Low Mass Drell-Yan Status Report

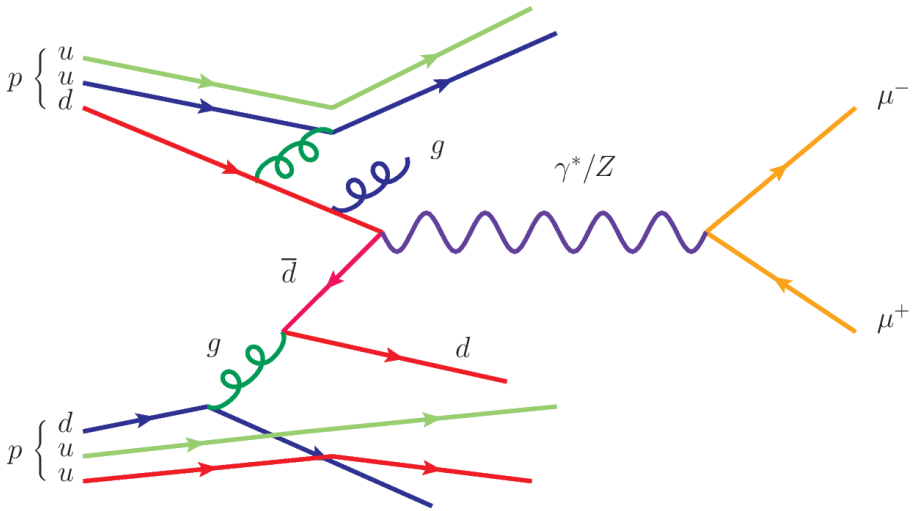
Marcin Chrząszcz
Katharina Müeller
Nicola Chiapolini

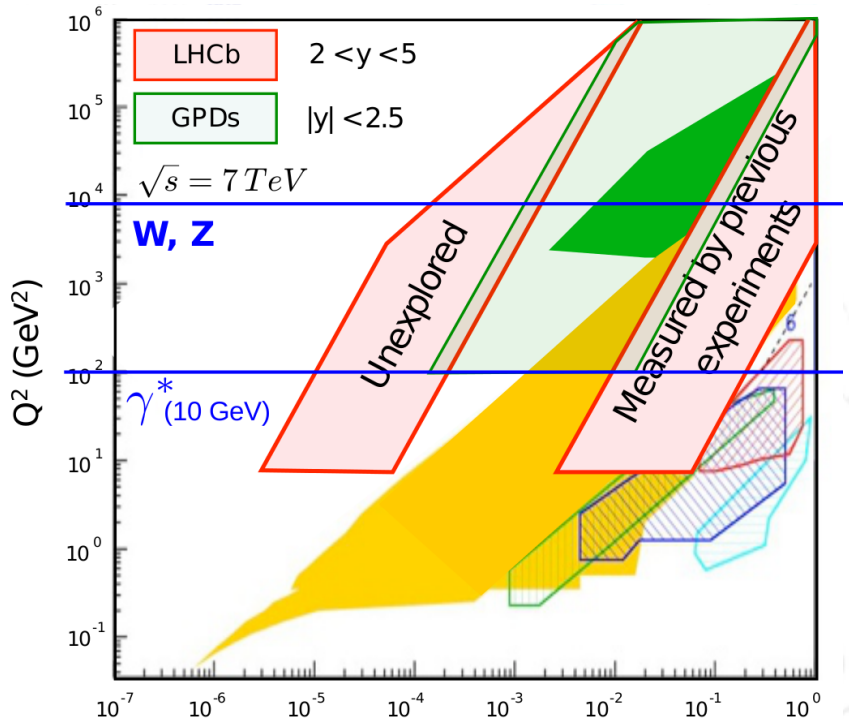
University of Zurich[UZH]

Electroweak WG, CERN
September 7, 2015

Introduction to Drell-Yan

- Drell-Yan are process of two quark anihilations in which neutral coupling to two leptons.
- The cross section of this process depends on two components:
  - Hard scattering process $\Rrightarrow$ 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.

Bins of search

$\Rightarrow$ The measurement will be performed in the bins of dimuon mass and pseudo-rapidity:

$M_{\mu\mu}$ [GeV/c^2]	10.5 – 11.0	11.0 – 11.5	11.5 – 12.0
	12.0 – 13.0	13.0 – 14.0	14.0 – 15.0
	15.0 – 17.5	17.5 – 20.0	20.0 – 25.0
	25.0 – 30.0	30.0 – 40.0	40.0 – 60.0
	60.0 – 70.0	70.0 – 80.0	80.0 – 90.0
	90.0 – 100.0	100.0 – 110.0	110.0 – 120.0
y	2.0 – 4.5		

$M_{\mu\mu}$ [GeV/c^2]	10.5 – 12.0	12.0 – 15.0	
	15.0 – 20.0	20.0 – 60.0	
y	2.0 – 2.25	2.25 – 2.5	2.5 – 2.75
	2.75 – 3.0	3.0 – 3.25	3.25 – 3.5
	3.5 – 3.75	3.75 – 4.0	4.0 – 4.5

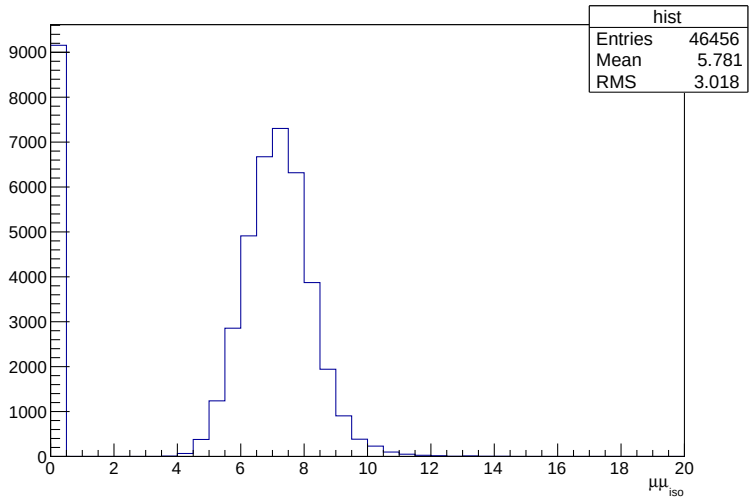
Isolation

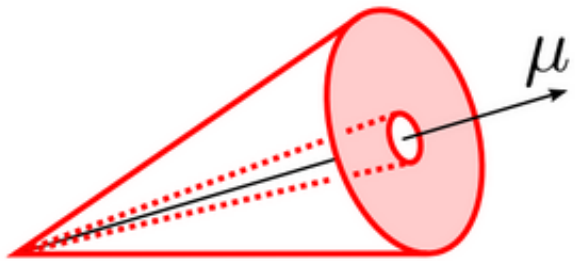
- Drell-Yan unfortunately do not peak in mass $\twoheadrightarrow$ need another variable to control the purity.
- Instead we define an isolation variable:

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

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

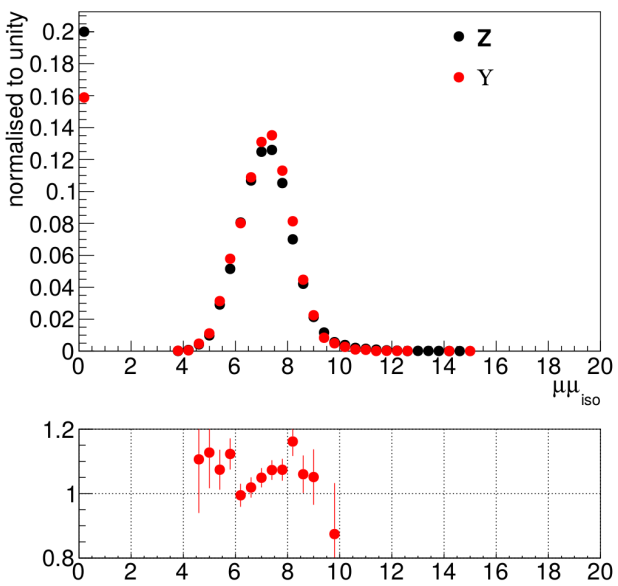
$$\mu\mu_{\text{iso}} = \max(\mu_{\text{iso}}^{+}, \mu_{\text{iso}}^{-})$$



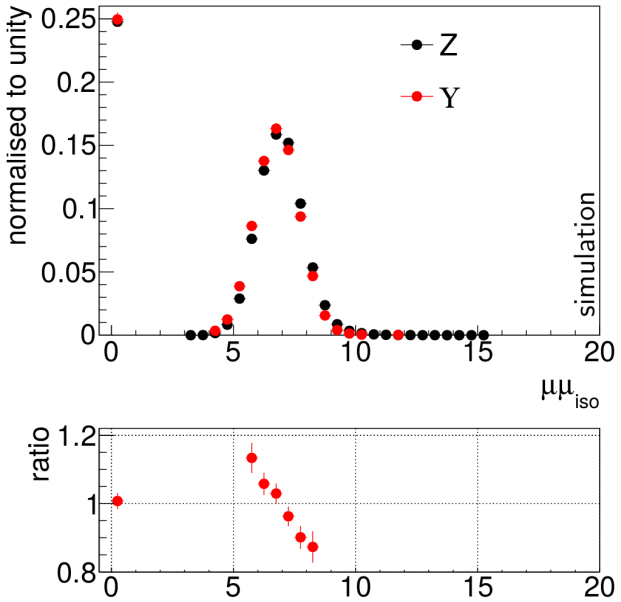


Isolation mass dependence

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



(a) data



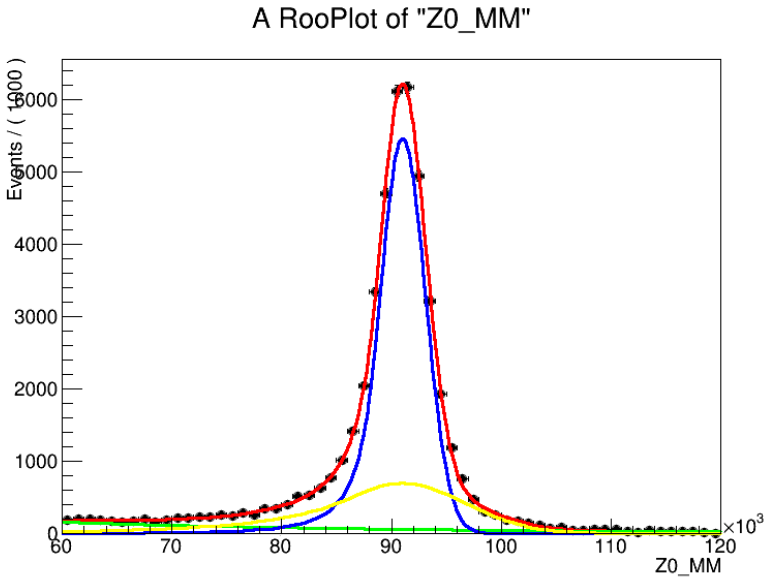
(b) simulation

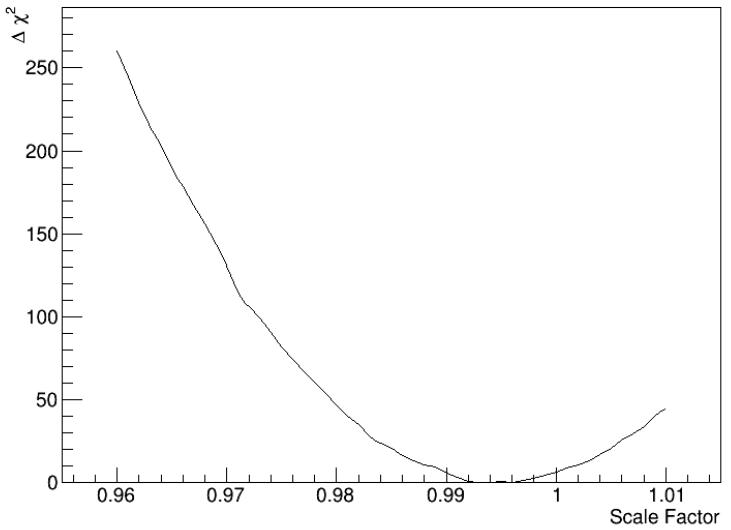
Backgrounds

- 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.

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.
- Possibility 1:
  - Take the *Splot* $Z \rightarrow \mu\mu$ from data and multiply it by the scale factor determined from minimalising the χ^2 between MC Z and DY in particular region.



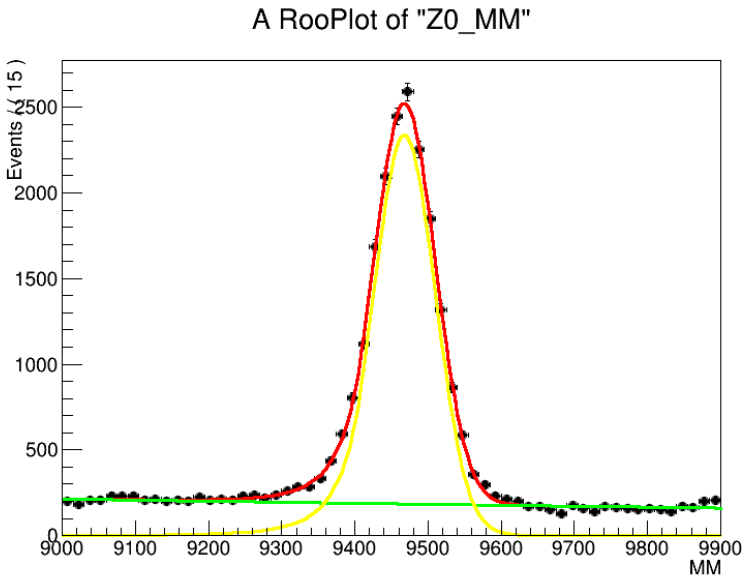


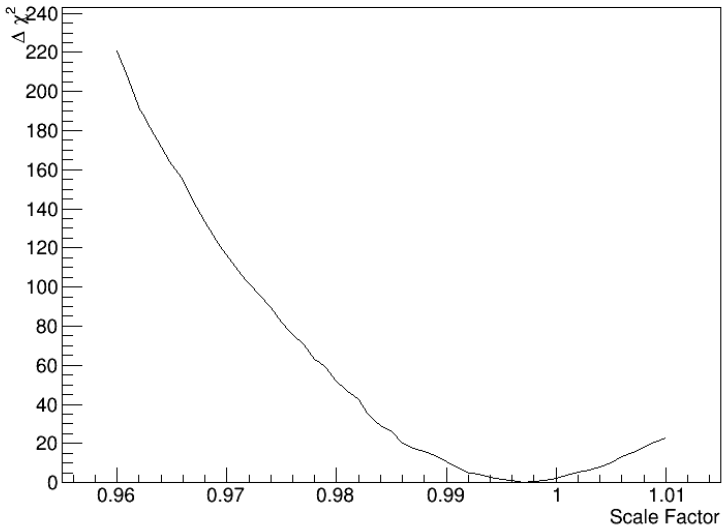
Signal template

- Possibility 2:
  - Use a second decay from data: $\Upsilon \rightarrow \mu\mu$.
  - The template for a given mass range $(M_{\min}, M_{\max})$ is choose as:

$$\mathrm{Temp}(M) = \mathrm{Temp}^{\Upsilon}\frac{(M_Z - M_\Upsilon - (M - M_\Upsilon))}{M_Z - M_\Upsilon} + \mathrm{Temp}^{Z}\frac{M - M_\Upsilon}{M_Z - M_\Upsilon}$$

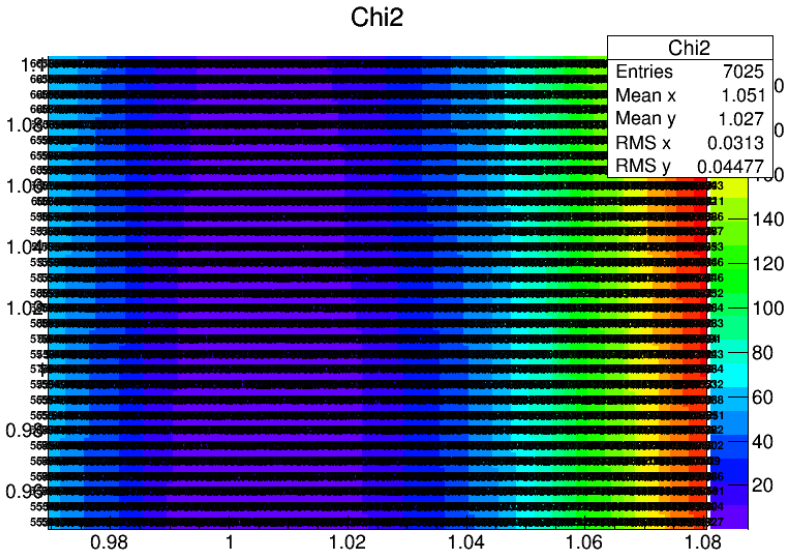
  - Then the new obtained template is scaled in the same way as the previous one.

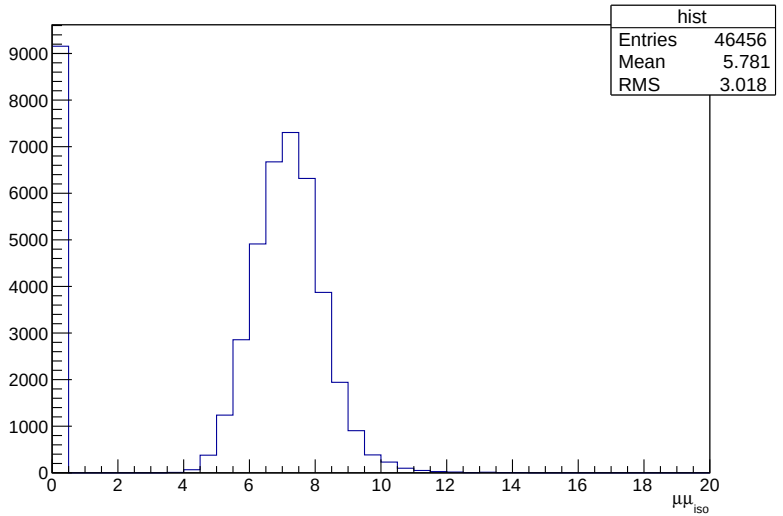




Signal template

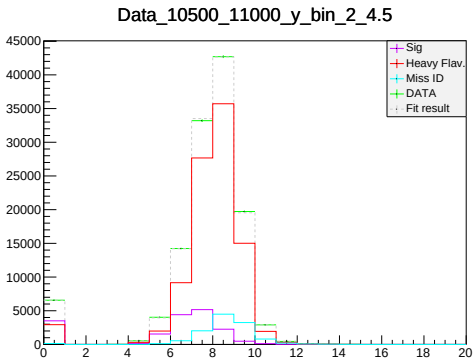
- Possibility 3:
  - The one problem with this distributions is that the first bin is insensitive to scaling factors.
  - On top of the previously defined template we define an additional scaling factor that modifies the ratio between the first and the rest of the bins.
  - The second scaling factor is the same as previous.

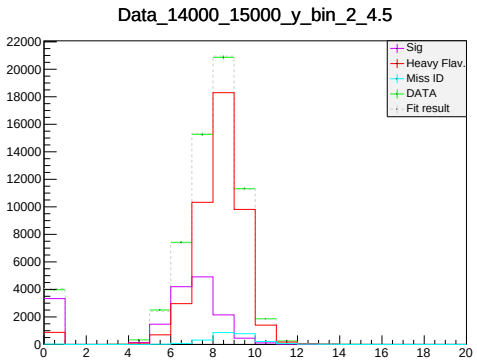


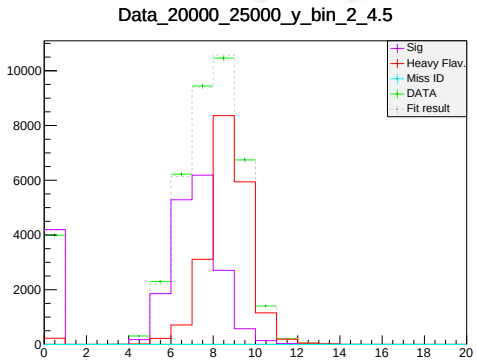


Signal template - Summary

- We are investigating the impact on the analysis for the different approaches
- For now it looks like the results are within the statistical error of the fits.
- The reason for this that in the high pseudo-rapidity region $4 < y < 4.5$ there is very small number of Z decays, so the additional Υ decays are helping.
- We are considering constrainting the background shape in the fits (we know background is exponential in mass).







Conclusions

$\Rightarrow$ Work that still needs to be done:

- Checking the efficiencies.
- Unfolding the mass distribution.
- FSR corrections.
- Write up the note for WG review.

Backup