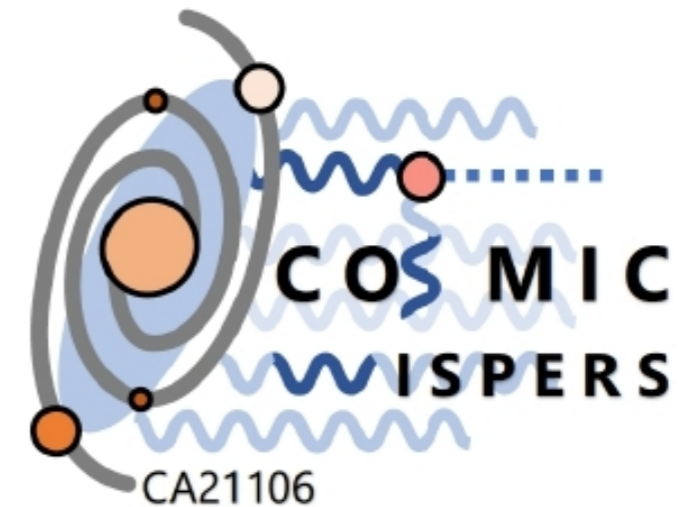


WG3 Report

Astrophysics goals and challenges

*Maurizio Giannotti,
Universidad de Zaragoza & CAPA
Barry University*



2nd General Meeting of COST Action COSMIC WISPerS
3-6 September, 2024

The WG3 at Glance

~130 Participants

Group Leader: Maurizio Giannotti mgiannotti@unizar.es

Deputy Group Leader: Oscar Straniero oscar.straniero@inaf.it

Mailing List wispers_wg3@inaf.it

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Large overlap with WG2, Dark Matter and Cosmology

→ Edoardo Vitagliano & Marco Gorghetto

Objectives

- Study the impact of WISPs in astrophysics,
- Identify observables
- Identify opportunities
- Cross Working Groups discussions to clarify the possible detection strategies
- Clarify the next generation needs to detect astrophysics WISP signatures
- Promote a roadmap to proceed with our tasks

Objectives

Objectives: promote the studies of the **signatures of WISPs in astroparticle physics** and facilitate the creation of networks to tackle these problems

- WISP oscillations into photons,
- WISP-induced energy loss in stellar systems
- WISP fluxes from astrophysics and experimental sensitivity to detect them (→ connection to WG4)
- signatures from gravitational waves and from primordial black-hole superradiance
- Astrophysical signatures of DM WISPs (e.g., DM ALP conversion in B) → connection to WG2
- Selection of models with specific properties of astrophysical relevance (e.g. Astrophobic models, photophilic models, etc.) → connection to WG1
- ...

Our work

1- Monthly meetings

Offer opportunities for (mostly) young researchers to present their work and to discuss their findings with the larger community.

Create networks.

2- Preparation of the White Paper

3- Planning of small workshops

4- Preparation of pedagogical materia

Currently, under discussion

Monthly Meetings

All the material is available at the → [WG3 Agenda](#)

Among the material discussed:

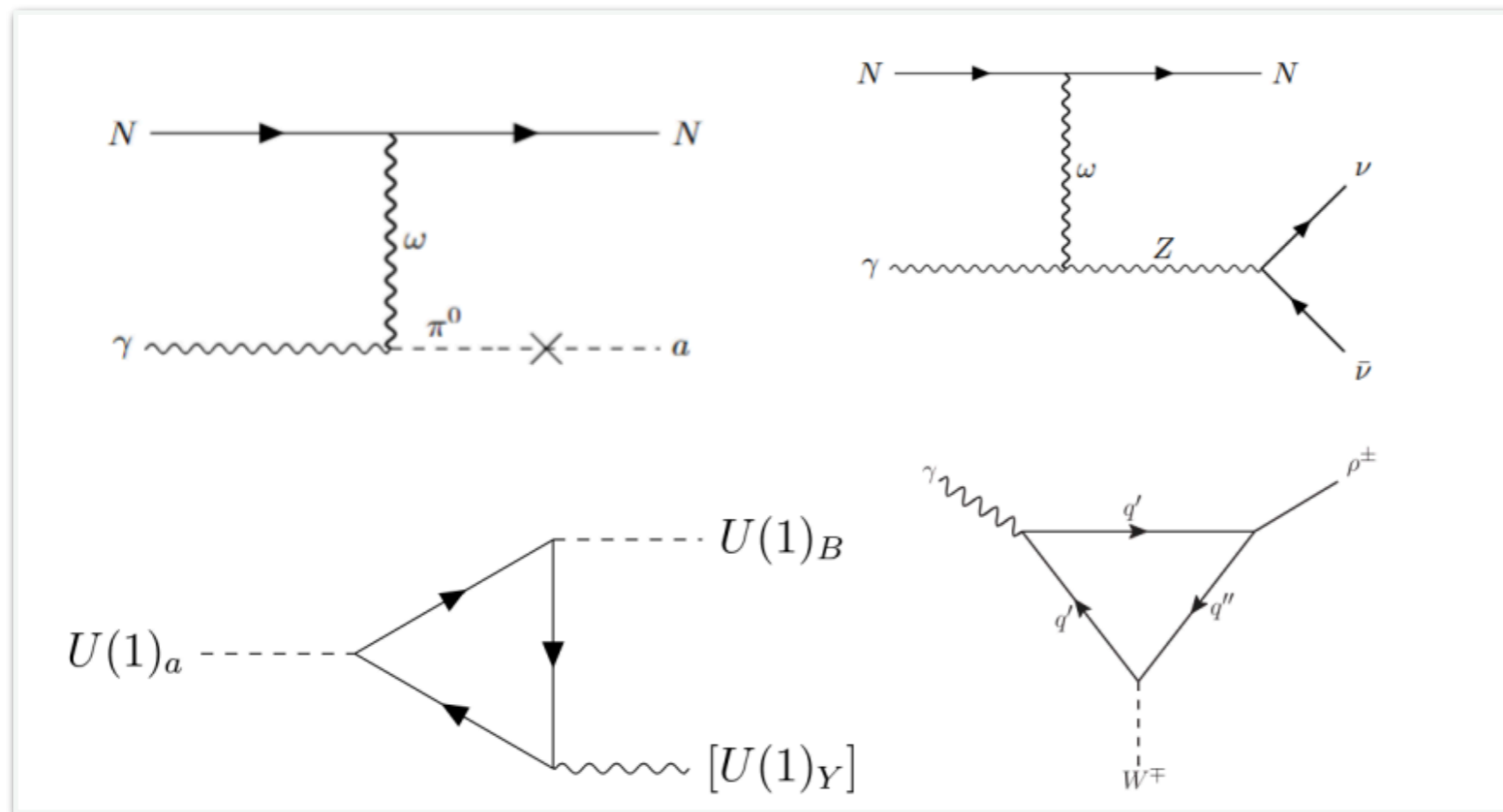
- Supernova Axions, new production mechanisms and new challenging
- Preparation of a workshop on Dynamical Tracers of the Nature of Dark Matter

Monthly Meetings

All the material is available at the → [WG3 Agenda](#)

New axion production channels in SN

Talks by Miguel Vanvlasselaer
and Diego Guadagnoli



Monthly Meetings

All the material is available at the → [WG3 Agenda](#)

New axion production channels in SN

Next meeting in October.

Antonio Gomez will present a talk on on “new bound on light QCD axions using neutron star cooling”.

COST White Paper

General overview of WISP Physics

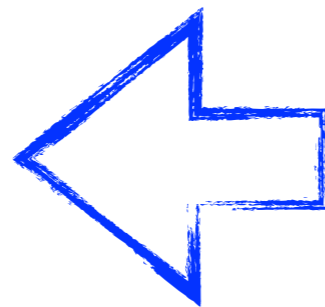
4 sections:

1.Theory

2.Cosmology

3.Astrophysics

4.Experiments



COST White Paper

Astrophysics Section

1 Astrophysical Sources and Related bounds

- Solar production
- Stellar production
- Compact Objects/final stages/Death
- Conversion of DM WISPs in magnetic fields
- Extragalactic sources

2 Astronomical Technology and Opportunities

- From radio to millimeter
- High Energy
- Other Messengers

COST White Paper

Astrophysics Section

1 Astrophysical Sources and Related bounds

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As of today, we have collected 11 contributions!

Networking

Short term missions

Alessandro Lella visited the University of Zaragoza to help with the proposal of an MeV detector for IAXO

Networking

Summer School in Ljubljana

Francesca Calore presented a set of lectures on
→ High Energy Astrophysics

Tutor Christopher Eckner

2023 Edition

Raffelt: lectures on stellar astrophysics

Tutor Andrea Caputo

See → [Lecture Notes](#)

Online Workshop Proposal

Dynamical Tracers of the Nature of Dark Matter

Organized (mostly) by María Benito and Diego Blas

Abstract: The empirically allowed properties of dark matter, such as its mass (e.g., ultra-light, axions, WDM-like, WIMP-like, PBHs) or interaction type (FDM, SIDM, CDM), lead to distinctive features in galactic dynamics. This online workshop aims to deepen the research on leveraging galactic dynamics as a tool for probing the nature of dark matter, with a particular emphasis on understanding how particular dynamical tracers in galaxies can be used to constrain specific properties of dark matter.

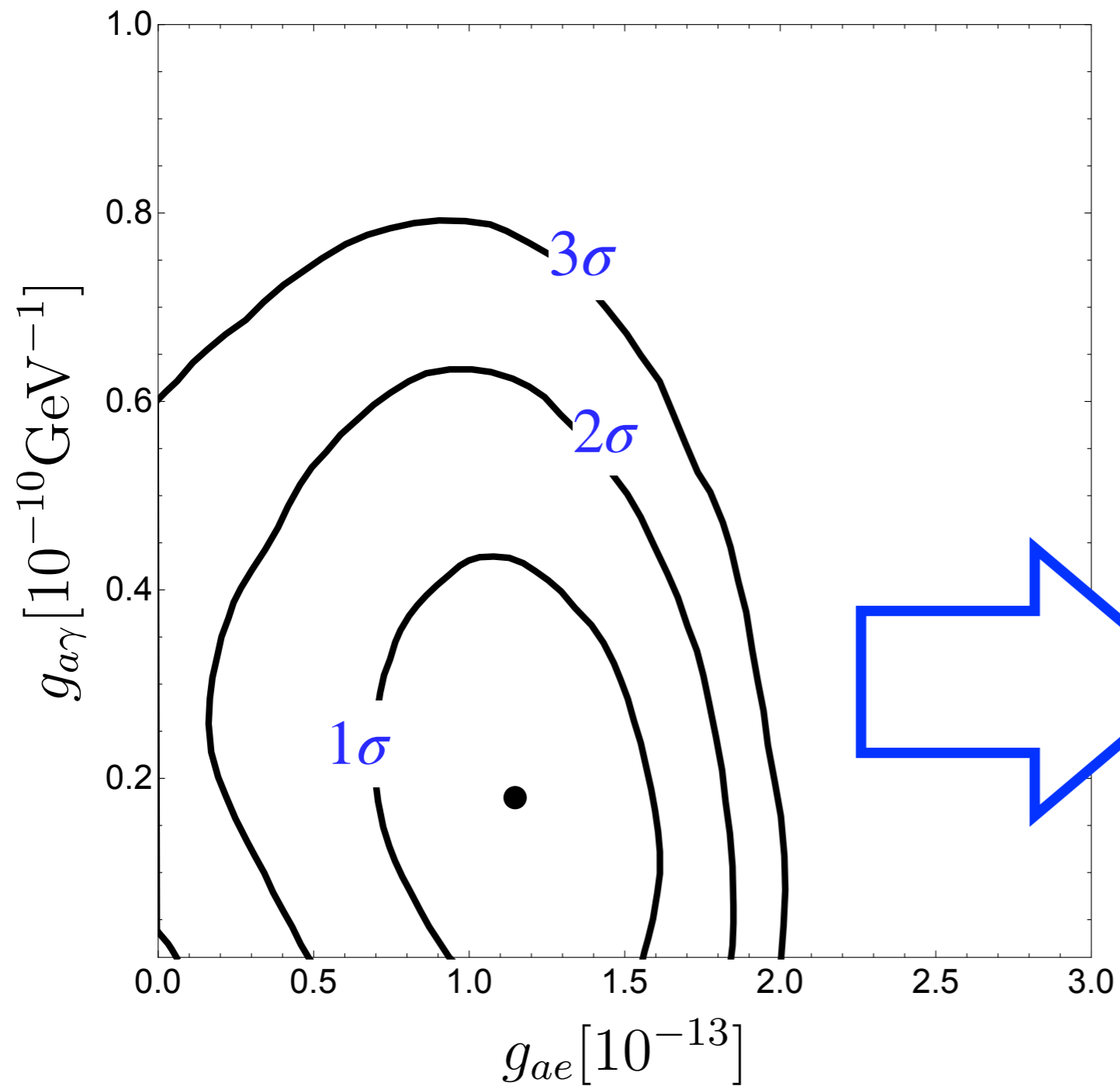
Format: 2 days: 3 invited talks per day [30 min (questions for the discussion session)] + 1 hour discussion. Total duration per day: 2:30 h.

Probably in March 2025



Large Overlap with WG2

The Road Ahead



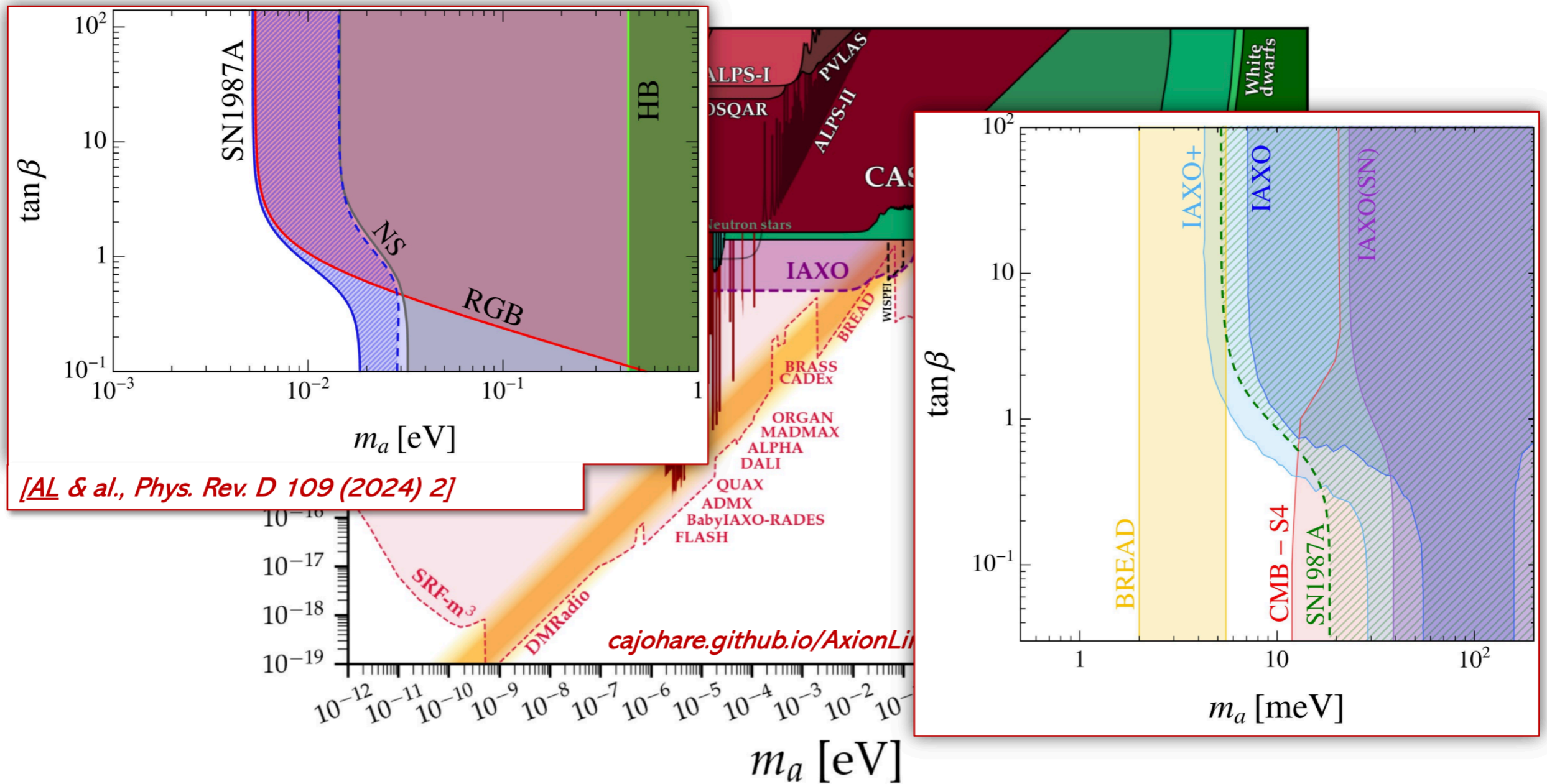
Revise stellar bounds/hints

Global analysis of WDs, RGB and HB stars shows a **preference for finite axion couplings** with electrons and photons

For QCD models \rightarrow
meV to ~ 100 meV mass region

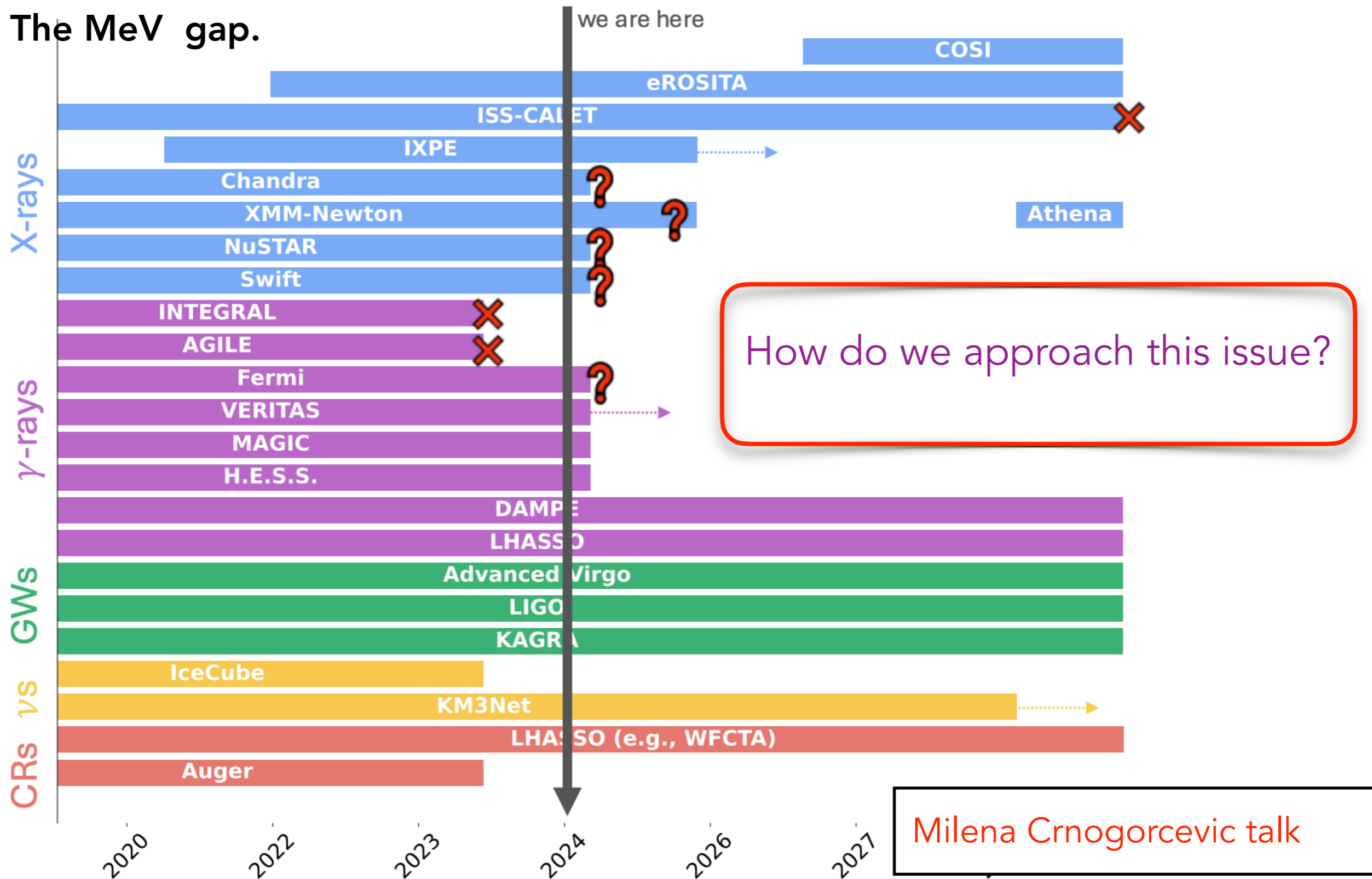
Is this a sweet spot to study
across the different groups?

The Road Ahead



From Alessandro Lella, DESY 2024

The Road Ahead



The Road Ahead

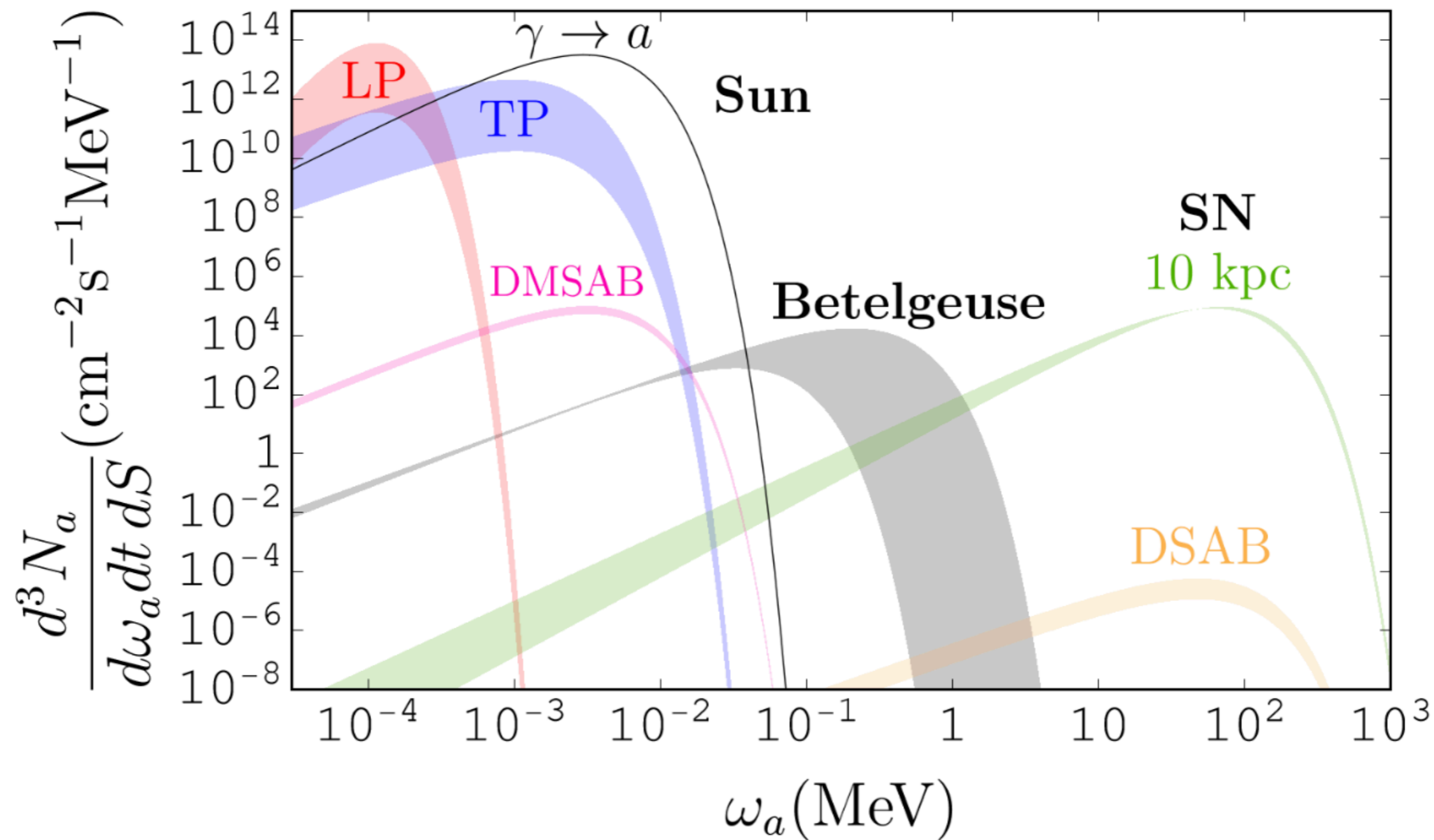
Technical aspects:

Improve knowledge on **Astrophysical magnetic fields**

- Solar, galactic, extragalactic, of other stars...

Other?

Opportunities: Axion Telescopes?



$$g_{a\gamma} = 0.65 \times 10^{-10} \text{ GeV}^{-1}$$

Opportunities: Axion Telescopes?

Detecting stellar axions would allow to understand a lot about stars.

- Solar magnetic field

C. A. J. O'Hare, A. Caputo, A. J. Millar, E. Vitagliano [Phys.Rev.D 102 \(2020\) 4](#)

- Solar temperature profile

S. Hoof, J. Jaeckel, L. J. Thormaehlen, [arXiv:2306.00077](#)

- Solar chemical composition

J. Jaeckel, L. J. Thormaehlen, [Phys.Rev.D 100 \(2019\) 12](#)

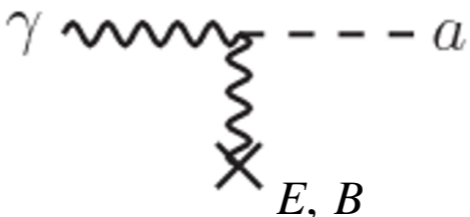
- Supergiant evolution

M. Xiao, et al., [Phys. Rev. D 106 \(2022\)](#)

- SN axions

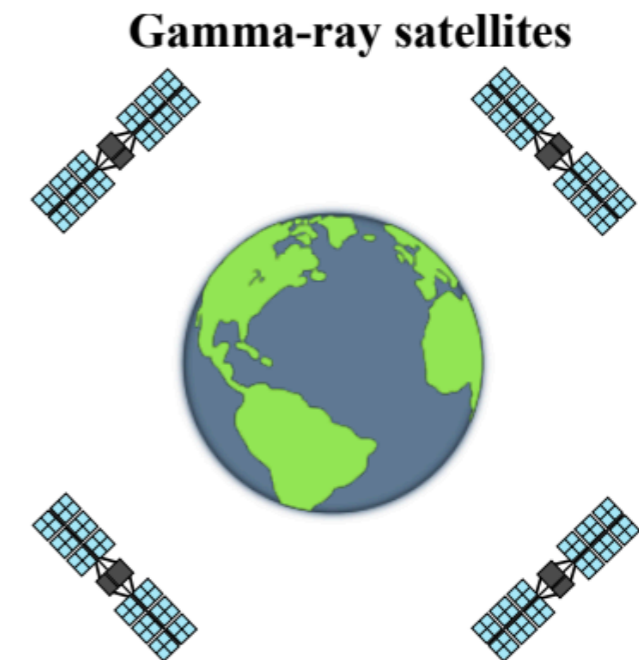
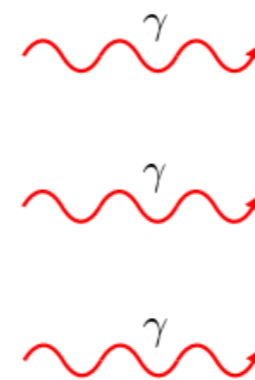
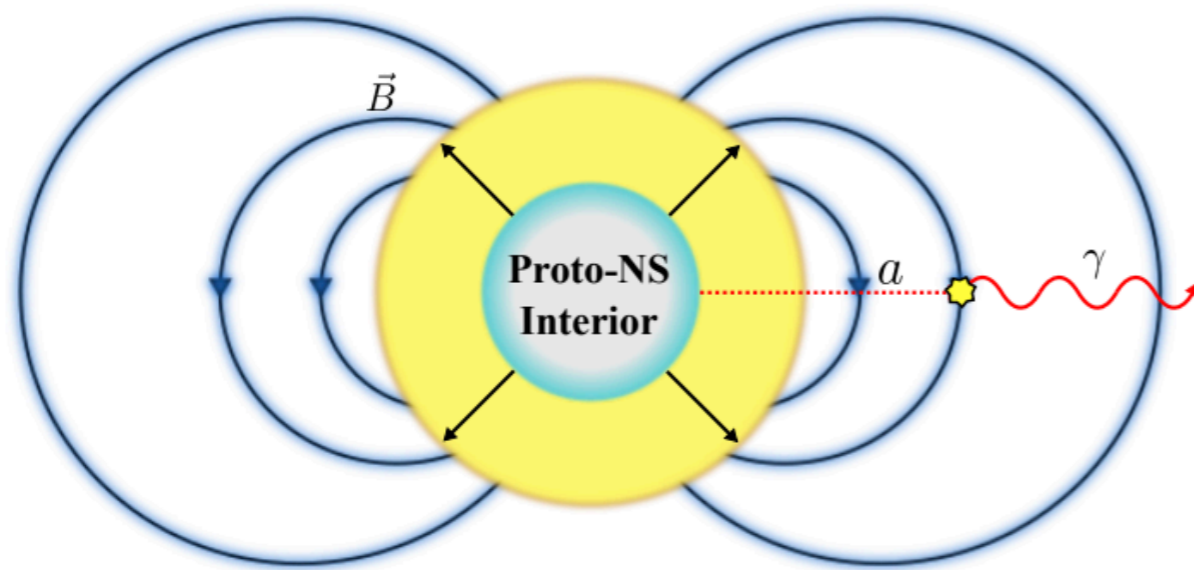
A. Lella, C. Eckner et al, In preparation; + IAXO Proposal in preparation + a lot more

The Sun as Axion Factory (Connect WG4)

Coupling	Process	Energy
$g_{a\gamma}$	Primakoff (E) 	$\sim (3 - 4) \text{ keV}$
	Primakoff (B)	$\sim (10 - 200) \text{ eV (LP)}$ $\lesssim 1 \text{ keV (TP)}$
g_{ae}	ABC e.g., $e + Ze \rightarrow Ze + e + a$	$\sim 1 \text{ keV}$
g_{aN}	nuclear reactions	
	$p + d \rightarrow {}^3\text{He} + a$	5.5 MeV
	Nuclear de-excitation	
	${}^{57}\text{Fe}^* \rightarrow {}^{57}\text{Fe} + a$	14.4 keV
	${}^7\text{Li}^* \rightarrow {}^7\text{Li} + a$	0.478 MeV
${}^{83}\text{Kr}^* \rightarrow {}^{83}\text{Kr} + a$	9.4 keV	
${}^{169}\text{Tm}^* \rightarrow {}^{169}\text{Tm} + a$	8.4 keV	

New Ideas?

GALactic AXion Instrument for Supernova (GALAXIS)



Manzari, Park, Safdi, Savoray [arXiv: 2405.19393](https://arxiv.org/abs/2405.19393)

Other WISPs

Dark Photons, scalars, Gravitational Waves etc.

Several talks in this meeting.

E.g. Tomas O'Shea, Anne Davis, Camilo Garcia Cely, Martti Raidal, and others.