Heavy Flavor Production at LHCb

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on behalf of the LHCb Collaboration

Massachusetts Institute of Technology

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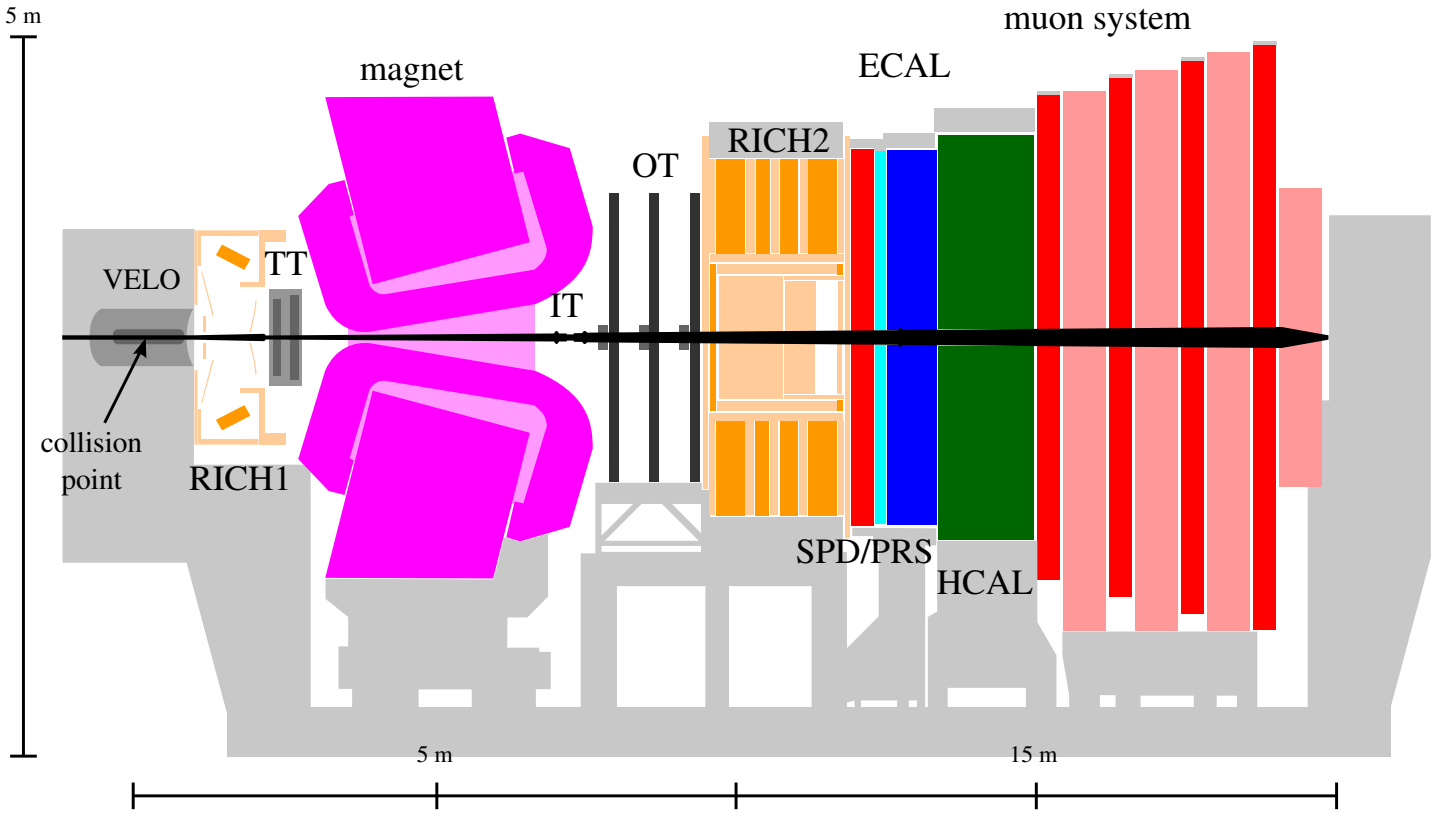
DPF 2017

Detector

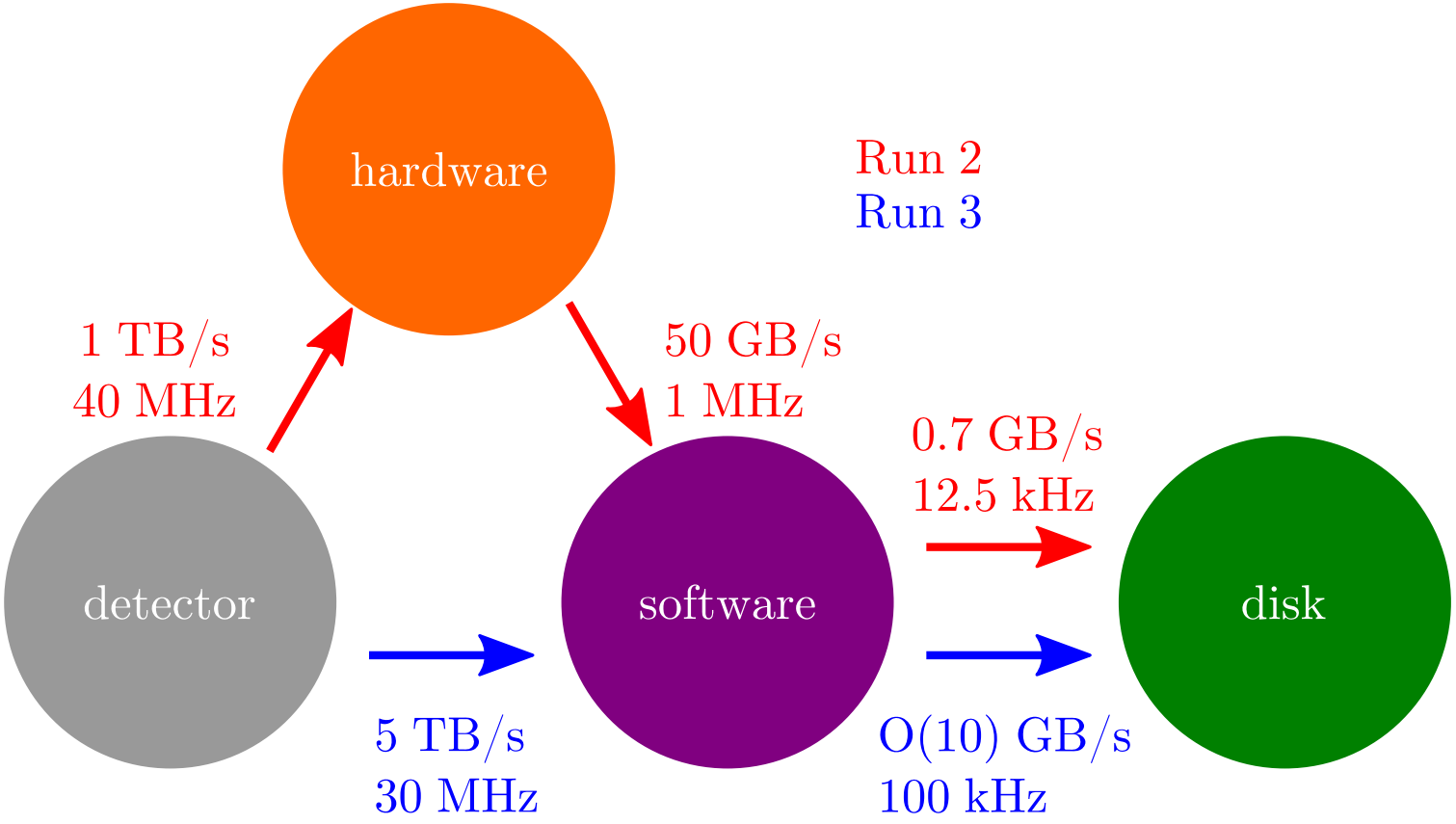
LHCb, IJMPA **30** (2015)



- fully instrumented between $2 < \eta < 5$
- momentum resolution between 0.5% at 5 GeV to 1% at 200 GeV
- impact parameter resolution of $13 - 20$ μm for tracks
- secondary vertex precision of $0.01 - 0.05(0.1 - 0.3)$ mm in $xy(z)$

Trigger

LHCb, JINST 8 (2013) P04022

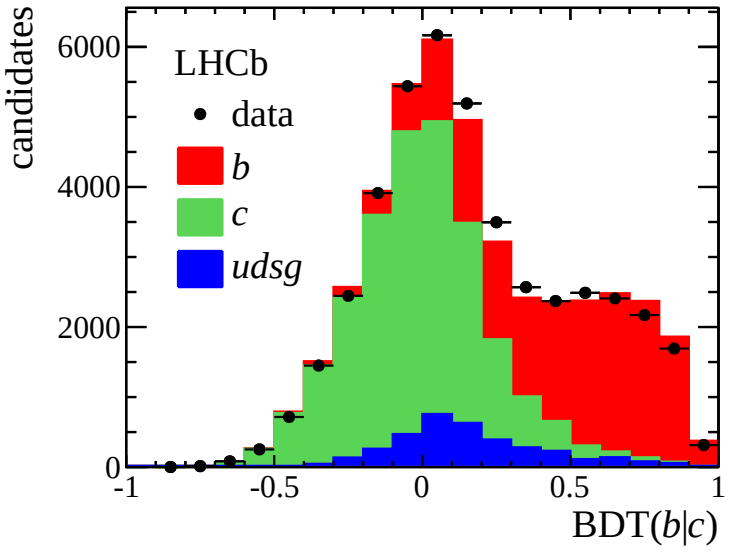


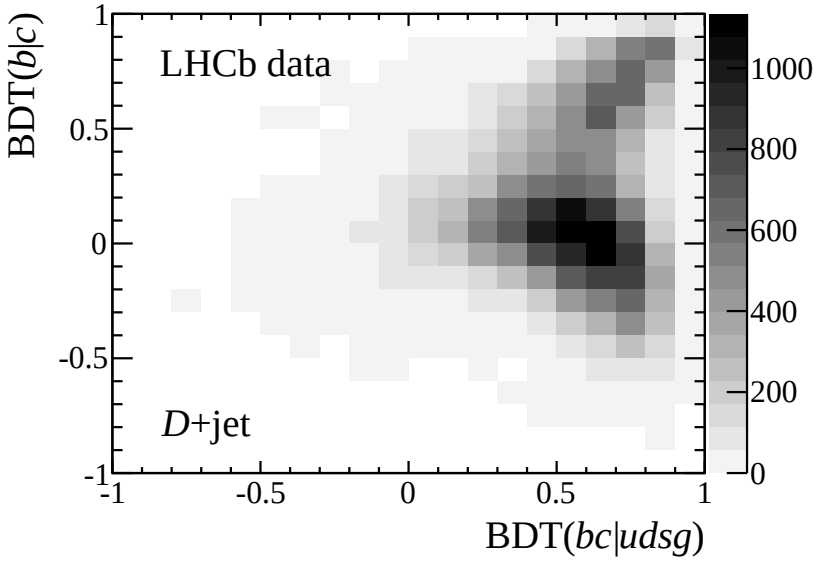
- real-time calibration and full event reconstruction in Run 2
- inclusive dimuon from threshold and jet triggers in Run 2
- full detector readout in Run 3

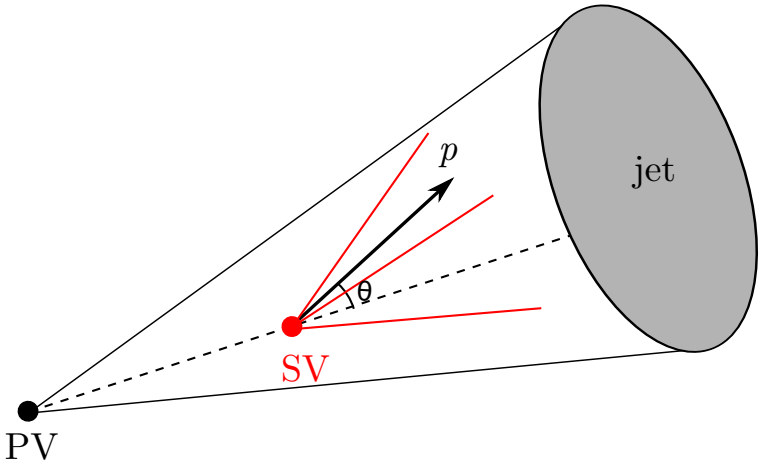
Heavy Flavor Jets

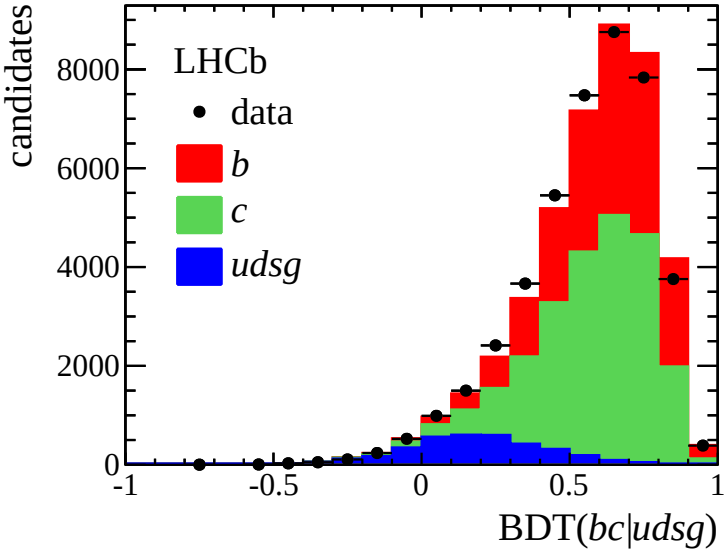
Heavy Flavor Tagging

LHCb, JINST **10** (2015)

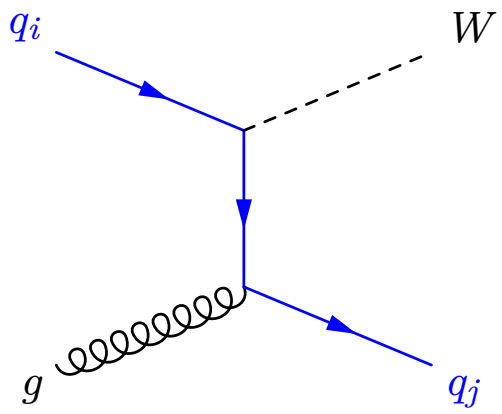




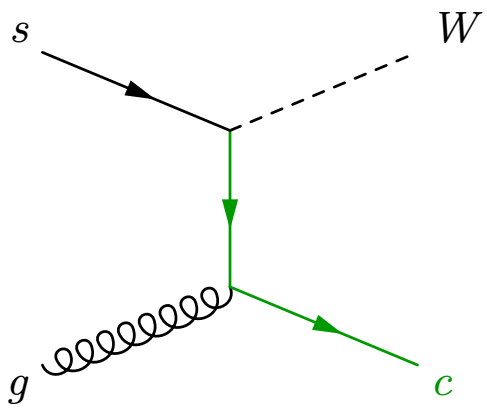




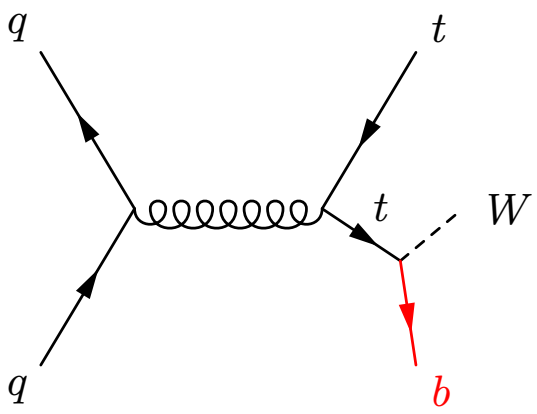
Heavy Flavor with Leptons



$W + udsg$-jet



$W + c$-jet

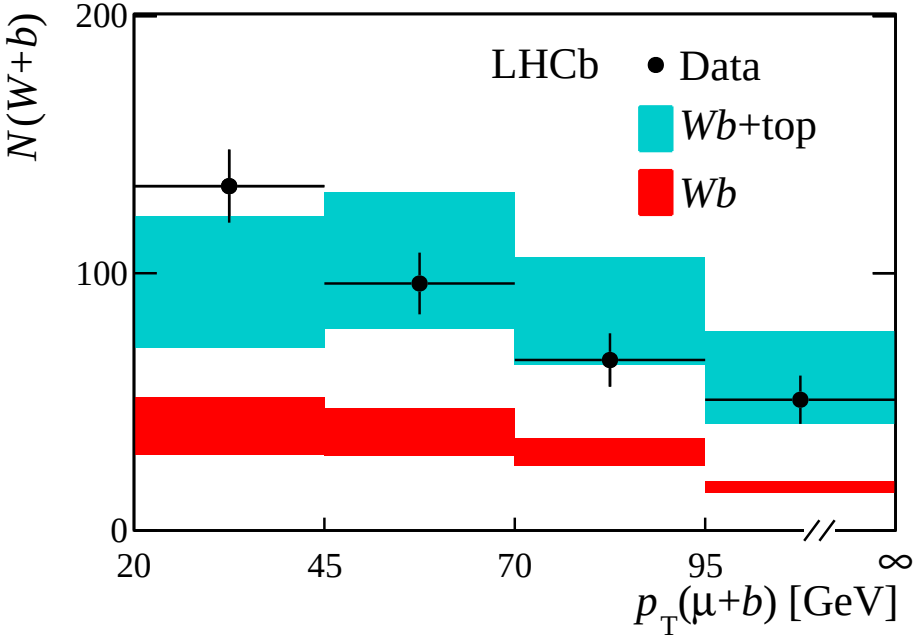


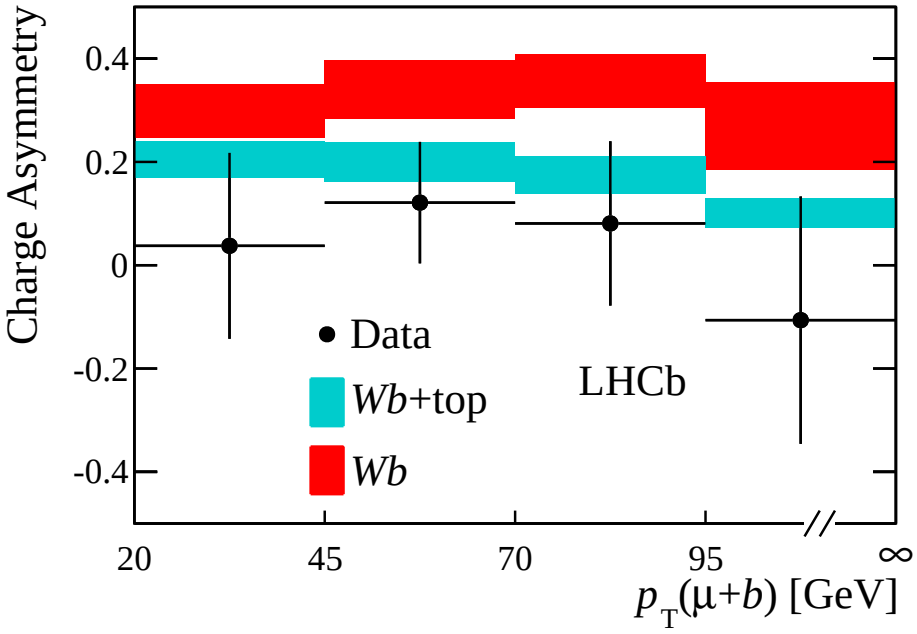
top

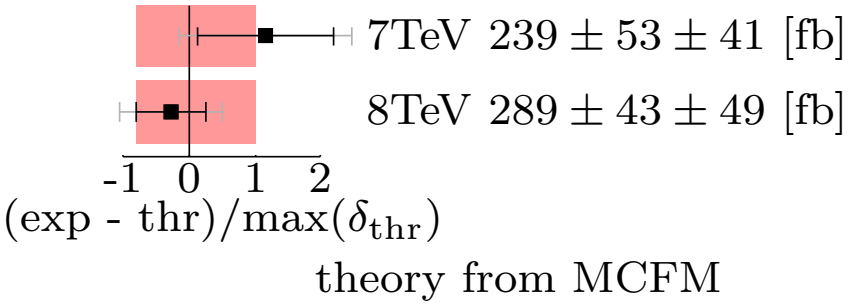
- LHCb, JINST **10** (2015): validation of performance
- LHCb, PRD **92** (2015): $W + c$ and $W + b$ measurement
- LHCb, PRL **115** (2015): first forward top measurement
- LHCb, PLB **767** (2017): $t\bar{t}$, $W + c\bar{c}$, and $W + b\bar{b}$

Top Results

LHCb, PRL **115** (2015)

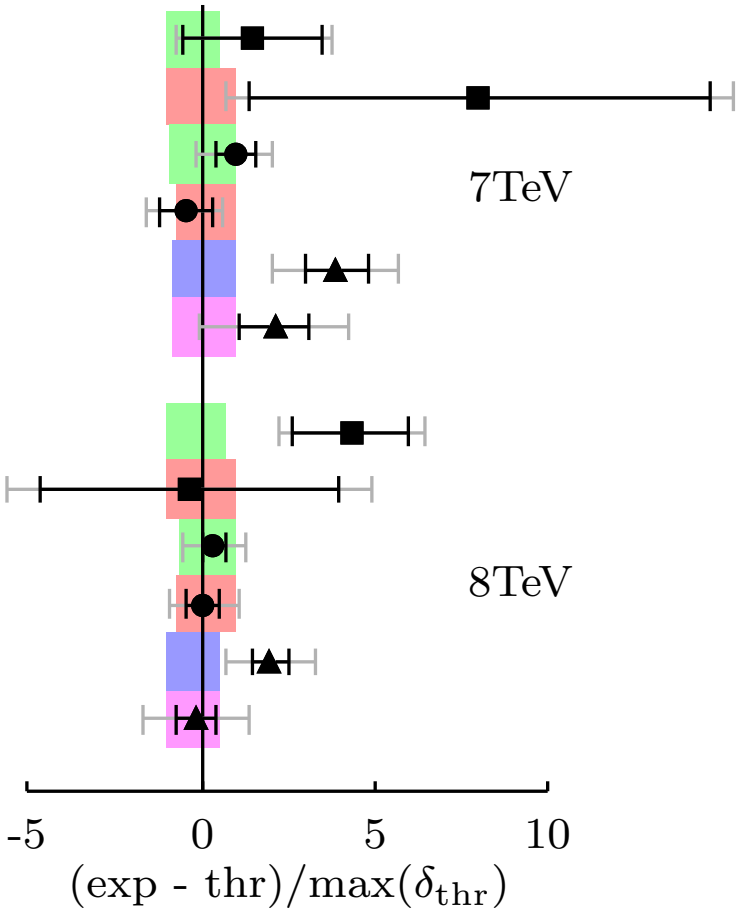






W+jet Results

LHCb, PRD **92** (2015)

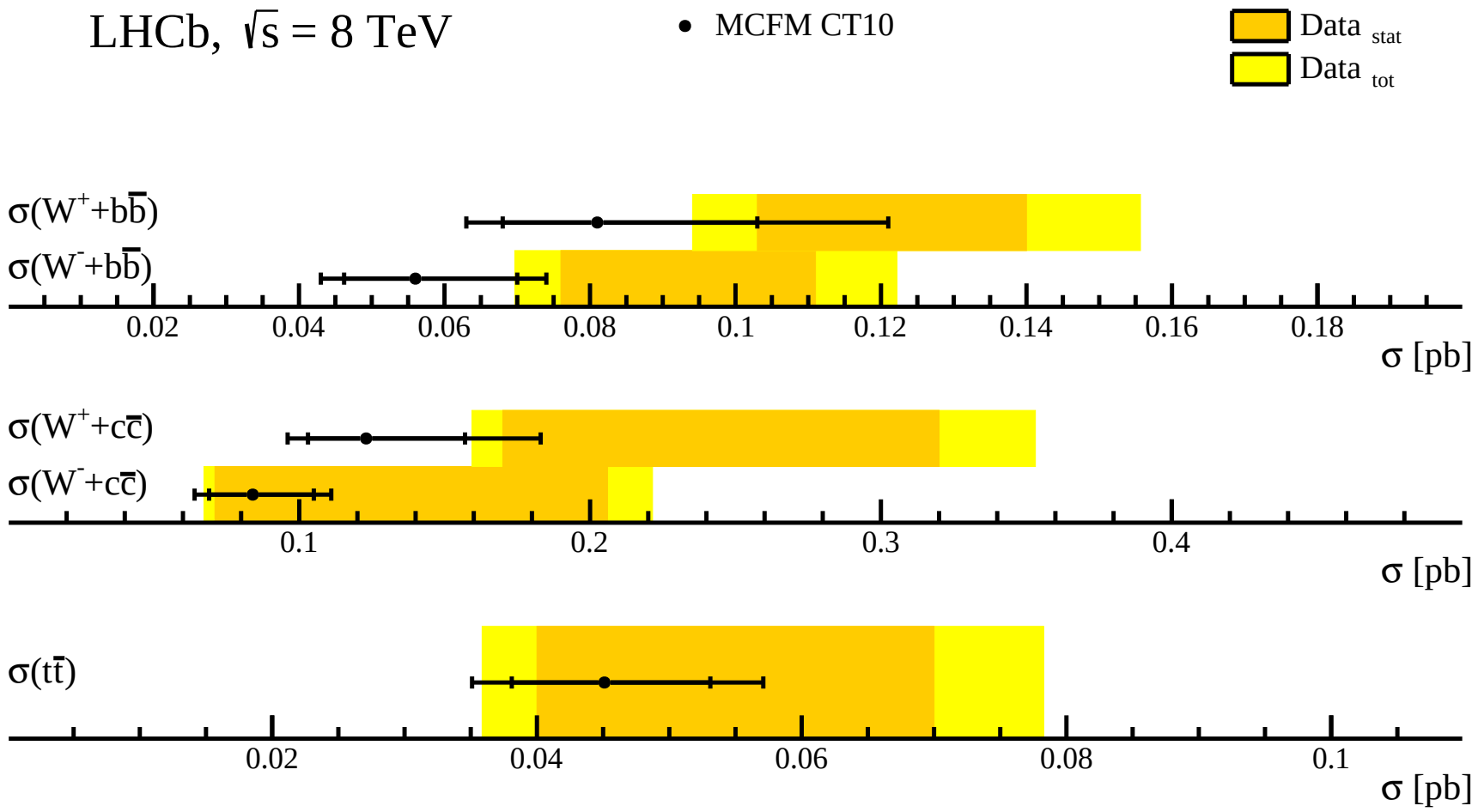


$-0.09 \pm 0.08 \pm 0.04$	$\mathcal{A}(Wc)$
$0.51 \pm 0.20 \pm 0.09$	$\mathcal{A}(Wb)$
$5.80 \pm 0.44 \pm 0.75$	$\sigma(Wc)/\sigma(Wj) \times 10^2$
$0.66 \pm 0.13 \pm 0.13$	$\sigma(Wb)/\sigma(Wj) \times 10^2$
$6.61 \pm 0.19 \pm 0.33$	$\sigma(W^-j)/\sigma(Zj)$
$10.49 \pm 0.28 \pm 0.53$	$\sigma(W^+j)/\sigma(Zj)$
$-0.01 \pm 0.05 \pm 0.04$	$\mathcal{A}(Wc)$
$0.27 \pm 0.13 \pm 0.09$	$\mathcal{A}(Wb)$
$5.62 \pm 0.28 \pm 0.73$	$\sigma(Wc)/\sigma(Wj) \times 10^2$
$0.78 \pm 0.08 \pm 0.16$	$\sigma(Wb)/\sigma(Wj) \times 10^2$
$6.02 \pm 0.13 \pm 0.30$	$\sigma(W^-j)/\sigma(Zj)$
$9.44 \pm 0.19 \pm 0.47$	$\sigma(W^+j)/\sigma(Zj)$

theory from MCFM

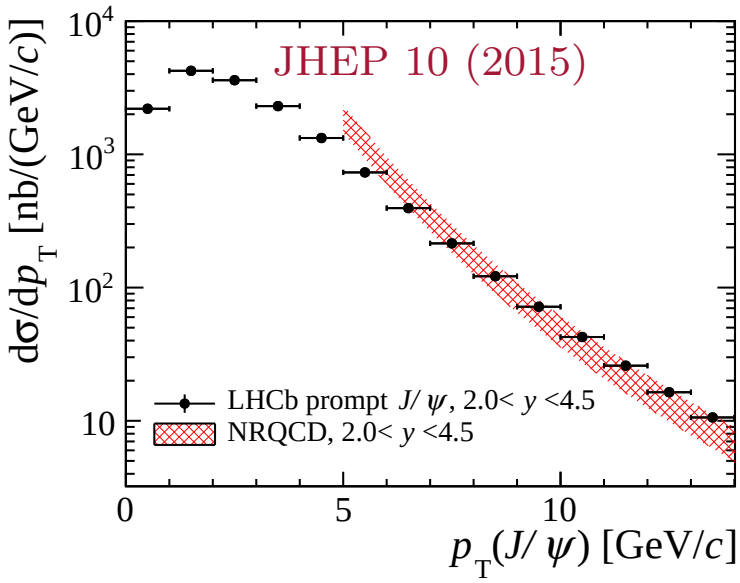
$W + Q\bar{Q}$ Results

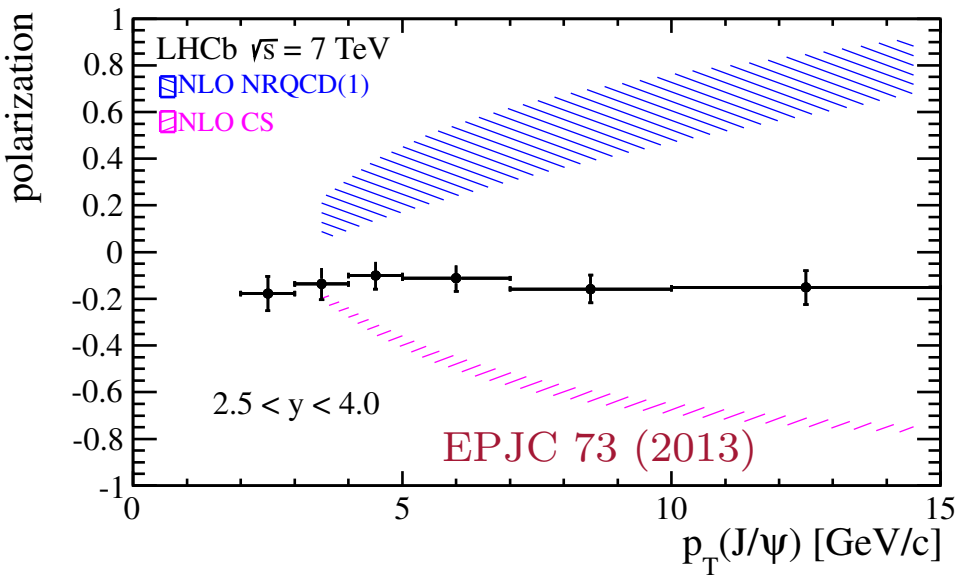
LHCb, PLB **767** (2017)

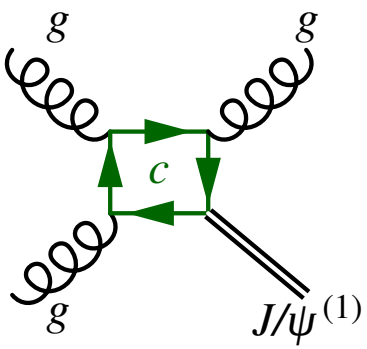


J/ψ Production in Jets

The Polarization Puzzle



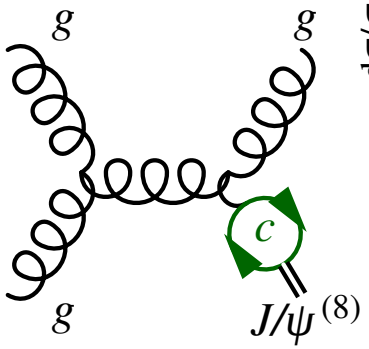




colour singlet

low p_T

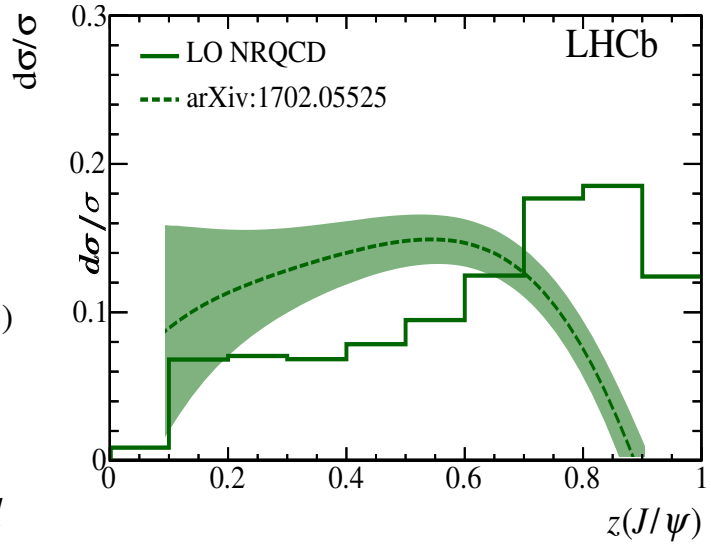
longitudinal polarized



colour octet

high p_T

transverse polarized

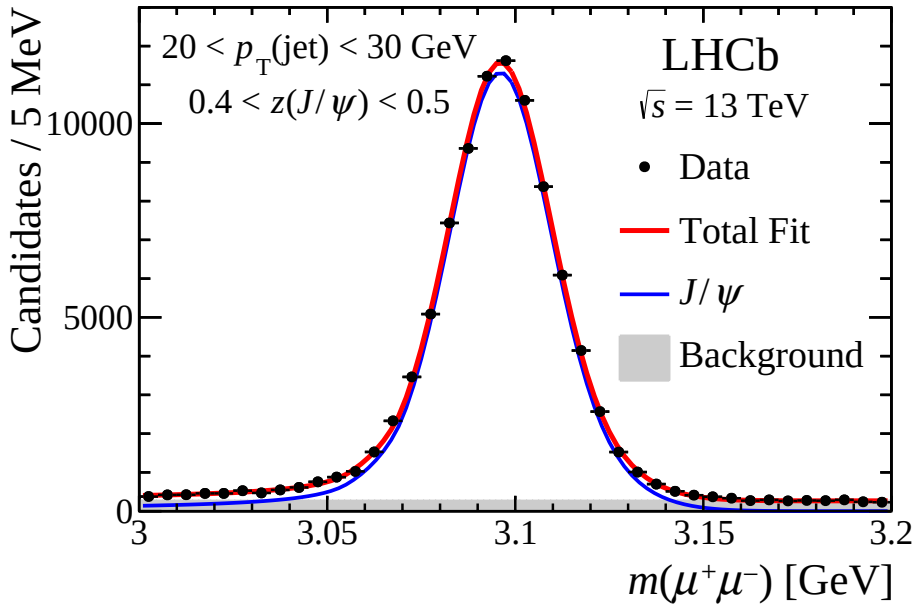


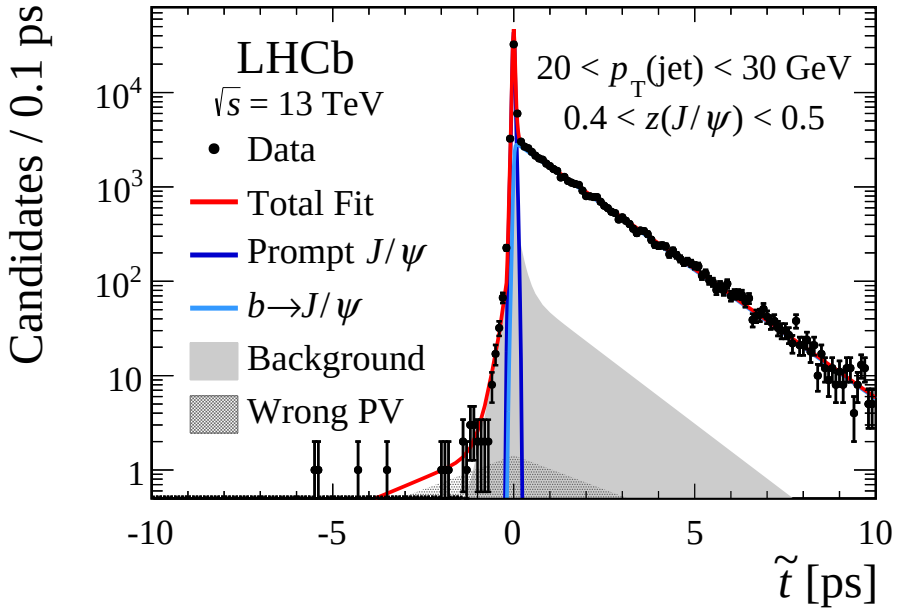
Signal Determination

LHCb, PRL **118** (2017)

- determine J/ψ signal yield with mass fits
- separate prompt from displaced yields with pseudo-lifetime fits

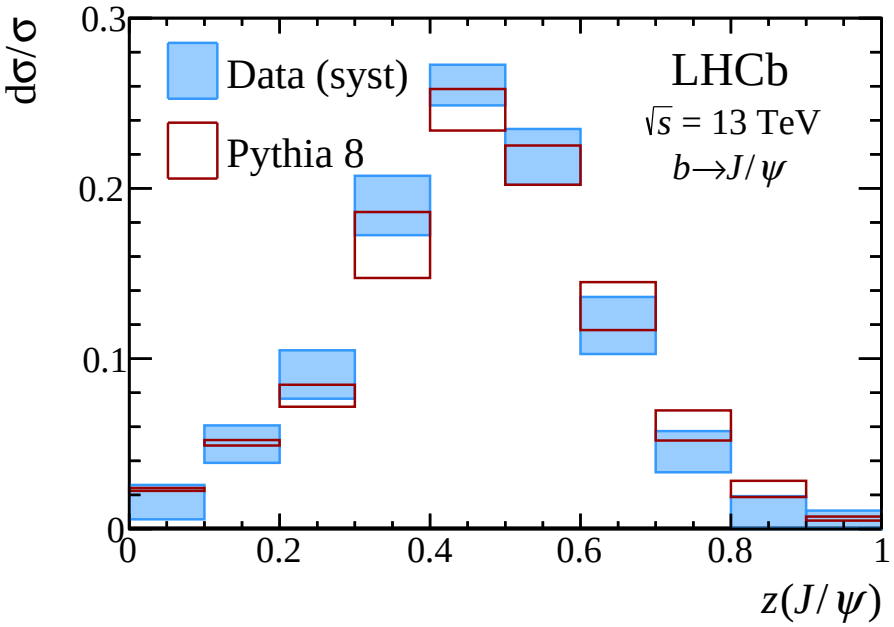
$$\tilde{\tau} \equiv (x_z - x_z(\mathrm{PV}))m/p_z$$

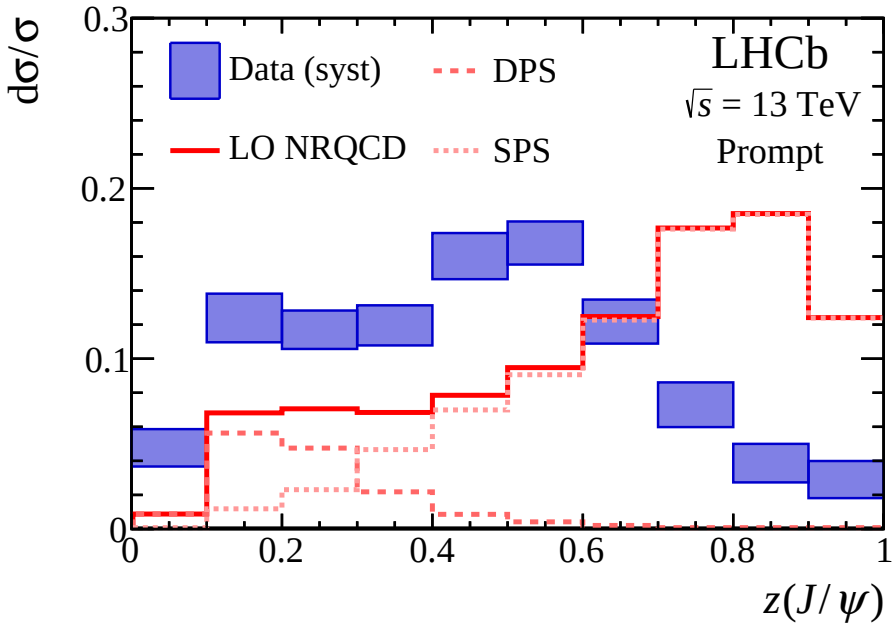




Results

LHCb, PRL **118** (2017)





- diplaced results can help tune b-fragmentation
- LO NRQCD predictions do not match prompt results
- DPS plays an important role, can explain low z behavior
- NLO* NRQCD cannot explain high z behavior

Outlook

Outlook

- robust and efficient $c(b)$-tagging algorithm validated against data
- could see strange asymmetries at end of Run 2
- strong constraints on high-x gluon from top
- top asymmetries should be observable by end of Run 3

- exciting new quarkonia physics underway
- new methods to directly test heavy flavor splitting

Thank you!

Backup

Datasets

V. Vagnoni (2015) HL-LHC

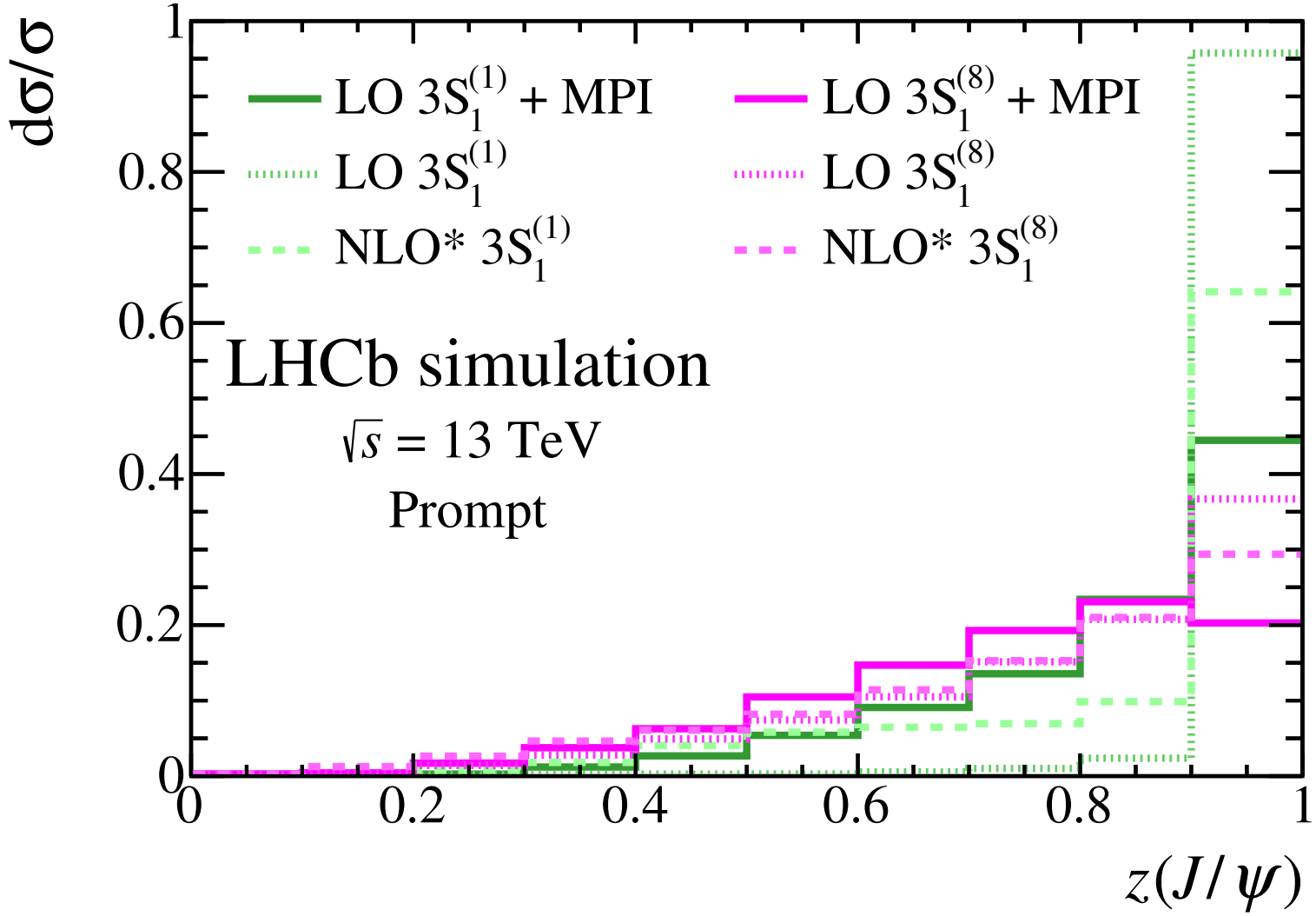
- projected luminosity per run

LHC era				HL-LHC era	
Run 1(a) 2011	Run 1(b) 2012	Run 2 2015 - 2019	Run 3 2021 - 2023	Run 4 2027 - 2029	Run 5 2031 - ?
1 fb^{-1}	2 fb^{-1}	5 fb^{-1}	15 fb^{-1}	23 fb^{-1}	300 fb^{-1}?

- LHCb upgrade during LS 2
  - LHCb-PUB-2014-040
  - replacement of readouts and photo-detectors for the RICHs
  - replacement of tracking detectors
  - **full software trigger**, see LHCb-TDR-016
    - currently limited by hardware readout at 1 MHz
    - upgrade will read out entire detector at 40 MHz

NLO* Predictions

LHCb, PRL **118** (2017)



SoftDrop

PI, Rodd, Thaler, and Williams, arXiv:1702.02947