MULTIJET CROSS SECTIONS AT THE LHC

Christine McLean,
on behalf of the CMS and ATLAS collaborations

DPF 2019
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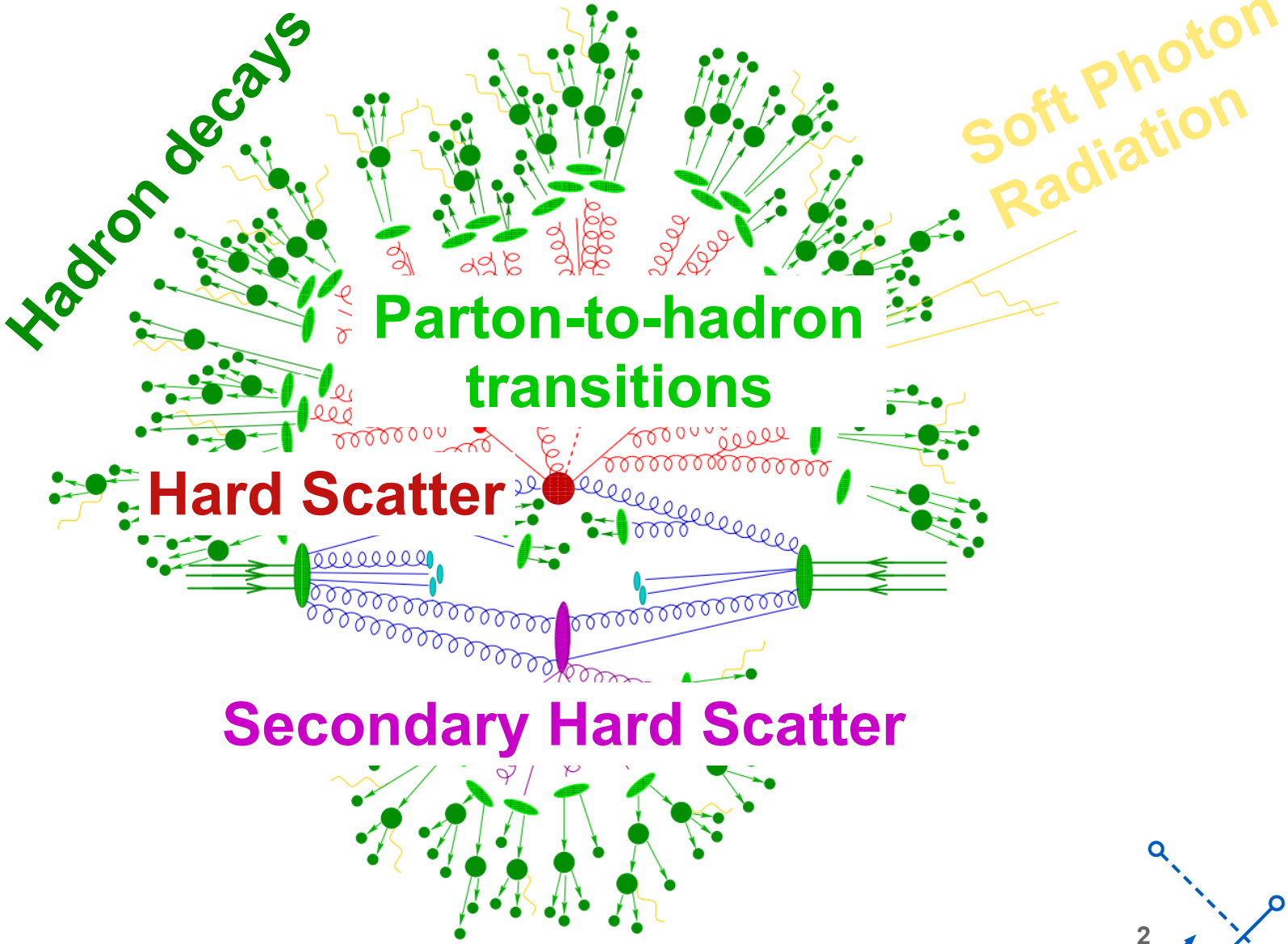
University at Buffalo The State University of New York

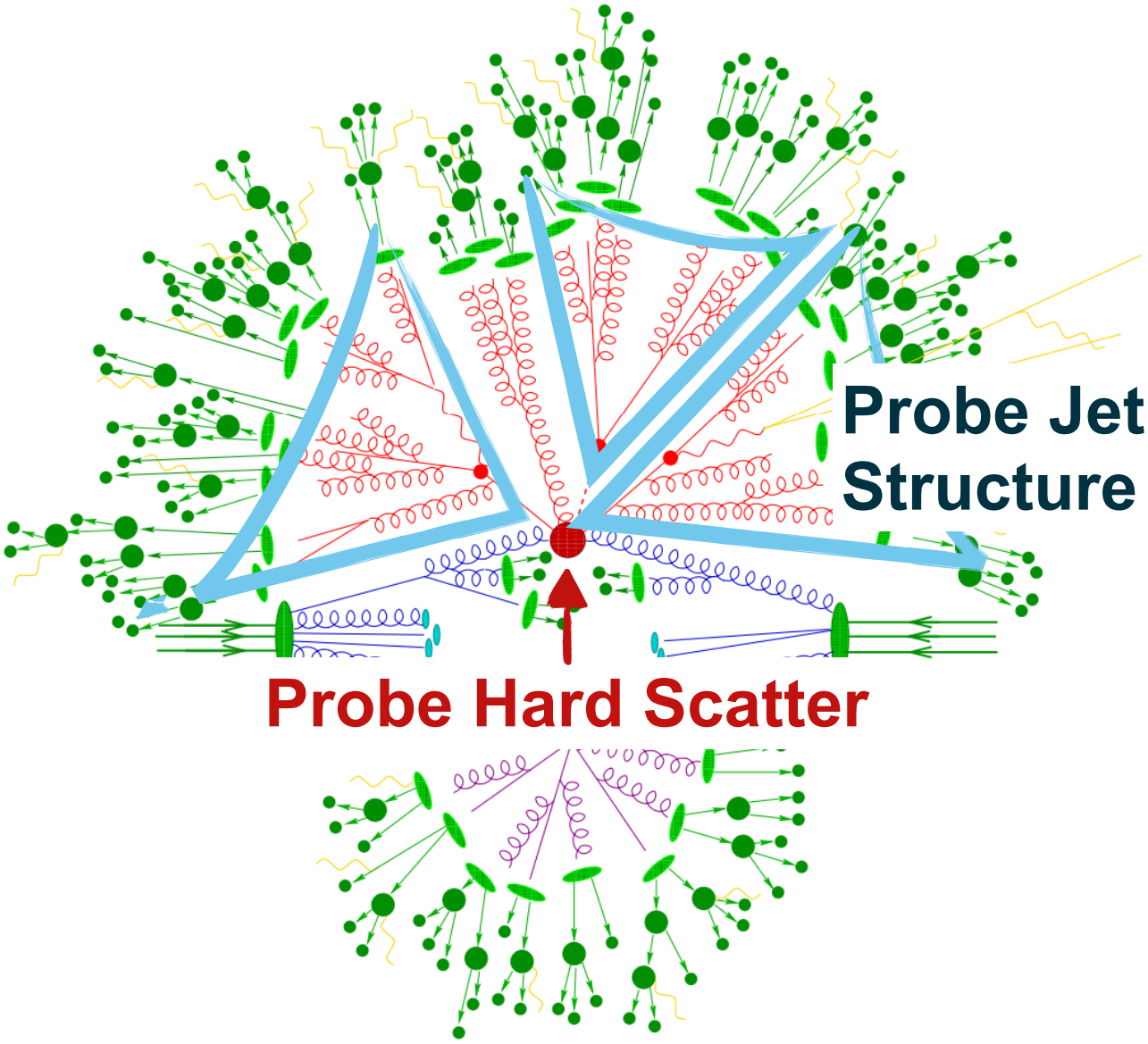
QCD

1411.4085

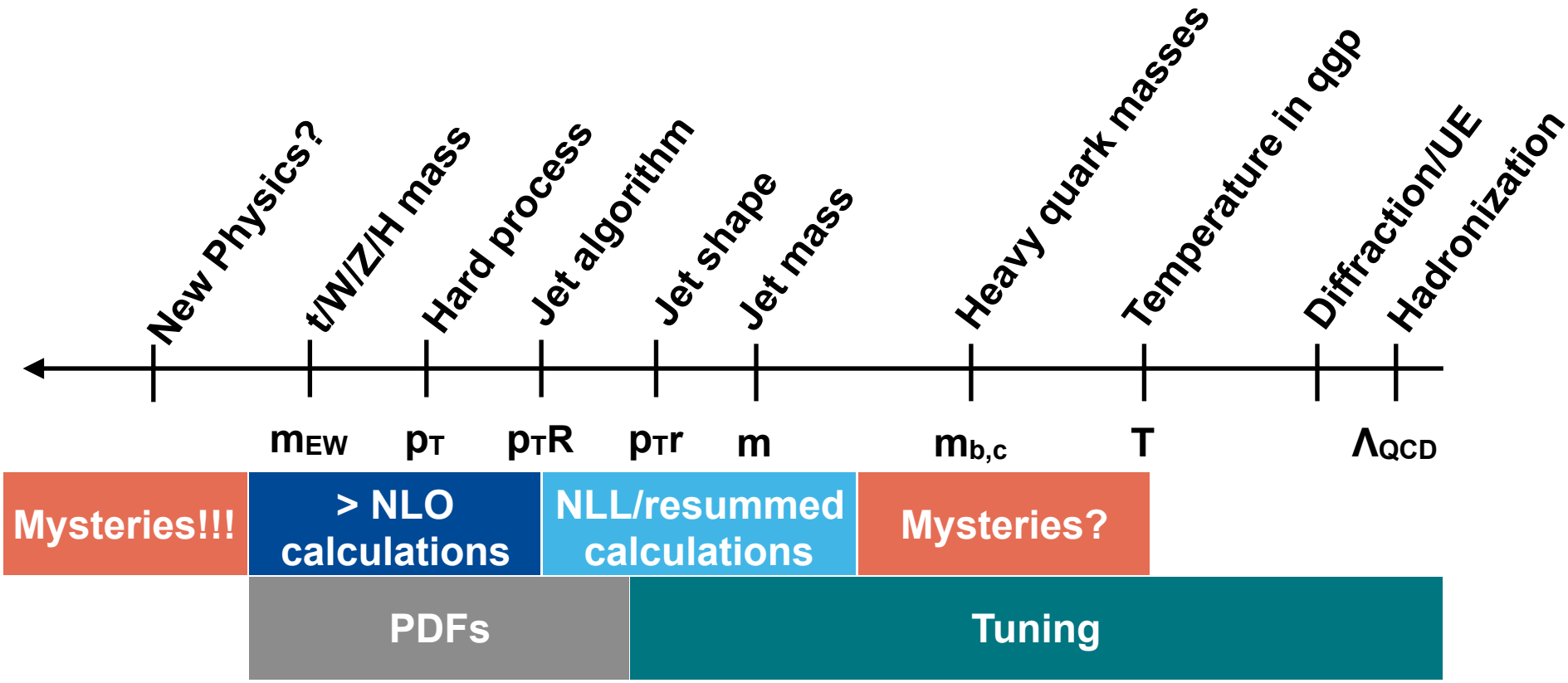


This Talk: Jets

1411.4085



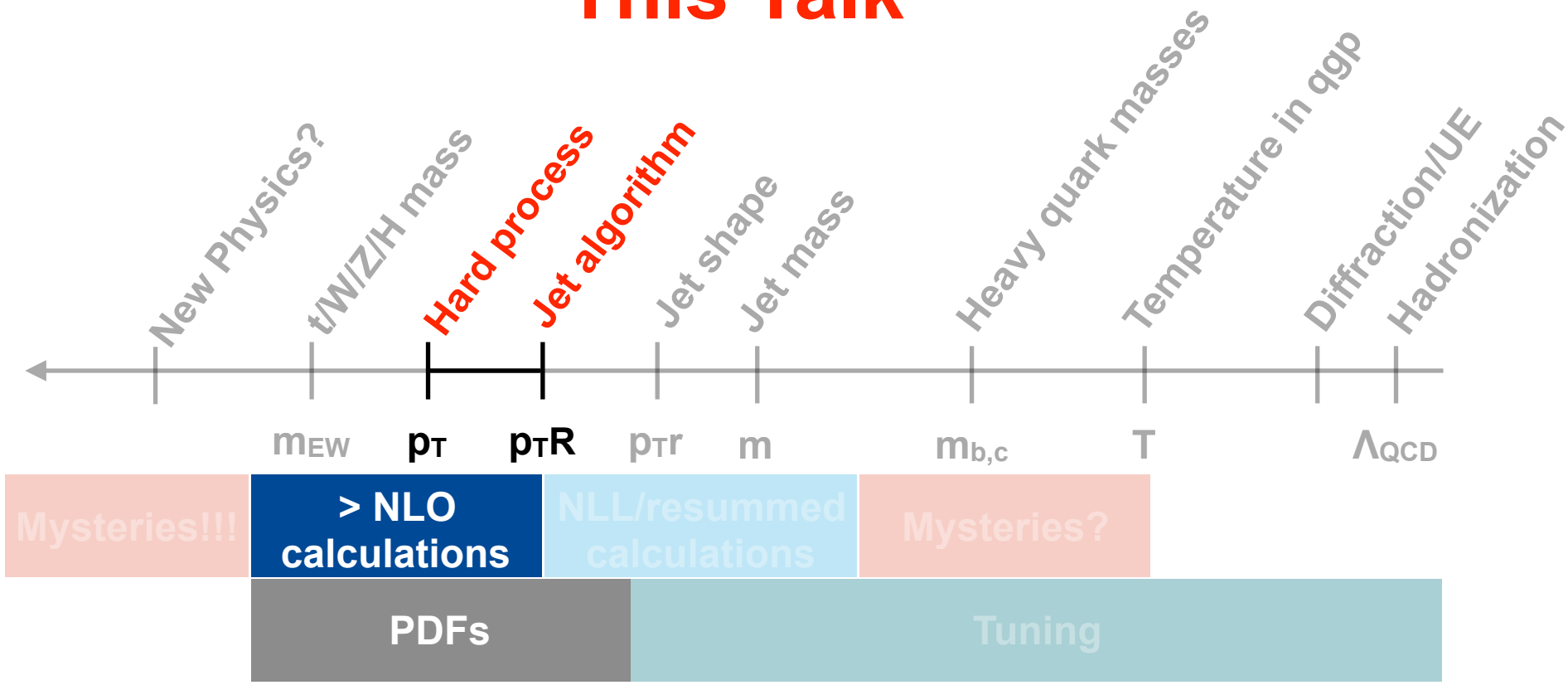
QCD at the LHC



H/T Y.-T. Chien, S. Rappoccio

Jet Production Cross Sections

This Talk

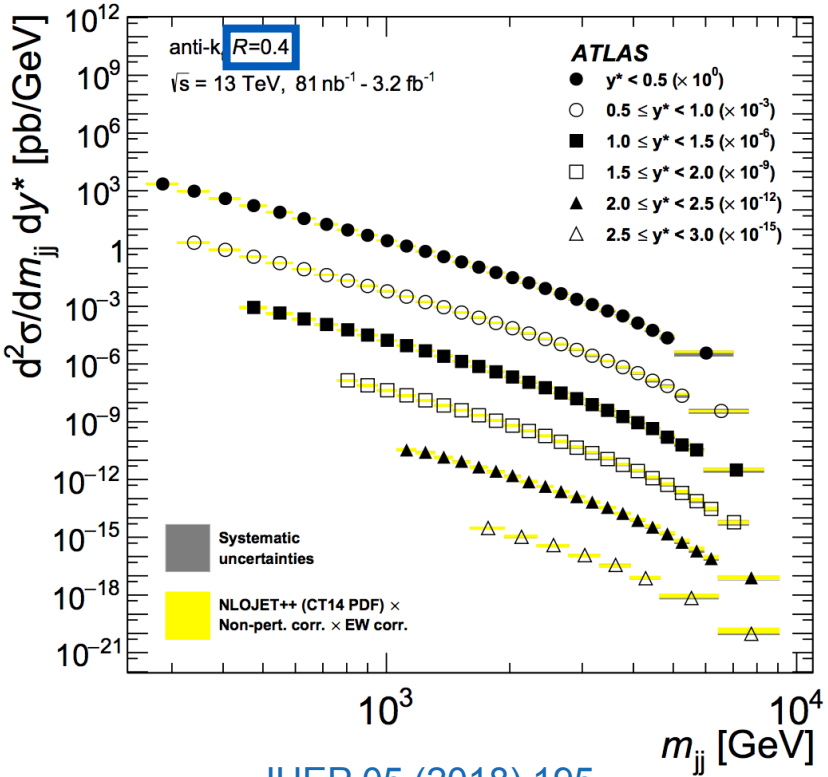


Jet substructure: see M. LeBlanc's talk

Dijet Cross Section

Test predictions of pQCD at high energy

ATLAS: 13 TeV double differential xs



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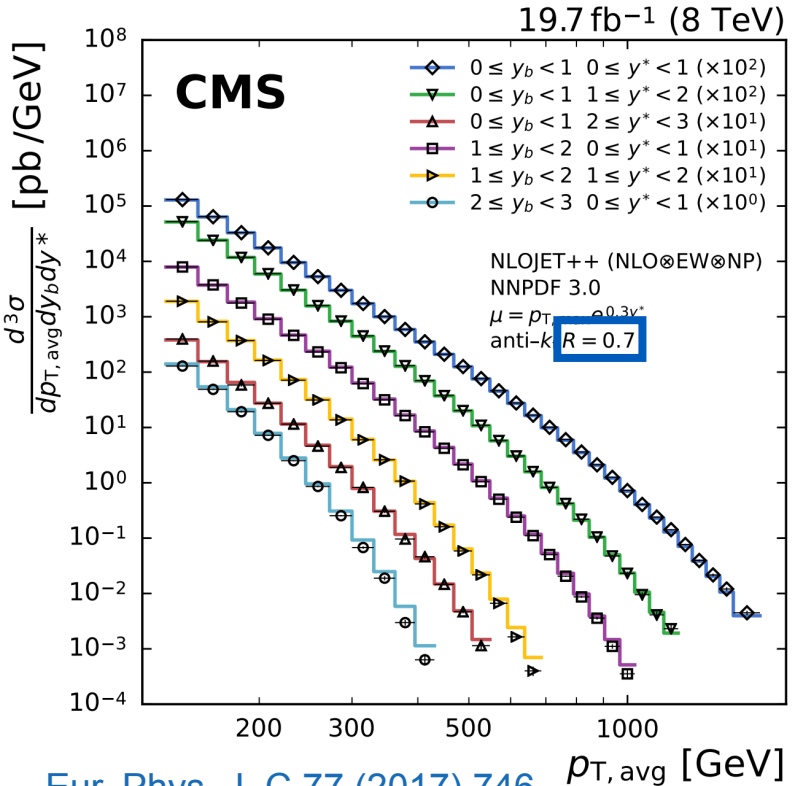
CMS: 8 TeV triple differential xs



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$$y^* = |y_1 - y_2|/2 \qquad p_{T,avg} = (p_{T,1} + p_{T,2})/2 \qquad y_b = |y_1 + y_2|/2$$

Dijet Cross Section

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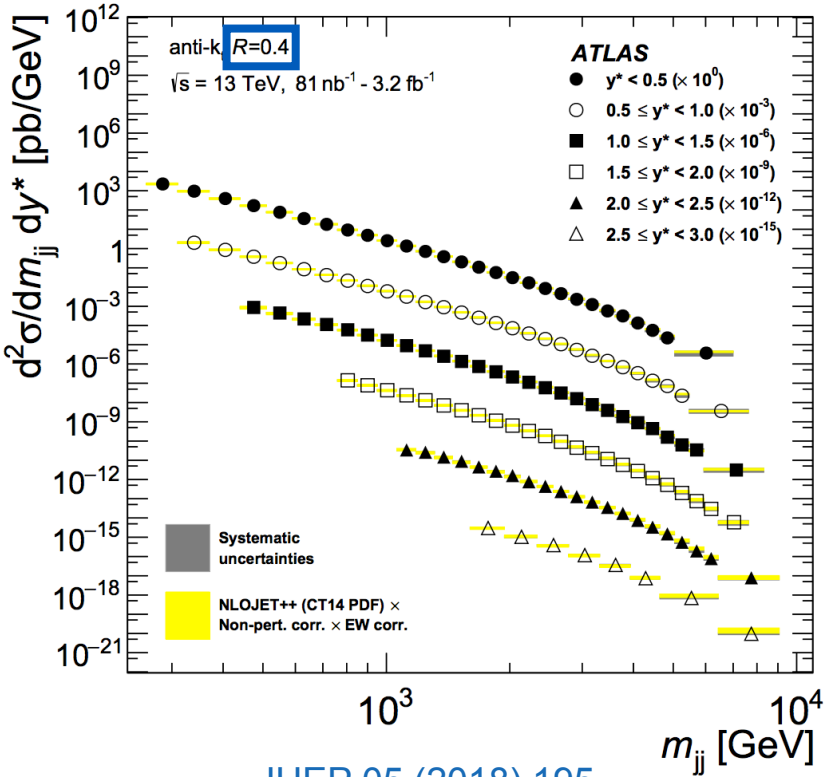

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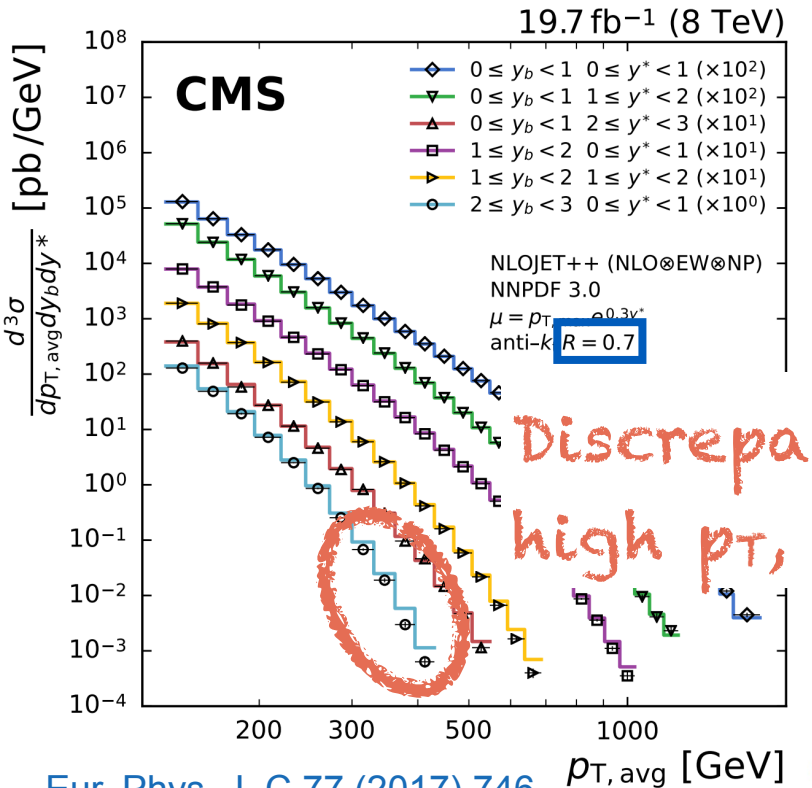

Discrepancy at high p_T, boost

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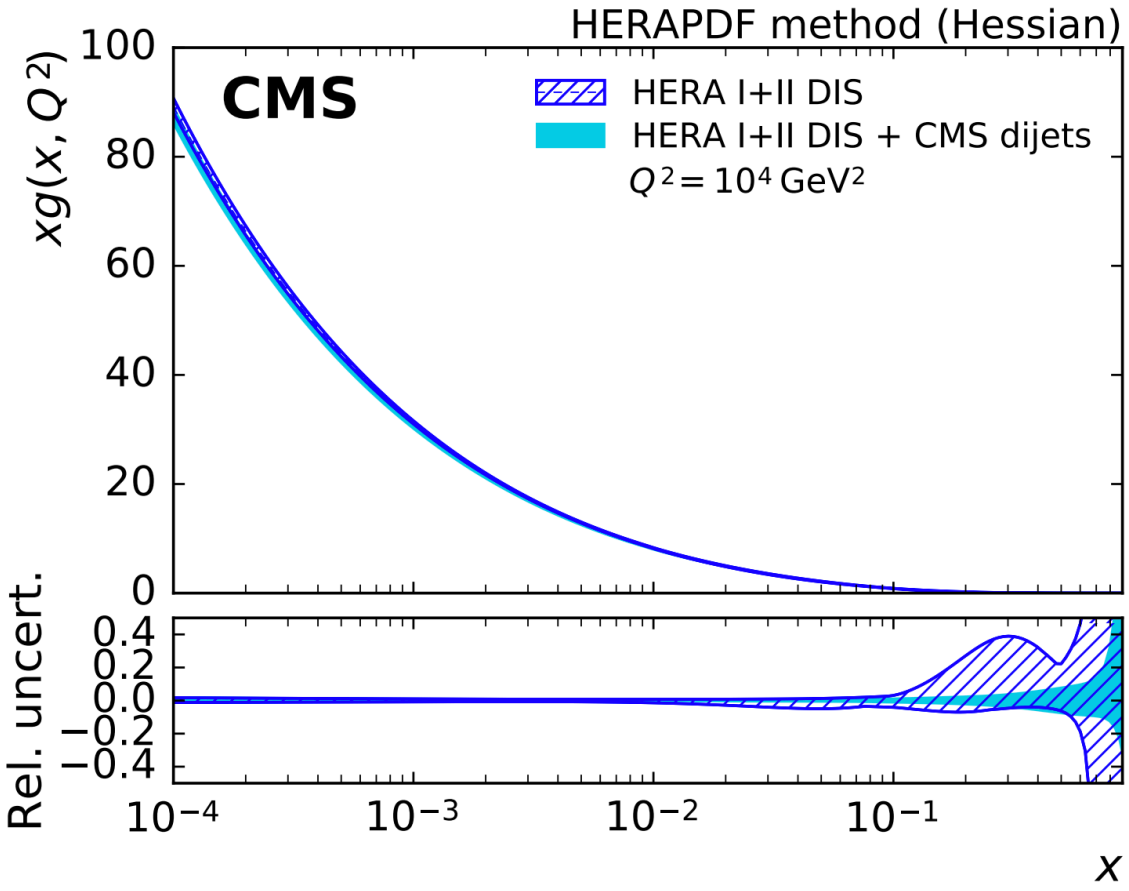
Dijet Cross Section

Constrain PDFs, measure α_S

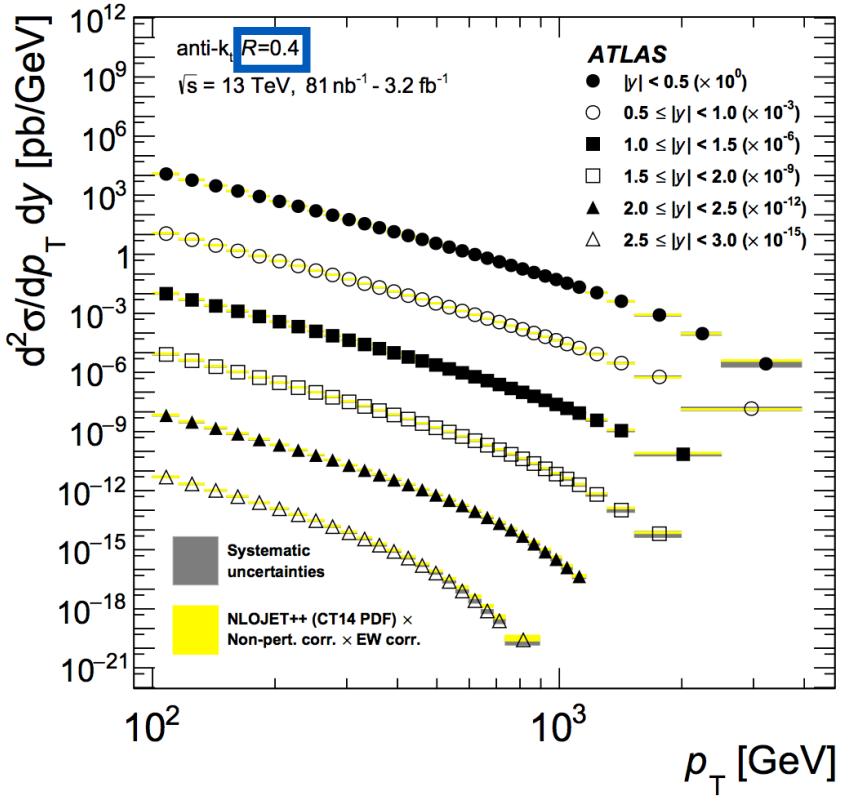


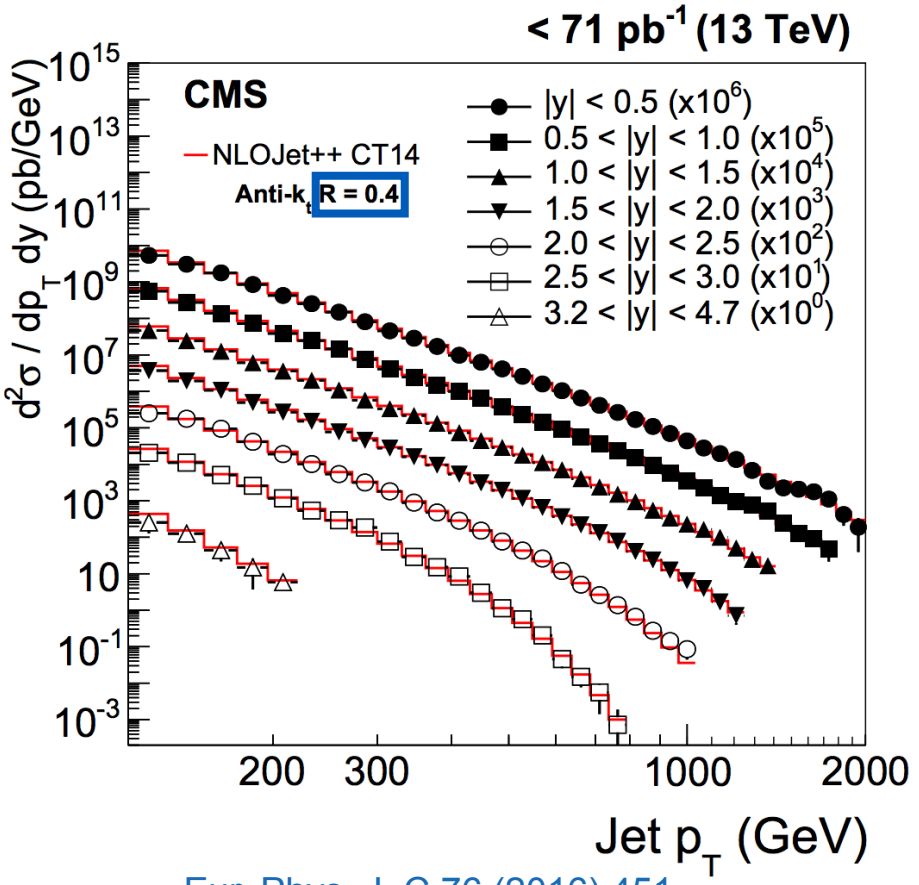
CMS dijet data reduces gluon PDF uncertainty at high x

$$\alpha_S(M_Z) = 0.1199 \pm 0.0015\,(\mathrm{exp})\,{}^{+0.0031}_{-0.0020}\,(\mathrm{theo})$$

Inclusive Jet Cross Section

ATLAS, CMS: 13 TeV double differential xs





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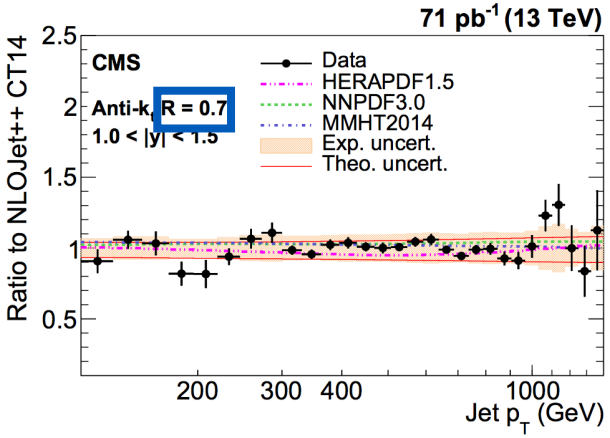
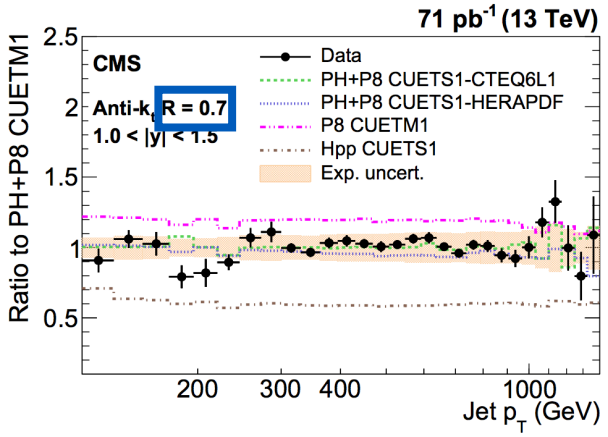
Data/prediction appear to agree relatively well

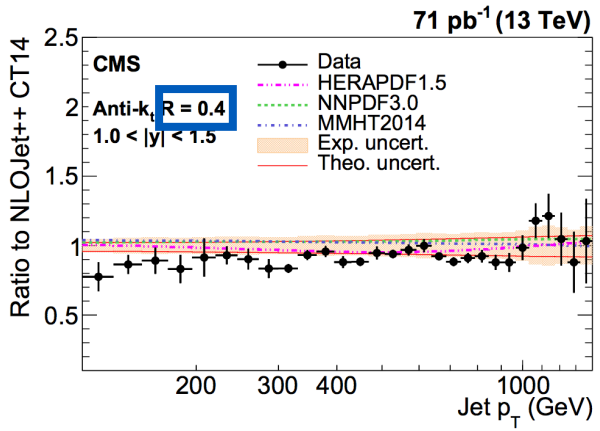
Eur. Phys. J. C 76 (2016) 451

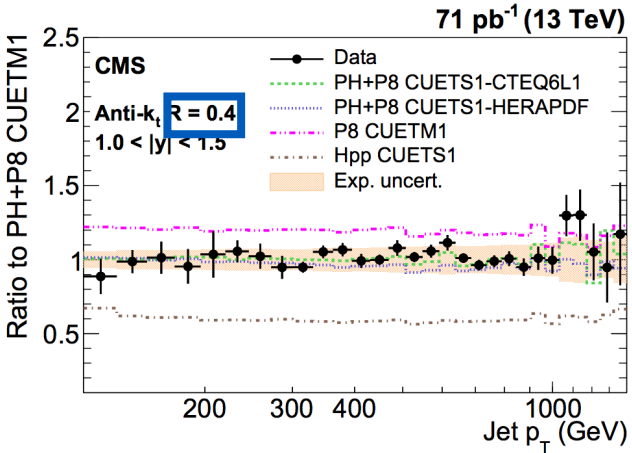
Inclusive Jet Cross Section

- **Closer look at CMS results**
  - Fixed-order NLO predictions + NP, EW corrections (NLOJet++)
    - Overestimates R=0.4 due to missing PS, soft-gluon resummation contributions
  - NLO predictions matched to parton showers (PH+P8) more effective overall



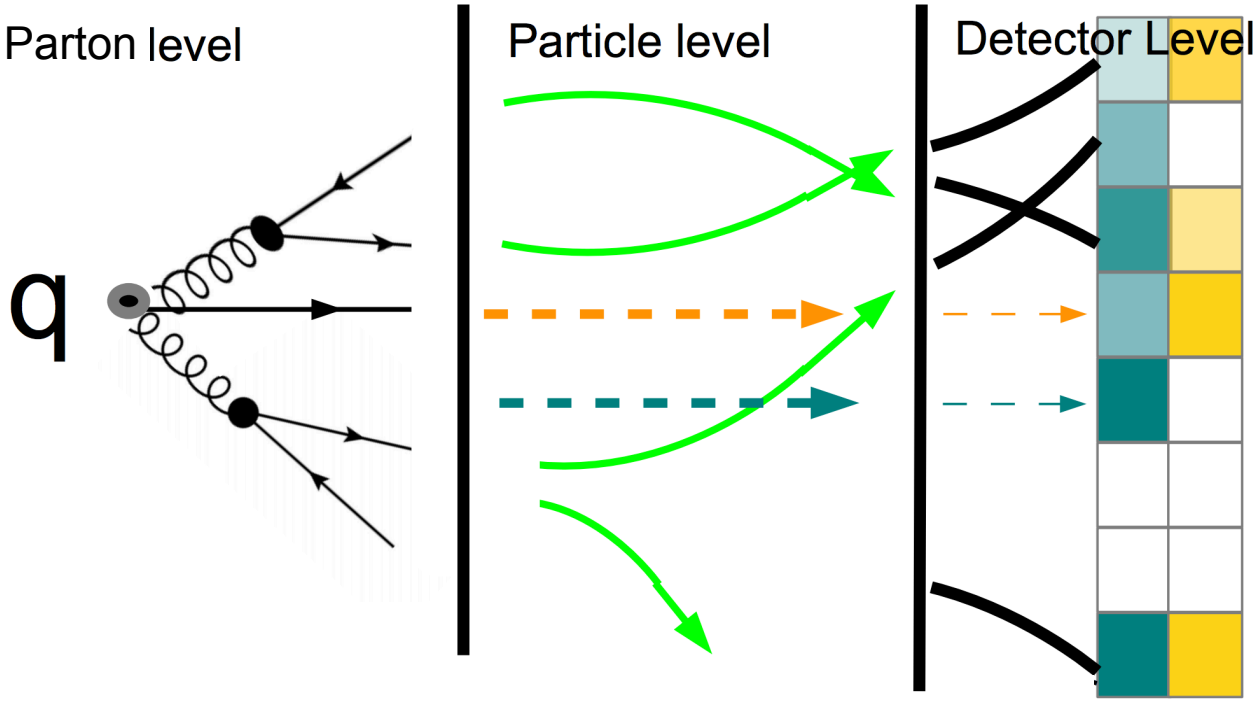




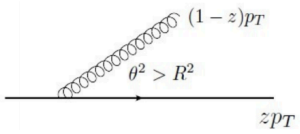


Jet Cone Size Matters

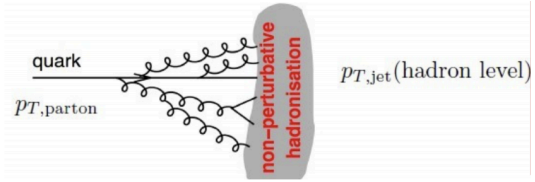
Measure jets with different cone sizes to probe different aspects of parton evolution



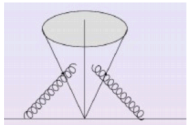
Parton shower: $(\delta p_T)_{PS} \sim \ln R^{-1}$



Hadronization: $(\delta p_T)_{HAD} \sim R^{-1}$



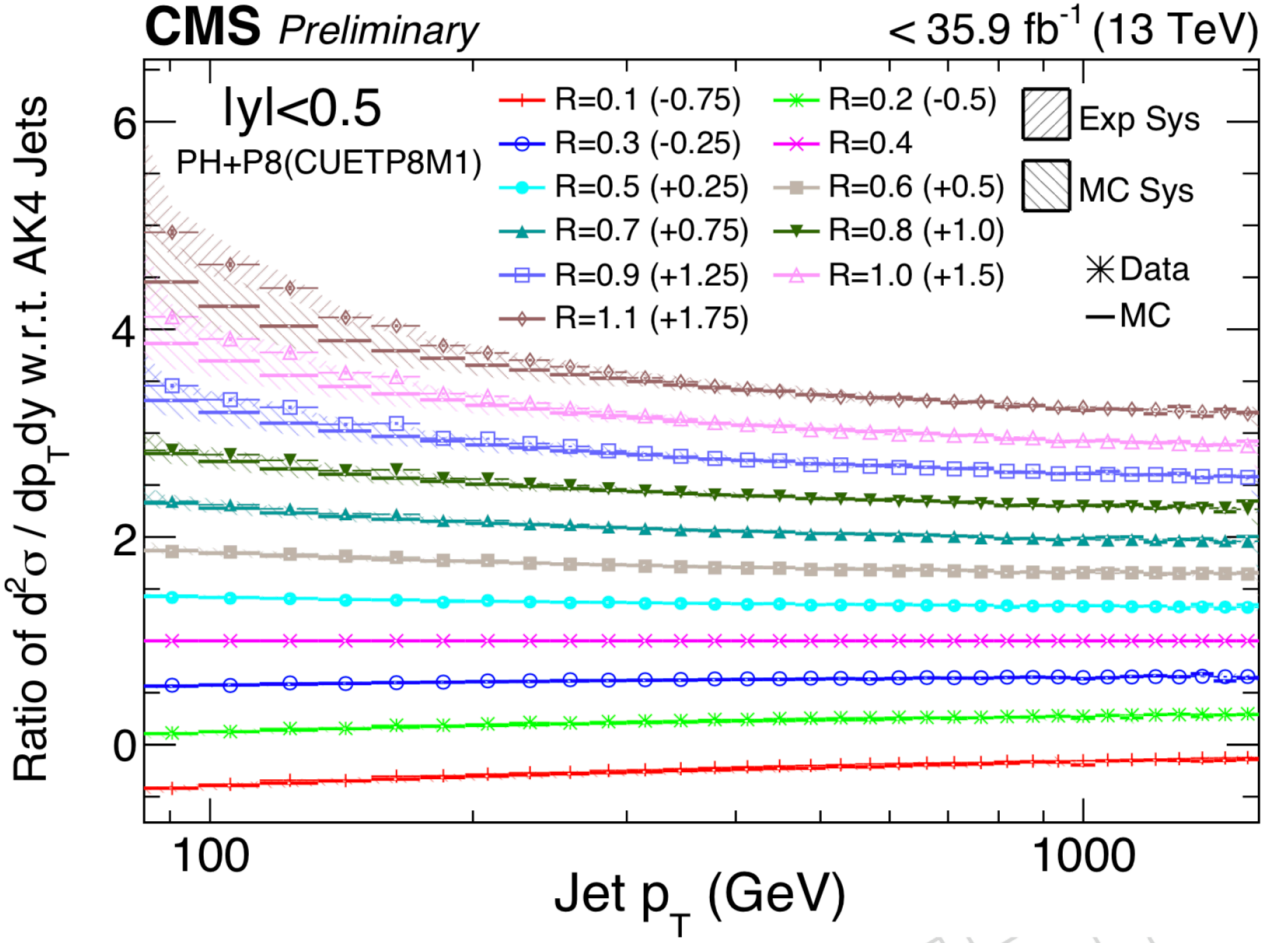
Underlying-event (MPI): $(\delta p_T)_{UE} \sim R^2$



H/T P. Harris, P. Gunnellini

Radius Scan

Test dependence of jet production xs on anti-k_T distance parameter



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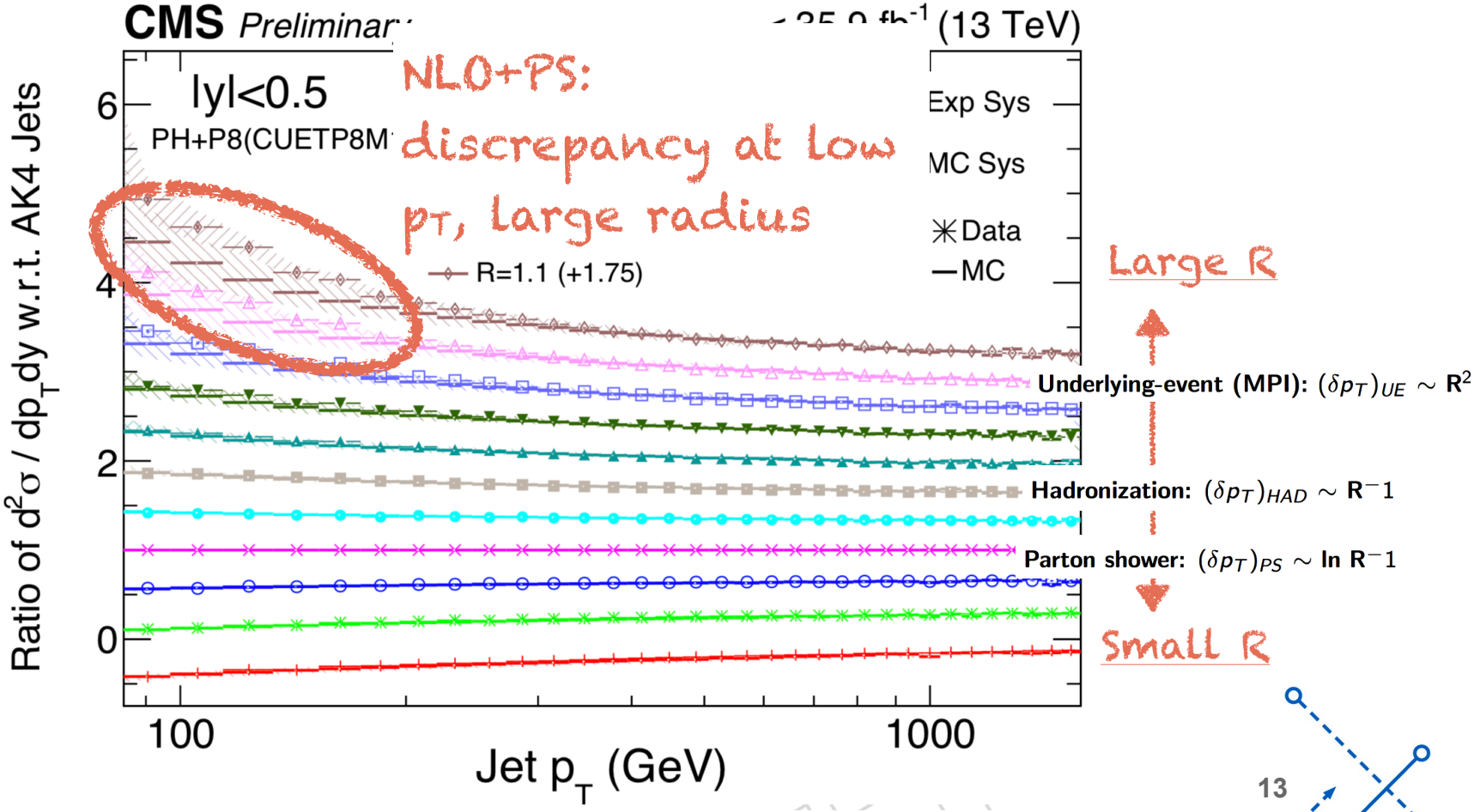
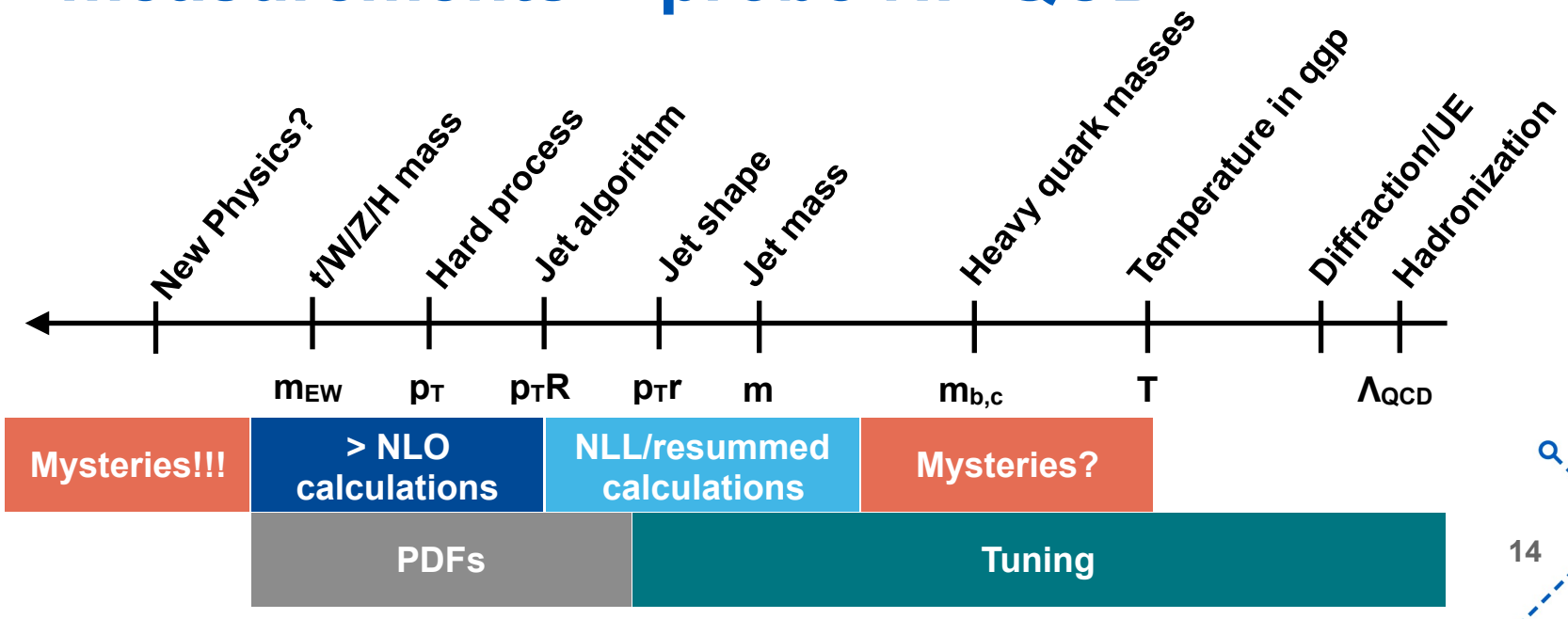
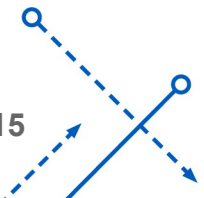


Jets at the LHC

- **Jet cross section measurements give us a handle on QCD**
  - pQCD, α_s, PDFs, …
- **Different jet cone sizes probe different regions of QCD**
- **See Matt's talk for jet substructure measurements - probe NP QCD**

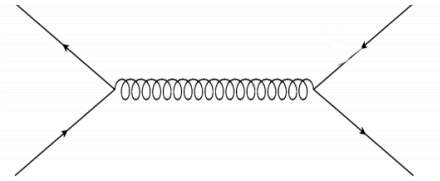


Additional Material



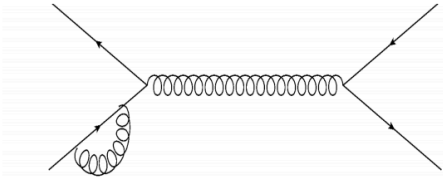
Generators

- PYTHIA8: 2→ 2 parton production @ LO + PS and UE
- HERWIG++ 2.7: 2→ 2 parton production @ LO + PS and UE
- HERWIG 7: 2→ 2 parton production @ NLO + PS and UE
- MADGRAPH_AMC@NLO+PYTHIA8: 2→ 2+n (with n<3) parton production @ LO + PS and UE
- POWHEG+PYTHIA8: 2→ 2 parton production @ NLO + PS and UE
- POWHEG+HERWIG++: 2→ 2 parton production @ NLO + PS and UE
- NLOJET++: 2→ 2 dijet production @ NLO



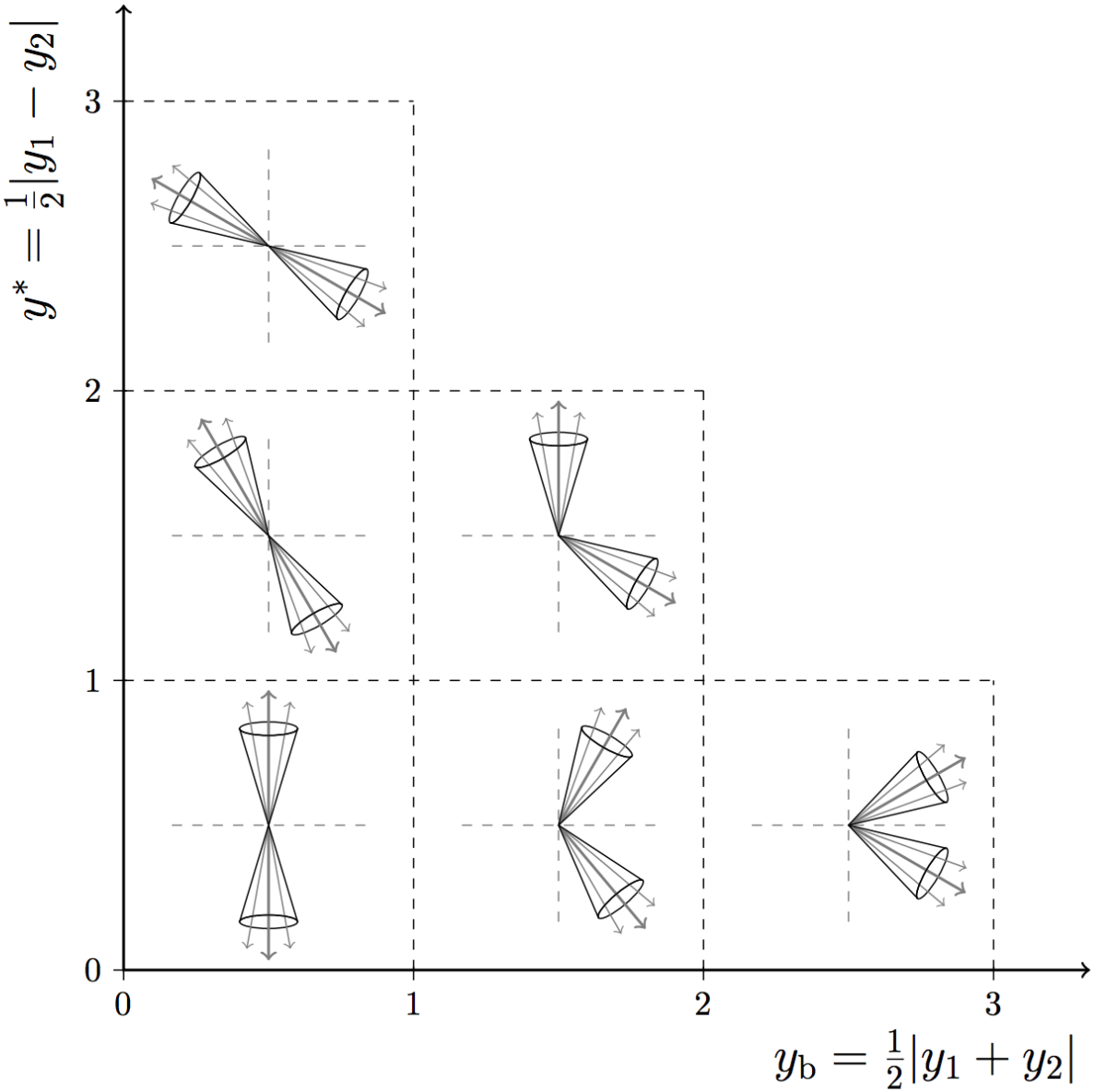
Leading order process

Real correction

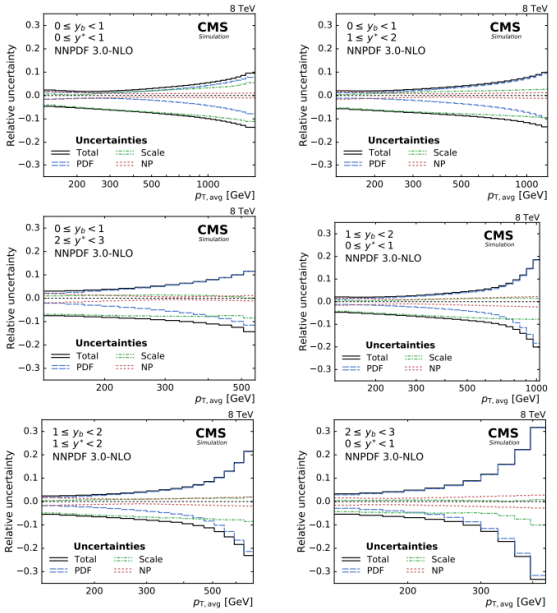


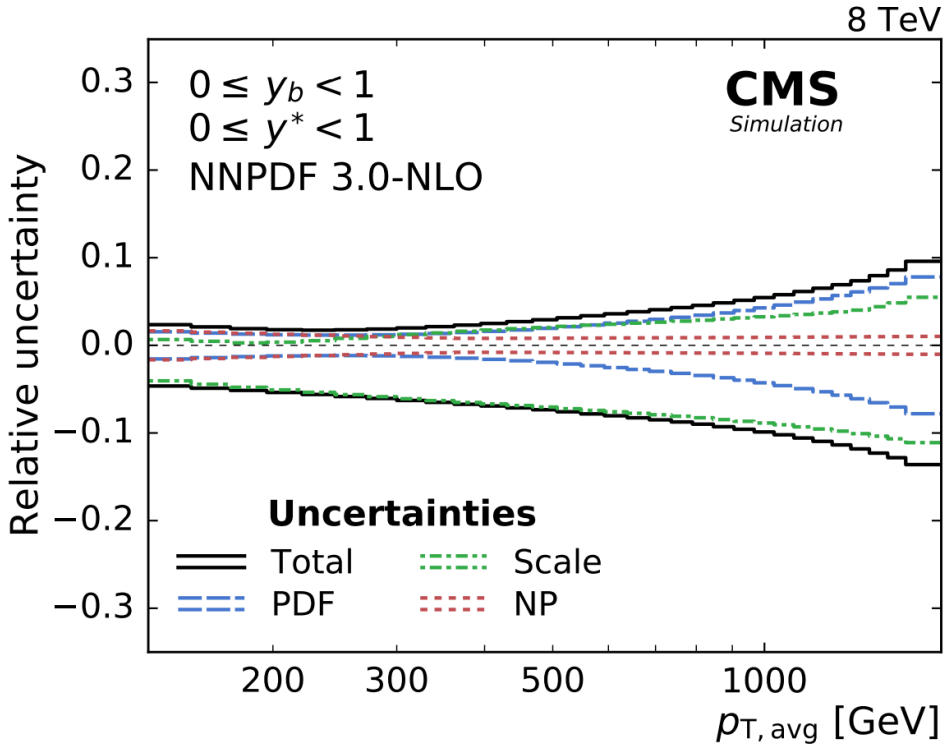
Virtual correction

CMS Dijet Cross Section



3D dijets: Theoretical uncertainties





- no uncertainties in the EW corrections are assigned

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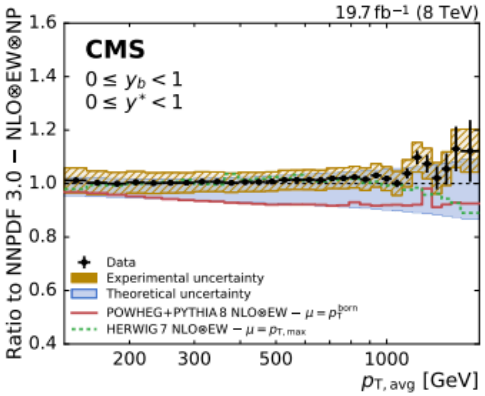
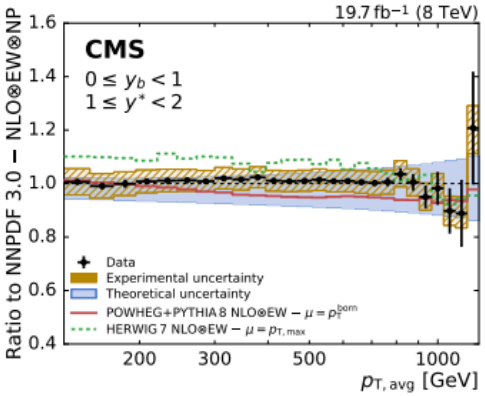
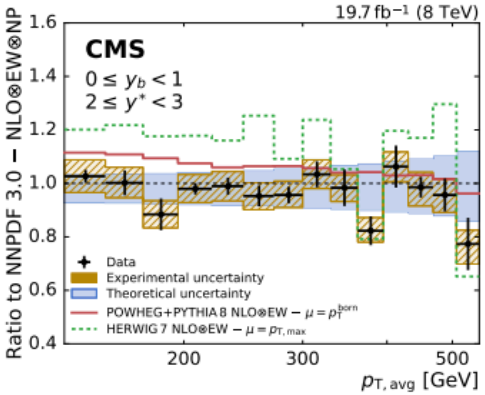
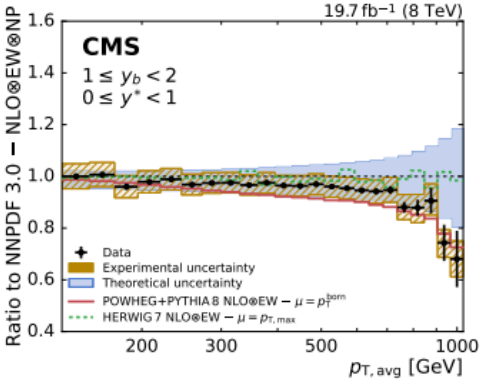
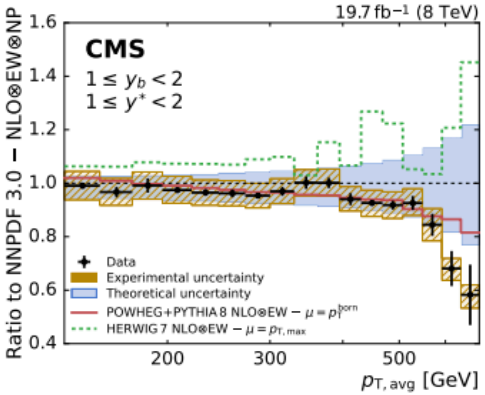
CMS Dijets: PDF Uncertainties

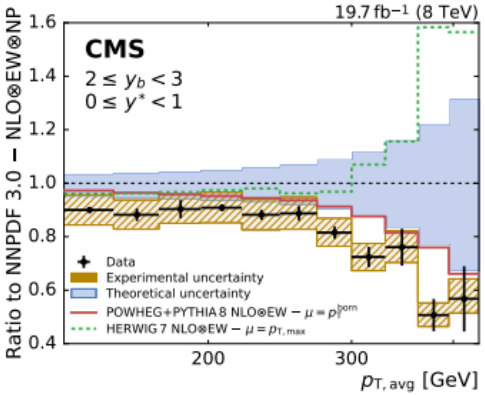




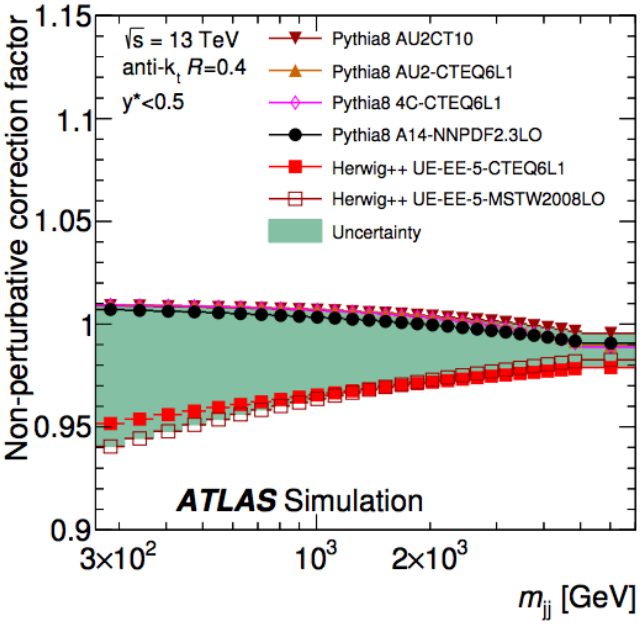


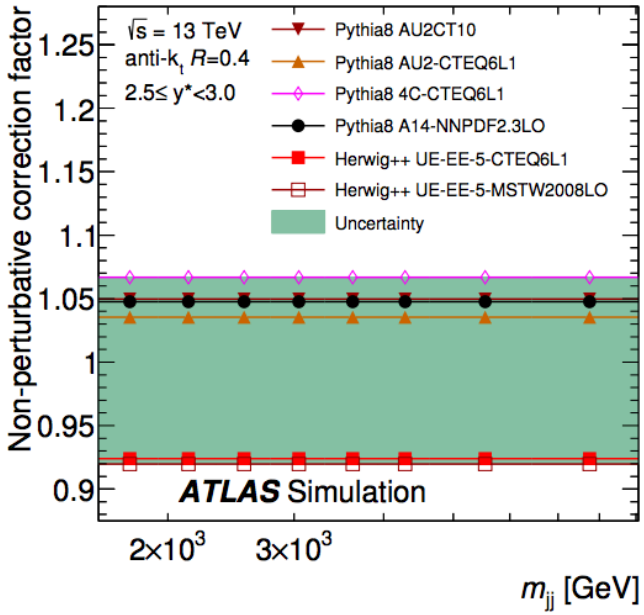


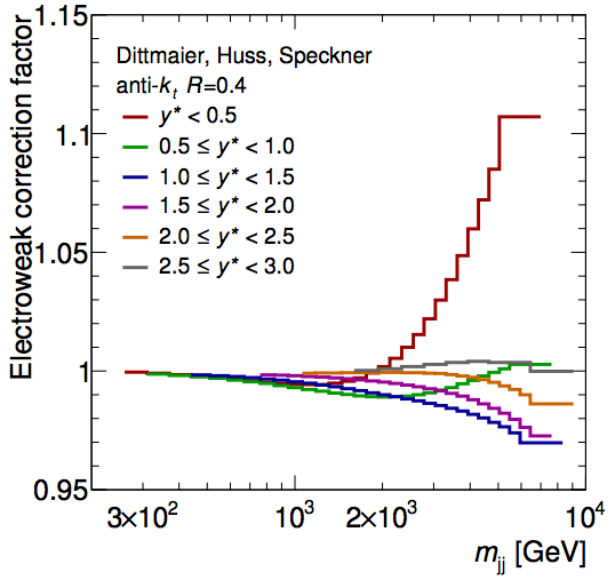




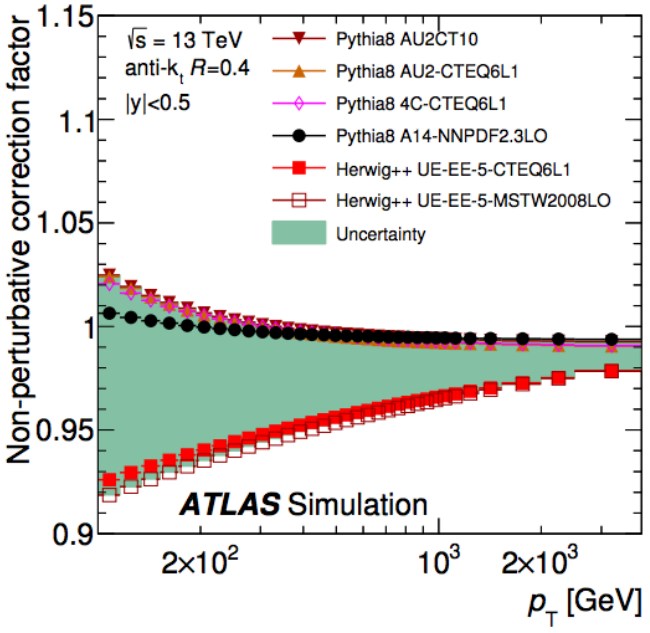
ATLAS Dijets: Theory Corrections

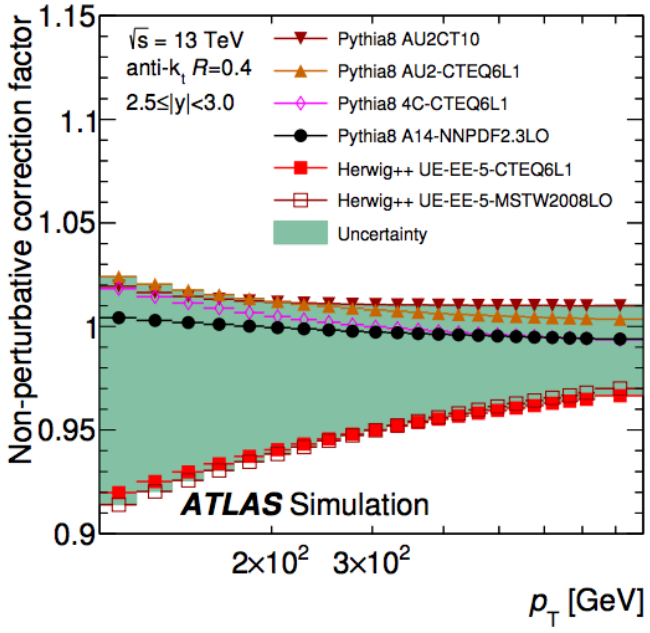


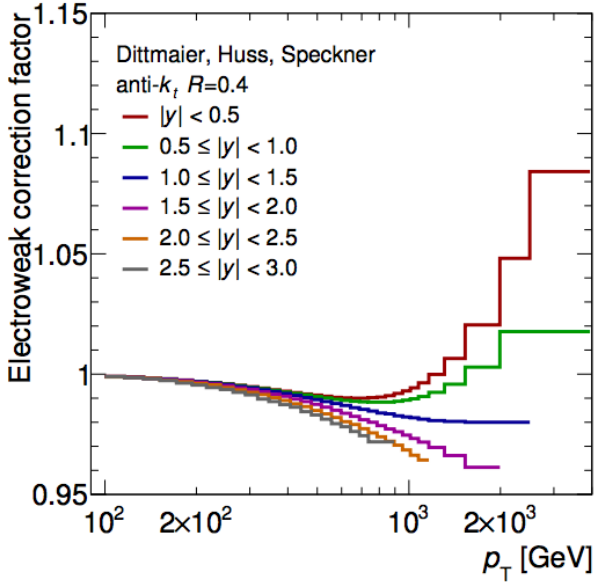




ATLAS Inclusive: Theory Corrections







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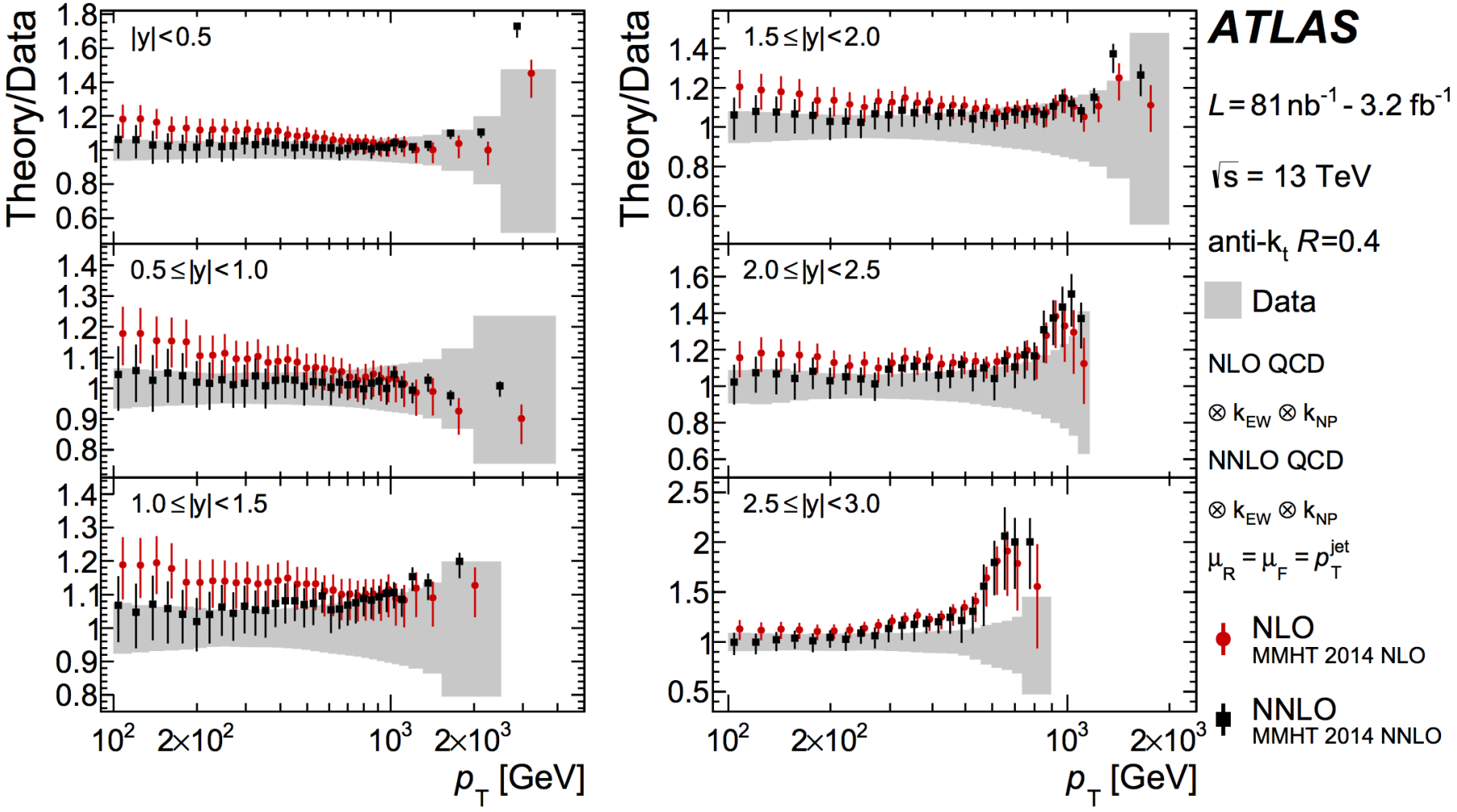
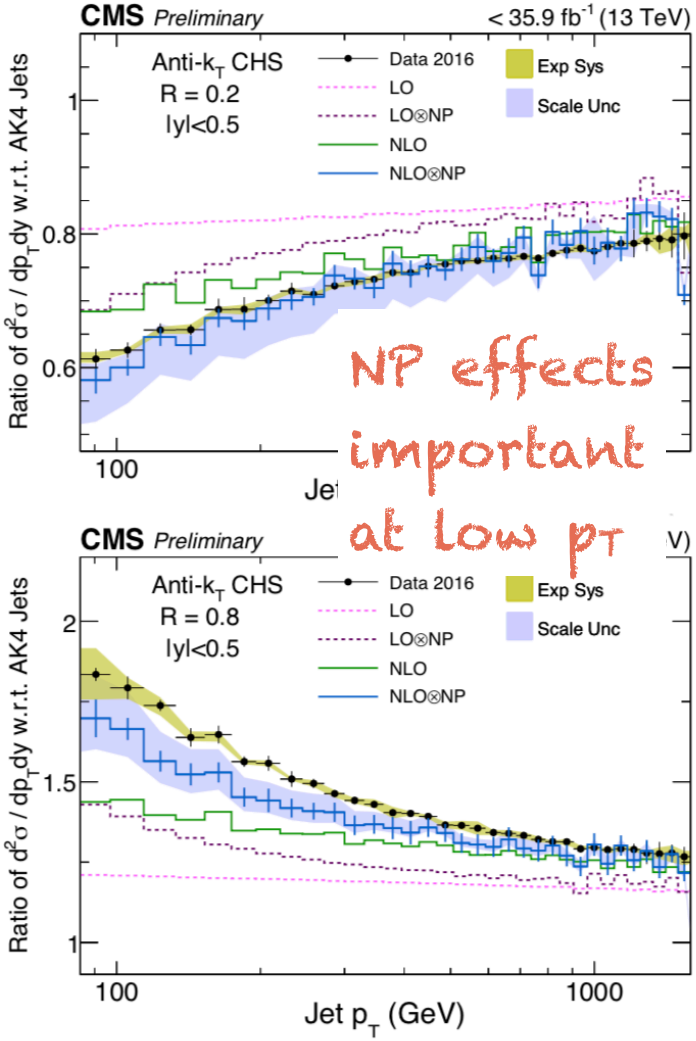
Jet Cross Sections



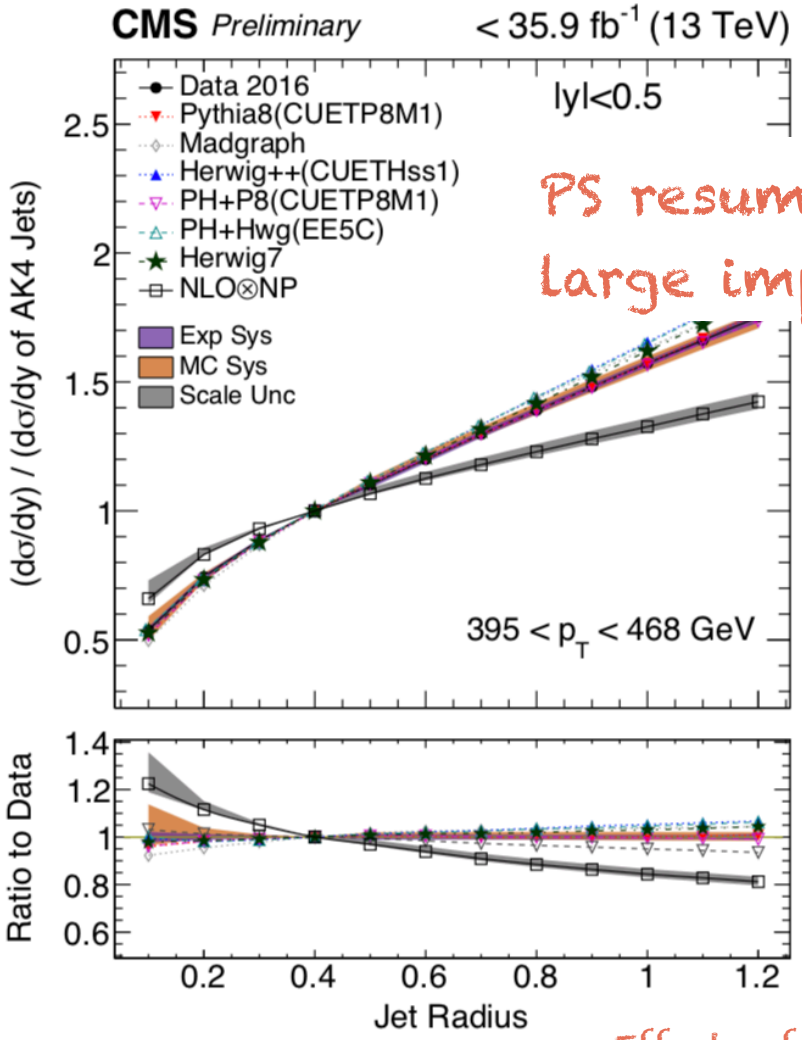
Radius Scan

Fixed order



NP effects important at low p_T

Fixed order vs MC with PS resummation



PS resummation: large impact

Soft radiation effects ⟷ Effects of hadronization, out-of-cone radiation