THE DIHADRON FRAGMENTATION FUNCTION AND ITS EVOLUTION : MEASURING TWO HADRON CORRELATION IN e^+e^- & HEAVY ION COLLISIONS

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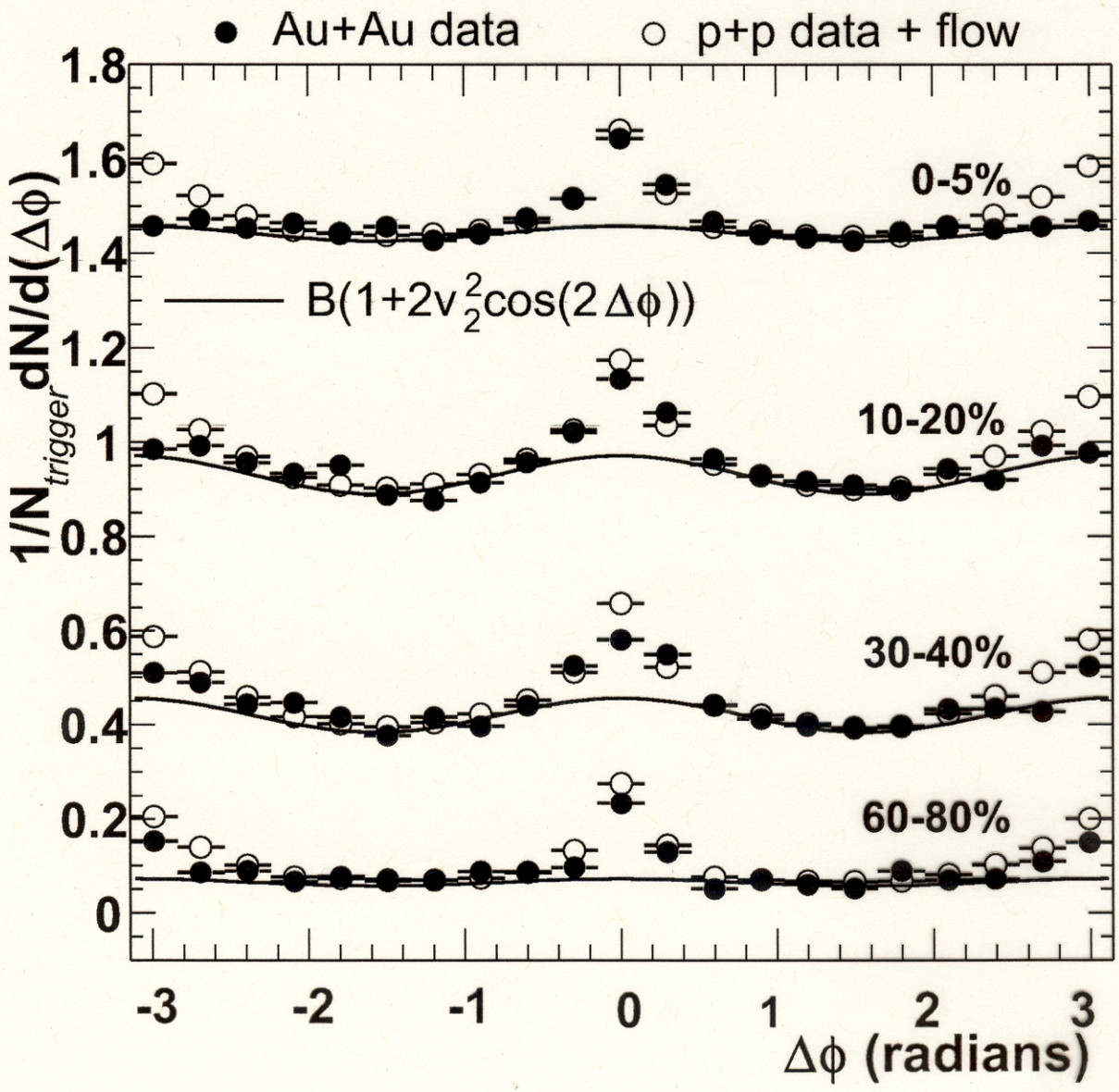
IN COLLABORATION WITH

X. N. WANG (LBNL)



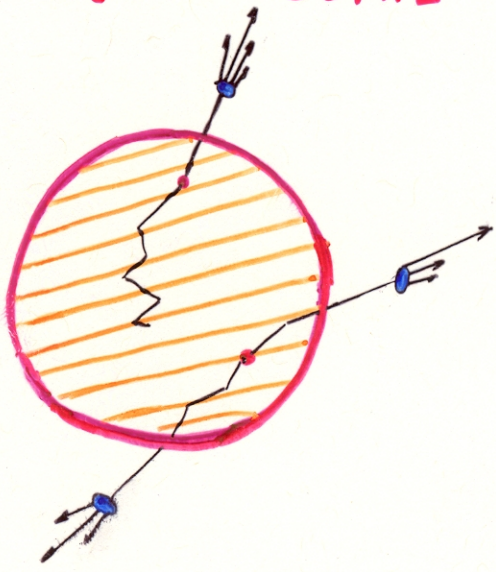
* AWAY-SIDE CORRELATION IS QUITE DIFFERENT FROM 'PP'

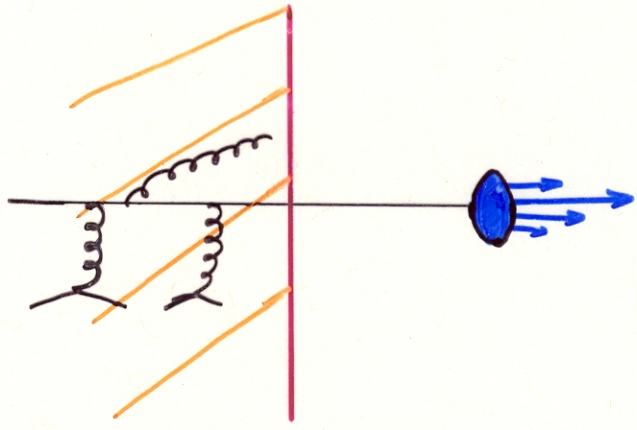
* SAME-SIDE LOOKS VERY SIMILAR TO 'PP' !

POINTS TO CONSIDER !

* HIGH P_T PARTONS ARE CREATED OVER THE ENTIRE REGION OF COLL. WITH SOME PROB. DISTRIBUTION

A)





ENERGY LOSS

* WE SEE FRAGMENTING PARTONS THAT STARTED OUT AT HIGHER E

* LOSE ENERGY BY PARTONIC RESCATTERING AND RADIATION

* PARTONIC ENERGY LOSS MODELS CAN EXPLAIN (B.D.M.P.S., G.L.V., G.W... WIEDEMANN...)

a) SINGLE INCLUSIVE

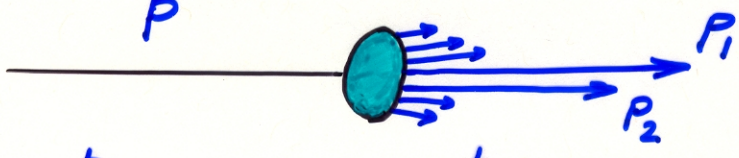
b) TWO HADRONS (BACK-TO-BACK) (X. N. WANG)

* REQUIRE HIGH DENSITY OF SCATTERERS

* HIGH DENSITY $\Rightarrow$ QGP!

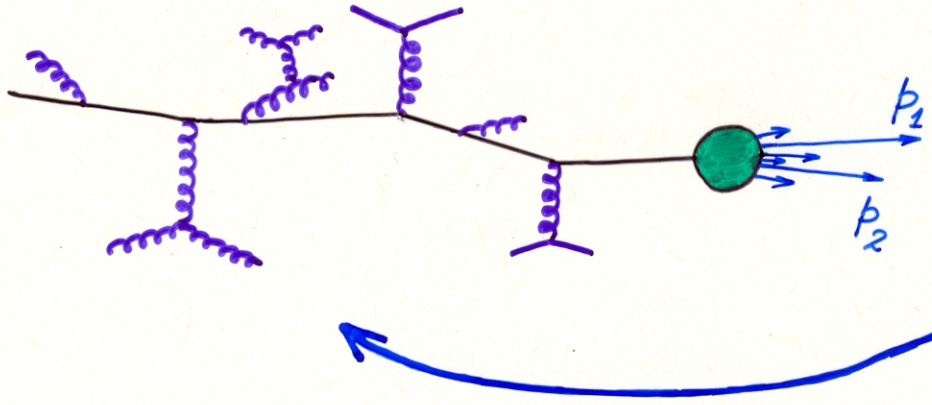
* WHAT ABOUT SAME SIDE?

REQUIRES $D_q^{h_1 h_2}(z_1, z_2)$!



$$z_1 = \frac{p_1}{p}, \quad z_2 = \frac{p_2}{p}$$

* NAIVELY,



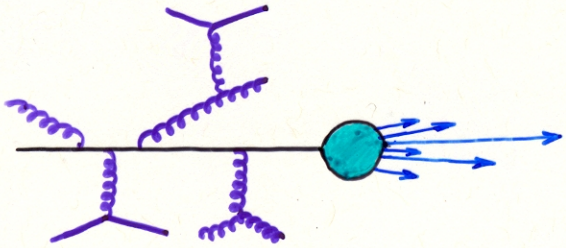
$\mathcal{D}\left(\frac{p_1^+}{p^+}, \frac{p_2^+}{p^+}\right)$

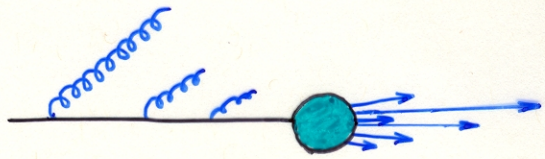
MORE SENSITIVE THAN $\mathcal{D}(p_1^+/p^+)$ TO MULT. SCATT.

WISH LIST!

i) EXACT DEFINITION OF $\mathcal{D}_q^{h_1 h_2}(z_1, z_2)$ IN OPERATOR FORMALISM ✓

ii) UNDERSTAND EFFECT OF E-LOSS ON $\mathcal{D}_q^{h_1 h_2}(z_1, z_2, Q^2)$





IN MEDIUM MODIFICATION ~ IN VACUUM EVOLUTION

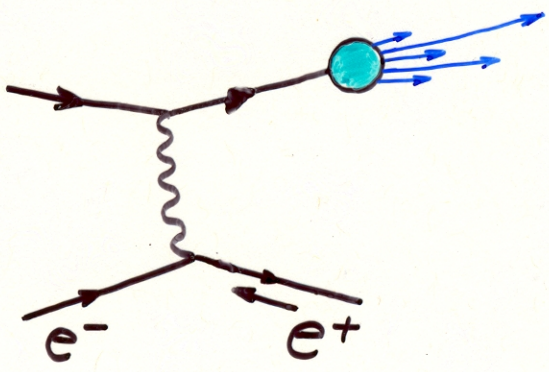
* BOTH CHANGE SCALE OF $\mathcal{D}(z_1, z_2, Q^2)$

iii) DGLAP EVOLUTION OF $\mathcal{D}_q^{h_1 h_2}(z_1, z_2, Q^2)$ ✓

BUT!

* HEAVY-ION ENVIRONMENT COMPLICATED

* USE SIMPLER e^+e^- COLLISIONS



CALCULATE

$$\frac{d^2\sigma}{dz_1 dz_2}$$

AT L.O. & N.L.O.

QUESTIONS:

i) CAN WE FACTORIZE AS IN $\mathcal{D}(z)$:

$$\frac{d\sigma}{dz} = \sigma_0 \left(\mathcal{D}_q^h(z) + \mathcal{D}_{\bar{q}}^h(z) \right) \; ?$$

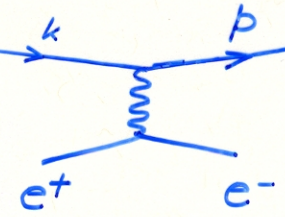
ii) WHAT KIND OF RESUMMATION INVOLVED IN DGLAP EVOL.?

iii) WHAT KIND OF EVOLUTION EQN?

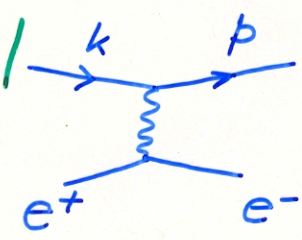
RESULTS PRESENTED IN "CUT-VERTEX" METHOD OF MUELLER

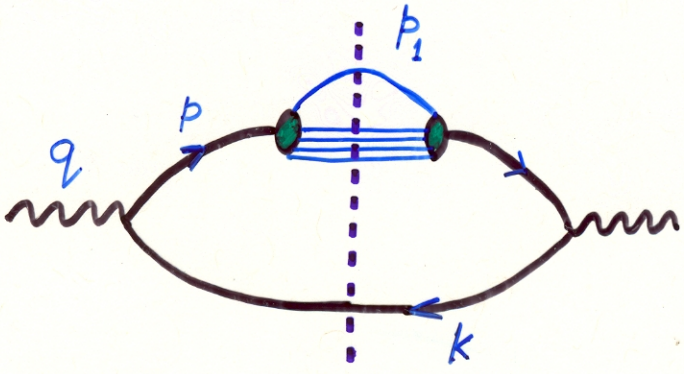
BASIC METHODOLOGY: AT L.O. α_s^0

$$\mathcal{D}_q^h(z) \longrightarrow \sum_{S-1} \Big| \langle k | \; k \;\; p \; | p_h, S-1 \rangle \Big|^2$$

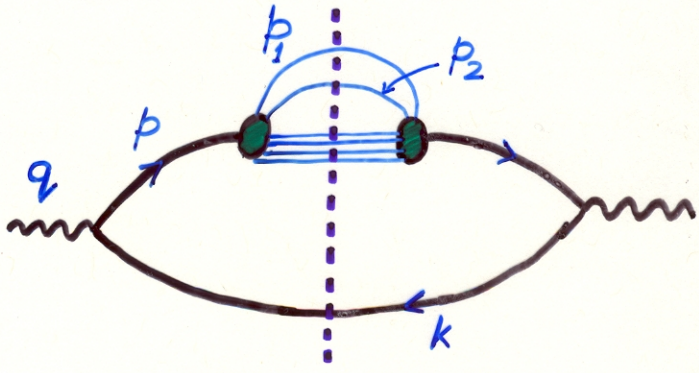


$$\mathcal{D}_q^{h_1 h_2}(z_1, z_2) \to \sum_{S-2} \Big| \langle k | \; k \;\; p \; | p_1, p_2, S-2 \rangle \Big|^2$$





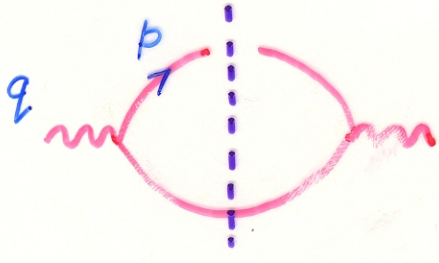
$\mathcal{D}(z)$

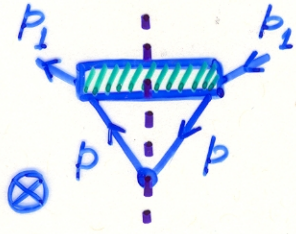


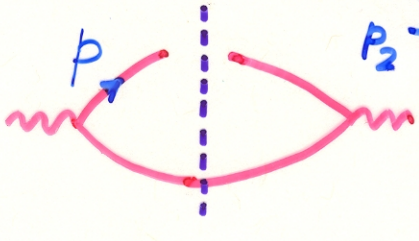
$\mathcal{D}(z_1, z_2)$

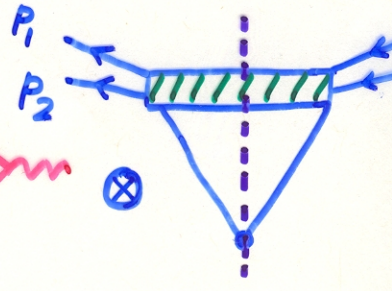
SET $p^+, p_h^+, p_1^+, p_2^+ \gg p^-, p_h^-, p_1^- \ldots$

$p_\perp, p_{h\perp}, p_{1\perp} \ldots$





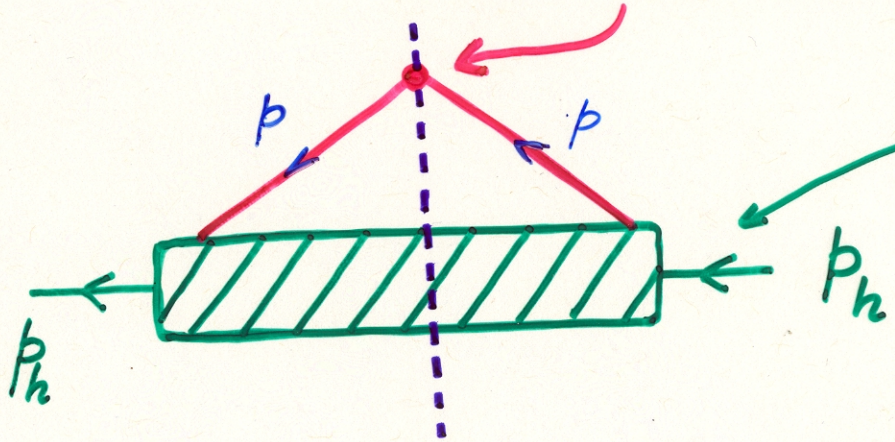




SINGLE FRAGMENTATION FUNCTION IN "CUT-VERTEX" FORMALISM

$$\mathcal{D}_q(z) = \frac{z^3}{2}\int\frac{d^4p}{(2\pi)^4}\,\mathrm{Tr}\left[\frac{\gamma^+}{2p_h^+}\,\delta\left(z-\frac{p_h^+}{p^+}\right)\,\hat{T}_q(p,p_h)\right]$$

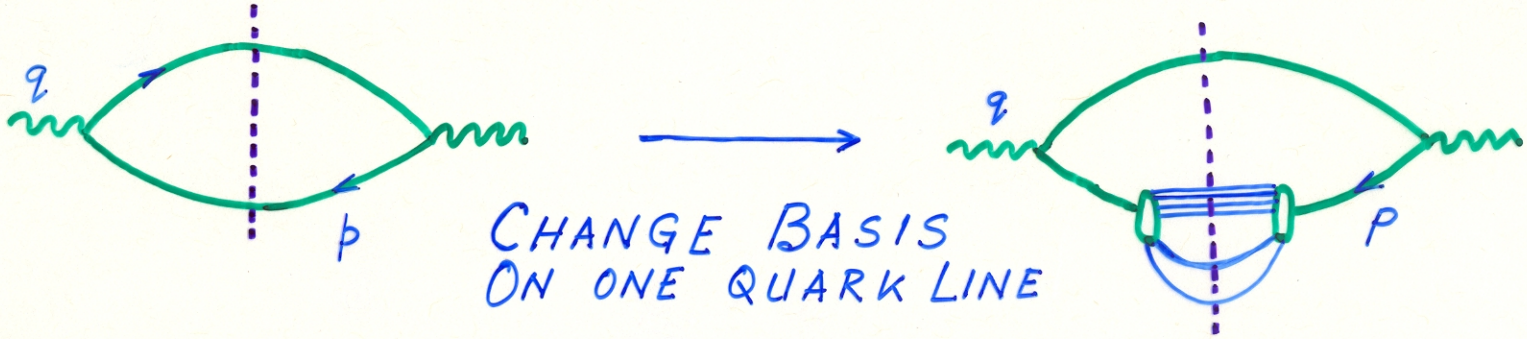
$$= \frac{z^3}{2}$$



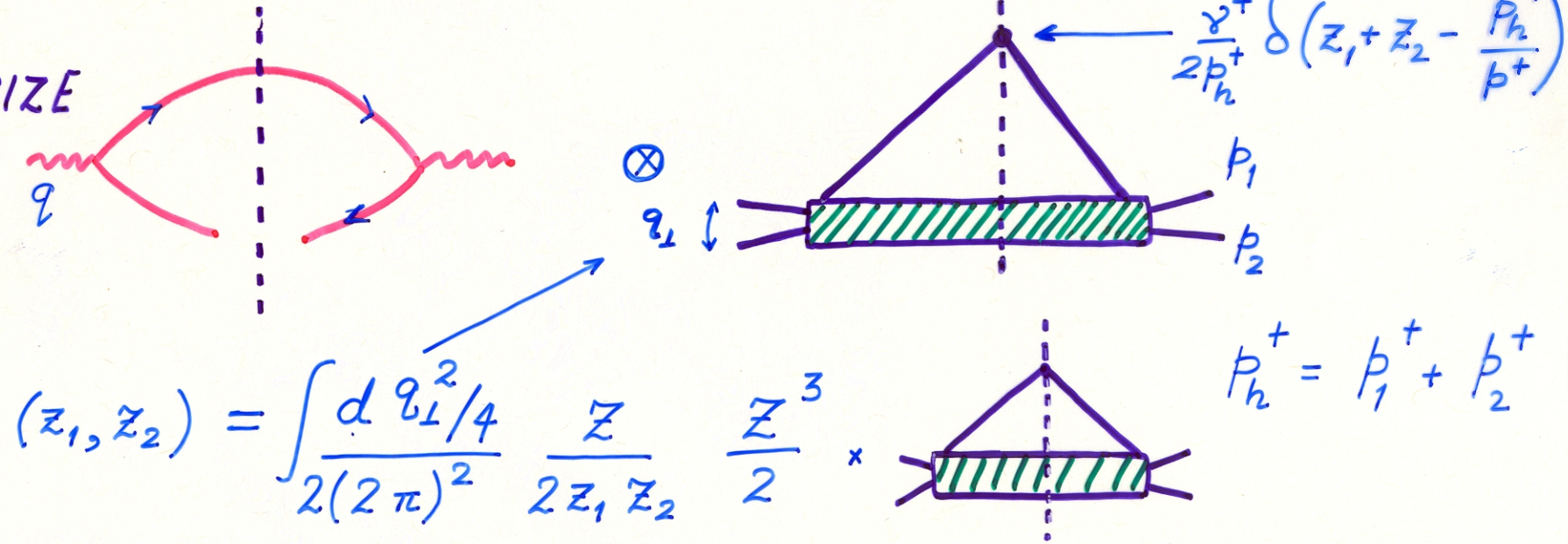
$$\hat{T}_q(p,p_h) = \int d^4x\, e^{-ip\cdot x}\sum_{S-1}\langle 0|\psi(0)|p_h,S-1\rangle \times \langle p_h,S-1|\,\bar{\psi}(x)\,|0\rangle$$

DOUBLE FRAGMENTATION FUNCTION

"IN CUT-VERTEX" NOTATION.



FACTORIZE

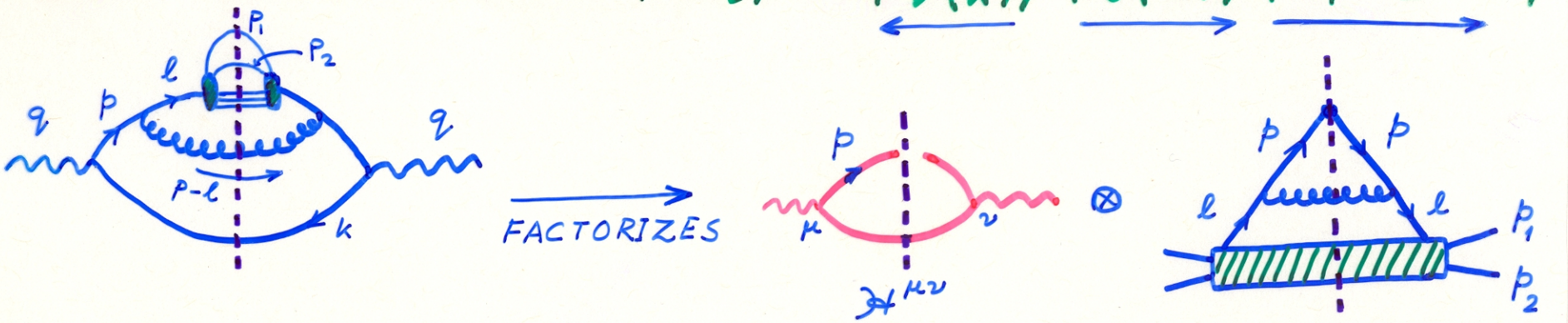


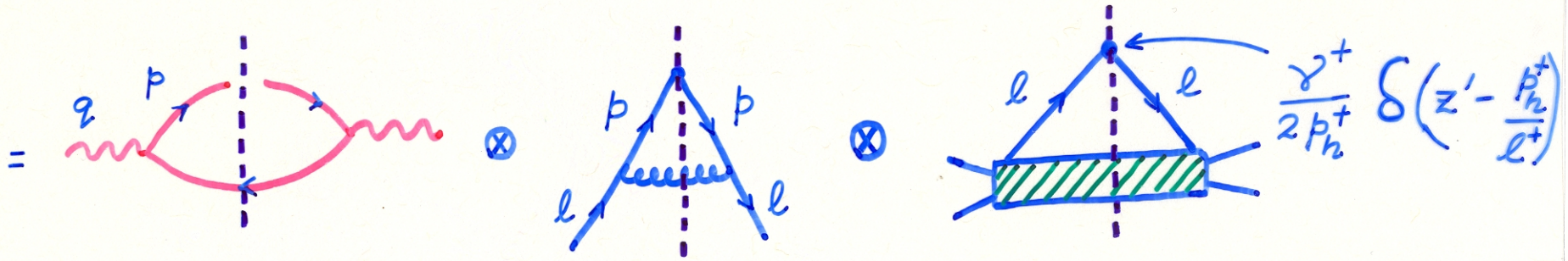
$$D_q(z_1,z_2) = \int \frac{d\,q_\perp^2/4}{2(2\pi)^2}\,\frac{z}{2z_1 z_2}\,\frac{z^3}{2}\times$$

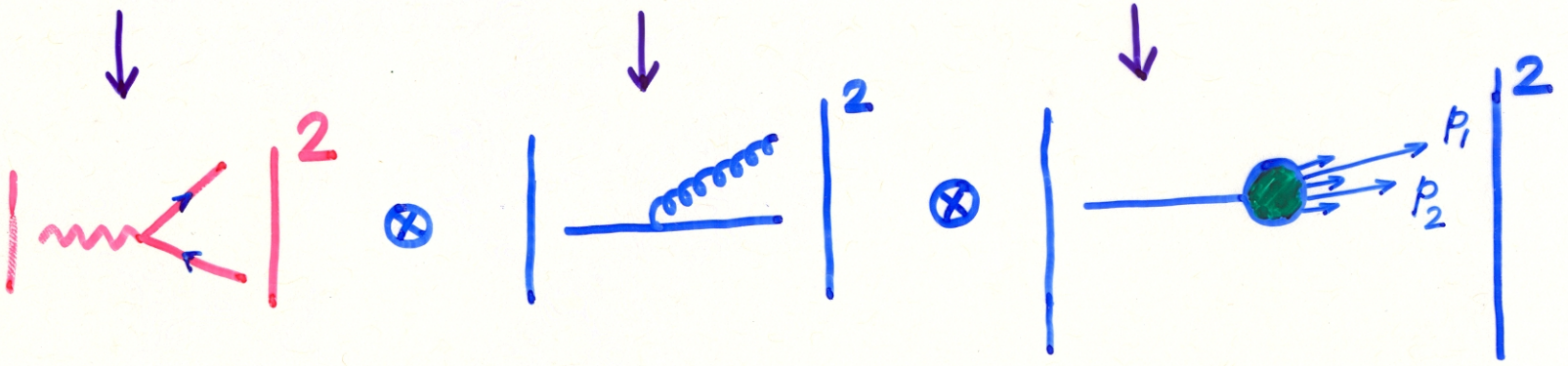
$$= \int \frac{d\,q_\perp^2}{8(2\pi)^2}\,\frac{z^4}{4z_1 z_2}\int\frac{d^4p}{(2\pi)^4}\,Tr\left[\frac{\gamma^+}{2P_h^+}\,\delta\left(z_1+z_2-\frac{P_h^+}{p^+}\right)\,\hat{T}_q(p;p_1,p_2)\right]$$

AT NEXT-TO-LEADING ORDER

* SET HAD. BASIS: $|z_h\rangle \to |\bar{q}(k)\rangle\, |g(\ell)\rangle\, |p_1\, p_2\, S{-}2\rangle$





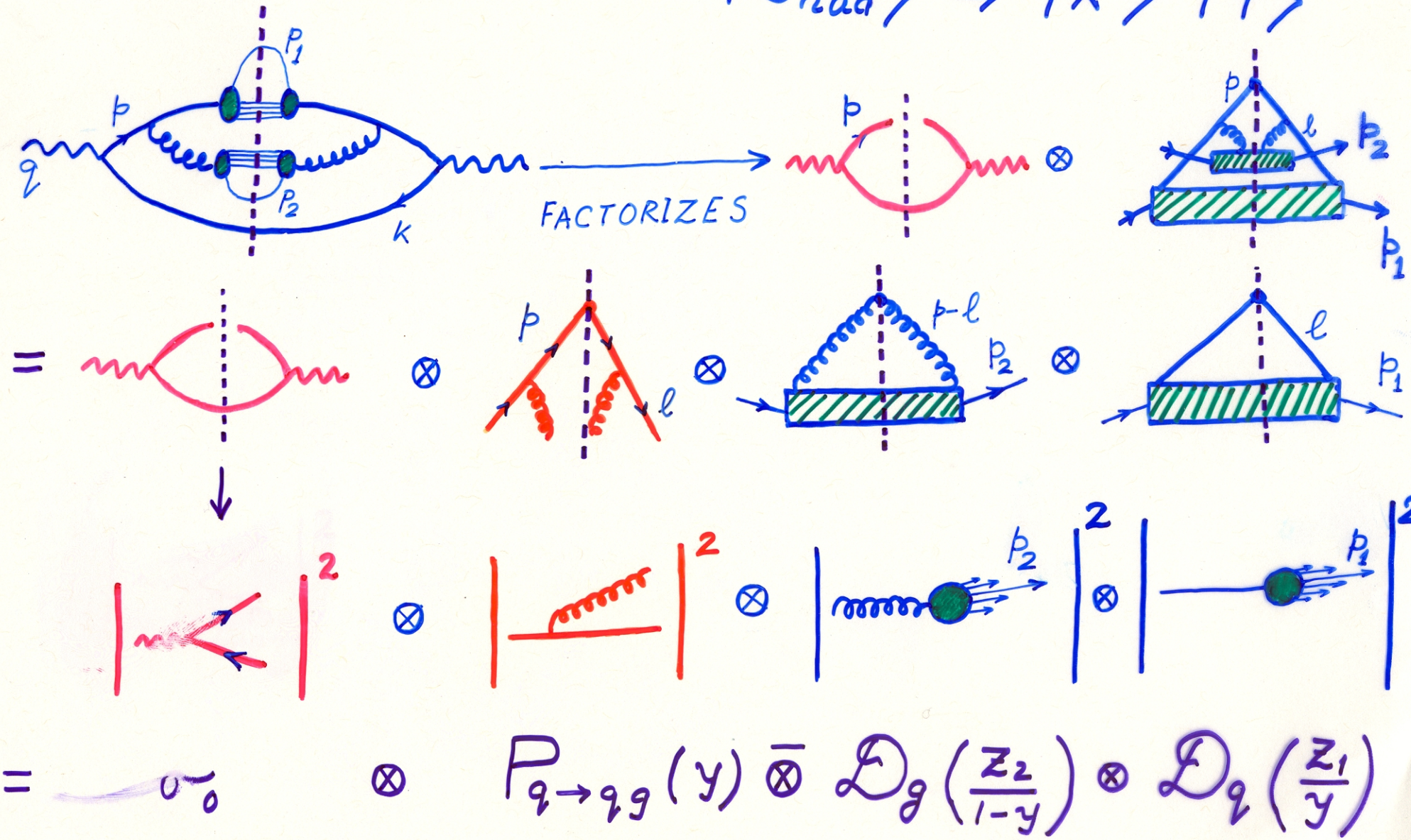


$$= \sigma_0 \otimes P_{q\to qg}(y) \otimes \mathcal{D}_q\left(\frac{z_1}{y}, \frac{z_2}{y}\right)$$

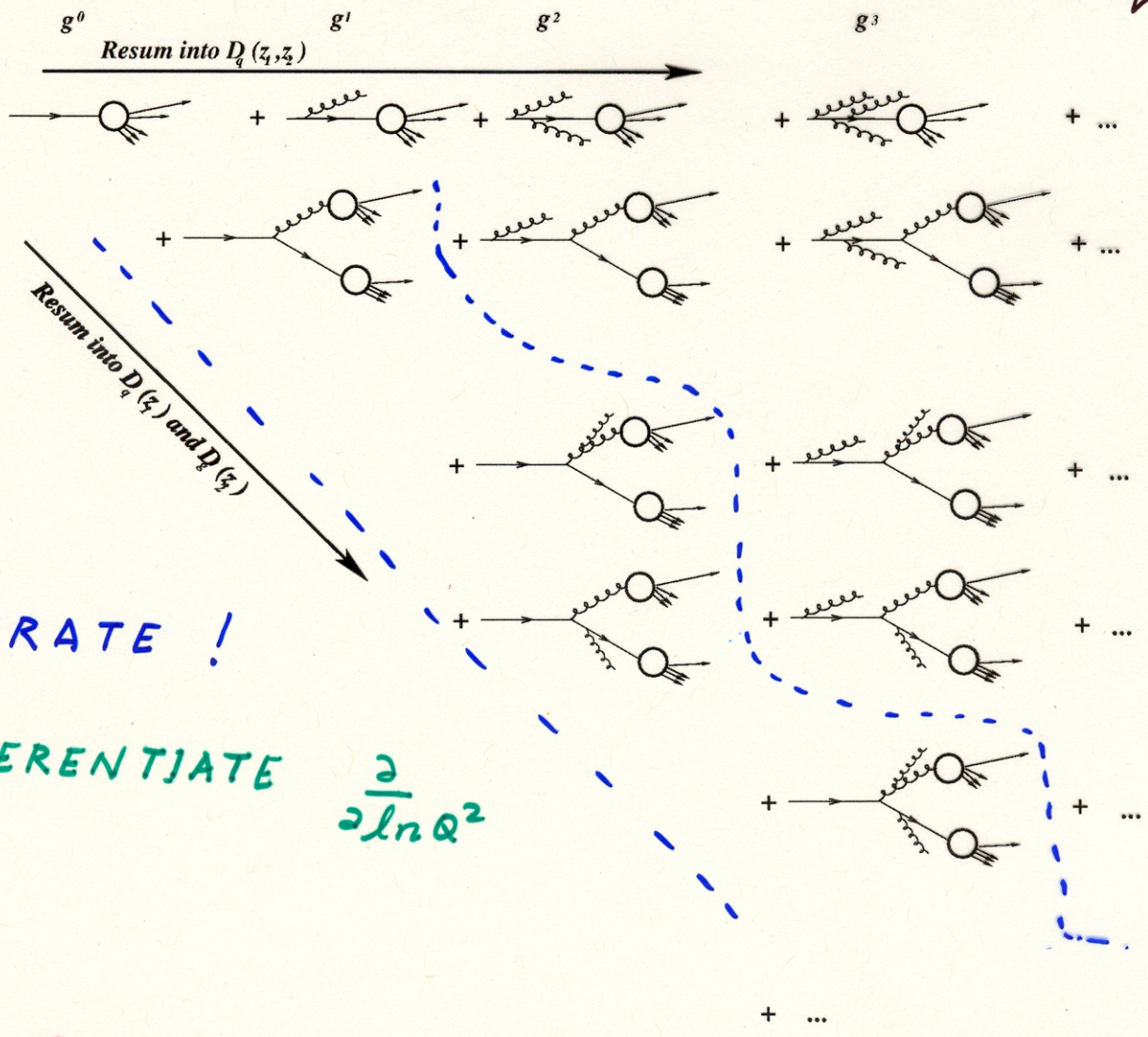
FROM: KONISHI, UKAWA, VENEZIANO, NPB 157, 45 (1979)

REPLACE: $|Z_h\rangle \to |\bar{q}(k)\rangle\, |P_1, X-1\rangle\, |P_2, Y-1\rangle$

WE HAVE FACTORED $|S_{had}\rangle \to |X\rangle\, |Y\rangle$

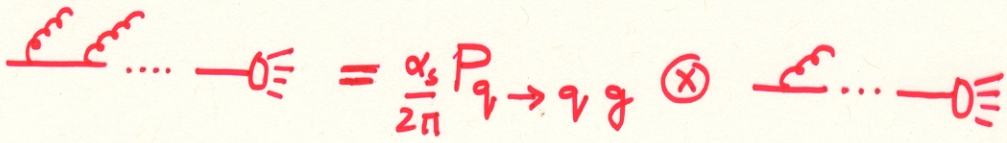


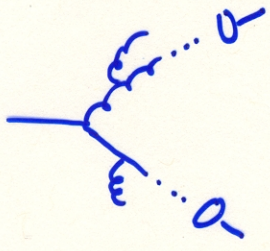
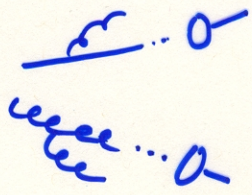
DGLAP EVOL. FOR NON-SINGLET $\mathcal{D}_q^{h_1 h_2}(Q^2)$



* ITERATE !

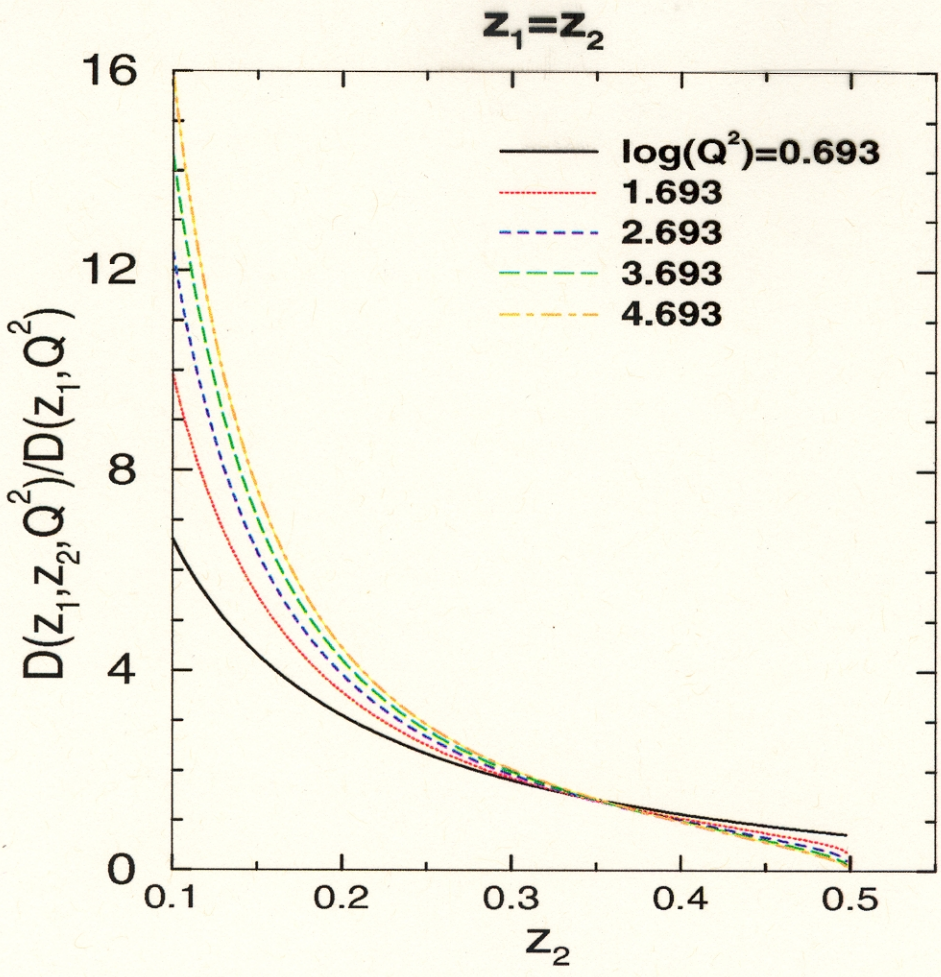
* DIFFERENTIATE $\frac{\partial}{\partial \ln Q^2}$

$$\frac{\partial}{\partial \ln Q^2}$$  $$= \frac{\alpha_s}{2\pi} P_{q\to qg} \otimes$$

$$\frac{\partial}{\partial \ln Q^2}$$  $$= \frac{\alpha_s}{2\pi} \hat{P}_{q\to qg} \otimes$$ 

$$\frac{\partial}{\partial \ln Q^2} \mathcal{D}_{NS}^{h_1 h_2}(Q^2) = \frac{\alpha_s}{2\pi} P_{q\to qg} \otimes \mathcal{D}_{NS}^{h_1 h_2}(Q^2)$$

$$+ \frac{\alpha_s}{2\pi} \hat{P}_{q\to qg} \otimes \mathcal{D}_{NS}^{h_1}(Q^2)\, \mathcal{D}_g^{h_2}(Q^2)$$

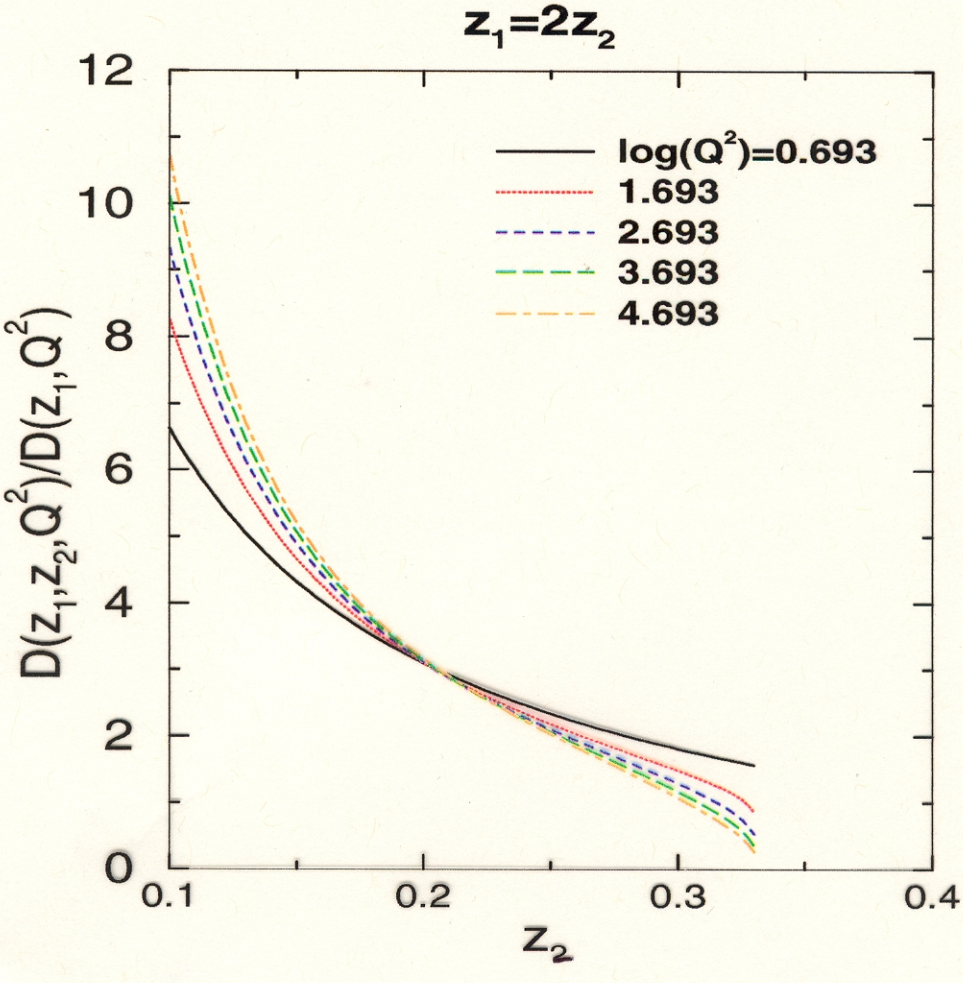


START WITH ANSATZ

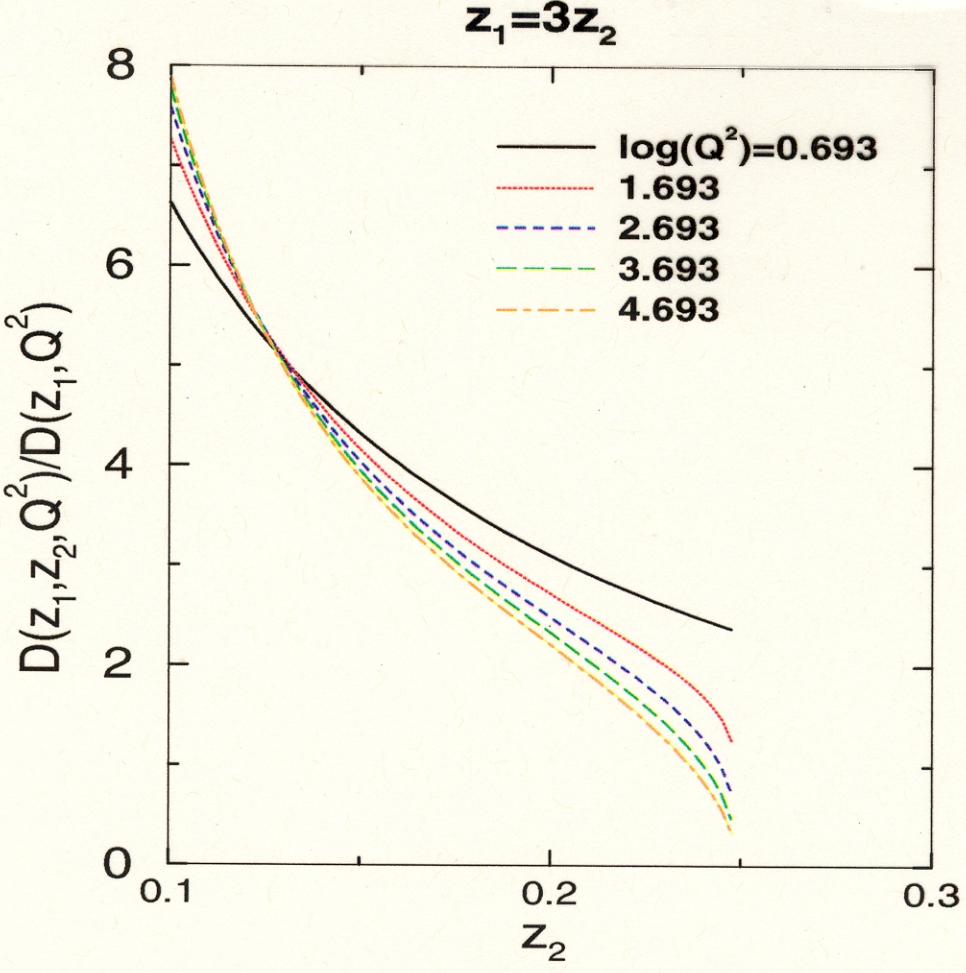
$D(z_1, z_2) =$

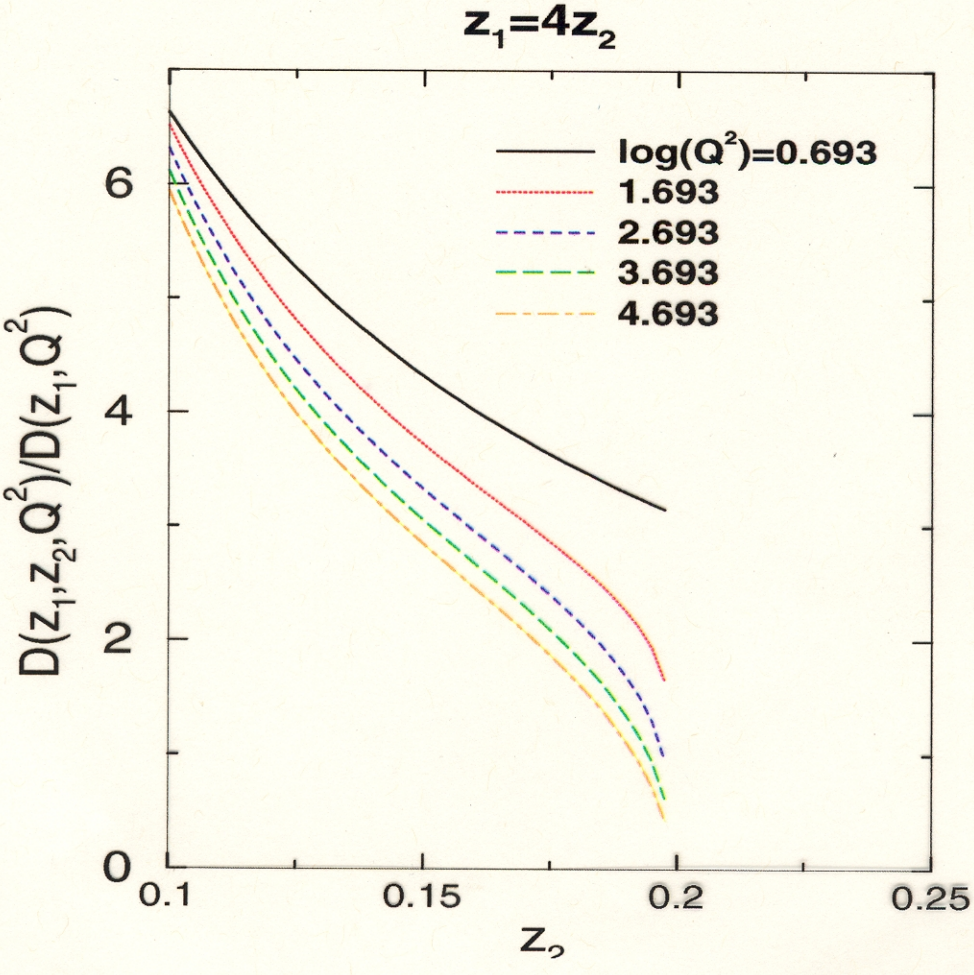
$\mathcal{D}(z_1)\ \mathcal{D}(z_2)$

AT $Q^2 = 2\ GeV^2$



VERY LITTLE CHANGE AT z_1, z_2 LARGE


$z_1=3z_2$
$\log(Q^2)=0.693$
1.693
2.693
3.693
4.693
$D(z_1,z_2,Q^2)/D(z_1,Q^2)$
z_2
0
2
4
6
8
0.1
0.2
0.3


$z_1=4z_2$
$\log(Q^2)=0.693$
1.693
2.693
3.693
4.693
$D(z_1,z_2,Q^2)/D(z_1,Q^2)$
z_2
0
2
4
6
0.1
0.15
0.2
0.25

CONCLUSIONS:

* EXACT OPERATOR DEFINITION FOR $\mathcal{D}_q^{h_1 h_2}(z_1, z_2)$

* DERIVED VACUUM EVOLUTION EQUATIONS FOR $\mathcal{D}(z_1, z_2, Q^2)$

* EVOLUTION OF $\mathcal{D}_{NS}^{h_1 h_2}(z_1, z_2)$ DEPENDS ON THE RATIO z_1/z_2

* RATIO $\mathcal{D}(z_1, z_2)/\mathcal{D}(z_1)$ SHOWS LITTLE CHANGE

* IN PROGRESS: $\mathcal{D}_S(z_1, z_2, Q^2)$, $\mathcal{D}_g(z_1, z_2, Q^2)$ MEDIUM EFFECTS!