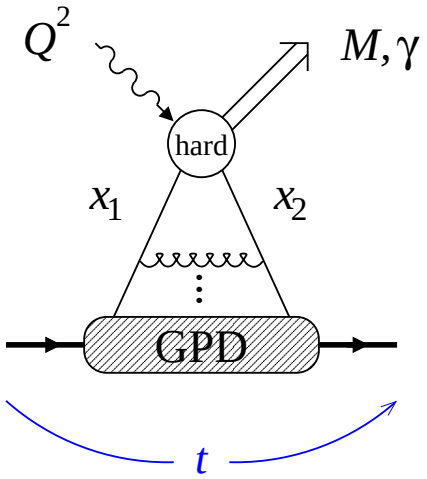
Exclusive processes with EIC: Physics at small and large t

C. Weiss (JLab), EIC Collaboration Meeting, CUA, Washington DC, 31–Jul–10



- Transverse gluon imaging

  Nucleon center requires $|t| > 1\,\mathrm{GeV}^2$

  Importance for saturation

  Proton dissociation

- Regge dynamics in QCD

  Disappearance of diffusion at large t

  Physics in large–t diffraction

- Chiral dynamics in peripheral collisions

  "Pion cloud" from $|t| \sim M_\pi^2$?

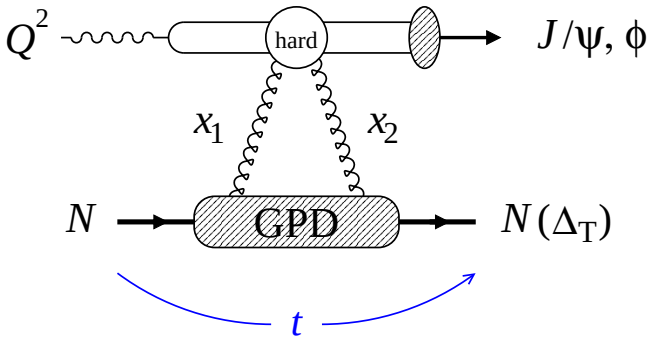
  Direct probe with large–t knockout processes $\gamma^* N \to N + \pi + V$

What t–ranges do we need for the physics?

$\to$ Detectors

$\to$ Luminosity, rates

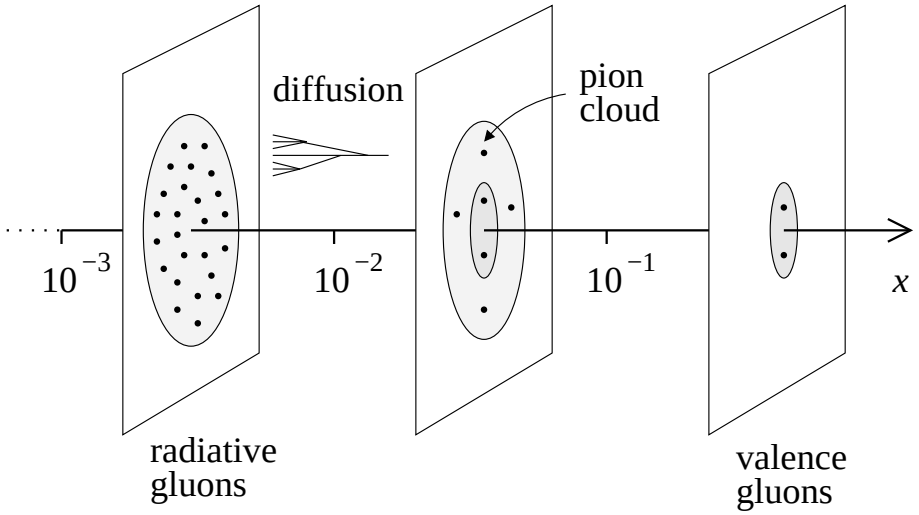
Gluon imaging: Exclusive processes



- $Q^2, M^2 \gg$ hadronic scale: Meson produced in small–size configuration

  QCD factorization theorem $Q^2_{\rm eff} \gg |t|$
  Collins, Frankfurt, Strikman 96

  GPDs: Gluonic form factor of nucleon, universal, process–independent

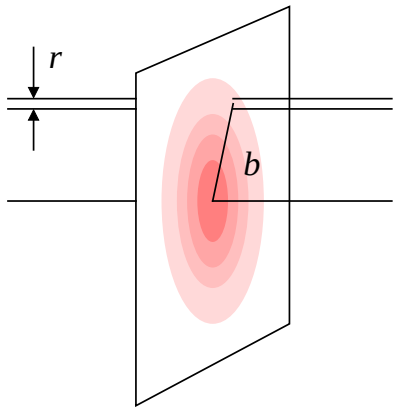


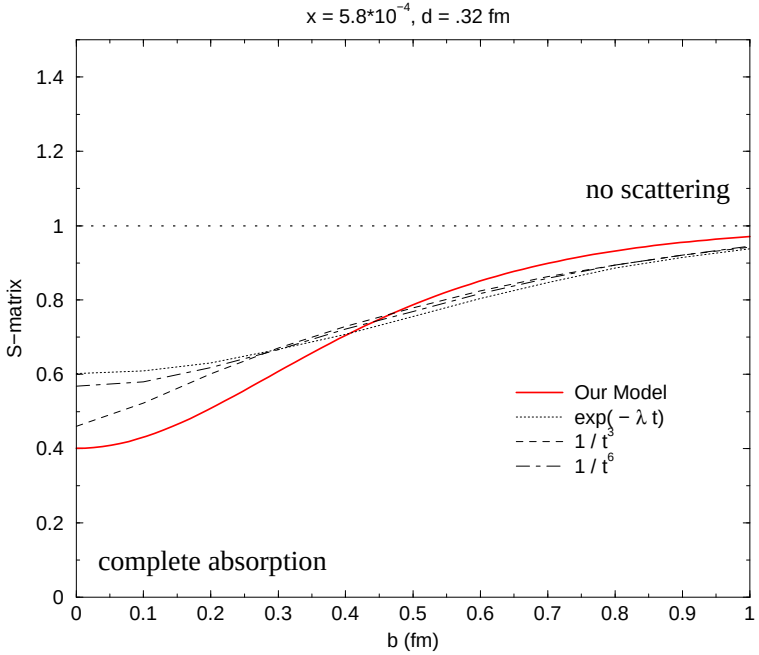
- Physical interest

  Transverse spatial distribution of gluons and its change with $x \to$ Dynamics!

  Longitudinal correlations $x_1 \neq x_2$

Gluon imaging: Importance for saturation





S–matrix of dipole–nucleon scattering. Rogers et al. 03

- Transverse spatial distribution of gluons essential input in saturation studies

  Gluons at $x > 10^{-2}$ define initial conditions for non-linear QCD evolution

  $Q_s \sim$ gluons/transverse area

- Dipole model phenomenology
  Kowalski, Teaney 03; Rogers, Guzey, Strikman, Zu 03

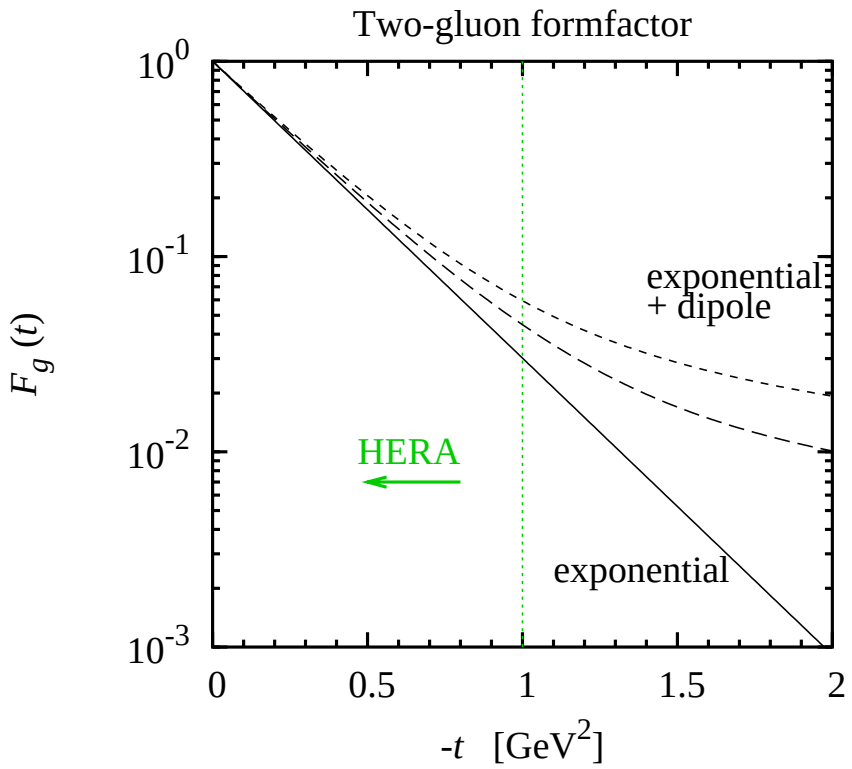
  Optical picture of dipole–nucleon scattering

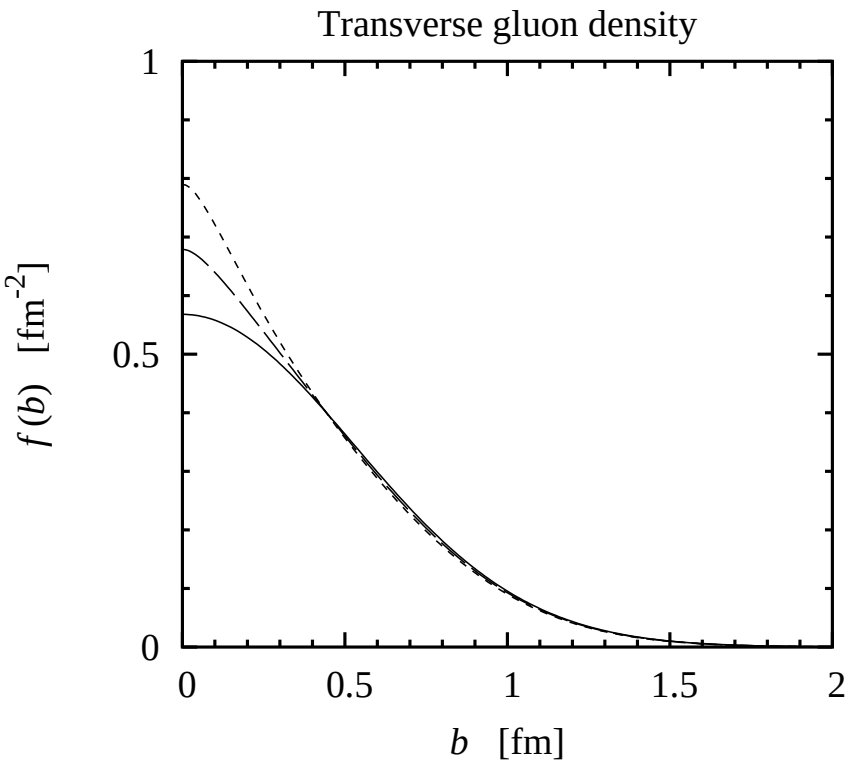
  Black–disk regime at high gluon density

- Considerable uncertainty in input for $b < 0.3$ fm! Munier, Stasto, Mueller 01; Rogers et al 03

Need transverse gluon density at proton center $b < 0.3$ fm!

Gluon imaging: Required t–range



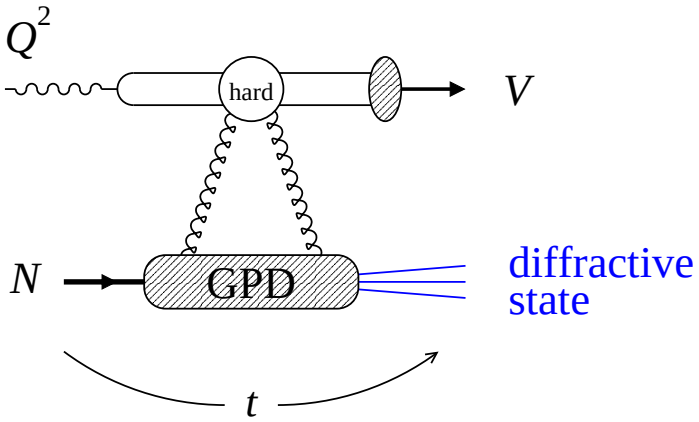


- Nucleon center $b < 0.3$ fm requires $|t| > 1\,\mathrm{GeV}^2$

  Expect power–like pQCD behavior at large $|t|$ . . . where does it start?

  $|t| > 1\,\mathrm{GeV}^2$ not covered at HERA

Gluon imaging: Challenges at large $|t|$



- High probability of nucleon dissociation

$$\frac{d\sigma/dt\,(\text{diss})}{d\sigma/dt\,(\text{el})} \approx 0.2\,e^{3.5|t|}$$ H1 2010

HERA: Model–dependent correction for nucleon dissociation precludes observation of pQCD power behavior
$\rightarrow$ Recoil detection!

- QCD factorization requires $Q^2_{\text{eff}} \gg |t|$

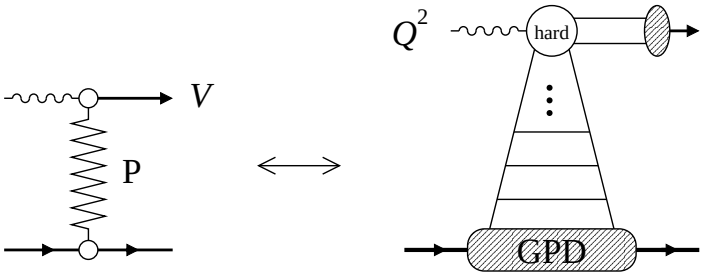
J/ψ photoproduction $Q^2_{\text{eff}} \approx 3\,\text{GeV}^2$

Electroproduction with $Q^2 > 10\,\text{GeV}^2$
$\rightarrow$ Luminosity

- Physics in diffractive dissociation: Quantum fluctuations of gluon density

Frankfurt, Strikman, Treleani, CW 08

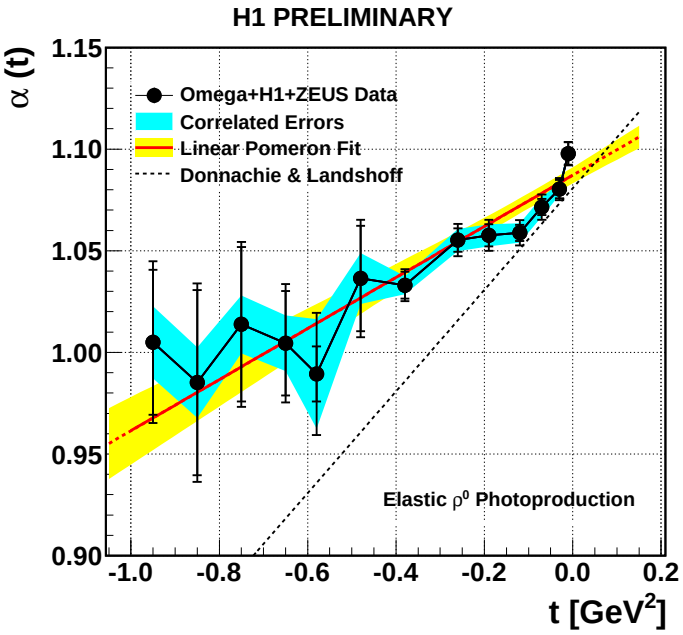
Regge dynamics in QCD



- Fundamental question: How Regge dynamics emerges from QCD

  Energy dependence at $t = 0$
  $W^{4(\alpha_P - 1)} \leftrightarrow [G(x, Q^2)]^2$

  Q^2 evolution: DGLAP, BFKL? HERA



Seen in HERA ρ^0 data? B. List, arXiv:0906.4945v1

- More insight from t–dependence: α' from "diffusion" in partonic ladder

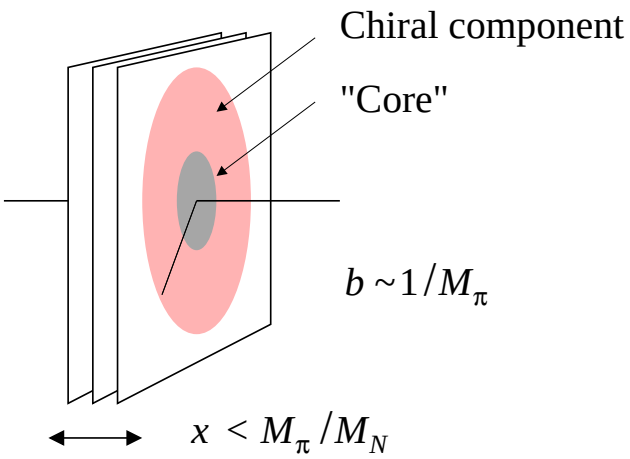
  Q^2 dependence explained by DGLAP
  FSW 04; Müller at al. 04

  Diffusion suppressed at $|t| \gg$ soft scale:
  Expect flattening of trajectory
  Blok, Frankfurt, Strikman, 10

- New physics in inelastic diffraction at $t \sim (Q^2 + M_V^2)$ BFS 10

Great interest in $|t| \sim$ few GeV^2

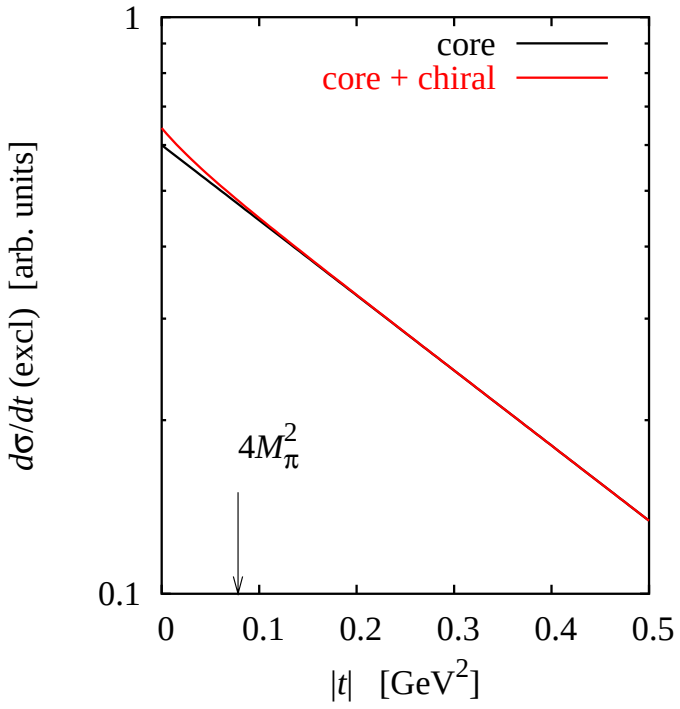
Chiral dynamics: Effect on t–distribution



- Large–distance component at $b \sim 1/M_\pi$ from chiral dynamics: "Pion cloud"

  Model–independent, cf. Yukawa tail
  Strikman, CW 03/09

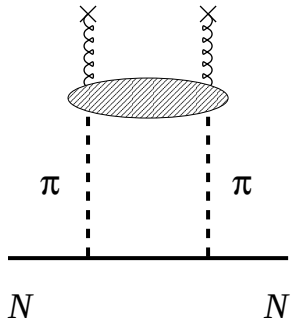
  Sizable contribution to $\langle b^2 \rangle$ at $x < 0.1$, different for quarks and gluons



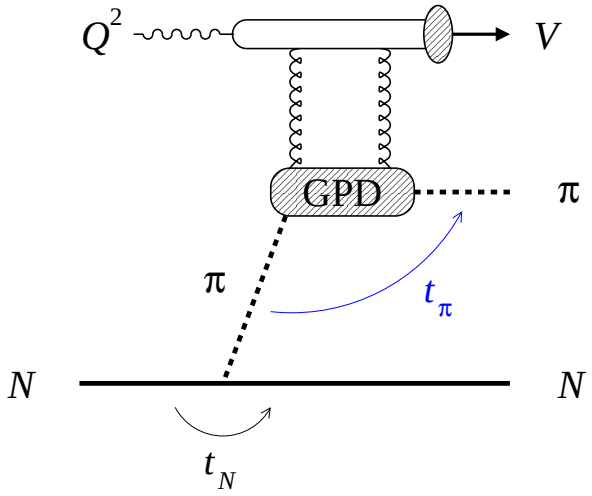
- Can we detect it in t–distribution?

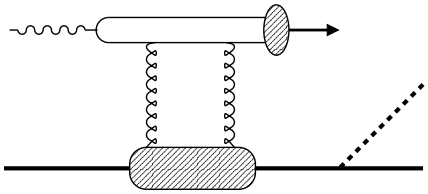
  Small effect – very challenging!

  Needs detailed modeling of non-chiral core



Chiral dynamics: Pion knockout processes





suppressed!

- Hard exclusive process on pion emitted by nucleon Strikman, CW 03

  $k_\pi^2 \sim M_\pi^2$ quasi-real

  Requires $x \ll M_\pi/M_N \sim 0.1$

- Kinematics with $p_T(\pi) \gg p_T(N)$ suppresses production on nucleon

  $F_{\pi NN}(t)$ softer than $\mathrm{GPD}_\pi(t)$

- Probe gluon GPD in pion at $|t_\pi| \sim 1\,\mathrm{GeV}^2$

  Fundamental interest

  Moments calculable in Lattice QCD

- Experimental requirements: Detection of forward nucleon and moderate–p_T pion

Direct probe of chiral component of partonic structure!

Summary

- Imaging of nucleon center requires $|t|$ up to ~ 2 GeV^2

  Essential input to saturation studies

- Great interest in elastic and dissociative vector meson production at $|t| \sim$ few GeV^2

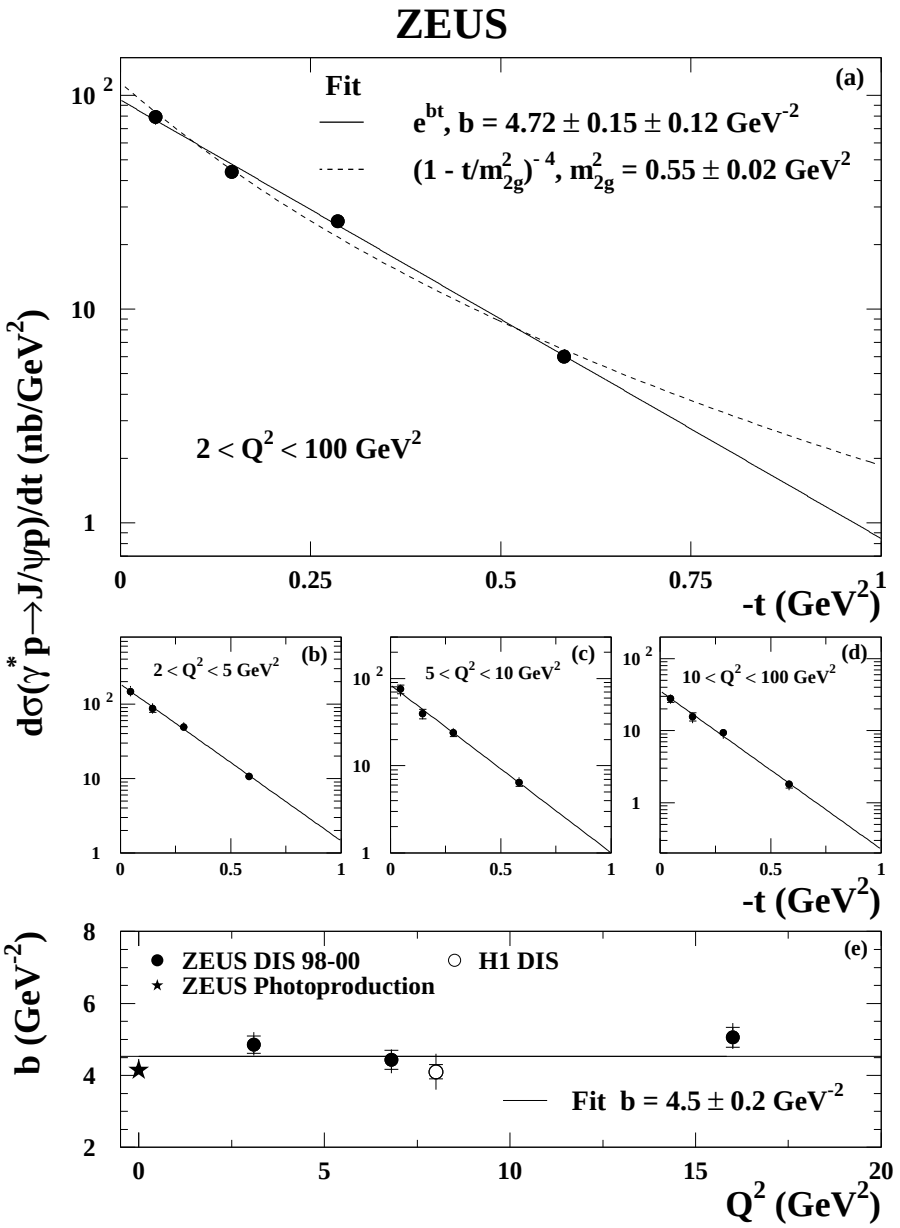
- Develop physics narrative for diffractive dissociation $\gamma^* N \to V + X$

  Quantum fluctuations of gluon density
  Diffusion dynamics in partonic many–body system
  Multiscale problem

- Chiral dynamics can be probed in knockout processes $\gamma^* N \to V + \pi + N$

Supplementary material

Gluon imaging: J/ψ in ep at HERA



- t–dependence of J/ψ electroproduction ZEUS 04