SANE: Fitting higher twists

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I. FITTING HIGHER TWISTS

The twist-3 distribution associated with the reduced matrix element,

$$d_2 = 2\int_0^1 x^2 D(x)dx = 2d_3 \ , \tag{1}$$

is used to calculate the twist-3 contribution to the g_2 structure function as

$$g_2^{\tau 3}(x) = D(x) - \int_x^1 \frac{D(y)}{y}dy \tag{2}$$

in the massless limit. A more complicated expression exists which includes the target mass effects. We parameterize $g_2^{\tau 3}(x)$ as a function of x with p parameters and we would now like to seek constraints to limit the number of free parameters.

The BC sum rule can provide a first constraint

$$\int_0^1 dx g_2^{\tau 3}(x) = 0. \tag{3}$$

Next we want to solve for $D(x)$ so we take the derivative of both sides of the equation **??** and dropping the indices on g

$$\frac{d}{dx}g = \frac{D(x)}{x} + \frac{d}{dx}D(x) \tag{4}$$

and solve for $D(x)$ with the boundary condition that the function vanishes at $x = 1$. This yields the solution

$$xD(x) = -\int_x^1 y\, g'(y)\, dy \tag{5}$$

This equation provides another constraint on the parameters which can be seen as removing the constant term in a polynomial expression due to the derivative.

$$g(x) = \sum_{i=0}^{4} p_i x^i \tag{6}$$

Applying the constraints gives

$$p_0 = \frac{p(2)}{3} + \frac{p(3)}{2} + \frac{3p(4)}{5} \tag{7}$$

$$p_1 = \frac{1}{30}(-40p(2) - 45p(3) - 48p(4)) \tag{8}$$

A. As a function of W

If we want to use W

$$g(x) = \sum_{i=0}^{2} p_i \left(\frac{1}{W}\right)^i \tag{9}$$

the constrained parameters are

$$p_0 = -\frac{p(2)\left(\mathrm{Mp}\sqrt{\mathrm{Mp}^2 - \mathrm{Q2}}\left(\mathrm{Mp}^2\log(\mathrm{Q2}) - \mathrm{Q2}\log\left(\frac{\mathrm{Q2}}{\mathrm{Mp}^2}\right) - 2\mathrm{Mp}^2\log(\mathrm{Mp})\right) + \left(\mathrm{Mp}^2 - \mathrm{Q2}\right)^2\sinh^{-1}\left(\sqrt{\frac{\mathrm{Mp}^2}{\mathrm{Q2}} - 1}\right)\right)}{\mathrm{Mp}\left(\mathrm{Mp}^2 - \mathrm{Q2}\right)^{3/2}\left(\mathrm{Mp}\sqrt{\mathrm{Mp}^2 - \mathrm{Q2}}\sinh^{-1}\left(\sqrt{\frac{\mathrm{Mp}^2}{\mathrm{Q2}} - 1}\right) - \mathrm{Mp}^2 + \mathrm{Q2}\right)} \tag{10}$$

$$p_1 = \frac{p(2)\left(-\mathrm{Mp}^2\log(\mathrm{Q2}) - \mathrm{Mp}^2 + 2\mathrm{Mp}^2\log(\mathrm{Mp}) + \mathrm{Q2}\right)}{\mathrm{Mp}\left(-\mathrm{Mp}\sqrt{\mathrm{Mp}^2 - \mathrm{Q2}}\sinh^{-1}\left(\sqrt{\frac{\mathrm{Mp}^2}{\mathrm{Q2}} - 1}\right) + \mathrm{Mp}^2 - \mathrm{Q2}\right)} \tag{11}$$

$$\tag{12}$$

however calculating these for higher powers becomes unwieldy. It is better to use a parameterization in x.

II. EVOLUTION OF HIGHER TWISTS

In [**?**] they also show that $g_2^{\tau 3}$ can be approximately evolved as a non-singlet distribution due to the very small gluon contribution (which only shows up at small x)

$$\frac{\mathrm{d}}{\mathrm{d}\ln Q^2} g_2^{NS}(x,Q^2) = \frac{\alpha_s(Q^2)}{4\pi}\int_x^1 \frac{dz}{z} P^{NS}(x/z) g_2^{NS}(z,Q^2) \tag{13}$$

where the splitting function is

$$P^{NS} = \left[\frac{4C_F}{1-z}\right]_+ + \delta(1-z)\Big[C_F + \frac{1}{N_c}\Big(2-\frac{\pi^2}{3}\Big)\Big) - 2C_F \tag{14}$$

and $C_F = (N_c^2-1)/(2N_c)$.

Using QCDNUM with this custom kernel implemented I can reproduce the LCWF distributions shown in FIG. 1 [**?**].

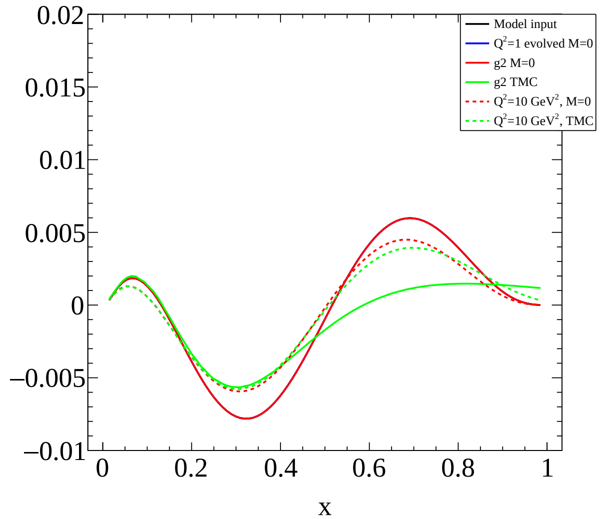

FIG. 1. Test of evolution using LCWF for comparison against the result of Braun, et.al.[**?**]

III. FIT RESULTS

Looking at the results to fitting just the SANE data shown in FIG. 2, the SANE-BETA data in the third panel with small error bars don't seem to be fit very well.

However raising the W_{min} on the fit data and including the world data helps pull the curve down for these points. This is shown in FIG. 3,

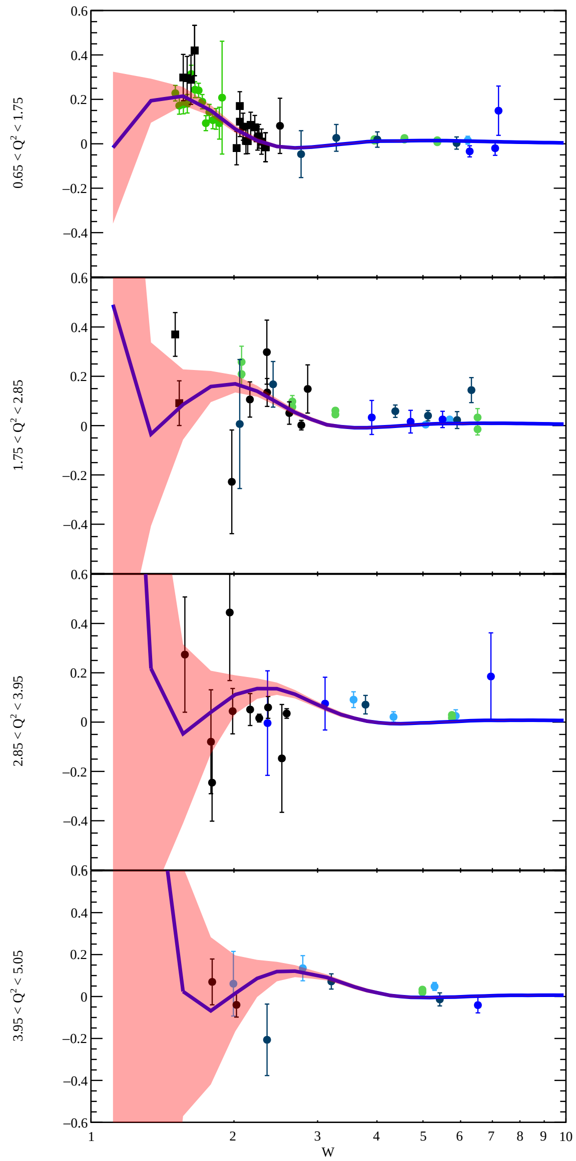

FIG. 2. Result using only SANE data and a low $W_{min} = 1500$ MeV. The black circles are SANE-BETA and the black squares are SANE-HMS.

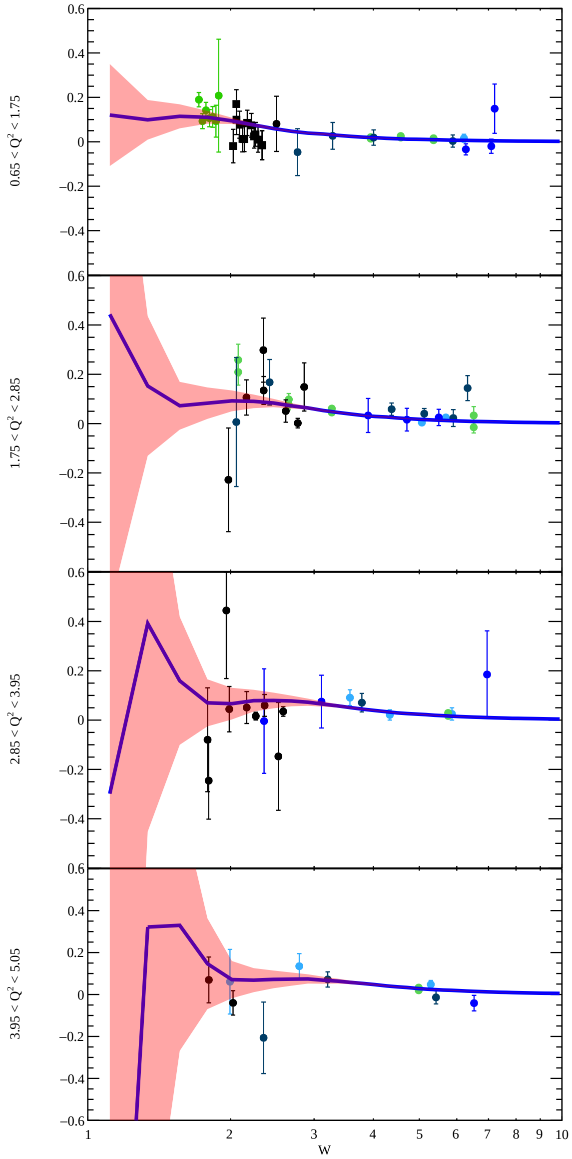

FIG. 3. Result using world data with a higher $W_{min} = 1700$ MeV. The black circles are SANE-BETA and the black squares are SANE-HMS.