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Measurement of associated $W + c$ production

 O. Kot, O. Zenaiev Validation of 2011 open data
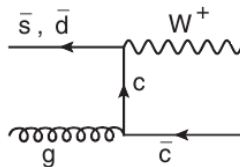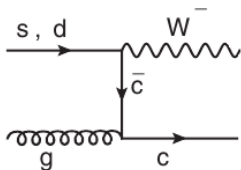
$W \to e$ or μ
$c \to D^*$, or D^+, or μ in jet

In total 6 final states
$\Rightarrow$ selecting events with isolated lepton and jet with charm 'signature'

Signal: oppositely signed (OS) W and c
Background: expect equal fraction of OS and same signed (SS) W and c
$\Rightarrow$: **suppressed background for OS-SS distributions**

Data samples:

- μ: 'SingleMu' dataset
- e: 'SingleEl' dataset

MC:

- W + jets (MadGraph + Pythia6) [signal]
- Drell-Yan (MadGraph + Pythia6) [background] — not included

Event selection

Lepton: leading p_T muon or electron:

- Muons ('muons')
  - $p_T > 25$ GeV
  - $|\eta| < 2.1$
  - isolated with $I_{\text{rel}}^{\Delta R < 0.4} < 0.12$ ($\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$)
  - $M_T > 40$ GeV, $M_T = \sqrt{2 p_T E_T^{\text{miss}}(1 - \cos(\phi_l - \phi_{E_T^{\text{miss}}}))}$
  - required to be global muons
  - at least 10 valid tracker hits and 2 pixel hits
  - global track fit $\chi^2/\text{dof} < 10$
  - impact parameter to PV < 0.02 cm in transverse plane and < 0.5 cm in z
  - no oppoiste sign muon with $p_T > 25$ GeV, $|\eta| < 2.4$
- Electrons ('gsfElectrons')
  - $p_T > 35$ GeV
  - $|\eta| < 2.1$, excluding $1.44 < |\eta| < 1.57$
  - $M_T > 55$ GeV, $M_T = \sqrt{2 p_T E_T^{\text{miss}}(1 - \cos(\phi_l - \phi_{E_T^{\text{miss}}}))}$
  - isolated with $I_{\text{rel}}^{\Delta R < 0.3} < 0.05$
  - no missing hits in the silicon tracker
  - no oppoiste sign electron with $p_T > 20$ GeV, $|\eta| < 2.5$

Jet ('ak5PFJets' + JEC): leading p_T with $p_T > 25$ GeV, $|\eta| < 2.5$ and charm 'tag'

- $D^+ \to K^- \pi^+ \pi^+$ candidate
- $D^{*+} \to D^0 \pi_s^+, D^0 \to K^- \pi^+$ candidate
- muon

- Crucial to suppress background for D^+, D^{*+}
- Differs from the paper:
    - open data: all track combinations fitted using AdaptiveVertexFitter [thanks to Nazar Stefaniuk for sharing basic code!]
    - paper: 'exclusive' vertices (no shared tracks)
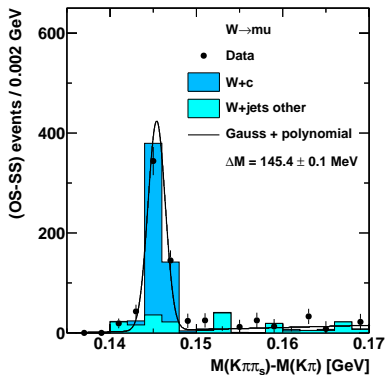- Expecting larger selection efficiency, but possibly larger background in open data
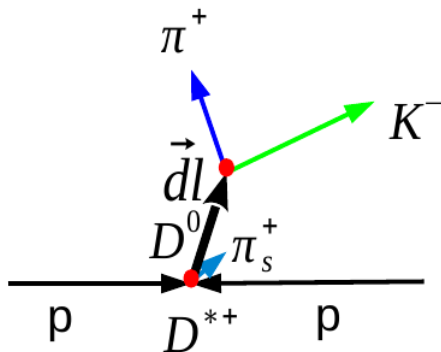
$$l_{proj} = \frac{(\vec{dl} \cdot \vec{p}_D)_{xy}}{|\vec{P}_D|_{xy}}, \quad \vec{p}_D = \vec{p}_{K^-} + \vec{p}_{\pi^+}$$

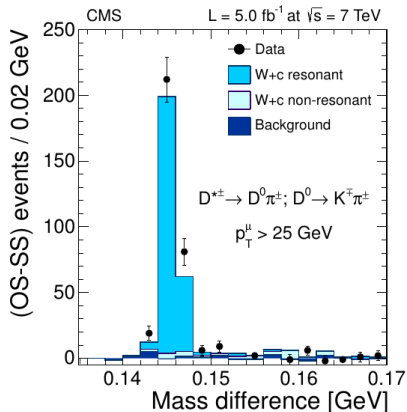$$s = \frac{l_{proj}}{\Delta l_{proj}}$$

Require:

- $s > 3$
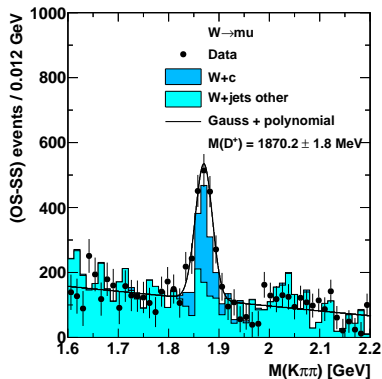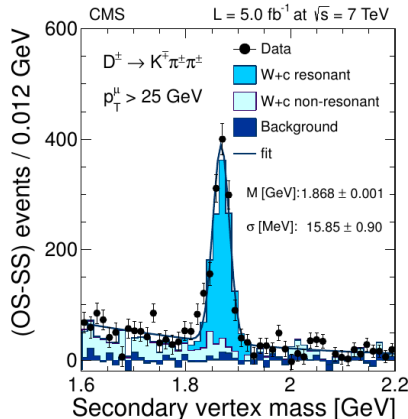- $(dl)_{xy} < 2$ cm, $(dl)_z < 2$ cm

Open Data

TOP-12-002

- Fitted to Gaus (signal) + 1st order polynomial (background)
- More signal events in open data
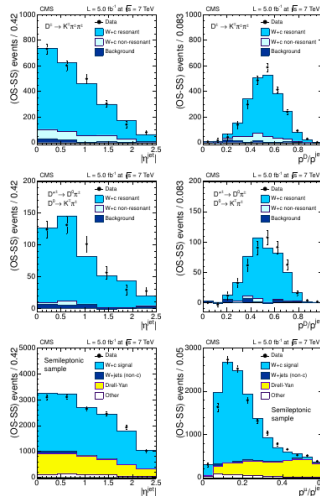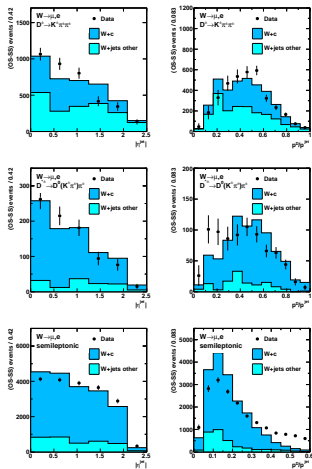- Similar signal / background ratio

Open Data

TOP-12-002

- Fitted to Gaus (signal) + 1st order polynomial (background)
- More signal events in open data
- Worse signal / background ratio
- *Drawback in open data vertexing: usage of Adaptive Vertex Fitter with track weighting*

Open Data

TOP-12-002

- Shapes very similar for D mesons
- MC < data for D^+, μ: missing background samples
- Prevents from measuring cross section in semileptonic channel

Cross section measured at parton level:
$p_T^c > 25$ GeV, $|\eta^c| < 2.5|$, $p_T^\mu > 25$ GeV, $|\eta^\mu| < 2.1|$:

$$\sigma = \frac{N_{Sig}}{ALB}, \ E = \frac{N_{MCreco}}{N_{MCgen}}$$

$L = 2.5$ fb^{-1}

D^* : $\quad B = f(c \to D^* \to D^0(K\pi)\pi) = 0.622\%$
D^+ : $\quad B = f(c \to D^+ \to K\pi)\pi) = 2.08\%$

N_{Sig} extracted from fit of invariant mass spectrum (differs from the paper)

Open data
$W \to \mu\nu, \ p_T^\mu > 25$ GeV
$\quad D^+$: $\quad 129.7 \pm 12.4$ (stat) pb
$\quad D^*$: $\quad 132.9 \pm 13.7$ (stat) pb
$W \to e\nu, \ p_T^e > 35$ GeV
$\quad D^+$: $\quad 46.9 \pm 9.8$ (stat) pb
$\quad D^*$: $\quad 58.5 \pm 11.8$ (stat) pb

TOP-12-002
$W \to \mu\nu, \ p_T^\mu > 25$ GeV
$\quad D^+$: $\quad 103.6 \pm 7.8$ (stat) + 8.1 (syst) pb
$\quad D^*$: $\quad 116.9 \pm 8.7$ (stat) + 10.0 (syst) pb
$W \to e\nu, \ p_T^e > 35$ GeV
$\quad D^+$: $\quad 83.5 \pm 6.3$ (stat) + 7.1 (syst) pb
$\quad D^*$: $\quad 83.3 \pm 10.4$ (stat) + 8.5 (syst) pb

$\Rightarrow$ **reasonable consistency with the paper**