

Exclusive ϕ Electroproduction with CLAS12

PR12-12-007

F.-X. Girod

for the CLAS collaboration

June 18th 2012

Measuring the gluonic radius of the nucleon across the valence region
in the kinematics $Q^2 = 1 \cdots 10 \text{ GeV}^2$ and $t_{\min} - t = 0 \cdots 4 \text{ GeV}^2$

Collaboration



Rensselaer



Fairfield
UNIVERSITY

and the CLAS collaboration

Co-spokespersons : F.-X. Girod, M. Guidal, A. Kubarovsky, V. Kubarovsky, P. Stoler, C. Weiss



F.-X. Girod
PR12-12-007

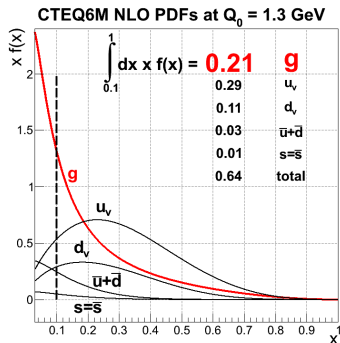
Exclusive ϕ electroproduction

June 18th 2012

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Gluons at large x

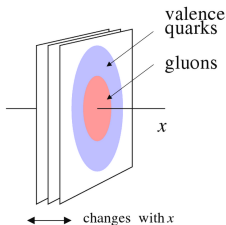


- Large glue density at $x > 0.1$

PDF from global fits

(F_2 evolution, ν_{DIS} , jets)

Gluons carry more than 30%
of the momentum for $0.1 < x$

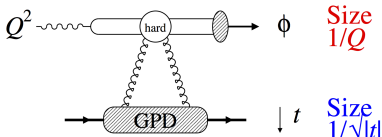


- 3D imaging of the nucleon

spatial distribution of valence quarks :
elastic scattering, DVCS, ...

Nucleon gluonic radius ?
exclusive ϕ

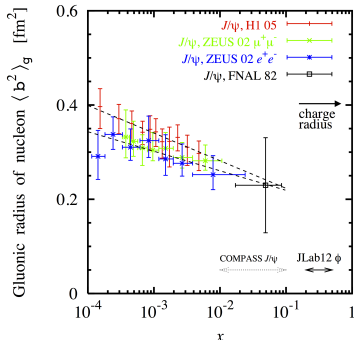
Nucleon gluonic radius at 11 GeV



- Exclusive ϕ electroproduction as the best probe of gluon GPD at 11 GeV

Dominance of small-size configurations at $Q^2 \sim \text{few GeV}^2$

GPD = Universal gluon form factor



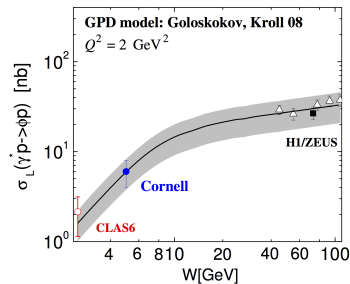
- Gluonic radius as a function of x

Small x : radius grows through parton diffusion

$x < 0.01$ measured: J/ψ and ϕ at HERA H1/ZEUS and Fermilab

$x > 0.1$ unknown range : ϕ with CLAS12

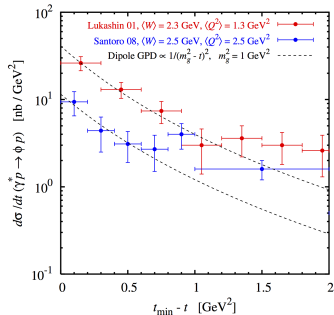
GPD description of ϕ production



- Goloskokov-Kroll 2008 model

includes finite size of $q\bar{q}$ pairs
(Sudakov suppression)

Describes well available cross-section data



- Gluonic radius at 4 and 6 GeV
from CLAS data consistent with
extrapolation from higher energy

dipole mass $m_g^2 \sim 1 \text{ GeV}^2$

Analysis of the cross-section in two steps :

- Test the approach to small-size regime, through model-independent features

When do t -slopes become independent of Q^2 ?

How does W -dependence change with Q^2 ?

L/T ratio and s -channel helicity conservation

- Extract the gluonic radius accross the valence region from the *relative* t -dependence of the differential cross-section

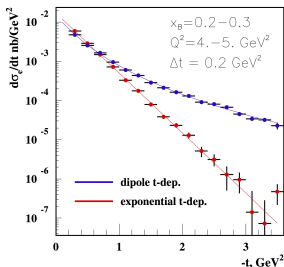
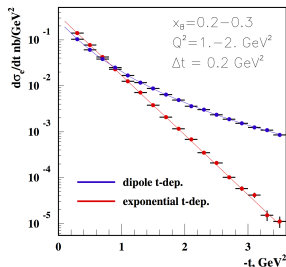
Average gluonic radius : model independent

Change with x : use GPD models (e.g. Double-Distribution)

$$\frac{\frac{d\sigma}{dt}(t)}{\frac{d\sigma}{dt}(t=0)} \propto \frac{\langle H^g(t) \rangle^2}{\langle H^g(t=0) \rangle^2} + E^g \text{ contribution}$$

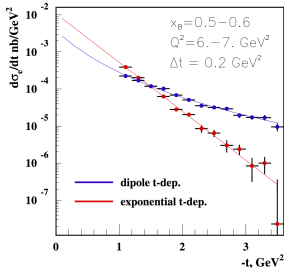
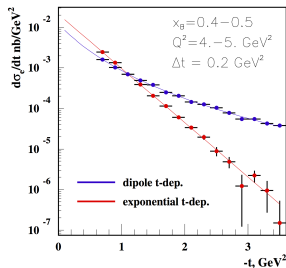
$\hookrightarrow \langle b^g \rangle^2$

Step 1 : Test of model-independent features



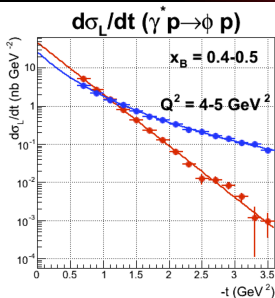
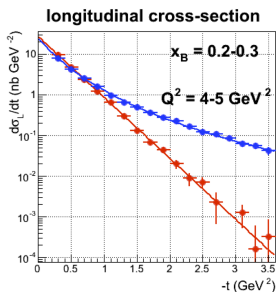
Unseparated cross-sections with exponential and dipole models

CLAS12 $d\sigma/dt$ (ep→epφ)



Precision measurement of t -slopes at fixed x_B

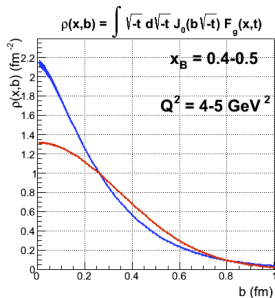
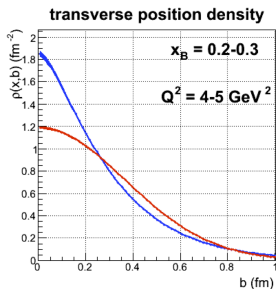
Step 2 : Extraction of gluonic profiles



Longitudinal cross-section

Corresponding sensitivity in transverse position space

$$b = 1/\sqrt{-t}$$



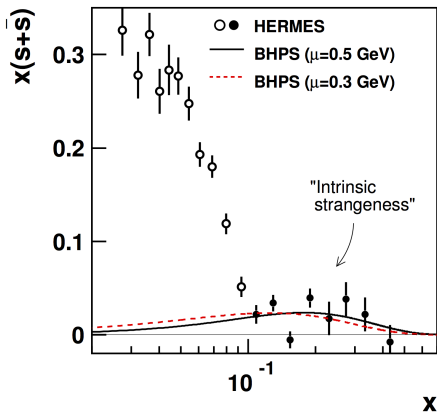
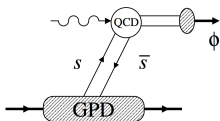
Shown here :
Error propagation study
Skewness $\xi \neq 0$ neglected
average radius

Model/parameterization
error : in progress
S. Venkat *et al*

Phys.Rev. C83 (2011) 015203



Intrinsic strangeness



- Possible contribution near threshold

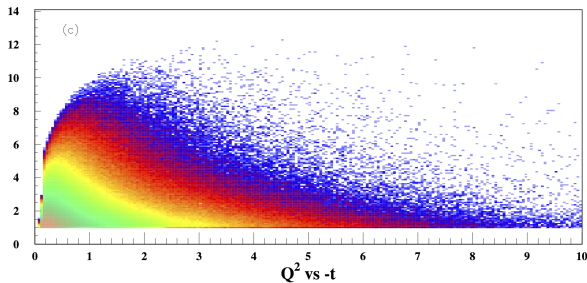
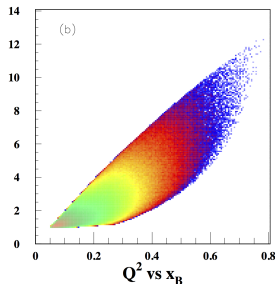
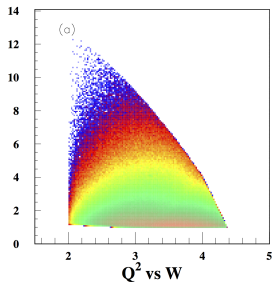
$s\bar{s}$ pair knockout
strange quark GPD in the ERBL region

- HERMES data hints

$s + \bar{s} \neq 0$ at large x ?
A. Airapetian *et al.*,
Phys. Lett. B 666 (2008) 446

- Very interesting if found !
- Theoretical studies in progress

CLAS12 kinematic coverage



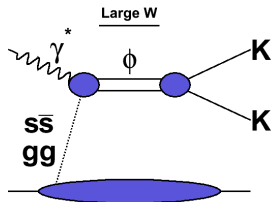
$E_b = 11$ GeV
5 cm LH target
 $\mathcal{L} = 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

3 channels :

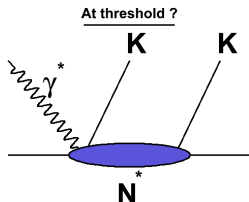
$(ep \rightarrow epK^+)K^-$
 $(ep \rightarrow epK_S)K_L$
 $\hookrightarrow \pi^+\pi^-$
 $(ep \rightarrow epK^+K^-)$

Simulations done with generator
adjusted to world data

ϕ detection mode



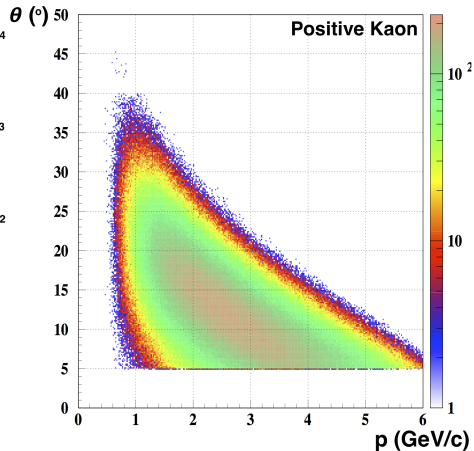
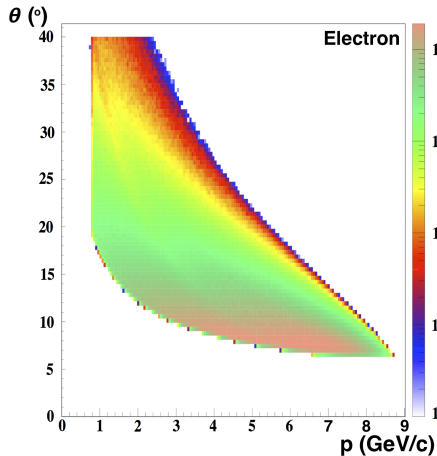
Large acceptance allows simultaneous detection of several decay modes
World first measurement in the neutral mode



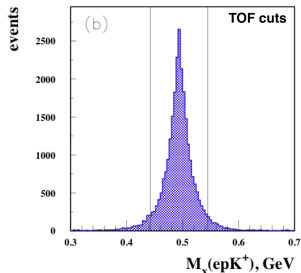
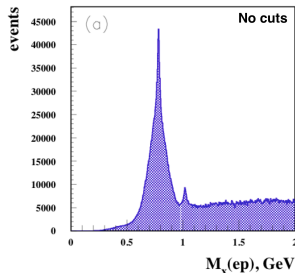
Different production mechanisms
 $\rightarrow \neq$ kinematical dependencies
 $K_L K_S \stackrel{?}{=} K^+ K^-$

Important cross-check for
Universality
Experimental systematic check

Particle kinematic coverage

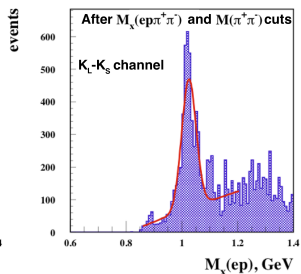
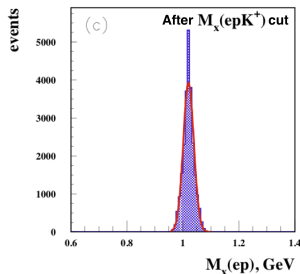


Particle identification



Charged hadrons identified with TOF

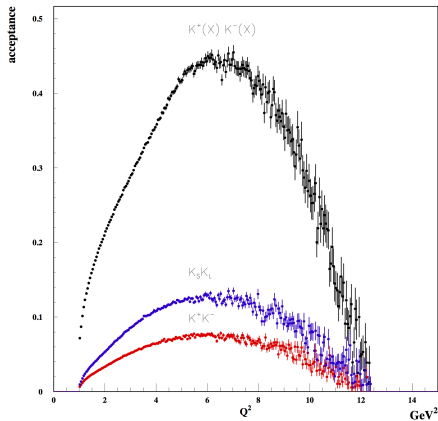
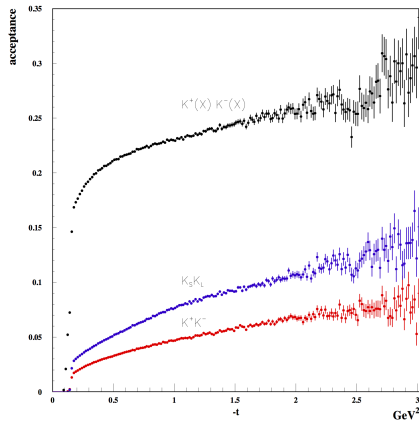
$2.5\sigma_t$ illustrated, up to 6 GeV/c



Large background essentially suppressed for the charged kaon channel

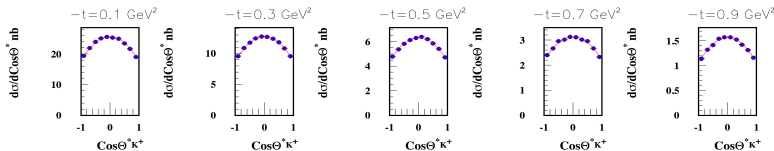
Remaining background in the neutral kaon mode can be subtracted

Acceptance

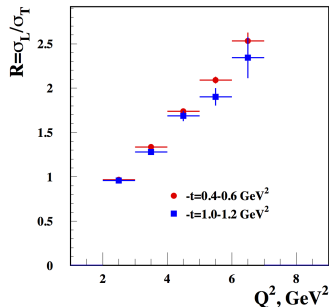
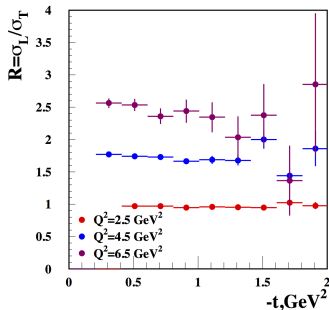


Control over acceptance systematic errors using several channels

Extraction of the LT-ratio

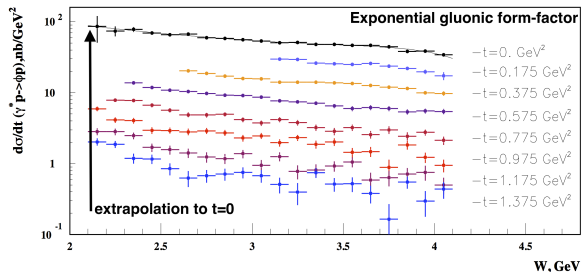


$x_B = 0.3 - 0.4$



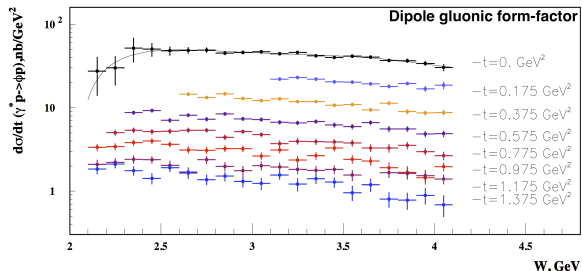
$$\frac{d\sigma}{d\cos\theta} = \frac{3}{4} [(1 - r_{00}^{04}) + (3r_{00}^{04} - 1) \cos^2 \theta_H] \quad , \quad R = \frac{r_{00}^{04}}{\epsilon(1 - r_{00}^{04})}$$

Projected results for the cross-sections



Test the reaction mechanism
 $\frac{d\sigma}{dt}(t=0)$ as a function of W

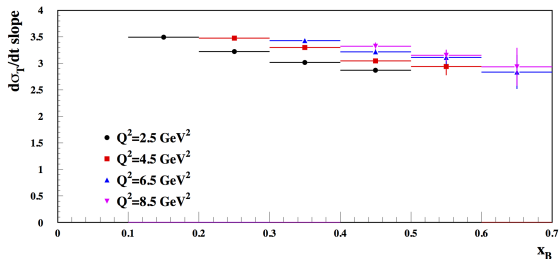
Extrapolation $t \rightarrow 0$
 Below t_{\min}



Good coverage
 \rightarrow accurate extrapolation
 exponential versus dipole FF

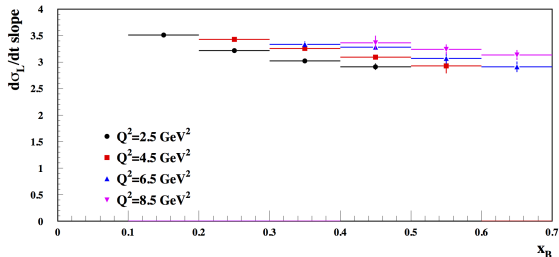
Projected t-slopes

$d\sigma/dt$ ($ep \rightarrow ep\phi$)



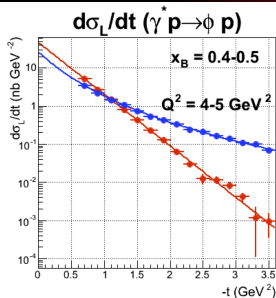
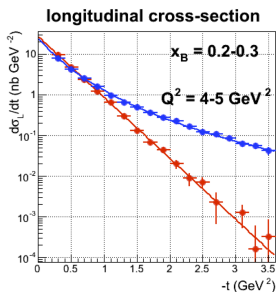
t-slopes as functions of x
as functions of Q^2

Q^2 independence :
→ small-size $q\bar{q}$ pair

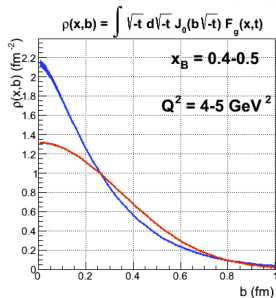
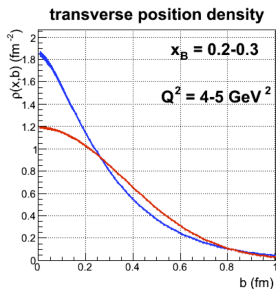


change with x :
→ Gluonic size

Extraction of gluonic profiles



Longitudinal cross-section



Corresponding sensitivity in transverse position space

$$b = 1/\sqrt{-t}$$

Error propagation study
Skewness $\xi \neq 0$ neglected

Summary and beam-time request

- PR12-12-007 : Exclusive ϕ Electroproduction with CLAS12
- Gluonic radius in the valence region : essentially unknown
- Unique channel for probing the gluonic structure at 11 GeV
- Missing piece of the larger GPD program with CLAS12
- Test the reaction mechanism and approach to small-size configuration dominance
- Extract the glue average radius in the valence region and explore the change of profile with x_B
- **Request : 60 days of beam time at $\mathcal{L} = 10^{35} \text{ cm}^{-2}\text{s}^{-1}$**
- Can run in parallel with proton group

Supplementary slides

Projected gluonic radius

