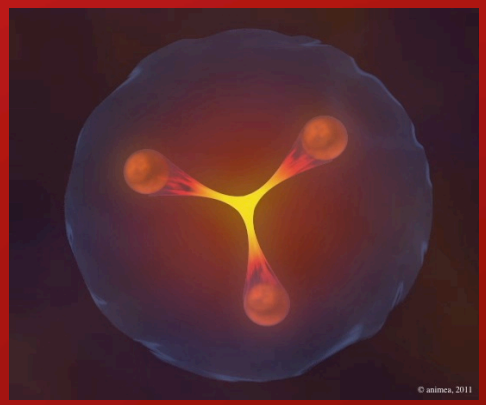
DE LA RECHERCHE À L'INDUSTRIE



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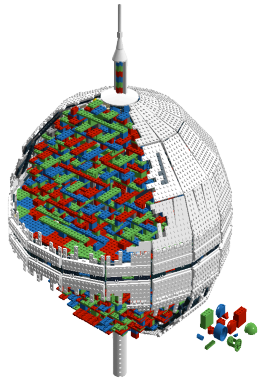
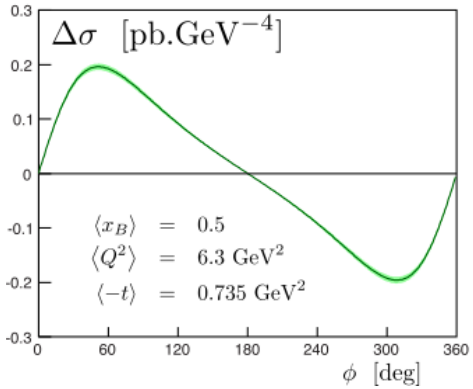
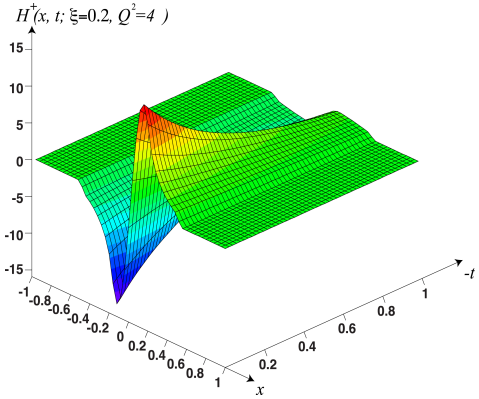
Nucleon tomography: Round table discussion







Nucleon and resonance structure | Hervé MOUTARDE

May 31st, 2017

université PARIS-SACLAY

Towards nucleon tomography.

Assumption: aim at following examples from PDF global fits.

Nucleon tomography

Hard exclusive processes

GPD metrology

Interpretation

1. Unified understanding of several hard exclusive processes.

   Are we measuring universal objects with a controlled scale dependence?

2. GPD metrology.

   Can we make the best from experimental data and their accuracy?

3. Interpretation of GPD extractions.

   What do we learn about QCD?

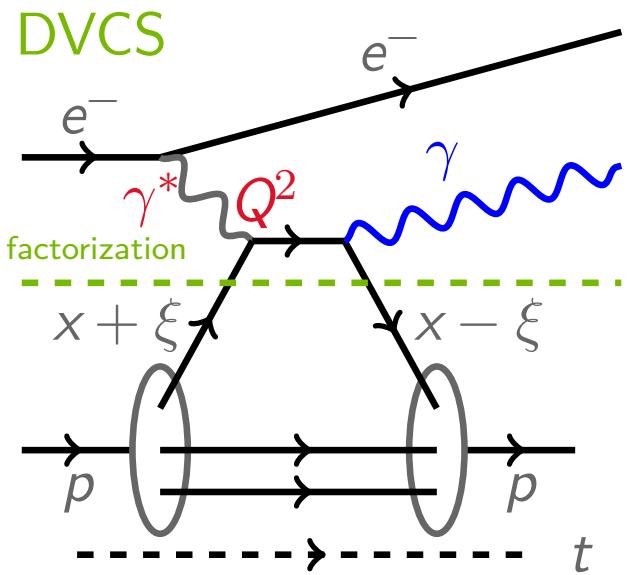
Hard exclusive processes

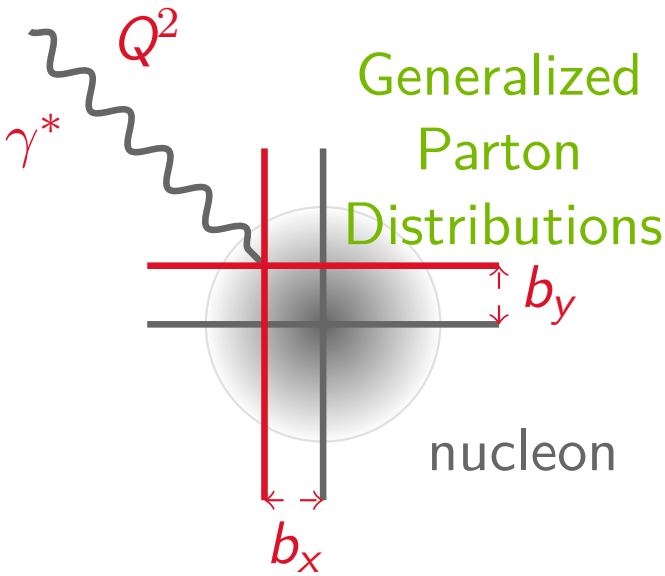
Nucleon tomography

Hard exclusive processes

GPD metrology

Interpretation



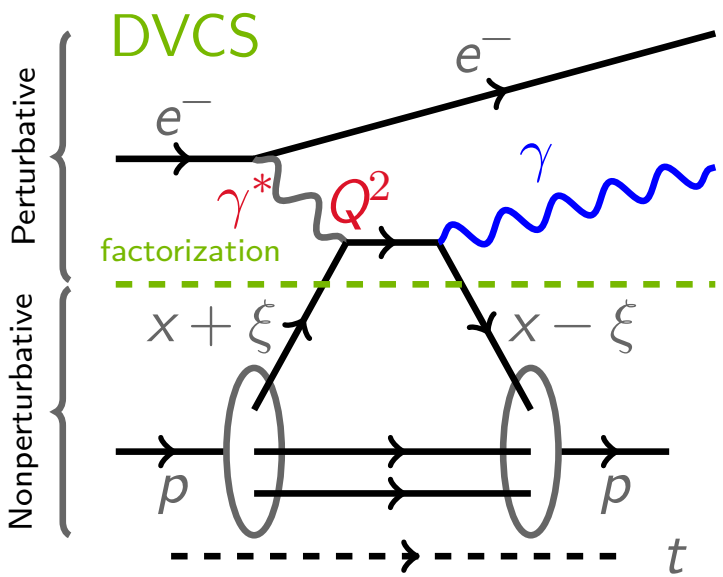


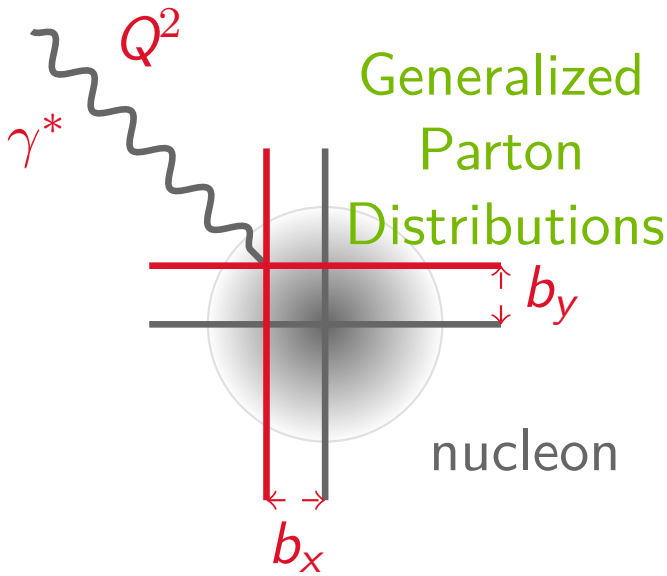
Nucleon tomography

Hard exclusive processes

GPD metrology

Interpretation





Nucleon tomography

Hard exclusive processes

GPD metrology

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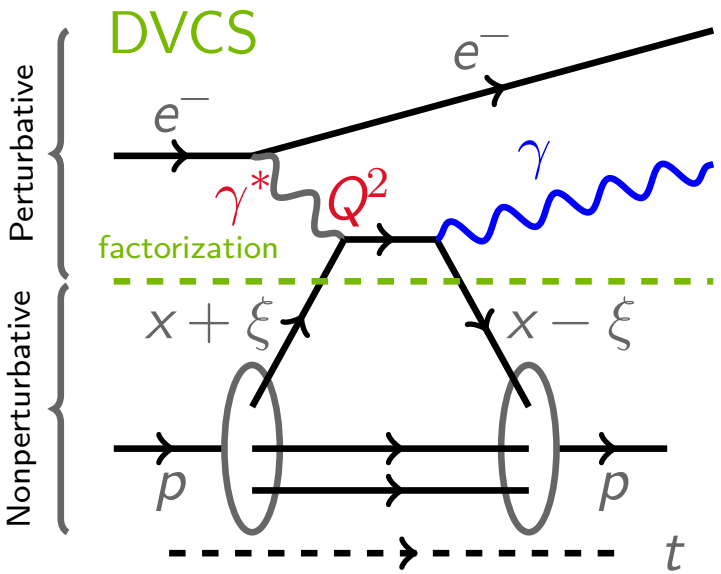

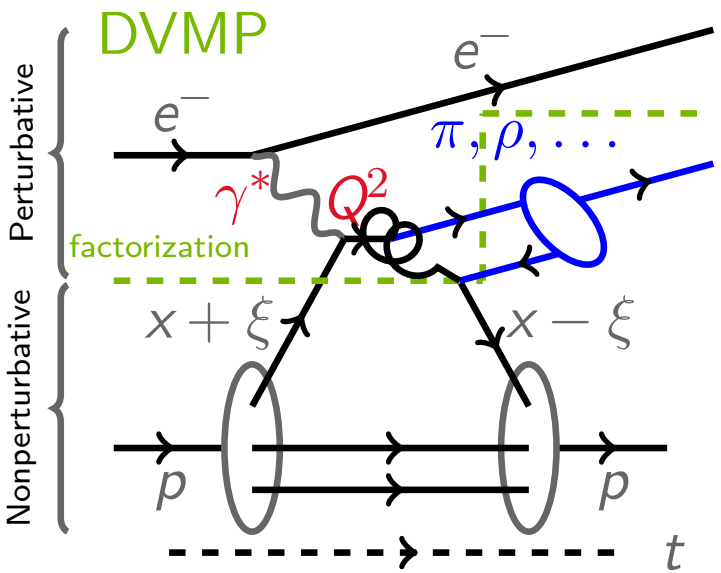

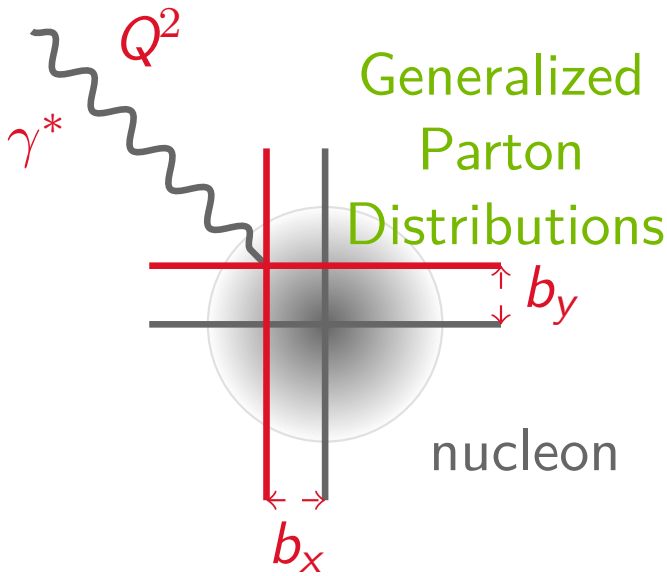

Nucleon tomography

Hard exclusive processes

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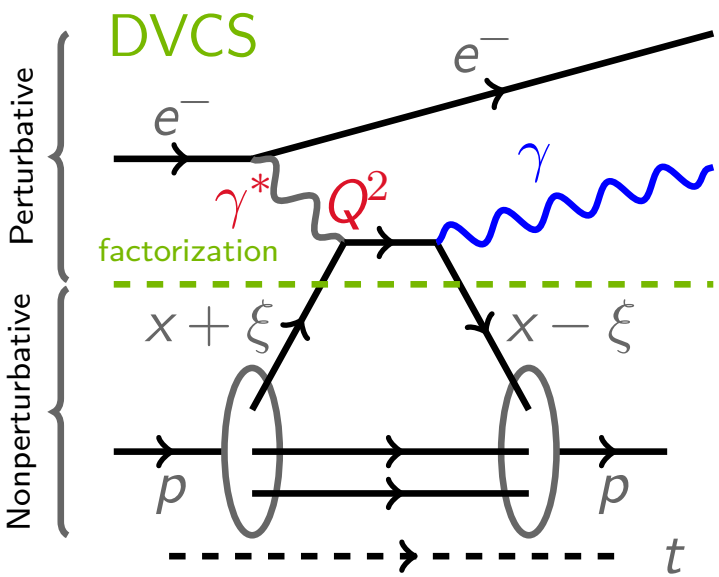
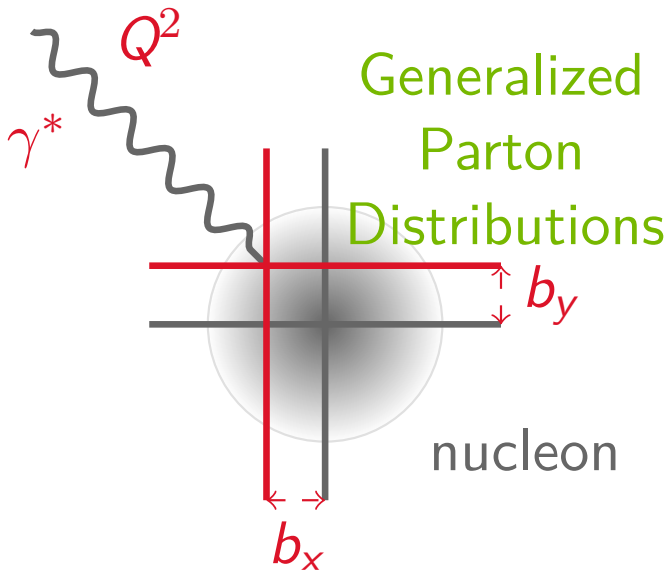
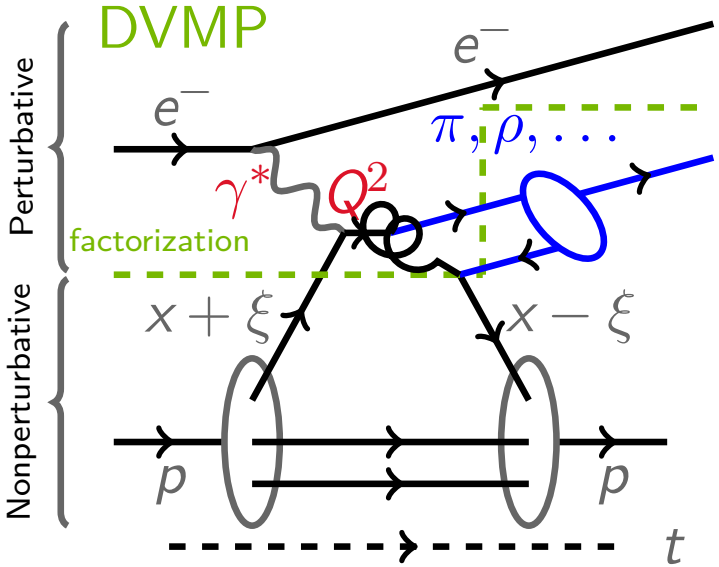
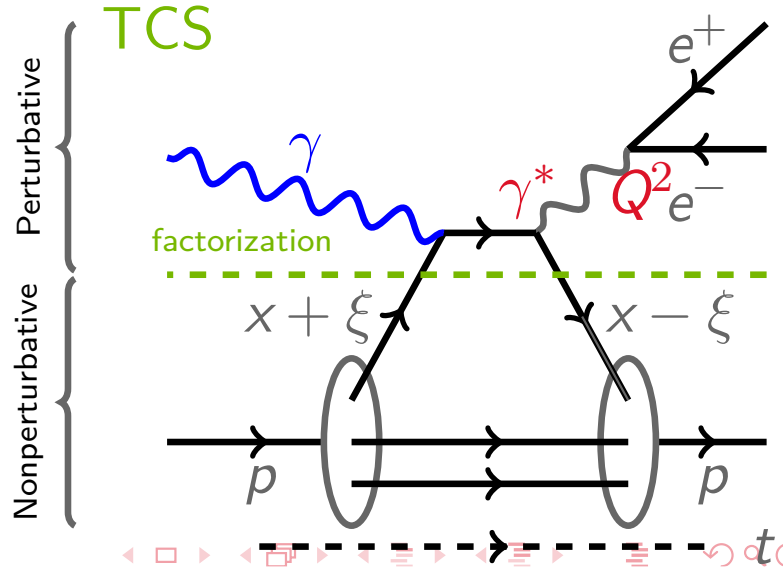
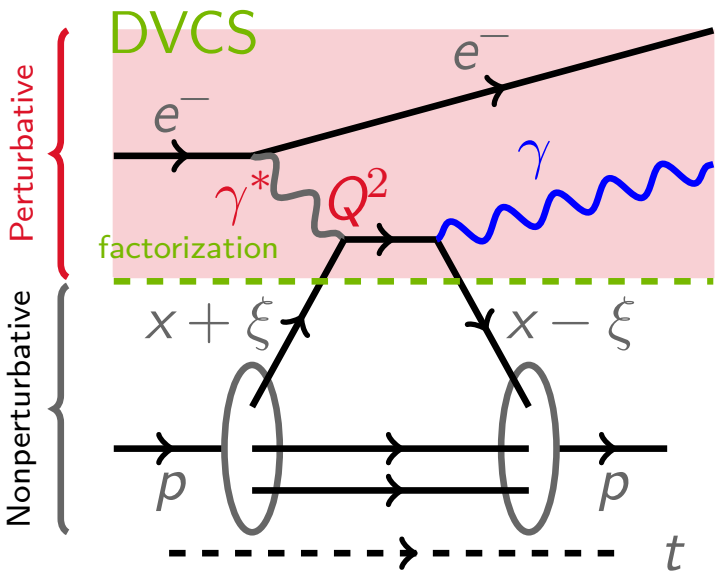


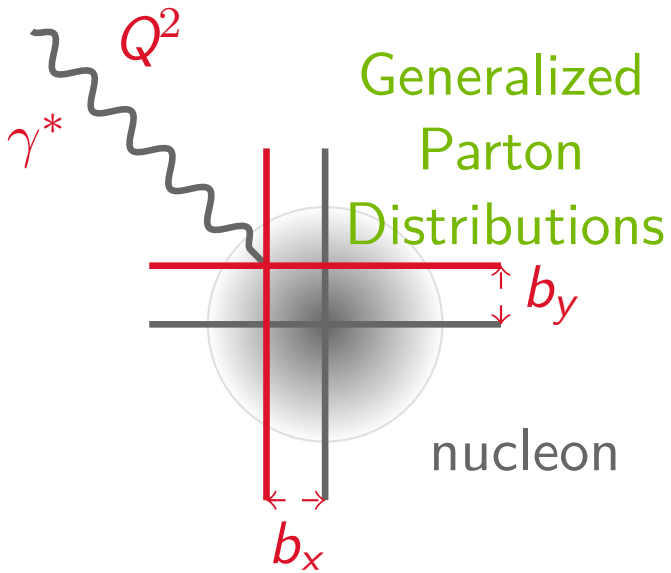


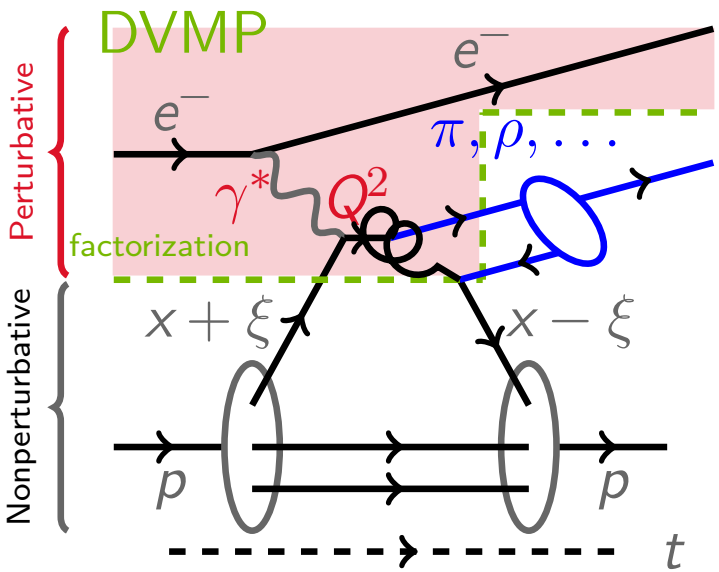


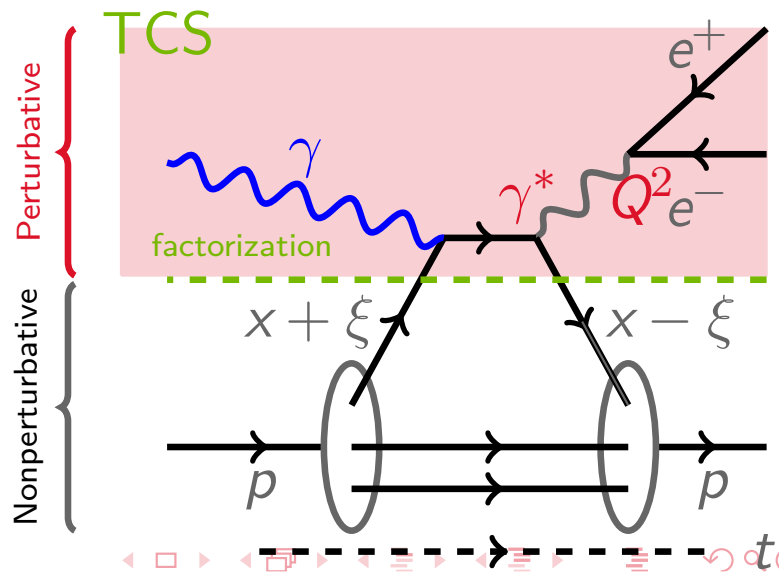


Hard exclusive processes.
Factorization and universality.



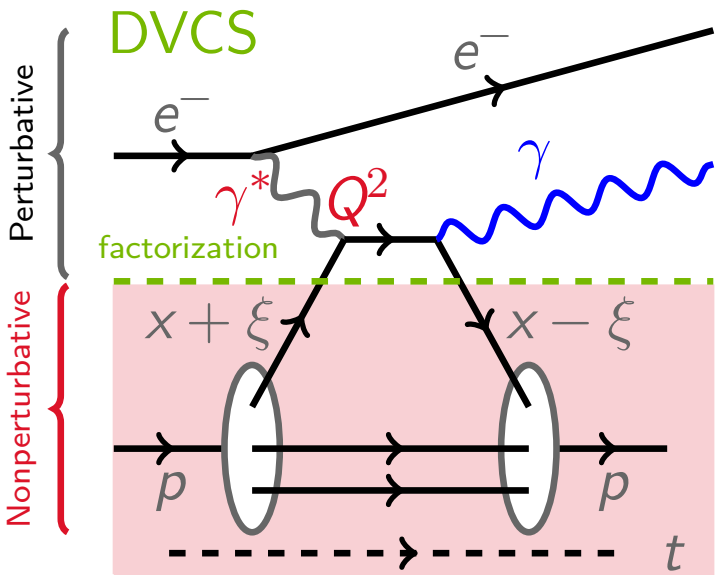


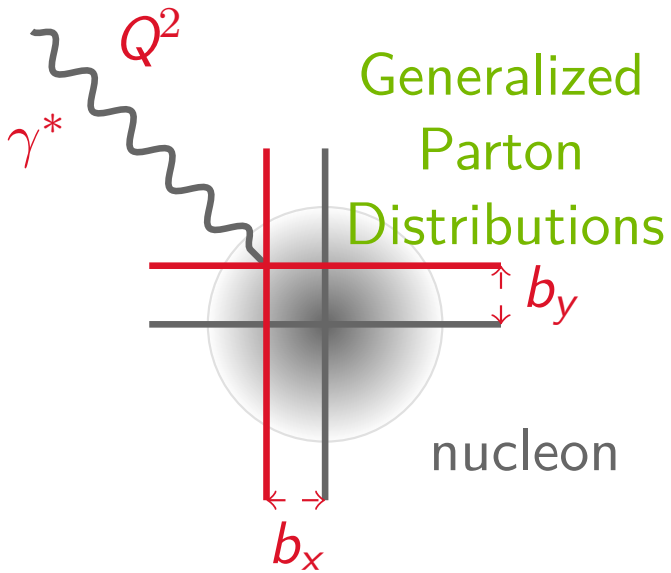


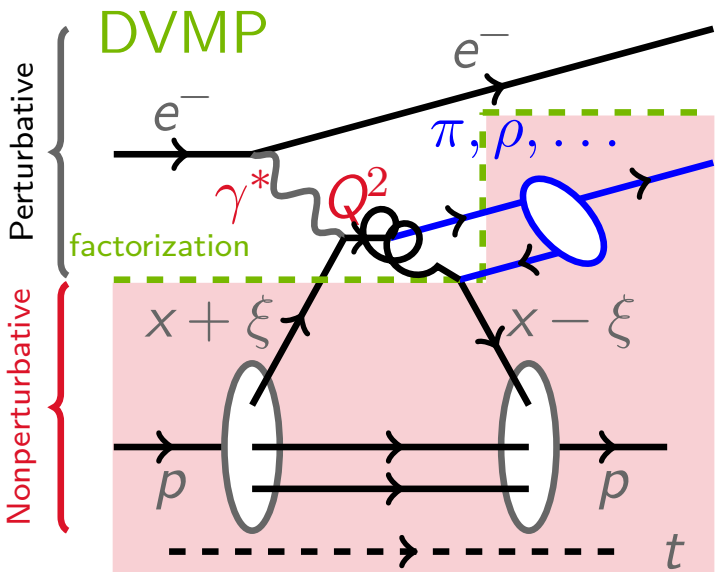


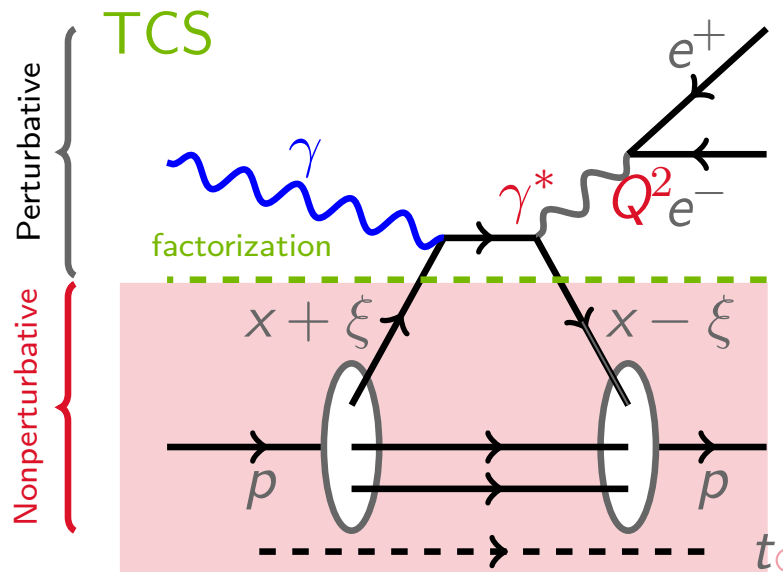
Hard exclusive processes.

Factorization and universality.









Nucleon tomography

Hard exclusive processes

GPD metrology

Interpretation

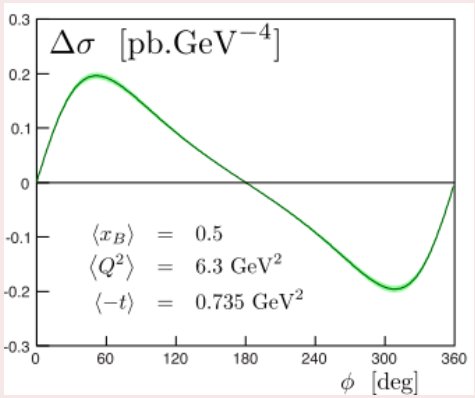
- Key features:
  - Multi-channel analysis (other channels can/are being/will be proposed).
  - Wide kinematic range (fixed-target and collider experiments).
  - Many different observables (spin physics).
  - Harmonic structure of observables (*e.g.* in DVCS).
  - Majority of data points with large M^2/Q^2, $|t|/Q^2$.
- Consequences:
  1. Software framework for global analysis?
  2. Further work in perturbative QCD (higher-orders in evolution/coefficient function kernels, resummation, etc.)?
  3. Higher-twist effects?

GPD metrology

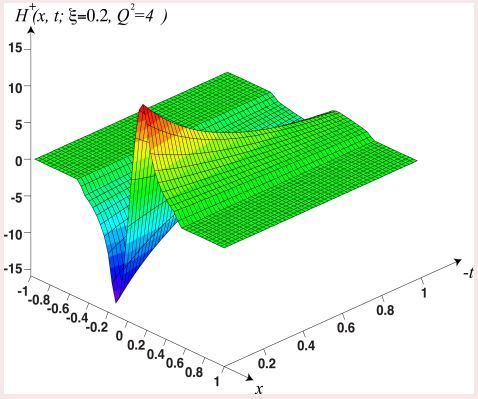
Imaging the nucleon. How?

Extracting GPDs is not enough...Need to extrapolate!

1. Experimental data fits



2. GPD extraction



3. Nucleon imaging

Images from Guidal et al., Rept. Prog. Phys. 76 (2013) 066202

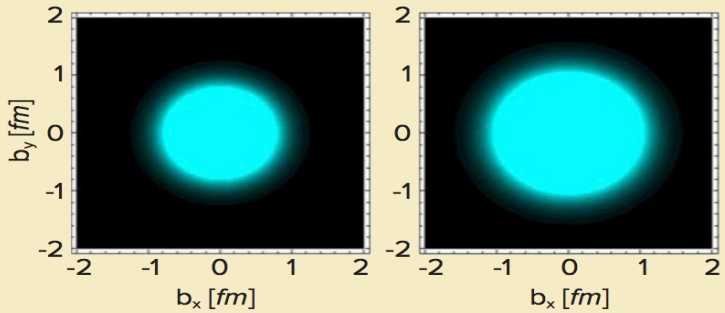
Reaching for the Horizon

The 2015 Long Range Plan for Nuclear Science

Sidebar 2.2: The First 3D Pictures of the Nucleon

A computed tomography (CT) scan can help physicians pinpoint minute cancer tumors, diagnose tiny broken bones, and spot the early signs of osteoporosis. Now physicists are using the principles behind the procedure to peer at the inner workings of the proton. This breakthrough is made possible by a relatively new concept in nuclear physics called generalized parton distributions.

An intense beam of high-energy electrons can be used



Imaging the nucleon. How?

Extracting GPDs is not enough...Need to extrapolate!

1. **Extract** $H(x, \xi, t, \mu_F^{\mathrm{ref}})$ from experimental data.
2. **Extrapolate** to vanishing skewness $H(x, 0, t, \mu_F^{\mathrm{ref}})$.
3. **Extrapolate** $H(x, 0, t, \mu_F^{\mathrm{ref}})$ up to infinite t and down to vanishing t.
4. **Compute** 2D Fourier transform in transverse plane:

$$H(x, b_\perp) = \int_0^{+\infty} \frac{\mathrm{d}|\Delta_\perp|}{2\pi} \, |\Delta_\perp| \, J_0(|b_\perp||\Delta_\perp|) \, H(x, 0, -\Delta_\perp^2)$$

5. **Propagate** uncertainties.
6. **Control** extrapolations with an accuracy matching that of experimental data with **sound** GPD models.

GPD metrology.

Nonperturbative QCD, fitting strategies and observable definitions.

Nucleon tomography

Hard exclusive processes

GPD metrology

Interpretation

- GPD models satisfying all theoretical constraints to decrease the volume of the functional space to be scanned.
- What about GPDs without "enough" phenomenological constraints (forward limit, etc.)?
- Fitting strategies?
- What are the "best" observables?

Interpretation of GPD extractions

Understanding QCD in the infrared?

What do we learn about QCD dynamics from the images?

- Frequently heard:
  - "motion of confined quarks"
  - "mapping confinement forces"
  - ...
- What are the **quantitative statements** we can actually make?
- What are the QCD key questions? (following Jaffe and Witten)
  1. Confinement?
  2. Dynamical chiral symmetry breaking?
  3. Existence of a mass gap?
- What are the relevant channels, observables or nonperturbative objects?

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