Expériences de haute sensibilité

Prospectives du LPSC

1 Juin 2015

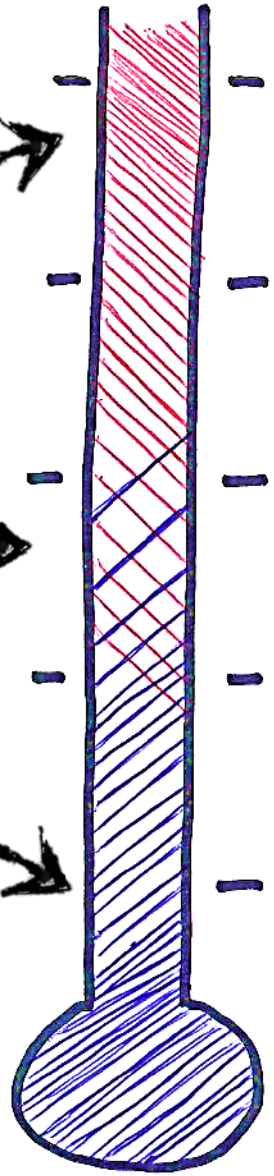
LPSC Grenoble

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

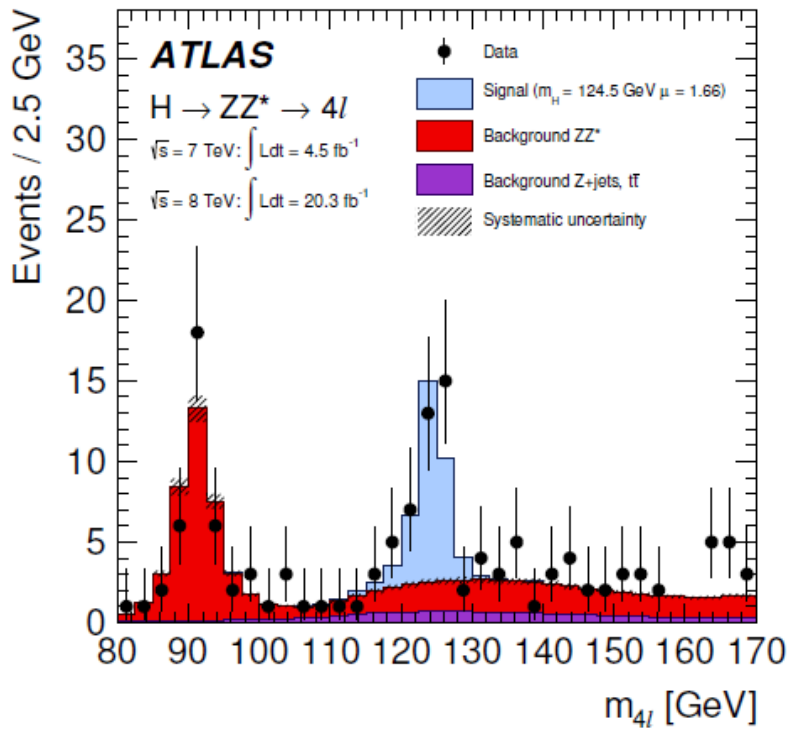
WIMPS

Large extra dimensions,

Axions and other light
bosons

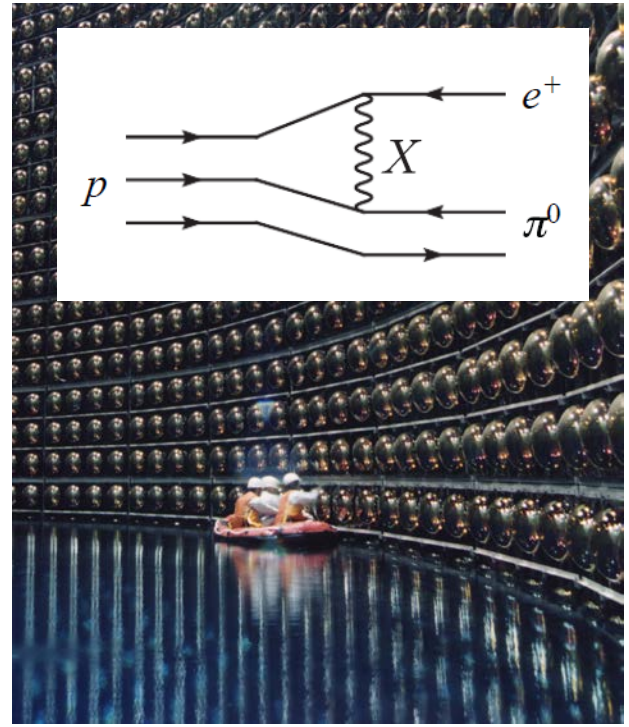
Cosmological scalar
fields, Chameleons

Direct versus indirect probes



Colliders are direct probes of the electroweak scale

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

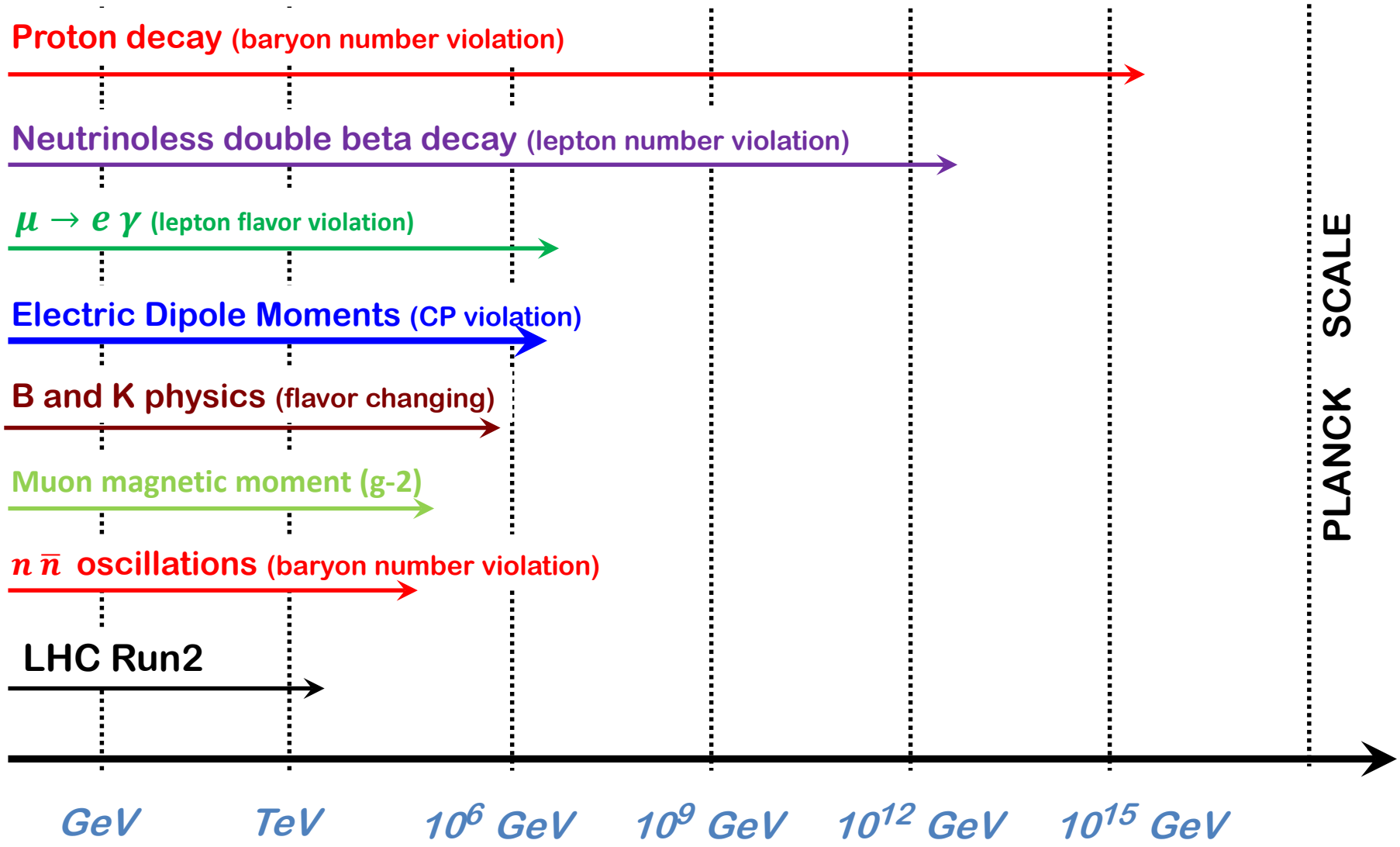


Proton lifetime: an example of an indirect probe.

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

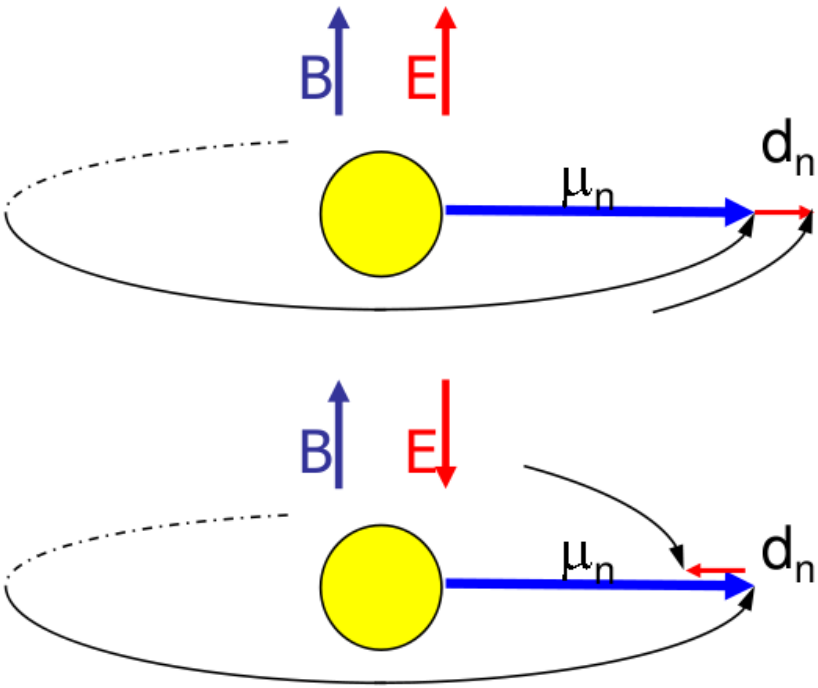
$$M_X > 10^{15}\mathrm{GeV}$$

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



Electric dipole moments

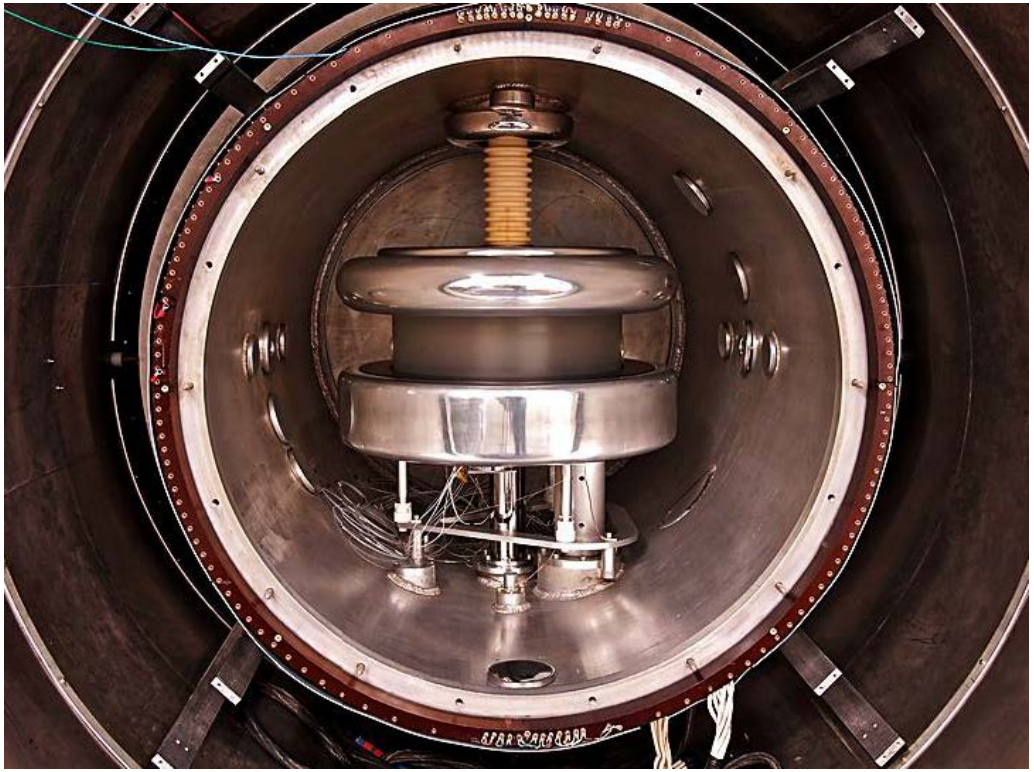
$$\hat{H} = -\mu_n\, B\, \hat{\sigma}_z - d_n\, E\, \hat{\sigma}_z = \pi\hbar\, f_L\, \hat{\sigma}_z$$



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

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

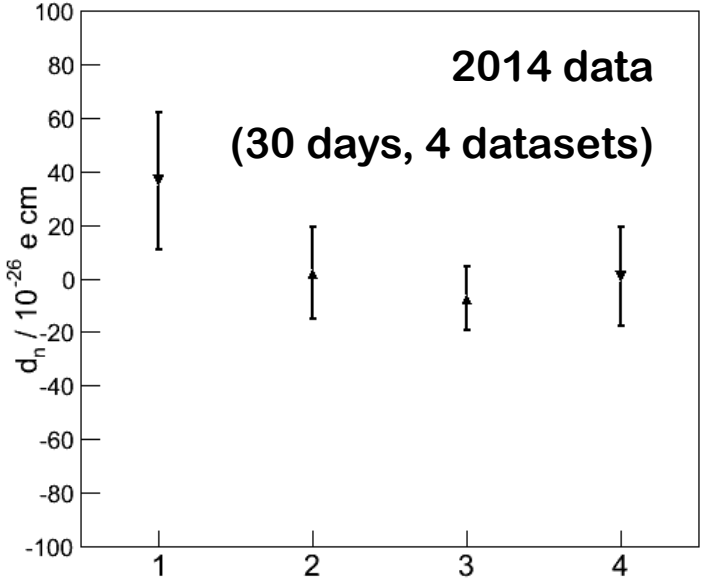
The running nEDM apparatus



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

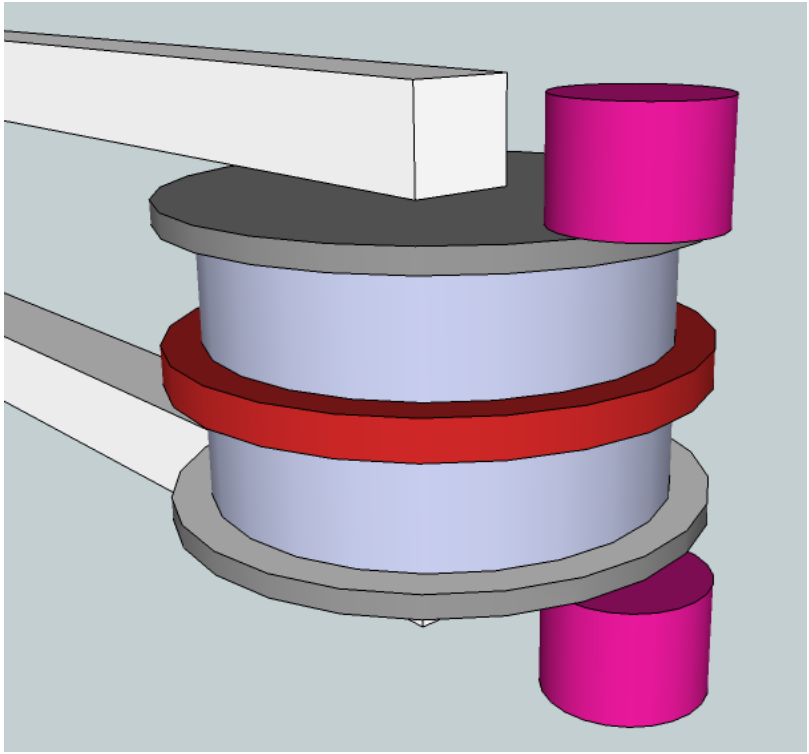


Electric field 150 kV / 12 cm

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

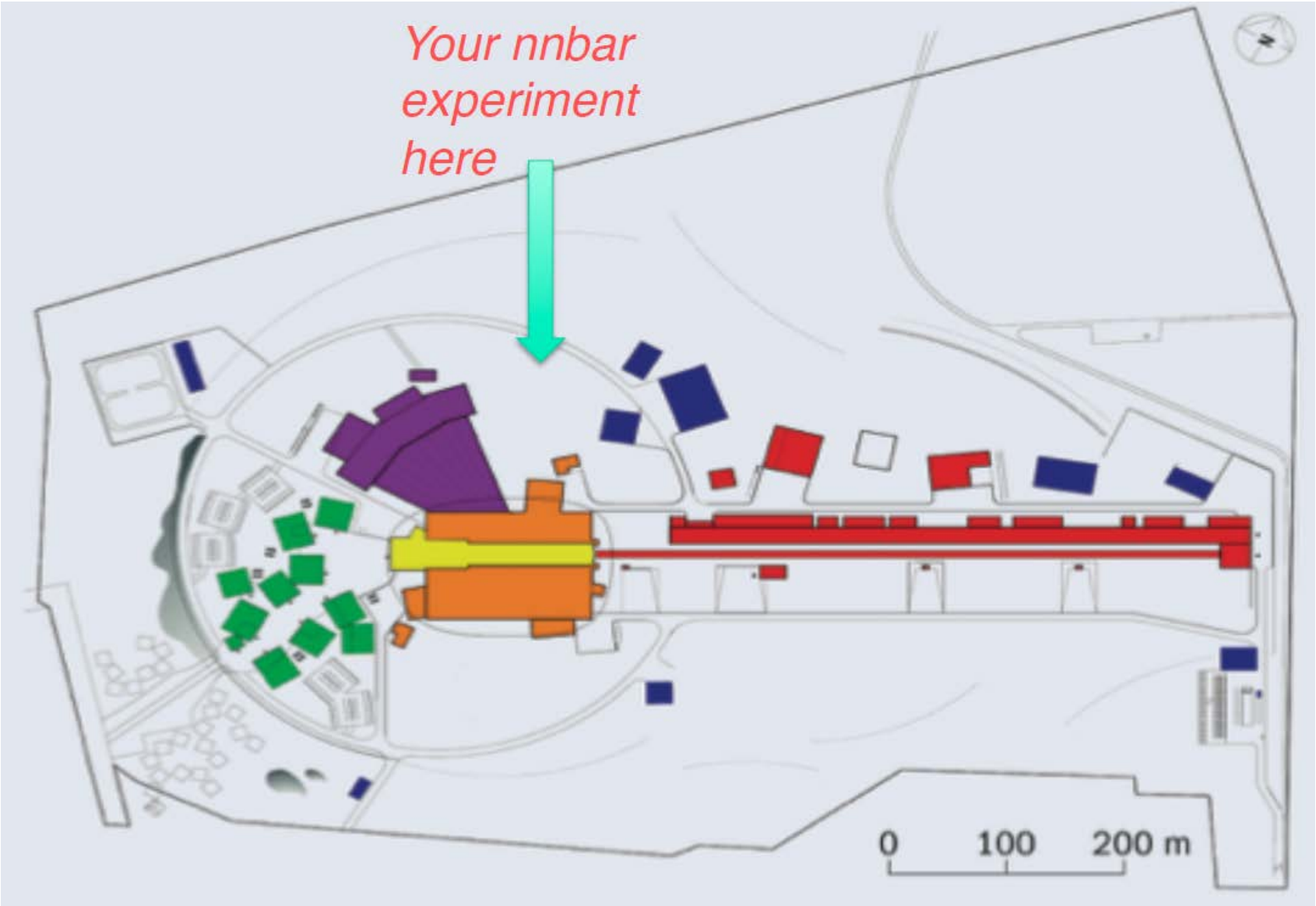
Operator responsible for n nbar

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

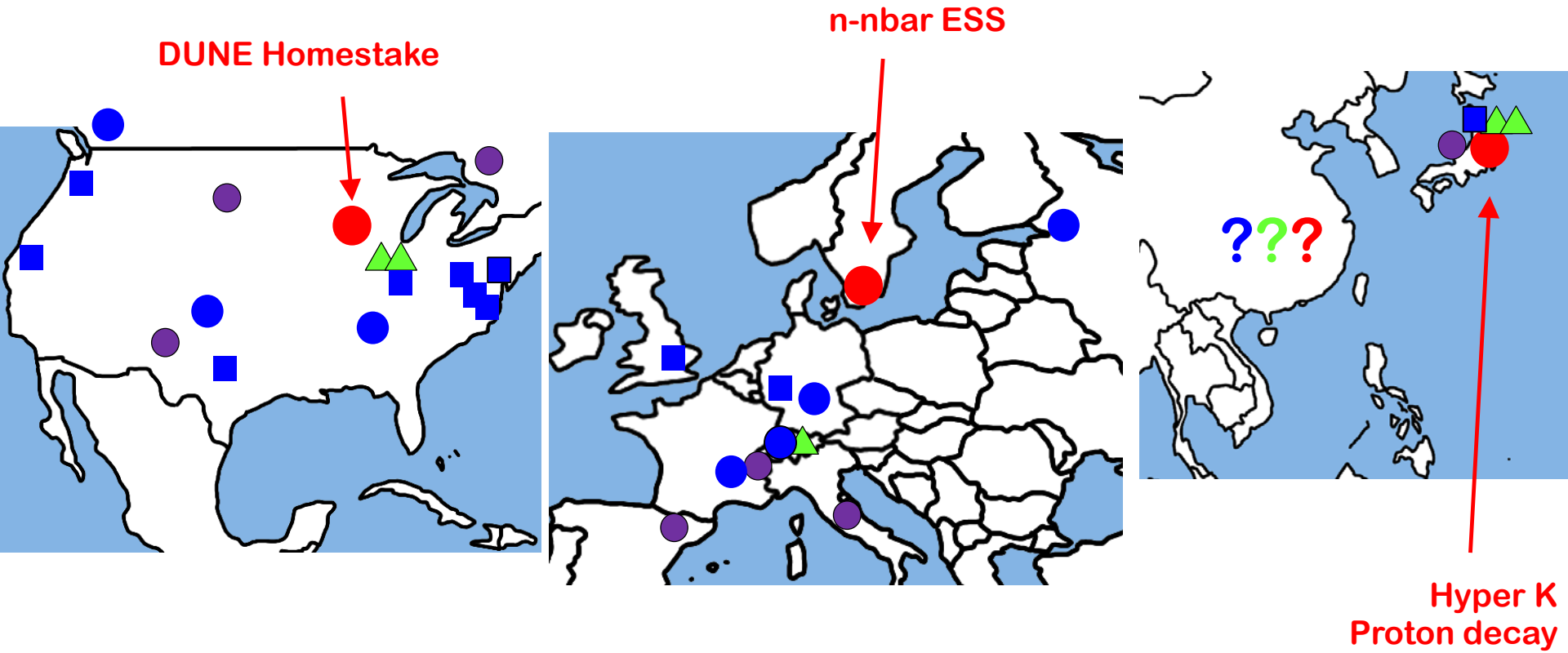
Result: $\mathrm{M_{eff}} > 100$ TeV

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)

$0\nu\beta\beta$ — 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