Inclusive jet cross section at 13 TeV

Sourav Dev, Giannis Flouris, **Paolo Gunnellini**,
Hannes Jung, Panos Kokkas, Ksenia Shchelina

Deutsches Elektronen-Synchrotron, Hamburg

- (Brief) introduction
- Event selection
- Trigger strategy
- Studies of detector effects
- Unfolding and closure tests
- Systematic uncertainties
- Results

SMP_15_007
ARC members
Robert Harris
Rainer Mankel
Philip Harris
Sung Won Lee

SMP-15-007
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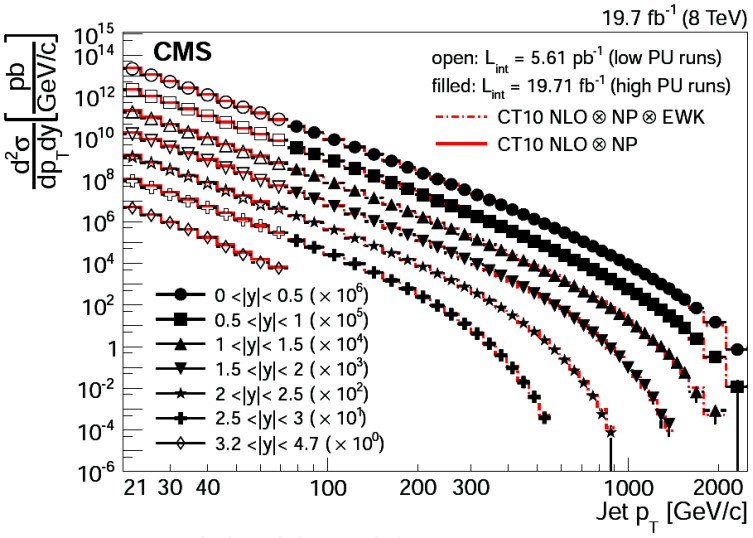
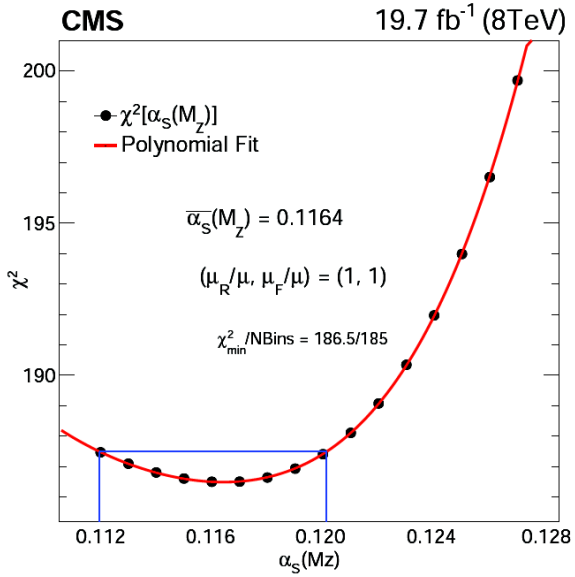
Pre-approval Meeting

Where do we stand?

Comparisons with theory predictions from NLO calculations with NP corrections





Good agreement in central and forward region with NLO predictions

CMS-SMP-14-001

Slight worse agreement at 7 TeV and Anti-k_T 0.5

Text-book measurement at 13 TeV needed with early data

- First measurement with limited statistics
- Paper with full data sample $\rightarrow$ jets up to $p_T \sim 3$ TeV
- Input to improve fixed order calculations and MC generators
- Measurement of α_S running up to 3 TeV for the first time
- Measurement of PDF down to lower x values

Event selection and samples used

Measurement of inclusive jet cross section at 13 TeV

- Including two clustering algorithm cones (AK7 and AK4)
- Including the forward region

Data sample:

- /JetHT/Run2015B-PromptReco-v1/AOD
- /JetHT/Run2015C-PromptReco-v1/AOD
- Recorded lumi: 72 pb^{-1} for $|y|$ <3 and 45 pb^{-1} for 3.2< $|y|$ <4.7

MC sample:

- QCD-sliced sample generated with PYTHIA 8 Tune CUETP8M1

Event Selection

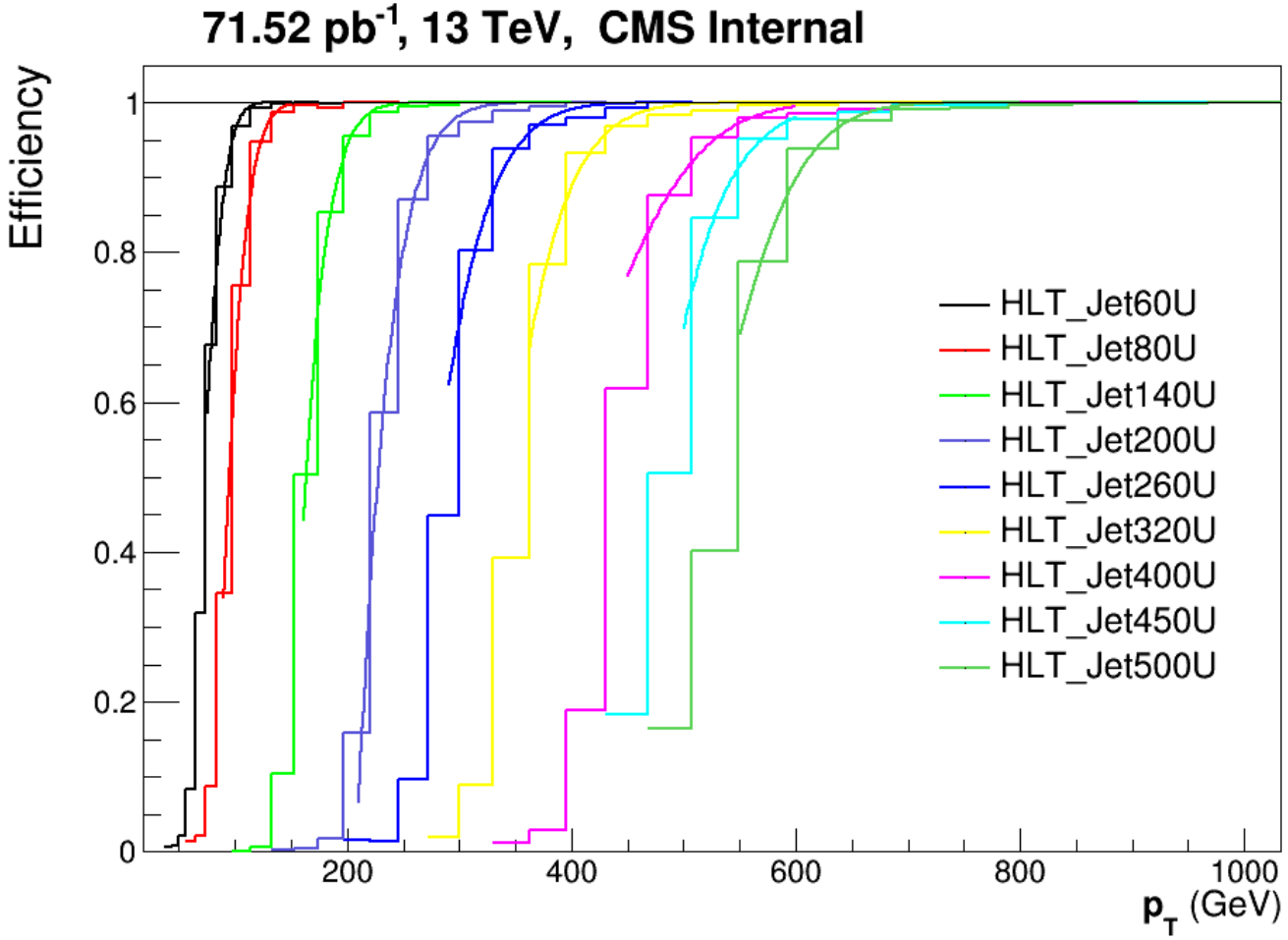
- PFJets clustered with ak7chs (ak4chs) in $|\eta| < 4.7$
- Tight jet ID applied in region $|\eta| < 3.0$ (0.3% reduction)
- **Summer15_50nsV5** corrections applied in MC and data (+res.)
  - JEC AK4CHS for AK4 jets
  - JEC AK8CHS for AK7 jets

Trigger strategy (I) - AK7

Exclusive division method: phase space is divided in regions according to the leading jet p_T and independent triggers are used in each region

The trigger efficiency is defined as:

$$HLT\_Jet_{eff}\,Y = \frac{InclusiveRecoJet\_P_T(HLT\_JetX + L1Object\_p_T > Z + HLTObject\_p_T > Y)}{InclusiveRecoJet\_p_T(HLT\_JetX)}$$



Requirement of ak7chs jet in $|\eta| < 4.7$

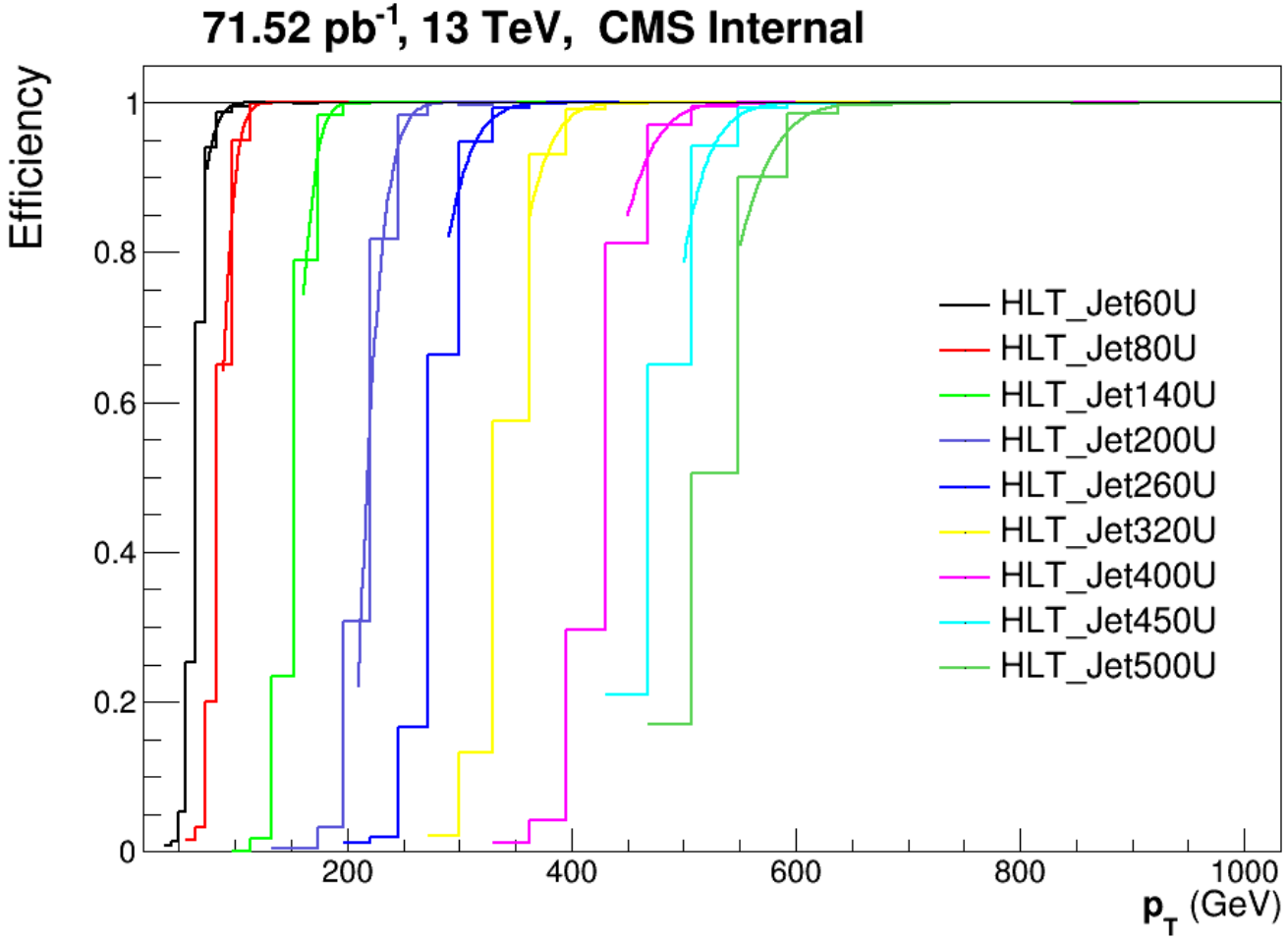
Trigger	Turnon
HLT60	105
HLT80	132
HLT140	220.6
HLT200	315.7
HLT260	399.8
HLT320	505.6
HLT400	602.1
HLT450	632.5

Trigger strategy (II) - AK4

Exclusive division method: phase space is divided in regions according to the leading jet p_T and independent triggers are used in each region

The trigger efficiency is defined as:

$$HLT\_Jet_{eff}\,Y = \frac{InclusiveRecoJet\_P_T(HLT\_JetX + L1Object\_p_T > Z + HLTObject\_p_T > Y)}{InclusiveRecoJet\_p_T(HLT\_JetX)}$$



Requirement of ak4chs jet in $|\eta| < 4.7$

Trigger	Turnon
HLT60	87.7
HLT80	111.2
HLT140	183.8
HLT200	257.1
HLT260	331.5
HLT320	399.8
HLT400	547.8
HLT450	608.2

Trigger strategy (III) - Cross check efficiency measurement

Measurement of the lowest p_T trigger using the tag-and-probe method

PROBE Jet:

- matched to HLT object with $\Delta R < 0.5$ and $p_T(\text{HLT}) > 40$ GeV

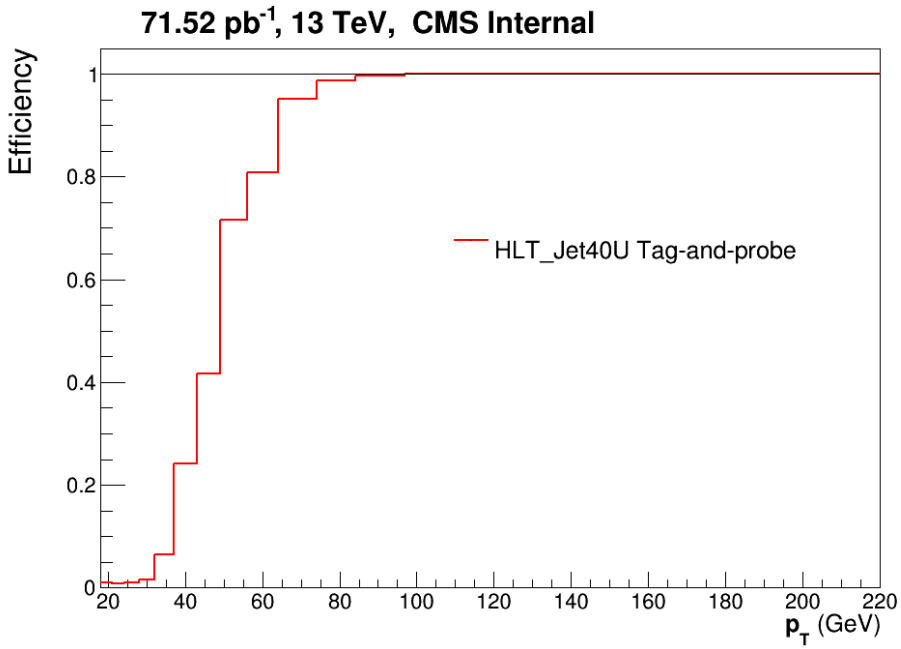
TAG Jet:

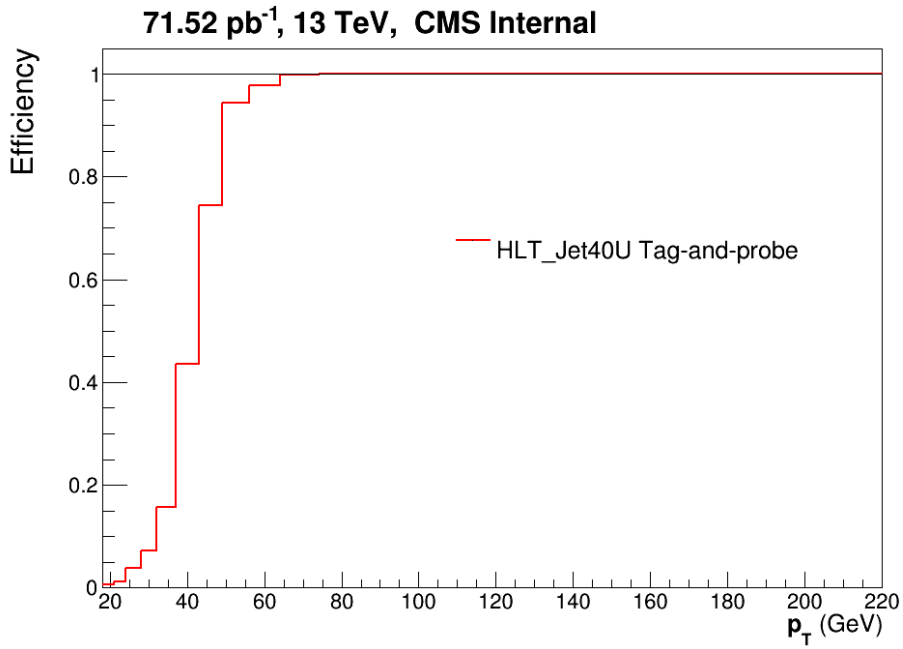
- matched to HLT object with $\Delta R < 0.5$

Further requirements:

- $\Delta\phi^{jets} > 2.7$
- $p_T^3 < 0.3(p_T^1 + p_T^2)/2$
- lead. and sublead. jets randomized as tag and probe jets

Plot of N(tag jet matched to HLT>40 GeV) / N(tag jet matched) for HLTJet40





LEFT: AK7, RIGHT: AK4

Trigger strategy (IV) - Cross check efficiency measurement

Comparison between emulation method (for jets in $|y| < 1.5$) and tag-and-probe

PROBE Jet:

- matched to HLT object with ΔR <0.5 and p_T(HLT) > 60 GeV

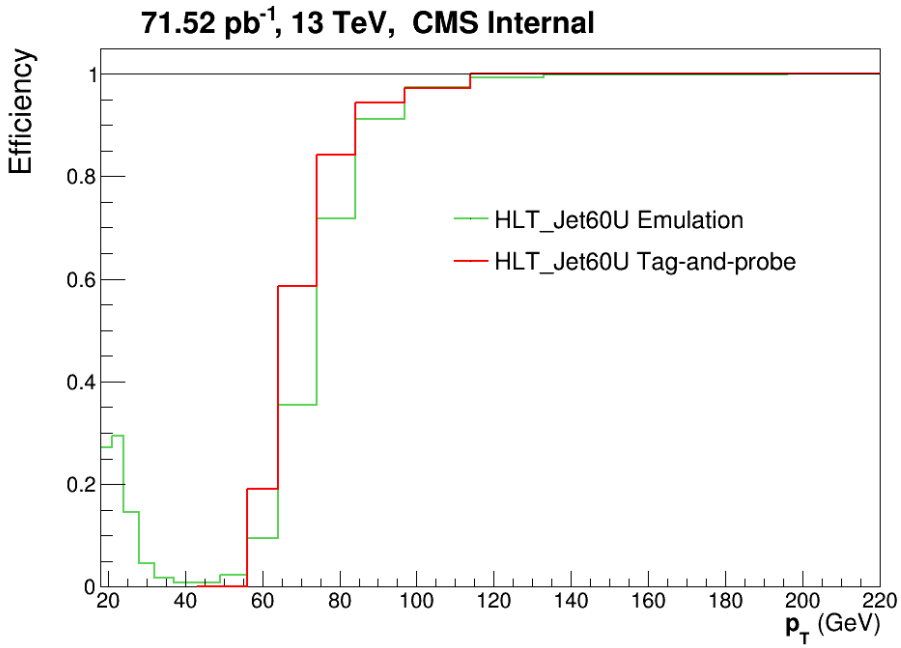
TAG Jet:

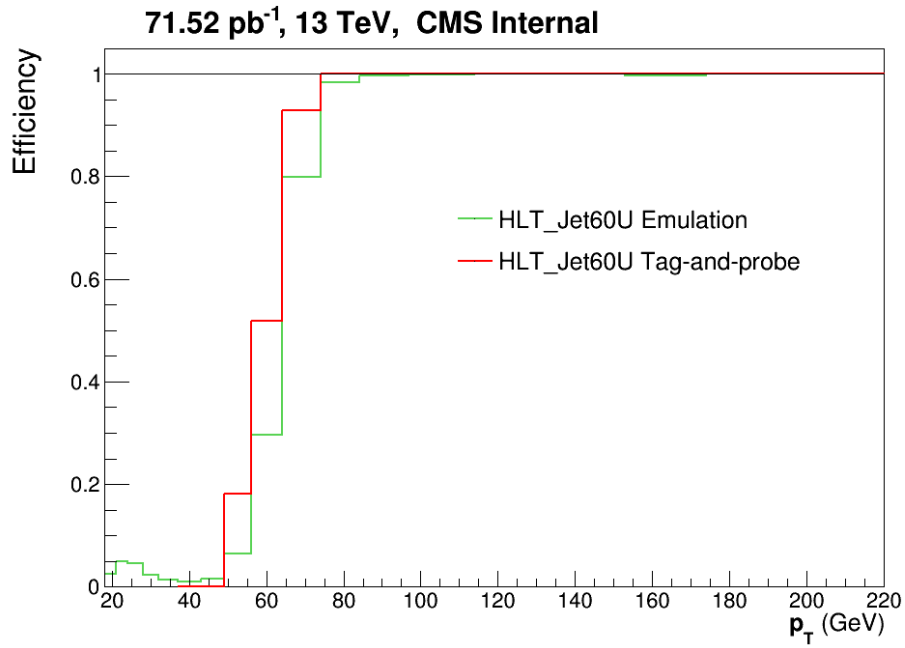
- matched to HLT object with ΔR <0.5

Further requirements:

- $\Delta\phi^{jets} > 2.7$
- $p_T^3 < 0.3(p_T^1 + p_T^2)/2$
- lead. and sublead. jets randomized as tag and probe jets

Plot of N(tag jet matched to HLT>60 GeV) / N(tag jet matched) for HLTJet60





LEFT: AK7, RIGHT: AK4

Trigger strategy (V)

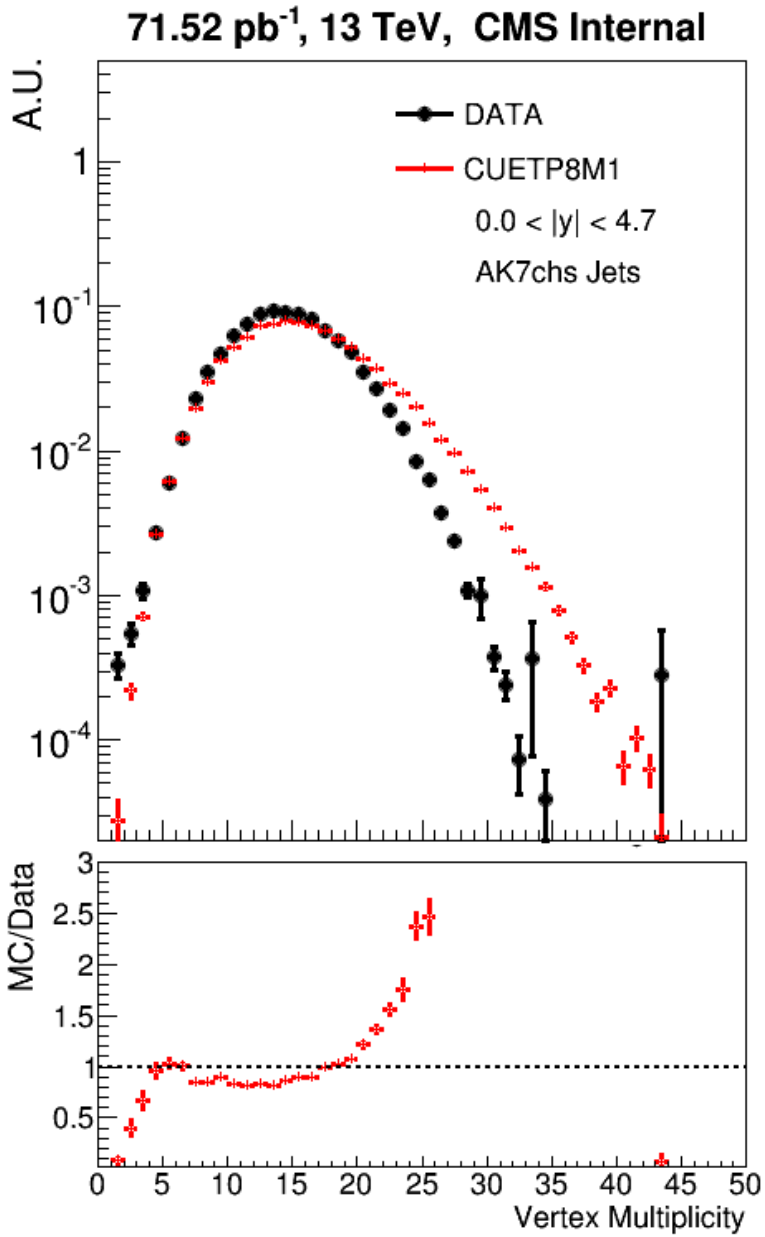
Exclusive division method: phase space is divided in regions according to the leading jet p_T and independent triggers are used in each region

The trigger efficiency is defined as:

$$HLT\_Jet_{eff}\, Y = \frac{InclusiveRecoJet\_P_T(HLT\_JetX + L1Object\_p_T > Z + HLTObject\_p_T > Y)}{InclusiveRecoJet\_p_T(HLT\_JetX)}$$

Trigger	Leading jet p_T
HLT_PFJet60_v2	114-133
HLT_PFJet80_v2	133-220
HLT_PFJet140_v2	220-300
HLT_PFJet200_v2	300-430
HLT_PFJet260_v2	430-507
HLT_PFJet320_v2	507-600
HLT_PFJet400_v2	638-737
HLT_PFJet450_v2	> 737

Pile-up scenarios in data and simulation



Selection of good vertices in data and simulation in events with:

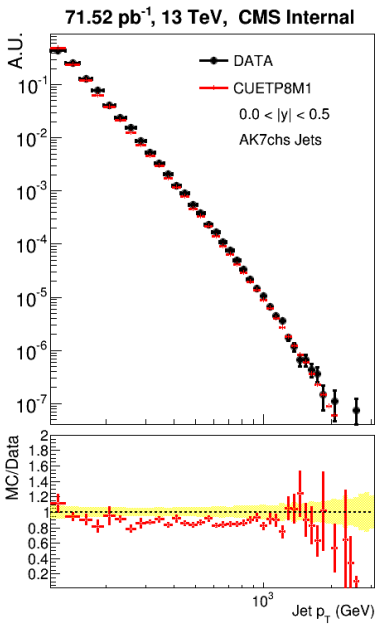
- AK7chs leading jet with $p_T > 114$ GeV in $|\eta| < 4.7$

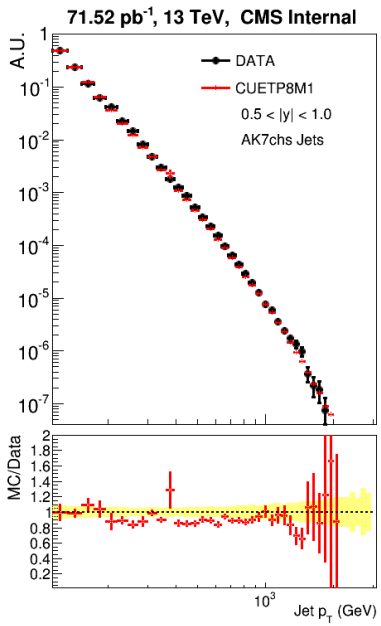
$\rightarrow$ Triggers in data applied as in the previous slide

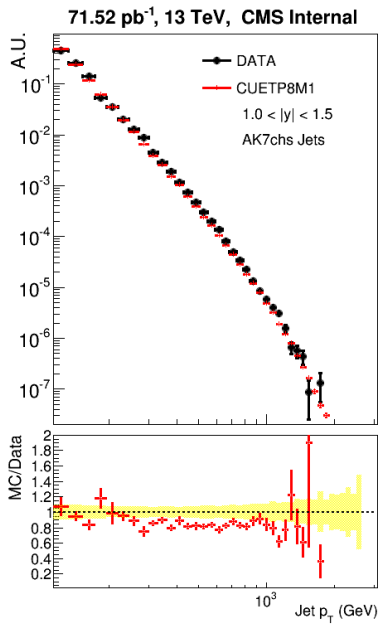
Reasonable agreement in the core of the distribution for the two scenarios

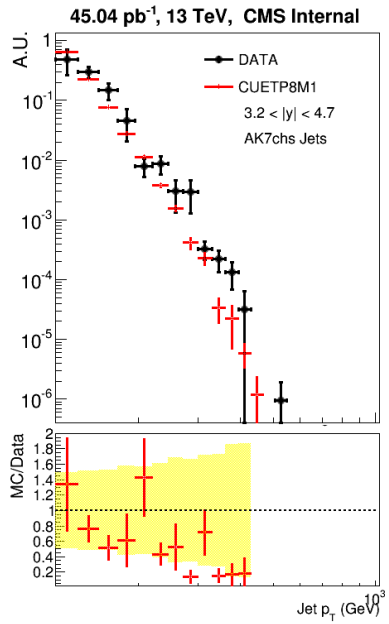
No pile-up reweighting applied yet!

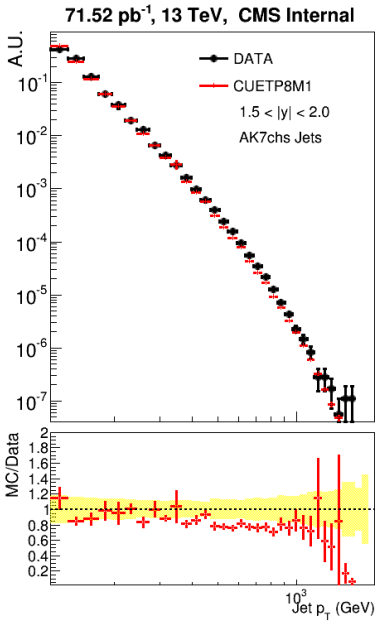
Control distributions (I) - AK7

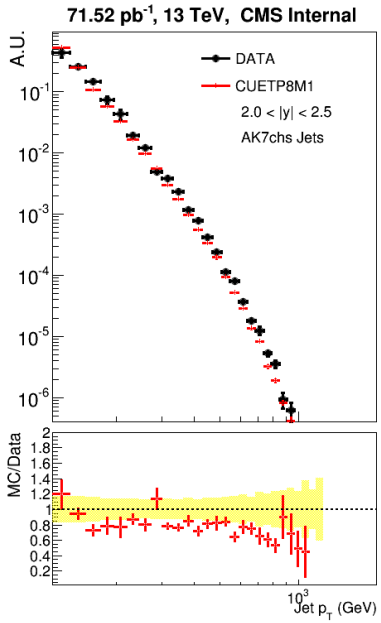


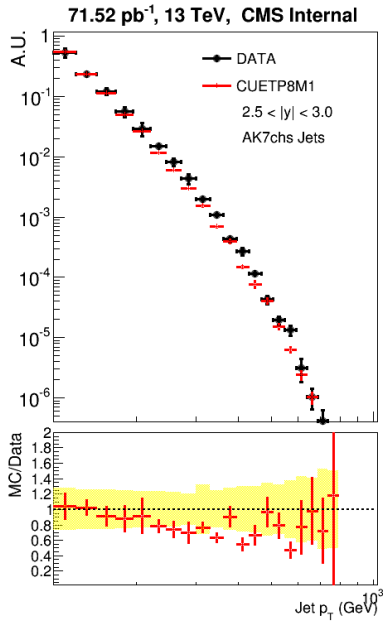








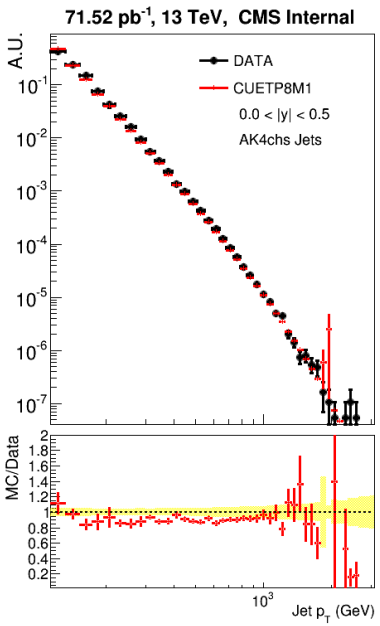


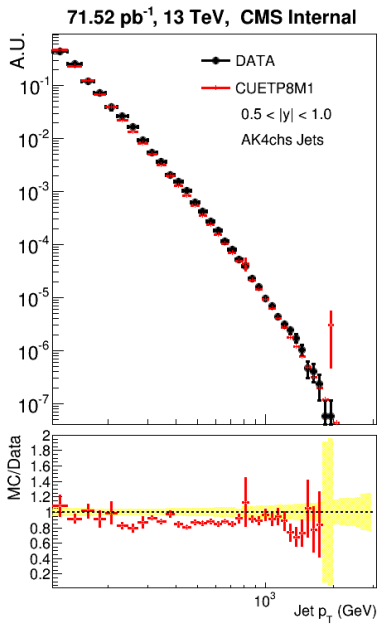


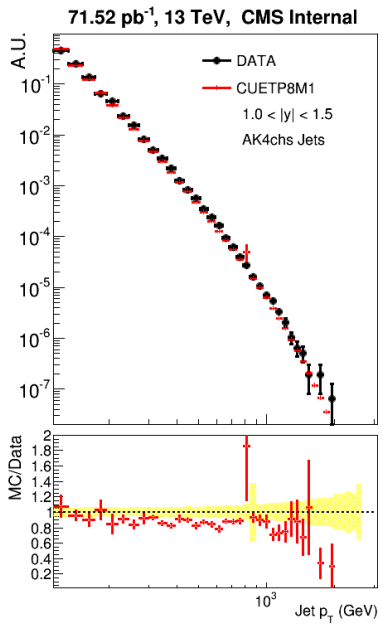
Inclusive jet transverse momentum in different $|y|$ bins

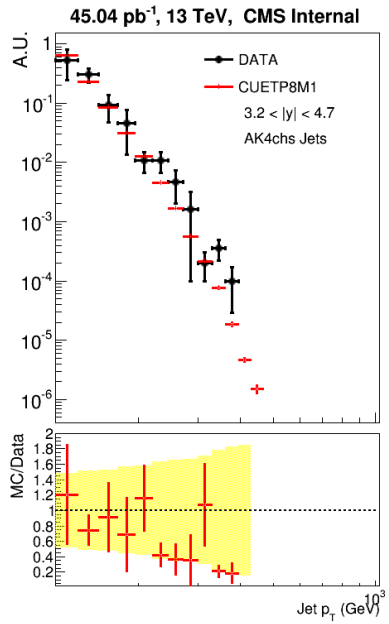
Data and simulation normalized to the respective total number of selected events

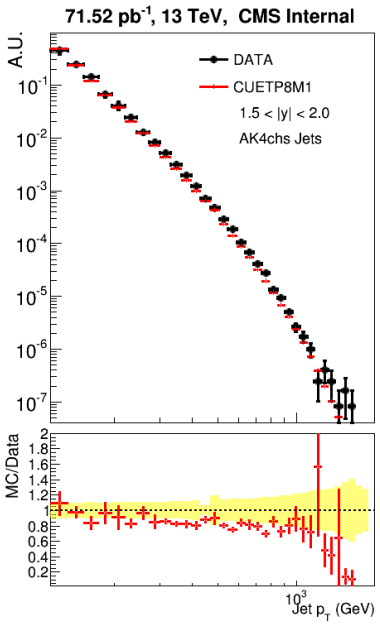
Control distributions (I) - AK4

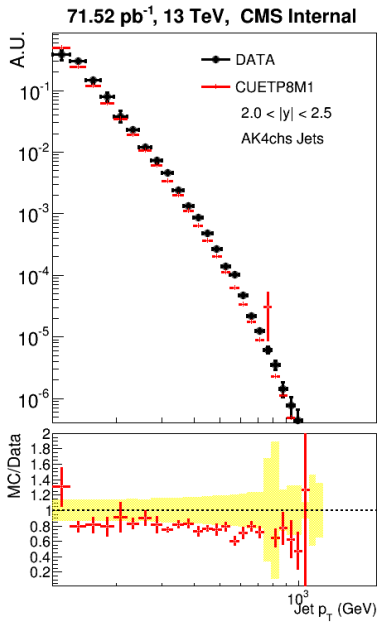


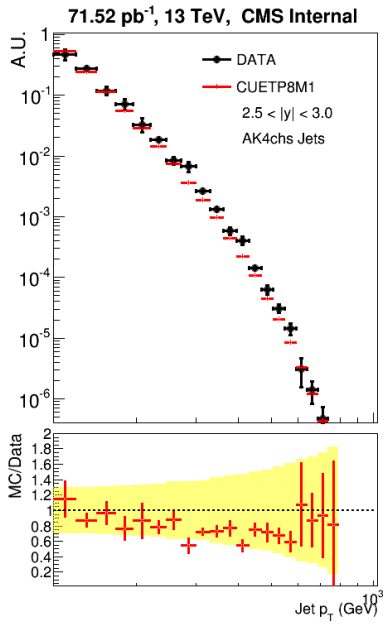








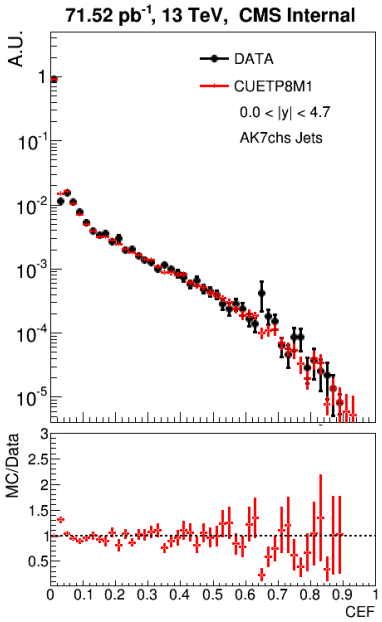


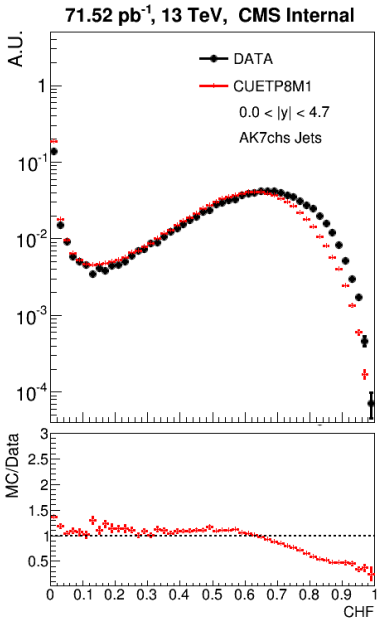


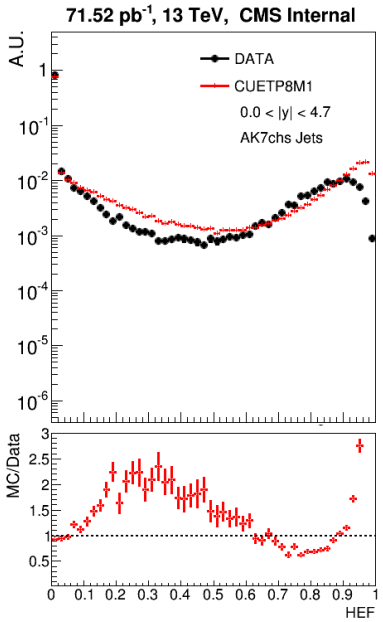
Inclusive jet transverse momentum in different $|y|$ bins

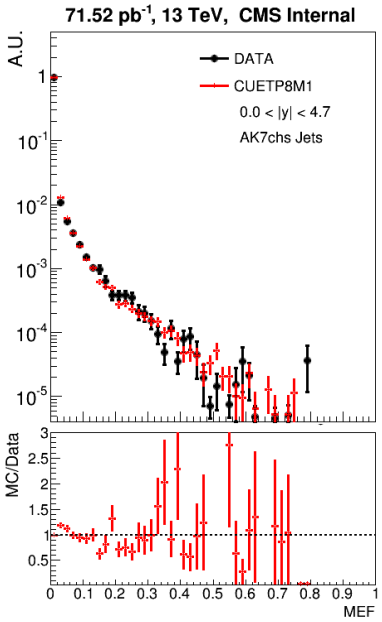
Data and simulation normalized to the respective total number of selected events

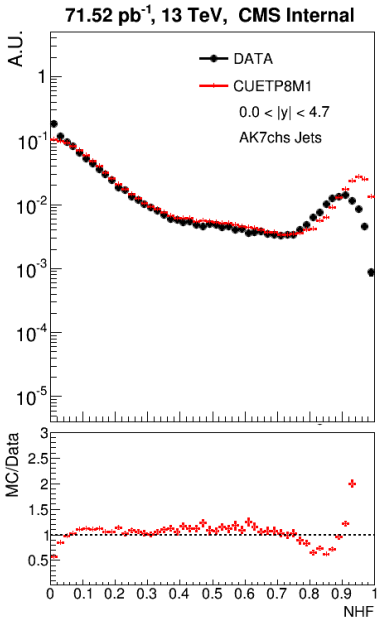
Control distributions (II)

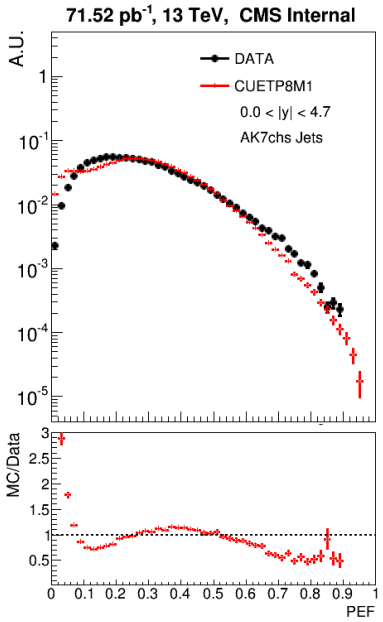












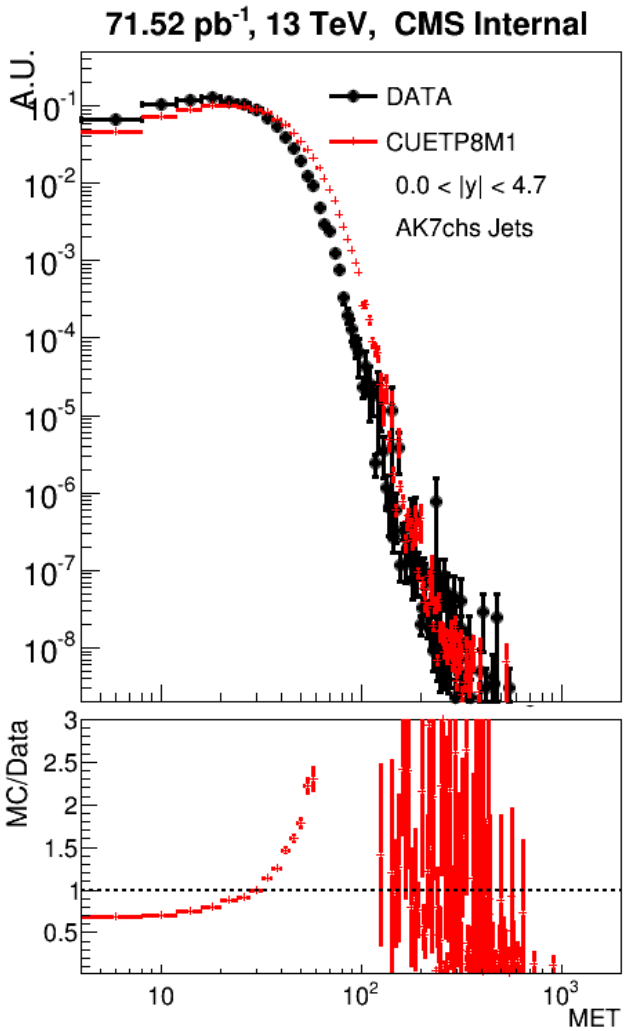
TOP:
Chg elm (left), chd hadron (center) and hadron elm (right) fraction,

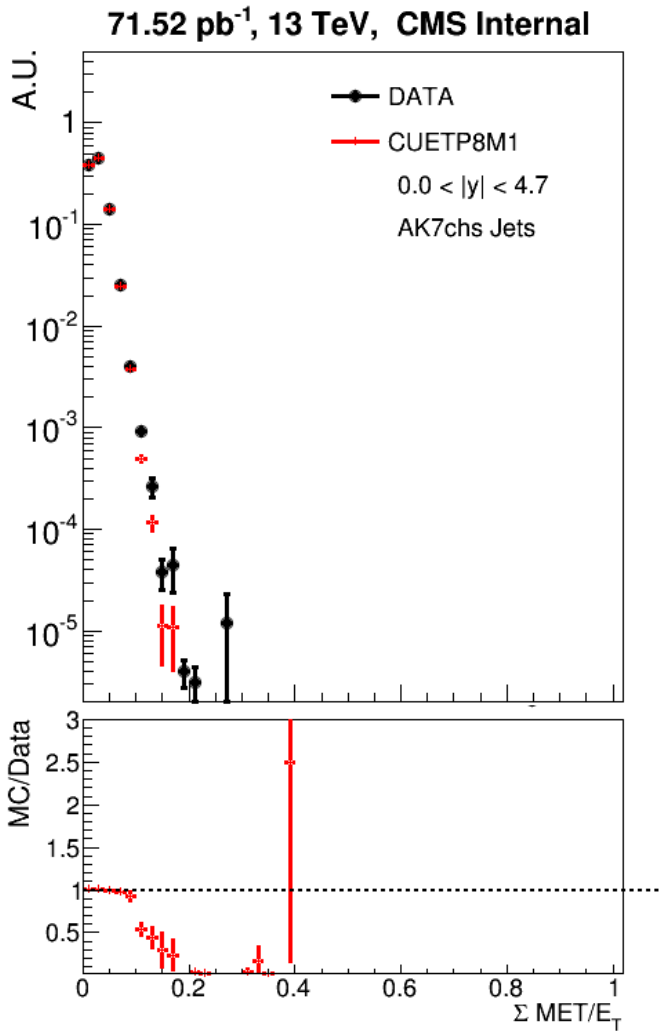
BOTTOM:
muon (left), neutral hadron (center) and photon fraction (right)

for selected jets ($p_T > 114$ GeV in $|\eta| < 4.7$)

Both normalized to the total number of selected events

Control distributions (MET)





MET (left) and MET fraction (right) fraction (top) for events with at least a jet with $p_T > 114$ GeV in $|\eta| < 4.7$

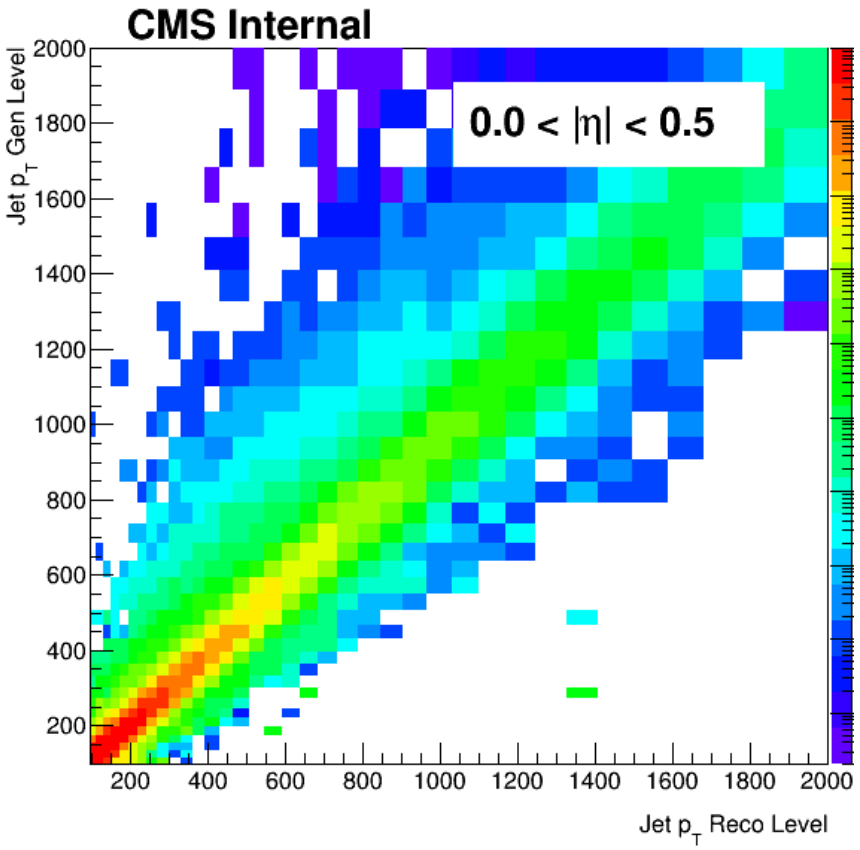
Both normalized to the total number of selected events

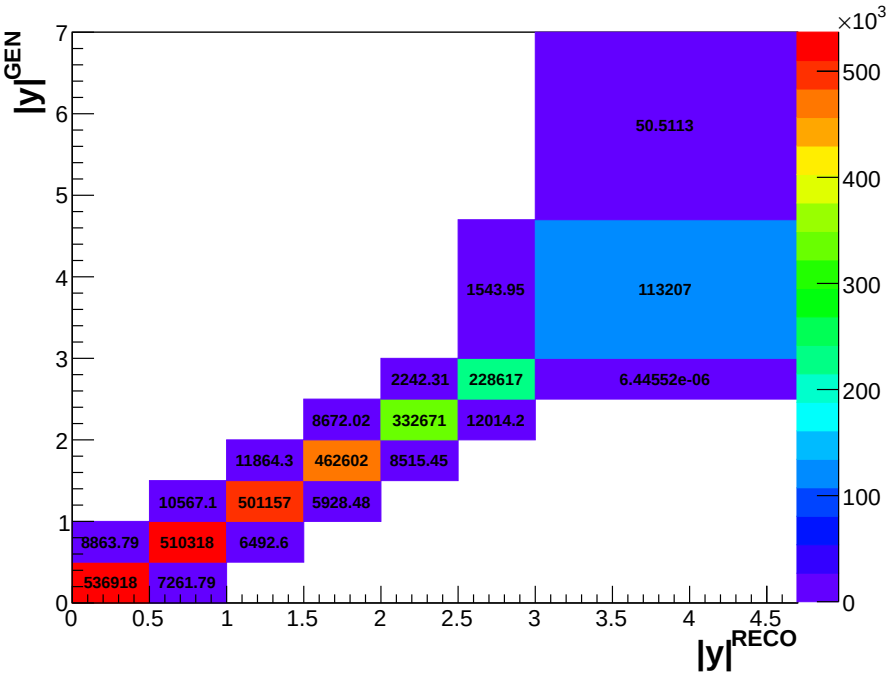
Not too bad agreement for MET and MET fraction!

No cut in MET fraction applied yet!

Studies of detector effects

Based on the MC sample from CUETP8M1





Reco-gen jet matching with $\Delta R = 0.3$

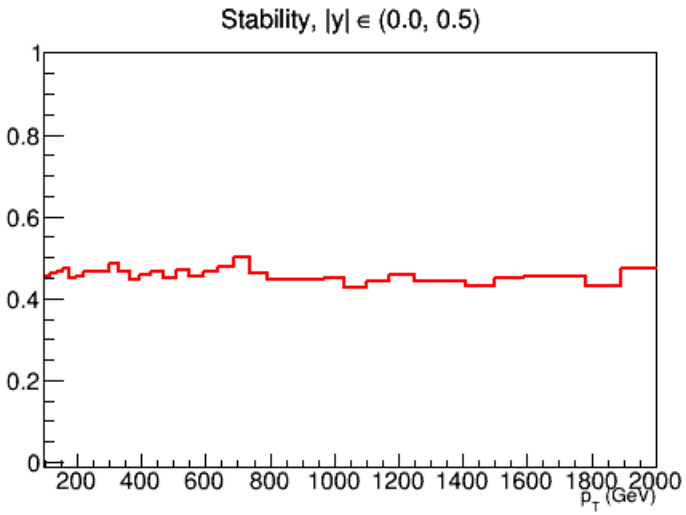
Diagonal form of the response matrix as a function of p_T

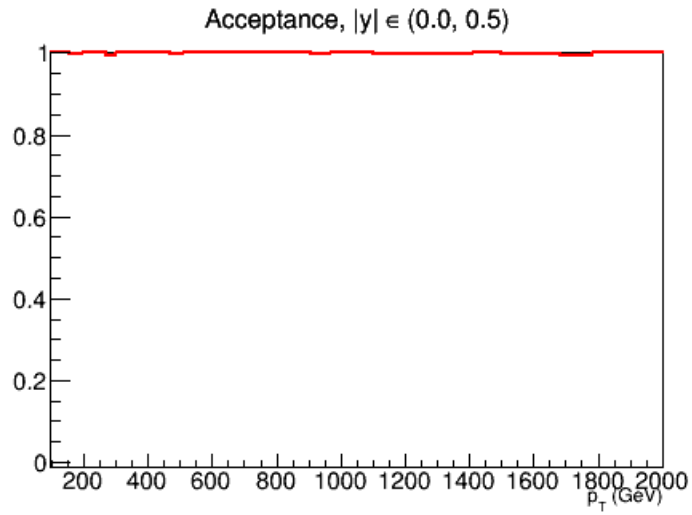
Migration effects in different rapidity bins are negligible ($< 3\%$)

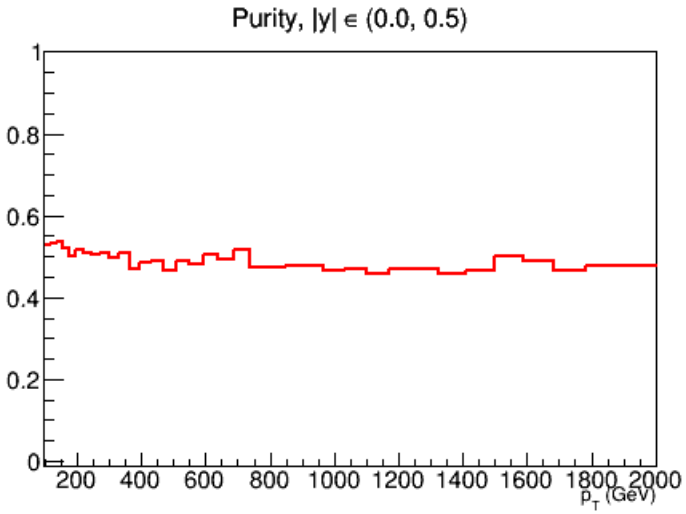
PLAN is to perform a 1D unfolding

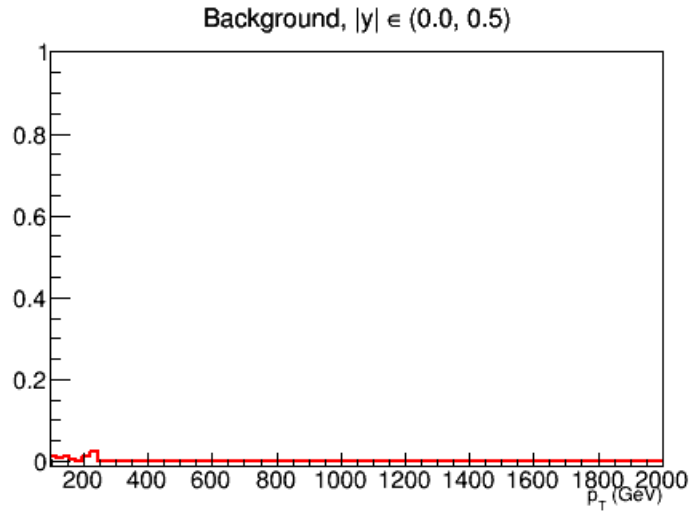
Purity, stability, acceptance, background

PURITY: jets selected at det. level stay at the same p_T bin at gen. level
STABILITY: jets selected at gen. level stay at the same p_T bin at det. level
ACCEPTANCE: jets at gen. level selected also at det. level
BACKGROUND: jets at det. level NOT corresponding to jets at gen. level









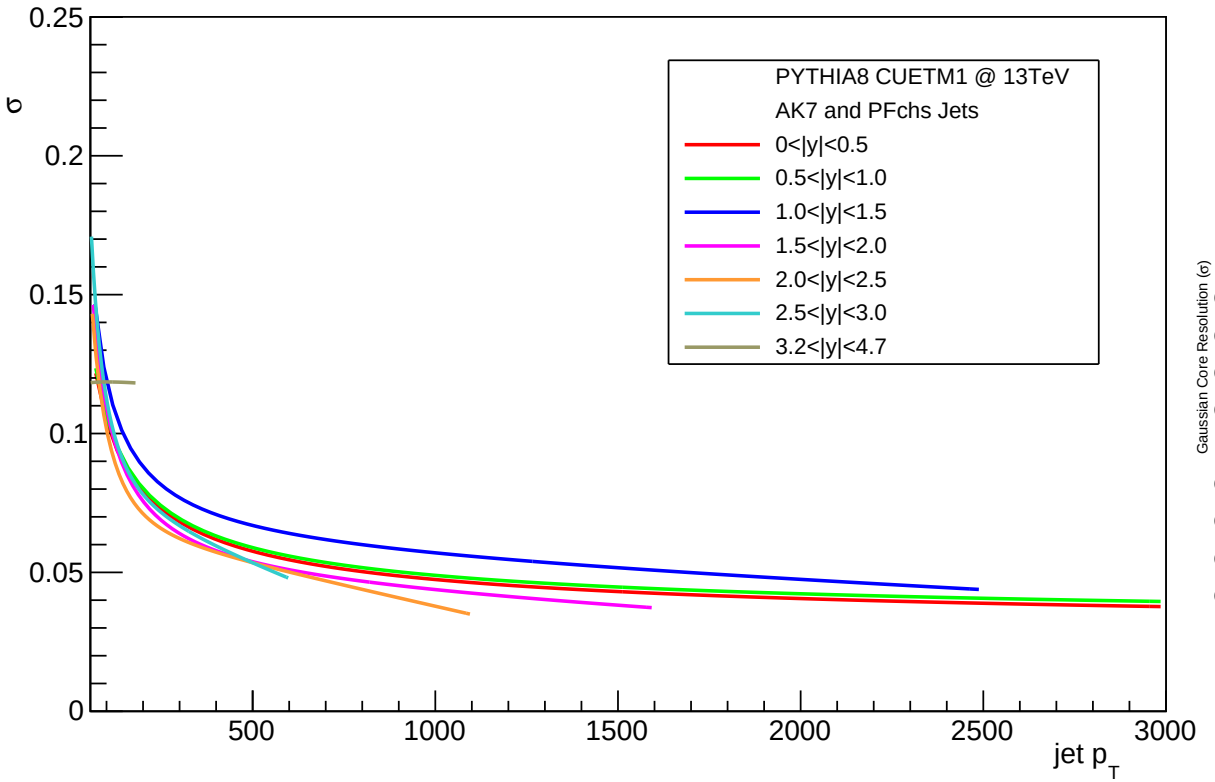
Resolution studies - AK7

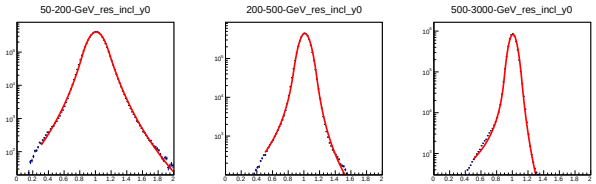
Relative p_T resolution are constructed from the P8 MC sample

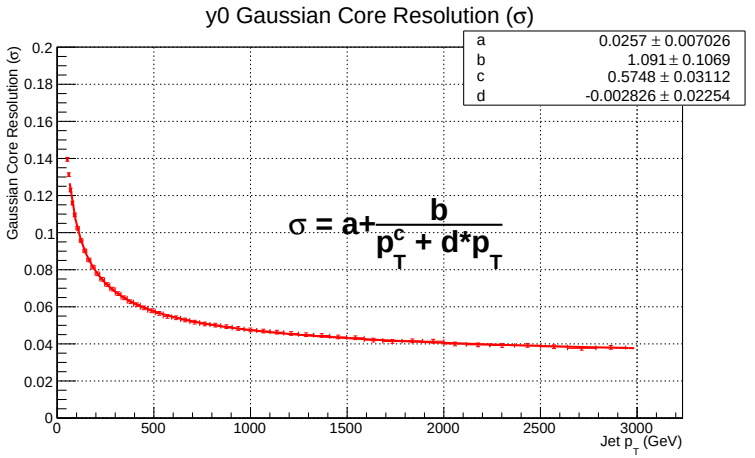
- Separate estimation in the considered jet p_T bins
- Fit to a double sided crystal ball function:

$$f(x; \mathbf{a}, n, \bar{x}, \sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant |\mathbf{a}| \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} > |\mathbf{a}| \end{cases}$$

Gaussian Core Resolution (σ)







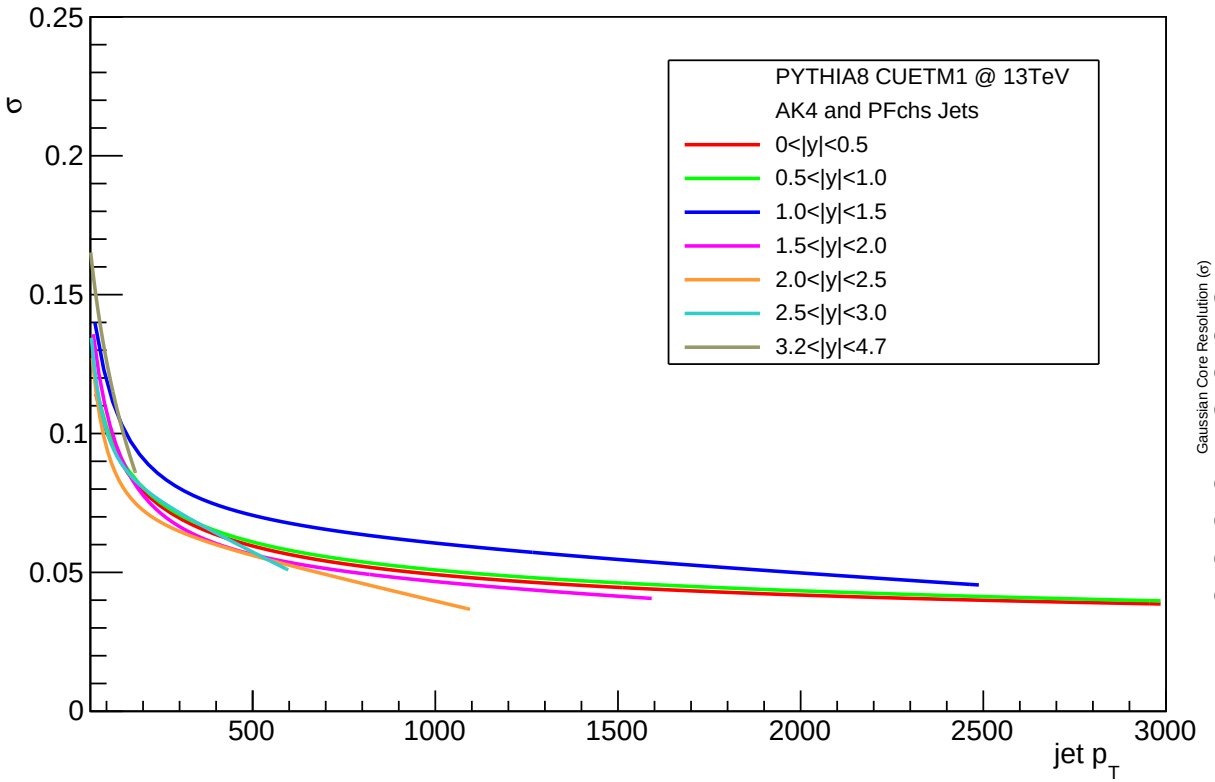
Resolution studies - AK4

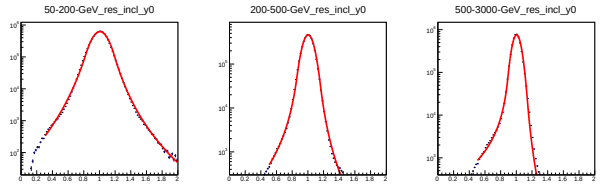
Relative p_T resolution are constructed from the P8 MC sample

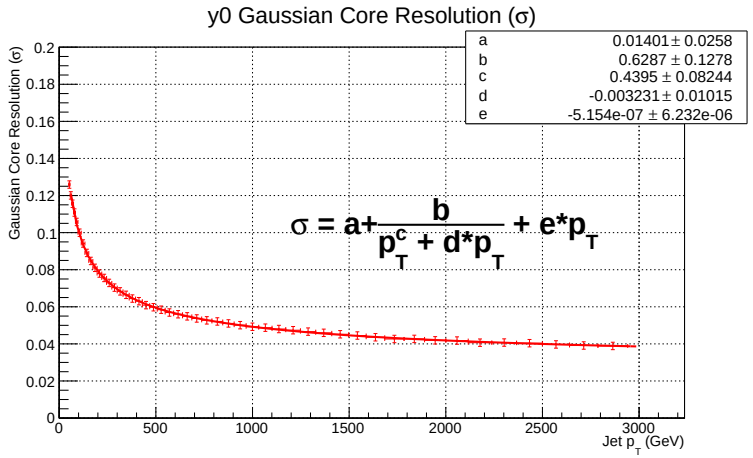
- Separate estimation in the considered jet p_T bins
- Fit to a double sided crystal ball function:

$$f(x; \mathbf{a}, n, \bar{x}, \sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant |\mathbf{a}| \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} > |\mathbf{a}| \end{cases}$$

Gaussian Core Resolution (σ)







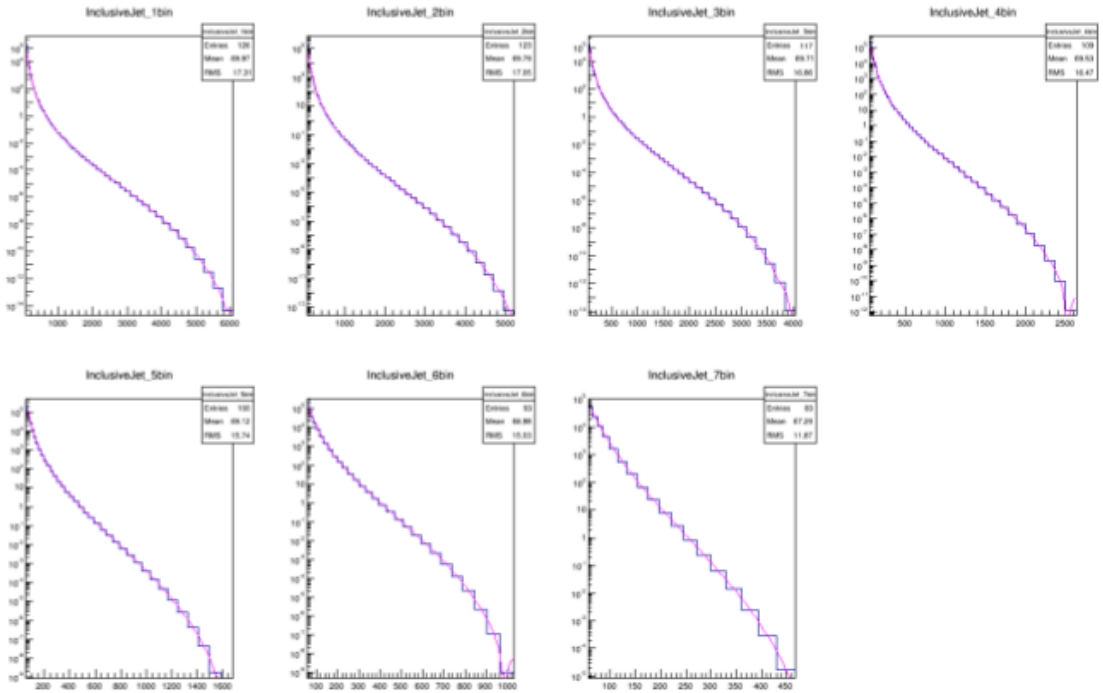
Unfolding procedure

Current strategy

- Smearing matrix from resolution in the MC
- Cross-check: Smearing matrix obtained from MC
- RooUnfoldBayes package for both (and studies of optimal N_{iter})

In detail:

- Fit of the generator spectrum from NLO calc.
- Gaussian/Crystal ball fit of the resolution from P8 in each y and p_T bin
- Smearing of the gen. spectrum for response matrix construction
- D'Agostini method with $N_{iter} = 4$



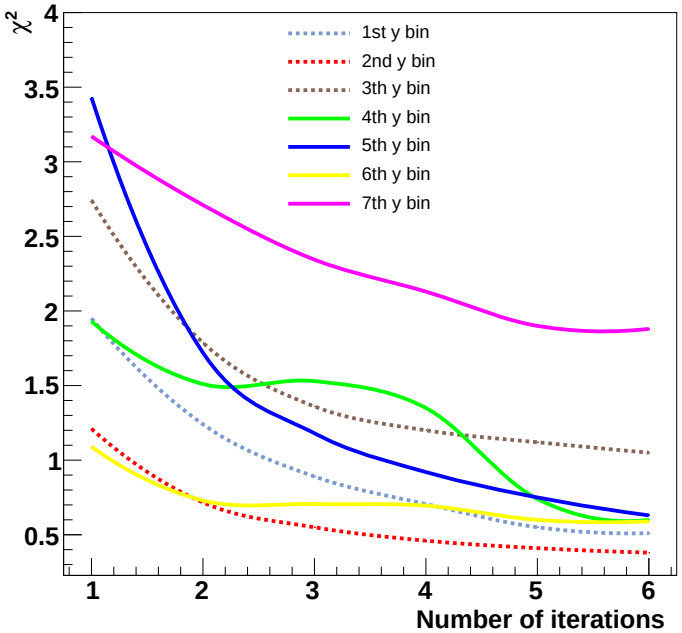
Are unfolded results reliable? (I)

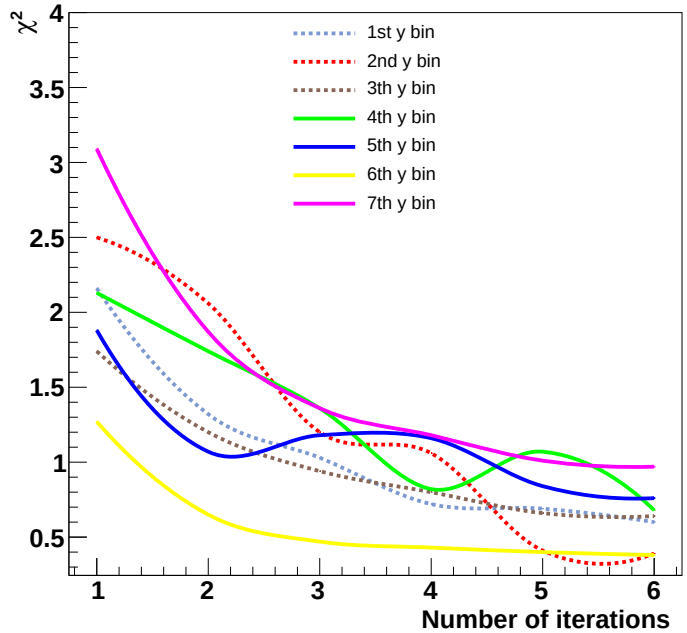
Backfolding → The unfolded distributions are folded back with PYTHIA response matrix and compared to the detector level

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

The quality of the backfolding is estimated by evaluating:

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

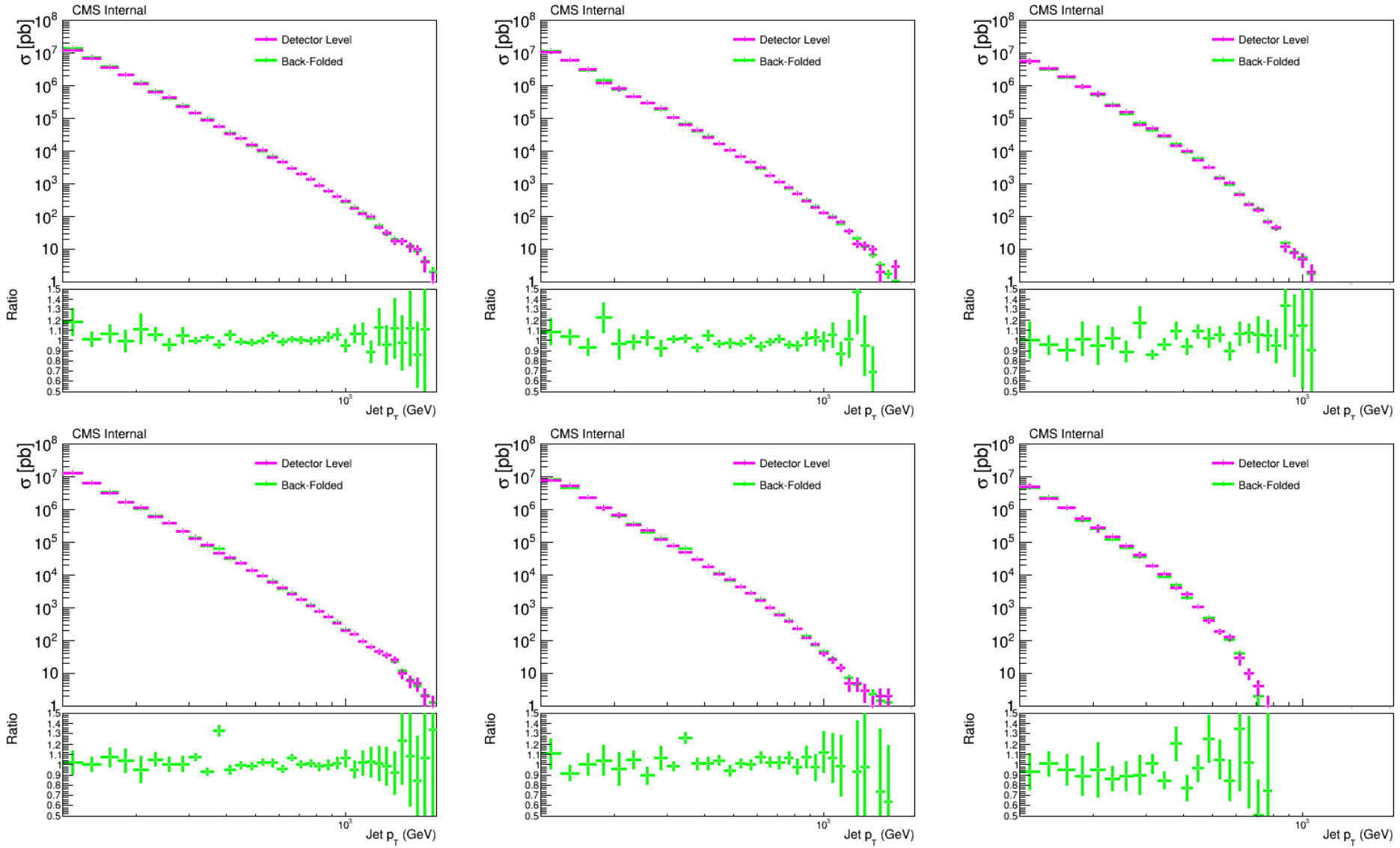




Reduced χ^2 as a function of the number of iteration of the Bayesian unfolding

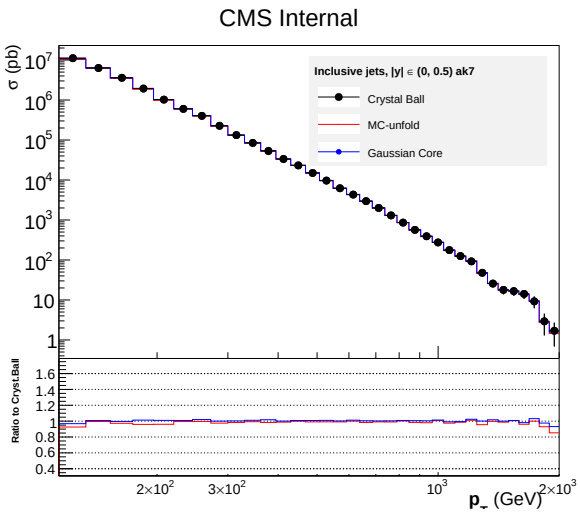
The number of iteration has been chosen to be **4** as the point where the χ^2 starts to flatten

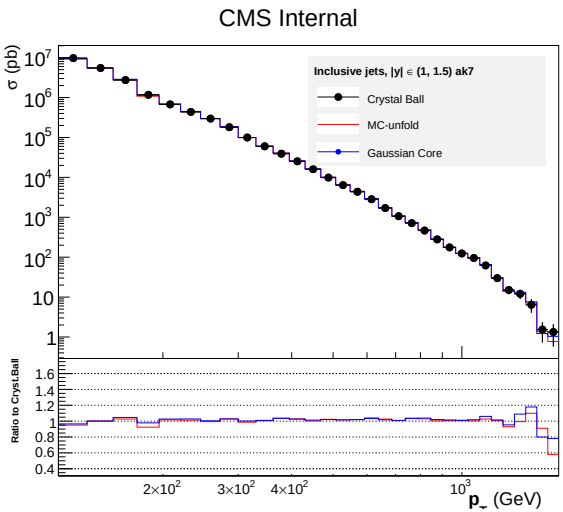
Are unfolded results reliable? (II)

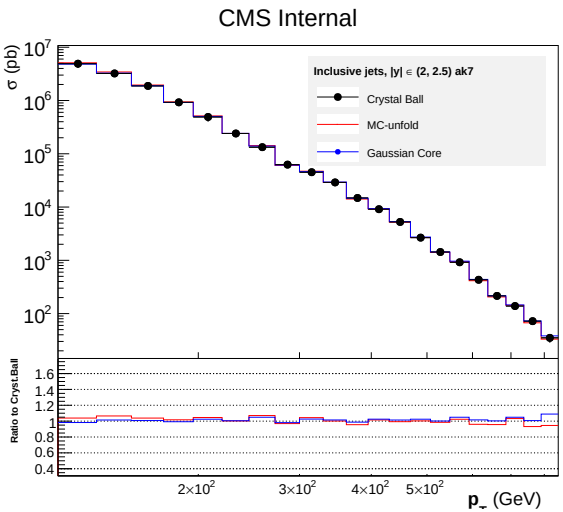


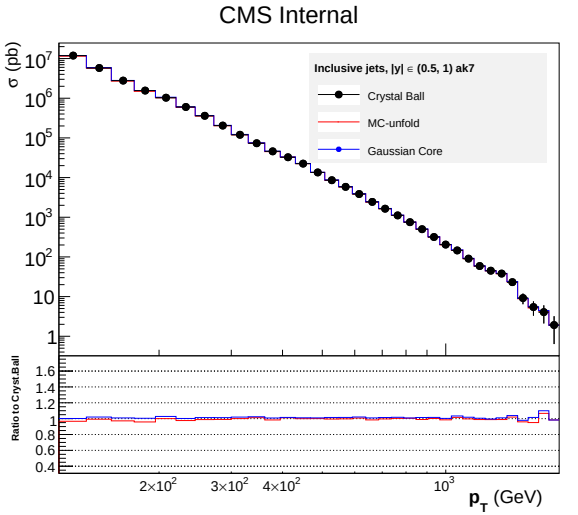
Comparisons between detector level distributions and folded-back ones

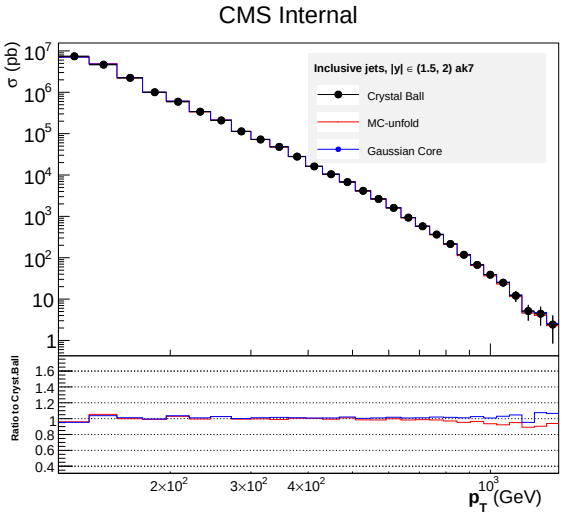
Unfolding closure tests - response matrix - AK7

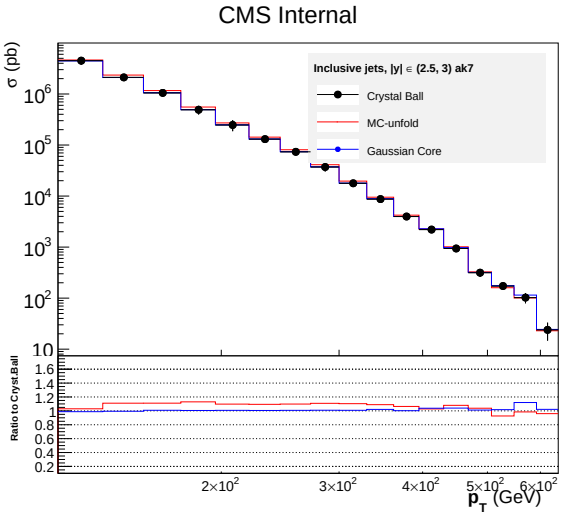






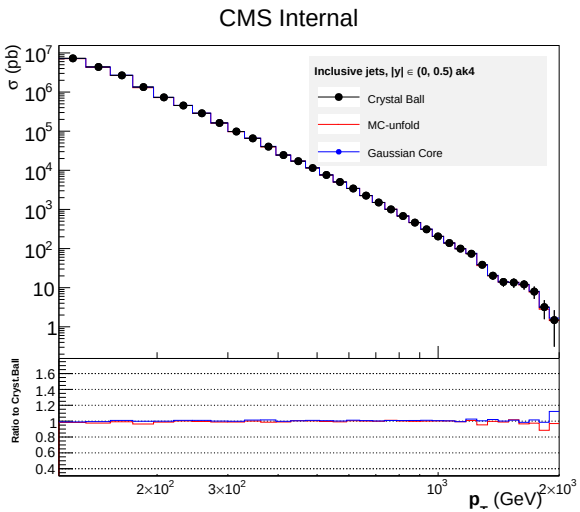


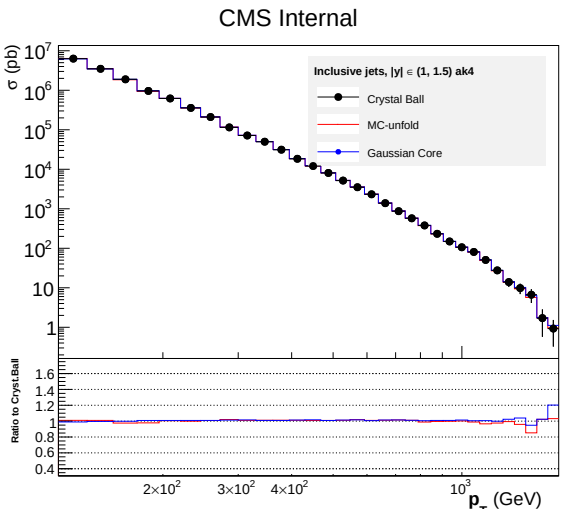


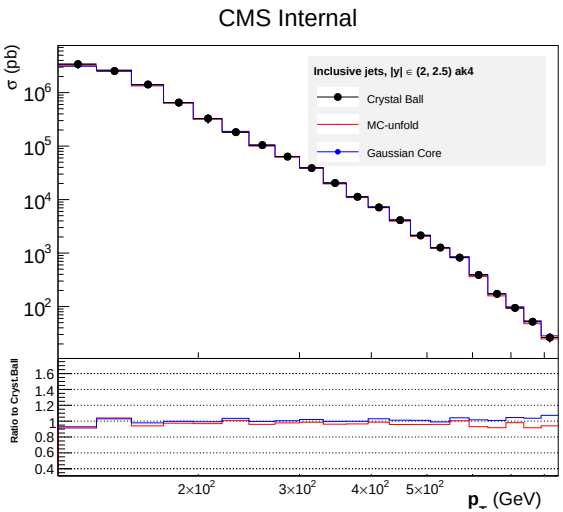


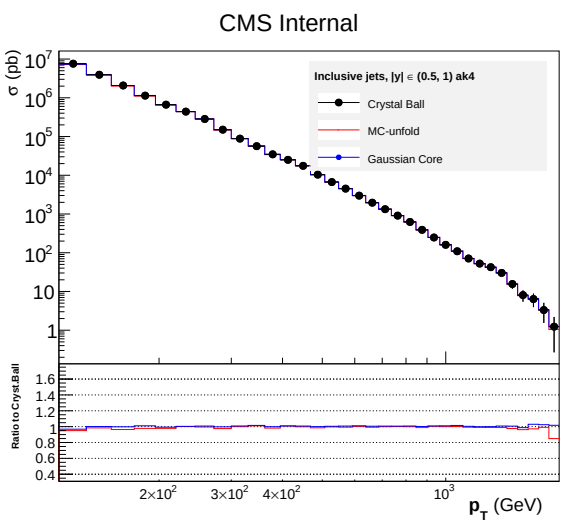
Unfolding using the (nominal) crystal-ball function, only the gaussian core and the MC matrix

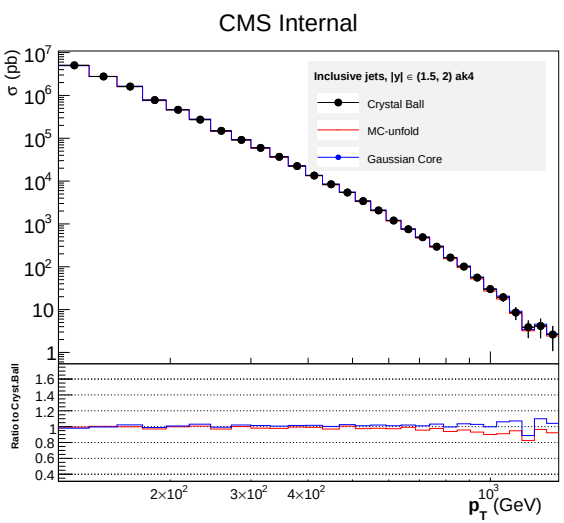
Unfolding closure tests - response matrix - AK4

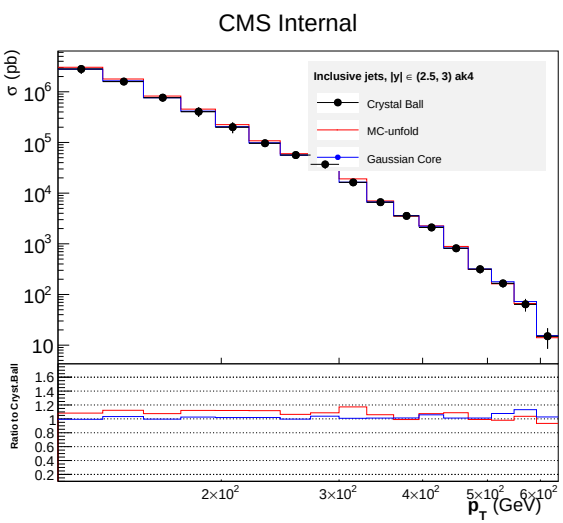












Unfolding using the (nominal) crystal-ball function, only the gaussian core and the MC matrix

Are unfolded results reliable? (III)

Other cross checks performed (and documented in the AN):

- Comparison among statistical errors of distributions before and after unfolding: errors after unfolding are always bigger
- Closure test: good compatibility on unfolding performance in MC
- Unfolding performed with gaussian core or response matrix from MC: very good compatibility between the three (considering the same number of iterations)

The results at stable-particle level are reliable!

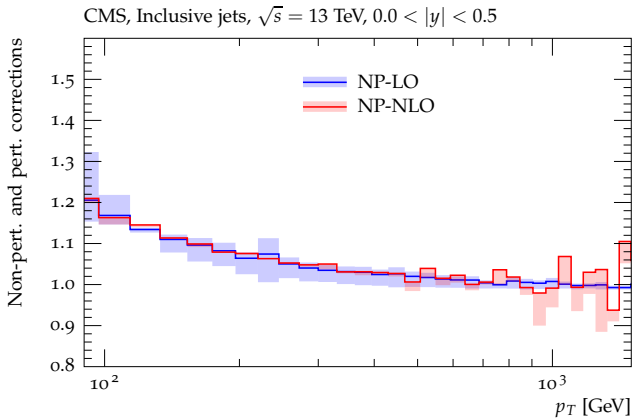
Non-perturbative corrections (I) -AK7

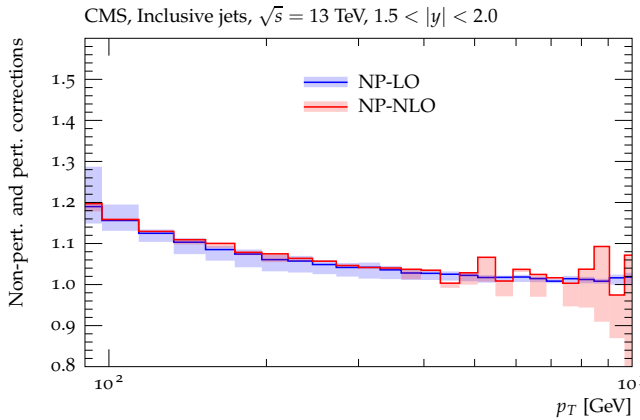
Corrections evaluated for various $|y|$ bins (p_T: 97-3000 GeV)

Considered MC event generators:

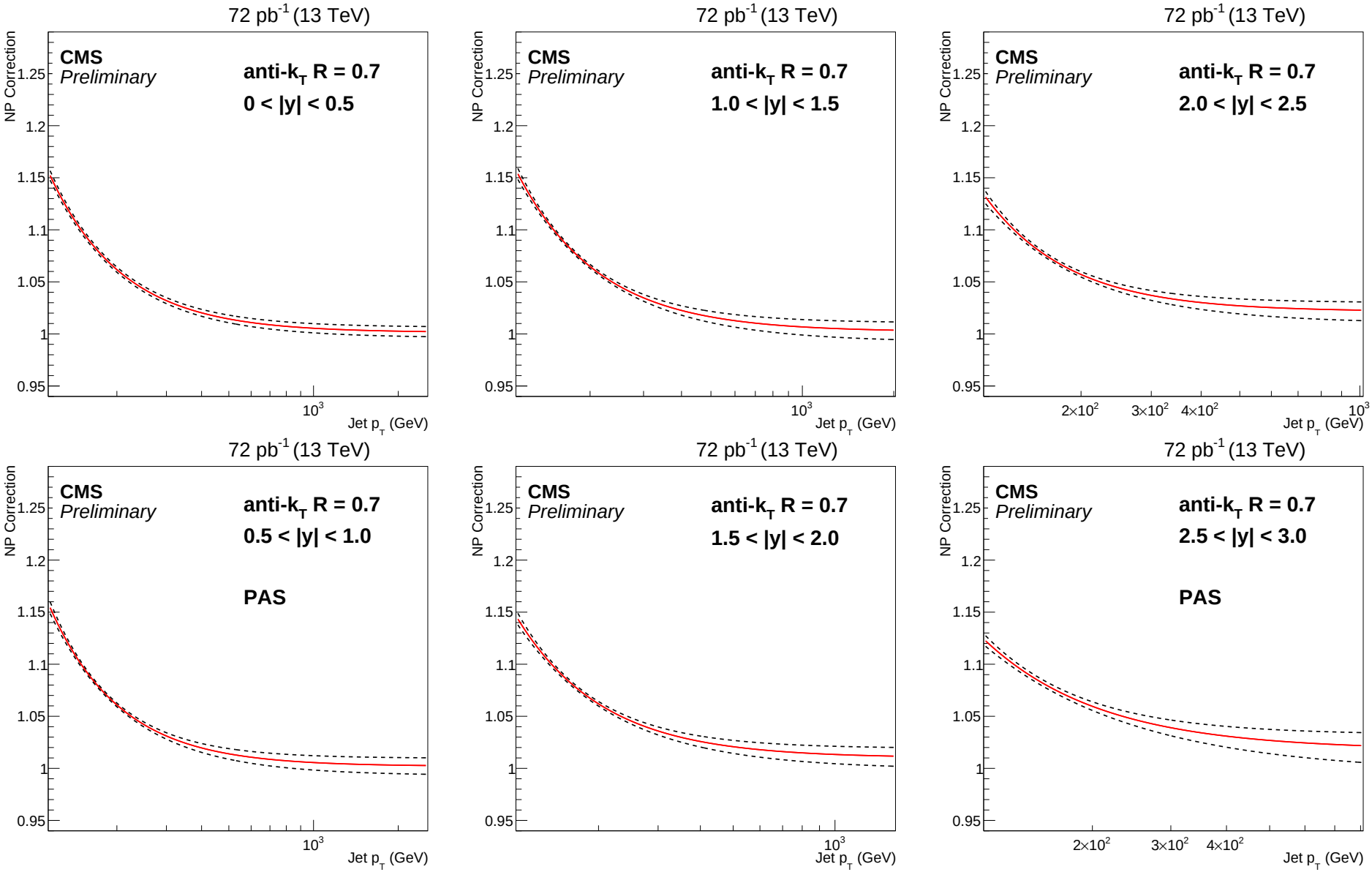
- POWHEG (CT10) + PYTHIA 8 - tune CUETP8M1
- POWHEG (HERAPDFNLO) + PYTHIA 8 - tune CUETP8S1-HERAPDF1.5LO
- POWHEG (CT10) + PYTHIA 8 - tune CUETP8M1
- PYTHIA8 + tune CUETP8M1
- HERWIG++ + tune CUETHppS1

$$C_{NP} = \frac{\frac{d\sigma^{nom.}}{dp_T}}{\frac{d\sigma^{MPI,Had\ off}}{dp_T}}$$





Non-perturbative corrections (II) -AK7



Fits to NP for AK7 and relative uncertainty for different rapidity bins

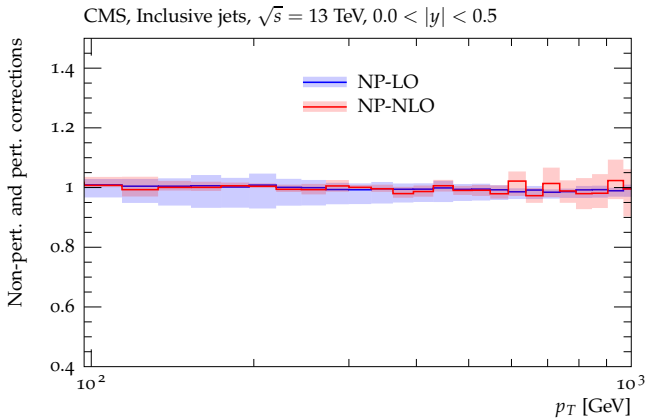
Non-perturbative corrections (III) - AK4

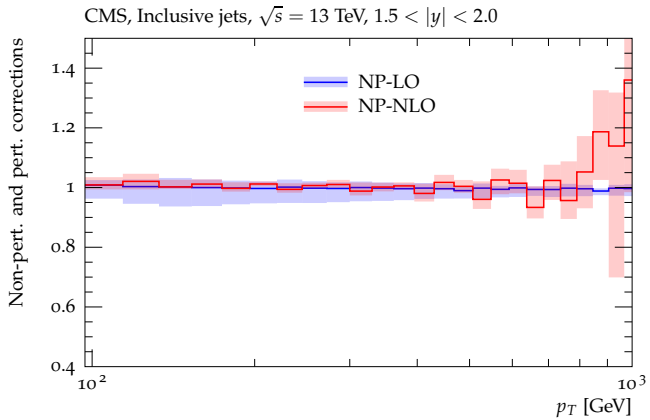
Corrections evaluated for various $|y|$ bins (p_T: 97-3000 GeV)

Considered MC event generators:

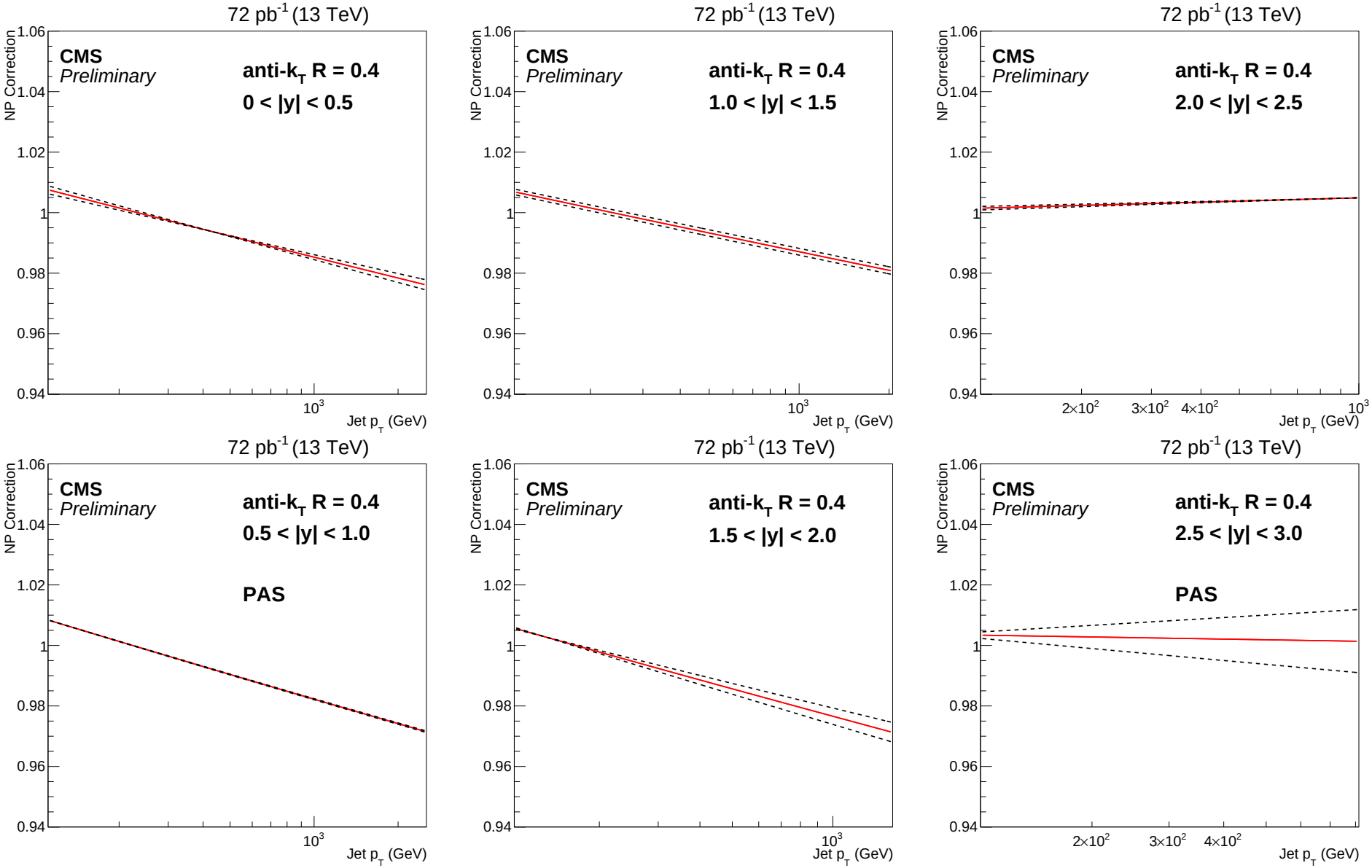
- POWHEG (CT10) + PYTHIA 8 - tune CUETP8M1
- POWHEG (HERAPDFNLO) + PYTHIA 8 - tune CUETP8S1-HERAPDF1.5LO
- POWHEG (CT10) + PYTHIA 8 - tune CUETP8M1
- PYTHIA8 + tune CUETP8M1
- HERWIG++ + tune CUETHppS1

$$C_{NP} = \frac{\frac{d\sigma^{nom.}}{dp_T}}{\frac{d\sigma^{MPI,Had\ off}}{dp_T}}$$





Non-perturbative corrections (IV) -AK4



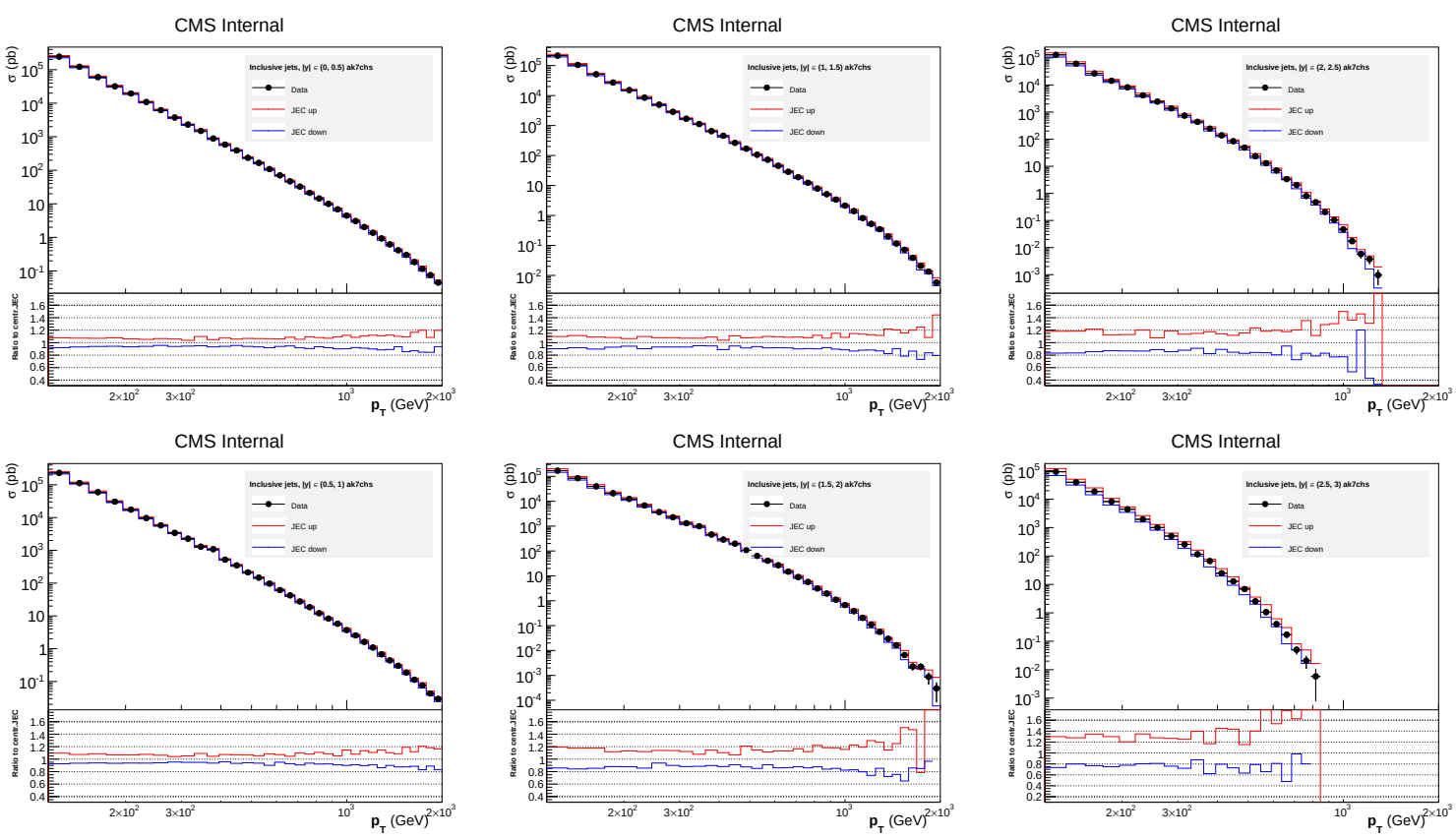
Fits to NP for AK4 and relative uncertainty for different rapidity bins

Systematic uncertainties

- Jet energy scale: JES uncertainty from Summer15_50nsV5 set (8-35% - η dependent)
- Pile-up: difference in spectra with and without PU reweighting
- Luminosity: 4.8% current stage
- Trigger efficiency: "standard" 1% uncertainty
- Unfolding:
  - Jet energy resolution: unfolding with up and down uncertainty of JER factors
  - Model dependence: unfolding with NLO-generator spectra with different PDF
- Theory uncertainty
  - NP corrections (from envelopes)
  - PDF: following the prescription of CT14 PDF set
  - Scale, α_S: variation of α_S by 0.001, and ren. and fact. scale according to 6 combinations in NLOJet++ predictions
  - Electroweak corrections (waiting for values)

Systematic uncertainties - JES AK7

Uncertainty estimated from MC with V5 correction uncertainties - ratio between up and down variations

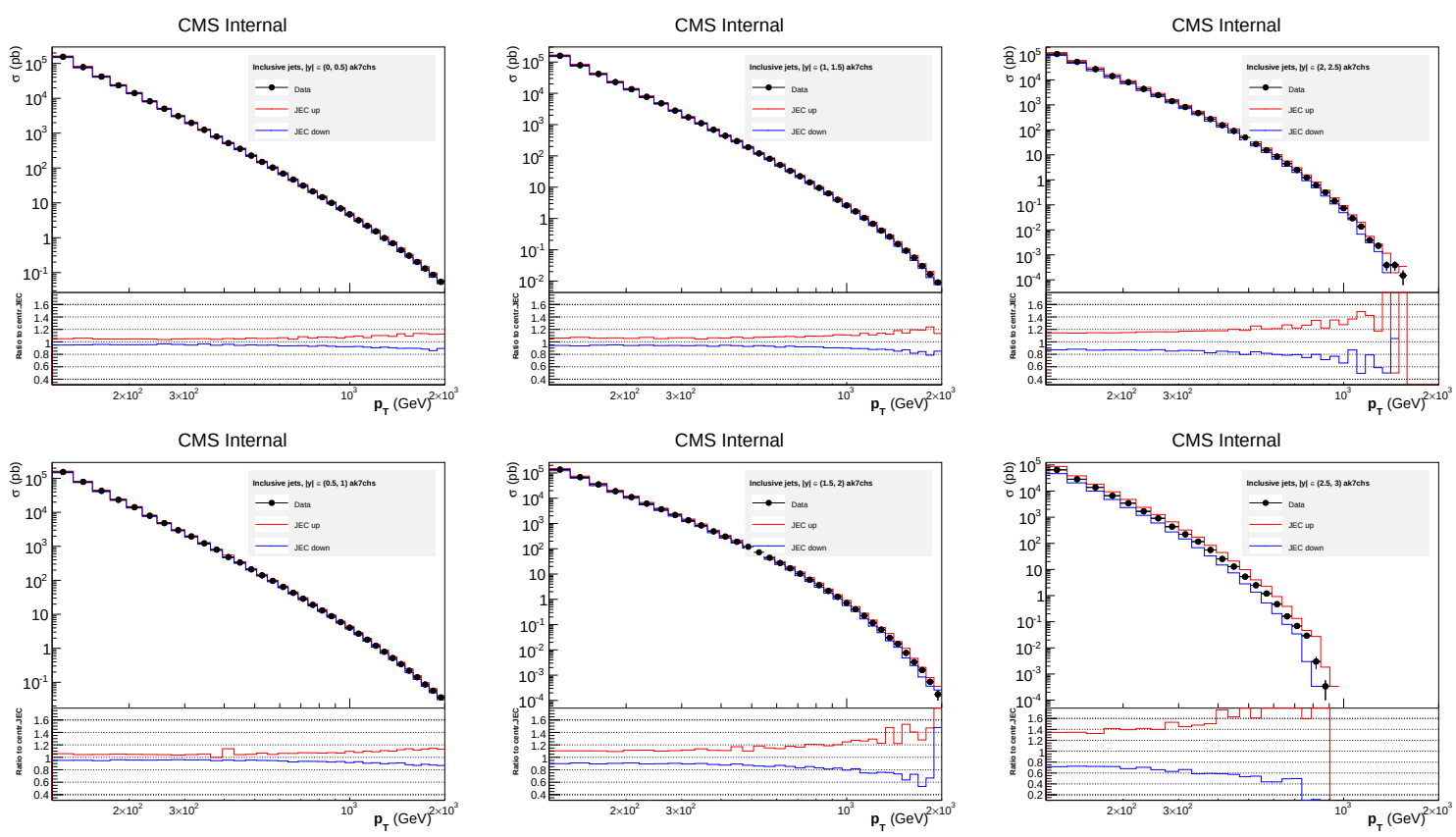


Inclusive jet transverse momentum in different $|y|$ bins

UNC $\sim$ 8-65% - drastic increase in the forward region

Systematic uncertainties - JES AK4

Uncertainty estimated from MC with V5 correction uncertainties - ratio between up and down variations



Inclusive jet transverse momentum in different $|y|$ bins

UNC $\sim$ 8-65% - drastic increase in the forward region

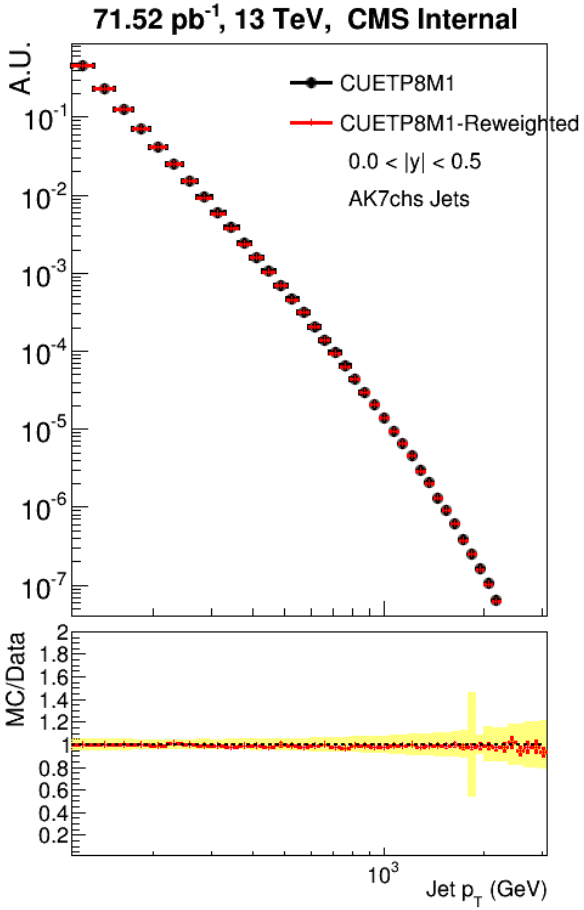
Studies on pile-up impact

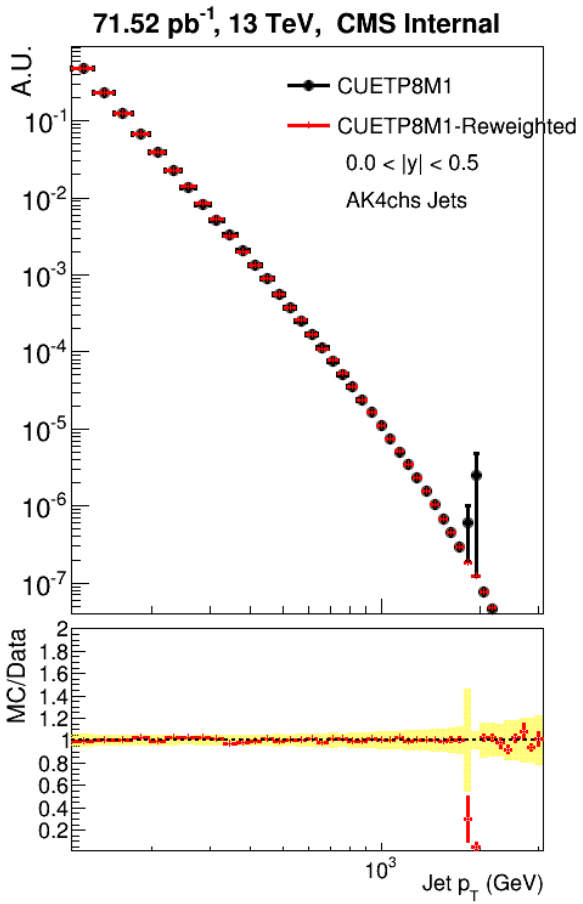
Two tests performed:

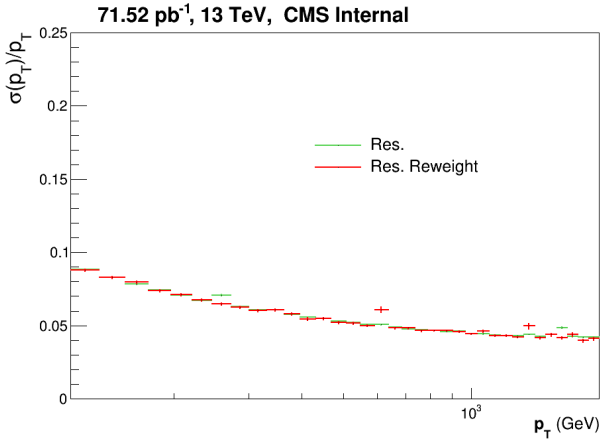
- reweighting through iterative method (left plot)
- reweighting through parsePileUp* tool (center plot)

*https://github.com/cihar29/OffsetAnalysis/blob/master/plugins/parsePileUpJSON2.h

Comparison of detector-level distributions with and without reweighting applied







Summary of assigned uncertainties

Systematic effect	σ(AK7)	σ(AK4)
JES	8-65%	8-65%
JER-unfolding	1-2%	1-2%
Luminosity	4.8%	4.8%
Trigger efficiency	1%	1%
Pile-up	negl.	negl.
Model-unfolding	negl.	negl.
PDF	1-8%	2-10%
Scale	1-12%	1-10%
NP Corrections	1%	2%
Electroweak corr.*	10% (p_T >1 TeV)	10% (p_T >1 TeV)

*Not yet assigned!

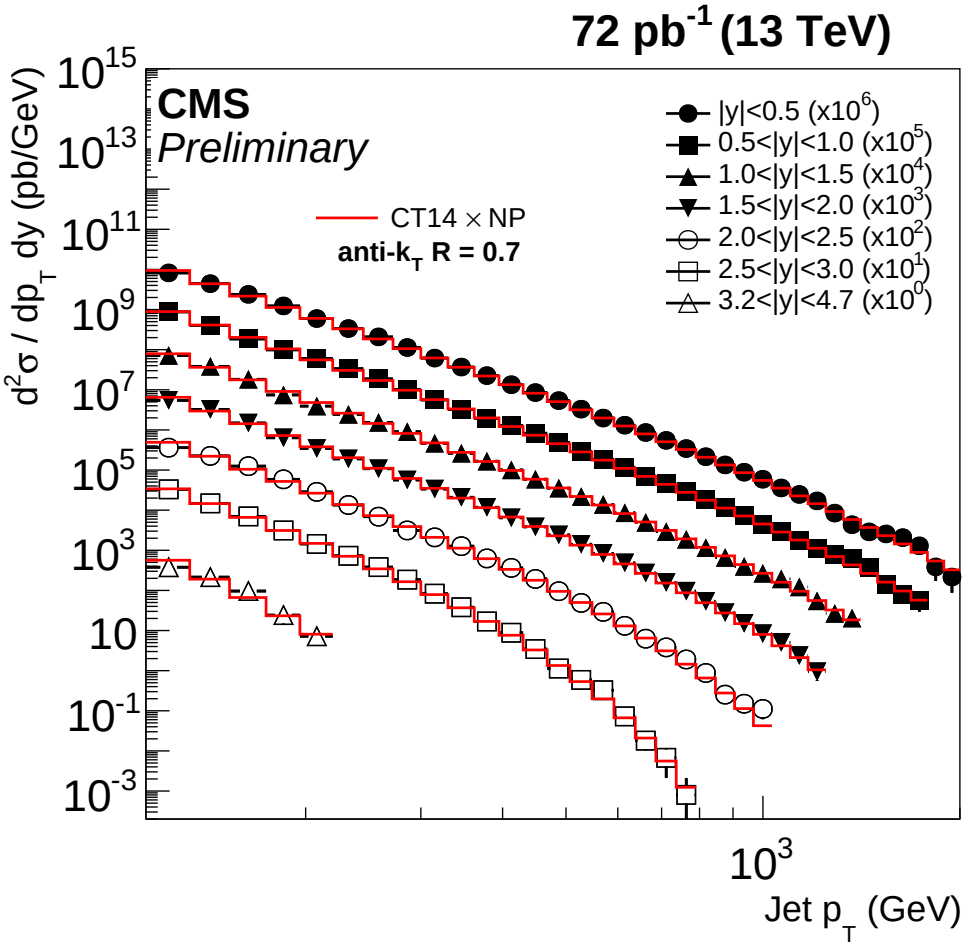
Final results

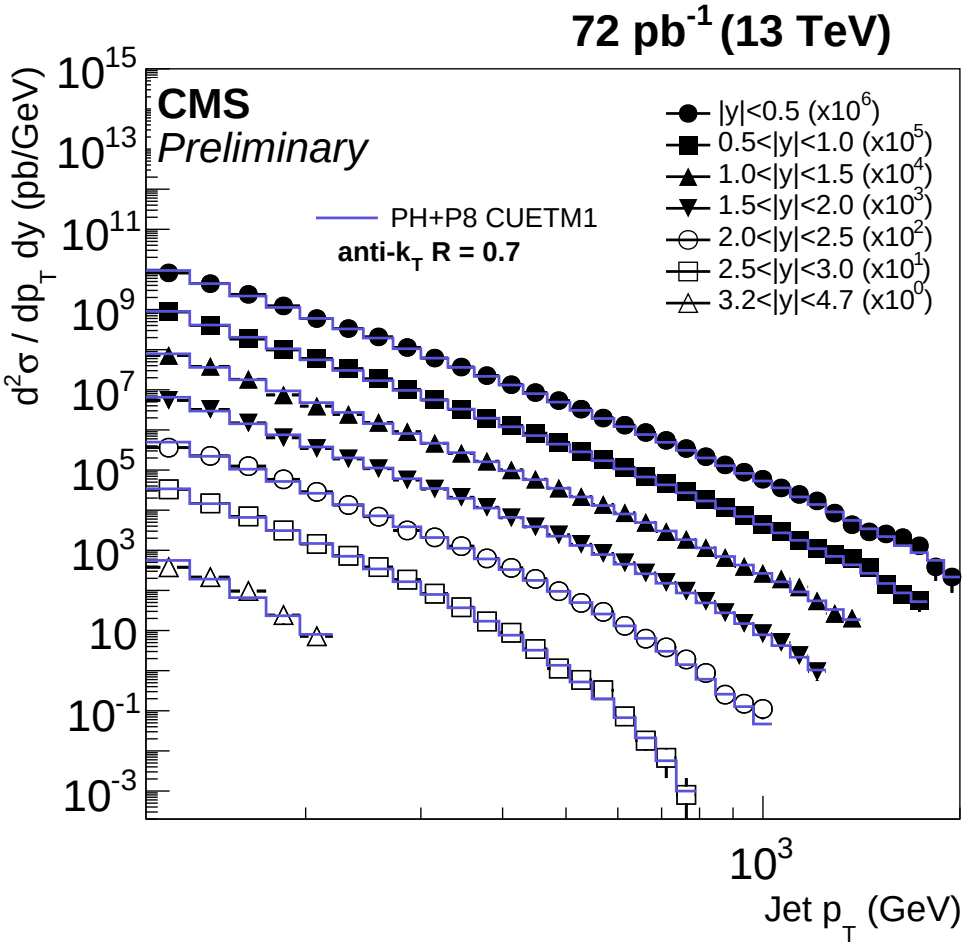
Comparison of double differential inclusive jet cross sections to predictions of:

- Fixed-order calculations from NLOJet++ with different (NLO) PDF:
  - CT14
  - NNPDF3.0
  - HERAPDF1.5
  - MMHT2014
- Monte Carlo event generators
  - POWHEG (CT10NLO) + CUETP8M1
  - POWHEG (HERAPDF1.5) + CUETP8S1-HERAPDF
  - CUETP8M1
  - CUETHppS1

All plots shown in the following are in the PAS!

Final results -AK7



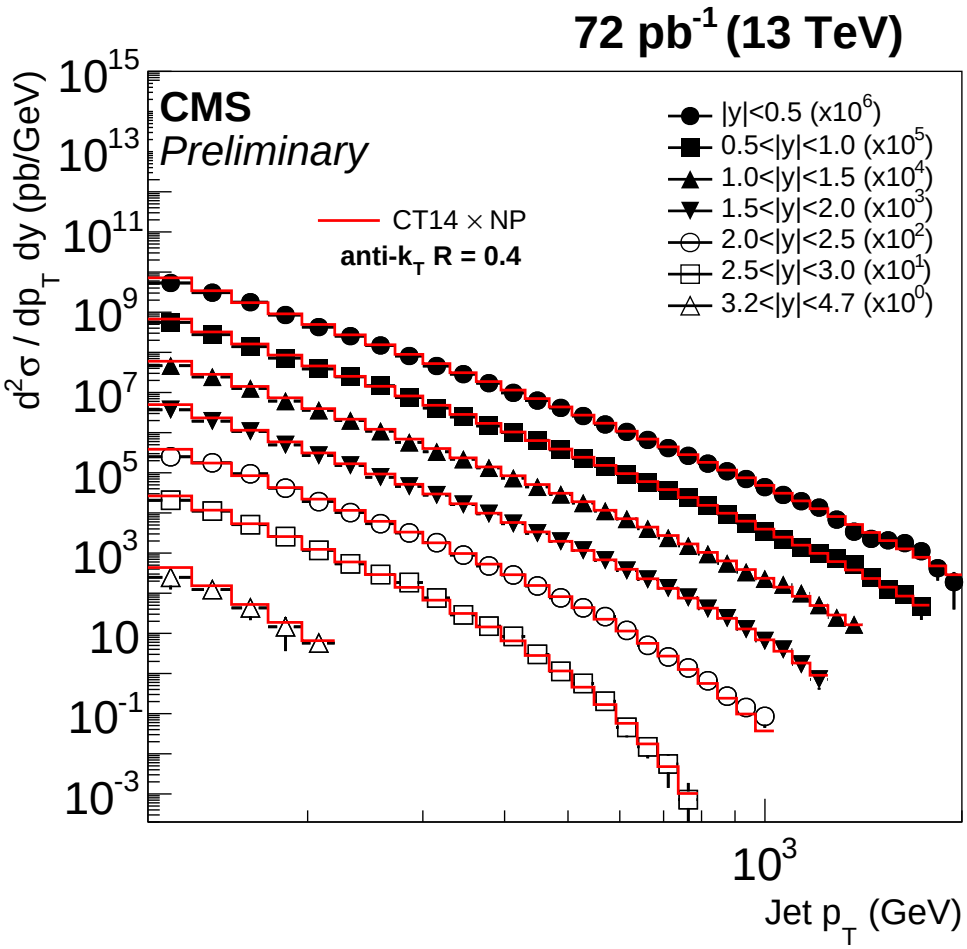


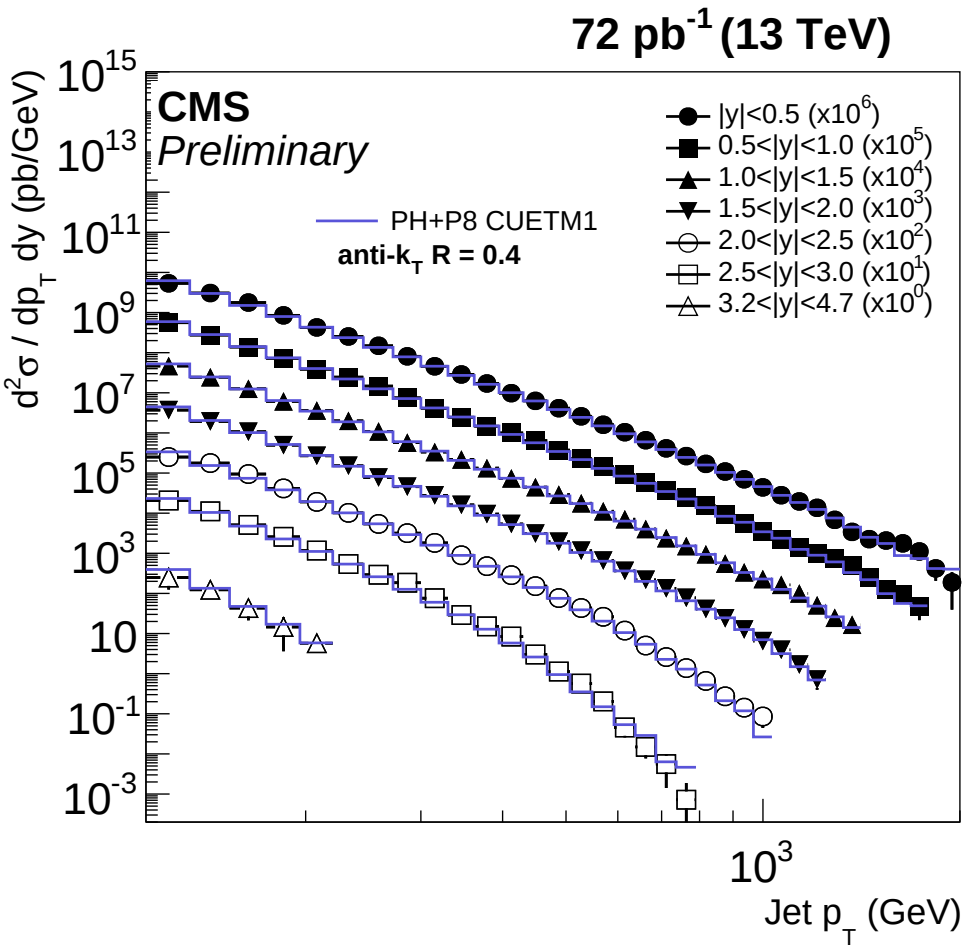
Unfolded results compared to predictions from:

- FastNLO with central NP
- POWHEG+PYTHIA8 CUETP8M1

For the first time HF region included!

Final results - AK4





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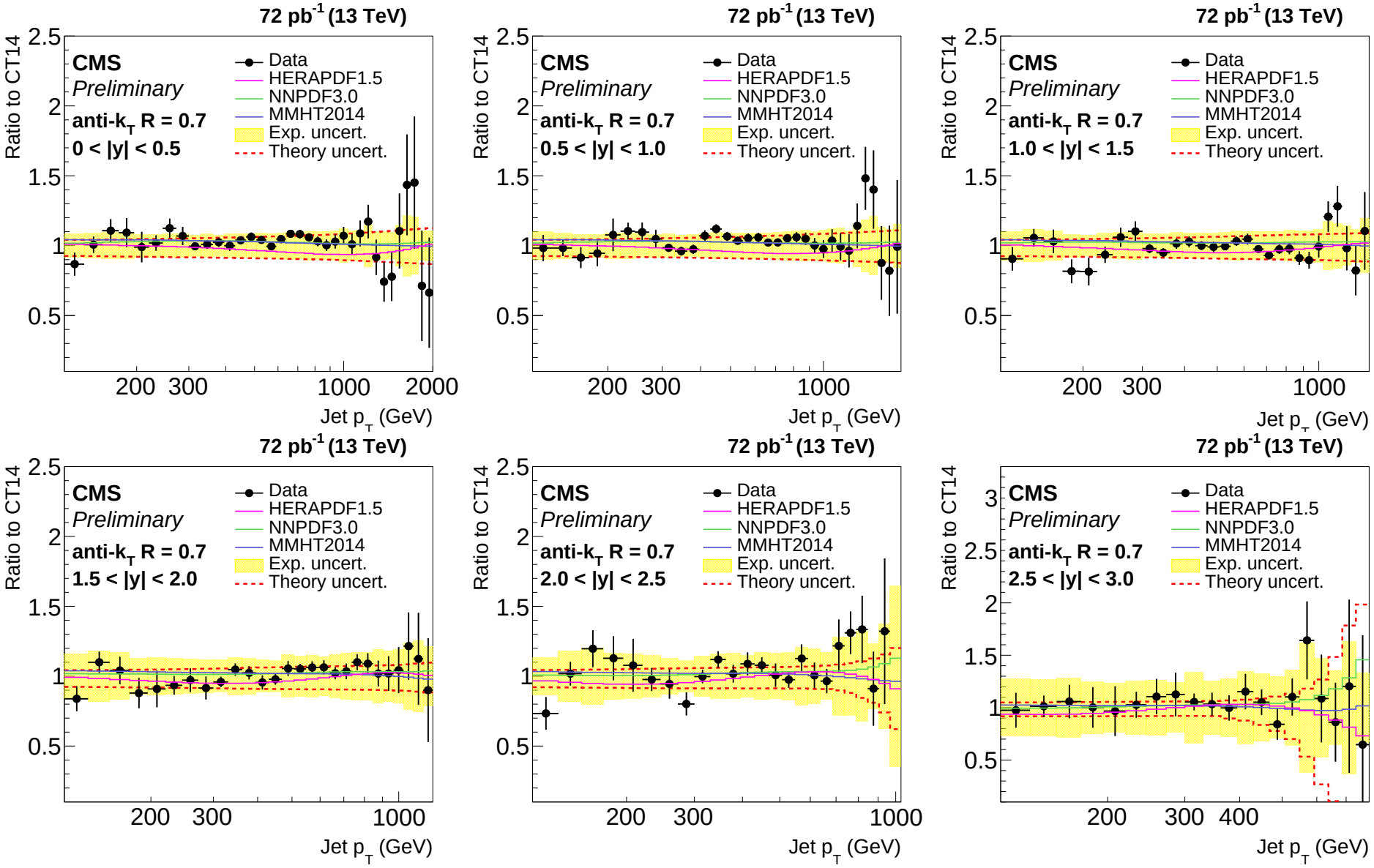
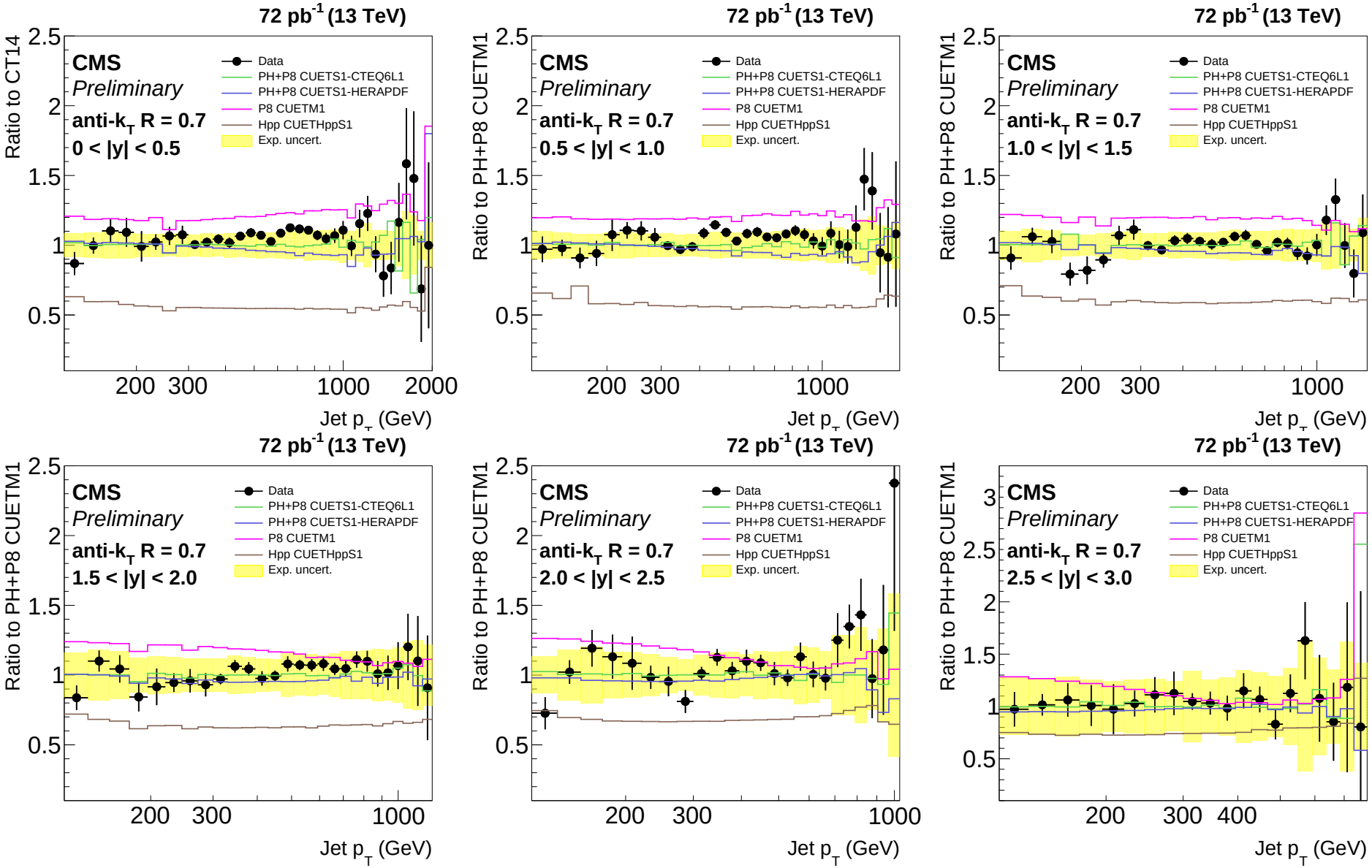
Preliminary results - AK7 - NLOJet++



Predicted cross sections follow the data quite well in each rapidity bin

Preliminary results - AK7 - MC generators



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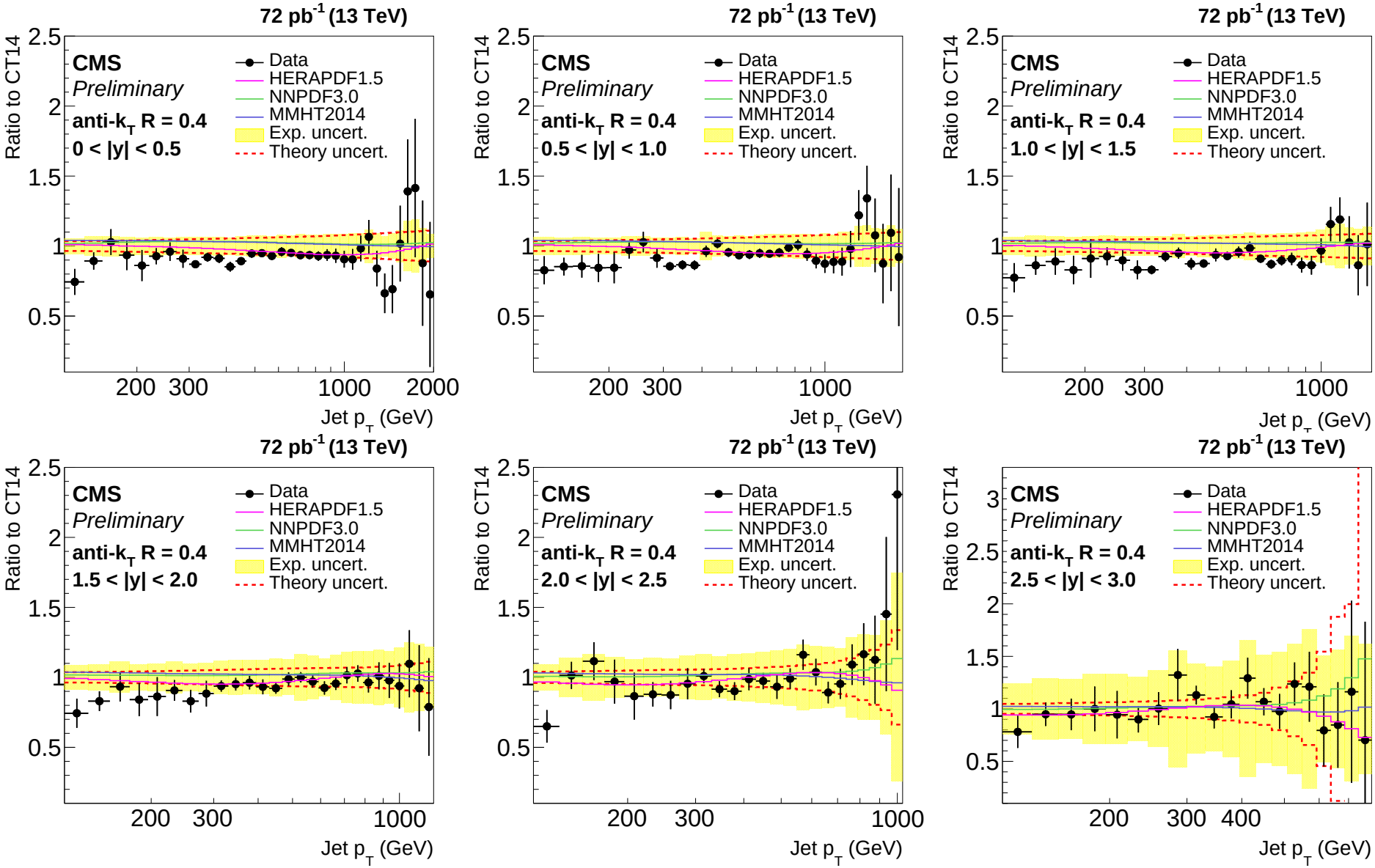
Preliminary results - AK4 - NLOJet++



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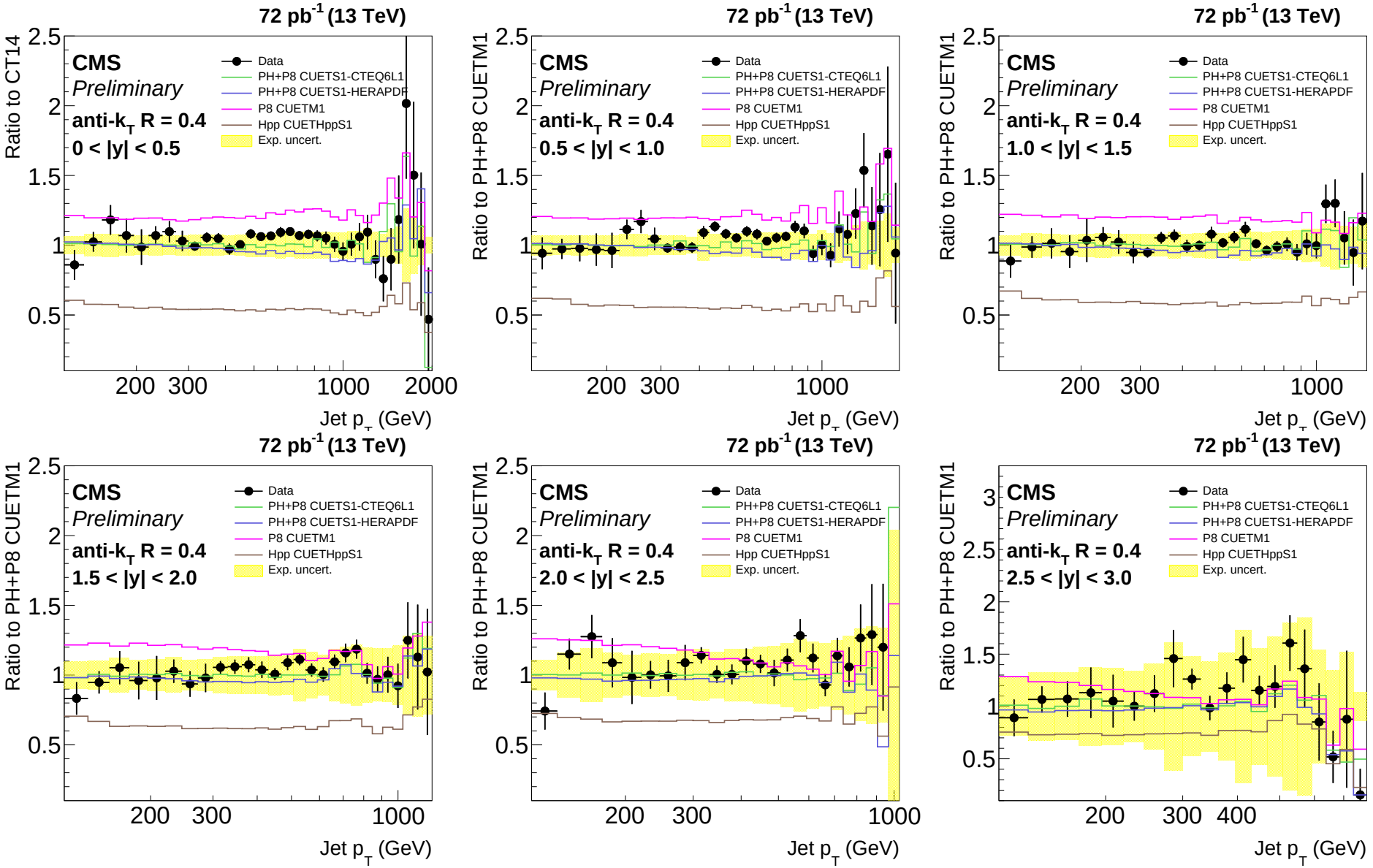
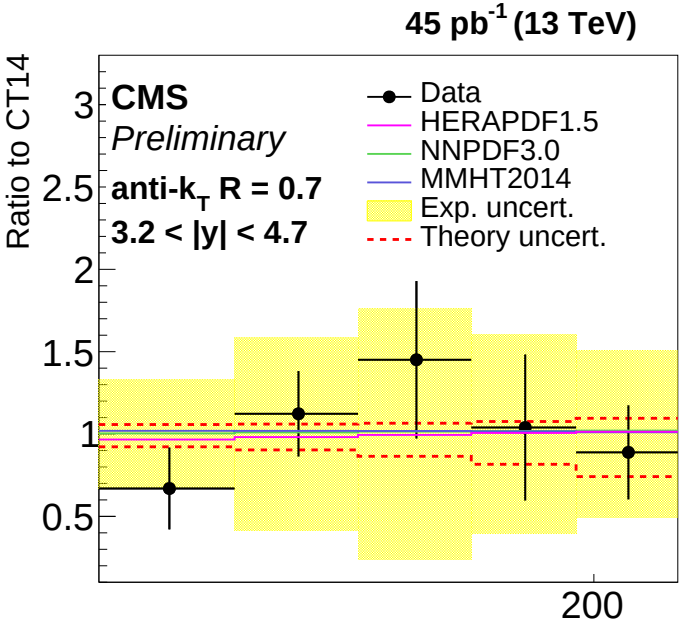
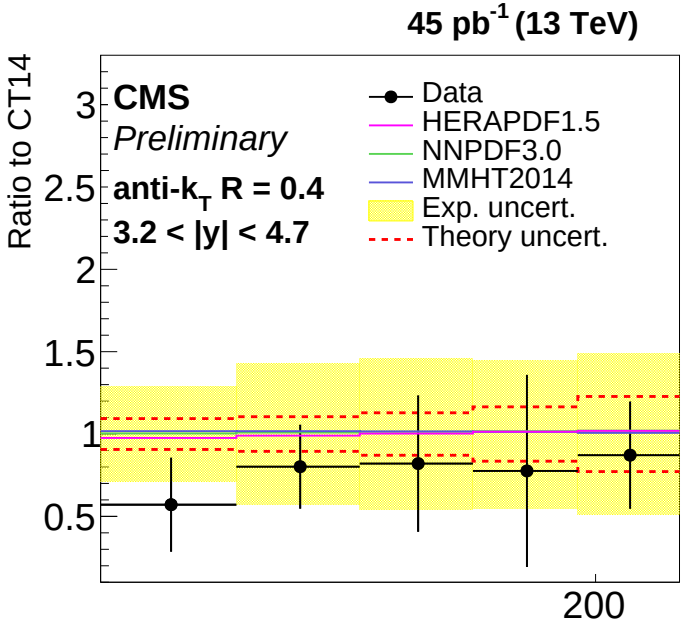
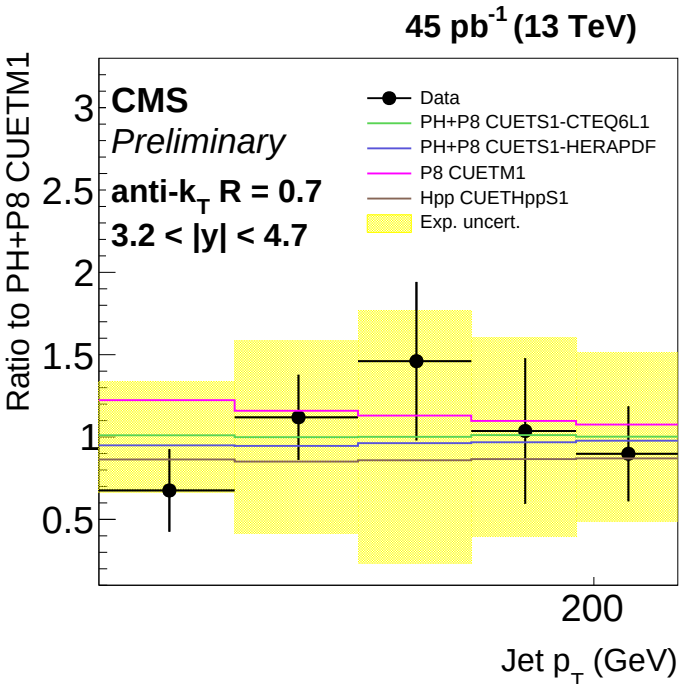


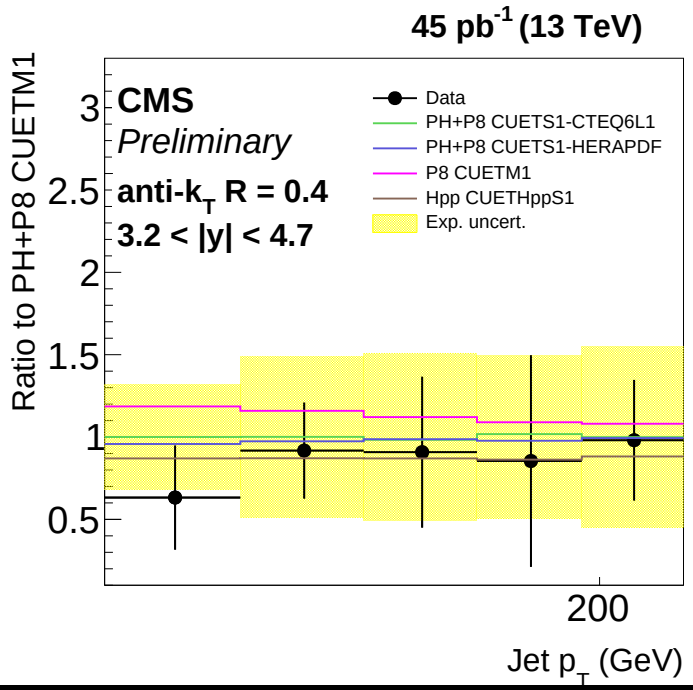
Predicted cross sections follow the data quite well in each rapidity bin

Preliminary results - forward region









Predicted cross sections follow the data quite well in each rapidity bin

Summary

- Preliminary cross section distributions are measured for inclusive jets in $p_T \in$ [114-2000] GeV, up to $|y| < 4.7$
- Systematic effects are considered with main contributions from JES and luminosity uncertainties
- NLOJet++ predictions reproduce well the inclusive jet cross section in various rapidity bins
- POWHEG+P8 seems to follow slightly better the data
- Results are shown for:
  - NLOJet++ with different PDFs
  - Predictions of POWHEG+P8 with different tunes and PDFs, LO MC event generators
- Wish to have event displays approved for conferences

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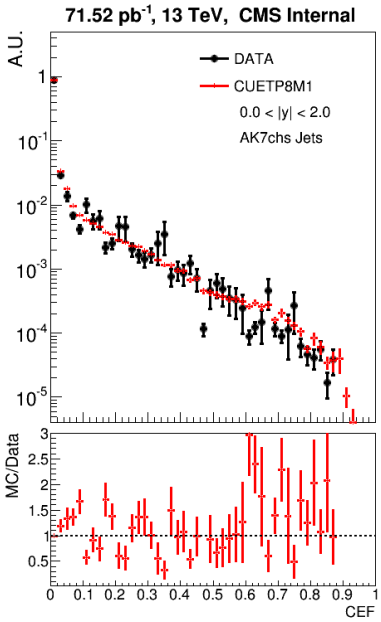
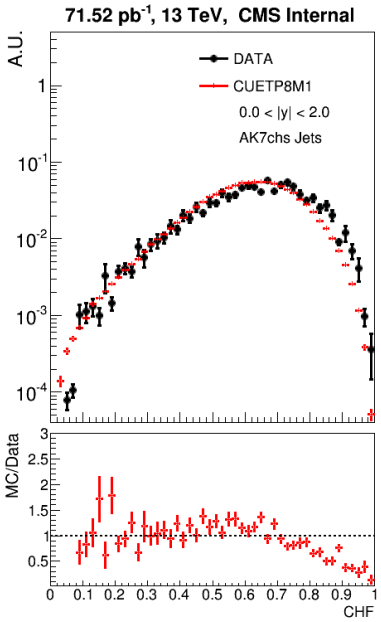
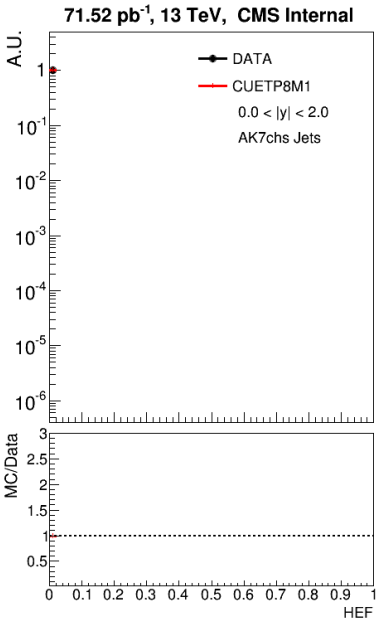
..asking for your preapproval and..

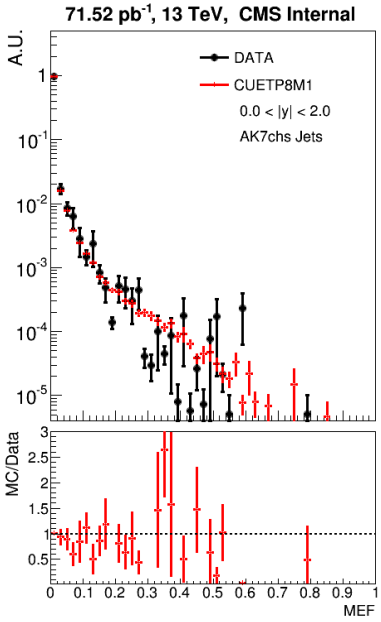
THANK YOU FOR YOUR ATTENTION!

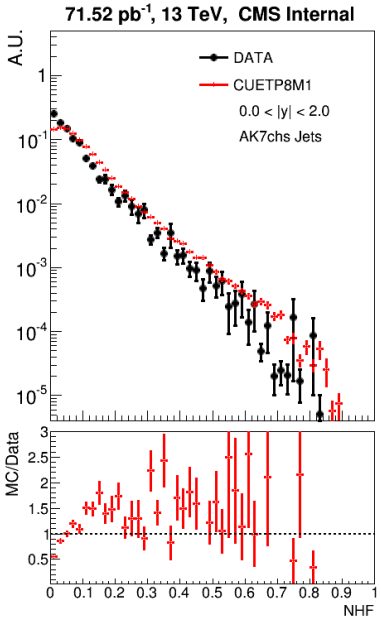
Control distributions - Central region

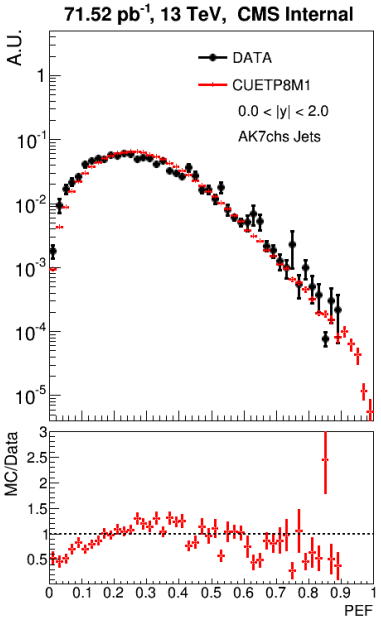












TOP:
Chg elm (left), chd hadron (center) and hadron elm (right) fraction,

BOTTOM:
muon (left), neutral hadron (center) and photon fraction (right)

for selected jets ($p_T > 114$ GeV in $|\eta| < 2.0$)

Both normalized to the total number of selected events

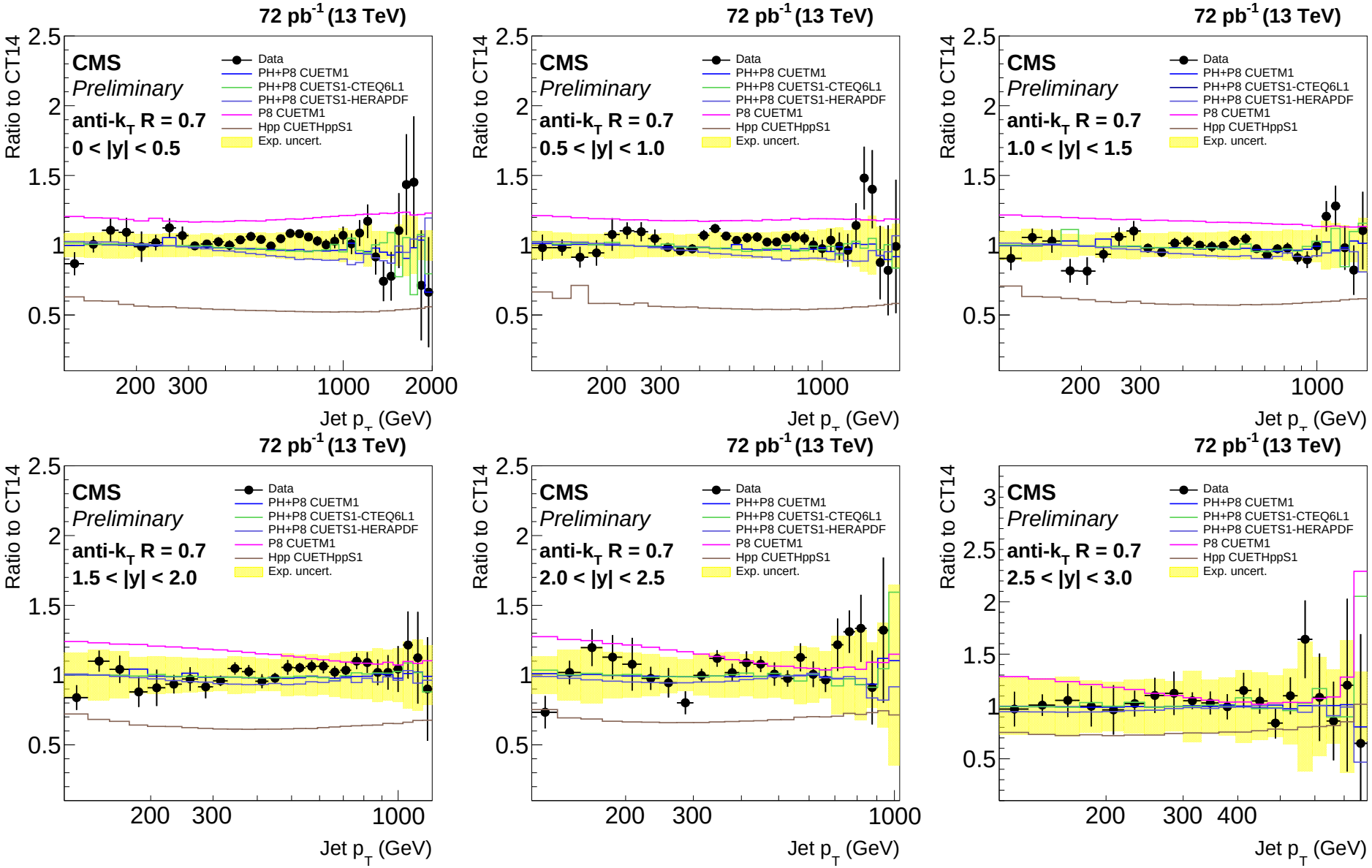
More in the forward region

Preliminary results look very good!

OPEN ISSUES:

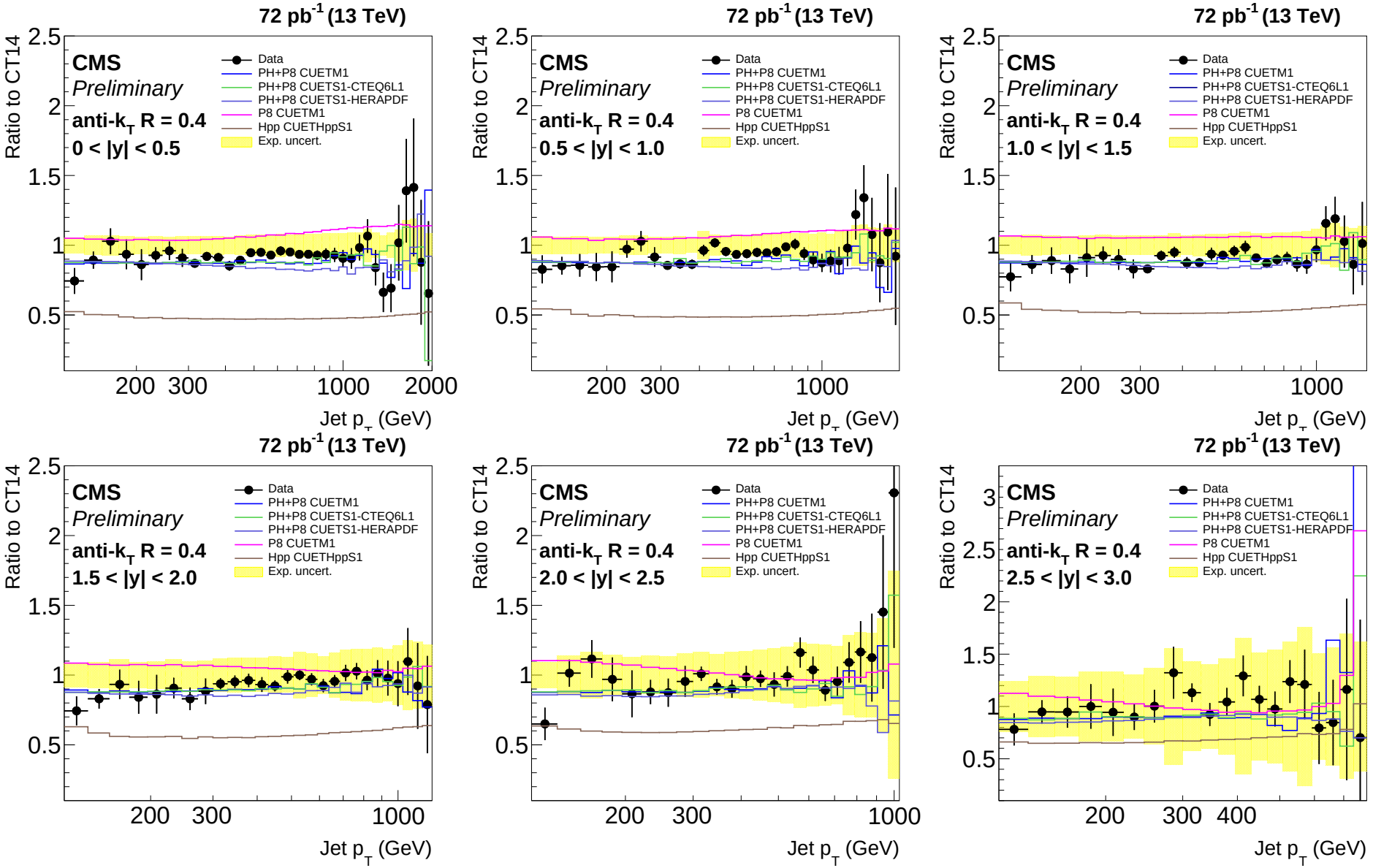
- Jet energy correction to be checked in the low p_T regime
- Missing statistics from the current sample $\rightarrow$ request for a new one (with fwd filter)
- low pile-up data sample gives sufficient events?
- triggers for low p_T jets
- Manpower?

Preliminary results - AK7 - Ratio to NLOJet++



Predicted cross sections follow the data quite well in each rapidity bin

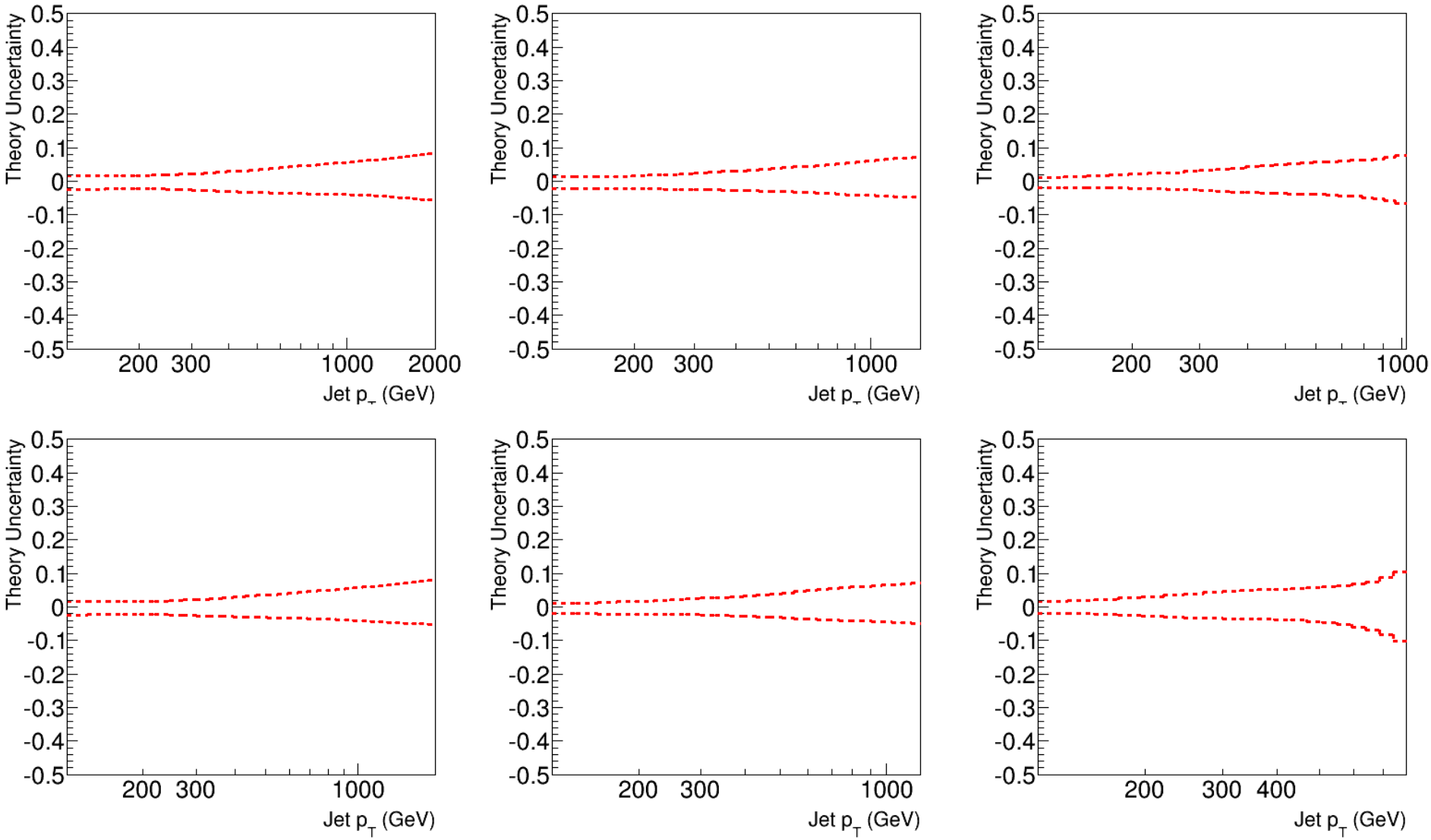
Preliminary results - AK4 - Ratio to NLOJet++



Predicted cross sections follow the data quite well in each rapidity bin

PDF Uncertainties - AK7

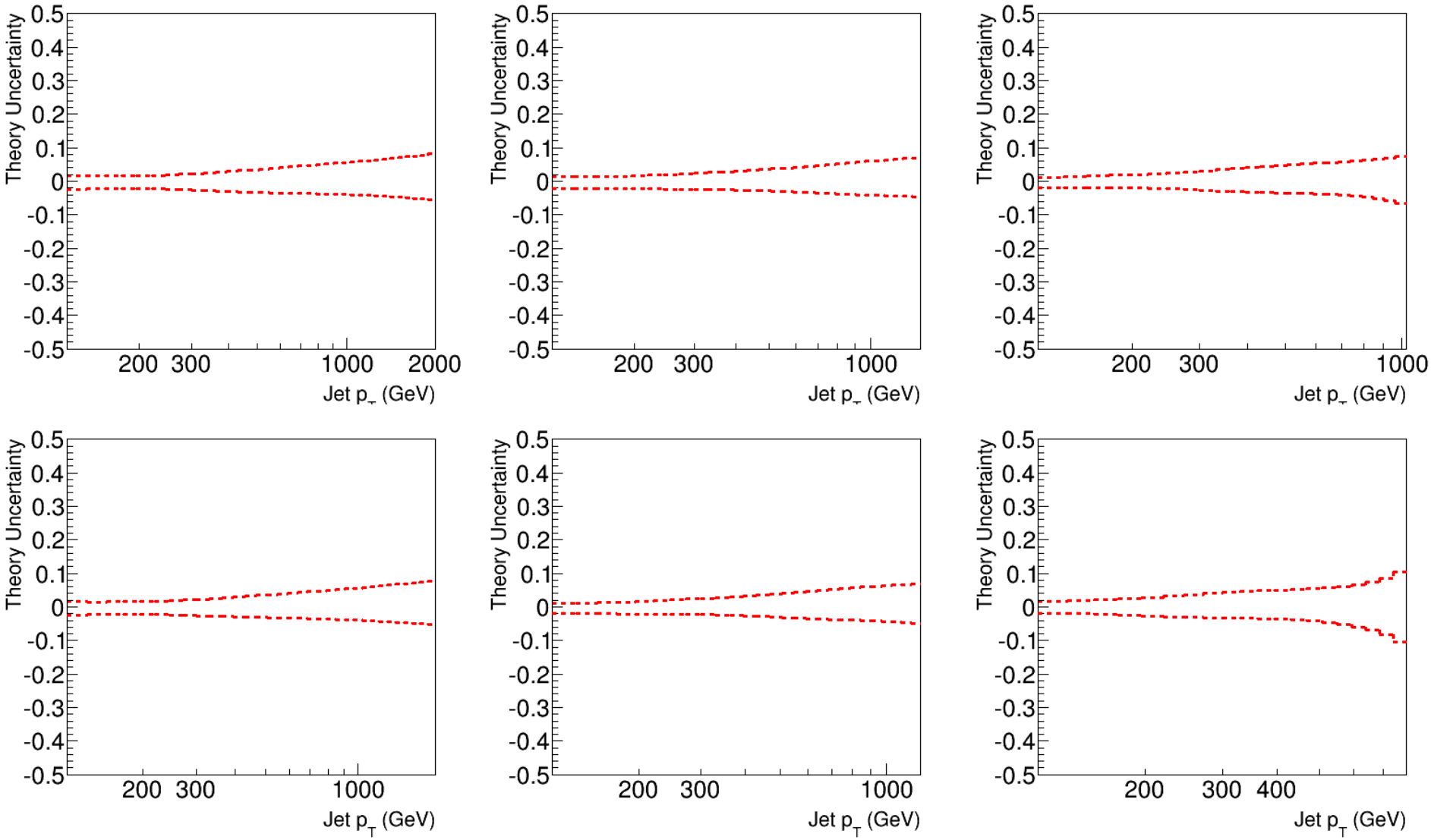
PDF uncertainties evaluated with CT14 corresponding to 68% significance



Envelopes of PDF uncertainties in various rapidity bins

PDF Uncertainties - AK4

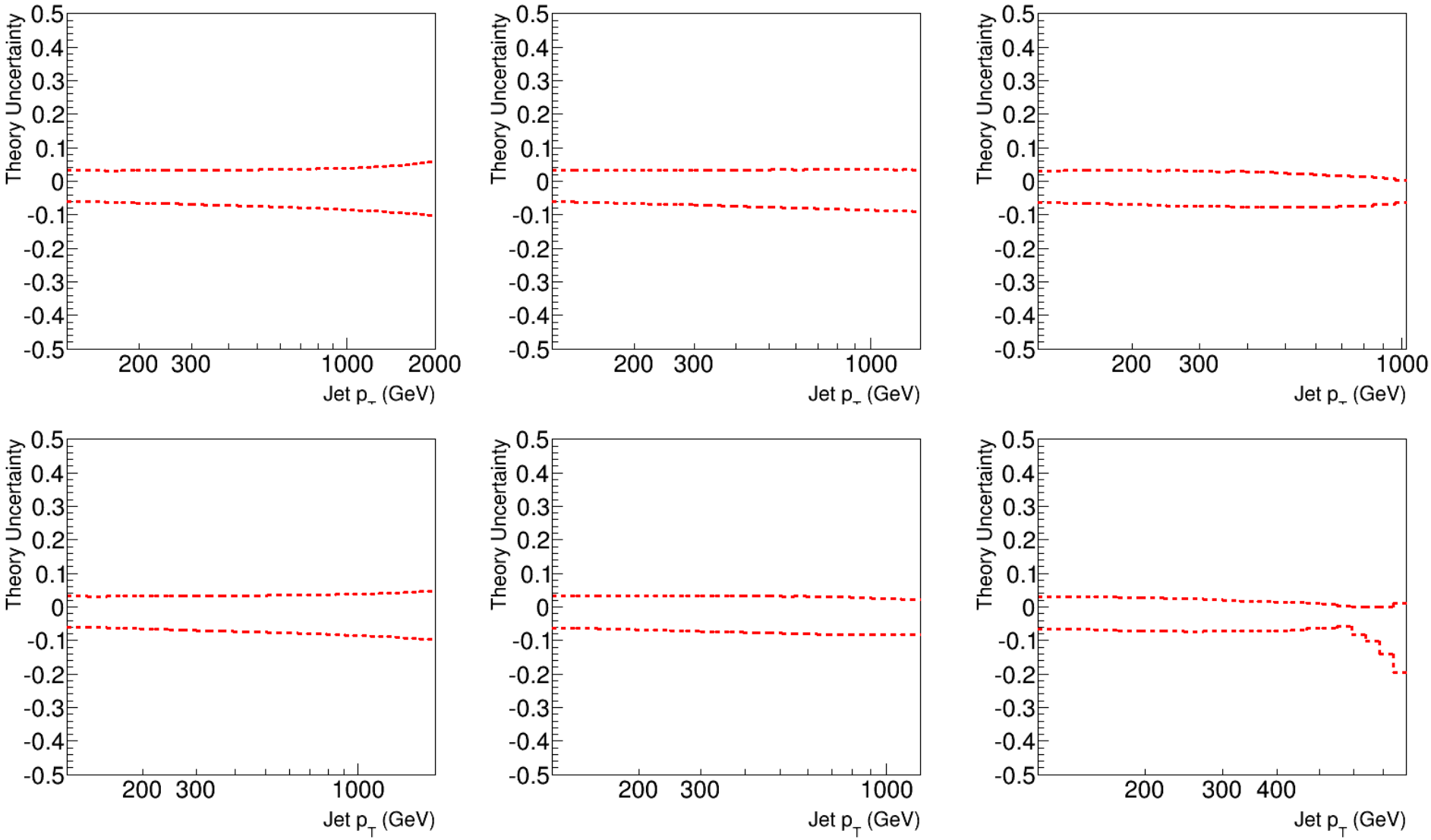
PDF uncertainties evaluated with CT14 corresponding to 68% significance



Envelopes of PDF uncertainties in various rapidity bins

Scale Uncertainties - AK7

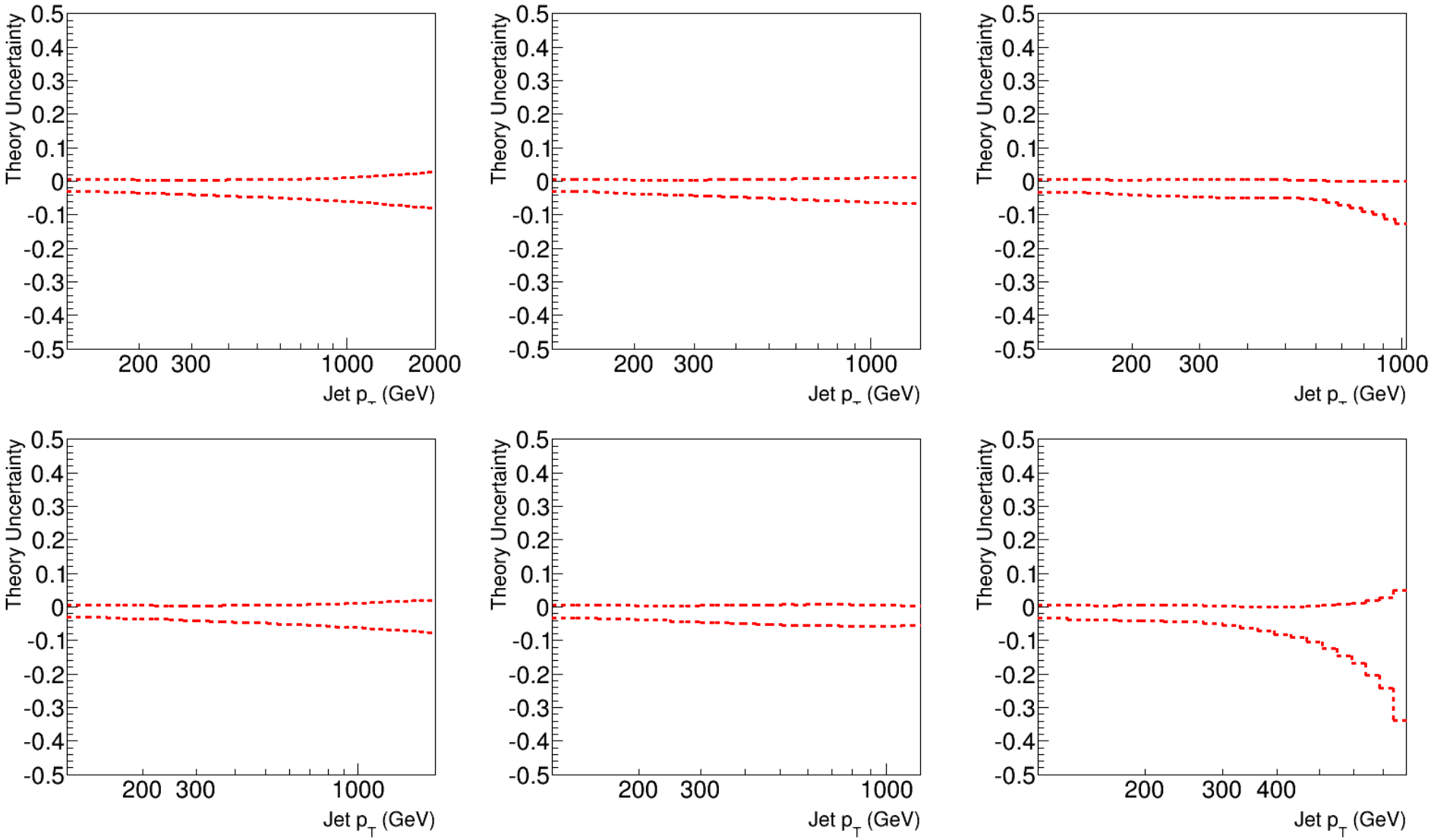
Uncertainties due to fact., ren. scales and α_S, corresponding to 68% sign.



Envelopes of scale uncertainties in various rapidity bins

Scale Uncertainties - AK4

Uncertainties due to fact., ren. scales and α_S, corresponding to 68% sign.



Envelopes of scale uncertainties in various rapidity bins

Trigger strategy - AK7

Exclusive division method: phase space is divided in regions according to the leading jet p_T and independent triggers are used in each region

The trigger efficiency is defined as:

$$HLT\_Jet_{eff}\, Y = \frac{InclusiveRecoJet\_P_T(HLT\_JetX + L1Object\_p_T > Z + HLTObject\_p_T > Y)}{InclusiveRecoJet\_p_T(HLT\_JetX)}$$

Trigger	Turn-on inclusive [GeV]	$\|y\| < 1.0$ [GeV]	$1.0 < \|y\| < 2.0$ [GeV]	$\|y\| > 2.0$ [GeV]
HLT_PFJet60	105.259	102.488	102.824	114.175
HLT_PFJet80	132.927	128.483	130.72	140.238
HLT_PFJet140	216.041	215.2	208.748	221.519
HLT_PFJet200	298.272	296.542	287.571	298.653
HLT_PFJet260	381.993	389.078	376.953	373.188
HLT_PFJet320	452.227	454.308	445.918	456.486
HLT_PFJet400	561.8	558.842	567.528	566.931
HLT_PFJet450	600.812	595.85	602.083	617.654
HLT_PFJet500	653.809	651.475	652.906	685.825

Trigger strategy - AK4

Exclusive division method: phase space is divided in regions according to the leading jet p_T and independent triggers are used in each region

The trigger efficiency is defined as:

$$HLT\_Jet_{eff}\,Y = \frac{InclusiveRecoJet\_P_T(HLT\_JetX + L1Object\_p_T > Z + HLTObject\_p_T > Y)}{InclusiveRecoJet\_p_T(HLT\_JetX)}$$

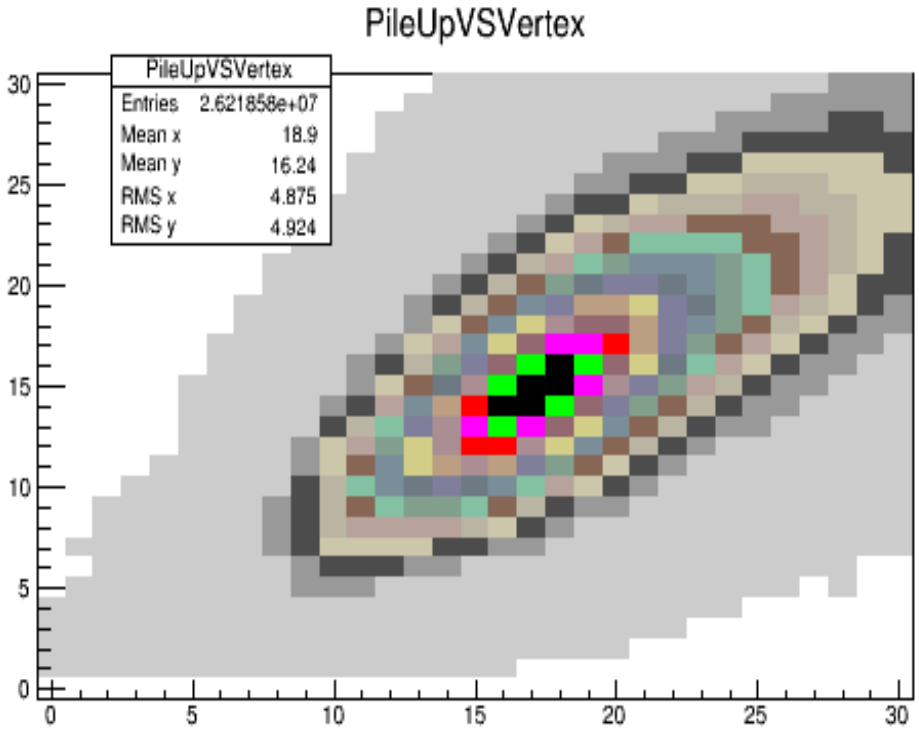
Trigger	Turn-on inclusive [GeV]	$\|y\| < 1.0$ [GeV]	$1.0 < \|y\| < 2.0$ [GeV]	$\|y\| > 2.0$ [GeV]
HLT_PFJet60	87.6735	78.4333	79.2786	96.402
HLT_PFJet80	111.236	102.771	107.758	118.463
HLT_PFJet140	183.822	172.06	175.855	190.404
HLT_PFJet200	257.09	246.306	252.216	269.315
HLT_PFJet260	331.50	312.59	321.831	351.323
HLT_PFJet320	399.874	388.914	394.942	426.14
HLT_PFJet400	494.961	483.452	492.94	535.773
HLT_PFJet450	547.823	536.515	548.65	592.945
HLT_PFJet500	608.266	593.825	615.188	665.516

Pile-up reweighting iterative method

The Monte Carlo are reweighted according to the true number of pile-up interactions

The iterative method

- Primary vertex distributions are obtained for data and MC
- The ratio between is evaluated to the MC for each bin assuming f(vertex) $\approx$ f(pile-up+1)
- The reweight is applied according to N_{pileup} and a new distribution for the MC is obtained
- The three steps are iteratively applied



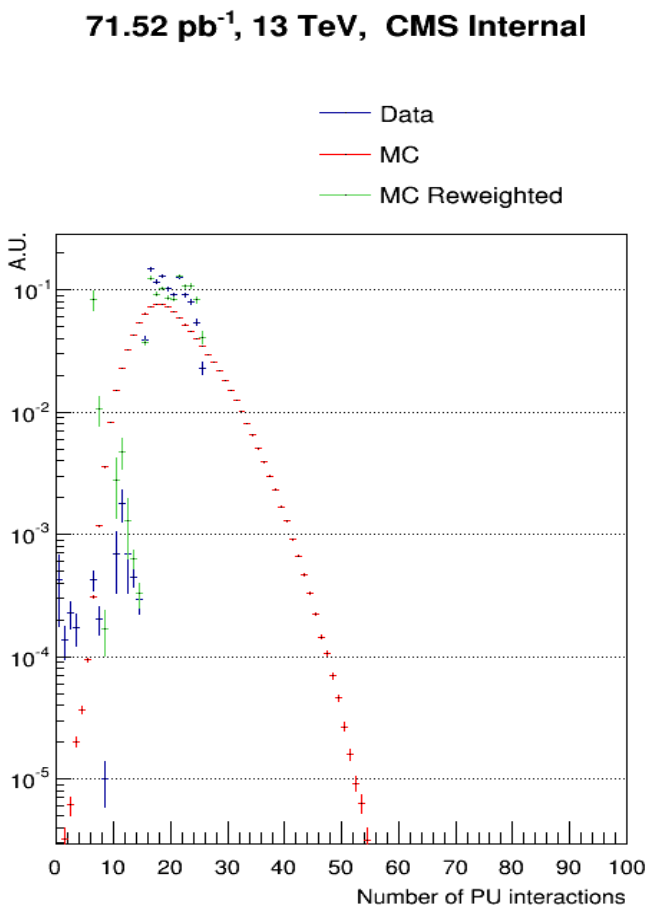
- After 5 iterations, a better (but not optimal) is obtained
- The MCs are reweighted accordingly
- Different weights are applied

Standard pile-up reweighting method

The Monte Carlo are reweighted according to the true number of pile-up interactions

The standard method

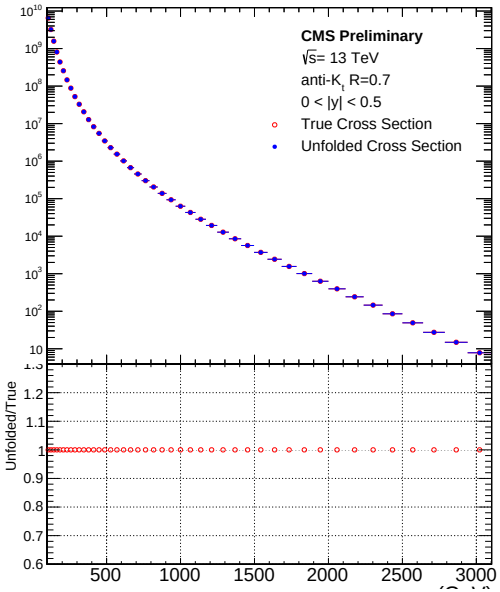
- Pile-up distribution is obtained from data through lumi information
- The ratio between data and MC pile-up distributions is taken and used in the MC

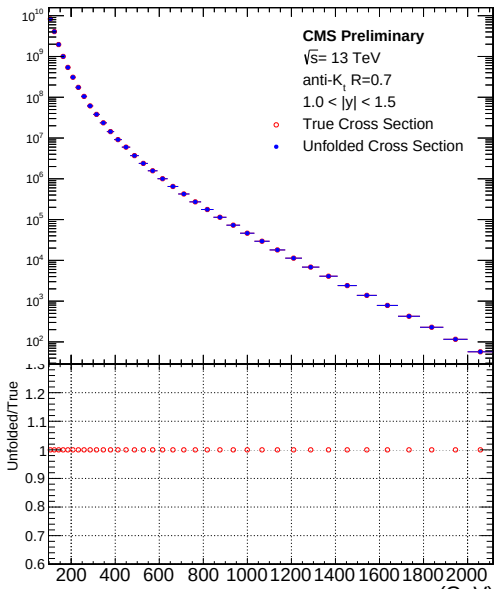


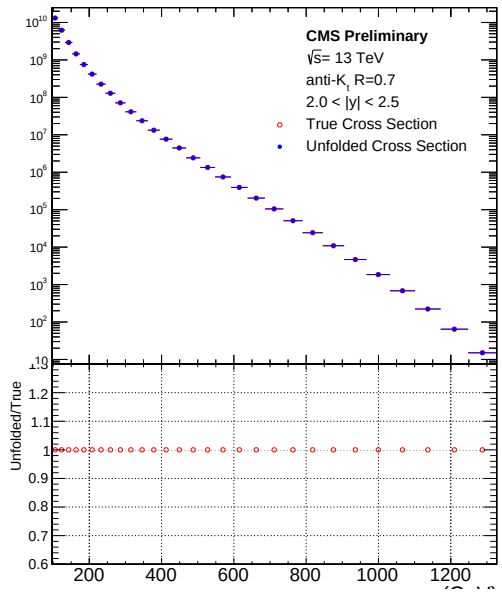
The comparison between data and MC in vertex multiplicity is still not perfect but better at high values

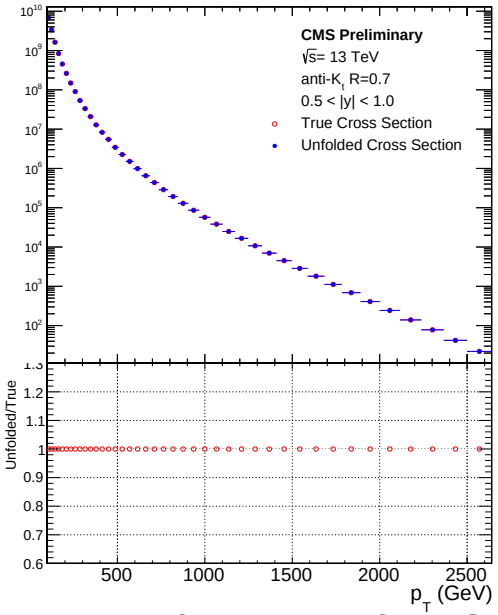
The analysis seems to be independent on the applied reweighting

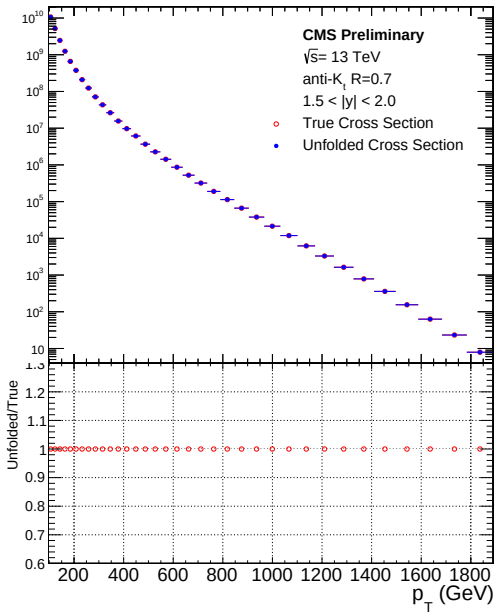
MC closure tests - AK7

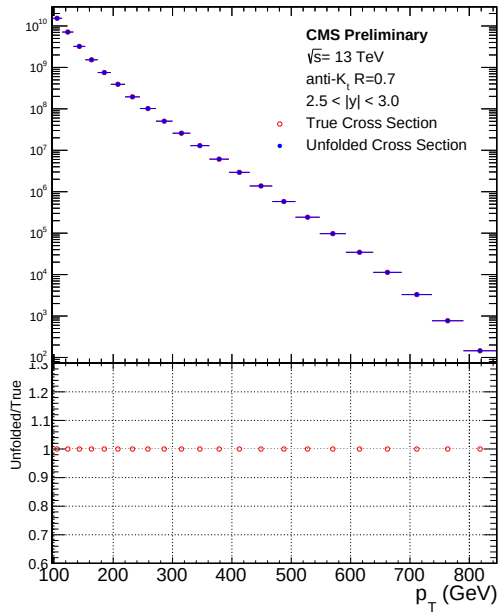






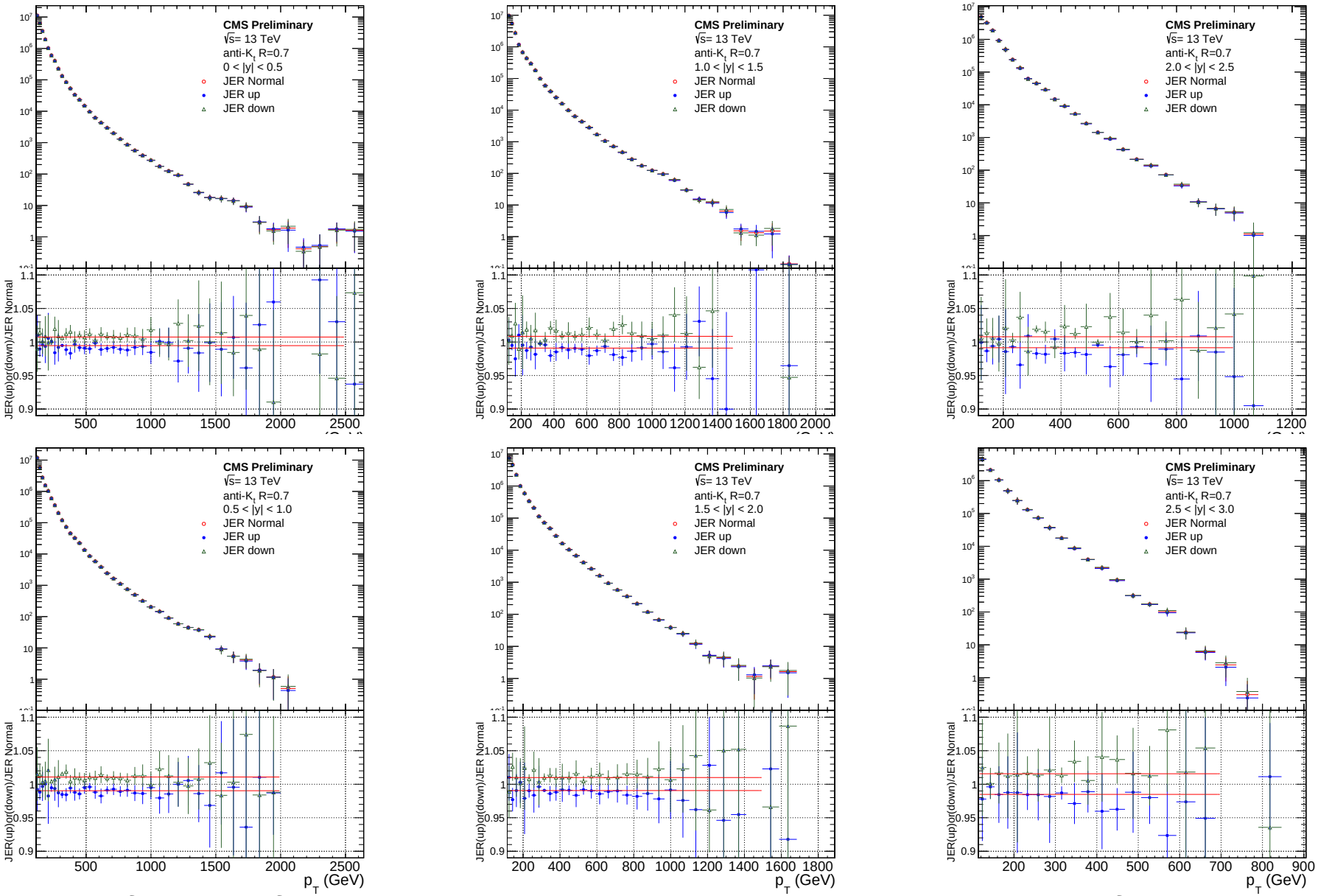






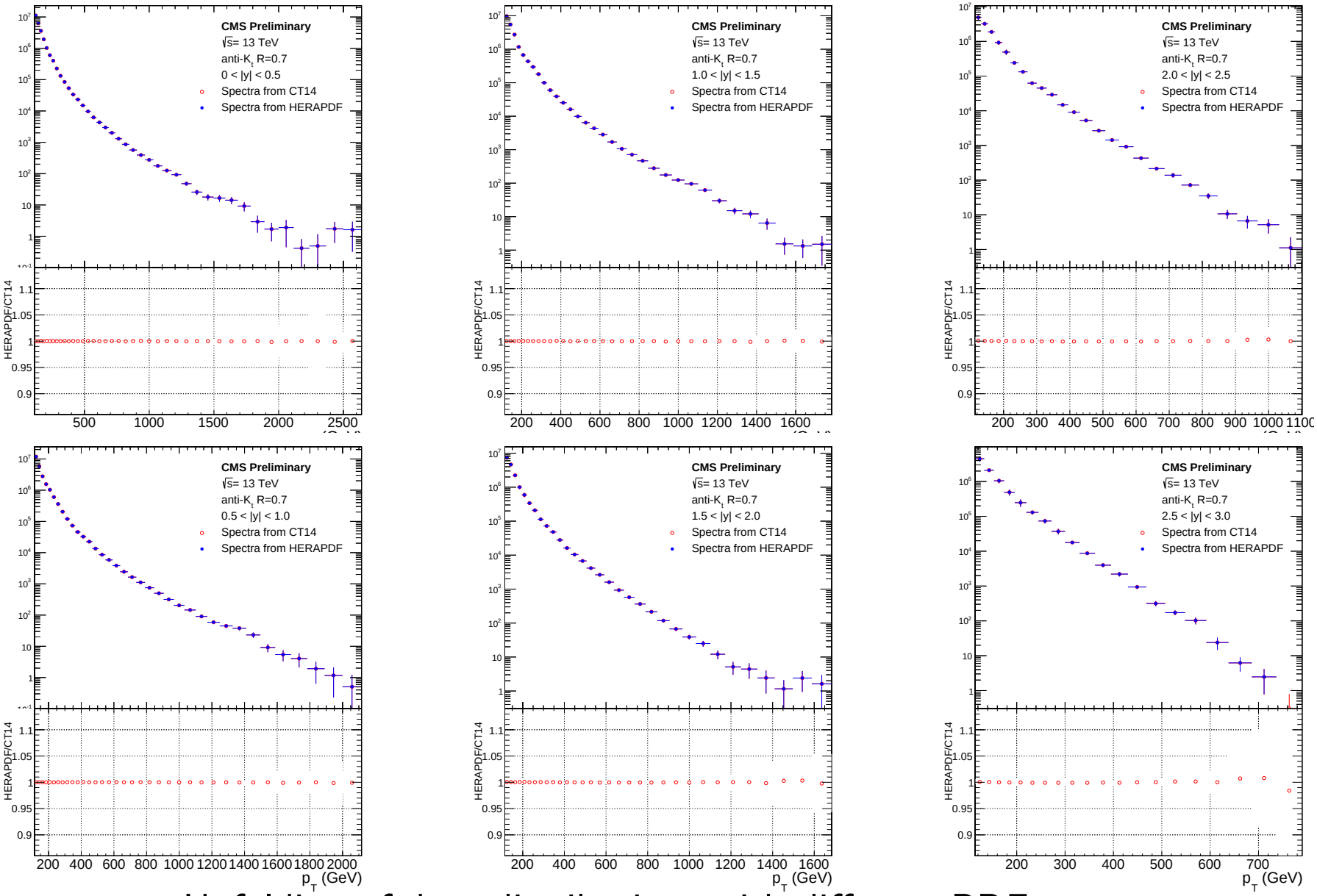
Unfolding of MC distributions compared to the generator-level ones

Resolution uncertainty in unfolding - AK7



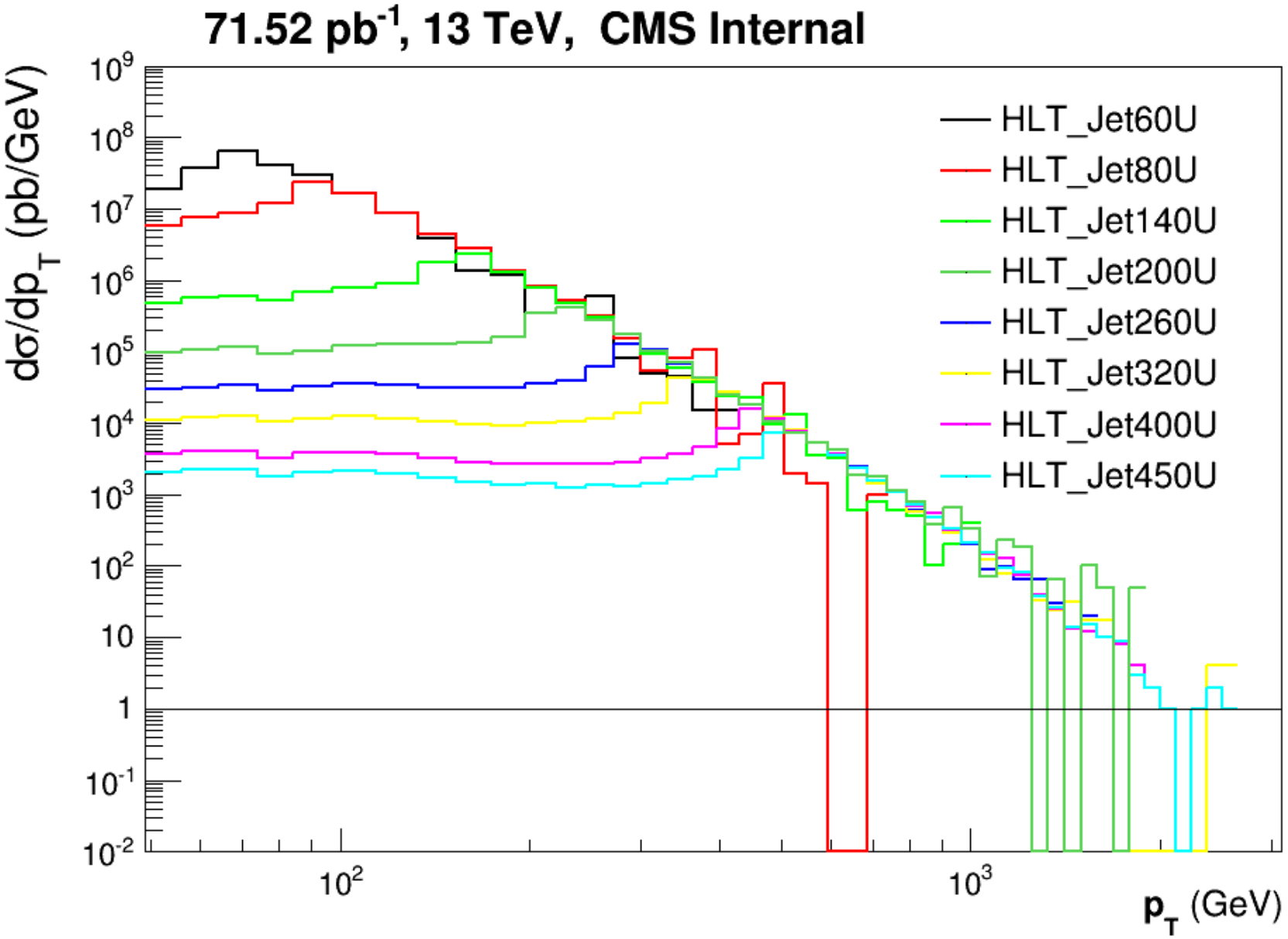
Unfolding of data distributions with up-down JER correction factors

PDF uncertainty in unfolding - AK7

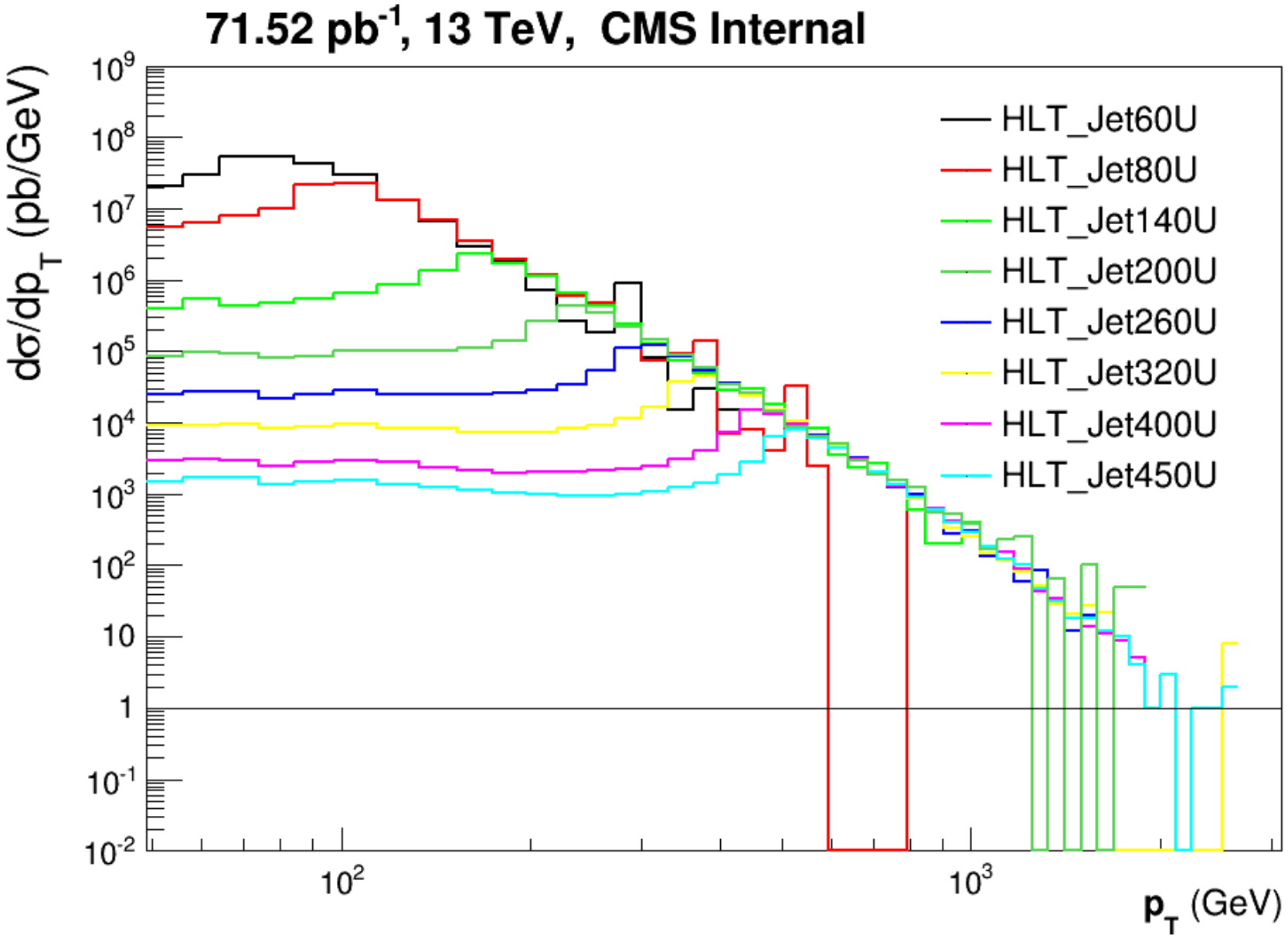


Unfolding of data distributions with different PDF sets

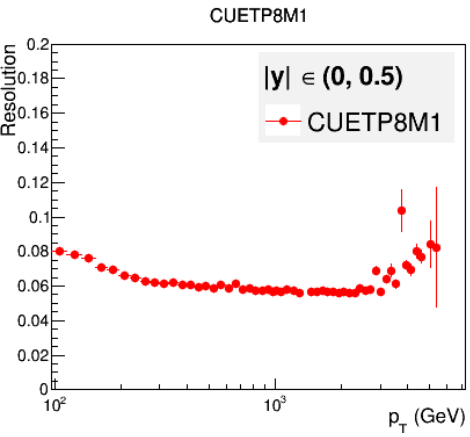
Cross section for different triggers - AK4

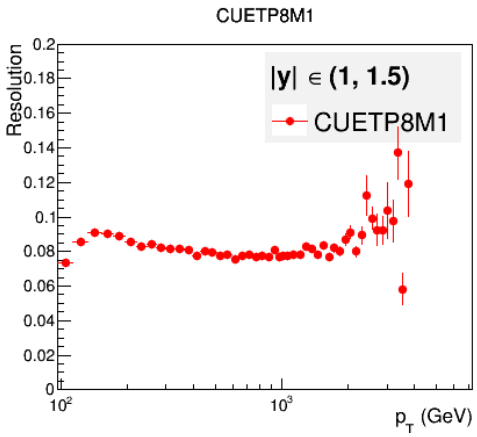


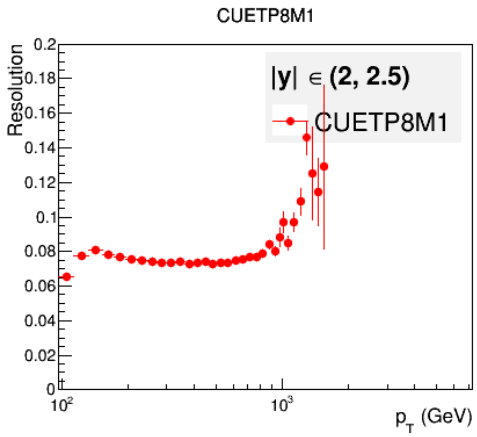
Cross section for different triggers - AK7

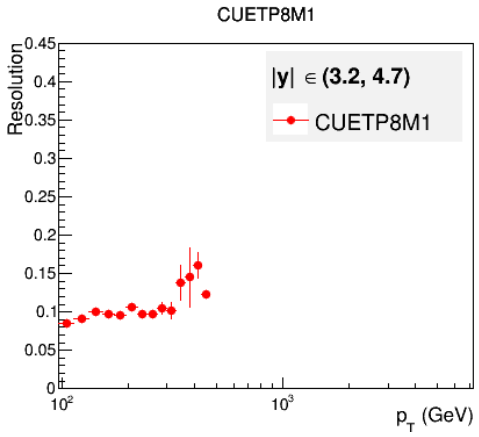


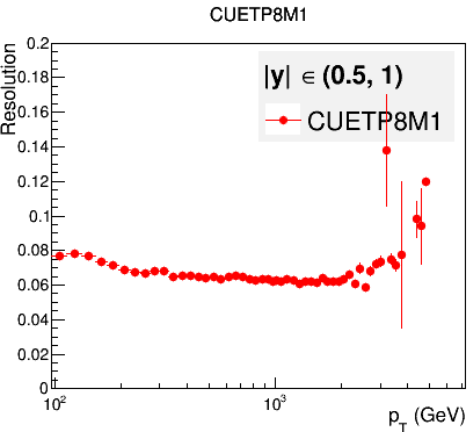
Relative resolution from MC

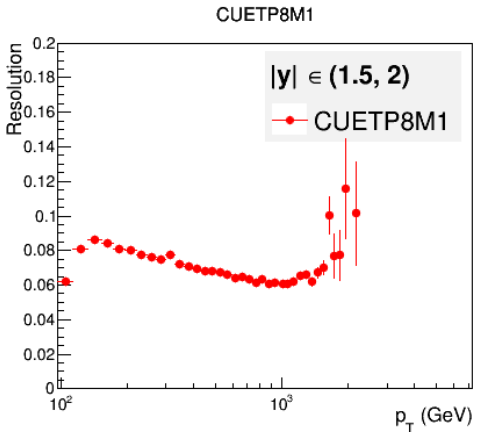


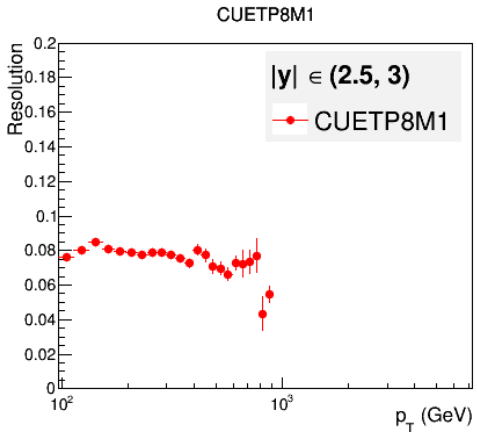








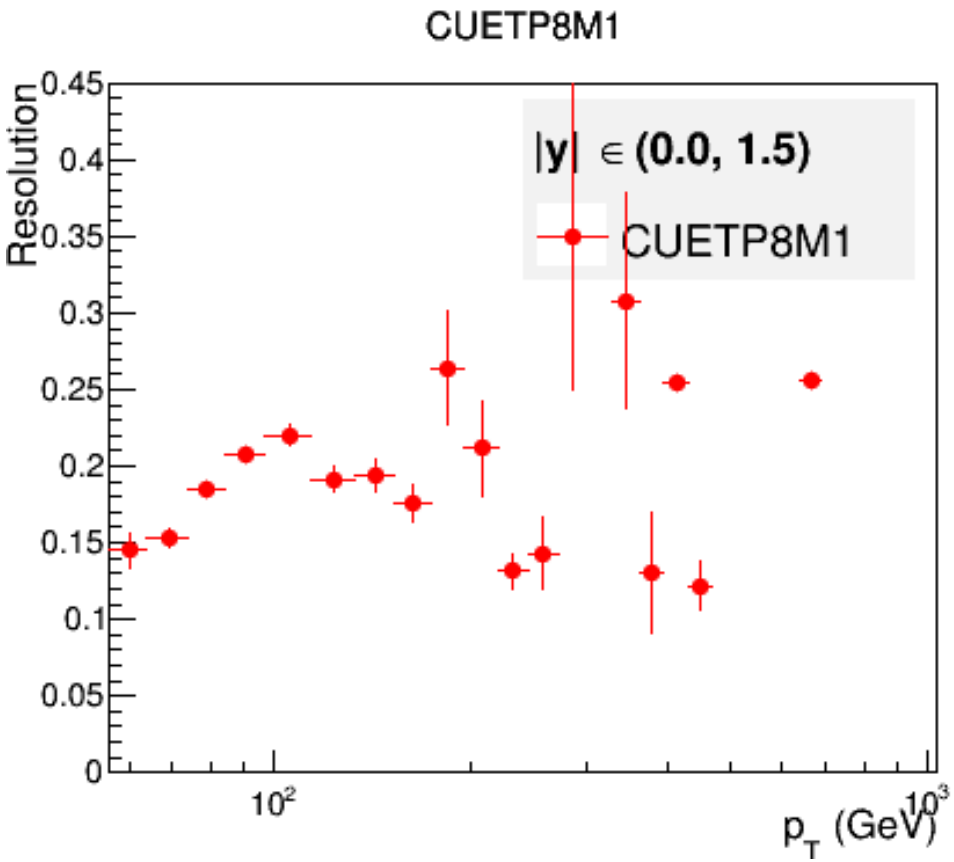


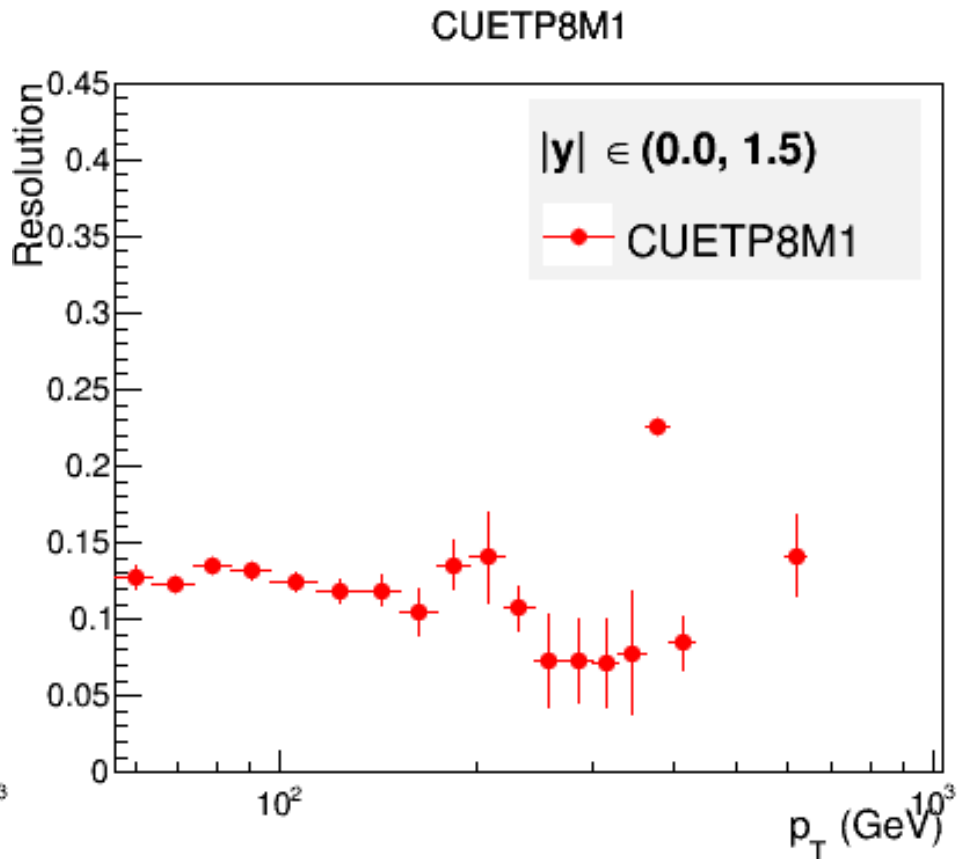


Relative transverse momentum resolution in different $|y|$ bins

Resolution of HLT objects

Relative p_T resolution between jets and matched HLT objects as a function of the reconstructed jet p_T





LEFT: AK7, RIGHT: AK4