tmini Weizmann Workshop

Top LHCb Physics

based on
Kagan, J.F.K., Perez & Stone, 1103.3747

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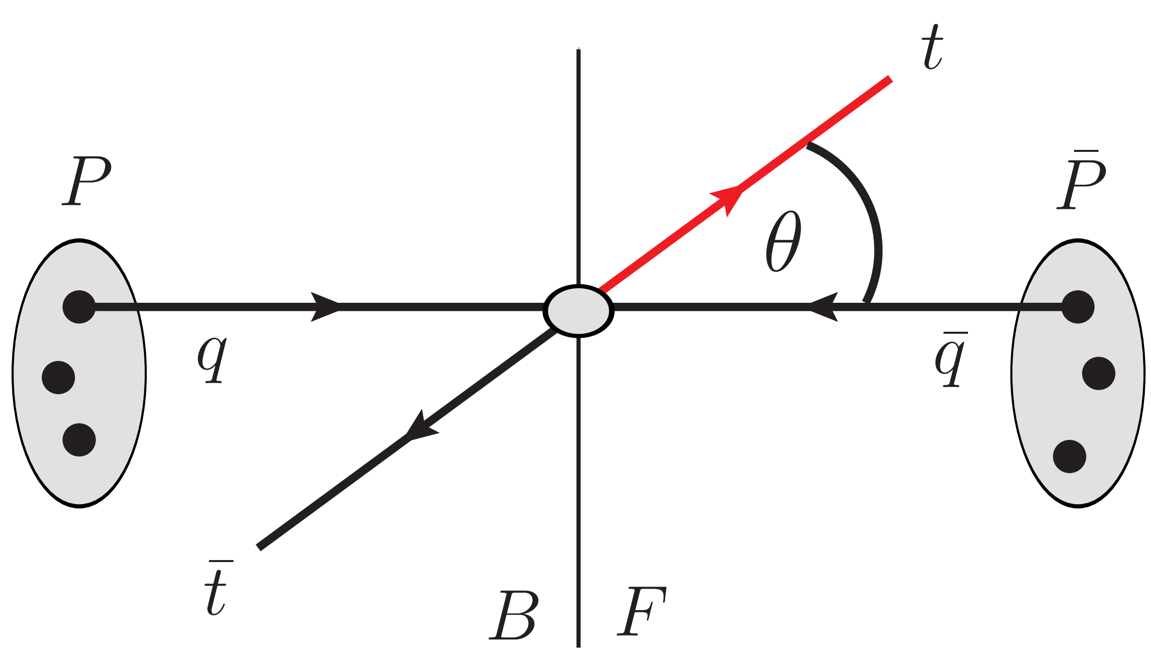
30/05/2011, Weizmann Inst.

Forward-backward asymmetry in $t\bar{t}$ production

- Charge (a)symmetric cross-section at the Tevatron



- In bins of Δy:

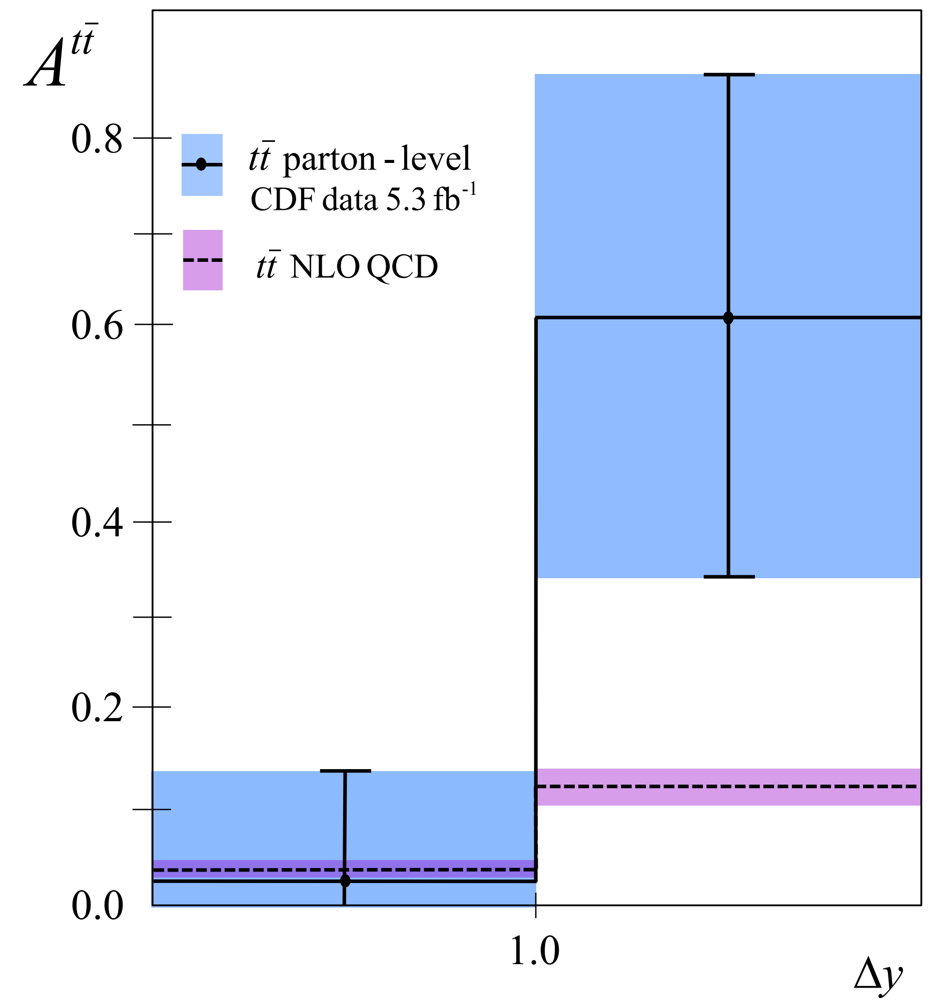
$$A^{\mathrm{t\bar{t}}}(\Delta y_i) = \frac{N(\Delta y_i) - N(-\Delta y_i)}{N(\Delta y_i) + N(-\Delta y_i)} \qquad \Delta y = y_t - y_{\bar{t}}$$

Forward-backward asymmetry in tt production

- Large AFB at large $t\bar{t}$ rapidity differences

$$A^{t\bar{t}}(|\Delta y| < 1.0) = 0.026 \pm 0.118$$
$$\boxed{A^{t\bar{t}}(|\Delta y| \geq 1.0) = 0.611 \pm 0.256}$$

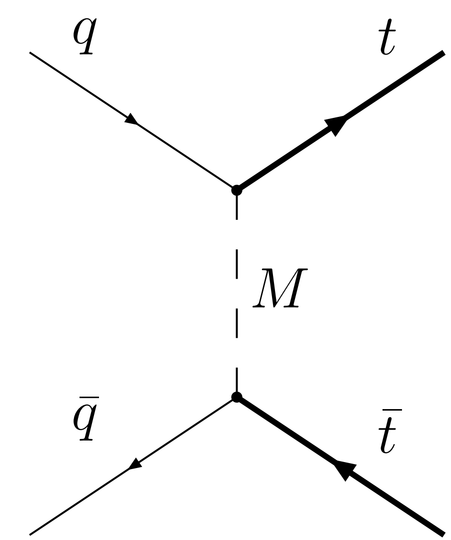
CDF, 1101.0034



New Physics Interpretation(s)

- ***Light to moderate mass t(u)-channel resonances***
  - Z', W', scalar color triplets, sextets See Jure's talk
  - Exhibit Rutherford scattering peak

$$\mathcal{M} \propto \frac{1}{\hat{t}} \propto \frac{1}{1 - \cos\theta}$$



$$\beta_t = \sqrt{1 - \frac{4m_t^2}{\hat{s}}}$$

$$\hat{t} = (p_q - p_t)^2$$

$$\hat{t} = m_t^2 - \frac{\hat{s}}{2}[1 - \beta_t \cos\theta]$$

  - enhanced forward x-section $(\cos\theta = \tanh \Delta y)$

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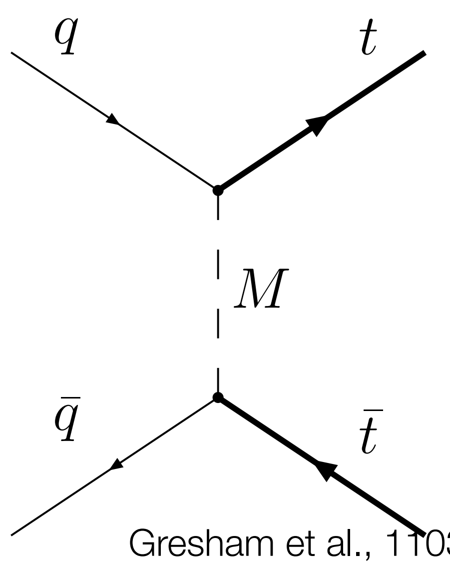
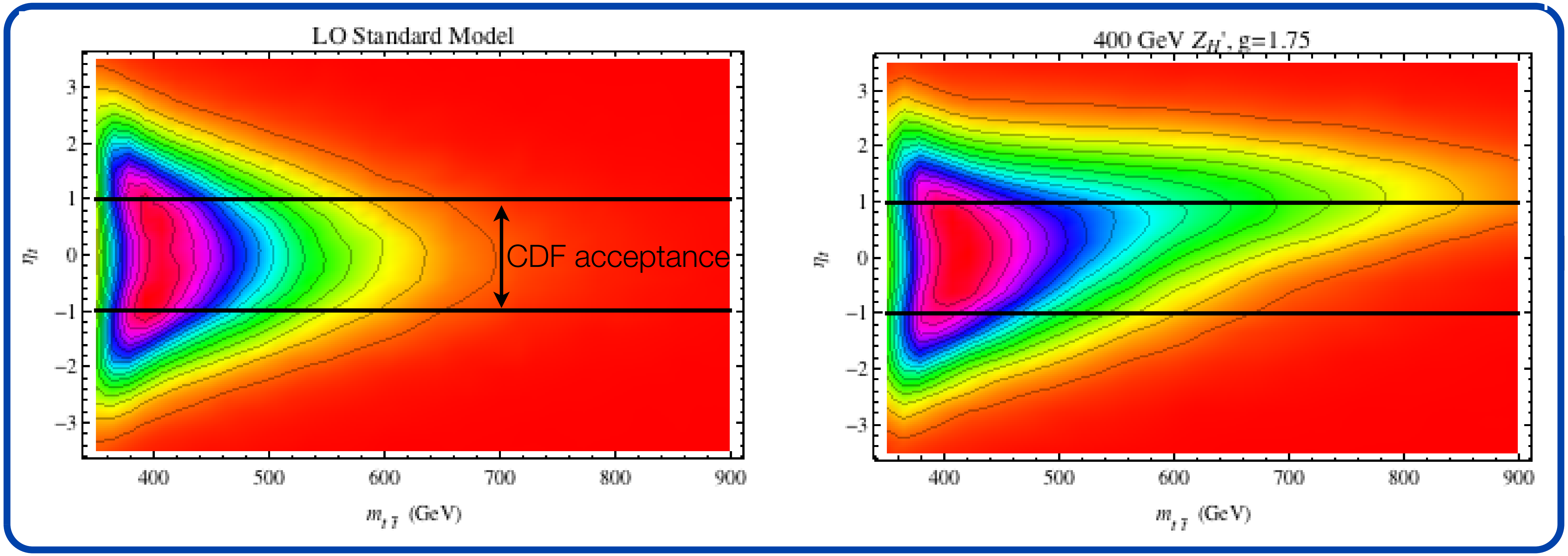
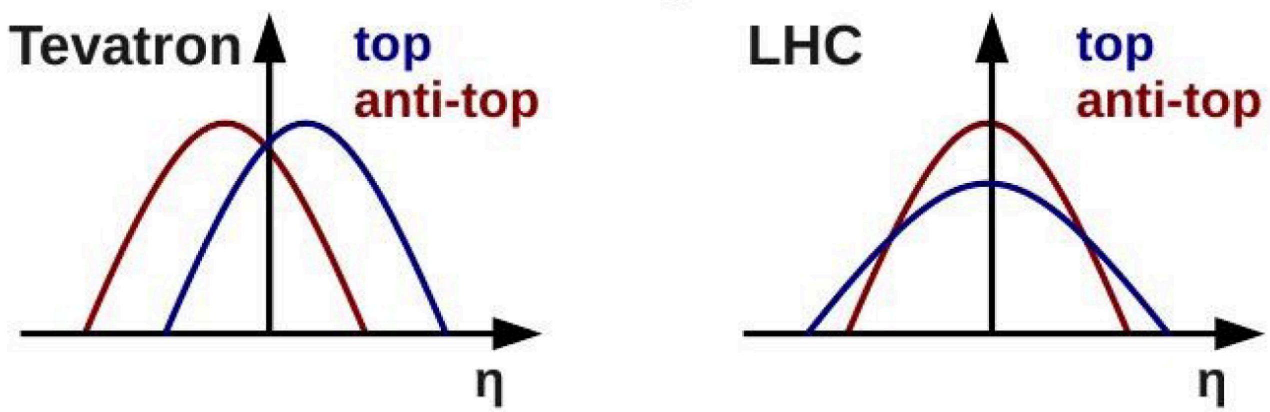


Gresham et al., 1103.3501



Cross-check of Tevatron A_{FB} measurements at LHC?

- initial state valence quarks dominate large x



Kuhn & Rodrigo, hep-ph/9802268
hep-ph/9807420

Antunano et al., 0709.1652

Hewett et al., 1103.4618

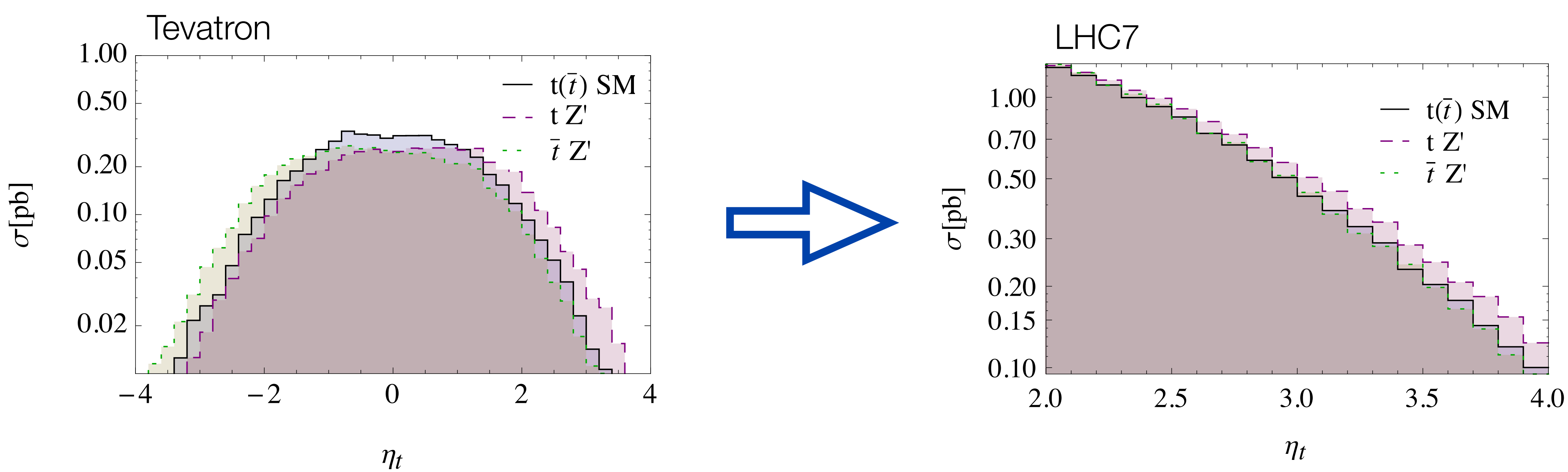
- result in rapidity dependent charge asymmetry

$$\mathcal{A}_F(y_0) = \frac{N_t(y_0 < |y| < 2.5) - N_{\bar{t}}(y_0 < |y| < 2.5)}{N_t(y_0 < |y| < 2.5) + N_{\bar{t}}(y_0 < |y| < 2.5)} \qquad \mathcal{A}_C(y_0) = \frac{N_t(|y| < y_0) - N_{\bar{t}}(|y| < y_0)}{N_t(|y| < y_0) + N_{\bar{t}}(|y| < y_0)}$$

Forward Central

Cross-check of Tevatron A_{FB} measurements at LHC?

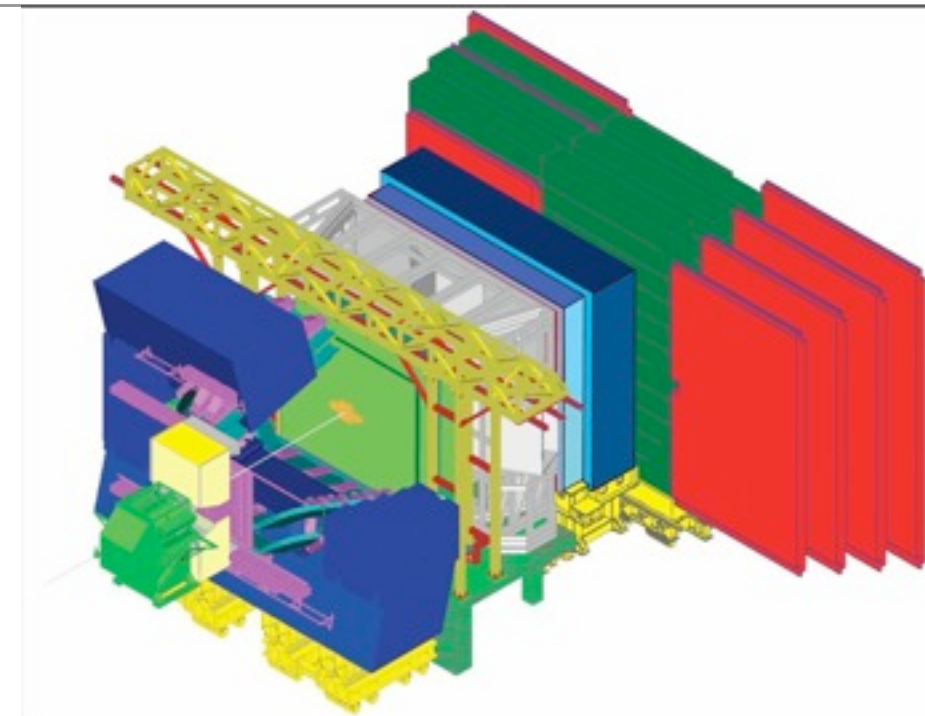
- t-channel contributions exhibit a forward scattering peak in σ
  - Effects at Tevatron and LHC correlated



  - expect sizable σ_t excess in the forward region: **top quarks at LHCb?**

LHC~~b~~ t

- Virtues/caveats of LHCb for top physics



- **High pseudorapidity coverage η<5 (4.5) for jets (muons)**
- Excellent vertexing, b-tagging capabilities
- Low calorimeter saturation energy, high punch-through rate
- Small phase-angle coverage (no E_{miss} constraints)

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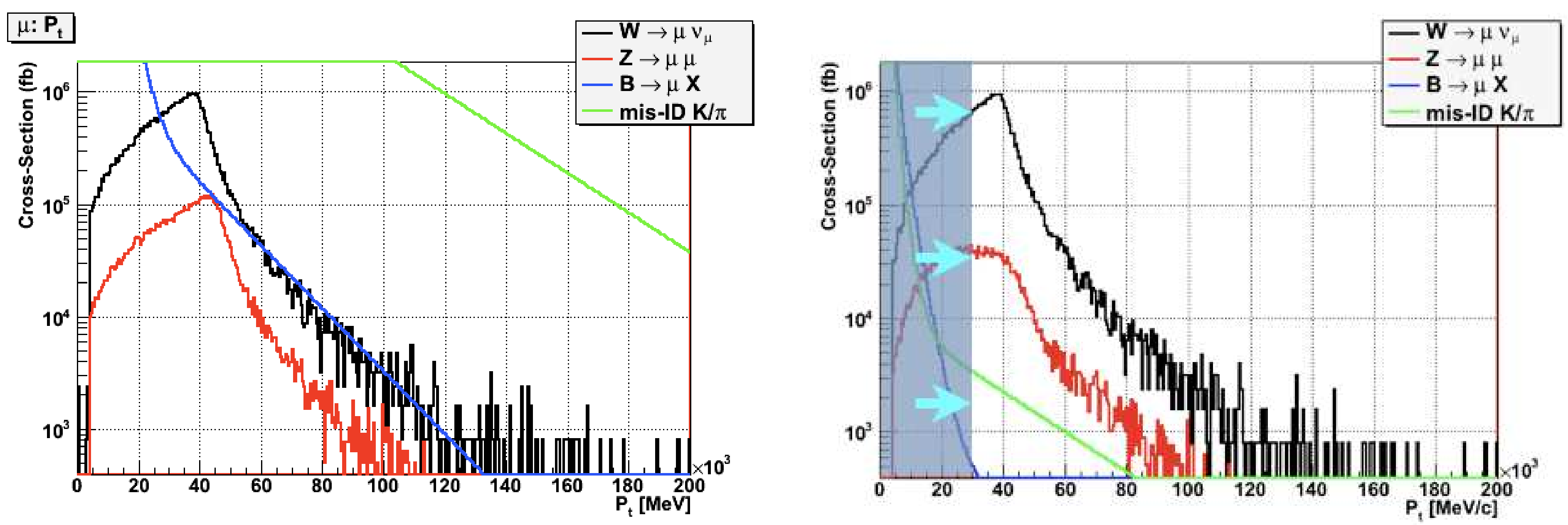
- Top quarks at LHCb identified via **single muon** and **b-tagged high-pT jet**
  $p_T^{b,\ell} > 50, 20\,\mathrm{GeV}$

  - Feasibility of high-pT track reconstruction and μ isolation demonstrated in *W/Z* studies

Keaveney [LHCb],1101.4897



(a) Before selection cuts

(b) After selection cuts

$$A_{pt} = \frac{Pt_\mu - Pt_{other\,tracks\,in\,event}}{Pt_\mu + Pt_{other\,tracks\,in\,event}}$$

$$C_{pt} = \frac{Pt_\mu - Pt_{all\,tracks\,in\,cone}}{Pt_\mu + Pt_{all\,tracks\,in\,cone}}$$

LHC~~b~~ t

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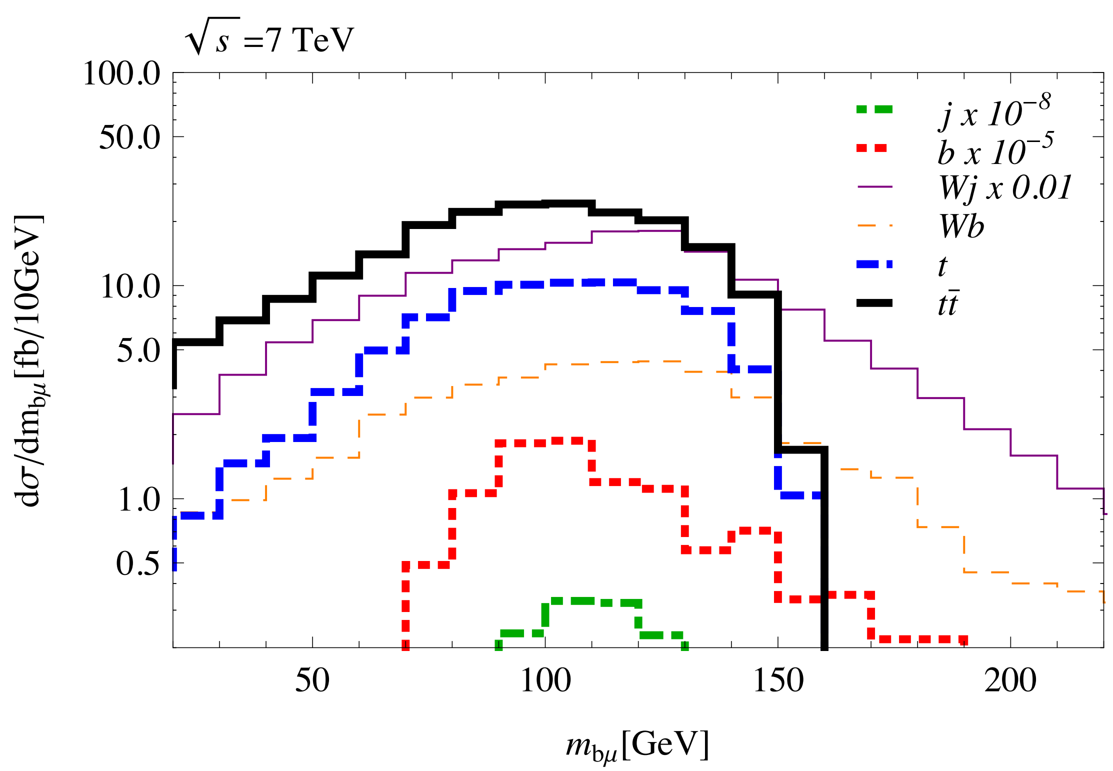
Keaveney [LHCb],1101.4897

  - Signature invariant mass distribution (*kinematic edge at $m_{b\mu}=m_t$*)



MadGraph/MadEvent 4.4.57
CTEQ6L1,

tt, t, Wj, Wb at partonic level
bb, jj Pythia & anti-kt jet recon.

LHC~~b~~ t

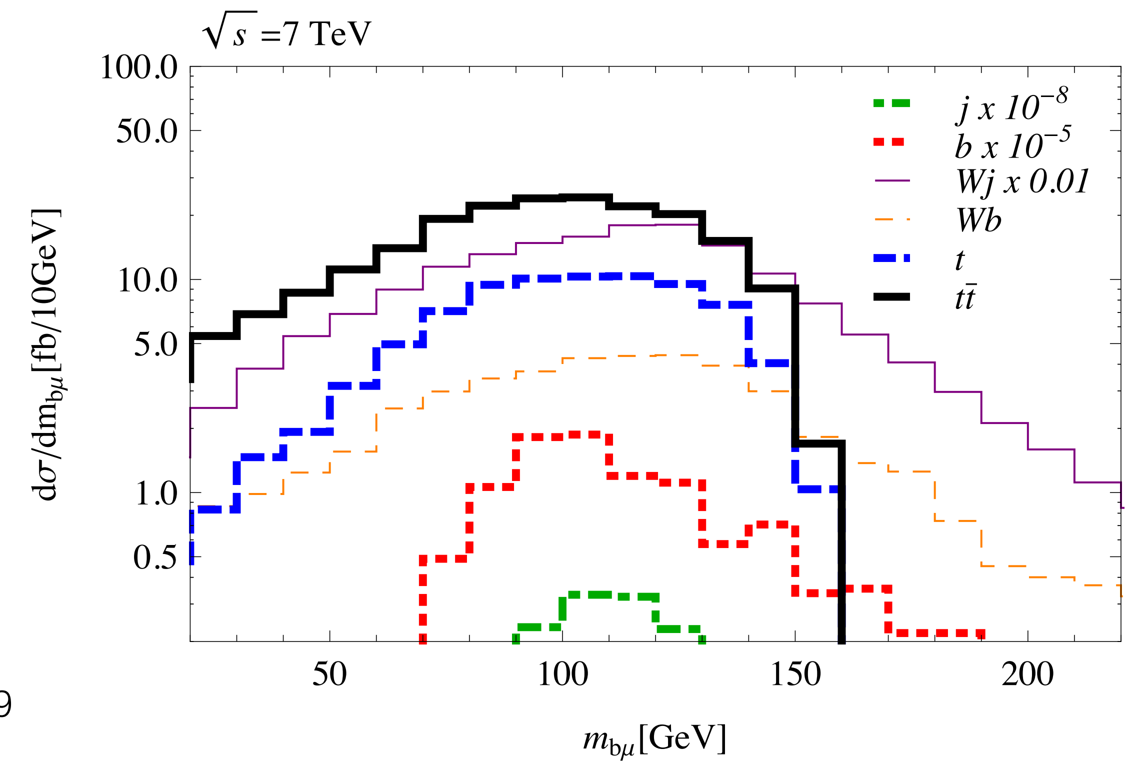
- Top quarks at LHCb identified via **single muon** and **b-tagged high-p_T jet**
  $p_T^{b,\ell} > 50, 20\,\mathrm{GeV}$

- **Backgrounds for $t\bar{t}$:**
  - *Real muons, jets: W+bb, W+jets* (+single top)
    - *j→b* mistag at 1%
    - demonstrated at ATLAS & CMS

CMS-PAS-BPH-08-004
ATLAS-CONF-2010-099

  - *Fake muons, jets: bb, jj*
    - Cal. punch-through & decay in flight
    - *j(b)*→isolated μ probability at $10^{-6(5)}$

J.S. Anderson,
CERN-THESIS-2009-020.



Estimate O(100) reconstructed events with 1 fb^{-1} (in SM)

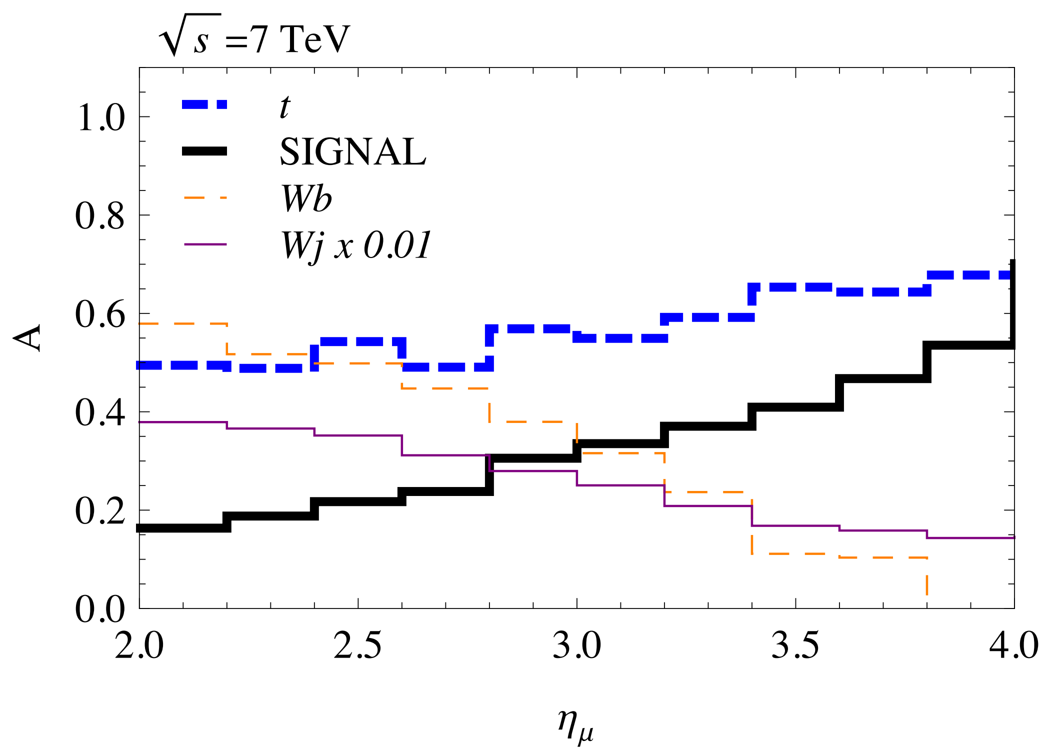
LHC~~b~~t

- Prospects for top charge asymmetry measurement

$$A_\eta^{t\bar{t}} = \left(\frac{d\sigma^t/d\eta - d\sigma^{\bar{t}}/d\eta}{d\sigma^t/d\eta + d\sigma^{\bar{t}}/d\eta} \right)$$

  - top rest-frame cannot be reconstructed

  - use μ, b pseudorapidity distributions instead



SIGNAL NP model
Jung et al., 0907.4112
reproduces measured
$A^{t\bar{t}}_{\Delta y>1}$ $\sigma^{t\bar{t}}$

LHC~~b~~ t

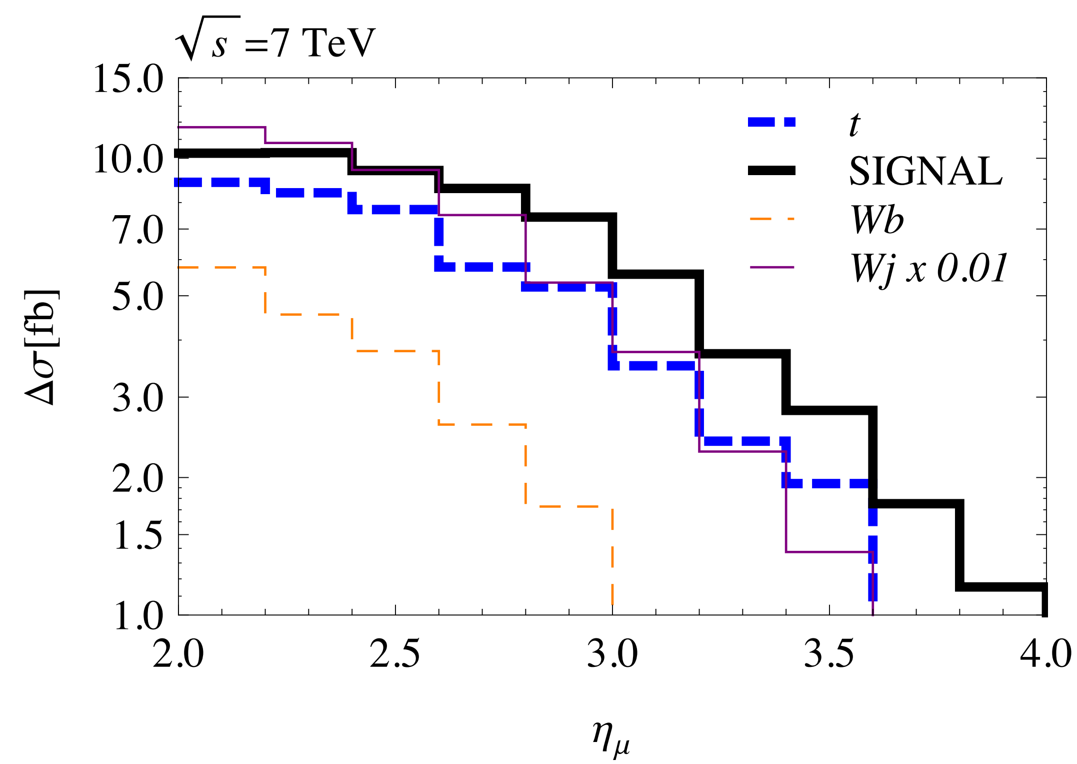
- Prospects for top charge asymmetry measurement
  - Study charged conjugated rate differences
  - Main background from *Wj*
    - could be measured directly *(knowing mistag rate)*
    - use central region data for MC calibrations

CMS-PAS-EWK-10-005

ATLAS, 1012.5382

CMS, 1103.3470

ATLAS, 1103.2929



Conclusions

- At LHC, A_{FB} manifestation as rapidity dependent charge asymmetry
  - In light t-channel models, forward region particularly enhanced
  - **Opportunities for top physics program at LHCb**
- High-p_t muon reconstruction demonstrated, b-tagging feasible
  - *use additional information (jets, etc.) in the detector to suppress backgrounds?*
- Possibilities to measure charge asymmetry in t and $\bar{t}$ rates
  - *even access to top polarization observables?*

Jung et al., 1011.5976
Cao et al. 1011.5564
Choudhury et al., 1012.4750