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L3Res global fit status

April 20, 2020

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Henning Kirschenmann, HIP

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Results for UL17_V1 inputs vs EOY17 reference

The Z+jet results use inputs posted on the JEC agenda of March 9, 2020 (https://indico.cern.ch/event/896070/#28-update-on-ul17-z-jet-l3resi). The multijet results were privately provided through Minsuk Kim's CERNbox. Photon+jet from Lucas Torterotot (/afs/cern.ch/work/l/ltortero/public/JEC-task/2017UL/combinationfiles/JEC_Summer19UL17_V1-JER_Fall17_V3b/2020-04-02/*).

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I would like to extend special thanks to

- Maximilian Horzela and Daniel Savoiu for Z+jet inputs
- Lucas Torterotot for γ+jet inputs
- Minsuk Kim for multijet inputs
- Henning Kirschenmann for maintaining global fit software in gitHub

Current to-do list:

- MPF uncertainties from FSR at high p_T should be smaller. This should increase response and pull UL17 closer to 2016, 2018. At low p_T MPF FSR uncertainty they can be larger, thus constrain L1Res bit less.
- No EM scale for Zee or *gamma*. **NB: Photon scale shifted down by 1% to match Zll**
- Need $|\eta_{e+,e-}| < 1.3$ break-up for Zee mass to use with γ
- Further input needed on photon scale uncertainties vs p_T
- Finish parameter pulls and correlations plots

Some notes about current global fit settings:

- Electron and muon scales are corrected with Z mass in RunBCDEF. This is measured in bins of Z p_T and fitted with quadratic logarithmic function (constant for Z$\mu\mu$). Z mass fit uncertainty is added to statistical uncertainty for each sample, and Zee and Z$\mu\mu$ are subsequently combined into Zll, which is used in global fit to avoid decorrelated k_{FSR}
- Photon scale is corrected with Zee mass at $p_{T,Z} = 2 \times p_{T,\gamma}$, and fit uncertainty is added to statistical uncertainty (**tbd:** get Zee mass with EB-EB only)
- Reference scale uncertainties are set to 0.2% for combined leptons (l=e+μ), **0.5% for photons with 1.0% rescaling** (since no EM scale yet)
- MPF method is given additional 0.5% uncertainty for γ+jet and 0.2% for Zll+jet (for 40% Zee+jet) to cover for possible residual EM footprint effects
- **New:** k_{FSR} central value and uncertainties are taken for all IOVs from BCDEF to reduce uncertainties and avoid decorrelation for pTbal
- JEC parameterization is the 2-p fit previously used in 2017

- Inputs are provided for MPF and p_T balance with $\alpha < 0.1, 0.15, 0.20$ and $\alpha < 0.3$; this last one is used for global fit vs p_T
- Other inclusive α bins are used to derive custom FSR+ISR corrections, under the assumption of linear dependence versus α cut and log-quadratic dependence versus p_T
- FSR+ISR corrections are further constrained in global fit under the assumption that both MPF and p_T balance converge to same ultimate result (within constraints of their uncorrelated systematics)
- γ+jet is also used only at $p_T > 105$ GeV to avoid QCD dijet contamination
- Compared to EOY17, re-enabled Z+jet pTbal at 30–100 GeV with $\alpha_{\mathrm{eff,max}} = 0.45$ (**tbd:** revisit pTbal FSR slope change at $p_T < 100$ GeV based on full Run 2 data, add MPF bias shape from unclustered energy)

- Multijets has both recoil p_T and leading jet p_T binning; **leading** used as current default (*plan: JER-syst. weighted average*)
- triggers:
  {"jt0","jt40","jt60","jt80","jt140","jt200","jt260","jt320","jt400","jt450","jt5
- leading thresholds:
  {{{0,64},{64,84},{84,114},{114,196},{196,272},{272,330},{330,395},{395,468
- recoil threhsolds:
  {{{0,97},{97,196},{196,220},{220,272},{272,395},{395,468},{468,592},{592,6
- **FSR** corrections applied (derived vs $p_{T,min}$), fit uncertainty added in global fit
- **JER** uncertainty included (derived for recoil and leading) in global fit (*plan: reduced with JER-syst. weighted average, derive 2nd order JER syst. e.g. from recoil vs leading*)

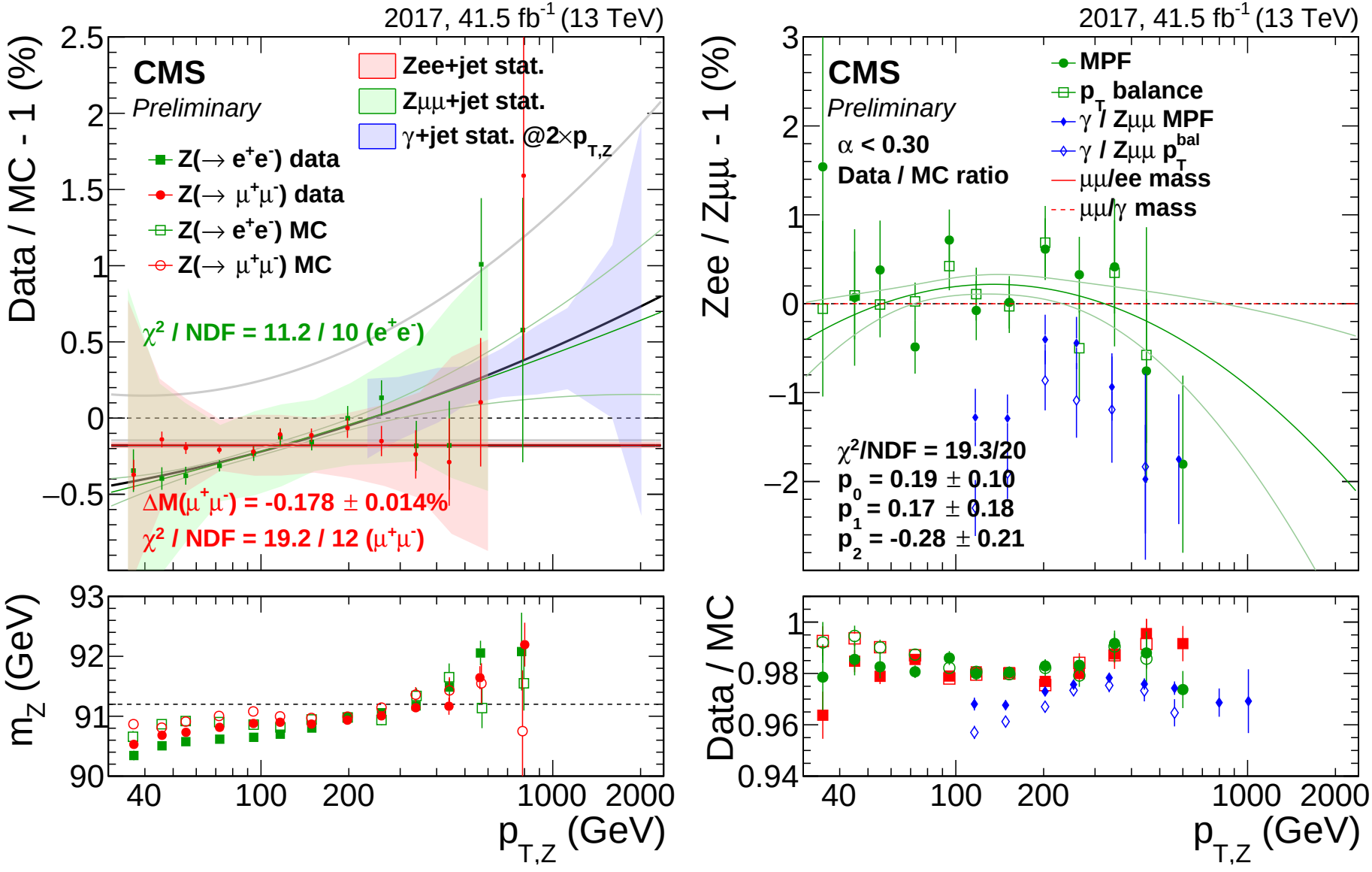
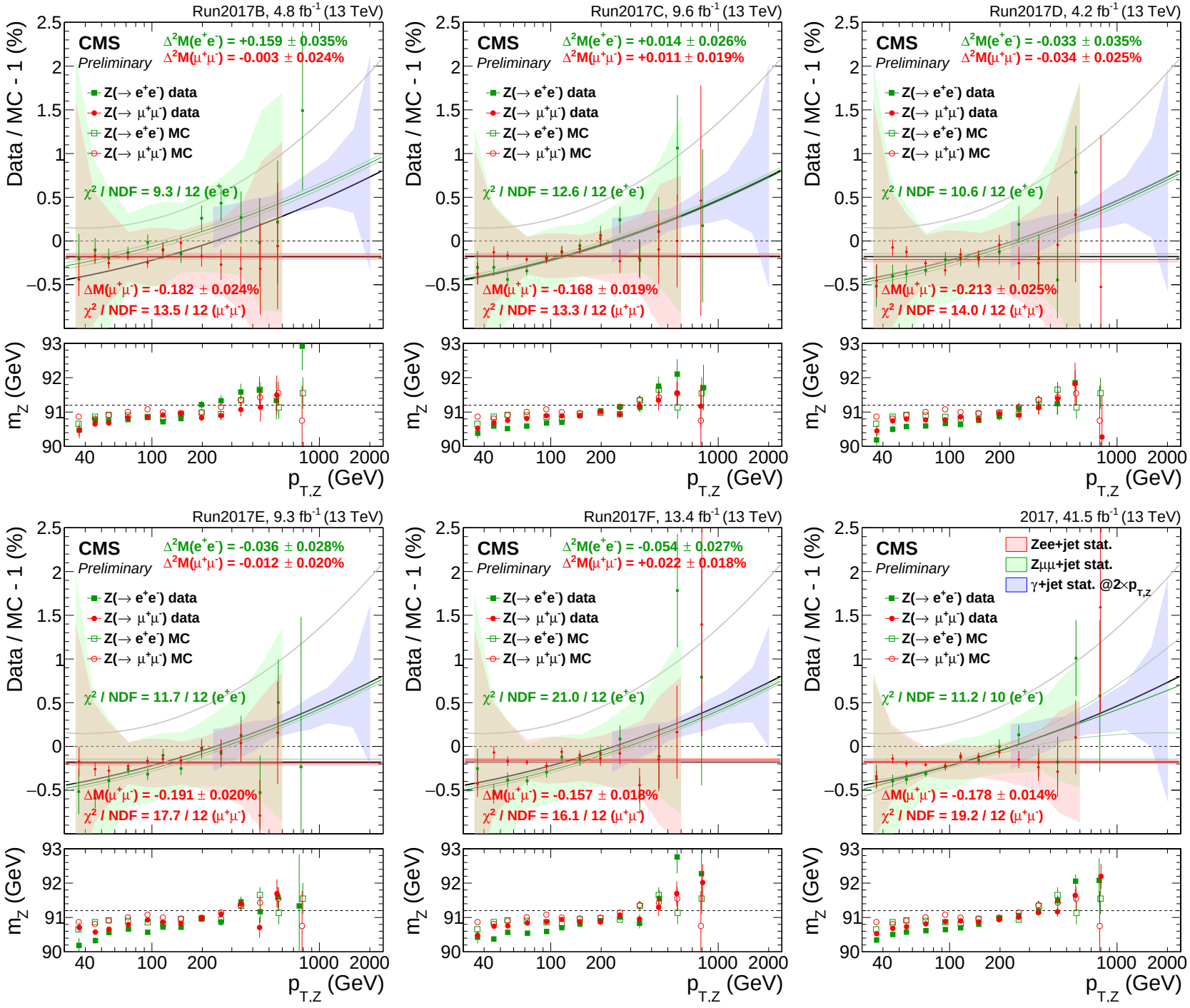
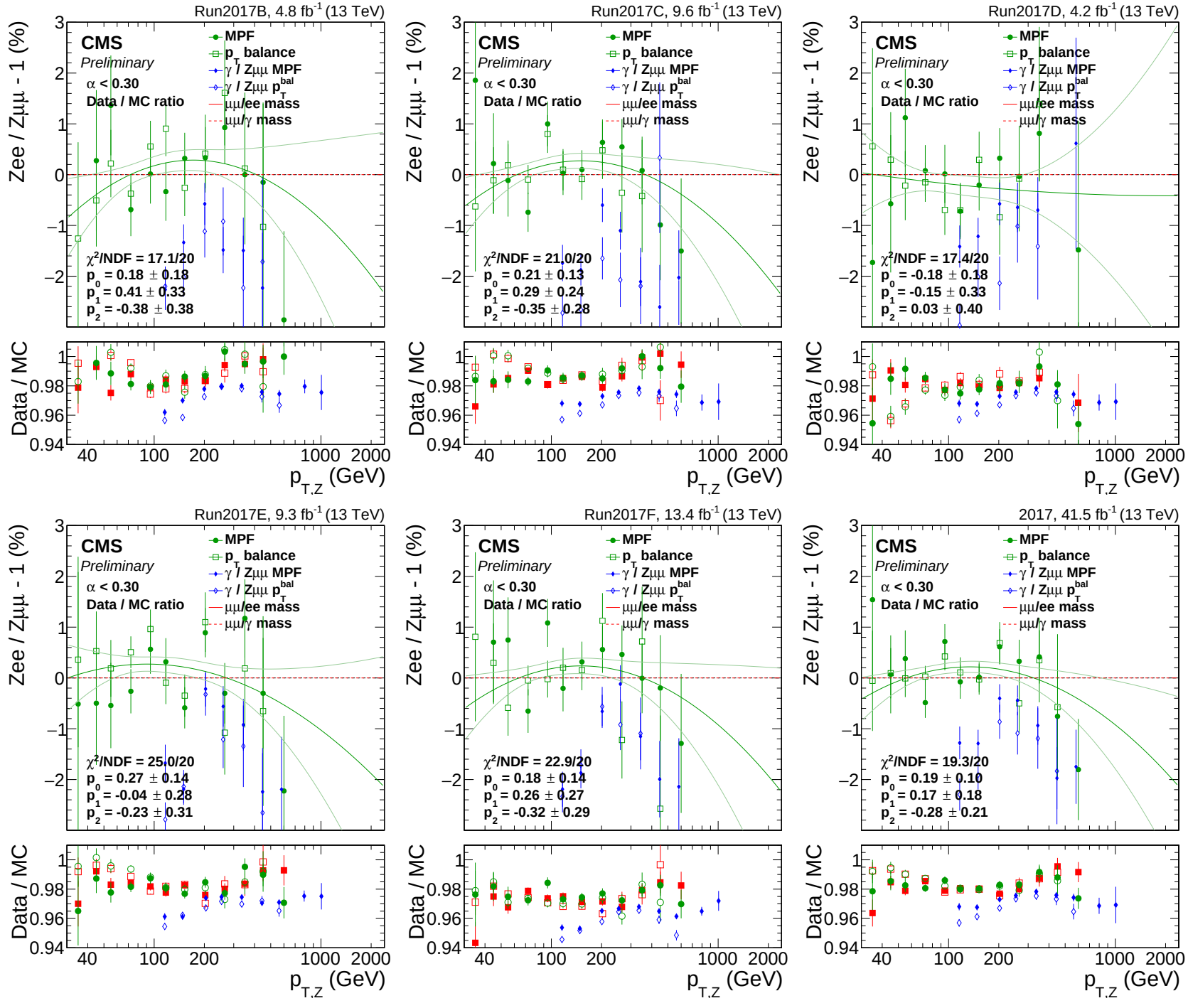


Figure : (a) Shift in Zee and Z$\mu\mu$ masses versus Z p_T. (b) MPF and p_T balance for Zee+jet and γ+jet versus Z$\mu\mu$+jet after mass (and FSR) corrections. **γ+jet is EOY17.**


Run2017B, 4.8 fb-1 (13 TeV)
Run2017C, 9.6 fb-1 (13 TeV)
Run2017D, 4.2 fb-1 (13 TeV)
Run2017E, 9.3 fb-1 (13 TeV)
Run2017F, 13.4 fb-1 (13 TeV)
2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
Δ2M(e+e-) = +0.159 ± 0.035%
Δ2M(μ+μ-) = -0.003 ± 0.024%
Δ2M(e+e-) = +0.014 ± 0.026%
Δ2M(μ+μ-) = +0.011 ± 0.019%
Δ2M(e+e-) = -0.033 ± 0.035%
Δ2M(μ+μ-) = -0.034 ± 0.025%
Δ2M(e+e-) = -0.036 ± 0.028%
Δ2M(μ+μ-) = -0.012 ± 0.020%
Δ2M(e+e-) = -0.054 ± 0.027%
Δ2M(μ+μ-) = +0.022 ± 0.018%
Z(→ e+e-) data
Z(→ μ+μ-) data
Z(→ e+e-) MC
Z(→ μ+μ-) MC
Zee+jet stat.
Zμμ+jet stat.
γ+jet stat. @2×pT,Z
χ2 / NDF = 9.3 / 12 (e+e-)
χ2 / NDF = 12.6 / 12 (e+e-)
χ2 / NDF = 10.6 / 12 (e+e-)
χ2 / NDF = 11.7 / 12 (e+e-)
χ2 / NDF = 21.0 / 12 (e+e-)
χ2 / NDF = 11.2 / 10 (e+e-)
ΔM(μ+μ-) = -0.182 ± 0.024%
ΔM(μ+μ-) = -0.168 ± 0.019%
ΔM(μ+μ-) = -0.213 ± 0.025%
ΔM(μ+μ-) = -0.191 ± 0.020%
ΔM(μ+μ-) = -0.157 ± 0.018%
ΔM(μ+μ-) = -0.178 ± 0.014%
χ2 / NDF = 13.5 / 12 (μ+μ-)
χ2 / NDF = 13.3 / 12 (μ+μ-)
χ2 / NDF = 14.0 / 12 (μ+μ-)
χ2 / NDF = 17.7 / 12 (μ+μ-)
χ2 / NDF = 16.1 / 12 (μ+μ-)
χ2 / NDF = 19.2 / 12 (μ+μ-)
Data / MC - 1 (%)
mZ (GeV)
pT,Z (GeV)


Run2017B, 4.8 fb-1 (13 TeV)
Run2017C, 9.6 fb-1 (13 TeV)
Run2017D, 4.2 fb-1 (13 TeV)
Run2017E, 9.3 fb-1 (13 TeV)
Run2017F, 13.4 fb-1 (13 TeV)
2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
α < 0.30
Data / MC ratio
MPF
pT balance
γ / Zμμ MPF
γ / Zμμ pTbal
μμ/ee mass
μμ/γ mass
χ2/NDF = 17.1/20
p0 = 0.18 ± 0.18
p1 = 0.41 ± 0.33
p2 = -0.38 ± 0.38
χ2/NDF = 21.0/20
p0 = 0.21 ± 0.13
p1 = 0.29 ± 0.24
p2 = -0.35 ± 0.28
χ2/NDF = 17.4/20
p0 = -0.18 ± 0.18
p1 = -0.15 ± 0.33
p2 = 0.03 ± 0.40
χ2/NDF = 25.0/20
p0 = 0.27 ± 0.14
p1 = -0.04 ± 0.28
p2 = -0.23 ± 0.31
χ2/NDF = 22.9/20
p0 = 0.18 ± 0.14
p1 = 0.26 ± 0.27
p2 = -0.32 ± 0.29
χ2/NDF = 19.3/20
p0 = 0.19 ± 0.10
p1 = 0.17 ± 0.18
p2 = -0.28 ± 0.21
Zee / Zμμ - 1 (%)
Data / MC
pT,Z (GeV)

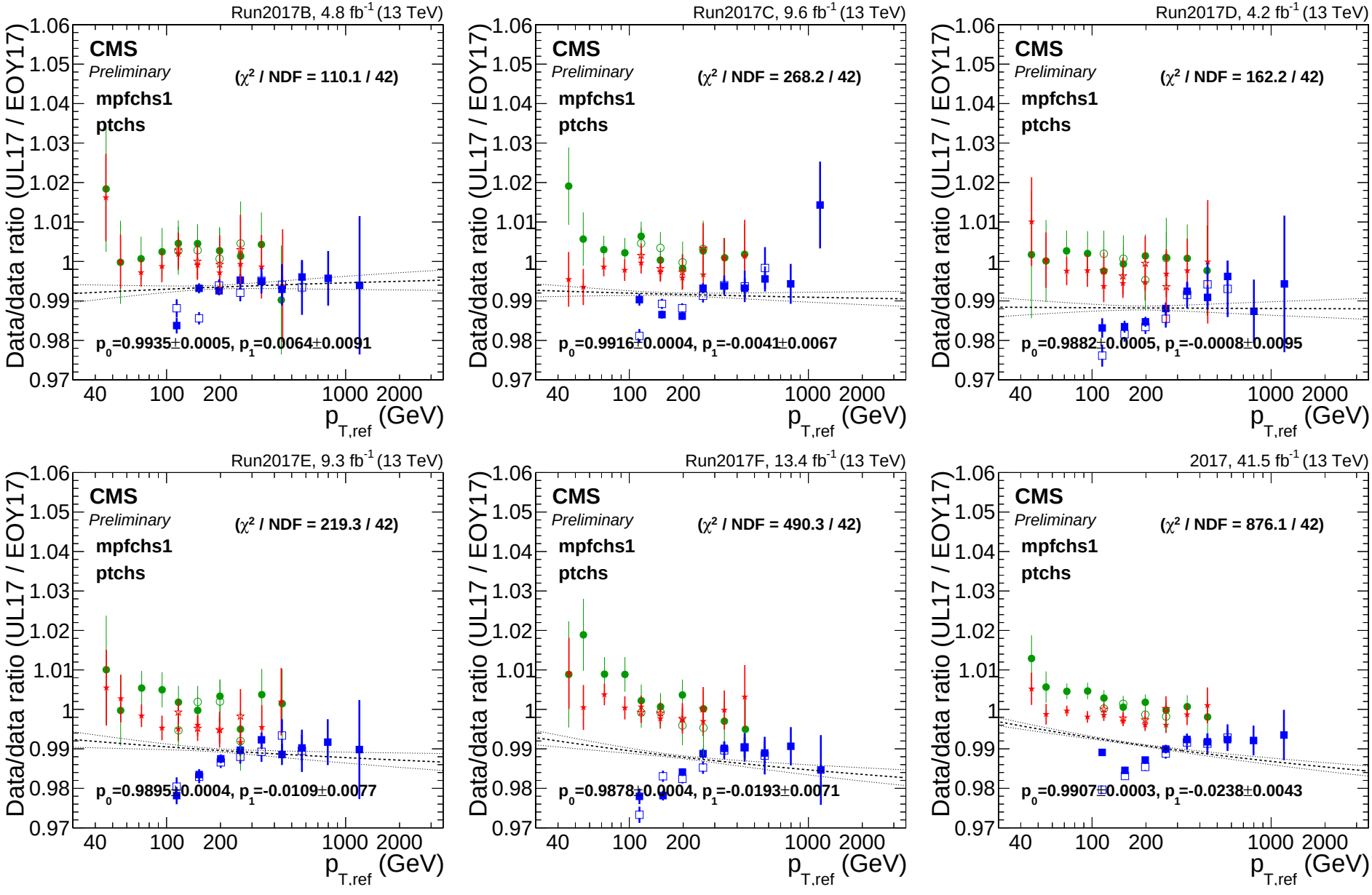


Figure : Data (UL17) vs data (EOY17)

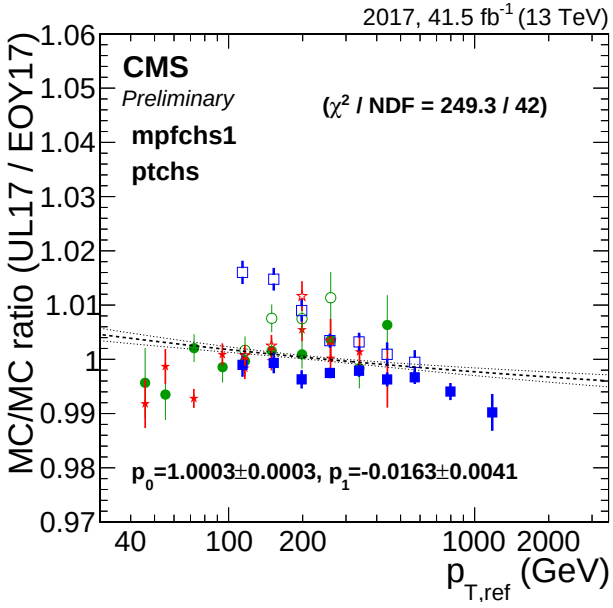


Figure : MC (UL17) vs MC (EOY17)

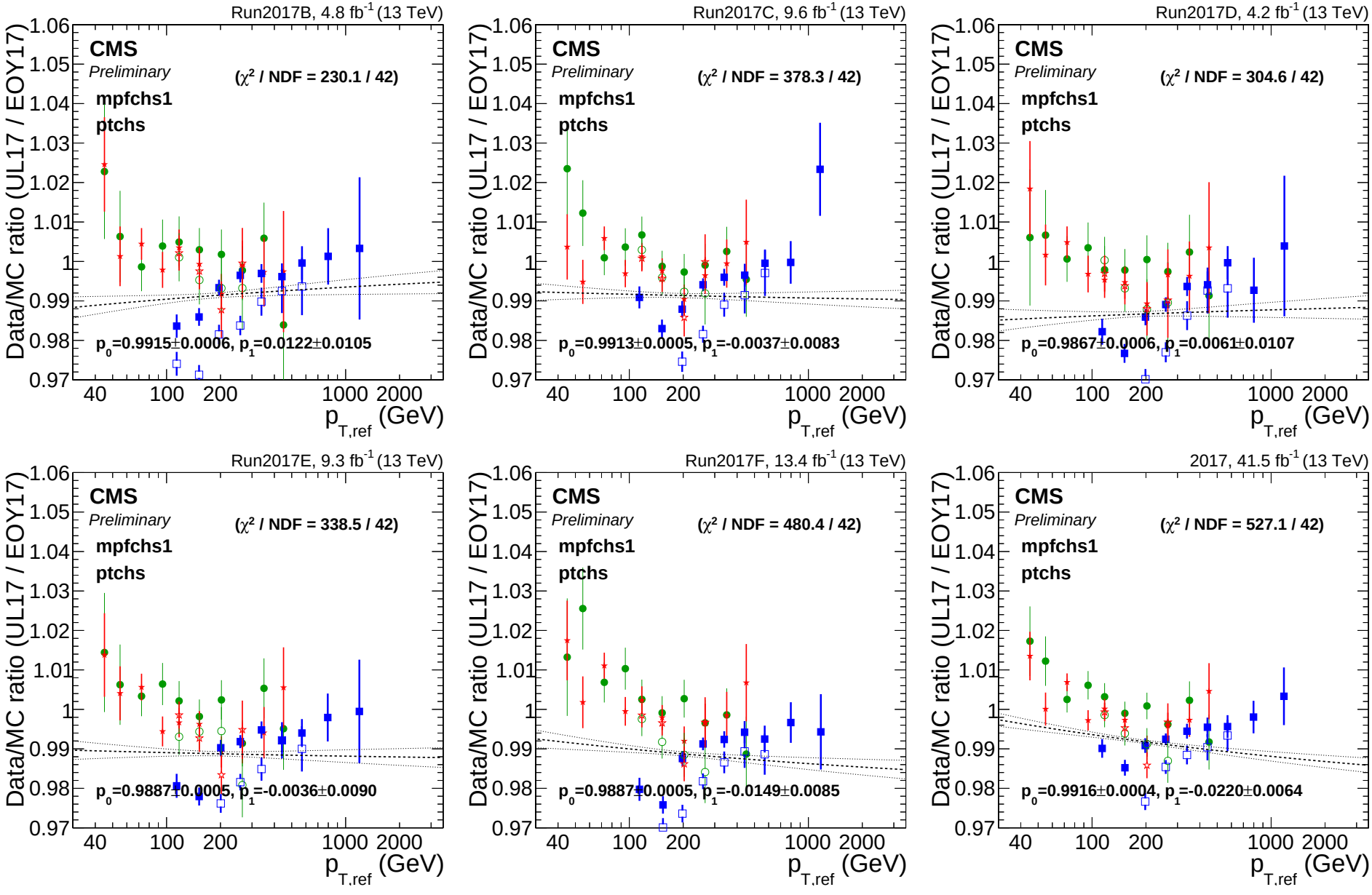


Figure : Data/MC ratio (UL17) vs Data/MC ratio (EOY17)

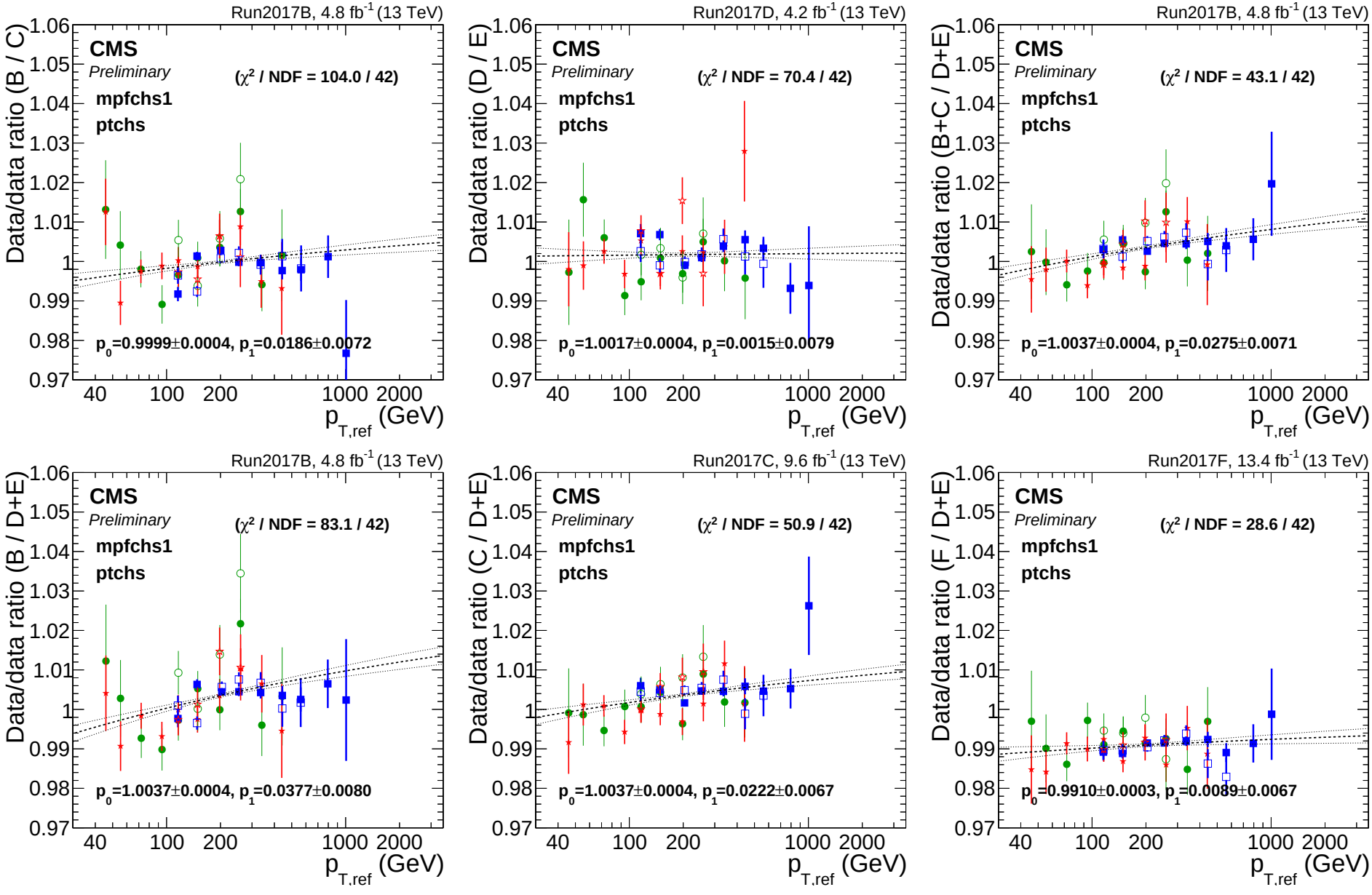


Figure : Stability checks between data IOVs.

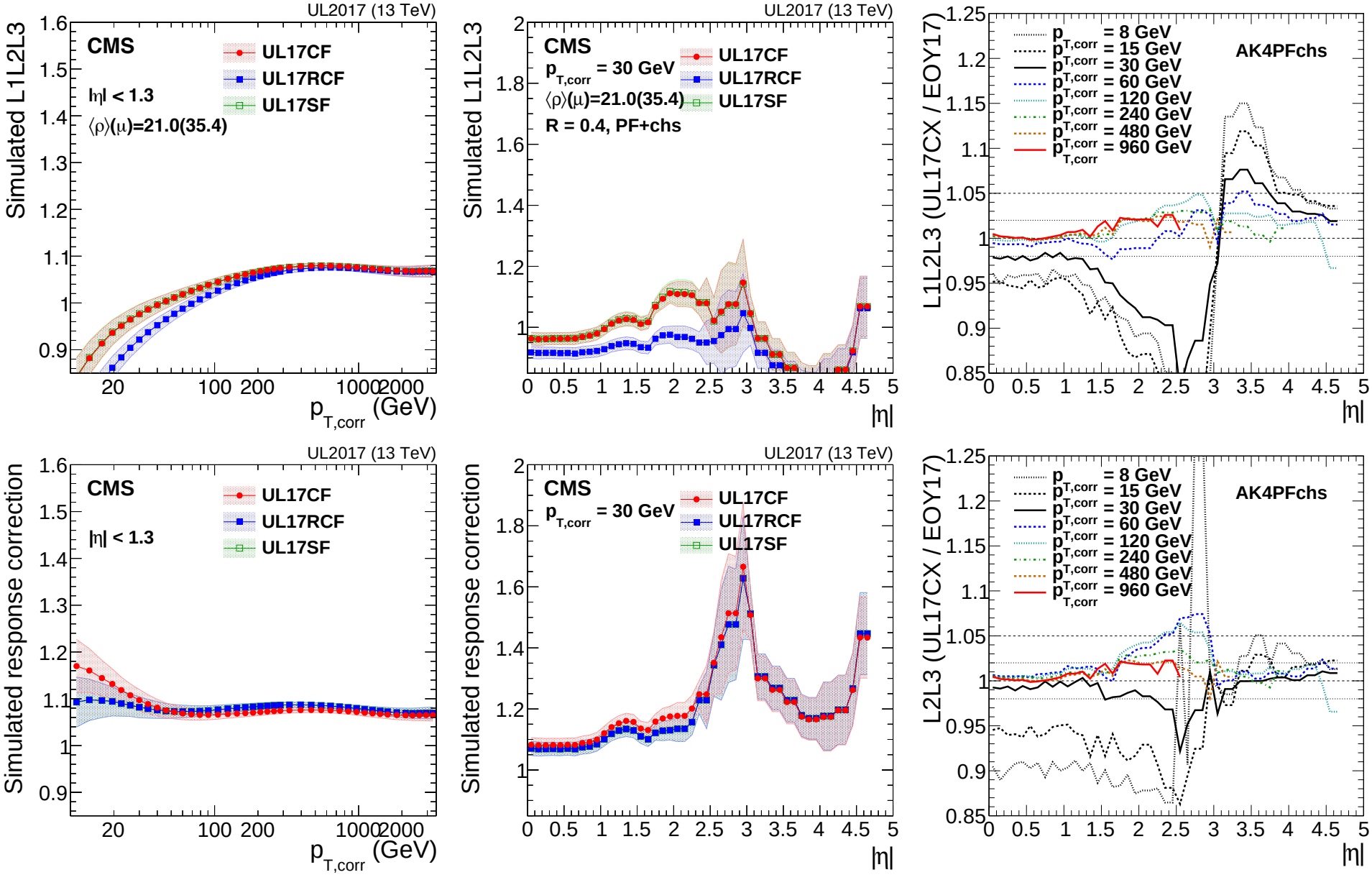


Figure : MC JEC UL17 V1 vs EOY17 V32 (CX=ComplexL1, S=SimpleL1).

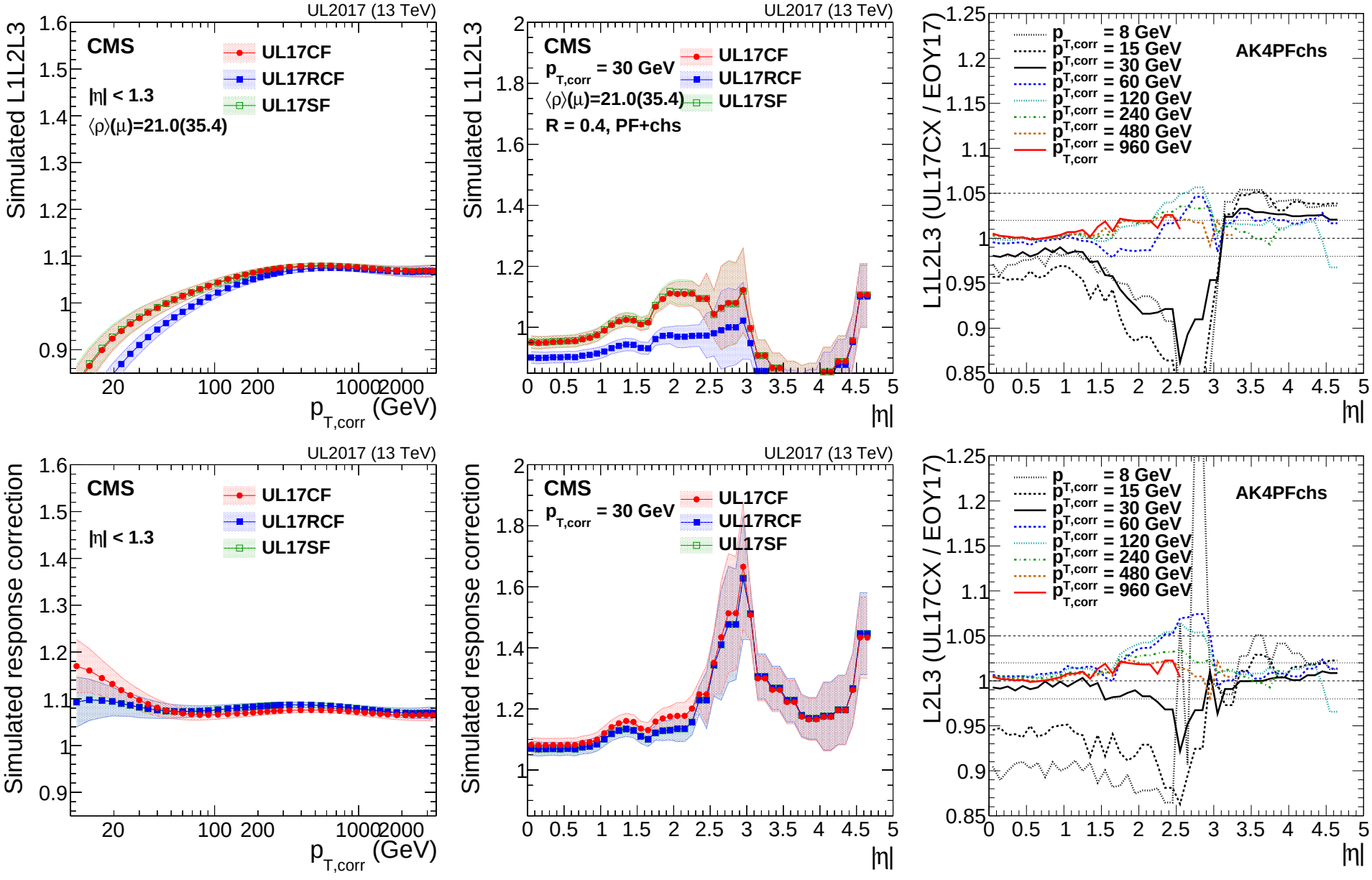


Figure : Data JEC UL17 V1 vs EOY17 V32 (CX=ComplexL1, S=SimpleL1).

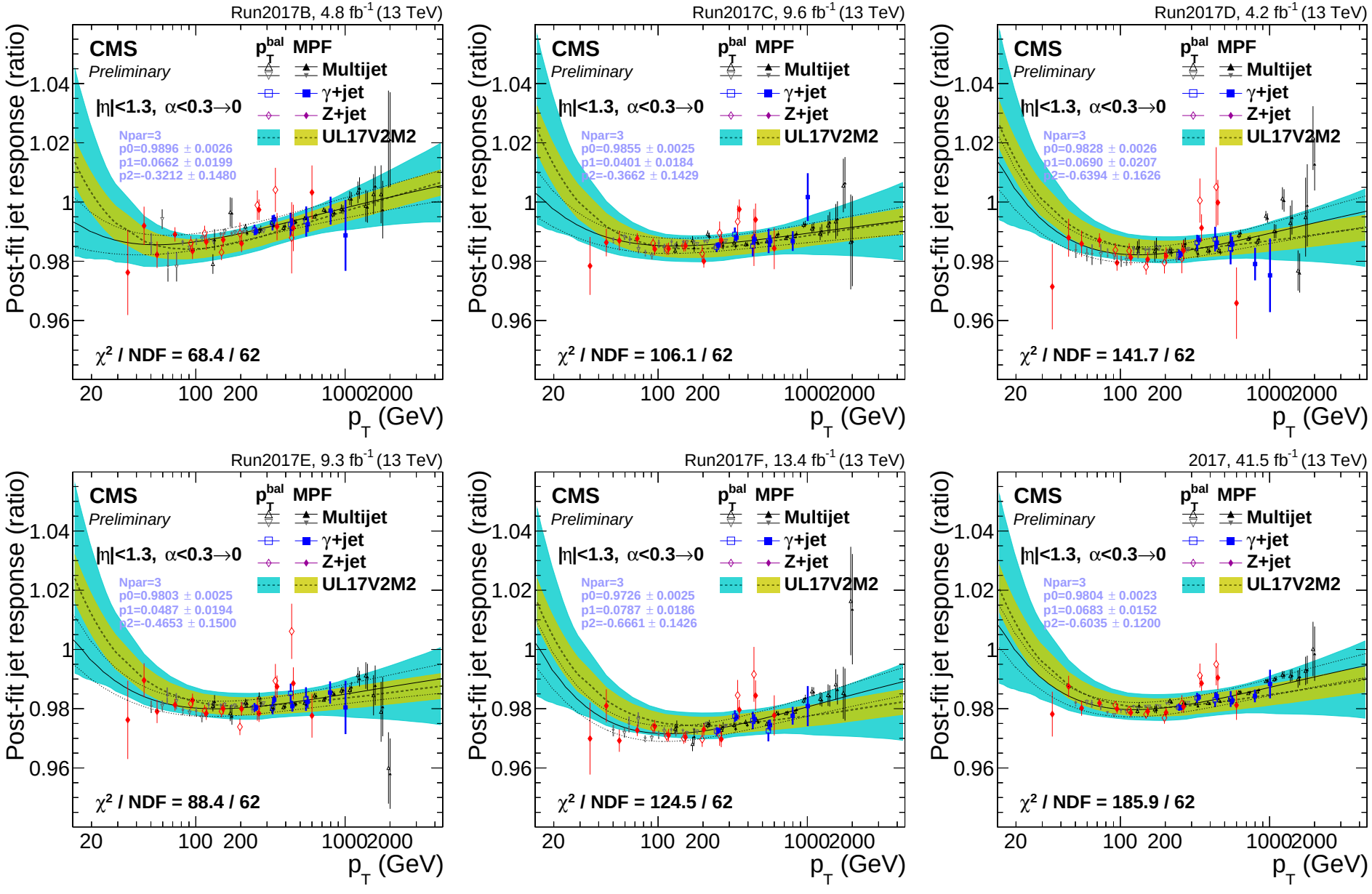


Figure : Final fit results.

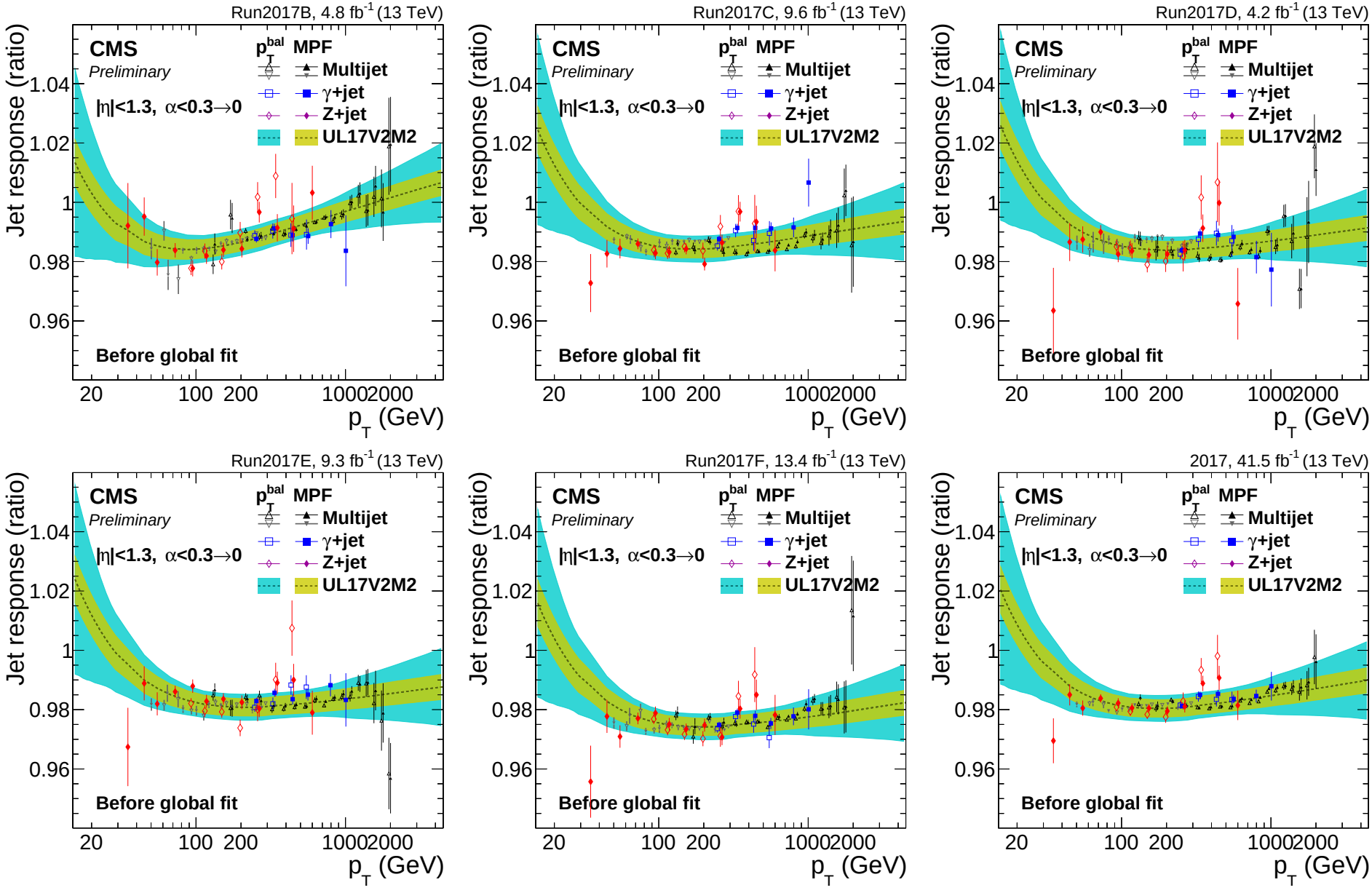


Figure : Pre-fit (post-FSR) results.

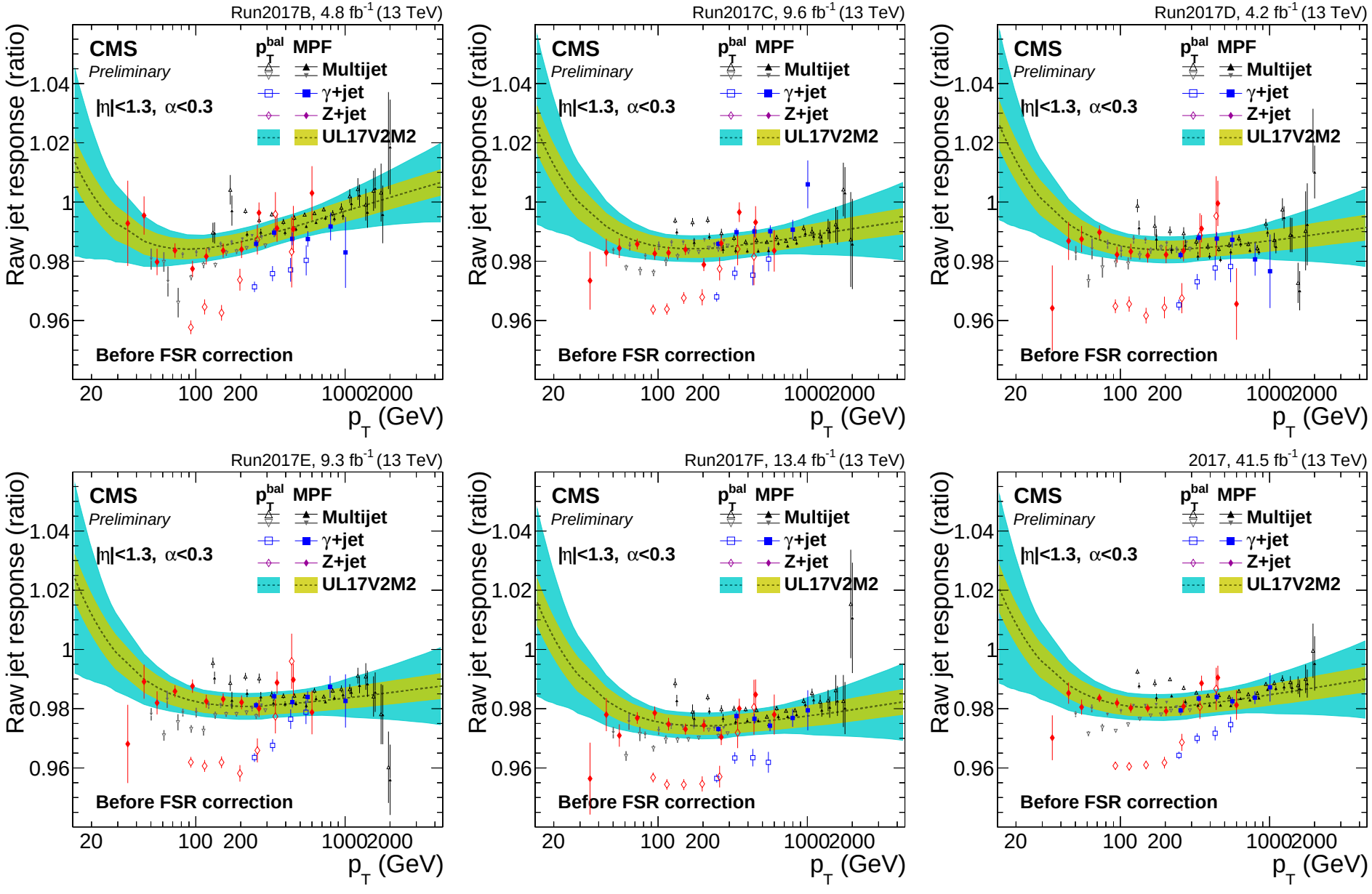
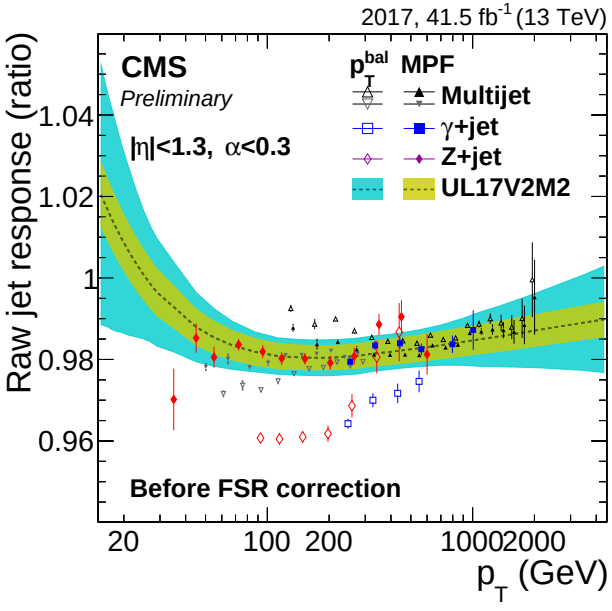
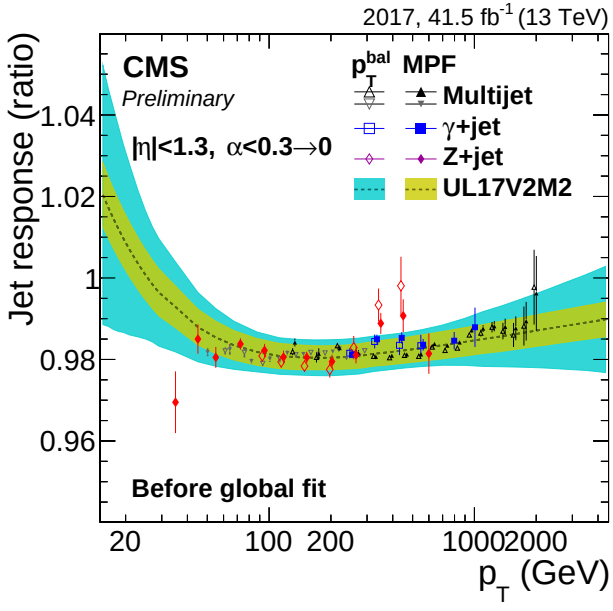
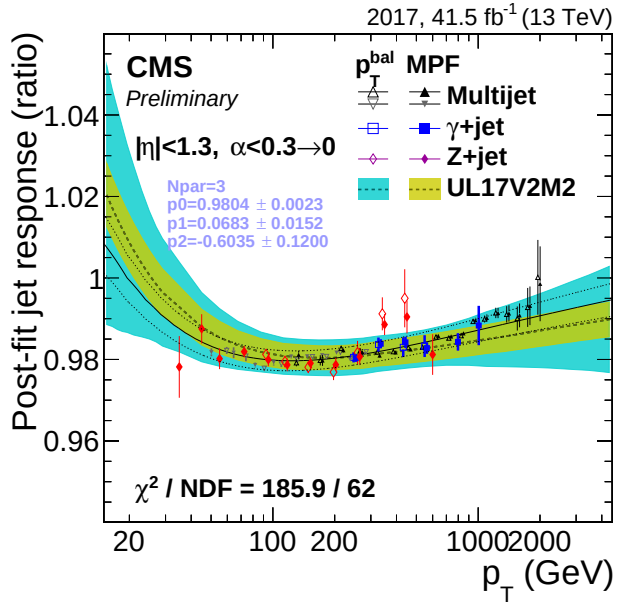
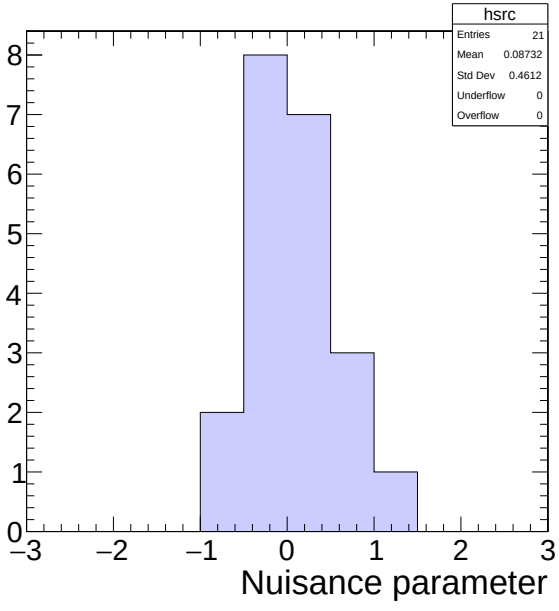


Figure : Raw (Pre-fit, pre-FSR) results.


2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before FSR correction
Raw jet response (ratio)
pT (GeV)


2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before global fit
Jet response (ratio)
pT (GeV)


2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9804 ± 0.0023
p1=0.0683 ± 0.0152
p2=-0.6035 ± 0.1200
χ2 / NDF = 185.9 / 62
Post-fit jet response (ratio)
pT (GeV)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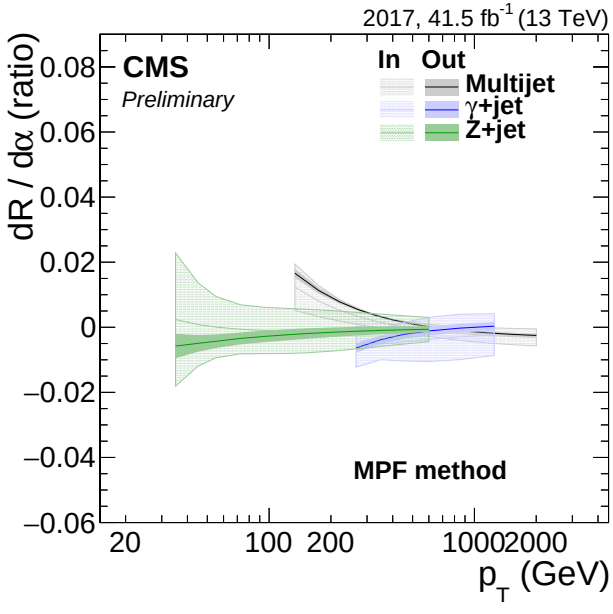
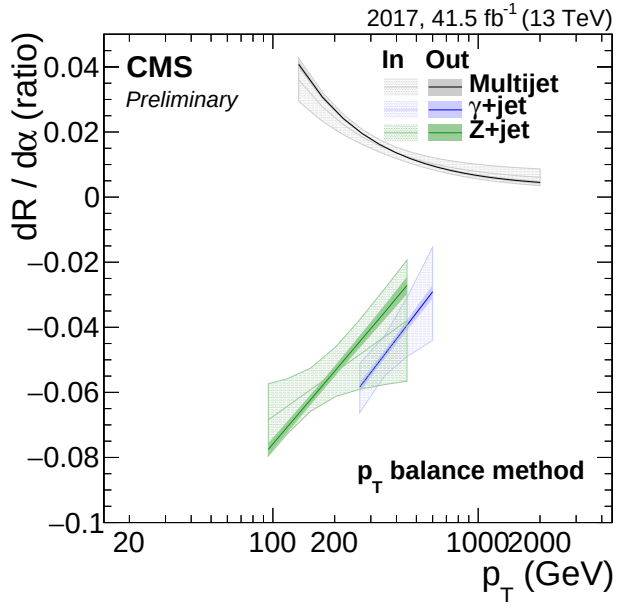
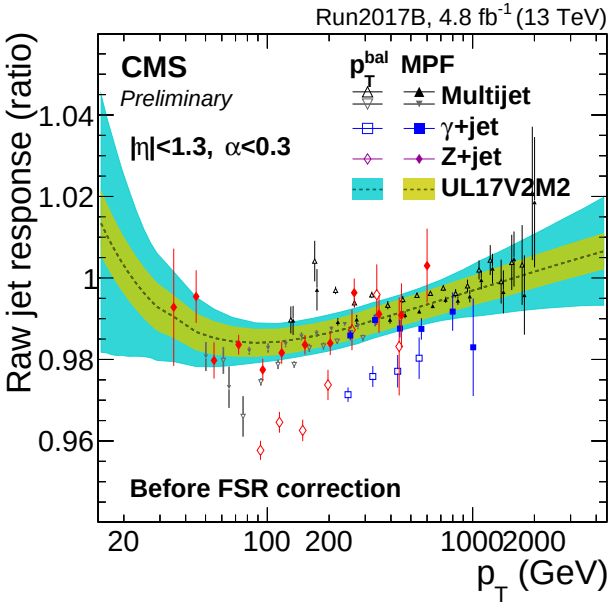
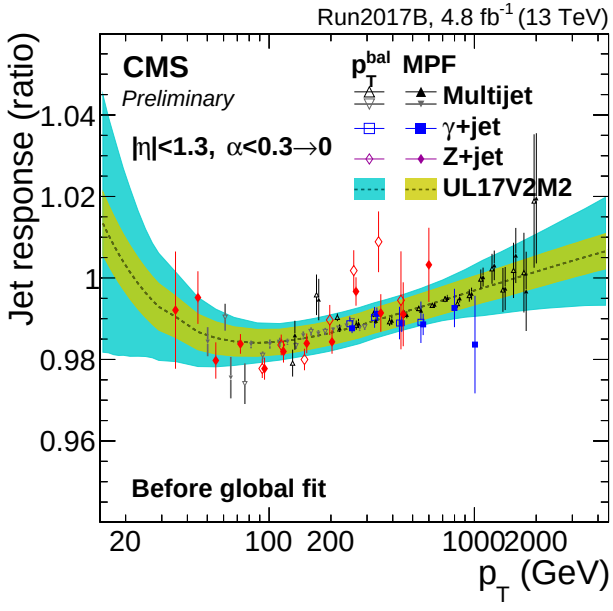
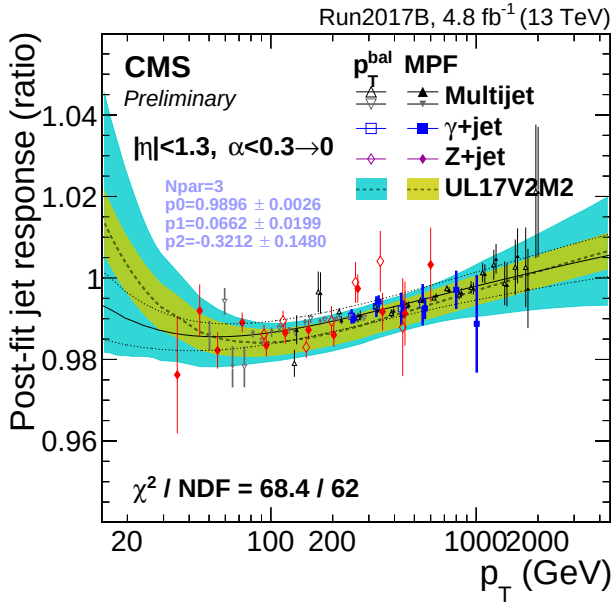
Entries 21
Mean 0.08732
Std Dev 0.4612
Underflow 0
Overflow 0
Nuisance parameter

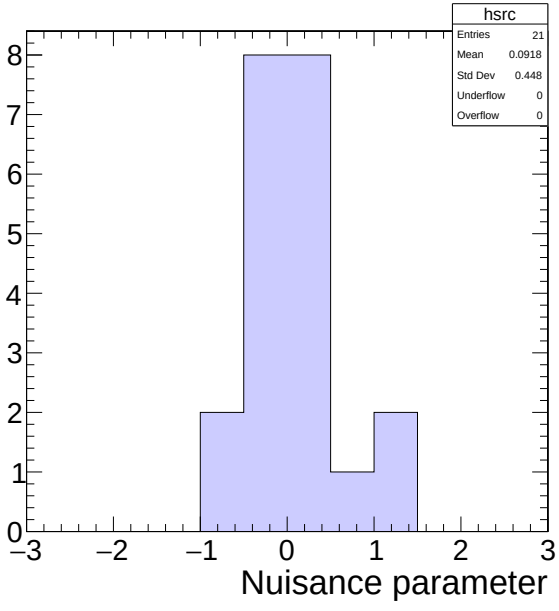

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
MPF method
dR / dα (ratio)
pT (GeV)

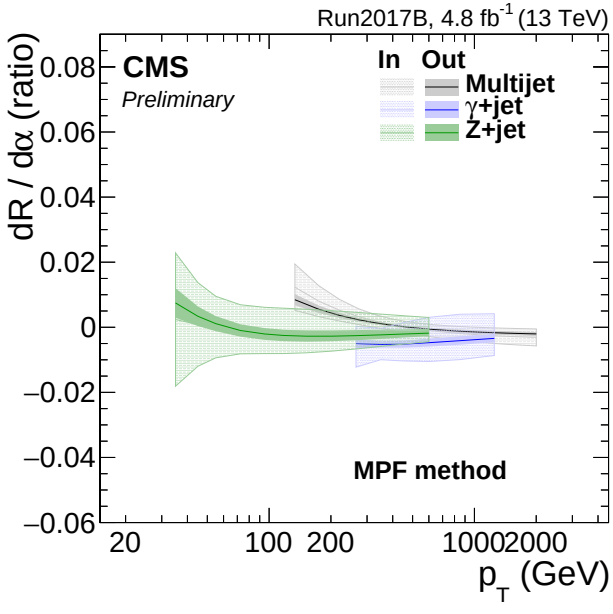

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
pT balance method
dR / dα (ratio)
pT (GeV)

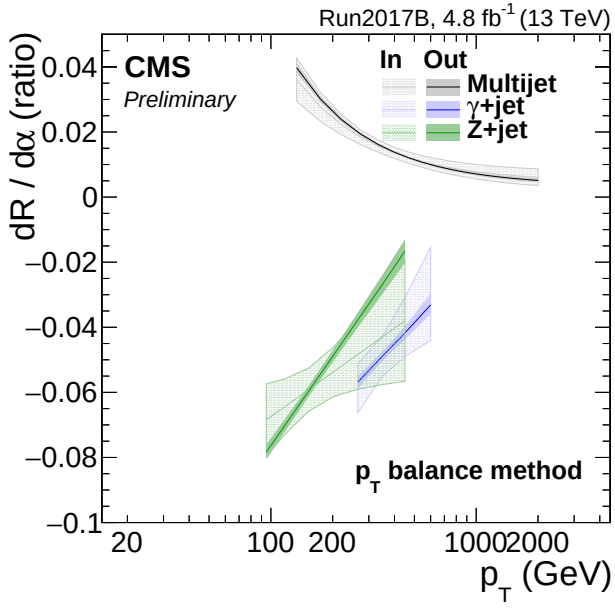

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before FSR correction
Raw jet response (ratio)
pT (GeV)

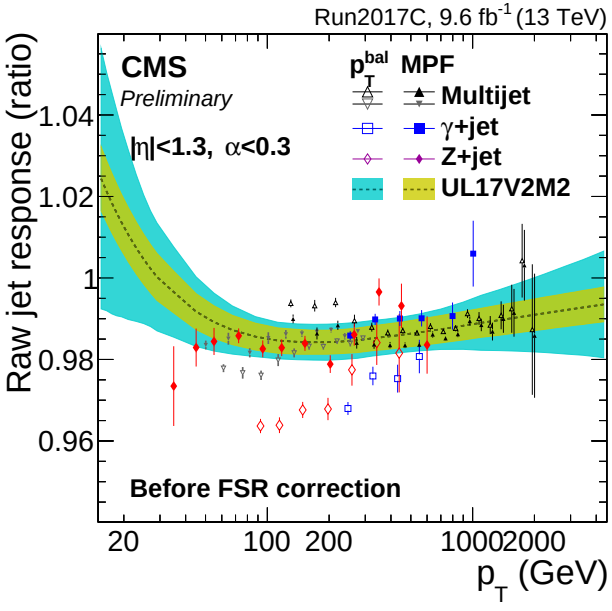

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before global fit
Jet response (ratio)
pT (GeV)

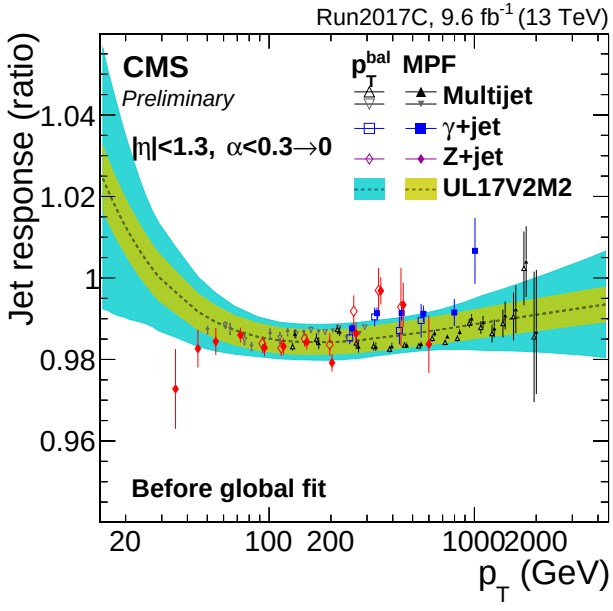

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9896 ± 0.0026
p1=0.0662 ± 0.0199
p2=-0.3212 ± 0.1480
χ2 / NDF = 68.4 / 62
Post-fit jet response (ratio)
pT (GeV)

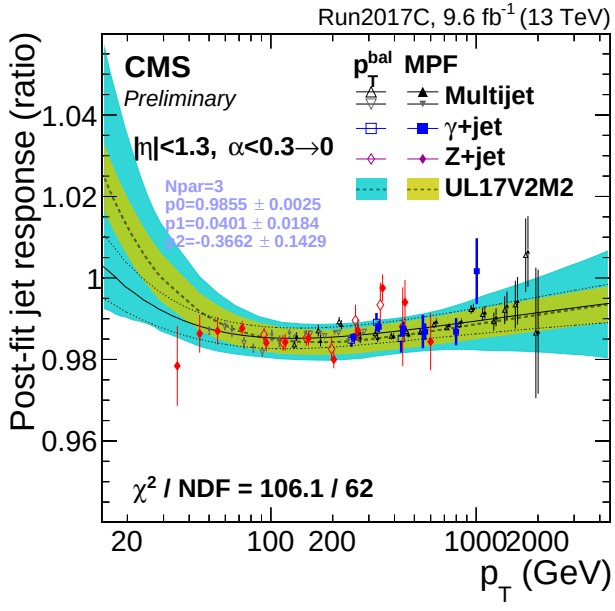

hsrc
Entries 21
Mean 0.0918
Std Dev 0.448
Underflow 0
Overflow 0
Nuisance parameter

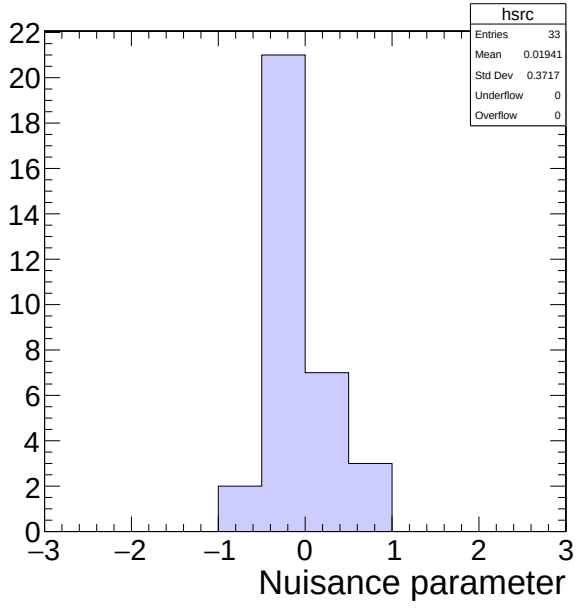

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
MPF method
dR / dα (ratio)
pT (GeV)


Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
pT balance method
dR / dα (ratio)
pT (GeV)


Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Raw jet response (ratio)
Before FSR correction
pT (GeV)


Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Jet response (ratio)
Before global fit
pT (GeV)


Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9855 ± 0.0025
p1=0.0401 ± 0.0184
p2=-0.3662 ± 0.1429
Post-fit jet response (ratio)
χ2 / NDF = 106.1 / 62
pT (GeV)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Entries 33
Mean 0.01941
Std Dev 0.3717
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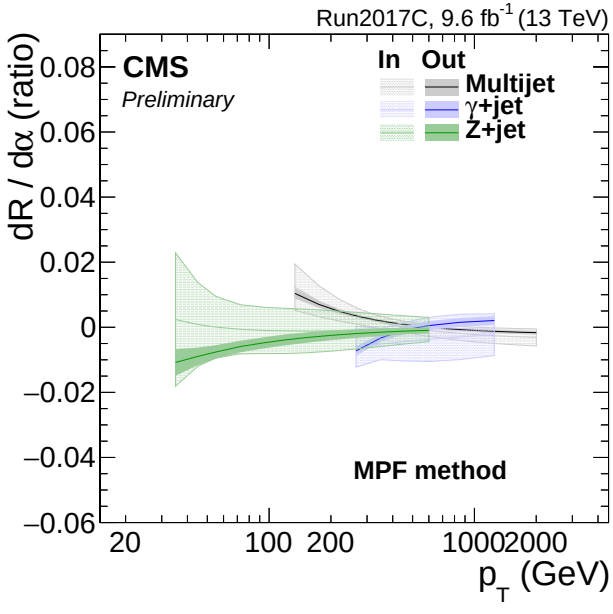
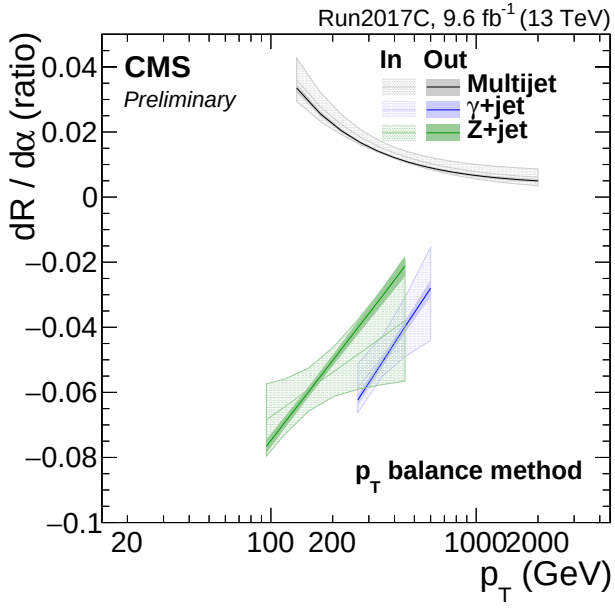
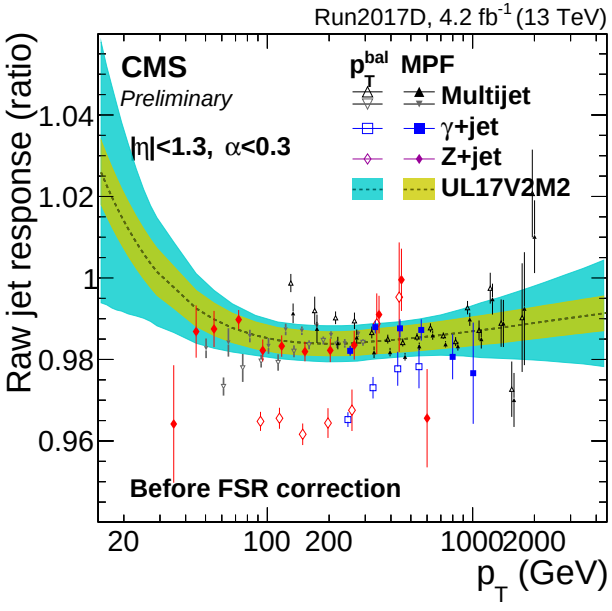
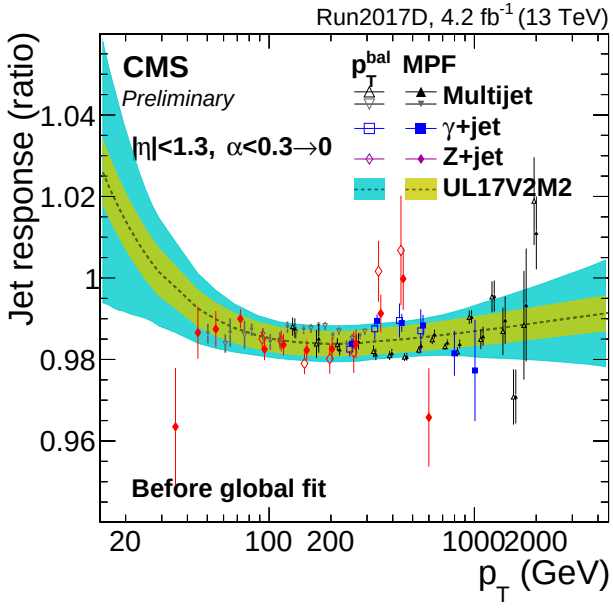
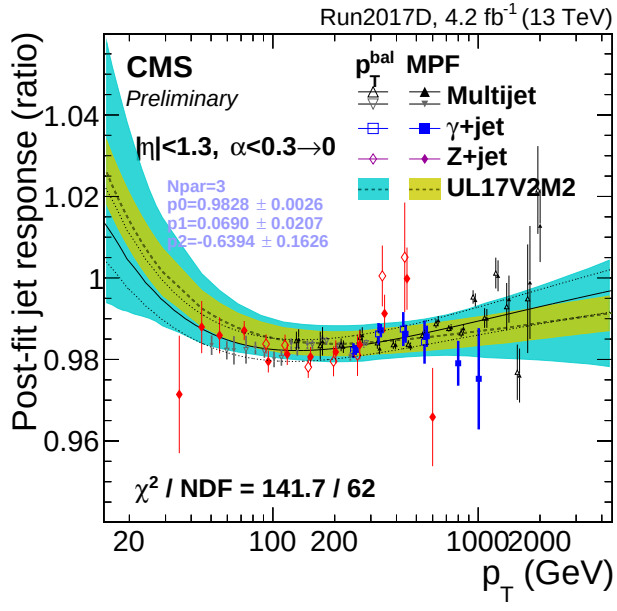
Overflow 0
Nuisance parameter

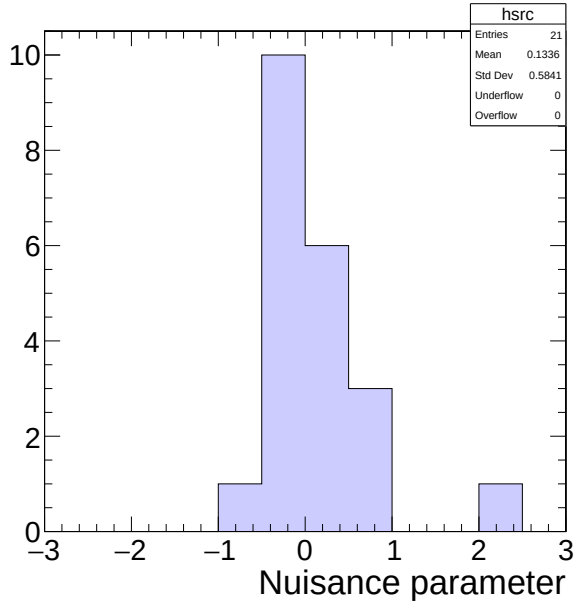

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
dR / dα (ratio)
MPF method
pT (GeV)

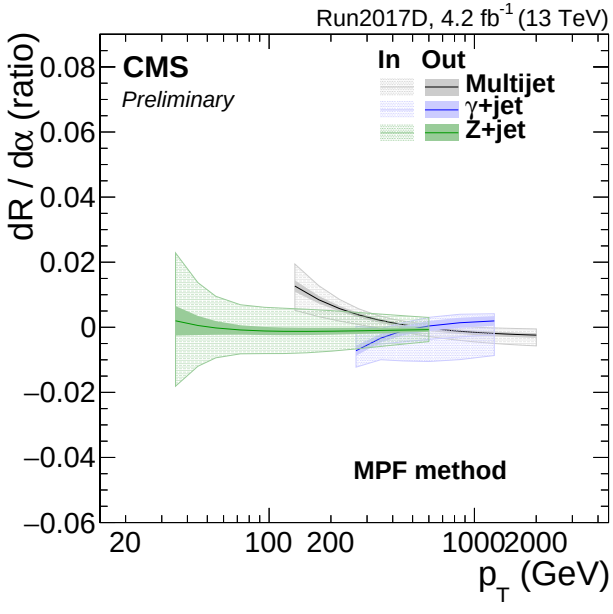

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
dR / dα (ratio)
pT balance method
pT (GeV)

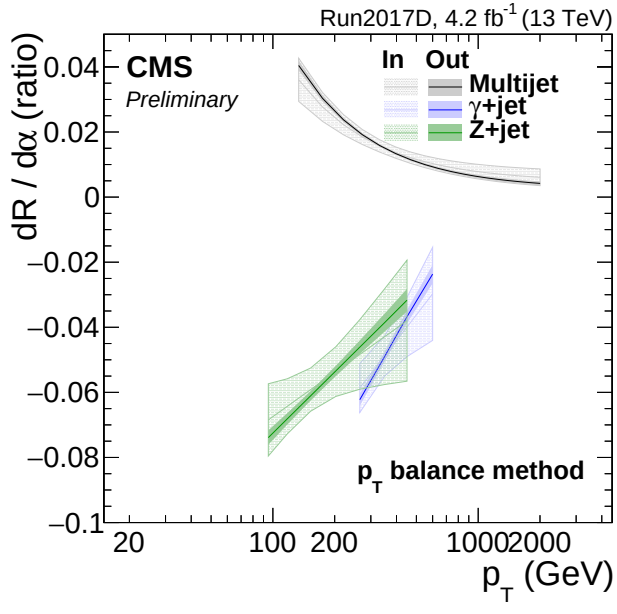

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pbal T MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before FSR correction
Raw jet response (ratio)
pT (GeV)

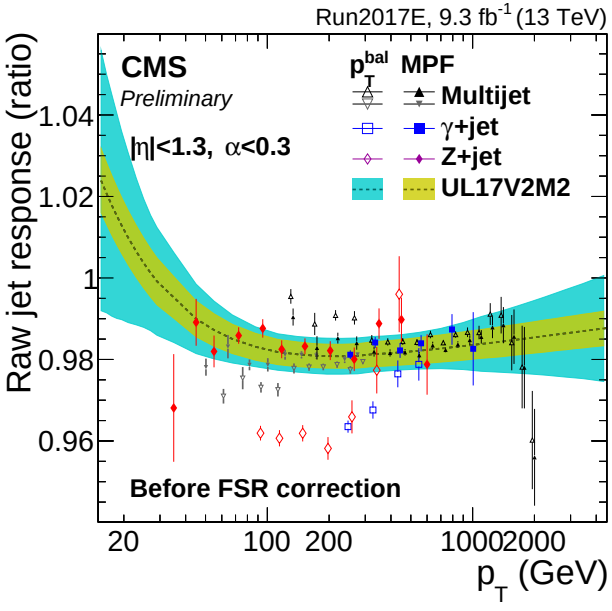

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal T MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before global fit
Jet response (ratio)
pT (GeV)

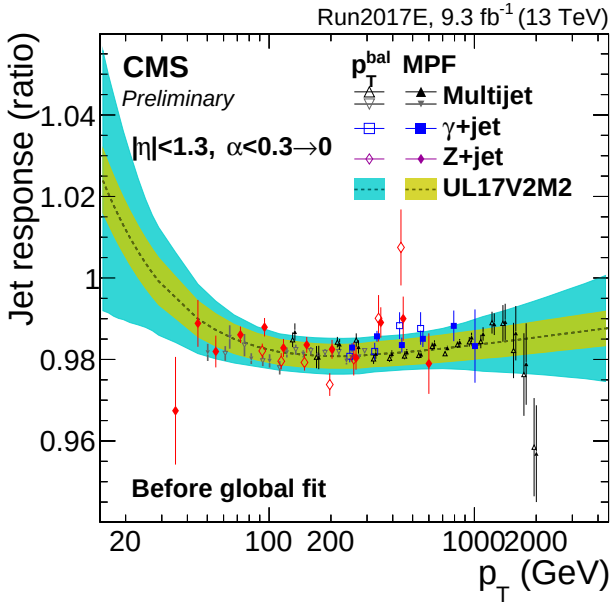

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal T MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9828 ± 0.0026
p1=0.0690 ± 0.0207
p2=-0.6394 ± 0.1626
χ2 / NDF = 141.7 / 62
Post-fit jet response (ratio)
pT (GeV)

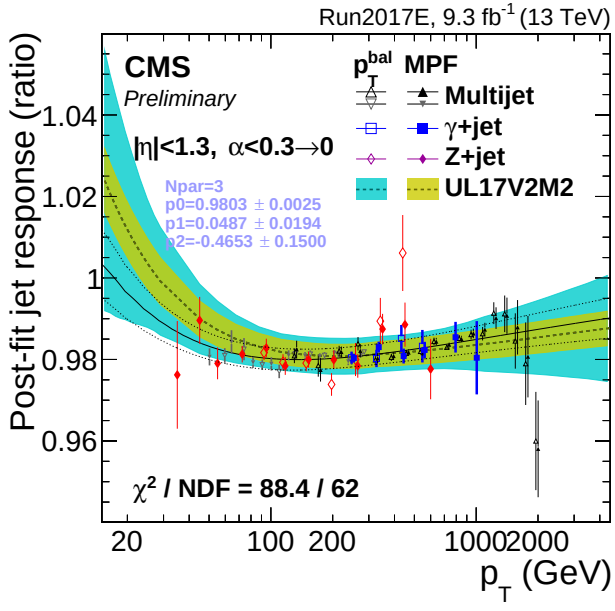

hsrc
Entries 21
Mean 0.1336
Std Dev 0.5841
Underflow 0
Overflow 0
Nuisance parameter

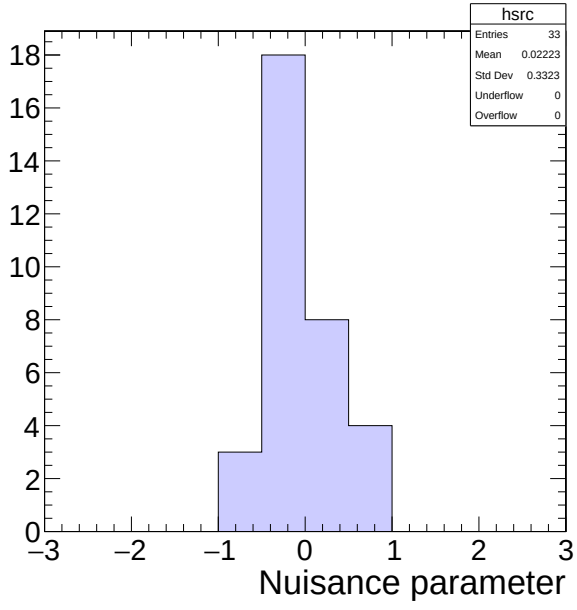

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
MPF method
dR / dα (ratio)
pT (GeV)

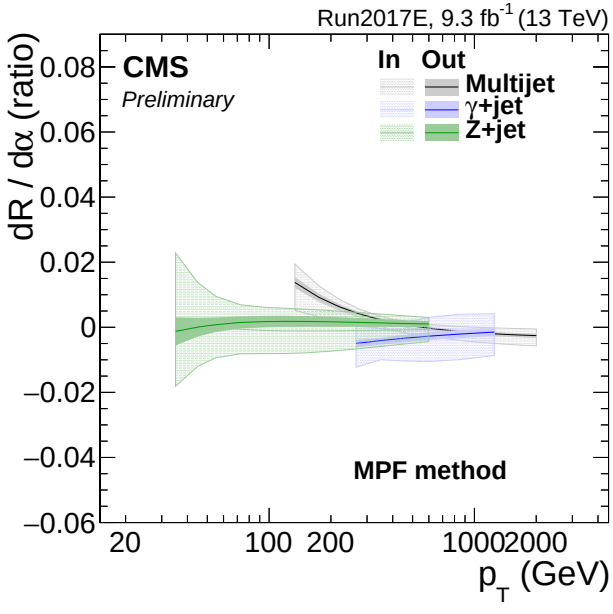

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
pT balance method
dR / dα (ratio)
pT (GeV)

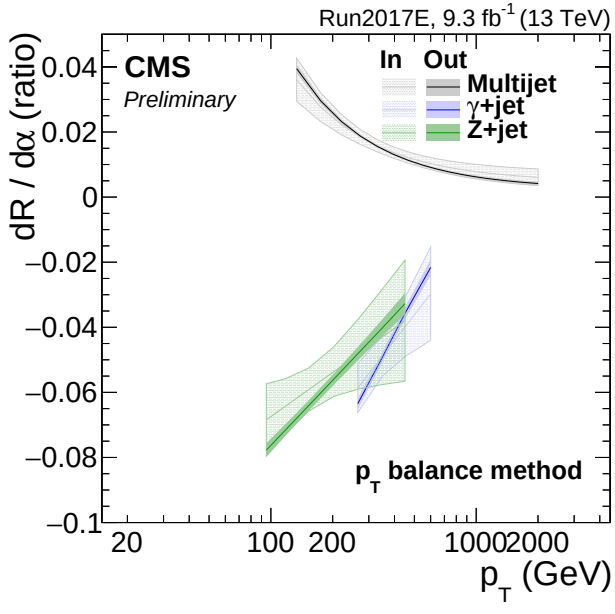

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before FSR correction
Raw jet response (ratio)
pT (GeV)

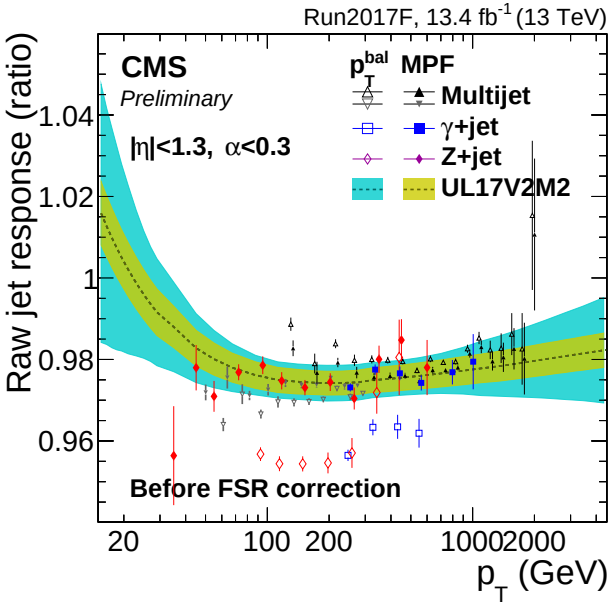

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before global fit
Jet response (ratio)
pT (GeV)

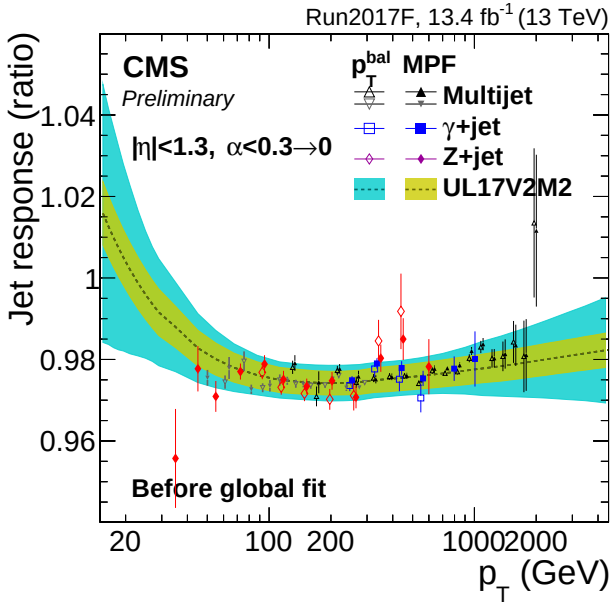

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pTbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9803 ± 0.0025
p1=0.0487 ± 0.0194
p2=-0.4653 ± 0.1500
χ2 / NDF = 88.4 / 62
Post-fit jet response (ratio)
pT (GeV)

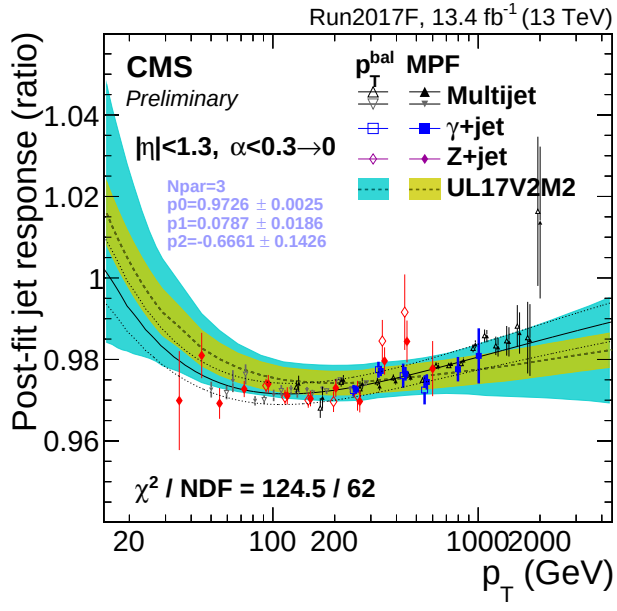

hsrc
Entries 33
Mean 0.02223
Std Dev 0.3323
Underflow 0
Overflow 0
Nuisance parameter

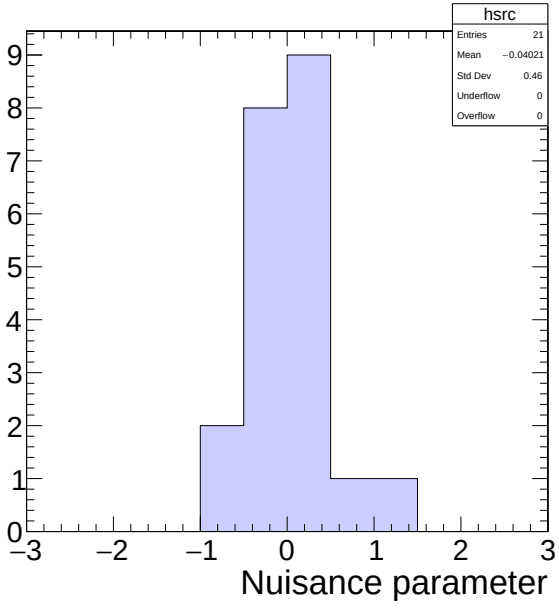

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
MPF method
dR / dα (ratio)
pT (GeV)

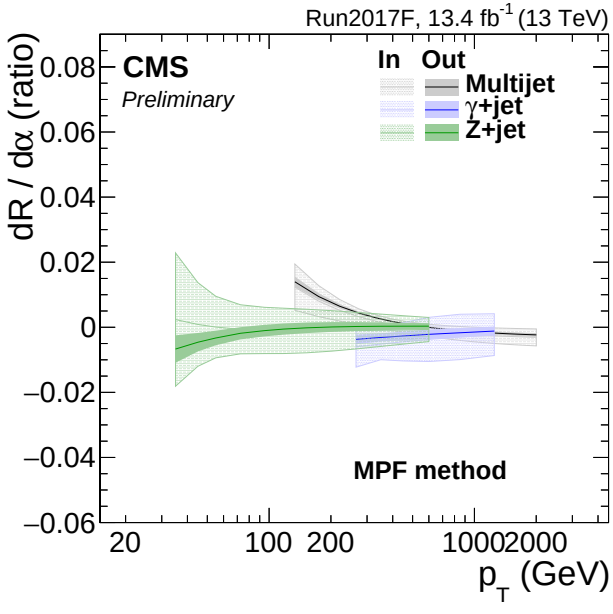

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
pT balance method
dR / dα (ratio)
pT (GeV)

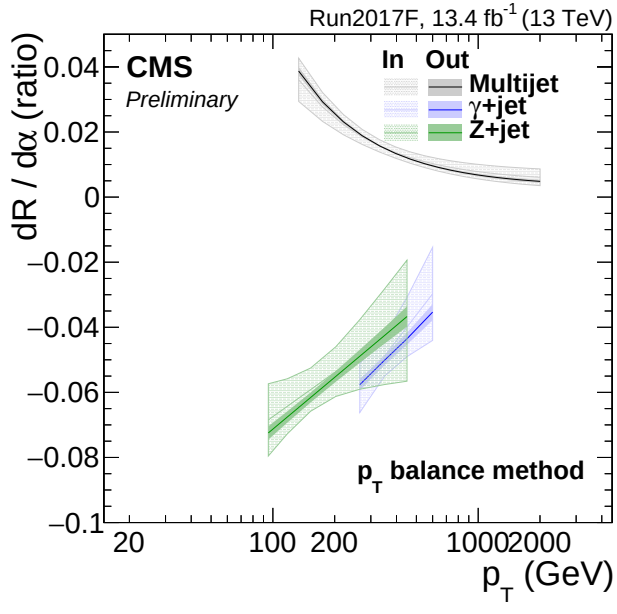

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before FSR correction
Raw jet response (ratio)
pT (GeV)

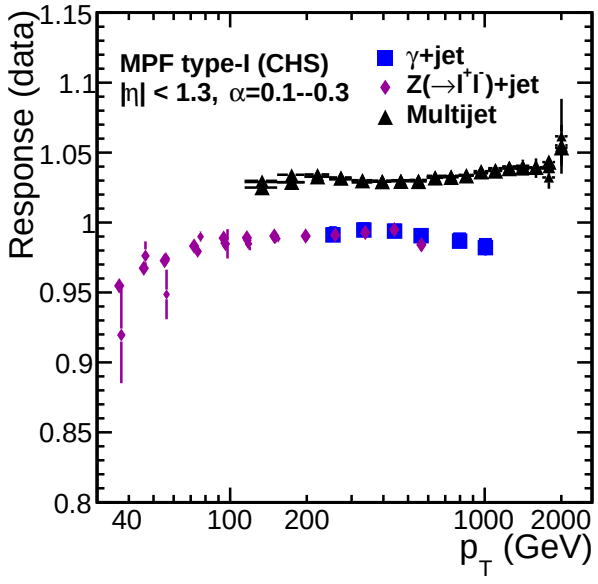

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Before global fit
Jet response (ratio)
pT (GeV)

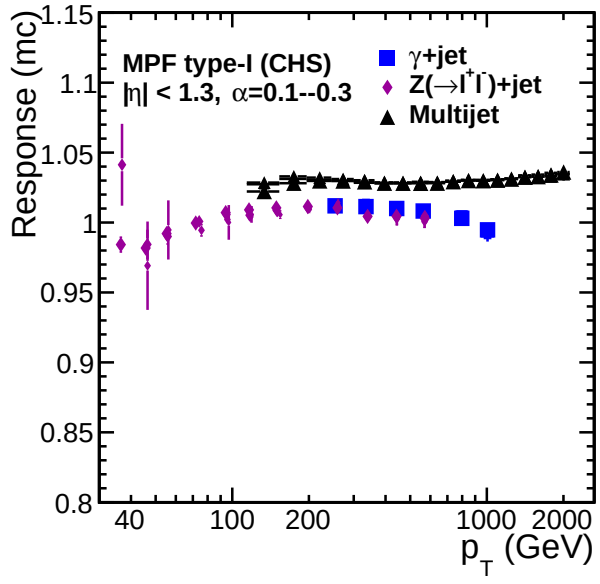

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
|η|<1.3, α<0.3→0
pbal MPF
Multijet
γ+jet
Z+jet
UL17V2M2
Npar=3
p0=0.9726 ± 0.0025
p1=0.0787 ± 0.0186
p2=-0.6661 ± 0.1426
χ2 / NDF = 124.5 / 62
Post-fit jet response (ratio)
pT (GeV)

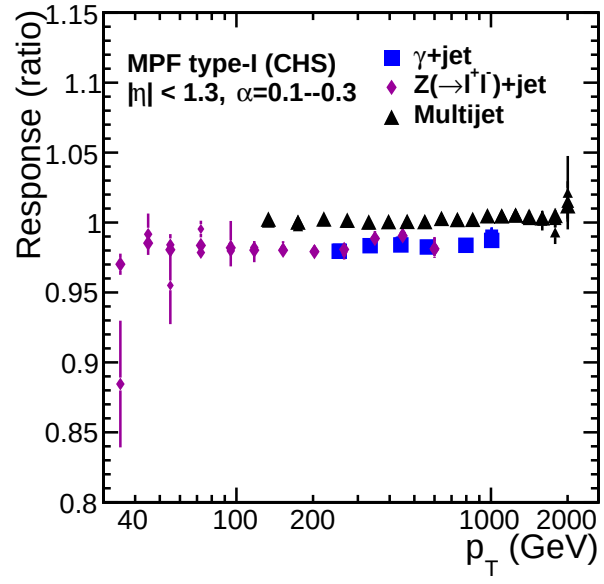

hsrc
Entries 21
Mean −0.04021
Std Dev 0.46
Underflow 0
Overflow 0
Nuisance parameter

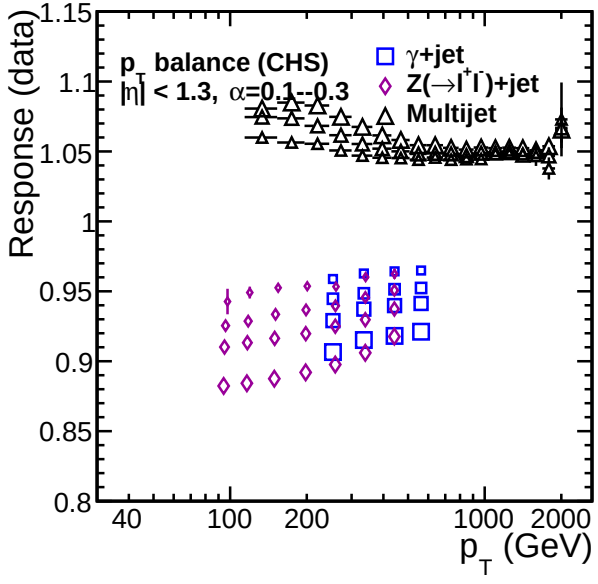

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
MPF method
dR / dα (ratio)
pT (GeV)

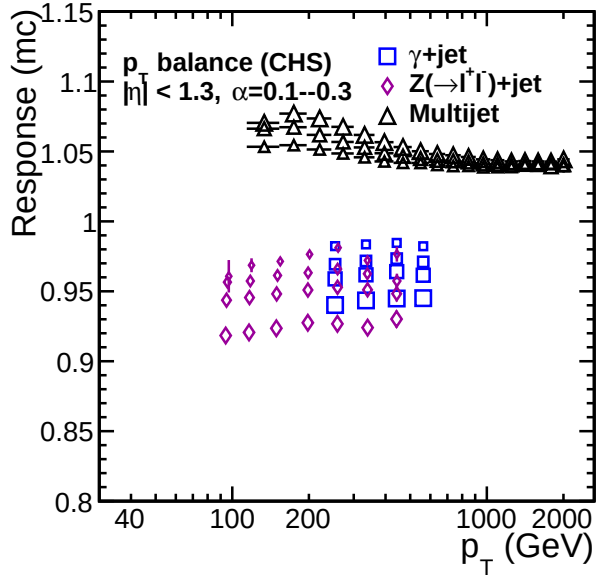

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
In Out
Multijet
γ+jet
Z+jet
pT balance method
dR / dα (ratio)
pT (GeV)

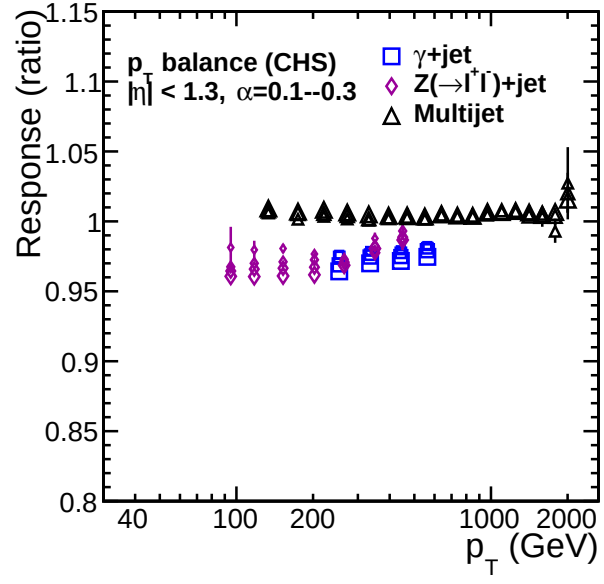

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

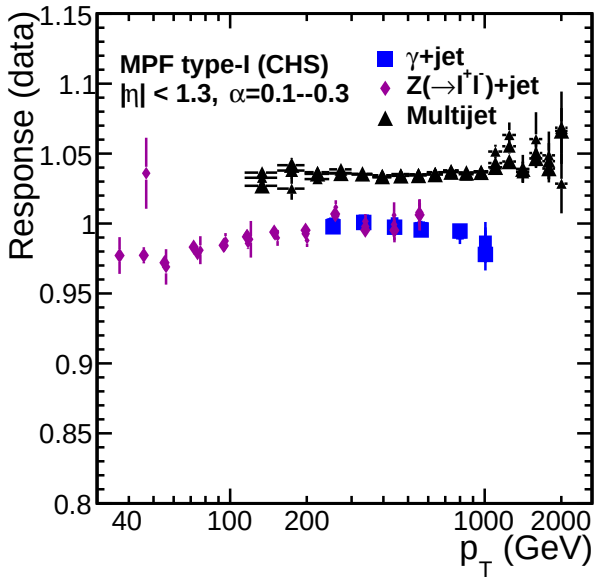

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

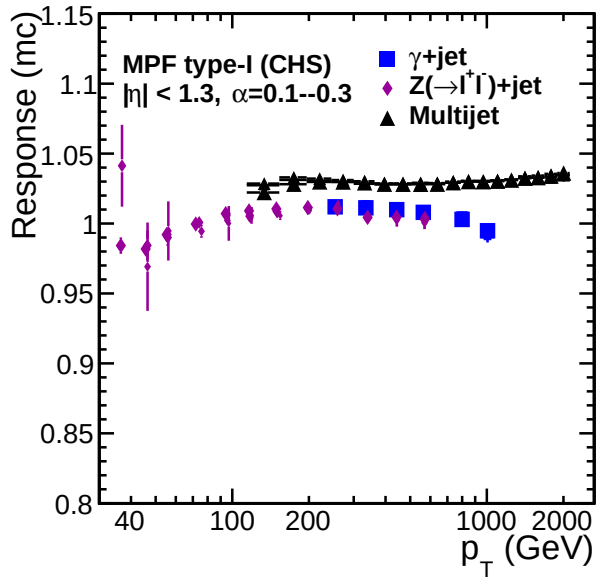

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

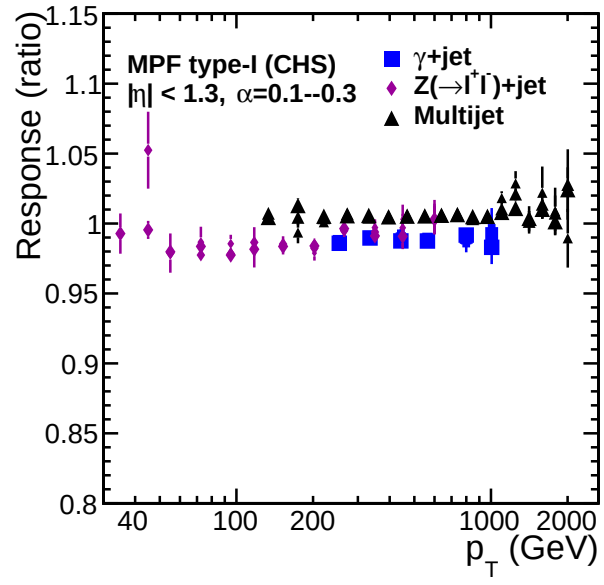

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

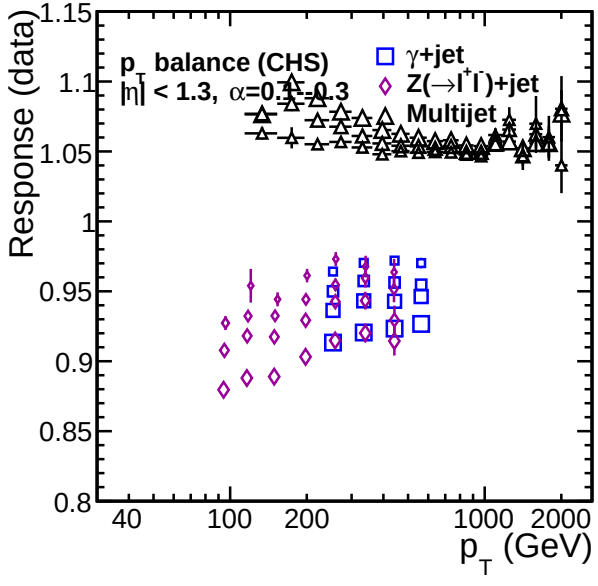

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

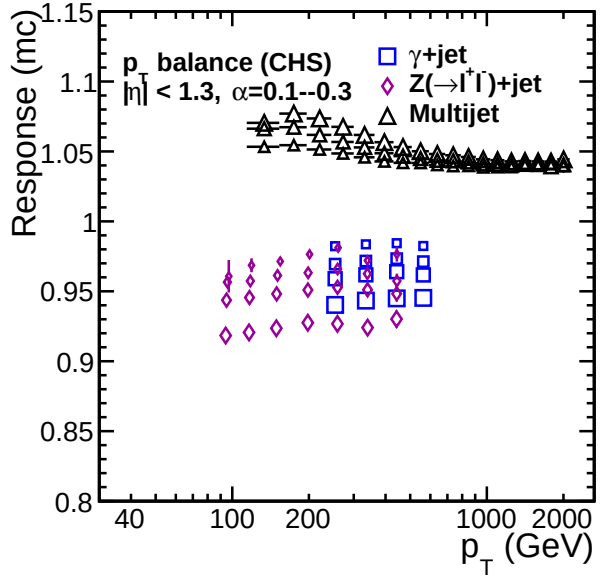

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

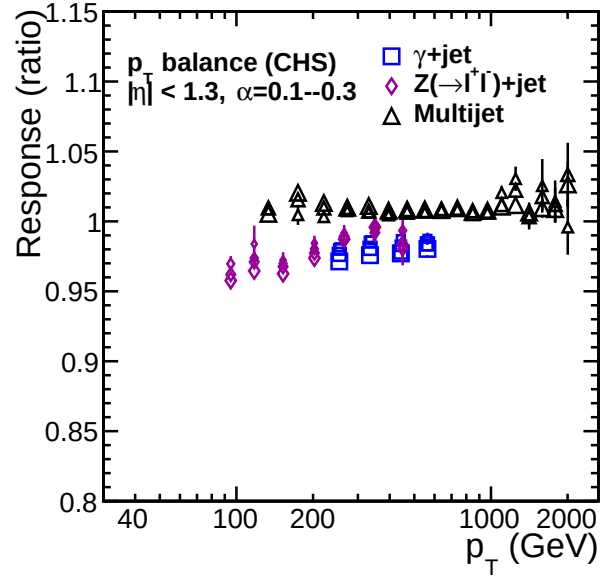

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

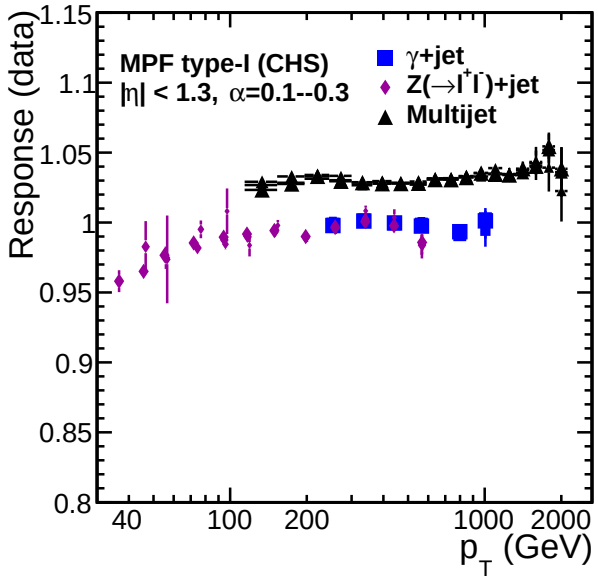

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

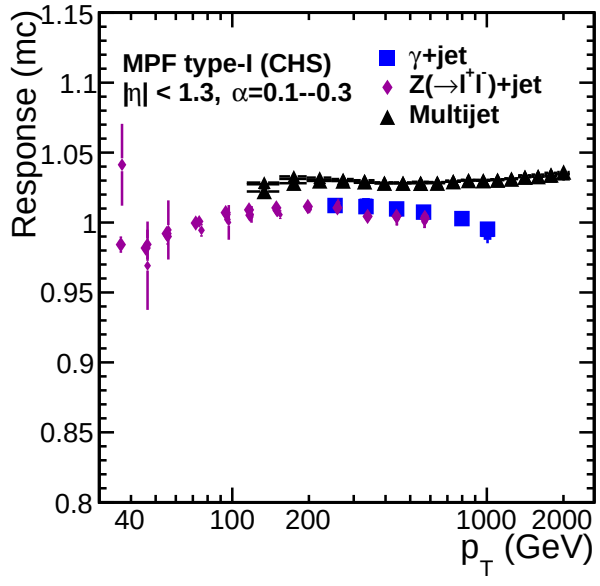

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

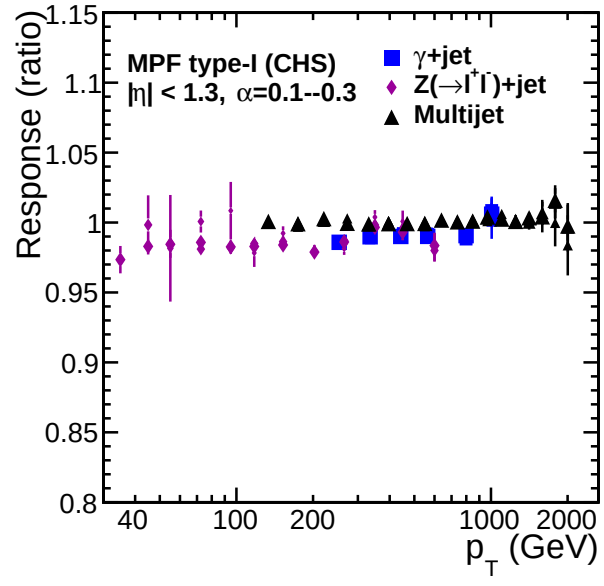

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

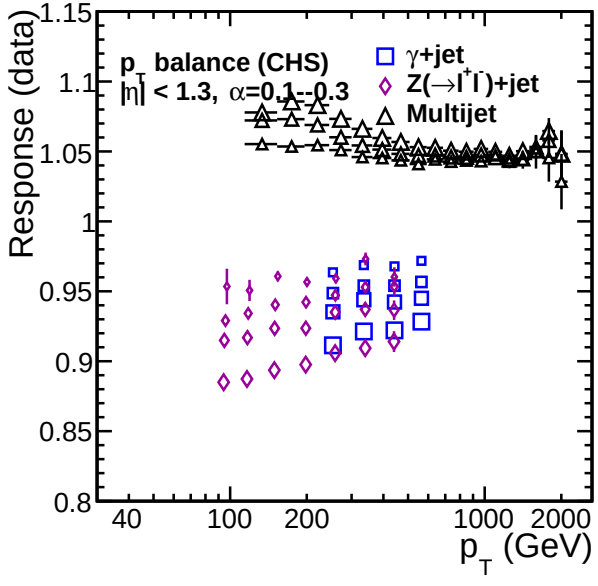

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

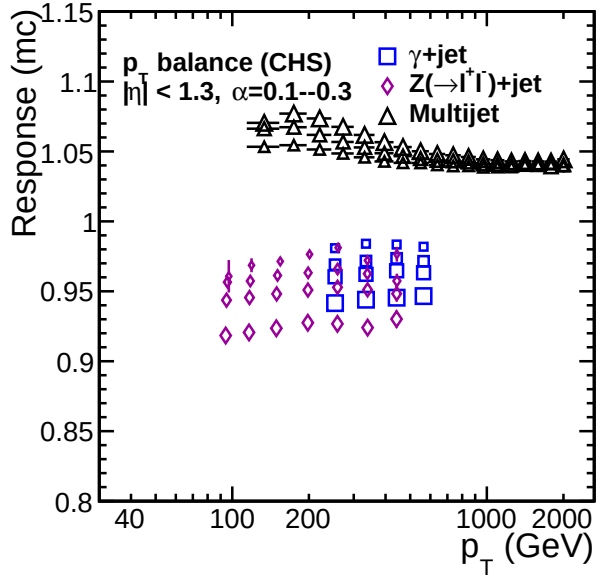

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

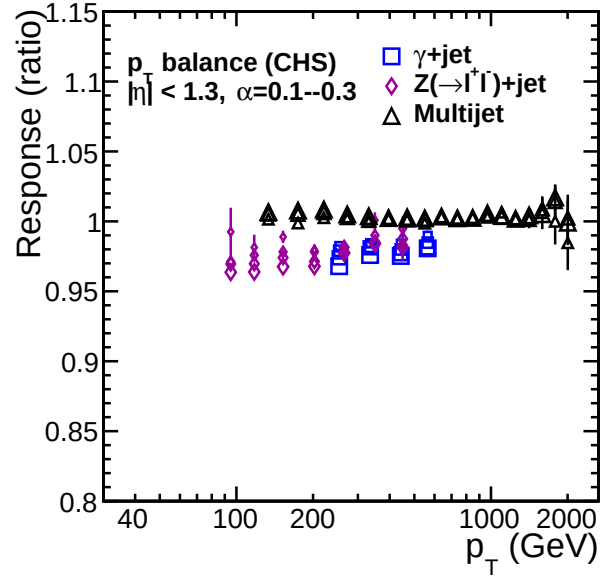

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

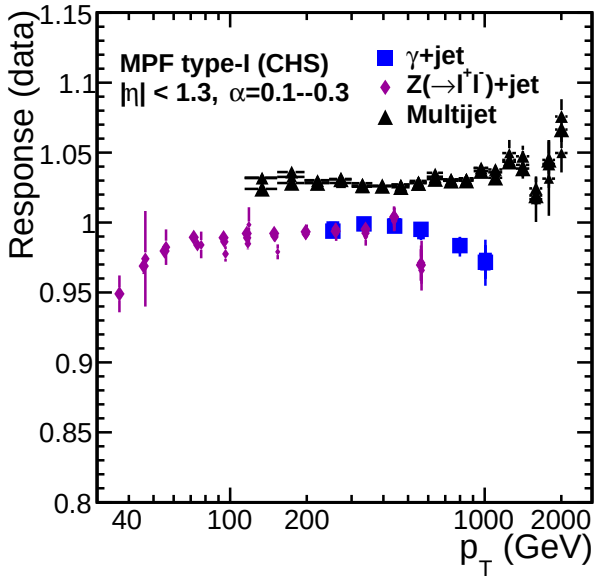

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

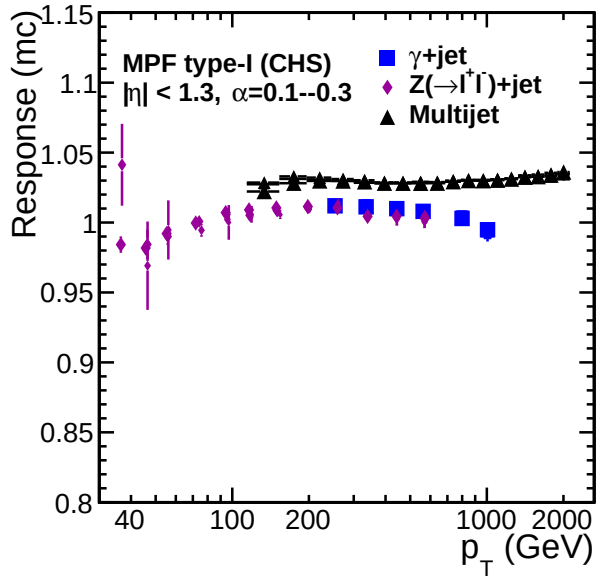

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

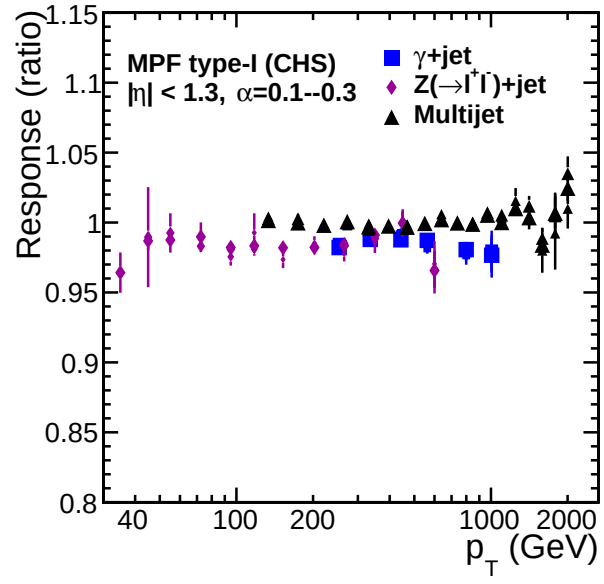

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

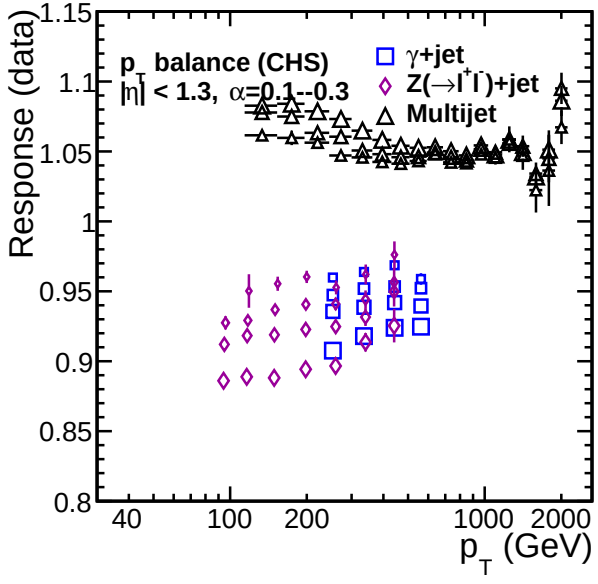

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

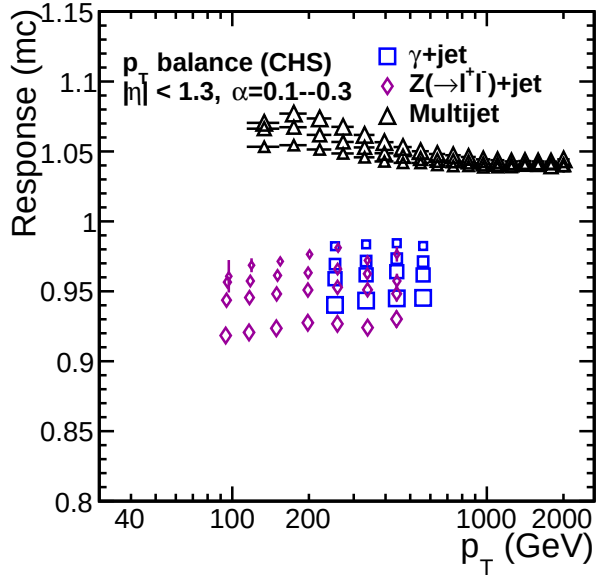

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

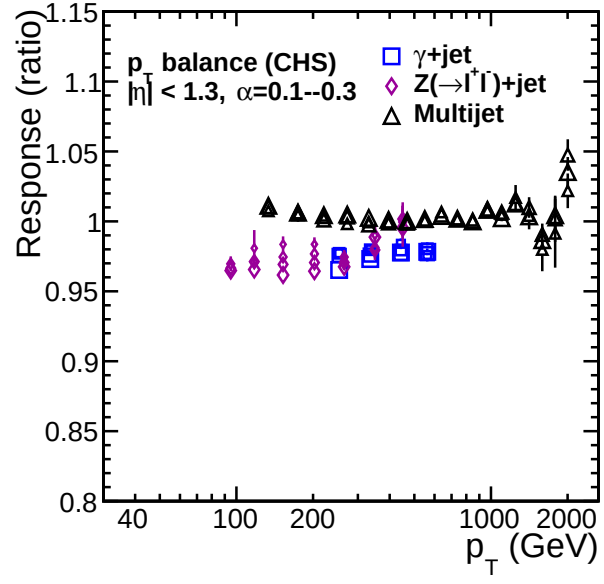

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

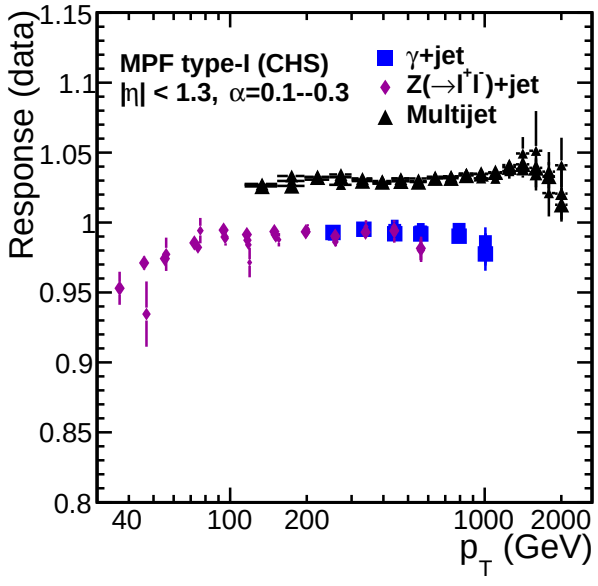

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

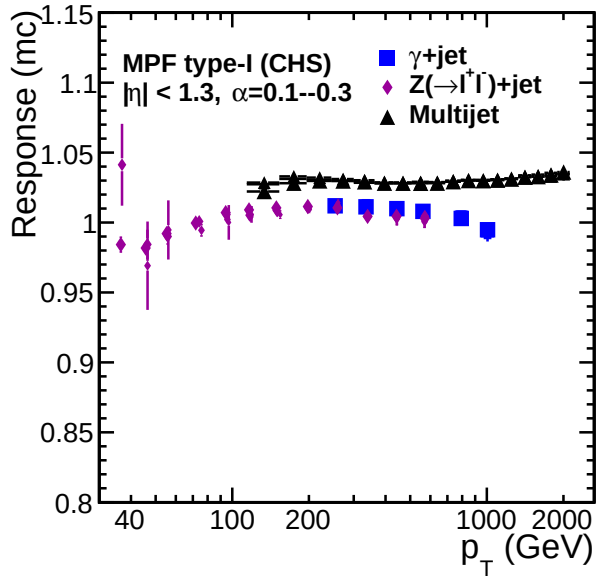

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

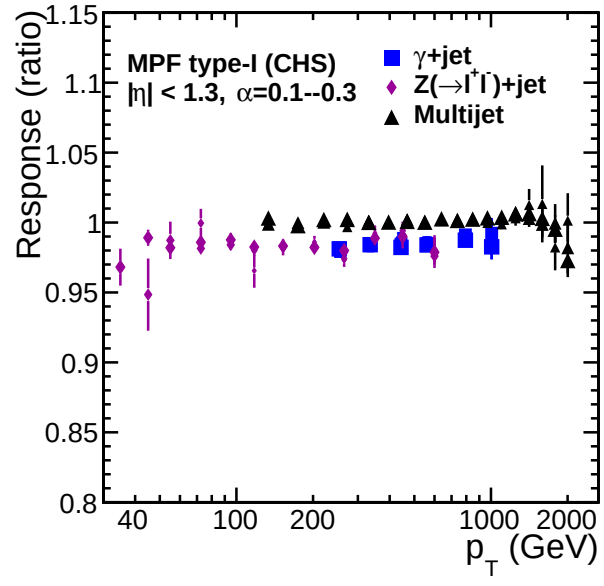

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

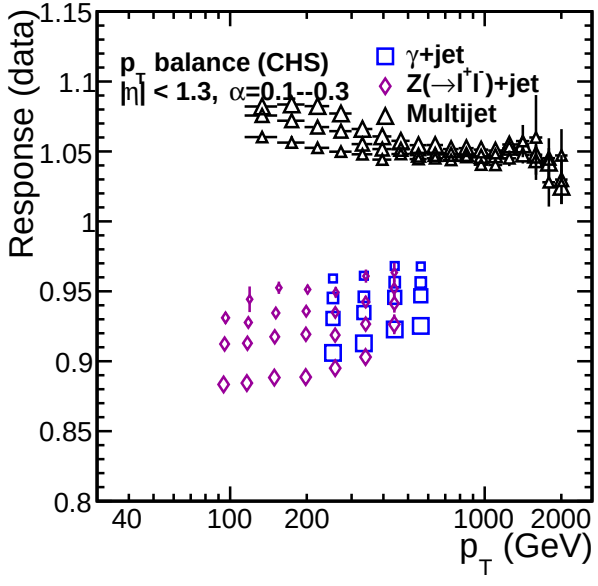

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

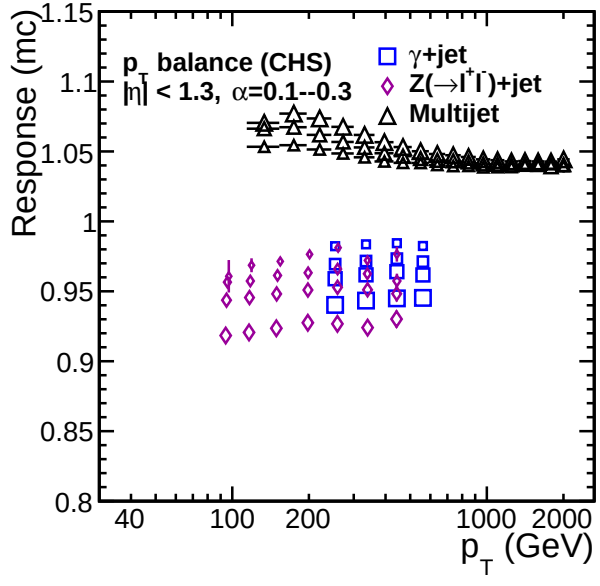

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

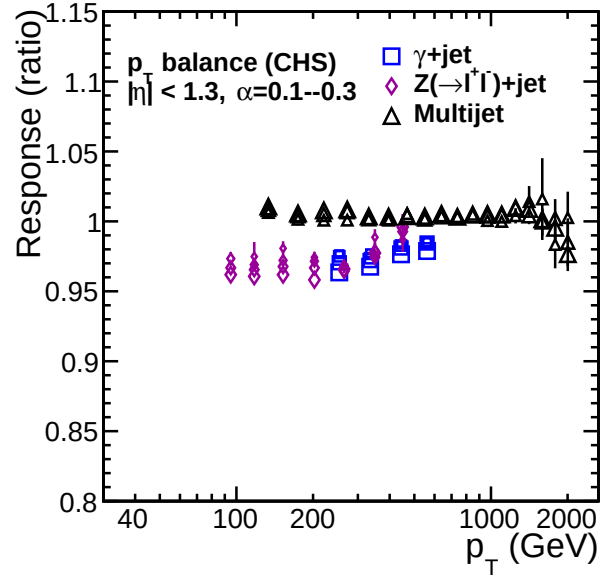

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

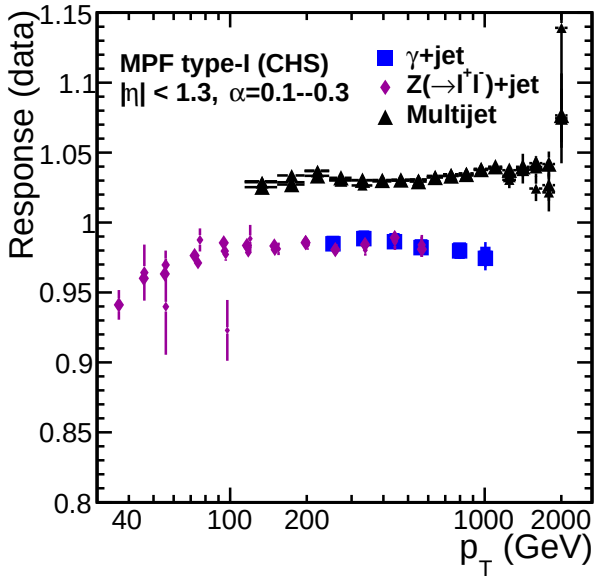

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

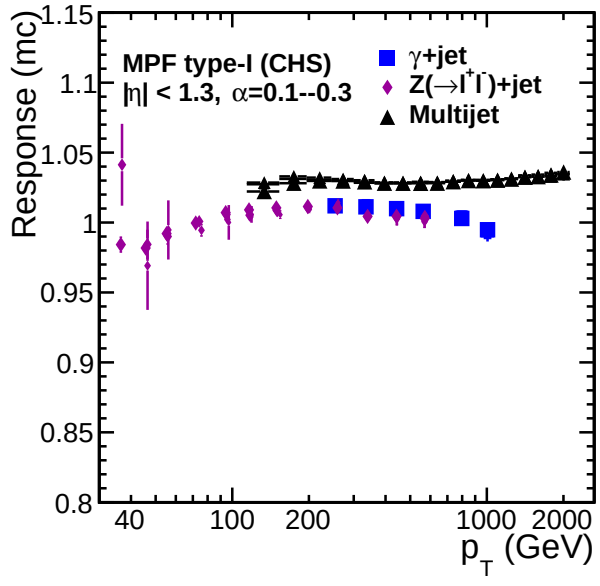

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

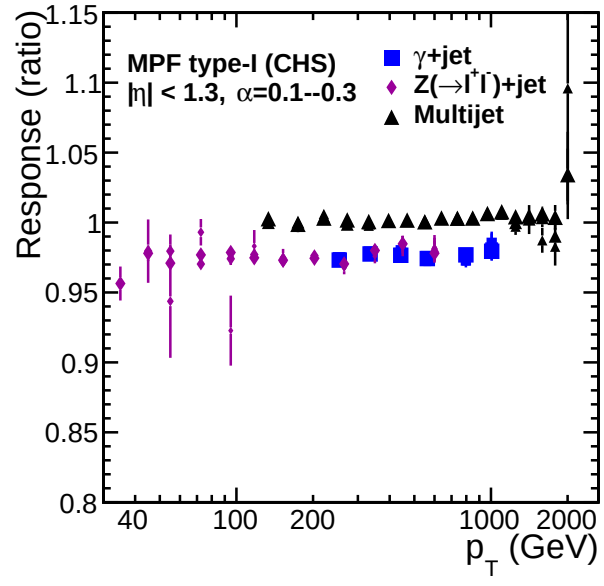

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

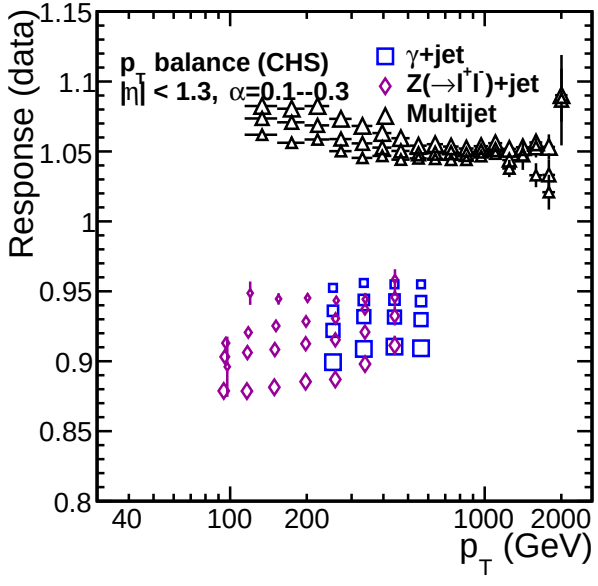

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

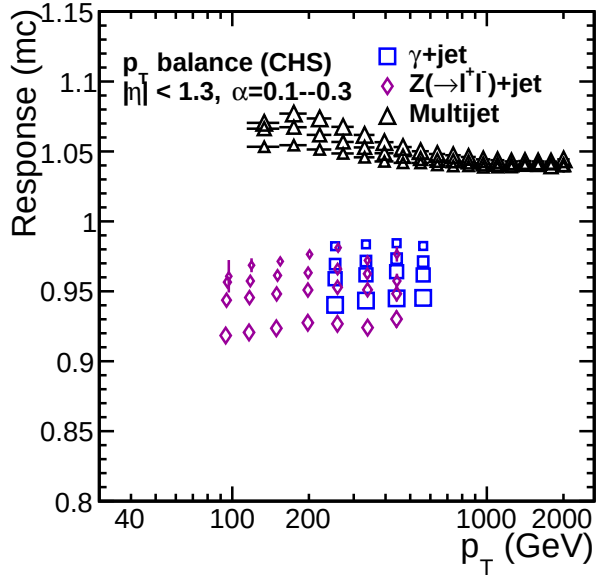

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

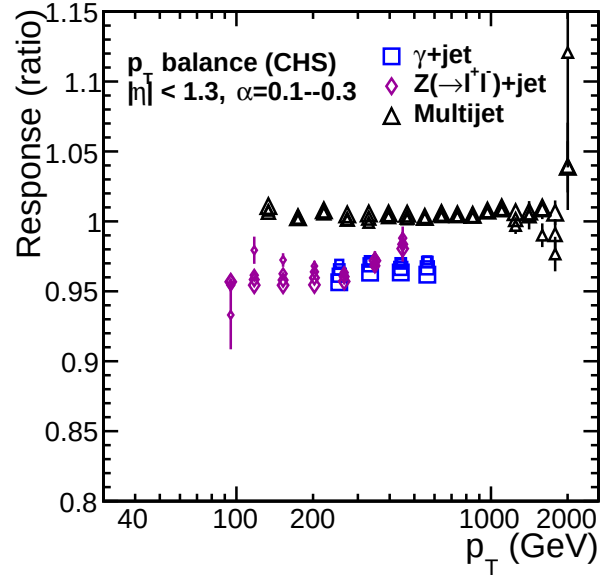

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

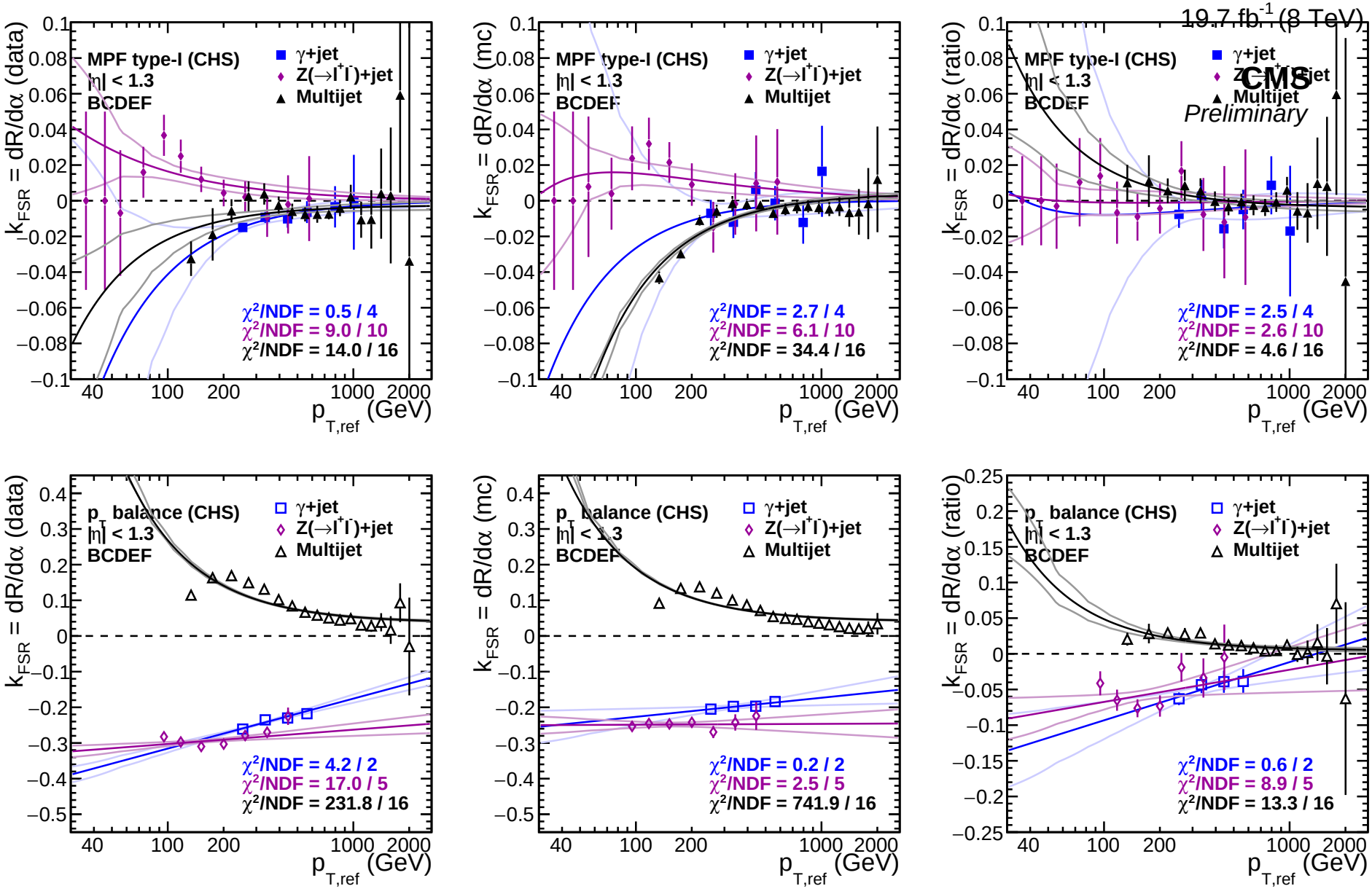

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

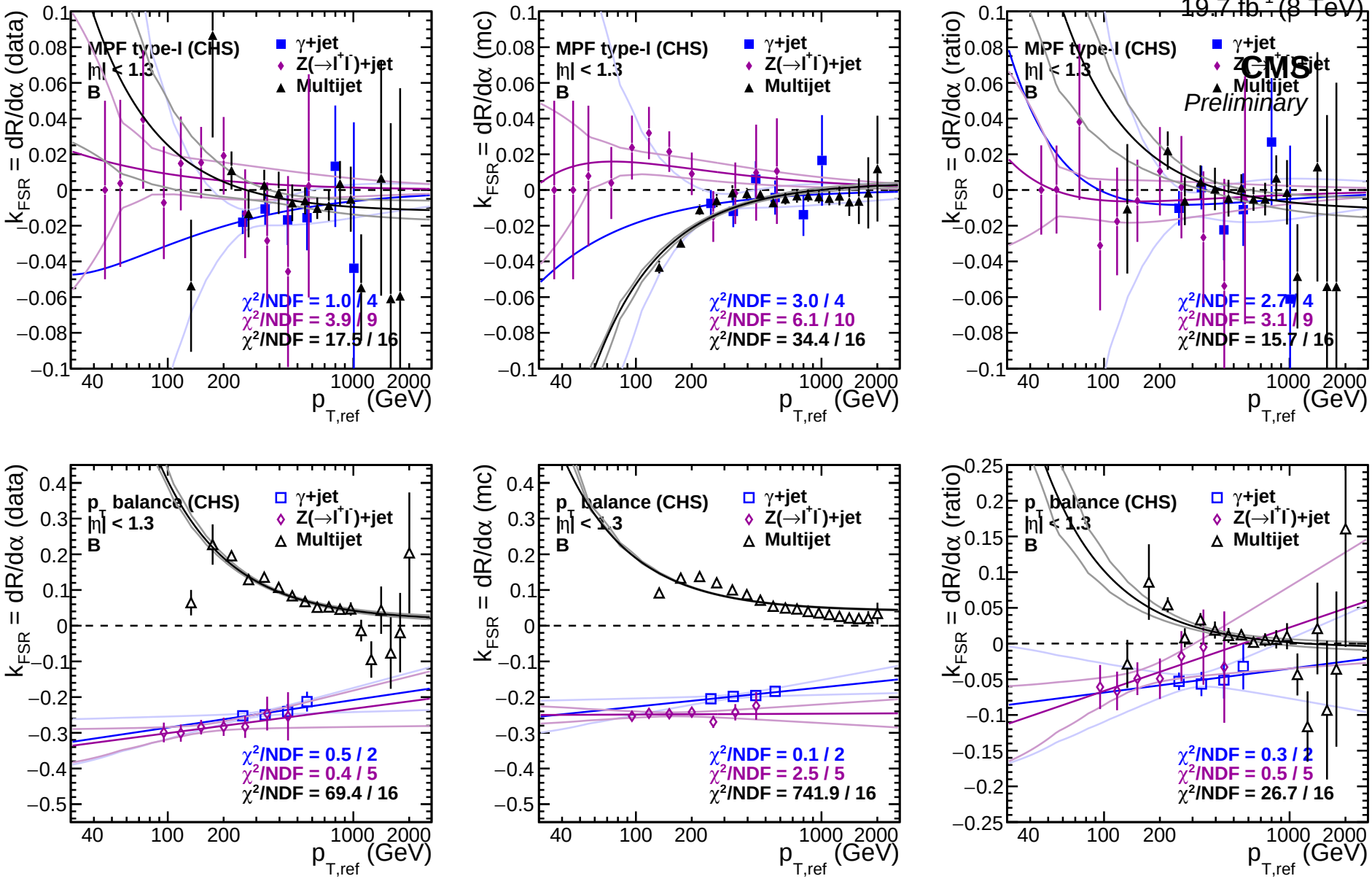

MPF type-I (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

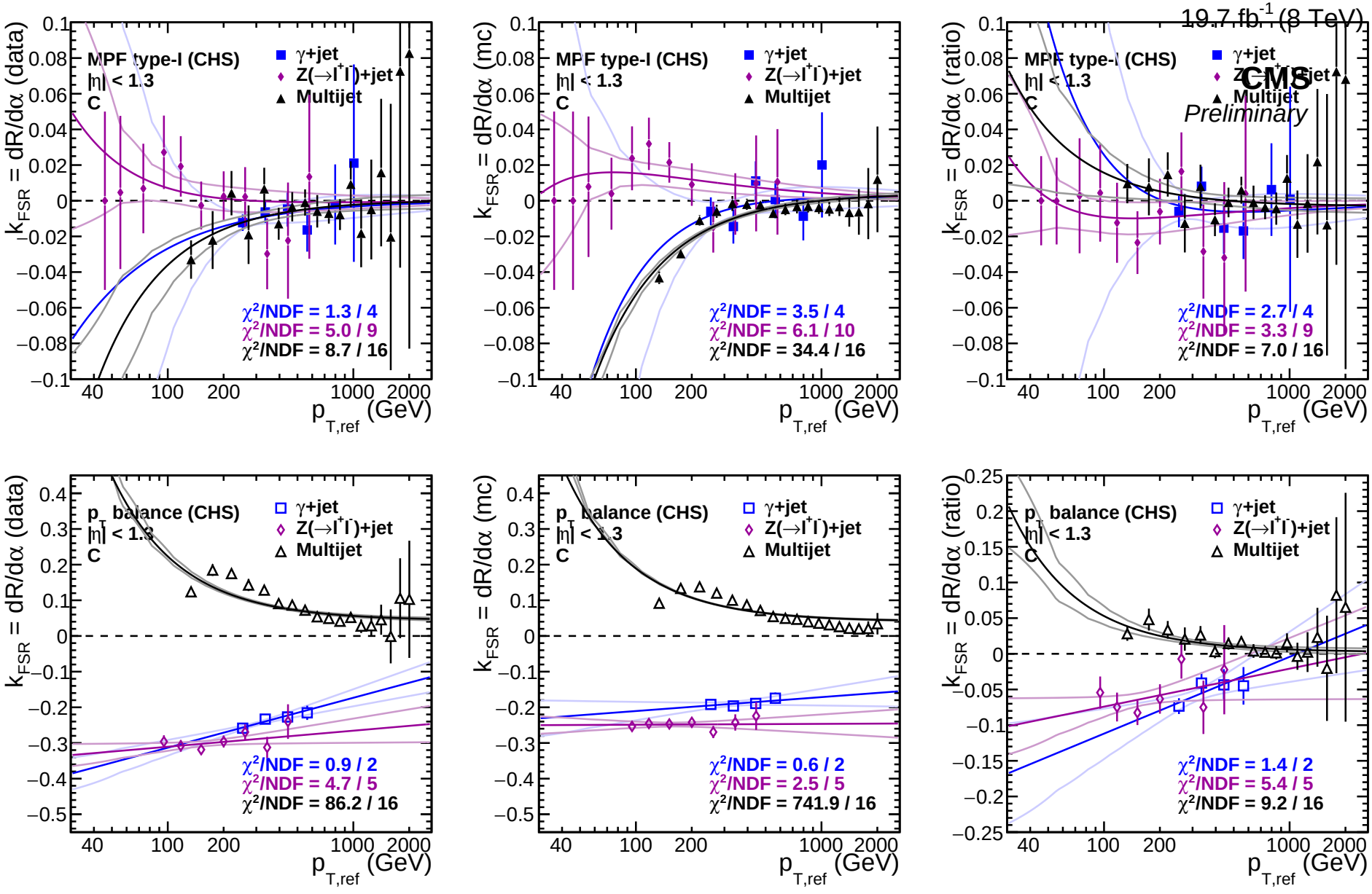

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (data)
p_T (GeV)

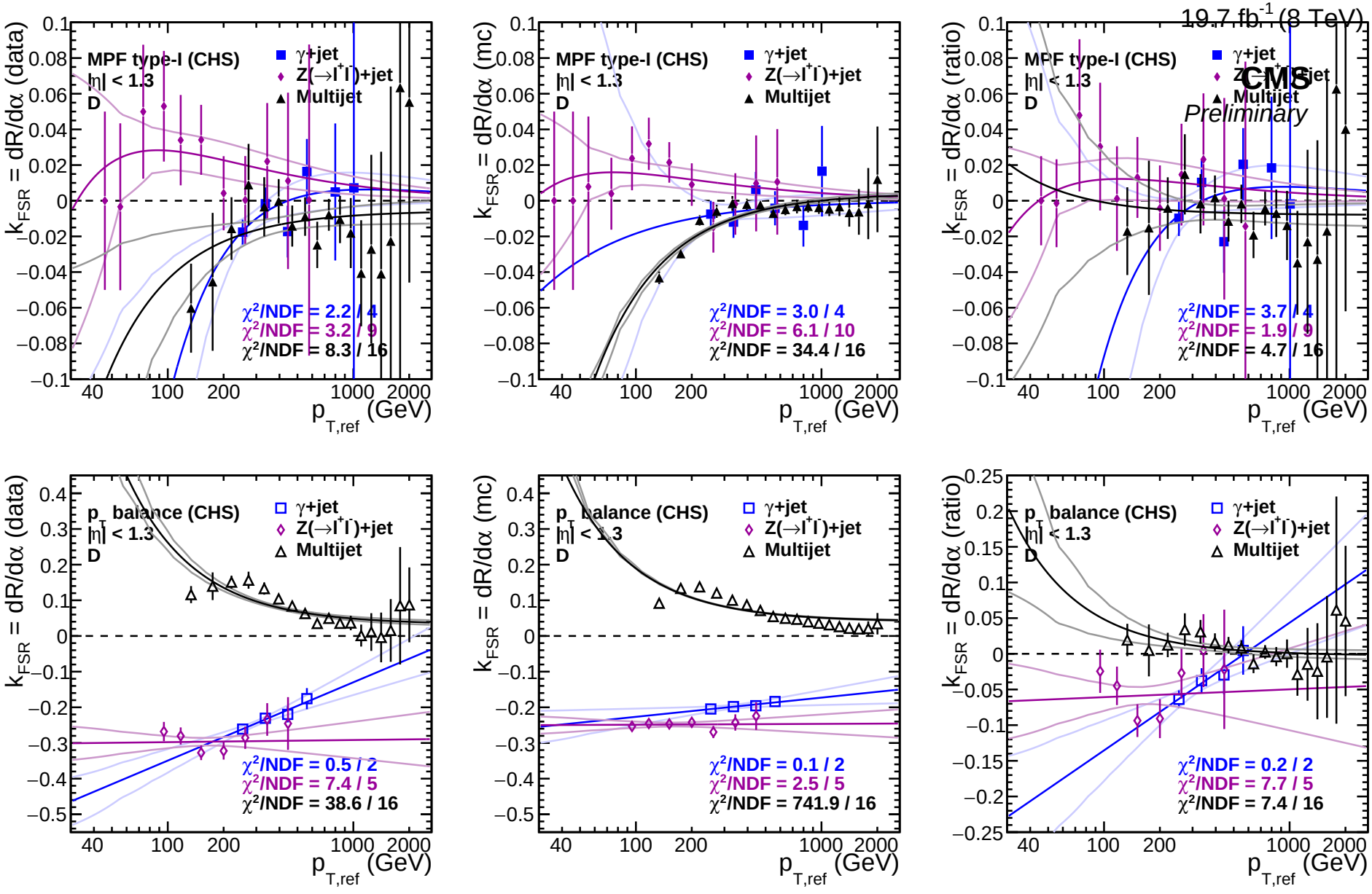

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (mc)
p_T (GeV)

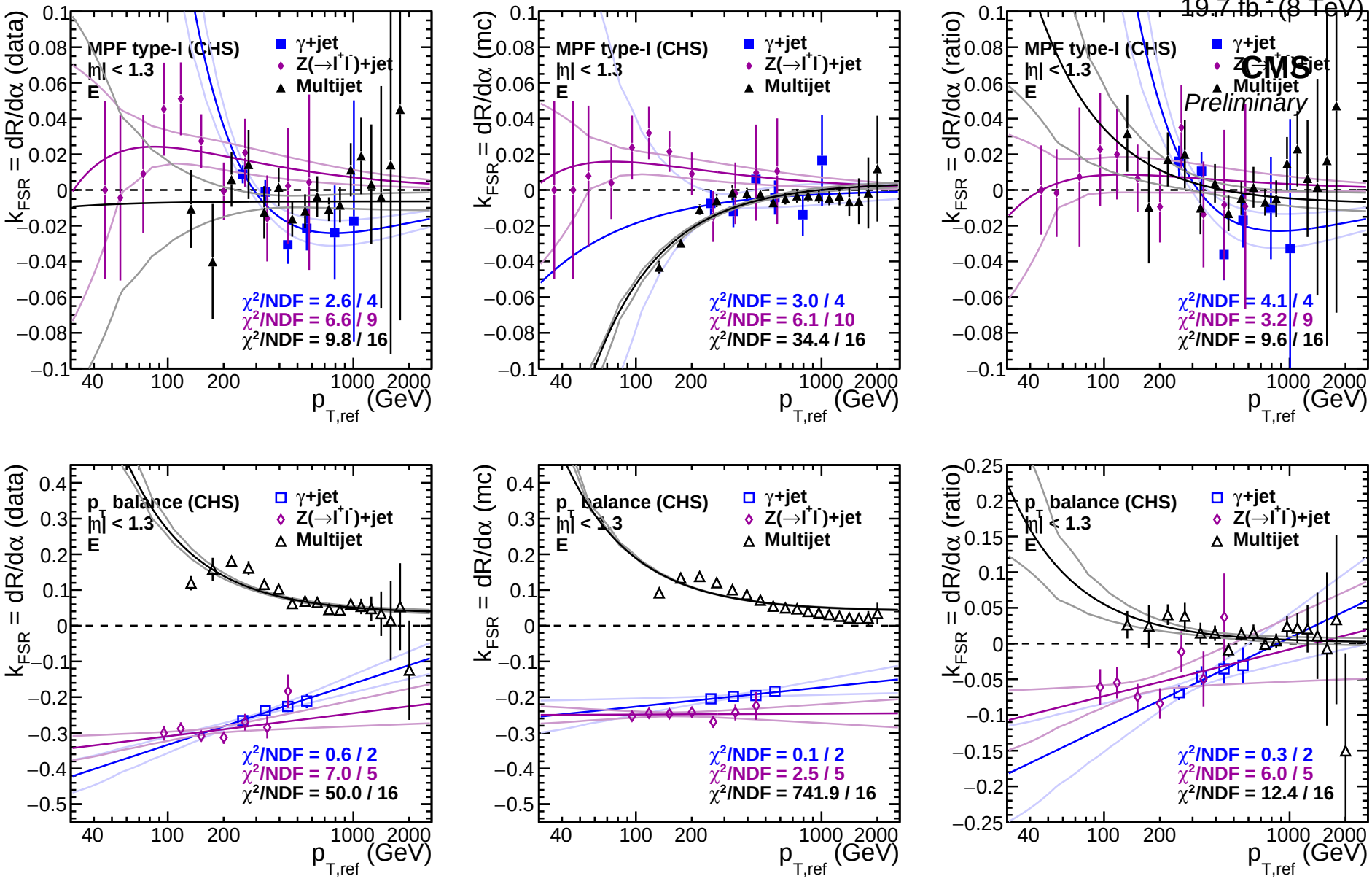

p_T balance (CHS)
|η| < 1.3, α=0.1--0.3
γ+jet
Z(→l+l-)+jet
Multijet
Response (ratio)
p_T (GeV)

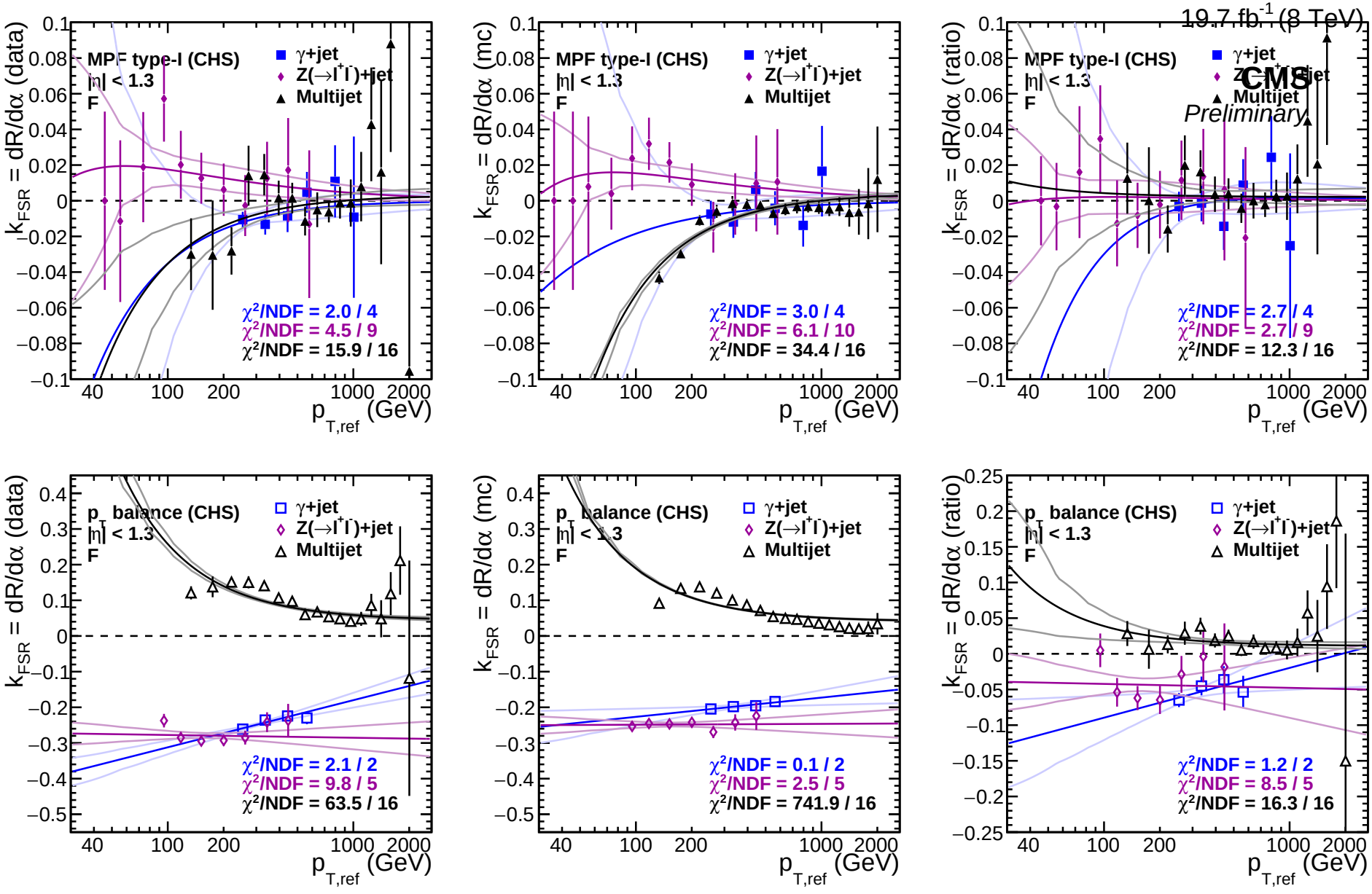

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
BCDEF
γ+jet
Z(→l+l-)+jet
Multijet
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
pT,ref (GeV)
χ2/NDF = 0.5 / 4
χ2/NDF = 9.0 / 10
χ2/NDF = 14.0 / 16
χ2/NDF = 2.7 / 4
χ2/NDF = 6.1 / 10
χ2/NDF = 34.4 / 16
χ2/NDF = 2.5 / 4
χ2/NDF = 2.6 / 10
χ2/NDF = 4.6 / 16
pT balance (CHS)
χ2/NDF = 4.2 / 2
χ2/NDF = 17.0 / 5
χ2/NDF = 231.8 / 16
χ2/NDF = 0.2 / 2
χ2/NDF = 2.5 / 5
χ2/NDF = 741.9 / 16
χ2/NDF = 0.6 / 2
χ2/NDF = 8.9 / 5
χ2/NDF = 13.3 / 16

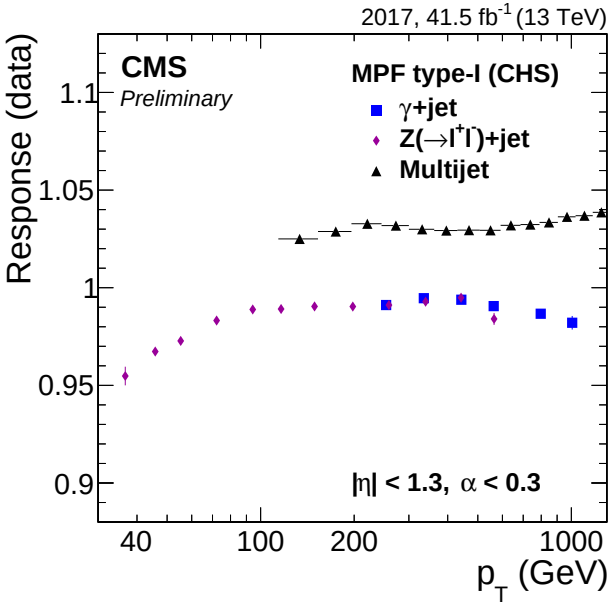

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
B
γ+jet
Z(→l+l-)+jet
Multijet
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
χ2/NDF = 1.0 / 4
χ2/NDF = 3.9 / 9
χ2/NDF = 17.5 / 16
χ2/NDF = 3.0 / 4
χ2/NDF = 6.1 / 10
χ2/NDF = 34.4 / 16
χ2/NDF = 2.7 / 4
χ2/NDF = 3.1 / 9
χ2/NDF = 15.7 / 16
pT balance (CHS)
|η| < 1.3
B
γ+jet
Z(→l+l-)+jet
Multijet
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
χ2/NDF = 0.5 / 2
χ2/NDF = 0.4 / 5
χ2/NDF = 69.4 / 16
χ2/NDF = 0.1 / 2
χ2/NDF = 2.5 / 5
χ2/NDF = 741.9 / 16
χ2/NDF = 0.3 / 2
χ2/NDF = 0.5 / 5
χ2/NDF = 26.7 / 16
pT,ref (GeV)

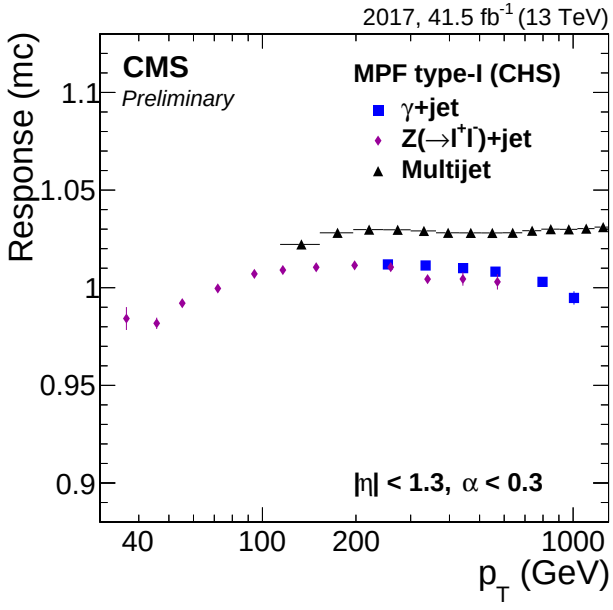

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
C
γ+jet
Z(→l+l−)+jet
Multijet
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
χ2/NDF = 1.3 / 4
χ2/NDF = 5.0 / 9
χ2/NDF = 8.7 / 16
χ2/NDF = 3.5 / 4
χ2/NDF = 6.1 / 10
χ2/NDF = 34.4 / 16
χ2/NDF = 2.7 / 4
χ2/NDF = 3.3 / 9
χ2/NDF = 7.0 / 16
pT balance (CHS)
χ2/NDF = 0.9 / 2
χ2/NDF = 4.7 / 5
χ2/NDF = 86.2 / 16
χ2/NDF = 0.6 / 2
χ2/NDF = 2.5 / 5
χ2/NDF = 741.9 / 16
χ2/NDF = 1.4 / 2
χ2/NDF = 5.4 / 5
χ2/NDF = 9.2 / 16
pT,ref (GeV)

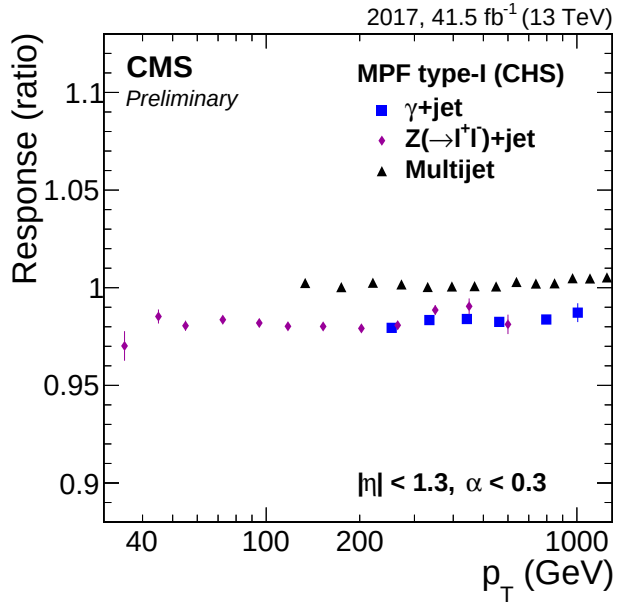

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
D
γ+jet
Z(→l+l-)+jet
Multijet
χ2/NDF = 2.2 / 4
χ2/NDF = 3.2 / 9
χ2/NDF = 8.3 / 16
χ2/NDF = 3.0 / 4
χ2/NDF = 6.1 / 10
χ2/NDF = 34.4 / 16
χ2/NDF = 3.7 / 4
χ2/NDF = 1.9 / 9
χ2/NDF = 4.7 / 16
pT balance (CHS)
χ2/NDF = 0.5 / 2
χ2/NDF = 7.4 / 5
χ2/NDF = 38.6 / 16
χ2/NDF = 0.1 / 2
χ2/NDF = 2.5 / 5
χ2/NDF = 741.9 / 16
χ2/NDF = 0.2 / 2
χ2/NDF = 7.7 / 5
χ2/NDF = 7.4 / 16
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
pT,ref (GeV)

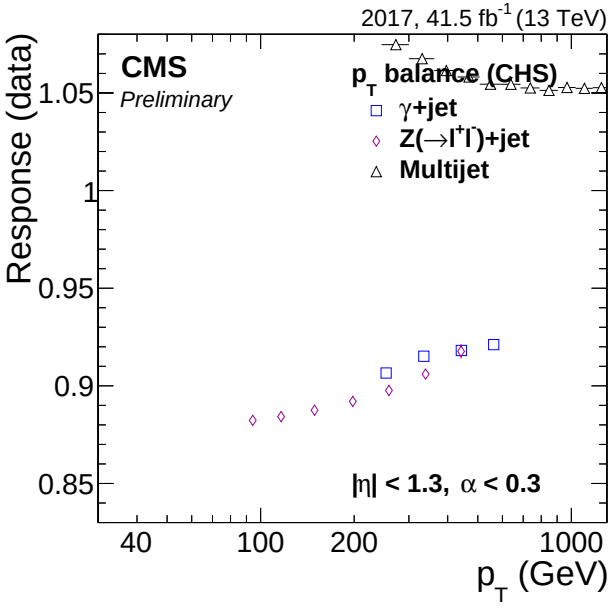

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
E
γ+jet
Z(→l+l-)+jet
Multijet
χ²/NDF = 2.6 / 4
χ²/NDF = 6.6 / 9
χ²/NDF = 9.8 / 16
χ²/NDF = 3.0 / 4
χ²/NDF = 6.1 / 10
χ²/NDF = 34.4 / 16
χ²/NDF = 4.1 / 4
χ²/NDF = 3.2 / 9
χ²/NDF = 9.6 / 16
pT balance (CHS)
χ²/NDF = 0.6 / 2
χ²/NDF = 7.0 / 5
χ²/NDF = 50.0 / 16
χ²/NDF = 0.1 / 2
χ²/NDF = 2.5 / 5
χ²/NDF = 741.9 / 16
χ²/NDF = 0.3 / 2
χ²/NDF = 6.0 / 5
χ²/NDF = 12.4 / 16
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
pT,ref (GeV)

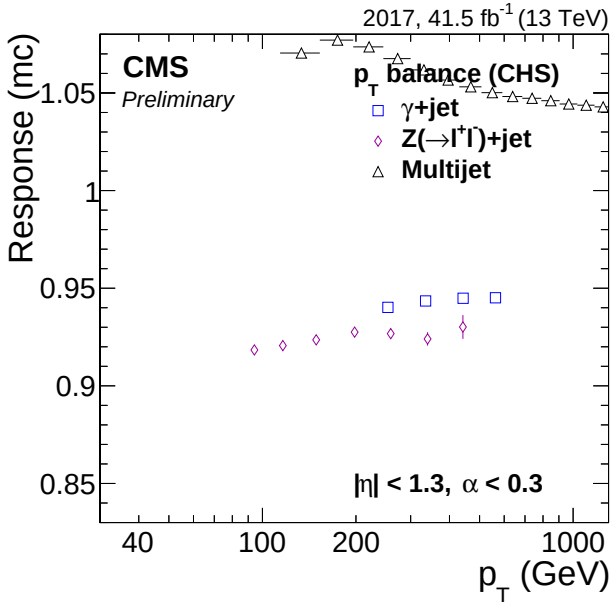

19.7 fb-1 (8 TeV)
CMS
Preliminary
MPF type-I (CHS)
|η| < 1.3
F
γ+jet
Z(→l+l-)+jet
Multijet
χ2/NDF = 2.0 / 4
χ2/NDF = 4.5 / 9
χ2/NDF = 15.9 / 16
χ2/NDF = 3.0 / 4
χ2/NDF = 6.1 / 10
χ2/NDF = 34.4 / 16
χ2/NDF = 2.7 / 4
χ2/NDF = 2.7 / 9
χ2/NDF = 12.3 / 16
pT balance (CHS)
χ2/NDF = 2.1 / 2
χ2/NDF = 9.8 / 5
χ2/NDF = 63.5 / 16
χ2/NDF = 0.1 / 2
χ2/NDF = 2.5 / 5
χ2/NDF = 741.9 / 16
χ2/NDF = 1.2 / 2
χ2/NDF = 8.5 / 5
χ2/NDF = 16.3 / 16
kFSR = dR/dα (data)
kFSR = dR/dα (mc)
kFSR = dR/dα (ratio)
pT,ref (GeV)

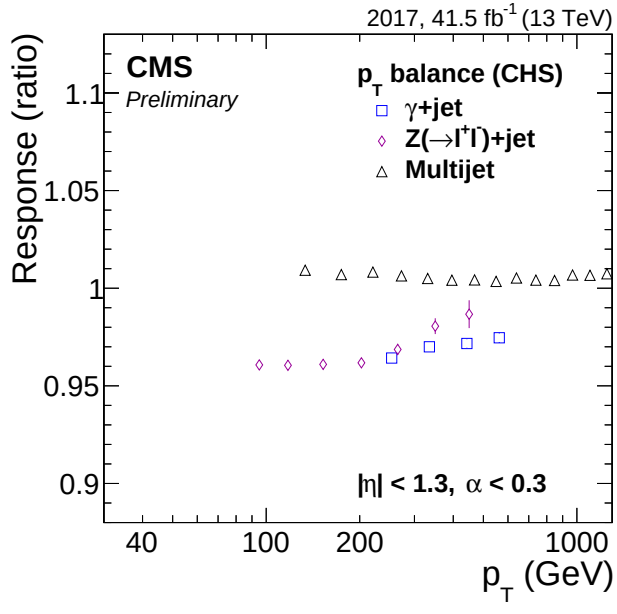

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

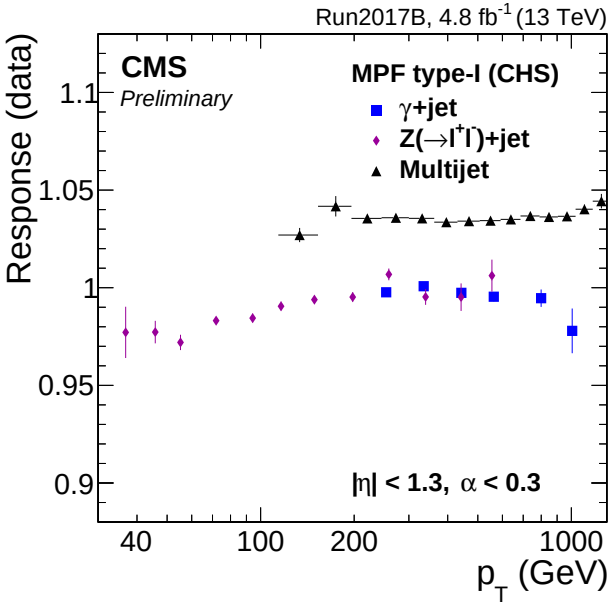

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

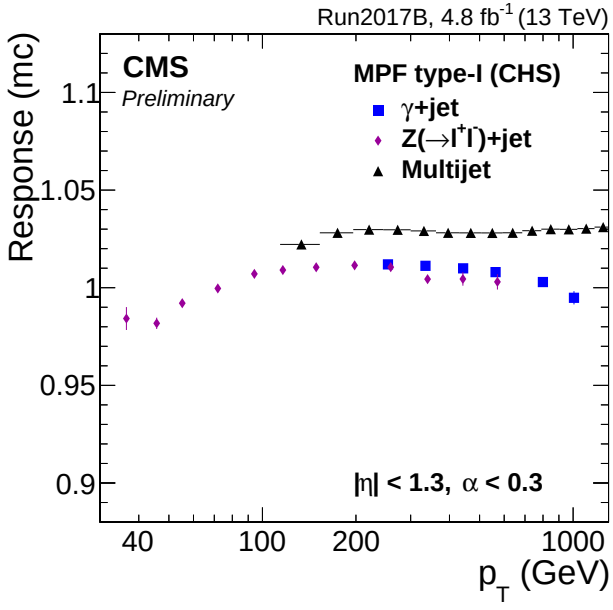

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

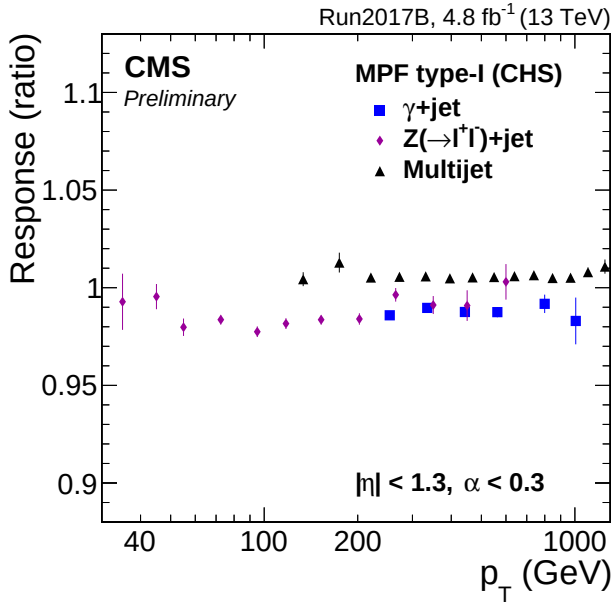

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

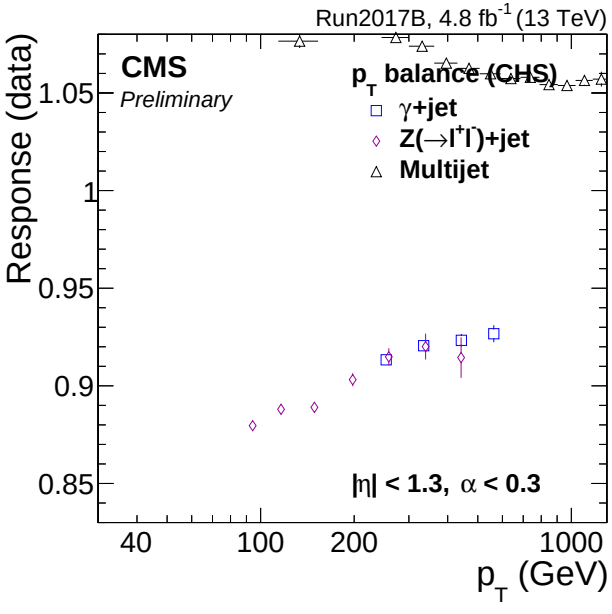

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

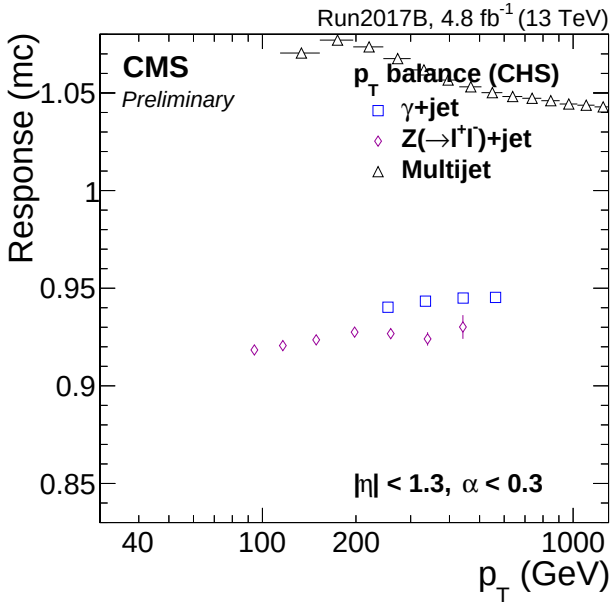

2017, 41.5 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

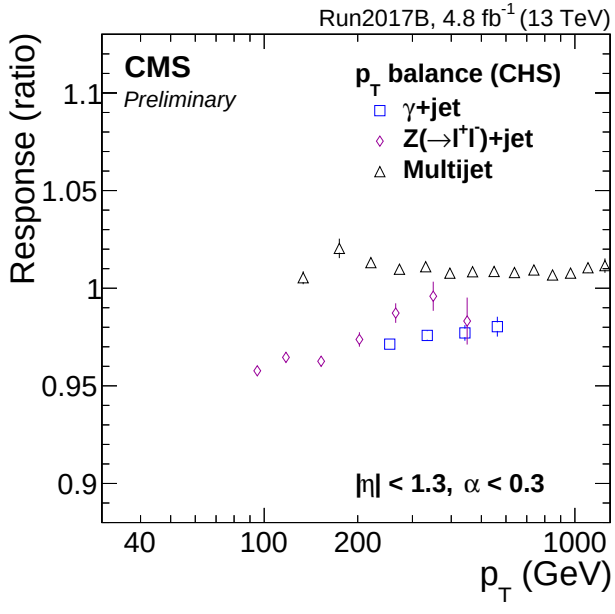

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

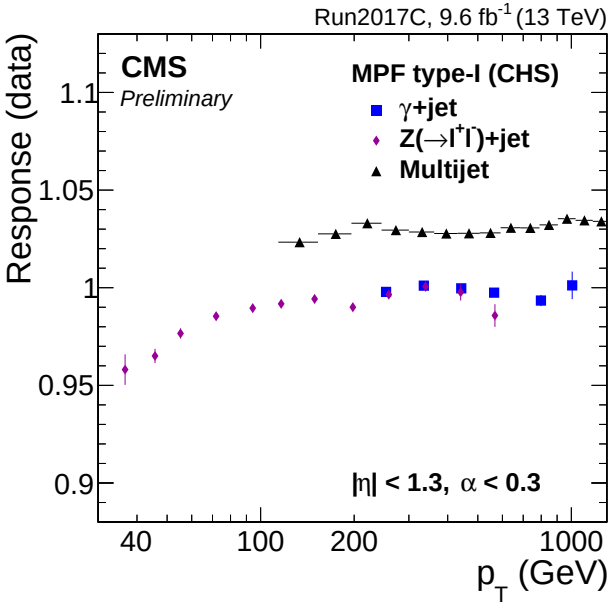

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

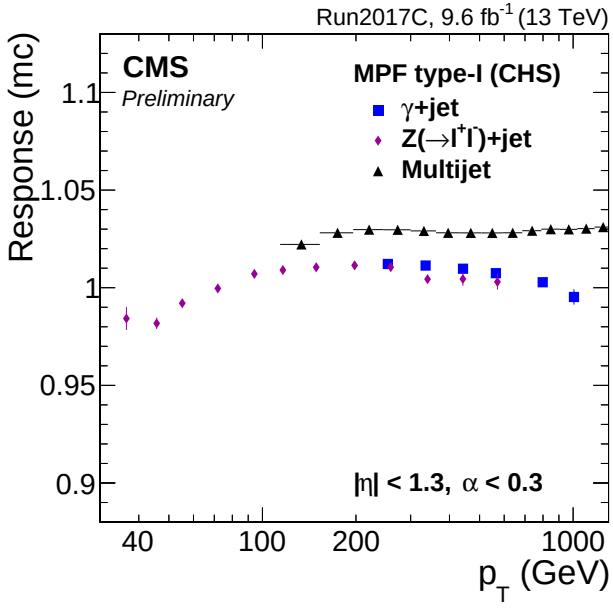

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

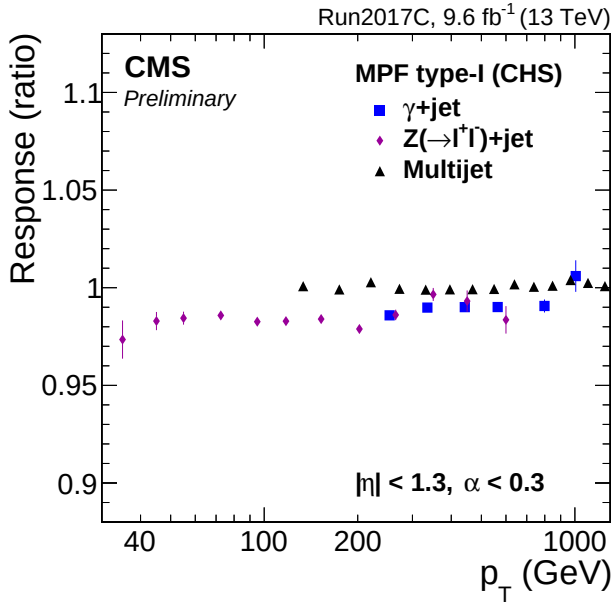

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

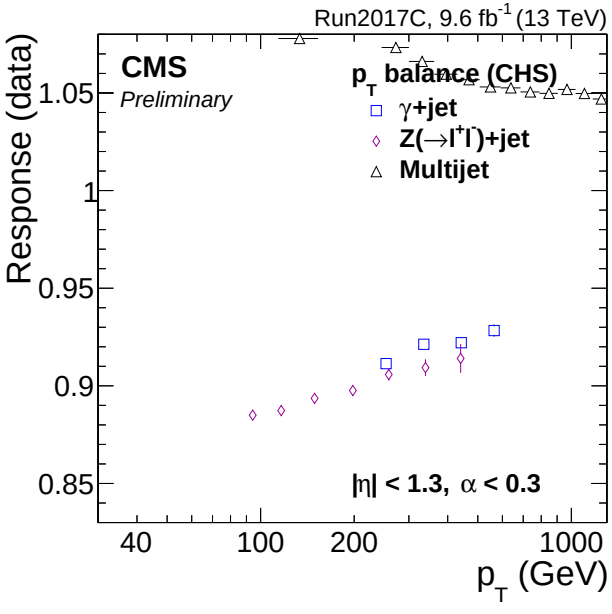

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

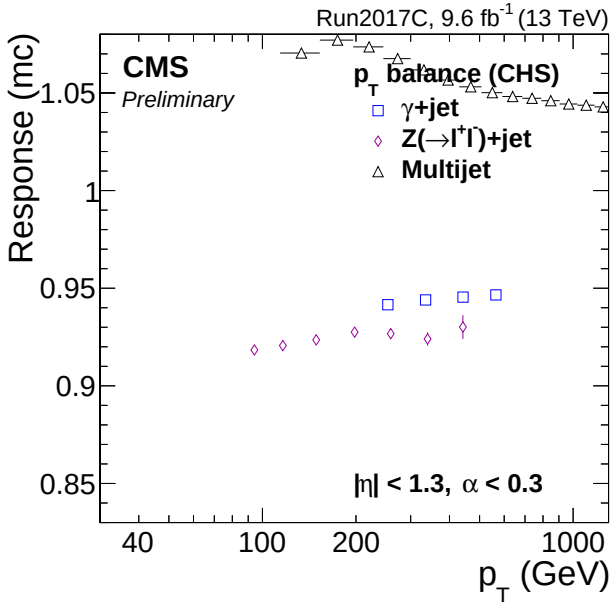

Run2017B, 4.8 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

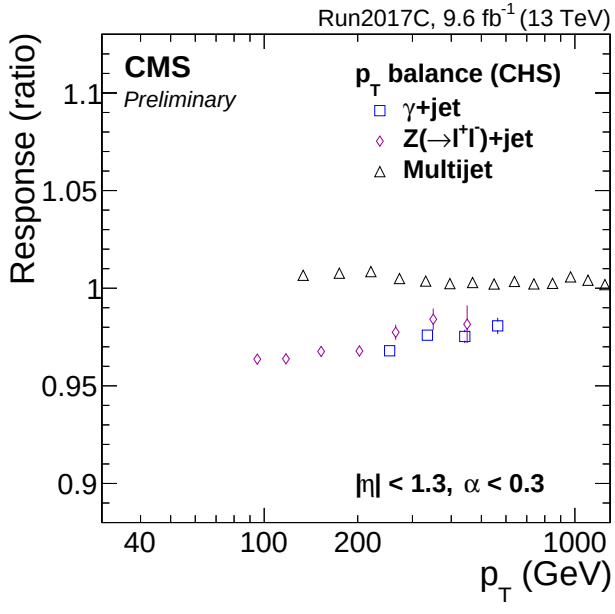

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

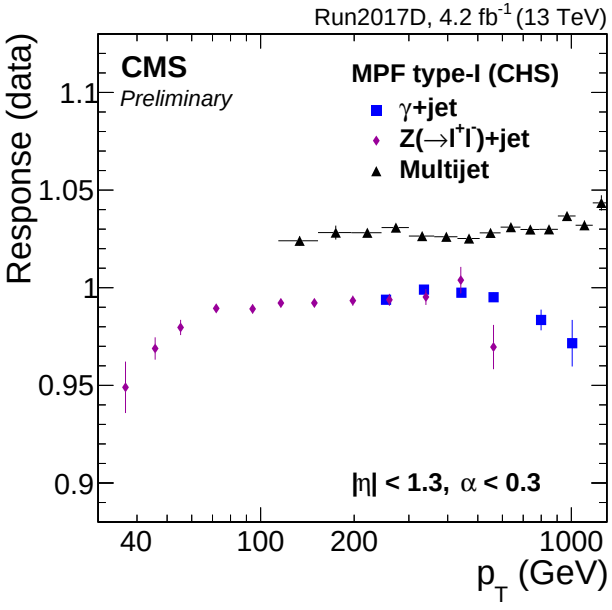

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

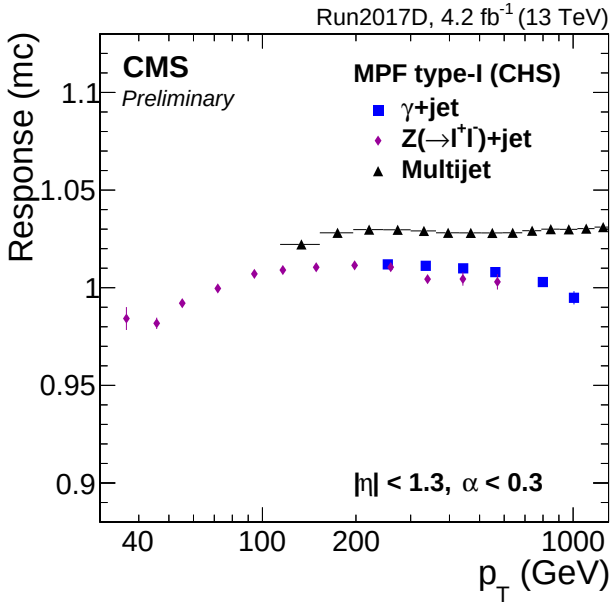

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

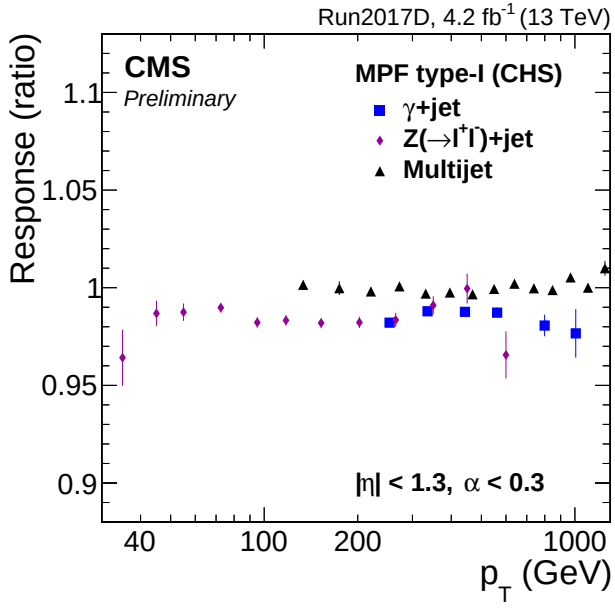

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

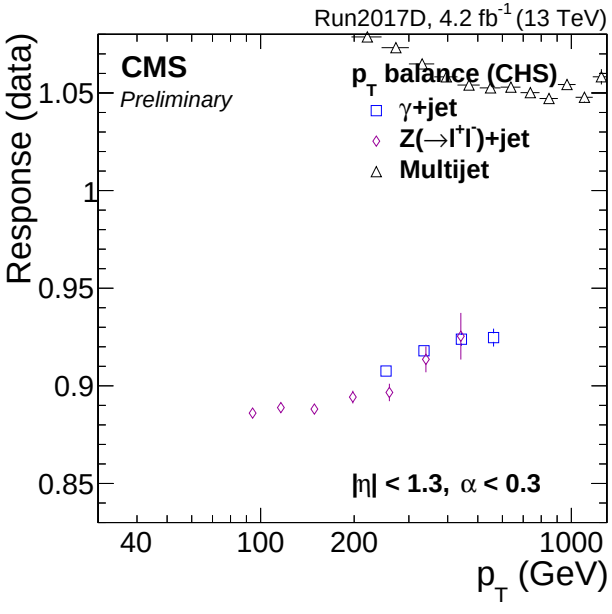

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

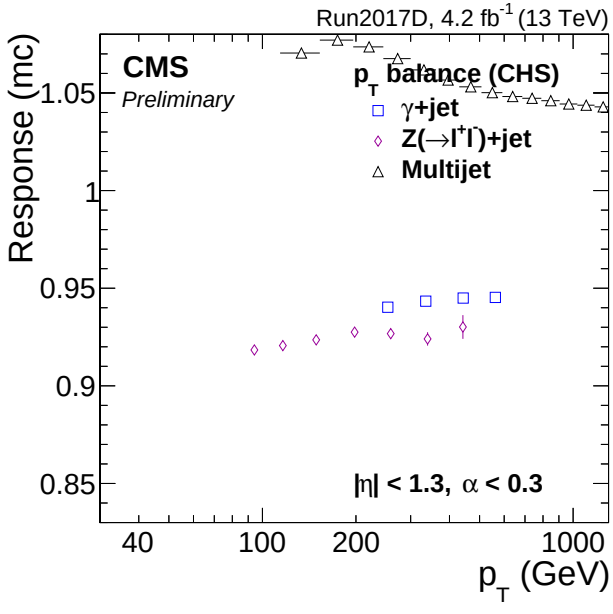

Run2017C, 9.6 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

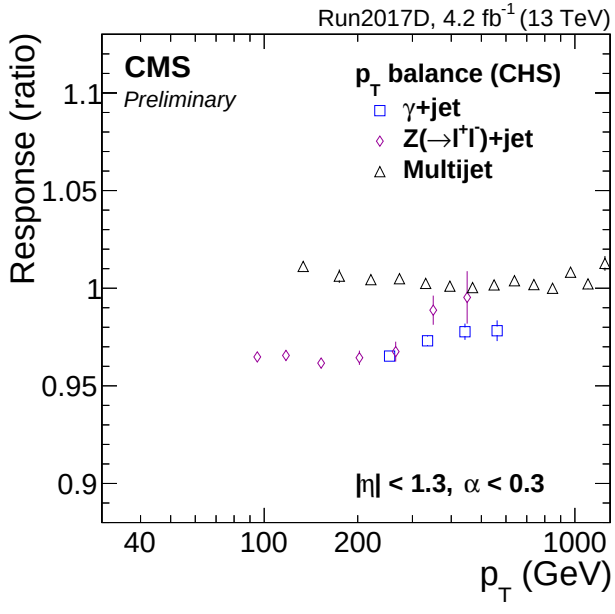

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

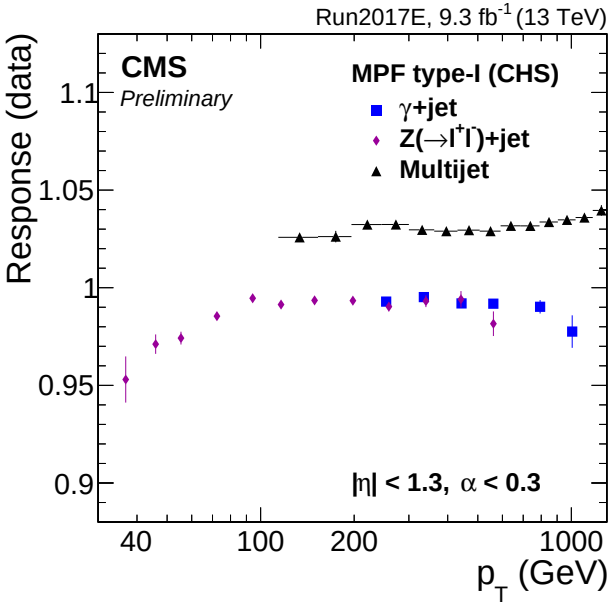

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

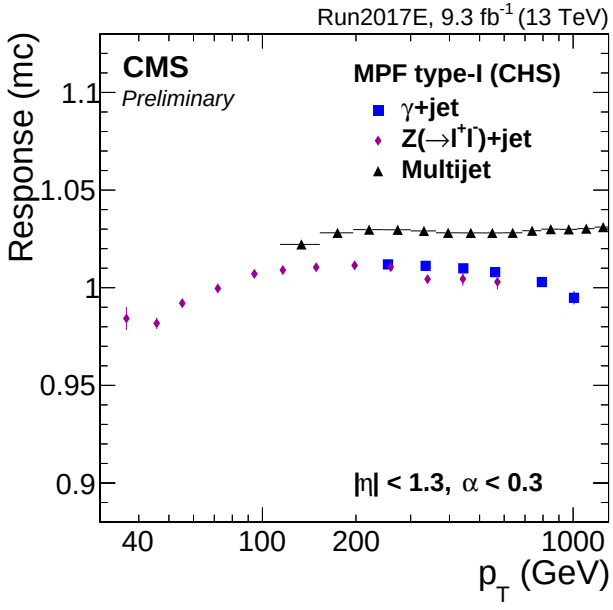

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

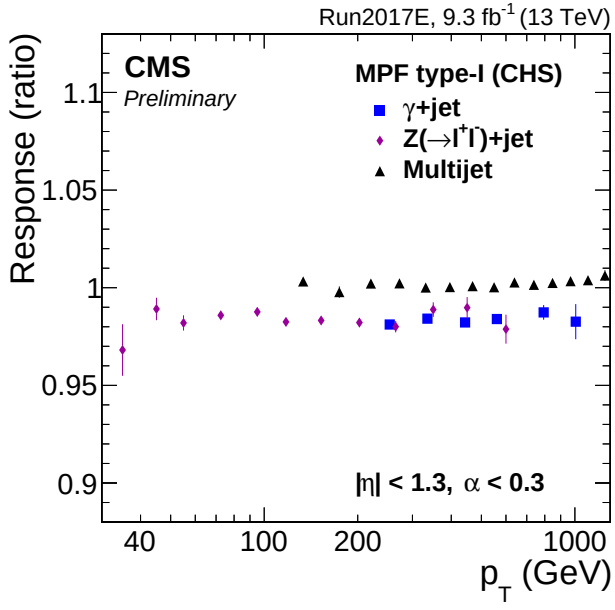

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

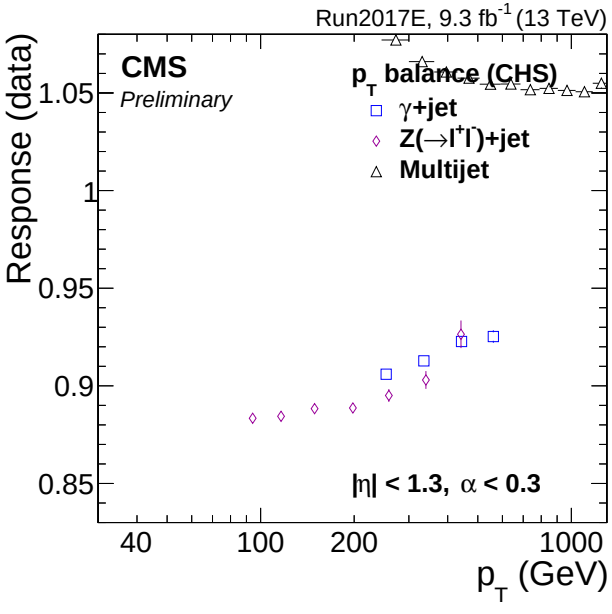

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

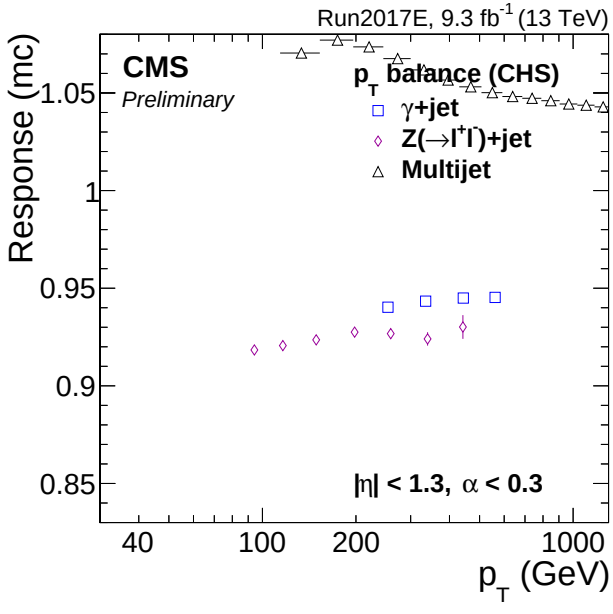

Run2017D, 4.2 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

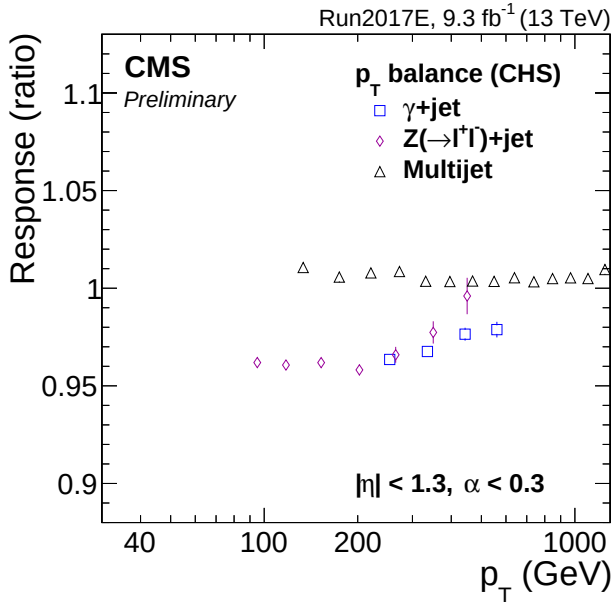

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

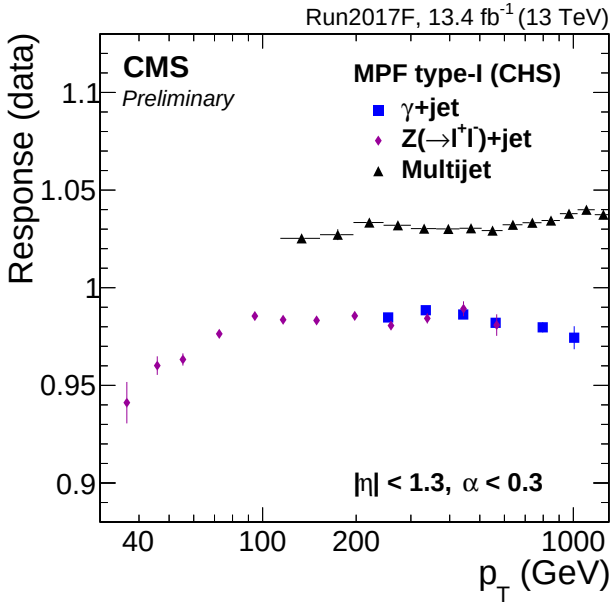

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

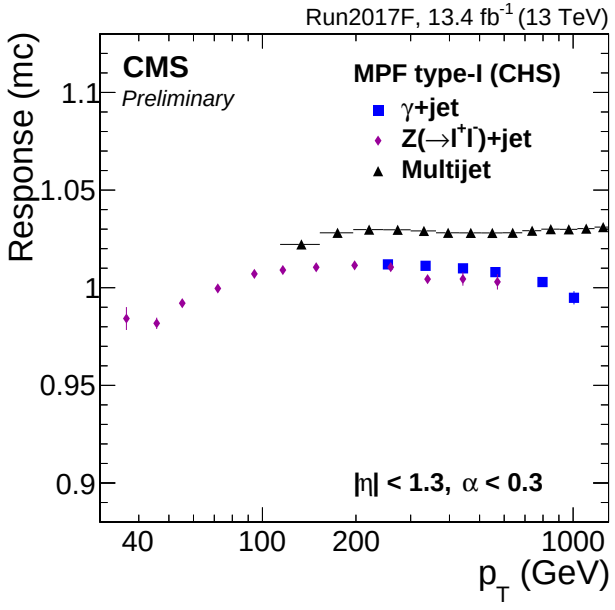

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

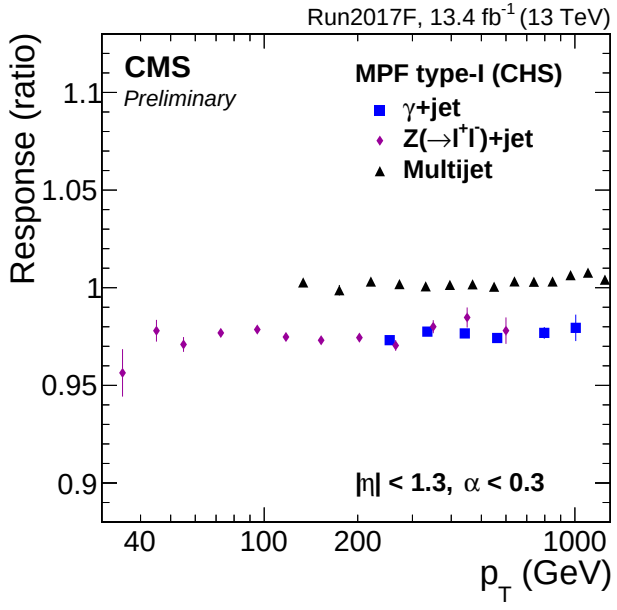

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)

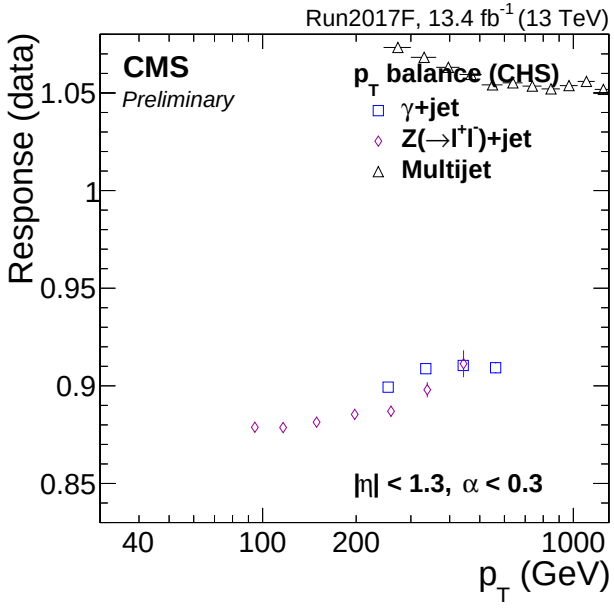

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)

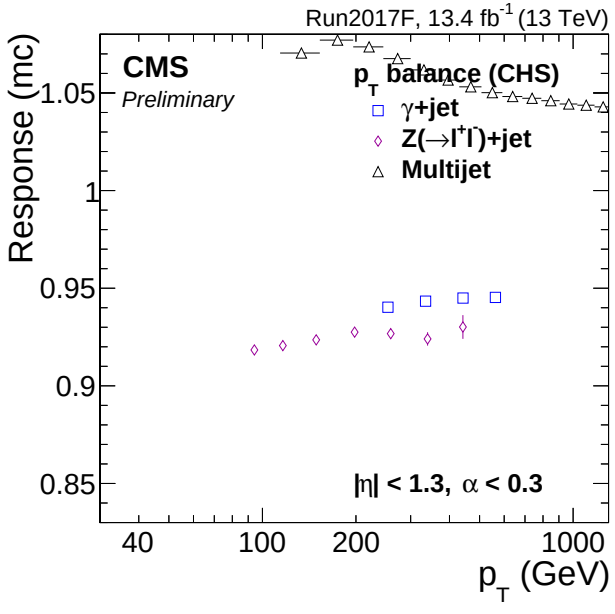

Run2017E, 9.3 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)

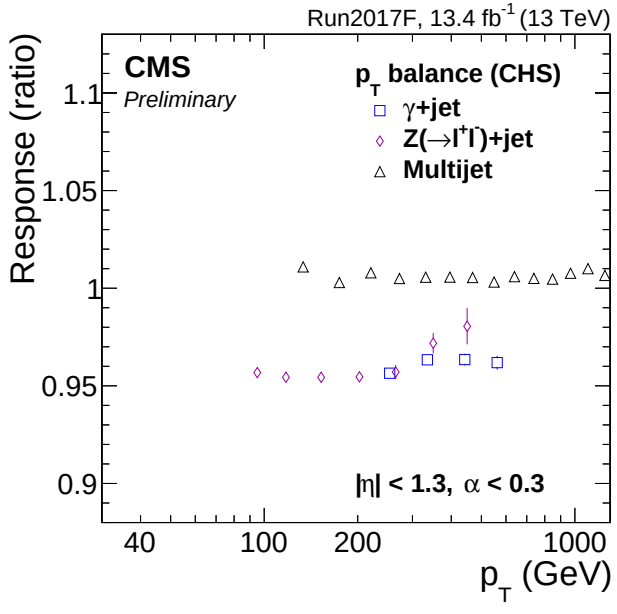

Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)


Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)


Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
MPF type-I (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)


Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (data)
pT (GeV)


Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (mc)
pT (GeV)


Run2017F, 13.4 fb-1 (13 TeV)
CMS
Preliminary
pT balance (CHS)
γ+jet
Z(→l+l-)+jet
Multijet
|η| < 1.3, α < 0.3
Response (ratio)
pT (GeV)