$D^{\star}\mu$ update: towards b-cross section

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Introduction

Progress since last month

- theoretical predictions for $\sigma(b \rightarrow D^{\star}\mu)$ have been studied and prepared using MC@NLO (some technical problems with POWHEG until now...)!
- main ingredients for differential $\sigma(b \rightarrow D^{\star}\mu)$ measurement on data are ready
- understand trigger efficiency and behaviour is the main challenge at the moment: the results shown in this presentation simply want to illustrate our strategy, they will be updated as soon as we will converge on trigger efficiency understanding

Theoretical estimates from MC@NLO

- NLO parton level event generation: MC@NLO 4.0 (newest version)
- showering and hadronization: HERWIG 6.520
- parameters: $\sqrt{s} = 7$ TeV, CTEQ6m, $m_b = 4.75$ GeV $\Rightarrow$ $\sigma_{b\bar{b}} = 238\mu$b
- basic uncertainty depends on the parameters choice (e.g. m_b, see Leonid's talk on June 18th): in progress
- generated 2M $b\bar{b}$ events $\rightarrow N_{D^\star\mu} \simeq 115$k $\Rightarrow$ $f(B \rightarrow D^\star \mu X) \simeq 2.87\%$ $\Rightarrow$ $\sigma(B \rightarrow D^\star \mu X) \simeq 6.83\mu$b
- from PDG: $f(B \rightarrow D^\star \mu X) = 2.75 \pm 0.19\%$
- inside the kinematical region: $|\eta_{D^\star}| < 2.1, |\eta_\mu| < 2.5$, $p_{T_{D^\star}} > 4.5$ GeV, $p_{T_\mu} > 4$ GeV $\rightarrow N_{D^\star\mu} \simeq 1800$

Additional data

Periods: A, B, C, D, E; L=1.2 pb^{-1}
GRL: Muon+b-tagging

$D^{\star}$ selection cuts:

- 5 silicon SPs, at least one of them in pixel for kaon, pion, soft pion
- $p_T > 1\ GeV$ for kaon and pion
- $M(K\pi) - M(D^0_{PDG})\ <\ 40\ MeV$
- $p_T(D^{\star}) > 4.5$ GeV, $|\eta(D^{\star})| < 2.1$

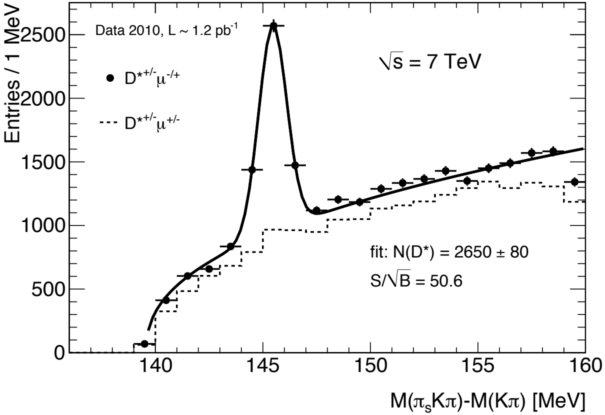
$D^{\star}\mu$ selection cuts:

- STACO muon
- $p_T(\mu) > 4GeV$, $|\eta(\mu)| < 2.5$
- $M(D^{\star}\mu) > 2.5\ GeV$

Trigger selection:

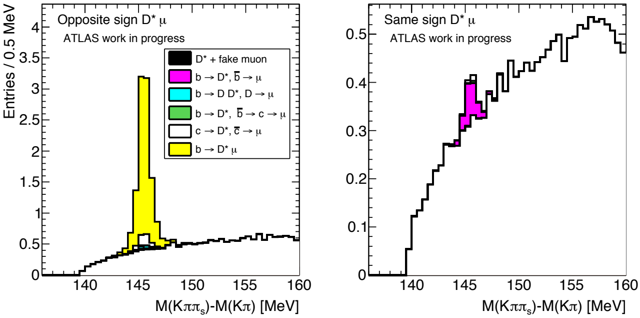
- EF_mu4

$D^{\star}\mu$ sample



$D^\star\mu$ sample composition

Use *bbmu4X* and *ccmu4X* (combine events taking into account cross sections).



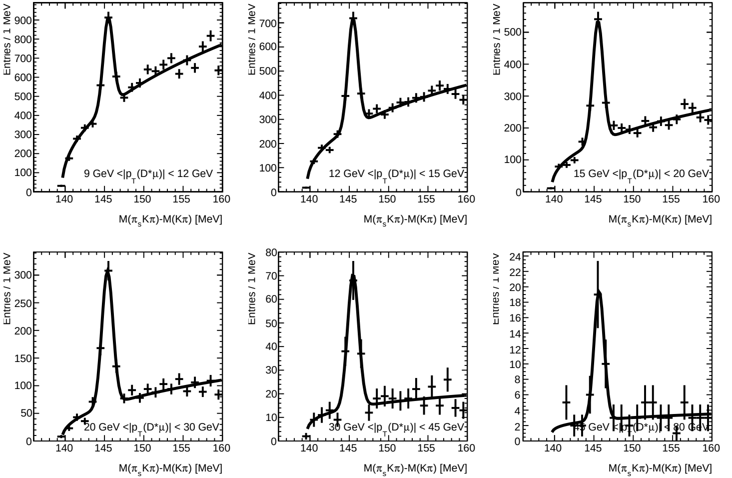
$f(b \to D^\star \mu) = 89.5 \pm 1.1\%$

$f(b \to D^\star D) = 1.5 \pm 0.1\%$

$f(c \to D^\star, \bar{c} \to \mu) = 7.4 \pm 0.3\%$

$f(b \to D^\star, \bar{b} \to \mu) = 1.4 \pm 0.1\%$

$D^\star\mu$ signal in different $p_T(D^\star\mu)$ bins



Efficiency vs $p_T(D^\star\mu)$

- reconstruction efficiency ϵ_r (MC sample $cb \to \mu$2.5Hadr):

$$\epsilon_r = \frac{D^\star\mu \text{ rec}}{D^\star\mu \text{ true from } b\ \dagger}$$

$\dagger$ $|\eta_{D^\star}| < 2.1, |\eta_\mu| < 2.5, p_T(\mu) > 4GeV, p_T(D^\star) > 4.5GeV$

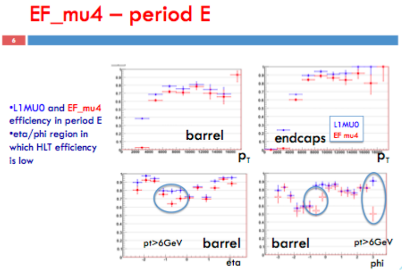
	9-12 GeV	12-15 GeV	15-20 GeV	20-30 GeV	30-45 GeV	45-80 GeV
ϵ_r	0.19 ± 0.04	0.26 ± 0.02	0.36 ± 0.02	0.47 ± 0.04	0.42 ± 0.09	0.5 ± 0.25

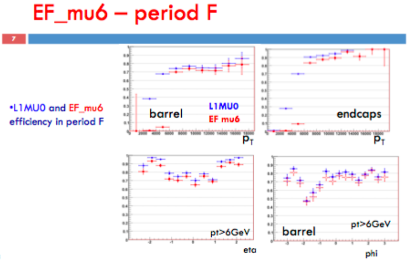
- EF_mu4 trigger efficiency included in ϵ_r (MC based) $\Rightarrow$ not reliable
- need to separately evaluate $\epsilon_{\mu 4}$ on data, and decide a correct $p_T(\mu)$ cut to avoid the trigger turn-on efficiency curve (more details following)

Trigger strategy for the future

Muon trigger evolution and efficiency

- our $D^{\star}\mu$ sample up to period E ($\mathcal{L} \sim 1.2$ pb^{-1}) with EF_mu4 trigger
- muon trigger not very stable up to period E3 (RPC timing updates in period E3) $\Rightarrow$ large part of our sample is included in this non stable periods
- efficiencies showed at Amsterdam Trigger Workshop (tag and probe method on J/ψ):





Trigger strategy for the future

Muon trigger evolution and efficiency

- EF_mu4 requires a cut $p_{T_\mu} > 6$ GeV to reach the plateau, the same requested by EF_mu6
- EF_mu6 is quite completely not prescaled in period F $\Rightarrow$ we could add ~ 2 pb^{-1} to our sample w.r.t. EF_mu4
- our plan: period E+F, EF_mu6 trigger, $p_{T_\mu} > 6$ GeV (~ 3 pb^{-1})
- contact MuonTrigger group to have efficiencies parametrizations on data

Differential $B \to D^\star \mu X$ cross section from data

$$\frac{d\sigma(B \to D^\star \mu X)}{dp_T(D^\star \mu)} = \frac{f_b N^{D^\star \mu}|_{\Delta p_T}}{2\mathcal{B}\mathcal{L}\Delta p_T}$$

- ATLAS luminosity has an 11% uncertainty at the moment:

$$\mathcal{L} = 1.20 \pm 0.13\,\mathrm{pb}^{-1}$$

- Number of observed $D^\star \mu$ pairs in the different p_T bins
- Sample composition:

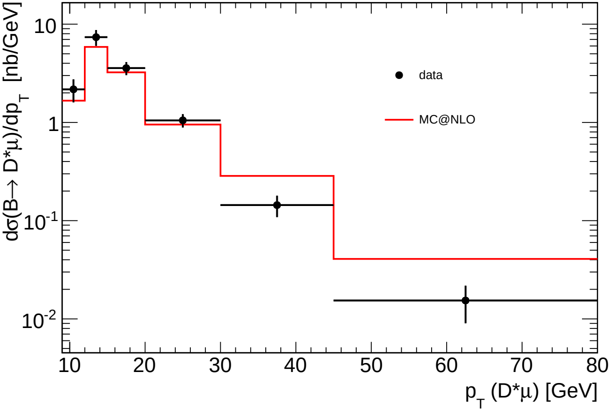
$$f_b = f(b \to D^\star \mu) = 0.895 \pm 0.011$$

- Total Branching Ratio $\mathcal{B}$ (values from PDG):

$$\mathcal{B} = BR(D^\star \to D_0 \pi) \cdot BR(D_0 \to K\pi) = (2.63 \pm 0.04) \cdot 10^{-2}$$

Differential $B \to D^{\star}\mu X$ cross section

kinematical region: $|\eta_{D^\star}| < 2.1$, $|\eta_\mu| < 2.5$, $p_{T_{D^\star}} > 4.5$ GeV, $p_{T_\mu} > 4$ GeV



Unfolding

- we have a measured distribution vs $p_T(D^\star\mu) \rightarrow$ we need to unfold the observed $p_T(B)$ distribution on MC basis:

$$w_{ij} = \frac{N([B]_i \rightarrow [D^\star\mu]_j)}{N([D^\star\mu]_j)}$$

where $N([B]_i \rightarrow [D^\star\mu]_j)$ is the number of b hadrons in a $p_T(B)$ bin i decaying to $D^\star\mu$ in $p_T(D^\star\mu)$ bin j

- unfolding:

$$N_i^B = \sum_{j=1}^{N} w_{ij} N_j^{D^\star\mu}$$

	9-12 GeV	12-15 GeV	15-20 GeV	20-30 GeV	30-45 GeV	45-80 GeV
$N^{D^\star\mu}$ †	3722	2646	1717	869	228	55
N^B	1838	2421	2712	1672	537	109

† weighted with the efficiency ϵ_r of the previous slide

Summary and plans

- $D^\star\mu$ sample up to period E ($\mathcal{L} \sim 1.2$ pb^{-1}) $\Rightarrow$ with EF_mu4 (EF_mu6 already available in our ntuples)
- plan to extend our sample to period F with EF_mu6
- method to evaluate $d\sigma(B \to D^\star \mu X)/dp_T$ in our kinematical range is ready
- muon trigger efficiency has to be correctly taken into account
- theoretical comparison with MC@NLO ready! as soon as possible comparisons with POWHEG will be added!
- as soon as the data cross section will be understood in our kinematical range $\Rightarrow$ extrapolation to the full kinematical region using MC@NLO (and POWHEG) comparison
- once we have $d\sigma(B \to D^\star \mu X)/dp_T$ in the full kinematical region:

$$d\sigma(B)/dp_T = \frac{d\sigma(B \to D^\star \mu X)/dp_T}{\mathcal{B}(b \to D^\star \mu)}$$