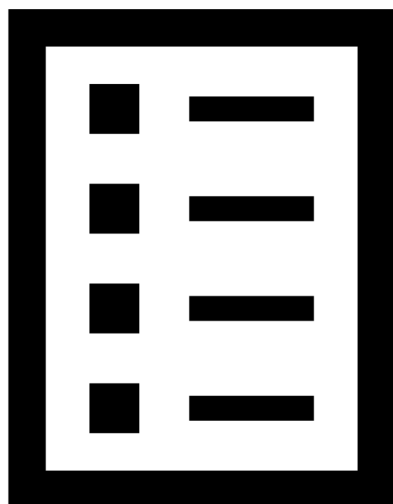




# WG4 – DIRECT WISP SEARCHES

C GATTI - M KARUZA



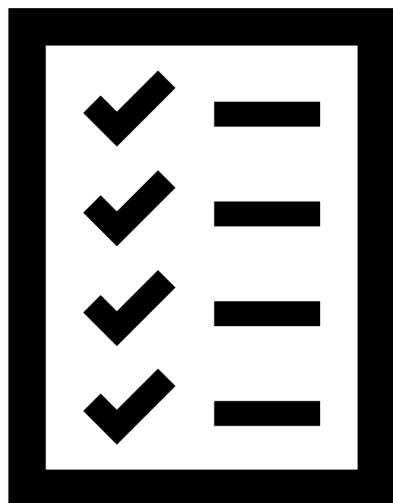
## Tasks

**T4.1:** [Review of present and future WISPs experiments](#) (including DM ones) in order to assess their discovery potential.

- **Subtask 4.1.1:** Perform an [update of summary plots](#) of present limits for various WISPs models (axion, hidden photons, chameleons etc.). For the axion constraints on the coupling with photons, electrons, nucleons. For HP, bounds on the kinetic mixing angle. [Reinterpretation of existing experimental limits](#) with new WISPs models.
- **Subtask 4.1.2:** [Combination of experimental results](#) with astrophysical and cosmological limits to extract summary plots.
- **Subtask 4.1.3:** [Highlight regions of the parameter space not yet covered](#) by experiments and discuss feasibility of the experimental searches in these regions. Discuss the feasibility of testing all the couplings (to leptons, photons, baryons etc.) in all the parameter space.

**T4.2:** Identify [progress need in the key technologies](#) and techniques (data analysis, signal filtering) for present and future experiments needed to cover the theoretically motivated region in the parameter space.

- **Subtask 4.2.1:** perform a survey of technology (materials, detection, sources, cryogenics, magnets, high resolution detectors) needed in WISP experiments.
- **Subtask 4.2.2:** perform a survey of solutions available (in SME or academic research) and of the competences available.



### Activities [WGI-4]:

- Organization of workshops on specific topics of the WGs.
- Organization of Short Term Scientific Missions (STSM).
- Organization of [Technology Forums](#) (WG4).
- Publication of report on the scientific results in the webpage (in cooperation with WG5). Participation in outreach activities (in cooperation with WG5).
- Preparation of the final White Paper and of the Training School Lecture Notes.

### Milestones [WGI-4]:

- WG meetings to track the progress of each WG and to take corrective measures in case of problems.

### Deliverables:

- D4.1 Draft Report on direct detection (month 12)
- D4.2 Interim Report on direct detection (month 24)
- D4.3 [Final Report on direct detection](#)
- D4.4 [Report on Technologies Forums](#)

## WG4 - General organization



- WG4 meetings one per month



- Report on direct detection and Tech. Forums: Overleaf LATEX



- WG4 documents on Drive/Dropbox



- Mailing List [cosmicwisperwg4@lists.infn.it](mailto:cosmicwisperwg4@lists.infn.it)
- INDICO meetings <https://agenda.infn.it/category/1831/>

# Contact Persons

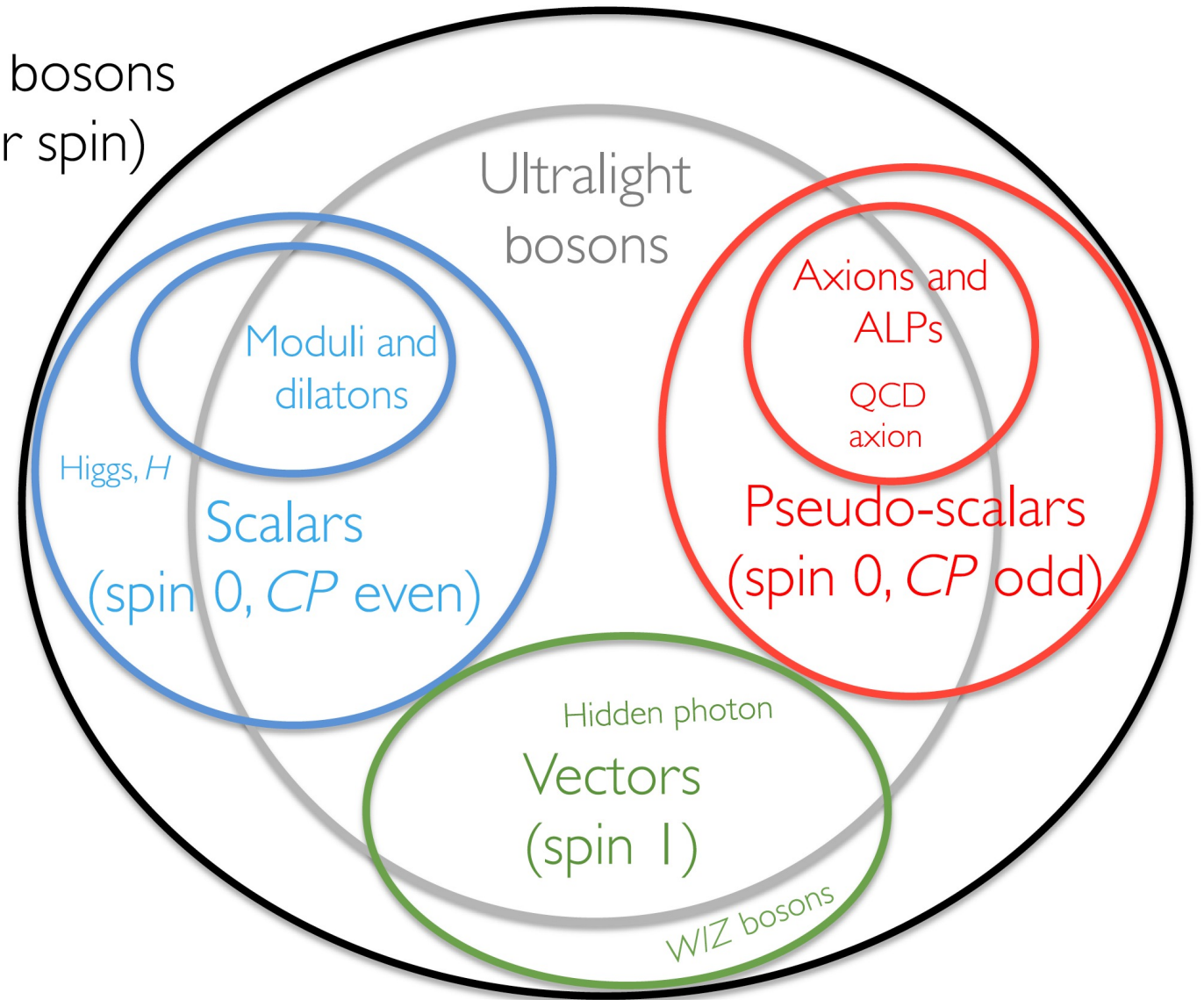


- WG contact persons:
  - WG1 Mario Reig
  - WG2 Jose Cembranos
  - WG3 Maurizio Giannotti, Federico Urban
  - WG5 Loredana Gastaldo, Serkant Ali Cetin
- Contact person with CERN-PBC Technology working group: Giovanni Cantatore, Pierre Pugnati
- Contact person with ECFA Quantum Sensing WG (tbd)

Inputs from WGI

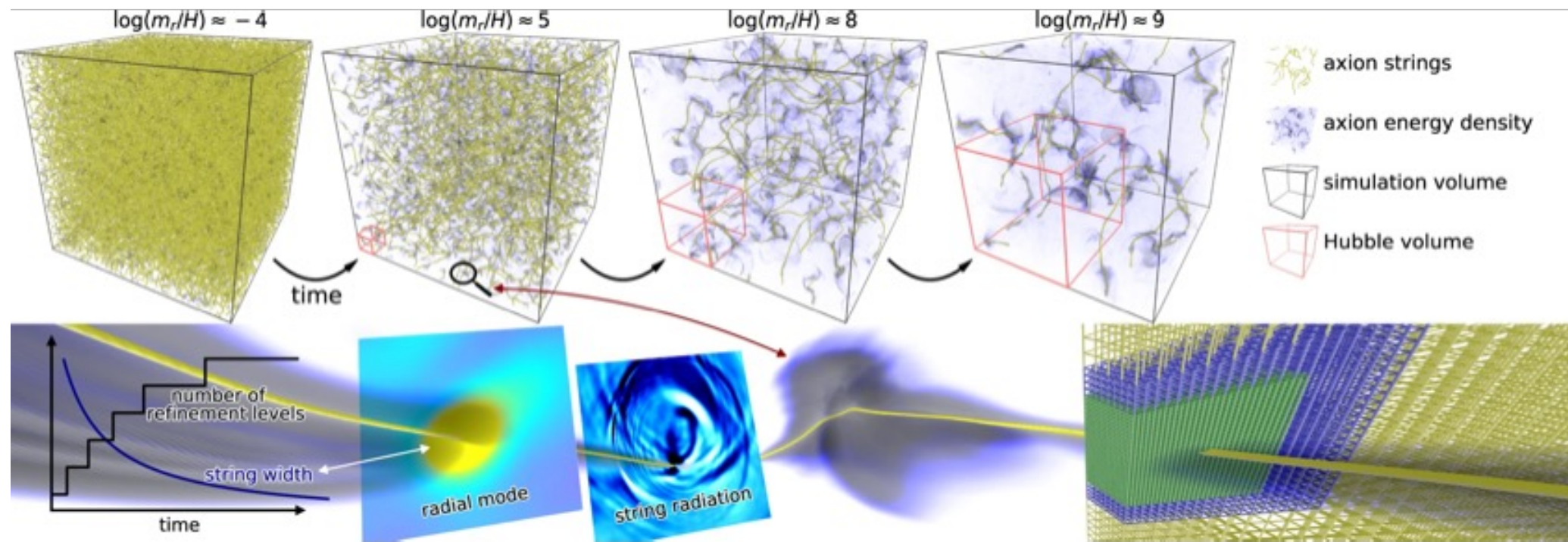
Models

Massive bosons  
(integer spin)



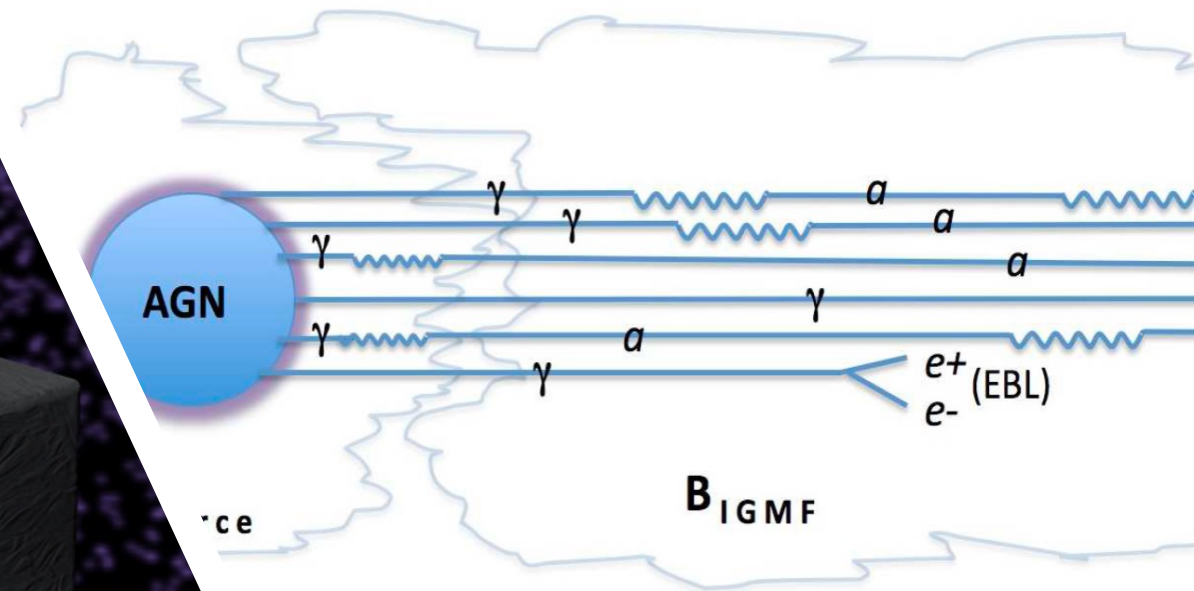
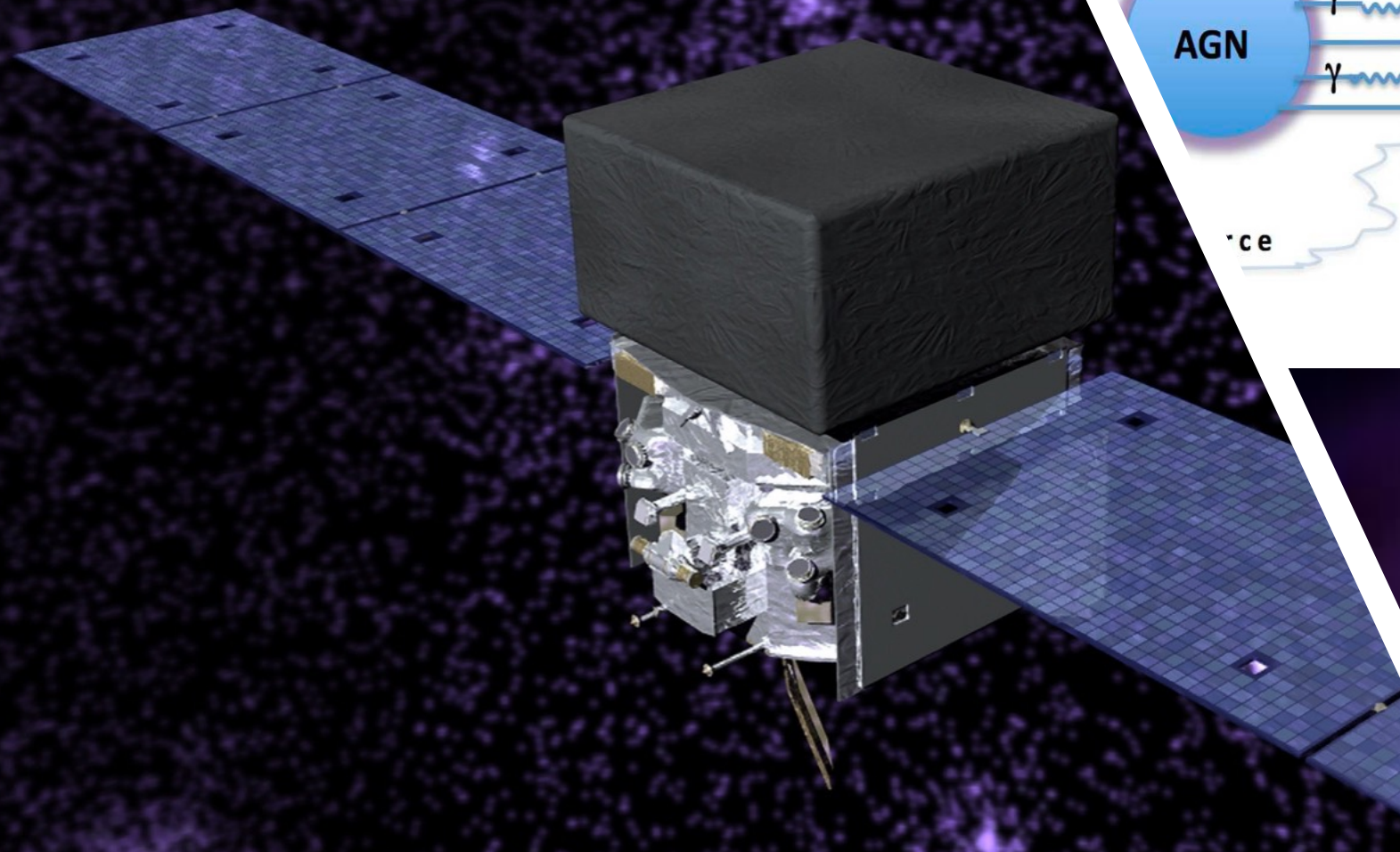
Inputs from WG2

Preferred parameter space for VVISP dark matter candidates





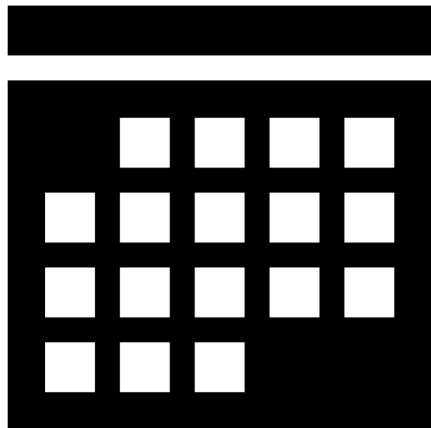
Inputs from WG3



Astrophysical experimental results (hints or limits)







## First year plan

- Make a list of WISPs models
- Make a list of WISPs experiments
- Preliminary Summary Plots
- Contact experts in specific experiments and techniques within and outside the COST. Invite them to join the COST.
- Make a list of technology needed by WISP experiments
- Draft of Direct Search Report

# TALKS IN 2023

Link to agenda: <https://agenda.infn.it/category/1835/>

## Experiments

Axion limits package and data combination - C Ohare  
BRASS Experiment - LH Nguyen  
WISPM Experiment - M Maroudas  
Haloscopes - A Rettaroli  
Helioscopes - J Vogel  
Gnome - G Zoran  
Searches at DESY – T Kozlowsky  
CAST – S Cetin  
PADME – V Kozhuharov  
VMB – S Kunc  
NA64 – L Marsicano  
WISPS at GW detectors – L Pierini  
X17 – A Krasznahorkay  
ALP at LHC – M Gallinaro  
Topological Defects - DG Martin

## Experimental techniques

Microcalorimeters at Heidelberg - L Gastaldo  
Chameleons detection – M Karuza  
Xray detector laxo– L Gastaldo

## Theory Models

Spin 2 ULDM - F Urban  
Chameleons – C Burrage

## Experimental Schemes

Axions in plasma - H Tercas  
Directly Deflecting Particle Dark Matter - S Ellis  
Searching for axion forces with spin precession in atoms and molecules – M Reig

# WG4 REPORT DRAFT

Link to Report: <https://www.overleaf.com/4678842289cfhfndnmvtyr>

## **CosmicWispers WG4 Report: WISPs direct searches**

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<sup>9</sup>Center for Astroparticles and High Energy Physics (CAPA), Universidad de Zaragoza, 50009 Zaragoza, Spain

<b>3</b>	<b>EU Experiments</b>	<b>3</b>
3.1	Pure lab (LSW, collider etc.) . . . . .	3
3.2	Helioscope . . . . .	4
3.3	Haloscope . . . . .	4
3.4	beam dump (Mj1 GeV) . . . . .	5
3.5	Non-WISP focused experiments with ability to detect WISPs . . . . .	5
3.6	TEMPLATE Experiment . . . . .	6
3.7	ALPS experiment . . . . .	7
3.8	The ATLAS and CMS experiments at the LHC . . . . .	7
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3.10	The IAXO experiment . . . . .	7
3.10.1	BabyIA XO . . . . .	9
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Many EU experiments already described in the report

# REPORT CONTENT

# LATEX TEMPLATE FOR EXPERIMENTS

## 3.6. TEMPLATE Experiment

- 5-10 lines of description (1 or 2 pictures of experimental site)
- Experimental site
- goal of experiment
- Collaboration
- Status: Proposal, R&D, Construction, Running, Finished
- (expected) Period of operation
- R&D and technologies
- Bibliography

Plots of results and projections will be shown in the summary plots by Ciaran in a separate section and are not needed here.

Additional information useful for the summary plots are:

- Definition of coupling (i.e. what lagrangian interaction term)
- Assumed dark matter density
- Definition of the projection (i.e. is it an estimated sensitivity, projected 90% CL limit, order-of-magnitude estimate etc.)
- Location (required for the dark photon case and for experiments sensitive to a daily modulation)

Template experiment uses the following Lagrangian definition:

$$\mathcal{L} = \frac{1}{2}(\partial^\mu a)(\partial_\mu a) + \frac{\alpha_s}{8\pi} \frac{a}{f_a} \tilde{G}^{\mu\nu} G_{\mu\nu} + \frac{1}{4} g_{a\gamma\gamma}^0 a \tilde{F}^{\mu\nu} F_{\mu\nu} + \frac{1}{2f_a} (\partial_\mu a) j_{a,0}^\mu, \quad (1)$$

Experiment position and orientation are listed in Tab. 1.

**Table 1. Position and magnetic-field direction of template experiment**

Latitude	41° 49' 26''
Longitude	12° 40' 13''
Elevation	100 m
B field direction	East—northeast



4	Summary Plots	27
5	Ongoing EU R&D	27
5.1	Ongoing R&D . . . . .	27
5.2	Resonators . . . . . NbTi, ReBCO, Nb <sub>3</sub> Sn, geometries tuning etc.	27
5.3	Magnets . . . . . First Tech forum	27
5.4	Sensors . . . . . Microcalorimeters, qubits, bolometers, membranes, ... and 2nd Tech forum	27
6	EU WISP Infrastructures and Labs	27
7	TEMPLATE Facility	27
8	The Frascati National Laboratory of INFN	27

In 2024 add contributions from: DESY, Grenoble, Canfranc, Mainz ...

# REPORT CONTENT

<b>9</b>	<b>New experimental schemes for WISPS searches</b>	<b>28</b>
9.1	Template Experimental Scheme . . . . .	28
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9.3	Production and detection of an axion dark matter echo arXiv:1902.00114	28
9.4	Directly Deflecting Particle Dark Matter PHYSICAL REVIEW LET- TERS 124, 011801 (2020) . . . . .	28
9.5	Sound of Dark Matter: Searching for Light Scalars with Resonant- Mass Detectors PRL 116, 031102 (2016) . . . . .	31
9.6	Axion production in unstable magnetized plasmas. Phys. Rev. D 101, 051701(R) . . . . .	31
9.7	Searching for axion forces with spin precession in atoms and molecules arXiv:2309.10023 . . . . .	31
9.8	Proposal for gravitational direct detection of dark matter PHYSICAL REVIEW D 102, 072003 (2020) . . . . .	33
9.9	Intensity interferometry for ultralight bosonic dark matter detection PHYSICAL REVIEW D 108, 015003 (2023) . . . . .	33
9.10	A Diffraction Grating for the Cosmic Neutrino Background and Dark Matter arXiv:2303.04814 . . . . .	33

# WG4 REPORT

# MATERIAL FOR THE ROUND TABLE DISCUSSION

## Common R&D:

- a) magnets
- b) quantum technologies
- c) quality optics, mirrors, cavities
- d) actuators
- e) detectors (radio, THz, IR, optics, xray, gamma)

Data taking and analysis (cloud computing)

Data preservation and access

Data combination

## Closer collaboration within VVGs:

- Modelling for HFGW with wisps detectors
- Cross sections calculations
- Sensitivity/exclusion plots prescriptions
- List of models/signals/etc to widen physics reach of experiments or modification to experiments
- Outreach: which are the tools, how to contribute? How to give new suggestions, social media etc.

## Axion astrophysics:

- a) EU Networks for astrophysical objects (GNOME-like)
- b) Supernova axions
- c) Link neutrino and axions
- d) HFGW

## Collaborations

“EU Funding Agency” problem

Connection with PBC@CERN and DRDC