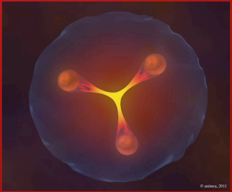
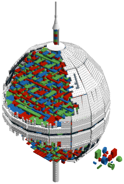
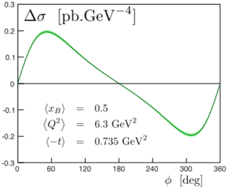
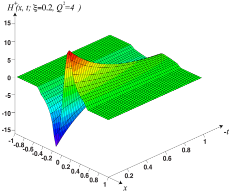
DE LA RECHERCHE À L'INDUSTRIE

Global analysis with PARTONS









CNF workshop | Hervé MOUTARDE

Feb. 10, 2021

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Cross sections or asymmetries?

The fitting framework should be able to handle all kinds of datasets.

- Already huge variety of existing observables.
- Probably more to come with future experiments, in particular from **new channels on new facilities**.
- **Delicate issues with uncertainty propagation** in the modification of available experimental data, *e.g.* from Fourier harmonics to ϕ-space in DVCS.

Considered in the design of PARTONS from the beginning

and measurements. The foreseen accuracy of experimental data to be measured at Jefferson Lab [15] and at COMPASS [16] requires the careful design of tools to meet the challenge of the high-precision era, and to be able to make the best from experimental data. The same tools should also be used to design future experiments or to contribute to the physics case of the foreseen Electron Ion Collider (EIC) [17] and Large Hadron Electron Collider (LHeC) [18]. Integrating those tools in one single framework is the aim of the PARTONS project.

matics. For fitting purposes, all observables (whatever the channel is) should be treated in the same manner in order to simplify handling of experimental data. We may want to check *e.g.* the impact of one specific data set on the general knowledge of GPDs, or to apply some kinematic cuts in order to guarantee that the analysis takes place in a range where factorization theorems apply. Note, that if we want to fit data (say, if we want to minimize a χ^2 value), then we will have to loop over such GPD-to-observables structure at each step of the minimization.

Berthou *et al.*, Eur. Phys. J. **C78**, 478 (2018)

Almost all existing DVCS data sets.

2600+ measurements of 30 observables published during 2001-17.

No.	Collab.	Year	Ref.	Observable		Kinematic dependence	No. of points used / all
1	HERMES	2001	[40]	A_{LU}^{+}		ϕ	10 / 10
2		2006	[41]	$A_{C}^{\cos i\phi}$	$i = 1$	t	4 / 4
3		2008	[42]	$A_{C}^{\cos i\phi}$	$i = 0, 1$	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	[43]	$A_{LU,\mathrm{I}}^{\sin i\phi}$	$i = 1, 2$	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	[44]	$A_{UL}^{+,\sin i\phi}$	$i = 1, 2, 3$	x_{Bj}	18 / 24
				$A_{LL}^{+,\cos i\phi}$	$i = 0, 1, 2$		
6		2011	[45]	$A_{LT,\mathrm{DVCS}}^{\cos(\phi-\phi_S)\cos i\phi}$	$i = 0, 1$	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	[46]	$A_{LU,\mathrm{I}}^{\sin i\phi}$	$i = 1, 2$	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	[47]	$A_{LU}^{-,\sin i\phi}$	$i = 1, 2$	—	0 / 2
9		2006	[48]	$A_{UL}^{-,\sin i\phi}$	$i = 1, 2$	—	2 / 2
10		2008	[49]	A_{LU}^{-}		ϕ	283 / 737
11		2009	[50]	A_{LU}^{-}		ϕ	22 / 33
12		2015	[51]	A_{LU}^{-}, A_{UL}^{-}, A_{LL}^{-}		ϕ	311 / 497
13		2015	[52]	$d^4\sigma_{UU}^{-}$		ϕ	1333 / 1933
14	Hall A	2015	[34]	$\Delta d^4\sigma_{LU}^{-}$		ϕ	228 / 228
15		2017	[35]	$\Delta d^4\sigma_{LU}^{-}$		ϕ	276 / 358
16	COMPASS	2018	[36]	$d^3\sigma_{UU}^{\pm}$		t	2 / 4
17	ZEUS	2009	[37]	$d^3\sigma_{UU}^{+}$		t	4 / 4
18	H1	2005	[38]	$d^3\sigma_{UU}^{+}$		t	7 / 8
19		2009	[39]	$d^3\sigma_{UU}^{\pm}$		t	12 / 12
						SUM	2624 / 3996

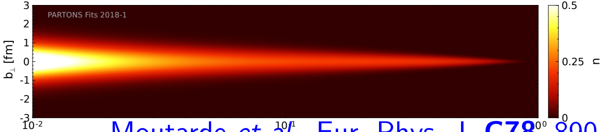
Moutarde *et al.*, Eur. Phys. J. **C78**, 890 (2018)

Moutarde *et al.*, Eur. Phys. J. **C79**, 614 (2019)

Modeling of H, $\widetilde{H}$, E and $\widetilde{E}$.

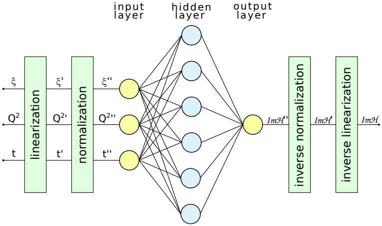
Implementation of DVCS dispersion relations at leading order.

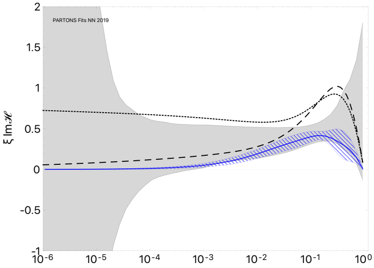
- From **LO dispersion relation** work only with **border function** $H(\xi, \xi, t)$ and D-term $D(t)$.
- Write border function in terms of **skewness function** $H(\xi, \xi, t)/H(\xi, 0, t)$.
- Implement large- and small-ξ behaviors in modeling of skewness function, PDF and elastic form factor limits.
- D-term fixed by assumption of **analytic continuation**.
- Get direct access to **transverse plane density**.
- Fit remaining free parameters from DVCS. (Only) 13 free parameters to describe all four H, $\widetilde{H}$, E and $\widetilde{E}$.



Moutarde *et al.*, Eur. Phys. J. **C78**, 890 (2018)

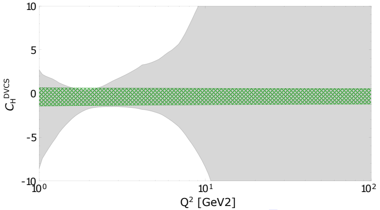
- Real and imaginary parts of CFFs parameterized by **neural networks**.
- Propagation of uncertainties through **replica method** and evaluation of 68 % **confidence levels**.

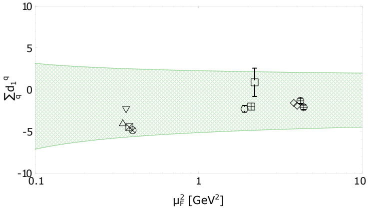




Moutarde *et al.*, Eur. Phys. J. **C79**, 614 (2019)

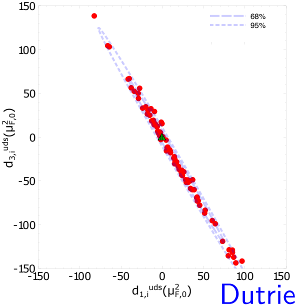
- Take real and imaginary parts of CFFs from the **neural network** global fit.
- Compute subtraction constant, propagate uncertainties through **replica method** and evaluate 68 % **confidence levels**.

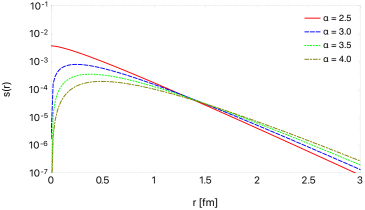




Dutrieux *et al.*, arXiv:2101.03855 [hep-ph]

- **No justification to truncate the subtraction constant expansion to its first term** and assume that it is the d_1 coefficient related to the energy-momentum tensor.
- Shape of pressure profile is **fixed** by multipole Ansatz. Actual value is **extremely sensitive** to its parameters.





Dutrieux *et al.*, arXiv:2101.03855 [hep-ph]

Many theoretical constraints on GPDs.

Constraints difficult to implement at the CFF level.

- Reduction to PDFs or elastic form factors.
- Implement *a priori* **positivity** and **polynomiality**. Still uncommon in many models or parameterizations used for phenomenology.
- **General solution** starting from overlap of (potentially effective) light front wave functions.
  Chouika *et al.*, Eur. Phys. J. **C77**, 906 (2017)
- Use of **evolution equations** to implement further constraints on the GPD functional form.
- Work **beyond leading-order** and depart from the parton model...
- Systematic impact study or use of **kinematic corrections** still missing.

- *In progress:* there exist **non-zero** GPDs with **vanishing forward limit** and **vanishing CFF** up to order α_s^2.
- Consequence: the DVCS deconvolution problem is **ill-posed** by **lack of uniqueness**.
- **Same conclusion holds** for TCS, DVMP at leading-order, etc. but not *e.g.* for DDVCS.
- Need for **multi-channel** analysis.
- **Define** and **implement** further criterions in fitting strategies to select one solution among infinitely many.

Multi-channel analysis.

An mandatory step.

- So far classically mentioned for **parton type separation** or **universality / factorization** tests.
- Now necessary also to decrease the *"blind spot effect"* induced by specific (channel-dependent) coefficient functions as much as possible.
- PARTONS now offers DVCS, TCS and π^0-production, all of them **having been used for the EIC Yellow Report**.

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