Toy MC Results

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Plan

1. Before we begin to explore the TOY MC let's see if we understand.
2. To X-Check:
   - Check EOS SM parameters.
   - Check unfolding.
3. Test various methods with data bins and statistics

Plan

- Take the full MC(without acceptance) and fit + count events.
- See if the results are consistent.
- Here we just fit signal(`bkgcat==0`)
- In yellow $> 3\ \sigma$ fluctuations, red $> 5\ \sigma$ fluctuations,

S_4 results

q^2	S_4^{true}	S_4^{fit}	S_4^{fold}	S_4^{MM}
[0.1, 1.0]	−0.0884	−0.0869 ± 0.0009(1.6)	−0.0874 ± 0.0010(1.0)	−0.0873 ± 0.0010(1.1)
[1.1, 2.0]	−0.0481	−0.0447 ± 0.0015(2.3)	−0.0462 ± 0.0017(1.1)	−0.0477 ± 0.0018(0.2)
[2.0, 3.0]	0.0480	0.0465 ± 0.0015(1.0)	0.0476 ± 0.0016(0.25)	0.0478 ± 0.0019(0.1)
[3.0, 4.0]	0.1255	0.1229 ± 0.0014(1.9)	0.1253 ± 0.0016(0.1)	0.1262 ± 0.0019(0.4)
[4.0, 5.0]	0.1765	0.1731 ± 0.0013(2.6)	0.1742 ± 0.0015(1.5)	0.1760 ± 0.0018(0.3)
[5.0, 6.0]	0.2089	0.2058 ± 0.0012(2.3)	0.2065 ± 0.0015(1.6)	0.2081 ± 0.0017(0.9)
[6.0, 7.0]	0.2295	0.2279 ± 0.0011(1.5)	0.2283 ± 0.0014(0.9)	0.2313 ± 0.0016(1.1)
[7.0, 8.0]	0.2609	0.2422 ± 0.0010(18.7)	0.2428 ± 0.0014(13)	0.2441 ± 0.0016(10.5)
[15.0, 16.0]	0.2822	0.2820 ± 0.0008(0.3)	0.2817 ± 0.0012(0.4)	0.2819 ± 0.0014(0.2)
[16.0, 17.0]	0.2888	0.2884 ± 0.0008(0.5)	0.2878 ± 0.0013(0.8)	0.2890 ± 0.0015(0.1)
[17.0, 18.0]	0.2987	0.2991 ± 0.0008(0.5)	0.2987 ± 0.0013(0.0)	0.2980 ± 0.0016(0.4)
[18.0, 19.0]	0.3139	0.3152 ± 0.0011(1.2)	0.3150 ± 0.0015(0.7)	0.3156 ± 0.0020(0.85)

S_5 results

q^2	S_5^{true}	S_5^{fit}	S_5^{fold}	S_5^{MM}
[0.1, 1.0]	0.2253	$0.2238 \pm 0.0008(1.9)$	$0.2253 \pm 0.0009(0.0)$	$0.2260 \pm 0.0009(0.8)$
[1.1, 2.0]	0.1652	$0.1673 \pm 0.0016(1.3)$	$0.1674 \pm 0.0016(1.4)$	$0.1671 \pm 0.0018(1.1)$
[2.0, 3.0]	-0.0287	$-0.0298 \pm 0.0016(0.7)$	$-0.0301 \pm 0.0017(0.8)$	$-0.0300 \pm 0.0019(0.7)$
[3.0, 4.0]	-0.1897	$-0.1911 \pm 0.0015(0.9)$	$-0.1919 \pm 0.0016(1.4)$	$-0.1891 \pm 0.0019(0.3)$
[4.0, 5.0]	-0.2969	$-0.2966 \pm 0.0014(0.2)$	$-0.2971 \pm 0.0015(0.1)$	$-0.2966 \pm 0.0018(0.3)$
[5.0, 6.0]	-0.3654	$-0.3678 \pm 0.0013(1.8)$	$-0.3682 \pm 0.0014(2.0)$	$-0.3700 \pm 0.0017(2.7)$
[6.0, 7.0]	-0.4084	$-0.4089 \pm 0.0012(0.4)$	$-0.4092 \pm 0.0013(0.6)$	$-0.4096 \pm 0.0016(0.8)$
[7.0, 8.0]	-0.4113	$-0.4356 \pm 0.0010(24.3)$	$-0.4364 \pm 0.0012(21)$	$-0.4356 \pm 0.0015(16)$
[15.0, 16.0]	-0.3654	$-0.3651 \pm 0.0008(0.6)$	$-0.3650 \pm 0.0011(0.4)$	$-0.3646 \pm 0.0012(0.3)$
[16.0, 17.0]	-0.3356	$-0.3347 \pm 0.0008(1.1)$	$-0.3349 \pm 0.0011(0.6)$	$-0.3359 \pm 0.0013(0.2)$
[17.0, 18.0]	-0.2911	$-0.2907 \pm 0.0009(0.4)$	$-0.2903 \pm 0.0013(0.6)$	$-0.2896 \pm 0.0014(1.1)$
[18.0, 19.0]	-0.2124	$-0.2153 \pm 0.0012(2.4)$	$-0.2152 \pm 0.0016(1.8)$	$-0.2158 \pm 0.0018(1.9)$

S_7 results

q^2	S_7^{true}	S_7^{fit}	S_7^{fold}	S_7^{MM}
[0.1, 1.0]	0.0212	$0.0206 \pm 0.0009(0.7)$	$0.0214 \pm 0.0009(0.2)$	$0.0208 \pm 0.0009(0.4)$
[1.1, 2.0]	0.0386	$0.0353 \pm 0.0016(2.1)$	$0.0352 \pm 0.0016(2.1)$	$0.0348 \pm 0.0018(2.1)$
[2.0, 3.0]	0.0379	$0.0349 \pm 0.0016(1.6)$	$0.0351 \pm 0.0017(1.6)$	$0.0353 \pm 0.0019(1.4)$
[3.0, 4.0]	0.0341	$0.0365 \pm 0.0016(0.5)$	$0.0368 \pm 0.0017(1.6)$	$0.0363 \pm 0.0019(1.2)$
[4.0, 5.0]	0.0306	$0.0293 \pm 0.0016(0.8)$	$0.0293 \pm 0.0016(0.8)$	$0.0303 \pm 0.0018(0.6)$
[5.0, 6.0]	0.0284	$0.0261 \pm 0.0015(1.5)$	$0.0262 \pm 0.0016(1.4)$	$0.0263 \pm 0.0018(1.2)$
[6.0, 7.0]	0.0278	$0.0282 \pm 0.0014(0.3)$	$0.0286 \pm 0.0015(0.5)$	$0.0287 \pm 0.0017(0.5)$
[7.0, 8.0]	0.0000	$0.0293 \pm 0.0014(20.9)$	$0.0290 \pm 0.0015(19.3)$	$0.0287 \pm 0.0016(18)$
[15.0, 16.0]	0.0000	$-0.0024 \pm 0.0013(1.8)$	$-0.0007 \pm 0.0014(0.5)$	$-0.0008 \pm 0.0014(0.6)$
[16.0, 17.0]	0.0000	$-0.0016 \pm 0.0014(1.1)$	$-0.0026 \pm 0.0015(1.6)$	$-0.0026 \pm 0.0015(1.7)$
[17.0, 18.0]	0.0000	$-0.0021 \pm 0.0015(1.4)$	$-0.0023 \pm 0.0016(1.6)$	$-0.0021 \pm 0.0017(1.2)$
[18.0, 19.0]	0.0000	$-0.0006 \pm 0.0019(0.3)$	$-0.0021 \pm 0.0021(1.0)$	$-0.0015 \pm 0.0021(0.6)$

S_8 results

q^2	S_8^{true}	S_8^{fit}	S_8^{fold}	S_8^{MM}
[0.1, 1.0]	-0.0038	$-0.0061 \pm 0.0010(2.3)$	$-0.0042 \pm 0.0010(0.4)$	$-0.0040 \pm 0.0010(0.2)$
[1.1, 2.0]	-0.0107	$-0.0133 \pm 0.0015(1.7)$	$-0.0142 \pm 0.0017(2.1)$	$-0.0135 \pm 0.0018(1.5)$
[2.0, 3.0]	-0.0123	$-0.0141 \pm 0.0015(1.2)$	$-0.0144 \pm 0.0017(1.2)$	$-0.0149 \pm 0.0019(0.3)$
[3.0, 4.0]	-0.0121	$-0.0109 \pm 0.0016(0.8)$	$-0.0112 \pm 0.0016(0.6)$	$-0.0117 \pm 0.0019(0.2)$
[4.0, 5.0]	-0.0114	$-0.0125 \pm 0.0015(0.8)$	$-0.0123 \pm 0.0016(0.6)$	$-0.0129 \pm 0.0018(0.8)$
[5.0, 6.0]	-0.0110	$-0.0115 \pm 0.0015(0.3)$	$-0.0118 \pm 0.0016(0.5)$	$-0.0115 \pm 0.0018(0.3)$
[6.0, 7.0]	-0.0110	$-0.0104 \pm 0.0014(0.4)$	$-0.0110 \pm 0.0016(0.0)$	$-0.0107 \pm 0.0017(0.2)$
[7.0, 8.0]	0.0007	$-0.0112 \pm 0.0013(8.1)$	$-0.0112 \pm 0.0015(7.0)$	$-0.0113 \pm 0.0016(6.6)$
[15.0, 16.0]	0.0003	$0.0006 \pm 0.0012(0.3)$	$-0.0015 \pm 0.0015(0.8)$	$-0.0016 \pm 0.0015(0.9)$
[16.0, 17.0]	0.0003	$-0.0023 \pm 0.0013(0.8)$	$-0.0020 \pm 0.0016(1.1)$	$-0.0022 \pm 0.0016(1.2)$
[17.0, 18.0]	0.0002	$0.0009 \pm 0.0015(0.5)$	$0.0023 \pm 0.0018(1.2)$	$0.0022 \pm 0.0018(1.1)$
[18.0, 19.0]	0.0002	$-0.0019 \pm 0.0019(0.9)$	$-0.0007 \pm 0.0022(0.2)$	$-0.0012 \pm -0.0022(0.5)$

What is going on in that bin?

- Following Einstein:

A scientific person will never understand why he should believe opinions only because they are written in a certain book.
Furthermore, he will never believe that the results of his own attempts are final.

- I start debugging my code.
- After several hours I said to Einstein to go to hell and start debugging EOS

WTH is going on with $[7.0, 8.0]$? 1/3

- With those parameters from EOS the PDF is negative? ¡- checked , no
- Some boundary conditions? ¡- checked by simulating my toy, no thing going on there.
- The parametrs that EOS gives you are not the one they simulated? ¡- YES!

WTH is going on with $[7.0, 8.0]$? 2/3

- First I simulated MY toy MC:

Listing 1: My unofficial MC:

```
FL_1   0.527066 +/-   0.000247033
FL_2   0.527066 +/-   0.000247033
FL_3   0.52083 +/-   0.00159866
FL_4   0.525139 +/-   0.000307114
J3   -0.0246584 +/-   0.000335458      true value:  -0.0248
J4   0.261117 +/-   0.000364695      true value: 0.2609
J5   -0.411436 +/-   0.000335284      true value:  -0.4113
J6s_1   -0.411211 +/-   0.000281637      true value:  -0.4113
J7   -0.000505415 +/-   0.000363604      true value: 0
J8   -0.000673747 +/-   0.000377374      true value:  -0.0007
J9   0.000422372 +/-   0.00033566      true value:  -0.0007
```

- PDF is fine, can be fitted(here MM).

WTH is going on with $[7.0, 8.0]$? 3/3

- Let's say if the predictions are internally consistent!

Listing 2: TABLE from email:

```
 Q2          Q2          S4                 S5                    S7
7.00   7.10      0.2375   -0.4250   -0.2818   0.0282   -0.0113
7.10   7.20      0.2388   -0.4275   -0.2890   0.0284   -0.0114
7.20   7.30      0.2399   -0.4299   -0.2960   0.0286   -0.0115
7.30   7.40      0.2411   -0.4321   -0.3030   0.0288   -0.0116
7.40   7.50      0.2422   -0.4343   -0.3098   0.0291   -0.0117
7.50   7.60      0.2432   -0.4363   -0.3165   0.0294   -0.0118
7.60   7.70      0.2442   -0.4383   -0.3230   0.0297   -0.0120
7.70   7.80      0.2451   -0.4401   -0.3295   0.0301   -0.0121
7.80   7.90      0.2460   -0.4418   -0.3358   0.0305   -0.0123
7.90   8.00      0.2623   -0.4199   -0.4330   0.0000   -0.0006
Full  Bin:
7.00   8.00      0.2609   -0.4113   -0.4113   0.0000  -0.0007
```

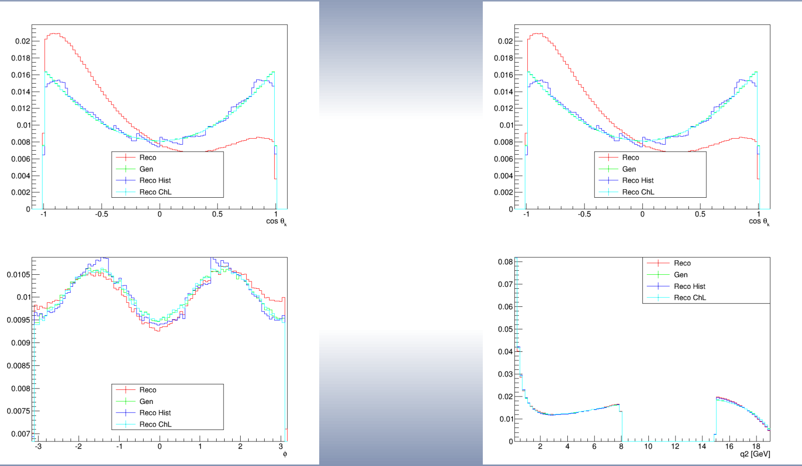
Conclusions part1

- EOS gives wrong prediction to the last bin before cc resonances region.
- Rest is consistent.

More x-checks

- Christoph also performed an unfolding.
- He parametrized the acceptance corrections using 7^{th} order polynomials.
- Also made a check of this.
- On his official TOY MC
- Reweighed events($1/\epsilon$) to get back the true distribution.
- For details see Christoph's talk

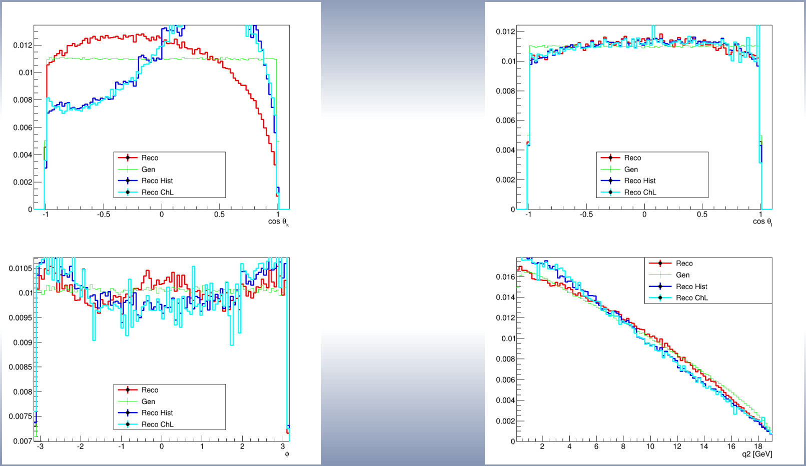
More x-checks



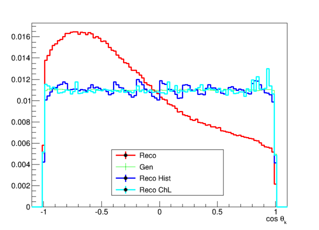
More x-checks

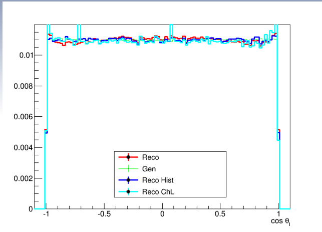
- Official TOY MC internally is consistent.
- For sanity reasons, let's try the official MC.

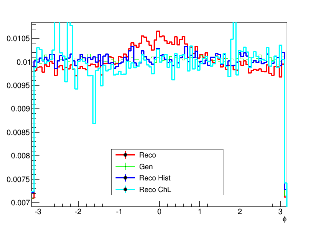
Not good!

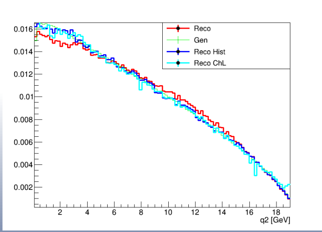

0.012
0.01
0.008
0.006
0.004
0.002
0
-1
-0.5
0
0.5
1
cos θ_K
Reco
Gen
Reco Hist
Reco ChL
0.012
0.01
0.008
0.006
0.004
0.002
0
-1
-0.5
0
0.5
1
cos θ_l
Reco
Gen
Reco Hist
Reco ChL
0.0105
0.01
0.0095
0.009
0.0085
0.008
0.0075
0.007
-3
-2
-1
0
1
2
3
ϕ
Reco
Gen
Reco Hist
Reco ChL
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2
4
6
8
10
12
14
16
18
q2 [GeV]
Reco
Gen
Reco Hist
Reco ChL

Magic happens when i don't require B^0 trueID









Unfolding conclusions

- MC was not truth matched for unfolding!
- Official TOY MC Internally is consistent but need to be careful for the future!

Strategy 1/3

- Divide the big OFFICIAL TOY MC in bins of q^2 that have number of events the same as data.
- For each of them make fit and counting experiment.
- See errors and pulls.

Strategy 2/3

- To estimate number of signal and background events we fit the events:
- For signal, I have assumed the PDF given by Christoph: LINK
- All parameters are for this pdf are fixed.
- For background I assume exponential, with free parameter.
- In summary the fit has 3 free parameters, n_{sig}, n_{bkg}, λ.
- Fit is done in region $5170, 5700 MeV$.

Strategy 3/3

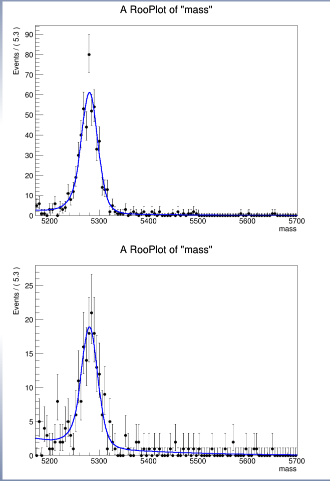
To get Signal moments(S_x) we do the following:

- Calculate background moments for m in $(5350, 5700)$ MeV
- Calculate "mixed" moments for m in $(5230, 5330)$ MeV
- Extract signal moments:

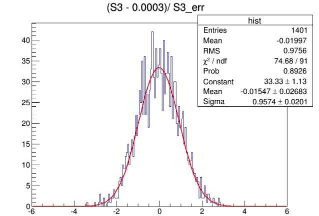
$$S_{sig} = \frac{S_{mix}(n_{sig} + n_{bck})}{n_{sig}} - \frac{n_{bck}S_{bck}}{n_{sig}}$$

Fits

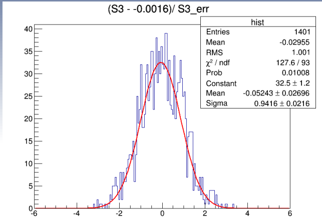
- All fits converged without any problem
- Got correlations Matrix.



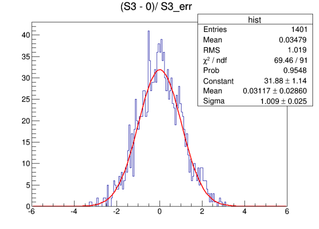
Pull plots S3



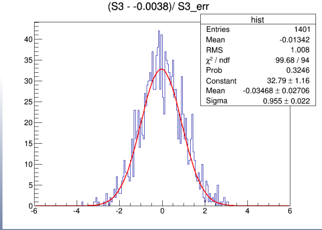
$Q^2(0.1, 1)$



$Q^2(2, 3)$

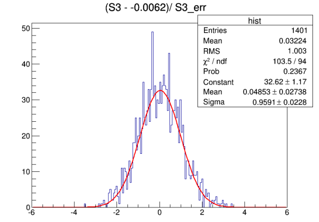


$Q^2(1.1, 2)$

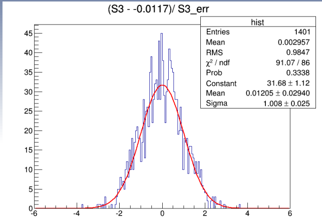


$Q^2(3, 4)$

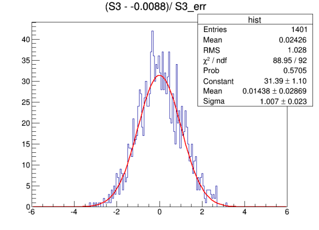
Pull plots S3



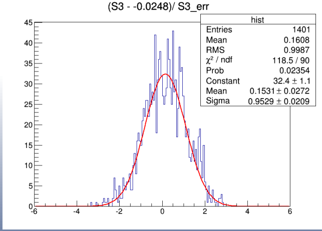
$Q^2(4,5)$



$Q^2(6,7)$

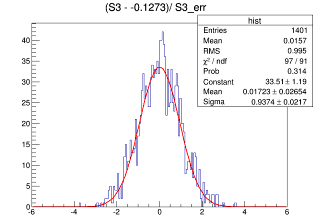


$Q^2(5,6)$

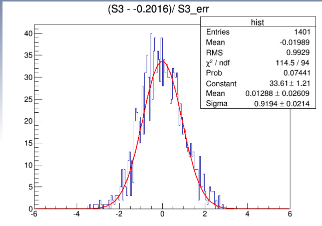


$Q^2(7,8)$

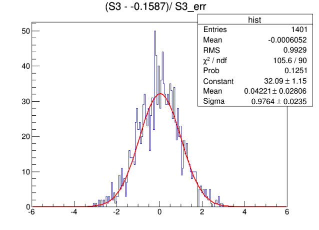
Pull plots S3



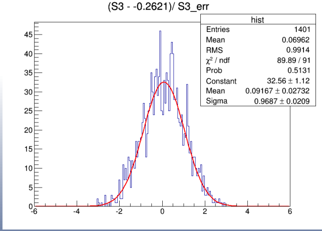
$Q^2(15, 16)$



$Q^2(17, 18)$

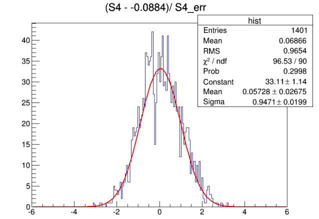


$Q^2(16, 17)$

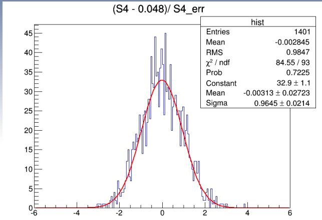


$Q^2(18, 19)$

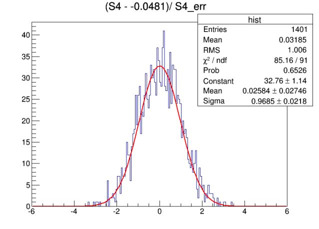
Pull plots S4



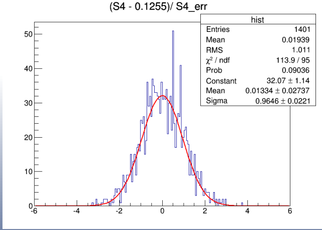
$Q^2(0.1, 1)$



$Q^2(2, 3)$

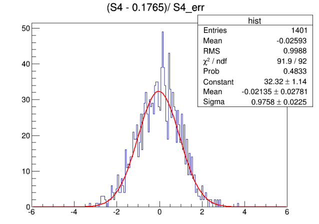


$Q^2(1.1, 2)$

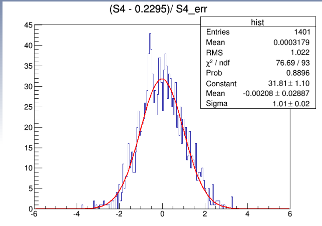


$Q^2(3, 4)$

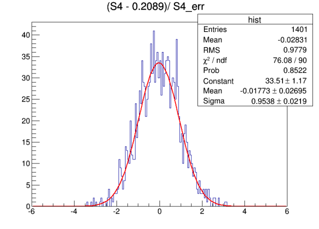
Pull plots S4



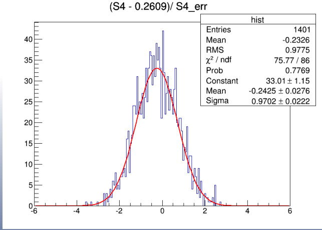
$Q^2(4,5)$



$Q^2(6,7)$

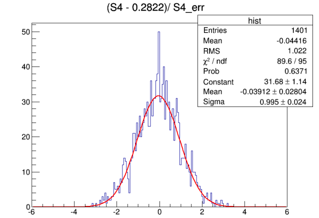


$Q^2(5,6)$

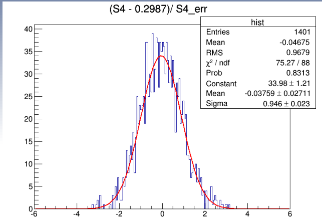


$Q^2(7,8)$

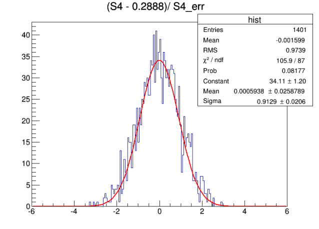
Pull plots S4



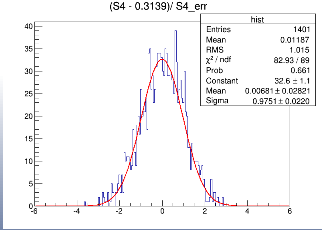
$Q^2(15, 16)$



$Q^2(17, 18)$

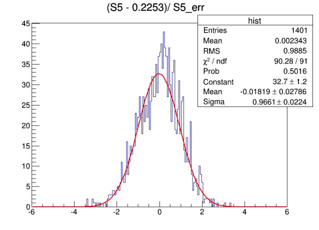


$Q^2(16, 17)$

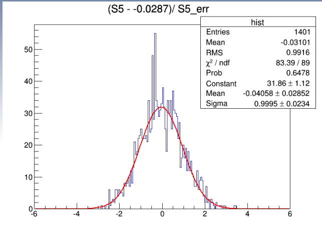


$Q^2(18, 19)$

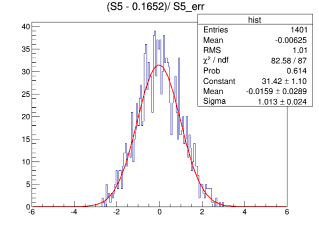
Pull plots S5



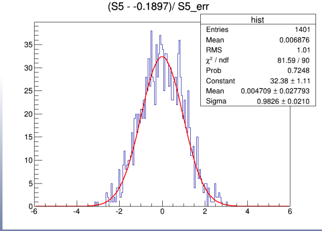
$Q^2(0.1, 1)$



$Q^2(2, 3)$

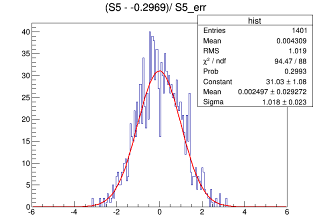


$Q^2(1.1, 2)$

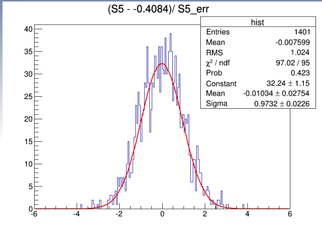


$Q^2(3, 4)$

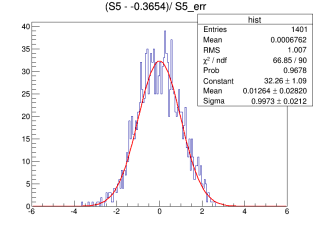
Pull plots S5



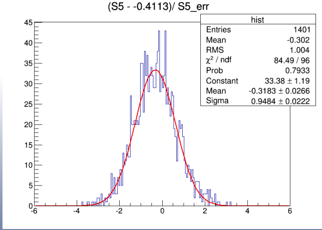
$Q^2(4,5)$



$Q^2(6,7)$

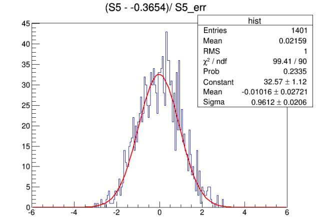


$Q^2(5,6)$

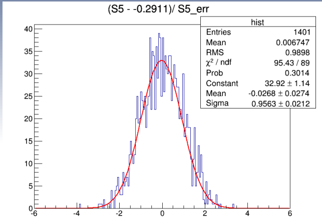


$Q^2(7,8)$

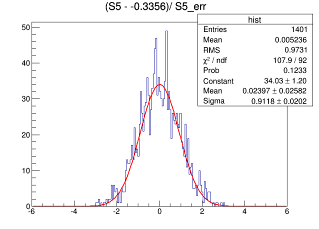
Pull plots S5



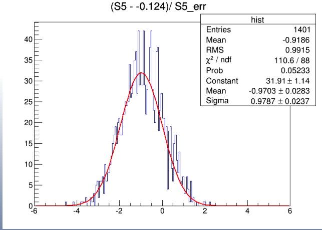
$Q^2(15, 16)$



$Q^2(17, 18)$

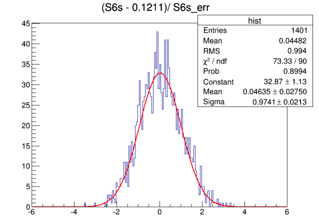


$Q^2(16, 17)$

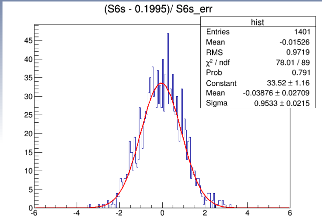


$Q^2(18, 19)$

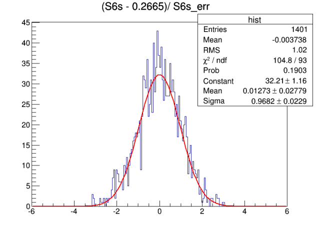
Pull plots S6



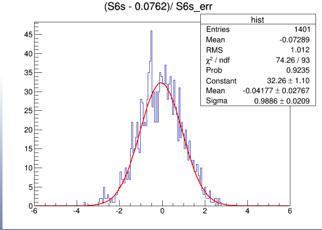
$Q^2(0.1, 1)$



$Q^2(2, 3)$

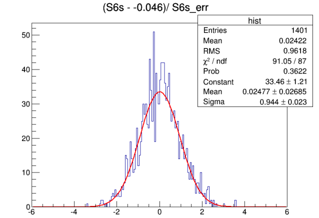


$Q^2(1.1, 2)$

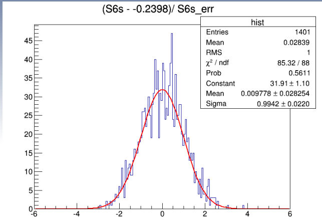


$Q^2(3, 4)$

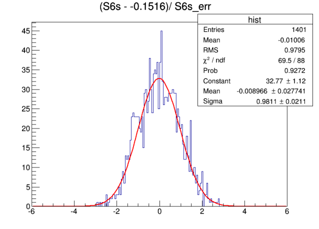
Pull plots S6



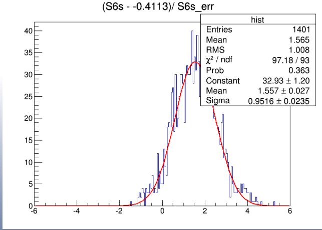
$Q^2(4,5)$



$Q^2(6,7)$

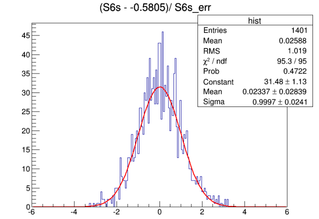


$Q^2(5,6)$

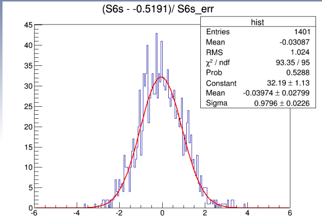


$Q^2(7,8)$

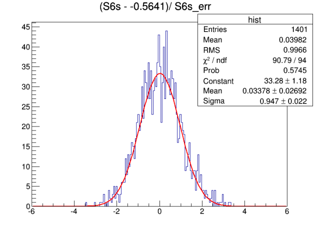
Pull plots S6



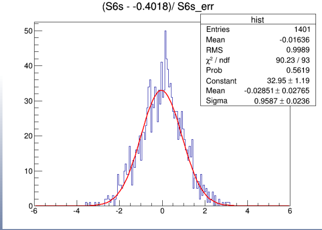
$Q^2(15, 16)$



$Q^2(17, 18)$



$Q^2(16, 17)$



$Q^2(18, 19)$

Conclusions

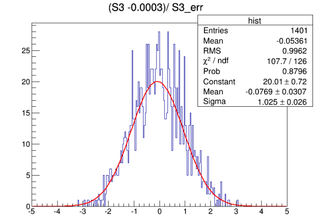
- Method of moments works perfectly with the TOY with our statistics.
- No bias seen in toys.

General way

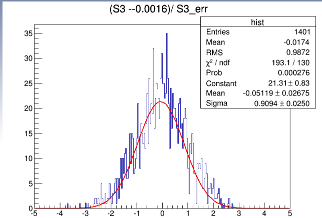
- The natural way of unfolding the method of moments is to reweigh events by $\frac{1}{\epsilon}$
- Similar to likelihood the normalization doesn't matter.
- Error is also calculated based on weights:

$$var = \frac{\sum_i w_i^2 \sigma_i}{(\sum_i w_i)^2} \tag{1}$$

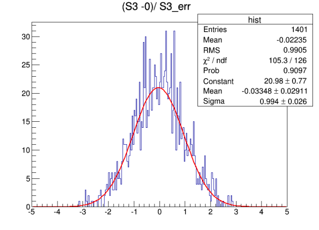
Pull plots S3



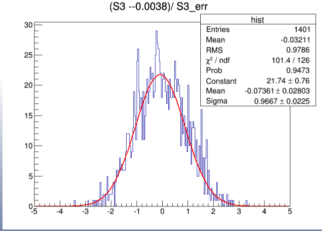
$Q^2(0.1, 1)$



$Q^2(2, 3)$

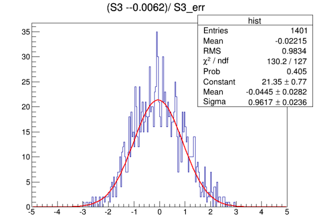


$Q^2(1.1, 2)$

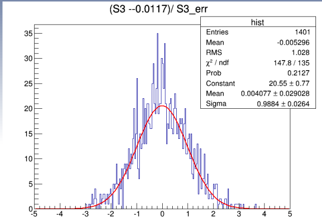


$Q^2(3, 4)$

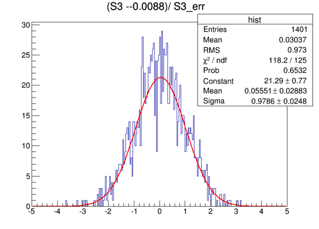
Pull plots S3



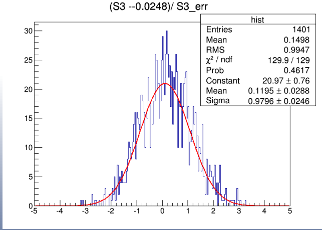
$Q^2(4,5)$



$Q^2(6,7)$

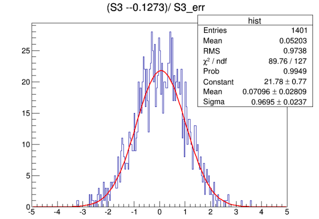


$Q^2(5,6)$

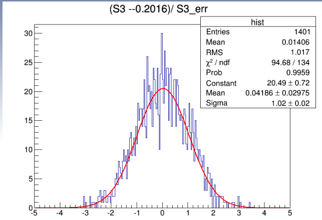


$Q^2(7,8)$

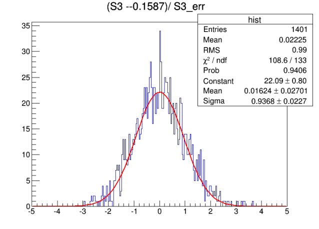
Pull plots S3



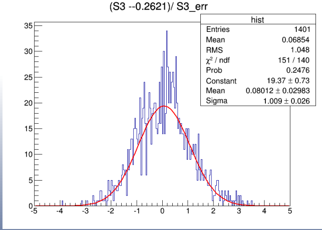
$Q^2(15, 16)$



$Q^2(17, 18)$



$Q^2(16, 17)$



$Q^2(18, 19)$

Conclusions

- Preliminary things look ok.
- However we plan to use a matrix method for unfolding $\rightarrow$ smaller errors.

Fitting strategy

- Performed fit on folded data set.
- Signal PDFs are like in 2011.
- Background PDFs are 2^{nd} order Chebyshev.
- PDF is parametrized:

$$PDF = PDF_{sig}(\cos\theta_k, \cos\theta_l, \phi) \times PDF_{sigm}(m) + PDF_{bkg}(\cos\theta_k, \cos\theta_l, \phi) \times PDF_{bkgm}(m)$$

- Fit the angles and mass in the full region

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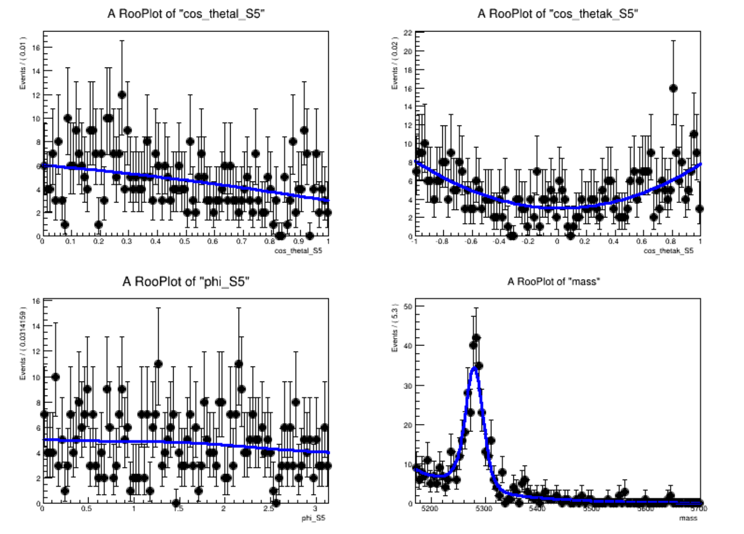
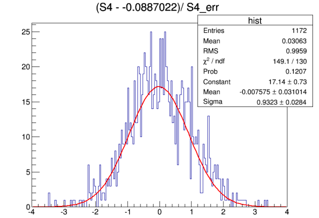
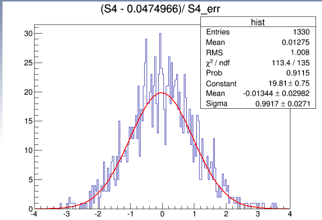
Examp


A RooPlot of "cos_thetal_S5"
Events / (0.01)
cos_thetal_S5
A RooPlot of "cos_thetak_S5"
Events / (0.02)
cos_thetak_S5
A RooPlot of "phi_S5"
Events / (0.0314159)
phi_S5
A RooPlot of "mass"
Events / (5.3)
mass

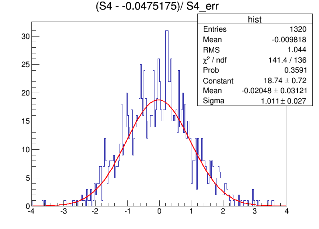
Pull plots S4



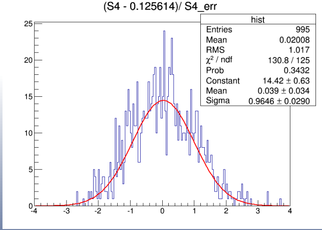
$Q^2(0.1, 1)$



$Q^2(2, 3)$

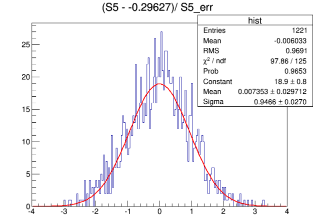


$Q^2(1.1, 2)$

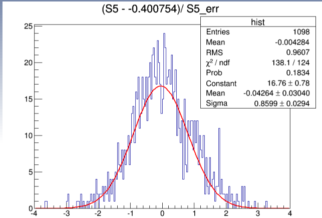


$Q^2(3, 4)$

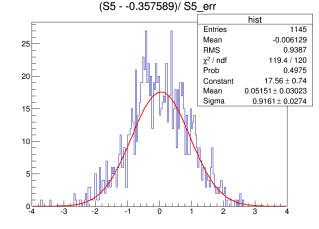
Pull plots S3



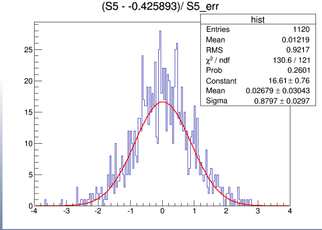
$Q^2(4,5)$



$Q^2(6,7)$

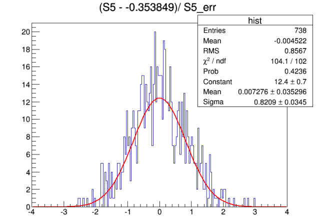


$Q^2(5,6)$

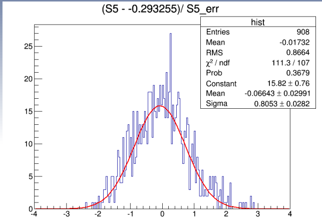


$Q^2(7,8)$

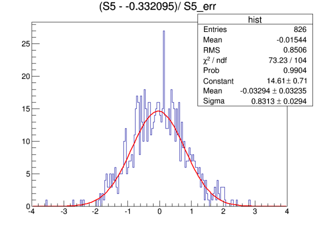
Pull plots S3



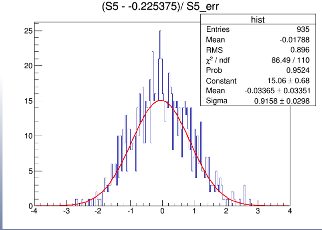
$Q^2(15, 16)$



$Q^2(17, 18)$



$Q^2(16, 17)$



$Q^2(18, 19)$

Conclusions of fitting

- Preliminary I see small bias, and error problems in the fits. To be x-checked.
- Need to check that unfolding doesn't do any harm.
- Hight fail rate! To be investigated.

Error summary

q^2	$Err.S_5^{MM}$	$Err.S_5^{fit}$
0	0.047	0.044
1	0.093	0.079
2	0.097	0.080
3	0.099	0.080
4	0.092	0.072
5	0.091	0.069
6	0.087	0.063
7	0.074	0.053
8	0.071	0.058
9	0.072	0.061
10	0.067	0.072
11	0.088	0.094

- On average MM are 18% worse here(improvement from 25% reported by Christoph).
- Still errors do not have full systematics.
- One expects the difference to shrink even more.

To do list

Before the Easter:

- Do include unfolding inside the fits.
- Repeat all the fits without folding.
- Compare all numbers!