Low Mass Drell-Yan Status Report

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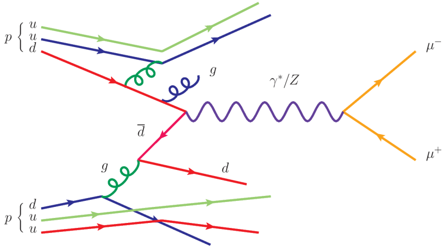
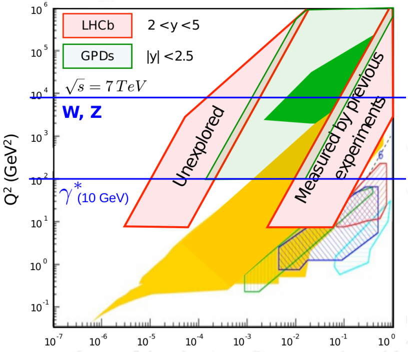
June 9, 2016

Introduction to Drell-Yan

- Drell-Yan are process of two quark anihilations in which neutral current couples to two leptons.
- The cross section of this process depends on two components:
  - Hard scattering process $\Rightarrow$ NNLO pQCD.
  - Parton Distribution Function (PDF).
- Measurement of the cross section have a high sensitivity to the PDF
- Due to unique coverage $2 < y < 5$ LHCb probes the $Q^2 - x$ region not covered by other experiments.





Selection

- Main topic of Nicolas PhD.
- Analysis based on 2011 data set.
- Trigger:
  - `L0_L0DiMuonDecision`,
  - `Hlt1DiMuonHighMassDecision`,
  - `Hlt2DiMuonDY(3,4)Decision`
- Stripping:
  - `StrippingDY2MuMuLine(3,4)`
- Selection:
  - $2 < \eta^{\mu} < 4.5$,
  - $p^{\mu} > 10$ GeV,
  - $p_T^{\mu} > 3$ GeV,
  - $\chi_{vtx}^{2,\mu\mu} < 5$,
  - $10 < m(\mu\mu) < 120$ GeV.

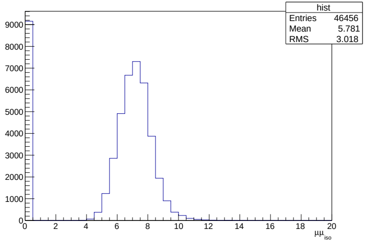
Isolation

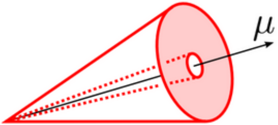
- Drell-Yan unfortunately do not peak in mass $\twoheadrightarrow$ need another variable to control the purity.
- Find mass independent isolation variable such that the signal template can be determined from data.
- We define an isolation variable:

$$\mu_{\text{iso}} = \log(p_T^{cone}(\mu, 0.5) - p_T^{cone}(\mu, 0.1))$$

- For two muons we take the maximum of the two isolations:

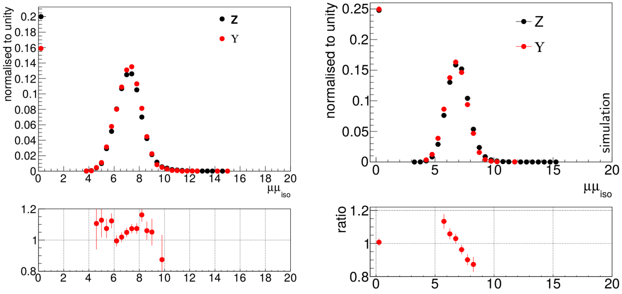
$$\mu\mu_{\text{iso}} = \max(\mu^{+}_{\text{iso}}, \mu^{-}_{\text{iso}})$$





Isolation mass dependence

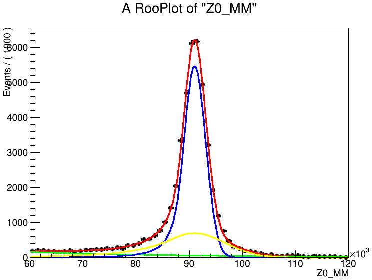
- Unfortunately the $\mu\mu_{iso}$ is showing some mass dependence:

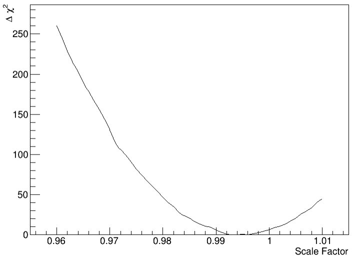


(a) data (b) simulation

Signal template

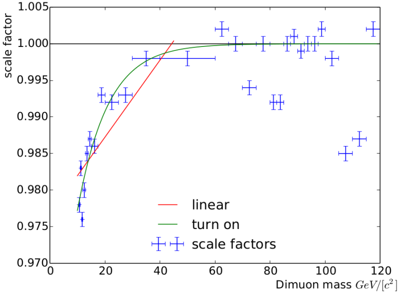
- We do not want to use MC for determination of the signal $\mu\mu_{iso}$ template.
- We adopted a data driven procedure:
  - The template is taken from data and scaled to account for $\mu\mu_{iso}$ mass dependence.
  - Take the *Splot* $Z \to \mu\mu$ from data and multiply it by the scale factor determined from minimalising the χ^2 between MC Z and DY in particular region.





Signal template - Summary

- We are investigating the impact on the analysis for the different approaches
- For now it looks like the results do not change with using different signal templates.
- Because templates are data driven we need to ensure a large statistics in each of the $m_{\mu\mu}$, y bins, because of this the last y bin is larger then the rest.



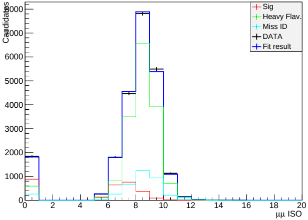
Backgrounds

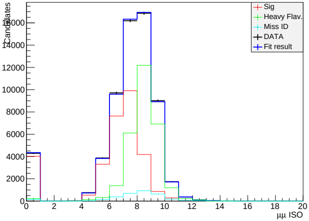
- There are two sources of backgrounds:
  - Heavy flavour decays.
  - Mis-ID.
- For fitting the $\mu\mu_{iso}$ we need to know both the signal and background distribution.
- Background templates can be determined from data
  - Heavy flavour decays:
    - ↬ Requiring the $\chi^{2,\mu\mu}_{vtx} > 16$
    - ↬ For cross-check $\mathrm{IP} > 5~\mathrm{mm}$
  - Miss-ID:
    - ↬ Require that both muons have the same sign.
    - ↬ For cross-check take the minimum bias stripping line.

Over all fits

- Using the above 3 mentioned templates the fits converge without any problems.
- The higher one goes in mass the cleaner the signal is.

Mass bin	Purity
$[40, 60]$ GeV	0.879 ± 0.019
$[30, 40]$ GeV	0.754 ± 0.015
$[25, 30]$ GeV	0.657 ± 0.011
$[20, 25]$ GeV	0.507 ± 0.008
$[17.5, 20]$ GeV	0.402 ± 0.007
$[15, 17.5]$ GeV	0.316 ± 0.006





Cross section calculations

- To calculate the cross section the luminosity will be used:

$$\sigma = \frac{\varrho f^{\mathrm{MIG}}}{\mathcal{L}\varepsilon^{\mathrm{SEL}}} \sum \frac{1}{\varepsilon^{\mathrm{TRIG}}\varepsilon^{\mathrm{MUID}}\varepsilon^{\mathrm{GEC}}\varepsilon^{\mathrm{TRACK}}},$$

where

- ϱ signal fraction from the fit.
- f^{MIG} correction to bin-bin migration.
- $\mathcal{L}$ integrated luminosity.
- $\varepsilon^{\mathrm{SEL}}$ efficiency on the vertex requirement.
- $\varepsilon^{\mathrm{MUID}}$ muon identification efficiency.
- $\varepsilon^{\mathrm{GEC}}$ global event cut efficiency.
- $\varepsilon^{\mathrm{TRACK}}$ tracking efficiency.

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$\Rrightarrow$ Done

$\varepsilon^{\mathrm{SEL}}$

⇛ Evaluated using MC sample:

2011 MagDown	0.21320 ± 0.00014
2011 MagUp	0.21306 ± 0.00014
2012 MagDown	0.20402 ± 0.00013
2012 MagUp	0.20372 ± 0.00013

⇛ Good agreement between polarities!

⇛ 2012 efficiency is lower then the 2011.

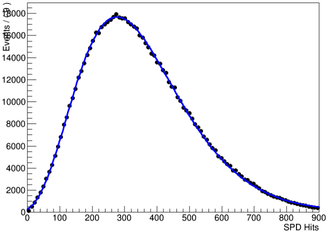
⇛ Will merge the polarities:

2011	0.21313 ± 0.00010
2012	0.20387 ± 0.00009

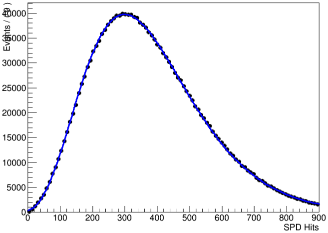
ε^{GEC}

⇛ Evaluated on data directly, by fitting the $\Gamma(\mathrm{SPDHits})$ to data:

⇛ 2011 data:

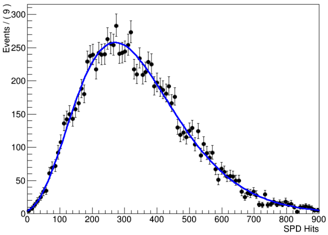


⇛ 2012 data:

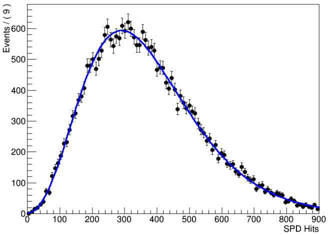


⇛ Testing the $y - M_{\mu\mu}$ dependence:

⇛ 2011 data
$y \in (2, 2.25)$
$M_{\mu\mu} \in (10.5, 12)$ GeV :



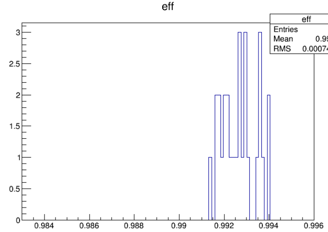
⇛ 2012 data
$y \in (2, 2.25)$
$M_{\mu\mu} \in (10.5, 12)$ GeV :



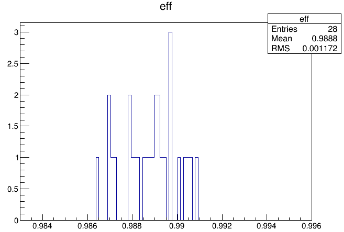
⇛ We didn't observe a variation of the efficiency as a function of $\mu\mu$ and y.

⇛ Proposed a systematic:

⇛ 2011 data:



⇛ 2012 data:



⇛ Suggest the RMS as small systematic.

Conclusions

⇛ The analysis was delayed due to lack of my time :(

⇛ I have stooped teaching so I expect much more time to continue this.

⇛ The remaining corrections could be taken from the $Z^0 \to \mu\mu$ analysis.

Backup