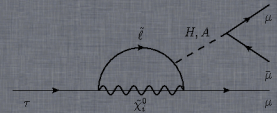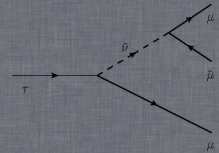# Breaking the ~~habbit~~ unfolding

Marcin Chrząszcz[1,2] , Nicola Serra[1]

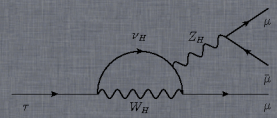[1] University of Zurich , [2] Institute of Nuclear Physics, Krakow,

May 13, 2014

University of Zurich[UZH]
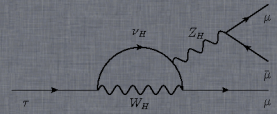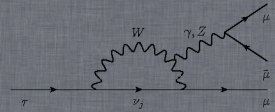
$K^*\mu\mu$ unfolding

Reverse Engineering Unfolding
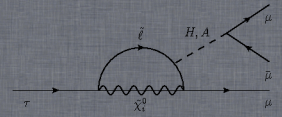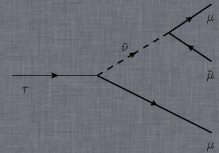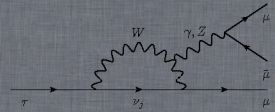
$\mathbf{K}^*\mu\mu$ unfolding

- As I studied on technical uni, they used to teach us:
  - "This is polytechnic, you got to try and break it"
- Let's finally break the method of moments :)
- A bit of equations:

Unfolding modification

$$M_i = \frac{\sum_j^n f_i(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j)}{n} \tag{1}$$

This goes with the unfolding to:

$$M_i = \frac{\sum_j^n w_j f_i(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j)}{\sum_j^n w_j} \tag{2}$$

, where $w_j = \dfrac{1}{eff(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j)}$

Breaking the ~~habbit~~ unfolding

Let's put small modification:

$$w_j \rightarrow \overline{w_j} = \frac{1}{\textit{eff}(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j)} \times \textit{corr}(\cos\theta_{l\ j}, \cos\theta_{k\ j}, \phi_j) \quad (3)$$

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

Corr1 functions
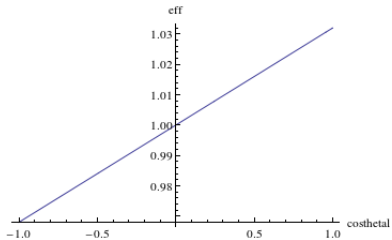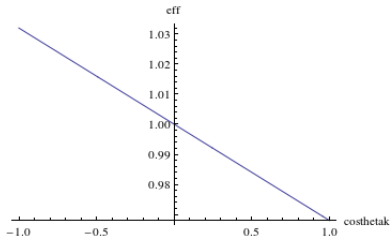
$$corr1(\cos_l, \cos_k, \phi) =$$
$$1 + 0.032 \cos_l - 0.032 \cos_k + 0.01\phi$$
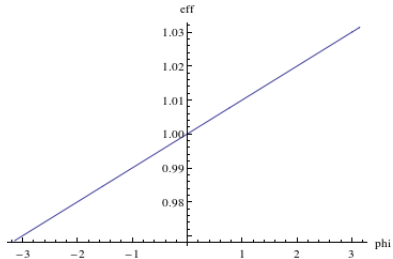
Corr2 functions

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

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

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

Corr1- MM
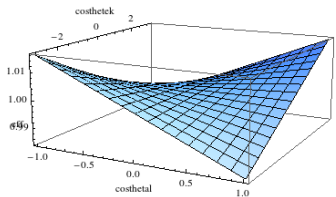
Much better then I expected :)

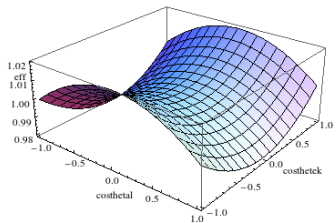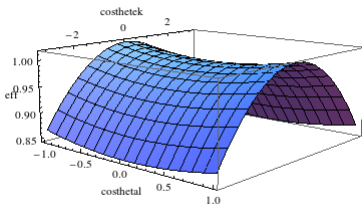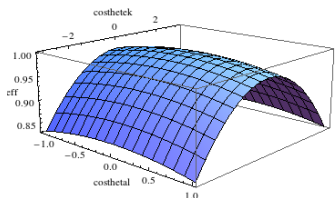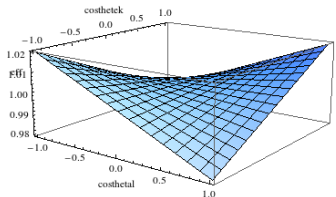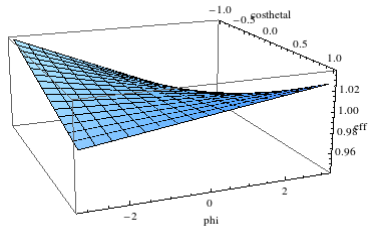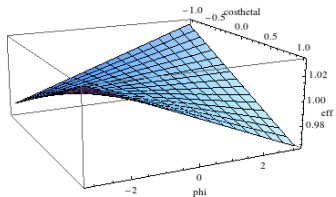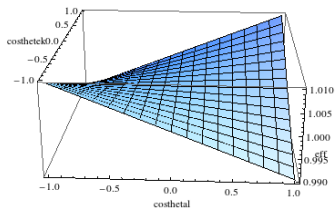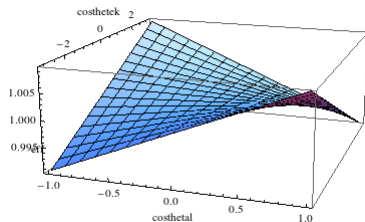| q^2	S_3	S_4	S_5	S_{6s}	S_{6c}	S_7	S_8
			Mean of the pull				
0	$0.0085 \pm 0.026(0.3)$	$0.13 \pm 0.027(4.6)$	$-0.025 \pm 0.027(-0.92)$	$0.46 \pm 0.027(17)$	$-0.13 \pm 0.028(-4.7)$	$0.029 \pm 0.028(1)$	$-0.66 \pm 0.027(-25)$
1	$0.0094 \pm 0.028(0.33)$	$0.078 \pm 0.028(2.8)$	$-0.02 \pm 0.028(-0.73)$	$0.24 \pm 0.028(8.5)$	$-0.075 \pm 0.028(-2.7)$	$-0.016 \pm 0.026(-0.63)$	$-0.39 \pm 0.028(-14)$
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

Much better then I expected :)

			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	$-0.15 \pm 0.027(-5.6)$	$0.025 \pm 0.026(0.96)$	$0.016 \pm 0.027(0.58)$	$-0.062 \pm 0.027(-2.3)$	$0.037 \pm 0.026(1.4)$	$0.026 \pm 0.027(0.96)$	$-0.016 \pm 0.027(-0.6)$
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	$-0.13 \pm 0.026(-5.1)$	$-0.0077 \pm 0.027(-0.28)$	$0.05 \pm 0.027(1.9)$	$-0.03 \pm 0.026(-1.2)$	$-0.012 \pm 0.028(-0.44)$	$-0.046 \pm 0.028(-1.7)$	$0.031 \pm 0.026(1.2)$
9	$-0.15 \pm 0.026(-5.7)$	$-0.0083 \pm 0.026(-0.32)$	$0.03 \pm 0.026(1.2)$	$0.044 \pm 0.027(1.6)$	$-0.07 \pm 0.026(-2.7)$	$-0.022 \pm 0.026(-0.84)$	$-0.045 \pm 0.026(-1.7)$
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	$-0.067 \pm 0.026(-2.6)$	$0.017 \pm 0.026(0.65)$	$-0.015 \pm 0.026(-0.56)$	$-0.051 \pm 0.026(-1.9)$	$-0.0086 \pm 0.026(-0.33)$	$-0.018 \pm 0.028(-0.67)$	$0.017 \pm 0.027(0.62)$

Corr3- MM

Much better then I expected :)

				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	$0.046 \pm 0.027(1.7)$	$-0.02 \pm 0.026(-0.76)$	$-0.04 \pm 0.027(-1.5)$	$-0.012 \pm 0.027(-0.44)$	$0.13 \pm 0.027(4.8)$	$-0.04 \pm 0.027(-1.5)$	$-0.0056 \pm 0.027(-0.21)$
6	$-0.013 \pm 0.026(-0.52)$	$0.041 \pm 0.027(1.5)$	$-0.033 \pm 0.028(-1.2)$	$-0.0019 \pm 0.027(-0.068)$	$0.15 \pm 0.027(5.4)$	$-0.034 \pm 0.027(-1.3)$	$-0.021 \pm 0.028(-0.75)$
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	$0.032 \pm 0.026(1.2)$	$0.024 \pm 0.026(0.91)$	$-0.04 \pm 0.026(-1.5)$	$-0.066 \pm 0.027(-2.5)$	$0.098 \pm 0.027(3.7)$	$-0.043 \pm 0.028(-1.6)$	$-0.0018 \pm 0.028(-0.064)$

Corr4- MM

Much better then I expected :)

				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	$-0.011 \pm 0.026(-0.42)$	$0.041 \pm 0.027(1.5)$	$-0.045 \pm 0.028(-1.6)$	$0.011 \pm 0.028(0.41)$	$-0.0089 \pm 0.027(-0.33)$	$0.067 \pm 0.027(2.5)$	$0.036 \pm 0.027(1.3)$
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!
  - $M_5 = 0.4S_5 \rightarrow M_5 = 0.00512S_5 + 0.4S_5 - 0.002S_7$
  - $M_8 = 0.32S_8 \rightarrow M_8 = 0.0016S_4 + 0.00512S_7 + 0.32S_8$
  - $M_7 = 0.4S_7 \rightarrow M_7 = 0.002S_5 + 0.4S_7 + 0.00512S_8$
  - $M_3 = 0.32S_7 \rightarrow M_3 = 0.32S_3 - 0.0008S_9$
- 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!
  - $M_5 = 0.4S_5 \rightarrow M_5 = 0.38S_5$
  - $M_8 = 0.32S_8 \rightarrow M_8 = 0.3066S_5$
  - $M_7 = 0.4S_7 \rightarrow M_7 = 0.385S_7$
  - $M_3 = 0.32S_7 \rightarrow M_3 = 0 - 0.0036 + 0.0012Fl + 0.303609S_3$
- The way you can look at this is that i just shown you how our unfolding matrix works like.

Summary

- What can i say; this is just COOL :)
- Need to do a comparison with fitting for completeness.
- And to bring peace to the republic: