WHSS: Charge flip study

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Internal
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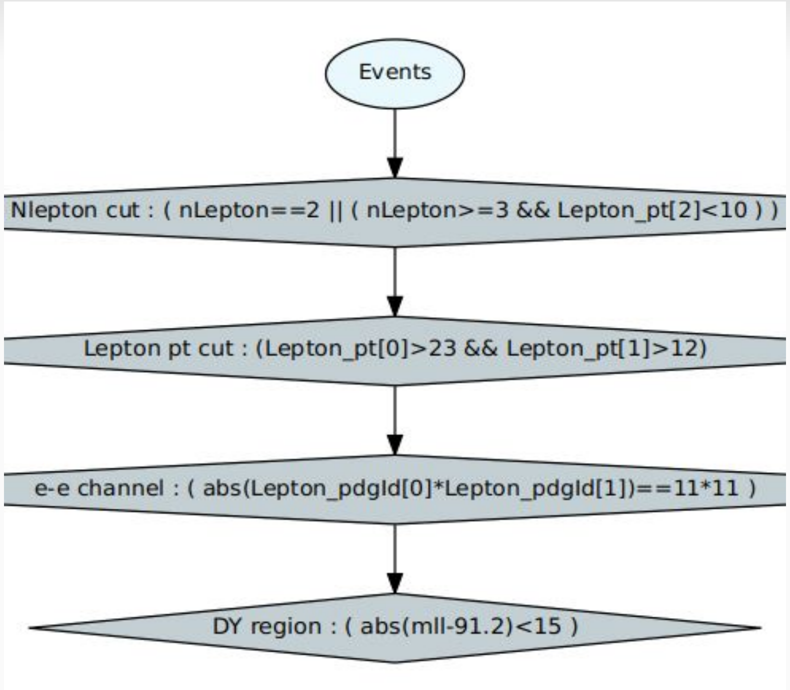
Introduction

- Charge flip study workflow:
  - Derivation:
    - Devises e-e enriched DY control region.
    - Remove other EWK backgrounds, elimination by fitting under Z mass peak.
  - Measurement:
    - Taking ratio of SS/OS, assessing Pt/ Eta dependency.
    - Measures ratio of SS/OS in Pt / Eta by fitting to a charge flip probability formula.
  - Validation:
    - Testing on three closure test.
  - Application:
    - Constructing total charge flip probability, apply as a weight on OS backgrounds.

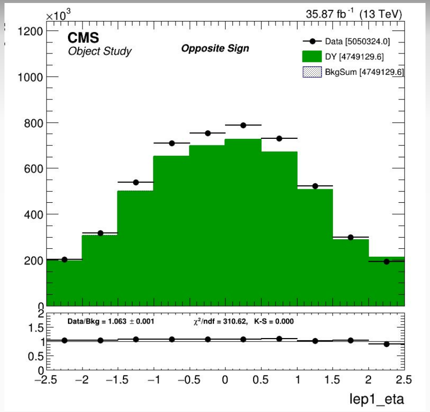
Study setup

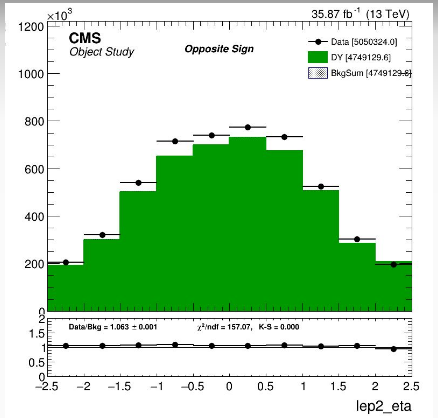
- Dataset Nanov5 for three years:
  - DoubleElectron (dblEl trigger)
  - DY (M-10-50 ; M-50) (DY ptll correction)
- Lepton WP = HWW + ttHMVA (Roberto's macro)
- Pt bin: lowpt = [15, 20] ; highpt = [20 , 200]
- Eta bin [0 , 1.4 , 2.5]
- Codes

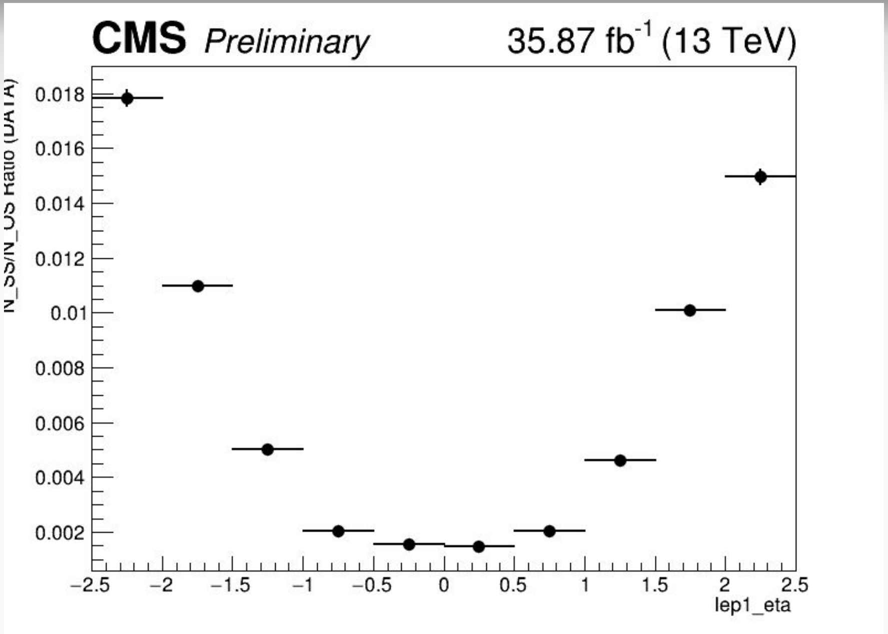


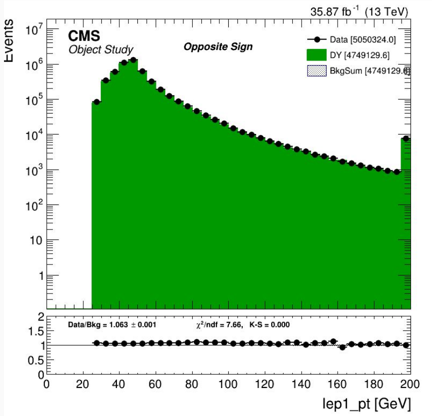
Same flavours region selection

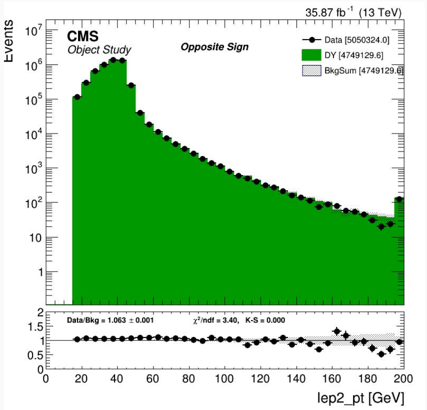
HWW+ttHMVA WP validation 2016





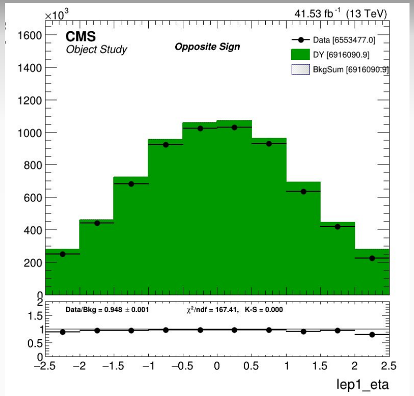


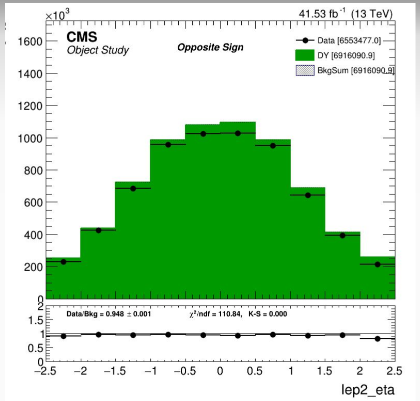


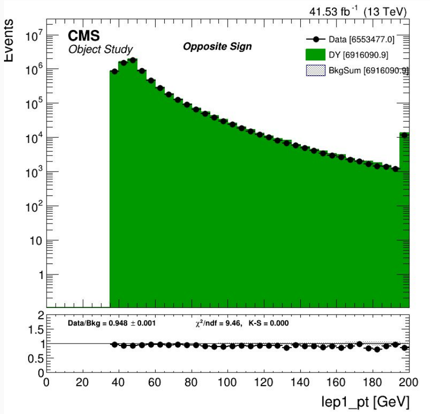


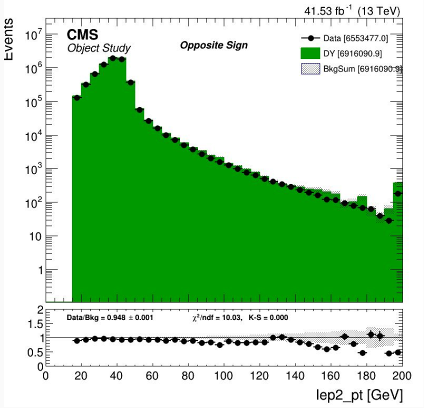
- N_SS / N_OS ratio , shows chare flip occurs often at high eta.

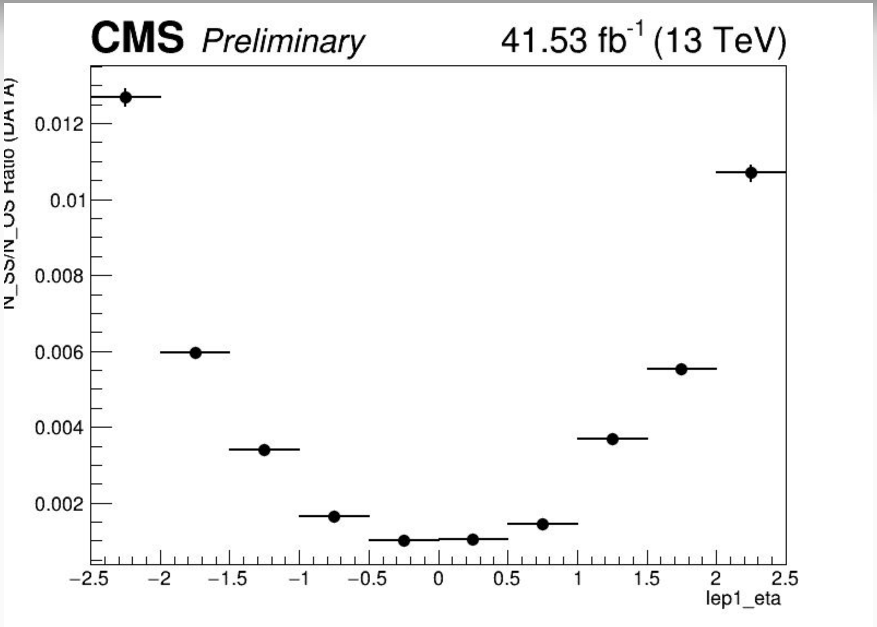
HWW+ttHMVA WP validation 2017





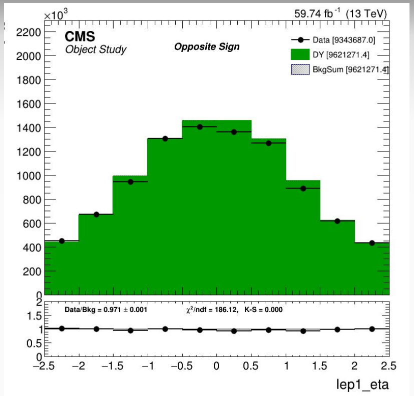


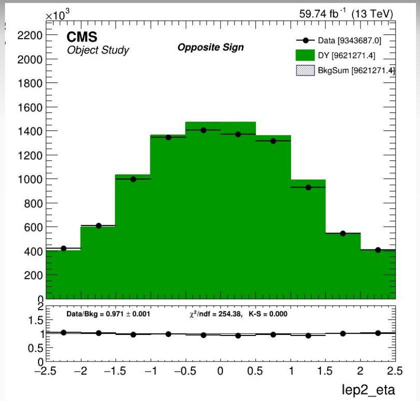


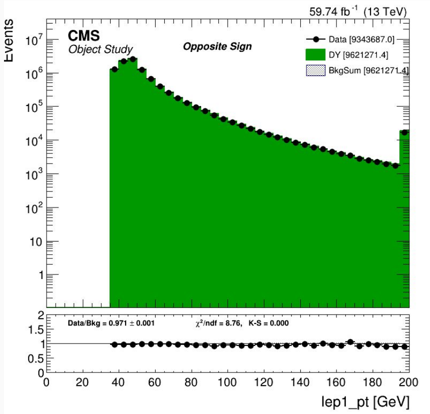


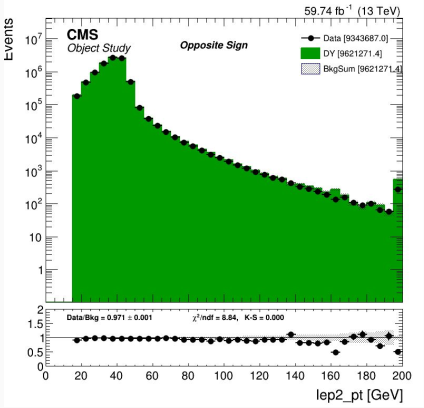
- N_SS / N_OS ratio , shows chare flip occurs often at high eta.

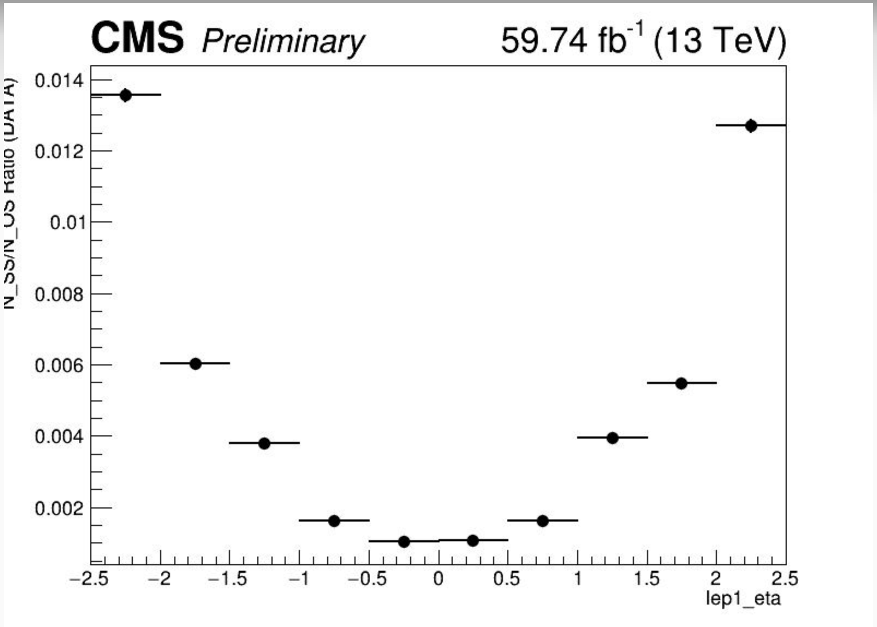
HWW+ttHMVA WP validation 2018





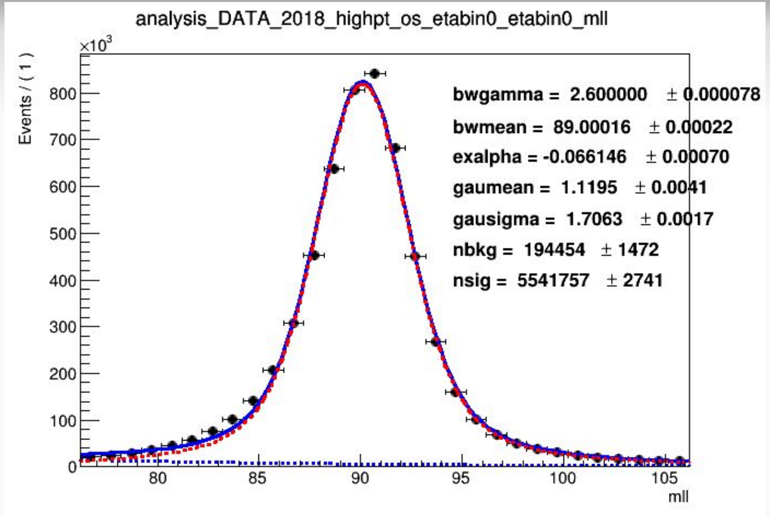




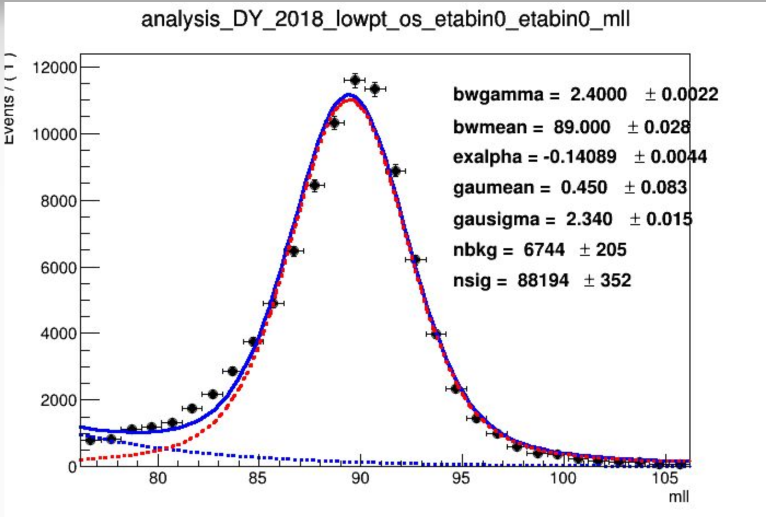


- N_SS / N_OS ratio , shows chare flip occurs often at high eta.

Fitting to Zmass



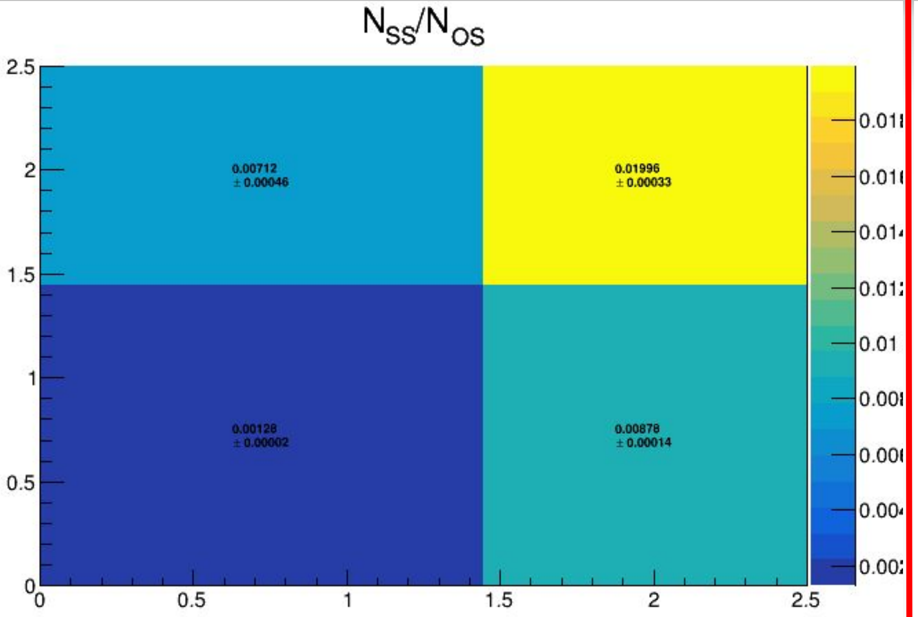
highpt



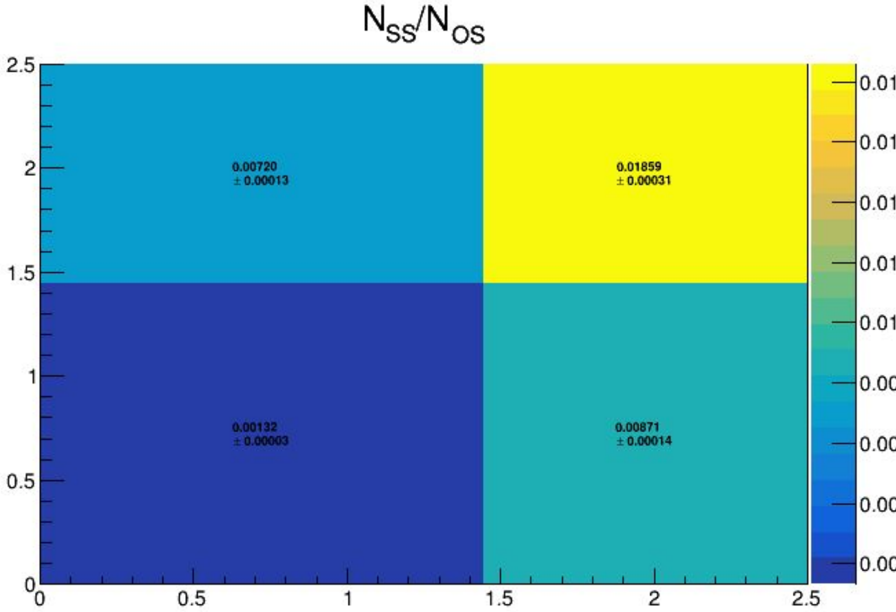
lowpt

Fit to the Zmass template to estimate the number of signal and backgrounds. The signal events will be taken for compute ratio N_ss/N_os

2016 Ratio N_SS / N_OS (Highpt)

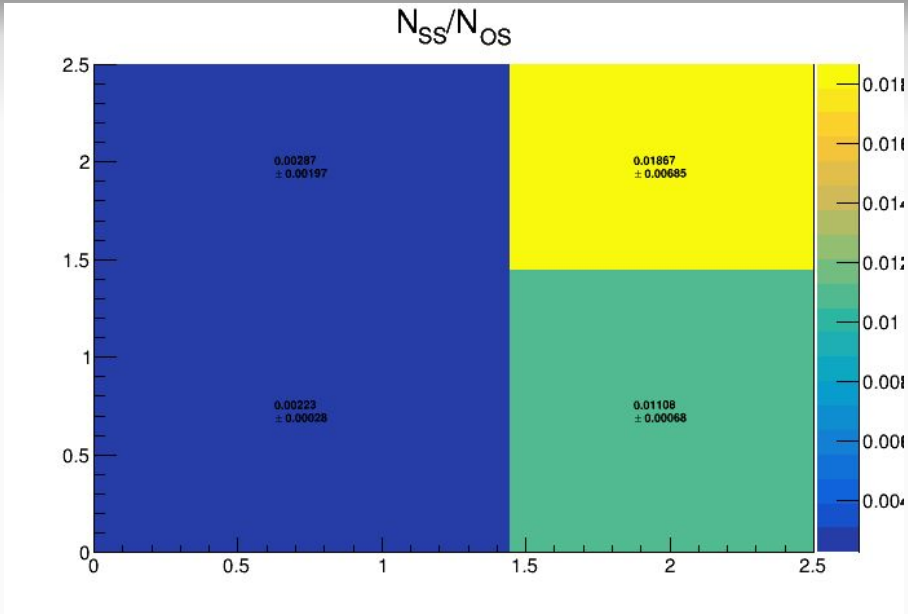


2016 Highpt , DATA

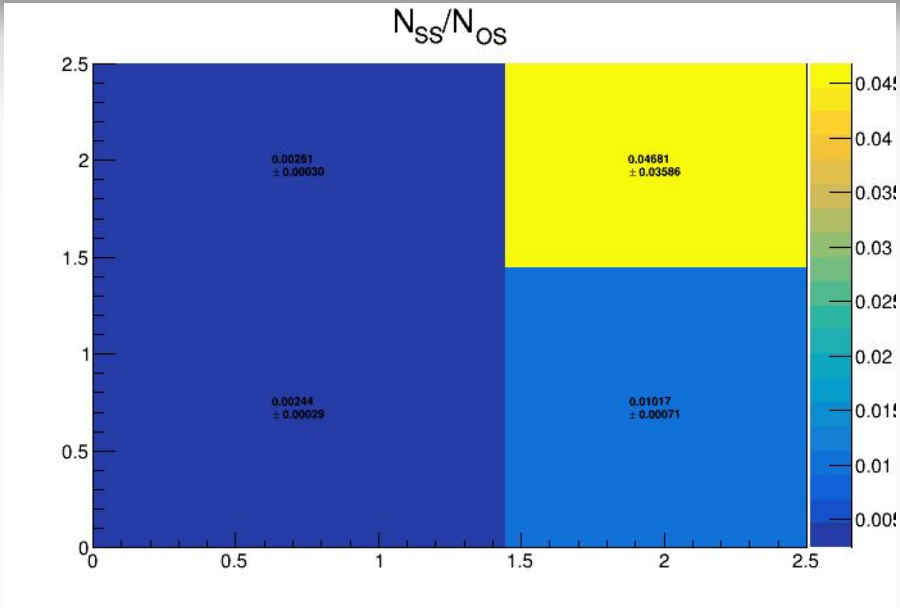


2016 Highpt , MC

2016 Ratio N_SS / N_OS (Lowpt)



2016 Lowpt , DATA



2016 Lowpt , MC

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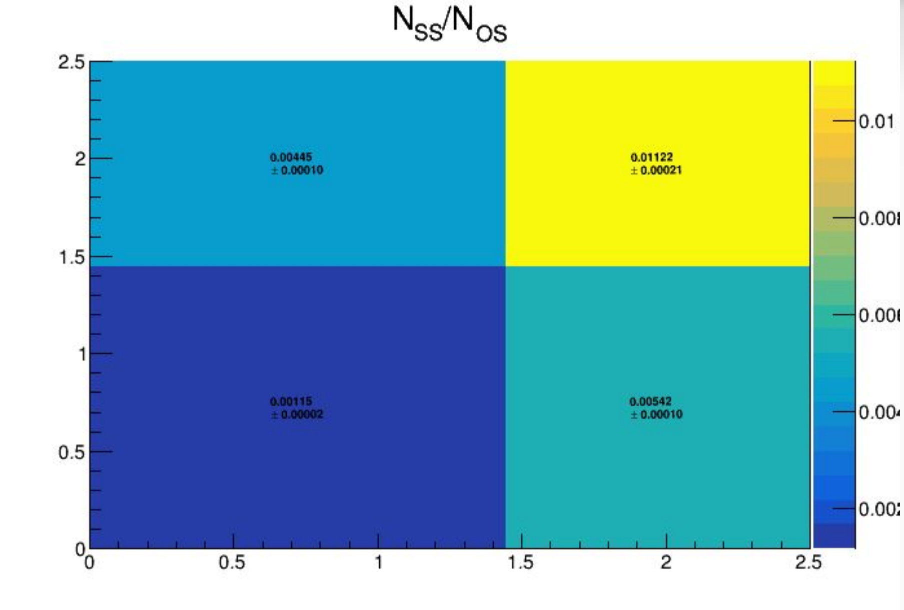
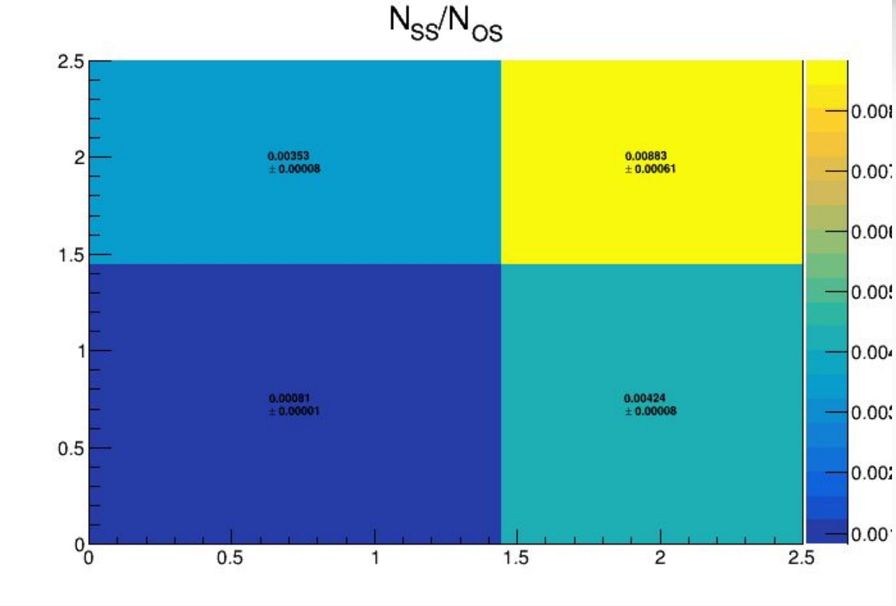


2017 Highpt , DATA



2017 Highpt , MC

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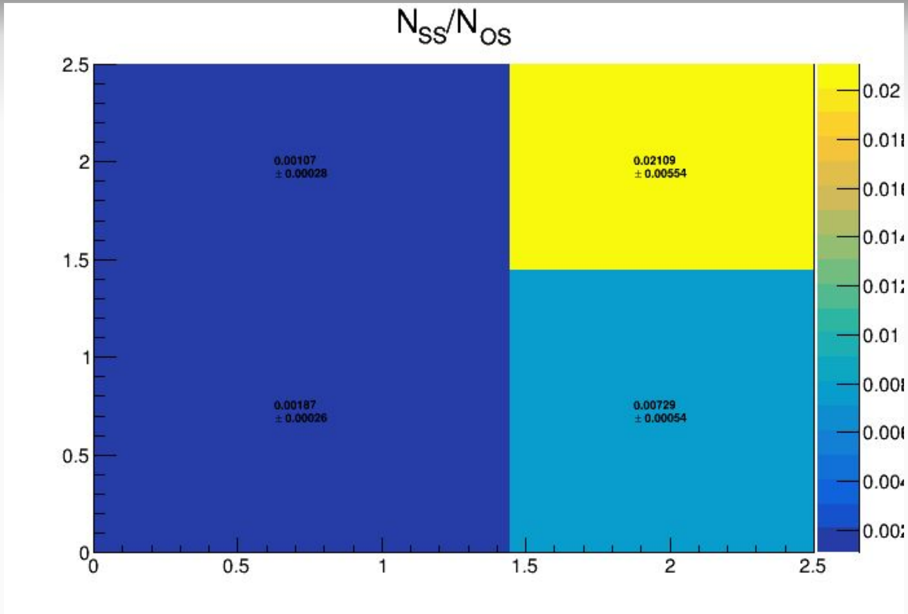
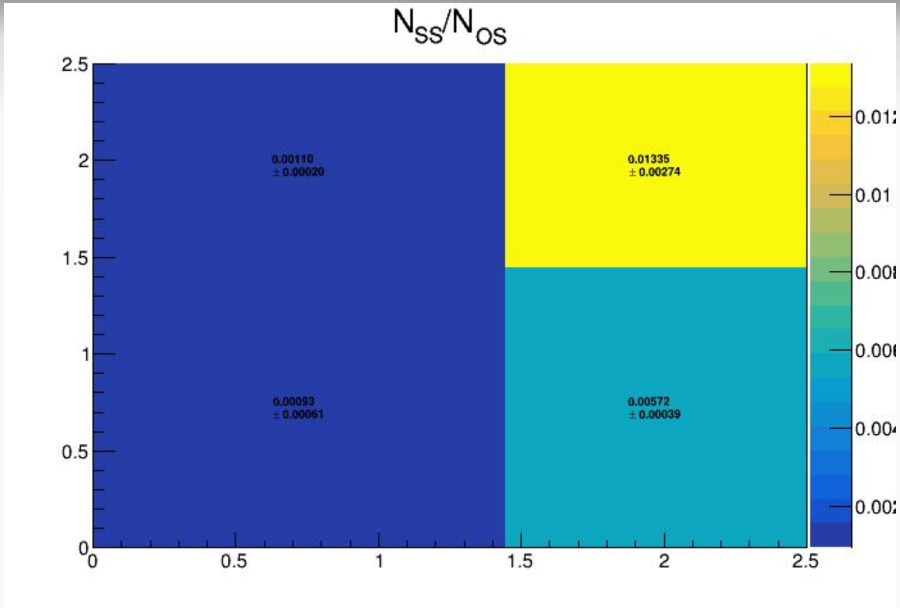
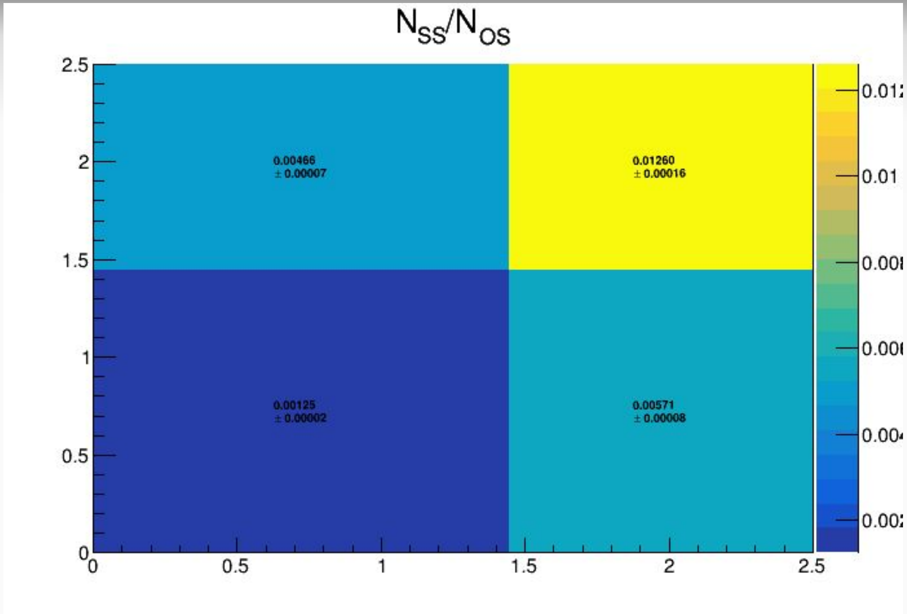


2017 Lowpt , DATA

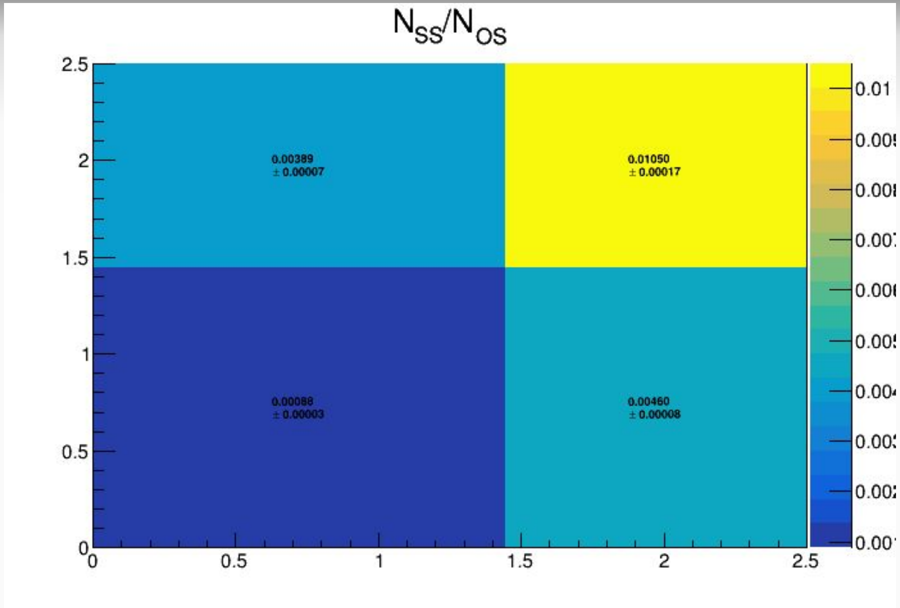


2017 Lowpt , MC

2018 Ratio N_SS / N_OS (Highpt)

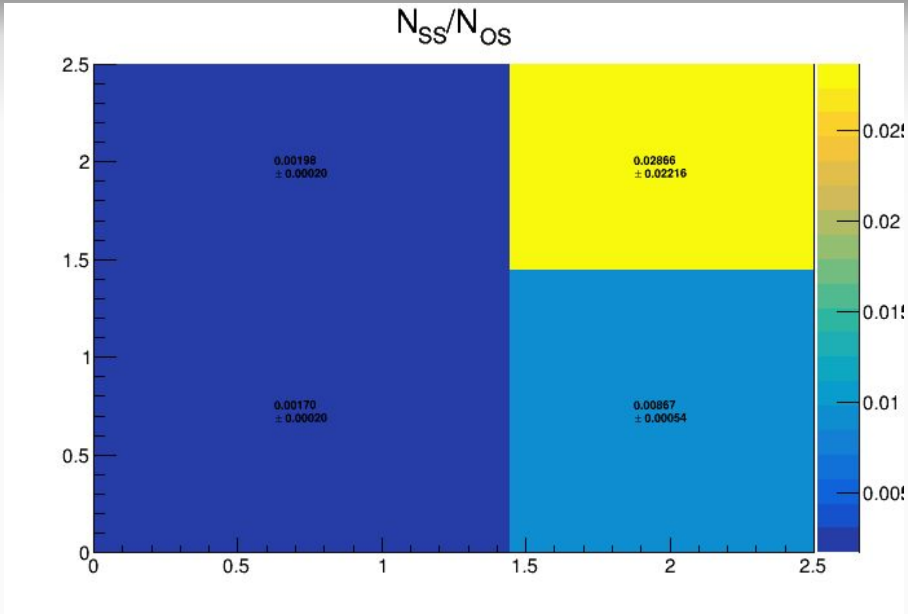


2018 Highpt , DATA

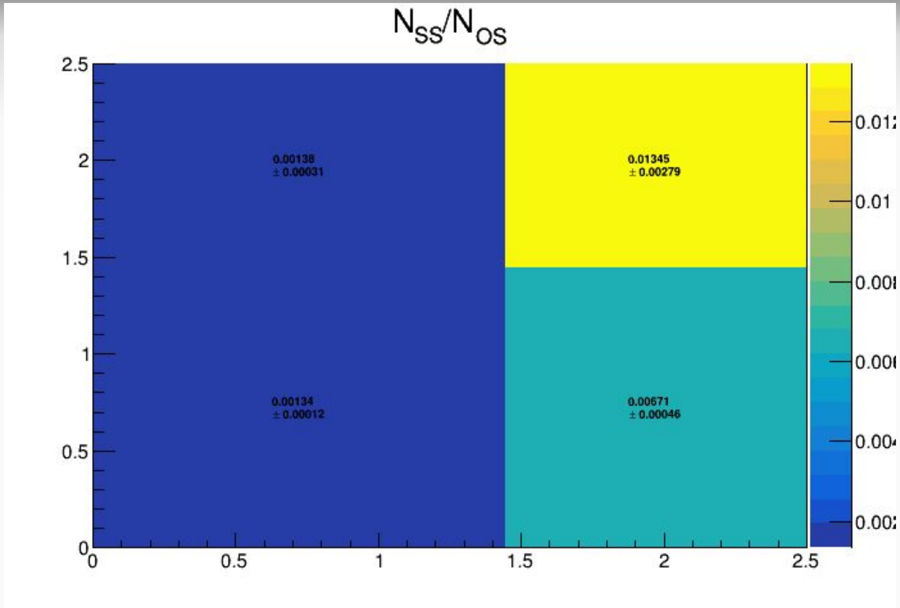


2018 Highpt , MC

2018 Ratio N_SS / N_OS (Lowpt)



2018 Lowpt , DATA

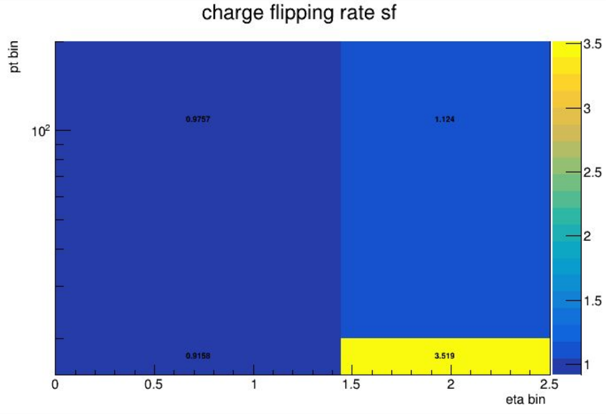


2018 Lowpt , MC

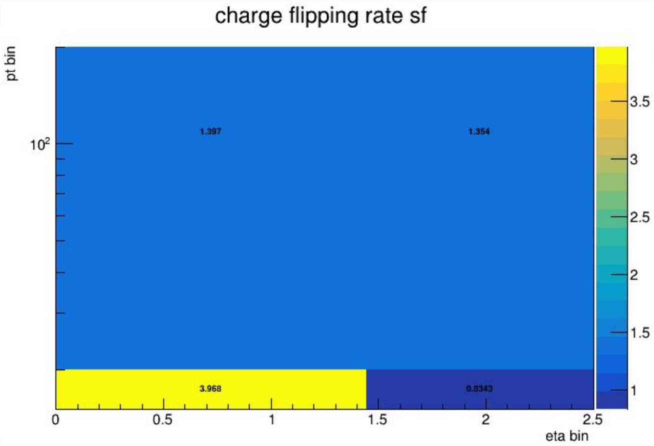
Charge flip probability and SF

- Charge flip probabilities are extracted by fitting to the model, with pt, eta information of the two electrons:

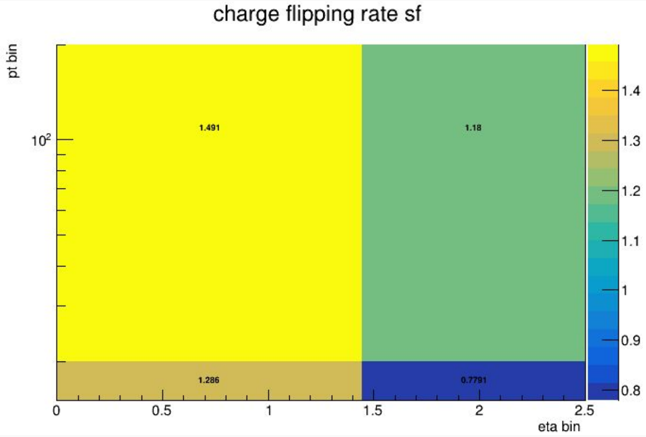
$$\frac{N_{SS}}{N_{OS}} = \frac{\epsilon(p_T^{(1)}, |\eta^{(1)}|) \cdot (1 - \epsilon(p_T^{(2)}, |\eta^{(2)}|)) + \epsilon(p_T^{(2)}, |\eta^{(2)}|) \cdot (1 - \epsilon(p_T^{(1)}, |\eta^{(1)}|))}{1 - [\epsilon(p_T^{(1)}, |\eta^{(1)}|) \cdot (1 - \epsilon(p_T^{(2)}, |\eta^{(2)}|)) + \epsilon(p_T^{(2)}, |\eta^{(2)}|) \cdot (1 - \epsilon(p_T^{(1)}, |\eta^{(1)}|))]}$$



2016



2017



2018

Charge flip probability and SF

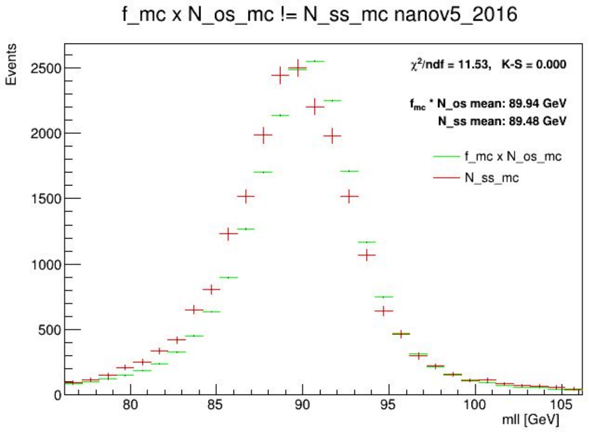
High pt

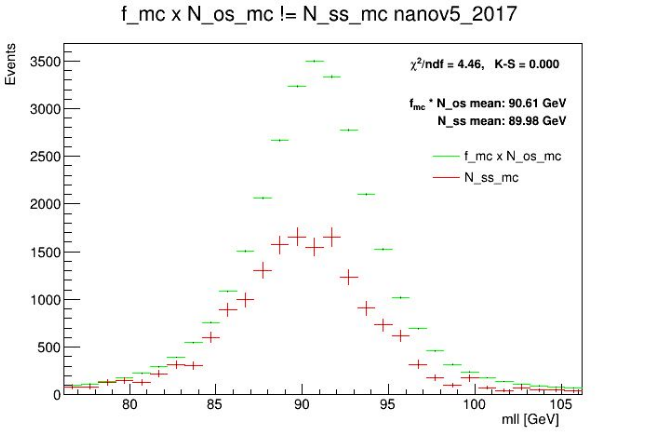
```
 ===> scale factor DATA/MC for 2016
q0 data : 6.316e-04 +/- 1.189e-05 ; mc : 6.473e-04 +/- 1.275e-05 ; SF : 9.757e-01 +/- 2.724e-02 ( rel.error : 2.79 % )
q1 data : 8.716e-03 +/- 1.042e-04 ; mc : 7.753e-03 +/- 7.931e-05 ; SF : 1.124e+00 +/- 1.573e-02 ( rel.error : 1.40 % )
 ===> scale factor DATA/MC for 2017
q0 data : 5.686e-04 +/- 1.026e-05 ; mc : 4.069e-04 +/- 6.365e-06 ; SF : 1.397e+00 +/- 2.388e-02 ( rel.error : 1.71 % )
q1 data : 4.749e-03 +/- 5.935e-05 ; mc : 3.508e-03 +/- 5.777e-05 ; SF : 1.354e+00 +/- 2.067e-02 ( rel.error : 1.53 % )
 ===> scale factor DATA/MC for 2018
q0 data : 6.131e-04 +/- 8.171e-06 ; mc : 4.112e-04 +/- 1.433e-05 ; SF : 1.491e+00 +/- 3.732e-02 ( rel.error : 2.50 % )
q1 data : 4.951e-03 +/- 4.348e-05 ; mc : 4.197e-03 +/- 4.626e-05 ; SF : 1.180e+00 +/- 1.409e-02 ( rel.error : 1.19 % )
```

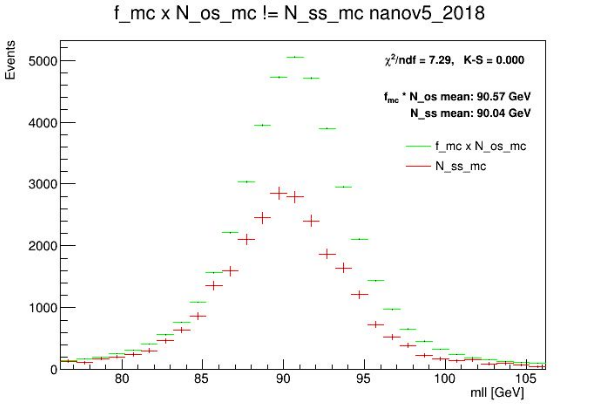
Low pt

```
 ===> scale factor DATA/MC for 2016
q0 data : 1.114e-03 +/- 1.386e-04 ; mc : 1.216e-03 +/- 1.447e-04 ; SF : 9.158e-01 +/- 1.722e-01 ( rel.error : 18.80 % )
q1 data : 9.033e-03 +/- 6.305e-04 ; mc : 2.567e-03 +/- 3.129e-04 ; SF : 3.519e+00 +/- 1.405e-01 ( rel.error : 3.99 % )
 ===> scale factor DATA/MC for 2017
q0 data : 9.134e-04 +/- 1.308e-04 ; mc : 2.302e-04 +/- 2.966e-04 ; SF : 3.968e+00 +/- 1.297e+00 ( rel.error : 32.67 % )
q1 data : 1.572e-03 +/- 2.801e-04 ; mc : 1.884e-03 +/- 3.392e-04 ; SF : 8.343e-01 +/- 2.533e-01 ( rel.error : 30.36 % )
 ===> scale factor DATA/MC for 2018
q0 data : 8.488e-04 +/- 1.015e-04 ; mc : 6.600e-04 +/- 6.098e-05 ; SF : 1.286e+00 +/- 1.511e-01 ( rel.error : 11.75 % )
q1 data : 1.931e-03 +/- 2.109e-04 ; mc : 2.478e-03 +/- 2.575e-04 ; SF : 7.791e-01 +/- 1.508e-01 ( rel.error : 19.35 % )
```

Charge flip weight validation







$$
\begin{aligned}
N_{SS} &= \frac{\epsilon_{(Data)}(l_1)\cdot(1-\epsilon_{(Data)}(l_2))+\epsilon_{(Data)}(l_2)\cdot(1-\epsilon_{(Data)}(l_1))}{1-\sum\limits_{\forall events\in MC}[\epsilon_{(MC)}(l_1)\cdot(1-\epsilon_{(MC)}(l_2))+\epsilon_{(MC)}(l_2)\cdot(1-\epsilon_{(MC)}(l_1))]}\cdot N_{OS} \\
&= \frac{\epsilon_{(Data)}(l_1)\cdot(1-\epsilon_{(Data)}(l_2))+\epsilon_{(Data)}(l_2)\cdot(1-\epsilon_{(Data)}(l_1))}{1-\frac{N_{SS}^{(MC)}}{N_{OS}^{(MC)}+N_{SS}^{(MC)}}}\cdot N_{OS} \\
&\approx [\epsilon_{(Data)}(l_1)\cdot(1-\epsilon_{(Data)}(l_2))+\epsilon_{(Data)}(l_2)\cdot(1-\epsilon_{(Data)}(l_1))]\cdot N_{OS}
\end{aligned}
$$

- Construct flip weights (f_{mc}) with charge flip probabilities computed from MC.
- F_{mc} x N_{OS} is to compare to N_SS (DATA).
- The correction shows shift to be near to the Zmass pole.

The denominator shows to be ~ 1