
Electroproduction of ϕ Mesons in CLAS

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Exclusive Reactions
May 21, 2007



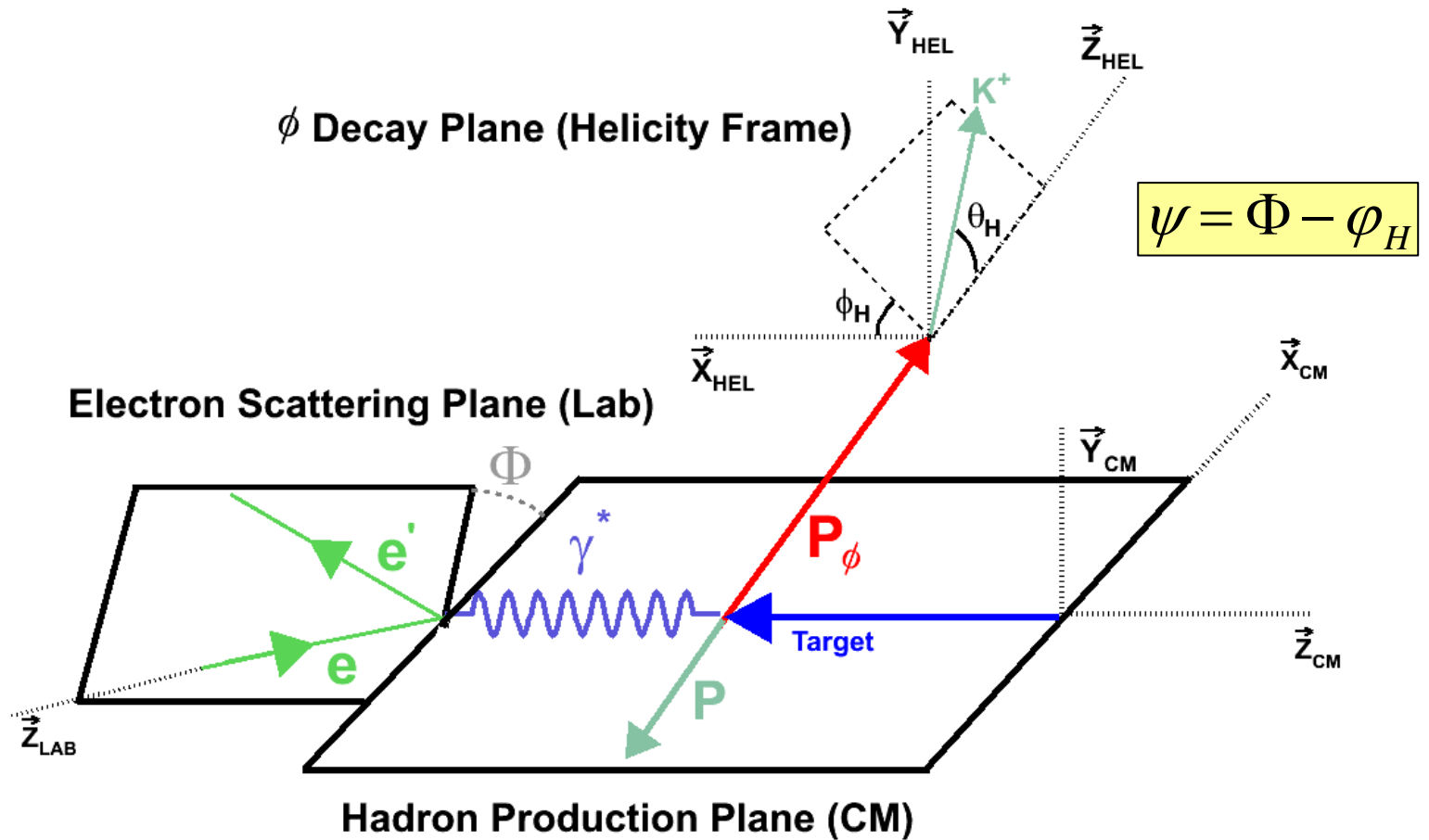
Exclusive Reactions May 21-24 2007

Kinematics

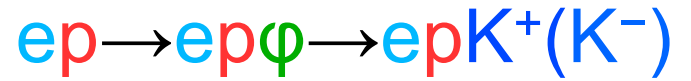
$$Q^2 = -(P_e^\mu - P_{e'}^\mu)^2$$

$$W = \sqrt{s} = M_P^2 + 2M_P v - Q^2$$

$$t = (P_{\lambda^*}^\mu - P_\phi^\mu)^2$$

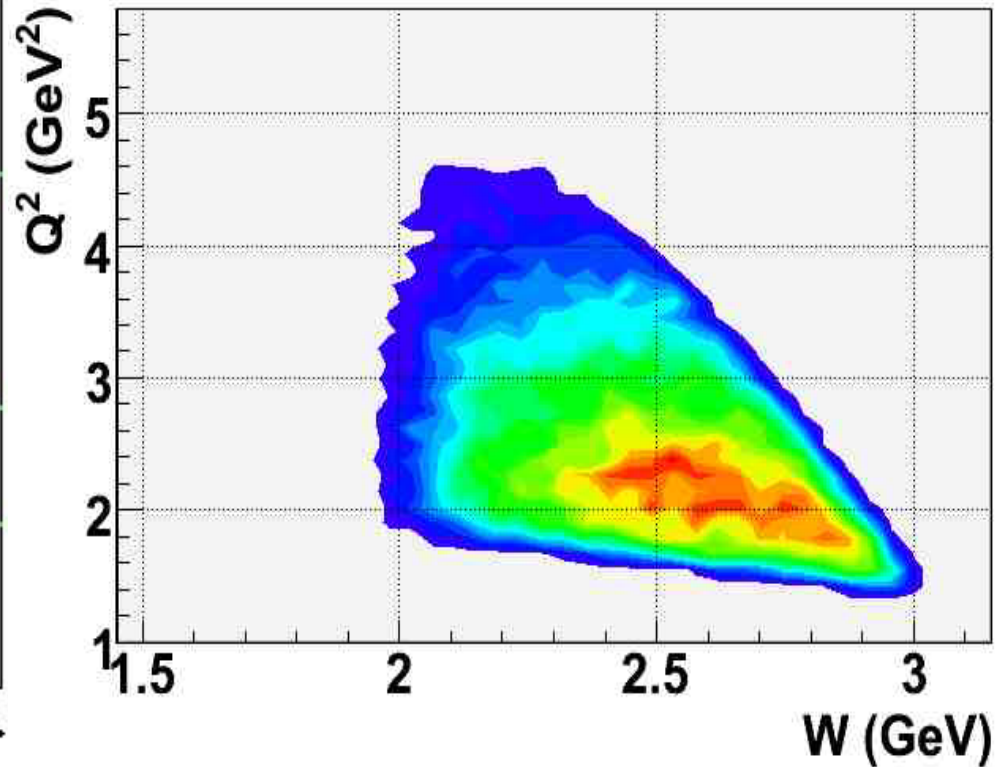
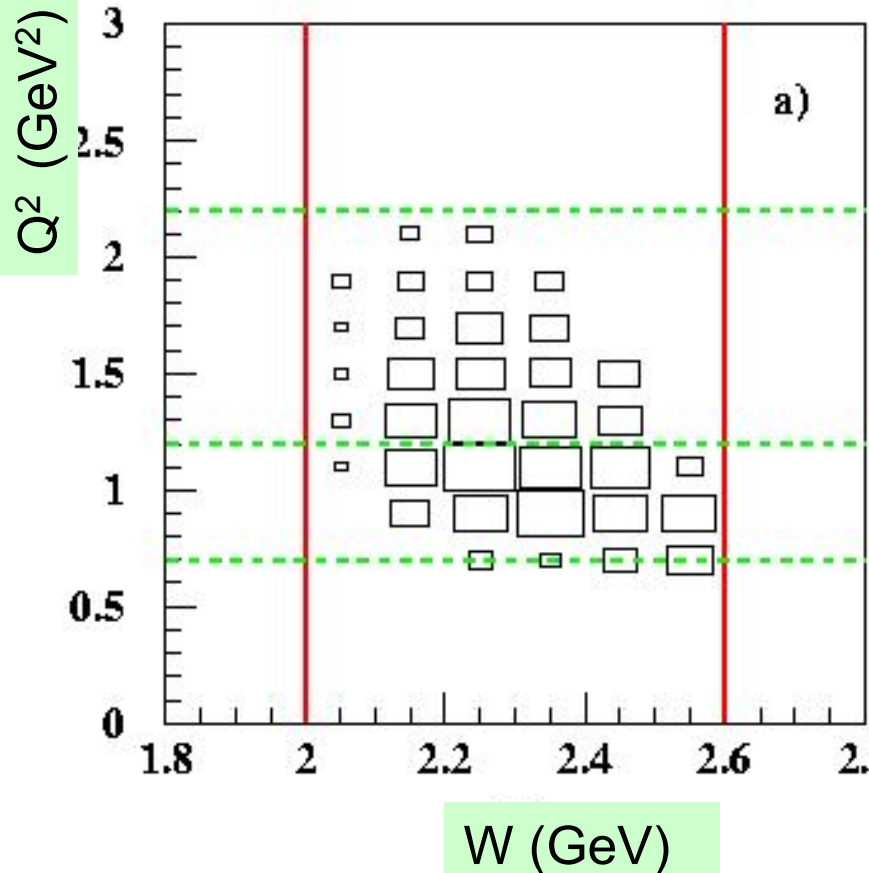


Kinematic Coverage



e1a/e1b: $E = 4.2 \text{ GeV}$,
 $Q^2 \sim 0.7 - 2.2 \text{ GeV}^2$

e1-6a: $E = 5.75 \text{ GeV}$
 $Q^2 \sim 1.7 - 3.8 \text{ GeV}^2$



e1-6 Experiment @ CLAS

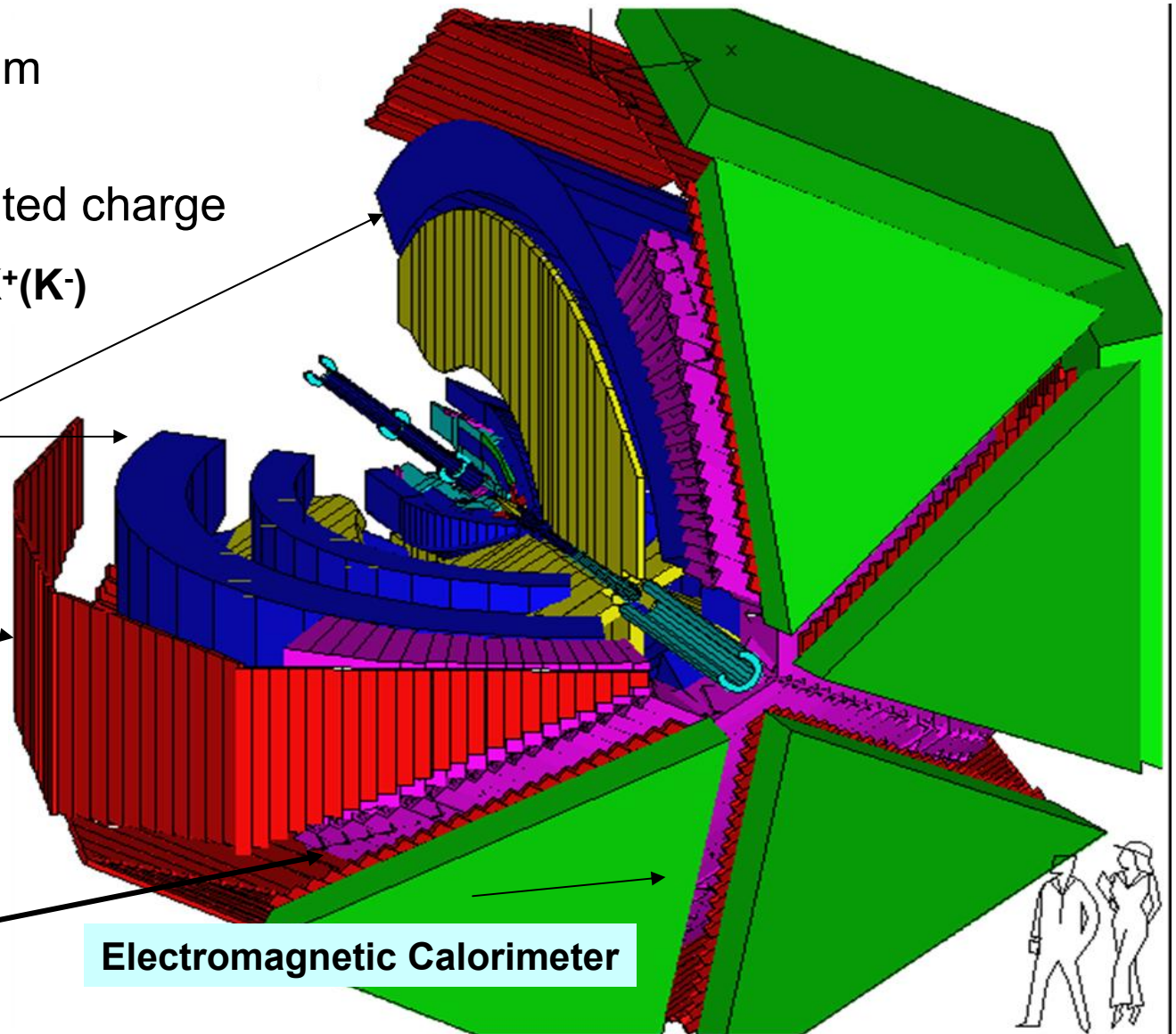
- 5.75 GeV Beam
- Proton Target
- 21 mC integrated charge
- $ep \rightarrow ep\psi \rightarrow K^+(K^-)$

Drift Chambers

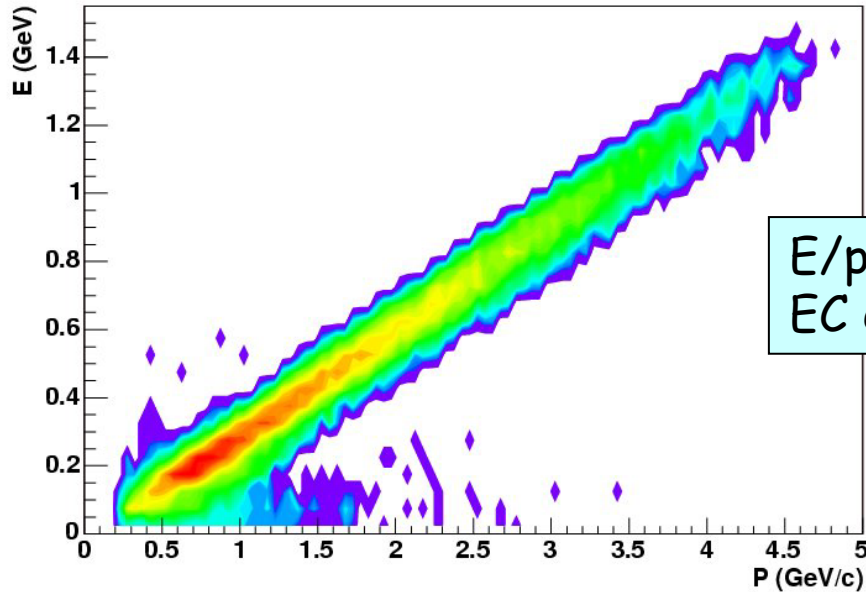
TOF

Cherenkov

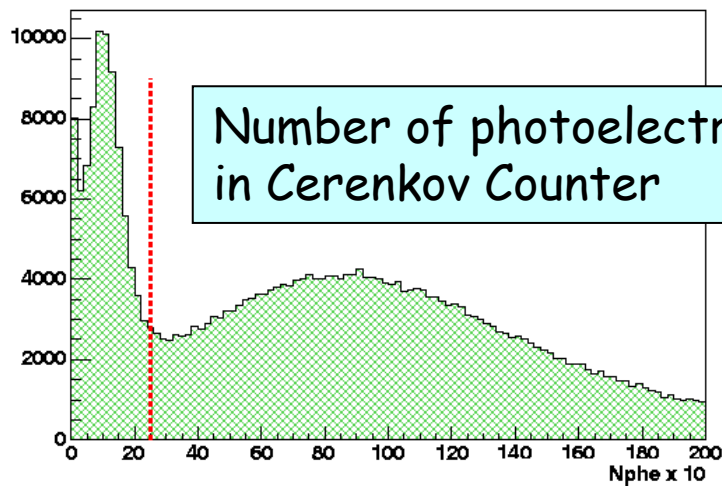
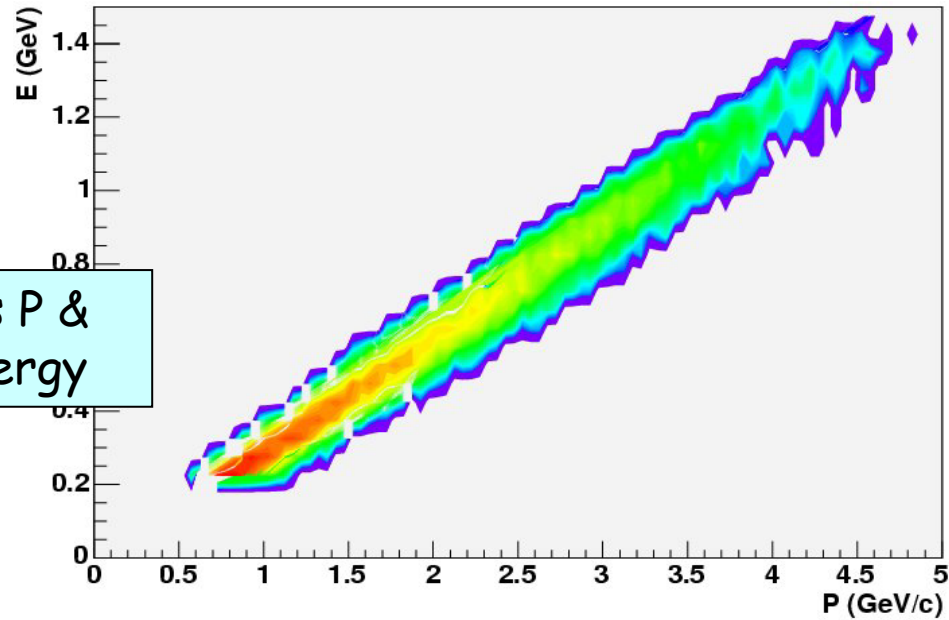
Electromagnetic Calorimeter



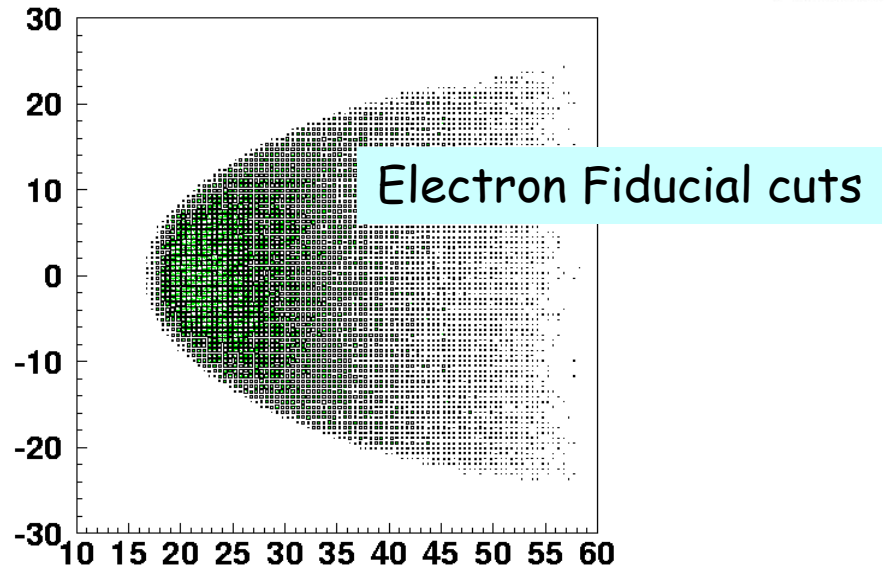
Electron Selection



E/p vs P &
EC energy



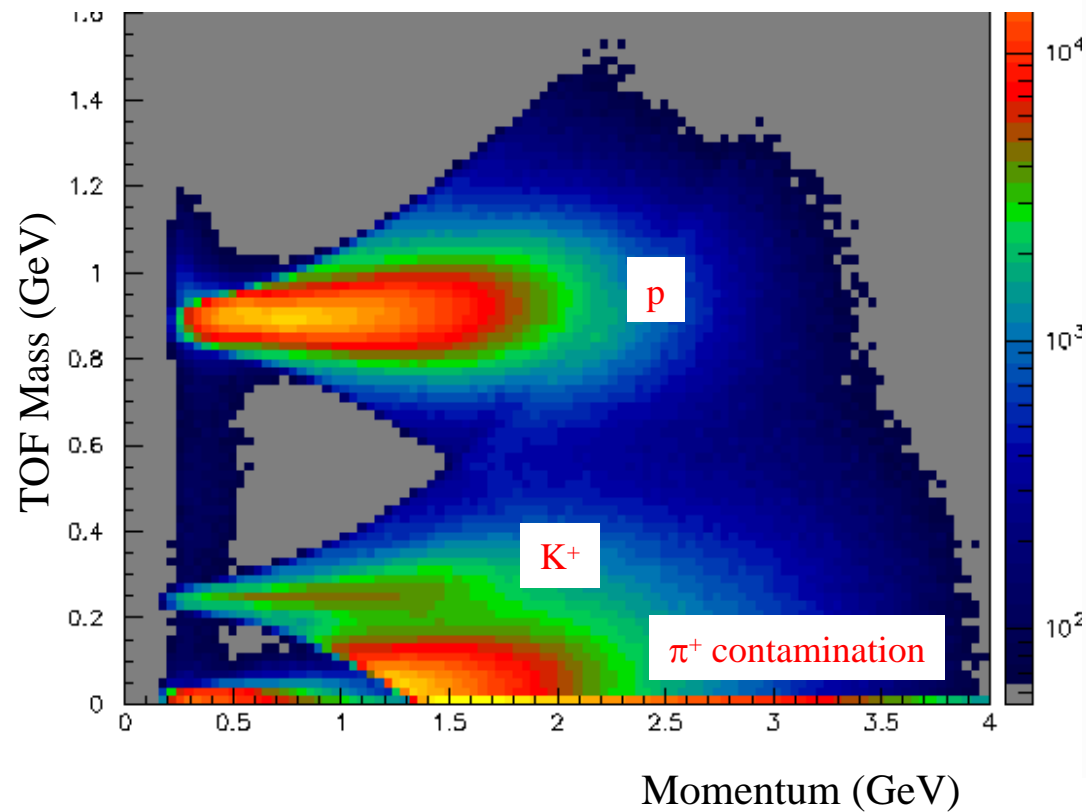
Number of photoelectrons
in Cerenkov Counter



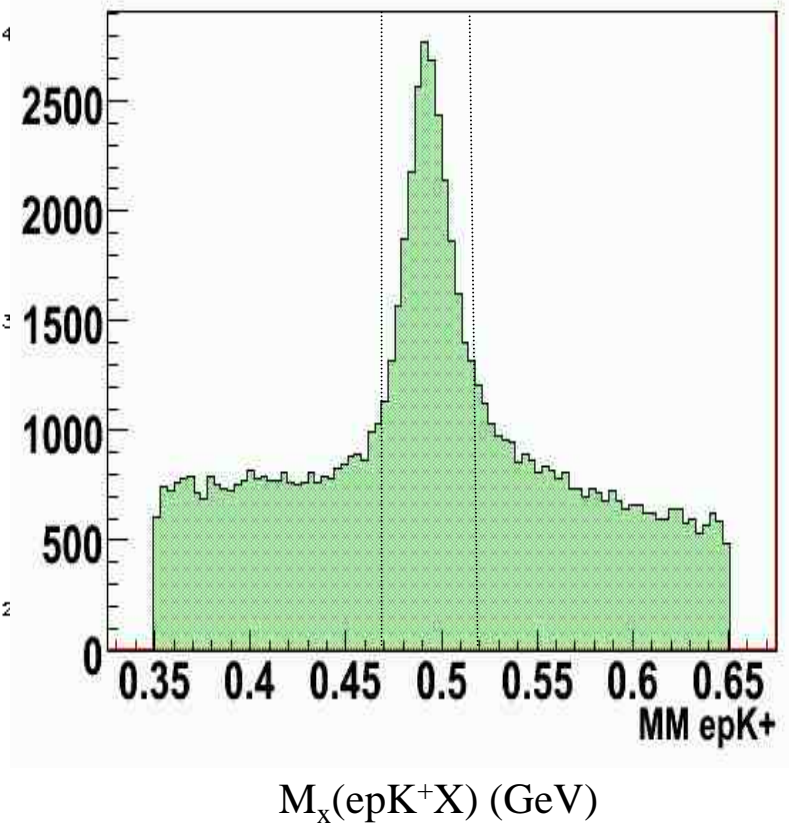
Electron Fiducial cuts

Hadron Identification

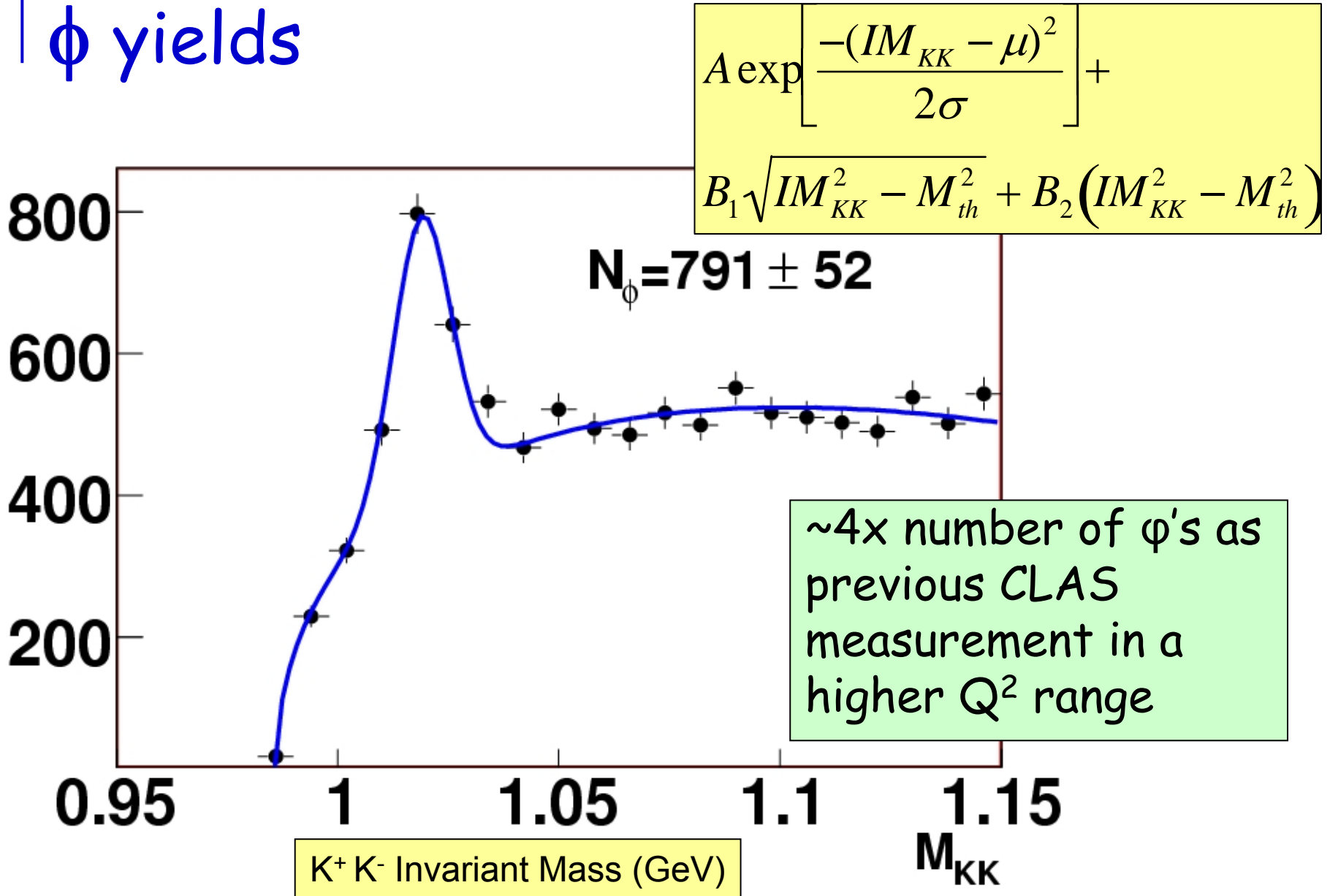
p and K^+ selection



K^- from missing mass
(2σ selection cut)



ϕ yields



6-D Acceptance Correction

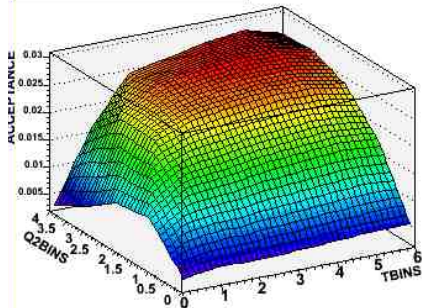
$$ACC(\Gamma) = \frac{N_{acc}(\Gamma)}{N_{gen}(\Gamma)}$$

Variable	Q^2	W	\dagger	$\cos(\theta_H)$	ψ	Φ
N_{bins}	5	4	7	5	8	6

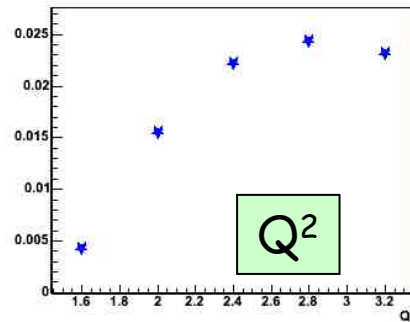
$$d\Gamma = dQ^2 dW dt d\cos\theta_H d\Phi d\psi$$

33,600 bins, 10^8 events

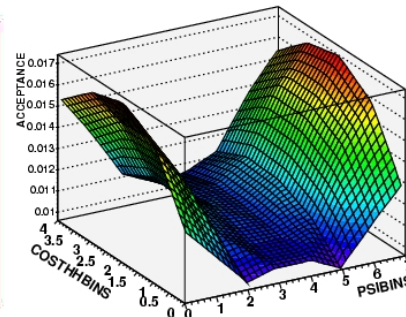
2-D Q^2 - \dagger ACCEPTANCE



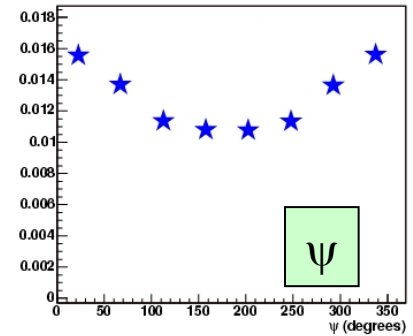
1-D Q^2 -ACCEPTANCE



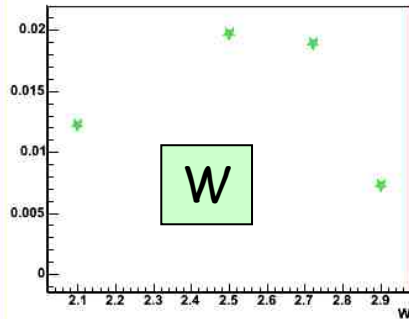
2-D ψ - $\cos\theta_H$ ACCEPTANCE



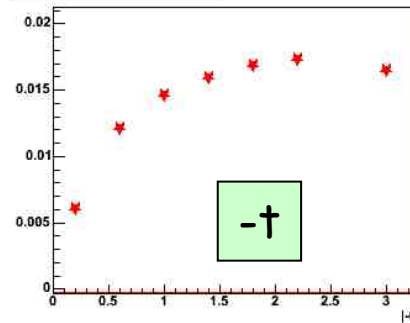
1-D ψ -ACCEPTANCE



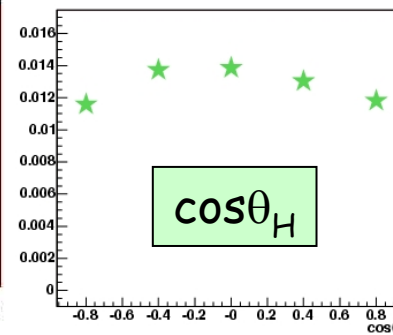
1-D W -ACCEPTANCE



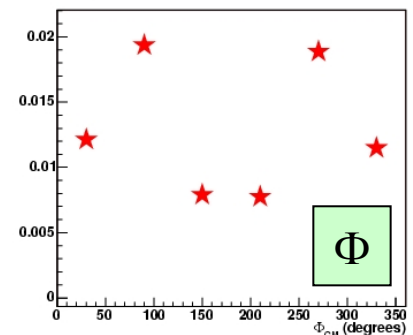
1-D \dagger -ACCEPTANCE



1-D $\cos\theta_H$ -ACCEPTANCE



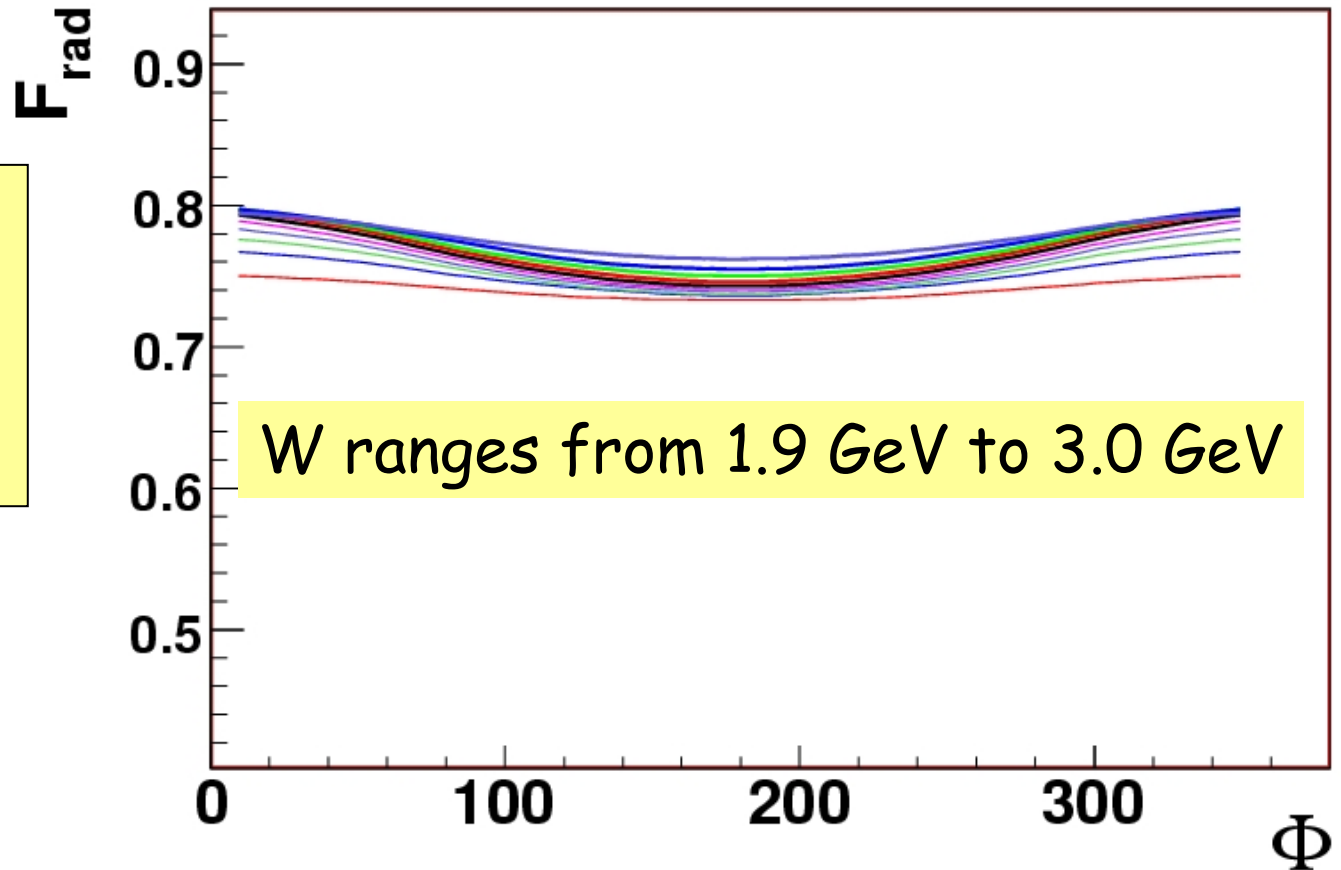
1-D Φ_{CM} -ACCEPTANCE



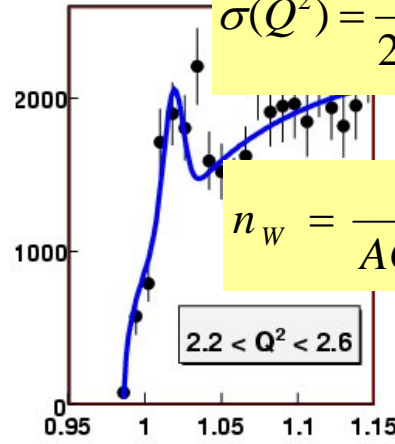
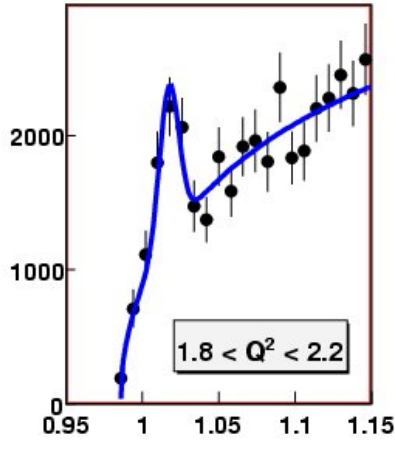
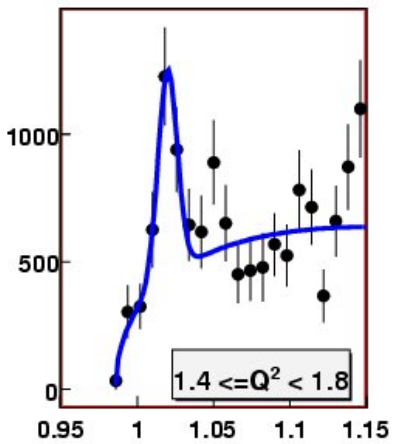
Radiative Corrections

$$\cos(\theta)_{CM} = 0.345, Q^2 = 2.47 \text{ GeV}^2$$

EXCLURAD was used to obtain corrections in $Q^2, W, \Phi,$ and $\cos(\theta)_{CM}$ bins



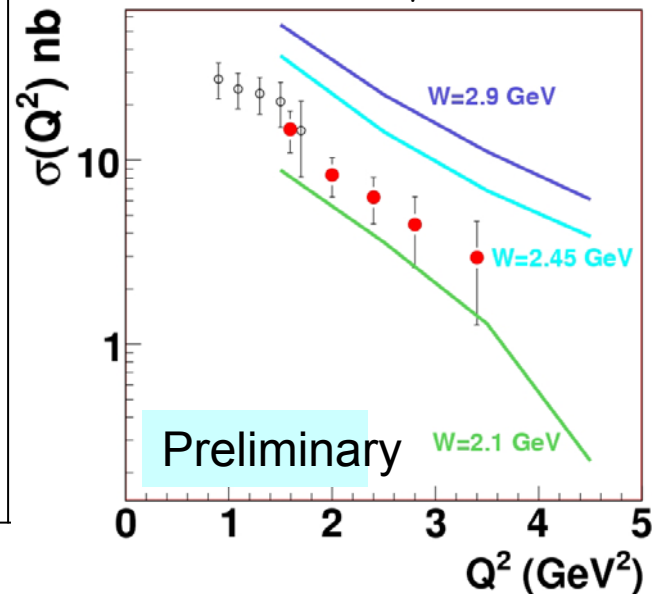
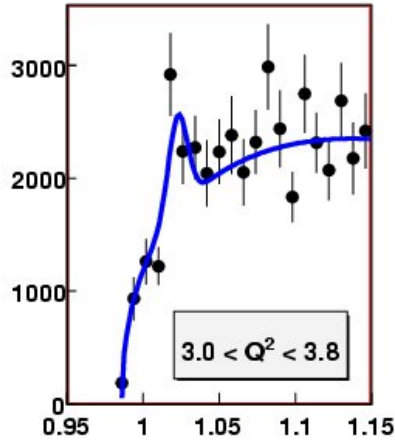
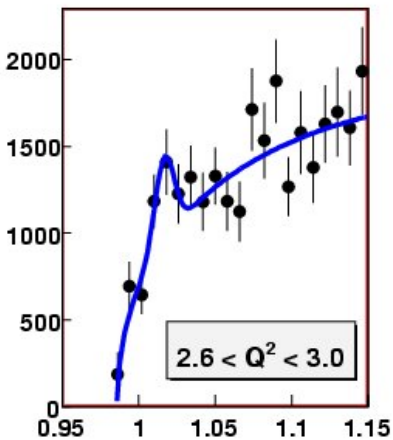
Total Cross Sections $\sigma(Q^2)$



$$\sigma(Q^2) = \frac{n_W}{2\pi \cdot BR_{\phi \Rightarrow K^+ K^-} \cdot \Delta Q^2 \Delta W \cdot L_{\text{int}} \cdot C_{BW} \cdot \text{eff}_W}$$

$$n_W = \frac{N_\phi}{ACC(\Gamma) \cdot \Gamma(Q^2, W) \cdot F_{\text{RAD}} \cdot CC_{\text{eff}}}$$

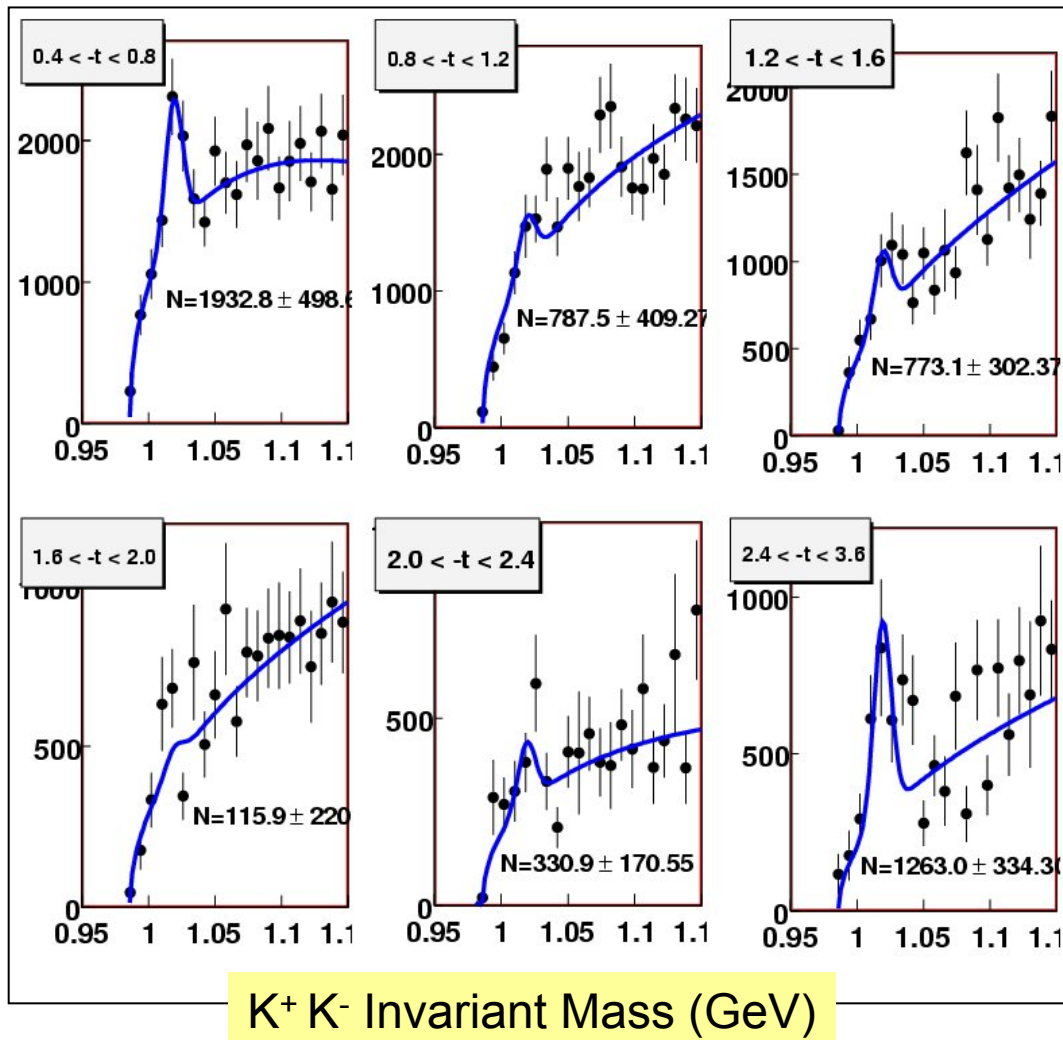
Laget Model
NP A581:397-428, 1995
Phys. Lett. B. 489:313-318, 2000



$K^+ K^-$ Invariant Mass (GeV)

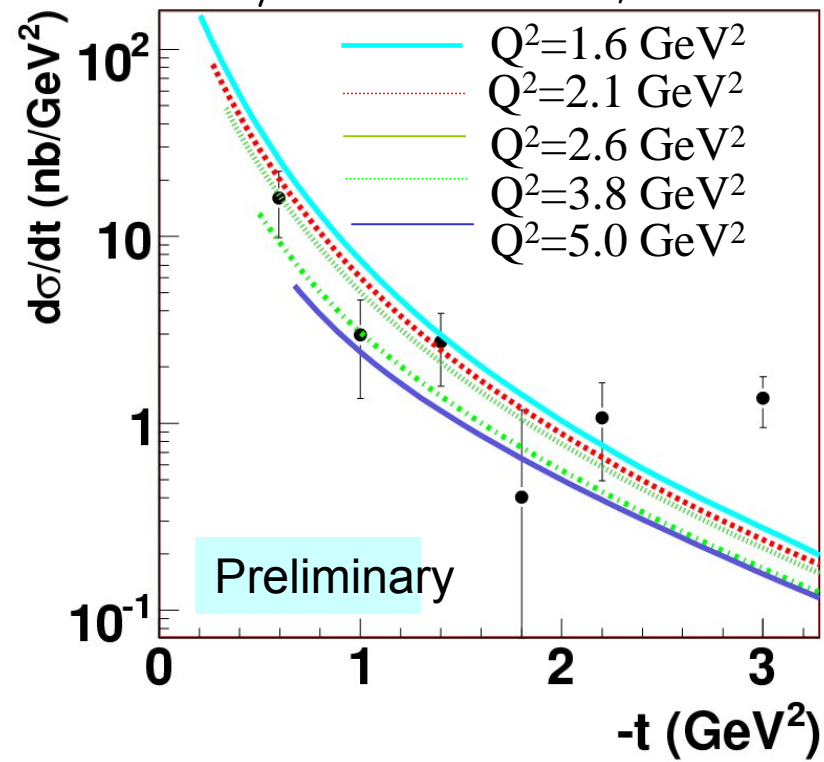


Differential Cross Section in t



$$\frac{d\sigma}{dt} = \frac{\sigma(Q^2)}{\Delta t_{bin} \cdot CORR_{t_{min}}}$$

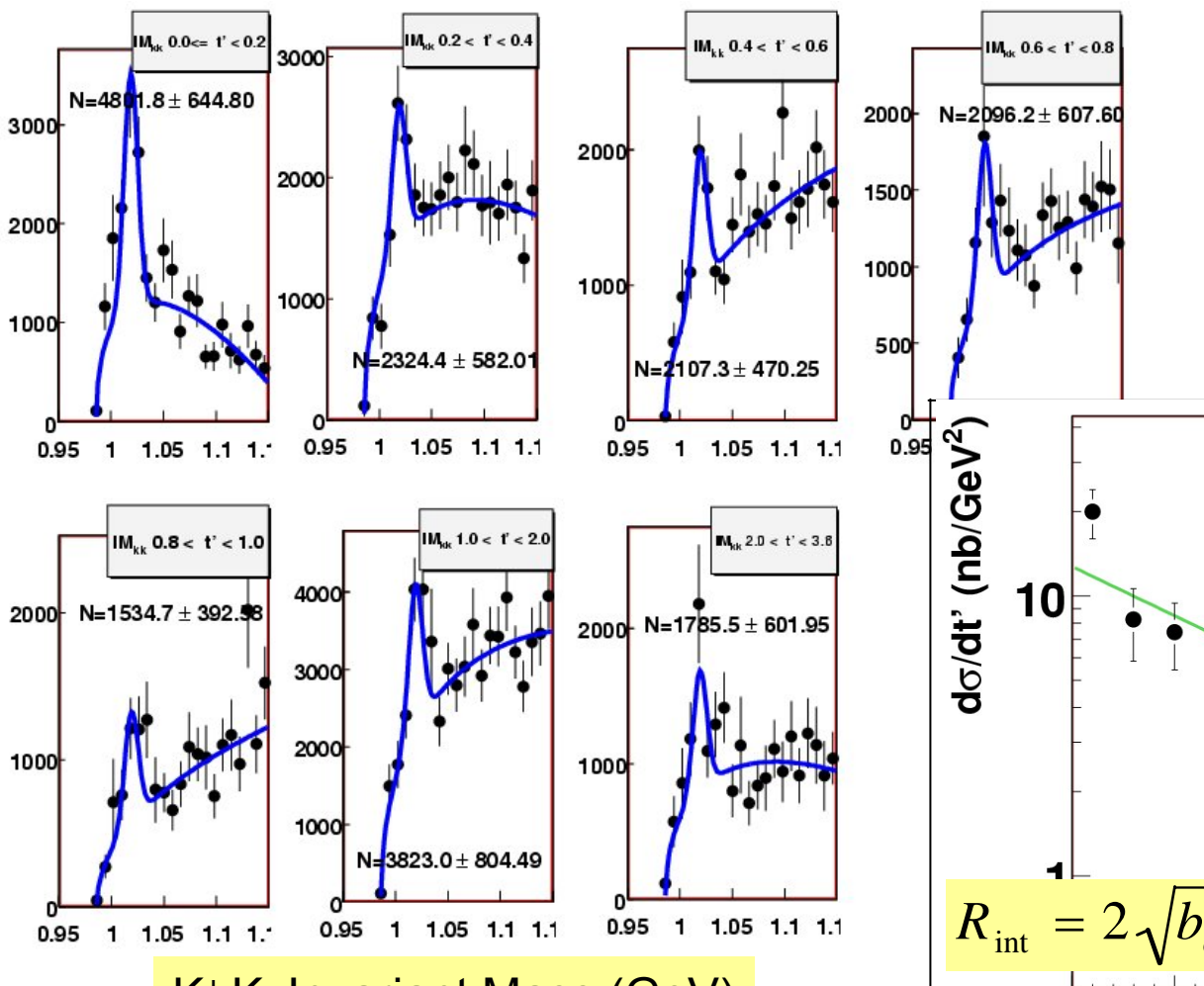
Nuc. Phys. A581:397-428, 1995
 Phys. Lett. B. 489:313-318, 2000



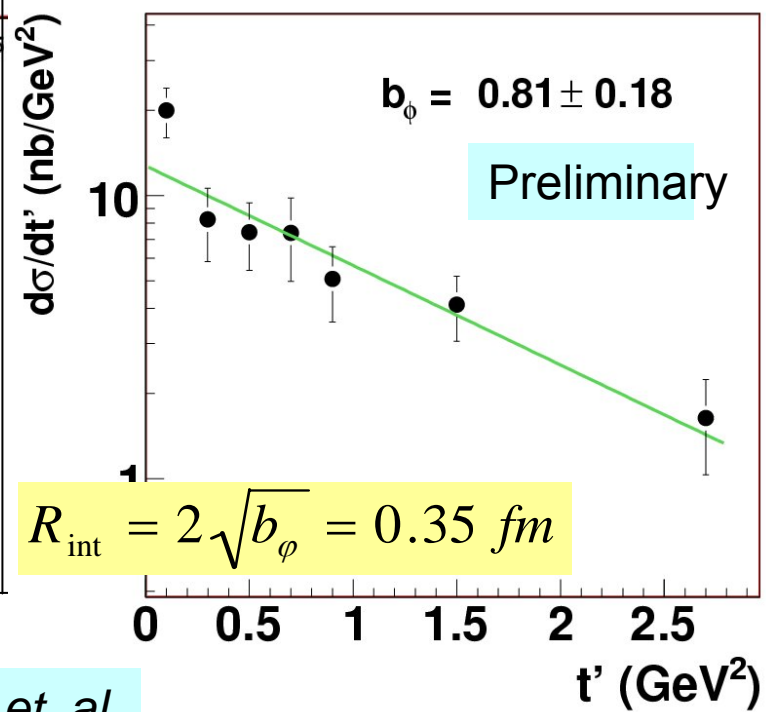
Differential Cross Section in t'

$$\frac{d\sigma}{dt'} = A_\phi e^{-b_\phi t'}$$

$b \downarrow$ as $Q^2 \uparrow$



$K^+ K^-$ Invariant Mass (GeV)

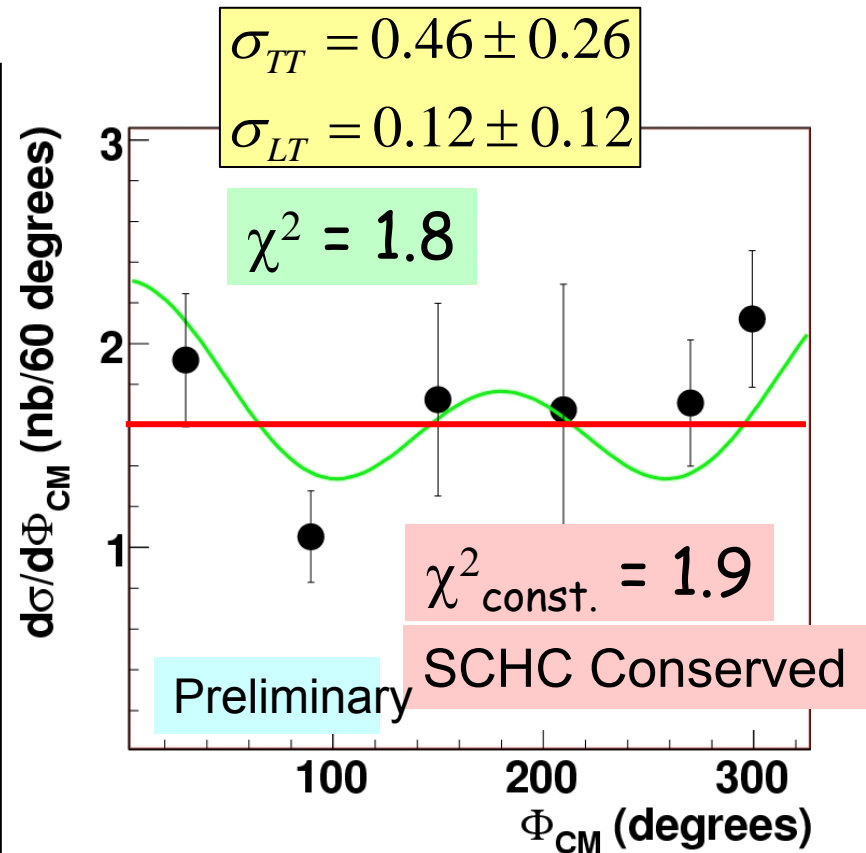
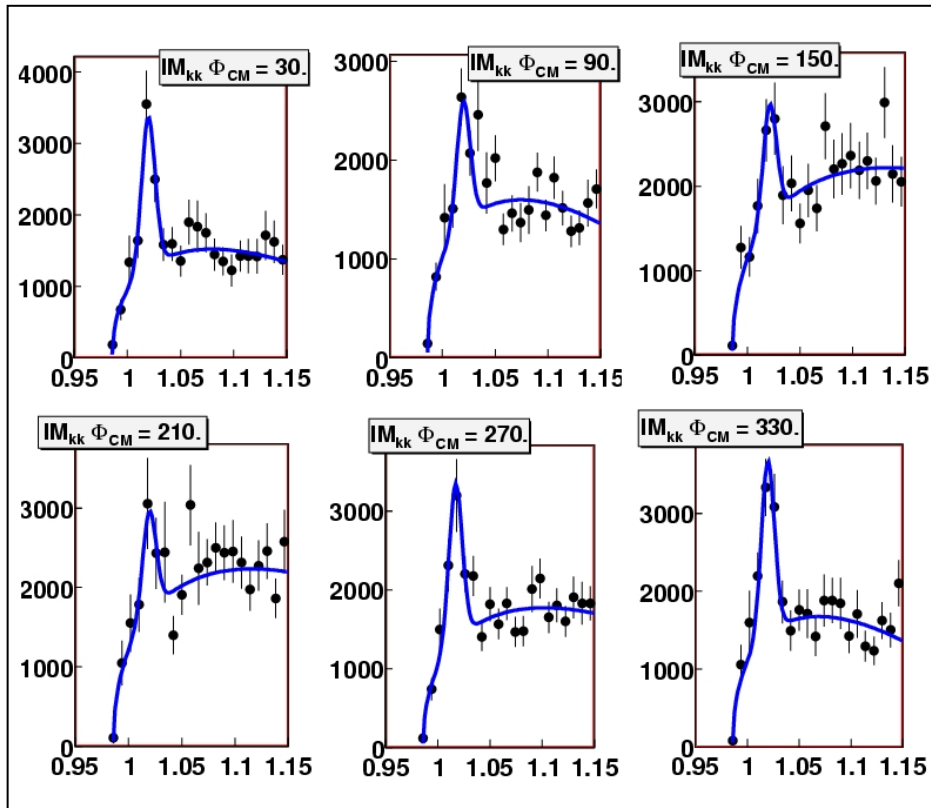


$b_{c\Delta\tau=0.6\text{fm}} = 1.61 \pm 0.31 \text{ GeV}^{-2}$

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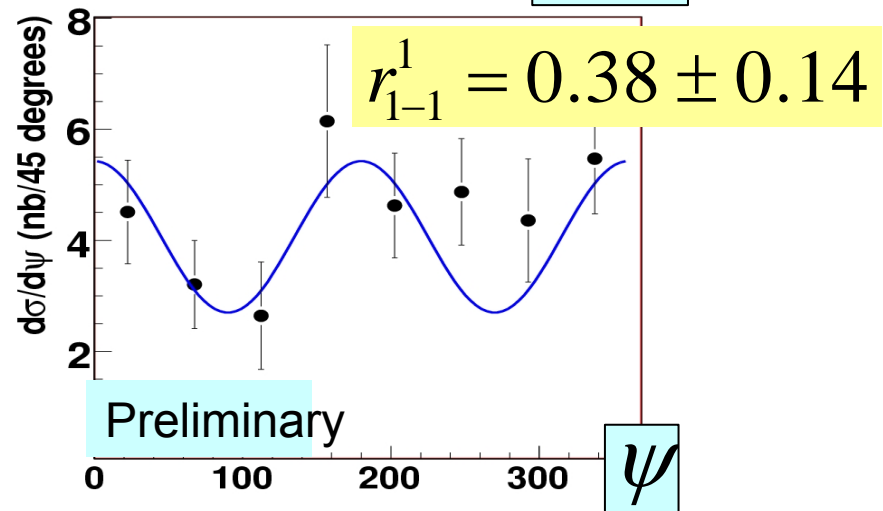
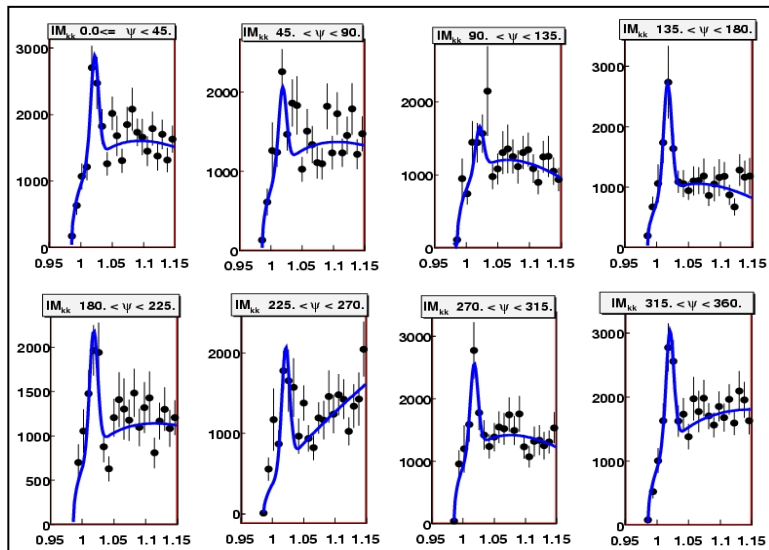
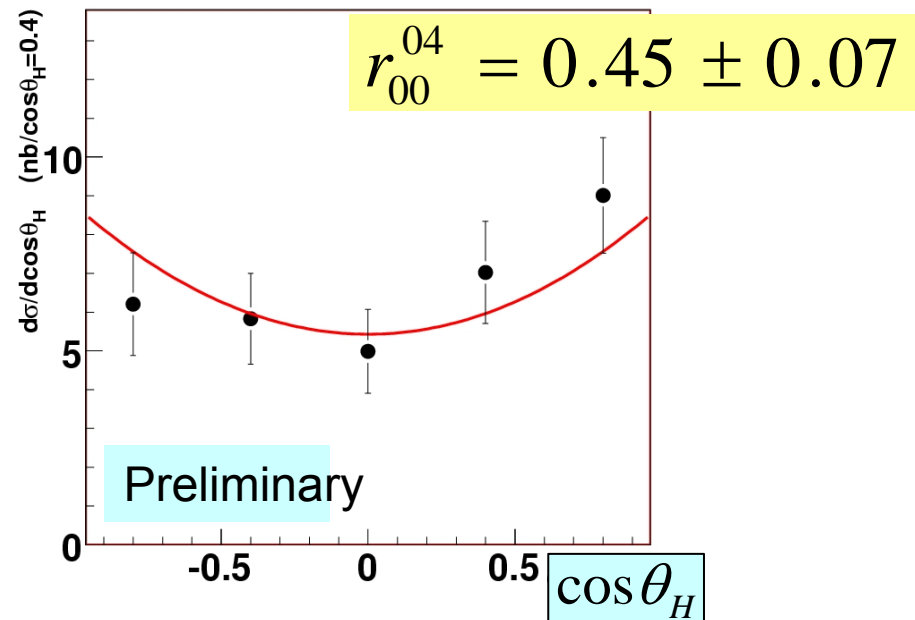
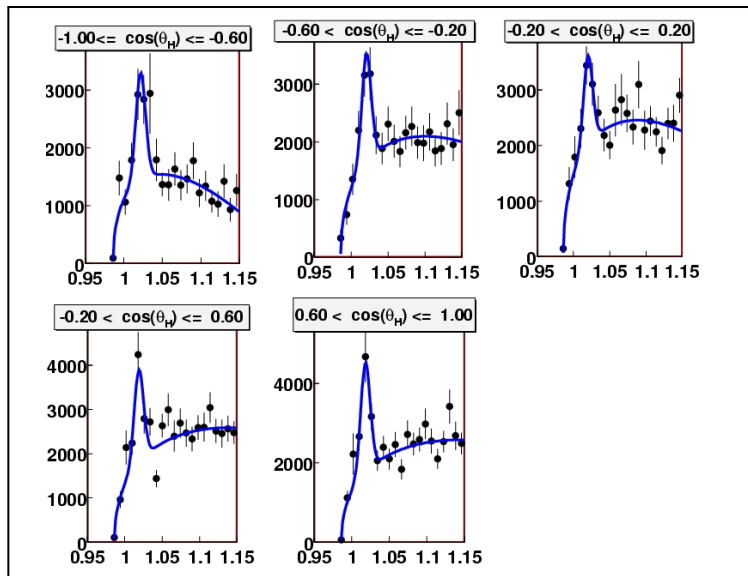


Differential Cross Section in Φ



$$\frac{d\sigma}{d\Phi} = \frac{1}{2\pi} \left(\sigma + \varepsilon \cos 2\Phi \sigma_{TT} + \sqrt{2\varepsilon(1+\varepsilon)} \cos \Phi \sigma_{LT} \right)$$

Angular Distributions



σ_L Extraction

$Q^2 \uparrow R \uparrow$

σ_L dominates

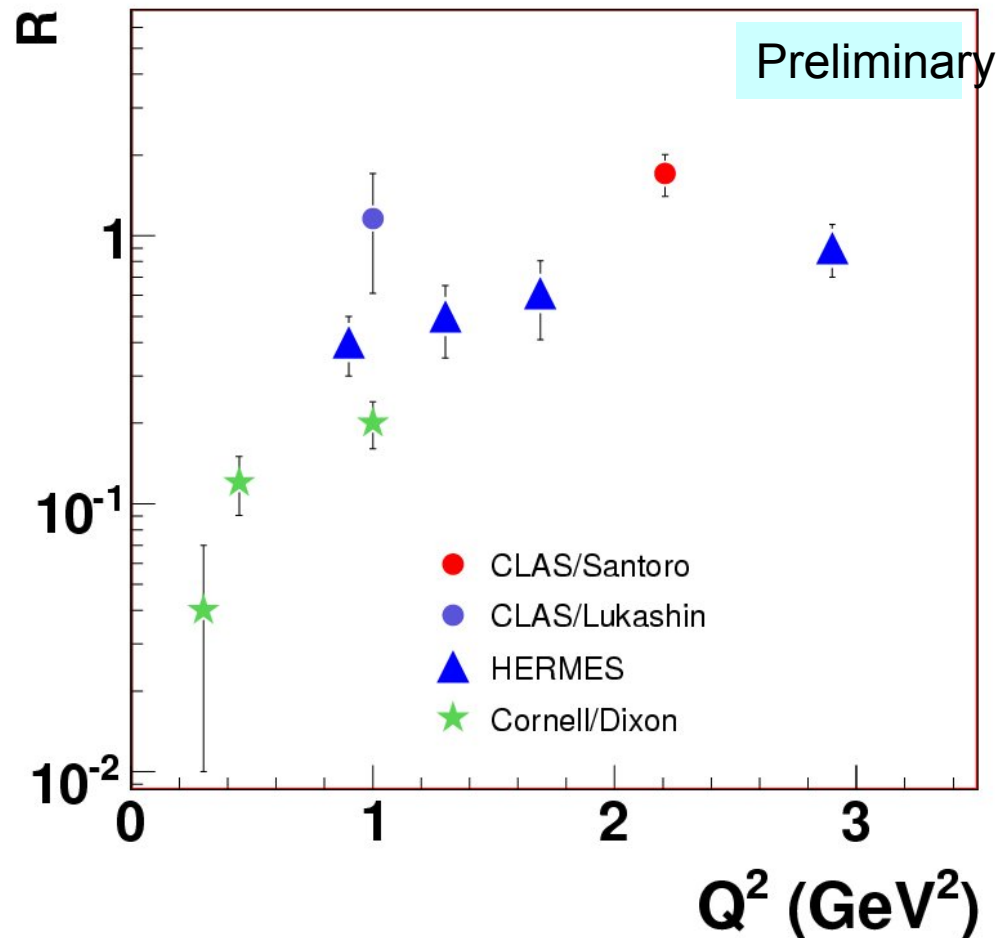
Assumes SCHC

$$R = \frac{1}{\epsilon} \left(\frac{r_{00}^{04}}{1 - r_{00}^{04}} \right)$$

$$\langle R \rangle = 1.71 \pm 0.3$$

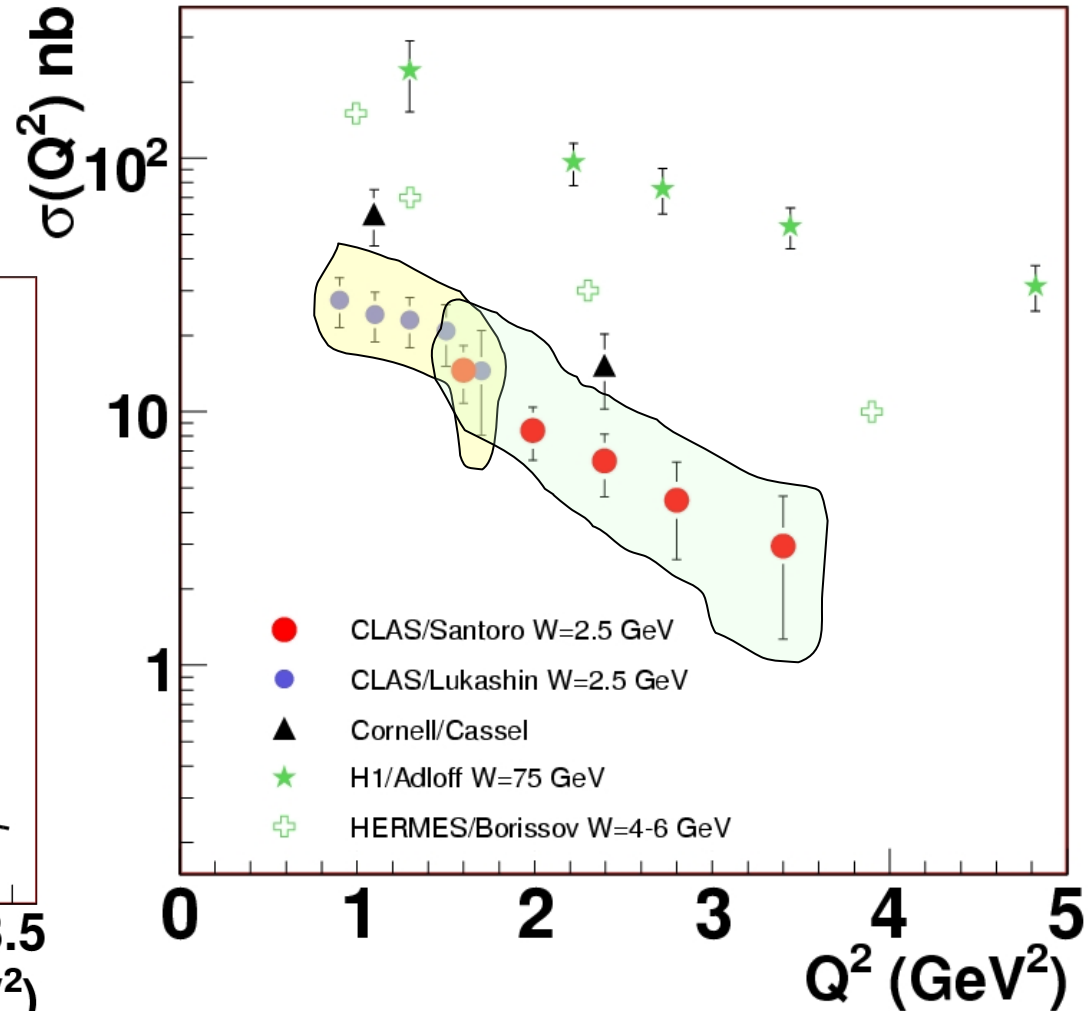
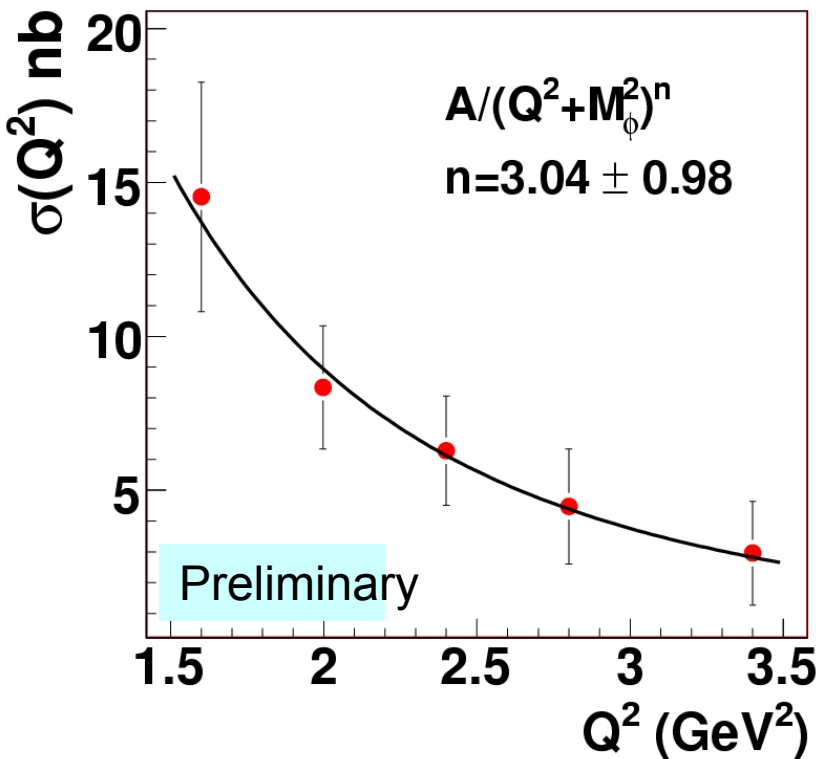
$$\langle R_{\langle Q^2 \rangle = 1.2 \text{ GeV}^2} \rangle = 1.16 \pm 0.55$$

$$\sigma_L = \frac{\sigma_{avg}}{R(1 + \langle \epsilon \rangle)} = 2.7 \pm 1.2 \text{ nb}$$



Comparison to World Data

Filled previously unexplored region of phase space (low W , low-medium Q^2)



ϕ production summary

- Kinematic Range
 - $1.6 \leq Q^2 \leq 3.8$, $0.0 \leq t' \leq -3.6$, $2.0 \leq W \leq 3.0$
- $\sigma(Q^2) \sim 1/(Q^2 + M_\phi^2)^{3 \pm 1}$
- Φ angular distribution consistent with SCHC
 - $R = 1.71 \pm 0.30$, $\sigma_L = 2.9 \pm 0.8$ nb integrated over Q^2
- t' distribution slope $b_\phi = 0.81 \pm 0.18 \text{ GeV}^2$
 - Interaction probes sizes $\sim 1/3$ fm.
- Theoretical input welcome.