Neutrinos from Common-Envelope Events

Joachim Kopp (CERN & JGU Mainz)

EP-NU Group Meeting | 31 October 2024

CERN

Neutrino PLATFORM

QUANTUM TECHNOLOGY INITIATIVE

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Neutrinos as Astrophysical Messengers

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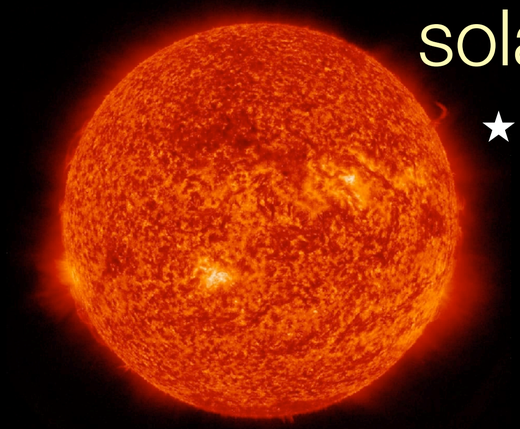
solar neutrinos

- ★ stellar evolution

Neutrinos as Astrophysical Messengers



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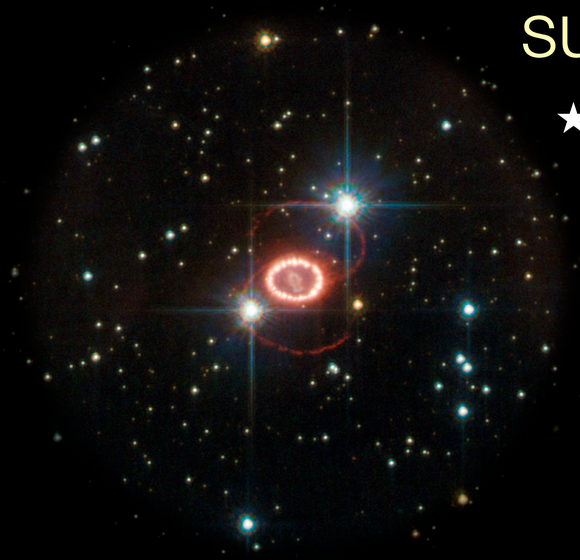

supernova neutrinos

- ★ death throes of massive stars
- ★ nucleosynthesis
- ★ matter under extreme conditions

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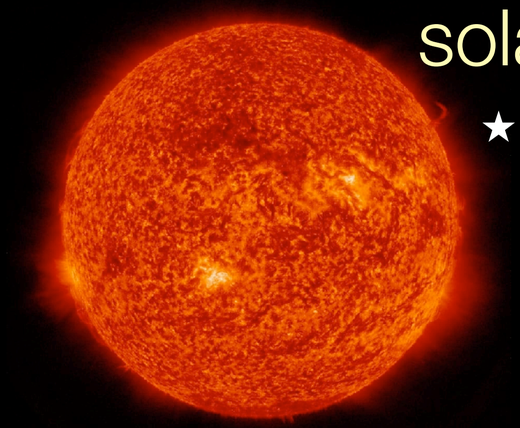

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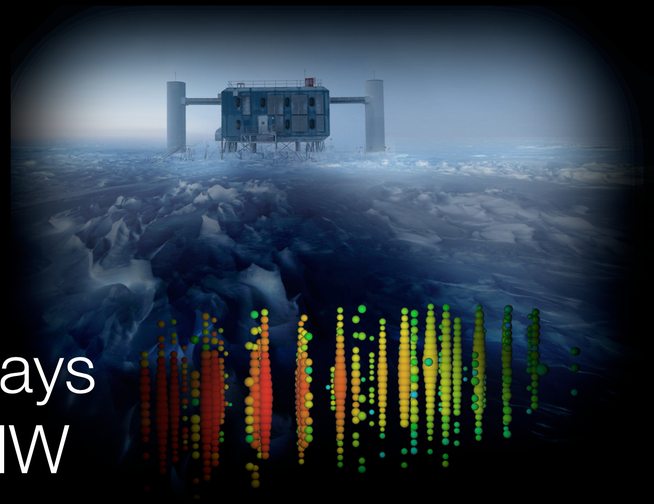
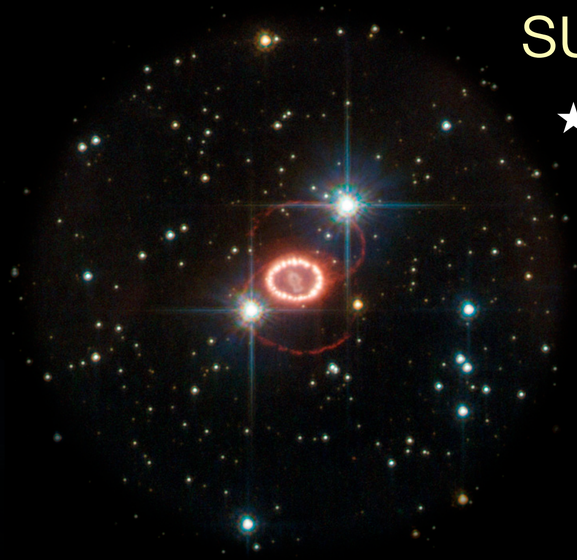


high-*E* neutrinos

- ★ origin of cosmic rays
- ★ AGNs, blazars, MW



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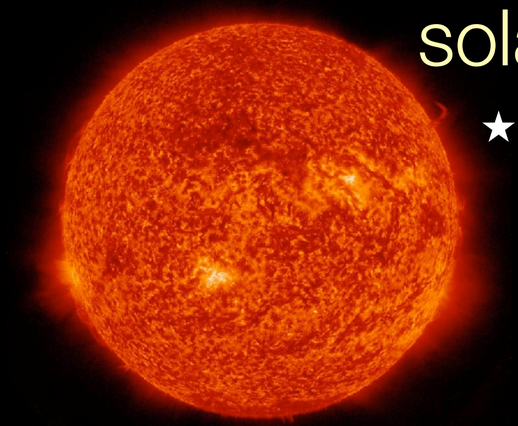

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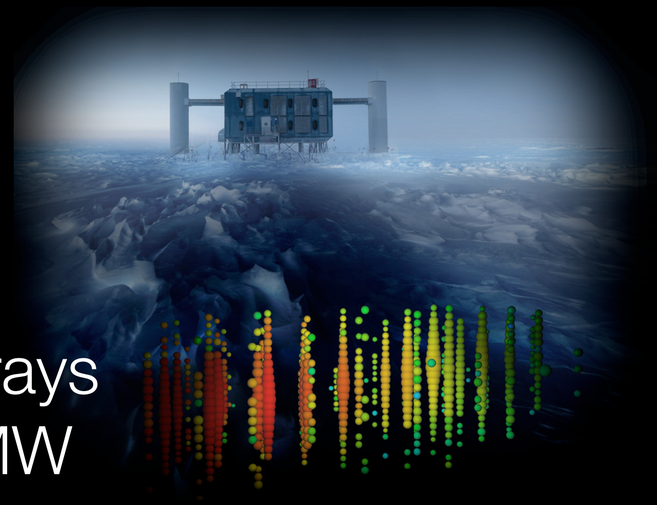

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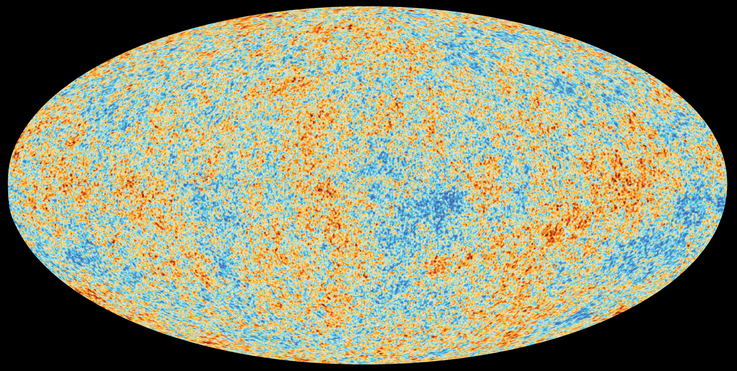
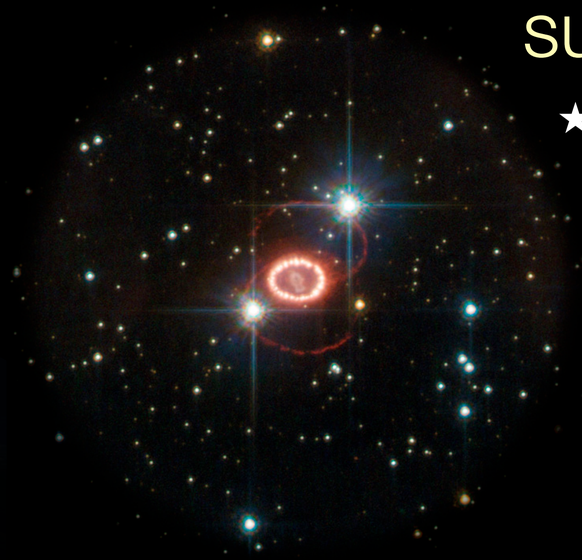


cosmology

- ★ early Universe



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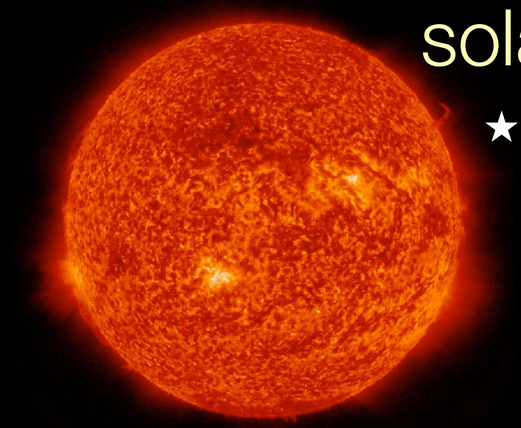

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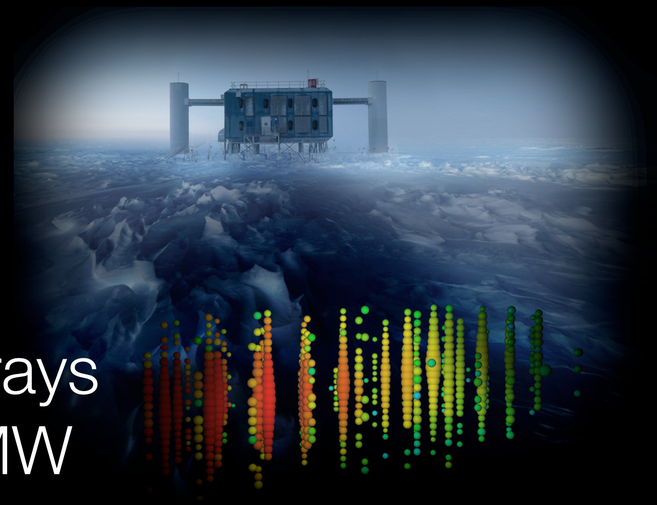

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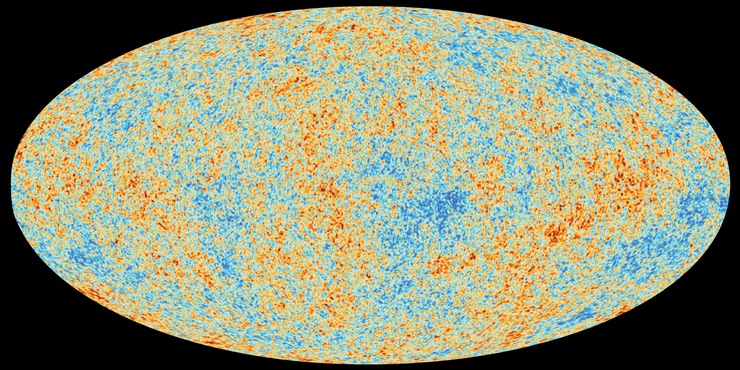

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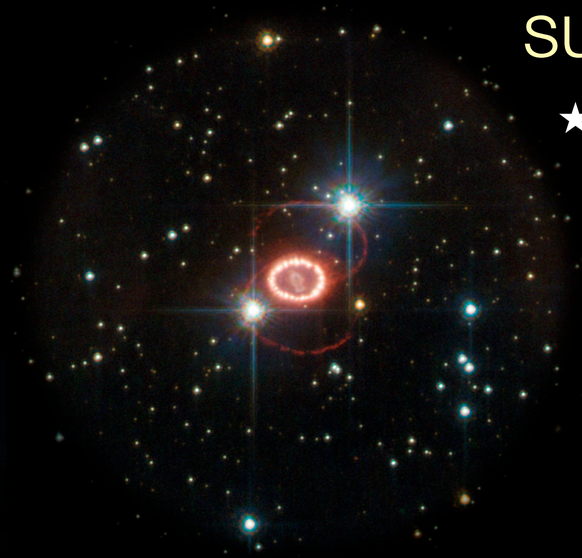

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- ★ death throes of massive stars
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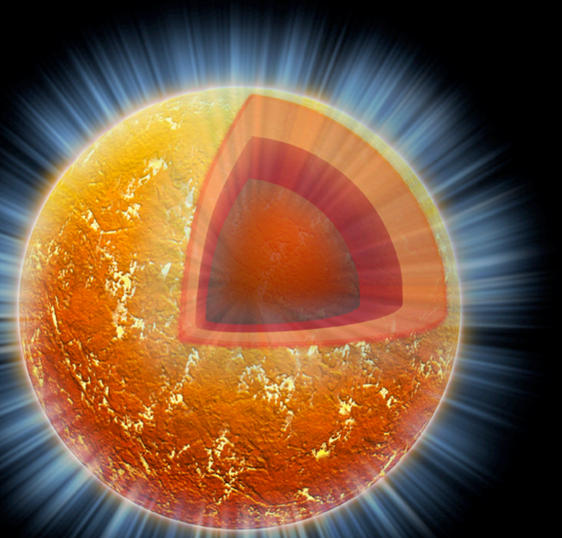
neutron stars

- ★ Urca cooling
- ★ muon decays
- ★ common-envelope evolution

➠ THIS TALK



Common-Envelope Evolution

- compact star (neutron star, black hole, white dwarf, …) enters companion star
- significant friction
- gigantic accretion rates (up to 0.1 $M_\odot$/yr for several months)
- crucial for the formation of gravitational wave sources
- **never observed**

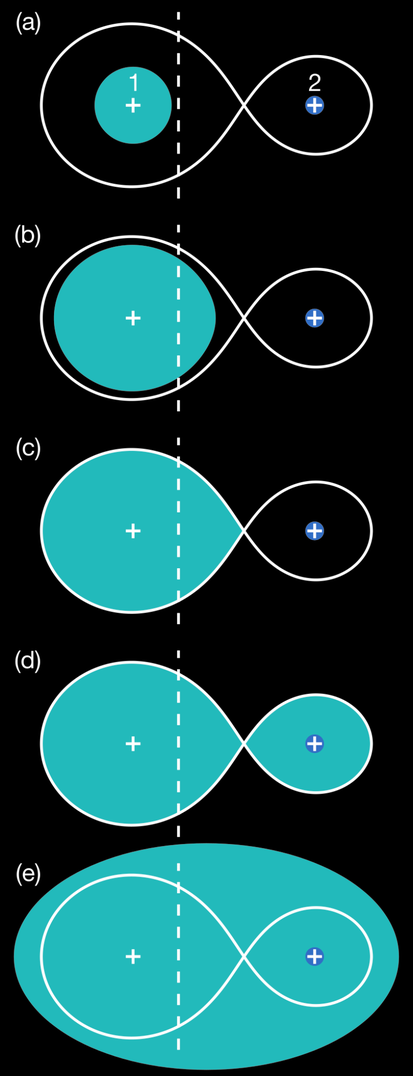
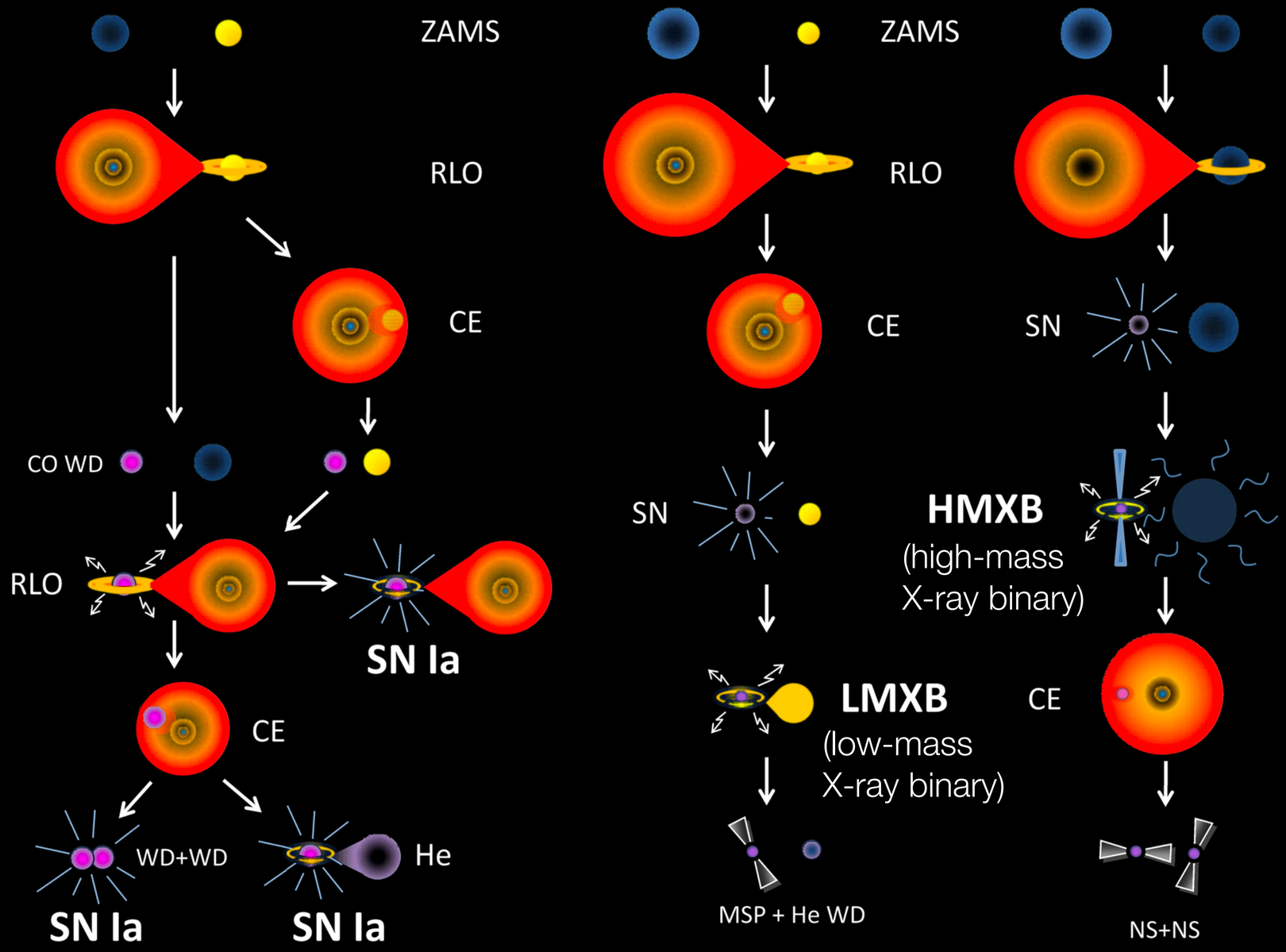


Image: Wikimedia Commons

Common-Envelope Evolution – Examples

Ivanova *et al.* 2012



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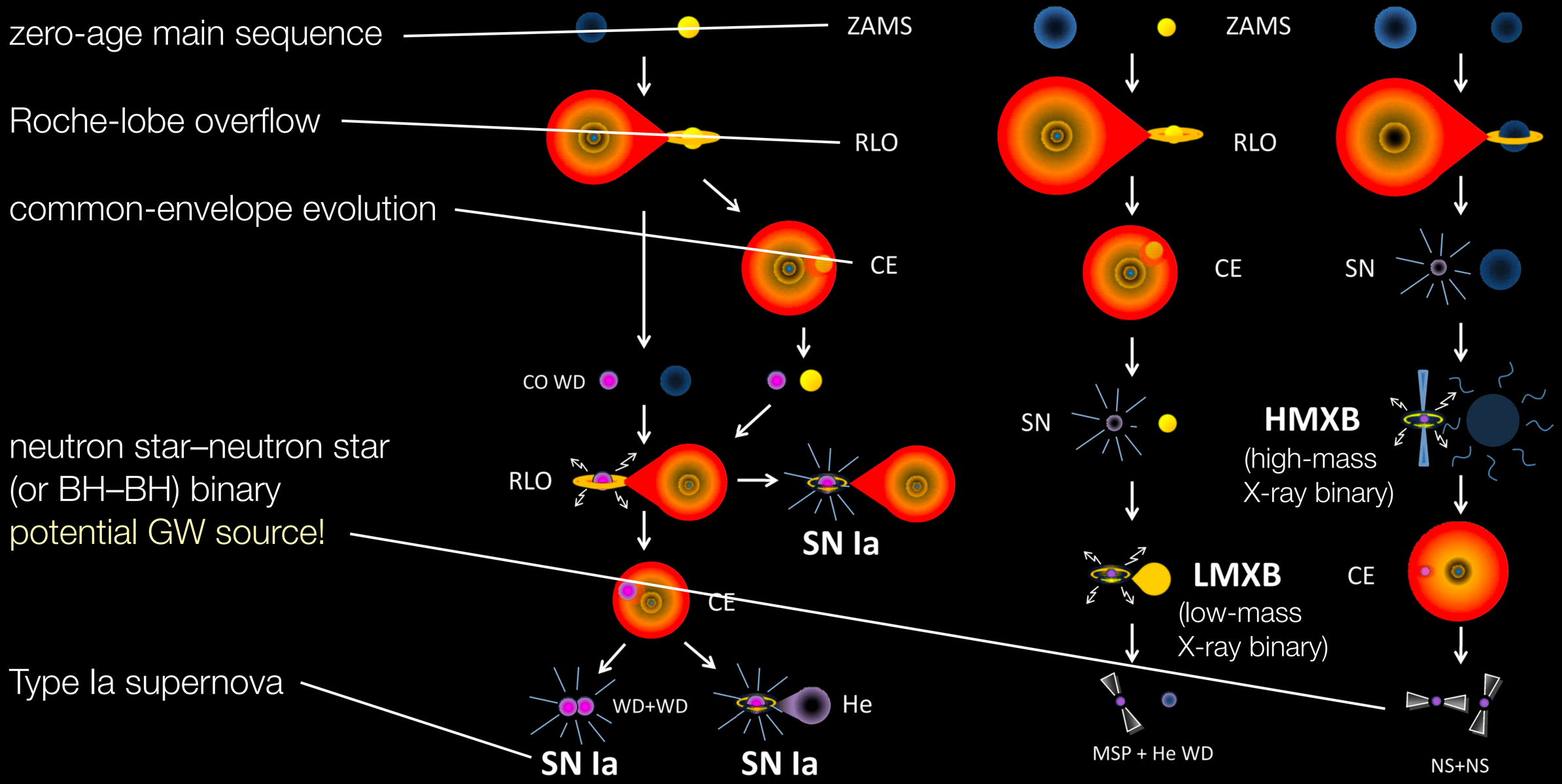
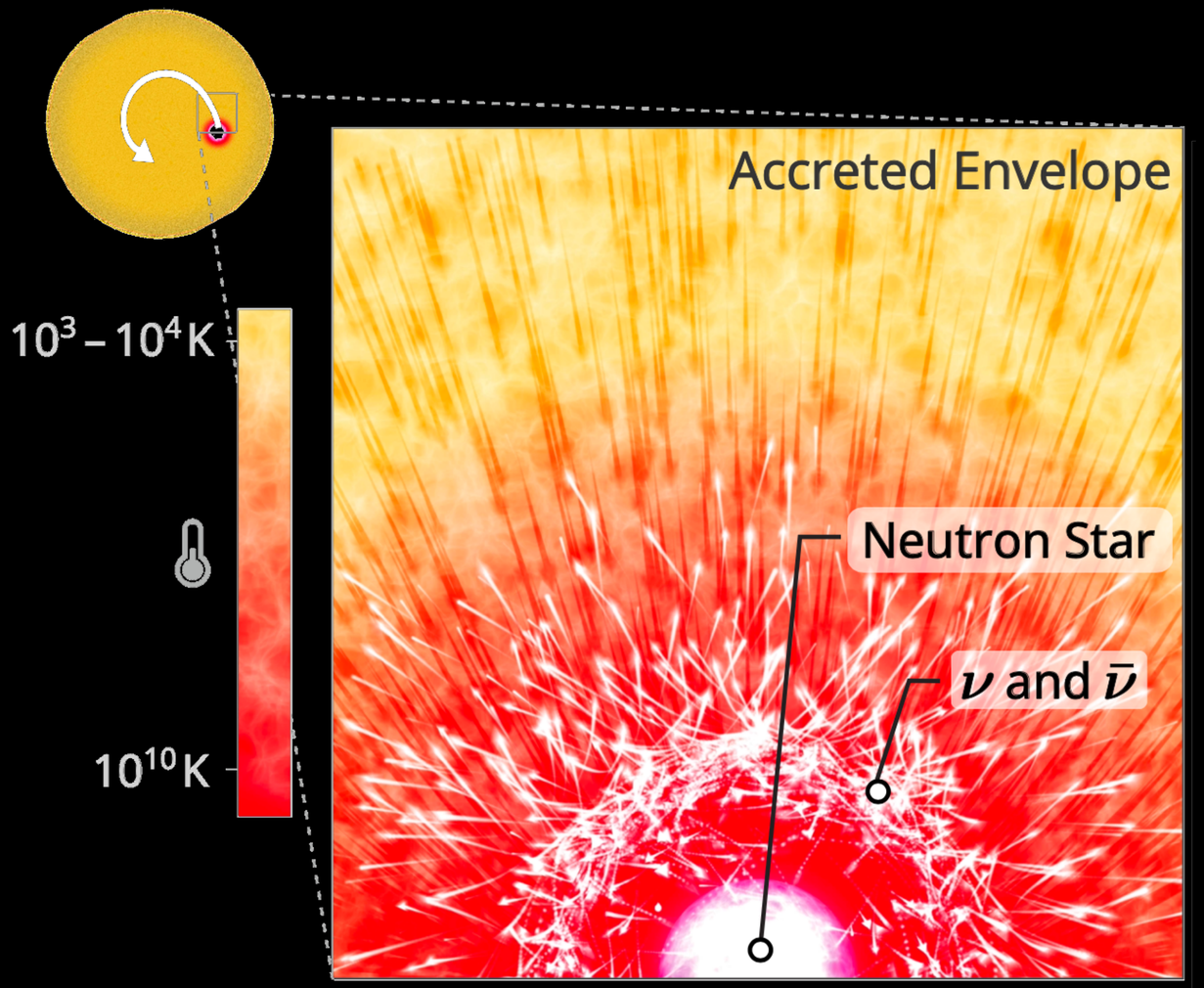


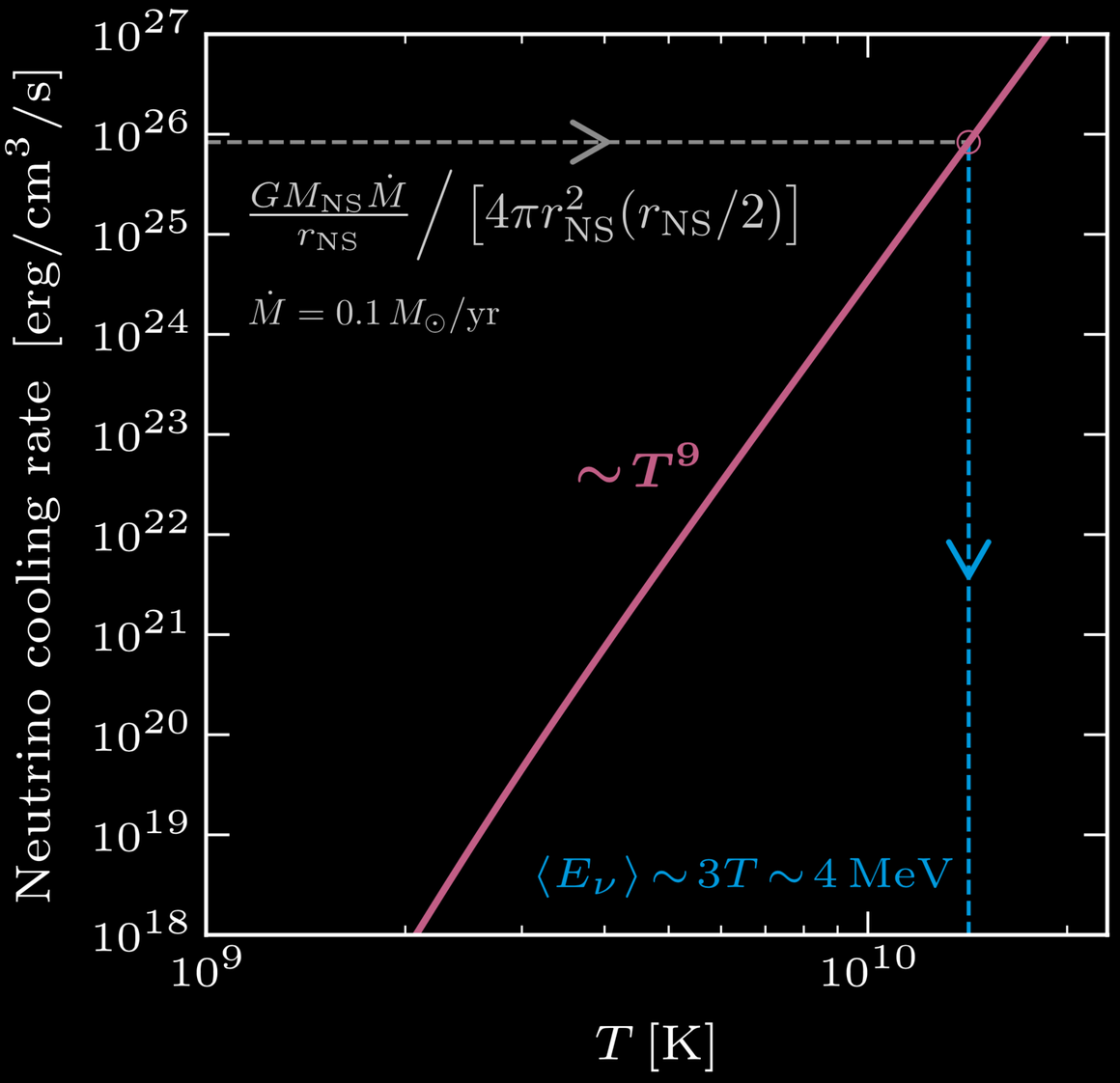
Common-Envelope Evolution – Neutrino Emission



- neutron star enters companion star
- gigantic accretion rates
  (up to 0.1 $M_\odot$/yr for several months)
- only cooling channel is via neutrinos
  ➠ new type of neutrino source
- Main production processes:
  - e^+e^- annihilation to neutrinos
  - plasmon decay

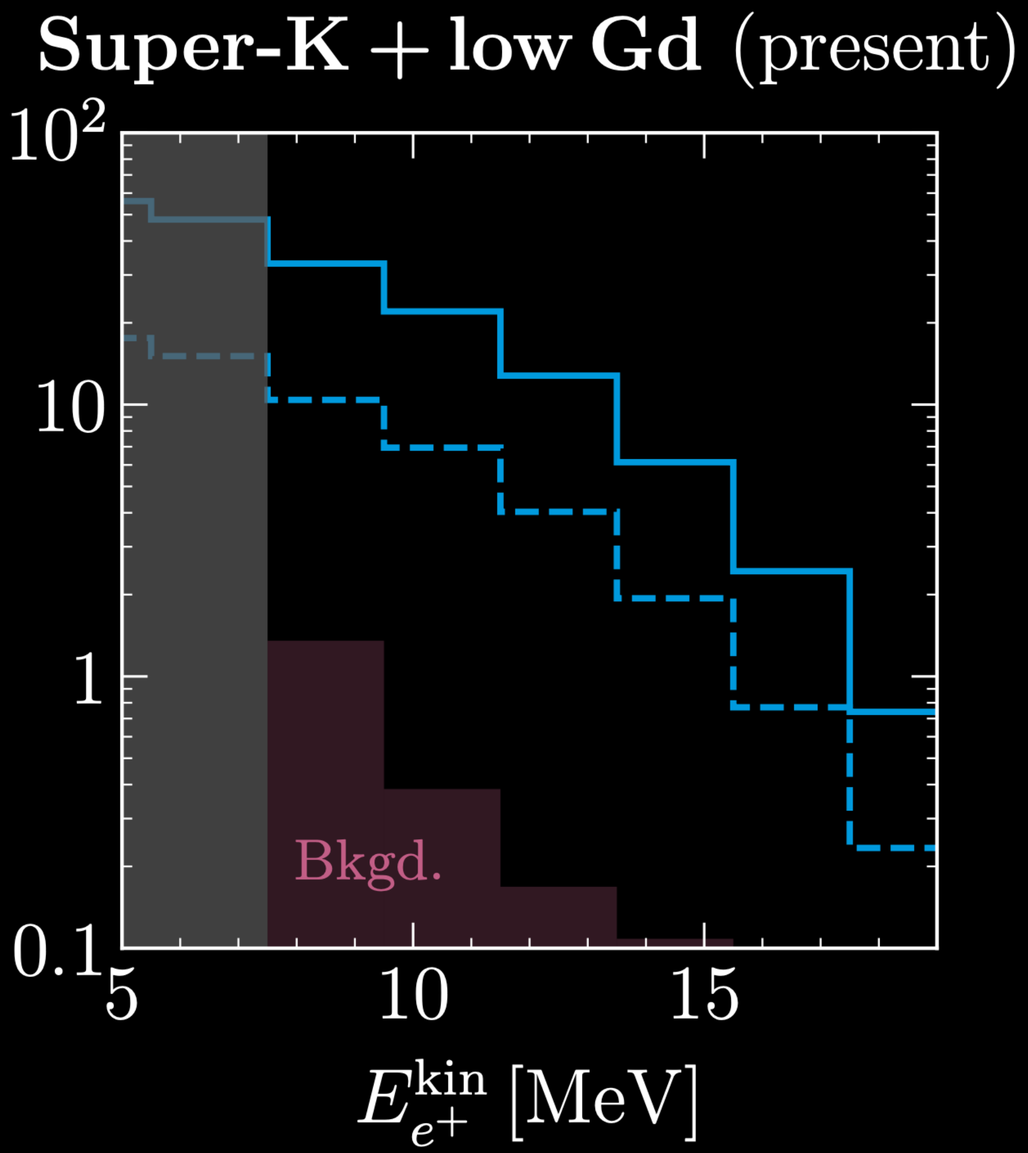
Esteban Beacom JK 2023

Neutrino Temperature



- Neutrino temperature: obtained by equating cooling rate = accretion rate

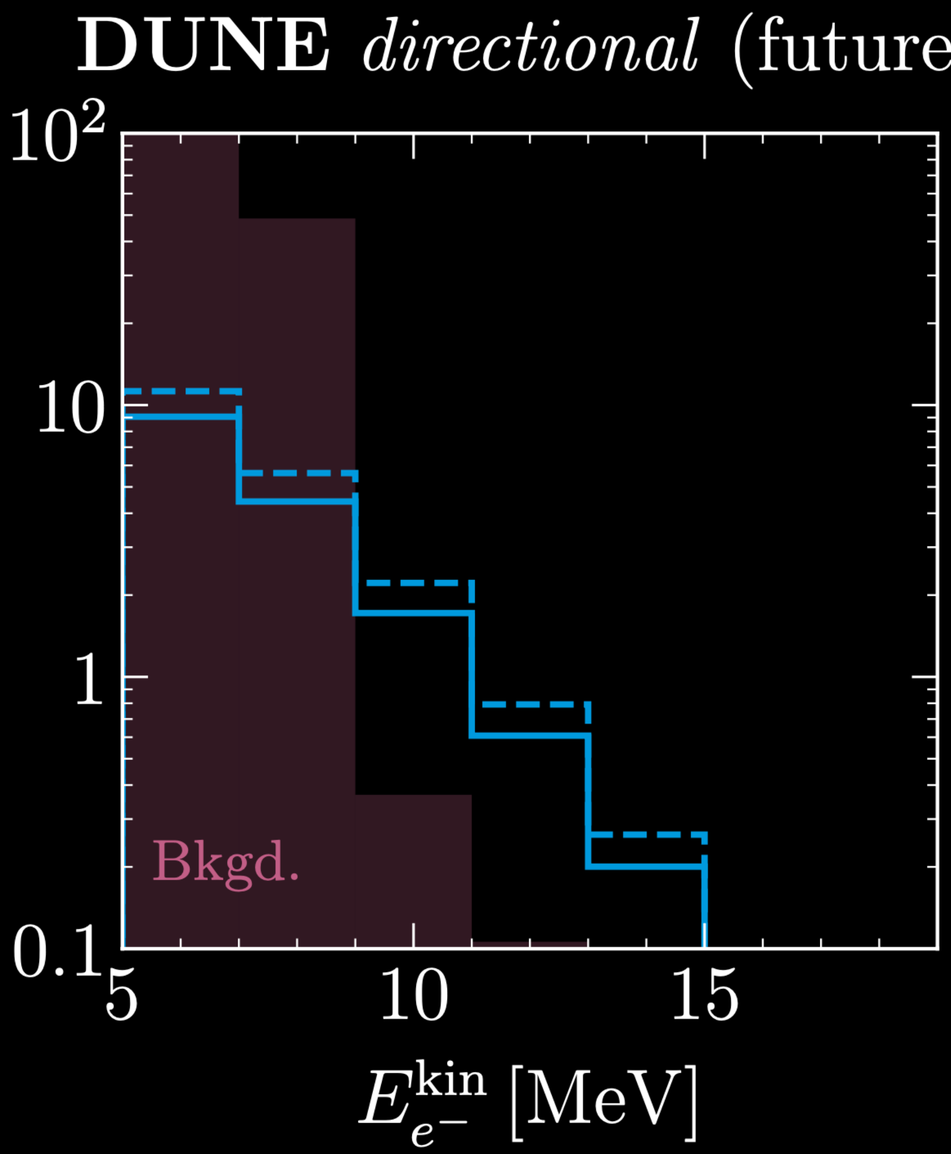
Backgrounds: Water Čerenkov



Main detection channel is IBD

- Accidental coincidences
- Li-9 from spallation
- NC interactions of atmospheric ν
- reactor ν, CC atmospheric

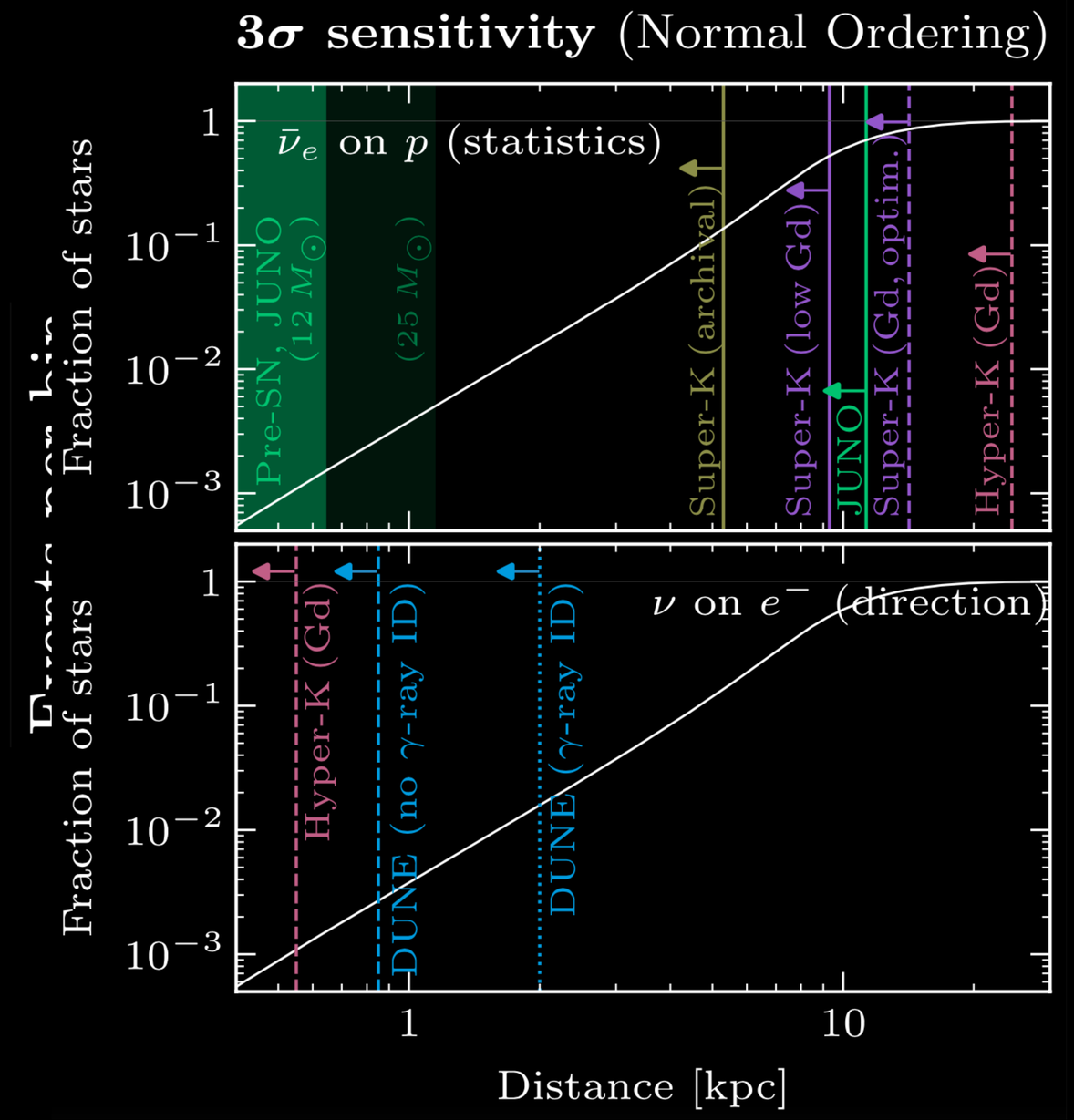
Backgrounds: Liquid Argon



Main detection channel is ν–e scattering

- neutrons from the surrounding rock
- we assume CC interactions of solar ν on ^{40}Ar are rejected by identifying de-excitation γ rays.

Discovery Prospects



- IBD generally offers better reach
  sensitive to events anywhere in the Milky Way
- but ν–e scattering in LAr provides directional information
- in addition: de-protonization
  (but signals expected to be about a factor ~100 smaller)
- Major caveat:
  CEE rate < core collapse SN rate


Thank You!
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