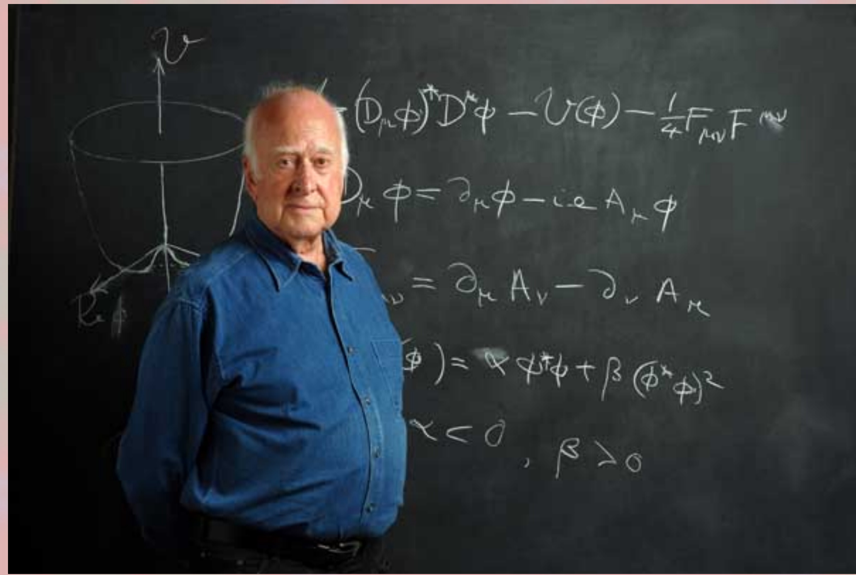
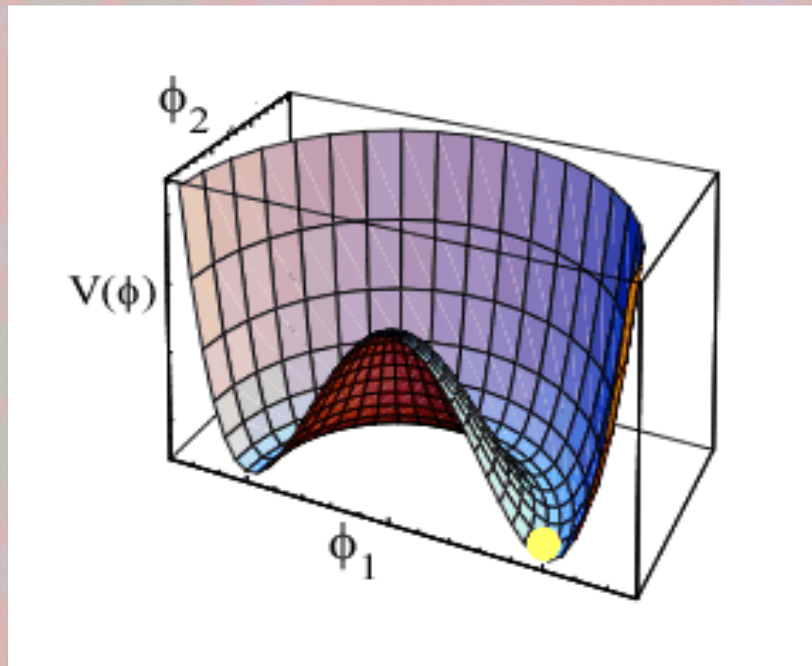
working with Graham Ross 1974-1984

Les Chemins de la Liberté

working with Graham Ross 1974-1984

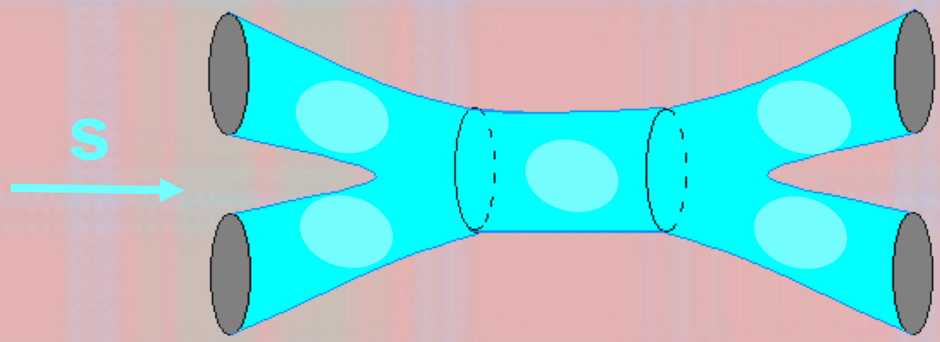
working with Graham Ross 1974-1984

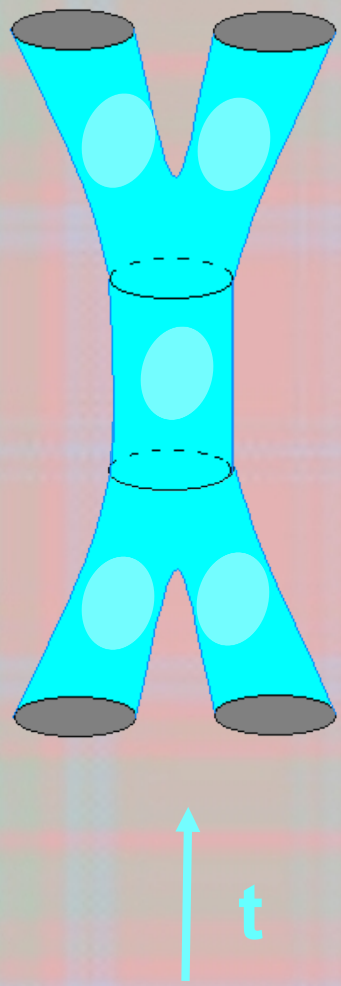


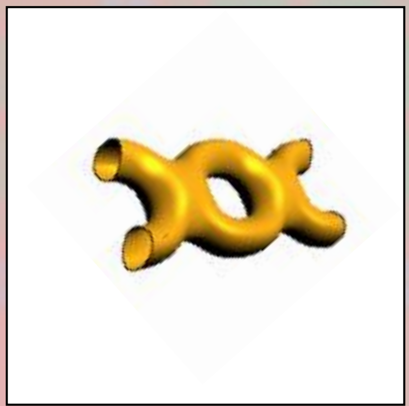


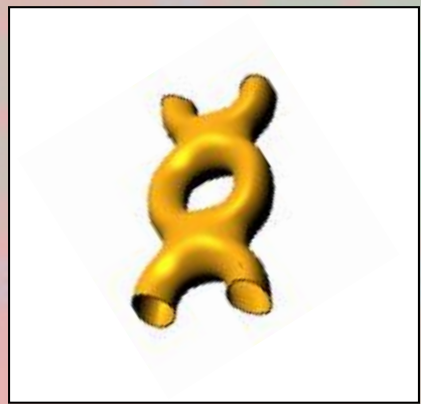
ϕ_2
$V(\phi)$
ϕ_1

Duality & Unitarisation

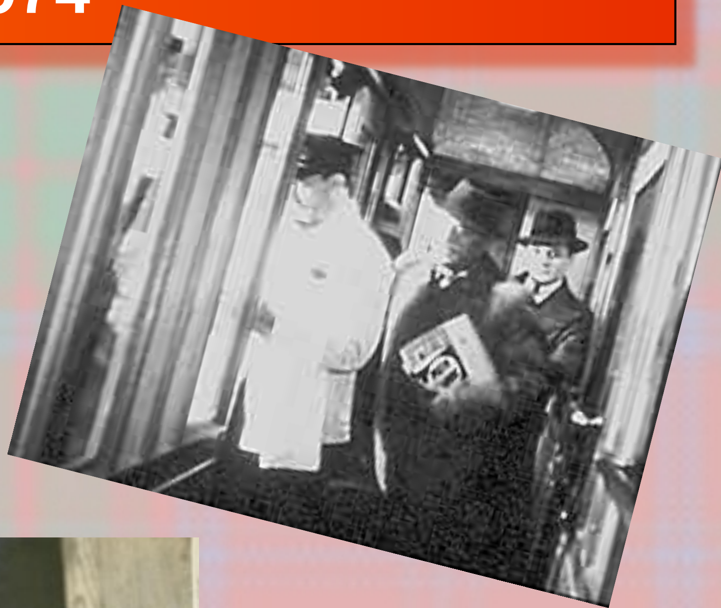




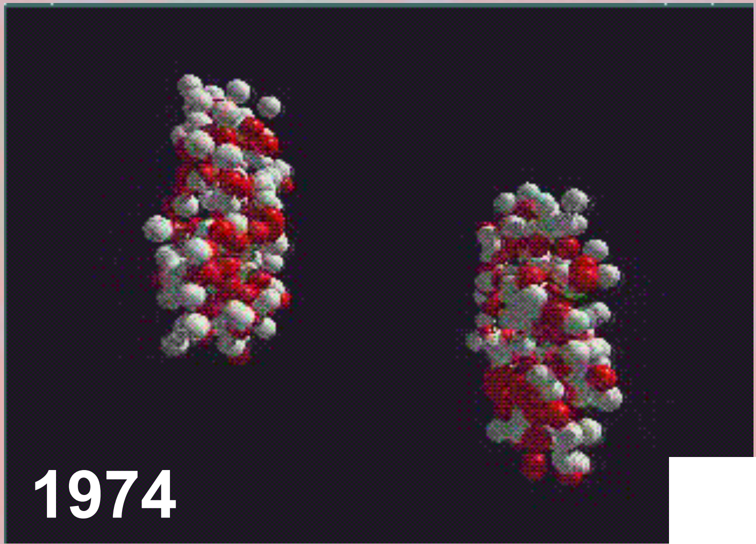


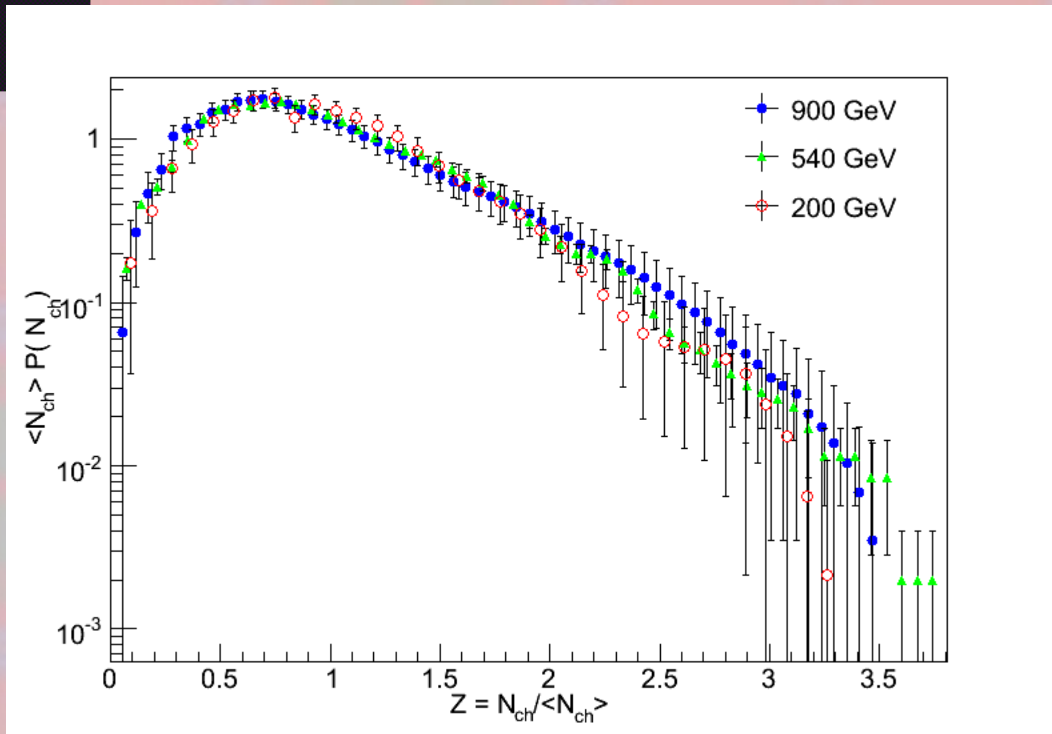


XVII International Conference on High Energy Physics, London, July 1974



Footnote in Physics





KNO Scaling

Footnote in Physic

Nuclear Physics B88 (1975) 237–256

TESTS OF GEOMETRICAL SCALING AND GENERALIZATIONS *

V. BARGER and J. LUTHE
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Received 9 December 1974

the prescription

$$\frac{d\sigma/dt(s,t)}{d\sigma/dt(s,0)} = f(\sigma_t^2 t/\sigma_{el}) ,$$

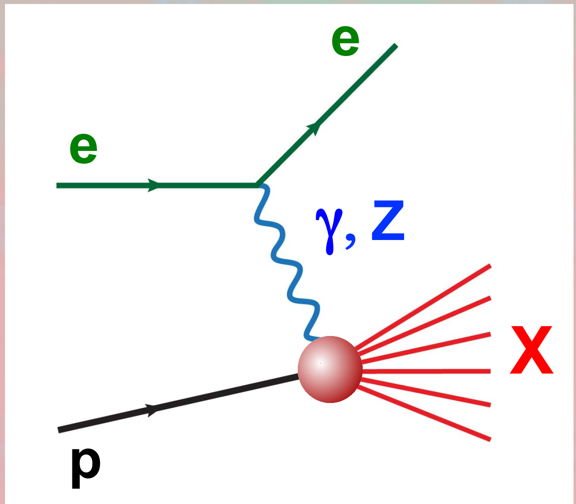
with imaginary non-flip amplitudes and f some universal function, proposed independently as a generalization of GS by Pennington and Ross [12]. For small t this prescription is almost trivial, since it is well known that $d\sigma/dt$ is universally exponential here [13]; the interest lies at larger t-values.

[11] A. Martin, Nucl. Phys. B77 (1974) 226.
[12] M.R. Pennington and G.G. Ross, to be published.
[13] V. Singh and S.M. Roy, Phys. Rev. Letters 24 (1970) 28.

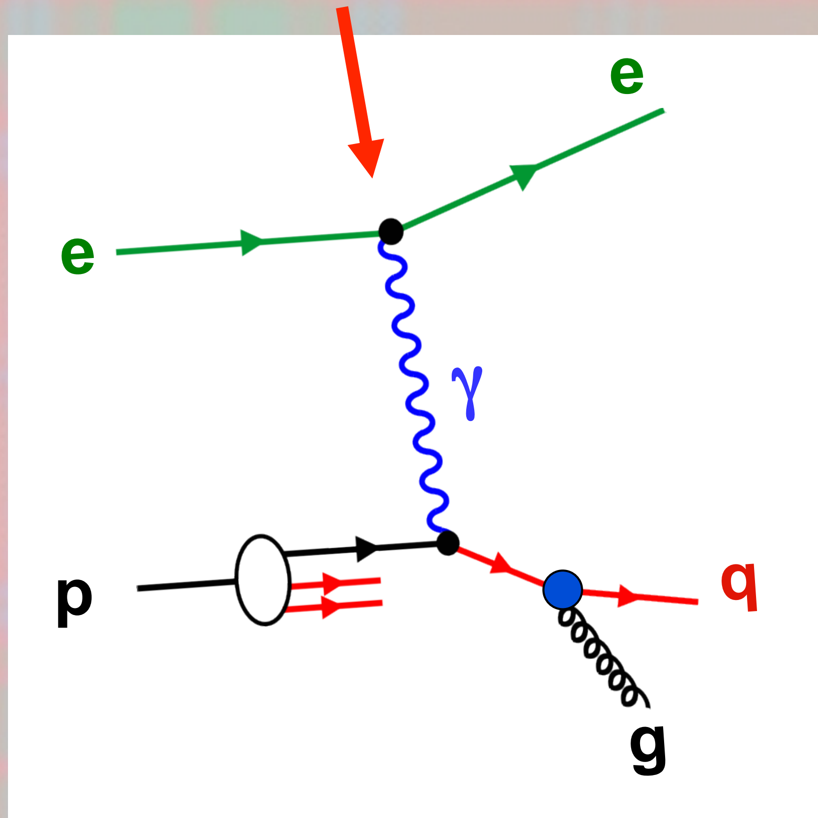
$$\mathcal{L}_{QCD} = \sum_{q=u,d,s,c,b} \bar{q}\,(i\gamma_{\mu} D^{\mu} - m_q)\, q - \frac{1}{4}\mathcal{F}^{\mu\nu}\mathcal{F}_{\mu\nu}$$

QCD

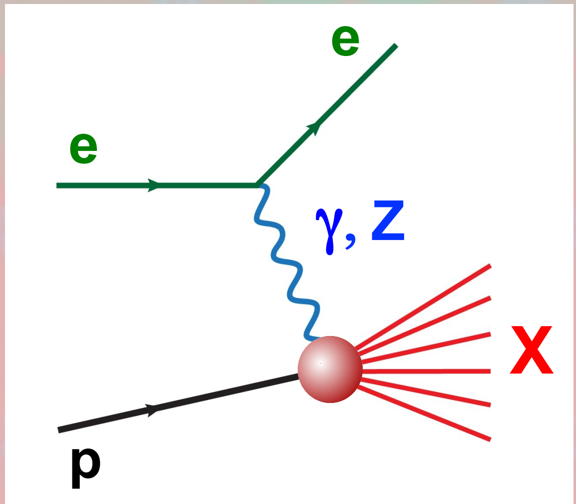
DIS, Renormalization Group & pQCD

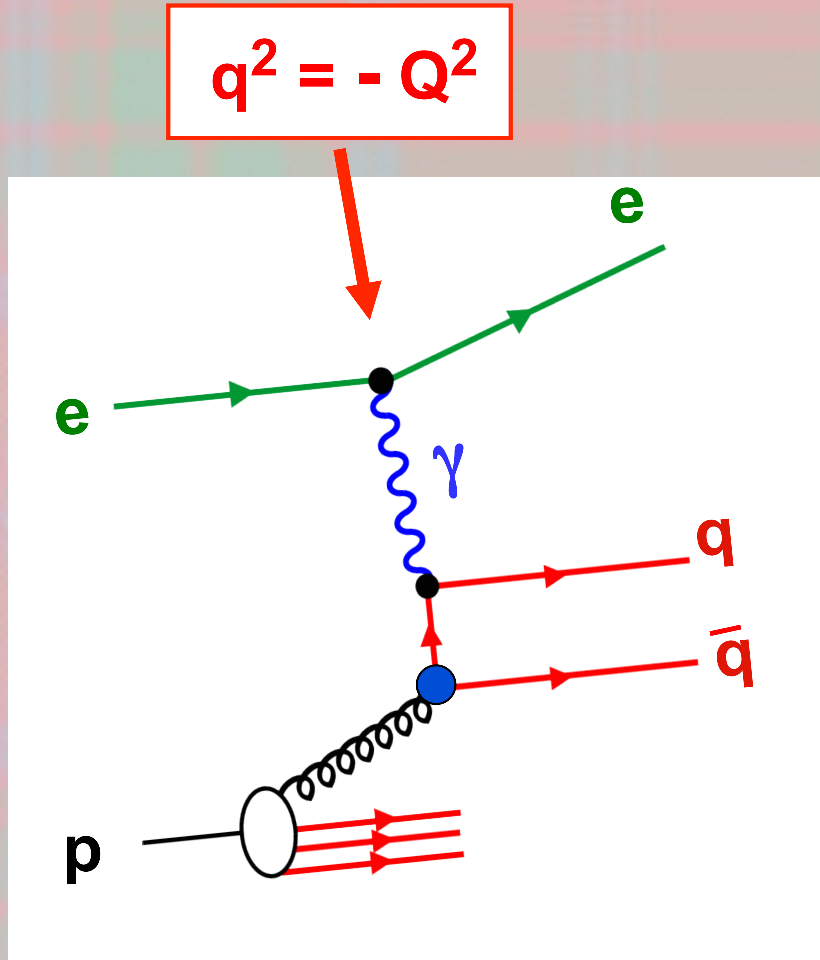


$q^2 = - Q^2$



DIS, Renormalization Group & pQCD





DIS, Renormalization Group & pQCD

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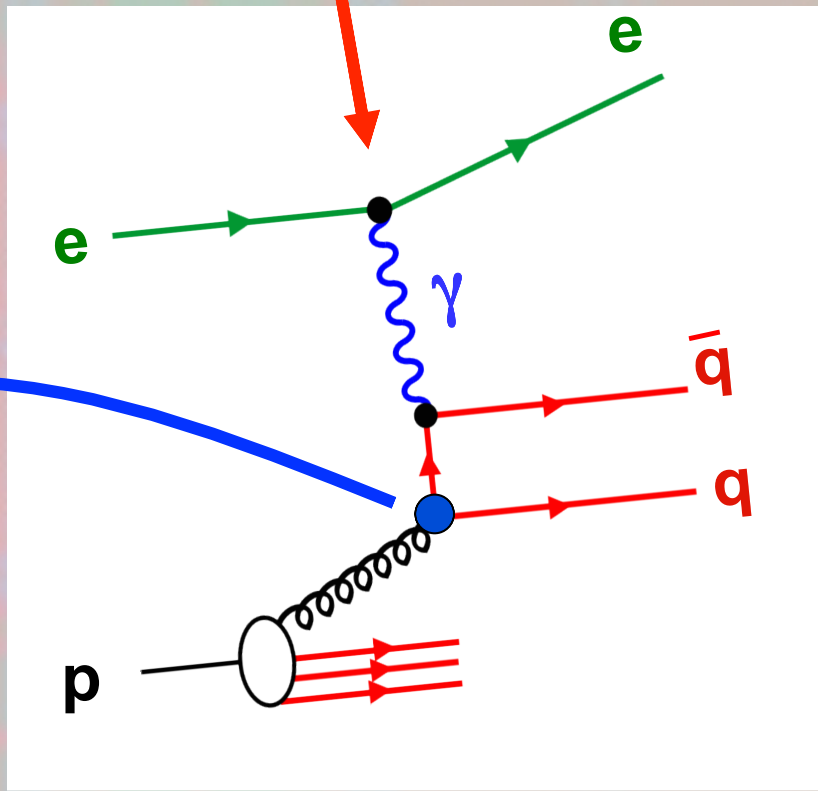
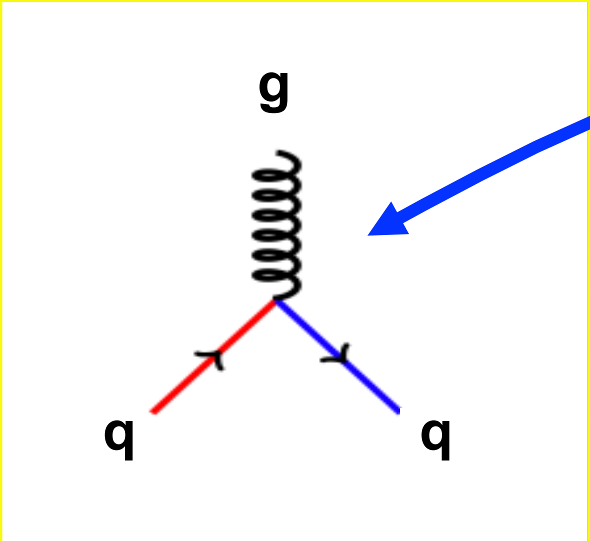
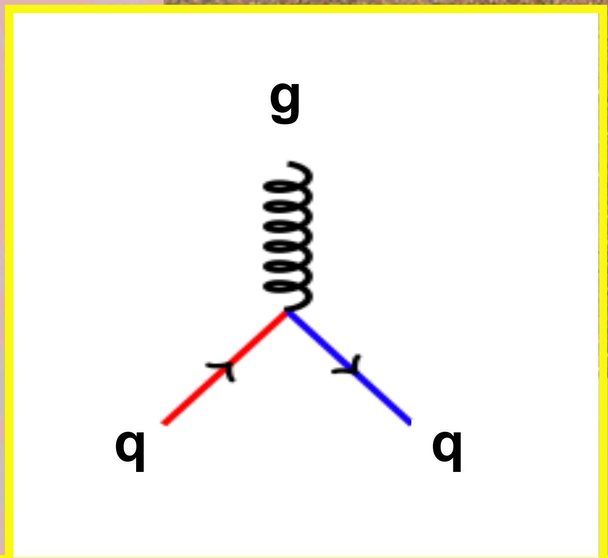




$\alpha\,(p_1^{\,2}, p_2^{\,2}, p_3^{\,2})$

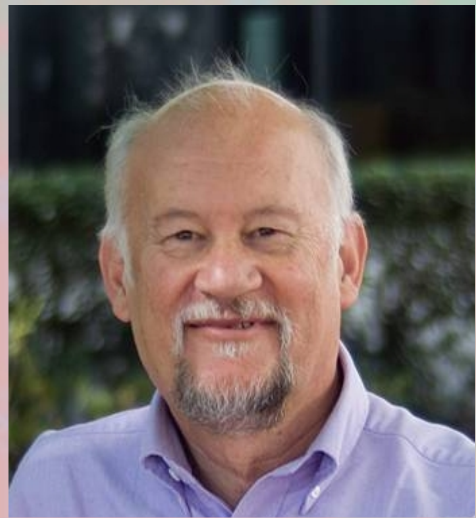
Les Chemins de la Liberté

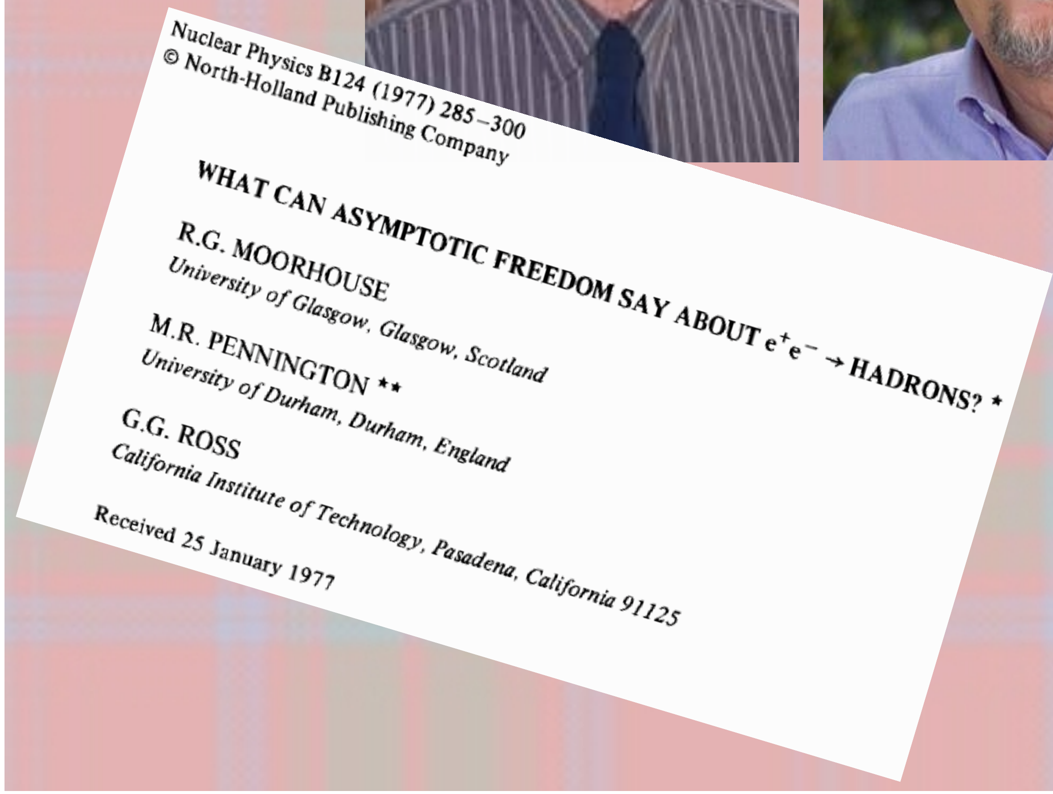


$\alpha\,(p_1^2, p_2^2, p_3^2)$

Les Chemins de la Liberté

What can asymptotic freedom say about $e^+e^- \rightarrow$ hadrons ?





Nuclear Physics B124 (1977) 285–300

WHAT CAN ASYMPTOTIC FREEDOM SAY ABOUT $e^+e^- \rightarrow$ HADRONS? *

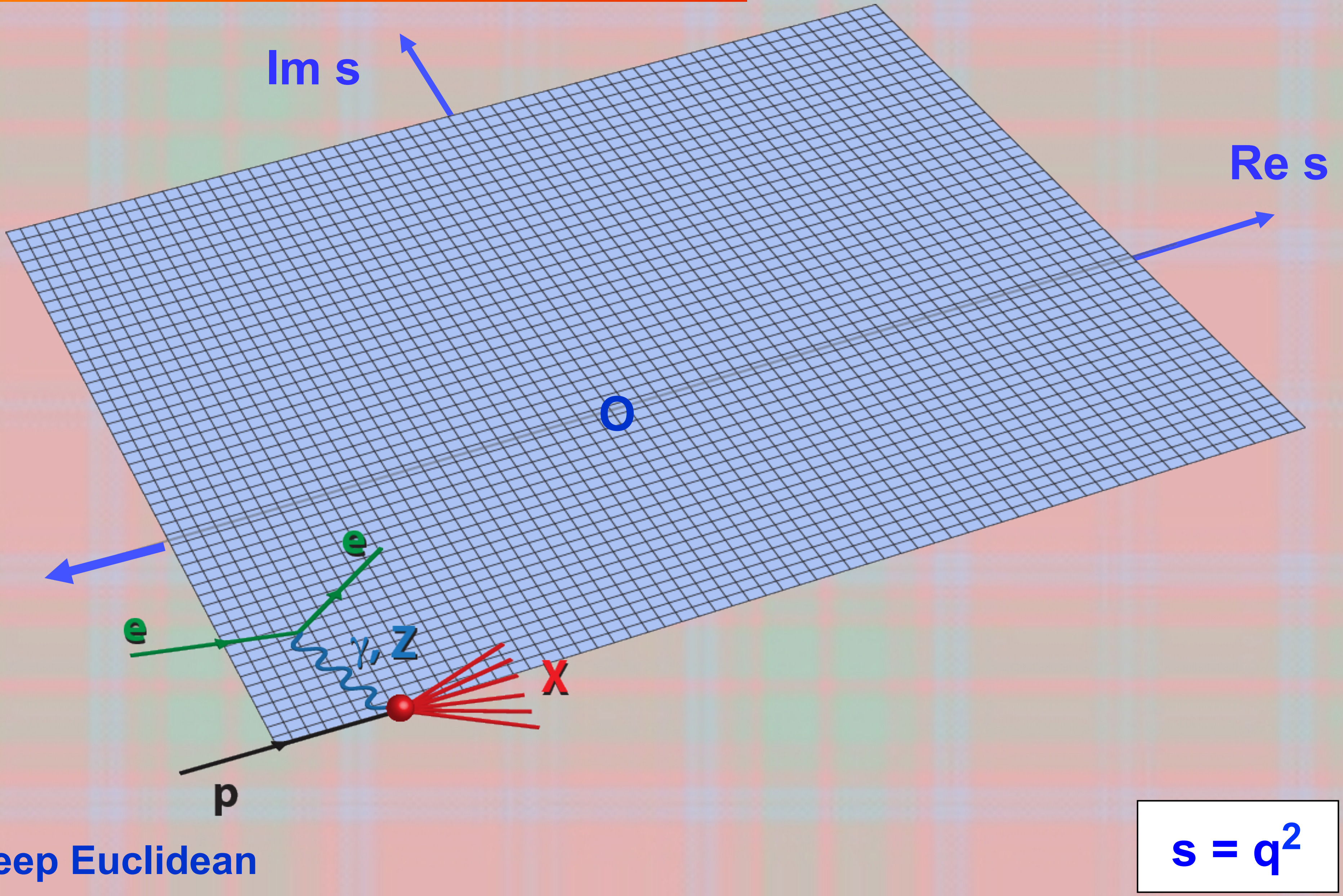
R.G. MOORHOUSE
University of Glasgow, Glasgow, Scotland

M.R. PENNINGTON **
University of Durham, Durham, England

G.G. ROSS
California Institute of Technology, Pasadena, California 91125

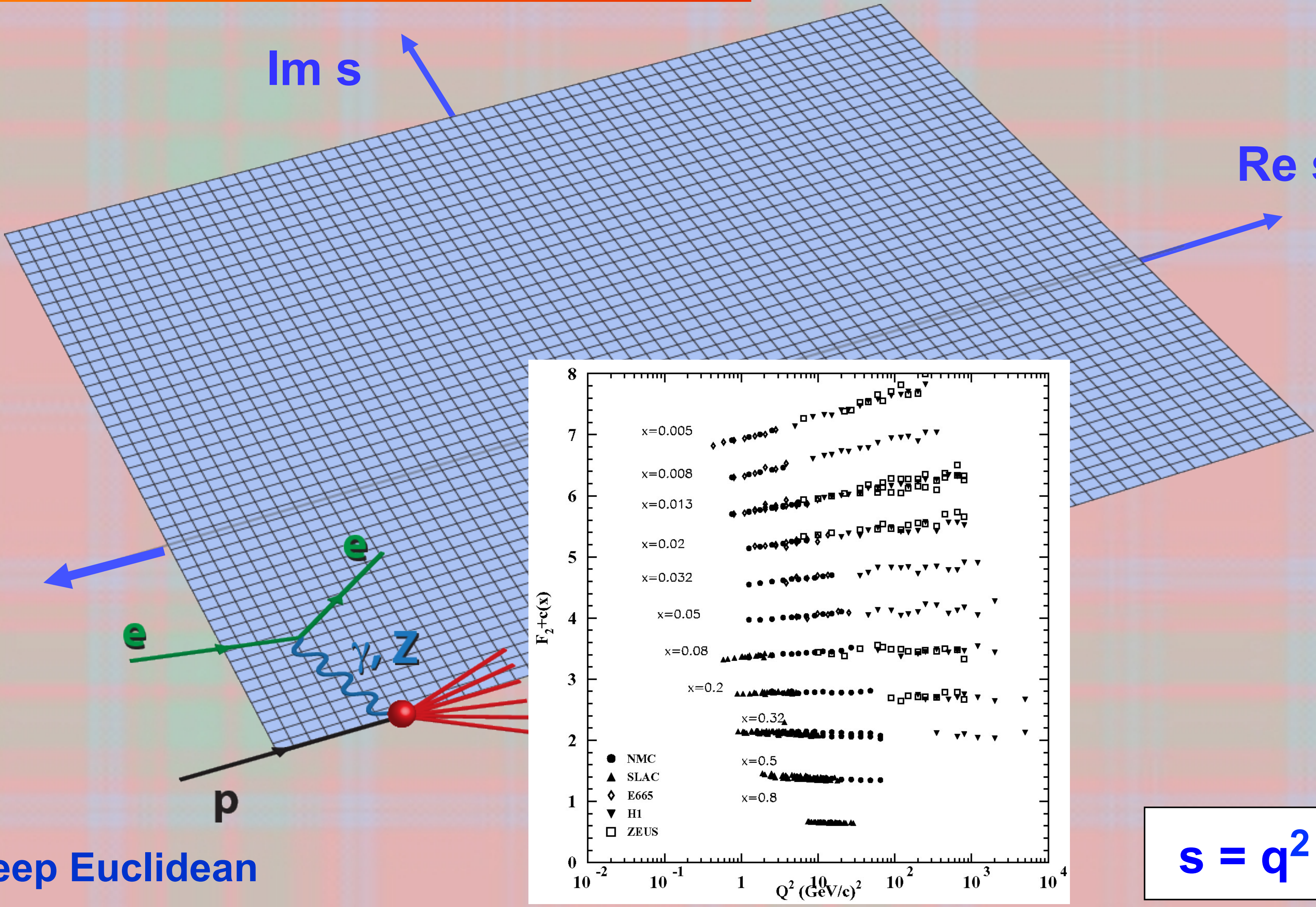
Received 25 January 1977

Where does pQCD apply?



deep Euclidean

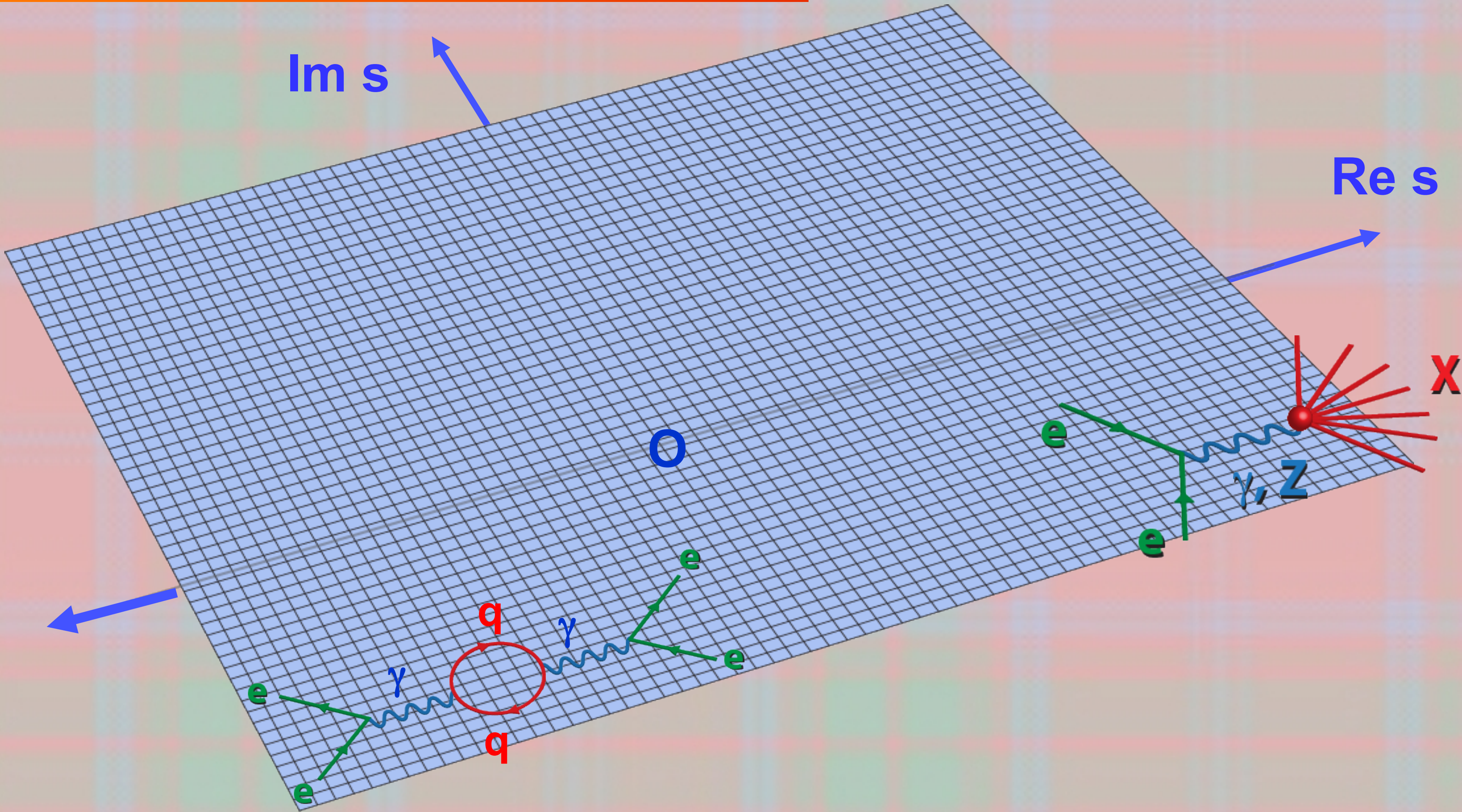
Where does pQCD apply?



deep Euclidean

$s = q^2$

Where does pQCD apply?



deep Euclidean

de Rujula, Georgi

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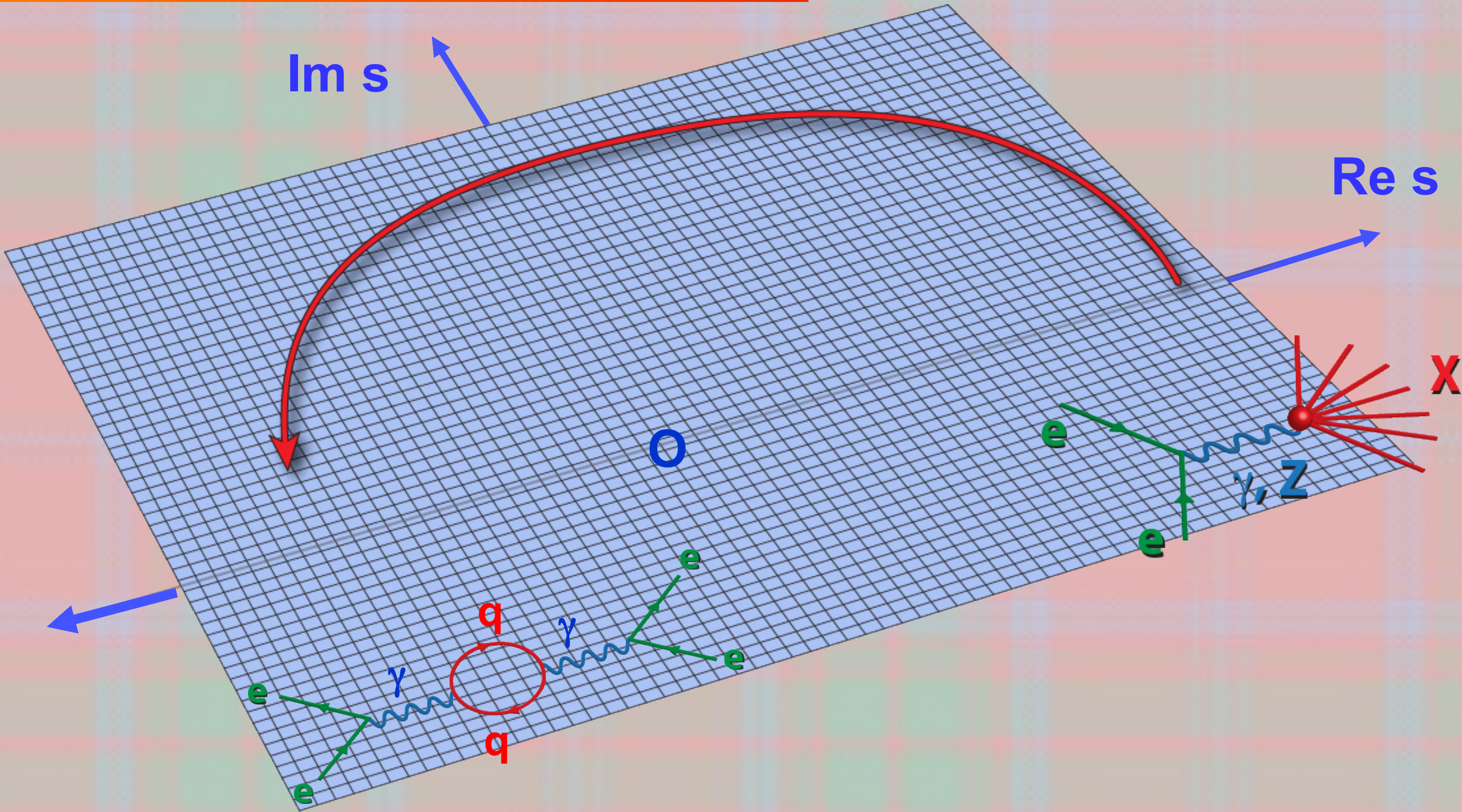
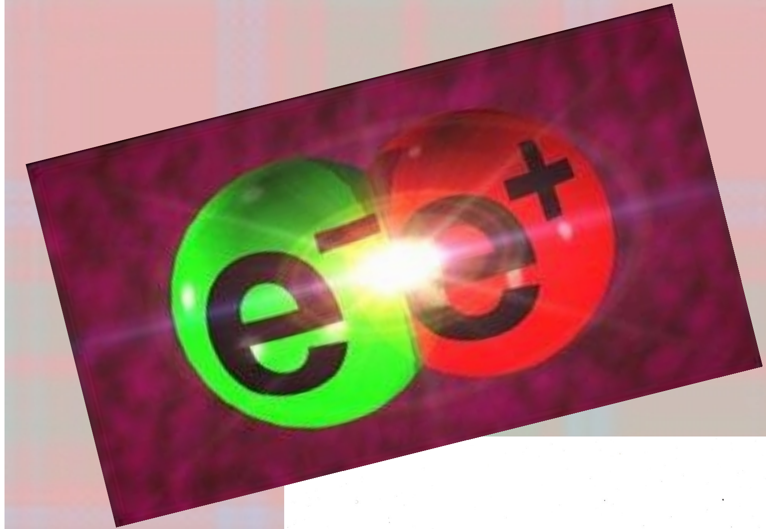


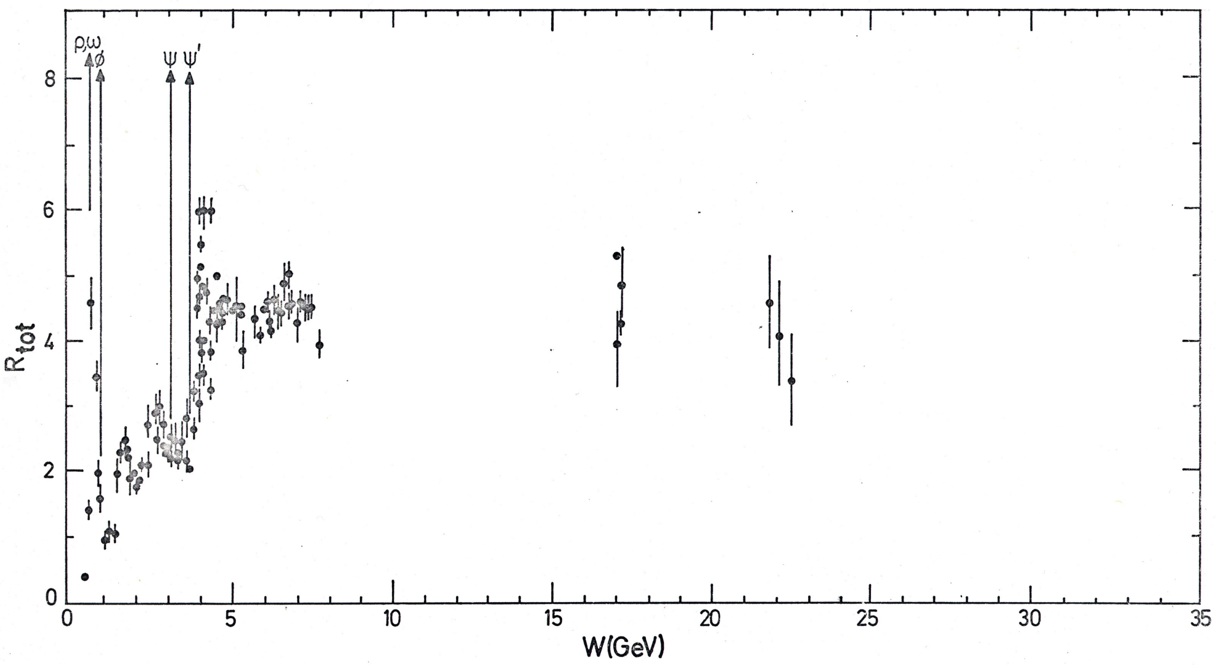
deep Euclidean

de Rujula, Georgi

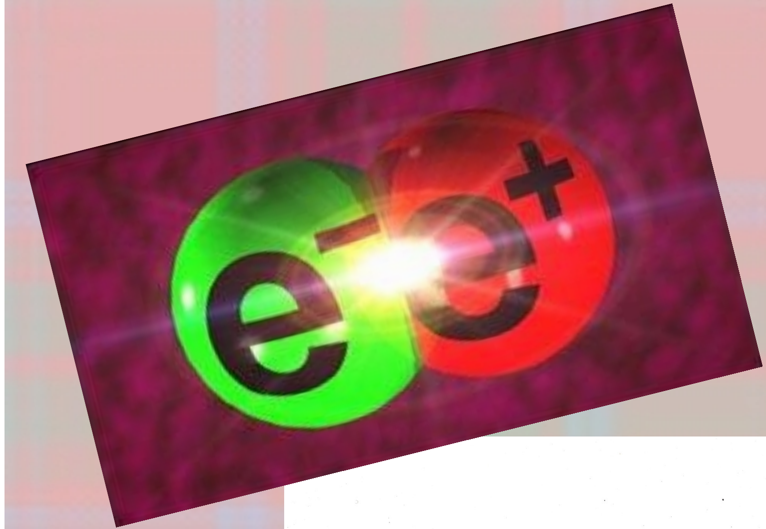
$s = q^2$

$$R(s) \equiv \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$





$s = W^2$



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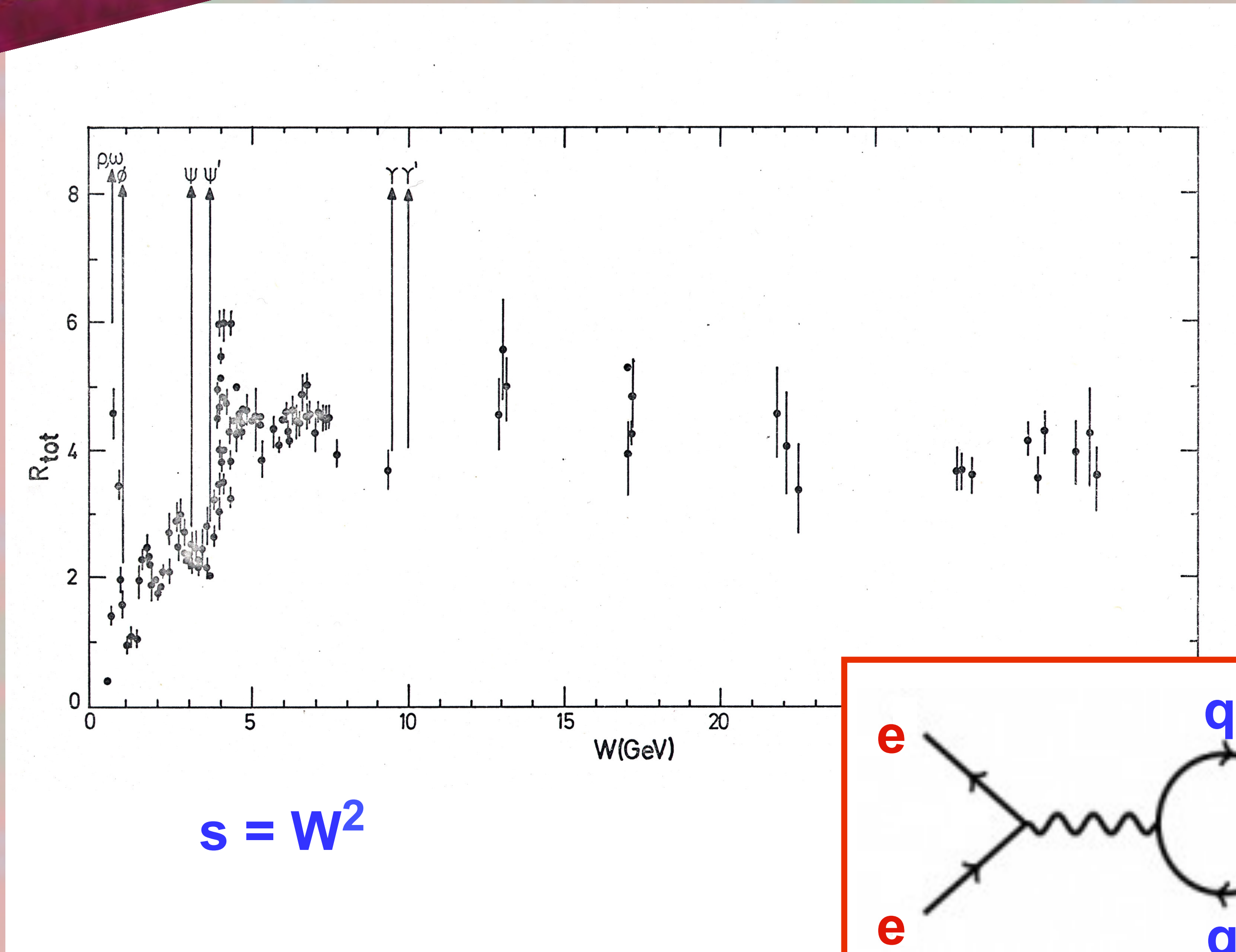

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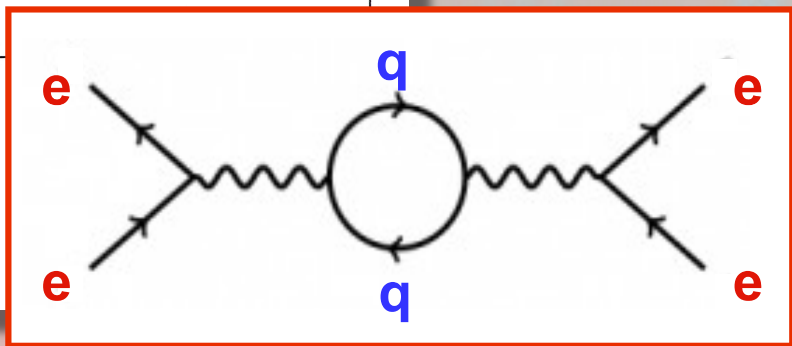

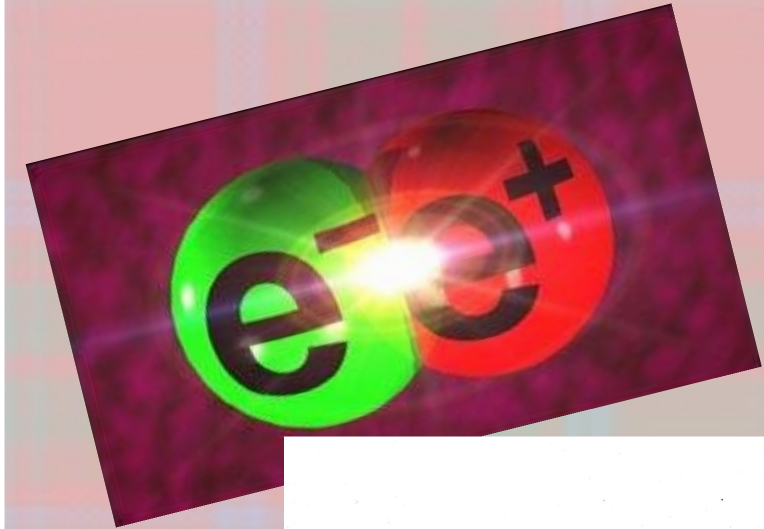

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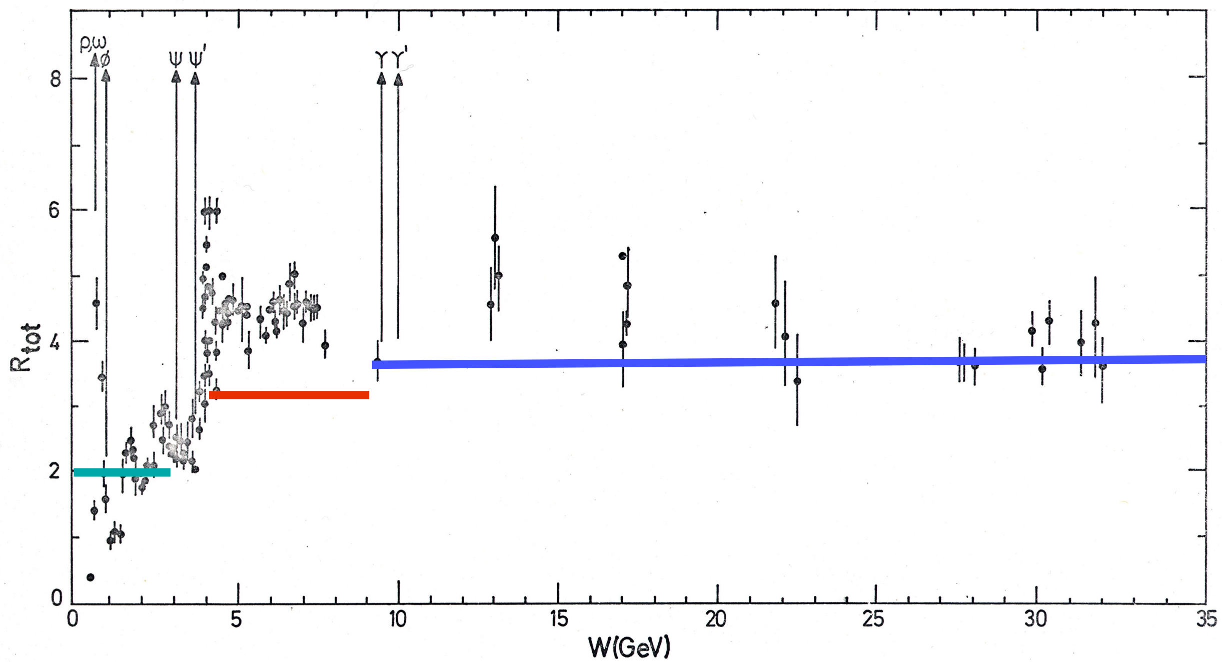
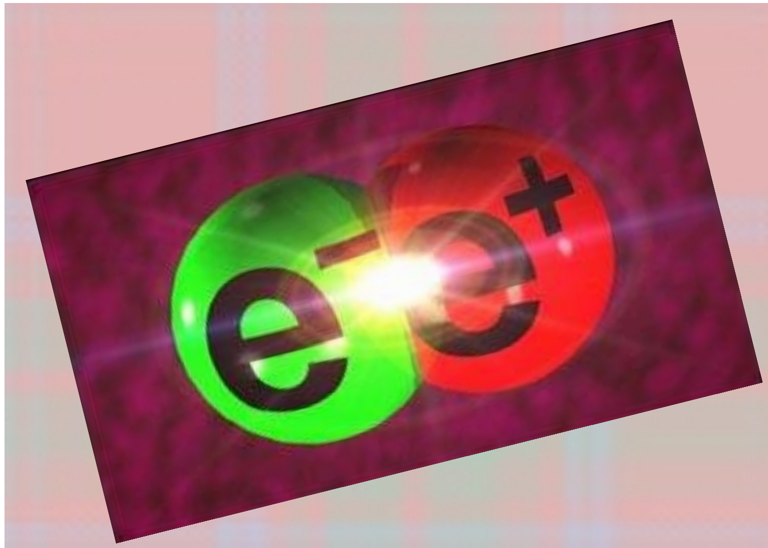
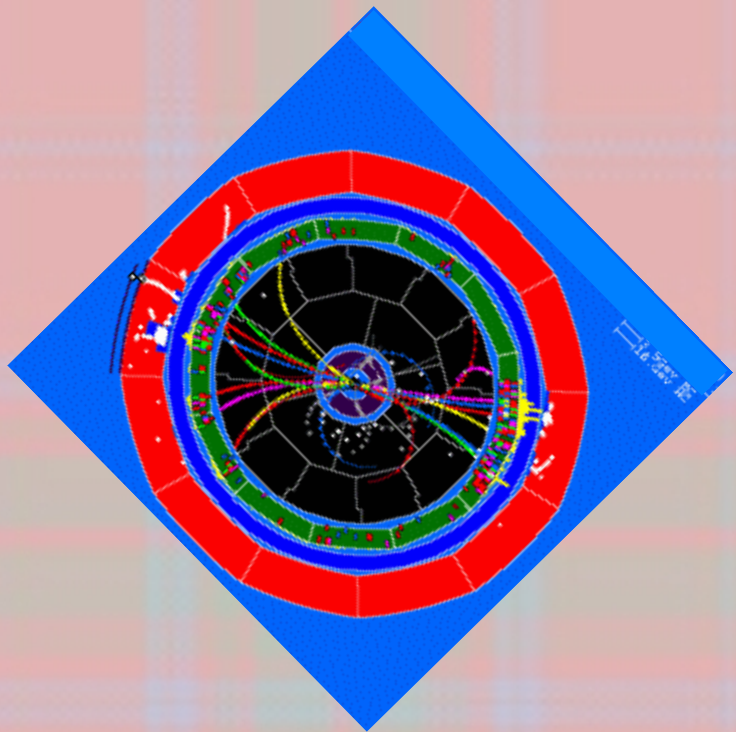
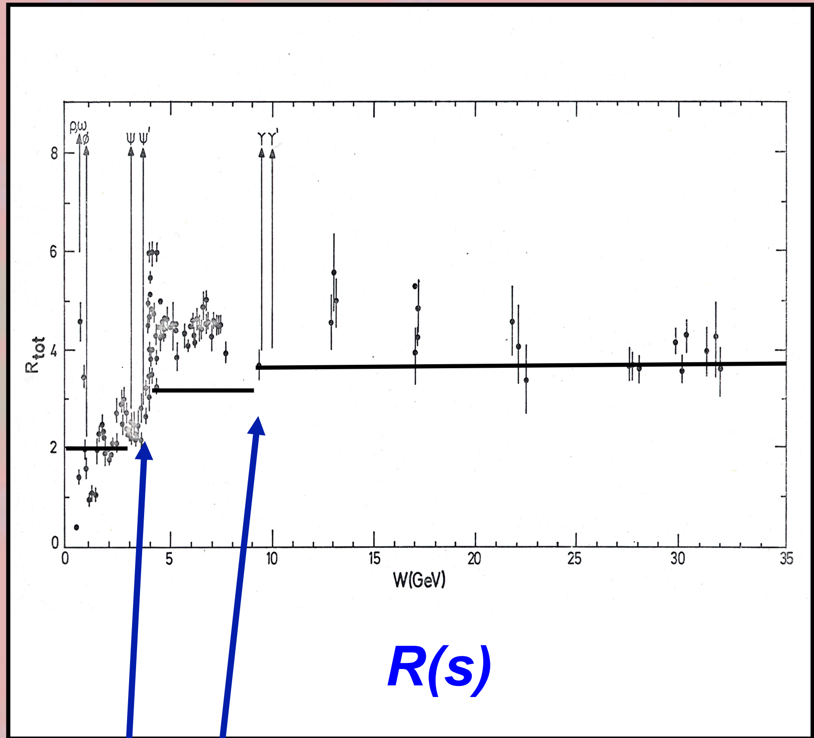


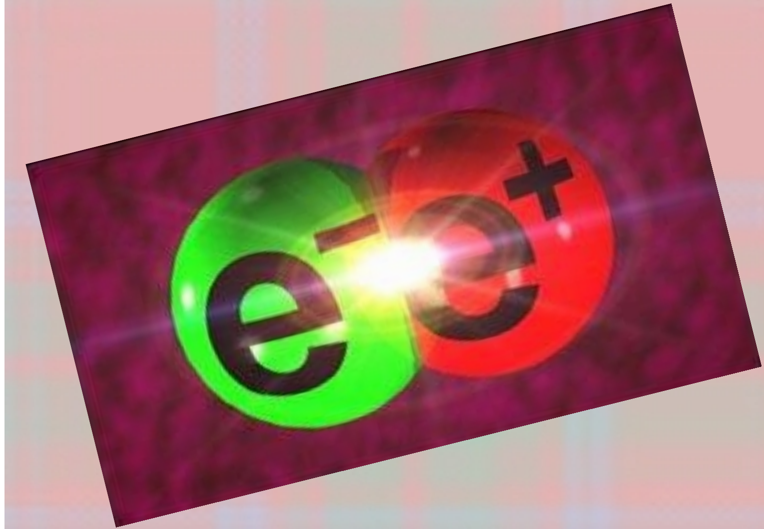
$$R(s) = N_c \sum_f e_f^2$$

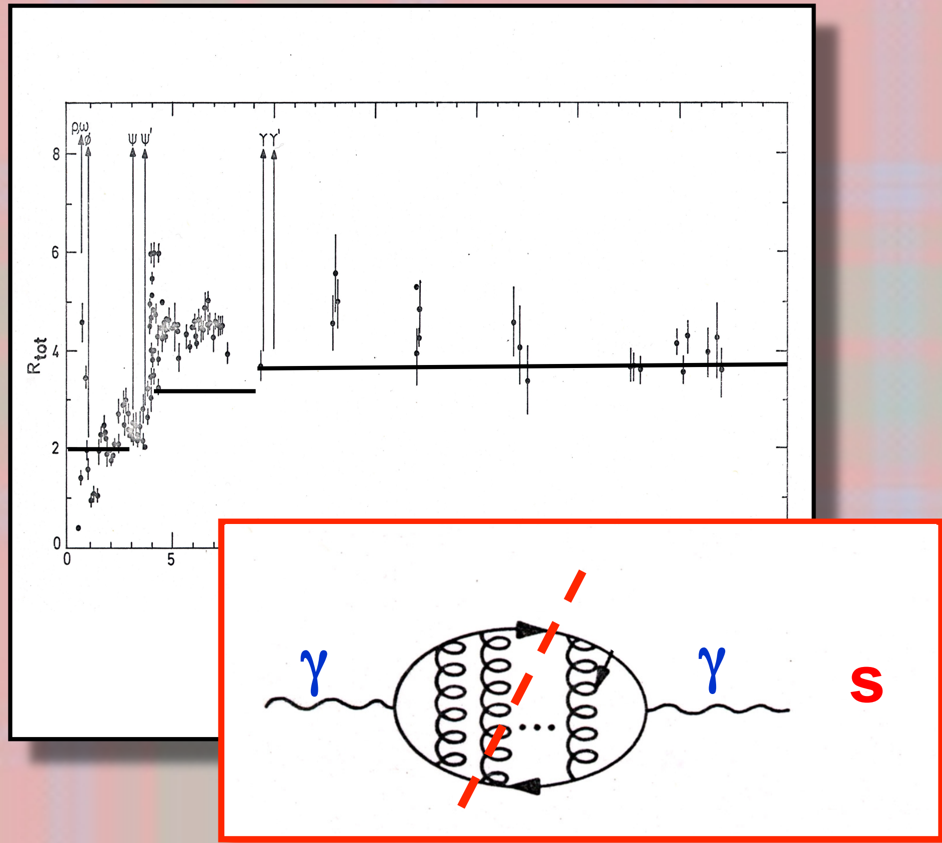


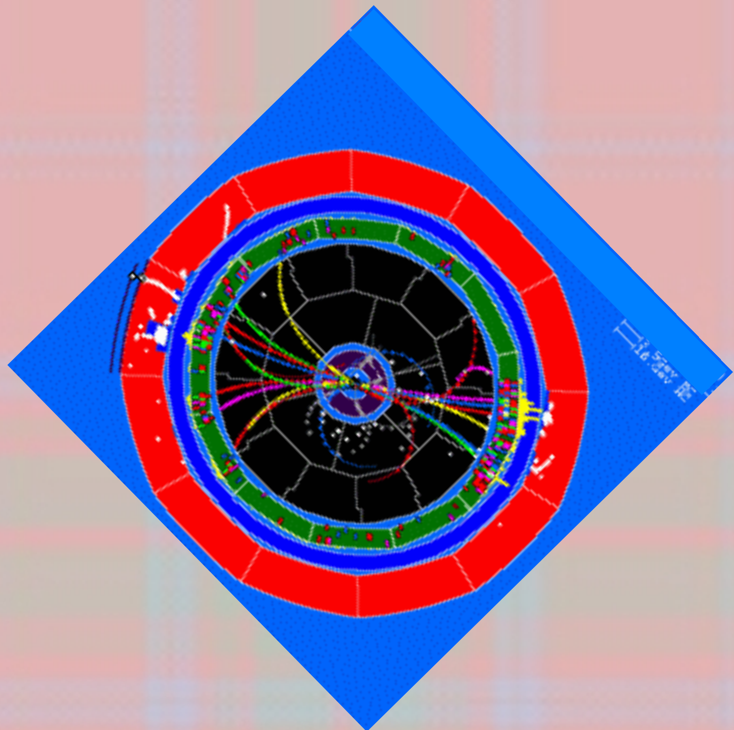




$$S_F(p) = \frac{\mathcal{F}(p)}{\not p - \mathcal{M}(p)}$$







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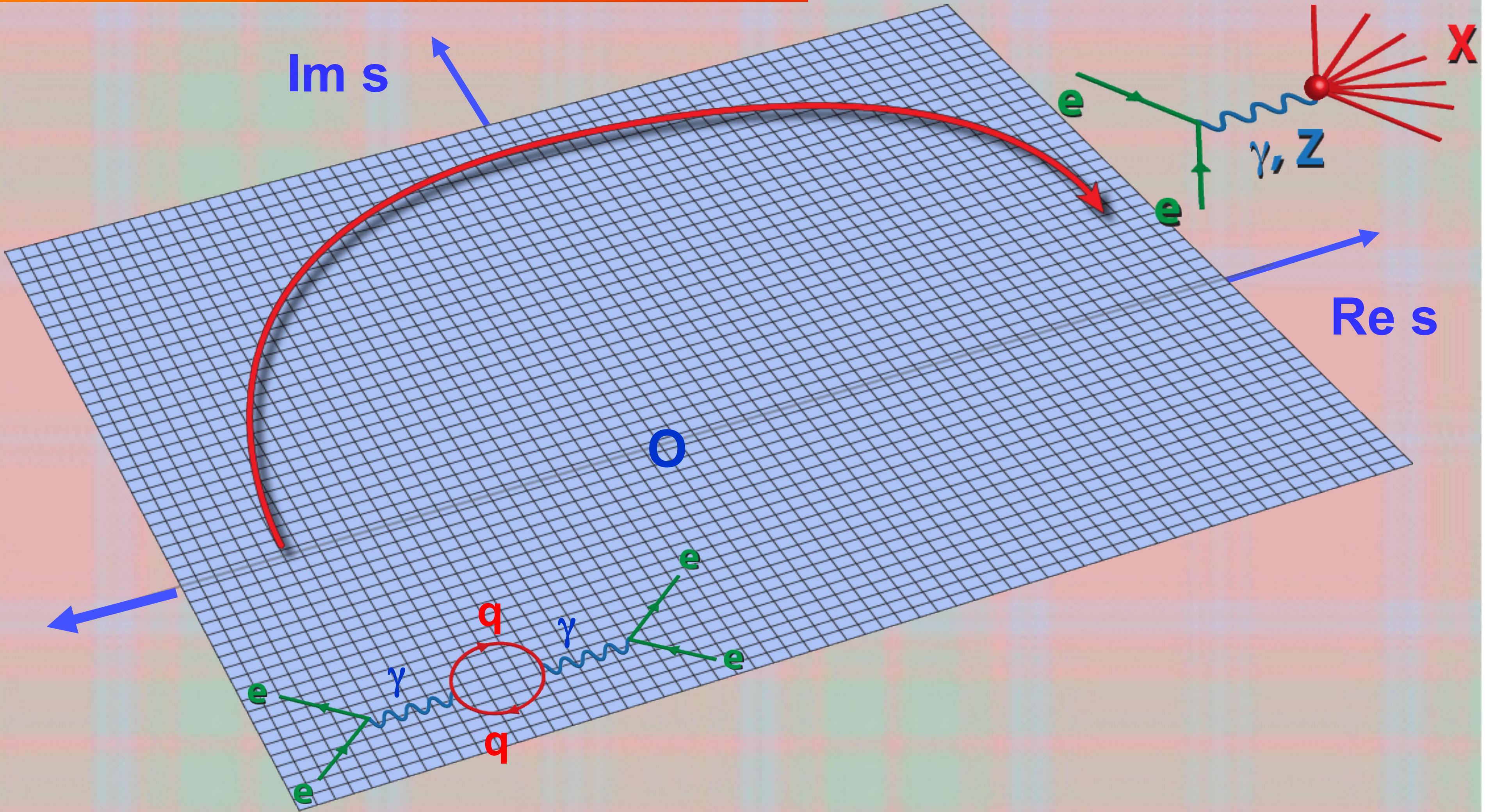
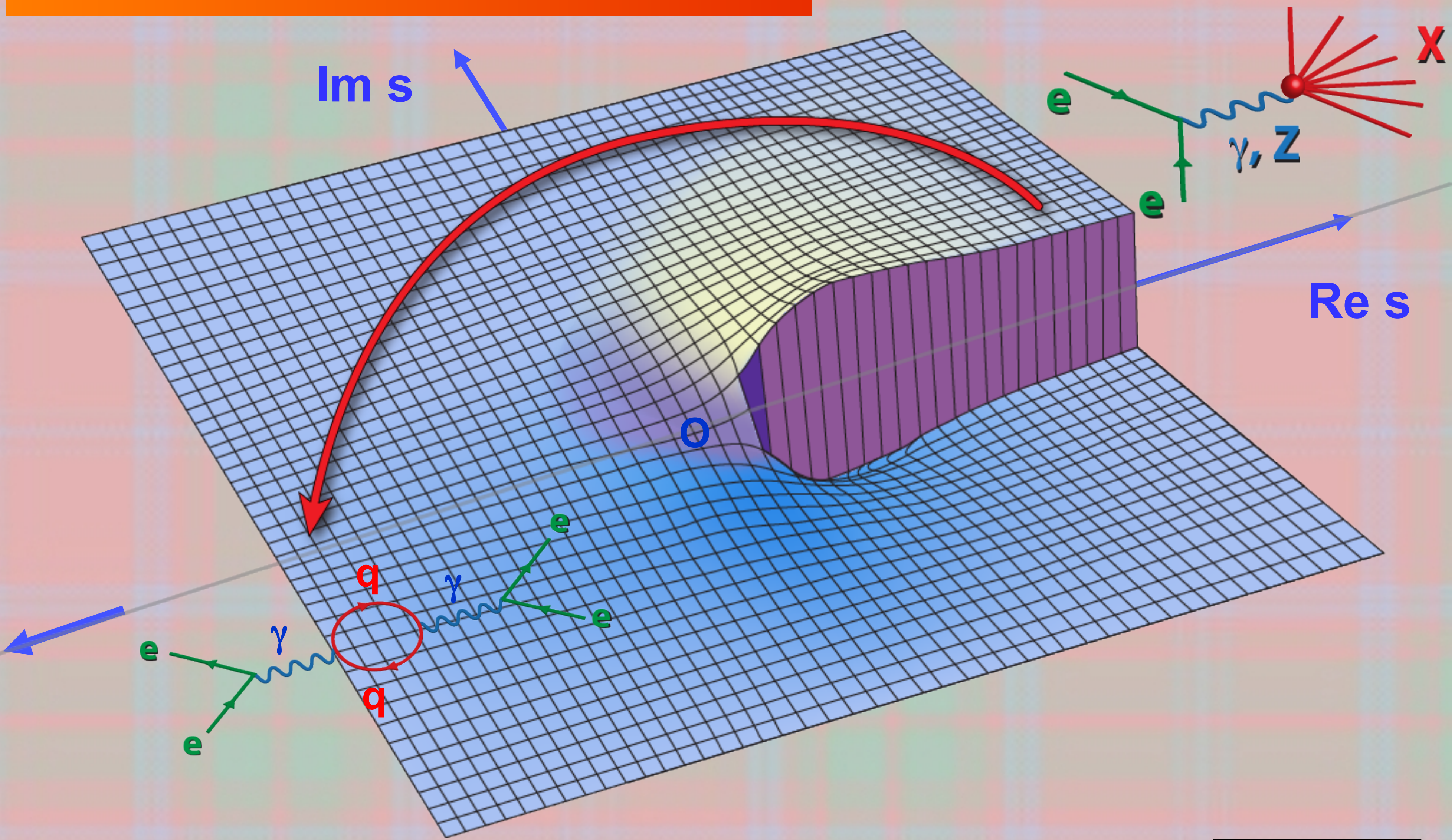


deep Euclidean

$s = q^2$

Where does pQCD apply?



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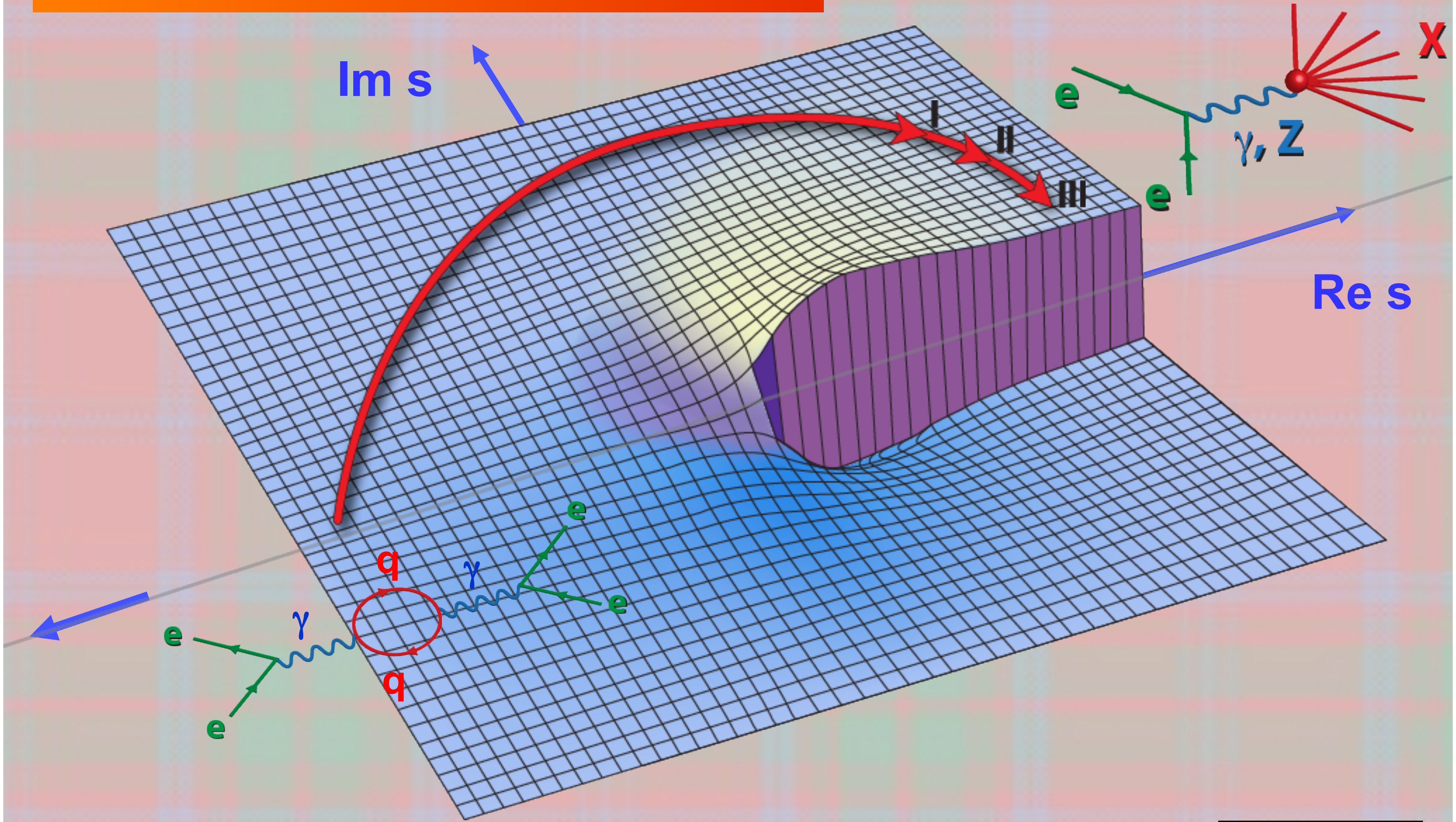
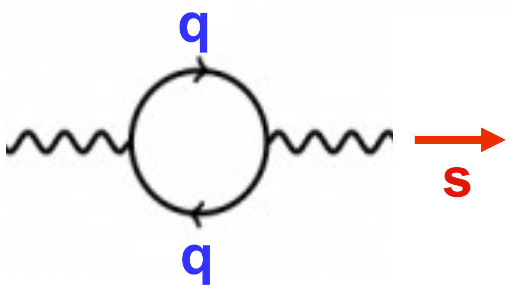


deep Euclidean

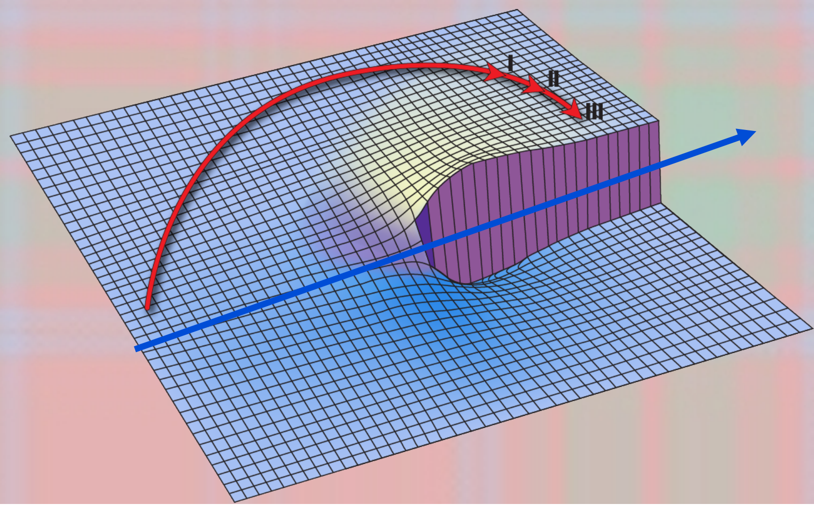
$s = q^2$

Adler $\mathcal{D}$ - function

$\Pi(s)$ 

$$\frac{1}{12\pi^3}\mathcal{D}(s) \equiv s\frac{\partial}{\partial s}\Pi(s)$$

$$\mathcal{D}\left(\frac{s}{\mu^2}, \alpha(\mu^2)\right) = \mathcal{D}(1, \alpha(s)) = \sum_{c,f} e_f^2 \left[1 + \frac{\alpha(s)}{\pi} + \mathcal{O}(\alpha^2)\right]$$

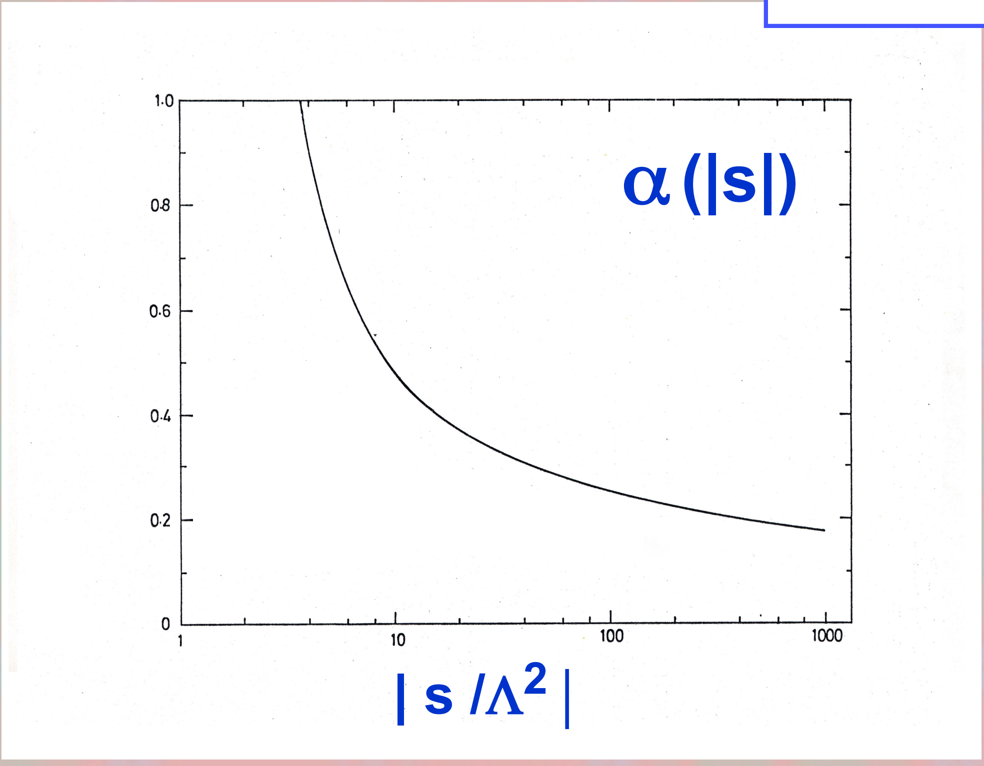


running coupling

$\mu^2 < 0$

$$\alpha(s) = \frac{\alpha(\mu^2)}{\left[1 + \frac{\beta_0}{4\pi}\alpha(\mu^2)\ln\frac{s}{\mu^2}\right]}$$

$$\beta_0 = \frac{11}{3}N_c - \frac{2}{3}n_f$$



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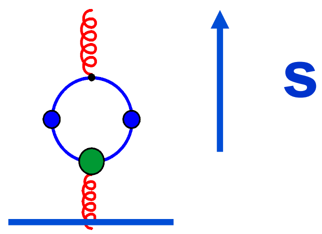
$$\beta_0 = \frac{11}{3}N_c - \frac{2}{3}n_f$$

timelike $s = q^2$

$s > 0$

$\mu^2 < 0$

$$\ln\left(\frac{s}{-\mu^2}\right) + i\pi$$



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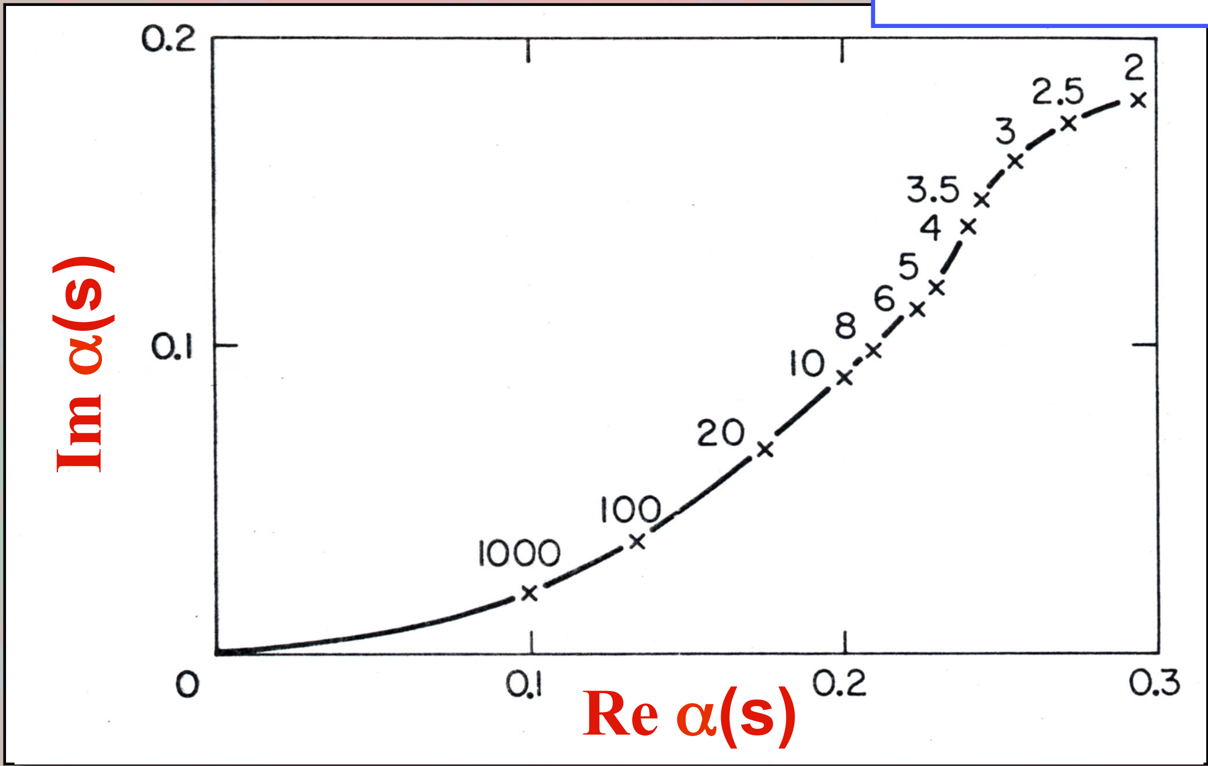


s > 0

$\mu^2 < 0$

$$S_F^{-1}(p,m)\Big|_{p^2=m^2} = \not{p} - m$$

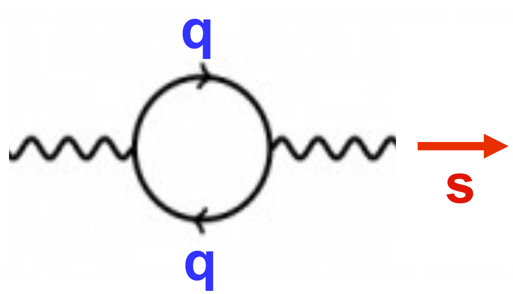
defining mass at pole

$$\left[\mu\frac{\partial}{\partial\mu} + \beta\left(g(\mu^2), m/\mu\right)\frac{\partial}{\partial g} + \sum_i \gamma_i\left(g(\mu^2), m/\mu\right)\right]\mathcal{D} = 0$$

$$\mathcal{D}\left(\frac{s}{\mu^2}, \frac{m^2}{\mu^2}, \alpha(\mu^2, m^2)\right) = \mathcal{D}\left(1, \frac{m^2}{s}, \alpha(s, m^2)\right)$$

$$\frac{1}{\alpha(s,m^2)} = \frac{1}{\alpha(\mu^2,m^2)} + \frac{1}{4\pi}\left[11\ln\frac{s}{\mu^2} - -\frac{2}{3}\sum_j\int_{\mu^2}^{s}\frac{dz}{z}F_1\left(\frac{m_j^2}{z}\right)\right]$$

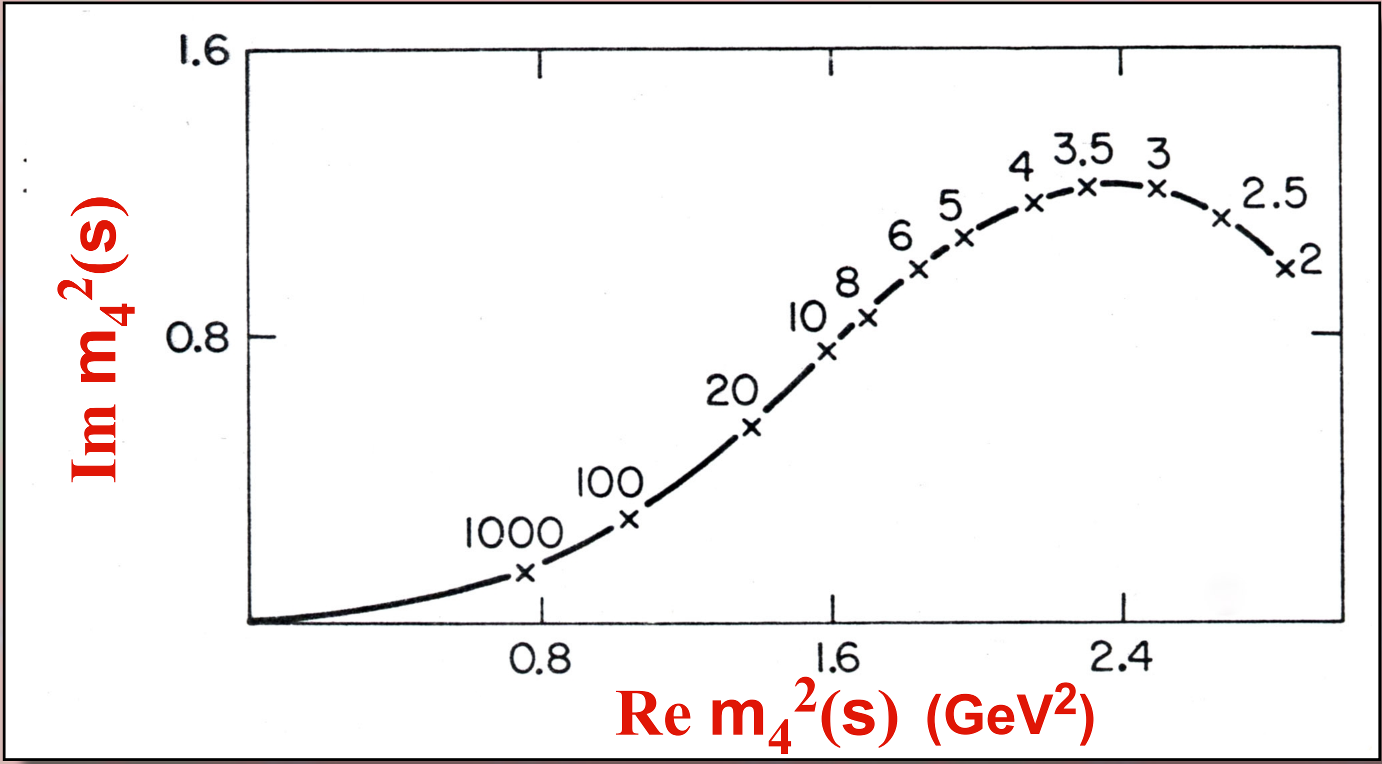
$$F_1(x) = 1 - 6x + \frac{12x^2}{\sqrt{1+4x}}\ln\left[\frac{\sqrt{1+4x}+1}{\sqrt{1+4x}-1}\right]$$

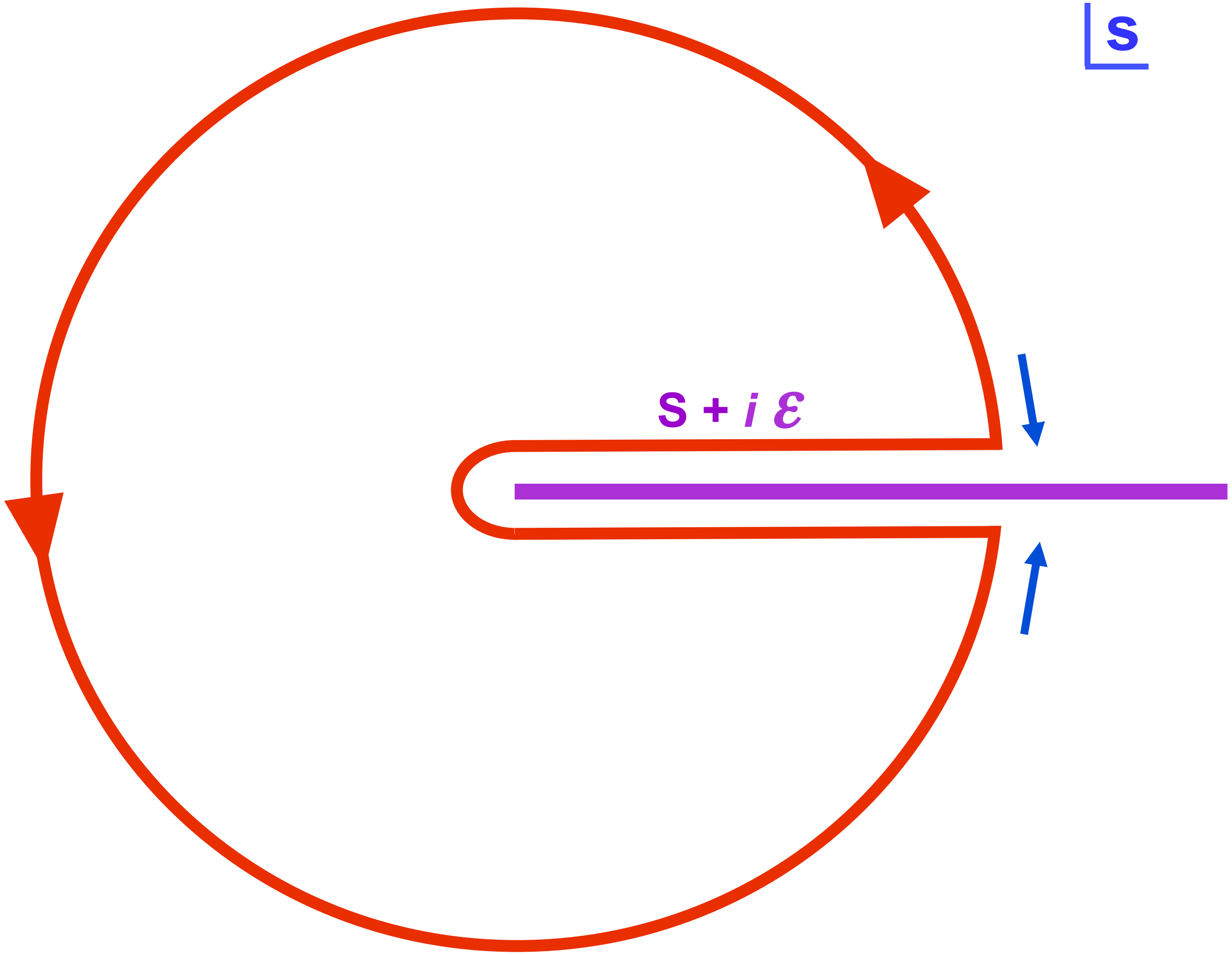


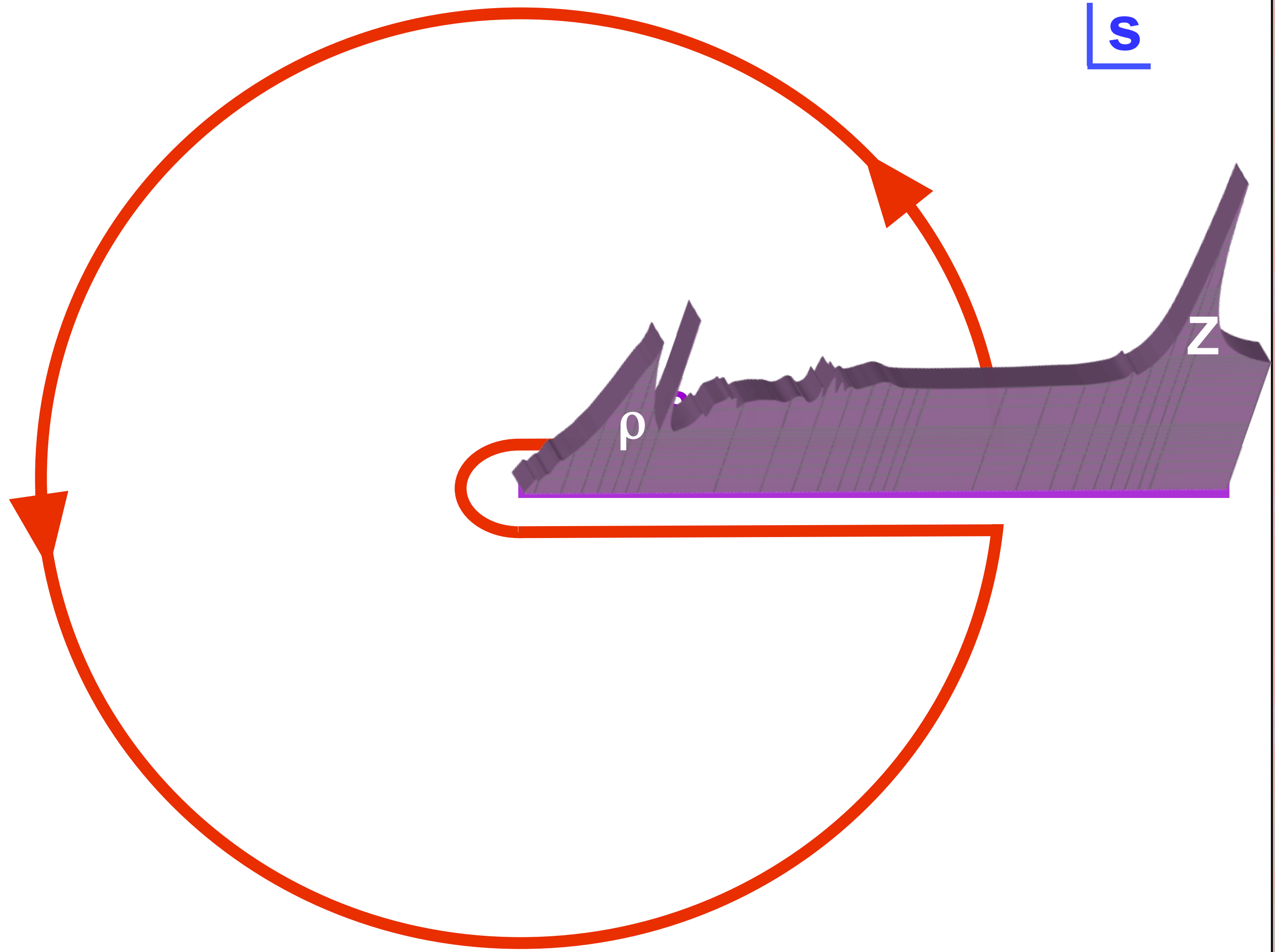
$$S_F^{-1}(p, m(\mu^2))\Big|_{p^2=\mu^2} = \not{p} - m(\mu^2)$$

defining mass at renorm. pt

$$m^2(s) \simeq m^2(\mu^2)\left(\frac{\alpha(s)}{\alpha(\mu^2)}\right)^{d_m}$$




s
s + i ε


s
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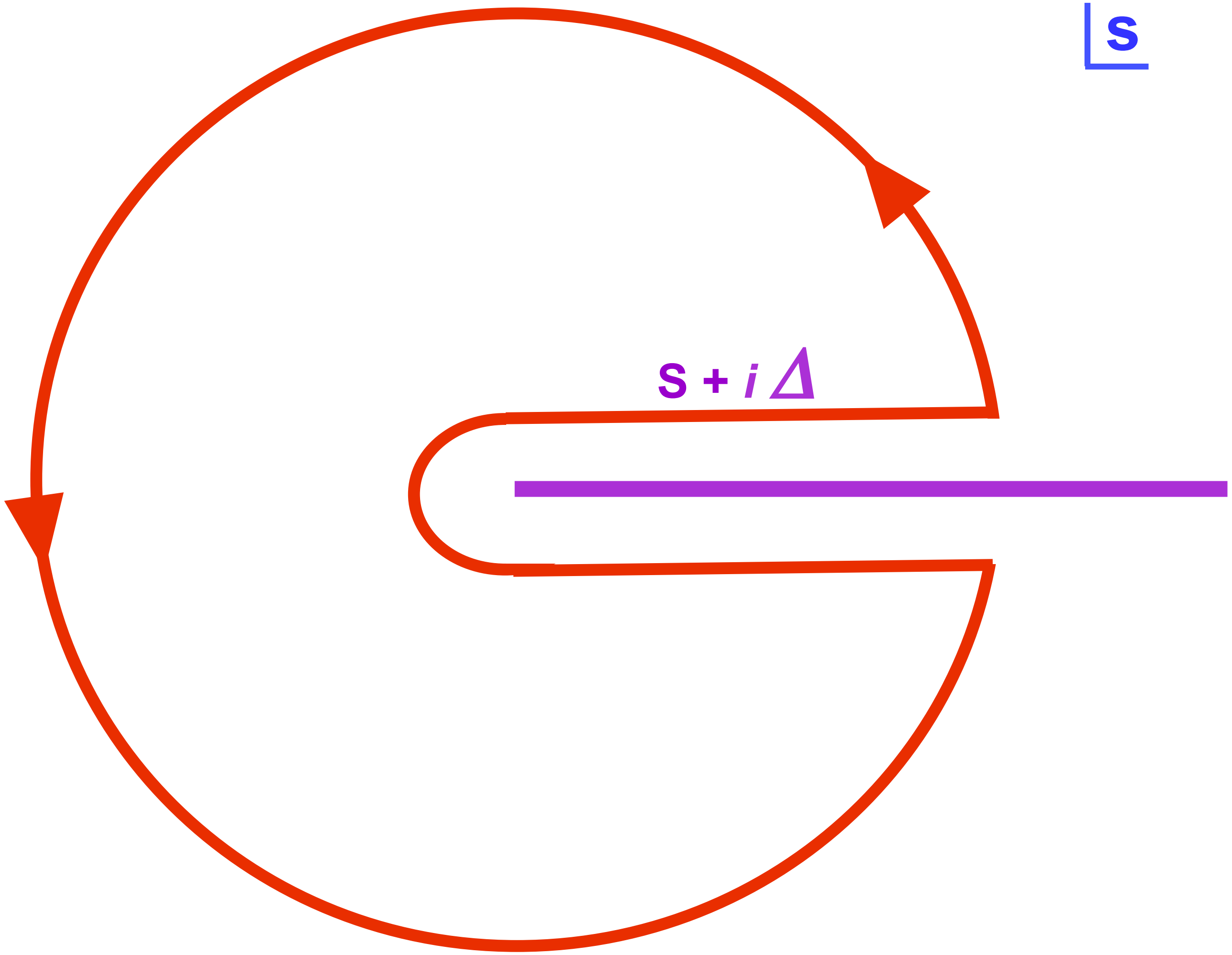
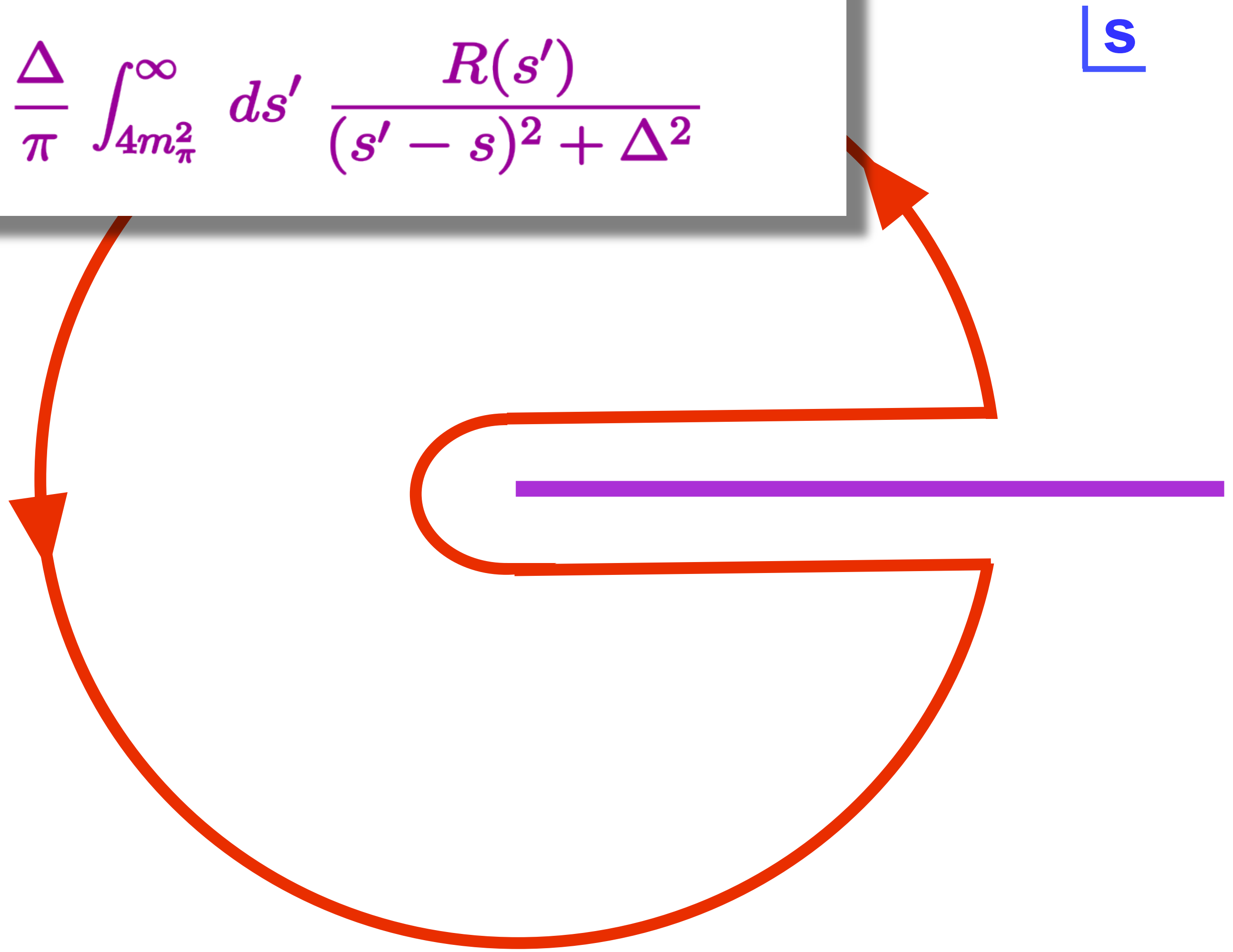


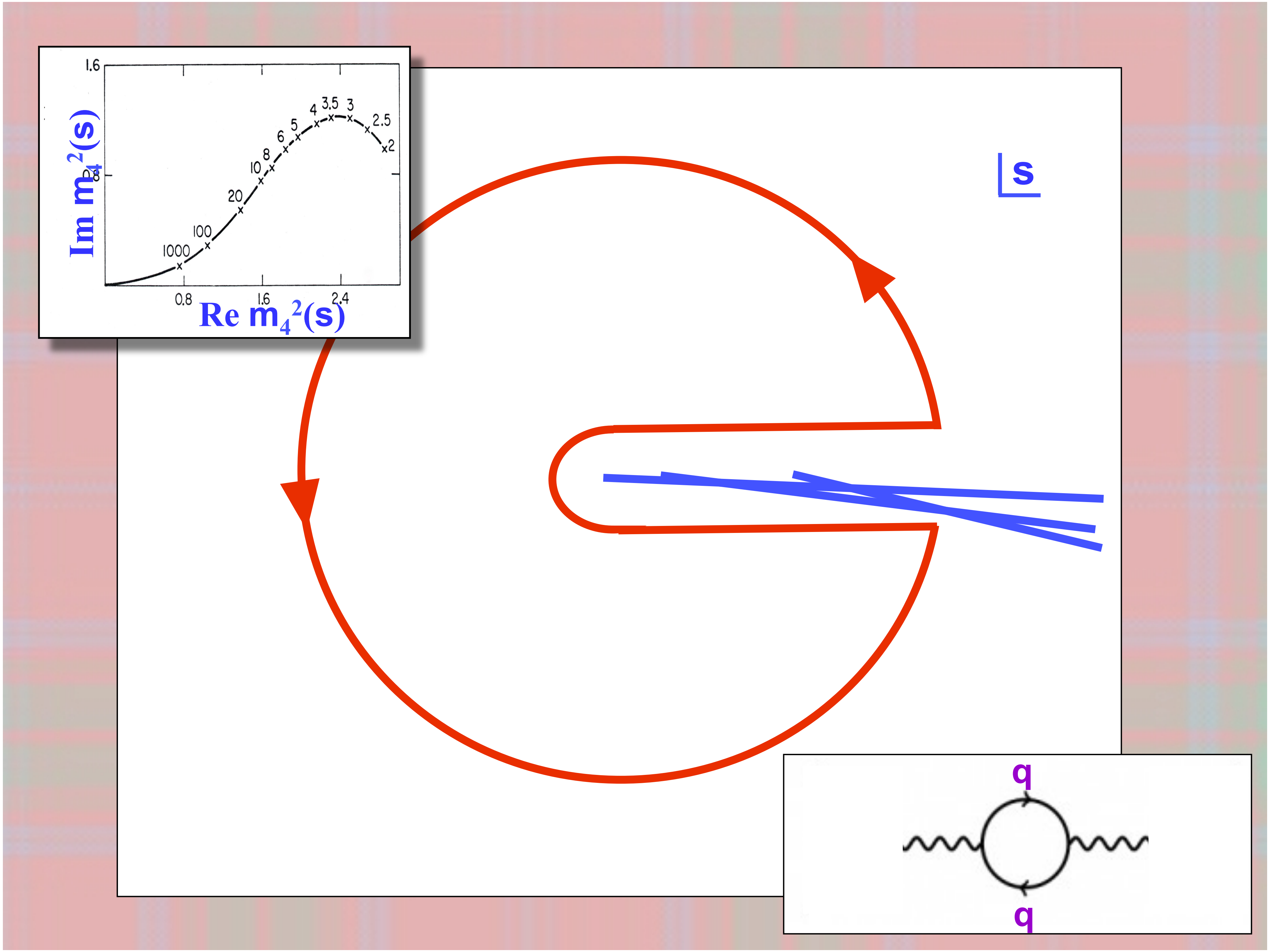
Poggio, Quinn, Weinberg

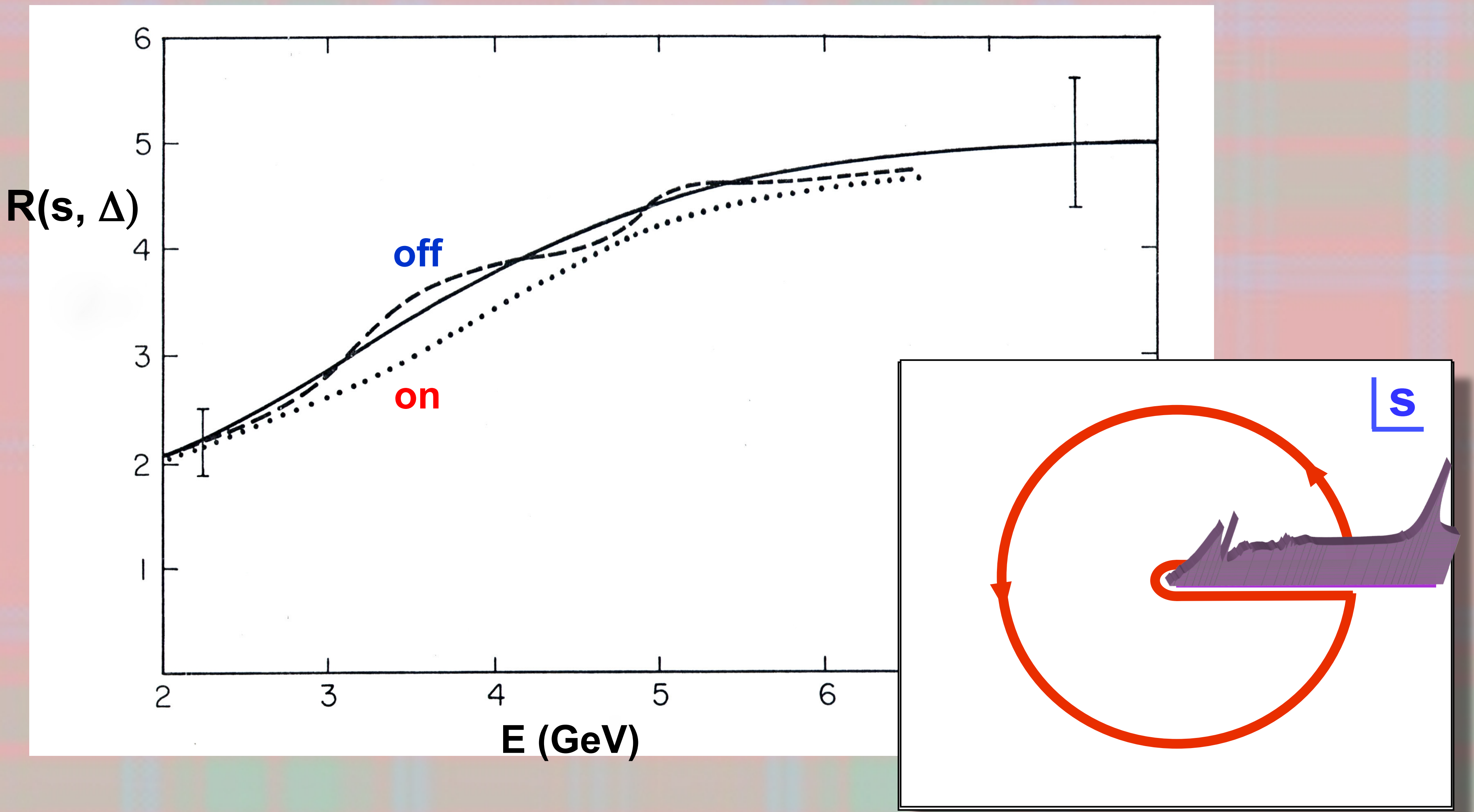
$$\mathcal{R}(s,\Delta) = \frac{1}{2i}\left[\Pi(s+i\Delta) - \Pi(s-\Delta)\right]$$

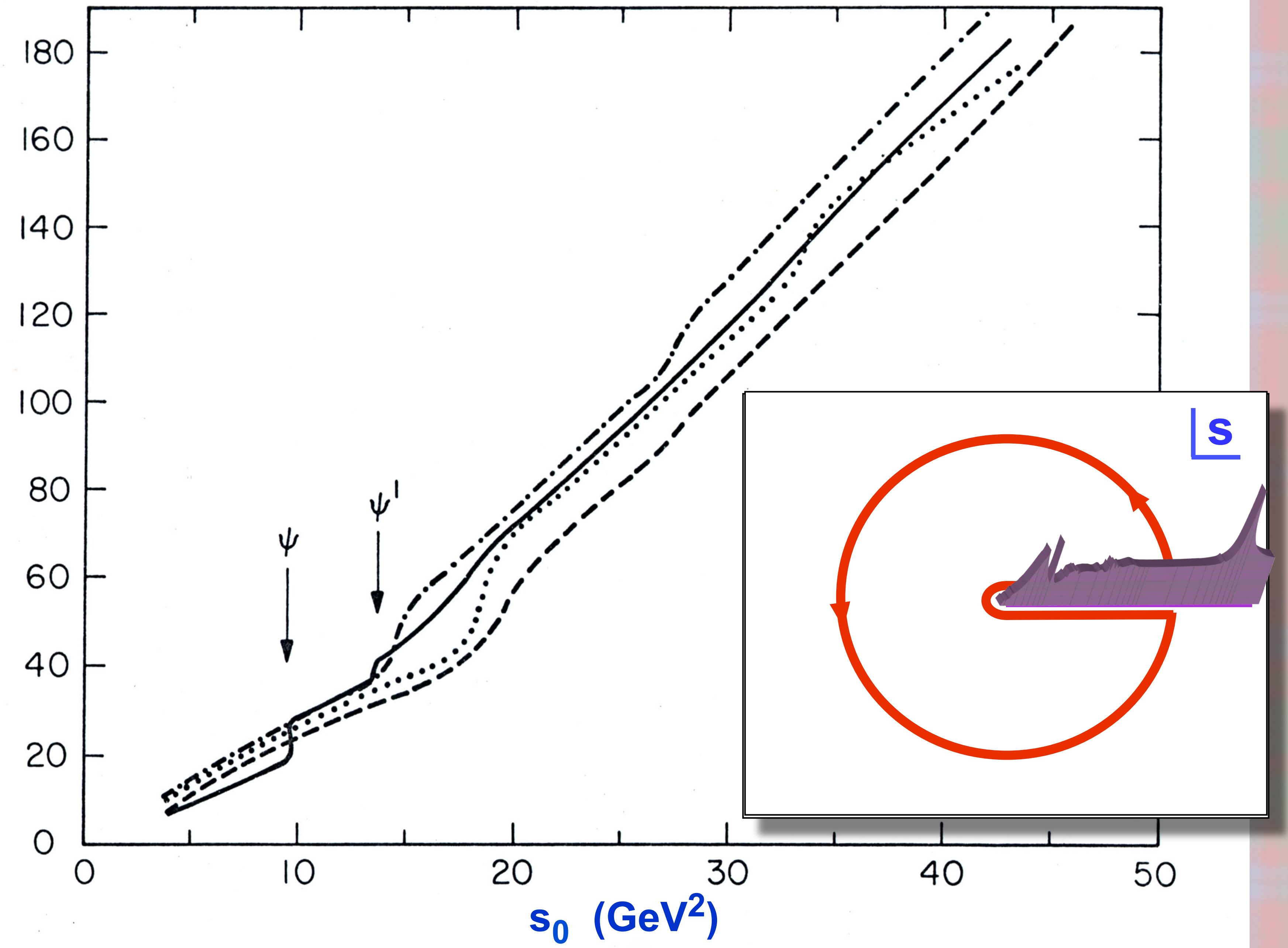
$$= \frac{\Delta}{\pi}\int_{4m_\pi^2}^{\infty} ds' \, \frac{R(s')}{(s'-s)^2+\Delta^2}$$

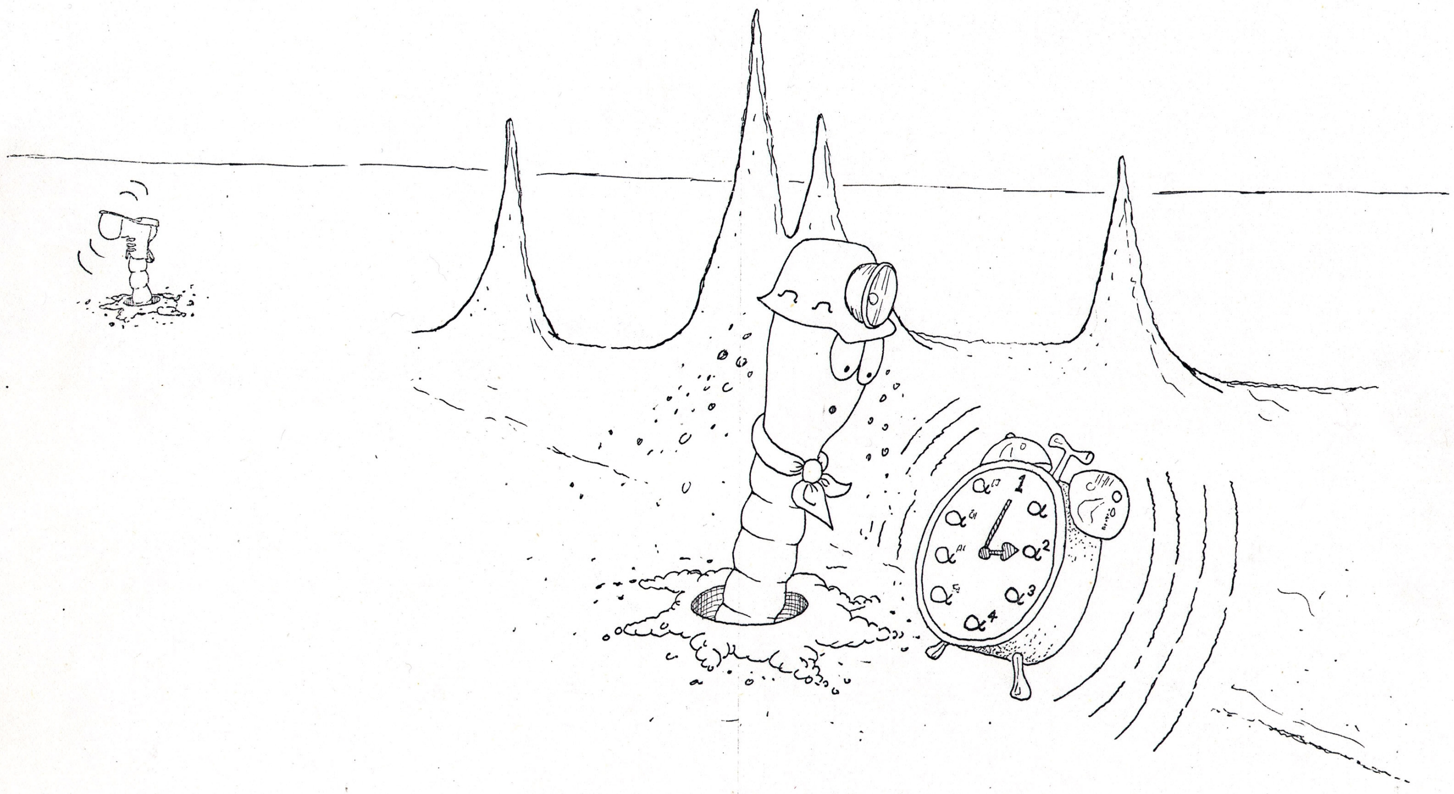


Poggio, Quinn, Weinberg


Im $m_4^2(s)$
Re $m_4^2(s)$
1.6
0.8
1.6
2.4
1000
100
20
10
8
6
5
4
3.5
3
2.5
2
s
q
q

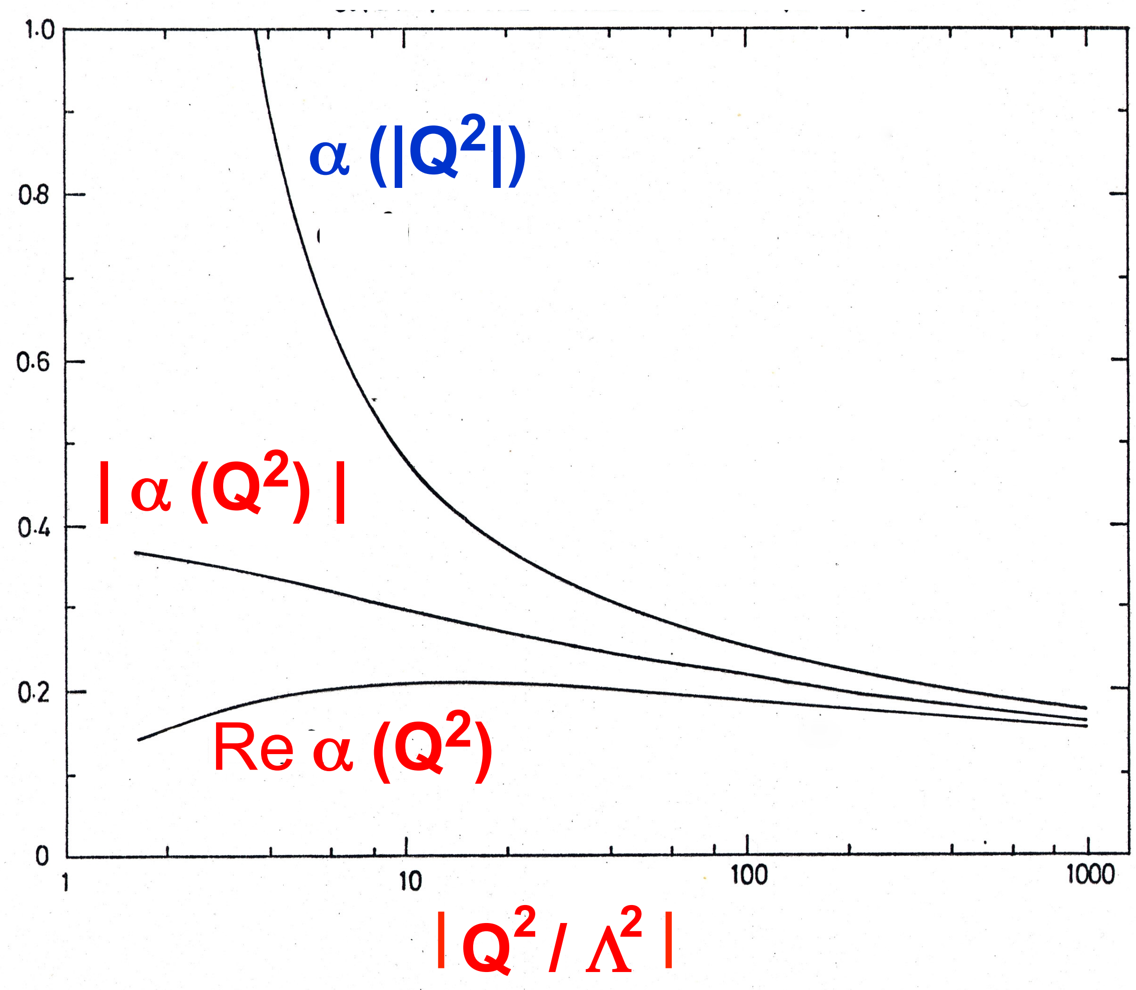

R(s, Δ)
6
5
4
3
2
1
off
on
2
3
4
5
6
E (GeV)
s


180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
ψ
ψ'
s
s_0 (GeV^2)

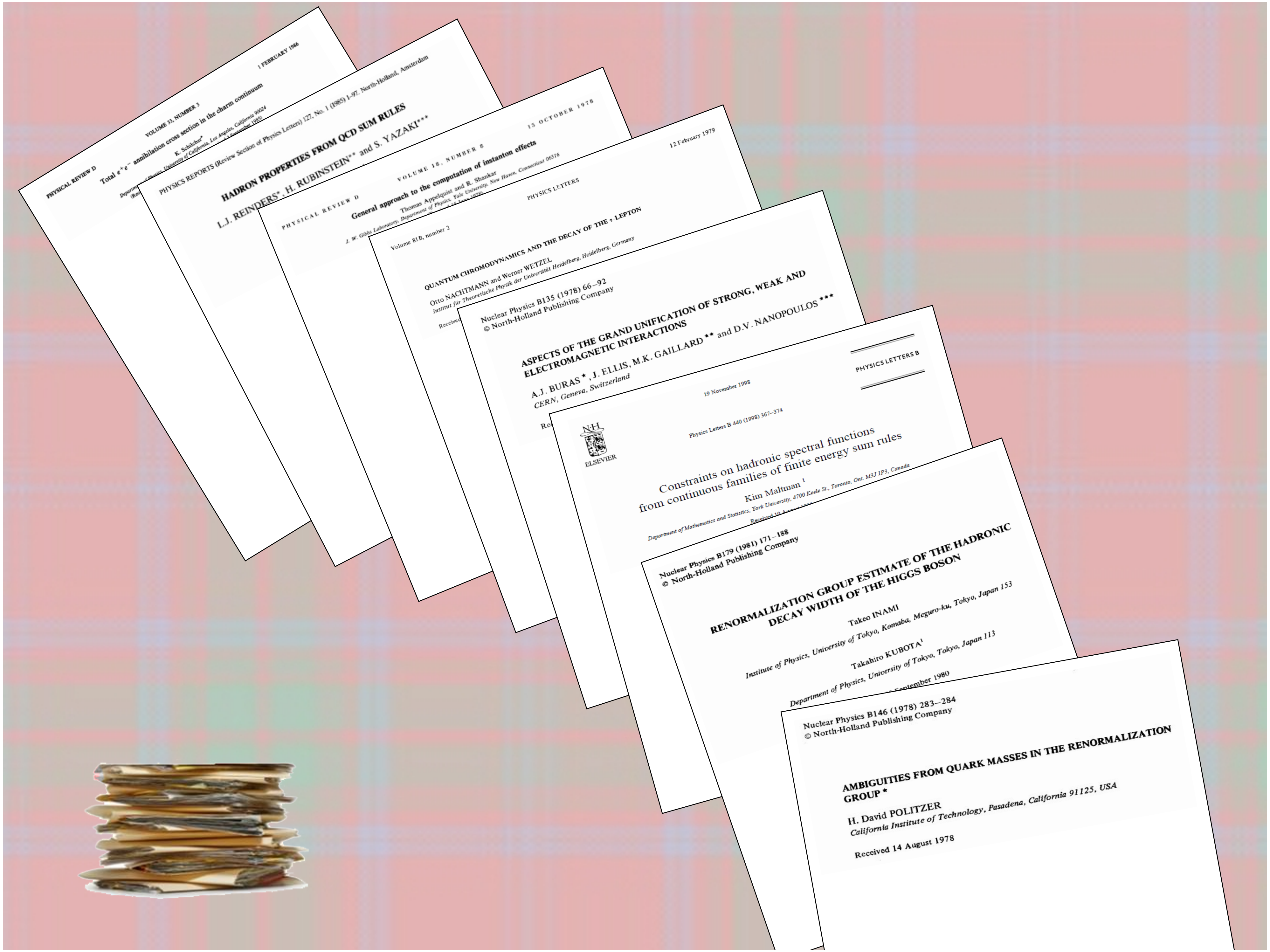


ANALYTIC CONTINUATION

$\alpha\,(Q^2/\Lambda^2)$ in timelike region $Q^2 < 0$



$A\,\alpha(s) + B\,\pi^2\,\alpha^3(s) + \ldots \longrightarrow A\,a(s)$


PHYSICAL REVIEW D
VOLUME 33, NUMBER 3
1 FEBRUARY 1986
Total e^+e^- annihilation cross section in the charm continuum
K. Schilcher
PHYSICS REPORTS (Review Section of Physics Letters) 127, No. 1 (1985) 1–97. North-Holland, Amsterdam
HADRON PROPERTIES FROM QCD SUM RULES
L.J. REINDERS*, H. RUBINSTEIN** and S. YAZAKI***
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General approach to the computation of instanton effects
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QUANTUM CHROMODYNAMICS AND THE DECAY OF THE τ-LEPTON
Otto NACHTMANN and Werner WETZEL
Institut für Theoretische Physik der Universität Heidelberg, Heidelberg, Germany
Nuclear Physics B135 (1978) 66–92
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ASPECTS OF THE GRAND UNIFICATION OF STRONG, WEAK AND ELECTROMAGNETIC INTERACTIONS
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CERN, Geneva, Switzerland
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19 November 1998
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ELSEVIER
Constraints on hadronic spectral functions from continuous families of finite energy sum rules
Kim Maltman 1
Department of Mathematics and Statistics, York University, 4700 Keele St., Toronto, Ont. M3J 1P3, Canada
Nuclear Physics B179 (1981) 171–188
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RENORMALIZATION GROUP ESTIMATE OF THE HADRONIC DECAY WIDTH OF THE HIGGS BOSON
Takeo INAMI
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Takahiro KUBOTA1
Department of Physics, University of Tokyo, Tokyo, Japan 113
Nuclear Physics B146 (1978) 283–284
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AMBIGUITIES FROM QUARK MASSES IN THE RENORMALIZATION GROUP *
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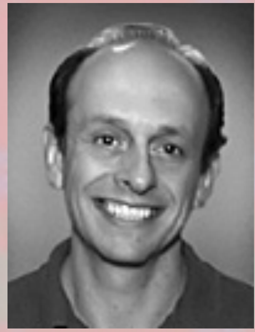

AMBIGUITIES FROM QUARK MASSES IN THE RENORMALIZATION GROUP *

H. David POLITZER

Renormalizability ensures that any consistent prescription will lead to the same physical predictions, whether the β functions are the same or not. More precisely, any discrepancies between two calculations carried out to a given order must be yet higher order in the coupling constant. One may still ask, in the spirit of Moorhouse, Pennington and Ross [4], whether one particular prescription is better than others in the following practical sense: if we compute to lowest order and ignore yet higher orders, may one prescription be closer to the complete theory than another? That is to ask: can choice of a particular prescription minimize the numerical coefficient of g^2 in the next correction? Typically the answer is yes, but it is impossible to prove without actually computing that next correction. However, for the bulk of phenomenological applications, the use of the light quark-gluon vertex to define g seems a likely candidate because it is precisely that vertex which occurs in lowest-order amplitudes and is subsequently renormalized by higher orders.

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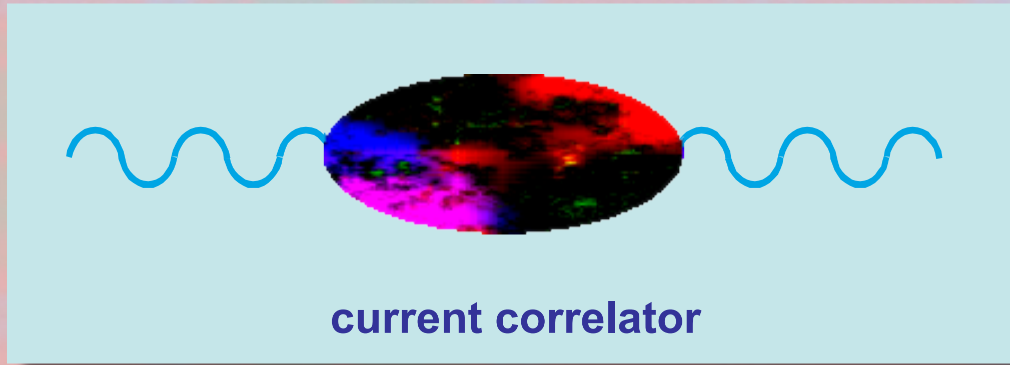
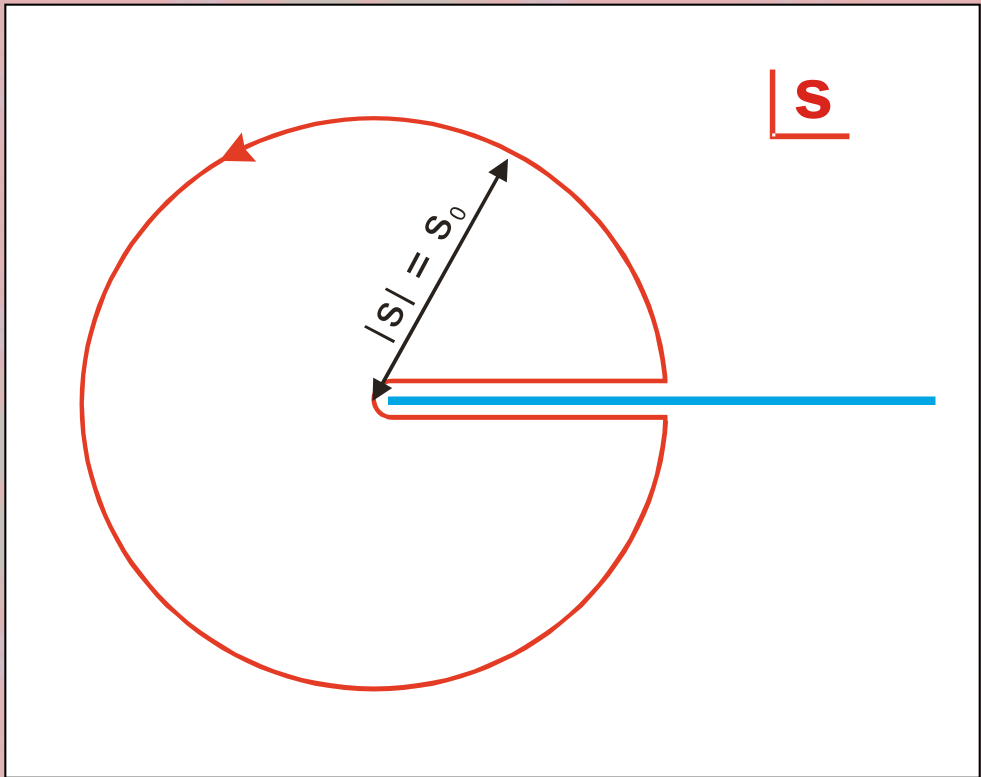
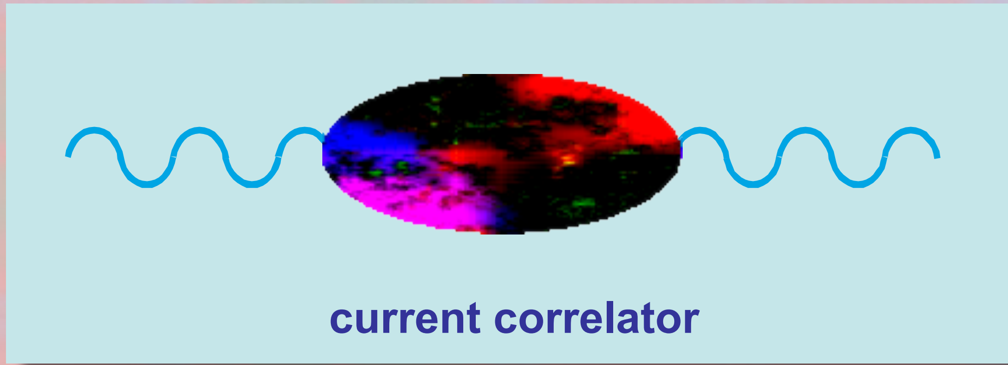
QCD Sum Rules

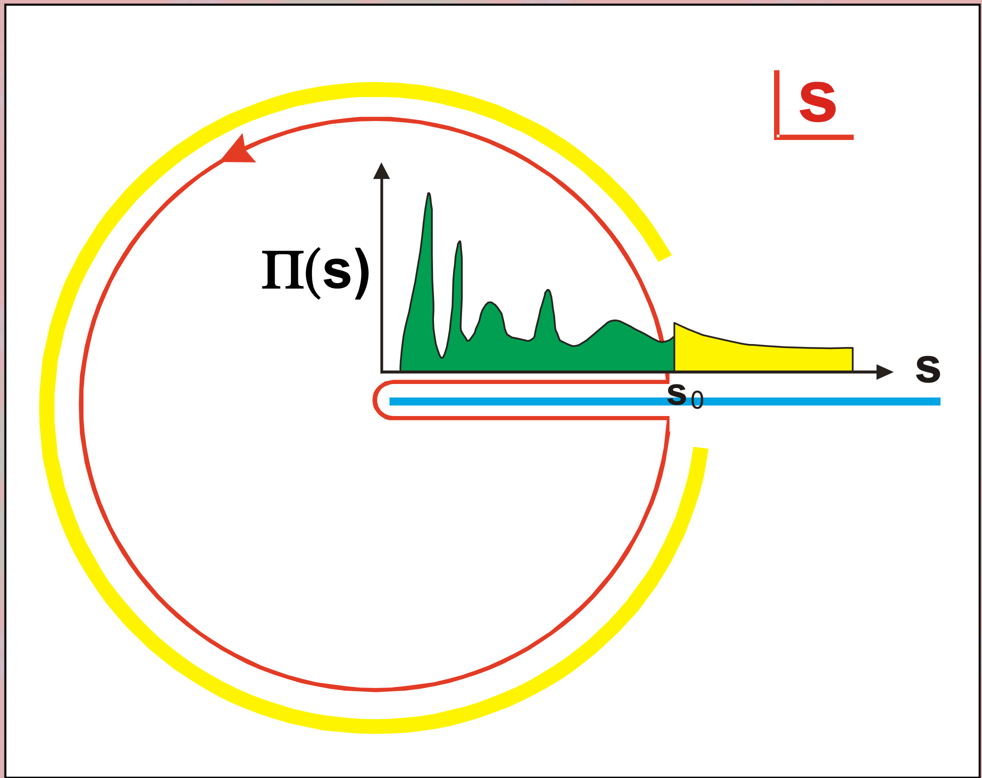




$$\oint ds\, \omega(s)\, \Pi(s) = 0$$

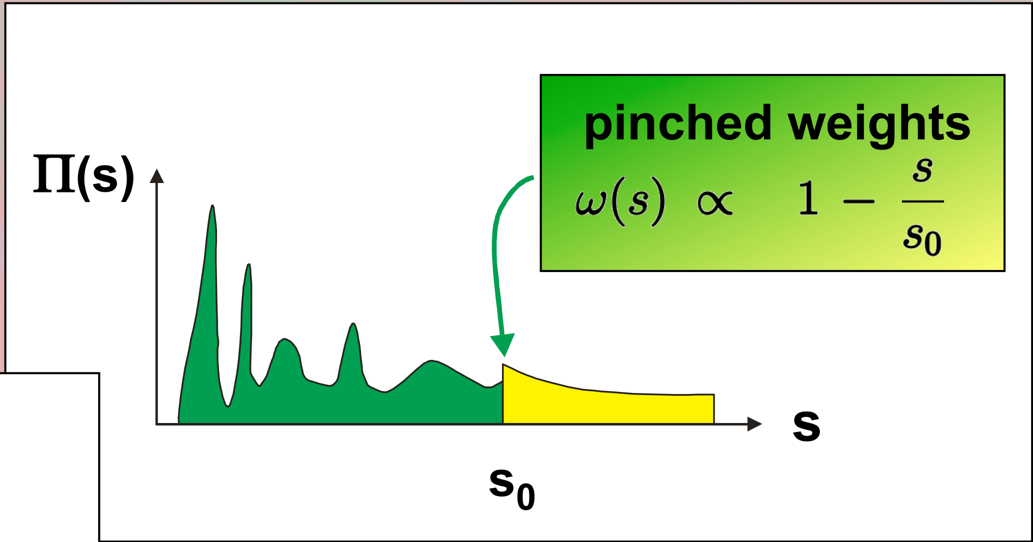
QCD Sum Rules

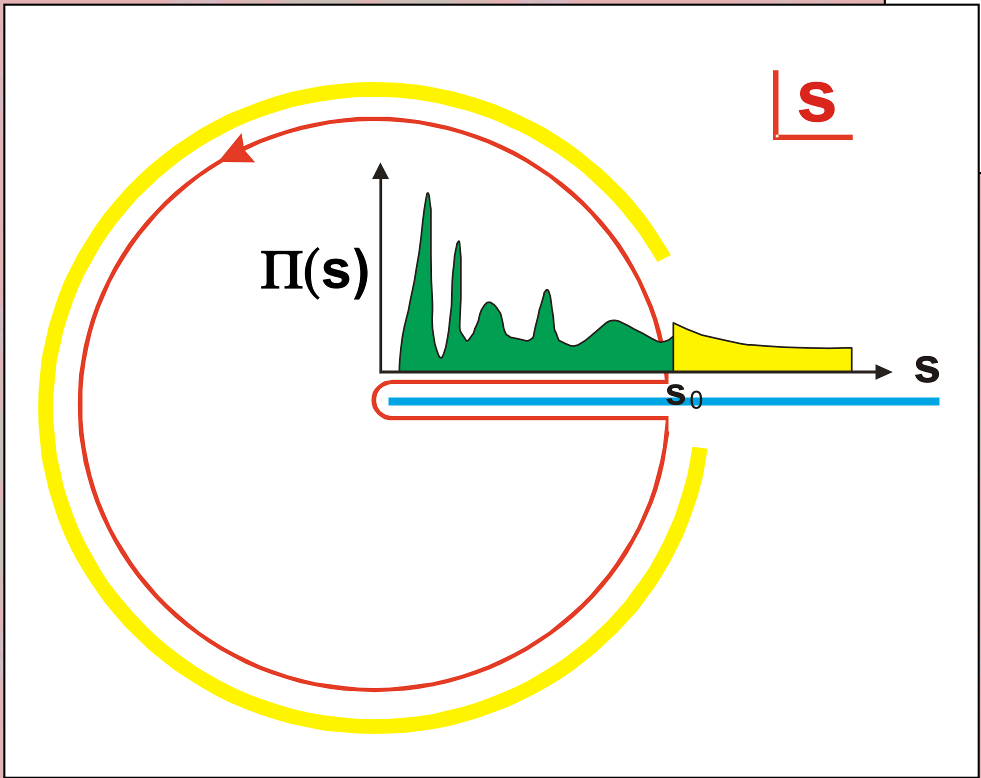




$< qq >_0$, $< \alpha\, GG >_0$, …

$$2i \int_0^{s_0} ds\, \omega(s)\, \mathrm{Im}\, \Pi(s) \;=\; - \oint_C ds\, \omega(s)\, \Pi(s)$$





working with Graham Ross 1974-1984