Top studies at LHCb

Victor Coco, on behalf of the LHCb Collaboration

CERN

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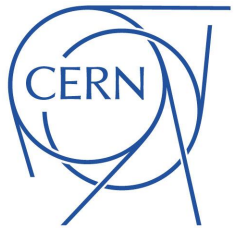


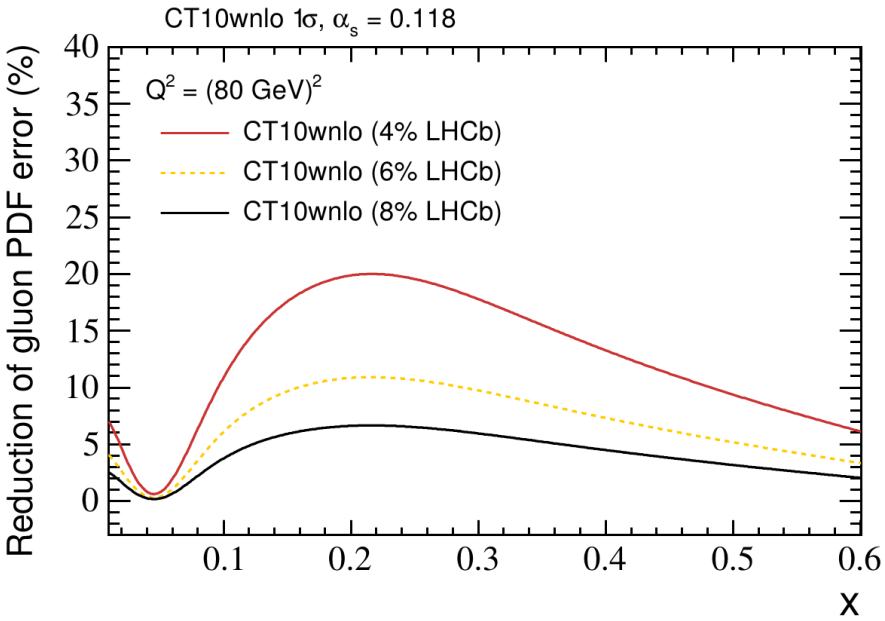
Implications of LHCb measurements and future prospects.

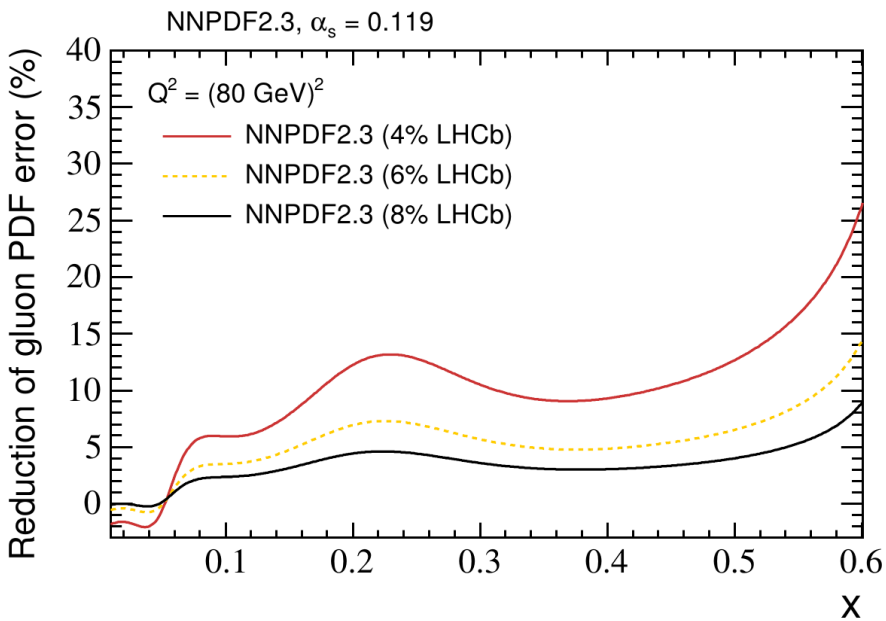
QEE WG Conveners: Katharina Mueller, Phil Ilten

contributions from R. Gauld, I. Counts, P. Ilten, M. Williams, M. Rangel, C. Potterat, O. Augusto, K. Petridis, W. Barter, A. Bursche, H. Brown, V. Salustino, ...

[JHEP(2014)126, Gauld]

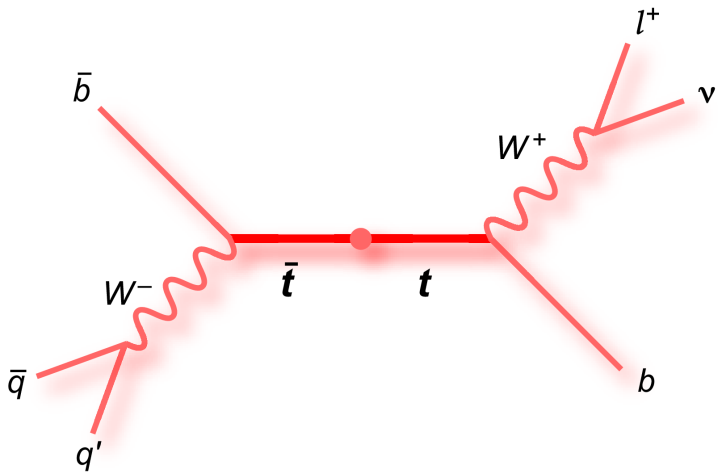
- Top production dominated by gluon initiated process.
- Top production @ LHCb involve high-x / low-x gluon.
- Large uncertainty on the high-x gluon PDFs.





Top final states in LHCb

- [PRL(2011)107, Kagan, Kamenik, Perez, Stone] ℓb final states can be used for $t\bar{t}$ asymmetry measurement.



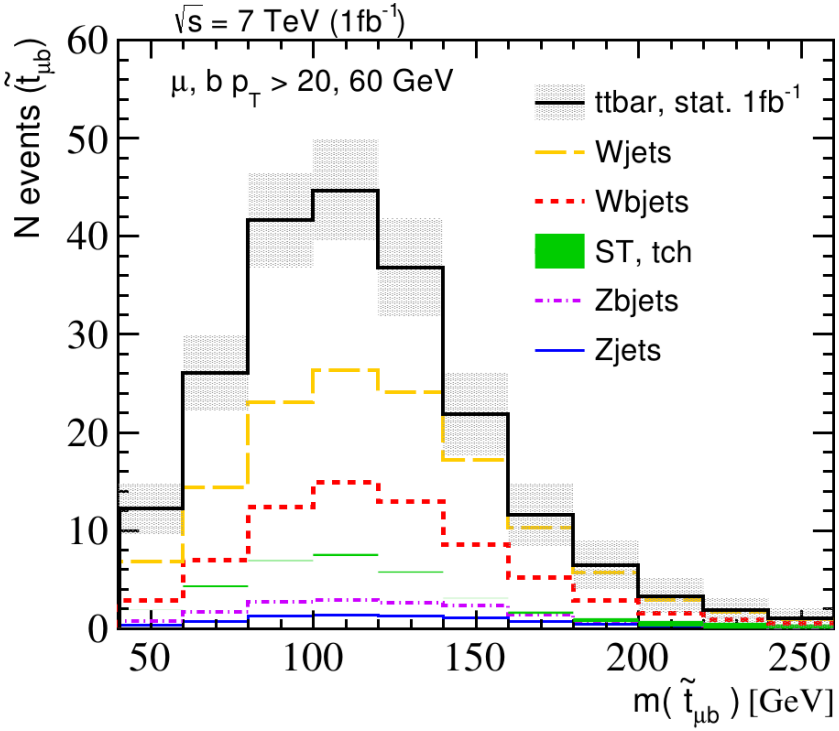
- $p_{T\ \ell} > 4\ GeV$, $p_{T\ b,j} > 20\ GeV$ and $2 < \eta_{\ell,b,j} < 4.5$, [LHCb-PUB-2013-009]:

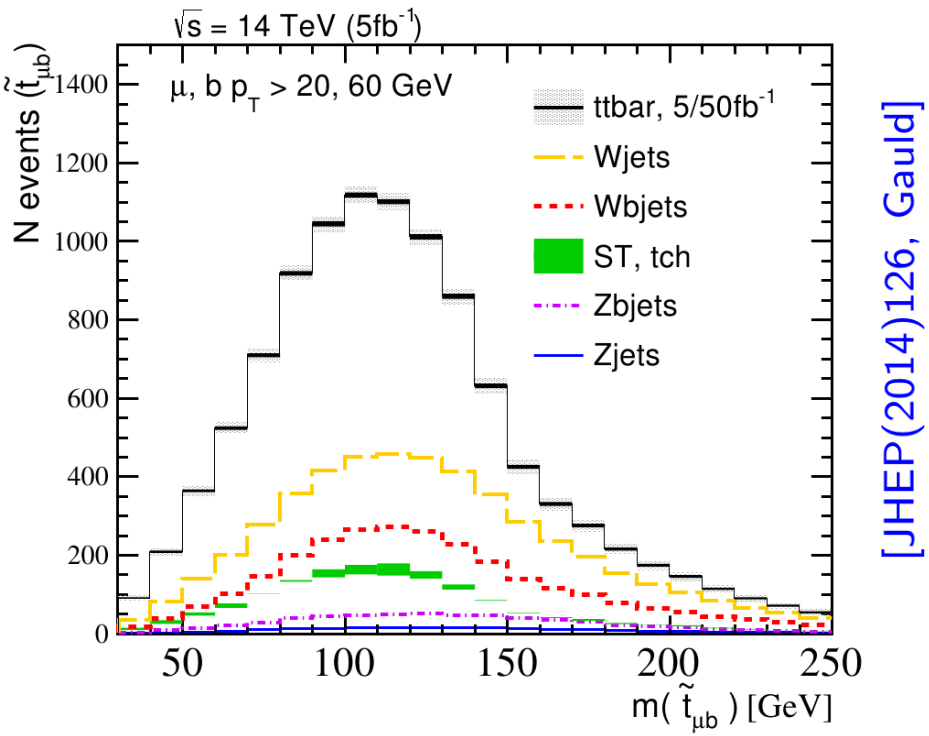
$d\sigma$(fb)	7 TeV			8 TeV			14 TeV		
lb	285	$\pm$	52	504	$\pm$	94	4366	$\pm$	663
lbj	97	$\pm$	21	198	$\pm$	35	2335	$\pm$	323
lbb	32	$\pm$	6	65	$\pm$	12	870	$\pm$	116
$lbbj$	10	$\pm$	2	26	$\pm$	4	487	$\pm$	76
l^+l^-	44	$\pm$	9	79	$\pm$	15	635	$\pm$	109
l^+l^-b	19	$\pm$	4	39	$\pm$	8	417	$\pm$	79

- ℓb and ℓbj more suited for Run I measurement.

Backgrounds in μb final state

- Assuming $\epsilon_{b-tag} \sim 70\%$, $\tau_{(c+\ell)\to b} \sim O(1\%)$, and $2 < \eta_{\mu,b} < 4.5$.
- $p_{T\ \mu} > 20\ GeV$, $p_{T\ b} > 60\ GeV$ to reduce the background.





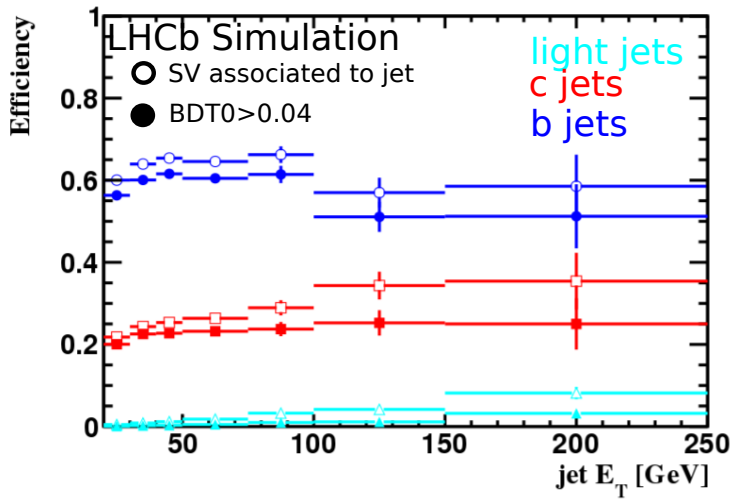
[JHEP(2014)126, Gauld]

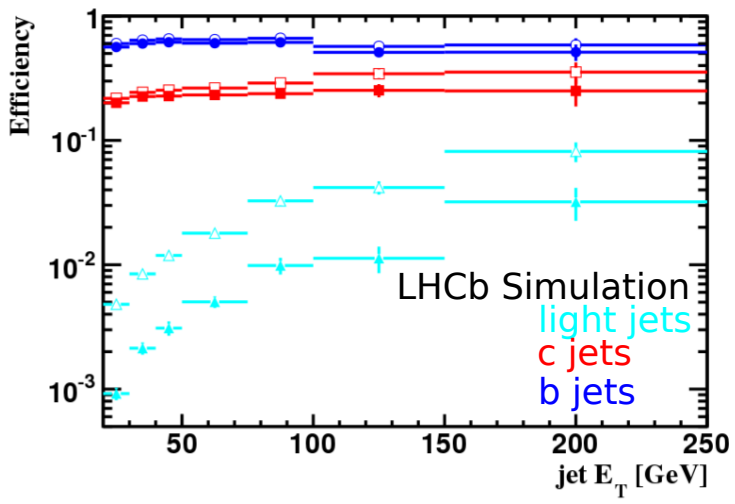
- $t\bar{t}$ and single-t considered together for Run I measurement.
- $b\bar{b}$ not considered here but need a careful treatment.

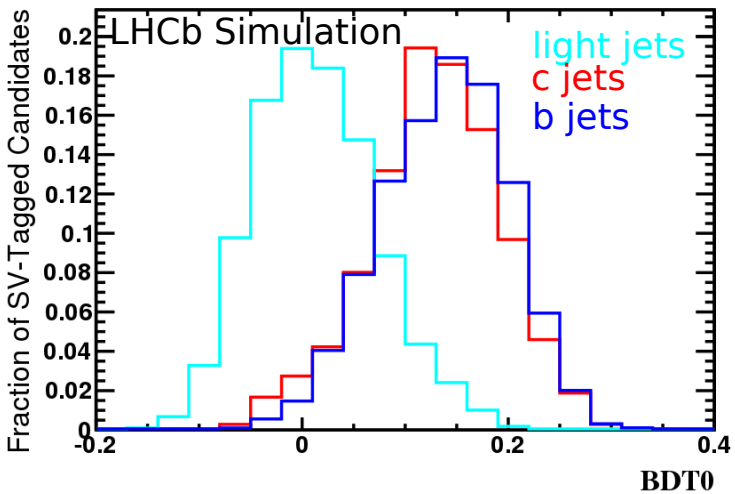
b-tagging

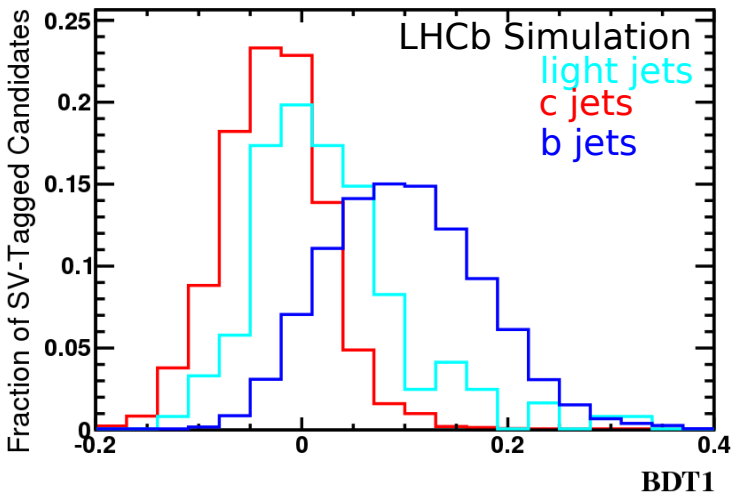
New development

- SV / jet matching in $A_C^{b\bar{b}}$ PRL 113 (2014) 082003 and Z+b-jet PAPER-2014-055.
- Since then improvement made on the inclusive SV reconstruction.
- SV based and jet based variables are inputs of 2 BDTs (ℓ vs. b, c and c vs. b):









Backgrounds to ℓb final state

Heavy flavour di-jet and V+jets

- Large background from heavy flavour di-jet production.
- high $p_{T\mu}$ ($> 20 - 30$ GeV) and prompt μ keeps the rate low.
- Isolation variable defined as $p_{T\mu}/p_{T\mu jet}$:

  Further reduce it and control the contamination in the signal region.

- Z+jet measured in JHEP01 (2014) 033 and Z+b-jet in PAPER-2014-055
- $W + (b, c, \ell)$jets production ratios measurement in review.
- Main discrimination wrt. V+jets from $p_{Tb} > 40 - 60$ GeV.
- Extra discrimination from $p_{T\mu b}$

  $\rightarrow$ Used in $W + (b, c, \ell)$jets analysis to estimate top pollution.
- An extra jet with $p_T > 20$ GeV in $\sim 50\%$ of $t\bar{t}$ events and $\sim 10\%$ of W+jets events.

Conclusion

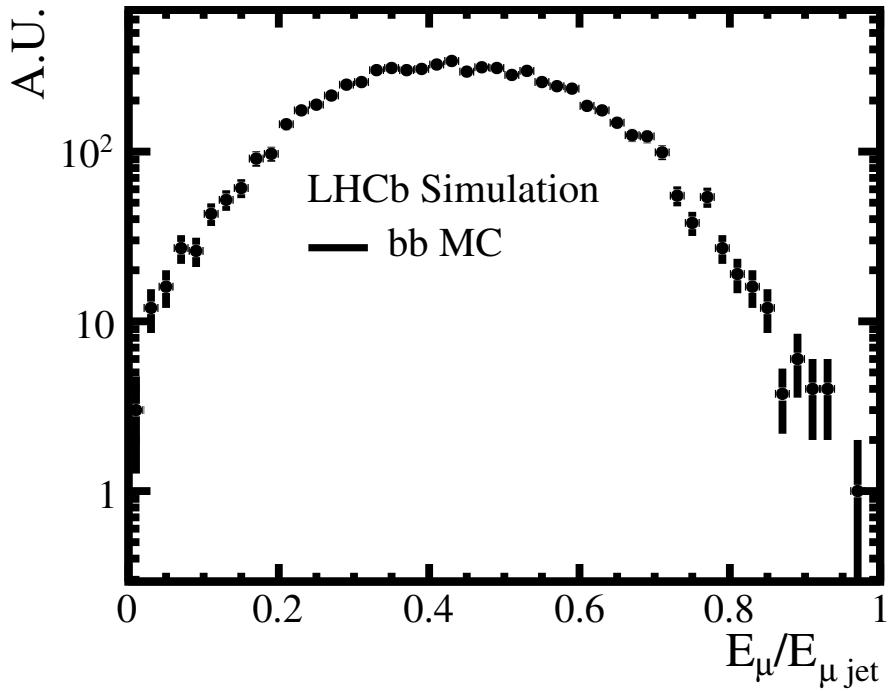
- All the experimental tool now in place (jet reconstruction, b-tagging).
- Main backgrounds have been measured.
- A lot in common with the W+(b,c,ℓ)jets production ratio measurement.
- Now optimising the selection for forward top production observation and cross section measurement.
- Should think to what would be the more interesting for Run2:
  - Differential cross section
  - single top vs. $t\bar{t}$
  - b jets property in top decay
  - Asymmetry

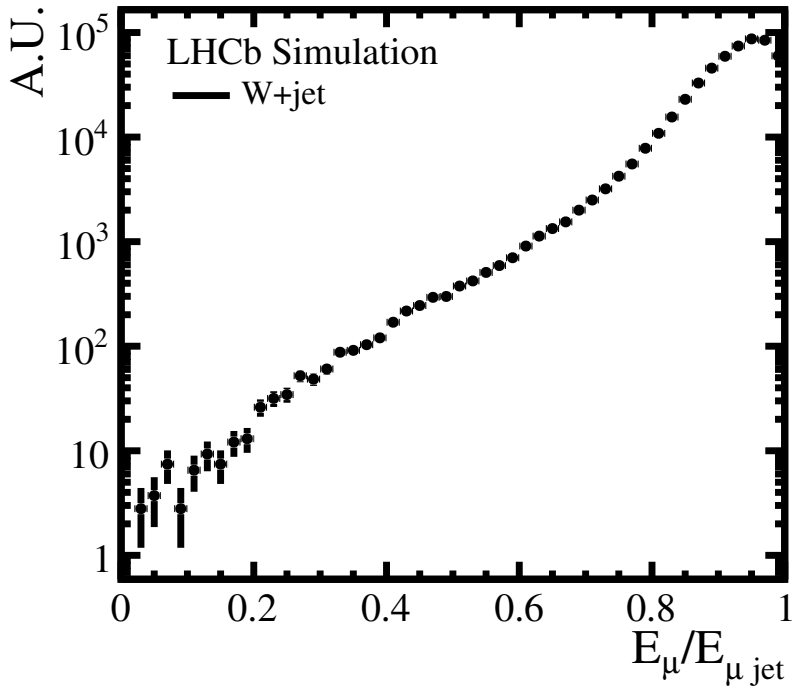
BACKUP

Backgrounds to ℓb final state

Heavy flavour di-jet

- Large background from heavy flavour QCD production.
- high $p_{T\mu}$, p_{Tb} and prompt μ keeps the rate low.
- Isolation of the μ defined as $p_{T\mu}/p_{T\mu jet}$.
- Control sample from $Z \to \mu\mu$ and displaced μ.
- Proof of principle in $W + (b, c, \ell) - jets$ analysis.



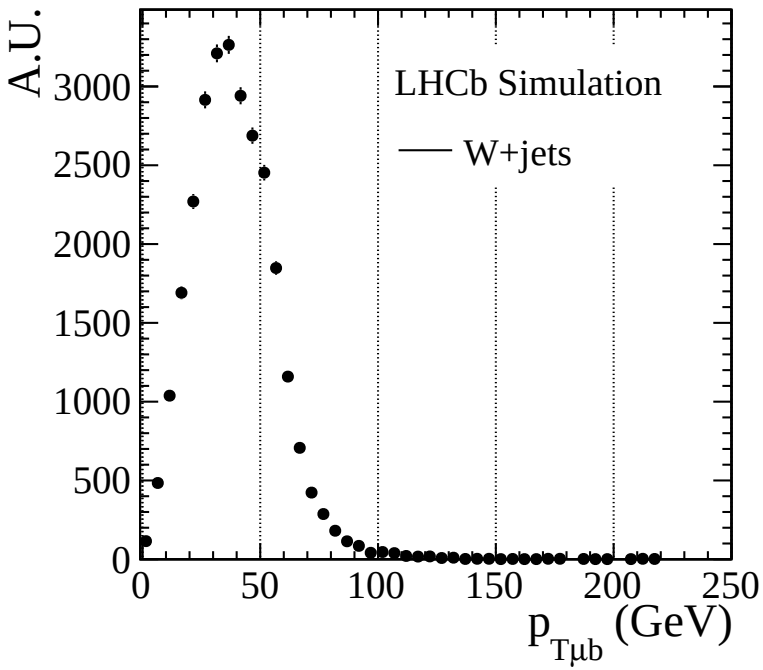


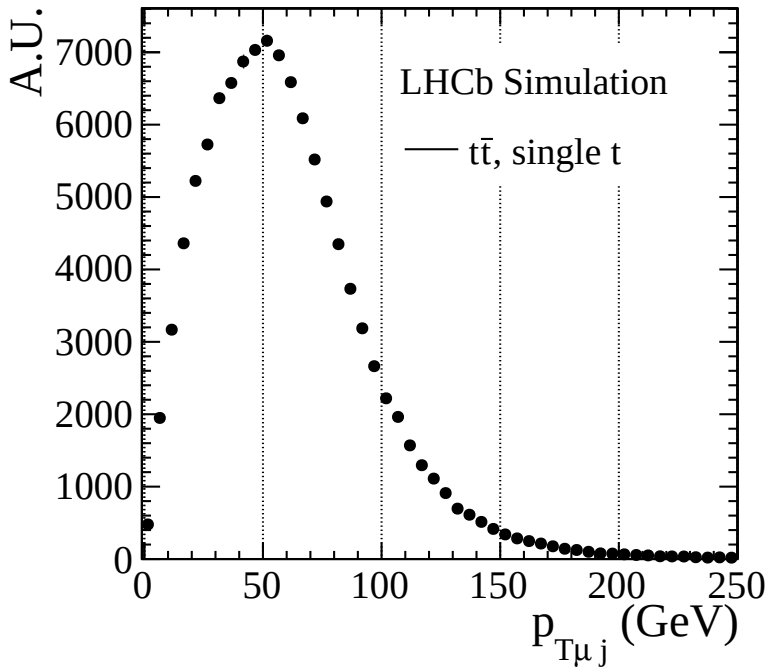
Backgrounds to ℓb final state

V+jets

- Z background can constrained from the case where the Z is fully reconstructed.
- Z+jet measured in JHEP01 (2014) 033 and Z+b-jet in PAPER-2014-055
- $W + (b, c, \ell)$jets production ratios measurement in review.
- Main discrimination wrt. V+jets from $p_{Tb} > 40 - 60\ GeV$.
- Extra discrimination from $p_{T\mu b}$

  $\rightarrow$ Used in $W + (b, c, \ell)$jets analysis to estimate top pollution.





- An extra jet with $p_T > 20\ GeV$ in $\sim 50\%$ of $t\bar{t}$ events and $\sim 10\%$ of W+jets events).

b-tagging

In $A_C^{b\bar{b}}$ and Z+b-jets

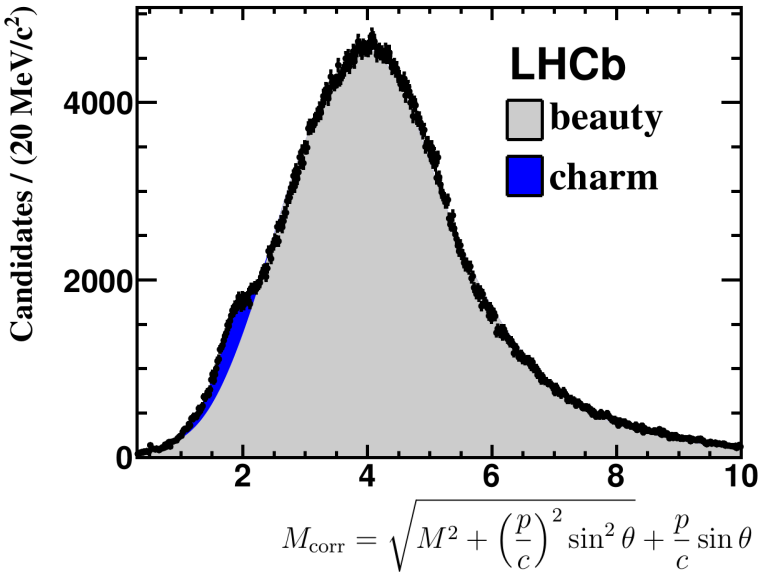
Based on SV made of 2, 3 or 4 displaced tracks matched with a jet.

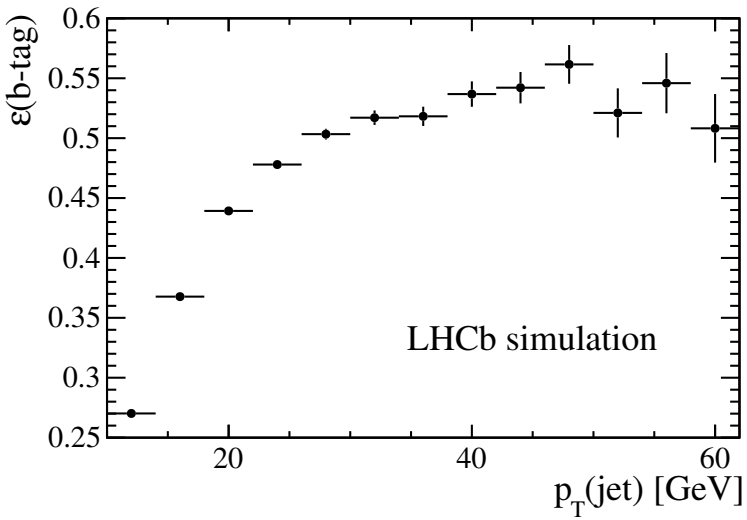
$A_C^{b\bar{b}}$ PRL 113 (2014) 082003:

- Trigger on a displaced μ
- $\epsilon_{b-tag} \sim 60\%$ for the b-jet with μ.
- $\epsilon_{b-tag} \sim 50\%$ for the other b-jet.
- non-$b\bar{b}$ contamination in final sample $3.6 \pm 1.2\%$

Z+b-jet cross section, PAPER-2014-055:

- Trigger on the Z
- ℓ, c-jet contribution from template fit to M_{corr}



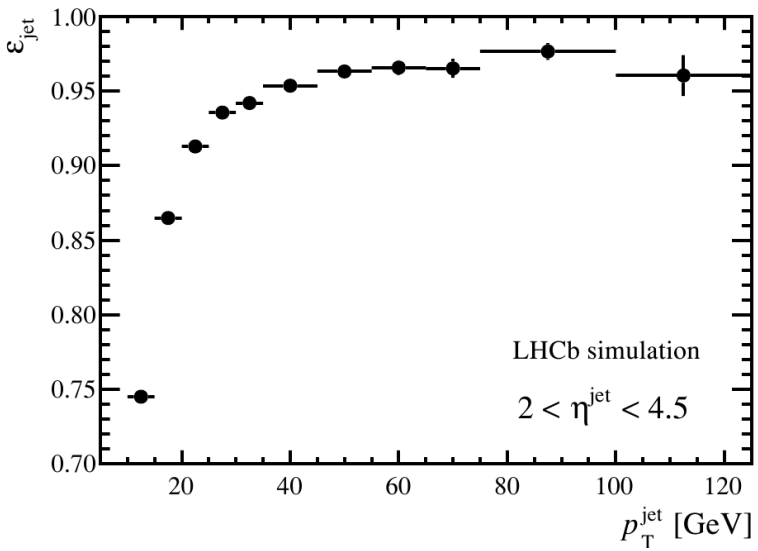


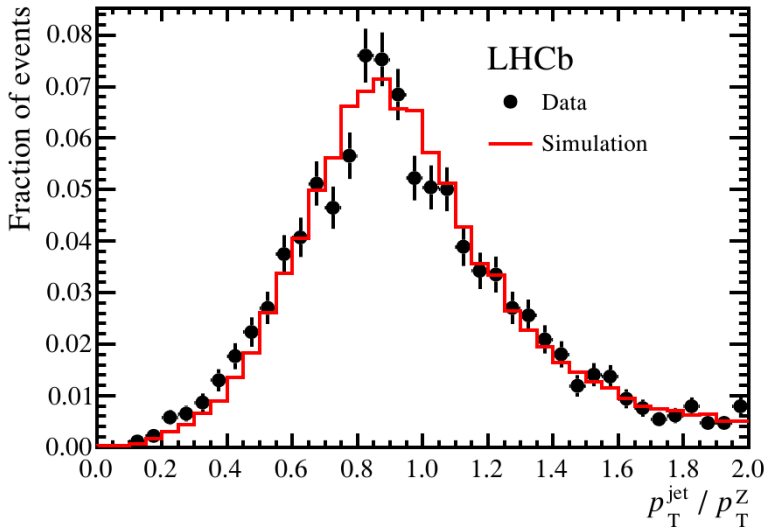
Inclusive Z production

- In pp collisions at $\sqrt{s} = 7\ TeV$, LHCb-CONF-2013-007
- In pA collisions at $\sqrt{s_{NN}} = 5\ TeV$,arXiv:1406.2885

First measurement with jets at LHCb, JHEP01 (2014) 033

- Fiducial volume of the measurement:
  - $2 < \eta_{jet} < 4.5$, $p_{T\ jet} > 10(20)\ GeV$
  - $60 < m_{\mu\mu} < 120\ GeV$, η_μ, $p_{T\ \mu}$.
  - $\Delta R(\mu, jet) > 0.4$
- Jet reconstruction:
  - Anti-k_T with R=0.5.
  - Inputs from particle flow algorithm.
  - Jet energy correction determined from MC (range from 0.9 - 1.1)
  - Validated on data, JES data vs. MC within 3%.
- Dominant uncertainties of the measurement
  - Jet energy scale, resolution
  - Jet reconstruction efficiency
  - Work on-going to improve these points.

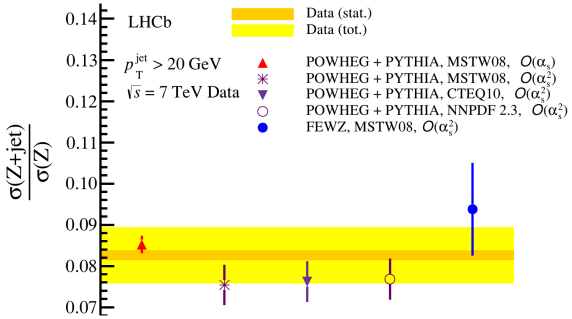


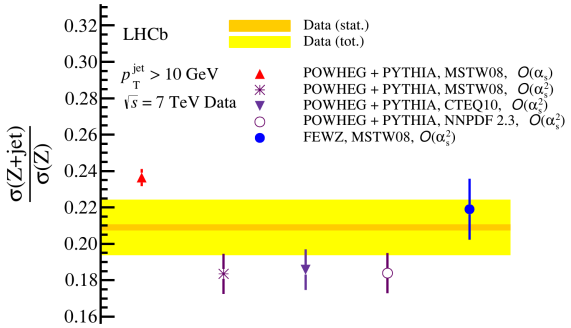


Z+jet production in pp at $\sqrt{s} = 7\ TeV$

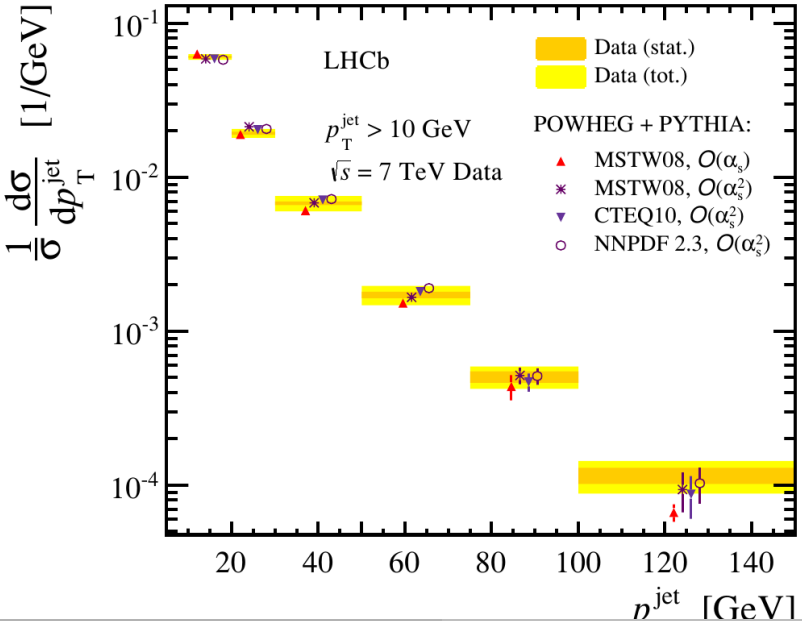
Result

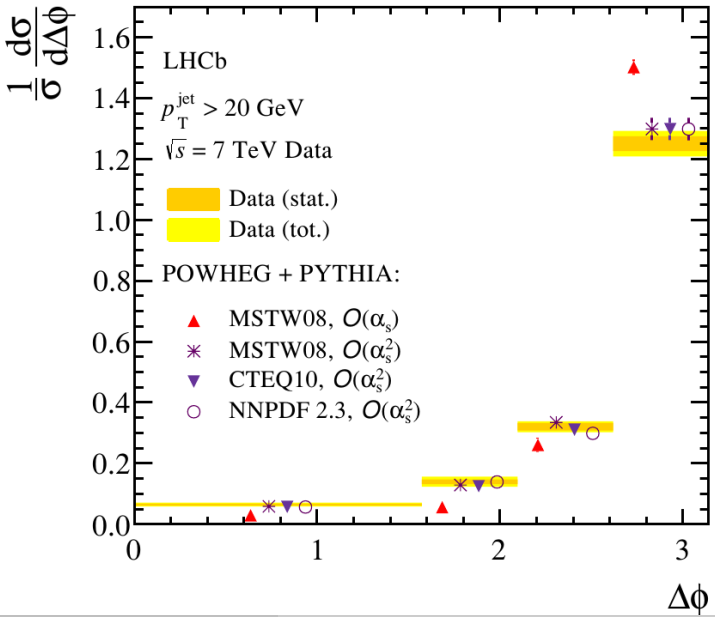
- Predictions from POWHEG+PYTHIA at $O(\alpha_s)$ and $O(\alpha_s^2)$ with different PDF sets.
- Predictions from FEWZ at $O(\alpha_s^2)$ not corrected for hadronisation and underlying event.





- Not corrected for FSR
- Shapes in good agreement with NLO





Central forward $b\bar{b}$ asymmetry $A_{FC}^{b\bar{b}}$

Motivation

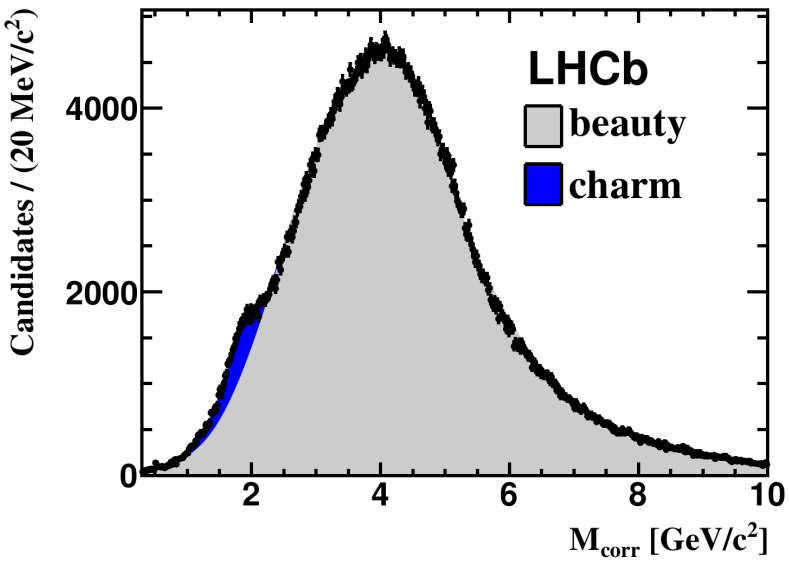
- Depending on new physics flavour structure, asymmetry could shows up in the bottom sector.

[arXiv:1108.3301,Kahawala et al.]

- At LHC access to the forward central asymmetry.
- Expected to be $O(1\%)$ from QCD with an extra $O(1\%)$ in the Z mass region.

PRL 113 (2014) 082003

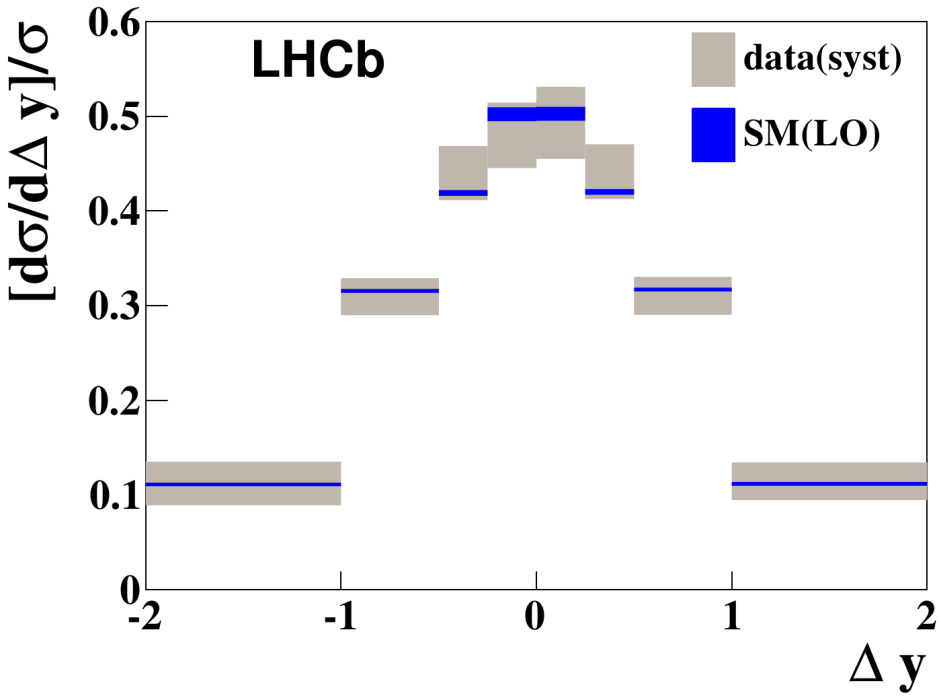
- Analysis performed with 1 fb^{-1}
- Pairs of b-jets with $\Delta\phi(bb) > 2.6$ rad.
- One of the b-jets charge is tagged with a muon.
- Purity of the charge tagging $70.3 \pm 0.3\%$



Central forward $b\bar{b}$ asymmetry $A_{FC}^{b\bar{b}}$

Result with 1 fb^{-1}

PRL 113 (2014) 082003



$A_{FC}^{b\bar{b}} = \frac{N(\Delta y>0)-N(\Delta y<0)}{N(\Delta y>0)+N(\Delta y<0)}$,
$\Delta y = |y_b| - |y_{\bar{b}}|$
In different m_{bb} bins:

- $A_{FC}^{b\bar{b}}(40, 75) = 0.4 \pm 0.4 \pm 0.3$ %
- $A_{FC}^{b\bar{b}}(75, 105) = 2.0 \pm 0.9 \pm 0.6$ %
- $A_{FC}^{b\bar{b}}(> 105) = 1.6 \pm 1.7 \pm 0.6$ %

- No deviation from expectation with available statistics.
- Still 2 fb^{-1} of the Run I data to be analysed.
- More efficient b-tagging available now.

Gluon PDF error reduction