Top Quark Physics at Hadron Colliders

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University of Oxford
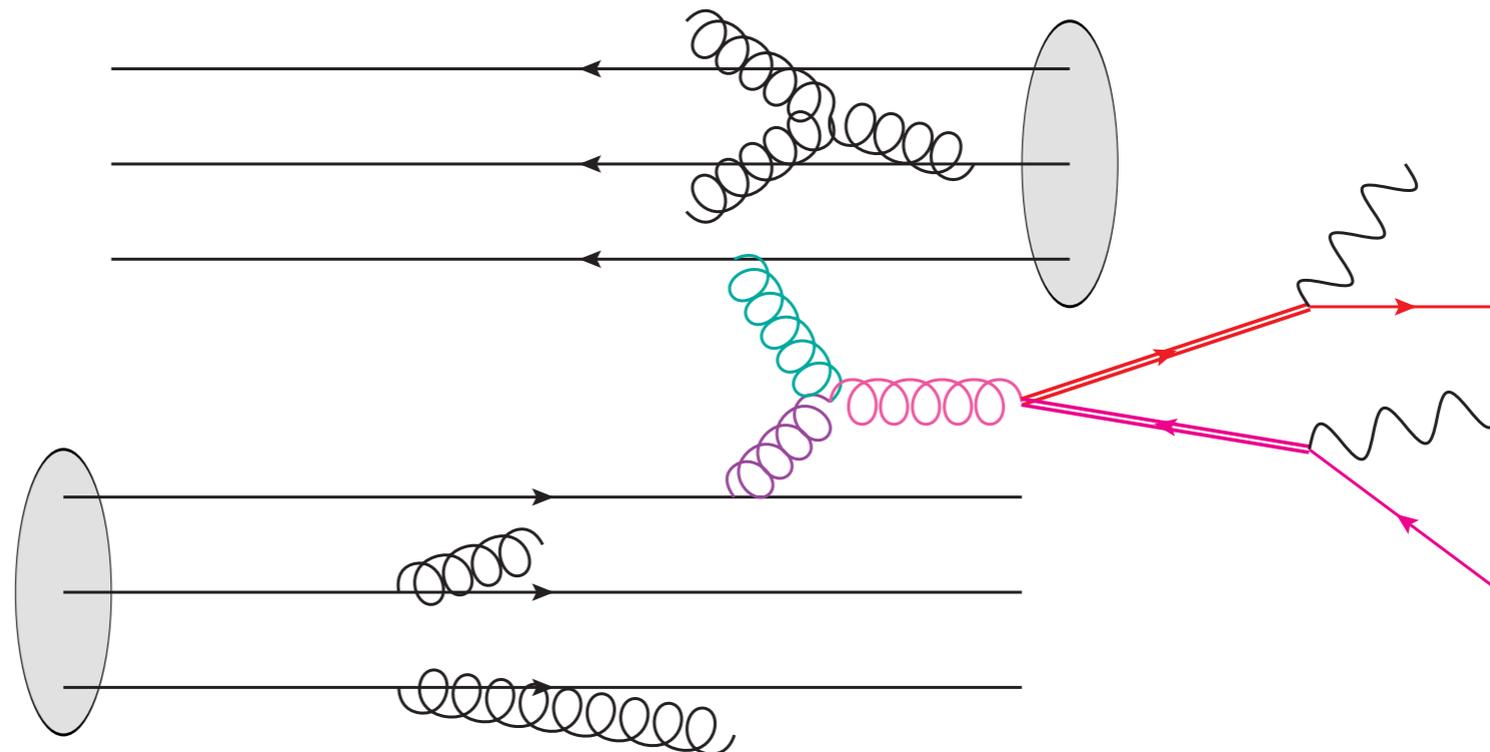
Why study top quarks?

Top Facts;

$$M_t \approx 173 GeV$$

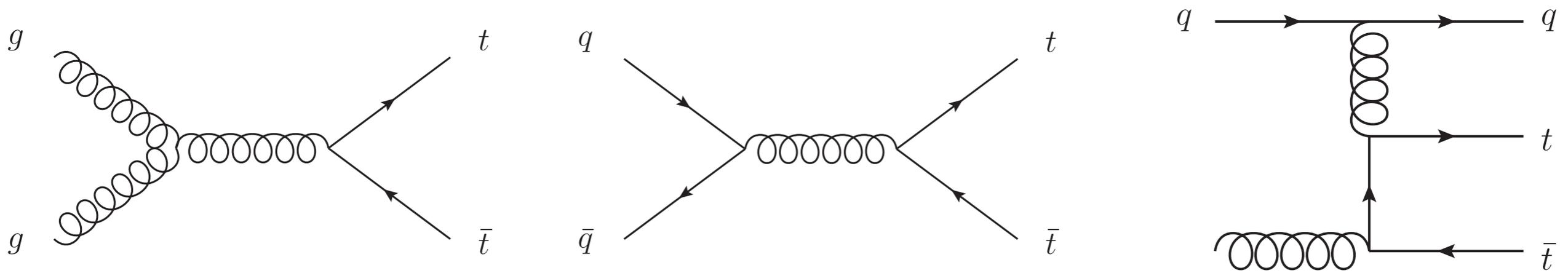$$\Gamma_t \approx 1.5 GeV$$

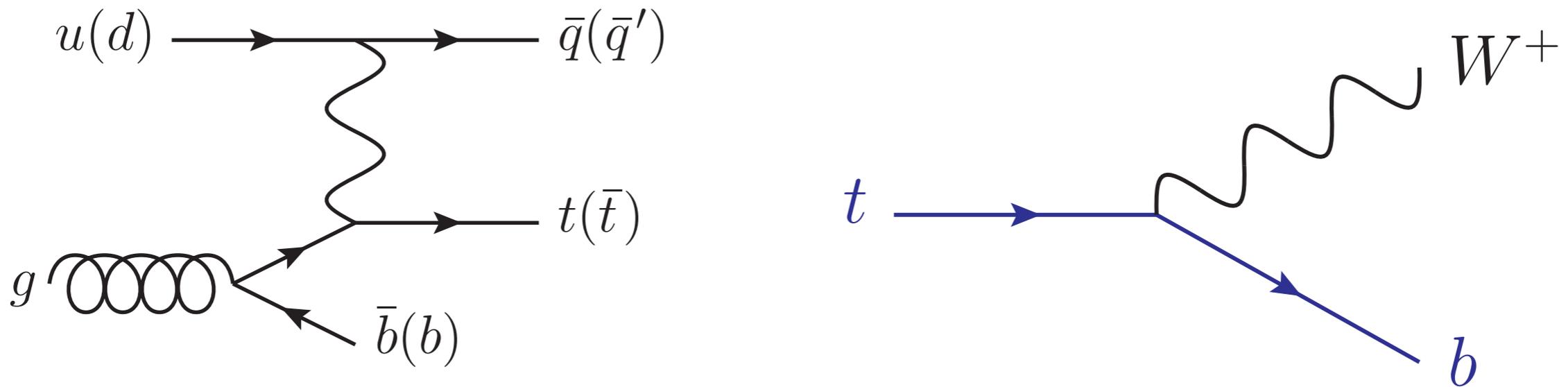$$\Gamma_t^{-1} < \Lambda_{QCD}^{-1}$$

- Probing QCD interactions over magnitudes of energy

- Important contribution to many loops

- Background for new physics!

Production and decay

- Some tree level contributions to pair production
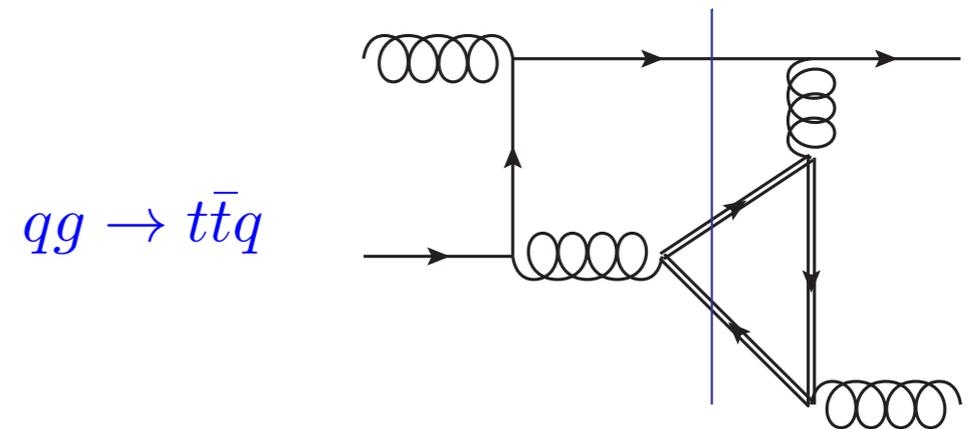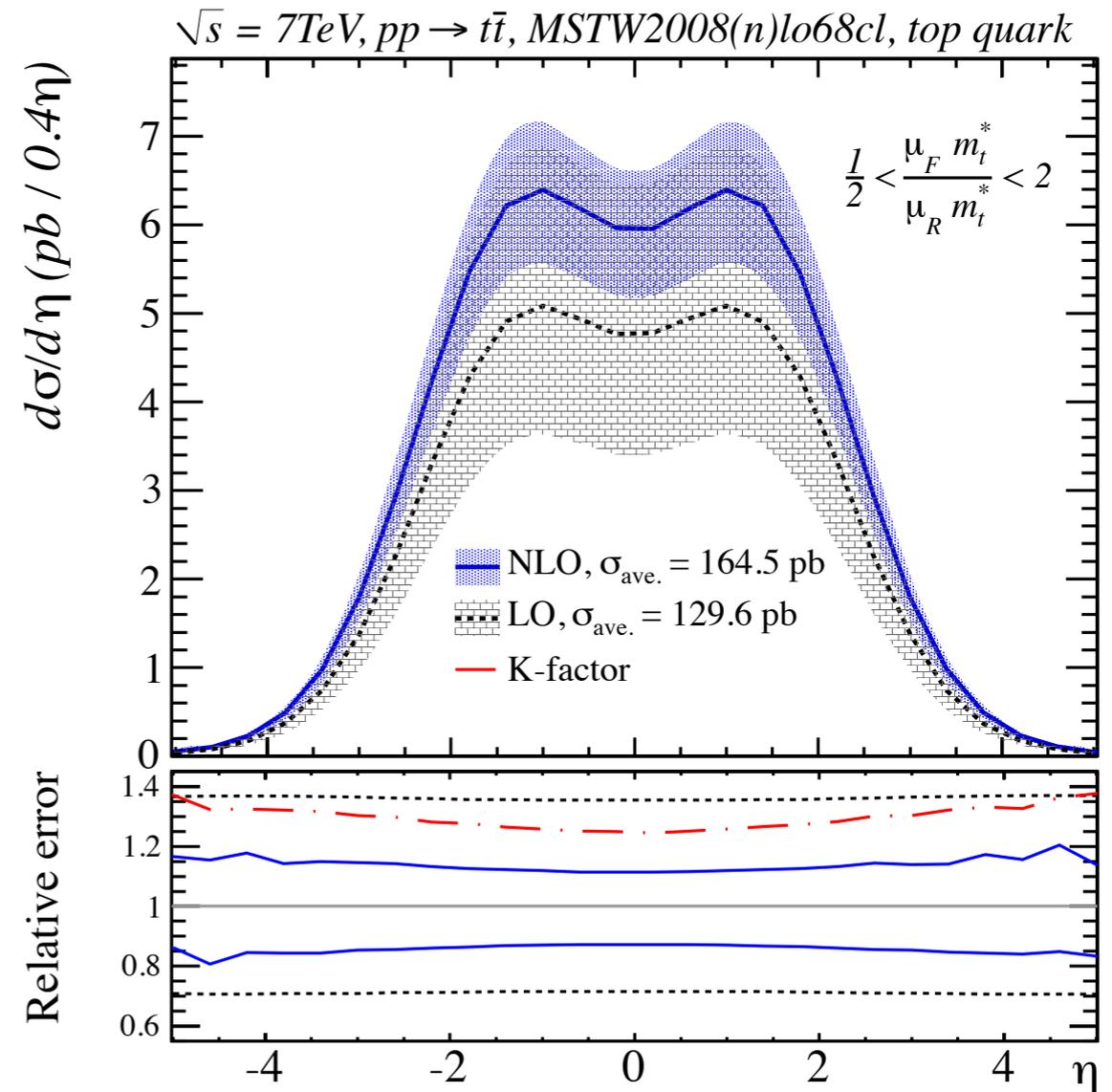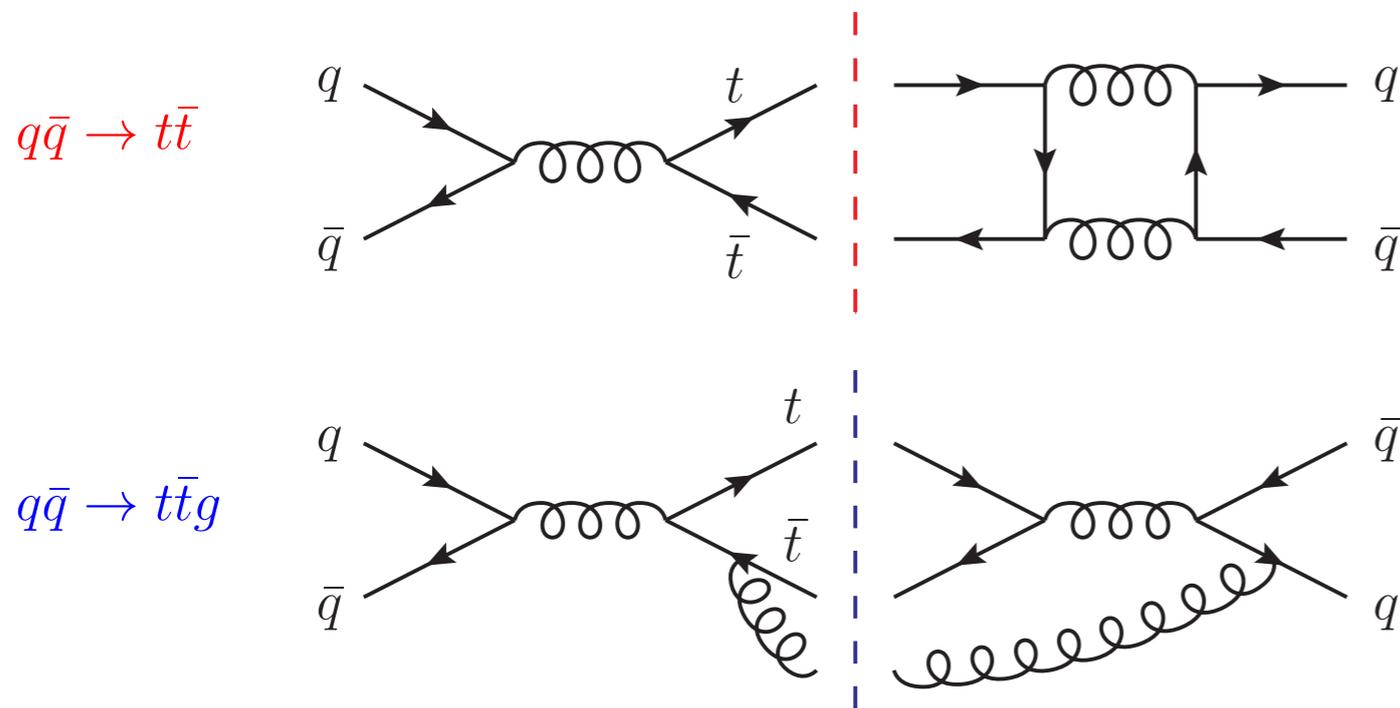

- Single top production / top decay

- Observe (b)-jets / charged leptons

Production and decay II

- ## Require NLO/NNLO

$$\alpha_S^{2-loop}(M_Z) \approx 0.119$$

- ## Asymmetric NLO contributions

$q\bar{q} \rightarrow t\bar{t}$

$q\bar{q} \rightarrow t\bar{t}g$

$qg \rightarrow t\bar{t}q$

$\sqrt{s} = 7TeV, pp \rightarrow t\bar{t}, MSTW2008(n)lo68cl, top\ quark$

$\frac{1}{2} < \frac{\mu_F}{\mu_R} \frac{m_t^*}{m_t^*} < 2$

$d\sigma/d\eta\ (pb\ /\ 0.4\eta)$

NLO, $\sigma_{ave.}$ = 164.5 pb

LO, $\sigma_{ave.}$ = 129.6 pb

K-factor

Relative error

Some Comparisons?

$\sqrt{s} = 7TeV$, MCFM6.2 $pp \rightarrow t\bar{t}$, top quark

$$\frac{1}{2} < \frac{\mu_F \, m_t^*}{\mu_R \, m_t^*} < 2$$

CT10, $\sigma_{ave.}$ = 154.5 pb
MSTW08, $\sigma_{ave.}$ = 164.5 pb
NNPDF22, $\sigma_{ave.}$ = 166.9 pb
$\sigma_{ave.}$ = 162.0$^{+25.2}_{-27.5}$ pb

xF(x, Q=83GeV, g) Ratio, PDF/MSTW

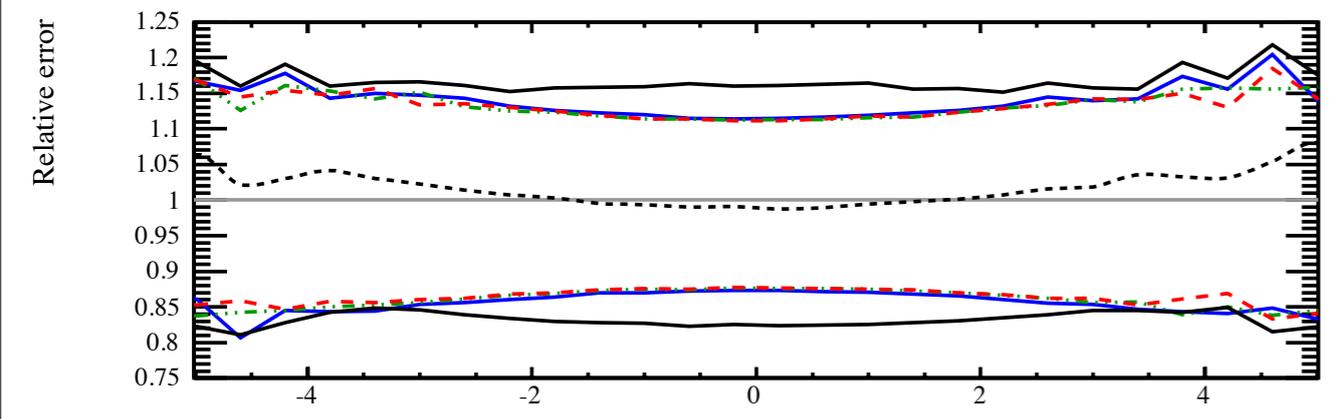MSTW08nlo68cl

NNPDF2.2nlo

CT10nlo
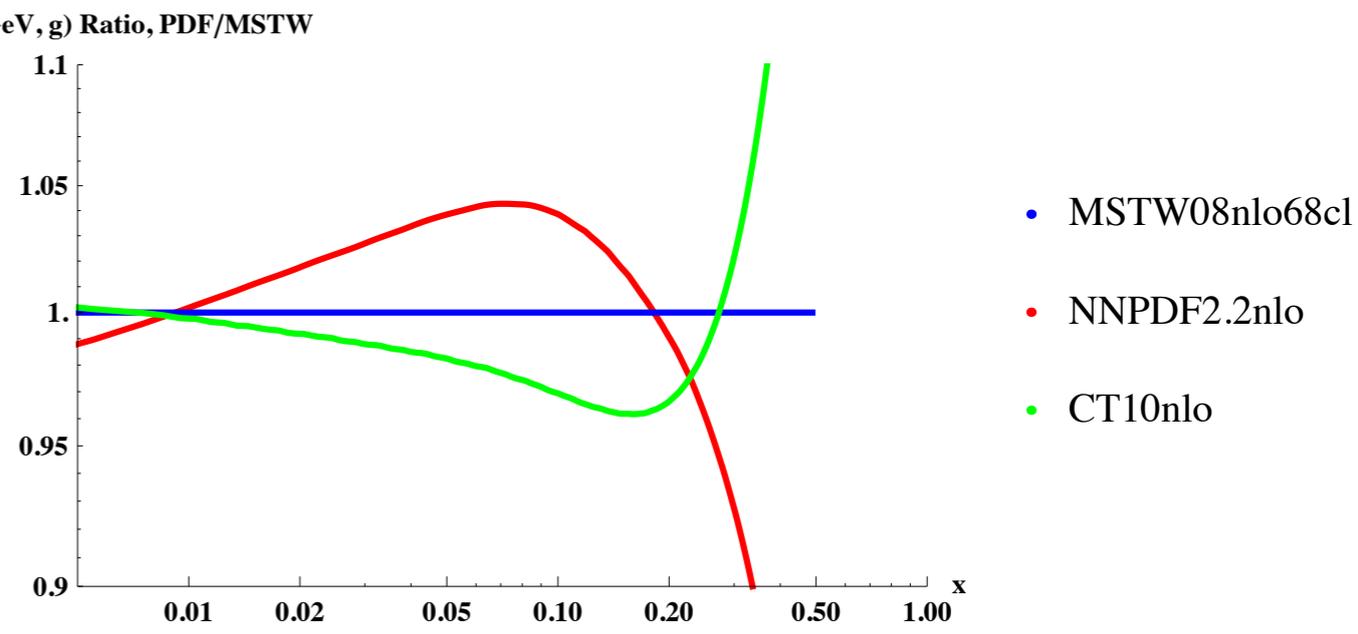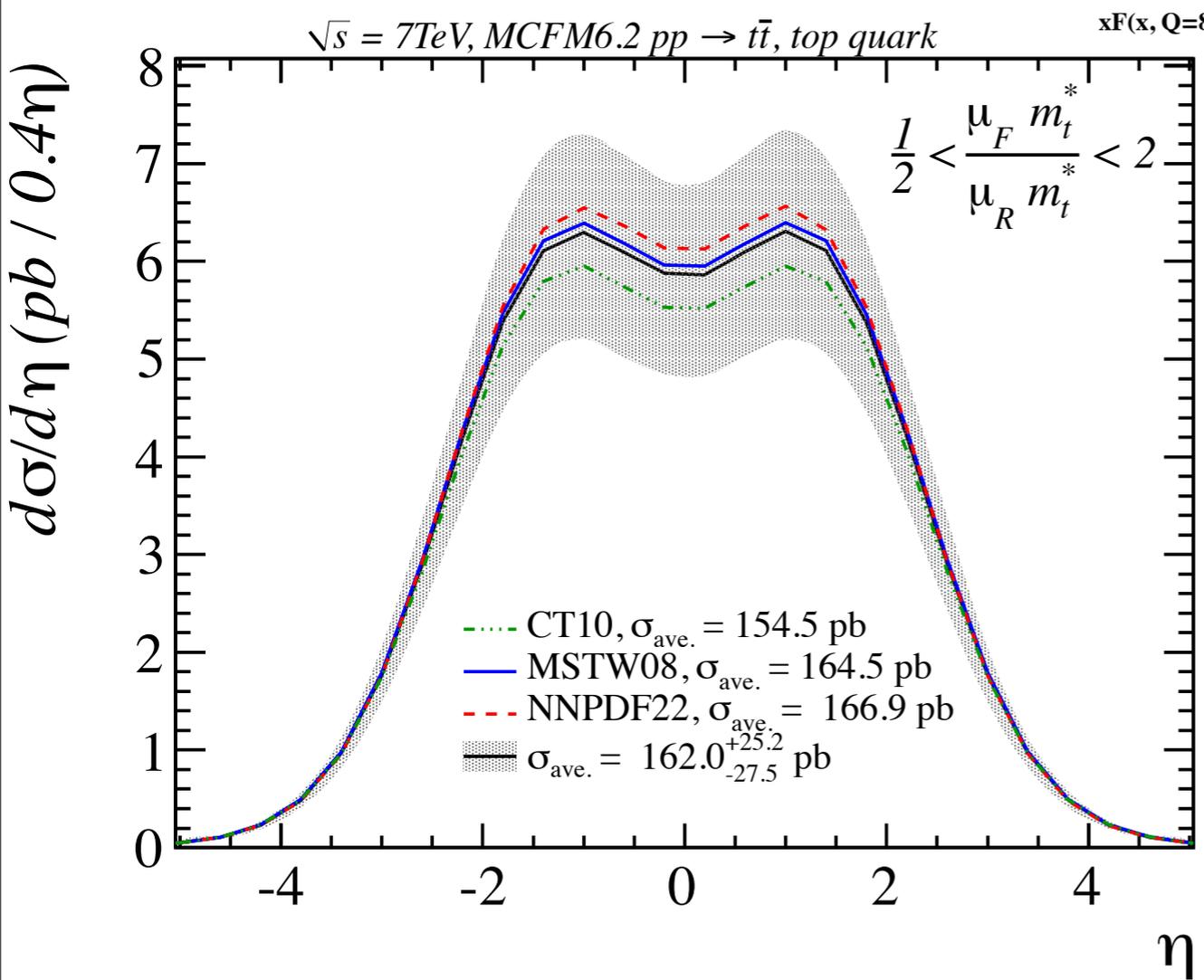
Sensitivity to;

PDF choice

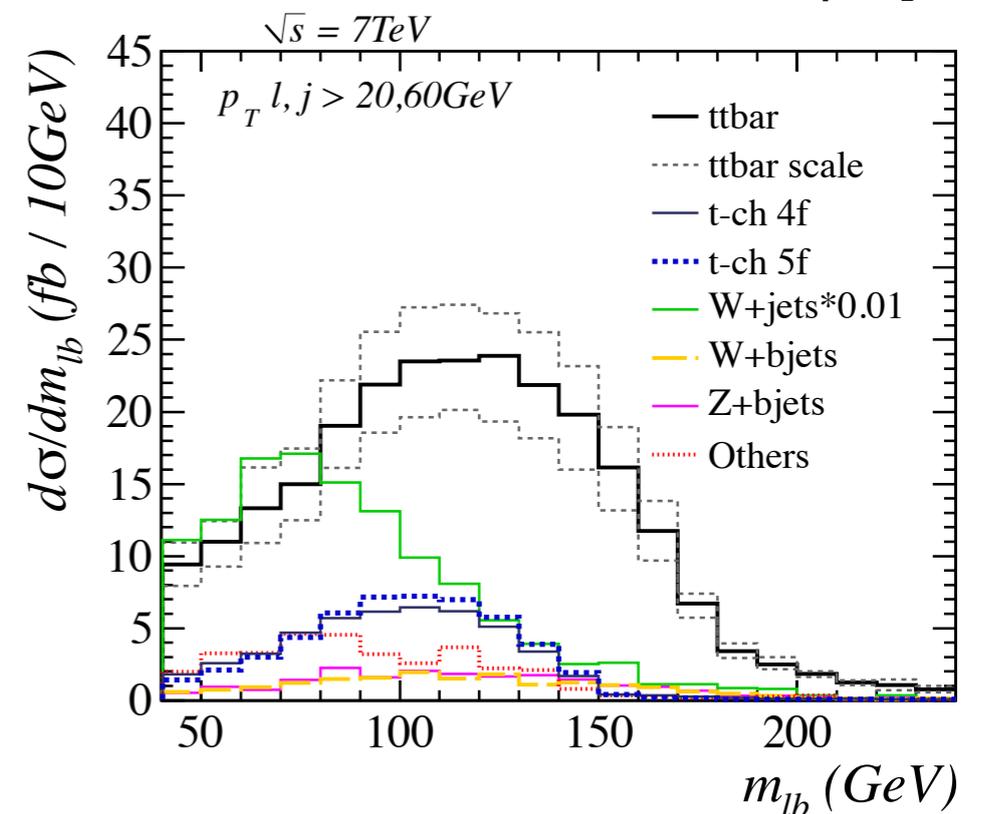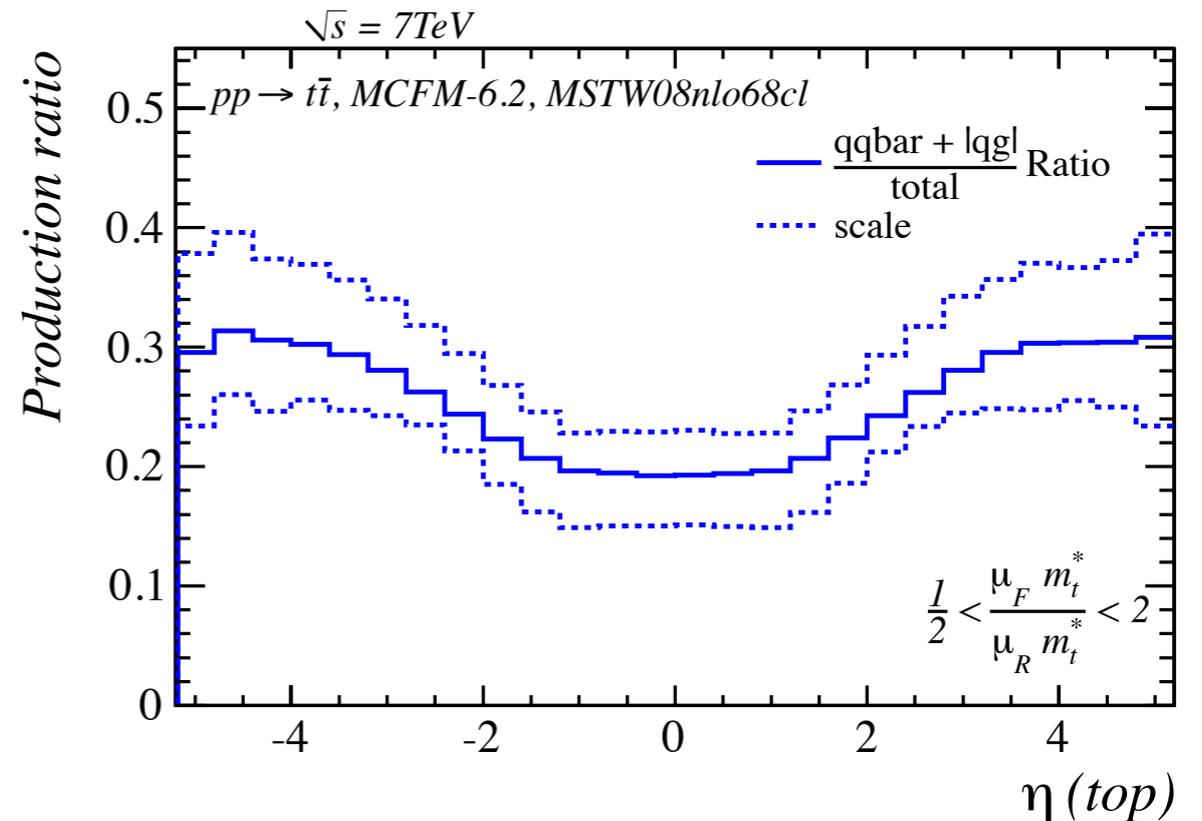## Scale choice

Top mass input

Looking at the forward region

- ## Production is phase space dependent

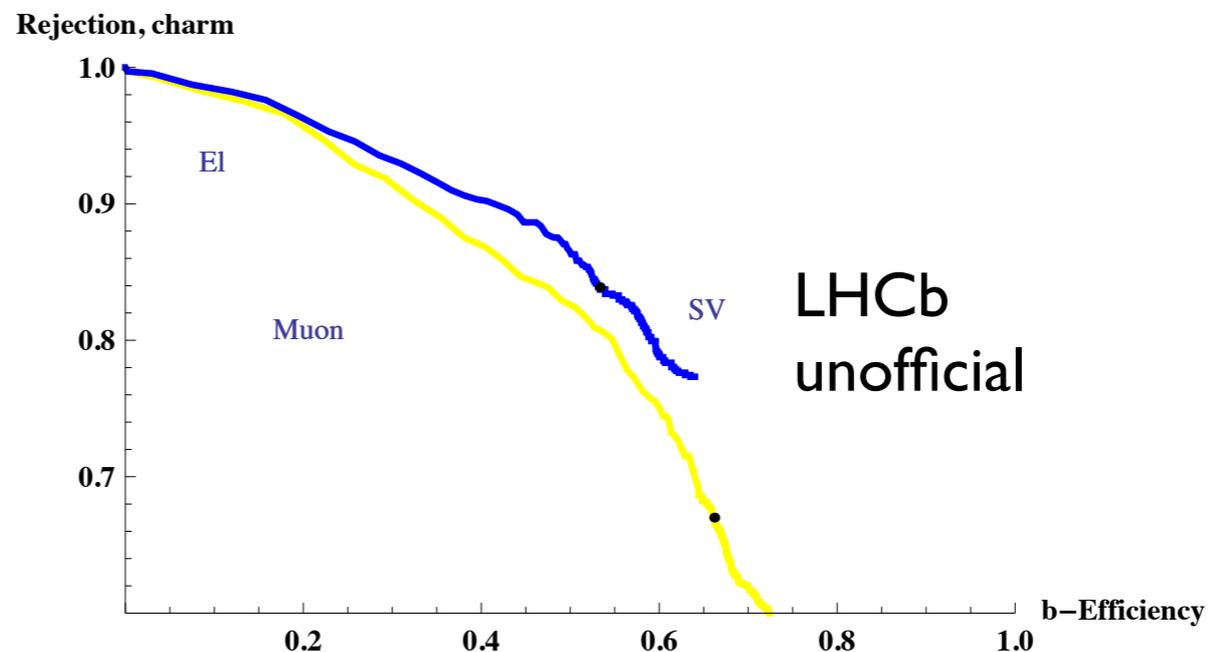- ## High eta more sensitive to asymmetric production

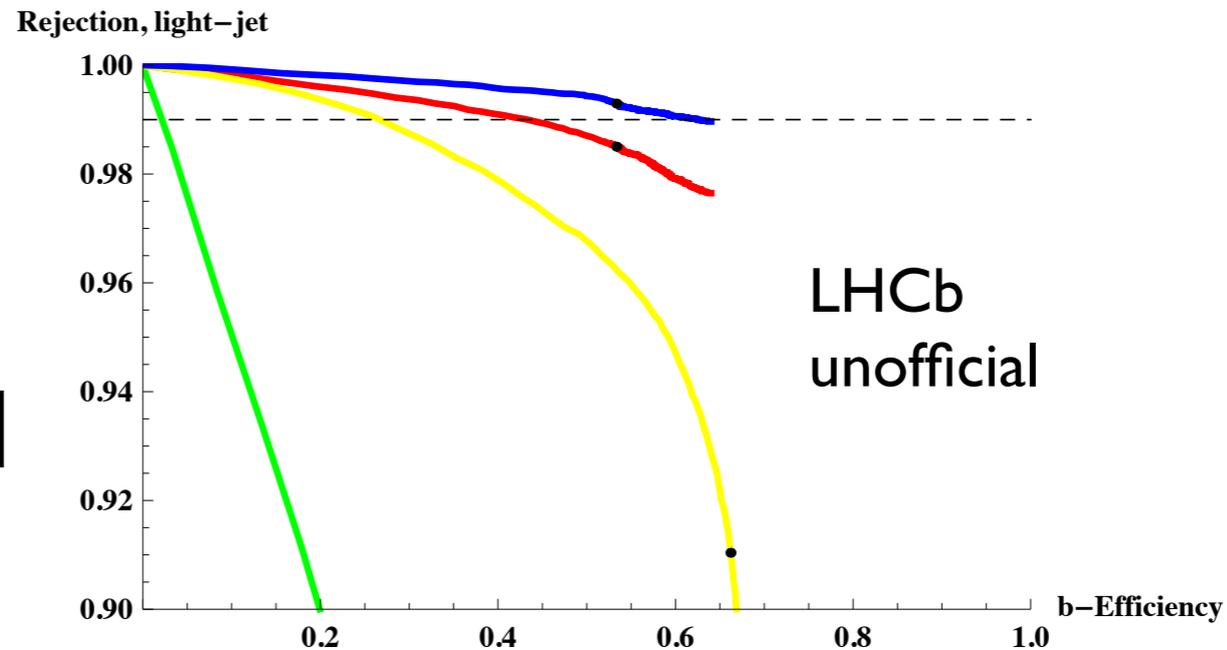## **Analysis of muon+b-jet**
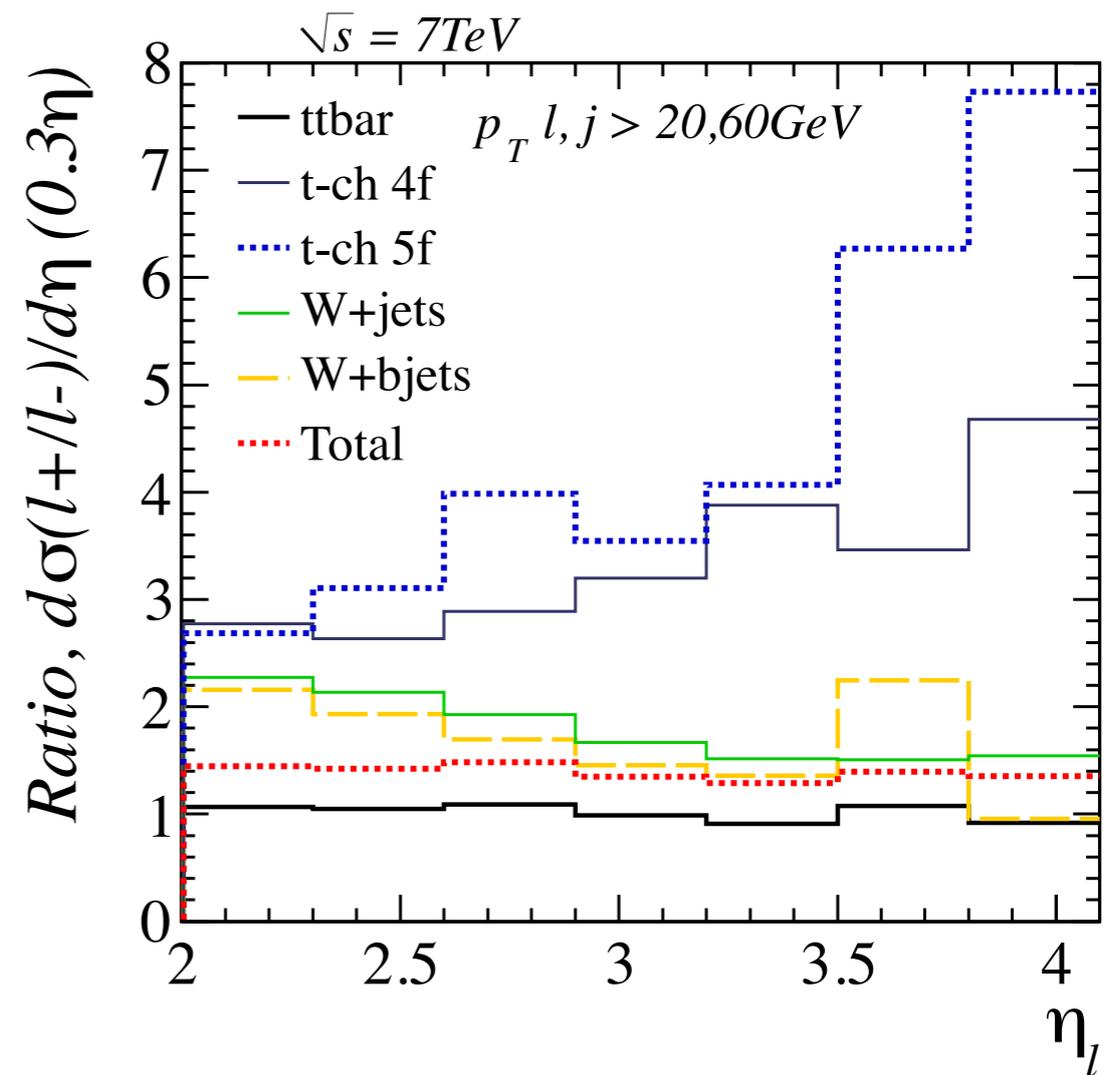
- ## b-tagged jet, pT > 60GeV

- ## Isolated muon, pT > 20GeV
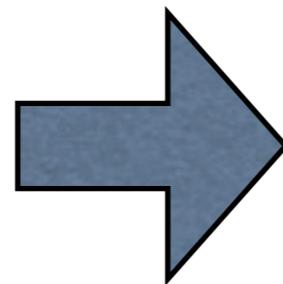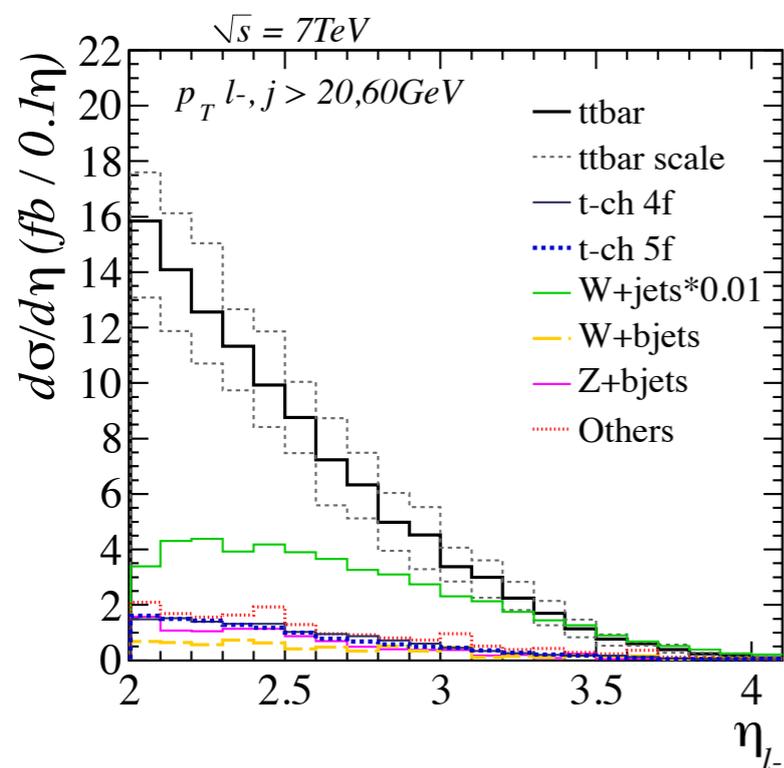
- ## Partially reconstruct **ttbar**

Jet-Tagging (7TeV)

- **R=0.5**, anti-kt

- $jet_{p_T} > 40 GeV$

- **track based Neural Network**

- **Topological tagger based on displaced vertex**

- **60% efficiency 1% mis-tag(light) 15% mis-tag(charm)**

Rejection, light−jet

- Topo+NN tag(Wjets)
- NN tag(Wjets)
- Topo+NN tag(ttbar)
- NN tag(ttbar)

LHCb unofficial

b−Efficiency

Rejection, charm

El

Muon

SV

LHCb unofficial

- Topo+NN tag(ttb)
- NN tag(ttb)
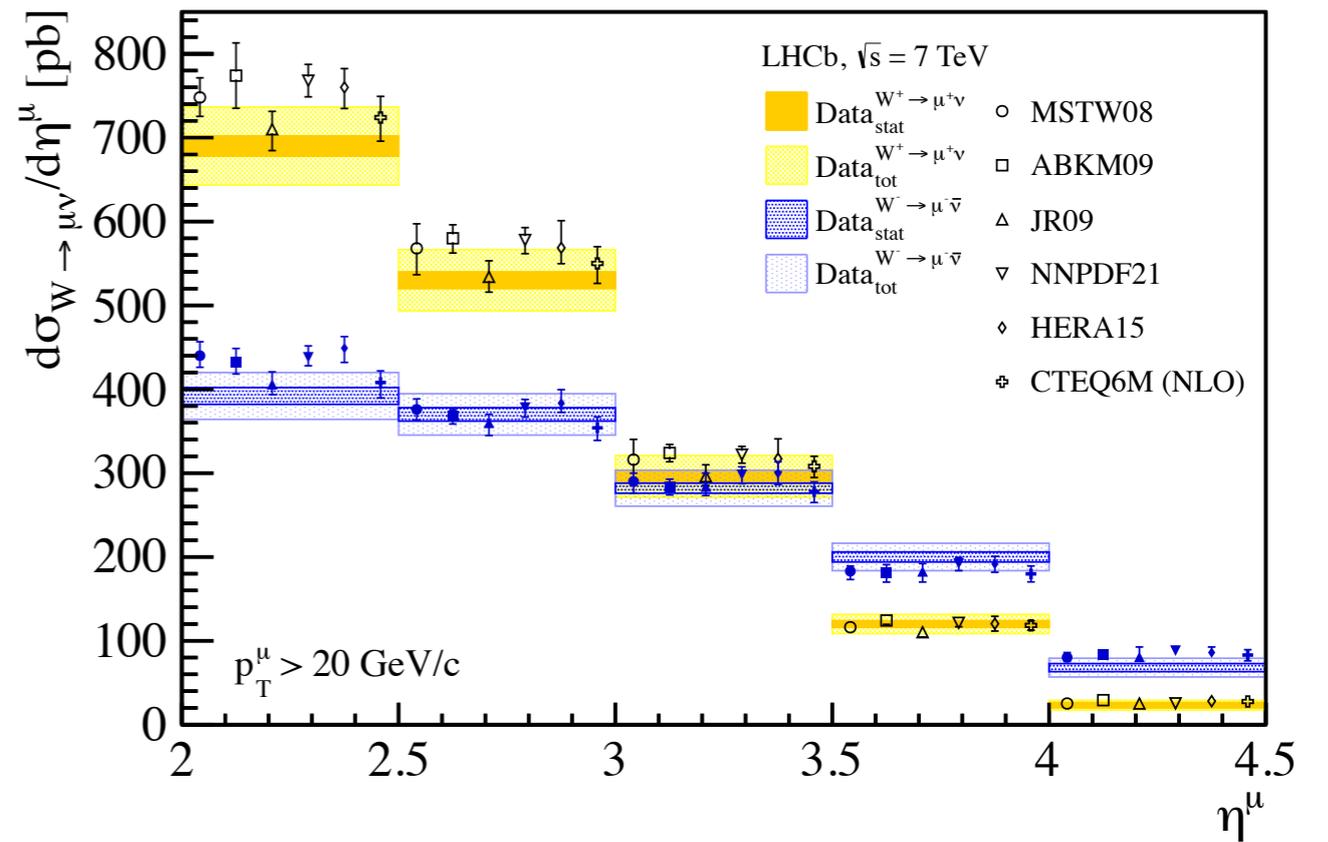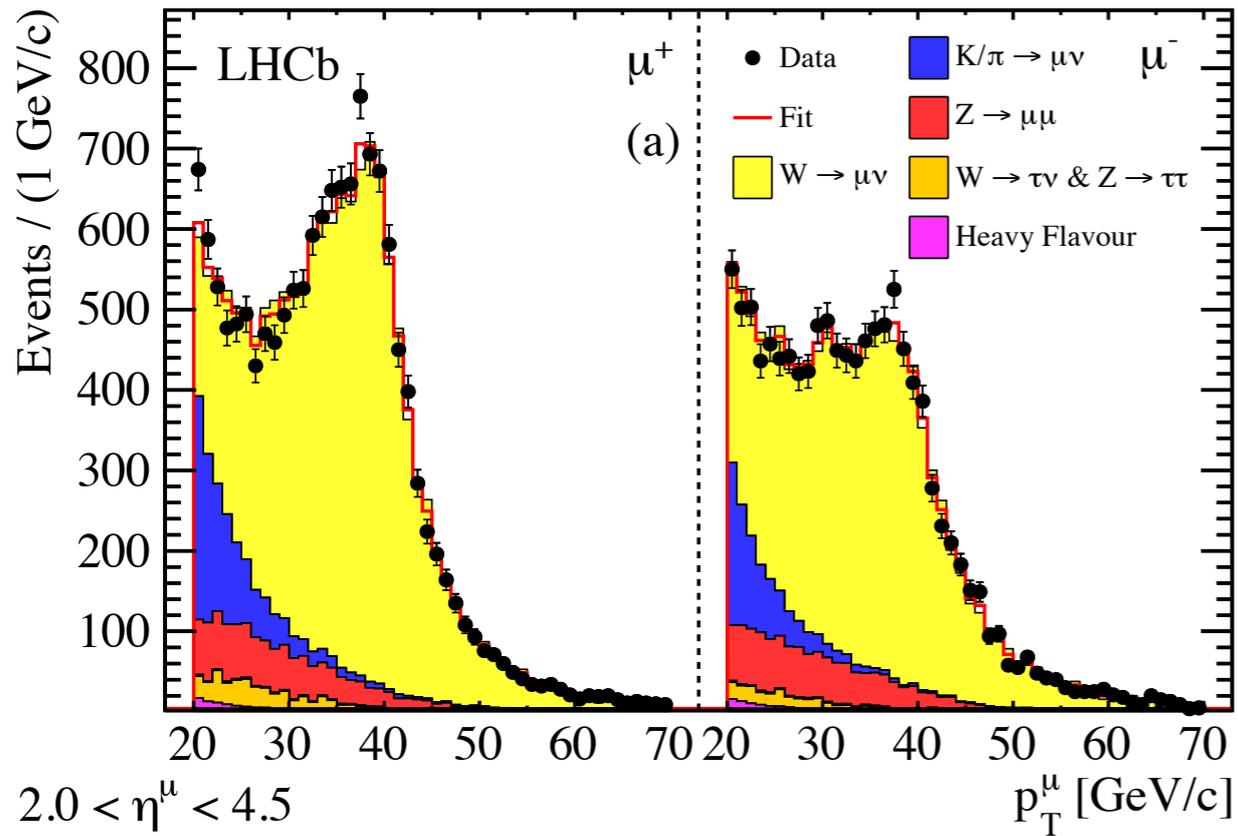
b−Efficiency

Asymmetric production in LHCb
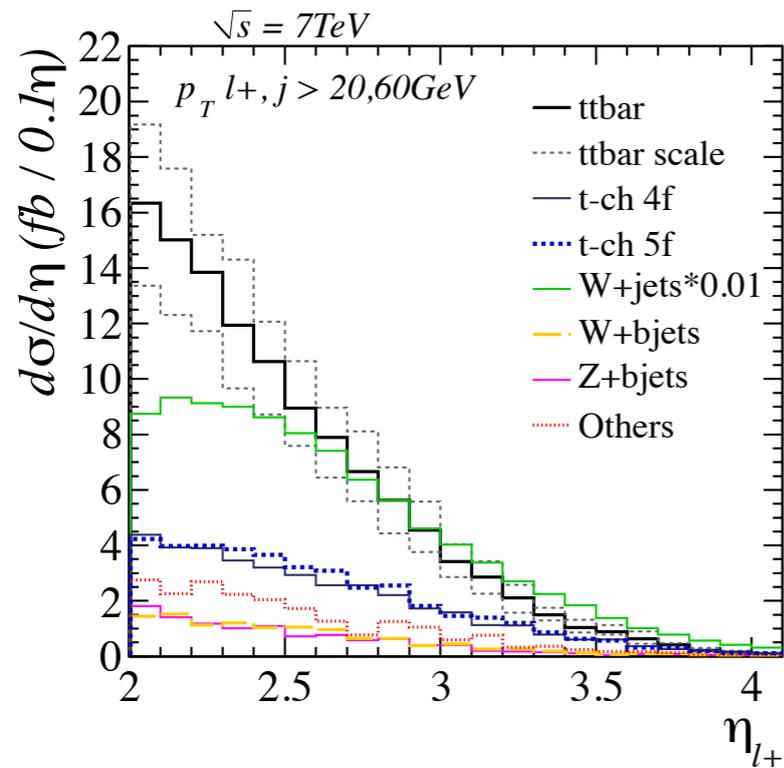
SM: $R_{l+/l-}(60) = 1.43^{+0.04}_{-0.03}$

LHCb: $R_{l+/l-}(60) = X^{+Y}_{-Z}$

Conclusions

- LHCb asymmetry analysis underway

- Many theoretical developments in progress
  - Improvement in shower description
  - NNLO differential distributions

- N(N)LO PDF errors improving with LHC data

Backups W Analysis

Backups

LHCb ttbar channels

$\sigma_{\eta \in 2-5}(pb)$	7TeV	8TeV	14TeV
l b	1.4	2.5	18.6
l b j	0.3	0.7	8
l b b	0.1	0.3	3.1
l+l-	0.02	0.05	0.8

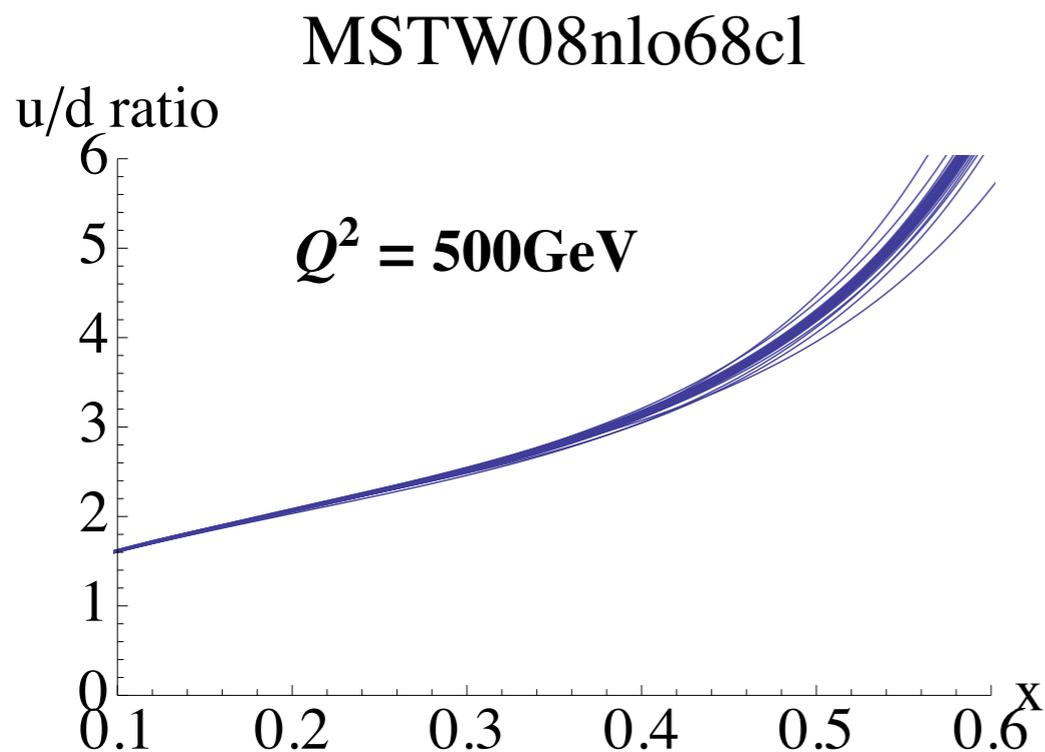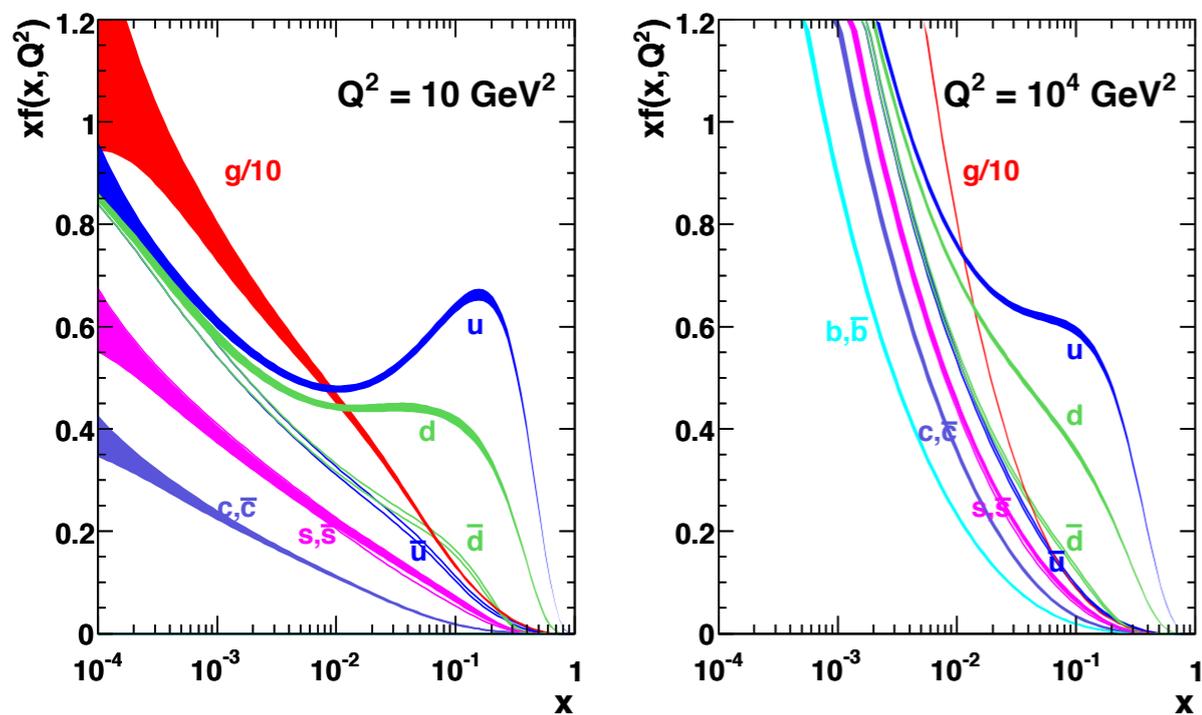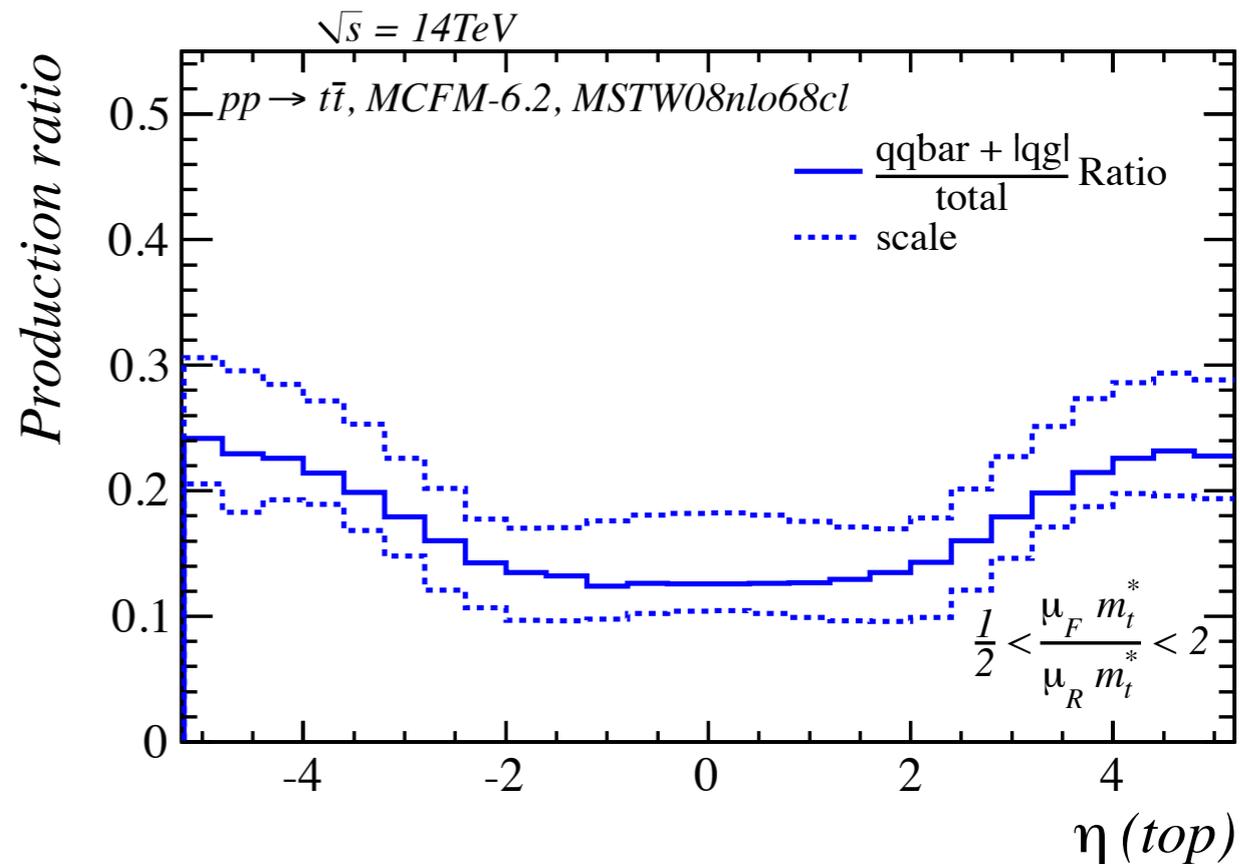Differential cross sections;

POWHEG->Pythia8

anti-kt jets with R = 0.5
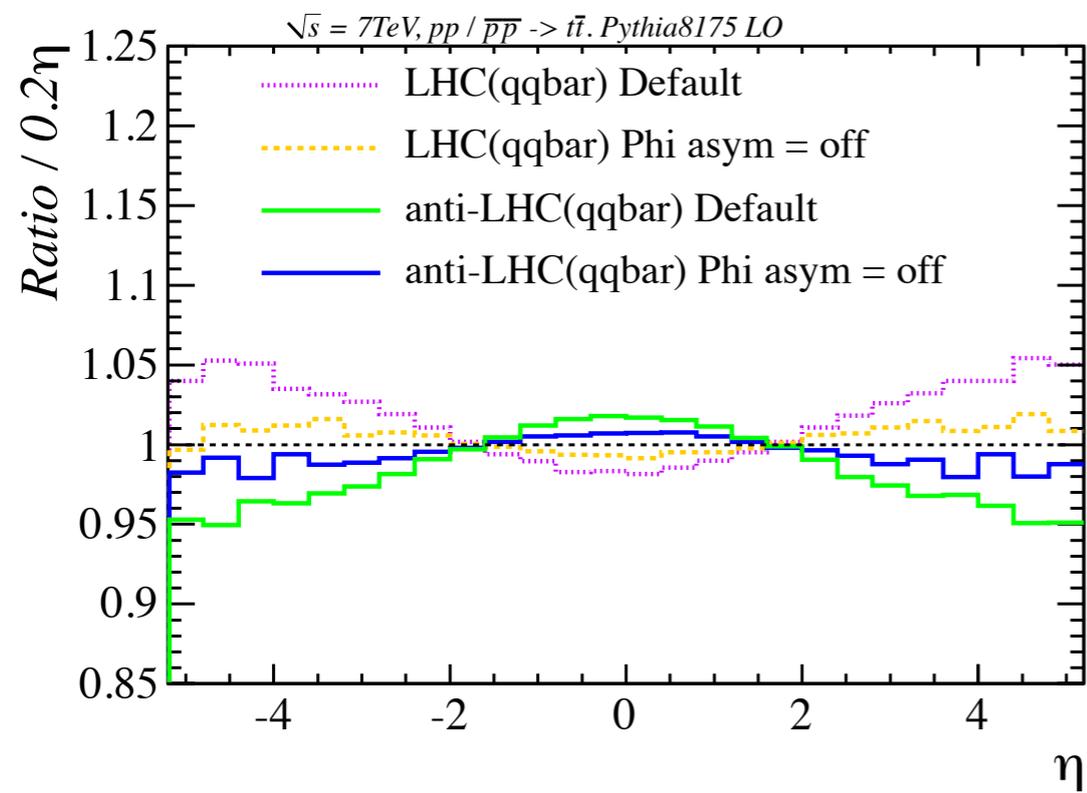
pT jets > 15 GeV

pT lepton > 8 GeV

b= truth tagged jet

Backups

Backups

$\sqrt{s} = 7TeV, pp \to t\bar{t}, Herwig++2.6.0$

ratio top/atop qqbar(reco)
ratio top/atop qqbar(parton)

$\sqrt{s} = 7TeV, pp \to t\bar{t}, Herwig++2.6.0$

ratio top/atop gg(reco)
ratio top/atop gg(parton)

$\sqrt{s} = 7TeV, pp / \overline{pp} \to t\bar{t}. Pythia8175 LO$

LHC(qqbar) Default
LHC(qqbar) Phi asym = off
anti-LHC(qqbar) Default
anti-LHC(qqbar) Phi asym = off

$\sqrt{s} = 7TeV, pp / \overline{pp} \to t\bar{t}. Pythia8175 LO$

LHC(gg) Default
LHC(gg) Phi asym = off
anti-LHC(gg) Default
anti-LHC(gg) Phi asym = off
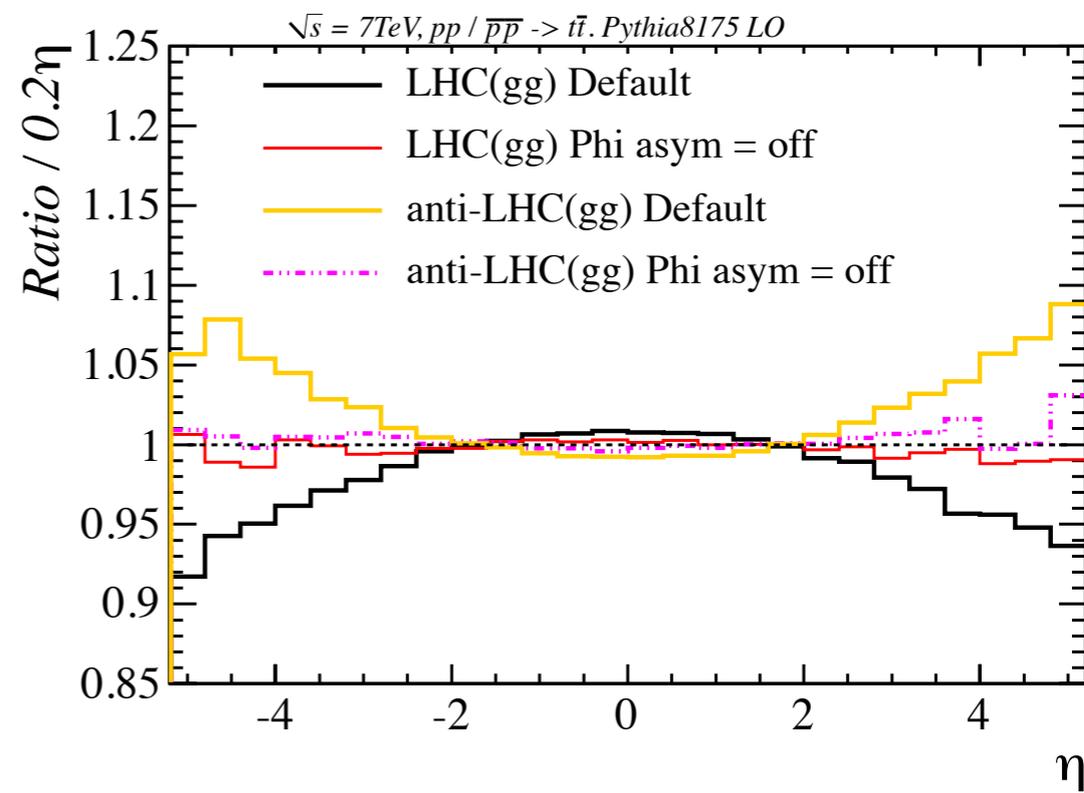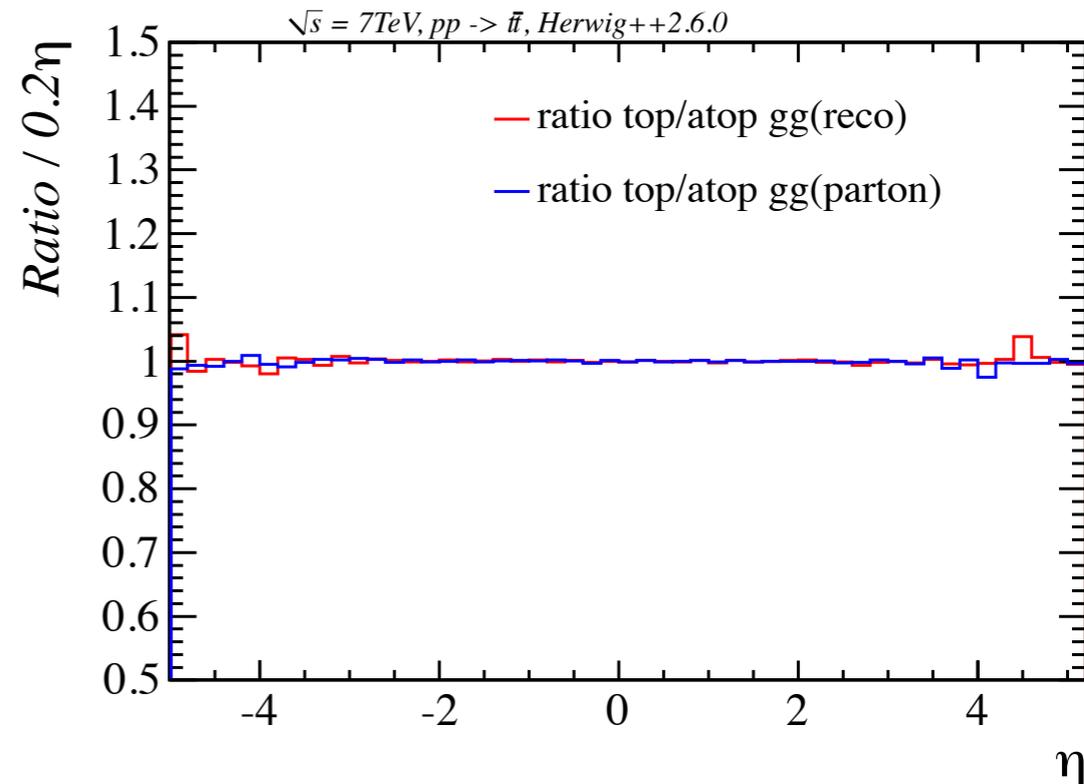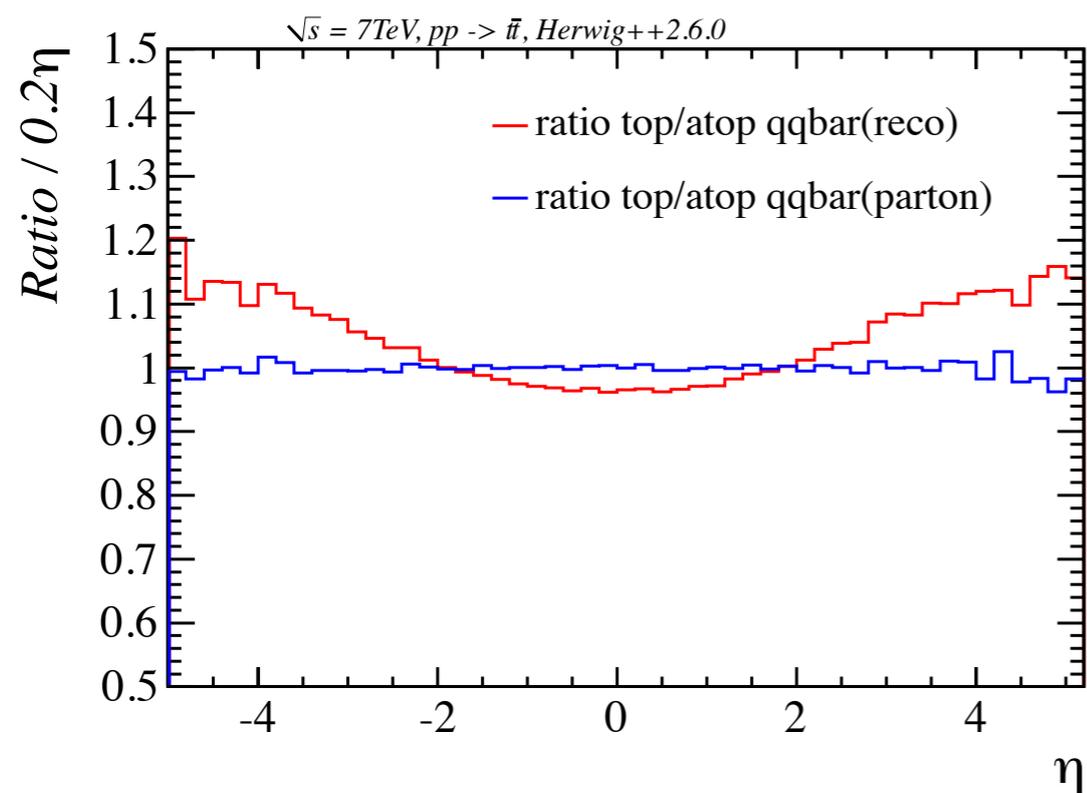
NLO Asymmetry
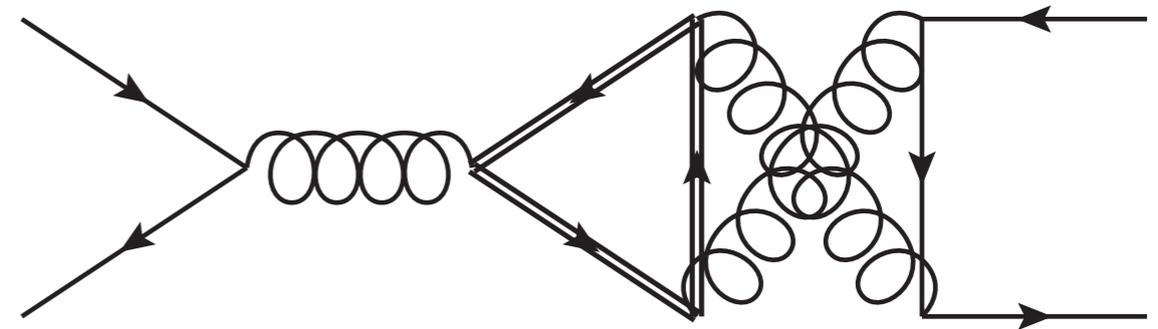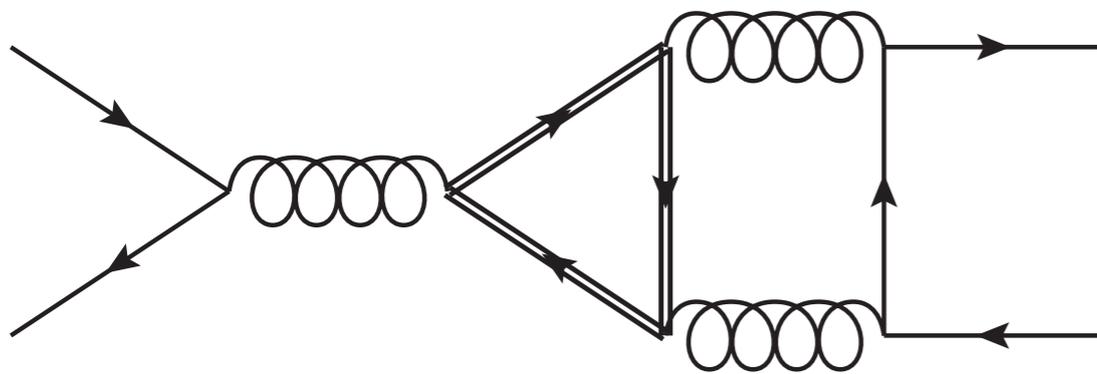
$$C_{planar} = \frac{1}{16N_c^2}(f_{abc}^2 + d_{abc}^2) \qquad C_{crossed} = \frac{1}{16N_c^2}(-f_{abc}^2 + d_{abc}^2)$$
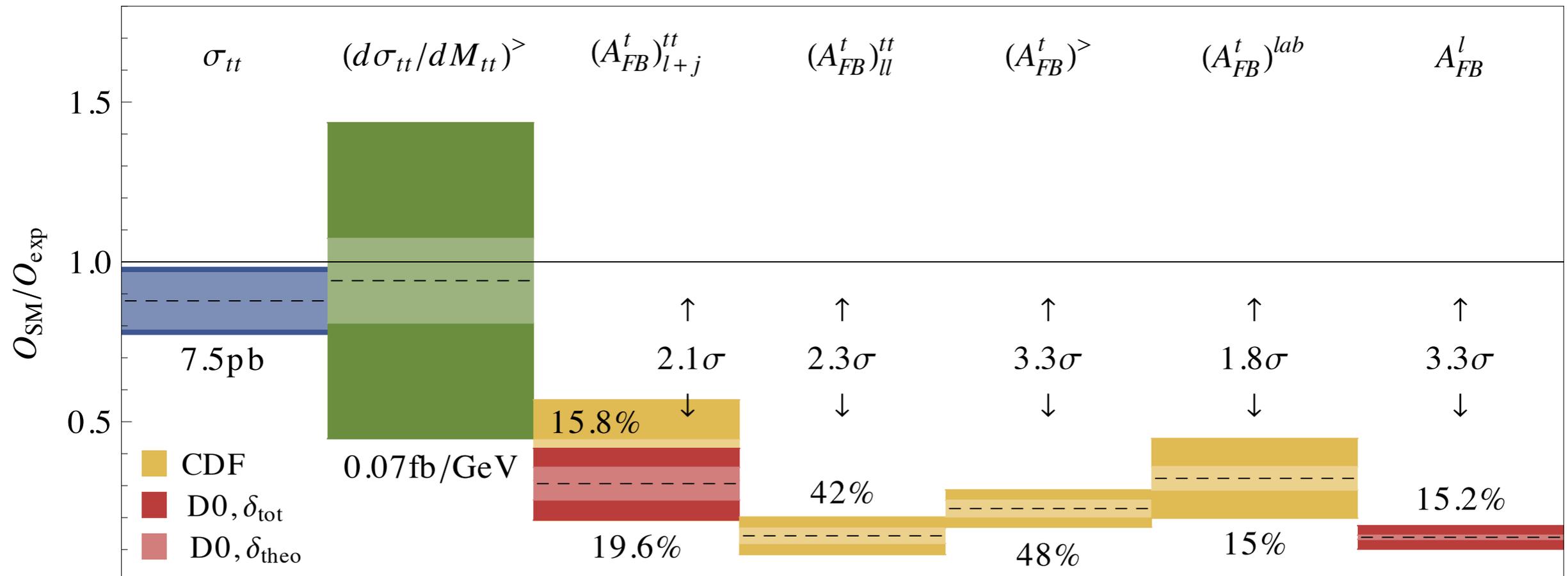
$$f_{abc}^2 = (N_c^2 - 1)N_c$$

$$d_{abc}^2 = (N_c^2 - 1)(N_c^2 - 4)/N_c$$

$$d_{abc}^2 = Tr[\{T^a, T^b\}T^c]^2$$

TeVatron summary

S. Westhoff, arXiv:1108.3341

Backups

$\sqrt{s} = 7TeV, pp \rightarrow t\bar{t}, MSTW2008nlo68cl, top\ quark$

$\frac{1}{2} < \frac{\mu_F\ m_t^*}{\mu_R\ m_t^*} < 2$

$d\sigma/d\eta\ (pb\ /\ 0.4\eta)$

MCFM, $\sigma_{ave.}$ = 164.5 pb

POWHEG, $\sigma_{ave.}$ = 157.1 pb

η

Relative error

$\sqrt{s} = 7TeV, pp \rightarrow t\bar{t}, MCFM, MSTW08nlo68cl, top\ quark$

$\mu_F = \mu_R = \frac{m'_t}{\mu_0}$

$d\sigma/d\eta\ (pb\ /\ 0.4\eta)$

MSTW40, $\sigma_{ave.}$ = 164.5$^{+2.7}_{-4.5}$ pb

η

Relative error