

AdS Hadronization Ideas

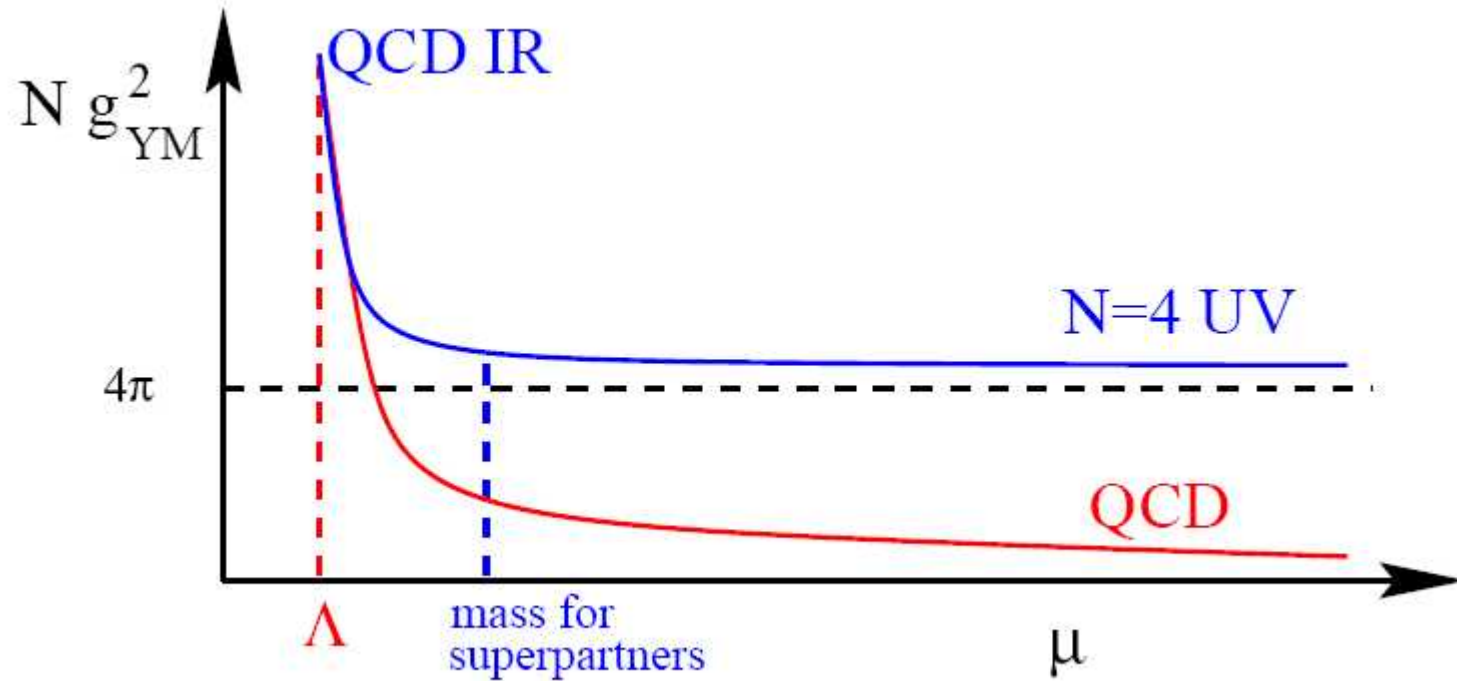
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Gauge theories - N=4 Derivatives



Computations by duality – ie classical 5d supergravity calculations

Hadronization

Perturbative separation



String breaking



Separating colour neutral clouds



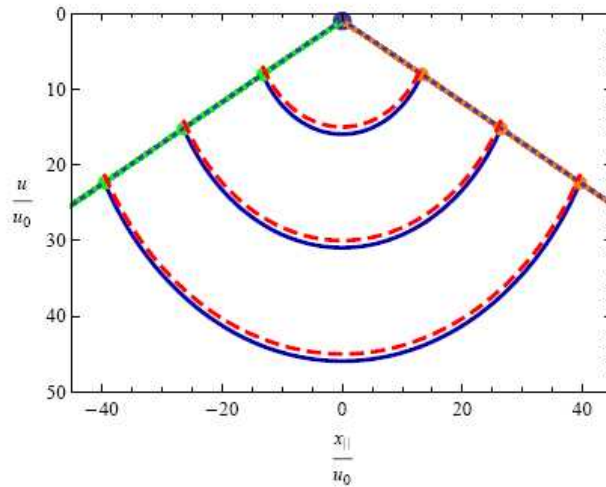
Phase One - Perturbative in QCD

- Strongly coupled, conformal $N=4$

Maldacena, Mueller – all pt emitted strongly – the jet becomes a ball very fast!

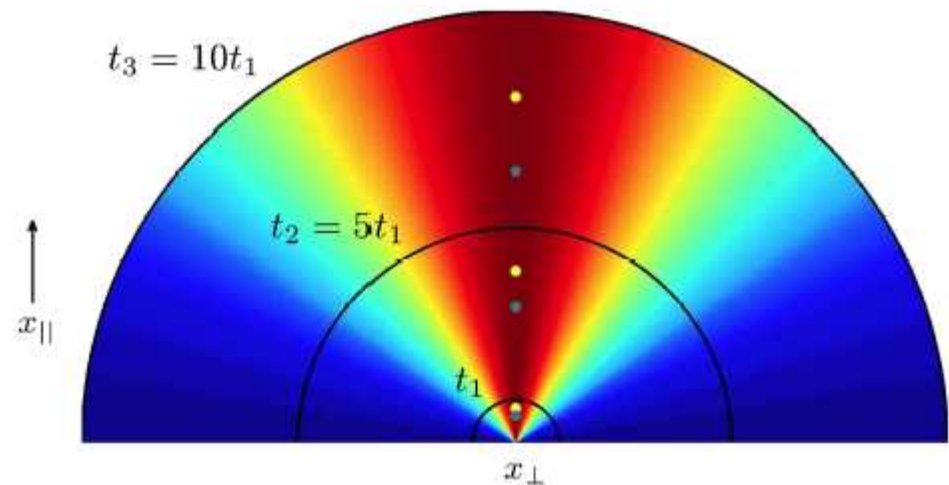
Hadronization – Phase 1

Karch



Open string end point motion in AdS

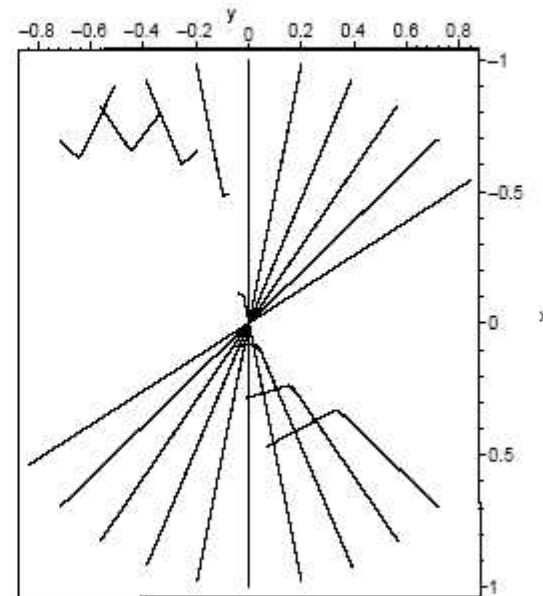
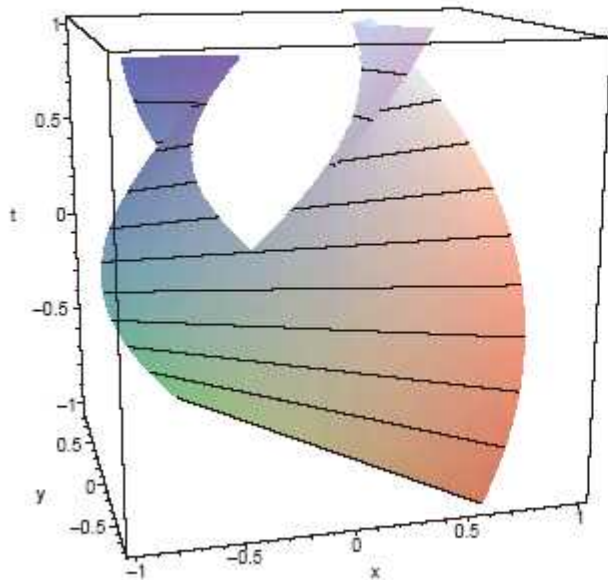
Leads to jet formation around the end point



Hadronization – Phase 2 – String Breaking

Peeters, Zamalkar

Breaking a spinning string in AdS leads to a propagating kink along the string and an energy dump off the end... main energy source for hadronization



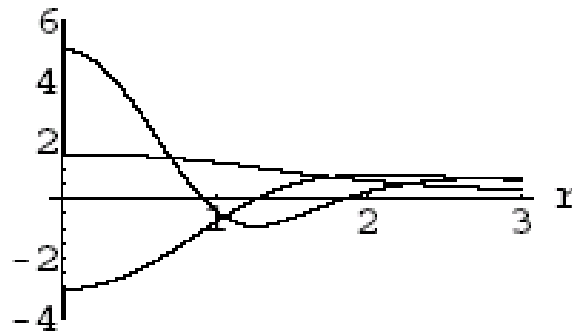
Hadronization – Phase 3 – Final State Multiplicities

Hadrons and their radially excited states are described by a 5d field . There are a set of orthogonal functions

$$g_n(r)e^{ik_n x}$$

Evans

Tedder



If we expand a Gaussian (centred on $r=0$, width 300MeV) initial condition in terms of these basis functions

$$c_n = \int_0^\infty \Psi(r) w(r) g_n(r) dr$$

We obtain the yields (c_n^2):

rho 15

rho* 3

rho** 0....



Final LEP Yields

Parameters

Width = 150 MeV

$\gamma_s = 0.97$

R = 2.6

Average E = 5.0 GeV

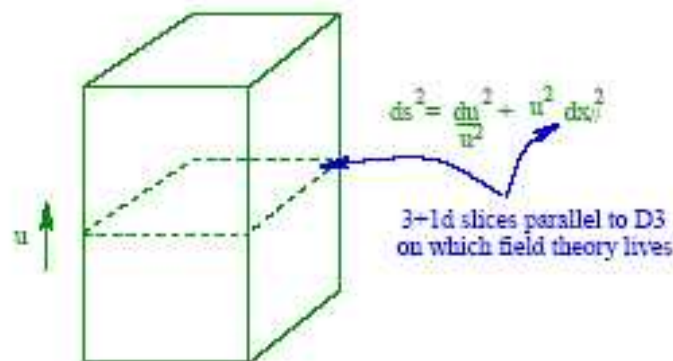
Hadron	Model	Expt
π^+	5.95	8.5
π^0	6.43	9.2
K^+	1.09	1.2
K^0	1.09	1.0
η	1.06	0.93
ρ^0	1.33	1.2
K^{*+}	0.387	0.36
K^{*0}	0.385	0.37
η'	0.042	0.13
p	0.41	0.406
ϕ	0.03	0.1
Λ	0.172	0.19
$\frac{\Sigma^{++} + \Sigma^{*-}}{2}$	0.0120	0.0094
Ξ^-	0.012	0.012
Ξ^{*0}	0.0040	0.0033
Ω	0.0011	0.0014

Decent match across orders of magnitude in production rates..

RMS of fit 37%

4d strongly coupled $\mathcal{N}=4$ SYM (conformal) = IIB strings on $\text{AdS}_5 \times \text{S}^5$

Pretty well established by this point!



u corresponds to energy (RG) scale in field theory

The SUGRA fields act as sources

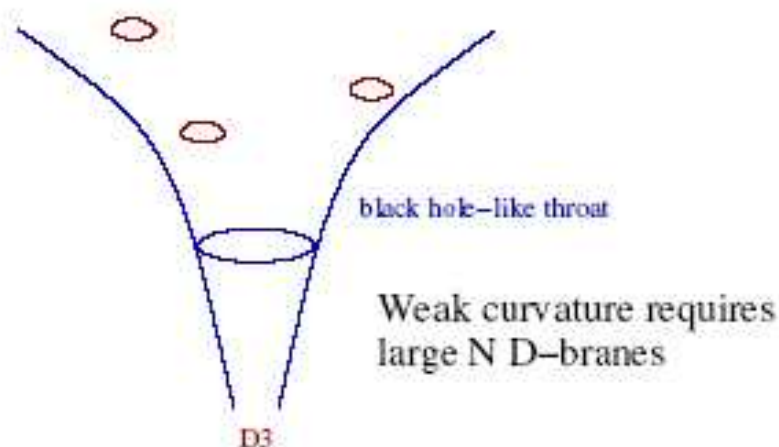
$$\int d^4x \phi_{SUGRA}(u_0) \lambda \lambda$$

eg asymptotic solution ($u \rightarrow \infty$) of scalar

$$\varphi \simeq \frac{m}{u} + \frac{\langle \lambda \lambda \rangle}{u^3}$$

Brane Construction

A large N stack of D3 branes generates curvature like a black hole:



The Tension $\rightarrow \infty$ limit blows up the throat

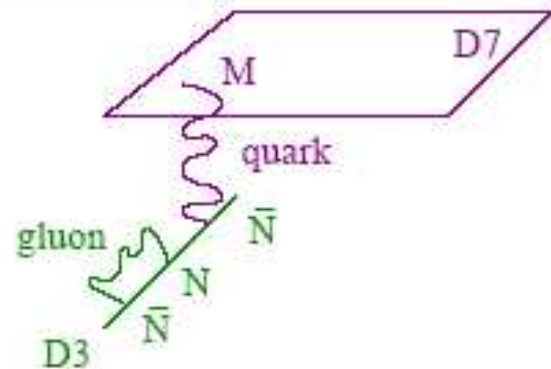
$$ds^2 = u^2 dx_{//}^2 + \frac{du^2}{u^2} + d\Omega_5^2$$

This is $AdS_5 \times S^5$

In this limit higher dimension operators linking the gauge theory on brane and gravity fluctuations off are suppressed - the two descriptions decouple.

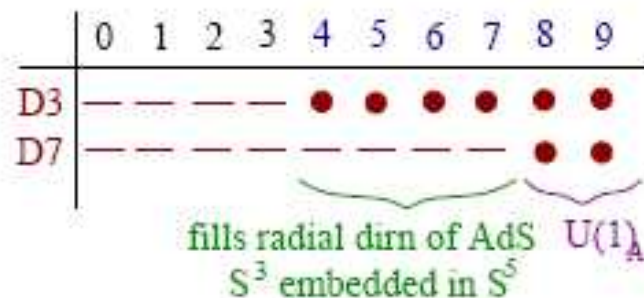
Adding Quarks

Bertolini, DiVecchia...; Polchinski, Grana; Karch, Katz...



The brane set up is

Quarks can be introduced via D7 branes in AdS

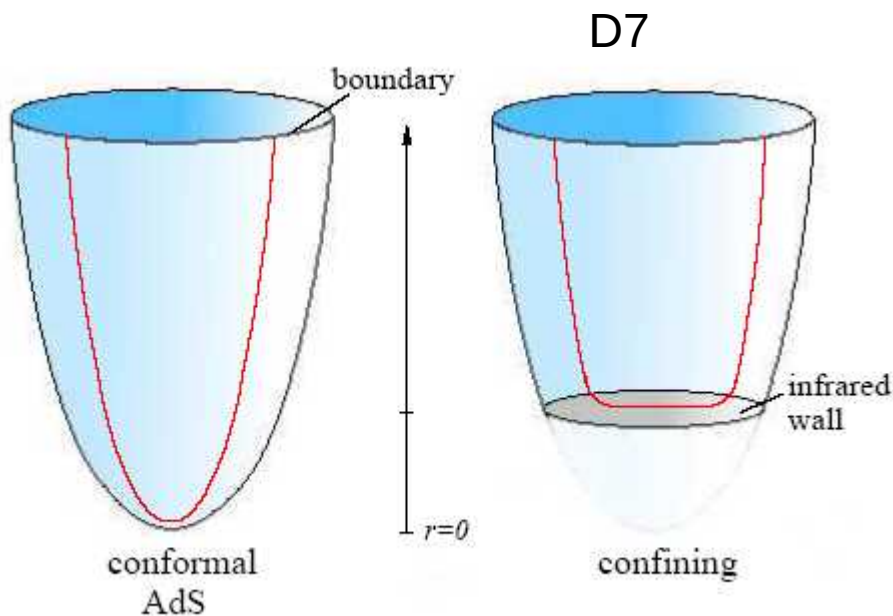


We will treat D7 as a probe - quenching in the gauge theory.

Minimize D7 world volume with DBI action

$$S_{D7} = -T_7 \int d\xi^8 \sqrt{P[G_{ab}]}, \quad P[G_{ab}] = G_{MN} \frac{dx^M}{d\xi^a} \frac{dx^N}{d\xi^b}$$

The interaction energy between a quark and an anti-quark is given by embedding a string in the space:



The singularity repels the string and it lies along the wall – a linear potential emerges

