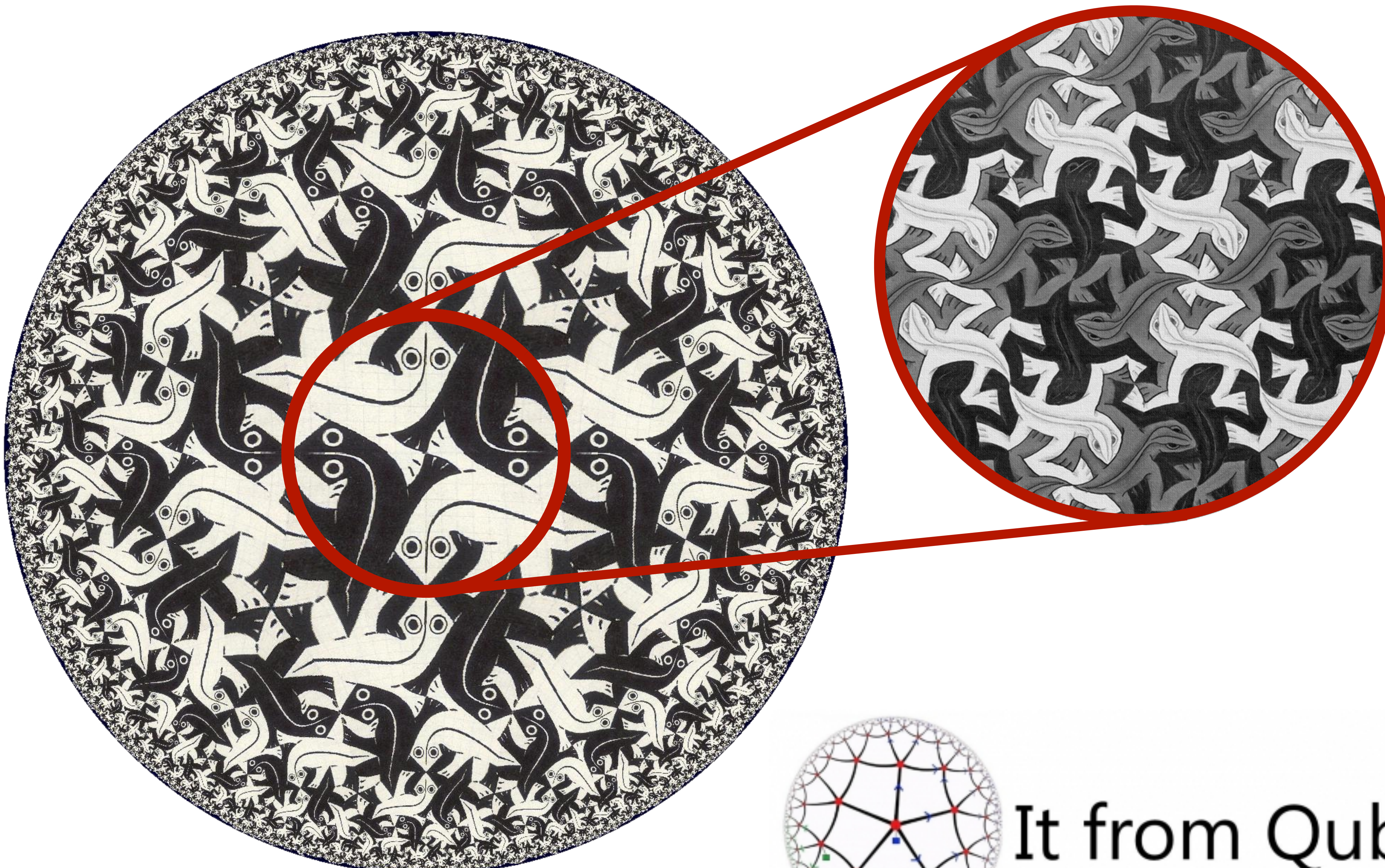
Flat space physics from AdS/CFT

Eliot Hijano

Based on arxiv:1905.02729



UBC

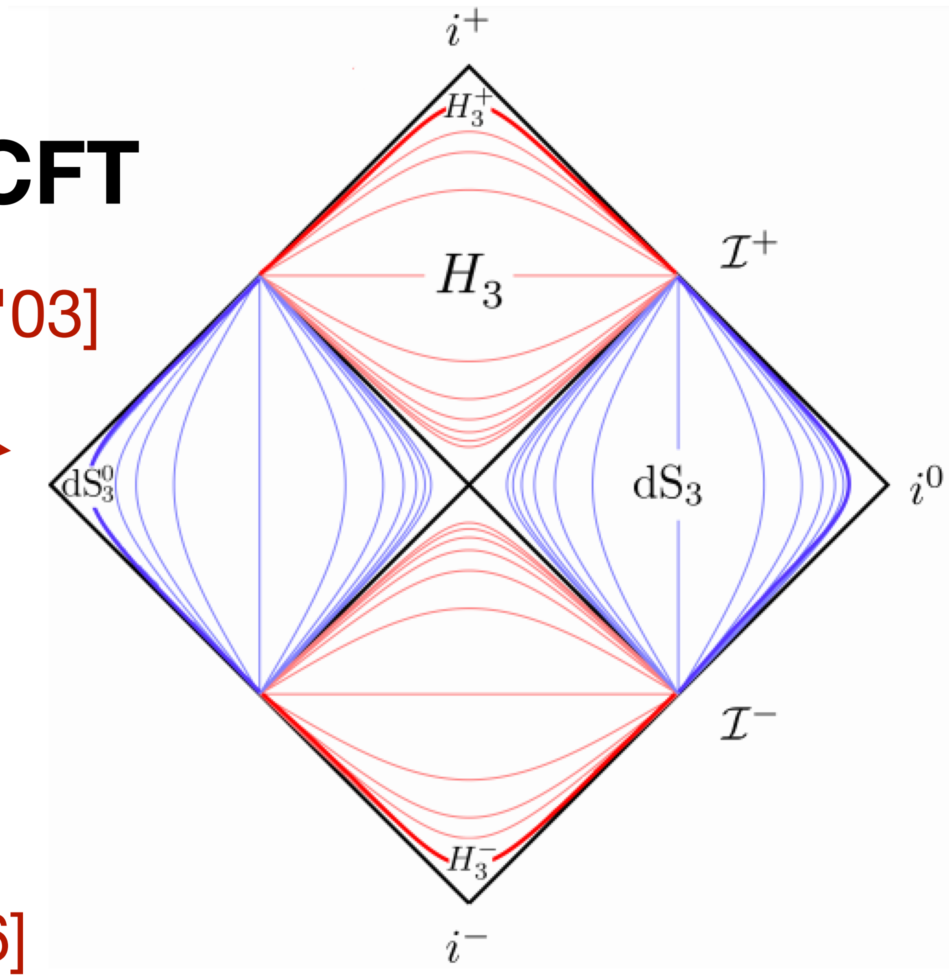
It from Qubit
Simons Collaboration on
Quantum Fields, Gravity and Information

Approaches to flat holography

Uplifting A(dS)/CFT

[de Boer, Solodukhin '03]

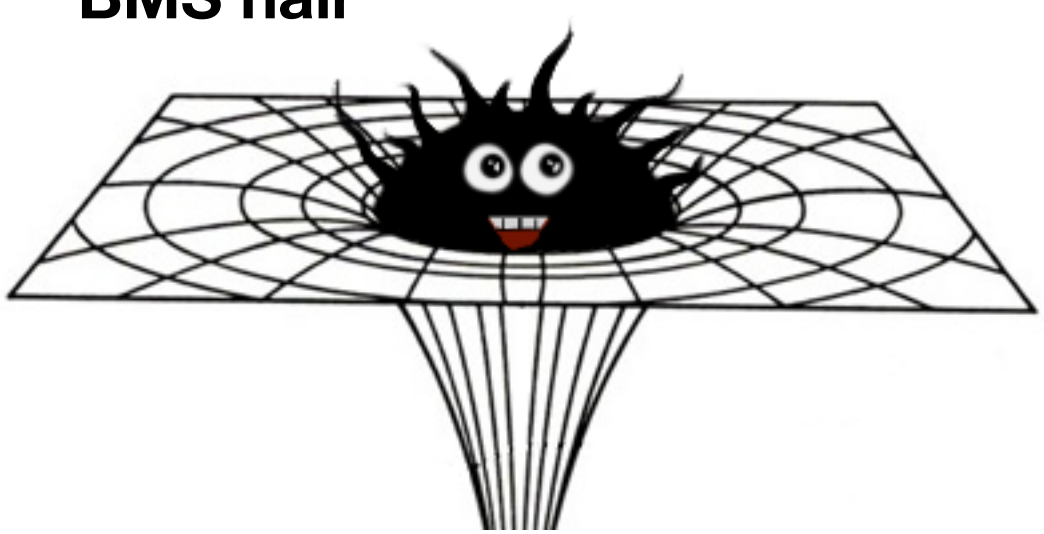
[Ball et al '19]



Direct approach

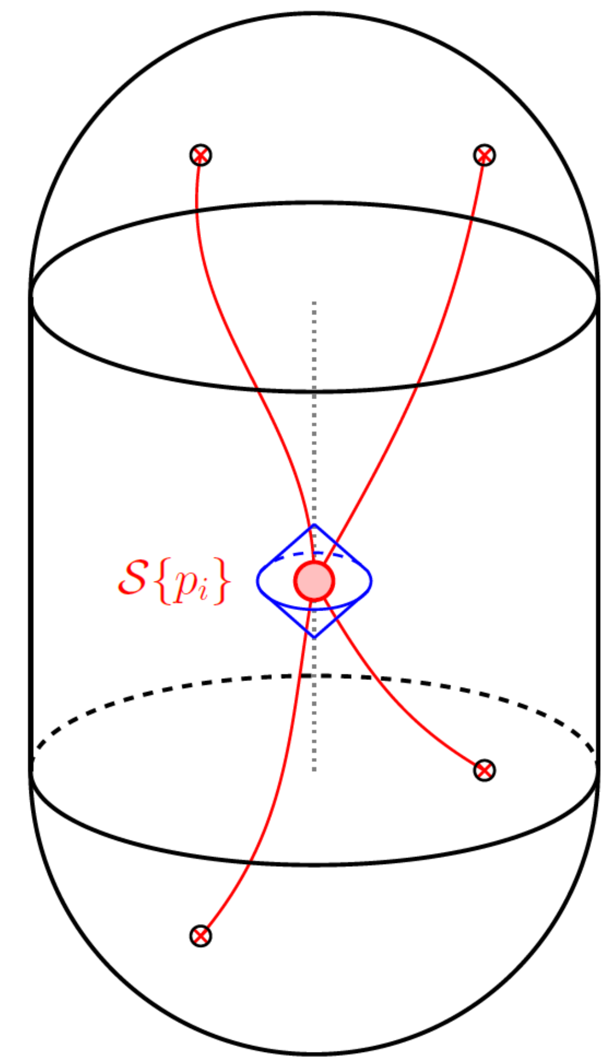
[Hawking, Perry, Strominger '16]

BMS hair

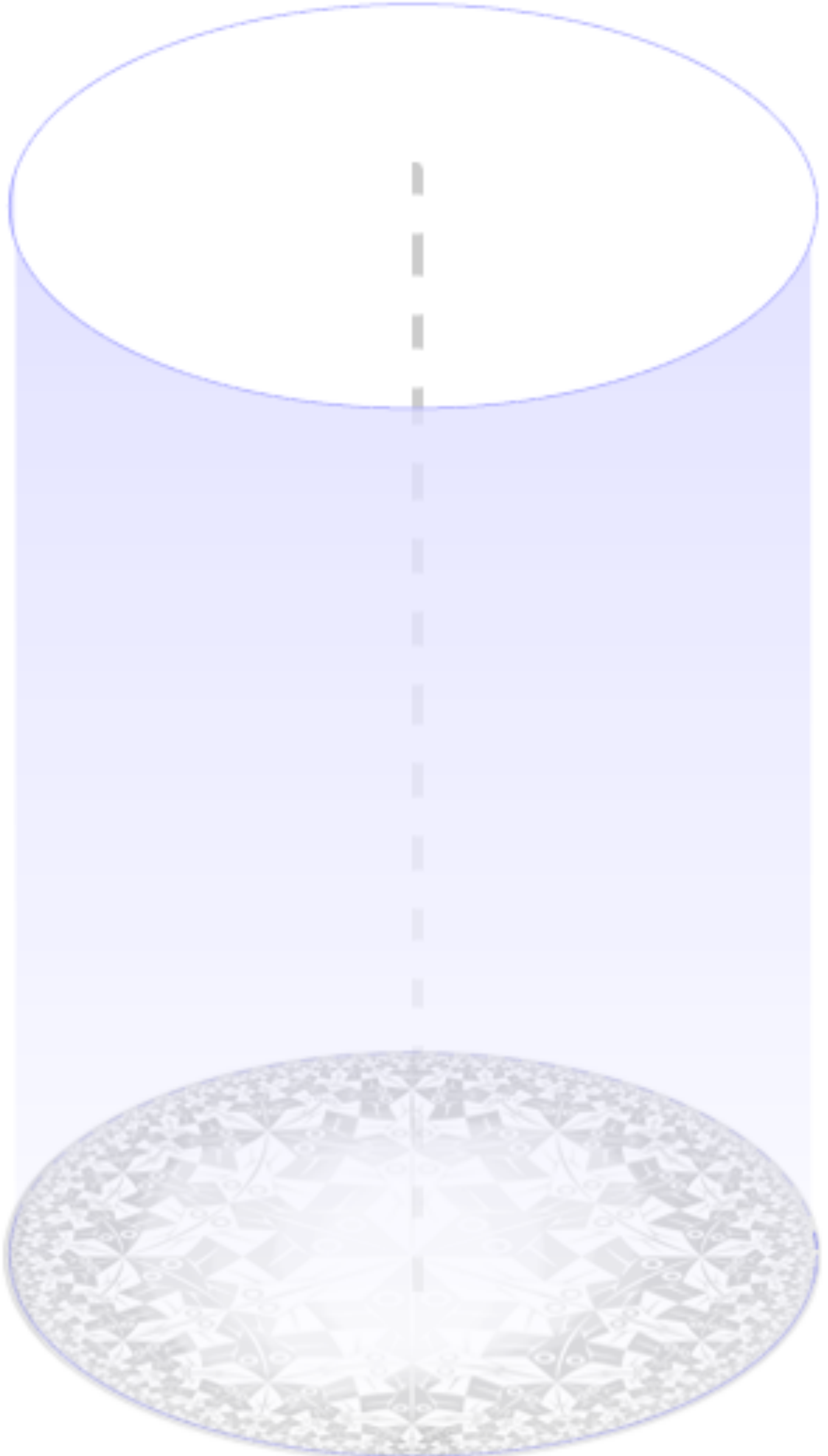


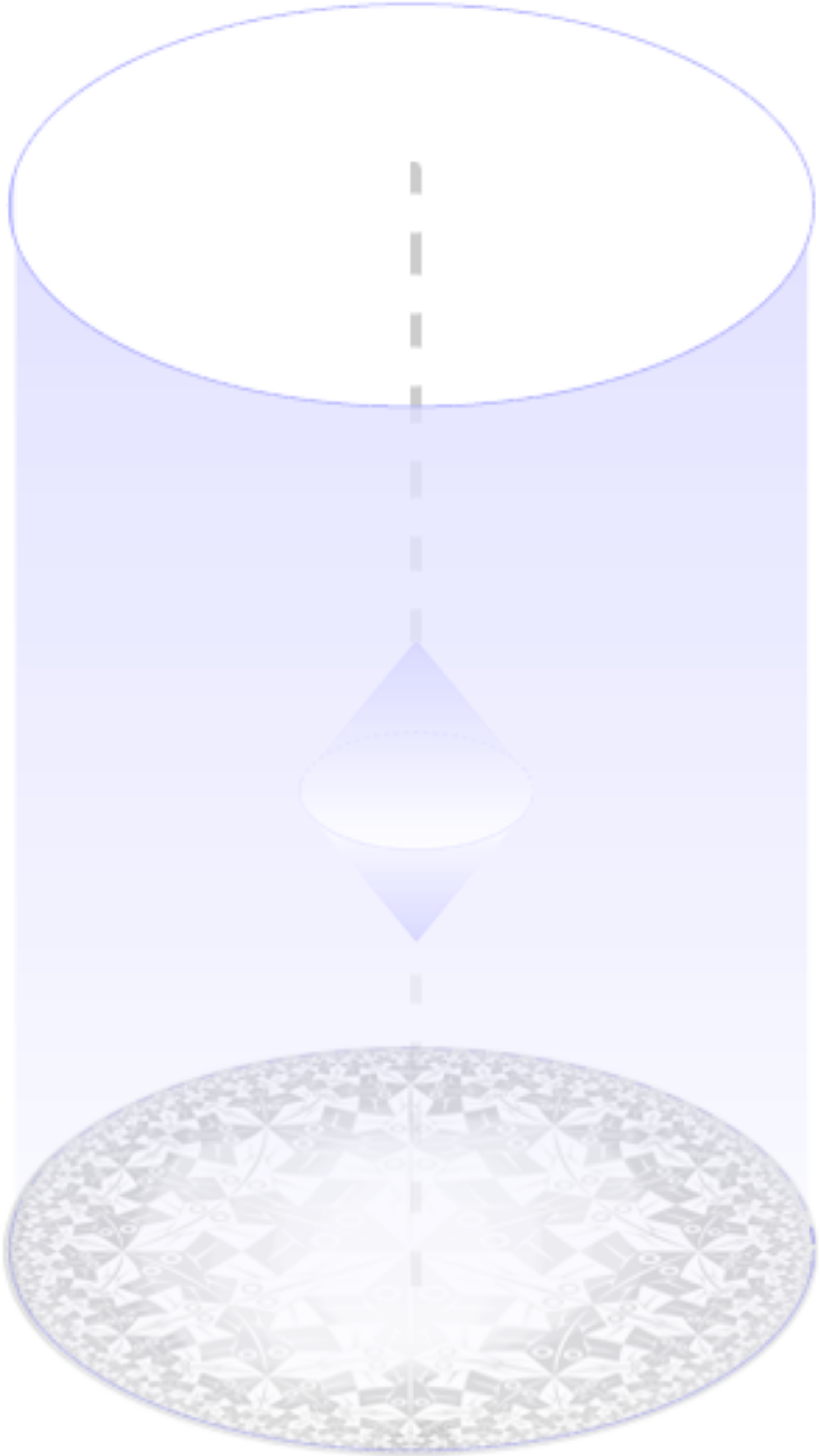
Indirect approach

[Penedones '10]
[Fitzpatrick, Kaplan '11]
[Paulos et al '17]
[EH, '19]



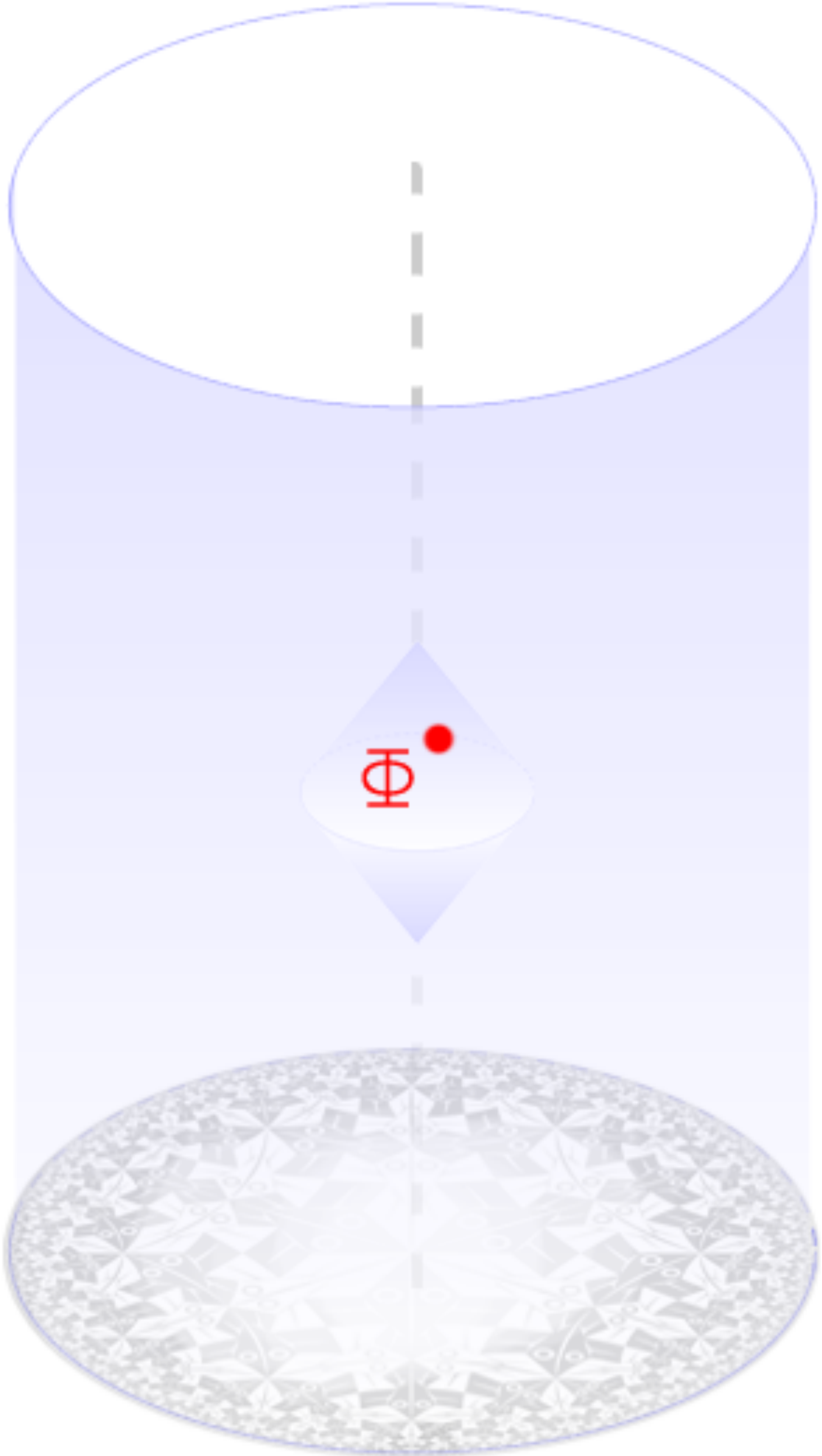
Start with Global AdS





Start with Global AdS

Define a scattering region at the center



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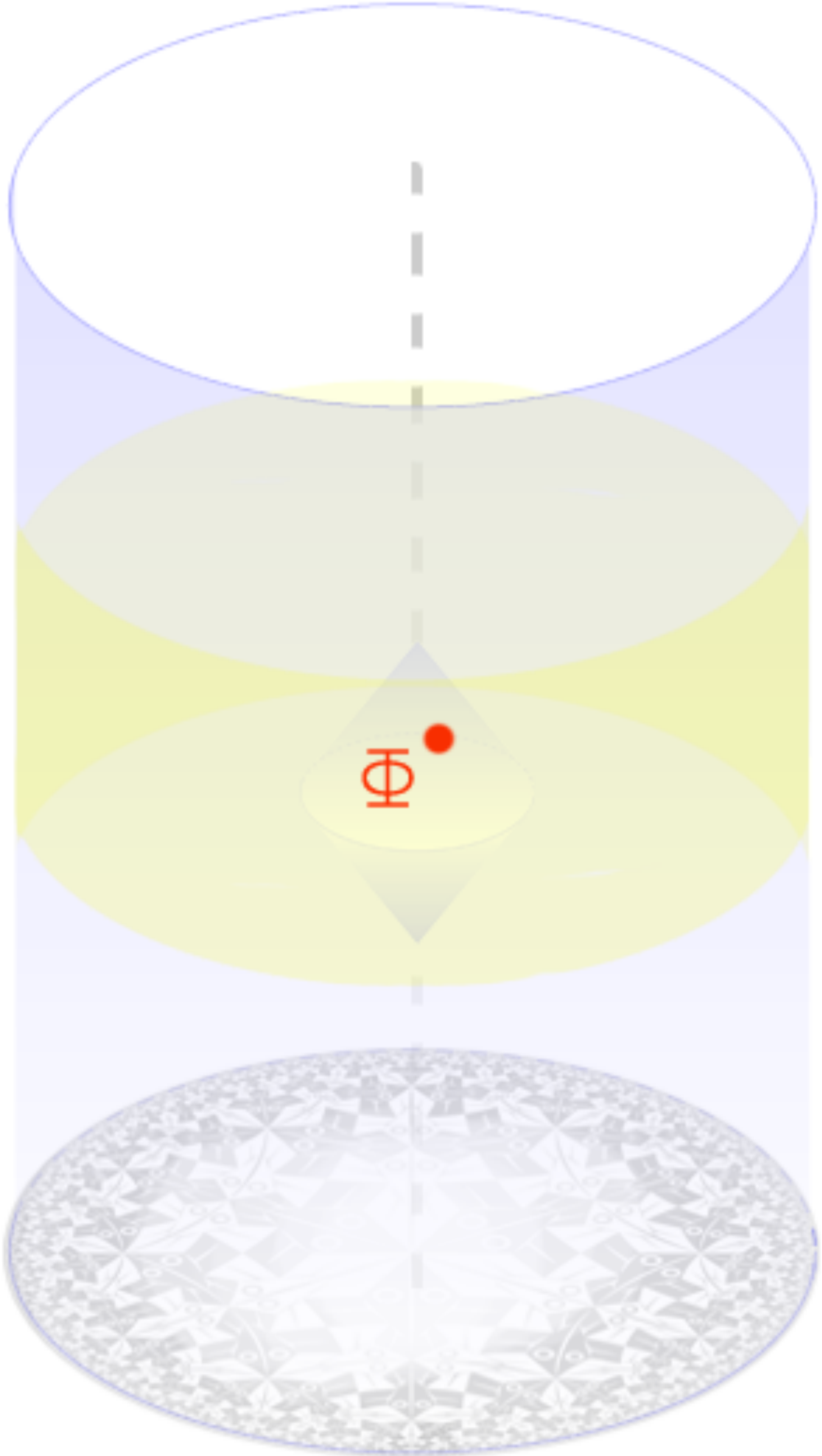
Define a scattering region at the center

Consider a local bulk operator in the scattering region



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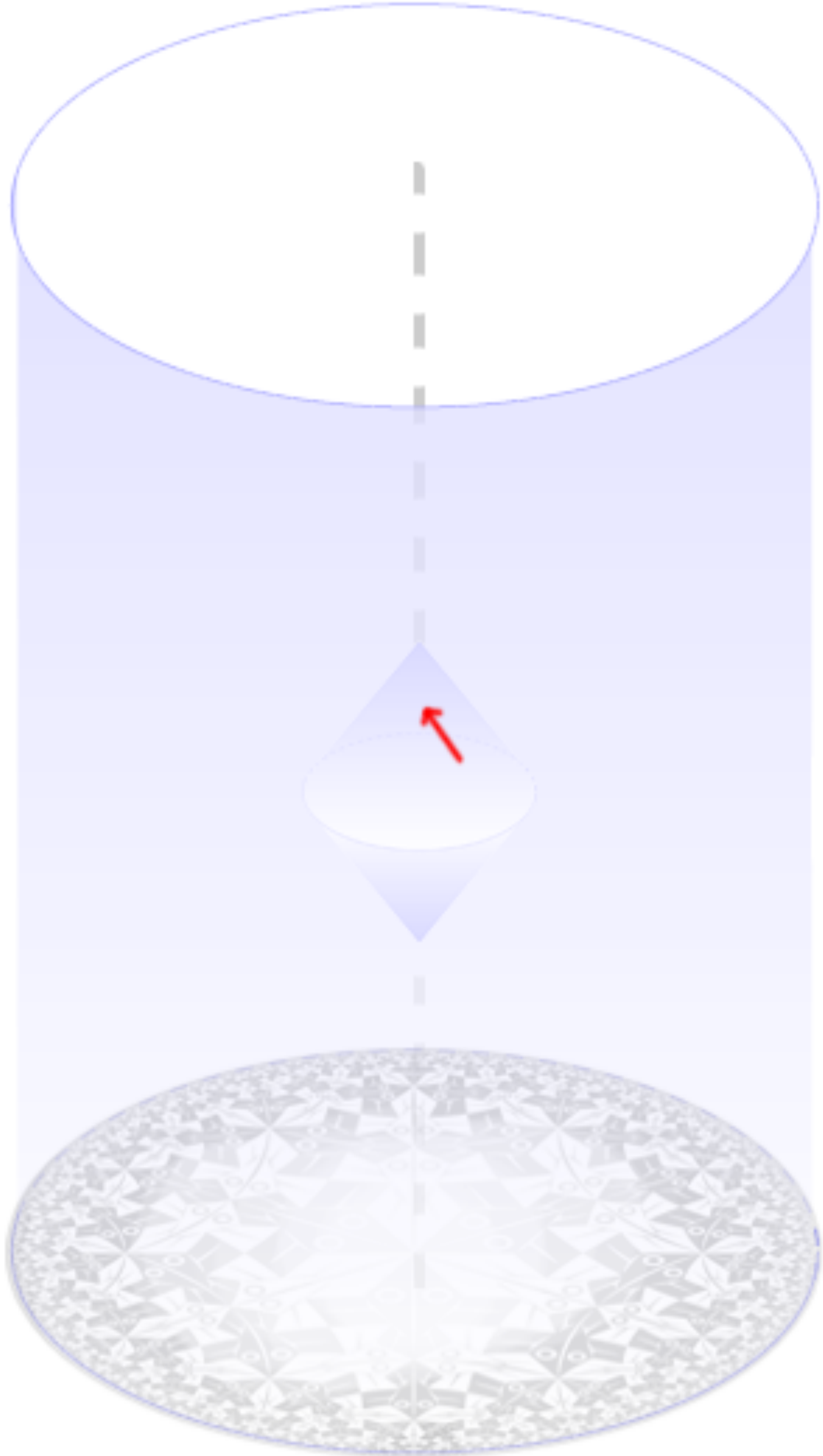
Define a scattering region at the center

Consider a local bulk operator in the scattering region

Reconstruct the operator at the conformal boundary (HKLL)

$$\Phi(X) = \int_{\partial \mathrm{AdS}_{d+1}} d^d x \, K_{\mathrm{HKLL}}(X, x) \mathcal{O}(x) \,.$$



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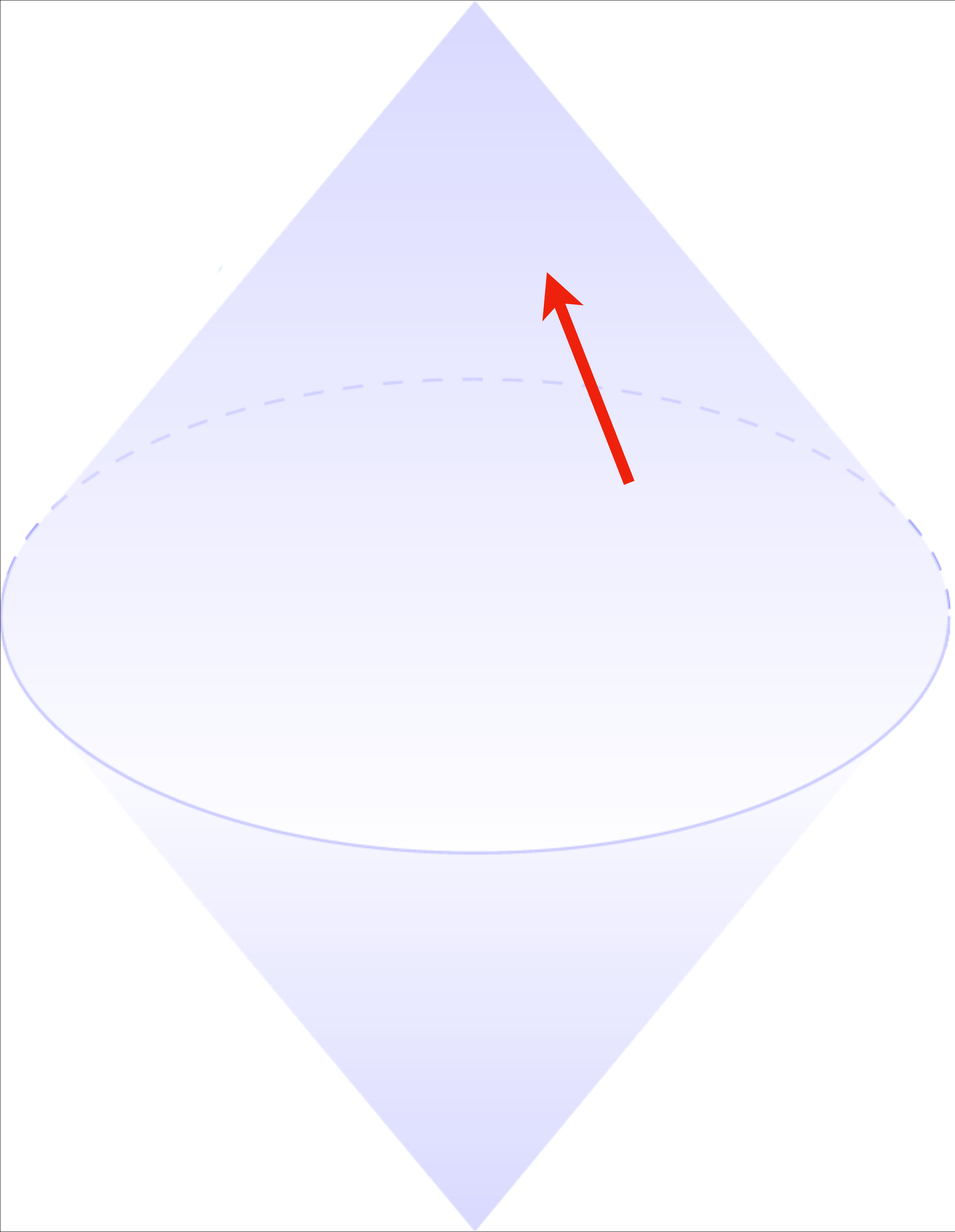
$$\Phi(p) = \int d^D X \, \Phi(X) e^{ip\cdot X}$$



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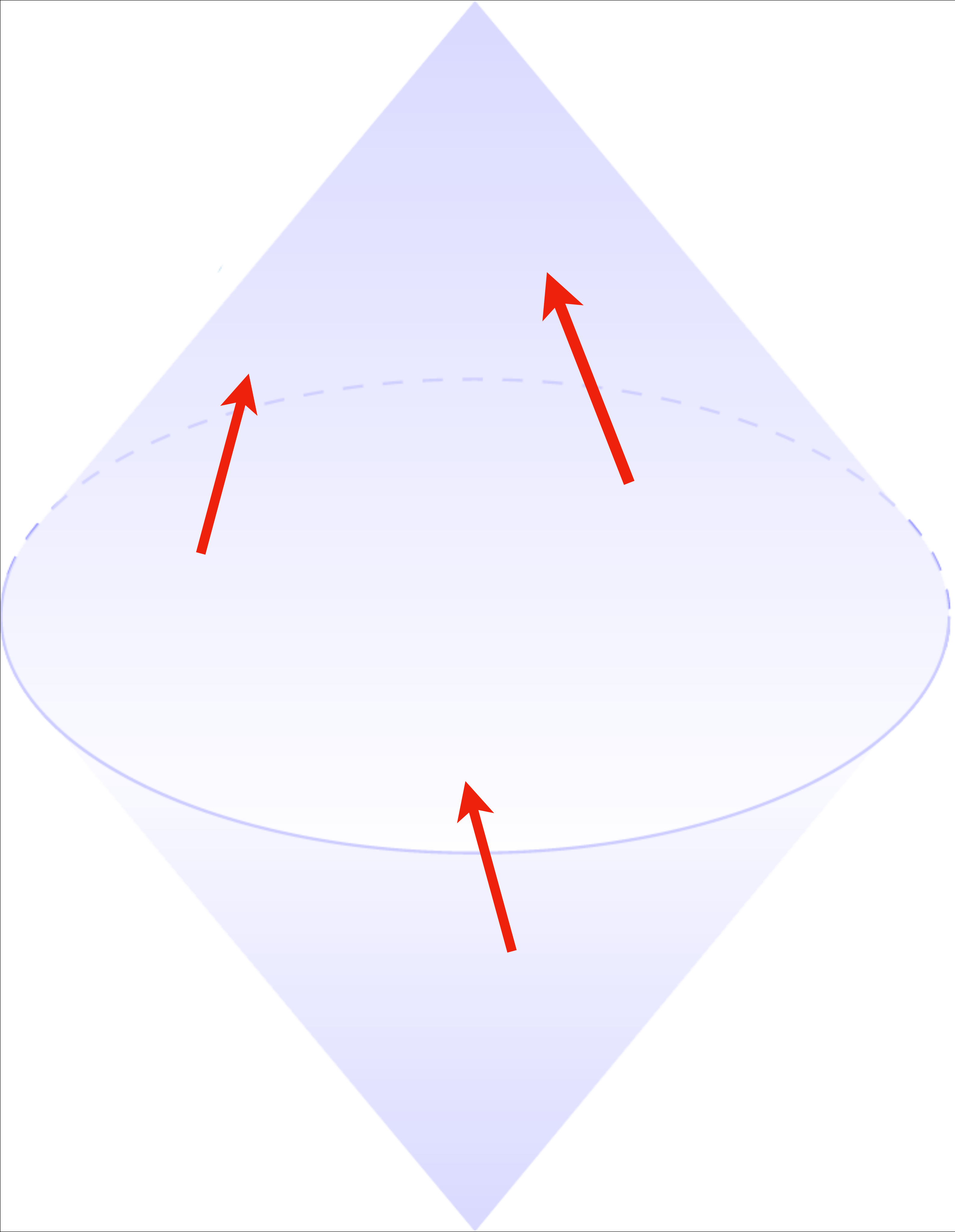
Large AdS radius limit zooms into the scattering region



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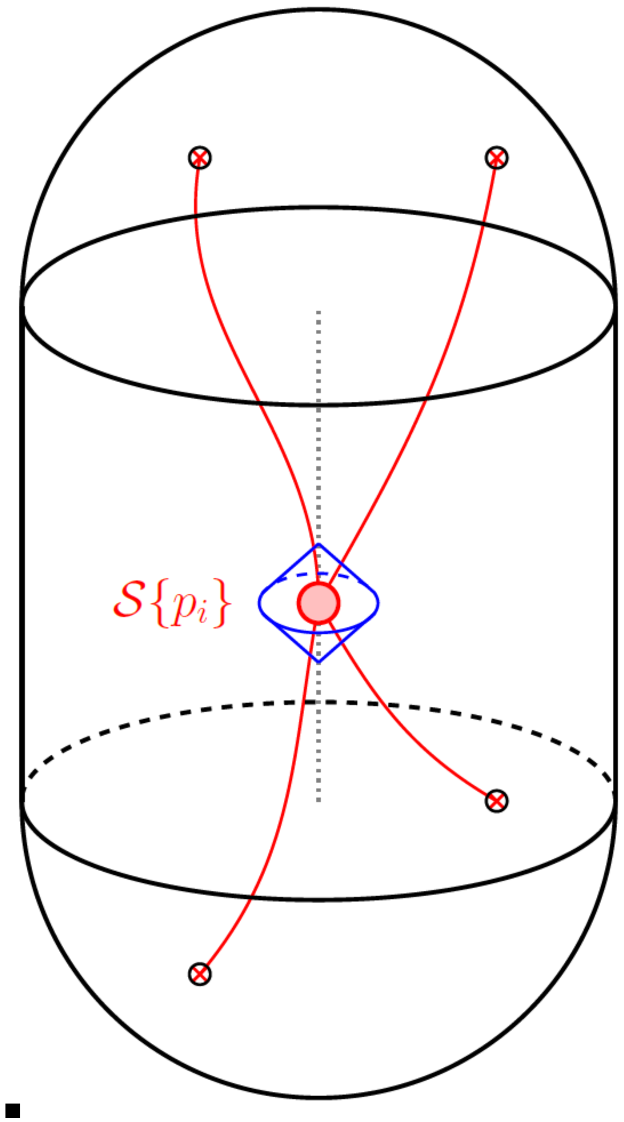
Large AdS radius limit zooms into the scattering region

Several insertions = Scattering amplitudes involving multiple particles

Scattering amplitude:

$$\mathcal{S}\{p_i\} = \lim_{l\to\infty} l^{\frac{d-3}{2}} \left[\prod_i C(p_i) \int dt_i\, e^{\pm i\omega_i t_i}\right] \langle 0|\mathcal{O}\left(\tau_1,\Omega_1\right)\cdots|0\rangle$$

$$\tau_i = \pm\frac{\pi}{2} \pm i\cosh^{-1}\frac{\omega_i}{k_i} + \frac{t_i}{l}, \quad \text{and} \quad \Omega_i - \chi_i = \frac{\pi}{2} \mp \frac{\pi}{2}\,.$$



Reduces to existing formulae in the literature when all particles are either simultaneously massive or massless.

Some easy examples in AdS$_{d+1}$:

$$\mathcal{S}\{p_1,p_2\} \sim \delta^{(d)}(p_1+p_2)\,,$$

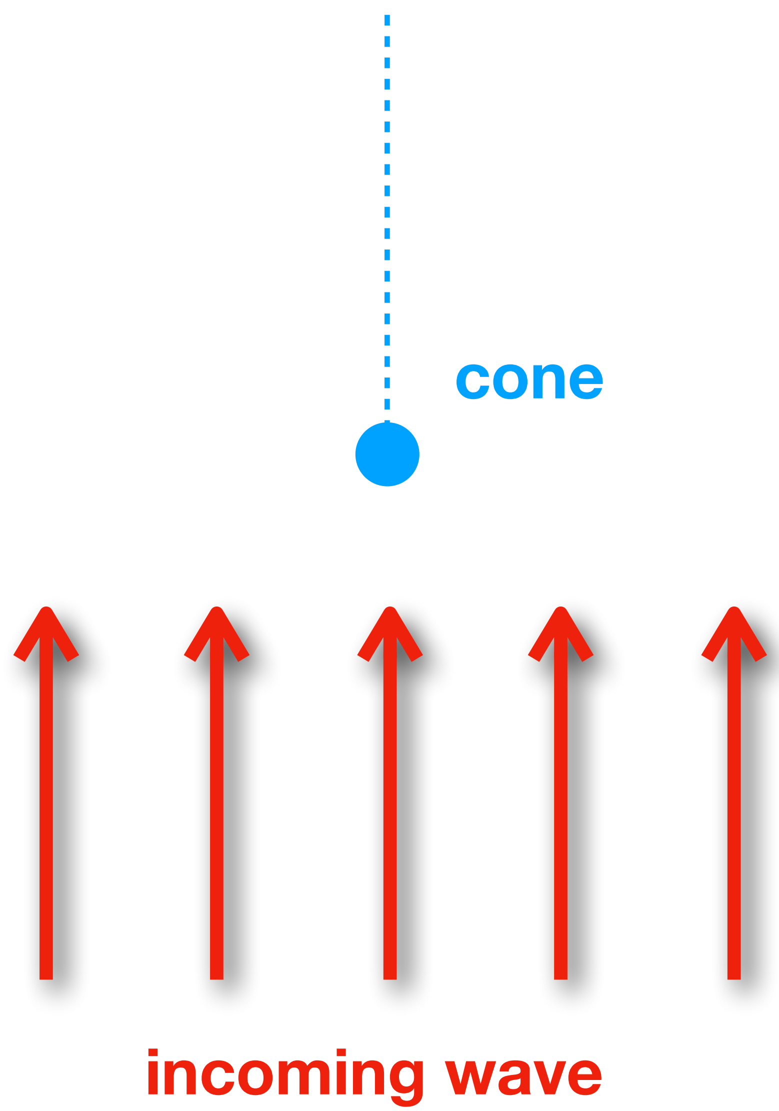
$$\mathcal{S}\{p_1,p_2,p_3\} \sim \delta^{(d)}(p_1+p_2+p_3)\,.$$

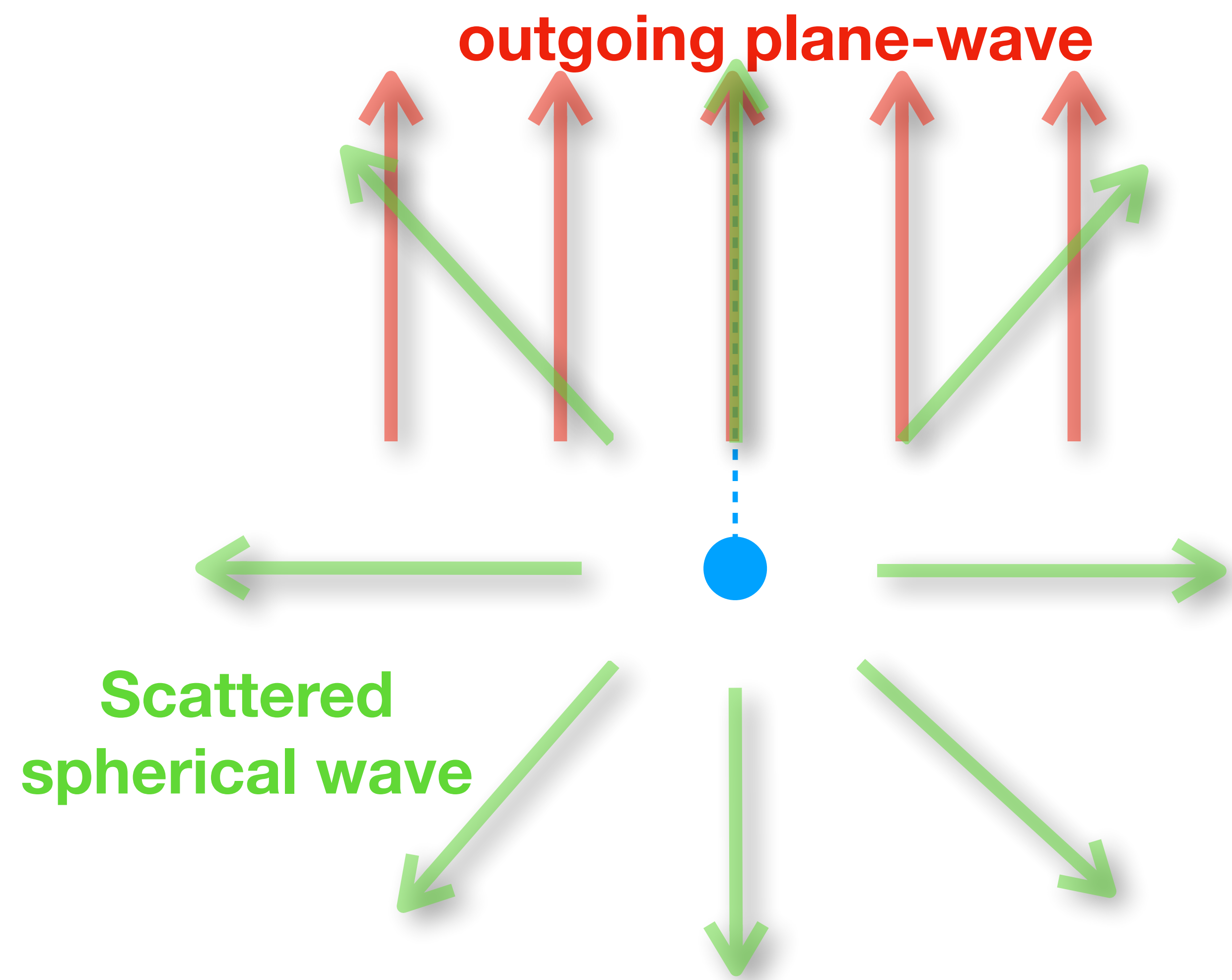
BMS$_3$ global block from CFT$_2$ global block:

$$\mathcal{S}\{p_1,p_2,p_3,p_4\}_{p'^2=-m'^2} \sim \delta^{(3)}(p_1+p_2+p_3+p_4)\delta\left(s+m'^2\right)\,.$$

Scattering against a cone (D=2+1)

[Deser and Jackiw '88, 't Hooft '88, Moreira '95]





$$\mathcal{S}\{p,p'\} = \delta^{(3)}(p+p') + \delta(\omega+\omega')\frac{\sin\frac{\pi}{\alpha}}{\cos\frac{\pi}{\alpha} - \cos(\phi-\phi')}$$

Same result from the flat limit of a CFT$_2$ correlator

CFT deficit state

$$|\alpha\rangle_{\mathrm{CFT}_2} = \mathcal{O}_{\Delta=\frac{c}{12}(1-\alpha^2)}|0\rangle_{\mathrm{CFT}_2}$$

Dual to a conical deficit AdS$_3$ geometry

$$ds^2 = \frac{l^2}{\cos^2\rho}\left(d\rho^2 - \alpha^2 d\tau^2 + \alpha^2\sin^2\rho^2 d\phi^2\right)$$

$$\mathcal{S}\{p_1, p_2\} = \lim_{l\to\infty} l^{\frac{d-3}{2}}\left[\prod_{i=1}^{2} C(p_i)\int dt_i\, e^{-i\omega_i t_i}\right]\langle\alpha\,|\mathcal{O}\left(\tau_1,\chi_1\right)\mathcal{O}\left(\tau_2,\chi_2\right)|\,\alpha\rangle$$

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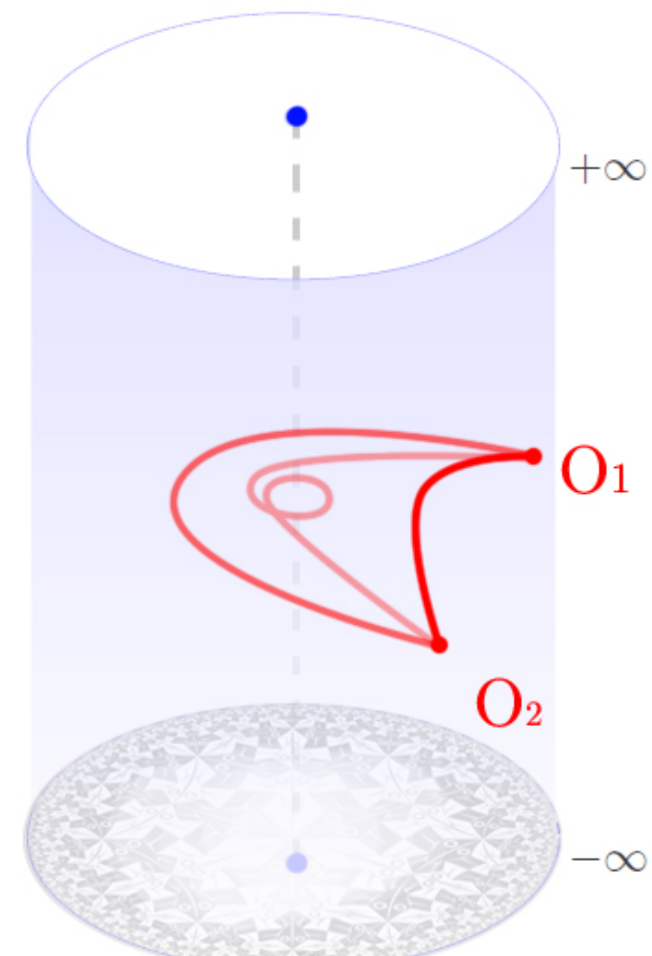

Non-trivial CFT$_2$ correlators turn into non-trivial scattering events in asymptotically flat geometries.

Current/Future Work

- Soft theorems. How do they arise from flat limits of conformal Ward identities? How do soft theorems look like in 2+1 dimensions?

- Exploration of scattering events in 4D black hole backgrounds. What features of conformal correlators imply unitarity of black hole evolution?
  't Hooft S-matrix ansatz: $S=S_{in}S_{hor}S_{out}$

- Implementation of CFT bootstrap programme. [Paulos et al '17]

- AdS/CFT: Are the divergences of the correlators that turn into S-matrices a further diagnostic of bulk locality?

ありがとうございます!