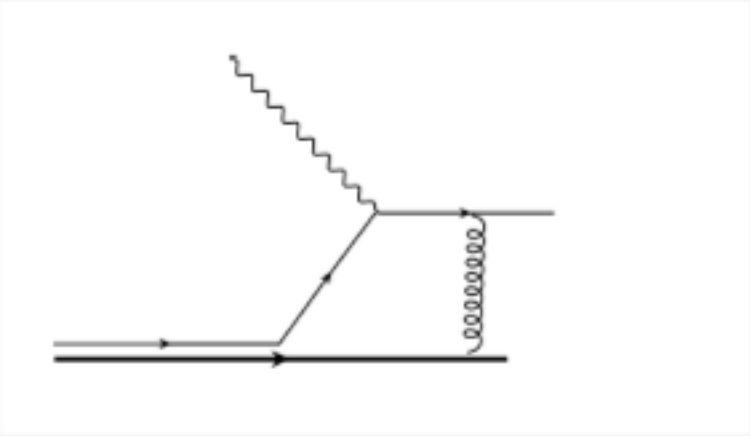
DI-HADRON BEAM SPIN ASYMMETRIES FOR DNP

Jefferson Lab

QUARK-GLUON INTERACTIONS

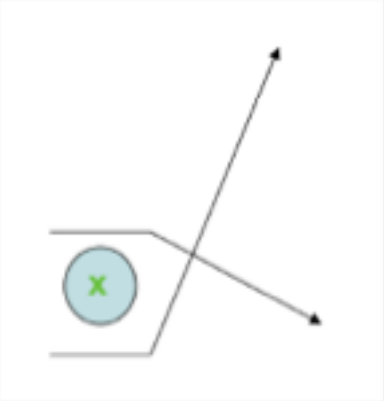
- Quarks probed in deep-inelastic scattering move in gluon background field
  - Gauge link Integrated effect of quark gluon interactions
- Some of the most interesting effects can be attributed to the dependence of these interactions on spatial deformations and polarization of PDFs
  - **Example: Sivers effect**

$$\langle \mathbf{k}_\perp \rangle \sim \left\langle P,S \left| \bar{q}(0)\gamma^+ \int_0^\infty d\eta^- G^{+\perp}(\eta) q(0) \right| P,S \right\rangle$$



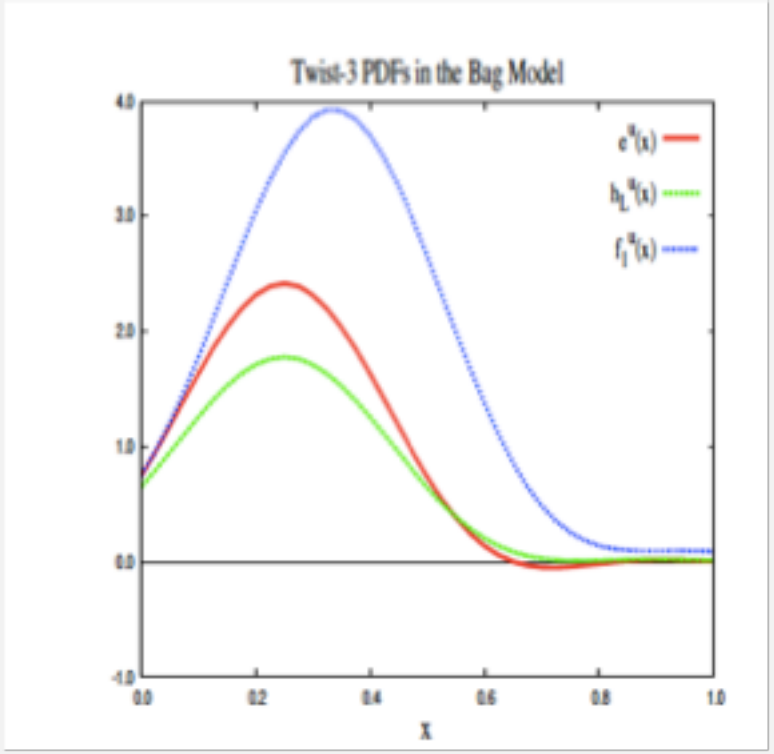
- The instant quark gluon interactions are described by Twist3 PDFs
- Projections of
-

$$\Phi^\mu_{Aij}(x) = \int \frac{\mathrm{d}\tau}{2\pi}\, \mathrm{e}^{\mathrm{i}\tau x} \langle PS|\bar{\phi}_j(0)\, gA^\mu(\tau n)\, \phi_i(\tau n)|PS\rangle\,.$$



EXAMPLE e(X)

- Transverse force on transversely polarized quarks (Burkhardt)
- Model calculations show significant magnitude:



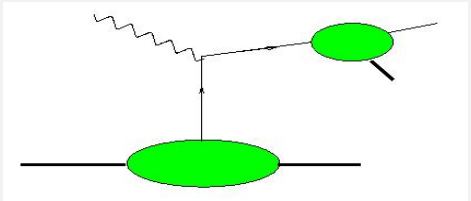
Jaffe, Ji, Nucl. Phys. **B**375, 527{560 (1992).

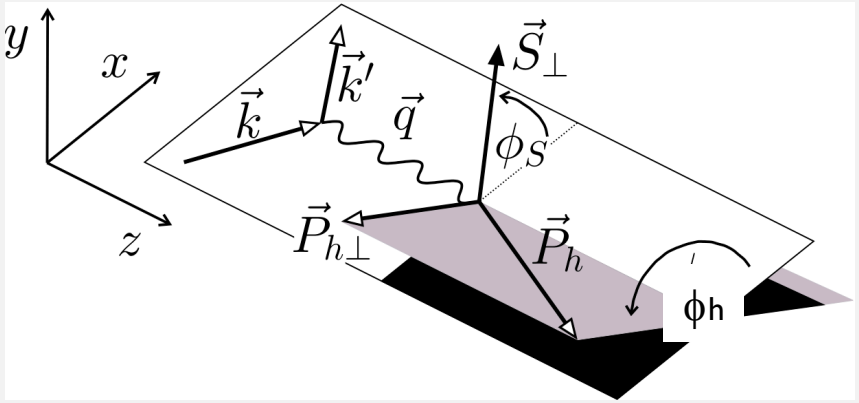
EXAMPLE, ACCESS OF e(x) in SIDIS X-SECTION

- Single hadron cross-section: mixes other contributions:

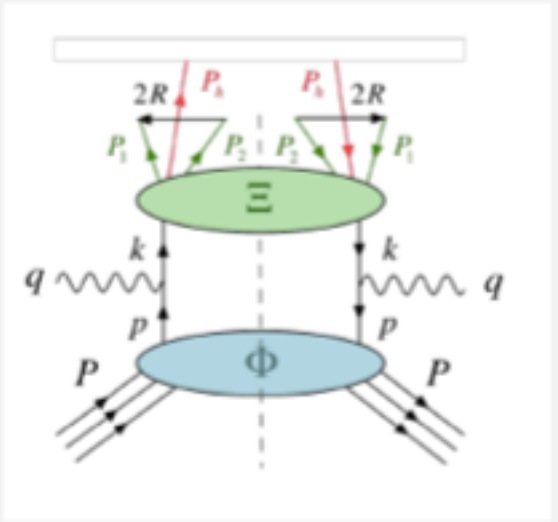
WW Approximation

$$F_{LU}^{\sin(\phi_h)} = \frac{2M}{Q}\mathcal{I}\left[-\frac{k_T\hat{P}_{h\perp}}{M_h}\left(xeH_1^\perp + \frac{M_h}{Mz}f_1\tilde{G}^\perp\right) + \frac{p_T\hat{P}_{h\perp}}{M}\left(xg^\perp D_1 + \frac{M_h}{Mz}h_1^\perp\tilde{E}\right)\right]$$

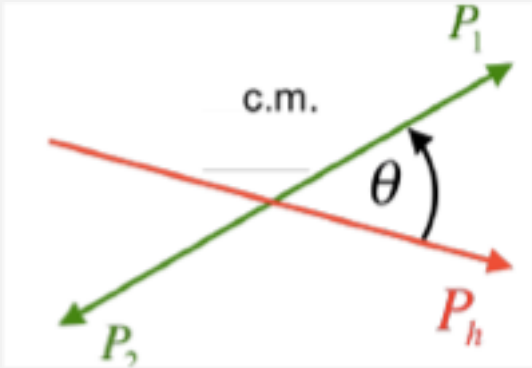




DI-HADRON FRAGMENTATION FUNCTIONS



- Additional degree of freedom ($\vec{R} = \overrightarrow{P_1} - \overrightarrow{P_2}$)
  - Relative momentum of hadrons can carry away angular momentum
  - Additional dependence on $M_{h_1 h_2}$, θ
  - Partial wave decomposition in θ
  - Relative and total angular momentum →In principle endless tower of FFs
  - Analogue of 1h production with spin in final state
- Transverse polarization dependence in collinear framework $H_1^{\angle}$→ **Most precise extraction of transversity**
- **Makes 'new' FFs possible,** such as $G_1^{\perp}$:T-odd chiral even. In 1h case, this needs polarized hadron in the final state **→Analysis proposal for BSA, TSA and BoerMulders underway!**



EXAMPLE, ACCESS OF e(x) in SIDIS X-SECTION

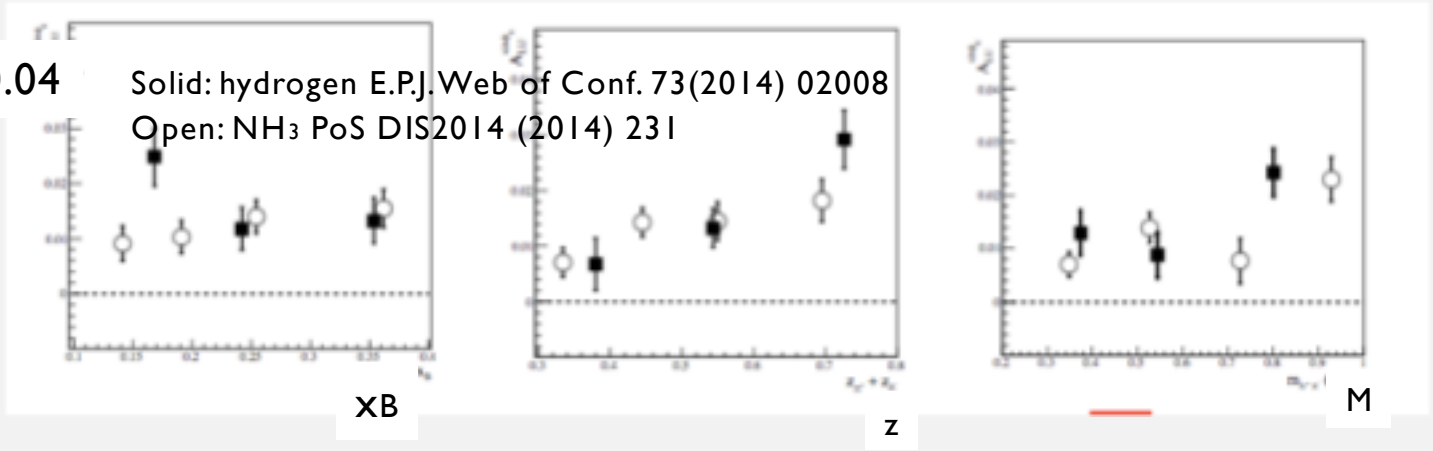
- Di-hadron cross section: Clean access to e(x)

WW Approximation
→not needed if combined with TSSA

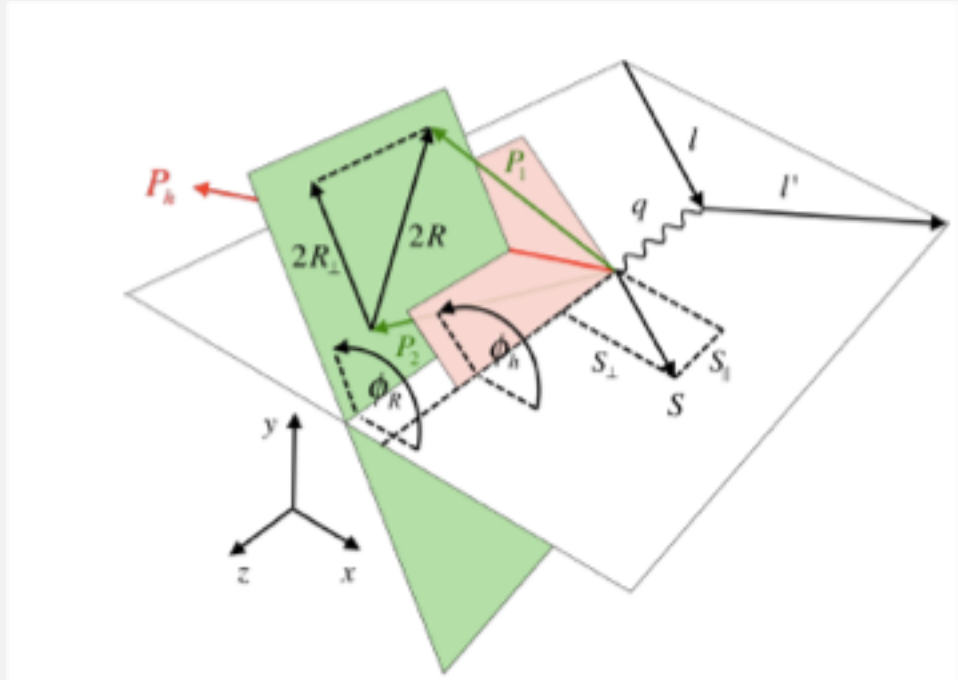
$$F_{LU}^{\sin\phi_R} = -x\frac{|\boldsymbol{R}|\sin\theta}{Q}\left[\frac{M}{m_{hh}}\,x\,e^q(x)\,H_1^{\sphericalangle q}(z,\cos\theta,m_{hh}) + \frac{1}{z}\,f_1^q(x)\,\tilde{G}^{\sphericalangle q}(z,\cos\theta,m_{hh})\right],$$

Known from e+e-

- Evidence from CLAS6:



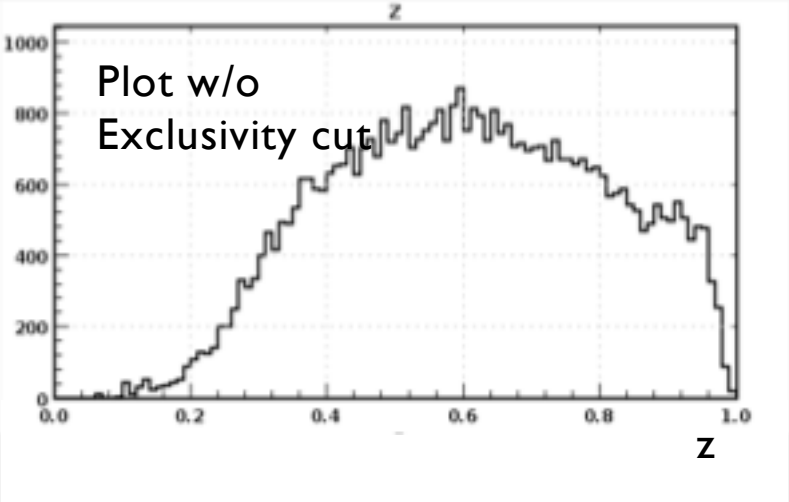
Solid: hydrogen E.P.J. Web of Conf. 73(2014) 02008
Open: NH_3 PoS DIS2014 (2014) 231

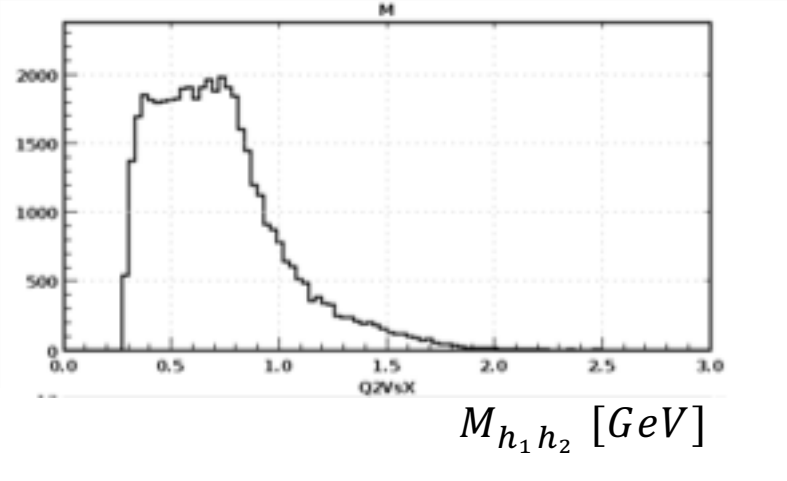


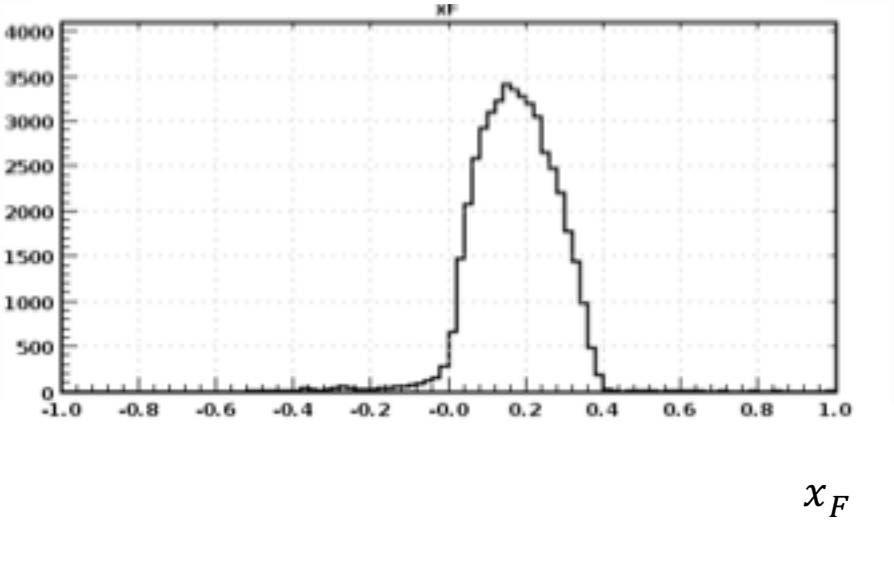
ANALYSIS AT CLAS12: GOALS FOR DNP

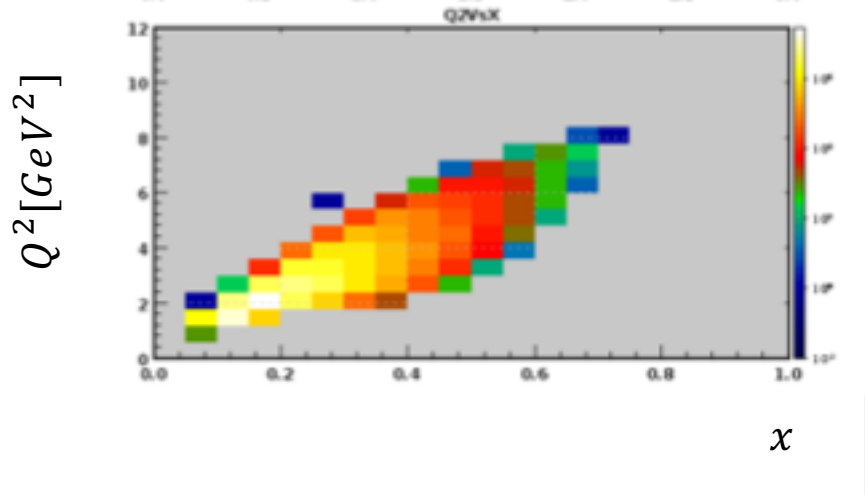
- Currently concentrating on beam spin asymmetries for pions detected in the forward tracker
  - →piggy back on single hadron analysis with added advantage that di-hadrons tend to be more forgiving wrt false asymmetries
  - Main requirements from detector/MC description: approximately truthful estimation of kinematic variables z,x,M, charged hadron reconstruction and correct pion fraction
- X-check with Timothy Hayward (W&M)→thesis topic
- Analysis chain implemented in Java (no fit yet)
- Two step analysis with intermediated microDSTs saved as serialized Java objects with MC truth-Data connection →needed for weighting
- Cuts
  - Event builder cuts and PID for pions
  - Q2> 1.0, W> 2.0
  - Missing mass > 1.05 GeV
  - Chi2pid < 5.0
  - z>0.1, xF>0.0

EXAMPLES OF KINEMATIC DISTRIBUTIONS

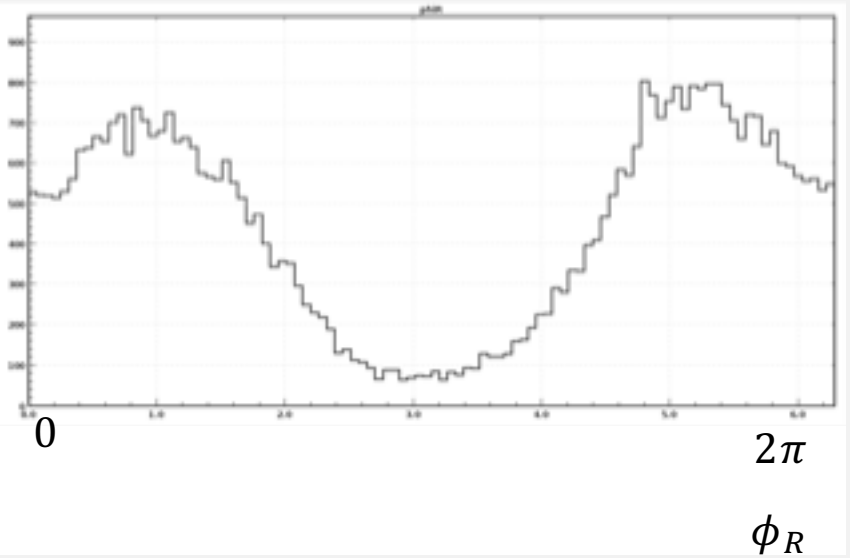


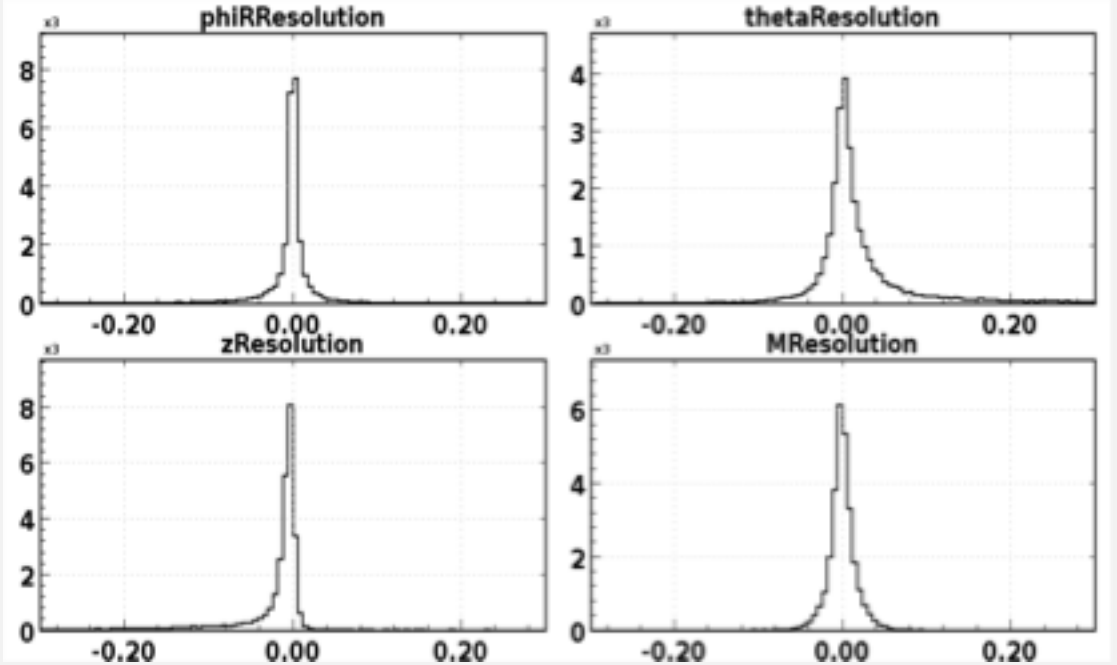






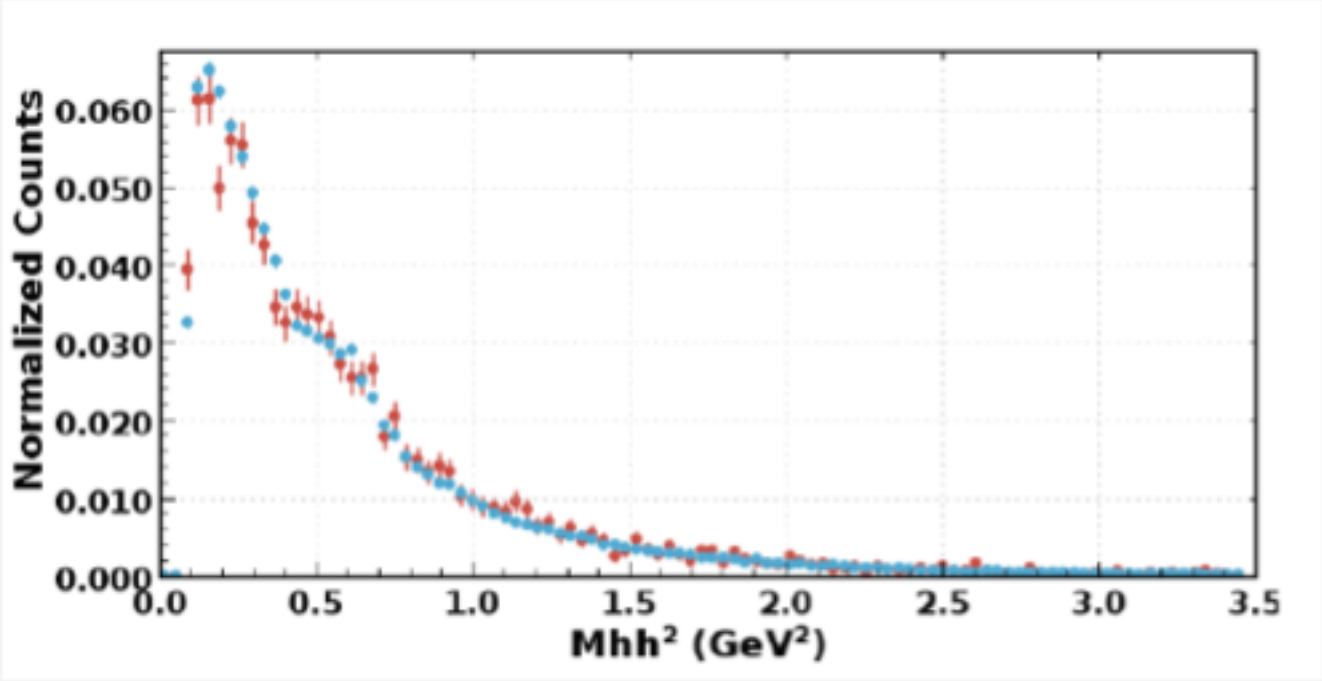
ϕ_R AND RESOLUTIONS FROM MC





- The purpose of these plots is to demonstrate the maturity of the analysis chain
- The resolutions per se are biased by the selection criteria that lead to about 60% matching for hadron pairs

- Example MC – Data comparison
- (from Timothy's presentation at the first experiment review)

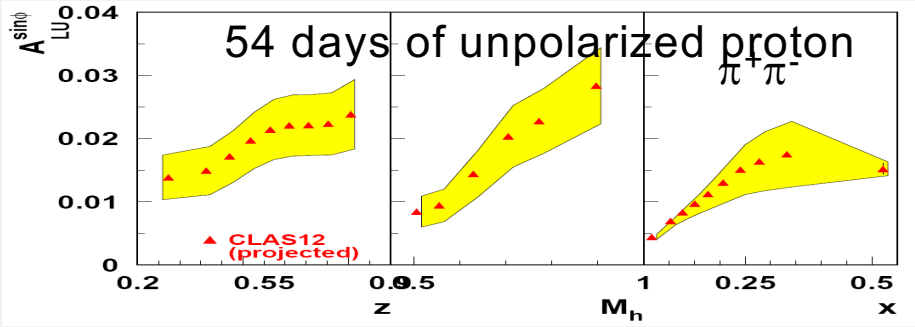


NEXT STEPS

- Implement Stefan's cut from the single pion analysis
- Evaluate MC/Data comparison for relevant variables
- Evaluate with weighted MC
- For DNP: Consider presentation of resulting asymmetries with large uncertainties
- Longer Term (past DNP)
  - Implement real closure test with TMDGen (see discussion in deeppwg)
  - Include $G_1^{\perp}$, Boer-Mulders and cross-section

SUMMARY: PROJECTIONS FOR DNP

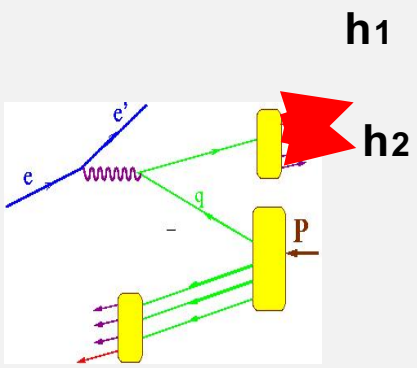
- Even with ~5% of the data should see significant asymmetries

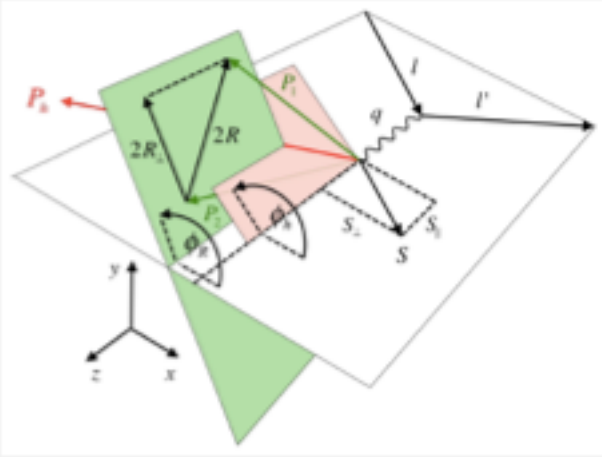


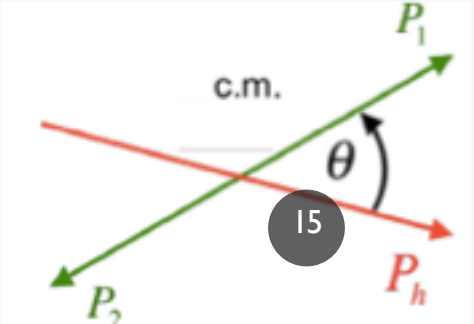
BACKUP

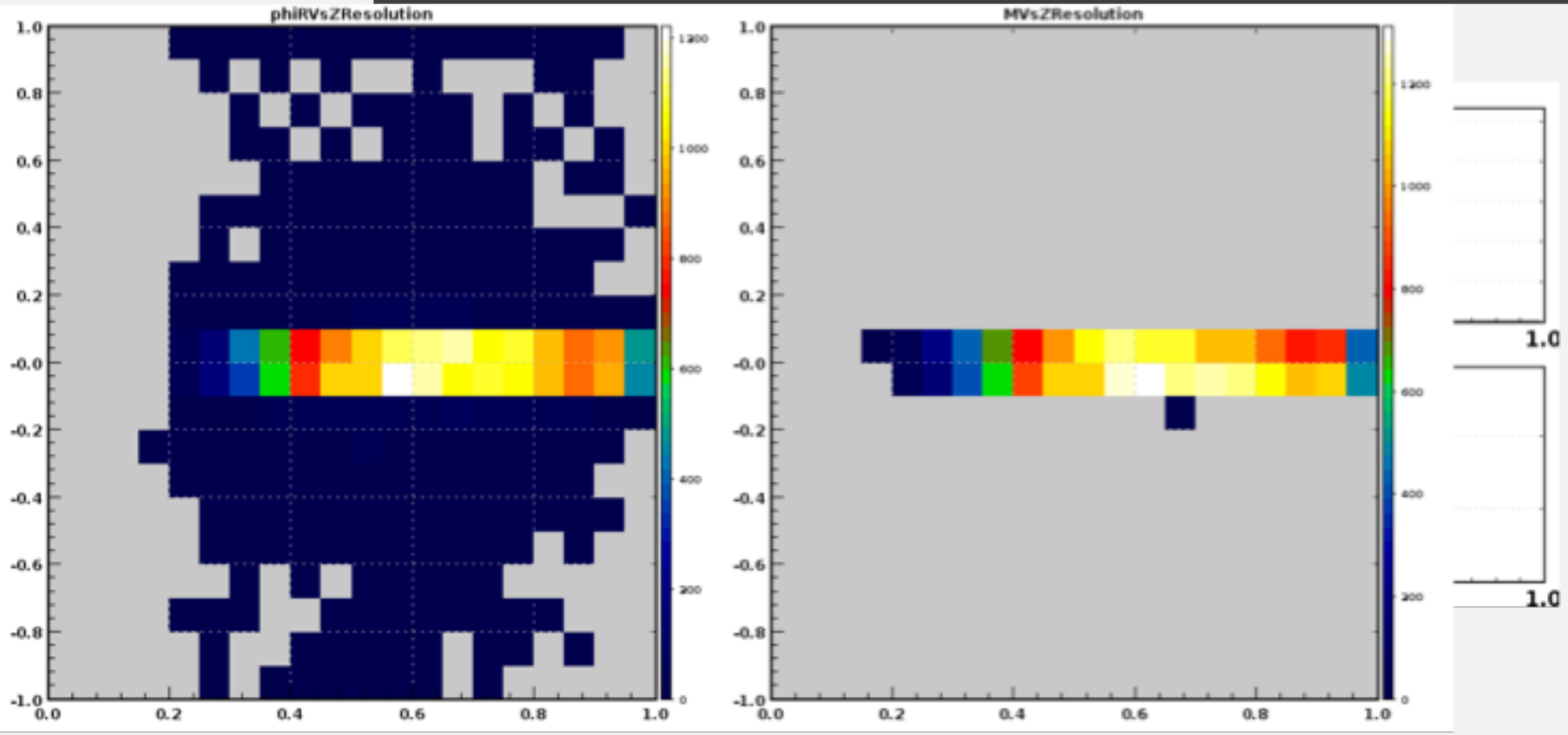
PHYSICS

- Looking at SIDIS process $ep \rightarrow e' h_1 h_2 + X$
- In factorized picture and small $M_{h_1 h_2}$ the cross-sections can be described by the convolution of PDF and di-hadron FF
- Compared to 1H FF, additional degree of freedom $\vec{R} = \overrightarrow{P_1} - \overrightarrow{P_2}$ → more targeted access to PDFs
- Collinear di-hadron FF picks up dependence on $M_{h_1 h_2}$ and θ








phiRVsZResolution
MVsZResolution
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1.0
1.0
0.8
0.6
0.4
0.2
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.0
0.2
0.4
0.6
0.8
1.0
1200
1000
800
600
400
200
0