ME/MC Matching: Does DØ Match?

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for the DØ Collaboration

Event Generators

- PYTHIA and HERWIG
  - Limited to $2 \longrightarrow 2$ hard processes
  - Integrated phenomenological parton shower and hadronization models
  - Difficult to produce high multiplicity events (eg, $W + 5$ jet)
- Generators with $2 \longrightarrow N$ matrix elements
  - ALPGEN and COMPHEP used by DØ
  - Add parton showers and hadronization via PYTHIA or HERWIG but double counting contributions an issue — matching mechanisms alleviate this problem

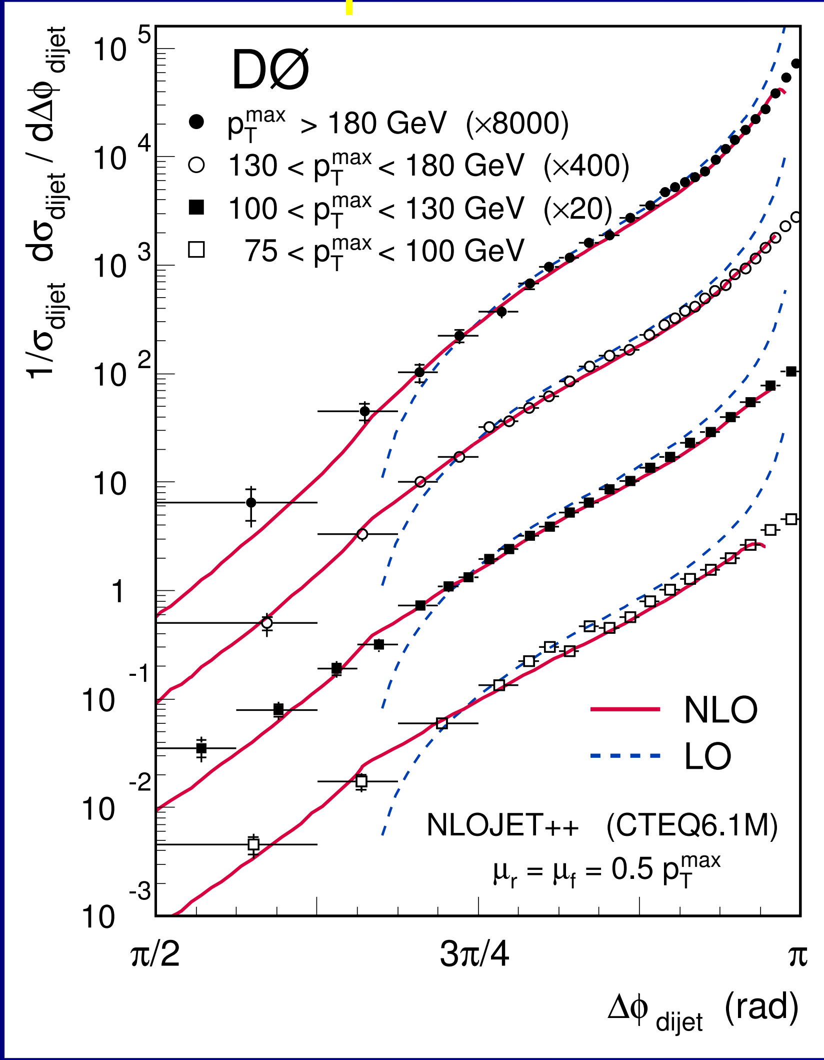
Matched Samples *vs* Data

- QCD
  - $\Delta\phi$ distributions in dijet events
- Top
  - Z + jets
  - W + jets
  - Heavy flavor fractions in W + jets

ϕ Decorrelation

hep-ex/0409040

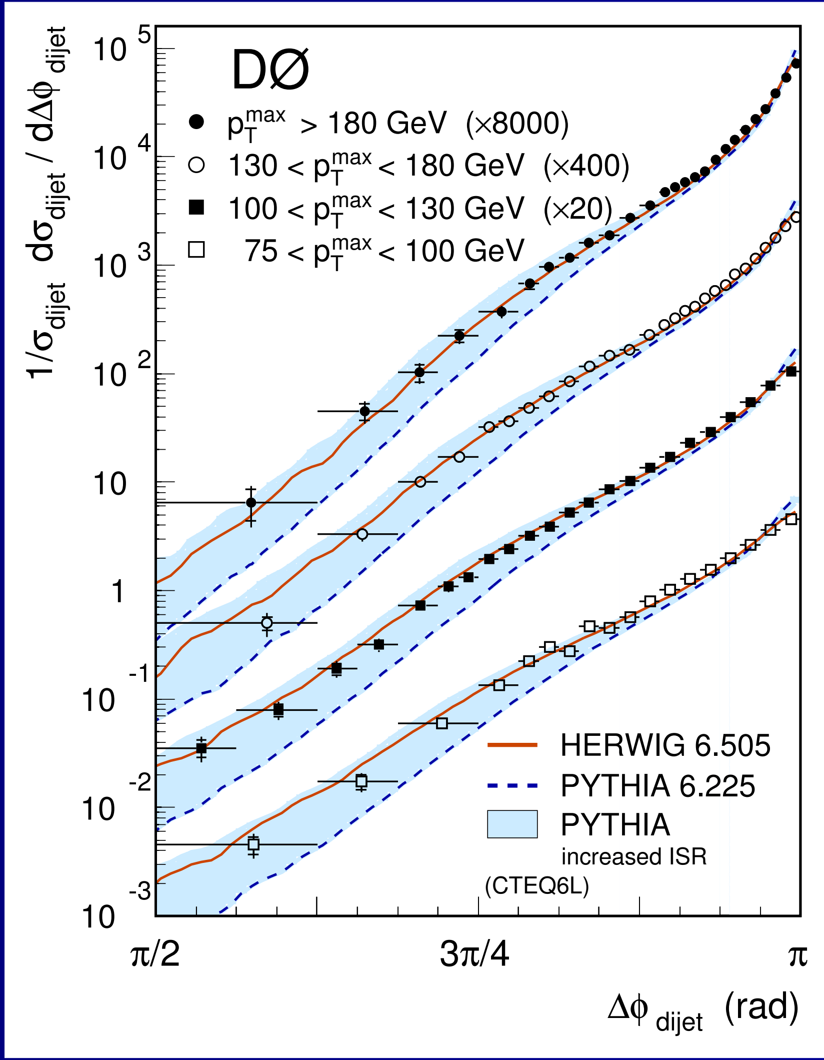
- $\frac{1}{\sigma_{\rm dijet}} \cdot \frac{d\sigma_{\rm dijet}}{d\Delta\phi_{\rm dijet}}$ is a *three-jet observable*
- NLO pQCD (in 3-jet prod.)
  - Good description over large range
  - Tree-level only for $\Delta\phi_{\rm dijet} < 2\pi/3$
  - divergent at $\Delta\phi_{\rm dijet} = \pi$
- LO pQCD (in 3-jet prod.)
  - Poor agreement
    no phase space at $< 2\pi/3$
  - divergent at $\Delta\phi_{\rm dijet} = \pi$



Event Generator Comparisons

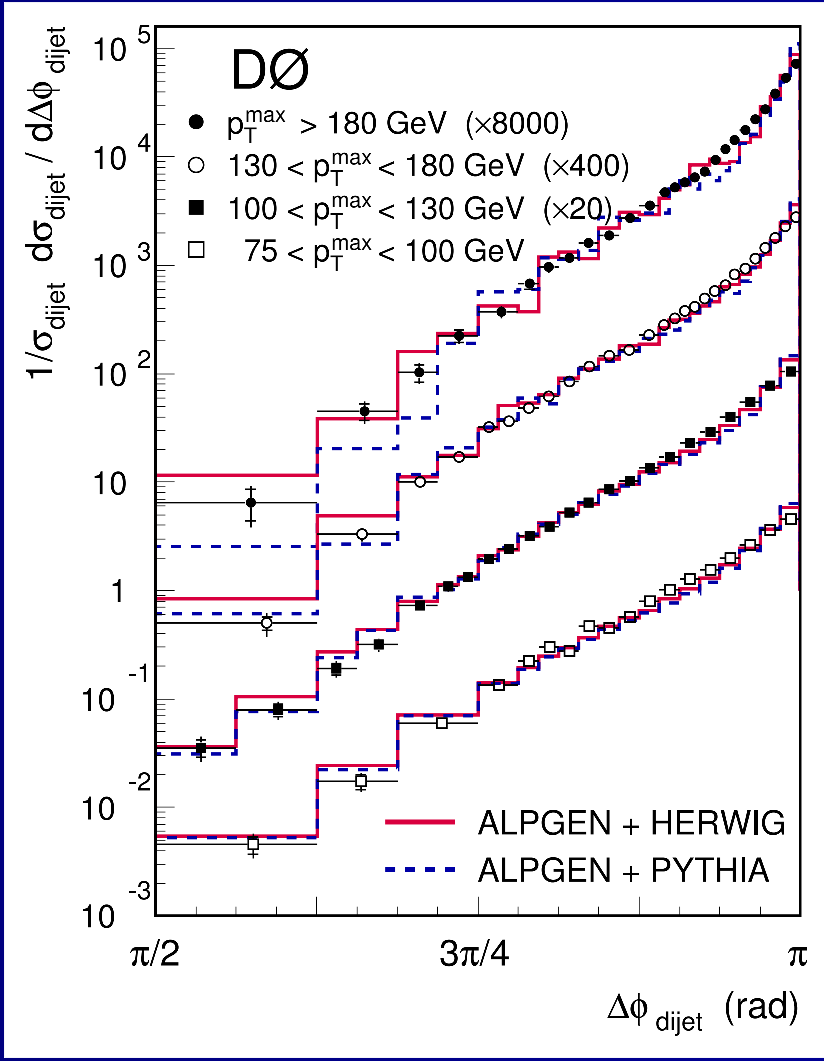
Third and fourth jets are generated via parton showers

- HERWIG v6.505
  - very good description
- PYTHIA v6.225
  - poor description
  - increase p_T cut-off in the ISR parton shower PARP(67)=1.0 $\Rightarrow$ 2.5 improves description

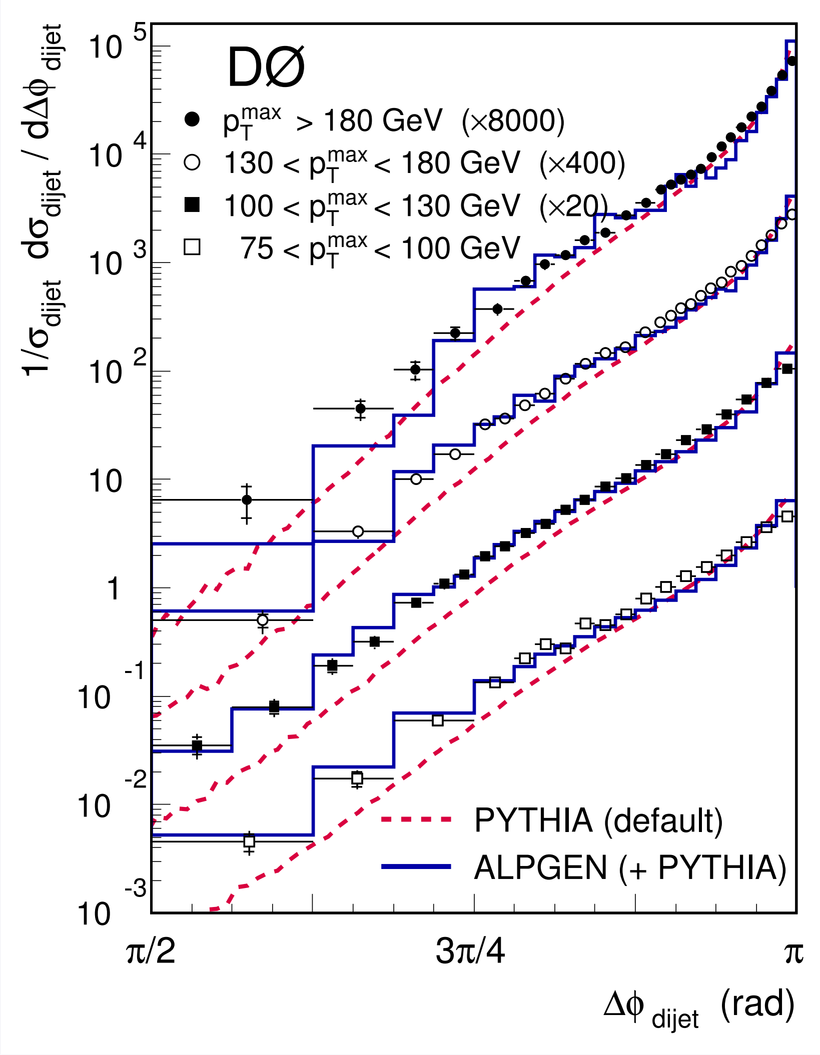


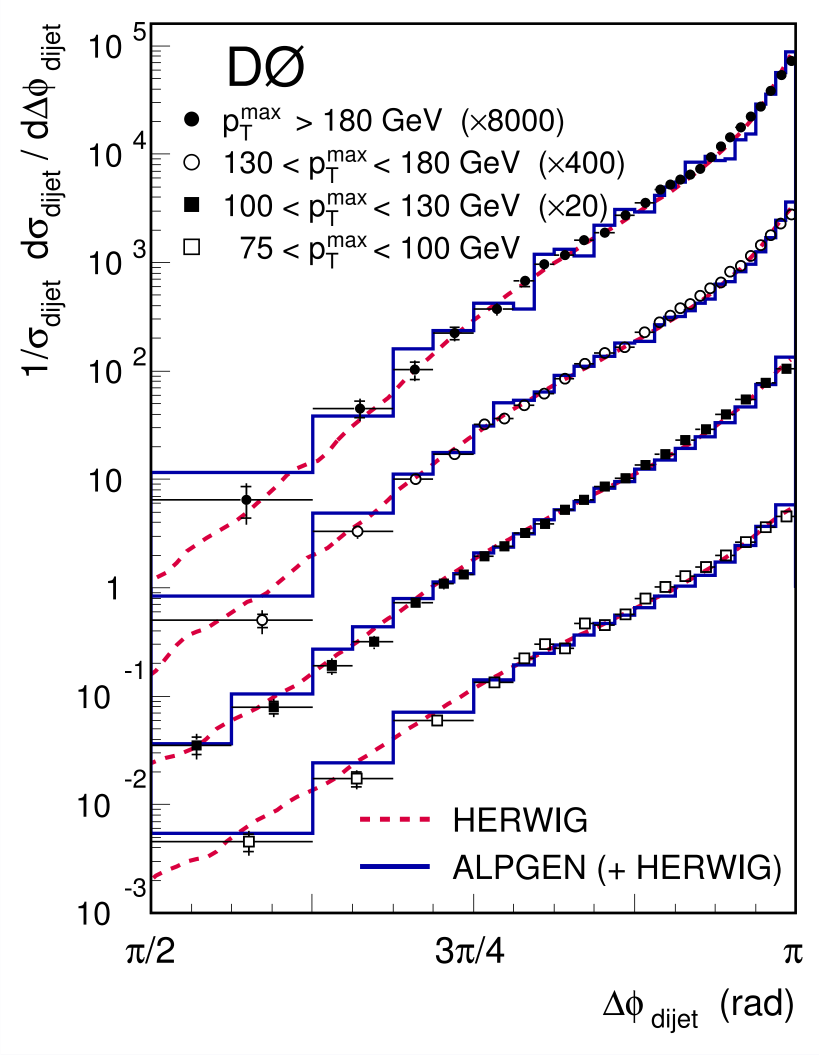
ALPGEN **Results**

- Tree-level production for $2 \rightarrow$ 2, 3,..., 6 jets
- Matched via MLM prescription
- ALPGEN + PYTHIA and ALPGEN + HERWIG yield similar results (details of parton shower model not relevant)
- Reasonable description of the data



ALPGEN Results





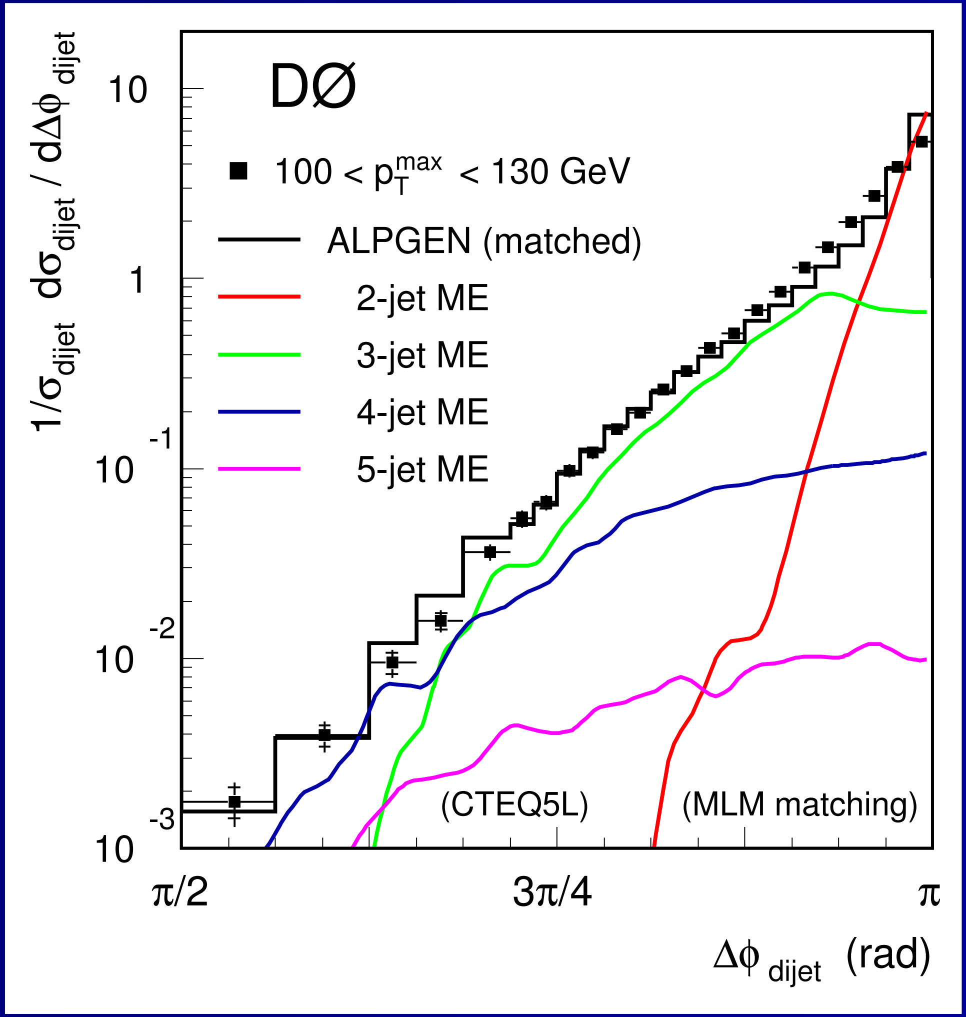
MLM Matching Prescription

- Generate parton-level configuration for a given multiplicity bin with cuts $p_T > p_{T\,min}$ and $\Delta R > R_{min}$
- Perform jet showering using HERWIG or PYTHIA
- Process showered event before hadronization with a jet algorithm
- Match partons and parton-shower jets:
  - a jet can only be matched to a single parton
  - Exclusive: every parton matched to a jet with $N_{jet} = N_{parton}$
  - Inclusive: all partons matched to jets

MLM Matching Prescription

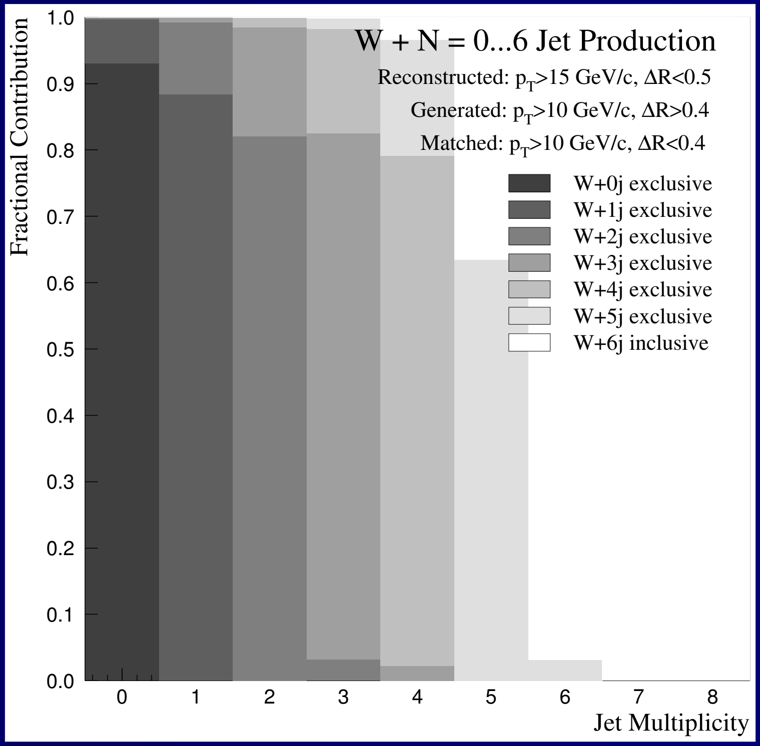
Combine exclusive event samples (constant luminosity) to obtain an inclusive sample containing events with all multiplicities.

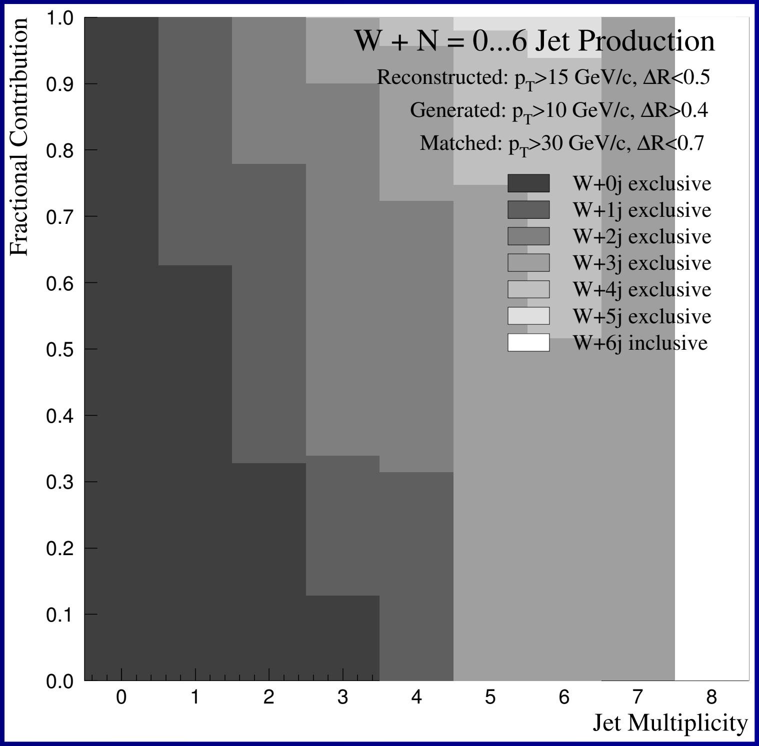
$$N = 2|_{exc} + 3|_{exc} + 4|_{exc} + 5|_{inc}$$



Multiplicity Mixing

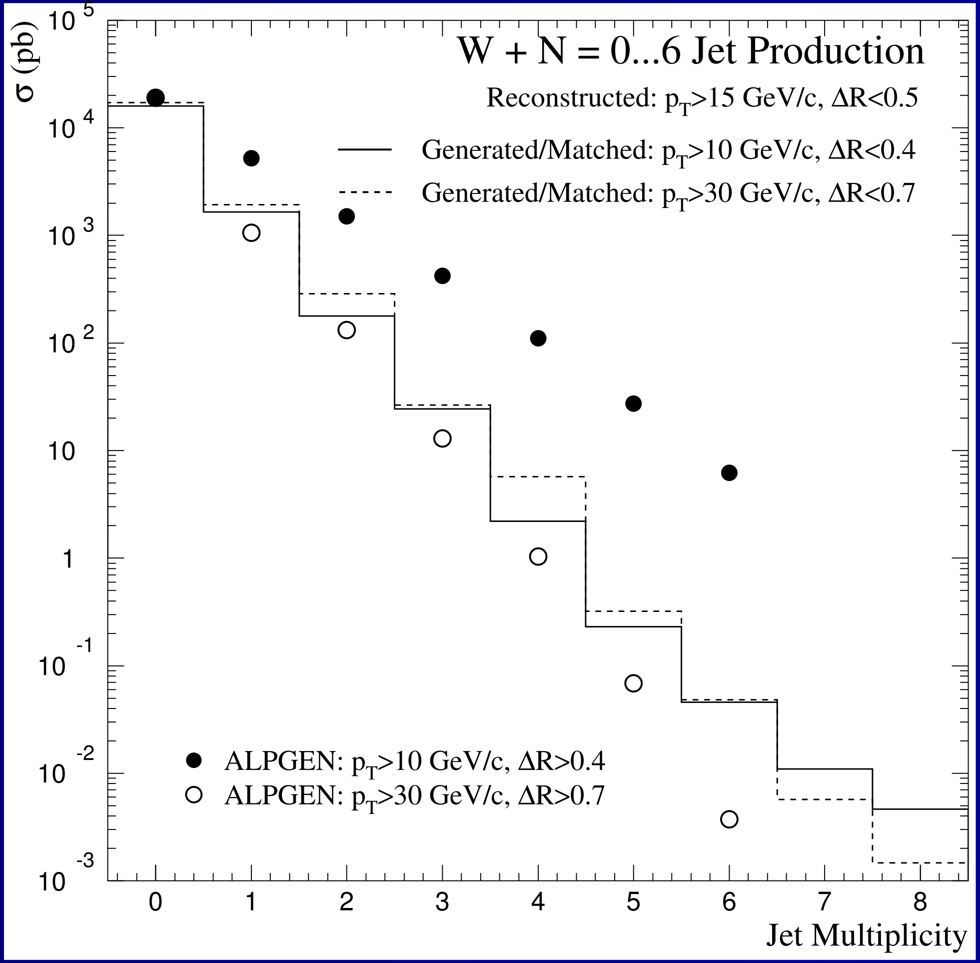
Event mixture by multiplicity bin highly dependent on matching parameter choices. This is an important consideration when creating samples.





Matching Stability

- Result does not depend on generator cuts or matching criteria
- Matched result lies between generated cross sections and has different multiplicity dependence



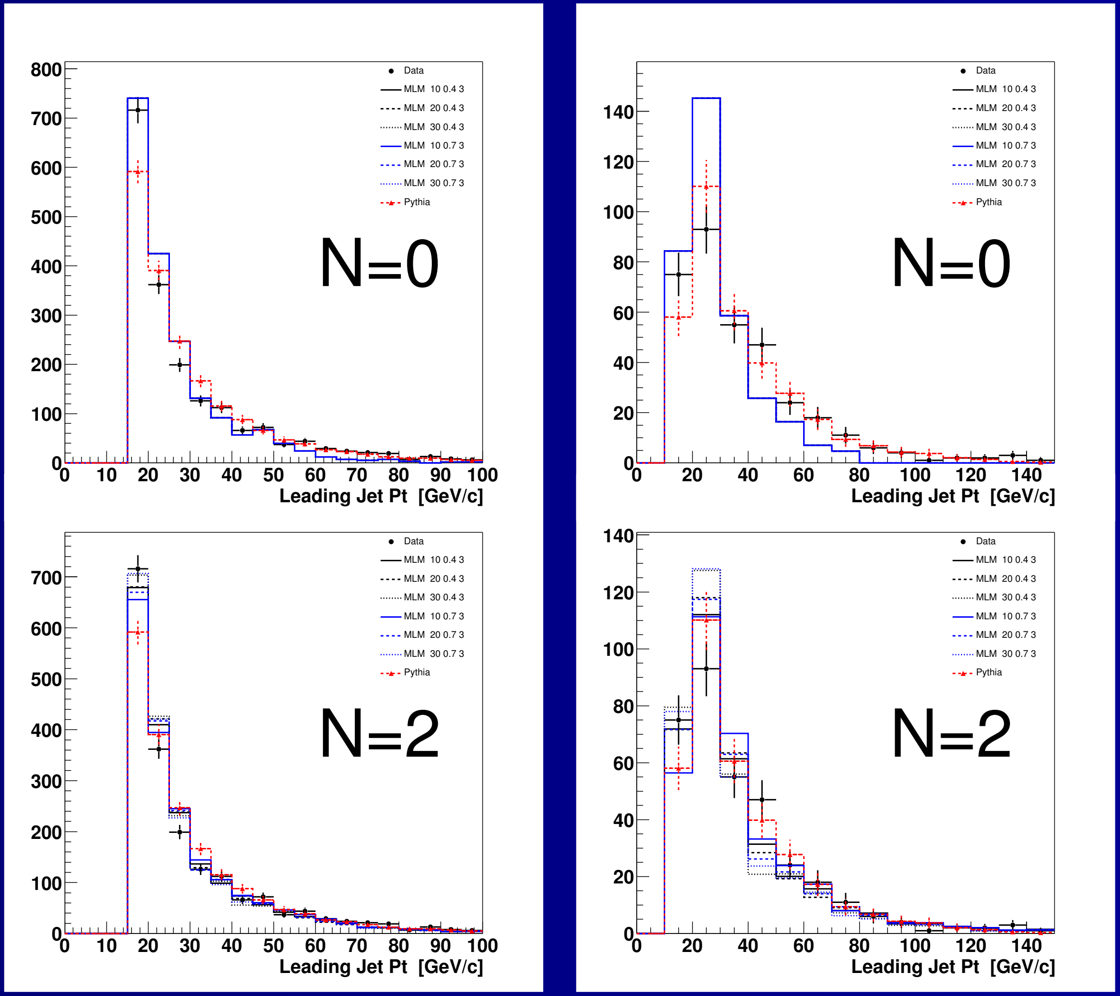
Matching in Top Samples

- Events in top analyses must be processed through the full simulation chain including GEANT
- For technical reasons, MLM matching is only applied at the end of the chain
  - Compare matched and unmatched samples for multiple parameter choices
  - Unmatched samples have $p_T > 8$ GeV and $\Delta R > 0.4$
- The low matching efficiency requires very high initial statistics so comparisons will be made in low multiplicity bins

Z + Jets: Leading Jet p_T

- $t\bar{t}$ analysis in dimuon channel
- Two isolated muons with $p_T > 15$ GeV
- $75 < M_{\mu\mu} < 105$ GeV

Z inclusive | Z + 2 jets



- Data
- PYTHIA
- – MLM Matched ALPGEN

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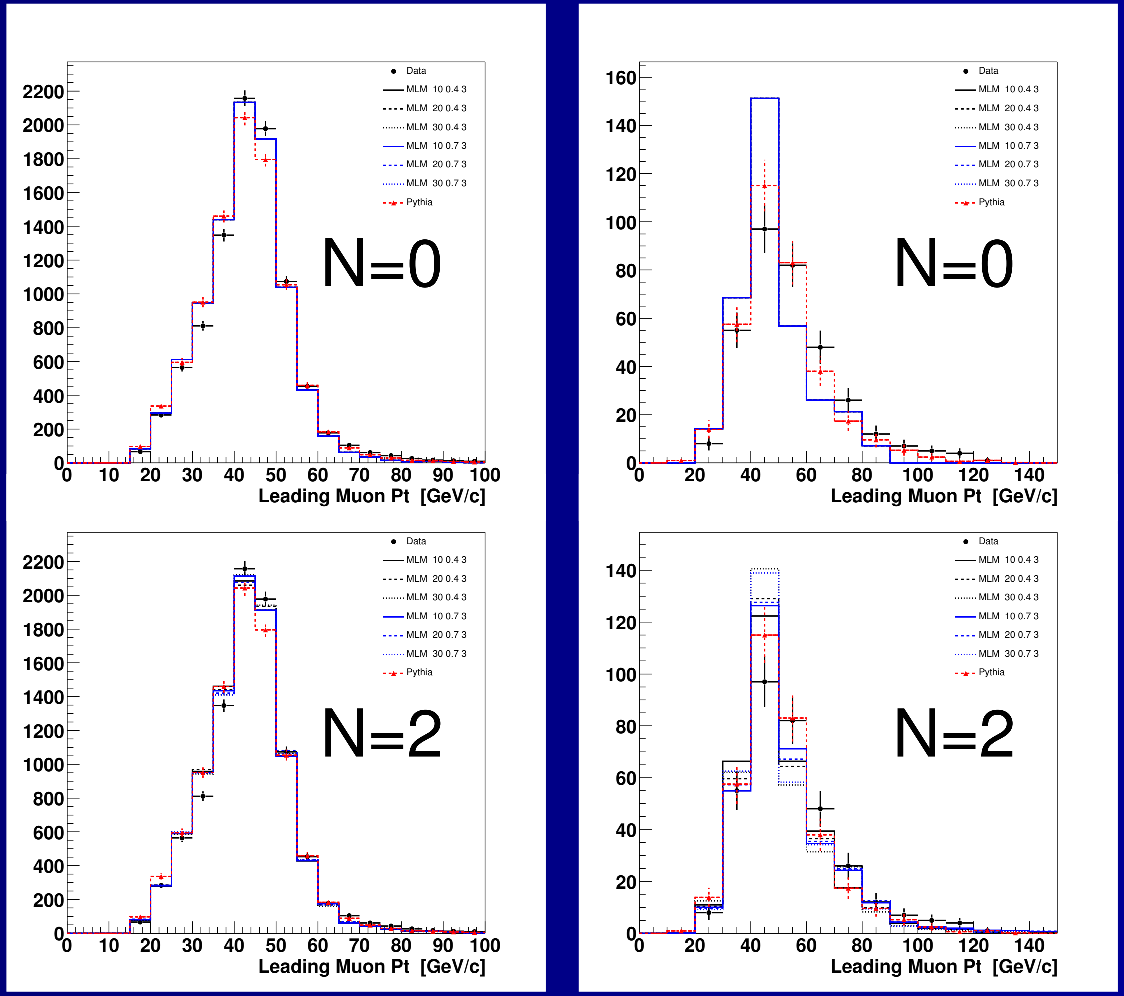

- ● Data
- ● PYTHIA
- – MLM Matched ALPGEN

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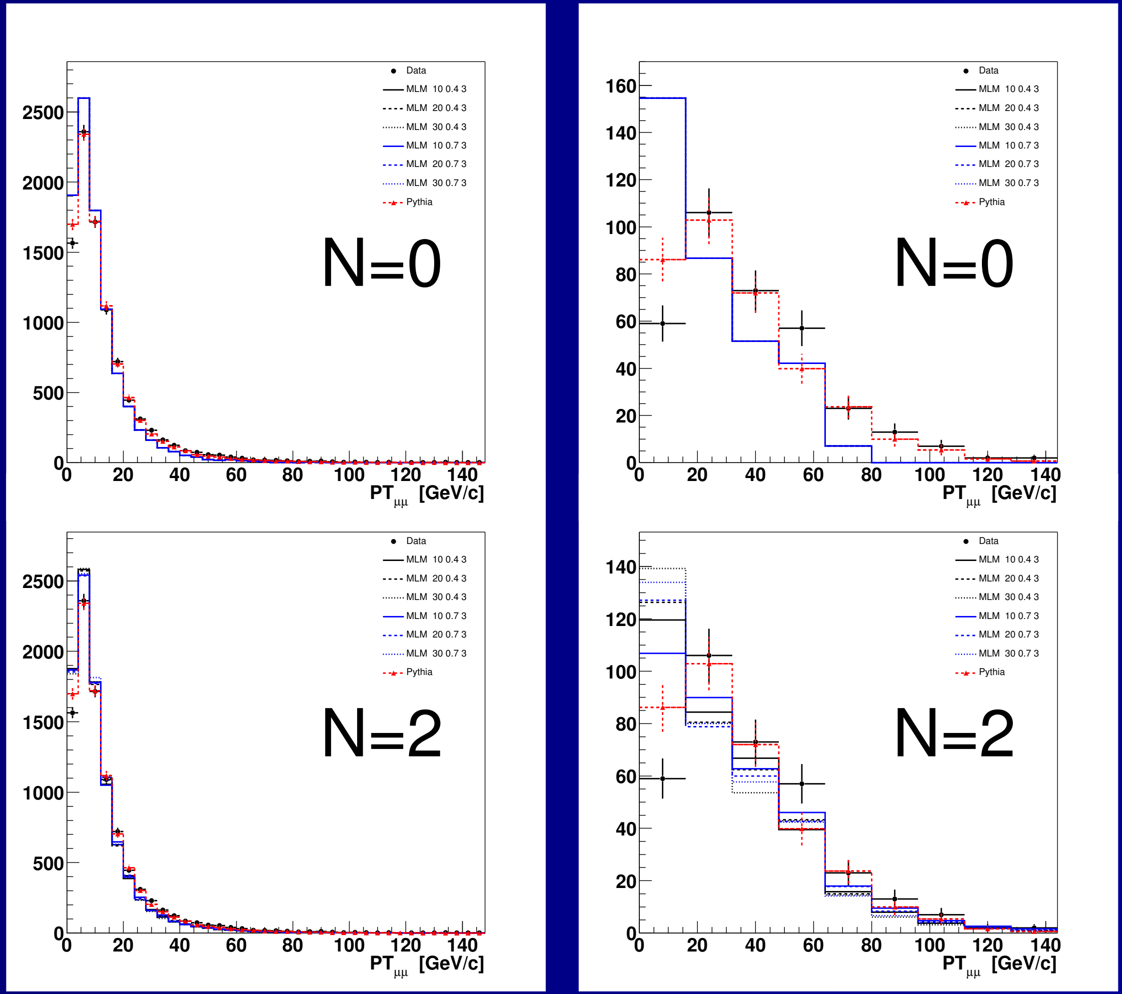


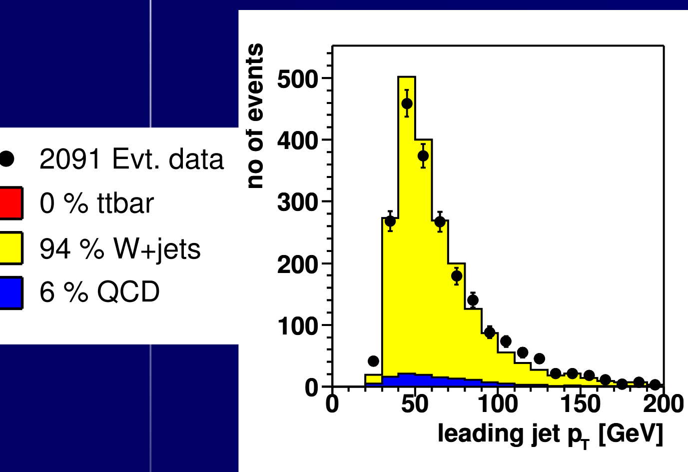
- Data
- PYTHIA
- – MLM Matched ALPGEN

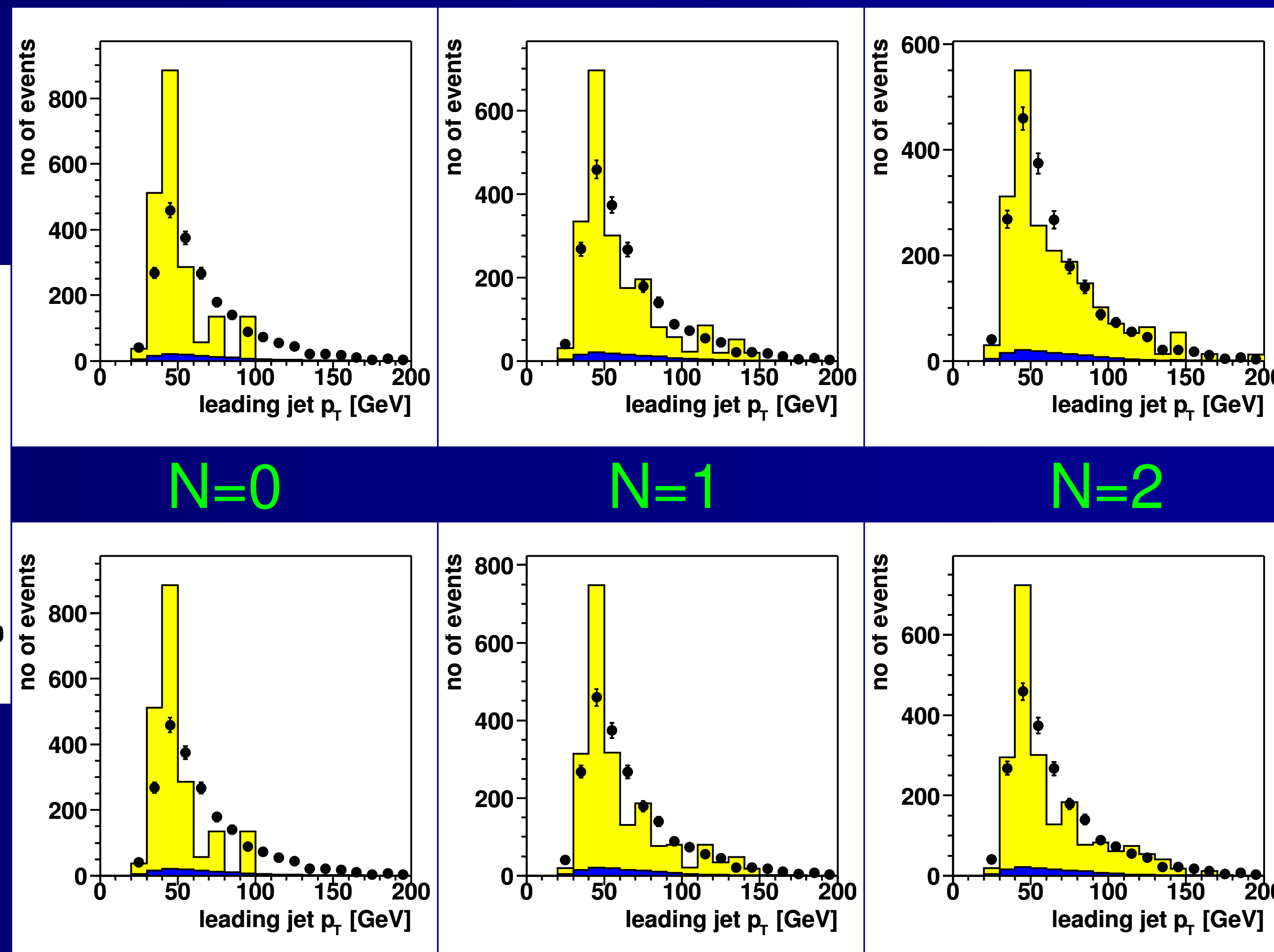
W + 2 Jets: Leading Jet p_T

Match $\longrightarrow$

$p_T > 10$ GeV

$\Delta R < 0.4$





Match $\longrightarrow$

$p_T > 30$ GeV

$\Delta R < 0.7$

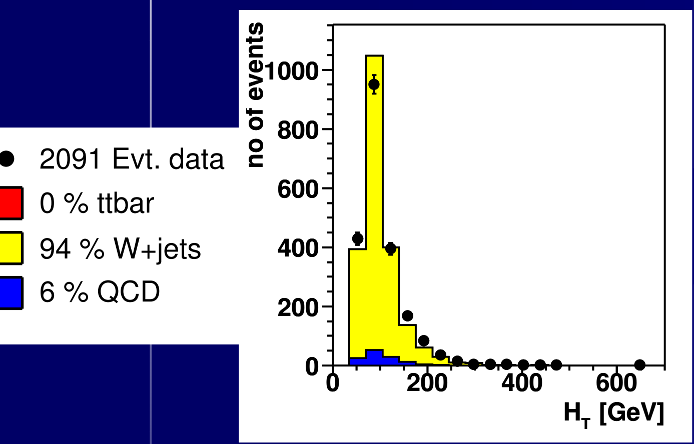
$t\bar{t}$ analysis in μ+jets channel

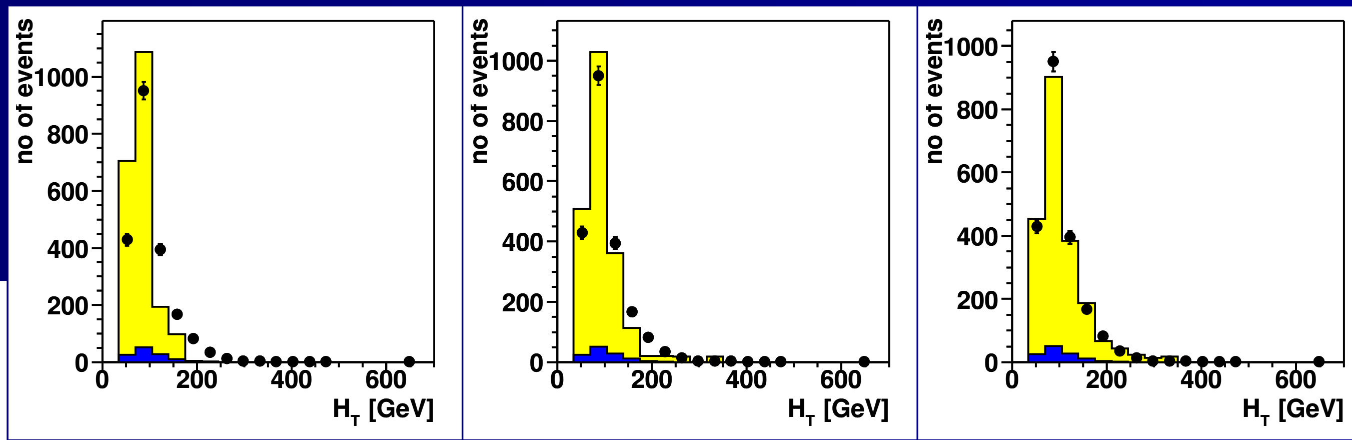
W + 2 Jets: H_T

Match $\longrightarrow$

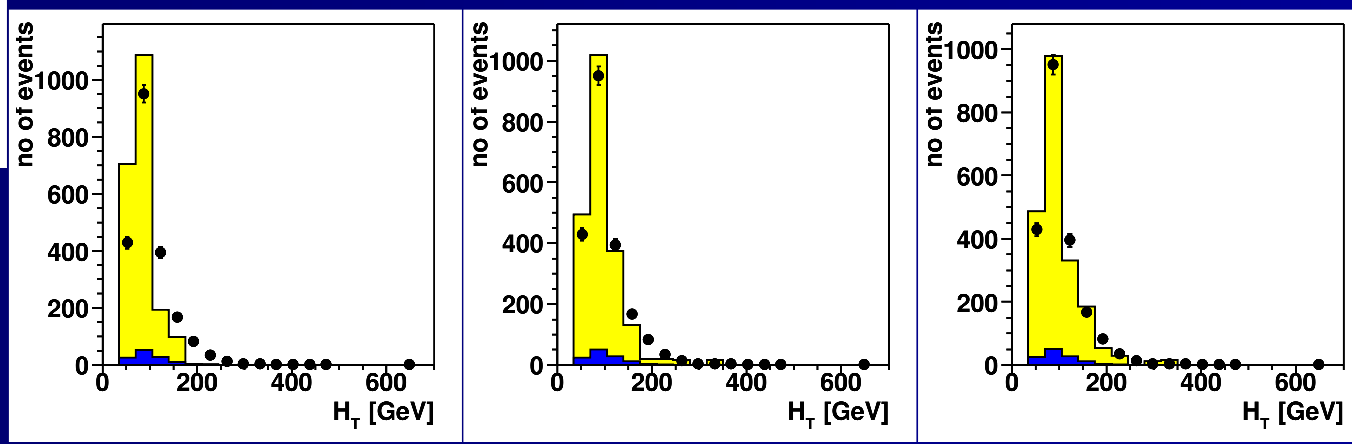
$p_T > 10$ GeV

$\Delta R < 0.4$





N=0 N=1 N=2



Match $\longrightarrow$

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$t\bar{t}$ analysis in μ+jets channel

W + 2 Jets: $\Delta\phi(\mu, E_T^{miss})$

Match $\longrightarrow$

$p_T > 10$ GeV

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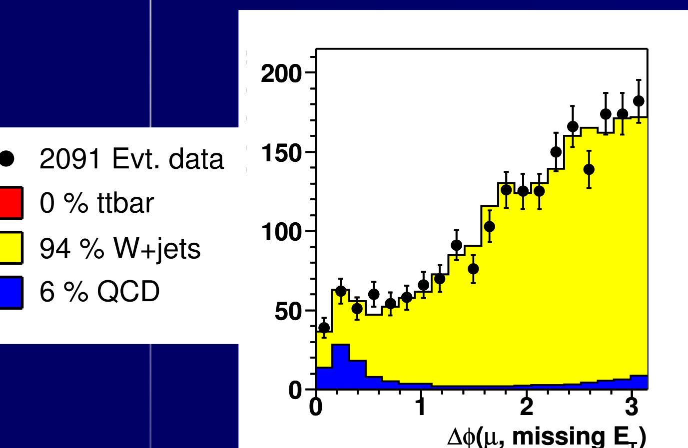

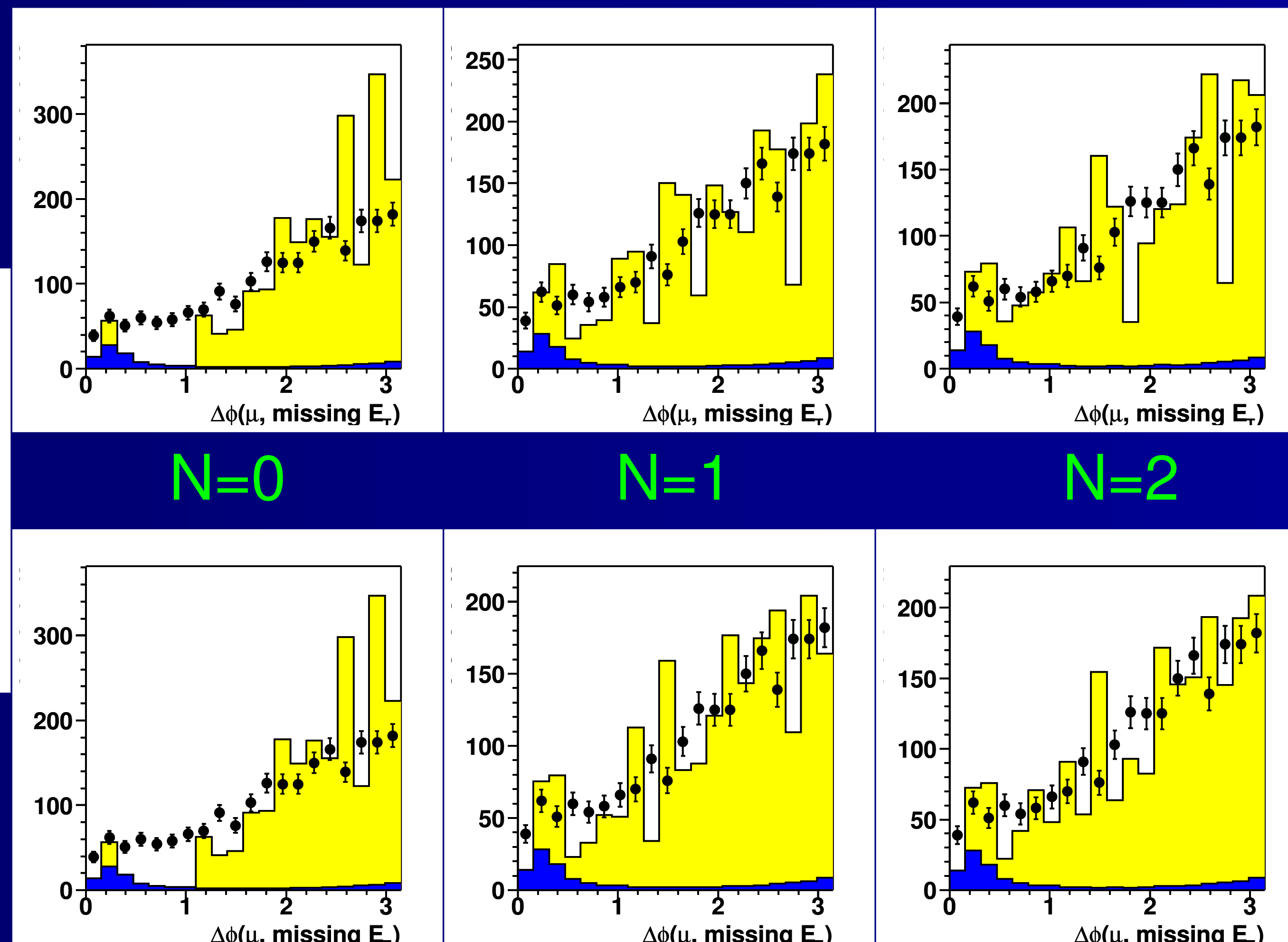

Match $\longrightarrow$

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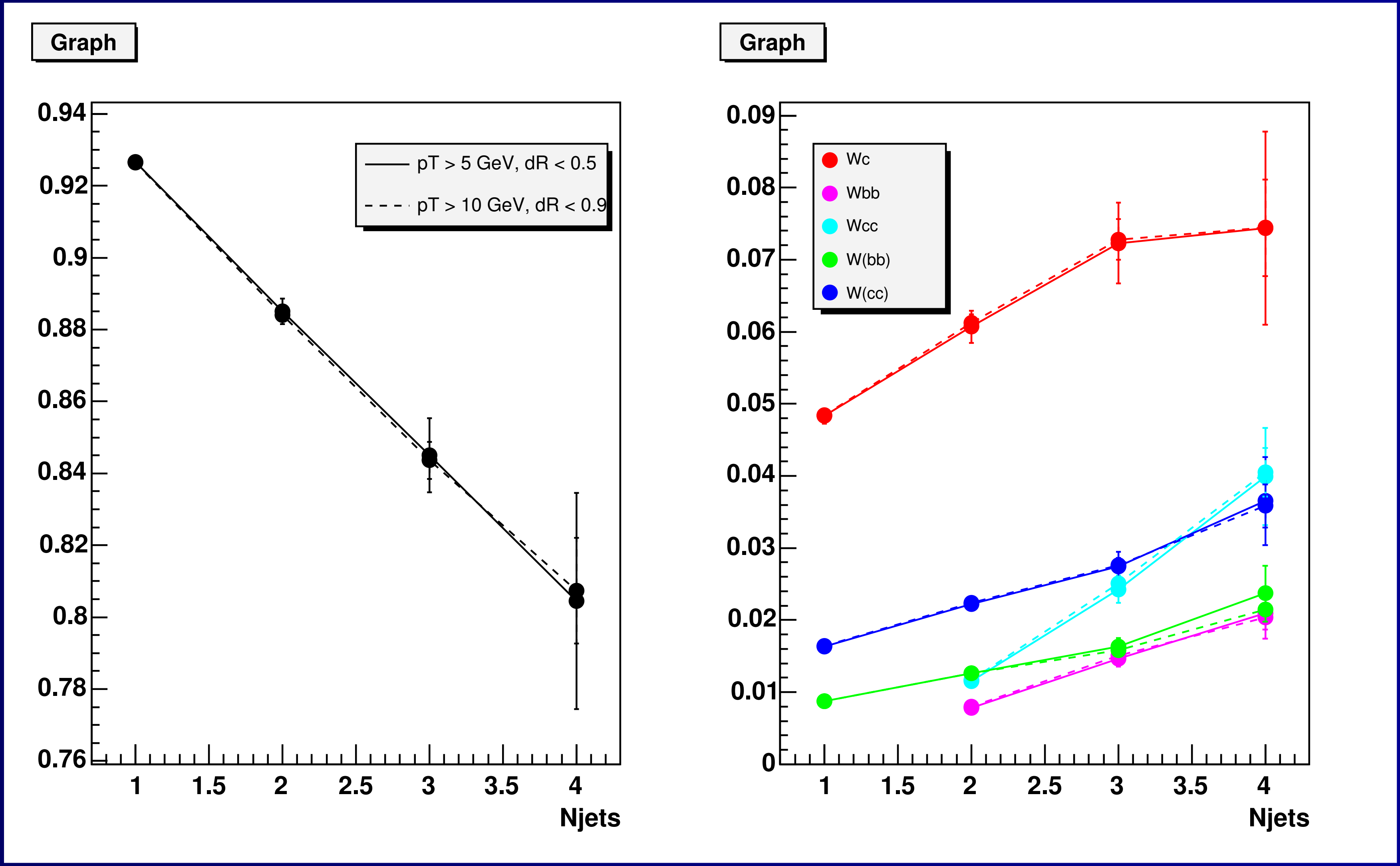
$t\bar{t}$ analysis in μ+jets channel

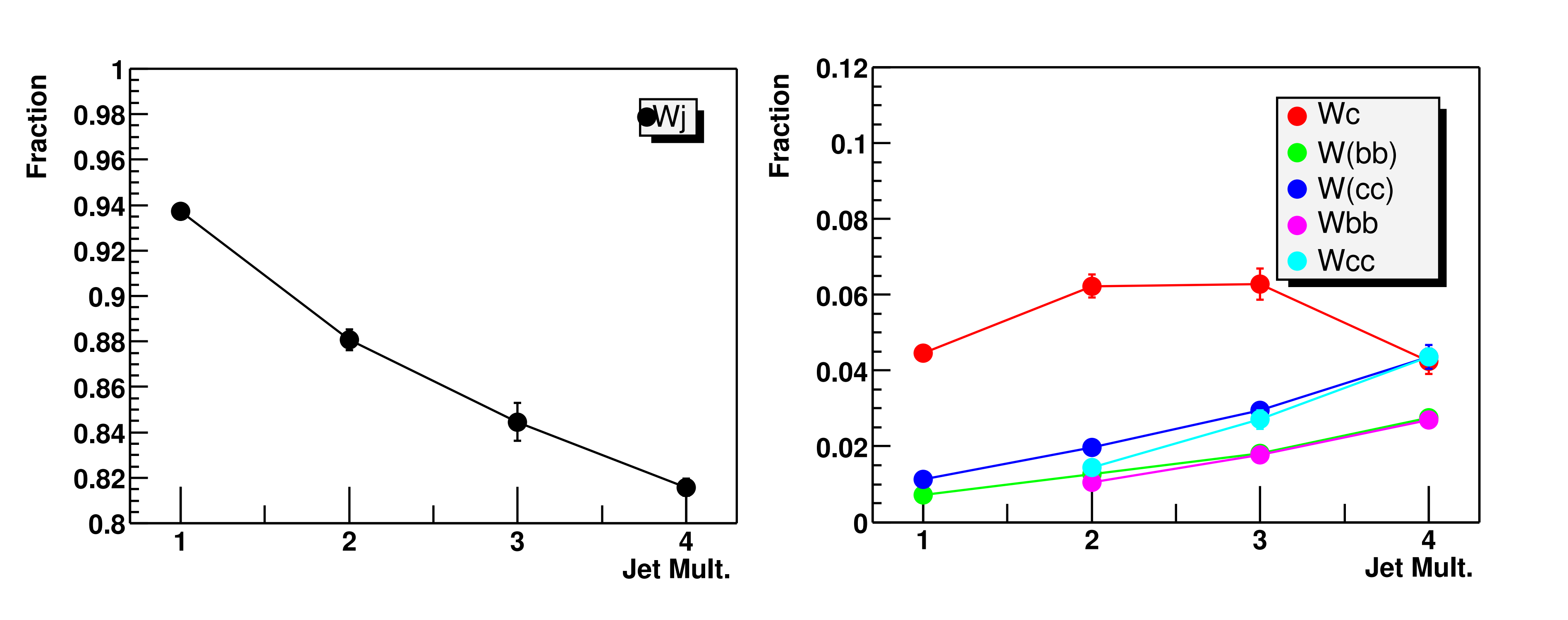
Heavy Flavor Fractions

- The flavor composition of backgrounds is important in b-tagged analyses
- Use W + jets samples (Wj, Wc, Wbb, Wcc, with up to 5 jets) to calculate flavor fractions
  - Coalescence of two b's or two c's within a single reconstructed jet is an important contribution to the background.
- Since our MLM matched ALPGEN samples have limited statistics, we employ an ad-hoc matching procedure:
  - Flavor tag reconstructed jets using generated information
  - Exclusively match keeping 4-jet bin inclusive

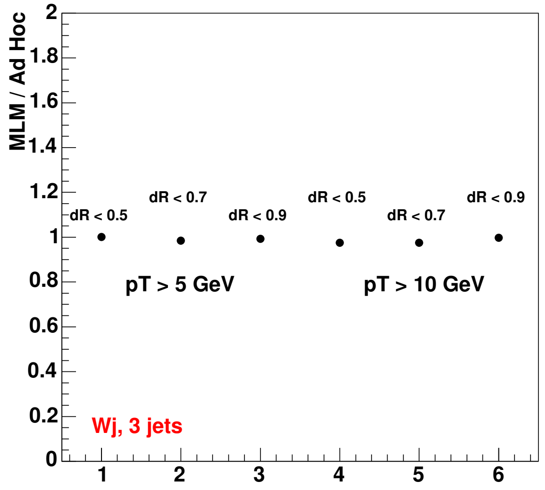
MLM Flavor Fractions

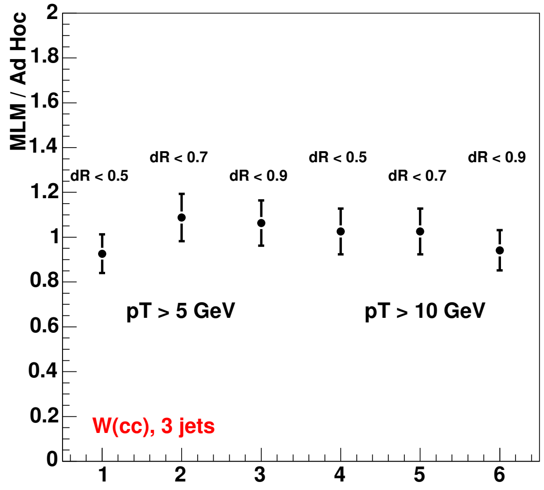


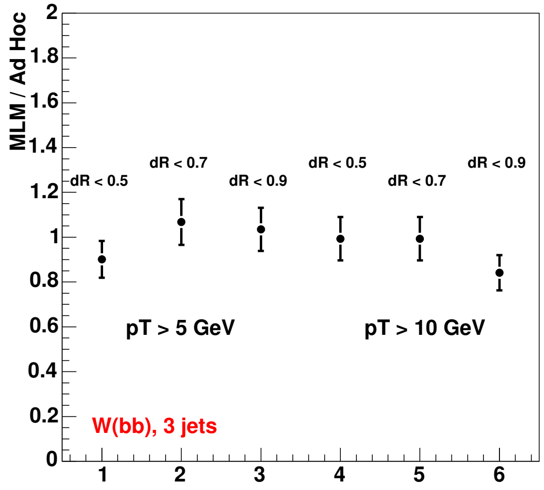
Ad-hoc Flavor Fractions

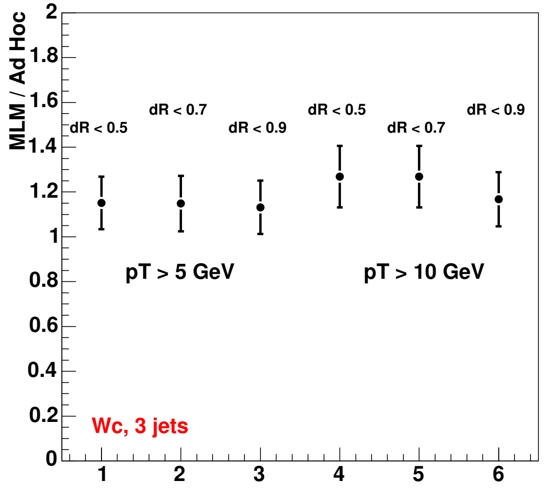


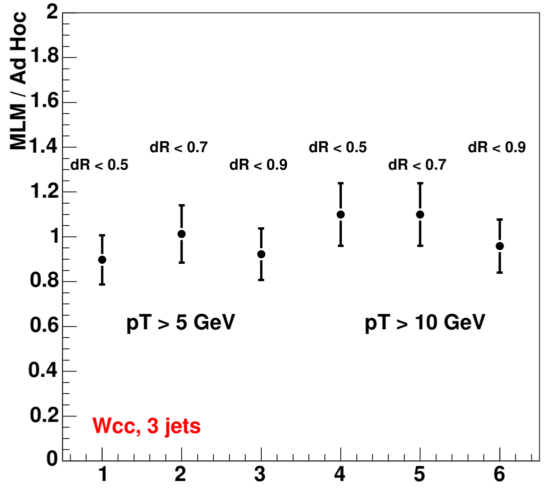
Flavor Fraction Ratios: W + 3 jets

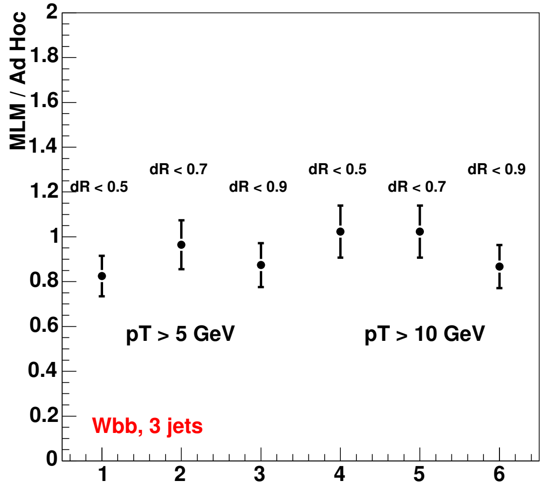




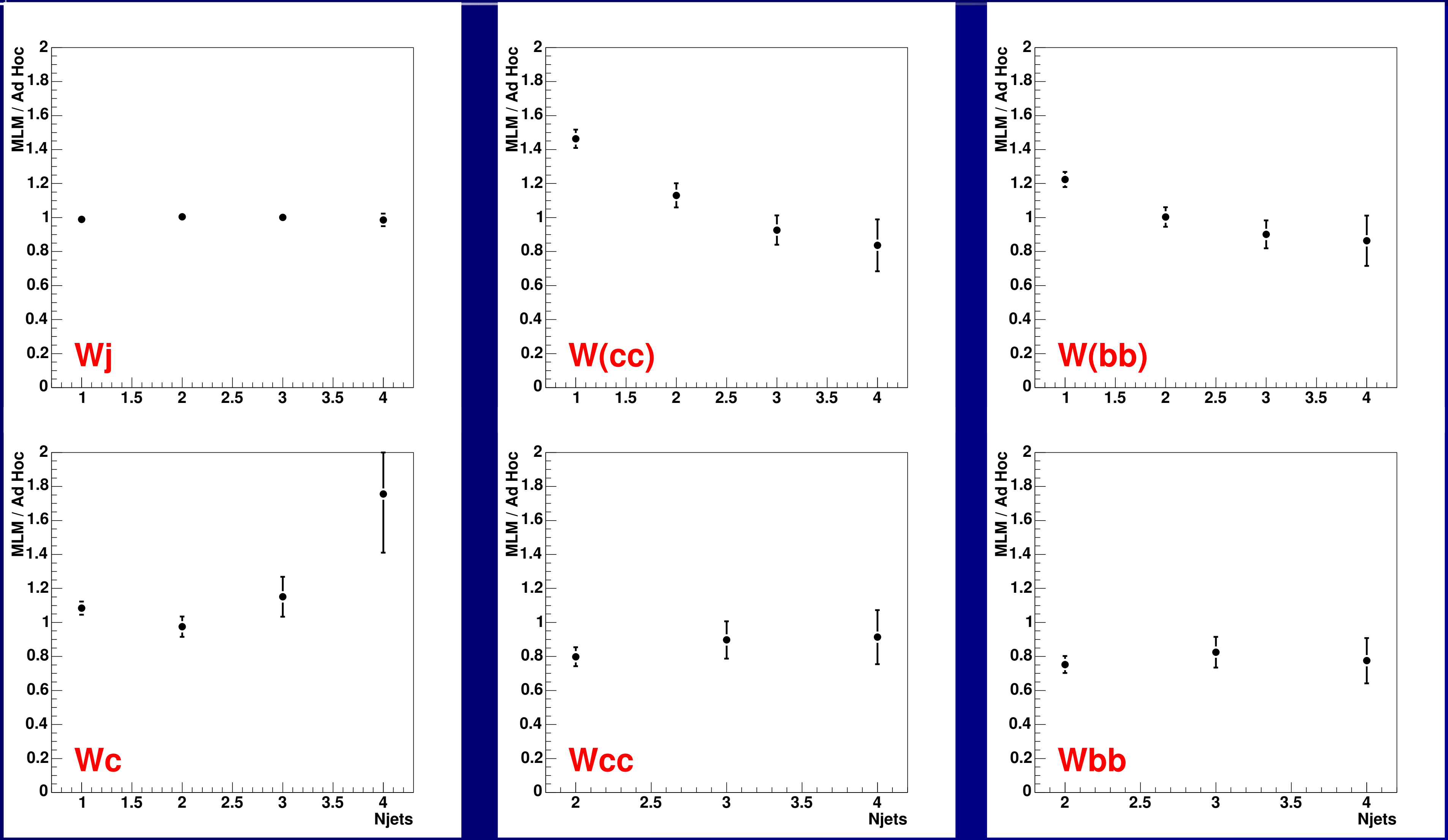








Flavor Fraction Ratios: Multiplicity



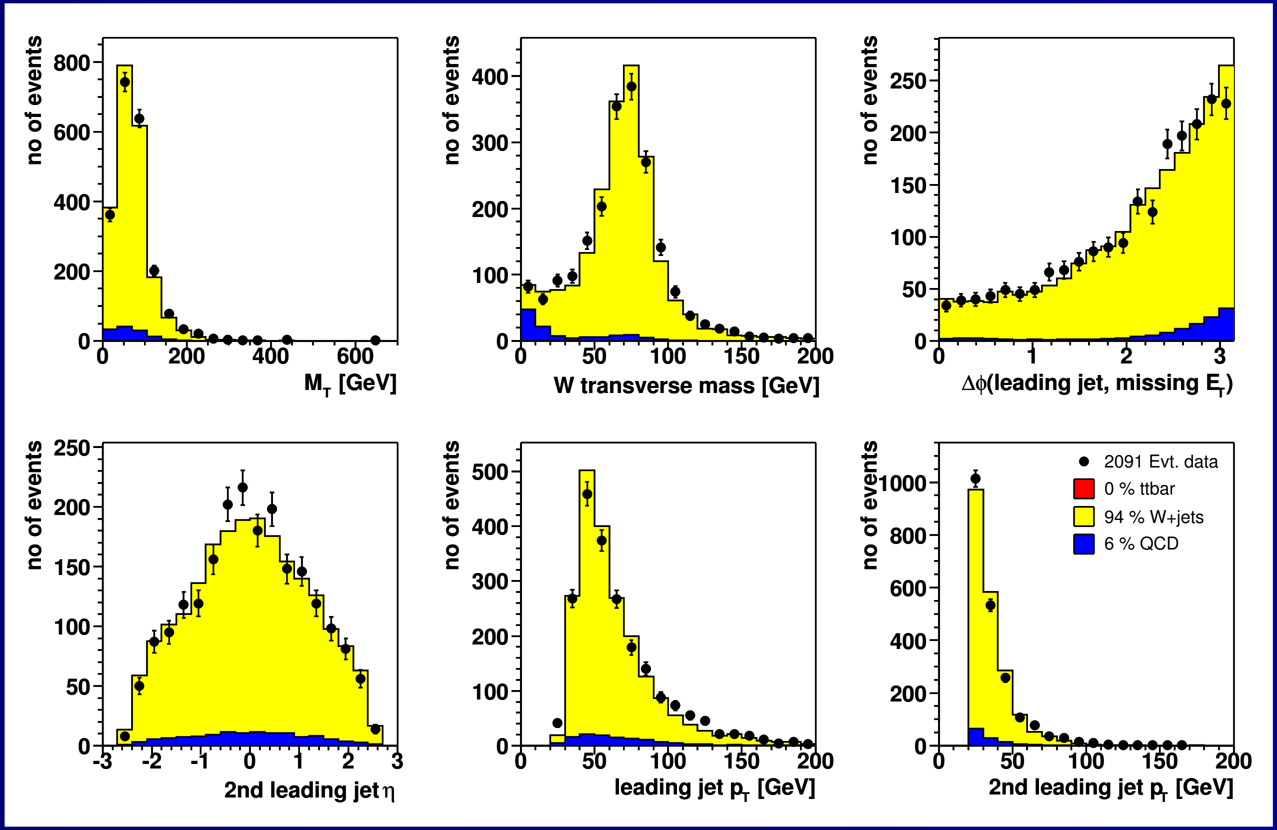
Conclusions

- MLM matched ALPGEN describes ϕ decorrelation in dijets.
- High statistics unmatched ALPGEN samples describe the W+jets and Z+jets distributions. Lower statistics MLM matched samples provide reasonable agreement.
- The ad-hoc matched W+jets flavor fractions are in fair agreement with the lower statistics MLM matched fractions.
- What's next?
  - Increase statistics in MLM matched samples
  - Investigate CKKW matching using Mrenna's W & Z samples and SHERPA

W + 2 Jet: Unmatched ALPGEN

- $t\bar{t}$ analysis in μ+jets channel
- Isolated high-p_T muon
- $E_T^{miss} > 20$ GeV
- $p_T^{jet} > 20$ GeV

unmatched W + 2 jet



Good agreement in all multiplicity bins

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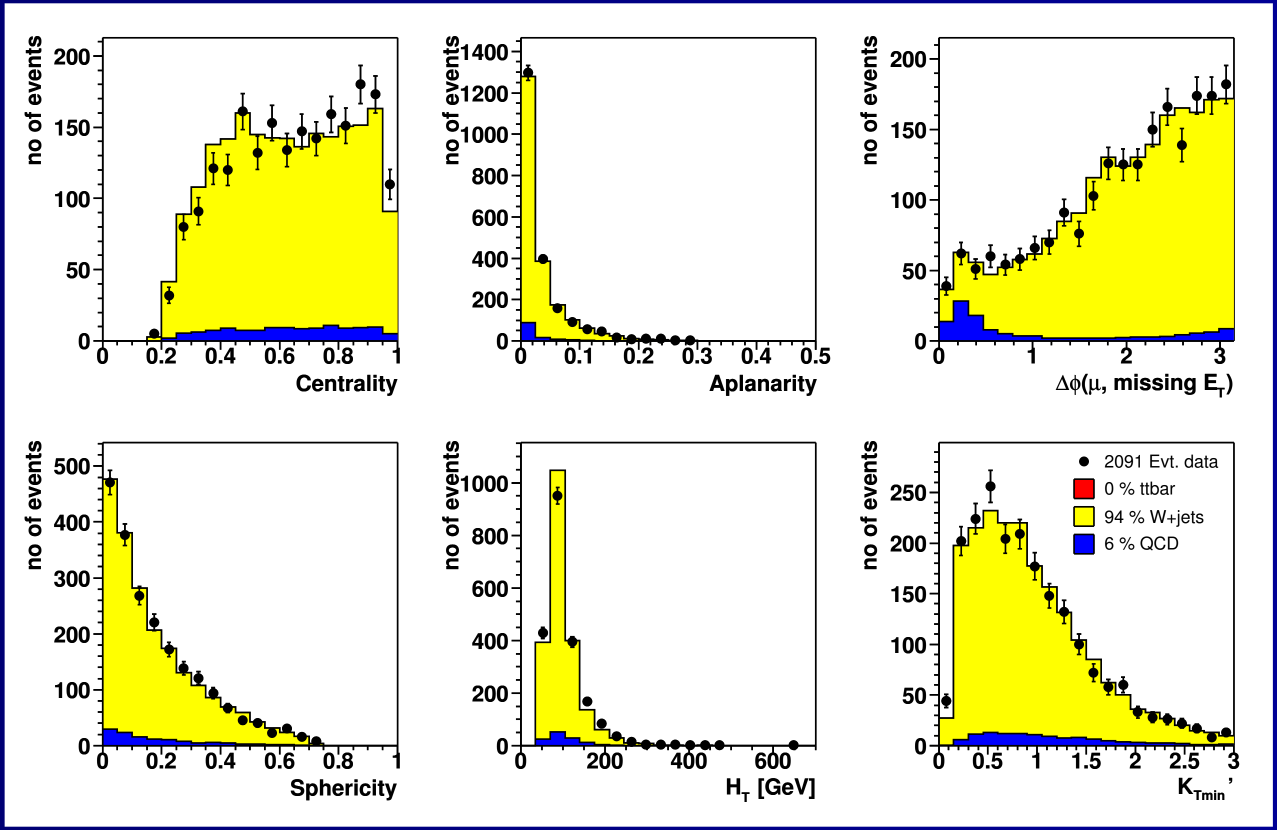

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