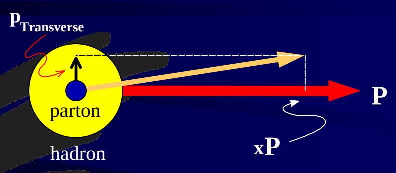
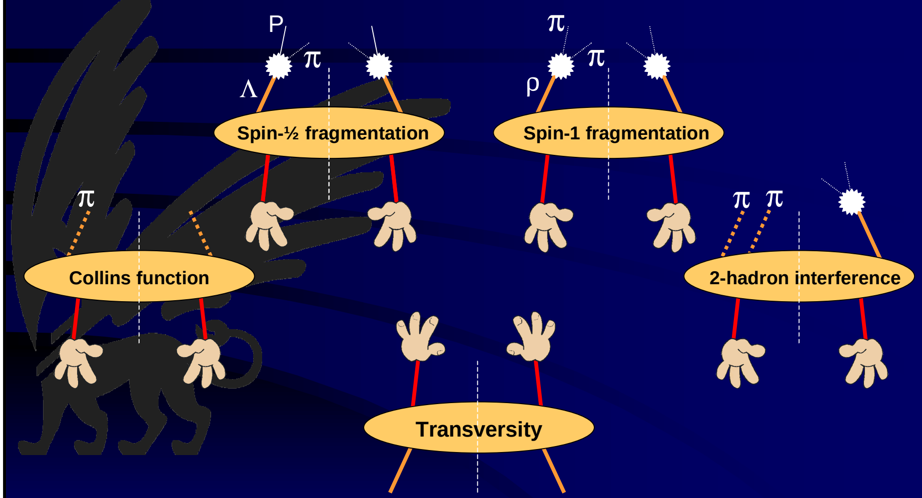
Inclusion of intrinsic transverse momentum



There are many more independent distribution functions and the puzzle becomes much bigger...

A chiral partner for transversity

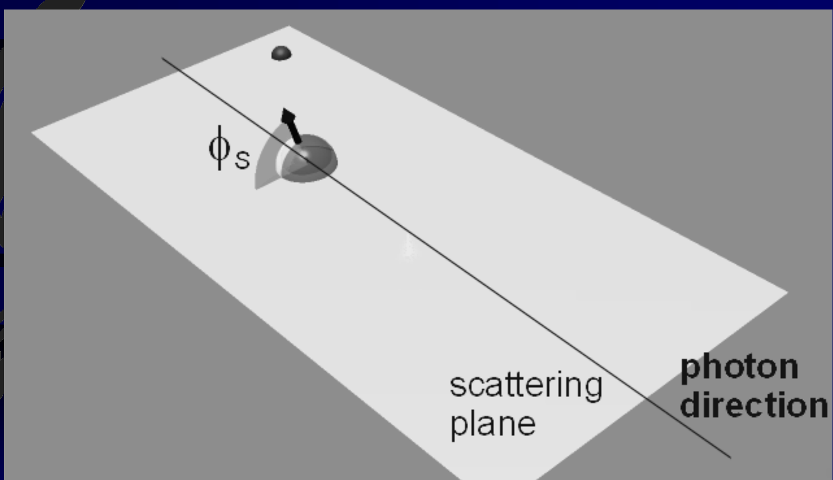


One-hadron transverse spin asymmetries

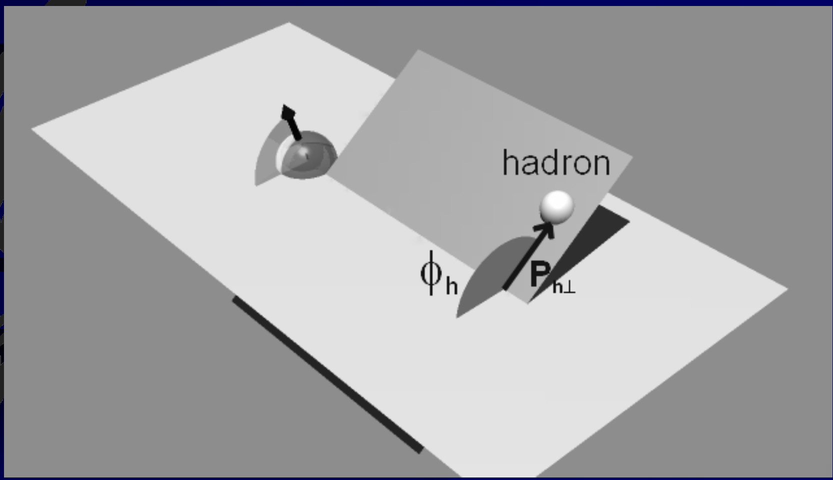
$$A_T = \frac{d^6\sigma^{\uparrow} - d^6\sigma^{\downarrow}}{d^6\sigma^{\uparrow} + d^6\sigma^{\downarrow}}$$

$$d^6\sigma = \frac{d^6\sigma}{dx\, dy\, dz\, d\left|\vec{P}_{h\perp}\right| d\phi_h\, d\phi_S}$$

Scattering plane angle



Hadron production angle



Unpolarized part

$$d^6\sigma^\uparrow + d^6\sigma^\downarrow \propto \left(1-y+\frac{y^2}{2}\right)\int d^2\vec{p}_T\, d^2\vec{k}_T\, \delta\left(\vec{p}_T - \frac{\vec{P}_{h\perp}}{z} - \vec{k}_T\right) f_1(x,p_T^2)\, D_1(z,-z^2k_T^2)$$

We can perform the integration over three variables

$$\int d\left|\vec{P}_{h\perp}\right| d\phi_h\, d\phi_S \left(d^6\sigma^\uparrow + d^6\sigma^\downarrow\right) \propto 2\pi\left(1-y+\frac{y^2}{2}\right) f_1(x)\, D_1(z)$$

Factorized

Polarized part

Transversity

$$d^6\sigma^\uparrow - d^6\sigma^\downarrow \propto (1-y)\sin(\phi_h+\phi_S)$$

$$\int d^2\vec{p}_T\, d^2\vec{k}_T\, \delta\left(\vec{p}_T - \frac{\vec{P}_{h\perp}}{z} - \vec{k}_T\right)\frac{\vec{P}_{h\perp}\cdot\vec{k}_T}{|\vec{P}_{h\perp}|\, M_h}\, h_1(x,p_T^2)\; H_1^\perp(z,-z^2k_T^2)$$

Collins function

The transversity appears in a complicated convolution with the Collins function

Factorizing the polarized part

$$d^6\sigma^\uparrow - d^6\sigma^\downarrow \propto (1-y)\sin(\phi_h+\phi_S)$$

$$\int d^2\vec{p}_T\, d^2\vec{k}_T\, \delta\left(\vec{p}_T - \frac{\vec{P}_{h\perp}}{z} - \vec{k}_T\right)\frac{\vec{P}_{h\perp}\cdot\vec{k}_T}{|\vec{P}_{h\perp}|\, M_h}\, h_1(x,p_T^2)\, H_1^\perp(z,-z^2k_T^2)$$

The only rigorous way to get a factorized expression is by weighting the integral

$$\int d|\vec{P}_{h\perp}|\, d\phi_h\, d\phi_S\, \sin(\phi_h+\phi_S)\frac{|\vec{P}_{h\perp}|}{M_h}\left(d^6\sigma^\uparrow - d^6\sigma^\downarrow\right)$$

$$\propto 2\pi(1-y)\, h_1(x)\, z^3 \int d^2\vec{k}_T\, \frac{k_T^2}{2M_h^2}\, H_1^\perp(z,-z^2k_T^2)$$

$$= 2\pi(1-y)\, h_1(x)\, z\, H_1^{\perp(1)}(z)$$

Factorized

The factorized expression should not be spoiled by perturbative corrections

A. Henneman, D. Boer, P. Mulders, hep-ph/0104271 (to appear in NPB)

Azymuthal asymmetry weighted with $\left|\vec{P}_{h\perp}\right|$

$$A_T \left\langle \frac{\left|\vec{P}_{h\perp}\right|}{M_h} \sin(\phi_h + \phi_S) \right\rangle (x, y, z) = \frac{(1-y)}{\left(1 - y + \frac{y^2}{2}\right)} \frac{h_1(x)\, z\, H_1^{\perp(1)}(z)}{f_1(x)\, D_1(z)}$$

Weighting factor in the numerator

Factorizing the polarized part

$$d^6\sigma^\uparrow - d^6\sigma^\downarrow \propto (1-y)\sin(\phi_h + \phi_S)$$

$$\int d^2\vec{p}_T\, d^2\vec{k}_T\, \delta\left(\vec{p}_T - \frac{\vec{P}_{h\perp}}{z} - \vec{k}_T\right) \frac{\vec{P}_{h\perp}\cdot\vec{k}_T}{\left|\vec{P}_{h\perp}\right| M_h} h_1(x, p_T^2)\, H_1^\perp(z, -z^2 k_T^2)$$

If we don't weight with $\left|\vec{P}_{h\perp}\right|$, we have to make simplifying assumptions on the intrinsic transverse momentum distribution. For instance:

$$h_1(x, p_T^2) \to h_1(x)\frac{\delta(p_T^2)}{\pi}$$

$$\int d^2\vec{P}_{h\perp}\, d\phi_S\, \sin(\phi_h + \phi_S)\left(d^6\sigma^\uparrow - d^6\sigma^\downarrow\right)$$

$$\propto 2\pi(1-y) h_1(x) z^2 \int d^2\vec{k}_T\, \frac{\left|\vec{k}_T\right|}{2M_h} H_1^\perp(z, -z^2 k_T^2)$$

$$= 2\pi(1-y) h_1(x)\, H_1^{\perp(1/2)}(z)$$

Factorized, but with problems