

Single top quark production at NLO at the LHC

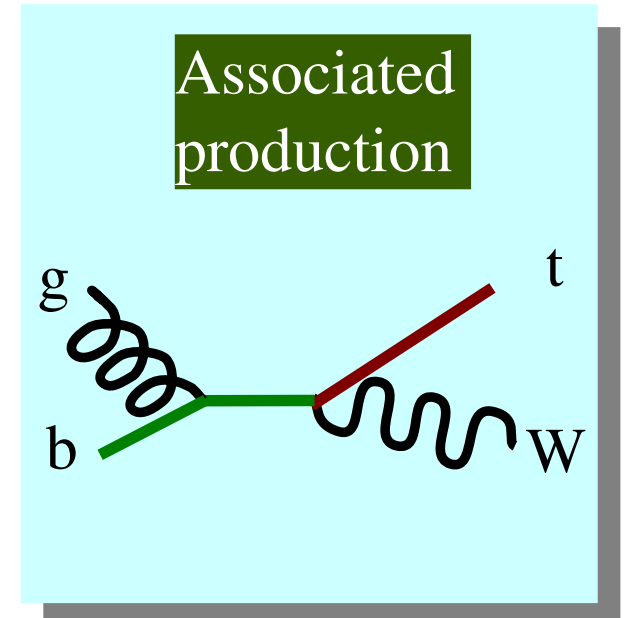
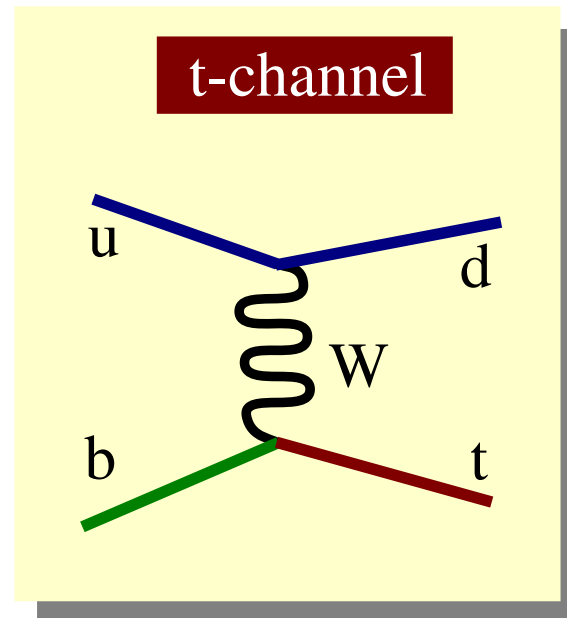
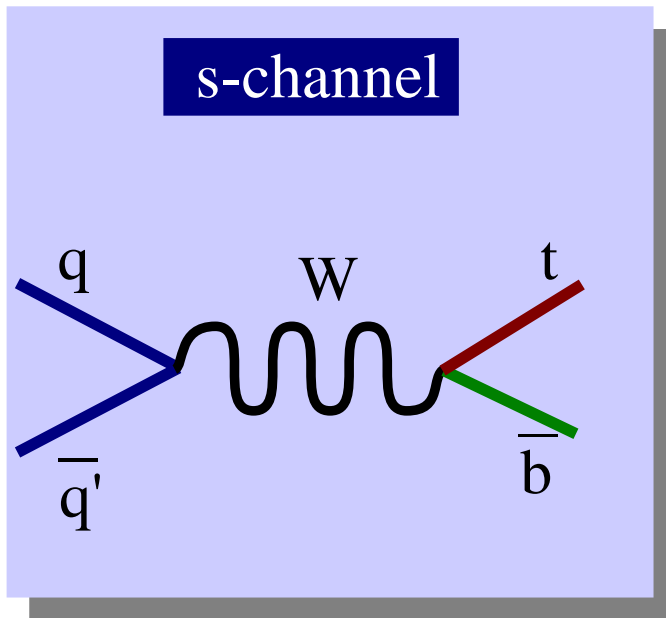
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With S. Heim, C. Mueller, Q.-H. Cao, C.-P. Yuan

MICHIGAN STATE
UNIVERSITY

PHENO 2010

LHC SM single top quark production



7 TeV:

$$\sigma_{\text{tot}} = 85 \text{ pb}$$

14 TeV:

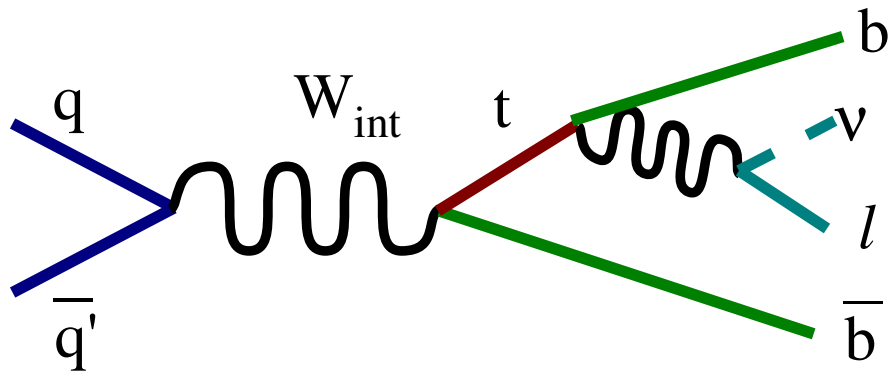
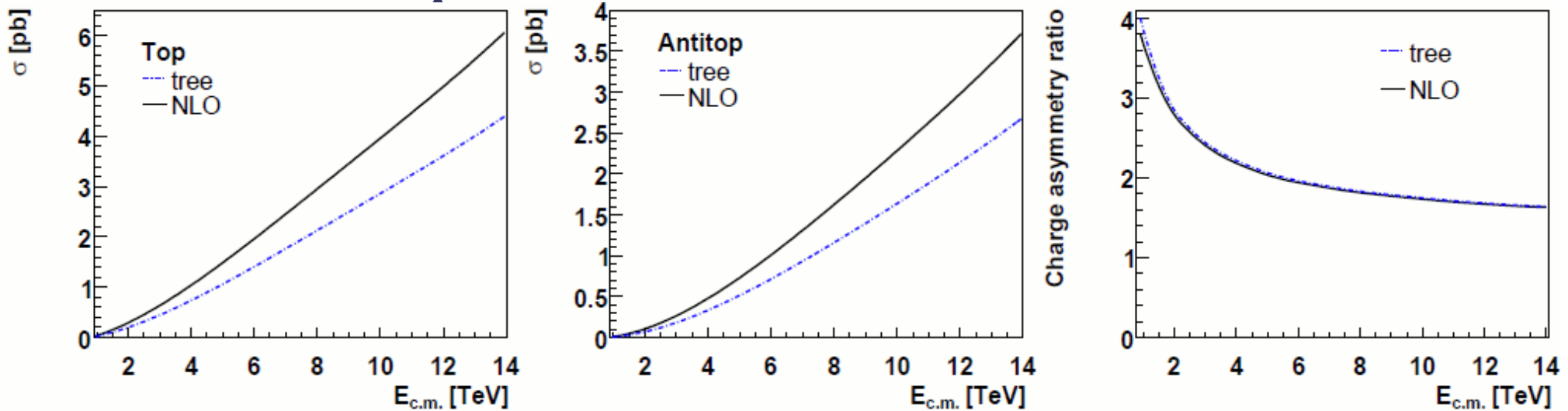
$$\sigma_{\text{tot}} = 320 \text{ pb}$$

- Precision tests of tWb coupling
- Sensitive to many models of new physics

Single top generator ONETOP

- NLO generator
Cao, Yuan, PRD71:054022,2005
 - Including corrections to top quark decay
 - Including all spin correlations
- s-channel study at the Tevatron:
Cao, RS, Yuan, PRD71:054023,2005
- t-channel study at the Tevatron:
Cao, Benitez, RS, Brock, Yuan, PRD72:094027,2005
- s-channel at NLO at the LHC:
Heim, Cao, Yuan, RS, PRD81: 034005,2010
- Here:
 - t-channel study at the LHC
 - CTEQ 6.6 PDFs
 - At 7 TeV, 10 TeV, 14 TeV

S-channel production at NLO at 14 TeV



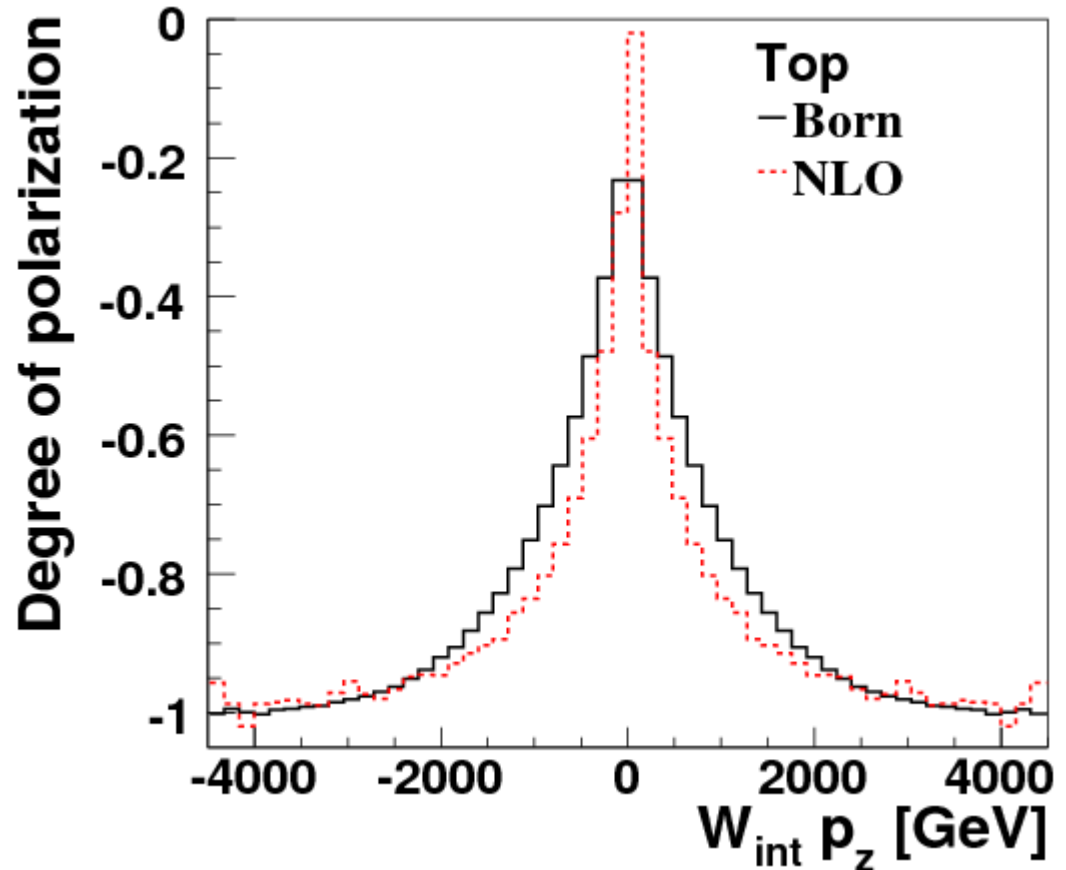
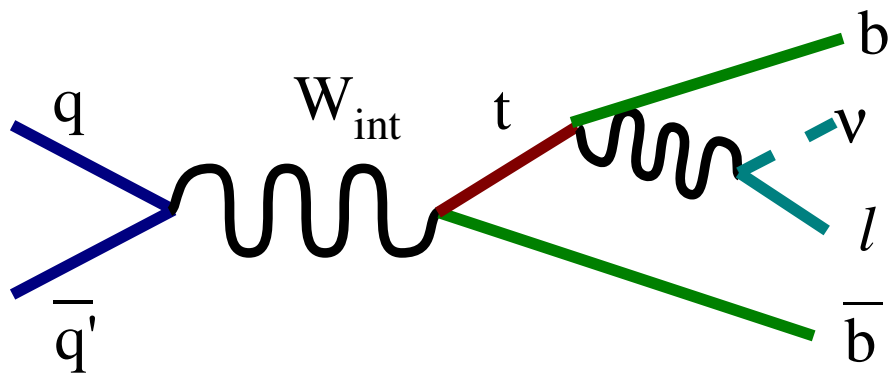
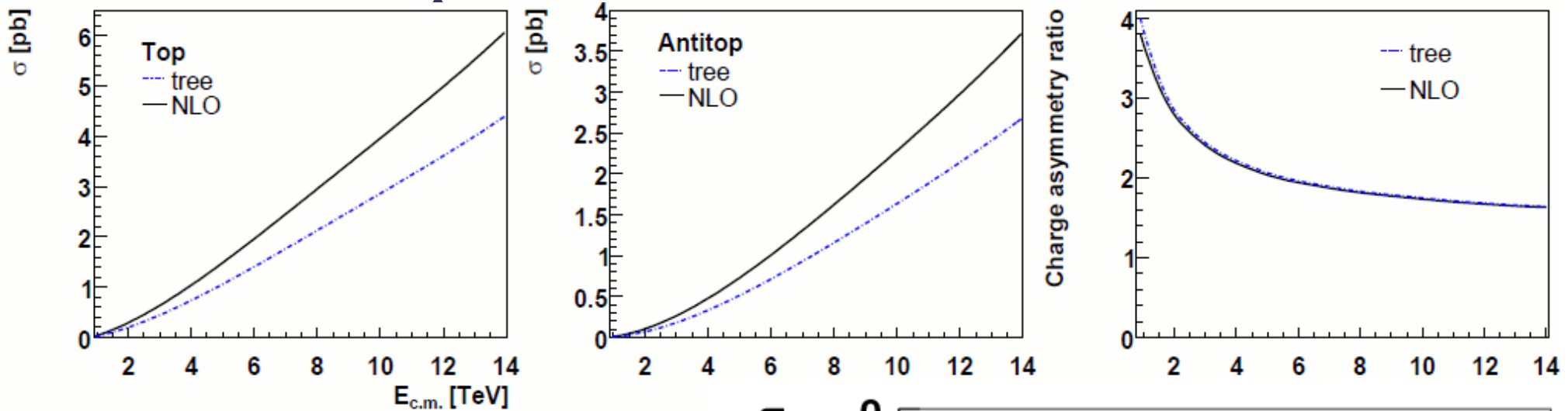
- LHC is pp collider

→ cannot distinguish q from \bar{q} direction

→ cannot identify spin in optimal basis

- Correlation of lepton and \bar{q}'

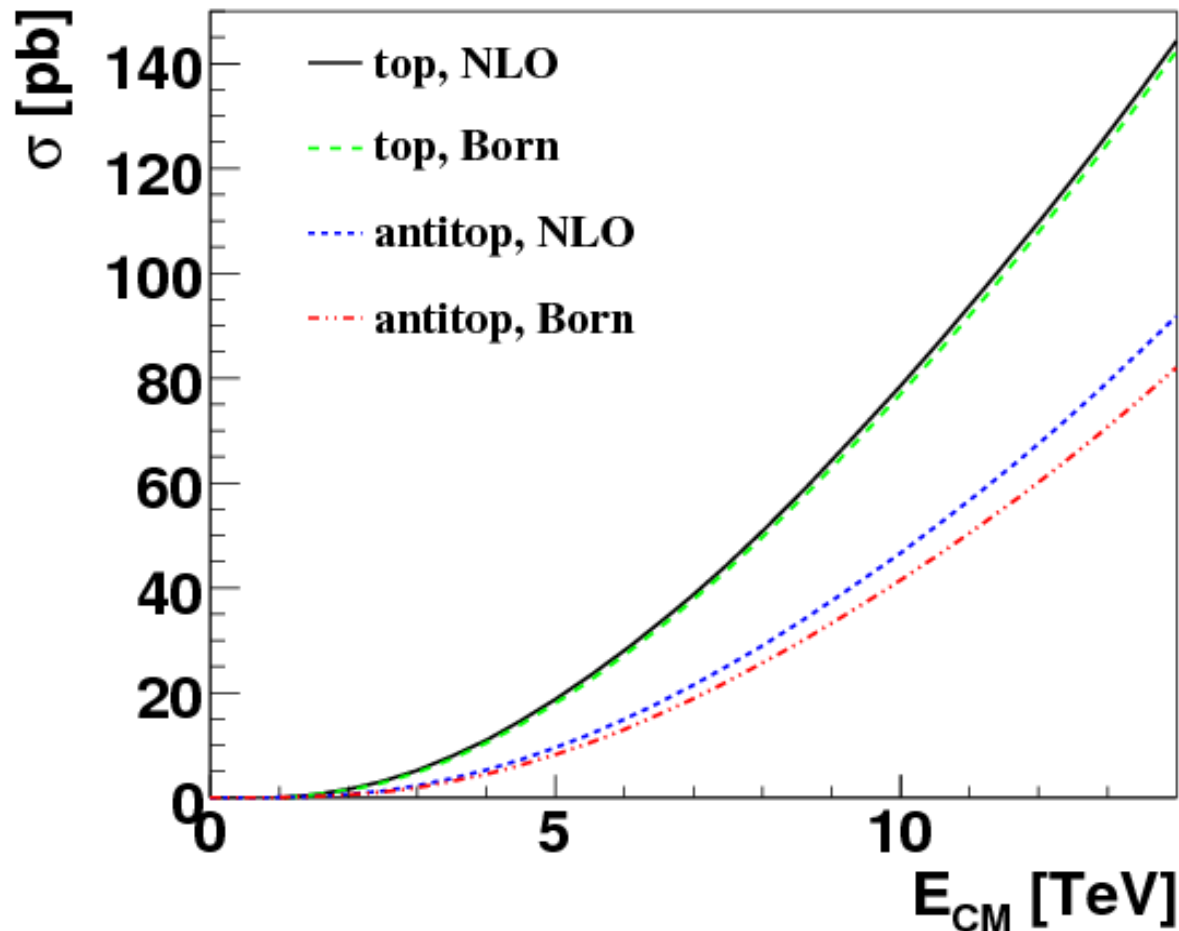
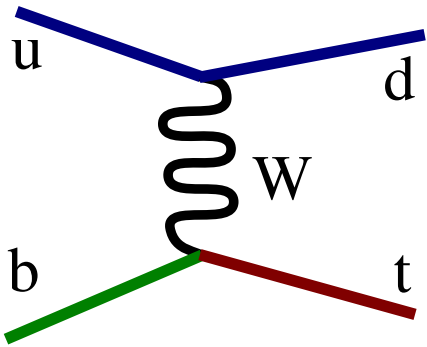
S-channel production at NLO at 14 TeV



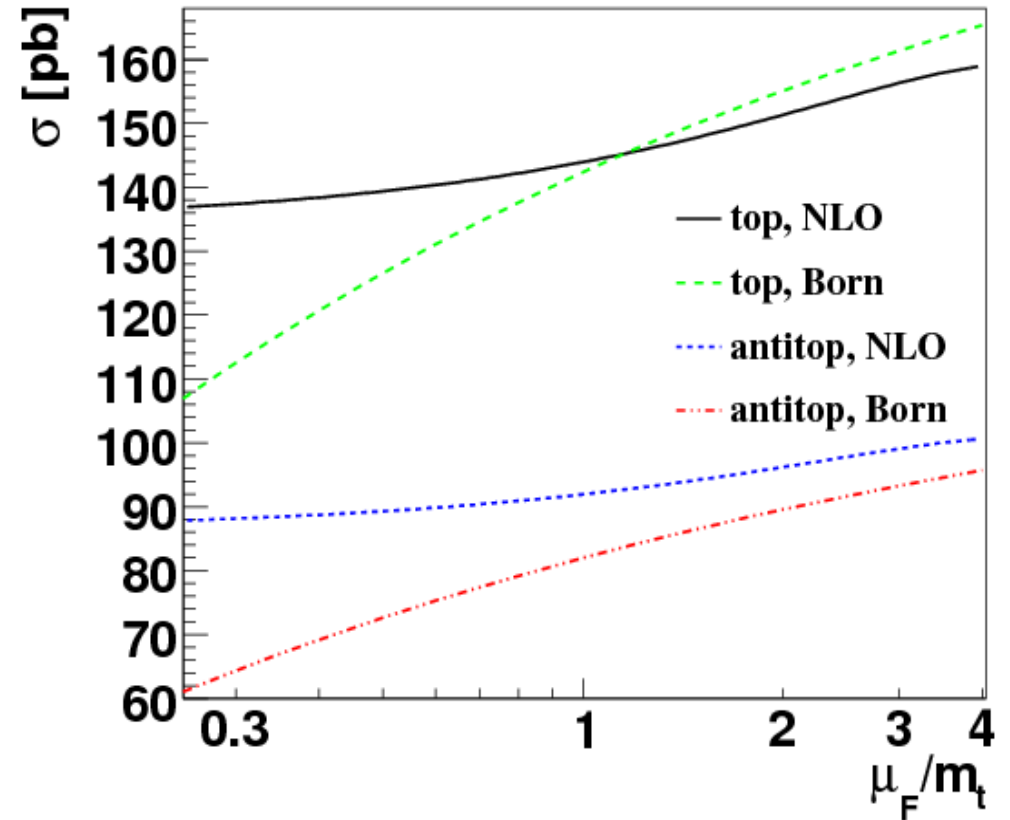
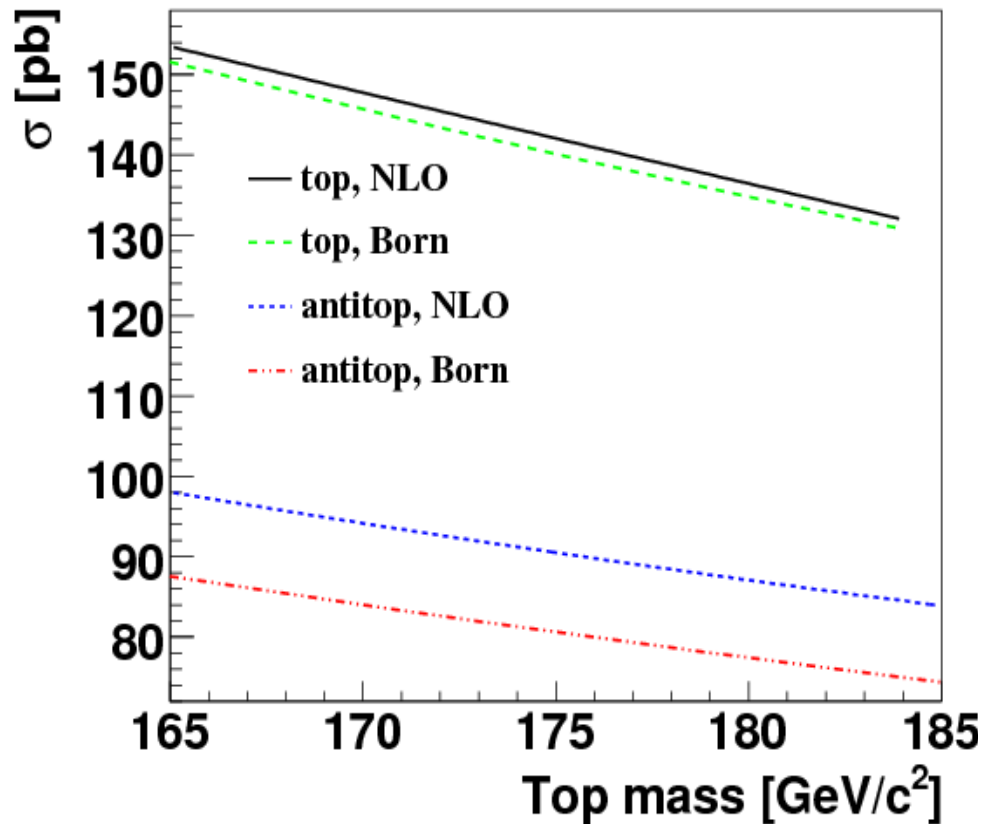
- Identify q as shell quark
- Higher momentum fraction
- Cut on p_z of W_{int}

t-channel single top cross section

- Dominant single top production mode at all CM energies
- Only single top mode observable at 7 TeV



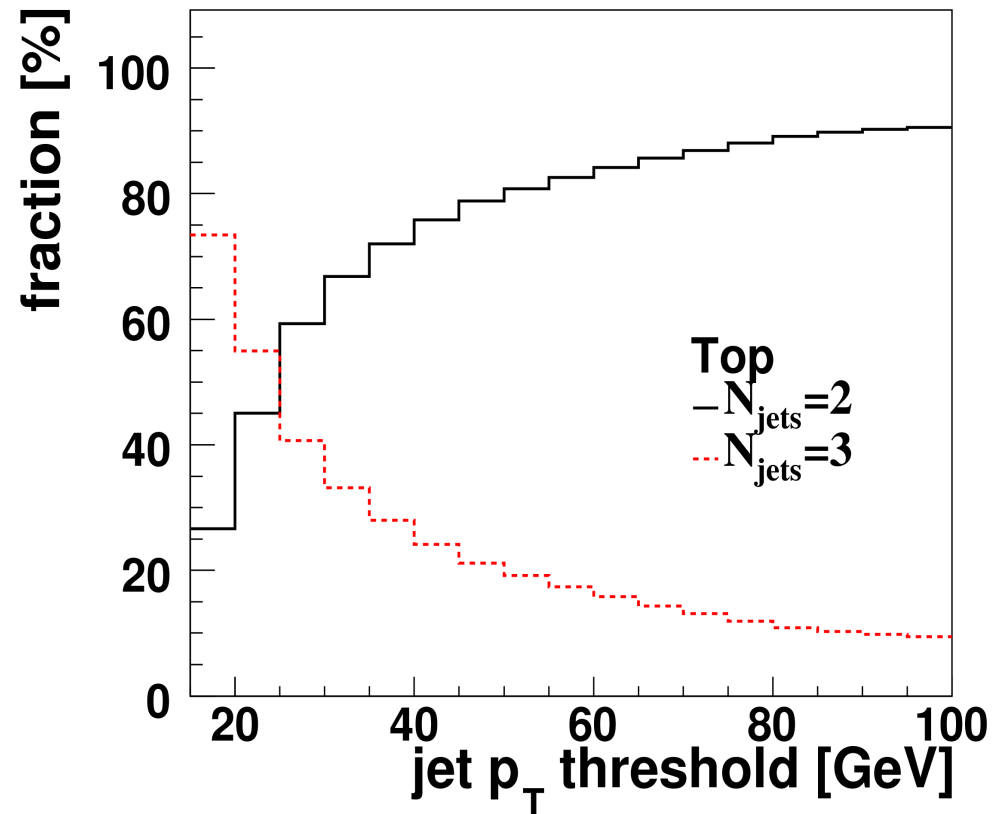
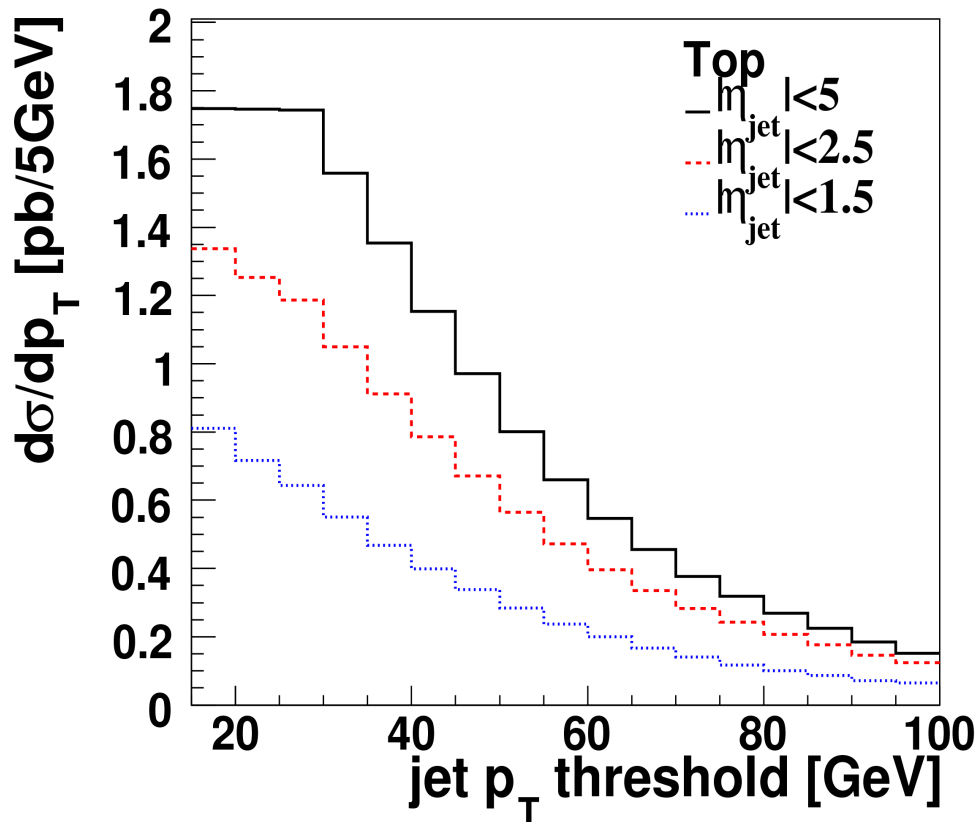
Mass and Scale dependence



- Cross section uncertainties:
 - Top mass: $\sim 1\%$ /GeV; Scale: $\sim 4\%$; PDF: $\sim 0.5\%$

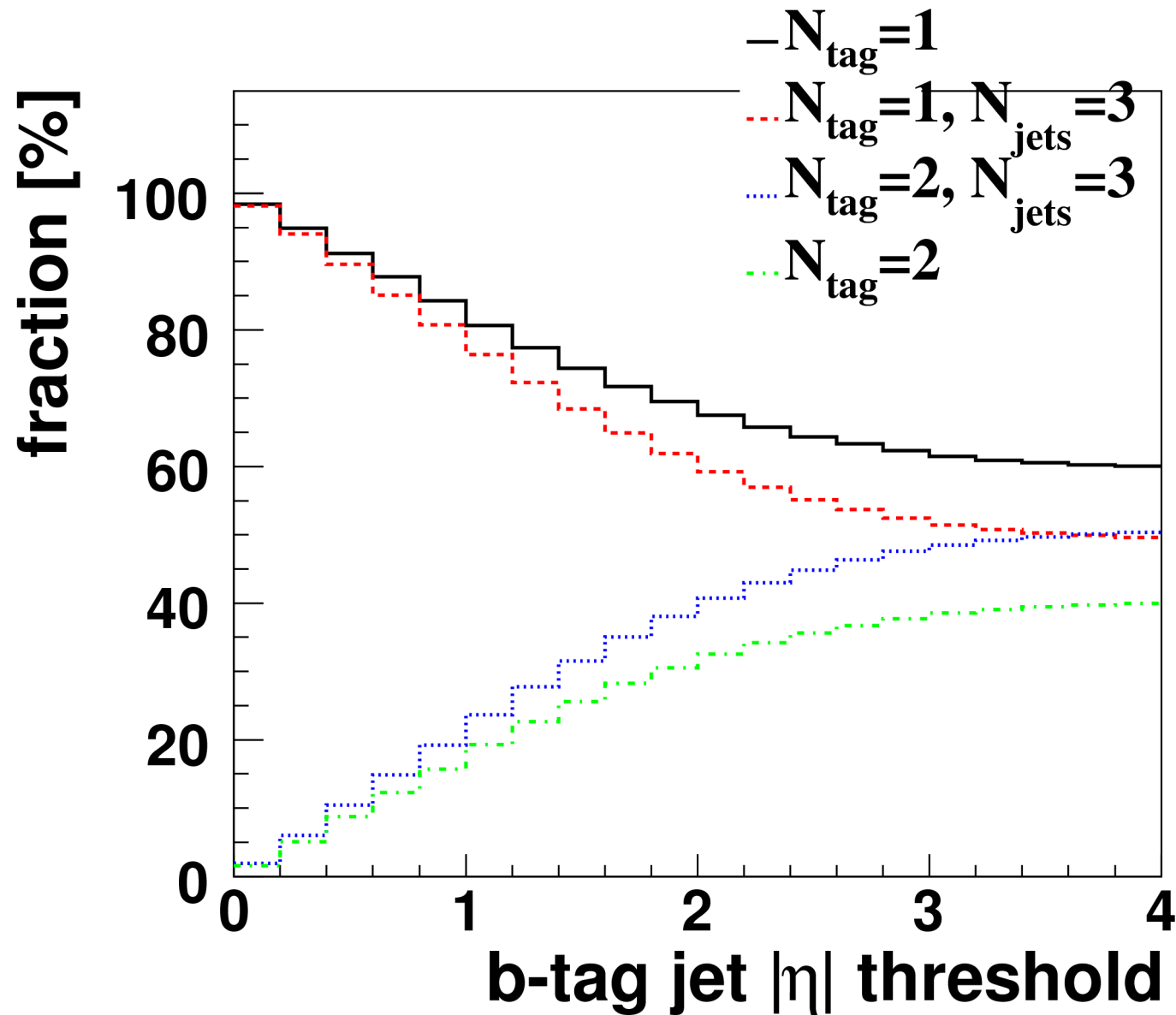
Acceptance study

- Typical experimental cuts on lepton, neutrino, jets
 - Minimum $p_T = 25\text{GeV}$
 - Jet cone size and lepton isolation $dR=0.4$
 - At 7 TeV:

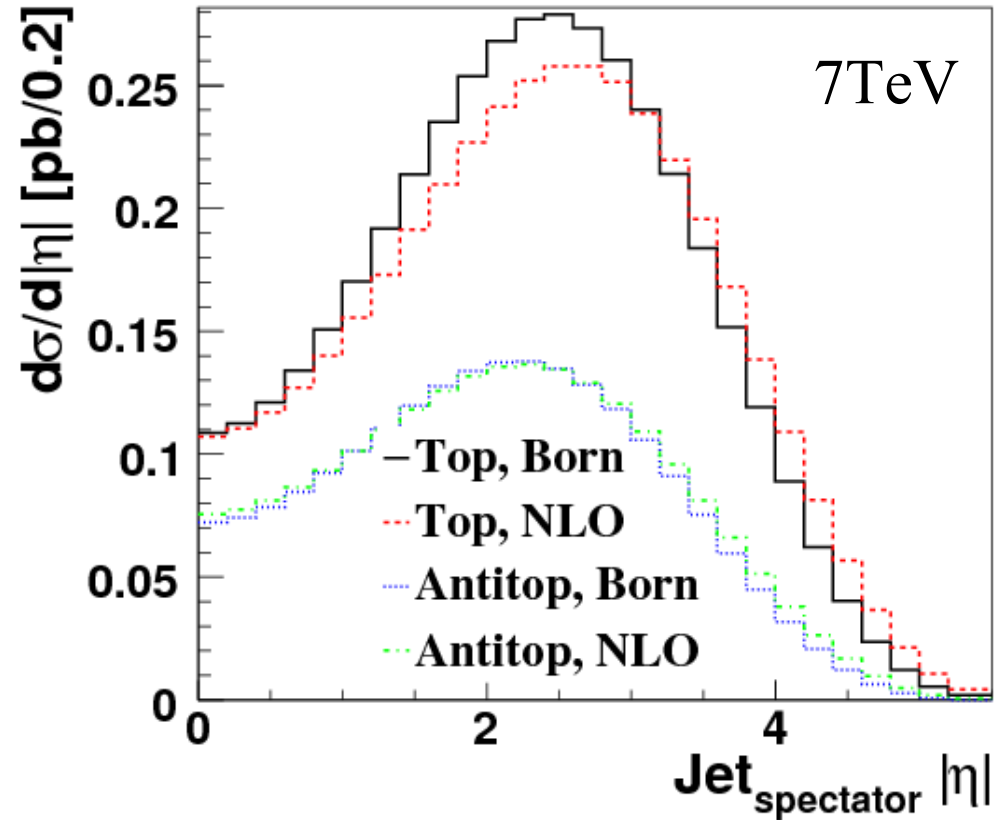
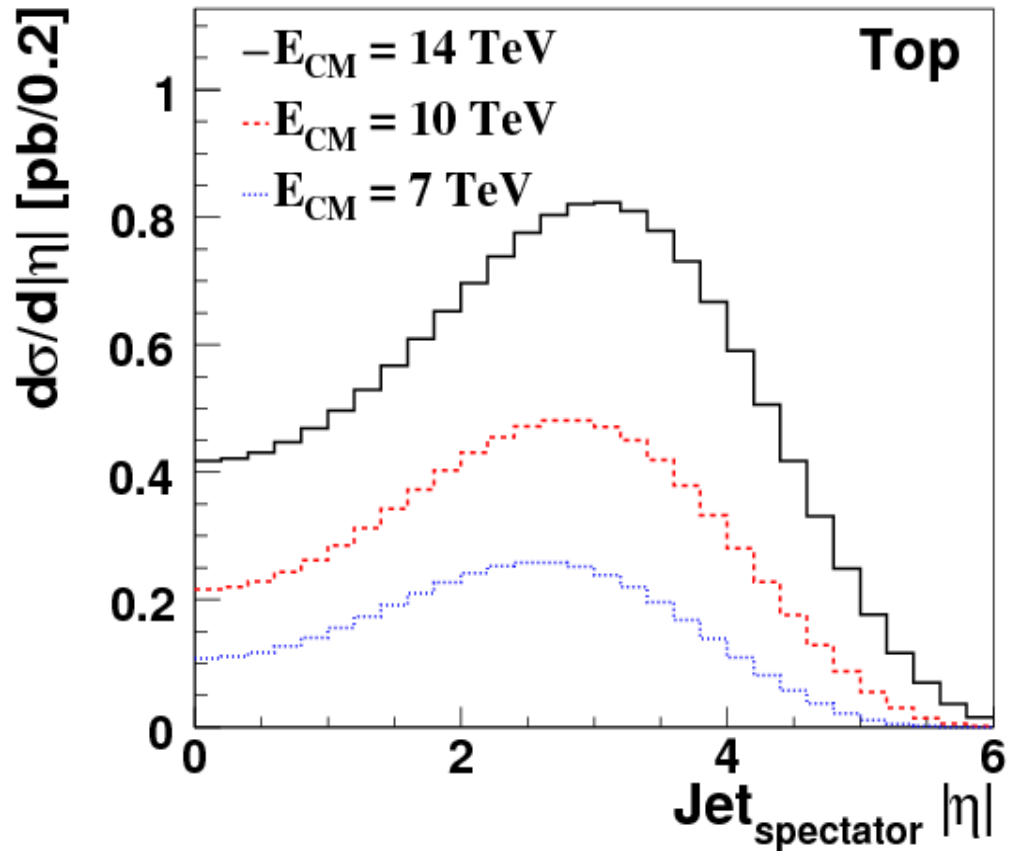


B-quark jet acceptance

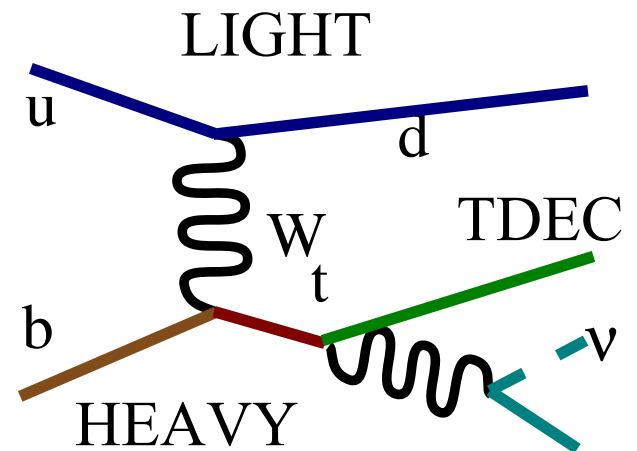
- Fraction of events containing 1 or 2 b-quark jets



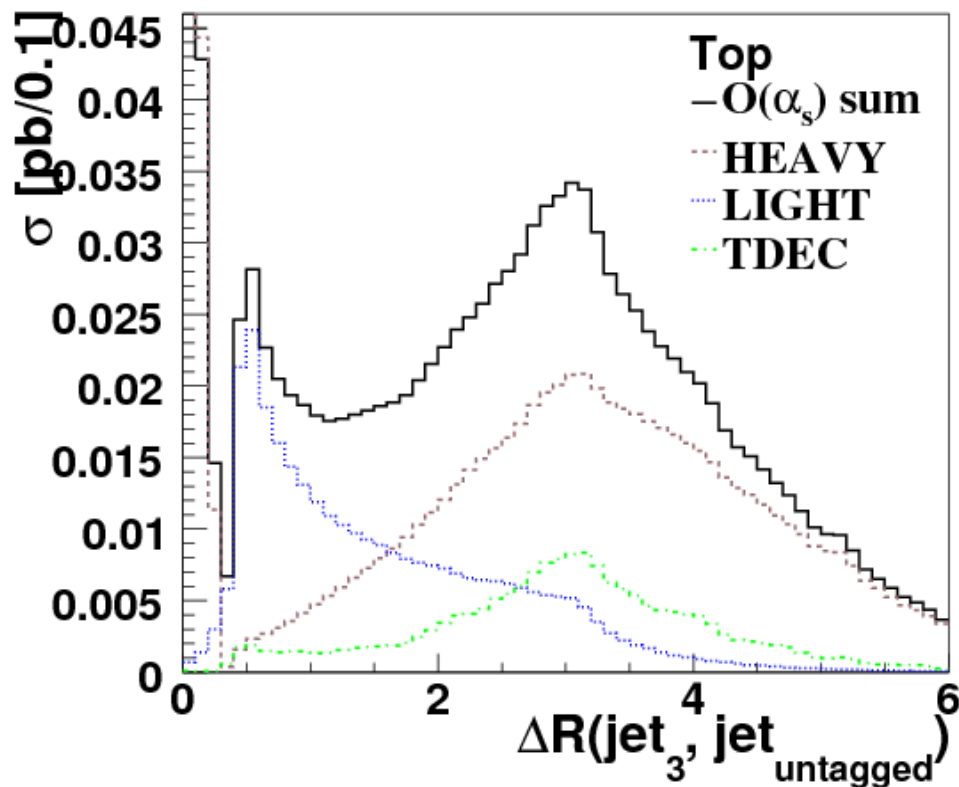
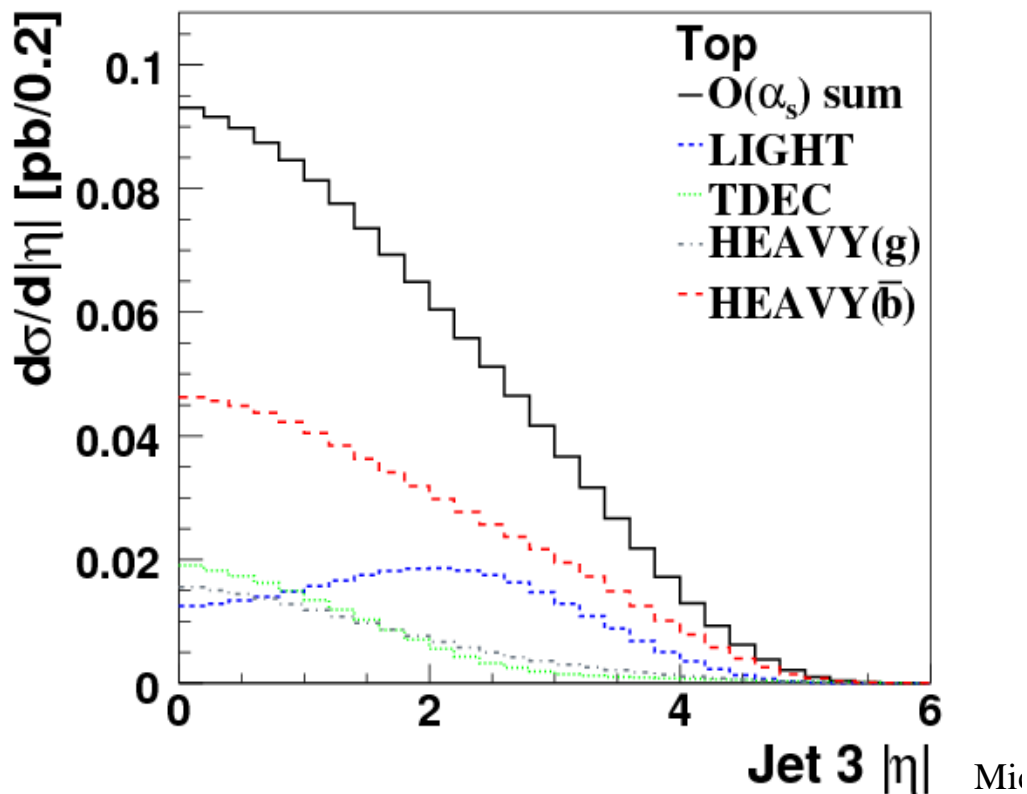
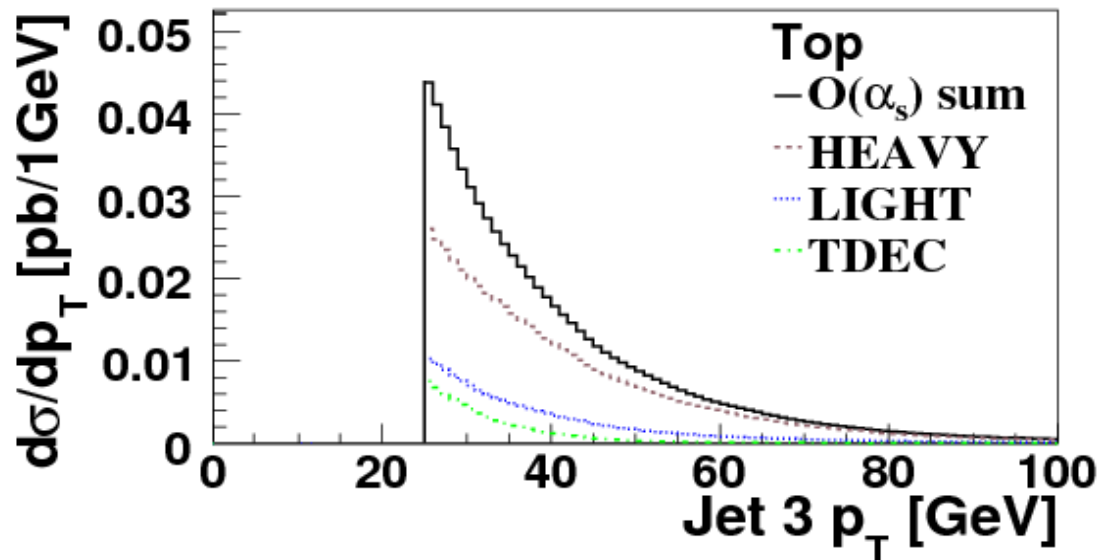
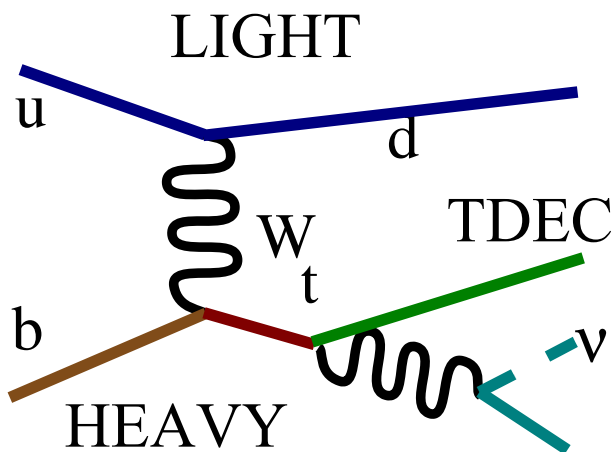
Spectator jet pseudorapidity



- pp collider $\rightarrow |\eta|$
- $O(\alpha_s)$ corrections: LIGHT shifts η up, HEAVY shifts η down
- Higher CM energy shifts η up



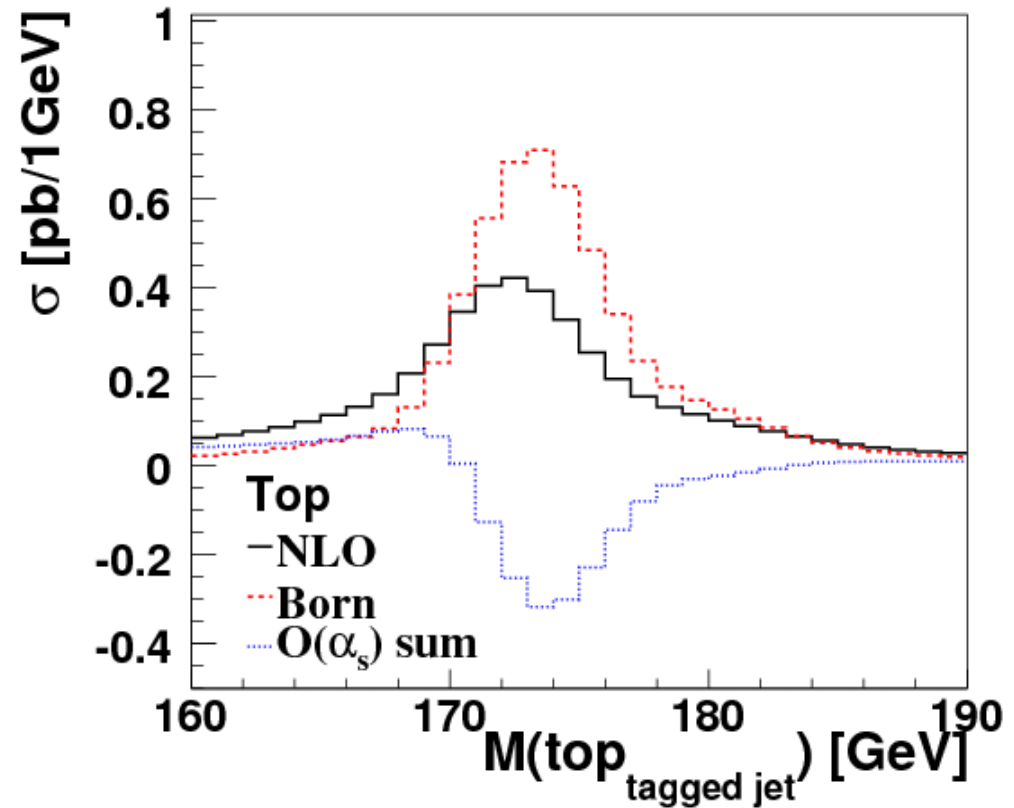
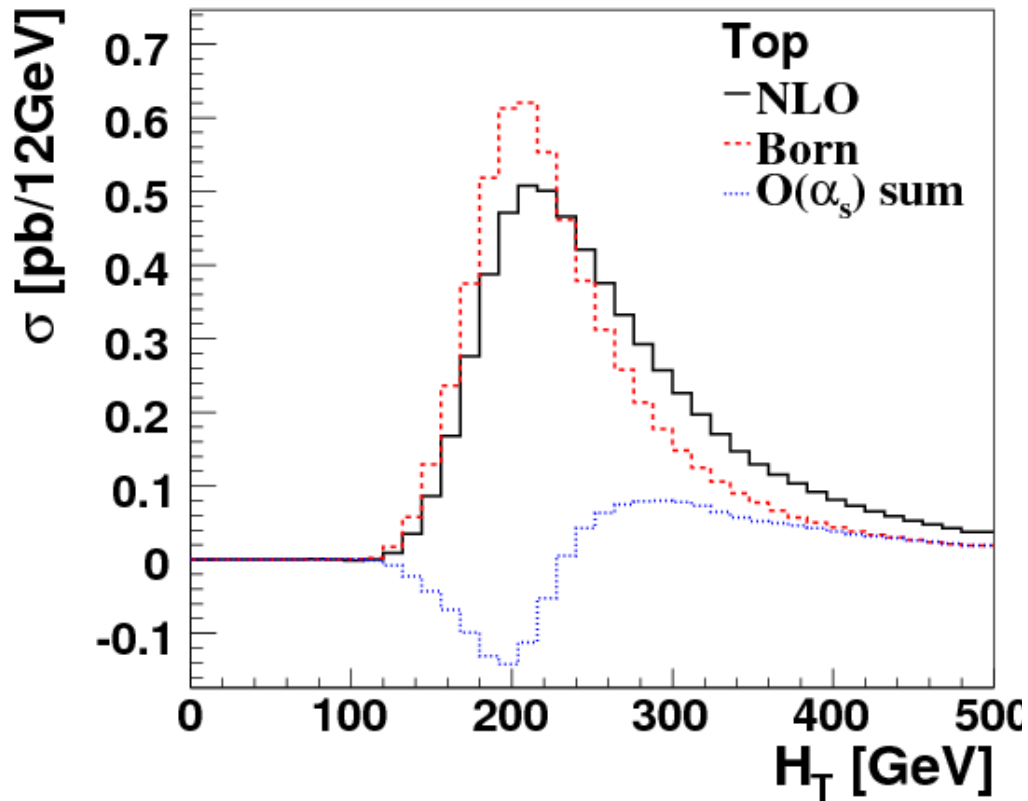
Third Jet



Event kinematics

Total transverse energy H_T

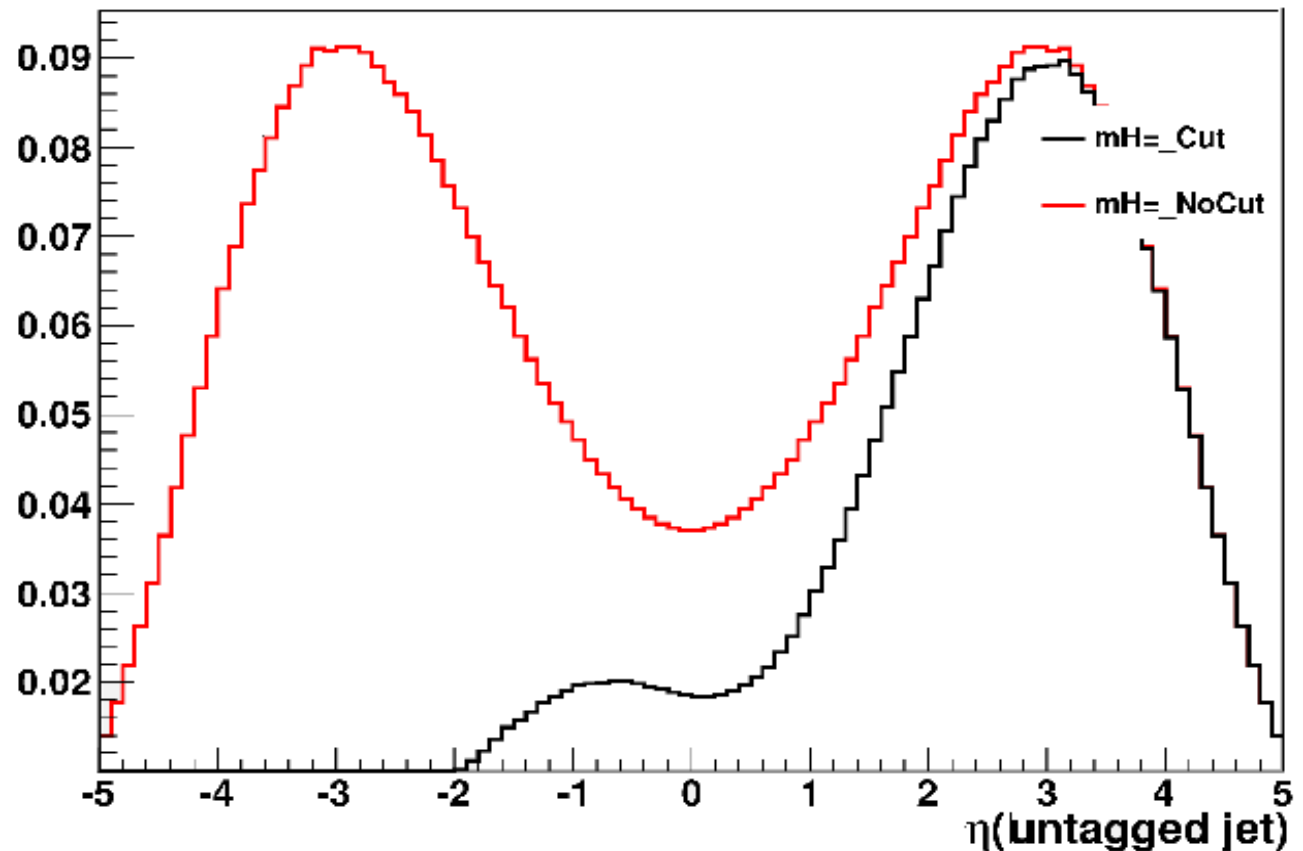
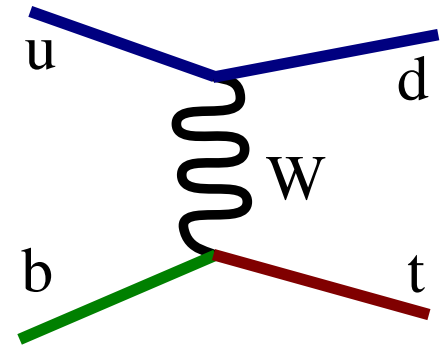
reconstructed top mass



Identifying the incoming quark direction

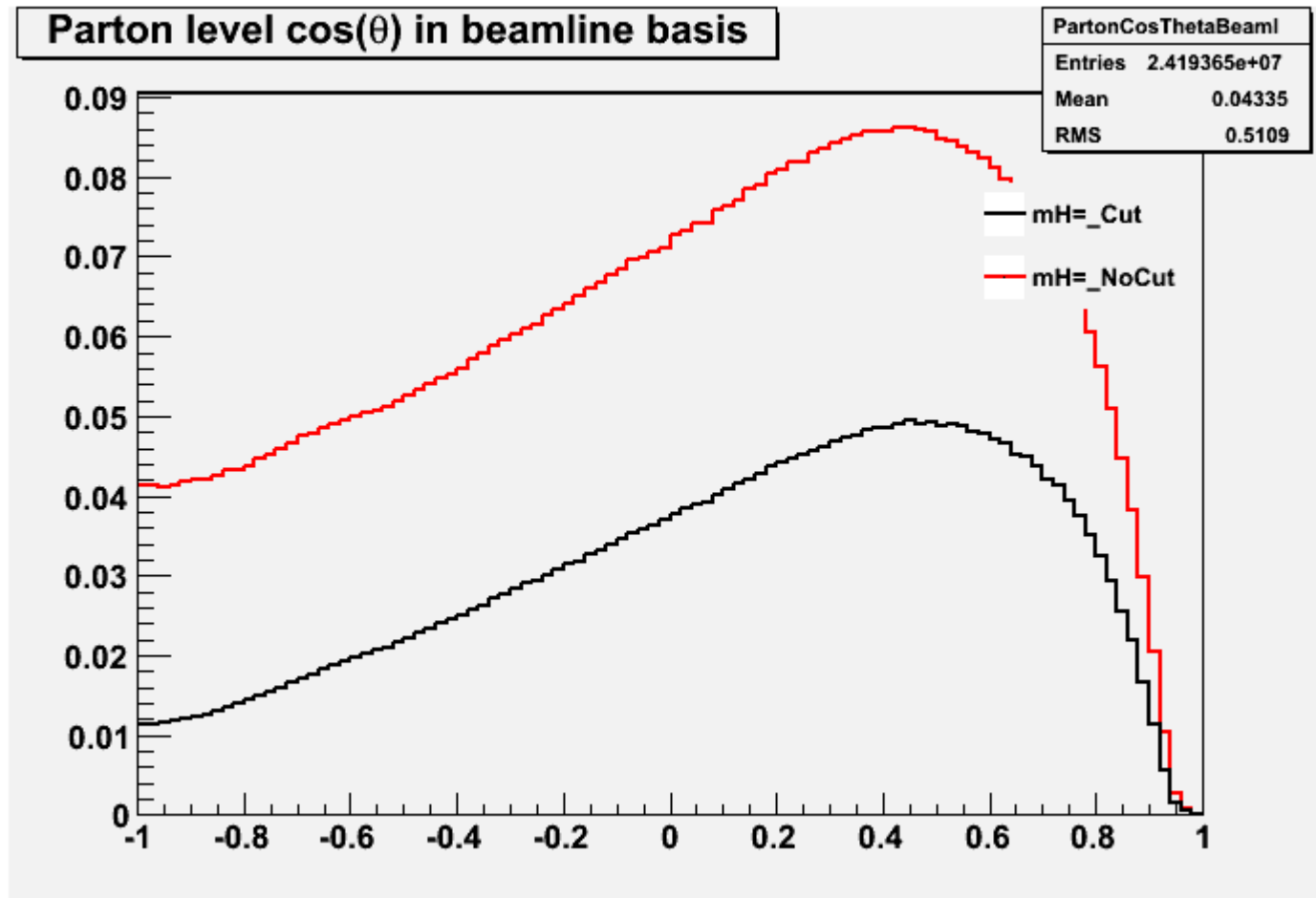
- LHC is pp collider and all final state distributions are symmetric in beam axis z
- up quark typically has larger p_z than b quark

→ identify up quark direction through $p_z^{S>0}$



Spin correlation for $p_z^S > 0$

- beamline basis spin correlation



Conclusions

- Single top s-channel cross section at 14TeV pp collider is
 - Top production: $6.1 \text{ pb} \pm 4.3\%$
 - Antitop production: $3.7 \text{ pb} \pm 4.3\%$
- Single top t-channel cross section at 7 TeV pp collider is
 - Top production: $40.1 \text{ pb} \pm 4.6\%$
 - Antitop production: $22.0 \text{ pb} \pm 4.1\%$
- Top and Antitop differ in cross section and in kinematics
- NLO corrections have a large impact
 - Most t-channel events contain 3 jets
- Spin correlations can be enhanced through cut on p_z of CM system