

FIPs 2020

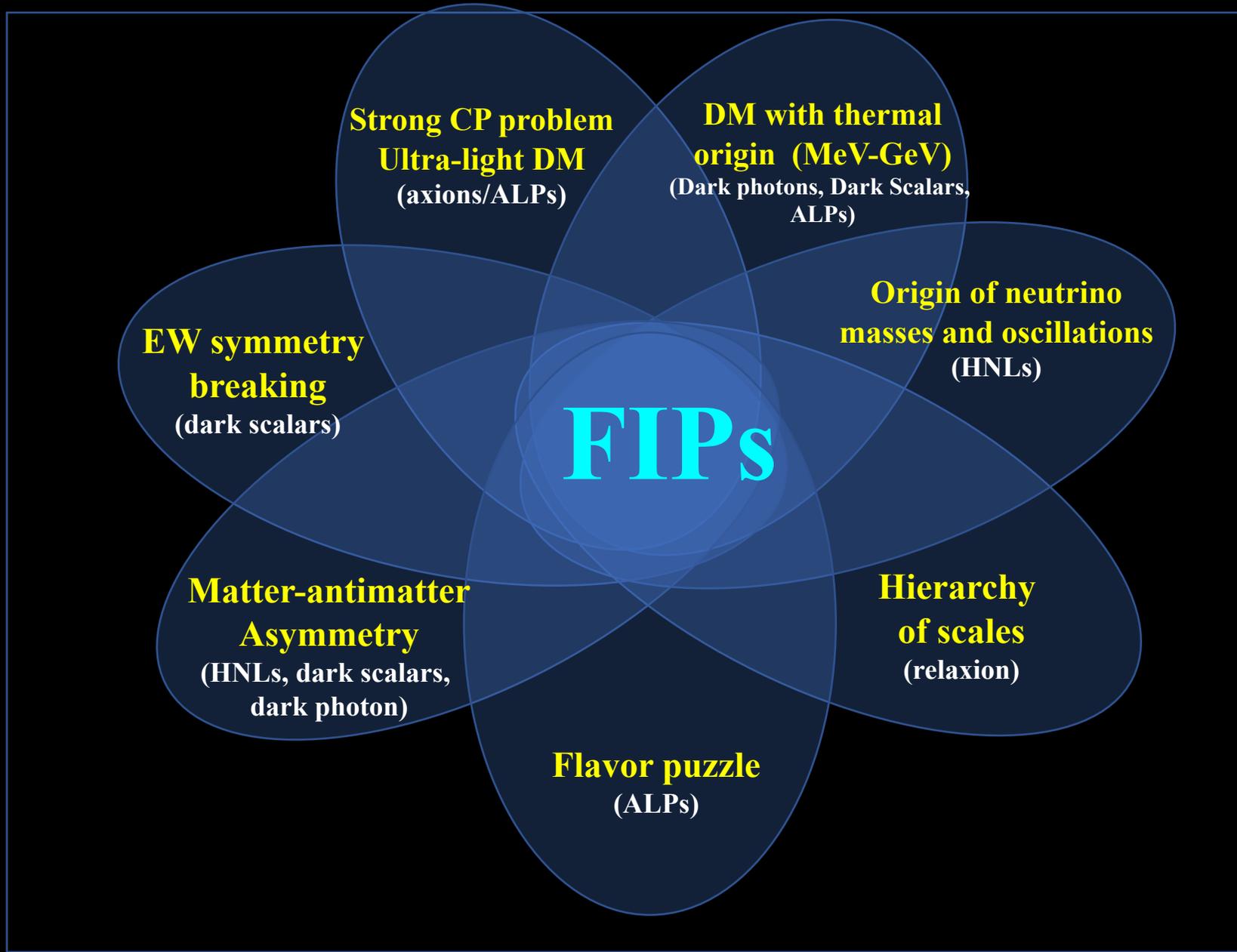
Workshop on
Feebly-Interacting Particles

Closing

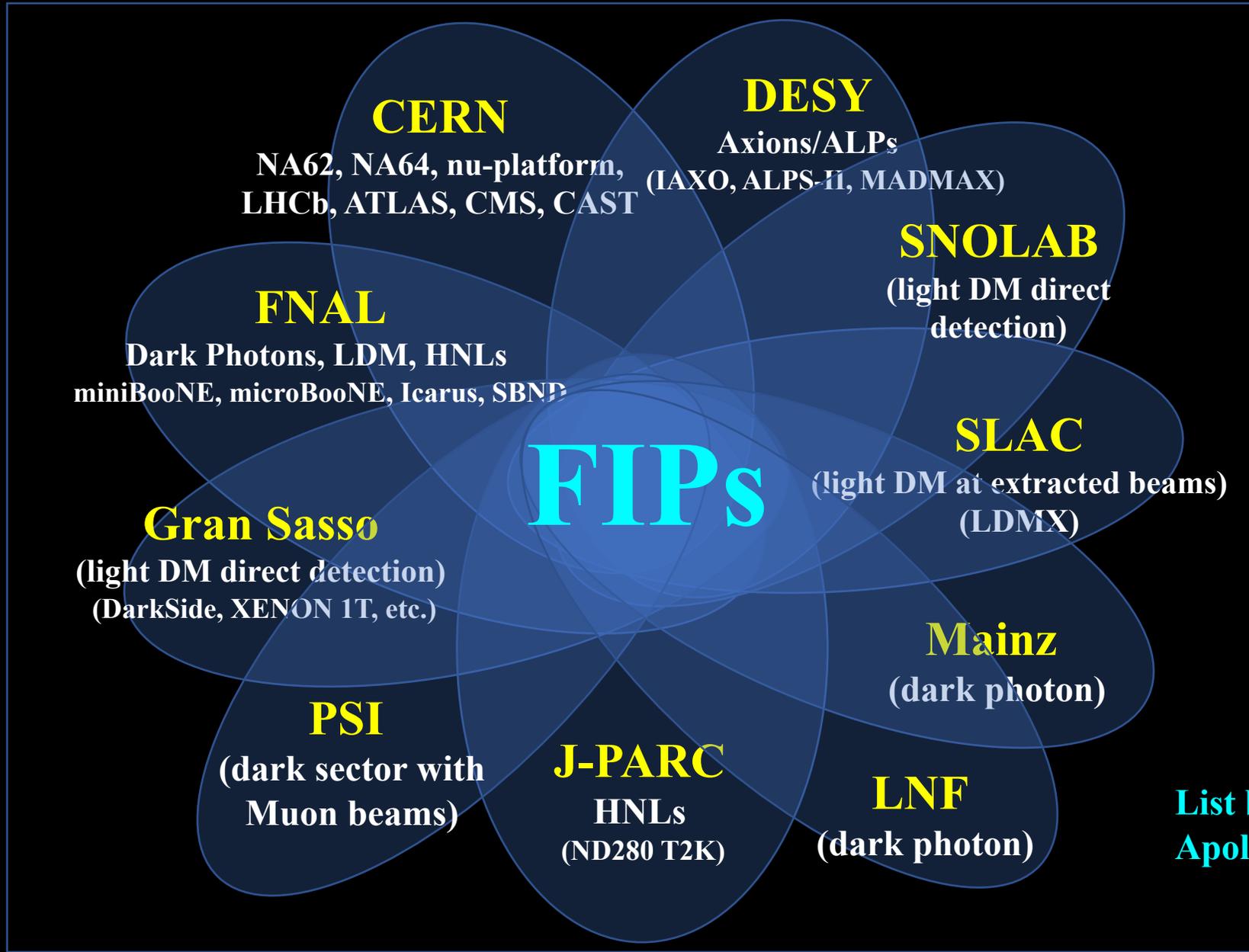
The Organizing Committee



FIPs 2020: a step in the quest for a new paradigm....



....involving many communities (and laboratories) usually very far apart



+ Modane,
CANFRANC,
JLAB,
Cornell,
BEPC-II (IHEP),
MPI (Munich),
Many others...

and results from
GAIA, Euclid, SKA,
NuSTAR,
XMM-Newton,...

List by far not complete....
Apologies in advance!

Open questions in the Standard Model

S. Knapen

Examples featuring

Origin of baryon asymmetry?



Dark photon

CP violation in QCD sector?



Axion-like particle (ALP)

Origin of the neutrino masses?



Heavy Neutral Lepton (HNL)

Electroweak hierarchy problem?



Dark Higgs

Origin of the dark matter?



Milicharged particle

These are just examples, other connections exist!

Especially ALPs, dark Higgs & dark photons are the “Swiss army knives” in a model builder’s toolbox

Do the Fab 5 frequently appear in complete models?



Yes
(but “falsifying” appears difficult)



No
(Especially @ LHC)

Are the Fab 5 sufficient?

The Fab 5 appear to be good representatives of complete models...

... but need to take care to not over interpret them! On their own, they have no predictive power

Question: Is our focus on the Fab 5 too narrow? Are we missing important alternatives?

Maybe... My feeling is that progress on this will come from top-down model building...

The Fab 5 look like the: “*Six characters in search of an author (Luigi Pirandello)*” :
Italian dramatist, novelist, poet, Nobel prize 1934.

They have a well defined and strong identity
they have been accepted by (almost) all the
experiments in the world..



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Of course: they still need a complete story to play (eg: top-down model building)

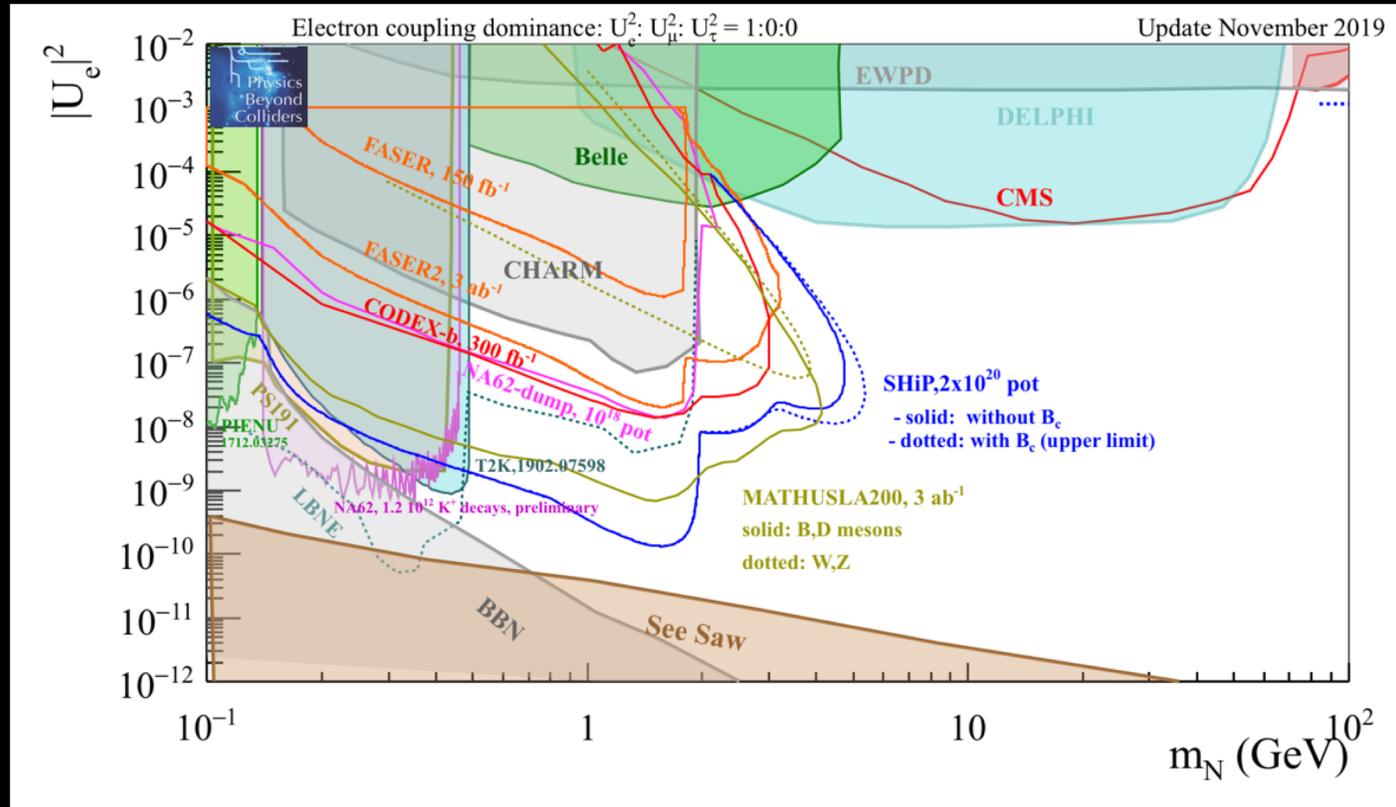
While waiting for a (more) complete story to play....

..... we can define better these “characters”

1. Fermion portal (HNLs):



PBC prescription: minimal model with 2 HNLs (the third is fully decoupled)
Single flavor dominance (only one coupling switched on at the time).



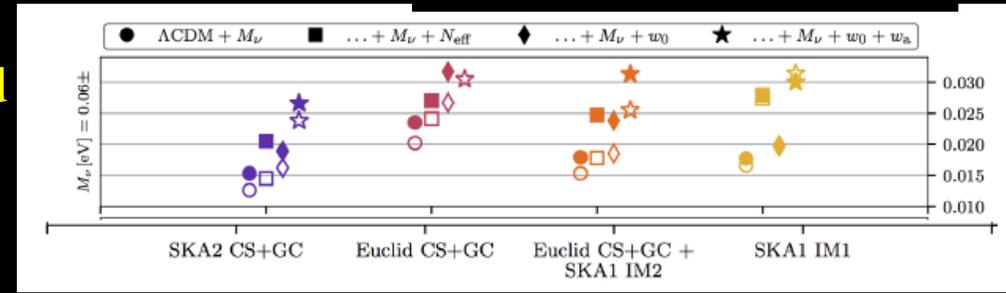
*This plot is already outdated given the amazing wealth of experimental results coming from experiments at accelerators all over the world...



1. Fermion portal (HNLs):

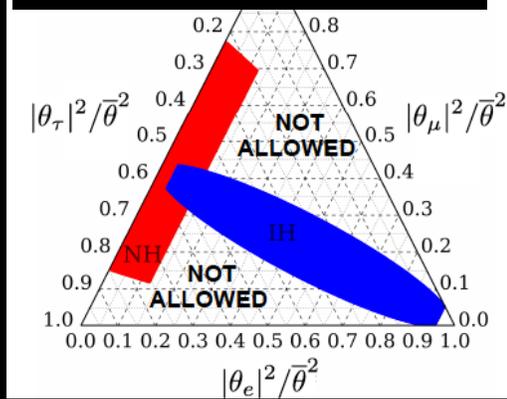
But we know much more than this and we should go beyond this simple approach...

Absolute neutrino masses

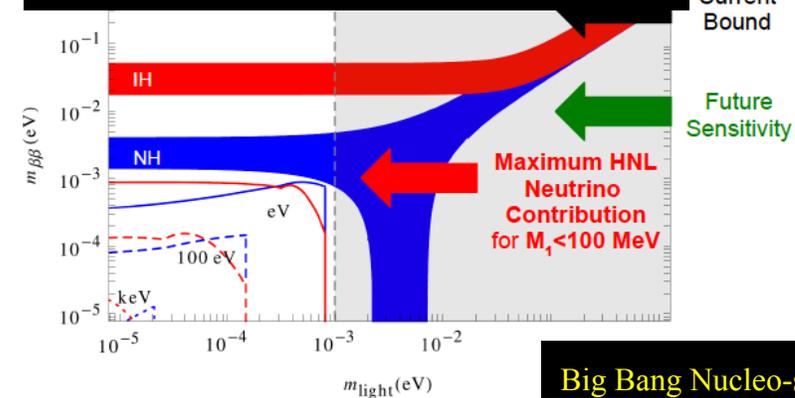


Drewes, Ruchayskiy, Lopez-Pavon, Izmaylov, Shchutska, Serra, Fischer,...

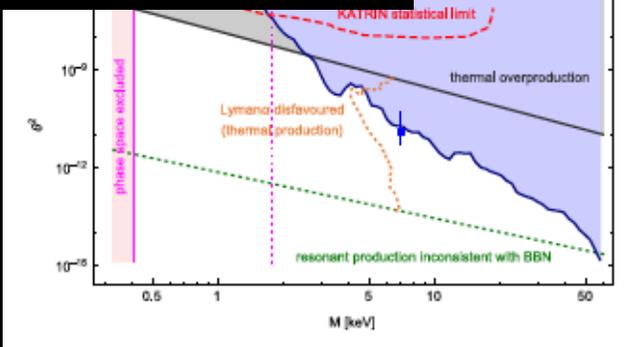
Oscillation parameters



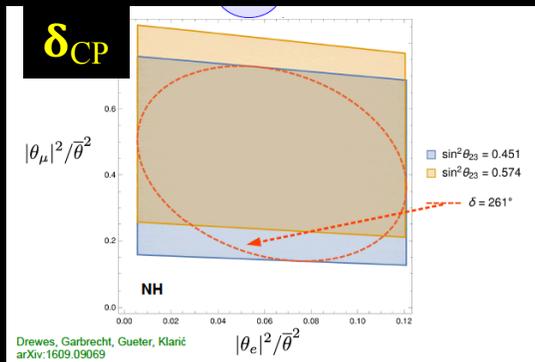
Neutrinoless double-beta decays



X-rays astrophysics

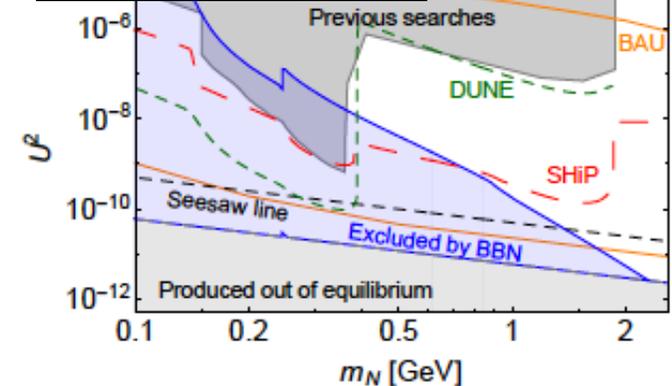


delta_CP



Hernandez, Ketic, JLP 2014

Big Bang Nucleo-synthesis = 0:1:0



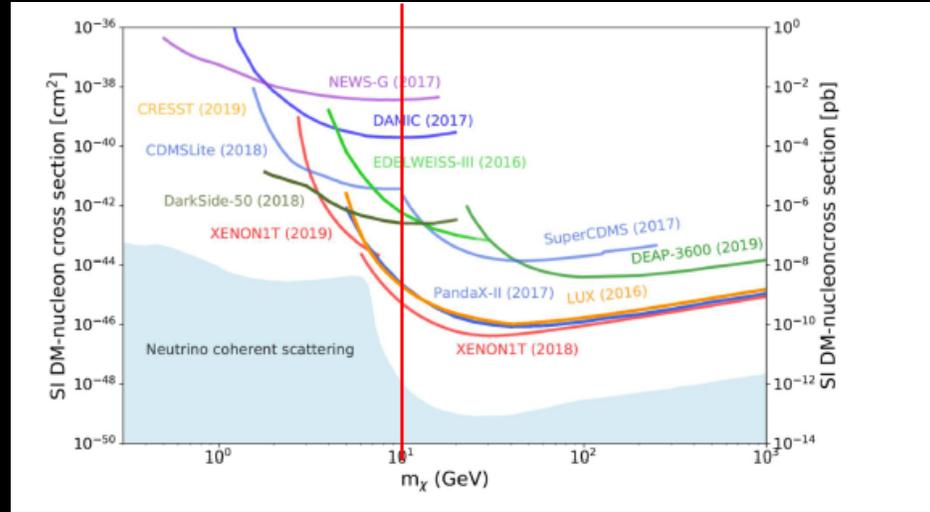
We need to guide experimental searches including results from neutrino physics, astrophysics and cosmology

2. Vector portal & Light DM: a field in full swing...

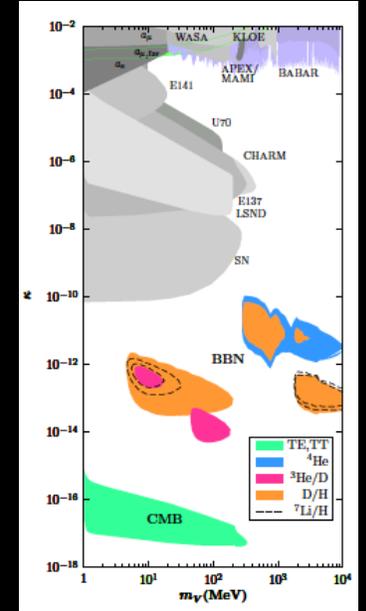
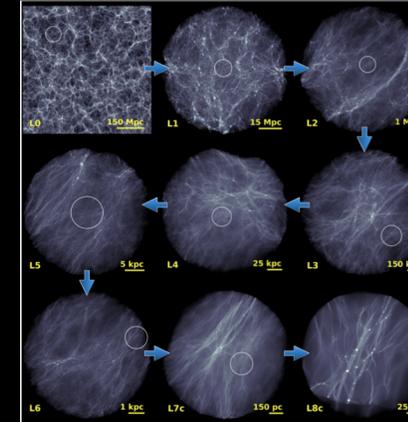


Berlin, Cebrian, Pospelov, Graziani, Iiten, Salfeld-Nebgen, Gninenko, Nelson, Boiarski, Echenard...

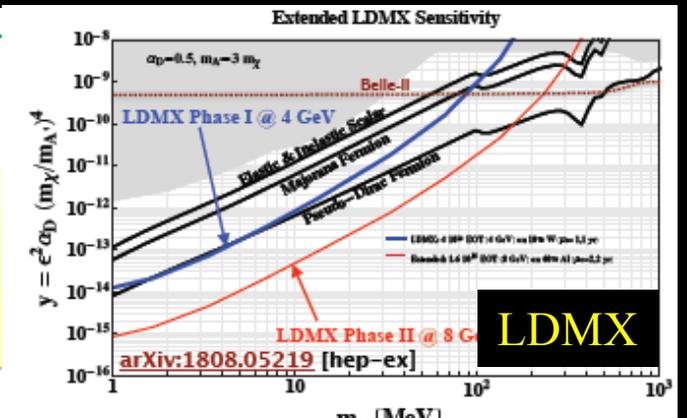
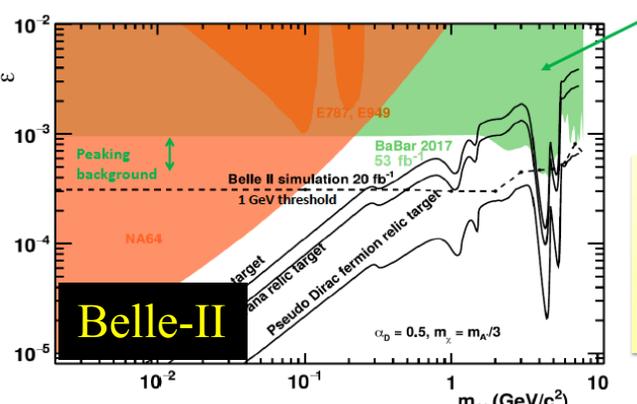
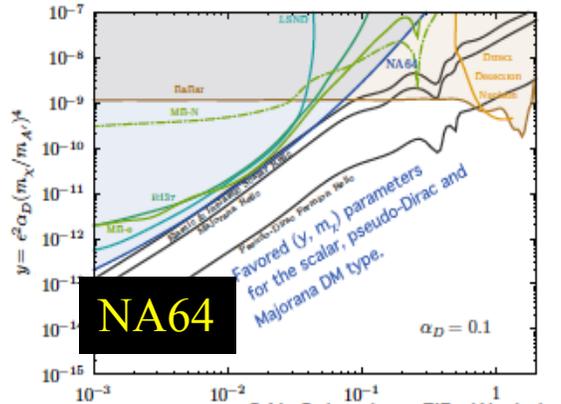
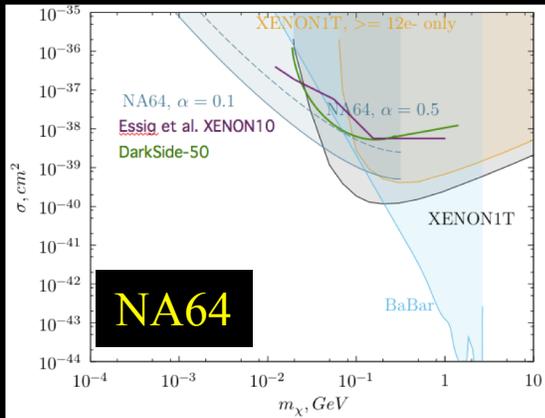
Light (< 10 GeV) DM DD: a field in full swing...



.. With deep connections with astroparticle and cosmology...



...That we try to catch up with accelerator-based experiments (NA64, Belle II, BDX, LDMX, ATLAS, CMS, you name it ...)



More and more there is the need of compare results from these communities in a clear and sound way.

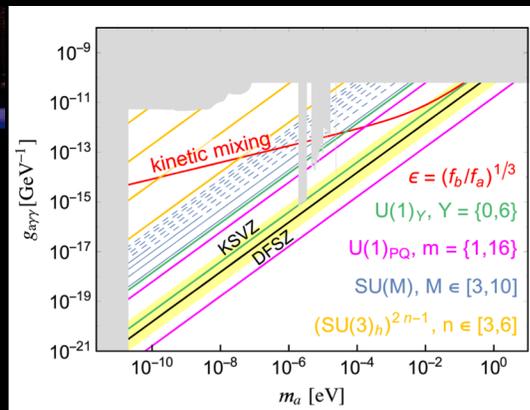
3. Pseudo-scalar portal (axion/ALP)



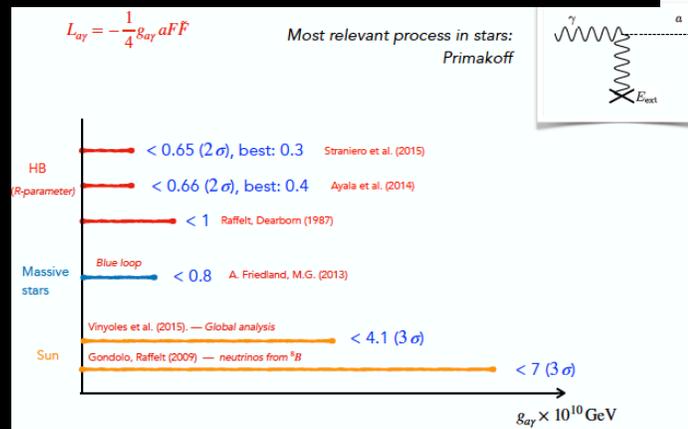
The little boy

Axions/ALPs in the sub-eV range: the parameter space is very open...

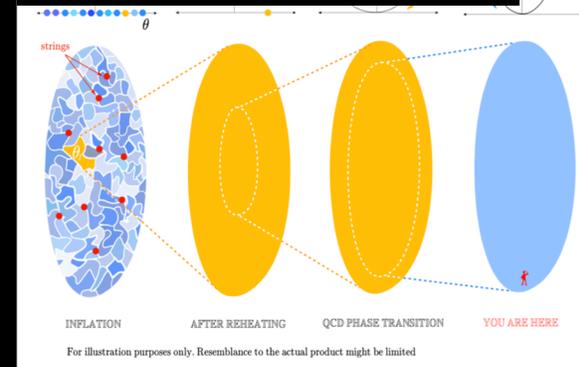
Giannotti, Agrawal, Ringwald, D'Enterria, Gninenko, Graziani, Irastorza, Kahlhoefer, Stadnik...



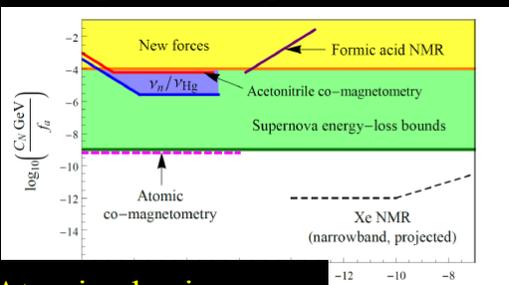
..can explain many astrophysical anomalies...



.. and be an excellent DM candidate

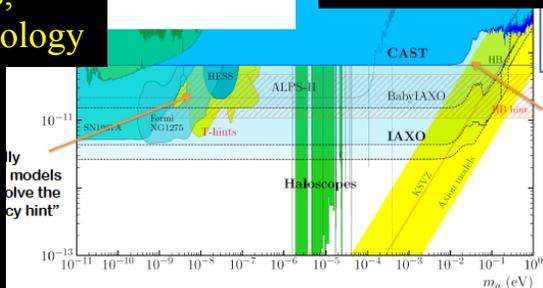


An explosion of experimental initiatives in the sub-eV range...

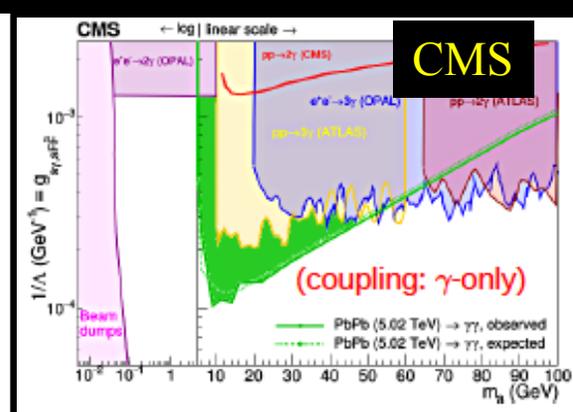
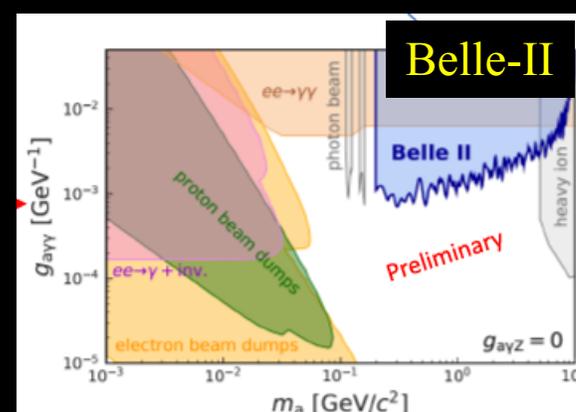
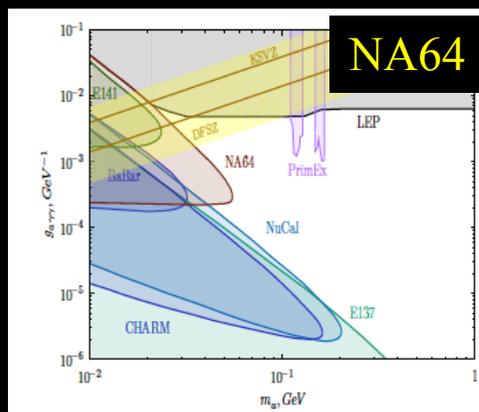


Atomic physics, Quantum technology

Helioscopes, haloscopes



Can accelerator based experiments play a role here? Yes!



We need to define a clear recipe for accelerator-based and quantum technology experiments (spell out which couplings are switched on, any model dependence, etc.)

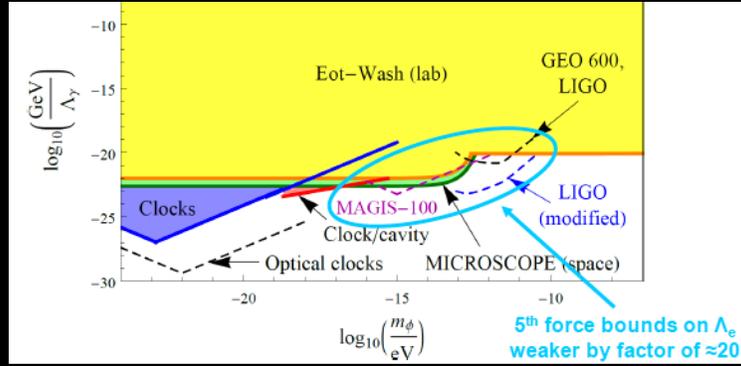
4. Scalar portal (the Higgs)

Higgs is naturally connected to any NP (the heart of the hierarchy problem), and be a gateway (portal) for Dark Matter. The scalar portal can induce oscillations in fundamental constants. It is already playing a full role in complete models (strong EW phase transition, Twin Higgs, ...).

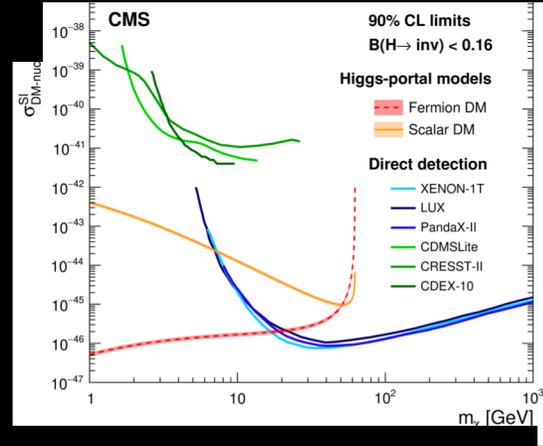


Bezrukov, Cepeda, Martinez Outschoorn, Swallow, Curtin, Gori, Stadnik

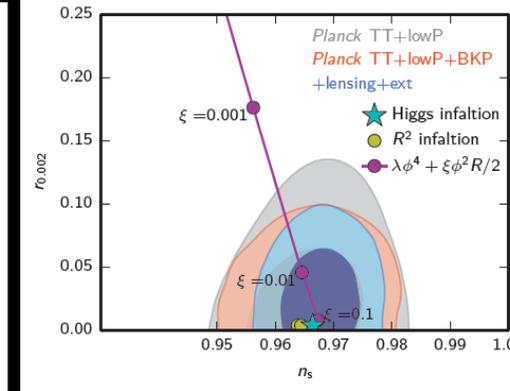
Scalar DM: Atomic interferometer searches of oscillation of fundamental constants



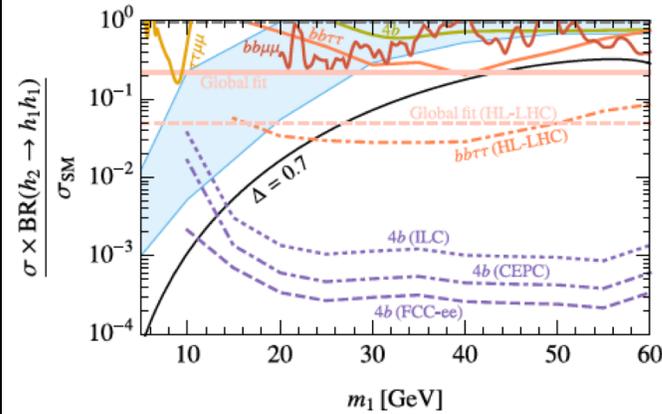
DM via Higgs portal



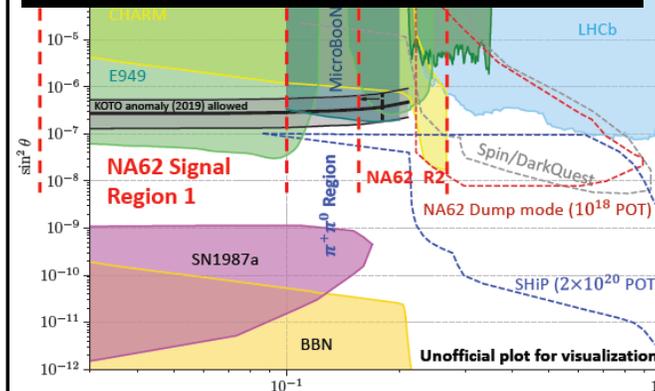
Higgs portal & inflation



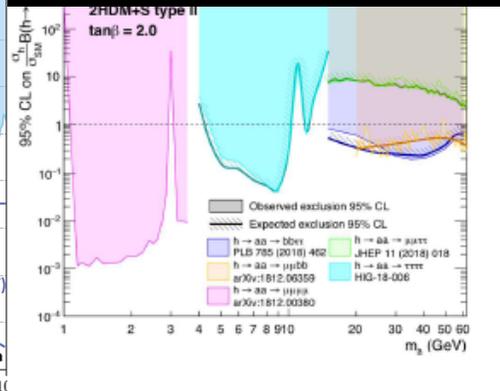
EW strong phase transition



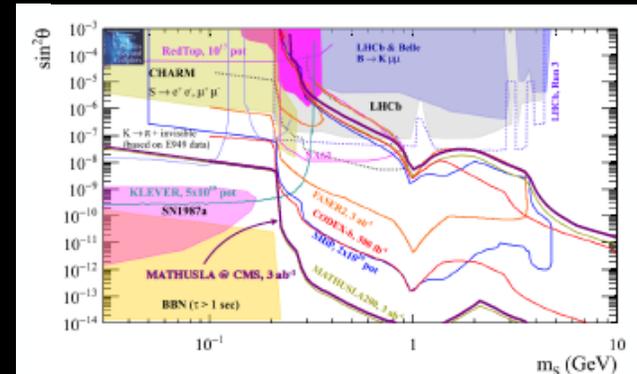
Light dark scalar at extracted beam lines



Light dark scalar at ATLAS and CMS



The future...



FIPs2020 Proceedings – Proposal:

✓ **We would like to put together your contributions in a digested and coherent form following the example of the PBC-BSM report (see arXiv:1901.09966) to be submitted to arXiv.**

✓ **This time we can try to do an extra step and show in the proceedings:**

1. The current knowledge we have of the state-of-the-art for minimal models

(eg: HNLs coupling ratios compliant with active neutrino data; a fair comparison between DD DM searches and accelerator-based DM searches, etc.);

2. Proposal for the experimental community to publish results in a – as much as possible – model independent way and provide all information for easy recast (efficiency maps as a function of lifetime, background per mass bin, etc.) ?

3. Proposal to move towards next-to-minimal models ? (eg: ALPs with more than one coupling switched on?).

✓ **We should discuss all this. Perhaps we can have a follow-up of the workshop for organizing the Proceedings – an (informal) topical meeting per portal with interested people ?**

✓ **We should aim at having by November 30th:**

- a few pages (max 5 pp) summarizing your talk (+ relevant bibliography).

- (whenever applicable) the electronic form of the curves showing of the sensitivity/bounds/theoretical predictions.

✓ **Then we (organizing committee + speakers) should try to put all together in a coherent form before submission to the arXiv.**

FIPs next edition:

FIPs 2021 or 2022

Workshop on
Feebly-Interacting Particles

Fall 2021 or Spring 2022
(hopefully) in person, @ CERN

Depending on the interest we can consider to have this workshop alternate in Europe and in US to strengthen the collaboration between the two communities.

Thanks to all the speakers for the lively participation and outstanding talks and to Antonella & Simona (Neutrino secretariat) for invaluable help.

