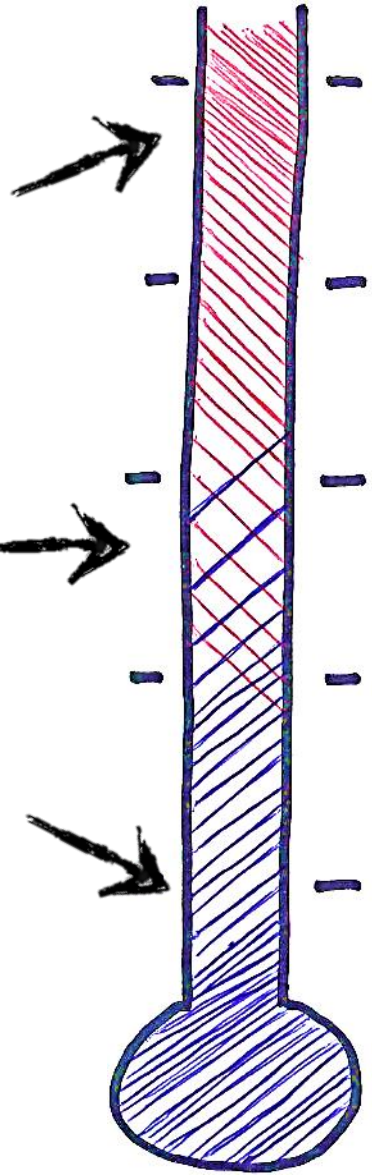
High sensitivity experiments

Prospectives du LPSC

1 Juin 2015

Where is new physics?



Ultraviolet:
Non-collider
experiments

colliders

Infrared:
Non-collider
experiments

10^{19} GeV
Planck scale

100 GeV
Electroweak
scale

1 meV

Quantum gravity,

Inflation,

Grand Unification

Right-handed neutrinos

Low energy SUSY,

Non standard Higgs

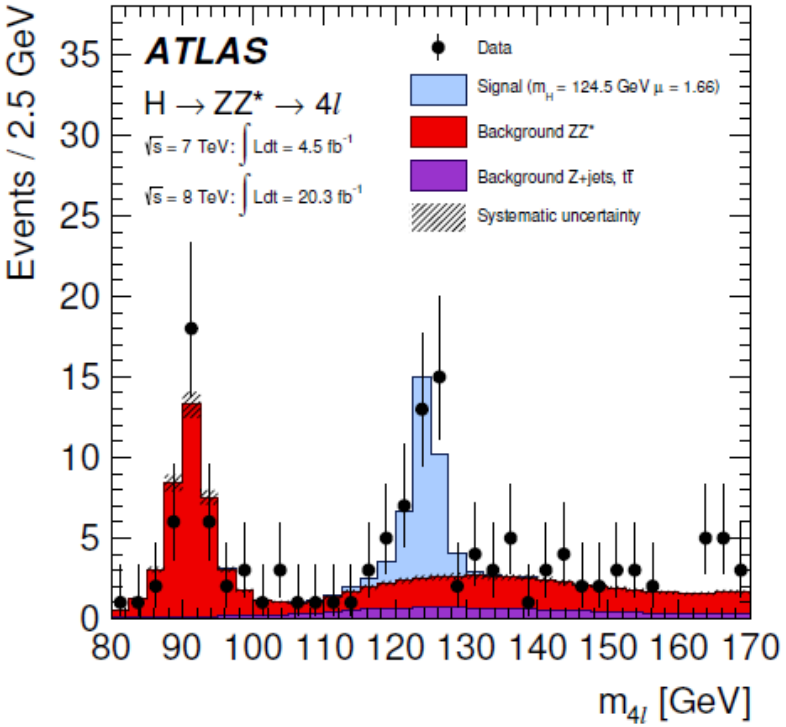
WIMPS

Large extra dimensions,

Axions and other light bosons

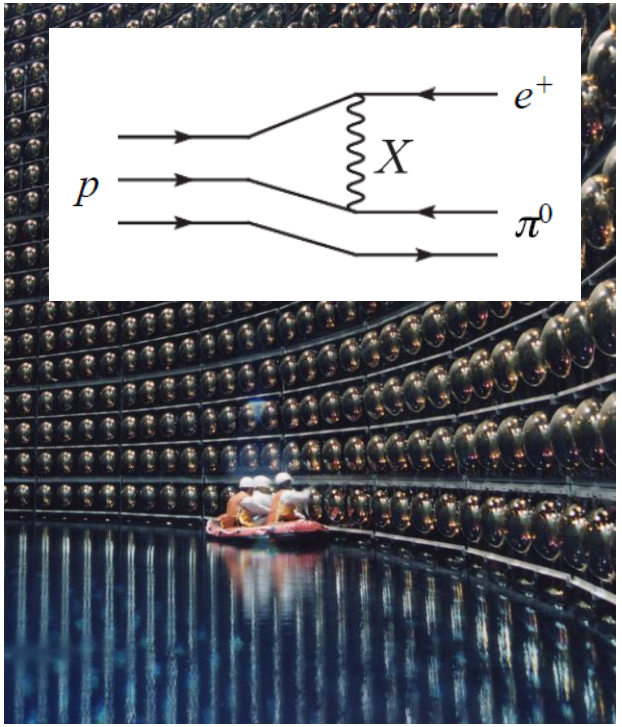
Cosmological scalar fields, Chameleons

Direct versus indirect probes



Colliders are direct probes of the electroweak scale

$$\mathrm{m_Z} = 91\ \mathrm{GeV}$$
$$\langle \mathrm{higgs} \rangle = 246\ \mathrm{GeV}$$
$$\mathrm{m_h} = 125\ \mathrm{GeV}$$

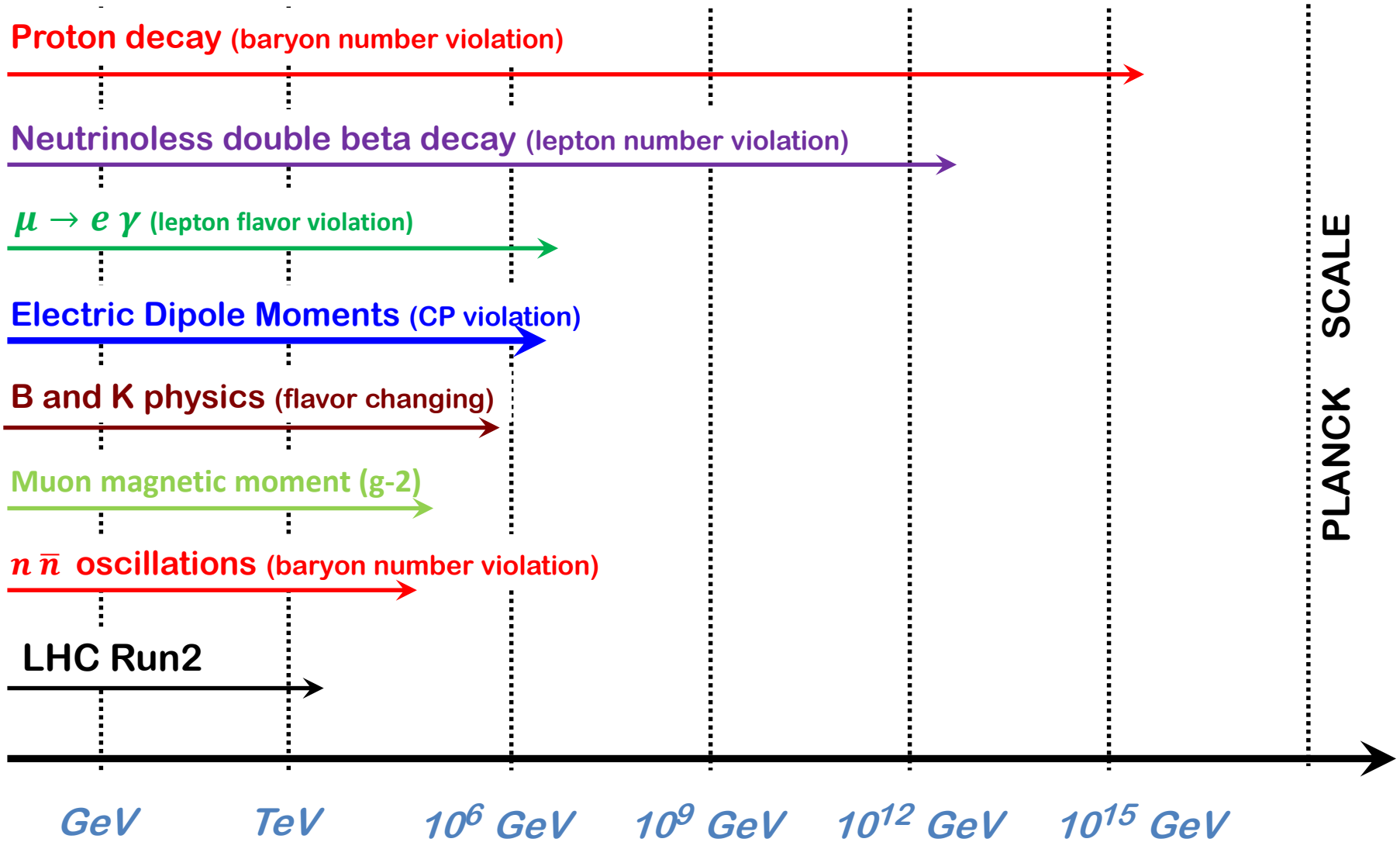


Proton lifetime: an example of an indirect probe.

$$\tau_p \approx \frac{M_X^4}{\alpha^2 m_p^5} > 10^{33}\ \text{years}$$

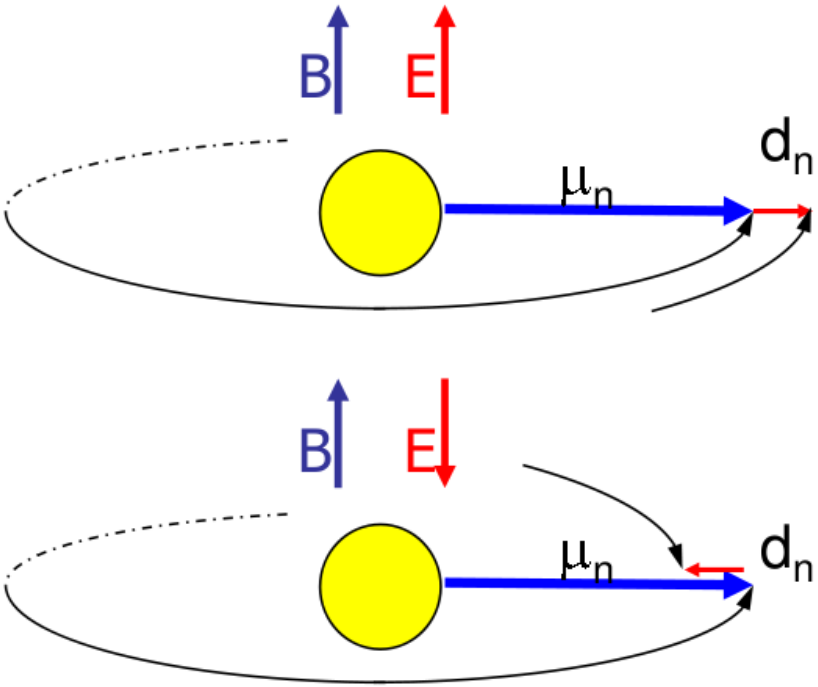
$$M_X > 10^{15}\,\mathrm{GeV}$$

High sensitivity experiments to probe new physics WELL beyond the Electroweak scale



Electric dipole moments

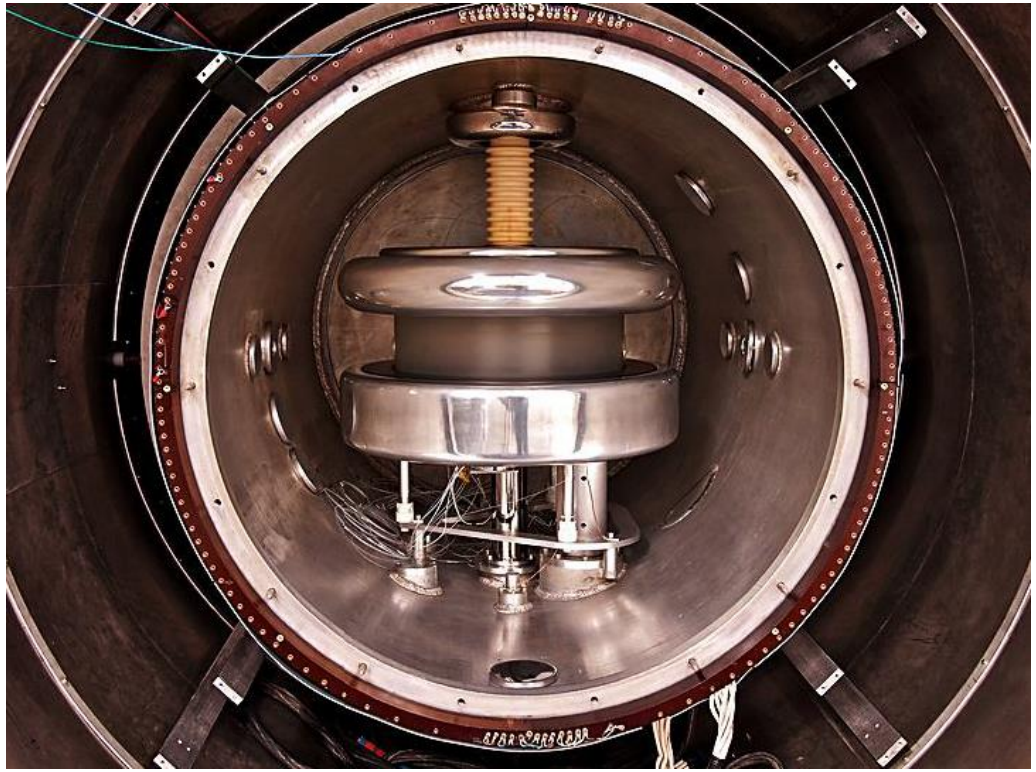
$$\hat{H} = -\mu_n \, B \, \hat{\sigma}_z - d_n \, E \, \hat{\sigma}_z = \pi\hbar \, f_L \, \hat{\sigma}_z$$



$$f_L(\uparrow\uparrow) - f_L(\uparrow\downarrow) = -\frac{2}{\pi\hbar} d_n \, E$$

A non-zero EDM violates T reversal
(thus violates CP symmetry)

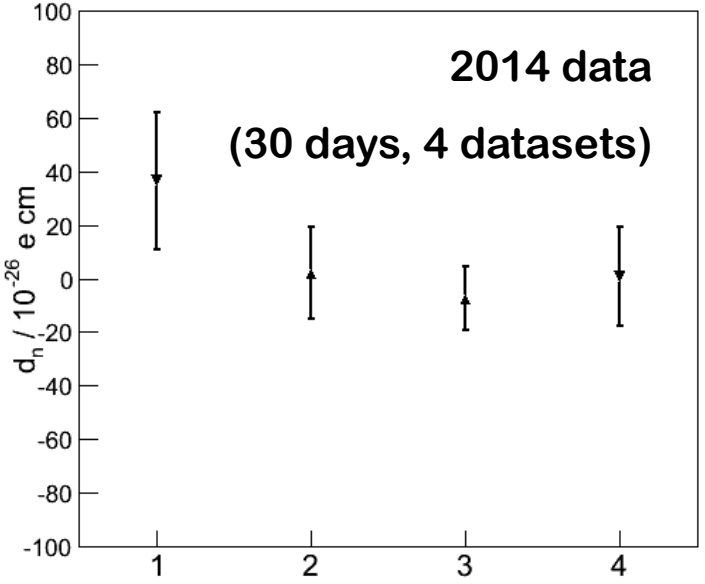
The running nEDM apparatus



Operated at ILL (2000-2006), providing the world limit

$$|d_n| < 3 \times 10^{-26}\ e\,\mathrm{cm}\ (90\,\%\ \mathrm{C.L.}).$$

data taking at the PSI UCN source since 2012

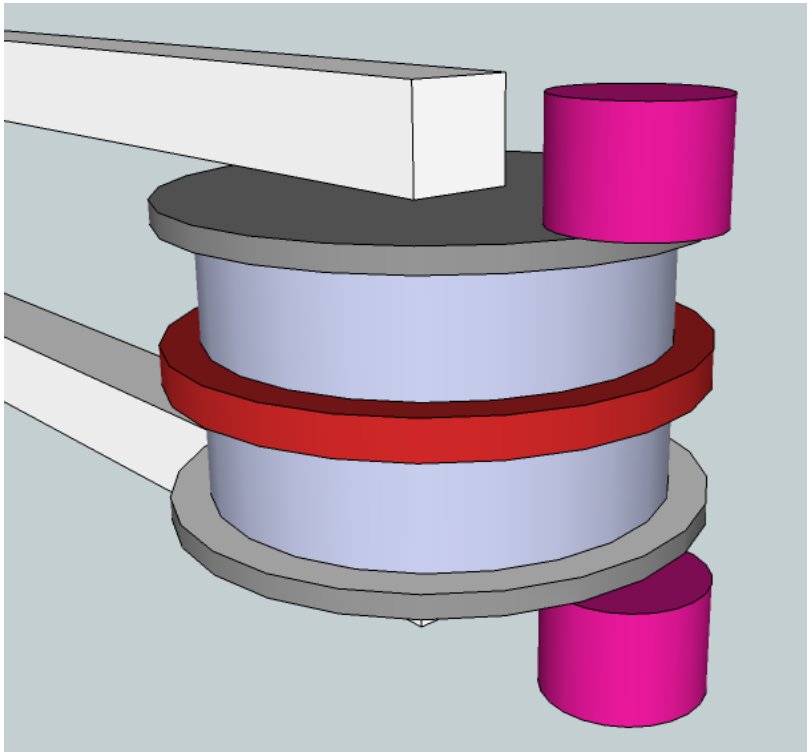


Electric field 150 kV / 12 cm

Shielded magnetic environment

B_0 = 1 μT Homogeneity < 10^{-3}
Time stability < 10^{-6}

Next, n2EDM



- Two large chambers with opposite E-field
- Hg comagnetometry + external magnetometers (Cs + 3He)
- Bigger and better mumetal magnetic shield

Assembly of the new apparatus in 2018

data taking starts 2020?

Target sensitivity 2×10^{-27} e cm

Neutron antineutron oscillation, the 1986 ILL experiment

Neutrons oscillate freely for 75 m

Annihilation of antineutrons (2 GeV event) detected with a 4pi detector.

Result: $\tau_{n\bar{n}} > 10^8$ s

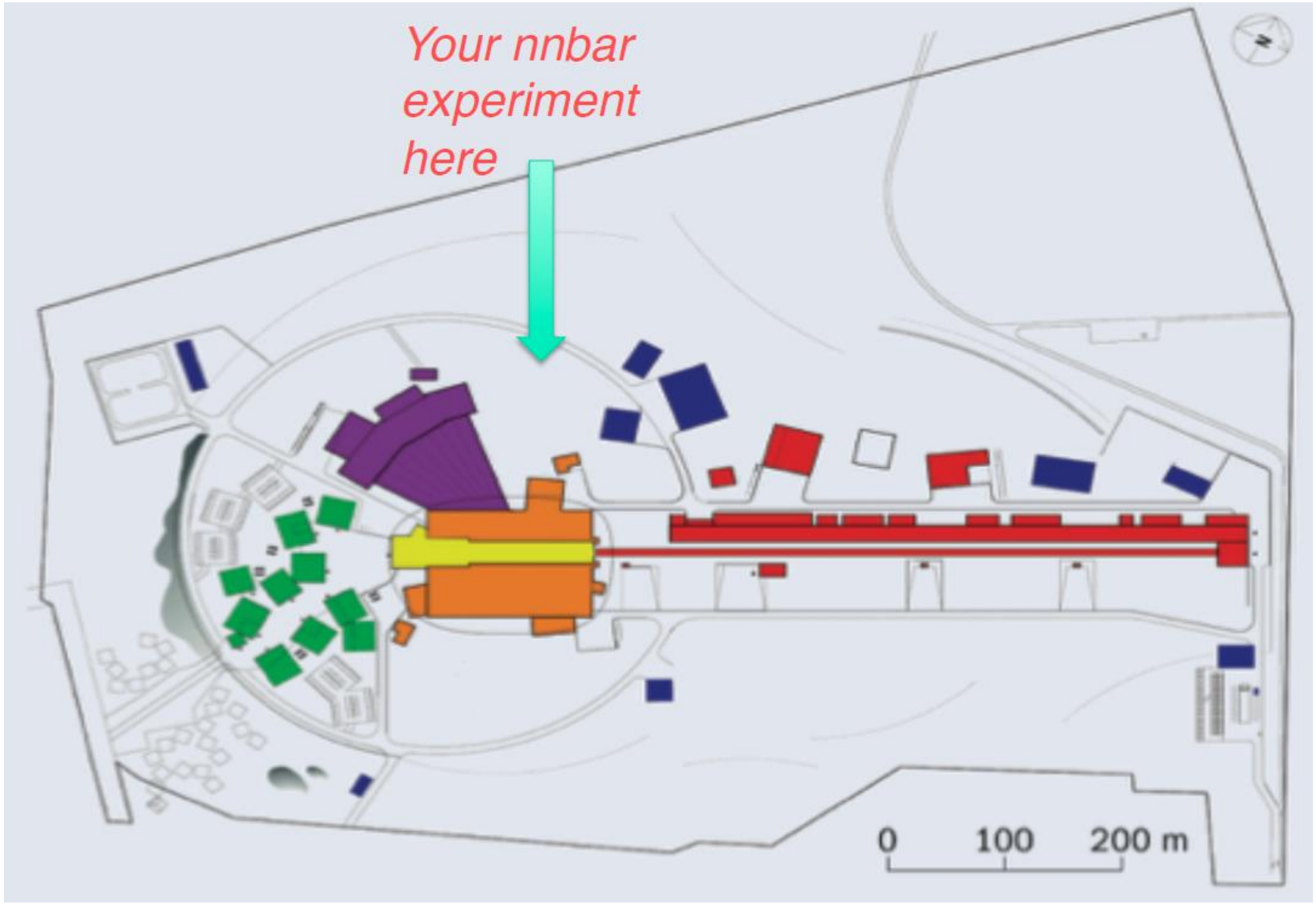
Operator responsible for n nbar

$$O_{\Delta B=2} = \frac{1}{M_{eff}^5} udd\bar{u}\bar{d}\bar{d}$$

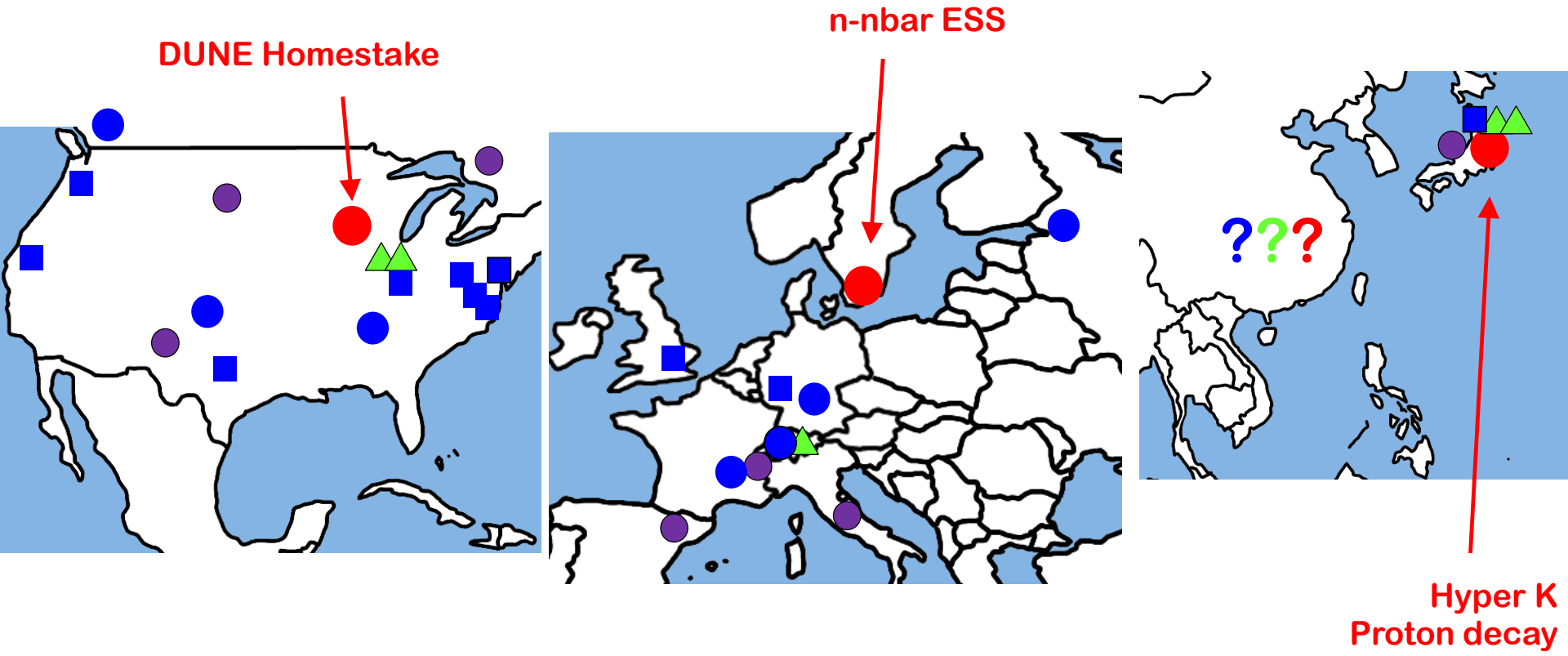
Result: $\mathrm{M_{eff}} > 100$ TeV

Notice the $\mathrm{M_{eff}^5}$ **suppression**

New project at the European Spallation Source (ESS)



Location of ~50 experiments



muons — MEG (PSI), Mu2e (Fermilab), g-2 (Fermilab), COMET (KEK), g-2 (KEK)

0νββ — EXO, SNO+, Kamland, NEXT, GERDA, CUORE, NEMO, MAJORANA

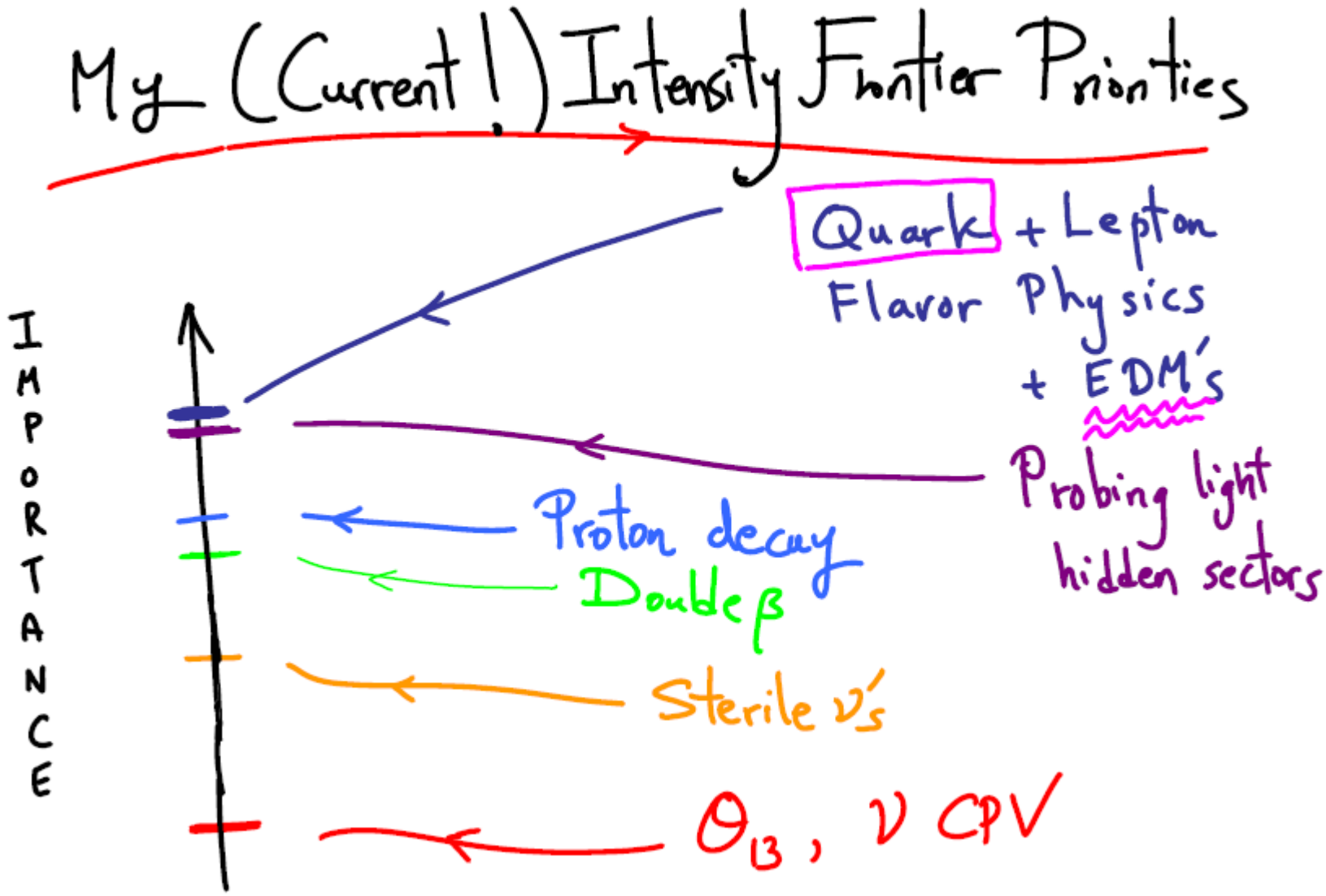
EDMs
- nEDM: PSI, ILL, FRM2, PNPI, SNS, Triumph
- pEDM & muEDM: BNL, FZJ, FNAL, JPARC
- atomEDM: Seattle, Princeton, Yale, Harvard, etc, etc…

Remarques finales

- Des experiences variées, complémentaires du LHC
- L'implication de l'IN2P3 est faible
- Des opportunités, par exemple:
  - Oscillation neutron-antineutron à ESS
  - EDM sur accélérateurs


BACKUPS

Nima Harkani Hamed



Planning the Future of U.S. Particle Physics
Report of the 2013 Community Summer Study
Chapter 2: Intensity Frontier

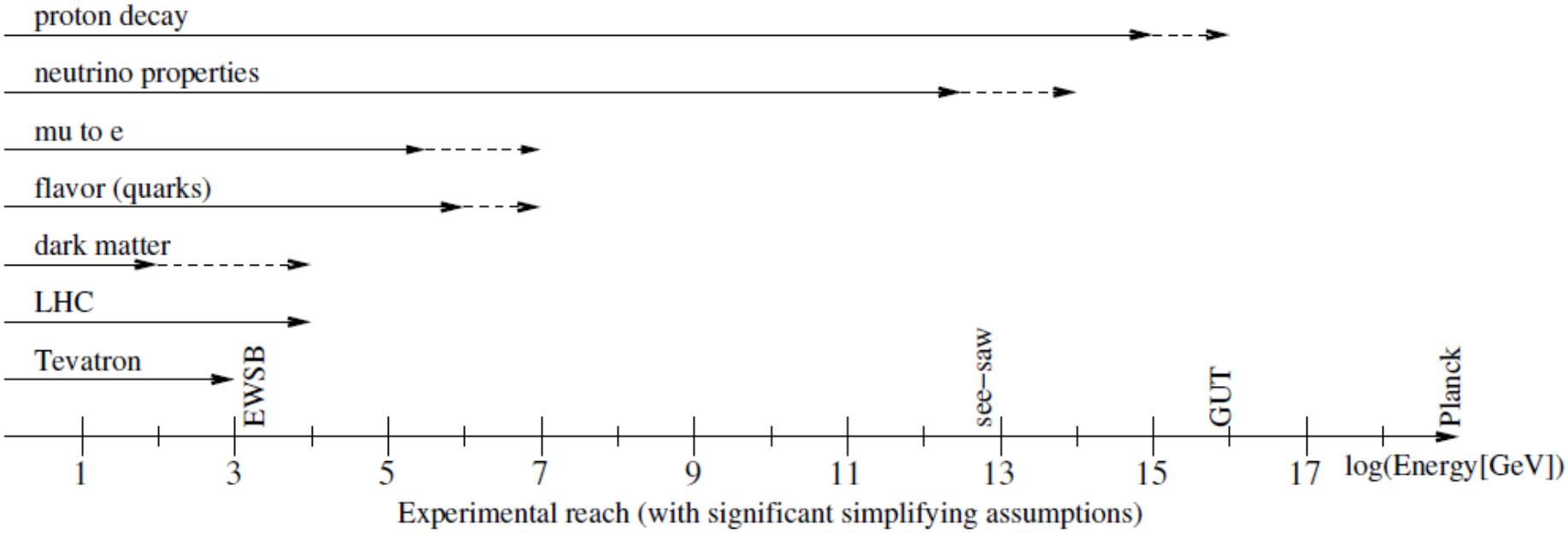
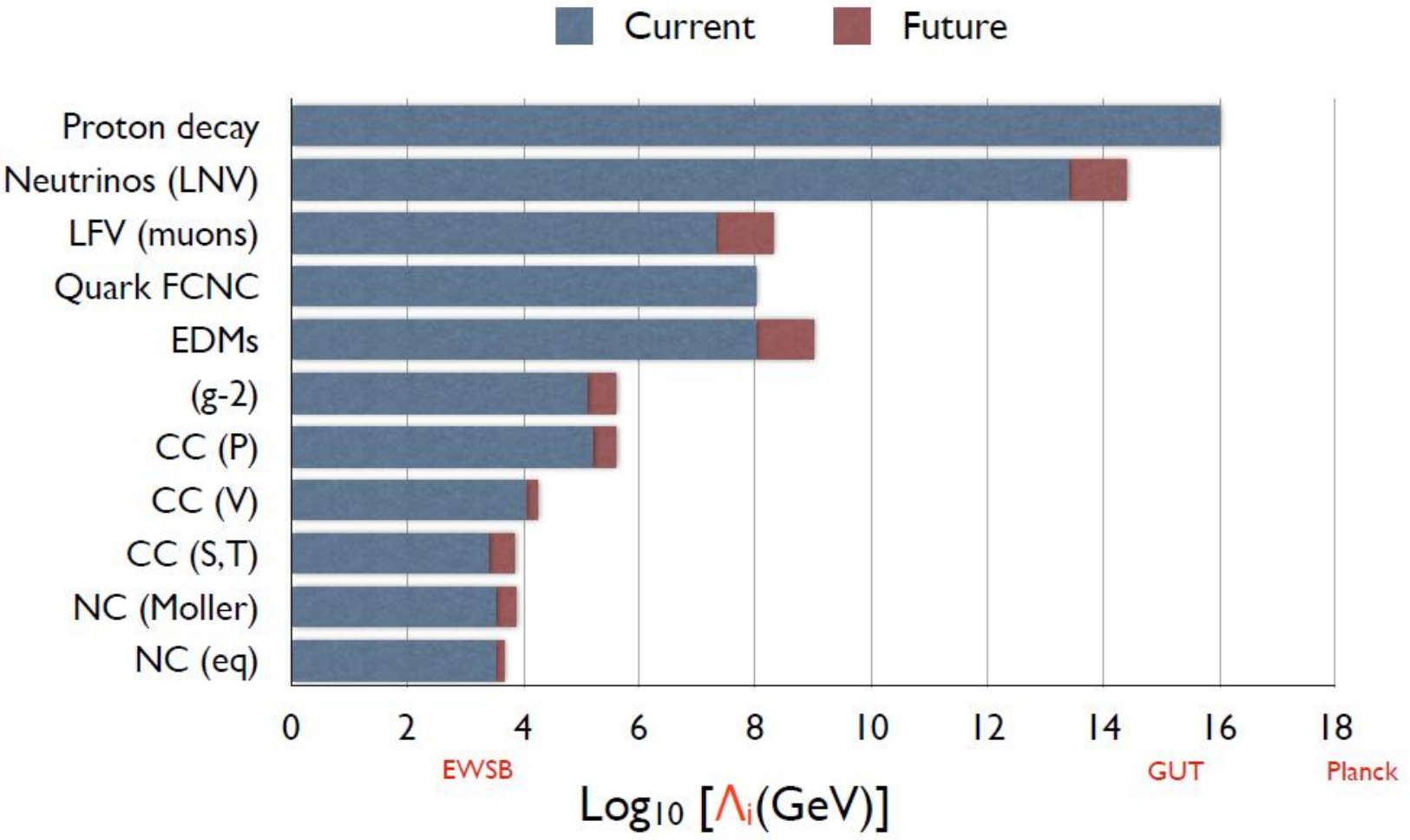
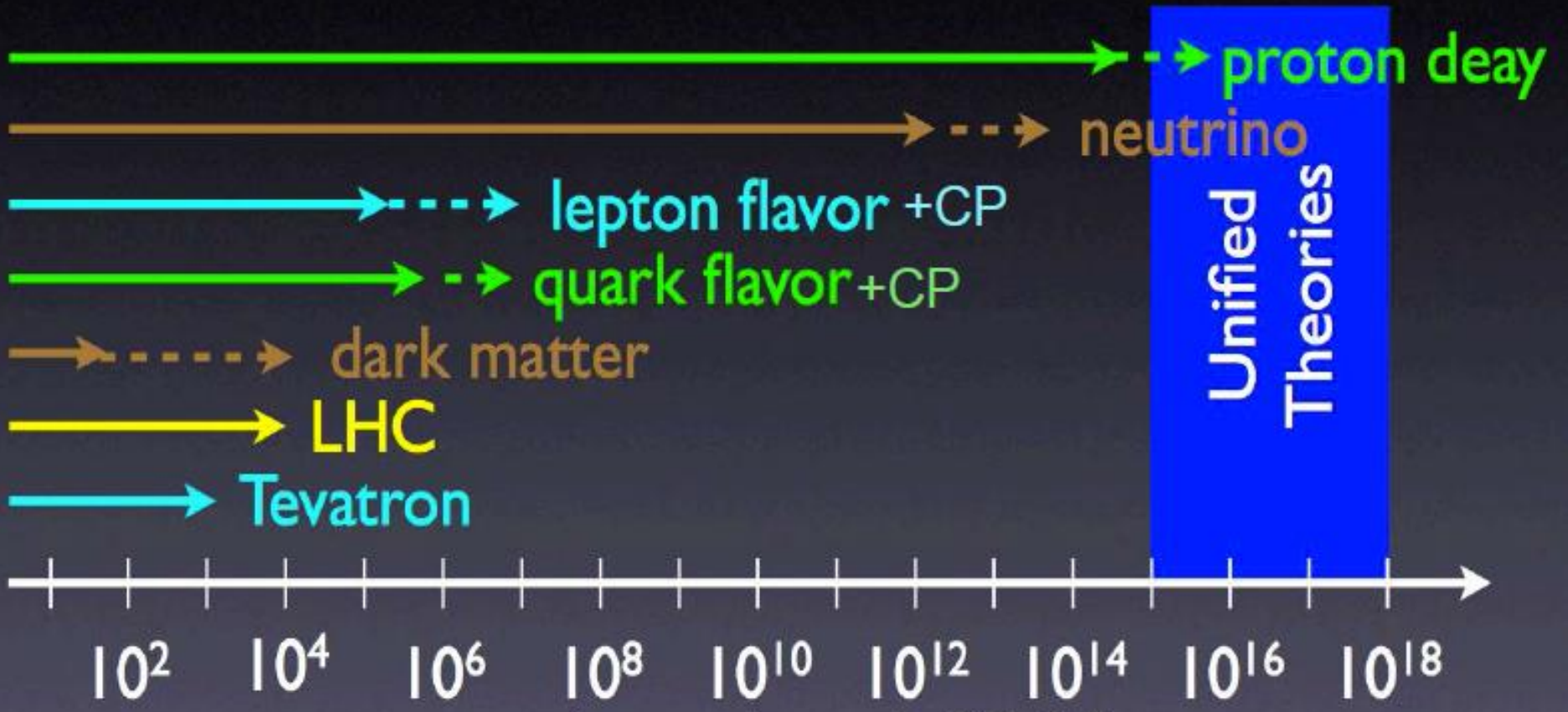


Figure 2-1. *The energy scale of new physics that is probed by various experimental programs as indicated. The solid line represents the present level of experimental sensitivity, while the dashed line indicates the expected sensitivity of proposed facilities. The Intensity Frontier programs (proton decay, neutrino properties, mu to e, flavor) provide indirect probes of new physics effects. In contrast, the results presented for the Cosmic (dark matter) and Energy (14 TeV LHC, Tevatron) Frontier programs represent the direct search for the production of new particles. Indirect searches are also possible at these facilities, and increase their sensitivity to high energy scales by roughly an order of magnitude. The vertical text shows the energy scale at which Electroweak Symmetry Breaking (EWSB), the neutrino see-saw mechanism, and Grand Unified Theories (GUT) occur, and where the quantum effects of gravity become strong (Planck).*

Low energy probes of BSM
Cirigliano and Ramsey-Mussolf

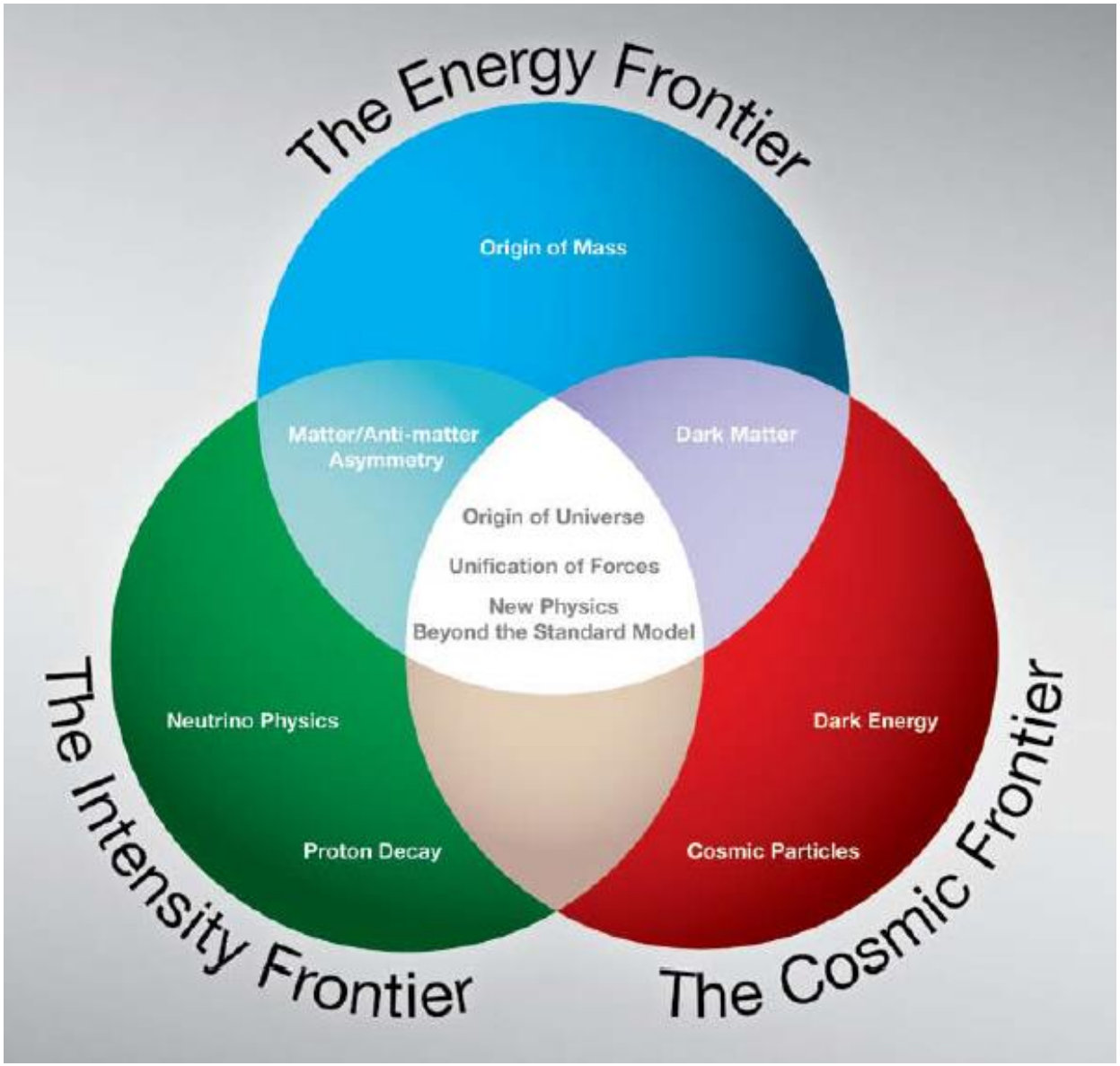


Power of Expedition



courtesy Ligeti/Murayama

US vision


The Energy Frontier
Origin of Mass
Matter/Anti-matter Asymmetry
Dark Matter
Origin of Universe
Unification of Forces
New Physics Beyond the Standard Model
Neutrino Physics
Proton Decay
Dark Energy
Cosmic Particles
The Intensity Frontier
The Cosmic Frontier

The Intensity Frontier Program

The Intensity Frontier is a broad and diverse, yet connected, set of science opportunities