Deeply virtual $\phi(1020)$ production in Hall A @ JLab 12 GeV.

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Hall A Collaboration

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Physics motivations

- Measure spatial distribution of gluons from t-distribution. (must be deconvoluted with spatial distribution of γ -> ϕ probe)

- Measure absolute cross sections over a wide x_{Bj}, Q^2 range, to test some models, since we do not expect simple $1/Q^6$ scaling.

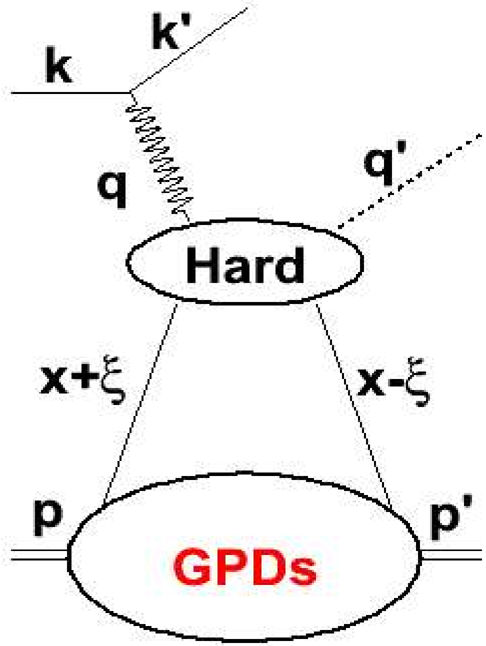
- Measurement of $R = \sigma_L/\sigma_T$, expected to be ~1 -> could sign a change from non-perturbative to perturbative dynamics.

- Test of s-channel helicity conservation (SCHC).

Outline

- Deeply virtual ϕ production in terms of GPDs
- Required Experimental Setup
- Proposed Kinematics
- Expected achievements/Results
- Conclusions/Perspectives

Deeply virtual ϕ production



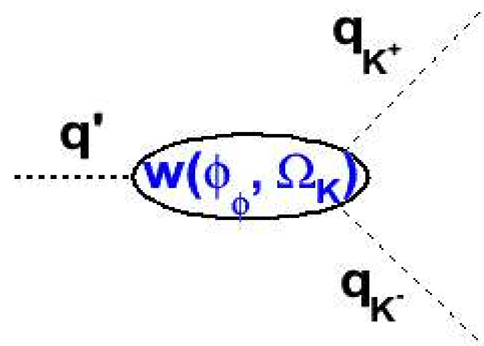
$$Q^2 = (k - k')^2$$

$$x_{Bj} = \frac{Q^2}{2\, p \cdot q}$$

$$W^2 = s = (q + p)^2 = M^2 - Q^2 + 2\, p \cdot q$$

$$t = \Delta^2 = (q - q')^2 = (p - p')^2$$

decay angular distribution



SCHC

$$w(\phi_\phi, \Omega_K) \quad \rightarrow \quad w(\cos\theta_K^{\phi\, RF}, \Psi)$$

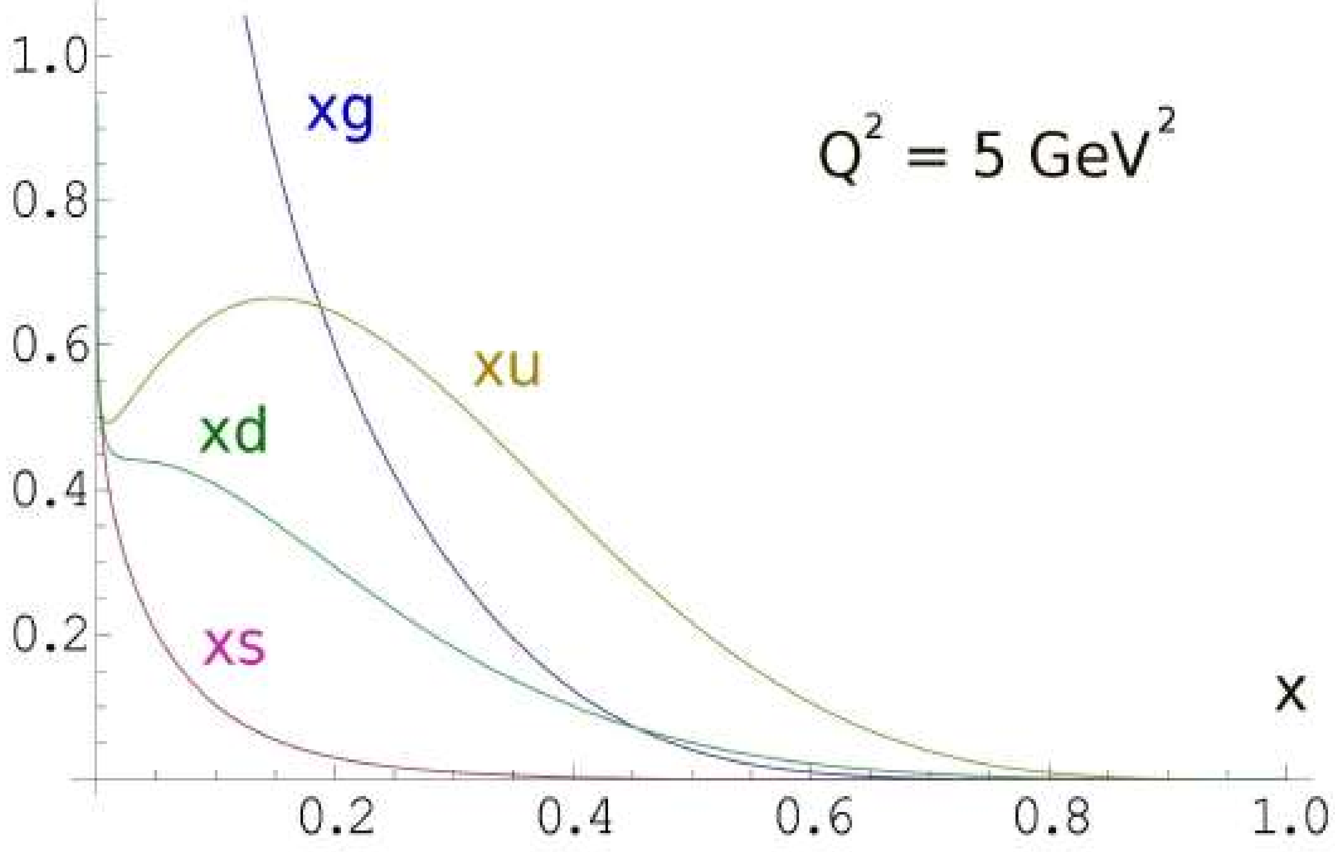
$$\Psi = \phi_\phi - \varphi_K$$

$$\phi_\phi = \phi(\vec{\gamma}, \vec{\phi})$$

$$\varphi_K = \phi(\vec{\gamma}, \vec{K})$$

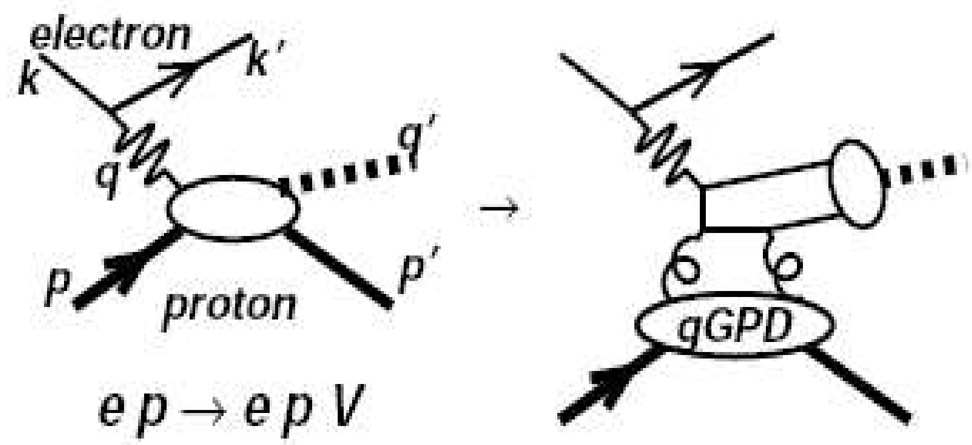
Deeply virtual ϕ production in terms of GPDs

PDFs distributions: xs negligible compared xg, even also at large x.



Deeply virtual ϕ production in terms of GPDs

=>



+ higher orders

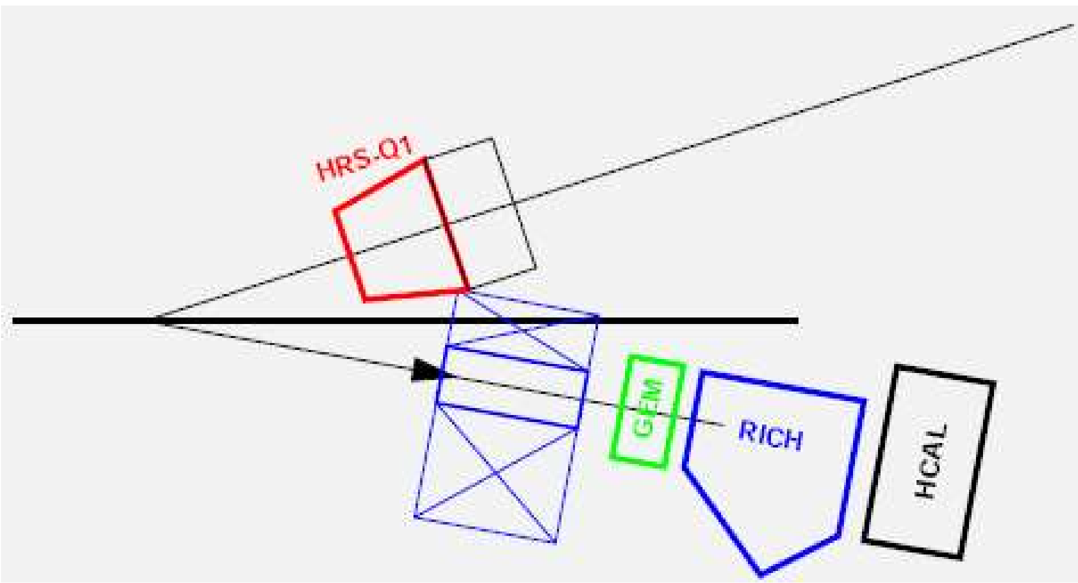
strong corrections to perturbative γp -> ϕp but supposed not to change the basic 2 gluon exchange in *t*-channel.

DVϕP would be a good window to access gluonic GPDs in valence region.

Experimental setup

ep -> epϕ :

- *e* in Left High Resolution Spectrometer (HRS)
- *ϕ -> 2K* in Super Bigbite Spectrometer (SBS) + RICH



=> SBS has to be "modified" to be compatible with HRS.

HRS resolutions:

$\sigma(\theta) = 0.5$ mrad(H), 1.0 mrad(V)

$\sigma p/p = 10^{-4}$.

"L-HRS compatible" SBS resolutions:

$\sigma(\theta) = 0.14 \text{ mrad} + 1.3 \text{ mrad.GeV} / p$

$\sigma(\theta) = 0.14 \text{ mrad} + 2.6 \text{ mrad.GeV} / p$

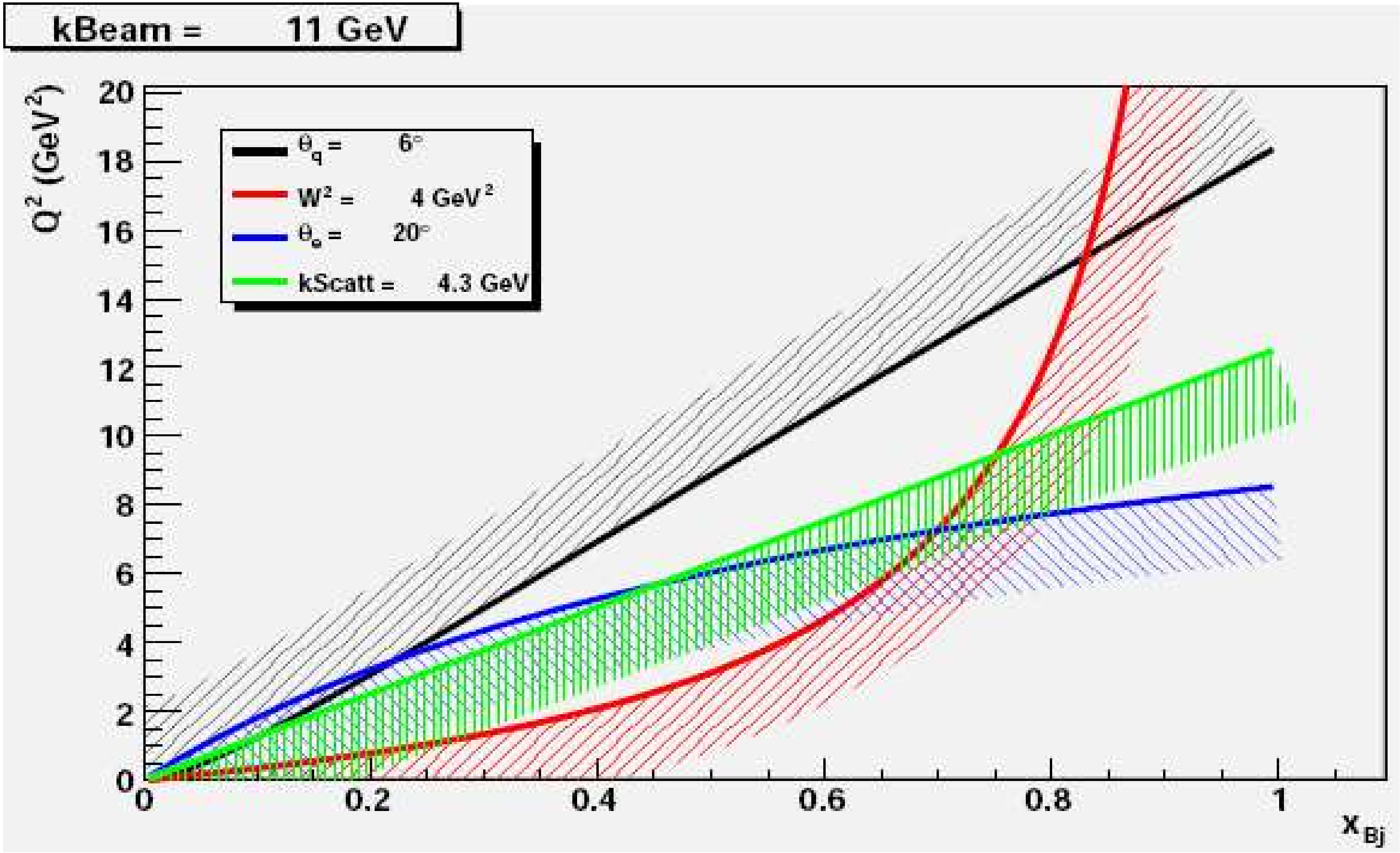
$\sigma p/p = 29.10^{-4} + 3.10^{-4} \text{ GeV}^{-1} p$

$\sigma p/p = 58.10^{-4} + 6.10^{-4} \text{ GeV}^{-1} p$

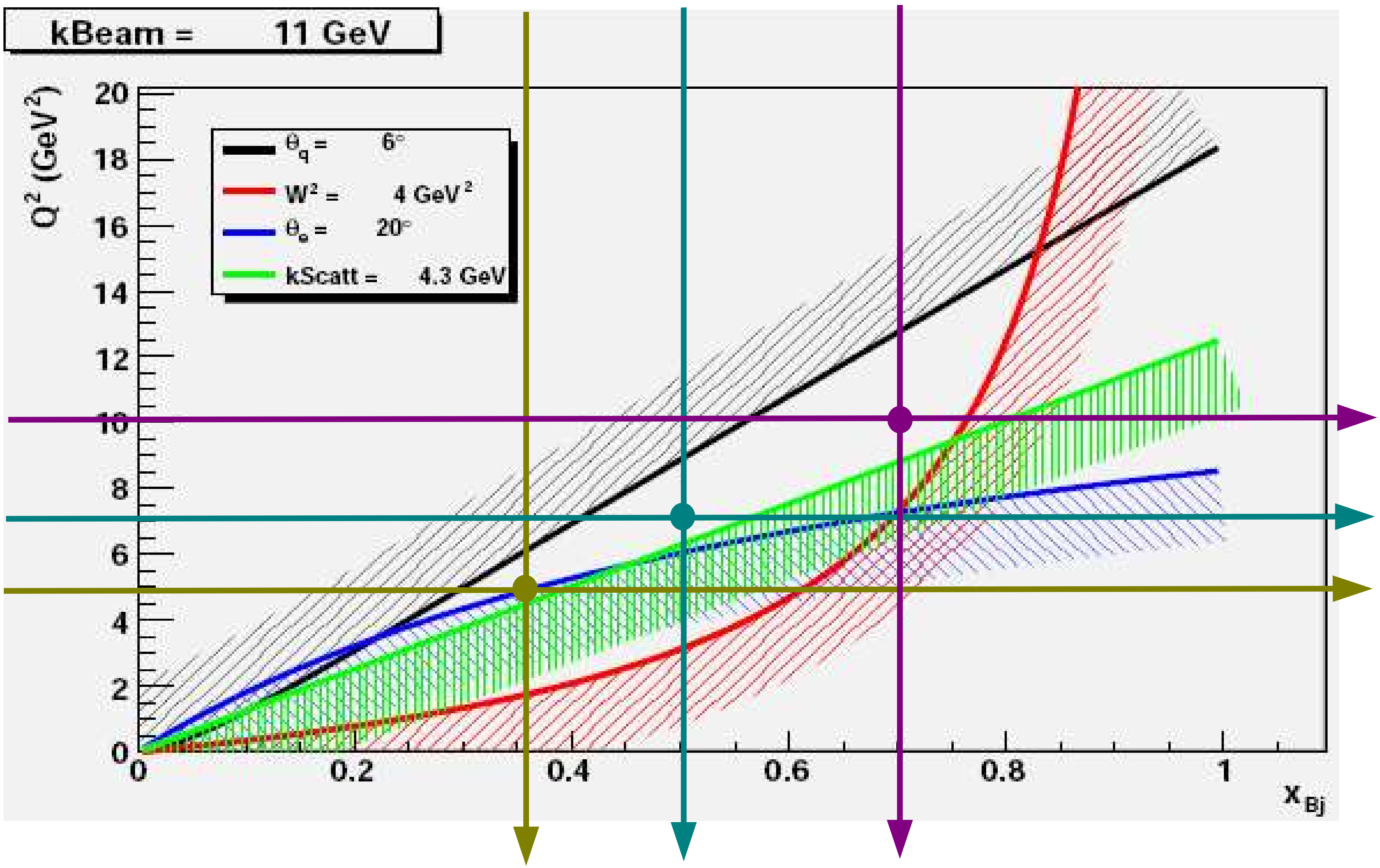
Proposed Kinematics

Kinematical constraints: see graph below

+ high ϕ energy, for 2K as forward as possible with boost

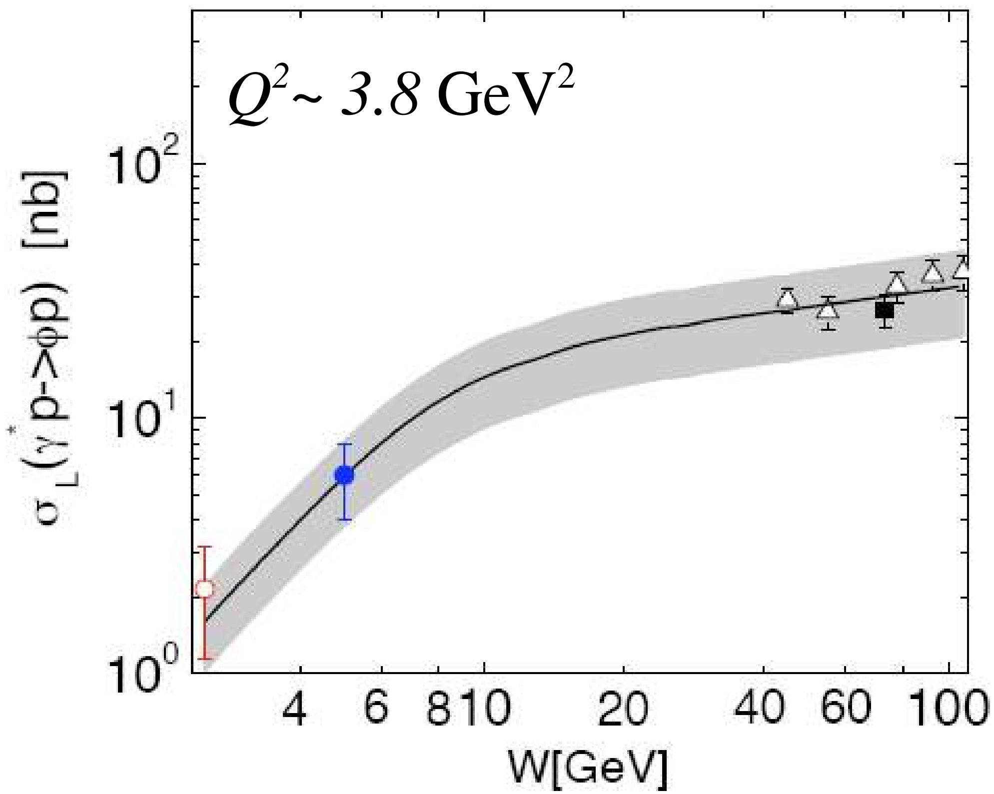


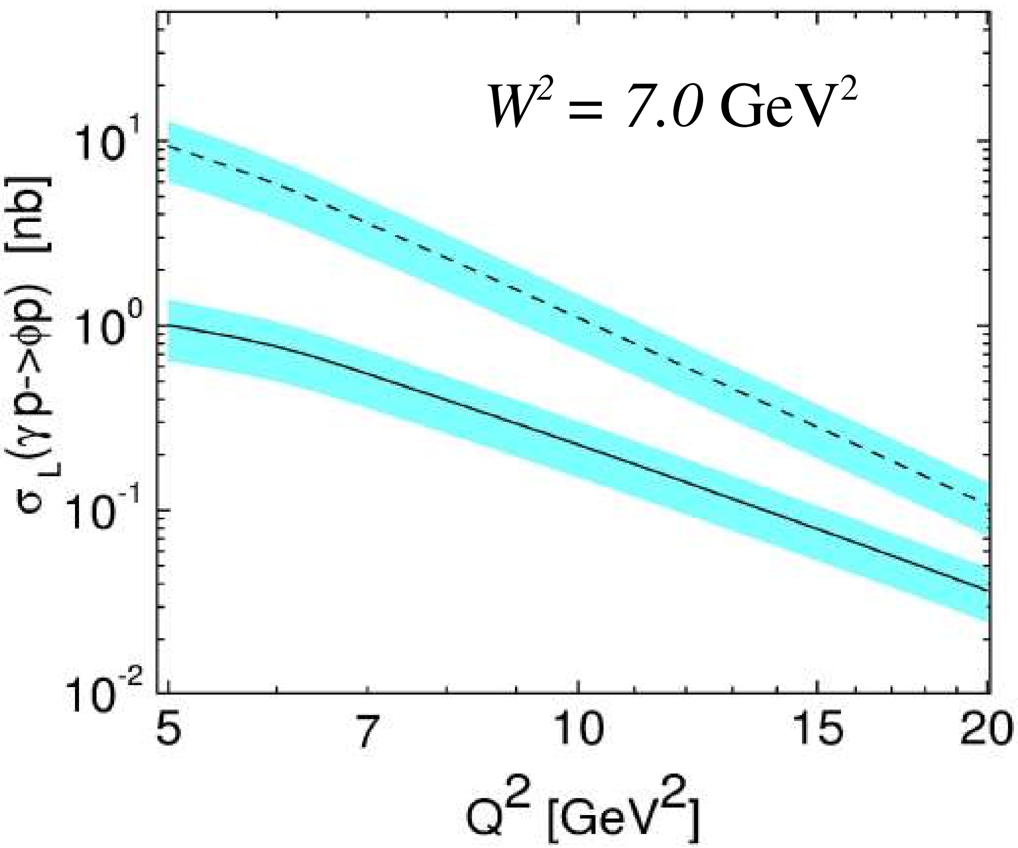
Proposed Kinematics



Counting rates estimation:

Performed with longitudinal cross sections modeled by Goloskokov and Kroll: [Eur. Phys. Jour. **C50**, 829 (2007)]



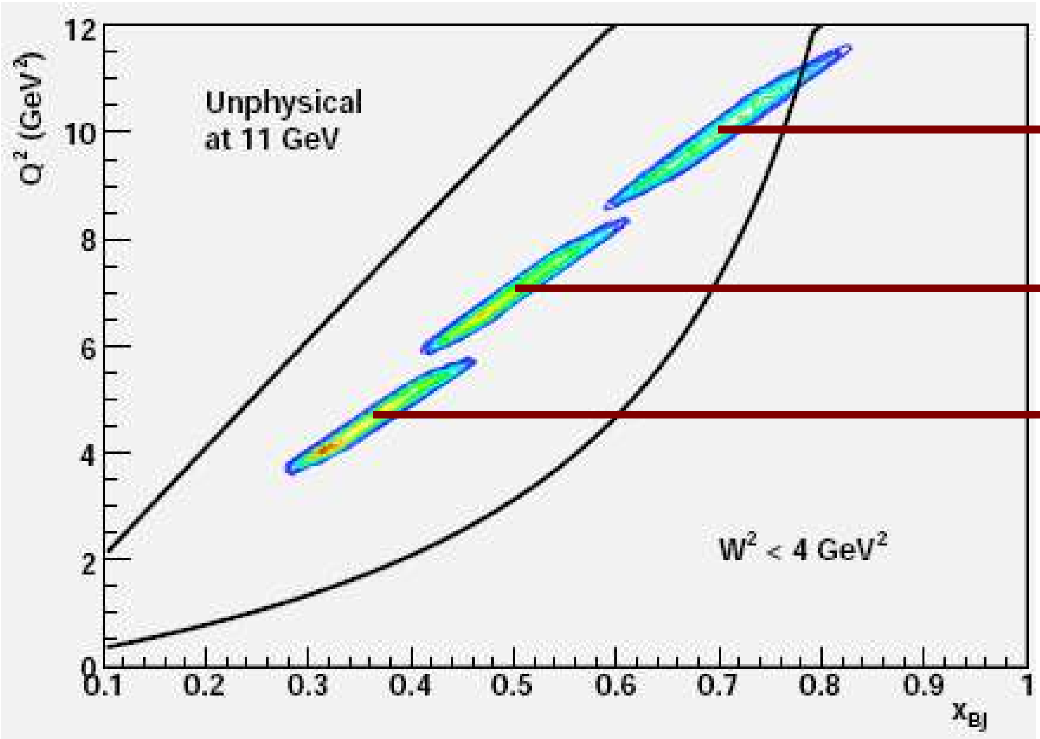


dash: Leading Order

solid: LO + sudakov suppresion

Counting rates estimation:

Total required beam time: 3 months
-> assuming 1 month (30 days) each.



Kin3: ~ 0.5 k evts.

Kin2: ~ 5.0 k evts.

Kin1: ~ 50.0 k evts.

Kin1: $\{x_{Bj} = 0.36, Q^2 = 4.6 \text{ GeV}^2\}$

Kin2: $\{x_{Bj} = 0.5, Q^2 = 7.0 \text{ GeV}^2\}$

Kin3: $\{x_{Bj} = 0.7, Q^2 = 10.0 \text{ GeV}^2\}$

Kin 1, 2, might be OK,
Kin 3: counting rate possibly too low.

Simulations

Simulations of *ep* -> *ep*ϕ with ϕ -> K^+K^- using C++, with:

- radiative corrections (using Mo and Tsai) on the incident and scattered electron.
- ϕ decay width (BW), and angular decay distribution (within SCHC).
- non resonant K^+K^- production (phase space m_{KK} distribution; isotropic decay)
- HRS and SBS resolutions effects (particle tri-momenta, vertex).

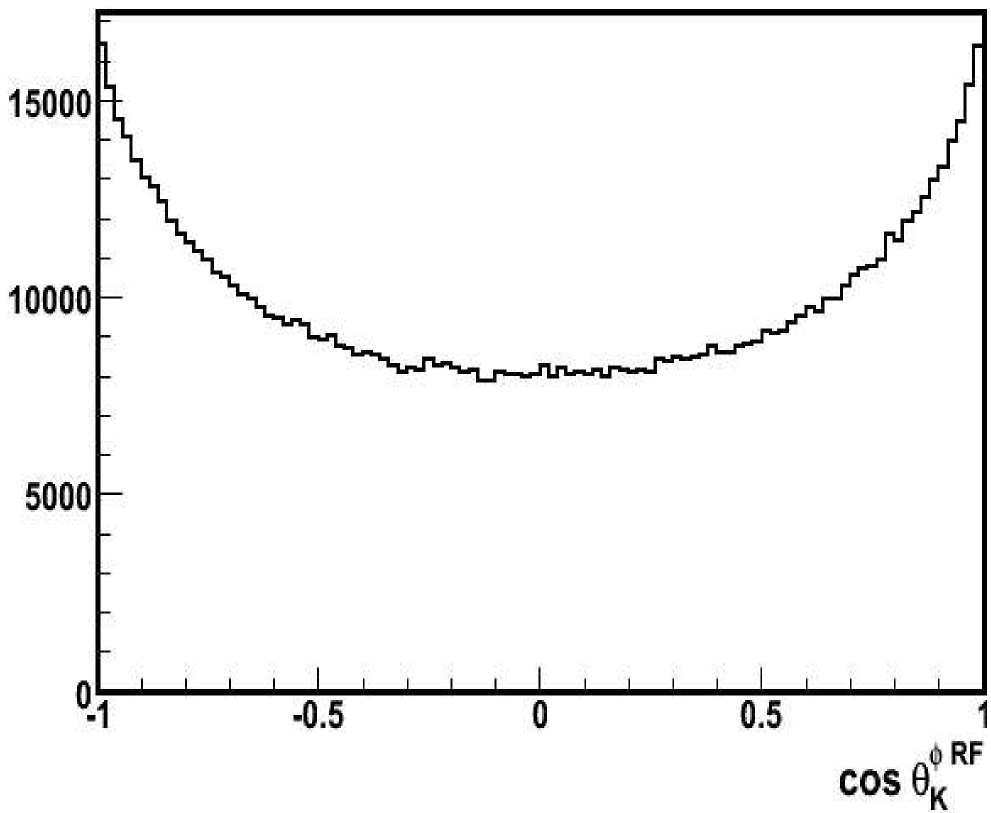
K/π separation via HERMES RICH: π/K contamination not in simulation

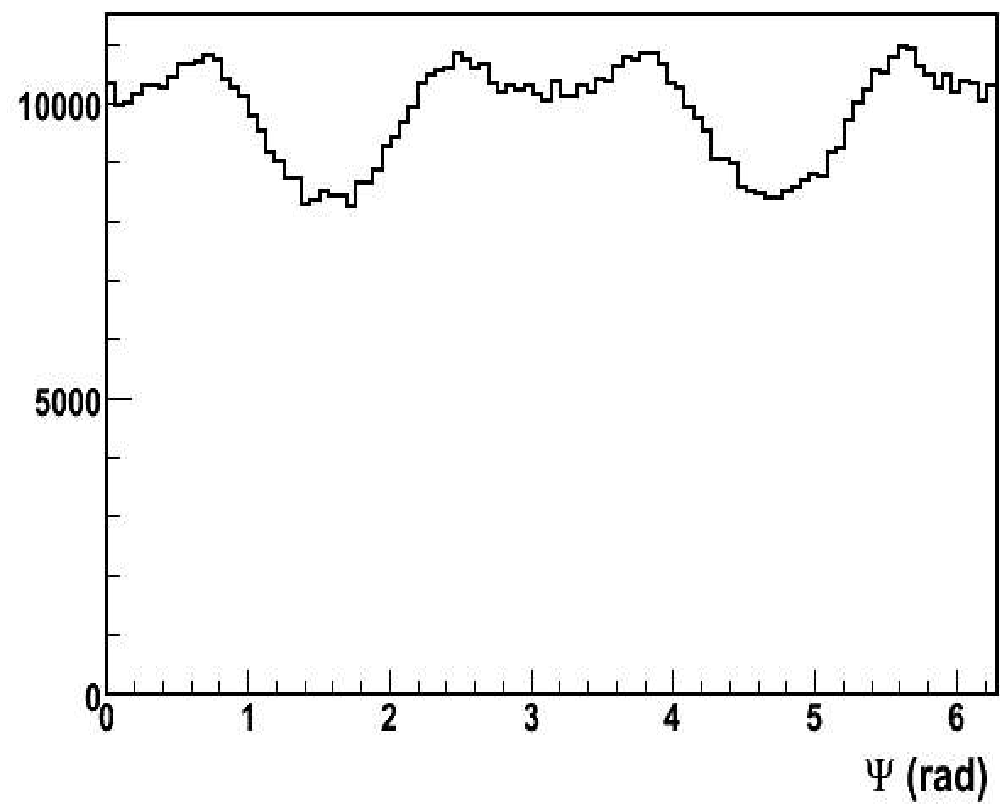
Expected achievements (for Kin1)

Acceptance (within t_{min}-t <1.0 GeV^2 and m_{KK} < 1.1 GeV):

Forward "peak" due to higher mass events.

=> complete SBS acceptance.



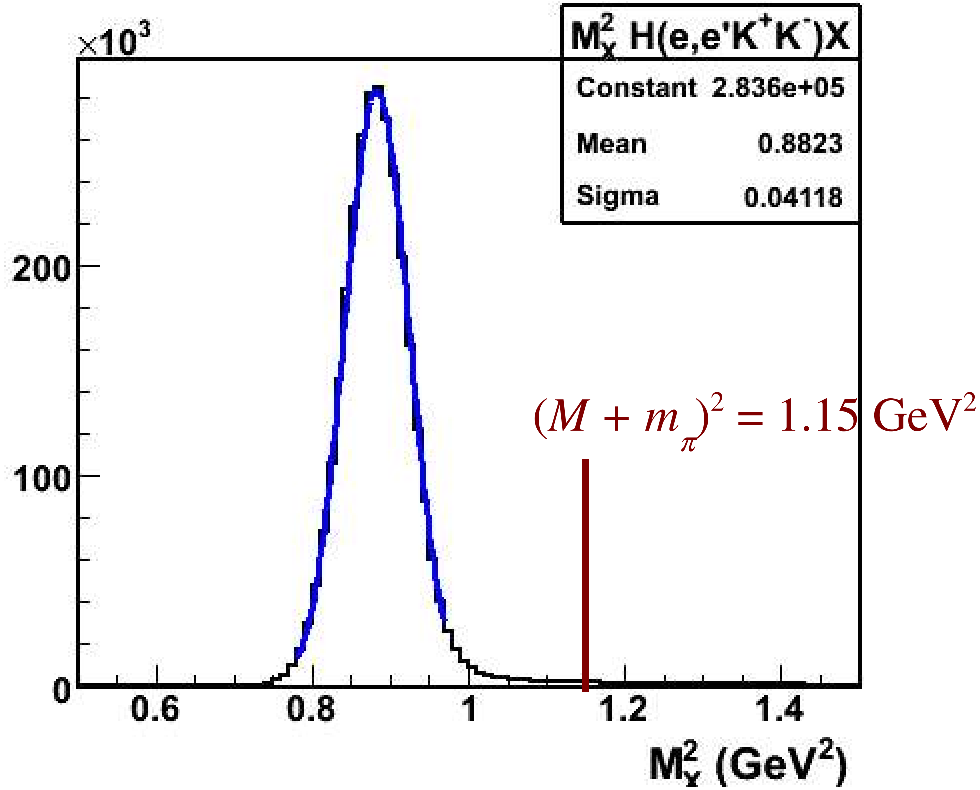


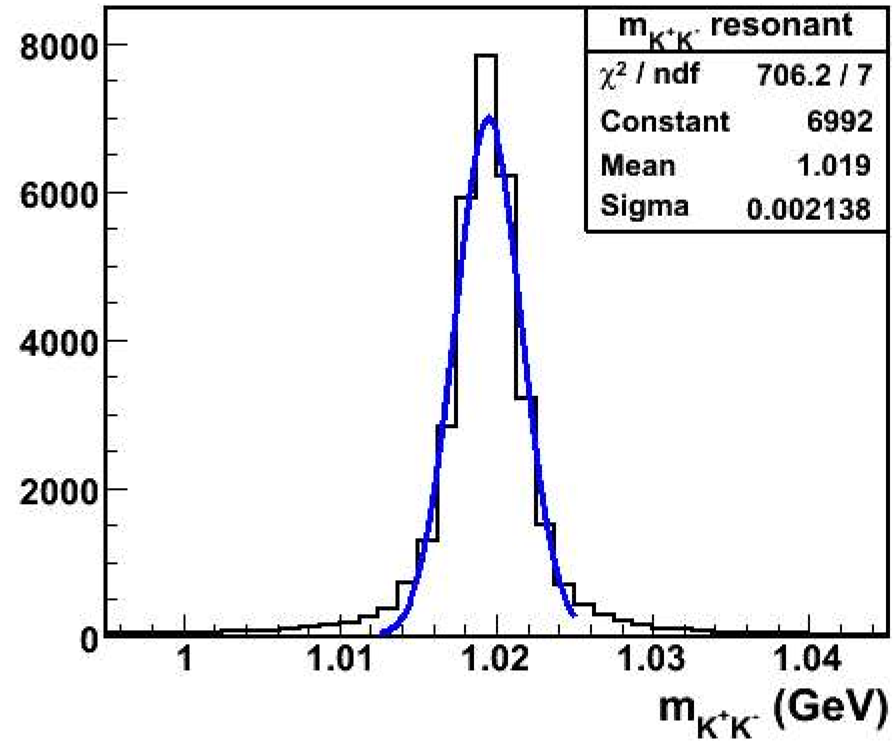
Expected achievements (for Kin1)

Uniform simulation resolution:

- M_X^2: $\sigma \sim 0.04$ GeV^2.
- m_{KK}: Gaussian resolution and ϕ decay width comparable.

=> Very good resolution achieved (with "HRS compatible" SBS).

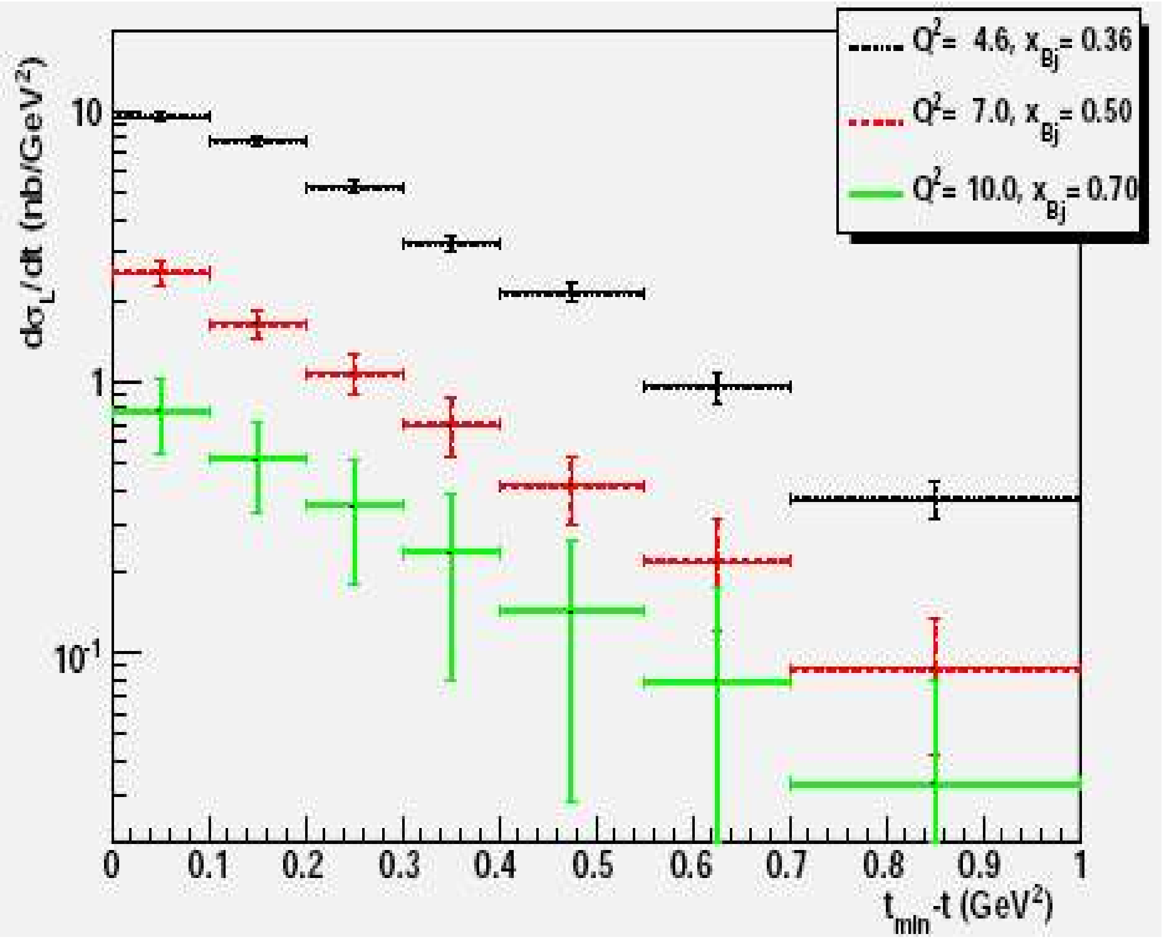




Results (for Kin1)

Extraction of $d\sigma_L/dt$ for t_{min}-t <1.0 GeV^2 for Kin1.

(Kin 2, 3 extrapolated)

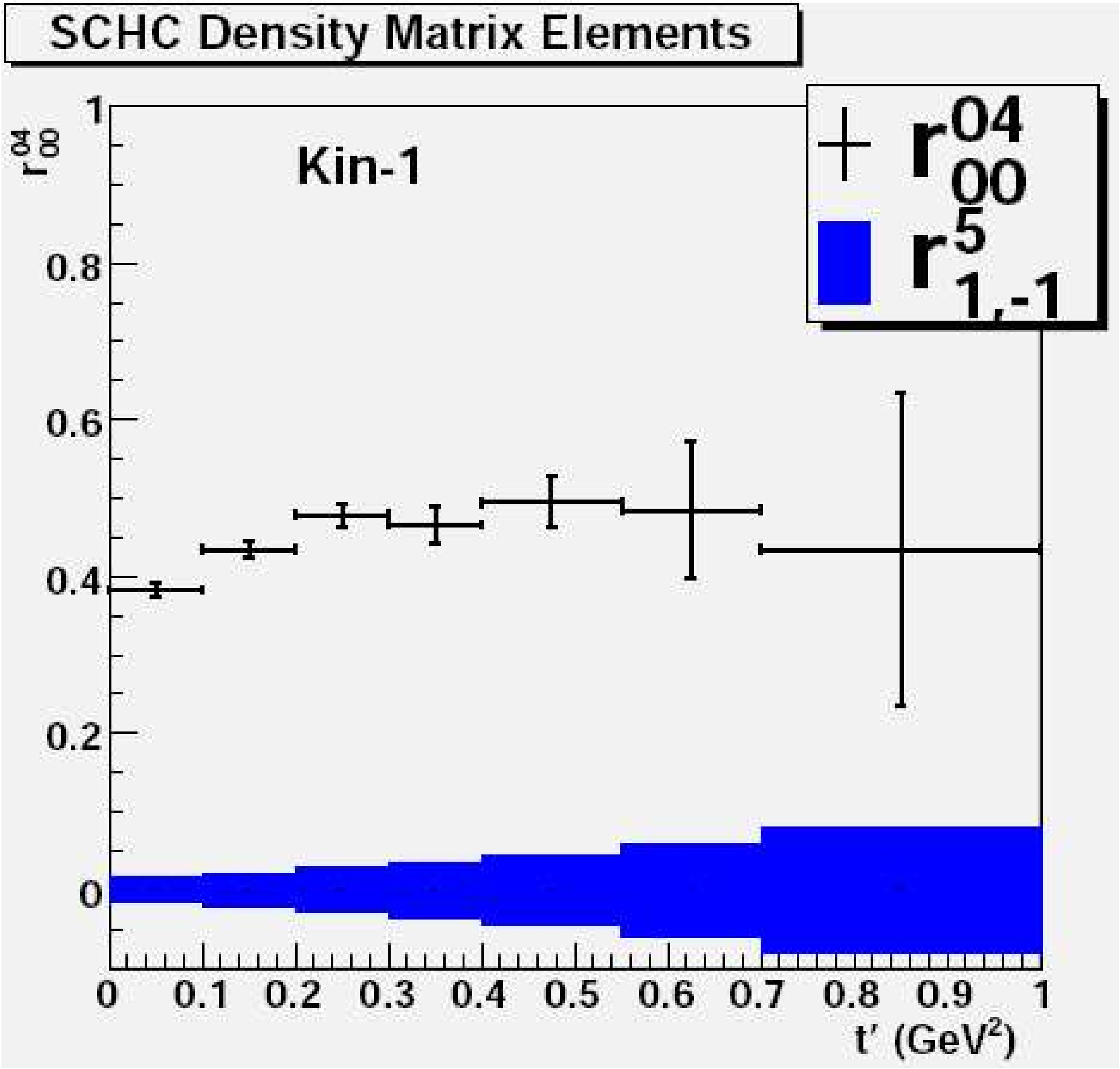


Assuming ~10% apparatus systematic errors:

- For Kin1, errors are dominated by statistics for t_{min}-t >0.55 GeV^2 : OK.
- For Kin2, errors would be dominated by statistics for t_{min}-t >0.3 GeV^2.

Results (for Kin1)

Extraction of r^{04}_{00} and estimation of $r^{5}_{1,-1}$ (a SCHC violating term) errors for t_{min}-t <1.0 GeV^2.



Conclusions

ϕ electroproduction experiment seems to be feasible in Hall A @ JLab 12 GeV, with HRS and SBS:

- Complete acceptance.
- Expected resolution is excellent.
- We are able to extract σ_L, σ_T, and r^{04}_{00}.

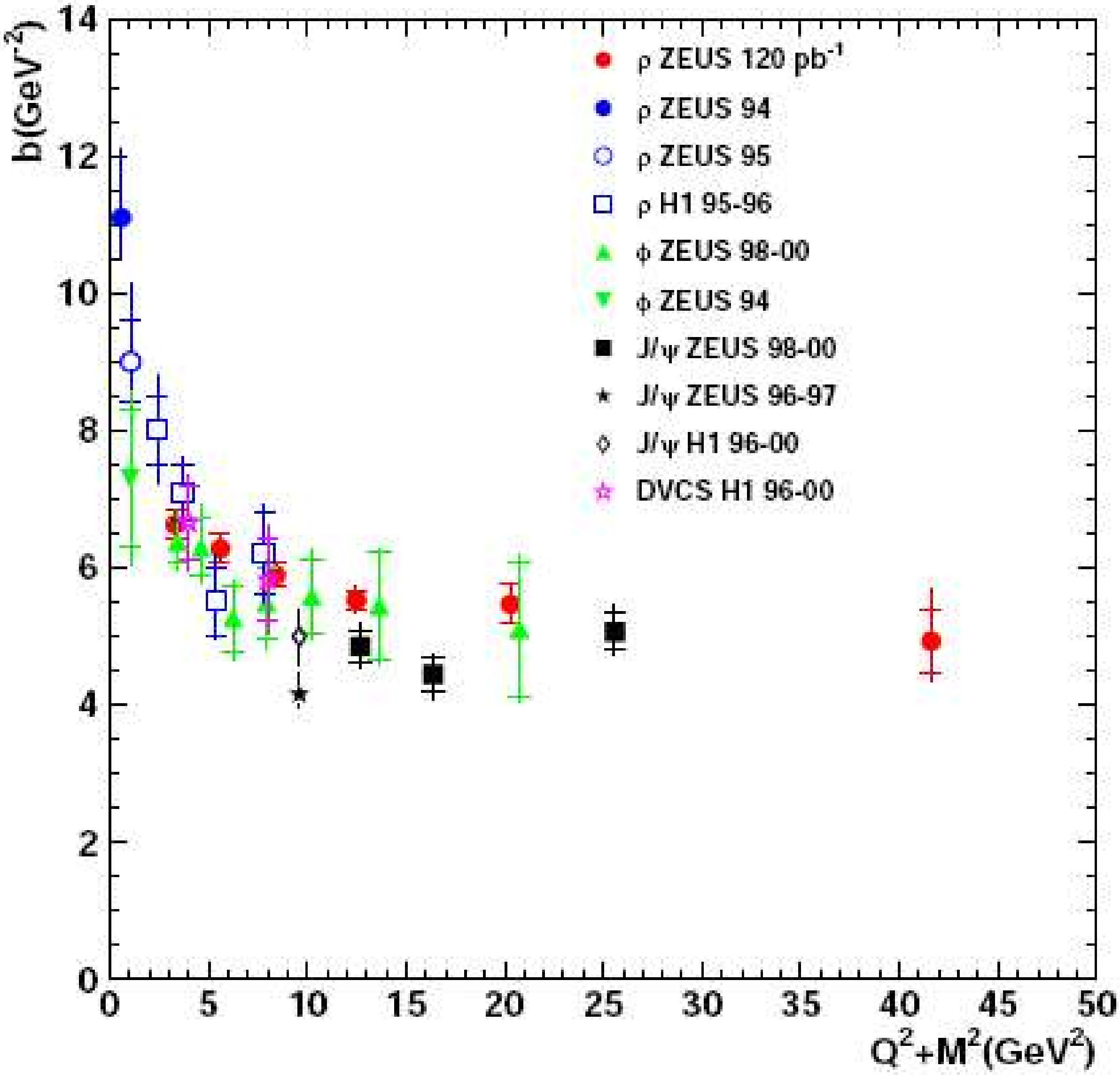
Future studies:

- Focus Kinematics on x_{Bj} range 0.3 - 0.6.
- Study of lower Q^2 point at each x_{Bj} (limited by SBS acceptance)
- Expanded study of precision of SCHC tests.

Perspectives

Remains to (more important to less):

- Test sensitivity to GPDs.
- improve analysis methods (e.g. Maximum Likelihood).
- estimate RICH kaon misidentification rate.


b(GeV^2)
Q^2+M^2(GeV^2)
0
5
10
15
20
25
30
35
40
45
50
2
4
6
8
12
14
ρ ZEUS 120 pb^{-1}
ρ ZEUS 94
ρ ZEUS 95
ρ H1 95-96
φ ZEUS 98-00
φ ZEUS 94
J/ψ ZEUS 98-00
J/ψ ZEUS 96-97
J/ψ H1 96-00
DVCS H1 96-00