$\mathbf{p(e, e'p)\omega^0}$ Analysis Update
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1 Changes from last report:

- Hermes diffractive ρ^0 model now used. This is based on a parameterization of Cornell, SLAC and Fermilab data.
- The $-t$ dependence of the model has been changed to use the parameterization in Cynthia Hajidakis' thesis, p. 146. This uses a fit to CLAS and Cornell electroproduction data.
- Diamond cuts and the cuts from p.80 of Jochen's thesis are applied.
- ρ^0 MCs have 2.5 million events per setting. ω^0 MCs have 150k events per setting.
- The quality of the fits are noticeably improved in comparison with the previous ρ^0 model.

2 Hermes ρ^0 Electroproduction Model

To fit the smooth background underneath the ω^0, I am now using a diffractive ρ^0 production model based on a fit to electroproduction data.

$$\frac{d\sigma}{dt} = \sigma_0(1+\epsilon R)\Big(\frac{m_\rho^2}{Q^2+m_\rho^2)}\Big)^{2.575} b_\rho e^{-b_\rho t'}$$

with

$$\sigma_0 = \frac{41.263}{\nu^{0.4765}},$$
$$R = 0.33\Big(\frac{Q^2}{m_\rho^2}\Big)^{0.61}$$

and $t =' t - t_{min}$.

The description of the $-t$ dependence is much simpler than the previous parameterization in terms of Q^2 and W, and is taken from a fit to CLAS and Cornell data

$$b_\rho = -0.0941 + 3.449c\Delta\tau$$

where $c\Delta\tau$ is the formation length (distance of fluctuation of the virtual photon to a real meson)

$$c\Delta\tau = \frac{\hbar c}{\sqrt{\nu^2+Q^2+m_\rho^2} - \nu}.$$

Finally, the Soding model correction taken from the old model is applied

$$\frac{d\sigma}{dtdM_x} = \frac{d\sigma}{dt}\Big(\frac{m_\rho}{M_x}\Big)^{5.2}.$$

3 $\mathbf{Q^2}$ =2.45 $\mathbf{GeV^2}$ $\epsilon = 0.54$

Fit parameters after the diamond cut is applied are given in the table below for all three HMS settings. If you compare these to the previous values in FpiLog 550, you will see that the MC multipliers are much more consistent than before.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = 00$			
Data	10501		
Omega	2308	0.220	20.3
Rho	8337	0.794	95.5
Right HMS $\theta_{pq} = +3$			
Data	12178		
Omega	3289	0.270	18.2
Rho	9018	0.741	63.7
Left HMS $\theta_{pq} = -3$			
Data	10452		
Omega	2701	0.259	25.8
Rho	7977	0.763	92.1

Similarly, you will find that the Q^2 and W distributions on the next pages are much better described by the MCs than previously.

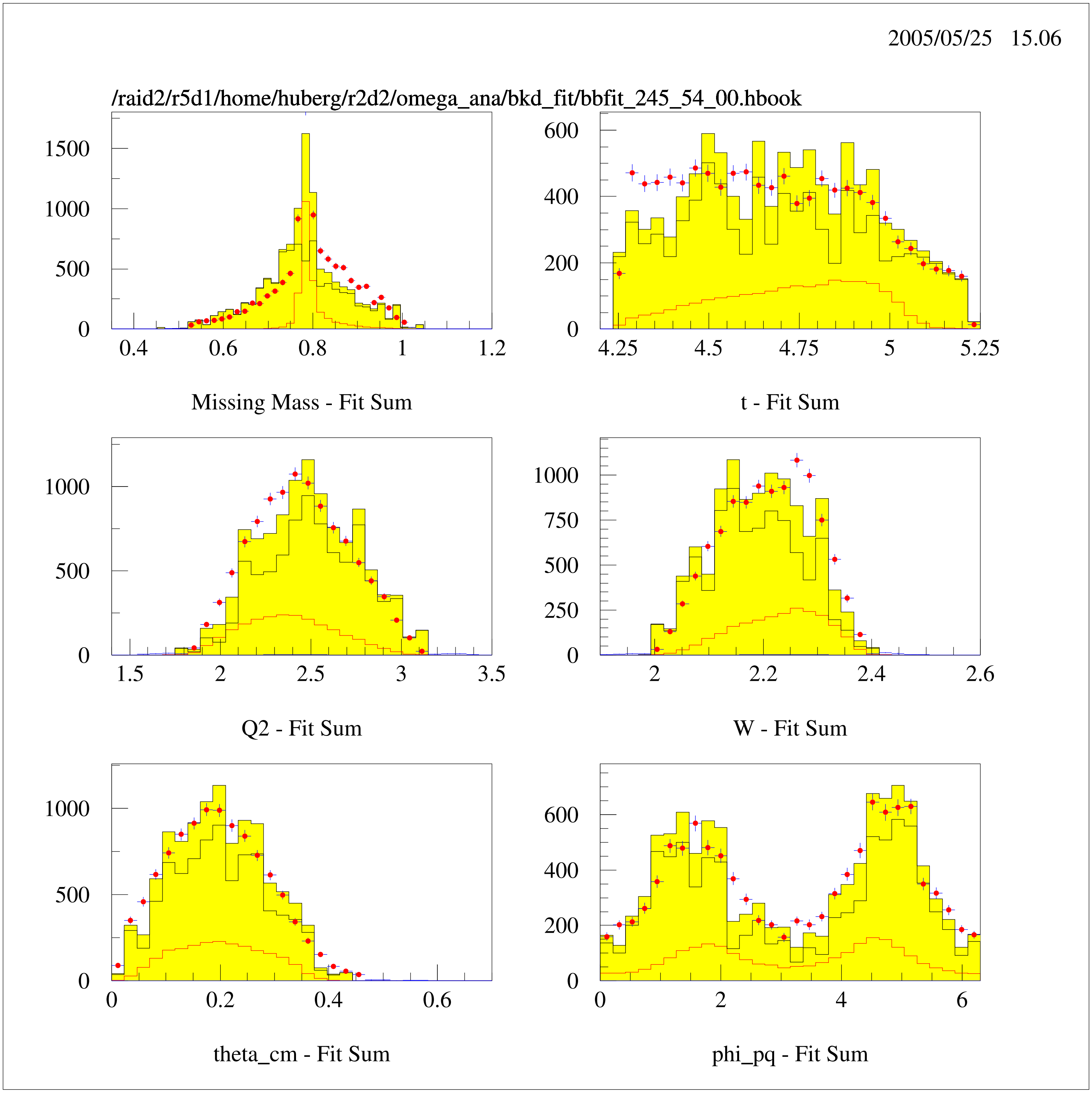

Figure 1: Fit to central HMS setting data at Q^2=2.45, ϵ=0.54. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

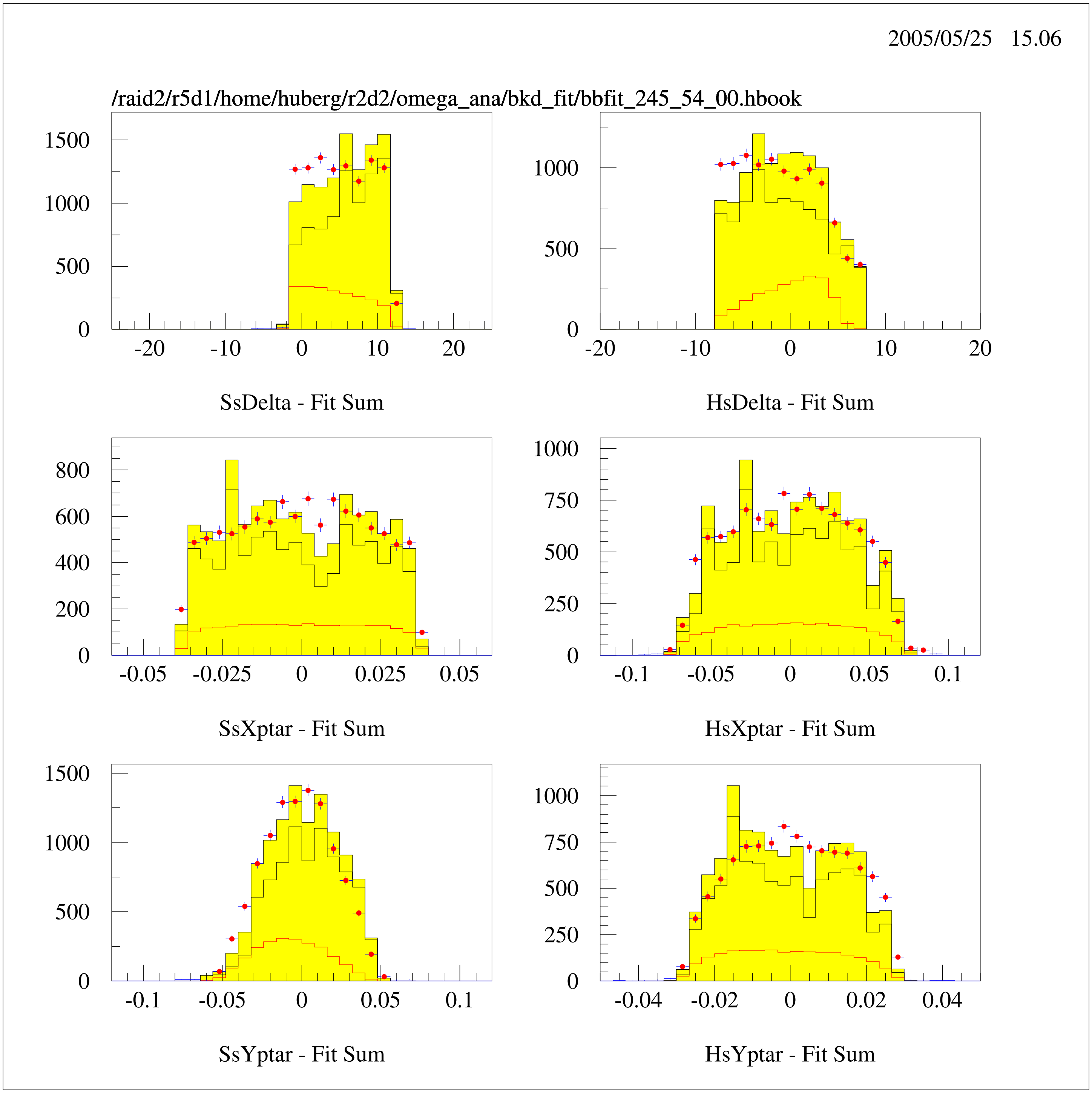

Figure 2: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

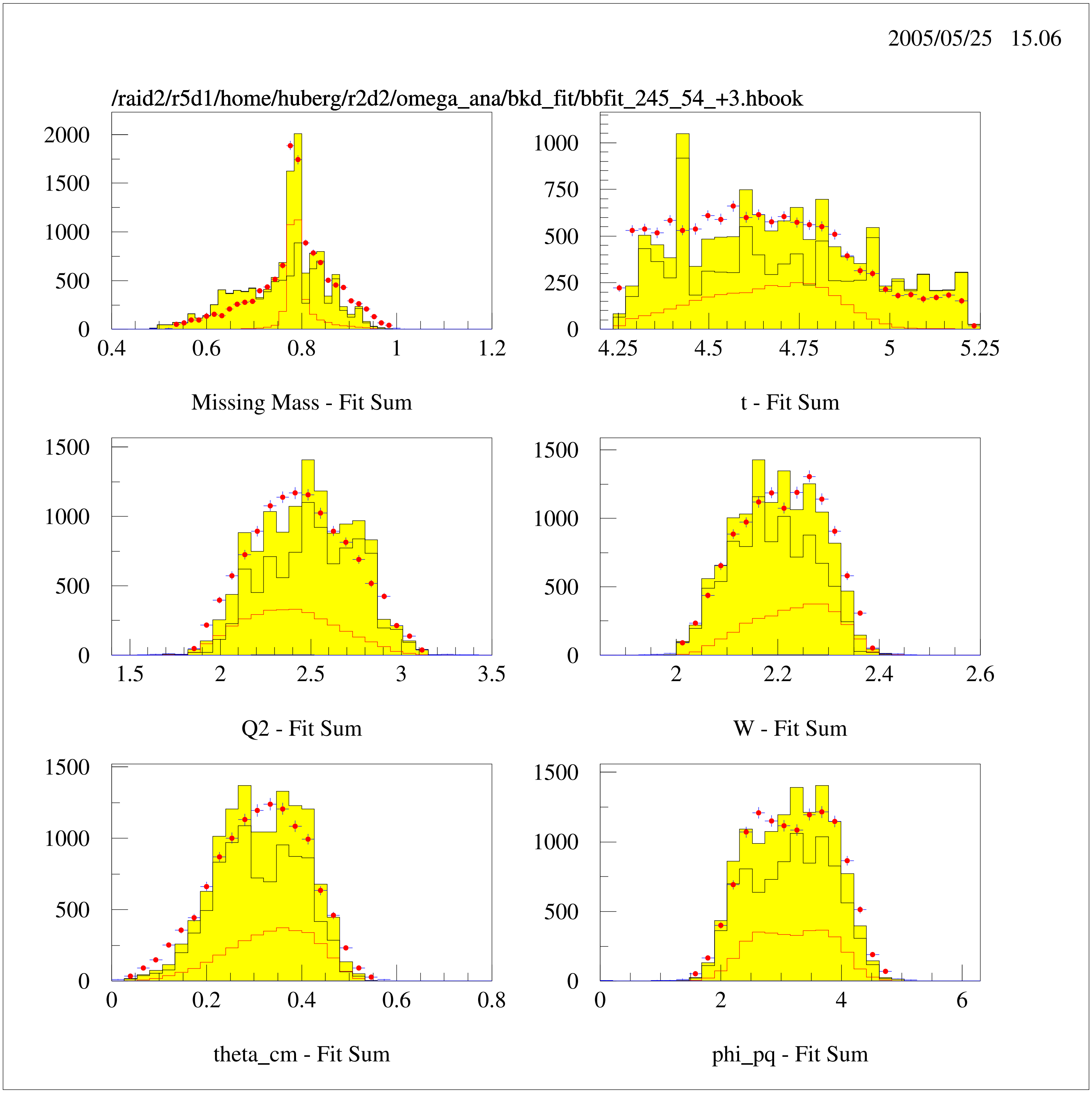

Figure 3: Fit to right HMS setting data at Q^2=2.45, ϵ=0.54. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

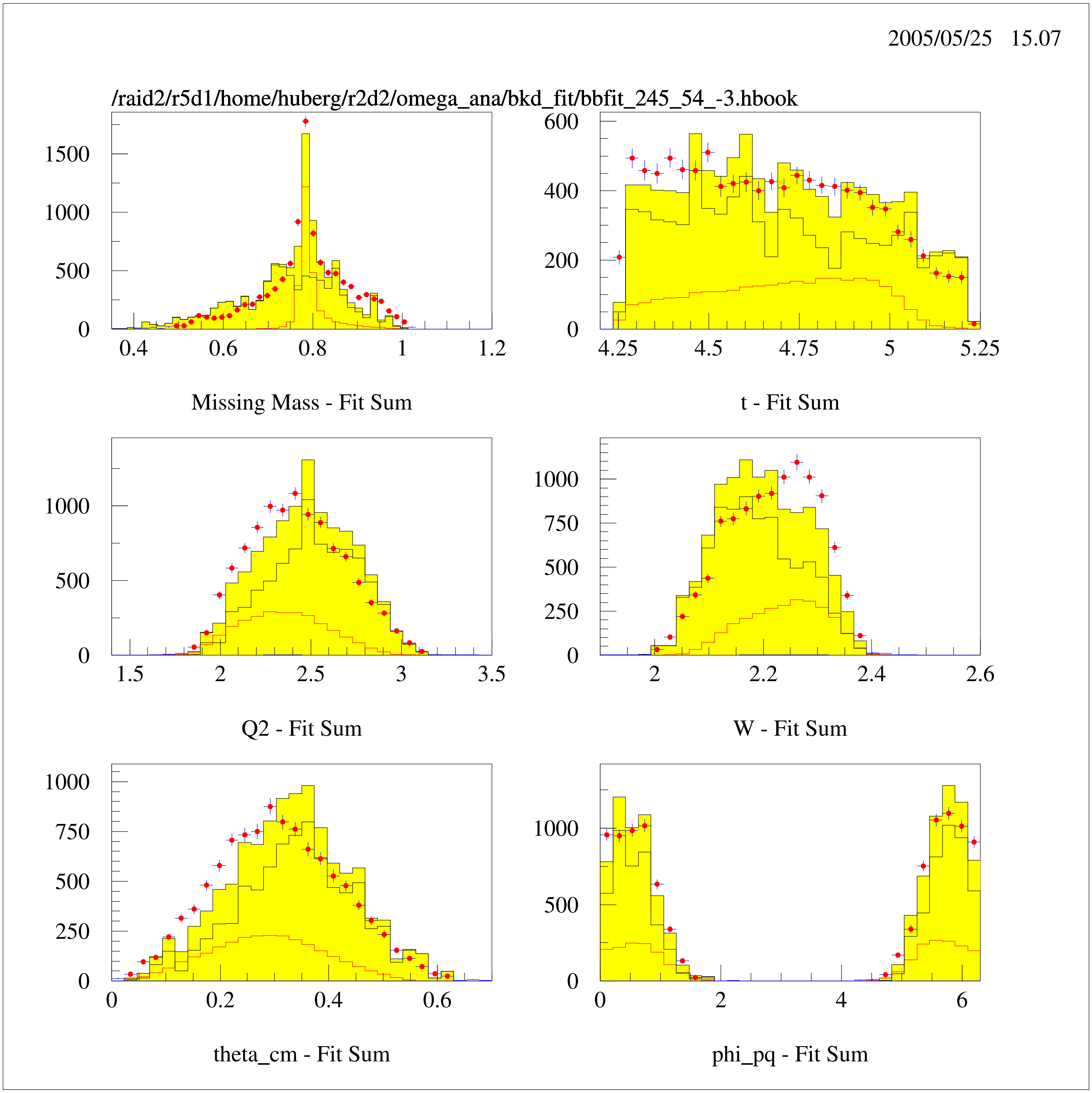

Figure 4: Fit to left HMS setting data at Q^2=2.45, ϵ=0.54. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

4 Q^2 =2.45 GeV^2 $\epsilon = 0.27$

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = +1$			
Data	12049		
Omega	2892	0.241	20.2
Rho	9372	0.778	80.3
Right HMS $\theta_{pq} = +3$			
Data	12359		
Omega	3327	0.269	20.0
Rho	9179	0.743	64.4

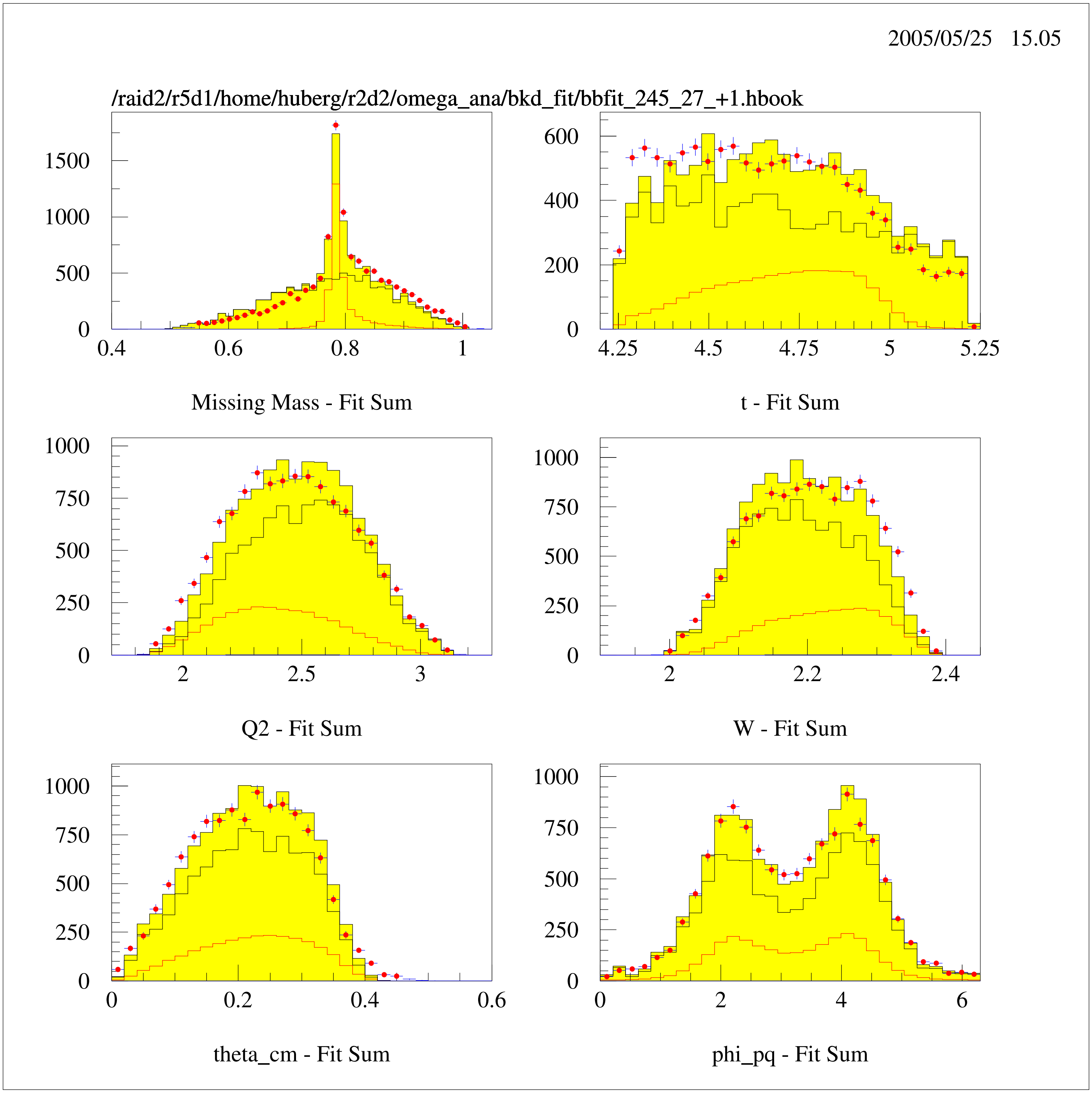

Figure 5: Fit to central HMS setting data at Q^2=2.45, ϵ=0.27. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

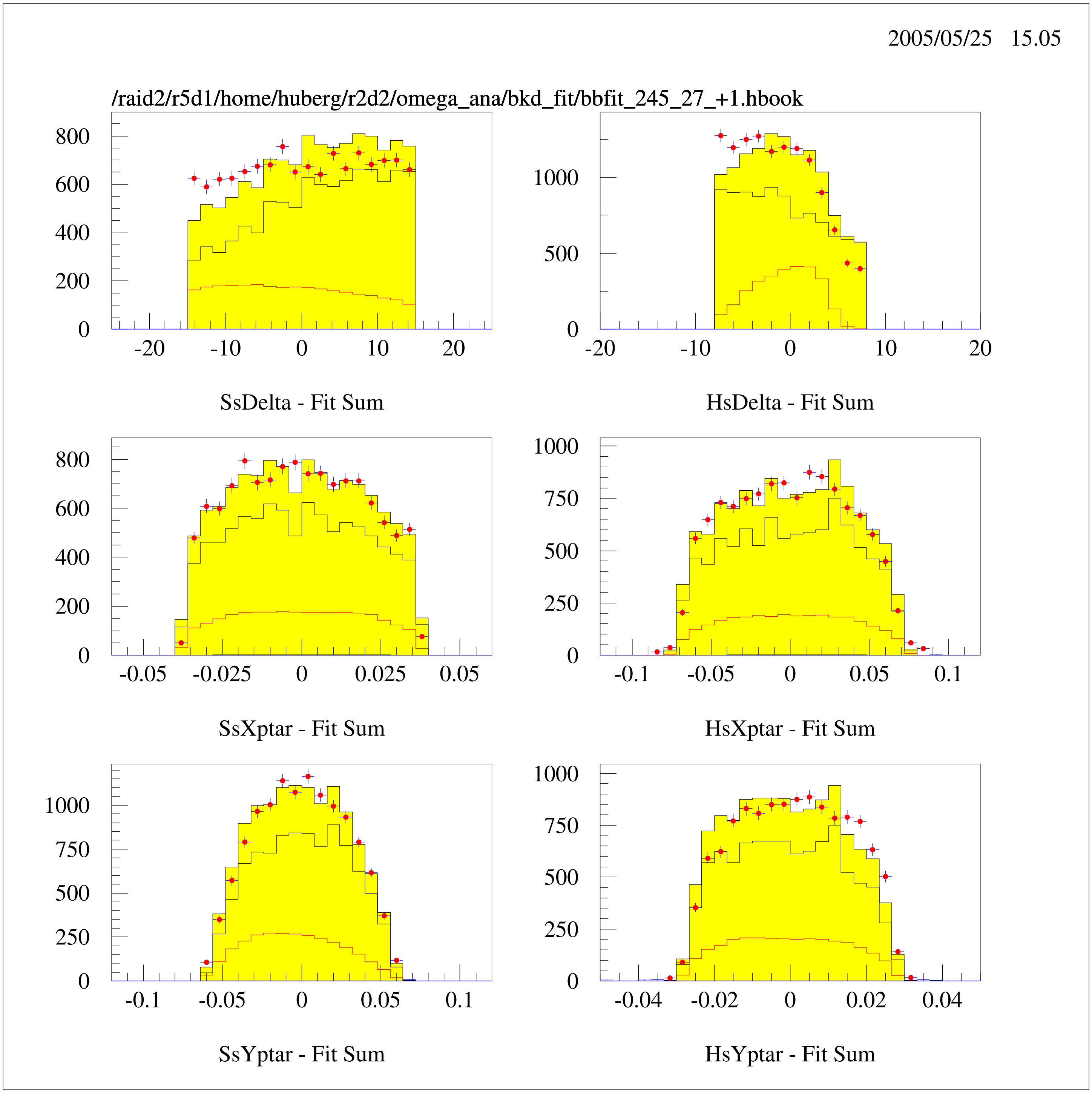

Figure 6: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

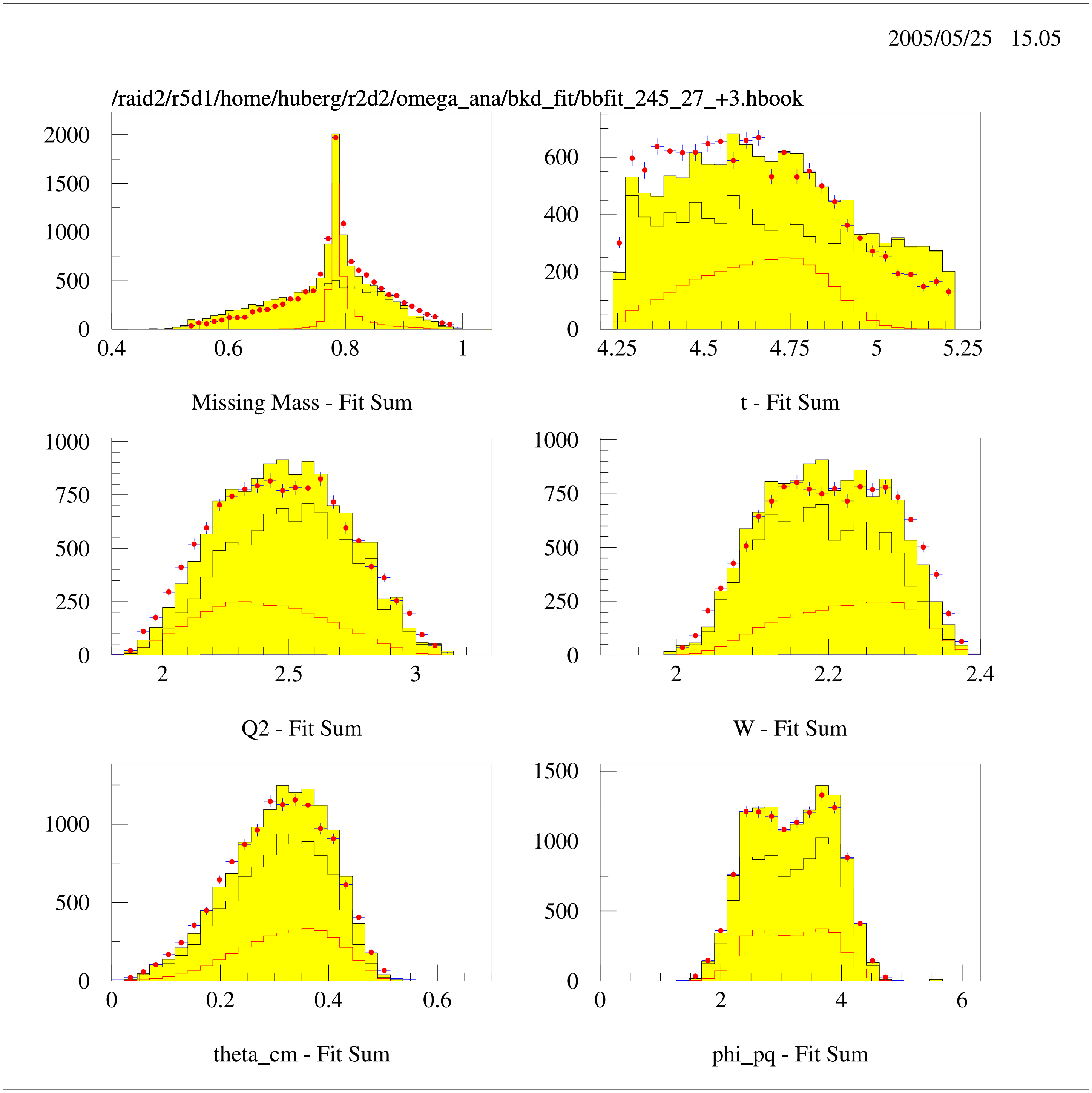

Figure 7: Fit to right HMS setting data at Q^2=2.45, ϵ=0.27. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

5 Q^2 =1.60 GeV^2 $\epsilon = 0.58$

The improvement in the fit quality (compared to FpiLog 550) is striking.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = 00$			
Data	8592		
Omega	2226	0.259	12.3
Rho	6485	0.755	72.6
Right HMS $\theta_{pq} = +3$			
Data	10145		
Omega	2933	0.289	10.9
Rho	7292	0.719	57.9
Left HMS $\theta_{pq} = -3$			
Data	9440		
Omega	2396	0.254	13.0
Rho	7183	0.761	66.2

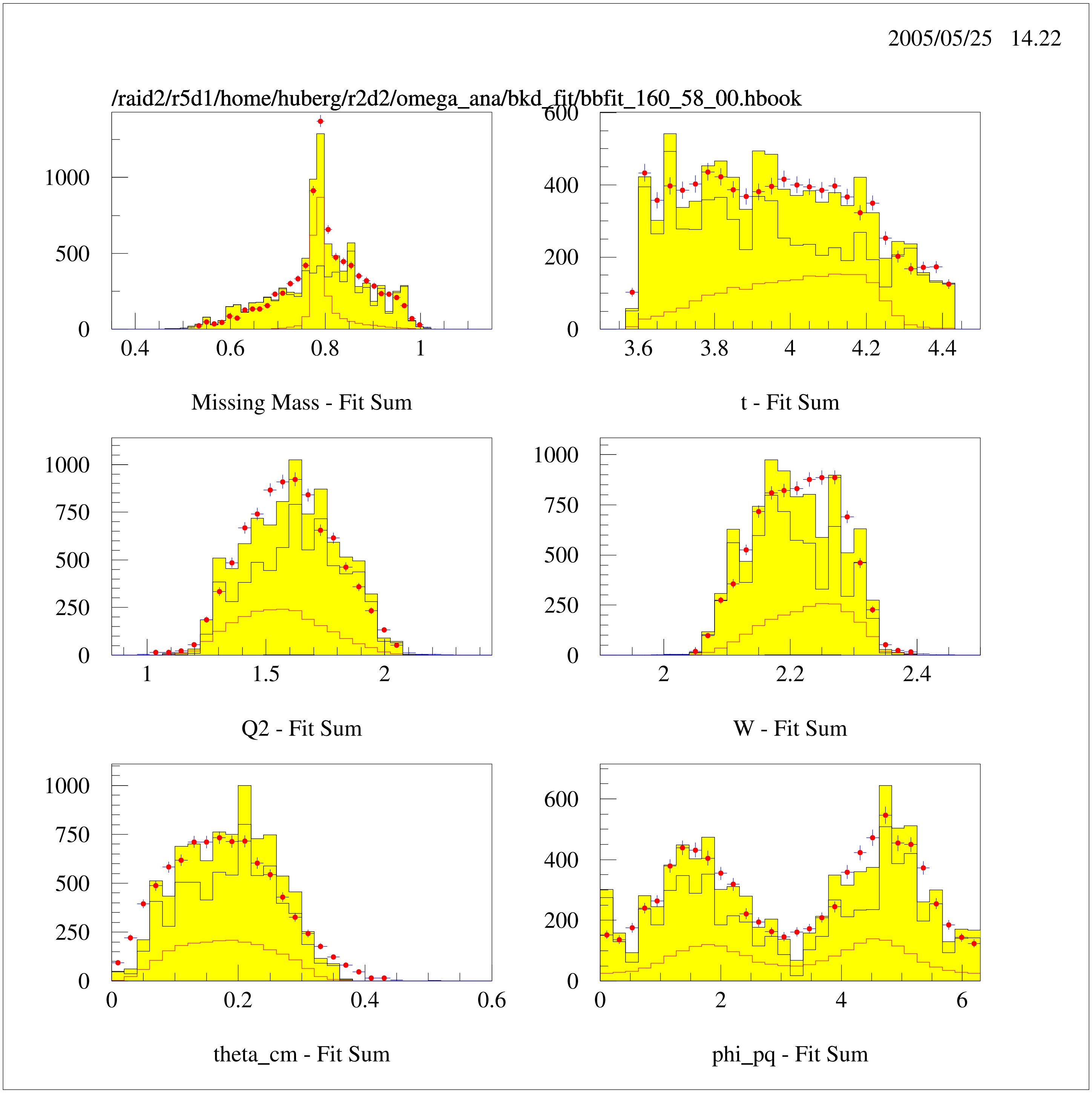

Figure 8: Fit to central HMS setting data at Q^2=1.60, ϵ=0.58. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

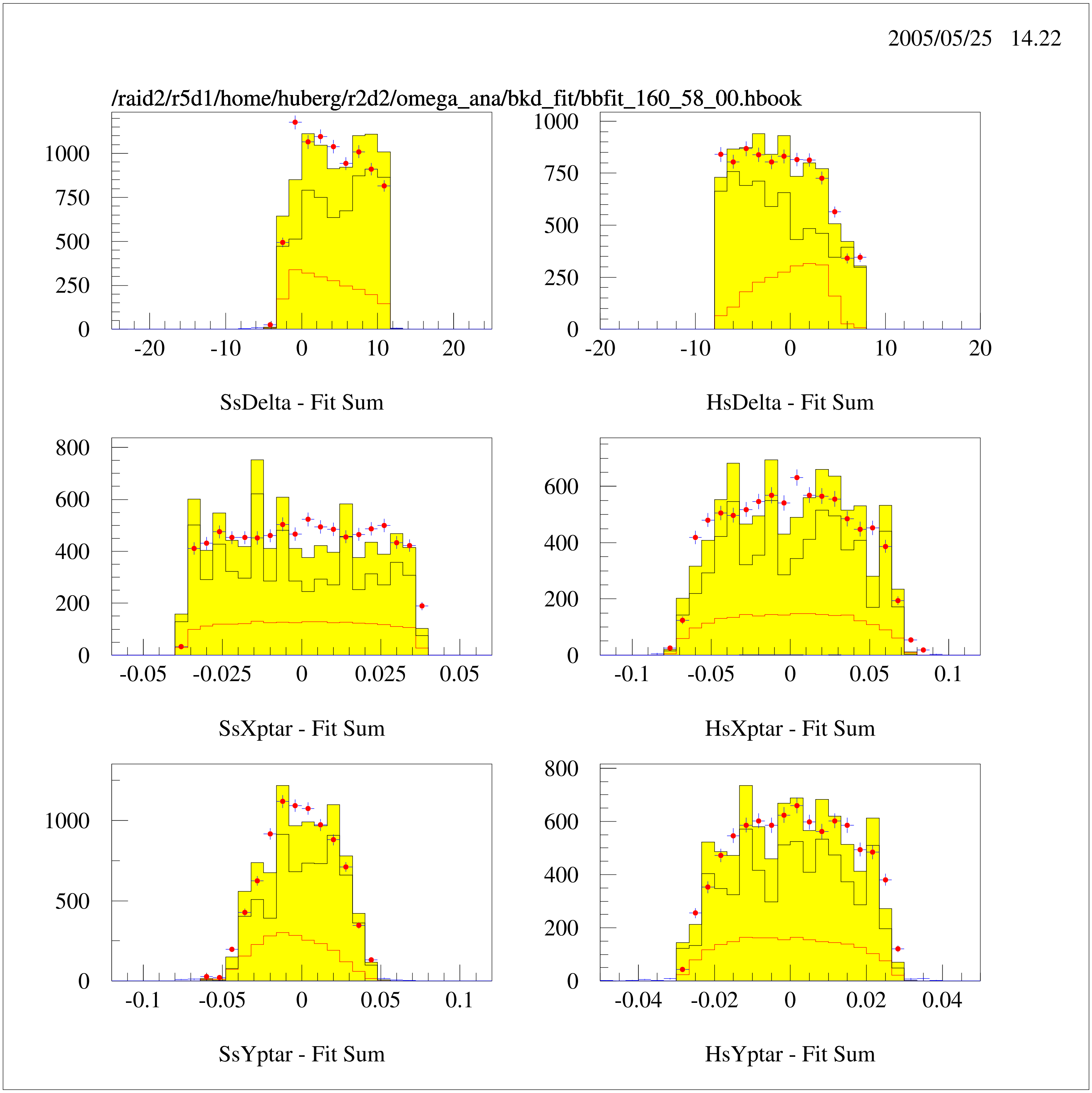

Figure 9: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

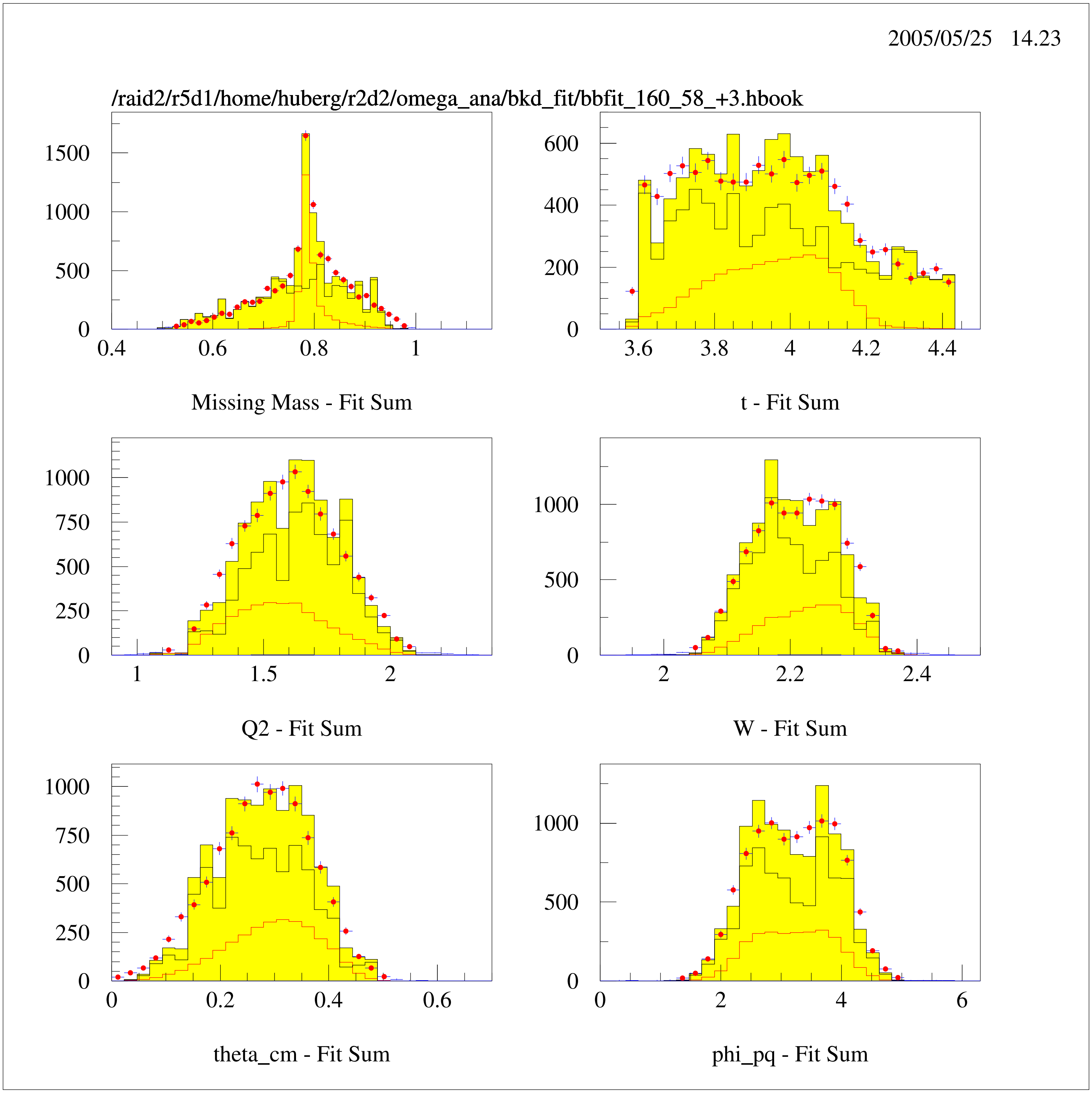

Figure 10: Fit to right HMS setting data at Q^2=1.60, ϵ=0.58. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

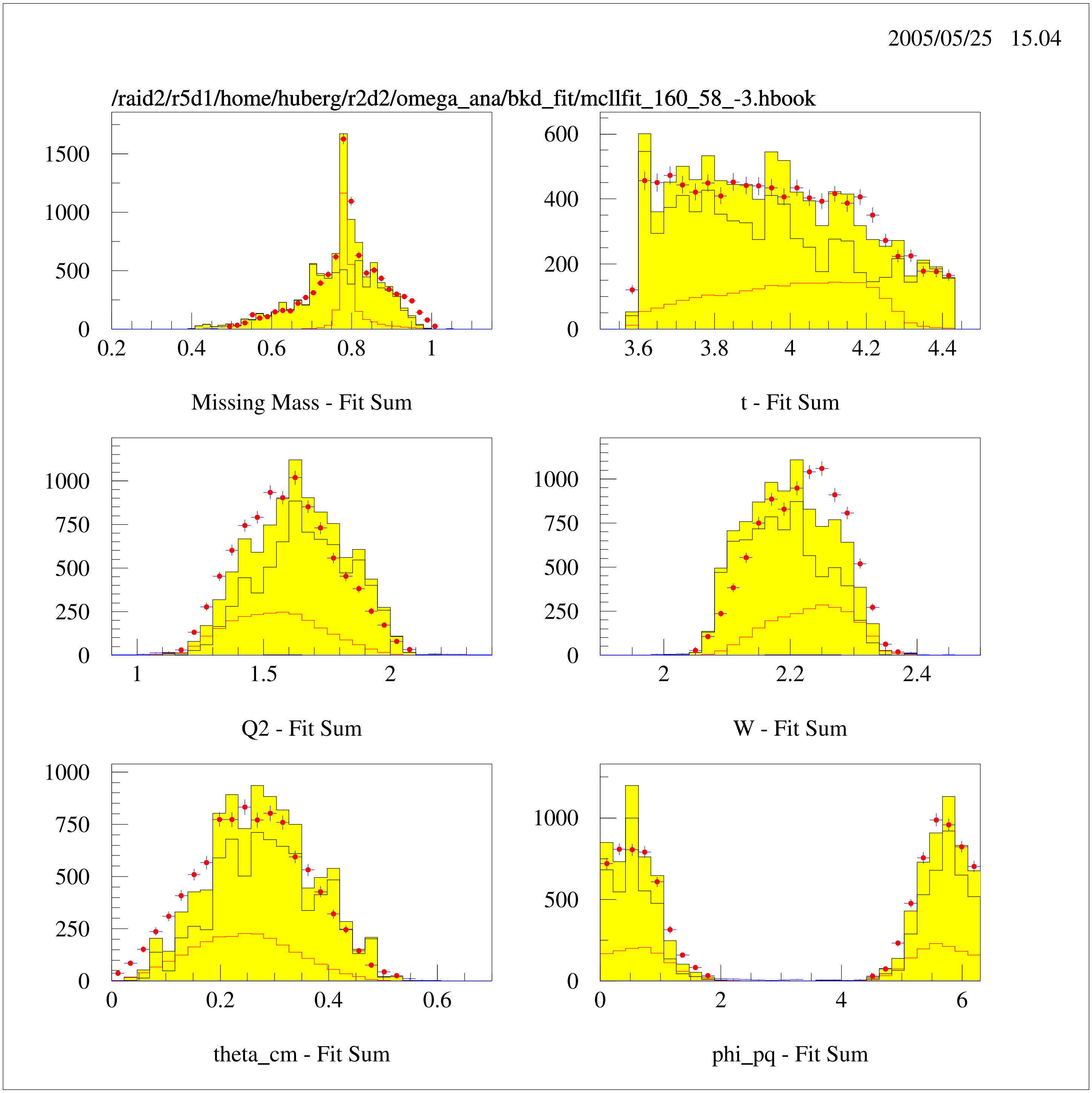

Figure 11: Fit to left HMS setting data at Q^2=1.60, ϵ=0.58. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

6 Q^2 =1.60 GeV^2 $\epsilon = 0.33$

The resulting fit parameters for the two remaining HMS settings are given in the table below.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = +1$			
Data	9770		
Omega	2238	0.229	10.3
Rho	7637	0.782	62.9
Right HMS $\theta_{pq} = +3$			
Data	10959		
Omega	2667	0.244	9.8
Rho	8406	0.767	54.7

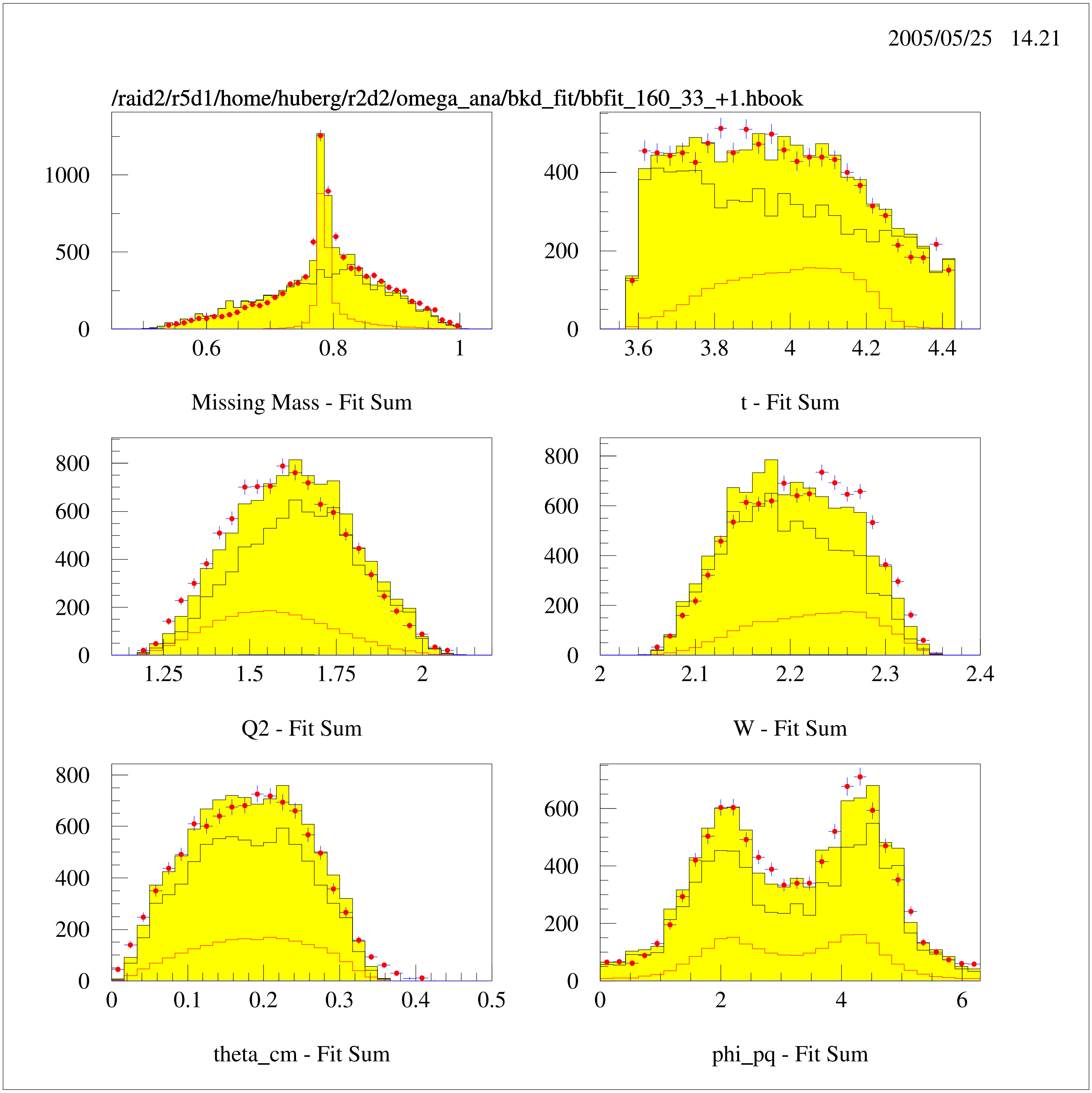

Figure 12: Fit to central HMS setting data at Q^2=1.60, ϵ=0.33. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}.

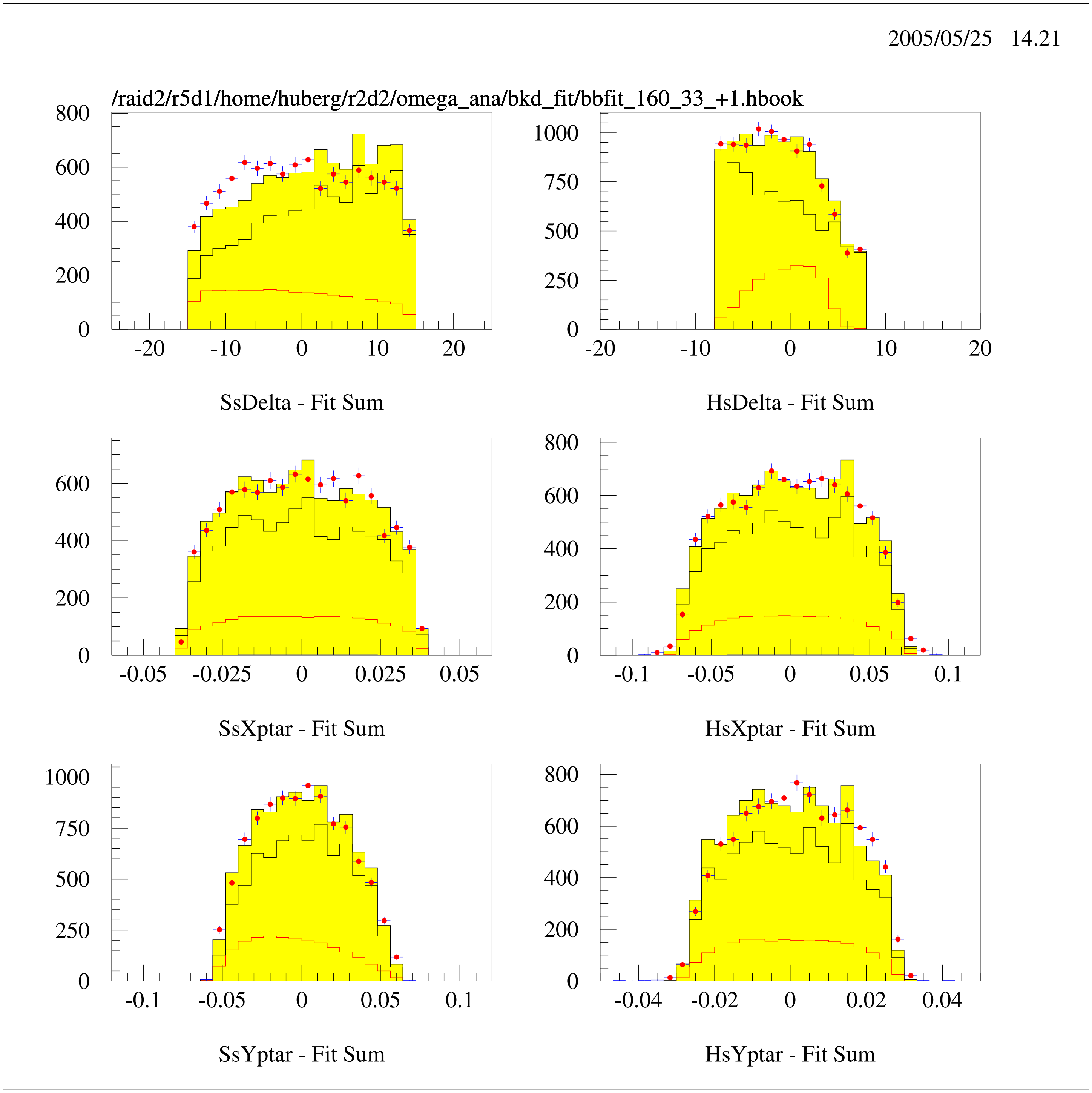

Figure 13: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

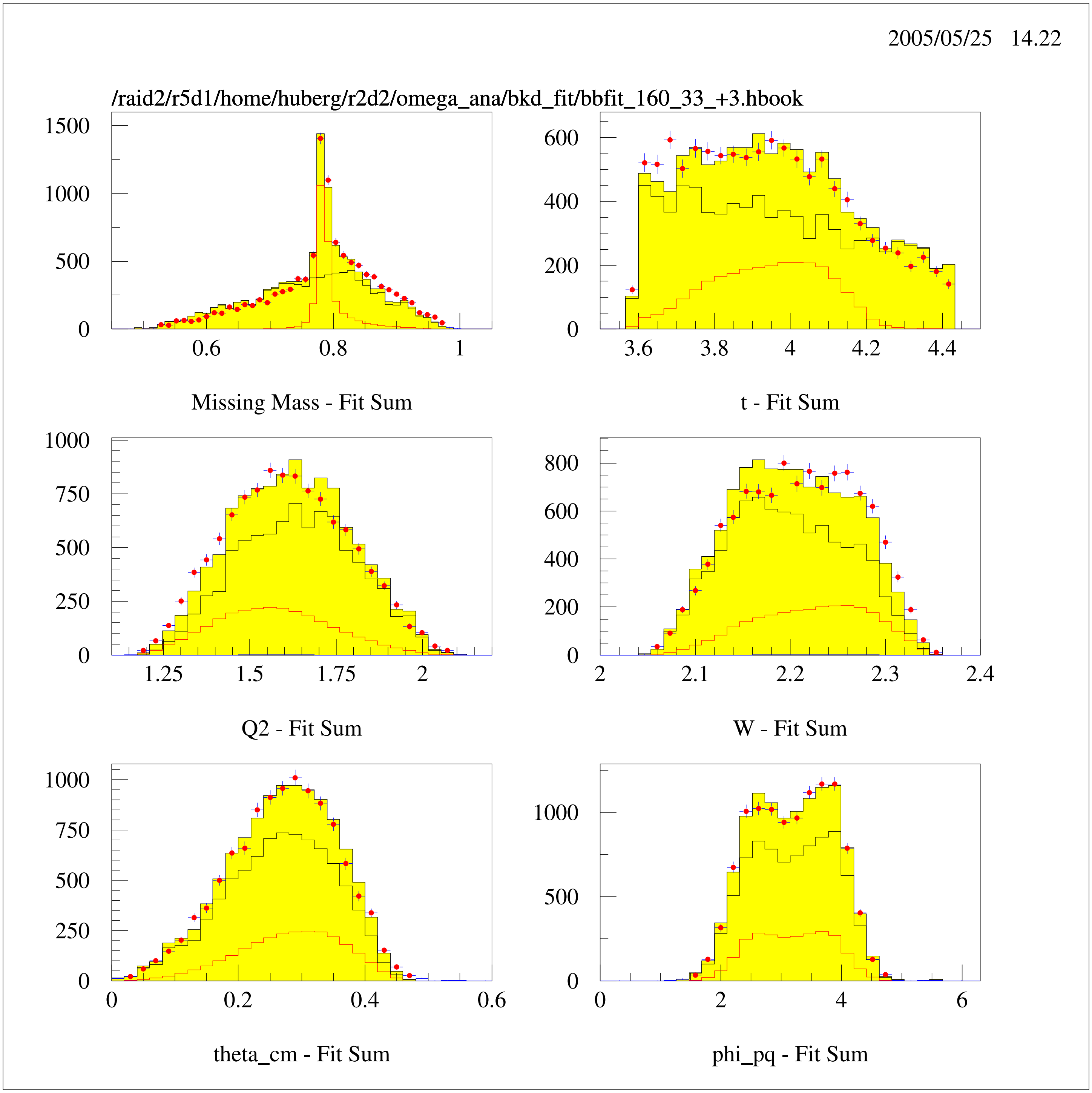

Figure 14: Fit to right HMS setting data at Q^2=1.60, ϵ=0.33. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}.

7 What next?

The unusual weighting function used for the ρ^0 MC is causing some difficulties. As you have likely noticed, the ρ^0 event distributions always look like they suffer large statistical variation, even when I have run very large event samples. The fact that the distributions are not smoothed as the statistics are increased is shown in the first figure.

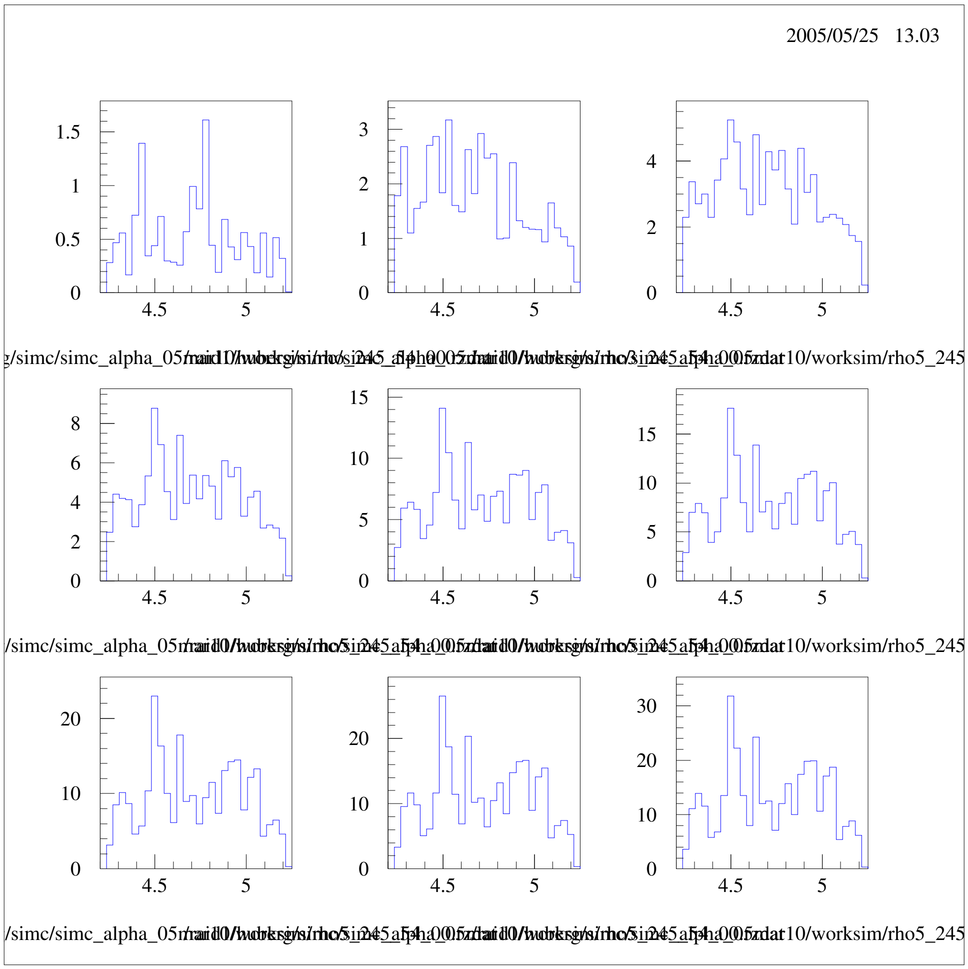

Figure 15: ρ^0 MC $-t$ distribution at $Q^2 = 2.45$, $\epsilon = 0.54$, $\theta_{pq} = 0$. From upper left to lower right, the sizes of the MC event samples are gradually increased, as you can tell from the increasing y-axis scales. The smallest event sample (upper left) is 500k events. The largest event sample (lower right) is 10 million events. Despite the much greater statistics, the random variation is not substantially improved.

I should note that these event samples are much larger than can be normally handled by SIMC. Without modification, SIMC will encounter memory allocation errors after generating coincidence ntuples greater than about 600k events and crash. To get around this problem, the jobs are broken into 500k event pieces, each with a different random number seed (call to sgrnd in mt19937.f), and the resulting coincidence ntuples are chained together. One possibility is that I am observing a limitation in the quality of the random number generator.

However, I think that this problem is likely related to the unusual shape of the ρ^0 weight distribution, where nearly all events are clustered with a weight near zero, but some events have far larger weights. These large weight events contribute to the large statistical fluctuation seen in the ρ^0 MC distributions because their contributions outweight those of thousands of low weight events. Events at large M_x have small weights due to the 5.2 power in the Soding correction factor.

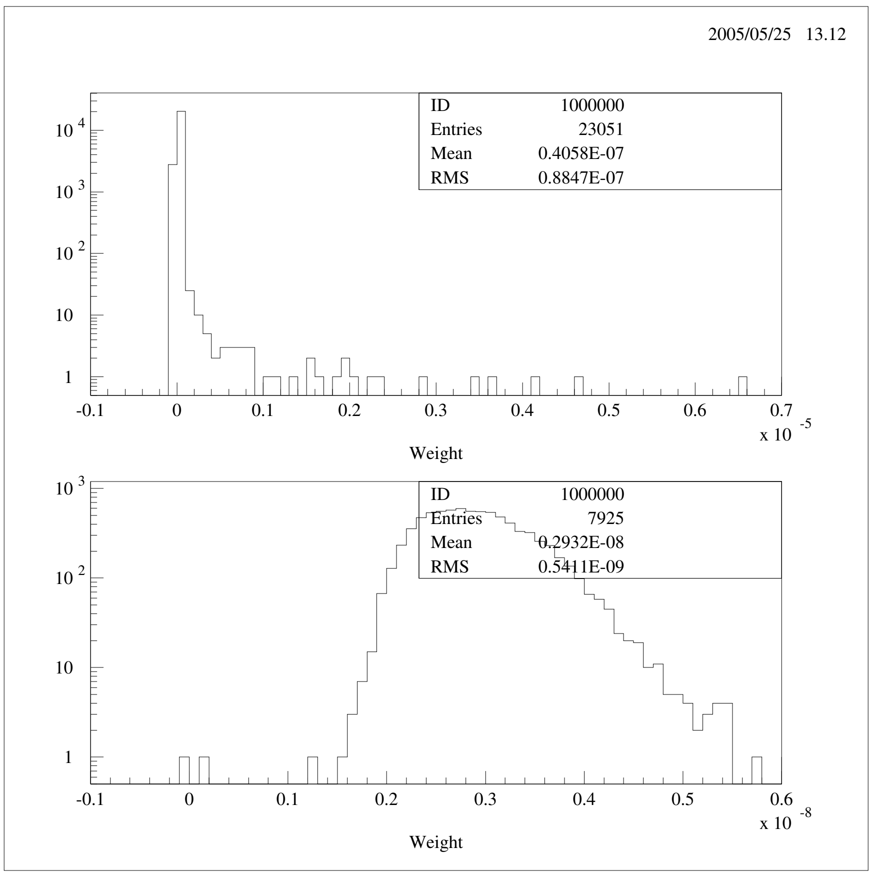

Figure 16: Weight distribution versus events for: Top=ρ^0 MC. Bottom=ω^0 MC.

I clearly need to make some modification to the ρ^0 MC so that the produced distributions do not suffer these random fluctuations. Until this problem is resolved, I will be unable to produce meaningful plots of MC/Data versus ϕ, which I need to better understand the deficiencies of the models. I request your suggestions for how to resolve this problem.