Dihadron Electroproduction in DIS with Transversely Polarized ^3He Target at 11 and 8.8 GeV

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Experiment Strategy

- 11 and 8.8 GeV electron beam, transversely polarized ^3He target
- Measure the single target spin asymmetries (SSA) of dihadron production, $^3He^{\uparrow}(e , e'\pi^+\pi^-)X$, in deep inelastic scattering (DIS) region
- Map the SSA data in a 4-D space of x, Q^2, z_$\pi^+\pi^-$ and M_$\pi^+\pi^-$

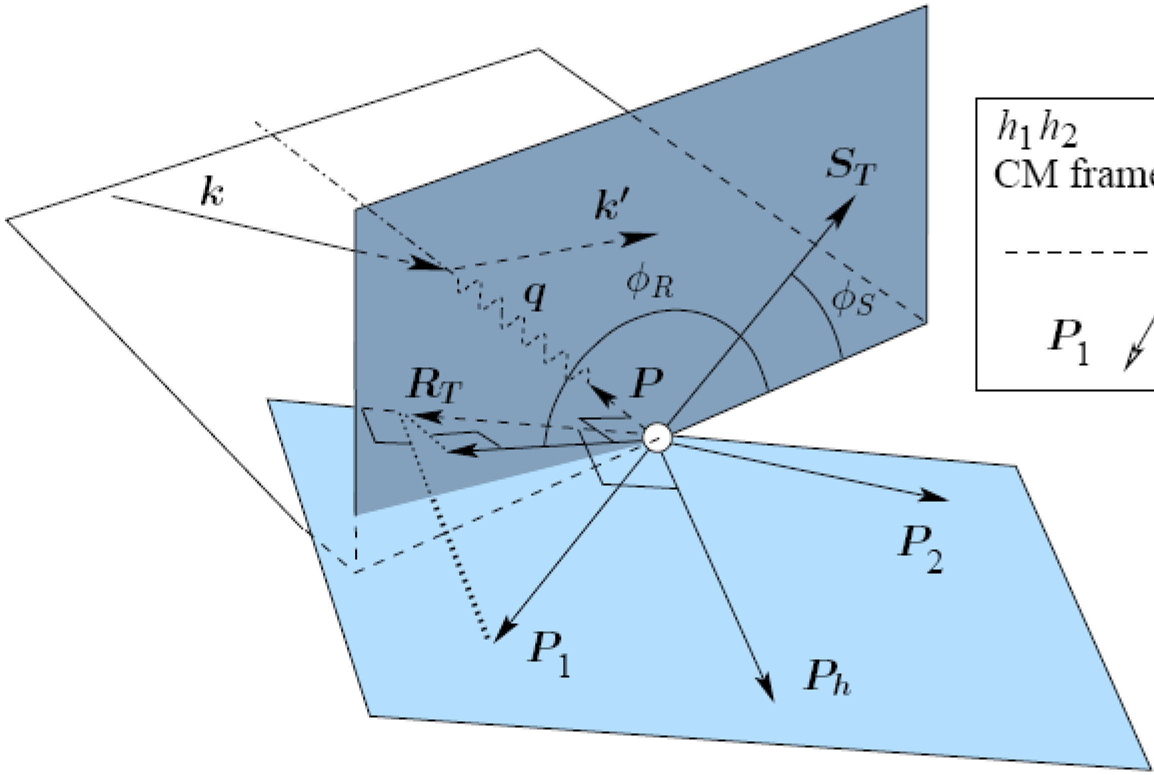
Then

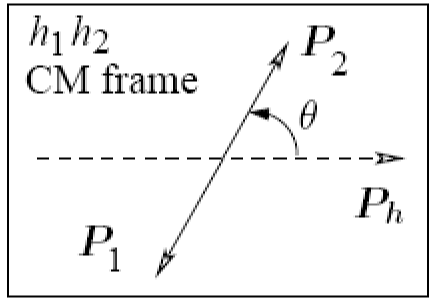
- Extract neutron SSA, need to correct the contribution from proton
- Combine with world data of dihadron fragmentation functions (DiFF) to extract transversity, h_1.

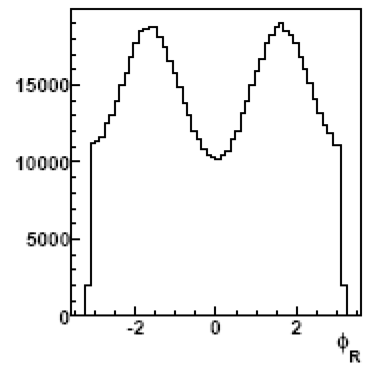
Future

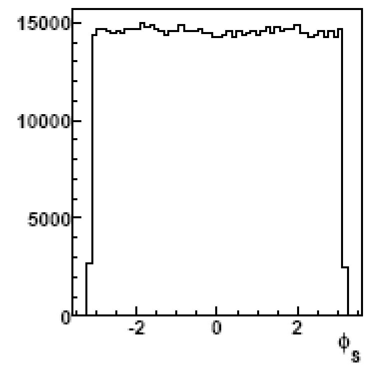
- Combine with transversity from transverse proton target experiment (SoLID E12-11-108 or CLAS E12-12-009) to do flavor separation

n(e, e′π⁺π⁻)X kinematics









$P_h = (P_1 + P_2)$

$R = (P_1 - P_2) / 2$

$$\phi_R \equiv \frac{(q\times k)\cdot R_T}{|(q\times k)\cdot R_T|} \arccos \frac{(q\times k)\cdot(q\times R_T)}{|q\times k||q\times R_T|}$$

$$\phi_S \equiv \frac{(q\times k)\cdot S_T}{|(q\times k)\cdot S_T|} \arccos \frac{(q\times k)\cdot(q\times S_T)}{|q\times k||q\times S_T|}$$

$Q^2 = 4\, E\, E`\, \sin^2(\theta/2)$

$x = Q^2 / (2\, P \cdot q)$

$y = (P \cdot q) / (P \cdot k)$

z_$\pi^+\pi^-$ $= (P \cdot P_h) / (P \cdot q)$

M_$\pi^+\pi^-$ $= (P_1 + P_2)^2$

How does SSA relate to transversity?

$$A_{UT}^{\sin(\phi_R+\phi_S)\sin\theta}(x,y,z,M_h,Q) = \frac{1}{|\boldsymbol{S}_T|}\,\frac{\frac{8}{\pi}\int d\phi_R\, d\cos\theta\ \sin(\phi_R+\phi_S)\,(d\sigma^{\uparrow}-d\sigma^{\downarrow})}{\int d\phi_R\, d\cos\theta\,(d\sigma^{\uparrow}+d\sigma^{\downarrow})}$$

$$= \frac{\frac{4}{\pi}\,\varepsilon\int d\cos\theta\, F_{UT}^{\sin(\phi_R+\phi_S)}}{\int d\cos\theta\,(F_{UU,T}+\varepsilon\, F_{UU,L})} \quad .$$

Where $F_{UU,T} = x\, f_1(x)\, D_1\big(z,\cos\theta, M_h\big) \quad ,$

$$F_{UU}^{\cos\phi_R} = -x\frac{|\boldsymbol{R}|\sin\theta}{Q}\,\frac{1}{z}\, f_1(x)\,\widetilde{D}^{\sphericalangle}\big(z,\cos\theta,M_h\big) \quad ,$$

$$F_{UT}^{\sin(\phi_R+\phi_S)} = x\frac{|\boldsymbol{R}|\sin\theta}{M_h}\, h_1(x)\, H_1^{\sphericalangle}\big(z,\cos\theta,M_h^2\big) \quad ,$$

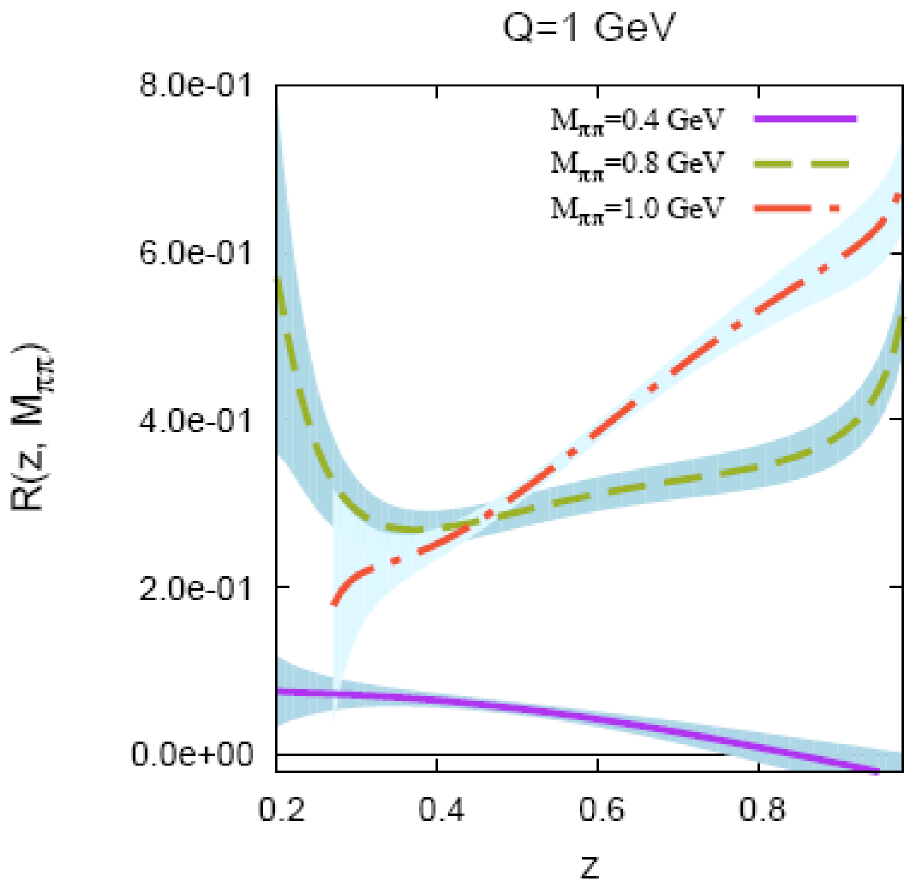
$$|\boldsymbol{R}| = \frac{1}{2}\sqrt{M_h^2 - 2(M_1^2+M_2^2) + (M_1^2-M_2^2)^2}$$

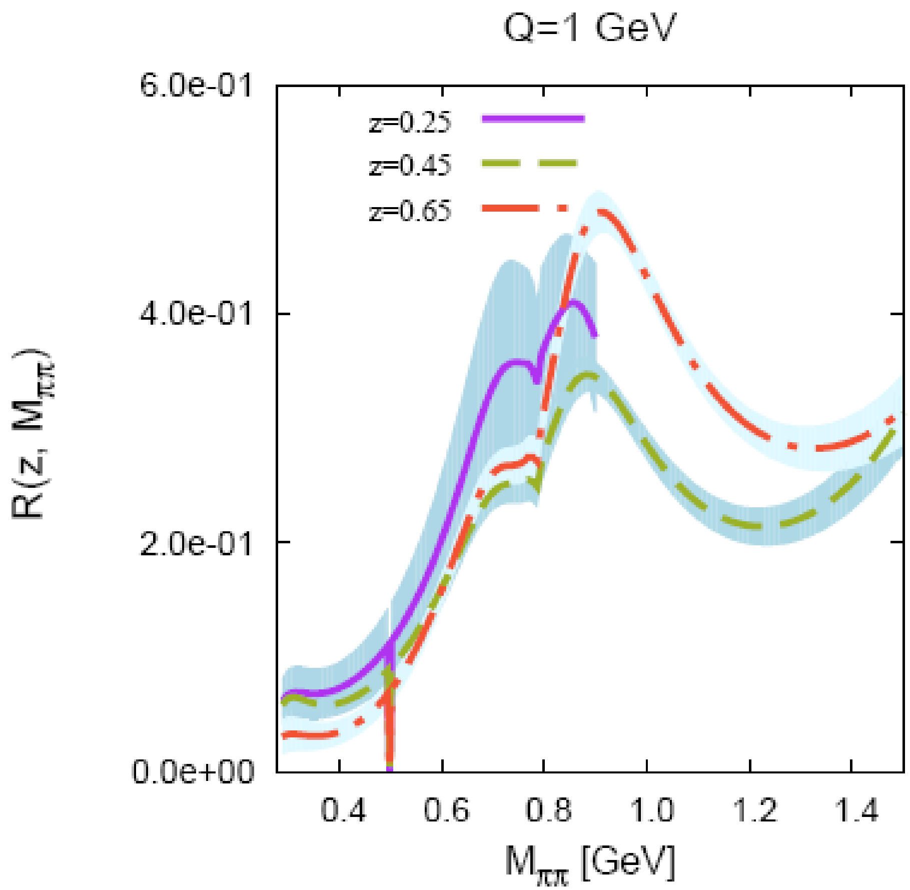
This is what we proposed to measure ...

dihadron fragmentation function (DiFF). Fitting from $e^+ e^-$ annihilation data of Belle

Current DiFF

Fitting from the Belle asymmetry, ***A.Vossen et al (Belle), PRL107 (11)***





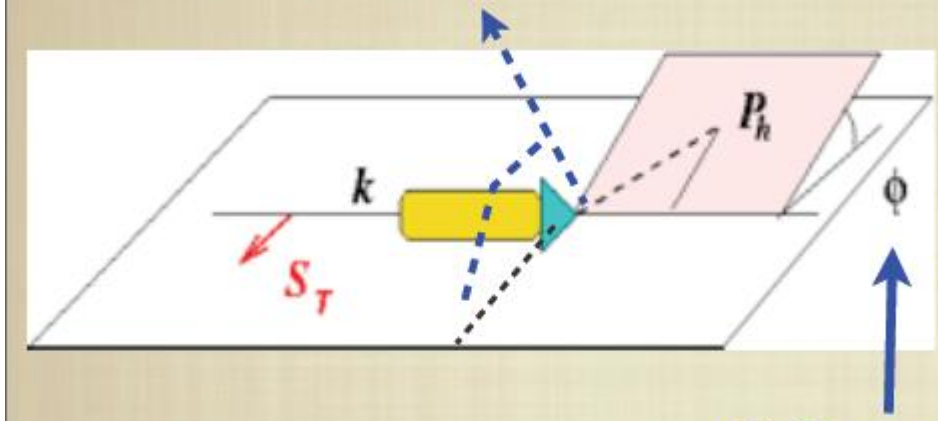
$$R(z, M_{\pi\pi}) = \frac{|\boldsymbol{R}|}{M_{\pi\pi}} \frac{H_{1,sp}^{\sphericalangle u}(z, M_{\pi\pi}; Q_0^2)}{D_1^u(z, M_{\pi\pi}; Q_0^2)}$$

A.Courtoy, A.Bacchetta, M.Radici, A.Bianconi, PRD 85 (12)

Why DiFF

The Collins mechanism

*J. Collins, NP**B396** (93)*



$$\mathbf{k} \times \mathbf{P}_h \cdot \mathbf{S}_T \propto \cos\left(\frac{\pi}{2} - \phi\right) = \sin\phi$$

transverse motion of hadron

=

spin analyzer of fragmenting quark

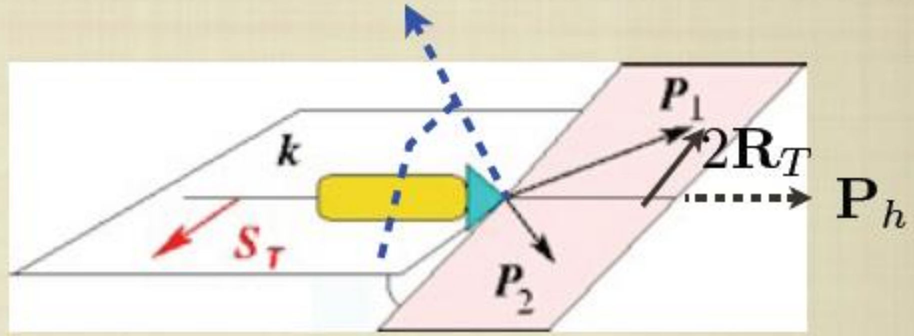
single-spin asymmetry → **convolution**

$$A_{UT}^{\sin(\phi)} \propto \left[h_1^q \otimes H_1^{\perp\, q\to h}\right]$$

TMD factorization

The IFF mechanism

*Collins, Heppelman, Ladinsky, NP **B420** (94)*



$$\begin{aligned}\mathbf{P}_h \times \mathbf{R}_T \cdot \mathbf{S}'_T &\propto \cos(\phi_{S'_T} - (\phi_{R_T} + \pi/2)) \\ &= \cos(\pi - \phi_S - (\phi_{R_T} + \pi/2)) \\ &= \sin(\phi_{R_T} + \phi_S)\end{aligned}$$

azimuthal orientation of hadron pair

=

spin analyzer of fragmenting quark

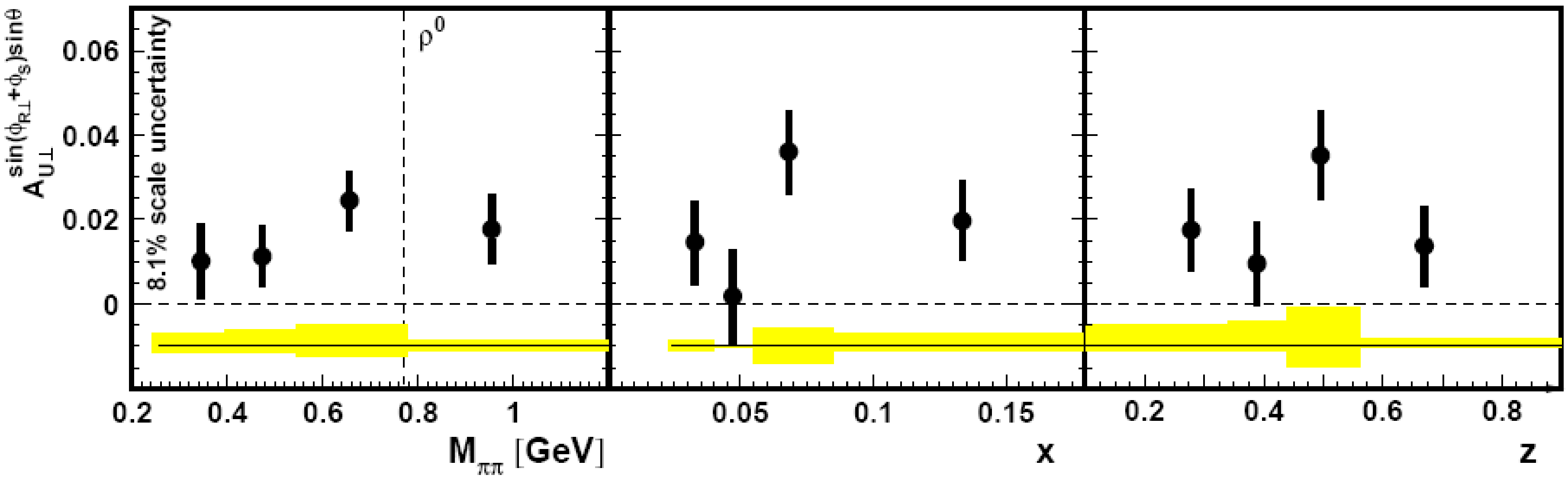
single-spin asymmetry → **product**

$$A_{UT}^{\sin(\phi_R+\phi_S)} \propto h_1^q(x)\, H_1^{\sphericalangle\, q\to h_1 h_2}$$

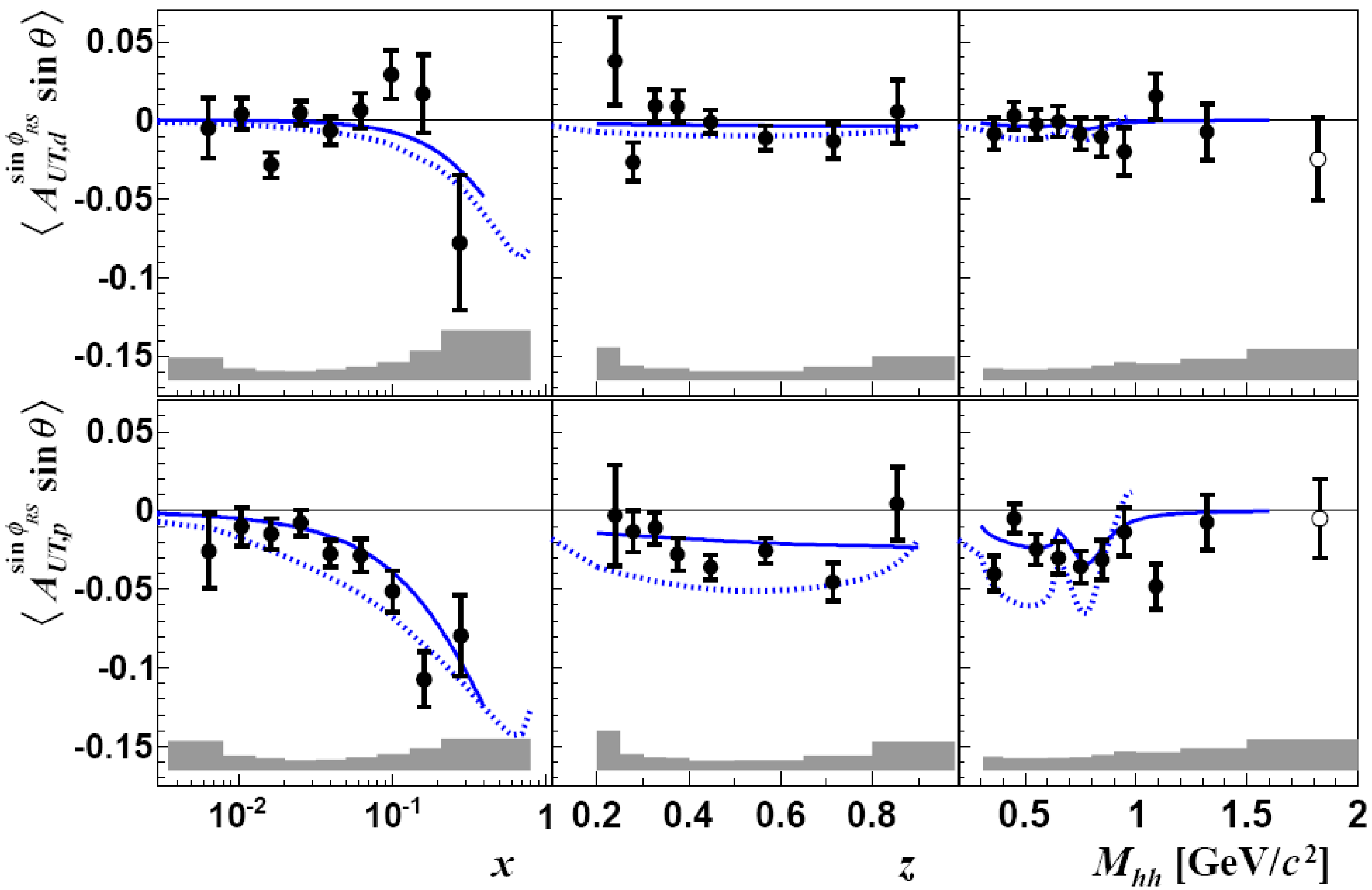
collinear factorization

From Marco Radici, QCD Evolution Workshop, 2013

Existing data



HERMES, JHEP 0806, 017 (2008)



Pavia prediction

She et al, P. R. D77(2008) 014035

C. Adolph et al, CERN-PH-EP-2012-053

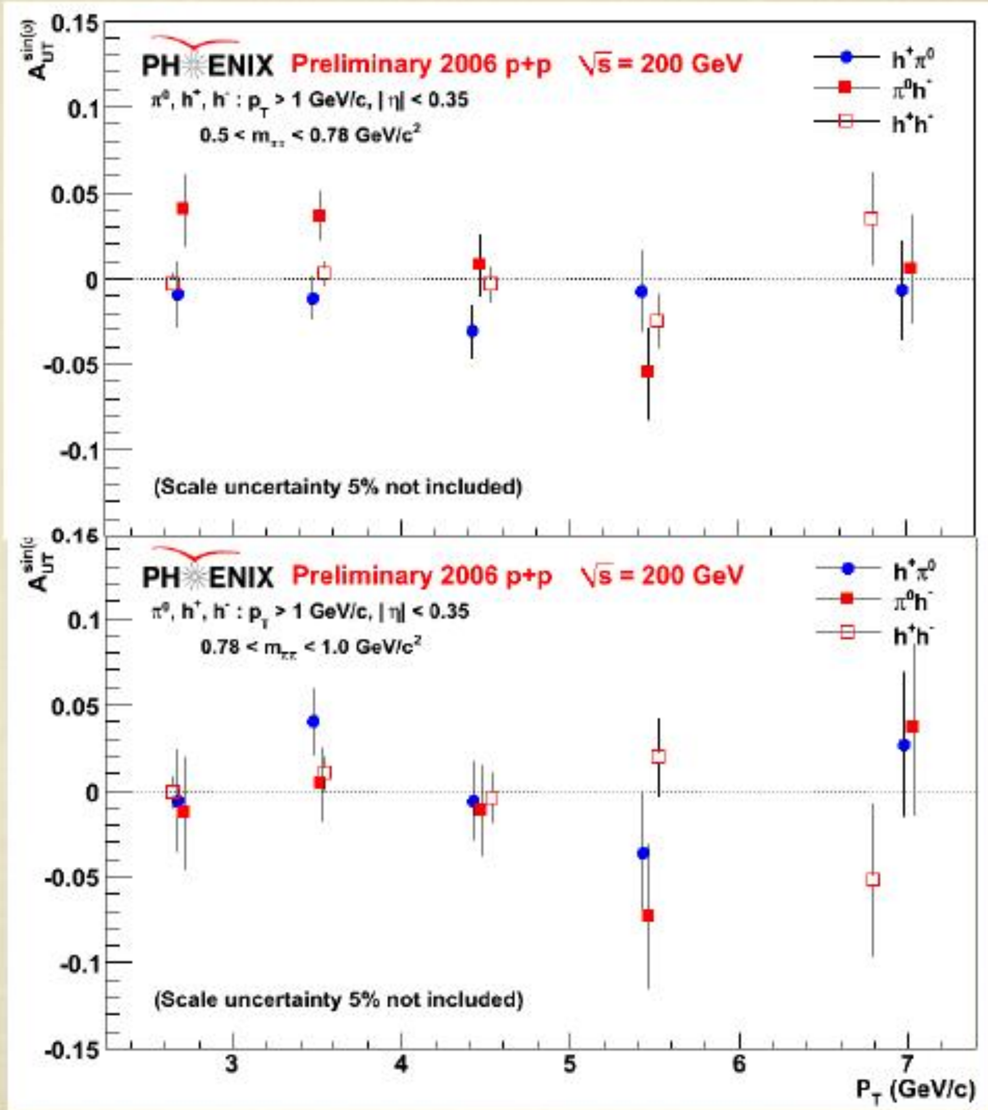
Data under analysis

PHENIX data on pp collisions

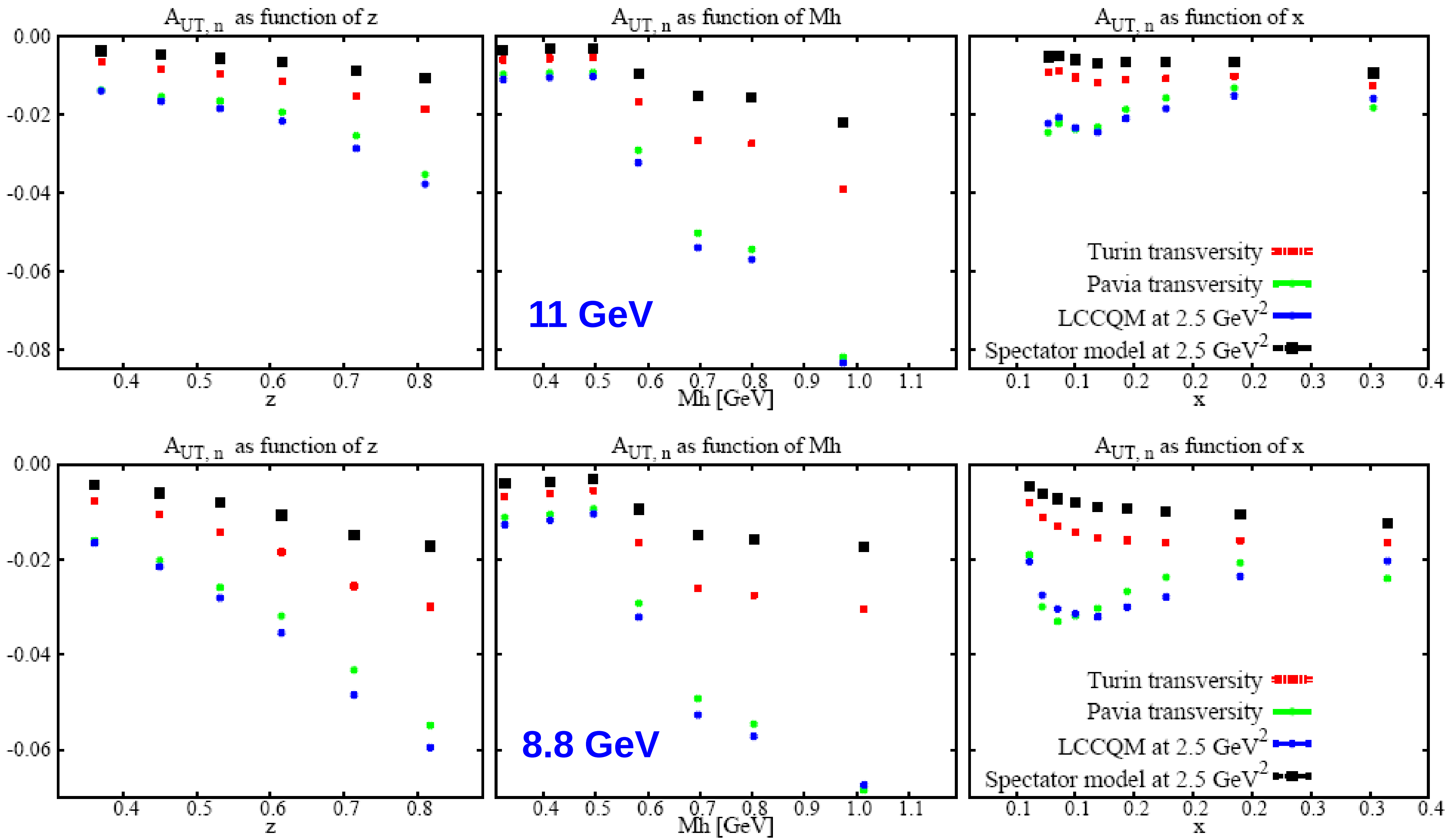
R.Yang, Beijing Transversity Workshop (08)

work on predictions for
$pp^{\uparrow} \rightarrow (\pi^+\pi^-)X$
still in progress..

Low x



Predicted A_{UT} in this experiment

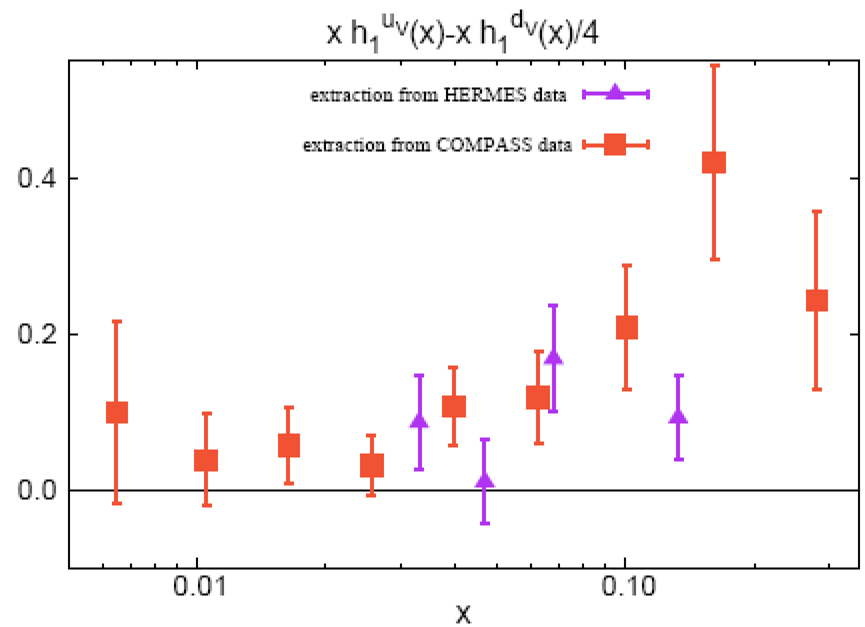


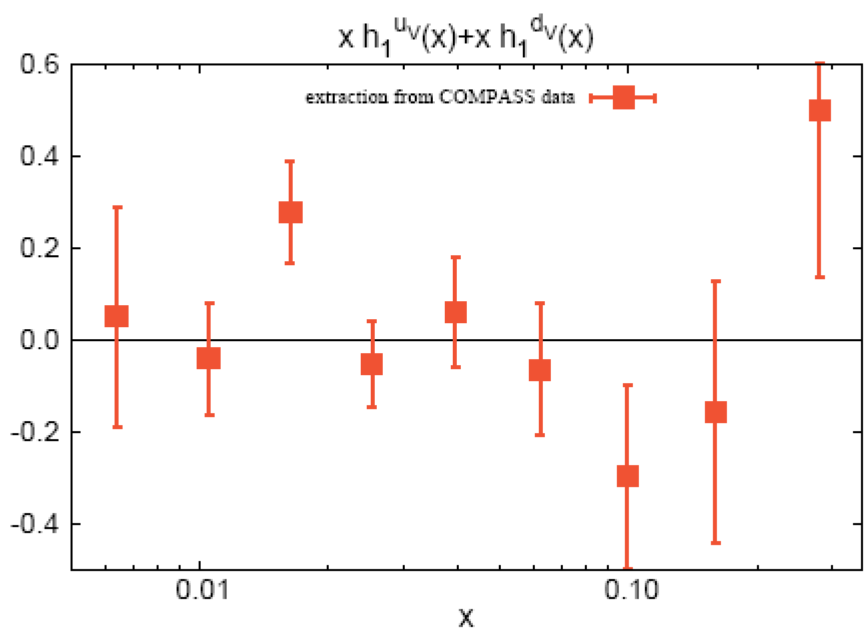
Flavor separation

$$A_{UT,n}^{\sin(\phi_R+\phi_S)\sin\theta}(x,y,z,M_{\pi\pi},Q) = -\frac{B(y)}{A(y)}\frac{|\boldsymbol{R}|}{M_{\pi\pi}}\frac{H_{1,sp}^{\sphericalangle,u}(z,M_{\pi\pi})\left[4\,h_1^{d-\bar{d}}(x) - h_1^{u-\bar{u}}(x)\right]}{D_1^u(z,M_{\pi\pi})\left[f_1^{u+\bar{u}}(x) + 4\,f_1^{d+\bar{d}}(x)\right] + D_1^s(z,M_{\pi\pi})\,f_1^{s+\bar{s}}(x)},$$

$$A_{UT,p}^{\sin(\phi_R+\phi_S)\sin\theta}(x,y,z,M_{\pi\pi},Q) = -\frac{B(y)}{A(y)}\frac{|\boldsymbol{R}|}{M_{\pi\pi}}\frac{H_{1,sp}^{\sphericalangle,u}(z,M_{\pi\pi})\left[4h_1^{u-\bar{u}}(x) - h_1^{d-\bar{d}}(x)\right]}{D_1^u(z,M_{\pi\pi})\left[4f_1^{u+\bar{u}}(x) + f_1^{d+\bar{d}}(x)\right] + D_1^s(z,M_{\pi\pi})\,f_1^{s+\bar{s}}(x)},$$

Proton data from:
SoLID E12-11-108
CLAS12 E12-12-009



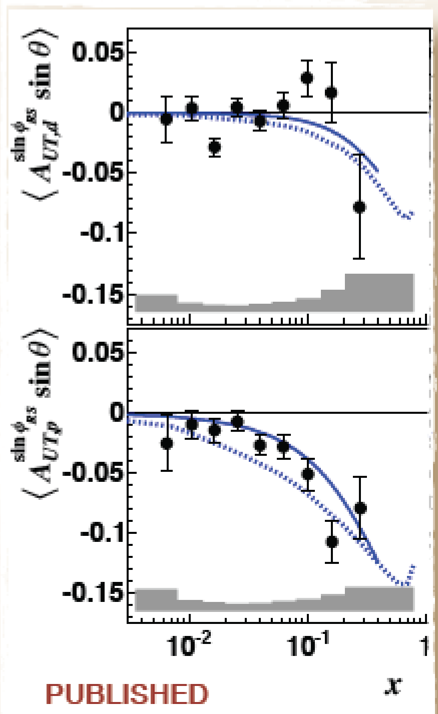


Transversity extracted via DiFF using HERMES proton data and COMPASS proton(NH_3) and deuteron (^{6}LiD) data

Phys.Rev.Lett. 107 (2011) 012001

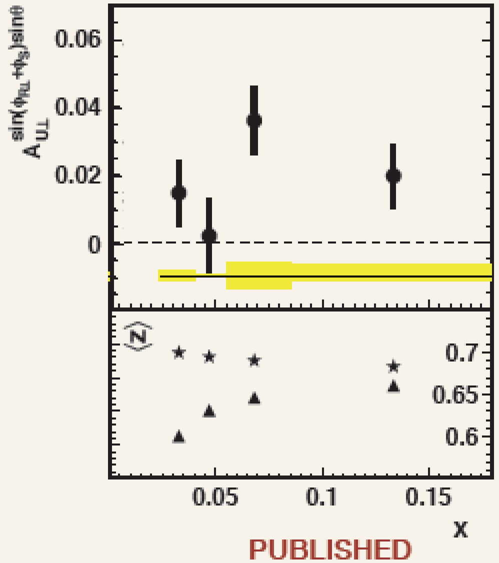
Tensor Charge

COMPASS data on proton and deuteron target



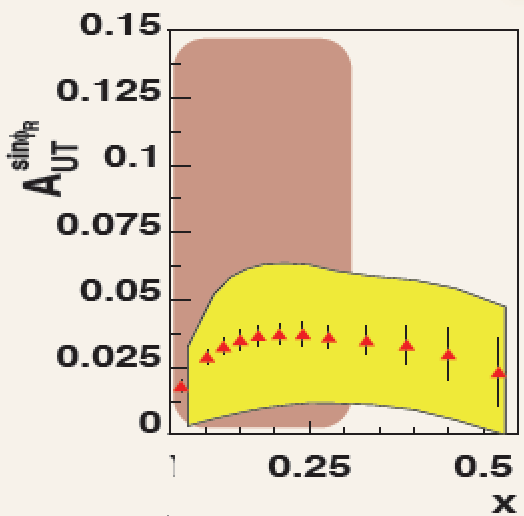
0.0064 < x < 0.28

HERMES data on proton target



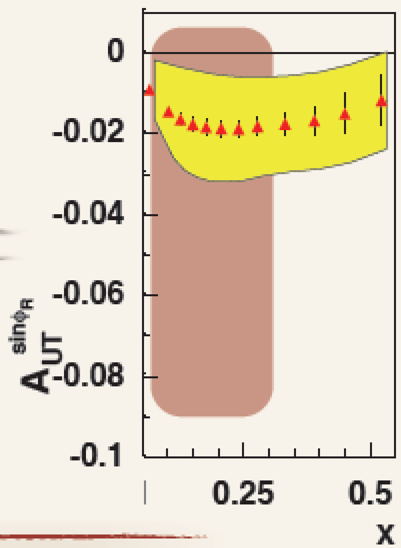
$$\delta q = \int_{-1}^{1} dx\, h_1^q(x)$$

CLAS12 projection on proton target



0.007 < x < 0.53

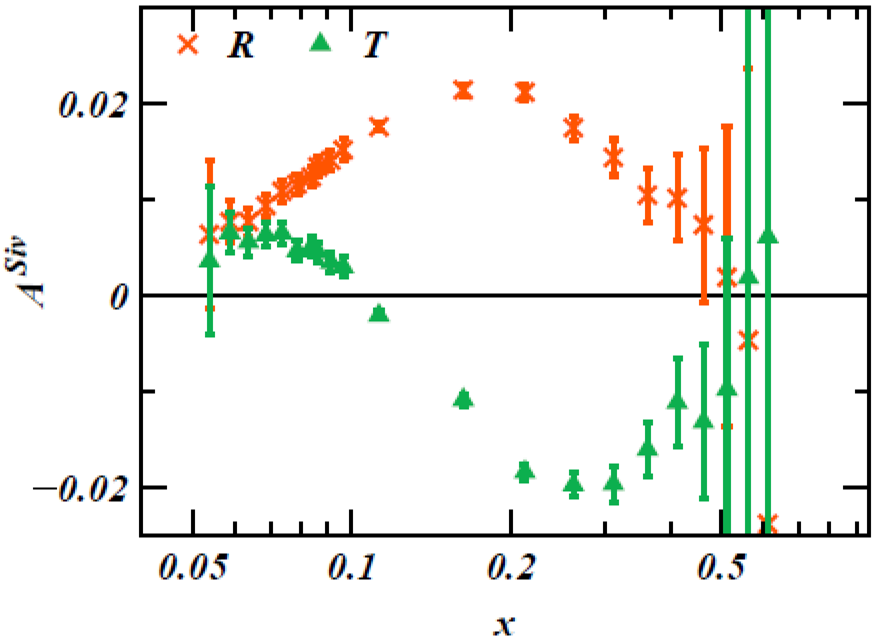
SoLID projection on neutron target

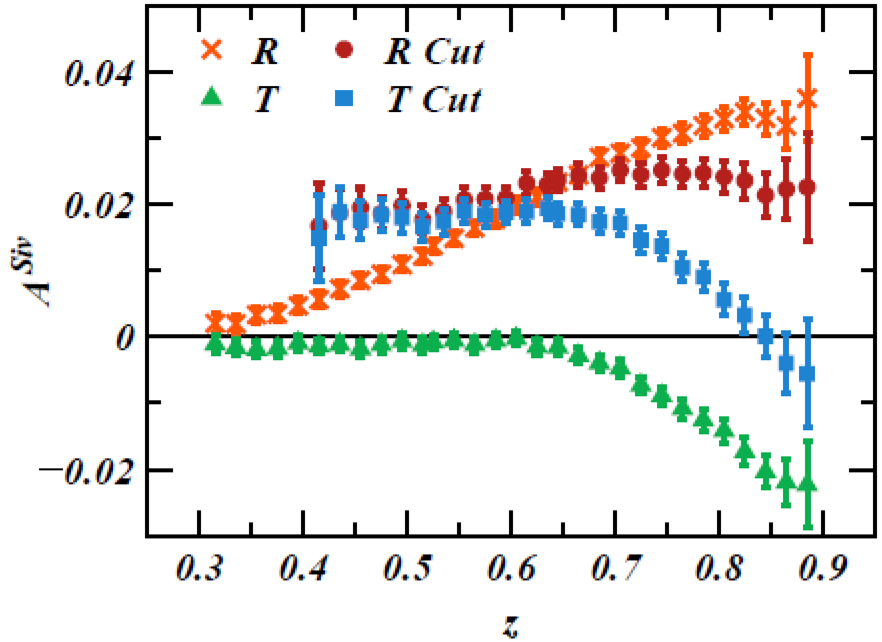


Future of the Tensor Charge

Silvers Asymmetries

x and z dependence of Sivers asymmetries, calculated for 11 GeV date set



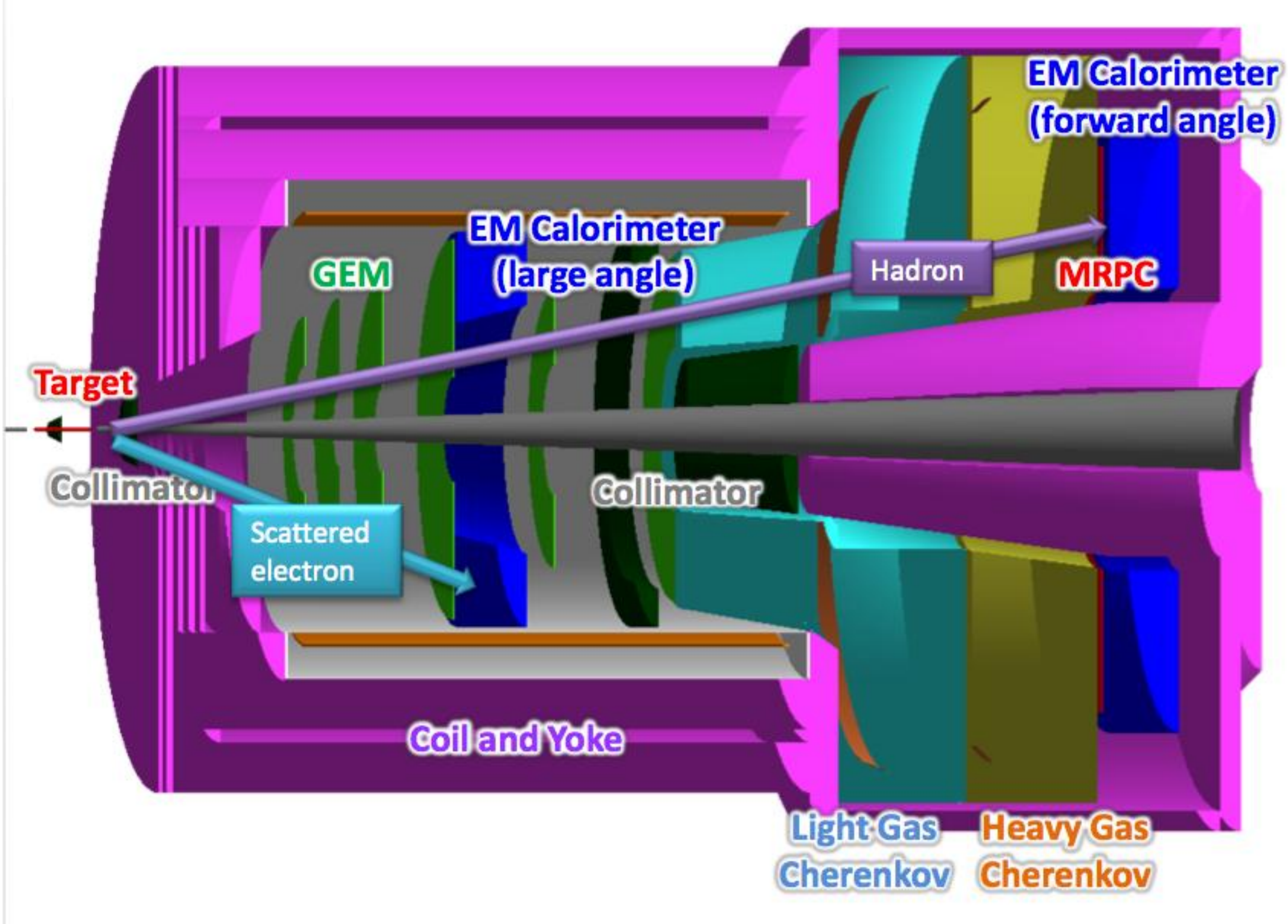


“T” and ”R” denote SSA corresponding to the Sivers type modulation of the total and relative transverse momenta of the hadron pair.

“Cut” denote additional cuts on the momentum of π^+: $z_{\_\pi+} > 0.3$, $P_{\_\pi+} > 0.3$ GeV .

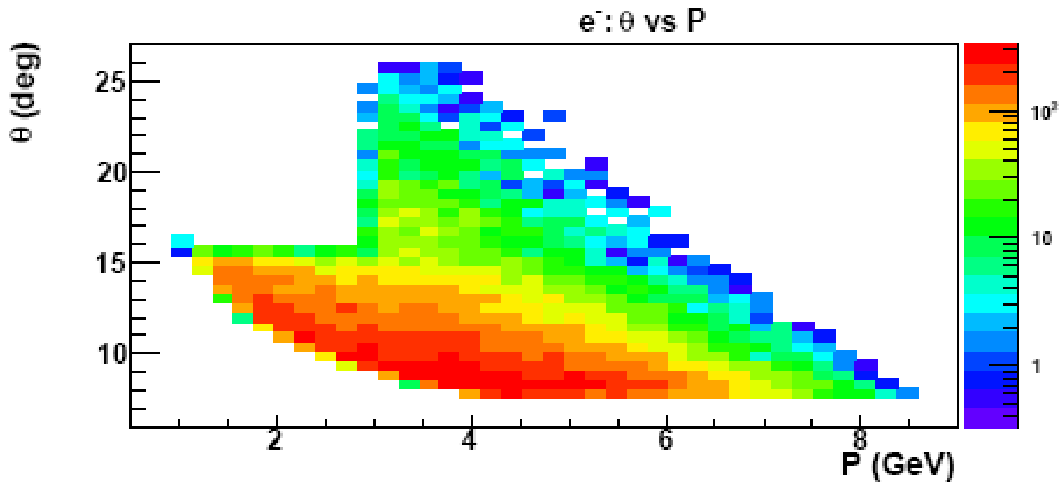
Thanks to Hrayr Matevosyan

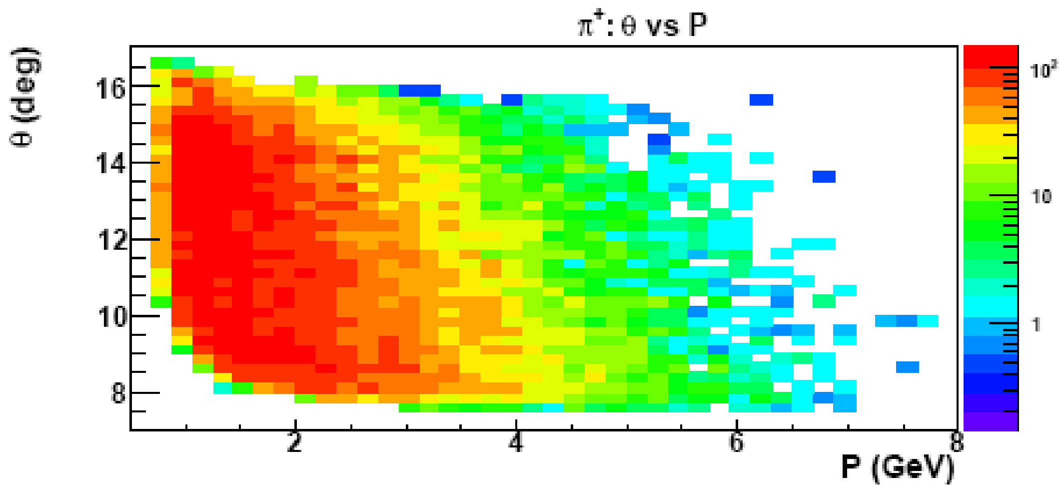
SoLID, in SIDIS configuration

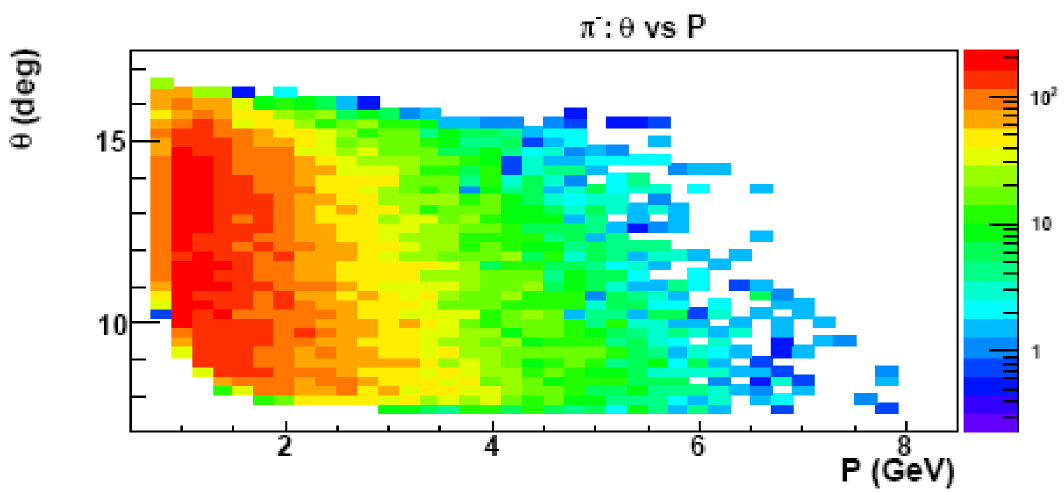


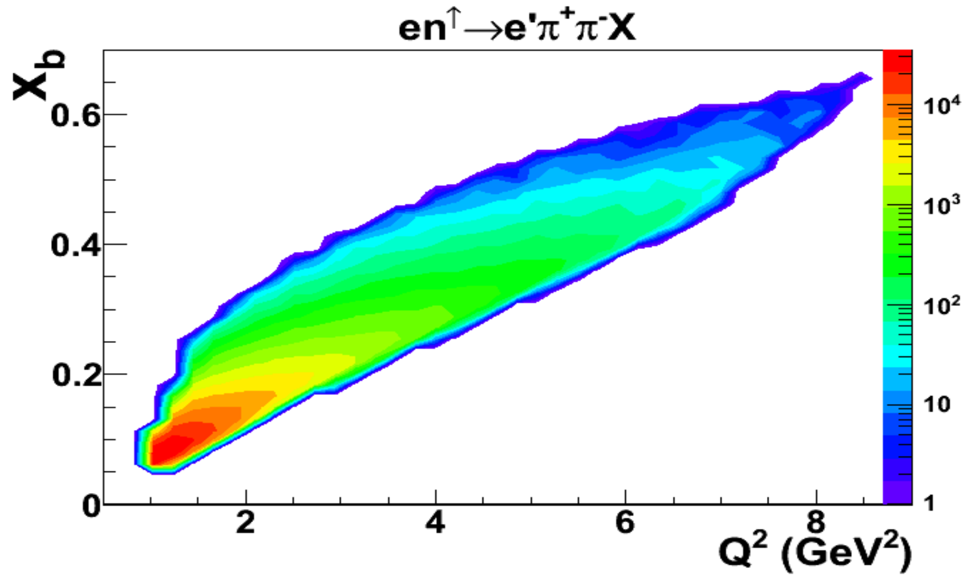
Electron will be detected by either FAEC (8^o-15^o) or LAEC(16^o-24^o)
Hadrons will be detected by FAEC
Trigger: electron + 1 hadron coincident
Energy threshold: FAEC = 0.8 GeV, LAEC = 3.0 GeV
15 μA beam current, 11 and 8.8 GeV beam, Luminosity = 10^{36} (n)/cm^2/s

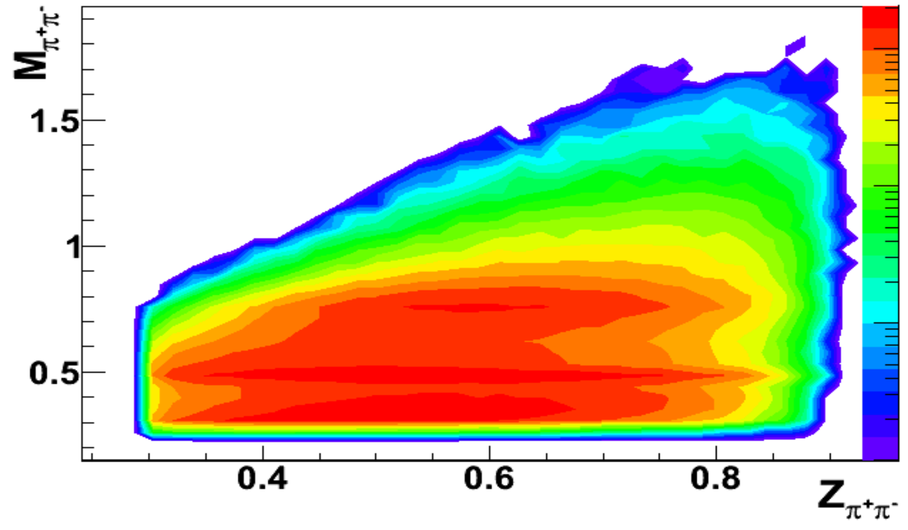
Kinematic coverages











$Q^2 > 1.0$ GeV^2

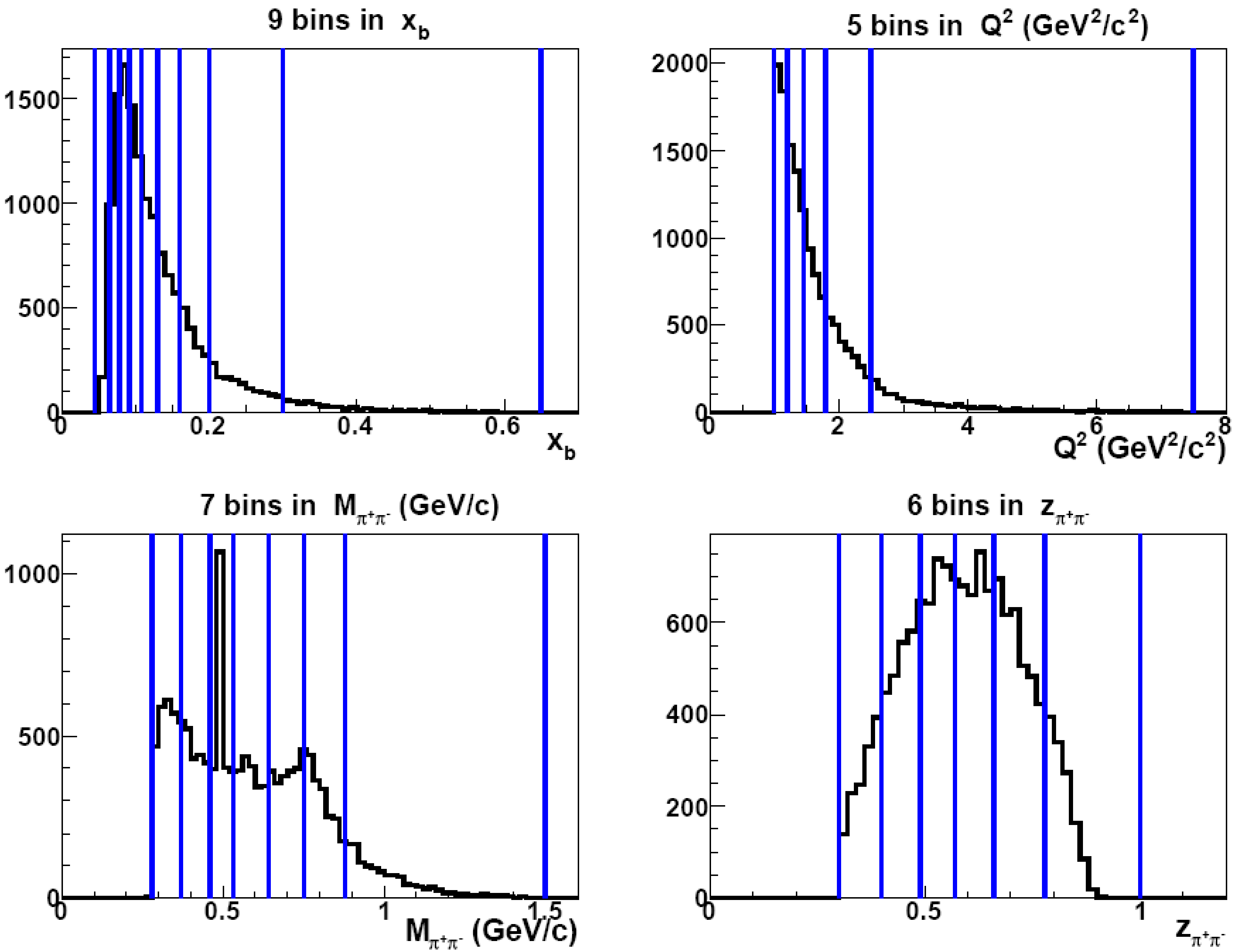
$x > 0.05$

W_$\pi^+\pi^-$ > 2.3 GeV

z_$\pi^+\pi^-$ > 0.3

M_$\pi^+\pi^-$ > 1.414 GeV/c

Binning information



This is the binning in the LoI. Plan to split the large x bin into 2 bins.

Event rates and requested beam time

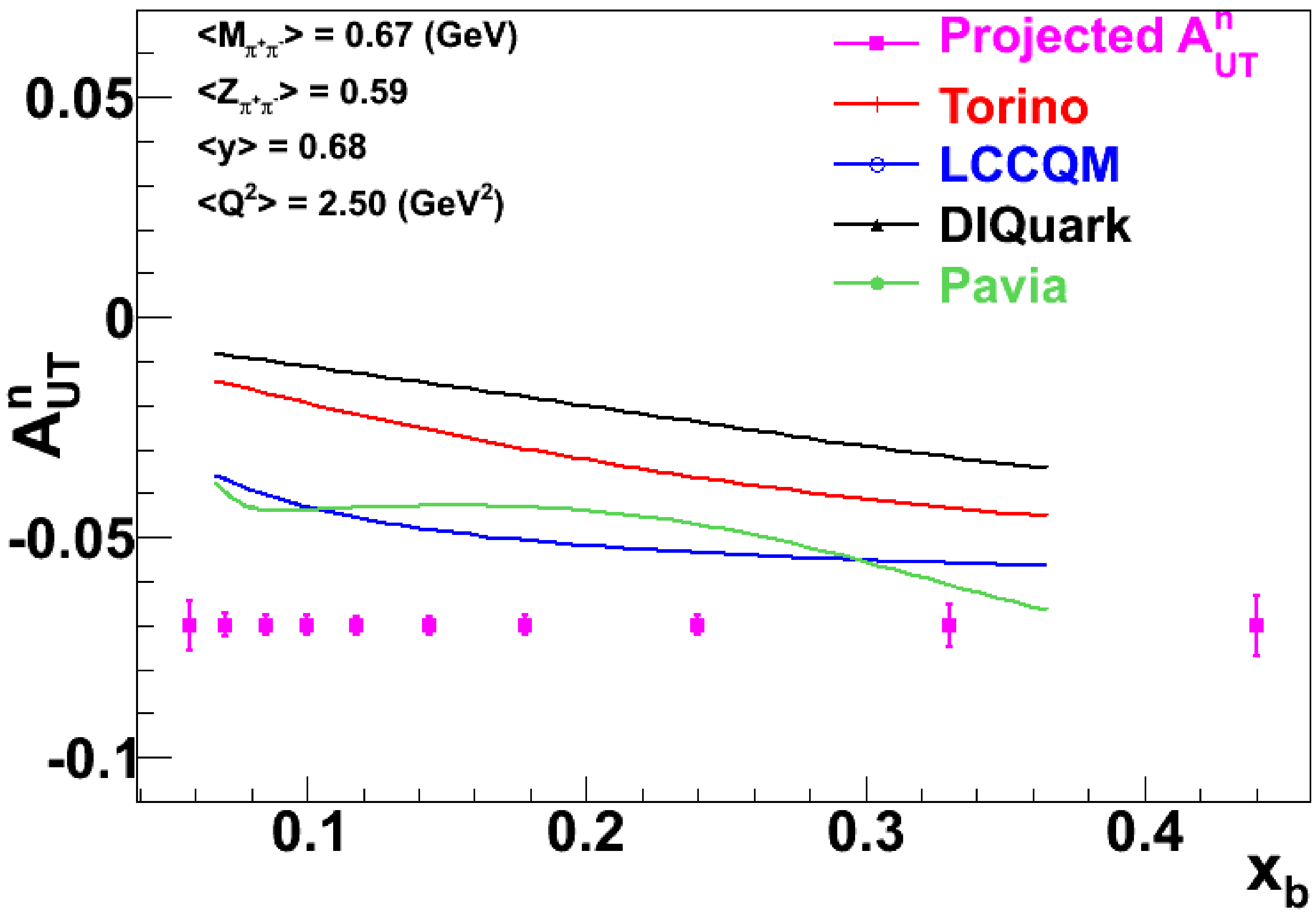
Process	Rates at 11 GeV	Rate at 8.8 GeV
$n(e, e'\pi^{\pm})$	1.87 kHz	1.21 kHz
$n(e, e'\pi^{+})$	1.05 kHz	0.61 kHz
$n(e, e'\pi^{-})$	0.87 kHz	0.56 kHz
$n(e, e'\pi^{+}\pi^{-})$	0.26 kHz	0.08 kHz

Rates are estimated with PEPSI code, the same one as CLAS12 E12-12-009, but different from the model used for E12-11-006. The single hadron coincident rate in PEPSI model is about 25% higher.

	Time (Hour)	Time (Day)
Production on Pol. ^{3}He at 11 GeV	**1152**	48
Production on Pol. ^{3}He at 8.8 GeV	**576**	24
Dedicated Hydrogen run at 11 GeV	84	3.5
Dedicated Deuterium run at 11 GeV	84	3.5
Dedicated Hydrogen run at 8.8 GeV	36	1.5
Dedicated Deuterium run at 8.8 GeV	36	1.5
Other reference cell runs, optics and detector check	72	3.
Target Overhead: spin rotation, polarization measurement	120	5.
Total Time Request	**2160**	**90 days**

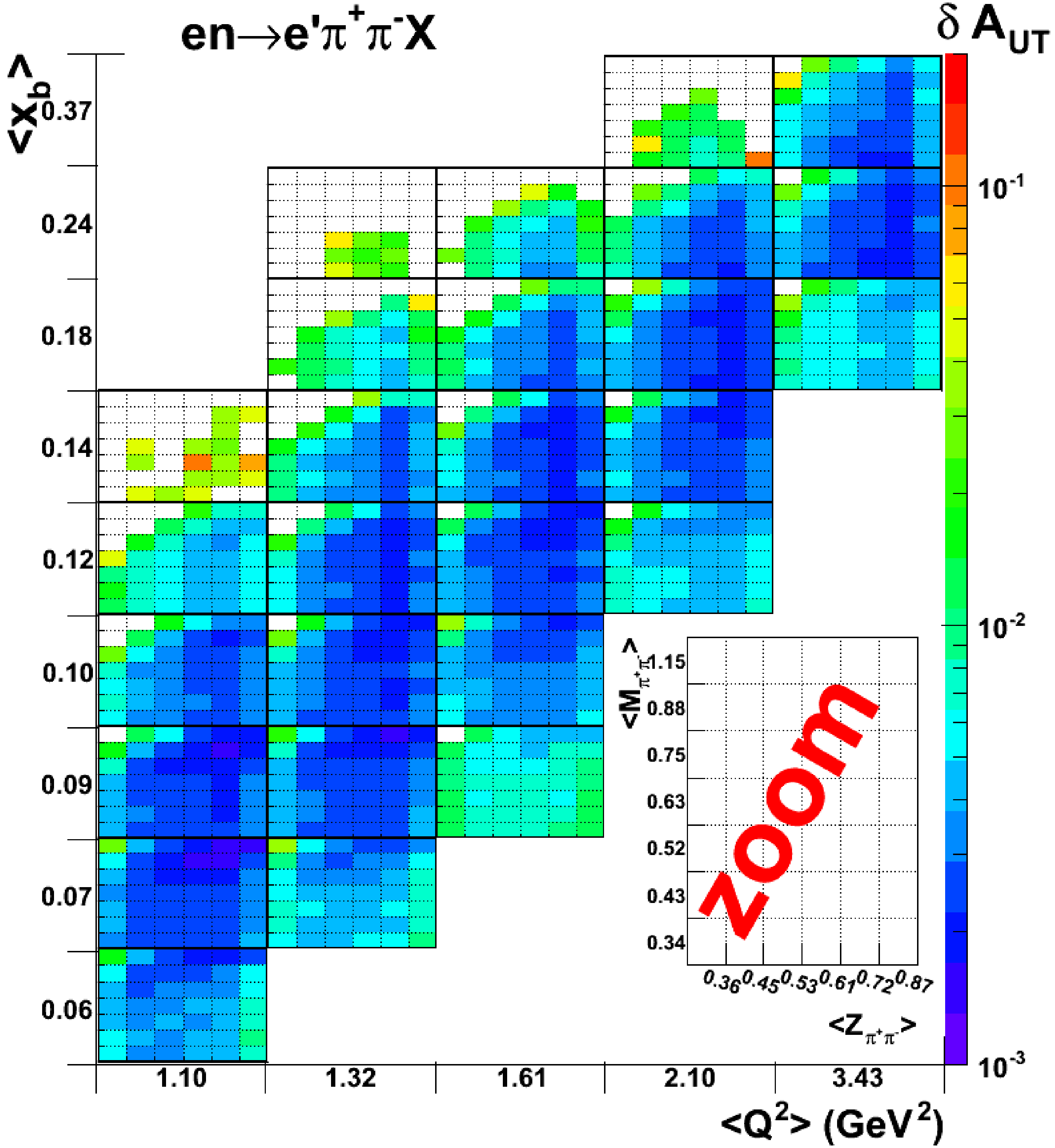
Beam time request follows what's proposed and approved for E12-11-006

Projection



Projected statistics error for one ($M_{\pi\pi}, z_{\pi\pi}$) bin, integrated over all y and Q^2 of 48 days of 11 GeV data of this experiment.

Projected statistics errors



- 48 days of 11 GeV data
- Polarized ^{3}He target, (~60% polarization)
- Lumi=10^{36} (n)/s/cm^2
- Wide x_b and Q^2 coverages
- Bin central values labeled on axises
- Z scale (color) represent stat. error
- Measure transversity via $\pi^+\pi^-$dihadron channel
- Combine with proton data can do flavor separation

Systematic errors

sources	δA_{UT}
background subtraction	5%
target polarization	3%
dilution factor	1%
nuclear effect	4%
radiative corrections	2%
total systematic uncertainty	7.4%

Summary

•We are proposing to measure the SSA of $^3He^{\uparrow}(e , e'\pi^+\pi^-)X$ in the DIS region with 11 and 8.8 GeV electron beam, using SoLID.

• This experiment will be run with already approved SoLID SIDIS program, E12-11-006, which will measure transversity via single hadron channel. No extra beam time requested.

• The neutron SSA will be extracted after making correction for proton contribution and nuclear effects.

• The transversity distribution, h_1, will be extracted via DiFF, which is extracted from Belle e^+e^- annihilation data. Currently no low x or high x data availabe.

•This experiment will provide precise measurement of tranversity, especially in high x region. It therefore will provide crucial impact to the DiFF. It will also provide better constrain to the tensor charge.

• Combining these data with the results from a transversely polarized proton target in a similar x region measured by 12 GeV CLAS (PR12-12-009) or SoLID (E12-11-108) will provide a unique possibility to extract, in a model independently way, the u and d transversity distribution.

Back up

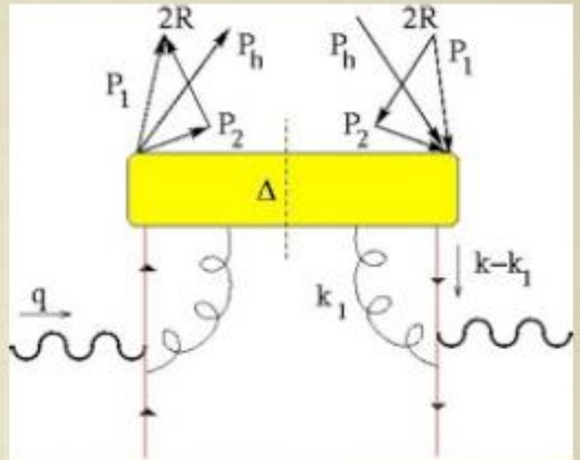
Dihadron cross section

$$
\begin{aligned}
&\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_R\,dM_h^2\,d\cos\theta} = \\
&\quad \frac{\alpha^2}{xy\,Q^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Bigg\{F_{UU,T} + \varepsilon\,F_{UU,L} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_R\,F_{UU}^{\cos\phi_R} \\
&\qquad + \varepsilon\cos(2\phi_R)\,F_{UU}^{\cos 2\phi_R} + \lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_R\,F_{LU}^{\sin\phi_R} \\
&\qquad + S_L\left[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_R\,F_{UL}^{\sin\phi_R} + \varepsilon\sin(2\phi_R)\,F_{UL}^{\sin 2\phi_R}\right] \\
&\qquad + S_L\lambda_e\left[\sqrt{1-\varepsilon^2}\,F_{LL} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_R\,F_{LL}^{\cos\phi_R}\right] \\
&\qquad + |\boldsymbol{S}_T|\Bigg[\sin(\phi_R-\phi_S)\left(F_{UT,T}^{\sin(\phi_R-\phi_S)} + \varepsilon\,F_{UT,L}^{\sin(\phi_R-\phi_S)}\right) \\
&\qquad\quad + \varepsilon\,\sin(\phi_R+\phi_S)\,F_{UT}^{\sin(\phi_R+\phi_S)} + \varepsilon\,\sin(3\phi_R-\phi_S)\,F_{UT}^{\sin(3\phi_R-\phi_S)} \\
&\qquad\quad + \sqrt{2\varepsilon(1+\varepsilon)}\,\sin\phi_S\,F_{UT}^{\sin\phi_S} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin(2\phi_R-\phi_S)\,F_{UT}^{\sin(2\phi_R-\phi_S)}\Bigg] \\
&\qquad + |\boldsymbol{S}_T|\lambda_e\Bigg[\sqrt{1-\varepsilon^2}\,\cos(\phi_R-\phi_S)\,F_{LT}^{\cos(\phi_R-\phi_S)} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_S\,F_{LT}^{\cos\phi_S} \\
&\qquad\quad + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos(2\phi_R-\phi_S)\,F_{LT}^{\cos(2\phi_R-\phi_S)}\Bigg]\Bigg\},
\end{aligned}
$$

What are DiFF

describe semi-inclusive production of hadrons P_1 and P_2

total pair momentum $\mathbf{P}_h$, **relative** momentum $\mathbf{R}$



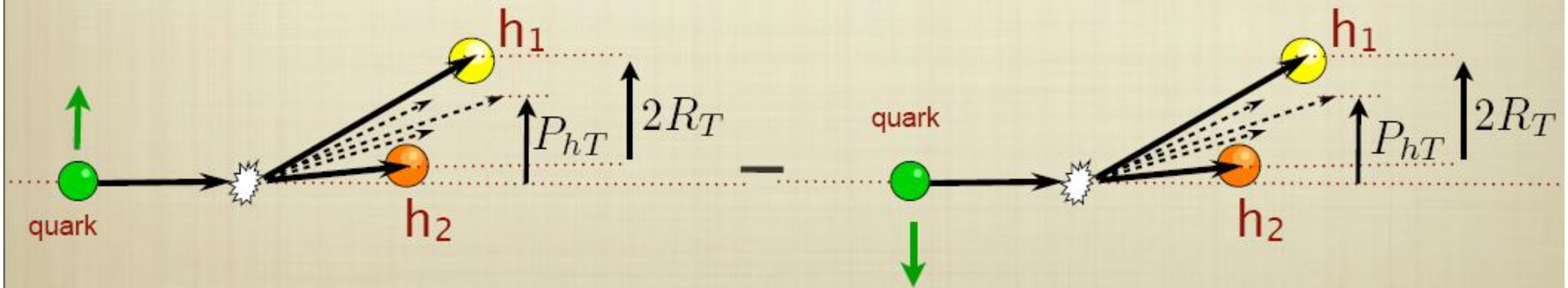
leading-twist projections of q-q correlator $\Delta(z_1, z_2, \mathbf{P}_{hT}, \mathbf{R}_T)$

$$\mathrm{Tr}\left[\Delta\,\gamma^-\right] \longrightarrow D_1^{q\to h_1 h_2}$$

$$\mathrm{Tr}\left[\Delta\,\gamma^-\gamma_5\right] \longrightarrow G_1^{\perp\, q\to h_1 h_2}$$

chiral-odd, also named Interference Fragmentation Functions (IFF)

$$\mathrm{Tr}\left[\Delta\, i\sigma^{i-}\gamma_5\right] \longrightarrow (\mathbf{S}_T^q \times \mathbf{P}_{hT})\, H_1^{\perp\, q\to h_1 h_2} + (\mathbf{S}_T^q \times \mathbf{R}_T)\, H_1^{\sphericalangle\, q\to h_1 h_2}$$



From Marco Radici, QCD Evolution Workshop, 2013

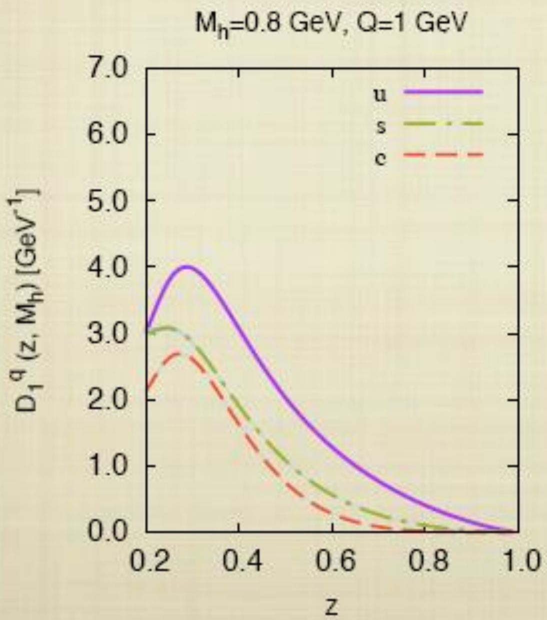
results for unpolarized DiFF D_1^q

* **40** (z) × **50** (M_h) × **4** flavors × **4** channels = **32000** bins
  $0.2 \leq z \leq 1$ $2m_\pi \leq M_h \leq 1.3$ GeV   (u,d,s,c)   (ρ,ω,K^0 decays + continuum)

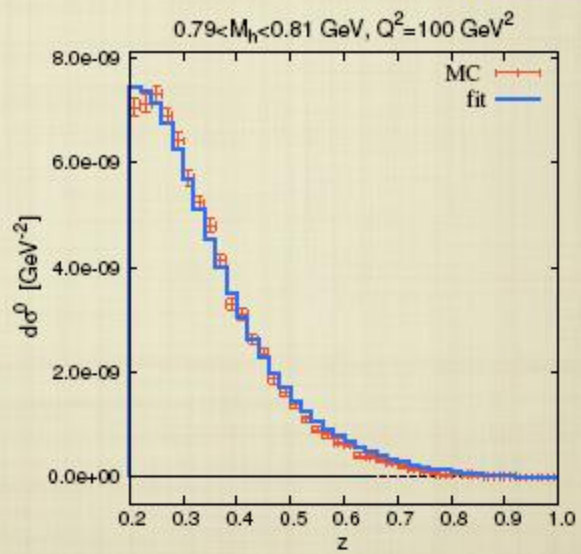
* isospin symmetry + charge conjugation : $u = \bar{u}$ $d = \bar{d}$ $s = \bar{s}$ $c = \bar{c}$
  (except $K^0 \to \pi^+\pi^-$)

* parameters **17**(continuum) + **20**(ρ) + **20**(ω) + **22**(K^0) = **79**
  χ^2/dof 1.69   1.28   1.68   1.85   1.62

D_1^q
M_h=0.8
Q_0^2=1



$d\sigma^0$
M_h=0.8
Q^2=100

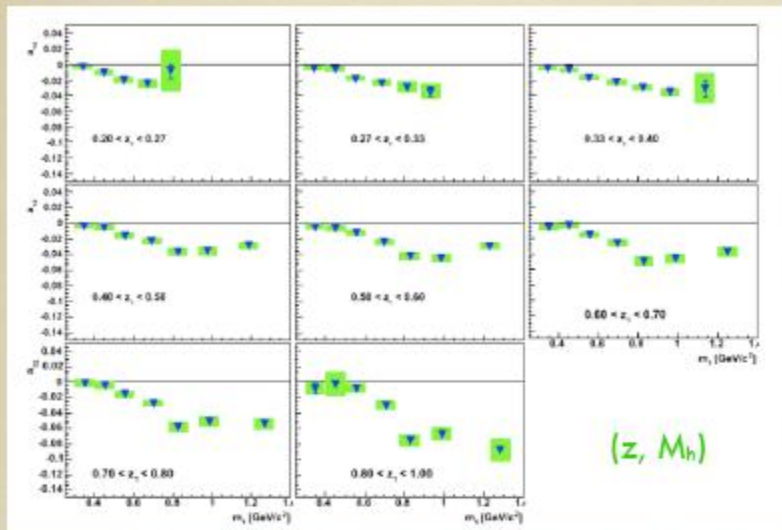


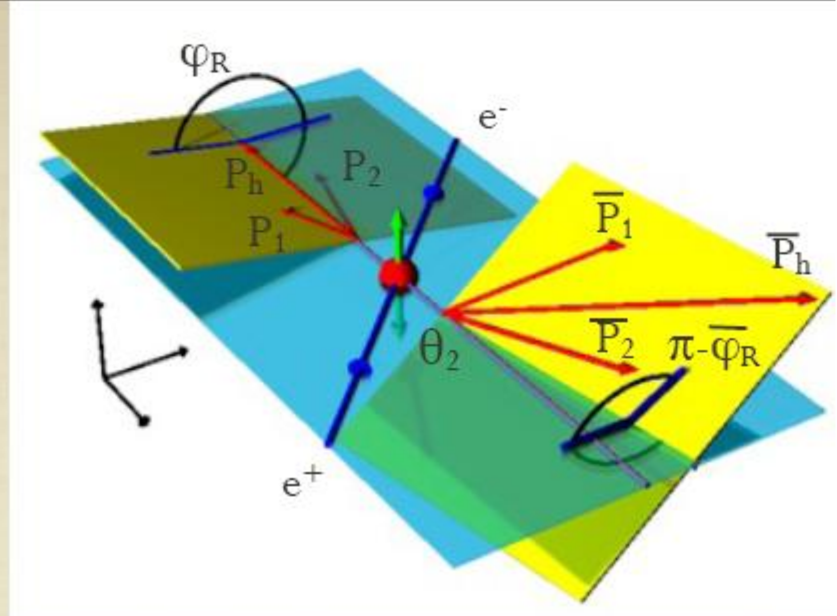
more details in

A.Courtoy, A.Bacchetta, M.R., A.Bianconi, PRD 85 (12)

fitting the Belle asymmetry A

A. Vossen et al. (Belle), PRL ***107*** *(11)*





$$d\sigma = \frac{1}{4\pi^2}\, d\sigma^0 \left(1 + \cos(\phi_R + \overline{\phi}_R)\, A\right)$$

$$A^{\cos(\phi_R+\overline{\phi}_R)} \propto \frac{\sum_q e_q^2\, H_{1,sp}^{\sphericalangle q}(z, M_h^2, Q^2)\, H_{1,sp}^{\sphericalangle \bar{q}}(\overline{z}, \overline{M}_h^2, Q^2)}{\sum_q e_q^2\, D_1^q(z, M_h^2, Q^2)\, D_1^{\bar{q}}(\overline{z}, \overline{M}_h^2, Q^2)}$$

integrating on one emisphere

$$A^{\cos(\phi_R+\overline{\phi}_R)}(z, M_h^2, Q^2) \propto \frac{\sum_q e_q^2\, H_{1,sp}^{\sphericalangle q}(z, M_h^2, Q^2)\, n_{\bar{q}}^{\uparrow}(Q^2)}{\sum_q e_q^2\, D_1^q(z, M_h^2, Q^2)\, n_q(Q^2)}$$

Single-Spin Asymmetry (SSA) in SIDIS

A.Bacchetta, A. Courtoy, M.R., PRL 107 (11)
A.Bacchetta, A. Courtoy, M.R., JHEP03 (13)

D_1 u=ū d=d̄
s=s̄ c=c̄

$H_1^{\sphericalangle}$ u=−d=−ū=d̄

$$A_{UT}^{\sin(\phi_R+\phi_S)} \propto \frac{\sum_q e_q^2\, h_1^q(x)\ H_{1,sp}^{\sphericalangle\, q}(z,M_h^2)}{\sum_q e_q^2\, f_1^q(x)\ D_1^q(z,M_h^2)}$$

flavor analysis

COMPASS, hermes — proton

$$A_{UT}^{\sin(\phi_R+\phi_S)}(x) \propto \frac{x h_1^{u_v} - \frac{1}{4} x h_1^{d_v}}{x f_1^{u+\bar{u}} + \frac{1}{4}\frac{n_d}{n_u}\, x f_1^{d+\bar{d}} + \frac{1}{4}\frac{n_s}{n_u}\, x f_1^{s+\bar{s}}}\ \frac{n_u^{\uparrow}(Q^2)}{n_u(Q^2)}$$

COMPASS — deuteron

$$A_{UT}^{\sin(\phi_R+\phi_S)}(x) \propto \frac{3}{4}\, \frac{x h_1^{u_v} + x h_1^{d_v}}{\left(x f_1^{u+\bar{u}} + x f_1^{d+\bar{d}}\right)\left(1+\frac{1}{4}\frac{n_d}{n_u}\right) + \frac{n_s}{2n_u} x f_1^{s+\bar{s}}}\ \frac{n_u^{\uparrow}(Q^2)}{n_u(Q^2)}$$

separate u & d valence transversities

(LO) evolved down from BELLE

$f_1(x)$ from MSTW08LO

TAC Questions 3 and 9

3. Like all SIDIS experiments, factorization is required for a clean interpretation of the measurements. There is much evidence from existing JLab data at 6 GeV that factorization holds for single pion electroproduction (in certain kinematic regimes). There is no such evidence to two-pion production. This proposal would benefit from a discussion of some ancillary measurements that could justify the assumption of factorization.

There are already CLAS data for dihadron events at 6 GeV (see for example EPJ Web Conf. 73 (2014) 02008). Factorization has not been checked explicitly but the analysis through the usual collinear factorizarion gives reasonable results (up to extreme kinematic conditions) as it can be seen in arXiv:1405.7659. We want to point out that, contrarily to the single-pion case, the usual collinear factorization applies here.

9. The ^{3}He polarization is sensitive to small gradients in the magnetic field around the target. While the fringe field of the SoLID magnet will be heavily shielded and is expected to be about 5 G at the opening, additional shielding around the target may be necessary for maximizing its polarization.

We totally agree that the ^{3}He polarization is sensitive to small gradients in the magnetic field. The target can be operated if the gradient is below about 30 mg/cm. During the operation, we will put correction coil pairs to correct the fringe field and its gradients from the CLEO magnet. These correction coils will suppress the gradients by a factor of 2 to 3. With a thick end cap, gradients of the CLEO magnet at the target area can be reduced to about 50 mg/cm from a recent estimation. Correction coils should be able to bring them down to an acceptable level.

TAC Questions 4 and 5

4. Related to the above comment, it is stated that a cut of $M_x > 1.414$ GeV (the mass of the undetected hadronic system) will be used to avoid the resonance region. While this has been shown to be adequate for single-pion production, this has not yet been demonstrated for two-pion production.

The cut in the missing mass is actually meant to avoid the EXCLUSIVE region (the "resonance" referred to is just an outgoing proton), so that's still justified for 2 pions as shown on Fig. 22 of the proposal.

5. A great deal of the proposal discusses the formalism for semi-inclusive two-pion production, and its relation to transversity. However, a discussion of relevant physics background processes is lacking, e.g., production of vector mesons that decay into π^+/π^- pairs.

In the partonic picture for the process of di-hadron electro-production in SIDIS, the active quark fragments in two hadrons. The fragmentation process is embedded in the di-hadron Fragmentation Functions. Contributions to this fragmentation come, for instance, from a quark fragmentating in a rho meson that then goes into 2 pions. In our present understanding/modelling of that process, the pion pairs actually come from contributions of a quark fragmenting in a vector meson that then decays into two pions as well as contributions coming from a non-resonant fragmentation process.

Since SIDIS kinematics are applied, the exclusive limit ($e + P \rightarrow e + P + \pi + \pi$) is excluded from the analysis —through the cut in missing mass discussed in point 4. However, we are aware that the study of such limits can bring important information on hadronic mechanisms, and we consider it as a possible development of the di-hadron SIDIS analysis performed at 6 GeV, even if no theoretical framework has been pointed out yet. In that exclusive limit, we think that the pion pair will be produced by gluon exchange with the VM component of the photon. To our knowledge, from the theoretical side, there is no evidence for a dual interpretation of the 2 mechanisms.

TAC Questions 6

6. Table 2 in the proposal lists the expected signal rate (an electron in coincidence with two pions) as well as the rate for single pion electroproduction. However, this is insufficient to really estimate the expected signal to background for this measurement. For example, one imagines that the probability to produce a single pion via $(e, e'\pi)$ could easily form a random coincidence with the photoproduction of another pion.

In the di-hadron SIDIS process, we expect to measure scattered electron, one positive pion and one negative pion simultaneously. The coincident background can be divided into these 4 components: 1) $(e, e'\pi^+)X$ coincident with single π^- ; 2) $(e, e'\pi^-)X$ coincident with single π^+ ; 3) $(e, e')X$ coincident with $\pi^+\pi^-$ pair; 4) $(e, e')X$ coincident with single π^+ then coincident with single π^-. We estimate the single pion rate using the WISER model. These rates can be found in Table. 1.

Process	Rates at 11 GeV	Rate at 8.8 GeV
single e^-	110 kHz	160 kHz
single π^+	2.9 MHz	2.5 MHz
single π^-	1.8 MHz	1.5 MHz
$(e, e'\pi^+)$	1.05 kHz	0.61 kHz
$(e, e'\pi^-)$	0.87 kHz	0.56 kHz
$(e, e'\pi^+\pi^-)$	0.26 kHz	0.08 kHz

Table 1: The estimated coincidence and single rates with 11 and 8.8 GeV electron beam.

Since SOLID vertex z resolution is about 0.8 cm, using a 3-σ cut, reduction of the coincident probability over the 40 cm long target is $6 \times 0.8/40 = 0.12$. Taking 2 ns coincident time window, the coincident probability for single π^+ (component 1) with 11 GeV beam energy is 0.0007, the coincident probability for single π^- (component 2) is 0.0004. We do not have a model to estimate the rate for $\pi^+\pi^-$ pair production, but this rate must be less than single π^+ rate. The contribution from component 3 is estimated to be less than 0.0007 and from component 4 is extremely tiny, 3.0E-7. The total accidental triple coincident probability for 11 GeV beam energy is 0.18%. A similar calculation with 8 GeV beam energy gives us the accidental triple coincident probability of 0.16%.