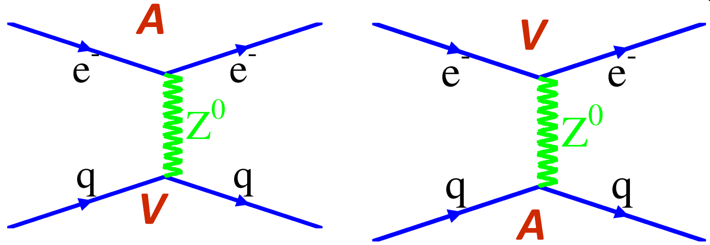
PVDIS with SoLID

and radiative corrections

PVDIS Theory

$$A_{\text{iso}} = \frac{\sigma^l - \sigma^r}{\sigma^l + \sigma^r}$$
$$= -\left(\frac{3G_F Q^2}{\pi\alpha 2\sqrt{2}}\right) \frac{2C_{1u} - C_{1d}(1+R_s) + Y(2C_{2u} - C_{2d})R_v}{5 + R_s}$$



$C_{1i} \equiv 2g_A^e g_V^i$ $\quad$ $C_{2i} \equiv 2g_V^e g_A^i$

$$Y = \frac{1-(1-y)^2}{1+(1-y)^2 - y^2\frac{R}{R+1}}$$

$$R(x, Q^2) = \sigma^l/\sigma^r \approx 0.2$$

$$C_{1u} = -\tfrac{1}{2} + \tfrac{4}{3}\sin^2\theta_W \approx -0.19$$
$$C_{1d} = \tfrac{1}{2} - \tfrac{2}{3}\sin^2\theta_W \approx 0.35$$
$$C_{2u} = -\tfrac{1}{2} + 2\sin^2\theta_W \approx -0.04$$
$$C_{2d} = \tfrac{1}{2} - 2\sin^2\theta_W \approx 0.04$$

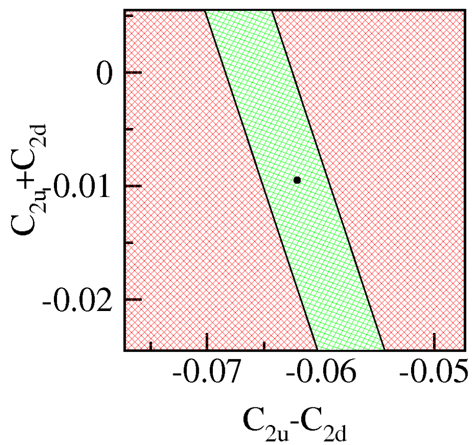
Cahn and Gilman, PRD **17** 1313 (1978) polarized electrons on deuterium

Motivation for PVDIS

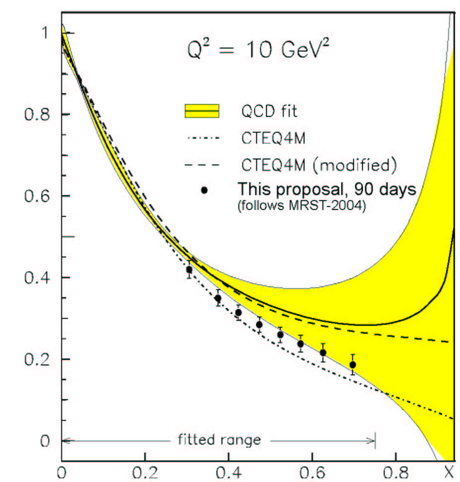
$$A_{PV} = \frac{G_F Q^2}{\sqrt{2}\pi\alpha}\left[\mathbf{a}(x) + Y(y)\,\mathbf{b}(x)\right]$$

Standard Model

$$b(x) = \frac{\sum_i C_{2i} Q_i f_i^-(x)}{\sum_i Q_i^2 f_i^+(x)}$$



d/u for Hydrogen



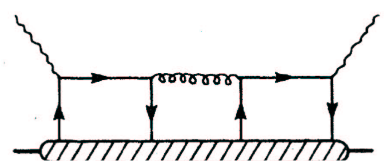
CSV at Quark Level

$$\delta u(x) = u^p(x) - d^n(x)$$

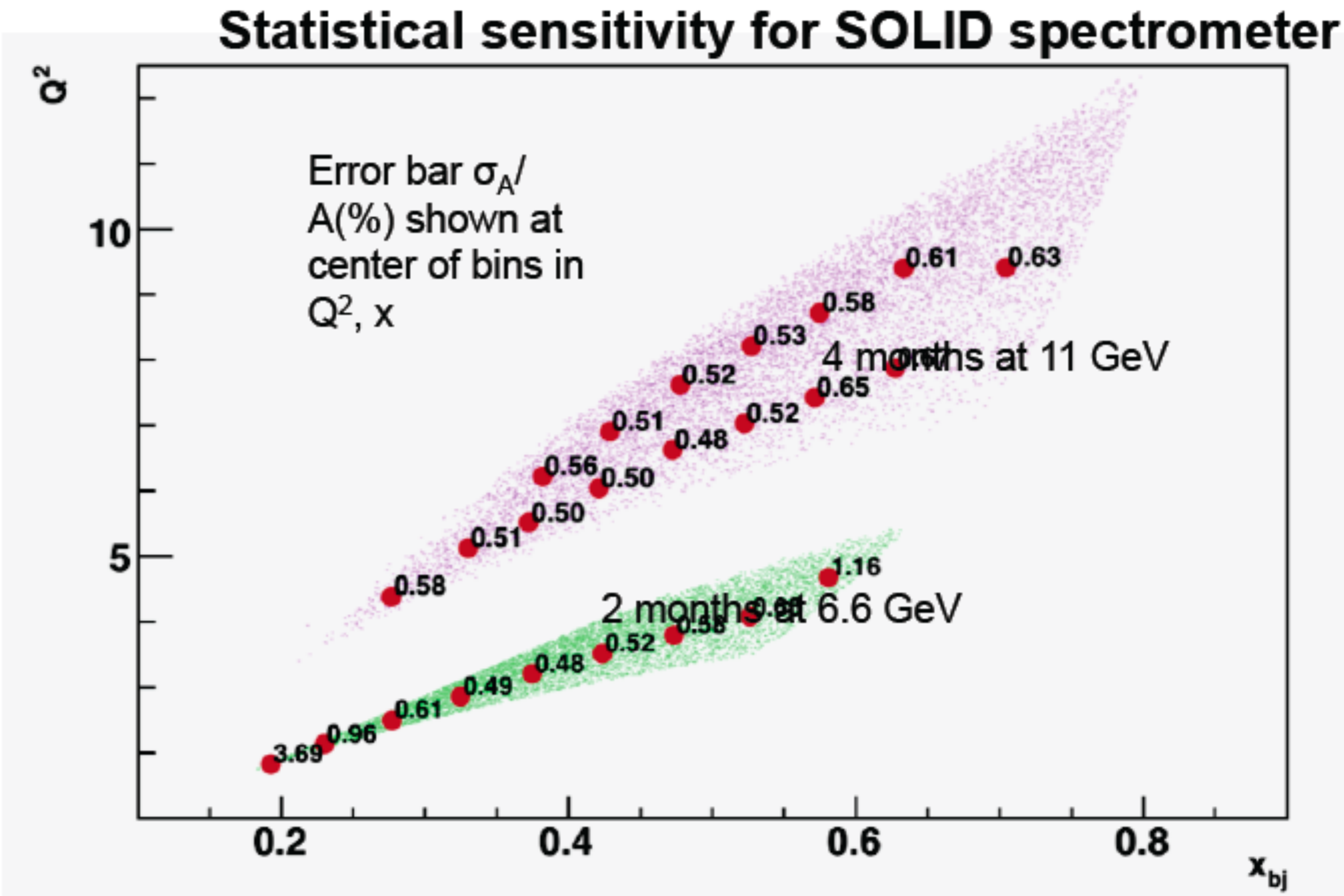
$$\delta d(x) = d^p(x) - u^n(x)$$

$$R_{CSV} = \frac{\delta A_{PV}(x)}{A_{PV}(x)} = 0.28\,\frac{\delta u(x) - \delta d(x)}{u(x) + d(x)}$$

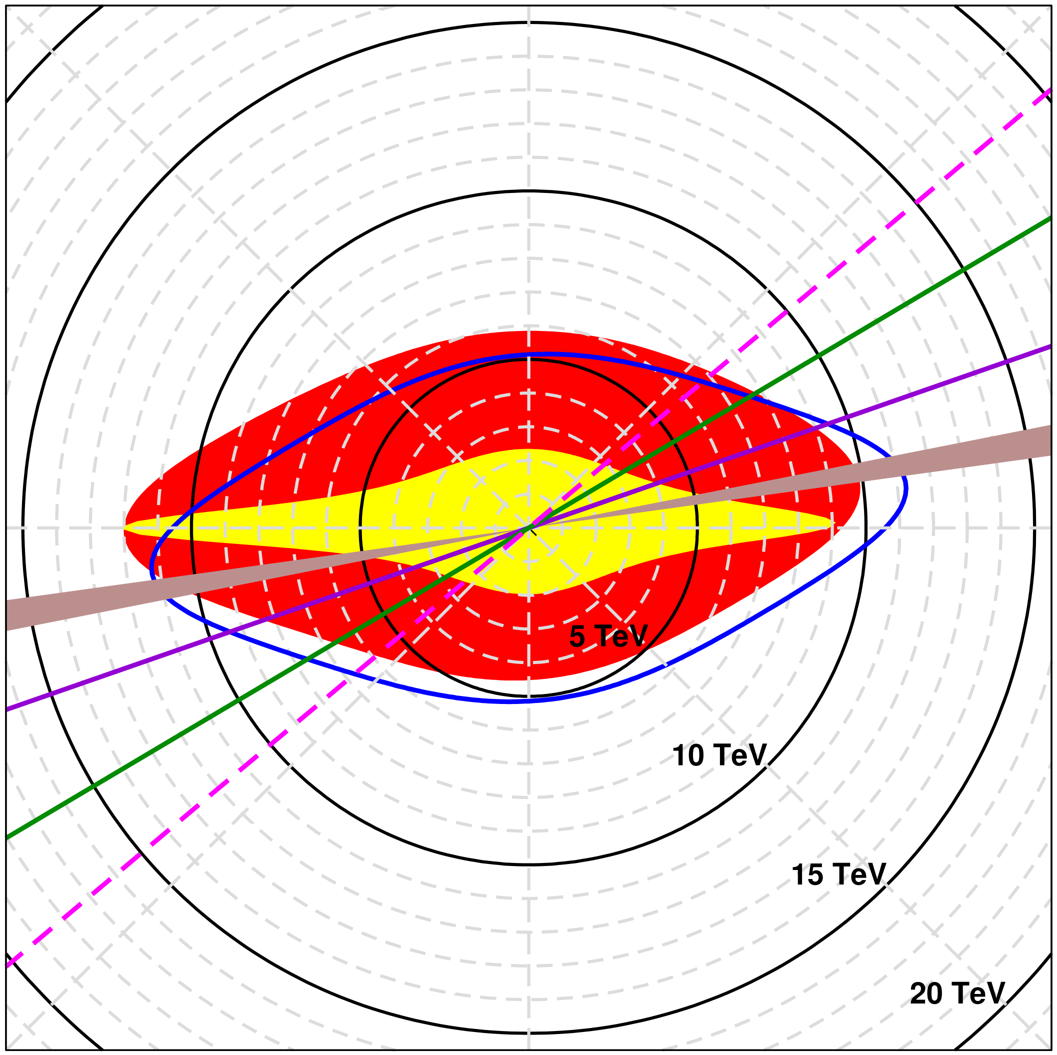
Di-quarks in the nucleon (Q^2 Dependence)

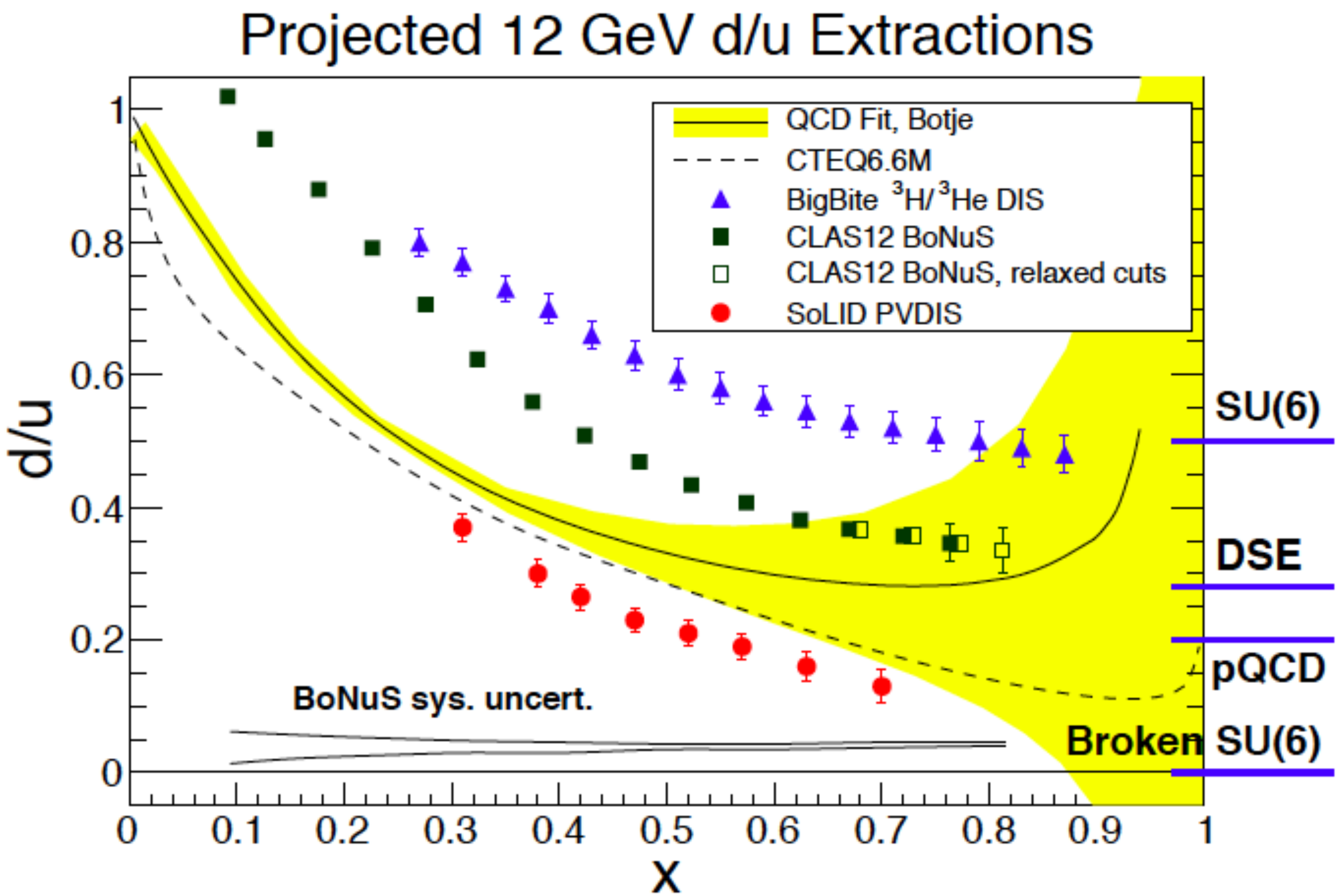


Statistical Errors (%) vs. Kinematics



6 GeV PVDIS Result: Contact Interactions

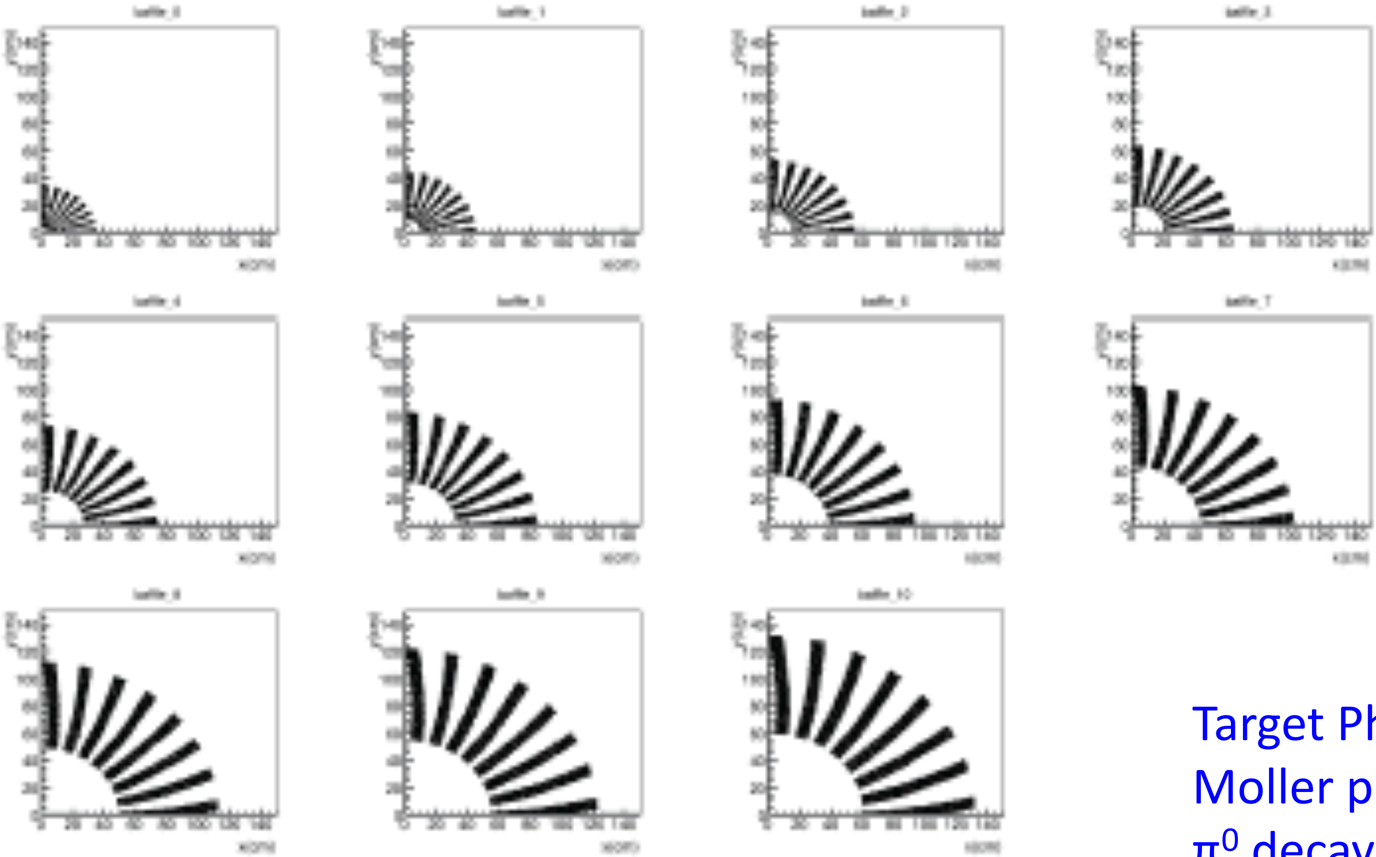




Projected 12 GeV d/u Extractions
QCD Fit, Botje
CTEQ6.6M
BigBite ^{3}H/^{3}He DIS
CLAS12 BoNuS
CLAS12 BoNuS, relaxed cuts
SoLID PVDIS
SU(6)
DSE
pQCD
Broken SU(6)
BoNuS sys. uncert.
d/u
x
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.2
0.4
0.6
0.8
1

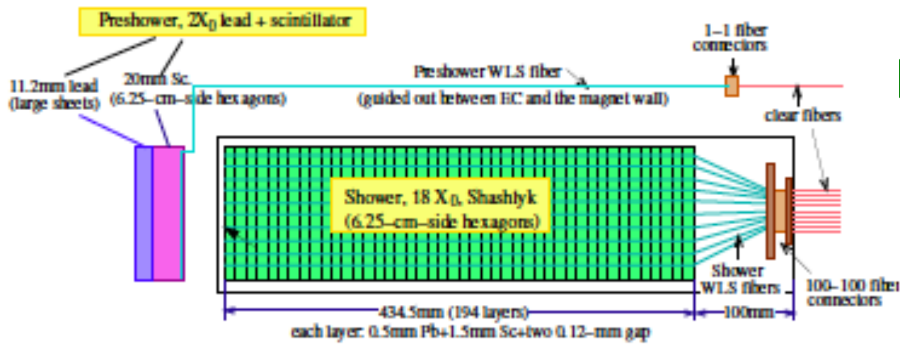
SoLID PVDIS Apparatus

Baffles Reduce Backgrounds

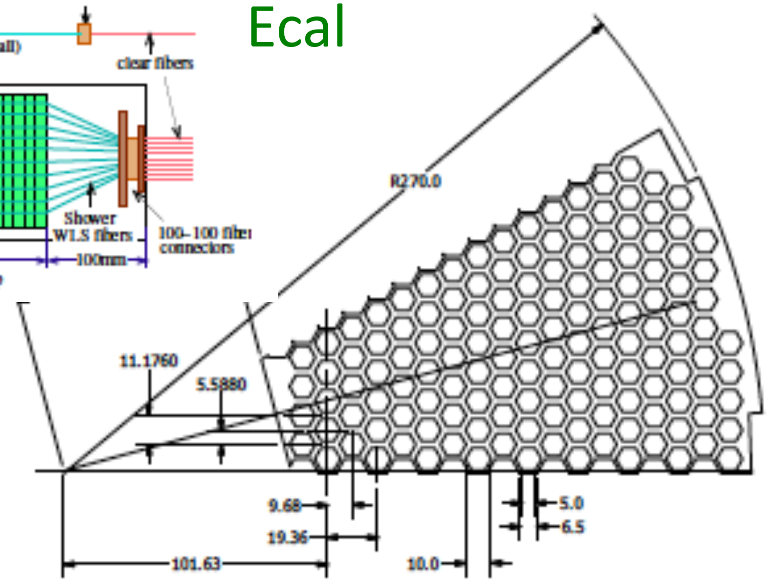


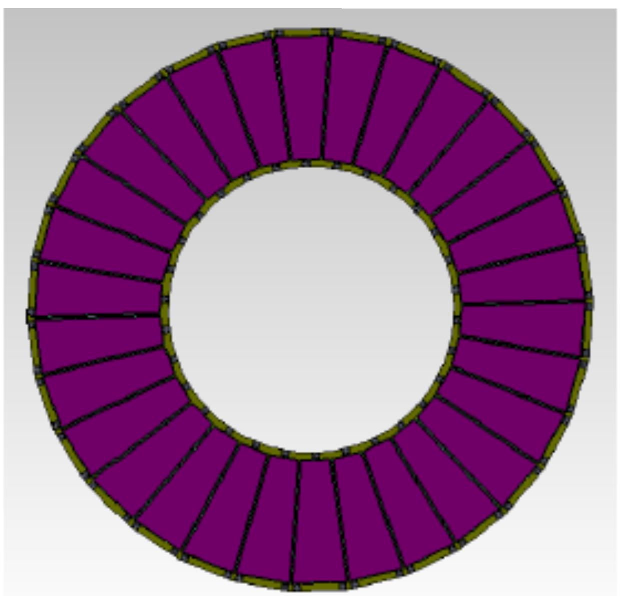
Target Photons
Moller photons
π^0 decay photons
Charged hadrons

Detectors

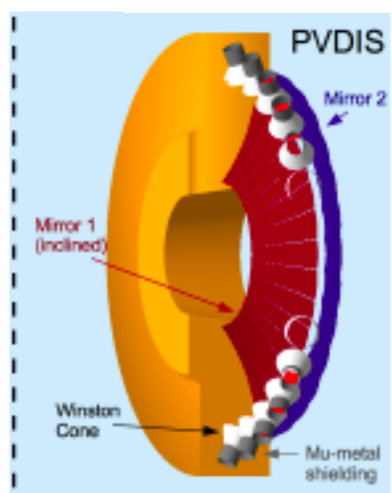


Ecal





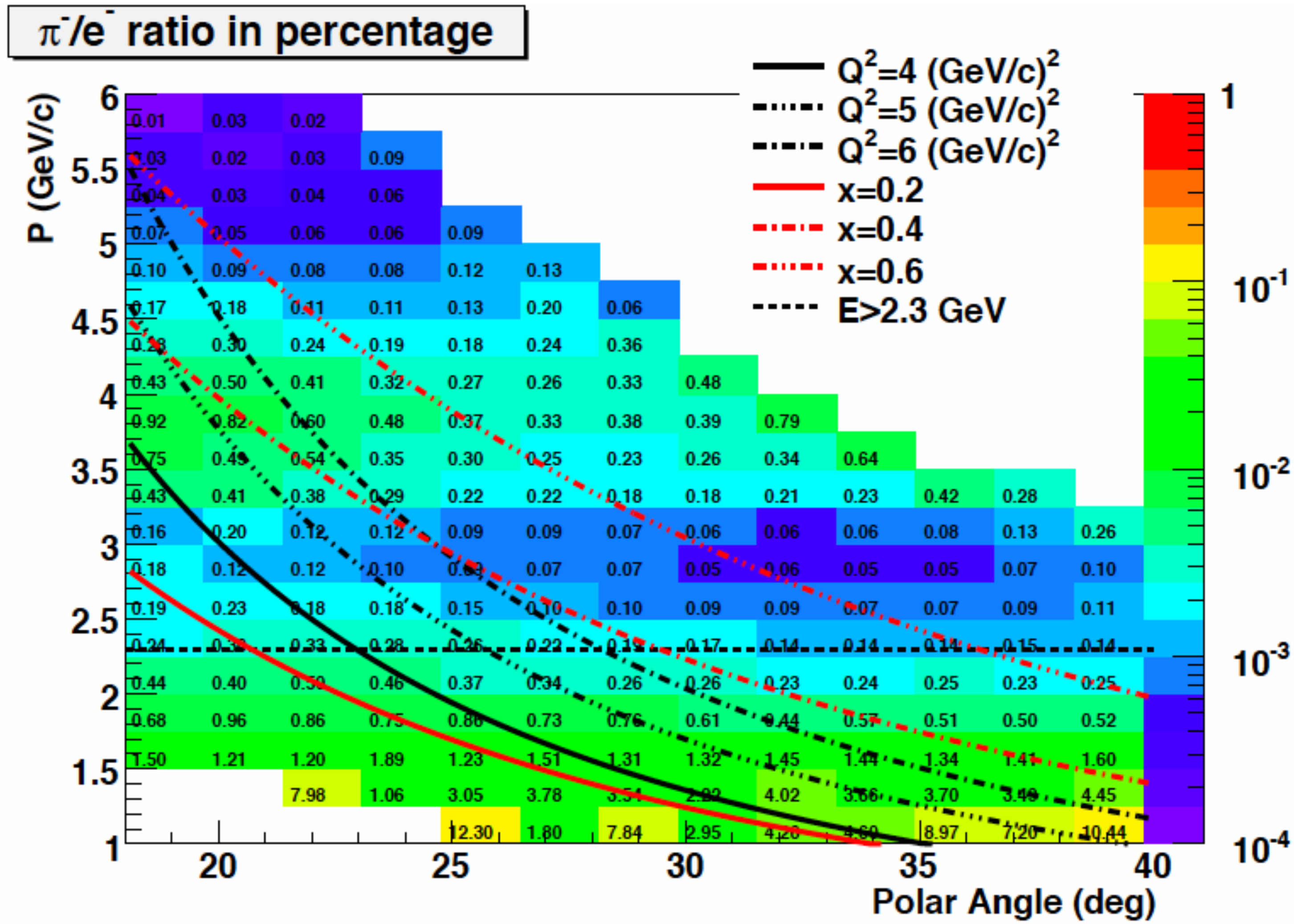
Gem Tracking Detector



Ecal Geometry

Cerenkov

Electron ID



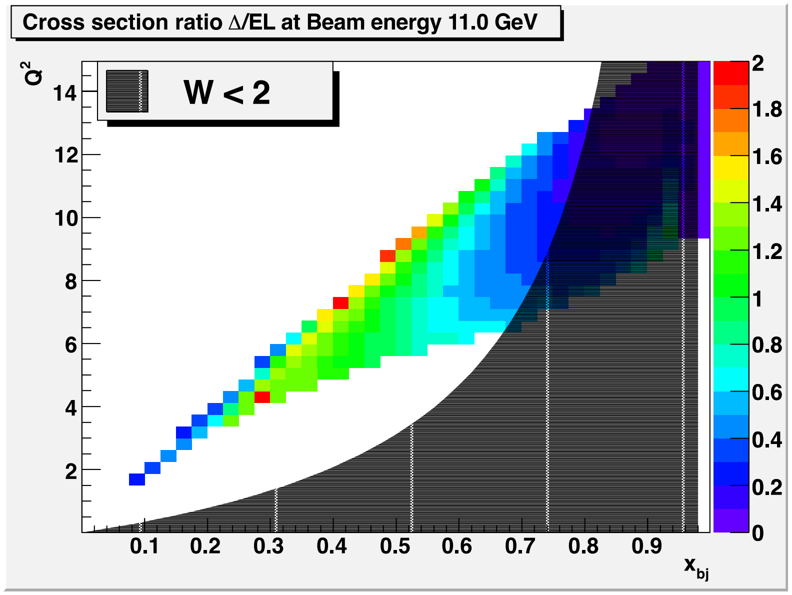
π⁻/e⁻ ratio in percentage
P (GeV/c)
Polar Angle (deg)
Q²=4 (GeV/c)²
Q²=5 (GeV/c)²
Q²=6 (GeV/c)²
x=0.2
x=0.4
x=0.6
E>2.3 GeV

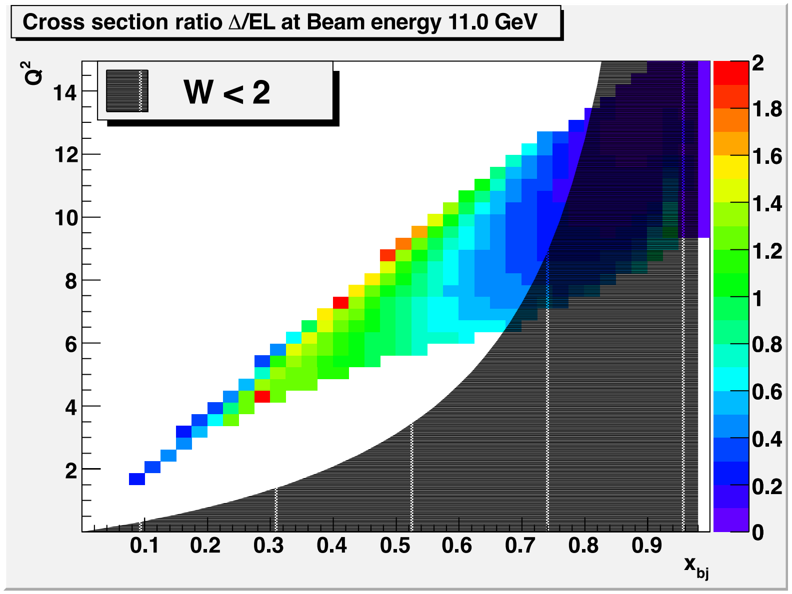
Issues (Quote JFK)

- What you can do for us:
  - Help with theory of radiative corrections
  - Tell what data we need for radiative corrections
- What we can do for you:
  - Obtain elastic data over a wide kinematic range

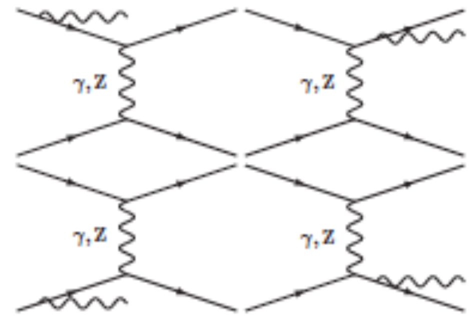
Radiative DIS Contamination (Peaking Approximation)

Most of our events are DIS,
not elastic or resonance events





Divergent Radiative Corrections



Zykunov , Suarez, Kolomensky, Tweedy (Moller)

$$\sigma^R = -\frac{\alpha^3}{4s\pi}\int_0^{v^{max}} dv \int \frac{d^3k}{k_0}\delta[(k_1+p_1-k_2-k)^2-m^2] \sum_{j,i=1,4} M_{ij}^R(-1)^{i+j} ,$$

$$(M_{ij}^R)_{zz} = \mathrm{Tr}[G_1^{\mu\alpha}\rho^{ij}(k_1)G_1^{\nu\alpha\,T}\Lambda(k_2)]\mathrm{Tr}[\gamma_\mu\rho^{ij}(p_1)\gamma_\nu\Lambda(p_2)]D^{it_1}D^{jt_1},$$
$$(M_{ij}^R)_{zv} = \mathrm{Tr}[G_1^{\mu\alpha}\rho^{ij}(k_1)\gamma_\nu\Lambda(k_2)]\mathrm{Tr}[\gamma_\mu\rho^{ij}(p_1)G_2^{\nu\alpha\,T}\Lambda(p_2)]D^{it_1}D^{jt},$$
$$(M_{ij}^R)_{vz} = \mathrm{Tr}[G_2^{\mu\alpha}\rho^{ij}(p_1)\gamma_\nu\Lambda(p_2)]\mathrm{Tr}[\gamma_\mu\rho^{ij}(k_1)G_1^{\nu\alpha\,T}\Lambda(k_2)]D^{it}D^{jt_1},$$
$$(M_{ij}^R)_{vv} = \mathrm{Tr}[G_2^{\mu\alpha}\rho^{ij}(p_1)G_2^{\nu\alpha\,T}\Lambda(p_2)]\mathrm{Tr}[\gamma_\mu\rho^{ij}(k_1)\gamma_\nu\Lambda(k_2)]D^{it}D^{jt},$$
$$(M_{ij}^R)_{f} = \mathrm{Tr}[G_1^{\mu\alpha}\rho^{ij}(k_1)G_3^{\nu\alpha}\Lambda(p_2)\gamma_\mu\rho^{ij}(p_1)\gamma_\nu\Lambda(k_2)]D^{it_1}D^{ju},$$
$$(M_{ij}^R)_{l} = \mathrm{Tr}[G_1^{\mu\alpha}\rho^{ij}(k_1)\gamma_\nu\Lambda(p_2)\gamma_\mu\rho^{ij}(p_1)G_4^{\nu\alpha}\Lambda(k_2)]D^{it_1}D^{jz_2},$$
$$(M_{ij}^R)_{tu} = \mathrm{Tr}[\gamma_\mu\rho^{ij}(k_1)G_3^{\nu\alpha}\Lambda(p_2)G_2^{\mu\alpha}\rho^{ij}(p_1)\gamma_\nu\Lambda(k_2)]D^{it}D^{ju},$$
$$(M_{ij}^R)_{s} = \mathrm{Tr}[\gamma_\mu\rho^{ij}(k_1)\gamma_\nu\Lambda(p_2)G_2^{\mu\alpha}\rho^{ij}(p_1)G_4^{\nu\alpha}\Lambda(k_2)]D^{it}D^{jz_2},$$

For PVDIS,
QCD effects
are also important.

Starting point:
HERA code

Compare to Moller: PVDIS 5x less sensitive, but quarks interact

Accessible Non-DIS Data