Standarad Model Physics

BOOST 2018

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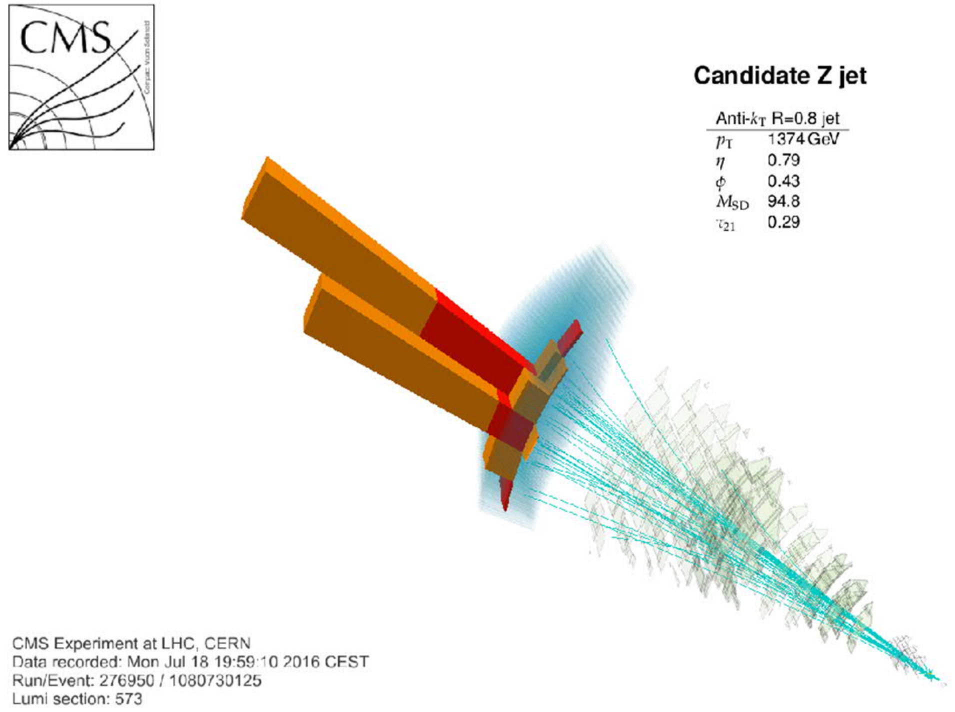
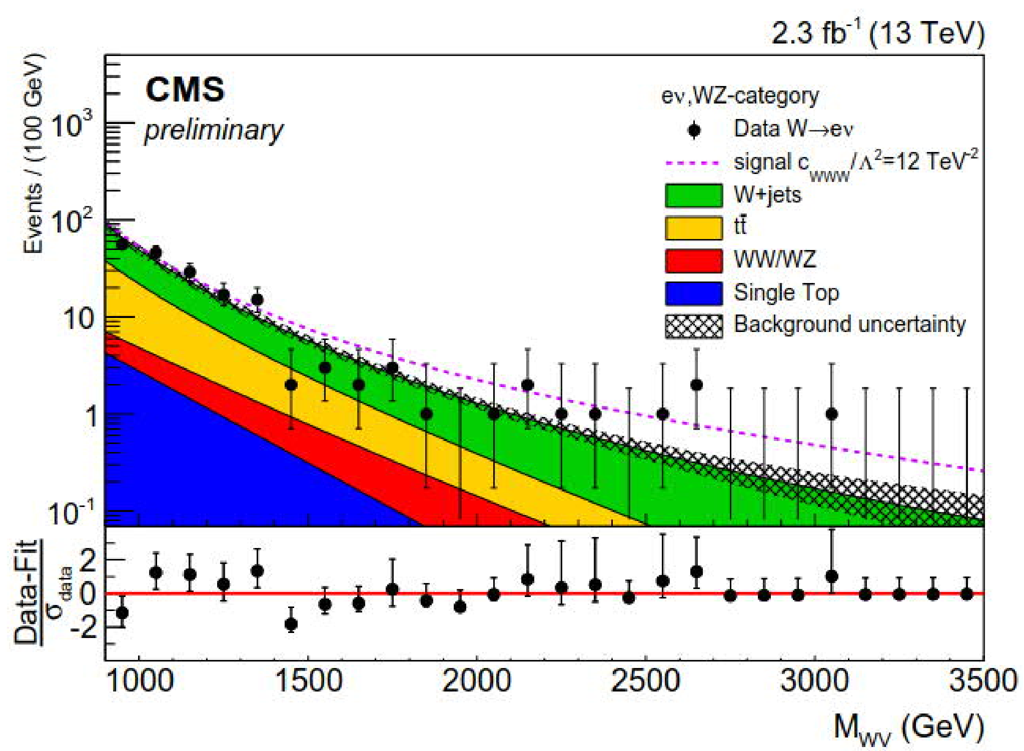
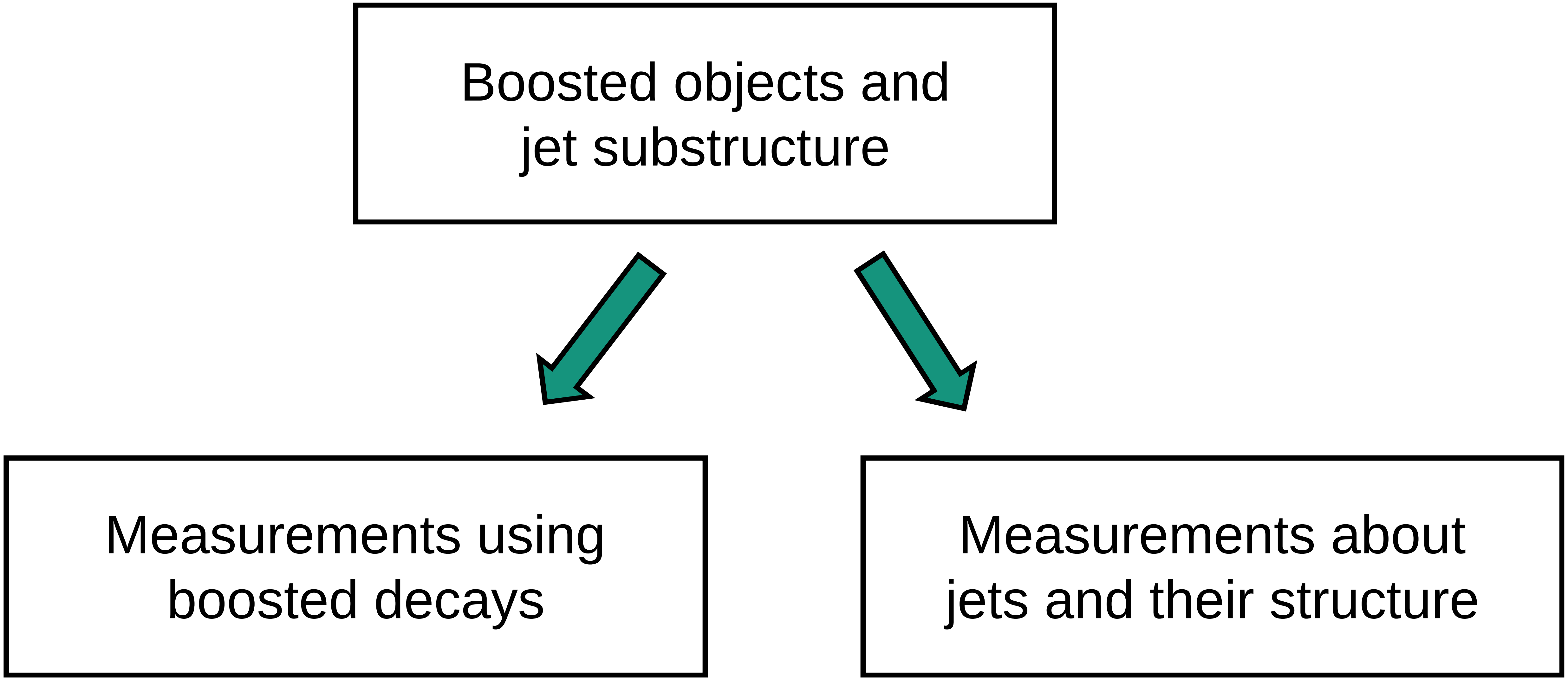




SM Measurements



Anomalous Couplings

- Assume new physics at some scale Λ
- Parameterize new physics at lower scales by developing as power series in Λ^{-1}
- Adds new higher Dimension parameters to the Lagrangian

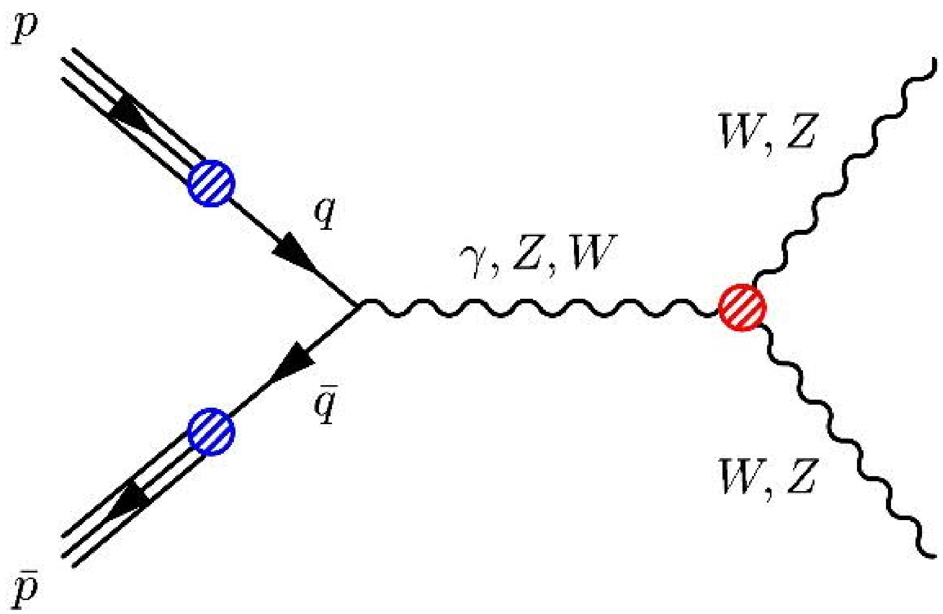
$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \frac{1}{\Lambda}\mathcal{L}_1 +$$

- SM covers all dim. 4 operators
- Dim. 5 violates lepton number (of interest for neutrino masses)
- Dim. 6: includes triple gauge couplings
- Dim. 8: includes quartic gauge couplings

Triple Boson Couplings

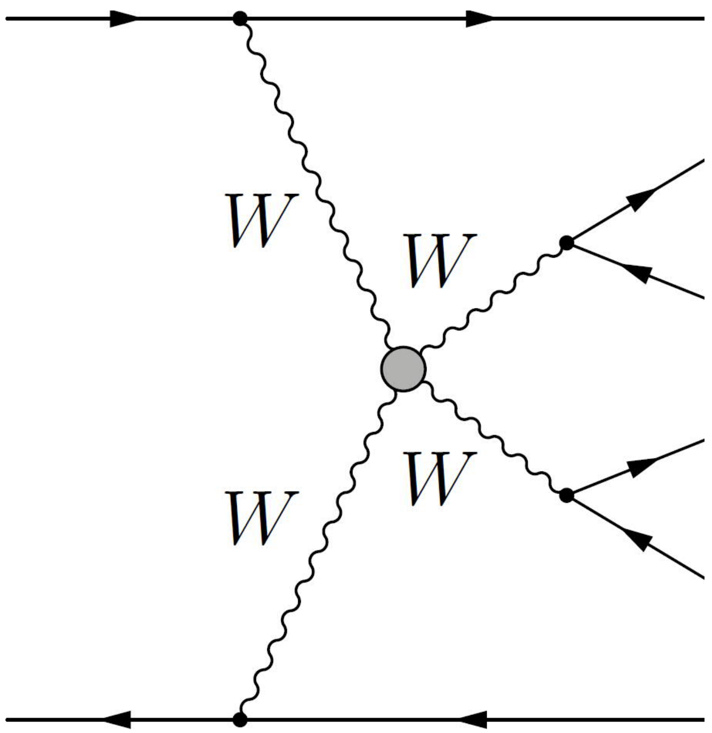
- Search for anomalous diboson production

- Influence of higher-order operators most prominent at
  => high boson pt
  => high diboson invariant mass



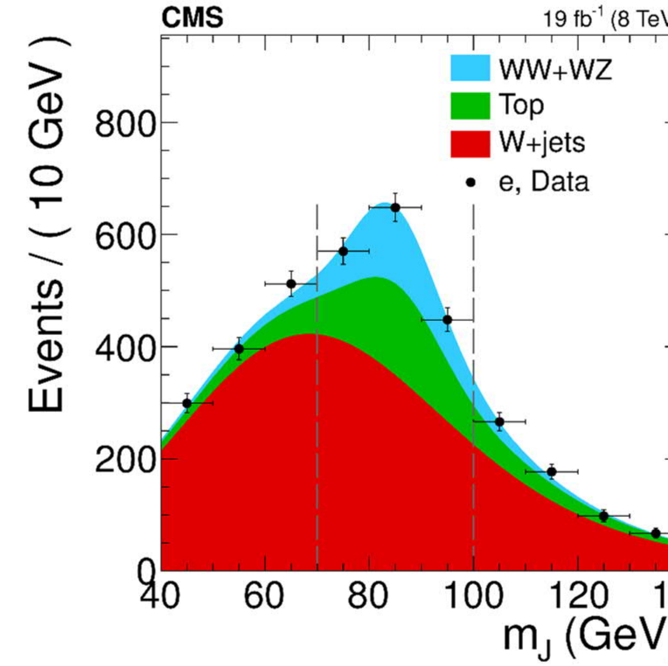
- Sensitivity driven by tails of distributions
  => expect good sensitivity
  from hadronic channels
  with high BR

- Of additional interest: VBS
  => related to ewk symmetry breaking
  => no public result (yet)

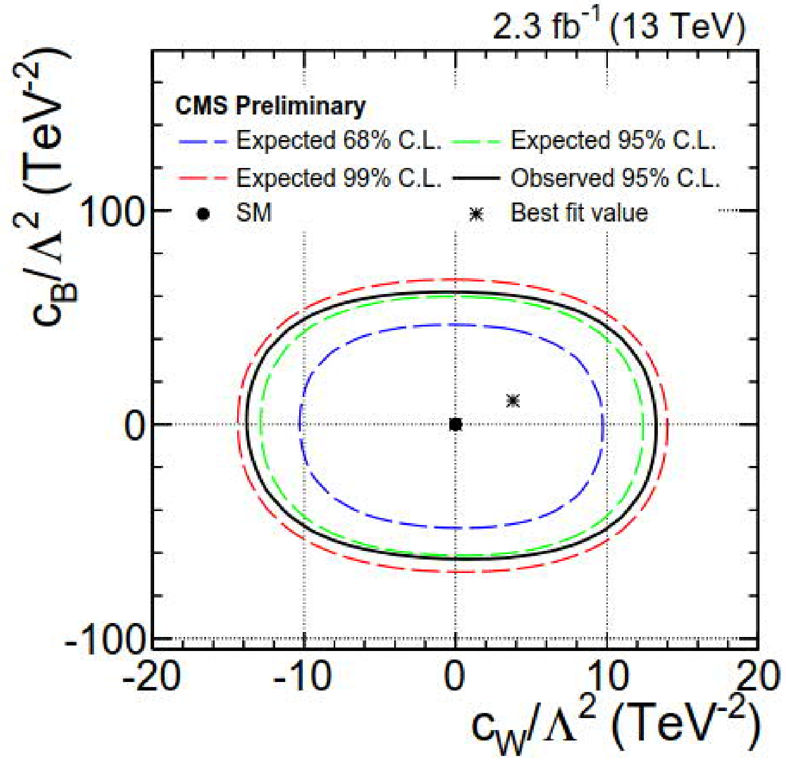


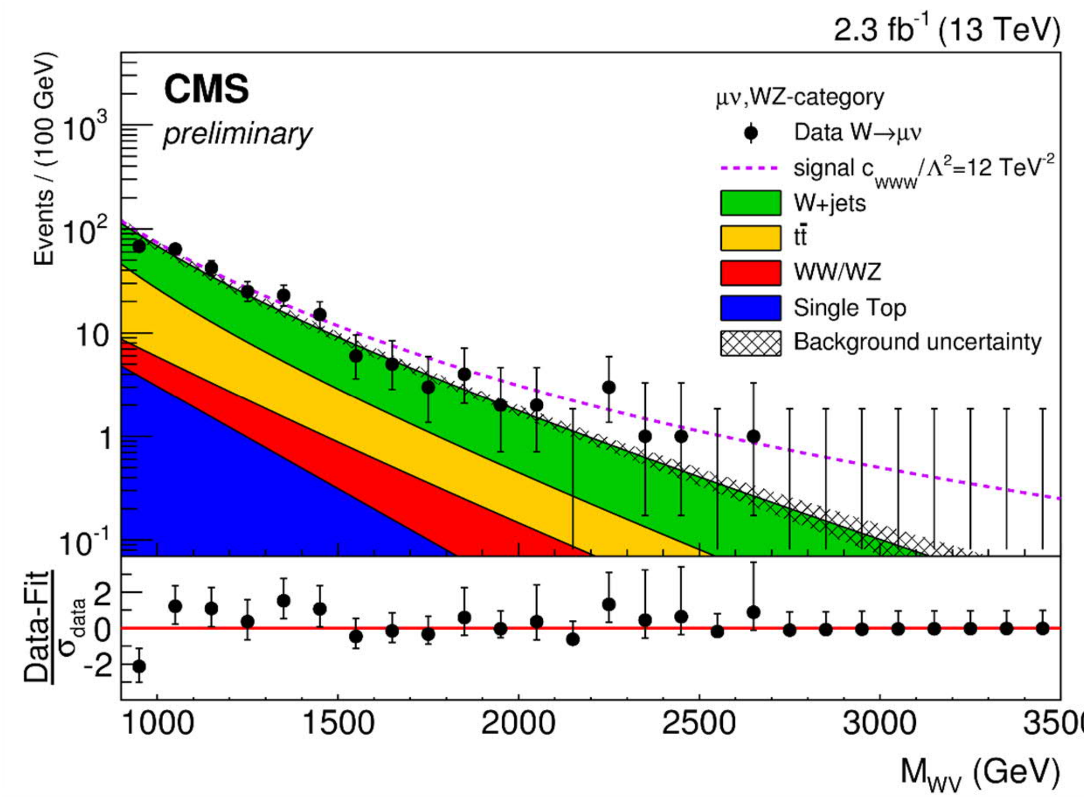
Triple Boson Couplings

- Two results: 8TeV ($20fb^{-1}$), 13TeV($2fb^{-1}$)
- Analysis work very similarly:
  leptonic W + fat jet:
  n-subjettiness and pruned mass enrich signal
- Look for deviations in sensitive variable
  $p_{t,J}$ (8TeV), M_{WV} (13TeV)
- 8TeV still more sensitive, waiting
  for 13TeV update



Phys. Lett. B 772 (2017) 21





CMS-SMP-16-012

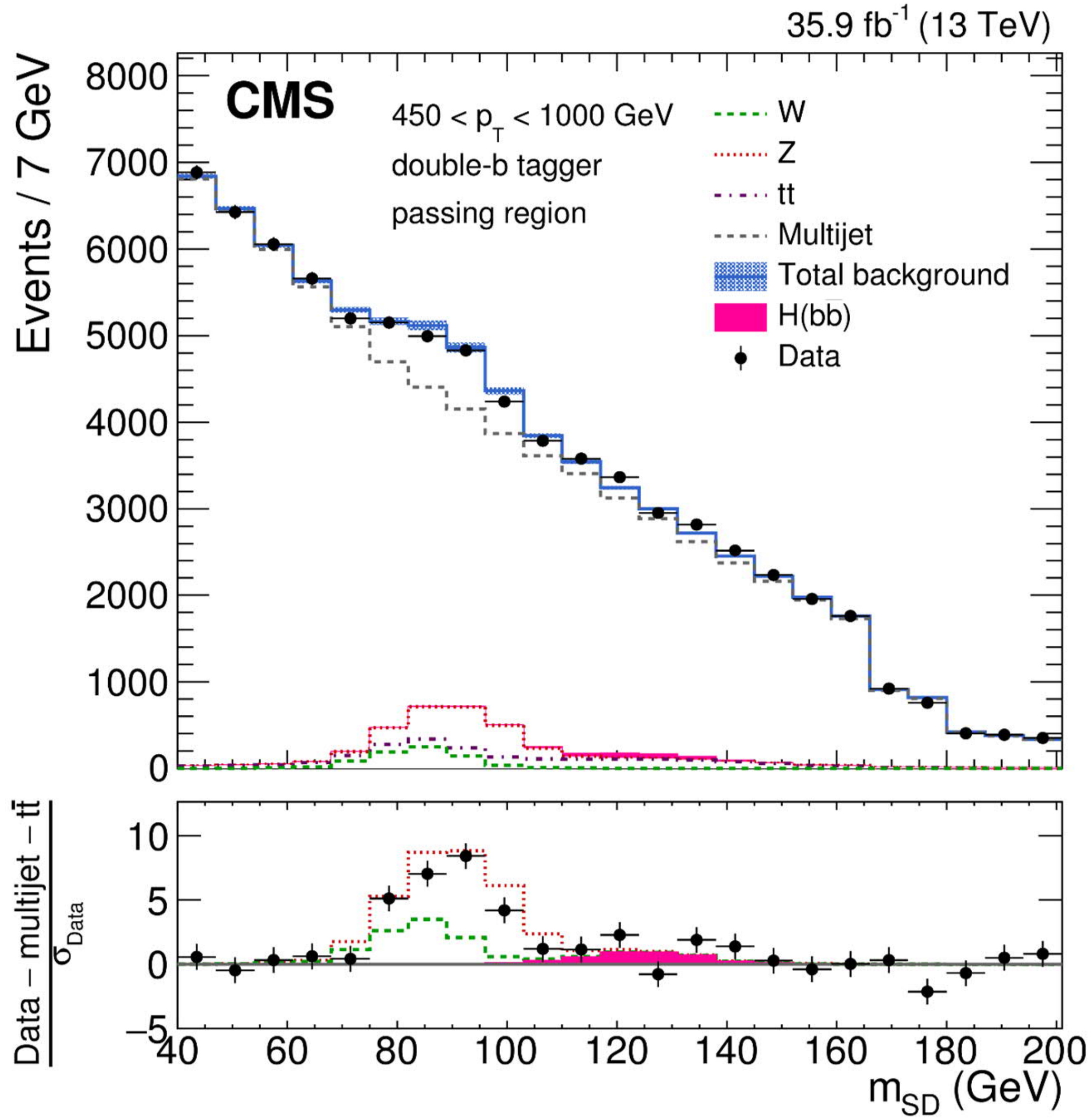
H→bb (ggF)

- Look at jets signal enriched with
  => double b-tagger
  => energy correlation function
  both decorrelated from jet kinmatics

- Z→bb decay observed
  at 5 σ

- Compatible with SM
  => validates double-b-tag

- SM Higgs xsec too low
  to see yet



Phys. Rev. Lett. 120 (2018) 071802

	H	H no p_T corr.	Z
Observed signal strength	$2.3^{+1.8}_{-1.6}$	$3.2^{+2.2}_{-2.0}$	$0.78^{+0.23}_{-0.19}$
Expected UL signal strength	< 3.3	< 4.1	—
Observed UL signal strength	< 5.8	< 7.2	—
Expected significance	0.7σ	0.5σ	5.8σ
Observed significance	1.5σ	1.6σ	5.1σ

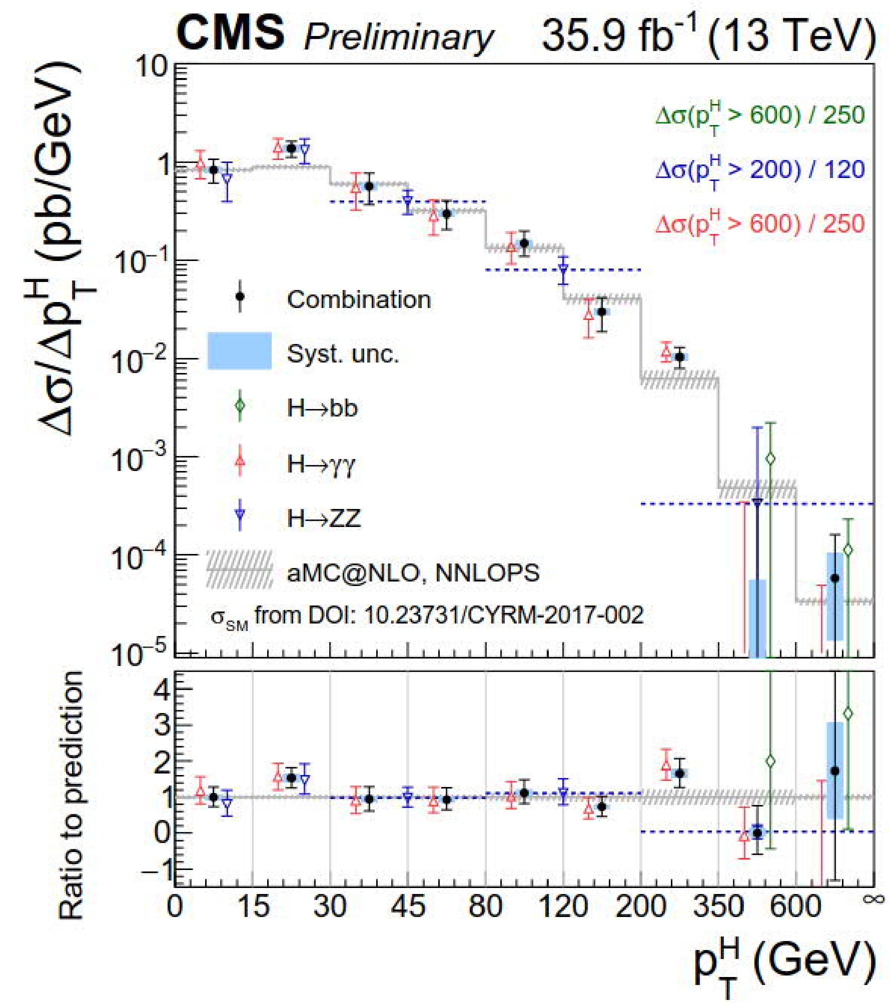
Differential x-sections

- Combine with
  $H \rightarrow \gamma\gamma$
  $H \rightarrow ZZ$
  => contribute in the highest pt bins

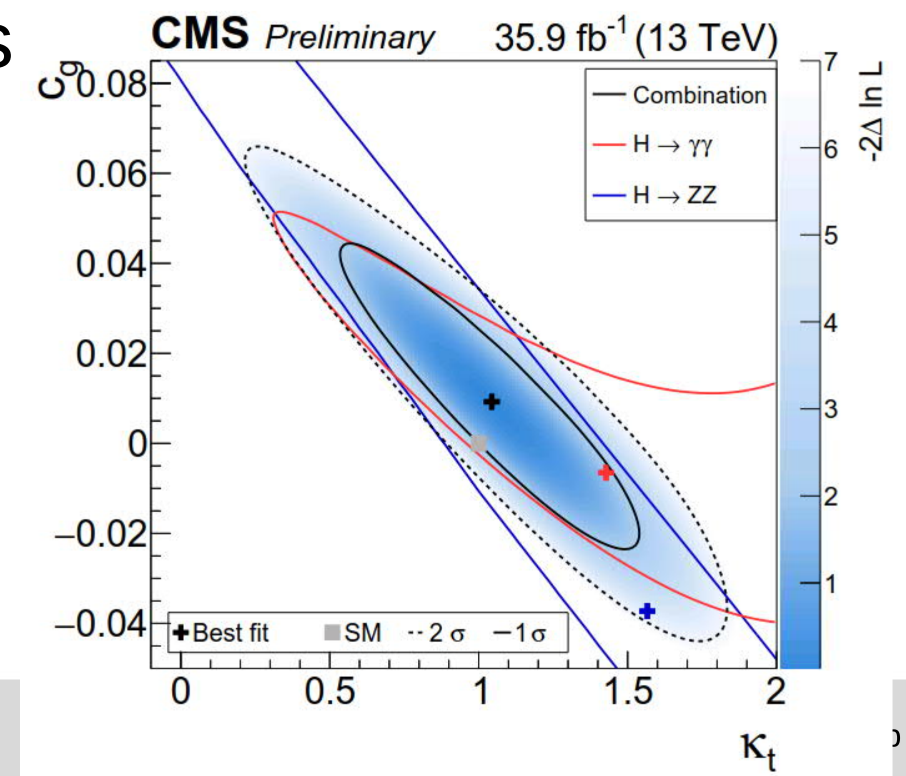
- Use results to limit deviations
  from SM Higgs couplings

- Currently boosted channel most
  powerful for limits on anomalous couplings

- Hope to surpass VH (H→bb) with
  better systematics
  => but needs significantly more lumi

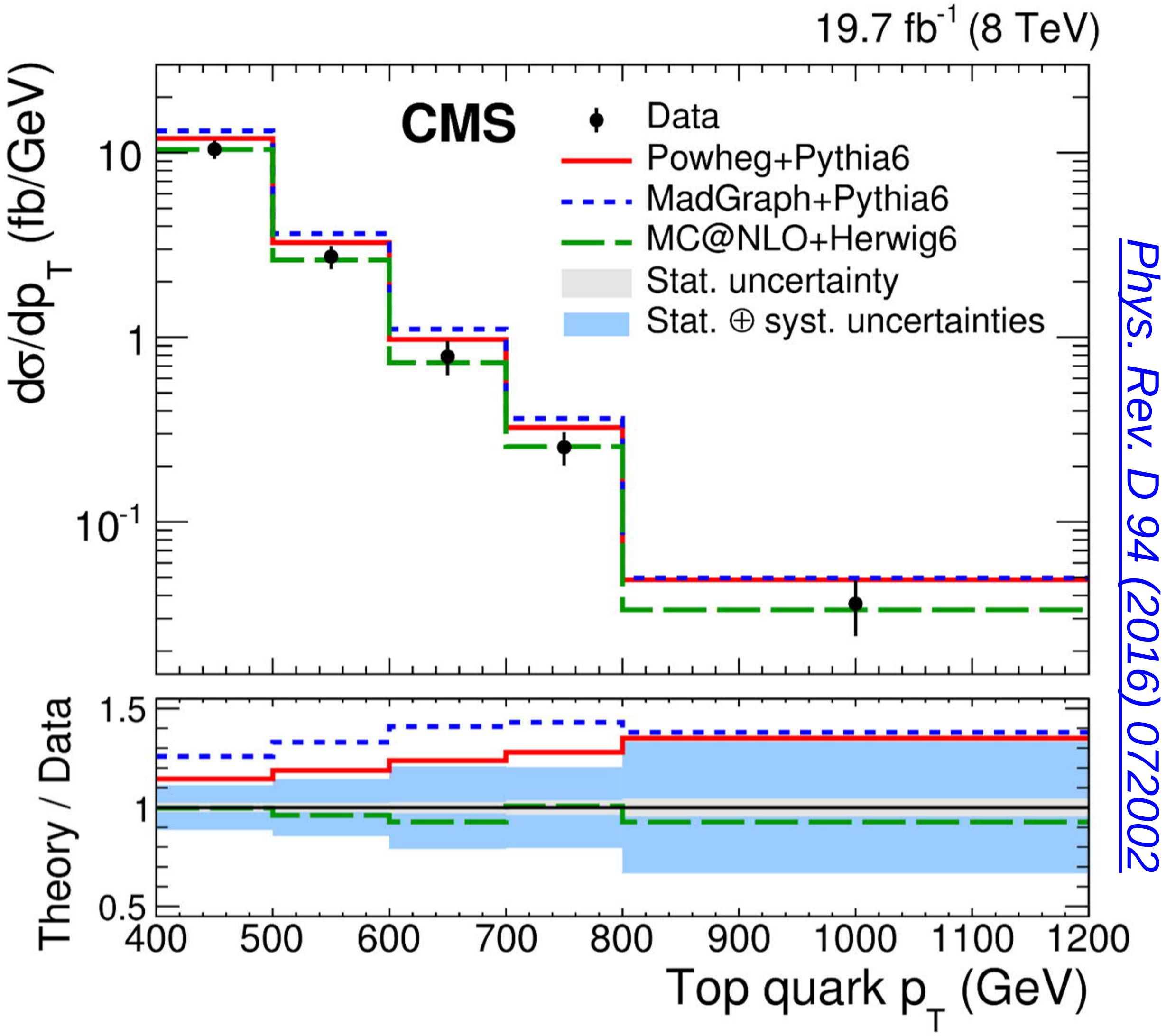


CMS-HIG-17-028



Top quark diff. xsec

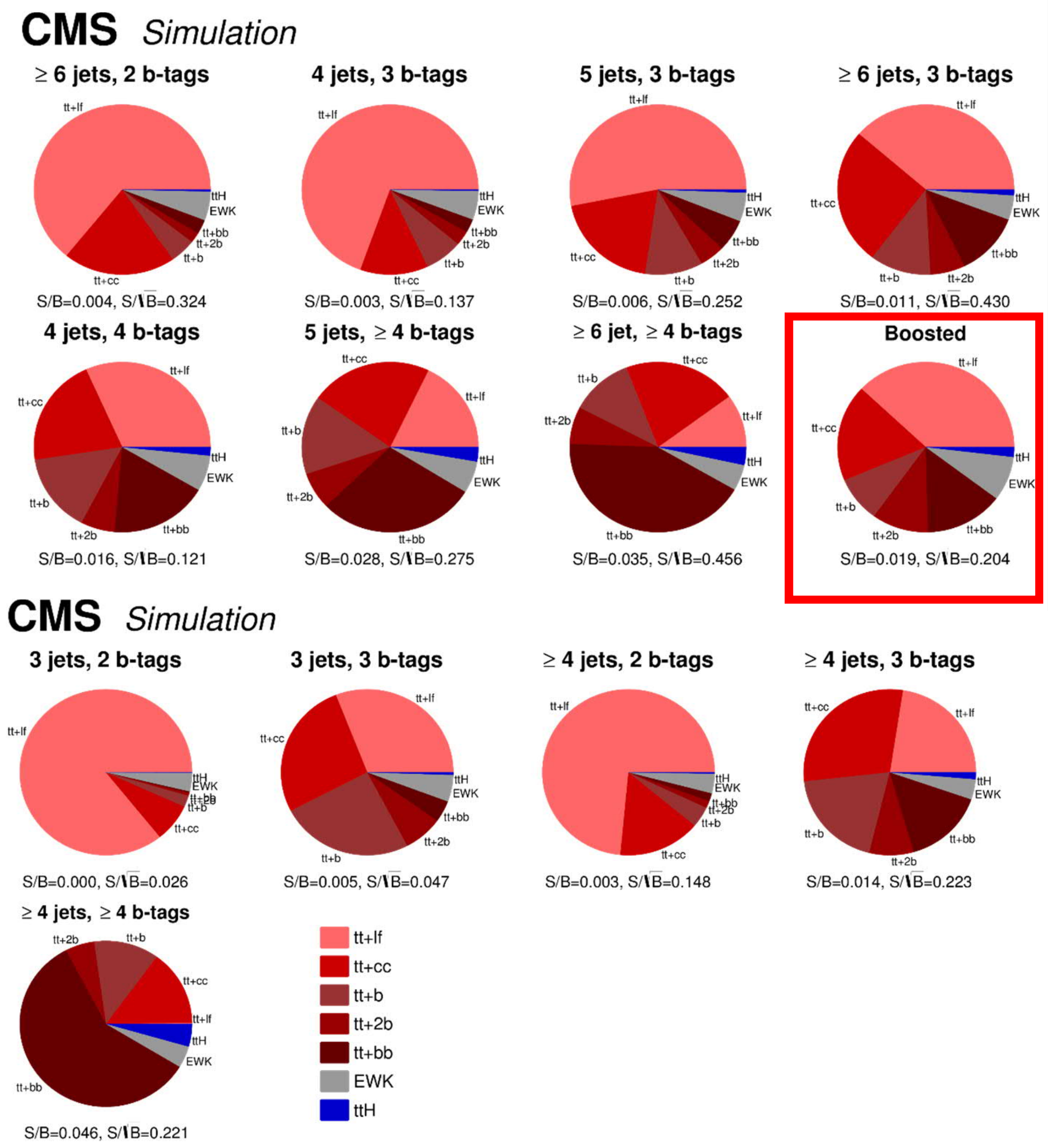
- One leptonic top quark and one boosted hadronic decay:
  => CMS-Top-Tagger
  with R=0.8
- Long standing issue with
  top p_t spectrum
  => not well described by MC
  => can lead to high uncertainties
- Very good lever-arm with boosted top decays
- Most likely resolution
  => higher orders of QCD



Phys. Rev. D 94 (2016) 072002

ttH

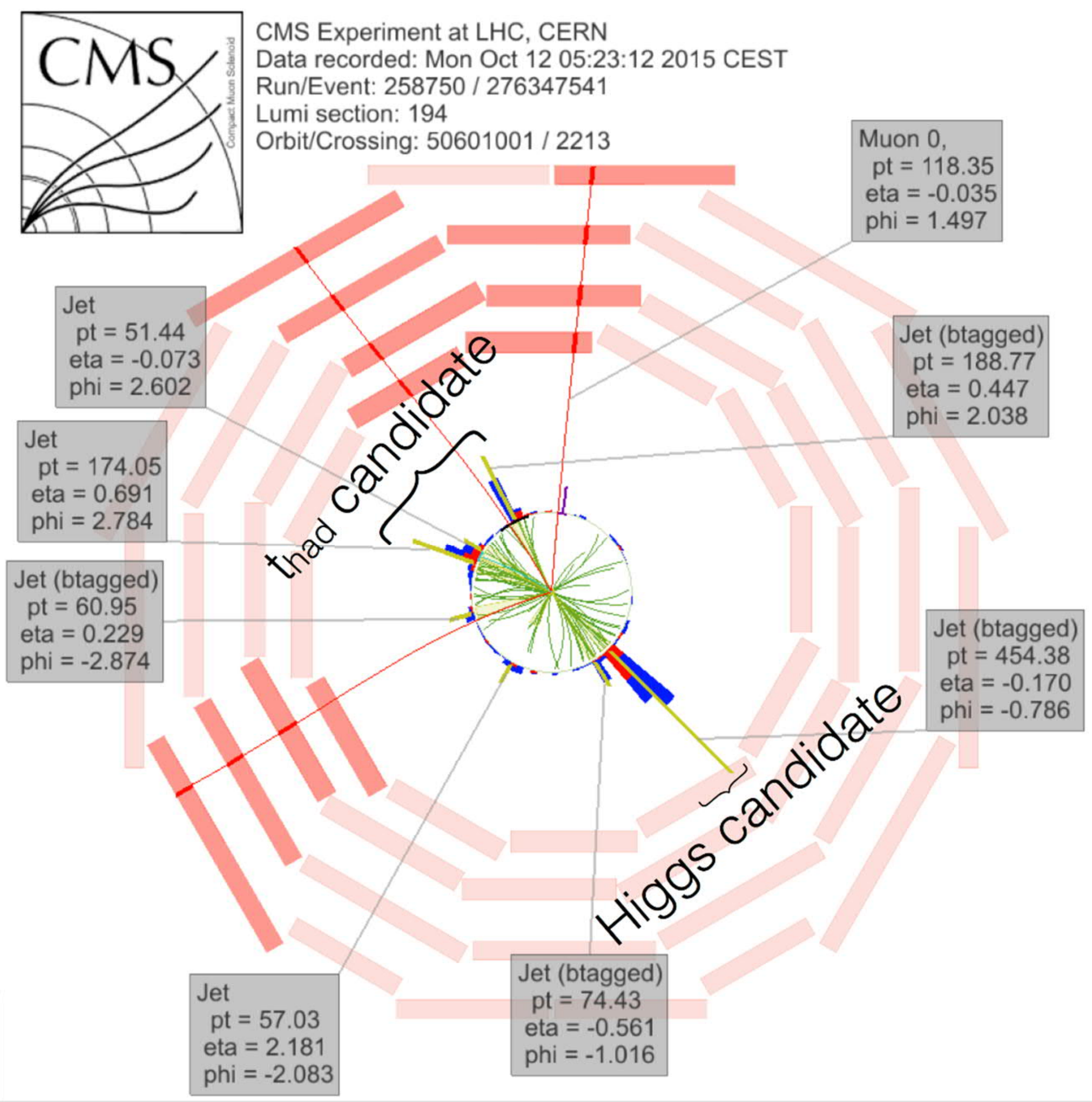
- Direct access to top Yukava coupling
- Low cross section and many decay channels:
  => combined analysis
  with many channels
- Include boosted channel
  => competitive S/B
  => but low statistics

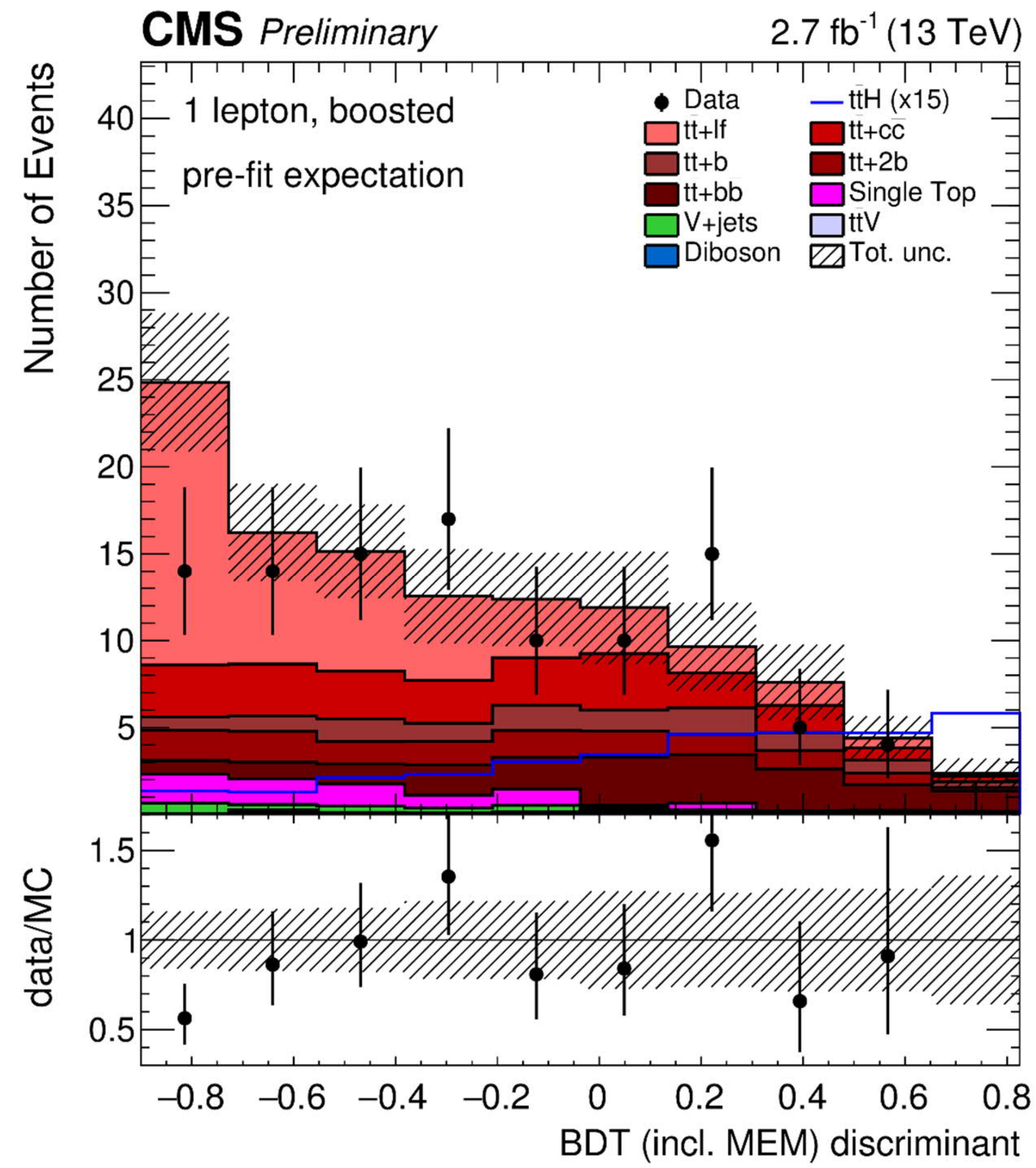


CMS-HIG-16-004

ttH

- HEP-Top-tagger for top
  Mass-drop + filtering for Higgs
- Included in preliminary HIG-16-004
  but dropped from discovery paper





CMS-HIG-16-004

Measureing Jet structure

- To understand boosted decay
  => understand single quark and gluon jets first

- CMS-TOP-17-013 :
  Study simple NON-boosted decays of top-quarks
  => interesting mixture of quark flavors and gluons

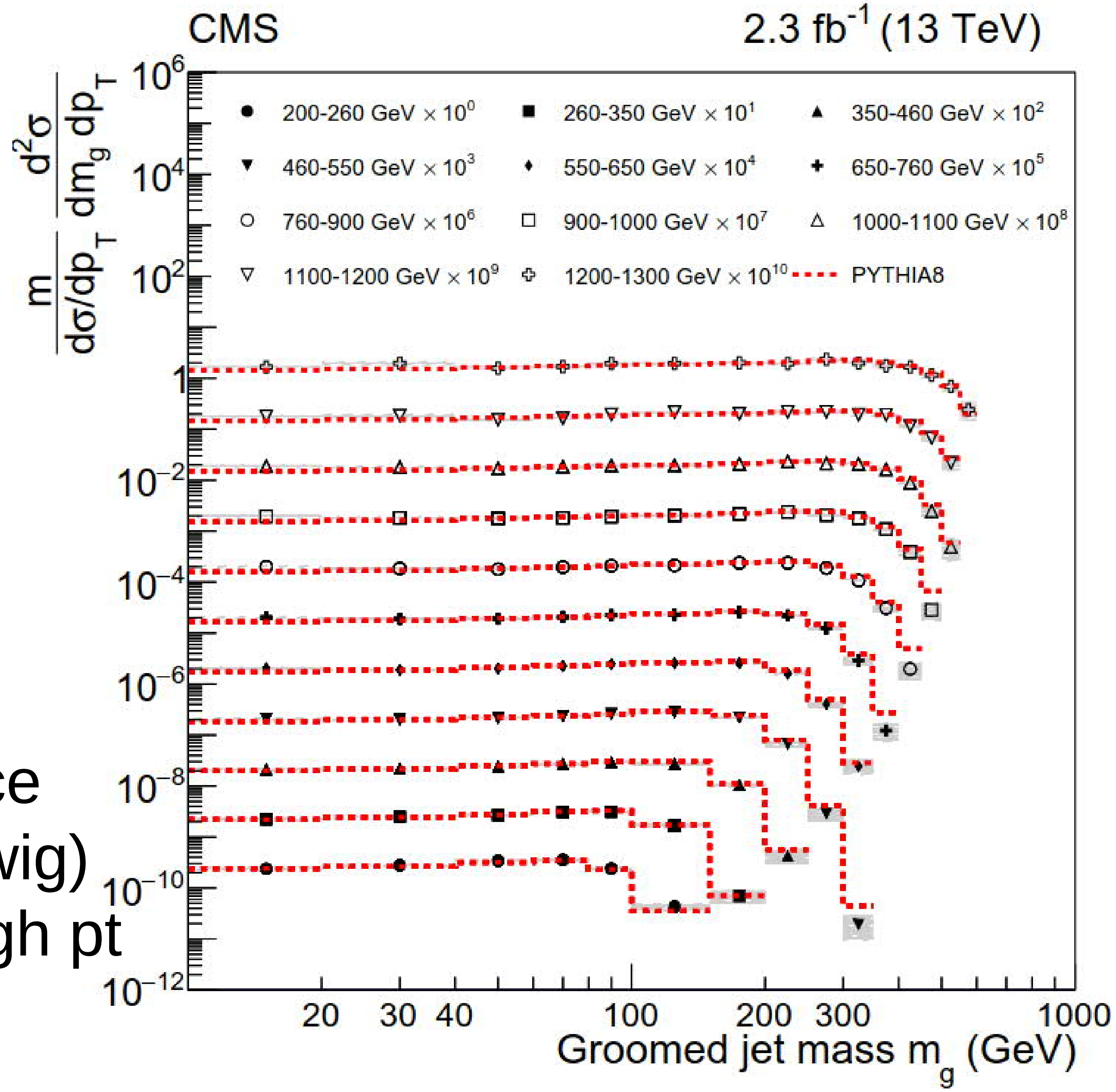
- Measure quantities typically used in substructure studies
  (n-subjettiness, energy-correlation functions, angularities, …)

- SMP-16-010:
  study jet mass in dijet events

- Tricky: unfolding from detector to stable particle level

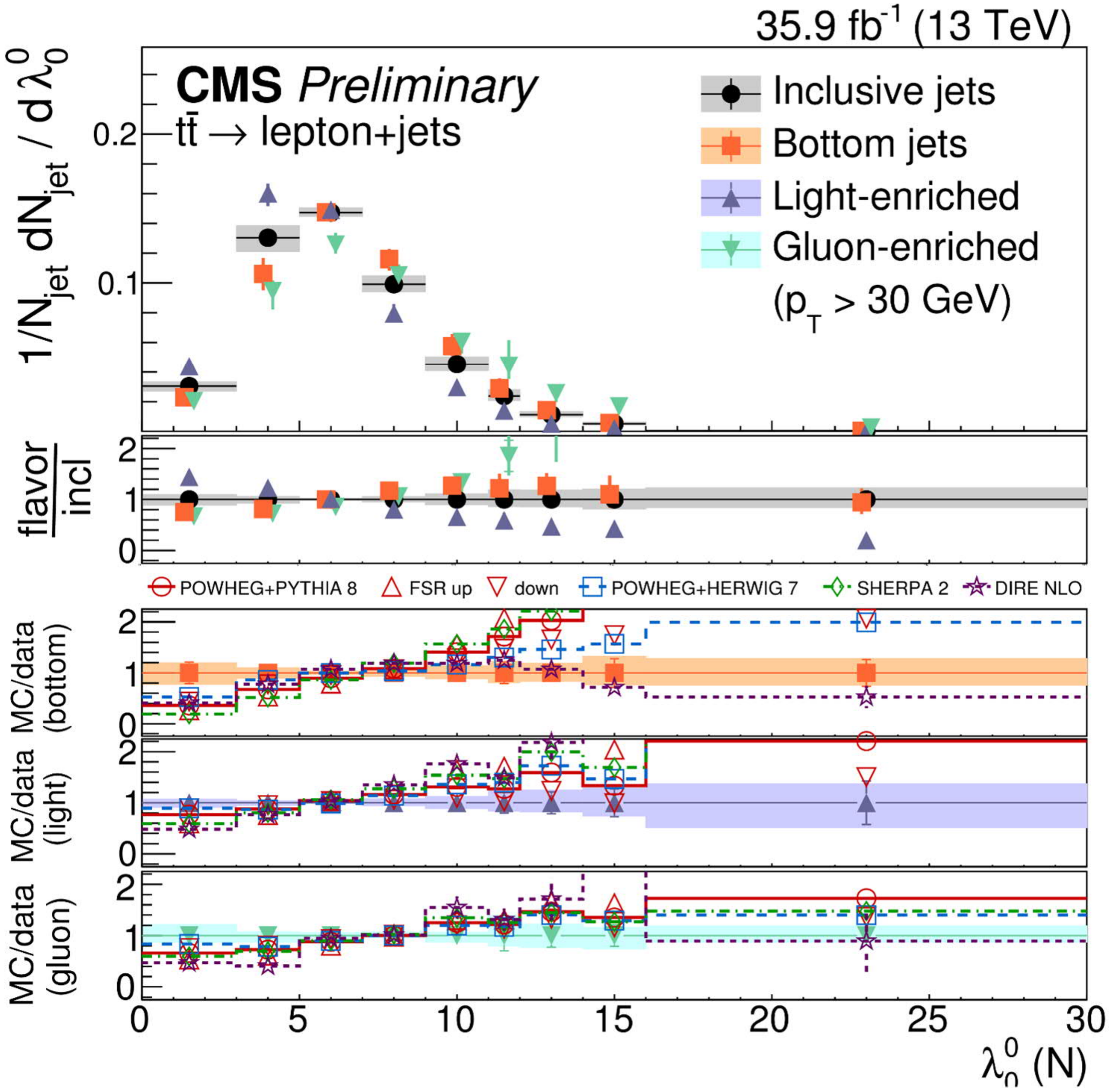
Measureing Jet structure

- SMP-16-010
- Studied with and without grooming (soft-drop)
- Measure as function of jet p_t
  => observe epxected scaling
  with $m^2/(p_t^2 R^2)$
- Good agreement with MC
  over large range of phasespace
  (pythia slighly better than Herwig)
  some disagreement at very high pt



Measureing Jet structure

- CMS-TOP-17-013
- Check distributions in several phase space regions:
  => B-enrichted: b-tagged jets
  => light quark (includes charm): pairs forming W-mass
  => gluon enriched: others
- Visible differences between flavors
  => flavor matters when estimating backgrounds



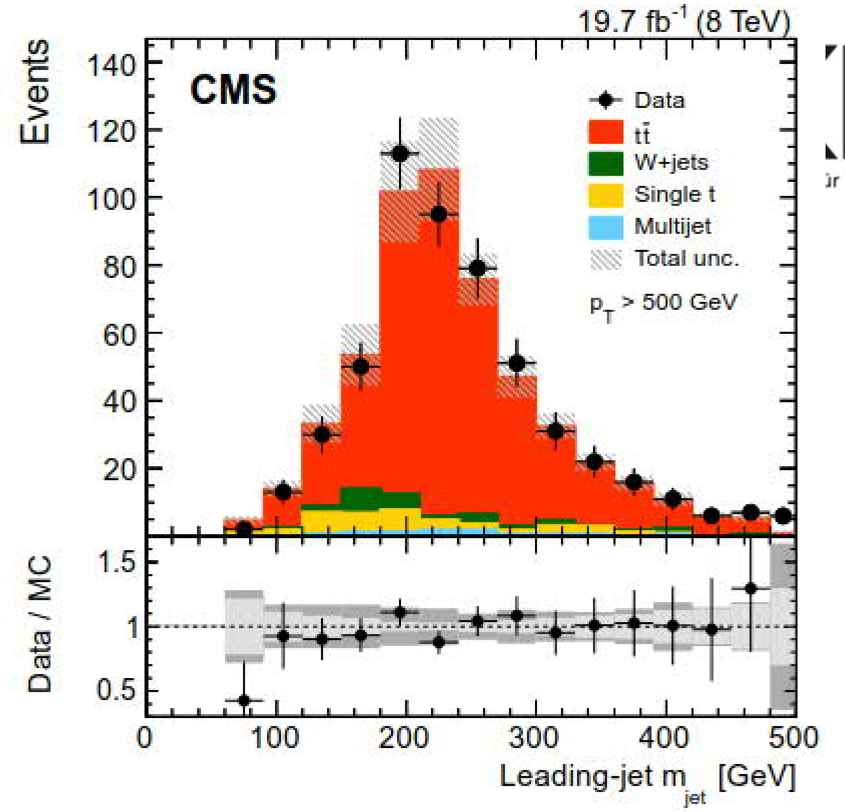
Boosted Top-Jets

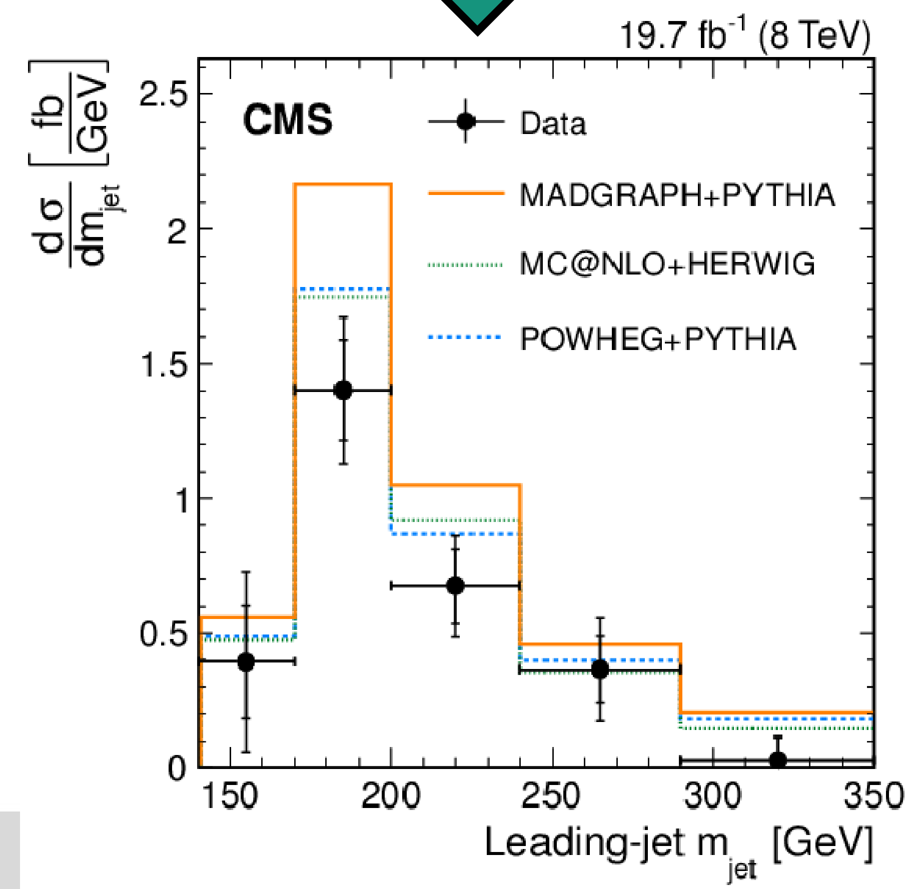
- Measuring properties of boosted top jets
  => better understanding of top jets for exotic searches

- Uses very large jets: CA12
  => better signal statistics by inlcuding lower p_t top quarks

- No grooming or substructure selection to avoid biases.

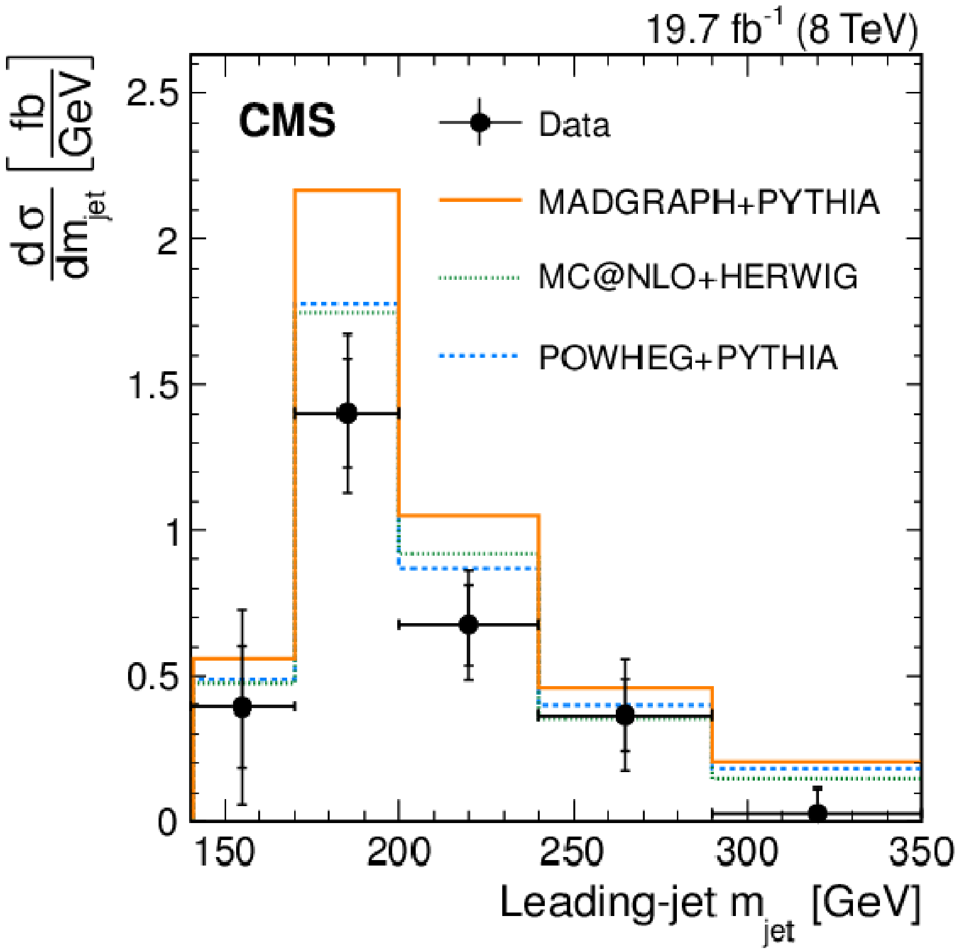
- Constrain mass-scale by checking calibrating on W-mass in semi-resolved events



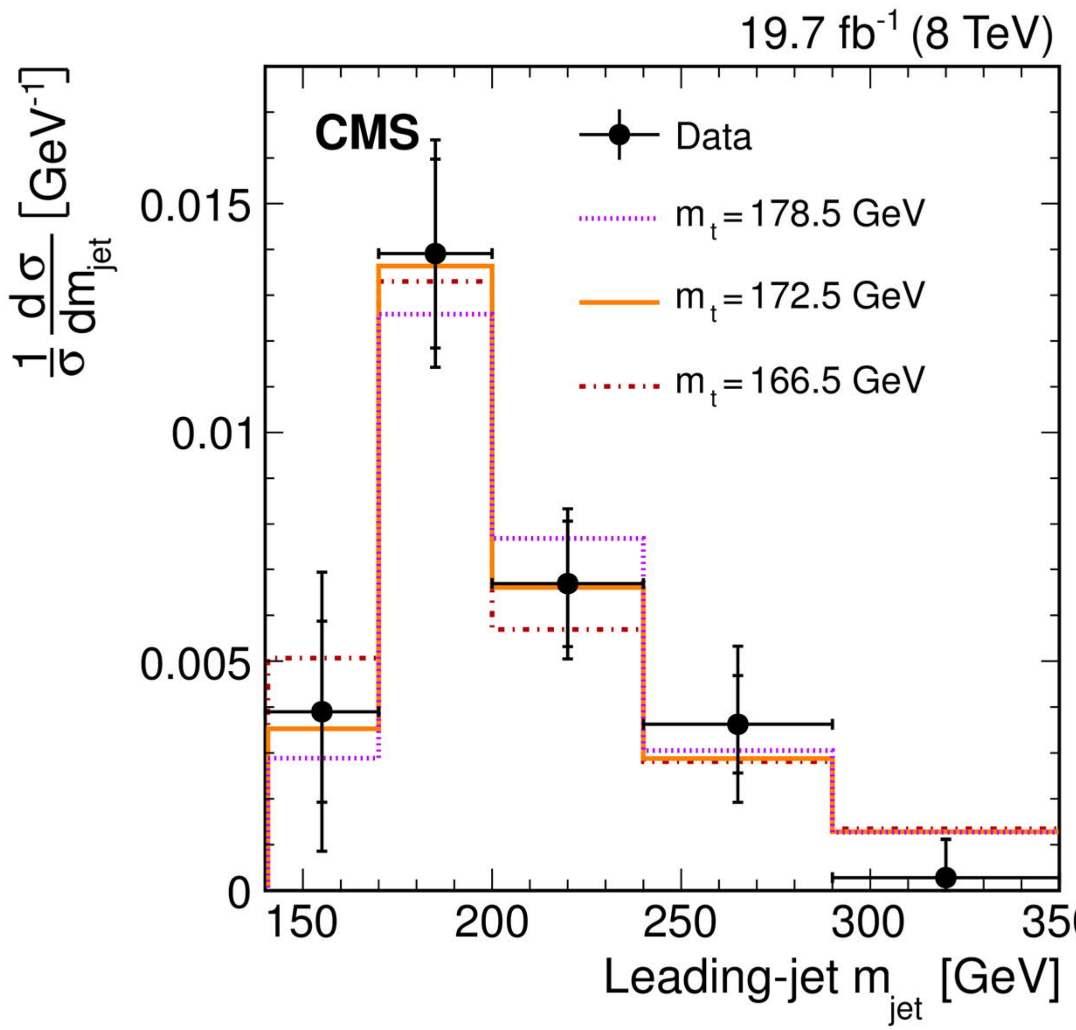


Eur. Phys. J. C 77 (2017) 467

Boosted Top-Jets



Shape analysis



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$$m_t = 170.8 \pm 6.0\,(\text{stat}) \pm 2.8\,(\text{syst}) \pm 4.6\,(\text{model}) \pm 4.0\,(\text{theo})\,\text{GeV}$$

- Top mass consistent with other measurements
  => still possible to improve with more statistics
  => Jet-mass modelling leading systematic uncertainty
  => uncertainties largely uncorrelated to other extraction methods

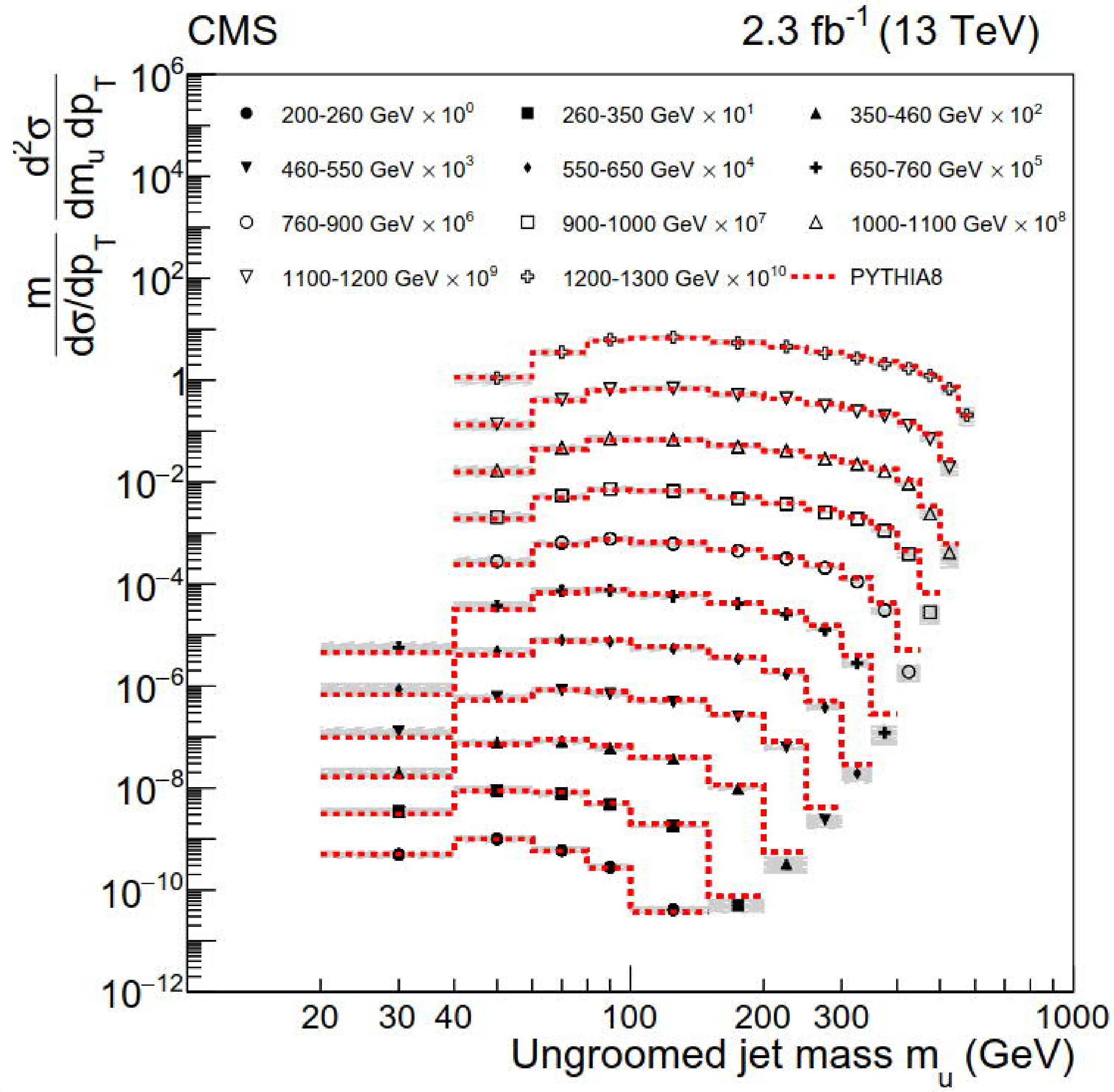
Summary

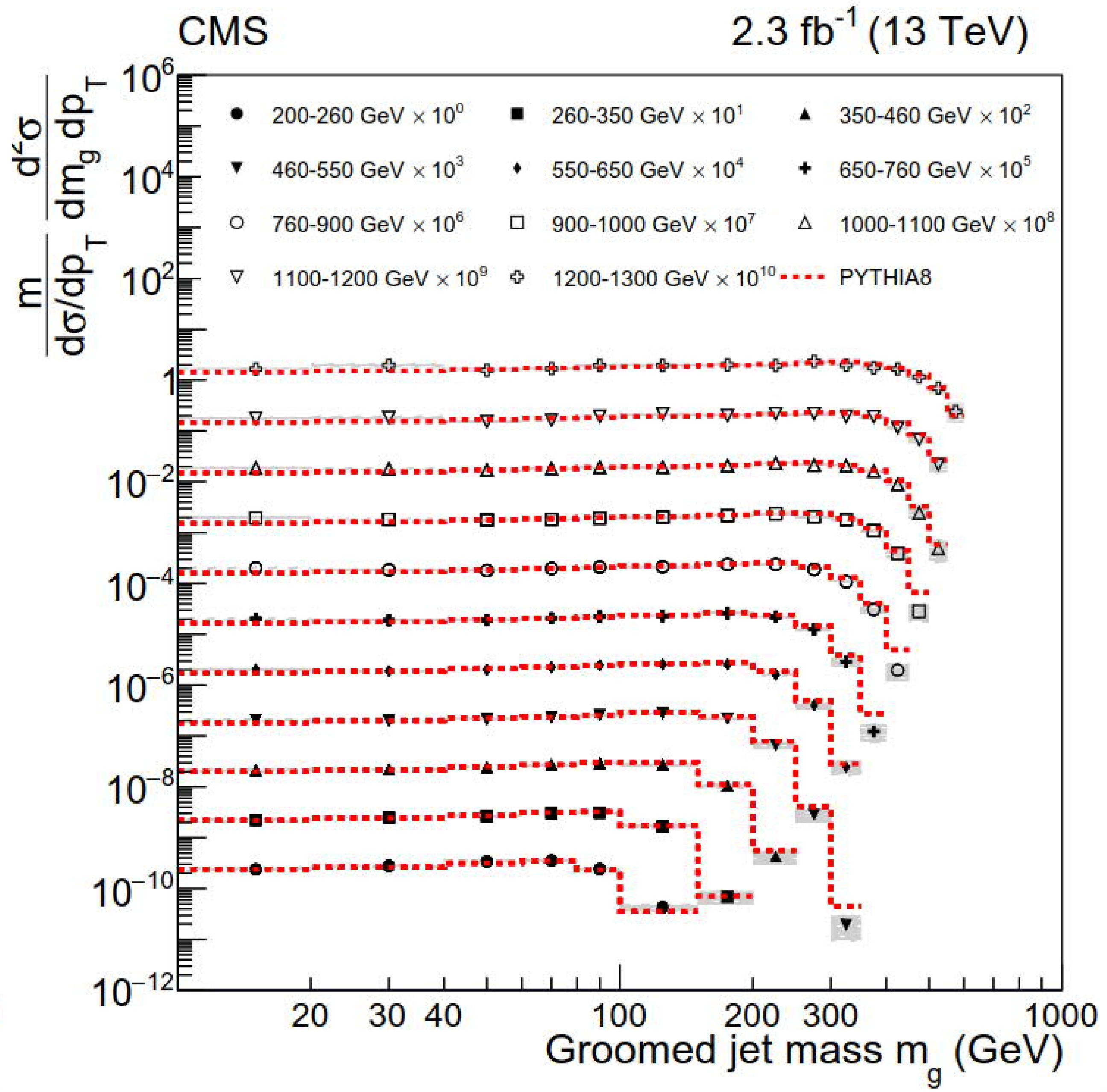
=> Big Push ongoing to use boosted jets in anomalous coupling studies:
- diboson / triple couplings
- vector boson scattering / quartic couplings (no public results yet)

=> Measurements of SM parameters from boosted objects:
- often not as precise as leptonic measurements
- but offer orthogonal systematics

=> Measurements of jet structure itself
- important input to QCD understanding
- generator tuning
- understanding of SM/BSM searches/measurements

Backup


CMS
2.3 fb^{-1} (13 TeV)
$\frac{m}{d\sigma/dp_T}\frac{d^2\sigma}{dm_u\,dp_T}$
200-260 GeV × 10^0
260-350 GeV × 10^1
350-460 GeV × 10^2
460-550 GeV × 10^3
550-650 GeV × 10^4
650-760 GeV × 10^5
760-900 GeV × 10^6
900-1000 GeV × 10^7
1000-1100 GeV × 10^8
1100-1200 GeV × 10^9
1200-1300 GeV × 10^10
PYTHIA8
Ungroomed jet mass m_u (GeV)


CMS
2.3 fb^{-1} (13 TeV)
$\frac{m}{d\sigma/dp_T}\frac{d^2\sigma}{dm_g\,dp_T}$
200-260 GeV × 10^0
260-350 GeV × 10^1
350-460 GeV × 10^2
460-550 GeV × 10^3
550-650 GeV × 10^4
650-760 GeV × 10^5
760-900 GeV × 10^6
900-1000 GeV × 10^7
1000-1100 GeV × 10^8
1100-1200 GeV × 10^9
1200-1300 GeV × 10^10
PYTHIA8
Groomed jet mass m_g (GeV)

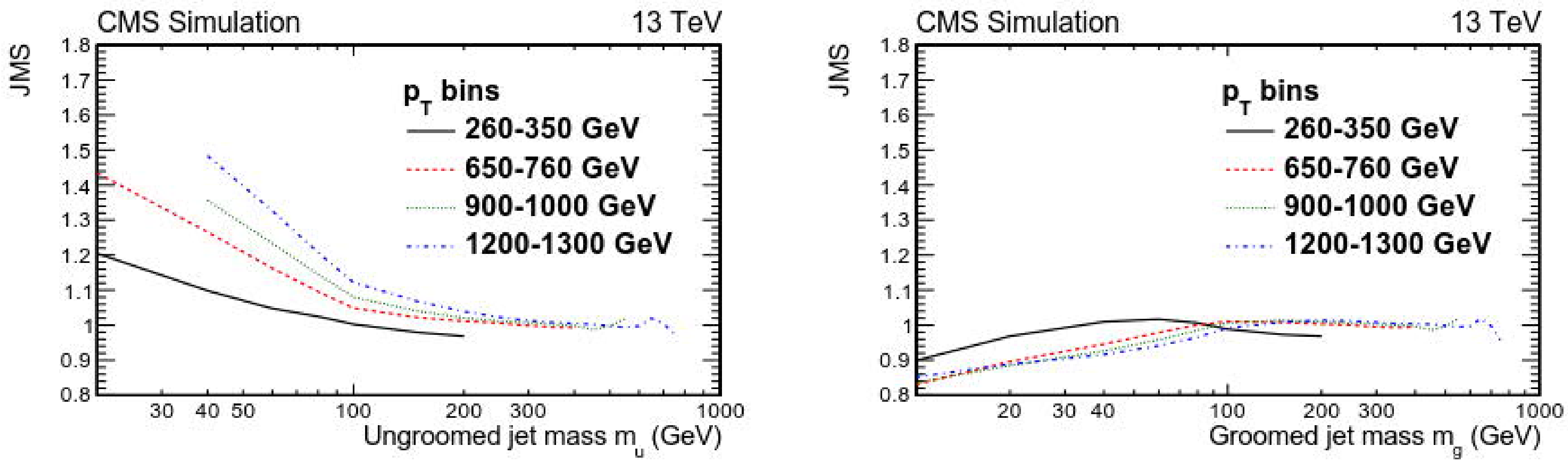


Figure 1: JMS in simulation (mean of a fit to $m_{\text{reco}}/m_{\text{gen}}$) for ungroomed (left) and groomed (right) jets in different generated p_{T} bins, as a function of generated mass.

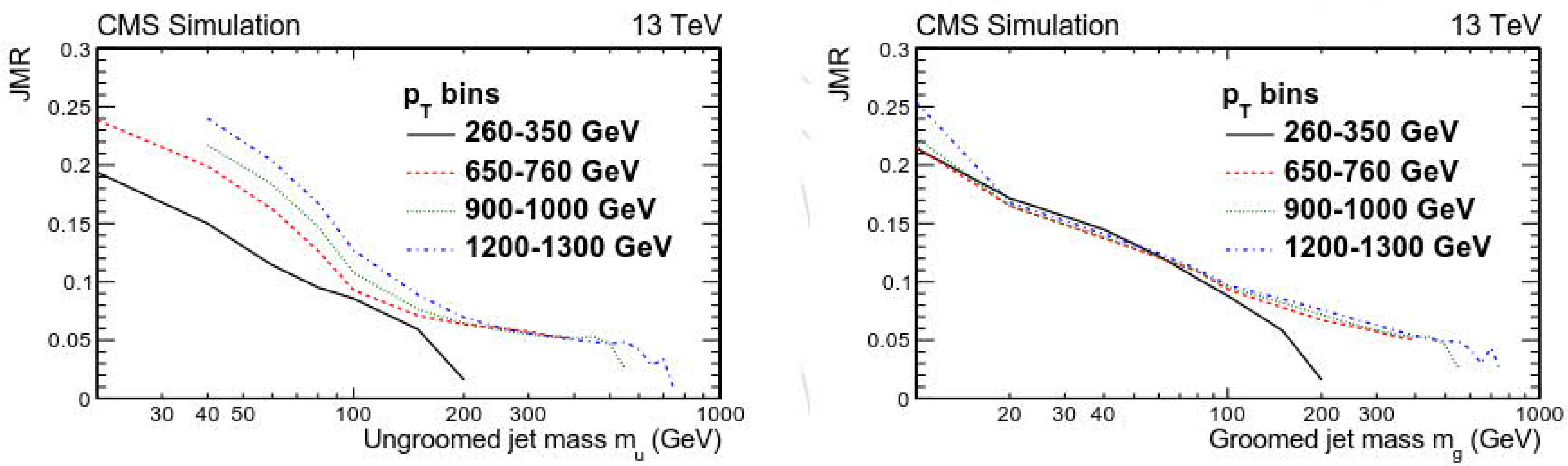
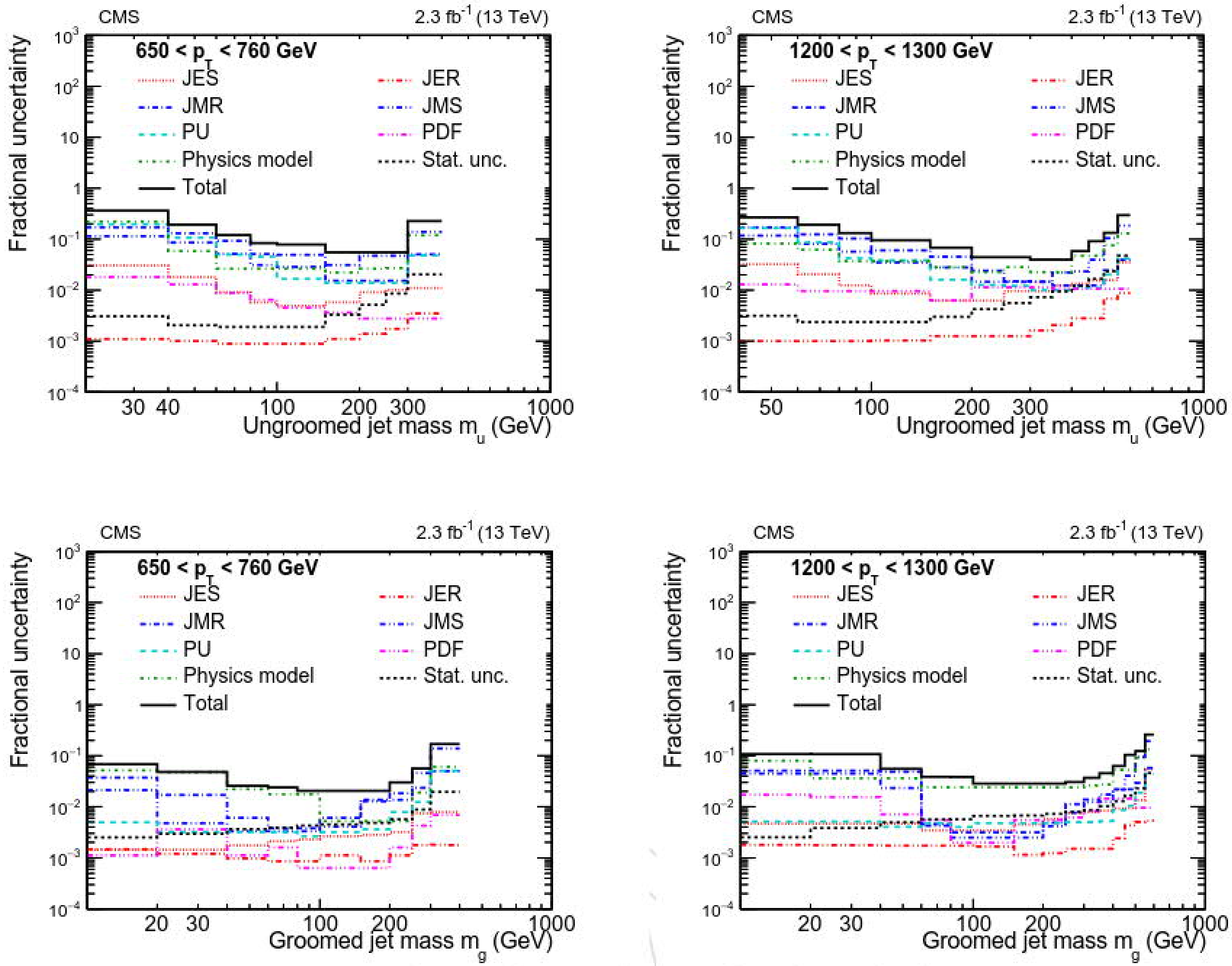


Figure 2: JMR in simulation (width of a fit to $m_{\text{reco}}/m_{\text{gen}}$) for ungroomed (left) and groomed (right) jets in different generated p_{T} bins, as a function of generated mass.


CMS
2.3 fb⁻¹ (13 TeV)
650 < pT < 760 GeV
1200 < pT < 1300 GeV
JES
JER
JMR
JMS
PU
PDF
Physics model
Stat. unc.
Total
Fractional uncertainty
Ungroomed jet mass mu (GeV)
Groomed jet mass mg (GeV)