

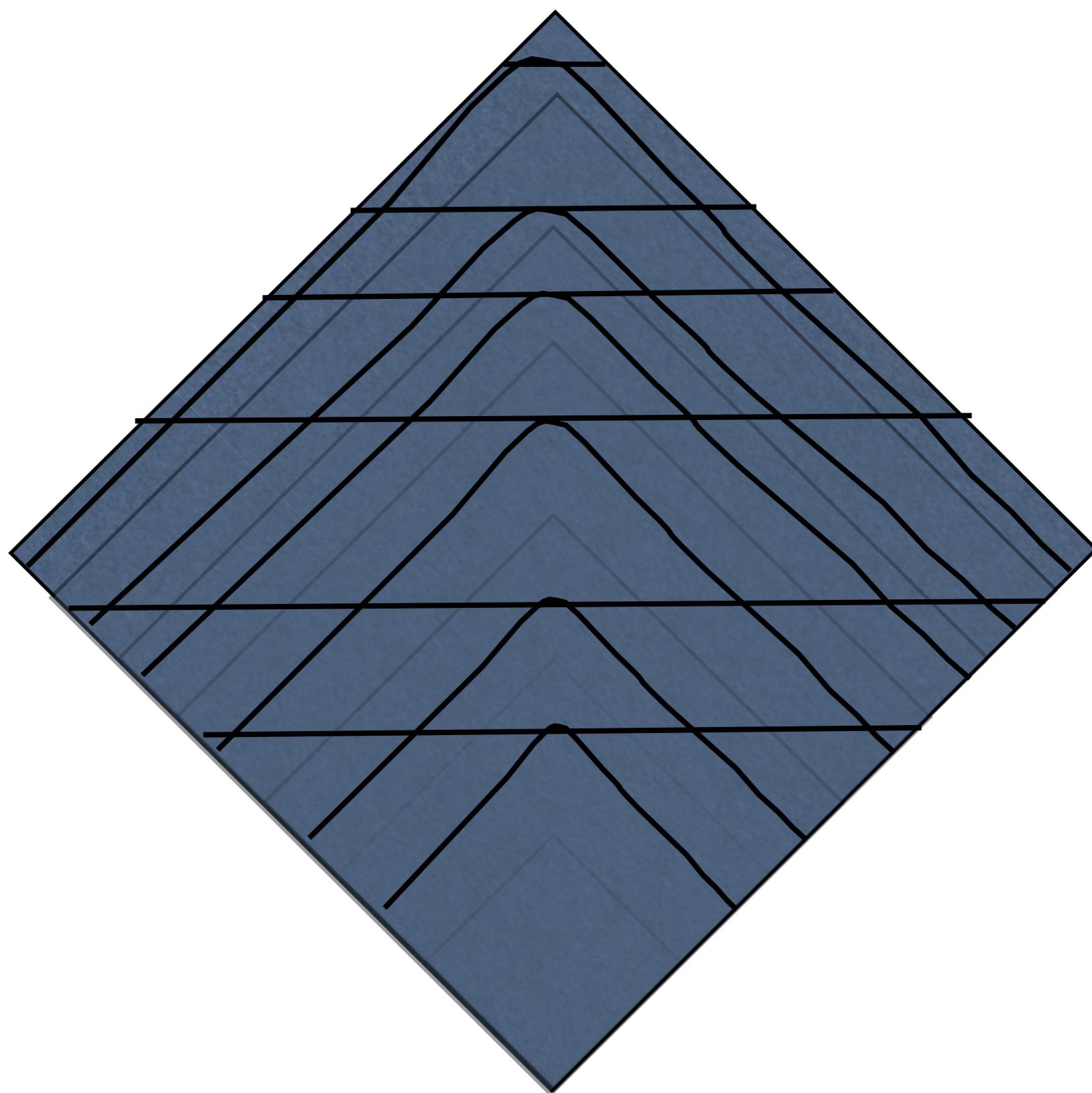
Why the c.c. is not an energy density.

- KITP Santa Barbara Vacuum Energy and Fine Tuning Workshop
- July 30, 2019
- Tom Banks - Rutgers NHETC

What is the Cosmological Constant?

Causal Diamonds in Lorentzian Space-time Have Two
Geometric Invariants:

- 1) Maximal proper time between past and future tips
- 2) Maximal area in null foliation of the boundary =
holoscreen area



Horizontals are FRW Slices
Curved Surfaces HST Slices

Covariant Entropy Principle

- Area of holoscreen = $4 \ln \dim(\mathcal{H}_{\text{DIAMOND}})$
- Jacobson (1995) $dE = T dS$ for infinite temp
Unruh trajectory near a point implies (Fischler-Susskind/Bousso 3+ years later).
- $k^m k^n (R_{mn} - g_{mn} R/2 - \kappa T_{mn})$ all null k
- i.e. C.C. does NOT contribute to hydrodynamic energy density

Instead

- TB and Fischler: c.c. determines relation between large proper time and large area limits of diamond (asymptotically symmetric spaces).
- Negative c.c. : Area goes to infinity at finite proper time. Conformal boundary is time-like. High energy spectrum controlled by C.C. : CFT scaling from AdS black hole entropy.
- Positive C.C. : time goes to infinity at finite area

- Maximal mass black hole determined by C.C.
- Vanishing C.C. $A \sim t^{d-2}$
- Implies C.C. related to High Energy Spectrum
- Cannot be Calculated in Low Energy QUEFT
- but is an input parameter characterizing large time/area asymptotics.

AdS/CFT

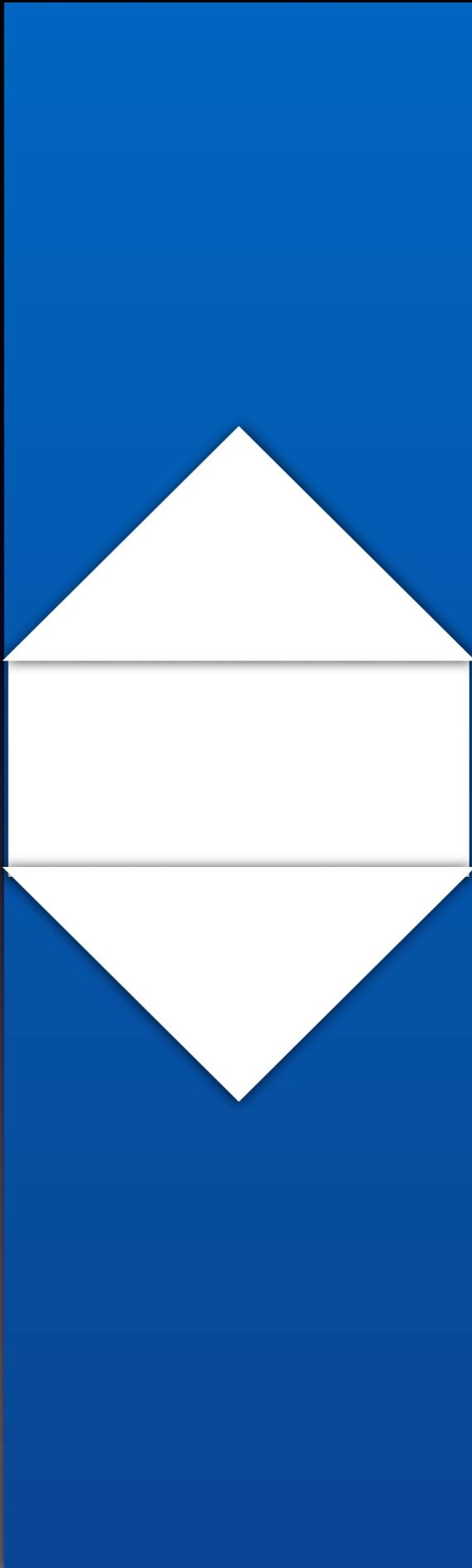
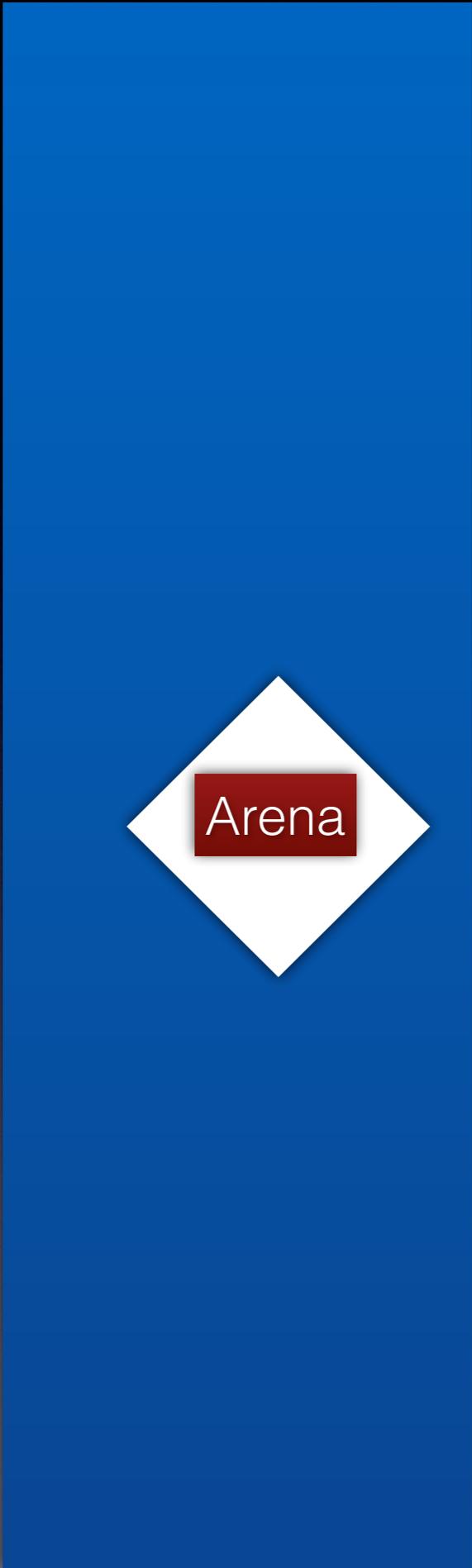
- Discrete values of c.c., related to high dimension spectrum/definition of the model
- Connected at most by RG flows and then only on the plane, which represents branes in flat space rather than global AdS
- No tunneling between different models
- Top 10^{500} reasons not to believe in calculability of c.c. in QUEFT

How Does QFT Emerge from QG?

- Empty dS space is maximal entropy state
- Localized objects are constrained states
- $ds^2 = -f dt^2 + dr^2/f + r^2 d\Omega^2$
- $f = - (r - R_+) (r - R_-) (r + R_+ + R_-)/r$
- Entropy deficit for $R_- \ll R_+ : M/T$

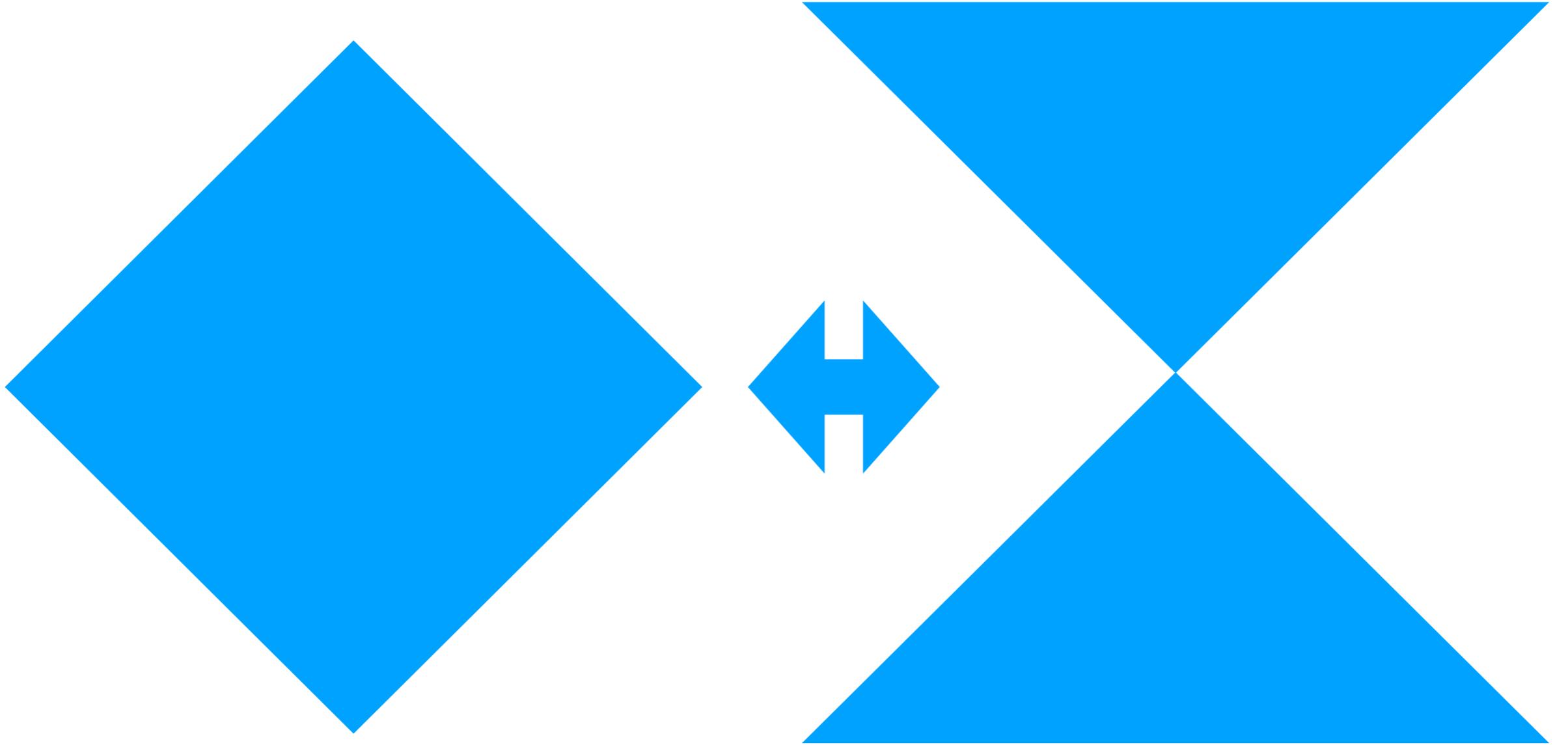
The Negative View

- Large radius AdS: (Polchinski - Susskind) : Arena = causal diamond \ll AdS radius
- Most boundary states leave arena empty. CEP implies Arena Hilbert space finite dimensional. Typical entanglement with the rest of CFT (Page) makes density matrix maximally uncertain. Agrees with dS picture: Minkowski vacuum is highly degenerate zero energy state.
- Soft gravitons!!!

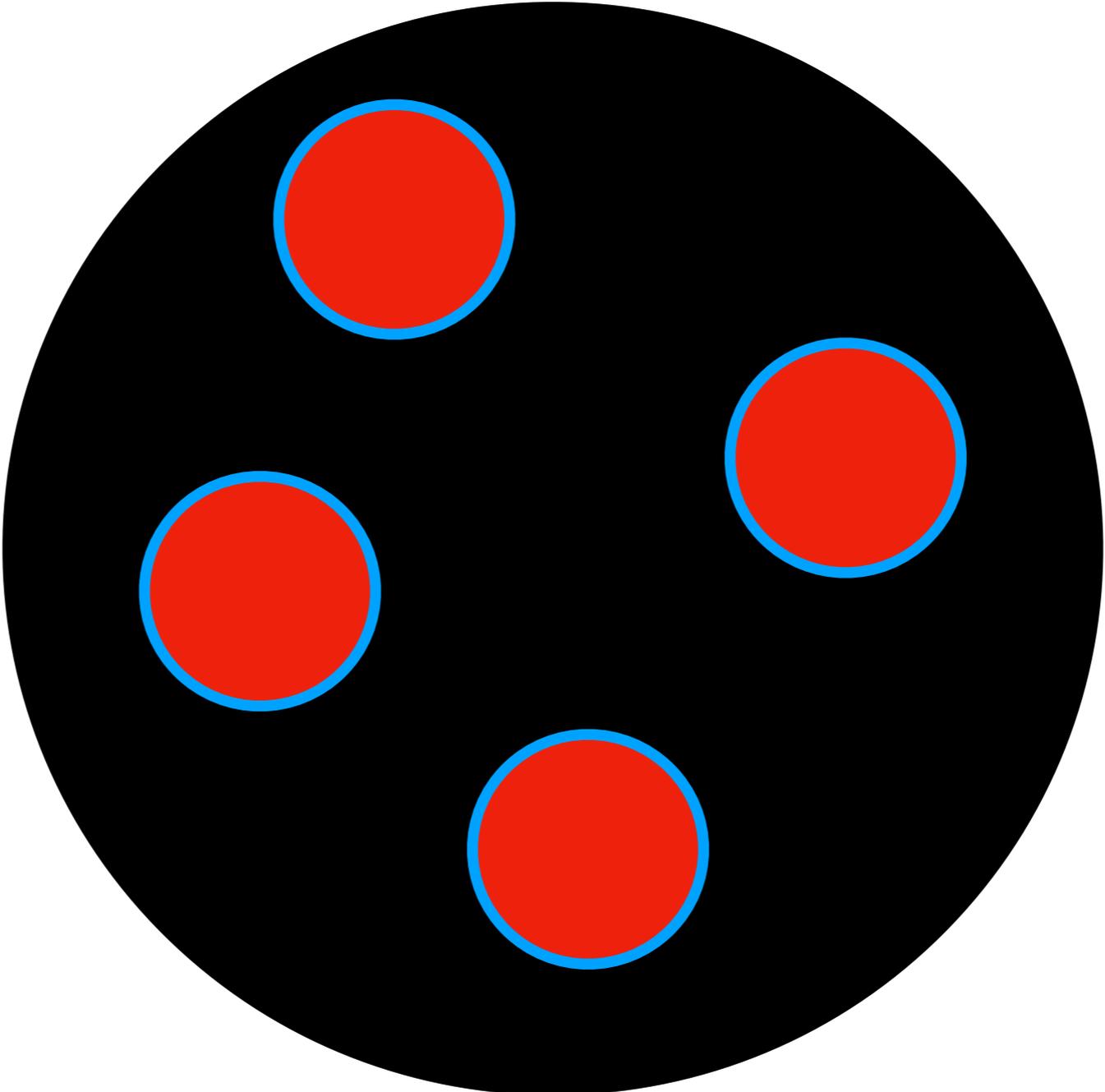


Gravitational Scattering Theory

- Conjecture: asymptotic operator algebra in Minkowski QG is current algebra describing flow of spin/helicity and other quantum numbers into and along the conformal boundary $Q_a(K)$
- Null Cone K Fourier Dual to Conformal Boundary
- Non-vanishing measure for tip of the cone (zero momentum gravitons)
- Exclusive Stermann Weinberg Jets



Fourier Transform at Null Infinity



Summary

C.C. is NOT a local energy density but controls relation between large area and large time limit of diamonds : due to Asymptotic Darkness this means it controls High Energy Spectrum. Not calculable in QUEFT

dS and Minkowski space have highly degenerate “vacuum” state, consisting of low energy states on the horizon. Bulk localized excitations are constrained states of a system with (fuzzy) area preserving map invariant dynamics: constraints on annuli, propagate into bulk. Quantum field theory emergent for states with finite number of ESW jets, which never form a black hole. Classical Field theory, following Jacobson, remains a valid hydrodynamic description of black holes but does not capture underlying quantum states, only coarse grained averages.