Some new results on "jet" stopping in AdS/CFT

Peter Arnold and Diana Vaman

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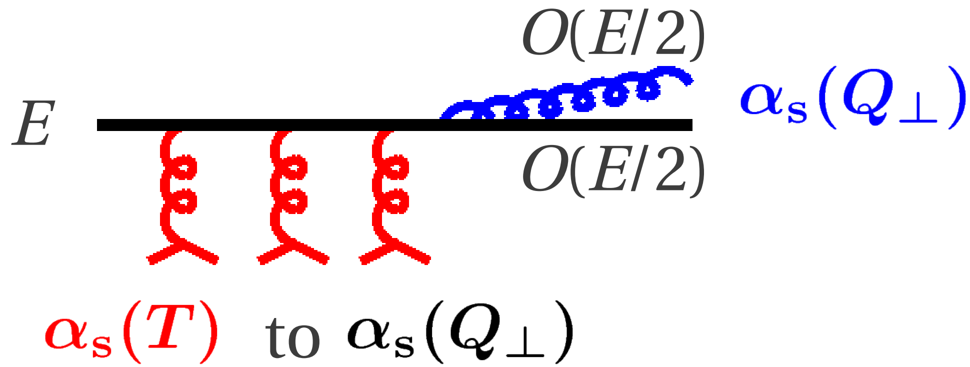

$$Q_\perp \sim (\hat{q}E)^{1/4}$$

typical transverse momentum transfer during formation time (infinite medium)

<u>How stopping length scales with energy</u> (massless case)

weak coupling: $\alpha_s \sim \alpha_s$ small $\quad l_{stop} \propto E^{1/2}$ (up to logs)

[this scaling a corollary of BDMPS and Z (1996)]

mixed coupling: α_s BIG, α_s small $\quad l_{stop} \propto E^{1/2}$ (believed)

$l_{stop} \sim \alpha_s^{-1}(E/\hat{q})^{1/2}$

[e.g. related to motivation behind Liu, Rajagopal, Wiedeman (2006)]

all strong coupling: $\alpha_s = \alpha_s$ BIG $\quad l_{stop} \propto E^{1/3}$
($\mathcal{N}=4$ SYM, etc.)

[Gubser, Gollota, Pufu, Rocha; Hatta, Iancu, Mueller; Chesler, Jensen, Karch, Yaffe (2008)]

<u>Interesting:</u> Exponent in $l_{stop} \propto E^\nu$ can depend on α_s.

Strongly Coupled Case Revisited

BIG α_s=α_s: Large-N_c $\mathcal{N}=4$ SYM, etc. with $N_c\alpha_s \to \infty$

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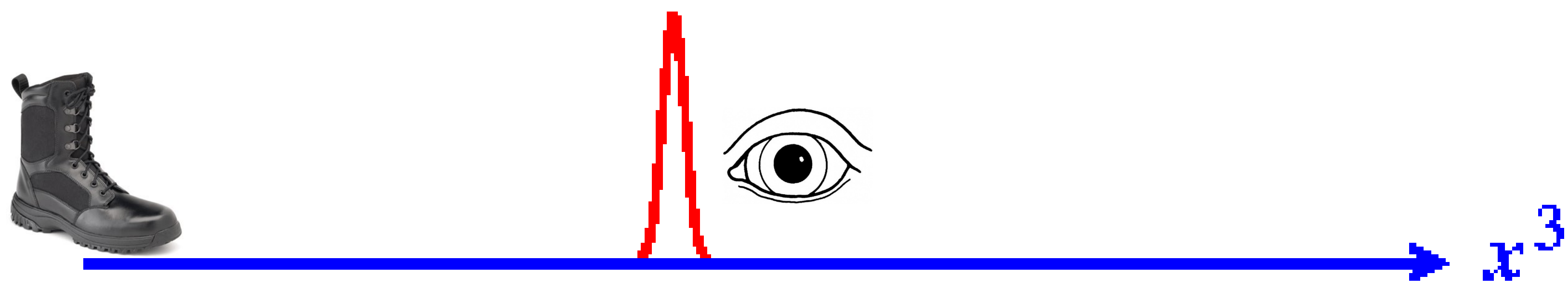

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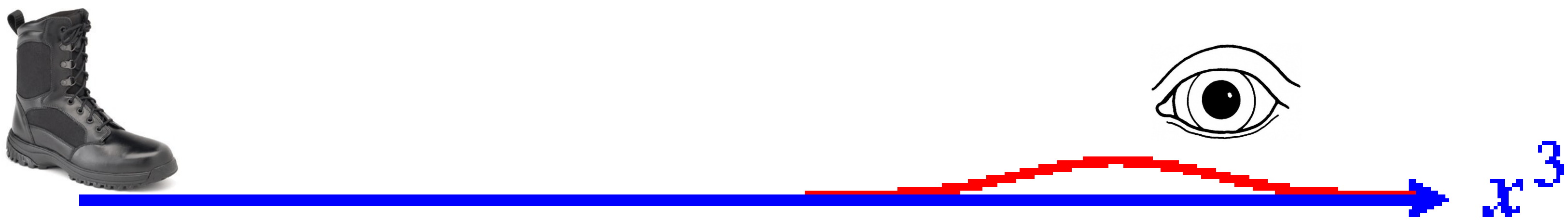

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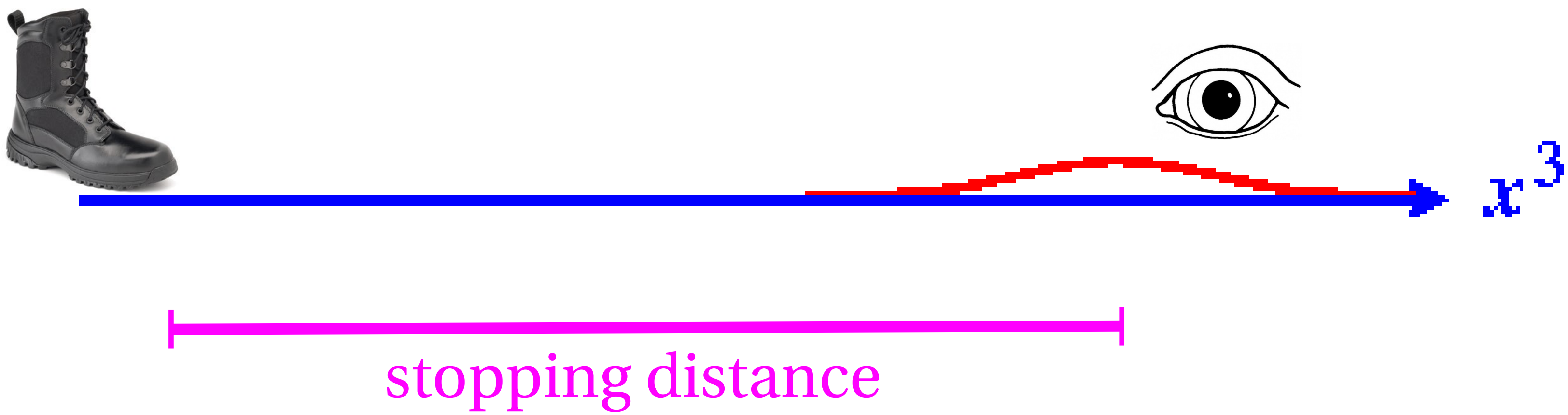
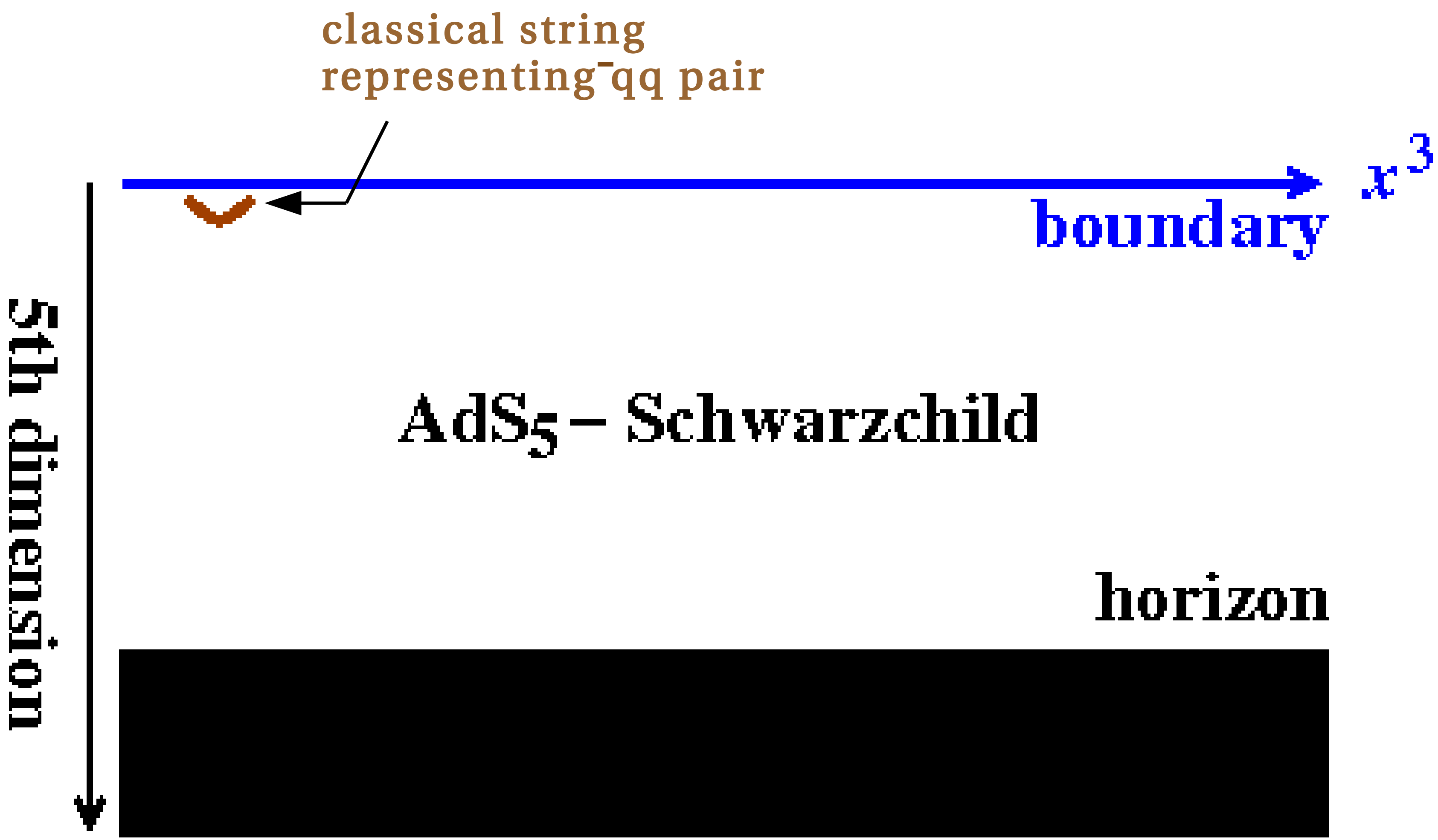


Previous AdS Calculations

Example: Classical string calculation of

Chesler, Jensen, Karch, Yaffe (2008)



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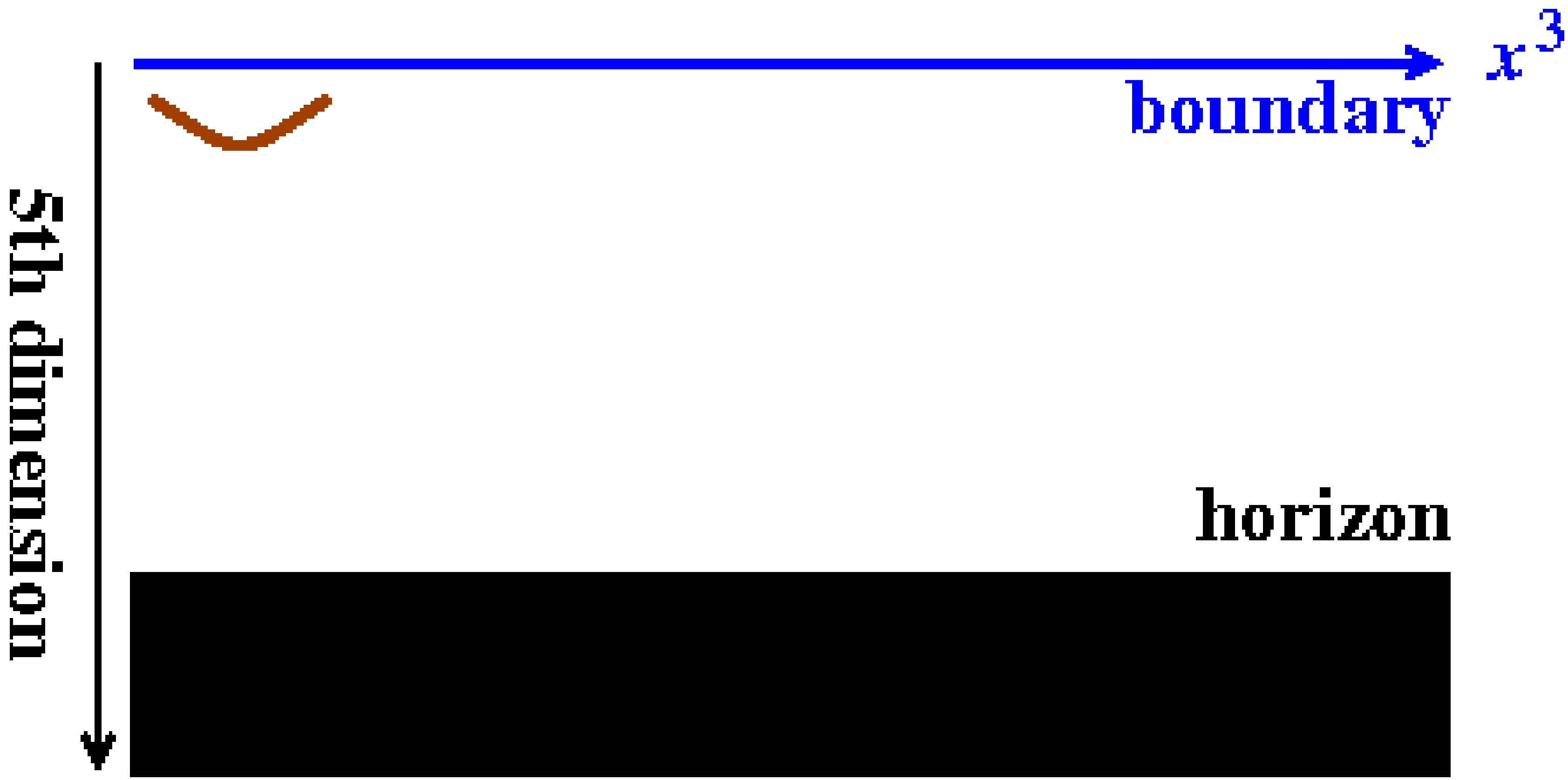

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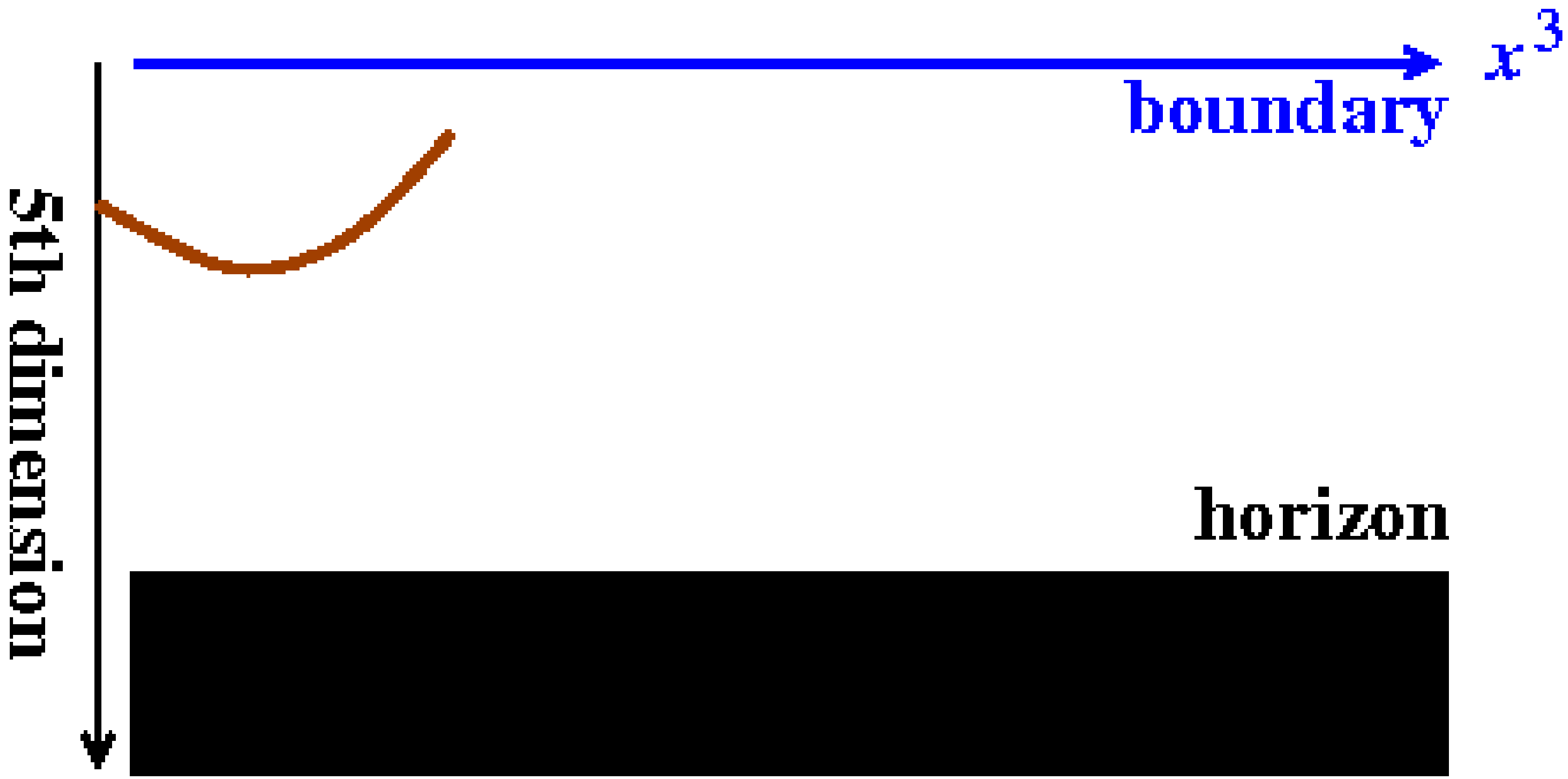

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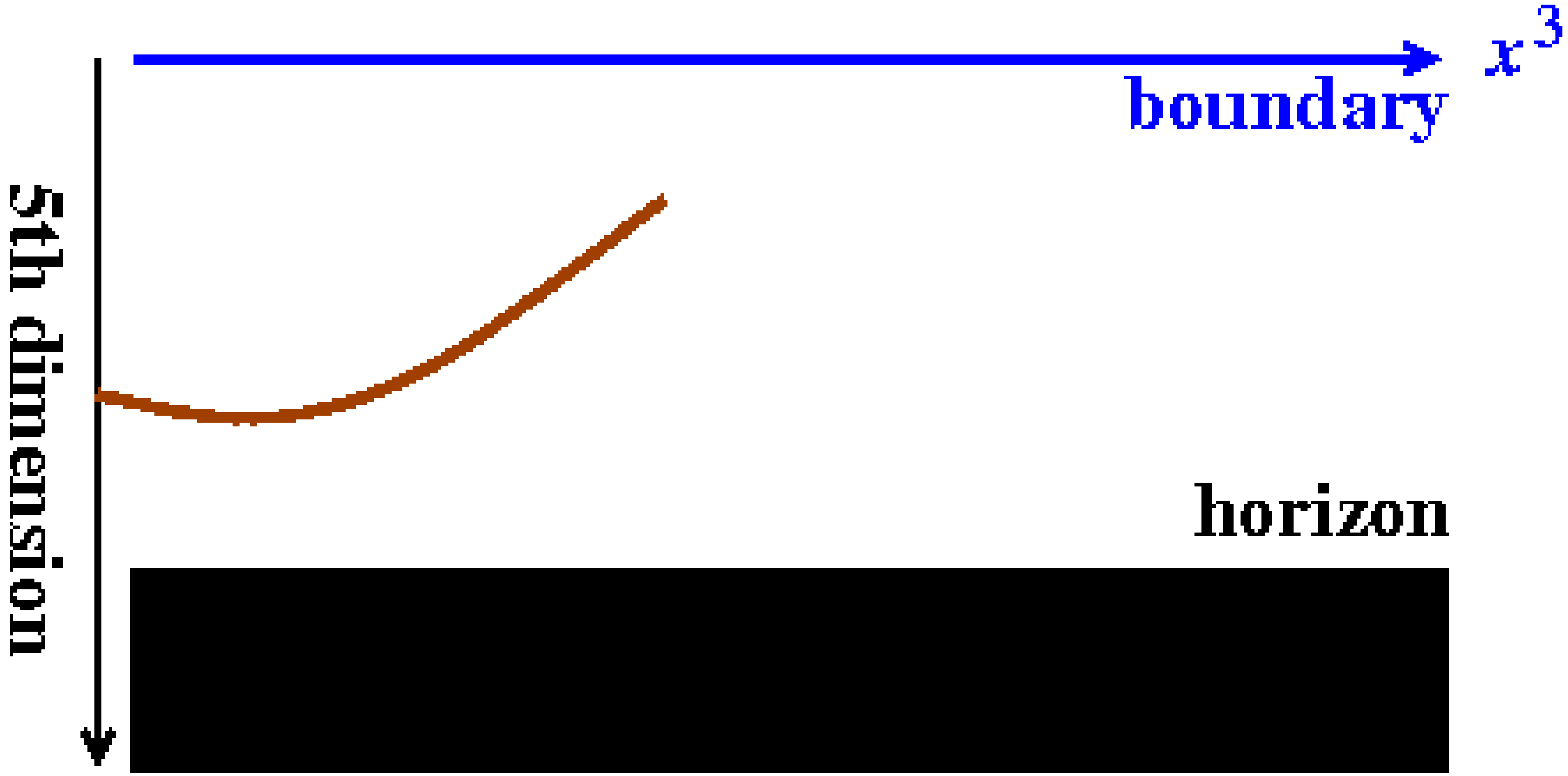

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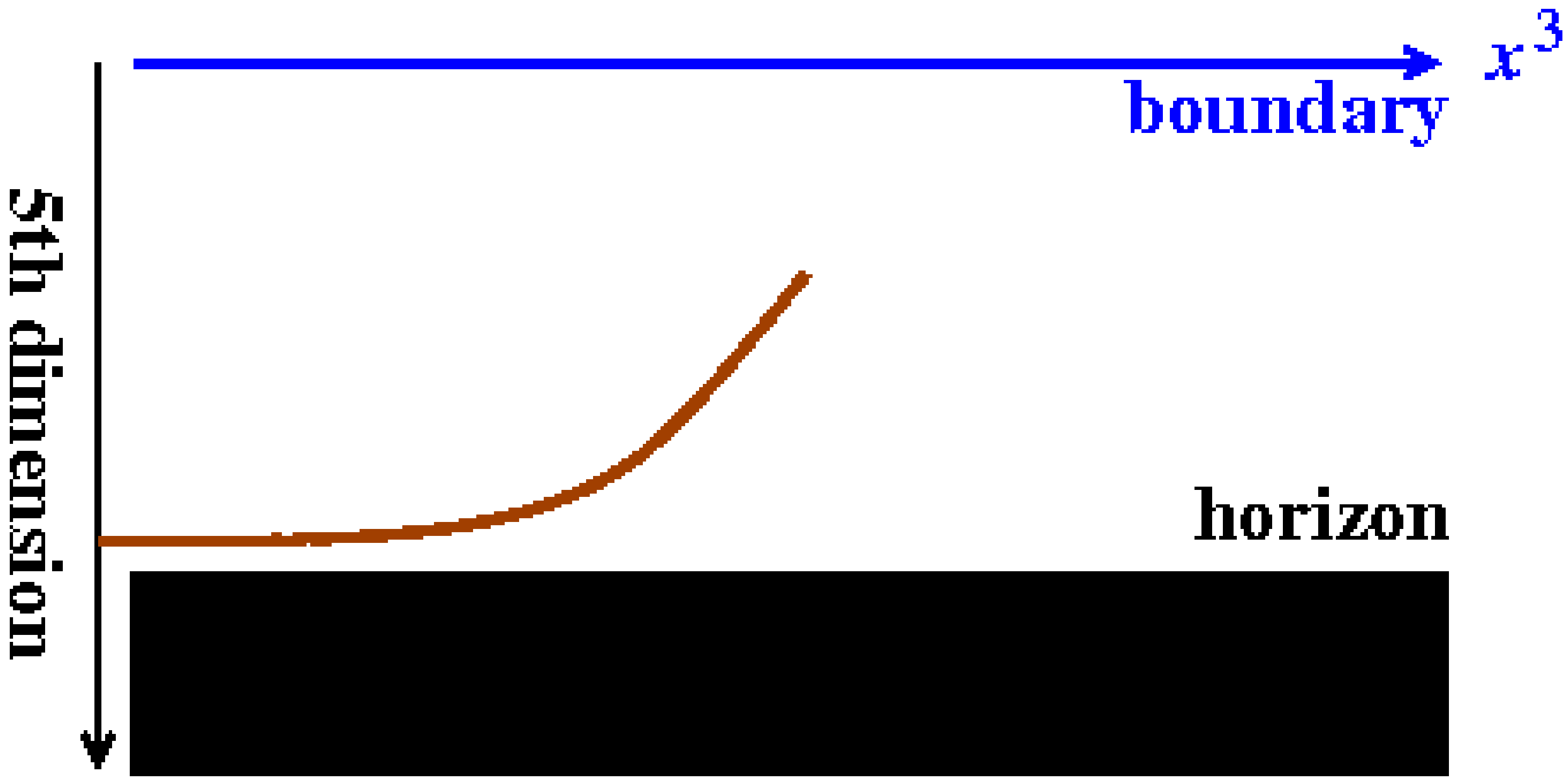

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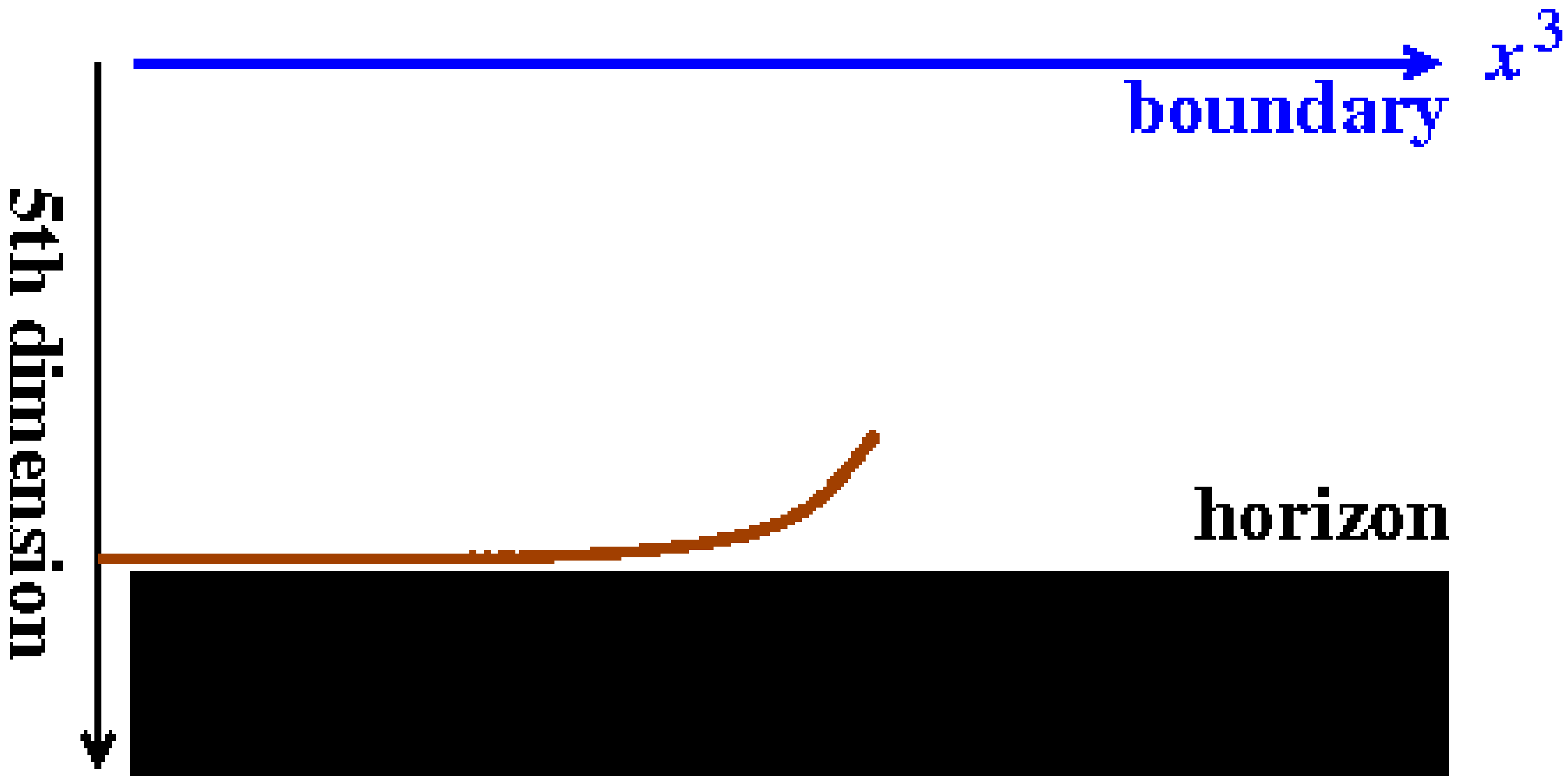

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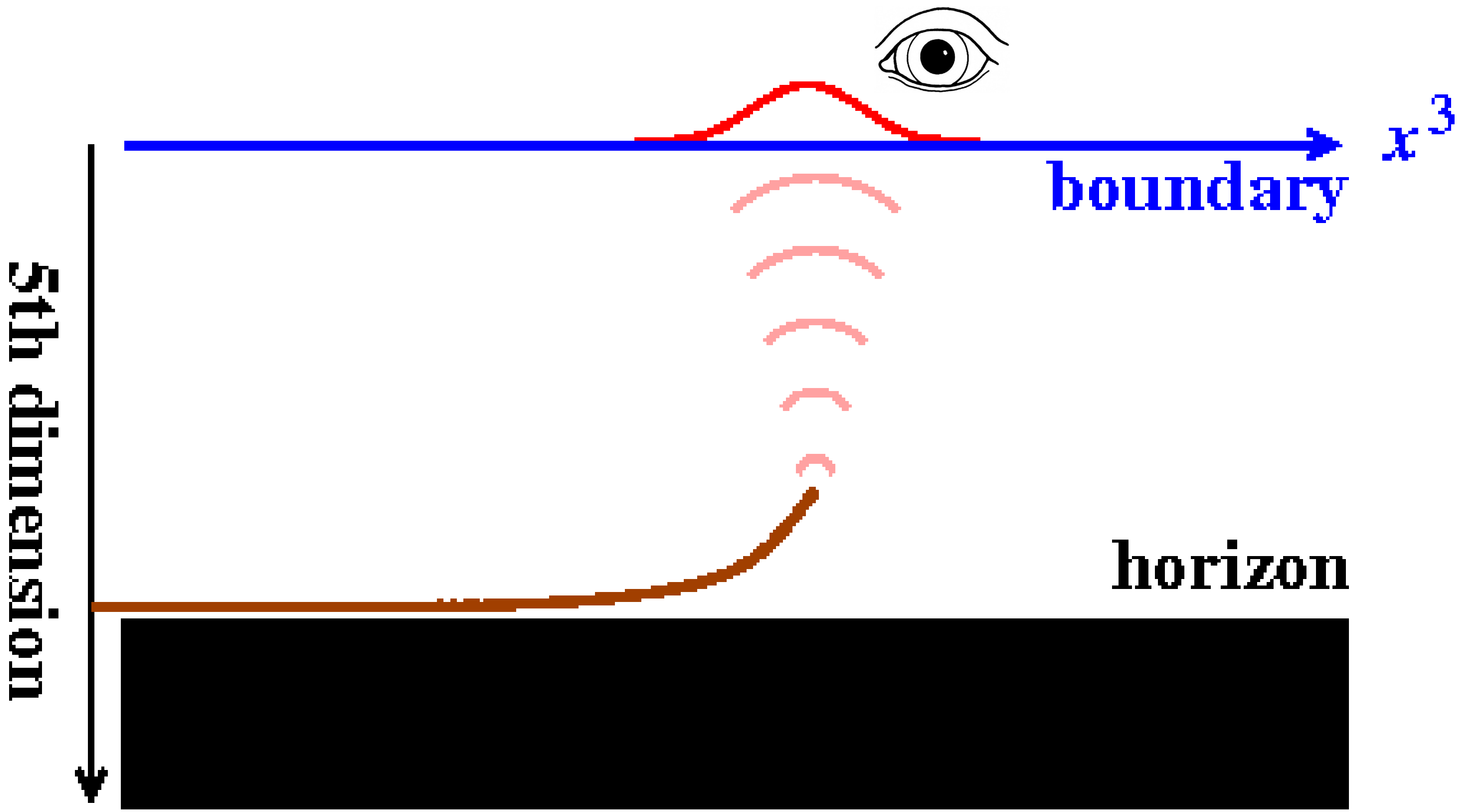
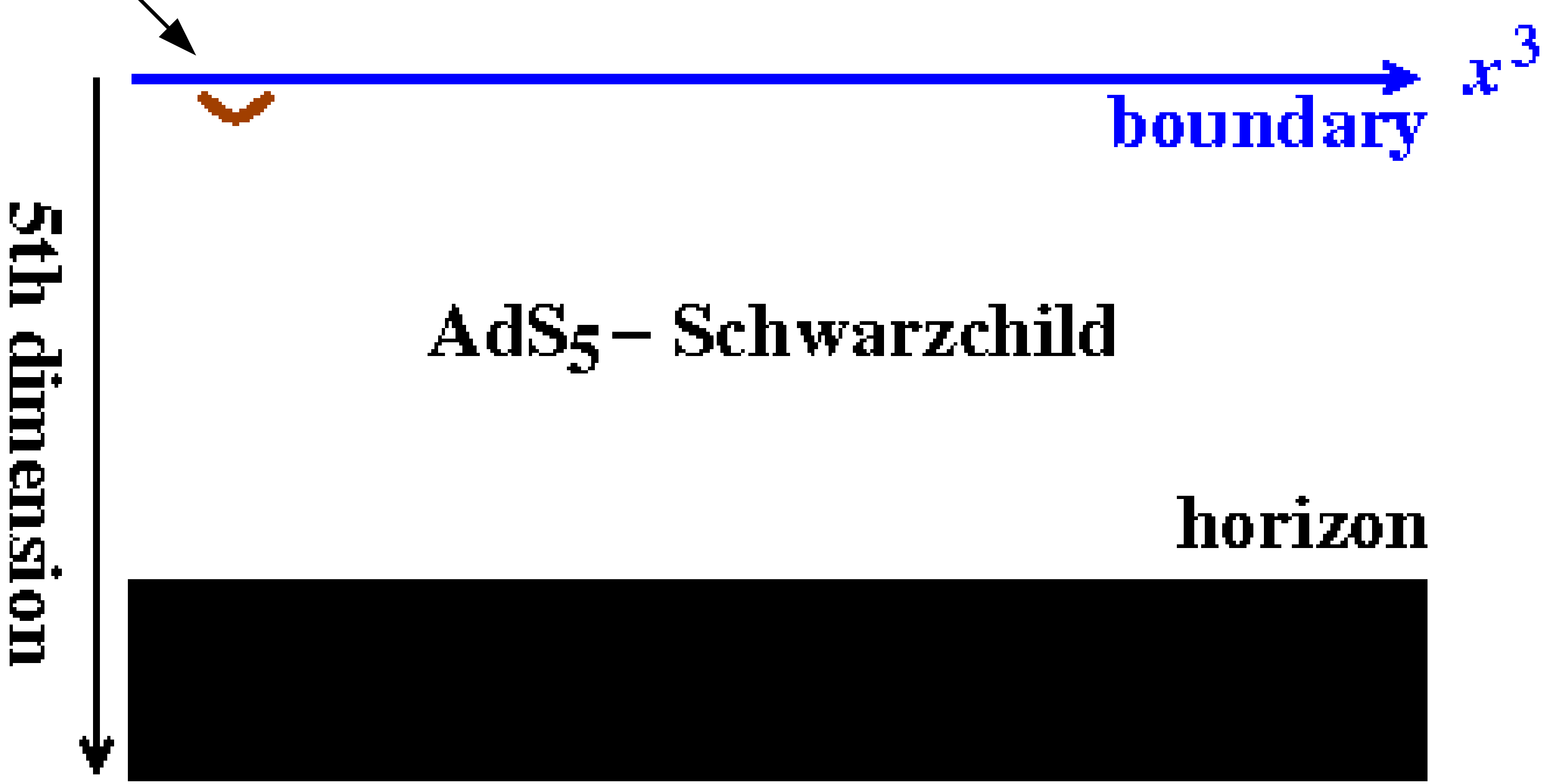


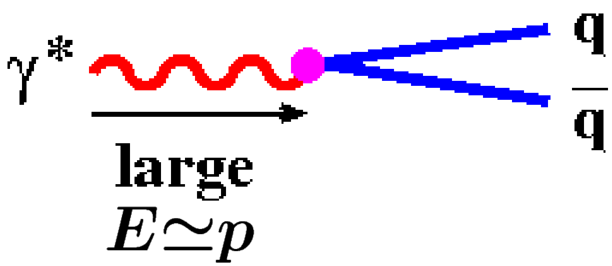
Something slightly dissatisfying: What is the  ?

The initial configuration has been expressed in the gravity dual.
How precisely do I set up the problem in the 3+1 dim. field theory?

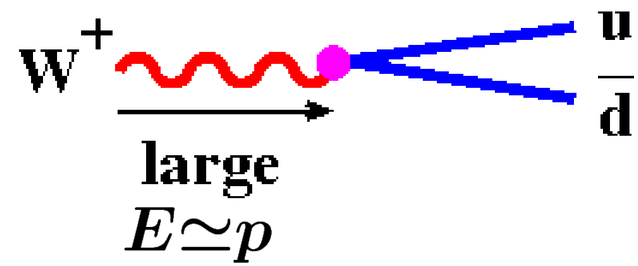


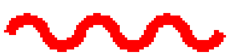
Our Method

In the field theory, think impressionistically of



or



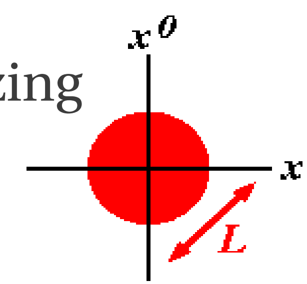
Treat  as a localized external field:

our 

$$\mathcal{L}_{\mathbf{QFT}} \to \mathcal{L}_{\mathbf{QFT}} + \boxed{\mathcal{O}(x)\,\Lambda_L(x)\,e^{i\bar{k}\cdot x}} \qquad \text{with } \bar{k}^\mu = (E, 0, 0, E)$$

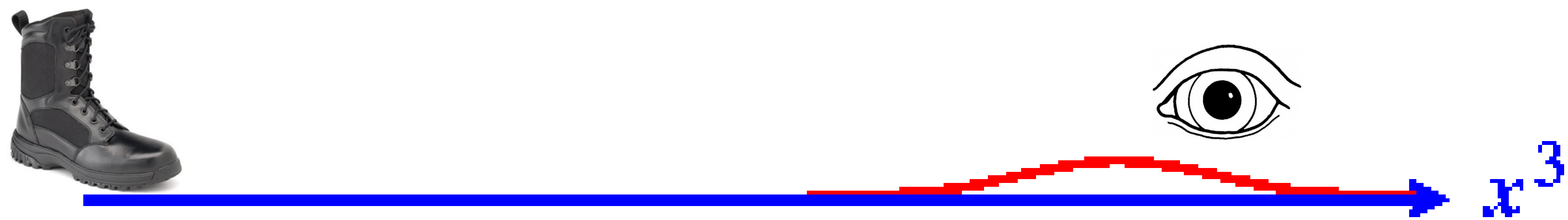
some source operator
e.g. $j_\mu(x)$

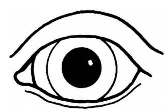
smooth envelope function localizing
source in space and time



Definition for purposes of this talk:

"jet" = localized, high-p excitation moving through the plasma.

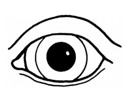
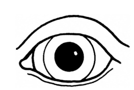


The response  is measured by a **3-point correlator**.

A crude way to understand this:

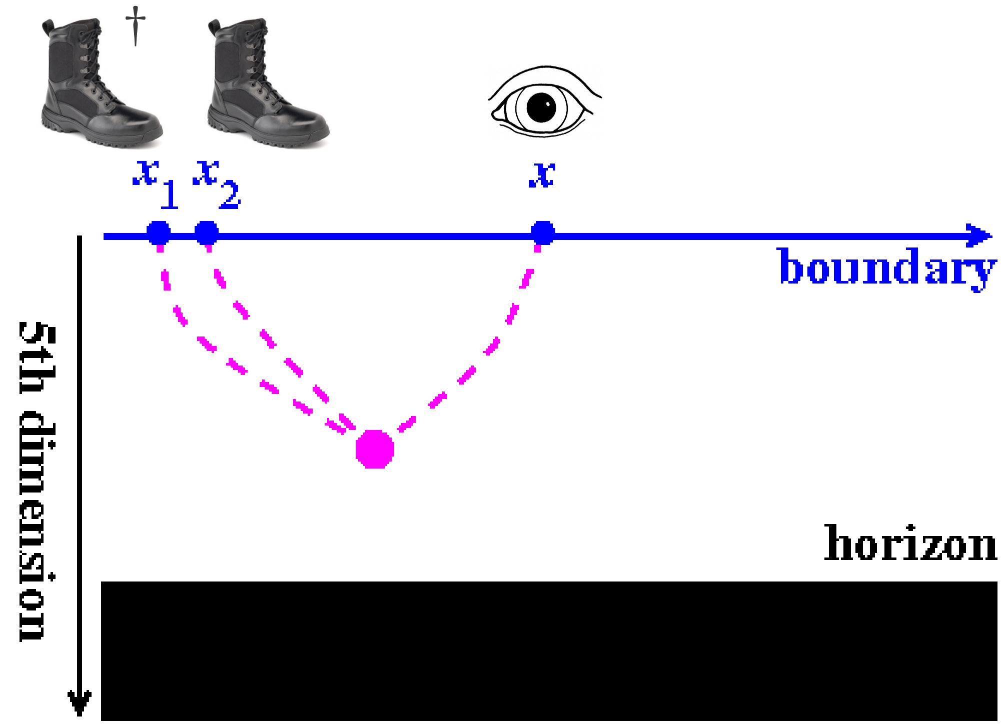
$|\mathbf{jet}\rangle$ =  $|\mathbf{plasma}\rangle$.

So we want

$\langle\mathbf{jet}|$  $|\mathbf{jet}\rangle$ = $\langle$  †   $\rangle$.

For *finite-temperature* AdS/CFT calculations:

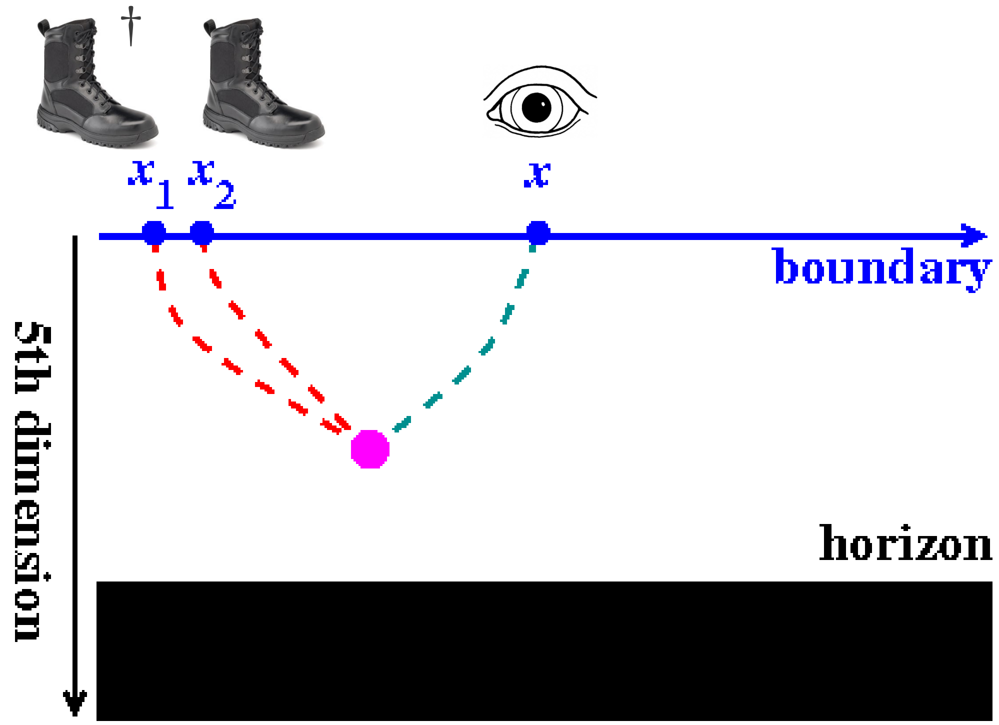
- lots in literature on computing 2-point correlators
- almost nothing on 3-point correlators



● = 5-dim. SUGRA vertex

– – – = a *Heun* function →
hard to make any analytic or numeric progress!

Fortunately, in our problem, ...

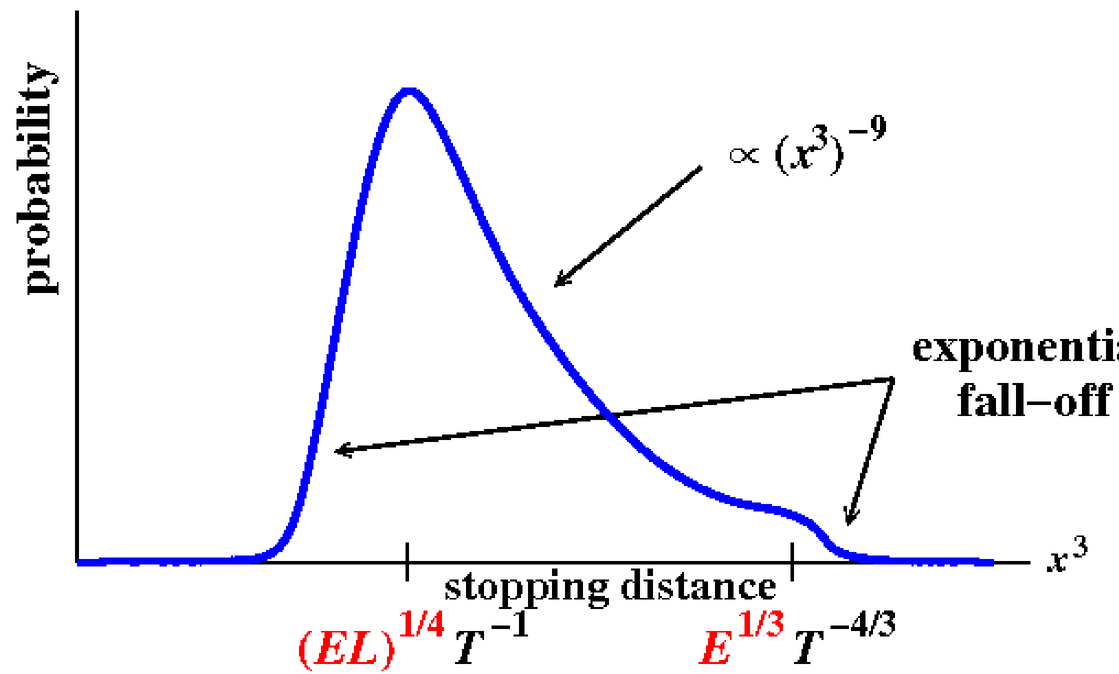


high-energy source →
high-k approximation (WKB / geometric optics)

want to observe late-time diffusion →
low-k approximation

Can do calculation!

Our Result



The farthest a jet will ever go is indeed $\propto E^{1/3}$.

> **But** almost all jets will instead stop sooner at $\propto (EL)^{1/4}$

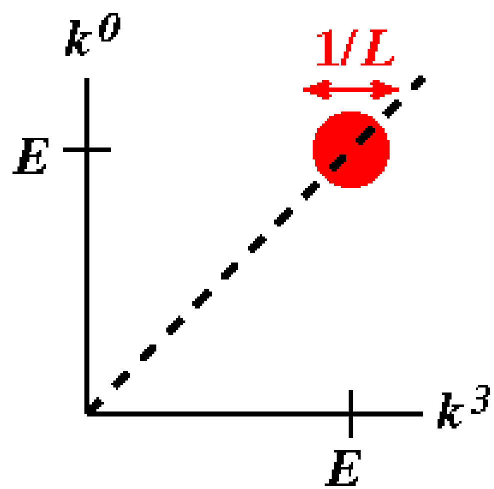
where L is the size of the space-time region in which the jet was initially created.

Q: What does the size L of the source have to do with it?

A: It determines how off-shell the source is.

 $\propto \quad \Lambda_L(x)\, e^{i\bar{k}\cdot x}$ with $\bar{k}^\mu = (E, 0, 0, E)$

implies that  has Fourier components



Typical stopping distance $(EL)^{1/4}$ really means $(E^2/q^2)^{1/4}$ where

q^2 = typical virtuality of the source