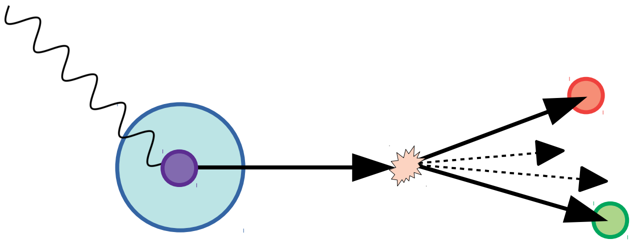
Accessing Spin-Dependent Fragmentation with SIDIS Dihadron Beam Spin Asymmetries at CLAS12



Christopher Dilks

For the CLAS Collaboration

APS GHP Workshop, April 2021

Research supported by the U.S. DEPARTMENT OF ENERGY | Office of Science

Duke UNIVERSITY

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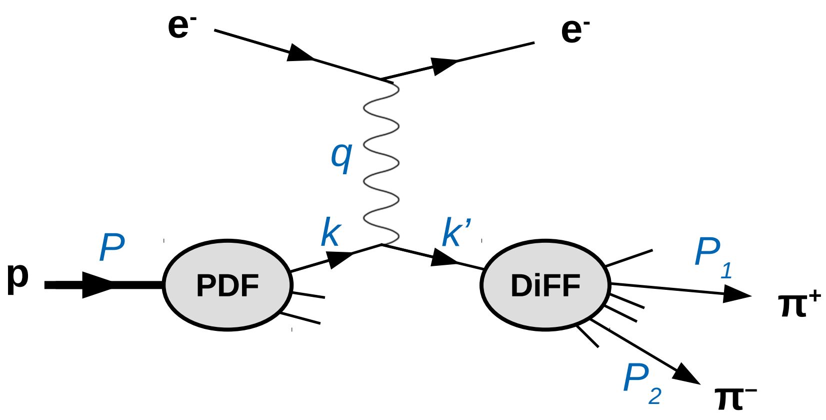
SIDIS Dihadron Kinematics



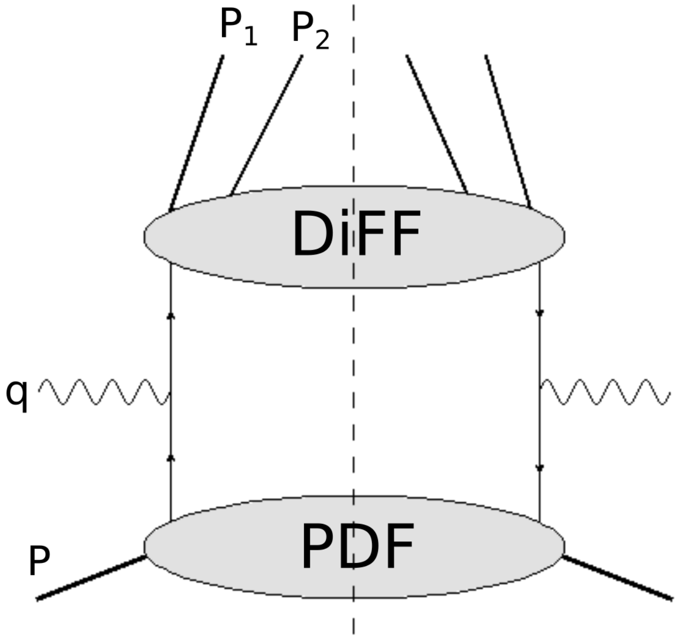
Beam Spin Asymmetry

$$A_{LU} = \frac{d\sigma_+ - d\sigma_-}{d\sigma_+ + d\sigma_-}$$

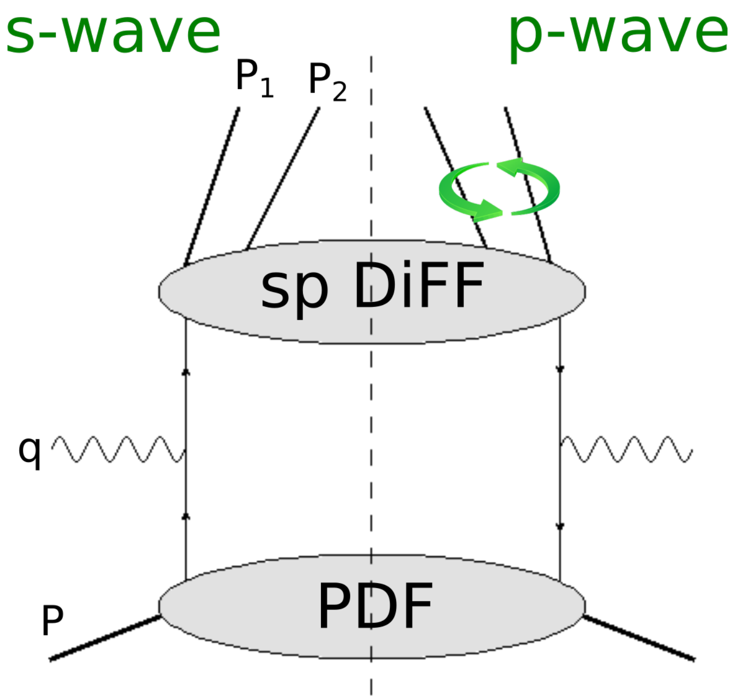
Sensitive to: $\mathrm{PDF} \otimes \mathrm{DiFF}$

- **Spin-momentum and spin-spin correlations in hadronization**
- **Complement single-hadron SIDIS, with the advantage of another degree of freedom**

Parton Distributions and Fragmentation Functions



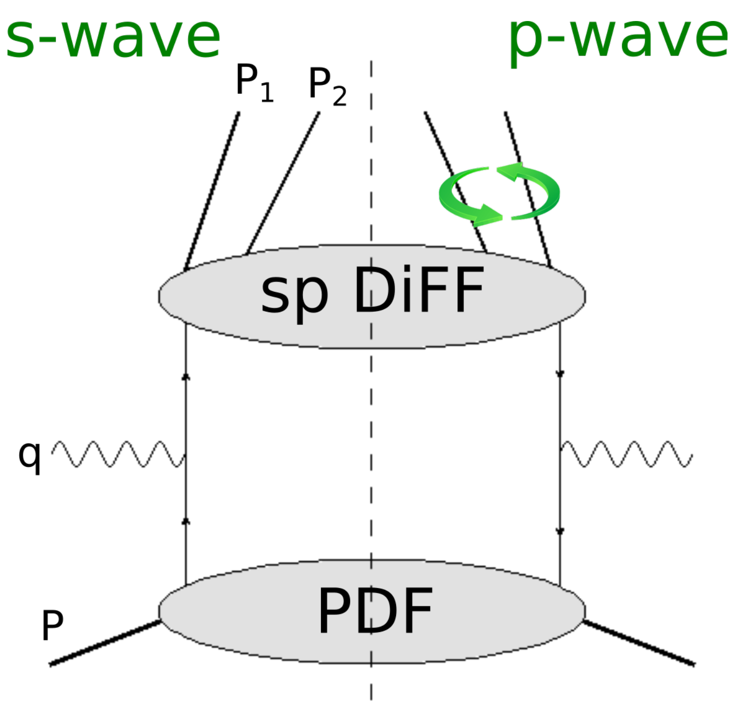
Parton Distributions and Fragmentation Functions



- Dihadron FF expands on a basis of spherical harmonics
- Angular momentum eigenvalues | ℓ, m >
- Explore dihadron fragmentation depending on relative angular momentum

Parton Distributions and Fragmentation Functions

Unpolarized (U)



- Dihadron FF expands on a basis of spherical harmonics
- Angular momentum eigenvalues | ℓ, m >
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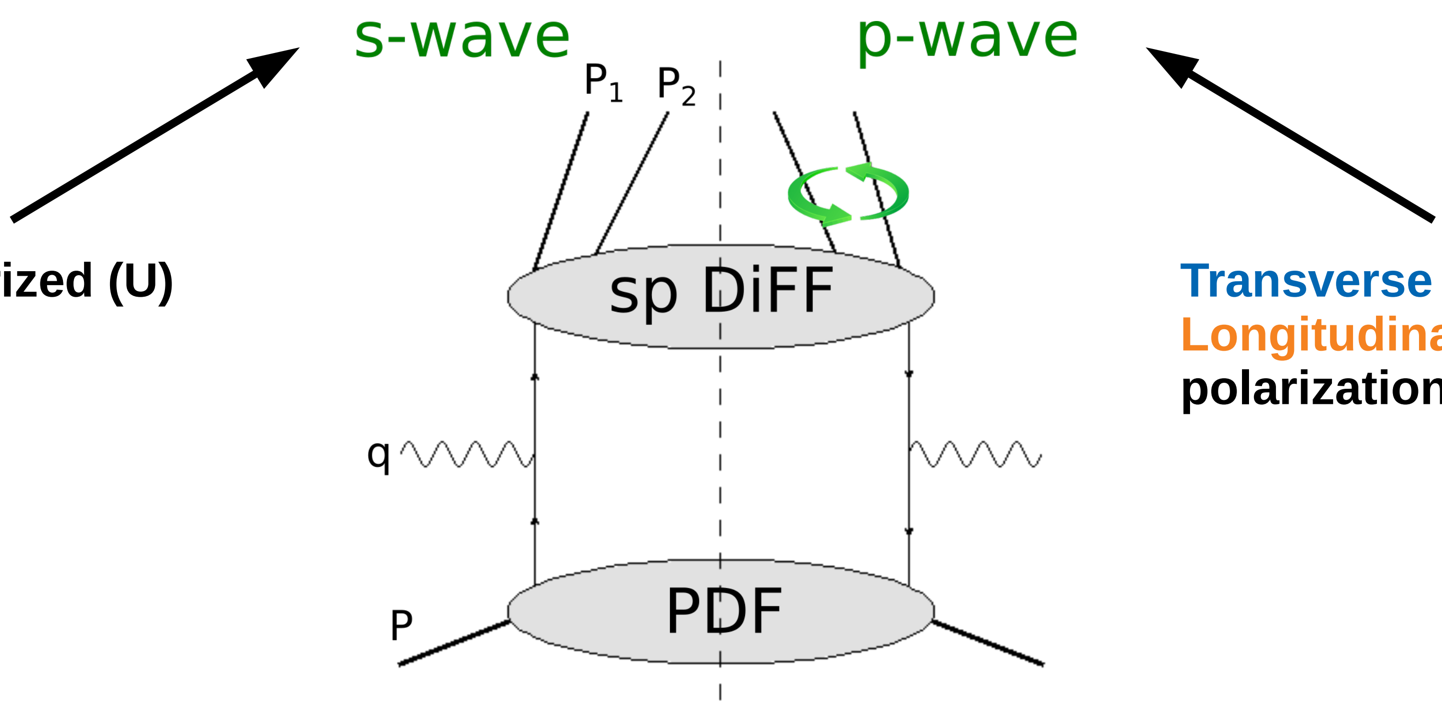
Parton Distributions and Fragmentation Functions

Unpolarized (U)



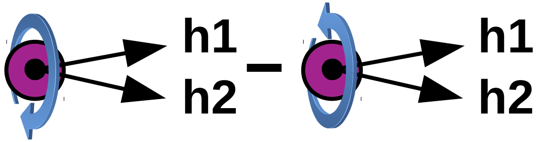
Transverse (T) **or** **Longitudinal (L)** **polarization**

- **Dihadron FF expands on a basis of spherical harmonics**
- **Angular momentum eigenvalues | ℓ, m >**
- **Explore dihadron fragmentation depending on relative angular momentum**

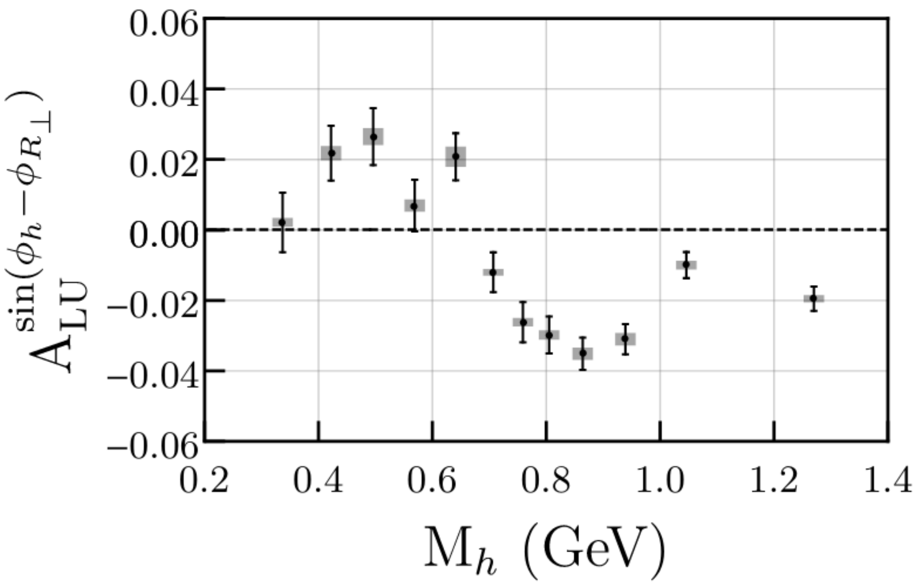
Twist 2

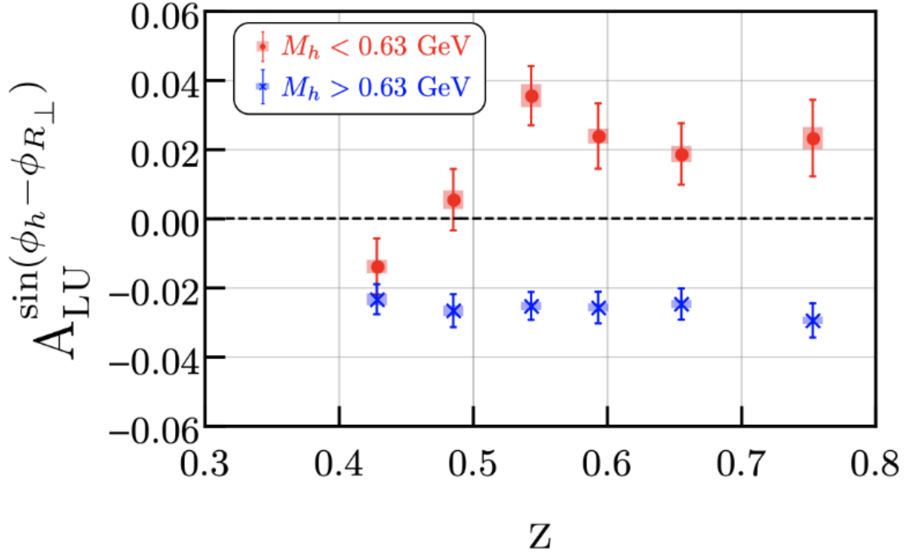
$$A_{LU} \sim f_1 G_1^{\perp|\ell,m\rangle}$$

$$G_1^{\perp|\ell,m\rangle} =$$



- Matevosyan, Kotzinian, Thomas, Phys.Rev.Lett. 120 (2018) 25, 252001
- Gliske, Bacchetta, Radici, Phys.Rev.D 90 (2014) 11, 114027, Phys.Rev.D 91 (2015) 1, 019902 (erratum)



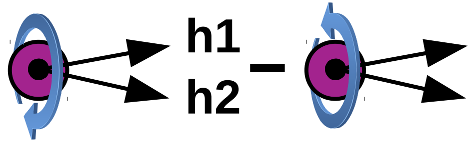


Hayward, CD, Vossen, Avakian, et al.,
Phys.Rev.Lett. 126 (2021) 15, 152501

CLAS12 Beam Spin Asymmetry Measurements

Twist 2

$$A_{LU} \sim f_1 G_1^{\perp|\ell,m\rangle} \qquad G_1^{\perp|\ell,m\rangle} =$$



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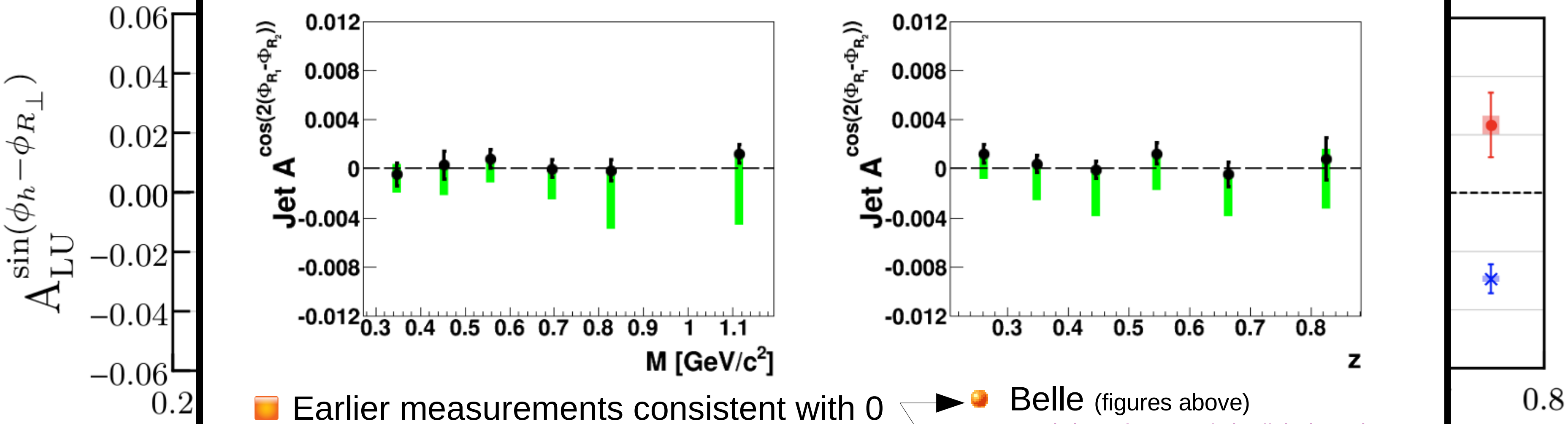


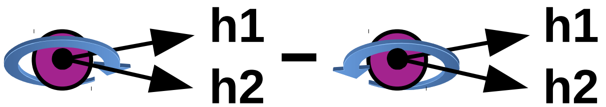
- Earlier measurements consistent with 0
- e+e-: Error in cross section expression → wrong modulation
  Matevosyan, Kotzinian, Thomas
  Phys.Rev.Lett. 120 (2018) 25, 252001

- Belle (figures above)
  - Abdesselam, et al. (Belle), (2015), arXiv:1505.08020 [hep-ex]
  - Vossen, PoS DIS2015, 216 (2015)
- COMPASS
  - Sirtl, SPIN2016, (2017)

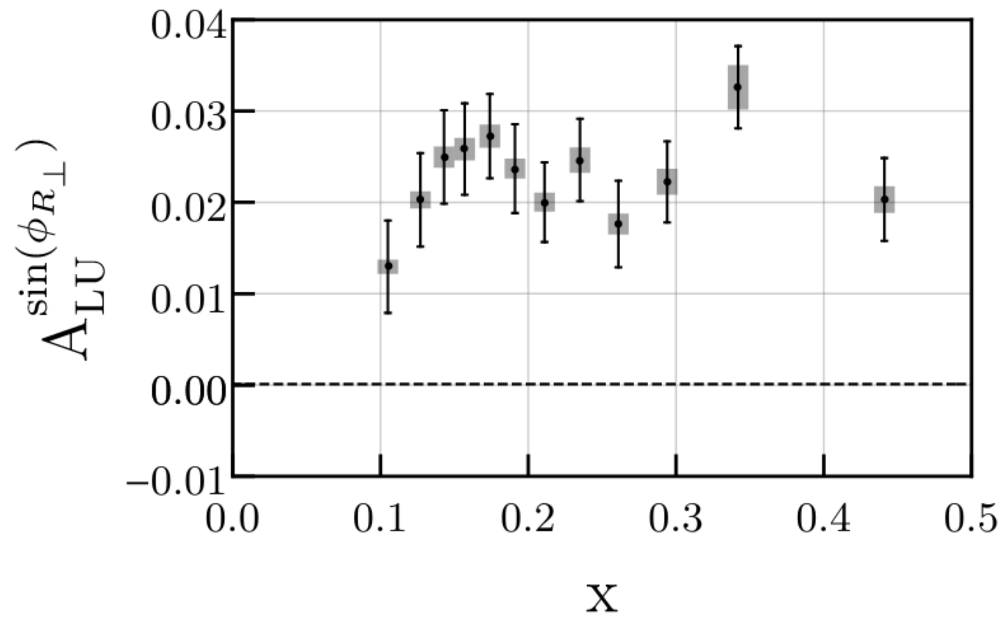
CLAS12 Beam Spin Asymmetry Measurements

Twist 3

$$A_{LU} \sim e\, H_1^{\perp|\ell,m\rangle} \qquad H_1^{\perp|\ell,m\rangle} =$$

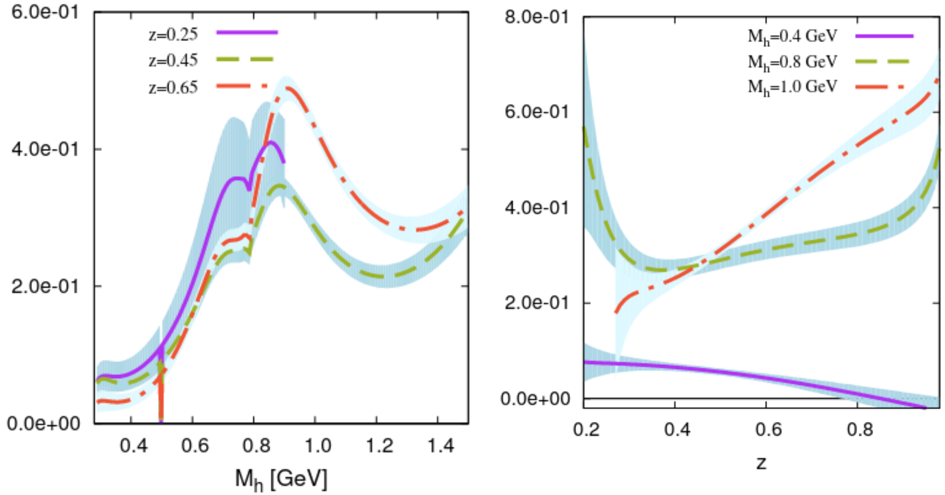


- Bacchetta, Radici, Phys.Rev.D 69 (2004) 074026
- Gliske, Bacchetta, Radici, Phys.Rev.D 90 (2014) 11, 114027, Phys.Rev.D 91 (2015) 1, 019902 (erratum)



Hayward, CD, Vossen, Avakian, et al.,
Phys.Rev.Lett. 126 (2021) 15, 152501

$$R(z, M_h) = \frac{|\boldsymbol{R}|}{M_h} \frac{H_{1,sp}^{\sphericalangle u}}{D_1^u}$$



$H_1^{<}$ Extractions from Belle Data

Courtoy, Bacchetta, Radici, Bianconi
Phys.Rev.D 85 (2012) 114023

C. Dilks

CLAS12 Beam Spin Asymmetry Measurements

Twist 3

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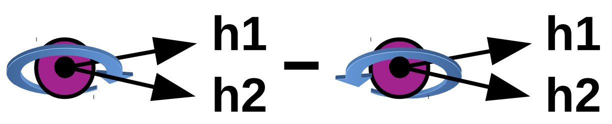

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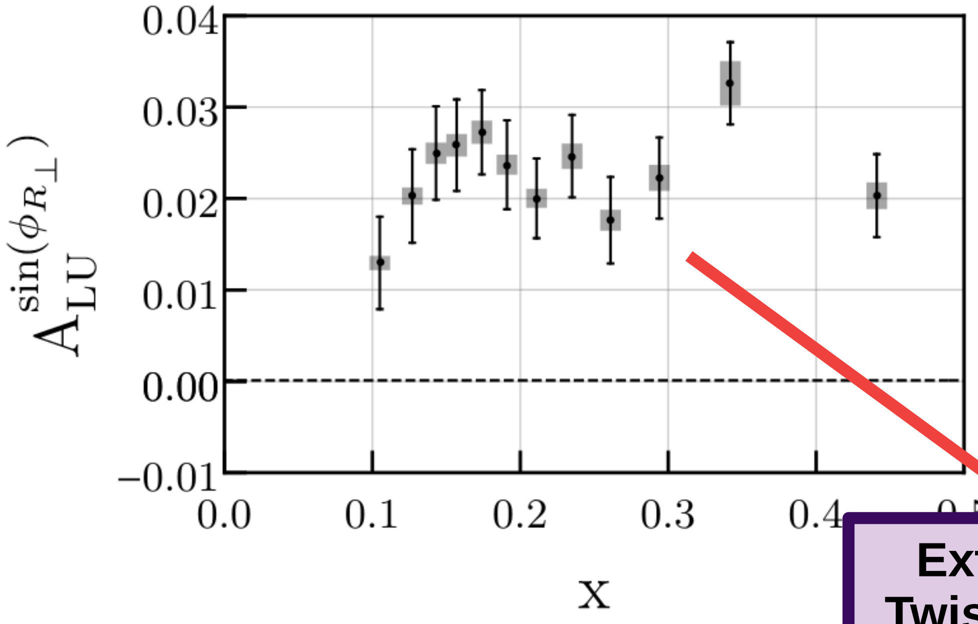

Hayward, CD, Vossen, Avakian, et al., Phys.Rev.Lett. 126 (2021) 15, 152501

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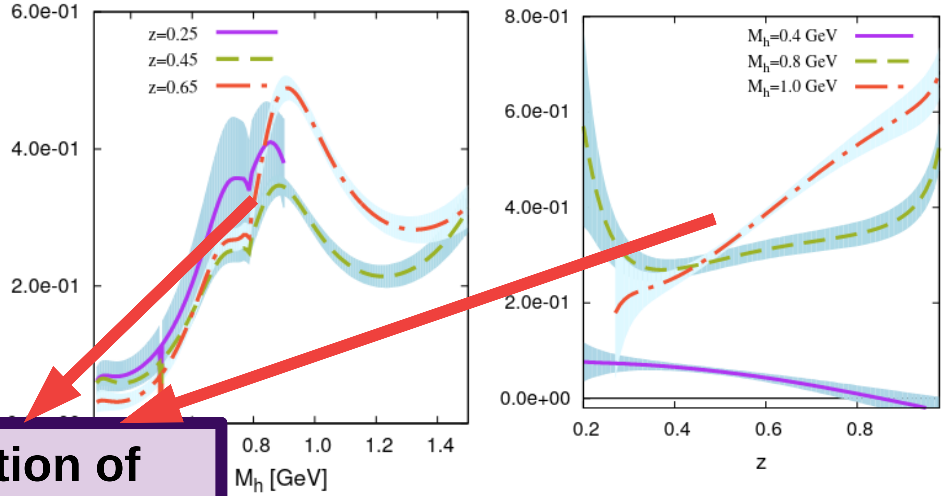

Extraction of Twist-3 PDF e(x)

Extractions from Belle Data

Courtoy, Bacchetta, Radici, Bianconi Phys.Rev.D 85 (2012) 114023

C. Dilks

Dihadron Fragmentation Functions

Quark Polarization

Dihadron Interference

$h_1 h_2 / q$	**U**	**L**	**T**
U U	$D_{1,OO}$		$H_{1,OO}^{\perp}$
U L	$D_{1,OL}$		$H_{1,OL}^{\perp}$
L L	$D_{1,LL}$		$H_{1,LL}^{\perp}$
U T	$D_{1,OT}$	$G_{1,OT}^{\perp}$	$\begin{cases} H_{1,OT}^{\perp} & \text{if } m < 0 \\ H_{1,OT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$
L T	$D_{1,LT}$	$G_{1,LT}^{\perp}$	$\begin{cases} H_{1,LT}^{\perp} & \text{if } m < 0 \\ H_{1,LT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$
T T	$D_{1,TT}$	$G_{1,TT}^{\perp}$	$\begin{cases} H_{1,TT}^{\perp} & \text{if } m < 0 \\ H_{1,TT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$

Dihadron Fragmentation Functions

Quark Polarization

Dihadron Interference

$h_1 h_2 / q$	U	L	T
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L L	$D_{1,LL}$		$H_{1,LL}^{\perp}$
U T	$D_{1,OT}$	$G_{1,OT}^{\perp}$	$\begin{cases} H_{1,OT}^{\perp} & \text{if } m < 0 \\ H_{1,OT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$
L T	$D_{1,LT}$	$G_{1,LT}^{\perp}$	$\begin{cases} H_{1,LT}^{\perp} & \text{if } m < 0 \\ H_{1,LT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$
T T	$D_{1,TT}$	$G_{1,TT}^{\perp}$	$\begin{cases} H_{1,TT}^{\perp} & \text{if } m < 0 \\ H_{1,TT}^{\sphericalangle} & \text{if } m > 0 \end{cases}$

Twist 2 A_{LU} **Twist 3 A_{LU}**

Dihadron Fragmentation Functions

Quark Polarization

Dihadron Interference

h_1h_2/q	U	L	T
U U	$D_{1,OO}$		$H_{1,OO}^{\perp}$
U T	$D_{1,OT}$	$G_{1,OT}$	$H_{1,OT}^{\triangleleft}$ if $m>0$
L T	$D_{1,LT}$	$G_{1,LT}^{\perp}$	$\begin{cases} H_{1,LT}^{\perp} & \text{if } m<0 \\ H_{1,LT}^{\triangleleft} & \text{if } m>0 \end{cases}$
T T	$D_{1,TT}$	$G_{1,TT}^{\perp}$	$\begin{cases} H_{1,TT}^{\perp} & \text{if } m<0 \\ H_{1,TT}^{\triangleleft} & \text{if } m>0 \end{cases}$

Goal: extend previous measurements, providing a precise disentanglement of the DiFF partial waves

Twist 2 A_{LU}

Twist 3 A_{LU}

Partial Waves

ℓ = 0 *ss*	$\lvert 0,0 \rangle$ **U U**

ℓ = 0 *ss*		$\lvert 0,0 \rangle$ **U U**	
ℓ = 1 *sp*	$\lvert 1,-1 \rangle$ **U T**	$\lvert 1,0 \rangle$ **U L**	$\lvert 1,1 \rangle$ **U T**

Partial Waves

			$\left\|0,0\right\rangle$ UU		
ℓ = 0 *ss*					
ℓ = 1 *sp*		$\left\|1,-1\right\rangle$ UT	$\left\|1,0\right\rangle$ UL	$\left\|1,1\right\rangle$ UT	
ℓ = 2 *pp*	$\left\|2,-2\right\rangle$ TT	$\left\|2,-1\right\rangle$ LT	$\left\|2,0\right\rangle$ LL	$\left\|2,1\right\rangle$ LT	$\left\|2,2\right\rangle$ TT

Partial Waves

ℓ = 0 ss			$\|0,0\rangle$ **U U** $G^{\perp}_{1,OO}$ $H^{\perp}_{1,OO}$		
ℓ = 1 sp		$\|1,-1\rangle$ **U T** $G^{\perp}_{1,OT}$ $H^{\perp}_{1,OT}$	$\|1,0\rangle$ **U L** $G^{\perp}_{1,OL}$ $H^{\perp}_{1,OL}$	$\|1,1\rangle$ **U T** $G^{\perp}_{1,OT}$ $H^{\sphericalangle}_{1,OT}$	
ℓ = 2 pp	$\|2,-2\rangle$ **T T** $G^{\perp}_{1,TT}$ $H^{\perp}_{1,TT}$	$\|2,-1\rangle$ **L T** $G^{\perp}_{1,LT}$ $H^{\perp}_{1,LT}$	$\|2,0\rangle$ **L L** $G^{\perp}_{1,LL}$ $H^{\perp}_{1,LL}$	$\|2,1\rangle$ **L T** $G^{\perp}_{1,LT}$ $H^{\sphericalangle}_{1,LT}$	$\|2,2\rangle$ **T T** $G^{\perp}_{1,TT}$ $H^{\sphericalangle}_{1,TT}$

Partial Waves

$\ell = 0$
ss

$|0,0\rangle$
U U
$G_{1,OO}^{\perp}$ $H_{1,OO}^{\perp}$

$\ell = 1$
sp

$|1,-1\rangle$
U T
$G_{1,OT}^{\perp}$ $H_{1,OT}^{\perp}$

$|1,0\rangle$
U L
$G_{1,OL}^{\perp}$ $H_{1,OL}^{\perp}$

$|1,1\rangle$
U T
$G_{1,OT}^{\perp}$ $H_{1,OT}^{\sphericalangle}$

$\ell = 2$
pp

$|2,-2\rangle$
T T
$G_{1,TT}^{\perp}$ $H_{1,TT}^{\perp}$

$|2,-1\rangle$
L T
$G_{1,LT}^{\perp}$ $H_{1,LT}^{\perp}$

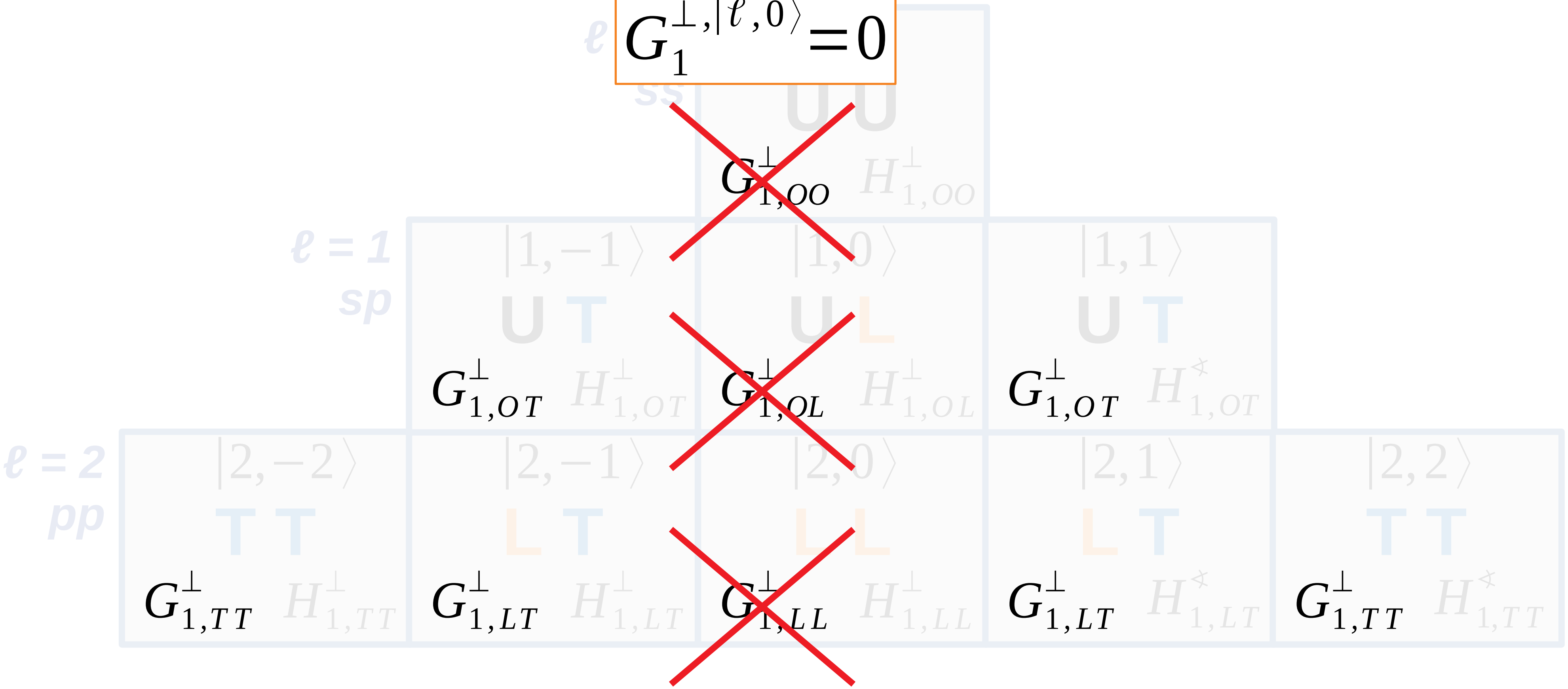
$|2,0\rangle$
L L
$G_{1,LL}^{\perp}$ $H_{1,LL}^{\perp}$

$|2,1\rangle$
L T
$G_{1,LT}^{\perp}$ $H_{1,LT}^{\sphericalangle}$

$|2,2\rangle$
T T
$G_{1,TT}^{\perp}$ $H_{1,TT}^{\sphericalangle}$

Partial Waves

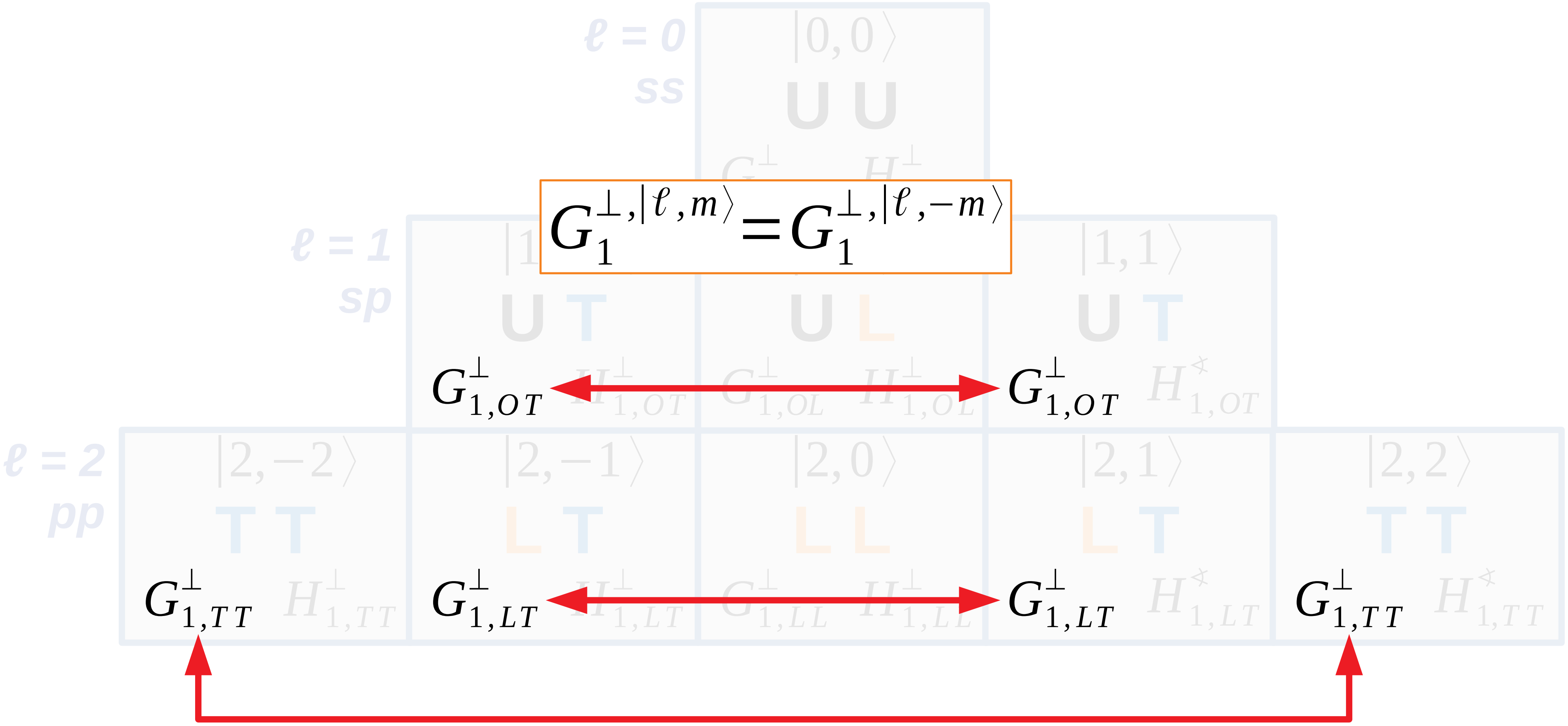
$$G_1^{\perp,|\ell,0\rangle} = 0$$



Partial Waves

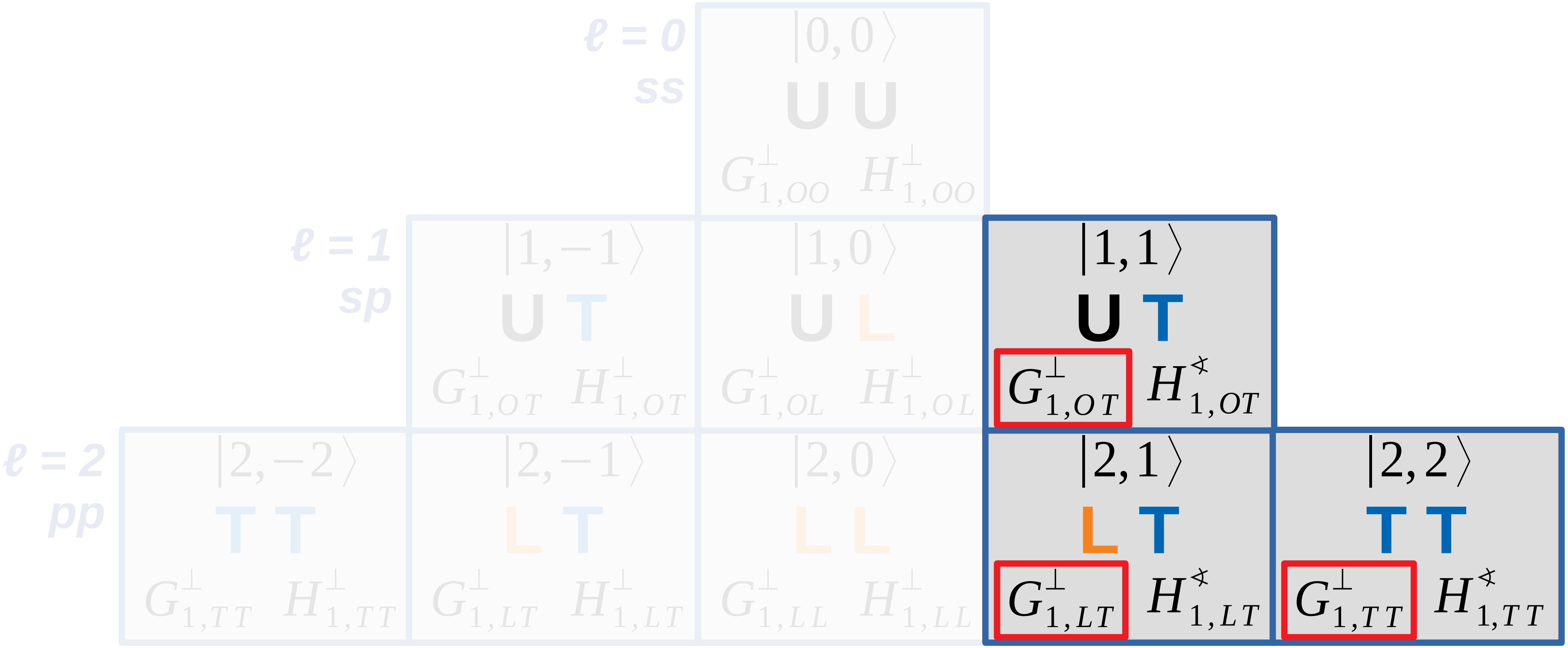
$\ell = 0$ ss			$\lvert 0,0\rangle$ UU $G_{1,OO}^{\perp}$ $H_{1,OO}^{\perp}$		
$\ell = 1$ sp		$\lvert 1,-1\rangle$ UT $G_{1,OT}^{\perp}$ $H_{1,OT}^{\perp}$	$\lvert 1,0\rangle$ UL $G_{1,OL}^{\perp}$ $H_{1,OL}^{\perp}$	$\lvert 1,1\rangle$ UT $G_{1,OT}^{\perp}$ $H_{1,OT}^{\sphericalangle}$	
$\ell = 2$ pp	$\lvert 2,-2\rangle$ TT $G_{1,TT}^{\perp}$ $H_{1,TT}^{\perp}$	$\lvert 2,-1\rangle$ LT $G_{1,LT}^{\perp}$ $H_{1,LT}^{\perp}$	$\lvert 2,0\rangle$ LL $G_{1,LL}^{\perp}$ $H_{1,LL}^{\perp}$	$\lvert 2,1\rangle$ LT $G_{1,LT}^{\perp}$ $H_{1,LT}^{\sphericalangle}$	$\lvert 2,2\rangle$ TT $G_{1,TT}^{\perp}$ $H_{1,TT}^{\sphericalangle}$

Partial Waves



$$G_1^{\perp,|\ell,m\rangle} = G_1^{\perp,|\ell,-m\rangle}$$

Partial Waves



Partial Waves

$\ell = 0$ ss			$\lvert 0,0\rangle$ U U $G^{\perp}_{1,OO}$ $H^{\perp}_{1,OO}$		
$\ell = 1$ sp		$\lvert 1,-1\rangle$ U T $G^{\perp}_{1,OT}$ $H^{\perp}_{1,OT}$	$\lvert 1,0\rangle$ U L $G^{\perp}_{1,OL}$ $H^{\perp}_{1,OL}$	$\lvert 1,1\rangle$ U T $G^{\perp}_{1,OT}$ $H^{\sphericalangle}_{1,OT}$	
$\ell = 2$ pp	$\lvert 2,-2\rangle$ T T $G^{\perp}_{1,TT}$ $H^{\perp}_{1,TT}$	$\lvert 2,-1\rangle$ L T $G^{\perp}_{1,LT}$ $H^{\perp}_{1,LT}$	$\lvert 2,0\rangle$ L L $G^{\perp}_{1,LL}$ $H^{\perp}_{1,LL}$	$\lvert 2,1\rangle$ L T $G^{\perp}_{1,LT}$ $H^{\sphericalangle}_{1,LT}$	$\lvert 2,2\rangle$ T T $G^{\perp}_{1,TT}$ $H^{\sphericalangle}_{1,TT}$

Partial Waves

$\ell = 0$ ss			$\lvert 0,0\rangle$ U U $G^{\perp}_{1,OO}$ $H^{\perp}_{1,OO}$		
$\ell = 1$ sp		$\lvert 1,-1\rangle$ U T $G^{\perp}_{1,OT}$ $H^{\perp}_{1,OT}$	$\lvert 1,0\rangle$ U L $G^{\perp}_{1,OL}$ $H^{\perp}_{1,OL}$	$\lvert 1,1\rangle$ U T $G^{\perp}_{1,OT}$ $H^{\measuredangle}_{1,OT}$	
$\ell = 2$ pp	$\lvert 2,-2\rangle$ T T $G^{\perp}_{1,TT}$ $H^{\perp}_{1,TT}$	$\lvert 2,-1\rangle$ L T $G^{\perp}_{1,LT}$ $H^{\perp}_{1,LT}$	$\lvert 2,0\rangle$ L L $G^{\perp}_{1,LL}$ $H^{\perp}_{1,LL}$	$\lvert 2,1\rangle$ L T $G^{\perp}_{1,LT}$ $H^{\measuredangle}_{1,LT}$	$\lvert 2,2\rangle$ T T $G^{\perp}_{1,TT}$ $H^{\measuredangle}_{1,TT}$

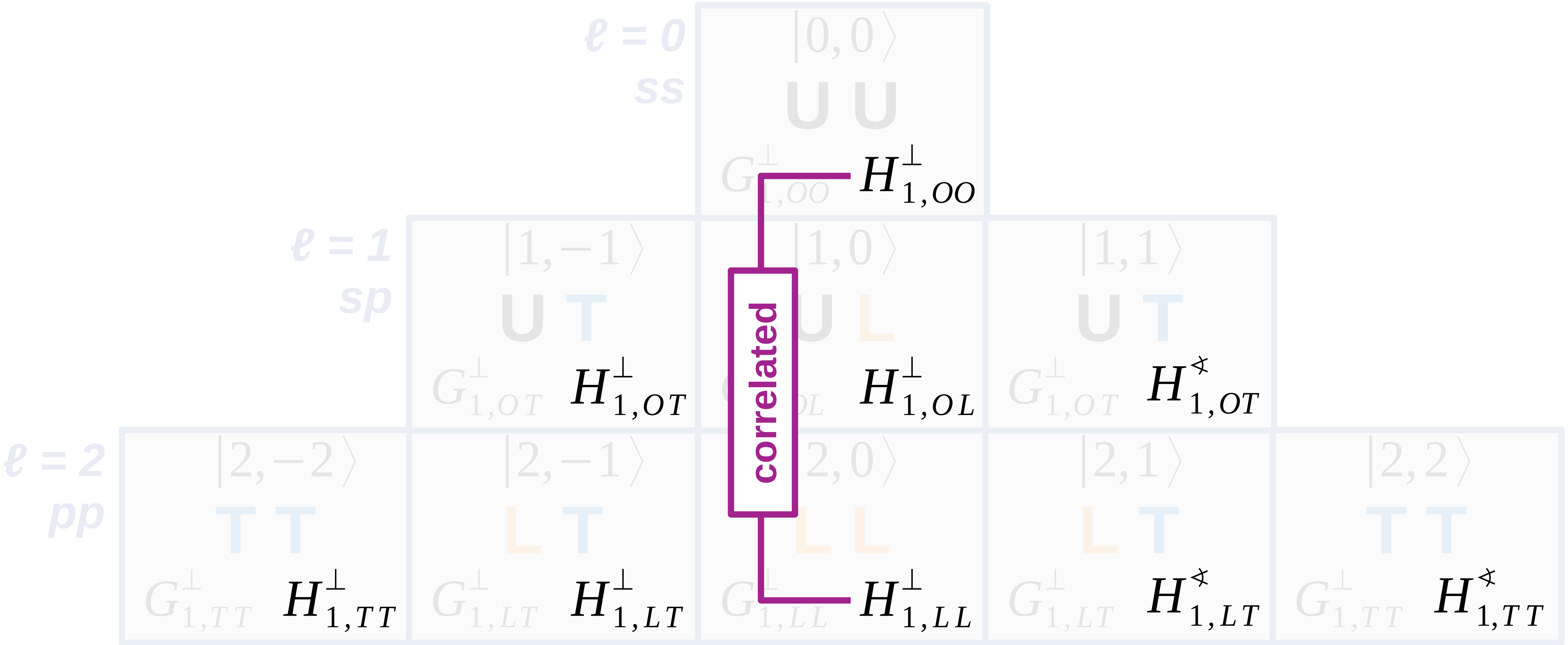
$H_1^{\perp}$

correlation with $\mathbf{k}_T$

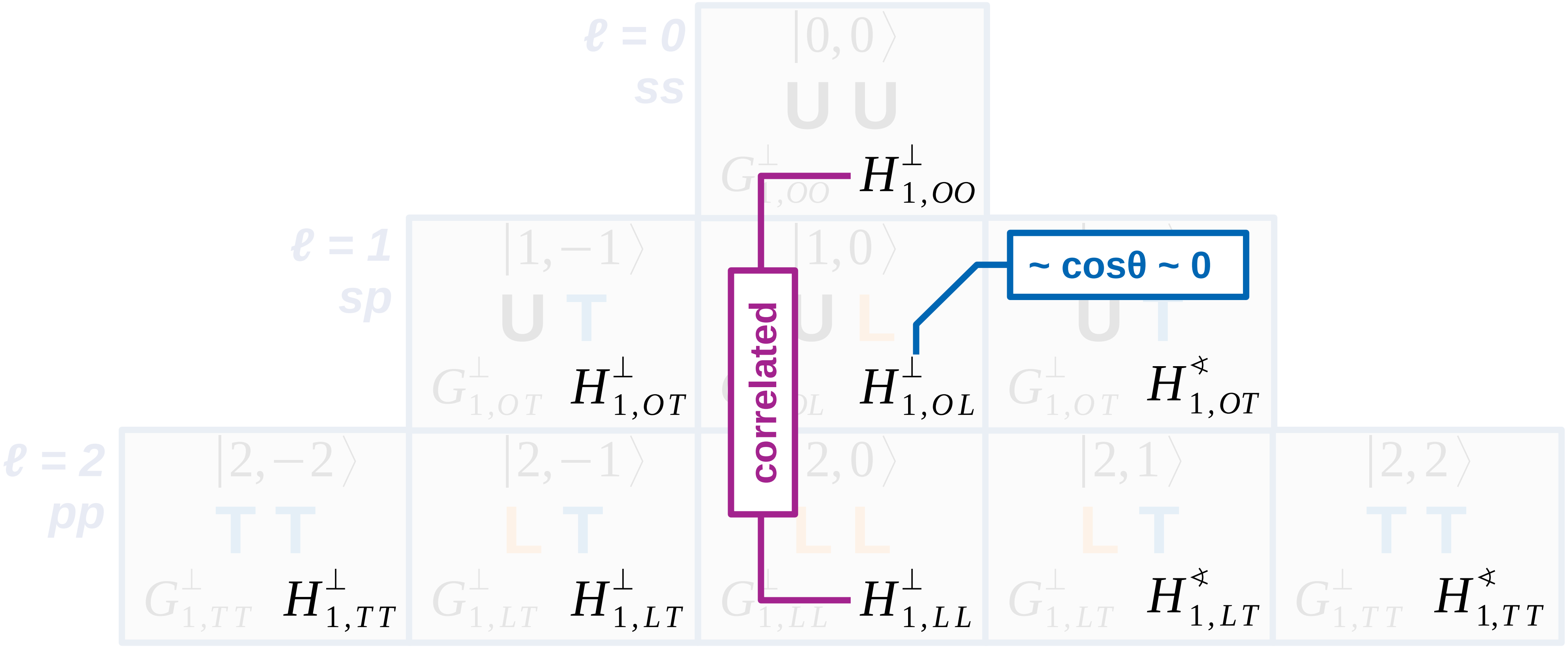
$H_1^{\triangleleft}$

correlation with **R**

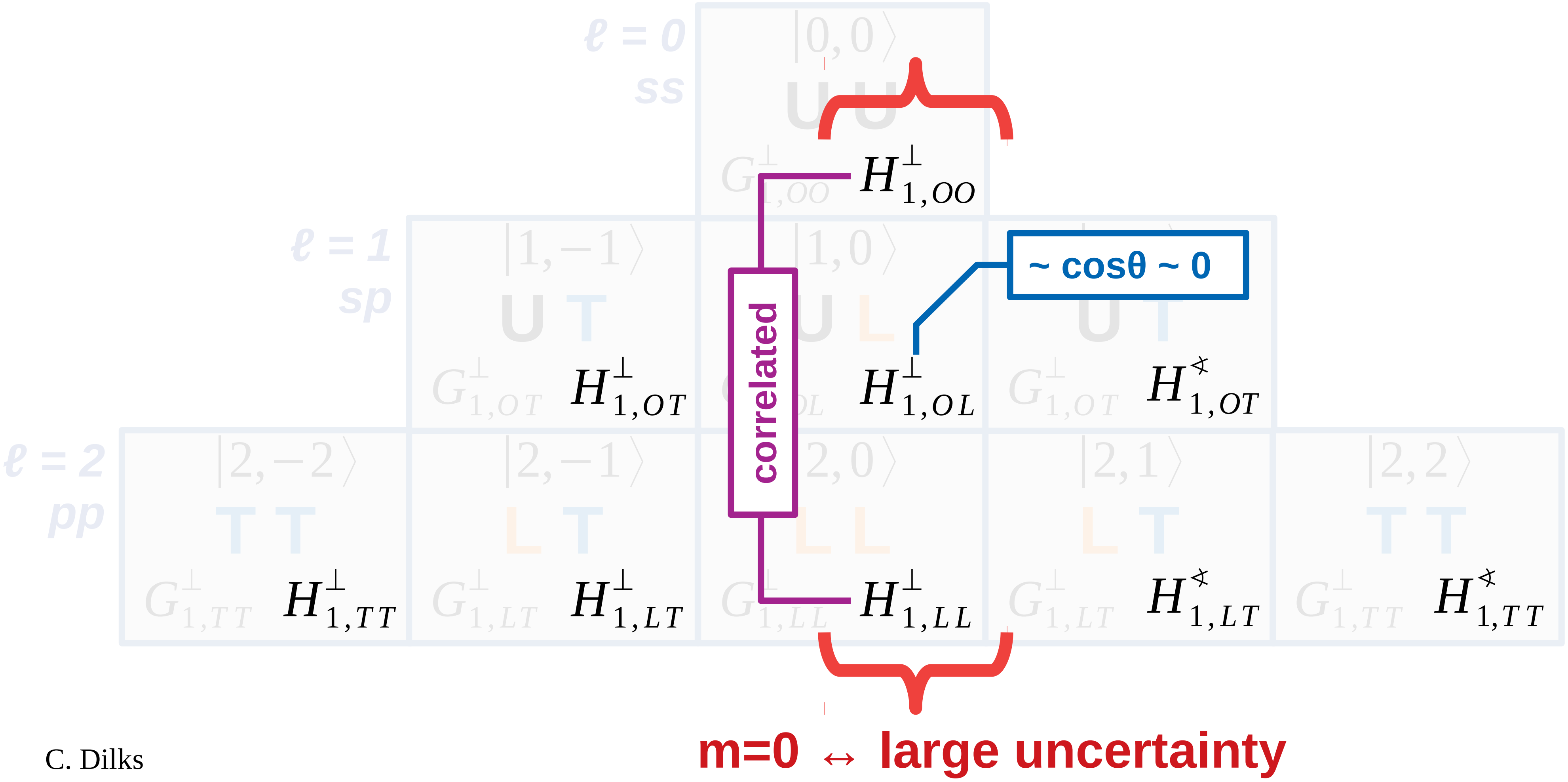
Partial Waves



Partial Waves



Partial Waves



Partial Waves

$\ell = 0$ ss			$\lvert 0,0 \rangle$ U U $G^{\perp}_{1,OO}$ $H^{\perp}_{1,OO}$		
$\ell = 1$ sp		$\lvert 1,-1 \rangle$ U T $G^{\perp}_{1,OT}$ $H^{\perp}_{1,OT}$	$\lvert 1,0 \rangle$ U L $G^{\perp}_{1,OL}$ $H^{\perp}_{1,OL}$	$\lvert 1,1 \rangle$ U T $G^{\perp}_{1,OT}$ $H^{\sphericalangle}_{1,OT}$	
$\ell = 2$ pp	$\lvert 2,-2 \rangle$ T T $G^{\perp}_{1,TT}$ $H^{\perp}_{1,TT}$	$\lvert 2,-1 \rangle$ L T $G^{\perp}_{1,LT}$ $H^{\perp}_{1,LT}$	$\lvert 2,0 \rangle$ L L $G^{\perp}_{1,LL}$ $H^{\perp}_{1,LL}$	$\lvert 2,1 \rangle$ L T $G^{\perp}_{1,LT}$ $H^{\sphericalangle}_{1,LT}$	$\lvert 2,2 \rangle$ T T $G^{\perp}_{1,TT}$ $H^{\sphericalangle}_{1,TT}$

Partial Waves

Twist 2

$$G_1^{\perp,|\ell,0\rangle}=0$$

$$G_1^{\perp,|\ell,m\rangle}=G_1^{\perp,|\ell,-m\rangle}$$

$\|1,1\rangle$ $G_{1,OT}^{\perp}$	
$\|2,1\rangle$ $G_{1,LT}^{\perp}$	$\|2,2\rangle$ $G_{1,TT}^{\perp}$

Twist 3

		$\|0,0\rangle$ $H_{1,OO}^{\perp}$		
	$\|1,-1\rangle$ $H_{1,OT}^{\perp}$	$\|1,0\rangle$ $H_{1,OL}^{\perp}$	$\|1,1\rangle$ $H_{1,OT}^{\sphericalangle}$	
$\|2,-2\rangle$ $H_{1,TT}^{\perp}$	$\|2,-1\rangle$ $H_{1,LT}^{\perp}$	$\|2,0\rangle$ $H_{1,LL}^{\perp}$	$\|2,1\rangle$ $H_{1,LT}^{\sphericalangle}$	$\|2,2\rangle$ $H_{1,TT}^{\sphericalangle}$

Twist 2

$$G_1^{\perp,|\ell,0\rangle} = 0$$

$$G_1^{\perp,|\ell,m\rangle} = G_1^{\perp,|\ell,-m\rangle}$$

- $|1,1\rangle$ $G_{1,OT}^{\perp}$
- $|2,1\rangle$ $G_{1,LT}^{\perp}$
- $|2,2\rangle$ $G_{1,TT}^{\perp}$

Twist 3

- $|0,0\rangle$ $H_{1,OO}^{\perp}$
- $|1,-1\rangle$ $H_{1,OT}^{\perp}$; $|1,0\rangle$ $H_{1,OL}^{\perp}$; $|1,1\rangle$ $H_{1,OT}^{\sphericalangle}$
- $|2,-2\rangle$ $H_{1,TT}^{\perp}$; $|2,-1\rangle$ $H_{1,LT}^{\perp}$; $|2,0\rangle$ $H_{1,LL}^{\perp}$; $|2,1\rangle$ $H_{1,LT}^{\sphericalangle}$; $|2,2\rangle$ $H_{1,TT}^{\sphericalangle}$

Partial Waves

Twist 2

$$G_1^{\perp,|\ell,0\rangle}=0$$

$$G_1^{\perp,|\ell,m\rangle}=G_1^{\perp,|\ell,-m\rangle}$$

$|1,1\rangle$ $G^{\perp}_{1,OT}$	
$|2,1\rangle$ $G^{\perp}_{1,LT}$	$|2,2\rangle$ $G^{\perp}_{1,TT}$

Twist 3

	$|1,-1\rangle$ $H^{\perp}_{1,OT}$	$|1,1\rangle$ $H^{\sphericalangle}_{1,OT}$	
$|2,-2\rangle$ $H^{\perp}_{1,TT}$	$|2,-1\rangle$ $H^{\perp}_{1,LT}$	$|2,1\rangle$ $H^{\sphericalangle}_{1,LT}$	$|2,2\rangle$ $H^{\sphericalangle}_{1,TT}$

Partial Waves

Twist 2

$$G_1^{\perp,|\ell,0\rangle} = 0$$

$$G_1^{\perp,|\ell,m\rangle} = G_1^{\perp,|\ell,-m\rangle}$$

$\|1,1\rangle$ $G_{1,OT}^{\perp}$	
$\|2,1\rangle$ $G_{1,LT}^{\perp}$	$\|2,2\rangle$ $G_{1,TT}^{\perp}$

Twist 3

	$\|1,-1\rangle$ $H_{1,OT}^{\perp}$	$\|1,1\rangle$ $H_{1,OT}^{\sphericalangle}$	
$\|2,-2\rangle$ $H_{1,TT}^{\perp}$	$\|2,-1\rangle$ $H_{1,LT}^{\perp}$	$\|2,1\rangle$ $H_{1,LT}^{\sphericalangle}$	$\|2,2\rangle$ $H_{1,TT}^{\sphericalangle}$

Belle (→ $H_{1,OT}^{\sphericalangle}$)

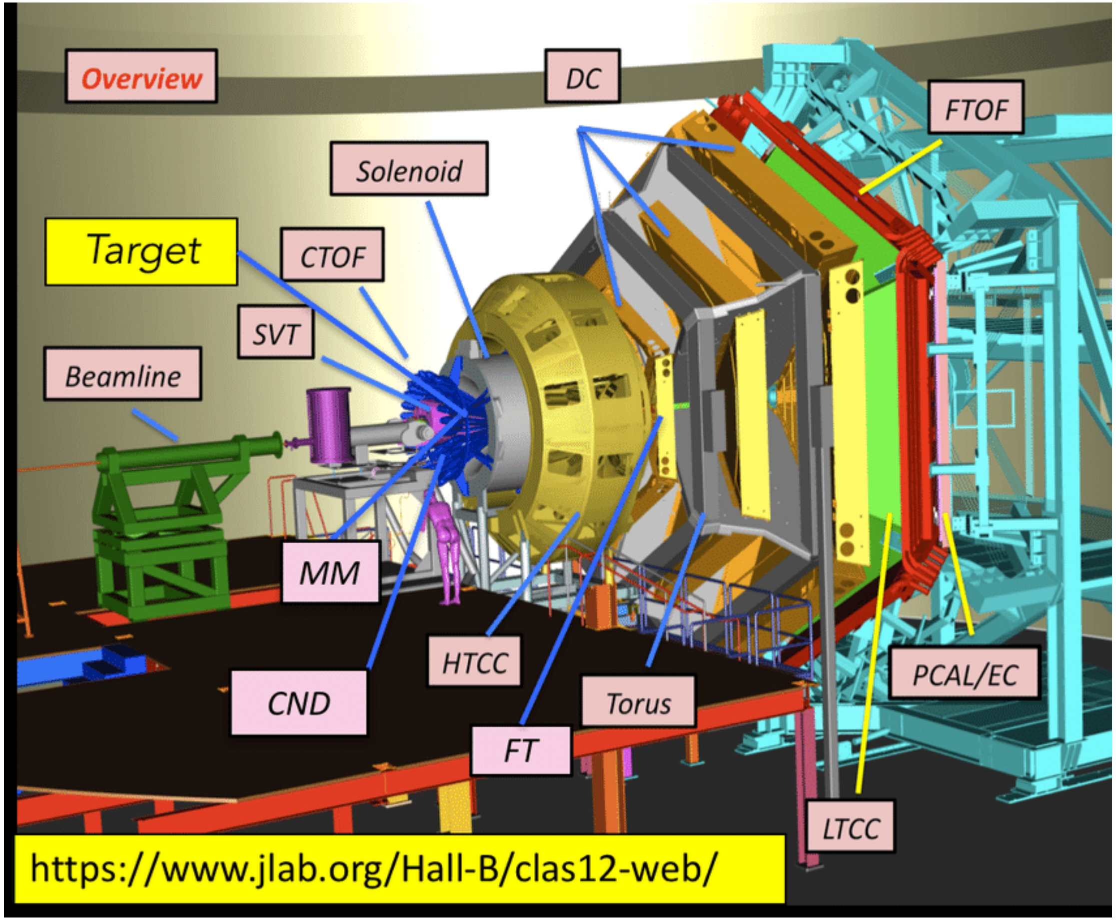
CLAS 12

Event Selection

Kinematics

C. Dilks

CLAS 12



Forward Detector

- Torus Magnet
- Drift Chamber (DC)
- Forward Time of Flight (FTOF)
- High-threshold Cherenkov Counter (HTCC)
- Low-threshold Cherenkov Counter (LTCC)
- Ring Imaging Cherenkov Detector (RICH)
- Preshower + Electromagnetic Calorimeter (PCAL/EC)
- Forward Tagger (FT)

- **Longitudinally Polarized Electron Beam**
  - E = 10.6 GeV
  - P = 86–89%
- **Unpolarized Liquid H_2 Fixed Target**
- Torus magnet → electrons inbending

V. Burkert et al., Nucl.Instrum.Meth.A 959 (2020) 163419

Event Selection

$$ep \to e\pi^+\pi^- X$$

SIDIS Cuts

- $Q^2 > 1$ GeV^2
- $W > 2$ GeV
- $y < 0.8$

Dihadron Cuts

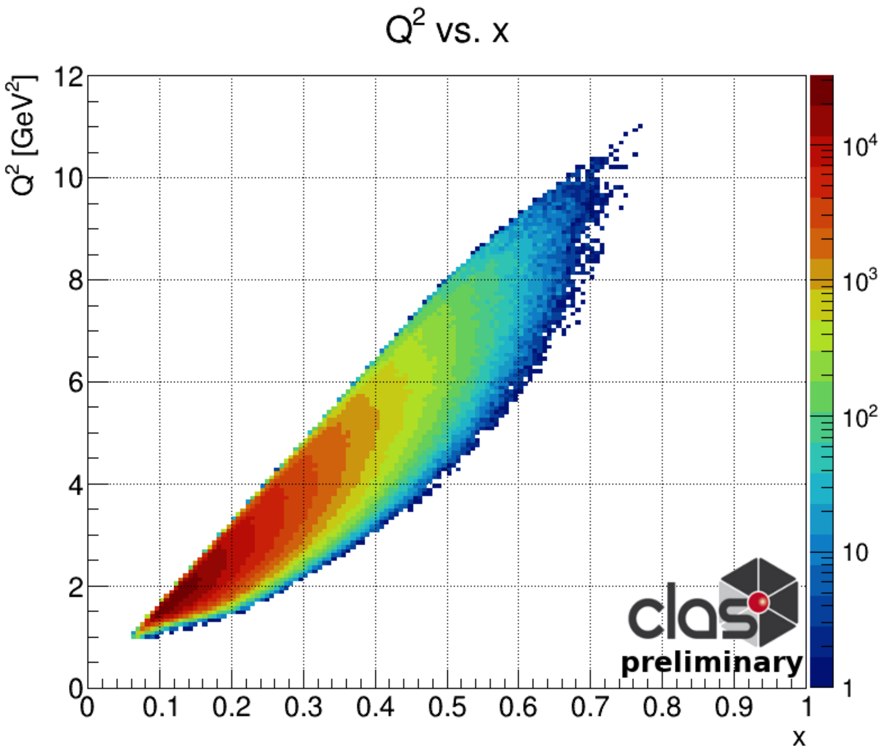
- $z_{pair} < 0.95$
- $M_x > 1.5$ GeV

Pion Cuts

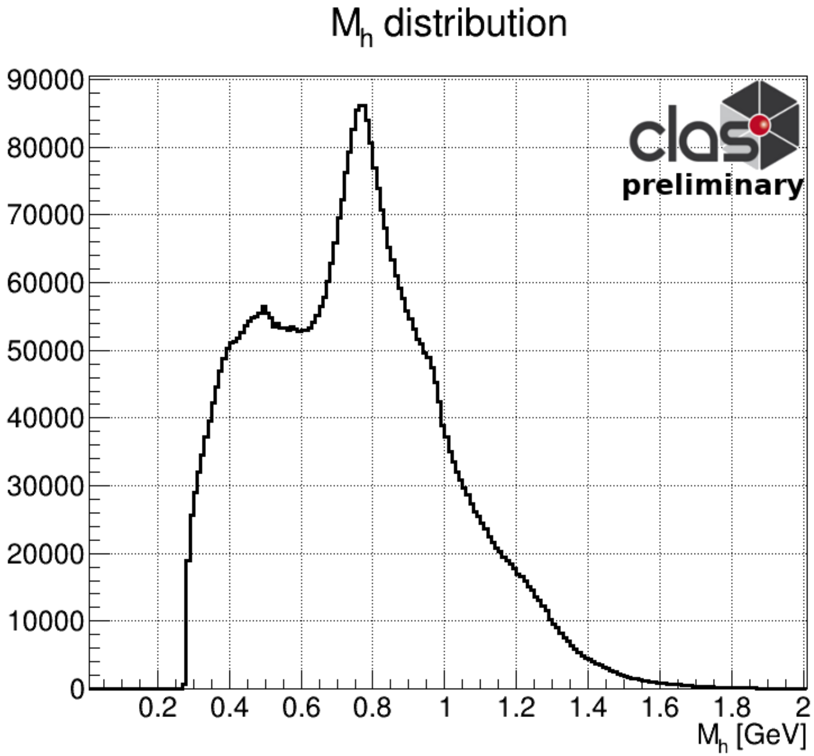
- $x_F > 0$
- $p_\pi > 1.25$ GeV

- Fiducial cuts
- PID cuts
- Vertex cuts

Kinematics

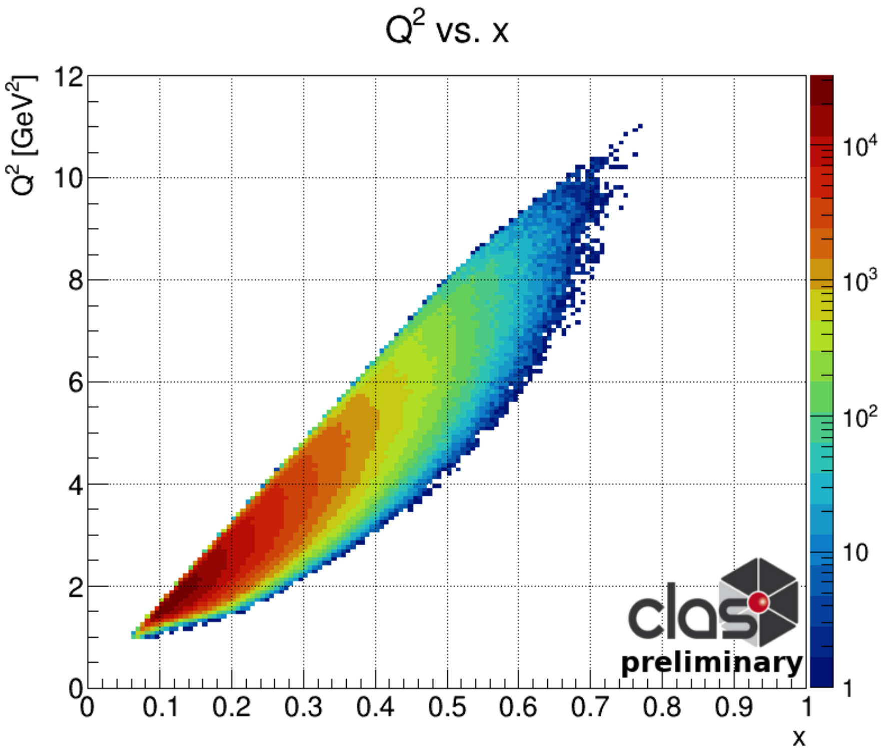


Q^2 vs. x
Q^2 [GeV^2]
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x
10^4
10^3
10^2
10
1
preliminary

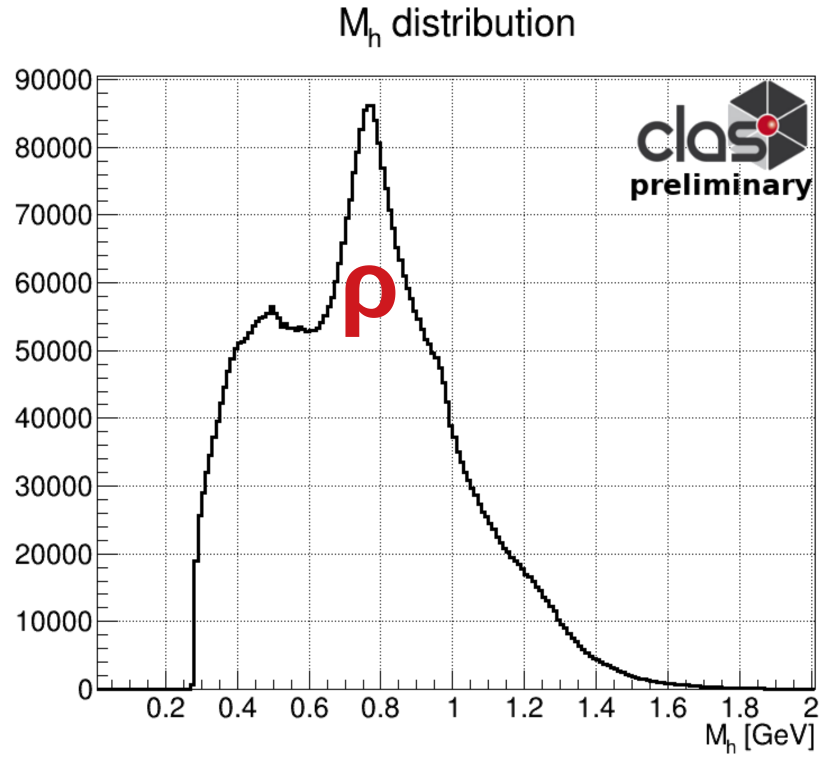


M_h distribution
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
M_h [GeV]
preliminary

Kinematics

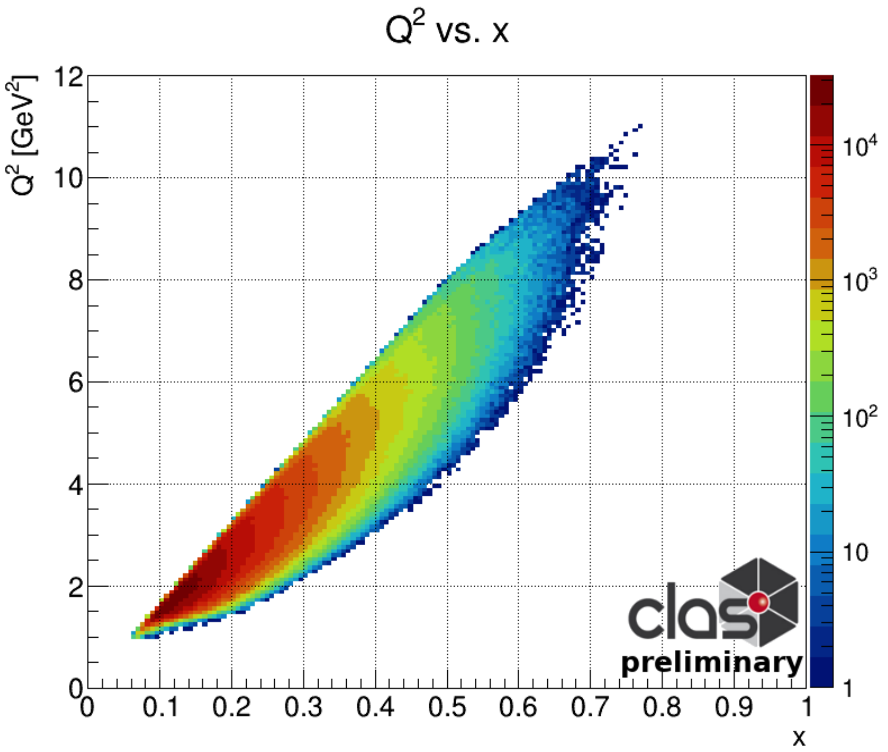


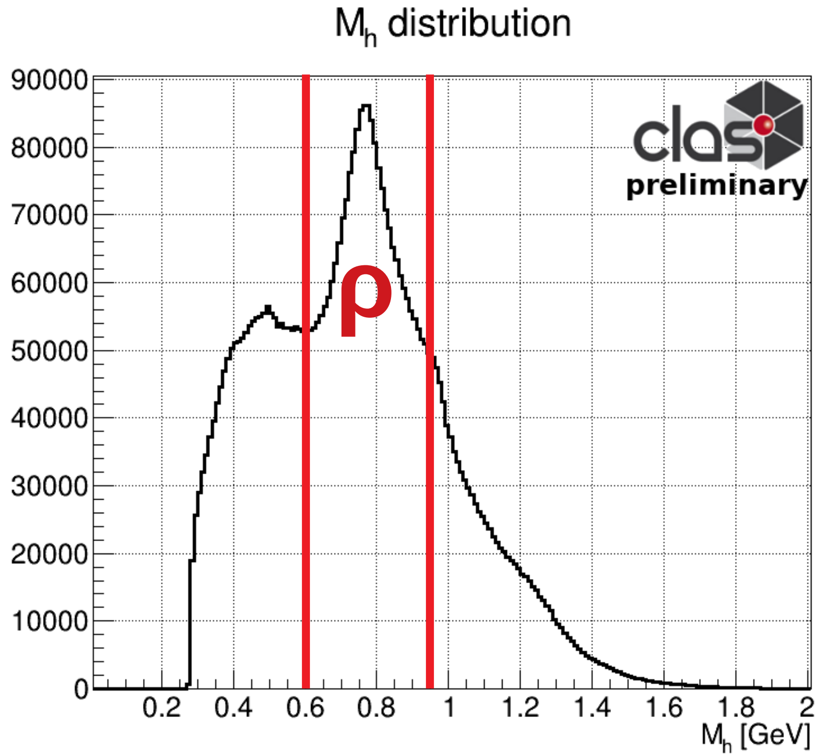
Q^2 vs. x
Q^2 [GeV^2]
x
clas
preliminary



M$_h$ distribution
M$_h$ [GeV]
ρ
clas
preliminary

Kinematics

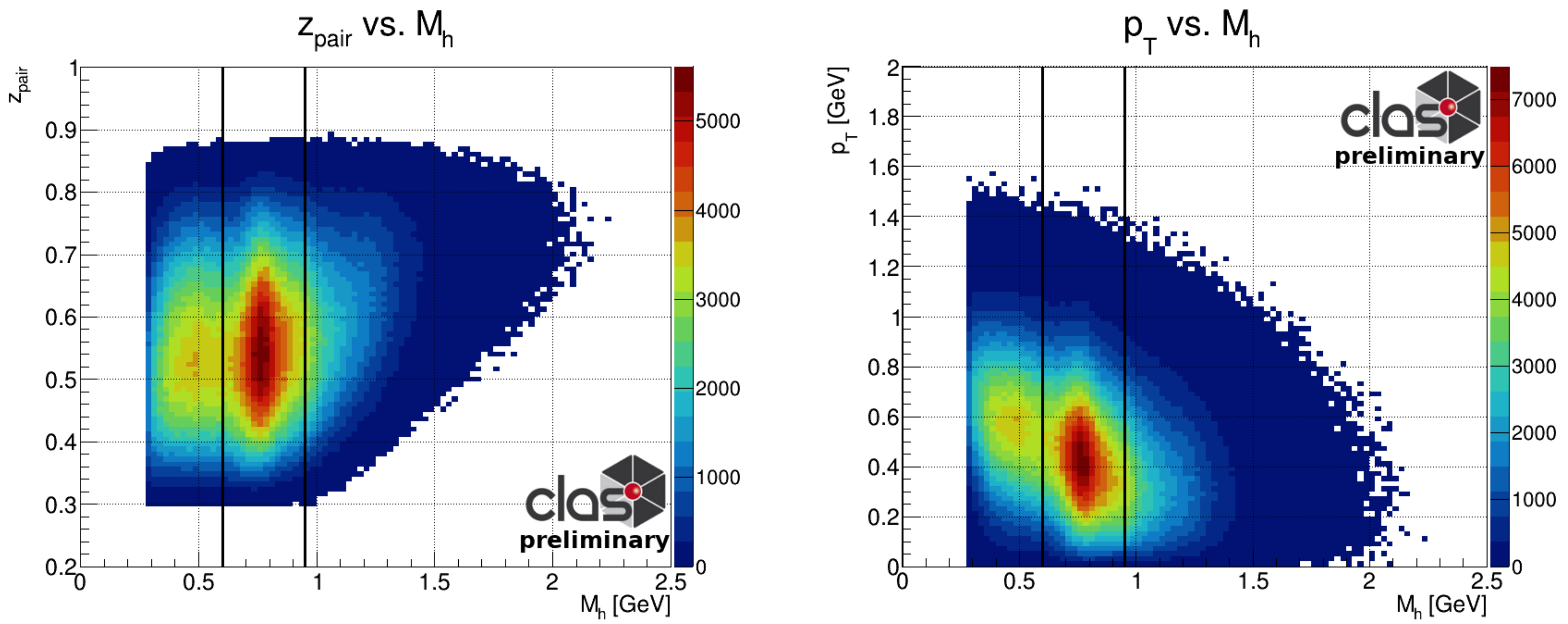




Multidimensional binning scheme in M_h

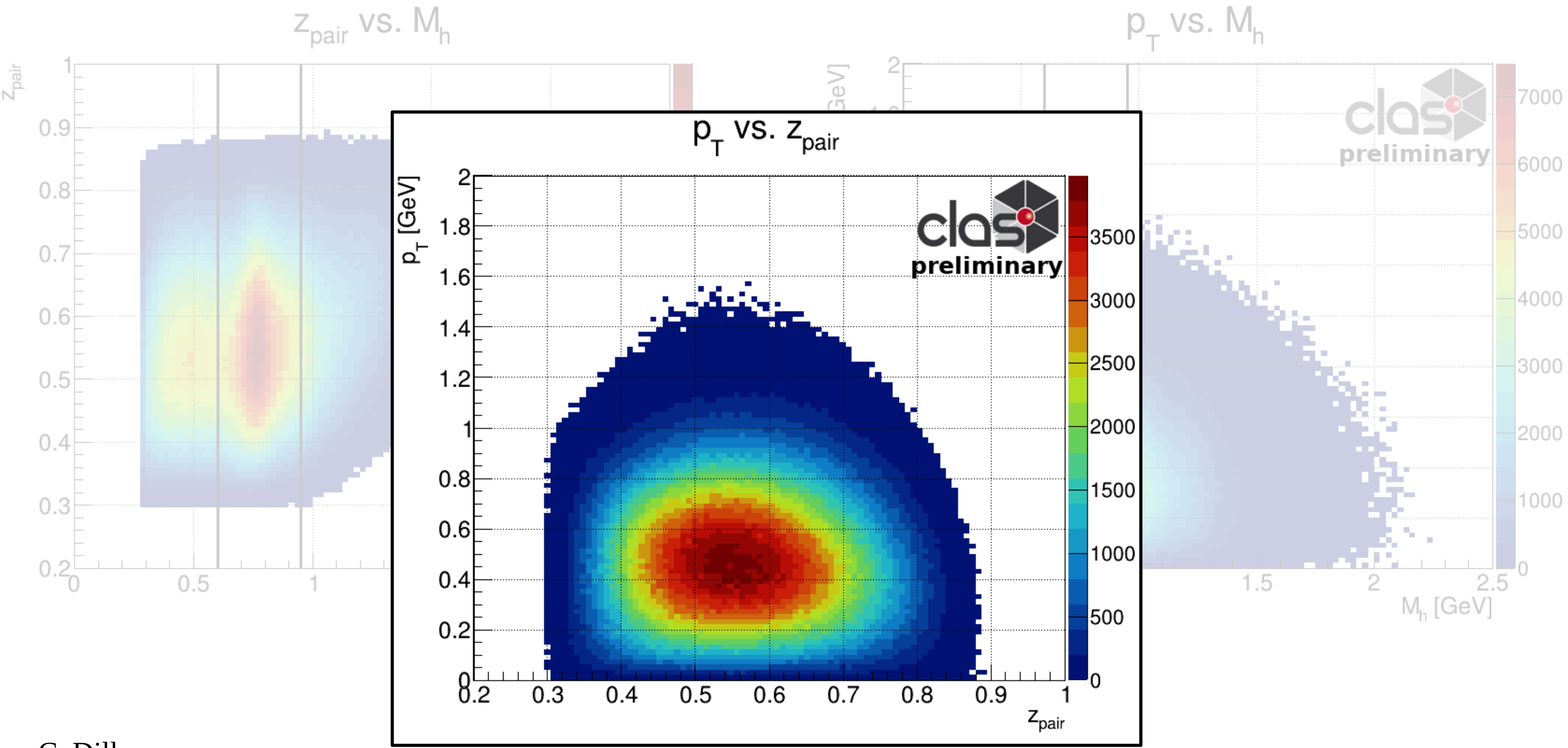
C. Dilks

Kinematics



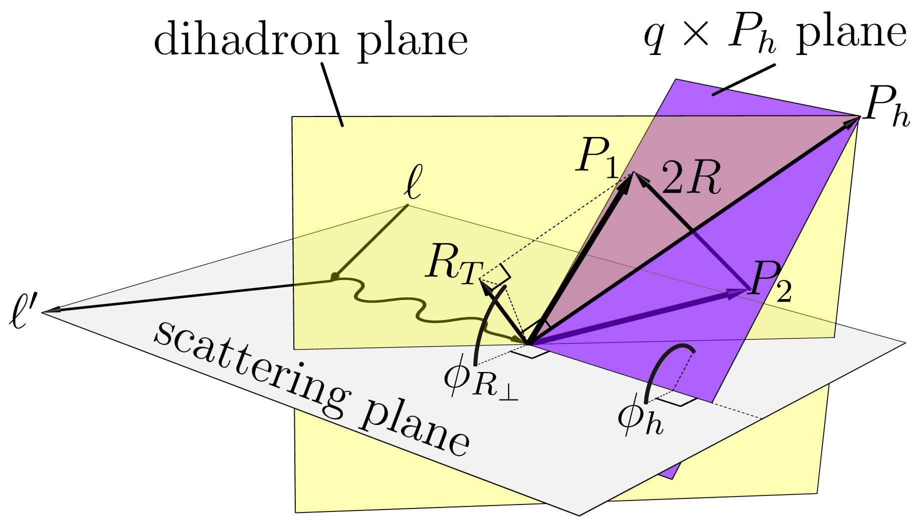
C. Dilks

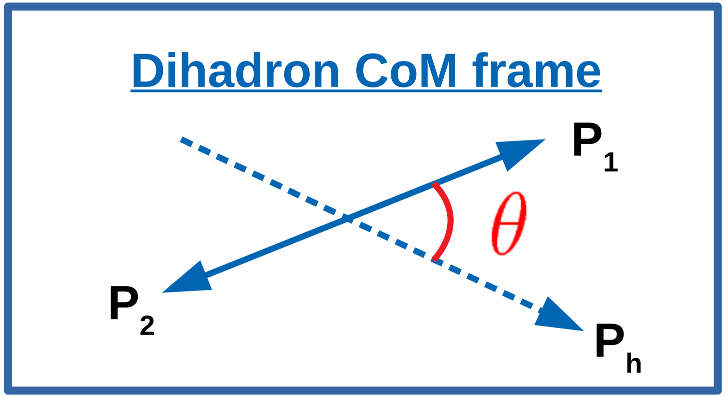
Kinematics



C. Dilks

Kinematics





A_{LU} Modulations

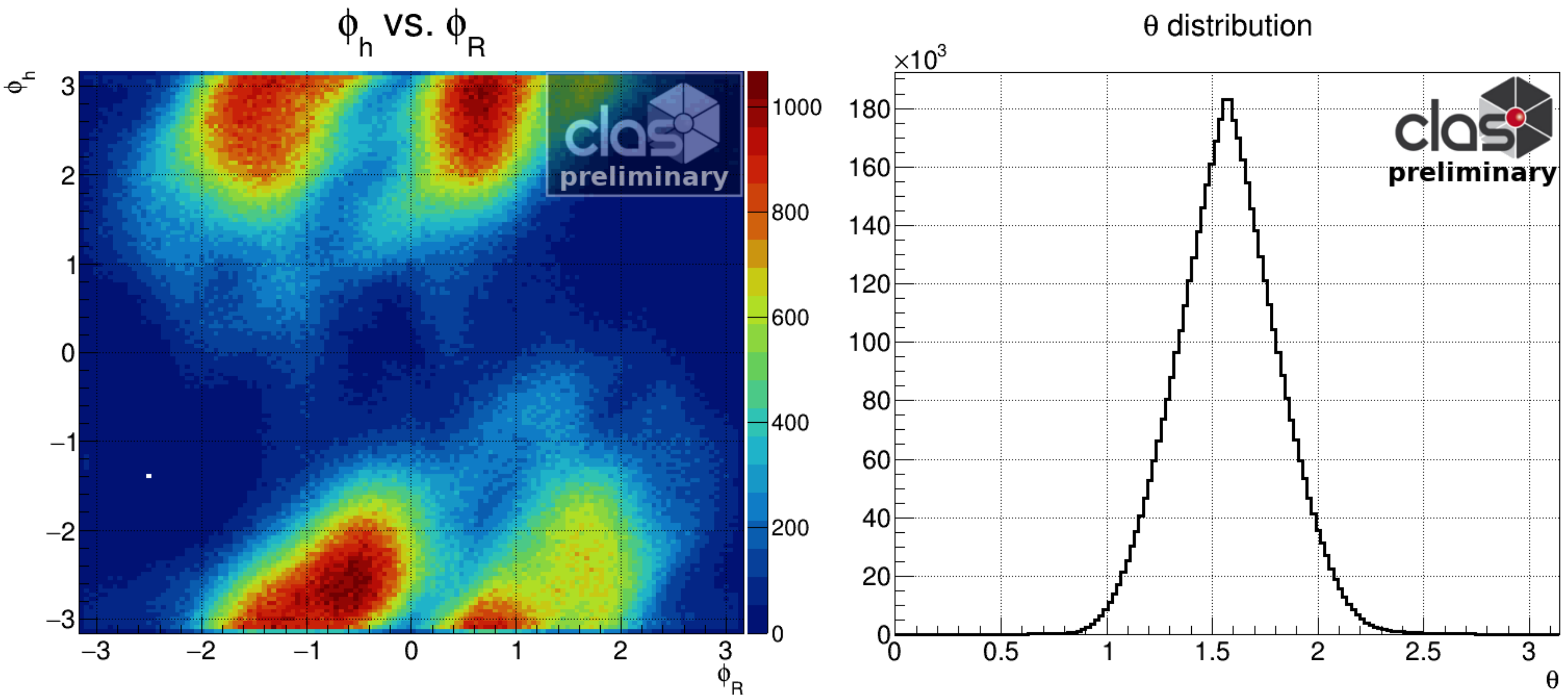
Twist 2: $P_{\ell,m}(\cos\theta) \cdot \sin(m\phi_h - m\phi_R)$

Twist 3: $P_{\ell,m}(\cos\theta) \cdot \sin((1-m)\phi_h + m\phi_R)$

associated Legendre polynomials

C. Dilks

Kinematics



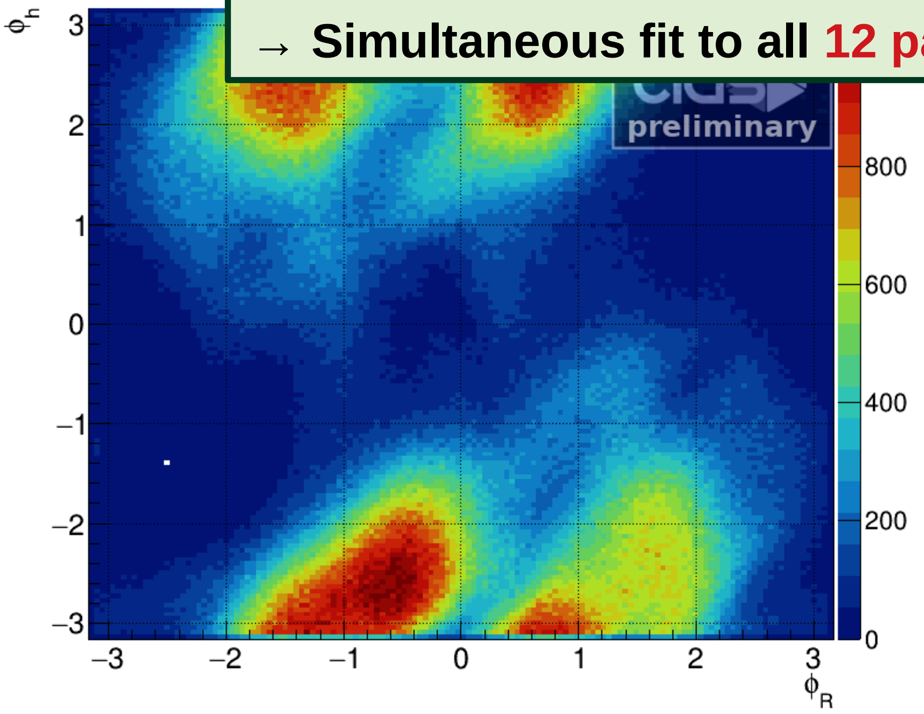
C. Dilks

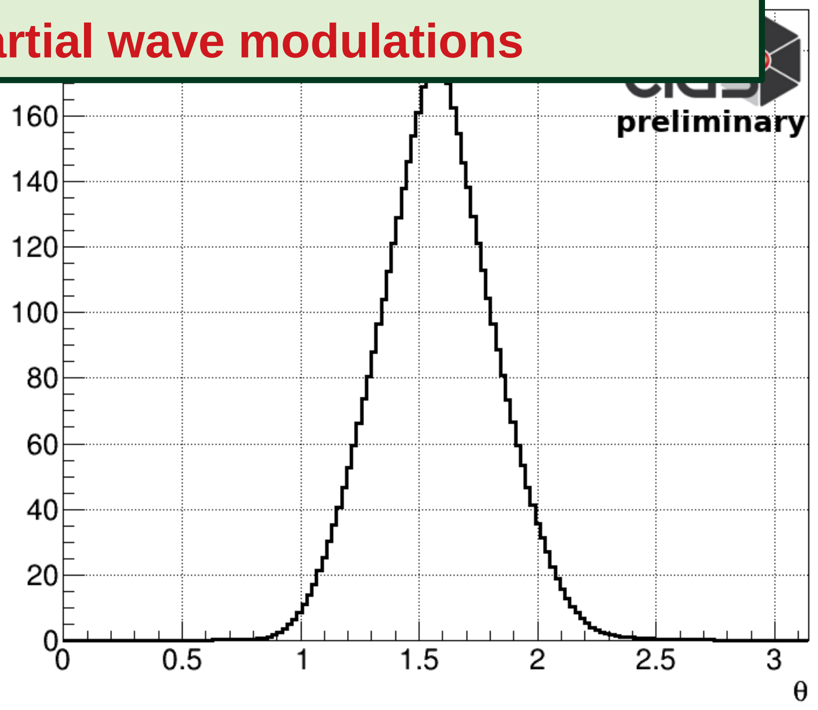
Kinematics

Limited (ϕ_h,ϕ_R,θ) range

→ non-orthogonality of modulations

→ **Simultaneous fit to all 12 partial wave modulations**





C. Dilks

Kinematics

Limited (ϕ_h,ϕ_R,θ) range

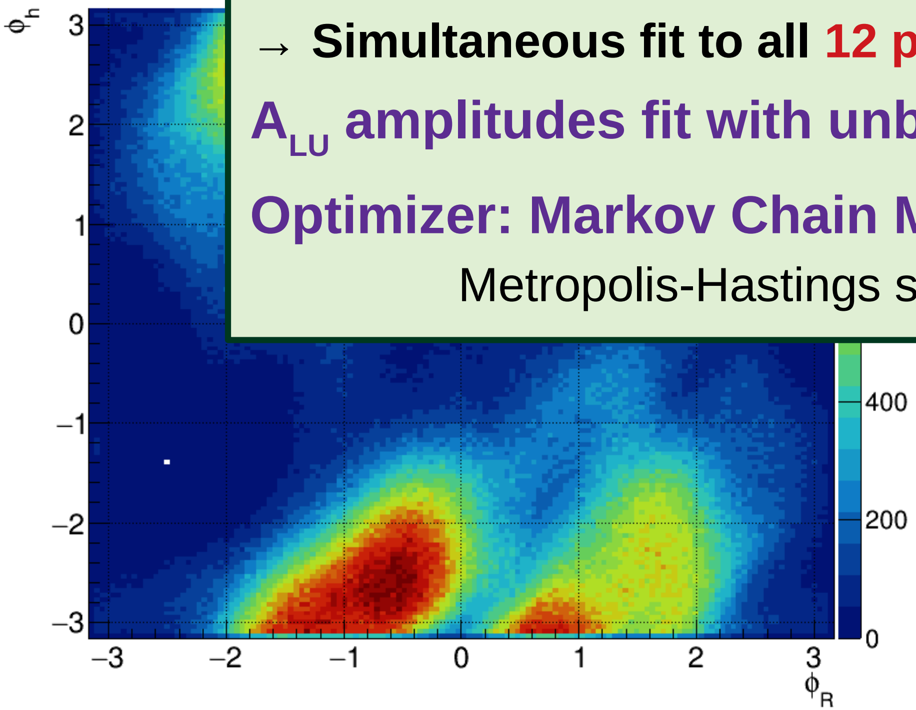
→ non-orthogonality of modulations

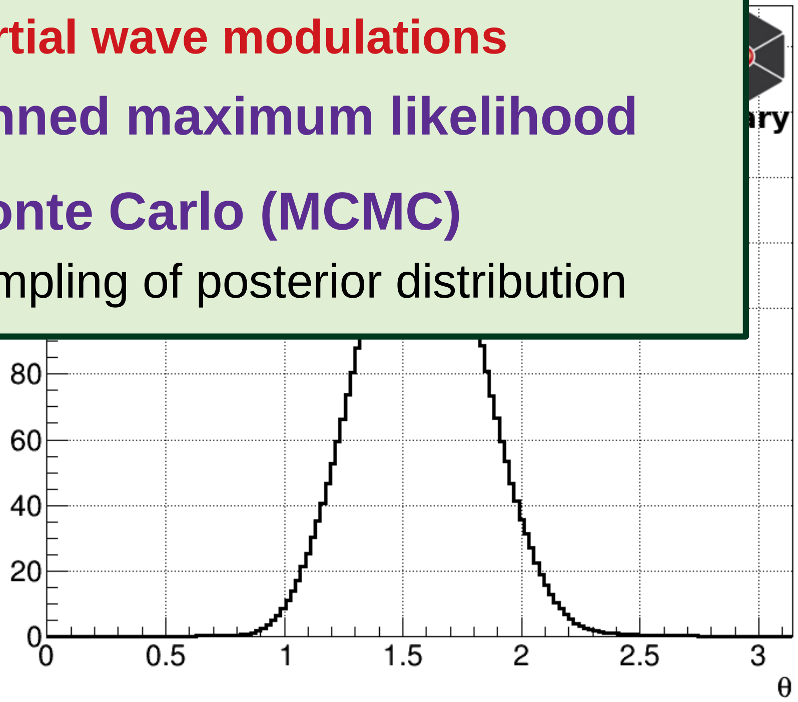
→ **Simultaneous fit to all 12 partial wave modulations**

A_{LU} amplitudes fit with unbinned maximum likelihood

Optimizer: Markov Chain Monte Carlo (MCMC)

Metropolis-Hastings sampling of posterior distribution



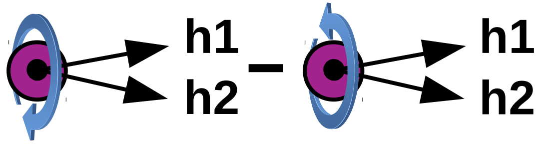


Asymmetry Measurements

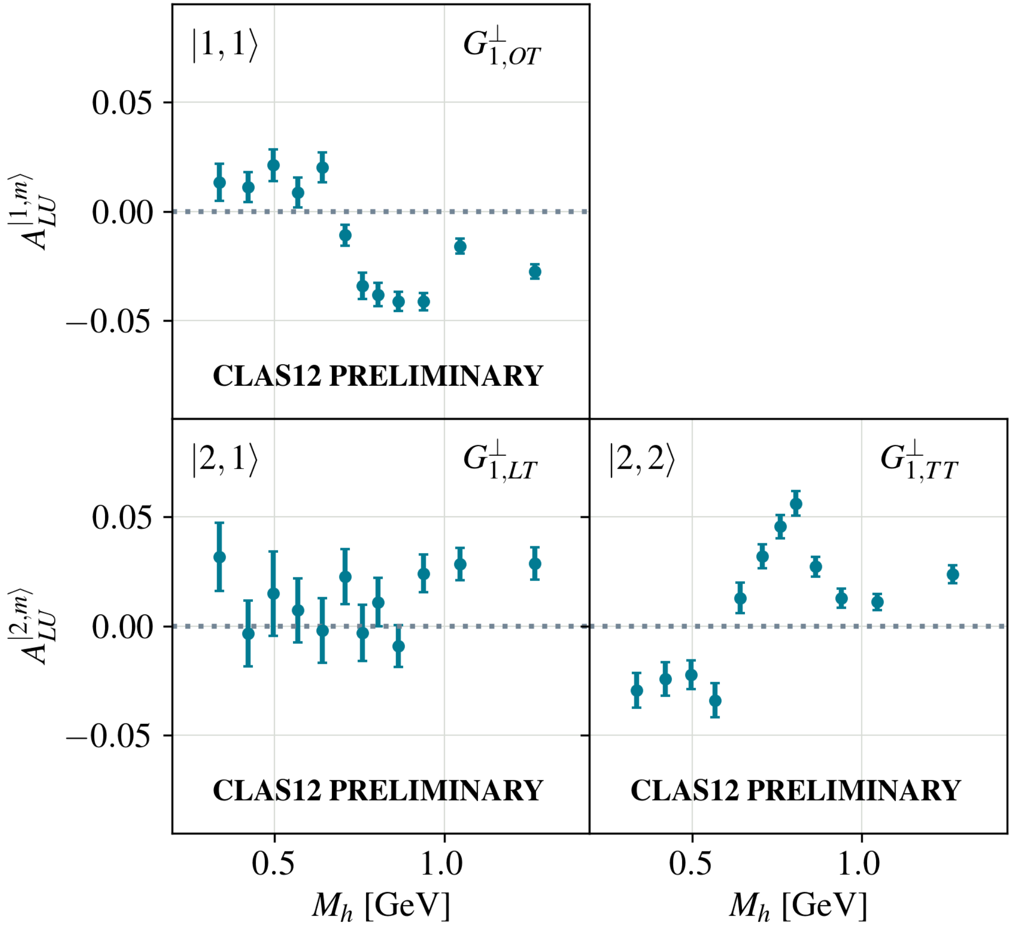
Twist 2

$$F_{LU,T} \sim f_1 \otimes G_1^{\perp|\ell,m\rangle}$$

$$G_1^{\perp|\ell,m\rangle} =$$



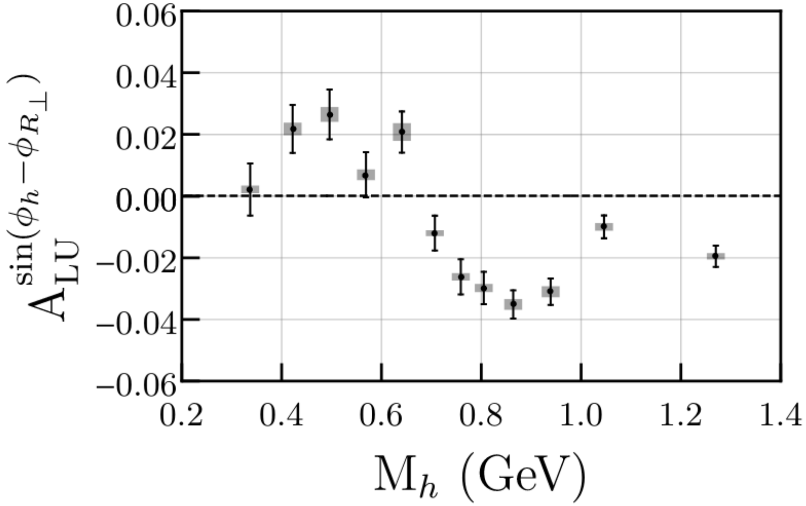
M_h Bins

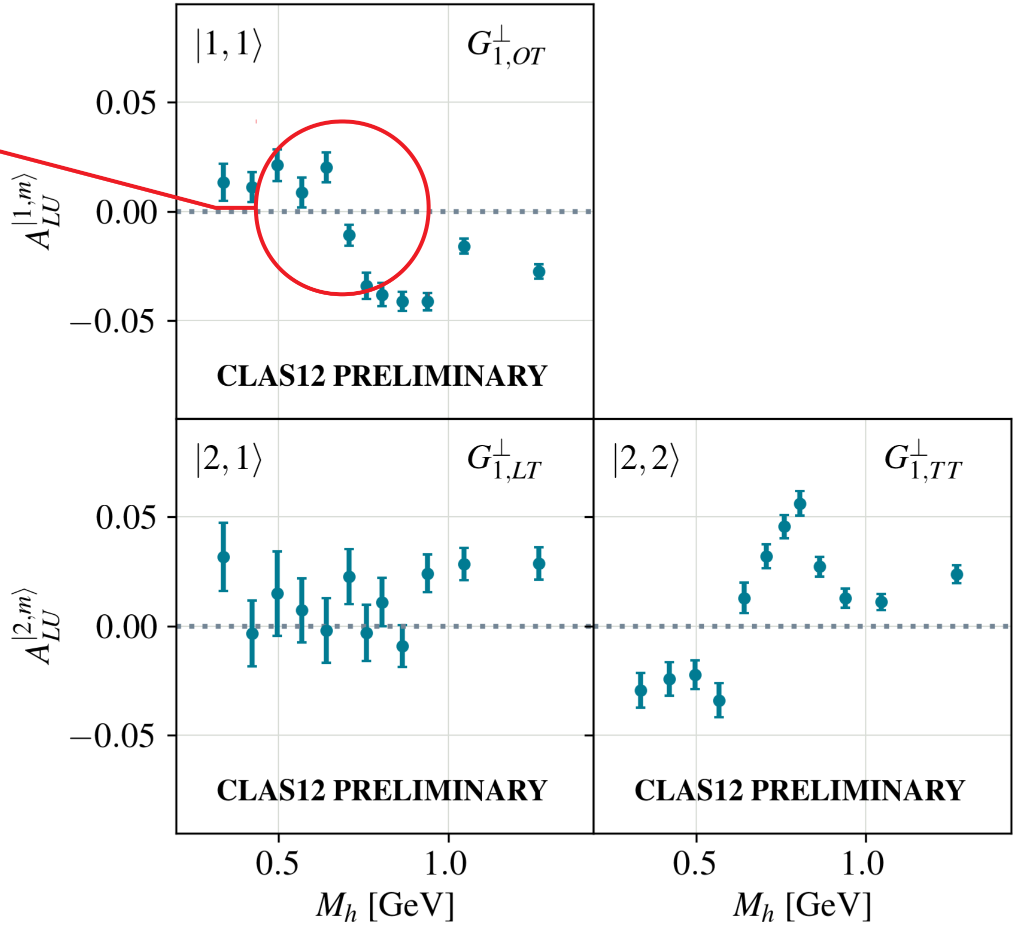


$|1,1\rangle$
$G_{1,OT}^{\perp}$
$|2,1\rangle$
$G_{1,LT}^{\perp}$
$|2,2\rangle$
$G_{1,TT}^{\perp}$
$A_{LU}^{|1,m\rangle}$
$A_{LU}^{|2,m\rangle}$
0.05
0.00
−0.05
0.5
1.0
M_h [GeV]
CLAS12 PRELIMINARY

M_h Bins

Sign change near ρ mass





Compare previous measurement:

- ~ ½ statistics
- Integrated over θ (sum over ℓ)
- Depolarization factor was not divided
- **Partial wave analysis is a *refinement* of this measurement**

Hayward, CD, Vossen, Avakian, et al.,
Phys.Rev.Lett. 126 (2021) 15, 152501

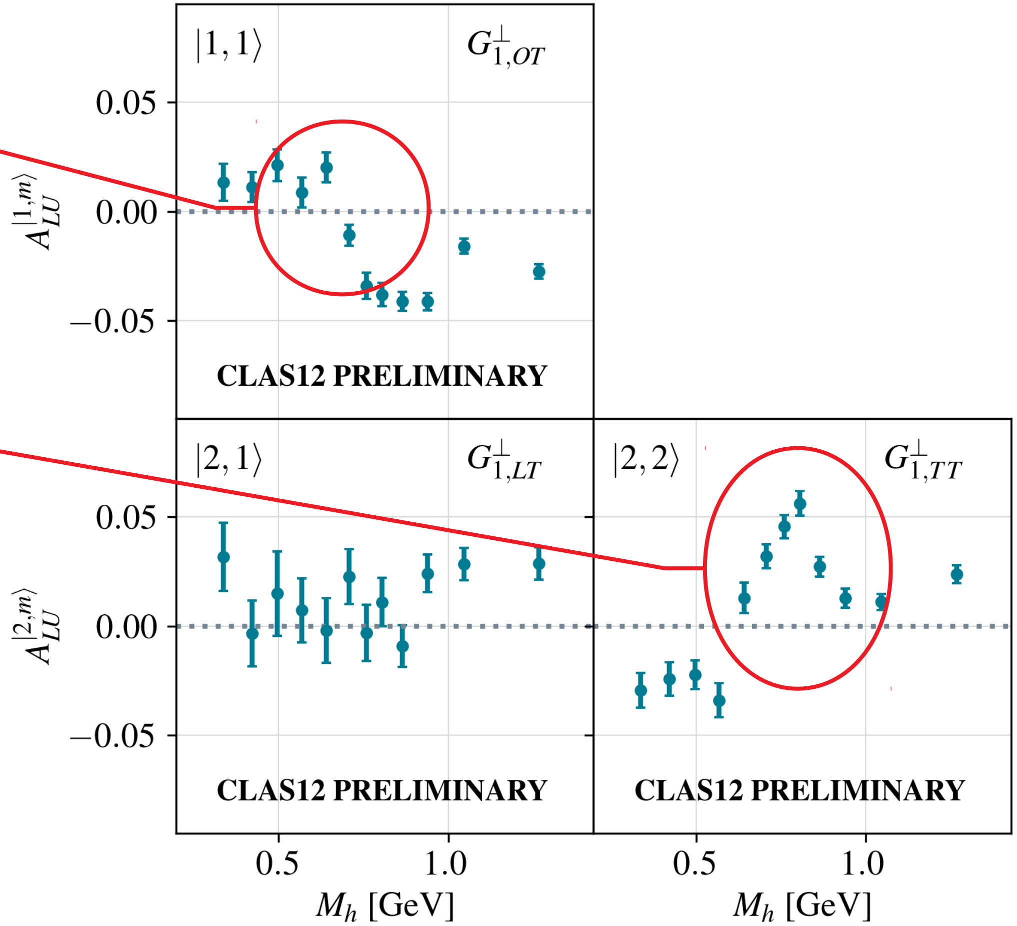
M_h Bins

Twist-2 A_{LU} Amplitudes

Sign change near
ρ mass

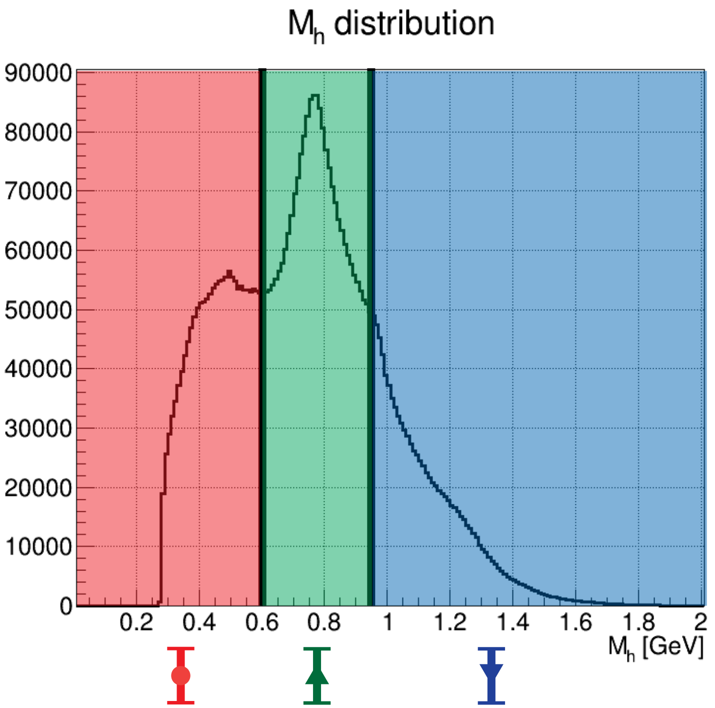
Enhancement at ρ mass

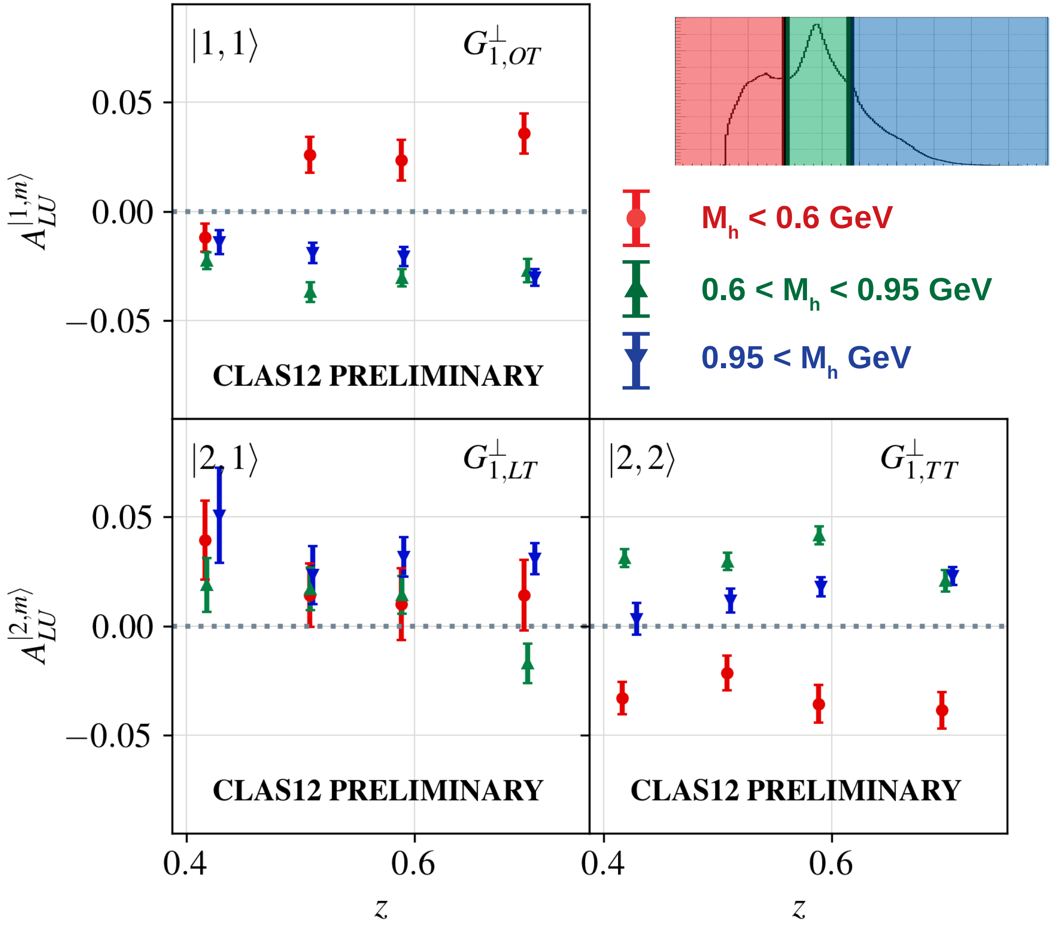
ρ meson → p-wave $\pi^+\pi^-$



C. Dilks

z Bins in 3 M_h Regions



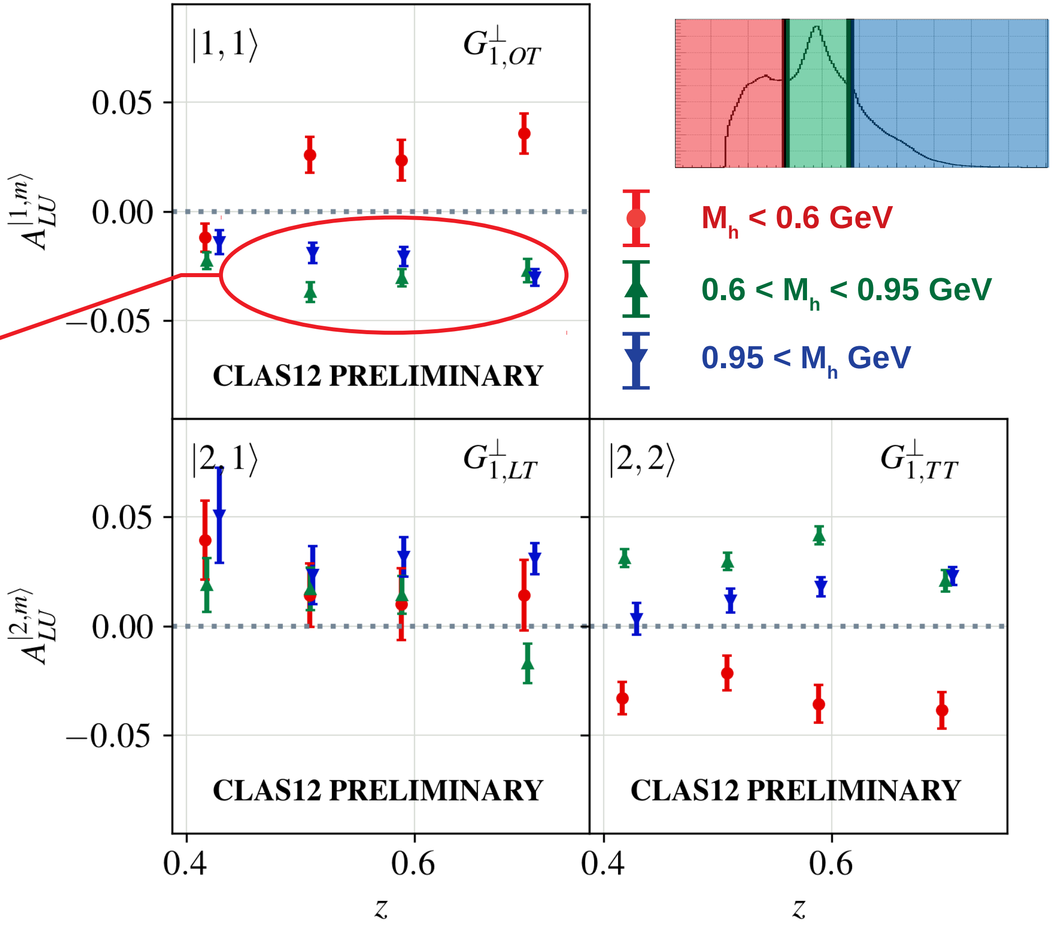


C. Dilks

z Bins in 3 M_h Regions

Twist-2 A_{LU} Amplitudes

Regions **at ρ mass** and **above ρ mass** similar

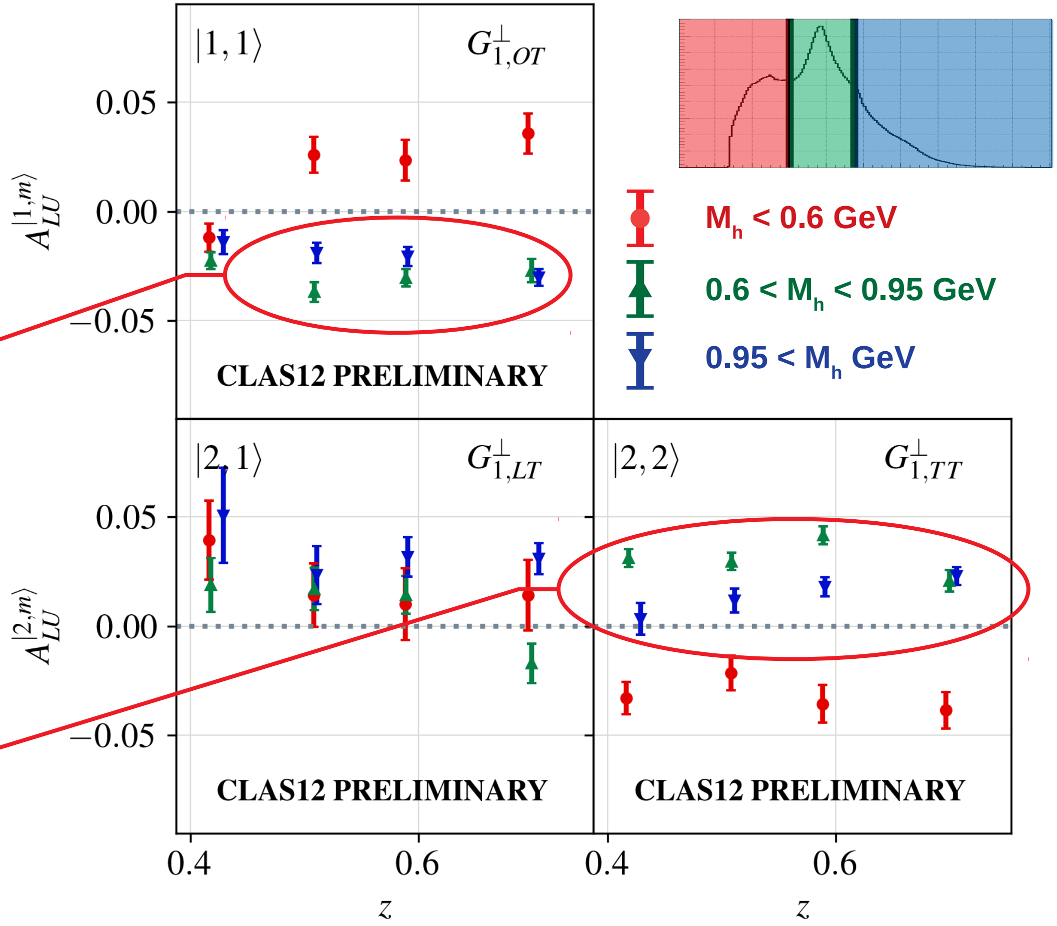


z Bins in 3 M_h Regions

Twist-2 A_{LU} Amplitudes

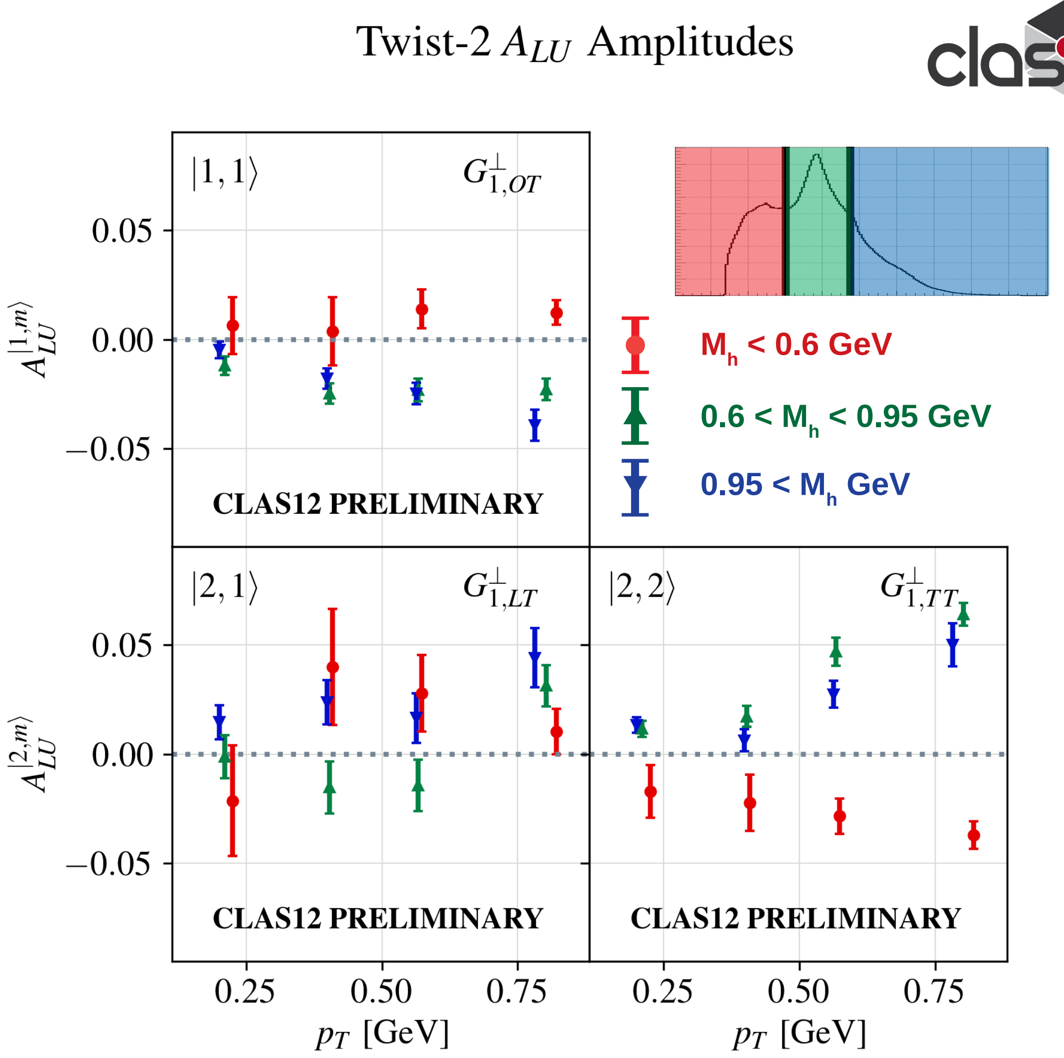
Regions **at ρ mass** and **above ρ mass** similar

Regions **at ρ mass** higher (cf. M_h dependence)



C. Dilks

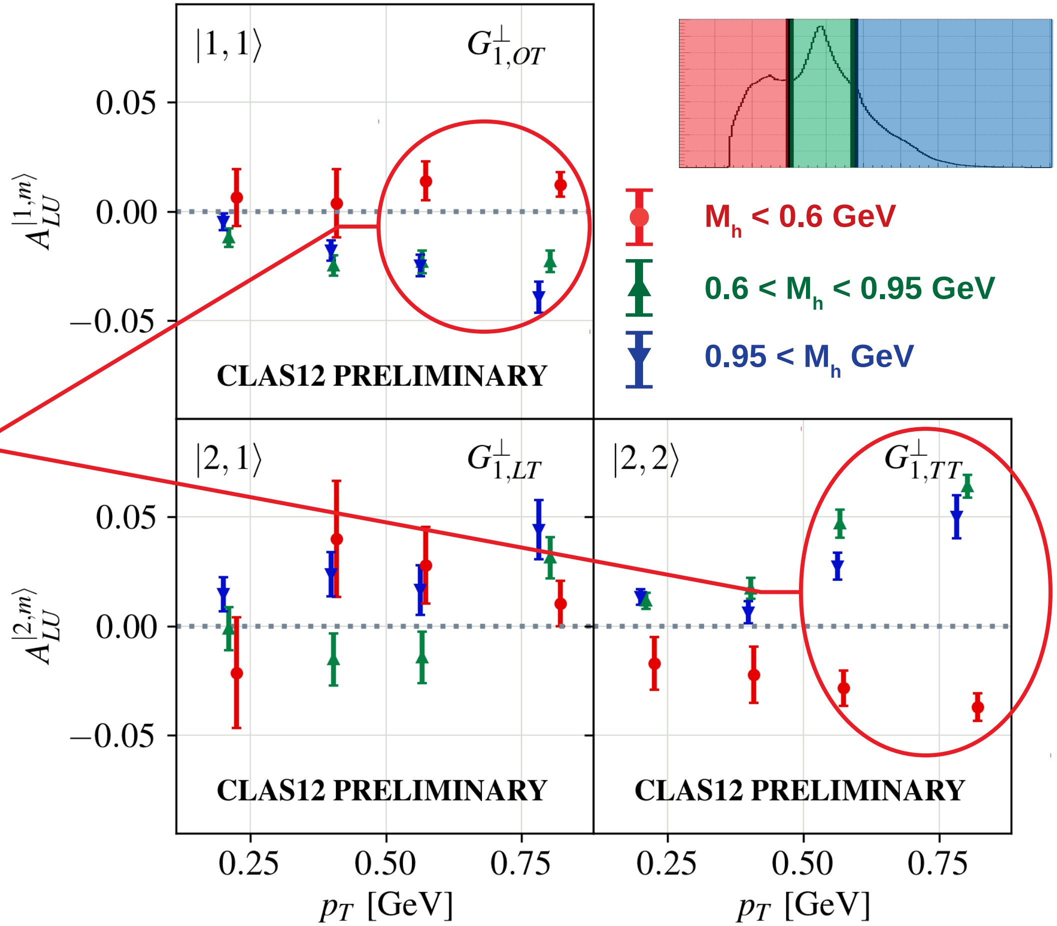
p_T Bins in 3 M_h Regions



p_T Bins in 3 M_h Regions

Twist-2 A_{LU} Amplitudes

High p_T → larger amplitudes, especially for high M_h

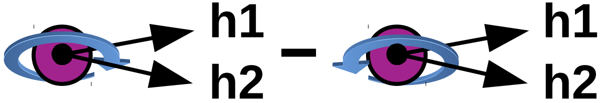


Asymmetry Measurements

Twist 3

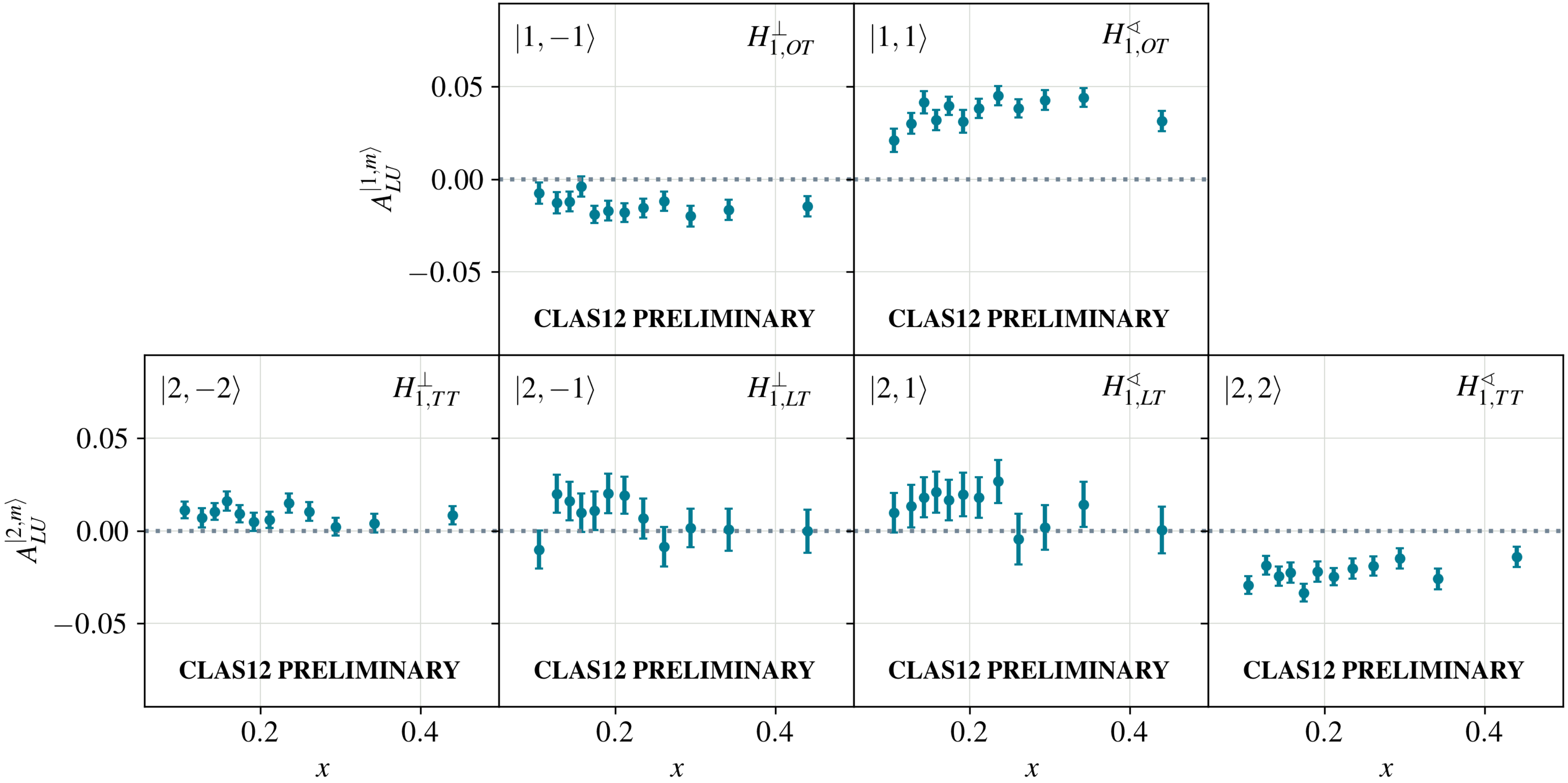
$$F_{LU} \sim e \otimes H_1^{\perp|\ell,m\rangle}$$

$$H_1^{\perp|\ell,m\rangle} =$$



x Bins

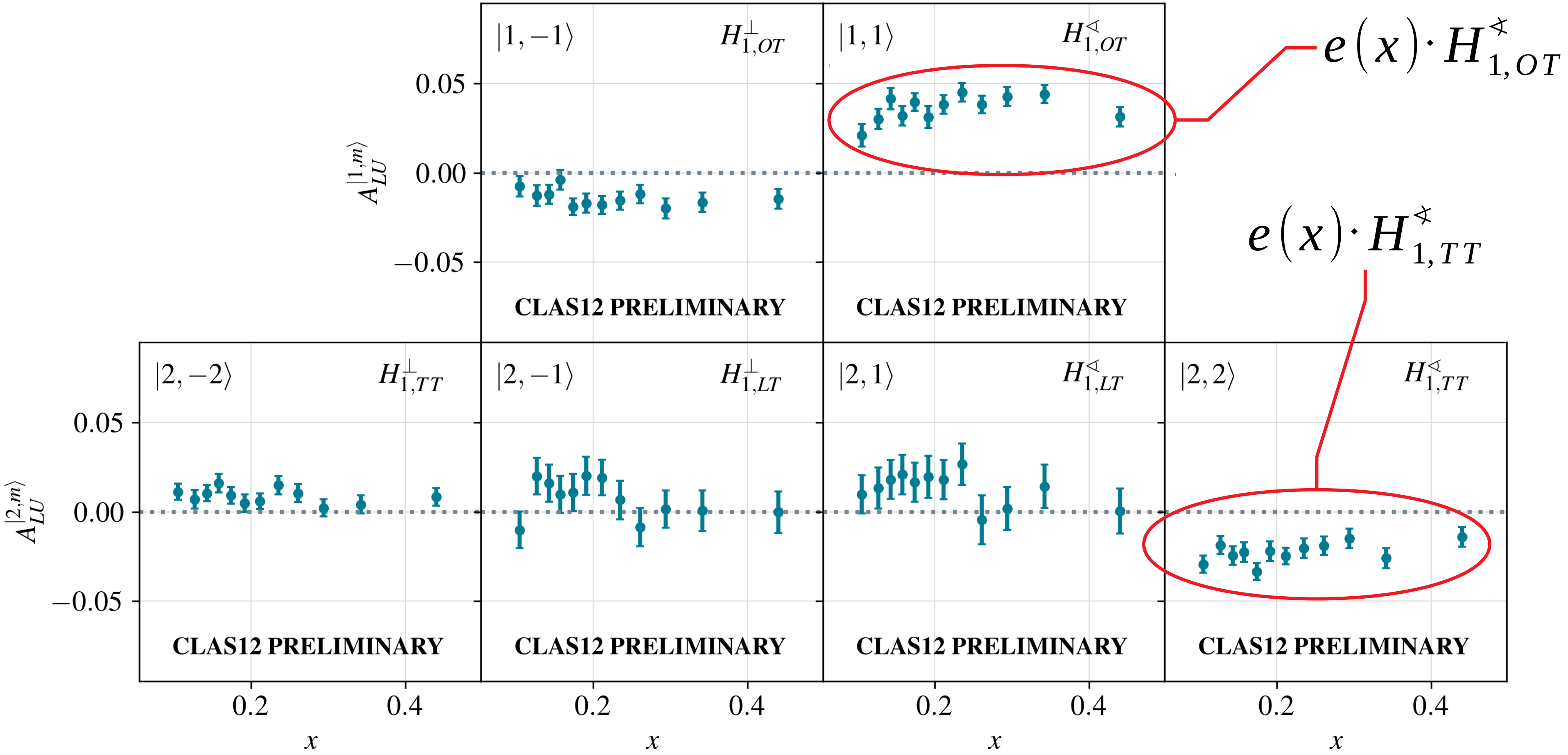
Twist-3 A_{LU} Amplitudes



C. Dilks

x Bins

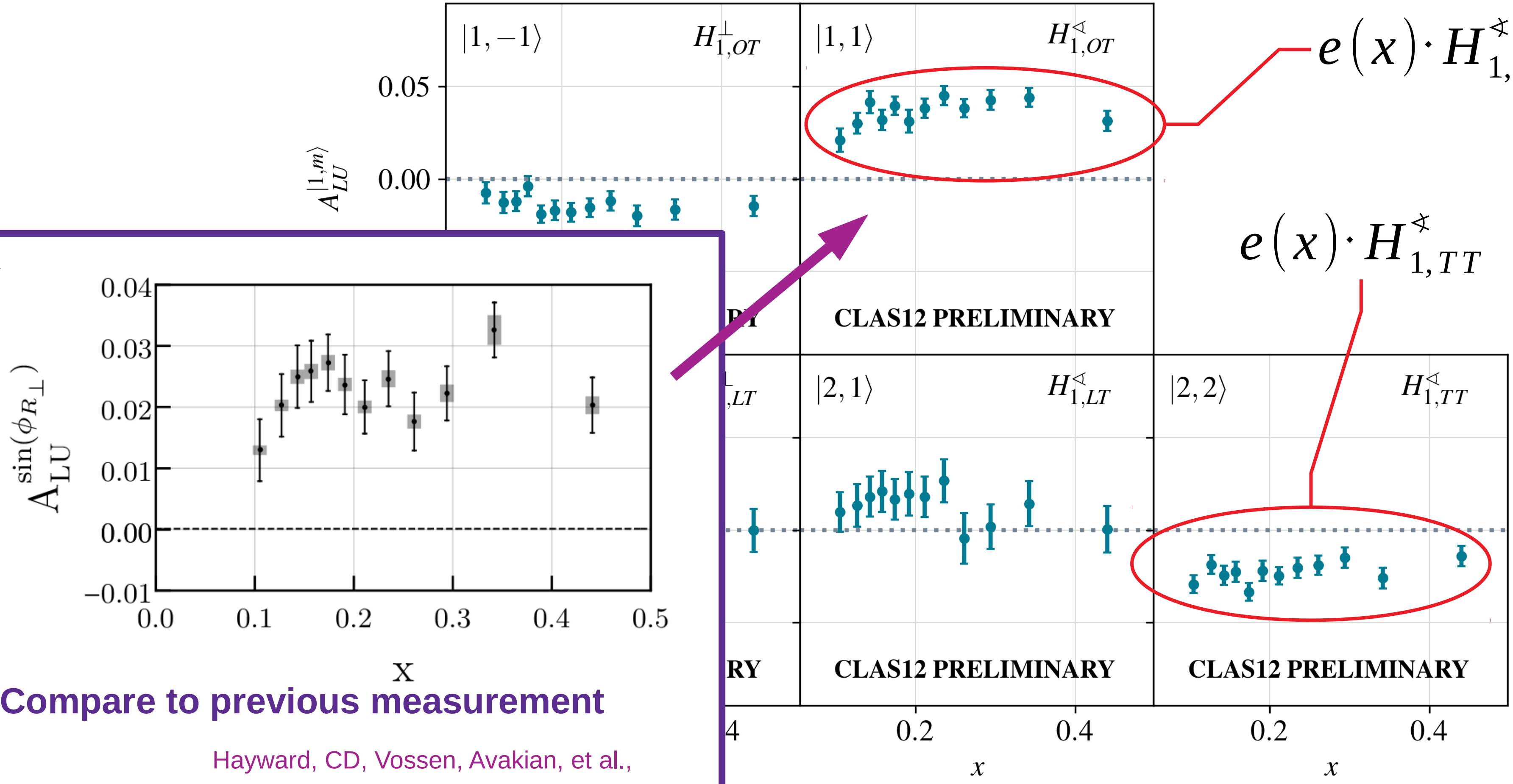
Twist-3 A_{LU} Amplitudes



C. Dilks

x Bins

Twist-3 A_{LU} Amplitudes



$e(x)\cdot H^{\sphericalangle}_{1,OT}$

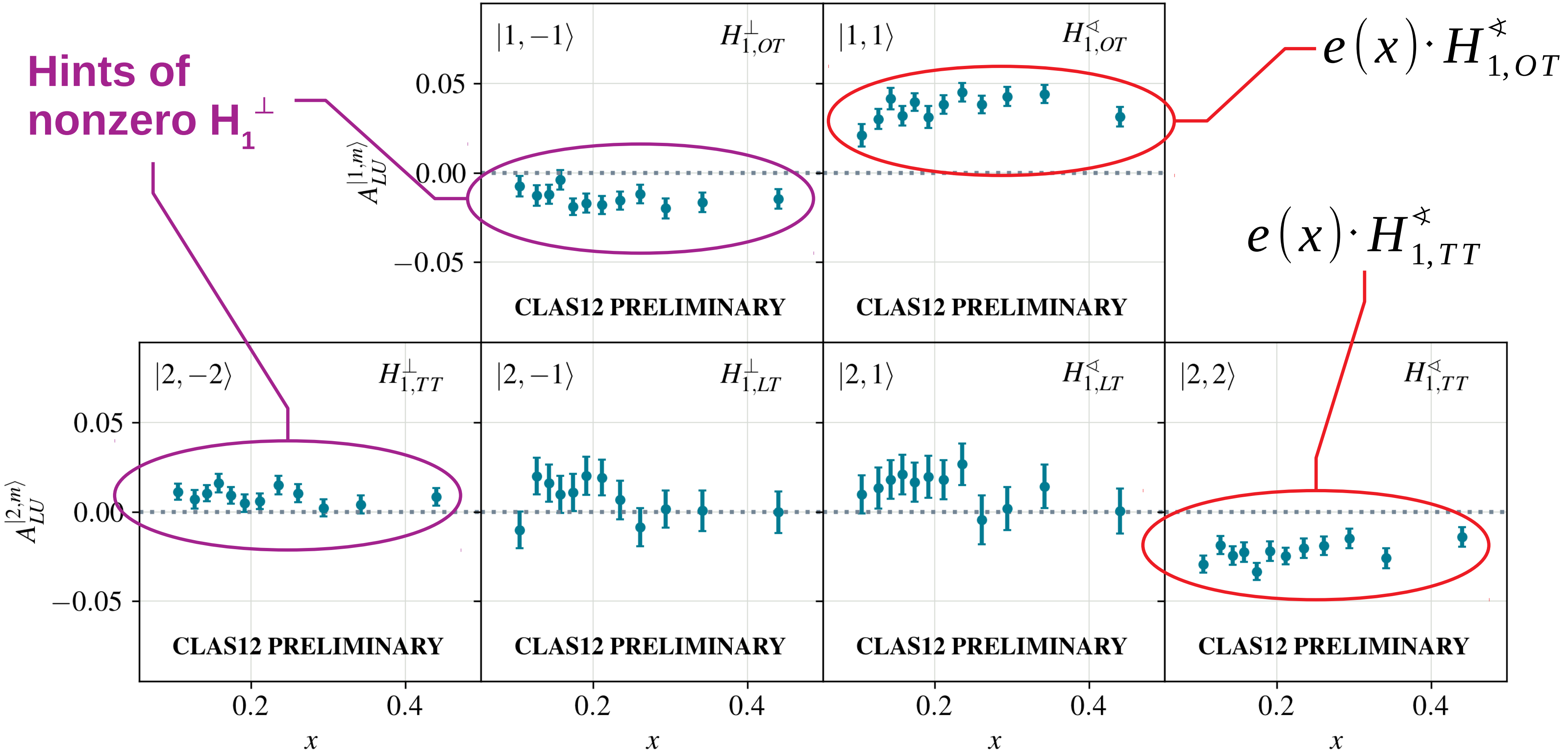
$e(x)\cdot H^{\sphericalangle}_{1,TT}$

Compare to previous measurement

Hayward, CD, Vossen, Avakian, et al.,
Phys.Rev.Lett. 126 (2021) 15, 152501

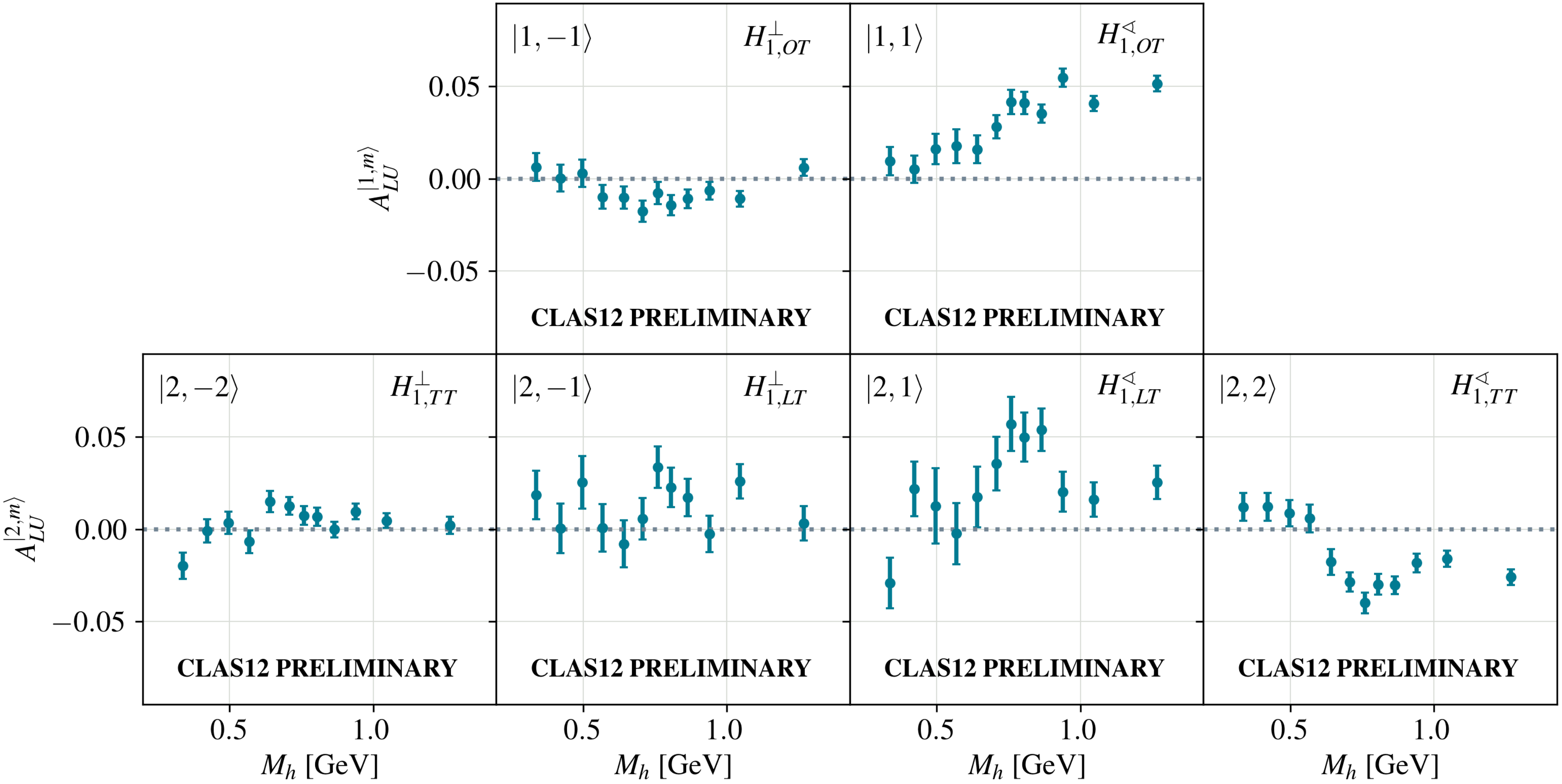
x Bins

Twist-3 A_{LU} Amplitudes



M_h Bins

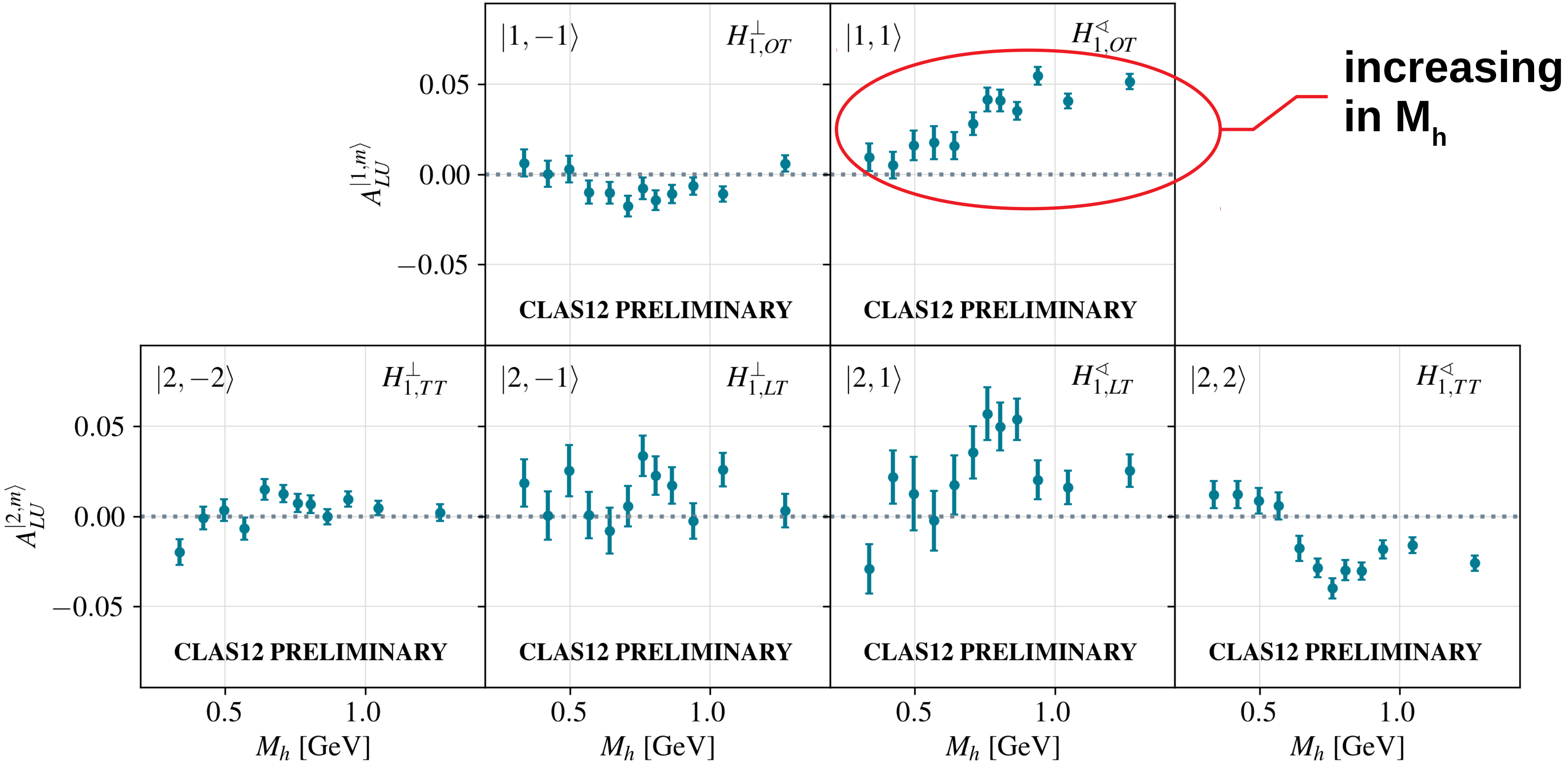
Twist-3 A_{LU} Amplitudes



C. Dilks

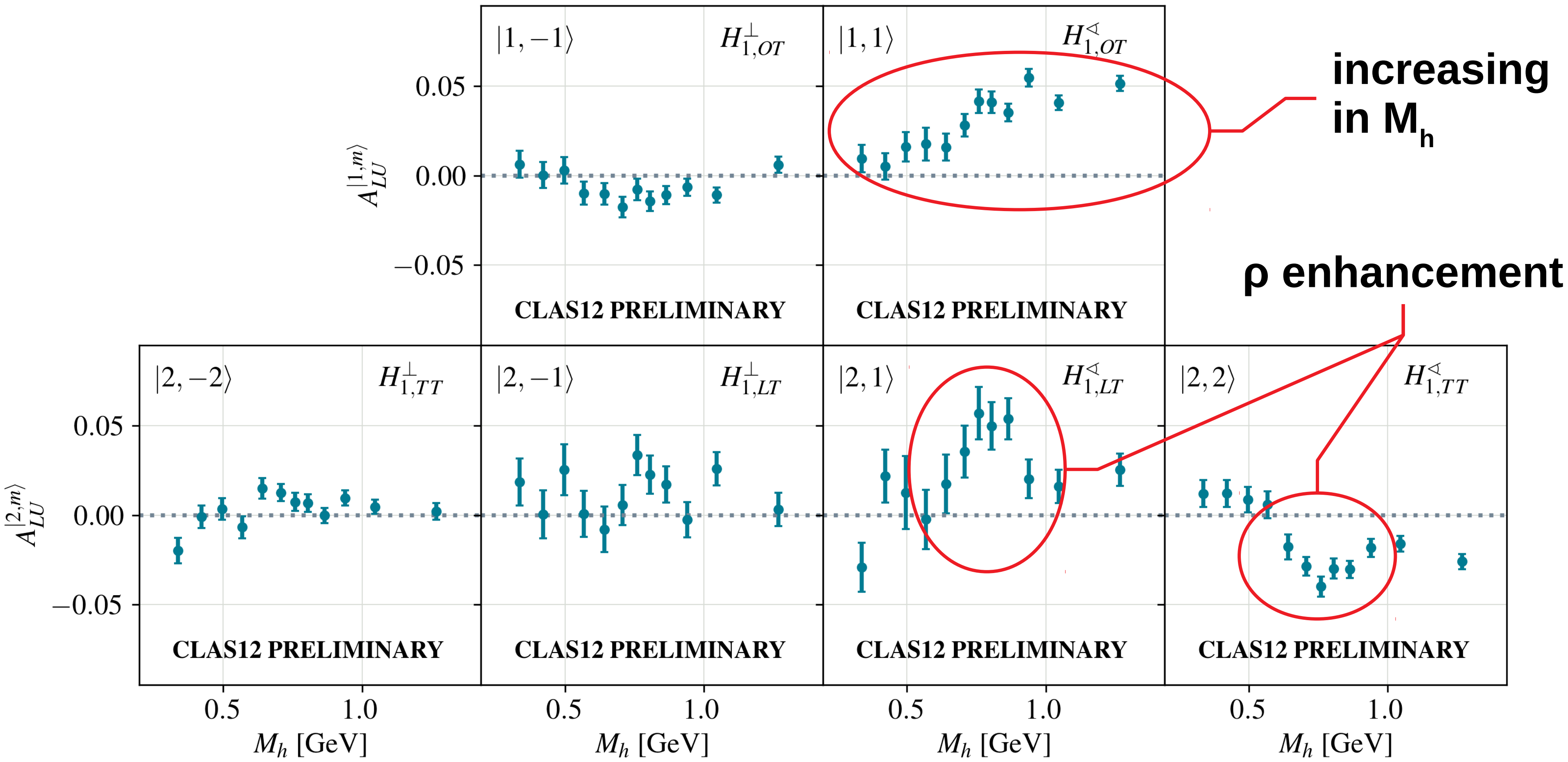
M_h Bins

Twist-3 A_{LU} Amplitudes



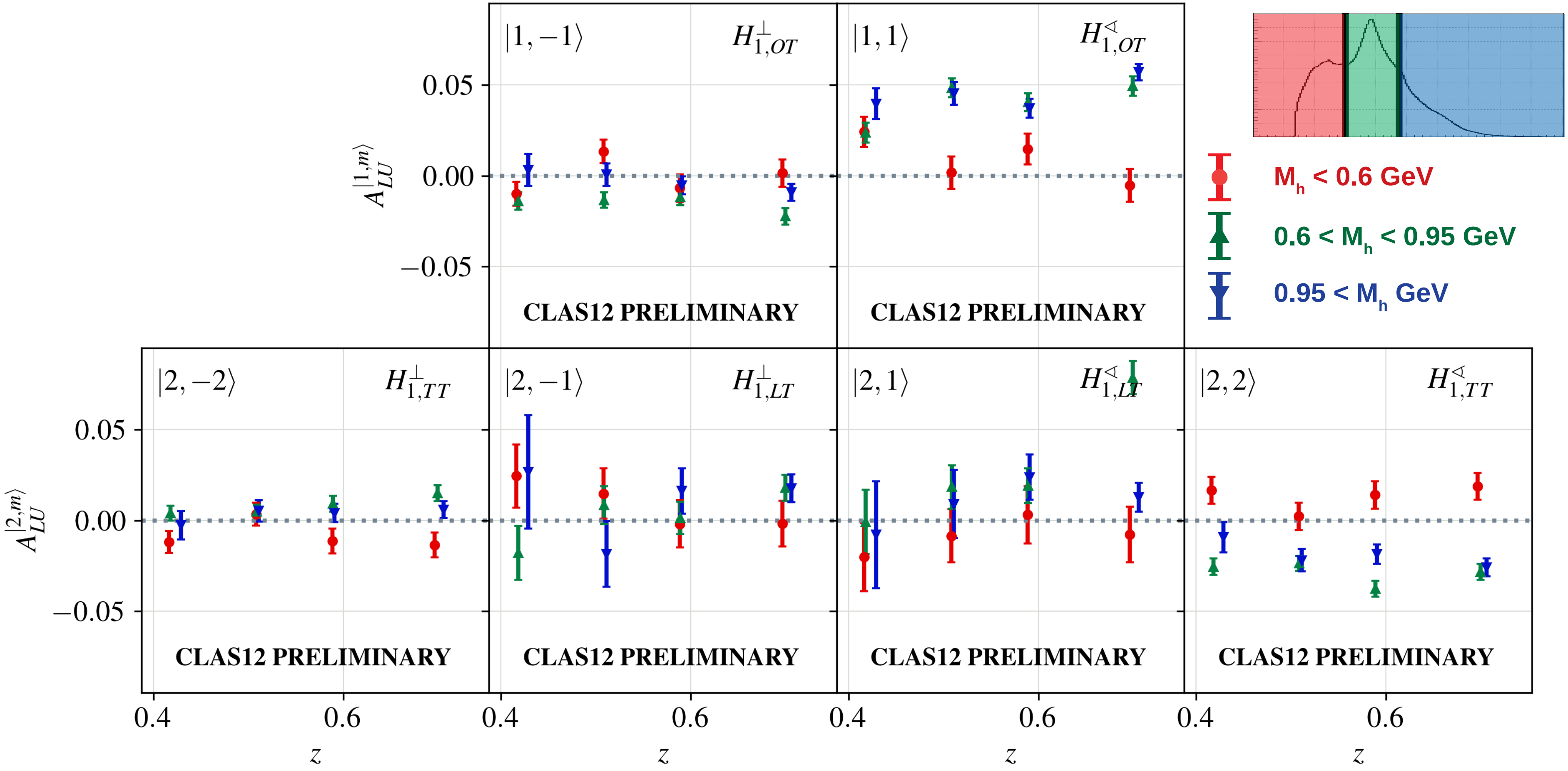
M_h Bins

Twist-3 A_{LU} Amplitudes



z Bins in 3 M_h Regions

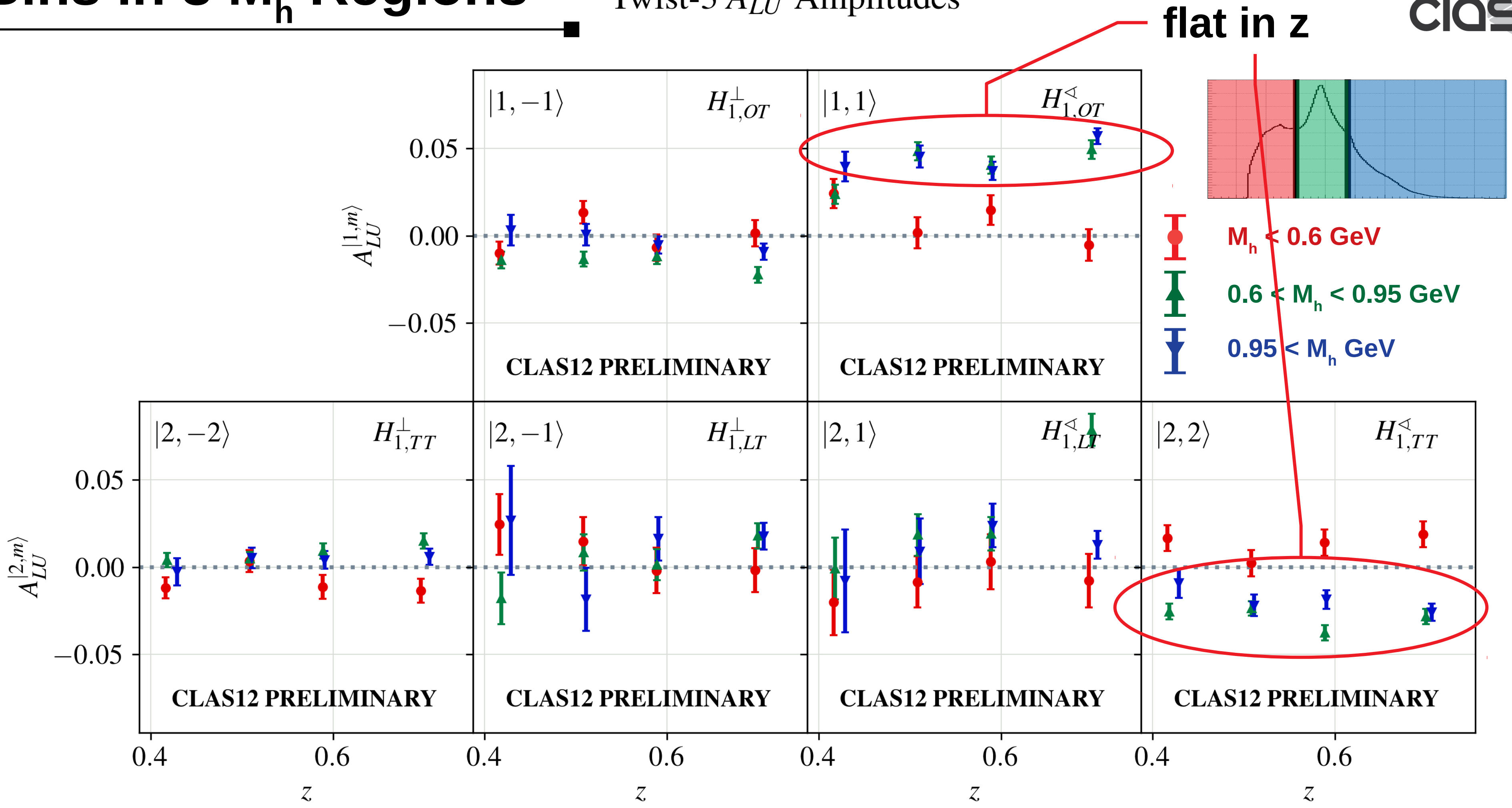
Twist-3 A_{LU} Amplitudes



C. Dilks

z Bins in 3 M_h Regions

Twist-3 A_{LU} Amplitudes



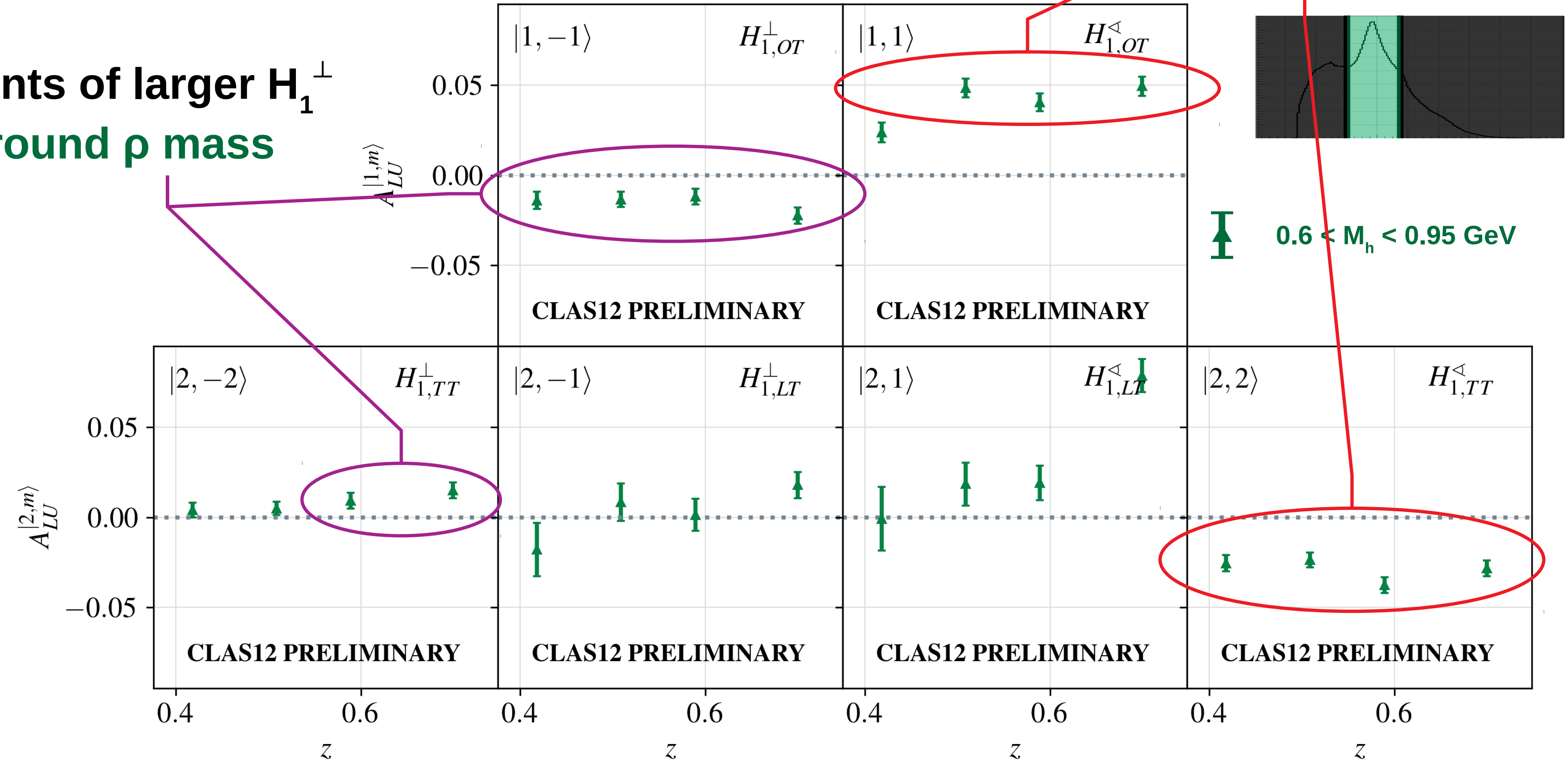
C. Dilks

z Bins, $M_h \sim M_\rho$

Twist-3 A_{LU} Amplitudes

flat in z

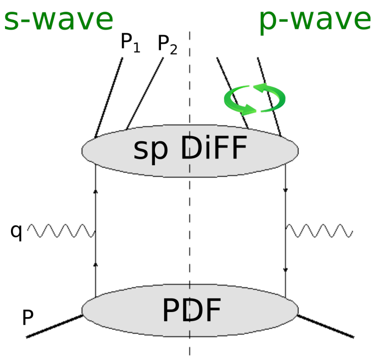
hints of larger $H_1^\perp$
around ρ mass



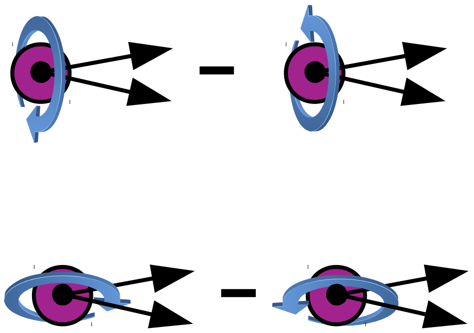
C. Dilks

Summary

- **SIDIS dihadron beam spin asymmetries are sensitive to:**
  - Dihadron fragmentation function $G_1^{\perp}$ and H_1
  - Twist-3 parton distribution function e(x)



- **Partial waves expansions provide:**
  - Dependence on dihadron polarizations
  - Refined access to $G_1^{\perp}$
  - Better understanding of $H_1^{<}$
  - Hints at nonzero $H_1^{\perp}$

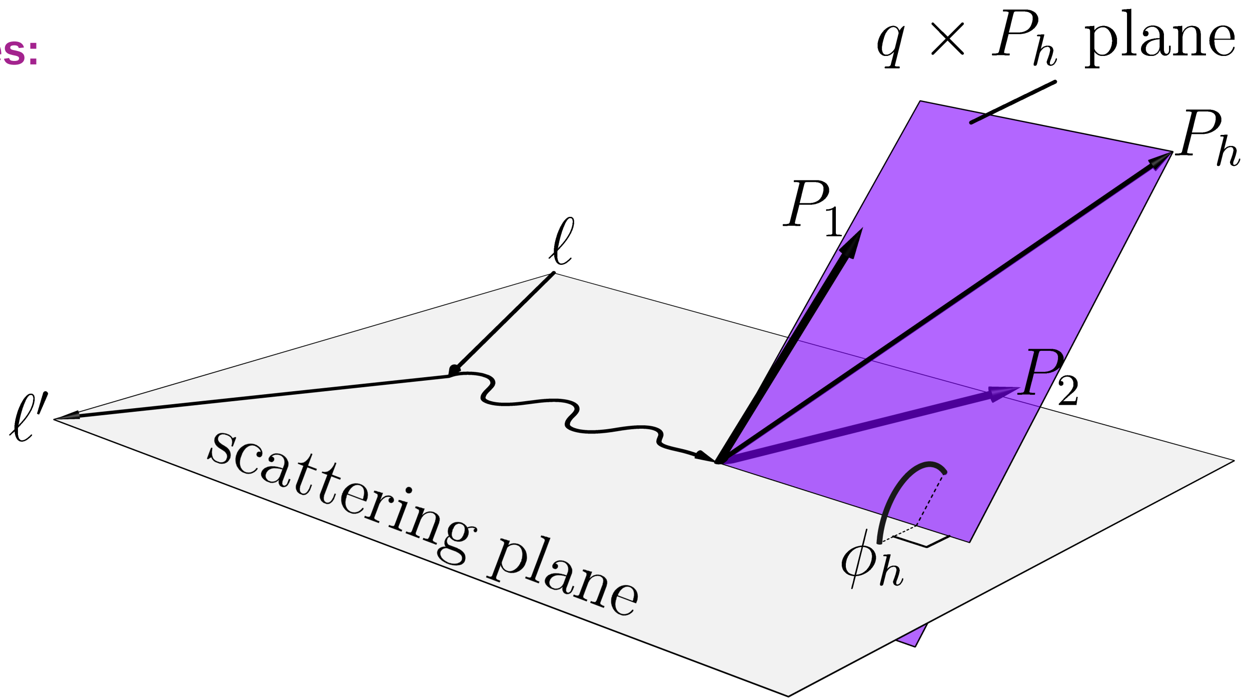


backup

SIDIS Dihadron Kinematics

A_{LU} modulated by functions of 3 angles:

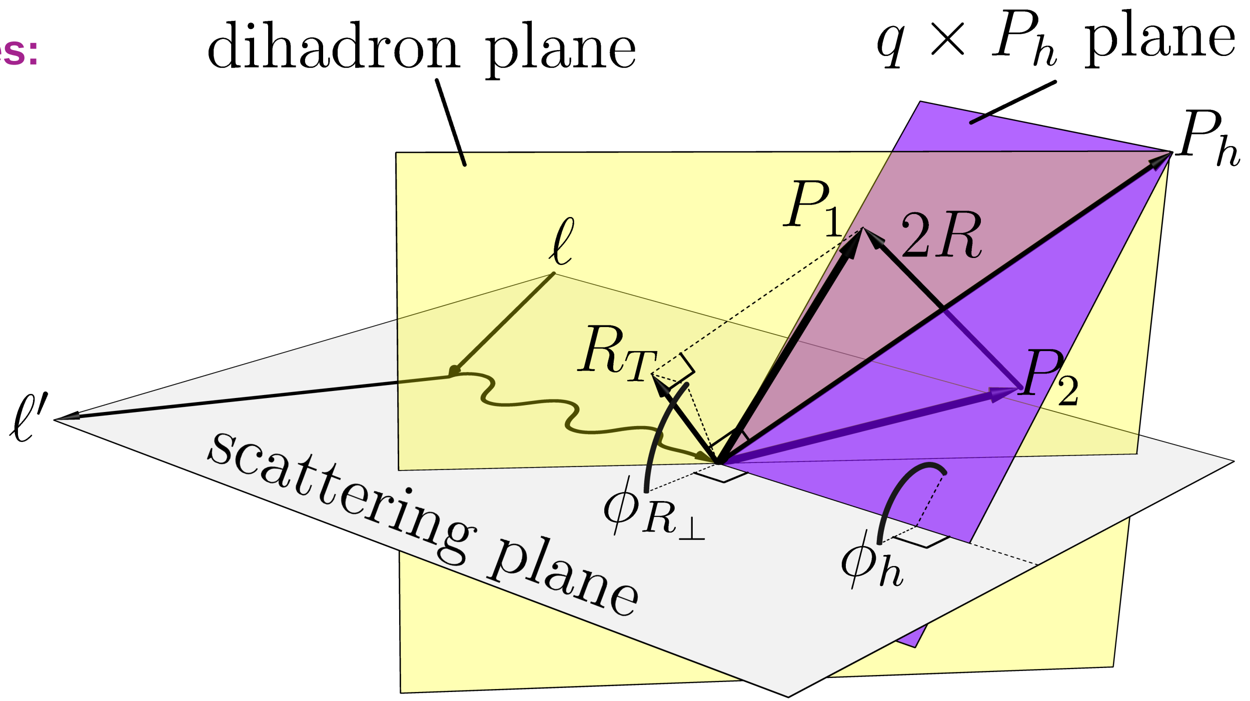
- **Azimuthal angles**
  - $P_h = P_1 + P_2$ → ϕ_h



SIDIS Dihadron Kinematics

A_{LU} modulated by functions of 3 angles:

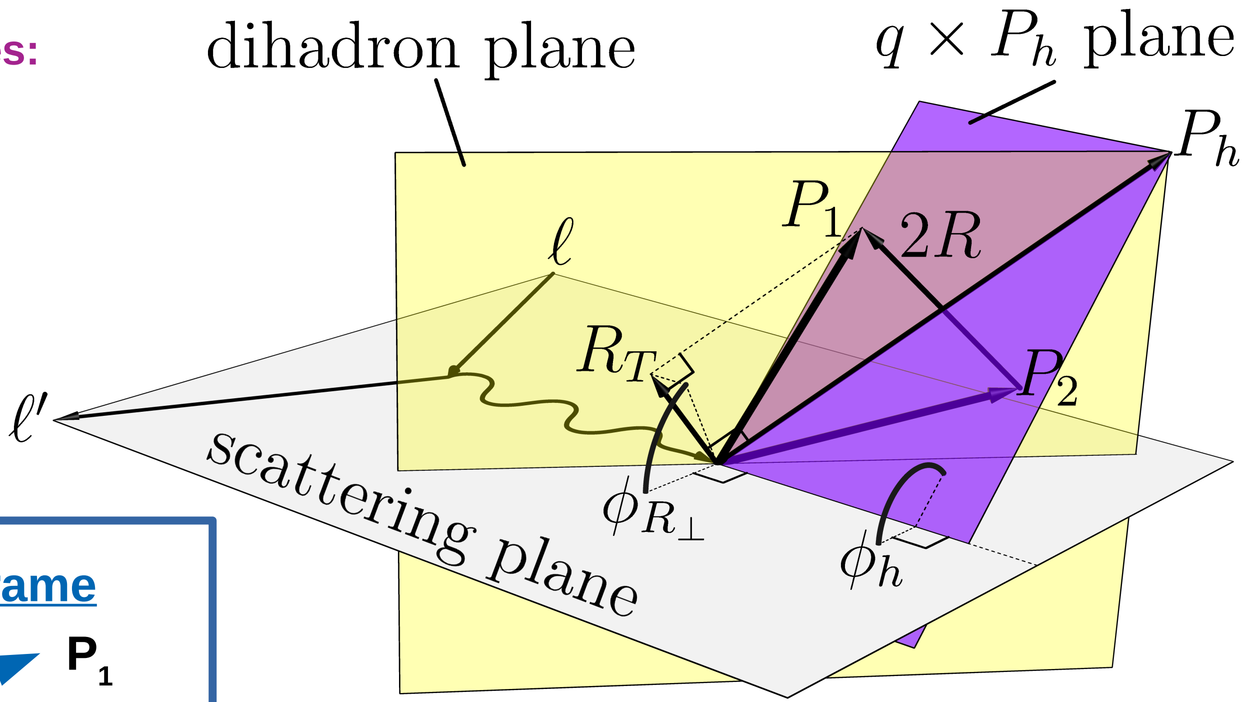
- **Azimuthal angles**
  - $P_h = P_1 + P_2$ → ϕ_h
  - $R = \frac{1}{2}(P_1 - P_2)$ → ϕ_R



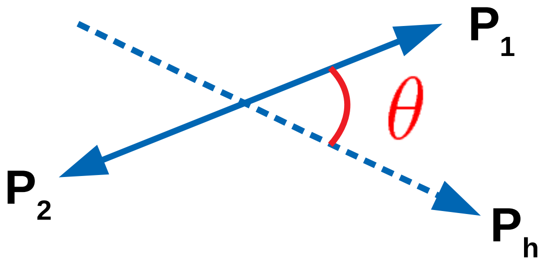
SIDIS Dihadron Kinematics

A_{LU} modulated by functions of 3 angles:

- **Azimuthal angles**
  - $P_h = P_1 + P_2$ → ϕ_h
  - $R = \frac{1}{2}(P_1 - P_2)$ → ϕ_R
- **Decay angle** θ



Dihadron CoM frame



C. Dilks