Tools for PDF and Structure Functions

… ManeParse, Python Jupyter, ...

Tim Hobbs, Pavel Nadolsky, Fred Olness

EIC Center at JLab & Southern Methodist University

Thanks for substantial input
from our friends & colleagues

Tools for nucleon and nuclear PDFs & SF's

ManeParse w/ Mathematica

Proton & Nuclear PDFs

Structure Functions

Python Jupyter Tools:

CTEQ-TEA **nCTEQ**

nuclear parton distribution functions

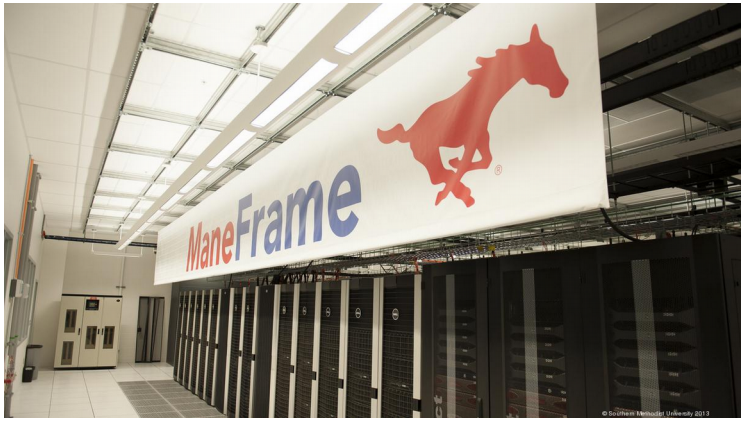
23 June 2020
IR4YR Virtual Meeting

Mathematica **ManeParse**

where did the name come from

SMU Mascot Peruna
a Shetland Pony

SMU's SuperComputer Cluster: **"ManeFrame"**



SMU Program for LHAPDF
grid interpolation.

"Mane" + Parse

Mathematica: ManeParse

www.ncteq.org

nCTEQ

nuclear parton distribution functions

ManeParse: A Mathematica Interface to the PDFs

ManeParse is a modular Mathematica package that provides access to PDFs for hadronic calculations. It allows LHAPDF6 files and estimates PDF errors for Hessian and MC releases.

ManeParse Publication:

Download the publication here:

- **ManeParse : A Mathematica reader for Parton Distribution Functions**
  D.B. Clark, E. Godat, F.I. Olness.
  Comput.Phys.Commun. 216 (2017) 126-137.
  or: arXiv:1605.08012 [hep-ph] .

ManeParse version 3.0, Mathematica package:

An SIMPLE example using LHAPDF Tables for PDFs:

This is an self-contained example that reads PDF tables in LHAPDF format.

PDF_DEMO_v01.zip
(850Kb, Version May 2020).
Includes PDF Grid files needed for demo.

A SIMPLE example using Structure Function Tables:

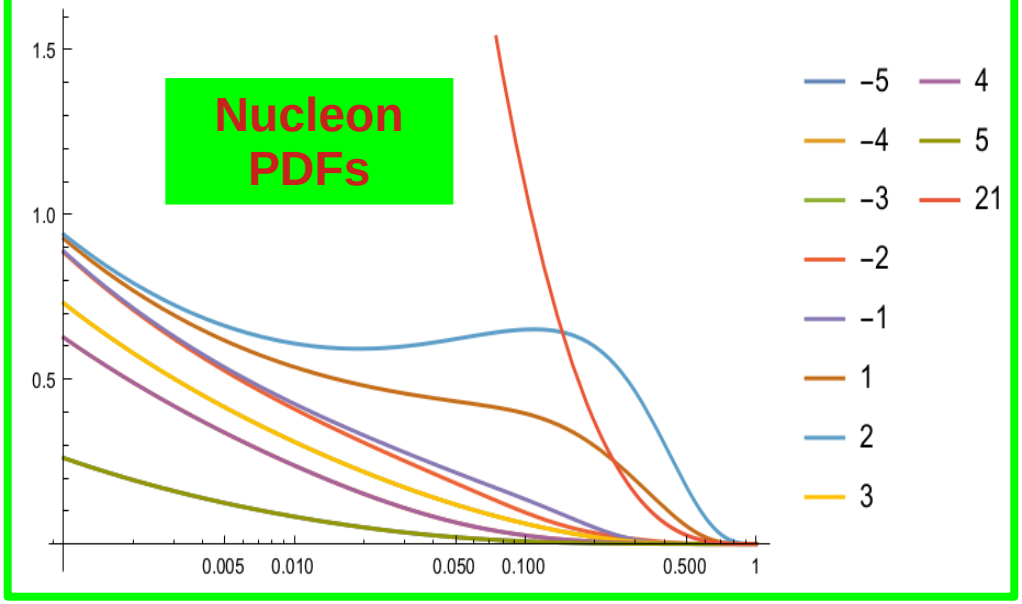
This is an self-contained example that reads Structure Function tables in LHAPDF format.

SF_DEMO_v01.zip
(460Kb, Version May 2020).
Includes Structure Function Grid files needed for demo.
Thanks to Tim Hobbs for supplying the sample tables.

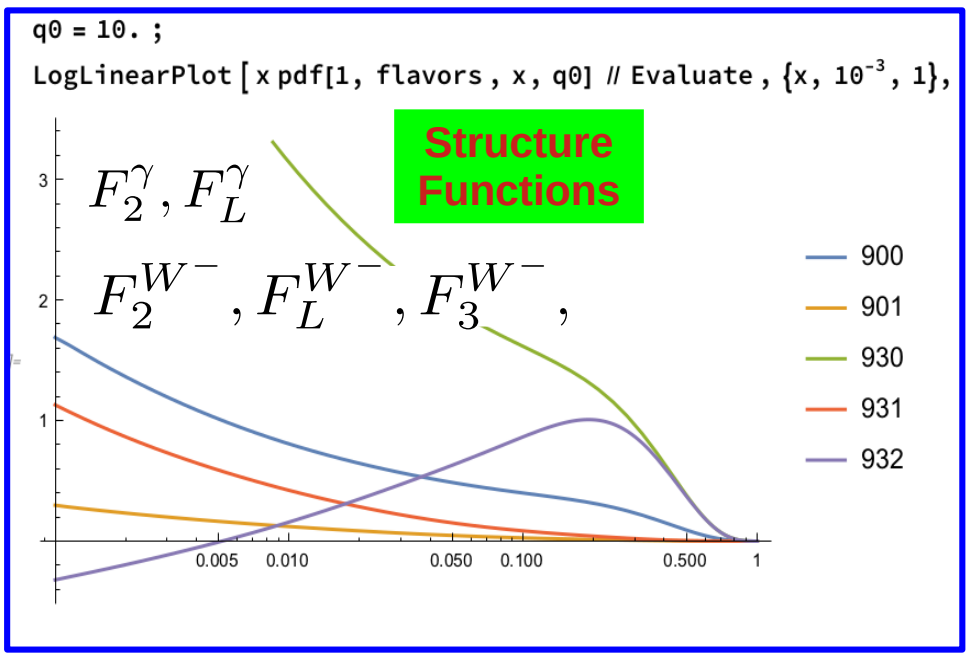
https://ncteq.hepforge.org/mma/index.html

(demo available for download)

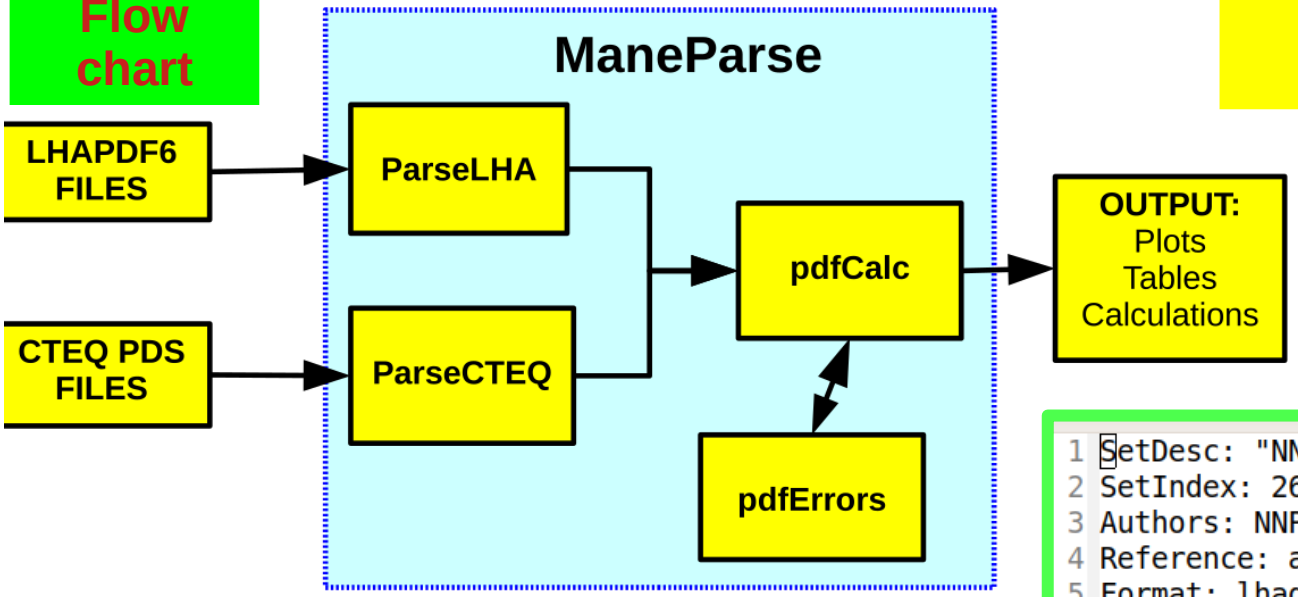
```
q0 = 10. ;
LogLinearPlot[x pdf[1, flavors, x, q0] // Evaluate, {x, 10^-3, 1}, Plo
```




```
q0 = 10. ;
LogLinearPlot[x pdf[1, flavors, x, q0] // Evaluate, {x, 10^-3, 1},
```



Flow chart



LHAPDF Table Manipulation

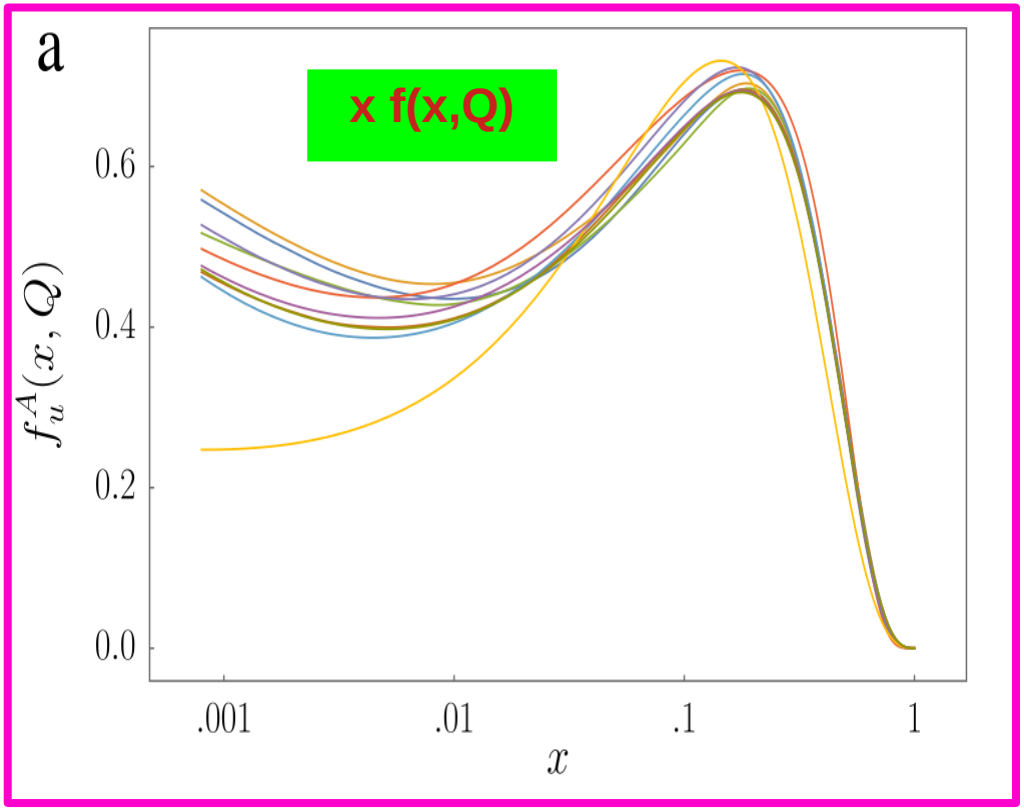
```
1 PdfType: central
2 Format: lhagrid1
3 ---
4 9.9999997E-10 1.4508288E-09 2.1049043E-
 -08 1.2618568E-07 1.8307382E-07 2.65608
 988E-05 1.5922828E-05 2.3101296E-05 3.3
 3848863E-03 2.0 2.9150532E-03
 1 1.1836734E-01 -01 1.5510204
 2E-01 3.5714287E-01 3.7551022E-01 3.938
 55101E-01 5.9591836E-01 6.1428571E-01 6
 8.1632656E-01 8.3469385E-01 8.5306120E-
5 1.0000000E+00 1.0796795E+00 1.1706605E+
6 -5 -4 -3 -2 -1 1 2 3 4 5 21
7  -1.1603039E-08  4.5299533E-09  3.68052
8   7.7883411E-09 -4.0451689E-08  4.87151
9  -3.4689905E-08 -2.9802309E-09  6.16576
10  3.5444898E-08 -9.7751623E-08  7.57705
11 -1.0252000E-08  4.3074293E-08  3.44348
```

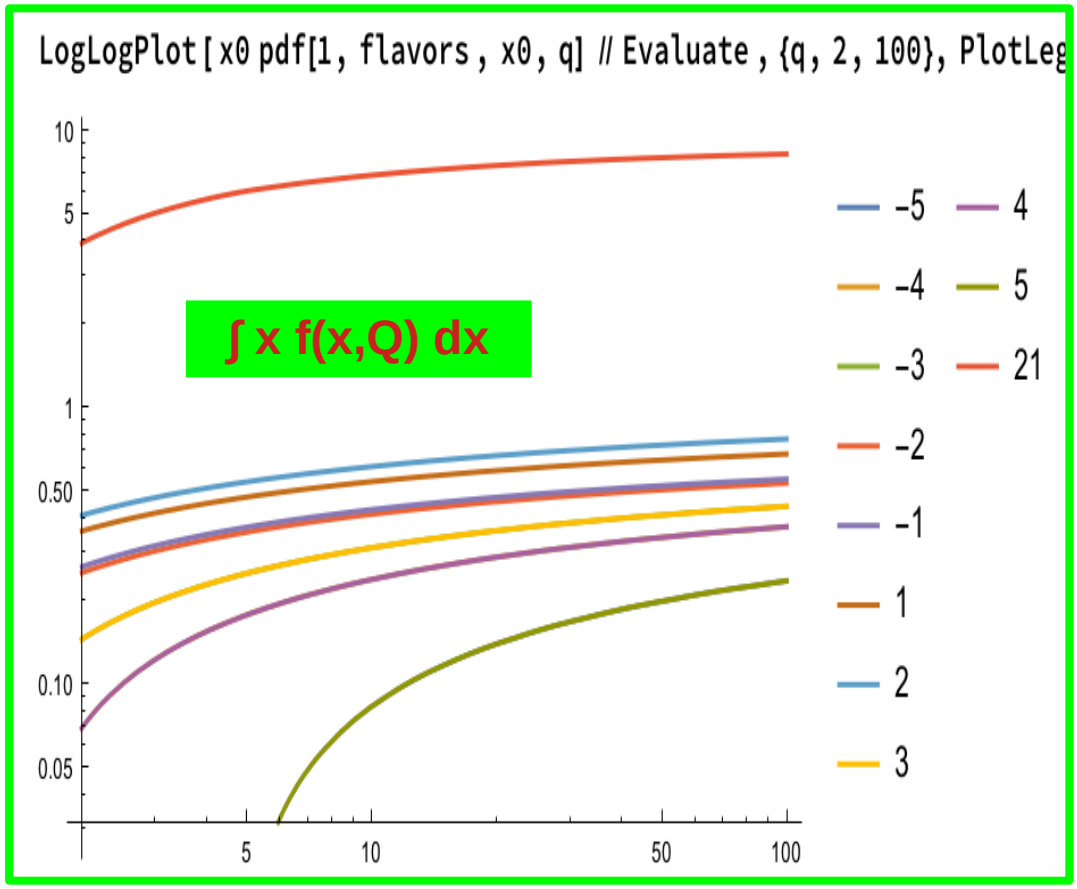
LHAPDF data file

```
1 SetDesc: "NNPDF3.0 NLO global fit, alphas(MZ)=0.118. me
2 SetIndex: 260000
3 Authors: NNPDF Collaboration. R.D. Ball, V. Bertone, S.
4 Reference: arXiv:1410.8849
5 Format: lhagrid1
6 DataVersion: 2
7 NumMembers: 101
8 Particle: 2212
9 Flavors: [-5, -4, -3, -2, -1, 1, 2, 3, 4, 5, 21]
10 OrderQCD: 1
11 FlavorScheme: variable
12 NumFlavors: 5
13 ErrorType: replicas
14 XMin: 9.9999997e-10
15 XMax: 1.0000000e+00
16 QMin: 1.0000000e+00
17 QMax: 1.0000000e+05
18 MZ: 9.1199997e+01
19 MUp: 0
20 MDown: 0
21 MStrange: 0
22 MCharm: 1.2750000e+00
23 MBottom: 4.1799998e+00
24 MTop: 1.7307001e+02
25 AlphaS_MZ: 0.1180000
26 AlphaS_OrderQCD: 1
27 AlphaS_Type: ipol
28 AlphaS_Qs: [1.0000000e+00, 1.0796795e+00, 1.1706605e+00
 140953e+00, 2.8283343e+00, 3.2010288e+00, 3.6457884e+00
```

LHAPDF info file

PDF Manipulation





PDF Set	Total	$\bar{u}$	$\bar{d}$	g	d	u	s	c	b
MSTW2008nnlo68cl [15]	99.87	3.3	3.8	43.5	14.6	29.3	2.0	0.7	0
CT14nnlo [16]	100.01	3.1	3.7	[illegible]	14.6	29.7	2.0	0.8	0
NNPDF30_nnlo_as_0118_nf_6 [17]	99.98	3.2	3.7	[illegible]	14.6	29.4	2.2	0.8	0
HERAPDF20_NLO_VAR [18]	99.98	3.9	[illegible]	41.7	14.6	31.2	2.2	0.6	0
abm12lhc_5_nnlo [19]	100.14	2.9	[illegible]	43.4	14.8	30.4	2.0	0.7	0
CJ15nlo [20]	99.96	3.0	3.7	43.3	15.1	29.8	[illegible]	[illegible]	[illegible]
nCTEQ15_1_1 [21]	100.10	3.1	3.8	43.0	15.0	30.2	[illegible]	[illegible]	[illegible]
nCTEQ15_208_82 [21]	99.99	2.7	3.4	44.6	17.0	27.2	[illegible]	[illegible]	[illegible]
ct10.pds [22]	99.97	3.0	3.7	43.4	14.6	29.6	2.2	0.7	0
ctq66m.pds [4]	99.98	2.9	3.6	43.6	14.5	29.4	2.3	0.7	0

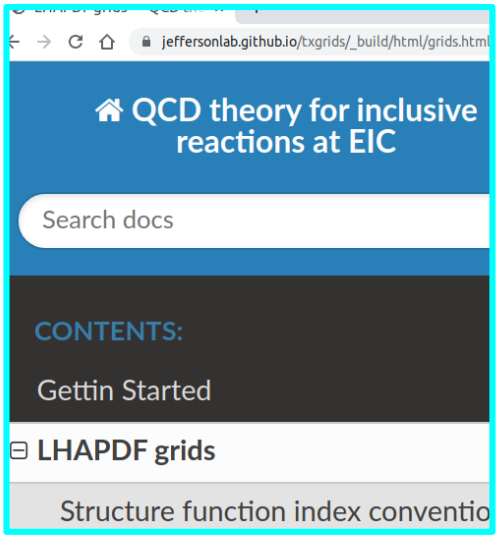
Proton & Nuclear

Momentum Fractions
∫ x f(x,Q) dx
Q=3 GeV

Mathematica: ManeParse

F_{123} Structure Functions

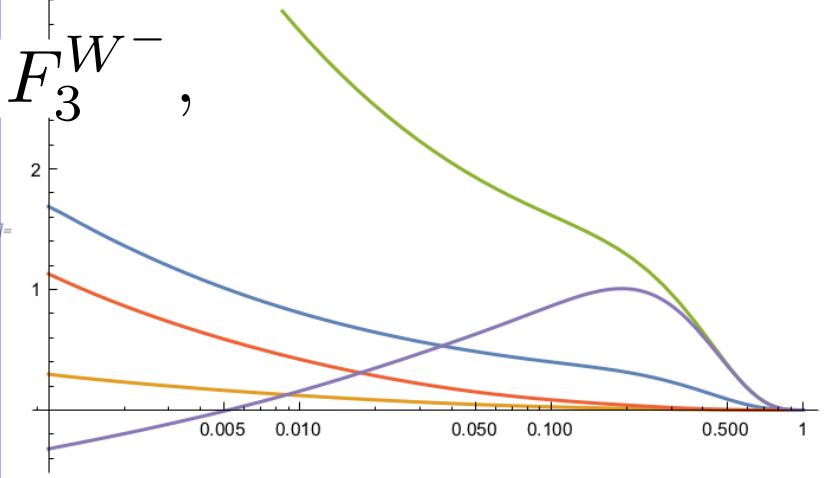
https://jeffersonlab.github.io/txgrids/_build/html/grids.html



$$F_2^{\gamma}, F_L^{\gamma}$$

$$F_2^{W^-}, F_L^{W^-}, F_3^{W^-},$$

```
q0 = 10. ;
LogLinearPlot[x pdf[1, flavors, x, q0] // Evaluate, {x, 10^-3, 1},
```



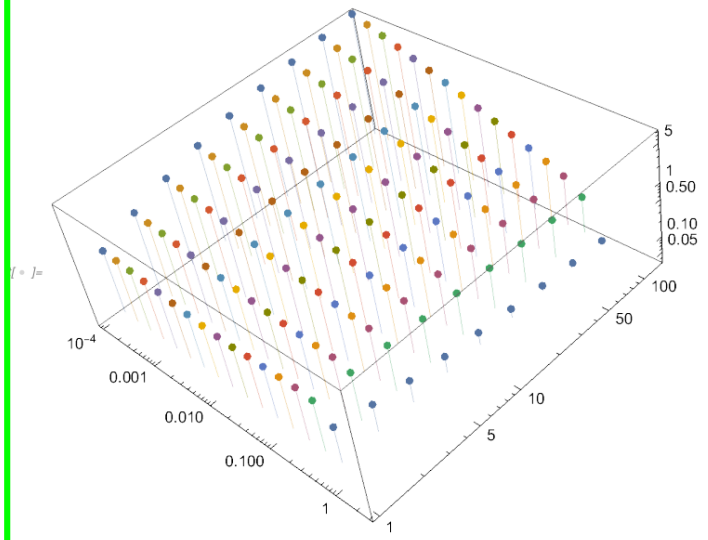
LHAPDF grids

Structure function index convention

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

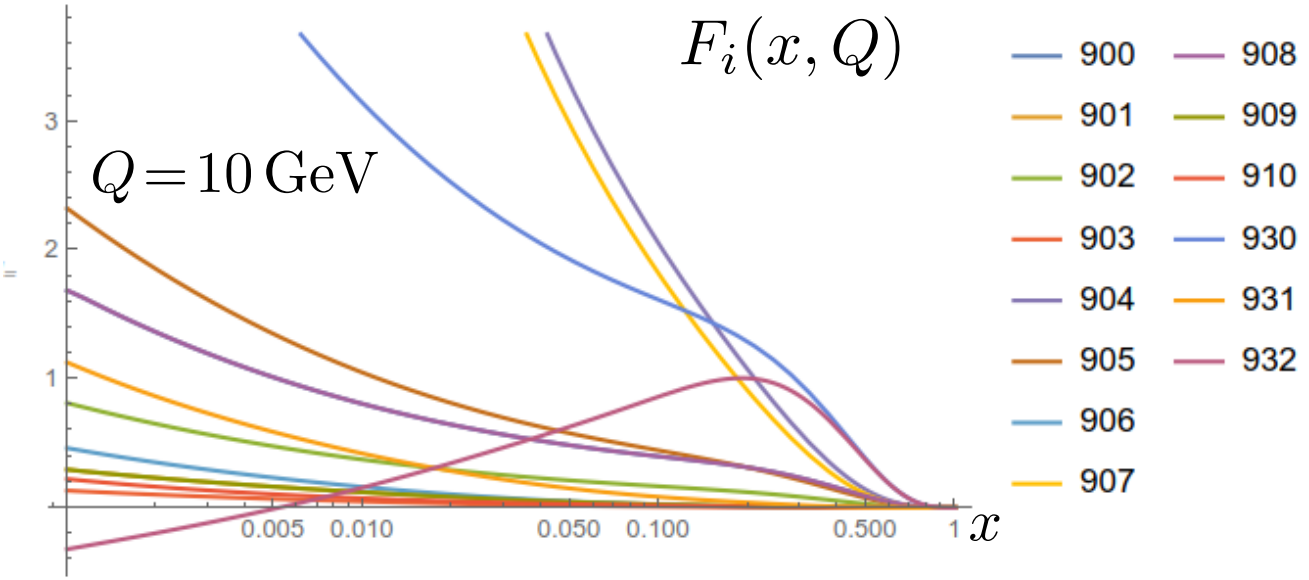
Reaction	Structure Functions	Index
$e^{\pm} + T \to e^{\pm} + X$	F_2^{γ}, F_L^{γ}	900, 901
	$F_2^{\gamma Z}$, $F_L^{\gamma Z}$, $F_3^{\gamma Z}$	902, 903, 904
	F_2^{Z}, F_L^{Z}, F_3^{Z}	905, 906, 907
	F_2^{NC}, F_L^{NC}, F_3^{NC}	908, 909, 910
	F_{2c}^{γ}, F_{Lc}^{γ}	911, 912, 913
	F_{2c}^{NC}, F_{Lc}^{NC},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

```
ListPointPlot3D[data, ScalingFunctions → {"Log", "Log", "Log"},
 Filling → Bottom]
```

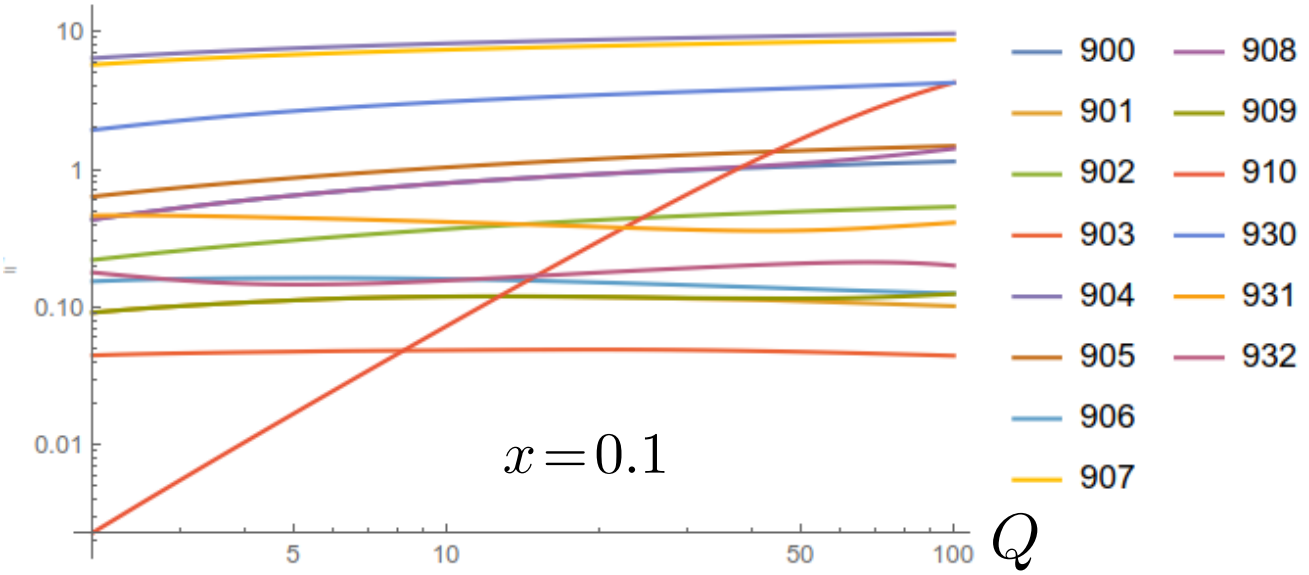


LHA input theory from CT18

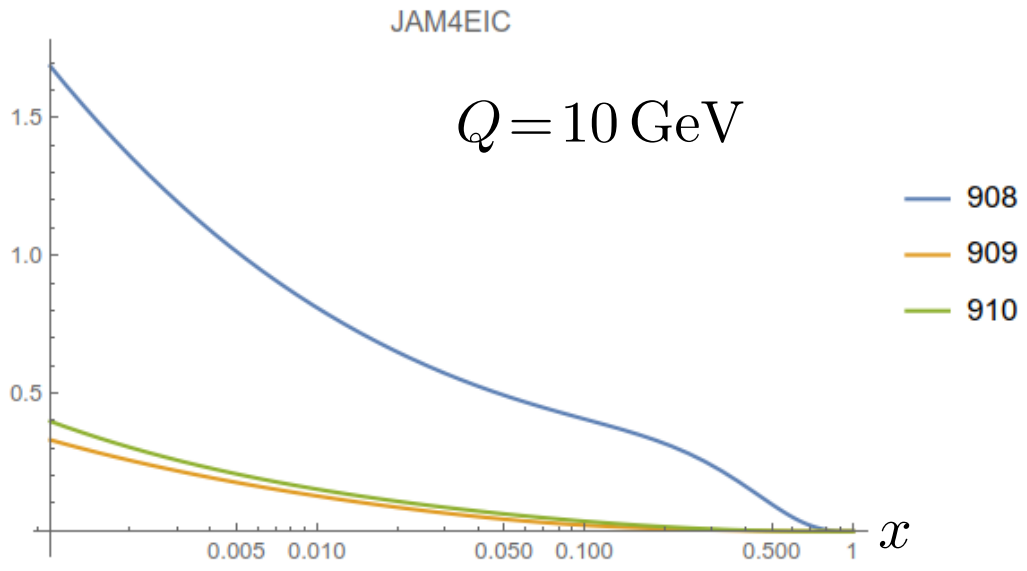
CT18 NNLO

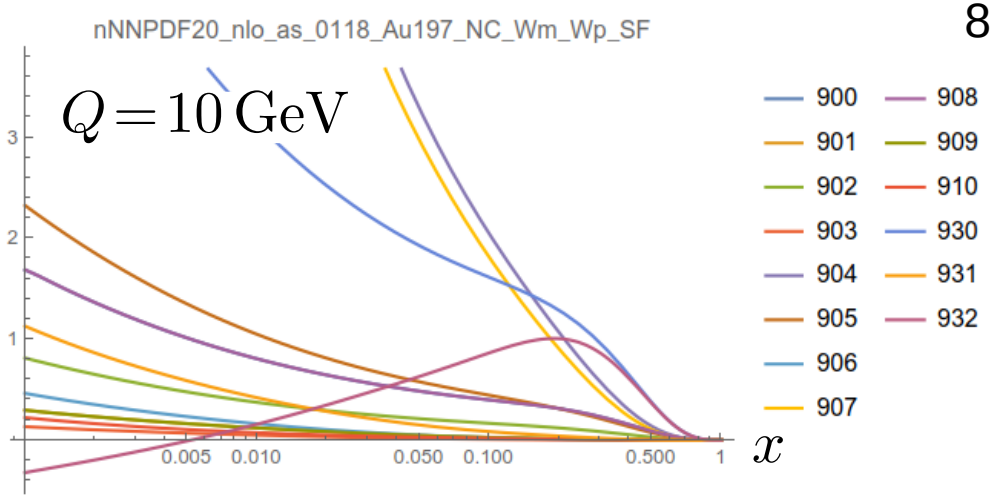


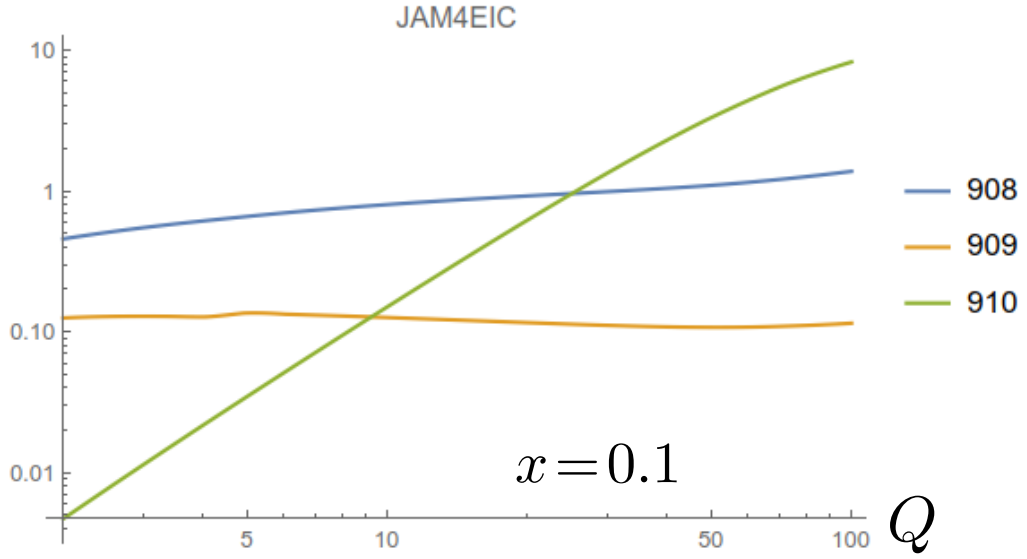
- proton structure functions are now available for many LHA indices in the CT18 framework

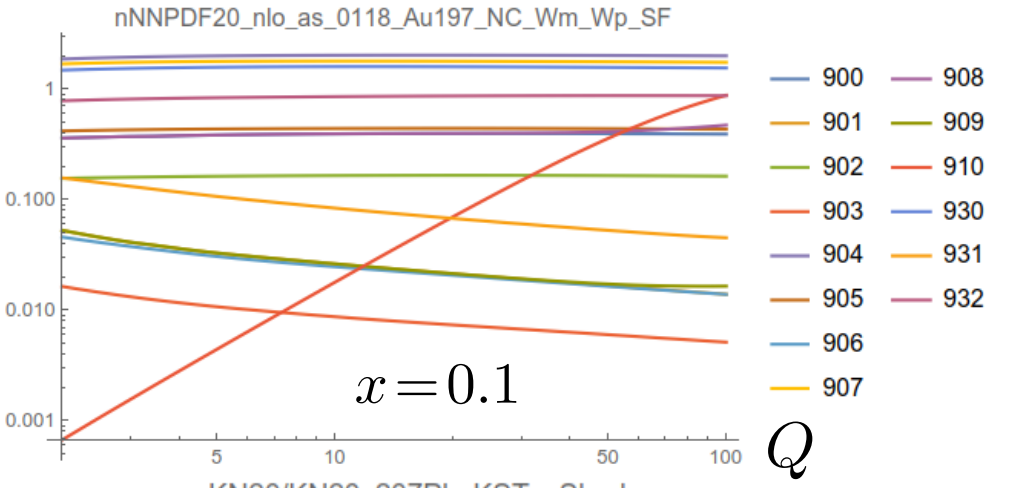


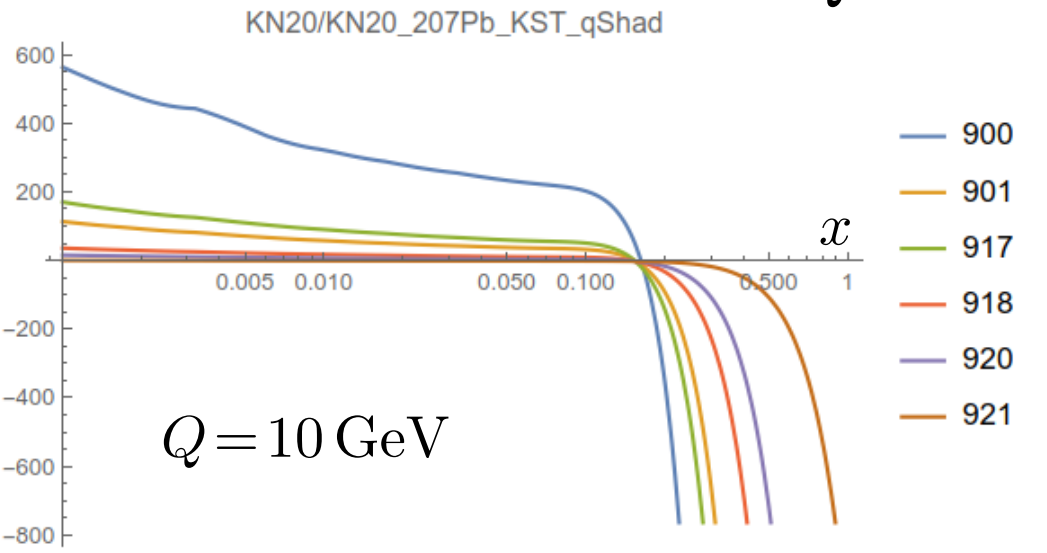
Structure Functions	Index
F_2^{γ}, F_L^{γ}	900, 901
$F_2^{\gamma Z}$, $F_L^{\gamma Z}$, $F_3^{\gamma Z}$	902, 903, 904
F_2^{Z}, F_L^{Z}, F_3^{Z}	905, 906, 907
F_2^{NC}, F_L^{NC}, F_3^{NC}	908, 909, 910
$F_2^{W^-}$, $F_L^{W^-}$, $F_3^{W^-}$	930, 931, 932
$F_2^{W^+}$, $F_L^{W^+}$, $F_3^{W^+}$	940, 941, 942











can compute/compare within other available frameworks

Python Jupyter Notebook

jupyter ReadPDF_short_v01 (autosaved)

Logout

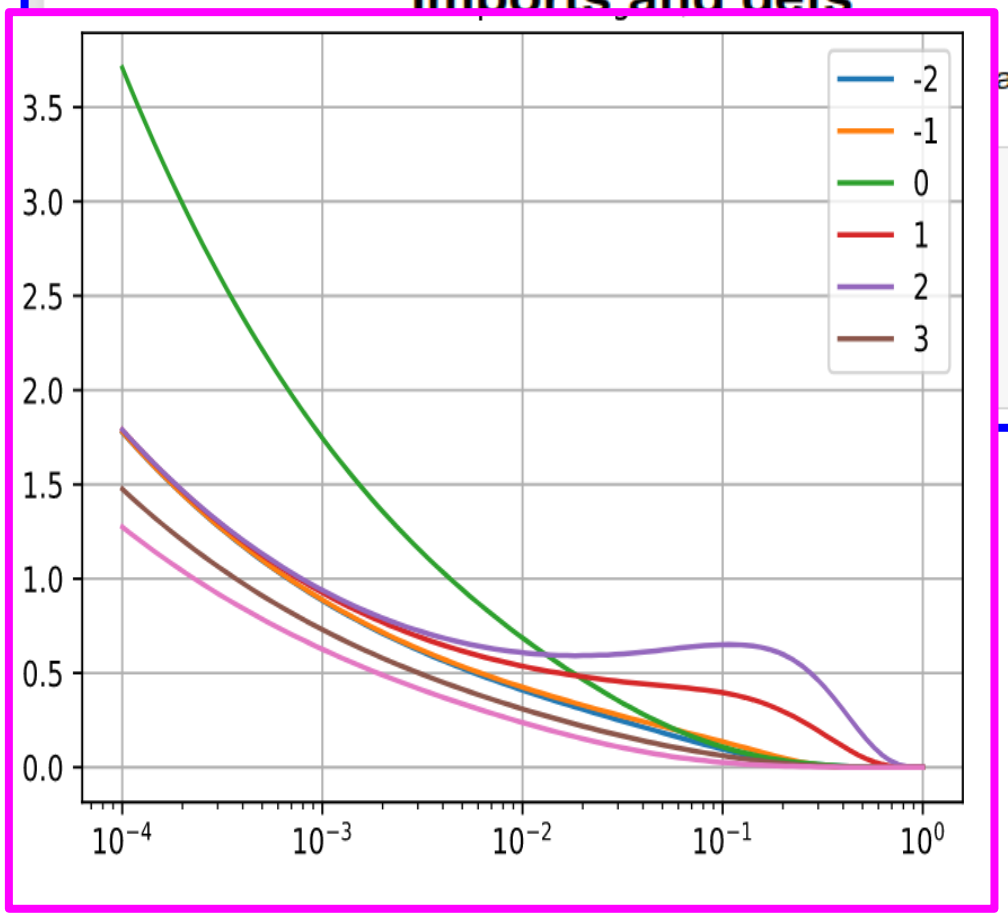
File Edit View Insert Cell Kernel Widgets Help Trusted Python 2

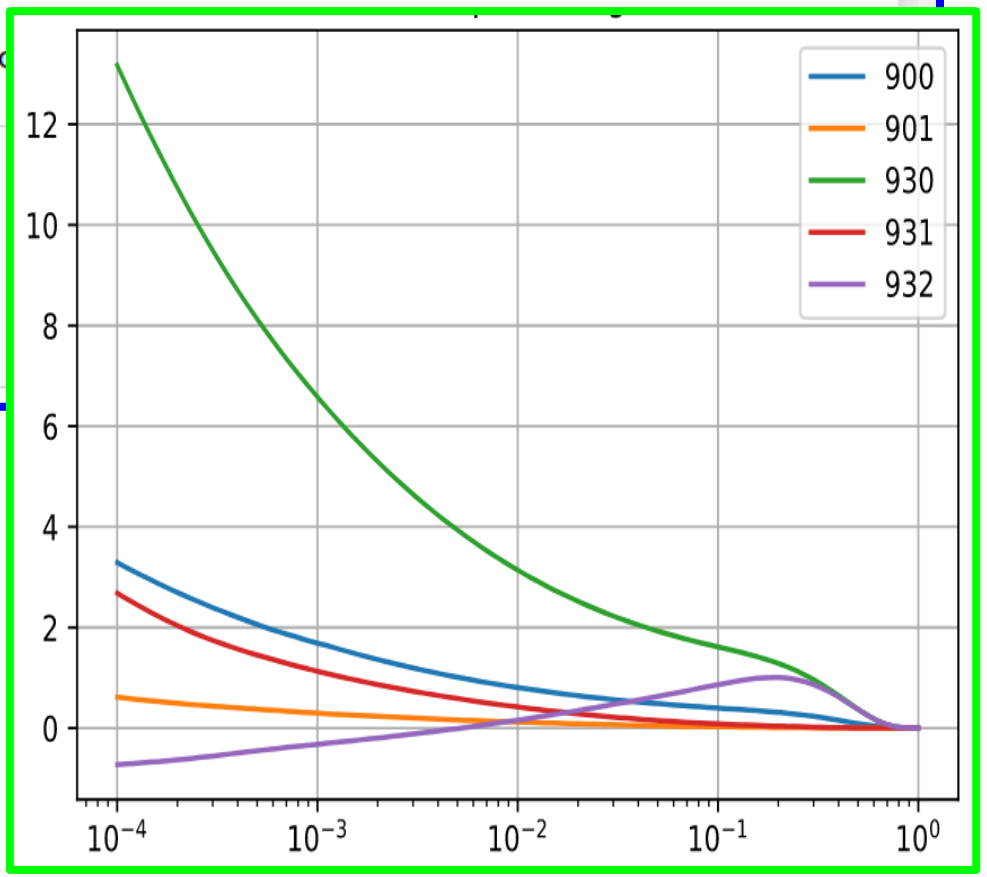
Run Markdown

Example plots with the IPython notebook

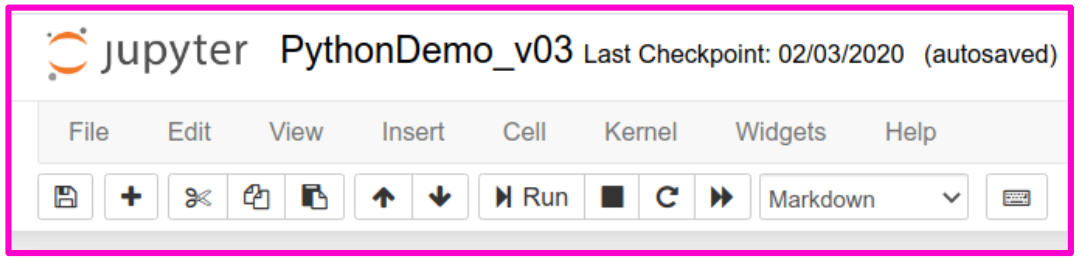
So I just use the lhapdf library for loading the PDFs and plot them

Imports and defs

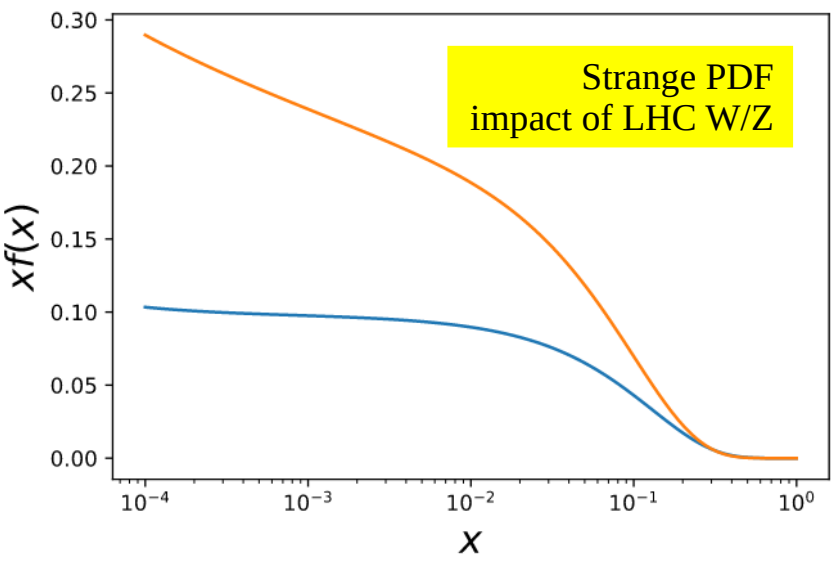


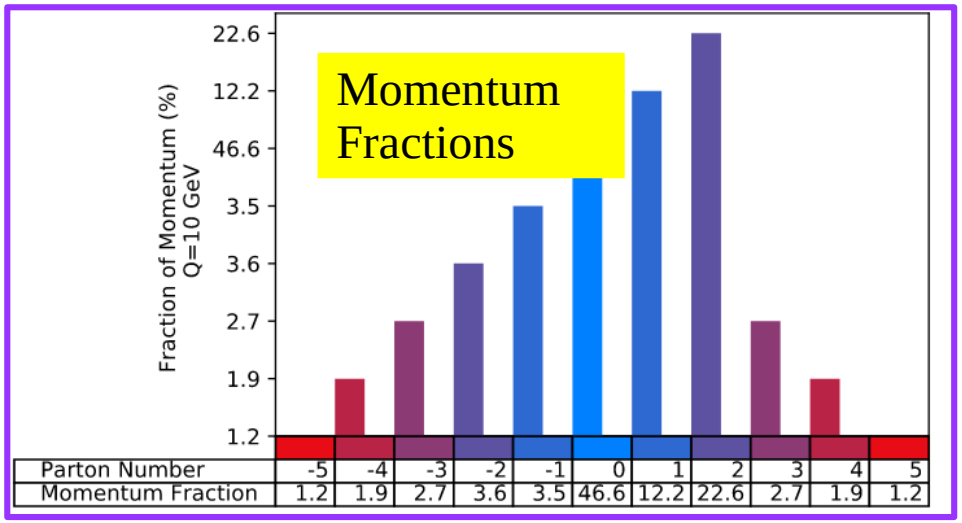


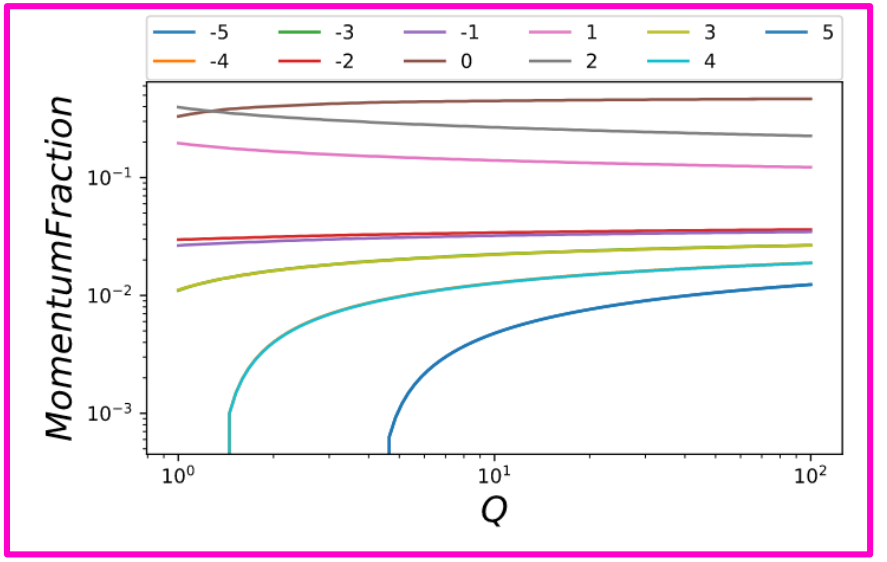
Python Jupyter Notebook




```
fig.savefig('testFigX.pdf')
```







Momentum Fractions vs. Q