PARTONS and GPD phenomenology

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Outline

- Introduction
- Experimental campaign
- Recent progress
- Numerical tools
- Summary

Introduction

Nucleon is not a point-like particle, it is made out of partons:

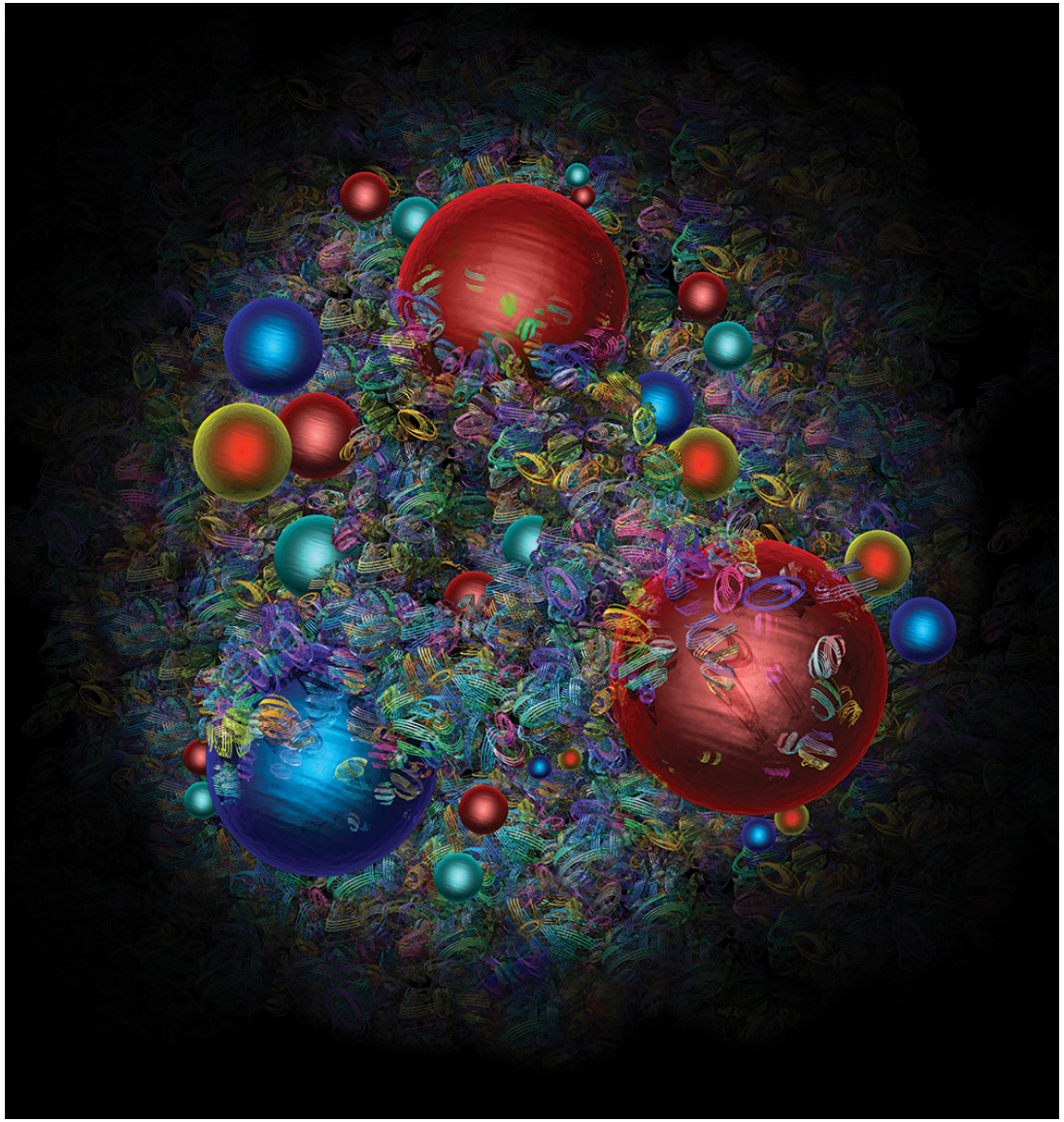
- valence quarks
- sea quarks
- gluons

How can we recover basic properties of nucleon from those of its constituents?

- charge
- spin
- mass

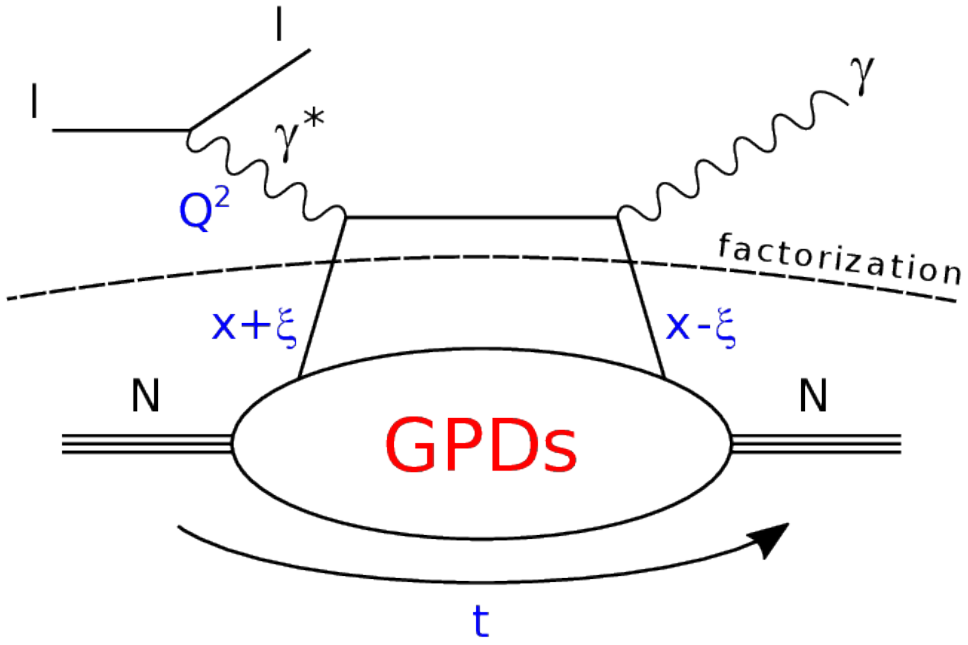
How partons are distributed inside nucleon?

- momentum (longitudinal and transverse)
- position
- polarisation
- mechanical properties



from CERN Courier / D. Dominguez

Deeply Virtual Compton Scattering (DVCS)



factorization for $|t|/Q^2 \ll 1$

Chiral-even GPDs:
(helicity of parton conserved)

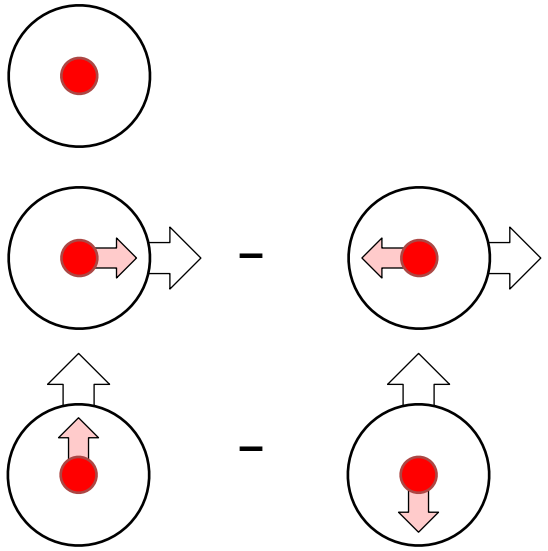
$H^{q,g}(x,\xi,t)$	$E^{q,g}(x,\xi,t)$	*for sum over parton helicities*
$\widetilde{H}^{q,g}(x,\xi,t)$	$\widetilde{E}^{q,g}(x,\xi,t)$	*for difference over parton helicities*
nucleon helicity conserved	*nucleon helicity changed*	

- Reduction to PDFs:

$$H^q(x,0,0) \equiv q(x)$$

$$\widetilde{H}^q(x,0,0) \equiv \Delta q(x)$$

$$H_T^q(x,0,0) \equiv h_1(x)$$



no corresponding relations exist for other GPDs

- Reduction to Elastic Form Factors (EFFs):

$$\int_{-1}^{1} dx\, H^q(x,\xi,t) \equiv F_1^q(t) \qquad \int_{-1}^{1} dx\, E^q(x,\xi,t) \equiv F_2^q(t)$$

$$\int_{-1}^{1} dx\, \widetilde{H}^q(x,\xi,t) \equiv g_A^q(t) \qquad \int_{-1}^{1} dx\, \widetilde{E}^q(x,\xi,t) \equiv g_P^q(t)$$

Polynomiality - non-trivial consequence of Lorentz invariance:

$$\int_{-1}^{1} \mathrm{d}x\ x^n H^q(x,\xi,t) = h_0^{q,n}(t) + \xi^2 h_2^{q,n}(t) + \ldots + \mathrm{mod}(n,2)\xi^{n+1} h_{n+1}^{q,n}(t)$$

$$\int_{-1}^{1} \mathrm{d}x\ x^n \widetilde{H}^q(x,\xi,t) = \tilde{h}_0^{q,n}(t) + \xi^2 \tilde{h}_2^{q,n}(t) + \ldots + \mathrm{mod}(n+1,2)\xi^{n} \tilde{h}_n^{q,n}(t)$$

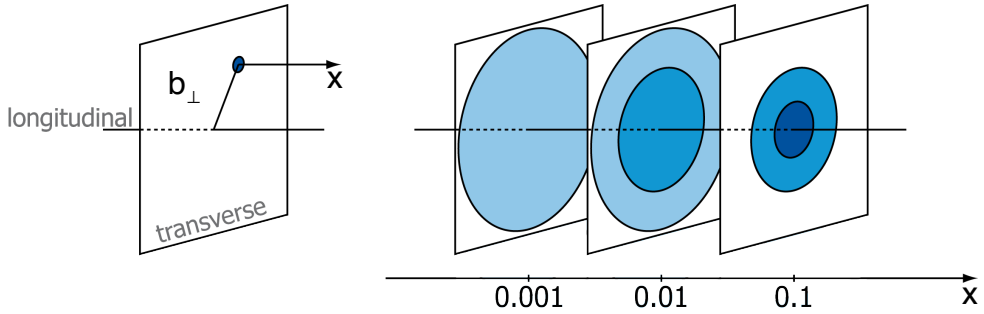
Positivity bounds - positivity of norm in Hilbert space, e.g.:

$$(1-\xi^2)\left(H^q - \frac{\xi^2}{1-\xi^2}E^q\right)^2 + \frac{t_0 - t}{4m^2}\left(E^q\right)^2 \leq q\left(\frac{x+\xi}{1+\xi}\right) q\left(\frac{x-\xi}{1-\xi}\right)$$

strong constraint on GPD parameterizations!

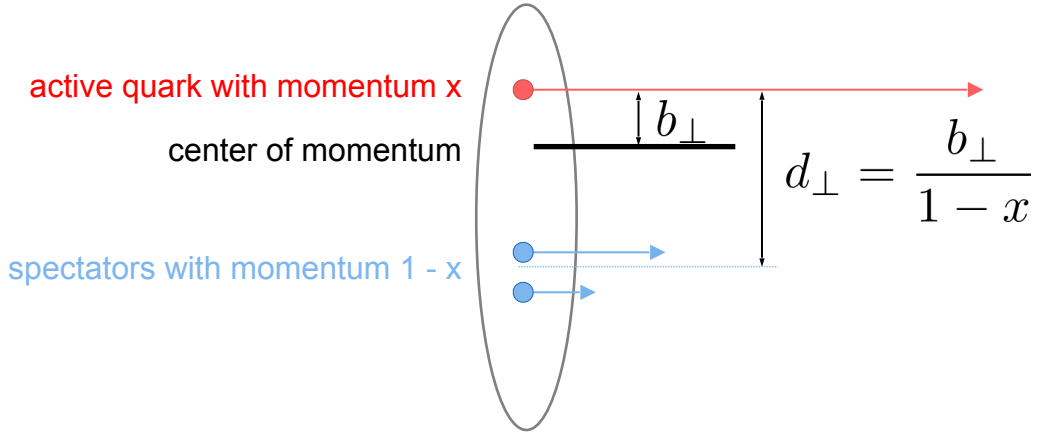
Nucleon tomography

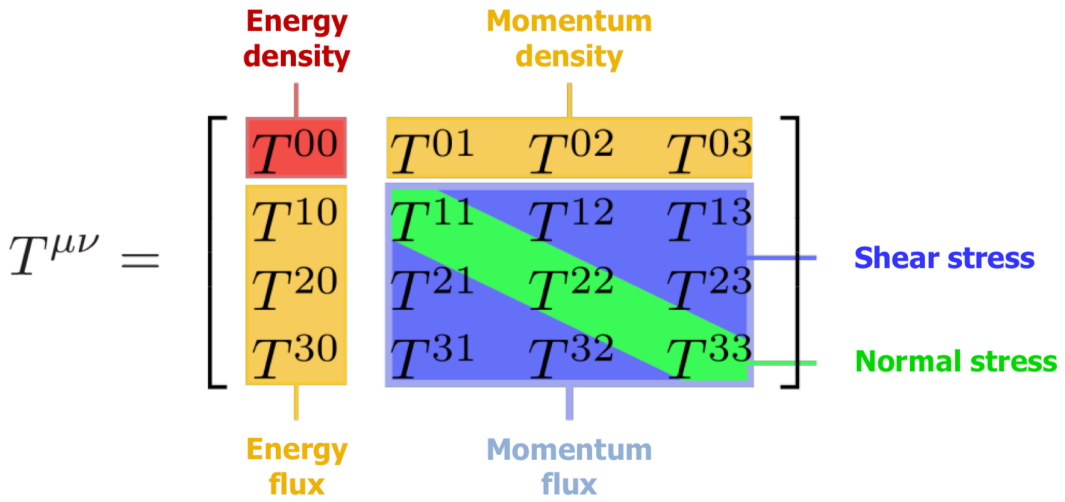
$$q(x, \mathbf{b}_\perp) = \int \frac{\mathrm{d}^2\boldsymbol{\Delta}}{4\pi^2} e^{-i\mathbf{b}_\perp \cdot \boldsymbol{\Delta}} H^q(x, 0, t = -\boldsymbol{\Delta}^2)$$



Study of long. polarization with GPD $\tilde{H}$
Study of distortion in transv. polarized nucleon with GPD E

Impact parameter $\mathbf{b}_\perp$ defined w.r.t. center of momentum, such as $\sum x\, \mathbf{b}_\perp = 0$





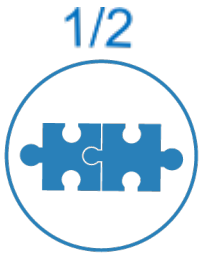
Energy momentum tensor in terms of form factors:

$$\langle p', s'|\widehat{T}^{\mu\nu}|p, s\rangle = \bar{u}(p', s')\left[\frac{P^\mu P^\nu}{M}A(t) + \frac{\Delta^\mu\Delta^\nu - \eta^{\mu\nu}\Delta^2}{M}C(t) + M\eta^{\mu\nu}\bar{C}(t) + \right.$$
$$\left.\frac{P^\mu i\sigma^{\nu\lambda}\Delta_\lambda}{4M}[A(t) + B(t) + D(t)] + \frac{P^\nu i\sigma^{\mu\lambda}\Delta_\lambda}{4M}[A(t) + B(t) - D(t)]\right]u(p, s)$$

Total angular momentum

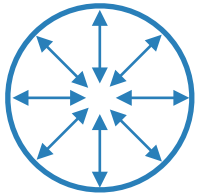
$$A^q(0) + B^q(0) = \int_{-1}^{1} x\,[H^q(x,\xi,0) + E^q(x,\xi,0)] = 2J^q$$

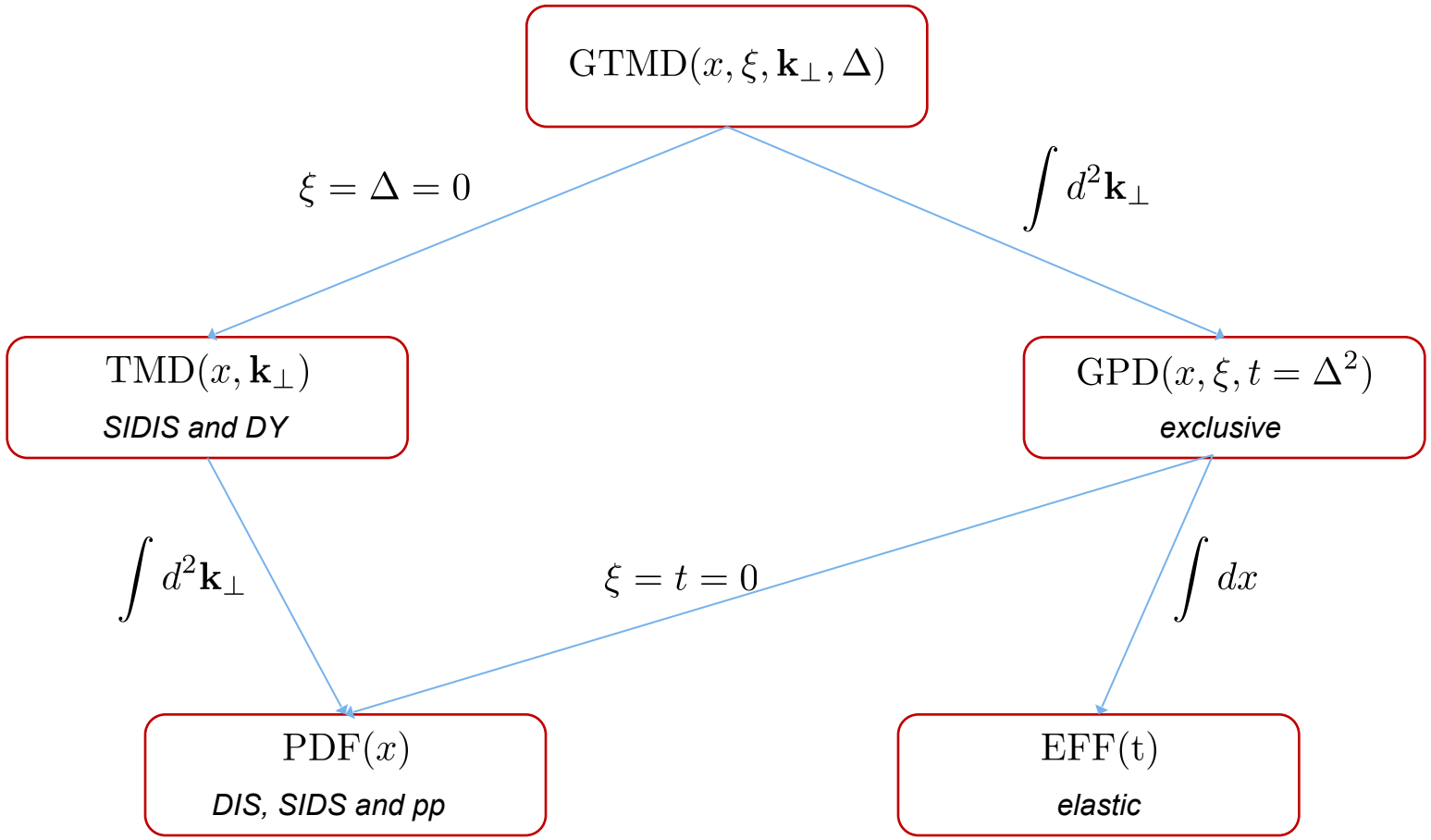
Ji's sum rule



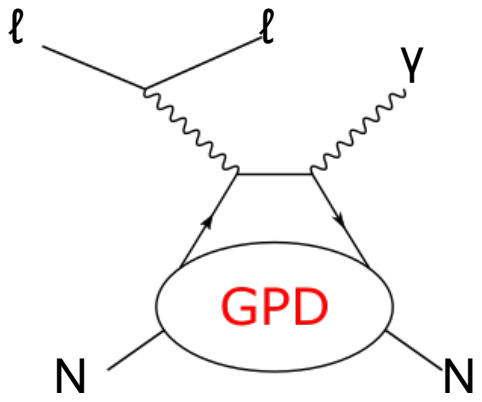
"Mechanical" forces acting on quarks, e.g. pressure in nucleon center

$$p(0) = \frac{1}{6\pi^2 M} \int_{-\infty}^{0} dt \sqrt{-t}\, t C(t)$$

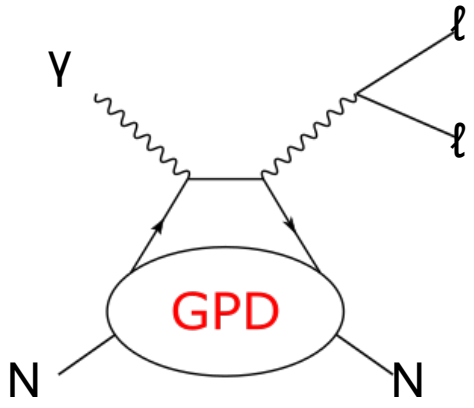



$\mathrm{GTMD}(x, \xi, \mathbf{k}_\perp, \Delta)$
$\xi = \Delta = 0$
$\int d^2\mathbf{k}_\perp$
$\mathrm{TMD}(x, \mathbf{k}_\perp)$
SIDIS and DY
$\mathrm{GPD}(x, \xi, t = \Delta^2)$
exclusive
$\int d^2\mathbf{k}_\perp$
$\xi = t = 0$
$\int dx$
$\mathrm{PDF}(x)$
DIS, SIDS and pp
$\mathrm{EFF(t)}$
elastic

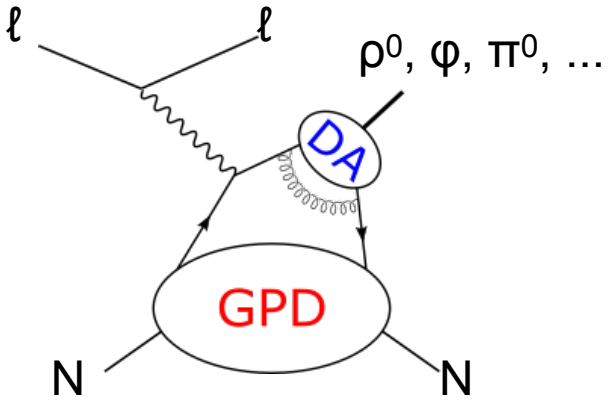
GPDs accessible in various production channels and observables
→ experimental filters



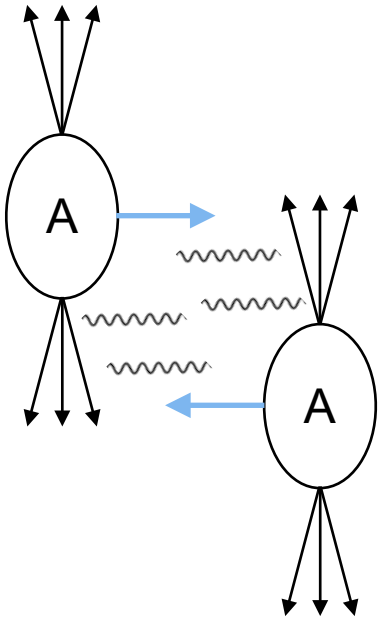
DVCS
Deeply Virtual Compton Scattering



TCS
Timelike Compton Scattering



HEMP
Hard Exclusive Meson Production



UPC
Ultra Peripheral Collisions

more production channels sensitive to GPDs exist!

Experimental campaign

GPDs studied in various laboratories
→ need to cover a broad kinematic range

experiments

closed **active** **planned**

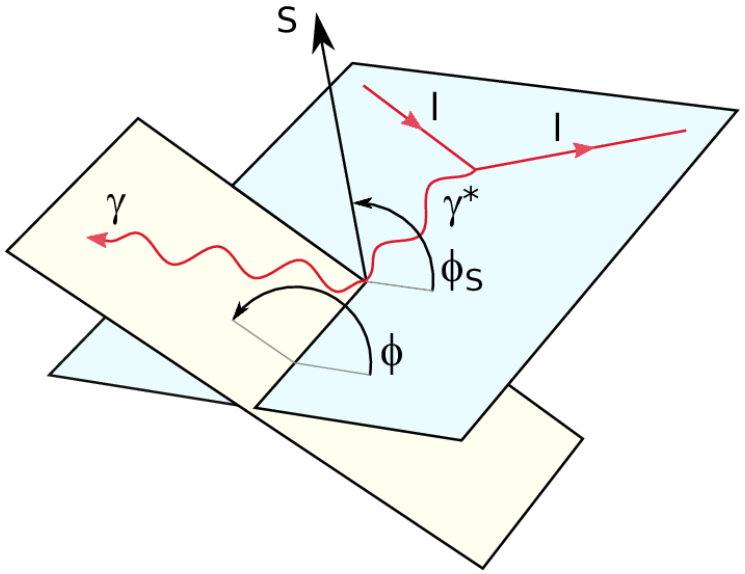
DVCS data

Kinematic cuts
used in presented analyses:

$$Q^2 > 1.5 \text{ GeV}^2$$

$$-t/Q^2 < 0.2$$

Angles:



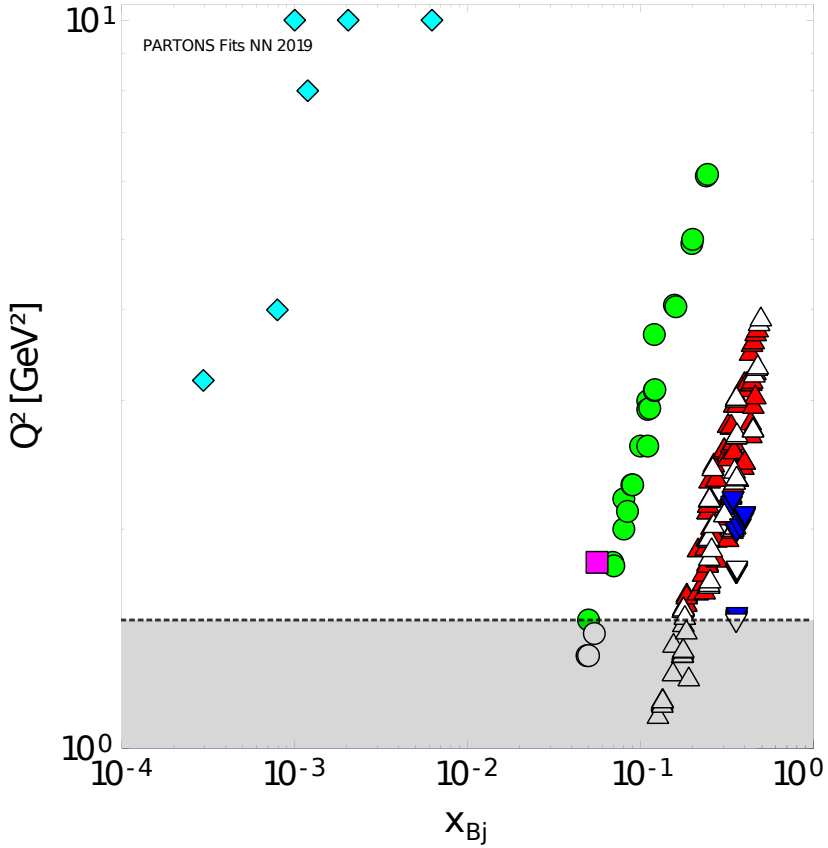
No.	Collab.	Year	Observable		Kinematic dependence	No. of points used / all
1	HERMES	2001	A_{LU}^{+}		ϕ	10 / 10
2		2006	$A_{C}^{\cos i\phi}$	$i=1$	t	4 / 4
3		2008	$A_{C}^{\cos i\phi}$	$i=0,1$	x_{Bj}	18 / 24
			$A_{UT,\mathrm{DVCS}}^{\sin(\phi-\phi_S)\cos i\phi}$	$i=0$		
			$A_{UT,\mathrm{I}}^{\sin(\phi-\phi_S)\cos i\phi}$	$i=0,1$		
			$A_{UT,\mathrm{I}}^{\cos(\phi-\phi_S)\sin i\phi}$	$i=1$		
4		2009	$A_{LU,\mathrm{I}}^{\sin i\phi}$	$i=1,2$	x_{Bj}	35 / 42
			$A_{LU,\mathrm{DVCS}}^{\sin i\phi}$	$i=1$		
			$A_{C}^{\cos i\phi}$	$i=0,1,2,3$		
5		2010	$A_{UL}^{+,\sin i\phi}$	$i=1,2,3$	x_{Bj}	18 / 24
			$A_{LL}^{+,\cos i\phi}$	$i=0,1,2$		
6		2011	$A_{LT,\mathrm{DVCS}}^{\cos(\phi-\phi_S)\cos i\phi}$	$i=0,1$	x_{Bj}	24 / 32
			$A_{LT,\mathrm{DVCS}}^{\sin(\phi-\phi_S)\sin i\phi}$	$i=1$		
			$A_{LT,\mathrm{I}}^{\cos(\phi-\phi_S)\cos i\phi}$	$i=0,1,2$		
			$A_{LT,\mathrm{I}}^{\sin(\phi-\phi_S)\sin i\phi}$	$i=1,2$		
7		2012	$A_{LU,\mathrm{I}}^{\sin i\phi}$	$i=1,2$	x_{Bj}	35 / 42
			$A_{LU,\mathrm{DVCS}}^{\sin i\phi}$	$i=1$		
			$A_{C}^{\cos i\phi}$	$i=0,1,2,3$		
8	CLAS	2001	$A_{LU}^{-,\sin i\phi}$	$i=1,2$	—	0 / 2
9		2006	$A_{UL}^{-,\sin i\phi}$	$i=1,2$	—	2 / 2
10		2008	A_{LU}^{-}		ϕ	283 / 737
11		2009	A_{LU}^{-}		ϕ	22 / 33
12		2015	A_{LU}^{-}, A_{UL}^{-}, A_{LL}^{-}		ϕ	311 / 497
13		2015	$d^4\sigma_{UU}^{-}$		ϕ	1333 / 1933
14	Hall A	2015	$\Delta d^4\sigma_{LU}^{-}$		ϕ	228 / 228
15		2017	$\Delta d^4\sigma_{LU}^{-}$		ϕ	276 / 358
16	COMPASS	2018	$d^3\sigma_{UU}^{\pm}$		t	2 / 4
17	ZEUS	2009	$d^3\sigma_{UU}^{+}$		t	4 / 4
18	H1	2005	$d^3\sigma_{UU}^{+}$		t	7 / 8
19		2009	$d^3\sigma_{UU}^{\pm}$		t	12 / 12
					SUM:	2624 / 3996

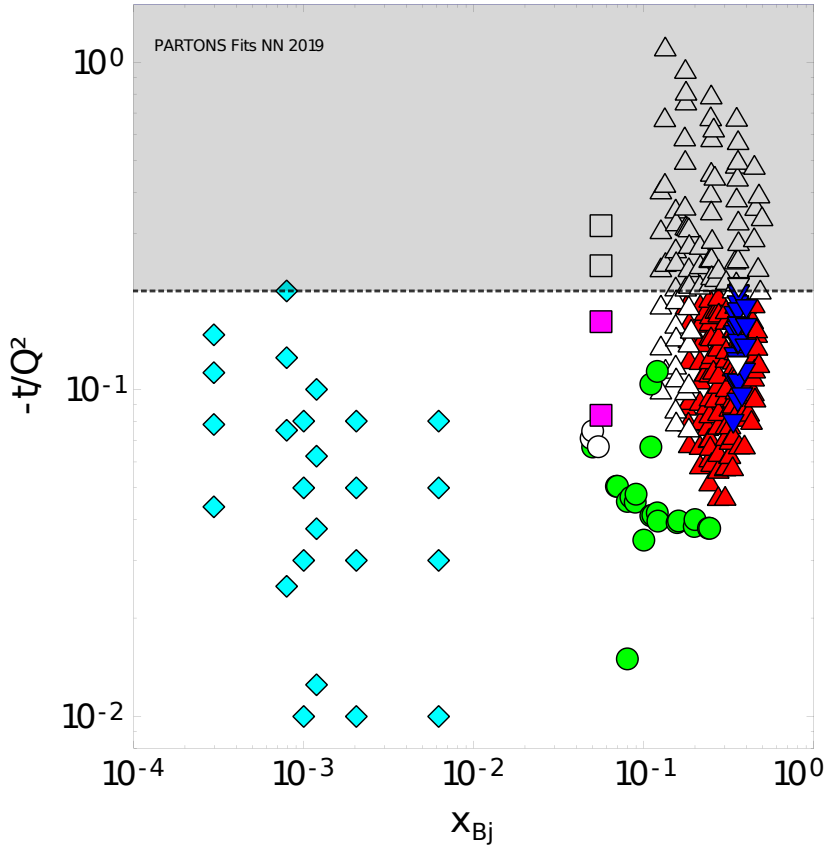
Kinematic cuts
used in our recent analyses:

$$Q^2 > 1.5\ \mathrm{GeV}^2$$

$$-t/Q^2 < 0.2$$

- HALL A
- CLAS
- HERMES
- COMPASS
- H1 and ZEUS

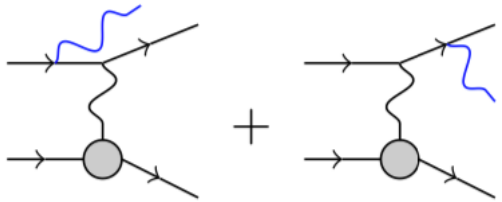




Cross-section for single photon production ($l + N \rightarrow l + N + \gamma$) :

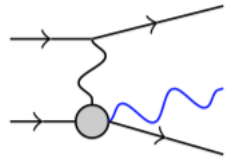
$$\sigma \propto |\mathcal{A}|^2 = |\mathcal{A}_{BH} + \mathcal{A}_{DVCS}|^2 = |\mathcal{A}_{BH}|^2 + |\mathcal{A}_{DVCS}|^2 + \mathcal{I}$$

Bethe-Heitler process



calculable within QED

DVCS



parametrised by CFFs

CFF - the most basic GPD-sensitive observables
- analogy with connection between structure functions and PDFs

DVCS Compton Form Factors

- imaginary part

$$Im\mathcal{G}(\xi,t) \quad = \pi G^{(+)}(\xi,\xi,t) = \pi \sum_q e_q^2 G^{q(+)}(\xi,\xi,t)$$

$$G^{q(+)}(x,\xi,t) = G^q(x,\xi,t) \mp G^q(-x,\xi,t)$$
$$G^{q(+)}(\xi,\xi,t) = G^{q_{\rm val}}(\xi,\xi,t) + 2G^{q_{\rm sea}}(\xi,\xi,t)$$

"−" for $G \in \{H, E\}$
"+" for $G \in \{\widetilde{H}, \widetilde{E}\}$

- real part

$$Re\mathcal{G}(\xi,t) = \mathrm{P.V.} \int_0^1 G^{(+)}(x,\xi,t) \left(\frac{1}{\xi - x} \mp \frac{1}{\xi + x} \right) \mathrm{d}x$$

$$Re\mathcal{G}(\xi,t) = \mathrm{P.V.} \int_0^1 G^{(+)}(x,x,t) \left(\frac{1}{\xi - x} \mp \frac{1}{\xi + x} \right) \mathrm{d}x + C_G(t)$$

$$C_H(t) = -C_E(t) \qquad C_{\widetilde{H}}(t) = C_{\widetilde{E}}(t) = 0$$

connected to EMT FF

Relation between subtraction constant and D-term:

$$C_G^q(t) = 2\int_{-1}^{1} \frac{D^q(z,t)}{1-z}\mathrm{d}z \equiv 4D^q(t)$$

where

$$z = \frac{x}{\xi}$$

Decomposition into Gegenbauer polynomials:

$$D^q(z,t) = (1-z^2)\sum_{i=0}^{\infty} d_i^q(t) C_{2i+1}^{3/2}(z)$$

Connection to EMT FF:

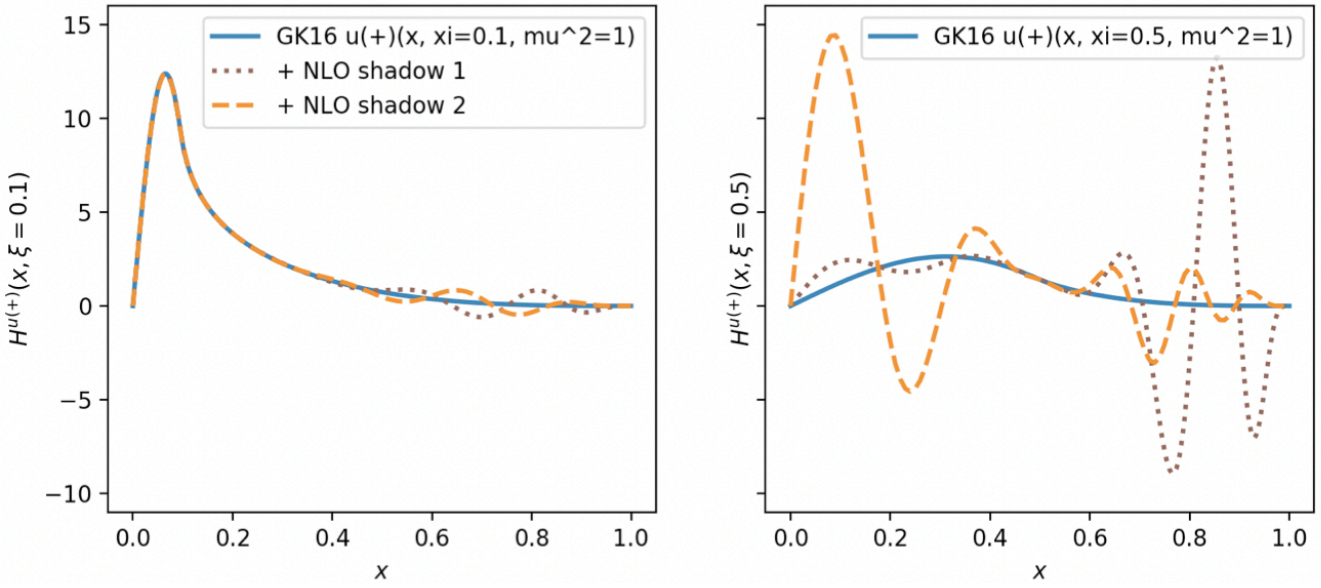
$$D^q(t) = \sum_{\substack{i=1 \\ \mathrm{odd}}}^{\infty} d_i^q(t) \qquad d_1^q(t) = 5C^q(t)$$

Deconvolution problem

V. Bertone et al.,
hep-ph/2104.03836

Shadow GPDs:

- gives null CFF and vanishes at x = 0
- gives negligible contribution due to evolution ($\mathcal{O}(\alpha_s^2(Q^2))$)



GK16

GK16 + NLO shadow GPD (i)

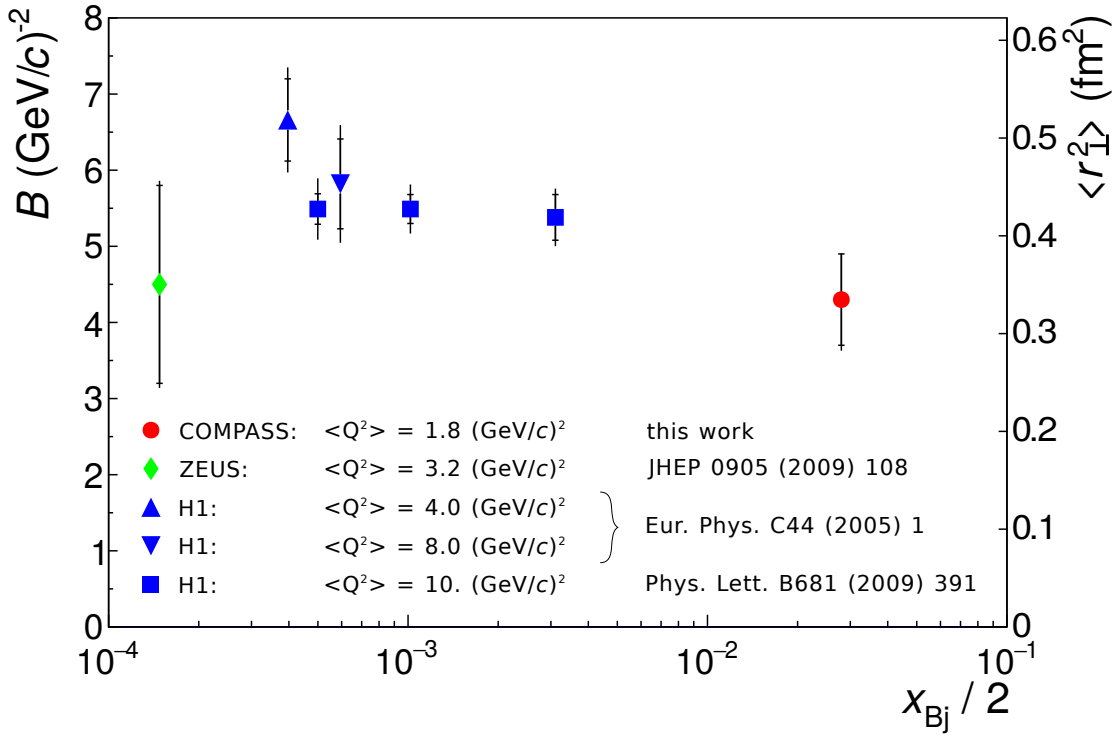
GK16 + NLO shadow GPD (ii)

All those GPDs will give approx. the same values of observables, no matter at which scale

We need processes like Double-DVCS to access GPDs outside x=xi line

- “Direct” measurement at low-x

COMPASS Collaboration, Phys. Lett. B793 (2019) 188



Slope of t-dependance:

$$\frac{d\sigma^{\gamma^* p \to \gamma p}}{dt} \propto e^{-Bt}$$

related to transverse extension of quarks:

$$\langle r_\perp^2(x_{\mathrm{Bj}}) \rangle \approx 2 \langle B(x_{\mathrm{Bj}}) \rangle$$

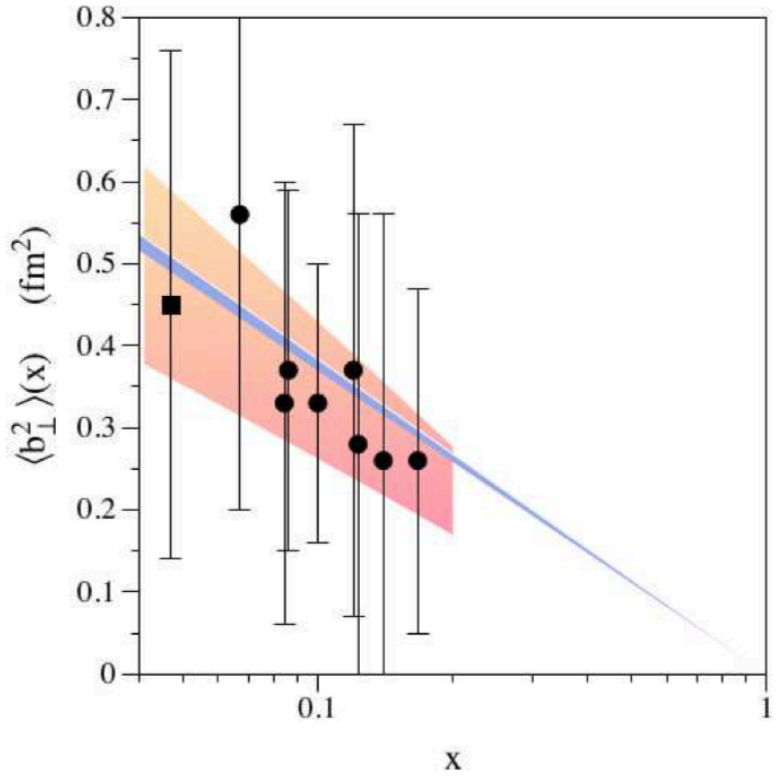
under following assumptions:

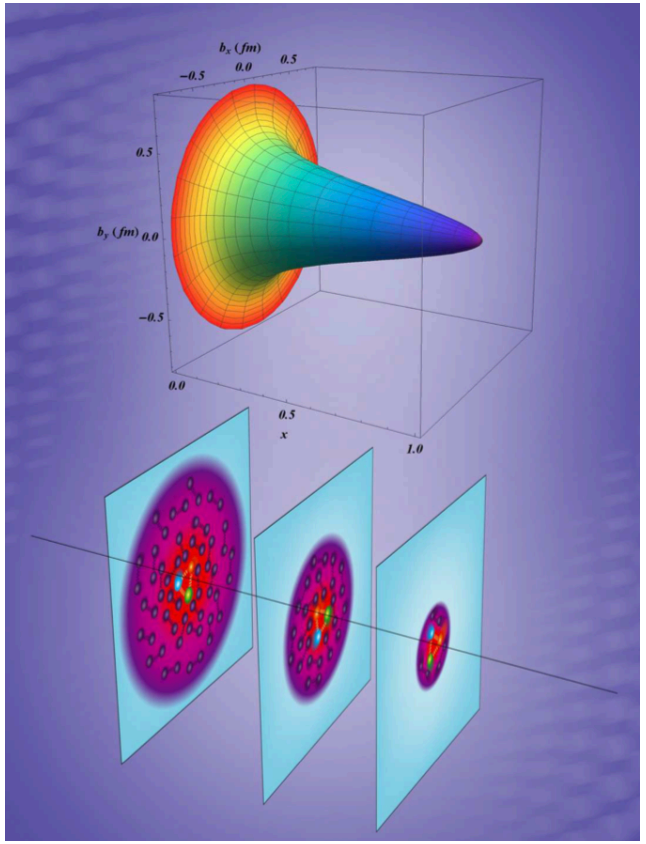
- single-exponential dependence
- dominance of CFF Im$\mathcal{H}$
- negligible “skewness effect” H(x, x, t) ~ H(x, 0, t)

which are applicable at low-x

- Local fits and de-skewness procedure at high-x

Dupre, Guidal, Vanderhaeghen, Phys. Rev. D95 (2017) no. 1, 011501
Dupré, Guidal, Niccolai, Vanderhaeghen, Eur. Phys. J. A53 (2017) no. 8, 171





The procedure:

1. Fit CFFs separately in each (x_B, t, Q^2) bin of data

2. Fit extracted ImH values with

$$Im\mathcal{H}(\xi, t, Q^2) = A(\xi)\ \exp(B(\xi)t)$$

$$A(\xi) = a_A \frac{1-\xi}{\xi}$$

$$B(\xi) = a_B \ln(1/\xi)$$

$$\xi \approx \frac{x_B}{2 - x_B}$$

Ansatz

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 78 (2018), 890

$$G^q(x,0,t) = \mathrm{pdf}_G^q(x)\ \exp(f_G^q(x)t) \qquad f_G^q(x) = A_G^q \log(1/x) + B_G^q(1-x)^2 + C_G^q(1-x)x$$

- reduction to PDFs and correspondence to EFFs
- modify "classical" log(1/x) term by $B_G^q(1\text{-}x)^2$ in low-x and by $C_G^q(1\text{-}x)x$ in high-x regions
- polynomials found in analysis of EFF data → good description of data
- allow to use the analytic regularisation prescription
- finite proton size at x → 1

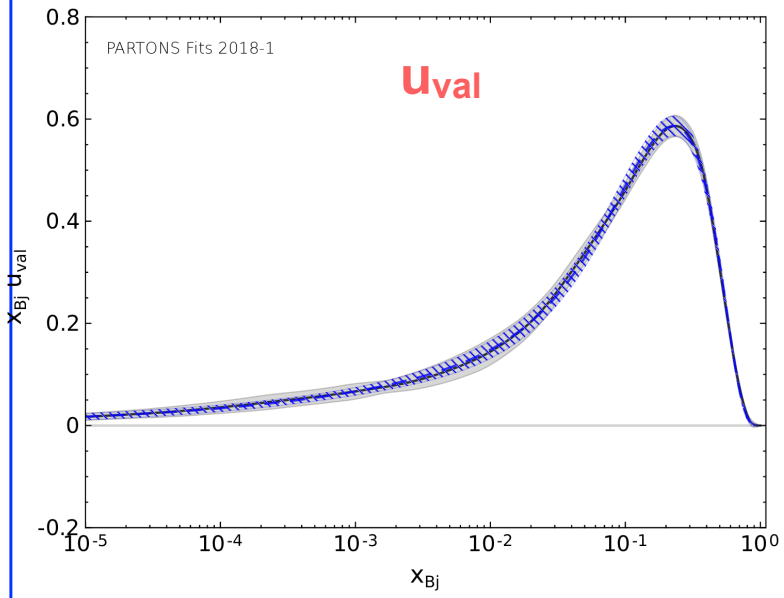
$$G^q(x,x,t) = G^q(x,0,t)\ g_G^q(x,x,t) \qquad g_G^q(x,x,t) = \frac{a_G^q}{(1-x^2)^2}\,(1 + t(1-x)(b_G^q + c_G^q \log(1+x)))$$

- at x → 0 constant skewness effect
- at x → 1 reproduce power behaviour predicted for GPDs in Phys. Rev. D69, 051501 (2004)
- t-dependence similar to DD-models with (1-x) to avoid any t-dep. at x = 1

$$C_G^q(t) = 2\int_{(0)}^{1} \left(G^{q(+)}(x,x,t) - G^{q(+)}(x,0,t)\right)\frac{1}{x}dx$$

- subtraction constant as analytic continuation of Mellin moments to *j* = -1

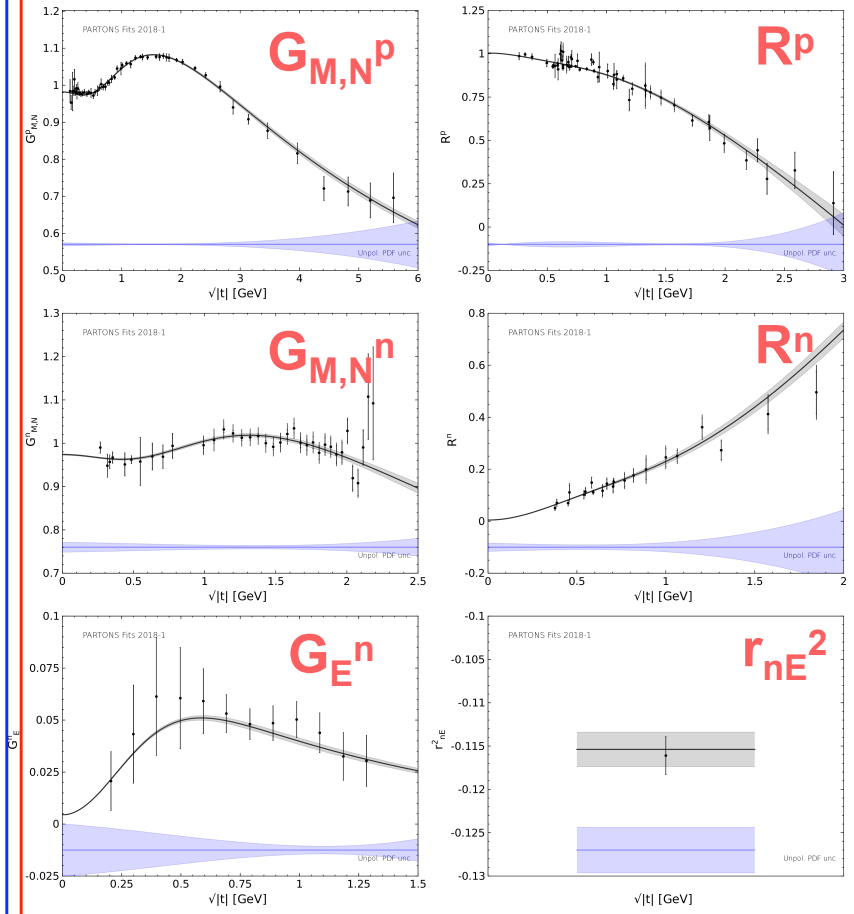
1. Analysis of PDF parameterisations



$$\mathrm{pdf}(x, Q^2) = x^{-g(\delta_p, \delta_q, Q^2)}(1-x)^{\alpha} \times \sum_{i=0}^{4} g(p_i, q_i, Q^2) x^i$$

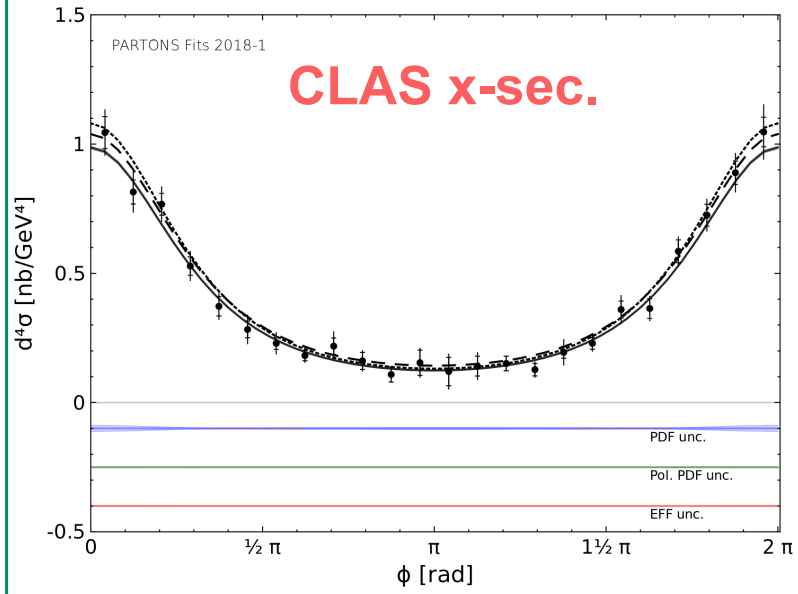
$$g(p, q, Q^2) = p + q \log \frac{Q^2}{Q_0^2}$$

2. Analysis of Elastic Form Factor data



$$\chi^2/\mathrm{ndf} = 129.6/(178-9) \approx 0.77$$

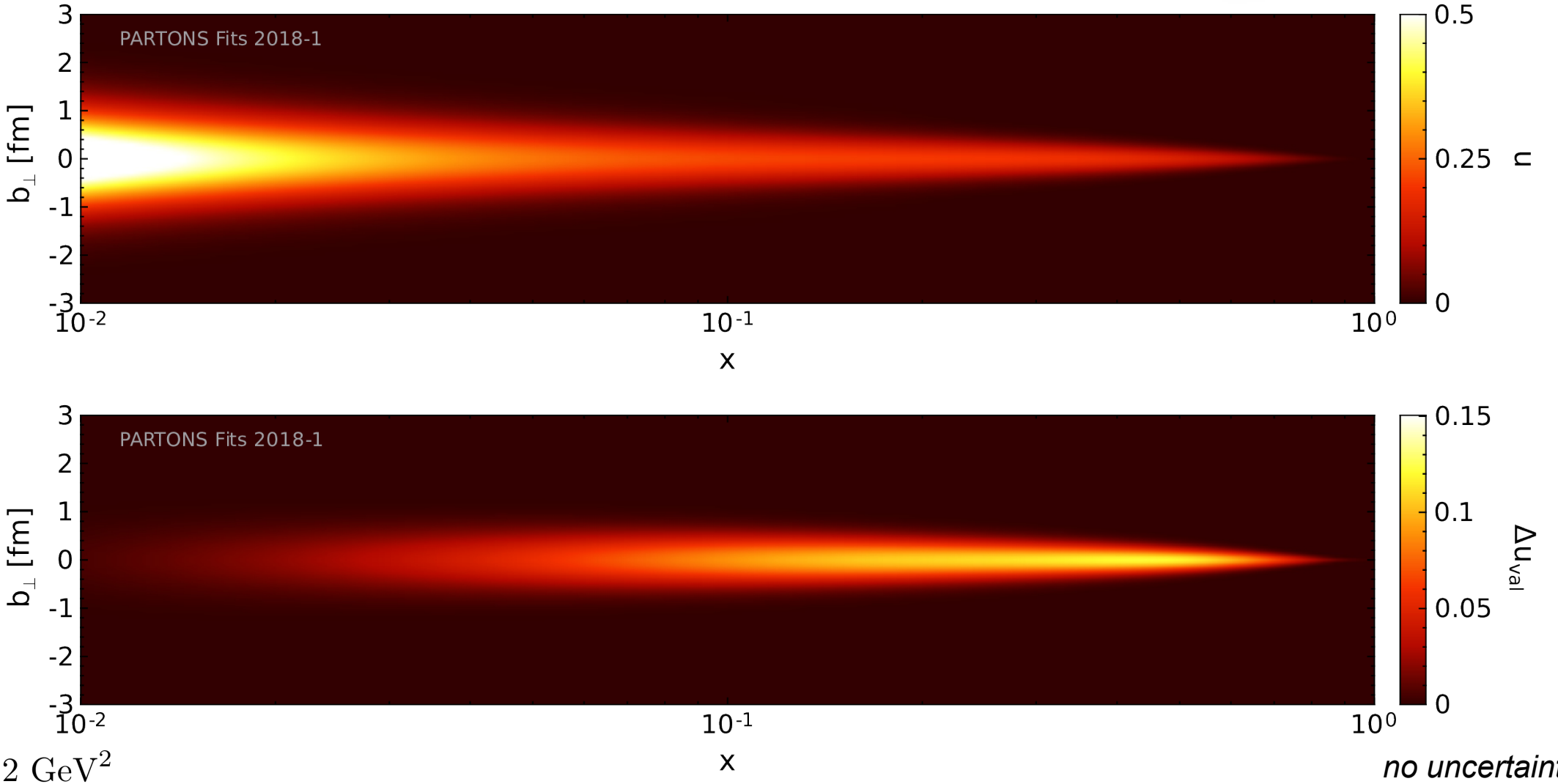
3. Analysis of DVCS data



$$\chi^2/\mathrm{ndf} = 2346.3/(2600-13) \approx 0.91$$

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 78 (2018), 890

Nucleon tomography:



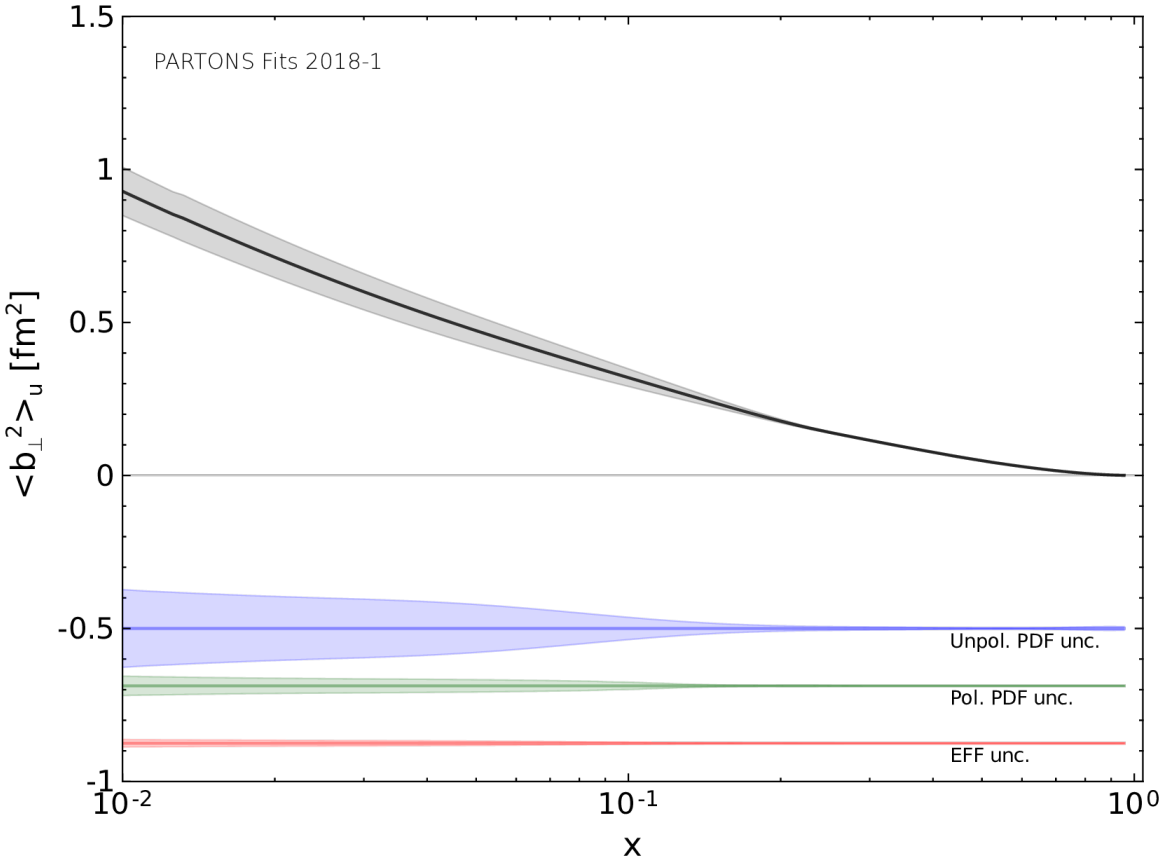
$Q^2 = 2\ \mathrm{GeV}^2$

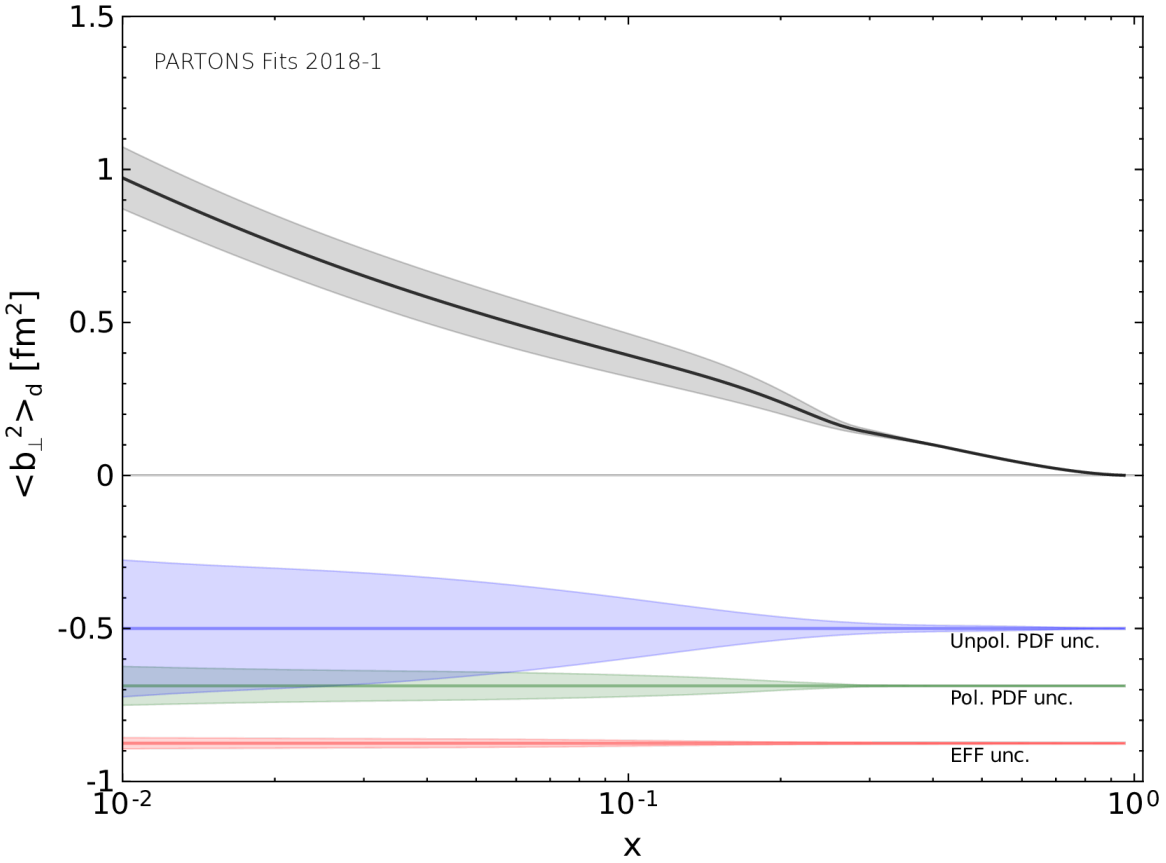
no uncertainties!

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 78 (2018), 890

Nucleon tomography:

$$\langle b_\perp^2 \rangle_q(x) = \frac{\int d^2\mathbf{b}_\perp \; \mathbf{b}_\perp^2 q(x, \mathbf{b}_\perp)}{\int d^2\mathbf{b}_\perp \; q(x, \mathbf{b}_\perp)}$$





$Q^2 = 2 \text{ GeV}^2$

Ji’s sum rule - TOAM

No recent progress here :-(

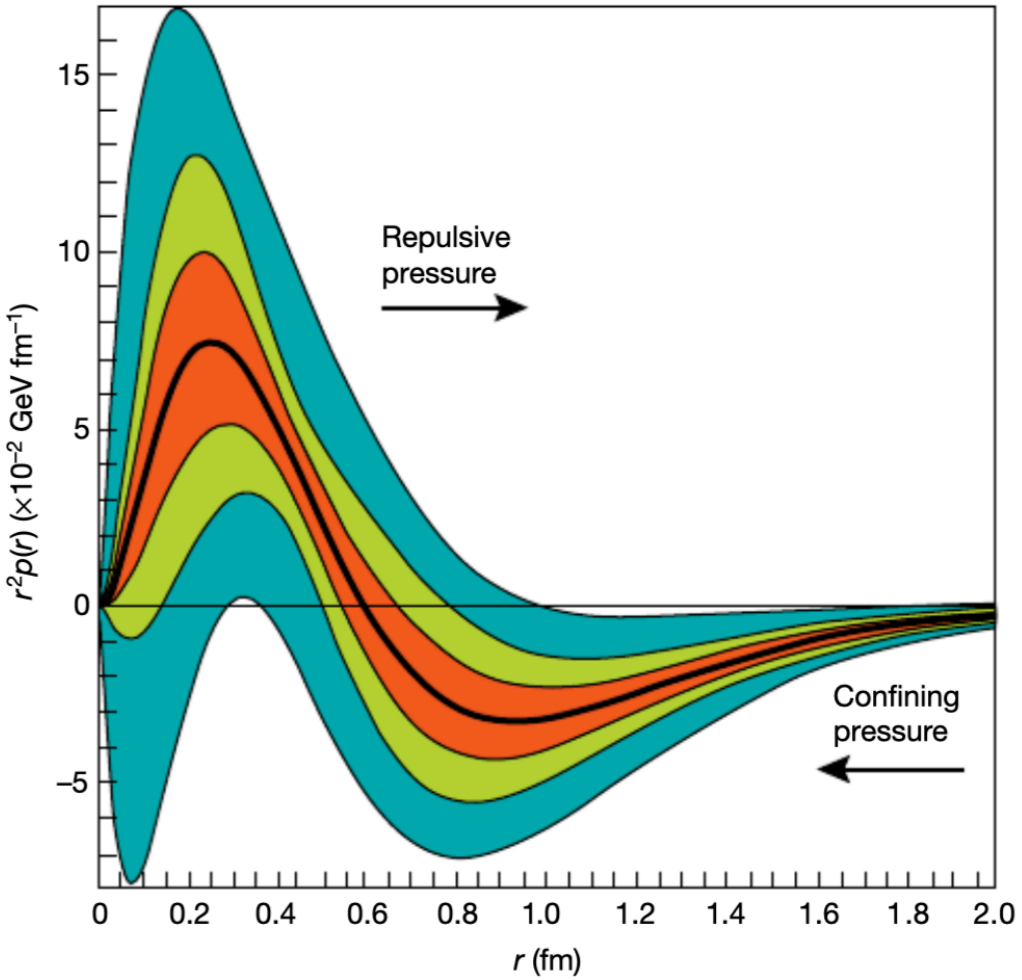
Need for more neutron data or data taken with transversely polarized targets

Need for modern GPD models to access H/E(x, const ξ, t=0) from exclusive data

Elastic data provide important constraints on GPDs E (however, only for valance contribution), see for instance Eur. Phys. J. C73 (2013) no. 4, 2397

Subtraction constant

V.D. Burkert, L. Elouadrhiri, F.X. Girod, Nature 557 (2018) no. 7705, 396



The procedure:

1. Extract subtraction constant using KM model and CLAS data

2. Fit extracted values with

$$d_1(t) = d_1(0)\left(1 - \frac{t}{M^2}\right)^{-\alpha}$$

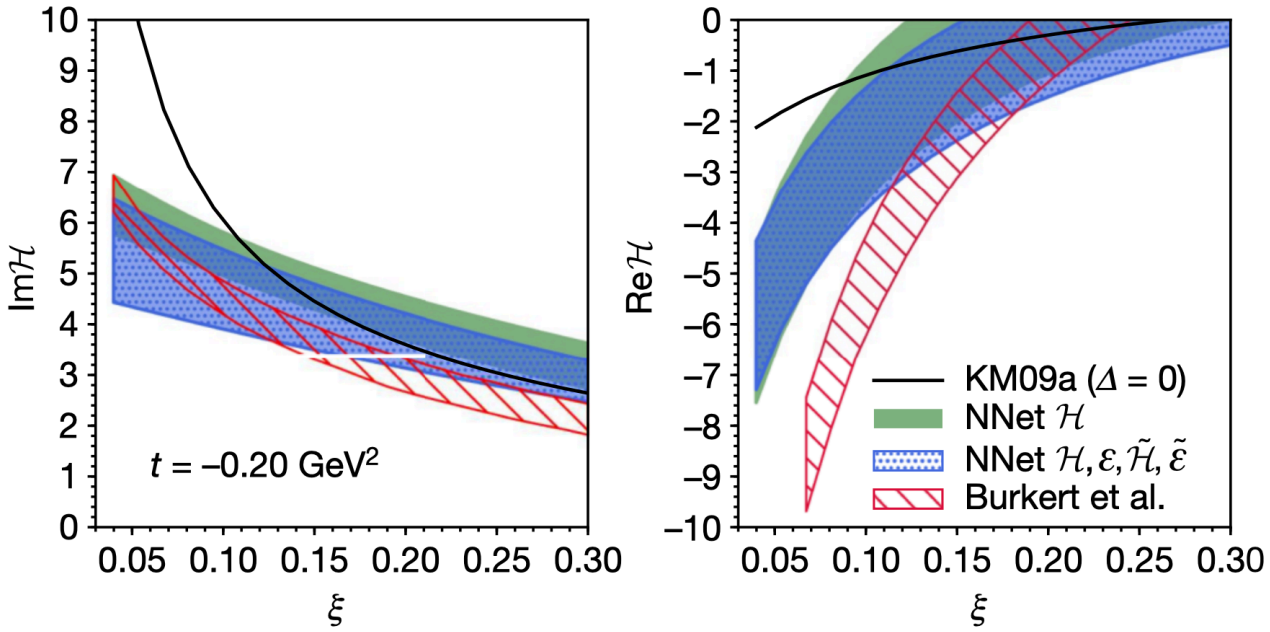
without JLab 6 GeV data

with JLab 6 GeV data

with JLab 12 GeV data (projected)

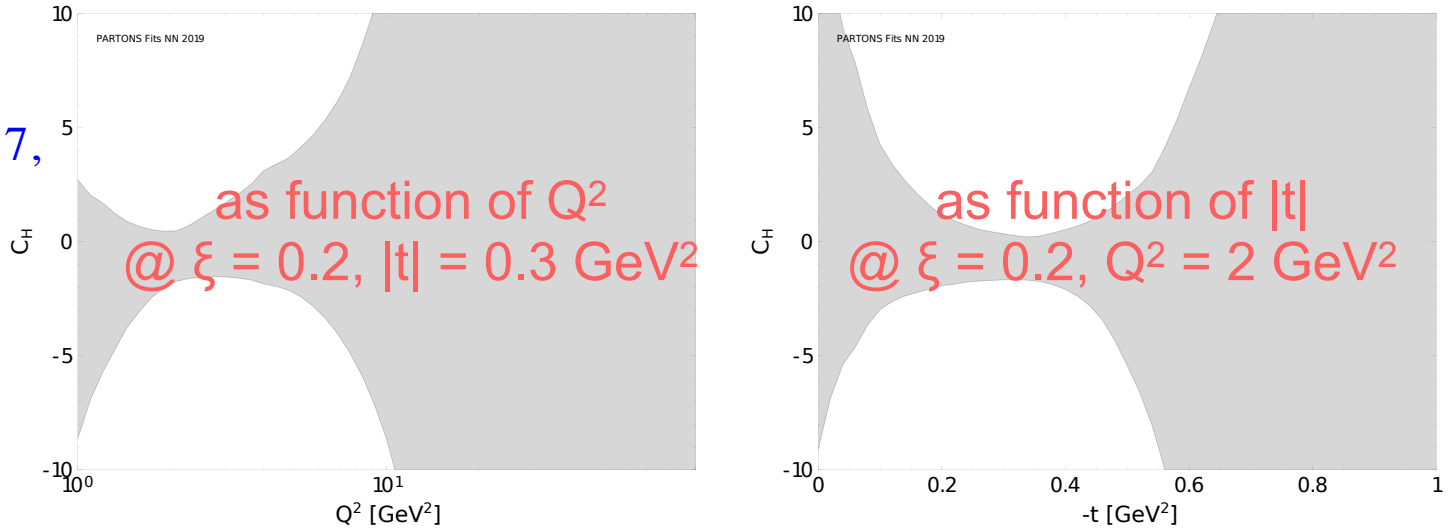
Subtraction constant

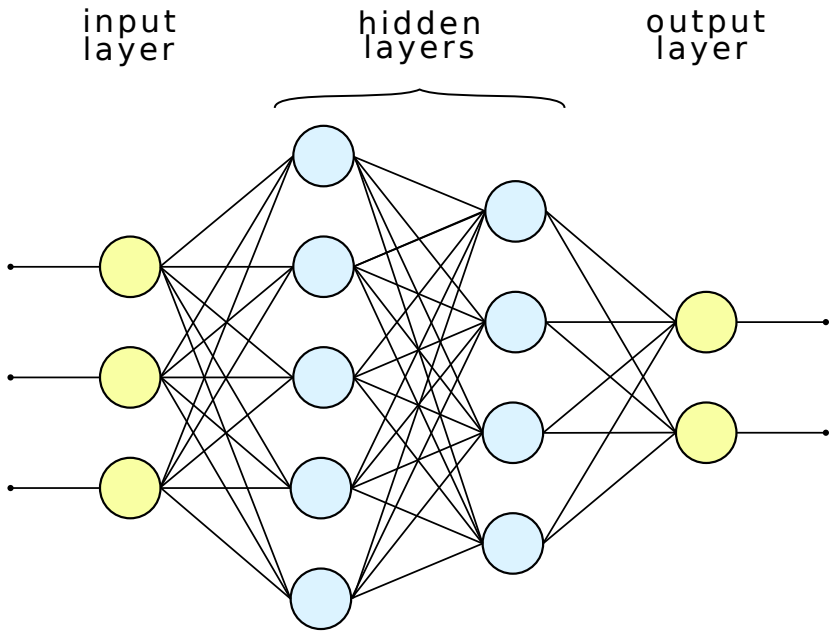
K. Kumerički, Nature 570 (2019) no.7759, E1



Result: C(t) = 0.78 ± 1.5
almost no t-dependence

H. Moutarde, PS, J. Wagner, Eur. Phys. J. C79 (2019) no. 7, 614



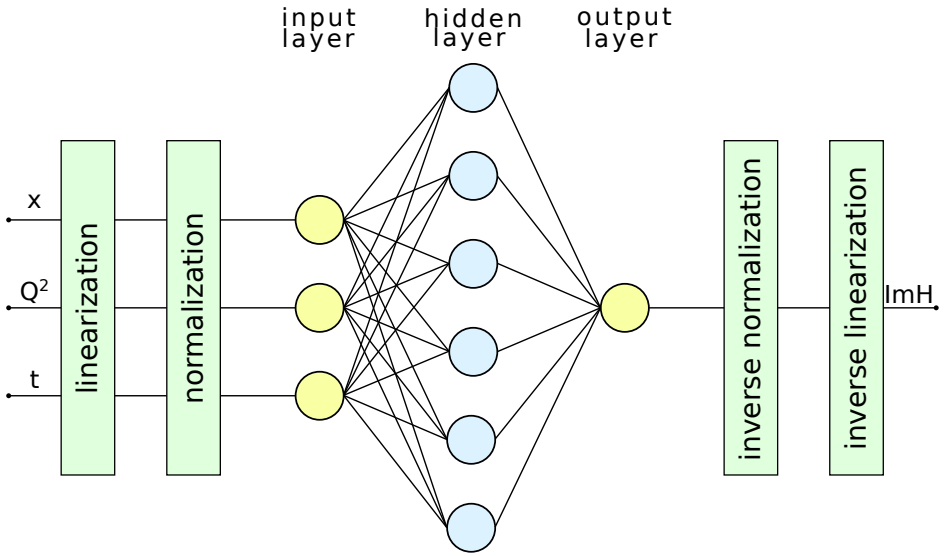


Artificial neural networks (ANNs)

- Data processing technique inspired by Nature
- Network made out of simple but highly connected elements → connectionists system
- Many variations, but most popular deep feed-forward ANNs
  - data processed layer by layer
    input layer → hidden layers→ output layer
  - generalisation capability given by consecutive hidden layers
    output of *i-1* layer is more refined than that of *i* layer
- Information containers

Neural Networks

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 79 (2019) 7, 614



DVCS cross-section can be parametrised by Compton Form Factors (CFFs)

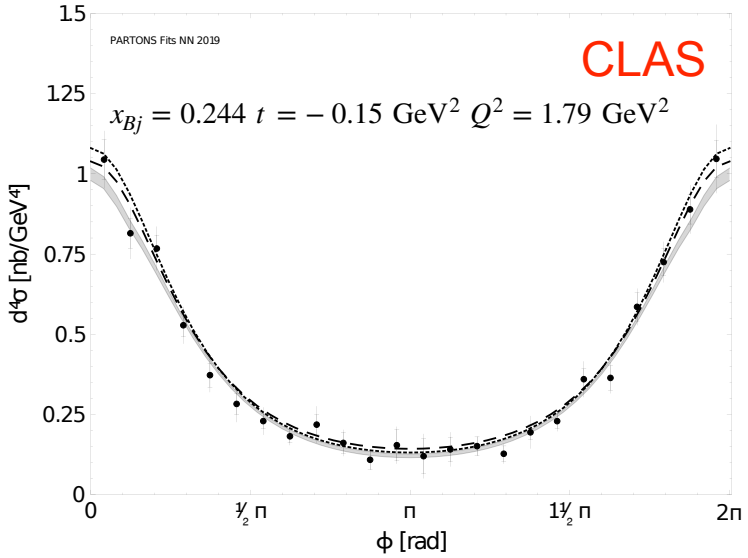
We extract those CFFs from world proton data

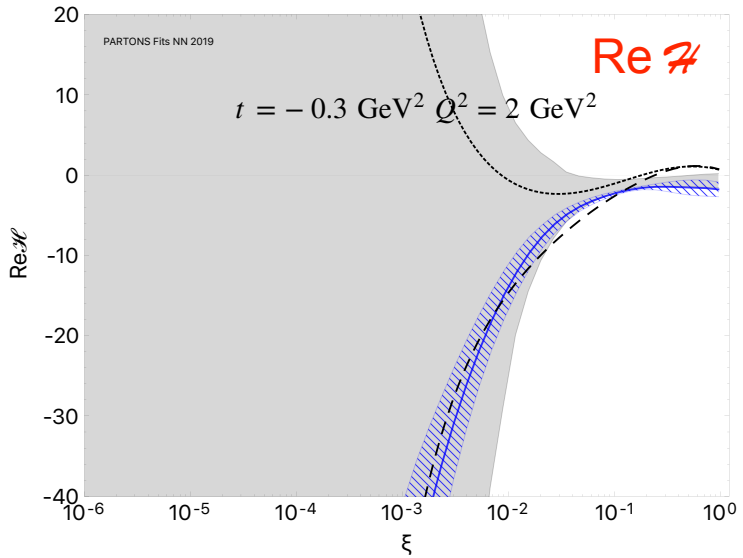
Features of analysis:

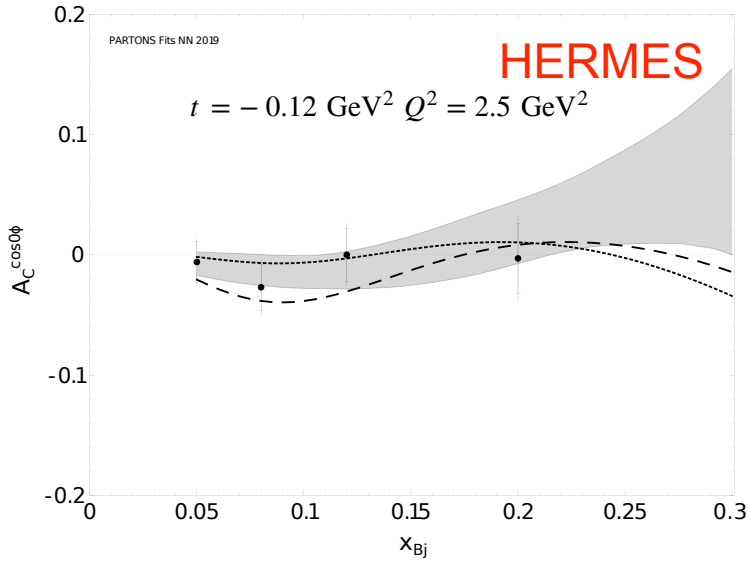
- Independent network for each CFF and Re/Im parts
- Functions of x_B, Q^2 and t
- Network size determined using benchmark sample
- No power-behaviour pre-factors
- Trained with genetic algorithm
- Regularisation method based on early stopping criterion
- Replica method for propagation of experimental uncertainties

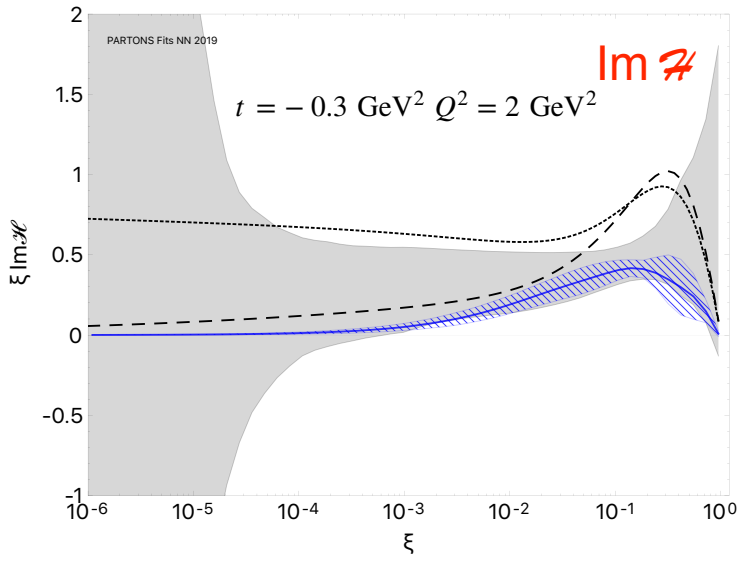
Neural Networks

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 79 (2019) 7, 614









PARTONS ANN

PARTONS 2018
EPJC 78 (2018) 11, 890

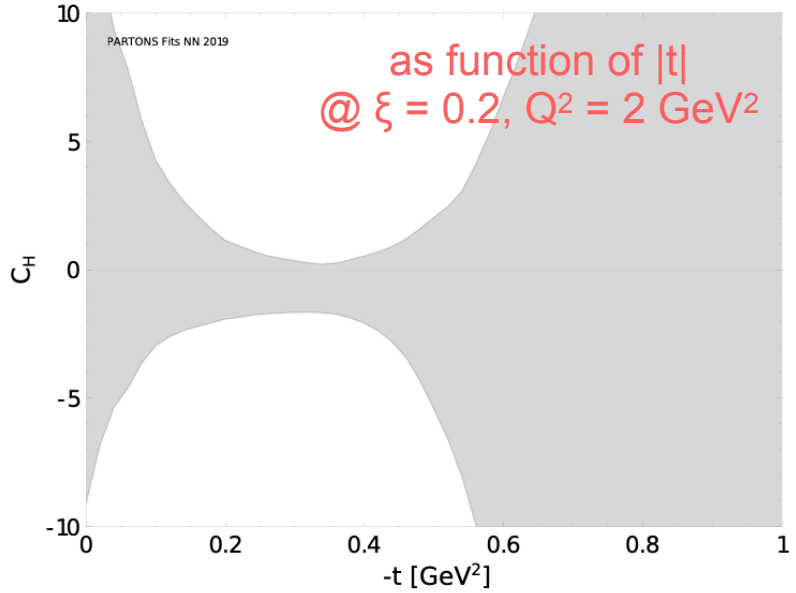
VGG
GK
} LO evaluation

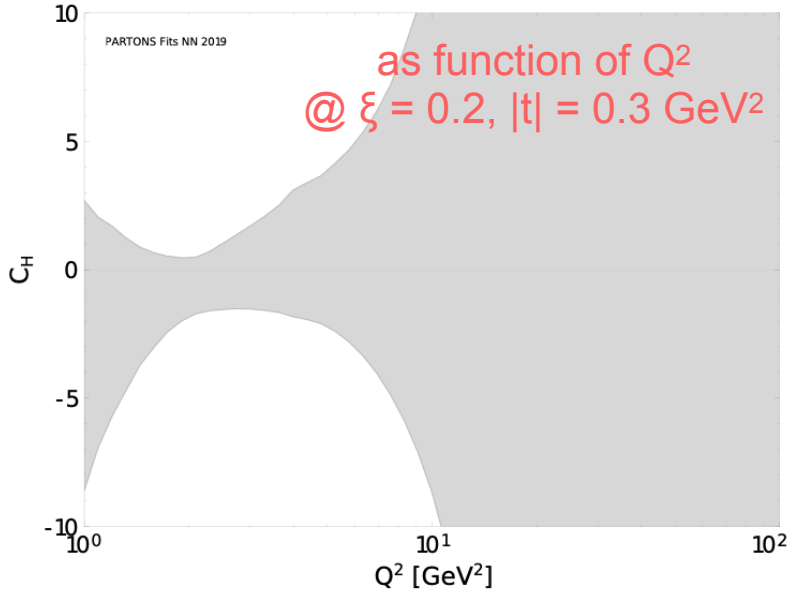
$$\xi \approx x_{Bj}/(2 - x_{Bj})$$

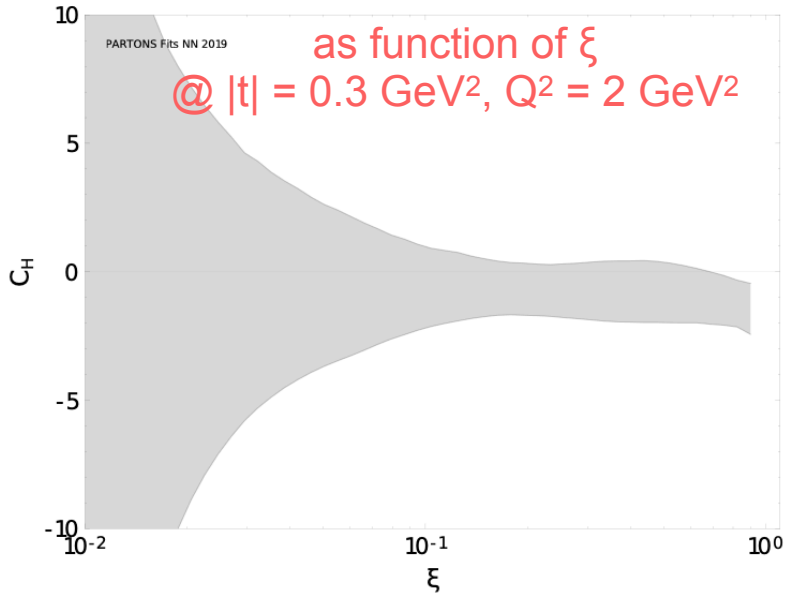
H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 79 (2019) 7, 614

Subtraction constant extracted using dispersion relation

$$\mathcal{C}_H(t,Q^2) = \mathrm{Re}\,\mathcal{H}(\xi,t,Q^2) - \frac{1}{\pi}\fint_0^1 \mathrm{d}\xi'\,\mathrm{Im}\,\mathcal{H}(\xi',t,Q^2)\left(\frac{1}{\xi-\xi'} - \frac{1}{\xi+\xi'}\right)$$







PARTONS ANN

Subtraction constant

H. Dutrieux et al.,
Eur. Phys. J. C 81 (2021), 300

Master formula:

$$\mathrm{Re}\mathcal{H}(\xi,t,Q^2) - \frac{1}{\pi}\fint_0^1 \mathrm{d}\xi'\,\mathrm{Im}\,\mathcal{H}(\xi,t,Q^2)\left(\frac{1}{\xi-\xi'} - \frac{1}{\xi+\xi'}\right) \overset{LO}{=} 4\sum_q e_q^2 \sum_{\text{odd } n} d_n^q(t,\mu_F^2 \equiv Q^2)$$

Extraction of subtraction constant from DVCS data requires:

- integral over ξ (alternatively: x_{Bj} or ν) between ε and 1

$$\epsilon = 10^{-6}$$

- good knowledge of both Re and Im parts of CFF *H*

Model assumptions to extract EMT FF C from subtraction constant:

- truncation to d1

$$C_H(t,Q^2) = 4\sum_q e_q^2\, d_1^q(t,\mu_F^2 \equiv Q^2)$$

- symmetry of light quark contributions

$$d_1^u(t,\mu_F^2) = d_1^d(t,\mu_F^2) = d_1^s(t,\mu_F^2) \equiv d_1^{uds}(t,\mu_F^2)$$

- sensitivity to gluon contribution via evolution

$$d_1^G(t,\mu_{F,0}^2) = 0 \qquad \mu_{F,0}^2 = 0.1\ \mathrm{GeV}^2$$

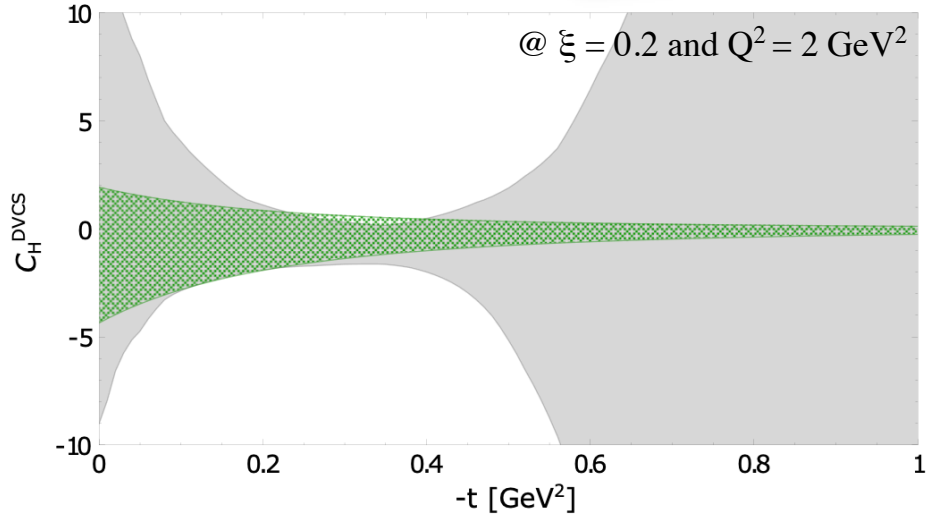
- tripole Ansatz for t-dependence

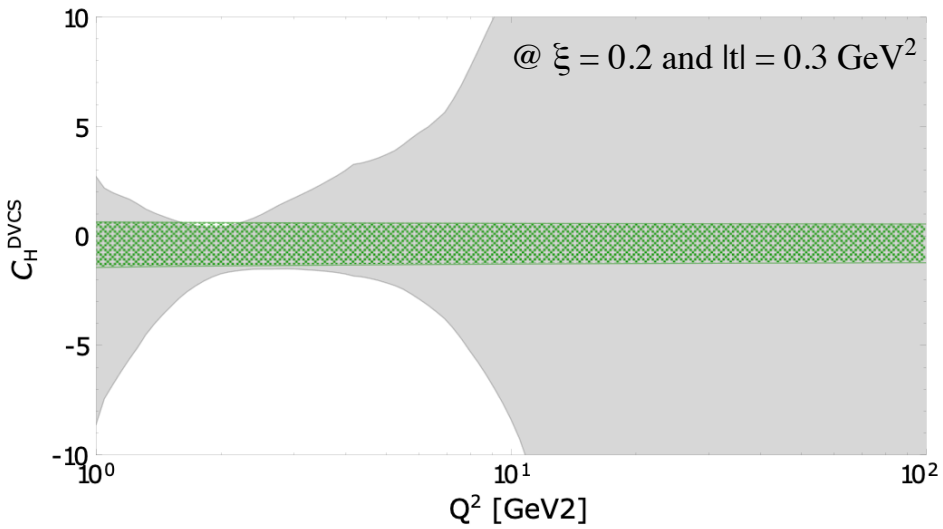
$$d_1^{uds}(t,\mu_F^2) = d_1^{uds}(\mu_F^2)\left(1 - \frac{t}{\Lambda^2}\right)^{-\alpha} \qquad \alpha = 3,\quad \Lambda = 0.8\ \mathrm{GeV}$$

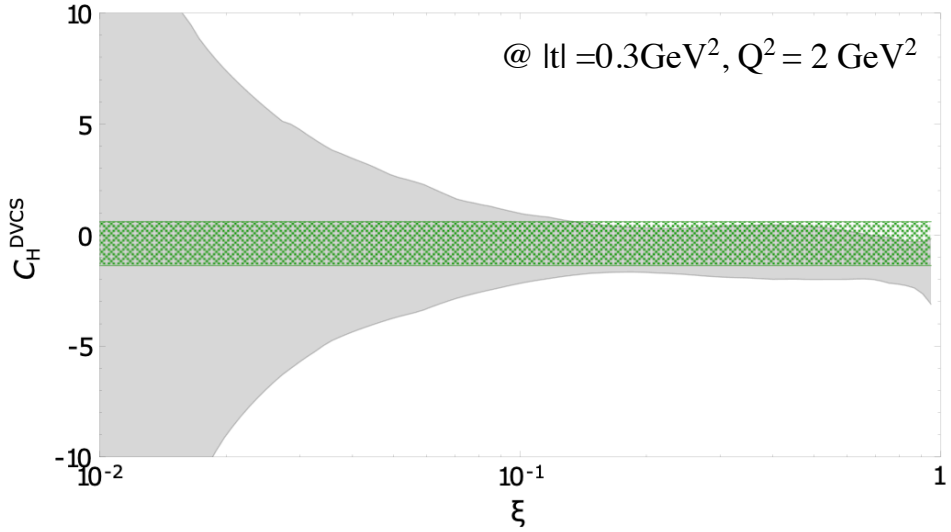
Subtraction constant

H. Dutrieux et al.,
Eur. Phys. J. C 81 (2021), 300

- Subtraction constant:
  - ANN analysis
  - Model dependent extraction







Subtraction constant

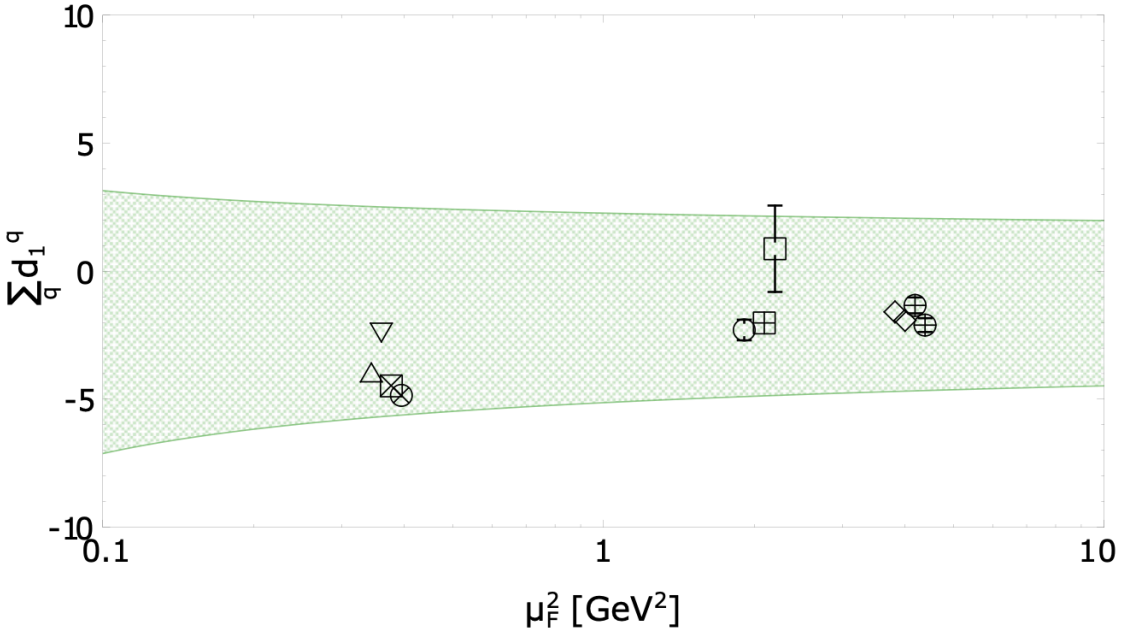
H. Dutrieux et al.,
Eur. Phys. J. C 81 (2021), 300

- Obtained values

Parameter	Value
$d_1^{uds}(\mu_F^2)$	-0.5 ± 1.2
$d_1^{c}(\mu_F^2)$	-0.0020 ± 0.0053
$d_1^{g}(\mu_F^2)$	-0.6 ± 1.6

@ $\mu_F^2 = 2$ GeV^2

- Comparison with other extractions and theory



No.	Marker	$\sum_q d_1^q(\mu_F^2)$	μ_F^2 in GeV^2	# of flavours	Type
1	○	$-2.30 \pm 0.16 \pm 0.37$	2.0	3	from experimental data
2	□	0.88 ± 1.69	2.2	2	from experimental data
3	◇	-1.59	4	2	t-channel saturated model
		-1.92	4	2	t-channel saturated model
4	△	-4	0.36	3	χQSM
5	▽	-2.35	0.36	2	χQSM
6	⊠	-4.48	0.36	2	Skyrme model
7	⊞	-2.02	2	3	LFWF model
8	⊗	-4.85	0.36	2	χQSM
9	⊕	-1.34 ± 0.31	4	2	lattice QCD ($\overline{\text{MS}}$)
		-2.11 ± 0.27	4	2	lattice QCD ($\overline{\text{MS}}$)

Subtraction constant

H. Dutrieux et al.,
Eur. Phys. J. C 81 (2021), 300

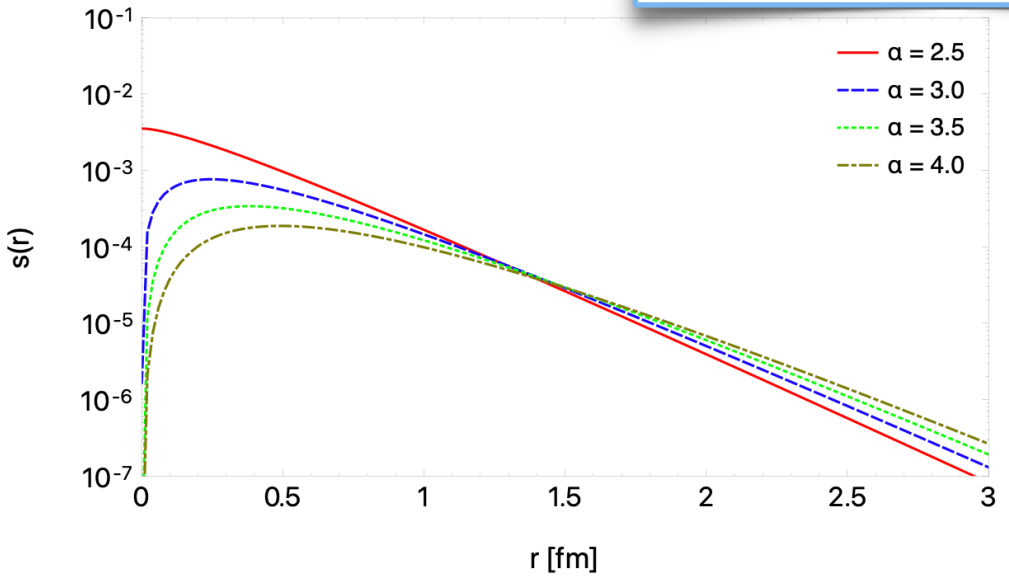
- In this analysis t-dependance of d_1 modelled as:

$$d_1(t) = d_1\left(1 - \frac{t}{\Lambda^2}\right)^{-\alpha}$$

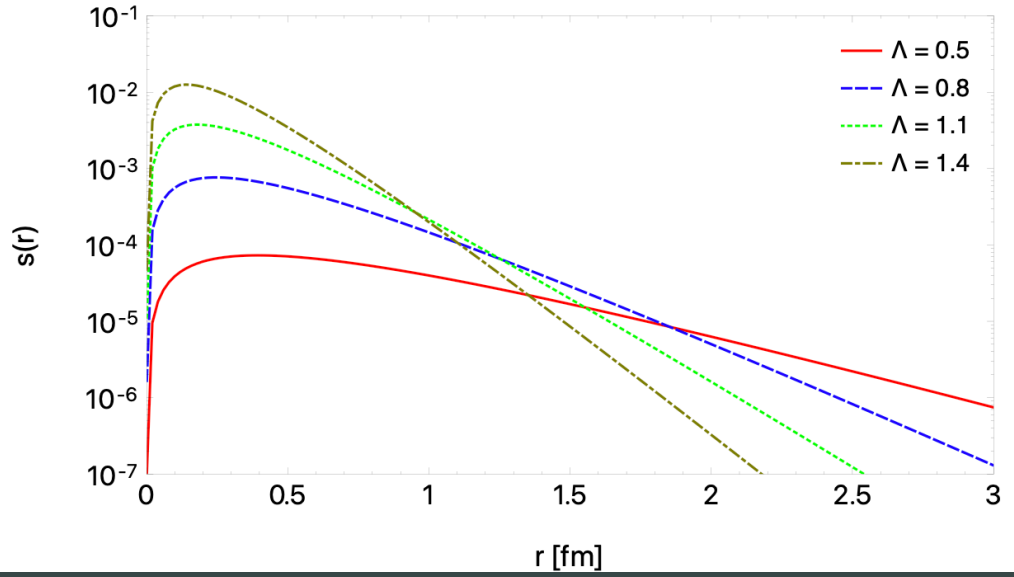
with

$$\alpha = 3 \qquad \Lambda = 0.8 \text{ GeV}$$

- Impact of parameter values on profiles of pressure anisotropies



@
d_1=-3
Λ=0.8 GeV

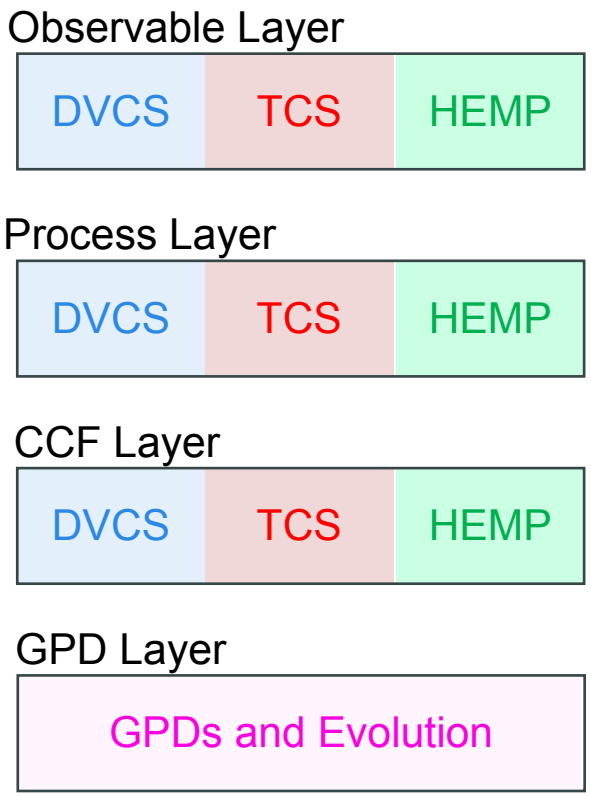


@
d_1=-3
α=3

PARTONS

H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 78 (2018), 478

- PARTONS - platform to study GPDs
- Come with number of available physics developments implemented
- Addition of new developments as easy as possible
- To support effort of GPD community
- Can be used by both theorists and experimentalists



PARTONS

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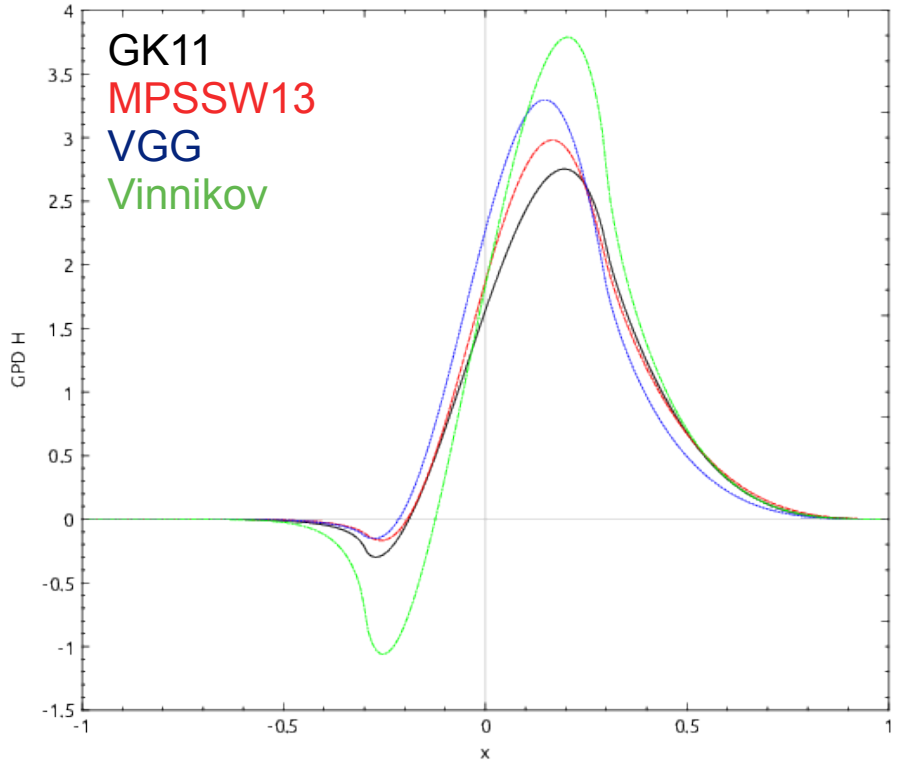
Eur. Phys. J. C 78 (2018), 478

- PARTONS - platform to study GPDs
- Come with number of available physics developments implemented
- Addition of new developments as easy as possible
- To support effort of GPD community
- Can be used by both theorists and experimentalists

H^u @ xi = 0.2, t = -0.1 GeV^2, μ_F^2 = 2 GeV^2



H. Moutarde, PS, J. Wagner,
Eur. Phys. J. C 78 (2018), 478

PARTONS is open source project distributed under following licenses (per subproject):

- elementary-utils: Apache
- numa, partons and partons-example: GPL

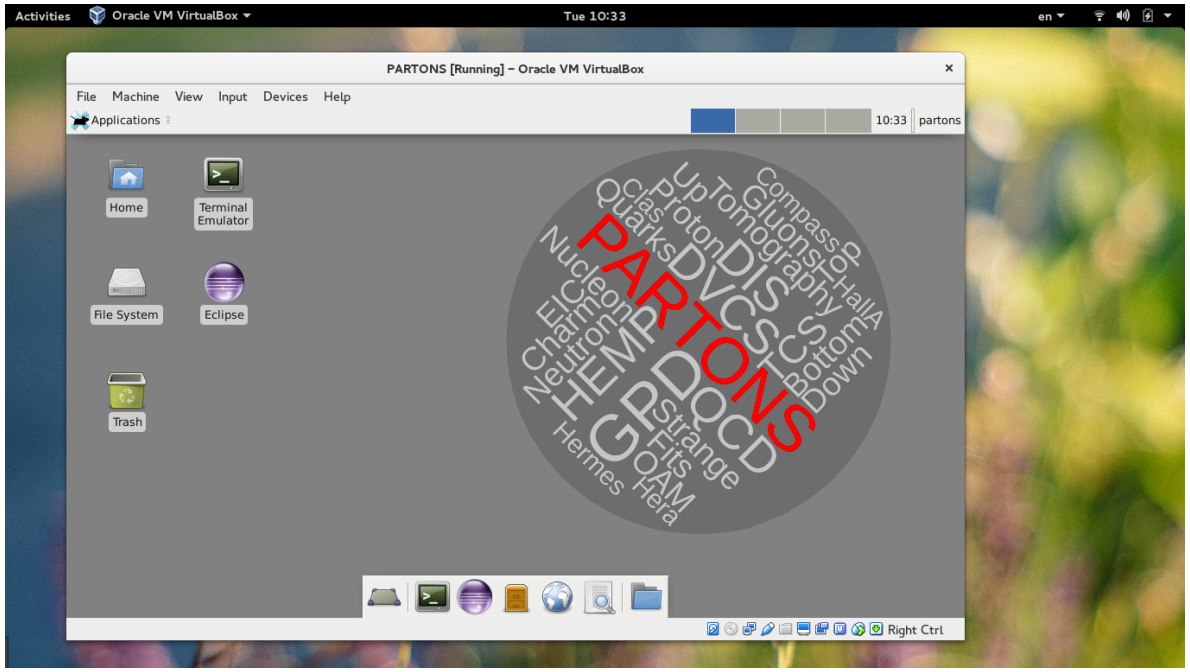
To download and for tutorials, useful information, reference documentation see:

http://partons.cea.fr

For detail description of architecture see:

Eur. Phys. J. C78 (2018), 478

Compile PARTONS from scratch
or use provided Virtual Machine / Docker image



EpIC

- Generic

  → to be used at CERN, JLab, EIC, … (no more “home-made” generators)

- Multichannel (DVCS, TCS, DVMP, …) capability

  → what is available in PARTONS will be available in new MC generator

- Modularity

  → for flexibility and simplicity

- Well developed

  → good coding practices, use modern programming language (c++) and paradigms

- Easy to maintain

  → we expect at least 20 years of lifetime, project must be well designed and properly established, must have useful documentation

- Robust
- Multithreaded

R. Abdul Khalek et al.,
physics.ins-det/2103.05419

- toyMC already used in
  EIC Yellow Report analysis

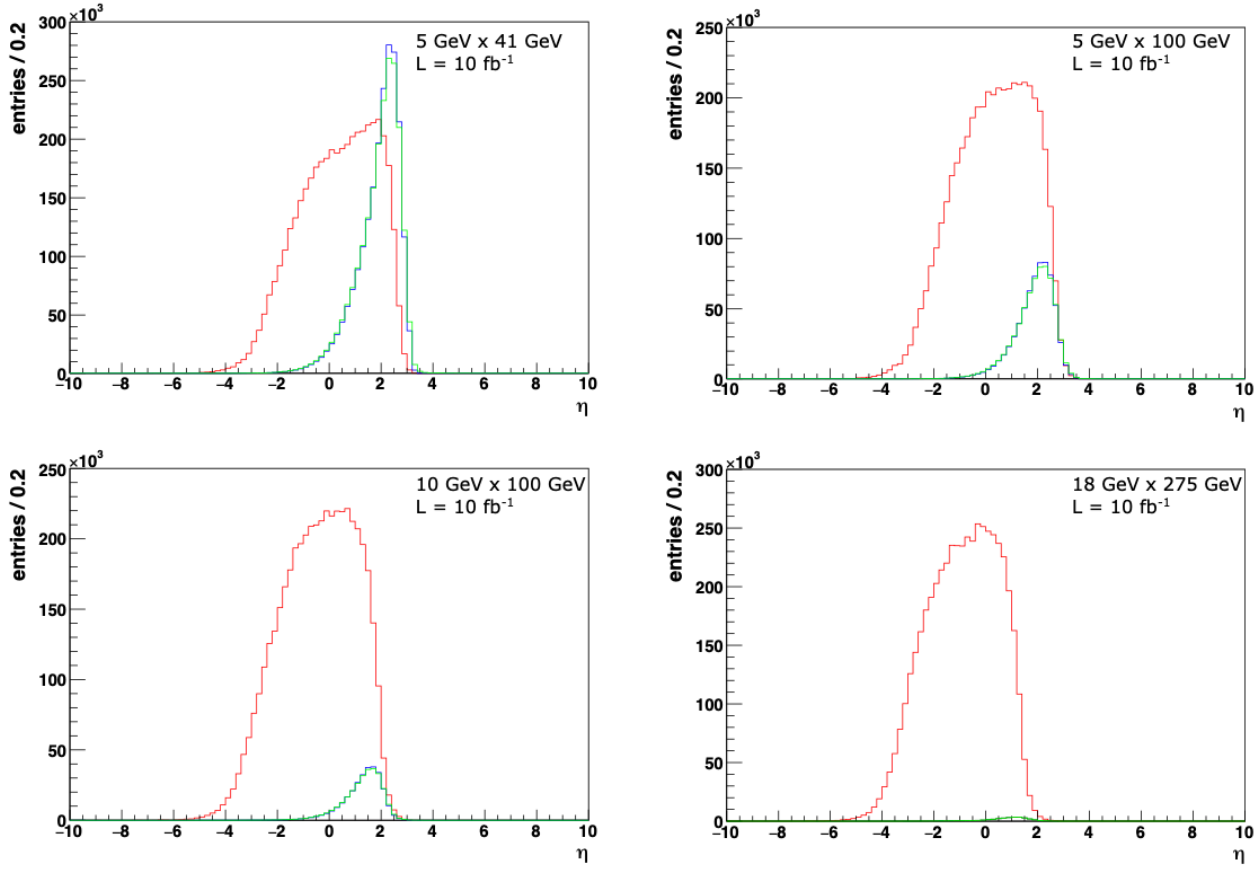
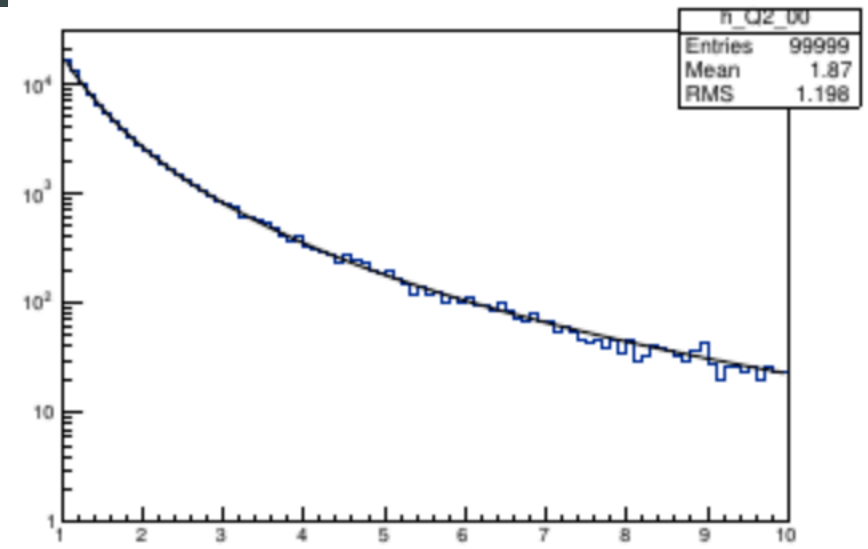
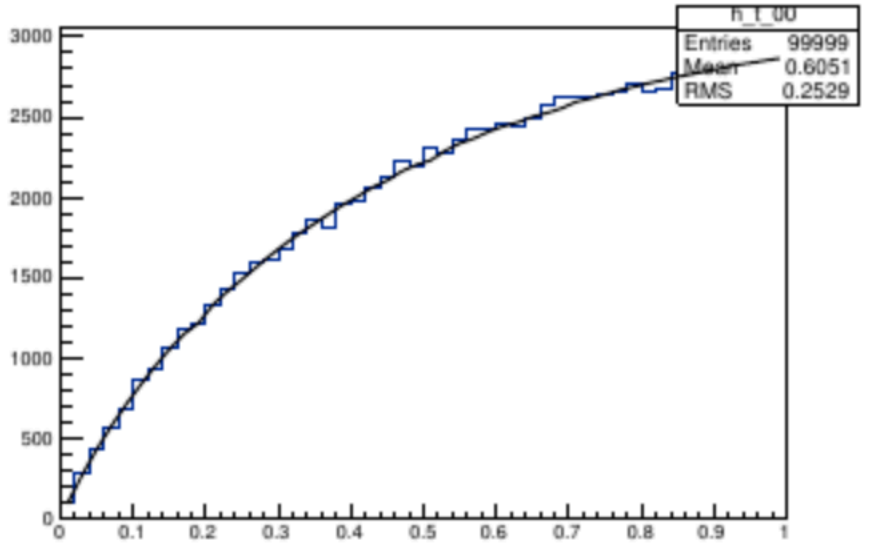


Figure 8.63: Distributions of pseudo-rapidity for DVCS photons (red), exclusive π^0 mesons (blue) and photons coming from decays of $\pi^0 \to \gamma\gamma$ (green, histogram scaled by $\frac{1}{2}$) for four beam energy configurations (see the insert labels) and 10 fb^{-1} of integrated luminosity.

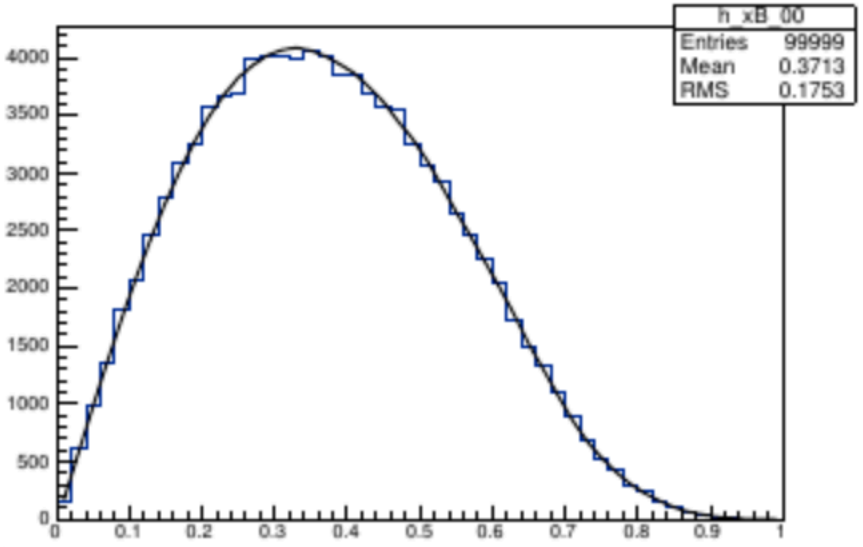
First tests:
distribution of events obtained with EpIC
vs. cross-section curves



Q^2 [GeV^2]



|t| [GeV^2]



xB

Summary

Generalised Parton Distributions

- novel way to describe partonic structure of nucleon
- allows to study (highlights):
  - → nucleon tomography
  - → total angular momentum of partons
  - → “mechanical” properties of parton distributions

What was discussed today?

- Introduction to GPDs
- Recent progress in phenomenology
- Review of available software