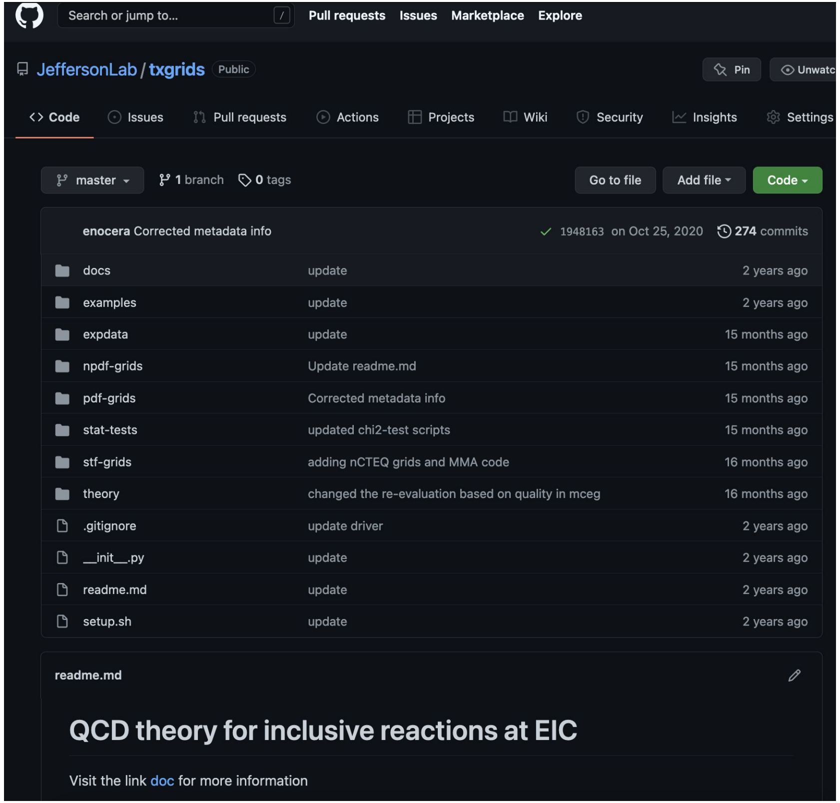
Theory tools

Nobuo Sato

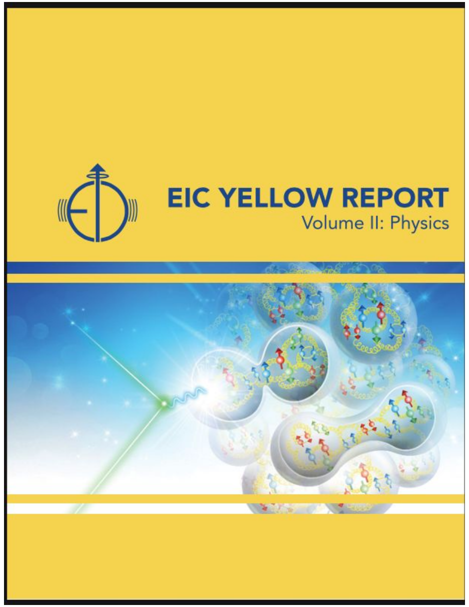
Jefferson Lab

Arxiv for DIS structure functions

https://github.com/JeffersonLab/txgrids



In collaboration with NNPDF, CJ, CT, JAM, …



QCD theory for inclusive reactions at EIC

Search docs

CONTENTS:

LHAPDF grids

Structure function index convention

$(T = p, n, d, \ldots, A)$

Reaction	Structure Functions	Index
$e^{\pm} + T \to e^{\pm} + X$	$F_2^{\gamma},\ F_L^{\gamma}$	$900,\ 901$
	$F_2^{\gamma Z},\ F_L^{\gamma Z},\ F_3^{\gamma Z}$	$902,\ 903,\ 904$
	$F_2^{Z},\ F_L^{Z},\ F_3^{Z}$	$905,\ 906,\ 907$
	$F_2^{NC},\ F_L^{NC},\ F_3^{NC}$	$908,\ 909,\ 910$
	$F_{2c}^{\gamma},\ F_{Lc}^{\gamma}$	$911,\ 912,\ 913$
	$F_{2c}^{NC},\ F_{Lc}^{NC},\ F_{3c}^{NC}$	$914,\ 915,\ 916$
	$F_{2b}^{\gamma},\ F_{Lb}^{\gamma}$	$917,\ 918,\ 919$
	$F_{2b}^{NC},\ F_{Lb}^{NC},\ F_{3b}^{NC}$	$920,\ 921,\ 922$
$e^{-} + T \to \nu + X$	$F_2^{W^-},\ F_L^{W^-},\ F_3^{W^-}$	$930,\ 931,\ 932$
	$F_{2c}^{W^-},\ F_{Lc}^{W^-},\ F_{3c}^{W^-}$	$933,\ 934,\ 935$
	$F_{2b}^{W^-},\ F_{Lb}^{W^-},\ F_{3b}^{W^-}$	$936,\ 937,\ 938$

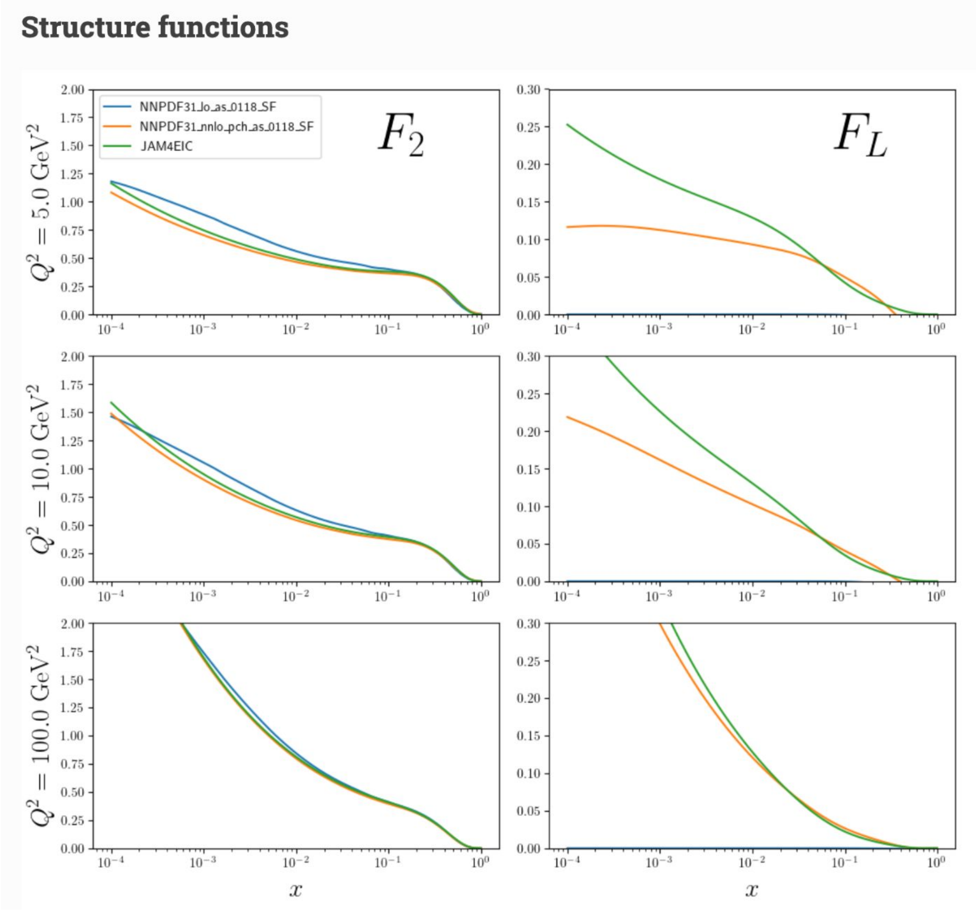
Available grids

Only those rows with lhapdf name is actually available

Group	Target	Structure Functions	Theory	Cuts (in GeV^2)
CJ	p	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$		
	d	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$		
CT	p	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$		
	d	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$		
JAM	p	$F_{2,L,3}^{NC}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	p	$F_{2,L,3}^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	d	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	$^3\mathrm{He}$	$F_{2,L,3}^{NC},\ F_{2,L,3}^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	p	$g_1^{NC},\ g_1^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	d	$g_1^{NC},\ g_1^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$
	$^3\mathrm{He}$	$g_1^{NC},\ g_1^{W^-}$	NLO(ZMFVS)	$Q^2 > 1.69,\ W^2 > 10$

Structure functions following PDG convention

MC errors sets from JAM & NNPDF



QCD theory for inclusive reactions at EIC

Search docs

main00.py

Gloals

- compute total cross section in *ep* reaction

Code

```
#!/usr/bin/env python

import sys,os
sys.path.append(os.path.dirname( os.path.dirname(os.path.abspath(__file__) ) ) )
import numpy as np
from theory.tools import save, load
from theory.idis  import IDIS

def get_tot_xsec(tabname,rs=140.7,Q2min=1.0,W2min=10.0,neval=100000):

    def veto(x,y,Q2,W2):
        if   W2 < W2min  : return 0
        elif Q2 < Q2min  : return 0
        else             : return 1

    data={}
    data['tabname'] = tabname
    data['iset']    = 0
    data['iF2']     = 908
    data['iFL']     = 909
    data['iF3']     = 910
    data['sign']    = 1 #--electron=1 positron=-1
    data['veto']    = veto

    idis=IDIS(**data)

    data['neval'] = neval
    data['rs']    = rs
    data['iw']    = 0
    data['units'] = 'fb'
    data['mode']  = 'tot'

    val,err,Q = idis.get_cross_section(**data)
```

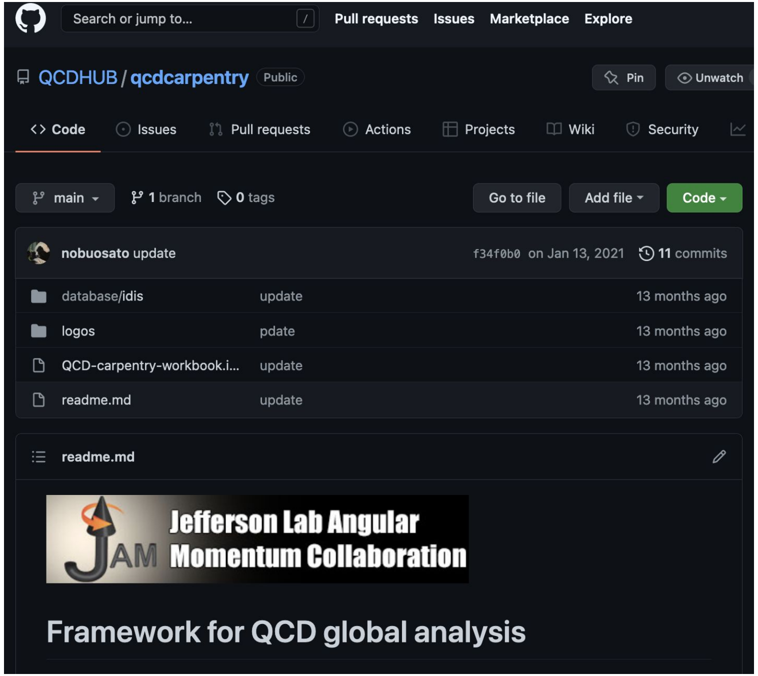
Get state of the art theory calculation for DIS observables

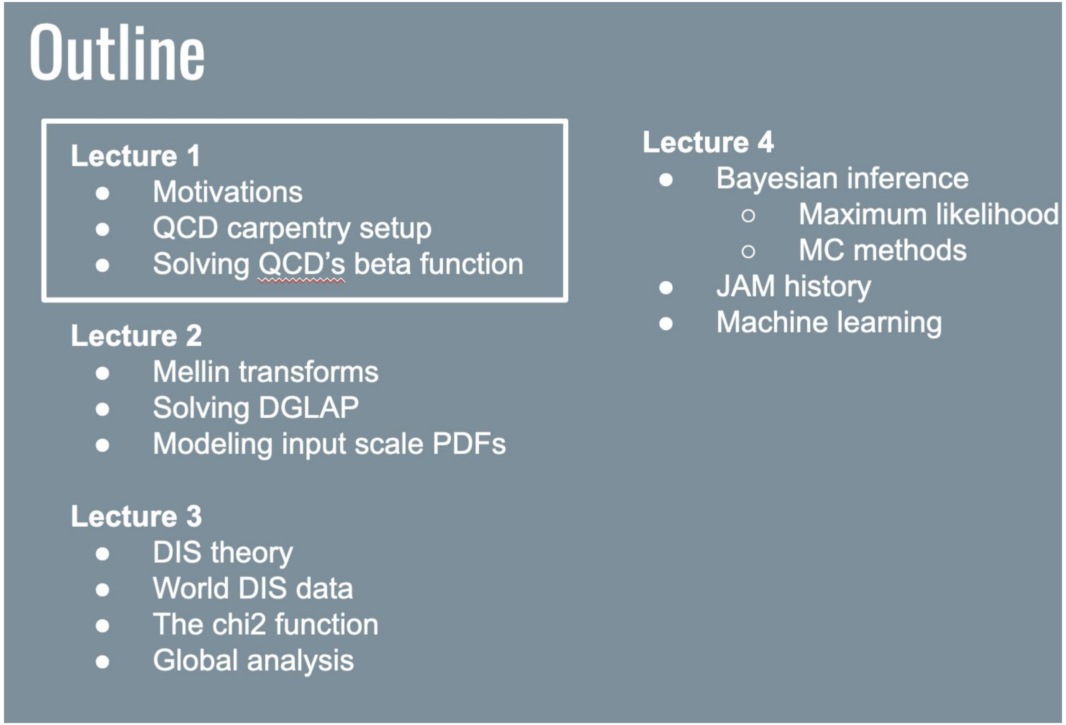
Use of Vegas integration -> weighted DIS events

QCD carpentry

Minimalistic version of JAM machinery

With lecture notes (link)



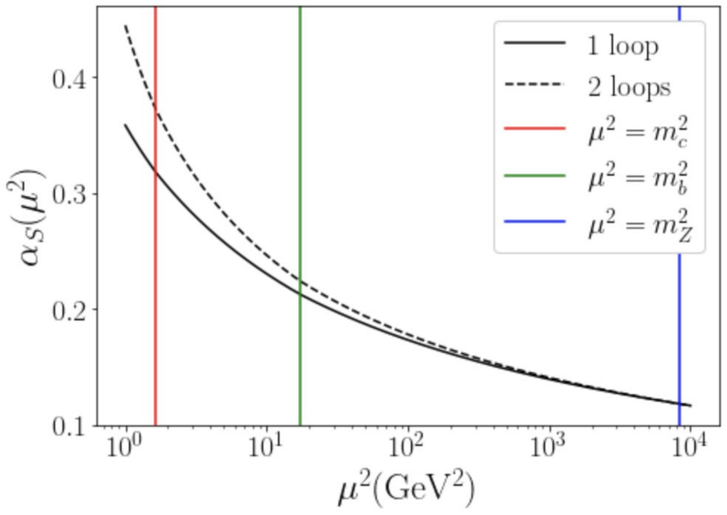


Framework for QCD global analysis

JAM Jefferson Lab Angular Momentum Collaboration

Author: Nobuo Sato (Jefferson Lab - Theory)

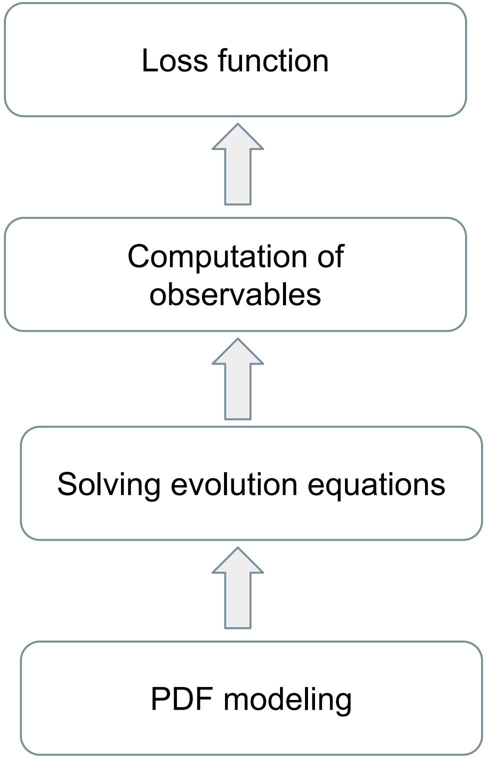
```
]: import sys,os,time
import numpy as np
import pandas as pd
import copy
import threading

#--matplotlib
import matplotlib
matplotlib.rcParams['text.latex.preamble']=[r"\usepackage{amsmath}"]
matplotlib.rc('text',usetex=True)
import pylab  as py
from matplotlib.lines import Line2D

#--scipy
from scipy.integrate import fixed_quad
from scipy.integrate import quad
from scipy.special import gamma

#--mpmath
from mpmath import fp

#--from scipy
from scipy.optimize  import minimize,leastsq
```



$$\frac{\partial}{\partial \ln \mu^2} f_{j/H}(\xi,\mu) = \sum_{j'} \int_\xi^1 \frac{dz}{z} P_{jj'}(z,g) f_{j'/H}(\xi/z,\mu)$$

All in one jupyter notebook!

Global analysis for dummies

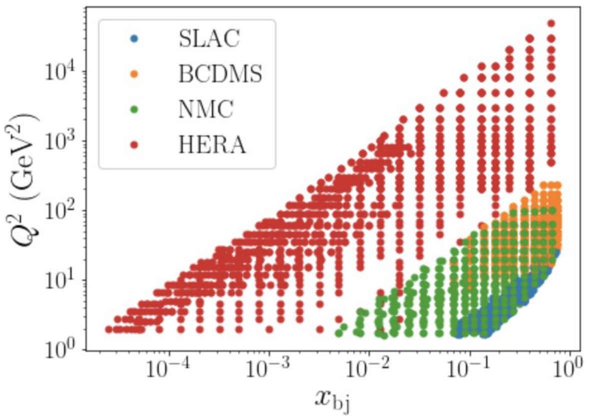


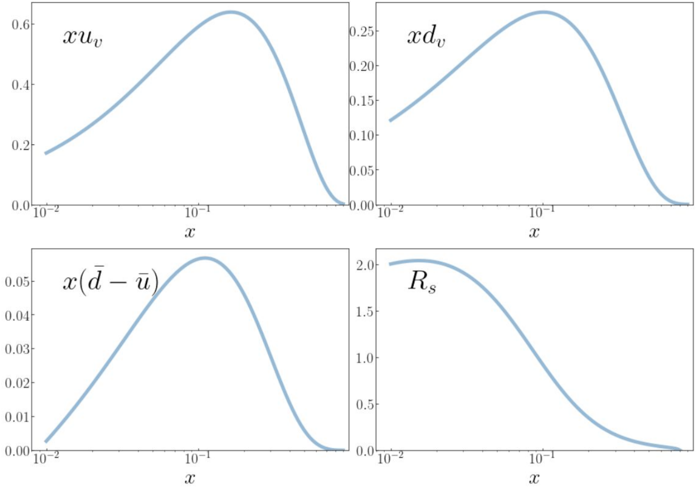
$$\chi^2(\boldsymbol{a}) = \sum_{i,e}\left(\frac{d_{i,e} - \sum_k r_e^k \beta_{i,e}^k - T_{i,e}(\boldsymbol{a})/N_e}{\alpha_{i,e}}\right)^2 + \sum_k \left(r_e^k\right)^2 + \left(\frac{1-N_e}{\delta N_e}\right)^2$$

$$F_i^p(x_{\rm bj}, Q^2) = \sum_q e_q^2 \int_{x_{\rm bj}}^1 \frac{d\xi}{\xi}\, f_{q/p}(\xi, \mu^2) C_{q,i}\left(\frac{x_{\rm bj}}{\xi}, \frac{Q^2}{\mu^2}, \alpha_S(\mu^2)\right) + (q \to g)$$

$$\frac{\partial}{\partial \ln \mu^2} f_{j/H}(\xi, \mu) = \sum_{j'} \int_\xi^1 \frac{dz}{z} P_{jj'}(z, g) f_{j'/H}(\xi/z, \mu)$$

$$T\left(\xi; \boldsymbol{a}\right) = \mathcal{M}\frac{\xi^\alpha \left(1-\xi\right)^\beta \left(1+\gamma\sqrt{\xi}+\delta\xi\right)}{\int_0^1 \mathrm{d}\xi\, \xi^{\alpha+1} \left(1-\xi\right)^\beta \left(1+\gamma\sqrt{\xi}+\delta\xi\right)}$$





summary | sum rules | chi2 per exp | parameters

JAM FITTER

var	value
count	52
elapsed time(mins)	0.34
shifts	2
npts	1503
chi2	1551.96
rchi2	51.64
nchi2	7.73
chi2tot	1611.33
dchi2(iter)	0.53
dchi2(local)	-0.00

summary | sum rules | chi2 per exp | parameters

reaction: unpol DIS
filters: Q2>1.612900
filters: W2>10.000000
reaction: unpol DIS

idx	col	obs	tar	npts	chi2	chi2/npts	rchi2	nchi2
10010	SLAC	F2	p	222.00	237.83	1.07	0.00	4.66
10016	BCDMS	F2	p	348.00	398.05	1.14	22.87	0.09
10020	NMC	F2	p	274.00	490.12	1.79	7.80	2.96
10026	HERA	sig_r	p	402.00	693.30	1.72	176.66	0.00
10027	HERA	sig_r	p	75.00	84.94	1.13	8.00	0.00
10028	HERA	sig_r	p	259.00	252.89	0.98	8.26	0.00
10029	HERA	sig_r	p	209.00	224.26	1.07	7.60	0.00
10030	HERA	sig_r	p	159.00	275.81	1.73	22.00	0.00
10031	HERA	sig_r	p	39.00	47.30	1.21	4.92	0.00
10032	HERA	sig_r	p	42.00	55.03	1.31	14.91	0.00
10011	SLAC	F2	d	231.00	200.65	0.87	0.00	6.66
10017	BCDMS	F2	d	254.00	288.39	1.14	12.08	0.40
10021	NMC	F2d/F2p	d/p	174.00	168.16	0.97	2.49	0.00