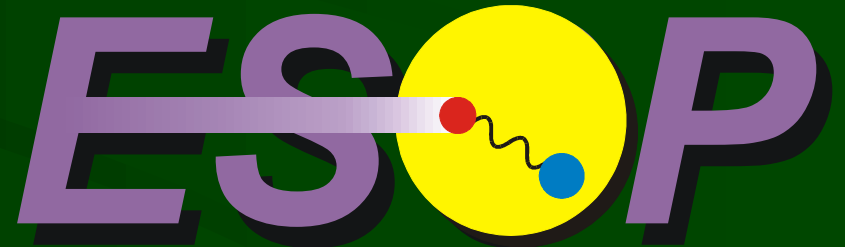


A theorist's contribution to the hunt for transversity

Alessandro Bacchetta

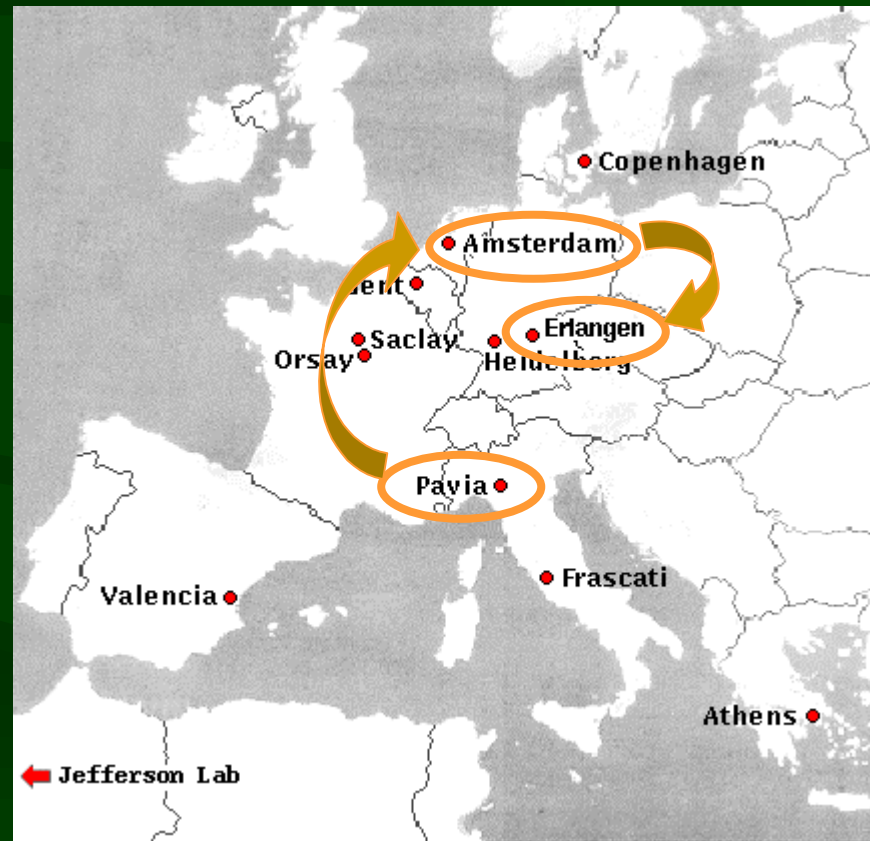


Universität Regensburg



*Electron Scattering Off
confined Partons*

My experience with the network



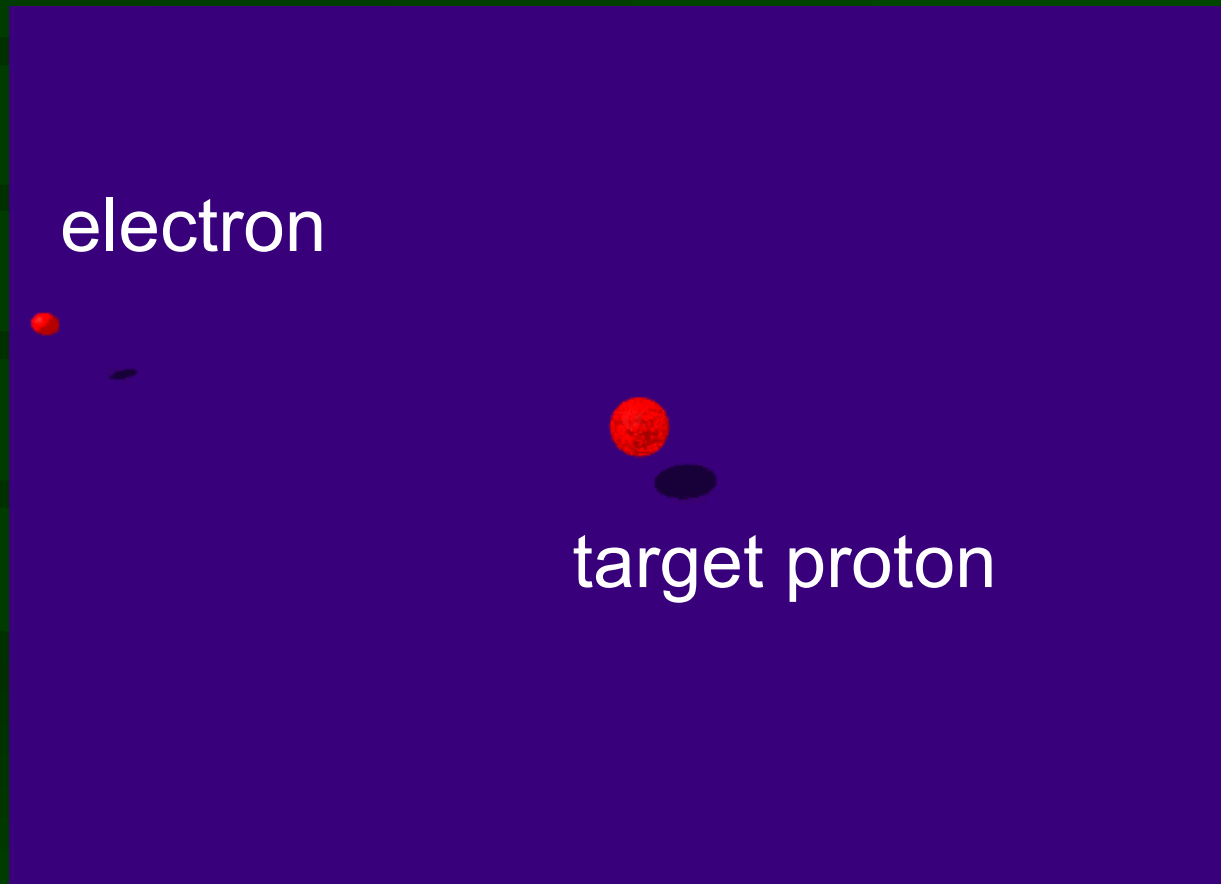
Outline

- Driving questions
- Transversity
- Collins function
- Two-hadron functions

Driving questions

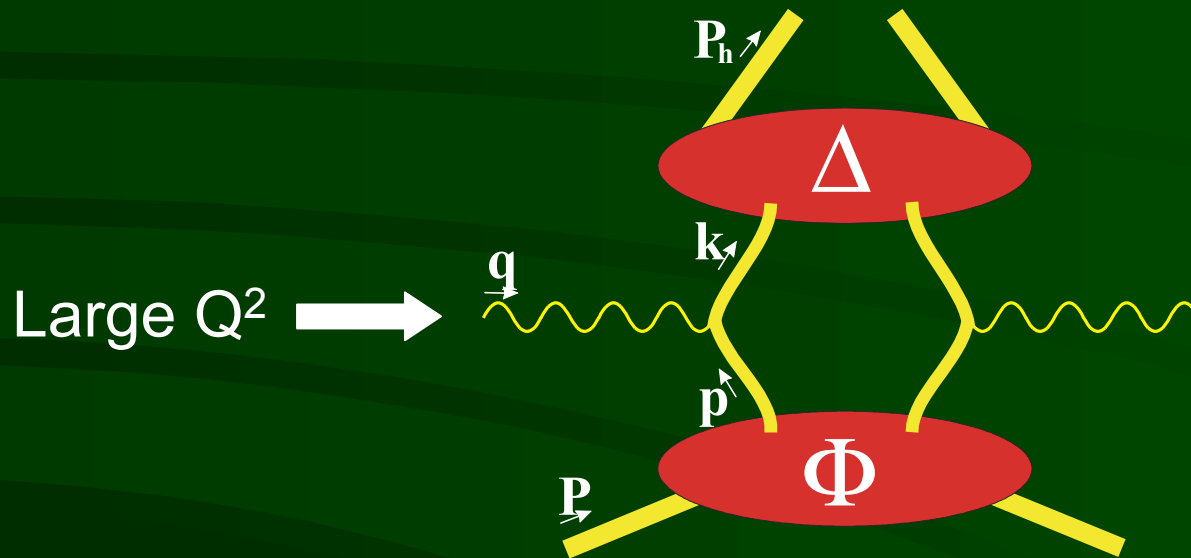
- What is the internal structure of the proton in terms of quarks and gluons?
- Where does the spin of the proton come from?

Deep inelastic scattering



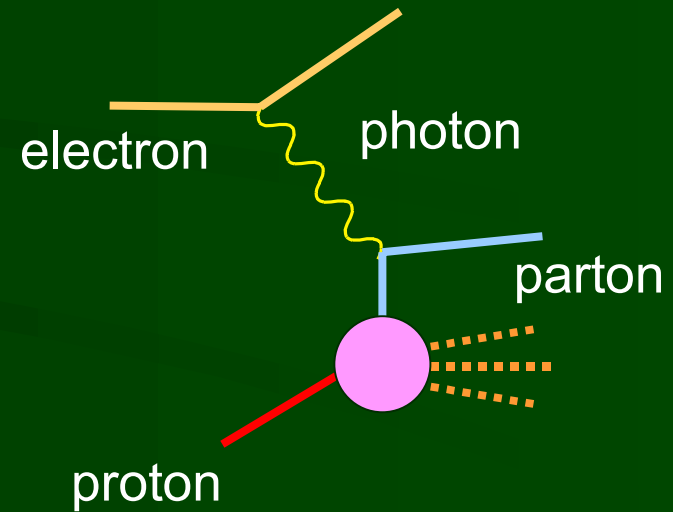
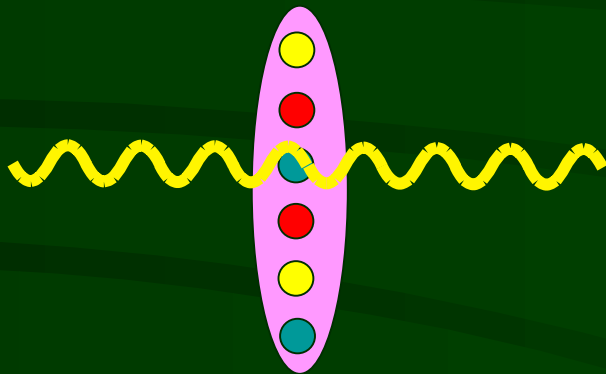
Semi-inclusive DIS

$$d\sigma (l + H \rightarrow l' + h + X) \propto L_{\mu\nu} W^{\mu\nu}$$

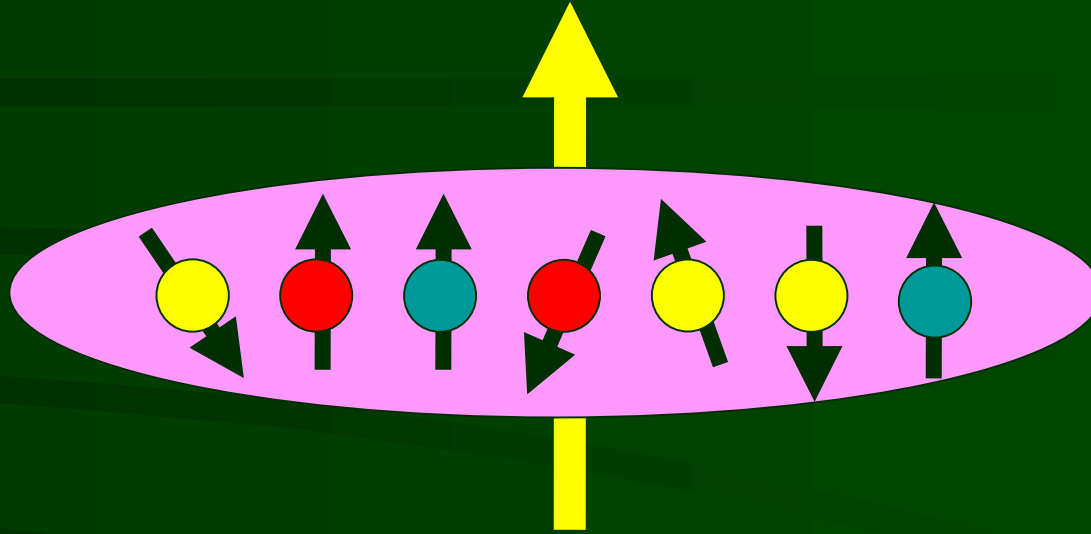


$$2M W^{\mu\nu} \propto \text{Tr}[\Phi(x_B) \gamma^\mu \Delta(z_h) \gamma^\nu]$$

The parton model



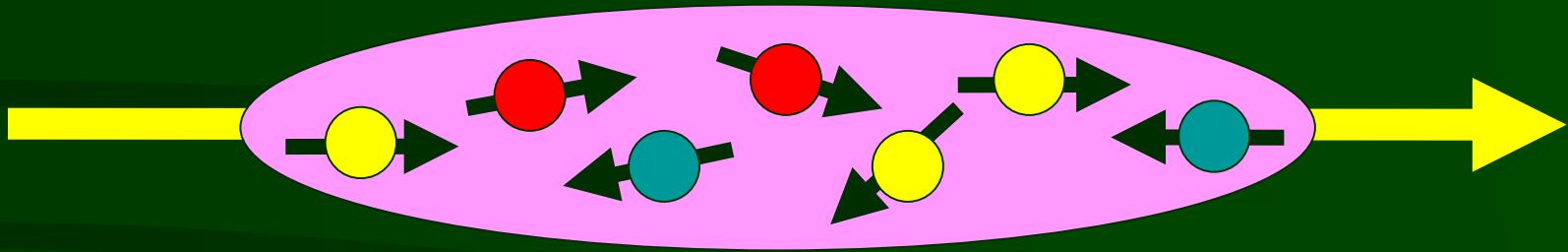
Helicity distribution g_1



$$g_1 = \Delta q = \frac{1}{2} \left(\begin{array}{c} \uparrow \\ \uparrow \end{array} \begin{array}{c} \uparrow \\ \uparrow \end{array} - \begin{array}{c} \downarrow \\ \uparrow \end{array} \begin{array}{c} \downarrow \\ \uparrow \end{array} \right)$$

Diagram illustrating the helicity distribution g_1 . It shows two orange ovals with dashed vertical lines. The left oval has red lines with upward arrows and orange lines with upward arrows. The right oval has red lines with downward arrows and orange lines with upward arrows. A minus sign is between them.

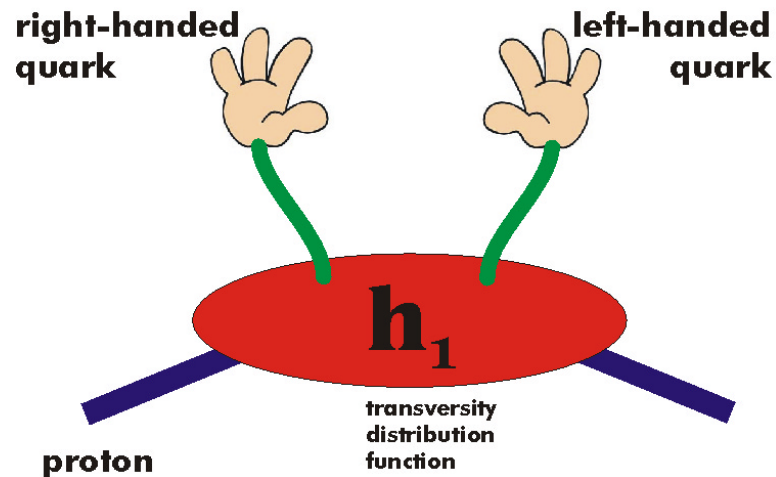
Transversity distribution h_1



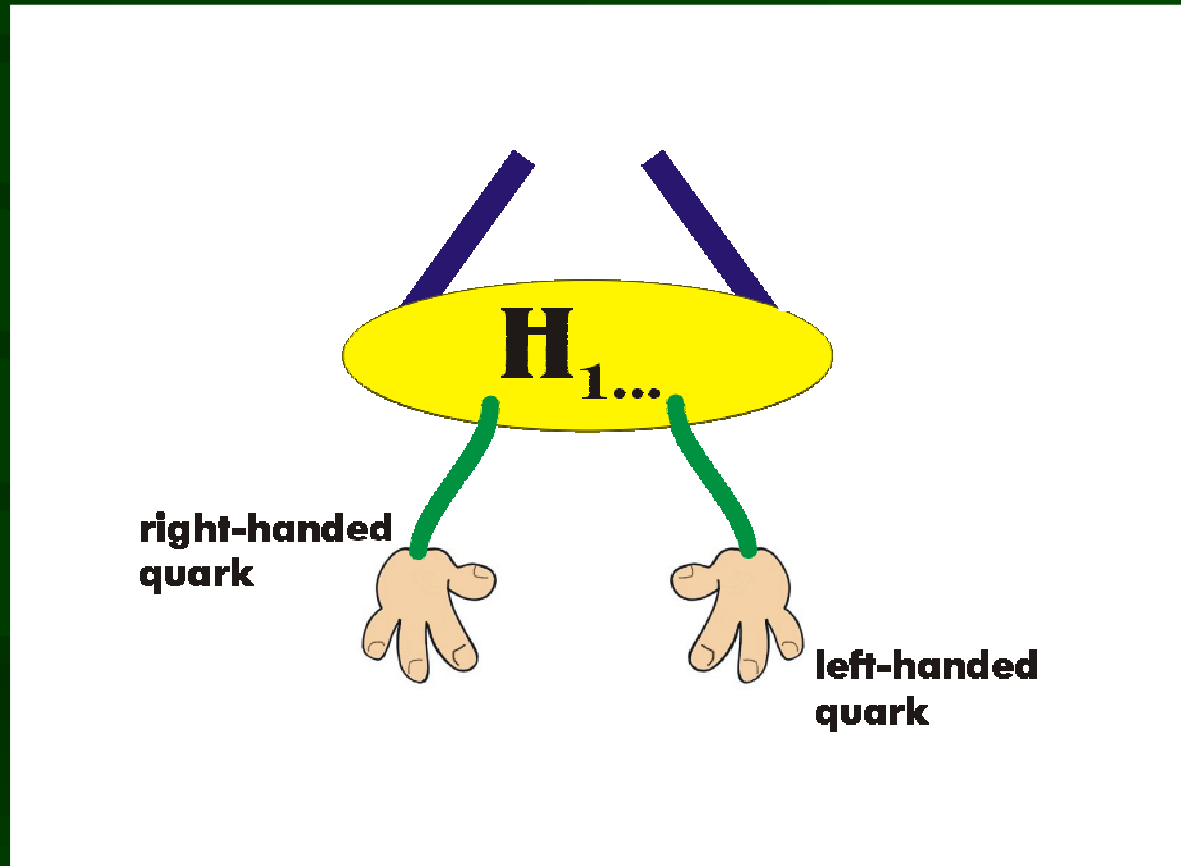
$$h_1 = \delta q = \frac{1}{2}$$

The diagram shows two configurations of a proton (represented by an orange oval) with a vertical dashed line through its center. The left configuration has four arrows pointing outwards: two red arrows pointing up and two orange arrows pointing down. The right configuration has four arrows pointing inwards: two red arrows pointing up and two orange arrows pointing down. A minus sign is placed between the two configurations, indicating that the transversity distribution h_1 is the difference between these two states.

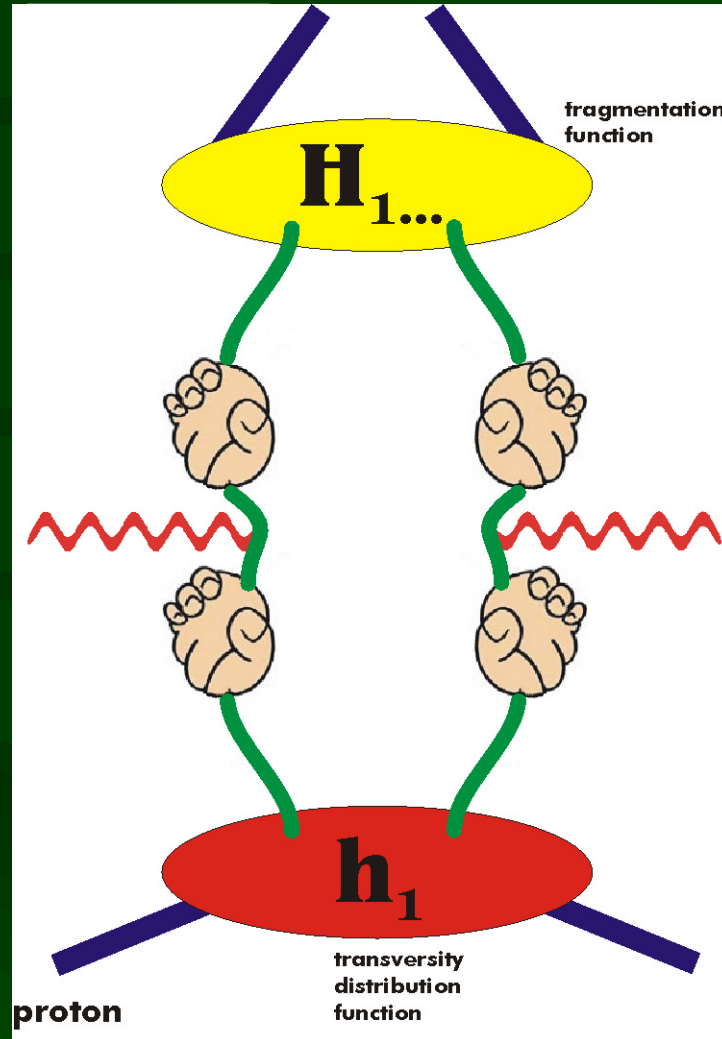
The problem of measuring transversity



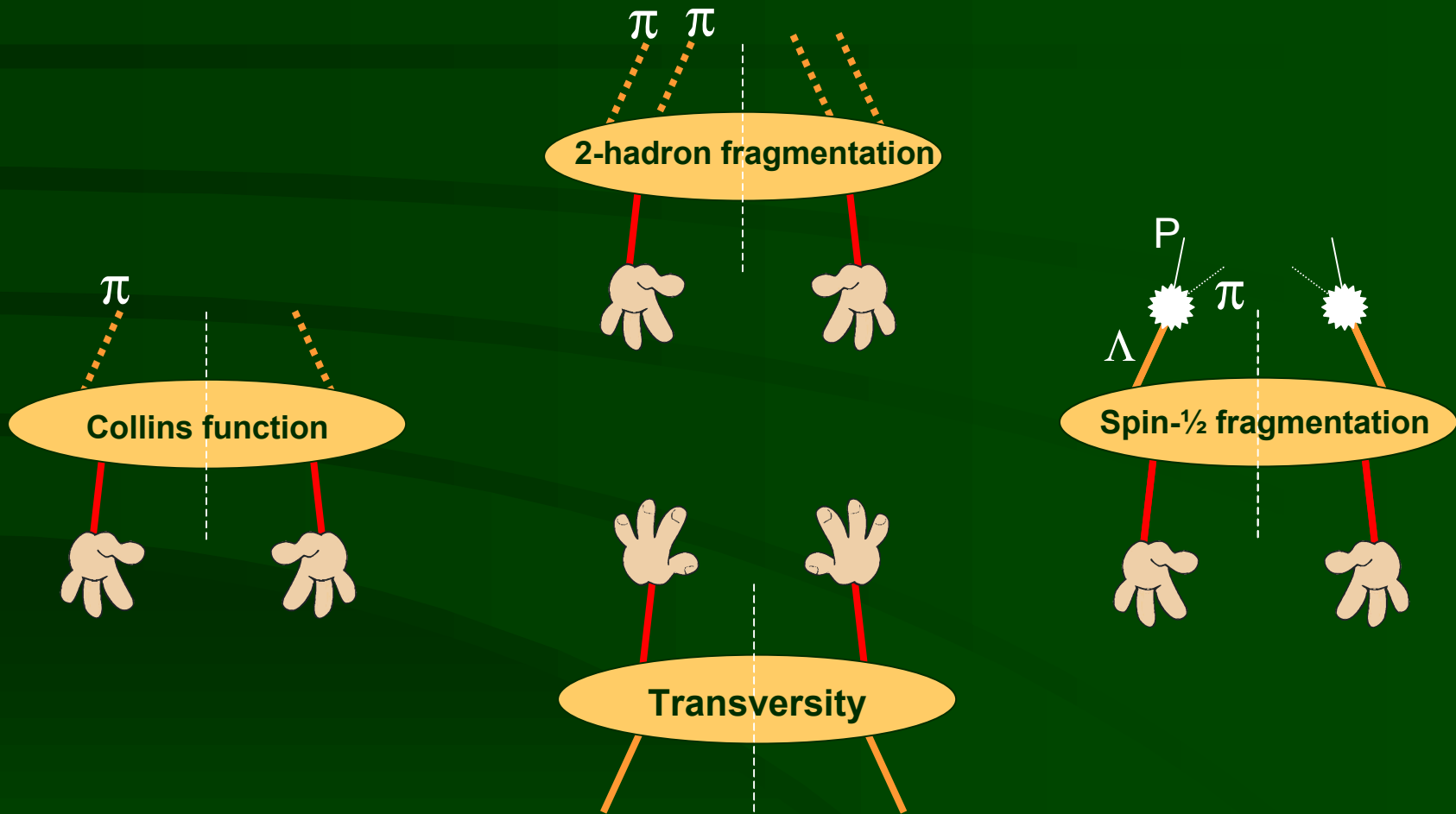
Chiral-odd fragmentation functions



A chiral partnership

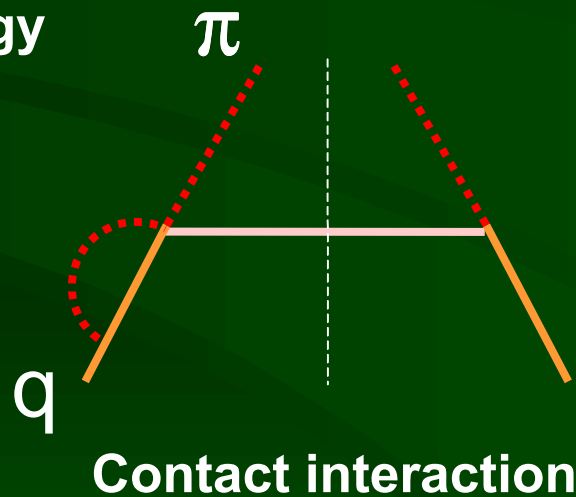
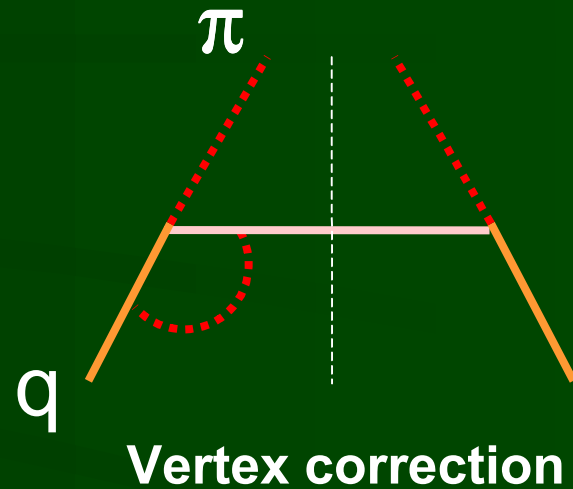
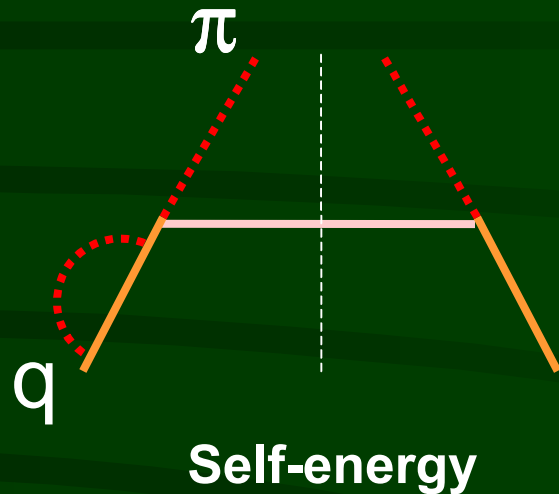


A chiral partner for transversity



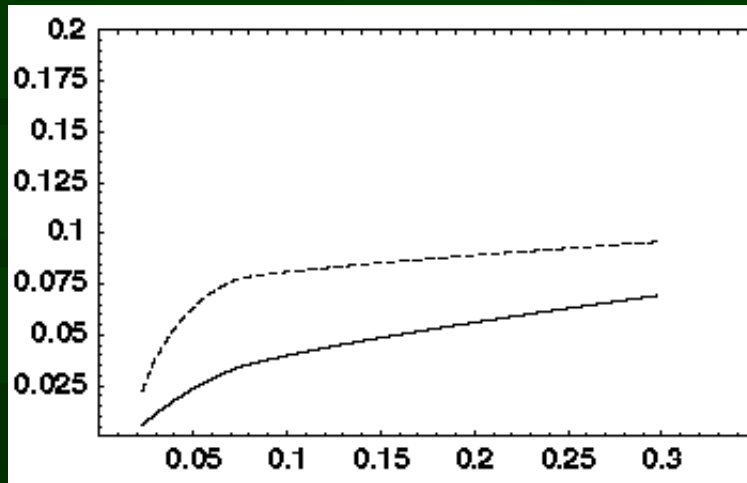
A model for the Collins function

A. B., R. Kundu, A. Metz, P. Mulders, PRD 65 (2002)

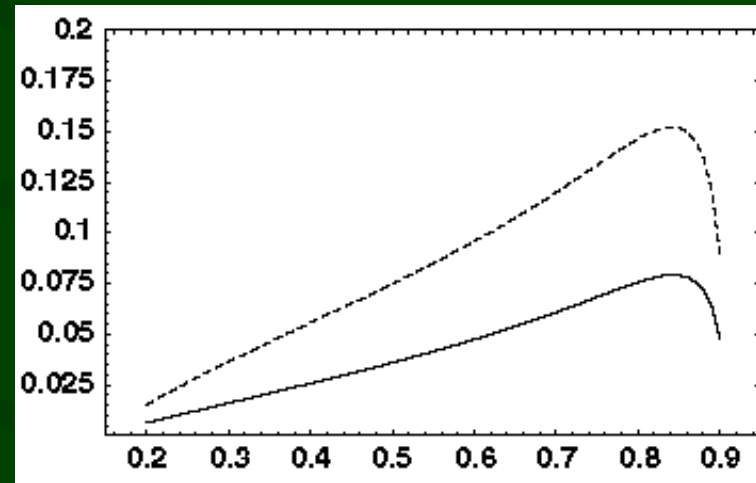


Predicted asymmetries

$$\langle \sin \phi \rangle_{UT}^{\pi^+}$$



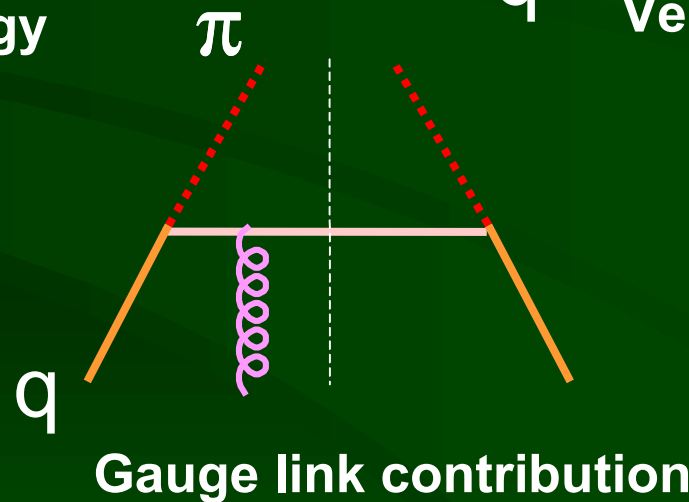
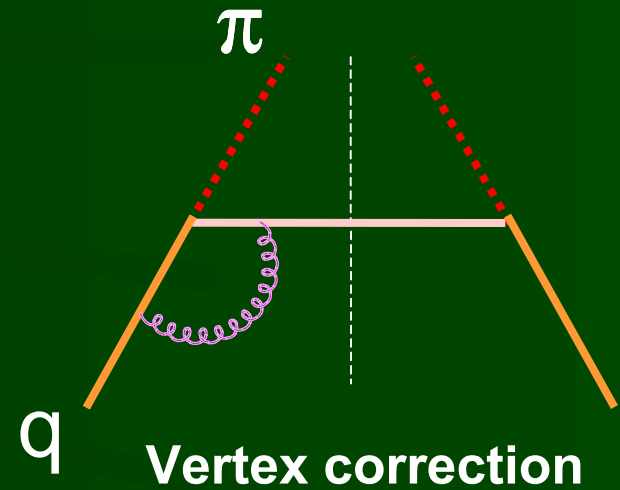
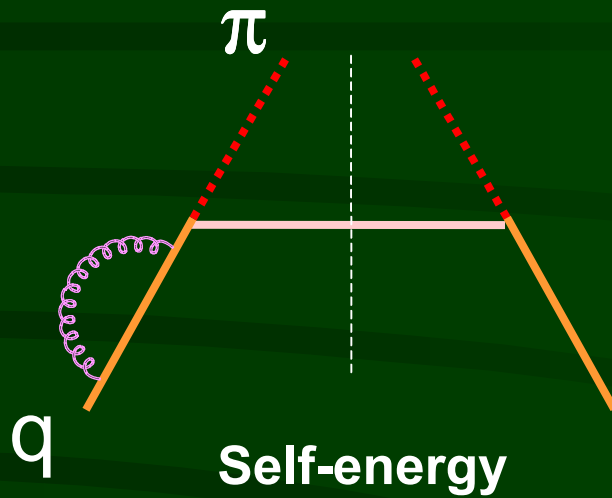
x



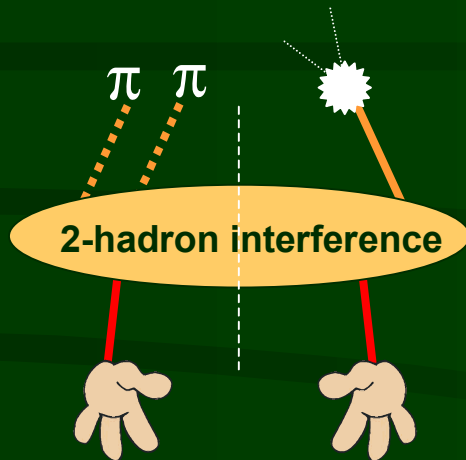
z

Collins function from gluons

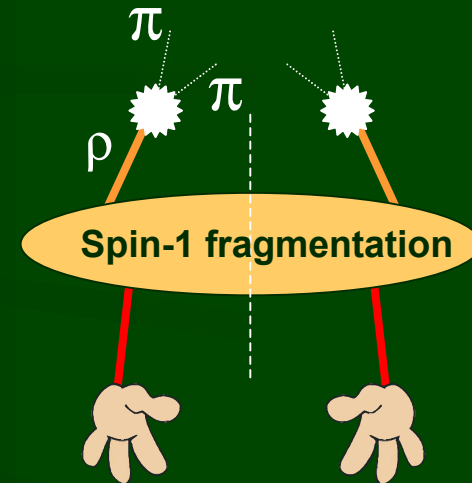
A. B., J. Yang, A. Metz



Two-hadron fragmentation functions



R. Jaffe, X. Jin, J. Tang, PRL 80 (1997)



A. B., P. Mulders, PRD 62 (2000)

$$d\sigma_{UT} \sim \sin(\phi_R + \phi_S) \sin\theta h_1 \left(\mathbf{H}_1^{s-p} + \cos\theta \mathbf{H}_1^{spin-1} \right)$$

A. B., M. Radici, PRD 67 (2003)

Spin-1 often neglected, but probably very important!

Subleading-twist analysis of two-hadron functions

A. B., M. Radici

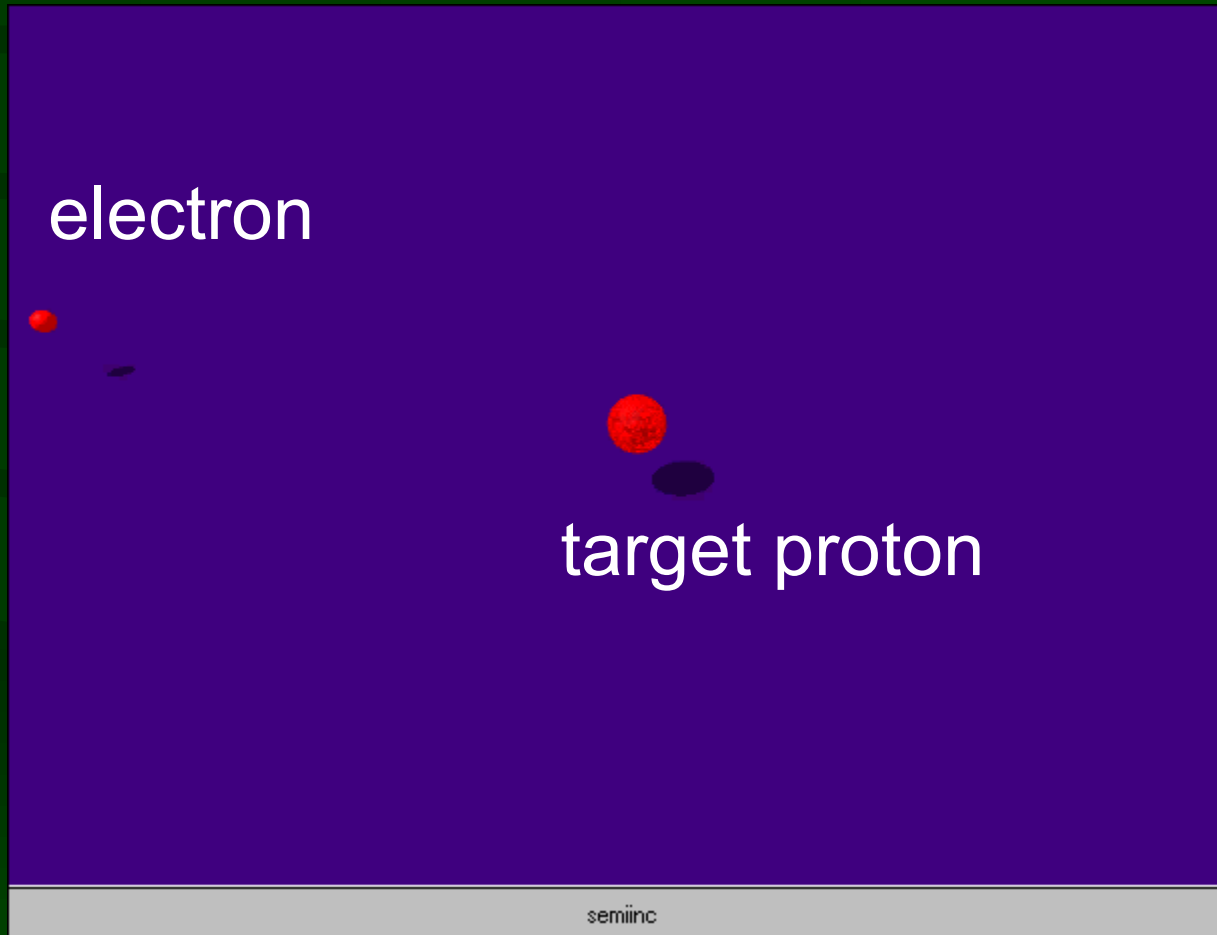
$$d\sigma_{UL} \sim \dots + \sin\phi_R \sin\theta h_1 \left(H_1^{s-p} + \cos\theta H_1^{spin-1} \right)$$

Conclusions

The hunt for transversity is going on...

...we are eagerly waiting for experimental data!

Deep inelastic scattering



Polarized function h_1

$$h_1 = \delta q = \frac{1}{2} \begin{array}{c} \uparrow \quad \downarrow \\ \diagdown \quad \diagup \\ \text{---} \\ \diagup \quad \diagdown \\ \uparrow \quad \downarrow \end{array}$$

$$|\uparrow\rangle = \frac{1}{\sqrt{2}} (|\rightarrow\rangle + |\leftarrow\rangle)$$

$$|\downarrow\rangle = -\frac{i}{\sqrt{2}} (|\rightarrow\rangle - |\leftarrow\rangle)$$

$$h_1 = \frac{1}{2} \begin{array}{c} \rightarrow \quad \rightarrow \\ \diagdown \quad \diagup \\ \text{---} \\ \diagup \quad \diagdown \\ \rightarrow \quad \rightarrow \end{array} - \begin{array}{c} \leftarrow \quad \leftarrow \\ \diagdown \quad \diagup \\ \text{---} \\ \diagup \quad \diagdown \\ \rightarrow \quad \rightarrow \end{array}$$

Transversity vs helicity

- Different evolution
- Different integrals (**axial** and **tensor charge** of the nucleon) from lattice QCD

$$\delta\Sigma \equiv \int h_1(x) dx \simeq 0.56, \quad \Delta\Sigma \equiv \int g_1(x) dx \simeq 0.18$$

S. Aoki et al., PRD 56 (1997)

- The difference between transversity and helicity has a dynamical origin

e.g. H. He, X. Ji, PRD 52 (1995)