TODO: update authors and affiliations

Extraction and Validation Framework (EVA)

A. Prokudin,[1] D. Riser,[1] N. Sato,[1] and K. Tezgin[1,*]

[1] *University of Conneticut*

*Electronic address: nsato@jlab.org; Electronic address: kemal.tezgin@uconn.edu; Electronic address: david.riser@uconn.edu

I. SIDIS SETUP

The differential cross section is given by

$$\frac{d\sigma}{dx\; dy\; d\phi_S\; dz\; d\phi_h\; dP_{hT}^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\sum_{i=1}^{18} F_i(x,z,Q^2,P_{hT}^2)\beta_i \tag{1}$$

F_i	Standard label	β_i
F_1	$F_{UU,T}$	1
F_2	$F_{UU,L}$	ε
F_3	$F_{UU}^{\cos\phi_h}$	$\sqrt{2\varepsilon(1+\varepsilon)}\;\cos\phi_h$
F_4	$F_{UU}^{\cos 2\phi_h}$	$\varepsilon\;\cos(2\phi_h)$
F_5	$F_{LU}^{\sin\phi_h}$	$\lambda_e\sqrt{2\varepsilon(1-\varepsilon)}\sin\phi_h$
F_6	$F_{UL}^{\sin\phi_h}$	$S_{\|\|}\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_h$
F_7	$F_{UL}^{\sin\;2\phi_h}$	$S_{\|\|}\varepsilon\sin(2\phi_h)$
F_8	F_{LL}	$S_{\|\|}\lambda_e\sqrt{1-\varepsilon^2}$
F_9	$F_{LL}^{\cos\phi_h}$	$S_{\|\|}\lambda_e\sqrt{2\varepsilon(1-\varepsilon)}\cos\phi_h$
F_{10}	$F_{UT,T}^{\sin(\phi_h-\phi_S)}$	$\|\vec{S}_\perp\|\sin(\phi_h-\phi_S)$
F_{11}	$F_{UT,L}^{\sin(\phi_h-\phi_S)}$	$\|\vec{S}_\perp\|\varepsilon\sin(\phi_h-\phi_S)$
F_{12}	$F_{UT}^{\sin(\phi_h+\phi_S)}$	$\|\vec{S}_\perp\|\varepsilon\sin(\phi_h+\phi_S)$
F_{13}	$F_{UT}^{\sin(3\phi_h-\psi_S)}$	$\|\vec{S}_\perp\|\varepsilon\sin(3\phi_h-\phi_S)$
F_{14}	$F_{UT}^{\sin\phi_S}$	$\|\vec{S}_\perp\|\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_S$
F_{15}	$F_{UT}^{\sin(2\phi_h-\phi_S)}$	$\|\vec{S}_\perp\|\sqrt{2\varepsilon(1+\varepsilon)}\sin(2\phi_h-\phi_S)$
F_{16}	$F_{LT}^{\cos(\phi_h-\phi_S)}$	$\|\vec{S}_\perp\|\lambda_e\sqrt{1-\varepsilon^2}\cos(\phi_h-\phi_S)$
F_{17}	$F_{LT}^{\cos\phi_S}$	$\|\vec{S}_\perp\|\lambda_e\sqrt{2\varepsilon(1-\varepsilon)}\cos\phi_S$
F_{18}	$F_{LT}^{\cos(2\phi_h-\phi_S)}$	$\|\vec{S}_\perp\|\lambda_e\sqrt{2\varepsilon(1-\varepsilon)}\cos(2\phi_h-\phi_S)$

- TODO: explicit expression for $|S_\perp|$
- TODO: explicit expression for ε

The 18 structure function in SIDIS at leading-order will be expressed in the context of WW-type approximation in terms of a "minimal" TMD basis using the gaussian ansatz:

$$\mathcal{F}_q(\xi, p_\perp) = \mathcal{K}_q \; \mathcal{C}_q(\xi) \frac{\exp\left(-k_\perp^2/\omega_q\right)}{\pi\omega_q} \tag{2}$$

$$\mathcal{D}_q(\xi, p_\perp) = \mathcal{K}_q \; \mathcal{C}_q(\xi) \frac{\exp\left(-P_\perp^2/\omega_q\right)}{\pi\omega_q}. \tag{3}$$

We denote the transverse momentum of the quark inside a fast moving proton by $\mathbf{k}_\perp$. We use the notation $\mathbf{P}_\perp$ for the transverse momentum of the quark relative to the original parton motion. The structure functions are expressed as

$$F = \sum_q e_q^2 \; \mathcal{K}_q \; \mathcal{F}_q(x) \; \mathcal{D}_q(z) \frac{\exp\left(-P_{hT}^2/\Omega_q\right)}{\pi\Omega_q} \tag{4}$$

$$\Omega_q = z^2 \langle k_\perp^2 \rangle_q + \langle P_\perp^2 \rangle_q \tag{5}$$

type	Name	$\mathcal{K}_q$	$\mathcal{C}_q$
$\mathcal{F}_q$	upol. PDF	1	f_1^q
$\mathcal{F}_q$	pol. PDF	1	g_1^q
$\mathcal{F}_q$	Transversity	1	h_1^q
$\mathcal{F}_q$	Sivers	$\frac{2M^2}{\omega_q}$	$f_{1T}^{\perp(1)q}$
$\mathcal{F}_q$	Boer-Mulders	$\frac{2M^2}{\omega_q}$	$h_1^{\perp(1)q}$
$\mathcal{F}_q$	Pretzelosity	$\frac{2M^4}{\omega_q^2}$	$h_{1T}^{\perp(2)q}$
$\mathcal{F}_q$	Worm Gear	1	$g_{1T}^{\perp q}$
$\mathcal{F}_q$	Worm Gear	1	$h_{1L}^{\perp q}$
$\mathcal{C}_q$	FF	1	D_1^q
$\mathcal{C}_q$	Collins	$\frac{2z^2 m_h^2}{\omega_q}$	$H_1^{\perp(1)q}$

TABLE I: The minimal basis

		$\mathcal{K}_q$	$\mathcal{F}_q(x)$	$\mathcal{D}_q(z)$
F_1	$F_{UU,T}$	x	f_1^q	D_1^q
F_2	$F_{UU,L}$	0		
F_3	F_{LL}	x	g_1^q	D_1^q
F_4	$F_{UT}^{\sin(\phi_h+\phi_S)}$	$\frac{2xzP_{hT}m_h}{w_q}$	h_1^q	$H_1^{\perp(1)q}$
F_5	$F_{UT,T}^{\sin(\phi_h-\phi_S)}$	$-\frac{2xzMP_{hT}}{w_q}$	$f_{1T}^{\perp(1)q}$	D_1^q
F_6	$F_{UT,L}^{\sin(\phi_h-\phi_S)}$	0		
F_7	$F_{UU}^{\cos(2\phi_h)}$	$\frac{4xz^2MP_{hT}^2m_h}{w_q^2}$	$h_1^{\perp(1)q}$	$H_1^{\perp(1)q}$
F_8	$F_{UT}^{\sin(3\phi_h-\phi_S)}$	$\frac{2xz^3P_{hT}^3m_hM^2}{w_q^3}$	$h_{1T}^{\perp(2)q}$	$H_1^{\perp(1)q}$
F_9	$F_{LT}^{\cos(\phi_h-\phi_S)}$	$\frac{2xzMP_{hT}}{w_q}$	$g_{1T}^{\perp q}$	D_1^q
F_{10}	$F_{UL}^{\sin(2\phi_h)}$	$\frac{4xz^2MP_{hT}^2m_h}{w_q^2}$	$h_{1L}^{\perp q}$	$H_1^{\perp(1)q}$
F_{11}	$F_{LT}^{\cos\phi_S}$	$-\frac{2M}{Q}x\frac{z^2\langle k_\perp^2\rangle_q\left[P_{hT}^2+\langle P_\perp^2\rangle_q\right]+\langle P_\perp^2\rangle^2}{w_q^2}$	$g_{1T}^{\perp q}$	D_1^q
F_{12}	$F_{LL}^{\cos\phi_h}$	$-\frac{2xzP_{hT}}{Q}\frac{\langle k_\perp^2\rangle_q}{w_q}$	g_1^q	D_1^q
F_{13}	$F_{LT}^{\cos(2\phi_h-\phi_S)}$	$-\frac{2xz^2MP_{hT}^2}{Q}\frac{\langle k_\perp^2\rangle_q}{w_q^2}$	$g_{1T}^{\perp q}$	D_1^q
F_{14}	$F_{UL}^{\sin\phi_h}$	$-\frac{8M^3}{Q}x\frac{z^2\langle k_\perp^2\rangle_q(P_{hT}^2-z^2\langle k_\perp^2\rangle_q)+\langle P_\perp^2\rangle_q^2}{w_q^3}$	$h_{1L}^{\perp q}$	$H_1^{\perp(1)q}$
F_{15}	$F_{LU}^{\sin\phi_h}$	0		
F_{16}	$F_{UU}^{\cos\phi_h}(i)$	$-\frac{8M}{Q}xzP_{hT}m_h\frac{\left[\langle P_\perp^2\rangle_q^2+z^2\langle k_\perp^2\rangle_q(P_{hT}^2-z^2\langle k_\perp^2\rangle_q)\right]}{w_q^3}$	$h_1^{\perp(1)q}$	$H_1^{\perp(1)q}$
F_{16}	$F_{UU}^{\cos\phi_h}(ii)$	$-\frac{2M}{Q}\frac{xzP_{hT}}{M}\frac{\langle k_\perp^2\rangle_q}{w_q}$	f_1^q	D_1^q
F_{17}	$F_{UT}^{\sin\phi_S}(i)$	$-\frac{2M}{Q}x\frac{z^2\langle k_\perp^2\rangle_q\left(P_{hT}^2+\langle P_\perp^2\rangle_q\right)+\langle P_\perp^2\rangle_q^2}{w_q^2}$	$f_{1T}^{\perp(1)q}$	D_1^q
F_{17}	$F_{UT}^{\sin\phi_S}(ii)$	$\frac{4xz^2m_h}{Q}\frac{\langle k_\perp^2\rangle_q\left(-P_{hT}^2+w_q\right)}{w_q^2}$	h_1^q	$H_1^{\perp(1)q}$
F_{18}	$F_{UT}^{\sin(2\phi_h-\phi_S)}(i)$	$-\frac{2M^2}{Q}x\frac{\langle k_\perp^2\rangle_qM}{w_q^2}$	$f_{1T}^{\perp(1)q}$	D_1^q
F_{18}	$F_{UT}^{\sin(2\phi_h-\phi_S)}(ii)$	$-\frac{2M^2}{Q}x\frac{4z^2P_{hT}^2m_h}{w_q^2}$	$h_{1T}^{\perp(2)q}$	$H_1^{\perp(1)q}$
F_{19}	$F_{CAHN}^{\cos(2\phi_h)}$	$\frac{1}{Q^2}\frac{2xz^2P_{hT}^2\langle k_\perp^2\rangle_q^2}{w_q^2}$	f_1^q	D_1^q

TABLE II: SIDIS structure functions up to twist 3

II. SIA SETUP

TODO: add table of SIA structure functions

III. TUTORIAL

TODO: Add more details

Here is a general workflow

- Identify which parameters are needed to be fitted for a given set of TMDs
- Identify available observables to extract the TMDs
- Create xlsx files for each data sets (see the database repo)
- Create and input file (see i.e. fitlab/inputs/upol.py). Here you will specify which data sets are going to be used
- Test in a single fit (fitter.py) that a reasonable χ^2 is obtained
- Once the test fit is ready, proceed to run a multinest which is an nested sampling algorithm to map out the likelihood function. In the input file you must specify the output. Look for the line "output dir " in the input file. It is recommended to store the results in the repo analysis.
- Once the multinest finishes it produces a nestout file at the path that was specified. Use one of the jupyter templates to proceed to analyze the output. You need to place the notebook at the root of analysis. Otherwise the paths wont match.

If you want to run the codes but you want to modify things here and there, create a new workspace via pacman/gen-fitpack, and cd to fitpack. The latter has an exact copy of all the repos, and you can do with that whatever you want. Once you see that some of your modifications should be placed in the actual repositories, proceed to do it.

IV. UNPOLARIZED TMDS

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

V. SIVERS

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

VI. COLLINS FUNCTION FROM e^+e^-

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

VII. TRANSVERSITY

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

VIII. BOER-MULDERS

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

IX. PRETZELOSITY

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece

X. WORM-GEAR

- TODO: table of data sets with the following columns: exp, observable, num points, chi2
- TODO: what TMDS are going to be fitted? what is the parametrization
- TODO: distribution of the parameters
- TODO: chi2 distributions for each data sets
- TODO: plot the x or z dependece
- TODO: plot the $k_\perp$ or $P_\perp$ dependece