Physics Beyond Colliders

The Search for Feebly-Interacting Particles within the Physics Beyond Colliders activity at CERN

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Laboratori Nazionali di Frascati – 10 June 2021

Preamble

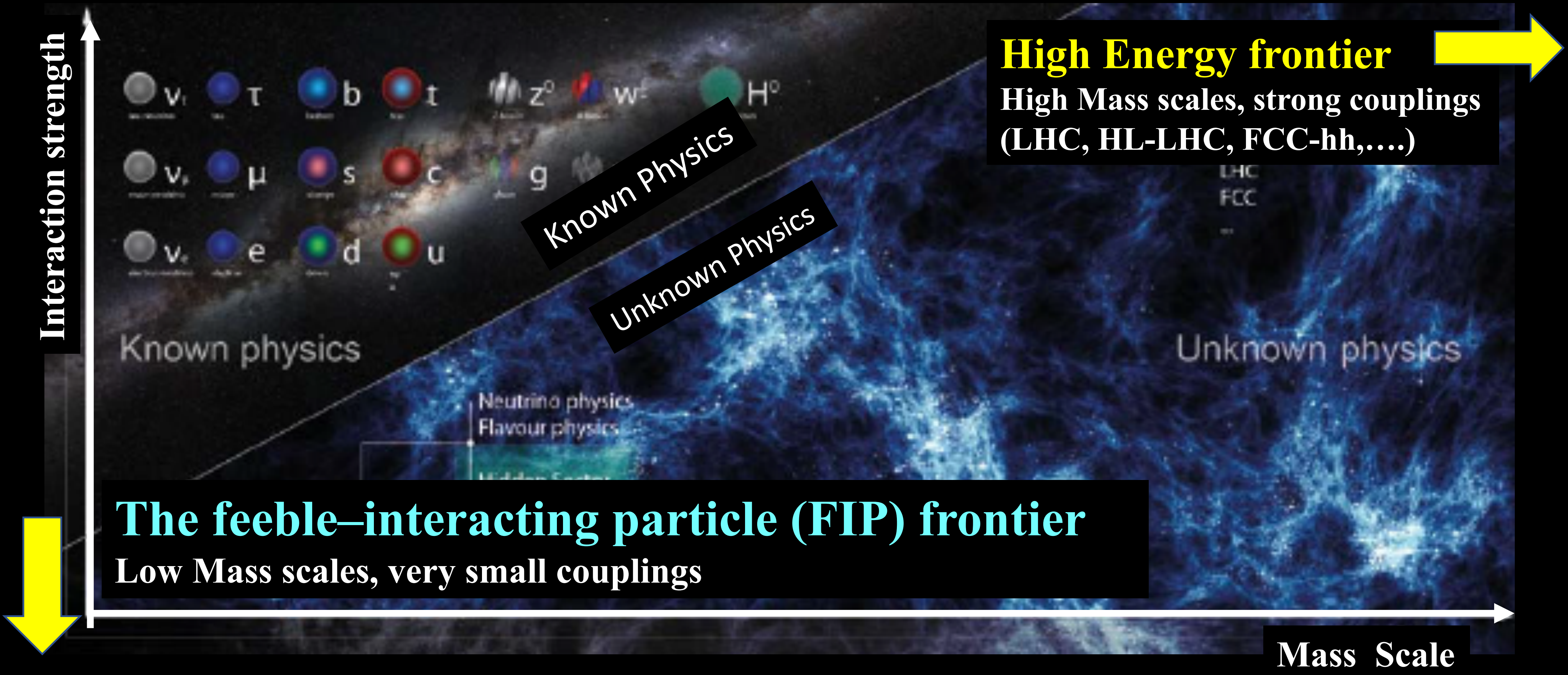
The Briefing Book of the European Strategy
arXiv:1910.11775 , BSM Chapter, p.141

" The absence, so far, of unambiguous signals of new physics from direct searches at the LHC, indirect searches in flavour physics and direct DM detection experiments invigorates the need for broadening the experimental effort in the quest for new physics and in exploring ranges of interaction strengths and masses different from those already covered by existing or planned projects.

While exploration of the high-mass frontier remains an essential target, other research directions have valid theoretical motivations and deserve equal attention.

Feebly-interacting particles (FIPs) represent an alternative paradigm with respect to the traditional BSM physics explored at the LHC. The full investigation of this paradigm over a large range of couplings and masses requires a great variety of experimental facilities."

The Quest for New Physics



A new paradigm has emerged in recent years…

An historical perspective

The first time that feebly-interacting particles (to my knowledge) appeared in official documents of funding agencies was in Snowmass 2013:

- Planning the future of U.S. Particle Physics (Snowmass 2013): Intensity Frontier, arXiv:1401.6077 - 12 citations
- Planning the future of U.S. Particle Physics (Snowmass 2013): Cosmic Frontier, arXiv:1401.6085 – 38 citations

Followed by two important community reports:

- Dark Sector 2016 Workshop: Community Report – arXiv: 1608.08632 – 322 citations
- US Cosmic Visions: New Ideas in Dark Matter 2017: Community Report – arXiv:1707.04591 – 286 citations

FIPs @ CERN: a recent history

Before 2013: FIPs searches performed parasitically with respect to main programs (mostly in LHCb)

October 2013: two Letters of Intent sent to the SPSC:

- P347: search for HNLs at the SPS (proto-SHiP)
- P348: search for Dark Photons at the SPS (proto-NA64).

January 2016: P348 approved as NA64

January 2017: Physics Beyond Colliders Study group…..

January 2017

Physics Beyond Colliders

Physics Beyond Colliders (PBC) and its mission in 2017-2019

"The PBC is an exploratory study aimed at exploiting the full scientific potential of CERN's accelerator complex and its scientific infrastructure through projects complementary to the LHC, HL-LHC and other possible future colliders. These projects would target fundamental physics questions that are similar in spirit to those addressed by high-energy colliders, but that require different types of beams and experiments"

Very broad mandate: No mention of FIPs. Focus on experiments at accelerators at CERN.
The PBC allowed us to perform a systematic investigation of the potential of CERN accelerator complex for feebly interacting particles beyond the LHC. Many new actors entered in the game, targeting the SPS but not only.

December 2018

The Physics Beyond Colliders BSM WG: activity & Report

arXiv:1901.009966, *J.Phys.G* 47 (2020) 1, 010501
209 citations to date (1 citation every 4 days since 2.5 years):

New actors entered in the game targeting FIPs in the MeV-GeV mass region….

FASER, MATHUSLA, CODEX-b, NA64 (muon), NA64 @ AWAKE, milliQan,…

…But also below:

Baby-IAXO (axion exp); CP-EDM (proton EDM)

A report containing the bounds and future perspectives for searching for FIPs in the coming decade was prepared and submitted to the ESPP.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

Physics Beyond Colliders

CERN-PBC-REPORT-2018-007

arXiv:1901.09966v2 [hep-ex] 2 Mar 2019

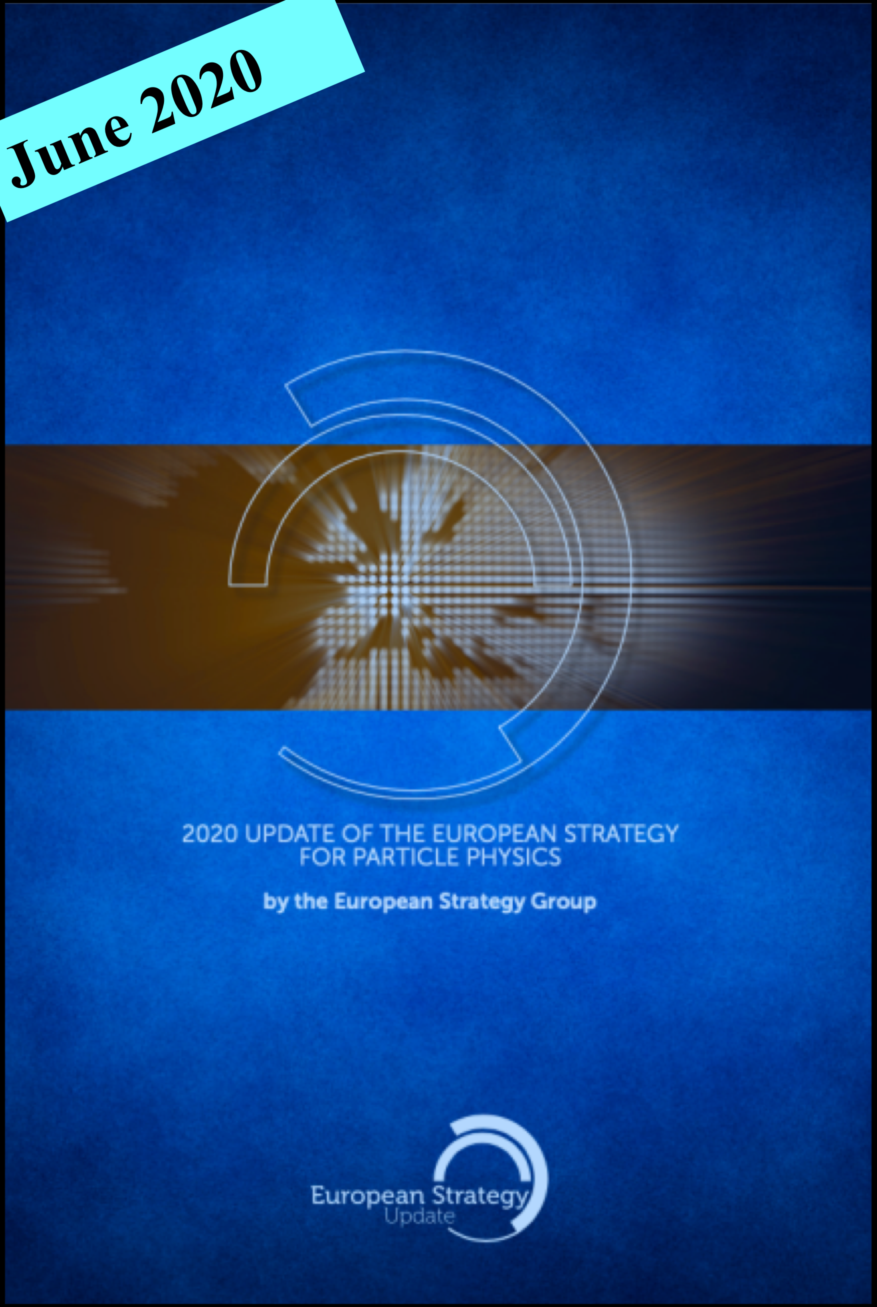
Physics Beyond Colliders at CERN
Beyond the Standard Model Working Group Report

J. Beacham[1], C. Burrage[2,*], D. Curtin[3], A. De Roeck[4], J. Evans[5], J. L. Feng[6], C. Gatto[7], S. Gninenko[8], A. Hartin[9], I. Irastorza[10], J. Jaeckel[11], K. Jungmann[12,*], K. Kirch[13,*], F. Kling[6], S. Knapen[14], M. Lamont[4], G. Lanfranchi[4,15,*,**], C. Lazzeroni[16], A. Lindner[17], F. Martinez-Vidal[18], M. Moulson[15], N. Neri[19], M. Papucci[4,20], I. Pedraza[21], K. Petridis[22], M. Pospelov[23,*], A. Rozanov[24,*], G. Ruoso[25,*], P. Schuster[26], Y. Semertzidis[27], T. Spadaro[15], C. Vallée[24], and G. Wilkinson[28].

Abstract: The Physics Beyond Colliders initiative is an exploratory study aimed at exploiting the full scientific potential of the CERN's accelerator complex and scientific infrastructures through projects complementary to the LHC and other possible future colliders. These projects will target fundamental physics questions in modern particle physics. This document presents the status of the proposals presented in the framework of the Beyond Standard Model physics working group, and explore their physics reach and the impact that CERN could have in the next 10-20 years on the international landscape.

* PBC-BSM Coordinators and Editors of this Report
** Corresponding Author: Gaia.Lanfranchi@lnf.infn.it

June 2020

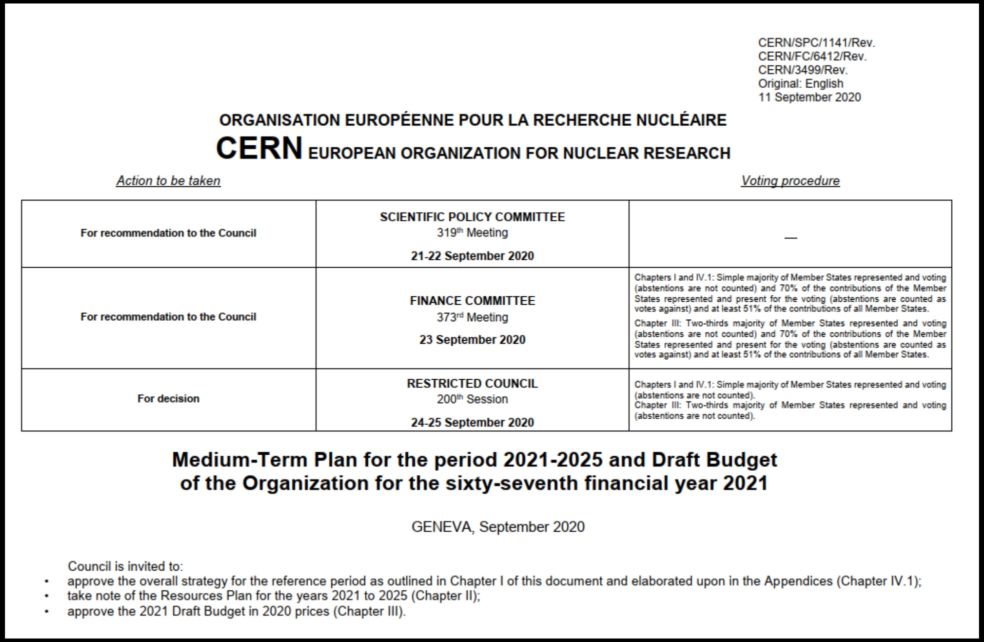


ESPP & PBC

- **Clear Recognition of the successful first phase of the Physics Beyond Colliders initiative**
- *"4. Other essential scientific activities for particle physics: a) The quest for dark matter and the exploration of flavour and fundamental symmetries are crucial components of the search for new physics.*
- *This search can be done in many ways, for example through precision measurements of flavour physics and electric or magnetic dipole moments, and searches for axions, dark sector candidates and feebly interacting particles.*
- *There are many options to address such physics topics including energy-frontier colliders, accelerator and non-accelerator experiments. A diverse programme that is complementary to the energy frontier is an essential part of the European particle physics Strategy.*

https://cds.cern.ch/record/2721370/files/CERN-ESU-015 2020%20Update%20European%20Strategy.pdf

CERN Medium Term Plan 2020 & PBC



CERN/SPC/1141/Rev.
CERN/FC/6412/Rev.
CERN/3499/Rev.
Original: English
11 September 2020

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting procedure
For recommendation to the Council	SCIENTIFIC POLICY COMMITTEE 319th Meeting 21-22 September 2020	–
For recommendation to the Council	FINANCE COMMITTEE 373rd Meeting 23 September 2020	Chapters I and IV.1: Simple majority of Member States represented and voting (abstentions are not counted) and 70% of the contributions of the Member States represented and present for the voting (abstentions are counted as votes against) and at least 51% of the contributions of all Member States. Chapter III: Two-thirds majority of Member States represented and voting (abstentions are not counted) and 70% of the contributions of the Member States represented and present for the voting (abstentions are counted as votes against) and at least 51% of the contributions of all Member States.
For decision	RESTRICTED COUNCIL 200th Session 24-25 September 2020	Chapters I and IV.1: Simple majority of Member States represented and voting (abstentions are not counted). Chapter III: Two-thirds majority of Member States represented and voting (abstentions are not counted).

Medium-Term Plan for the period 2021-2025 and Draft Budget of the Organization for the sixty-seventh financial year 2021

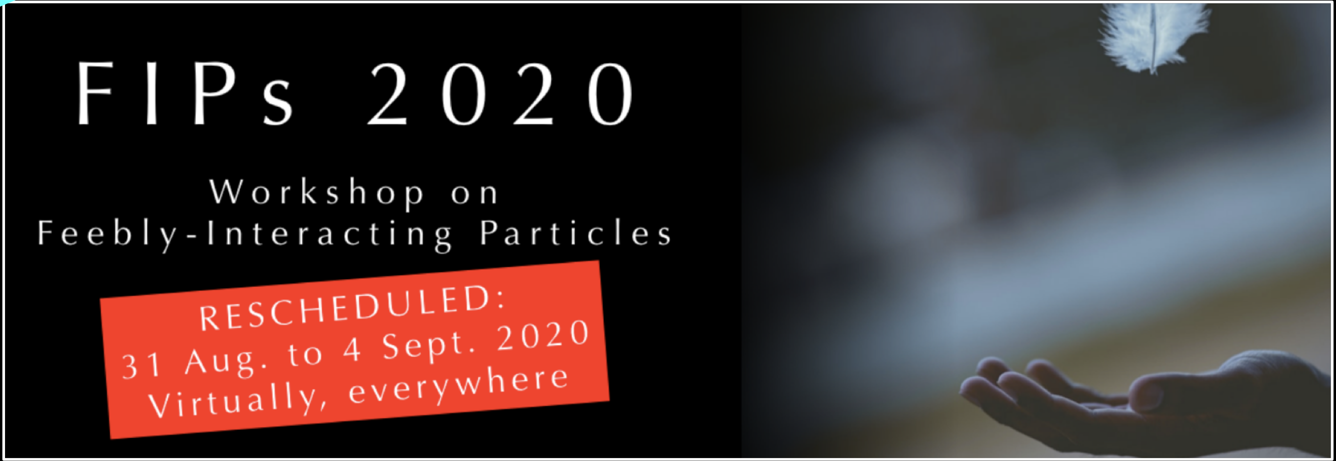
GENEVA, September 2020

Council is invited to:
- approve the overall strategy for the reference period as outlined in Chapter I of this document and elaborated upon in the Appendices (Chapter IV.1);
- take note of the Resources Plan for the years 2021 to 2025 (Chapter II);
- approve the 2021 Draft Budget in 2020 prices (Chapter III).

- *…….A diverse scientific programme is strongly supported by the 2020 Strategy update, which also recognised the role of the Physics Beyond Colliders (PBC) study group as the focal point for promoting and channelling new research initiatives.……*
- *………Given the importance of a diverse scientific programme to addressing the outstanding questions in particle physics in a way complementary to high-energy colliders <u>PBC activities are funded with an increased budget of ~3 MCHF/year in this MTP (up from 1 MCHF/year)…….</u>*

The FIPs 2020 workshop & Report

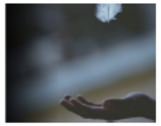
https://indico.cern.ch/event/864648/



The main goal of the workshop was to bring together experts from collider, beam dump, fixed target, astrophysics, axions/ALPs searches; current/future neutrino experiments; and DM direct detection communities to discuss progress in experimental searches and underlying theory models.

The document (submitted to EPJC)
contains the state-of-the-art of current results
on FIPs physics from all these communities and a few proposals
for new benchmarks.

⟶Most of the plots presented in this talk come from there



CERN - 24 February 2021

arXiv:2102.12143v1 [hep-ph] 24 Feb 2021

Feebly-Interacting Particles: FIPs 2020 Workshop Report

P. Agrawal[1], M. Bauer[2,a], J. Beacham[3,a], A. Berlin[4], A. Boyarsky[5], S. Cebrian[6], X. Cid-Vidal[7], D. d'Enterria[3], A. De Roeck[3,a], M. Drewes[8], B. Echenard[9], M. Giannotti[10], G. F. Giudice[3,a], S. Gninenko[11], S. Gori[12,13], E. Goudzovski[14], J. Heeck[15], P. Hernandez[16,a], M. Hostert[24,25,38], I. Irastorza[6,a], A. Izmaylov[11], J. Jaeckel[17,a], F. Kahlhoefer[18], S. Knapen[3,b], G. Krnjaic[19,20,a], G. Lanfranchi[21,a,b,*], J. Monroe[22,a], V. Martinez-Outschoorn[23], J. Lopez-Pavon[16], S. Pascoli[2,39,a], M. Pospelov[24,25], D. Redigolo[3,26,b], A. Ringwald[27], O. Ruchayskiy[28] J. Ruderman[4,27,a], H. Russell[3], J. Salfeld-Nebgen[29], P. Schuster[30,a], M. Shaposhnikov[31,a], L. Shchutska[31], J. Shelton[32,a], Y. Soreq[33] Y. Stadnik[34], J. Swallow[14], K. Tobioka[35,36], Y.-D. Tsai[23,37]

Abstract: With the establishment and maturation of the experimental programs searching for new physics with sizeable couplings at the LHC, there is an increasing interest in the broader particle and astrophysics community for exploring the physics of light and feebly-interacting particles as a paradigm complementary to a New Physics sector at the TeV scale and beyond. FIPs 2020 has been the first workshop fully dedicated to the physics of feebly-interacting particles and was held virtually from 31 August to 4 September 2020. The workshop has gathered together experts from collider, beam dump, fixed target experiments, as well as from astrophysics, axions/ALPs searches, current/future neutrino experiments, and dark matter direct detection communities to discuss progress in experimental searches and underlying theory models for FIPs physics, and to enhance the cross-fertilisation across different fields. FIPs 2020 has been complemented by the topical workshop "Physics Beyond Colliders meets theory", held at CERN from 7 June to 9 June 2020. This document presents the summary of the talks presented at the workshops and the outcome of the subsequent discussions held immediately after. It aims to provide a clear picture of this blooming field and proposes a few recommendations for the next round of experimental results.

Physics Beyond Colliders

December 2020

The new PBC mandate

"The main goal of the Study Group remains to explore the opportunities offered by CERN's unique accelerator complex, its scientific and technical infrastructure, and its know-how in accelerator and detector science and technology, to address today's outstanding questions in particle physics through initiatives that complement the goals of the main experiments of the Laboratory's collider programme.

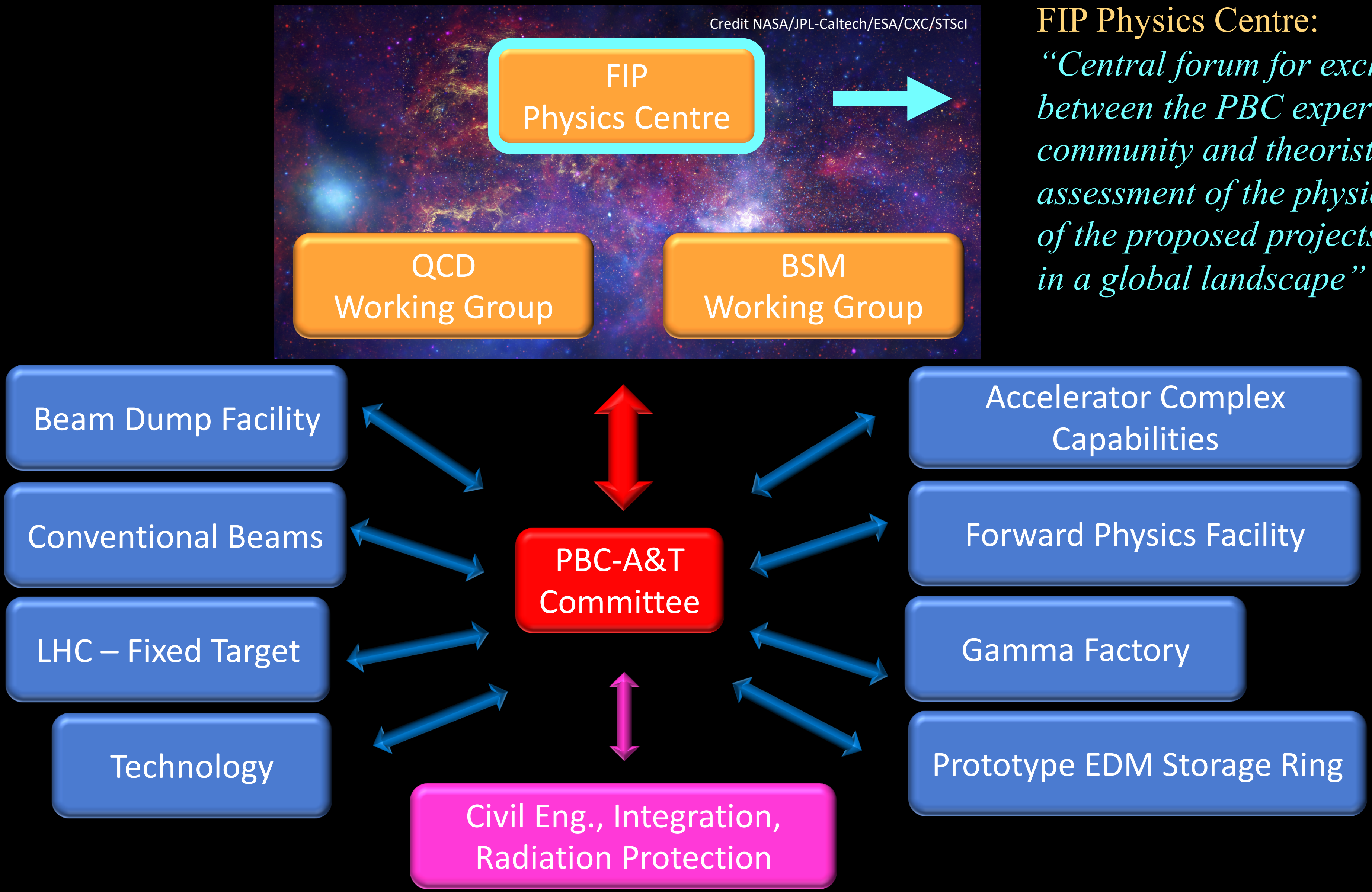
Examples of physics objectives include dedicated experiments for studies of rare processes and searches for feebly interacting particles.

The physics objectives also include projects aimed at addressing fundamental particle physics questions using the experimental techniques of nuclear, atomic, and astroparticle physics, as well as emerging technologies such as quantum sensors, that would benefit from the contribution of CERN competences and expertise.

The study group will primarily investigate, and, where appropriate, provide support to, projects expected to be sited at CERN. The study group may also examine ideas and provide initial support for contributions to projects external to CERN. The study group is also expected to act as a central forum for exchanges between the PBC experimental community and theorists for assessment of the physics reach of the proposed projects in a global landscape. "

May 2021

May 2021: The New PBC Structure



FIP Physics Centre:
"Central forum for exchanges between the PBC experimental community and theorists for assessment of the physics reach of the proposed projects in a global landscape"

What are Feebly-Interacting Particles (FIPs)?

What are Feebly-Interacting Particles (FIPs)?

Very roughly:
any NP with (dimensional or dimensionless) effective couplings $\ll 1$
(in the PBC we concentrate on FIPs with mass below the EW scale).

[The smallness of the couplings can be generated by an approximate symmetry almost unbroken, and/or a large mass hierarchy between particles (as data seem to suggest)]

Fully complementary to high-energy searches.
Naturally long-lived.

What FIPs can provide us?

1) Thermal DM candidates that extend the WIMP paradigm in the MeV-GeV range.
2) Ultra-light non thermal DM candidates;
3) The simplest theories to explain the origin of CP-symmetry in strong interactions
4) Candidates to explain the origin of neutrino masses and the matter/anti-matter asymmetry in the Universe;

and:

Candidates to address the electro-weak hierarchy problem, possible answers to the flavor puzzle, answers to many astrophysical anomalies,…..

What FIPs can provide us?

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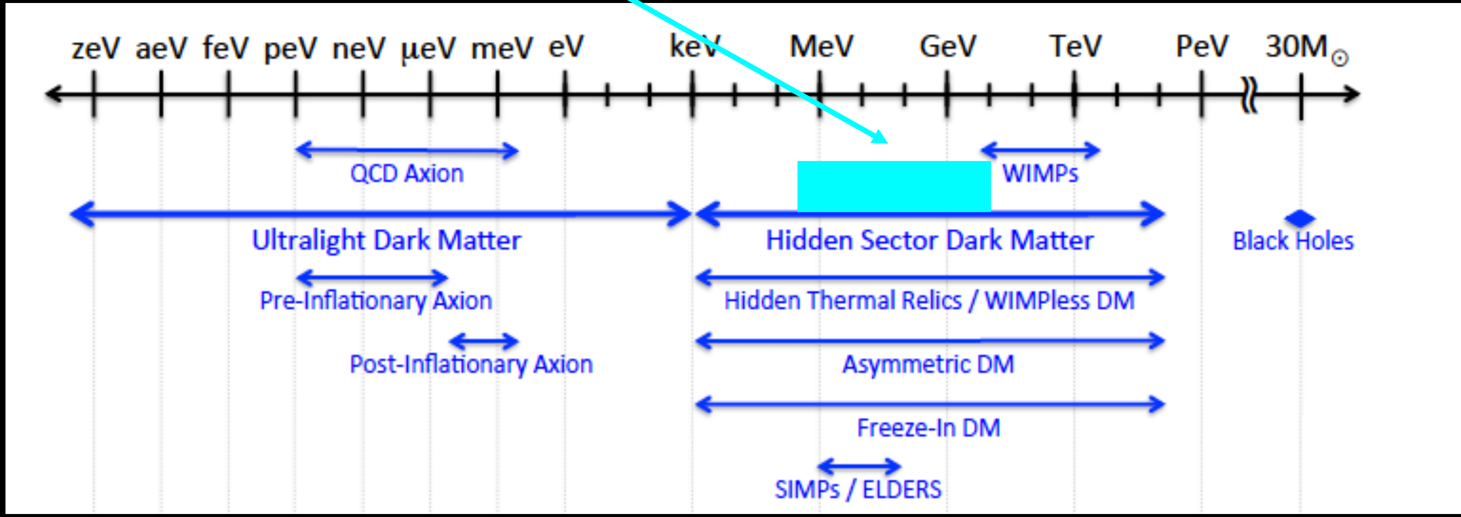
DM available mass range
~ 80 orders of magnitude..



Cosmic Visions, arXiv:1707.04591

Dark Matter as a thermal relic: What do we know?

1. Thermal relics: range MeV-100 TeV

- 100s GeV-1 TeV well explored, MeV-GeV poorly explored, below MeV disfavored by BBN & CMB

2. To reproduce DM abundance sub-GeV DM has to interact with SM world via new forces

- to avoid the Lee-Weinberg bound;

3. For s-wave annihilating DM, measurements of the CMB rule out m_{DM} < O(10) GeV

- other viable options:

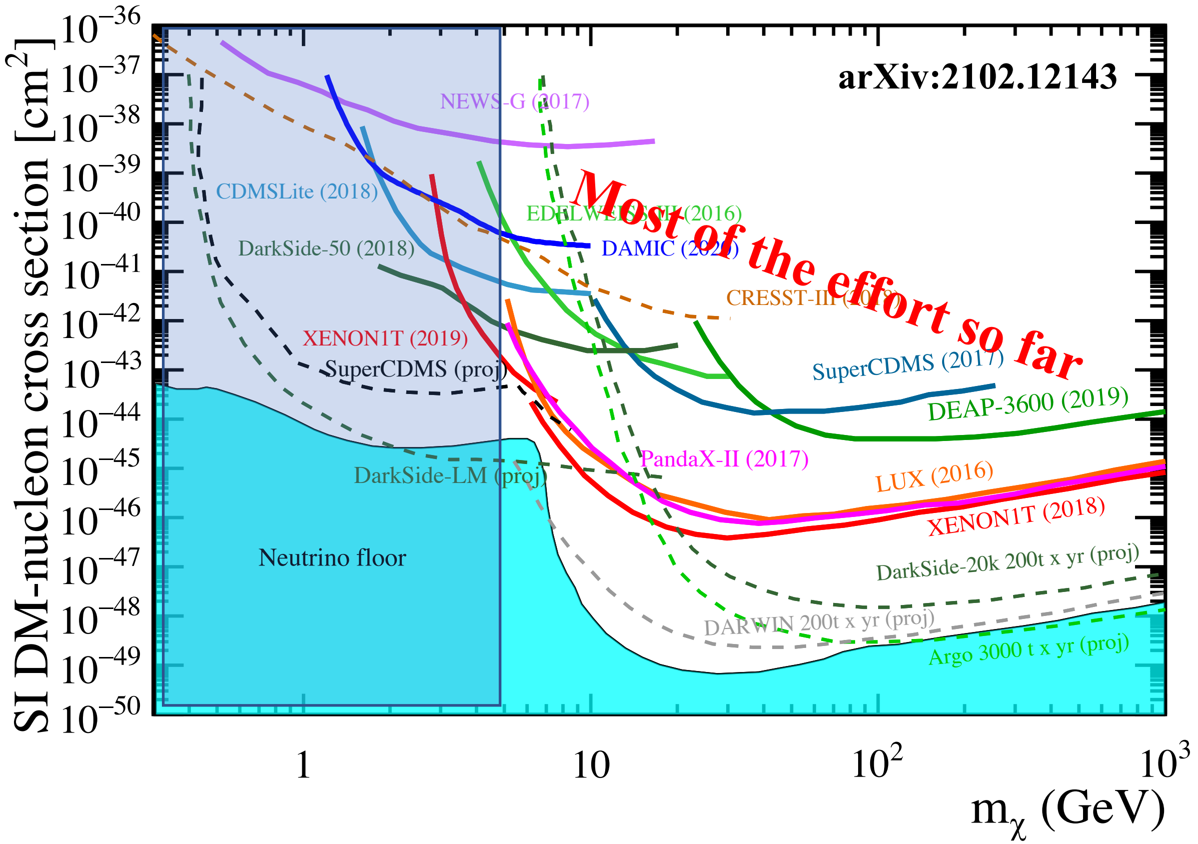
- DM annihilated in p-wave (hence the **σ**v is v^2 suppressed, hence smaller at low-T).
- Presence of a mechanism that cuts off late time annihilation, as eg. mass splitting in the $\chi-\bar{\chi}$ system

4. DM & mediators must be SM-neutral

- if the carry ew quantum numbers they would have been already observed at LEP, Tevatron and LHC
- only three possible operators at dim-4: vector, scalar, and fermion portals.

Direct Detection DM searches below a few GeV: A vibrant field.

DM in the MeV-GeV range: a blooming field



DM direct detection experiments are pushing the exploration down to the neutrino floor in the MeV-GeV range

MeV-GeV range is accessible also by accelerator-based experiments.

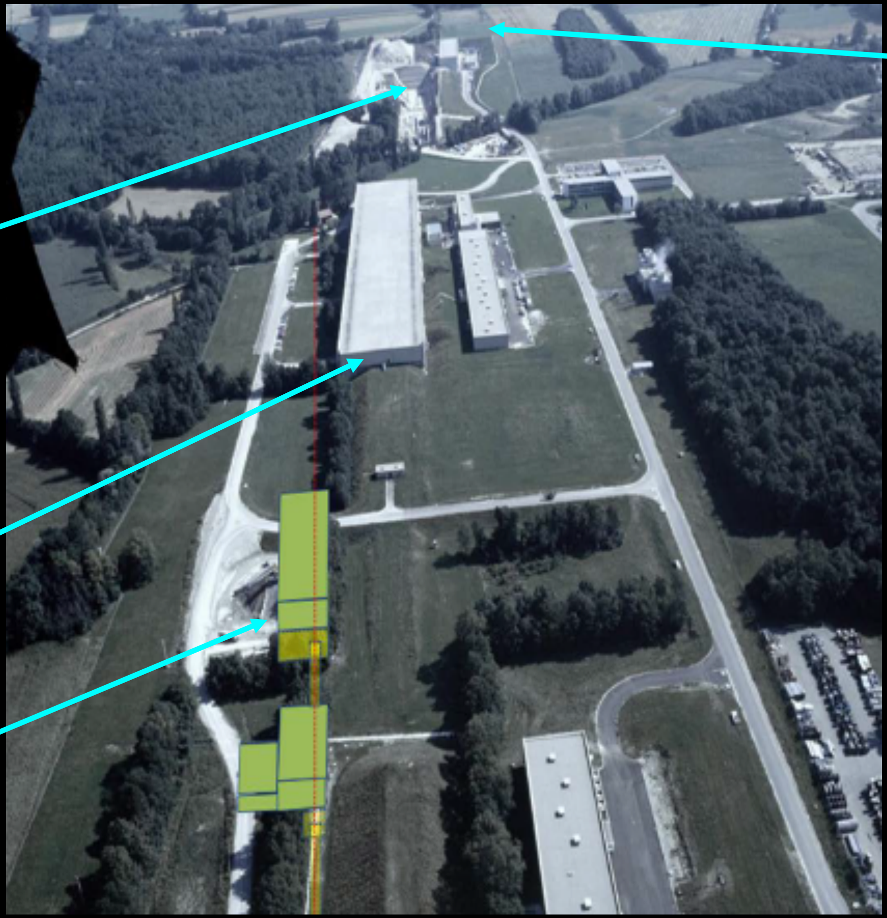
Physics Beyond Colliders

FIPs @ CERN – The North Area: a unique infrastructure…

ECN3:
P42/K12: 400 GeV p beam
up to 3x10^{18} pot/year (now)
→ **NA62 (and its upgrades)**
up to a few 10^{19} pot/year
→ **SHADOWS**

EHN1:
H4: 100 GeV e- beam
up to 5x10^{12} eot/year
→ **NA64^{++} (e), NA64^{++}(hadrons)**

Medium-long term projects:
SHiP@ BDF, etc



EHN2:
M2: 100-160 GeV, mu beam
up to 10^{13} μ/year
→ **NA64^{++} (mu)**

… to search for FIPs at extracted beam lines

A Hidden Sector Campus.

Light DM with thermal origin with a new light Vector Mediator

(with new forces/interactions the Lee-Weinberg bound can be evaded)

Accelerator-based experiments

Production of DM at accelerators
(via SM (electron/proton/..) particles)

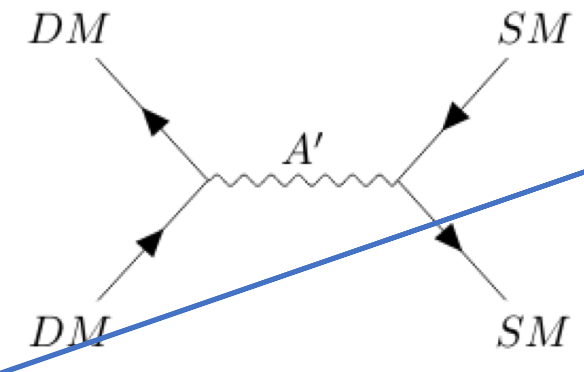
$$< \sigma v > \sim \alpha_D \varepsilon^2 \alpha \times \frac{m_{\rm DM}^2}{m_{A'}^4} \times m_{\rm DM}^2 \times \frac{1}{m_{\rm DM}^2}$$

y variable

DM Direct detection experiments

DM scattering with e/protons

$$\sigma(DMe^- \to DMe^-) \sim 3.7 \cdot 10^{-27} \mathrm{cm}^2 \times \left(\frac{10\ \mathrm{MeV}}{m_{\rm DM}}\right)^4 \times y$$



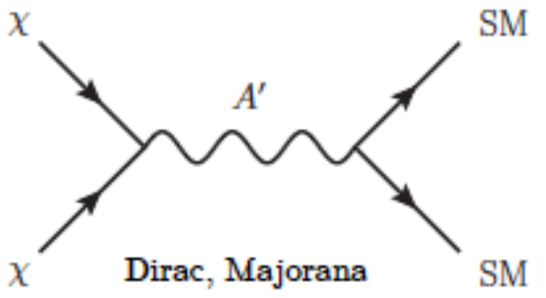
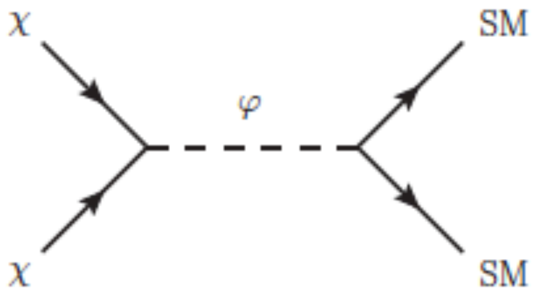
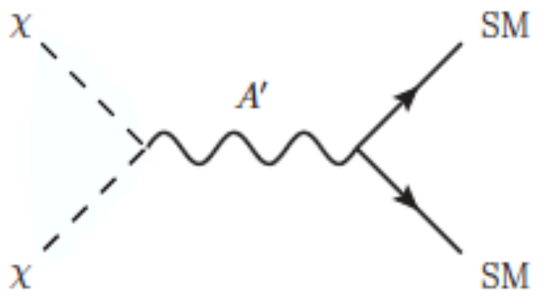
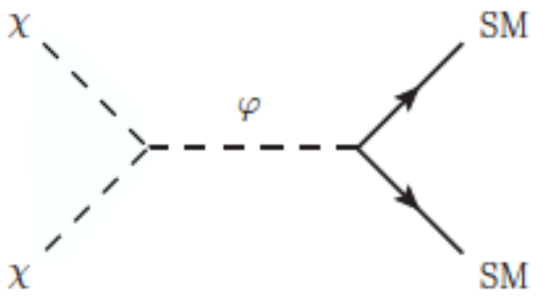
Astroparticle, cosmology

Direct DM annihilation
(main process to get the thermal relic abundance)

$$\Omega_{\rm DM} h^2 \sim \frac{10^9\ \mathrm{GeV}^{-1}}{M_{\rm pl}} \frac{1}{\langle \sigma v \rangle}$$

Vector & Scalar mediators DM-SM:
different combinations are allowed in p- and s-wave.

Berlin, FIPs 2020

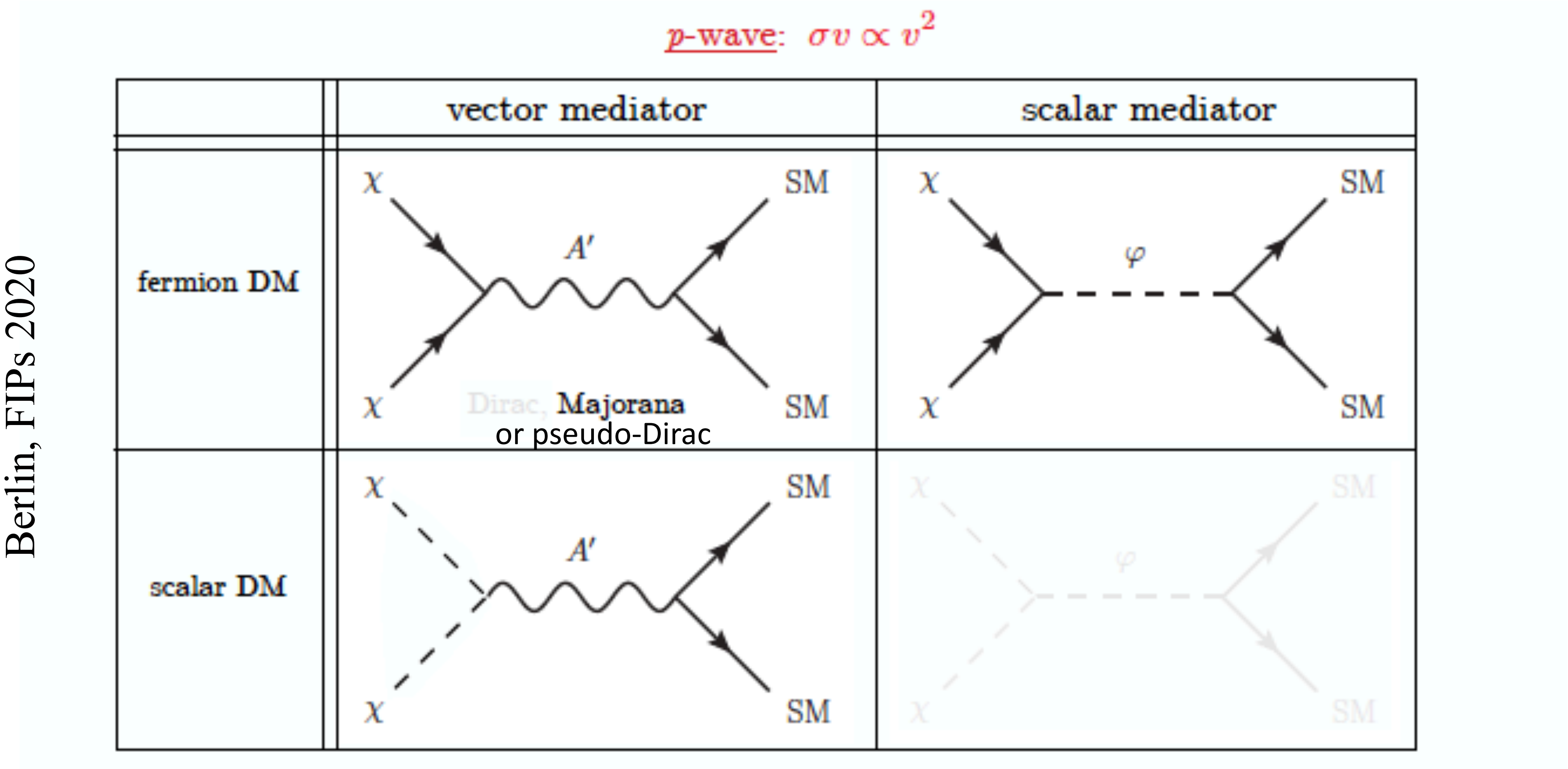
	vector mediator	scalar mediator
fermion DM		
scalar DM		

But remember: DM below 10 GeV annihilating in s-wave is excluded by CMB…

Vector & Scalar mediators DM-SM:

different combinations are allowed in p- ~~and s-wave.~~

Berlin, FIPs 2020

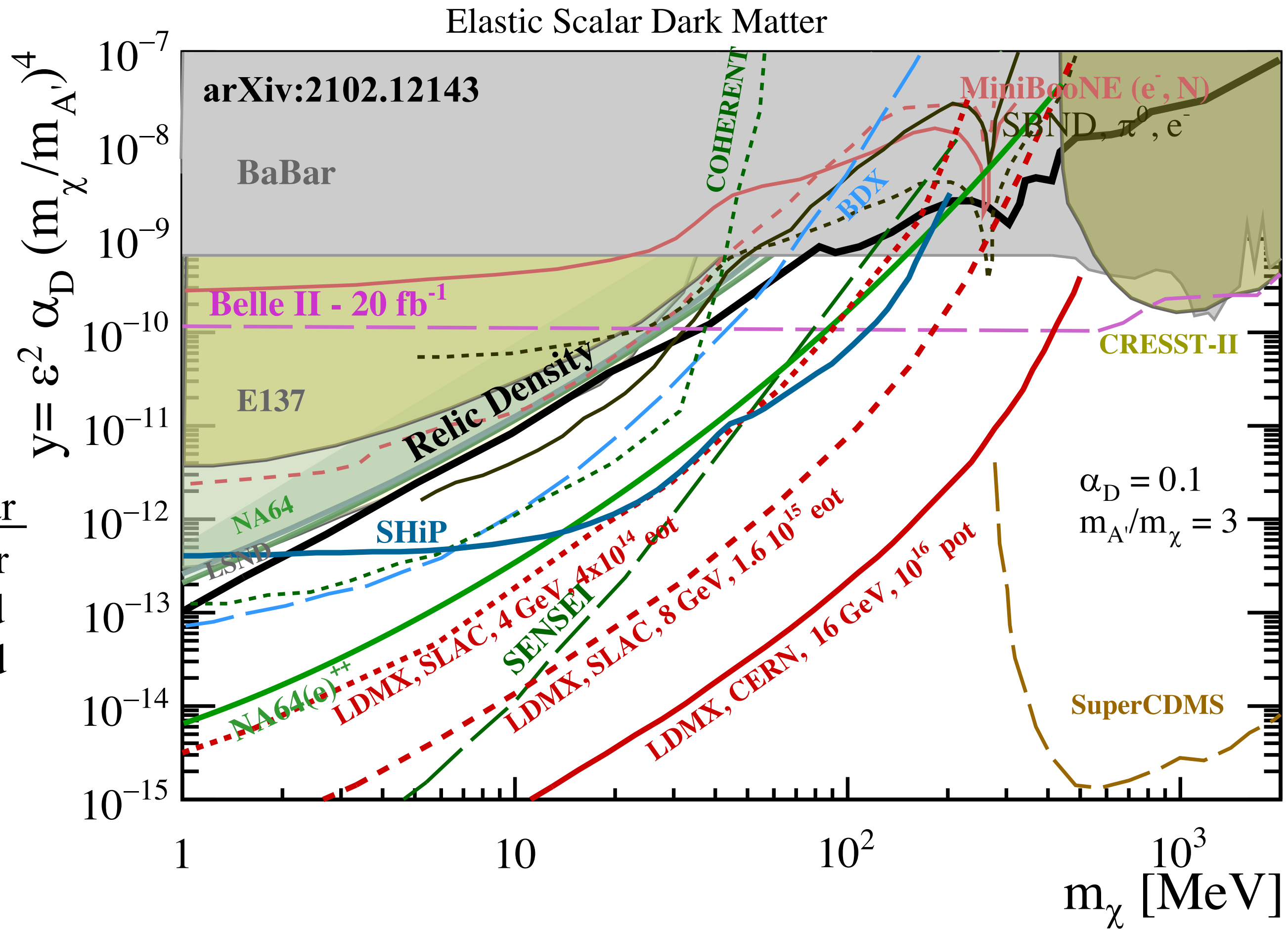


If it is in p-wave, the annihilation rate will be smaller at low temperatures as the velocity redshifts with Hubble expansion.

Light DM with thermal origin with a new light Vector Mediator

(with new forces/interactions the Lee-Weinberg bound can be evaded)

If the DM is Elastic Scalar the annihilation via vector mediator is in p-wave and the CMB bound is evaded



PBC projects:

NA64^{++}(e), NA64(μ), SHiP,…

Worldwide landscape:

- Accelerator-based:
  Belle-II, BDX, SBND, MiniBooNE, LDMX,…
- Direct Detection:
  CRESST-II, SuperCDMS, SENSEI..

Major Labs involved:

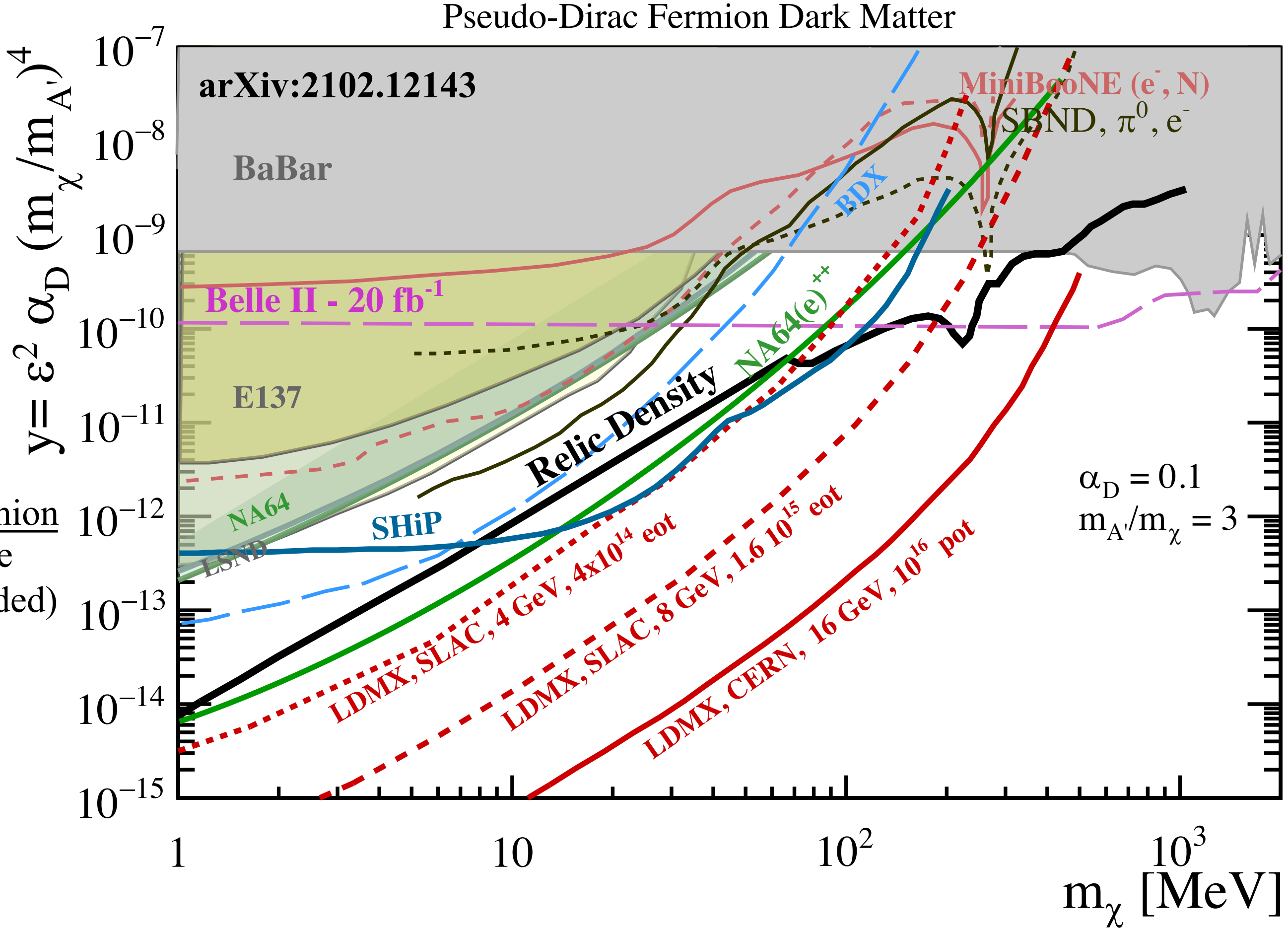
CERN, KEK, JLAB, FNAL, SLAC, SNOLAB, Gran Sasso,…

Within this model accelerator-based results can be directly compared with DD:

Natural synergy between accelerator-based and direct detection experiments.

Light DM with thermal origin with a new light Vector Mediator

(with new forces/interactions the Lee-Weinberg bound can be evaded)



If the DM is Pseudo-Dirac fermion the annihilation is cut-off at late times (CMB bound can be evaded)

PBC projects:

NA64, NA64^{++}(e), NA64(μ), SHiP,…

Worldwide landscape:

Belle-II, BDX, SBND, MiniBooNE, LDMX,…

Major Labs involved:

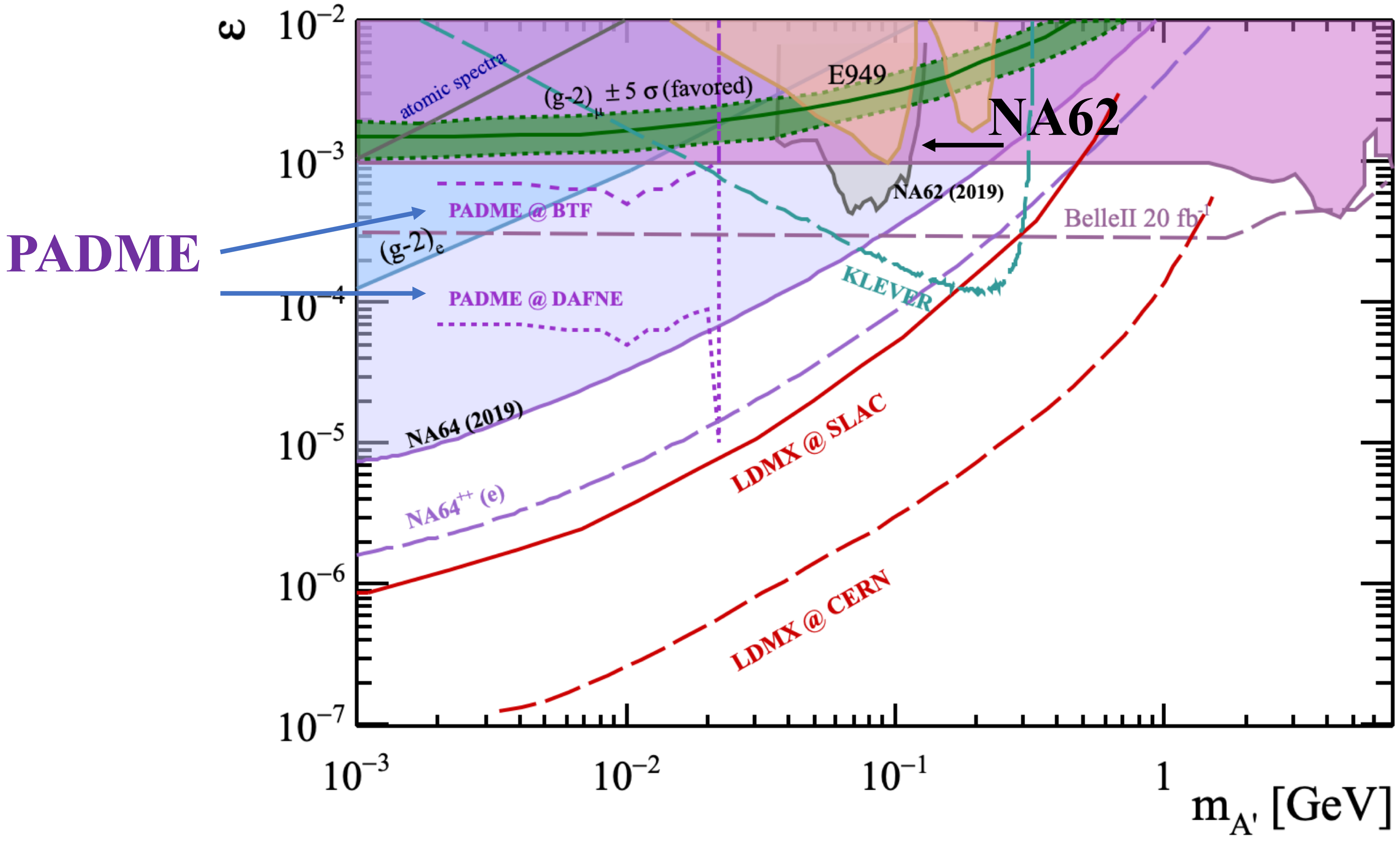
CERN, KEK, JLAB, FNAL, SLAC, ..

In this case accelerator-based experiments can see a signal while DD can not.

Natural complementarity between the two approaches.

Light DM with thermal origin with a new light Vector Mediator

(with new forces/interactions the Lee-Weinberg bound can be evaded)



Of course we can be also agnostic: we do not assume any specific nature of DM

Light DM as a product of secluded annihilation via light feebly-interacting scalars

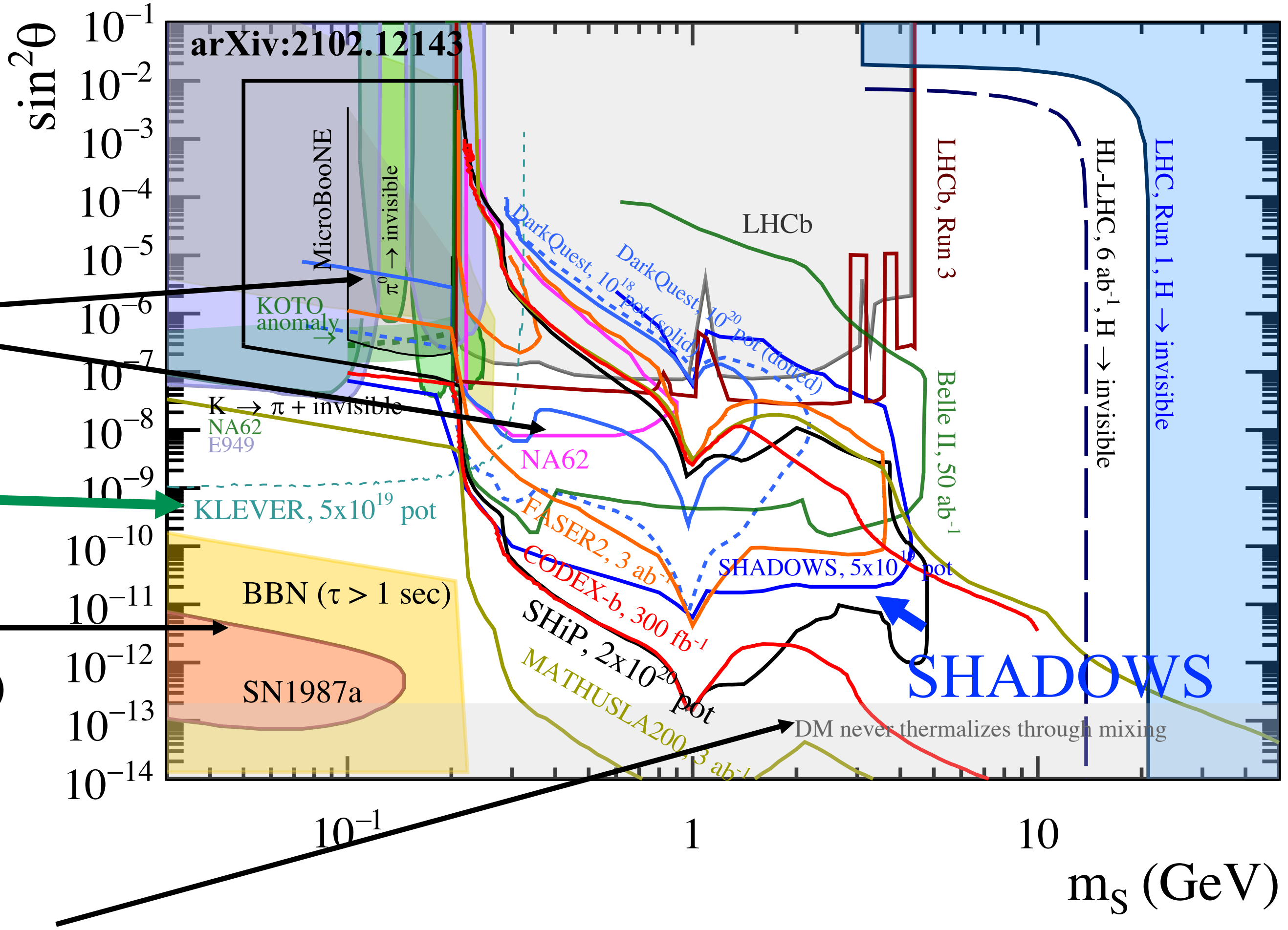
a simple but UV complete model, fully compliant with astroparticle & cosmology

$$\mathrm{DM\ DM} \rightarrow S^* S^* \rightarrow \mathrm{SM\ SM\ SM\ SM}$$

NA62

KLEVER

Astroparticle, Cosmology (SN 1987A, BBN)



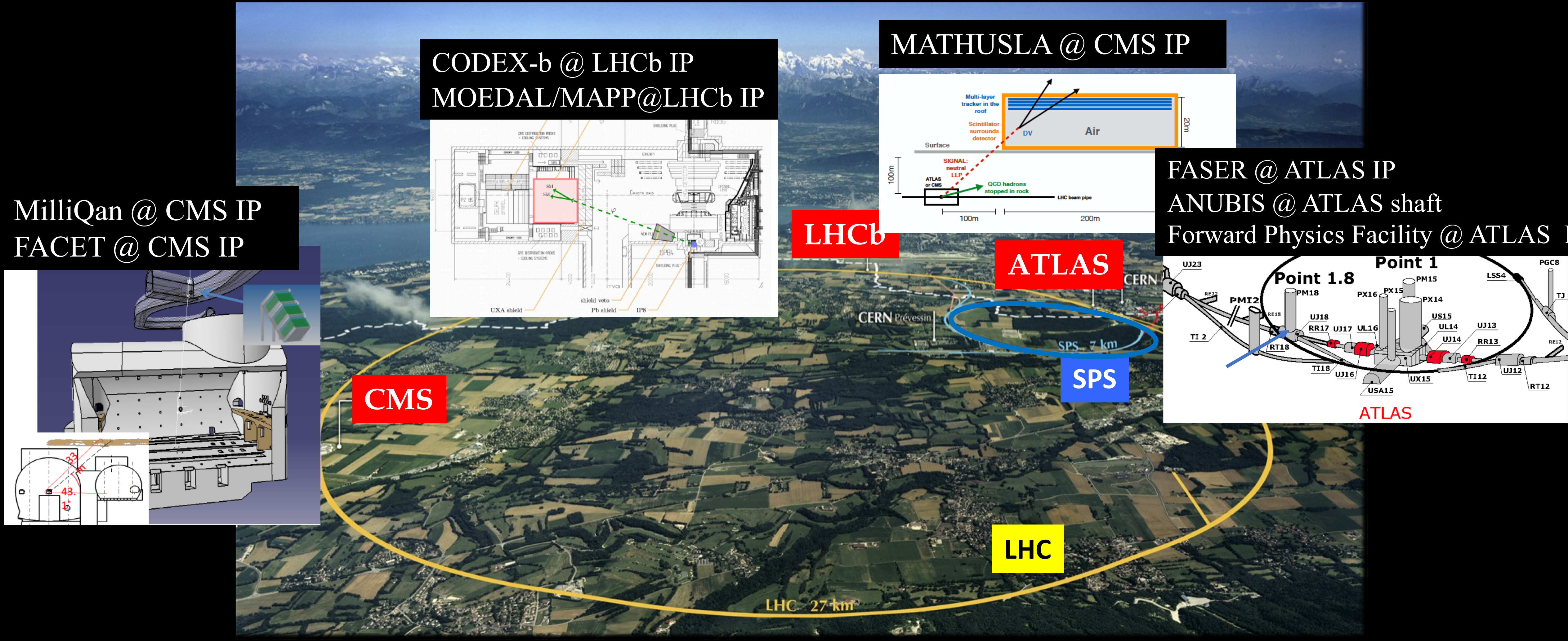
Lower bound in coupling strength if DM is a thermal relic….

CERN projects:
NA62, KLEVER, FASER2, CODEX-b, SHiP, MATHUSLA, SHADOWS…

Worldwide landscape:
MicroBooNE, KOTO, DarkQuest, Belle-II, LHCb, ATLAS, CMS

Major LABs involved:
CERN, KEK, JPARC, FNAL,…

FIPs @ CERN –The Long-Lived Particle detectors at the LHC IPs



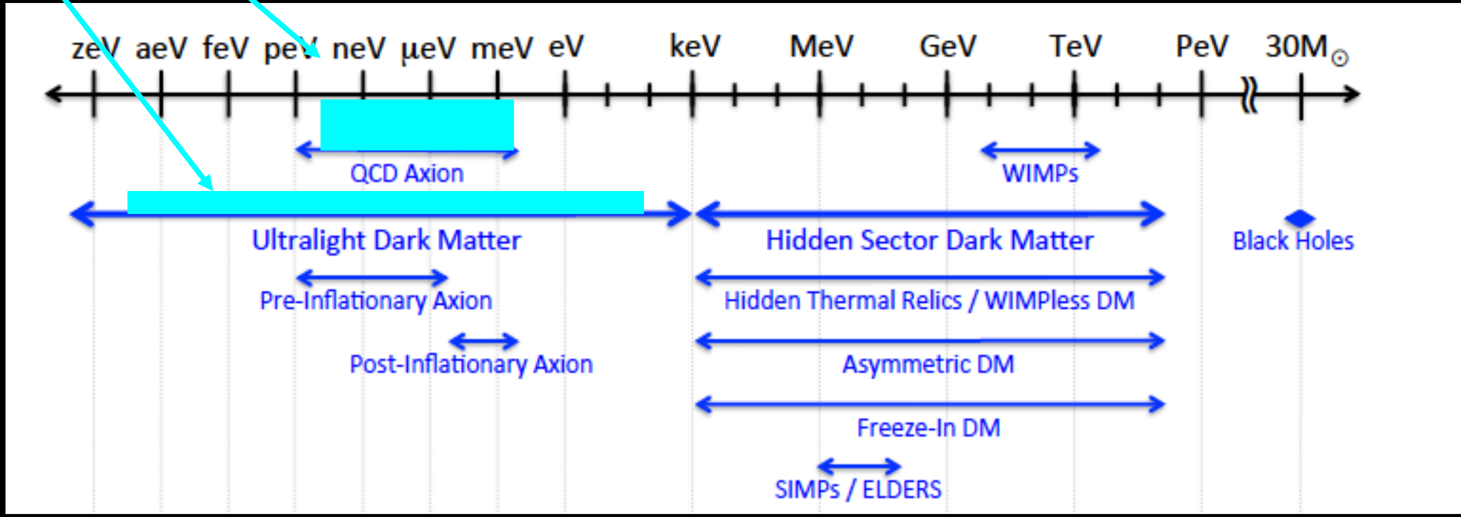
+ an active LLP community inside ATLAS, CMS, and LHCb collaborations

..But DM can be also a non-thermal, bosonic condensate:

1) Thermal DM candidates that extend the WIMP paradigm.
2) Ultra-light non thermal DM candidates;
3) The simplest theories to explain the origin of CP-symmetry in strong interactions
4) Candidates to explain the origin of neutrino masses and the matter/anti-matter asymmetry in the Universe;

and:

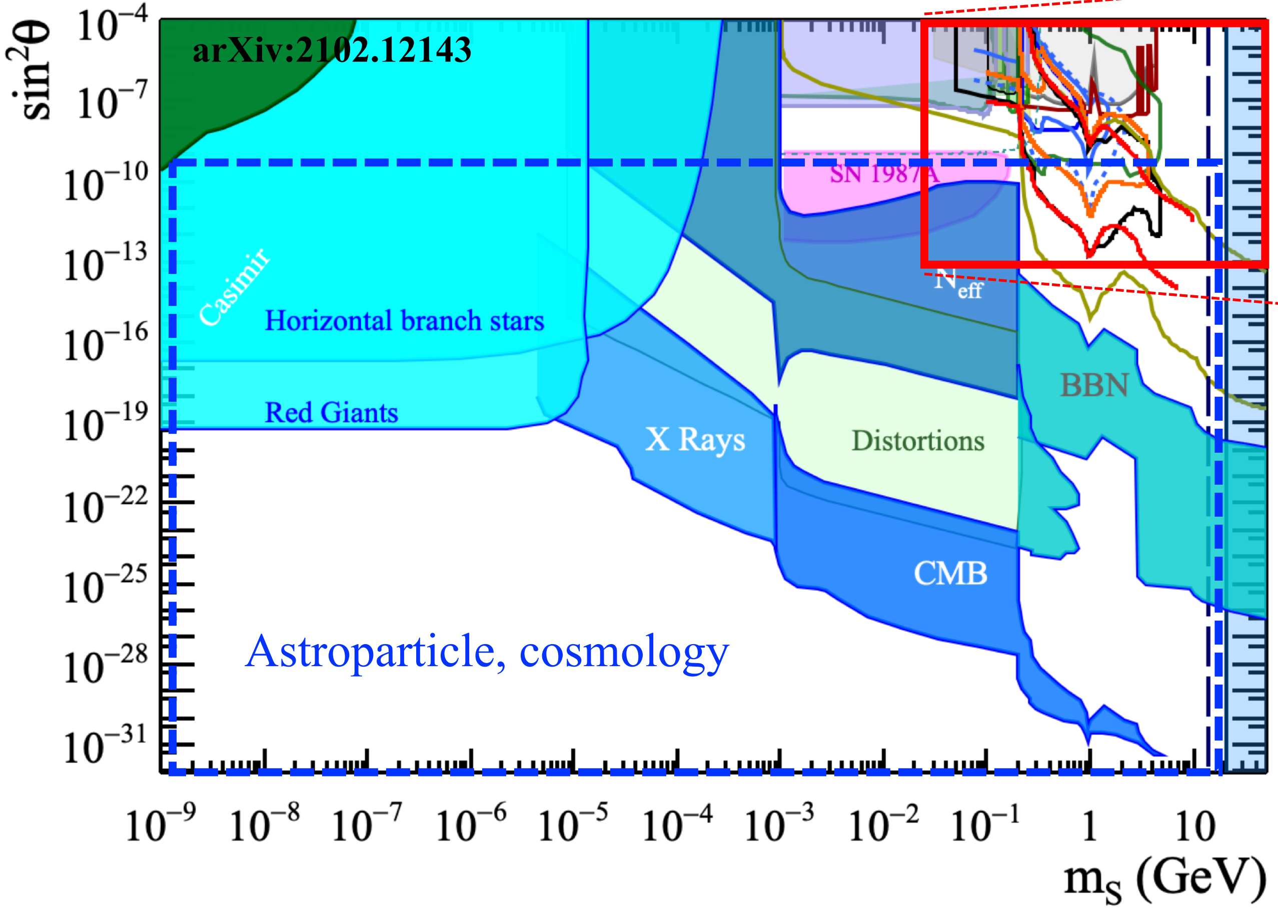
Candidates to address the electro-weak hierarchy problem, possible answers to the flavor puzzle, answers to many astrophysical anomalies,…..

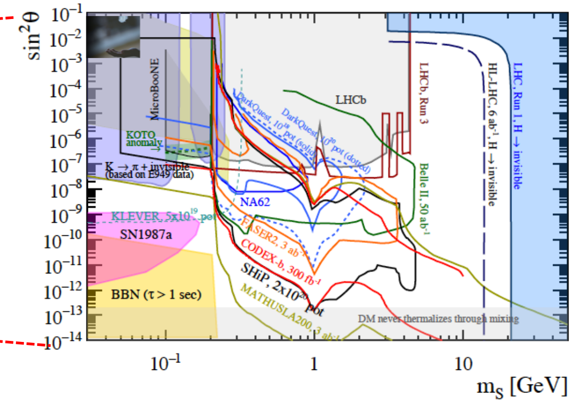


Cosmic Visions, arXiv:1707.04591

A light scalar as a non-thermal bosonic DM condensate

a simple but UV complete model, fully compliant with astroparticle & cosmology



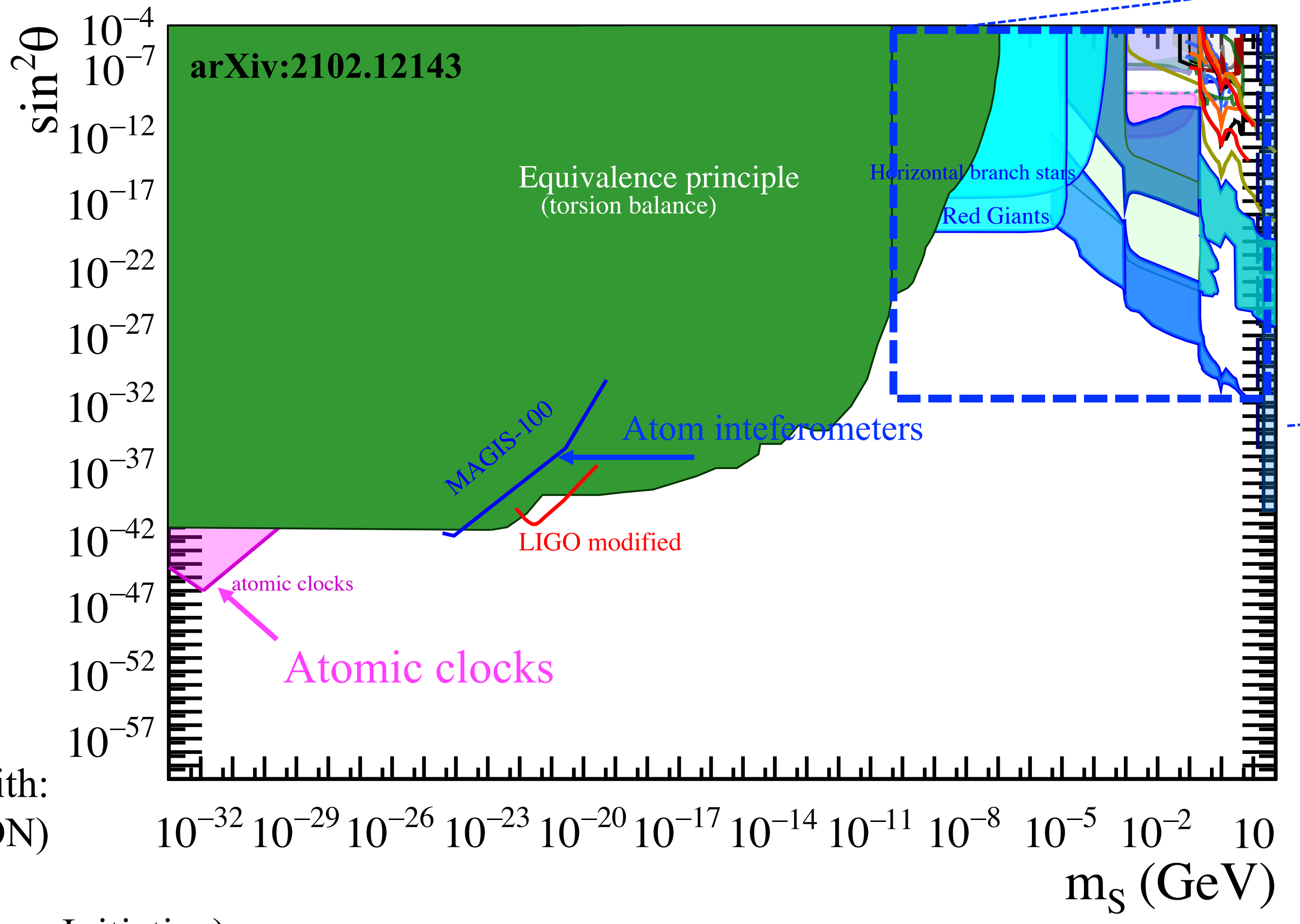


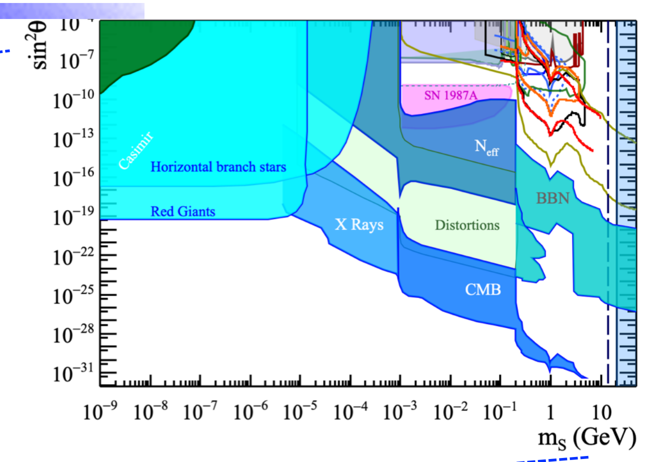
Accelerator-based experiments

Astroparticle, cosmology go deep inside in the “natural” region of parameter space covering 10 orders of magnitude in mass and 20 in coupling.

A light scalar as a non-thermal bosonic DM condensate

a simple but UV complete model, fully compliant with astroparticle & cosmology (CMB)





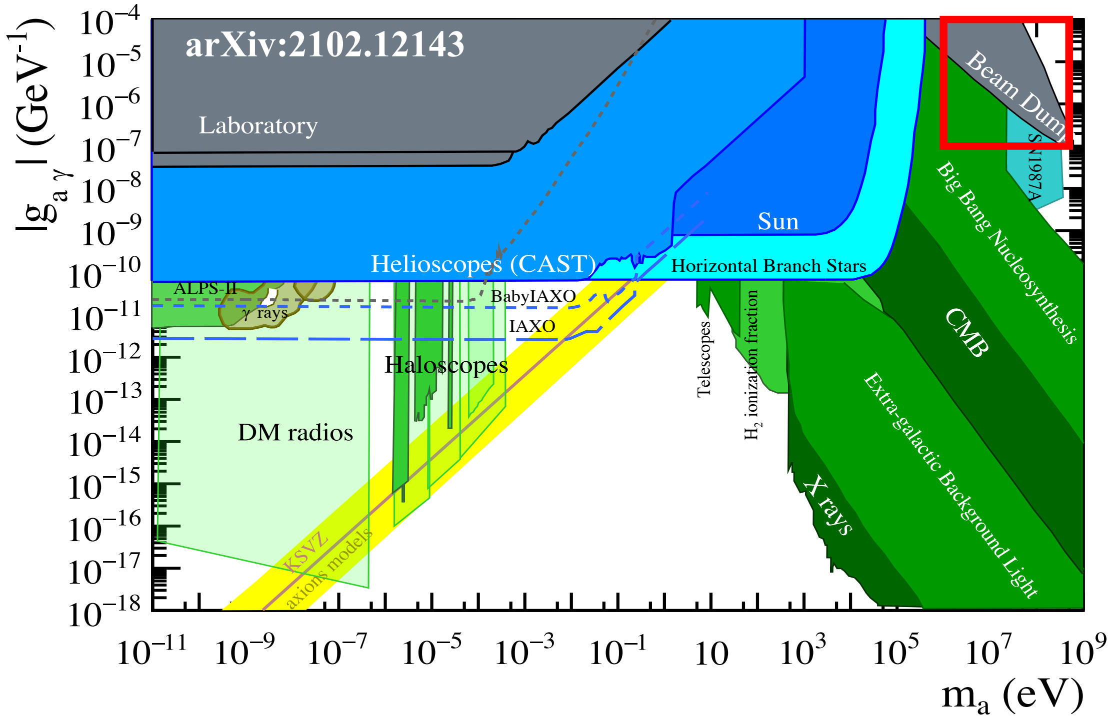
<u>New PBC activities:</u>

Ultra-light DM searches with:

- atom interferometry (AION)
- atomic clocks, (BASE)
- quantum sensors, (Quantum Initiative)
- emerging technologies,…

In the same mass range we can search for axions/ALPs……

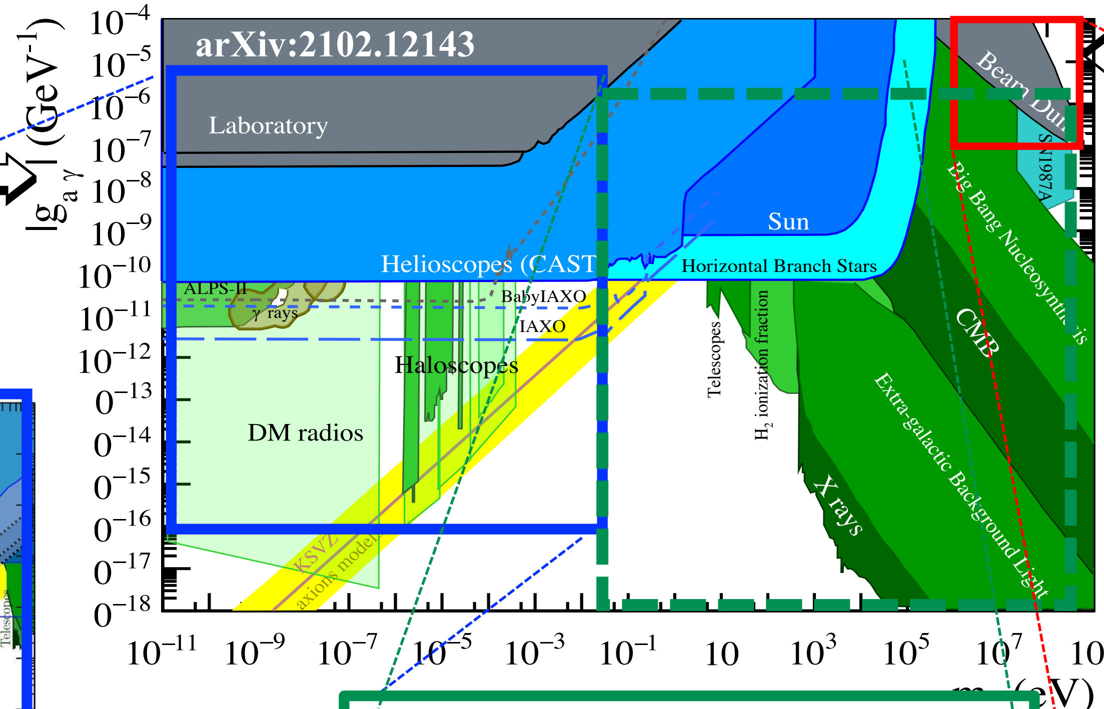
A light axion/ALP as a non-thermal bosonic DM condensate



The search for axions: A worldwide effort.

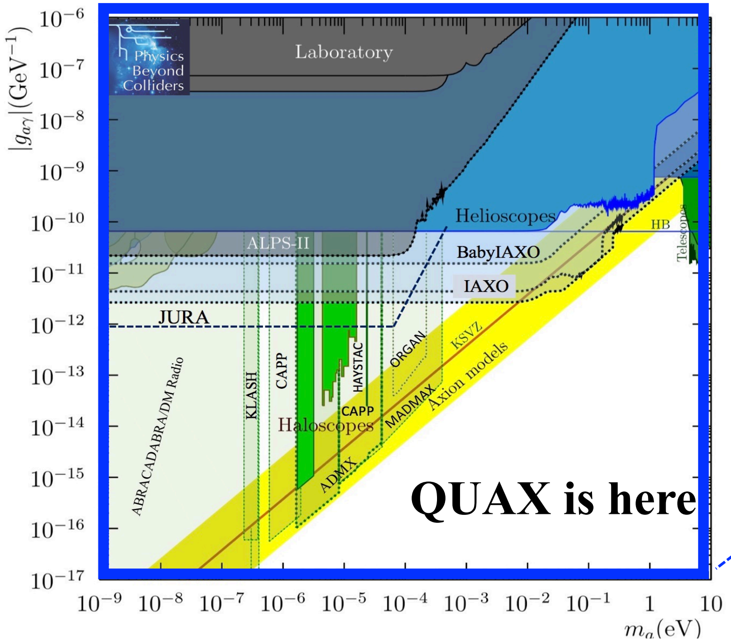
A light axion/ALP as a non-thermal bosonic DM condensate and at the QCD scale

sub-eV range accessible at **helioscopes and haloscopes**

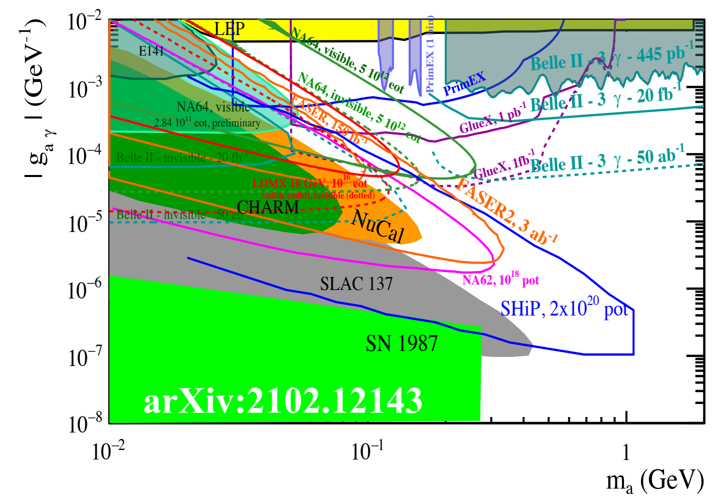


MeV-10 GeV range accessible at **accelerator based experiments**

Here axion/ALP can be DM



Astroparticle/cosmology realm:
BBN, CMB, X-rays, SN1987,
Solar lifetime, etc..



CERN projects: Baby-IAXO (IAXO),VMB, …

Worldwide landscape: All the others...

CERN experiments/projects:

NA64(e), FASER(2), SHiP, NA62 (dump), …

Physics Beyond Colliders

What FIPs can provide us?

Not only DM but also Heavy Neutrinos…

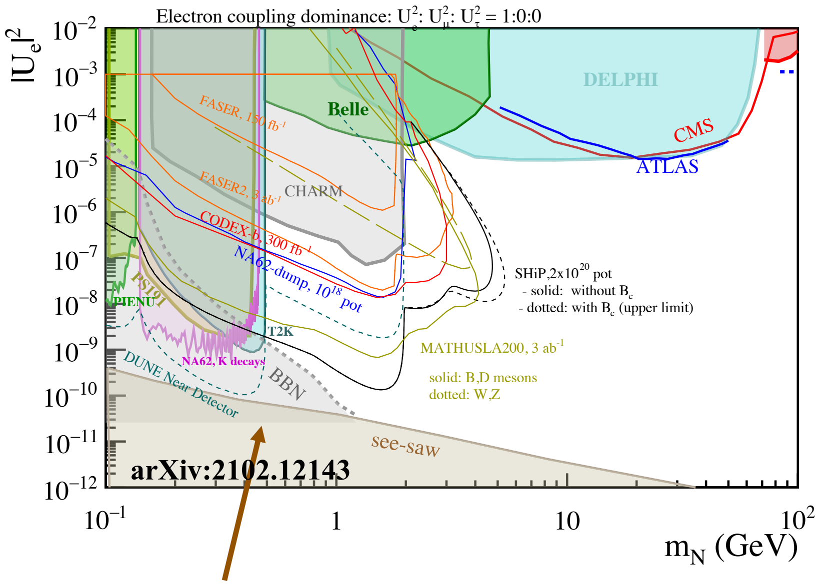
1) Thermal DM candidates that extend the WIMP paradigm.
2) Ultra-light non thermal DM candidates;
3) The simplest theories to explain the origin of CP-symmetry in strong interactions
4) Candidates to explain the origin of neutrino masses and the matter/anti-matter asymmetry in the Universe;

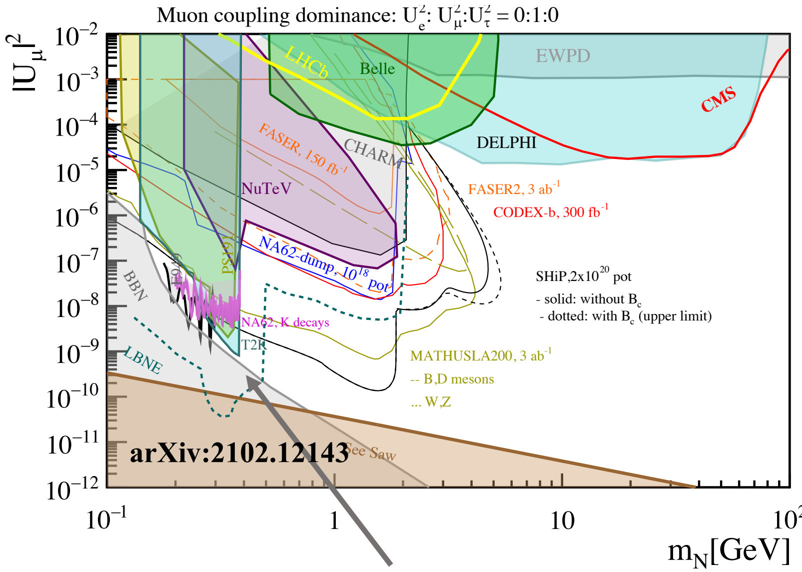
and:

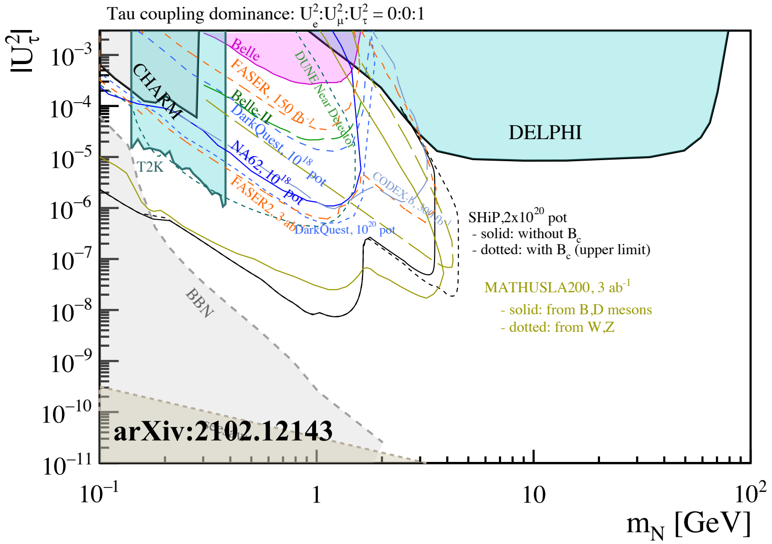
Candidates to address the electro-weak hierarchy problem, possible answers to the flavor puzzle, answers to many astrophysical anomalies,…..

Heavy Neutral Leptons as Heavy Neutrinos?

current worldwide experimental status - couplings to the three lepton generations







The seesaw line depends on the knowledge of $m_{lightest}$ which in turn depends on the **knowledge of the sum on the light neutrino masses** (SKA, Euclid, GC, ….)

BBN: HNLs must decay before BBN in order to not affect **abundances of primordial elements** observationally well constrained.

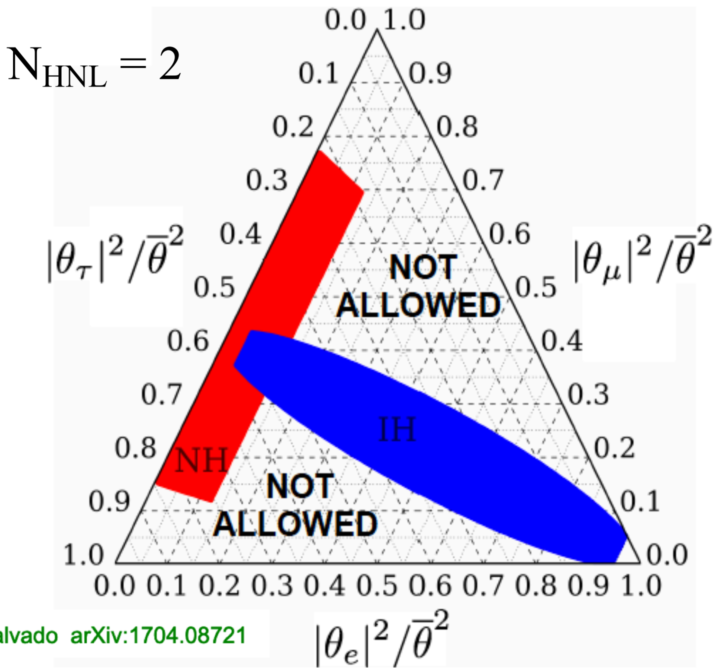
CERN experiments/projects: CODEX-b, FASER(2), MATHUSLA, SHiP, NA62, SHADOWS, LHCb, ATLAS, CMS, …
Worldwide landscape: T2K, Belle-II, DarkQuest, DUNE near detectors, …
Labs involved: CERN, KEK, JPARC, FNAL, …

A lively field.

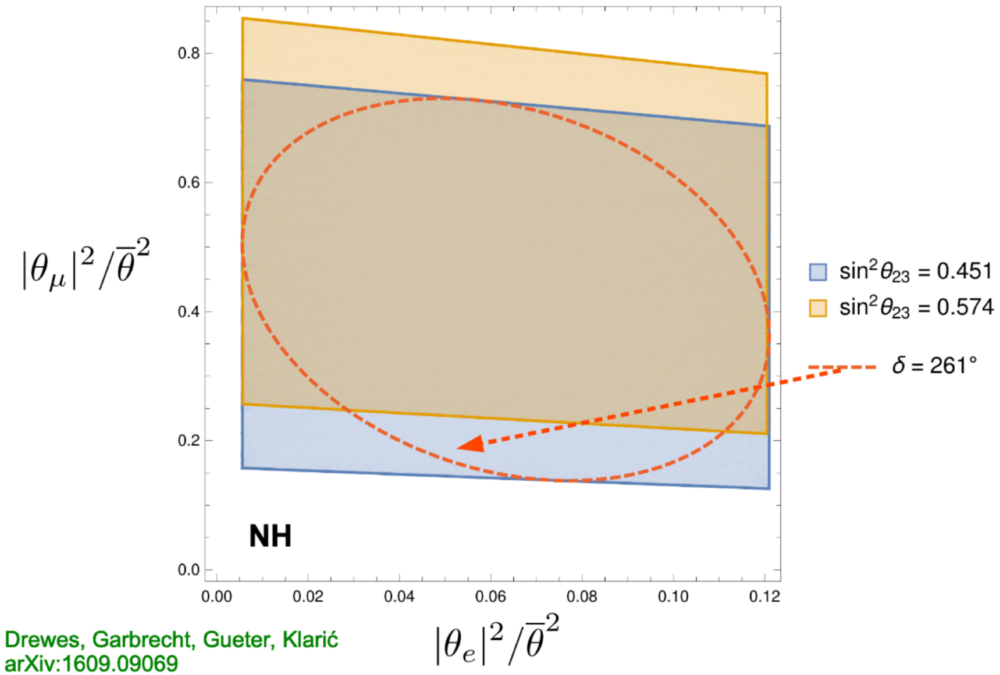
Heavy Neutral Leptons as Heavy Neutrinos?

Connection to light neutrino mixing parameters, $\boldsymbol{\delta}_{CP}$, $0\nu\beta\beta$ decays, etc.

N-ν mixing angles must be compatible with active neutrino mixing parameters & δ_{CP}



Caputo, Hernandez, JLP, Salvado arXiv:1704.08721



Drewes, Garbrecht, Gueter, Klarić arXiv:1609.09069

Important synergy with light neutrino experiments (current and future) to identify HNLs as Heavy Neutrinos in case of discovery.

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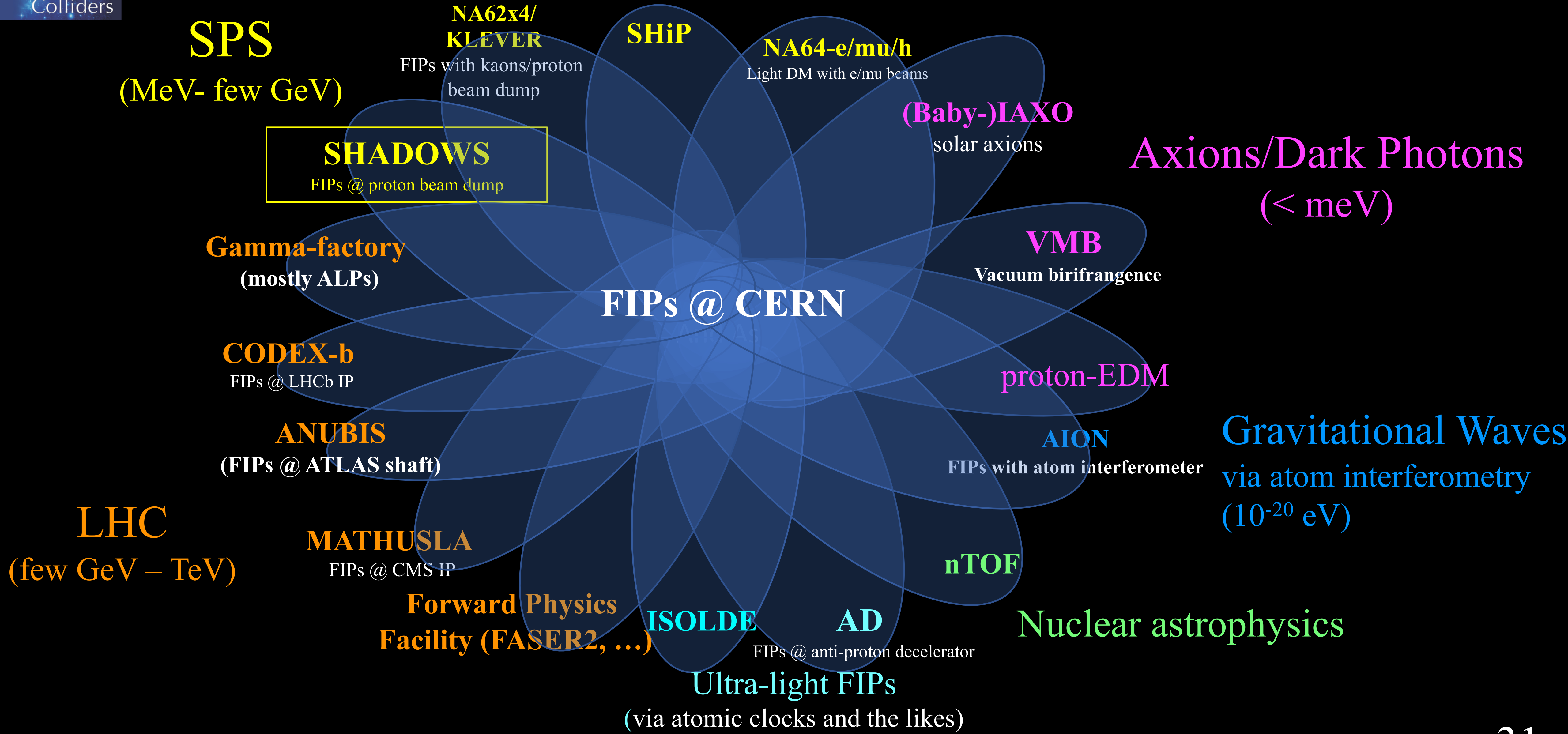
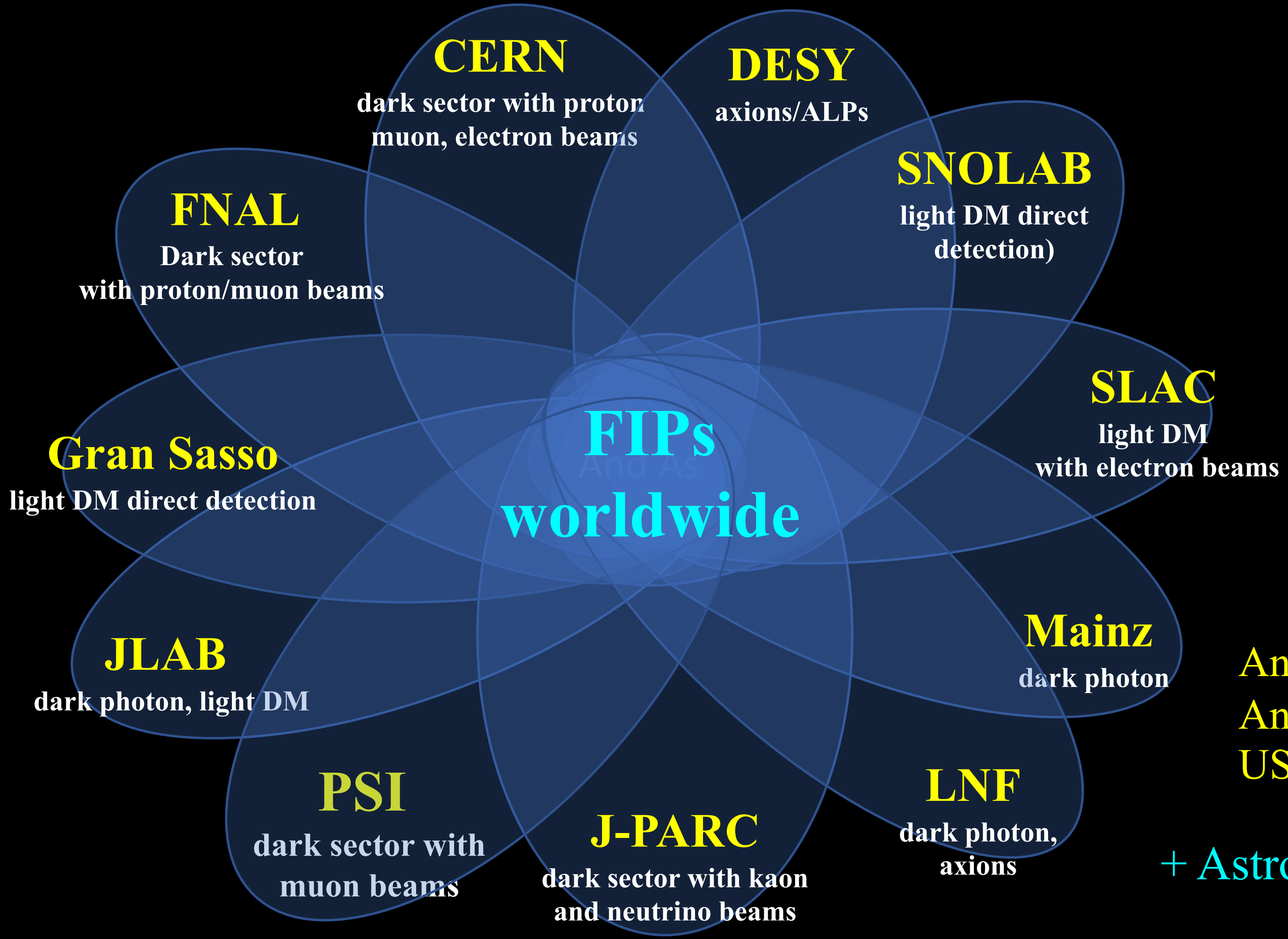
CERN: Experiments/proposals related to FIPs in PBC



.. And many more joining…

The Search for Feebly-Interacting Particles: A multi-community effort



And: MODANE, CANFRANC,…
And: many Universities in Europe
US, and beyond…

+ Astroparticle, cosmology

First pillar: Experiments

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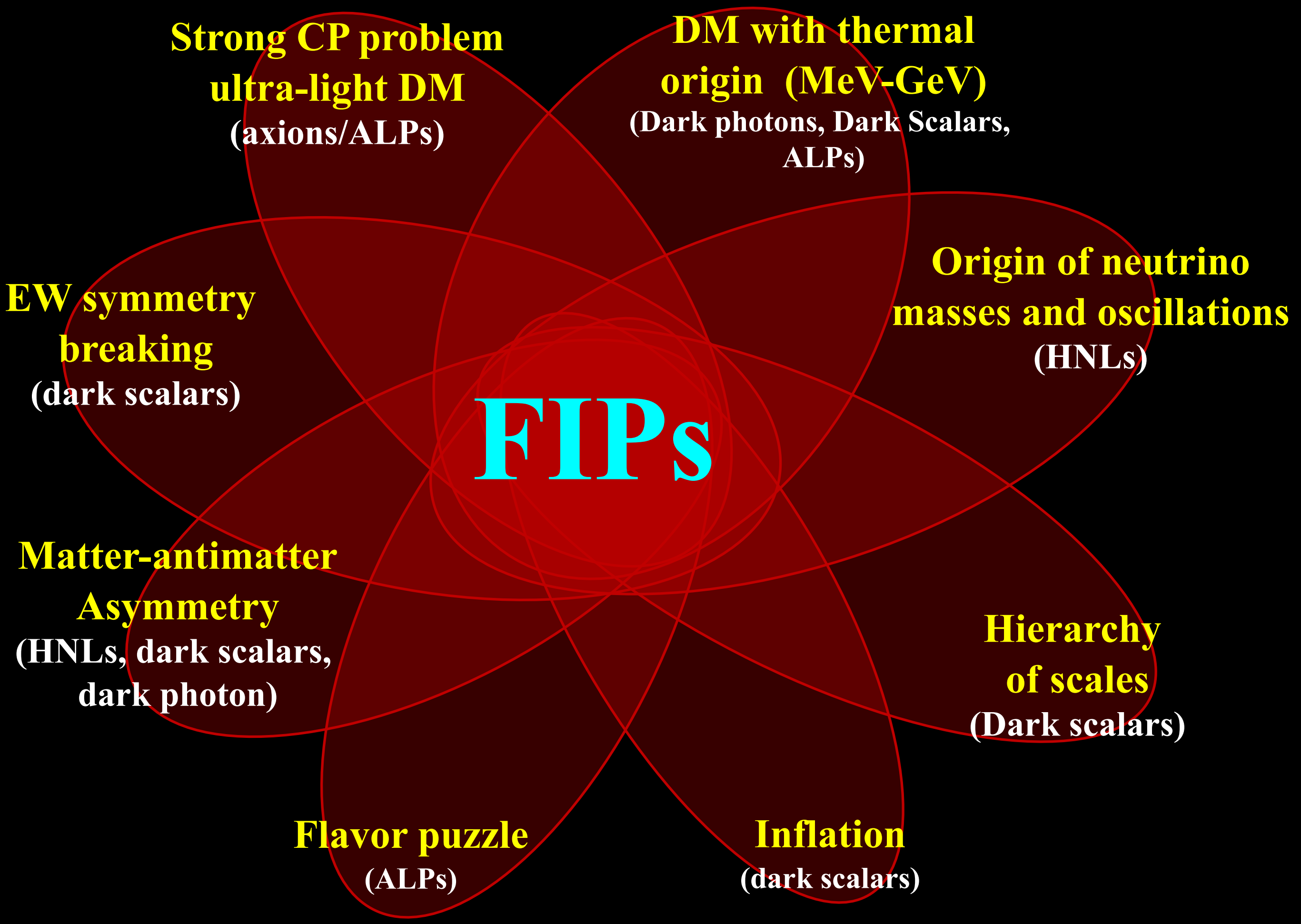
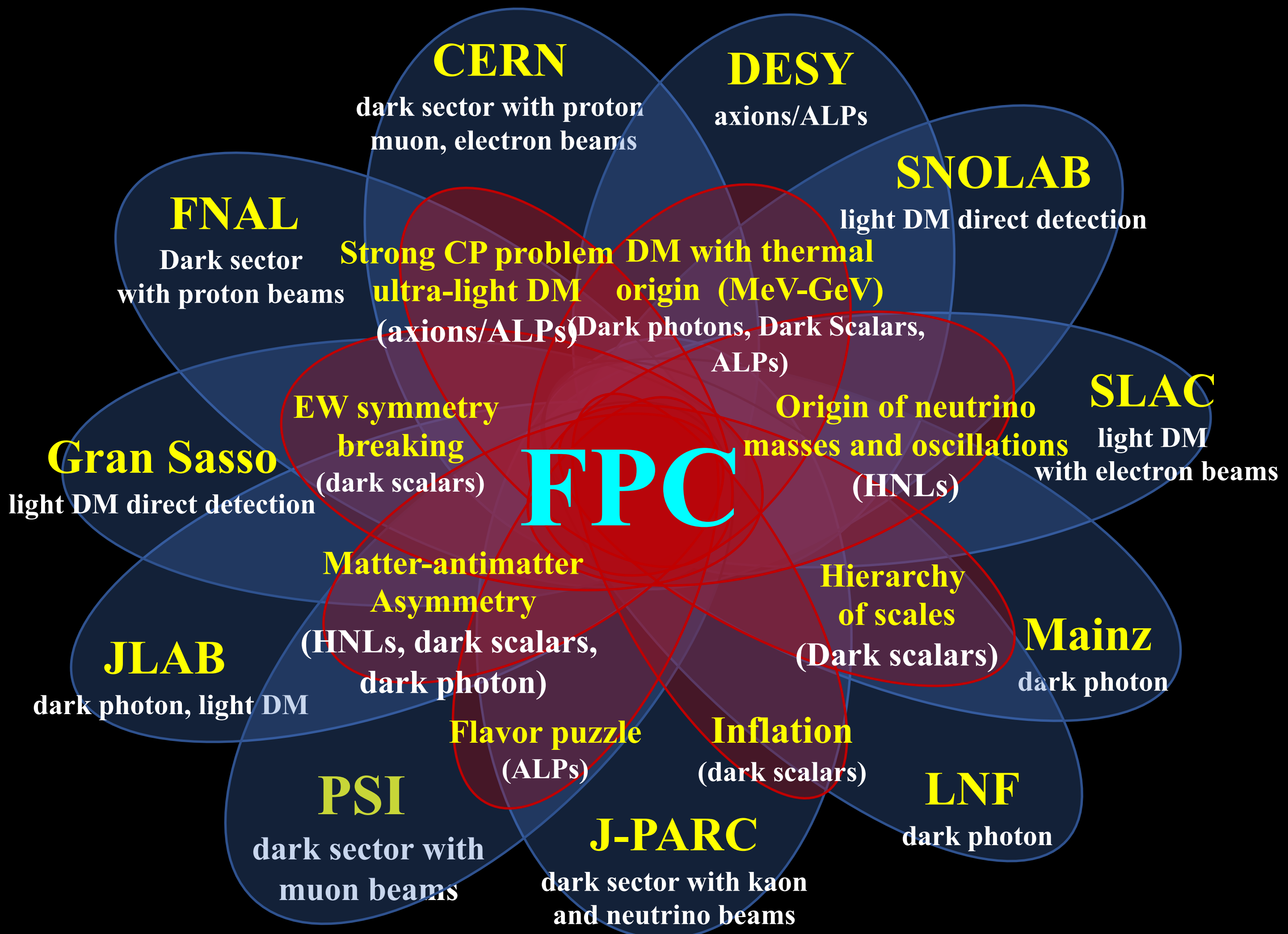
Fundamental Physics questions might be naturally intertwined. Need for a common theoretical approach within the FIPs paradigm.



<u>Second pillar: Theory</u>

The FIP Physics Center (FPC) in the new PBC activity



Third pillar: Communication

(Theory vs Experiments, accelerator-based vs non accelerator based experiments)

FIP Physics Center

Maxim Pospelov & GL

Mikhail Shaposhnikov
Gian Francesco Giudice
Jacobo Lopez-Pavon
Stefania Gori
Philip Schuster
Marco Drewes
Albert De Roeck
Martin Bauer
Silvia Pascoli
Maurizio Giannotti
Gordan Krnajic
Jocelyn Monroe
Felix Kahlhoefer
Pilar Hernandez
Joerg Jaeckel
James Beacham
Igor Irastorza
Joshua Ruderman
Yevgeni Stadnik
Stefan Ulmer
Jessie Shelton

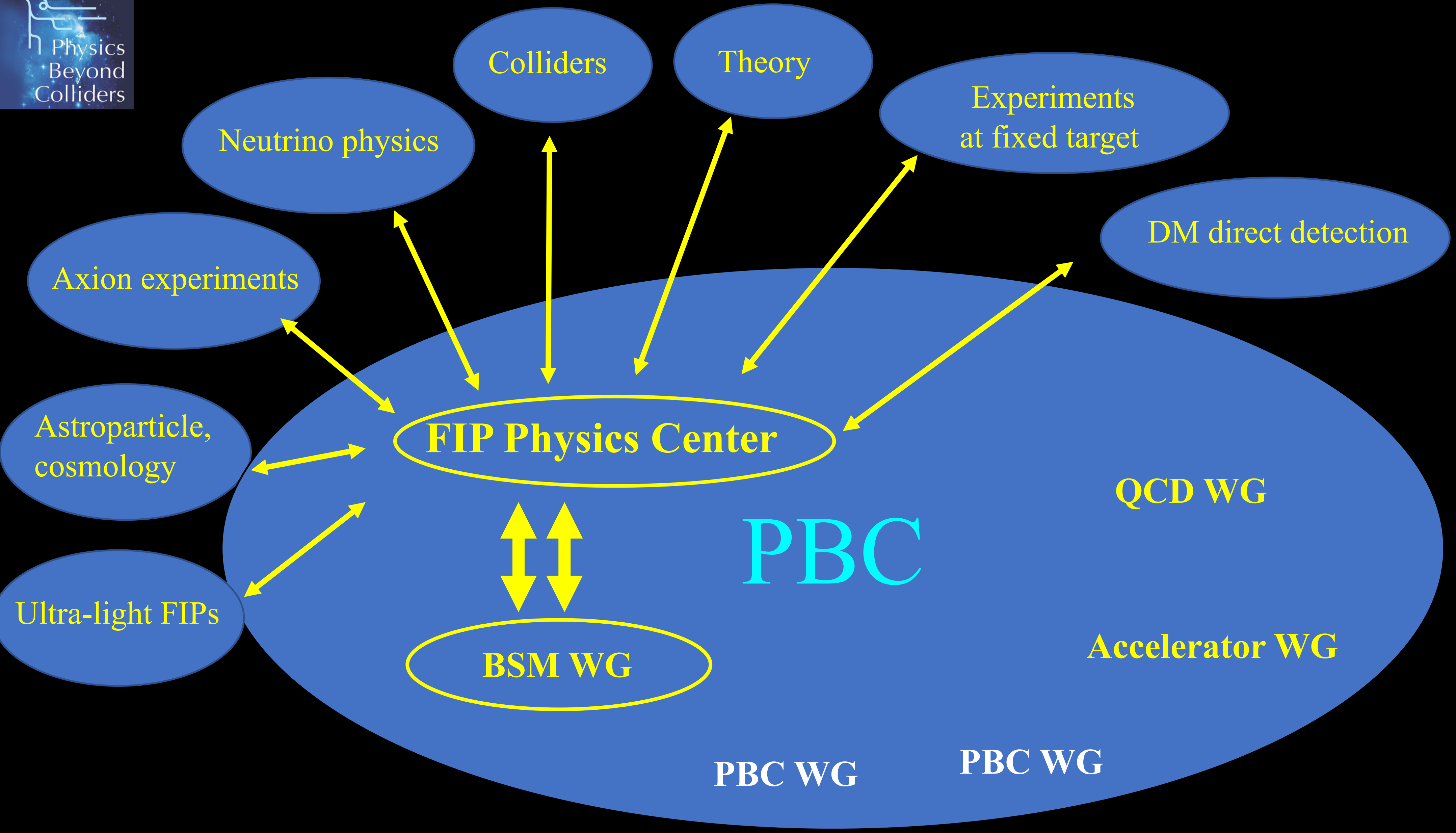
+ one representative per PBC experiment related to FIP physics

FPC main driver:

Exploit and further boost the potential of PBC experiments for FIP physics, taking into account the worldwide context, recent theory progress and related results from neighboring fields (axion physics, DM direct detection, astroparticle/cosmology, active neutrino physics, ….)

The FPC will act as "central forum for exchanges between the PBC experimental community and theorists for assessment of the physics reach of the proposed projects in a global landscape."

Physics Beyond Colliders



The “FIP Physics Center” as the PBC “portal” towards the external world

Conclusions

The breadth of the open questions in particle physics and their deep interconnection,
together with the failure so far of standard paradigms,
requires today more than ever a diversified research programme
targeting the physics of Feebly-Interacting Particles over a broad range of mass & couplings
with different experimental objectives and techniques,
and with strong and focused theoretical involvement.

FIP physics in the new Physics Beyond Colliders activity
will be an important step in this direction.

Physics Beyond Colliders

Thank you for your attention.