





carlo

Steve





Carlo:
... yes, I agree

Steve:
... something strange must happen outside the horizon





Carlo:
... yes, I agree

Steve:
... standard qft over a given geometry must be violated





Carlo:
... yes, I agree

Steve:
... this must bring information out

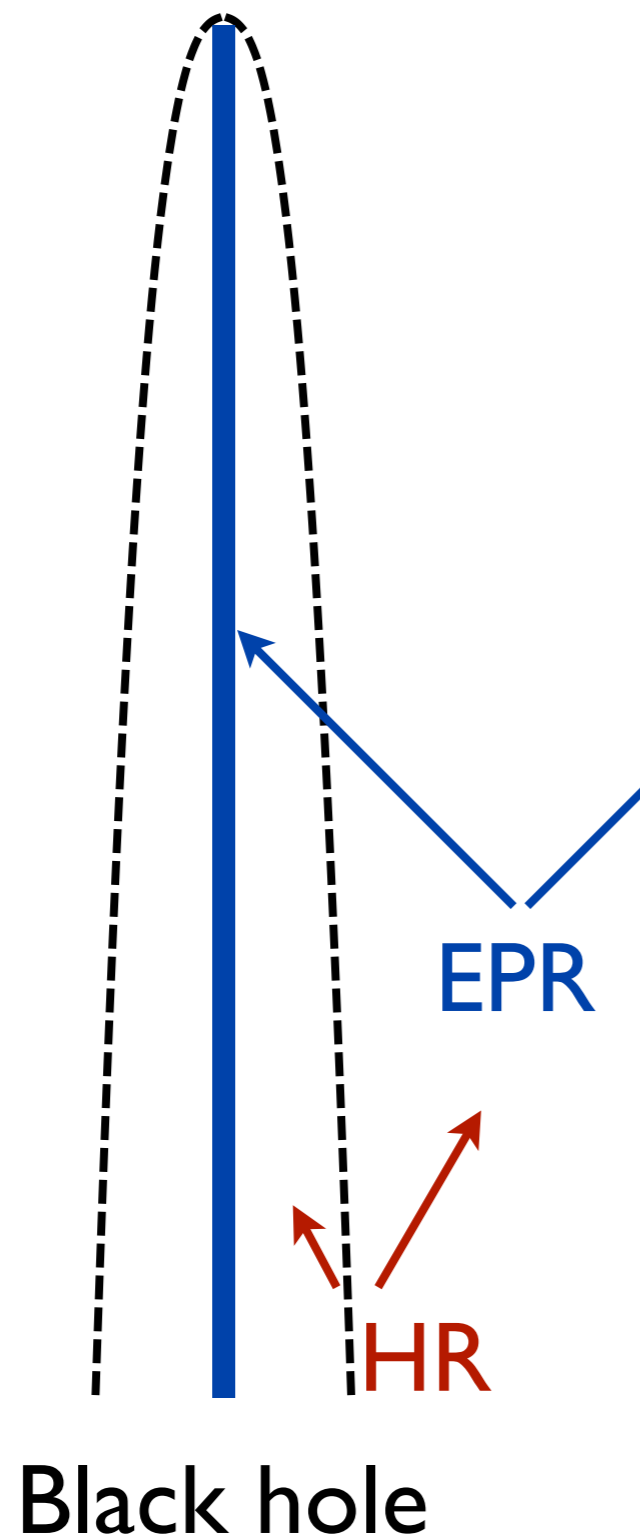




Carlo:
... yes, I agree

Steve:
... but we are not sure of the time scale of this





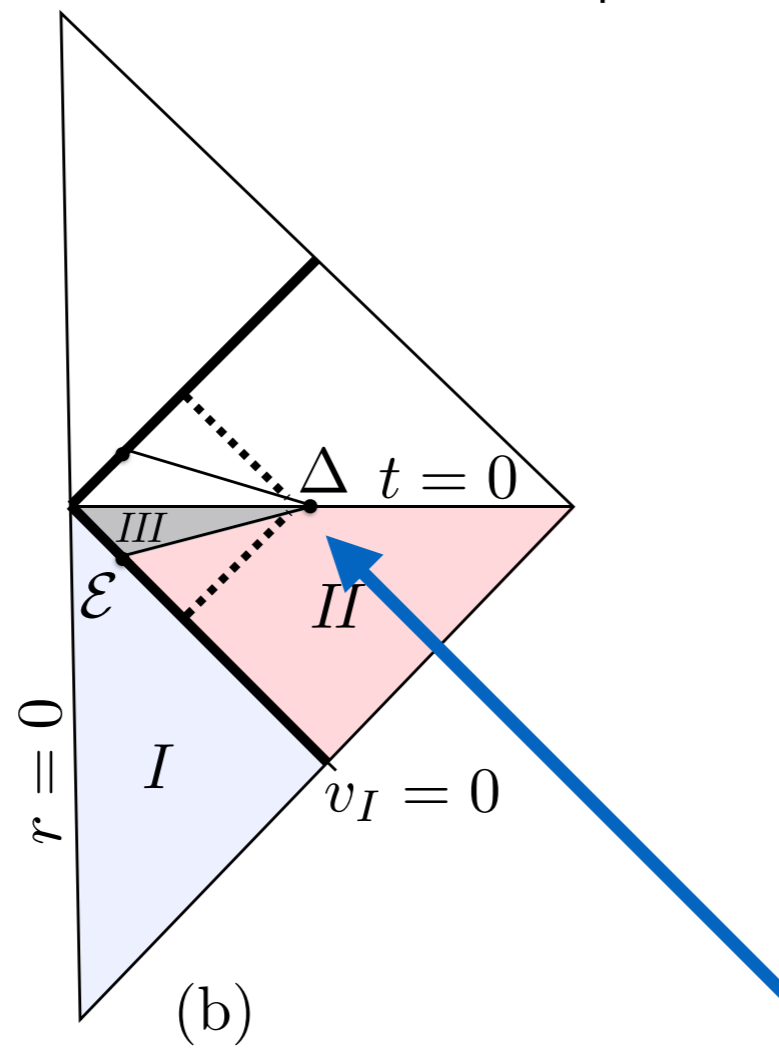
This is based on physics we know and love ...
Semiclassical spacetime + local QFT

... but yields a fundamental conflict





Quantum gravity is **not**
quantum field theory on a geometry!



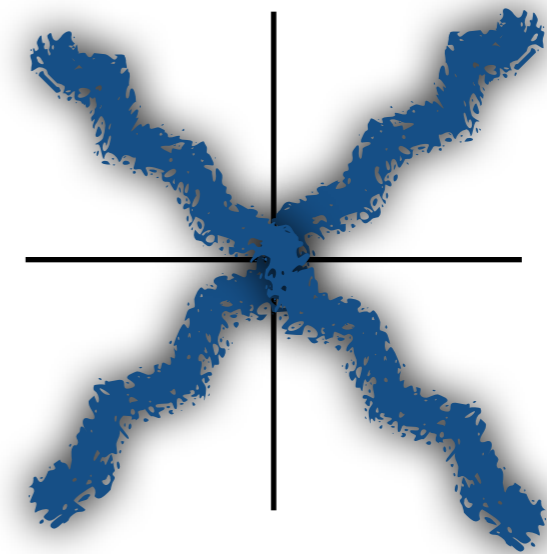
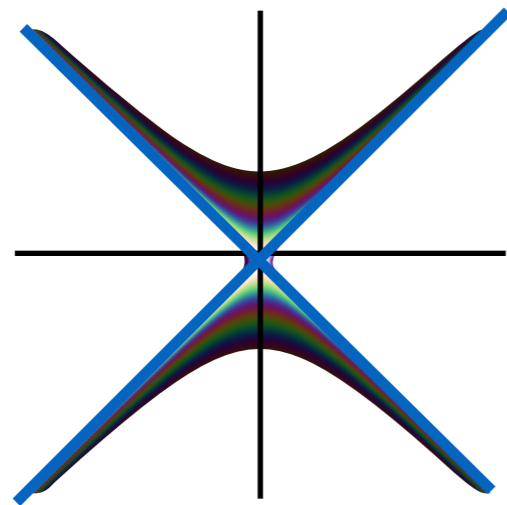
Quantum effect leak outside
the horizon

(cfr Gia Dvali,
Roberto Casadio,
Andrea Giugno)



Quantum gravity is **not** quantum field theory on a geometry!

$$\hat{g}_{\mu\nu} = \eta_{\mu\nu} + \hat{h}_{\mu\nu}$$




The relevant causal structure is **not** that of the background geometry, because **the causal structure undergoes quantum fluctuations** together with the gravitational field

Einstein
equations

Standard
QFT

Horizon entanglement entropy and
universality of the graviton coupling
Eugenio Bianchi
arXiv:1211.0522


$$\delta S_{entangl} = 2\pi \frac{1}{8\pi\hbar G} \delta A = \frac{1}{4\hbar G} \delta A$$

BH entropy **is** entanglement entropy

Entanglement entropy is **the same** as
entropy due to the fluctuation of the geometry.

because one of the fields is the geometry itself.

The finiteness is due to the UV,
but the $\frac{1}{4}$ is a **low energy** phenomenon

(cfr Gia Dvali,
Roberto Casadio,
Andrea Giugno)

What is the time scale for this to happen?

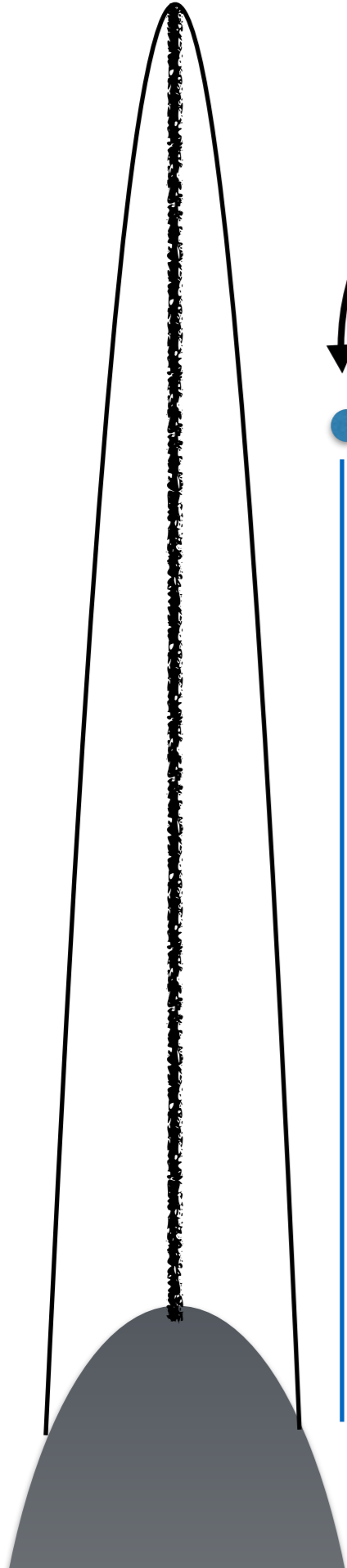
$$T = \begin{cases} \sim e^{m^2} \\ \sim m^3 \\ \sim m^2 \\ \sim m \ln m \end{cases}$$

Naive expectation from analogy with tunnelling in space
Balanced by phase space factor?

Page time. Requiring that AMPS firewall are avoided

Minimal failure of local qft: $RT > L_{Planck}^{-1}$

Calculation from LQG, first contribution (too short!)
Time from for Hawking radiation to emerge.



Curvature
is small

Wave function
spread of the geometry
has time to build up

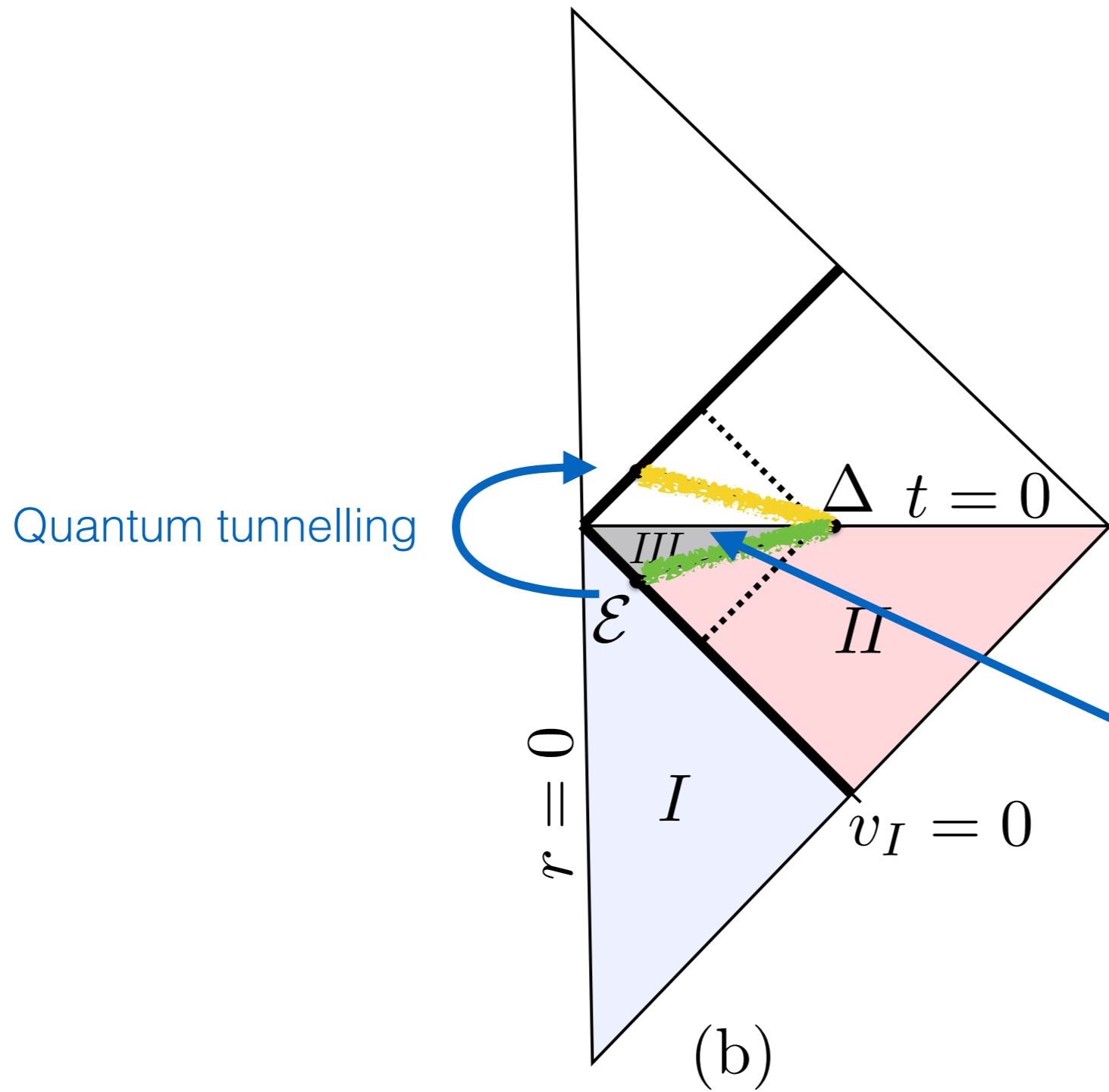
But time
is very long

$$R t \sim \frac{1}{l_{Pl}}$$

$$r \sim \frac{7}{6} (2M)$$

$$T \sim m^2$$

Quantum tunnelling is a non perturbative phenomenon

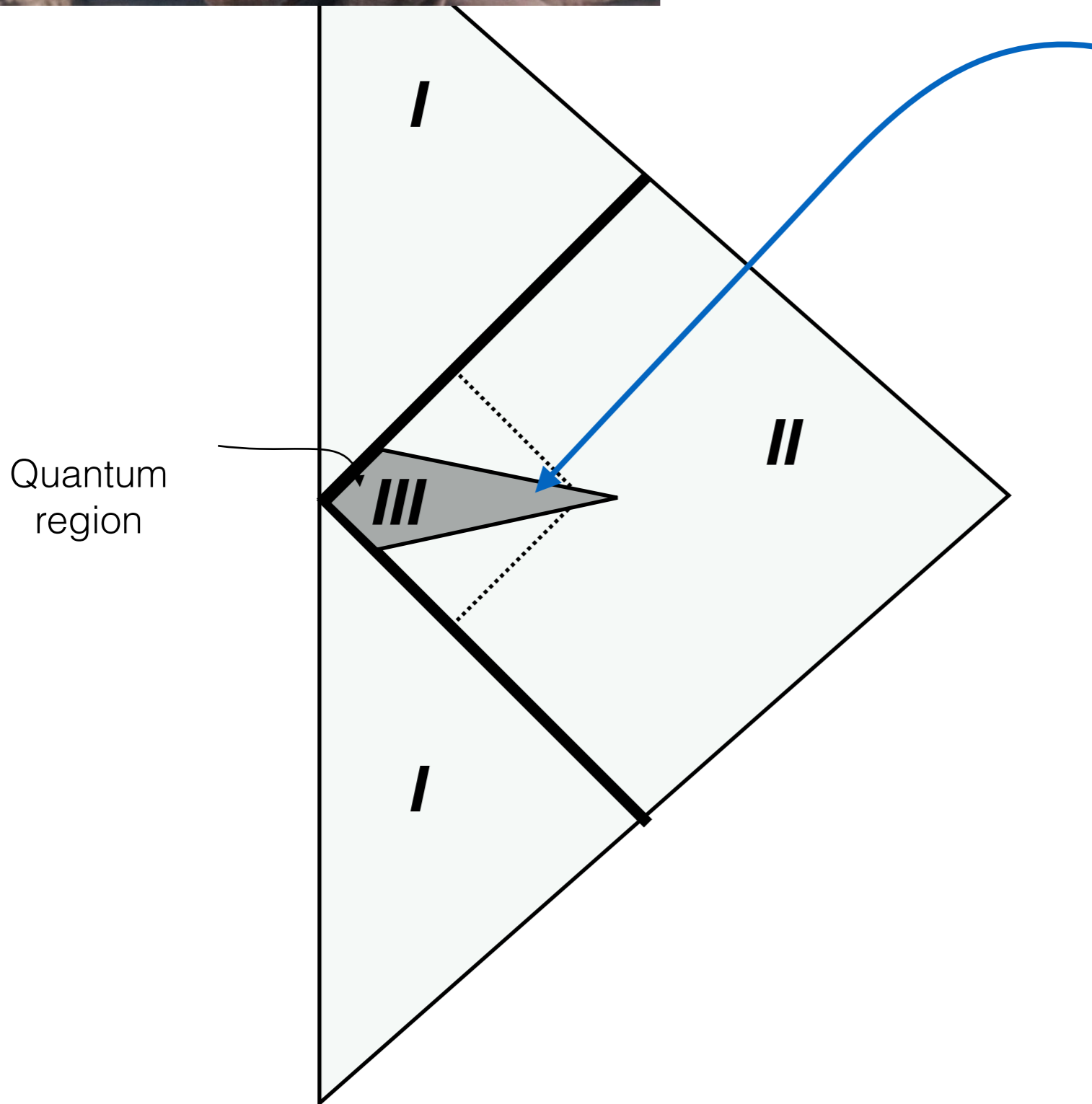


Quantum gravity provides
a mechanics for information
to come out

**Forget the background
causal structure
inside here !**



Local Quantum Theory
on a background geometry
fails here



There is no background
spacetime with a fixed
causal structure in this region





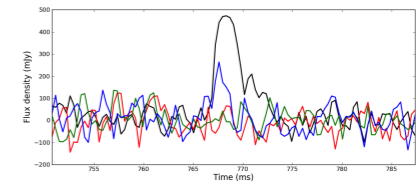
Already observed?? Fast Radio Burst

(cfr talk Luciano Rezzolla)

Unknown source!

$$\lambda \sim 20 \text{ cm}$$

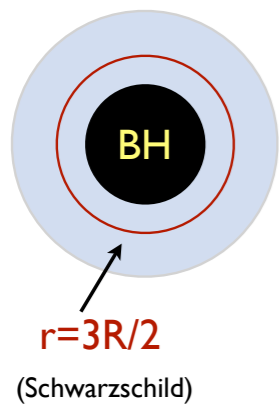
- Short
 - Observed width \approx milliseconds
- No Afterglow
 - No Long GRB associated
- Punctual
 - No repetition
- Enormous flux density
 - Energy $\approx 10^{38}$ erg
- Likely Extragalactic
 - Dispersion Measure: $z \approx 0.5$
- 10^4 event/day
 - A pretty common object?



Thornton et al. 1307.1628
Spitler et al. 1404.2934
E. Petroff et al. 1412.0342

An opportunity:

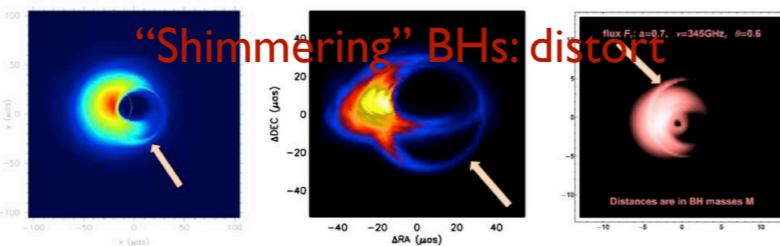
arXiv:1406.7001



Event horizon telescope:



Sgr A*



SBG/Psaltis, WIP

Theoretical uncertainty:

$$t_{qn} \sim t_{Fast Sc} \sim R \log R \sim 8 \text{ hr}$$

$$t_{1/2} \sim R^3 \sim 10^{74} t_{\text{Universe}}$$

} bounds

If due to inaccuracy of geometrical description, $R \ln R$ reasonable

