times \frac{1}{N^{\text{det sel}}_{\text{evt data}}} \times \frac{N^{\text{det sel}}_{\text{track data}}(\eta)}{\Delta\eta}$$

$\Delta\eta$	the bin width
$N^{\text{det sel}}_{\text{evt data}}$	number of selected events in data
$N^{\text{det sel}}_{\text{track data}}(\eta)$	number of tracks in a given η bin

Final correction factor = average of PYTHIA8 and EPOS predictions

Correction Factors

$$C(\eta) = \frac{N^{\text{det sel}}_{\text{evt MC}}}{N^{\text{particle sel}}_{\text{evt MC}}} \times \frac{N^{\text{particle sel}}_{\text{ch MC}}(\eta)}{N^{\text{det sel}}_{\text{track MC}}(\eta)}$$

$N^{\text{det sel}}_{\text{evt MC}}$

$N^{\text{particle sel}}_{\text{evt MC}}$

numbers of selected events in the Monte Carlo by the selection at **detector level** and stable **particle level**

$N^{\text{det sel}}_{\text{track MC}}(\eta)$

$N^{\text{particle sel}}_{\text{ch MC}}(\eta)$

numbers of tracks in a given η bin in the Monte Carlo at **detector level** and **number of stable charged particles** in a given η bin at **particle level**

Systematic uncertainties

Systematic effect	Inclusive	Inelastic	NSD	SD
Model Dependence	1%	1%	0.5%	7%
Event selection	N.A.	0.1%	0.5%	4%
Pile Up dependence	1.5%	1.5%	3%	4%
Tracking reconstruction	4%			
Total	4.5%	4.5%	5%	10%

After symmetrization: half of the difference between averaged bins is taken as an additional systematic uncertainty .

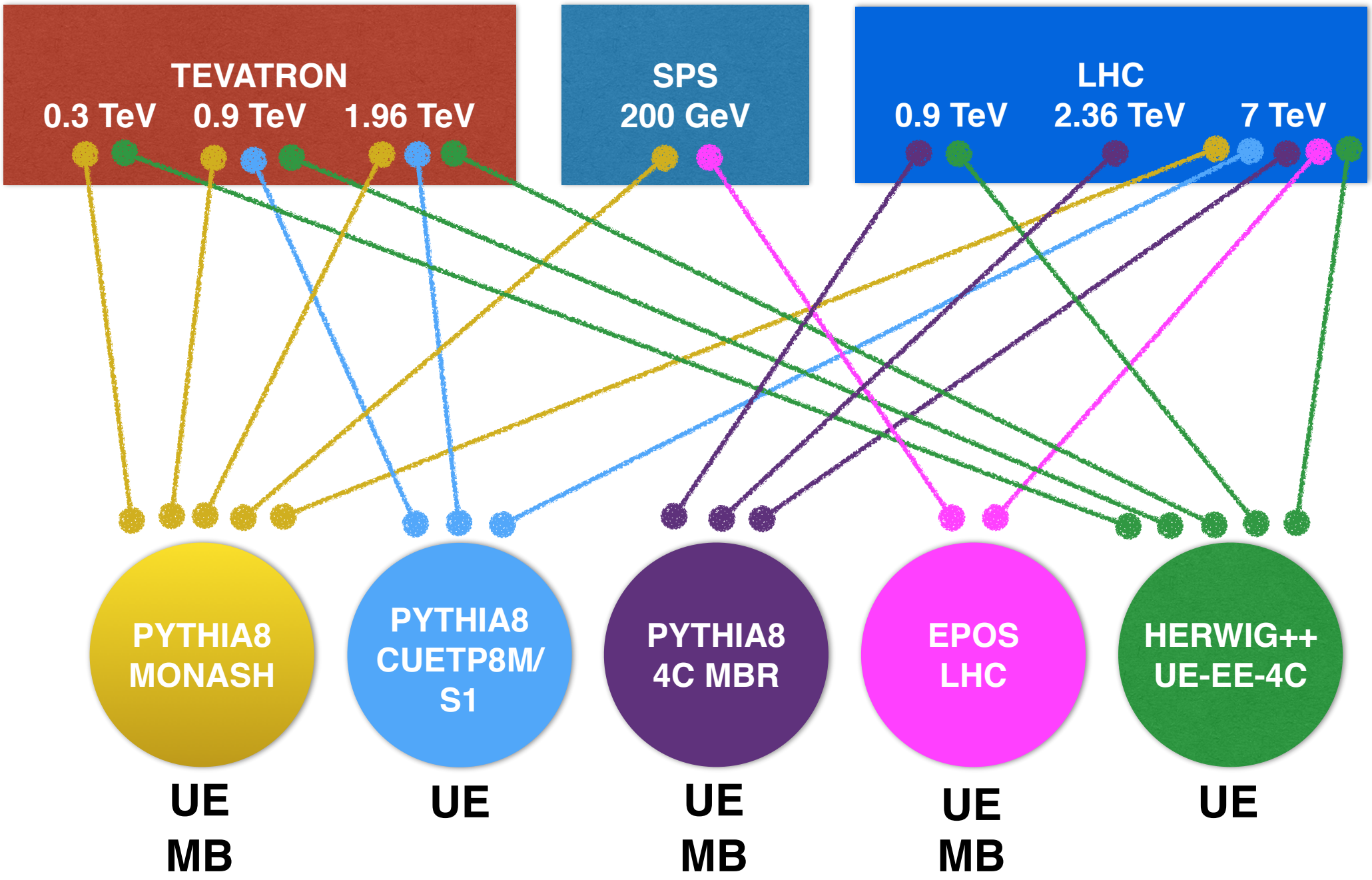
Monte Carlo models

- **PYTHIA8 (MBR)**
  - Partonic interaction + parton showers
    - Parton showers —> DGLAP + Lund string model for hadronisation
  - Diffraction generated
    - Schuler-Sjöstrand model in PYTHIA8
    - Renormalized Regge model in PYTHIA8 MBR

- **EPOS**
  - Cosmic ray physics generator
  - String model for hadronisation
  - Soft processes: Gribov's Reggeon field theory
    - MPI: Multi-pomeron exchanges

- **HERWIG++**
  - Partonic interaction (like in PYTHIA8) + parton showers
    - Parton showers —> DGLAP + angular ordering + cluster fragmentation for hadronisation
  - No soft diffraction modelling

The tunes


TEVATRON
0.3 TeV
0.9 TeV
1.96 TeV
SPS
200 GeV
LHC
0.9 TeV
2.36 TeV
7 TeV
PYTHIA8 MONASH
PYTHIA8 CUETP8M/ S1
PYTHIA8 4C MBR
EPOS LHC
HERWIG++ UE-EE-4C
UE
MB
UE
UE
MB
UE
MB
UE

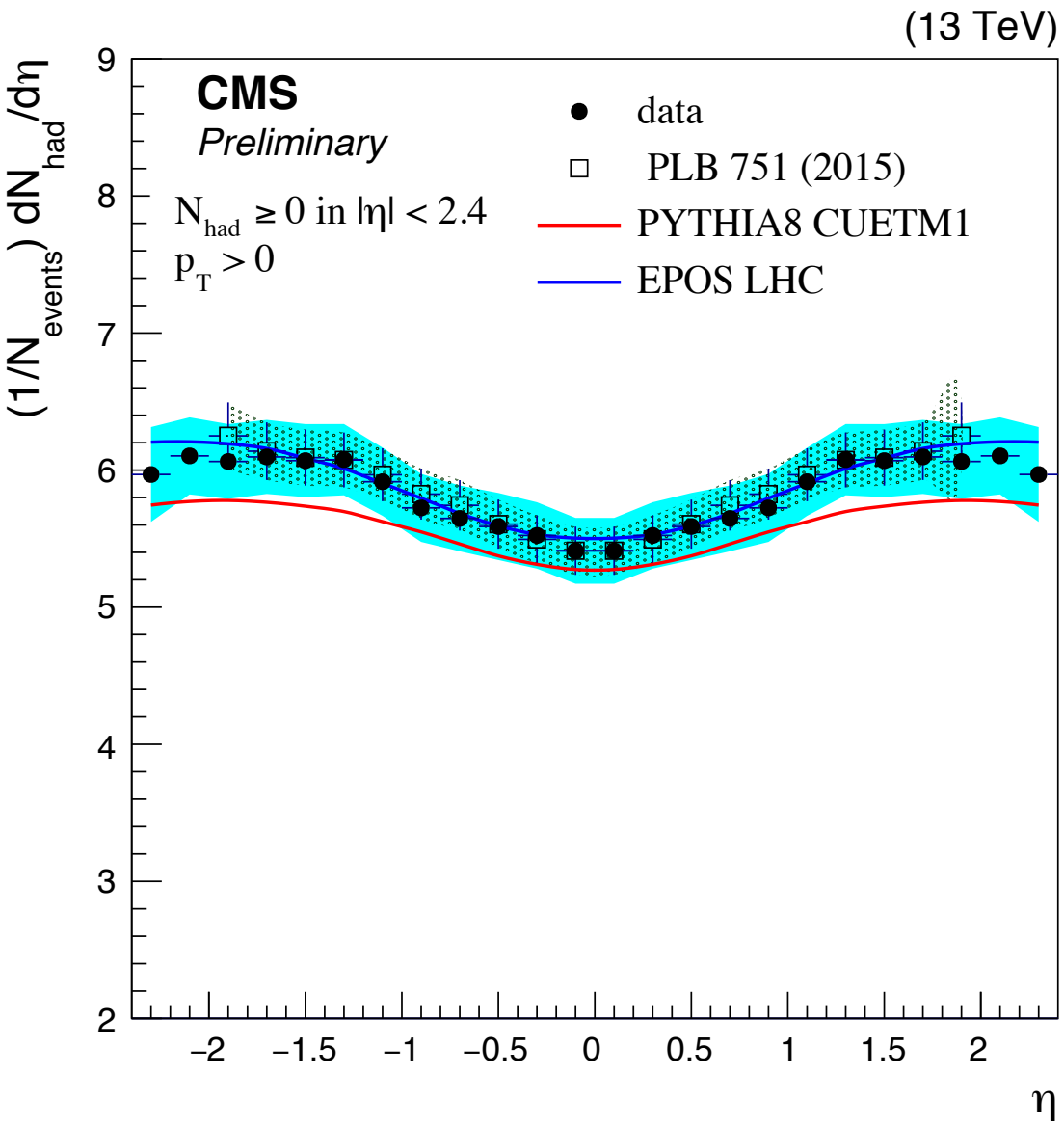
Comparison 13 TeV, inelastic enhanced selection

Cross check with published result **extrapolation to pT = 0**

Different:

- ✦ data set
- ✦ tracking algorithm
- ✦ PileUp conditions

Good agreement!



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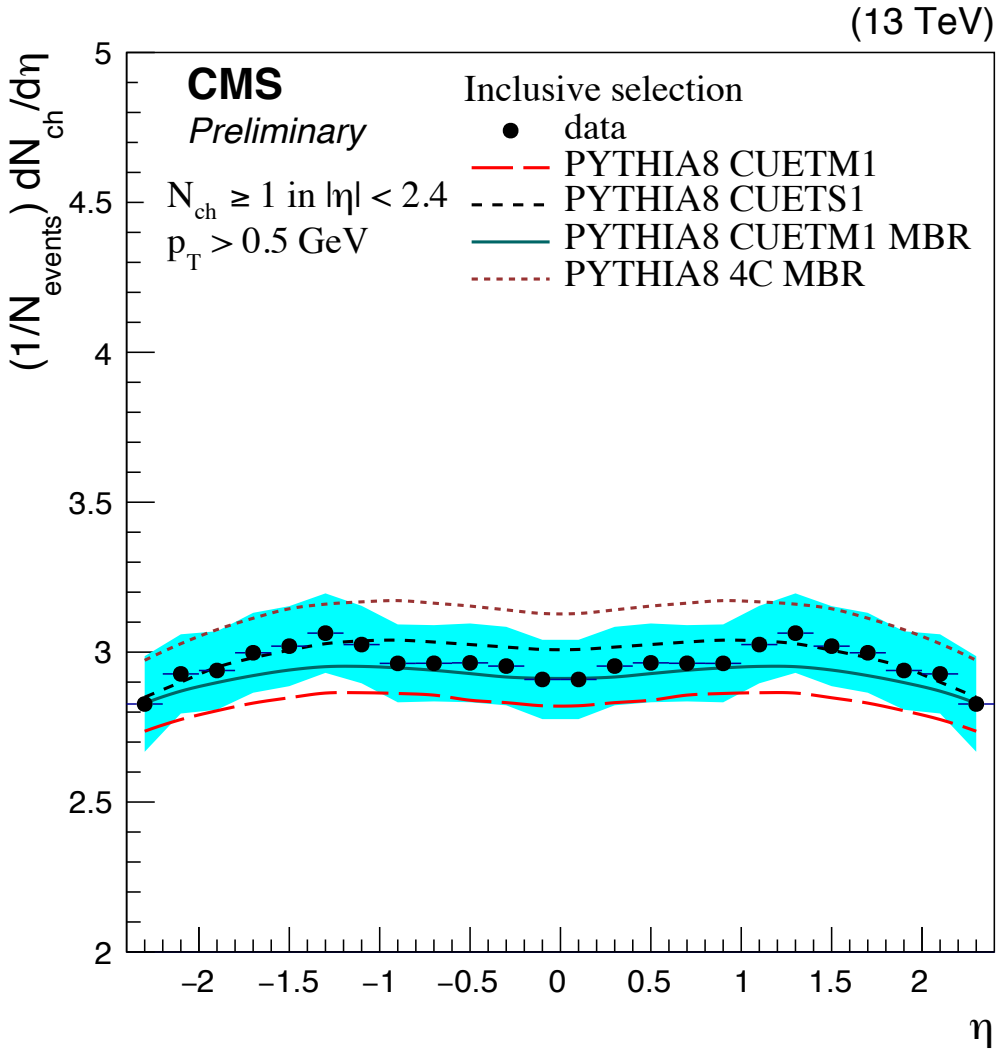
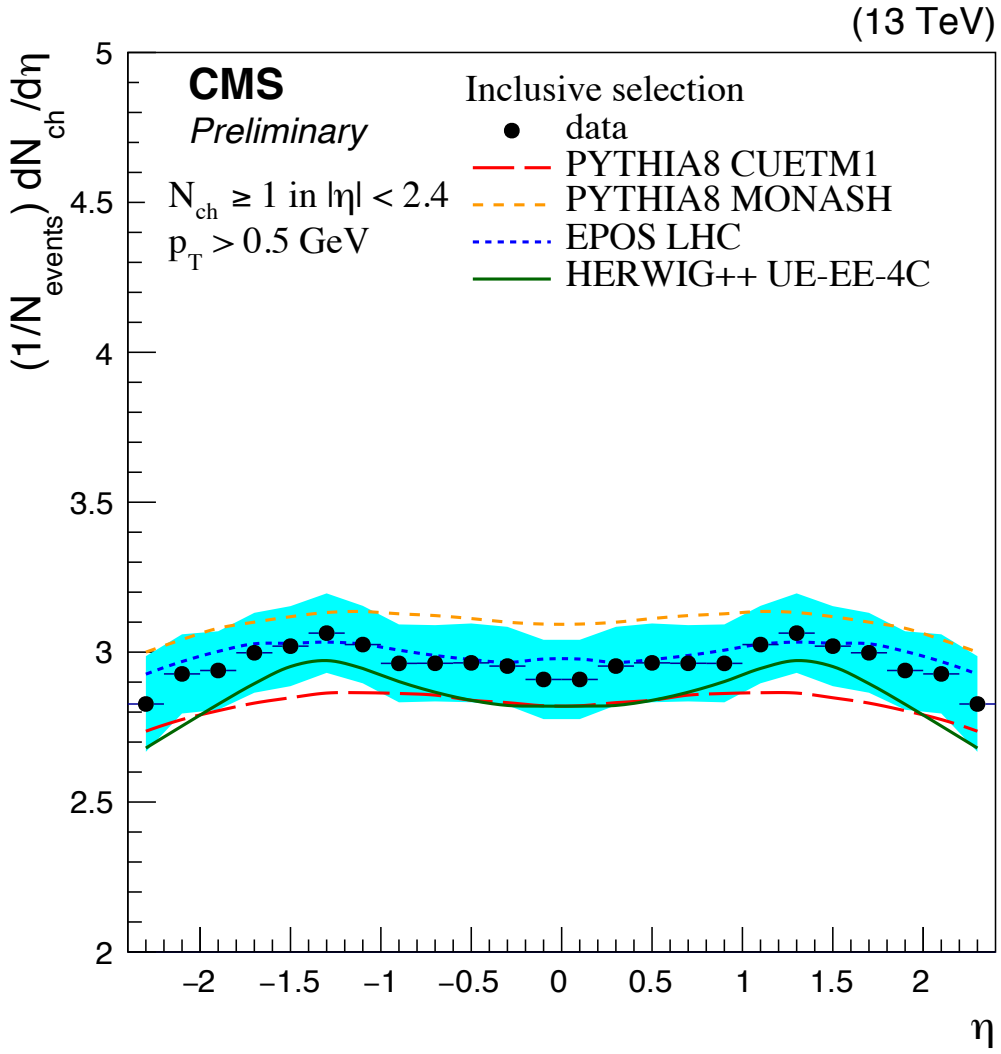
Now some new measurements!

Inclusive selection

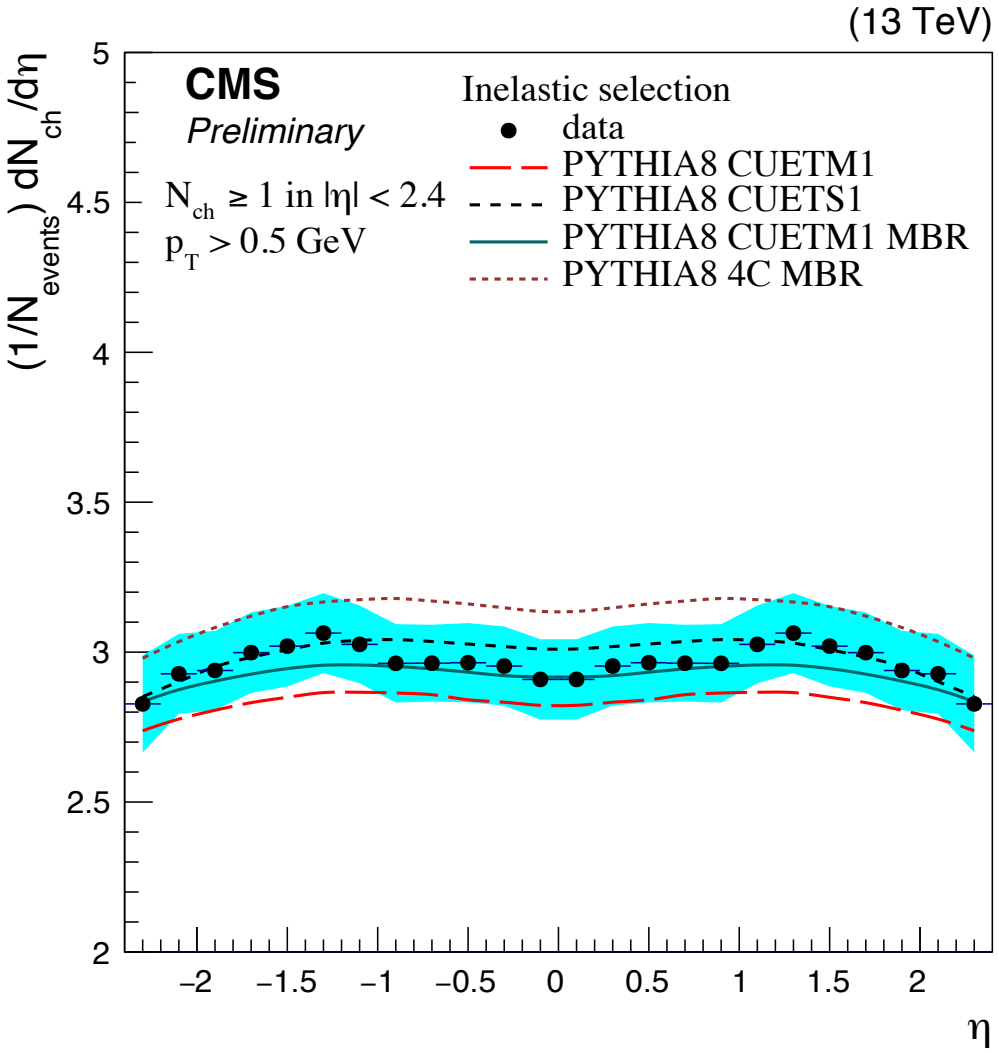


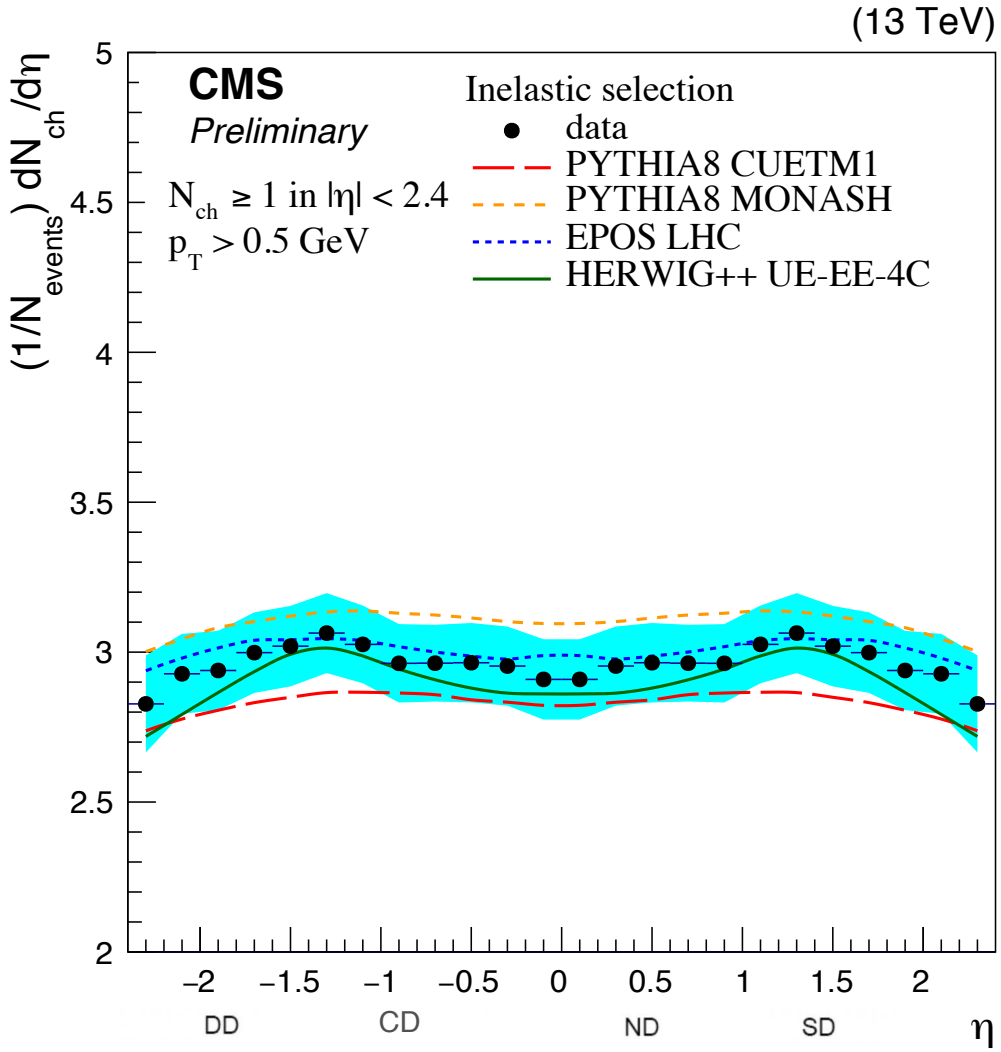


PYTHIA8 CUETP8S1, **PYTHIA8 MBR CUETP8M1**, **EPOS LHC** and **HERWIG++ UE-EE-4C** describe the inclusive election.

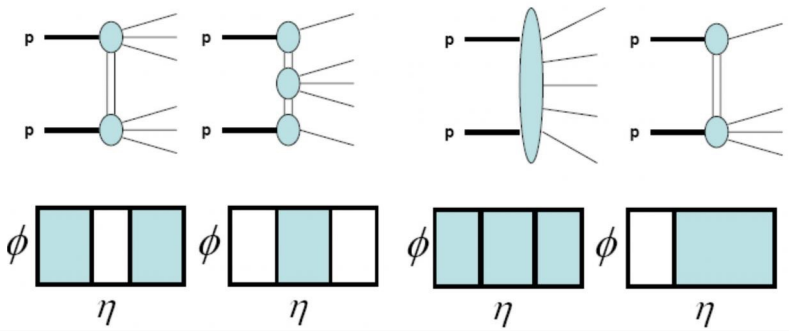
At least 1 charged particle { pT > 0.5 GeV, |η| < 2.4

Inelastic enhanced selection

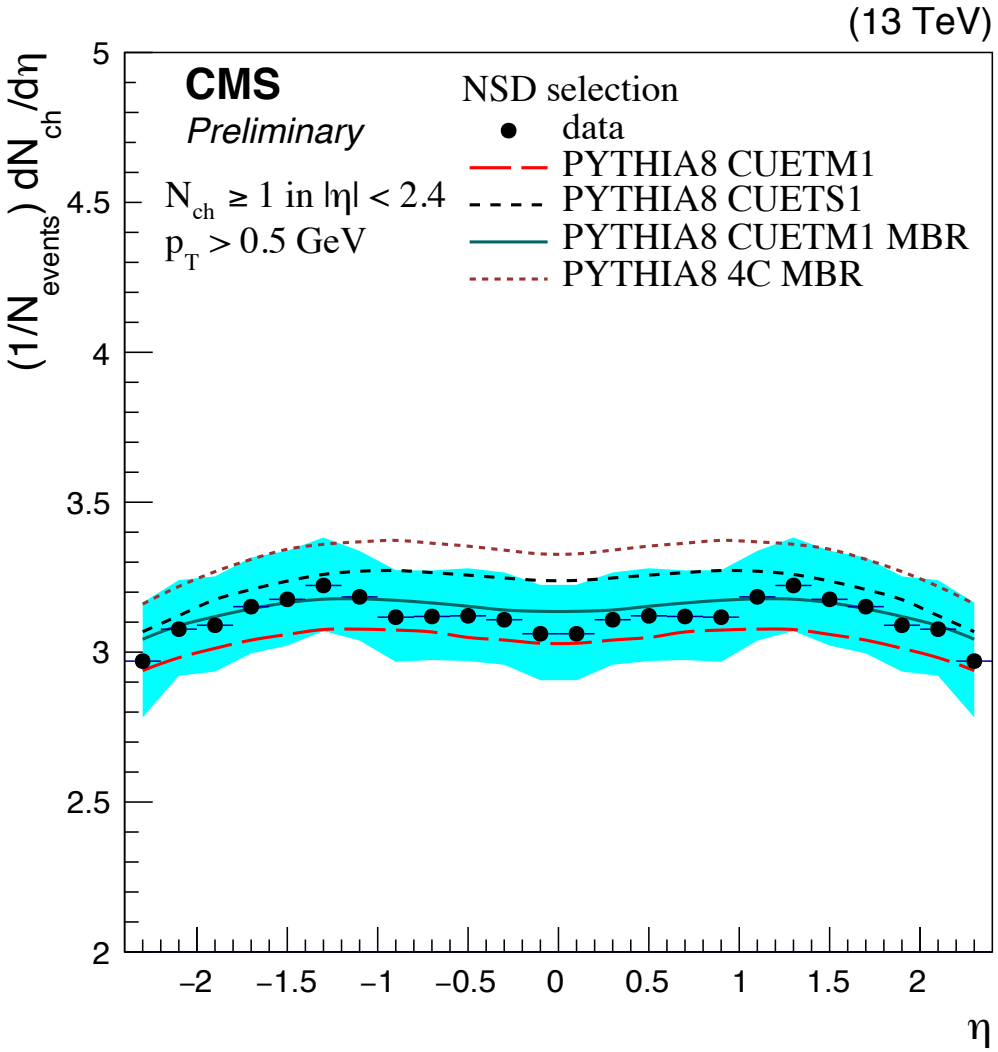


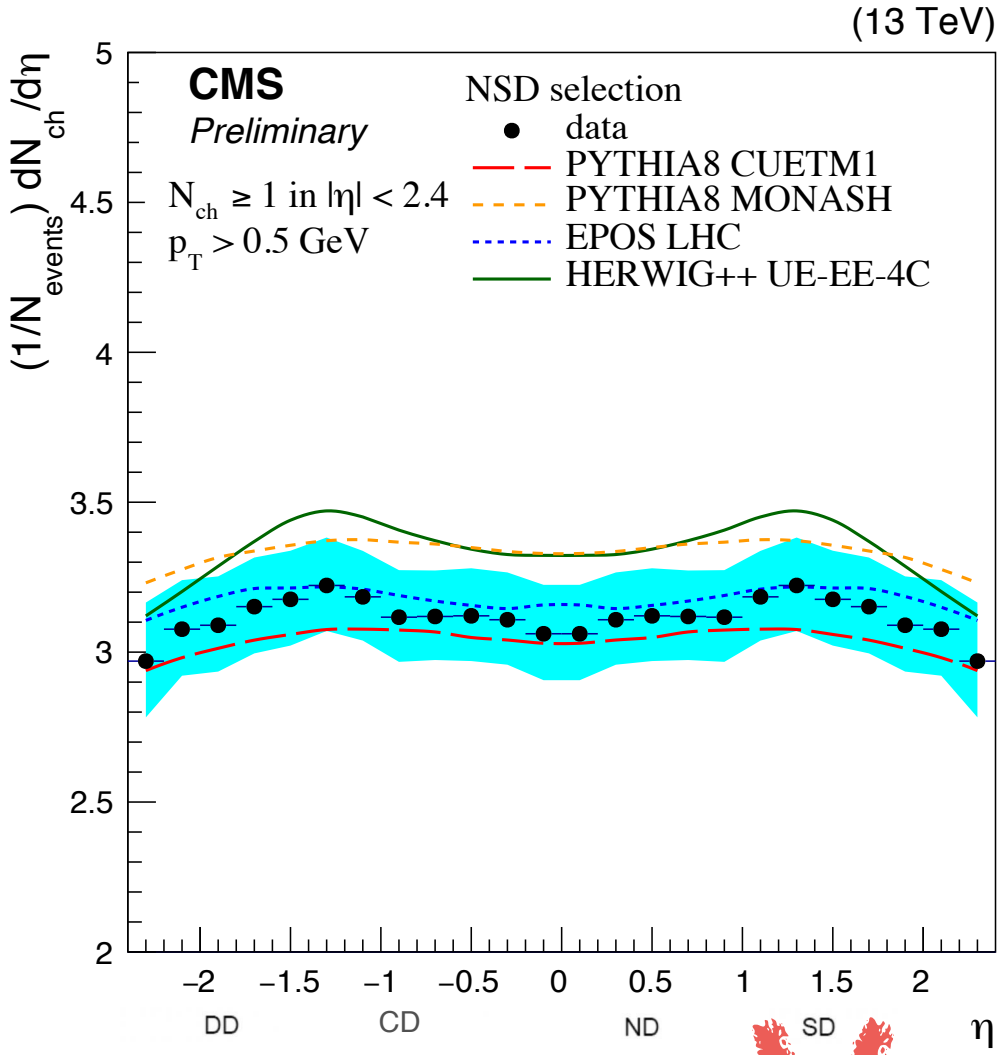


PYTHIA8 CUETP8S1, **PYTHIA8 MBR**
CUETP8M1, **EPOS LHC** and **HERWIG++**
UE-EE-4C describe the inelastic enhanced selection.

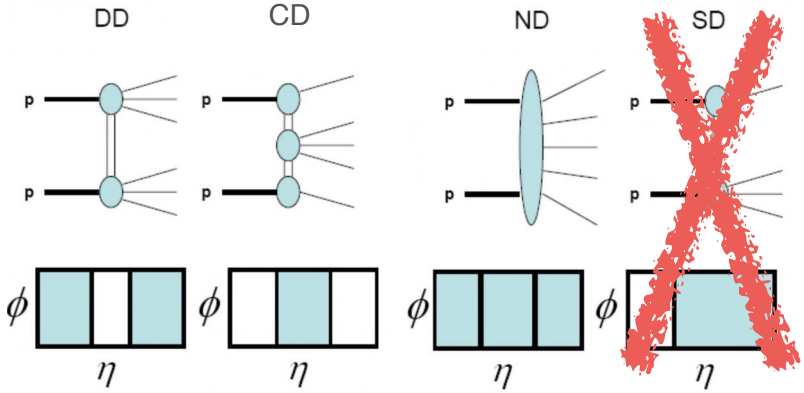


NSD enhanced selection

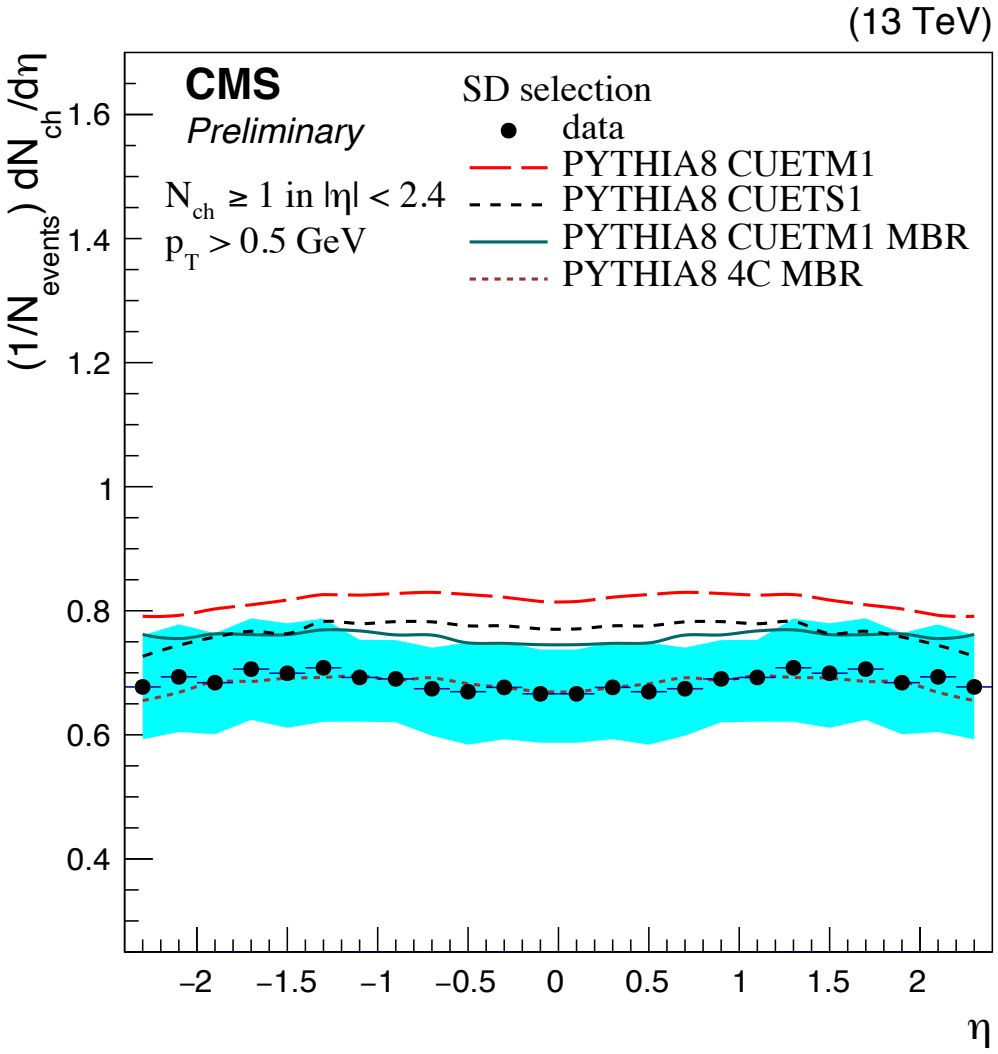


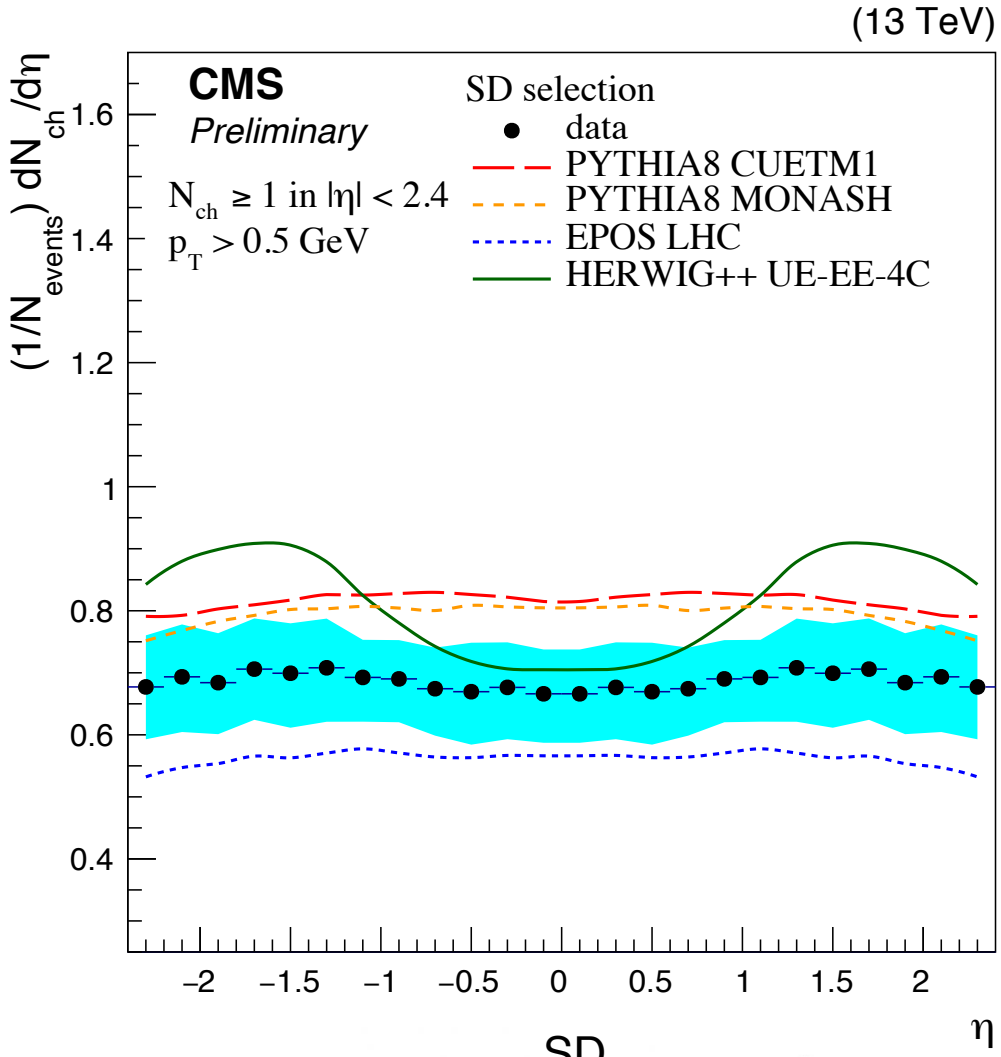


PYTHIA8 MBR CUETP8M1, **PYTHIA8 CUETP8M1**, and **EPOS LHC** give good agreement.

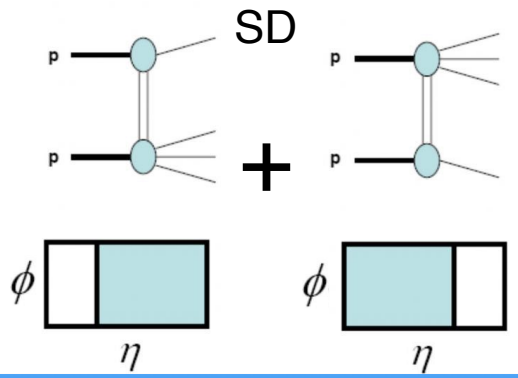


SD enhanced selection

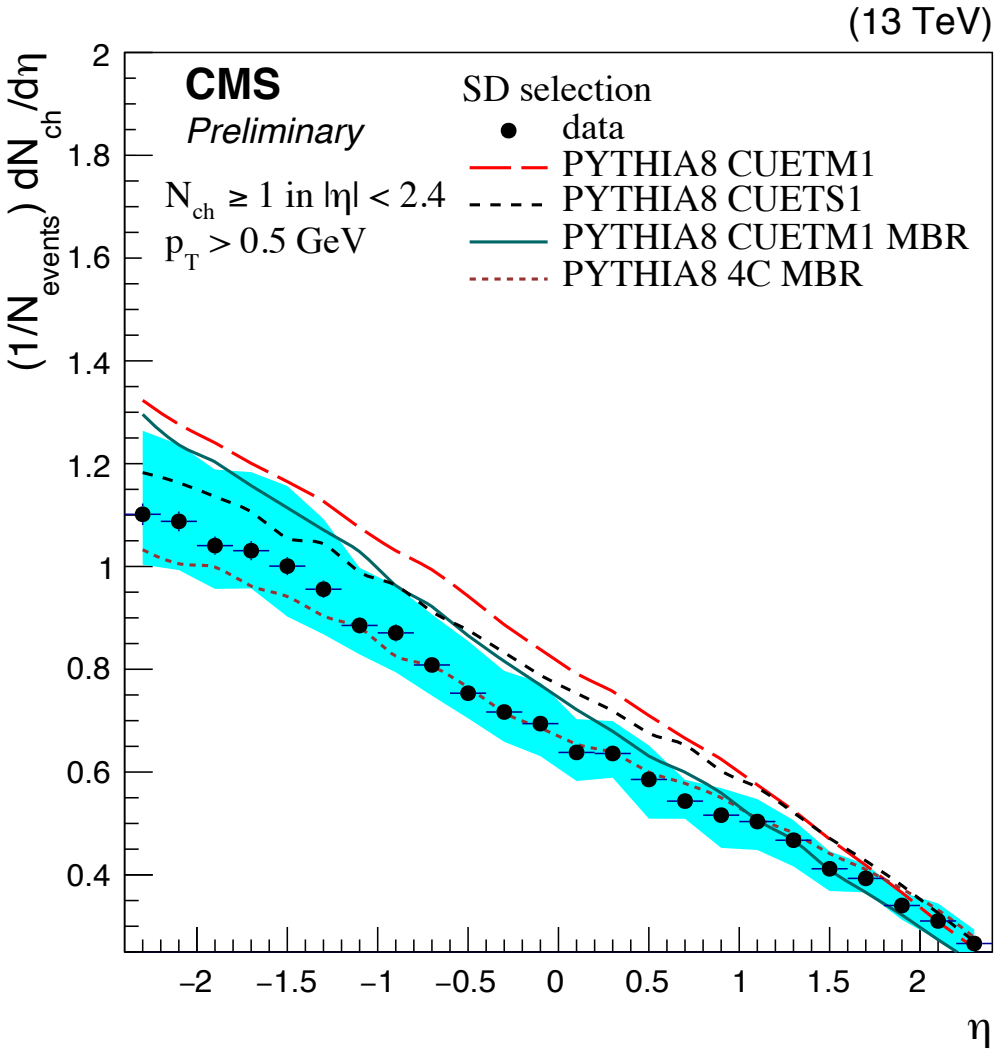


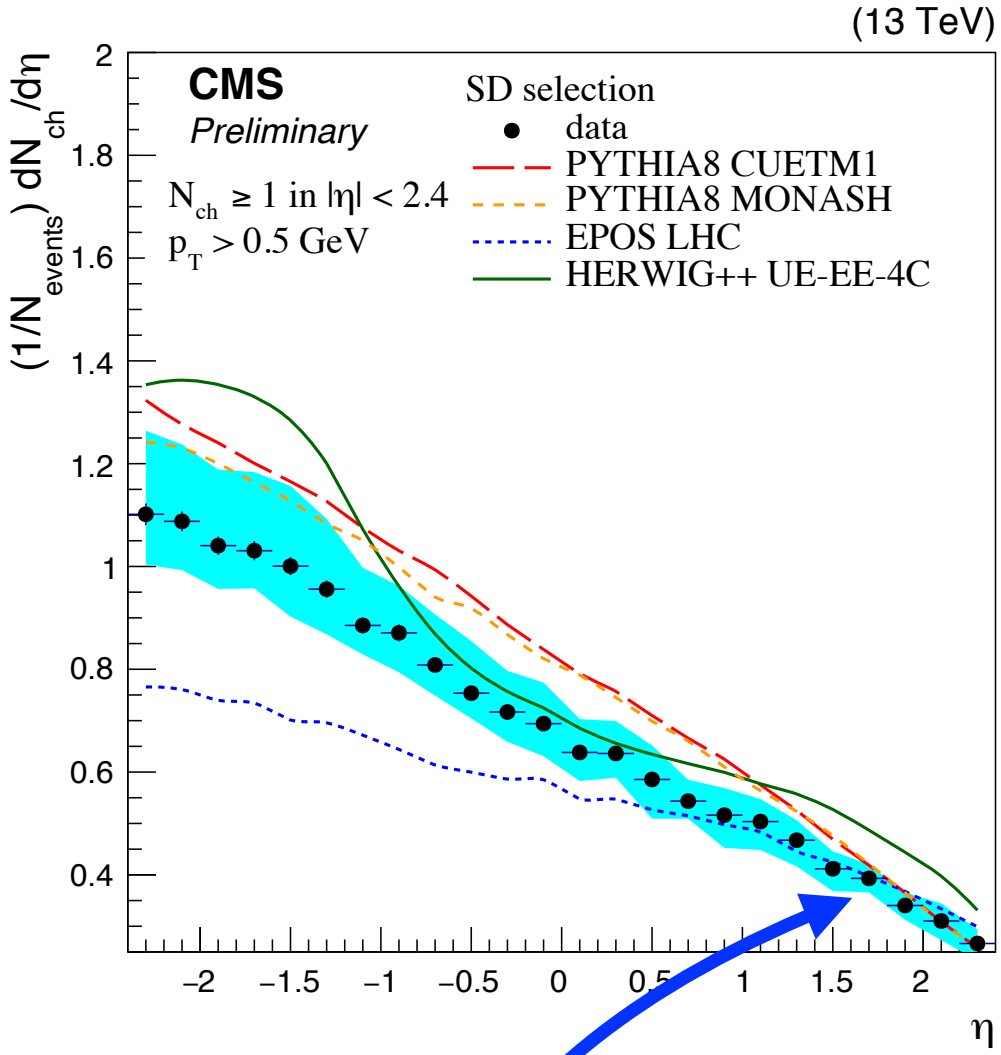


4C MBR gives best description of the data.

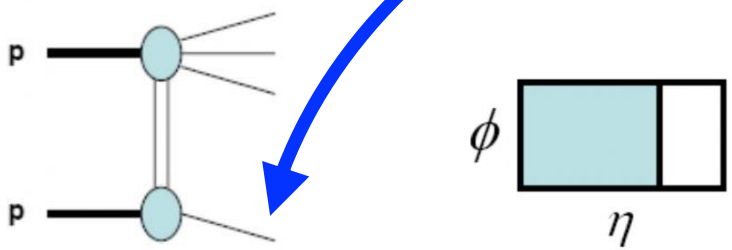


One sided SD enhanced selection

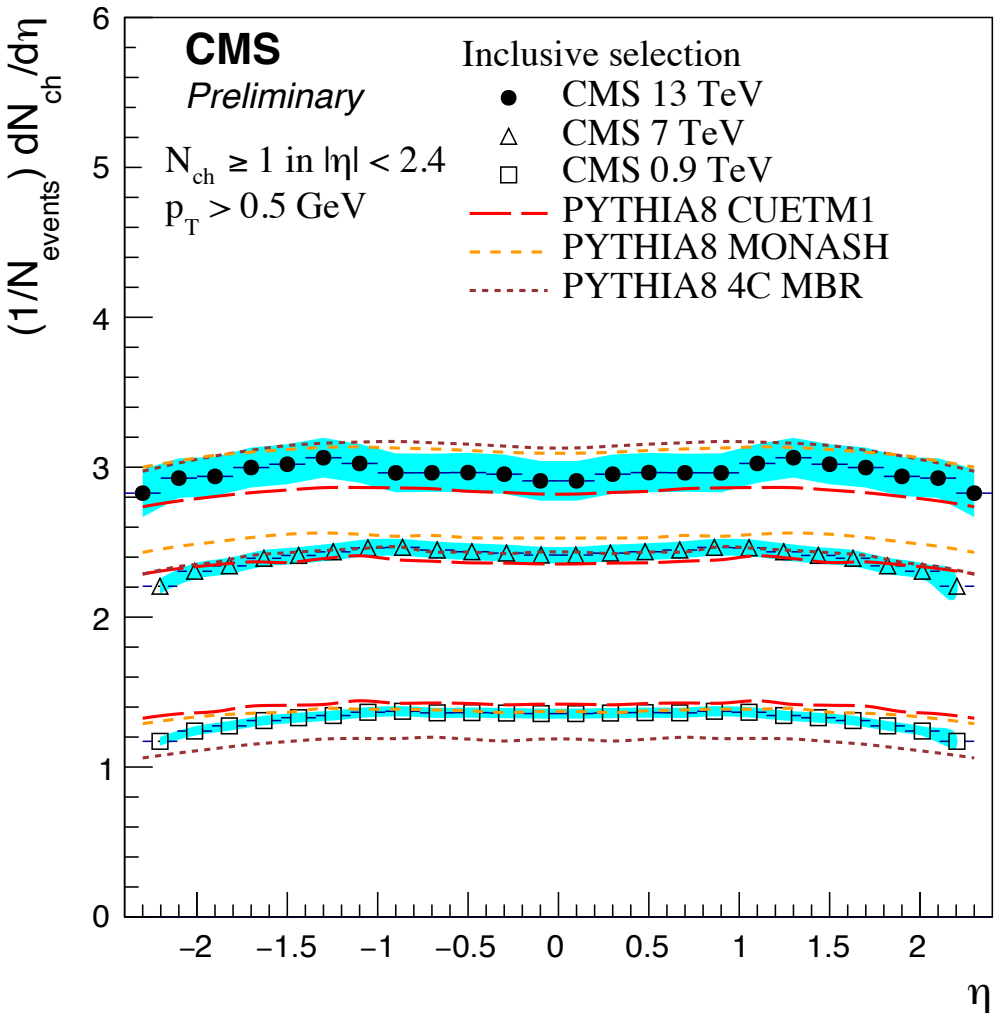


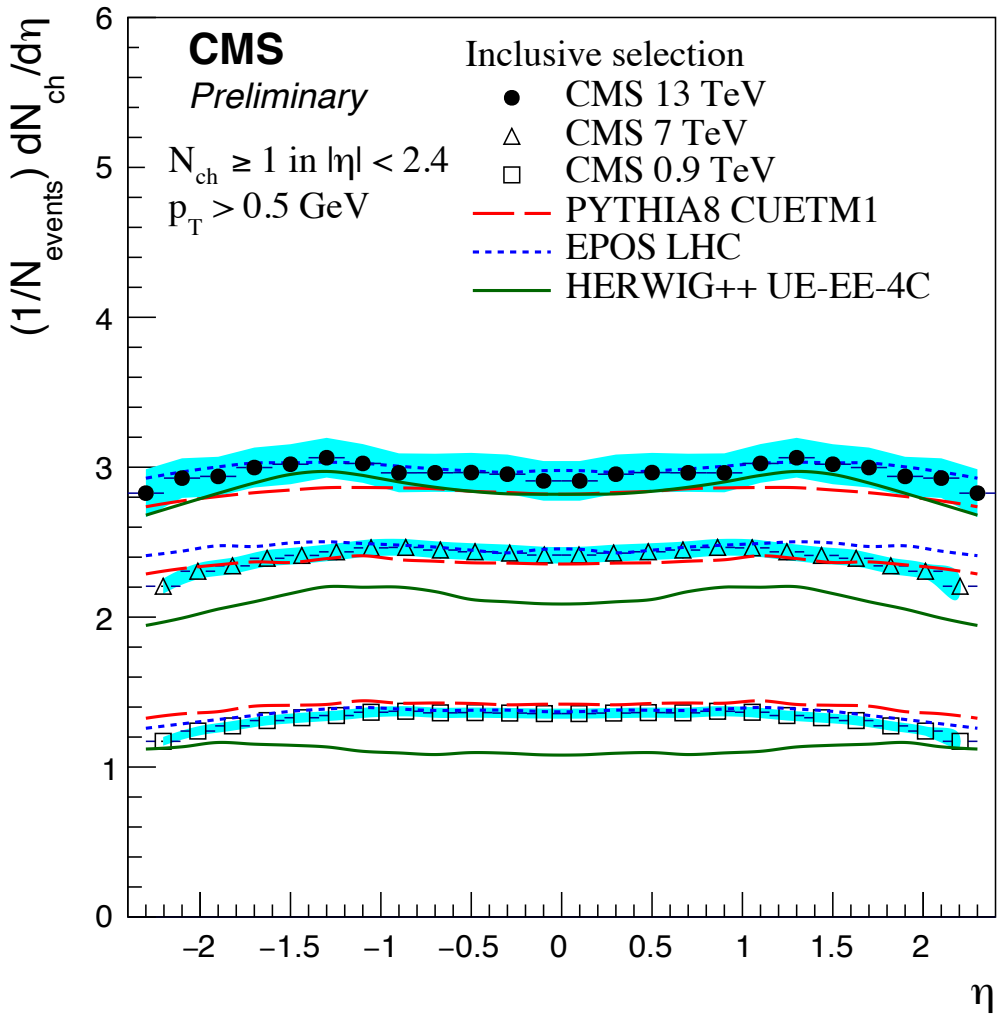


Most MC's describe the scattered proton side.



Comparison 0.9 and 7 TeV, Inclusive enhanced selection





EPOS LHC describes central region at all energies.

CMS PAS QCD-10-024

Summary

- First pseudorapidity measurement for **different event selections** at $\sqrt{s}$ =13 TeV
- Looking at dN/dη for different event selections gives extra information on the diffractive and non diffractive components —> **Valuable input for MC tuning**
  - All models give reasonable overall description of the data
    - **PYTHIA8 CUETP8S1**, **PYTHIA8 MBR CUETP8M1**, **EPOS LHC** and **HERWIG++ UE-EE-4C** describe the inelastic enhanced selection.
    - **PYTHIA8 MBR CUETP8M1**, **PYTHIA8 CUETP8M1**, and **EPOS LHC** good description of the Non-Diffractive enhanced selection.
    - **4C MBR** provides the best description of the SD enhanced selection.
    - **MONASH** always over estimates the data.