EIC Yellow Report Workshop, Pavia

21 May 2020

TMD grids and tools for predictions

Chiara Bissolotti
University of Pavia and INFN

and

Alessandro Bacchetta, Valerio Bertone, Giuseppe Bozzi,
Filippo Delcarro, Fulvio Piacenza, Marco Radici, Andrea Signori

3DSPIN
MAPPING
THE PROTON IN 3D

erc
European Research Council

INFN
Istituto Nazionale
di Fisica Nucleare

UNIVERSITÀ
DI PAVIA

for qT « Q , cross section and structure functions are convolutions of **TMDs**

$$F_{XY} \propto f_X \otimes d_Y$$

we created

NangaParbat

TMD fitting framework

tools also present in

arTeMiDe

grid production

interpolation

convolution

how to make theoretical predictions available?

Grids for cross section and structure function

two options

grids with infinitesimal steps

sparse grids + interpolation

PRO

simplest solution
(temporary)

CON

huge size of grids
(several GB)

only selected kinematic
only selected process

SIDIS
$\{x, z, Q, p_T\}$

how to include theory errors?

from Alexey Vladimirov's talk

Grids for TMDs and convolution tool

PRO

simple to include theory errors

wide application range
no restrictions on kinematics

small size of grids (10-20 MB)

more freedom

$$F_{XY} \propto f_X(x, \mathbf{k}_1^2, Q) \otimes d_Y(z, \mathbf{k}_2^2, Q)$$

need some standardized code

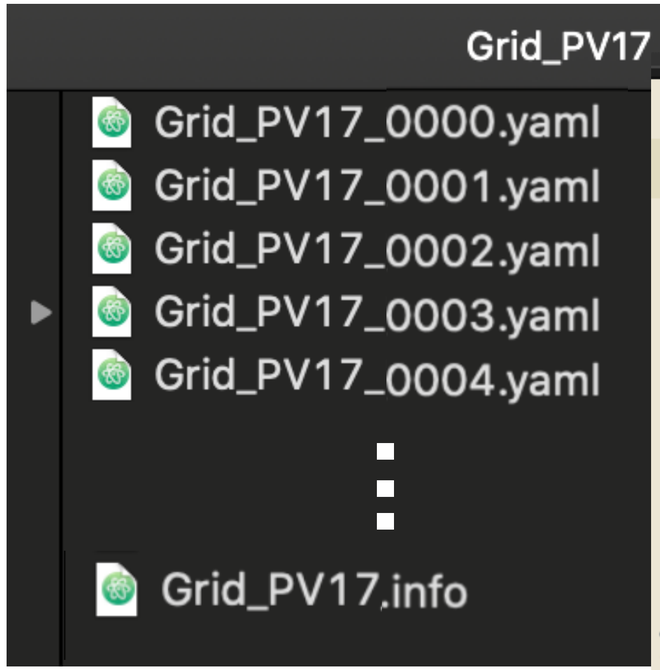
computation slightly longer (still very fast)

CON

from Alexey Vladimirov's talk

TMD grids with NangaParbat

- format in file**.yaml** ⟶ `key: value`
- **LHAPDF** style: info file and replicas



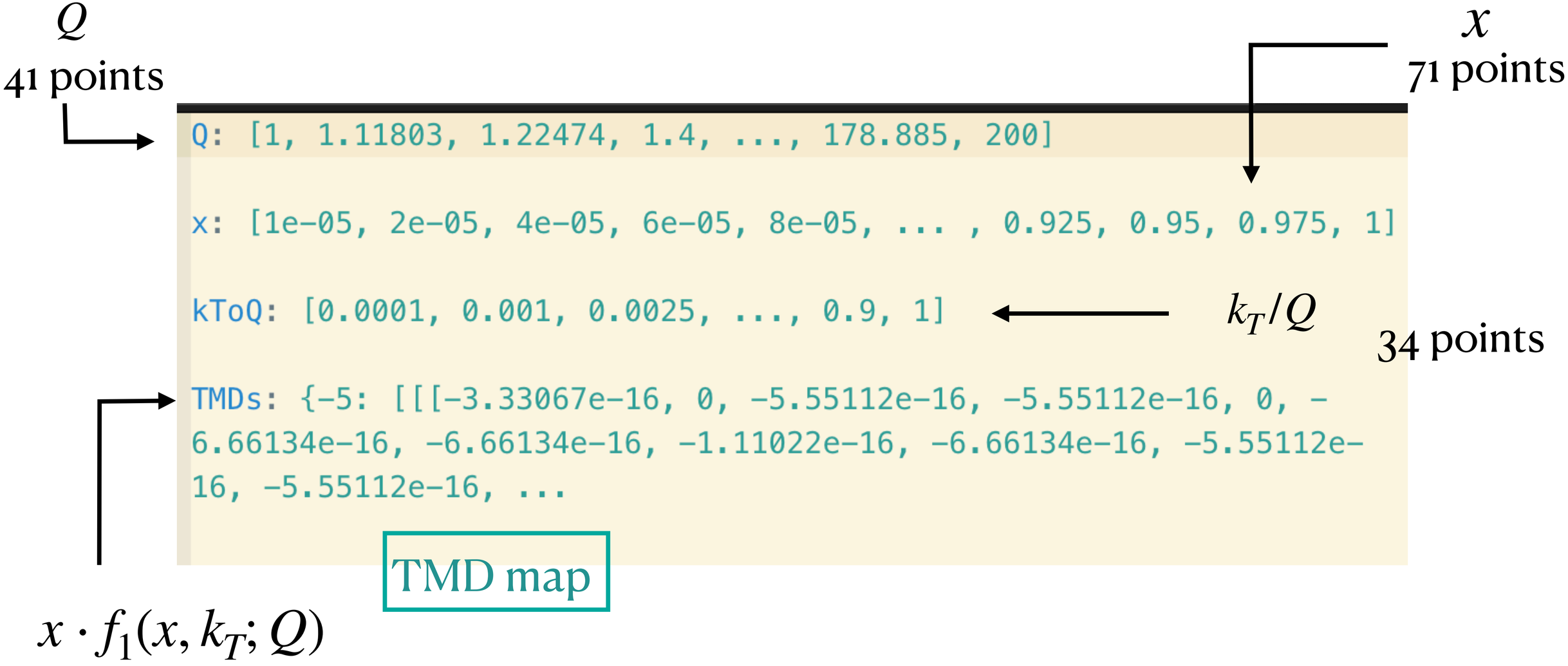

```
1  SetDesc: Set produced with NangaParbat + APFEL++
2  Authors: A. Bacchetta, F. Delcarro, C. Pisano, M. Radici, A. Signori
3  Reference: arXiv:1703.10157
4  SetIndex: 000000
5  TMDType: pdf
6  CollDist: MMHT2014lo68cl
7  CollDistMember: 0
8  Format: TMDlib1
9  DataVersion: 1
10 OrderQCD: NLL
11 Regularisation: bstarmin
12 NumMembers: 1
13 ErrorType: Monte Carlo
```

Bacchetta *et al.*, JHEP **06** (17) 081
arXiv:1703.10157

standard
and
flexible format

NangaParbat TMD grids

grids.yaml for TMD PDFs



NangaParbat grids and interpolator

we can provide

TMD PDF and TMD FF grids

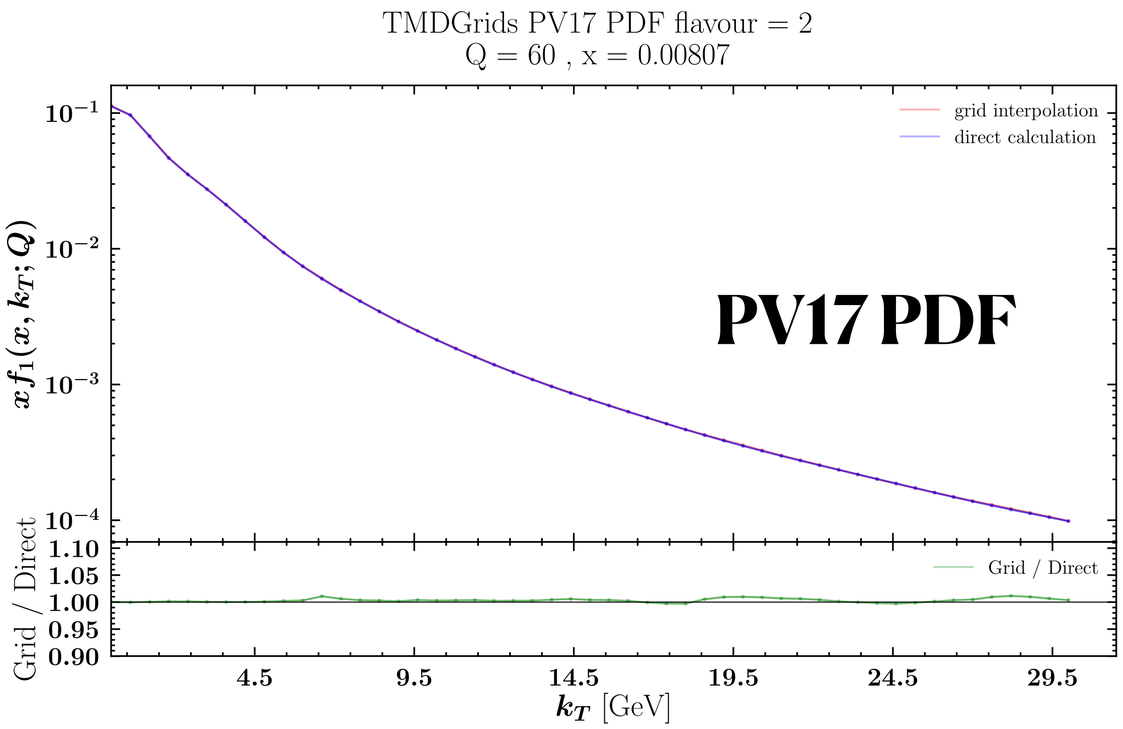
PRO
small size of grids

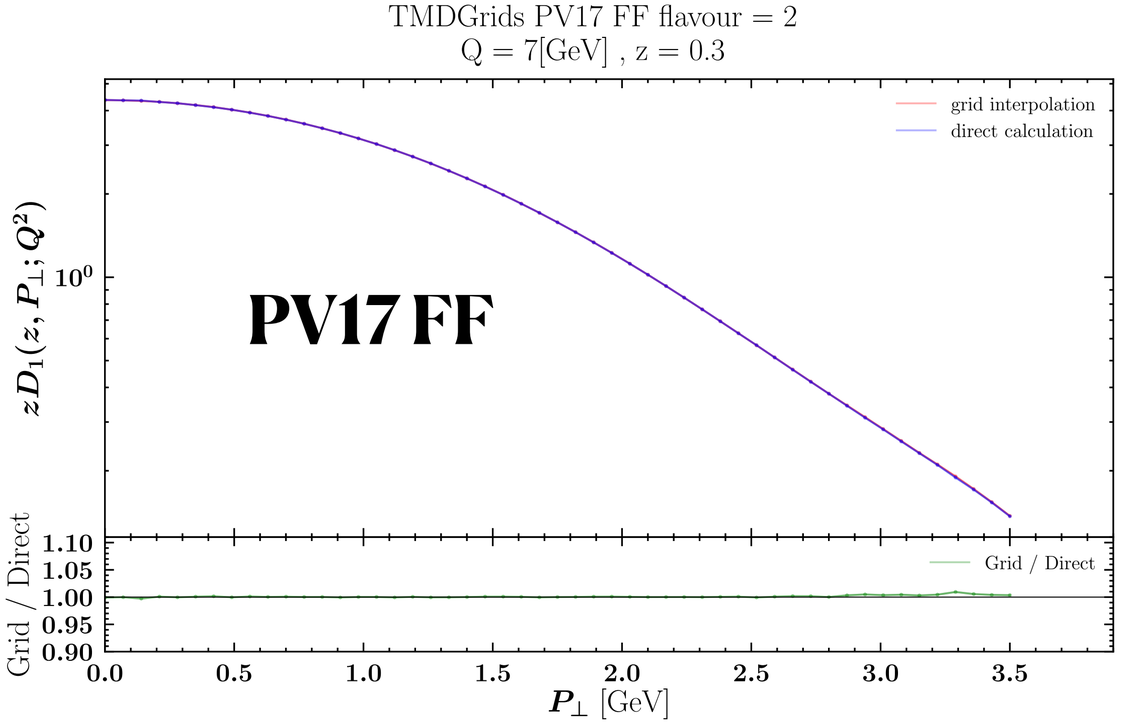
AND

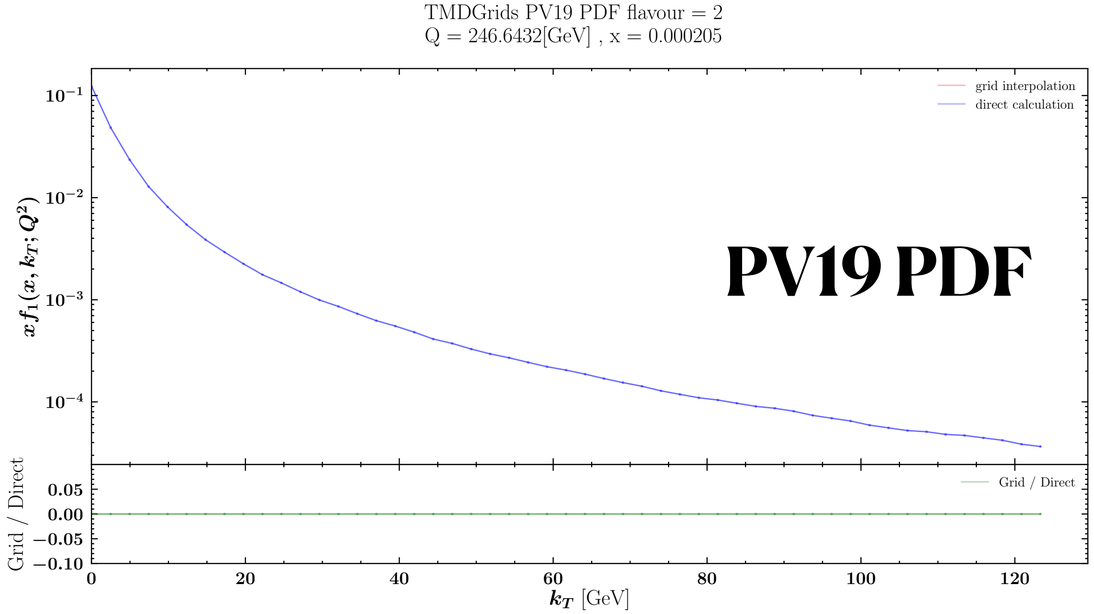
polynomial
interpolator

APFEL++ based

package to
release on **TMDlib**



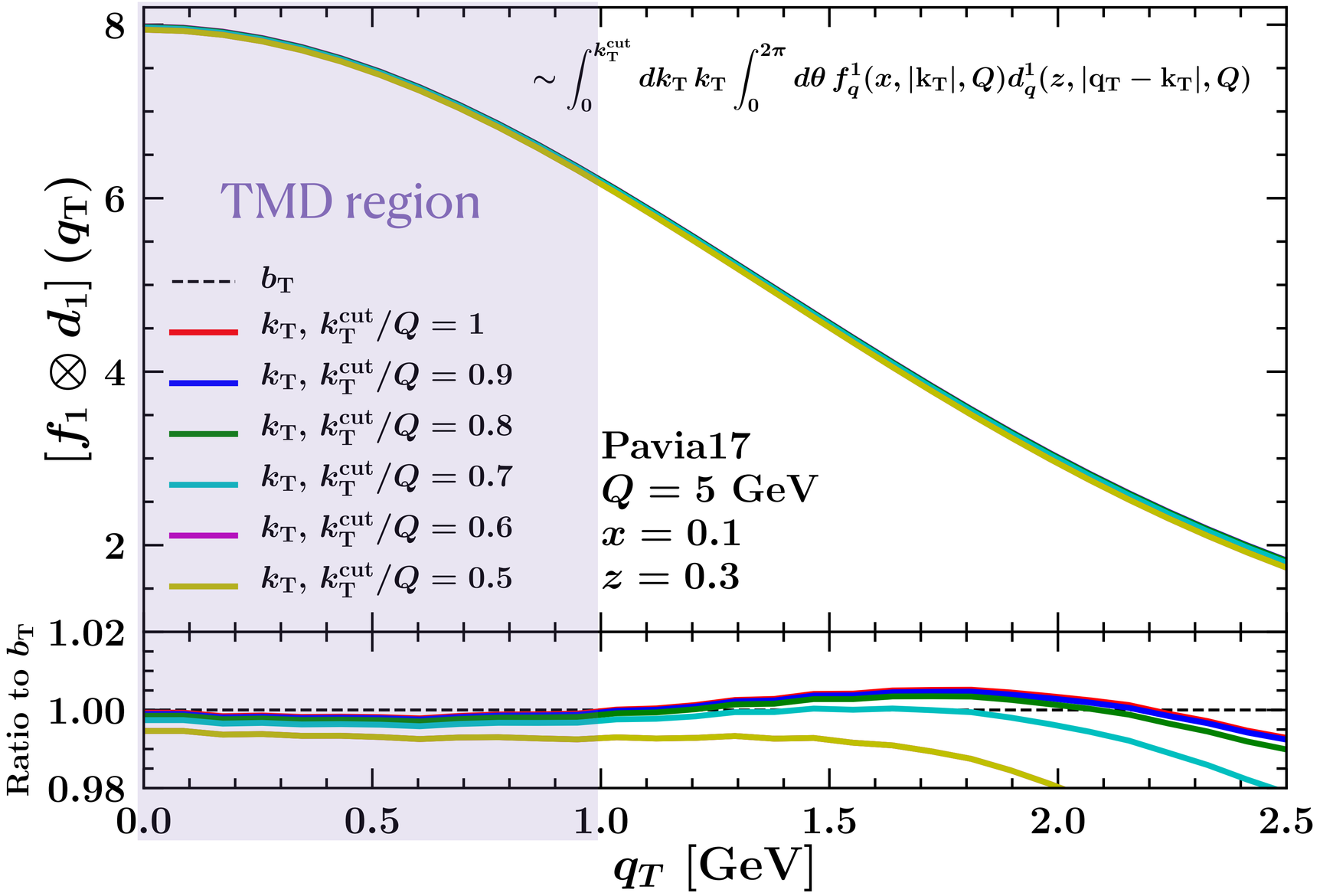




TMD grids

we tested the interpolator
in many kinematical regions

Convolution

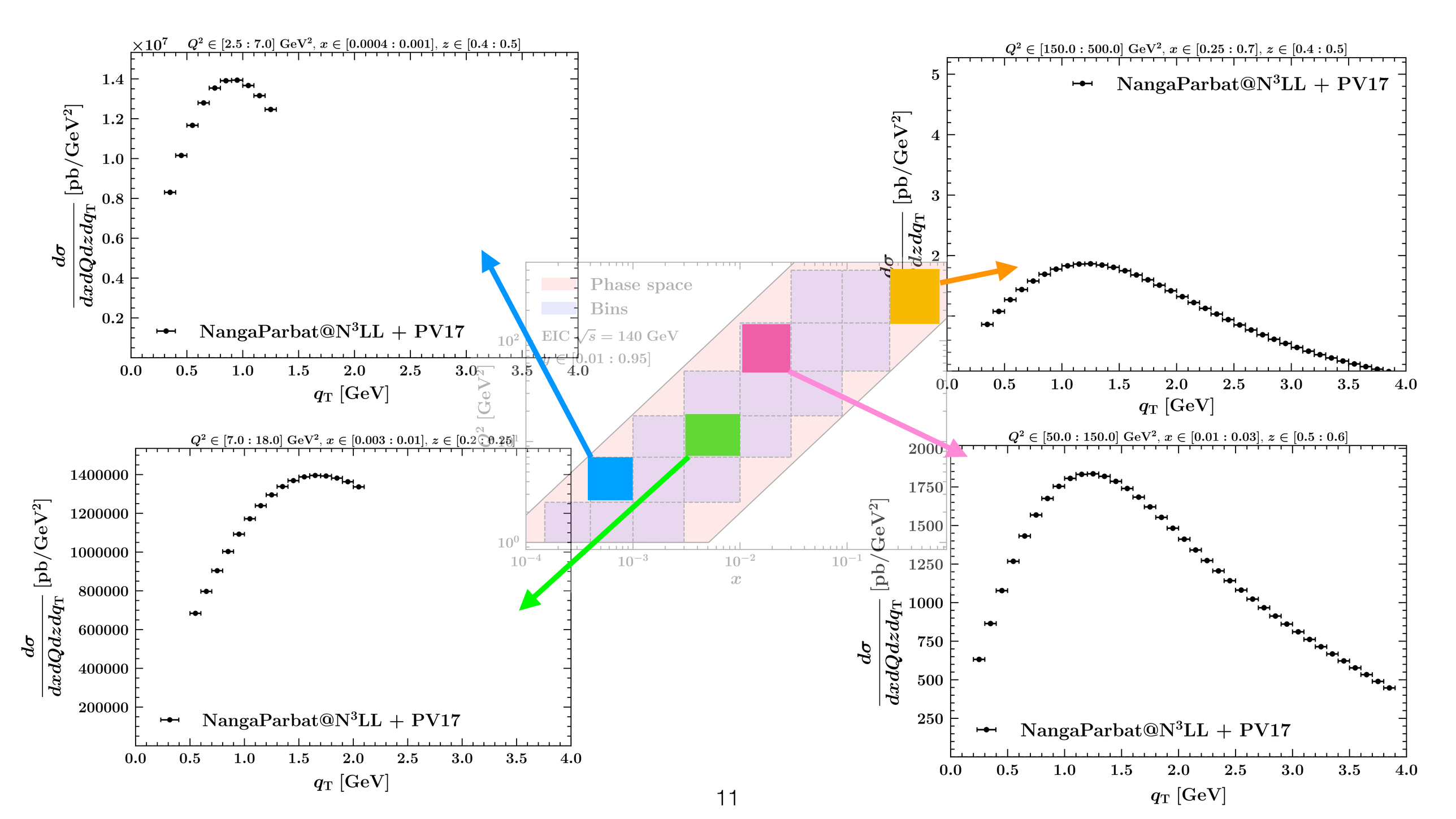


SIDIS observable

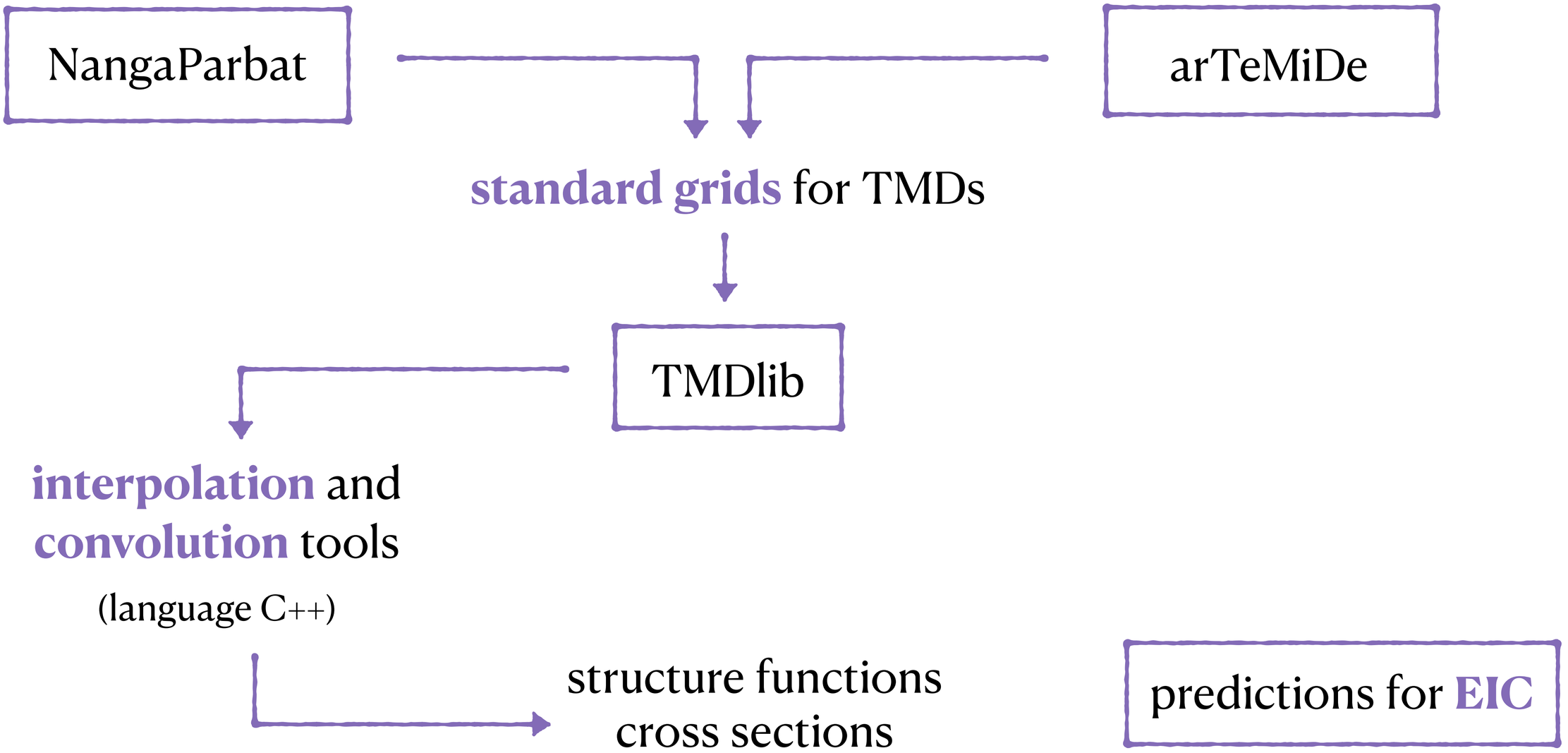
- unpolarized fully differential cross section

$$\frac{d\sigma}{dx\, dQ\, dz\, dq_T} \quad \left[\frac{\text{pb}}{\text{GeV}^2}\right]$$

- NangaParbat framework:
  Bacchetta *et al.*, arXiv:1912.07550
  - resummation at N3LL
  - hard cross section and Wilson coeffs. at NNLO
  - no Y term
  - input TMD PDF and TMD FF from PV17 fit (replica 105) Bacchetta *et al.*, JHEP **06** (17) 081 arXiv:1703.10157

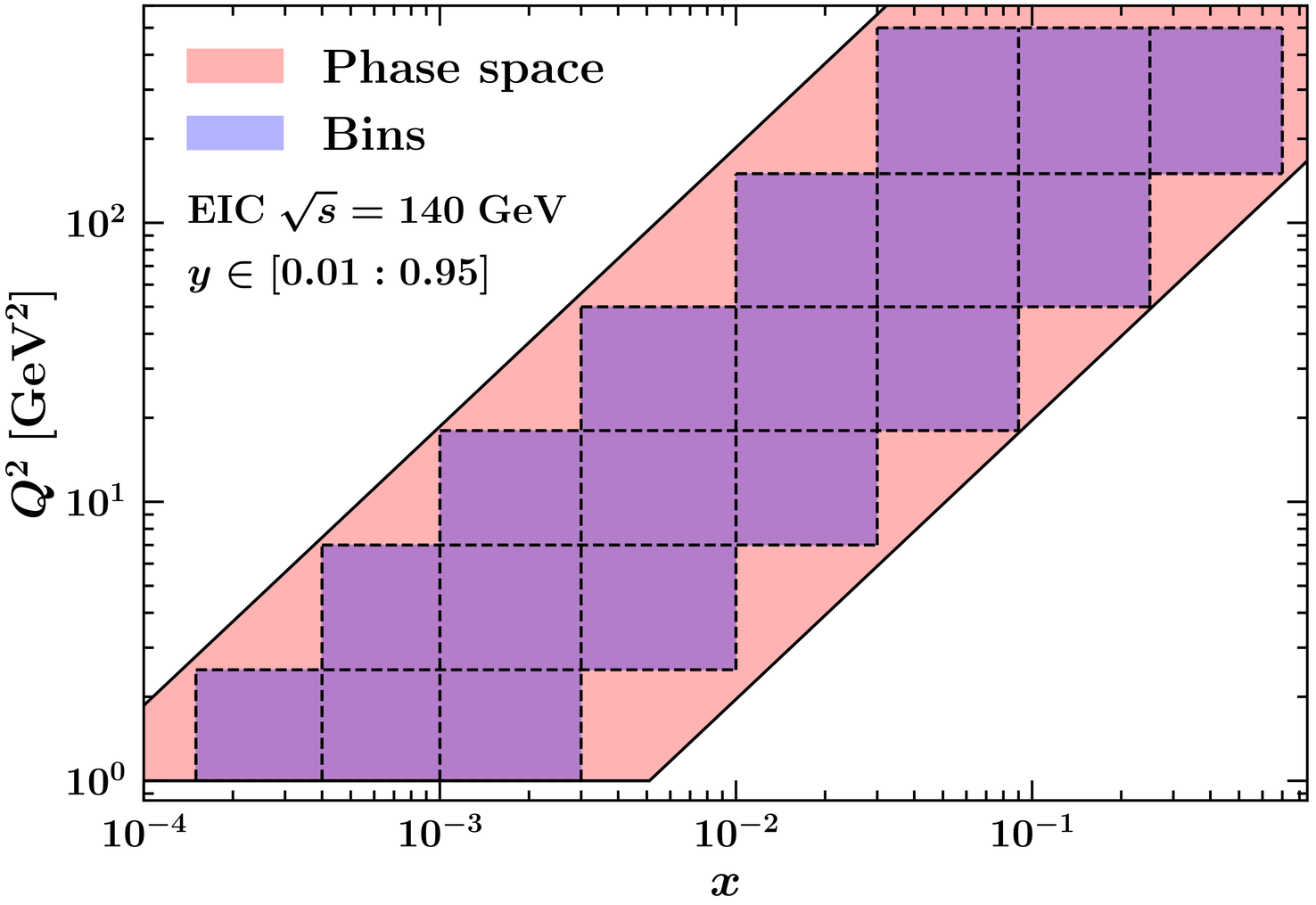

$\times 10^7$ $Q^2 \in [2.5 : 7.0]$ GeV^2, $x \in [0.0004 : 0.001]$, $z \in [0.4 : 0.5]$
$\frac{d\sigma}{dxdQdzdq_T}$ [pb/GeV^2]
NangaParbat@N^{3}LL + PV17
q_T [GeV]
$Q^2 \in [150.0 : 500.0]$ GeV^2, $x \in [0.25 : 0.7]$, $z \in [0.4 : 0.5]$
$\frac{d\sigma}{dzdq_T}$ [pb/GeV^2]
NangaParbat@N^{3}LL + PV17
q_T [GeV]
Phase space
Bins
EIC $\sqrt{s} = 140$ GeV
$y \in [0.01 : 0.95]$
Q^2 [GeV^2]
x
$Q^2 \in [7.0 : 18.0]$ GeV^2, $x \in [0.003 : 0.01]$, $z \in [0.2 : 0.25]$
$\frac{d\sigma}{dxdQdzdq_T}$ [pb/GeV^2]
NangaParbat@N^{3}LL + PV17
q_T [GeV]
$Q^2 \in [50.0 : 150.0]$ GeV^2, $x \in [0.01 : 0.03]$, $z \in [0.5 : 0.6]$
$\frac{d\sigma}{dxdQdzdq_T}$ [pb/GeV^2]
NangaParbat@N^{3}LL + PV17
q_T [GeV]

Conclusions



Backup

binning in (x, Q^2)



Bins have same size to allow recursive integration.

It can be changed on demand..

Arbitrary cuts:

- $x \leq 0.7$
- $Q^2 \leq 500$ GeV^2