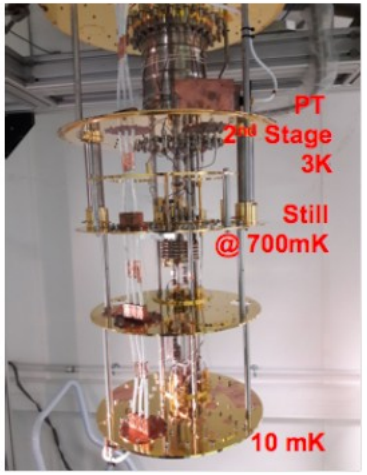
Prospectives DM / Neutrinos

- État de l'art IP2I

  → Groupes : MANOIR (6 permanents) / Neutrinos (4 permanents)

  → Projets : EDW-Ricochet + ERC + ANR / DUNE + "muons"

- Plateformes de développement, financement LIO



Prospectives GT06

Un groupe de travail (GT) a été mis en place pour la thématique « physique des neutrinos et matière noire » pour répondre aux questions scientifiques suivantes :

- ***La nature, la masse et le mélange des neutrinos ?***
- ***La nature de la matière noire ?***

La priorité est mise sur une déclinaison nationale des priorités stratégiques européennes de la feuille de route 2017-2026 de l'APPEC.

Science drivers

- Pursue the physics associated with the **nature of the neutrino**
- Explore the **PMNS neutrino mixing paradigm and CP-violation**
- Determine the **neutrino mass and ordering**
- Explore the **physics beyond the three neutrino flavour mixing**
- Identify the **nature of dark matter**

Program-wide recommendations

- **1:** Pursue a research program to address the five science Drivers.
- **2:** Improve French DM and neutrino scientific exchanges
- **3:** Enhance theoretical physics impact
- **4:** Maintain a program of projects of all scales, from the largest international projects to mid-and small-scale R&D projects, for both neutrino and DM areas.

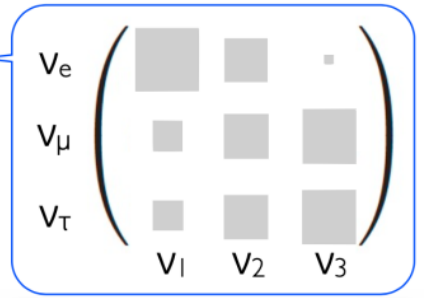
Project-wide recommendations

- **5:** Complete JUNO and KM3NeT-ORCA as planned
- **6:** Invest in DUNE as a major step forward in neutrino science
- **7:** Consolidate French participation in the neutrino program in Japan
- **8:** Complete XENON-nT and define G3 plans
- **9:** Complete SuperNEMO and define a $0\nu2\beta$ path forward

neutrinos

The discovery of the neutrino oscillation requires to extend the SM to describe the neutrino masses

$$\begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix}$$



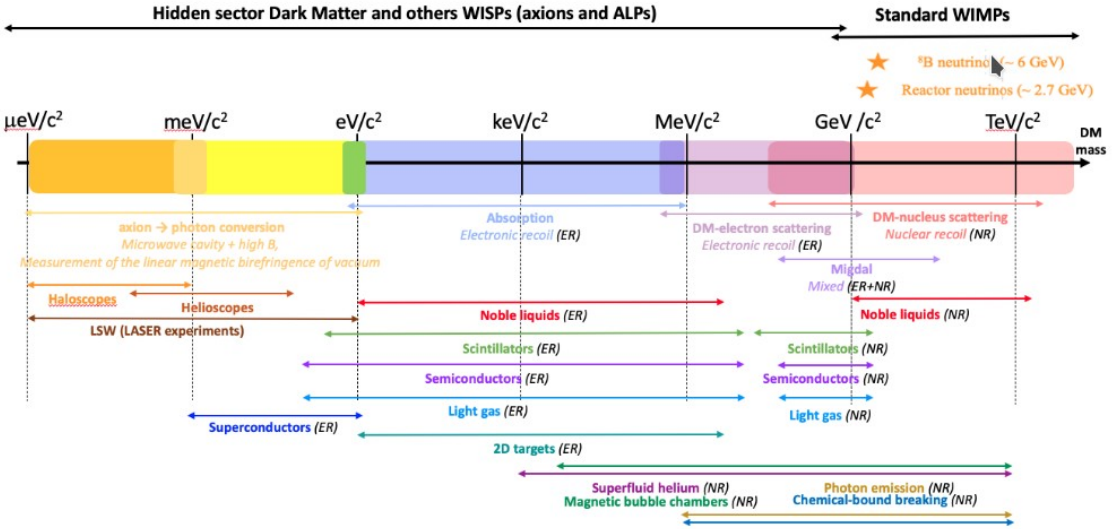
Open Questions:

- The CP violation predicted in the SM is insufficient to explain the observed matter/antimatter asymmetry in the Universe
- The Baryon/Lepton number violation
- Is the neutrino its own antiparticle (i.e. Majorana or Dirac neutrino)?
- Neutrino Mass generation mechanism
- The unitarity PMNS mixing matrix violation

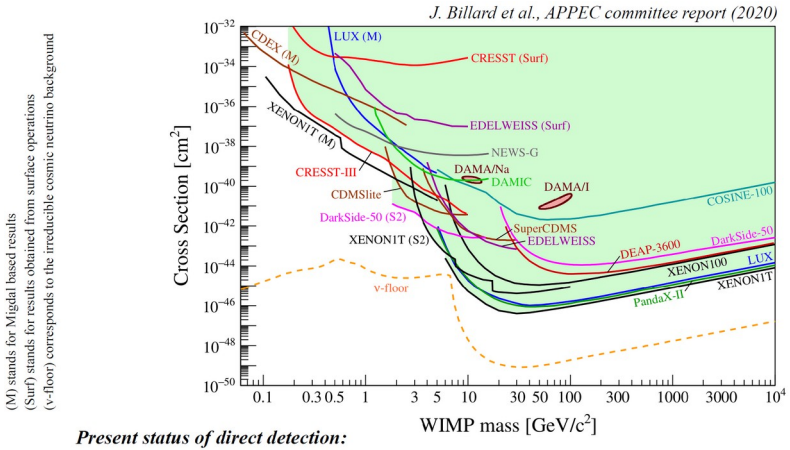
DM

Physics goal (both theory and exp) :

Search for physics beyond the SM



Exp : Direct detection of light dark matter: EDELWEISS-SubGeV



Present status of direct detection:

- About 25 experiments worldwide are aiming at directly detect dark matter
- Aside from the DAMA claim, no evidence of a positive DM detection down to 10^{-46} cm²
- Low WIMP mass region (<10 GeV): cryogenic and ionization based experiments
- High WIMP mass region (>10 GeV): single and dual phase noble gas detectors

The EDELWEISS collaboration focuses on the light Dark Matter requiring the lowest energy thresholds

TH : Implication of the measurements and limits for New Physics scenarios :

- « mainstream » WIMP scenarios (supersymmetry,…)
- « unconventional » DM scenarios

WIMP scenarios

- Tests of the Higgs sector: Higgs portal

  - Higgs coupling to DM

  - Higgs decaying to DM

- Simplified DM scenarios : DM@LHC

  - Interplay between LHC and direct DM detection

- DM code developments (SuperIso Relic, MARTY, BlackHawk, AlterBBN)

- Link with cosmology: CMB, BBN, baryogenesis,...

- Decaying DM scenarios (e.g. **gravitino DM** or **light primordial black holes**, impacts on CMB and BBN)

Unusual DM production

- Composite Higgs models

$\mathcal{G}_0/\mathcal{H}_0$	$\mathbb{Z}_2$–odd pNGBs
$\mathbb{Z}_2$–odd pNGBs	$\mathbb{Z}_2$–even pNGBs

Strong phase transition (confinement) to a Higgsless “Technicolor” vacuum, global U(1) emerges naturally.
Asymmetric production of U(1) charged Dark Matter. **PRL 125 (2020) 2**

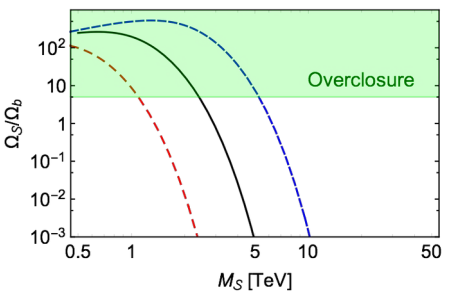
- $SU(2)_L$ broken by the composite Higgs mechanism. Possible strong phase transition

→ Gravitational Waves predicted by the strong phase transitions **arXiv:2111.09319**

- Minimal SU(5) asymptotic Grand Unification

SU(5) GUT on a compact 5-dimensional orbifold

- Yukawa couplings do NOT unify.
- Gauge couplings tend asymptotically to the same values in the deep UV
- Set of new fermions predicted



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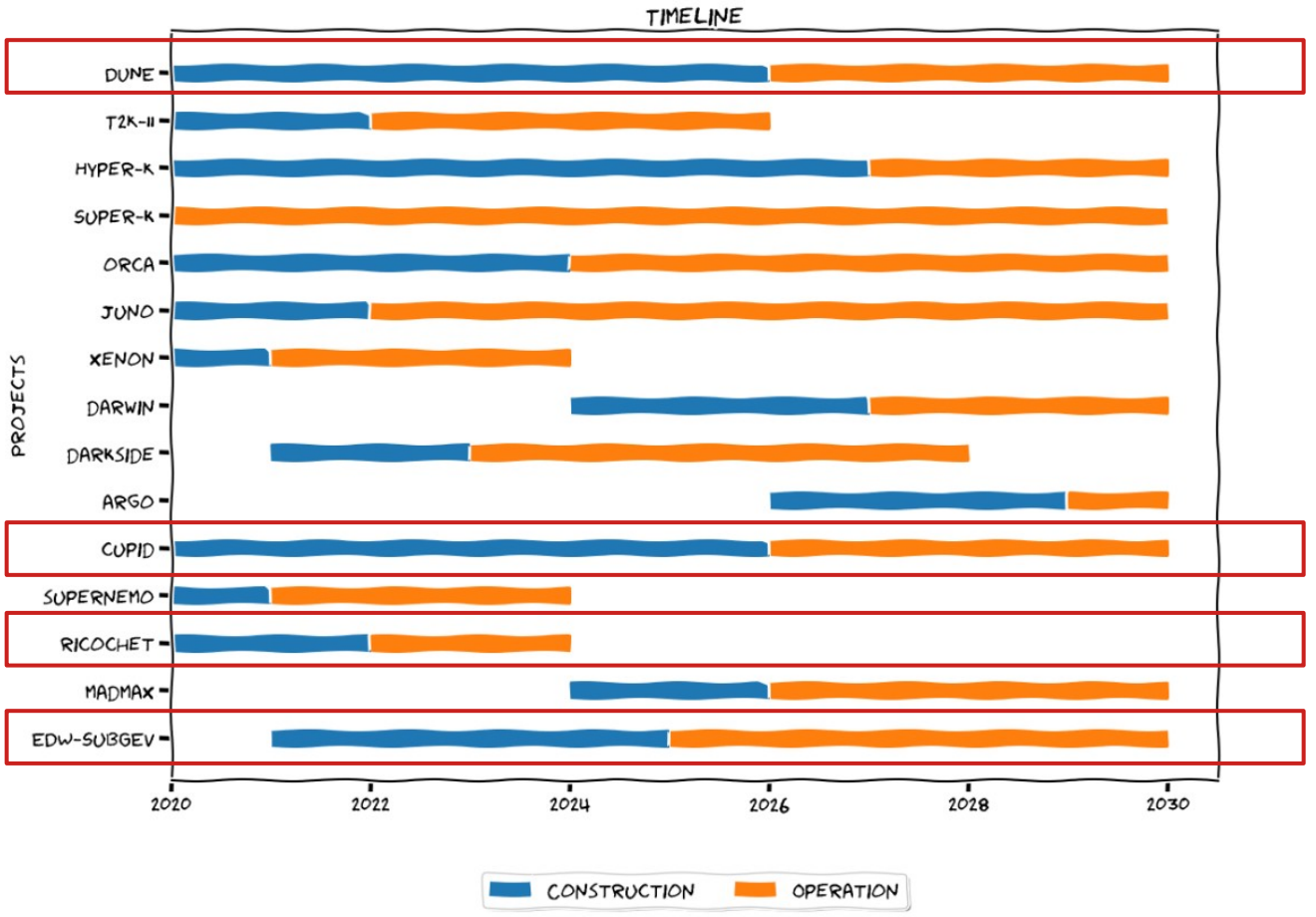
Lightest state is a DM candidate, produced as asymmetric candidate.

Flavour physics, neutrino mass generation (leptogenesis) and collider signatures under investigation

- Building and testing new models for vector DM: Contact interactions and top-philic scalar DM
- DM and the top quark sector: Contact interactions and top-philic scalar dark matter

Prospectives GT06



Prospectives GT 06 @IP2I

Exemples de questions ouvertes :

- *Synergie avec la théorie ?*
- *Connexions entre recherche directe et indirecte en DM ?*
- *Complémentarité entre le programme US et Japon : implications ?*
- *Hardware & innovation : pôle détecteurs cryogéniques ? Haefely ?*
- *Pérennité des plateformes post-LIO ?*