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

- Dummy target data have been subtracted from the LH data, using the target thicknesses listed on Tanja's website, and the ratio of effective beam charges. The target cell missing mass distribution is a smooth background underneath the ω peak. After normalization, the target cell events are 10-15% of the total.

  Note that Pawel Ambrosewicz did not perform any dummy cell subtraction in his analysis, as he assumed its contribution would look similar to the phase-space distribution he needed to subtract underneath the ω peak anyways.

- The log likelihood routine was modified to fit the MCs to only the missing mass variable, instead of the multi-variable fit done previously.

- The number of ρ MC events used in the fits have been increased from 150k to 2.5 million per kinematic setting. The number of ω MC events per setting remains at 150k.

- New routines written to bin data and MCs according to M_x, $-t$, θ^*_{pq} and ϕ_{mq}.

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

The resulting fit parameters for all three HMS settings are given in the table below.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = 00$			
Data	32236		
Omega	7054	0.219	21.1
Rho	25389	0.788	116.7
Right HMS $\theta_{pq} = +3$			
Data	38715		
Omega	11216	0.290	17.8
Rho	27610	0.713	68.9
Left HMS $\theta_{pq} = -3$			
Data	34743		
Omega	5841	0.168	20.1
Rho	29623	0.852	233.9

As we have little idea of the ω^0 and ρ cross sections in this kinematic region, the cross sections assumed in the MC models are very approximate. The MC multiplier is the ratio of fit events attributed to the MC process to the number of events predicted by the model for the setting's integrated luminosity, i.e. the actual cross sections are higher than the model cross sections by these approximate values. A ratio far from one is of no concern, provided that it is constant with HMS angle.

As you see, the MC multiplier is nearly independent of angle for the ω^0 MC, which indicates that for these kinematics the θ^* and $-t$ dependences assumed in the ω^0 model are fairly good. But the MC multiplier for the ρ MC varies widely, and this means that a major modification to the ρ generator is likely necessary.

The next two pages of plots show the quality of the fit histograms for the central HMS setting.

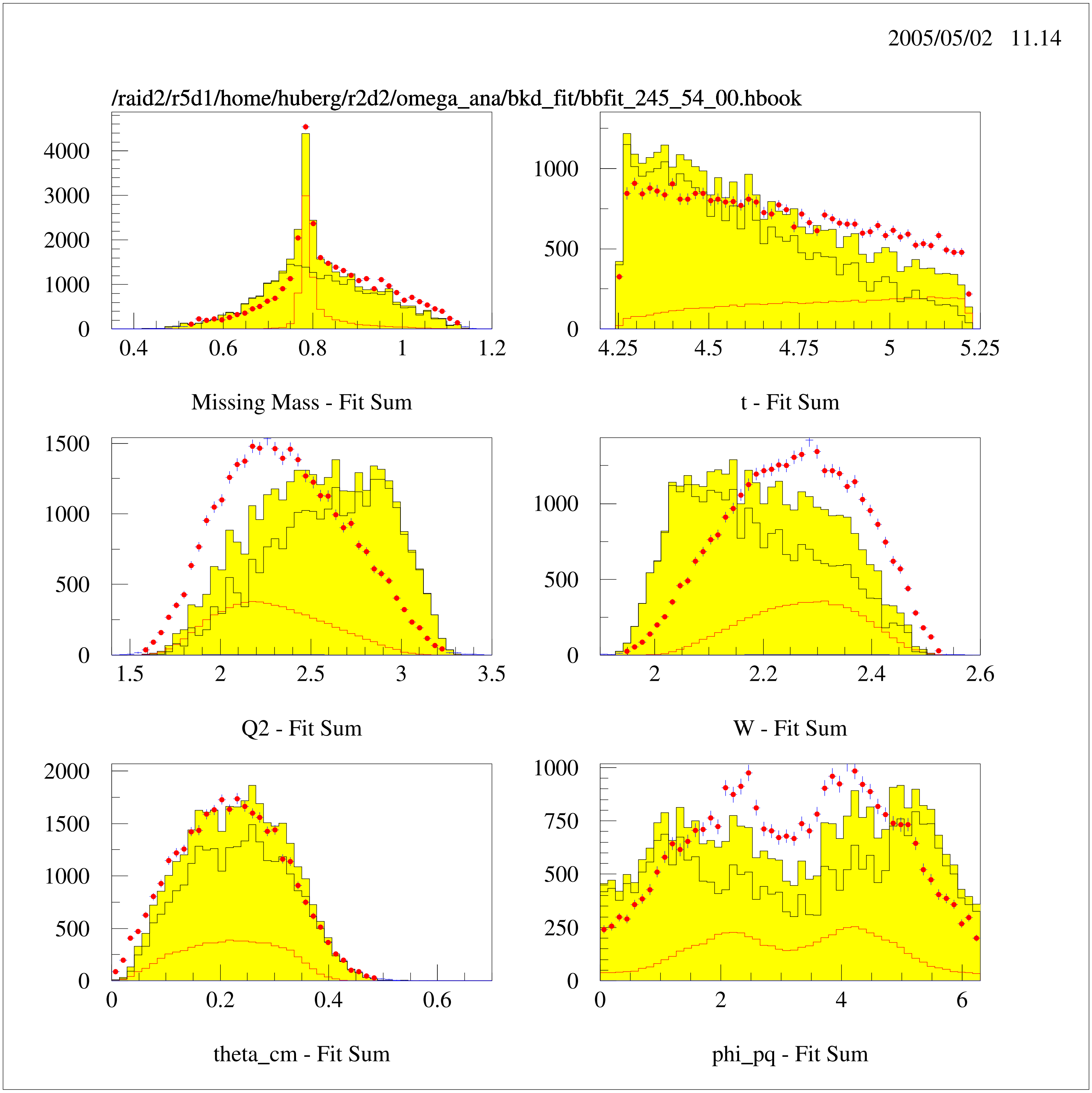

Figure 1: Fit to central HMS setting data at Q^2=2.45, ϵ=0.54. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

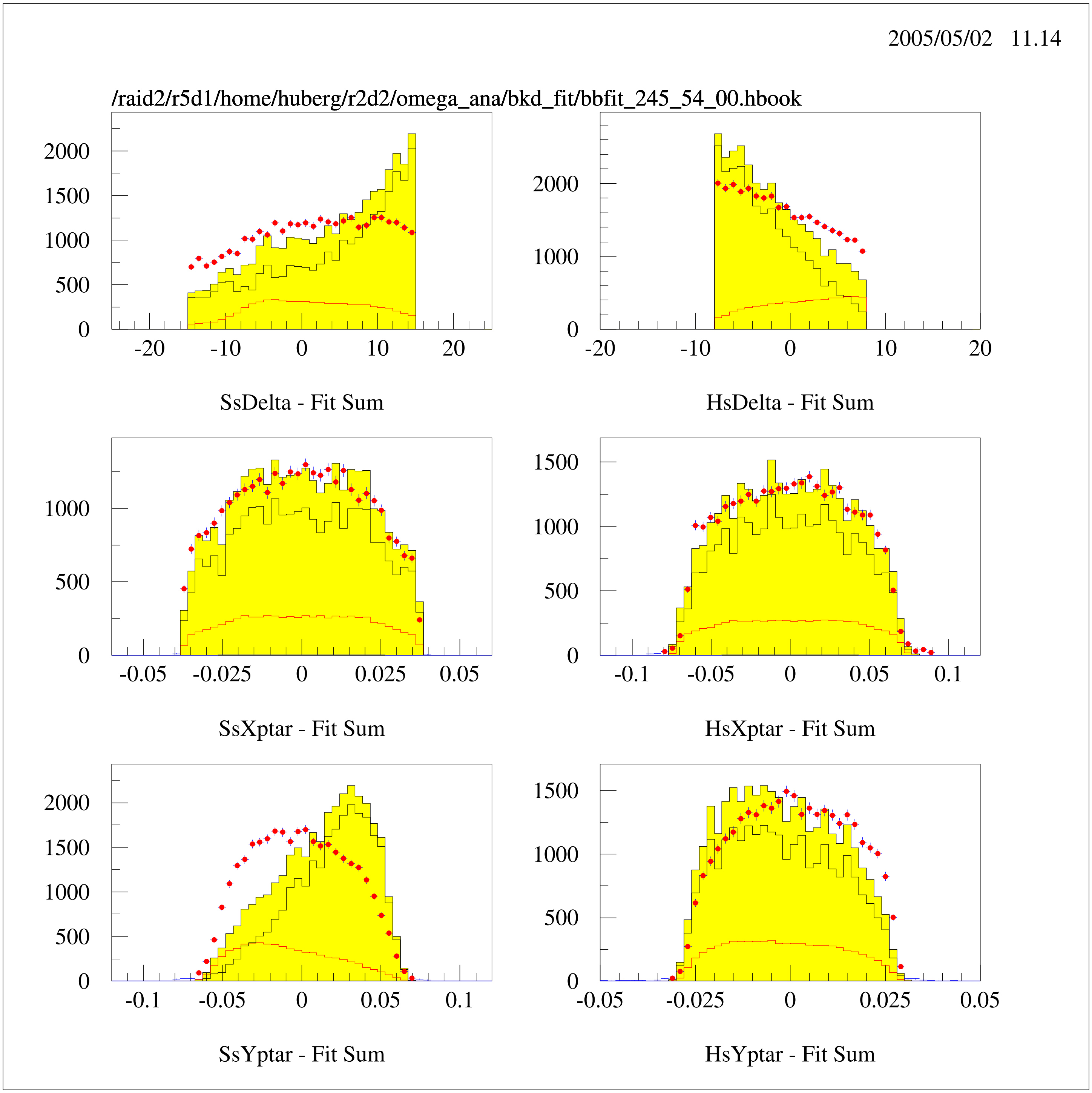

Figure 2: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

Binning in M_x, $-t$, θ^*_{pq} and ϕ_{mq} is done as follows:

- Missing mass is divided into three unequal width bins, 660-770 MeV, 770-800 MeV, and 800-1000 MeV. The central bin encloses nearly all of the ω events, as the peak is $\sim$25 MeV wide at its base. The other two bins are to indicate the θ^* and ϕ distribution of the ρ background underneath.

- $-t$ is divided into four equal bins, spanning 4.15-5.30 GeV^2 at $Q^2 = 2.45$ and 3.45-4.55 GeV^2 at $Q^2 = 1.60$.

- The center of mass pq scattering angle θ^*_{pq} from 0 to 22^o is divided into four equal bins.

- The azimuthal angle between the missing mass and the q-vector, ϕ_{mq} is divided into eight equal bins spanning 0 to 2π.

- The data coincidences (after random and dummy target subtraction) are individually binned and divided by the experimental efficiency (but not charge) for the three different HMS settings. The bins for the three HMS settings are then combined to yield the complete ϕ distributions.

- For each MC, the simulated distributions for each HMS setting are individually binned, and normalized to the effective beam charge used in each HMS setting. No further correction should then be necessary for the different luminosities of the three HMS settings.

- For each MC, the bin values for all three HMS settings are further multiplied by the fit factor obtained from the fit to the central HMS setting data. A common fit factor is used for all three HMS settings, so as not to obsure the flaws in the θ^* description of the data.

  From variation of the fit factors in the table on page 2, we should expect the sum of the two fitted MCs to undershoot the data for positive θ_{pq} (ϕ near zero) and overshoot the data for negative θ_{pq} (ϕ near π).

- The Data/MC ratio is then computed separately for each bin, with full error propagation.

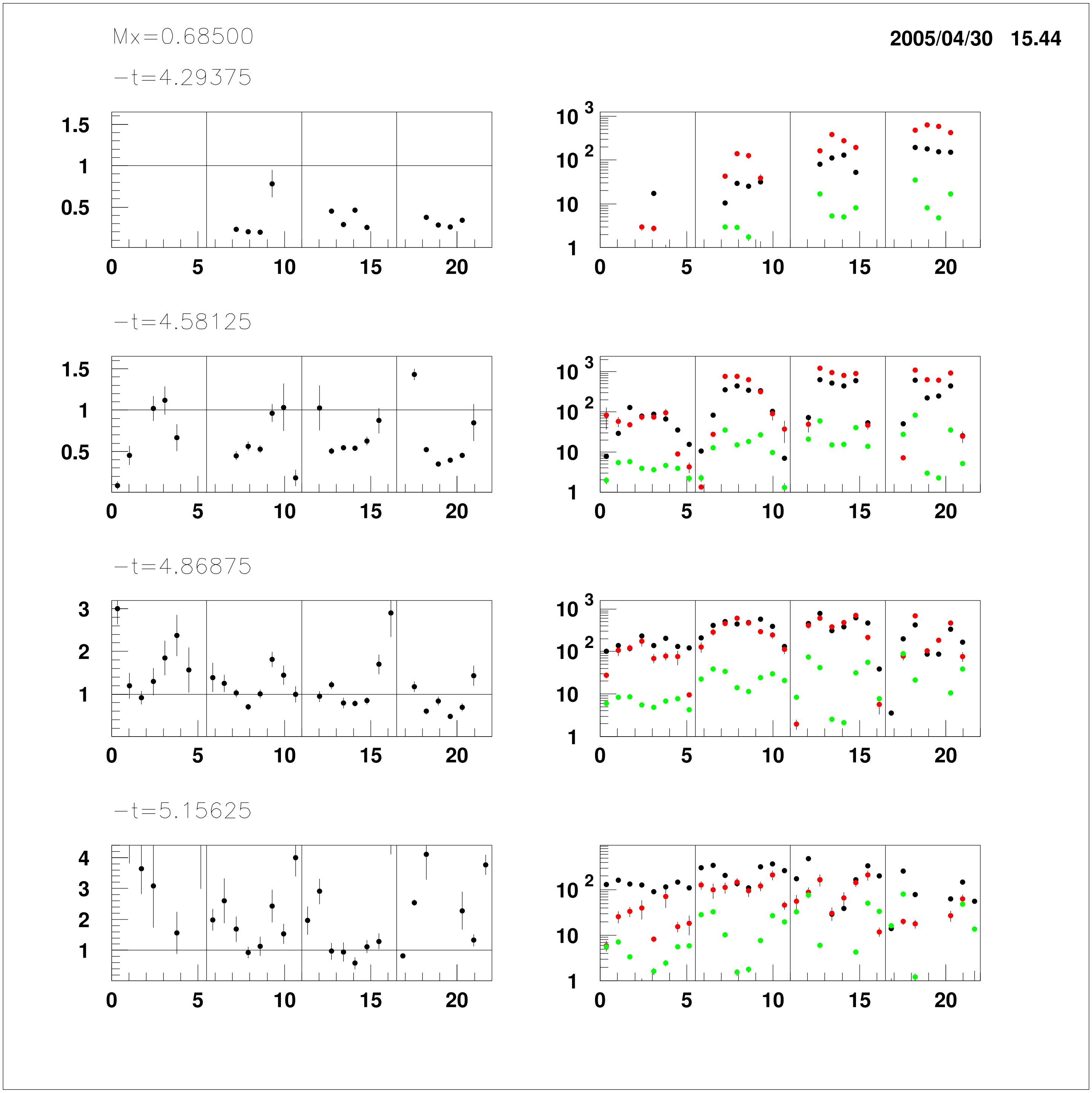

Figure 3: Low M_x bin data at $Q^2 = 2.45$, $\epsilon = 0.54$. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

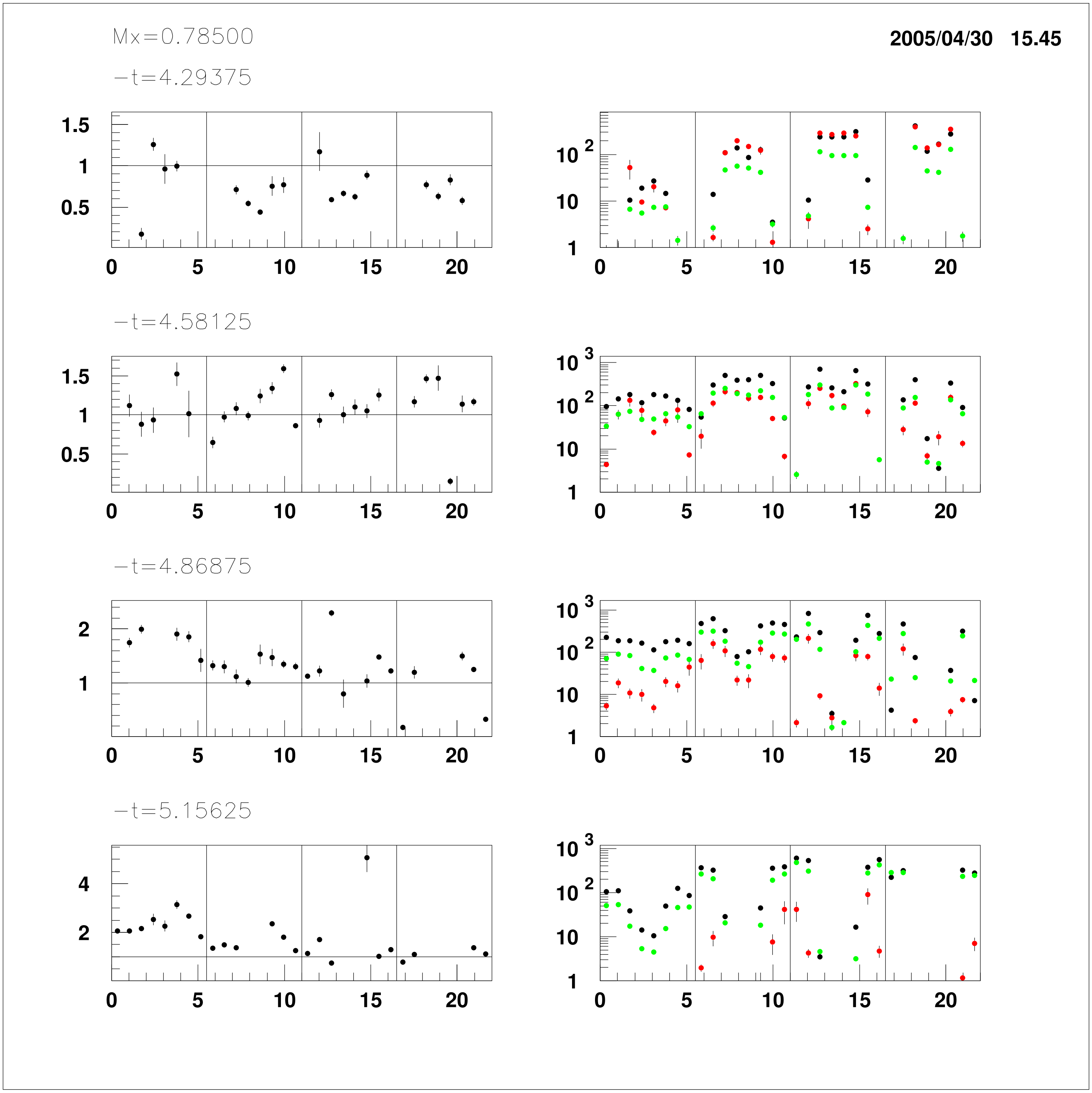

Figure 4: M_x centered on ω peak, for $Q^2 = 2.45$, $\epsilon = 0.54$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

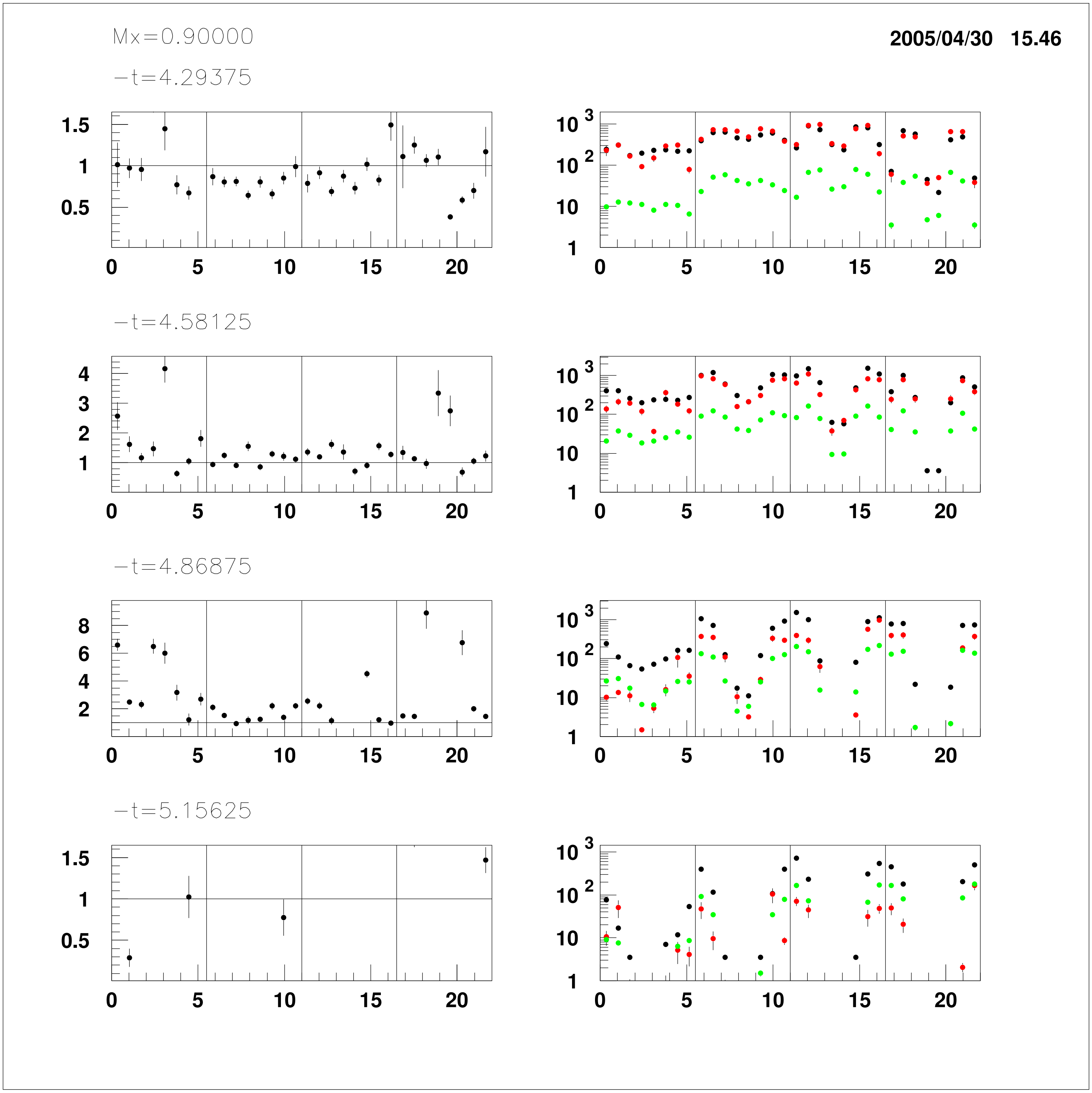

Figure 5: High M_x bin data at $Q^2 = 2.45$, $\epsilon = 0.54$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

3 $\mathbf{Q^2}$ =2.45 GeV^2 $\epsilon = 0.27$

The fits to the low ϵ $Q^2 = 2.45$ data are generally superior to the fits to the high ϵ data shown in the previous section. This is shown by the more constant fit multipliers in the table below, as well as the comparisons to the data distributions on the two following pages. Given the statistics and incomplete ϕ coverage of the experiment, the MC descriptions of the ϕ distributions also appears to be reasonably good.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = +1$			
Data	13228		
Omega	3099	0.234	20.6
Rho	10221	0.773	60.4
Right HMS $\theta_{pq} = +3$			
Data	13657		
Omega	3404	0.249	19.5
Rho	10350	0.758	50.7

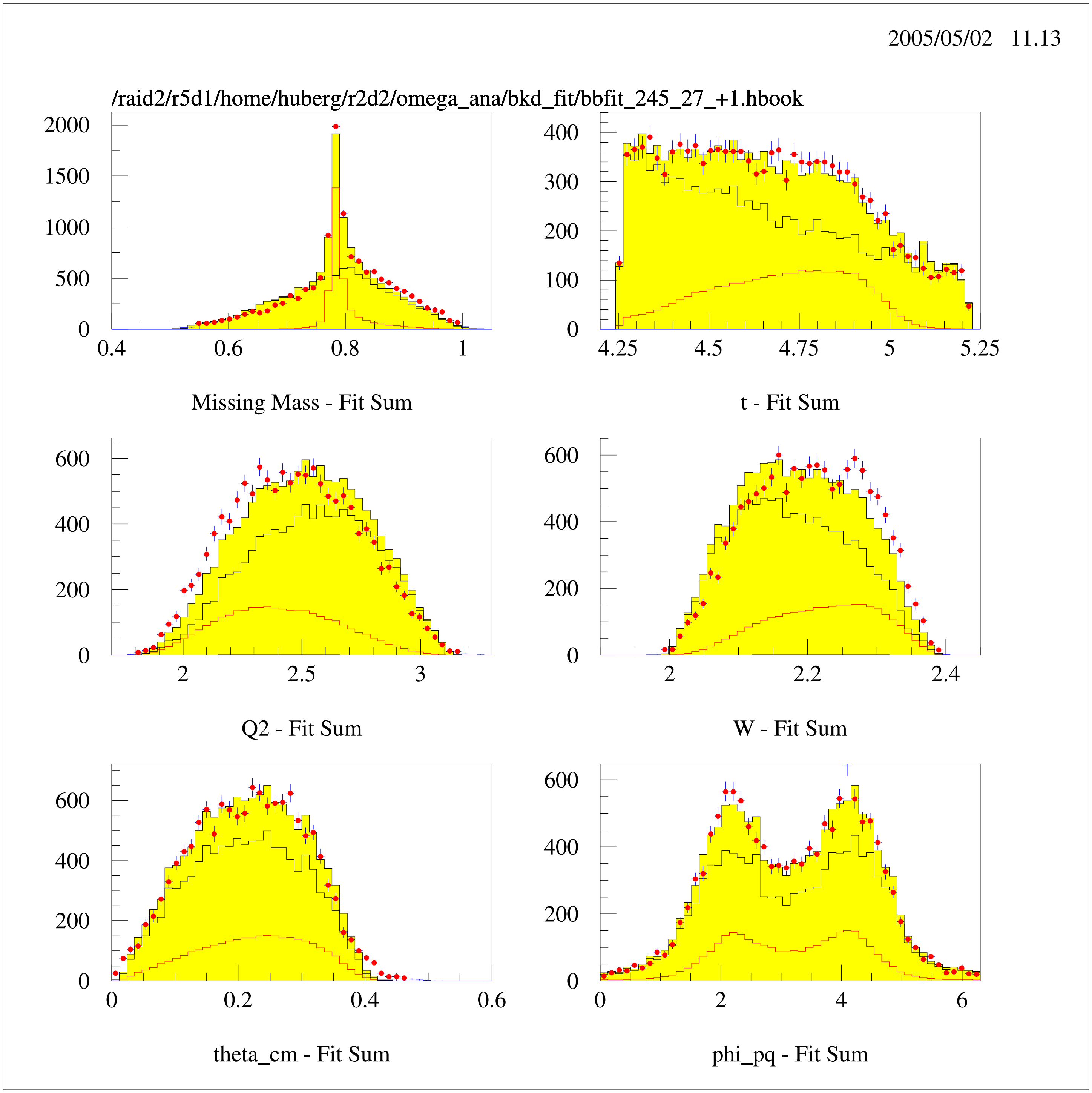

Figure 6: Fit to central HMS setting data at Q^2=2.45, ϵ=0.27. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

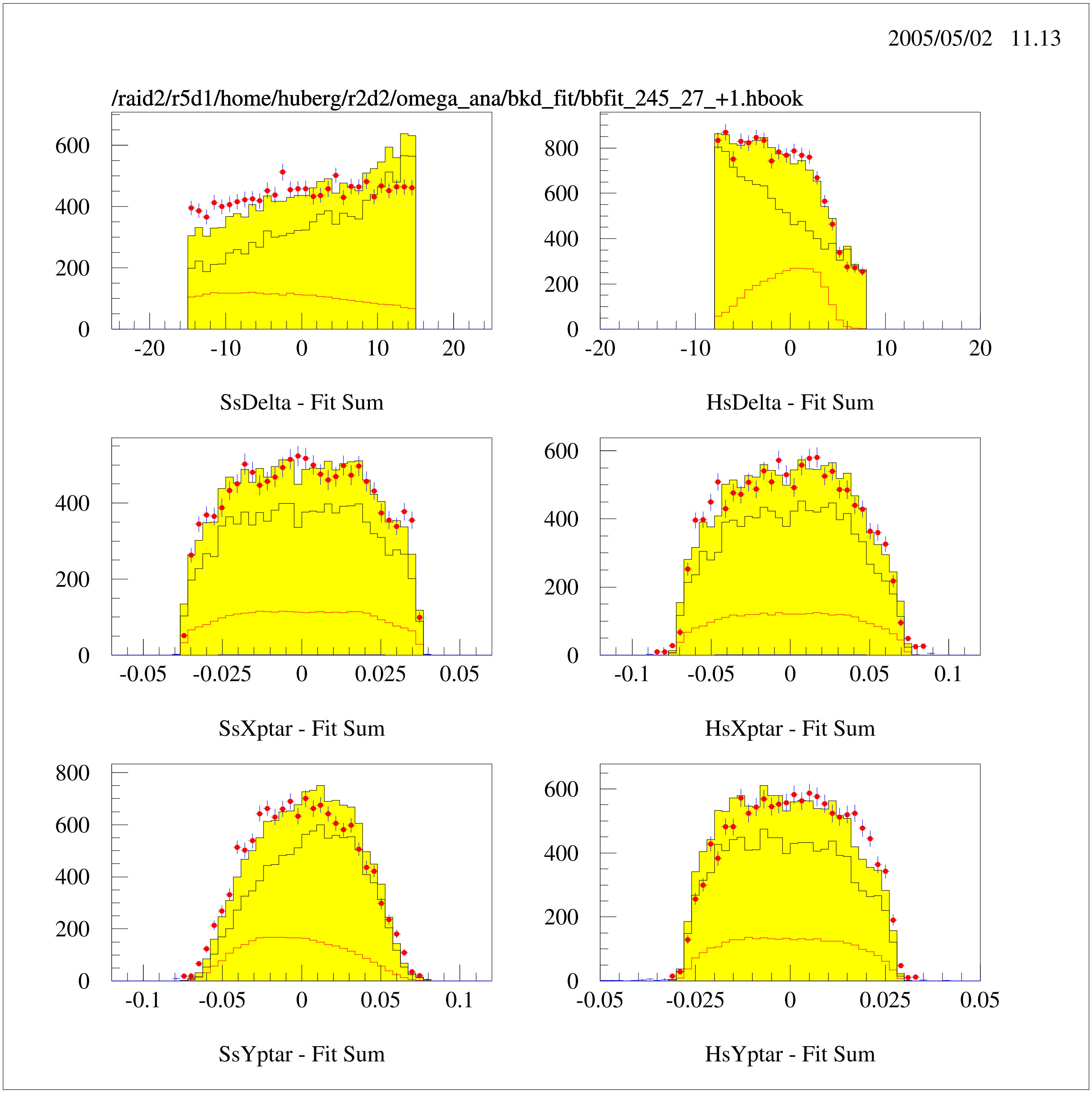

Figure 7: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

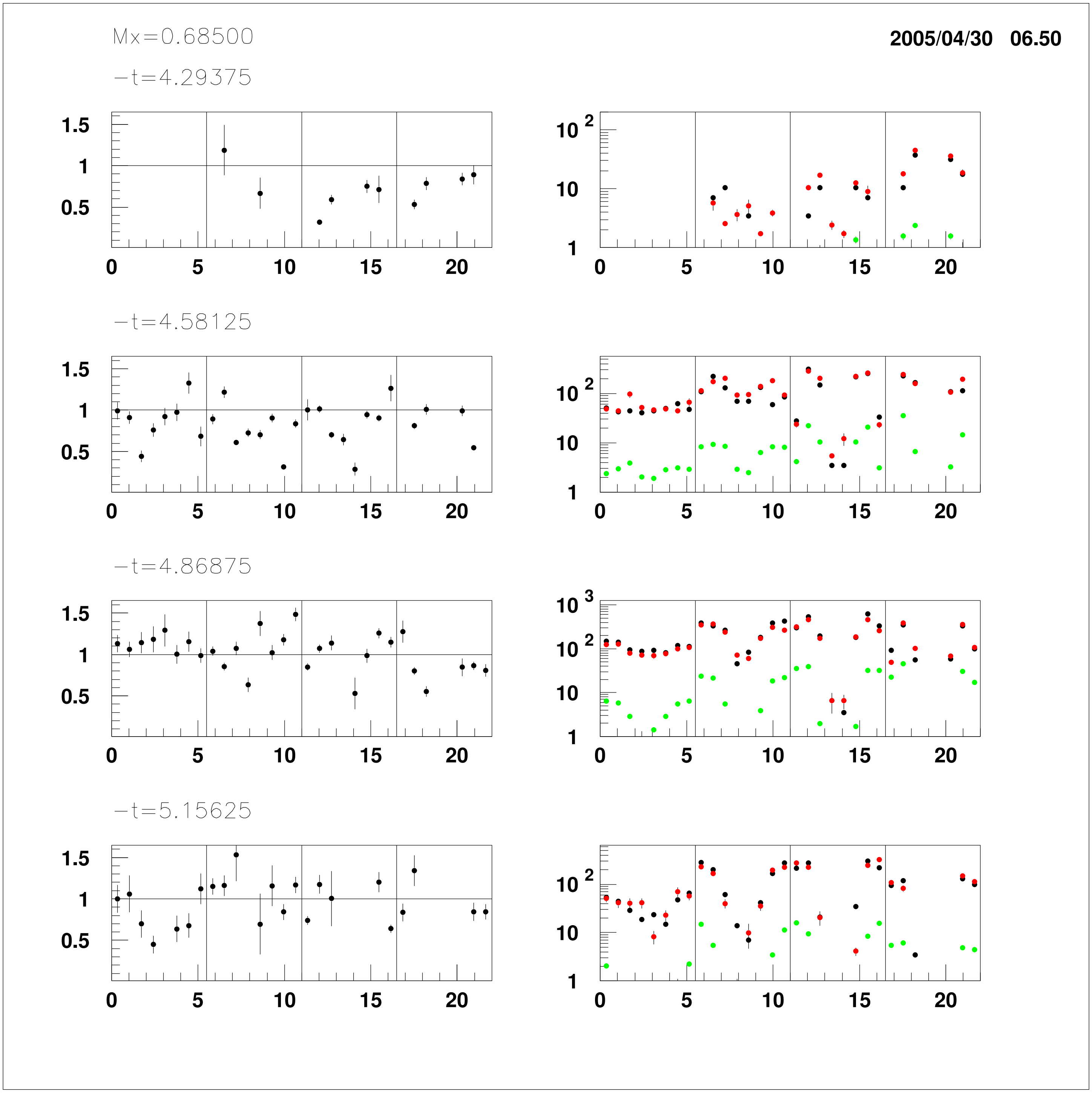

Figure 8: Low M_x bin data at $Q^2 = 2.45$, $\epsilon = 0.27$. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

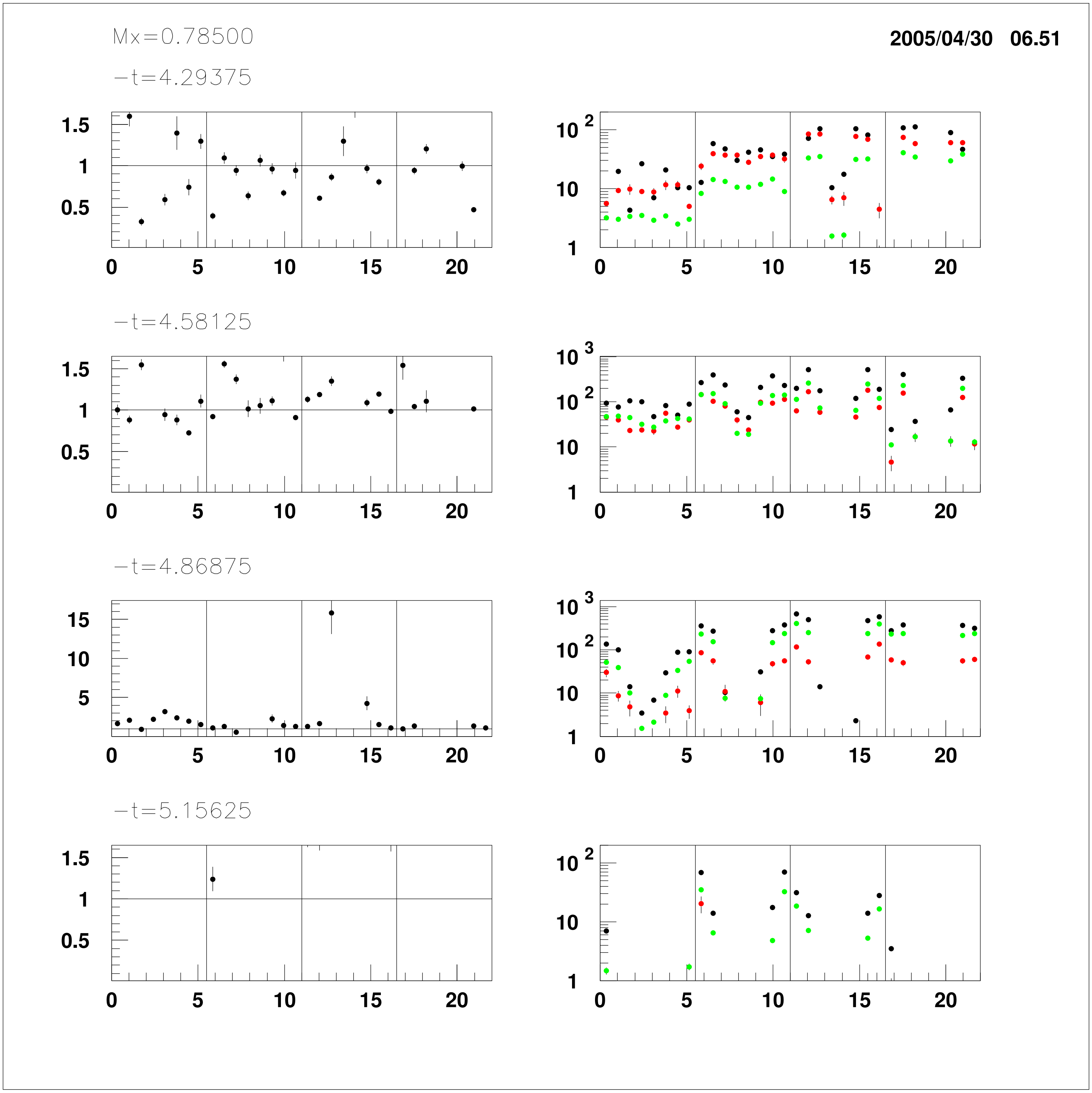

Figure 9: M_x centered on ω peak, for $Q^2 = 2.45$, $\epsilon = 0.27$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

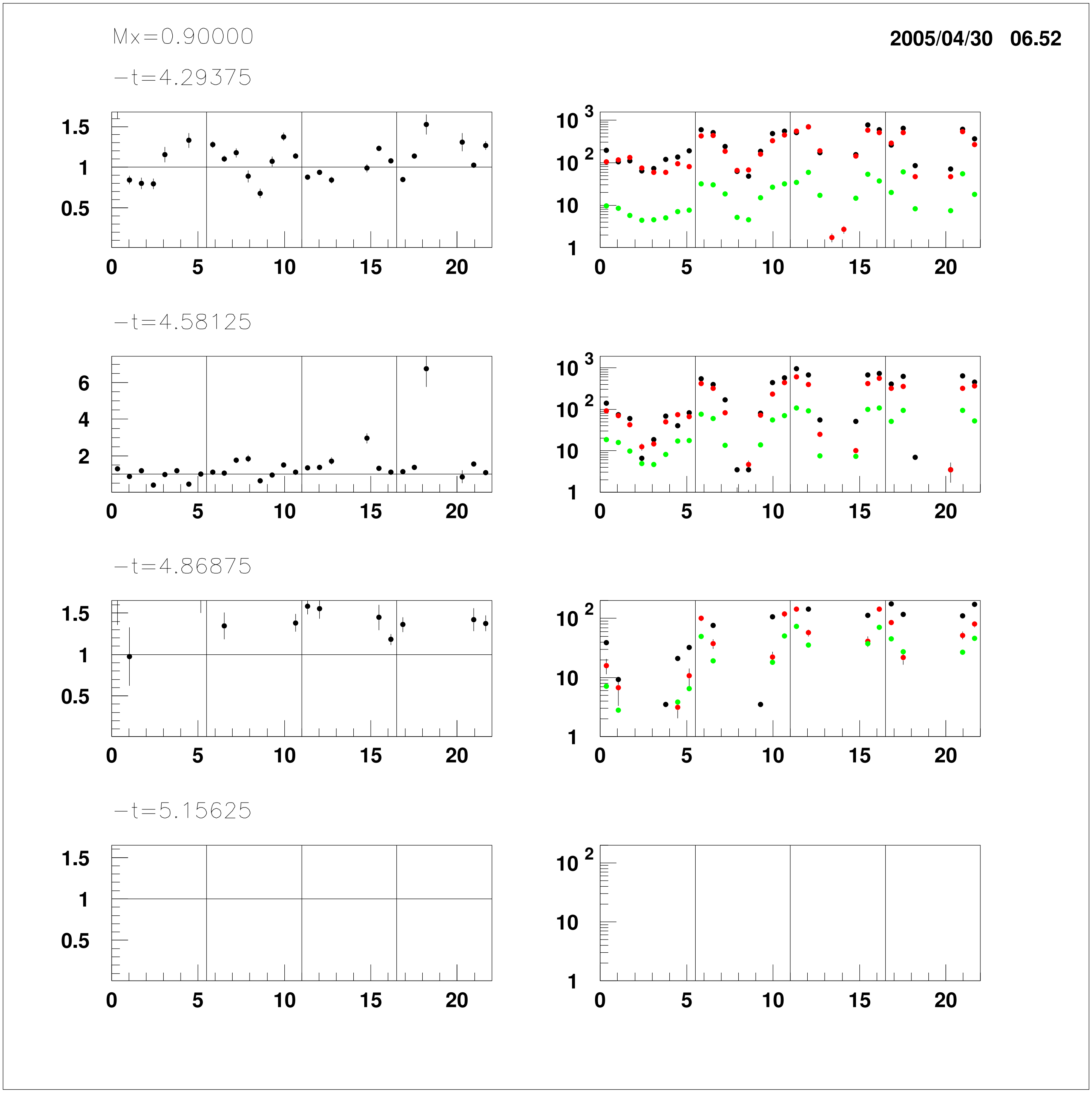

Figure 10: High M_x bin data at $Q^2 = 2.45$, $\epsilon = 0.27$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

4 $\mathbf{Q^2}$ =1.60 $\mathbf{GeV^2}$ $\epsilon = 0.58$

As at Q^2=2.45, the MC multiplier for the ρ MC varies greatly with HMS angle, indicating a significant ϵ-dependent deficiency in the θ^*-dependence in the ρ cross section model. Suggestions are requested on possible strategies for the modification of the model.

To recap, at present the ρ^0 model assumes purely diffractive production

$$\frac{d\sigma}{dtdM_x} = \left(\frac{m_\rho}{M_x}\right)^n De^{bt'},$$

where $t =' t - t_{min}$ and D is the photoproduction cross section with a Q^2 dependence introduced by the square of the ρ^0 propagator, and the exponential slope b is parameterized in terms of W and Q^2.

The ω cross section model also needs modification, but this probably can not be attempted until the deficiencies in the ρ model are better understood.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = +1$			
Data	27040		
Omega	3513	0.130	6.7
Rho	24659	0.912	424.4
Right HMS $\theta_{pq} = +3$			
Data	32075		
Omega	6599	0.206	7.3
Rho	25922	0.808	243.0
Left HMS $\theta_{pq} = -3$			
Data	30010		
Omega	2817	0.094	5.63
Rho	28994	0.966	778.9

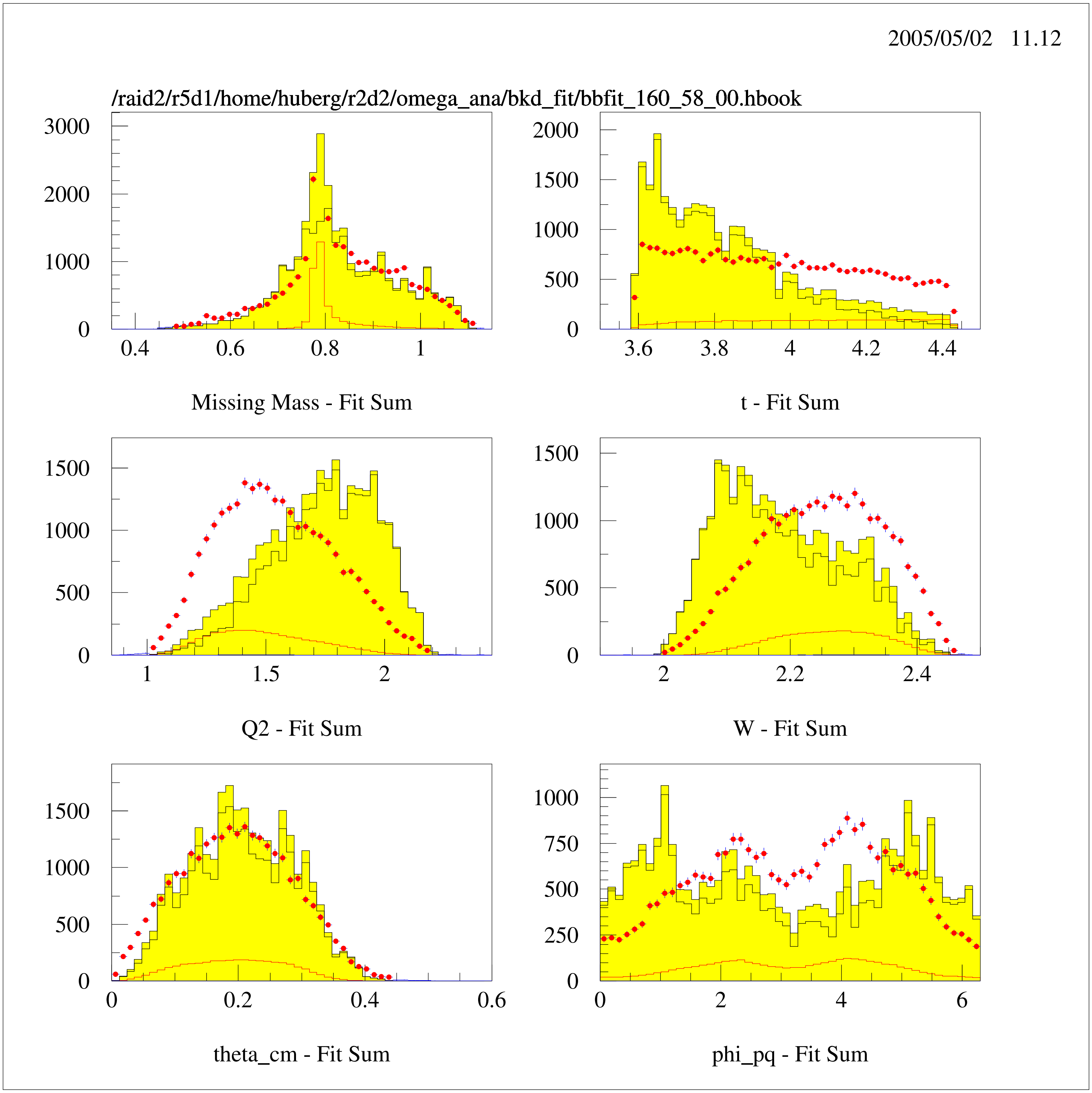

Figure 11: Fit to central HMS setting data at Q^2=1.60, ϵ=0.58. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's.

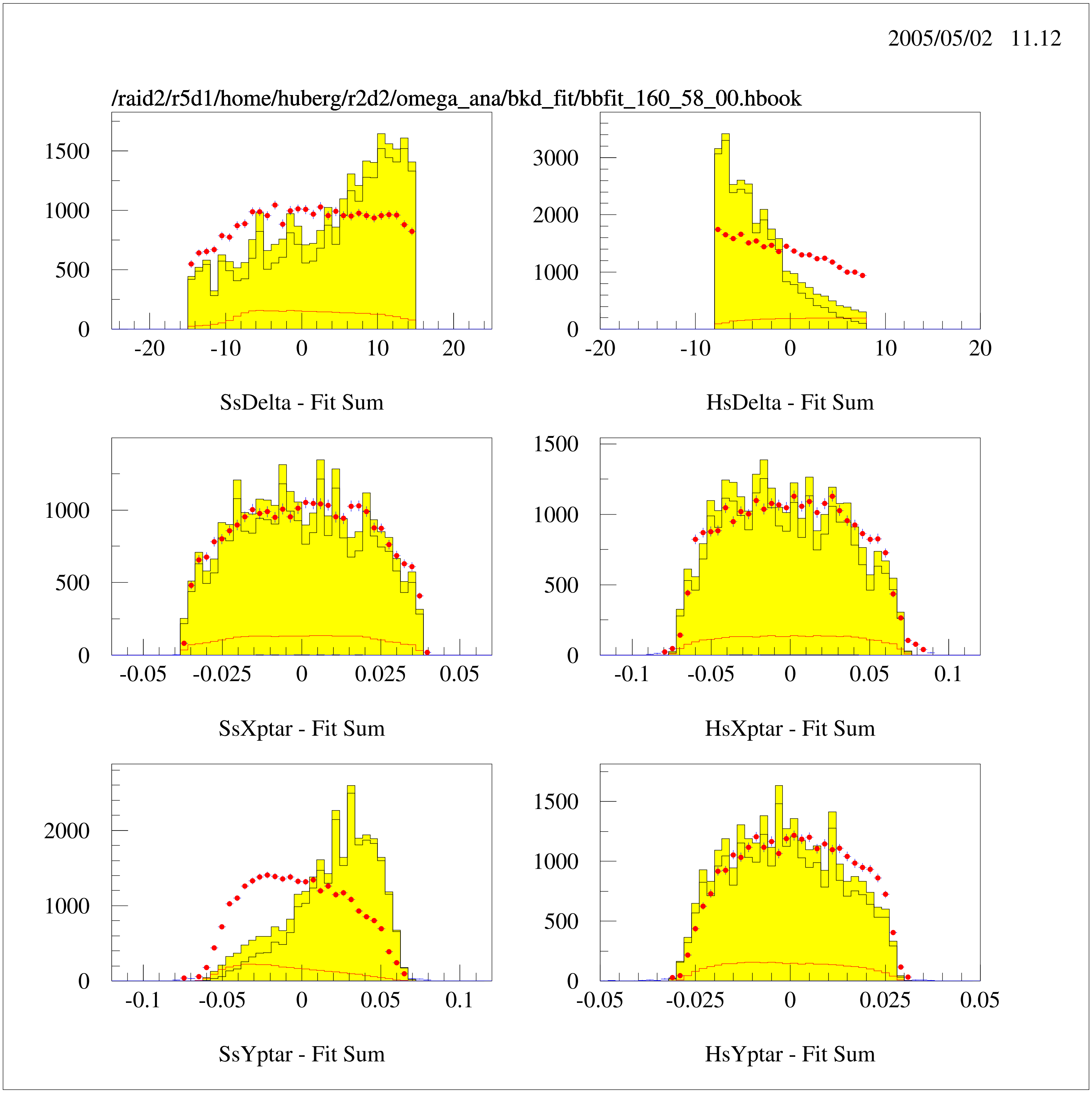

Figure 12: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

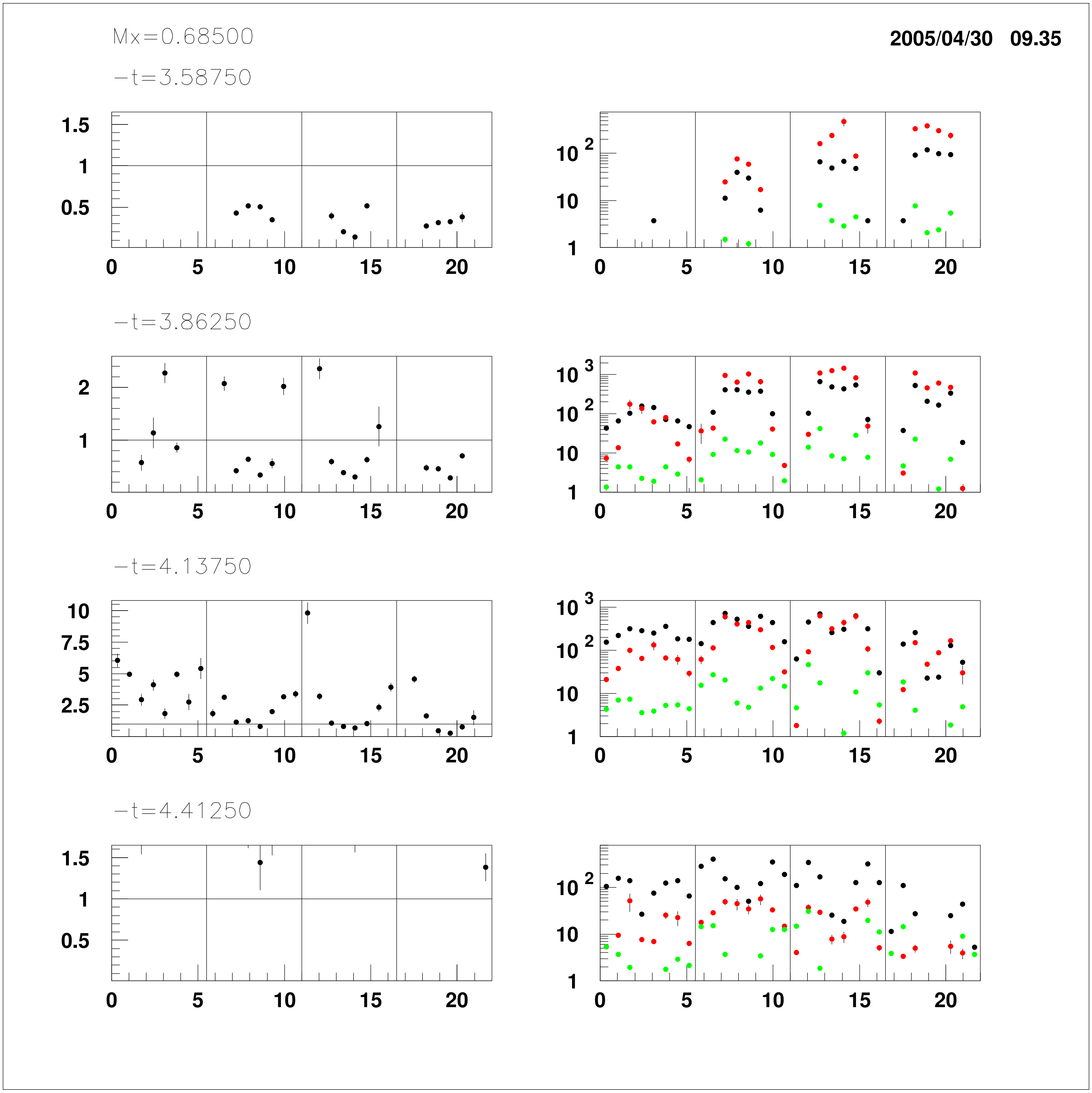

Figure 13: Low M_x bin data at $Q^2 = 1.60$, $\epsilon = 0.58$. On the left are the Data/(Rho+Omega MC) ratios. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

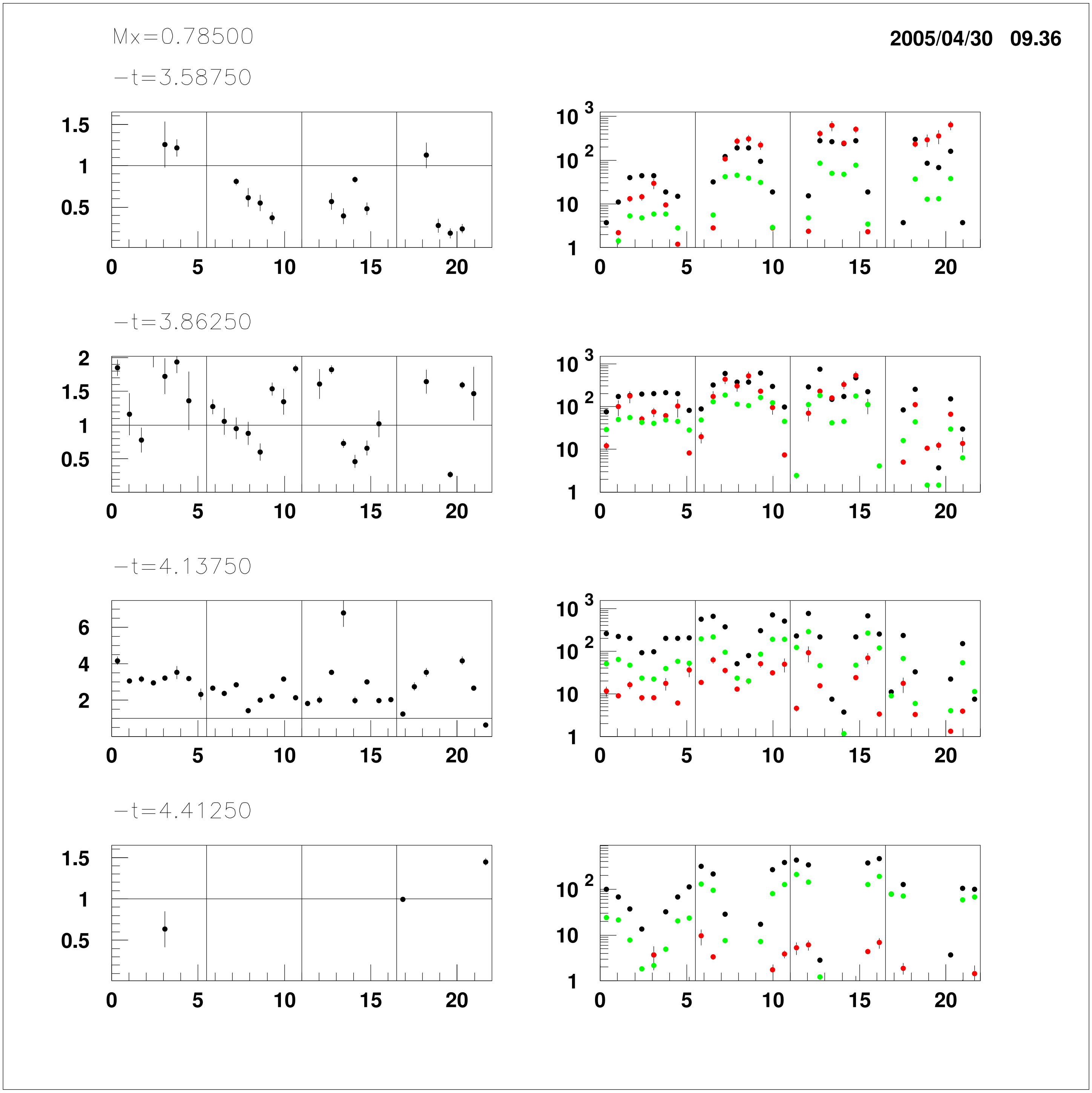

Figure 14: M_x centered on ω peak, for $Q^2 = 1.60$, $\epsilon = 0.58$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

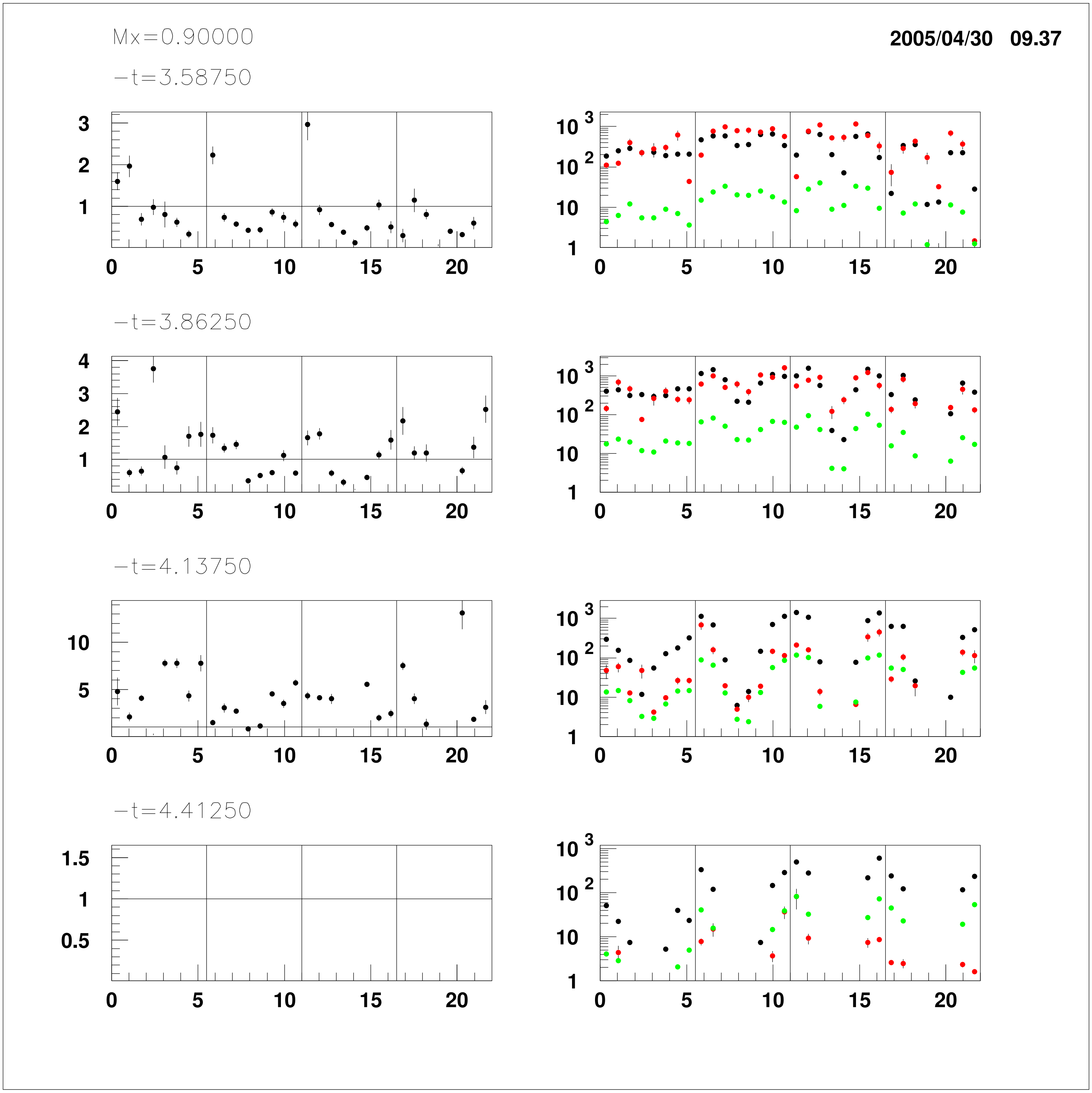

Figure 15: High M_x bin data at $Q^2 = 1.60$, $\epsilon = 0.58$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

5 $\mathbf{Q^2}$ =1.60 GeV^2 $\epsilon = 0.33$

The resulting fit parameters for the two remaining HMS settings are given in the table below. As at $Q^2 = 2.45$, the fits to the low ϵ data are generally better than the fits to the high ϵ data.

	Counts	Fit Fraction	MC multiplier
Central HMS $\theta_{pq} = +1$			
Data	11133		
Omega	2088	0.188	8.9
Rho	9446	0.849	152.8
Right HMS $\theta_{pq} = +3$			
Data	12448		
Omega	2657	0.213	8.9
Rho	10032	0.806	110.9

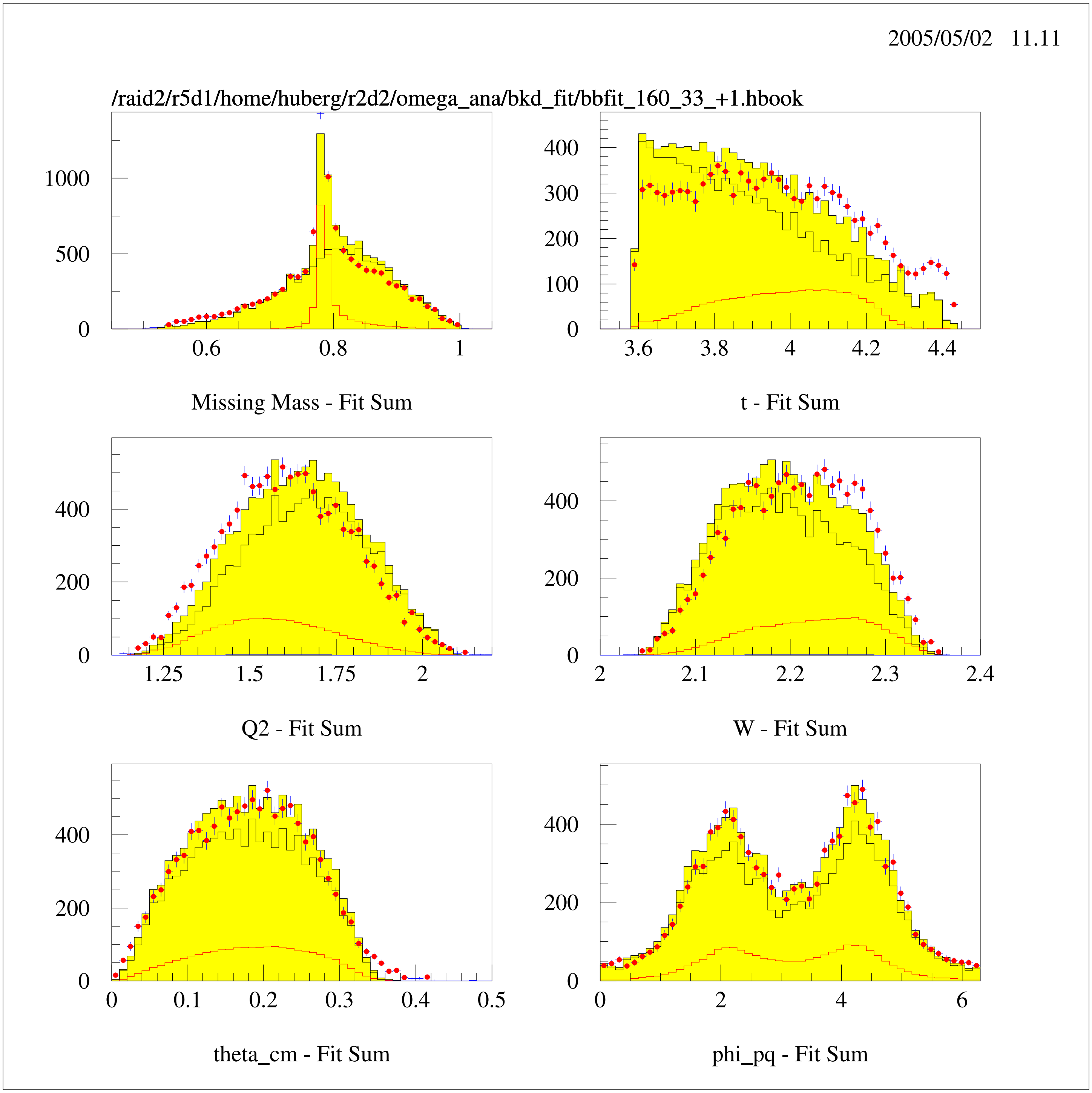

Figure 16: Fit to central HMS setting data at Q^2=1.60, ϵ=0.33. The red points are the experimental data, the red curve is the fit ω MC, the black curve the ρ MC and the yellow region the sum of the two MC's. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}.

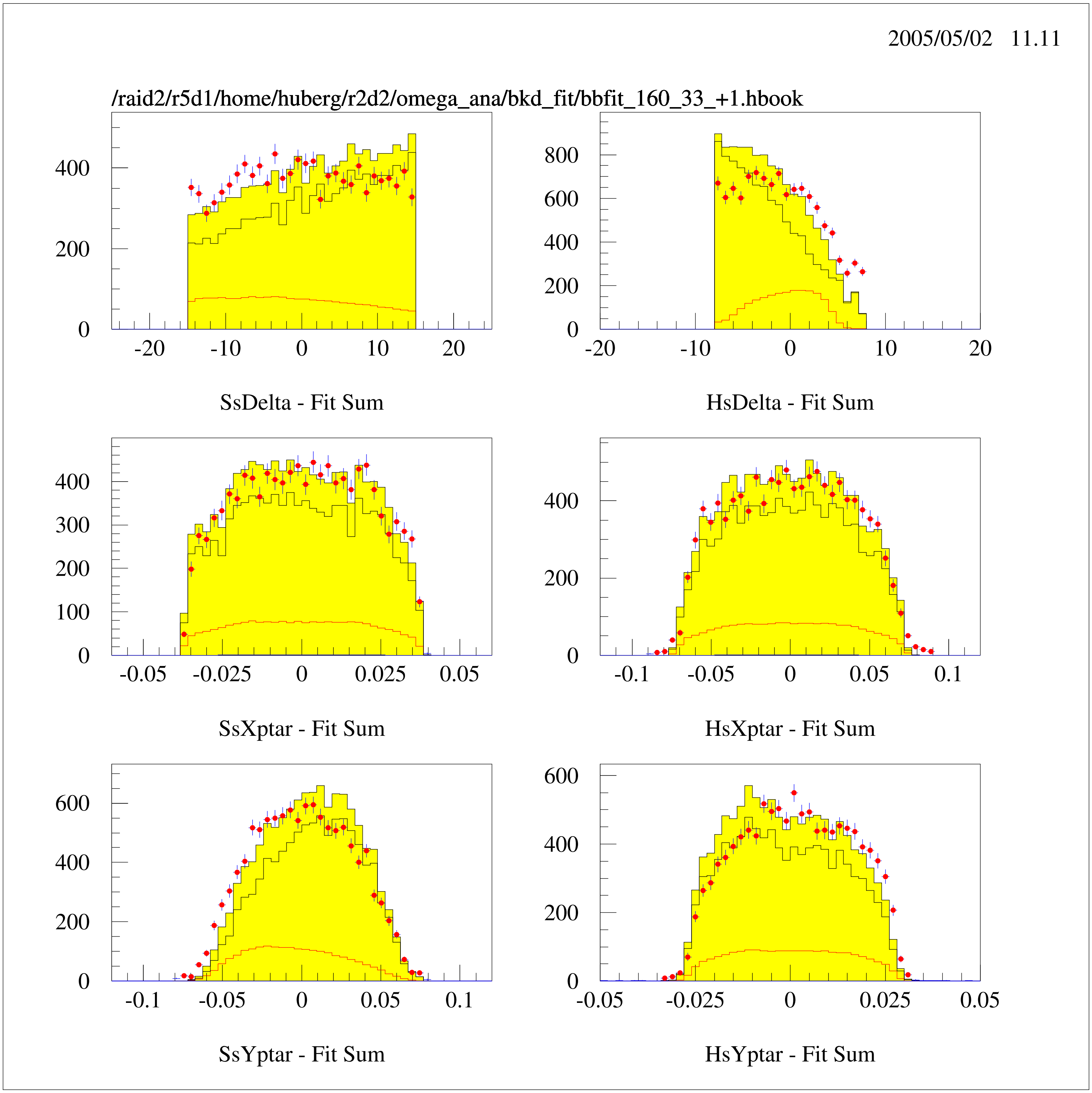

Figure 17: Spectrometer variable distributions for the same fit to missing mass shown on the previous page.

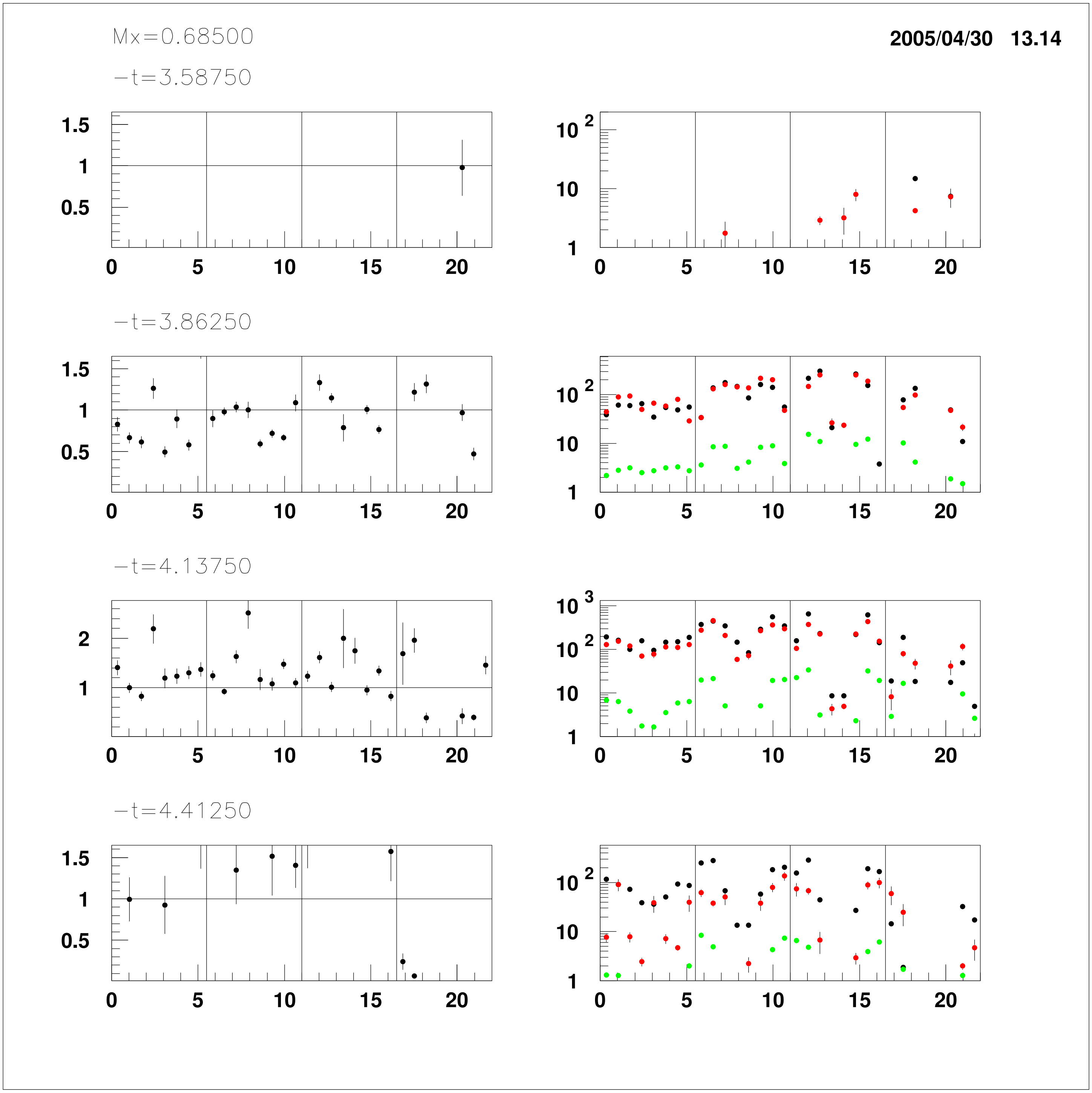

Figure 18: Low M_x bin data at $Q^2 = 1.60$, $\epsilon = 0.33$. On the left are the Data/(Rho+Omega MC) ratios. For each $-t$ bin, ϕ distributions are shown for each of the four θ^* bins, in order of increasing θ^*_{pq}. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

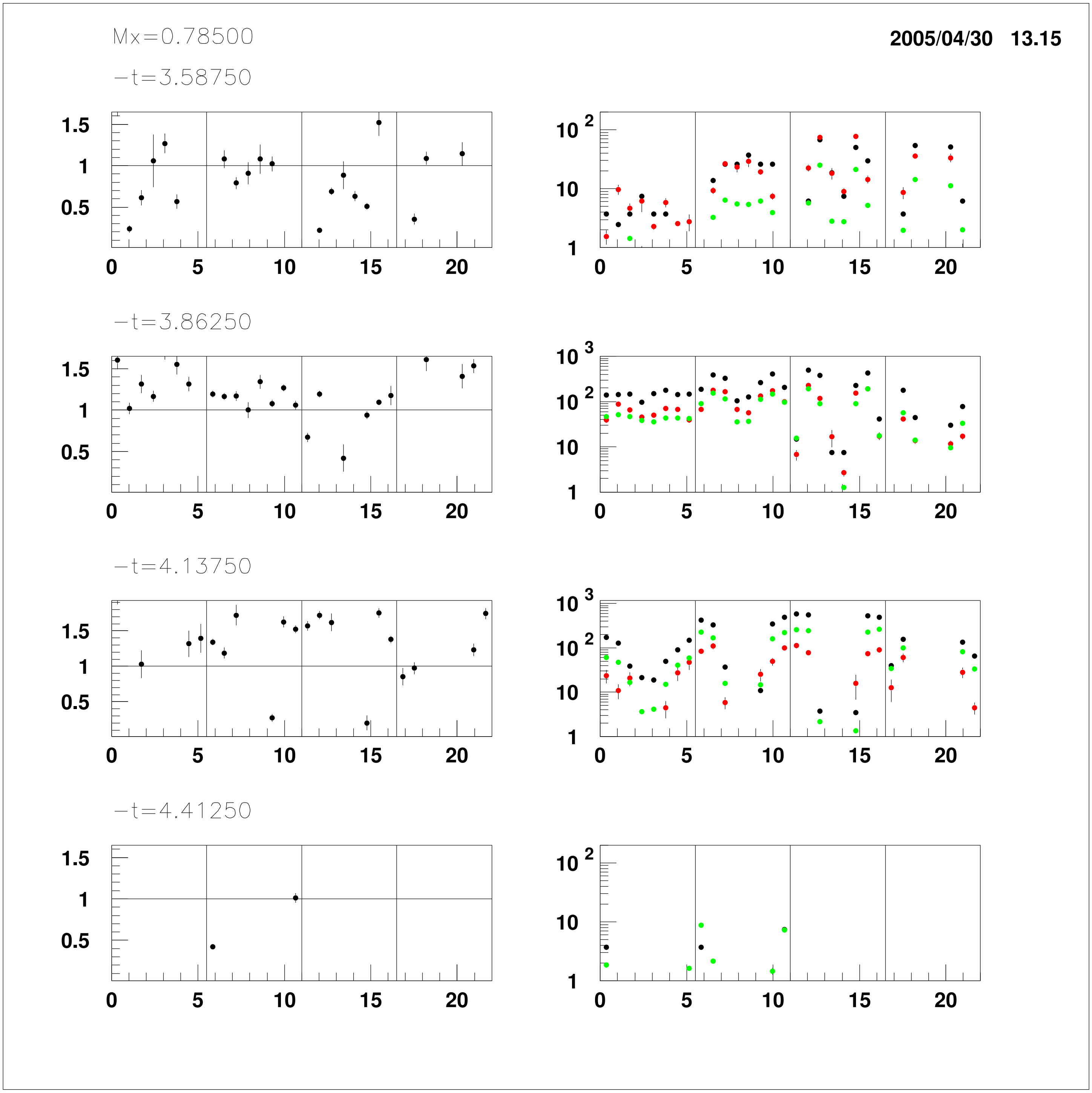

Figure 19: M_x centered on ω peak, for $Q^2 = 2.45$, $\epsilon = 0.54$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

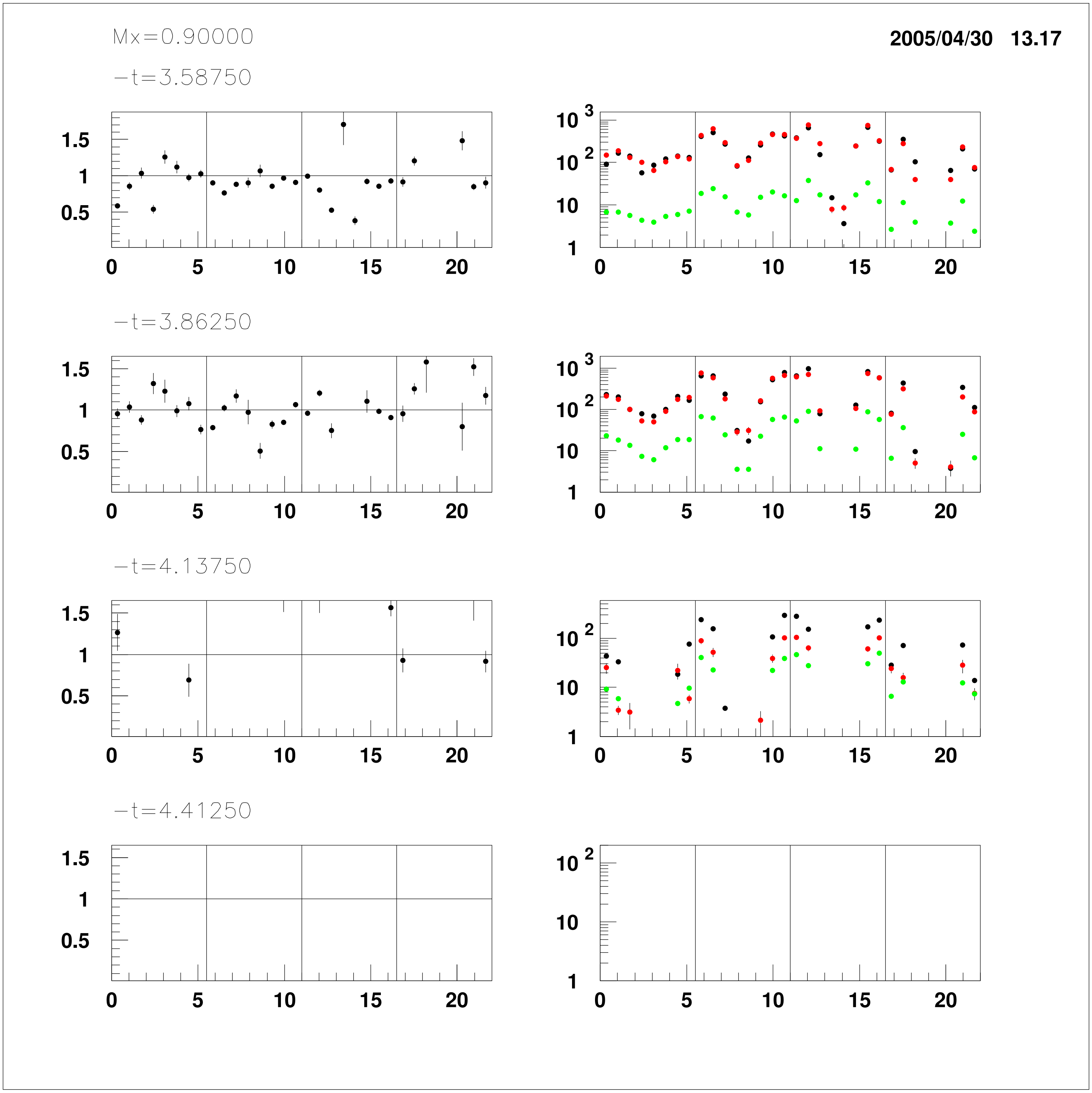

Figure 20: High M_x bin data at $Q^2 = 1.60$, $\epsilon = 0.33$. On the left are the Data/(Rho+Omega MC) ratios. On the right are the counts per bin, black=experiment, red=rho MC, green=omega MC.

6 What next?

This is the first time I have looked at the ϕ coverage of the data in detail. The experiment's ϕ coverage is strongly dependent upon missing mass, and for the ω peak the ϕ coverage is good over only a relatively narrow range of $-t$. This is discouraging, as it will greatly limit what conclusions we can extract from the data.

1. We need to discuss realistic physics goals for the data analysis, now that we have seen how our kinematic coverage varies with missing mass. We are the first experiment with the ability to measure the ϵ-dependence of ω^0 electroproduction, but our ability to separate σ_{LT} and σ_{TT} from σ_L is clearly limited.

   We should also think about how the combination of our data with Peter's ω data from the Baryons experment (lower W but much higher Q^2) can be used to maximize the physics output.

2. Given our gaps in coverage, suggestions on strategies for the modification of the cross section models with as few additional assumptions as possible.

   In particular, suggestions for modifications to the functional dependence of the ρ^0 cross section model, or useful references I could consult, would be most useful.

3. Any other issues I may have forgotten.