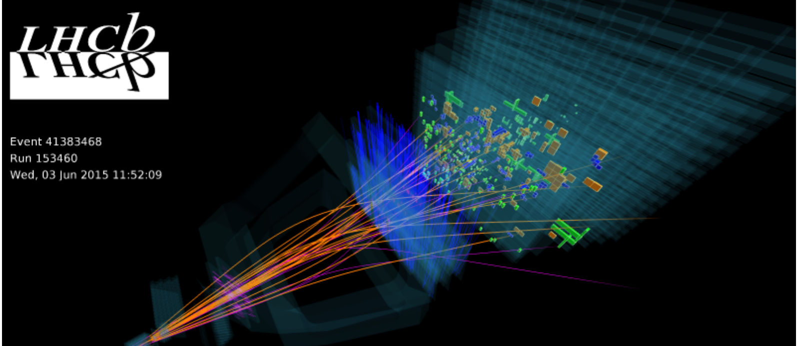


LHCb measurements at 13 TeV

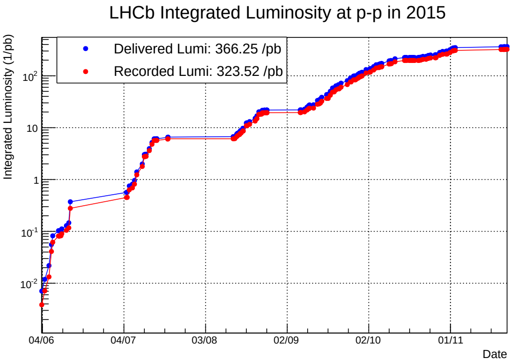
Sevda Esen
on behalf of the LHCb collaboration

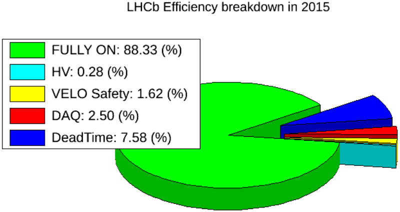
XXII Cracow EPIPHANY Conference
on the Physics in LHC Run2
7-9 January 2016

UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

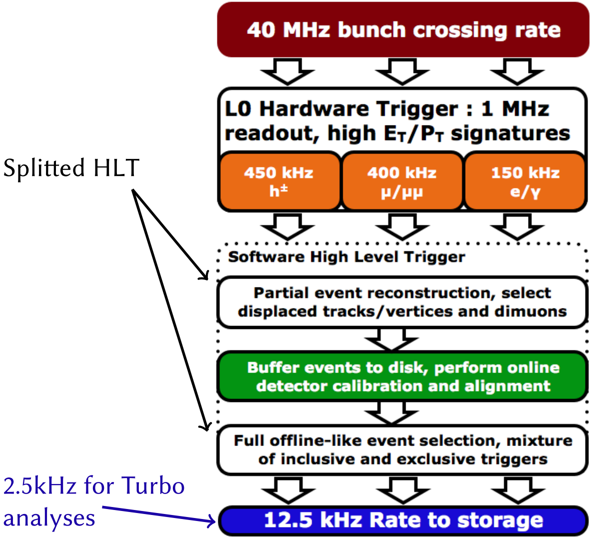
WHAT WE HAVE COLLECTED IN 2015

- $\sim$6pb^{-1} with 50ns bunch spacing
  - fast and clean cross-section measurements
  - check detector efficiencies and new algorithms
- $\sim$ 300pb^{-1} with 25ns
  - no results yet
  - performance studies ongoing
- and some more..
  - pp and PbPb at 5TeV
  - specials data for luminosity calibrations





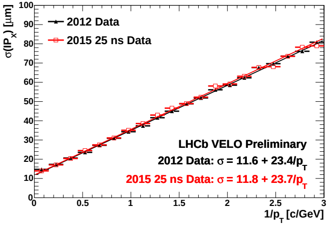
LHCb trigger for Run II

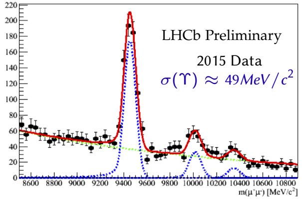


- Events from lower trigger levels can be buffered on disk while performing alignment and calibration
- Last trigger level uses the same reconstruction as offline
- Same alignment and calibration constants to be used for offline reconstruction

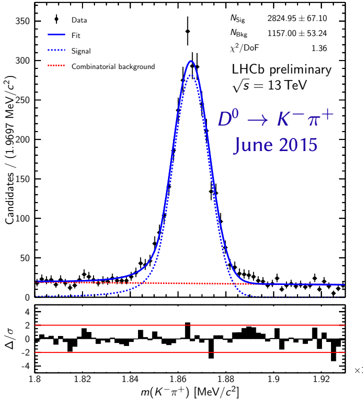
Online tracking, calibration and alignment

- Identical track reconstruction online and offline
  - new reconstruction chain is ∼2 times faster
  - better or equivalent performance as in Run I (TBC)
- Real-time detector alignment
  - Specific procedures for each subdetector
  - Iterative procedure:
    - Perform reconstruction using "old" alignment constants
    - Determine new constants by global χ^2 minimization
    - Repeat until converged, $\Delta\chi^2$ below the threshold
  - New set of parameters are ready in few minutes
  - Excellent momentum resolution at trigger level
- Calibration as soon as enough statistics available
- Same reconstruction as offline, complete alignment and PID calibration allows to apply a tighter selection on kinematic quantities



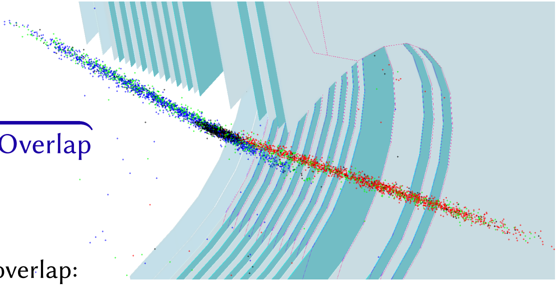


- idea: save only the trigger level objects that caused it to fire
  - tracks and vertices
  - no raw data, no offline processing
- Event size is much smaller
  - full event: $\sim$70kB
  - turbo event: $\sim$5kB
- dedicated $\sim$2.5kHz of the output stream
  – compare to 10kHz for full stream
- Especially useful for high yield exclusive modes
  - can reduce the pre-scaling
- wider range of use expected for run III



Lumonosity measurement

$$\mu^{ref} = \sigma^{ref} \times \overbrace{\underbrace{N_1 N_2}_{\text{Bunch intensity}} \times \text{Overlap}}^{\mathcal{L}}$$



- Two methods to measure the overlap:
  - **Van der Meer scans:** with LHC moving the beams with respect to each other in small steps
  - **Beam Gas Imaging Method:** with gas injection into the path of the beam to reconstruct beam shape at the interaction point
- Combination gives $\sim$ 1% of uncertainty
  - with BGI alone, 3.8% uncertainty for early 2015 measurements

$$\left.\begin{aligned} \mathcal{L}_{int}^{J/\psi} &= (3.05 \pm 0.12)\mathrm{pb}^{-1} \\ \mathcal{L}_{int}^{charm} &= (4.98 \pm 0.19)\mathrm{pb}^{-1} \end{aligned}\right\}$$ the results presented today

Heavy flavor production

- Vital to improve our understanding of QCD
  - Test precise cross-section predictions
  - provide empirical fragmentation functions
  - probe proton structure
- LHCb covers a partonic momentum fraction x complementary to HERA
  HERA: $10^{-4} < x \lesssim 10^{-1}$
  LHCb: $5 \times 10^{-6} < x \lesssim 10^{-4}$
- Necessary for MC generator tuning
  - Inputs for precision measurements
  - Feasibility studies i.e., rare decays, new experiment designs
- Precise knowledge of SM backgrounds to new physics processes

Cross-section measurement techniques

- Double-differential cross-section

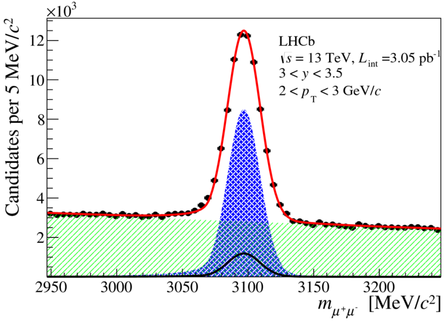
$$\frac{\mathrm{d}^2\sigma_i H}{\mathrm{d}p_T\mathrm{d}y} = \frac{1}{\Delta p_T \cdot \Delta y}\frac{N_s(H \to f + c.c.)}{\epsilon_i(H \to f) \cdot \mathcal{B}(H \to f) \cdot \mathcal{L}_{int}}$$

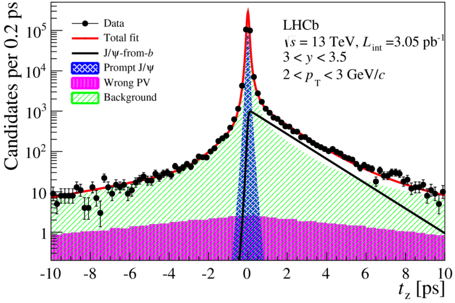
- Use events in $2.0 < y < 4.5$ and $p_T < 15\mathrm{GeV/c}$
  ** not possible for every decay
- signal and background separation from fit to mass distributions
- prompt and secondary decays distinguished either using pseudo-lifetime or impact parameter significance
- Evaluate total $b\bar{b}$ and $c\bar{c}$ production cross-section
  - for $c\bar{c}$, we use fragmentation fractions from e^+e^- colliders
  - for $b\bar{b}$, only a naive 4π extrapolation will be shown
    ** dedicated analyses are ongoing

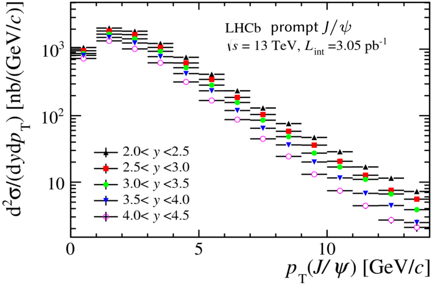
J/ψ CROSS-SECTION

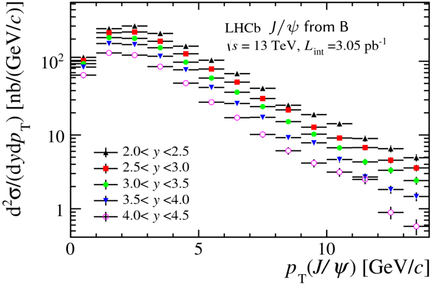
- J/ψ production from $J/\psi \to \mu^+\mu^-$ decay
- Fraction of secondary J/ψ's from b-hadrons estimated using a pseudo-lifetime variable

$$t_Z = \frac{(z_{J/\psi} - z_{PV}) \cdot M_{J/\psi}}{p_Z}$$



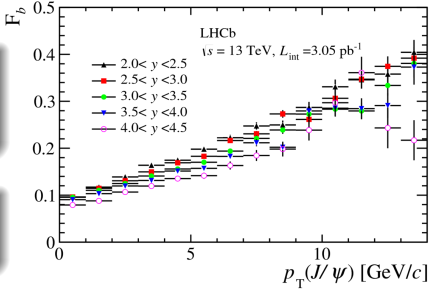






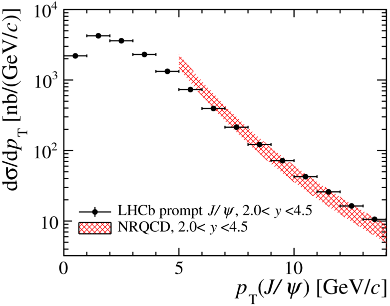
J/ψ cross-section in LHCb acceptance

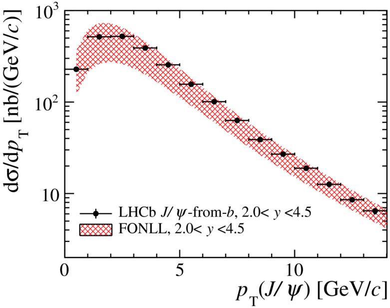
$$\sigma(prompt) = 15.30 \pm 0.03 \pm 0.86 \mu b$$
$$\sigma(fromb) = 2.34 \pm 0.01 \pm 0.13 \mu b$$



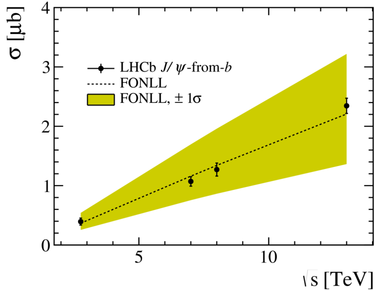
$b\bar{b}$ cross-section with 4π extrapol.

$$\sigma(b\bar{b}) = 515 \pm 2 \pm 53 \mu b$$

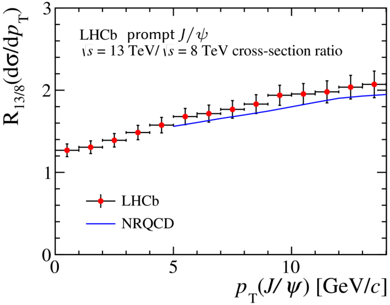


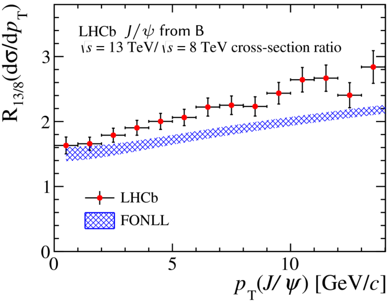


H.-S.Shao *et al.*, JHEP05 (2015) 103
M. Cacciari *et al.*,CERN-PH-TH/2015-171
M. Cacciari *et al.*, JHEP 9805:007,1998

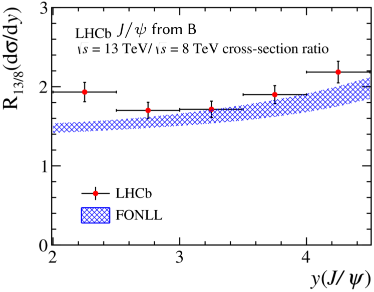


J/ψ cross-section ratios 13/8





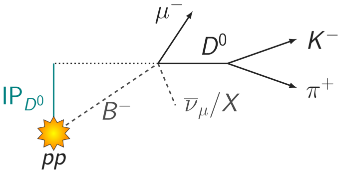
** In the cross-section ratios, many of the systematic uncertainties cancel because of correlations between the two measurements

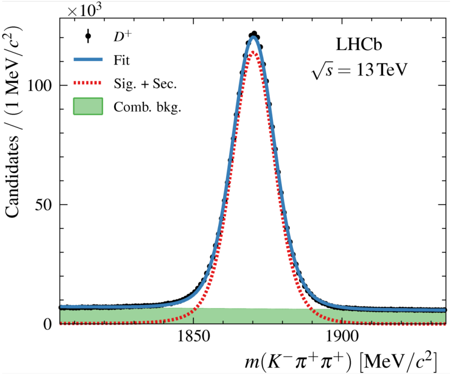


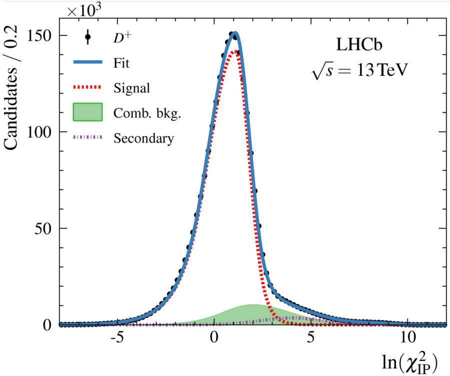
H.-S.Shao *et al.*, JHEP05 (2015) 103
M. Cacciari *et al.*,CERN-PH-TH/2015-171

Charm cross-sections

- Decay modes: $D^0 \to K^-\pi^+$, $D^+ \to K^-\pi^+\pi^+$, $D_s^+ \to K^- K^+\pi^+$ and $D^{*+} \to D^0\pi^+$
- Impact parameter significance to disentangle B decays

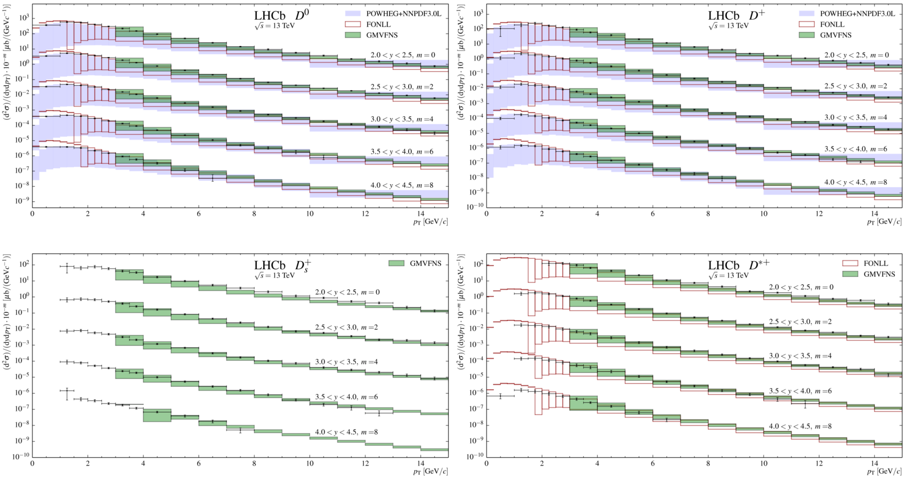






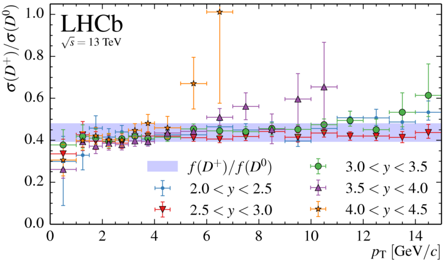
Charm cross-sections

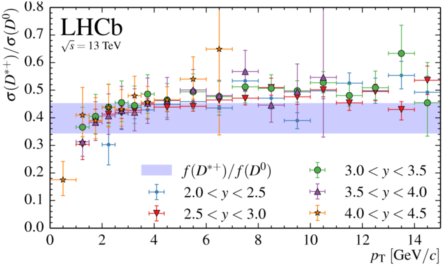
arXiv:1510.01707



M. Cacciari *et al.*,CERN-PH-TH/2015-171
R. Gauld *et al.*,arXiv:1506.08025 [hep-ph]
B. A, Kniehl *et al.*,Eur. Phys. J. C72 (2012) 2082,

Charm cross-sections



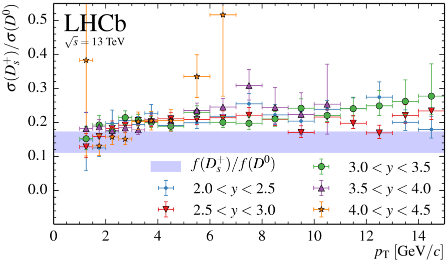


$0 < y < 4.5$ & $0 < p_T < 8$ GeV

$$\sigma(D^0) = 3300 \pm 4 \pm 179 \mu b$$
$$\sigma(D^+) = 1239 \pm 6 \pm 112 \mu b$$

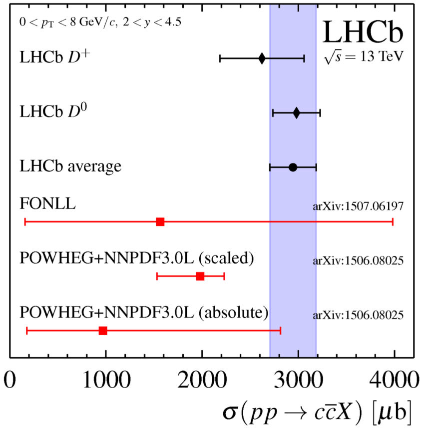
$0 < y < 4.5$ & $1 < p_T < 8$ GeV

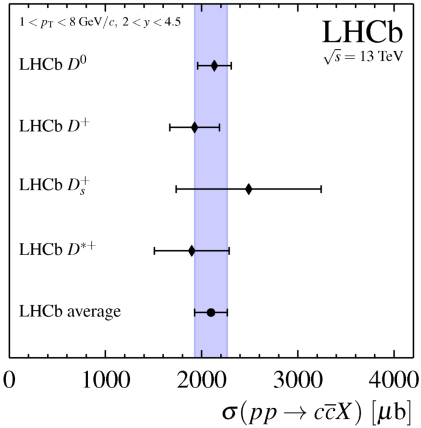
$$\sigma(D_s^+) = 398 \pm 5 \pm 43 \mu b$$
$$\sigma(D^{*+}) = 850 \pm 6 \pm 84 \mu b$$

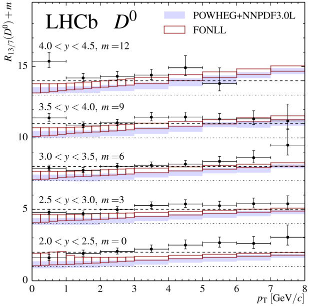


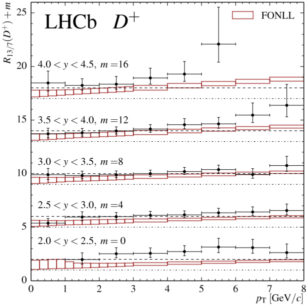
$0 < y < 4.5$ & $0 < p_T < 8$ GeV

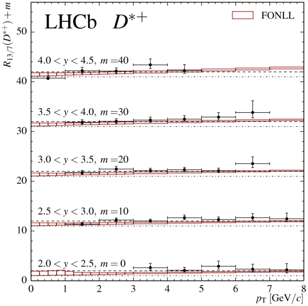
$\sigma(c\bar{c}) = 2850 \pm 3 \pm 180 + 140(\text{frag})\mu b$

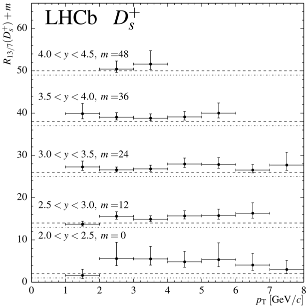












- using LHCb measurements at $\sqrt{s} = 7$ TeV
  Nucl. Phys. B871 (2013)
- No theory prediction for D_s^+

SUMMARY

- Updated LHCb trigger performs very well
- measured various cross-sections using new Turbo stream
- other cross-section measurements at 13TeV on the way
- precision measurements to be updated with 2015+2016 data