Unfolding for counting experiments

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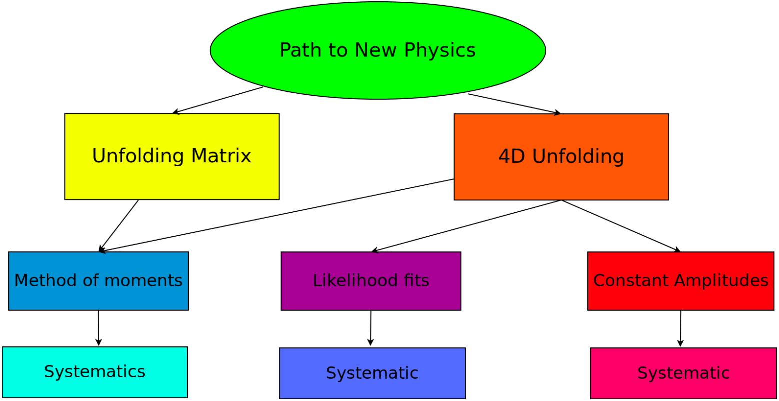
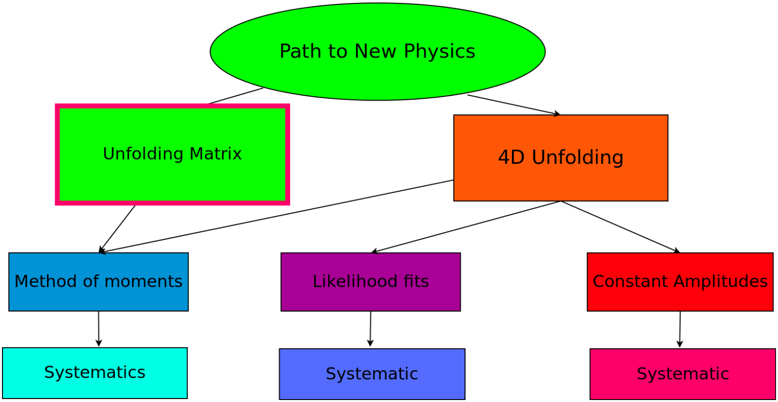
Quo vadis $B^0 \to K^*\mu\mu$?



Quo vadis $\mathbf{B^0} \to \mathbf{K}^*\mu\mu$?



4D unfolding

- Method of moments can use 2 different unfolding techniques.
- One of them is Christophs 4D unfolding
- Easy peasy:

$$\widehat{x} = \sum_i^n = \frac{f(\theta_{li}, \theta_{ki}, \phi_i)}{n} \rightarrow \frac{f(\theta_{li}, \theta_{ki}, \phi_i) \times w_i}{\sum_j^n w_j} \quad (1)$$

Very easy and has proved to work. See presentation LINK

Matrix unfolding

- Our PDF is a vector in 8 dim space, where the dimensions are: f_x[1]
- Our acceptance is a function:

$$\epsilon(\cos\theta_k, \cos\theta_l, \phi) \tag{2}$$

- We assume it's a smooth function(C^{∞}).
- Normal moments:

$$M_x = \int PDF \times f_x \rightarrow \overline{M_x} = \int PDF \times f_x \times \epsilon(\cos\theta_k, \cos\theta_l, \phi) \tag{3}$$

- Let's play Christophs trick:

$$\epsilon(\cos\theta_k, \cos\theta_l, \phi) = \sum A_{\alpha,\beta,\gamma} \cos^{\alpha}\theta_k \cos^{\beta}\theta_l \phi^{\gamma} \tag{4}$$

[1]See 1st presentation on Method of moments.

Matrix unfolding

- Our Moments will become:

$$\int PDF \times f_x \times \epsilon(\cos\theta_k, \cos\theta_l, \phi) = \sum A_{\alpha,\beta,\gamma} \int PDF \times f_x \times \cos^{\alpha}\theta_k \cos^{\beta}\theta_l \phi^{\gamma} \quad (5)$$

- We just need to show that:

$$\int PDF \times f_x \times \cos^{\alpha}\theta_k \cos^{\beta}\theta_l \phi^{\gamma} = \sum_y B_y \int PDF \times f_y = \sum_y B_y \, M_y \quad (6)$$

- This is a bit nasty but doable, using Mathematica. You just need to check 8 base functions.
- As expected it's is linear terms.
- I also checked this using analytical calculations.

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Constructing Matrix unfolding

- Ok, so we know that the matrix exists.
- How ever we don't know explicate

$$\epsilon(\cos\theta_k, \cos\theta_l, \phi) \quad (7)$$

- We don't, we just need to calculate matrix elements
- Let's use PHSP MC.
- Moments for PHSP MC are: $v_{gen}^T = (2/3, 0, 0, 0, 0, 0, 0, 0)$
- After reconstruction we get: $v_{rec}^T = (0.7069, 0.0077, -0.00236466, 0.0005, 0.0007, 0.0011, 0.0011, -0.0012)$

Constructing Matrix unfolding

- We got first column of the unfolding matrix.

$$\begin{pmatrix} 1.06 & \cdots & a_{1,8} \\ 0.01157 & \cdots & a_{2,8} \\ -0.003547 & \ddots & \vdots \\ 0.0007841 & \ddots & \vdots \\ 0.001126 & \ddots & \vdots \\ 0.001766 & \ddots & \vdots \\ 0.001664 & \ddots & \vdots \\ -0.001937 & \cdots & a_{8,8} \end{pmatrix}$$

- How about the others?
- We can reweight accordingly to f_x.

Constructing Matrix unfolding

- To get S_3 each event i^{th} has has weight $f_{S_3}(\cos\theta_{k_i}, \cos\theta_{l_i}, \phi_i)$
- One can calculate on MC the reweighed moments in PHPS:

$$\int PDF * f_{S_3} = \frac{32}{225} \quad (8)$$

- Our base vector now is:$v_{gen}^T = (0, \frac{32}{225}, 0, 0, 0, 0, 0, 0)$
- So lets see what do we get as reconstructed vector(after multiplying by $\frac{225}{32}$. $v_{rec}^T =$ $(0.042, 1.105, -0.005, 0.003, -0.0023, -0.005, -0.005, -0.006)$

Constructing Matrix unfolding

- Now the matrix looks like:

$$\begin{pmatrix} 1.06 & 0.042 & \cdots & a_{1,8} \\ 0.01157 & 1.105 & \cdots & a_{2,8} \\ -0.003547 & -0.005 & \ddots & \vdots \\ 0.0007841 & -0.005 & \ddots & \vdots \\ 0.001126 & 0.003 & \ddots & \vdots \\ 0.001766 & -0.0023 & \ddots & \vdots \\ 0.001664 & -0.005 & \ddots & \vdots \\ -0.001937 & -0.006 & \cdots & a_{8,8} \end{pmatrix}$$

- The others go in the same way.
- Repenting this exercise from 1^{st} year algebra we can get the full matrix

Constructing Matrix unfolding

- The full transformation matrix from generator space to reconstructed space:

$$A_{gen\rightarrow reco} = \begin{pmatrix} 1.06 & 0.0423 & -0.0081 & 0.0022 & 0.0049 & 0.0037 & 0.0028 & -0.0065 \\ 0.0115 & 1.105 & -0.0050 & 0.0027 & -0.0018 & -0.0040 & -0.0054 & -0.0065 \\ -0.0035 & -0.0050 & 0.981 & 0.0005 & -0.0025 & 0.0002 & -0.0037 & -0.0048 \\ 0.00078 & 0.0034 & 0.0006 & 1.002 & -0.0032 & -0.0040 & 0.0003 & 0.0018 \\ 0.001126 & -0.0023 & -0.0032 & -0.0032 & 1.055 & 0.001 & -0.004 & 0.0023 \\ 0.00176 & -0.0050 & 0.00036 & -0.0040 & 0.0011 & 0.96 & -0.0057 & 0.0009 \\ 0.0016 & -0.005 & -0.003 & 0.00029 & -0.003 & -0.004 & 0.9543 & 0.0000 \\ -0.0019 & -0.0065 & -0.004 & 0.001 & 0.0018 & 0.0007 & 0.000 & 1.098 \end{pmatrix}$$

- Inverting the matrix is simple, and doable

$$A_{reco\rightarrow gen} = \begin{pmatrix} 0.9434 & -0.036 & 0.007 & -0.0020 & -0.0044 & -0.0038 & -0.0030 & 0.0054 \\ -0.009 & 0.90 & 0.0045 & -0.0024 & 0.0016 & 0.003873 & 0.00527 & 0.005 \\ 0.003 & 0.00454 & 1.019 & -0.00058 & 0.0025 & -0.000291 & 0.004 & 0.004 \\ -0.00071 & -0.0030 & -0.0007 & 0.9977 & 0.0030 & 0.004206 & -0.0003 & -0.0017 \\ -0.001 & 0.0020 & 0.0031 & 0.0030 & 0.9483 & -0.0010 & 0.004626 & -0.0019 \\ -0.001 & 0.004 & -0.0003 & 0.0042 & -0.001087 & 1.037 & 0.0063 & -0.0009 \\ -0.0017 & 0.0053 & 0.0042 & -0.0002 & 0.00370 & 0.0050 & 1.048 & 0.0000 \\ 0.0016 & 0.0053 & 0.00452 & -0.001 & -0.001582 & -0.0007213 & 0.000 & 0.9105 \end{pmatrix}$$

Sensitivity to unknowns

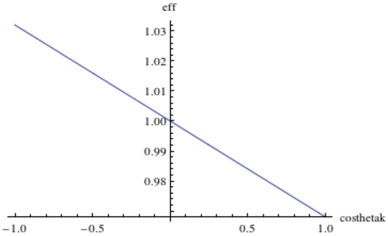
- We are unfolding based on MC.
- There are MC/Data differences, which can have impact on the unfolding.

Let's put small modification:

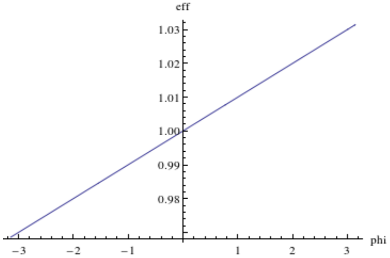
$$w_j \rightarrow \overline{w_j} = \frac{1}{eff(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j)} \times corr(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j) \quad (9)$$

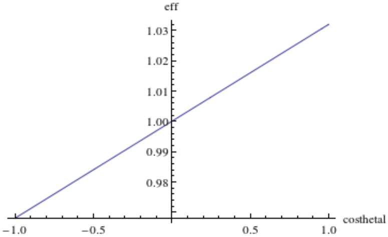
Unfortunately God didn't allowed me sneak peak into his cards so I don't know $corr(\cos\theta_l, \cos\theta_k, \phi)$, but let's try out some functions and see what happens :)

Corr1 functions



$$corr1(\cos_l, \cos_k, \phi) =$$
$$1 + 0.032\cos_l - 0.032\cos_k + 0.01\phi$$





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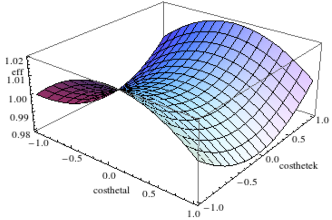
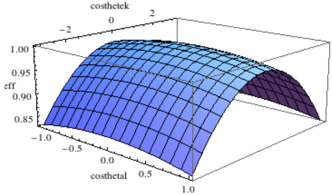
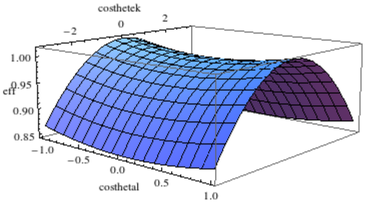
Corr2 functions

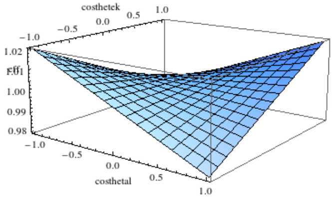


$$corr2(\cos_l, \cos_k, \phi) =$$
$$-0.02\cos_l^2 + 0.02\cos_k^2 - 0.015\phi^2 + 1$$

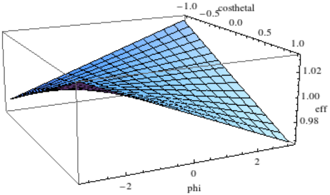


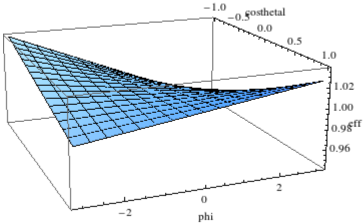


Corr3 functions

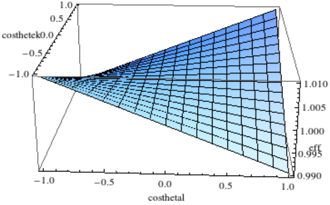


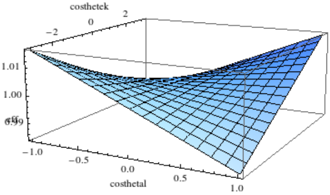
$$corr3(\cos_l, \cos_k, \phi) = 0.02 \cos_l \cos_k + 0.01 \cos_k \phi - 0.01 \phi \cos_l + 1$$



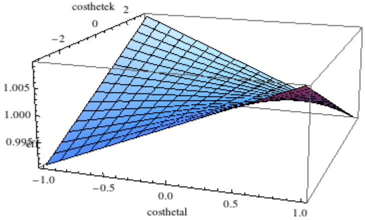


Corr4 functions





$corr3(\cos_l, \cos_k, \phi) =$
$0.01 \cos_k \cos_l \phi + 1$



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Corr1- MM

Mean of the pull							
q^2	S_3	S_4	S_5	S_{6s}	S_{6c}	S_7	S_8
0	$0.0085 \pm 0.026(0.3)$	$0.13 \pm 0.027(4.6)$	$-0.025 \pm 0.027(-0.92)$	$0.46 \pm 0.027(17)$	$-0.13 \pm 0.028(-4.7)$	$0.029 \pm 0.028(1)$	$-0.66 \pm 0.027(-25)$
1	$0.0094 \pm 0.028(0.33)$	$0.078 \pm 0.028(2.8)$	$-0.02 \pm 0.028(-0.73)$	$0.24 \pm 0.028(8.5)$	$-0.075 \pm 0.028(-2.7)$	$-0.016 \pm 0.026(-0.63)$	$-0.39 \pm 0.028(-14)$
2	$-0.02 \pm 0.027(-0.72)$	$0.027 \pm 0.026(1)$	$-0.024 \pm 0.027(-0.91)$	$0.18 \pm 0.027(6.8)$	$-0.024 \pm 0.027(-0.89)$	$-0.067 \pm 0.027(-2.5)$	$-0.39 \pm 0.028(-14)$
3	$0.013 \pm 0.028(0.46)$	$-0.0089 \pm 0.027(-0.32)$	$0.055 \pm 0.026(2.1)$	$0.12 \pm 0.027(4.7)$	$0.11 \pm 0.027(3.9)$	$-0.018 \pm 0.028(-0.63)$	$-0.43 \pm 0.027(-16)$
4	$-0.0054 \pm 0.029(-0.18)$	$-0.066 \pm 0.027(-2.4)$	$0.037 \pm 0.028(1.3)$	$0.22 \pm 0.027(8.1)$	$0.099 \pm 0.027(3.7)$	$-0.1 \pm 0.026(-3.8)$	$-0.41 \pm 0.026(-15)$
5	$0.06 \pm 0.027(2.2)$	$-0.069 \pm 0.026(-2.6)$	$-0.013 \pm 0.028(-0.49)$	$0.21 \pm 0.027(7.8)$	$0.093 \pm 0.027(3.5)$	$-0.083 \pm 0.028(-3)$	$-0.41 \pm 0.028(-15)$
6	$0.0064 \pm 0.026(0.25)$	$-0.051 \pm 0.027(-1.9)$	$-0.029 \pm 0.028(-1)$	$0.26 \pm 0.028(9.2)$	$0.14 \pm 0.027(5.1)$	$-0.081 \pm 0.027(-3)$	$-0.45 \pm 0.028(-16)$
8	$0.023 \pm 0.027(0.85)$	$-0.031 \pm 0.028(-1.1)$	$0.0042 \pm 0.028(0.15)$	$0.21 \pm 0.026(7.8)$	$0.12 \pm 0.028(4.2)$	$-0.13 \pm 0.027(-4.8)$	$-0.48 \pm 0.026(-18)$
9	$-0.017 \pm 0.027(-0.63)$	$-0.015 \pm 0.026(-0.56)$	$-0.0052 \pm 0.026(-0.2)$	$0.27 \pm 0.027(10)$	$0.046 \pm 0.026(1.7)$	$-0.12 \pm 0.026(-4.4)$	$-0.5 \pm 0.026(-19)$
10	$-0.054 \pm 0.027(-2)$	$-0.056 \pm 0.026(-2.2)$	$0.036 \pm 0.026(1.4)$	$0.16 \pm 0.028(5.7)$	$0.077 \pm 0.028(2.8)$	$-0.034 \pm 0.027(-1.3)$	$-0.39 \pm 0.028(-14)$
11	$0.023 \pm 0.027(0.88)$	$0.021 \pm 0.027(0.8)$	$-0.011 \pm 0.027(-0.41)$	$0.14 \pm 0.027(5)$	$0.042 \pm 0.027(1.6)$	$-0.098 \pm 0.028(-3.5)$	$-0.3 \pm 0.027(-11)$

Corr2- MM

Mean of the pull							
q^2	S_3	S_4	S_5	S_{6s}	S_{6c}	S_7	S_8
0	$-0.21 \pm 0.026(-8.1)$	$0.061 \pm 0.026(2.3)$	$-0.016 \pm 0.026(-0.63)$	$0.048 \pm 0.026(1.8)$	$-0.0062 \pm 0.027(-0.23)$	$-0.012 \pm 0.028(-0.44)$	$0.0091 \pm 0.026(0.36)$
1	$-0.12 \pm 0.028(-4.5)$	$0.032 \pm 0.027(1.2)$	$-0.0071 \pm 0.026(-0.27)$	$0.02 \pm 0.027(0.75)$	$-0.086 \pm 0.027(-3.2)$	$-0.03 \pm 0.025(-1.2)$	$0.021 \pm 0.027(0.79)$
2	$-0.15 \pm 0.027(-5.8)$	$-0.013 \pm 0.026(-0.49)$	$0.011 \pm 0.026(0.44)$	$-0.039 \pm 0.026(-1.5)$	$-0.032 \pm 0.027(-1.2)$	$-0.066 \pm 0.027(-2.5)$	$0.018 \pm 0.028(0.64)$
3	$-0.15 \pm 0.027(-5.6)$	$0.025 \pm 0.026(0.96)$	$0.016 \pm 0.027(0.58)$	$-0.062 \pm 0.027(-2.3)$	$0.037 \pm 0.026(1.4)$	$0.026 \pm 0.027(0.96)$	$-0.016 \pm 0.027(-0.$
4	$-0.12 \pm 0.028(-4.5)$	$-0.024 \pm 0.026(-0.92)$	$0.045 \pm 0.027(1.6)$	$0.0075 \pm 0.026(0.29)$	$0.015 \pm 0.027(0.53)$	$-0.036 \pm 0.026(-1.4)$	$0.037 \pm 0.026(1.4)$
5	$-0.095 \pm 0.027(-3.6)$	$-0.032 \pm 0.026(-1.2)$	$0.014 \pm 0.026(0.52)$	$-0.013 \pm 0.026(-0.48)$	$-0.0093 \pm 0.027(-0.35)$	$-0.013 \pm 0.026(-0.51)$	$0.042 \pm 0.027(1.6)$
6	$-0.17 \pm 0.025(-6.5)$	$0.008 \pm 0.027(0.3)$	$0.012 \pm 0.027(0.45)$	$0.029 \pm 0.027(1.1)$	$0.0072 \pm 0.027(0.27)$	$-0.0012 \pm 0.026(-0.046)$	$0.011 \pm 0.027(0.42)$
8	$-0.13 \pm 0.026(-5.1)$	$-0.0077 \pm 0.027(-0.28)$	$0.05 \pm 0.027(1.9)$	$-0.03 \pm 0.026(-1.2)$	$-0.012 \pm 0.028(-0.44)$	$-0.046 \pm 0.026(-1.7)$	$0.031 \pm 0.026(1.2)$
9	$-0.15 \pm 0.026(-5.7)$	$-0.0083 \pm 0.026(-0.32)$	$0.03 \pm 0.026(1.2)$	$0.044 \pm 0.027(1.6)$	$-0.07 \pm 0.026(-2.7)$	$-0.022 \pm 0.026(-0.84)$	$-0.045 \pm 0.026(-1.$
10	$-0.15 \pm 0.025(-5.8)$	$-0.032 \pm 0.025(-1.3)$	$0.059 \pm 0.026(2.2)$	$-0.072 \pm 0.028(-2.6)$	$-0.029 \pm 0.027(-1.1)$	$0.064 \pm 0.027(2.4)$	$0.014 \pm 0.027(0.51)$
11	$-0.067 \pm 0.026(-2.6)$	$0.017 \pm 0.026(0.65)$	$-0.015 \pm 0.026(-0.56)$	$-0.051 \pm 0.026(-1.9)$	$-0.0086 \pm 0.026(-0.33)$	$-0.018 \pm 0.028(-0.67)$	$0.017 \pm 0.027(0.62)$

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Corr3- MM

Mean of the pull							
q^2	S_3	S_4	S_5	S_{6s}	S_{6c}	S_7	S_8
0	$-0.021 \pm 0.026(-0.81)$	$0.041 \pm 0.026(1.5)$	$0.009 \pm 0.027(0.34)$	$0.043 \pm 0.026(1.6)$	$0.13 \pm 0.028(4.8)$	$-0.0072 \pm 0.028(-0.26)$	$0.044 \pm 0.026(1.7)$
1	$-0.014 \pm 0.028(-0.51)$	$0.03 \pm 0.027(1.1)$	$0.022 \pm 0.027(0.82)$	$0.015 \pm 0.028(0.53)$	$0.078 \pm 0.028(2.8)$	$-0.037 \pm 0.025(-1.4)$	$0.057 \pm 0.027(2.1)$
2	$-0.037 \pm 0.027(-1.4)$	$-0.0013 \pm 0.027(-0.048)$	$-0.015 \pm 0.027(-0.54)$	$-0.052 \pm 0.026(-2)$	$0.1 \pm 0.027(3.8)$	$-0.051 \pm 0.026(-1.9)$	$0.022 \pm 0.028(0.78)$
3	$-0.015 \pm 0.027(-0.55)$	$0.036 \pm 0.028(1.3)$	$-0.039 \pm 0.027(-1.4)$	$-0.072 \pm 0.027(-2.7)$	$0.17 \pm 0.027(6.2)$	$-0.0044 \pm 0.028(-0.15)$	$-0.024 \pm 0.027(-0.9$
4	$-0.00047 \pm 0.029(-0.017)$	$-0.012 \pm 0.027(-0.43)$	$0.0099 \pm 0.028(0.35)$	$-0.002 \pm 0.026(-0.076)$	$0.17 \pm 0.028(6.2)$	$-0.062 \pm 0.027(-2.3)$	$0.0086 \pm 0.027(0.32)$
5	$0.046 \pm 0.027(1.7)$	$-0.02 \pm 0.026(-0.76)$	$-0.04 \pm 0.027(-1.5)$	$-0.012 \pm 0.027(-0.44)$	$0.13 \pm 0.027(4.8)$	$-0.04 \pm 0.027(-1.5)$	$-0.0056 \pm 0.027(-0.$
6	$-0.013 \pm 0.026(-0.52)$	$0.041 \pm 0.027(1.5)$	$-0.033 \pm 0.028(-1.2)$	$-0.0019 \pm 0.027(-0.068)$	$0.15 \pm 0.027(5.4)$	$-0.034 \pm 0.027(-1.3)$	$-0.021 \pm 0.028(-0.7$
8	$0.039 \pm 0.026(1.5)$	$0.01 \pm 0.028(0.36)$	$-0.027 \pm 0.028(-0.96)$	$-0.024 \pm 0.026(-0.9)$	$0.12 \pm 0.027(4.3)$	$-0.092 \pm 0.026(-3.5)$	$-0.036 \pm 0.027(-1.3$
9	$-0.01 \pm 0.027(-0.38)$	$0.0024 \pm 0.027(0.09)$	$-0.018 \pm 0.026(-0.68)$	$0.022 \pm 0.028(0.79)$	$0.068 \pm 0.027(2.6)$	$-0.069 \pm 0.026(-2.6)$	$-0.078 \pm 0.026(-3)$
10	$-0.017 \pm 0.027(-0.62)$	$-0.015 \pm 0.026(-0.57)$	$0.012 \pm 0.027(0.46)$	$-0.074 \pm 0.028(-2.6)$	$0.1 \pm 0.027(3.8)$	$-0.003 \pm 0.027(-0.11)$	$-0.043 \pm 0.029(-1.5$
11	$0.032 \pm 0.026(1.2)$	$0.024 \pm 0.026(0.91)$	$-0.04 \pm 0.026(-1.5)$	$-0.066 \pm 0.027(-2.5)$	$0.098 \pm 0.027(3.7)$	$-0.043 \pm 0.028(-1.6)$	$-0.0018 \pm 0.028(-0.$

Corr4- MM

Mean of the pull							
q^2	S_3	S_4	S_5	S_{6s}	S_{6c}	S_7	S_8
0	$-0.019 \pm 0.026(-0.71)$	$0.048 \pm 0.027(1.8)$	$0.018 \pm 0.027(0.67)$	$0.059 \pm 0.027(2.2)$	$-0.015 \pm 0.028(-0.55)$	$0.061 \pm 0.027(2.2)$	$0.012 \pm 0.027(0.44)$
1	$-0.014 \pm 0.028(-0.51)$	$0.043 \pm 0.027(1.6)$	$0.013 \pm 0.027(0.49)$	$0.024 \pm 0.028(0.86)$	$-0.038 \pm 0.028(-1.4)$	$0.024 \pm 0.026(0.94)$	$0.037 \pm 0.027(1.3)$
2	$-0.03 \pm 0.027(-1.1)$	$-0.0021 \pm 0.027(-0.076)$	$-0.01 \pm 0.027(-0.39)$	$-0.017 \pm 0.027(-0.61)$	$-0.016 \pm 0.027(-0.58)$	$0.013 \pm 0.027(0.49)$	$0.027 \pm 0.028(0.98)$
3	$-0.007 \pm 0.027(-0.26)$	$0.03 \pm 0.028(1.1)$	$-0.036 \pm 0.027(-1.3)$	$-0.074 \pm 0.027(-2.8)$	$0.041 \pm 0.027(1.5)$	$0.08 \pm 0.028(2.9)$	$-0.0083 \pm 0.027(-0.31$
4	$0.00089 \pm 0.029(0.031)$	$-0.021 \pm 0.027(-0.77)$	$0.0032 \pm 0.028(0.11)$	$0.0031 \pm 0.026(0.12)$	$0.012 \pm 0.027(0.44)$	$0.019 \pm 0.026(0.71)$	$0.034 \pm 0.027(1.3)$
5	$0.044 \pm 0.028(1.6)$	$-0.022 \pm 0.026(-0.82)$	$-0.041 \pm 0.027(-1.5)$	$-0.014 \pm 0.027(-0.53)$	$-0.029 \pm 0.027(-1.1)$	$0.041 \pm 0.027(1.5)$	$0.042 \pm 0.028(1.5)$
6	$-0.011 \pm 0.026(-0.42)$	$0.041 \pm 0.027(1.5)$	$-0.045 \pm 0.028(-1.6)$	$0.011 \pm 0.027(0.41)$	$-0.0089 \pm 0.027(-0.33)$	$0.067 \pm 0.027(2.5)$	$0.036 \pm 0.027(1.3)$
8	$0.05 \pm 0.026(1.9)$	$0.0021 \pm 0.028(0.074)$	$-0.025 \pm 0.028(-0.91)$	$-0.023 \pm 0.026(-0.87)$	$-0.024 \pm 0.028(-0.85)$	$0.022 \pm 0.026(0.82)$	$0.026 \pm 0.026(0.98)$
9	$-0.0064 \pm 0.027(-0.23)$	$0.012 \pm 0.027(0.44)$	$-0.0075 \pm 0.026(-0.28)$	$0.029 \pm 0.027(1.1)$	$-0.087 \pm 0.027(-3.2)$	$0.036 \pm 0.027(1.3)$	$-0.02 \pm 0.026(-0.76)$
10	$-0.019 \pm 0.027(-0.71)$	$-0.0051 \pm 0.025(-0.2)$	$0.0081 \pm 0.026(0.31)$	$-0.077 \pm 0.028(-2.7)$	$-0.03 \pm 0.027(-1.1)$	$0.11 \pm 0.027(4.1)$	$0.013 \pm 0.028(0.46)$
11	$0.027 \pm 0.026(1)$	$0.032 \pm 0.027(1.2)$	$-0.038 \pm 0.027(-1.4)$	$-0.048 \pm 0.026(-1.8)$	$-0.021 \pm 0.027(-0.77)$	$0.019 \pm 0.028(0.69)$	$0.035 \pm 0.027(1.3)$

Reverse Engineering- Corr1

- Let's try to understand if we can understand why this happens:
- Let's calculate what should I expect with the unfolding
- This is up to normalization!
  - $M_5 = 0.4S_5 \rightarrow M_5 = 0.00512S_3 + 0.4S_5 - 0.002S_7$
  - $M_8 = 0.32S_8 \rightarrow M_8 = 0.0016S_4 + 0.00512S_7 + 0.32S_8$
  - $M_7 = 0.4S_7 \rightarrow M_7 = 0.002S_5 + 0.4S_7 + 0.00512S_8$
  - $M_3 = 0.32S_3 \rightarrow M_3 = 0.32S_3 - 0.0008S_9$
- The way you can look at this is that i just shown you how our unfolding matrix works like.

Reverse Engineering- Corr2

- Let's try to understand if we can understand why this happens:
- Let's calculate what should I expect with the unfolding
- This is up to normalization!
  - $M_5 = 0.4S_5 \rightarrow M_5 = 0.4S_5$
  - $M_8 = 0.32S_8 \rightarrow M_8 = 0.32S_5$
  - $M_7 = 0.4S_7 \rightarrow M_7 = 0.4S_7$
  - $M_3 = 0.32S_3 \rightarrow M_3 = -0.0036 + 0.0012FI + 0.32S_3$
- The way you can look at this is that i just shown you how our unfolding matrix works like.

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Summary

- Developed a systematic way how to get Unfolding matrix
- Moments are resistant against variety of unfolding discrepancies.
- This might lead to reduced systematics in the future.