



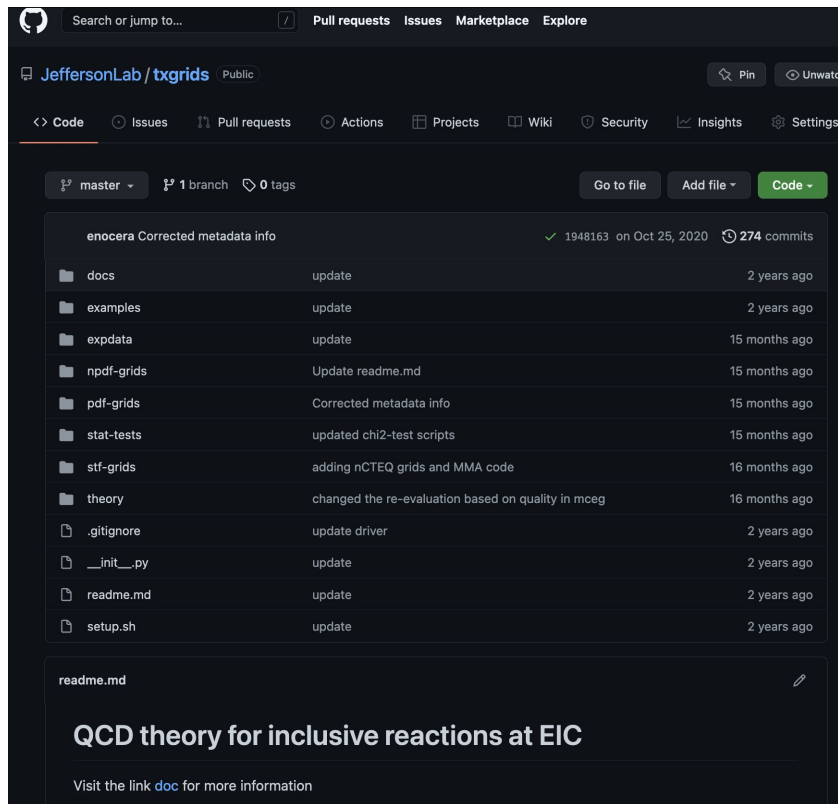
# Theory tools

Nobuo Sato



# Arxiv for DIS structure functions

<https://github.com/JeffersonLab/txgrids>

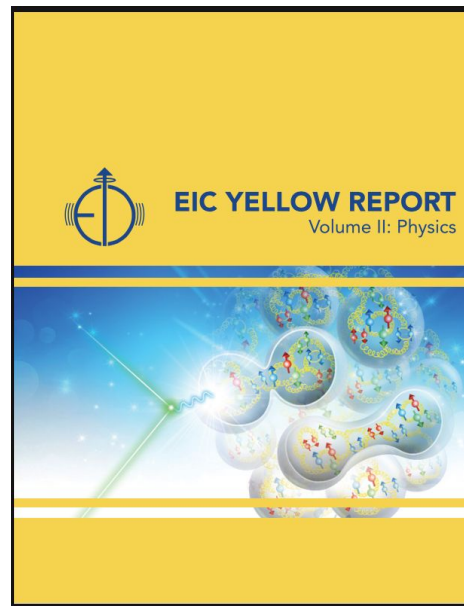


The screenshot shows the GitHub repository page for `JeffersonLab/txgrids`. The repository is public and has 1 branch and 0 tags. The commit history shows 274 commits, with the latest commit on Oct 25, 2020. The file list includes:

File	Commit Message	Time Ago
docs	update	2 years ago
examples	update	2 years ago
expdata	update	15 months ago
npdf-grids	Update readme.md	15 months ago
pdf-grids	Corrected metadata info	15 months ago
stat-tests	updated chi2-test scripts	15 months ago
stf-grids	adding nCTEQ grids and MMA code	16 months ago
theory	changed the re-evaluation based on quality in mceq	16 months ago
.gitignore	update driver	2 years ago
__init__.py	update	2 years ago
readme.md	update	2 years ago
setup.sh	update	2 years ago

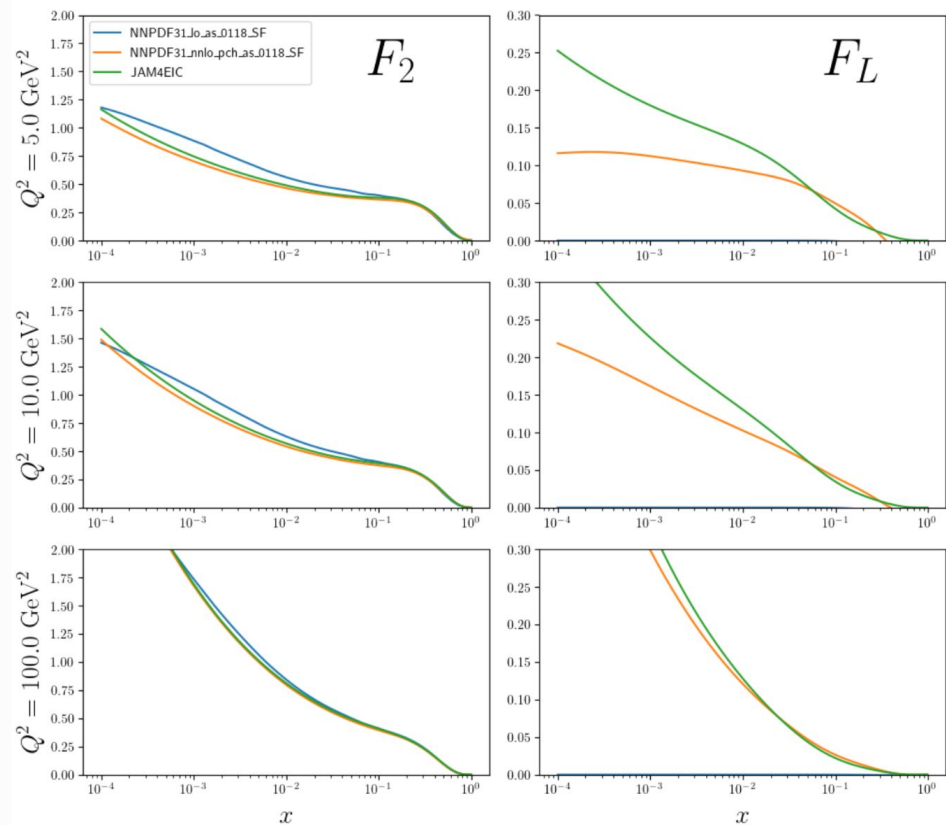
The `readme.md` file is titled "QCD theory for inclusive reactions at EIC" and includes a link to a document for more information.

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





## Structure functions



## MC errors sets from JAM & NNPDF

master [txgrids / stf-grids / JAM4EIC\\_p /](#)

Christopher Cocuzza update

- ..
- JAM4EIC\_p.info
- JAM4EIC\_p\_0000.dat
- JAM4EIC\_p\_0001.dat
- JAM4EIC\_p\_0002.dat
- JAM4EIC\_p\_0003.dat
- JAM4EIC\_p\_0004.dat
- JAM4EIC\_p\_0005.dat
- JAM4EIC\_p\_0006.dat
- JAM4EIC\_p\_0007.dat
- JAM4EIC\_p\_0008.dat
- JAM4EIC\_p\_0009.dat
- JAM4EIC\_p\_0010.dat

CONTENTS:

Gettin Started

LHAPDF grids

Benchmarks

Codes

example programs

example programs

main00.py

Gloals

Code

main01.py

main02.py

## 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'

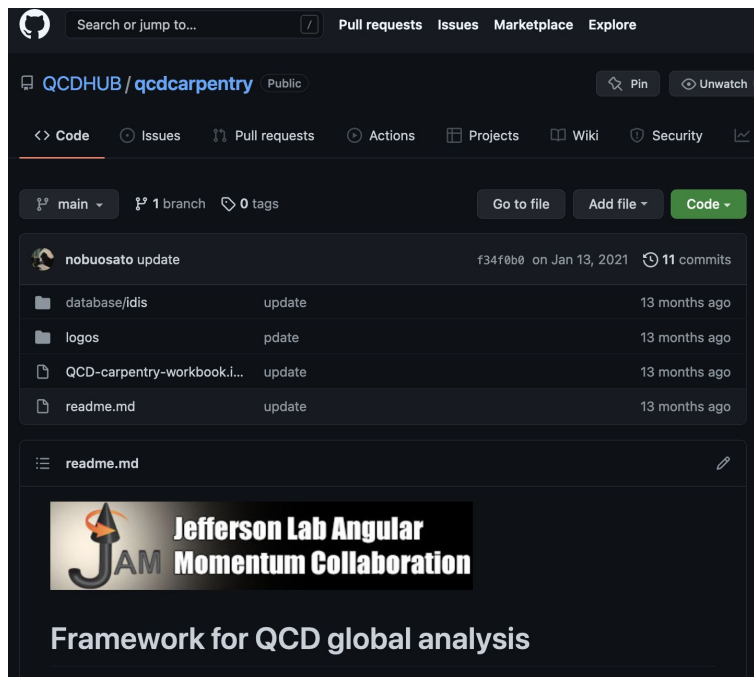
    val,err,Q = idis.get_cross_section(**data)
```

Get state of the  
art theory  
calculation for  
DIS observables

Use of Vegas  
integration ->  
weighted DIS  
events

# QCD carpentry

With lecture notes ([link](#))



## Minimalistic version of JAM machinery

### Outline

#### Lecture 1

- Motivations
- QCD carpentry setup
- Solving QCD's beta function

#### Lecture 2

- Mellin transforms
- Solving DGLAP
- Modeling input scale PDFs

#### Lecture 3

- DIS theory
- World DIS data
- The  $\chi^2$  function
- Global analysis

#### Lecture 4

- Bayesian inference
  - Maximum likelihood
  - MC methods
- JAM history
- Machine learning

# Framework for QCD global analysis



Author: Nobuo Sato (Jefferson Lab - Theory)

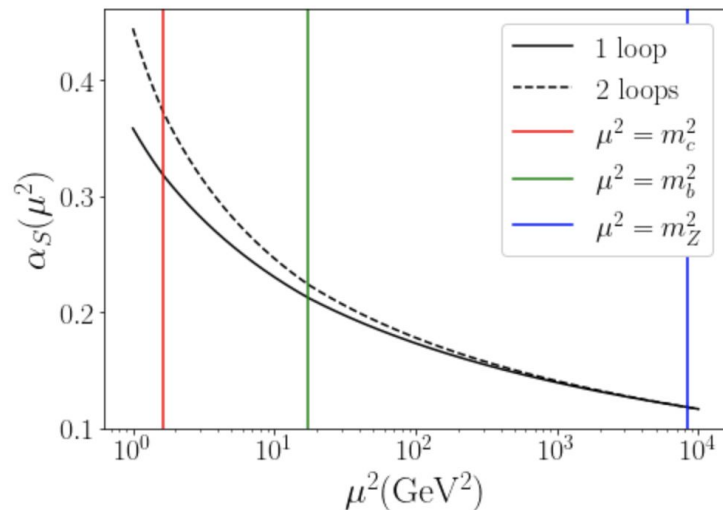
```
1: import sys,os,time
import numpy as np
import pandas as pd
import copy
import threading

#--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

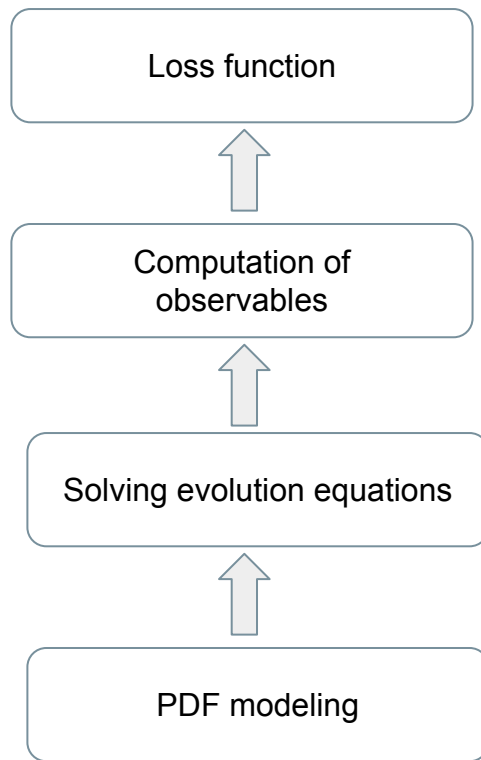
#--from scipy
from scipy.optimize import minimize,leastsq
```



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

All in one jupyter  
notebook!

# Global analysis for dummies



A dashed box containing mathematical equations that correspond to the steps in the flowchart. A red arrow points from the 'PDF modeling' step to the equation  $T(\xi; \mathbf{a})$ . Subsequent upward-pointing arrows connect the equations in sequence, corresponding to 'Solving evolution equations', 'Computation of observables', and 'Loss function'.

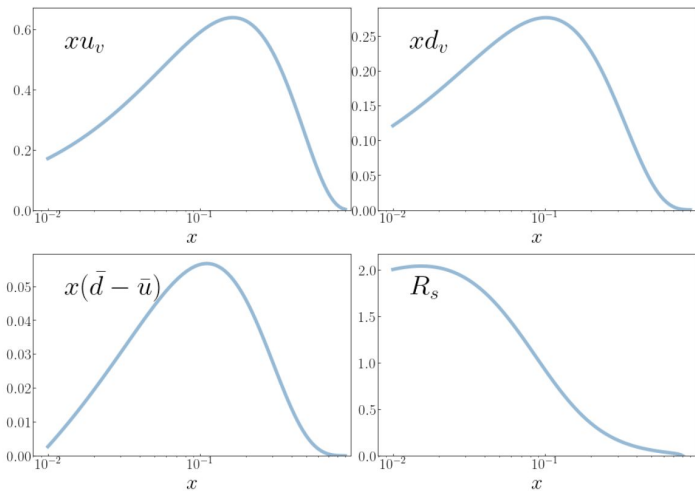
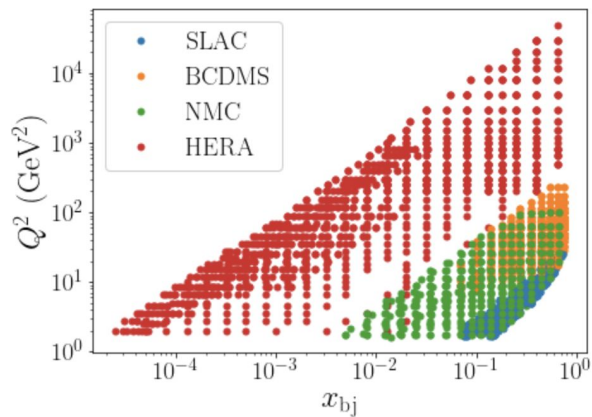
$$T(\xi; \mathbf{a}) = \mathcal{M} \frac{\xi^\alpha (1 - \xi)^\beta (1 + \gamma\sqrt{\xi} + \delta\xi)}{\int_0^1 d\xi \xi^{\alpha+1} (1 - \xi)^\beta (1 + \gamma\sqrt{\xi} + \delta\xi)}$$

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

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

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





## 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