# Physics at the LHC

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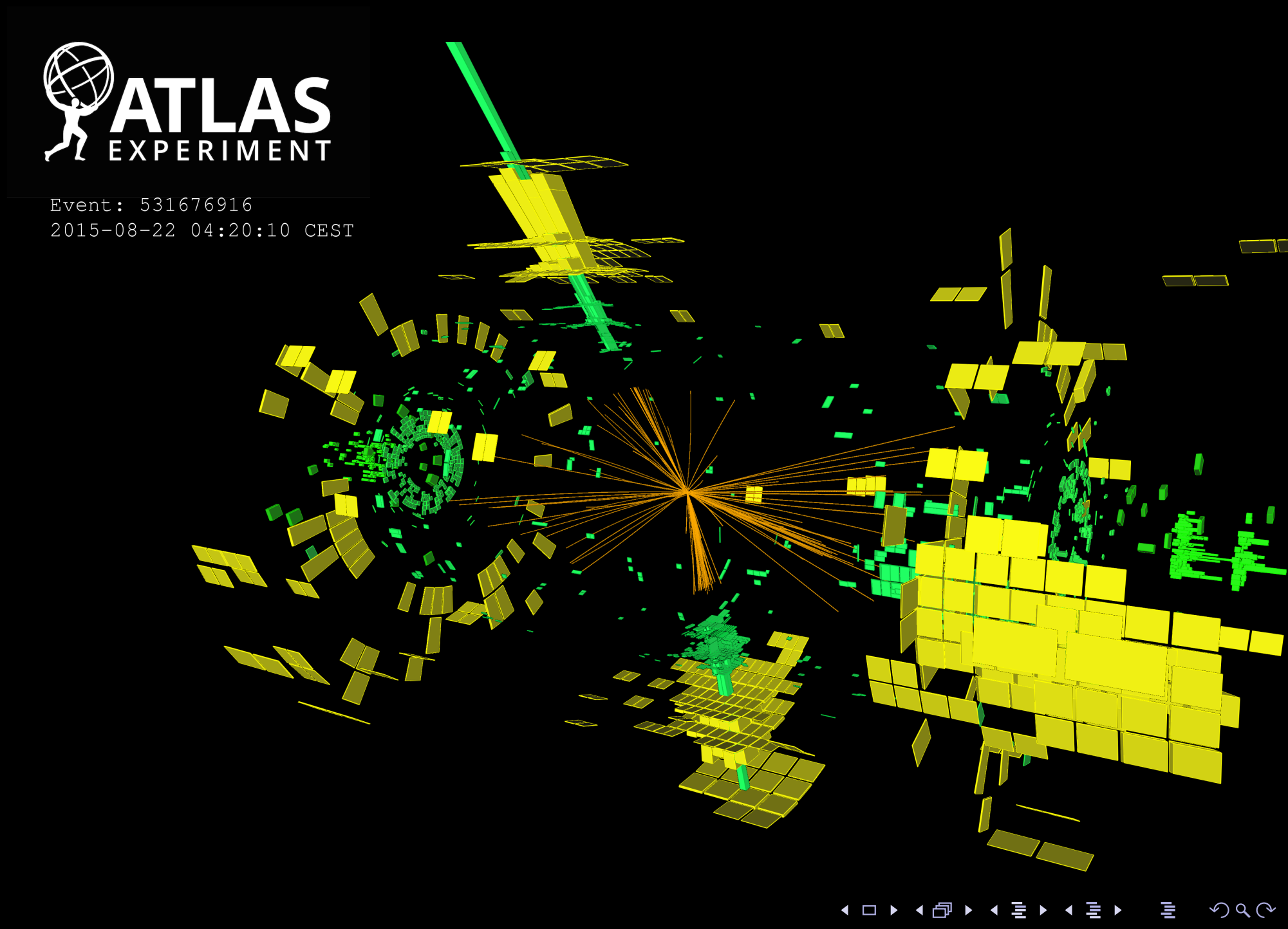
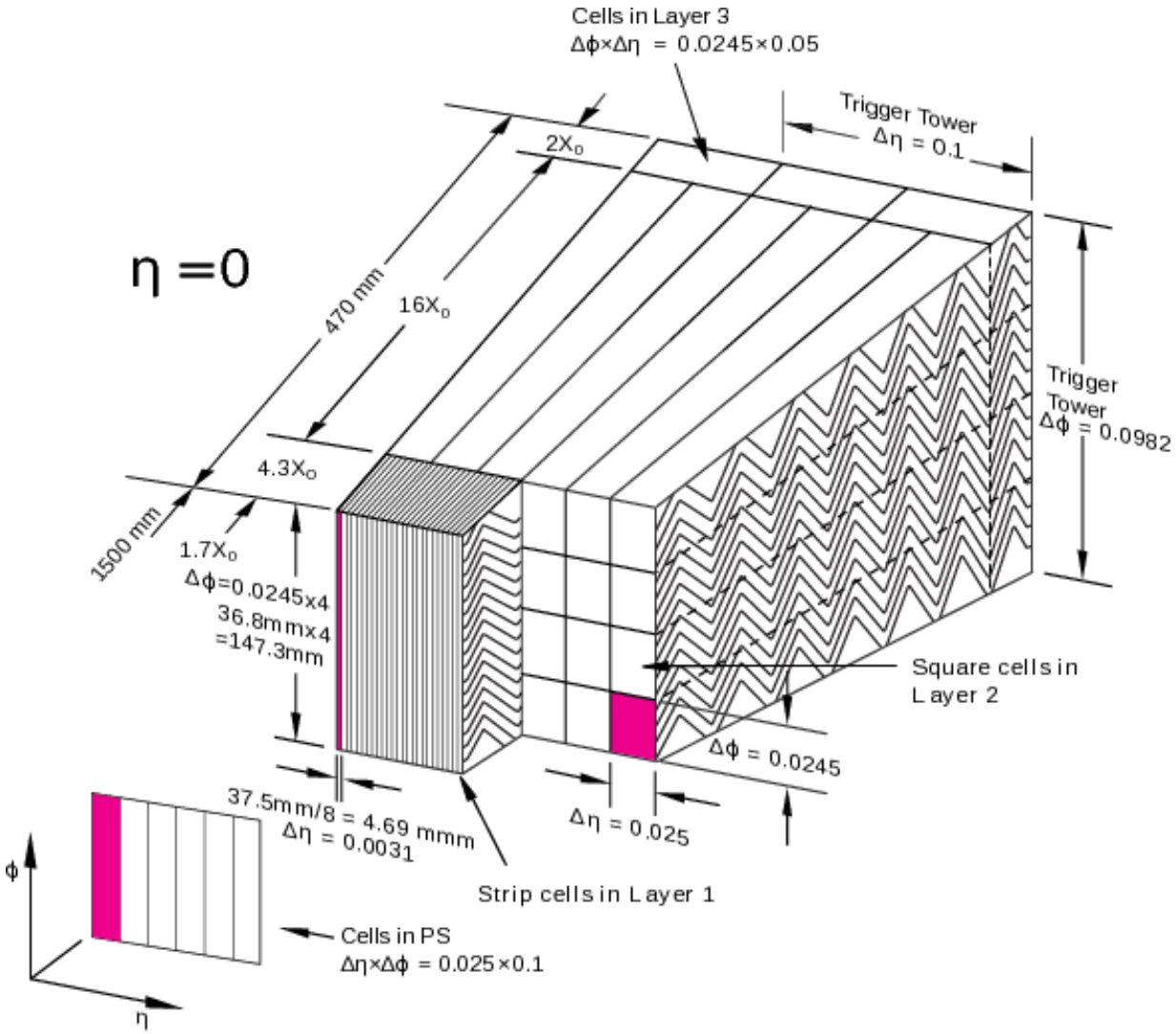
November 26, 2019

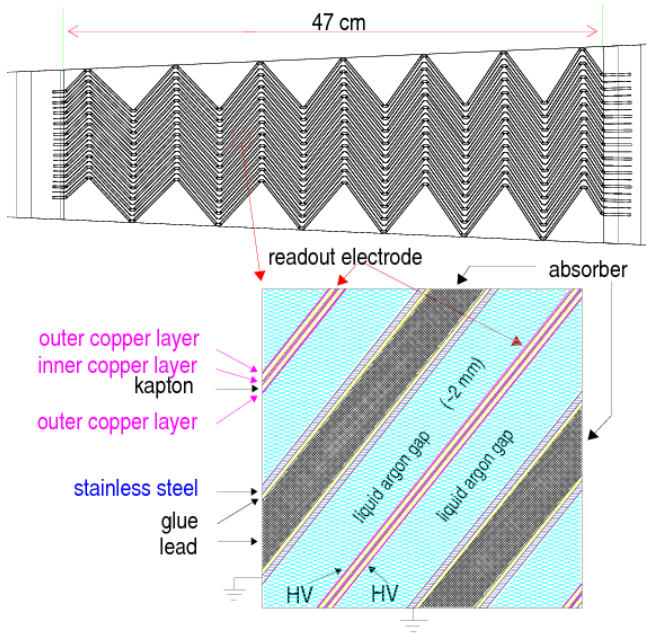

ATLAS
EXPERIMENT
Event: 531676916
2015-08-22 04:20:10 CEST

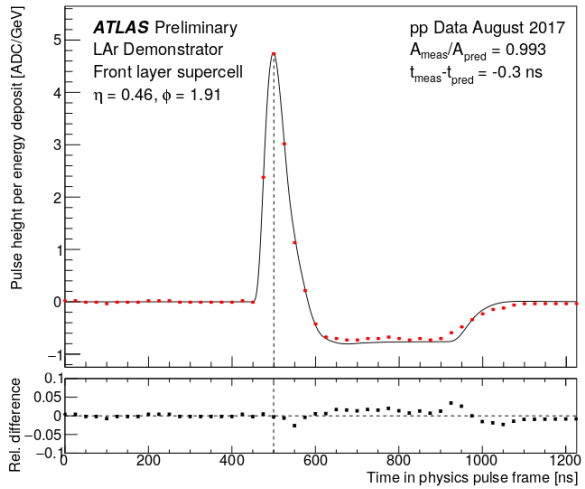
# Outlook

- ATLAS detector
  - Calorimeters : electromagnetic and hadronic
- Jet definition, reconstruction and calibration
  - jet algorithms, infra-red stability, pileup, topo-clusters, jet energy calibration
- Jet cross-section measurements at 13 TeV
  - trigger strategy, event selection, detector effects, theory model, quantitative data to theory comparison
- Searches for a low-mass dijet resonance at 13 TeV
  - trigger strategy, data analysis, fit model, interpretation

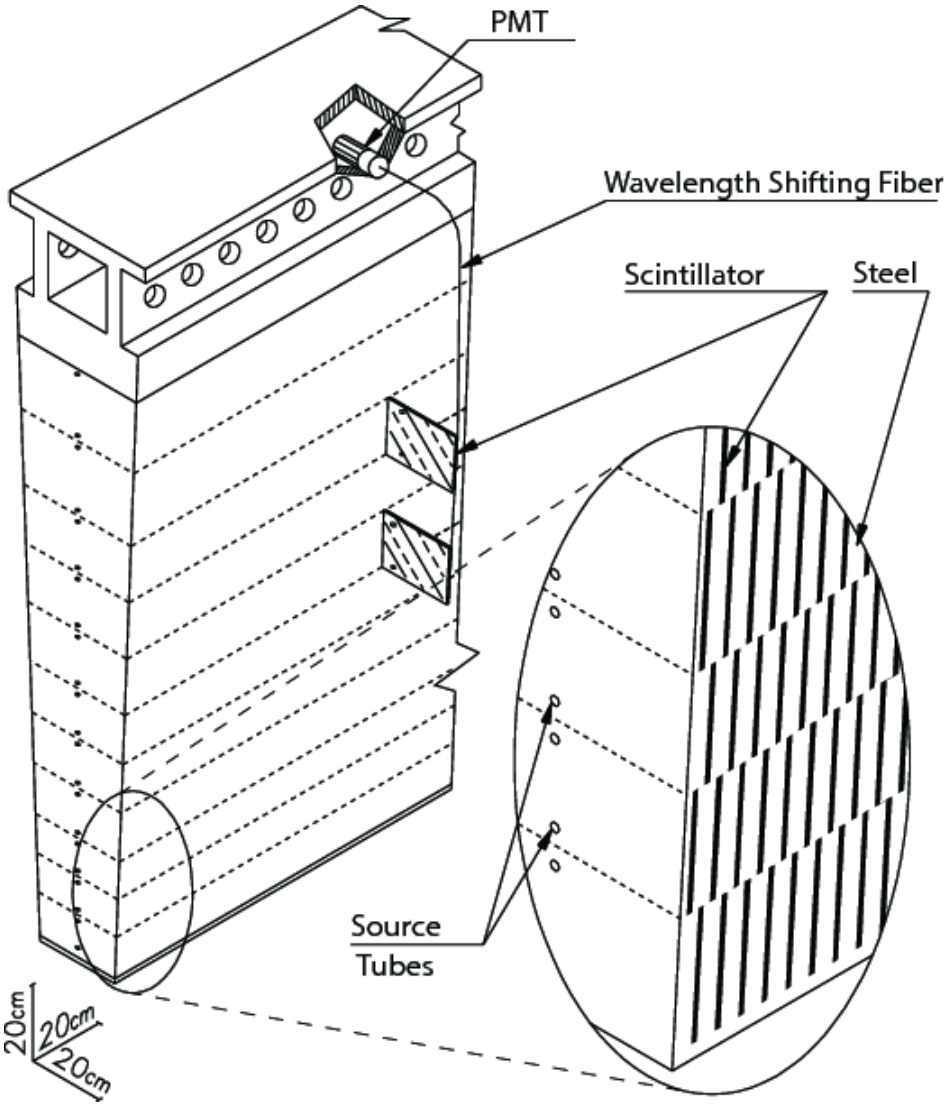
# LAr Calorimeter

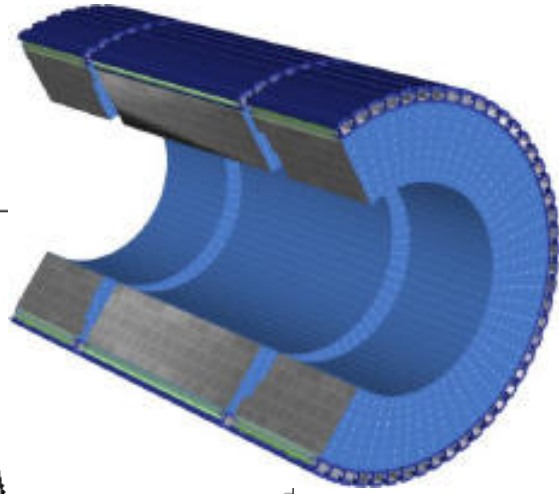


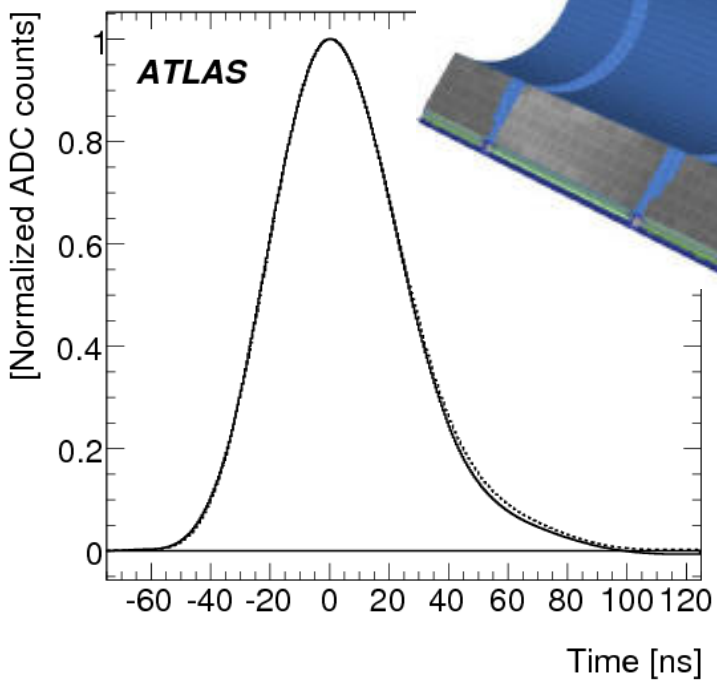



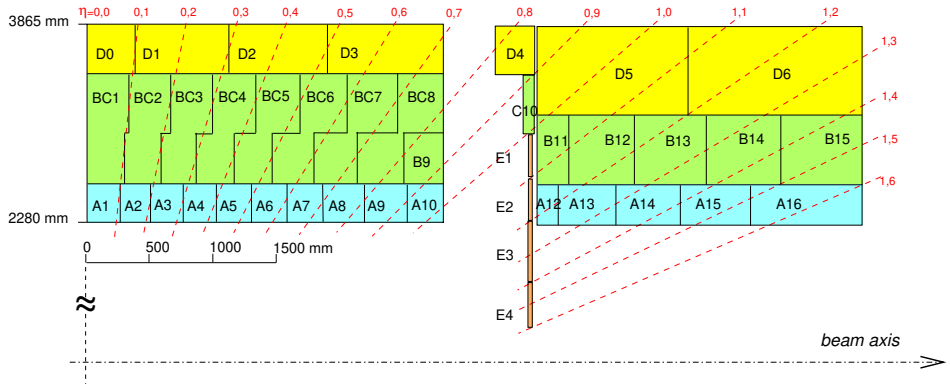



# Tile Calorimeter

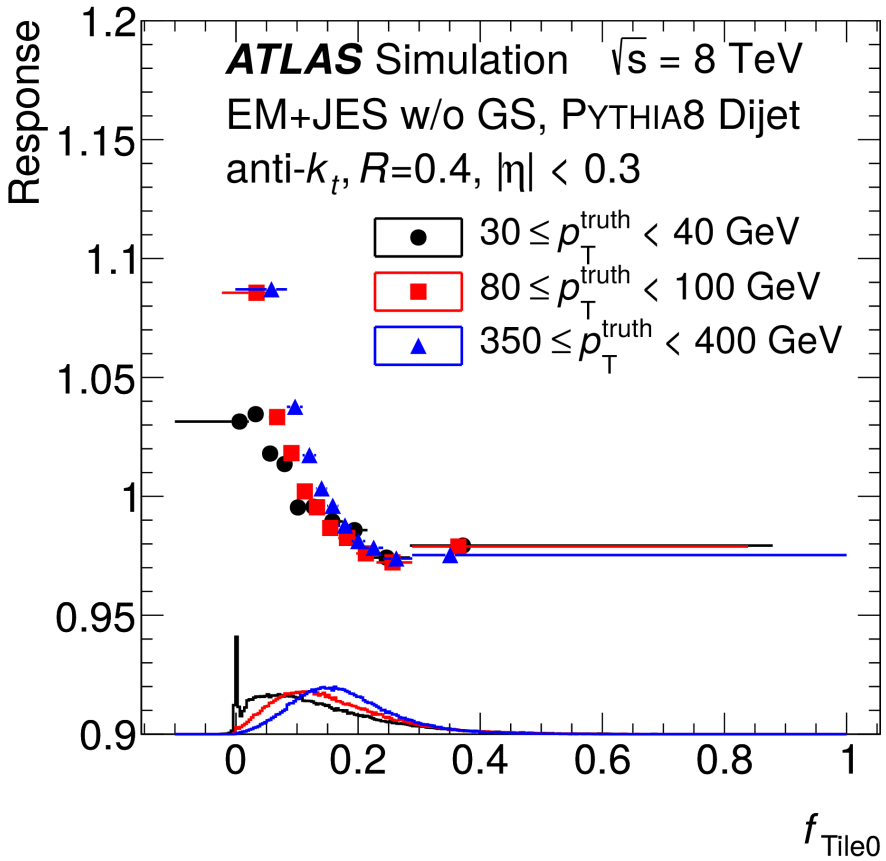


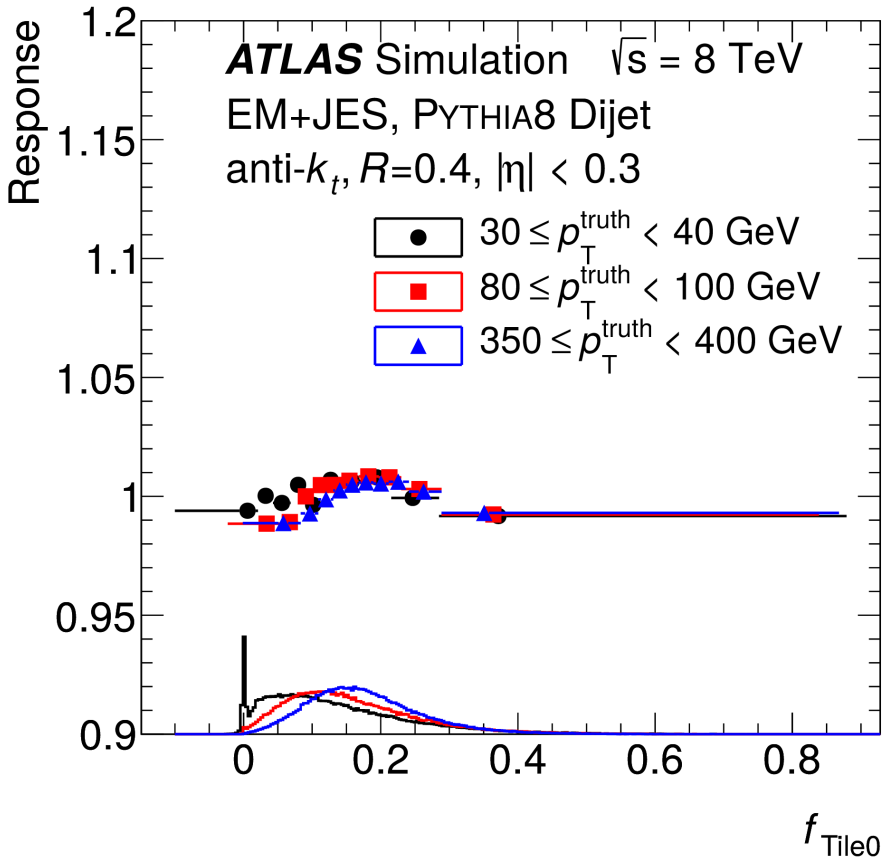





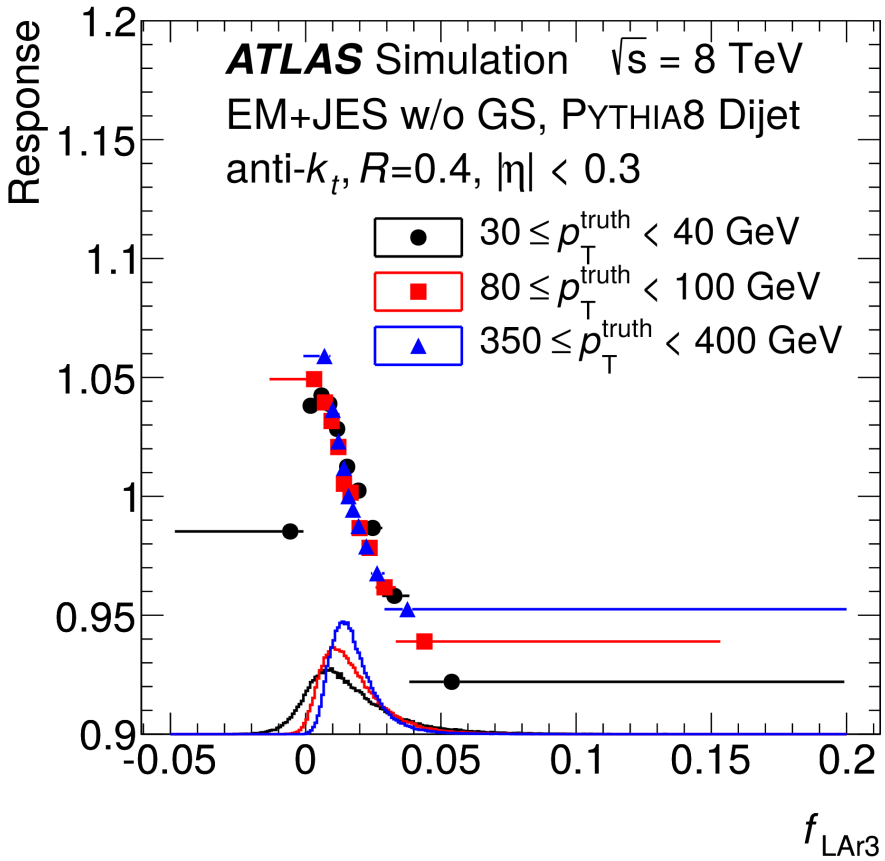



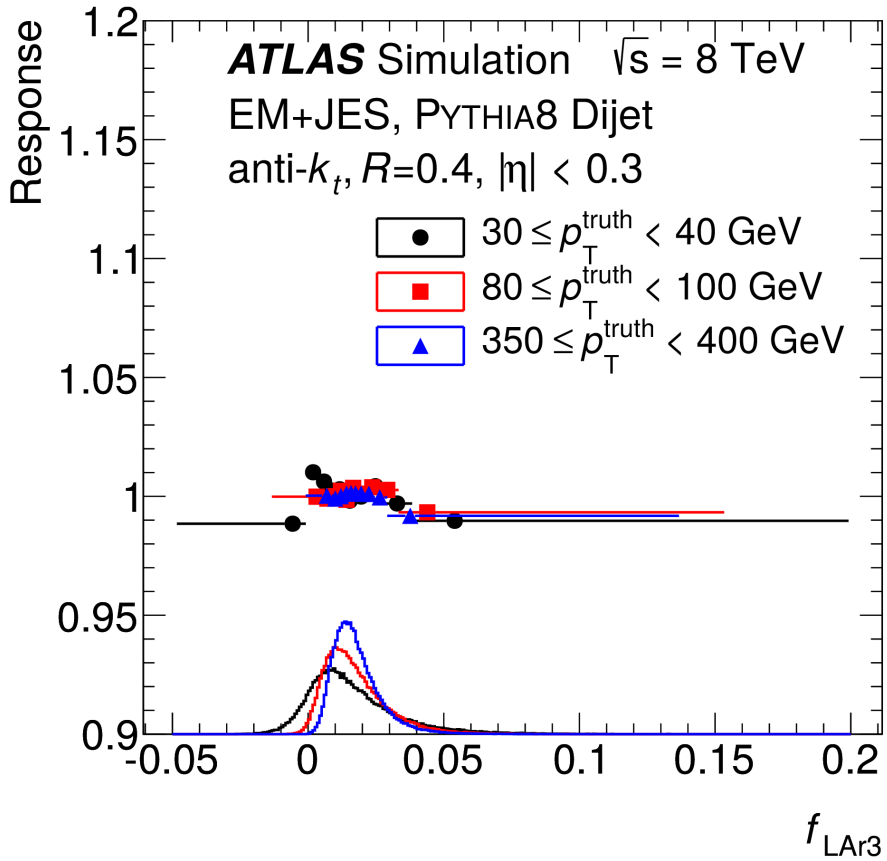
# GSC


ATLAS Simulation √s = 8 TeV
EM+JES w/o GS, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$f_{Tile0}$

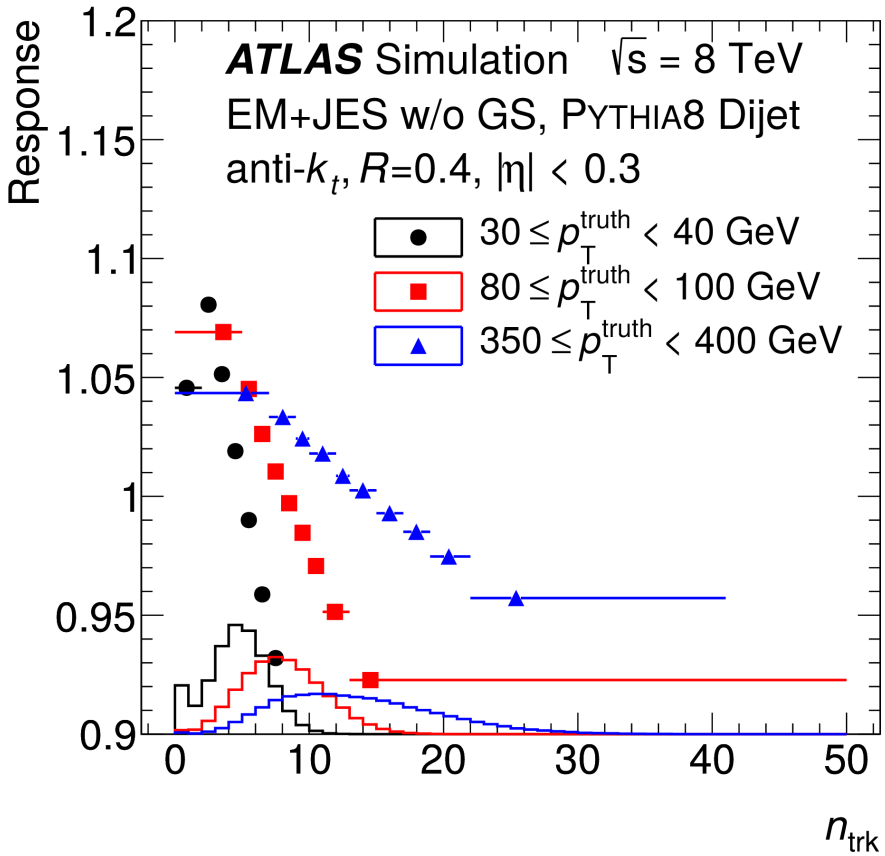

ATLAS Simulation √s = 8 TeV
EM+JES, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$f_{Tile0}$

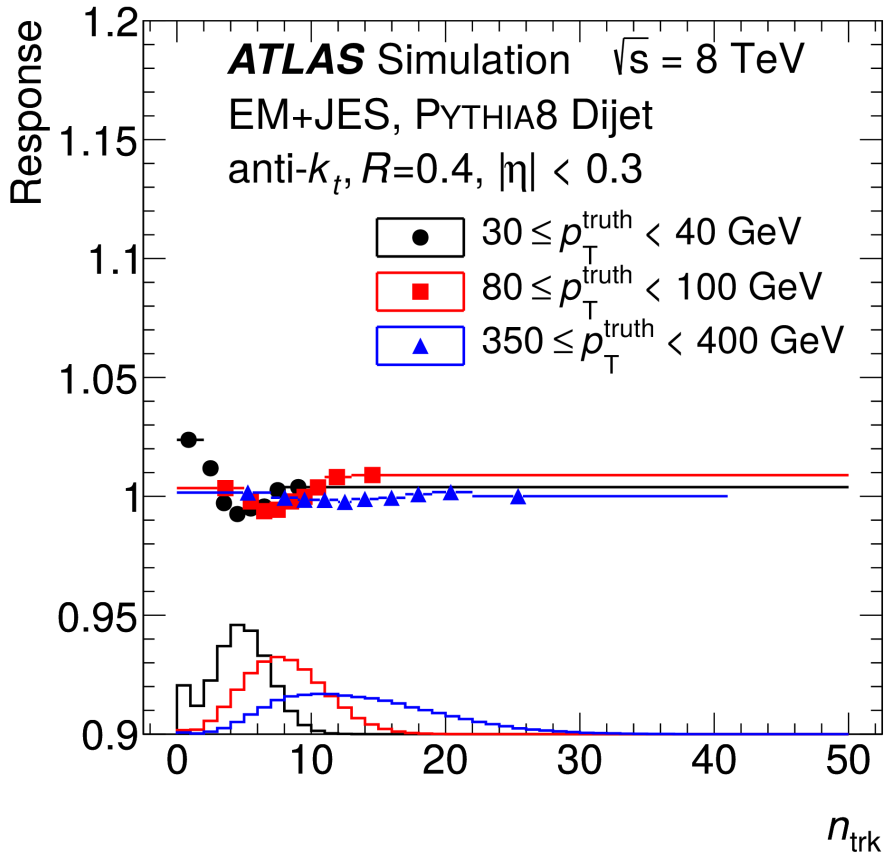
# GSC


ATLAS Simulation √s = 8 TeV
EM+JES w/o GS, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$f_{LAr3}$

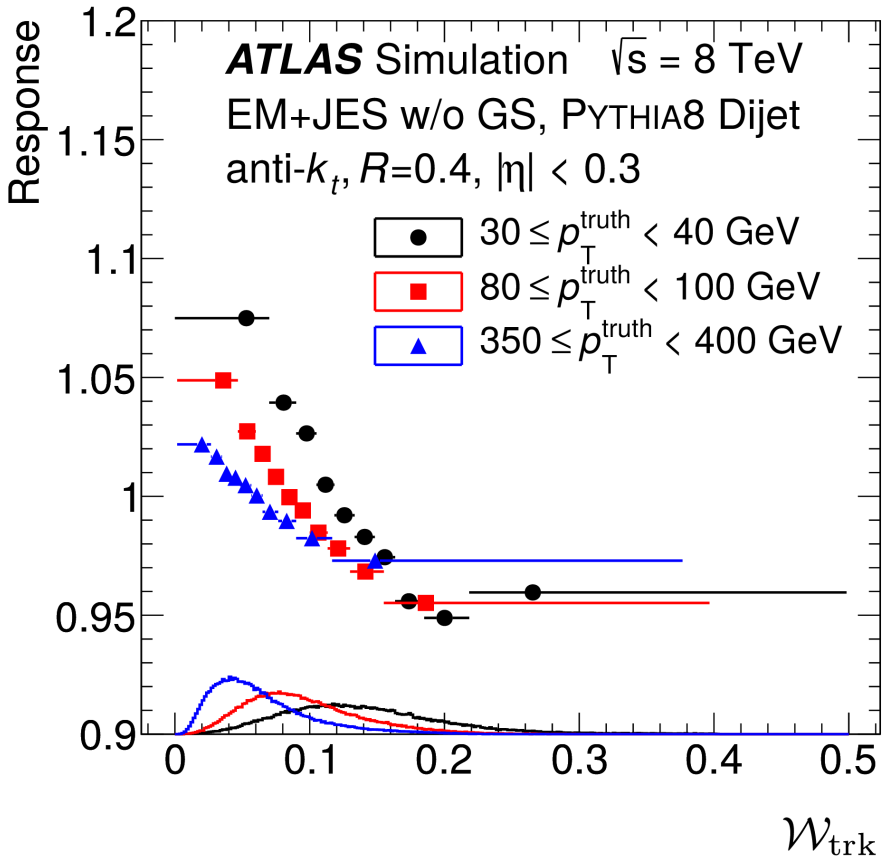

ATLAS Simulation √s = 8 TeV
EM+JES, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$f_{LAr3}$

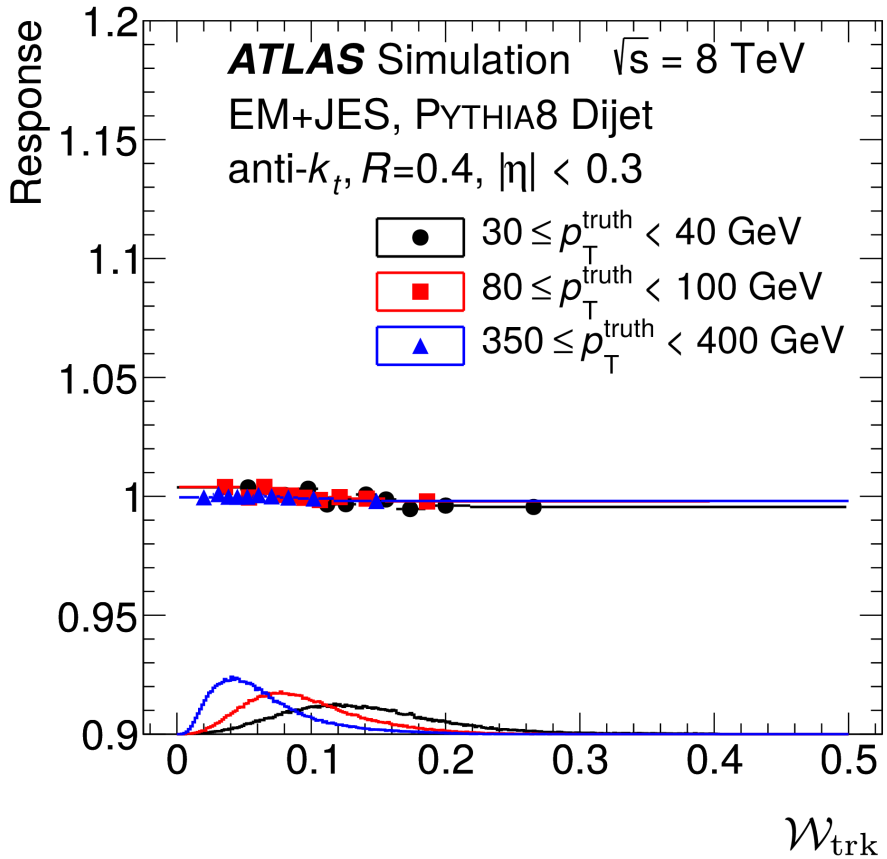
# GSC


ATLAS Simulation √s = 8 TeV
EM+JES w/o GS, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$n_{trk}$

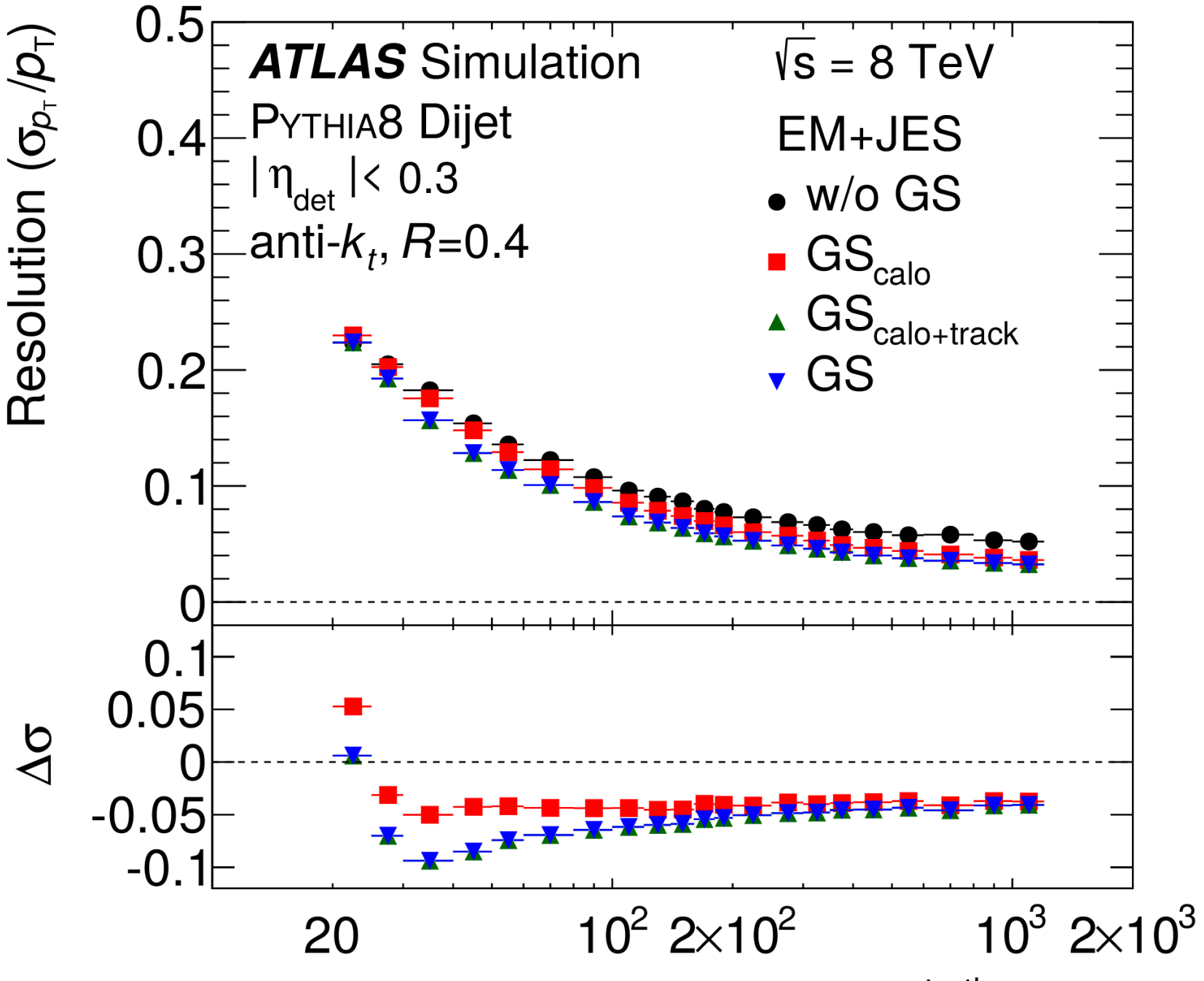

ATLAS Simulation √s = 8 TeV
EM+JES, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
30 ≤ $p_T^{truth}$ < 40 GeV
80 ≤ $p_T^{truth}$ < 100 GeV
350 ≤ $p_T^{truth}$ < 400 GeV
Response
$n_{trk}$

# GSC

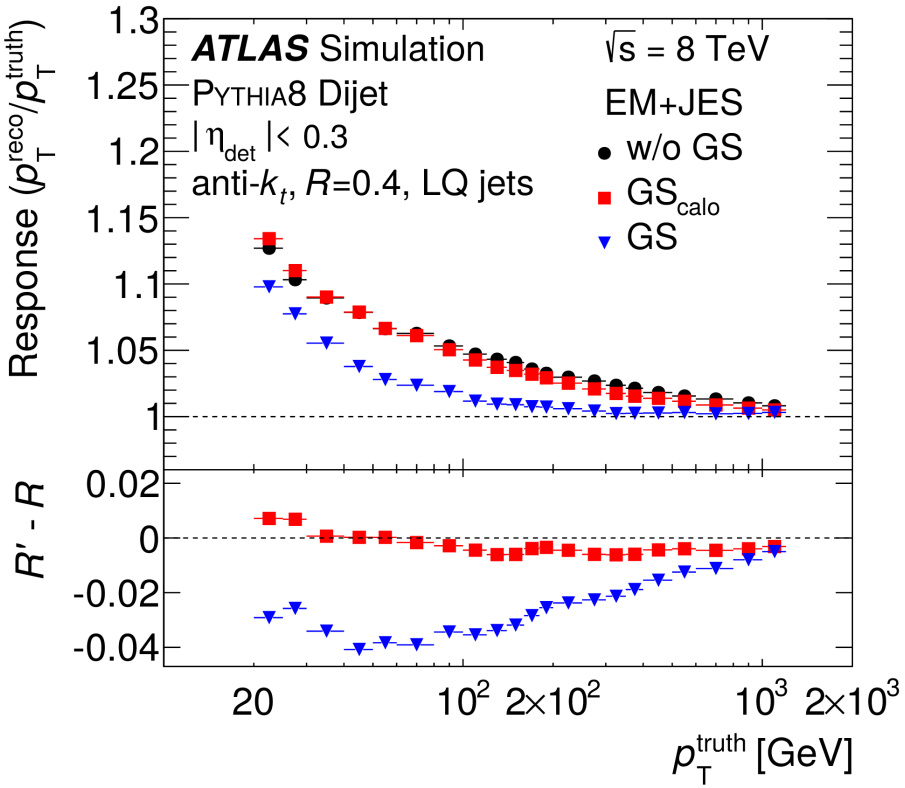

ATLAS Simulation √s = 8 TeV
EM+JES w/o GS, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
$30 \le p_T^{truth} < 40$ GeV
$80 \le p_T^{truth} < 100$ GeV
$350 \le p_T^{truth} < 400$ GeV
Response
$\mathcal{W}_{trk}$

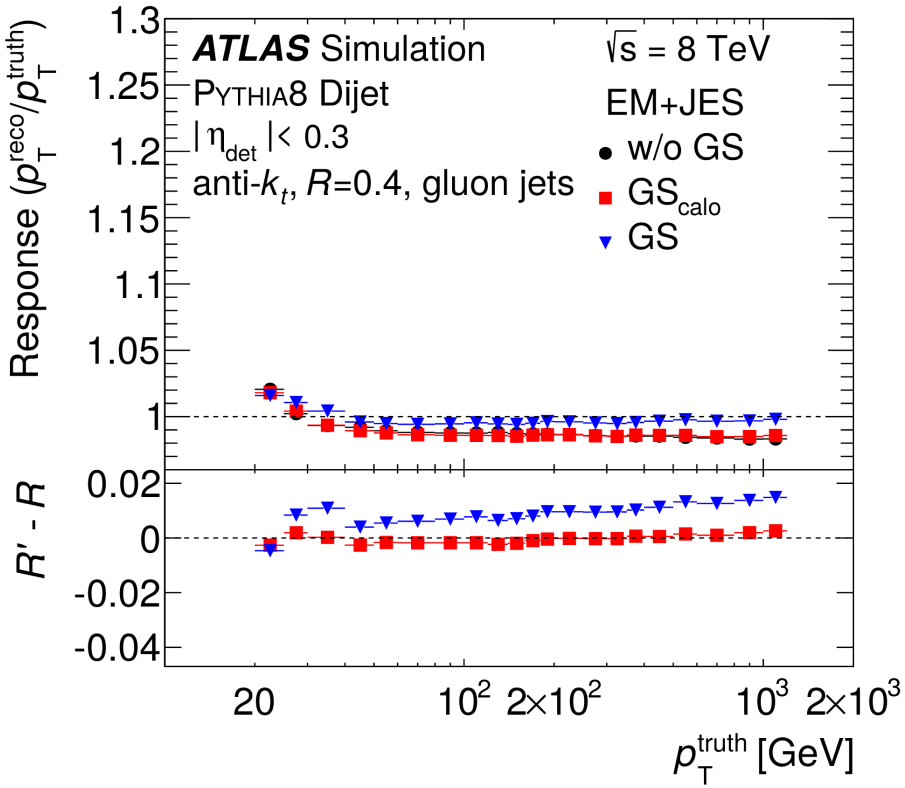

ATLAS Simulation √s = 8 TeV
EM+JES, PYTHIA8 Dijet
anti-$k_t$, $R$=0.4, |η| < 0.3
$30 \le p_T^{truth} < 40$ GeV
$80 \le p_T^{truth} < 100$ GeV
$350 \le p_T^{truth} < 400$ GeV
Response
$\mathcal{W}_{trk}$

# GSC


ATLAS Simulation
√s = 8 TeV
PYTHIA8 Dijet
EM+JES
|η_det| < 0.3
anti-k_t, R=0.4
w/o GS
GS_calo
GS_calo+track
GS
Resolution (σ_pT/p_T)
Δσ
0.5
0.4
0.3
0.2
0.1
0
0.1
0.05
0
-0.05
-0.1
20
10^2
2×10^2
10^3
2×10^3

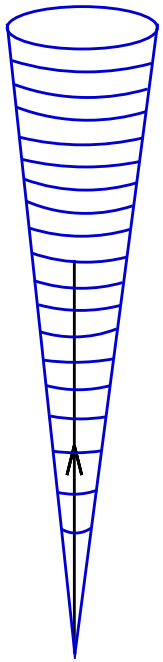
# GSC


ATLAS Simulation
√s = 8 TeV
PYTHIA8 Dijet
EM+JES
|η_det| < 0.3
anti-k_t, R=0.4, LQ jets
w/o GS
GS_calo
GS
Response (p_T^reco/p_T^truth)
R' - R
p_T^truth [GeV]

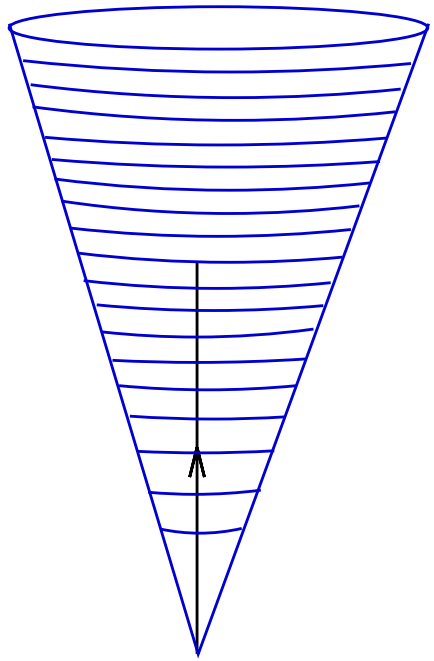

ATLAS Simulation
√s = 8 TeV
PYTHIA8 Dijet
EM+JES
|η_det| < 0.3
anti-k_t, R=0.4, gluon jets
w/o GS
GS_calo
GS
Response (p_T^reco/p_T^truth)
R' - R
p_T^truth [GeV]

# Small- vs Large-R jets

**Small jet radius**



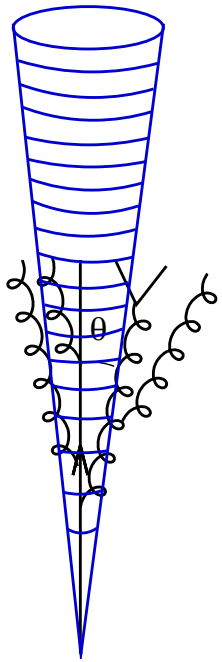
**Large jet radius**



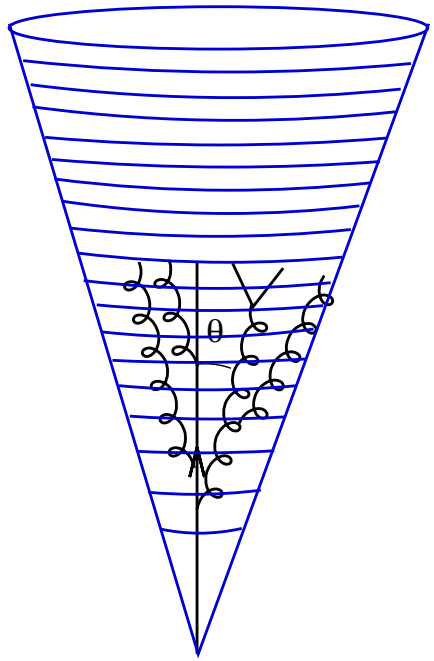
single parton @ LO: **jet radius irrelevant**

# Small- vs Large-R jets

**Small jet radius**



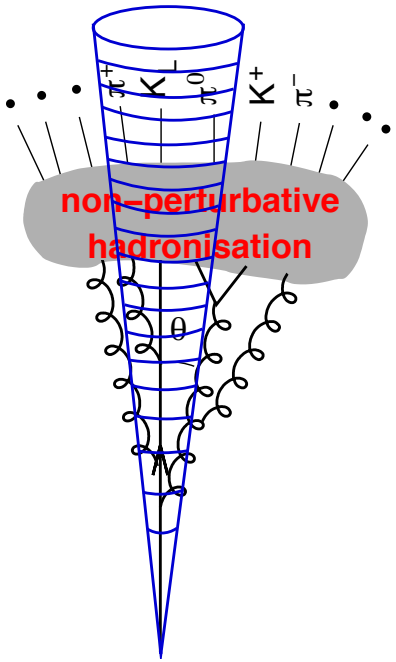

**Large jet radius**



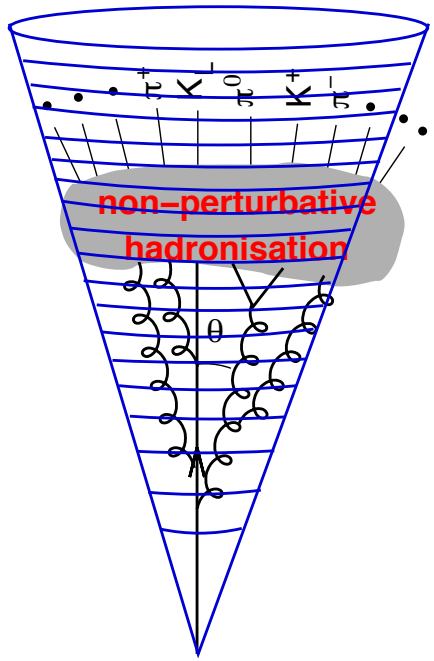

perturbative fragmentation: **large jet radius better**
(it captures more)

# Small- vs Large-R jets

**Small jet radius**



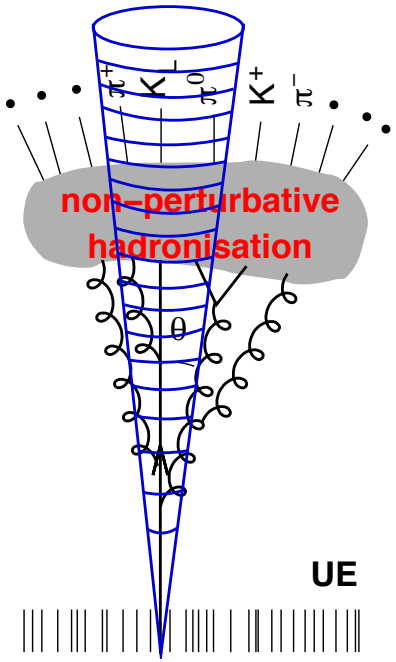

**Large jet radius**



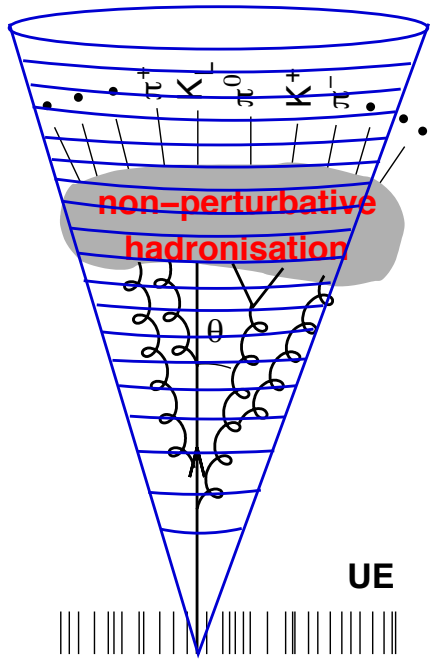

non-perturbative fragmentation: **large jet radius better**
(it captures more)

# Small- vs Large-R jets

**Small jet radius**



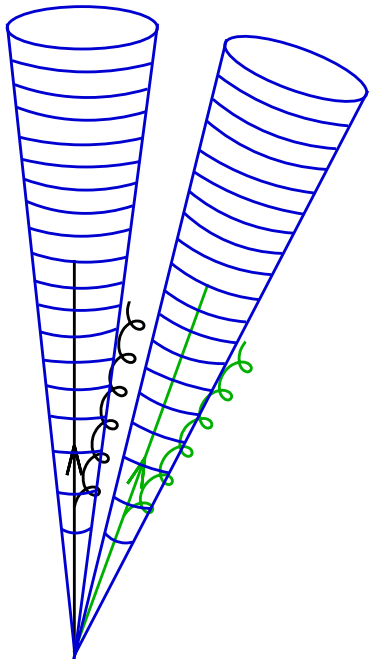

**Large jet radius**



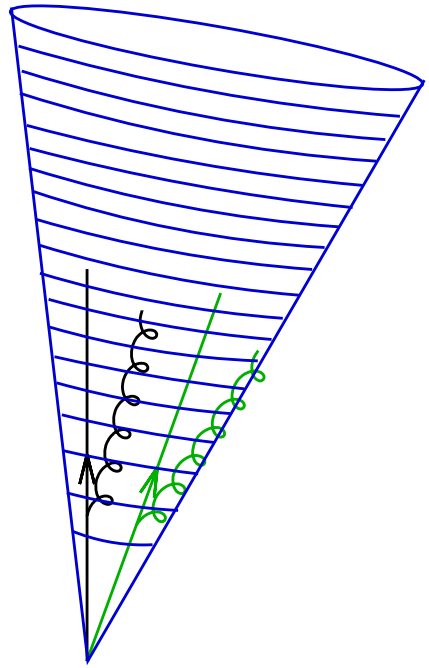

underlying ev. & pileup "noise": **small jet radius better**
(it captures less)

# Small- vs Large-R jets

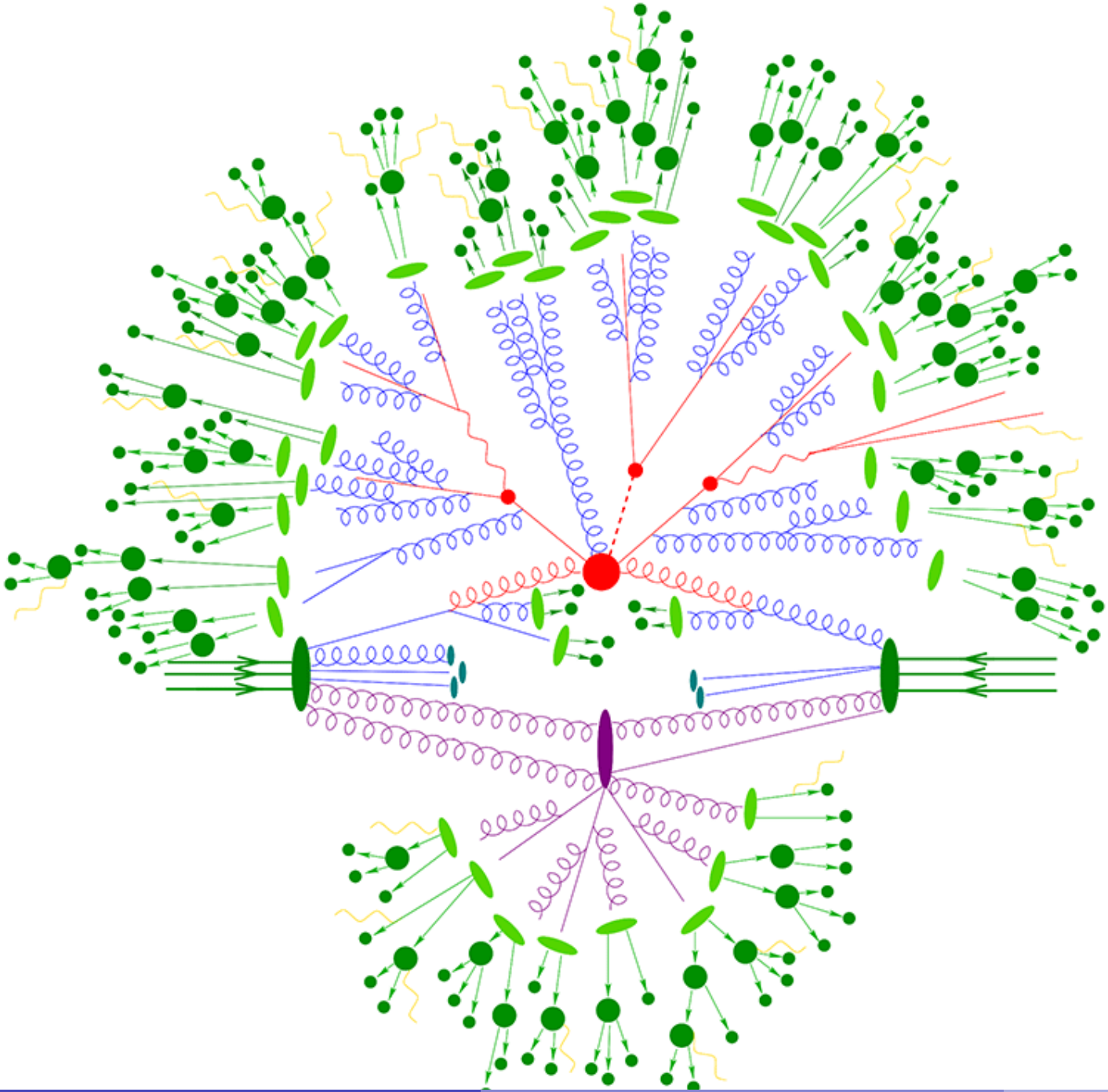
**Small jet radius**

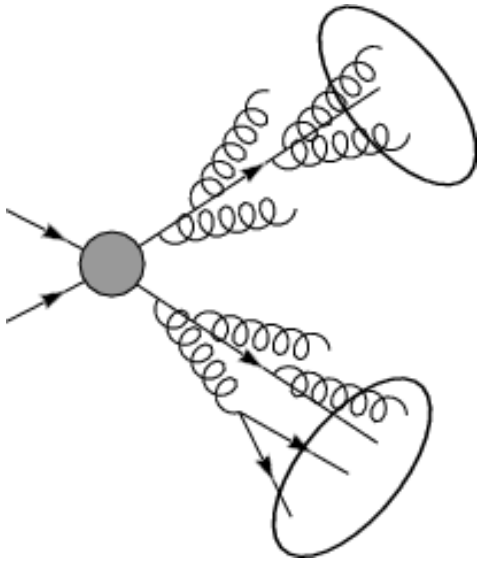


**Large jet radius**

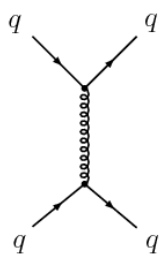


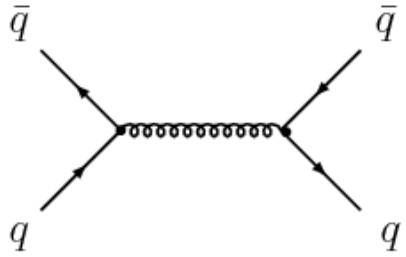
multi-hard-parton events: **small jet radius better**
(it resolves partons more effectively)

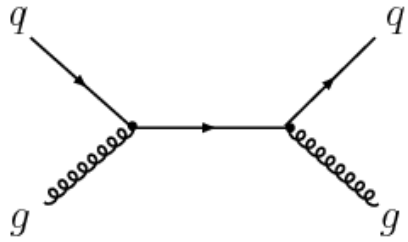


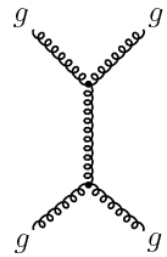


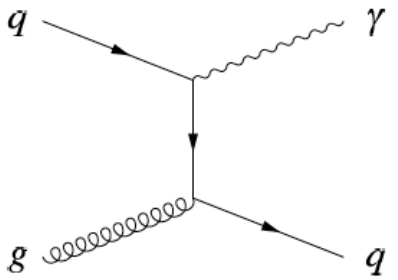
# Calibration in situ

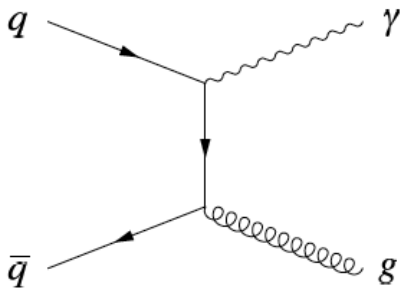


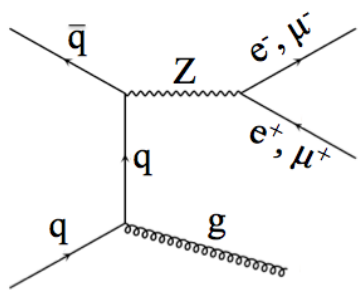



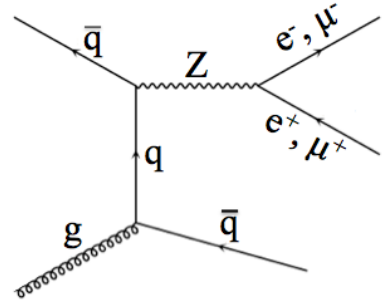



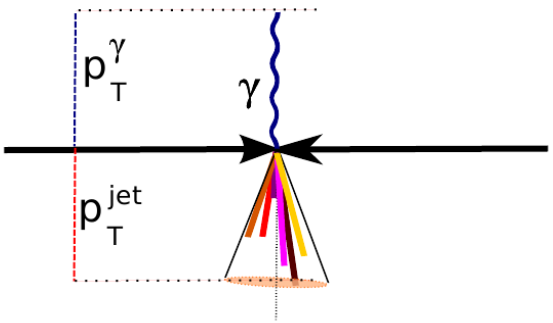



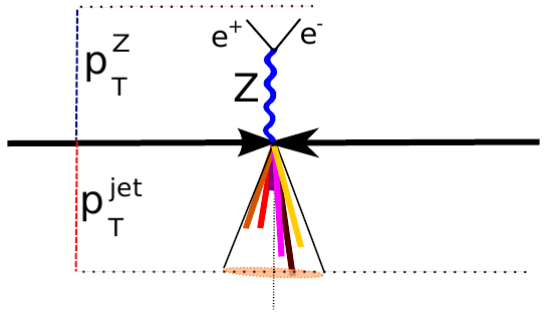



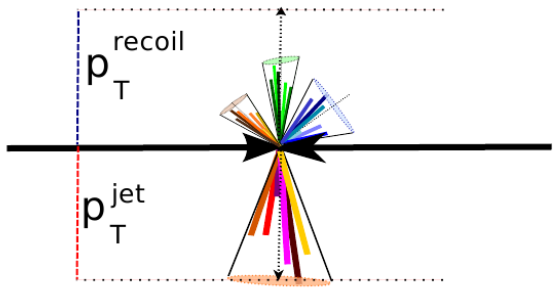

Photon-jet balance



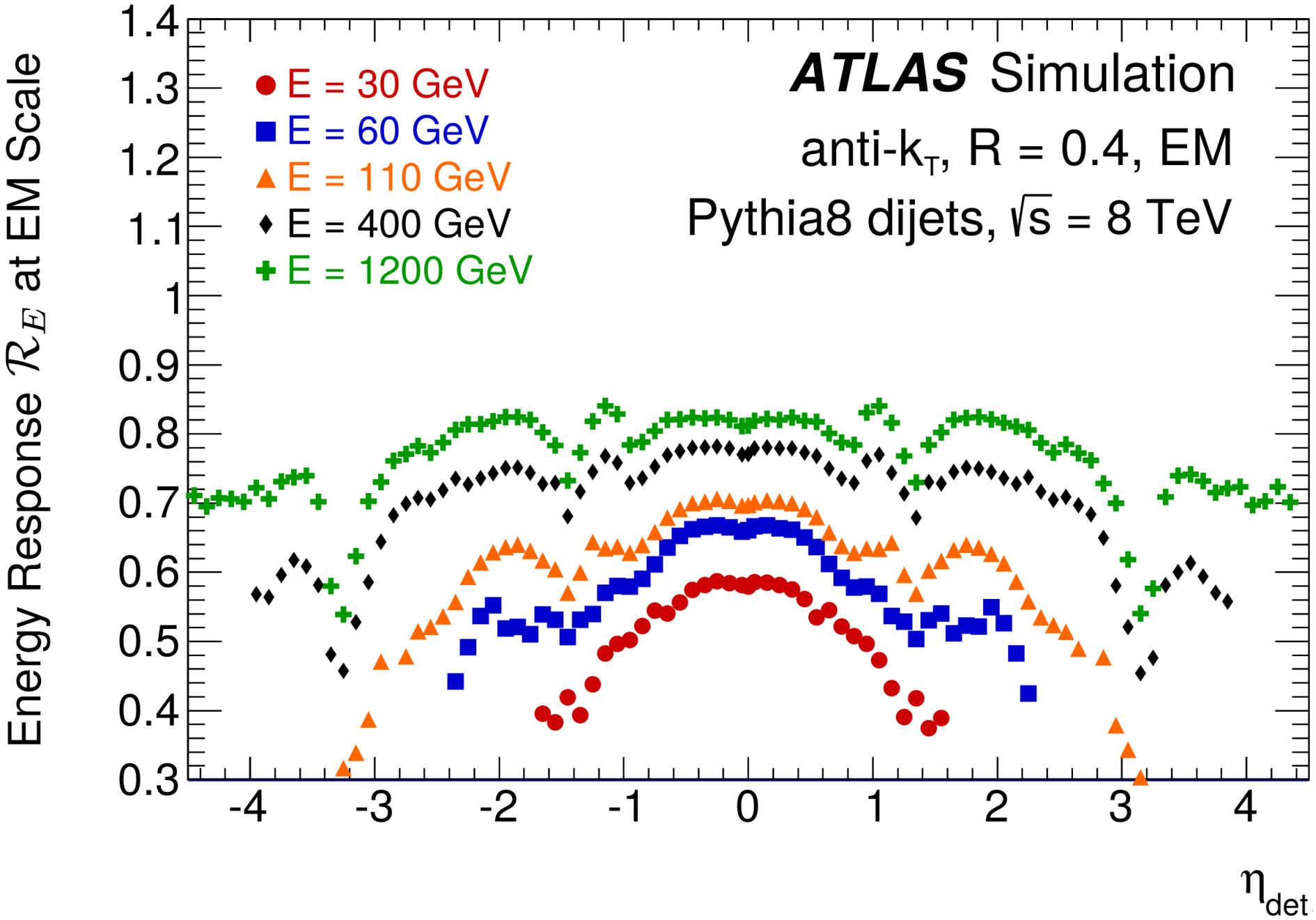

Z-jet balance



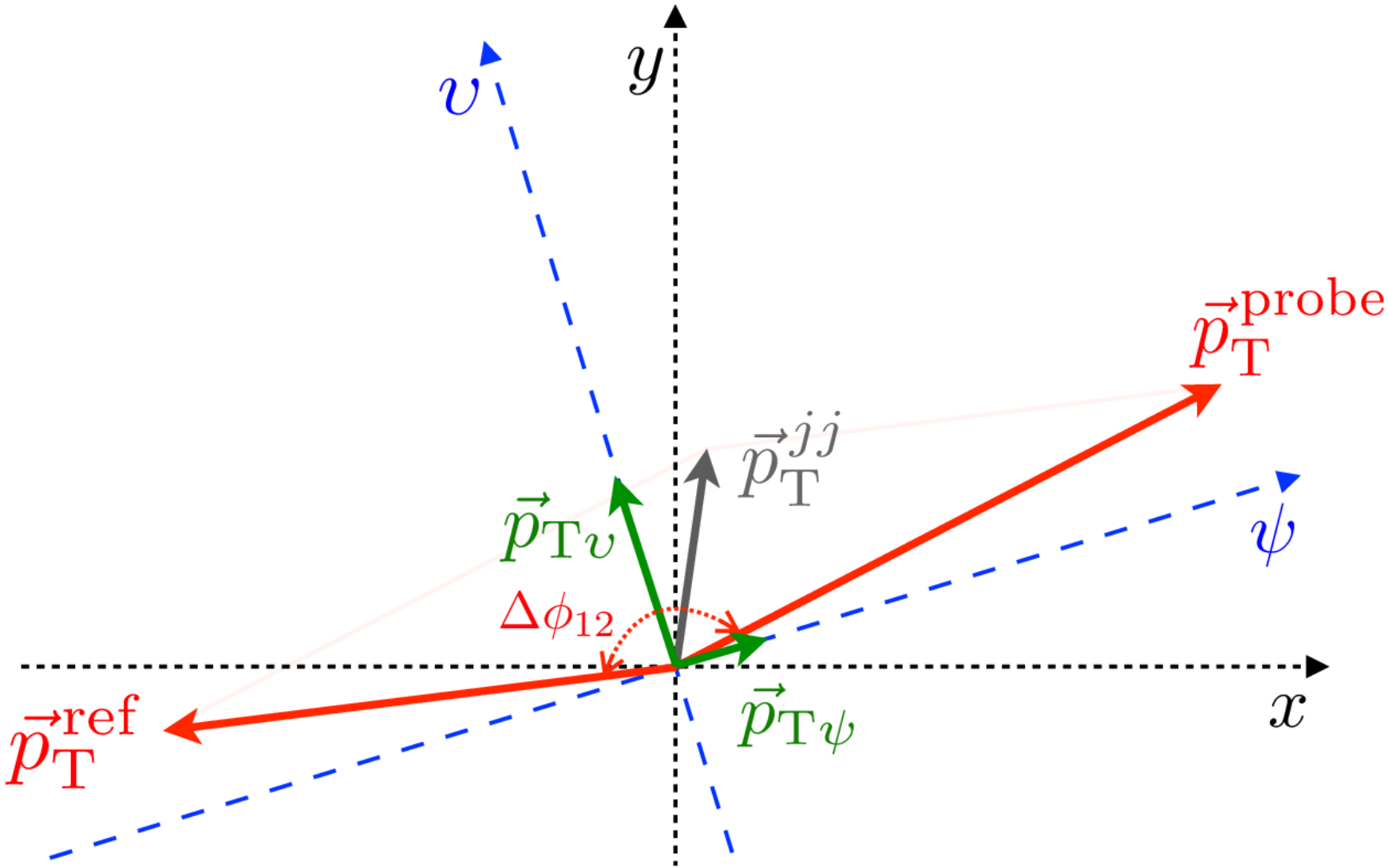

Multi-jet balance



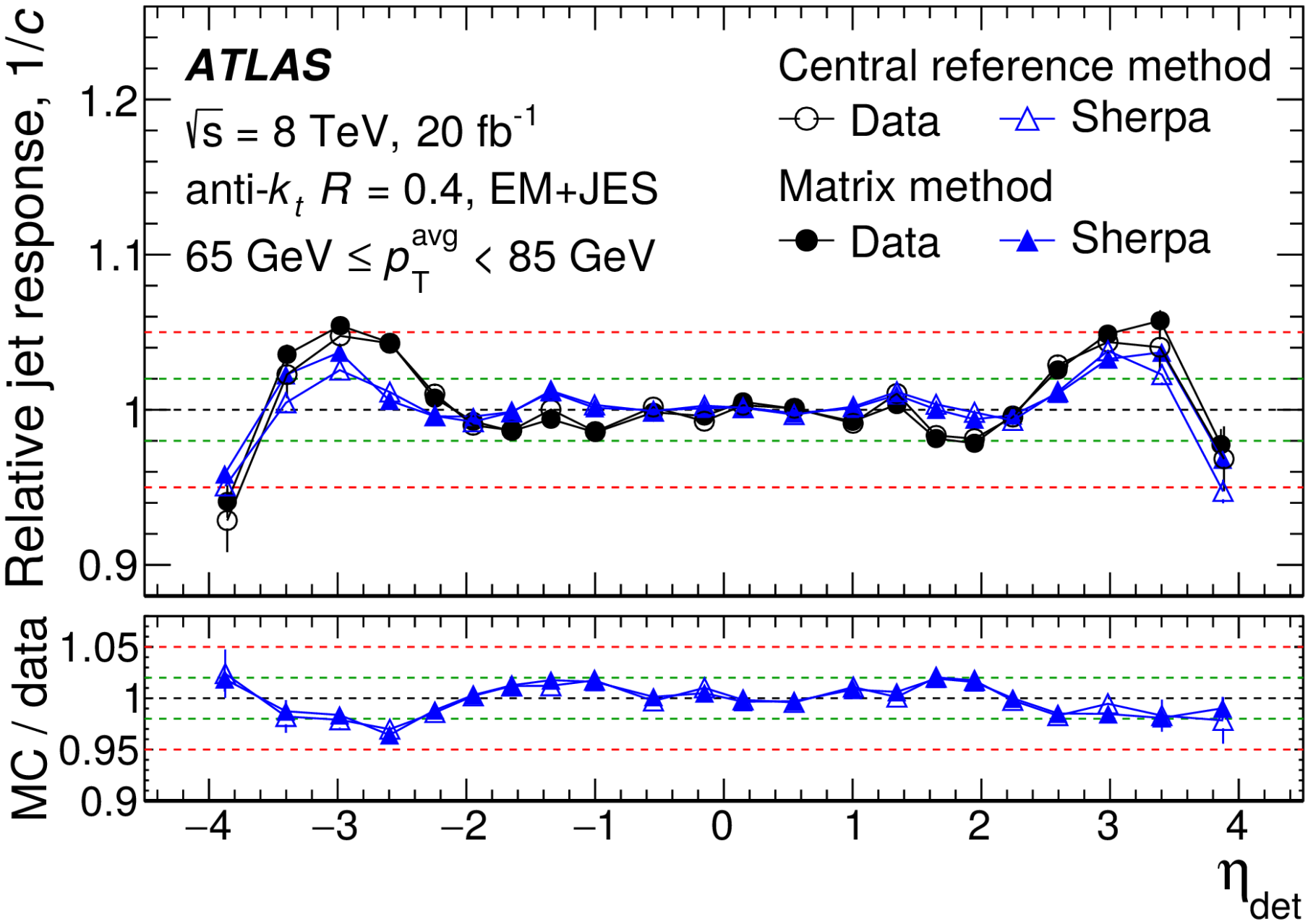
# MC calibration



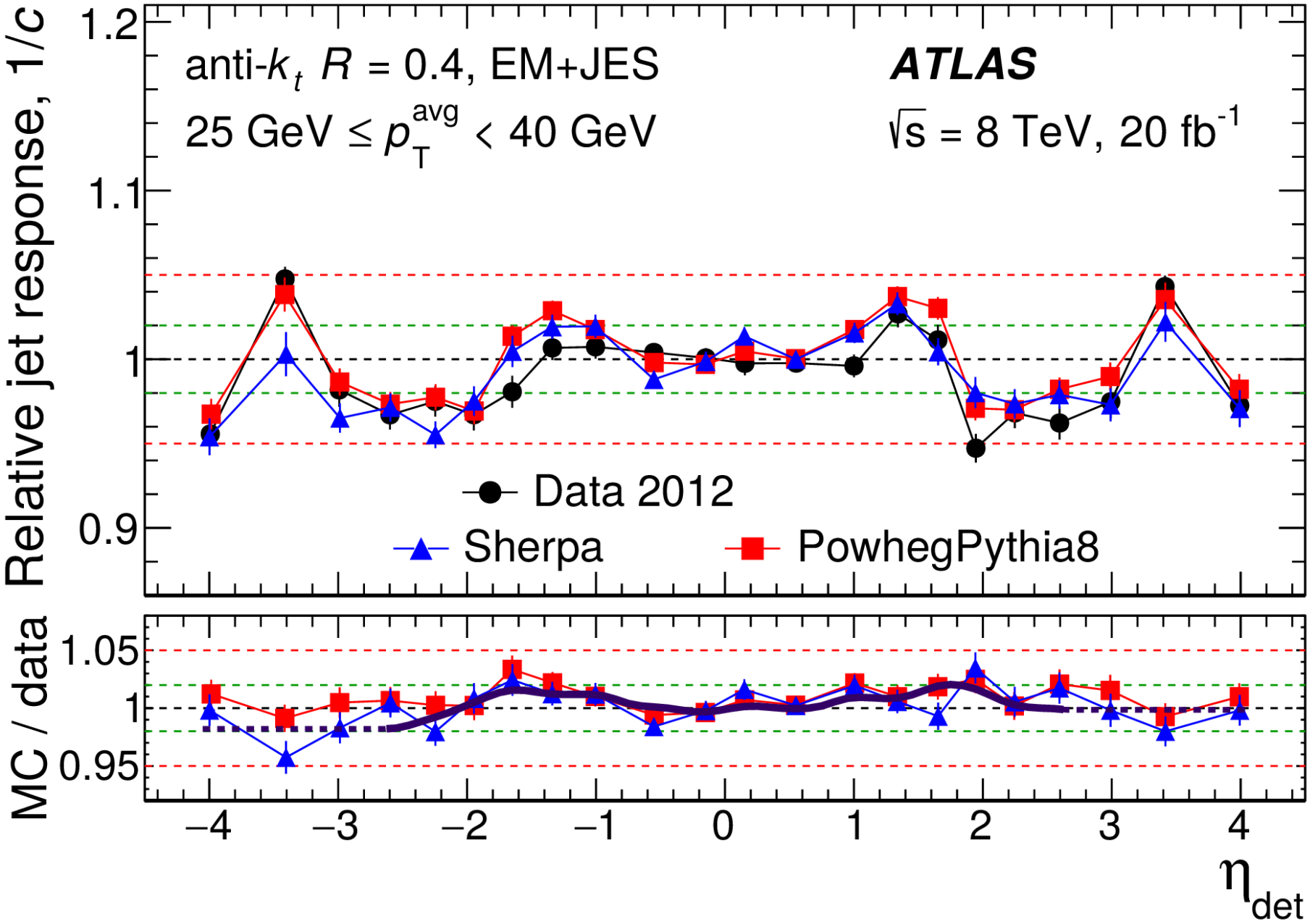
# Dijet intercalibration



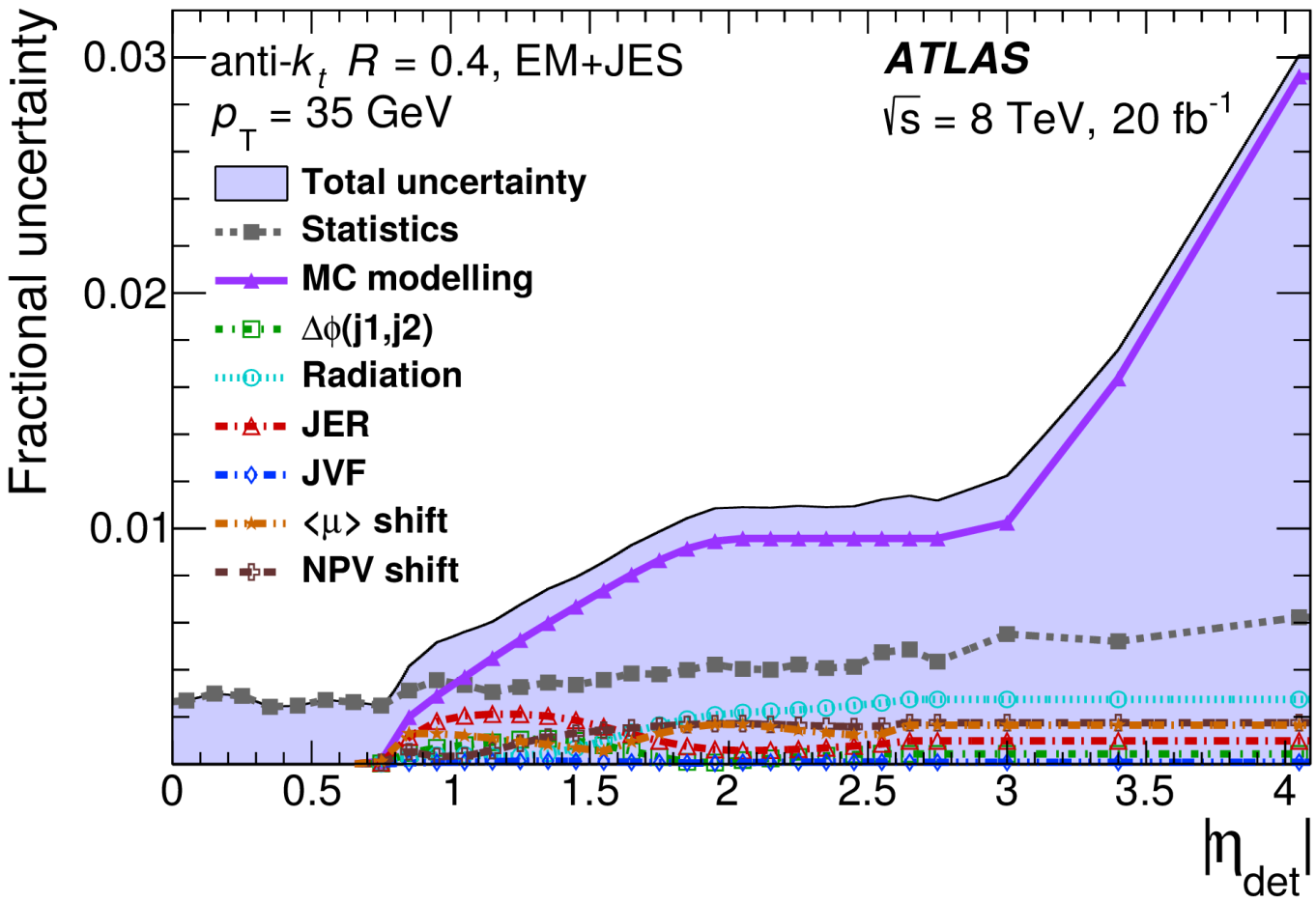
# Dijet intercalibration: matrix vs single reference

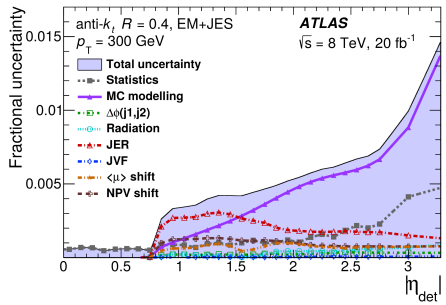


# Dijet intercalibration calibration factors

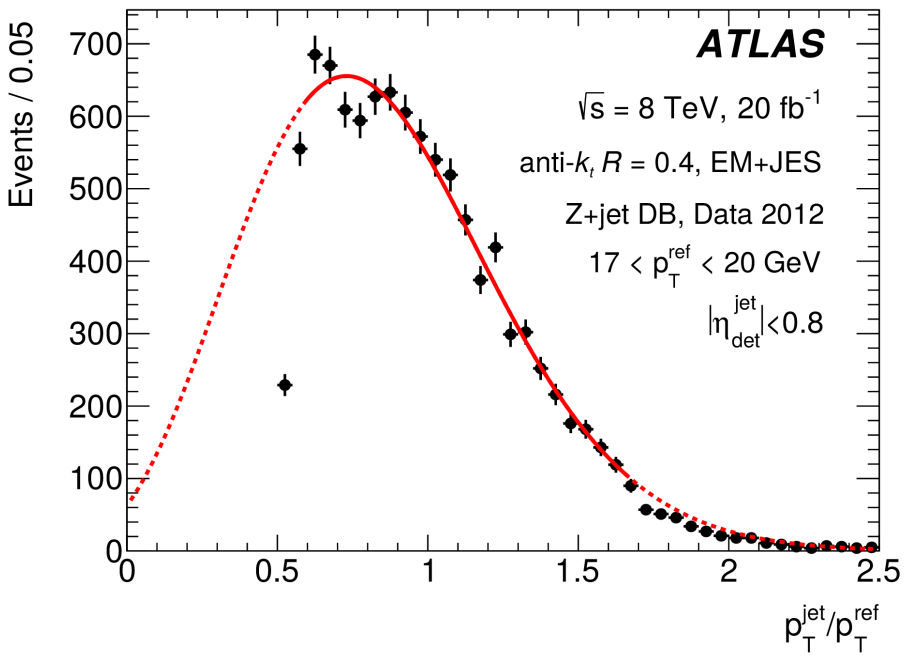


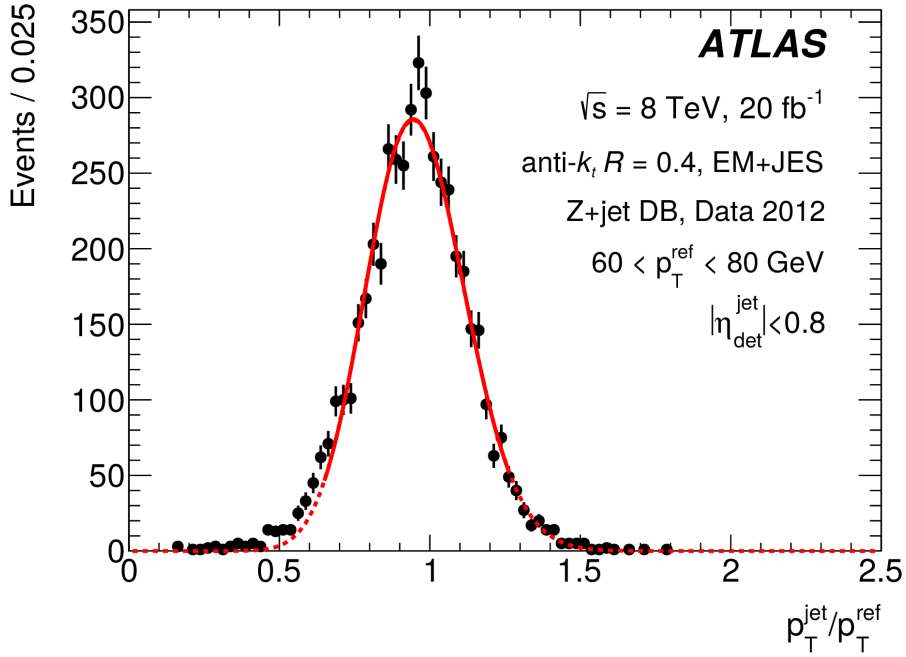
# Dijet intercalibration uncertainties



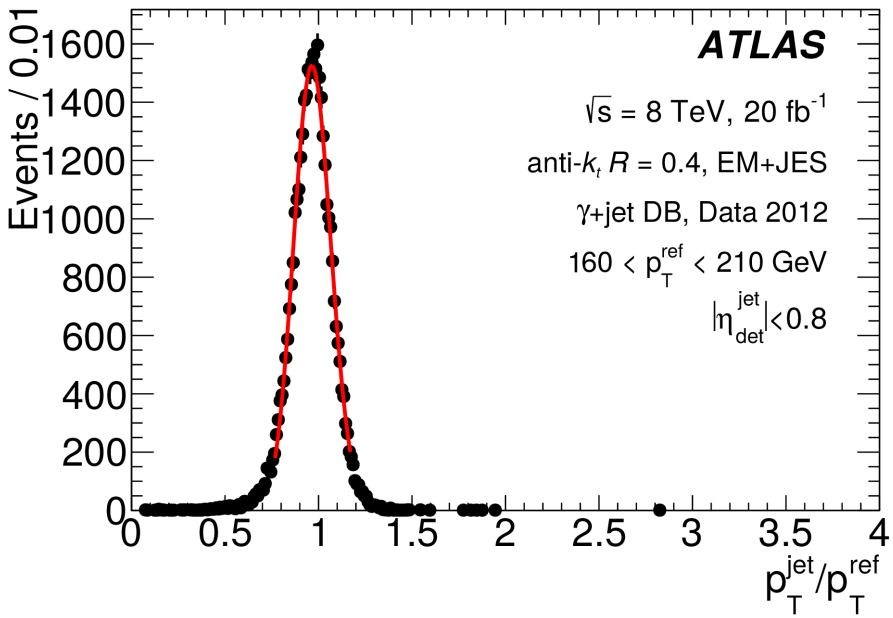



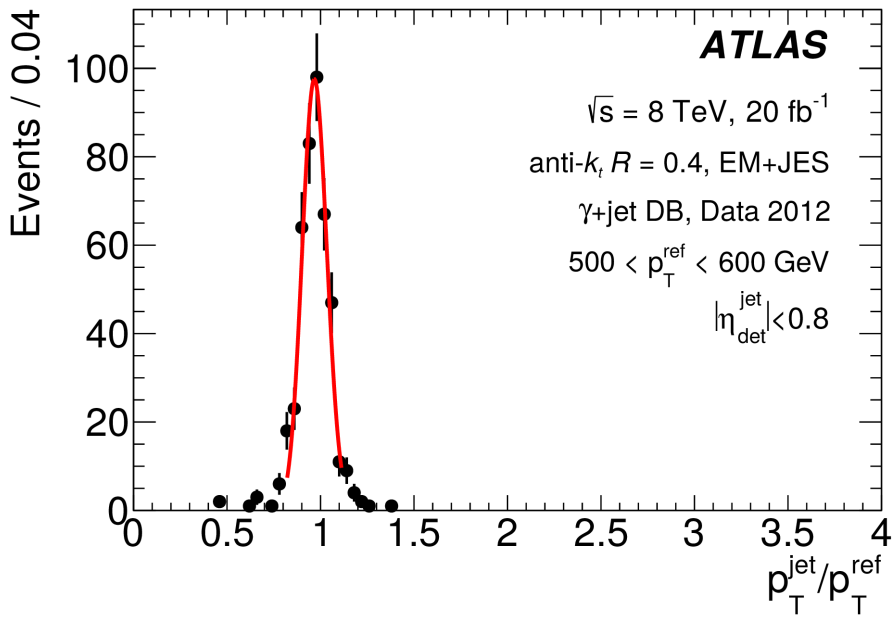
# Direct balance Zjet



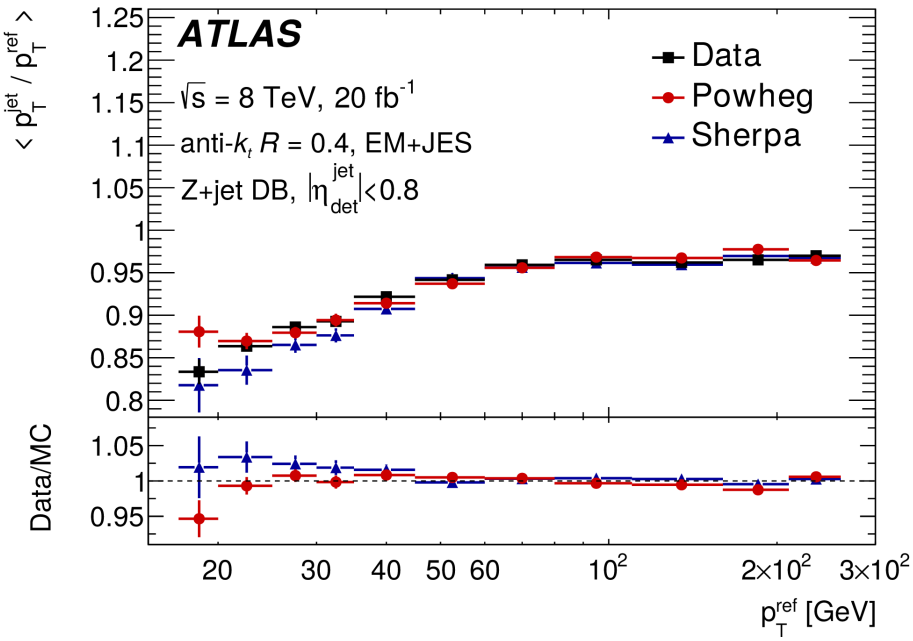



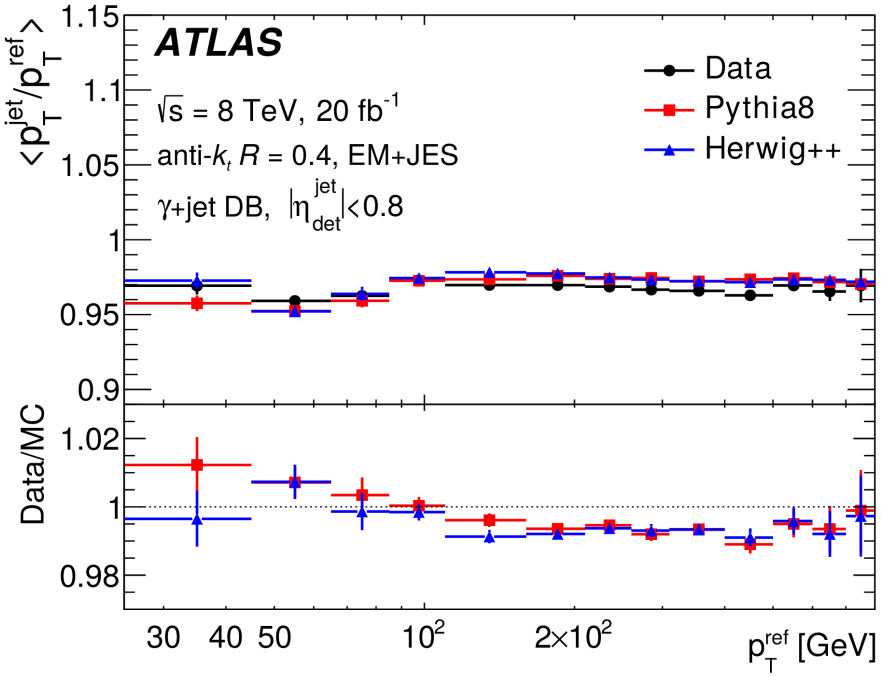
# Direct balance Gjet



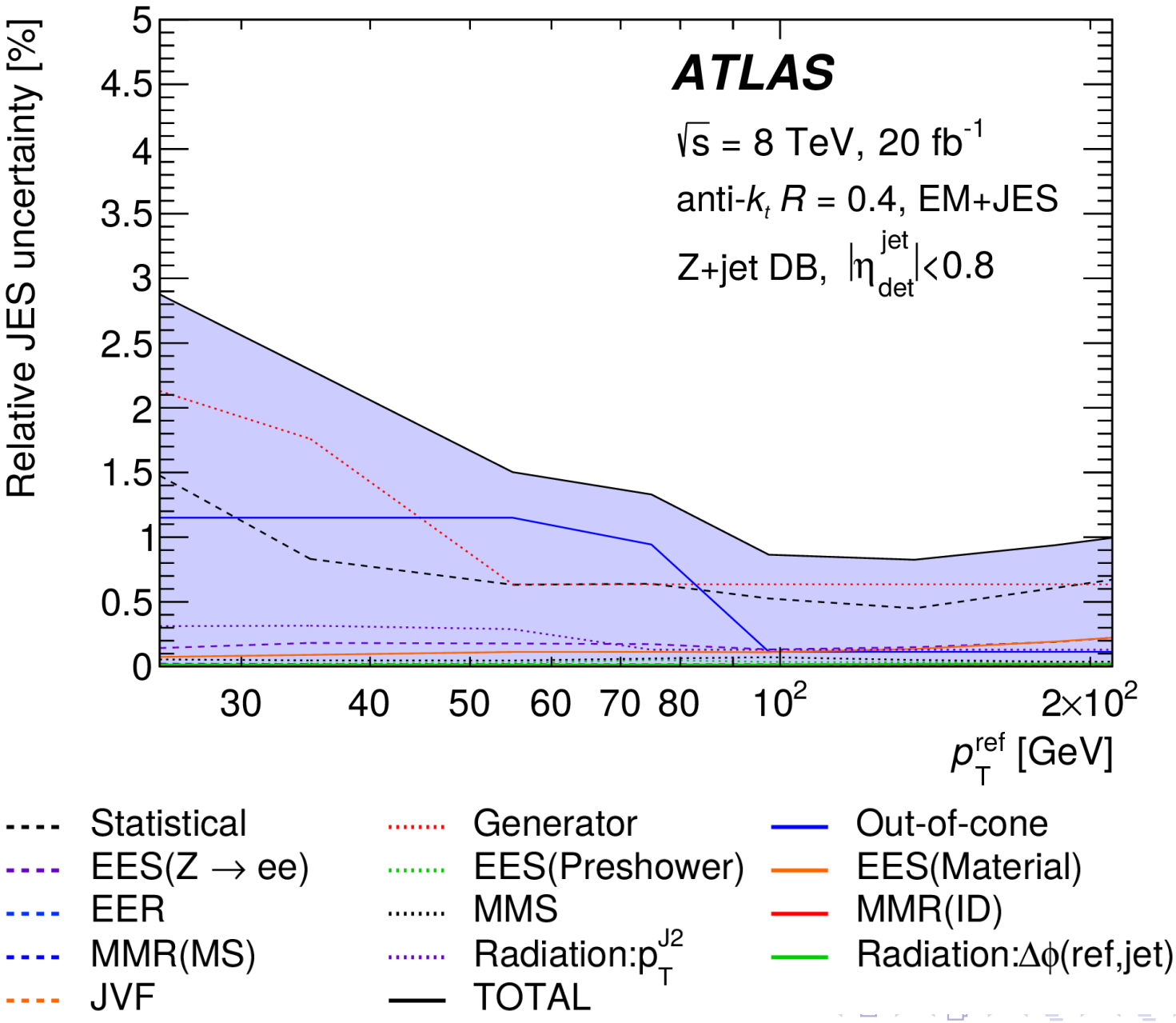



# Direct balance response

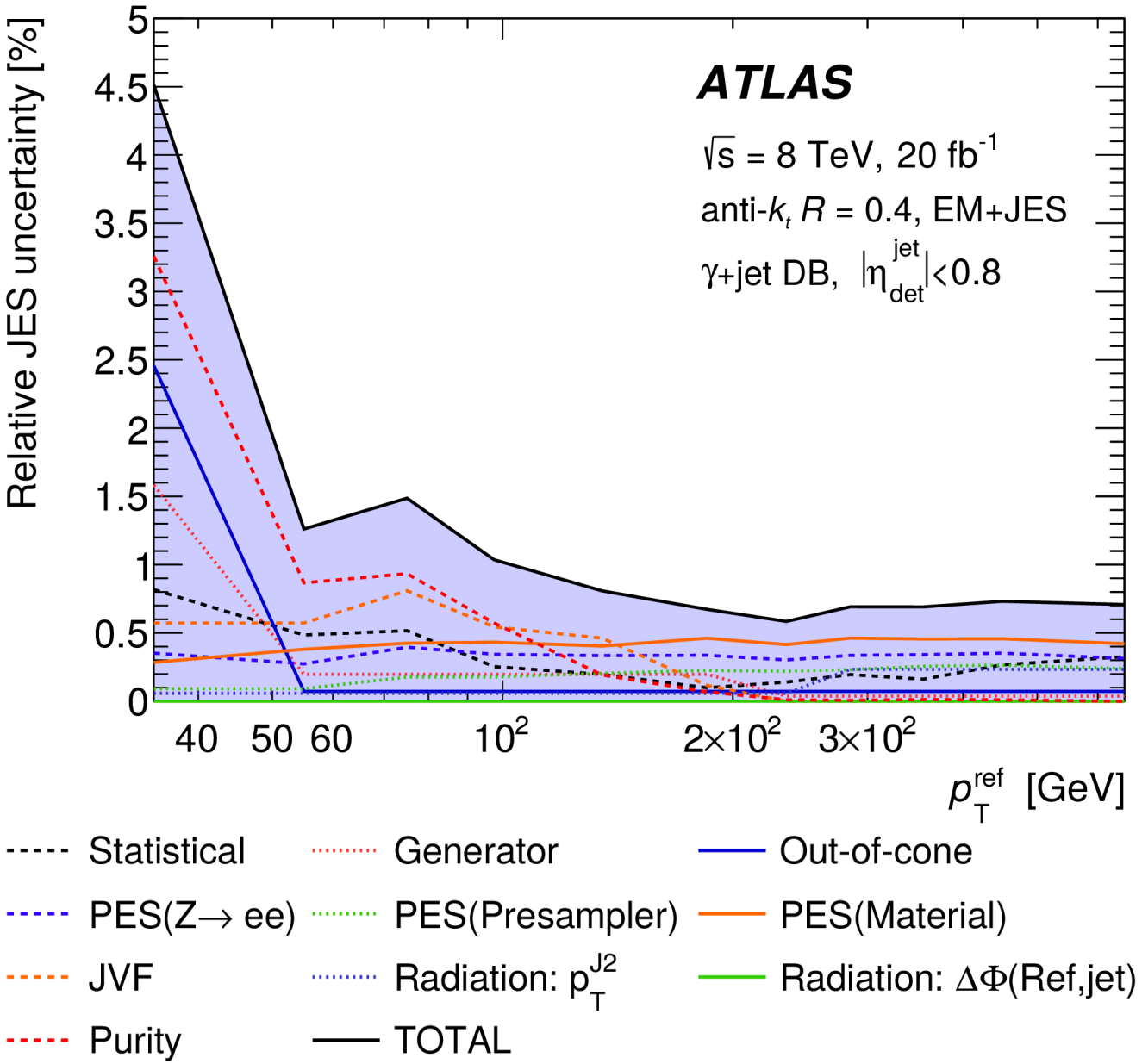


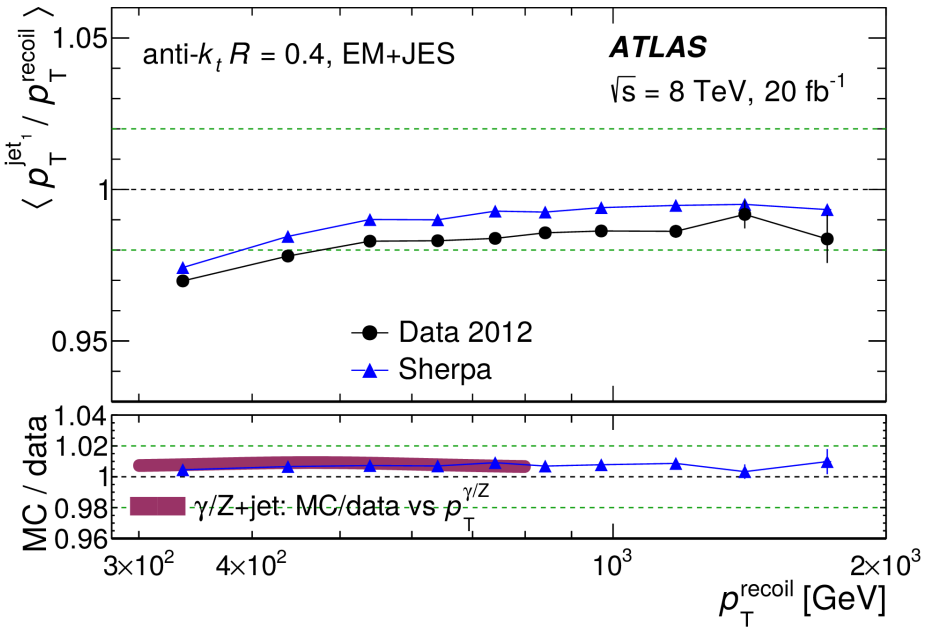
# Direct balance uncertainty

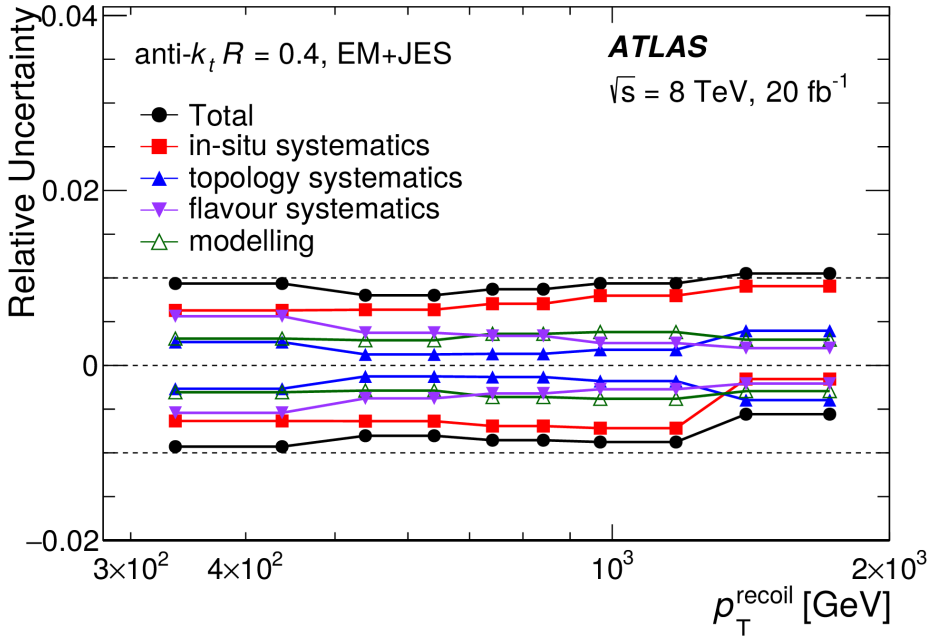


# Direct balance uncertainty

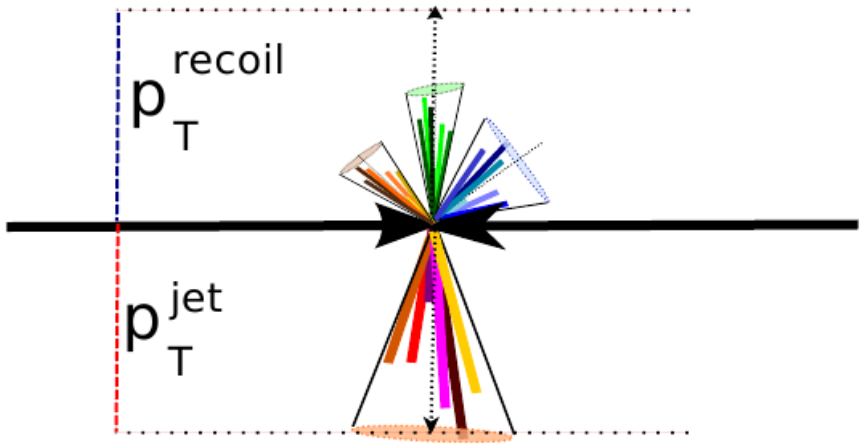


# Multi-jet balance

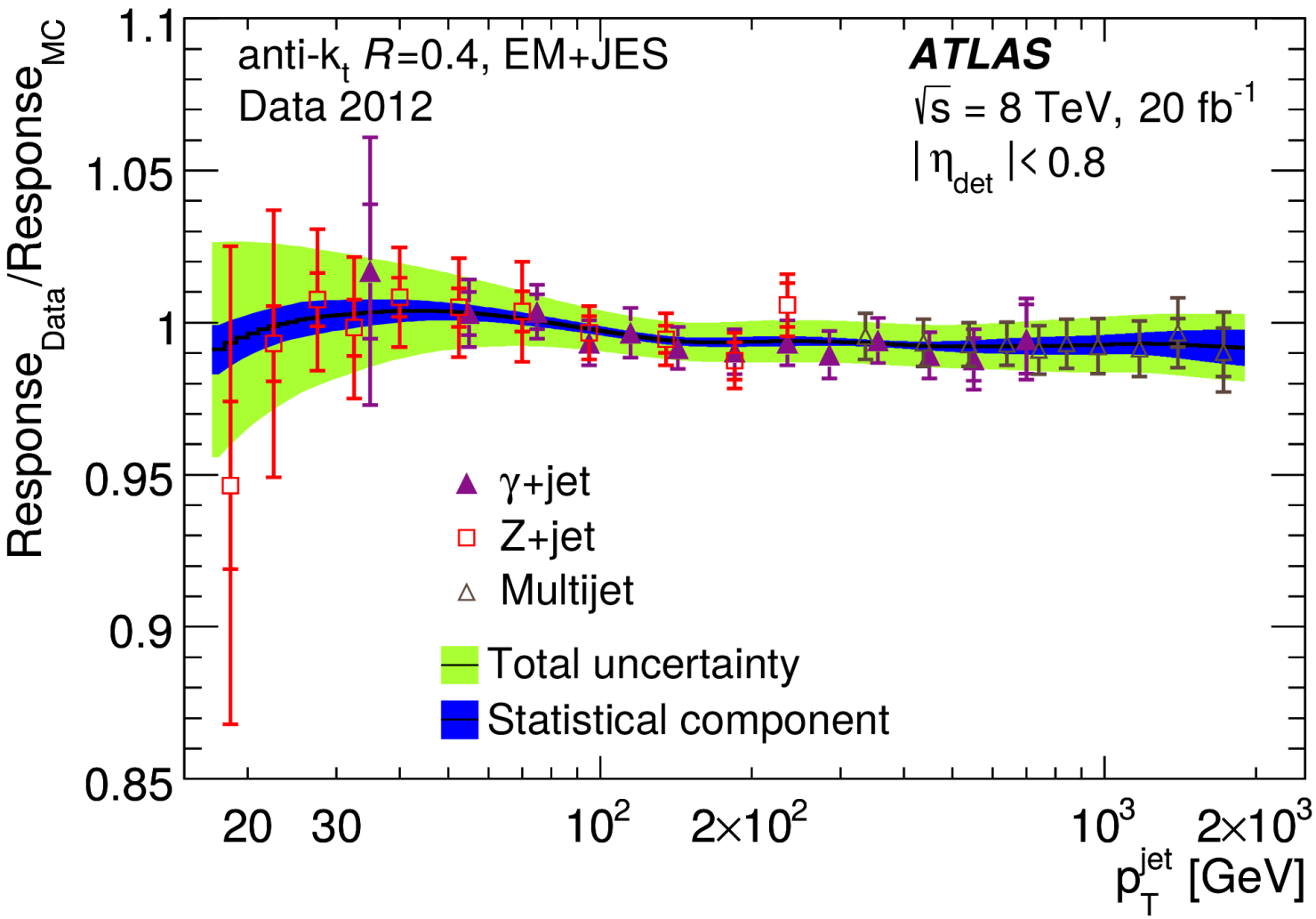


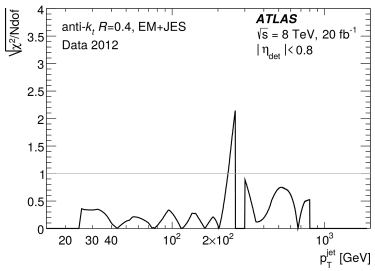




## Multi-jet balance

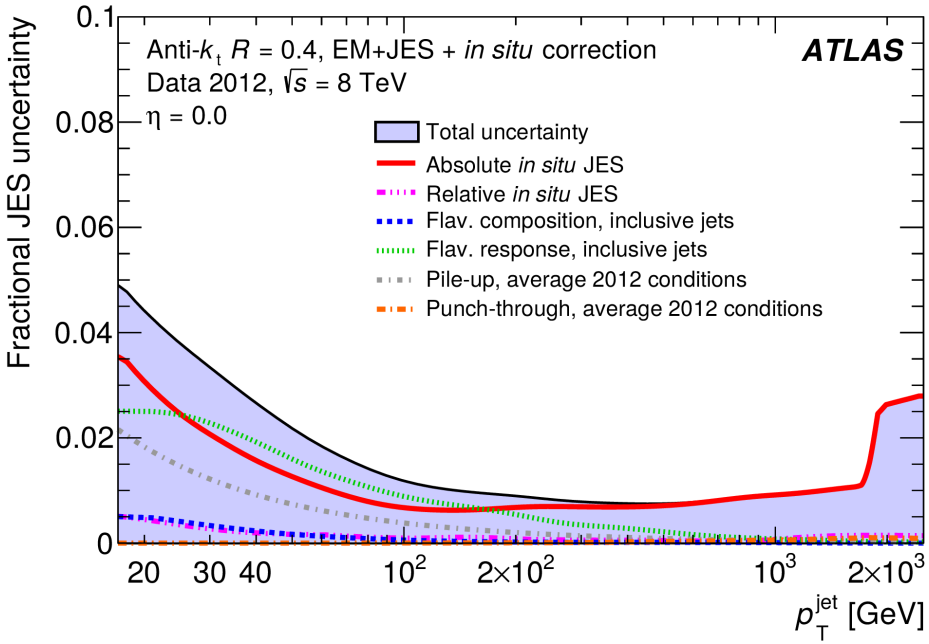


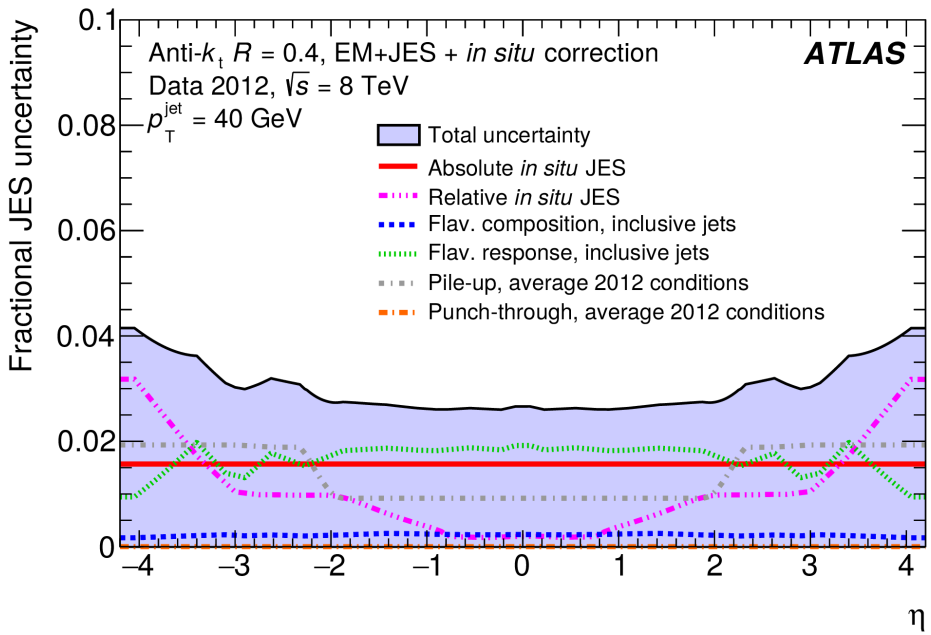
# Combination



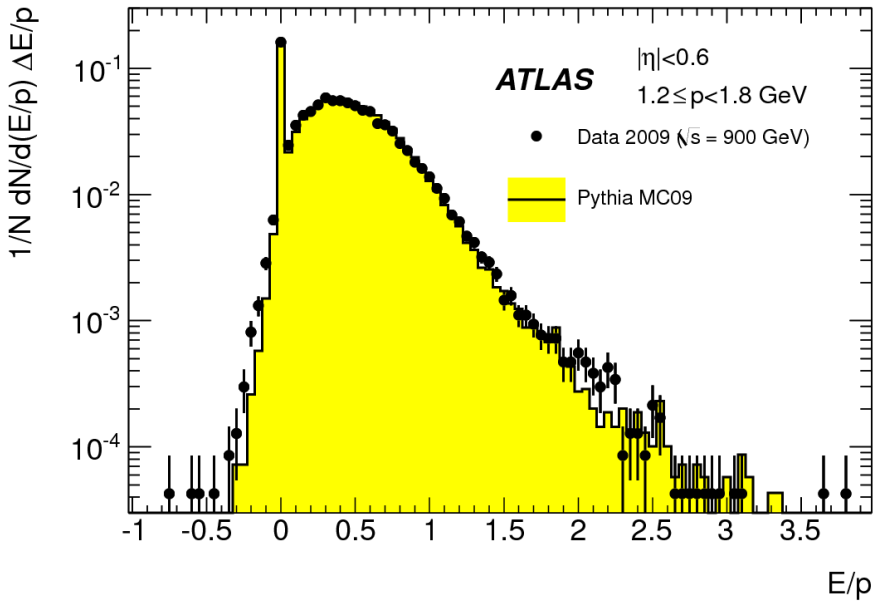



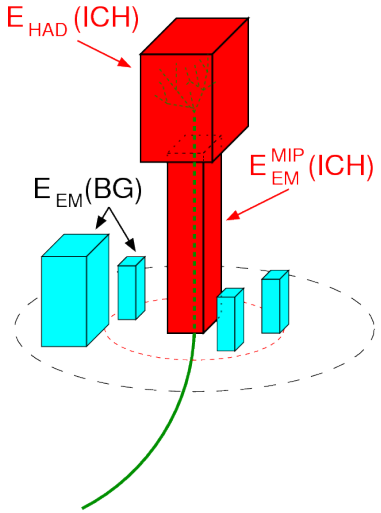
# Final JES precision

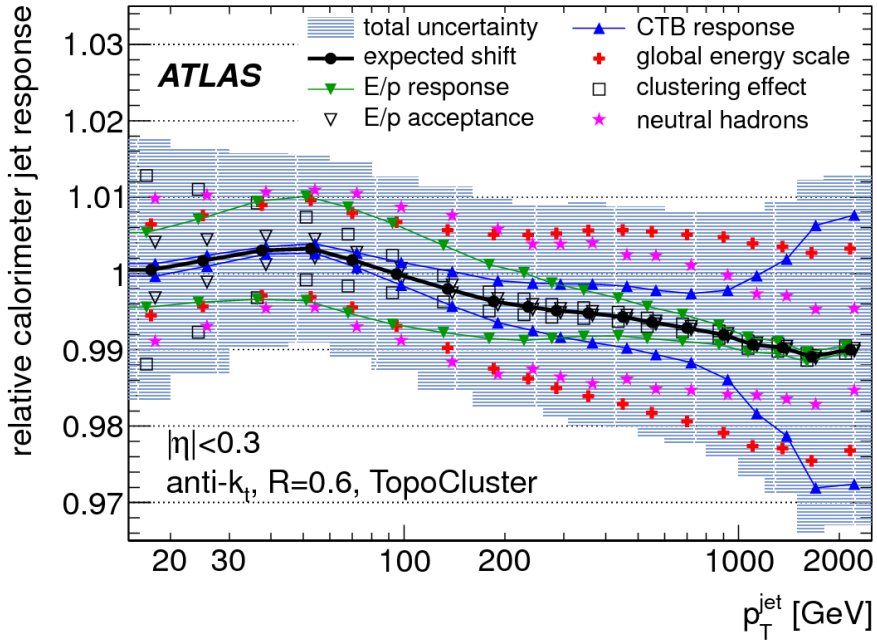


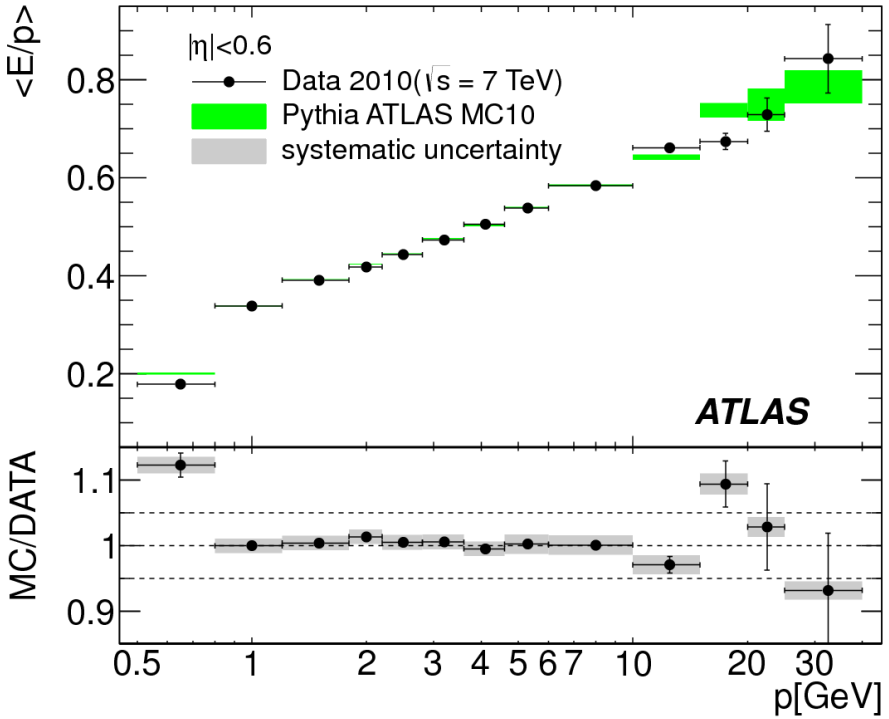



# Final JES precision single particles



# Final JES precision

| Name | Description | Category |
|---|---|---|
| $Z$+jet | | |
| $e$ $E$-scale material | Material uncertainty in electron energy scale | det. |
| $e$ $E$-scale presampler | Presampler uncertainty in electron energy scale | det. |
| $e$ $E$-scale baseline | Baseline uncertainty in electron energy scale | mixed |
| $e$ $E$-scale smearing | Uncertainty in electron energy smearing | mixed |
| $\mu$ $E$-scale baseline | Baseline uncertainty in muon energy scale | det. |
| $\mu$ $E$-scale smearing ID | Uncertainty in muon ID momentum smearing | det. |
| $\mu$ $E$-scale smearing MS | Uncertainty in muon MS momentum smearing | det. |
| MC generator | Difference between MC generators | model |
| JVF | JVF choice | mixed |
| $\Delta\phi$ | Extrapolation in $\Delta\phi$ | model |
| Out-of-cone | Contribution of particles outside the jet cone | model |
| Subleading jet veto | Variation in subleading jet veto | model |
| Statistical components | Statistical uncertainty | stat./meth. |
| $\gamma$+jet | | |
| $\gamma$ $E$-scale material | Material uncertainty in photon energy scale | det. |
| $\gamma$ $E$-scale presampler | Presampler uncertainty in photon energy scale | det. |
| $\gamma$ $E$-scale baseline | Baseline uncertainty in photon energy scale | det. |
| $\gamma$ $E$-scale smearing | Uncertainty in photon energy smearing | det. |
| MC generator | Difference between MC generators | model |
| $\Delta\phi$ | Extrapolation in $\Delta\phi$ | model |
| Out-of-cone | Contribution of particles outside the jet cone | model |
| Subleading jet veto | Variation in subleading jet veto | model |
| Photon purity | Purity of sample in $\gamma$+jets | det. |
| Statistical components | Statistical uncertainty | stat./meth. |
| Multijet balance | | |
| $\alpha$ selection | Angle between leading jet and recoil system | model |
| $\beta$ selection | Angle between leading et and closest subleading jet | model |
| MC generator | Difference between MC generators (fragmentation) | mixed |
| $p_{\mathrm{T}}$ asymmetry selection | Asymmetry selection between leading and subleading jet | model |
| Jet $p_{\mathrm{T}}$ threshold | Jet $p_{\mathrm{T}}$ threshold | mixed |
| Statistical components | Statistical uncertainty | stat./meth. |