Cosmic Frontier Dark Matter Strategy

Aaron S. Chou for Snowmass 2021 Cosmic Frontier

7/21/2022

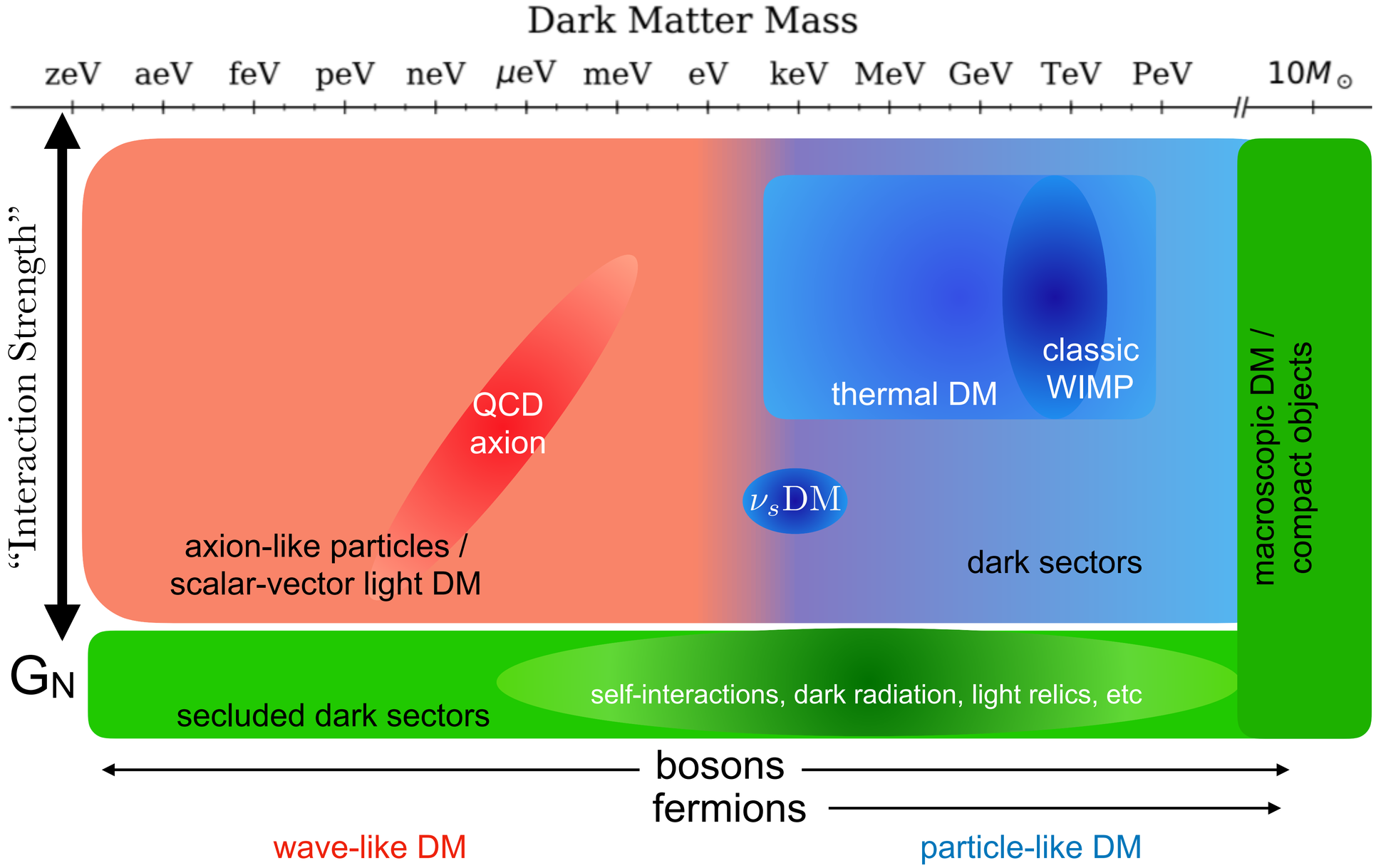
Dark Energy Camera image

dark matter
experiment
particle
detector
measurement
search
model
data
Interest
Standard Model
development
program
system
including
background
searches
precision
test
number
based
source
photon
coupling
additional
important
allow
probe
limit
single
light
application
low
method
studies
cross section
time
future
possible
expected
target
project
National Laboratory
current
many
beyond
LHC
enable
effect
resolution
increase
effort
event
work
cosmic ray
observation
result
require
shown
technology
constraint
production
process
level
order
large
sensitivity
potential
used
analysis
simulation
detection
include
electron
decay
field
different
example
Science
Reference
Snowmass
University
Department
Cosmic Acceleration
Snowmass LOI Word Cloud
by Gordon Watts

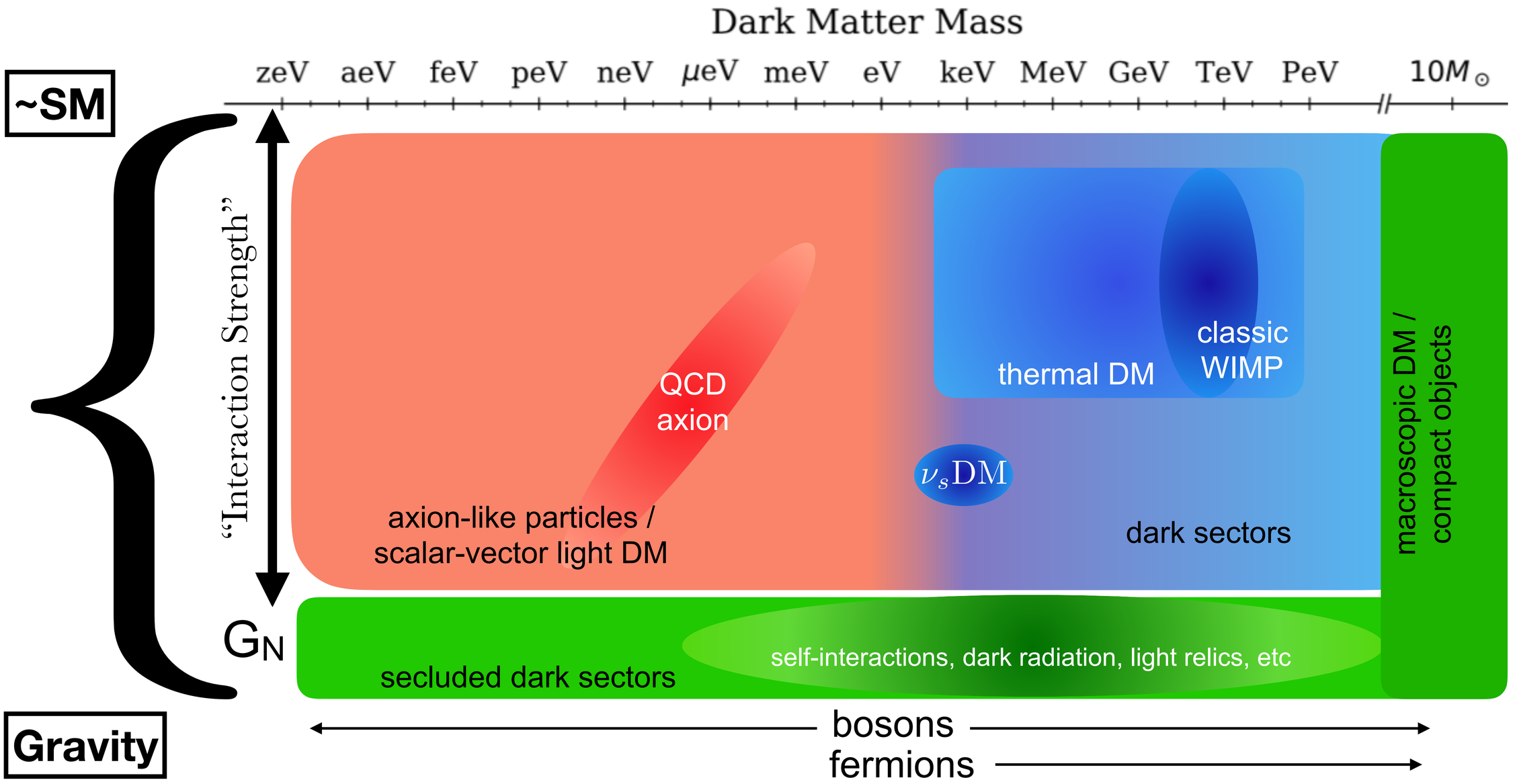
Dark Matter Strategy

- **Dark matter poses a profound and exciting challenge to our understanding of fundamental physics.**
- **Maximize the probability of discovery**
  - **Delve Deep:** Fully explore high-priority theoretical target regions (e.g., WIMPs and QCD axions).
  - **Search Wide:** Deploy new techniques and pathfinder experiments to access unexplored dark matter scenarios and lay the groundwork to go deep on future targets.
- **Dark Matter Crosses Boundaries:** Complementarity across frontiers including a vibrant theory program is critical for the discovery and characterization of dark matter and dark sectors.

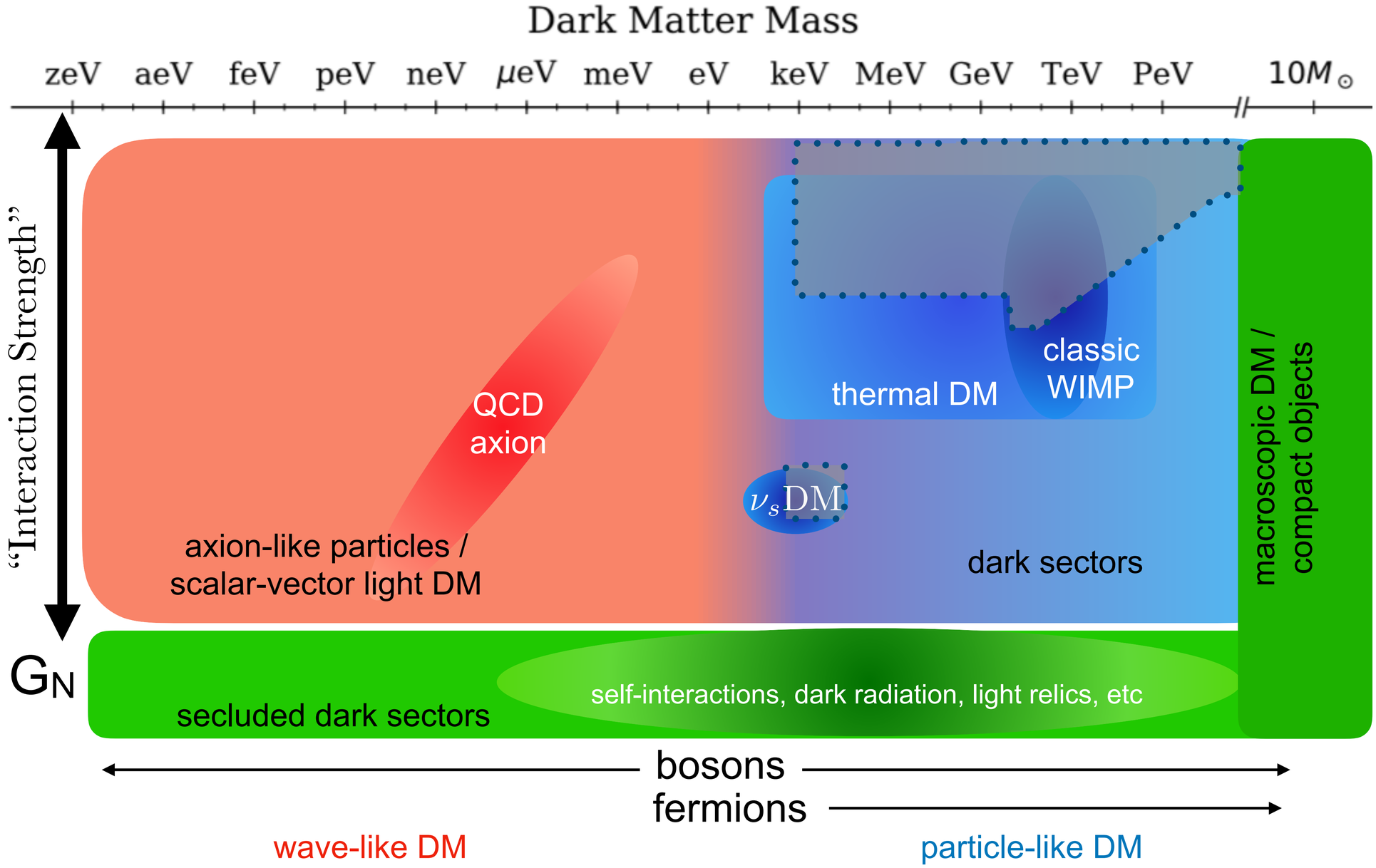
The range of DM masses being studied seriously by the community spans many orders of magnitude



Possible interaction strengths range from the scale of the standard model to the scale of gravity



Above ~1 eV, use sensitive detectors to search for the scattering, absorption, decay, and annihilation of particle DM



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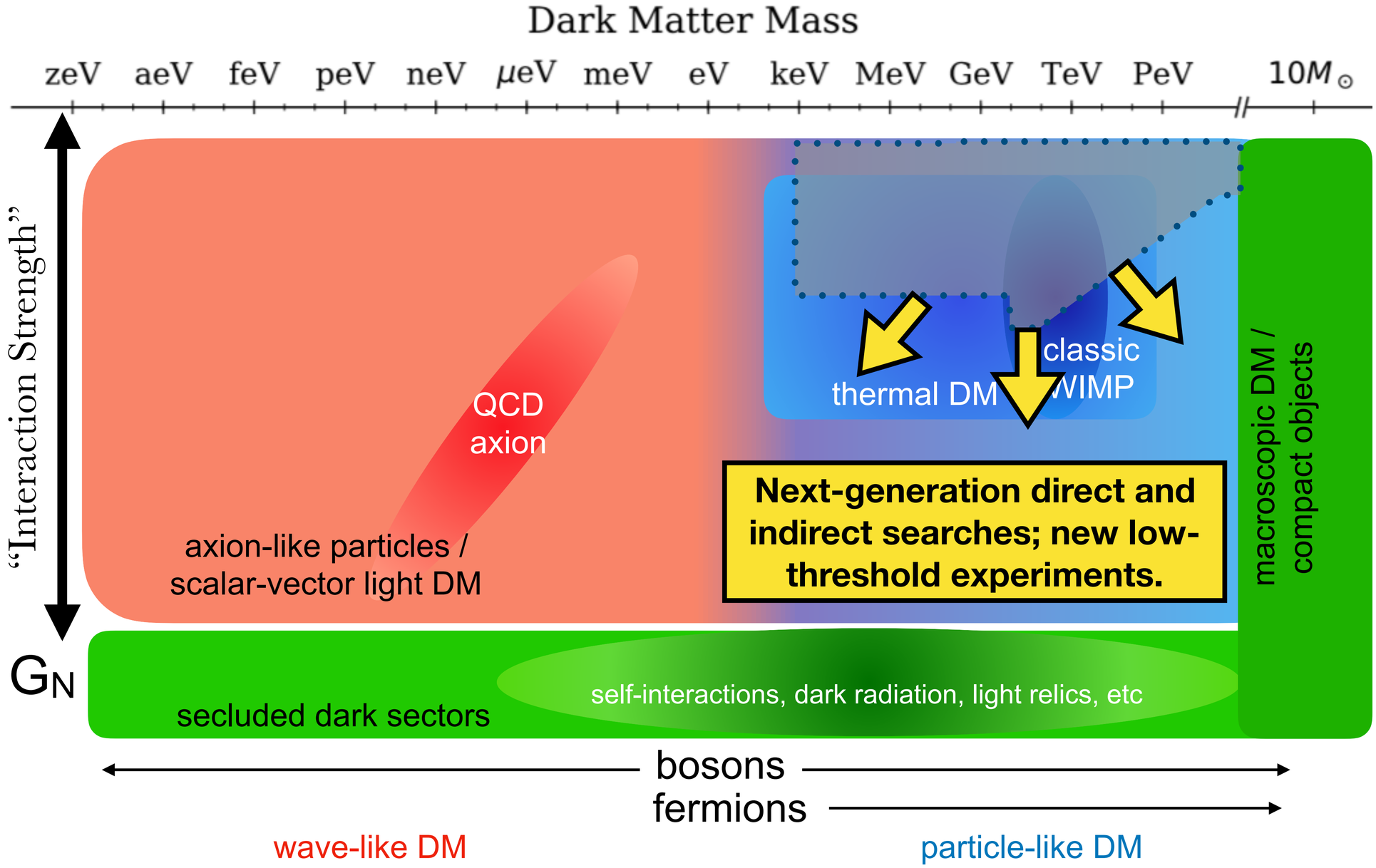
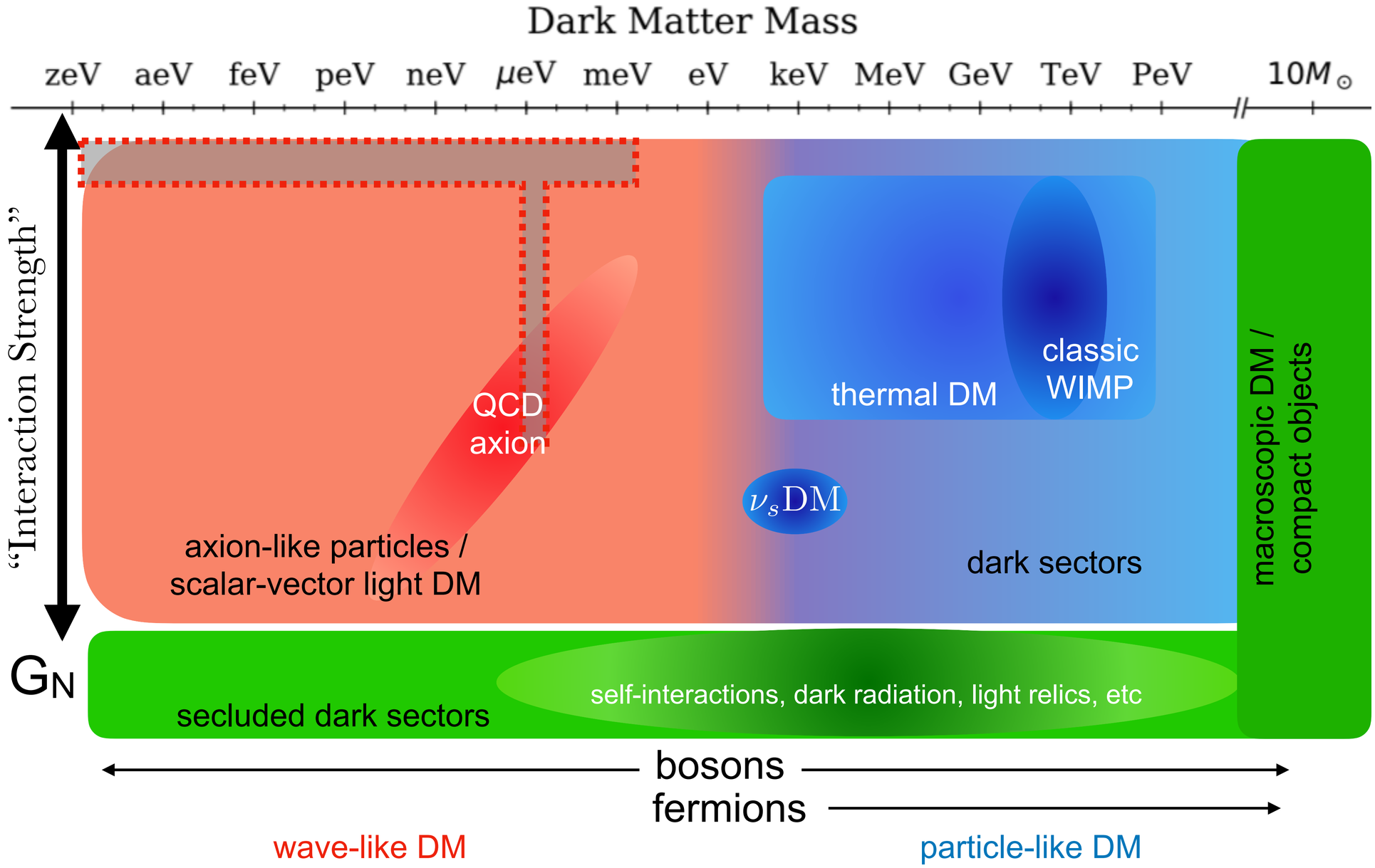


Below ~1 eV, use quantum sensing techniques to detect feeble forces exerted by wave-like DM.



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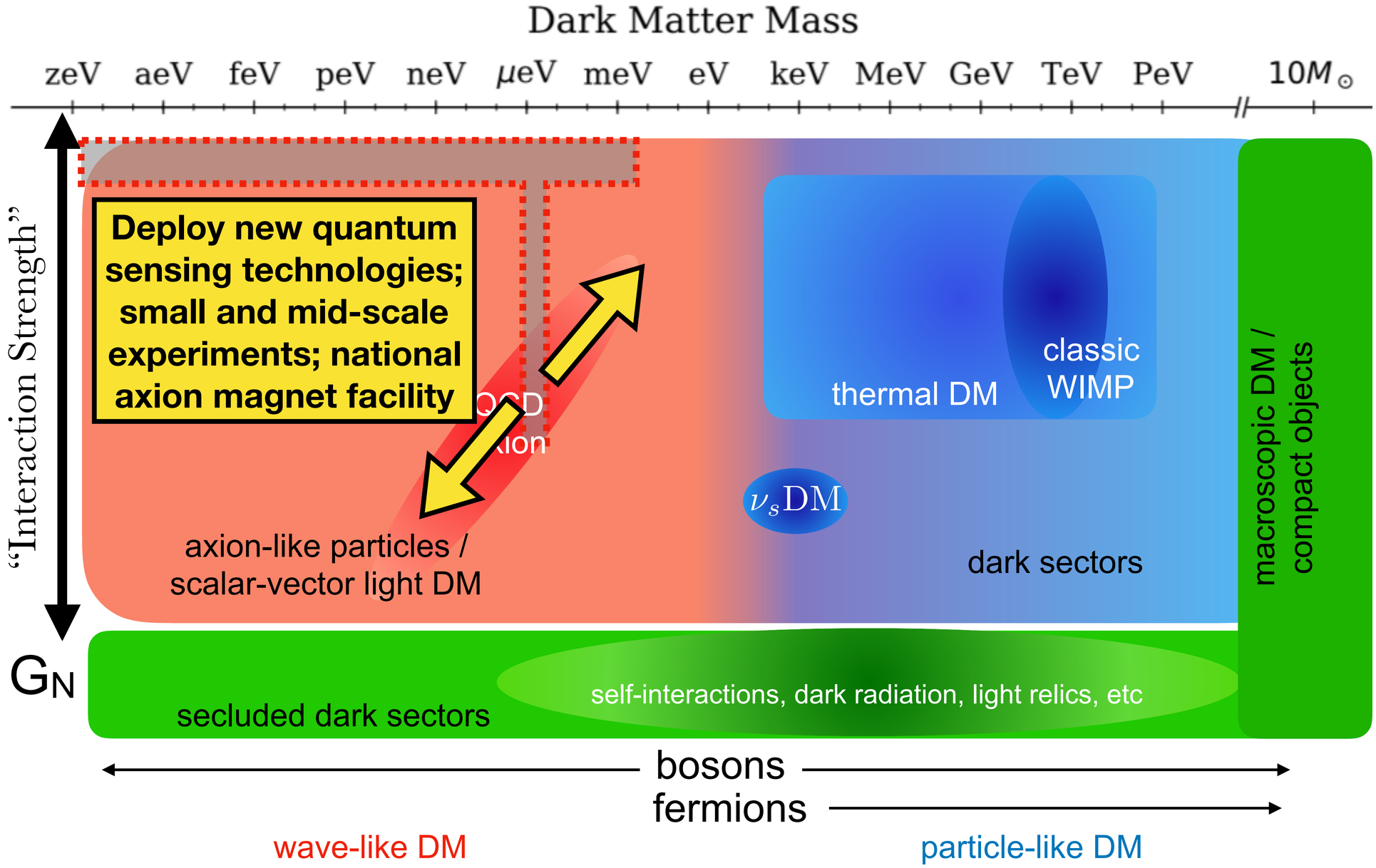
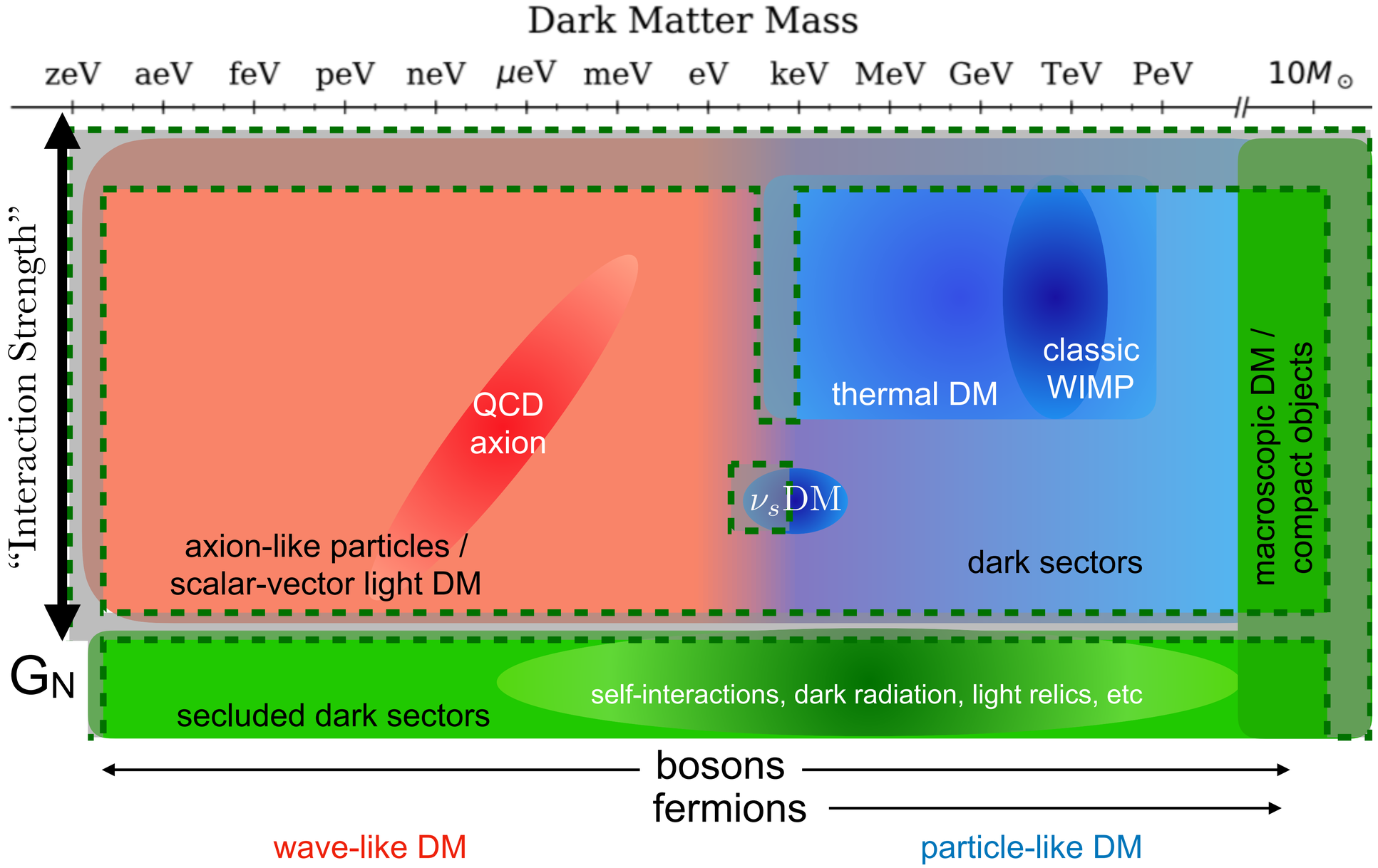
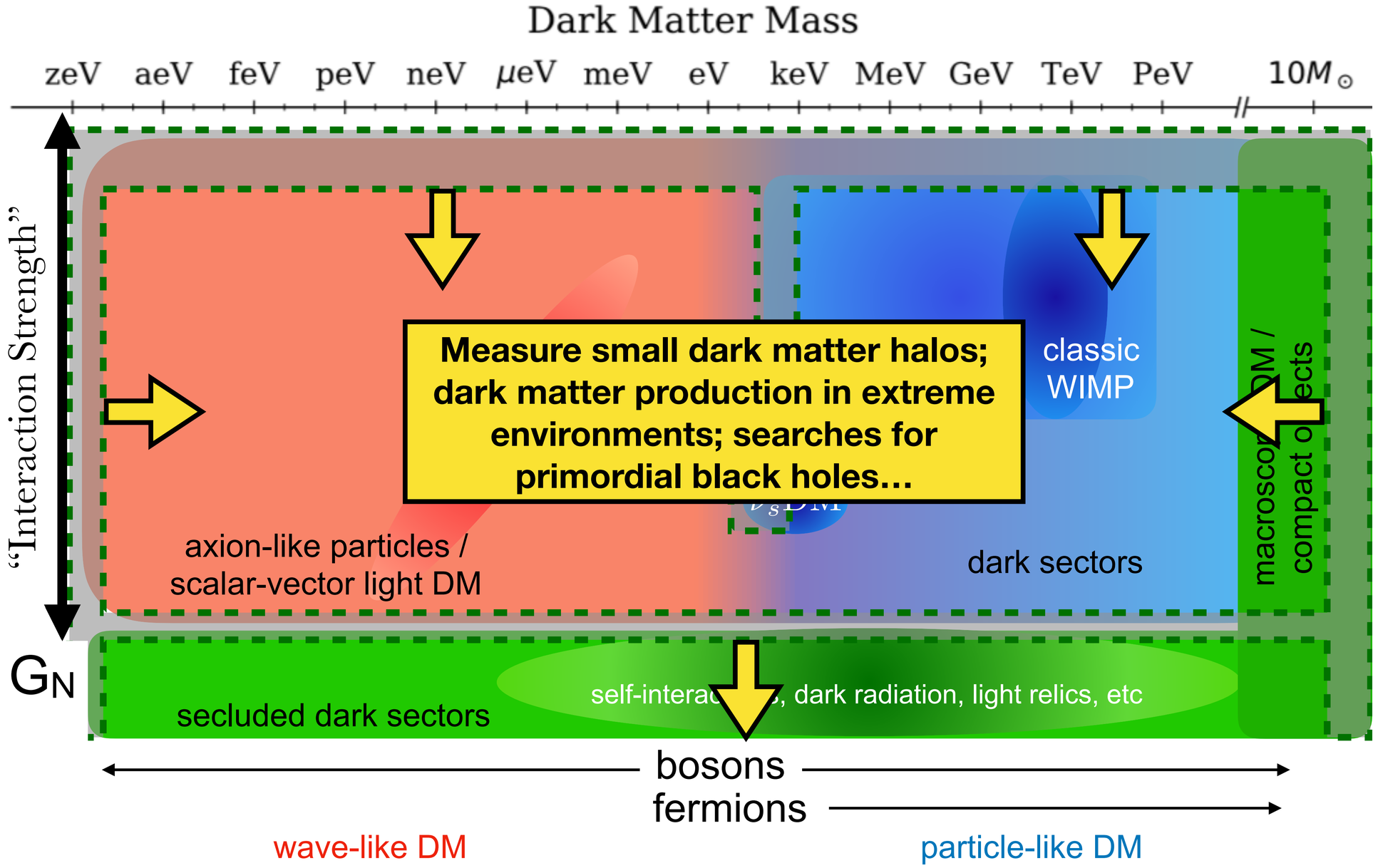


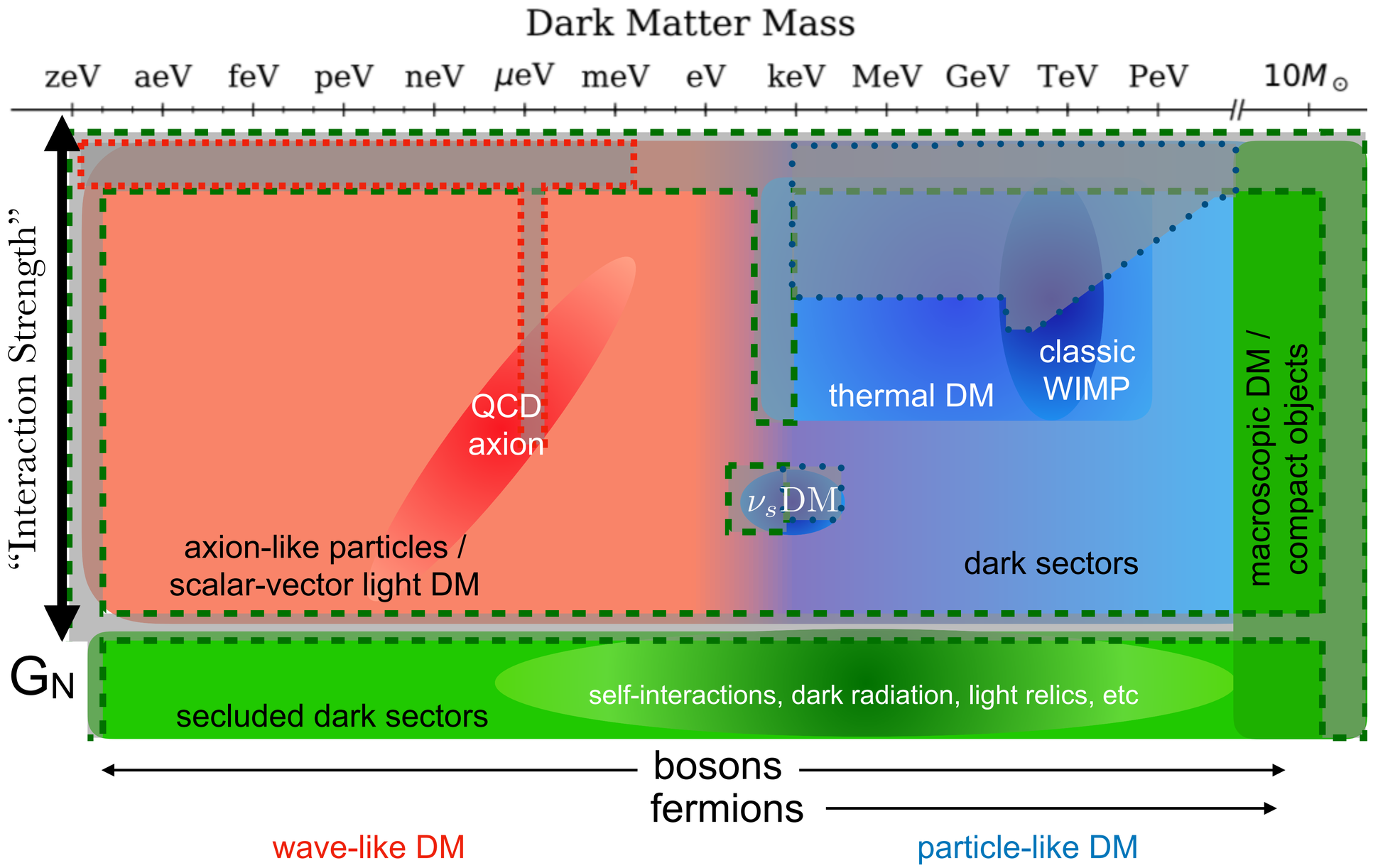
Cosmic observations can detect DM interactions in extreme environments and through gravity alone.



Cosmic probes from telescopes can detect DM interactions in extreme environments and through gravity alone.

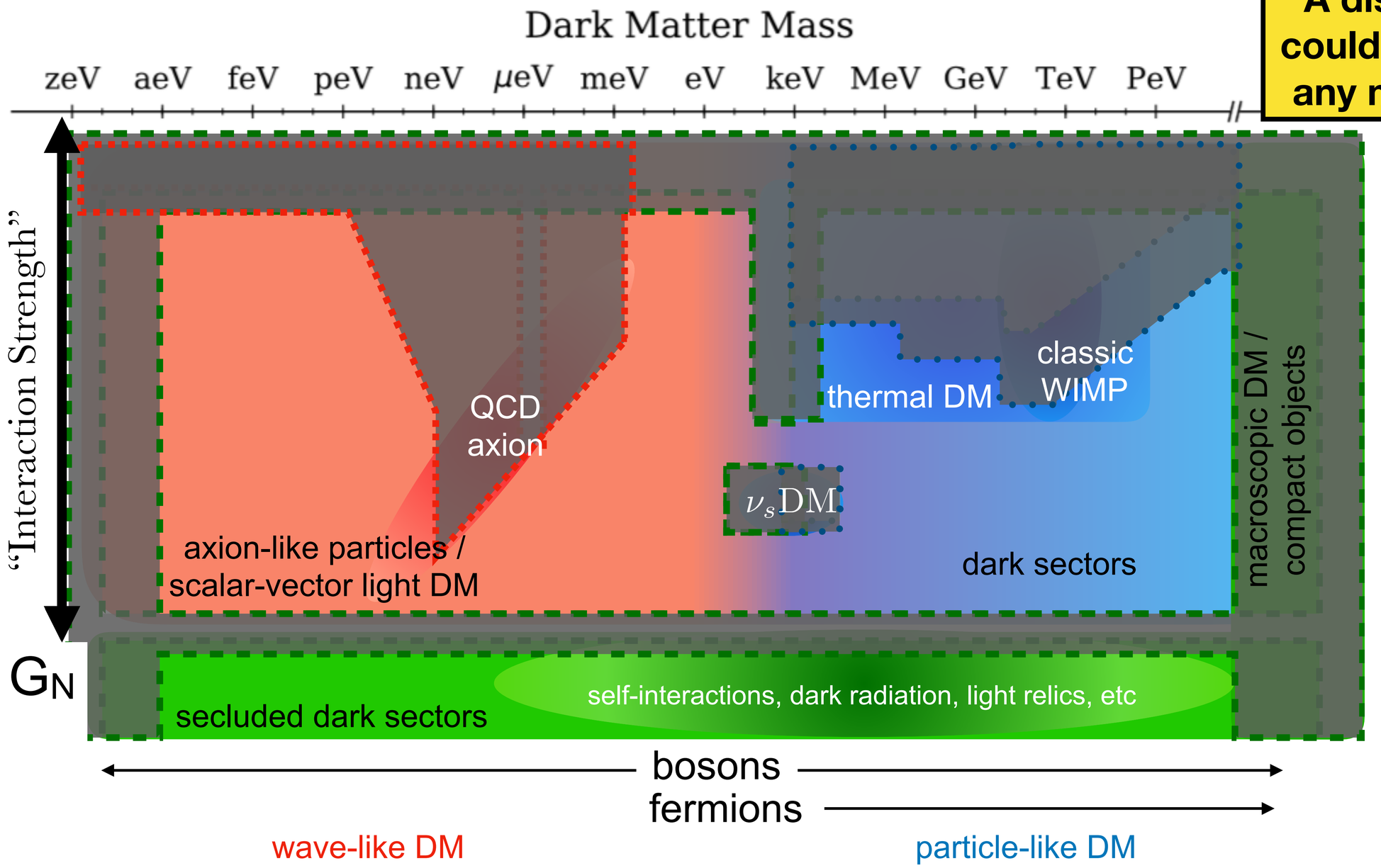


Delve Deep, Search Wide!



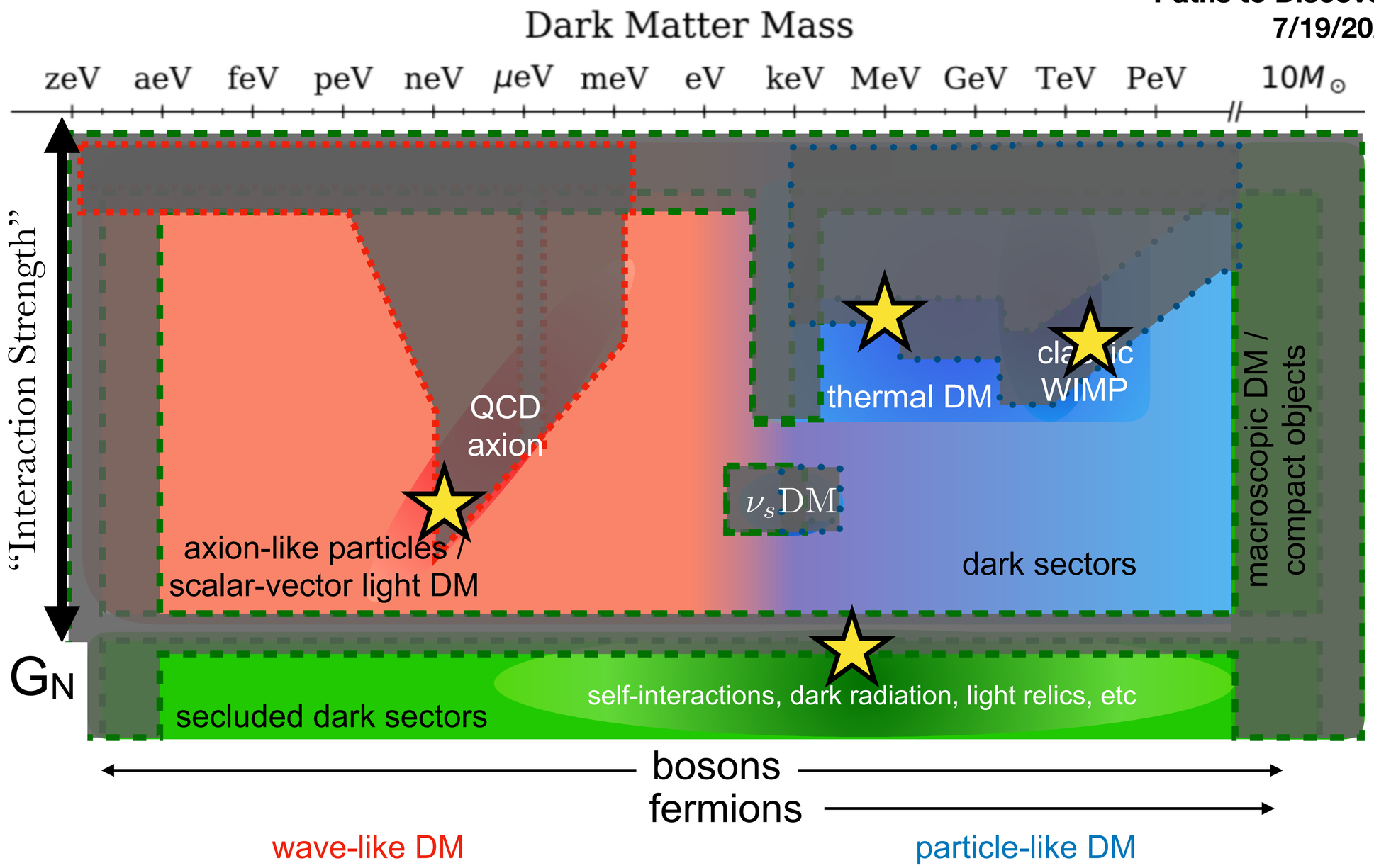
By the next Snowmass—broad coverage including high priority target regions.

A discovery could come at any moment!



Or multiple discoveries in a rich dark sector!!!

cf. Tracy Slatyer and Risa Wechsler's talks from "Paths to Discovery" Session 7/19/2022



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Additional Slides

Community Priorities

- **CF1: Dark Matter Particle-Like**
  - **Particle dark matter has strong theoretical motivation with tremendous discovery opportunity.**
  - **Support for a diversity of experimental scale and technique maximizes the probability of discovery.**
  - **Understanding how signals and backgrounds manifest is essential to enable discovery.**
- **CF2: Dark Matter Wave-Like**
  - **Definitive search for the QCD axion.**
  - **Pursue a theory and pathfinder program to elucidate the opportunities beyond the QCD axion.**
- **CF3: Dark Matter Cosmic Probes**
  - **Support cosmic searches for dark matter with current/near-future cosmic surveys**
  - **Future cosmic surveys are critical for expanding our understanding of dark matter**
  - **Theory, simulation, observation and experiment must be supported together to maximize the efficacy of cosmic probes.**