Tidally disrupted stars as possible common origin of UHECRs and neutrinos

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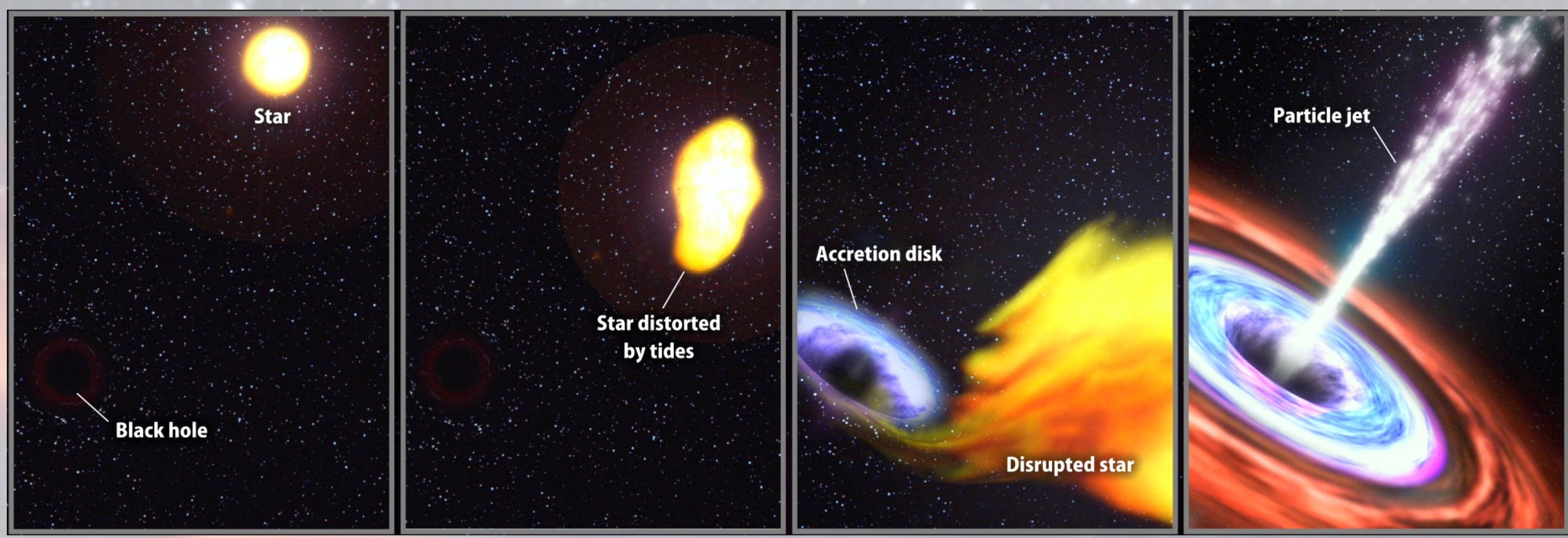
Introduction

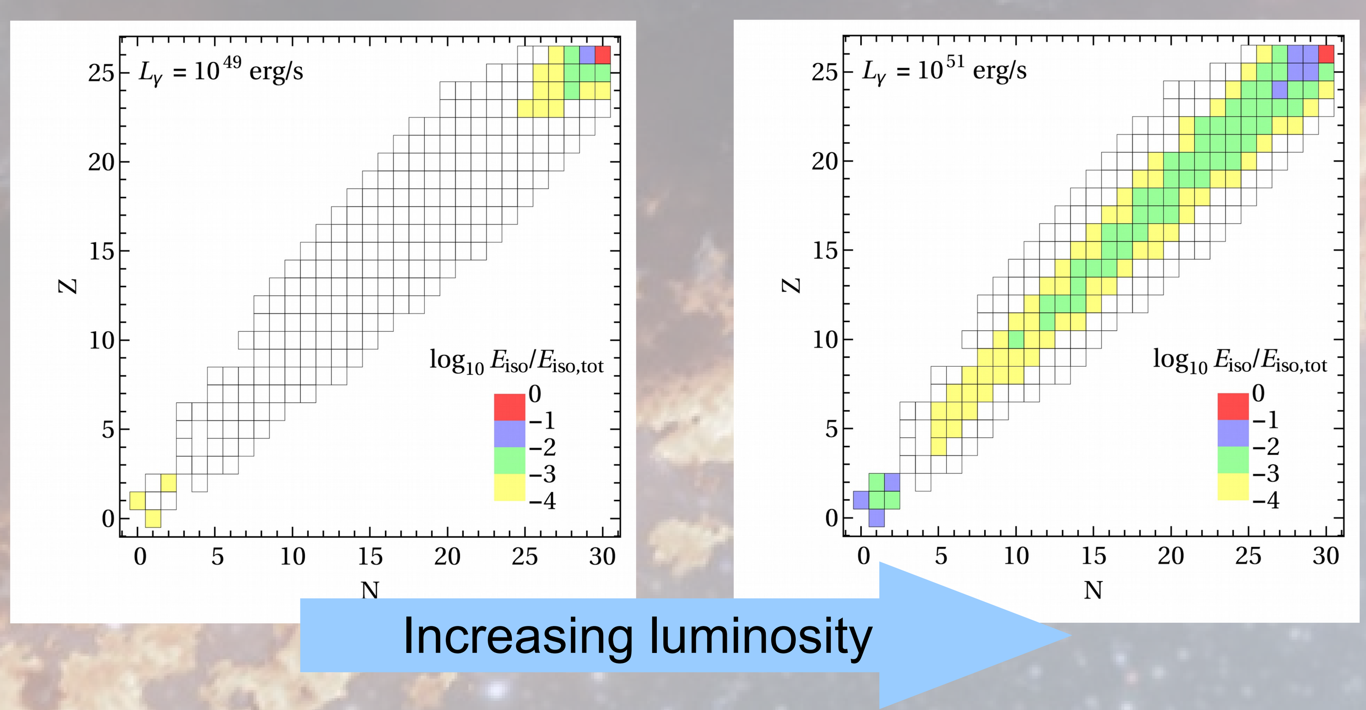
- The origin of ultra-high energy cosmic rays (UHECRs) is still unclear
- They are likely producing very high energy neutrinos in hadronic interactions
- Extremely powerful sources are required to accelerate particles to such high energies, e.g. GRBs, AGNs, **Tidal Disruption Events (TDEs)**
- TDEs are processes in which a star gets too close to a black hole and is ripped apart by tidal forces – in some cases, a relativistic jet is launched



Schematic illustration of a tidal disruption event (Credit: NASA)

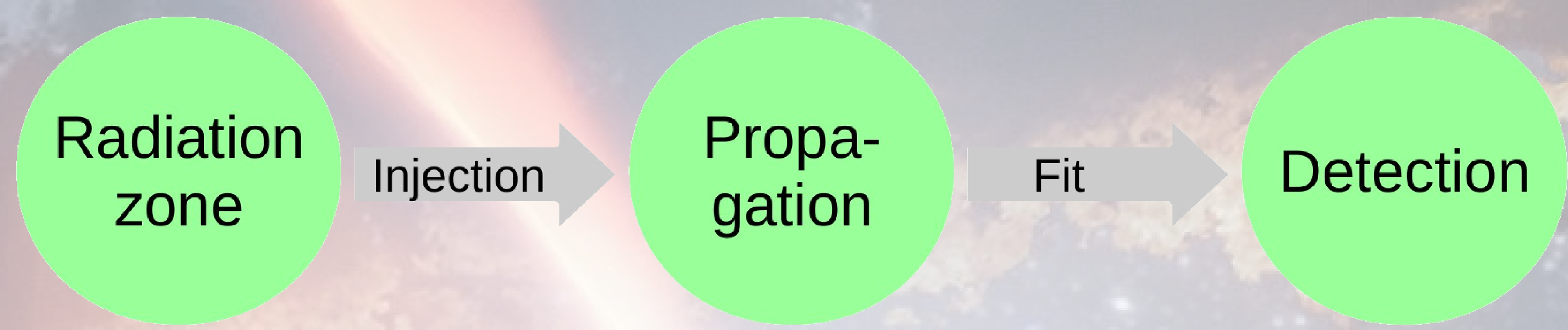
The nuclear cascade

- Nuclei are accelerated in the jet and interact with ambient photons of the prompt emission, in particular they can disintegrate, i.e. lighter nuclei are produced
- If the radiation density is high enough, this process can trigger a nuclear cascade [1,2] in the jet
- Luminosity and size are the main control parameters for the nuclear cascade and neutrino production



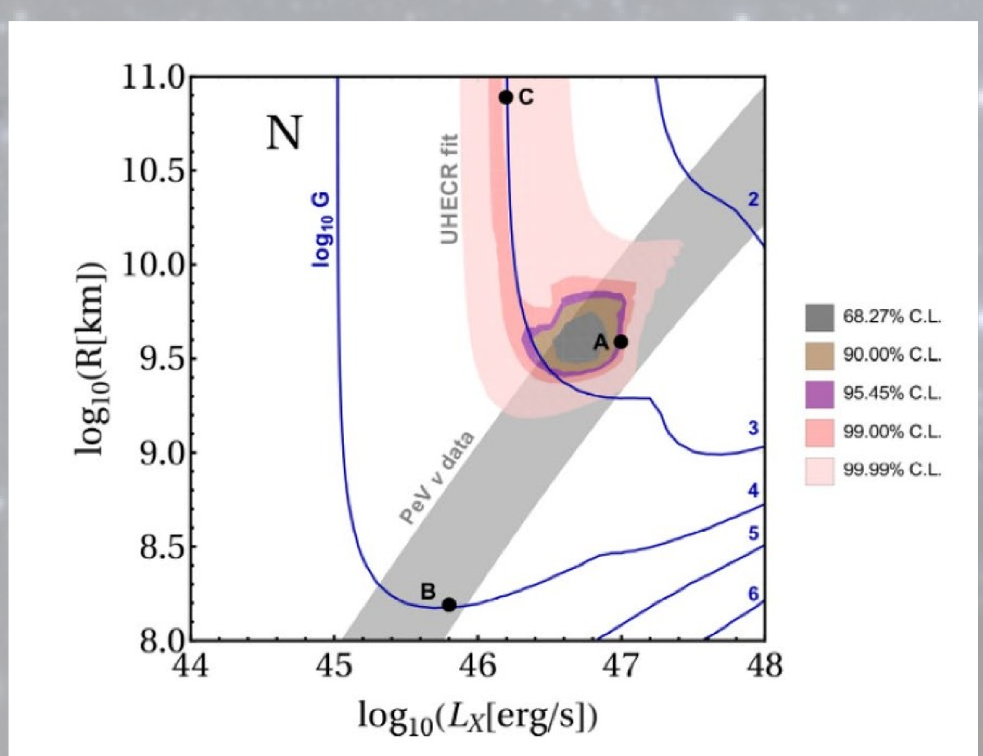
Development of the nuclear cascade (pure iron injected)

Combined source-propagation models



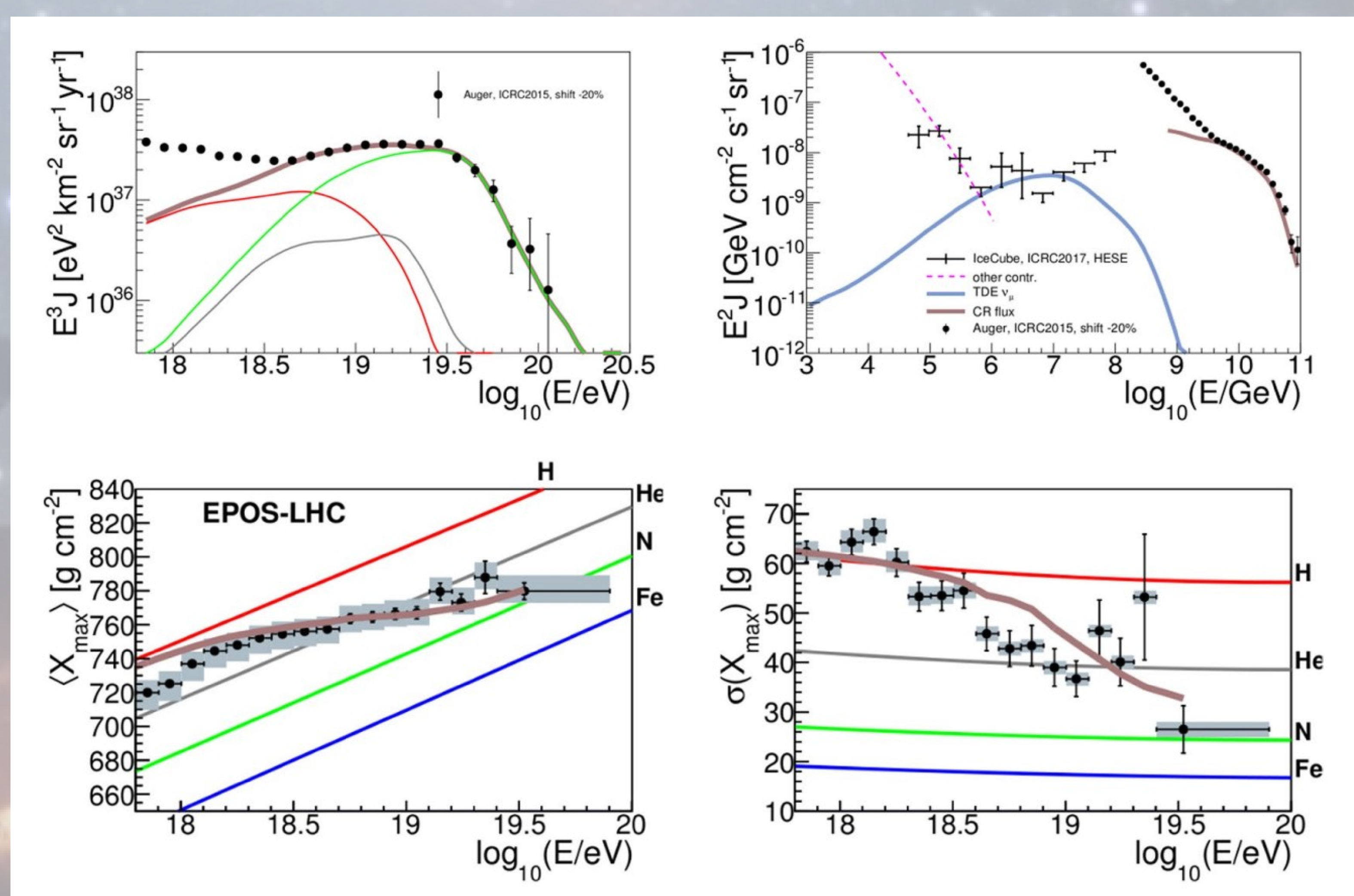
- Source injection composition depends on progenitor scenario, e.g. intermediate mass black hole + white dwarf (carbon-oxygen injection), super massive black hole + main sequence star (iron injection)
- Depending on the compactness of the source, the nuclear cascade develops (including all interactions in the source!), leading to a complex mixture of many different isotopes escaping from the source
- The ejected cosmic rays serve as input for propagation [3], taking into account interactions with cosmic backgrounds (CMB, CIB, …), source evolution, interactions in the atmosphere (optional: luminosity distribution)
- Fit to UHECR spectrum and composition in luminosity, size of the object and normalization parameter (degenerate in cosmic ray power and event rate), compatibility check with PeV neutrino data [4], many possible applications

Fit of UHECR spectrum & composition and description of PeV neutrino data



Parameter space and common fit region

- Cosmic ray fit follows the maximum energy required to fit Auger spectrum and composition [5]
- PeV neutrino data [6] corresponds to 1σ region of IceCube PeV events (following radiation density)
- Region preferred by neutrino data coincides with the nuclear cascade region, cannot be neglected
- **It is possible to fit both within 1σ of each other**



Results of the fit to UHECR spectrum and composition

[Background image credit: NASA / JPL-Caltech]

References

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