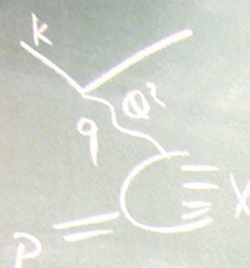
A. DIS:

$$\sum_X \left| \; \right|^2$$



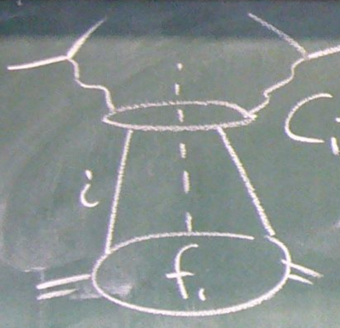
$Q^2 = -q^2$

$x = \frac{Q^2}{2pq}, \quad y = \frac{qp}{kp}$

$Q^2 = sxy$

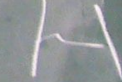
$$\frac{d^2\sigma}{dx\,dQ^2} = \frac{4\pi\alpha^2}{Q^4}\left[(1+(1-y)^2)F_2 + \frac{1-y}{x}\left(F_2 - 2xF_1\right)\right]$$

$$F_2(x,Q^2) = x\sum_q e_q^2 \int_x^1 \frac{d\xi}{\xi}\, q(\xi,Q^2)\, C_q\!\left(\frac{x}{\xi}\right) + x\sum_q e_q^2 \int \frac{d\xi}{\xi}\, g(\xi,Q^2)\, C_g\!\left(\frac{x}{\xi}\right)$$

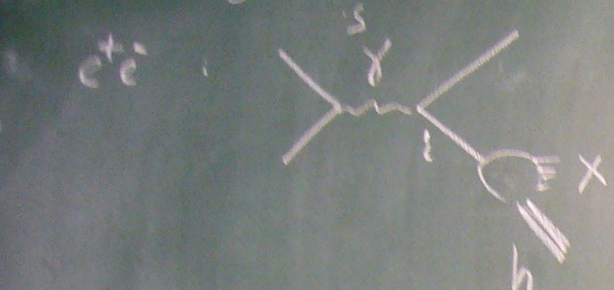


$$= x\sum_f e_f^2 \sum_i \int_x^1 \frac{d\xi}{\xi}\, \underline{f_i(\xi,Q^2)}\; \underline{C_i\!\left(\frac{x}{\xi}\right)} \qquad t = \ln\frac{Q^2}{\mu^2}$$

$$t\frac{\partial}{\partial t} f_i(x,t) = \frac{\alpha_s(t)}{2\pi}\sum_j \int_x^1 \frac{dz}{z}\, P_{ij}(z)\, f_j\!\left(\frac{x}{z},t\right)$$

$t\frac{\partial}{\partial t}$  $= \ldots$  $\leftarrow P_{ij}(z)$ 

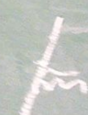
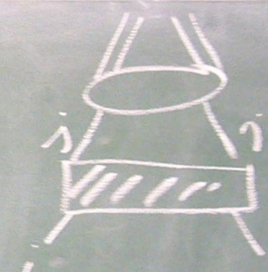
C, P: have expansion in powers of α_s



$$F_h(x,s) = \frac{1}{\sigma_{tot}} \frac{d\sigma}{dx} (e^+e^- \to h X)$$

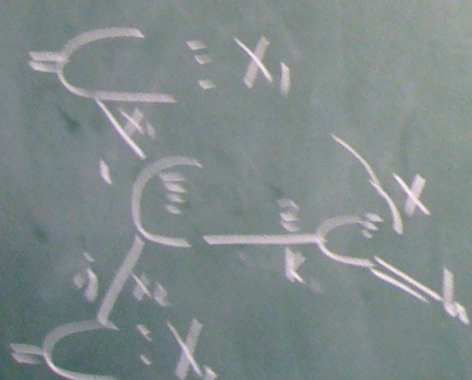
$$F_h(x,s) = \sum_i \int_x^1 \frac{dz}{z} C_i(s,z) \underline{D_i^h\left(\frac{x}{z}, s\right)}$$

$$t\frac{\partial}{\partial t} D_i^h(x,s) = \frac{\alpha_s}{2\pi} \sum_j \int_x^1 \frac{dz}{z} P_{ji}(z) D_j^h\left(\frac{x}{z}, t\right)$$

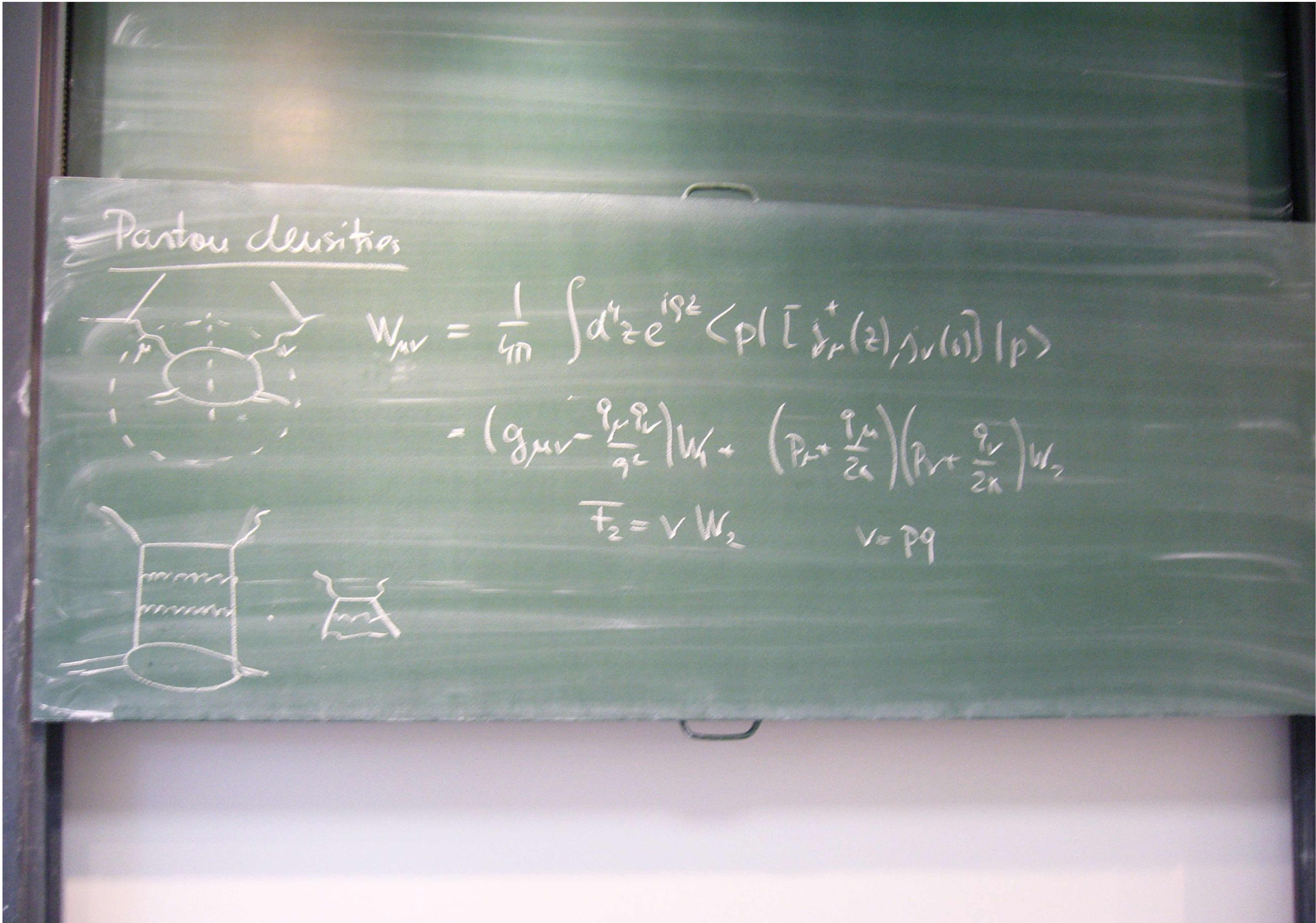
$t\frac{\partial}{\partial t}$    P_{ji}

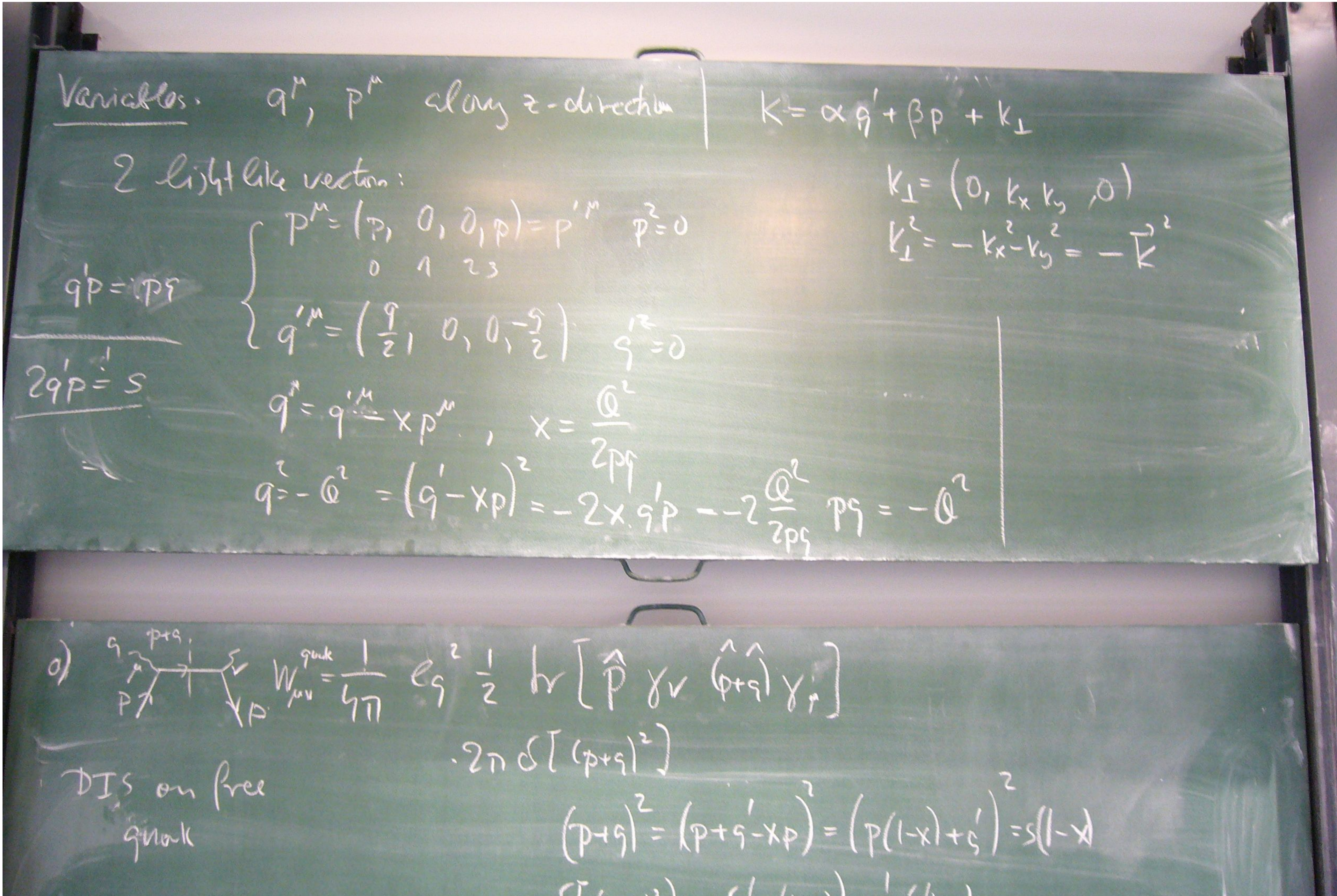
comp. in pQCD

D: pp-scattering, hadroproduction



$$E_h \frac{d\sigma}{d^3p_h} = \sum_{i,j,k} \int dx_1 dx_2 \int \frac{dz}{z} f_i(x_1) f_j(x_2) \, |k_k| \, \frac{d\hat{\sigma}}{d^3k_k}\left(\frac{k_k}{2\sqrt{s}}\right) D_k^h(z)$$


Parton densities
$W_{\mu\nu} = \frac{1}{4\pi} \int d^4z\, e^{iqz} \langle p | [j^+_\mu(z), j_\nu(0)] | p \rangle$
$= \left(g_{\mu\nu} - \frac{q_\mu q_\nu}{q^2}\right) W_1 + \left(p_\mu + \frac{q_\mu}{2x}\right)\left(p_\nu + \frac{q_\nu}{2x}\right) W_2$
$F_2 = \nu W_2$
$\nu = pq$


Variables: q^μ, p^μ along z-direction
$k = \alpha q' + \beta p + k_\perp$
2 lightlike vectors:
$p^\mu = (p, 0, 0, p) = p'^\mu \quad p^2 = 0$
0 1 2 3
$k_\perp = (0, k_x\, k_y, 0)$
$k_\perp^2 = -k_x^2 - k_y^2 = -\vec{k}^2$
$q'p = pq$
$q'^\mu = \left(\frac{q}{2}, 0, 0, -\frac{q}{2}\right) \quad q'^2 = 0$
$2q'p \stackrel{!}{=} s$
$q^\mu = q'^\mu - x p^\mu, \quad x = \frac{Q^2}{2pq}$
$q^2 = -Q^2 = (q' - xp)^2 = -2x\, q'p = -2\frac{Q^2}{2pq}\, pq = -Q^2$
a)
q
$p+q$
p
p
$W_{\mu\nu}^{quark} = \frac{1}{4\pi} e_q^2 \frac{1}{2} \mathrm{tr}\left[\hat{p}\, \gamma_\nu\, (\hat{p}+\hat{q})\, \gamma_\mu\right]$
$\cdot 2\pi\, \delta[(p+q)^2]$
DIS on free quark
$(p+q)^2 = (p+q'-xp)^2 = (p(1-x)+q')^2 = s(1-x)$

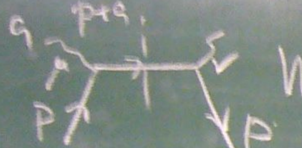
$$\text{0 1 2 3}$$

$$q'p = pq \qquad q'^{\mu} = \left(\frac{q}{2}, 0, 0, -\frac{q}{2}\right) \qquad q'^2 = 0$$

$$p = s$$

$$q^{\mu} = q'^{\mu} - x p^{\mu}, \quad x = \frac{Q^2}{2pq}$$

$$q^2 = -Q^2 = (q' - xp)^2 = -2x\, q'p = -2\frac{Q^2}{2pq}\, pq = -Q^2$$

a) 

$$W^{quark}_{\mu\nu} = \frac{1}{4\pi} e_q^2 \, \frac{1}{2} \, \mathrm{tr}\left[\hat{p}\, \gamma_\nu\, (\hat{p}+\hat{q})\, \gamma_\mu\right] \cdot 2\pi\, \delta\left[(p+q)^2\right]$$

DIS on free quark

$$(p+q)^2 = (p+q'-xp)^2 = \left(p(1-x)+q'\right)^2 = s(1-x)$$

$$\delta\left[(p+q)^2\right] = \delta\left(s(1-x)\right) = \frac{1}{s}\delta(1-x)$$

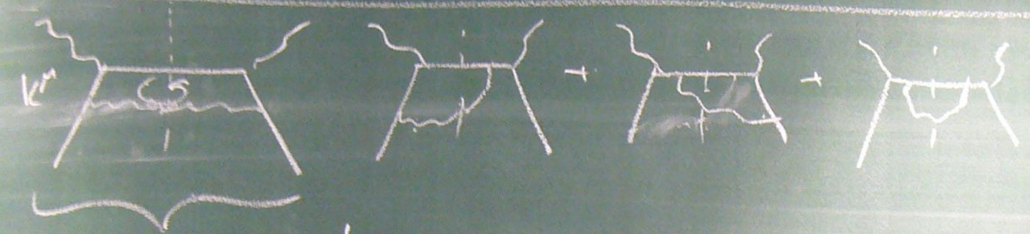
$$\mathrm{tr}\left[\hat{a}\hat{b}\hat{c}\hat{d}\right] = 4\left(ab\, cd + ad\, bc - ac\, bd\right)$$

$$\mathrm{tr}\left[\hat{p}\gamma_\nu(\hat{p}+\hat{q})\gamma_\mu\right] = 8 p_\nu p_\mu + 4(p_\mu q_\nu + p_\nu q_\mu) - 4 g_{\mu\nu}\, p(p+q)$$

$$W_2^{quark} = 2 e_q^2 \, \delta\left[s(1-x)\right]$$

$$F_2^{quark} = \nu W_2^{quark} = e_q^2\,\delta(1-x) \qquad \frac{2\nu}{s} = \frac{2ps}{2pi}$$

$O(\alpha_s)$: k^μ



$\underline{\alpha_s \ln \frac{Q^2}{\mu^2}}$

$$\int_0^1 \frac{dx}{xs+a} = \frac{1}{s}\int_0^s \frac{dx'}{x'+a} = \frac{1}{s}\ln(x'+a)\Big|_0^s = \frac{1}{s}\ln\frac{s+a}{a} = \underline{\frac{1}{s}\left[\ln\frac{s}{a} + O\left(\frac{1}{s}\right)\right]}$$

$x' = xs$

$s \gg a$

$x < 1$

$a < xs$

$$\int_0^1 \frac{dx}{xs+a} \sim \int_{a/s}^1 \frac{dx}{xs} = \frac{1}{s}\ln x\Big|_{a/s}^{1} = \frac{1}{s}\ln\frac{s}{a}$$