$dp \to dp\eta$ process at ANKE at 3.7 GeV/c

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March 23, 2010

Below we try to extract the number of $np \to d\eta$ events and compare it with simulation based on different cross section inputs. As one can see in Fig. 1, the setup acceptance covers the full angular range for this process. But the width of the η peak in the missing mass spectrum and thus, the background situation, changes strongly with the angle (the resolution changes more then 3 times). We will consider few angular ranges below with θ higher then 0, 30, 60 and 90 degree. The $np \to d\eta$ events are selected in unequal bins of 5-10 MeV width within the Q range of (-5, 45) MeV.

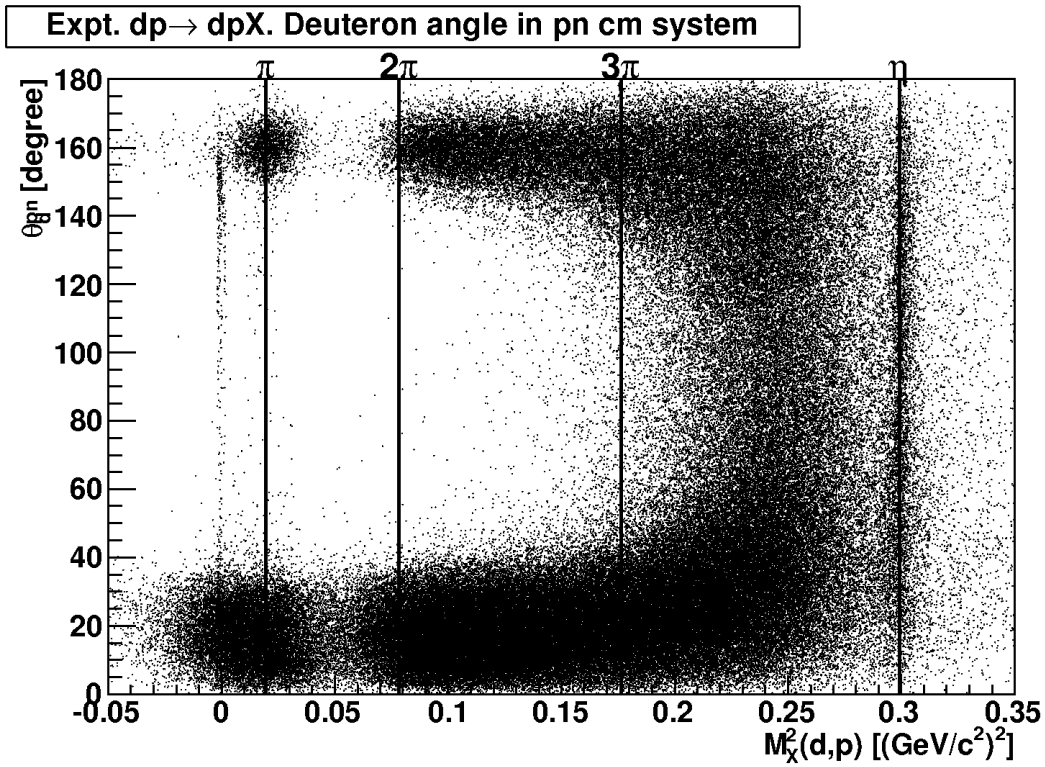


Figure 1: Experimental spectra of the deuteron scattering angle in the pn system vs the mass of the missing meson system.

1 Background

1.1 Description of background shape

The background subtraction will be illustrated by the $\theta > 0$ data sample. We attempted to extract the shape of the multipion background from the same experimental data. For this purpose the events within an subthreshold Q range of (-55,-5) MeV were used. At first, evolution of the background shape with Q was studied. To study the shape of background accumulated within the 5 (10) MeV wide bins, the (-55,-5) MeV range was divided into such bins, and M_x spectra were filled for each of them. The values of M_x were increased by the value of Q at the low boundary of the bin in order to simulate the spectrum of Q=0 – 5 (10) MeV bin. Such scaling can be applied because the highest M_x value changes linearly with the total energy available and is not limited by acceptance (Fig. 2).

In Fig. 3 the resulting histograms from the subthreshold Q bins are shown together with their sum. As one can see, the width of the Q bin used matters. In Fig. 4 the ratio of the spectra accumulated in each Q bin to the sum subthreshold spectrum is shown for 10 MeV wide bins. As one can see, the background shape changes very little with Q below the threshold and so we can assume it constant in the next 50 MeV of Q, where the summed spectra for 5 and 10 MeV bins will be used. The last spectrum in in Fig. 4 is partly above the threshold and contains the η peak. This spectrum is also shifted by 5 MeV up in the same fashion as the others.

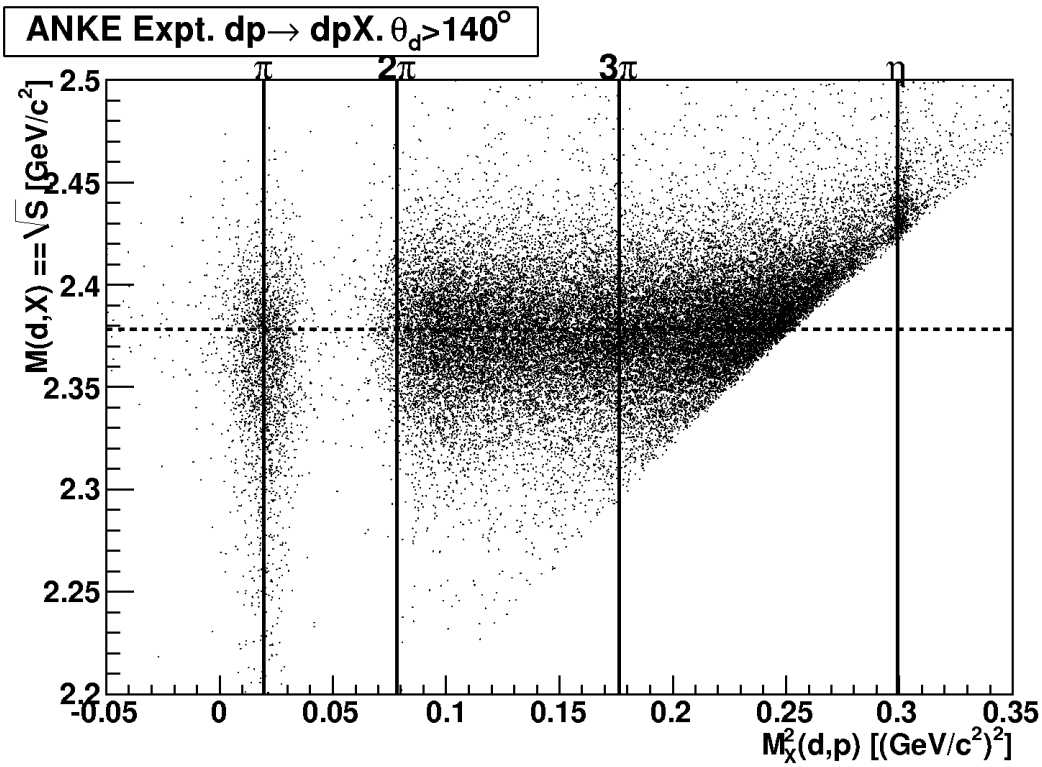
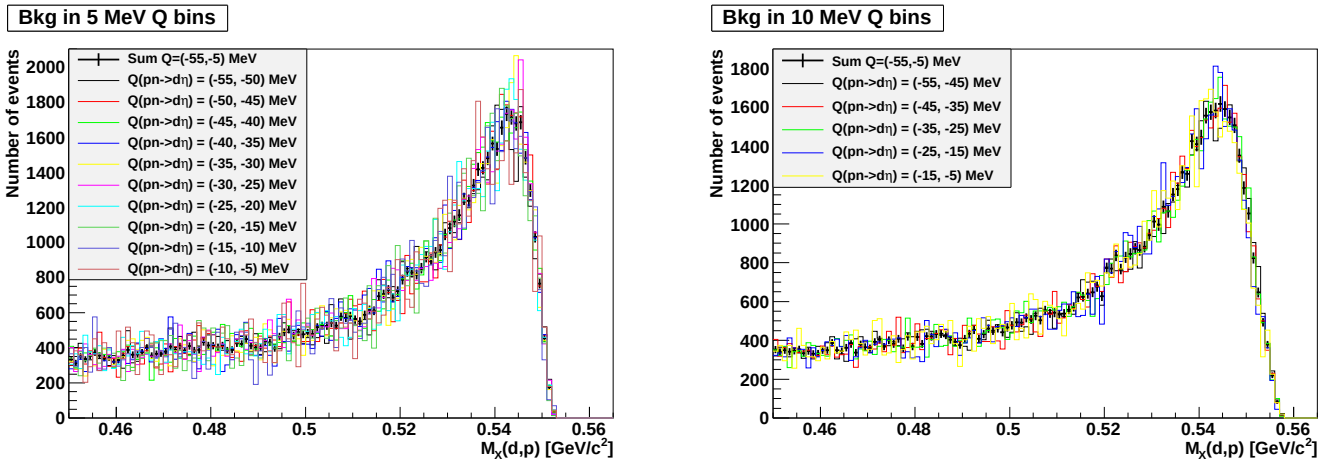


Figure 2: Mass of pn system vs missing mass of $np \to dX$ process.



(a) 5 MeV wide bins

(b) 10 MeV wide bins

Figure 3: Normalized subthreshold missing mass spectra shifted up to the threshold.

1.2 Background subtraction

As result, to subtract background in, for example 10 MeV wide Q bin starting at Q_0, the sum a subthreshold M_x spectra of 10 MeV Q width was used. Each of the subthreshold spectrum, accumulated from, to say Q_0^{bg}

was shifted by the value of $\Delta M_x = Q_0 - Q_0^{bg}$. This sum was normalized outside of the η peak ($M_x < 0.53$ or $M_x > 0.56$) and subtracted. In Fig. 5 the raw event distribution is shown together with the normalized background for the event sample with $\theta_d > 0$, and in Fig. 6 the same spectra are shown for 90^o cut.

The results of subtraction are shown in Figs.7-10. From the figures presented it is clear that the multipion background changes slowly with Q and even the naïve approach of shifting the M_x spectrum applied here, produces reasonable results. This results can probably still be improved in future.

2 Results

The extracted number of $np \to d\eta$ events was compared to results of simulation made under assumptions of constant cross section ("flat"), constant matrix element ("phase space") and with FSI taken into account as suggested by Colin ("PS*FSI"). In Fig. 11 the normalized event counts obtained in these approaches are compared with the experiment. The ratios of experimental data to the simulated histograms are shown in Fig. 2. One can see that *i*) results obtained with different angular cuts are essentially the same except for the last points were statistics for higher angles is quite small, *ii*) the data do not follow the phase space dependence, *iii*) FSI (over) compensates influence of the phase space and brings the simulation closer to the data.

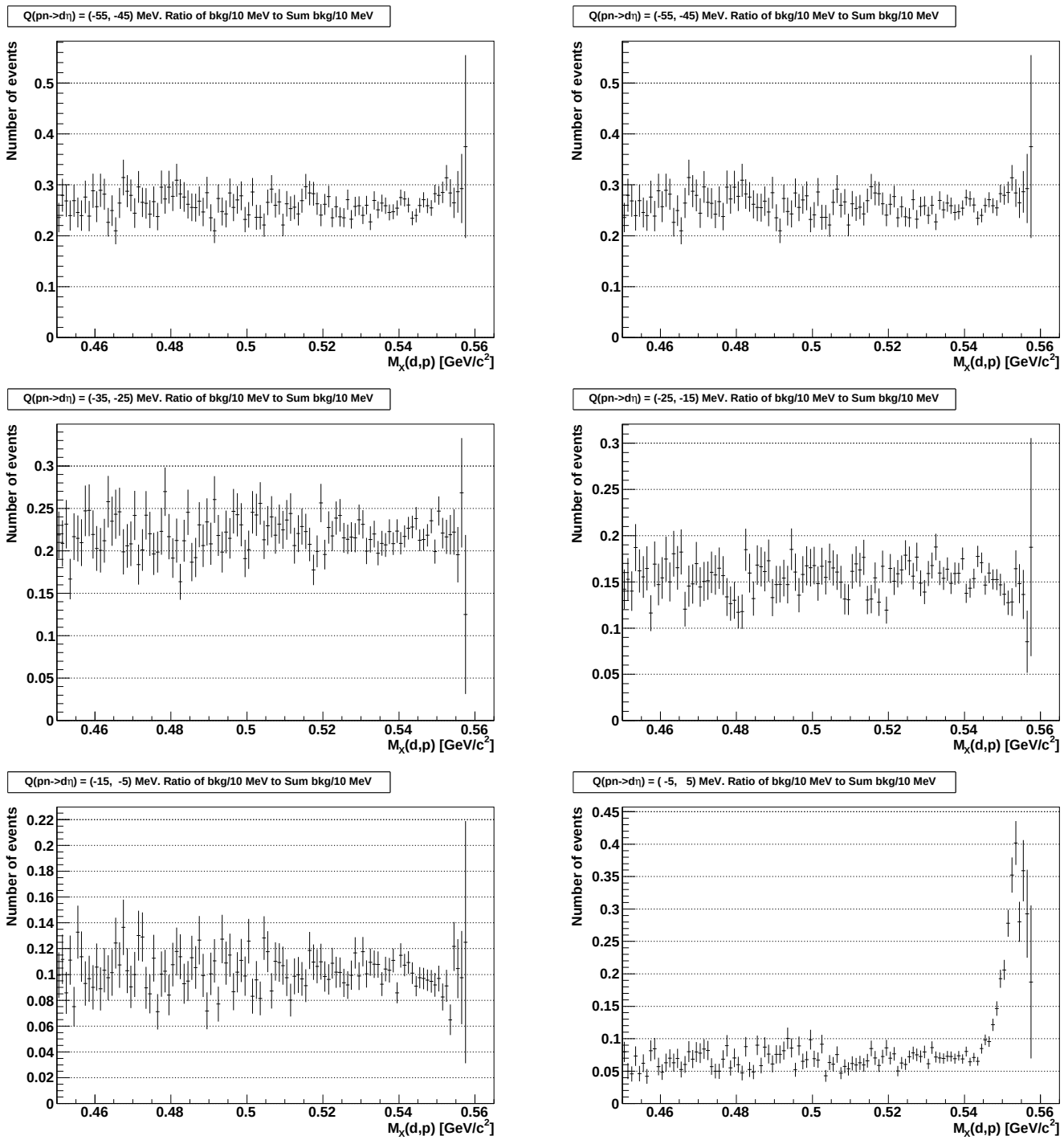


Figure 4: Ratio of the shifted missing mass spectra to the sum of 5 subthreshold Q bins.

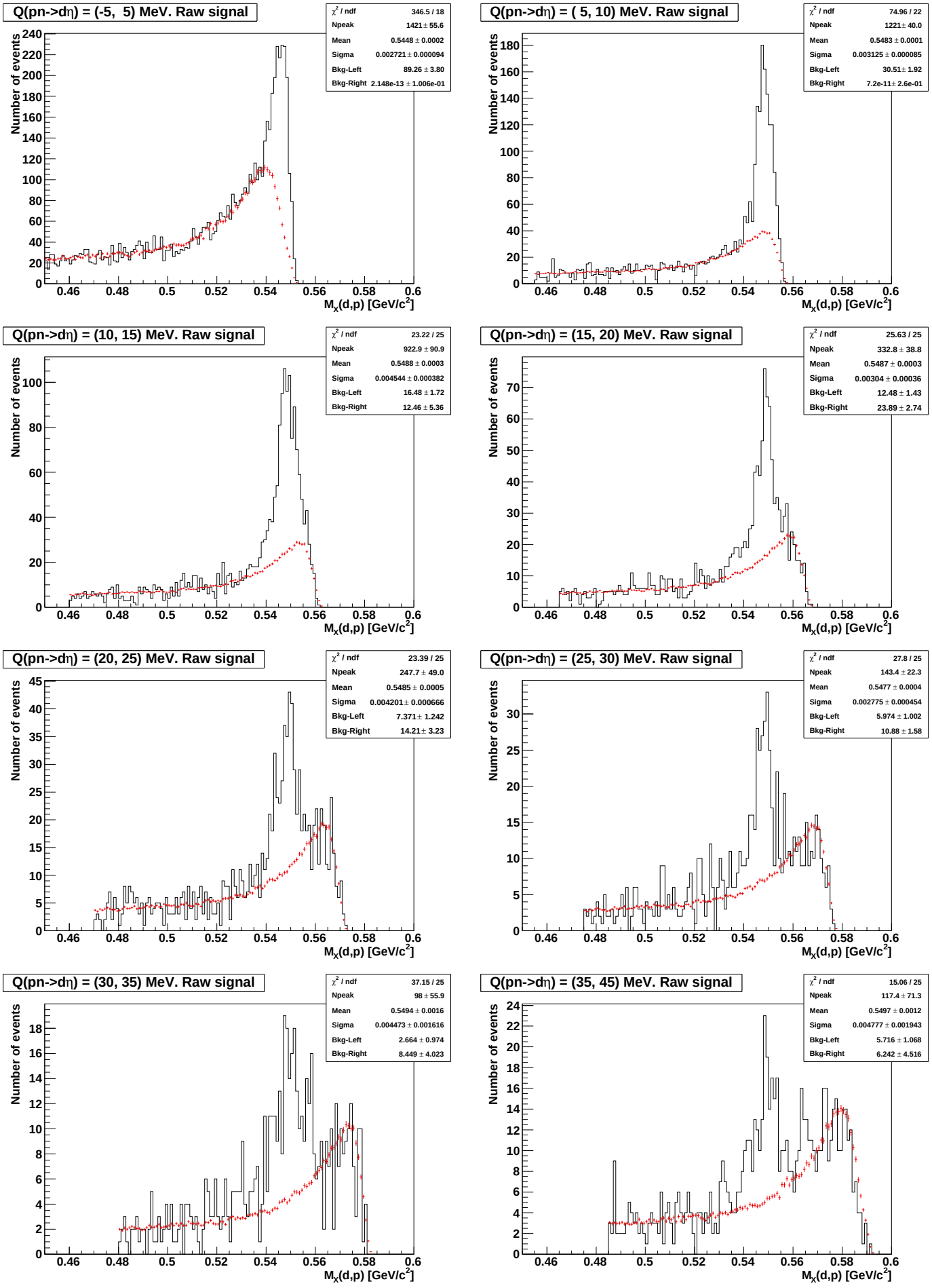


Figure 5: Raw M_x distributions together with the background spectra for $\theta_d > 0^0$ cut.

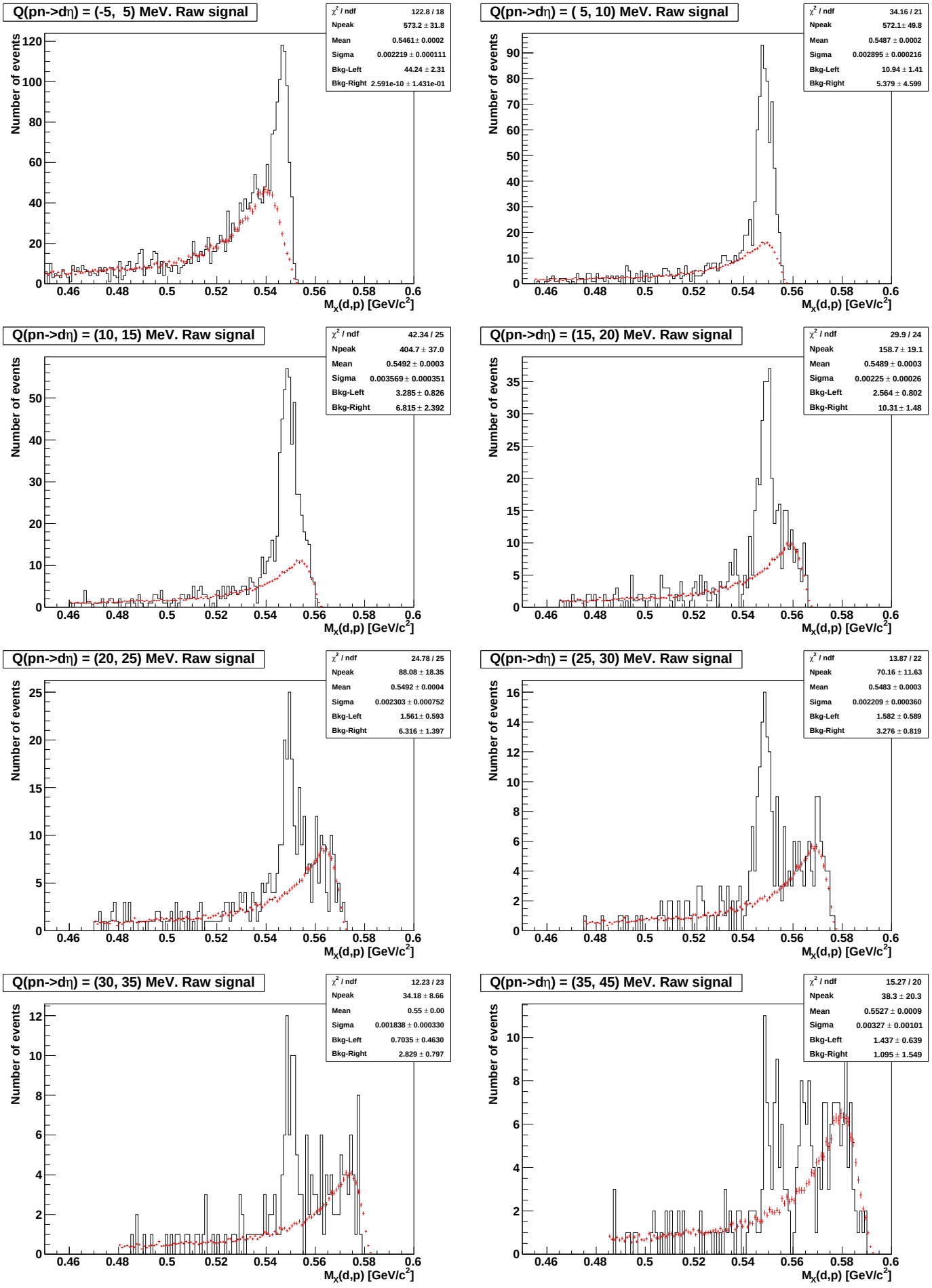


Figure 6: Raw M_x distributions together with the background spectra for $\theta_d > 90^0$ cut.

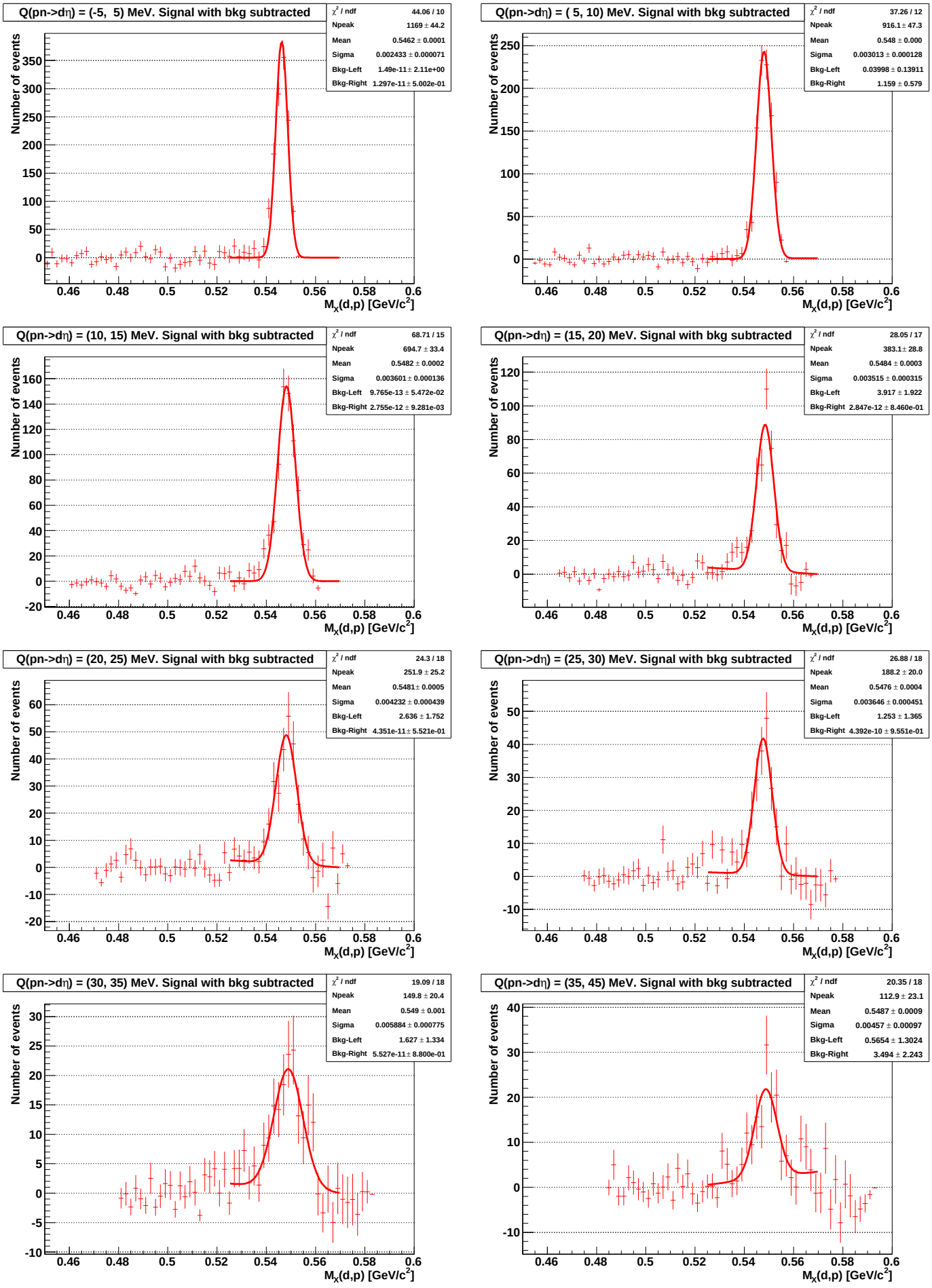


Figure 7: Results of background subtraction for $\theta_d > 0^o$ cut.

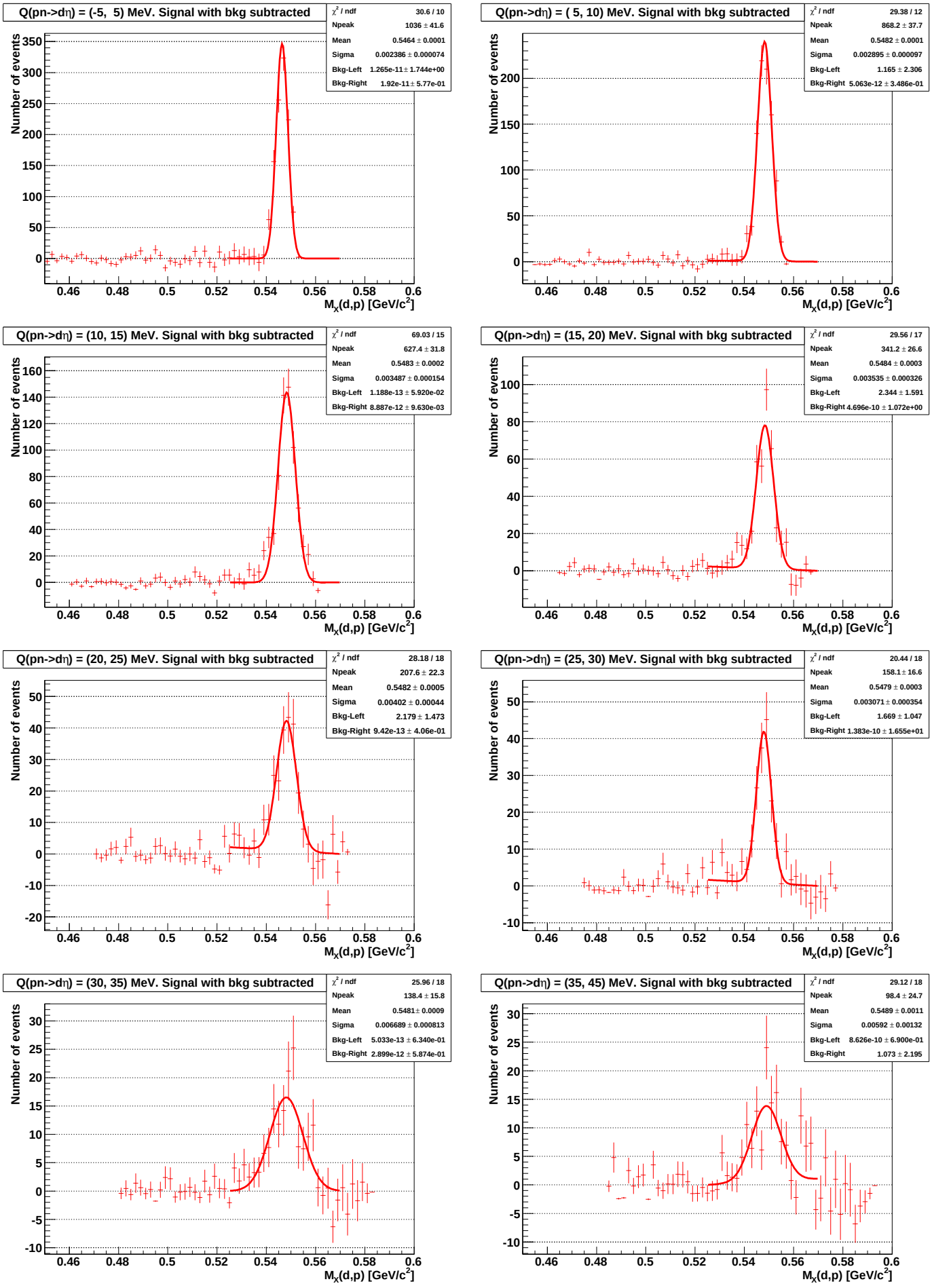


Figure 8: Results of background subtraction for $\theta_d > 30^o$ cut.

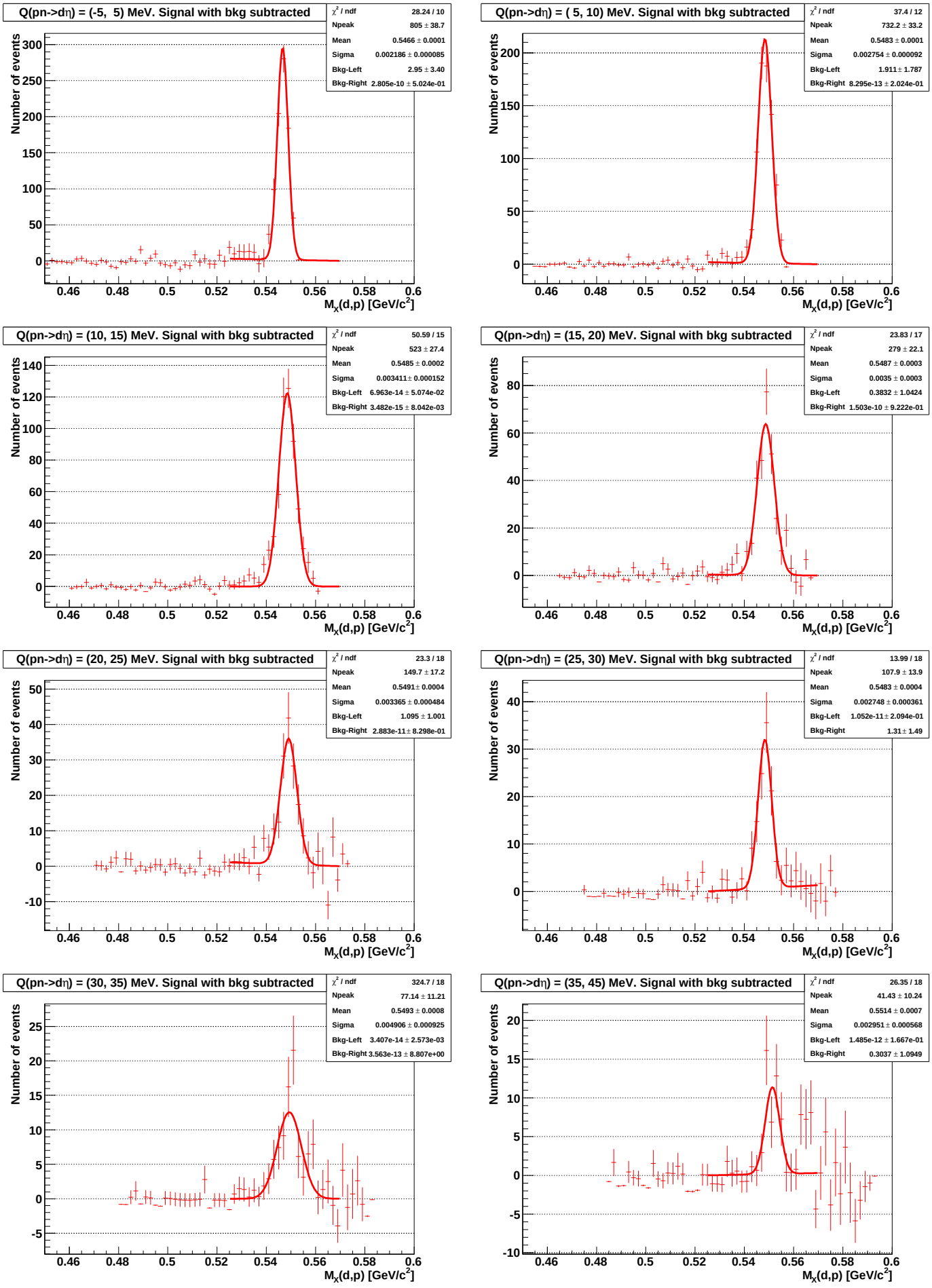


Figure 9: Results of background subtraction for $\theta_d > 60^o$ cut.

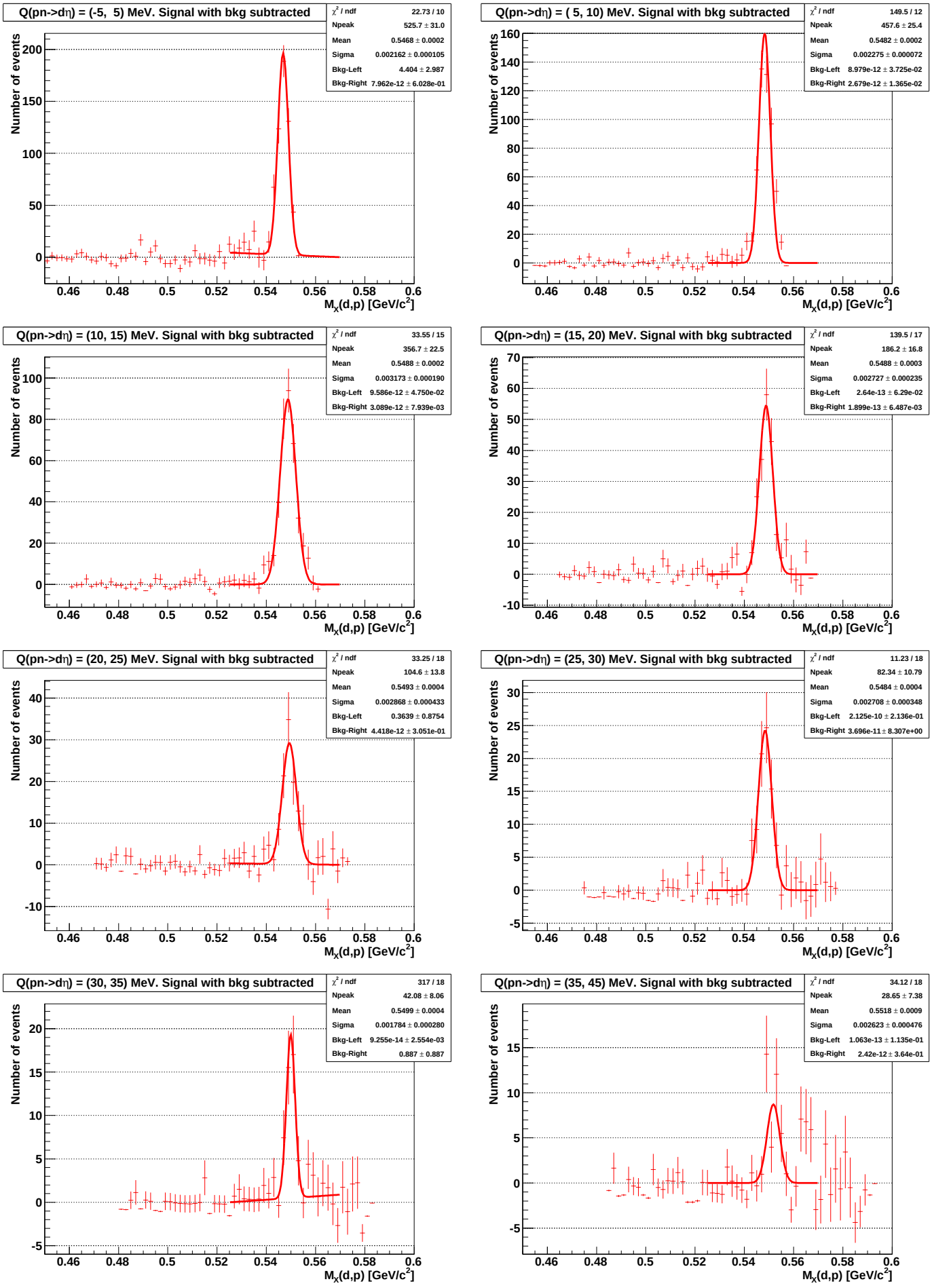
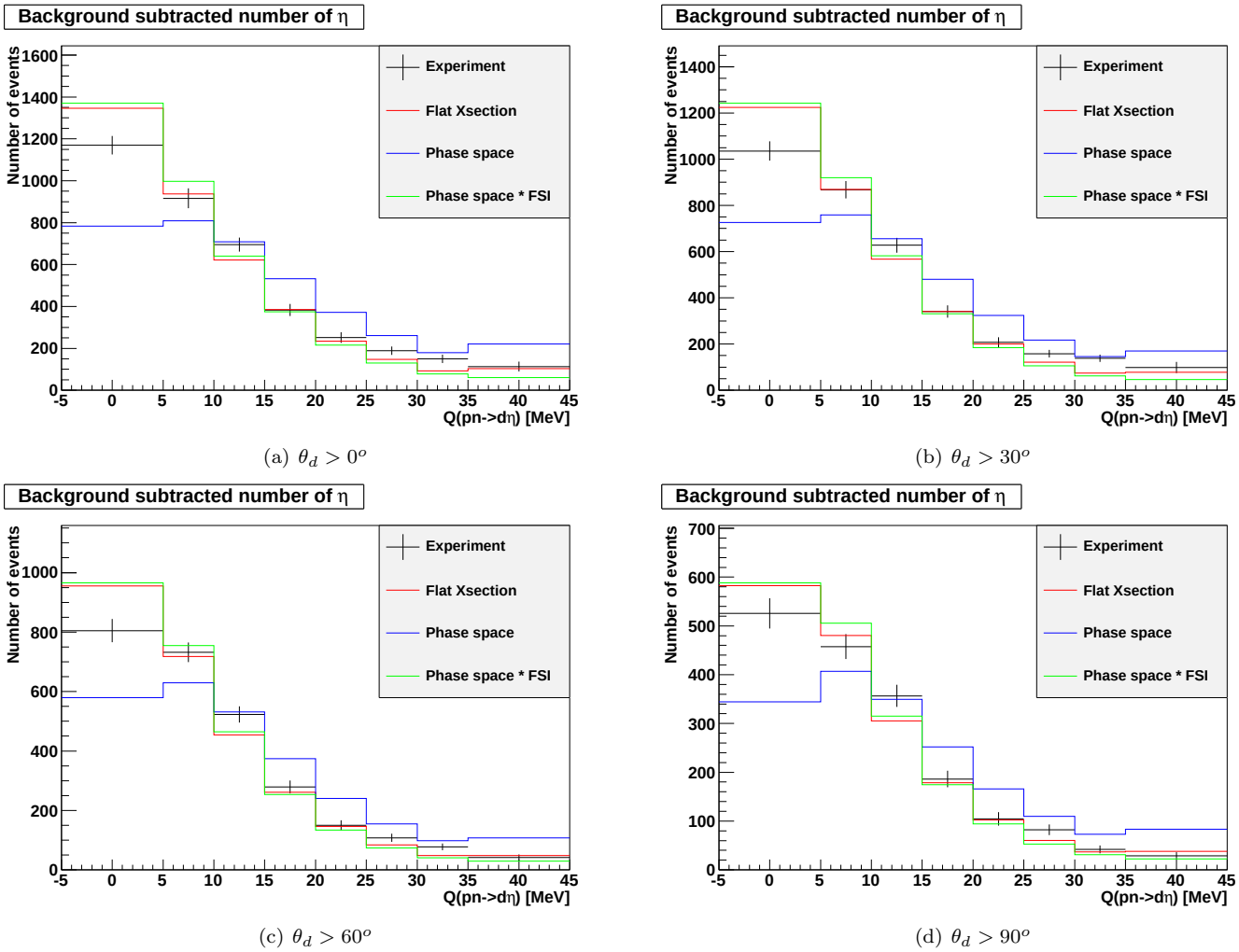


Figure 10: Results of background subtraction for $\theta_d > 90^o$ cut.



(a) $\theta_d > 0^o$

(b) $\theta_d > 30^o$

(c) $\theta_d > 60^o$

(d) $\theta_d > 90^o$

Figure 11: Event counts of $np \to d\eta$ after background subtraction in comparison with simulation.

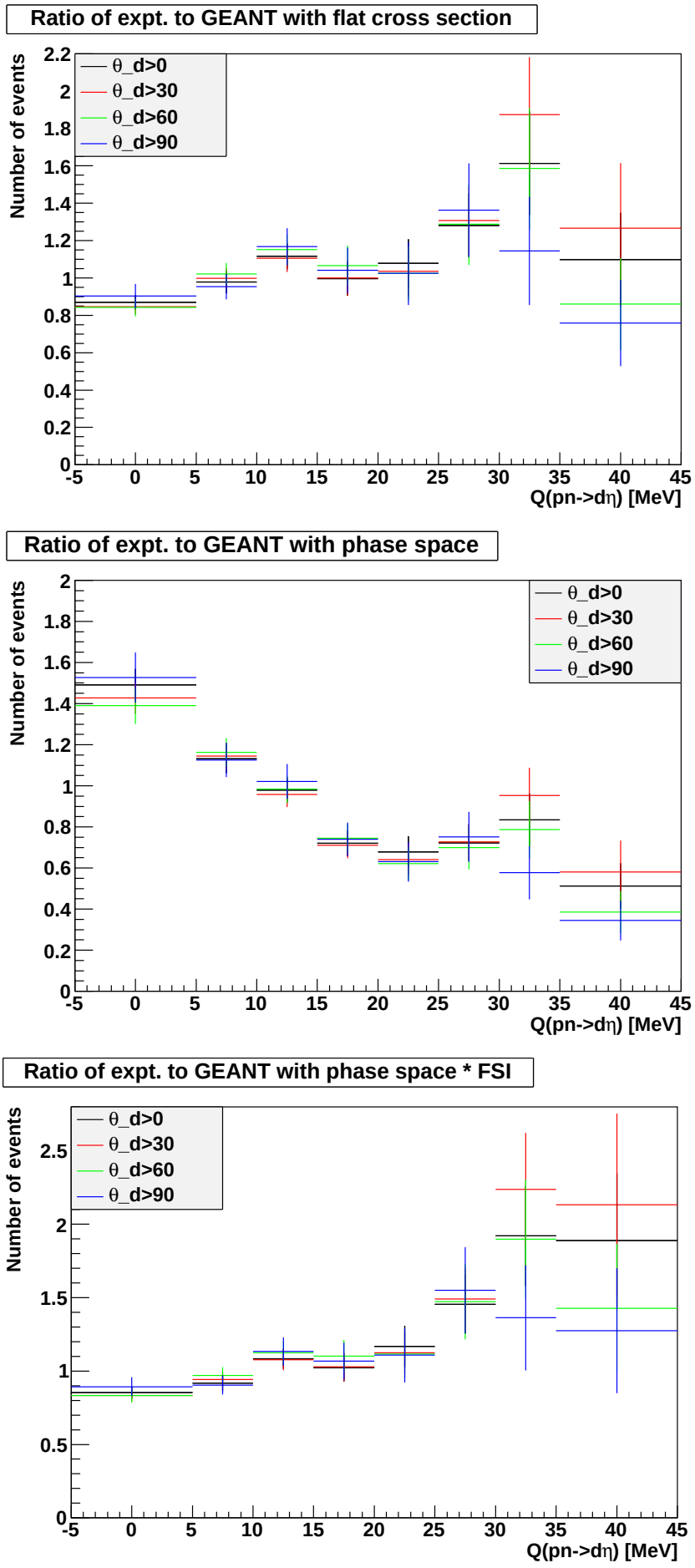


Figure 12: Ratio of expt. distribution to simulation for different θ_d ranges.