Aspects of GPDs

- Unified description of nucleon structure probed in

  Inclusive DIS
  Elastic form factors
  Hard exclusive processes

- Access to operators not available in standard electroweak interactions

  EM Tensor, J_q

- Quark/gluon imaging of nucleon

  2D "tomography"
  3D imaging

Q: What can measurements of hard exclusive processes

DVCS
meson production

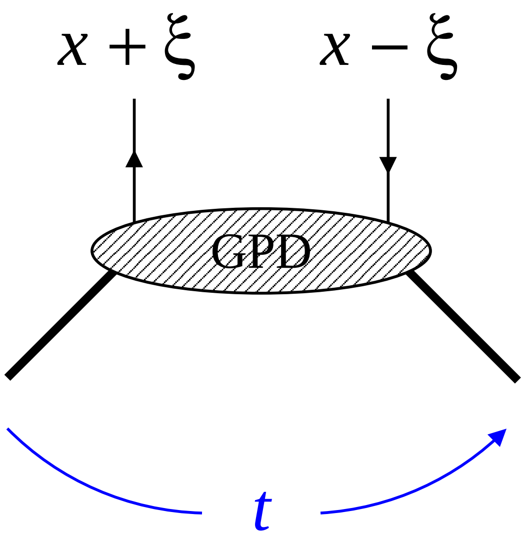
contribute to our knowledge of GPDs?

GPDs: Distinguish three regions

$\longrightarrow$ Interest for nucleon structure

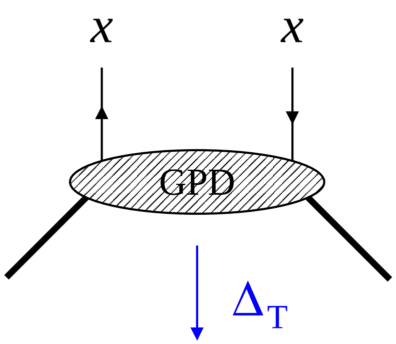
$\longrightarrow$ Experimental access

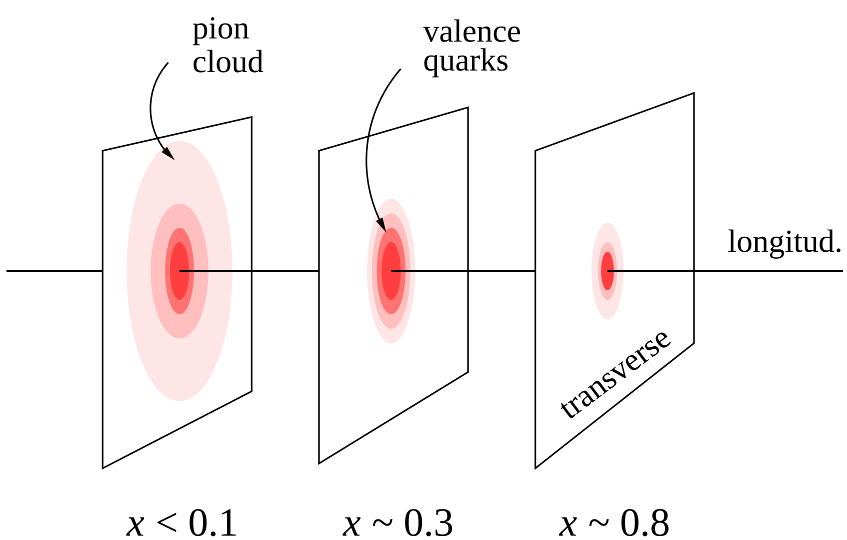
$\longrightarrow$ Theoretical understanding



I)	$\xi = 0$	Transverse quark imaging (“tomography”)
II)	$x = \xi$	“Stopping” of fast quark
III)	$x \neq \xi$	3D imaging, sum rules

I) GPDs at $\xi = 0$: Transverse parton imaging



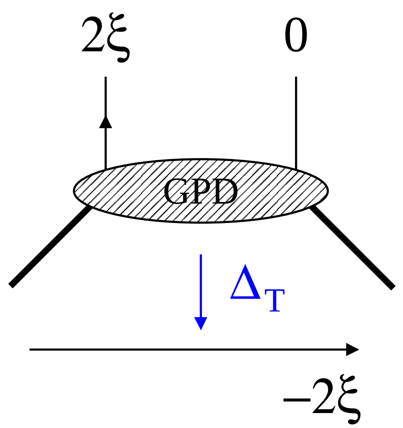


- Input: PDFs, Formfactors
- Correlation $x \leftrightarrow t$
  - $x \to 1$: pQCD
  - Small x: Regge, DGLAP evolution
  - Intermediate x: Lattice
- Interesting: Transverse spin, etc.

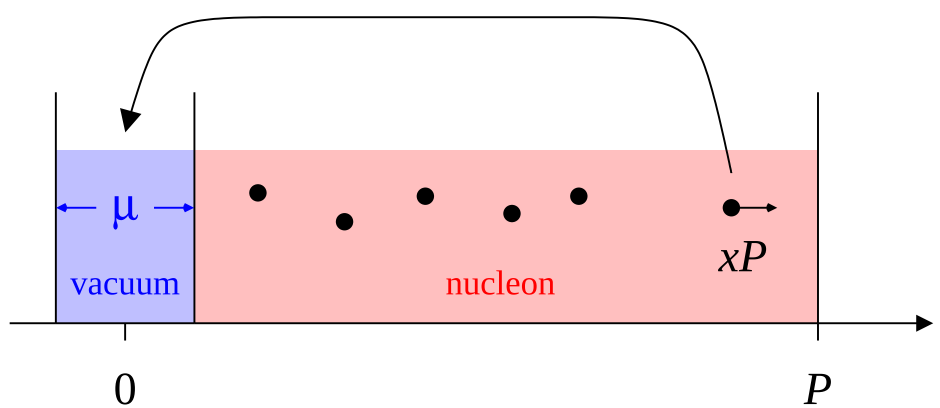
Theory well understood;
No direct access at large x
$(\xi, t_{\min} \neq 0)$

Small $x \to$ tomorrow

II) GPDs at $x = \xi$: Stopping of fast quark



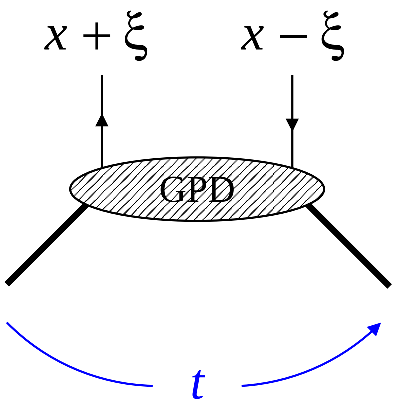
- Probed by $\mathrm{Im(DVCS)}$ at leading twist
- Overlap of very different configurations in nucleon wave function
  - Role of vacuum structure?
  - Hard–soft separation, QCD evolution?



Directly accessible in experiment

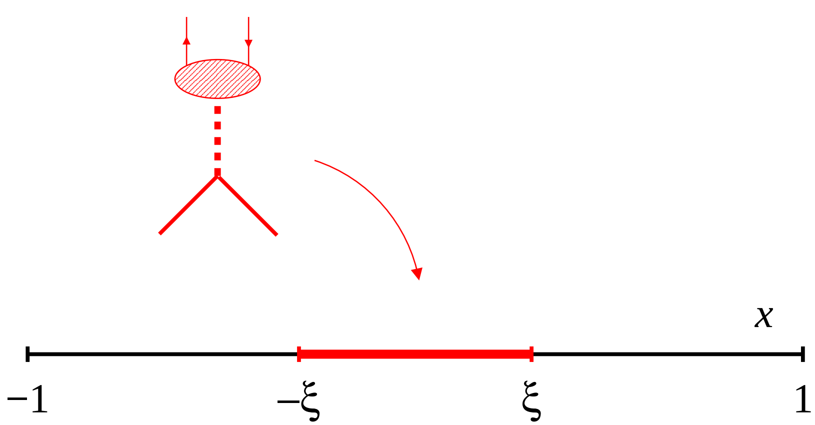
Challenge for theory: Can we relate it to PDF/formfactor?

III) GPDs at $x \neq \xi$: General case



- Needed for 3D imaging,
  Ji's angular momentum sum rule
  $\int dx\, x\, [H_q(x,\xi) + E_q(x,\xi)]_{t=0} = 2J_q$

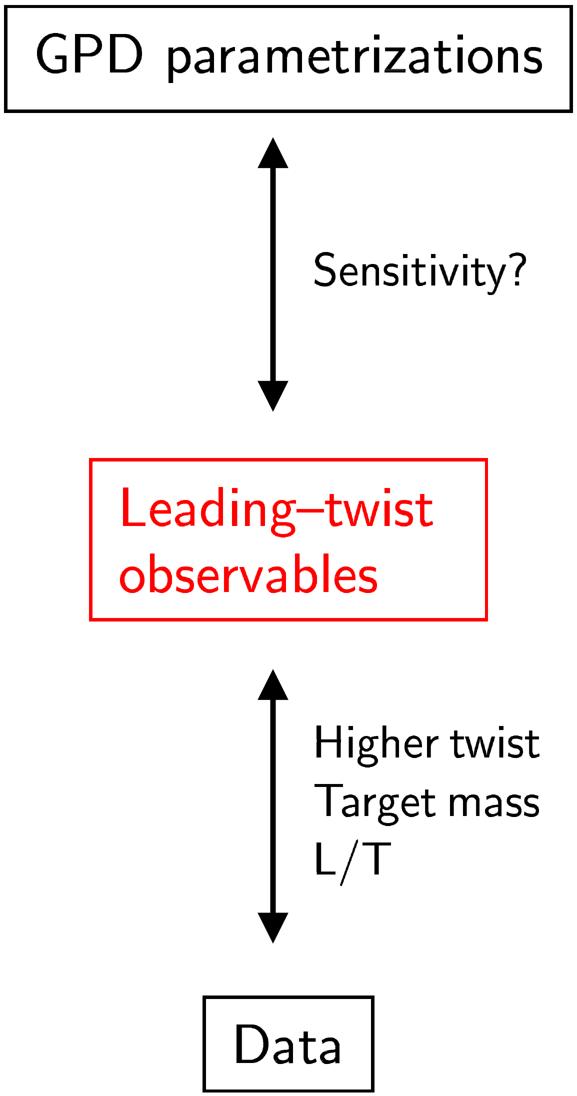
- Probed by $\mathrm{Re(DVCS)}$ at leading twist



- Two–component structure:
  "Meson exchange" contributions
  for $-\xi < x < \xi$

Challenging for both experiment and theory!

From electroproduction data to GPDs



2D/3D Imaging
Sum rules J_q

$$\mathrm{Im(Amp)} \quad \sim \quad H(x = \xi, t)$$

$$\mathrm{Re(Amp)} \quad \sim \quad \int dx \, \frac{H(x, \xi, t)}{x \pm \xi}$$

$(e, e'\gamma)$ cross section,
target/beam spin asymmetry

$(e, e' \, \mathrm{meson})$ cross section
and response fns (L/T)

GPD Parametrizations

GPD parametrizations: Requirements

Kinematic/ geometric constraints

- PDF, formfactor as limits
- Polynomiality: $\int dx\, x^n\, H(x,\xi) = \mathrm{Pol}_{n+1}(\xi)$

- Non-perturbative dynamics at $x \to \xi$

Dynamical input

- "Meson exchange" contributions at $-\xi < x < \xi$
- Correlation $x \leftrightarrow t$ dependence

GPD parametrizations: Overview

	Basic idea	Comments
Double distribution	Spectral representation symmetric in P, Δ; Polynomiality	Widely used at large x Relation to nucleon structure?
"Dual" parametrization	t–channel partial wave expansion; "Dual" amplitudes	LO evolution included Natural small–x expansion Useful at large x?
Conformal parametrization	Diagonalization of QCD evolution; Complex angular momentum representation	LO/NLO evolution; Connection with Regge phenomenology at small x

1) Radyushkin 96; Polyakov, CW 99; Belitsky, Müller 00; Goeke, Polyakov,Vanderhaeghen, 2001

2) Polyakov, Shuvaev 02; Polyakov, Guzey 06

3) Müller, Schäfer 05

GPD parametrizations: Questions

- Do we understand the $x \to \xi$ behavior?

  How do measurements of $H(x = \xi) \sim \mathrm{Im(DVCS)}$ constrain GPDs elsewhere?

- Sensitivity of $\mathrm{Re(DVCS)}$ to parameters?

- What can lattice calculations of moments contribute?