FASER update report

Paulina 01/04/26

Proton target

running-scales/1TeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	4.4403	4.5133	1.0164	+1.64
Eh	4.4403	4.5133	1.0164	+1.64
Q2	4.4403	4.5133	1.0164	+1.64
bjx	4.4403	4.5133	1.0164	+1.64
theta	4.4400	4.5133	1.0165	+1.65
inel	4.4403	4.5133	1.0164	+1.64

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Agreement is good

1.64% off is bugging me, unexplained

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ)

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+03]	1.0164	0.1956	+1.64	31	GOOD
Eh	[0.938, 1.01e+03]	1.0164	0.2177	+1.64	31	GOOD
Q2	[4, 1.88e+03]	1.0183	0.0196	+1.83	53	GOOD
bjx	[1e-08, 1]	1.0160	0.1618	+1.60	48	GOOD
theta	[1e-06, 1.57]	0.9920	0.0912	-0.80	50	EXCELLENT
inel	[0, 1]	1.0164	0.3387	+1.64	50	GOOD

running-scales/10TeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	36.2310	36.2020	0.9992	−0.08
Eh	36.2310	36.2020	0.9992	−0.08
Q2	36.2310	36.2020	0.9992	−0.08
bjx	36.2310	36.2020	0.9992	−0.08
theta	36.2309	36.2020	0.9992	−0.08
inel	36.2310	36.2020	0.9992	−0.08

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Agreement is excellent

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHE

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+04]	0.9992	0.2322	−0.08	31	EXCELLENT
Eh	[0.938, 1.01e+04]	0.9992	0.2145	−0.08	31	EXCELLENT
Q2	[4, 1.88e+04]	0.9995	0.0220	−0.05	73	EXCELLENT
bjx	[1e−08, 1]	0.9992	0.1552	−0.08	50	EXCELLENT
theta	[1e−06, 1.57]	0.9901	0.0815	−0.99	50	EXCELLENT
inel	[0, 1]	0.9992	0.4838	−0.08	50	EXCELLENT

running-scales/100TeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	180.7146	179.8576	0.9953	-0.47
Eh	180.7146	179.8576	0.9953	-0.47
Q2	180.7146	179.8576	0.9953	-0.47
bjx	180.7146	179.8576	0.9953	-0.47
theta	180.7146	179.8576	0.9953	-0.47
inel	180.7146	179.8576	0.9953	-0.47

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Agreement is excellent

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWH

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+05]	0.9953	0.2444	-0.47	31	EXCELLENT
Eh	[0.938, 1.01e+05]	0.9953	0.2595	-0.47	31	EXCELLENT
Q2	[4, 1.88e+05]	0.9954	0.0347	-0.46	92	EXCELLENT
bjx	[1e-08, 1]	0.9953	0.1007	-0.47	50	EXCELLENT
theta	[1e-06, 1.57]	0.9927	0.0158	-0.73	25	EXCELLENT
inel	[0, 1]	0.9953	0.5744	-0.47	50	EXCELLENT

running-scales/1PeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	541.4138	616.2632	1.1382	+13.82
Eh	541.4138	616.2632	1.1382	+13.82
Q2	541.4138	616.2632	1.1382	+13.82
bjx	541.4138	616.2632	1.1382	+13.82
theta	541.4138	616.2632	1.1382	+13.82
inel	541.4138	616.2632	1.1382	+13.82

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Disagreement is significant

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+06]	1.1382	0.3223	+13.82	31	CHECK
Eh	[0.938, 1.01e+06]	1.1382	0.3531	+13.82	31	CHECK
Q2	[4, 1.88e+06]	1.1383	0.0563	+13.83	111	CHECK
bjx	[1e-09, 1]	1.1382	0.0821	+13.82	50	CHECK
theta	[1e-06, 1.57]	1.1355	0.0021	+13.55	10	CHECK
inel	[0, 1]	1.1382	0.6730	+13.82	50	CHECK

Probably: x can get too low for PDF set grids

running-scales/10PeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	1772.3785	1832.1357	1.0337	+3.37
Eh	1772.3785	1832.1357	1.0337	+3.37
Q2	1772.3785	1832.1357	1.0337	+3.37
bjx	1772.3785	1832.1357	1.0337	+3.37
theta	1772.3785	1781.2762	1.0050	+0.50
inel	1772.3785	1832.1357	1.0337	+3.37

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Some fuckery going on with theta

Disagreement is significant

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ)

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+07]	1.0337	0.2521	+3.37	31	MODERATE
Eh	[0.938, 1.01e+07]	1.0337	0.3295	+3.37	31	MODERATE
Q2	[4, 1.12e+07]	1.0337	0.0757	+3.37	129	MODERATE
bjx	[1e-09, 1]	1.0337	0.0737	+3.37	50	MODERATE
theta	[1e-06, 1.57]	1.0025	0.0000	+0.25	1	EXCELLENT
inel	[0, 1]	1.0337	0.6273	+3.37	50	MODERATE

Probably: x can get too low for PDF set grids, somehow better than 1PeV??

Neutron target

running-scales/1TeV/LO-nue-n

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	1772.3785	8.0765	0.0046	-99.54
Eh	1772.3785	8.0765	0.0046	-99.54
Q2	1772.3785	8.0765	0.0046	-99.54
bjx	1772.3785	8.0765	0.0046	-99.54
theta	1772.3785	8.0765	0.0046	-99.54
inel	1772.3785	8.0765	0.0046	-99.54

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Something is not right here…

Xsec for both def. Wrong

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.02e+03]	–	–	–	–	N/A
Eh	[0.938, 1.02e+03]	–	–	–	–	N/A
Q2	[4, 1.88e+03]	0.0118	0.0191	-98.82	53	CHECK
bjx	[1e-09, 1]	0.0046	0.0209	-99.54	50	CHECK
theta	[1e-06, 1.57]	0.0035	0.0000	-99.65	1	CHECK
inel	[0, 1]	0.0046	0.0052	-99.54	50	CHECK

running-scales/10TeV/LO-nue-p

INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	57.5310	57.4295	0.9982	−0.18
Eh	57.5310	57.4295	0.9982	−0.18
Q2	57.5310	57.4295	0.9982	−0.18
bjx	57.5310	57.4295	0.9982	−0.18
heta	57.5308	57.4295	0.9982	−0.18
inel	57.5310	57.4295	0.9982	−0.18

its: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Agreement is excellent

Shape ratio is excellent

Spread < 0.01%

DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+04]	0.9982	0.2304	−0.18	31	EXCELLENT
Eh	[0.938, 1.01e+04]	0.9982	0.2119	−0.18	31	EXCELLENT
Q2	[4, 1.88e+04]	0.9985	0.0227	−0.15	73	EXCELLENT
bjx	[1e−09, 1]	0.9982	0.2621	−0.18	50	EXCELLENT
heta	[1e−06, 1.57]	0.9903	0.0825	−0.97	50	EXCELLENT
inel	[0, 1]	0.9982	0.4762	−0.18	50	EXCELLENT

running-scales/100TeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	239.4095	238.6143	0.9967	−0.33
Eh	239.4095	238.6143	0.9967	−0.33
Q2	239.4095	238.6143	0.9967	−0.33
bjx	239.4095	238.6143	0.9967	−0.33
theta	239.4095	238.6143	0.9967	−0.33
inel	239.4095	238.6143	0.9967	−0.33

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

Agreement is excellent

Shape ratio is excellent

Spread < 0.01%

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ)

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+05]	0.9967	0.2306	−0.33	31	EXCELLENT
Eh	[0.938, 1.01e+05]	0.9967	0.2449	−0.33	31	EXCELLENT
Q2	[4, 1.88e+05]	0.9968	0.0349	−0.32	93	EXCELLENT
bjx	[1e−09, 1]	0.9967	0.1716	−0.33	50	EXCELLENT
theta	[1e−06, 1.57]	0.9936	0.0172	−0.64	29	EXCELLENT
inel	[0, 1]	0.9967	0.5486	−0.33	50	EXCELLENT

running-scales/1PeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	636.4451	706.6725	1.1103	+11.03
Eh	636.4451	706.6725	1.1103	+11.03
Q2	636.4451	706.6725	1.1103	+11.03
bjx	636.4451	706.6725	1.1103	+11.03
theta	636.4451	706.6725	1.1103	+11.03
inel	636.4451	706.6725	1.1103	+11.03

Units: pb. A/P = Analytical / POWHEG.

Kinematic cuts:

Qmin 2

Wmin 2

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ)

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+06]	1.1103	0.3026	+11.03	31	CHECK
Eh	[0.938, 1.01e+06]	1.1103	0.3310	+11.03	31	CHECK
Q2	[4, 1.88e+06]	1.1104	0.0561	+11.04	111	CHECK
bjx	[1e-09, 1]	1.1103	0.1218	+11.03	50	CHECK
theta	[1e-06, 1.57]	1.1078	0.0020	+10.78	7	CHECK
inel	[0, 1]	1.1103	0.6315	+11.03	50	CHECK

running-scales/10PeV/LO-nue-p

1. INTEGRATED CROSS-SECTIONS (native full histogram ranges)

Obs	POWHEG σ	Analyt. σ	A/P	Δ (%)
El	1772.3785	1832.1357	1.0337	+3.37
Eh	1772.3785	1832.1357	1.0337	+3.37
Q2	1772.3785	1832.1357	1.0337	+3.37
bjx	1772.3785	1832.1357	1.0337	+3.37
theta	1772.3785	1781.2762	1.0050	+0.50
inel	1772.3785	1832.1357	1.0337	+3.37

Units: pb. A/P = Analytical / POWHEG.

Theta analytical xsec different…

1bin???

Kinematic cuts:

Qmin 2

Wmin 2

2. DISTRIBUTION-LEVEL RATIO (Analytical/POWHEG over full overlap, weighted by POWHEG dσ)

Obs	Overlap window	Mean	Std	Δ(%)	Bins	Verdict
El	[0, 1.01e+07]	1.0337	0.2521	+3.37	31	MODERATE
Eh	[0.938, 1.01e+07]	1.0337	0.3295	+3.37	31	MODERATE
Q2	[4, 1.12e+07]	1.0337	0.0757	+3.37	129	MODERATE
bjx	[1e-09, 1]	1.0337	0.0737	+3.37	50	MODERATE
theta	[1e-06, 1.57]	1.0025	0.0000	+0.25	1	EXCELLENT
inel	[0, 1]	1.0337	0.6273	+3.37	50	MODERATE

What this isn’t

- Mismatched PDFs
- Mismatched parameters (CKM, Gf, EW etc)
- Mismatched cuts
- Scale mismatch
- Integration grid convergence
- Use of YADISM — compared to calculating LO direct from PDF set F_x

Comparison to papers

- Pheno paper (2024):
  - good agreement at 1, 10 TeV
  - Residual diff at large-x small-Q2 regions bc of m_p =/=0
- BRG18:
  - Doesn’t use POWHEG
  - Analytical results for isoscalar CC total xsec:
    - 1 PeV: 628 pb , mine: 660.9 pb (+5.2%)
    - 10 PeV: 1.71e3 pb, mine: 1767.6 pb (+3.4%)