Gamma-ray observation of SN axion conversion in stellar magnetic field

with Claudio Andrea Manzari, Benjamin R. Safdi, and Inbar Savoray
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Axions

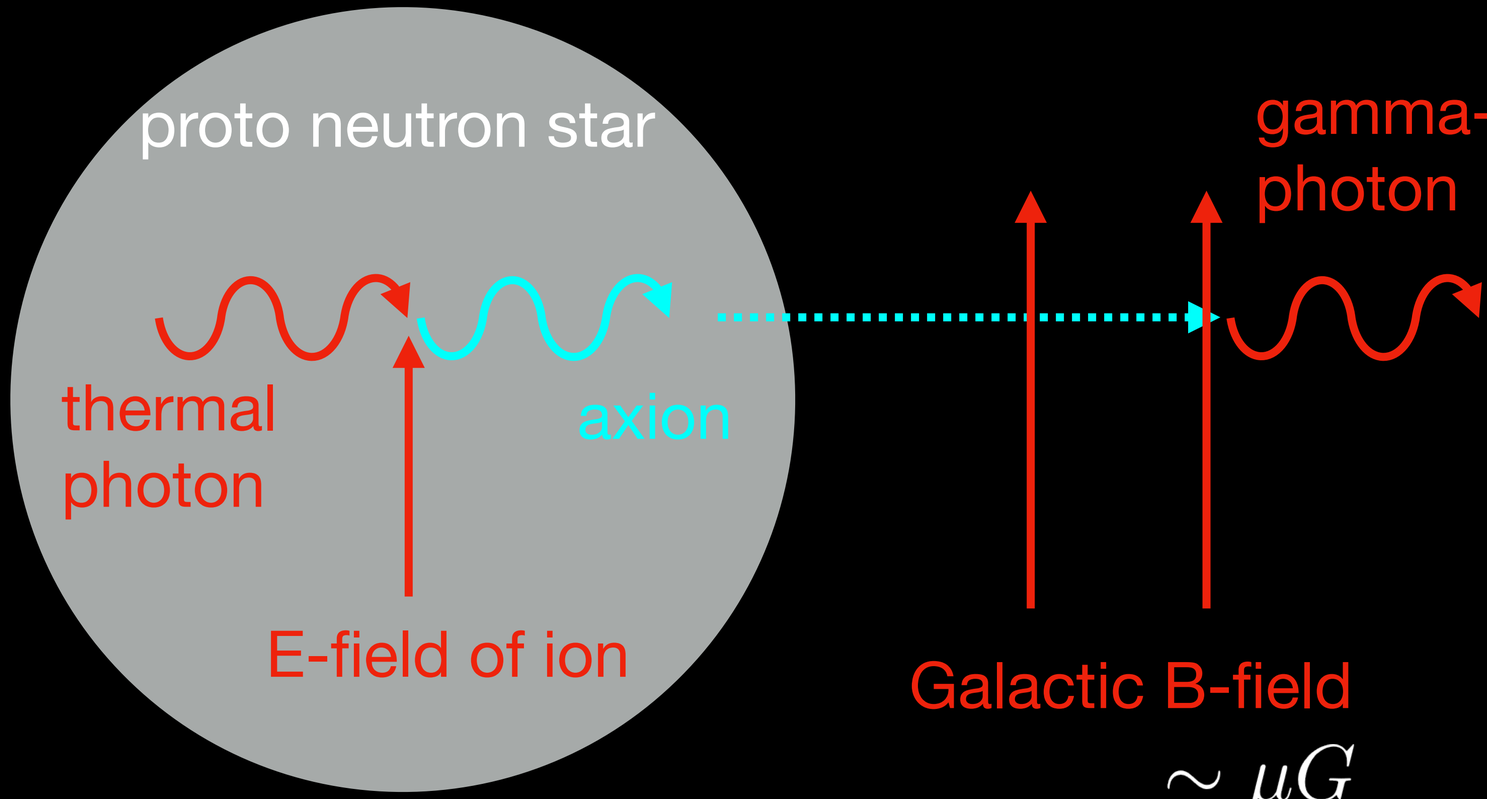
- Light pseudoscalar boson with a two-photon coupling
- Addresses the strong CP problem
- Dark matter candidate
- Additional theoretical motivation in quantum gravity and string theory

$$\mathcal{L} \supset \frac{1}{4} g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu} = g_{a\gamma\gamma} a \, \mathbf{E} \cdot \mathbf{B}$$

Axion conversion in galactic B field

With SN1987A

- distance : 50kpc



Solar Maximum Mission (Wikipedia)

Axion conversion in galactic B field

With SN19

- distar

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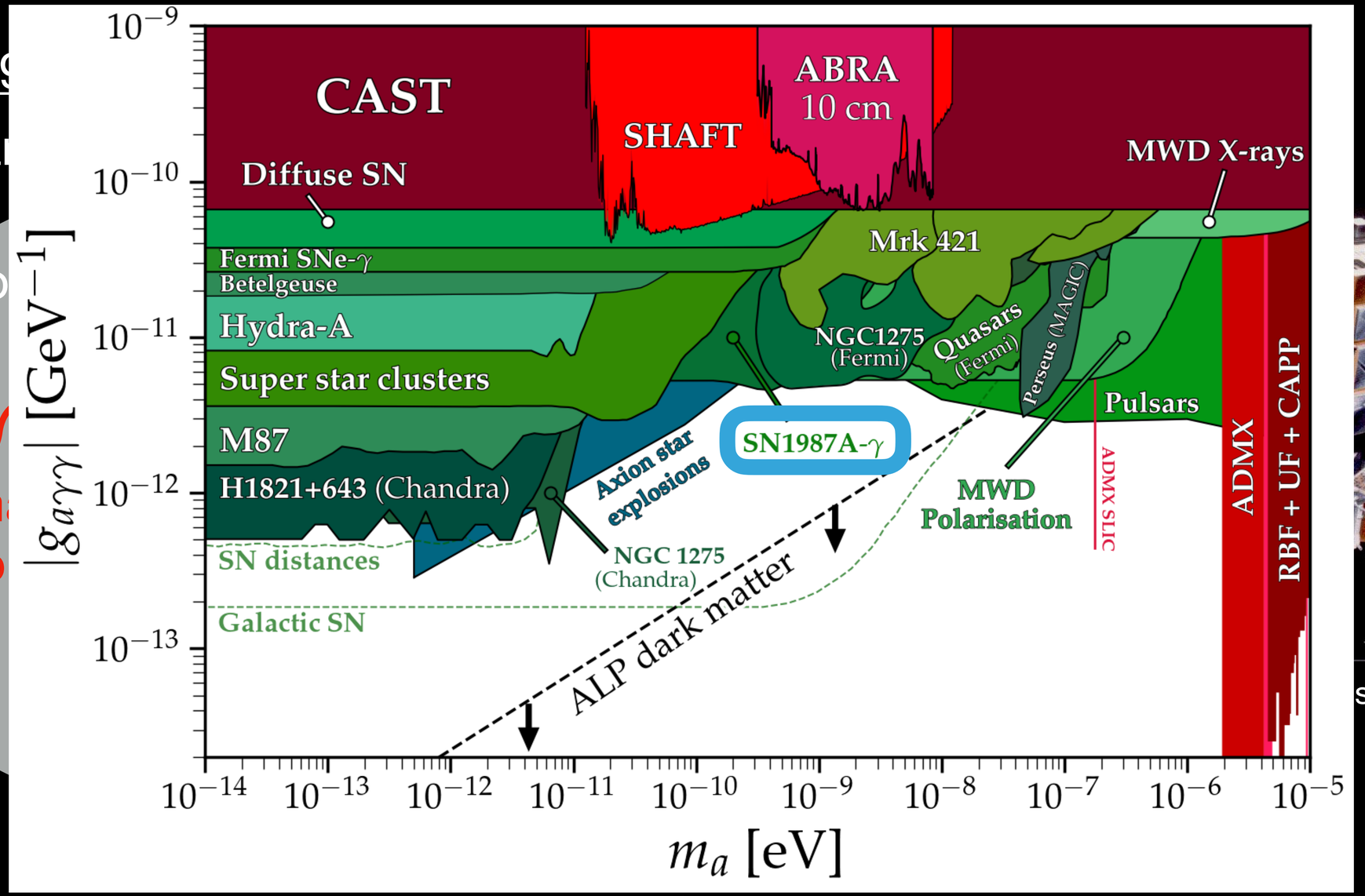

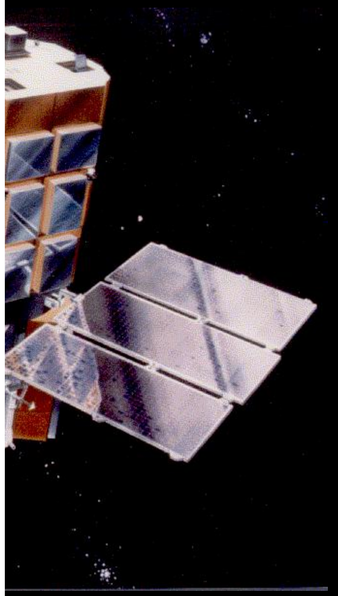

sion (Wikipedia)

Axion conversion in galactic B field

<u>With SN1987A</u>

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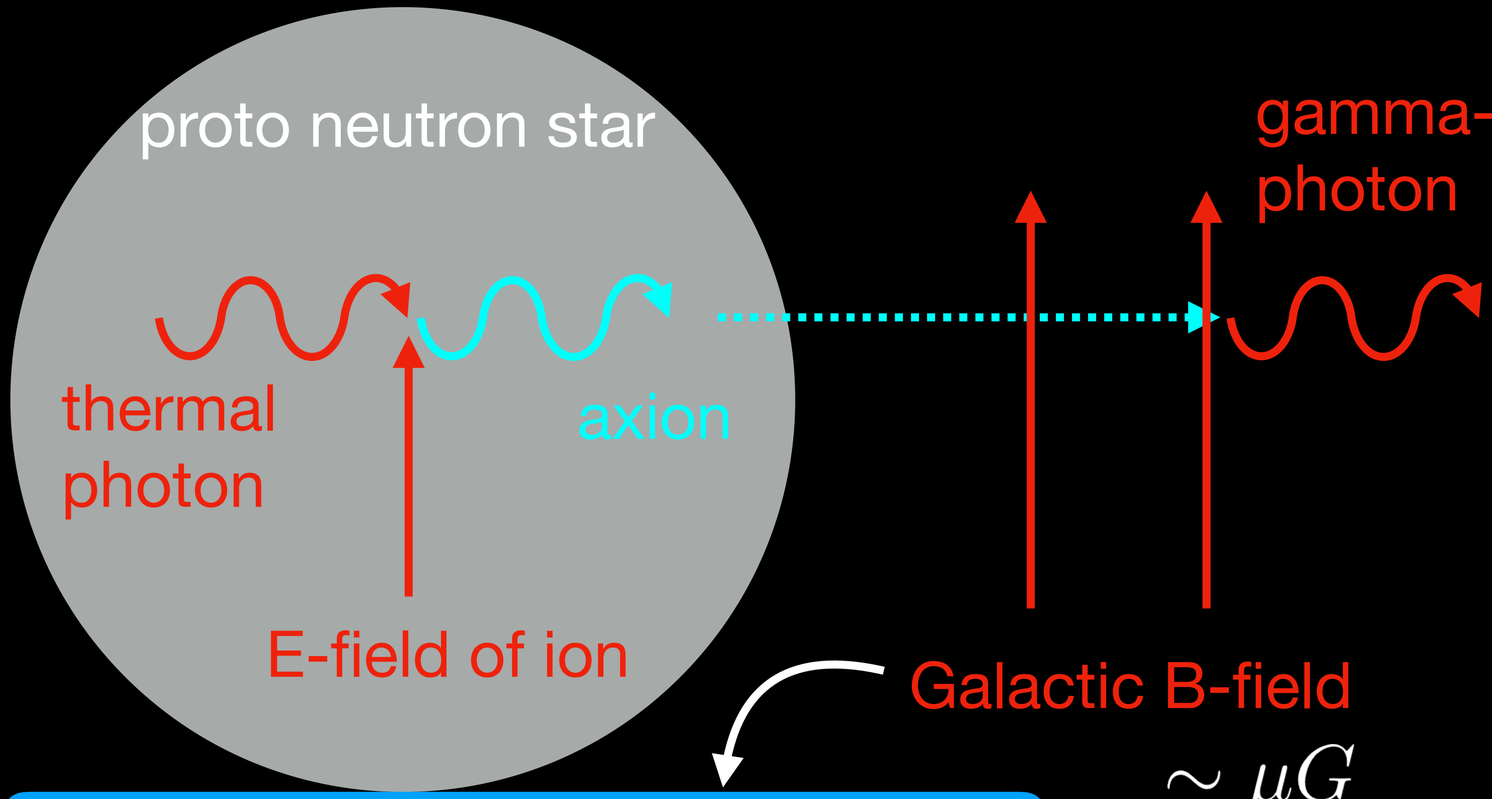
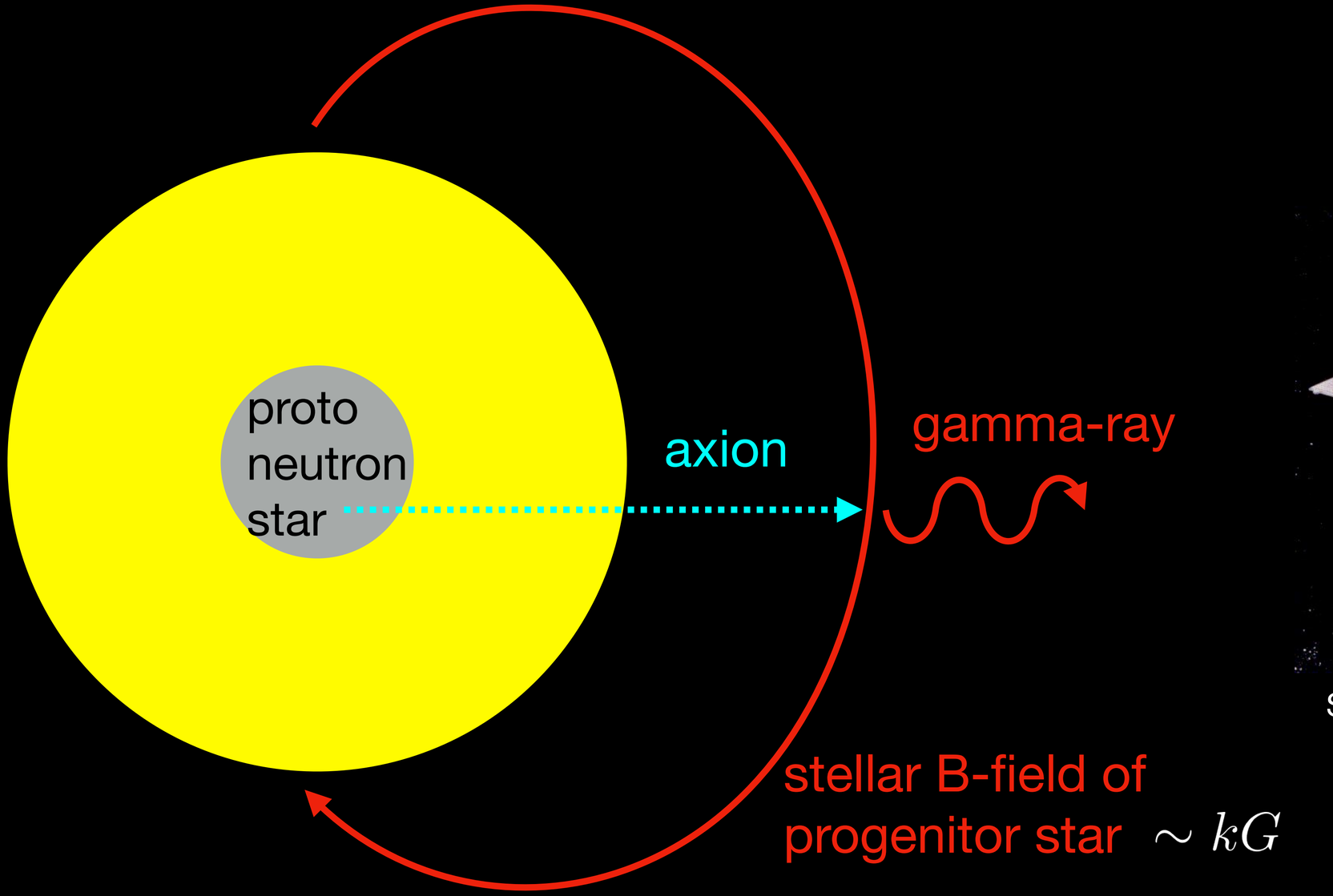


use stellar magnetic field instead?

Solar Maximum Mission (Wikipedia)

This work : axion conversion in stellar B-field



Solar Maximum Mission (Wikipedia)

This work : axion conversion in stellar B-field

conversion probability for SN1987A

$$P_{a\gamma} \sim g_{a\gamma\gamma}^2 B^2 L^2 \sim g_{a\gamma\gamma}^2 (1\mathrm{kG})^2 (45 R_\odot)^2$$

$$\sim 10^{-5} \left(\frac{g_{a\gamma\gamma}}{10^{-12}\mathrm{GeV}^{-1}} \right)^2$$

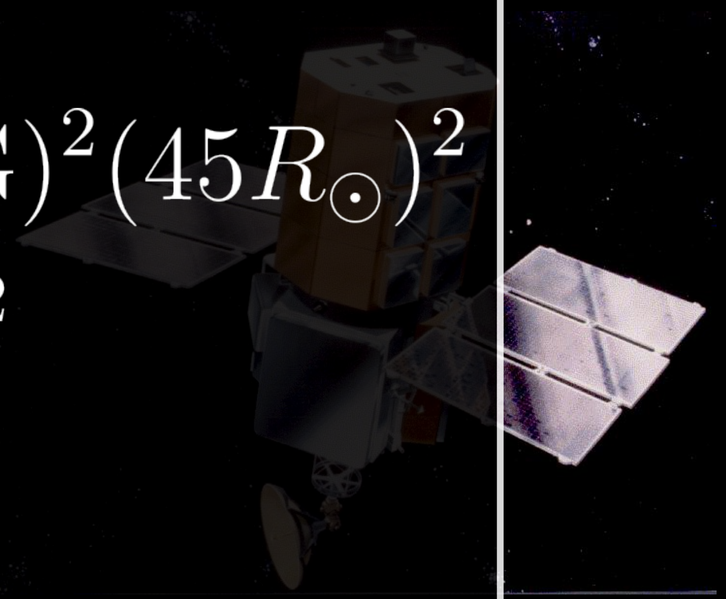
proto neutron star

axion

gamma-ray

→ comparable to galactic conversion probability

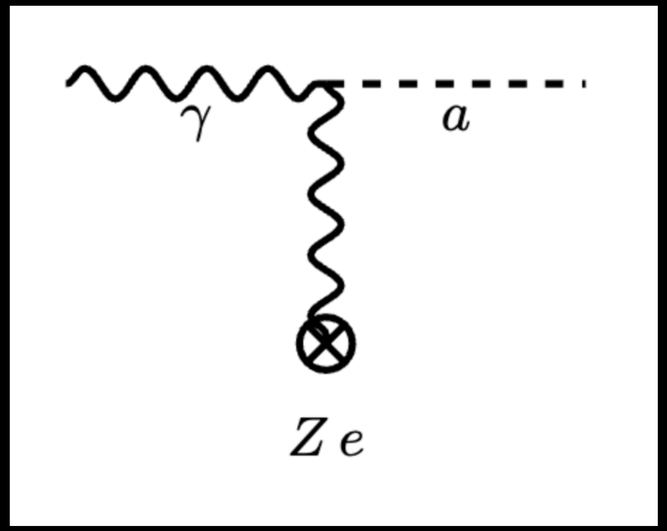
stellar B-field of progenitor star $\sim kG$



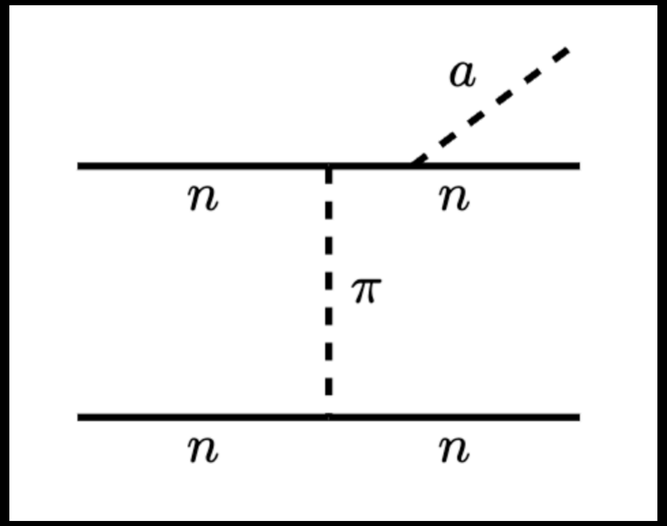
m Mission (Wikipedia)

Axion production mechanisms

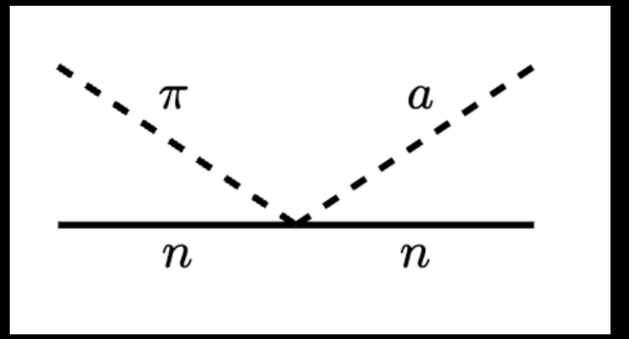
Primakoff

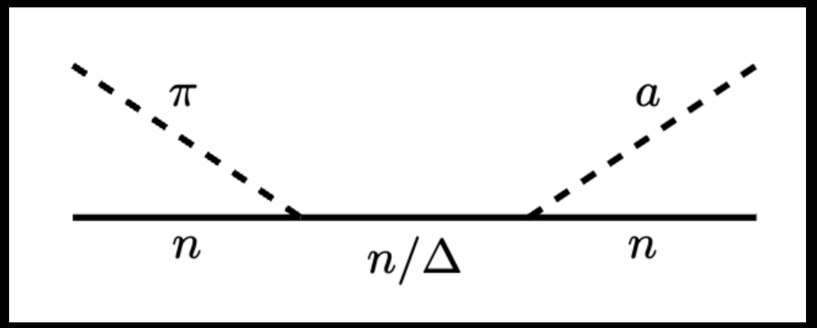


Nucleon Bremsstrahlung



Pion conversion





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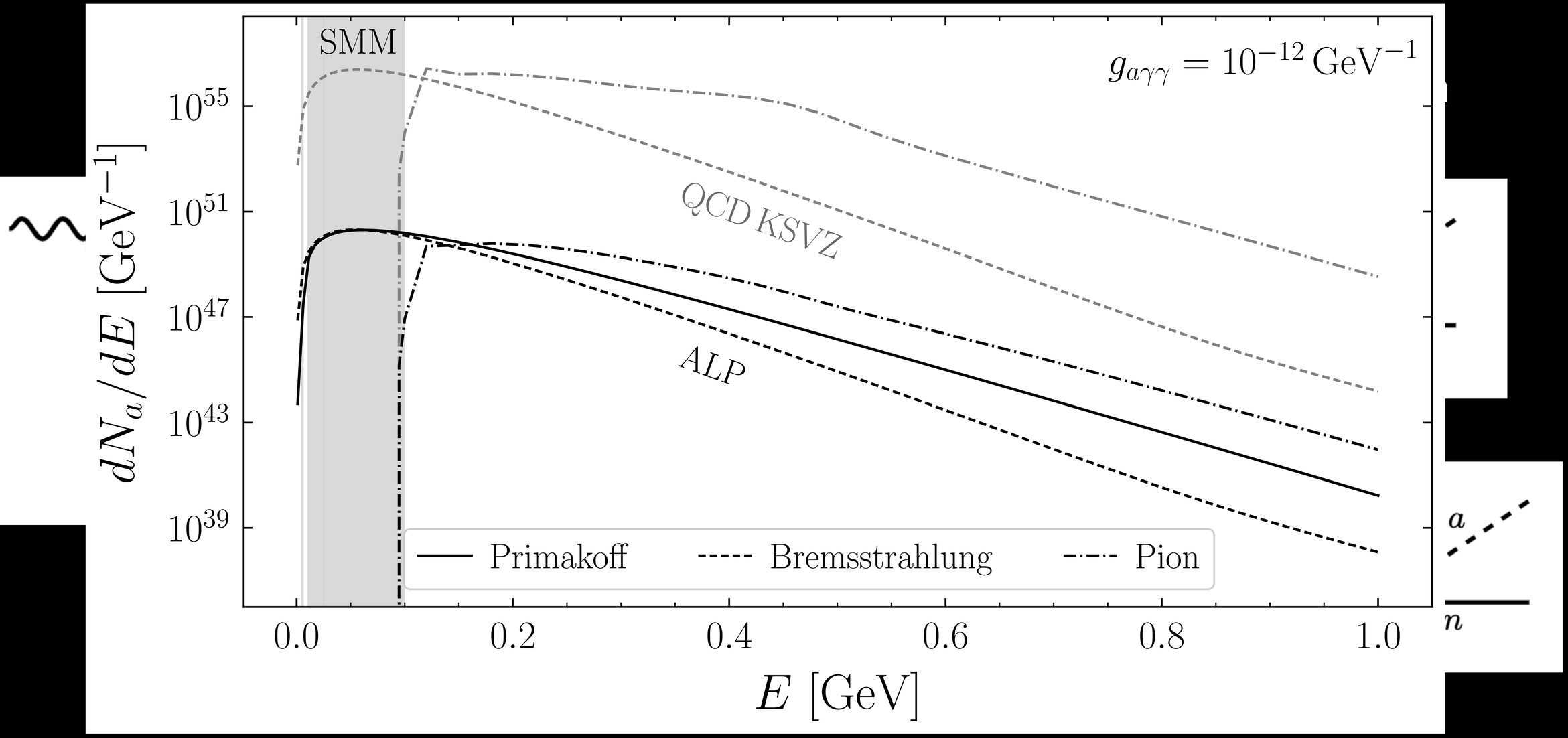

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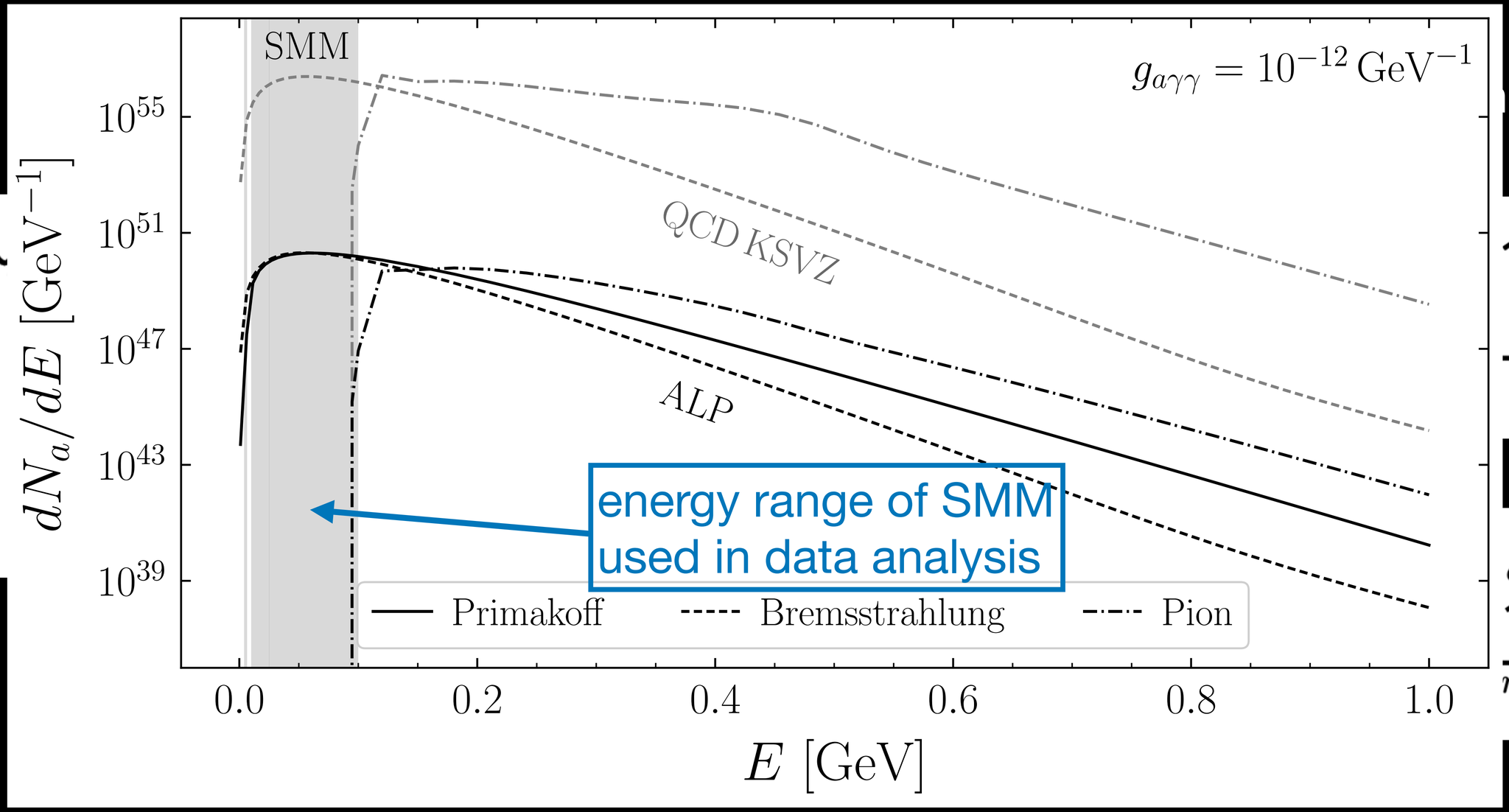

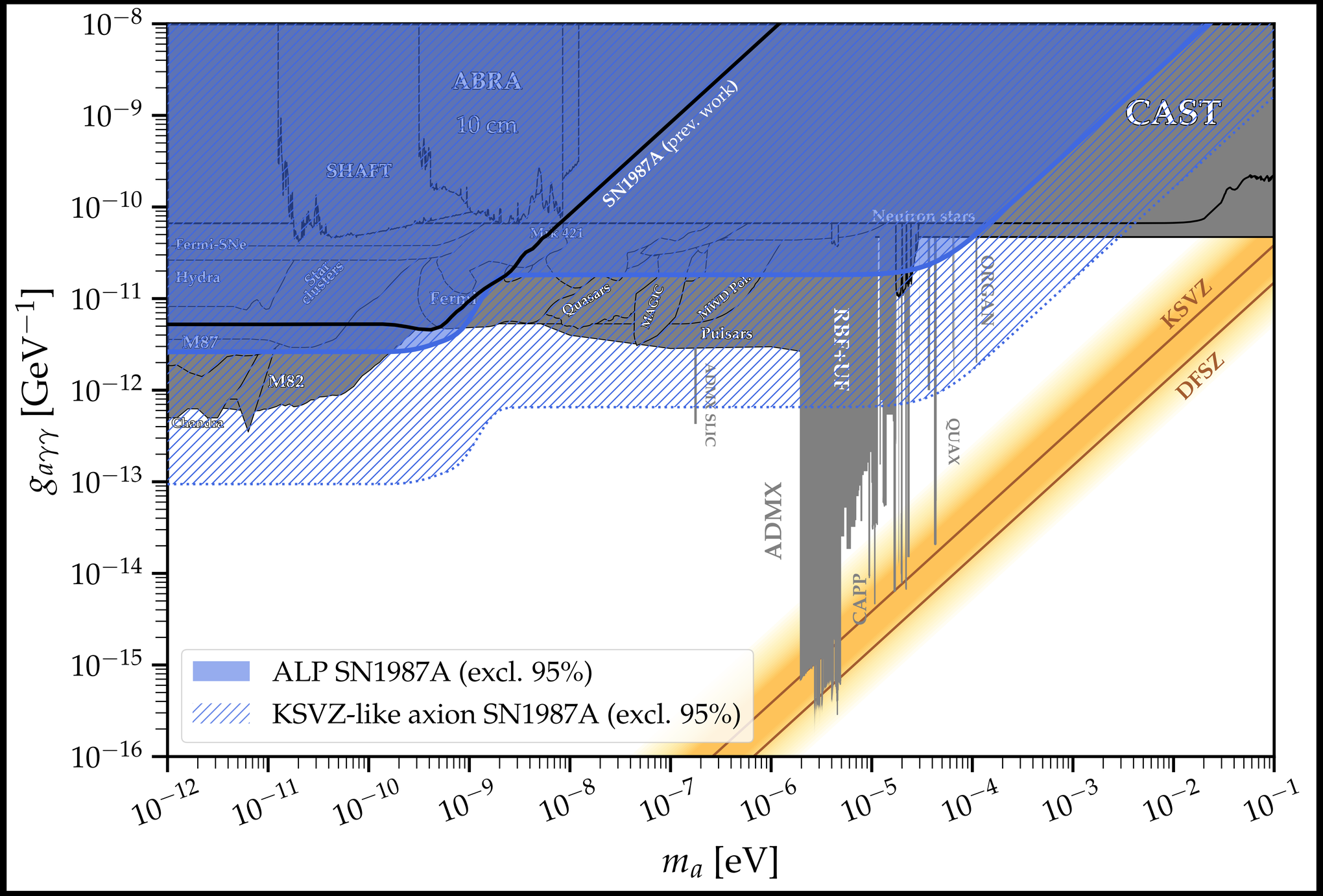
ABRA
10 cm
SHAFT
SN1987A (prev. work)
CAST
Neutron stars
Fermi-SNe
Hydra
Star clusters
Mrk 421
Fermi
Quasars
MAGIC
MWD Pol.
Pulsars
M87
M82
Chandra
ADMX SLIC
RBF+UF
ORGAN
QUAX
KSVZ
DFSZ
ADMX
CAPP
ALP SN1987A (excl. 95%)
KSVZ-like axion SN1987A (excl. 95%)
$g_{a\gamma\gamma}$ [GeV^{-1}]
m_a [eV]
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10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
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10^{-9}
10^{-8}
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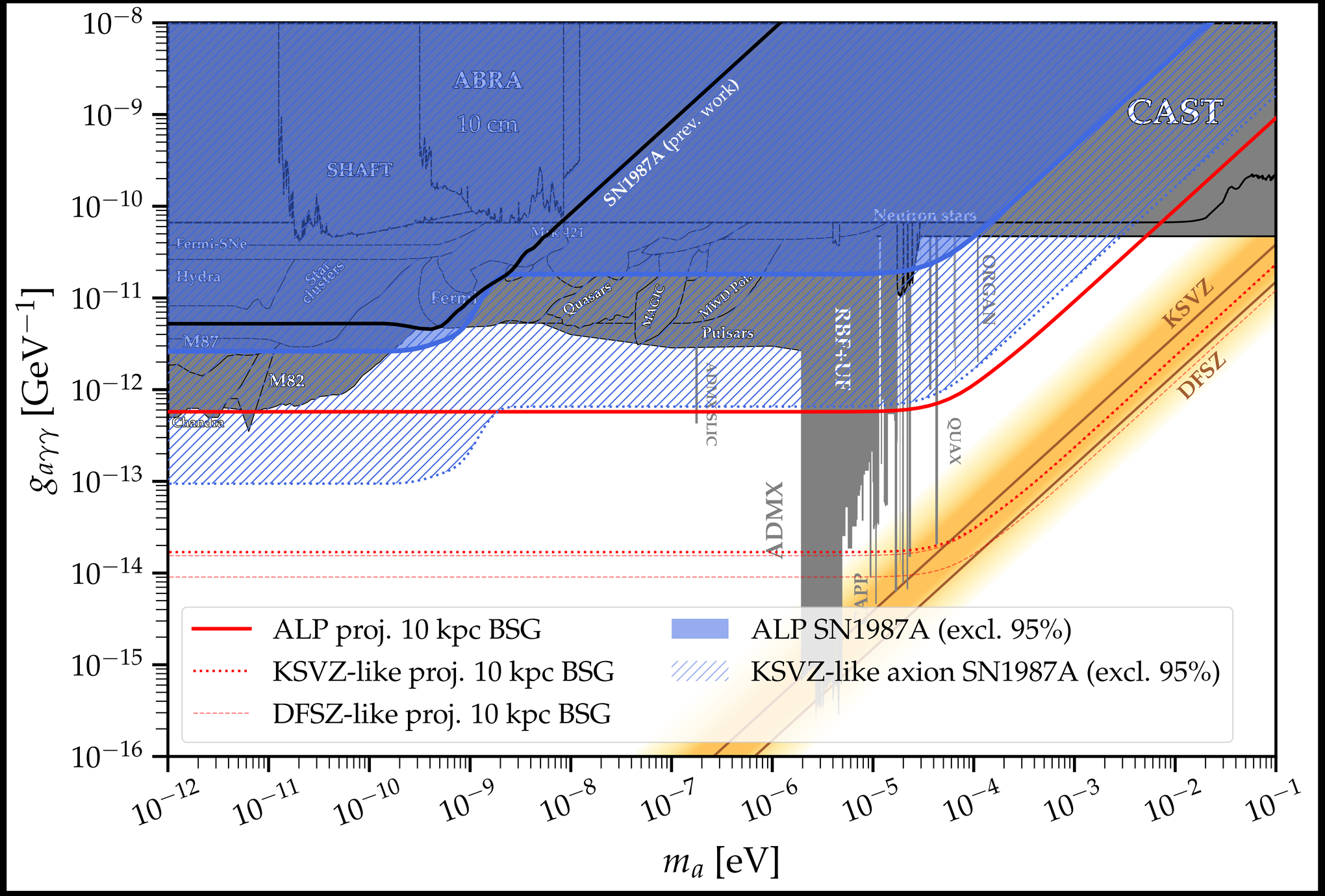
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}

Future galactic supernova observation?

- Galactic supernova rate : 1 in every ~100 yrs
  → could occur very soon!

- Would we observe this?
  → unlikely due to Fermi-LAT observing portion of the sky at a time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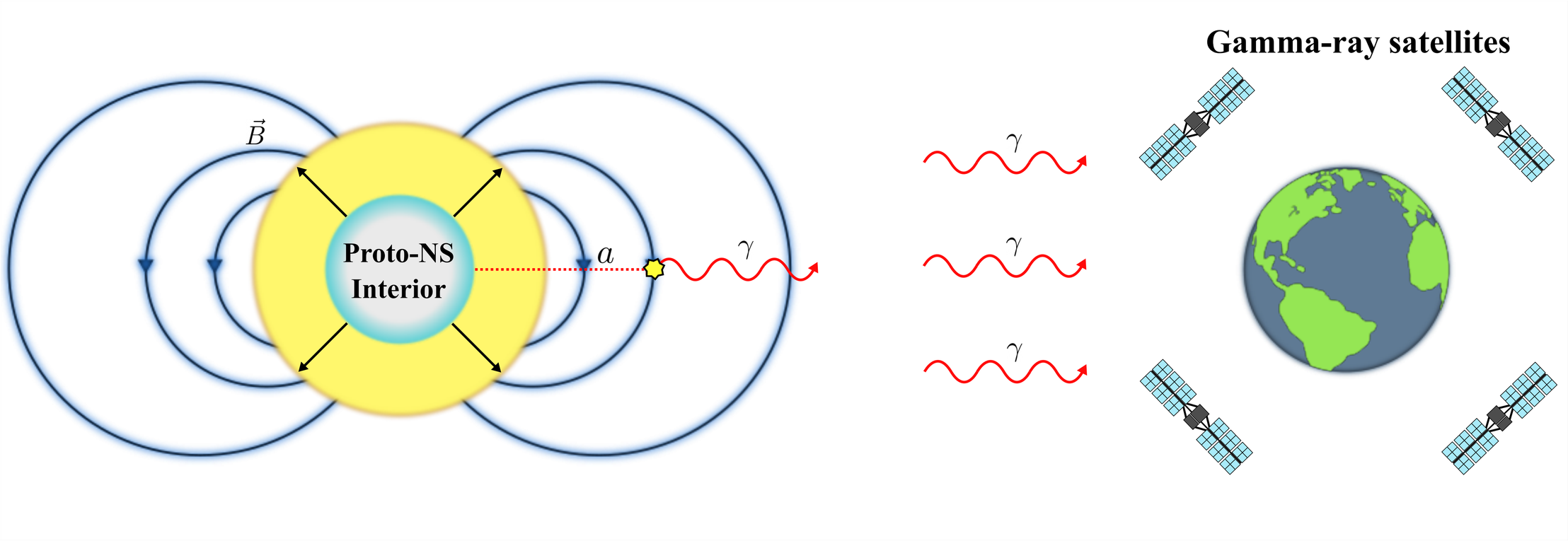
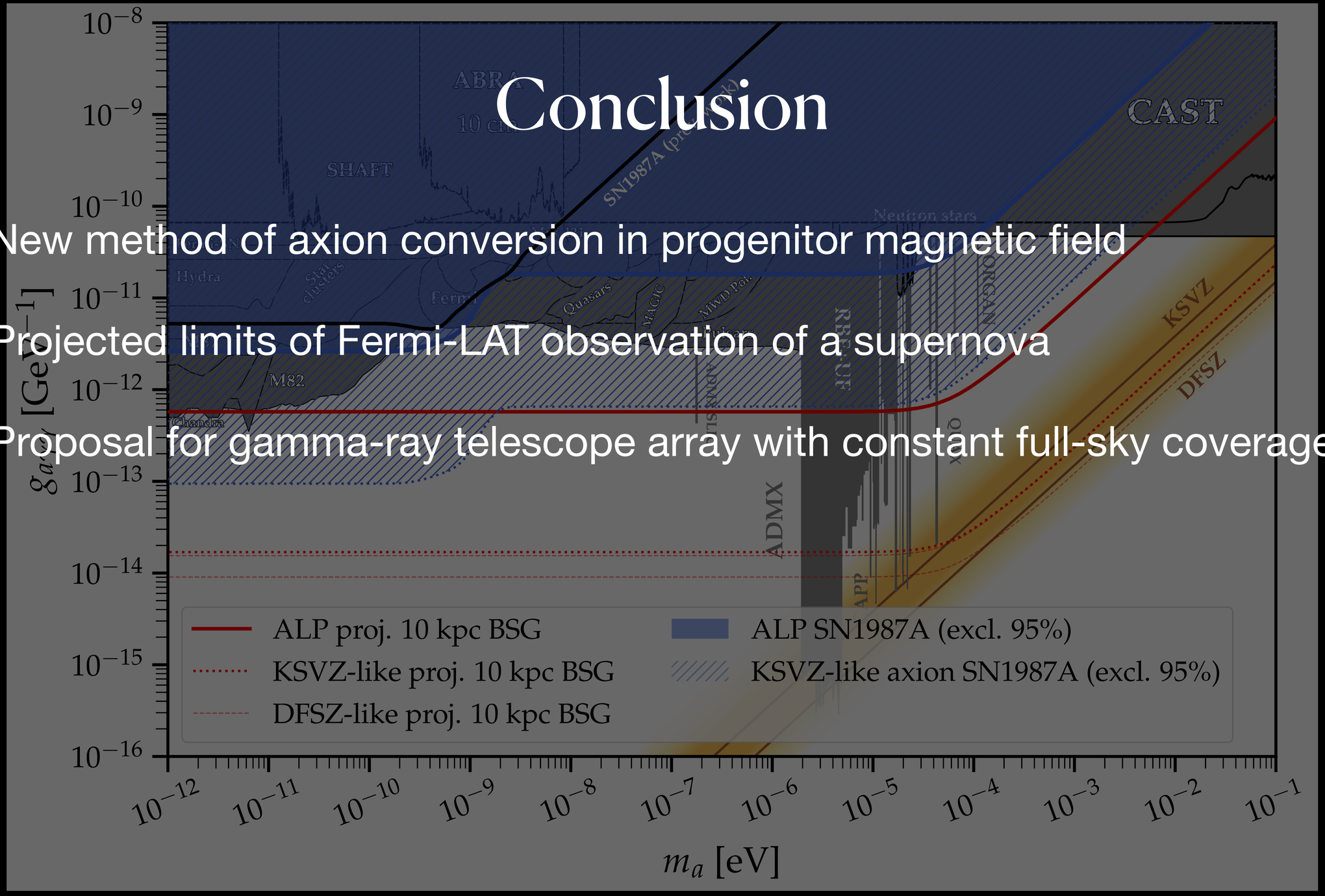
Proposal

Constellation of small satellites for continuous, full-sky ~100-500 MeV gamma-ray detection



Conclusion

- New method of axion conversion in progenitor magnetic field
- Projected limits of Fermi-LAT observation of a supernova
- Proposal for gamma-ray telescope array with constant full-sky coverage