ISR/FSR/NLO Related Uncertainties

Un-ki Yang
University of Chicago

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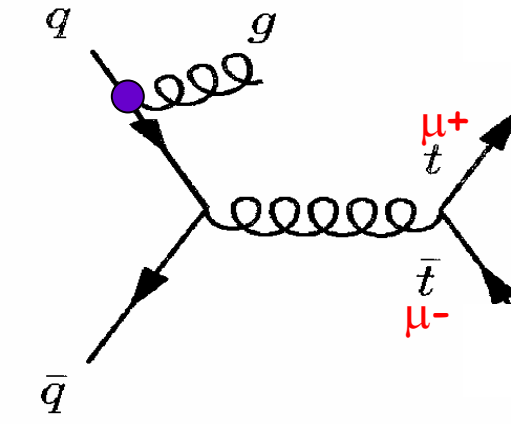
Outline

- How did we establish ISR/FSR syst?
- How can we improve ISR/FSR syst?
- What is the size of the NLO effect?
- How much is covered by ISR/FSR syst?

ISR syst. in $t\bar{t}$ system?

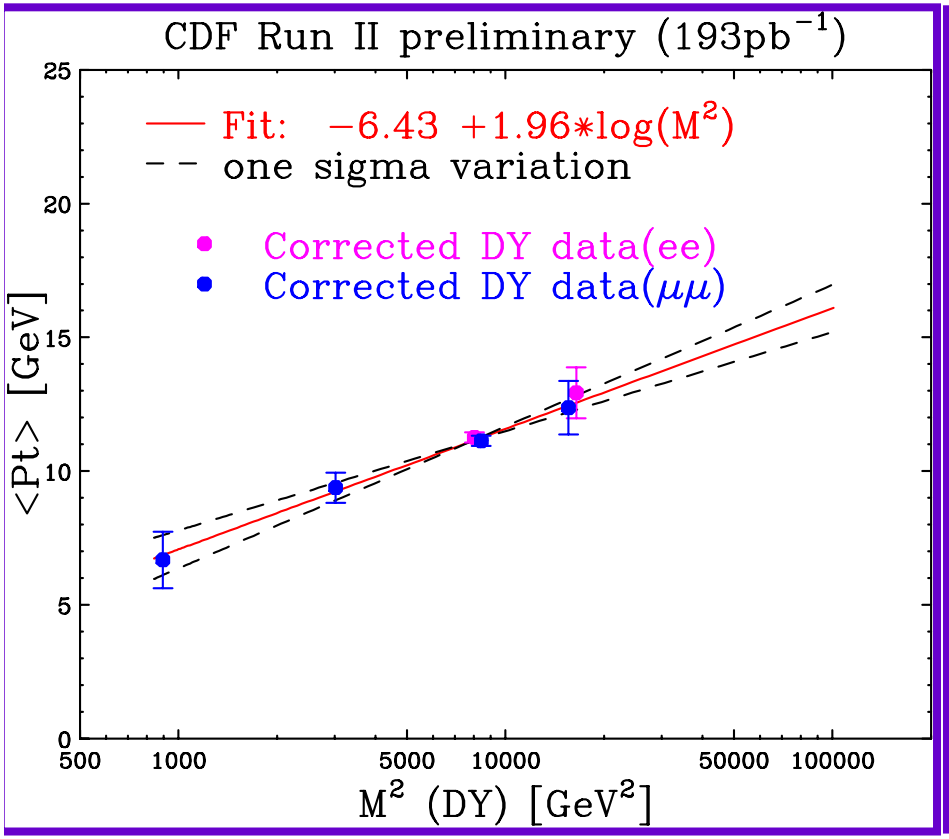
- New approach
  - ISR is governed by DGLAP eq.: Q^2, Λ_{QCD}, splitting functions, PDFs
  - Use DY data (no FSR): study Pt of the dilepton, Njets for different mass regions (~different Q^2)

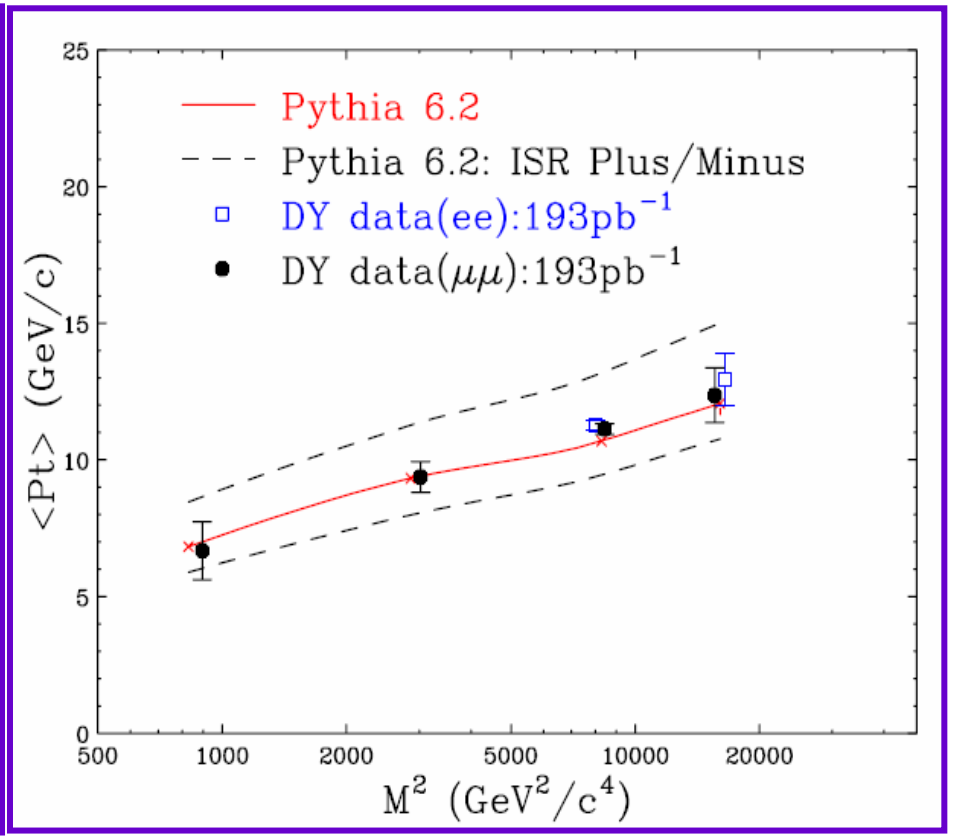


$q\bar{q}$ -> $t\bar{t}$(85%)

$$\frac{dq(x,Q^2)}{d\ln Q^2} = \int \frac{dy}{y} \alpha_s \left(\frac{Q^2}{\Lambda^2_{QCD}}\right) P_{q\to qg}\left(\frac{x}{y}, Q^2\right) q(y,Q^2)$$

<Pt (dilepton)> as a function of M^2(ll)



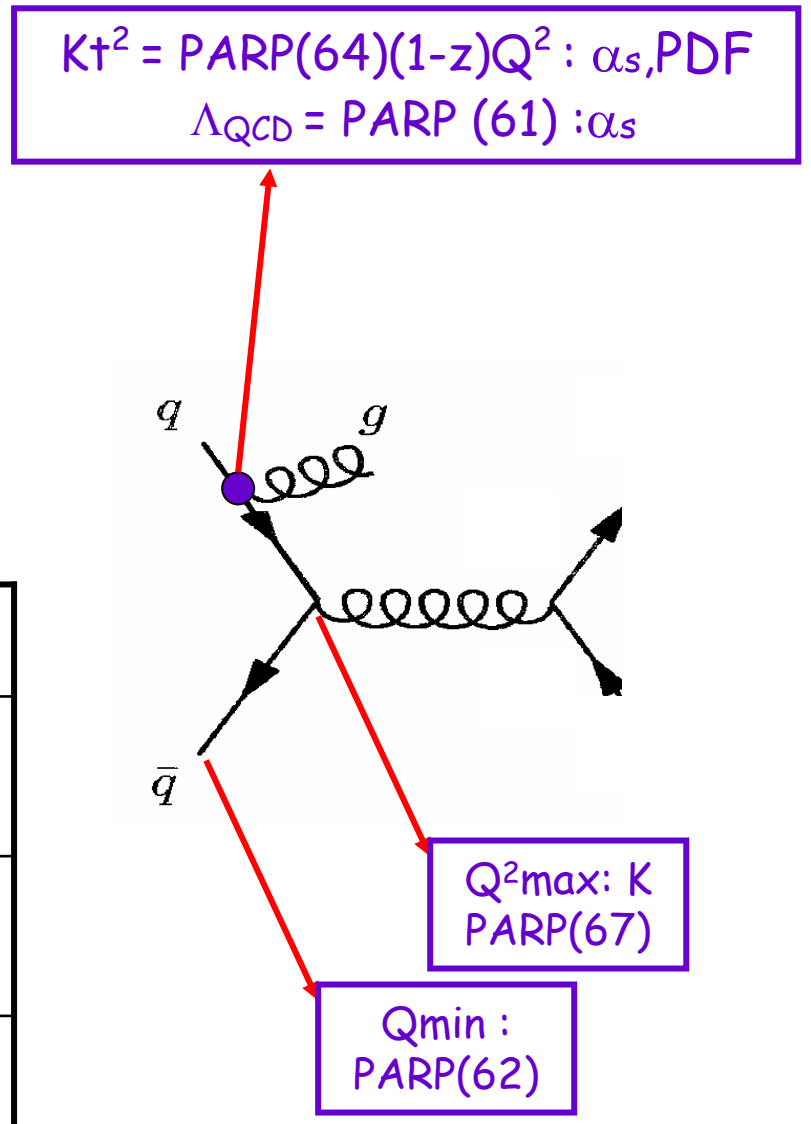


- A good logarithmic Q^2 (~M^2) dependence is observed.
- Conservative ISR syst. (more/less) for ttbar are established
  - <Pt(dilepton)>: sensitive to only total size of ISR, but missing Njet
  - Extrapolate to top pair production region using LO MC.

ISR uncertainty

- ISR uncertainty is only due to uncertainty in shower processing
  - PDF, factorization scale uncertainties are not treated as a part of the ISR uncertainty.

Pythia	ISR more	ISR less
PARP(61) (D=0.146)	0.292 (5 flavour)	0.073
PARP(64) (D=1.0)	0.25	4.0
PARP(67) (D=1.0)	4.0 (Tune-A)	



FSR syst. in $t\bar{t}$ system

- FSR syst. is based on the ISR syst. studies
  - Both ISR and FSR have same parton shower process (DGLAP), except that the PDF evolution is involved in ISR showering.

Pythia	FSR more (Top std)	FSR less (Top std)
PARP(72)	0.292 (5fl: LO)	0.073
PARP(71) D=4	8	2.0

Default FSR syst:
No change in color singlet
(including resonance decay)
Constrained by LEP data

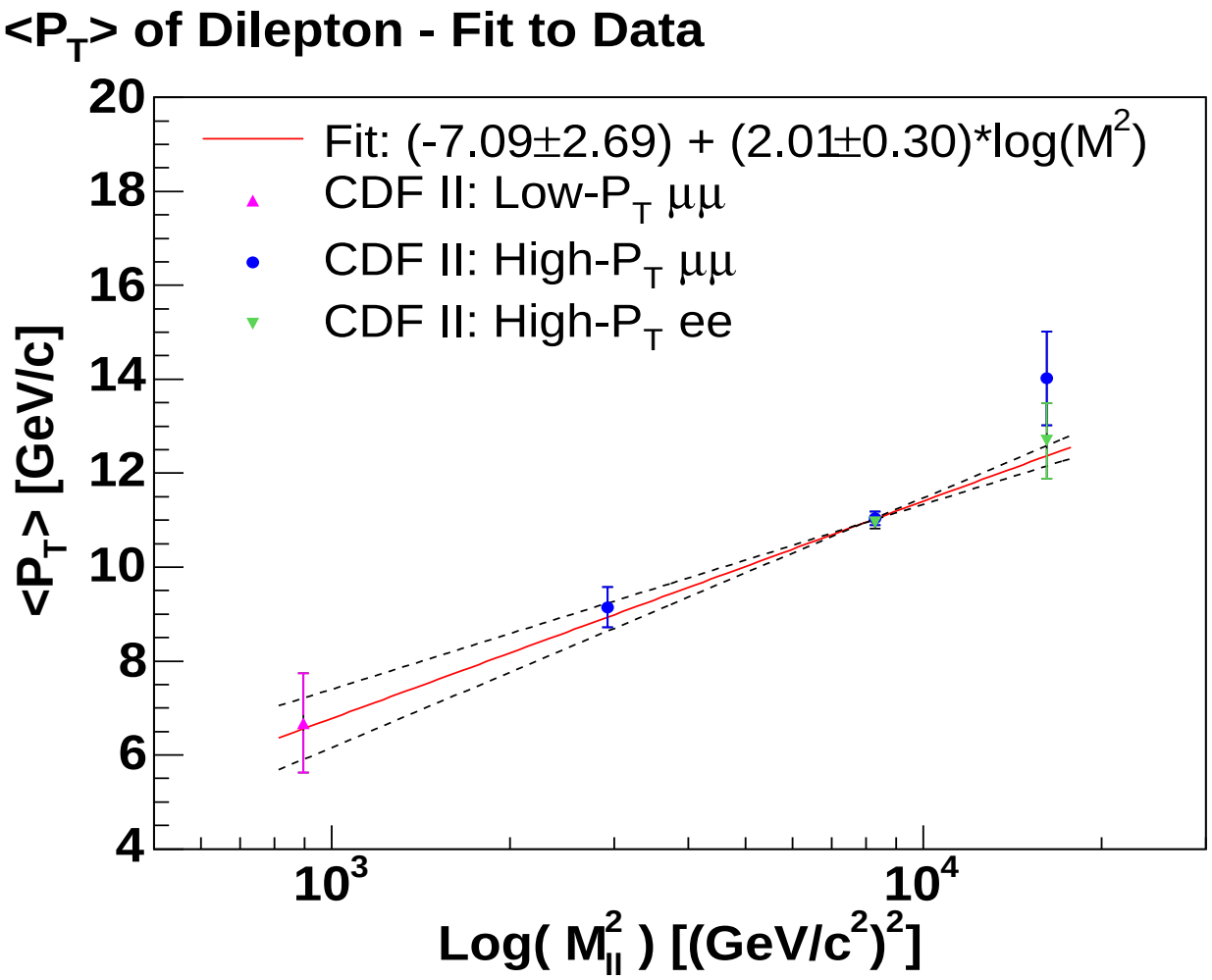
Pythia	FSR more (Top cntrl)	FSR less (Top cntrl)
PARP(72)	0.292	0.073
PARJ(81) D=0.290	0.580 (4fl: LO)	0.145
PARP(71)	8	2.0

Even allow variation
in color singlet
(conservative)

How can we improve the ISR/FSR syst.?

- The ISR studies was updated by Sasha Rahlin (Chicago REU student): see her talk in Top Mass Meeting, Aug 17th
  - More DY data : 340pb-1
  - Njet, $\delta\phi$(ll) distributions are included: good agreement with Pythia and data
  - Q2 dependences on Njet, $\delta\phi$(ll) are under studies.
  - Low-pt DY data (with SUSY dilepton trigger) will be added
- How much these syst. cover the NLO effect
- Future improvement
  - ttbar data (with 1fb-1 data)
  - CKKW ALPGEN, MadGraph ttbar + Njets, MC@NLO
  - Especially helpful in pinning down FSR syst.
  - Study with Pythia 6.3?

Updated results on <pt(dilepton)>



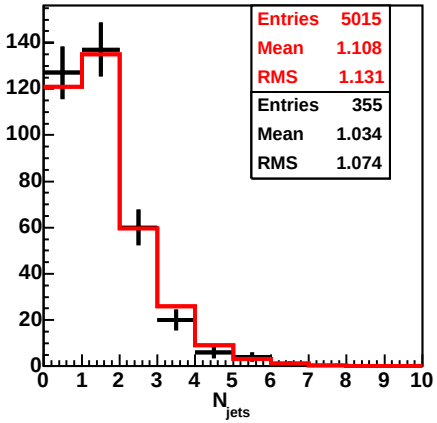
N_{jets} Distribution

Pythia 6.2

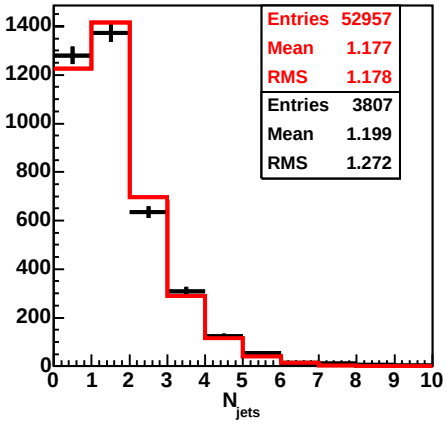
Dimu data

$4 < E_T < 15$ GeV
(Soft Jets)

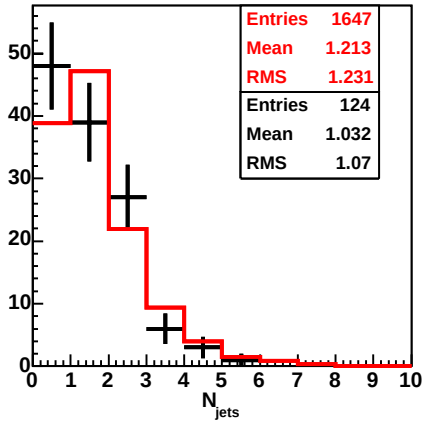
40<M<76 (low)



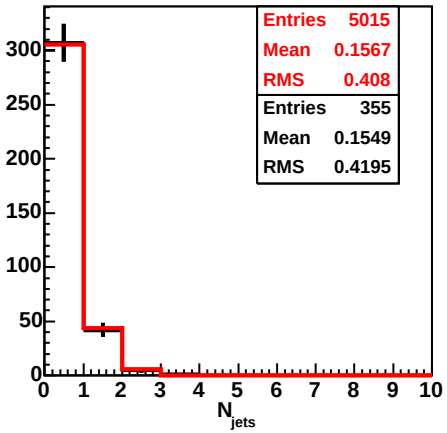
76<M<106 (Z)



106<M<200 (high)



40<M<76 (low)



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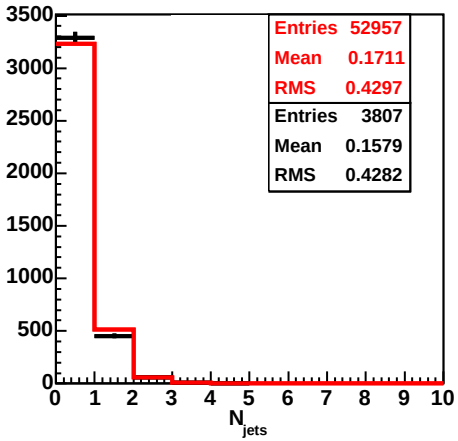
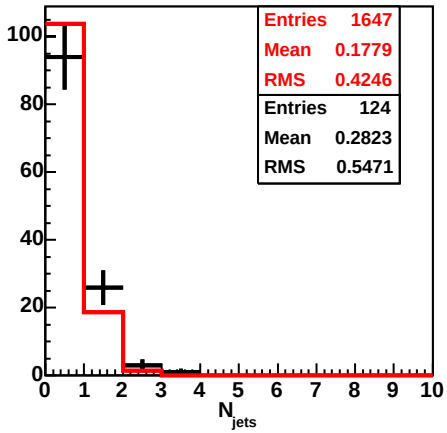
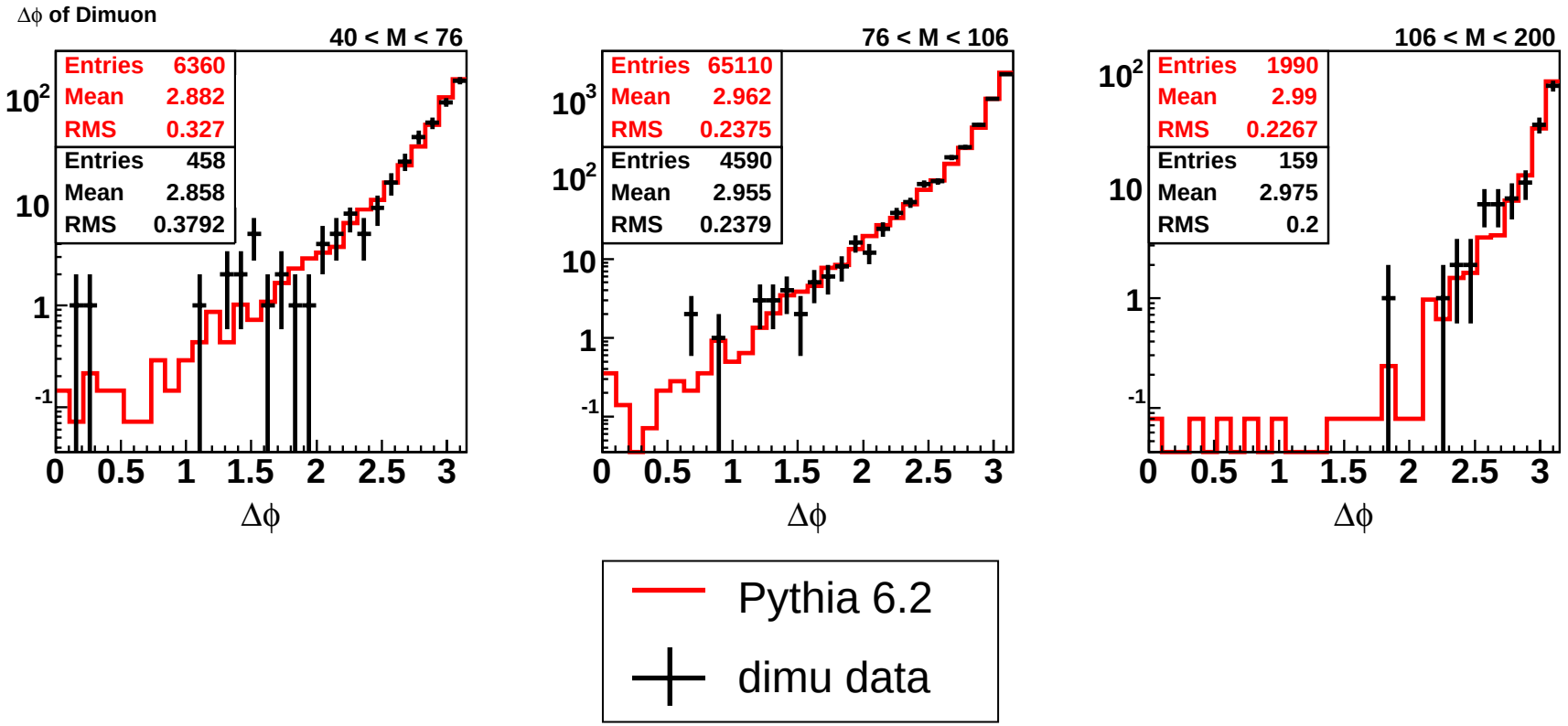


106<M<200 (high)



$E_T > 15$ GeV
(Hard Jets)

$\Delta\phi(\mu\mu)$ Distribution



MC@NLO Overview

- MC@NLO is a Parton shower MC (like PYTHIA, HERWIG),
  but the partonic hard processes are calculated up to the full NLO QCD corr.

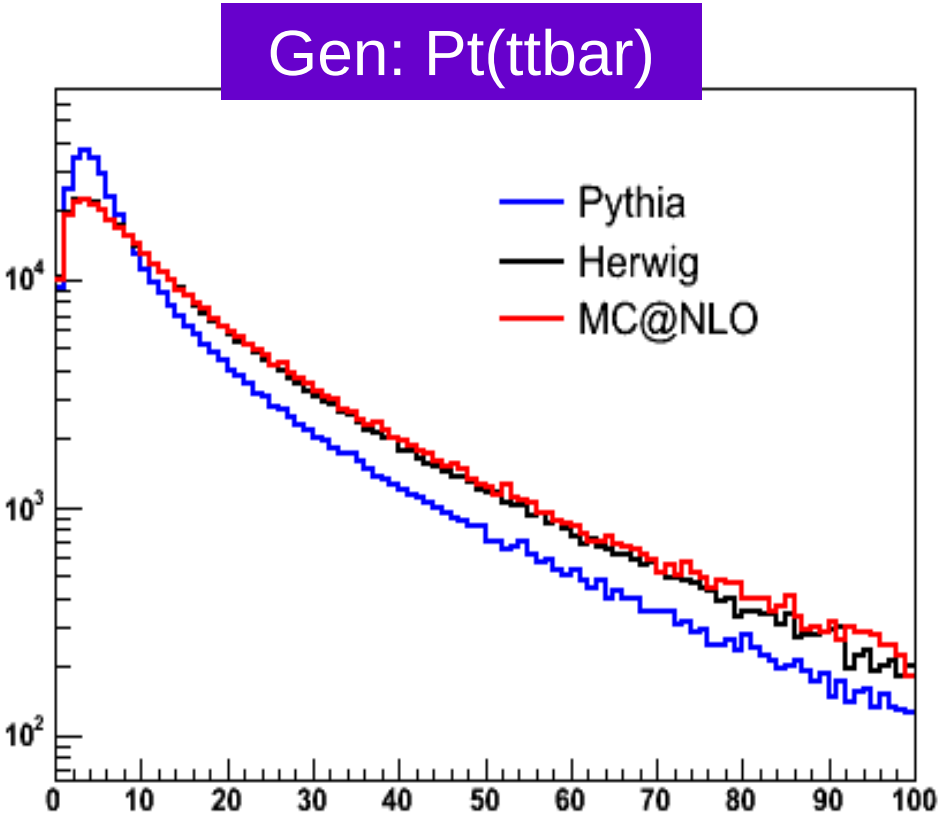
  - Only sensible way to compute K factor event by event.
  - Pythia and HERWIG LO MC are poor for multi-jets
  - ME (ALPGEN, MadGraph) are fine for multi-jets, once double counting problem is removed using CKKW or MLM, but still LO accuracy (K factor still necessary)

  - MC@NLO:
    - Soft, collinear region: by HERWIG
    - NLO for partonic hard process (not on the decay, t->bW)
    - Involve with negative weight.
    - But not all processes are available
      - (W/Z, bbar, ttbar, and diboson)
    - Spin-correlation is not included (effect is small in ttbar)

- Ref:hep-ph/0204244, hep-ph/0305252

Issues in top pair production

- Size of the extra hard gluon emission due to NLO?
- Different production rate for qq vs gg, but gg has a higher acceptance (more ISR jets)
  - LO (5.5% gg) : CTEQ5
  - NLO (14.3% gg)

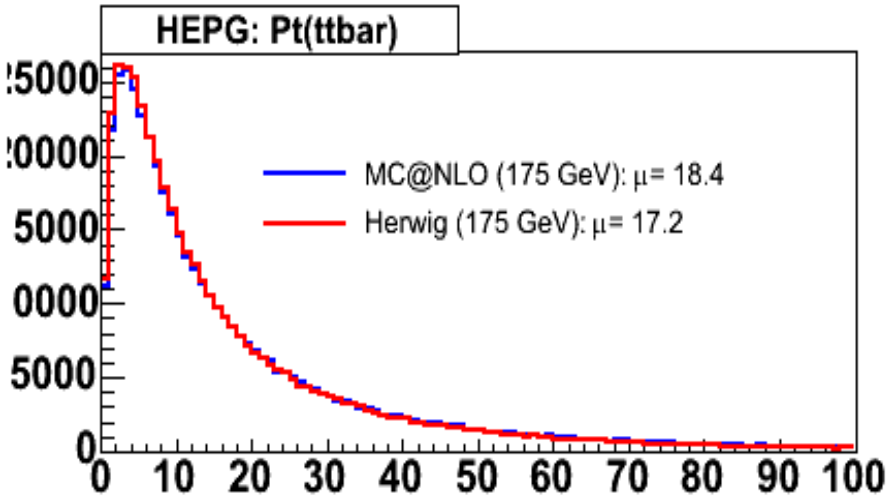


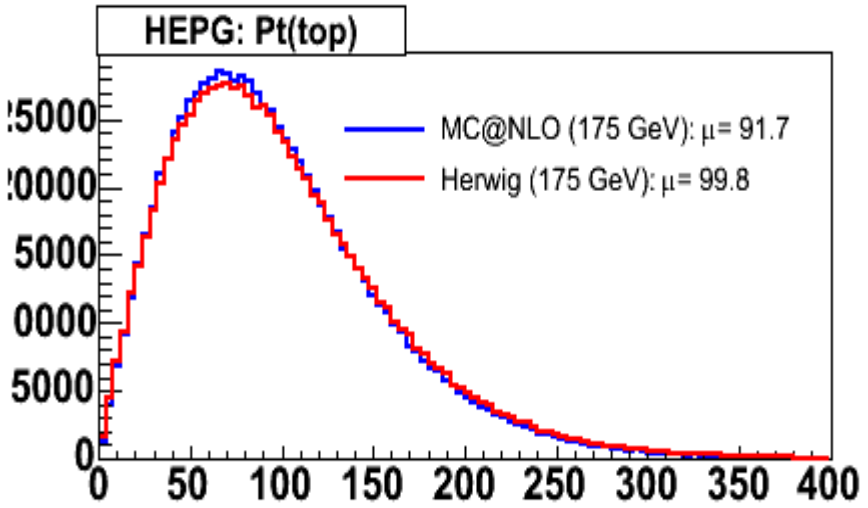
Herwig and MC@NLO: similar

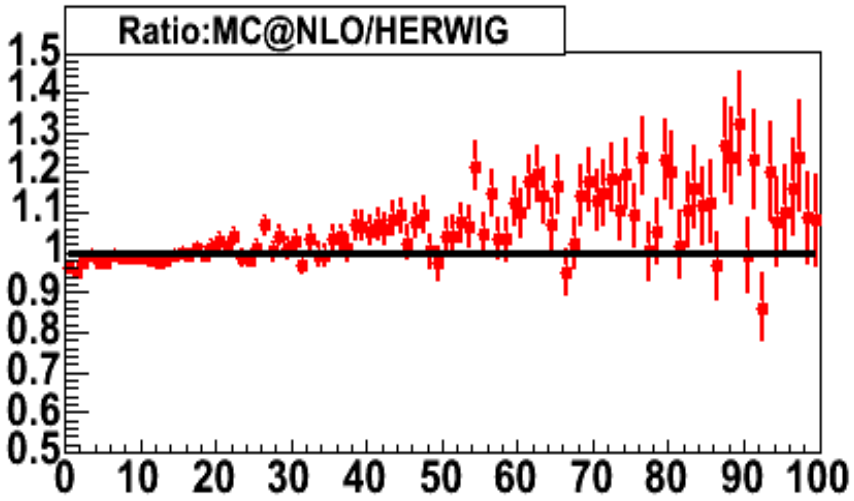
A brief summary on the comparison of MC@NLO and HERWIG

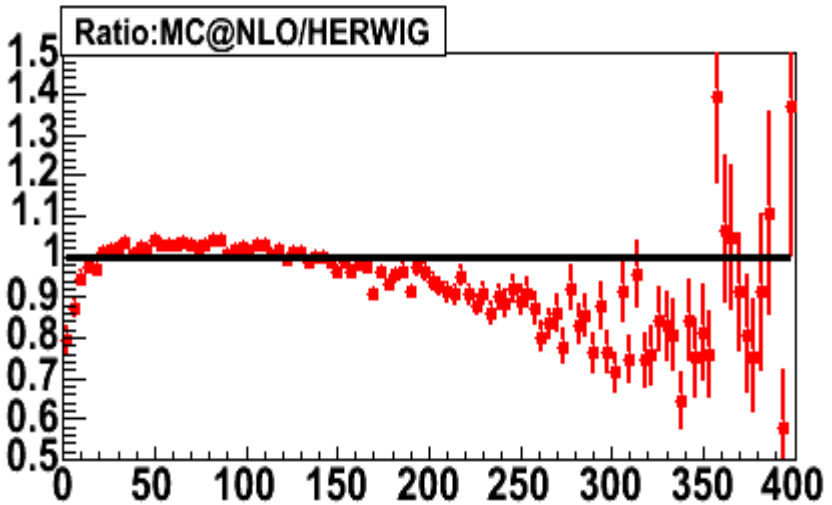
- MC@NLO (Mtop=175 GeV, no spin-corr) vs HERWIG (spin-corr on)
- Comparison at HEPG level
  - NLO effect at the Tevatron is small.
  - Pt(ttbar): good agreement, but harder at Pt~100 GeV by 10%
  - Njets (loose jets): increased by 10% at Njet~7.
  - Pt(top): good agreement except very low Pt and high Pt regions
  - Pt of W,b and leading jet Et: all good agreement
  - More tops from gg channel are produced in plug region
- NLO vs ISR/FSR syst.?
  - Pt(ttbar), Njets(loose): most of effects seem to be covered by the ISR/FSR syst.

Pt of $t\bar{t}$ and top

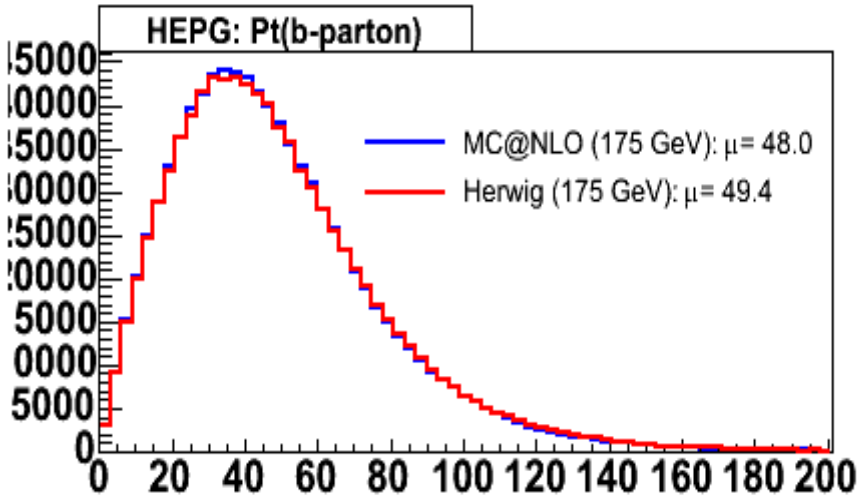


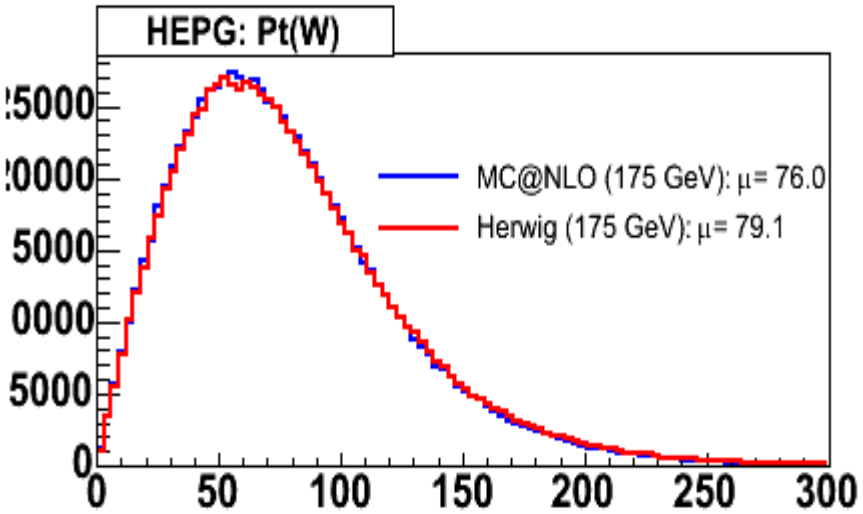


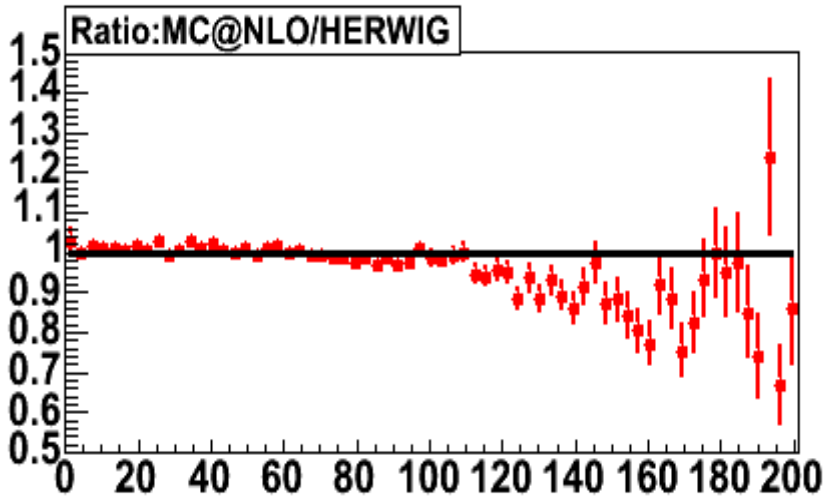


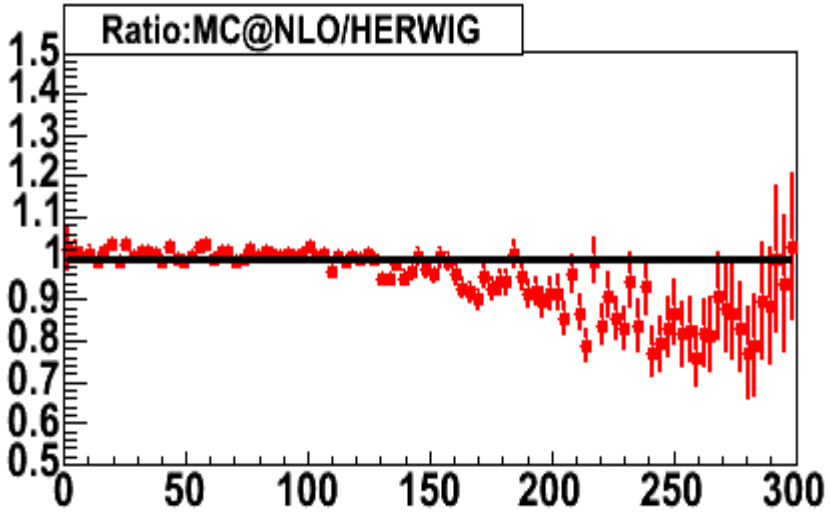


Pt of b-parton and W

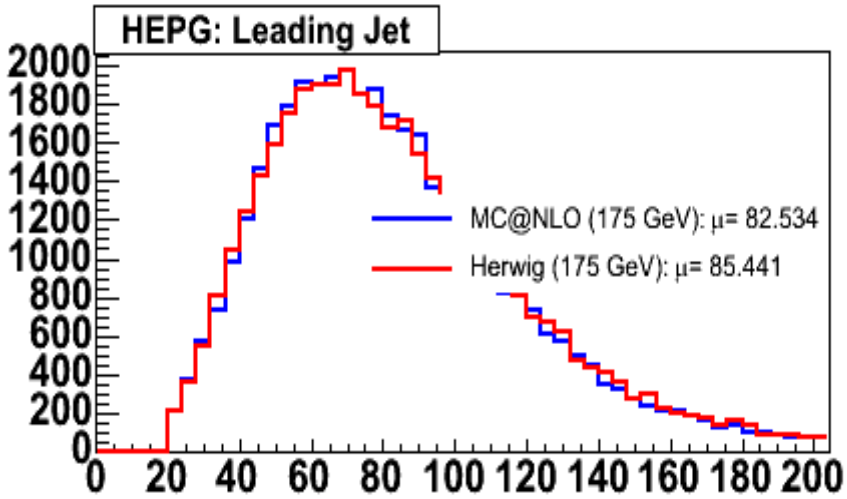


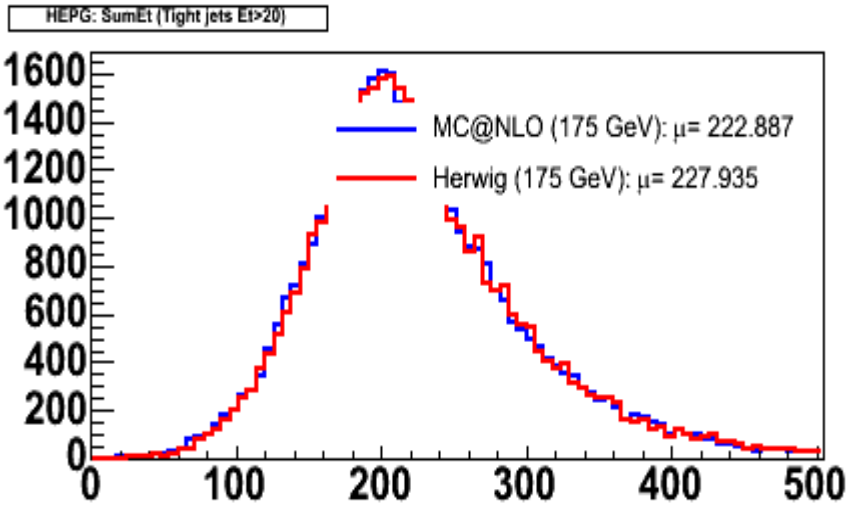


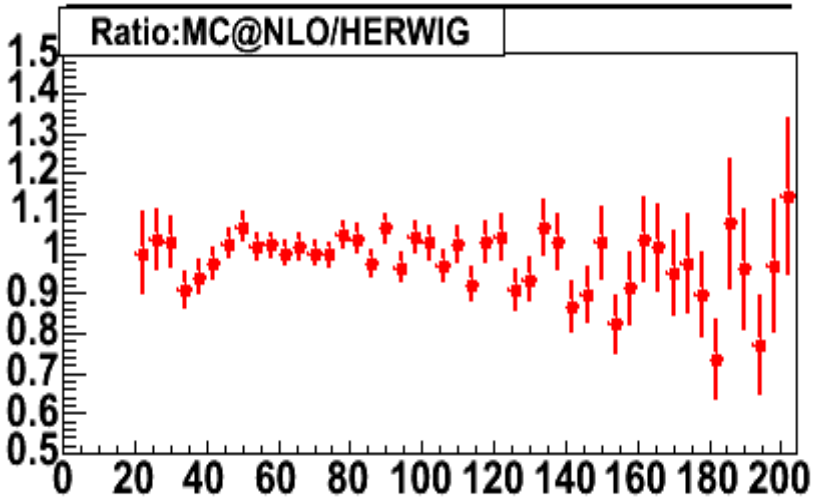


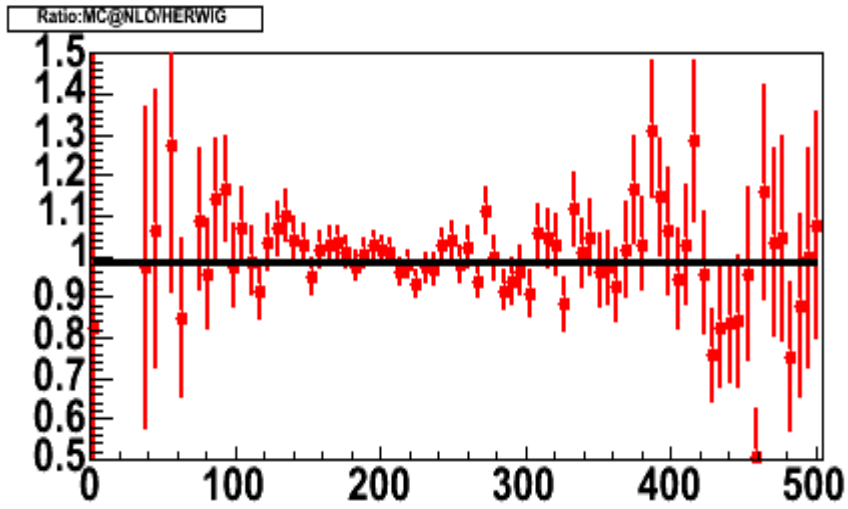


Leading Jet and Sum Jet Ets

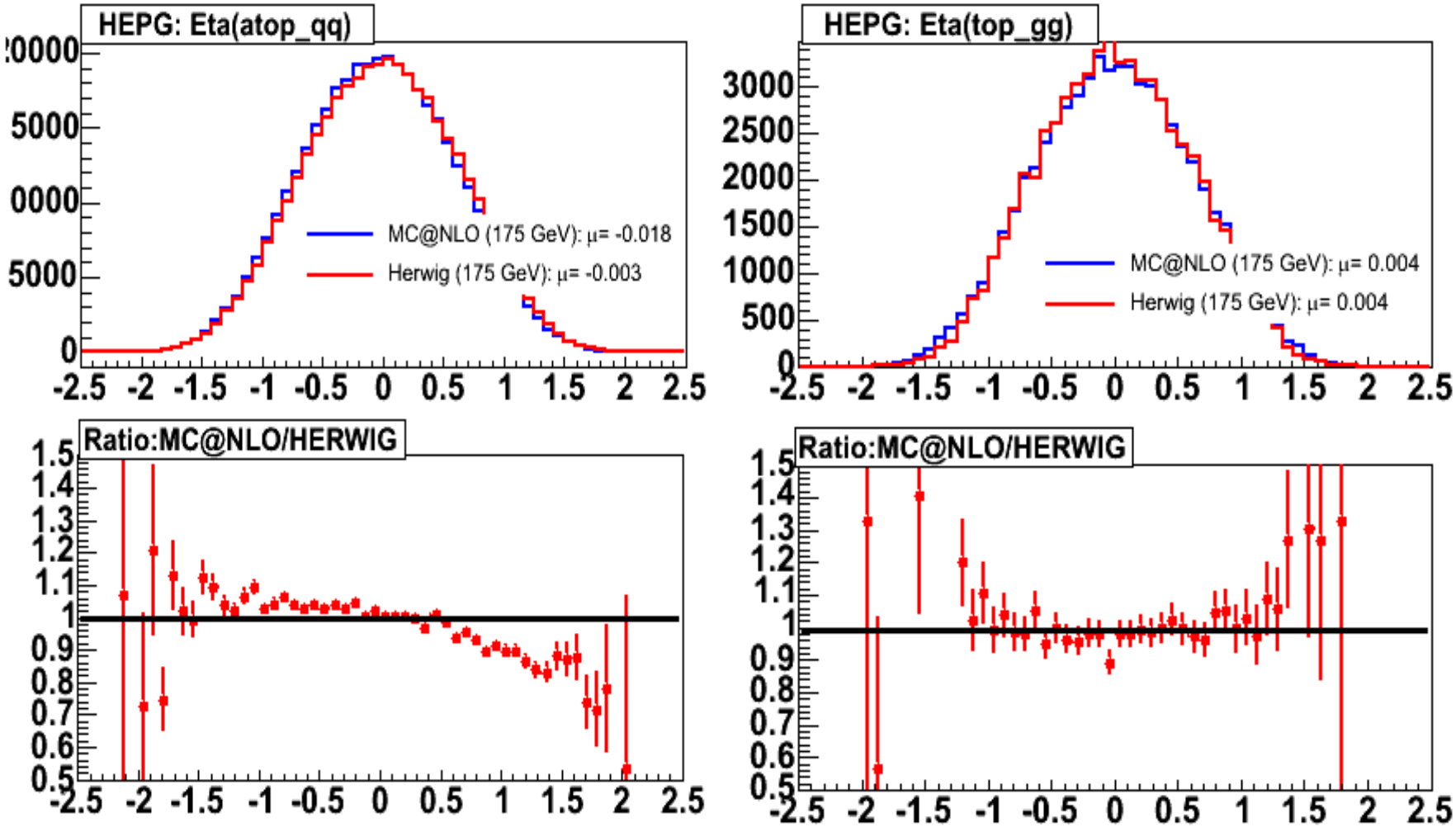




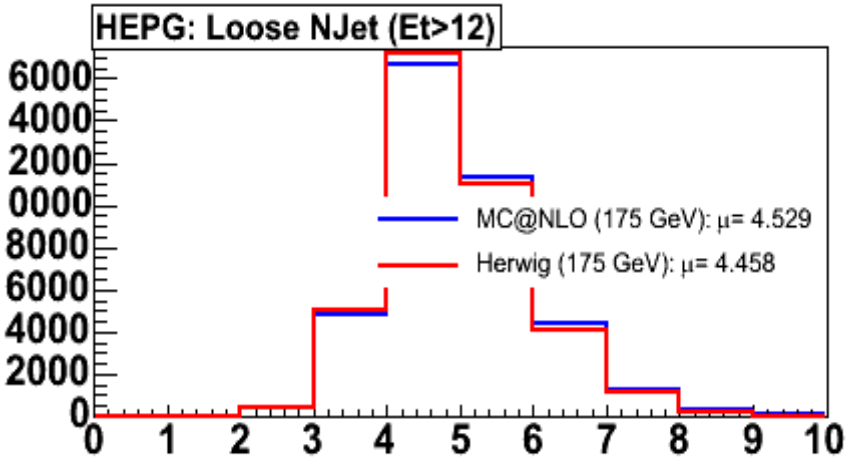


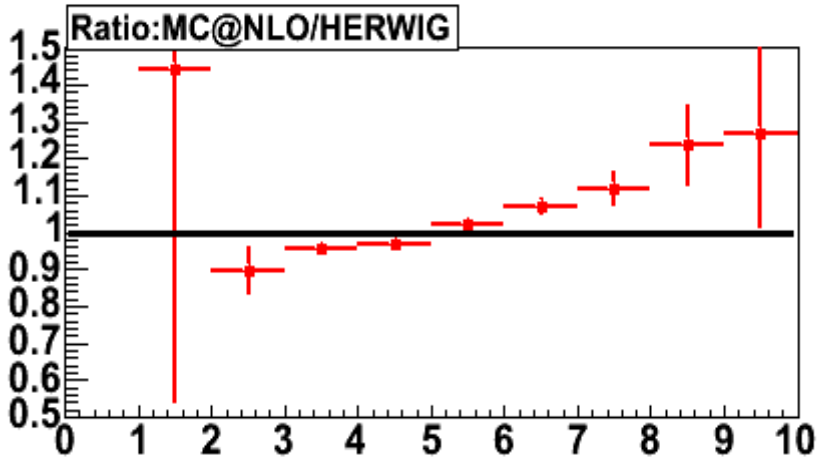


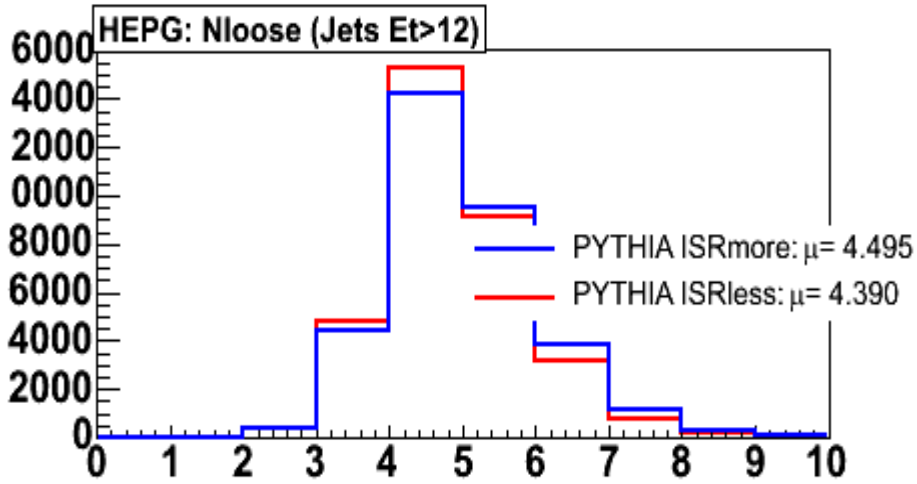
Eta of top (qq vs gg)

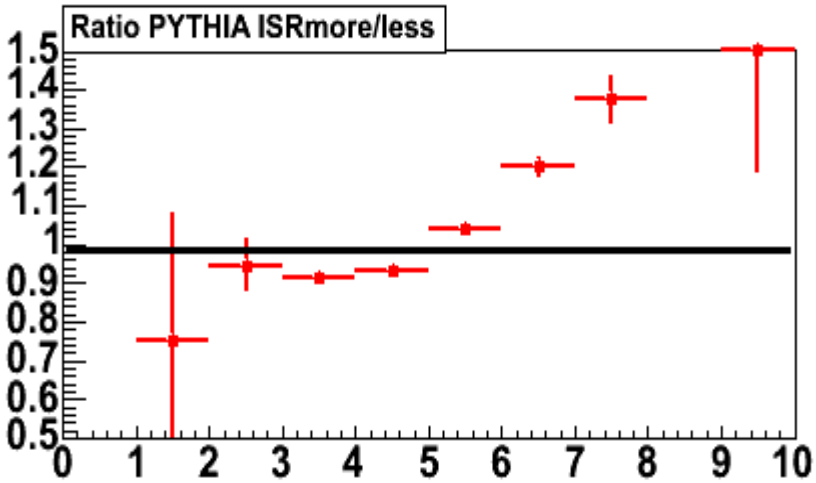


Njets (Et>12 GeV at HEPG particles)
NLO vs ISR syst.

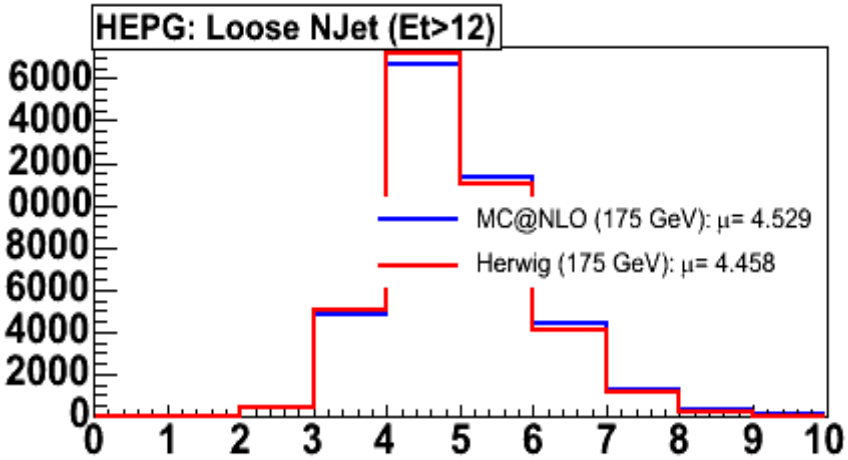


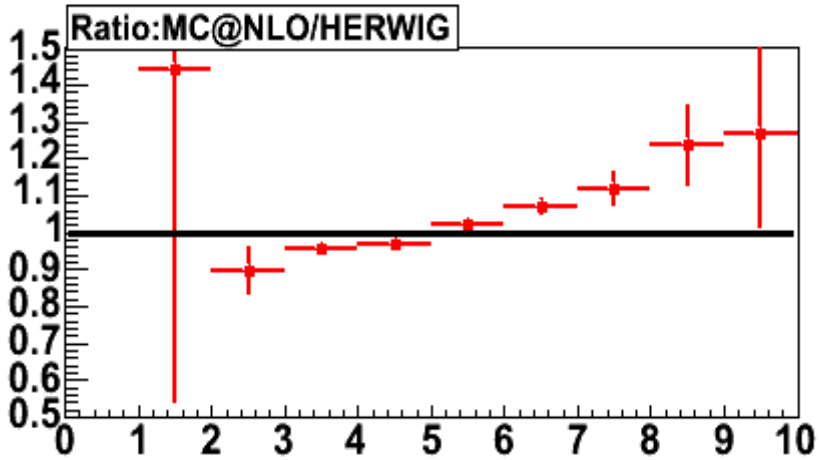


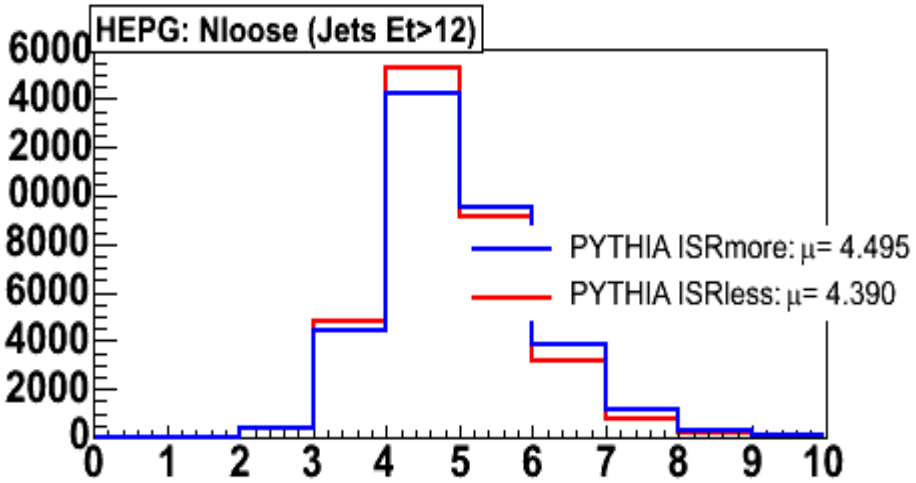




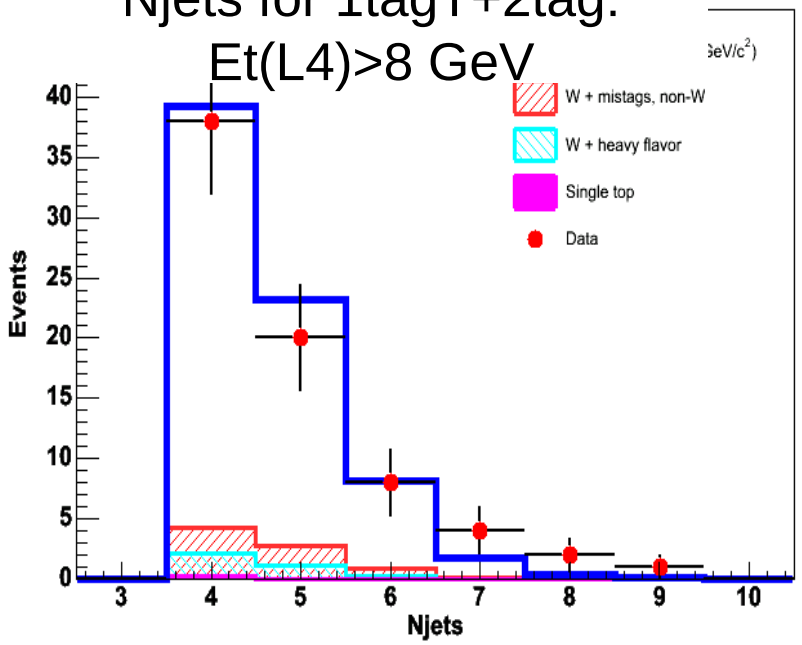
Njets (Et>12 GeV ~ 8 GeV at L4)
NLO vs ISR syst.



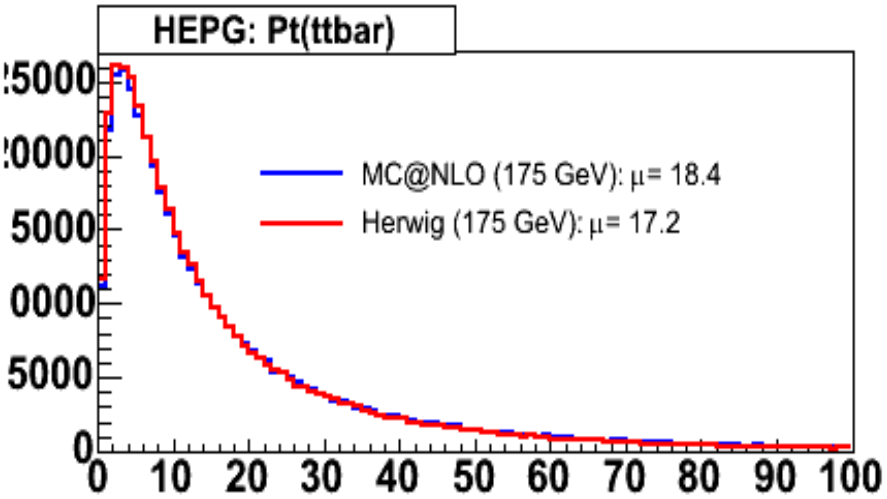


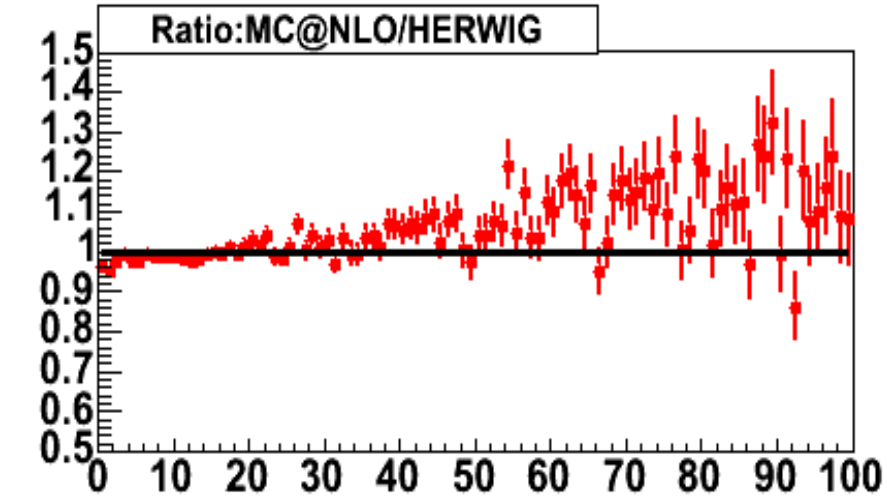


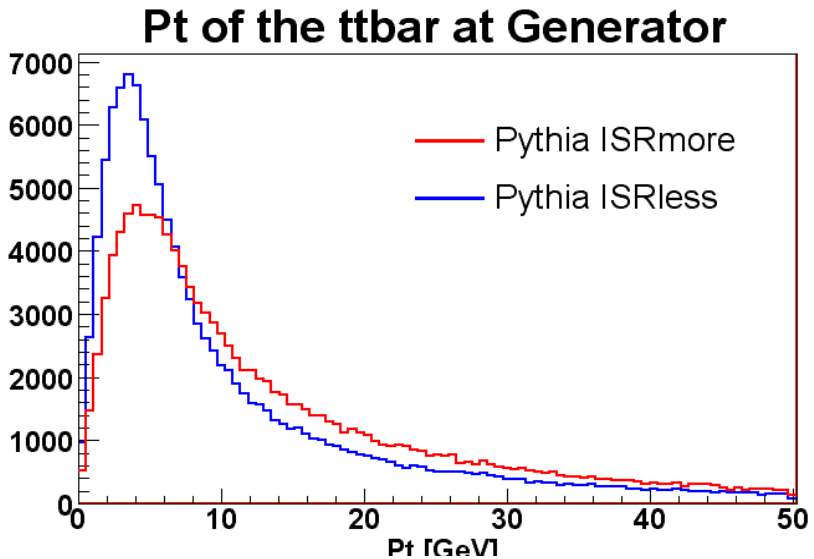
Njets for 1tagT+2tag:
Et(L4)>8 GeV

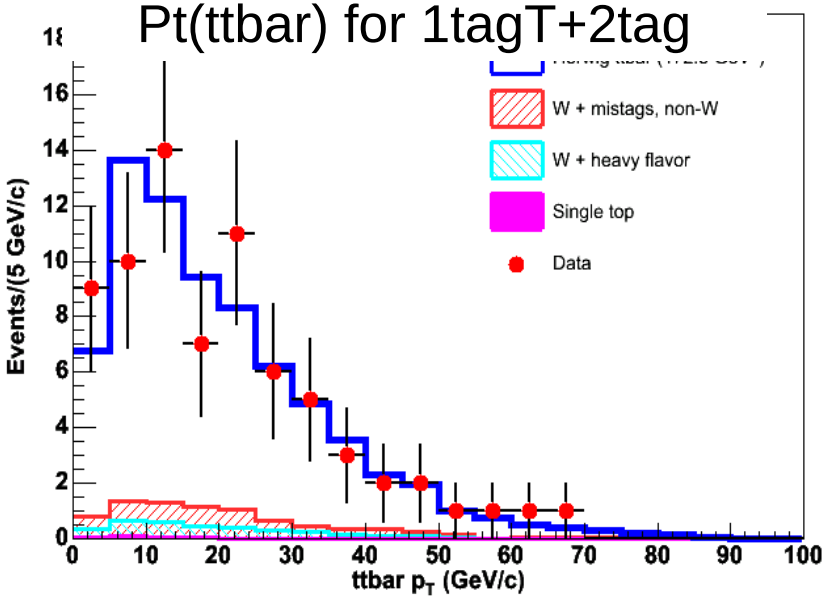


Pt of $t\bar{t}$: NLO vs ISR syst.









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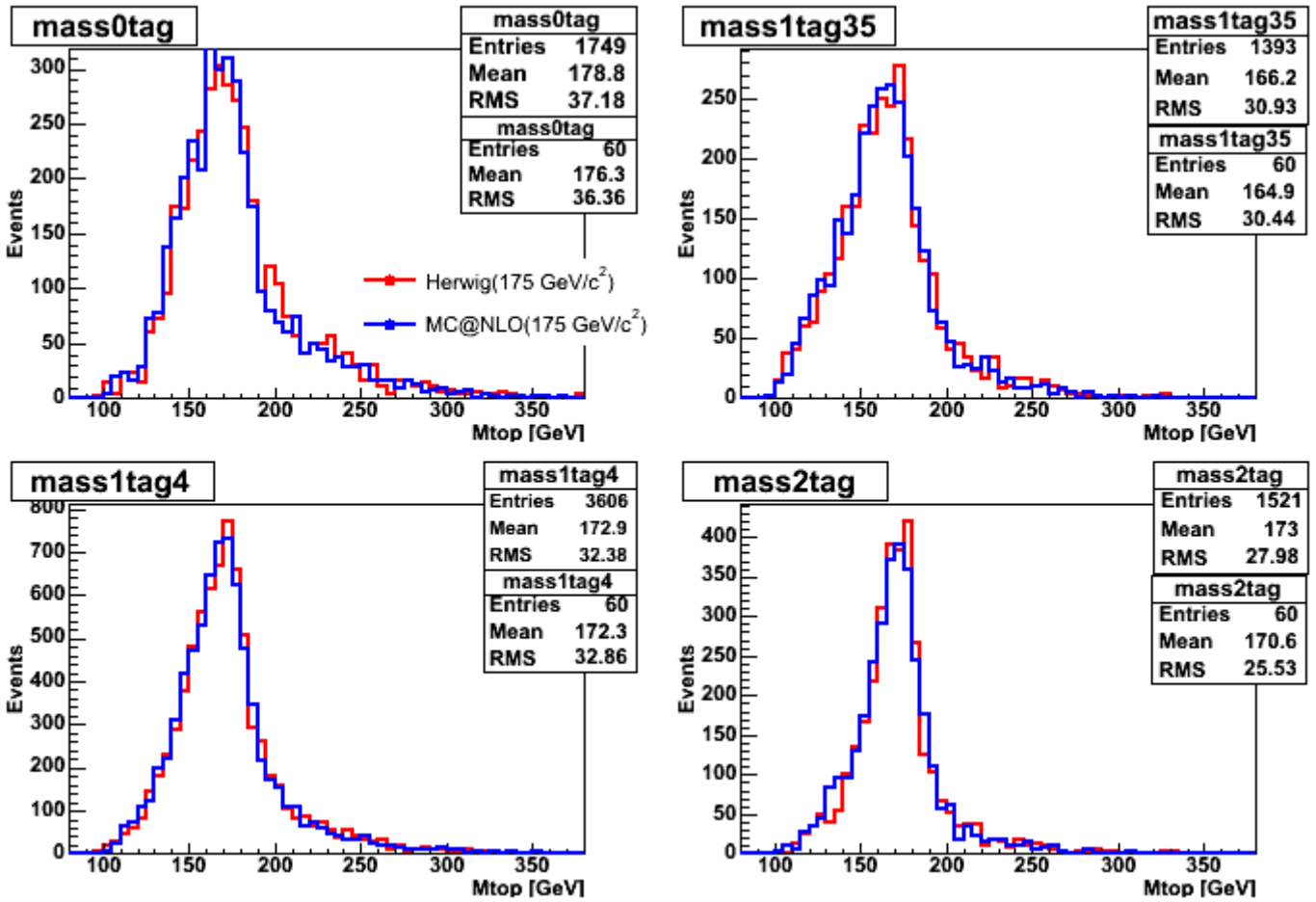
NLO effect on Mtop



- PE results : MC@NLO: 174.56 +- 0.25 GeV vs HERWIG : 175.25 +- 0.36 GeV
  -0.69 +- 0.43 GeV (need to remove spin-corr. effect)

Discussions

- ISR/FSR syst. will be updated based on Sasha's studies.

- Tasks with MC@NLO
  - ✓ More validations on MC@NLO MC
  - ✓ Extra jets:
    - Extra jets from MC@NLO (mainly ISR) are covered by the ISR syst.
    - FSR jets from b-quark or light quark (from W): this is not handled by MC@NLO but by Herwigh PS: need to check with CKKW ALPGEN or MadGraph
  - ✓ Q2 scale dependence? (Q=0.5Mtop to 2*Mtop, never done)
  - ✓ PDF uncertainty with CTEQ6 PDF series