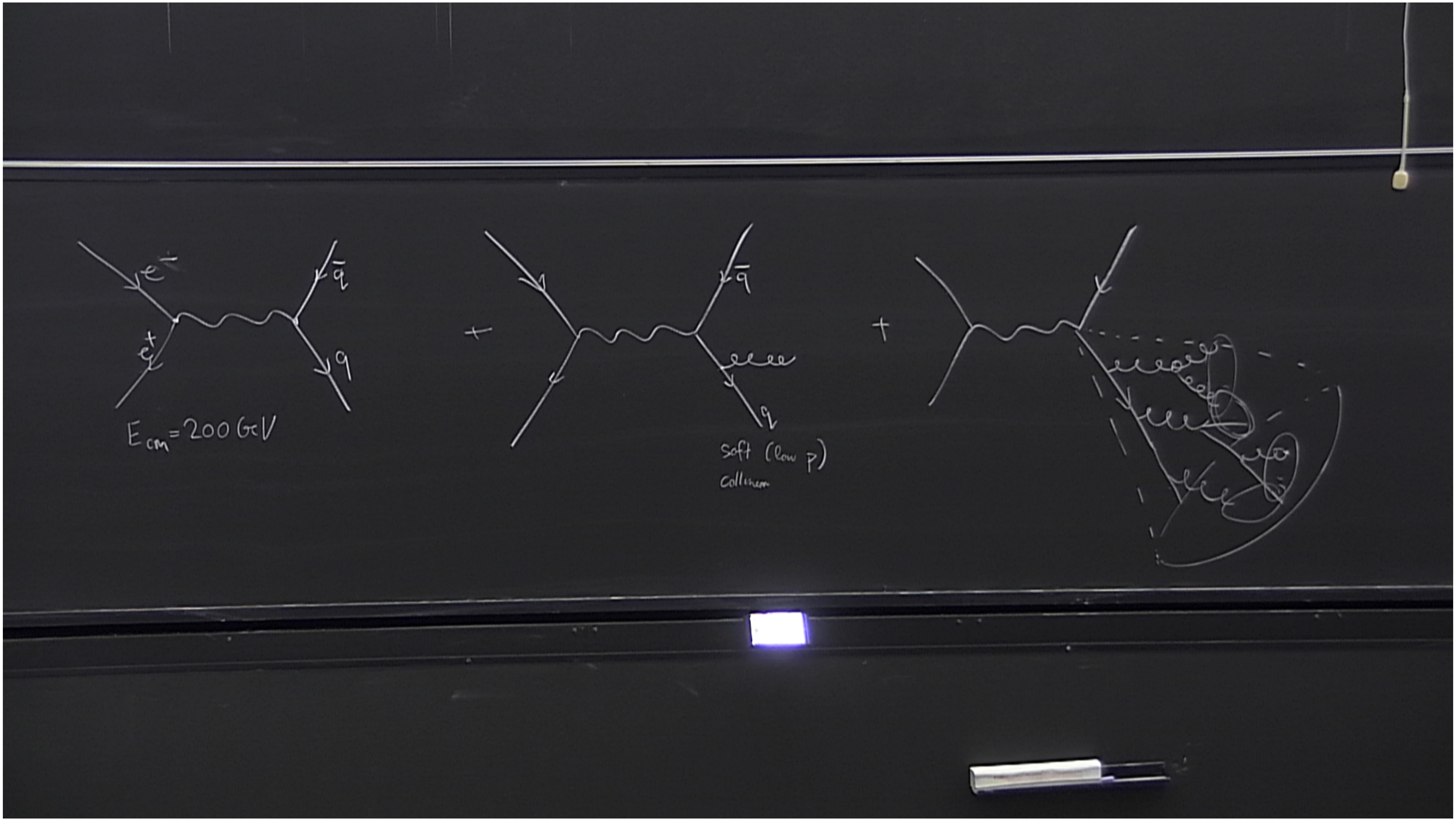
Title: Standard Model (Review) - Lecture 12

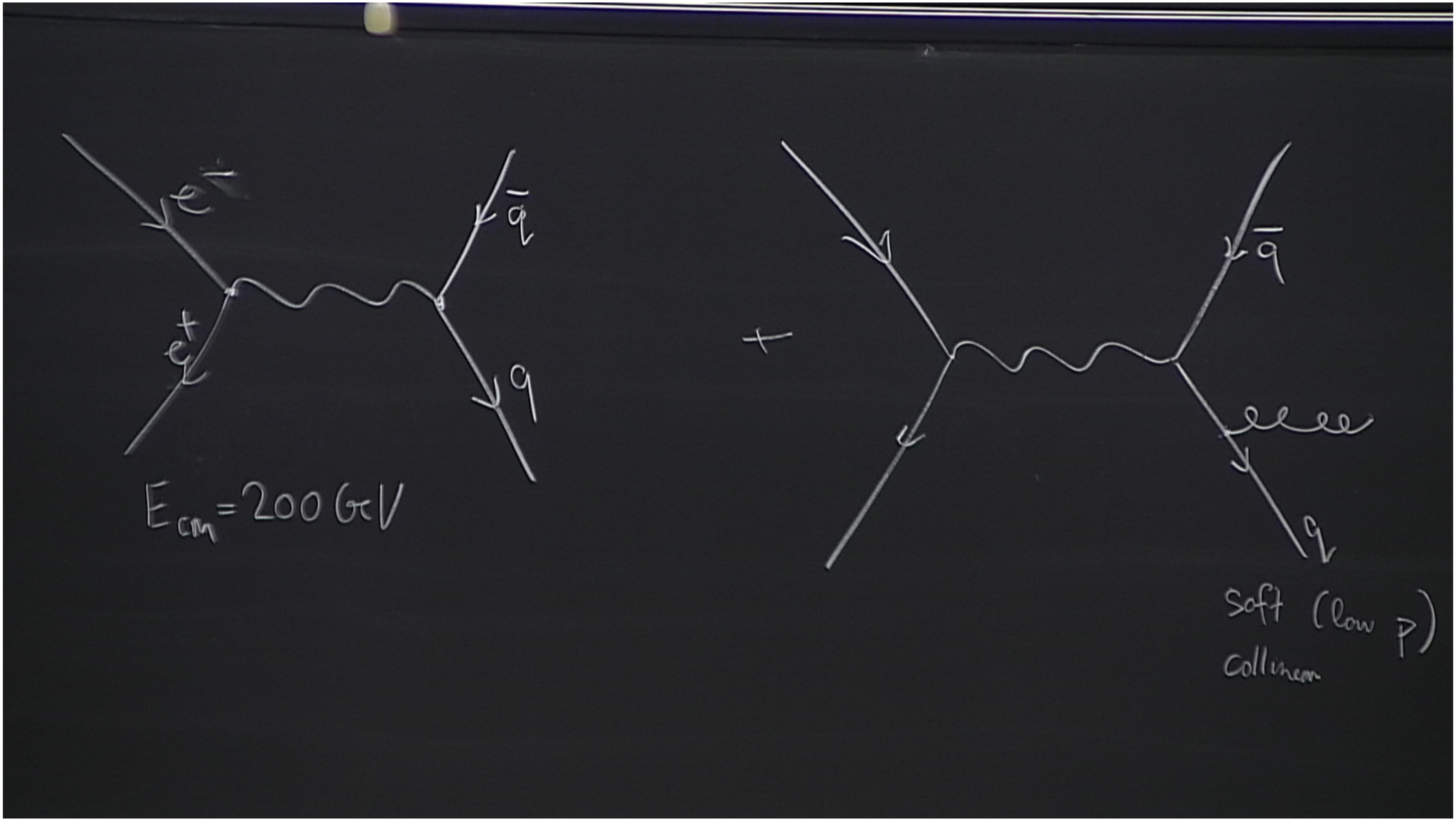
Date: Jan 17, 2012 09:00 AM

URL: http://pirsa.org/12010015

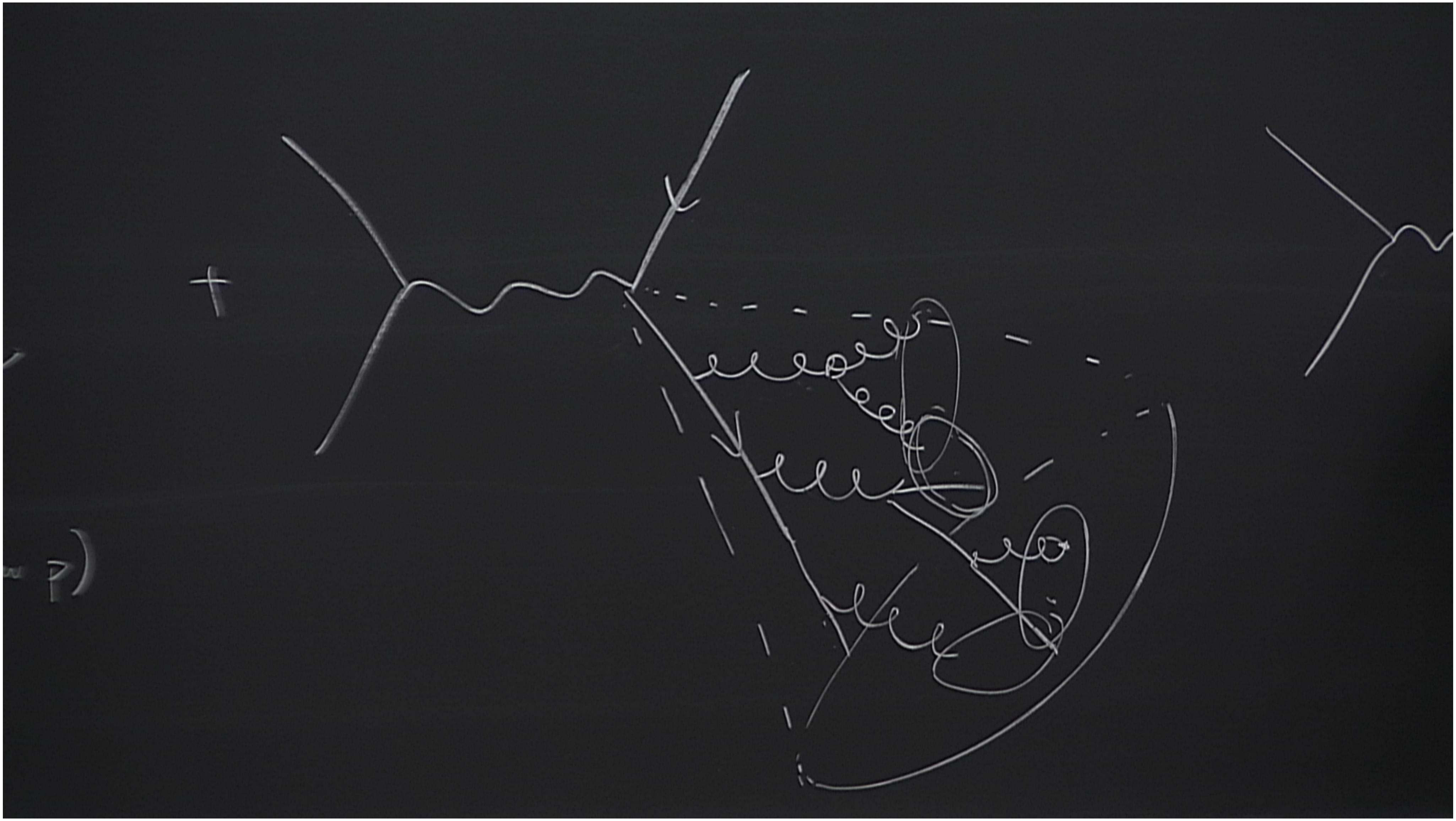
Abstract:

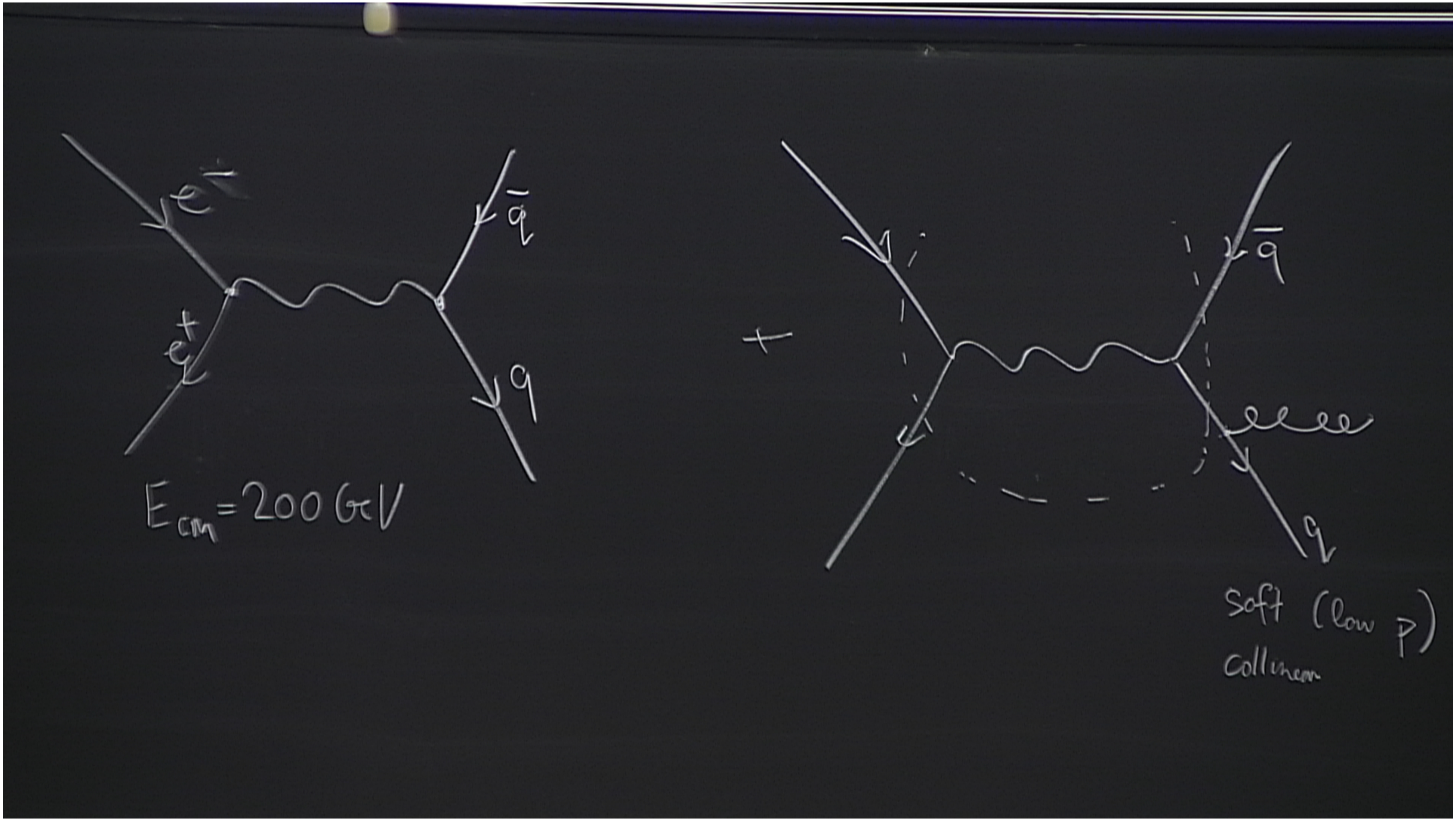


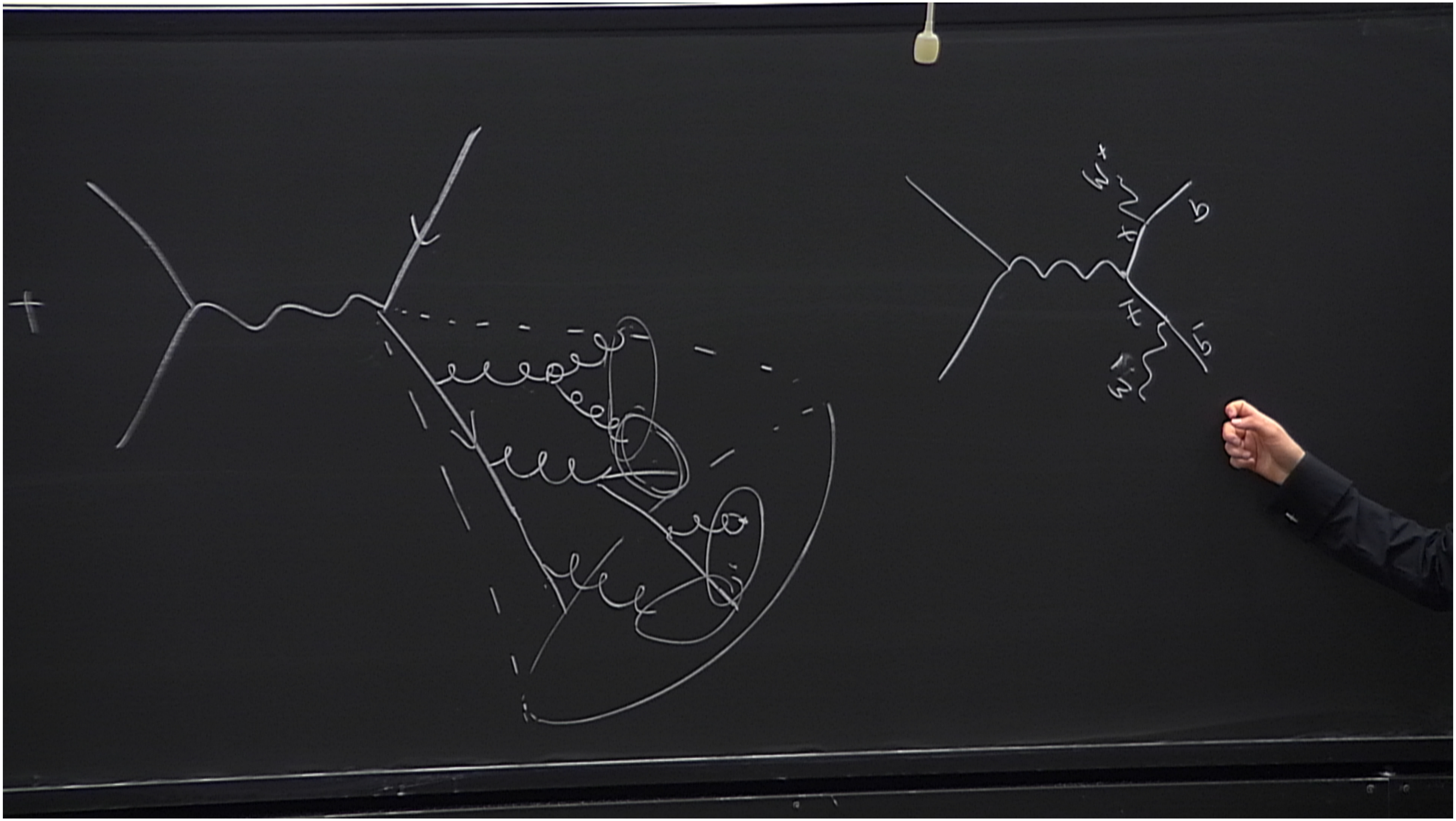
e⁻
e⁺
q̄
q
E_cm = 200 GeV
+
q̄
q
soft (low p)
collinear
+



e^-
$\bar{q}$
e^+
q
$E_{cm} = 200\,GeV$
$+$
$\bar{q}$
q
soft (low p)
collinear

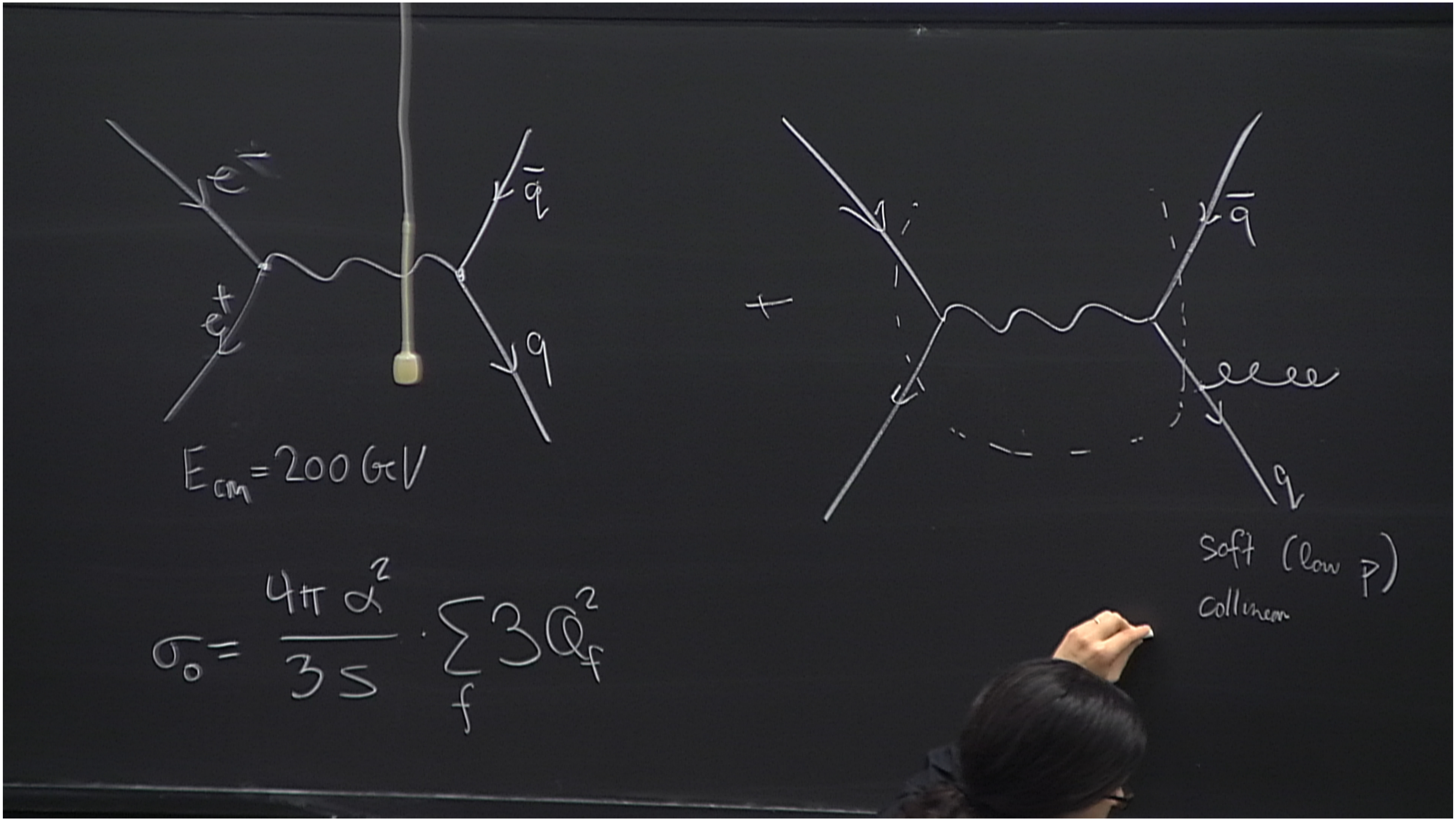


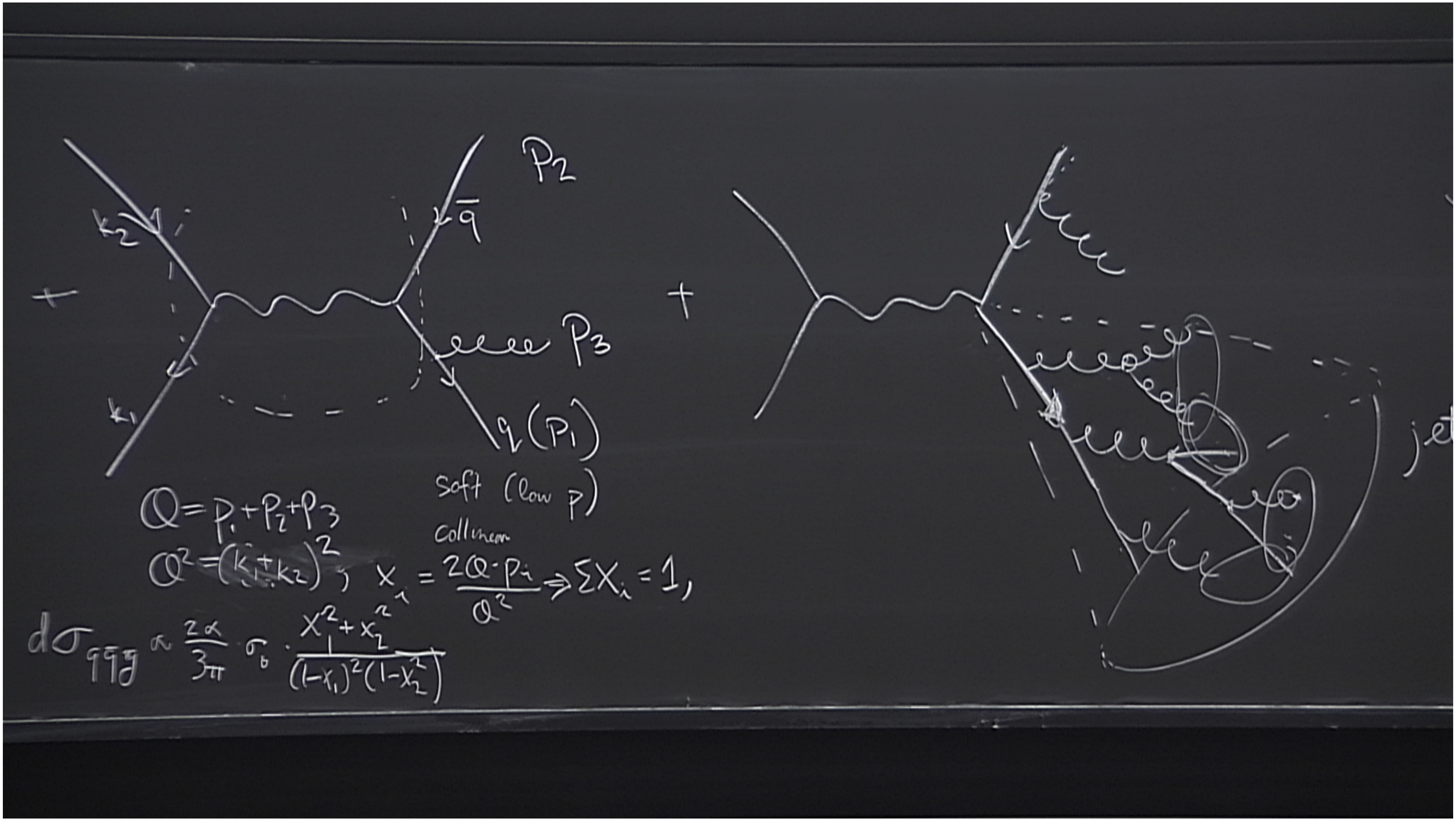

e⁻
q̄
e⁺
q
E_cm = 200 GeV
+
q̄
q
Soft (low p)
collinear

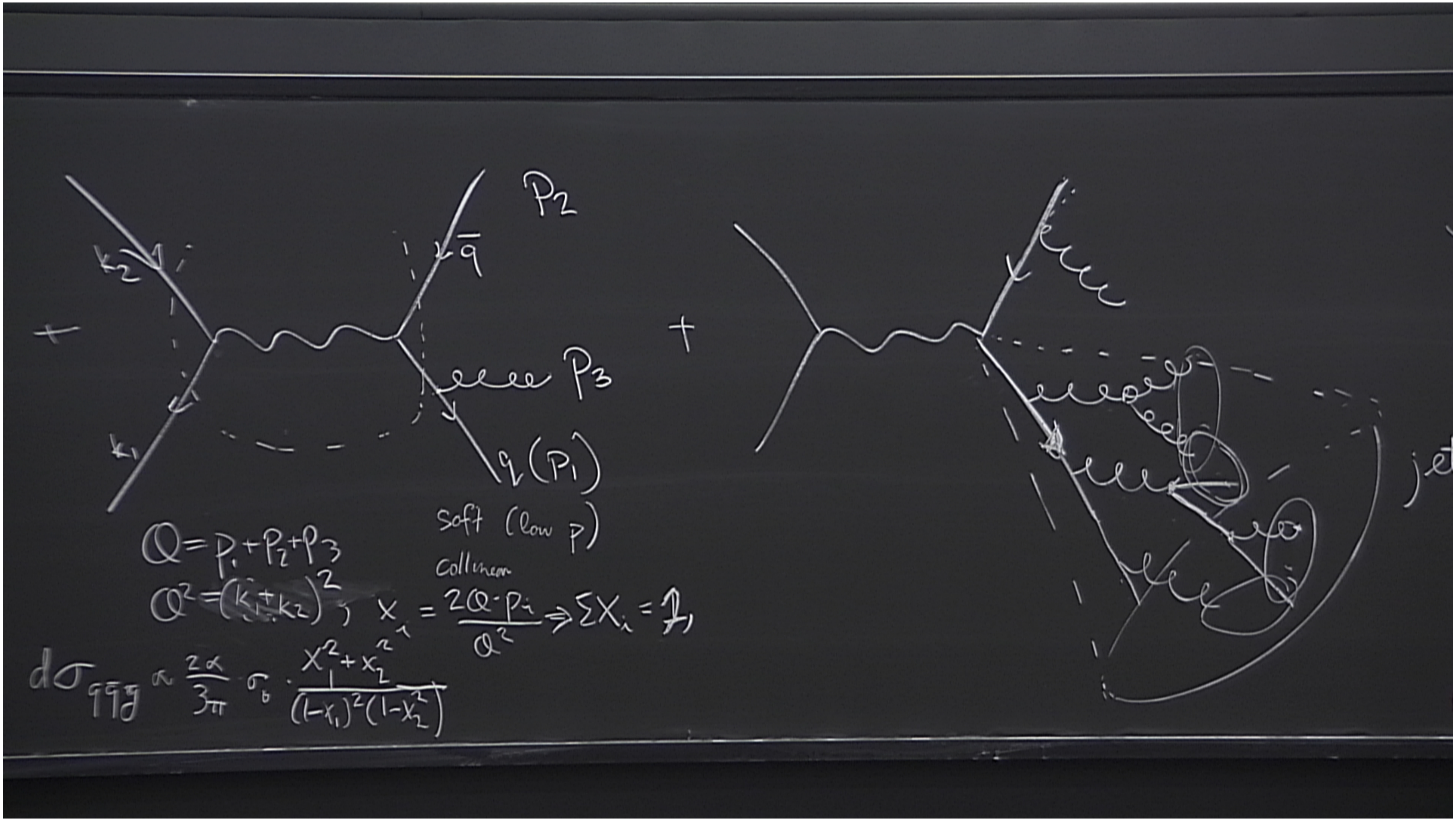


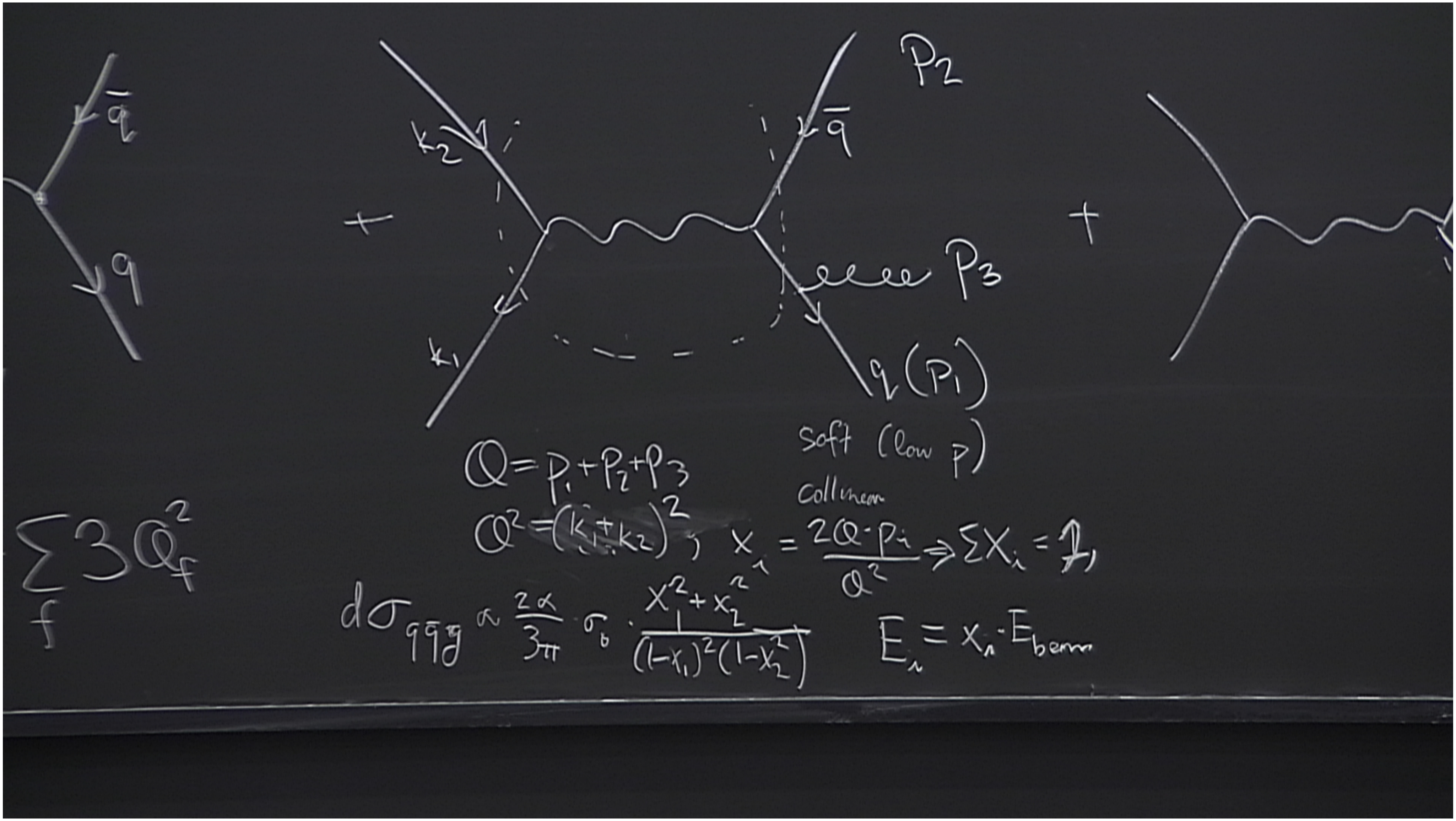
W^+
t
b
$\bar{t}$
$\bar{b}$
W^-

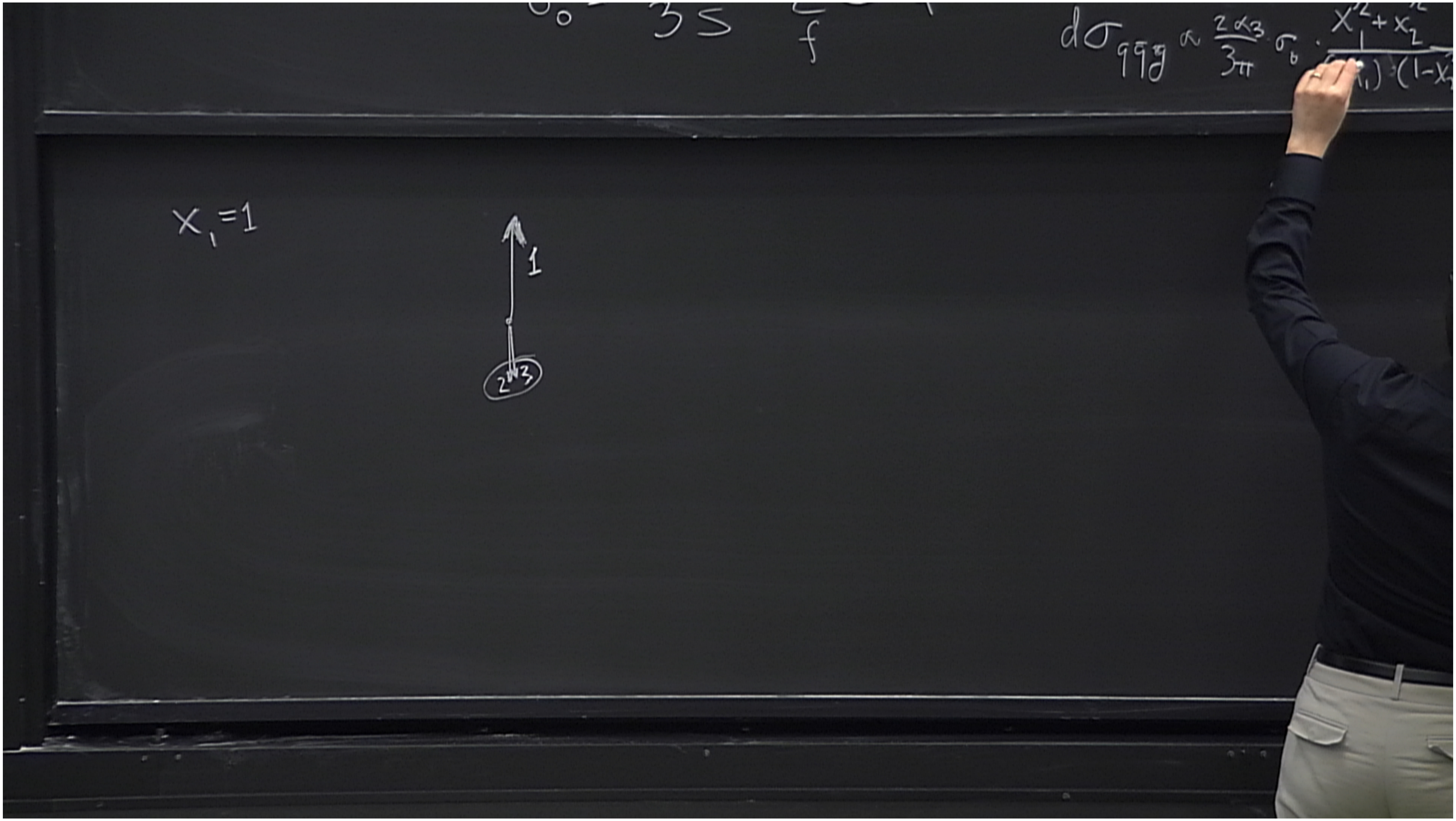

q̄
q
soft (low p)
collinear
+
jets
b
b̄

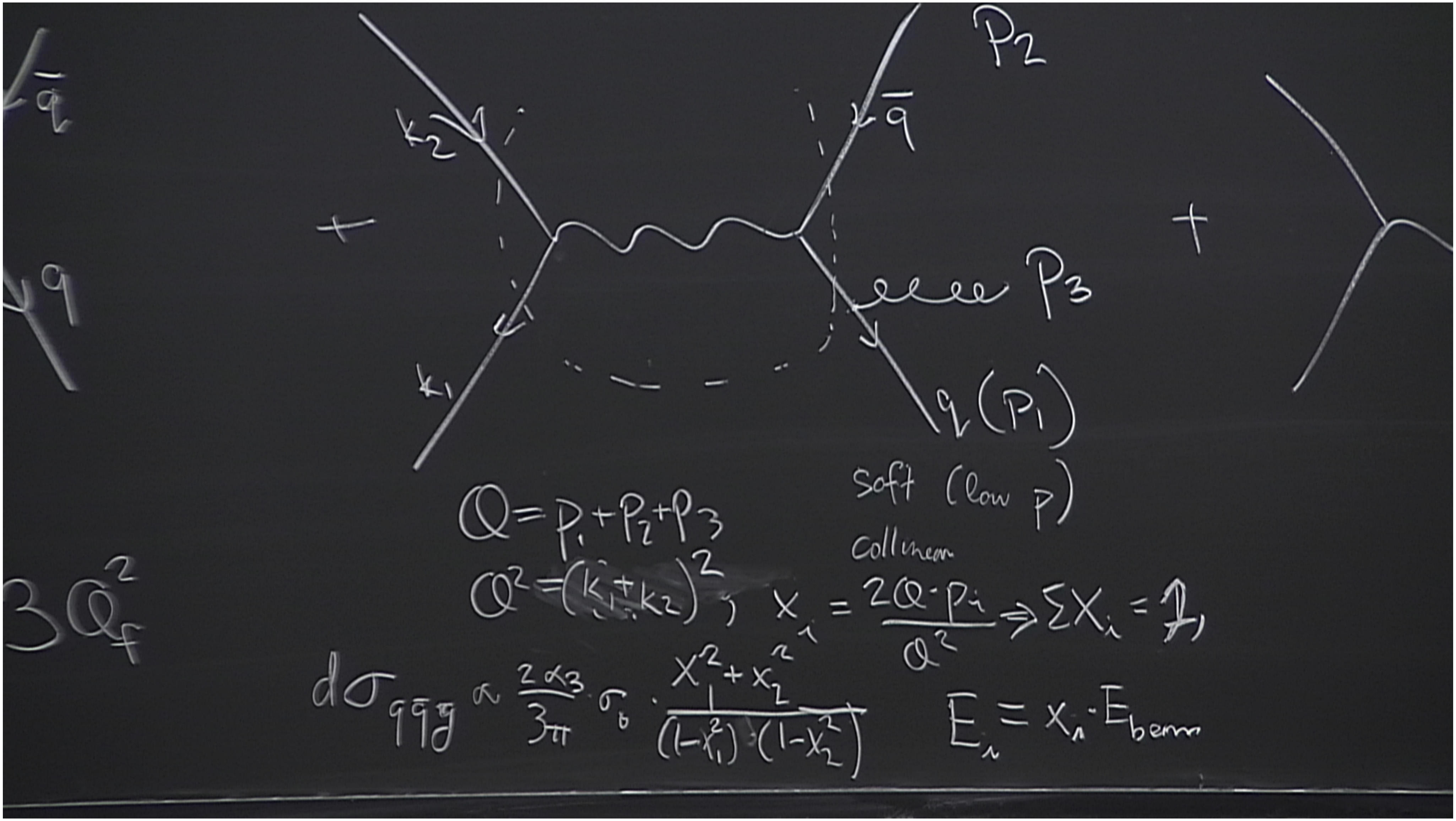

e^-
$\bar{q}$
e^+
q
$E_{cm} = 200\ \mathrm{GeV}$
$\sigma_0 = \frac{4\pi\alpha^2}{3s} \cdot \sum_f 3Q_f^2$
+
$\bar{q}$
q
soft (low p)
collinear

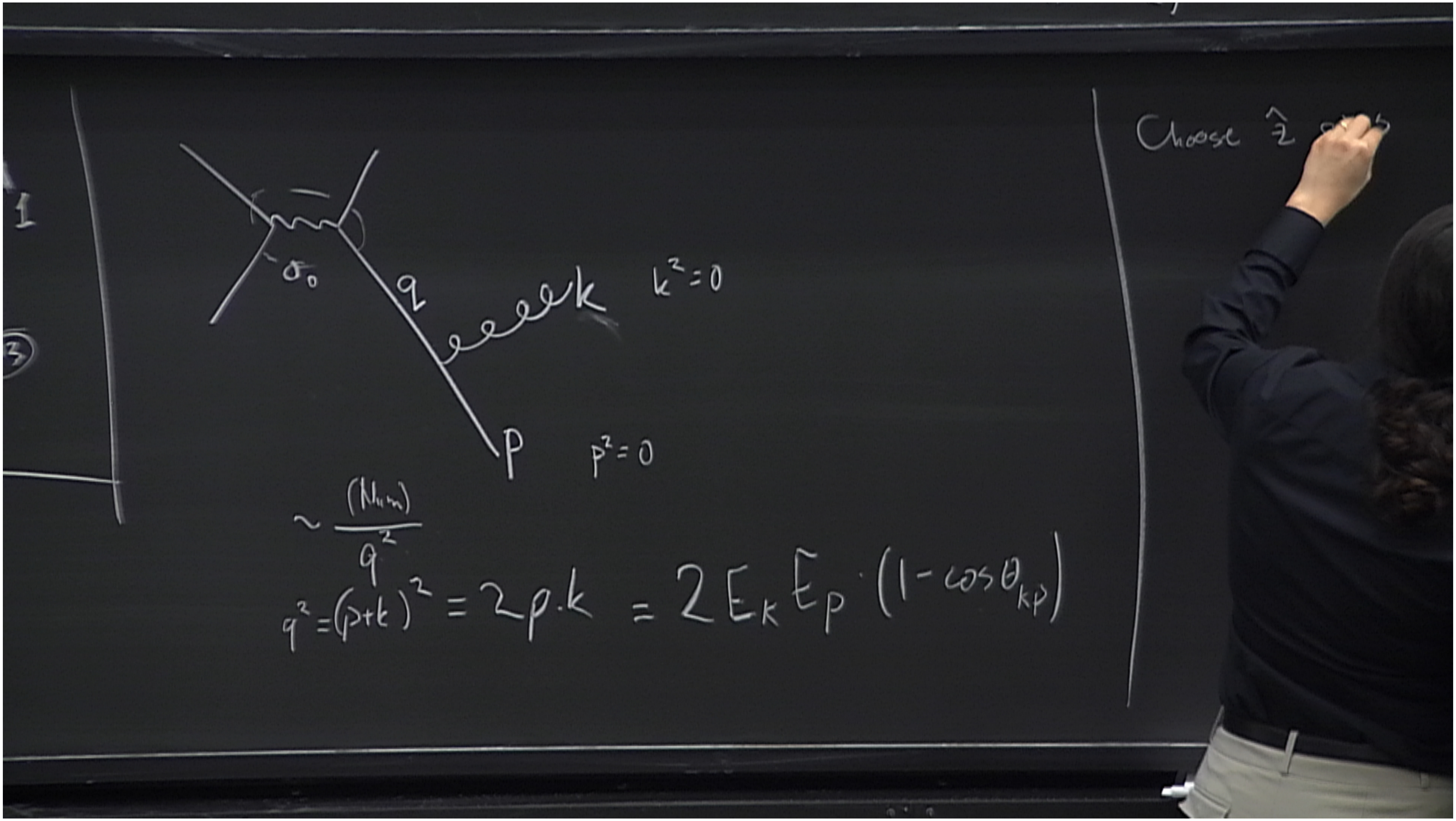

p_2
$\bar{q}$
k_2
k_1
$+$
p_3
$q(p_1)$
soft (low p)
collinear
$Q = p_1 + p_2 + p_3$
$Q^2 = (k_1 + k_2)^2$, $x_i = \frac{2Q \cdot p_i}{Q^2} \Rightarrow \sum x_i = 1$,
$d\sigma_{q\bar{q}g} \propto \frac{2\alpha}{3\pi} \sigma_0 \cdot \frac{x_1^2 + x_2^2}{(1-x_1)^2(1-x_2^2)}$
$+$
jet


P_2
k_2
$\bar{q}$
$+$
P_3
k_1
$q(P_1)$
soft (low p)
collinear
$Q = P_1 + P_2 + P_3$
$Q^2 = (k_1 + k_2)^2$, $x_i = \frac{2Q\cdot p_i}{Q^2} \Rightarrow \sum X_i = 2$,
$d\sigma_{q\bar{q}g} \propto \frac{2\alpha}{3\pi} \sigma_0 \cdot \frac{x_1^2 + x_2^2}{(1-x_1)^2(1-x_2^2)}$
$+$
jet


q̄
q
k2
k1
q̄
P2
P3
q(p1)
soft (low p)
collinear
Q = p1 + p2 + p3
Q² = (k1 + k2)²
x_i = 2Q·p_i / Q² ⇒ ΣX_i = 2
dσ_qq̄g ∝ (2α / 3π) · σ0 · (x1² + x2²) / ((1−x1)²(1−x2²))
E_i = x_i · E_beam
Σ_f 3Q_f²


dσ qq̄g ∝ 2αs/3π σ0
x1=1
1
2 3


P2
q̄
k2
P3
k1
q (P1)
soft (low p)
collinear
Q = p1 + p2 + p3
Q² = (k1 + k2)²
x_i = 2Q·p_i / Q² ⇒ ΣX_i = 2
3Q_f²
dσ_qq̄g ∝ 2α3/3π · σ0 · (x1² + x2²) / ((1 − x1²)·(1 − x2²))
E_i = x_i · E_beam


Choose $\hat{z}$
σ_0
q
k
$k^2=0$
p
$p^2=0$
$\sim \frac{(\text{Num})}{q^2}$
$q^2=(p+k)^2=2p\cdot k=2E_k E_p\,(1-\cos\theta_{kp})$

Choose $\hat{z}$ axis along $\vec{q}$ momentum, $\vec{q}=(E,0,0,q)$

$$p = \left(zE,\ k_T,\ 0,\ zE - \frac{k_T^2}{2zE}\right)$$

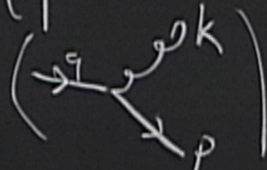
$$k = \left((1-z)E,\ -k_T,\ 0,\ (1-z)E - \frac{k_T^2}{2(1-z)E}\right)$$

Choose $\hat{z}$ axis along $\vec{q}$ momentum, $\vec{q} = (E, 0, 0, q)$

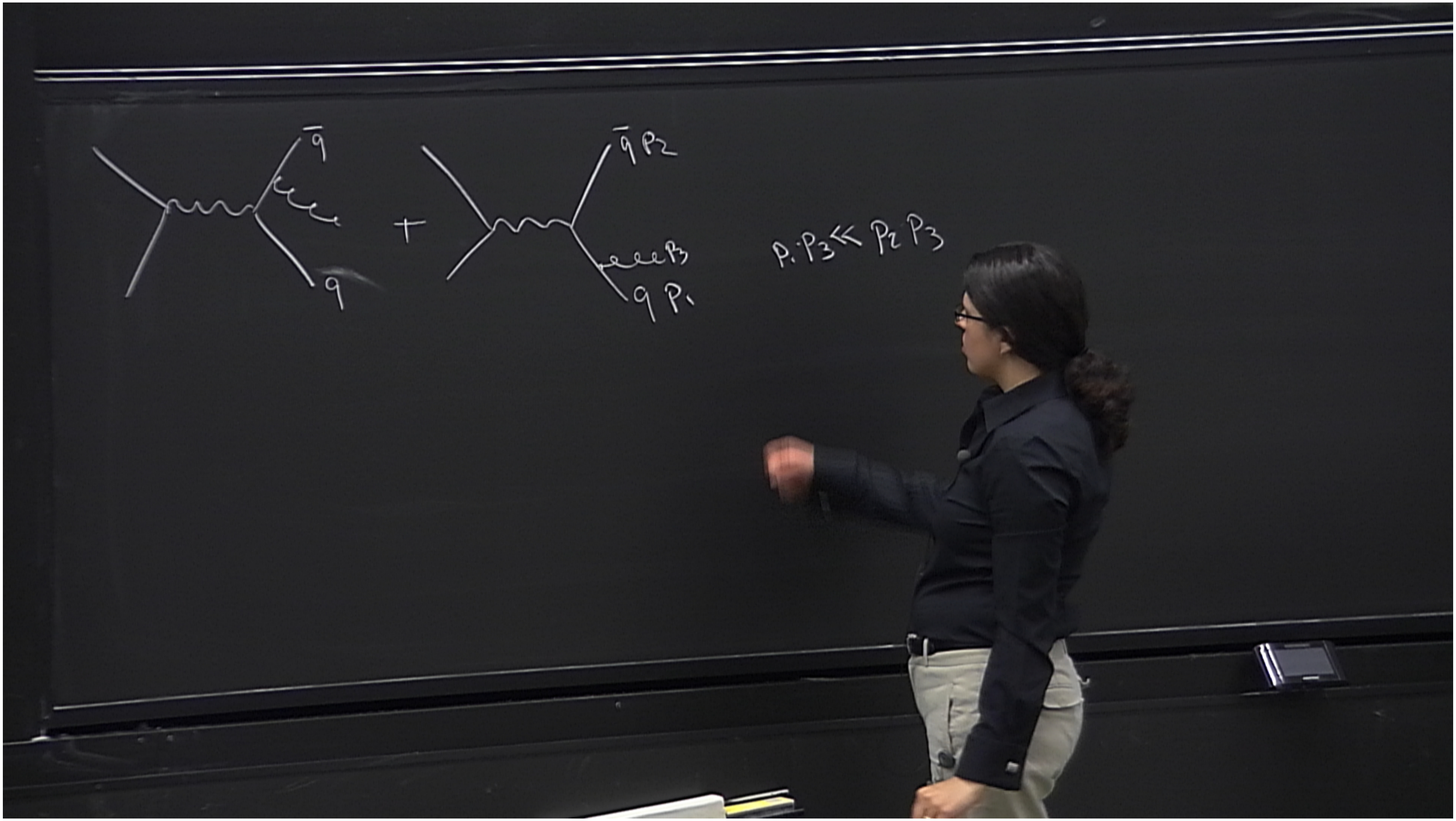
$$p = \left(zE,\ k_T,\ 0,\ zE - \frac{k_T^2}{2zE}\right) \Rightarrow q^2 = \frac{k_T^2}{z(1-z)}$$

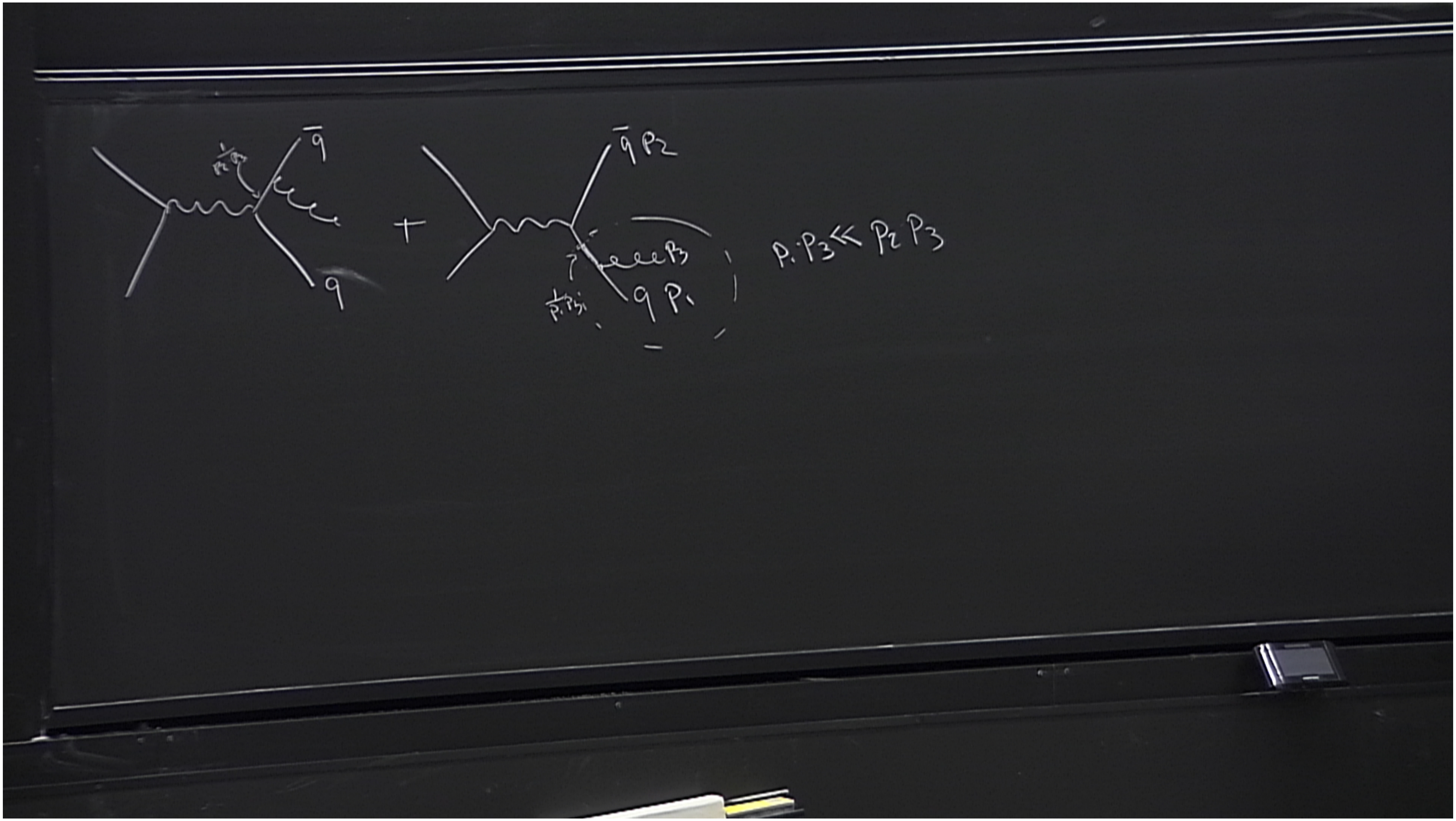
$$k = \left((1-z)E,\ -k_T,\ 0,\ (1-z)E - \frac{k_T^2}{2(1-z)E}\right)$$

$$\sum_{\epsilon(k),\ \text{pol of } q} |M|^2$$



$$= \frac{4}{3} g_s^2 \frac{2k_T^2}{z^2(1-z)} \left[1 + (1-z)^2\right]$$


$\bar{q}$
q
$+$
$\bar{q}\ p_2$
p_3
$q\ p_1$
$p_1 \cdot p_3 \ll p_2 \cdot p_3$


q̄
q
+
q̄ p2
p3
q p1
p1·p3 ≪ p2·p3

$$q^2 = (p+k)^2 = 2p\cdot k = 2E_k E_p (1 - \cos\theta_{kp})$$

Relate k, p phase space to q p.s. plus ...

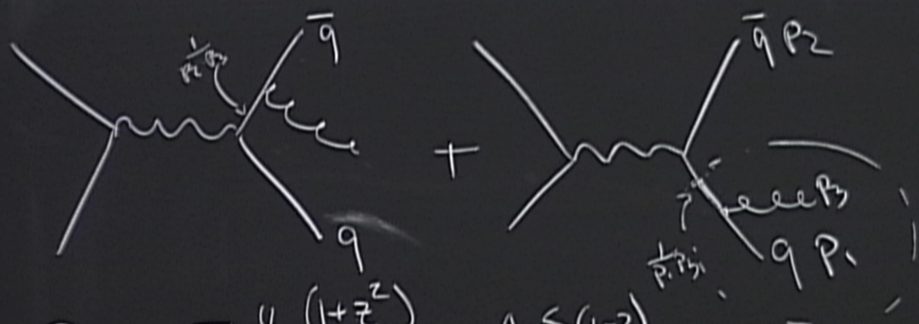
$$\frac{d^3k}{2E_k(2\pi)^3}\,\frac{d^3p}{2E_p(2\pi)^3} = \underbrace{\frac{d^3q}{2E_q(2\pi)^3}}_{d\tilde{P}S_{(q)}} \times \underbrace{\frac{1}{2(1-z)}\frac{1}{(2\pi)^3}k_T\,dk_T\,\frac{dz}{z}\,d\phi}_{dPS_{split}}$$

$d\phi \to 2\pi$

fn. of $\vec{q}, k_T, z$

$$d\sigma_{q\bar{q}g} = \sigma_0 \times dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \Sigma |\mathcal{M}|^2_{(\ldots)}$$

$$= \sigma_0 \cdot \frac{dk_T}{k_T}\, dz \cdot \underbrace{\frac{4}{3}\,\frac{\left(1+(1-z)^2\right)}{z}}_{P_{q\to g}(z)} \frac{\alpha_s}{\pi}$$



$p_1\cdot p_3 \ll p_2\, p_3$

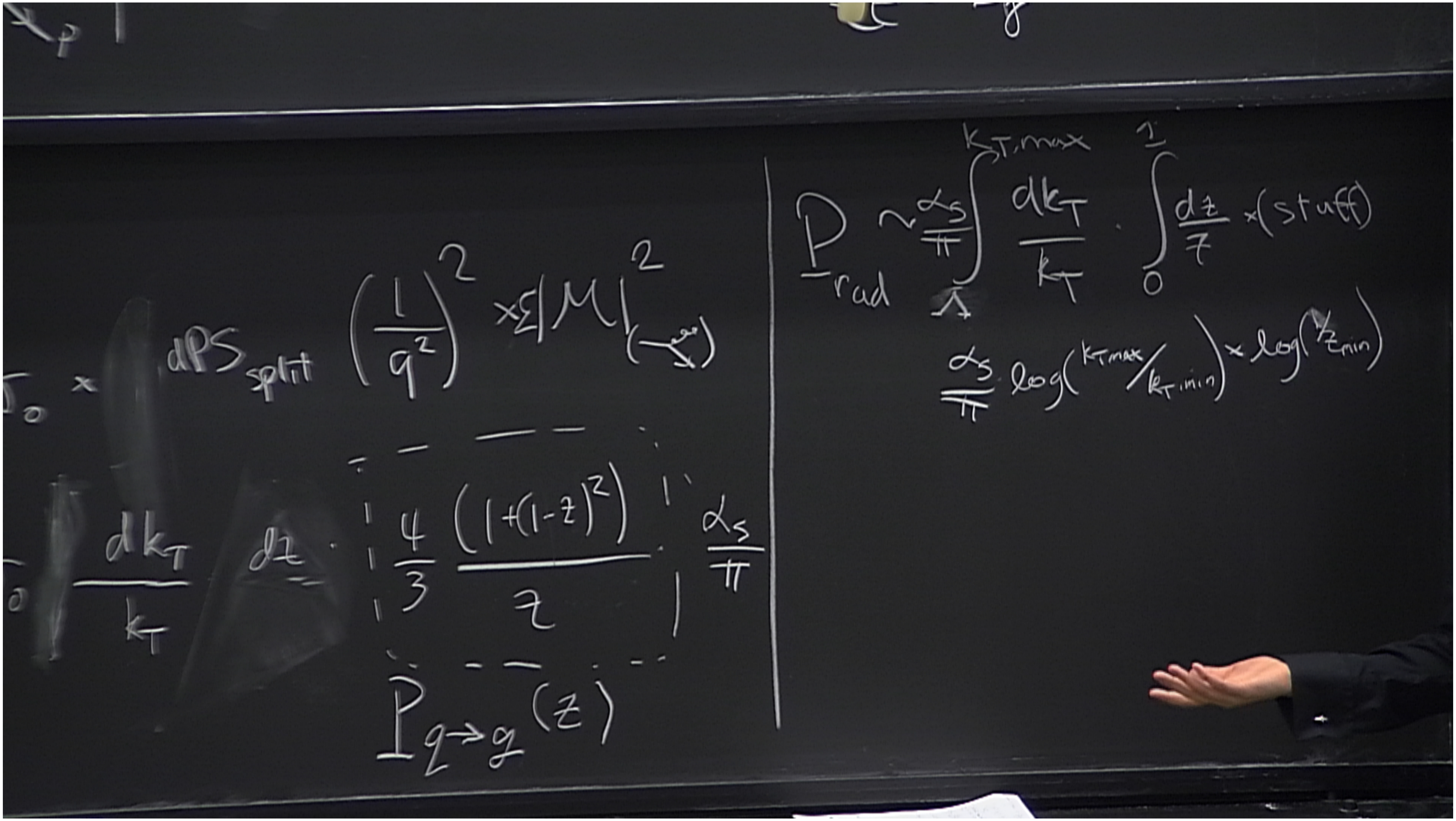
$$P_{q\to q} = \frac{4}{3}\frac{(1+z^2)}{(1-z)} - A\,\delta(1-z)$$

$$P_{g\to q\,(\text{or }\bar q)} = \frac{1}{2}\left[z^2 + (1-z)^2\right]$$

$$\sigma_0 \times \int dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \sum |\mathcal{M}|^2_{(\ldots)}$$

$$\int_0 \frac{dk_T}{k_T}\, dz \cdot \underbrace{\frac{4}{3}\,\frac{\left(1+(1-z)^2\right)}{z}}_{P_{q\to g}(z)} \cdot \frac{\alpha_s}{\pi}$$

$$P_{rad} \sim \frac{\alpha_s}{\pi}\int_{\Lambda}^{k_{T,max}} \frac{dk_T}{k_T} \cdot \int_0^1 \frac{dz}{z} \times (\text{stuff})$$


dPS split
(1/q²)² × Σ|M|²
dk_T / k_T
dz
4/3 (1+(1-z)²)/z
α_s/π
P_q→g (z)
P_rad ~ α_s/π ∫ dk_T/k_T · ∫ dz/z × (stuff)
α_s/π log(k_T,max/k_T,min) × log(1/z_min)

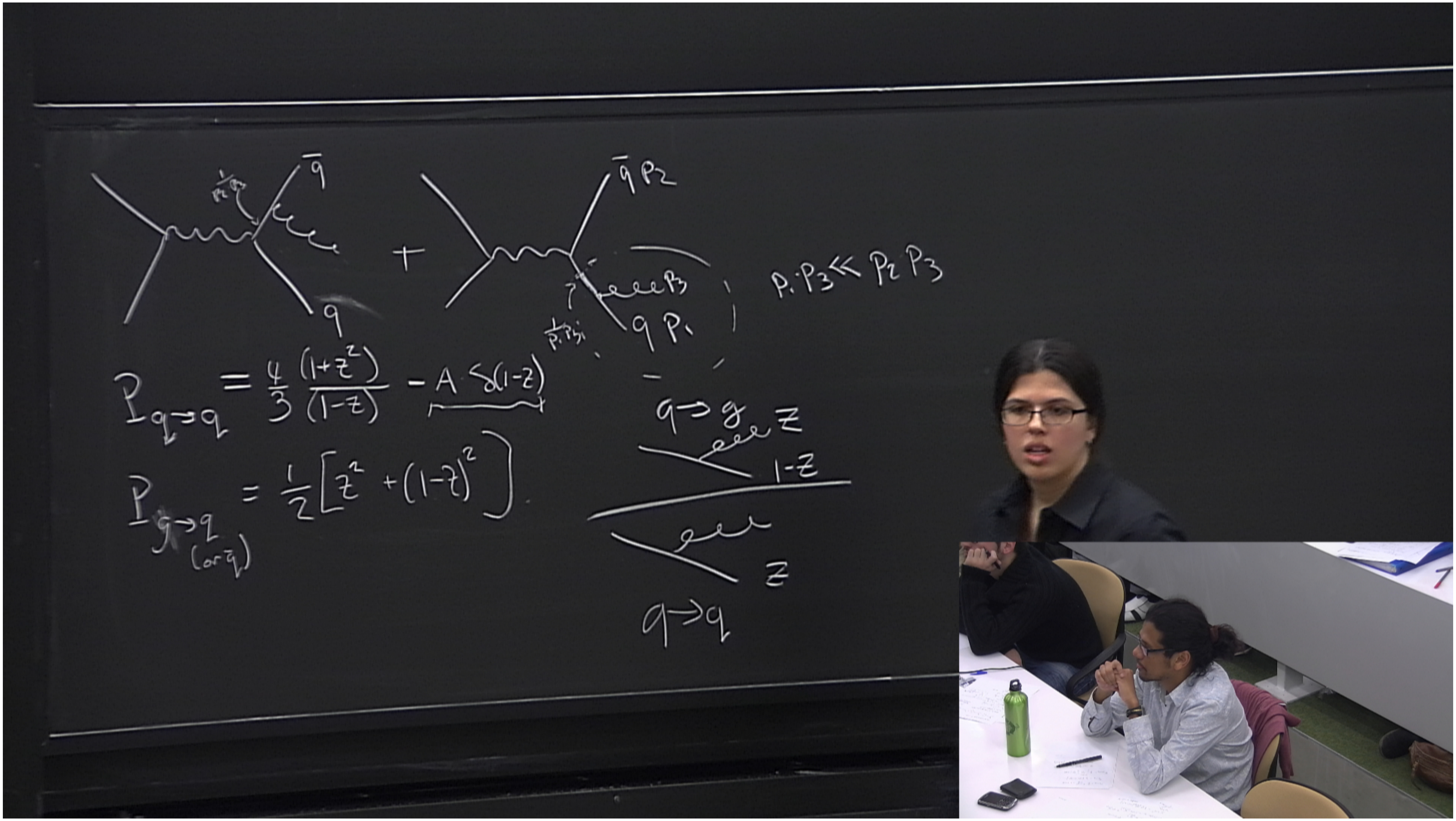
$$\sigma_0 \times dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \Sigma |\mathcal{M}|^2_{(\to)}$$

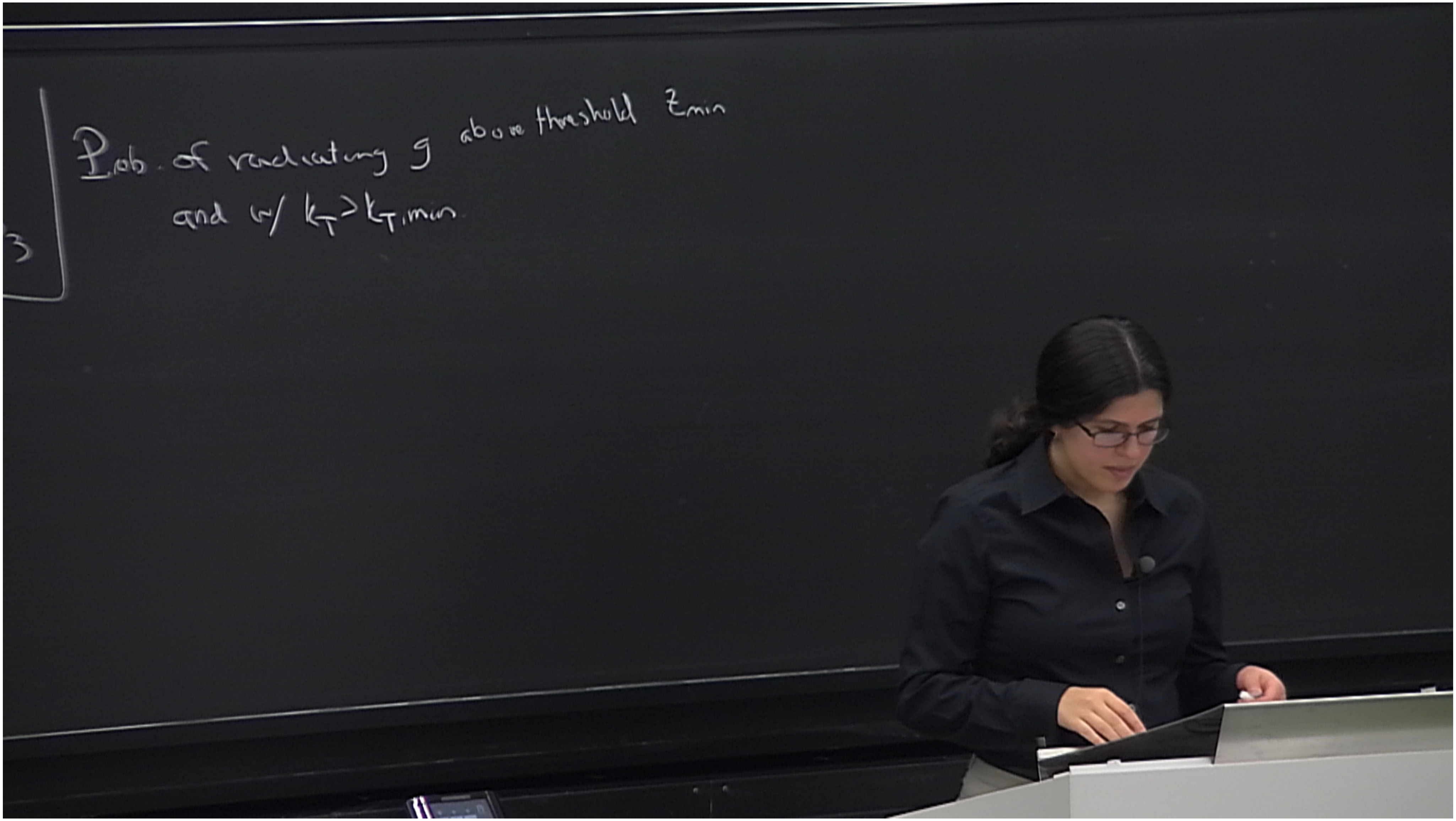
$$\sigma_0 \frac{dk_T}{k_T}\, dz \cdot \underbrace{\frac{4}{3}\frac{\left(1+(1-z)^2\right)}{z}}_{P_{q\to g}(z)} \cdot \frac{\alpha_s}{\pi}$$

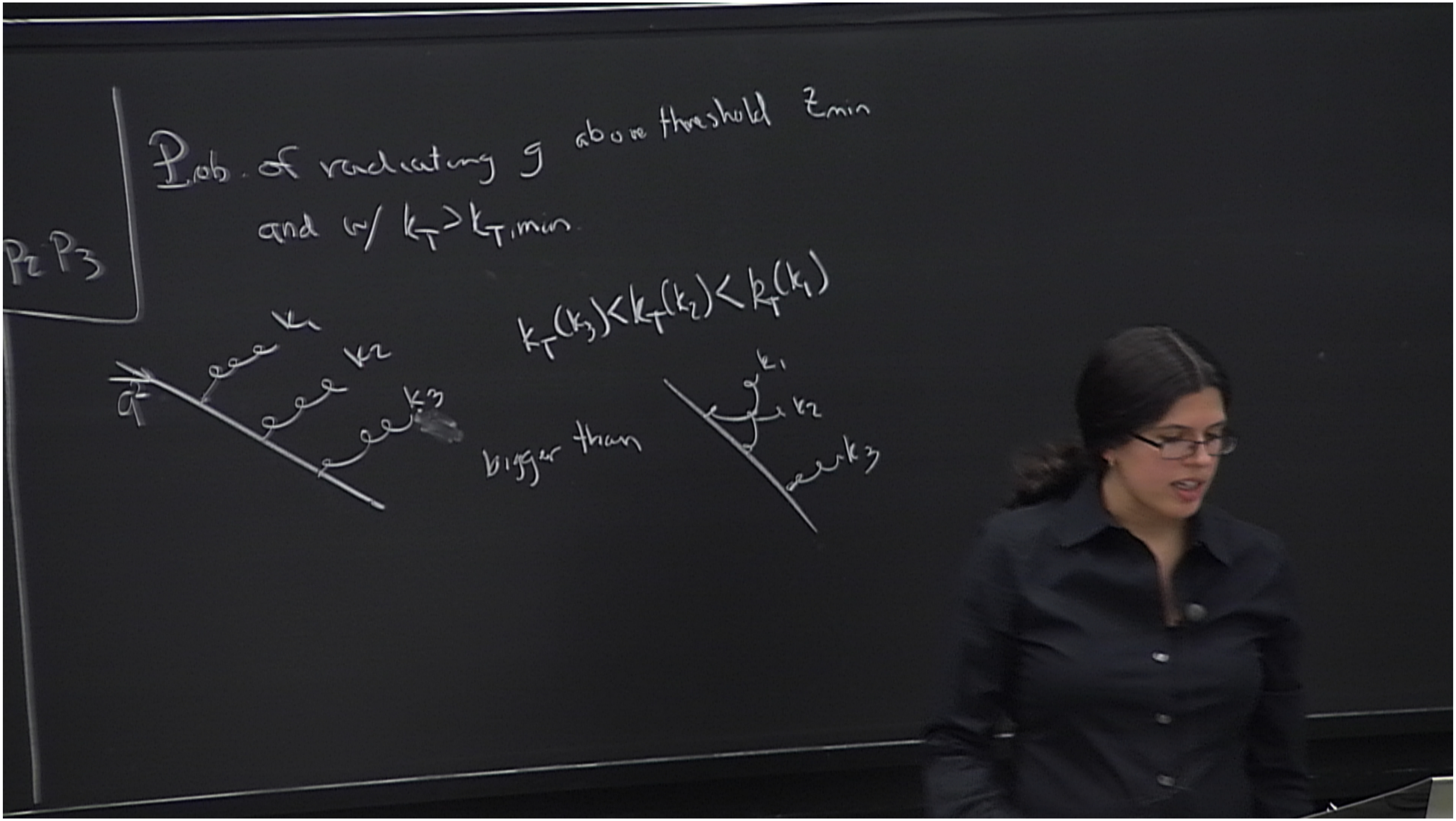
$$P_{rad} \sim \frac{\alpha_s}{\pi}\int_{\Lambda}^{k_{T,max}} \frac{dk_T}{k_T} \cdot \int_0^1 \frac{dz}{z} \times (\text{stuff})$$

$$\frac{\alpha_s}{\pi} \log\left(k_{T,max}/k_{T,min}\right) \times \log\left(1/z_{min}\right)$$

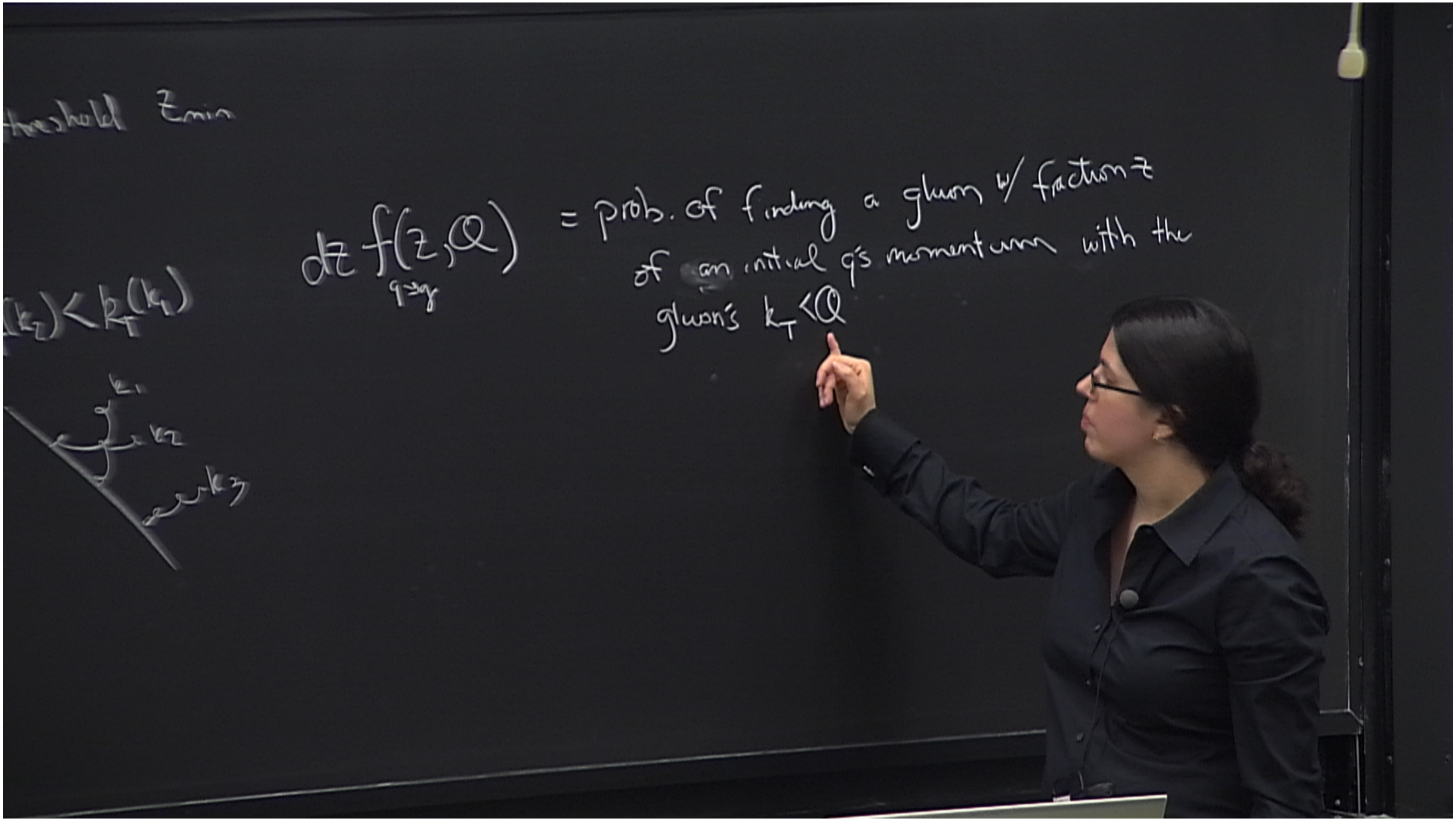
$>1 \Rightarrow$ not really a probability.


$p_1 \cdot p_3 \ll p_2 \cdot p_3$
$P_{q\to q} = \frac{4}{3}\frac{(1+z^2)}{(1-z)} - A\,\delta(1-z)$
$P_{g\to q \,(\text{or } \bar{q})} = \frac{1}{2}\left[z^2 + (1-z)^2\right]$
$q \to g$
$q \to q$


Prob. of radiating g above threshold z min
and w/ kT > kT,min



Prob. of radiating g above threshold z_min
and w/ k_T > k_T,min
P2 P3
k_T(k3) < k_T(k2) < k_T(k1)
k1
k2
k3
q
bigger than
k1
k2
k3


threshold z_{min}
$dz\, f_{q\to g}(z, Q)$ = prob. of finding a gluon w/ fraction z
of an initial q's momentum with the
gluon's $k_T < Q$
k_1
k_2
k_3

threshold z_{min}

$dz\, f_{q\to g}(z,Q)$ = prob. of finding a gluon w/ fraction z of an initial q's momentum with the gluon's $k_T < Q$

$(k_2) < k_T(k_1)$

$$f_{q\to g}(z,Q') = f(z,Q) + \int_Q^{Q'} \frac{dk_T}{k_T} \int dx\; P_{p\to p''}(\omega)\, f_{p''\to p'}(x,Q)$$

q'' energy ωE_q

$Q' > Q$

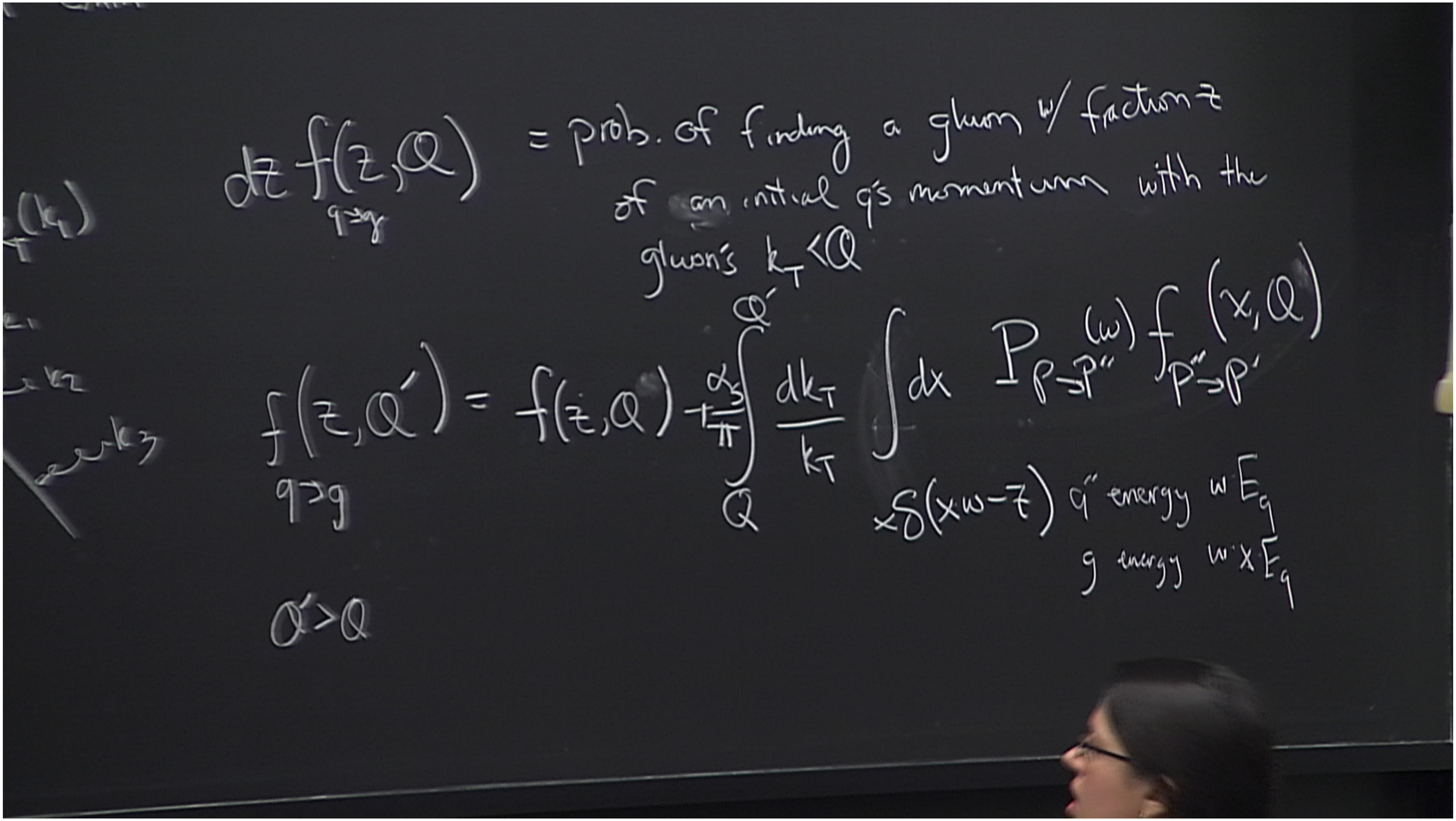
$dz\, f_{q\to g}(z,Q)$ = prob. of finding a gluon w/ fraction z of an initial q's momentum with the gluon's $k_T < Q$

$$f_{q\to g}(z,Q') = f(z,Q) + \int_{Q}^{Q'} \frac{dk_T}{k_T} \int dx\; P_{p\to p''}(w)\, f_{p''\to p'}(x,Q) \times \delta(xw - z)$$

q'' energy $w\, E_q$

g energy $w \cdot x\, E_q$

$Q' > Q$


$dz\, f_{q\to g}(z,Q)$ = prob. of finding a gluon w/ fraction z
of an initial q's momentum with the
gluon's $k_T < Q$
$f_{q\to g}(z,Q') = f(z,Q) + \frac{\alpha_s}{\pi}\int_Q^{Q'} \frac{dk_T}{k_T} \int dx\, P_{p\to p''}(w)\, f_{p''\to p'}(x,Q)$
$\times\, \delta(xw - z)$
q'' energy $w \cdot E_q$
g energy $w \cdot x \cdot E_q$
$Q' > Q$

$dz\, f_{q\to g}(z, Q)$ = prob. of finding a gluon w/ fraction z of an initial q's momentum with the gluon's $k_T < Q$

$$f_{q\to g}(z,Q') = f(z,Q) + \frac{\alpha_s(Q)}{\pi}\int_{Q}^{Q'} \frac{dk_T}{k_T} \int dx\; P_{p\to p''}(w)\, f_{p''\to p'}(x,Q)$$

$$\times\, \delta(xw - z)$$

q'' energy $w E_q$

g energy $w \cdot x \cdot E_q$

$Q' > Q$

$$\frac{d}{d\log Q'} f(z,Q') = \frac{\alpha_s(Q')}{\pi}\int \frac{dw}{w}\sum_{p''} P_{p\to p''}(w)\, f\!\left(\frac{z}{w}, Q'\right)$$

$dz\, f_{q\to g}(z,Q)$ = prob. of finding a gluon w/ fraction z of an initial q's momentum with the gluon's $k_T < Q$

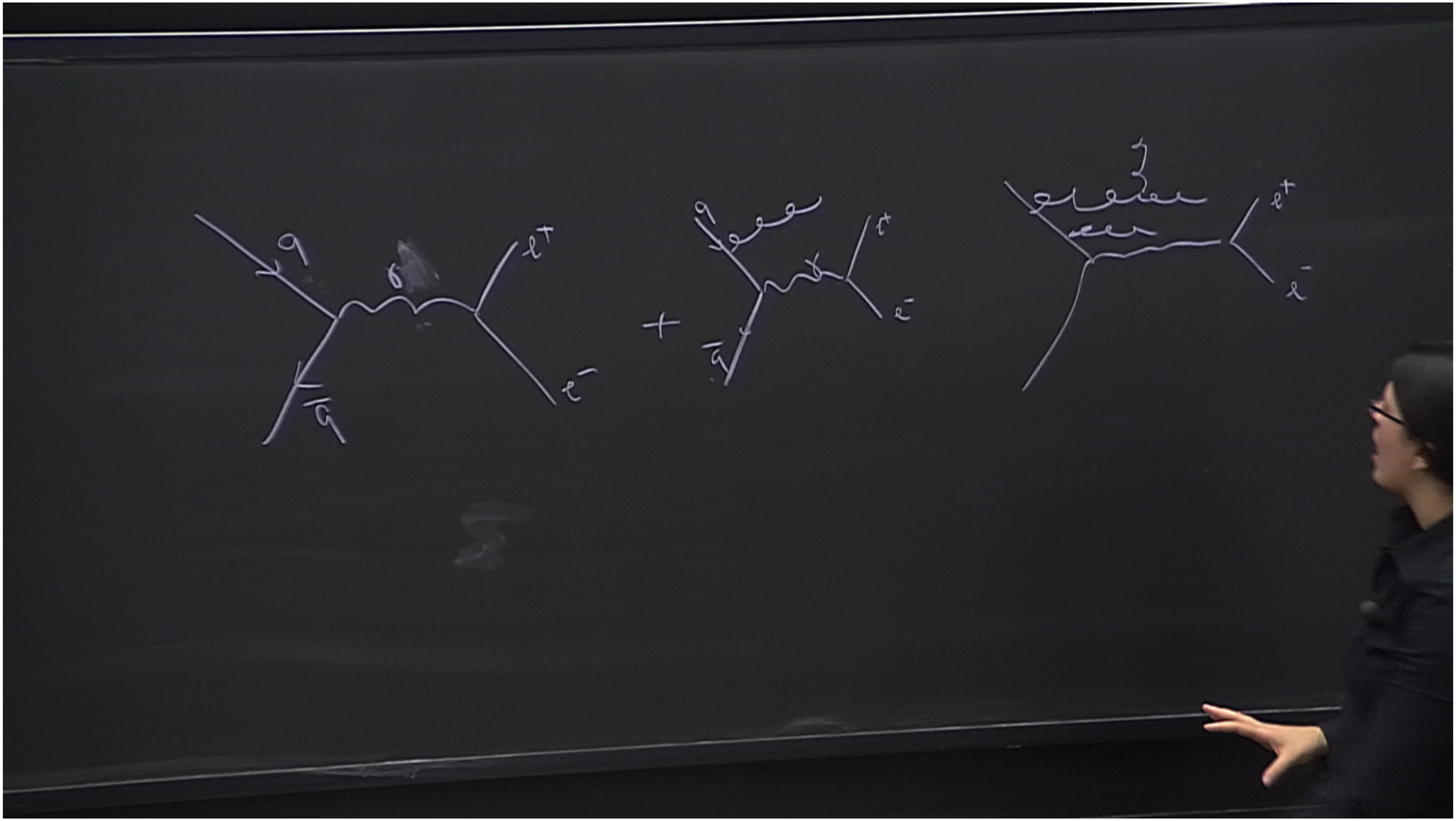
$$f_{q\to g}(z,Q') = f(z,Q) + \frac{\alpha_s(Q)}{\pi}\int_Q^{Q'} \frac{dk_T}{k_T}\int dx\, P_{p\to p''}(w)\, f_{p''\to p'}(x,Q)\times\delta(xw-z)$$

q'' energy $w E_q$

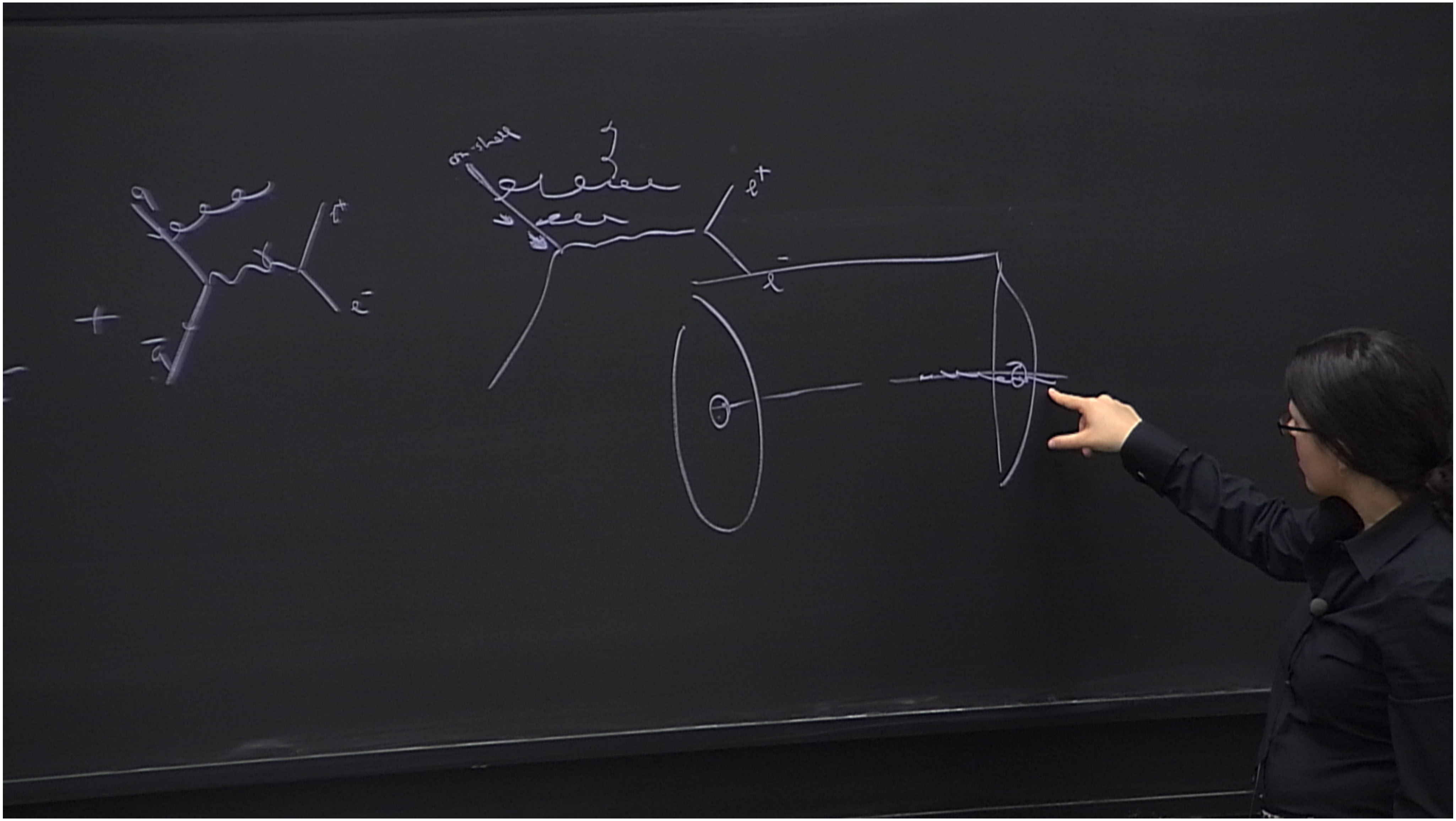
g energy $w \cdot x \cdot E_q$

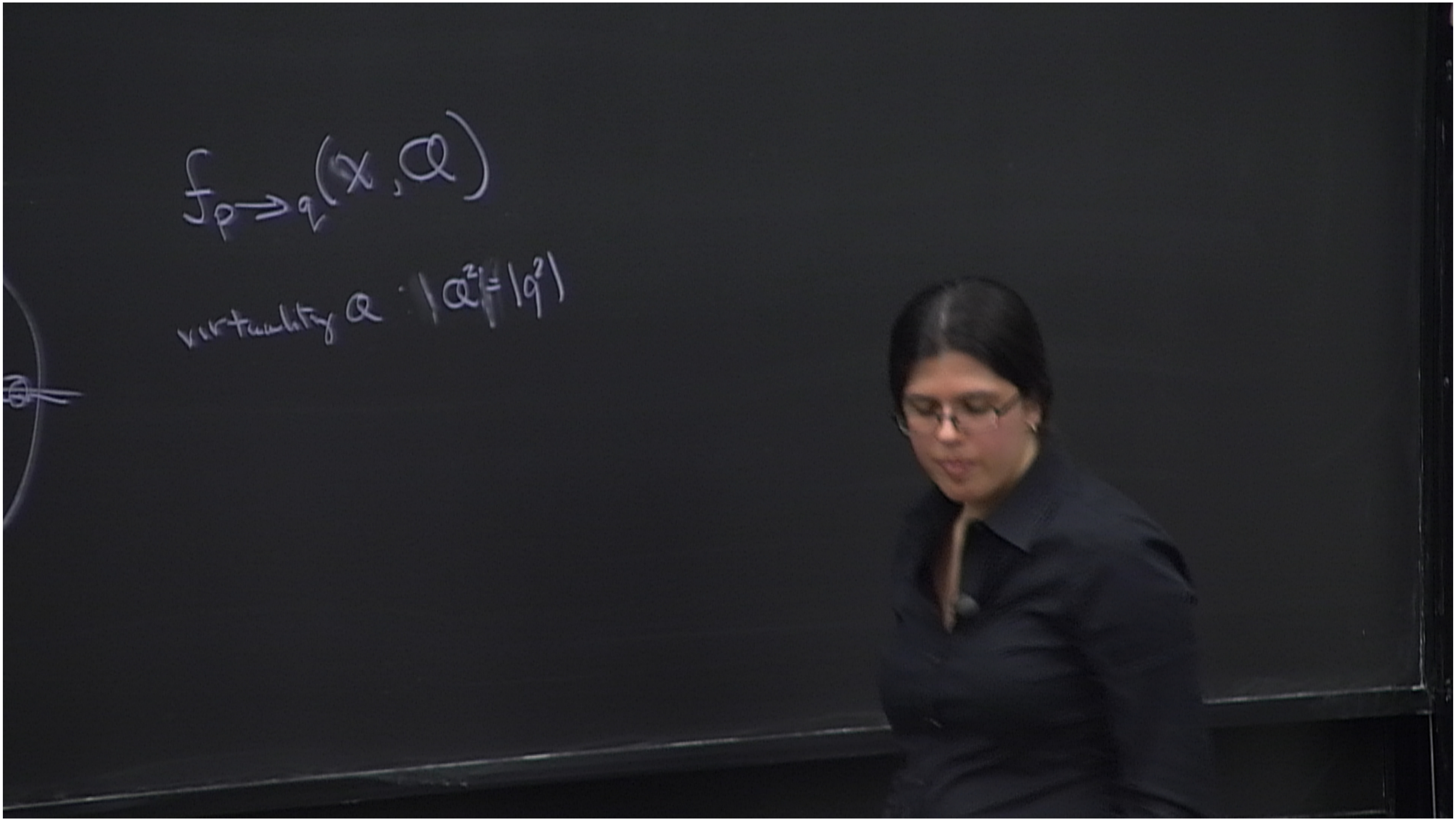
$Q'>Q$

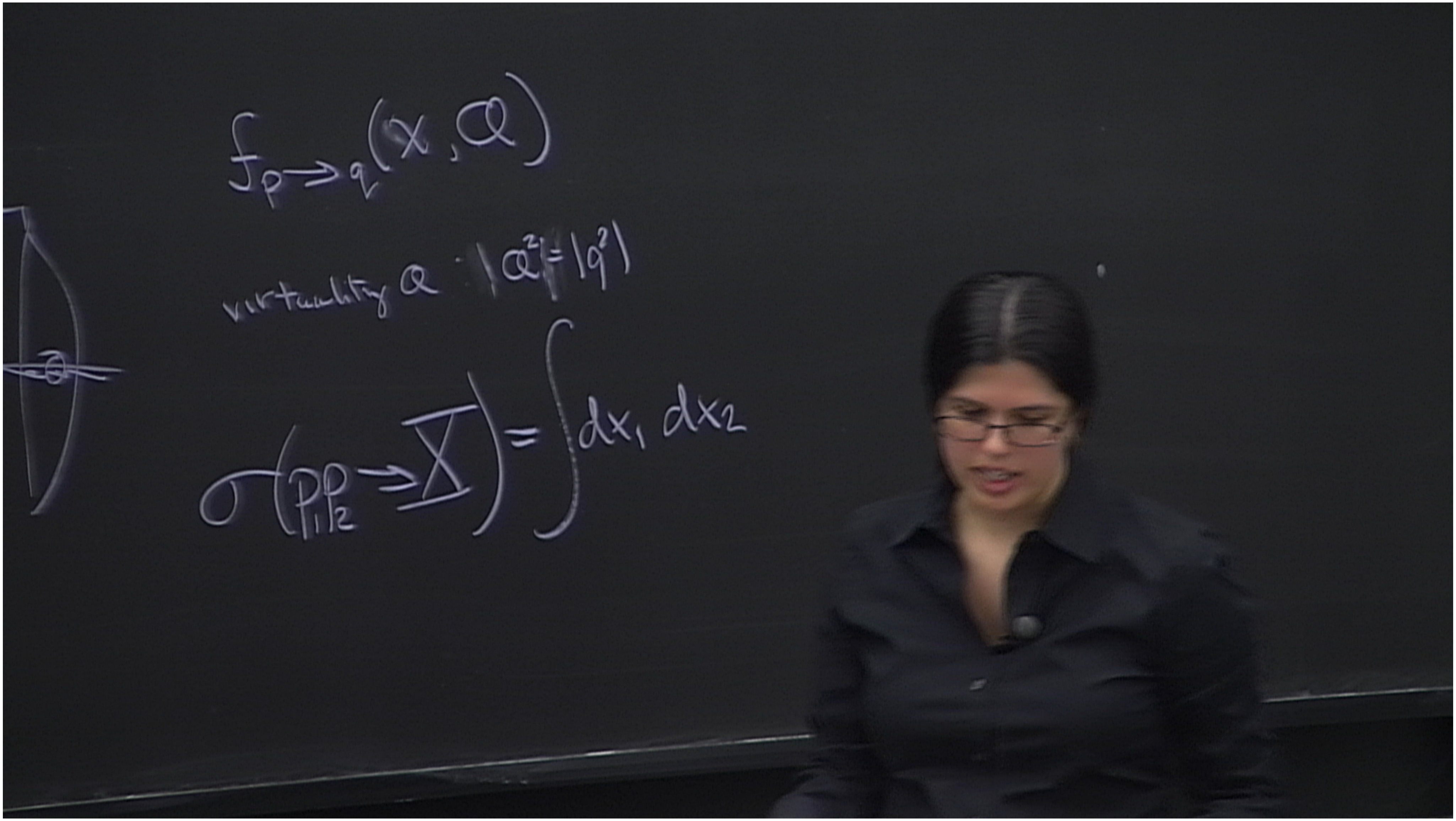
$$\boxed{\frac{d}{d\log Q'} f(z,Q') = \frac{\alpha_s(Q')}{\pi}\int\frac{dw}{w}\sum_{p''} P_{p\to p''}(w)\, f_{p'' \to p'}\left(\frac{z}{w},Q'\right)}$$



q
$\bar{q}$
γ
e^+
e^-
+
q
$\bar{q}$
γ
e^+
e^-
e^+
e^-


on-shell
q
$\bar{q}$
ℓ^+
ℓ^-
+

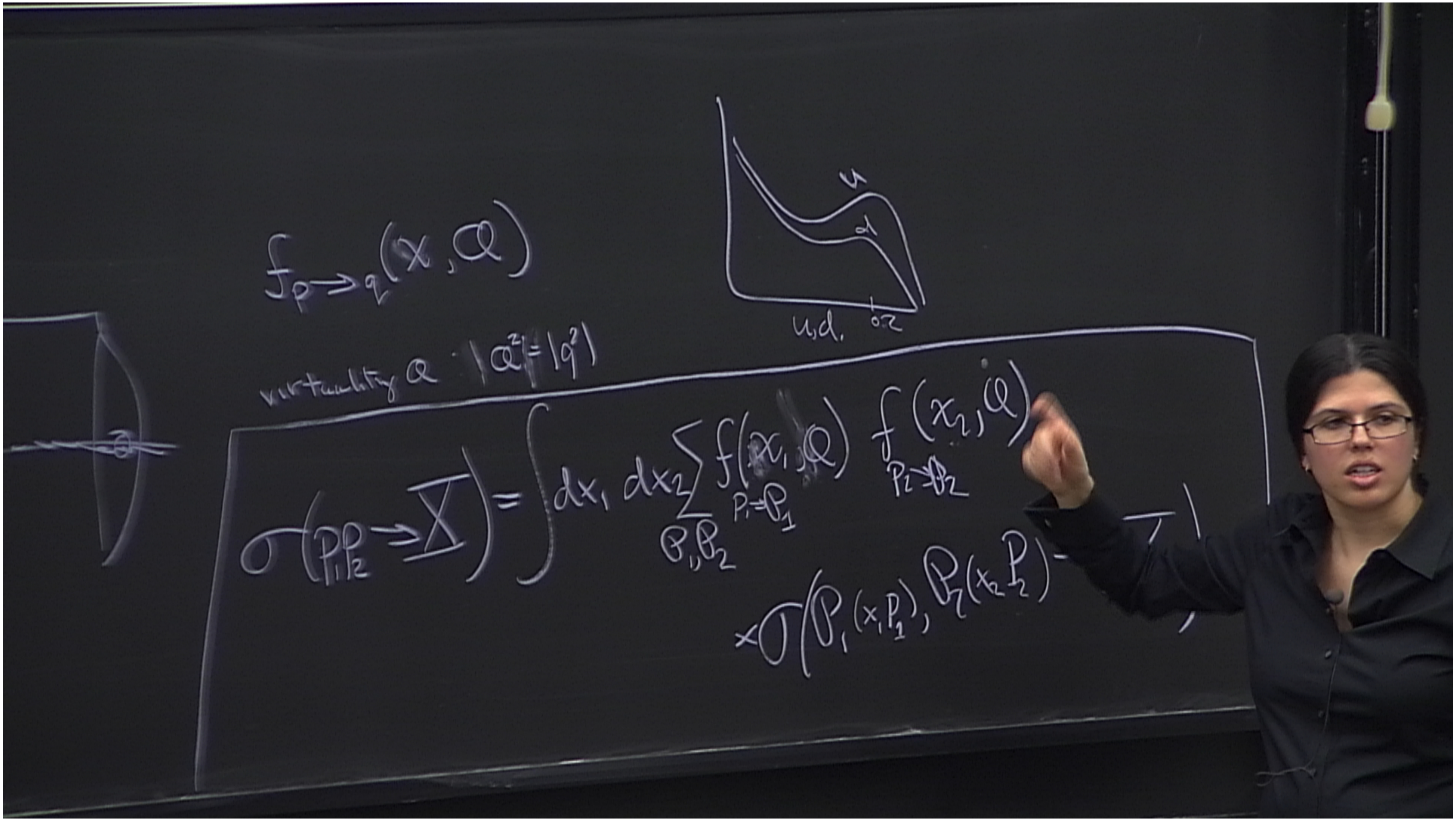

$f_{p \to q}(x, Q)$
virtuality Q : $|Q^2| = |q^2|$


$f_{p \to q}(x, Q)$
virtuality Q : $|Q^2| = |q^2|$
$\sigma(P_1 P_2 \to X) = \int dx_1 \, dx_2$

$f_{p \to q}(x, Q)$

virtuality Q : $|Q^2| = |q^2|$

$$\sigma(P_1 P_2 \to X) = \int dx_1\, dx_2 \sum_{\mathcal{P}_1, \mathcal{P}_2} f_{P_1 \to \mathcal{P}_1}(x_1, Q)\, f_{P_2 \to \mathcal{P}_2}(x_2, Q) \times \sigma\big(\mathcal{P}_1(x_1 P_1), \mathcal{P}_2(x_2 P_2) \to X\big)$$


virtuality Q