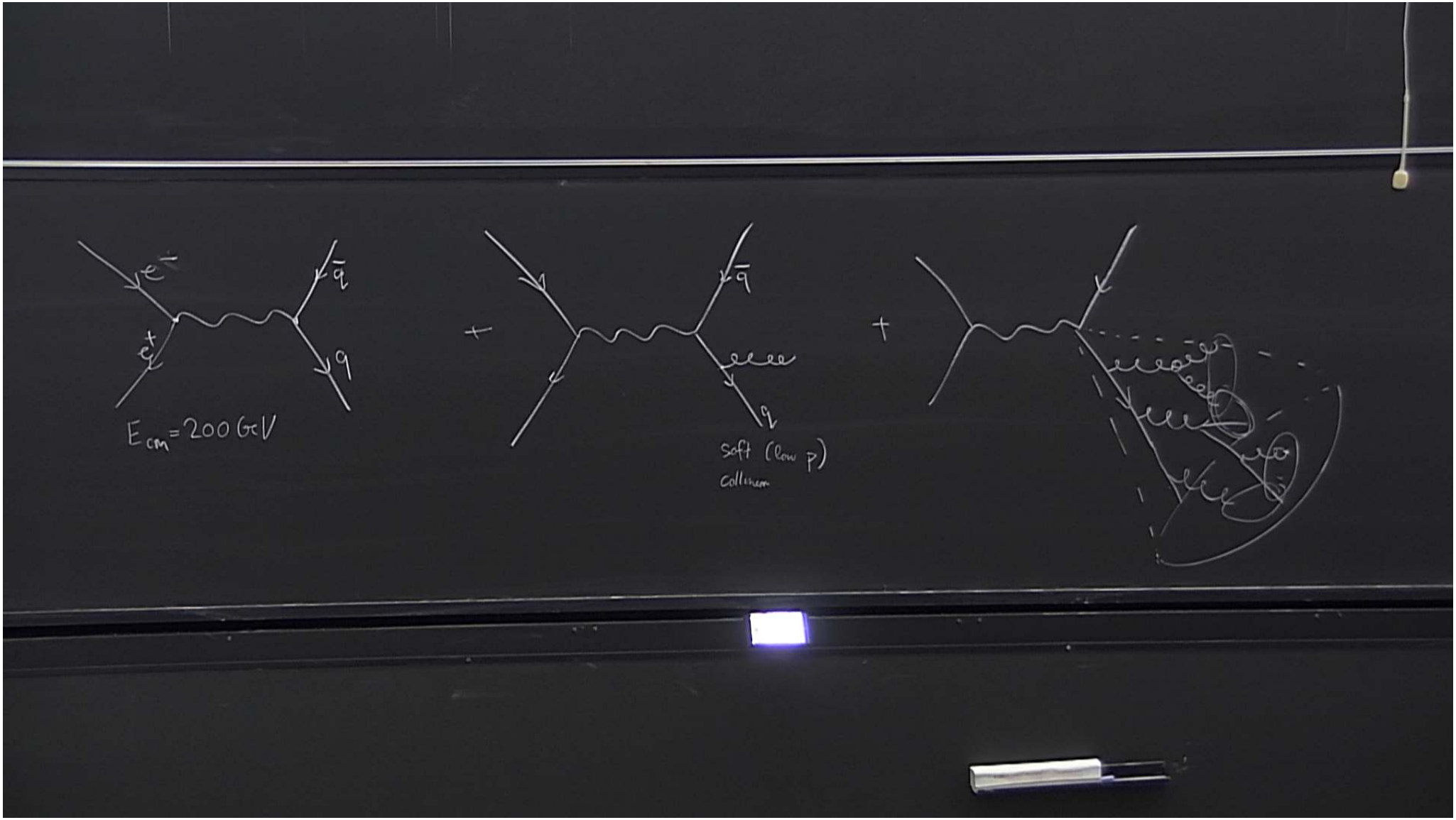
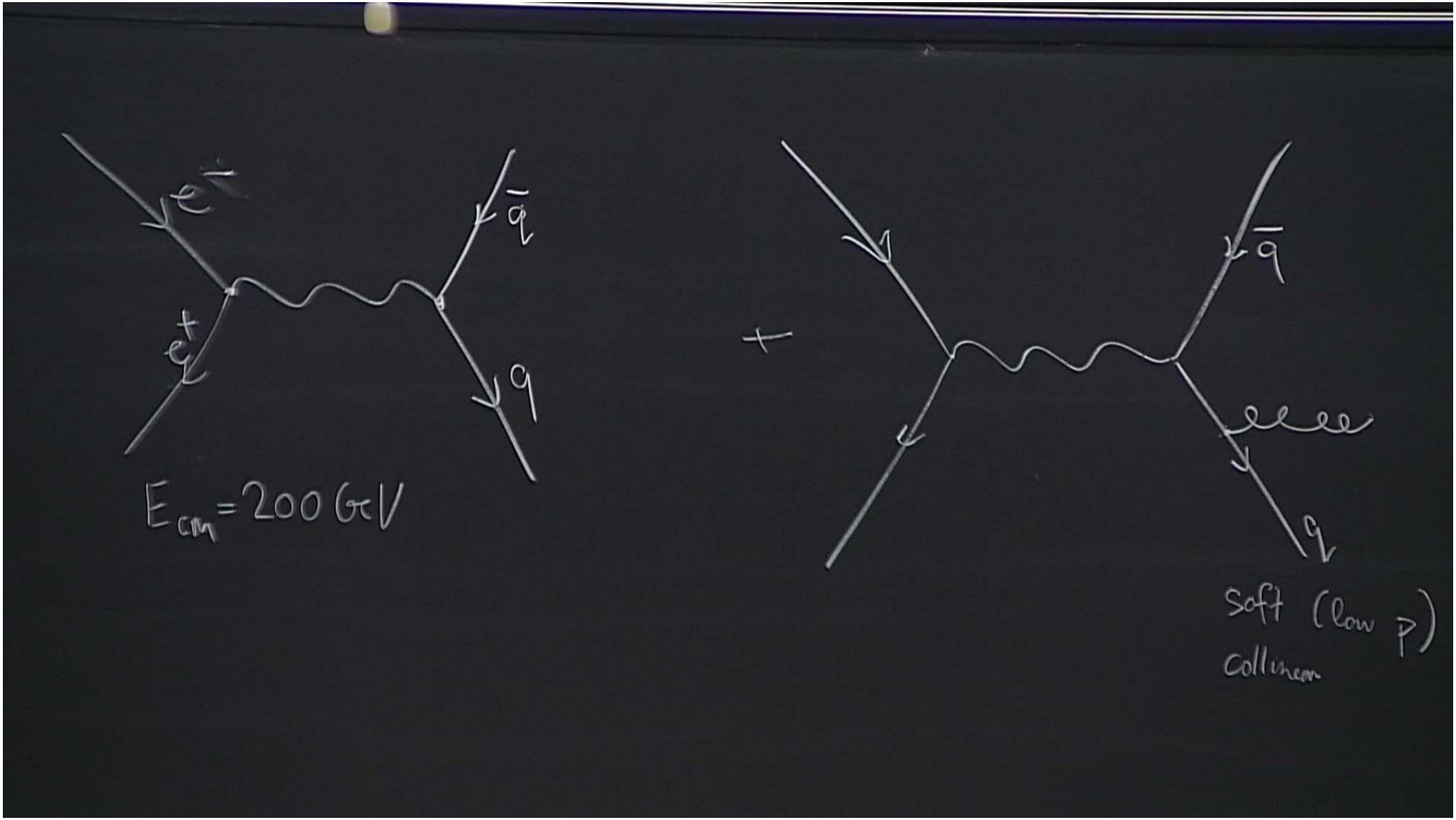
Title: Standard Model (Review) - Lecture 12

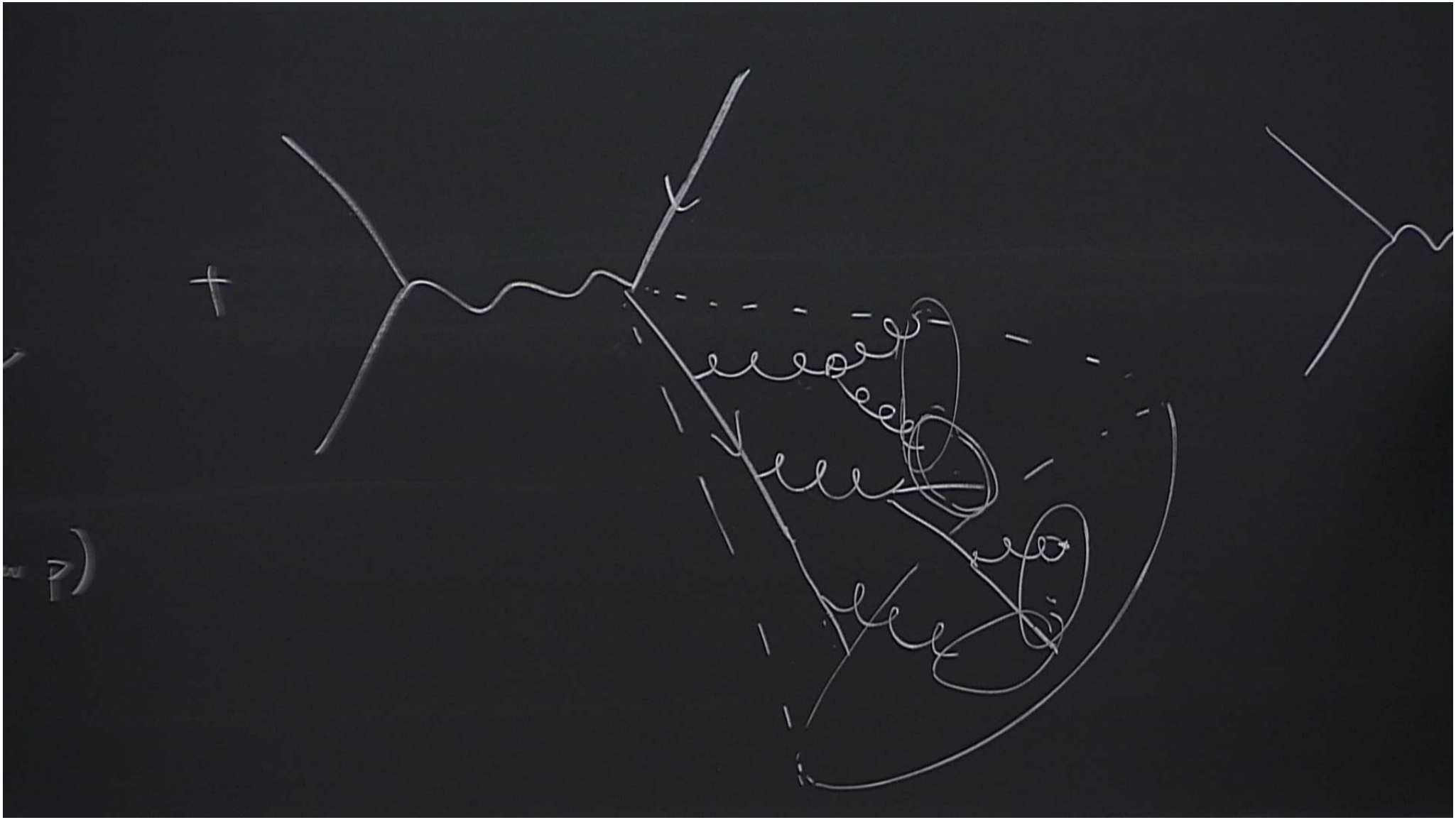
Date: Jan 17, 2012 09:00 AM

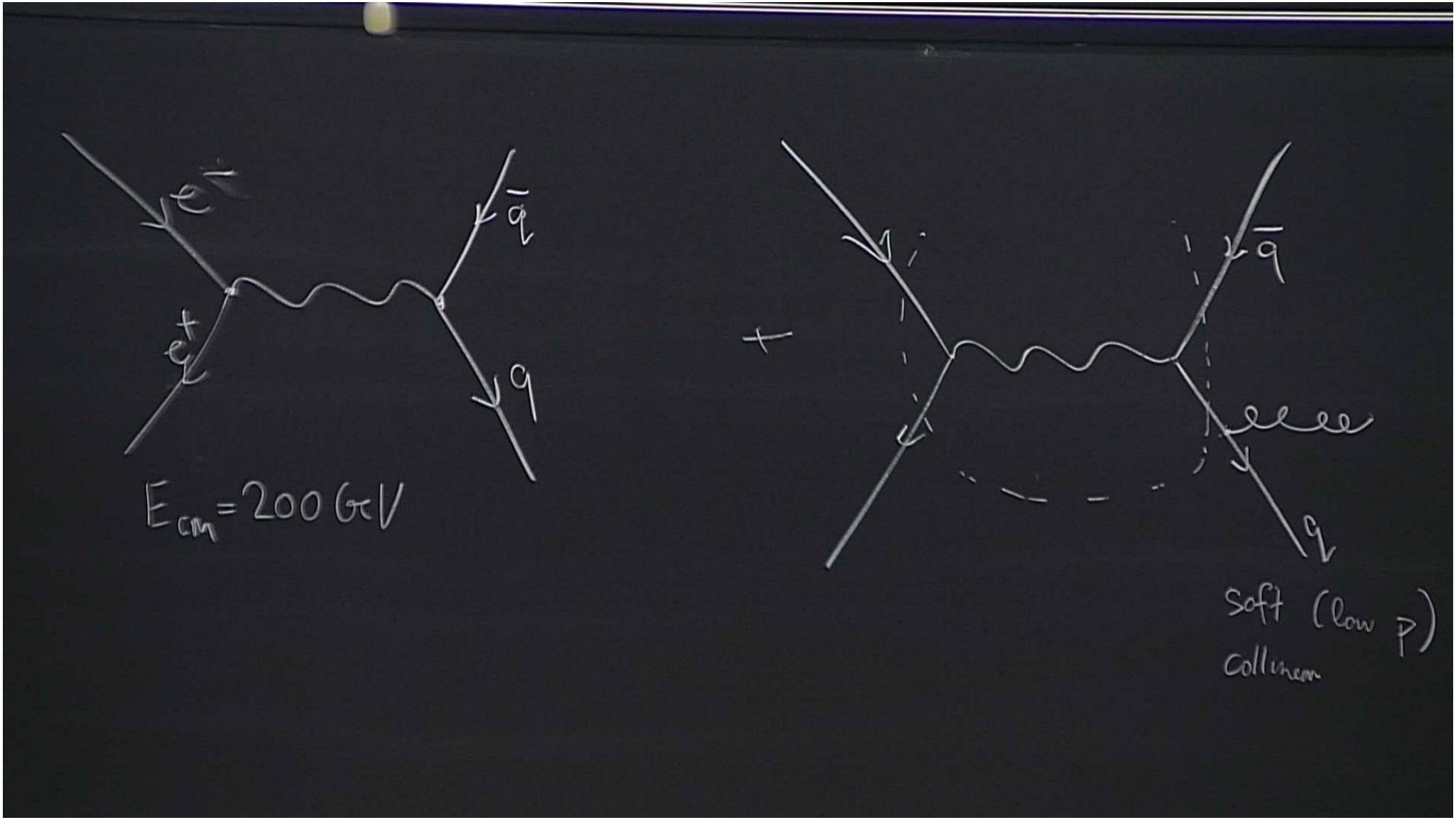
URL: http://pirsa.org/12010015

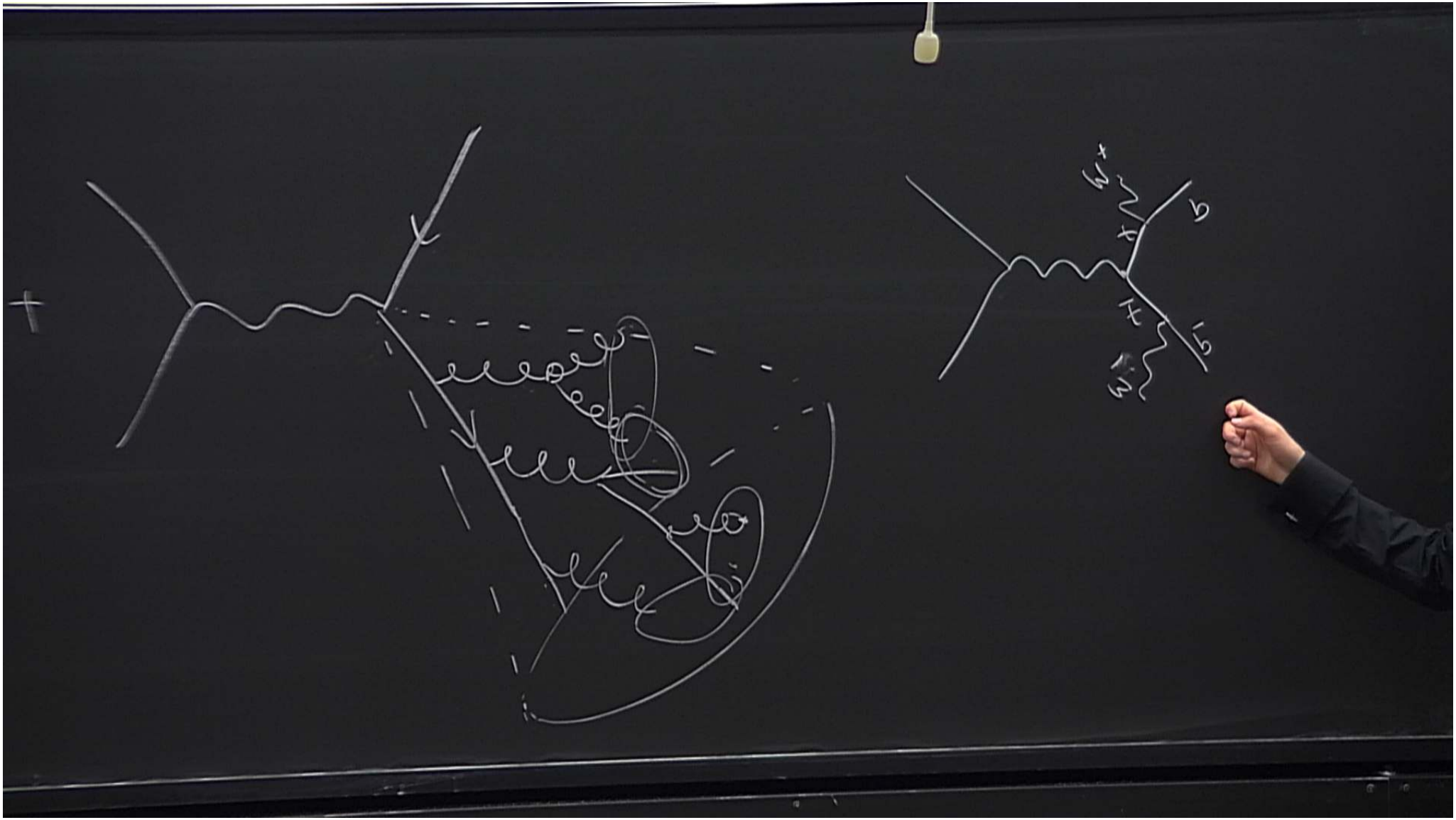
Abstract:


e⁻
e⁺
q̄
q
E cm = 200 GeV
+
q̄
q
Soft (low p)
Collinear
+

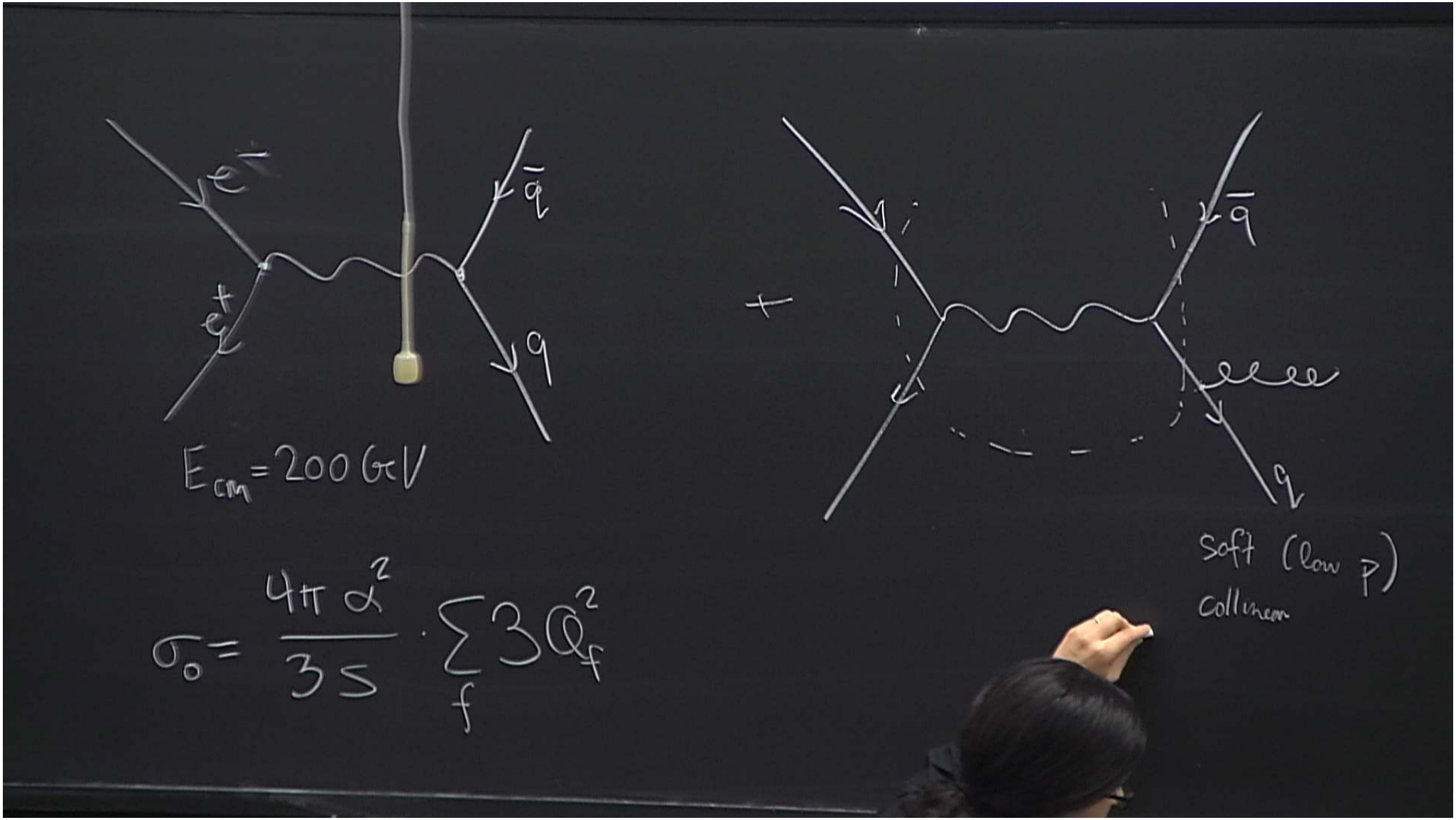

e^-
e^+
$\bar{q}$
q
$E_{cm} = 200\ GeV$
+
$\bar{q}$
q
Soft (low p)
Collinear

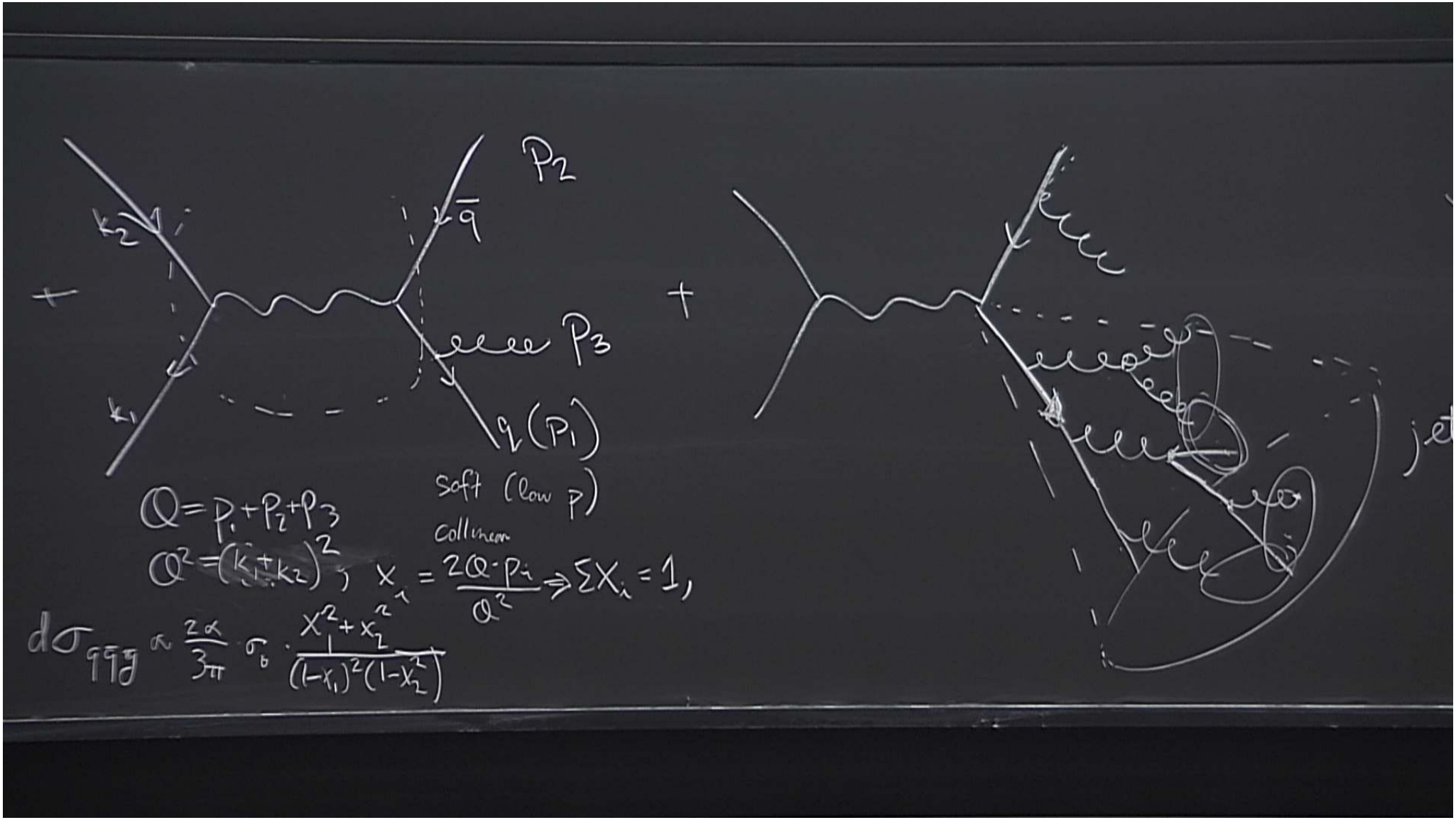


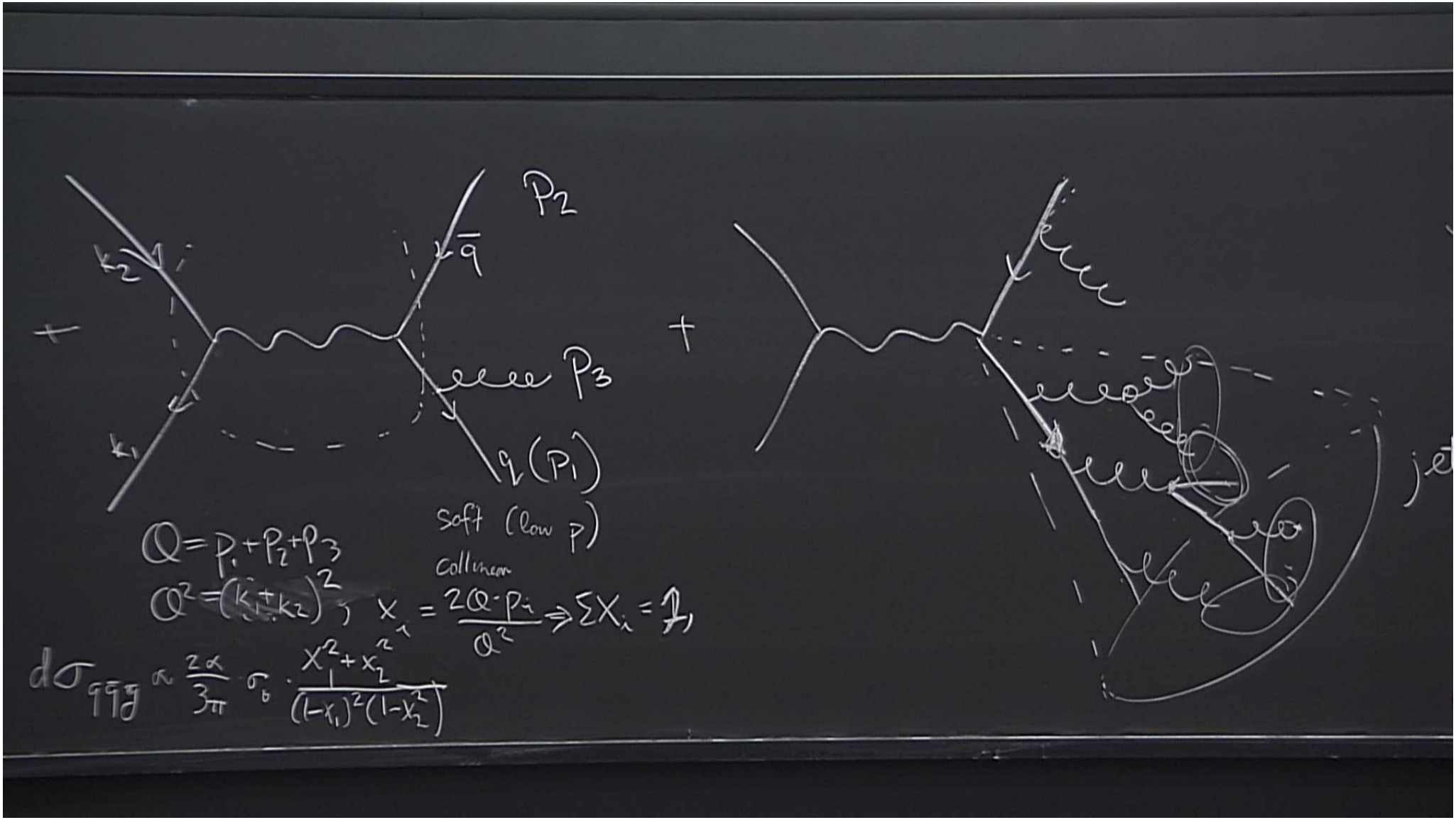

e^-
e^+
$\bar{q}$
q
$E_{cm} = 200\ GeV$
+
$\bar{q}$
q
Soft (low p)
Collinear

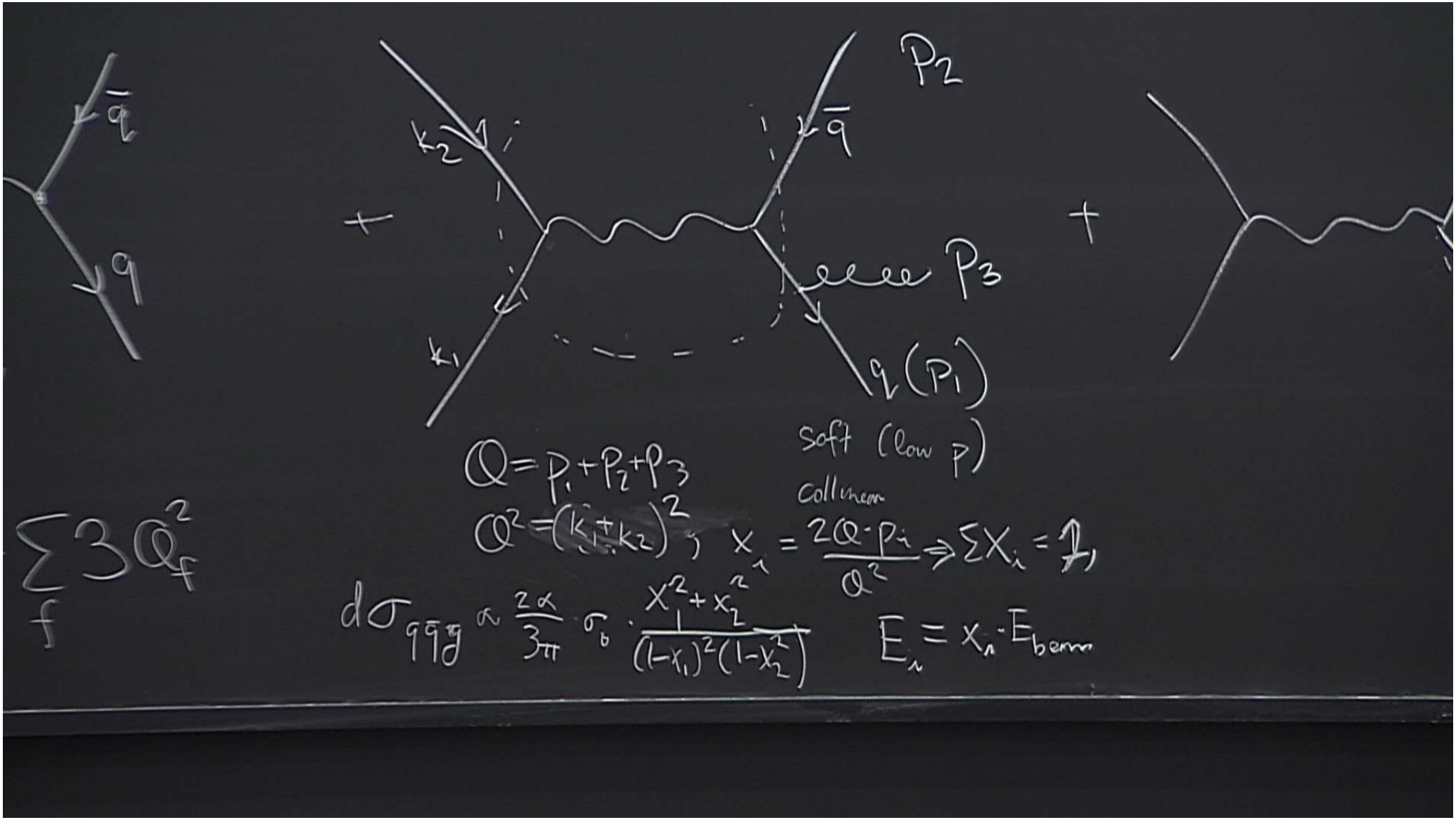


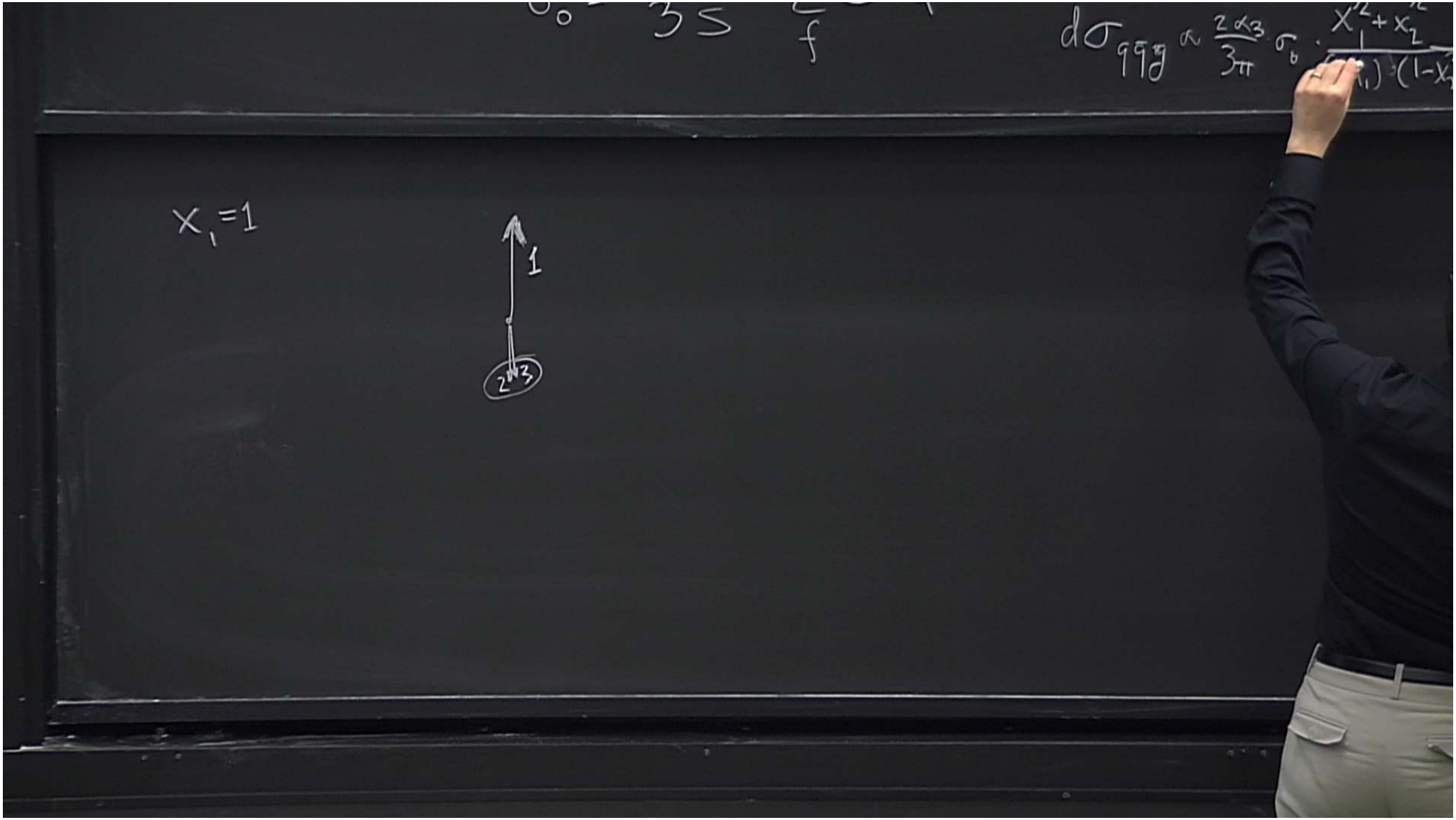
q̄
q
Soft (low p)
Collinear
+
jets

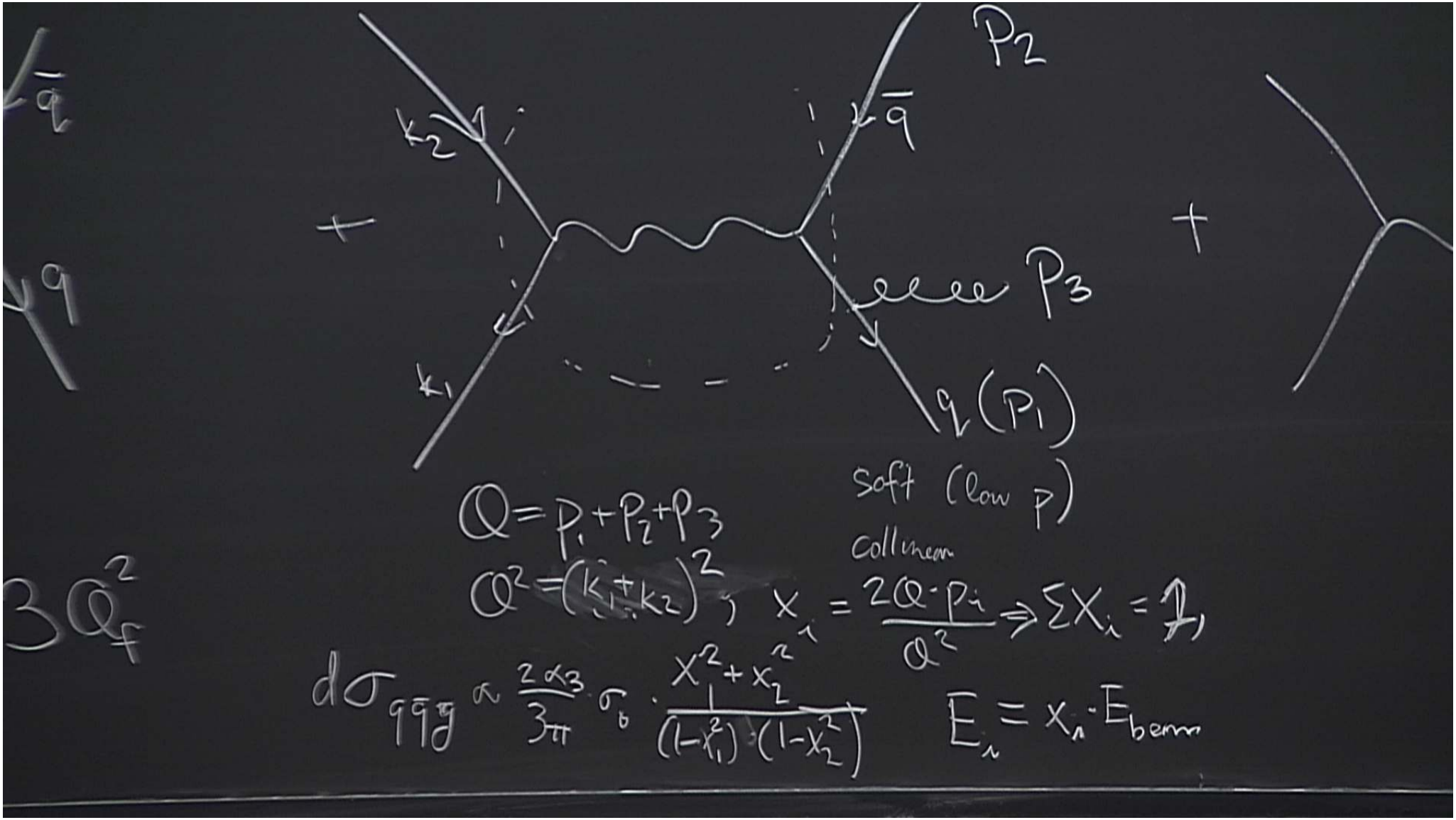

e^-
e^+
$\bar{q}$
q
$E_{cm} = 200\ GeV$
$\bar{q}$
q
Soft (low p)
Collinear
$\sigma_0 = \frac{4\pi\alpha^2}{3s} \cdot \sum_f 3Q_f^2$

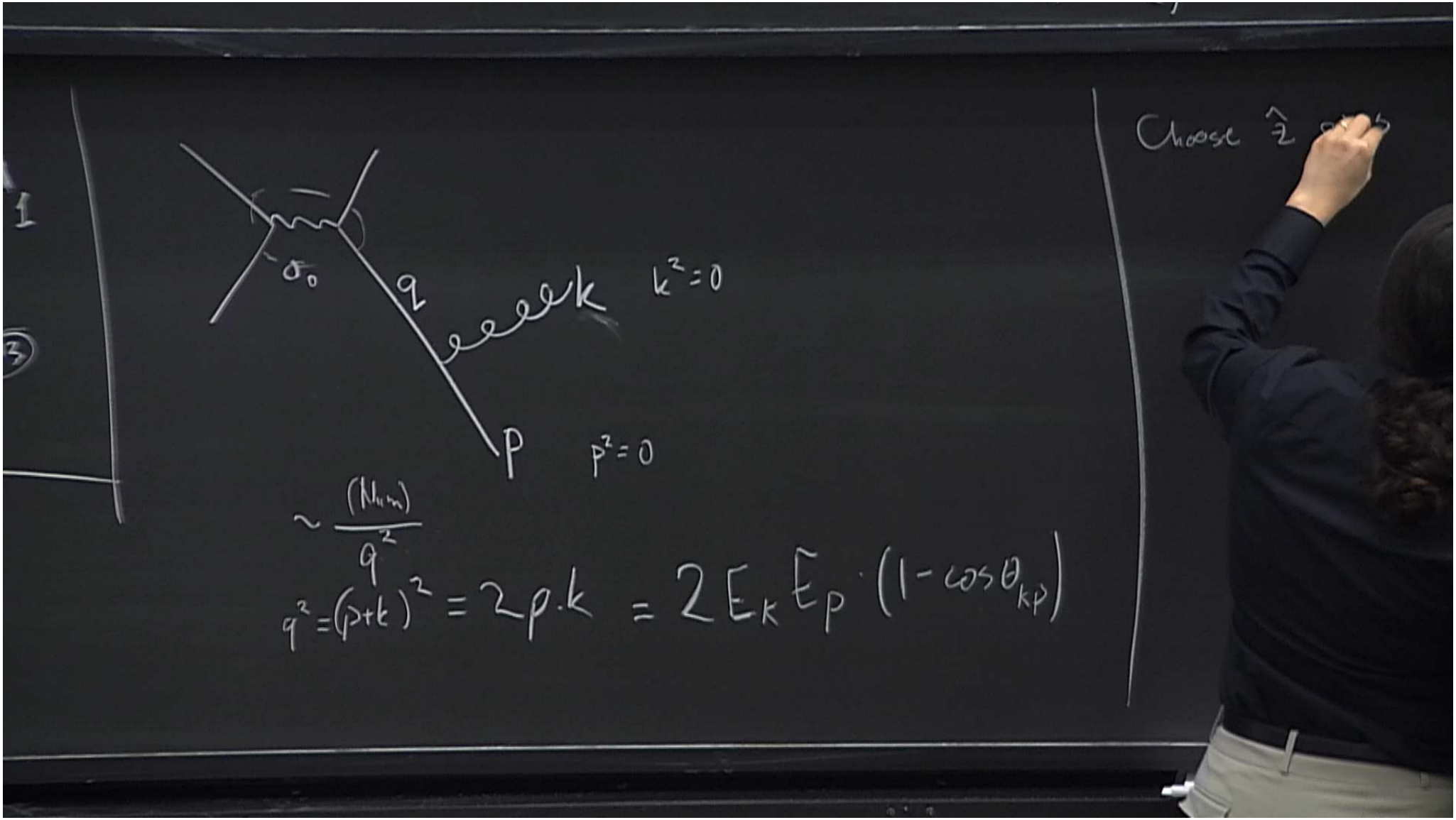

p_2
$\bar{q}$
k_2
p_3
k_1
$q(p_1)$
+
+
jet
$Q = p_1 + p_2 + p_3$
soft (low p)
collinear
$Q^2 = (k_1 + k_2)^2$, $x_i = \frac{2Q \cdot p_i}{Q^2} \Rightarrow \Sigma x_i = 1$,
$d\sigma_{q\bar{q}g} \propto \frac{2\alpha}{3\pi} \sigma_0 \cdot \frac{x_1^2 + x_2^2}{(1-x_1)^2(1-x_2^2)}$

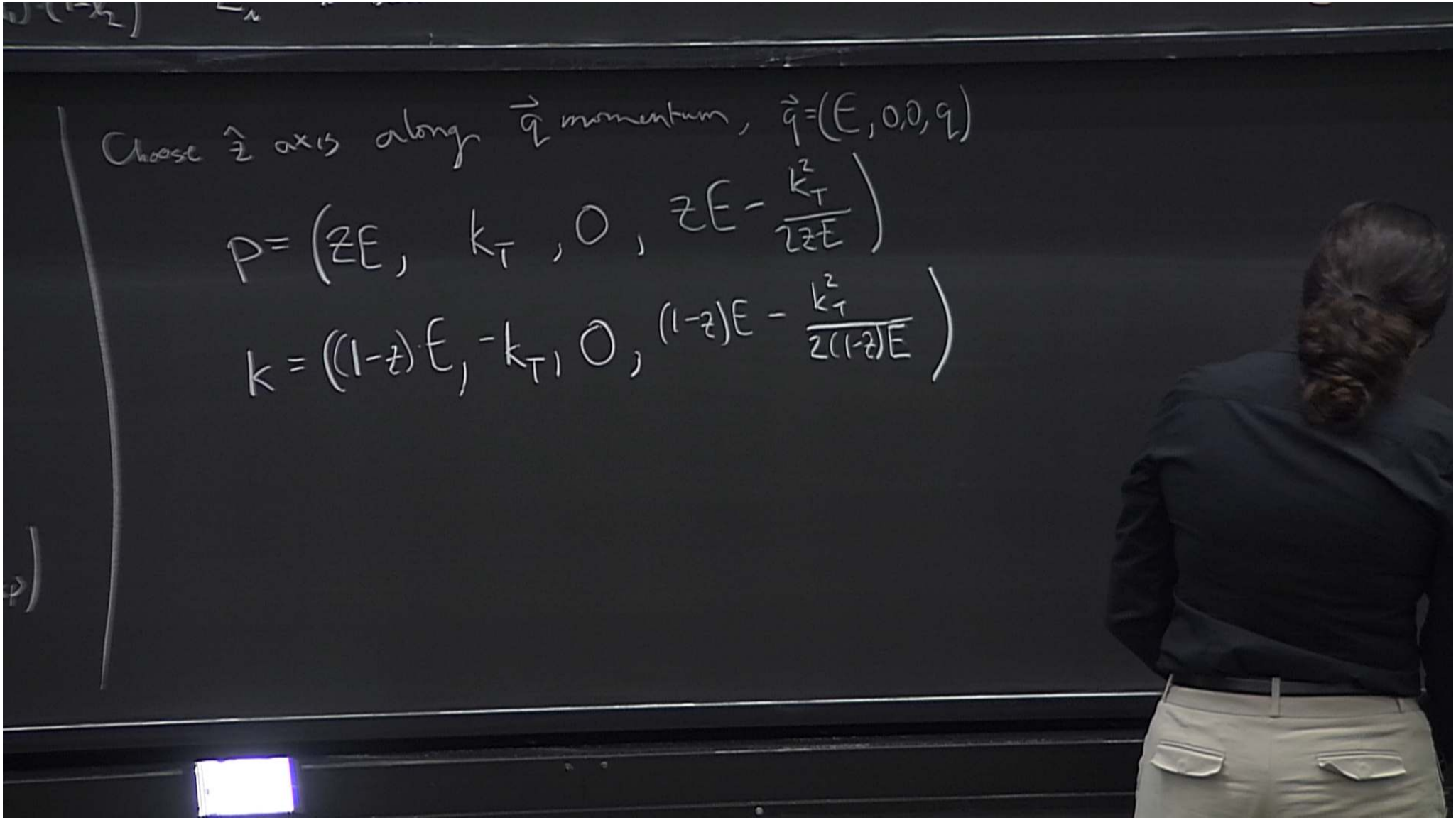

p_2
$\bar{q}$
k_2
p_3
k_1
$q(p_1)$
soft (low p)
collinear
$Q = p_1 + p_2 + p_3$
$Q^2 = (k_1 + k_2)^2$
$x_i = \frac{2Q \cdot p_i}{Q^2} \Rightarrow \sum x_i = 2$
$d\sigma_{q\bar{q}g} \propto \frac{2\alpha}{3\pi} \sigma_0 \cdot \frac{x_1^2 + x_2^2}{(1-x_1)^2(1-x_2^2)}$
jet


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


$X_1 = 1$
1
2+3


$\bar{q}$
q
k_2
k_1
$\bar{q}$
P_2
P_3
$q(P_1)$
+
+
+
$Q = P_1 + P_2 + P_3$
$Q^2 = (k_1 + k_2)^2$
soft (low p)
collinear
$x_i = \frac{2Q \cdot P_i}{Q^2} \Rightarrow \Sigma x_i = 1$
$E_i = x_i \cdot E_{beam}$
$3Q_f^2$
$d\sigma_{qq\bar{q}g} \propto \frac{2\alpha_s}{3\pi} \sigma_0 \cdot \frac{x_1^2 + x_2^2}{(1-x_1)\cdot(1-x_2)}$


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

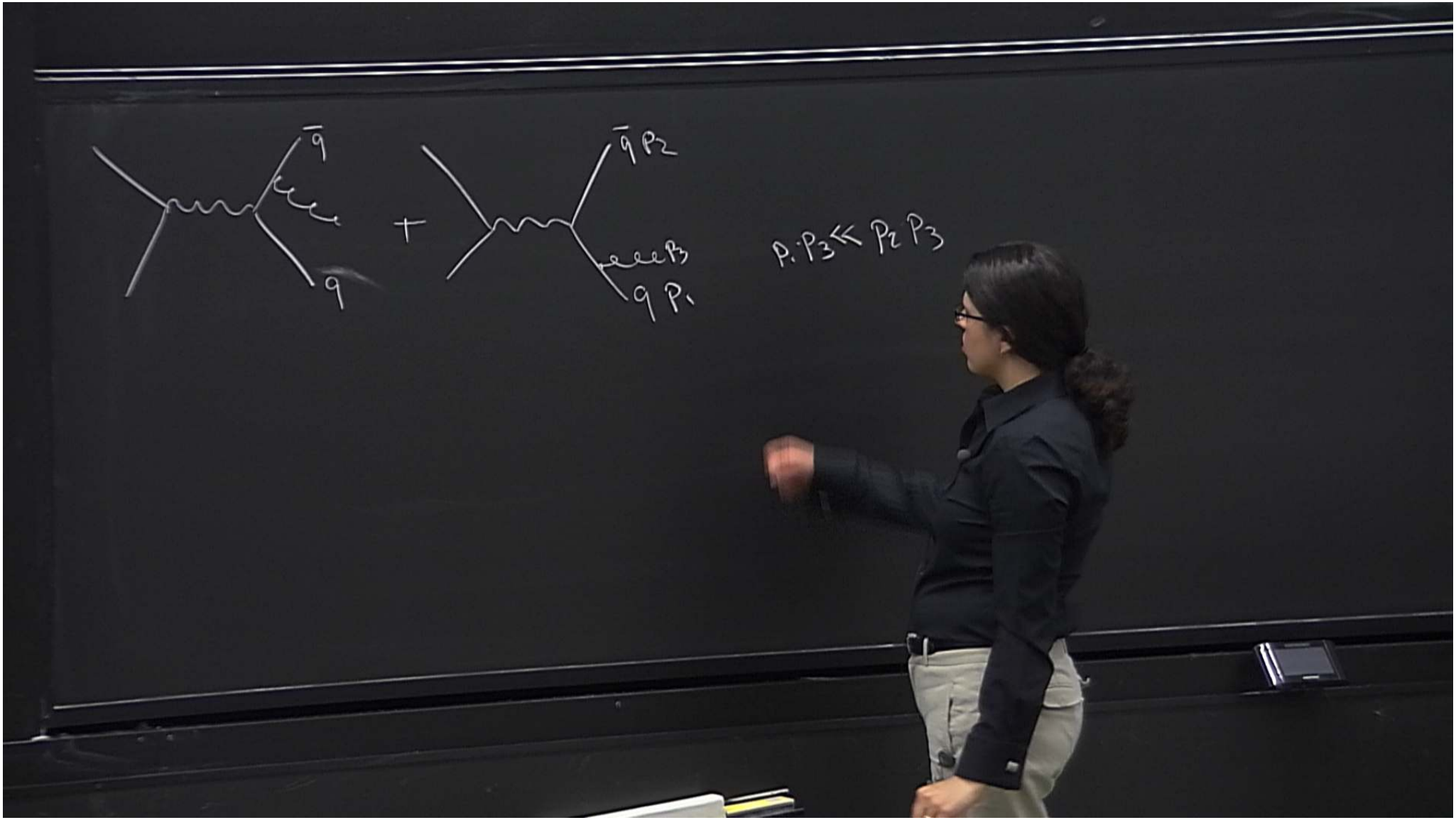

Choose $\hat{z}$ axis along $\vec{q}$ momentum, $\vec{q}=(E,0,0,q)$
$p=\left(zE,\ k_T,\ 0,\ zE-\frac{k_T^2}{2zE}\right)$
$k=\left((1-z)E,\ -k_T,\ 0,\ (1-z)E-\frac{k_T^2}{2(1-z)E}\right)$

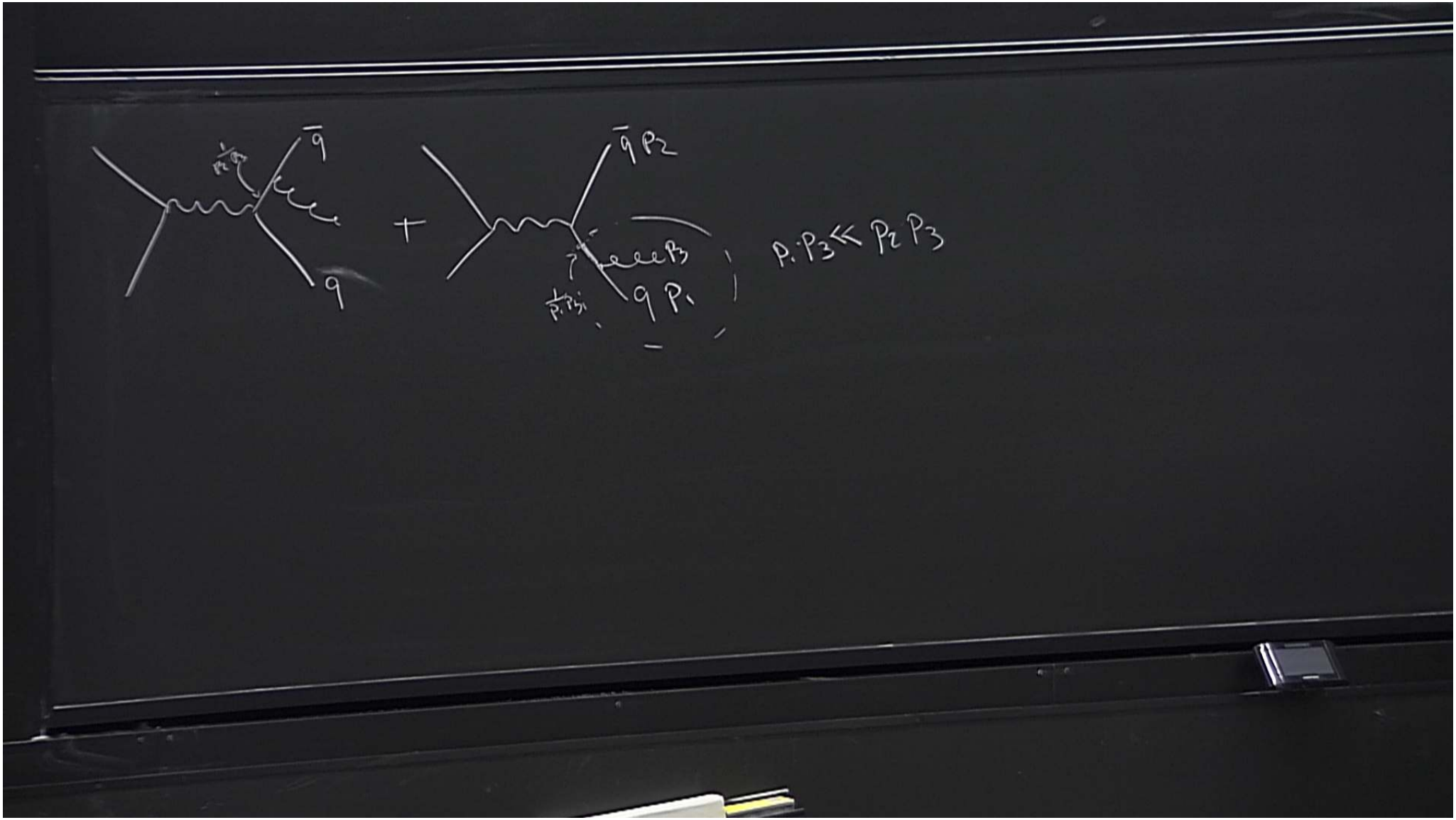
Choose $\hat{z}$ axis along $\vec{q}$ momentum, $\vec{q}=(E,0,0,q)$

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

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

$$\sum_{\epsilon(k),\text{pol of } q} |M|^2 \left(\vec{q} \rightarrow \text{vertex} \rightarrow k,\ p\right) = \frac{4}{3} g_3^2 \frac{2k_T^2}{z^2(1-z)}\left[1+(1-z)^2\right]$$


$\bar{q}$
q
+
$\bar{q}$ p_2
g 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

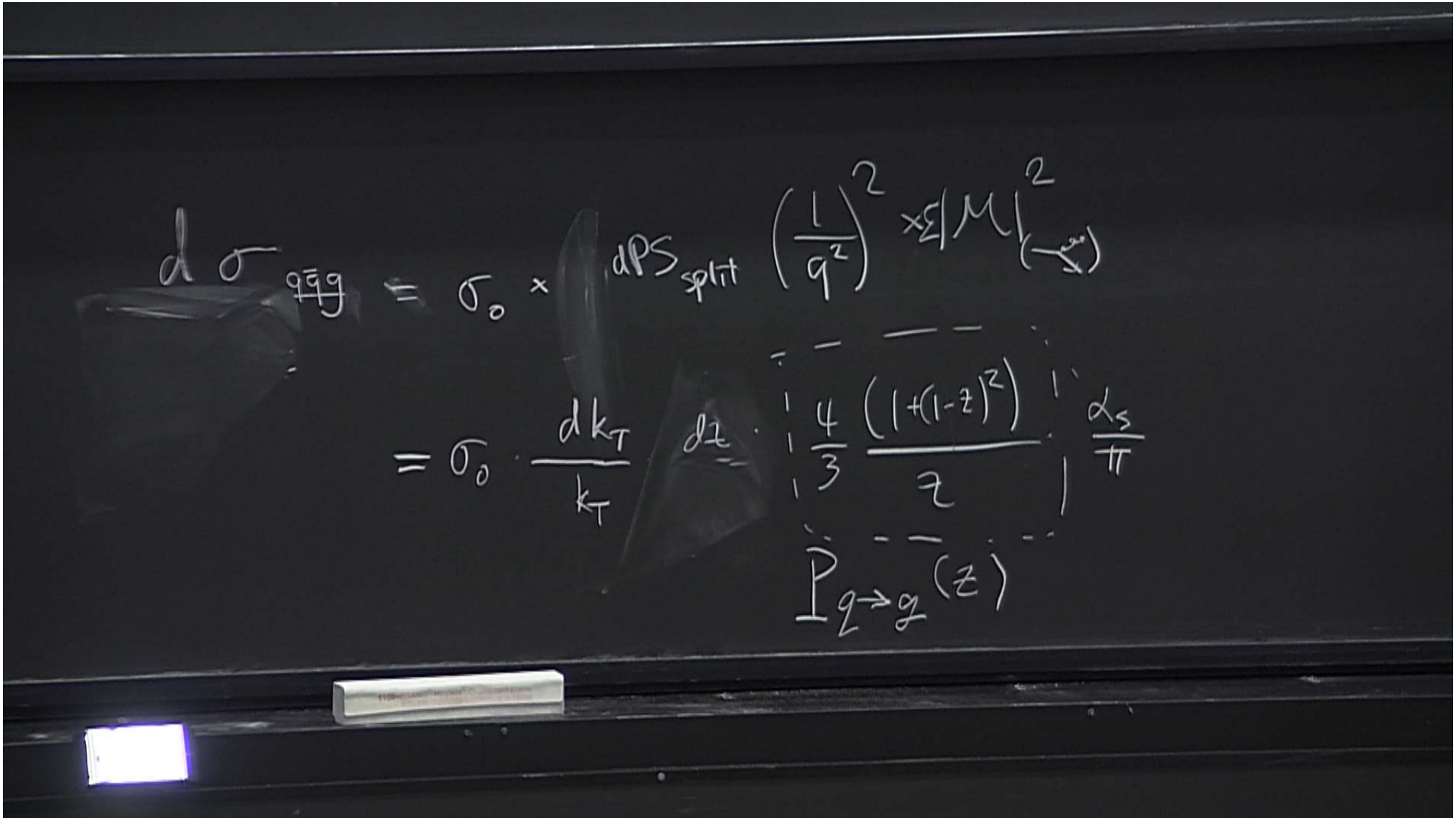
$q^2 = (p+k)^2 = 2p\cdot k = 2E_k E_p (1 - \cos\theta_{kp})$

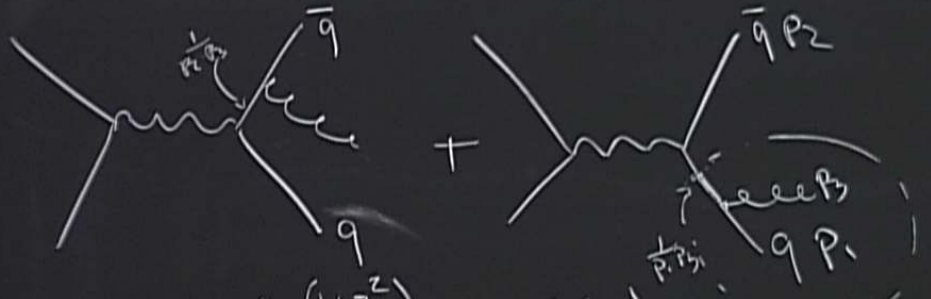
Relate k, p phase space to q p.s. plus ...

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

($d\phi \to 2\pi$)

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


$d\sigma_{qg\bar{q}g} = \sigma_0 \times dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \sum |M|^2_{(q\bar{q})}$
$= \sigma_0 \cdot \frac{dk_T}{k_T} \cdot dz \cdot \frac{4}{3} \frac{(1+(1-z)^2)}{z} \cdot \frac{\alpha_s}{\pi}$
$P_{q \to q}(z)$



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

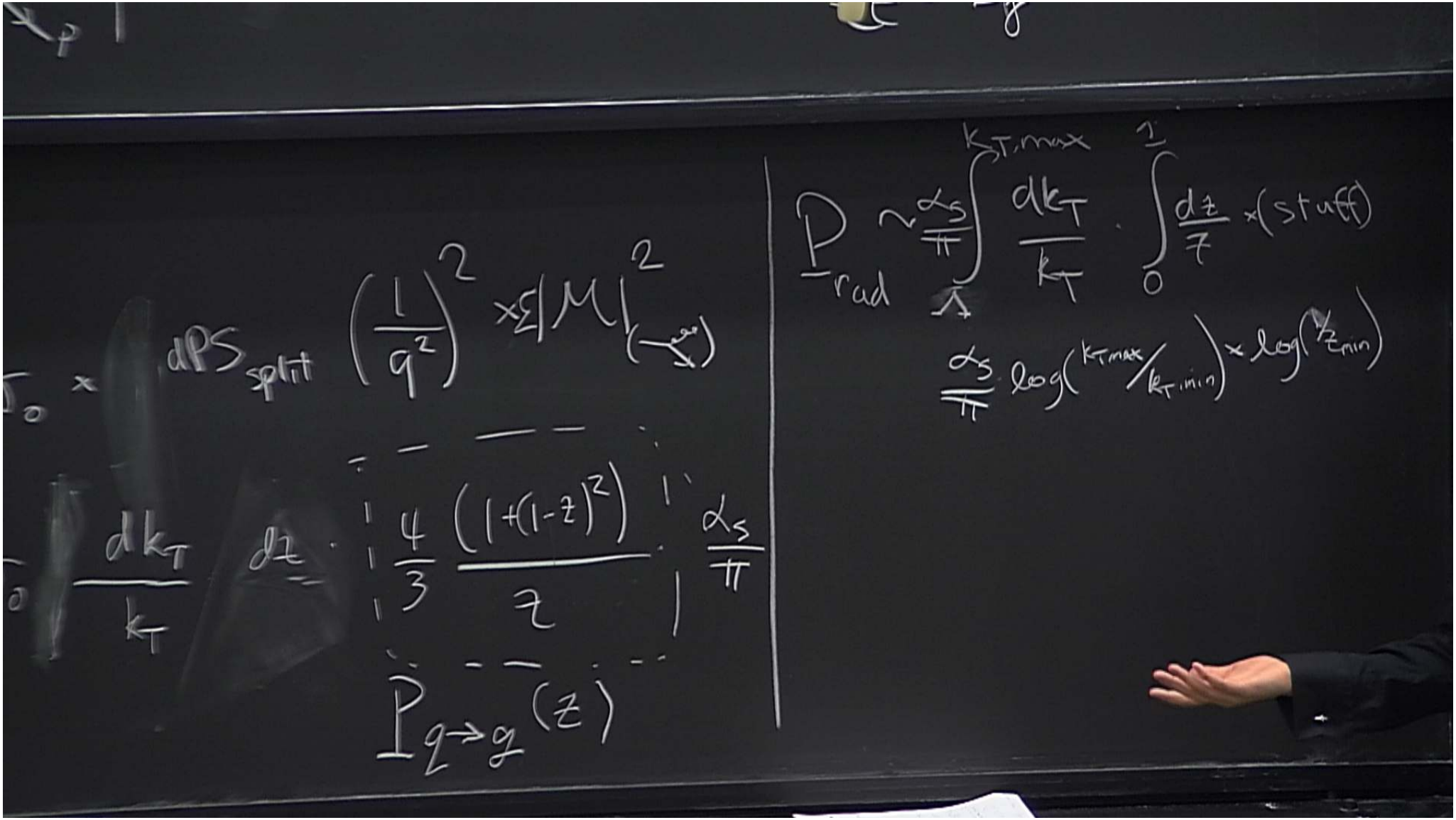
$$P_{g\to q\ (\text{or}\ \bar{q})} = \frac{1}{2}\left[z^2 + (1-z)^2\right]$$

$$\Gamma_0 \times \int dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \sum |M|^2_{(-\infty)}$$

$$\int \frac{dk_T}{k_T} \, dz \cdot \frac{4}{3} \frac{\left(1+(1-z)^2\right)}{z} \cdot \frac{\alpha_s}{\pi}$$

$$P_{q \to g}(z)$$

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


$\int dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \Sigma |M|^2_{(-\infty)}$
$\int \frac{dk_T}{k_T} dz \cdot \frac{4}{3} \frac{(1+(1-z)^2)}{z} \cdot \frac{\alpha_s}{\pi}$
$P_{q \to g}(z)$
$P_{rad} \sim \frac{\alpha_s}{\pi} \int_{\Lambda}^{k_{T,max}} \frac{dk_T}{k_T} \cdot \int_0^1 \frac{dz}{z} \times (stuff)$
$\frac{\alpha_s}{\pi} \log(k_{T,max}/k_{T,min}) \times \log(1/z_{min})$

$$\int_0 \times \int dPS_{split} \left(\frac{1}{q^2}\right)^2 \times \sum |M|^2_{(-\infty)}$$

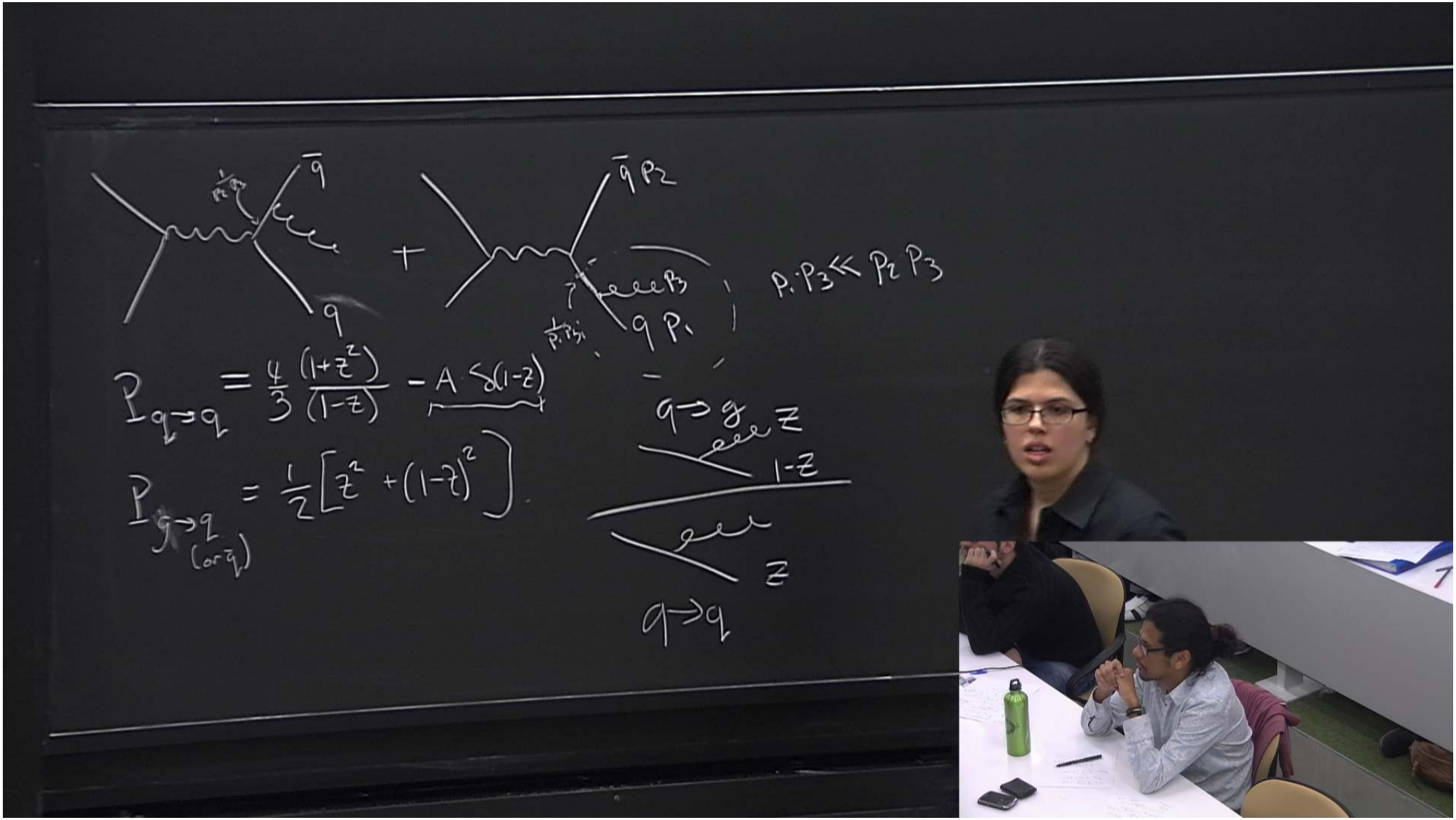
$$\int_0 \frac{dk_T}{k_T} \, dz \cdot \frac{4}{3} \frac{\left(1+(1-z)^2\right)}{z} \cdot \frac{\alpha_s}{\pi}$$

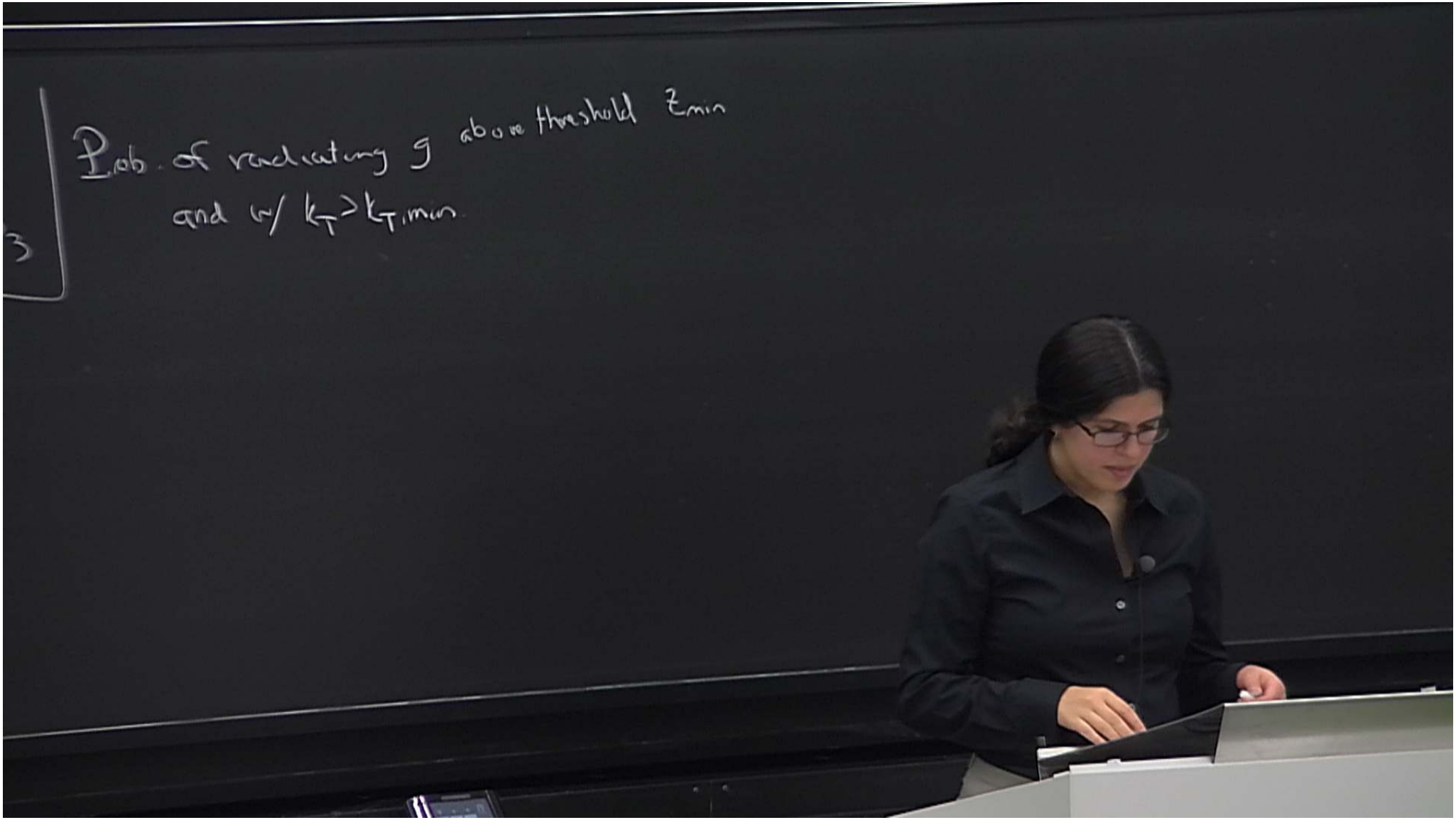
$$P_{q \to g}(z)$$

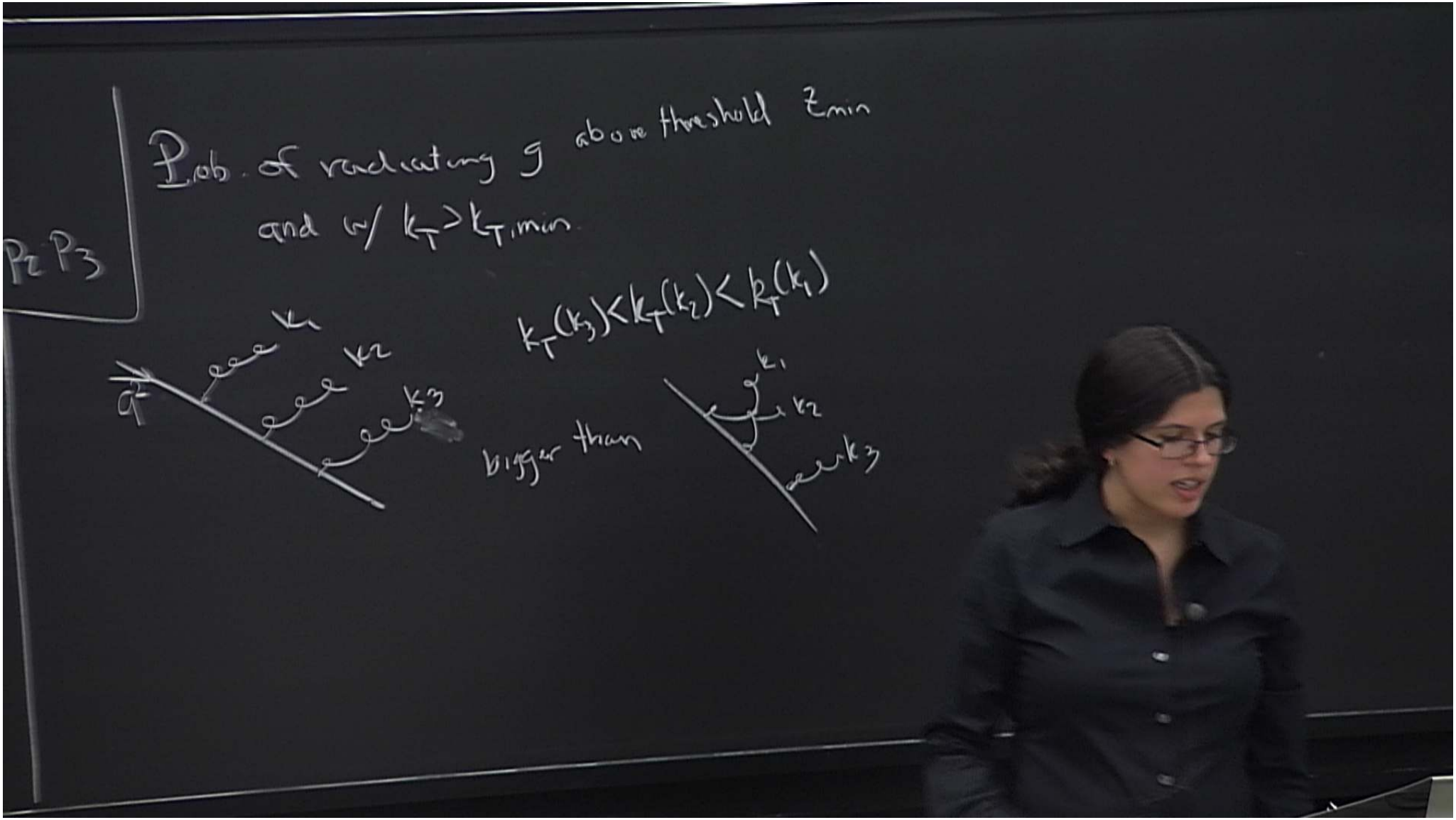
$$P_{rad} \sim \frac{\alpha_s}{\pi} \int_{\Lambda}^{k_{T,max}} \frac{dk_T}{k_T} \cdot \int_0^1 \frac{dz}{z} \times (\text{stuff})$$

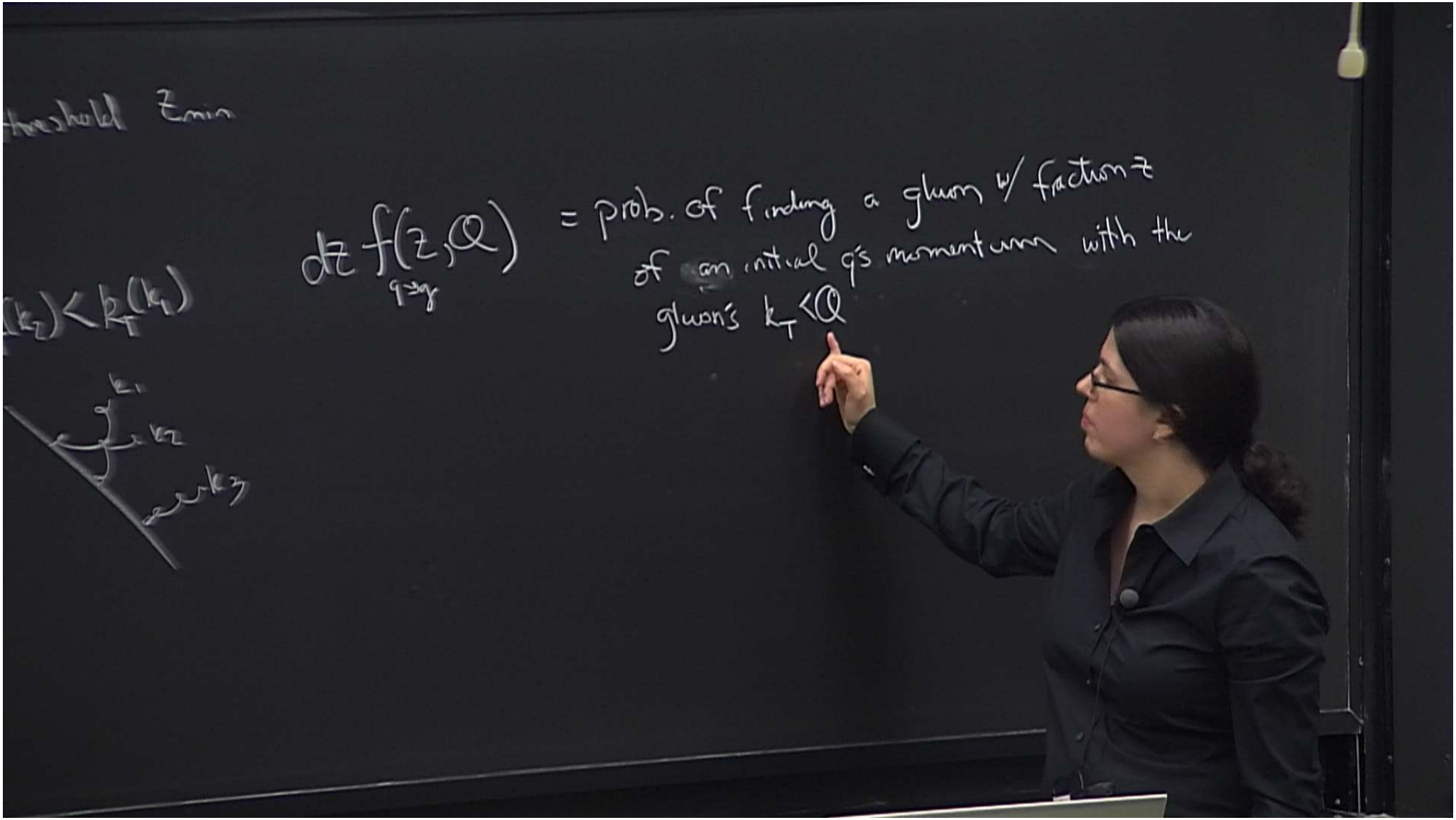
$$\frac{\alpha_s}{\pi} \log\left(k_{T,max}/k_{T,min}\right) \times \log\left(1/z_{min}\right)$$

$> 1 \Rightarrow$ not really a probability.


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


Prob. of radiating g above threshold z_{min}
and w/ $k_T > k_{T,min}$


Prob. of radiating g above threshold z_{min}
and w/ $k_T > k_{T,min}$
$P_2 P_3$
$k_T(k_3) < k_T(k_2) < k_T(k_1)$
k_1
k_2
k_3
bigger than
k_1
k_2
k_3


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

threshold z_{min}

$k_T(k_2) < k_T(k_1)$

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

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

q'' energy w 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 $k_T < Q$

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

$\times \delta(x\omega - z)$ q'' energy ωE_q

g energy $\omega x E_q$

$Q' > Q$

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

$$f_{q\to g}(z,Q') = f(z,Q) + \frac{\alpha_s}{2\pi}\int_{Q}^{Q'} \frac{dk_T}{k_T} \int dx\; P^{(\omega)}_{p\to p''' p''} f_{p'''\to p'}(x,Q)$$

$\times \delta(x\omega - z)$ q'' energy ωE_q

g energy $\omega x E_q$

$Q' > Q$

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

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

$\times \delta(x\omega - z)$ q'' energy ωE_q

q energy $\omega \times E_q$

$Q' > Q$

$$\frac{d}{d\log Q'} f(z,Q') = \frac{\alpha_s(Q')}{\pi}\int \frac{d\omega}{\omega} \sum_{p''} P^{(\omega)}_{p\to p''} f\left(\frac{z}{\omega}, Q'\right)$$

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

$q \to g$

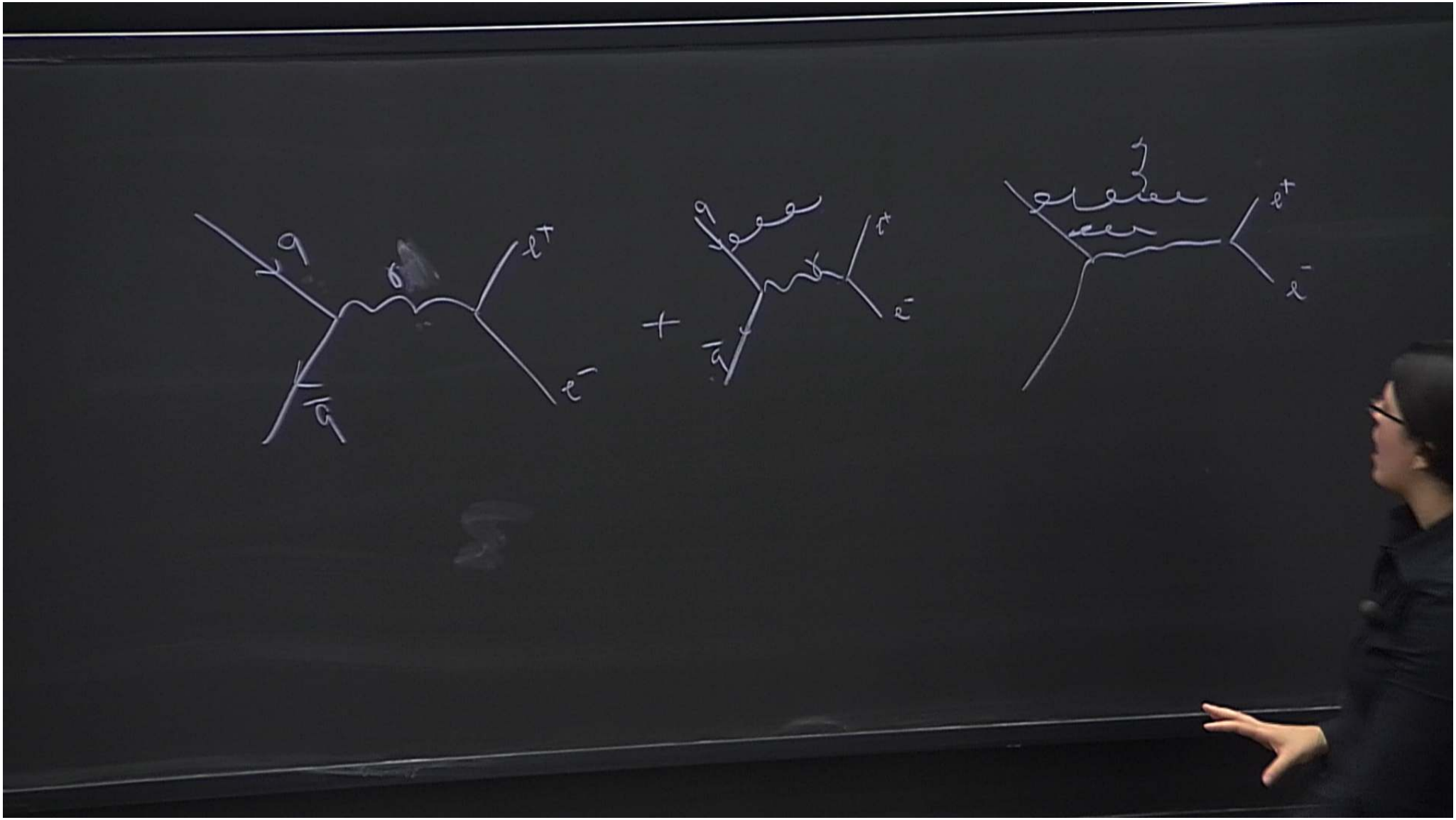
$$f(z,Q') = f(z,Q) + \frac{\alpha_s}{\pi} \int_{Q}^{Q'} \frac{dk_T}{k_T} \int dx \; P^{(\omega)}_{p \to p'' p'} \, f_{p'' \to p'}(x,Q)$$

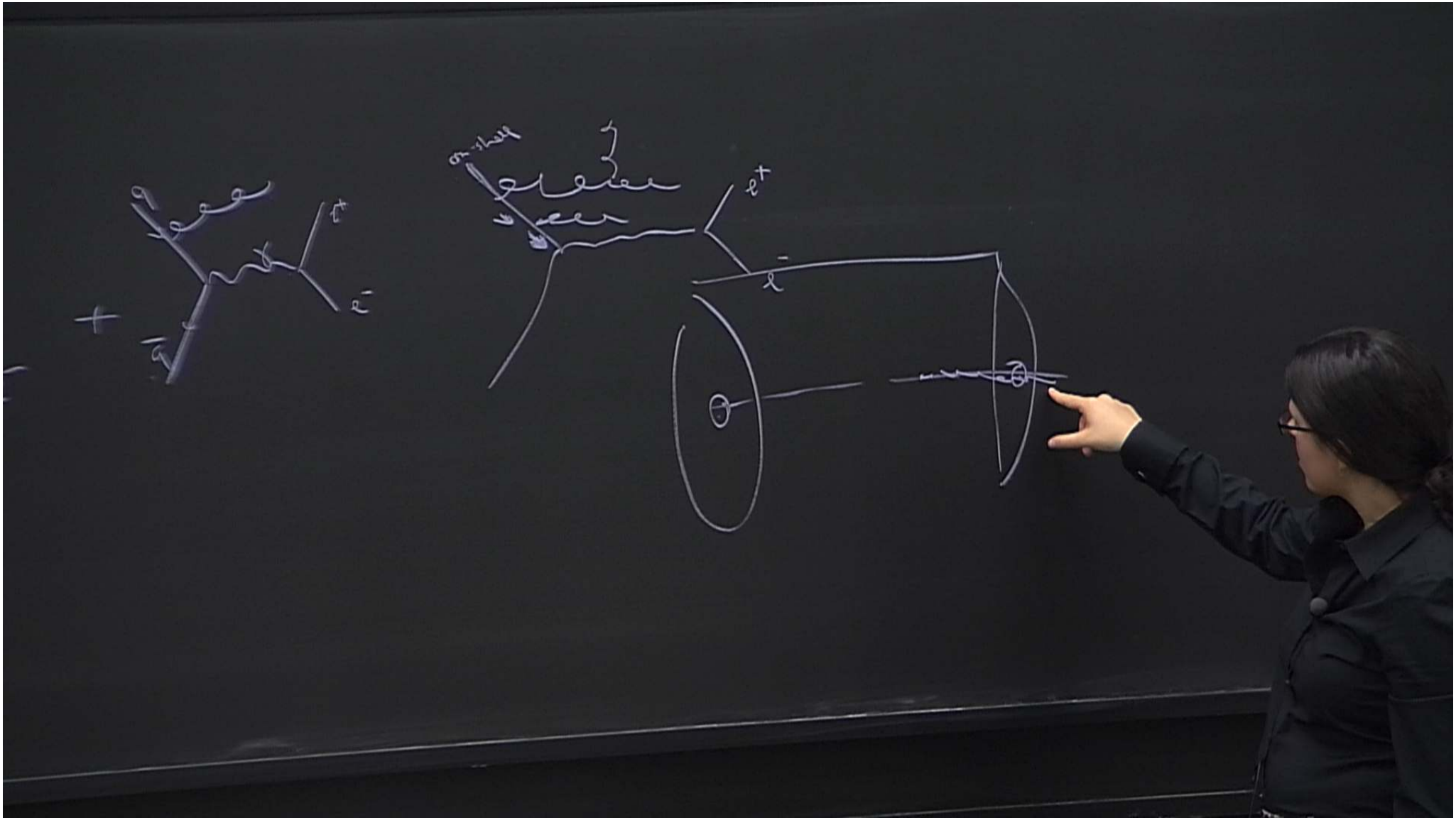
$\times \delta(x\omega - z)$ q'' energy ωE_q

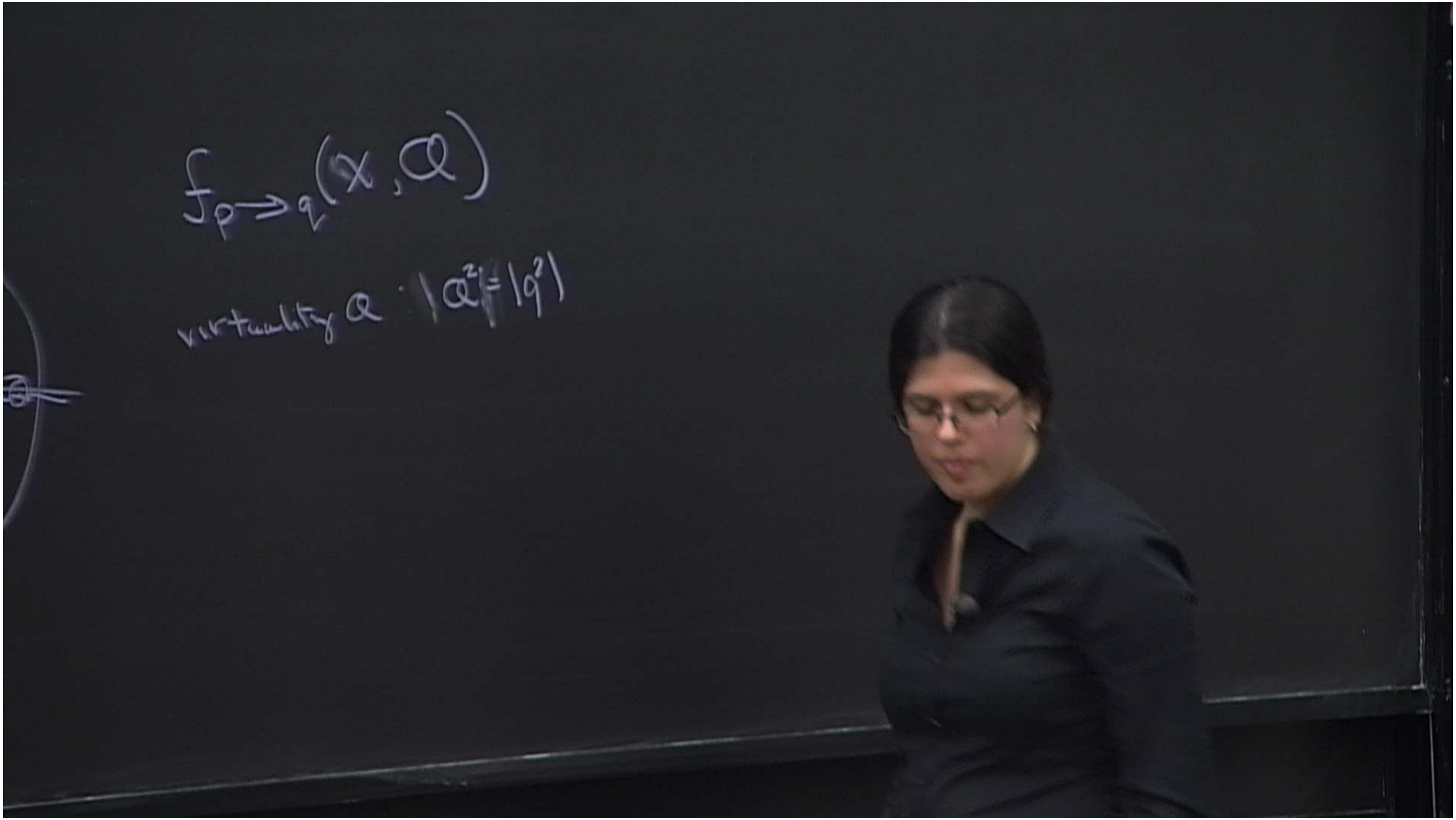
q energy $(1-\omega) E_q$

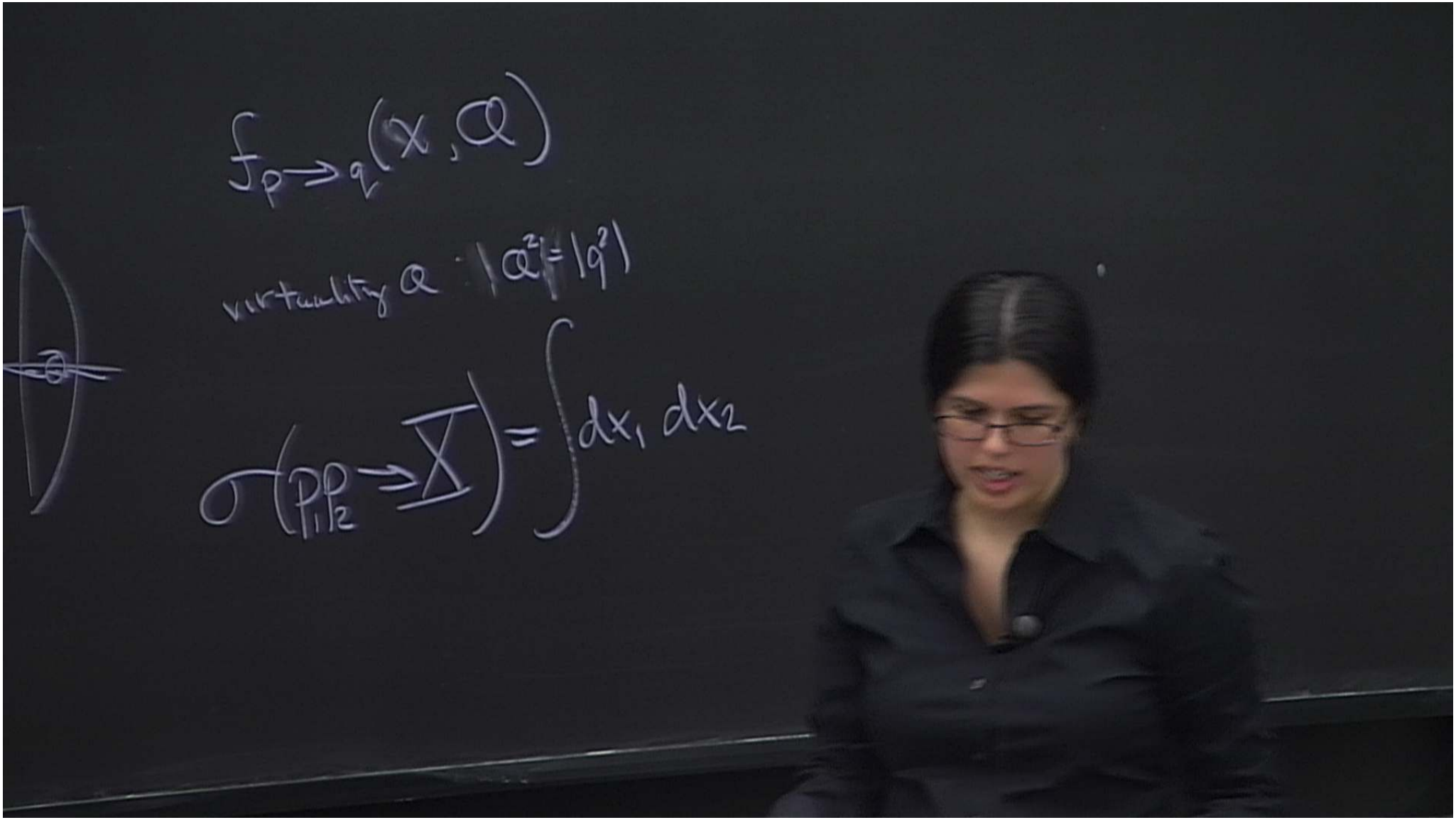
$Q' > Q$

$$\frac{d}{d \log Q'} f(z,Q') = \frac{\alpha_s(Q')}{\pi} \int \frac{d\omega}{\omega} \sum_{p''} P^{(\omega)}_{p \to p'' p'} \, f_{p' \to p'}\left(\frac{z}{\omega}, Q'\right)$$


q
γ
e+
e−
q̄
+
q
e+
e−
q̄
e+
e−




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

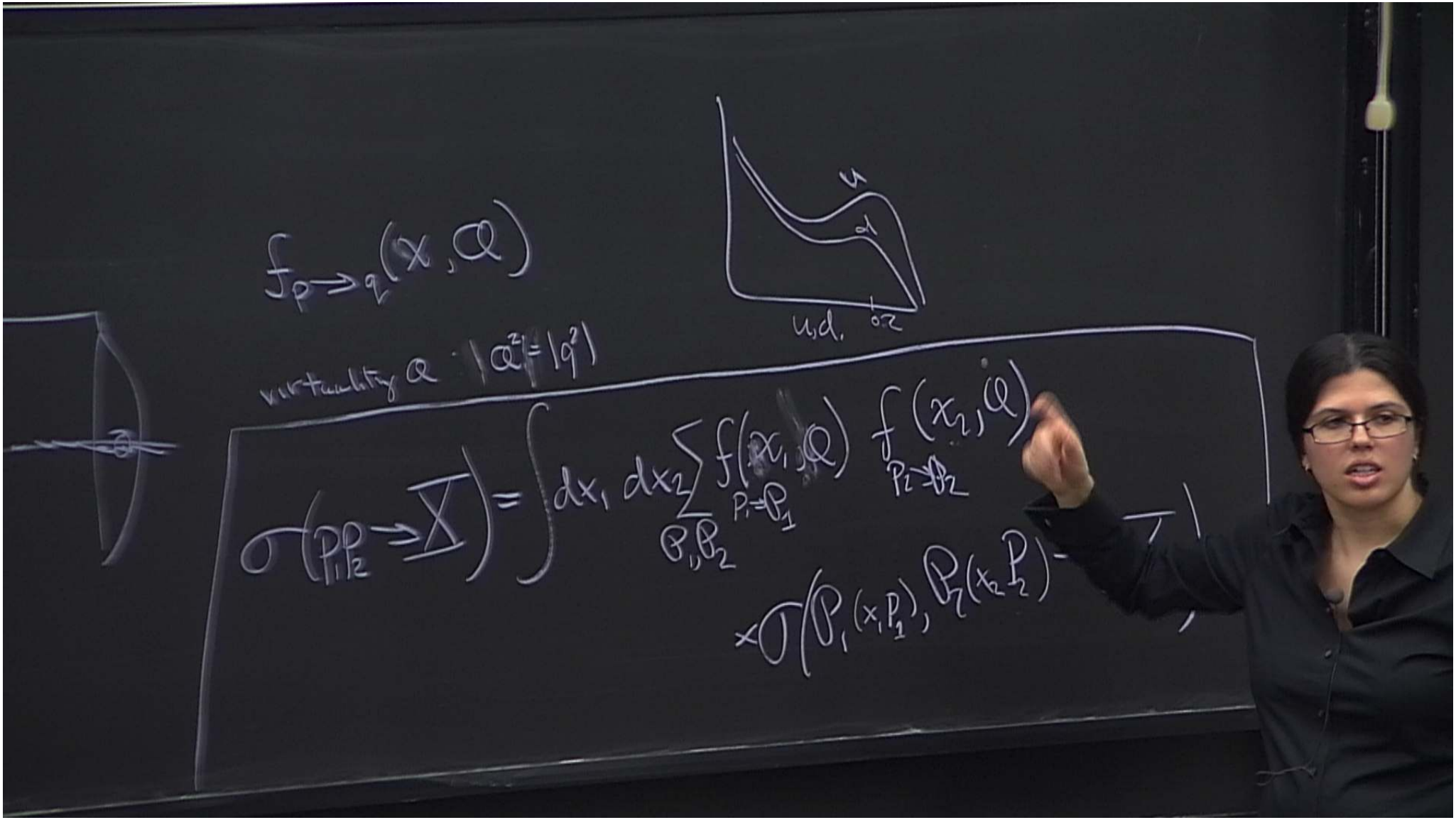

$f_{p \to q}(x, Q)$
virtuality Q : $|Q^2| = |q^2|$
$\sigma(P_1 P_2 \to X) = \int dx_1\, dx_2$

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

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

$$\sigma(P_1 P_2 \to X) = \int dx_1\, dx_2 \sum_{p_1, p_2} f_{P_1 \to p_1}(x_1, Q)\; f_{P_2 \to p_2}(x_2, Q)$$

$$\times \sigma(p_1(x_1 P_1), p_2(x_2 P_2) \to X)$$


$f_{p\to q}(x,Q)$
virtuality $Q^2 = |q^2|$
u
d
u,d, $\bar{u}\bar{d}$
$\sigma(P_1P_2 \to X) = \int dx_1\, dx_2 \sum_{P_1,P_2} f(x_1,Q)\, f(x_2,Q)$
$P_1\to P_1$
$P_2\to P_2$
$\times \sigma(P_1(x_1P_1), P_2(x_2P_2)) -$