Exclusive ϕ and gluonic structure
E12-12-007

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Hall B

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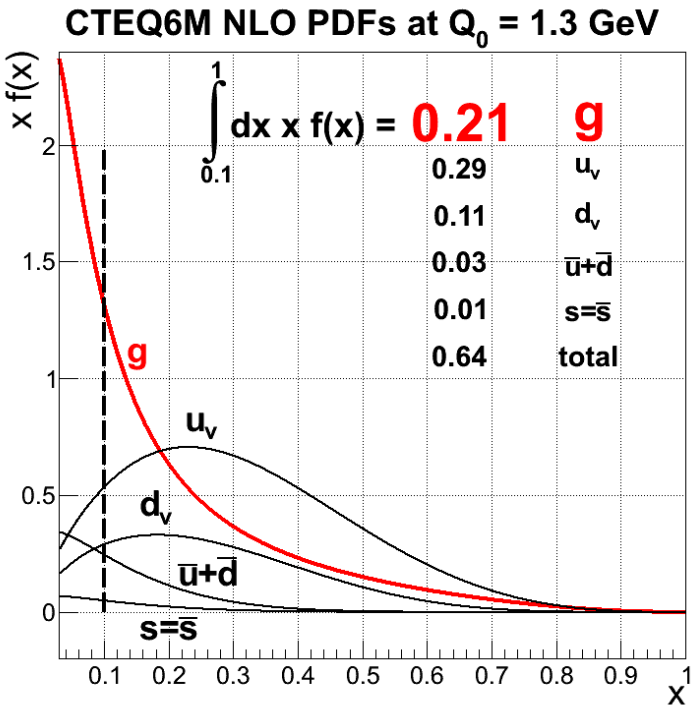
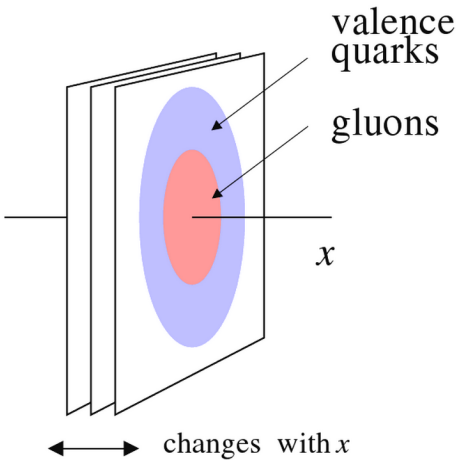
Measuring the gluonic radius of the nucleon accross the valence region
in the kinematics $Q^2 = 1 \cdots 10$ GeV^2 and $t_{\text{min}} - t = 0 \cdots 4$ GeV^2

Gluons at large x





- Large glue density at $x > 0.1$

  PDF from global fits
  (F_2 evolution, ν_{DIS}, jets)

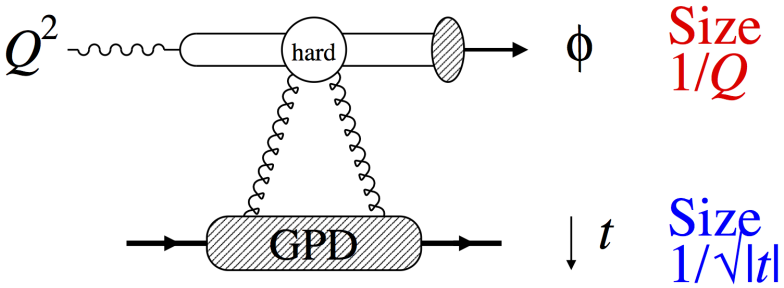
  Gluons carry more than 30%
  of the momentum for $0.1 < x$

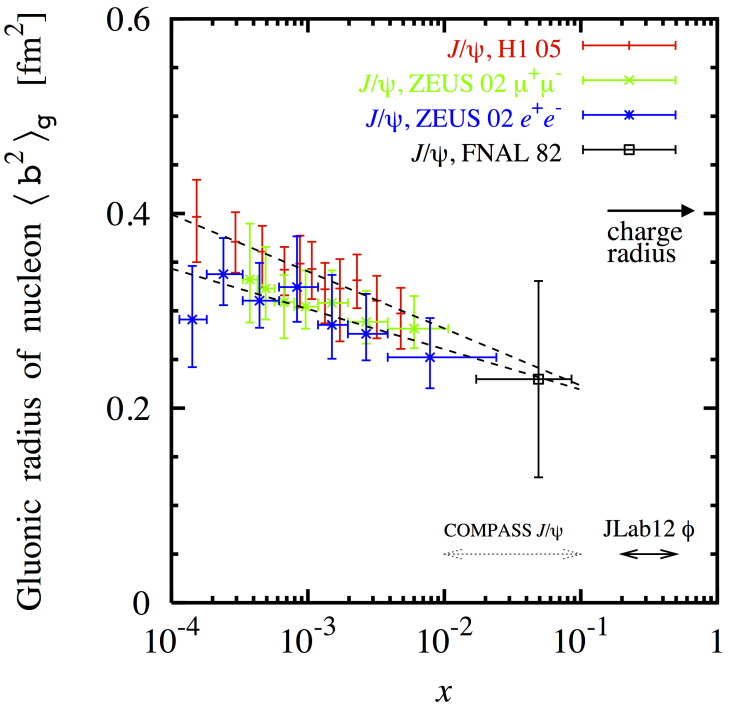
- 3D imaging of the nucleon

  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 $Q^2 \sim$ few GeV^2

  GPD = Universal gluon form factor

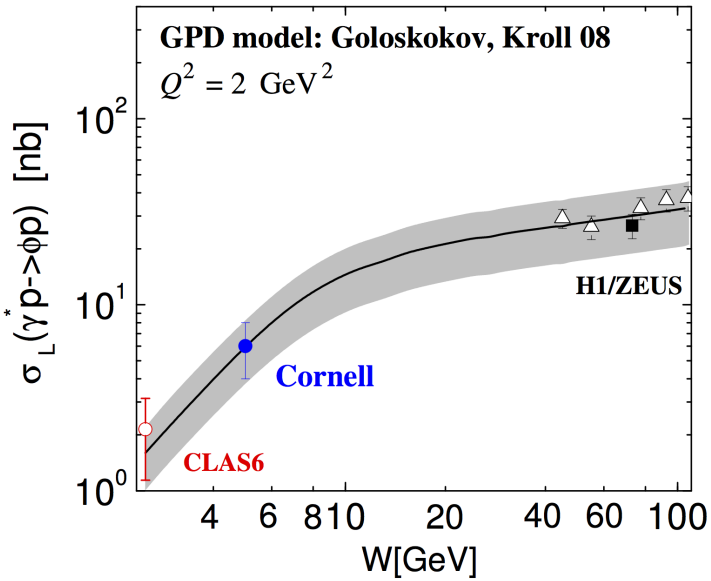
- Gluonic radius as a function of x

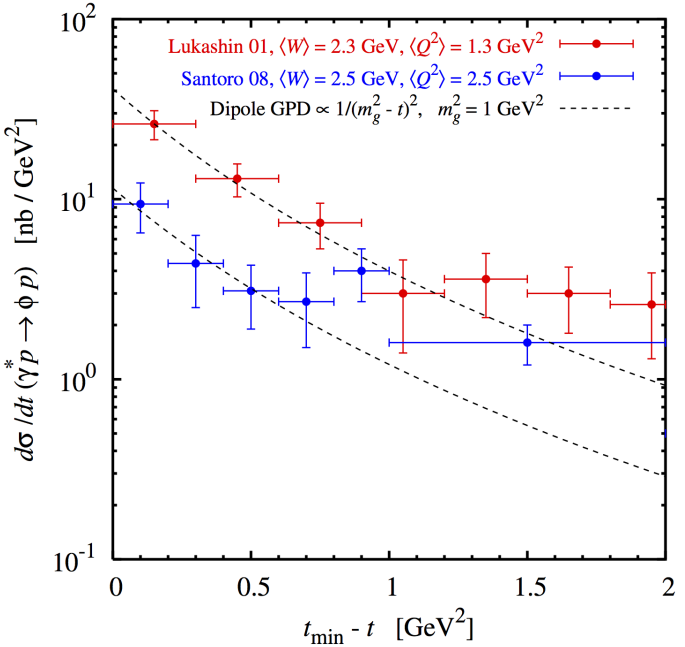
  Small x : radius grows through parton diffusion

  $x < 0.01$ 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 $m_g^2 \sim 1$ GeV^2

CLAS12 Exclusive ϕ electroproduction

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

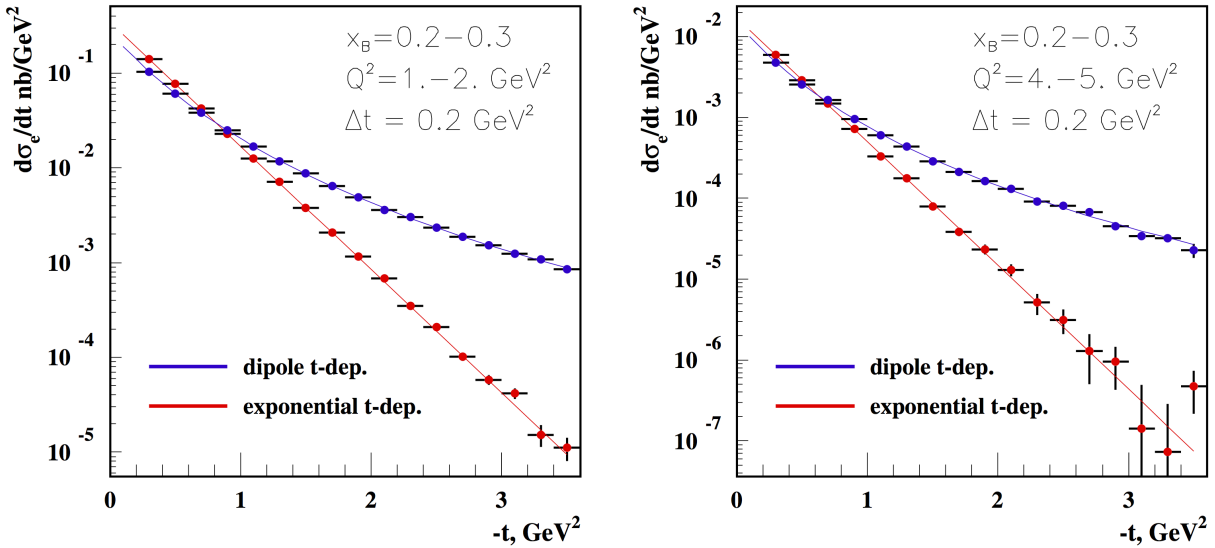
- Extract the gluonic radius accross the valence region from the *relative* t-dependence of the differential cross-section

  Average gluonic radius : model independent
  Change with x : use GPD models (e.g. Double-Distribution)

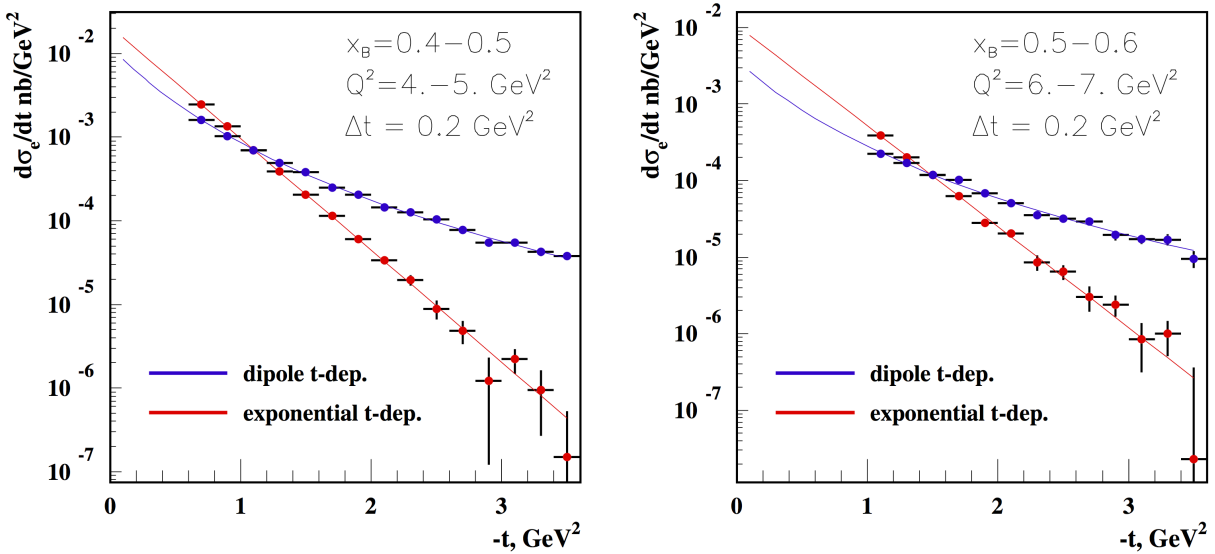
$$\frac{\frac{d\sigma}{dt}(t)}{\frac{d\sigma}{dt}(t=0)} \propto \frac{\langle H^g(t)\rangle^2}{\langle H^g(t=0)\rangle^2} \quad + E^g \text{ contribution}$$

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

Step 1 : Test of model-independent features



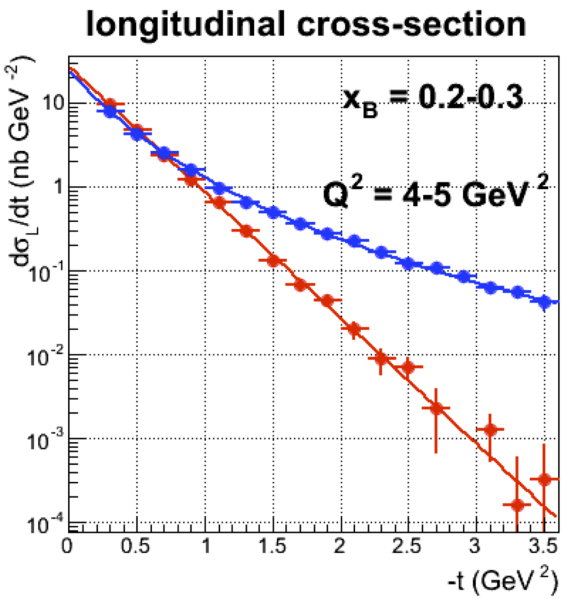
CLAS12 dσ/dt (ep->epϕ)

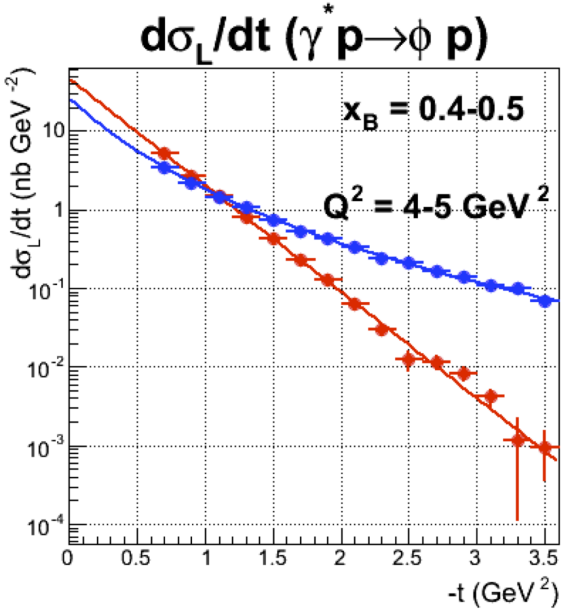


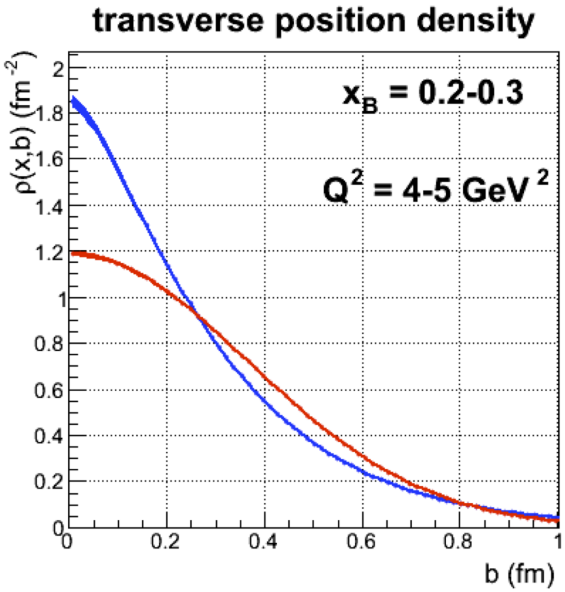
Unseparated cross-sections with exponential and dipole models

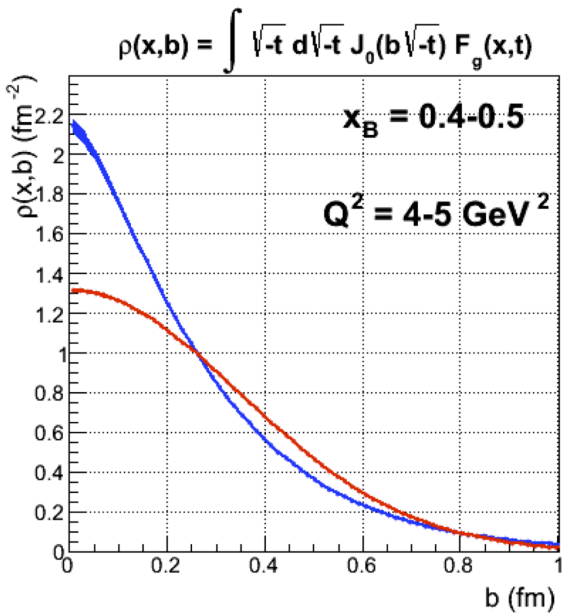
Precision measurement of t-slopes at fixed x_B

Step 2 : Extraction of gluonic profiles









Longitudinal cross-section

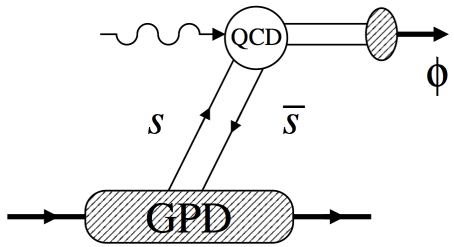
Corresponding sensitivity in transverse position space

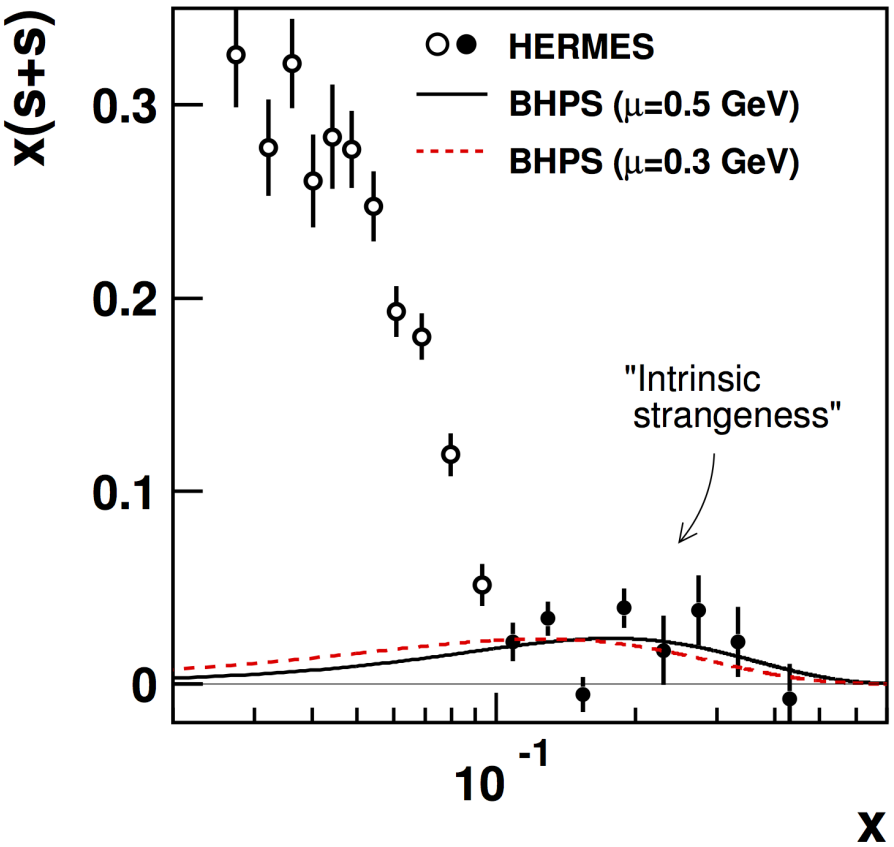
$$b = 1/\sqrt{-t}$$

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

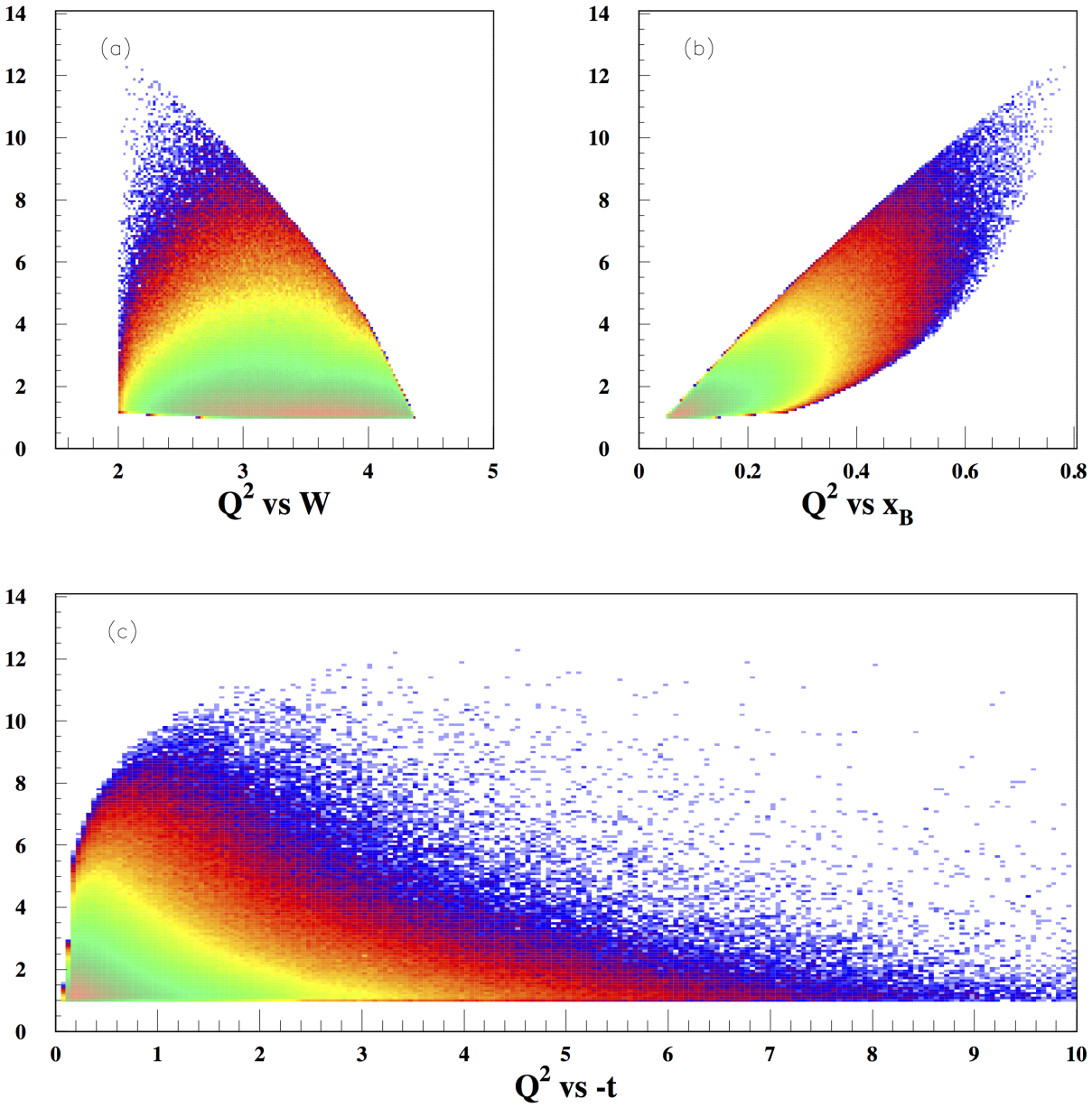
Intrinsic strangeness





- 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

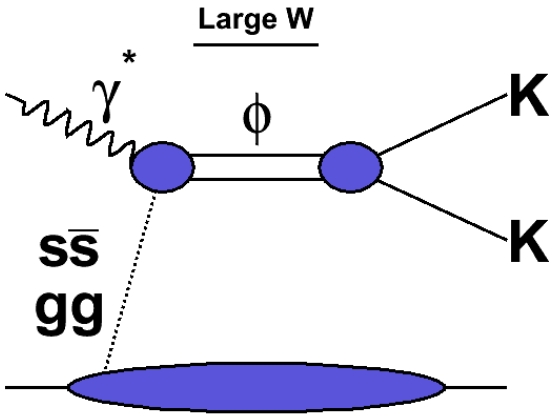


$E_b = 11$ GeV
5 cm lH target
$\mathcal{L} = 10^{35}$ cm^{-2}s^{-1}

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

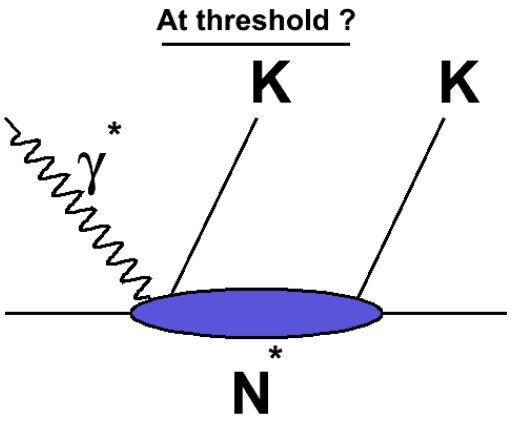
Simulations done with generator adjusted to world data

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
$K_L K_S \stackrel{?}{=} K^+ K^-$

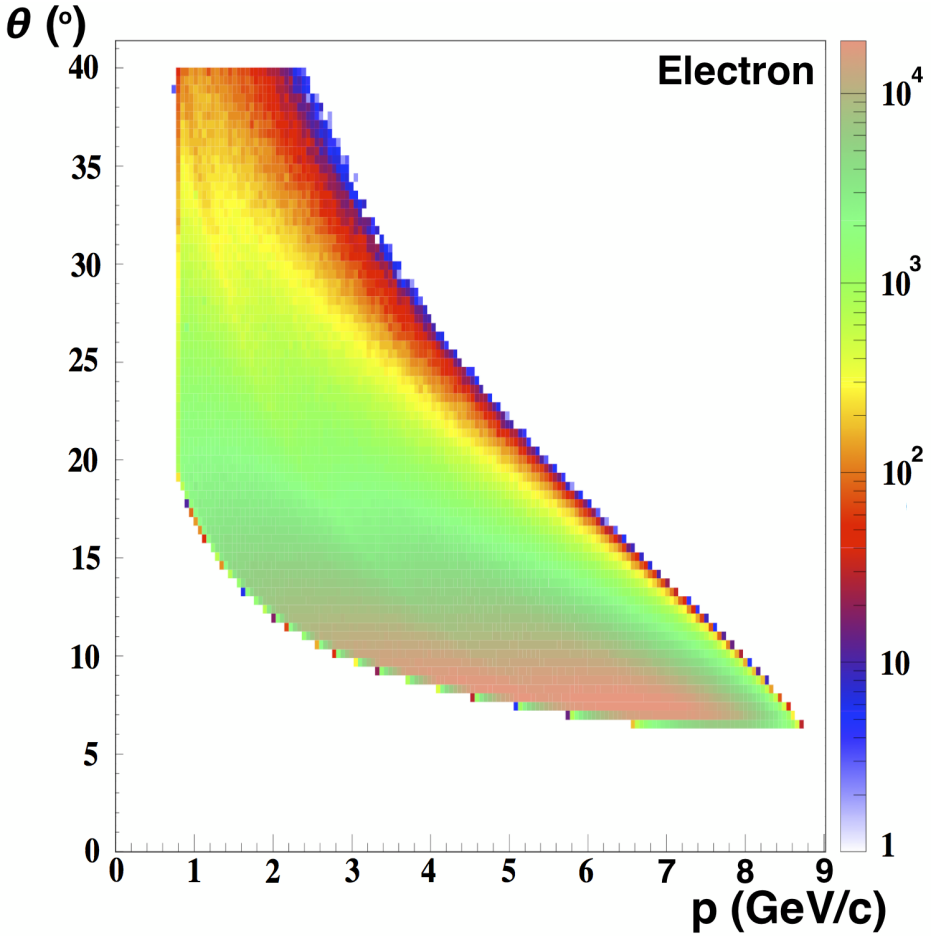


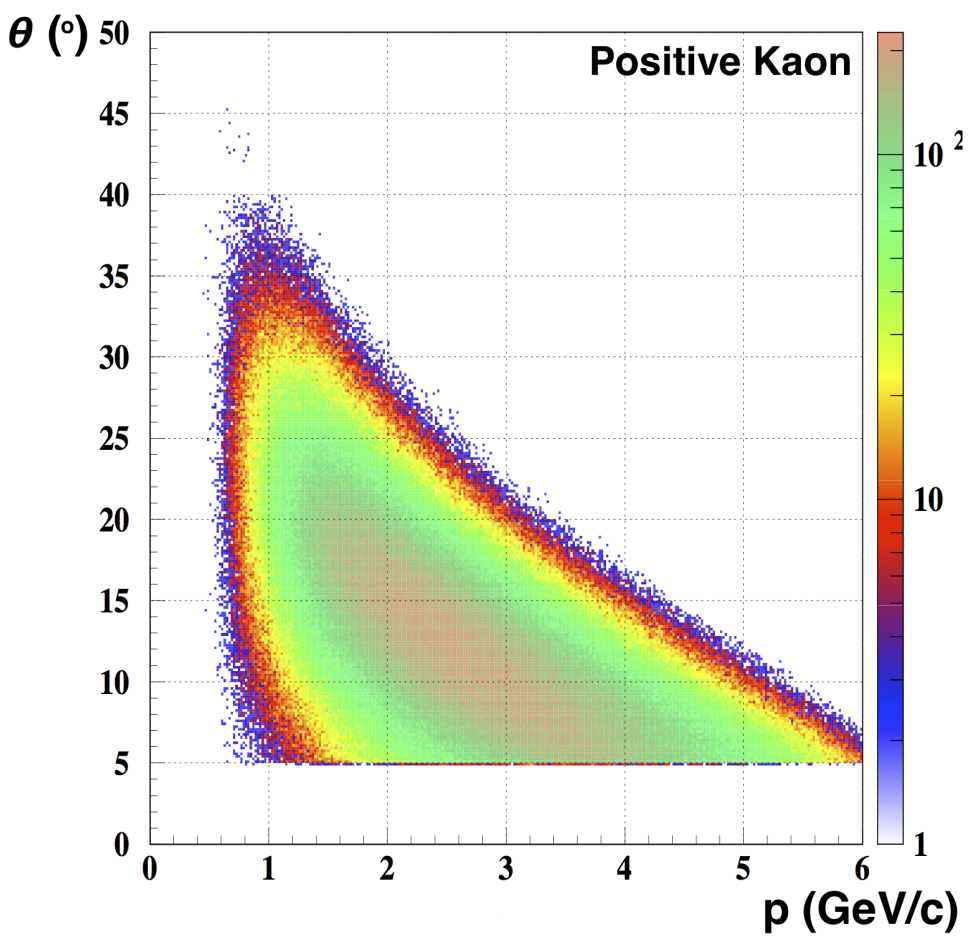
Important cross-check for

Universality

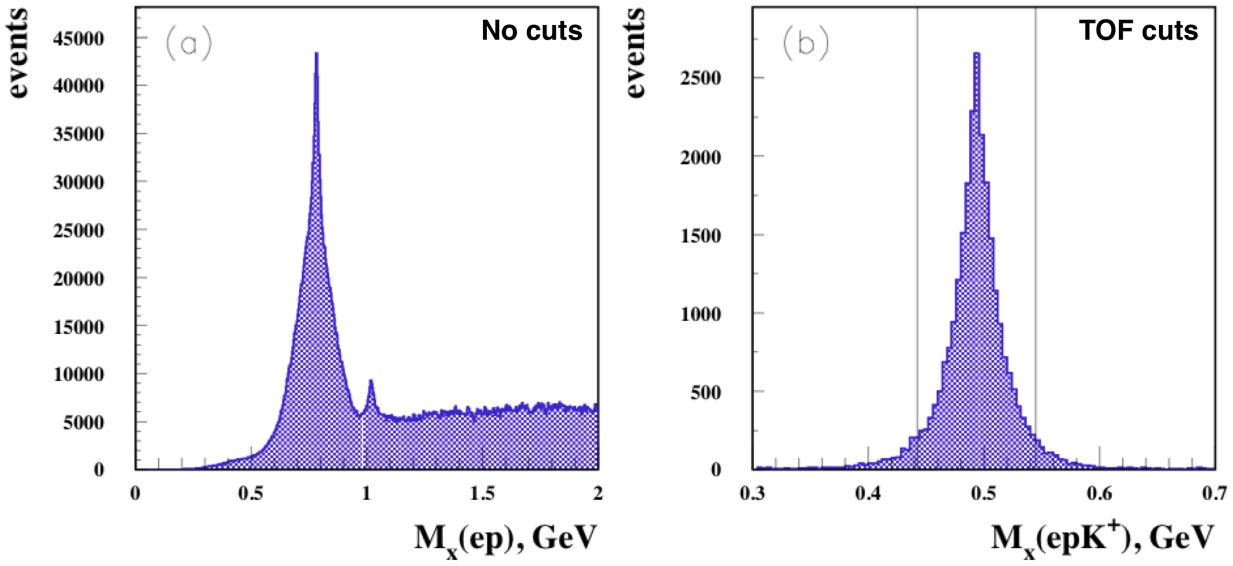
Experimental systematic check

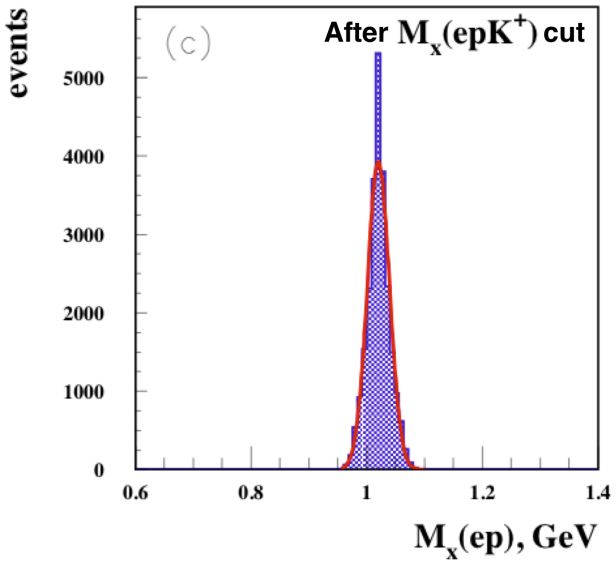
Particle kinematic coverage

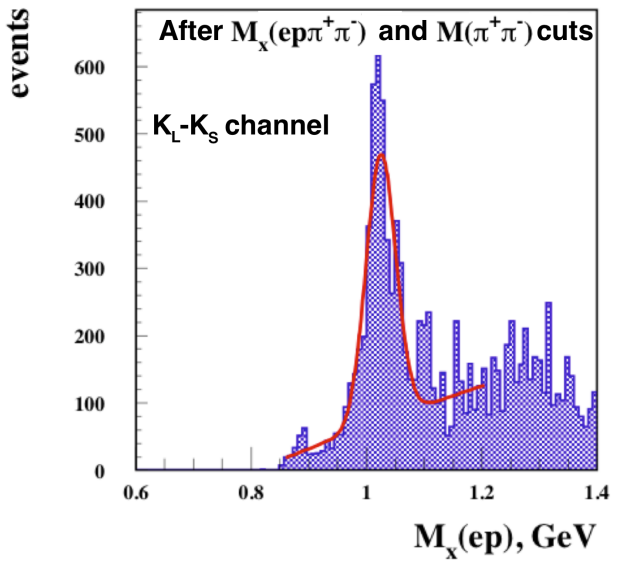




Particle identification







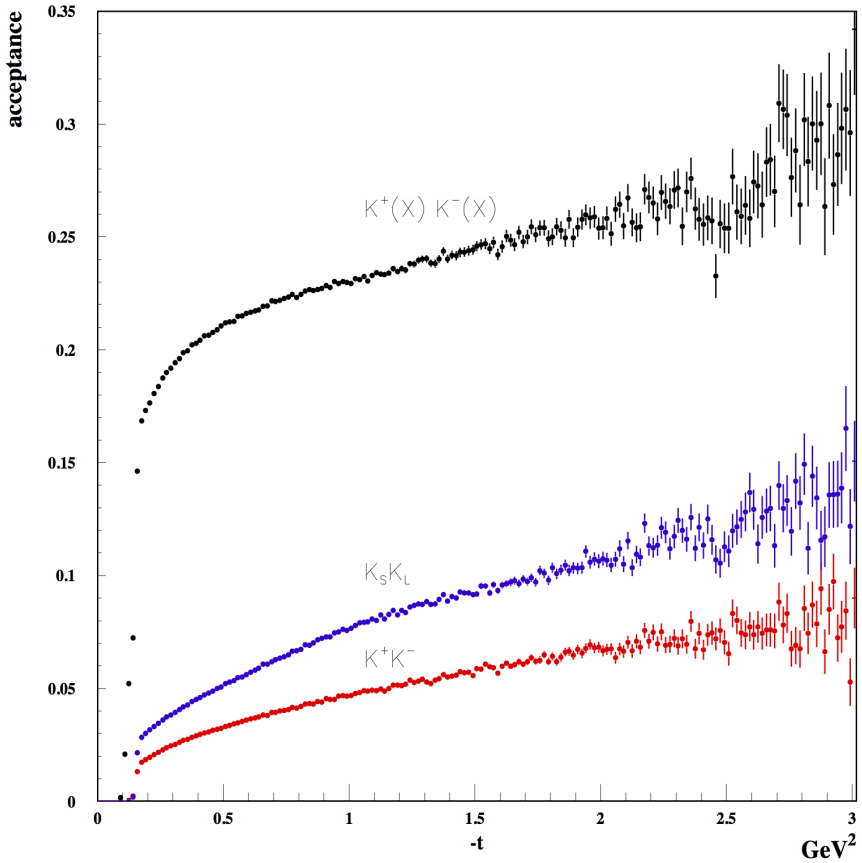
Charged hadrons identified with TOF $\sigma_t \approx 80$ ps

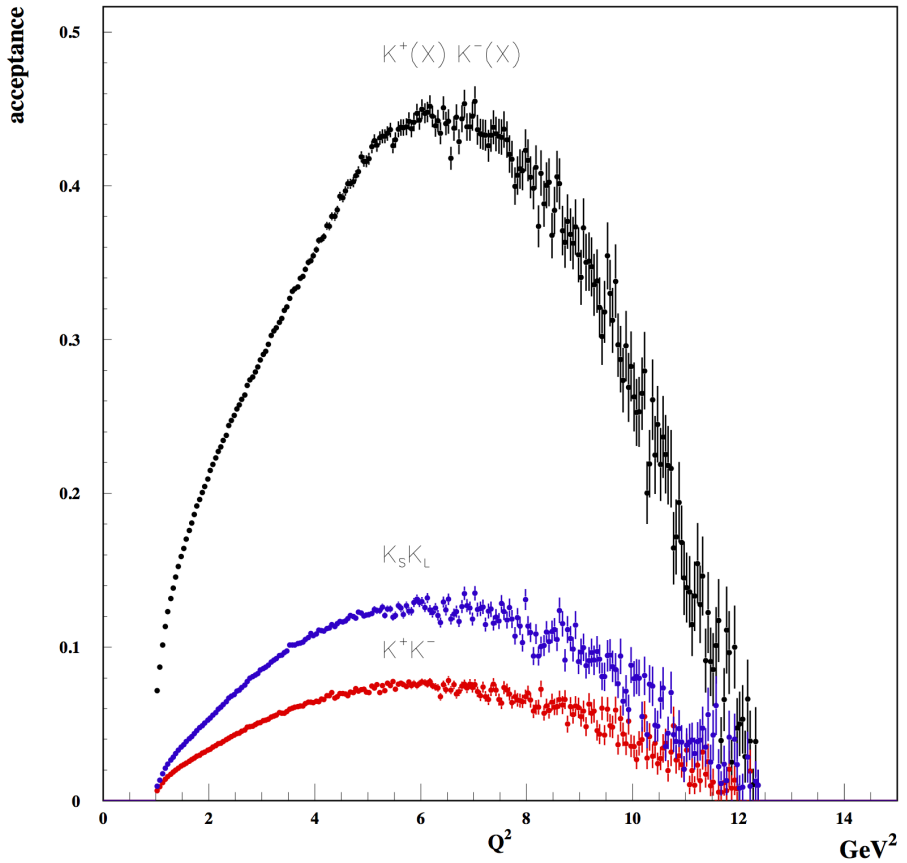
$2.5\sigma_t$ illustrated, up to 6 GeV/c

Large background essentially suppressed for the charged kaon channel

Remaining background in the neutral kaon mode can be subtracted

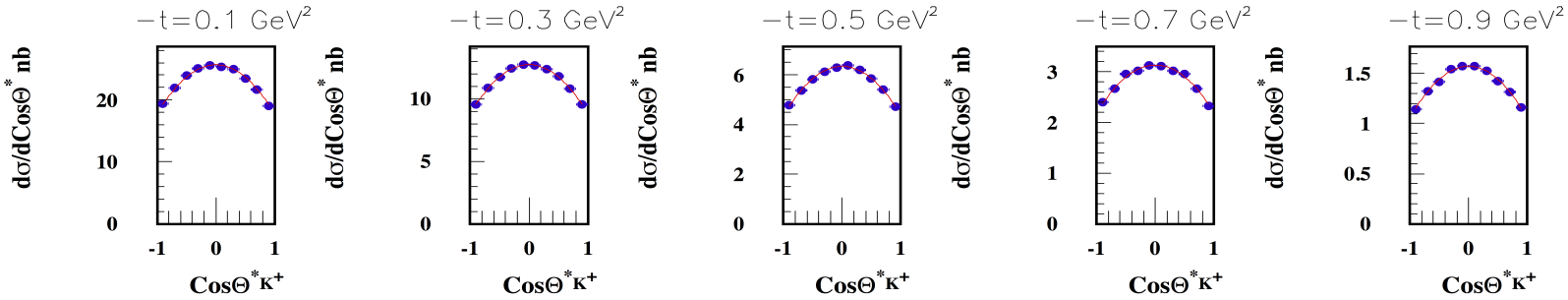
Acceptance

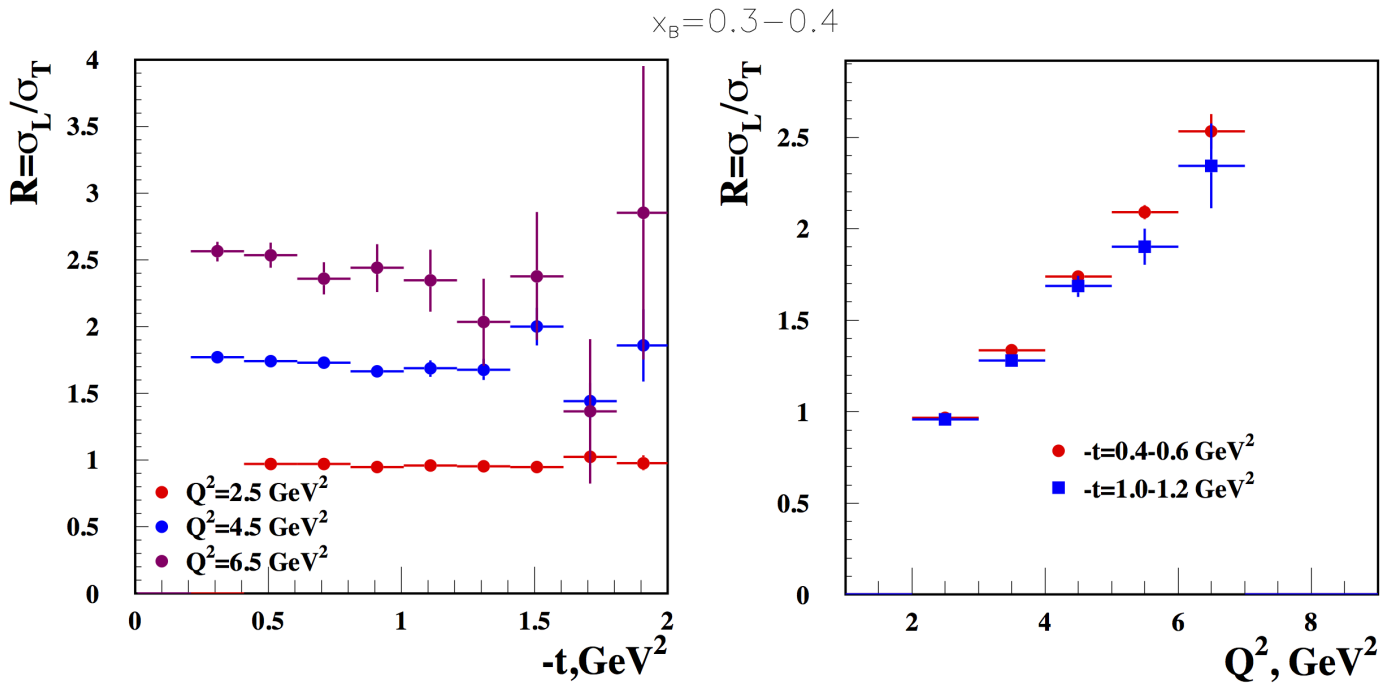




Control over acceptance systematic errors using several channels

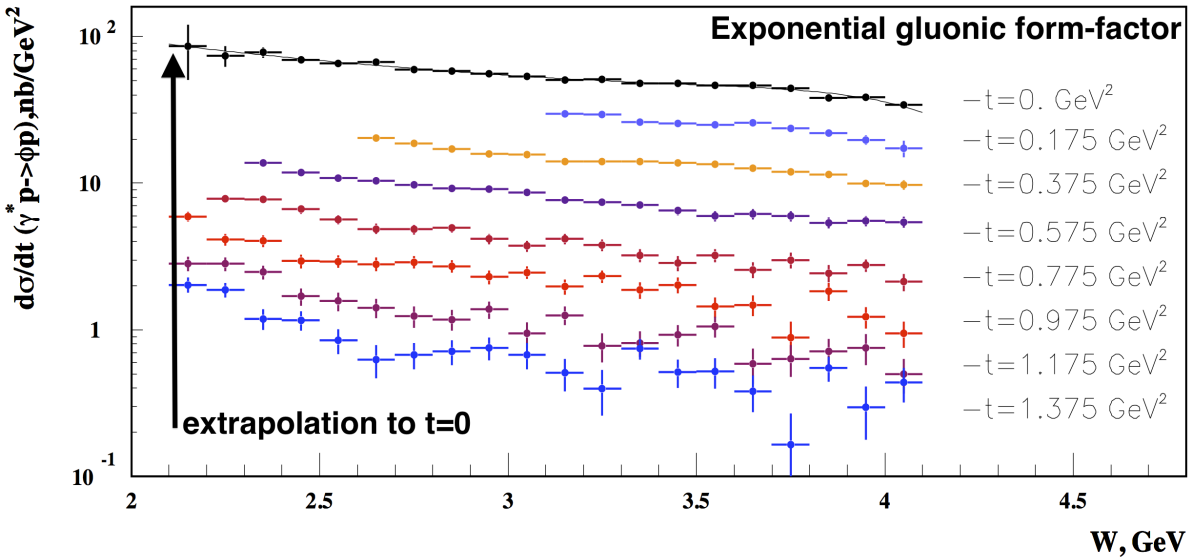
Extraction of the LT-ratio





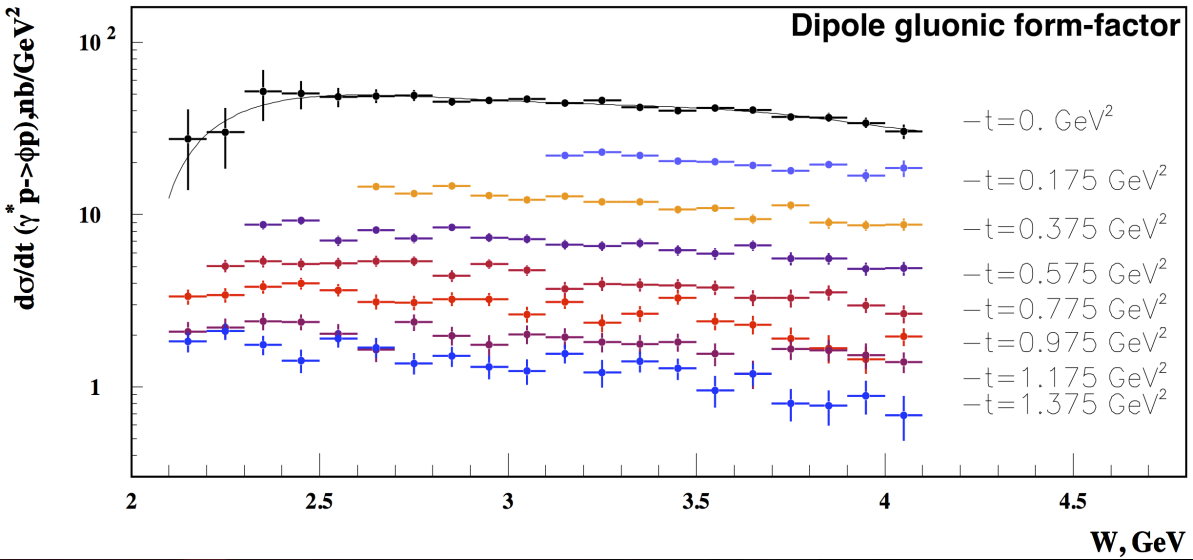
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\cos\theta} = \frac{3}{4}\left[(1-r_{00}^{04}) + (3r_{00}^{04}-1)\cos^2\theta_H\right] \quad , \quad R = \frac{r_{00}^{04}}{\epsilon(1-r_{00}^{04})}$$

Projected results for the cross-sections



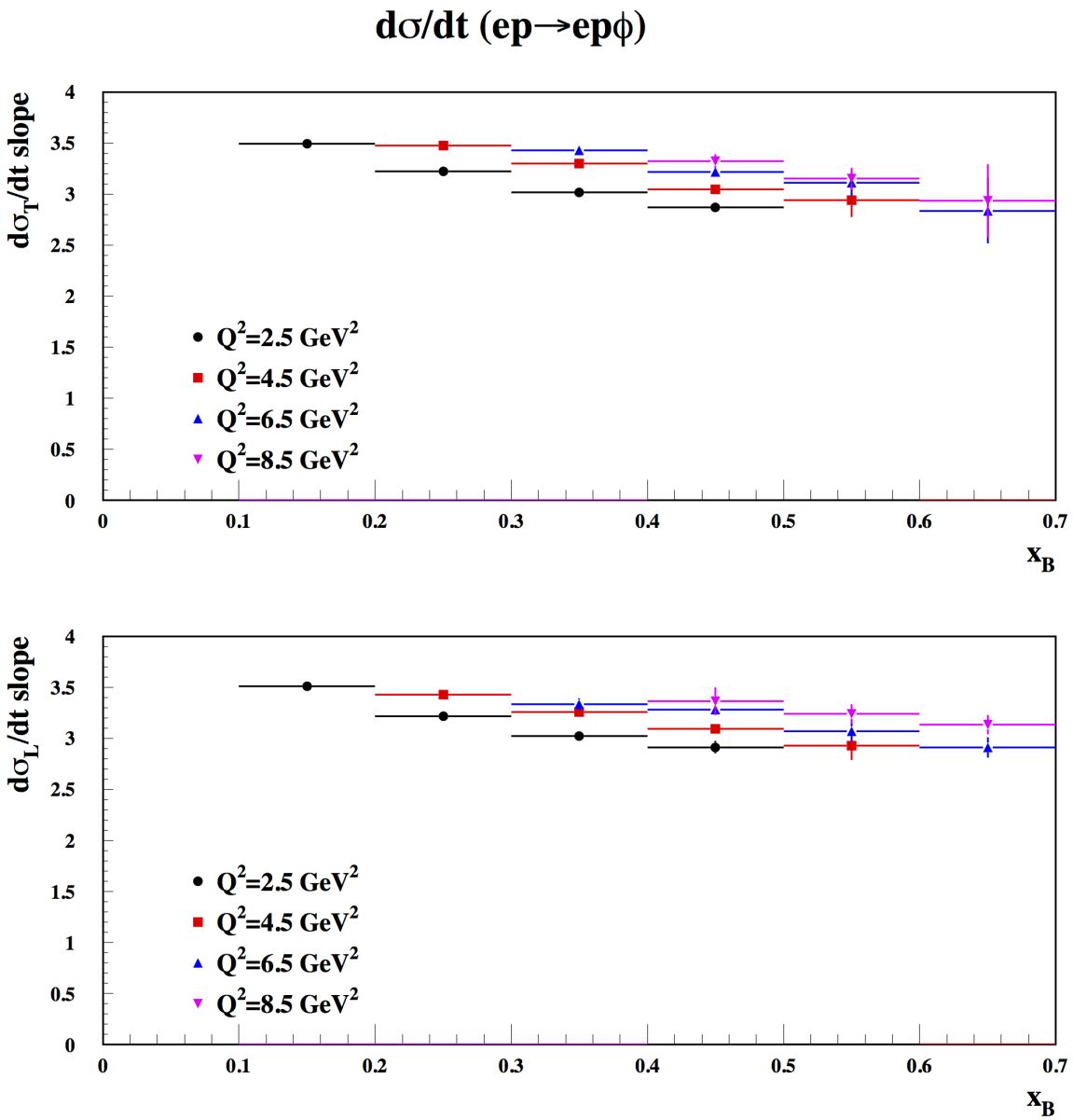
Test the reaction mechanism
$\frac{d\sigma}{dt}(t=0)$ as a function of W

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



Good coverage
→ accurate extrapolation
exponential versus dipole FF

Projected t-slopes

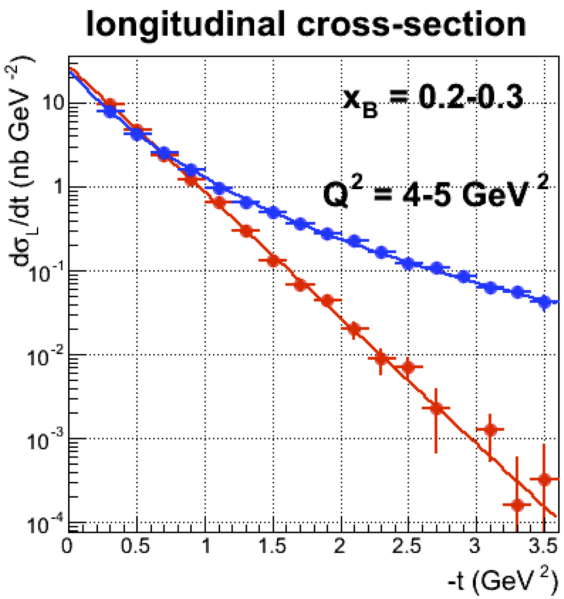


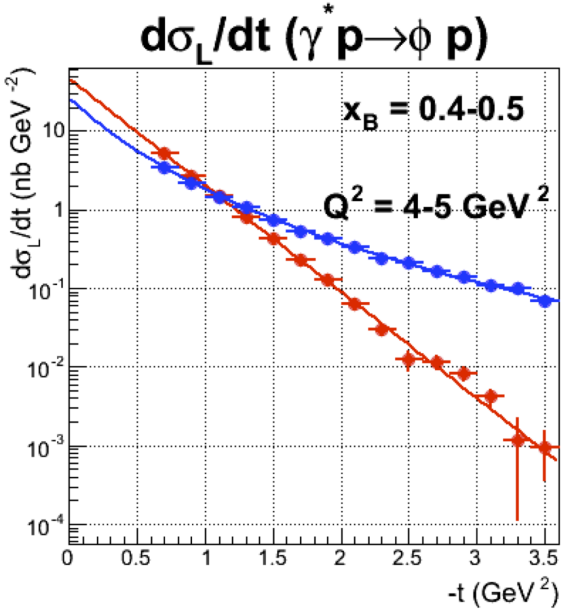
t-slopes as functions of x
as functions of Q^2

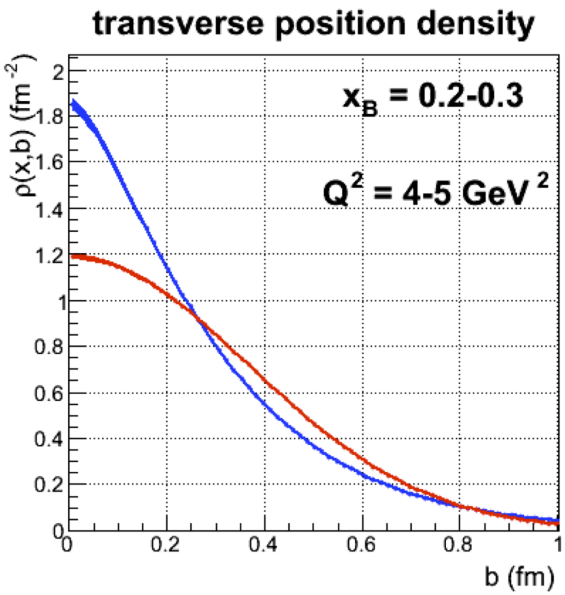
Q^2 independence :
$\rightarrow$ small-size $q\bar{q}$ pair

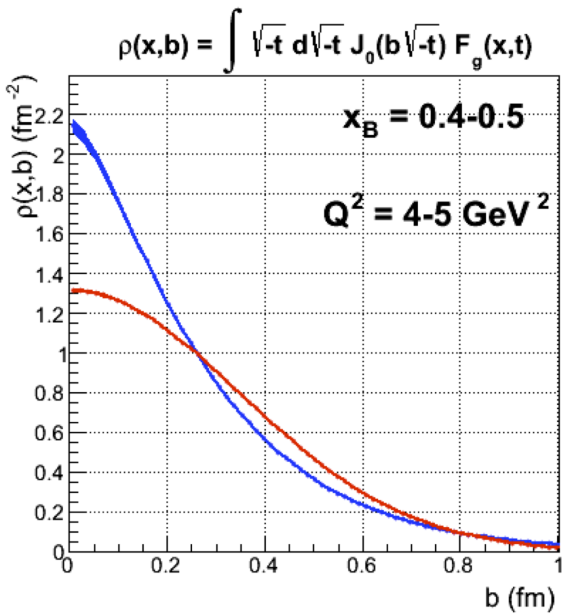
change with x :
$\rightarrow$ Gluonic size

Extraction of gluonic profiles









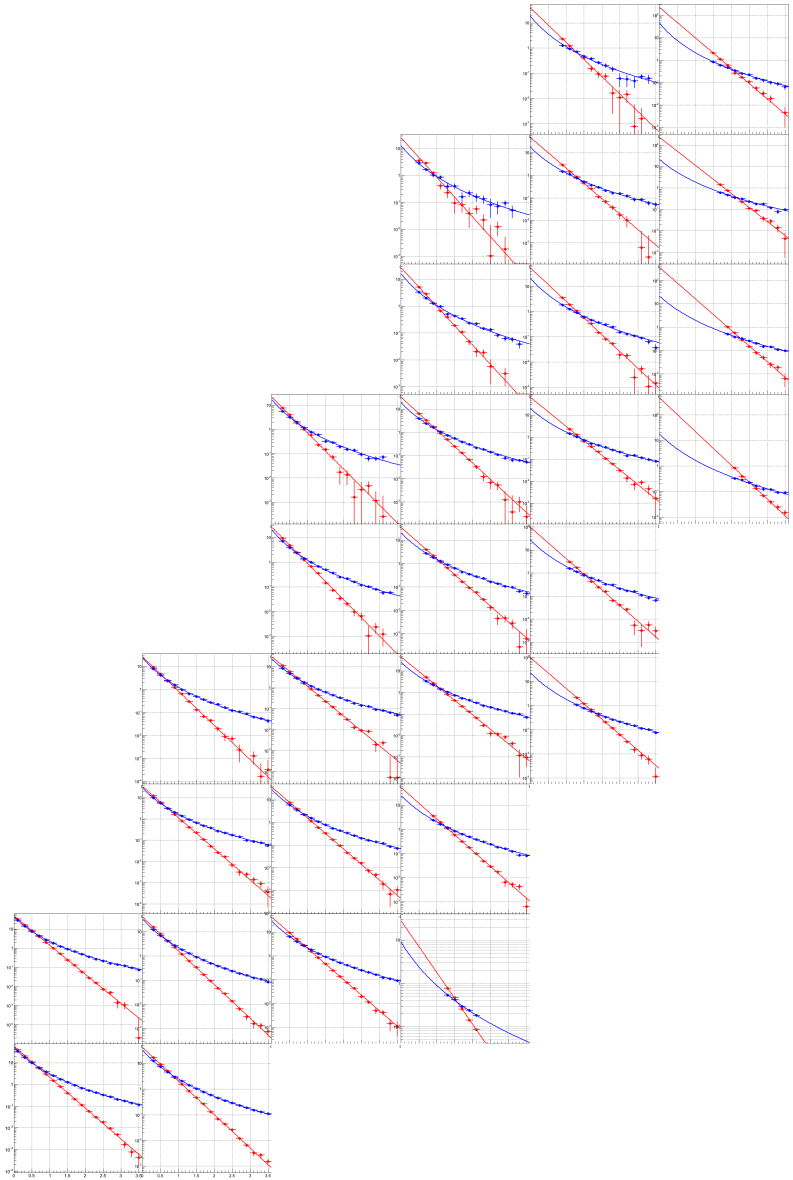
Longitudinal cross-section

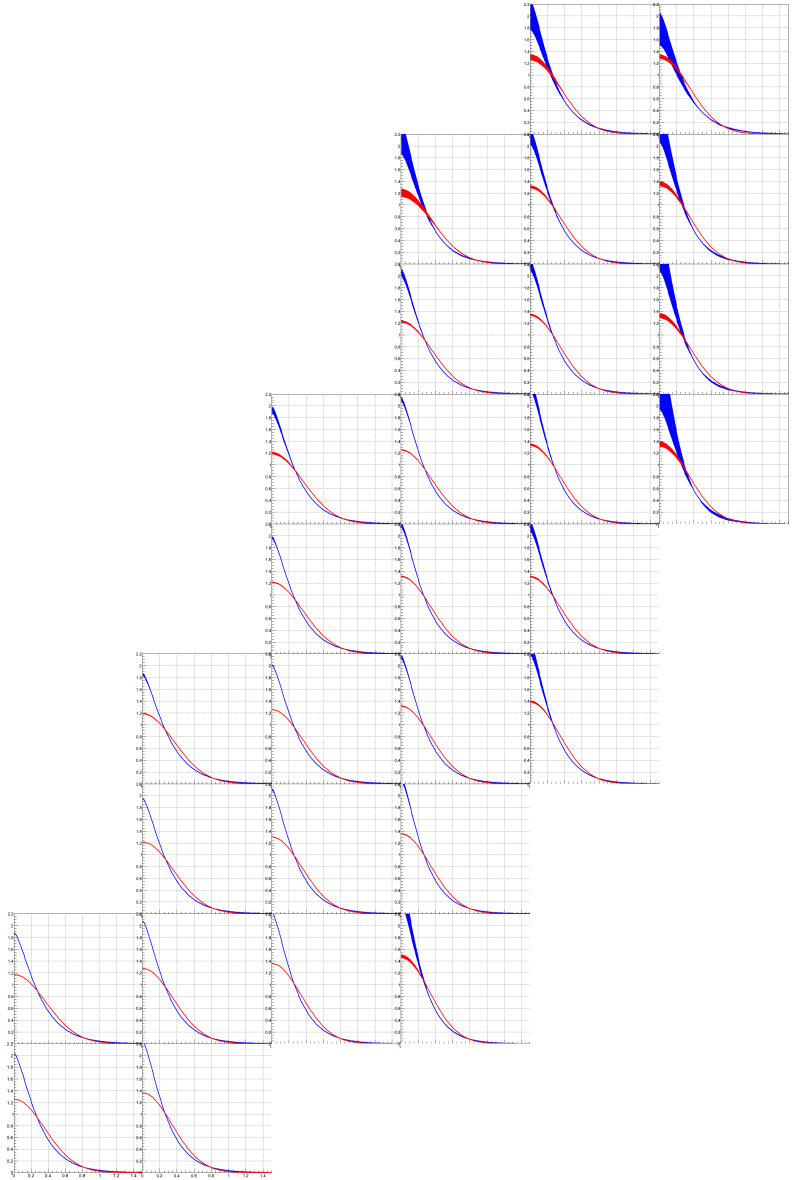
Corresponding sensitivity in transverse position space

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

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

Projected gluonic radius





Summary

- **ER12-12-007 : 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
- Will run in parallel with proton group