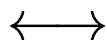


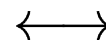
Hard QCD Processes: Connecting ep at JLAB and pp at LHC

Ch. Weiss (JLAB), PN12 Workshop, 11/2/04

Exclusive processes
in ep scattering
at large Q^2



Transverse spatial
distribution of partons
in nucleon
“GPD’s”



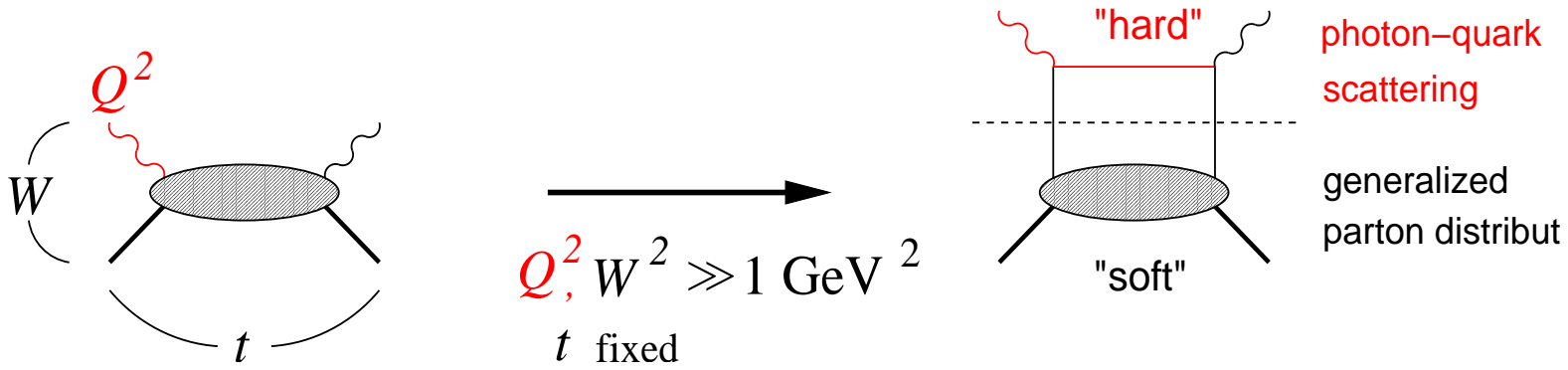
Hard processes in
high-energy pp collisions
(dijets, Higgs production)

JLAB at 12 GeV
HERMES, COMPASS

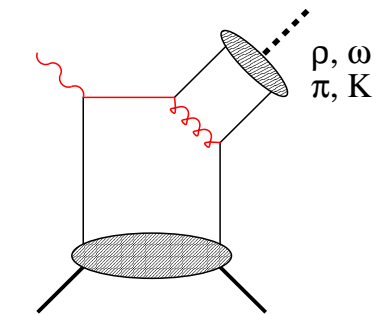
HERA, EIC

LHC
Tevatron
RHIC

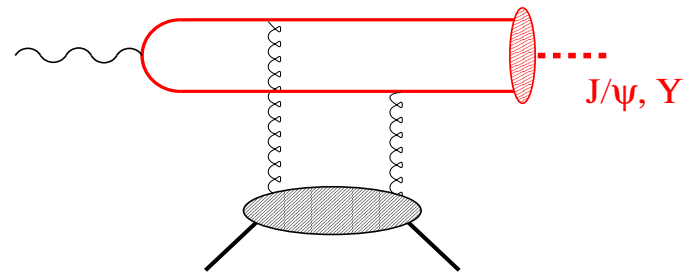
- Exclusive processes in ep : Factorization



... Similarly:

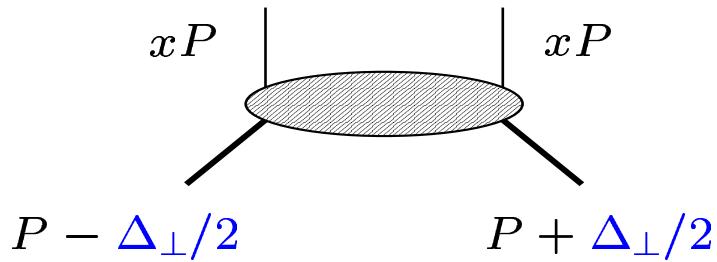


light meson
electroproduction



heavy quarkonium
photoproduction

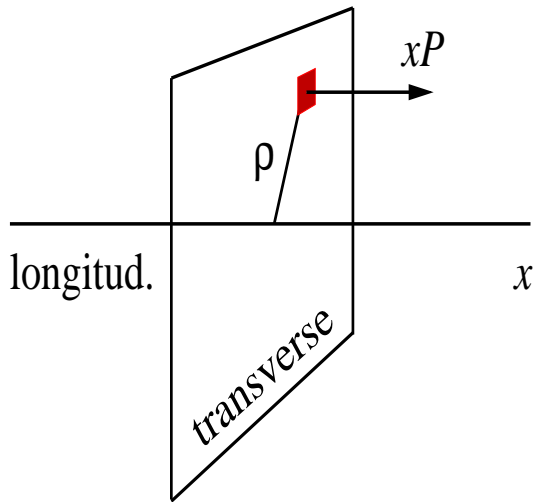
- Transverse spatial distribution of partons [Burkardt 02]



$$H(x, t) = \int d^2\rho e^{-i\vec{\Delta}_\perp \cdot \vec{\rho}} q(x, \rho)$$

form factor
of quarks with
longitudinal
momentum xP

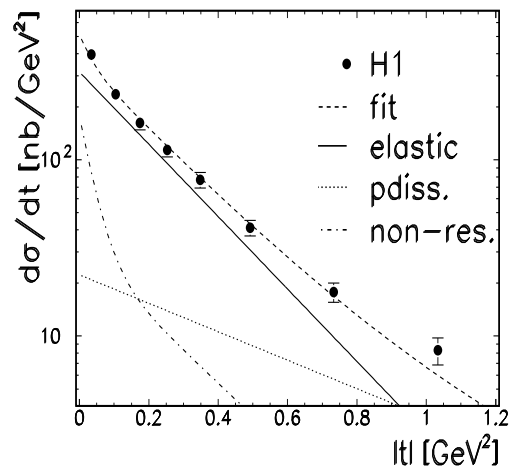
transverse spatial
distribution



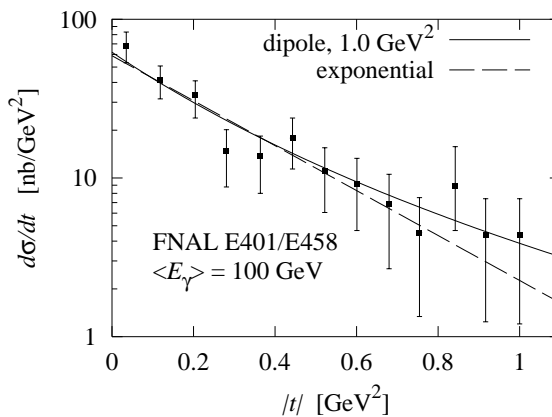
$$\int d^2\rho q(x, \rho) = q(x) \quad \text{total quark density}$$

$$\langle \rho^2 \rangle_x = 4 \frac{\partial}{\partial t} \frac{H(x, t)}{H(x, t=0)} \quad \text{transv. size of nucleon, } x\text{-dependent!}$$

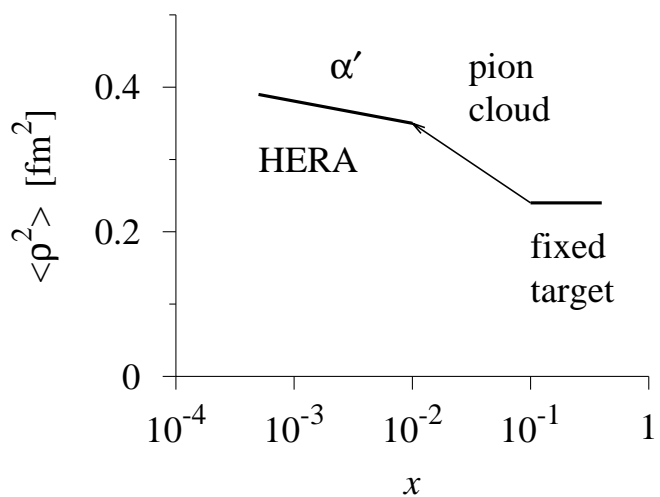
- J/ψ photoproduction: $\langle \rho^2 \rangle_{\text{gluon}}$ from $\frac{d\sigma}{dt} \propto [H_{\text{gluon}}(x, t)]^2$



HERA H1 (00)

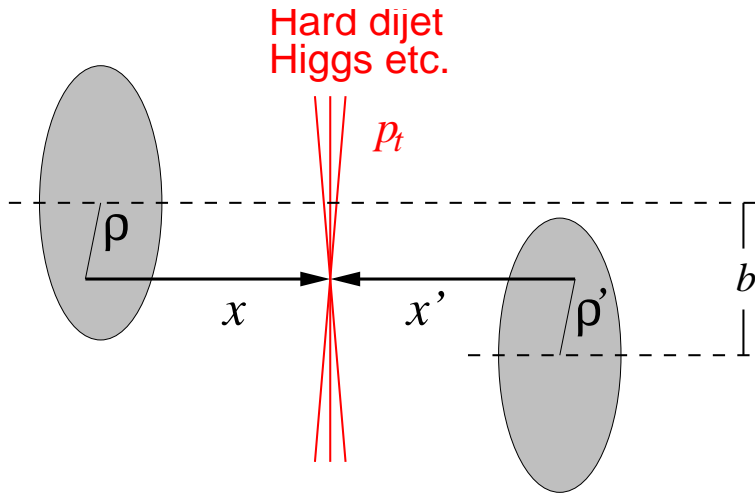


Fermilab E458 (82)



[Strikman, CW 03/04]

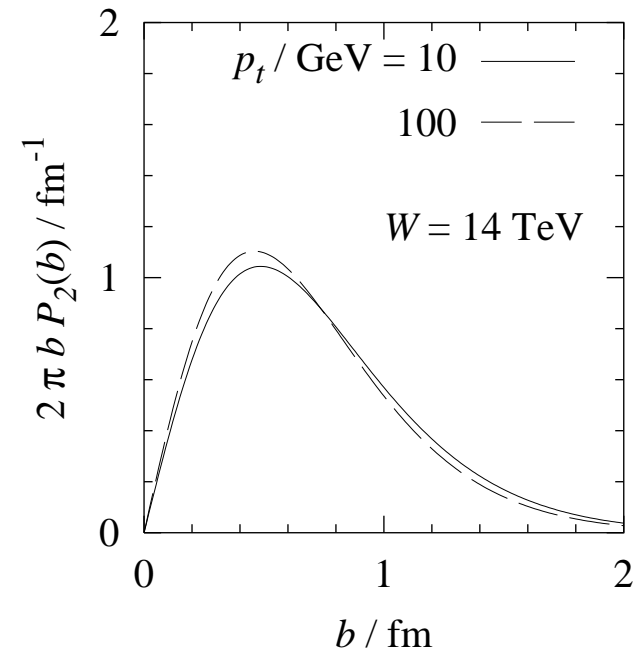
- Application: Hard processes in high-energy pp ($p\bar{p}$) collisions



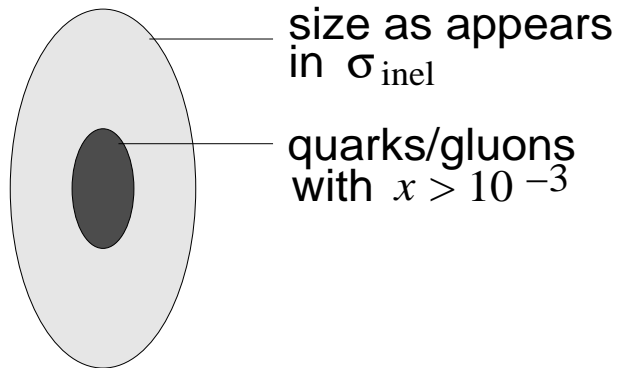
Overlap of transverse spatial distns of partons determines impact parameter (b) dependence of cross section

$$P_2(b) = \int d^2\rho \int d^2\rho' \delta(\mathbf{b} - \boldsymbol{\rho} + \boldsymbol{\rho}') \times \frac{g(x, \rho)}{g(x)} \frac{g(x', \rho')}{g(x')}$$

[Frankfurt, Strikman, CW 03/04]



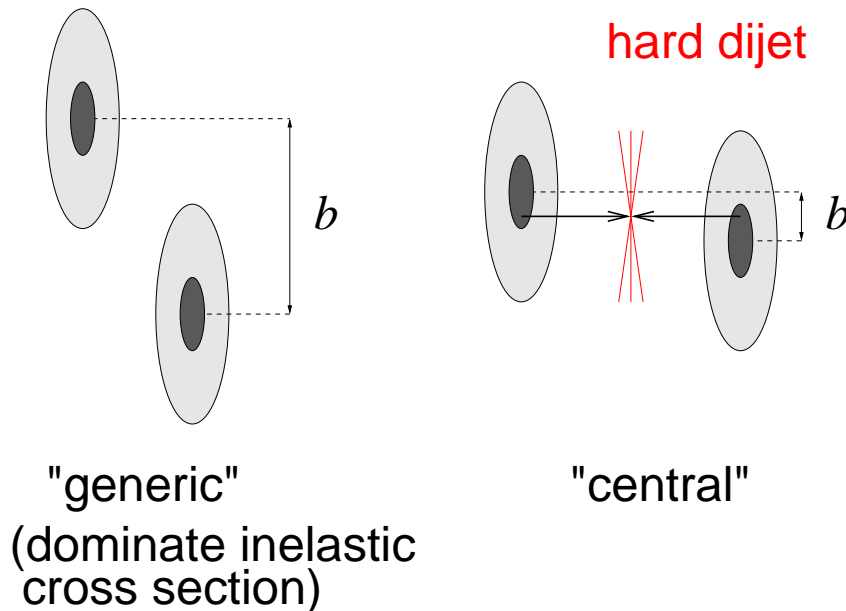
- Events with hard dijets vs. generic inelastic events



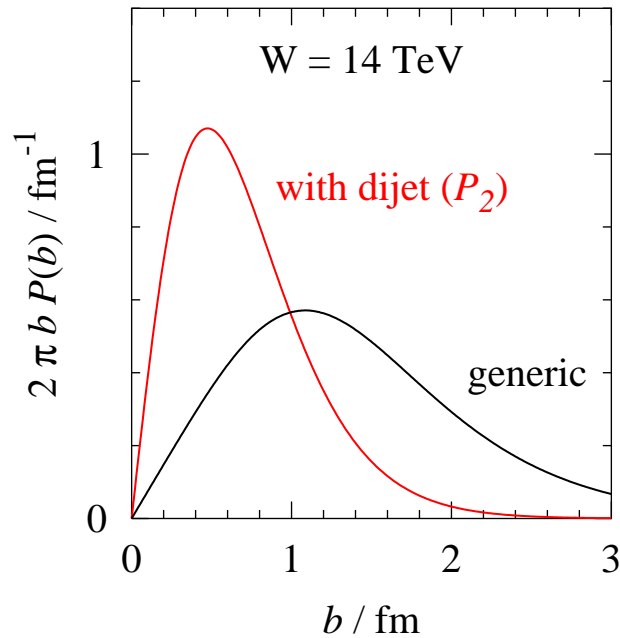
$$\langle \rho^2 \rangle_{q,g} \ll R_{\text{inel}}^2 \text{ at high energies}$$

... Two scales!

→ Classification
of pp events



- Comparison of impact parameter distributions



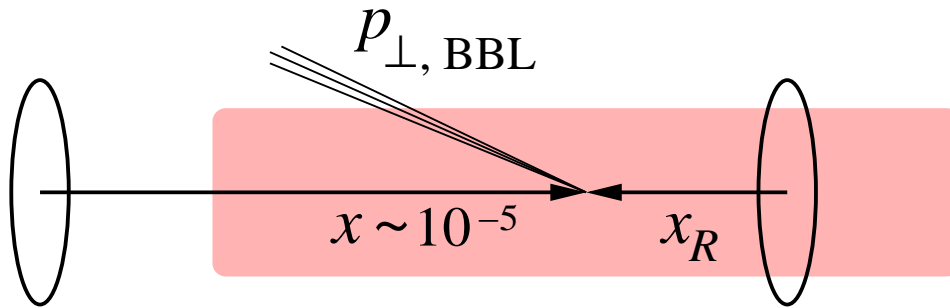
$\langle b^2 \rangle$ [fm²] average impact parameter

	W/TeV	dijet	double dijet	generic
LHC	14	0.67	0.26	2.7
Tevatron	1.8	0.63	0.24	1.8
RHIC	0.5	0.59	0.23	1.43

Hard dijet production: “Filter” for central pp collisions (Trigger)

... Numerous applications!

- Strong gluon fields in central pp collisions at LHC



Interaction of
“spectator” parton
with other proton

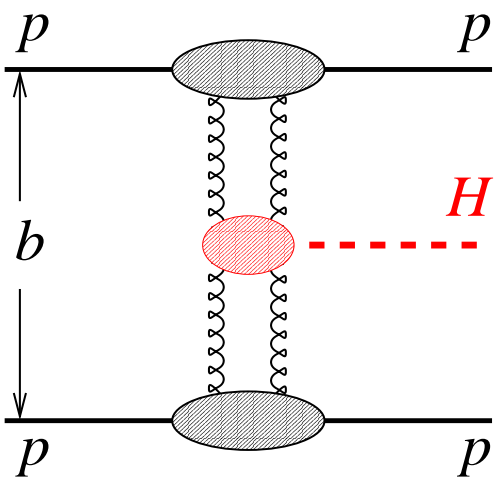
→ Unitarity (“black body”) limit: $P(\text{inelastic}) \rightarrow 1$

→ Spectator parton acquires **large transverse momentum**:
 $p_{\perp, \text{BBL}}^2 \sim 10 \text{ GeV}^2 \gg \Lambda_{\text{QCD}}^2$

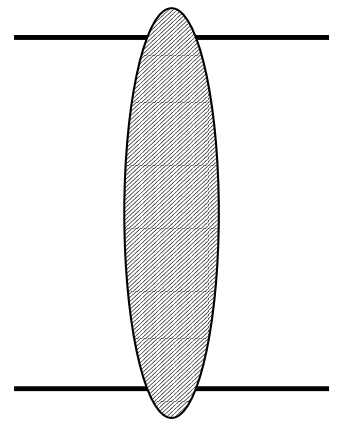
→ Resolved by collision with parton in other proton ($x_R \sim 10^{-1}$):
Hadron production at backward/forward rapidities
modified by large p_{\perp} and absorption effects

[Frankfurt, Strikman, CW 03]

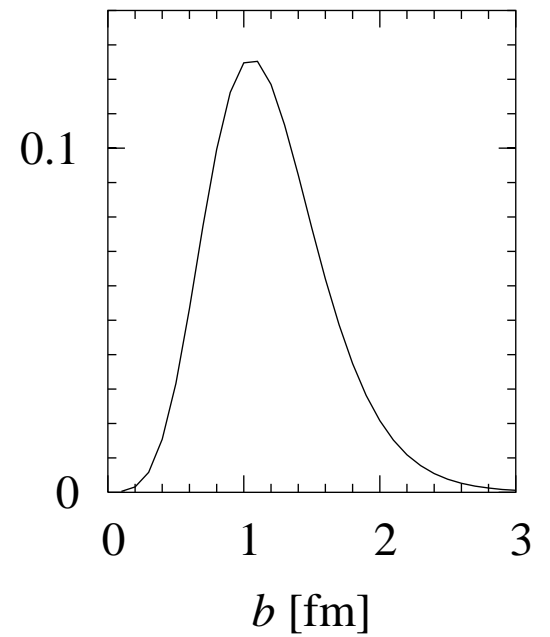
- Diffractive Higgs production at LHC [Frankfurt, Strikman, CW 04]



partonic process



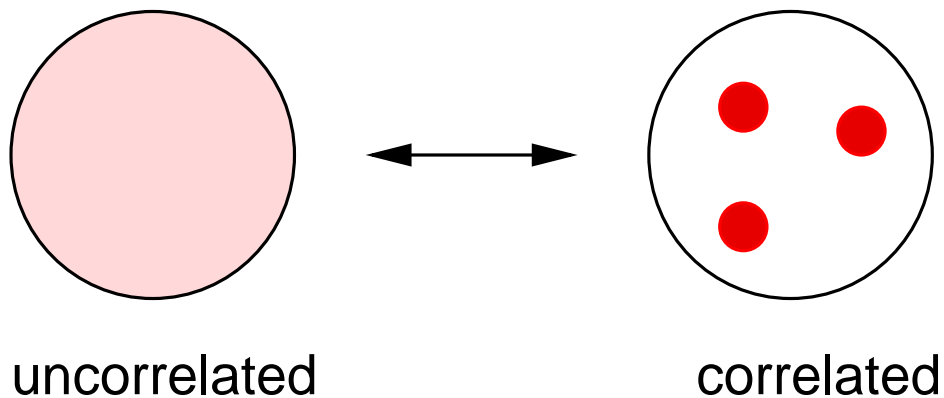
soft interactions
(must preserve rapidity gaps!)



$$P_4(b) \quad \times \quad P[\text{no inelastic}](b)$$

→ Suppression factor $S^2 = 0.03 - 0.06$
 cf. double Pomeron model [Khoze et al. 00]

- Correlations in transverse position of partons



. . . Can be probed in
double dijet production!

CDF (Fermilab) data compatible with
“constituent quarks” of size $\rho \sim 0.3$ fm
cf. Instanton liquid picture of QCD vacuum
[Diakonov, Petrov 84]

[Frankfurt, Strikman, CW 04]

Summary

- Hard QCD processes provide a “handle” on effective impact parameters in high–energy pp collisions
 - ... Trigger on central collisions
- Need more information about the spatial distribution of partons from **exclusive ep scattering**
 - Valence vs. sea quarks, gluons
 - x –dependence of transverse size

JLAB at 12 GeV will help
make the nucleon fit for 14 TeV!