

eEDM VistaUpdate

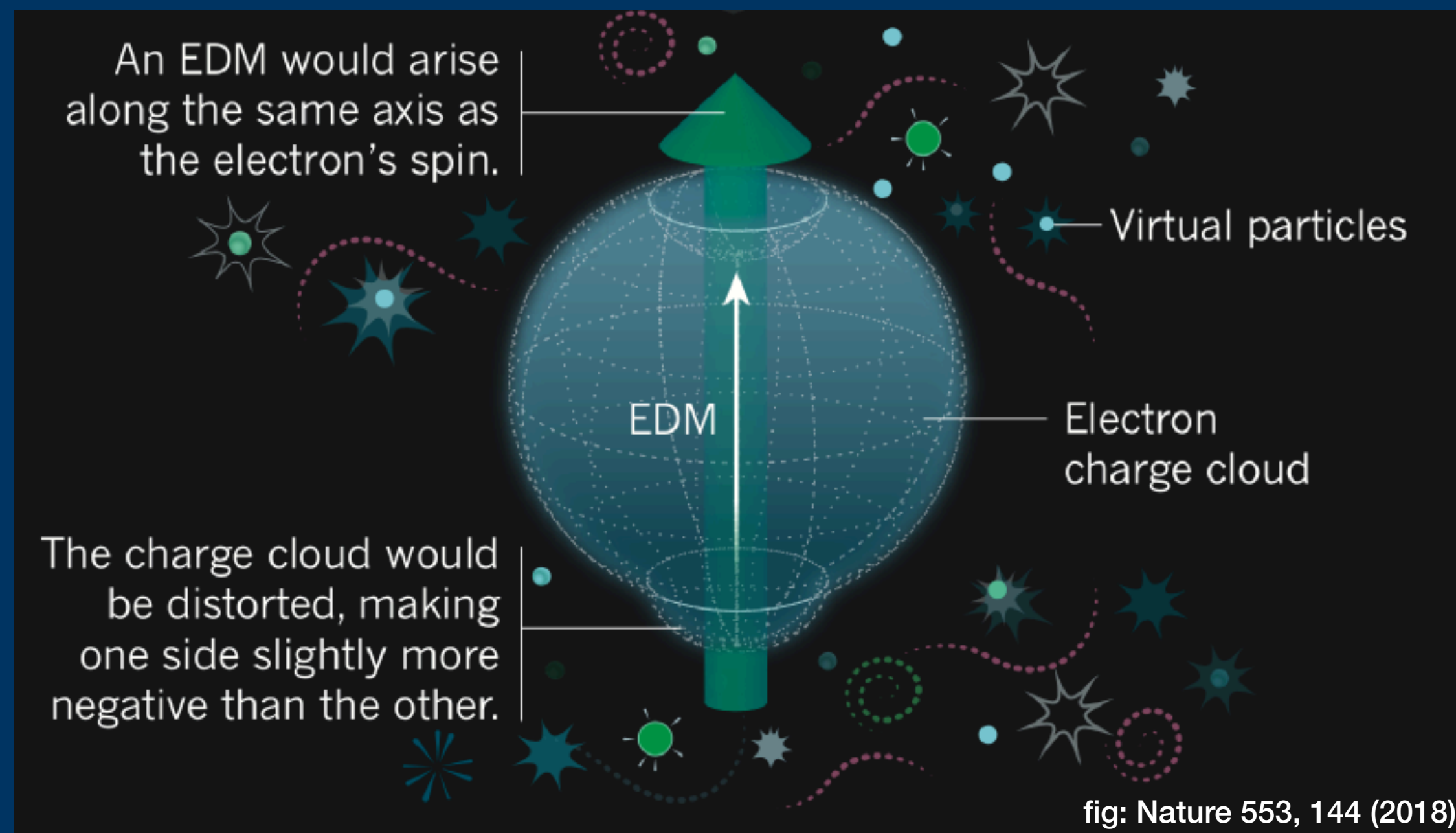
Ambitions for 2030



Steven Hoekstra for NL-eEDM team, Nikhef VistaUpdate 21/10/2020

Introduction to electron-EDM

probing CP violation beyond the standard model



eEDM violates P, T and CP symmetry (provided CPT holds)

eEDM magnitude
(e cm)

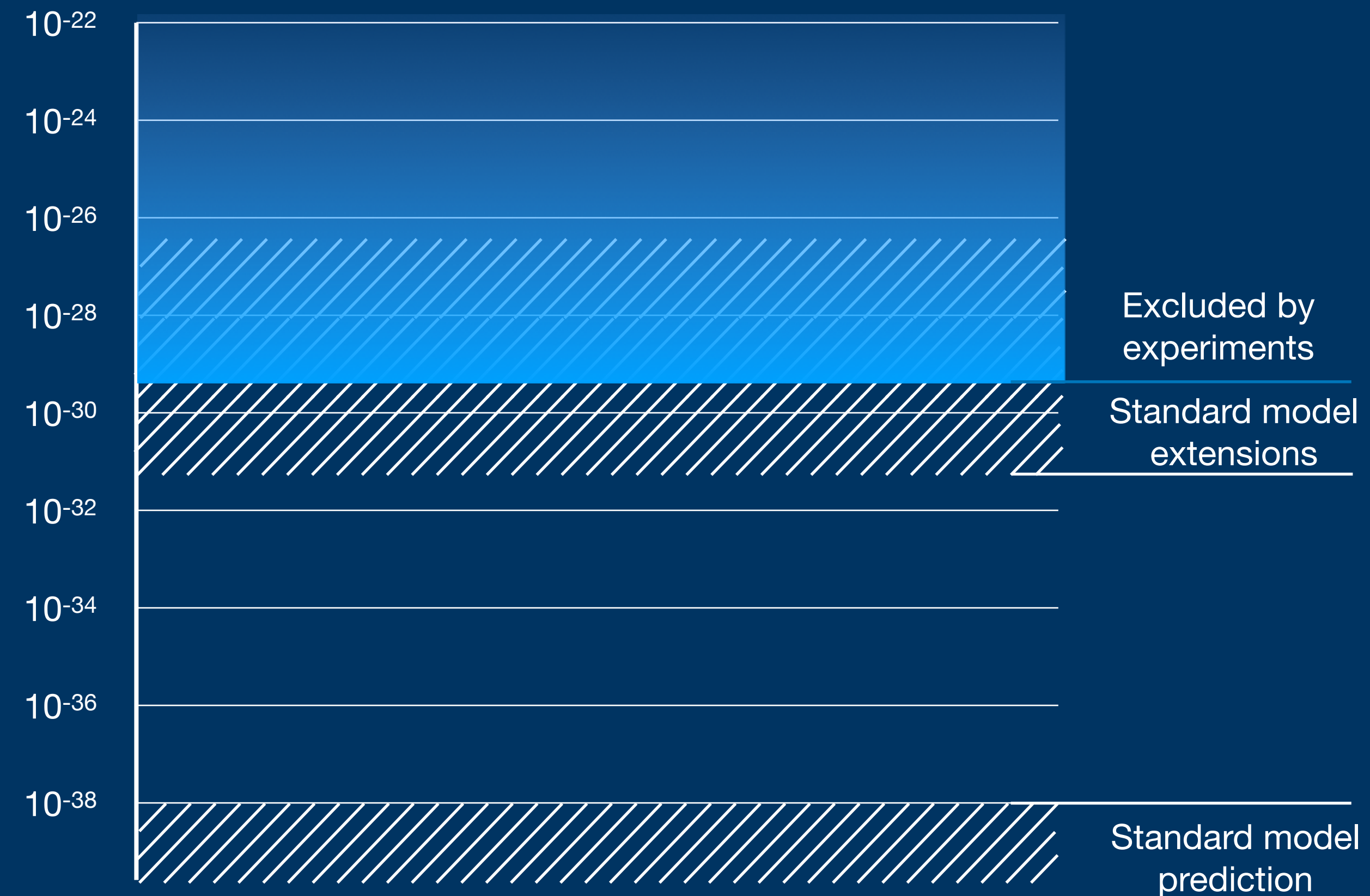
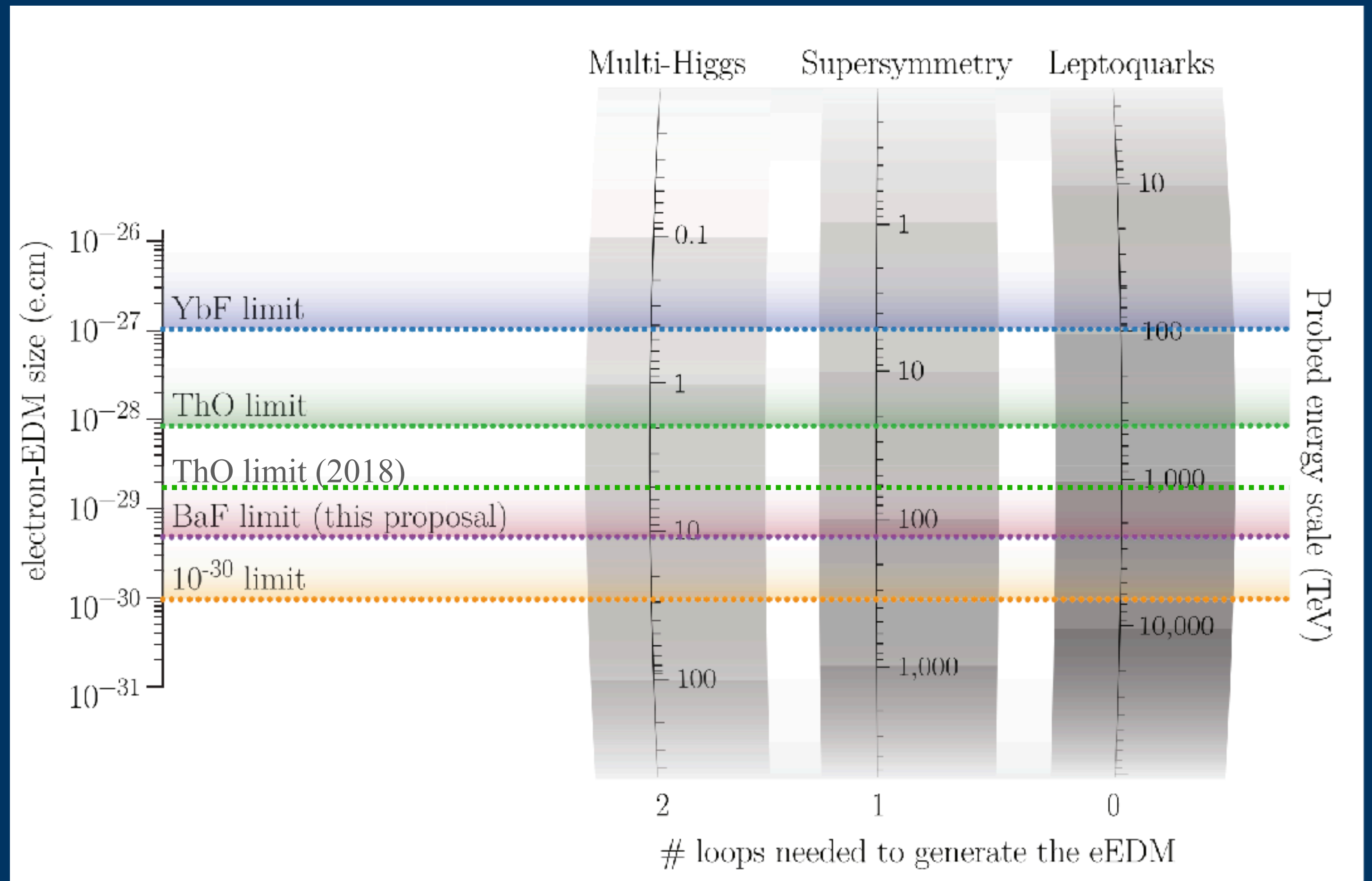
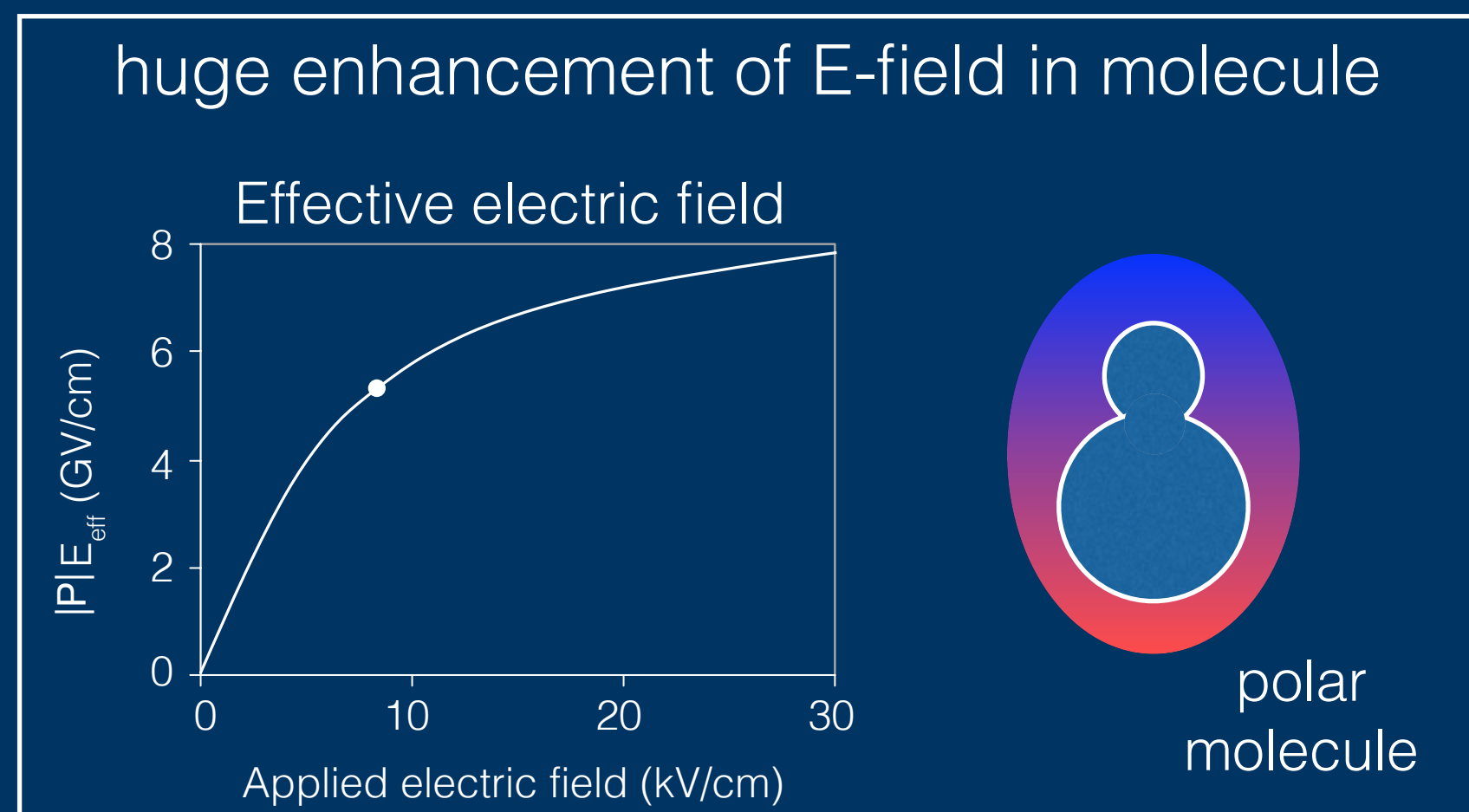
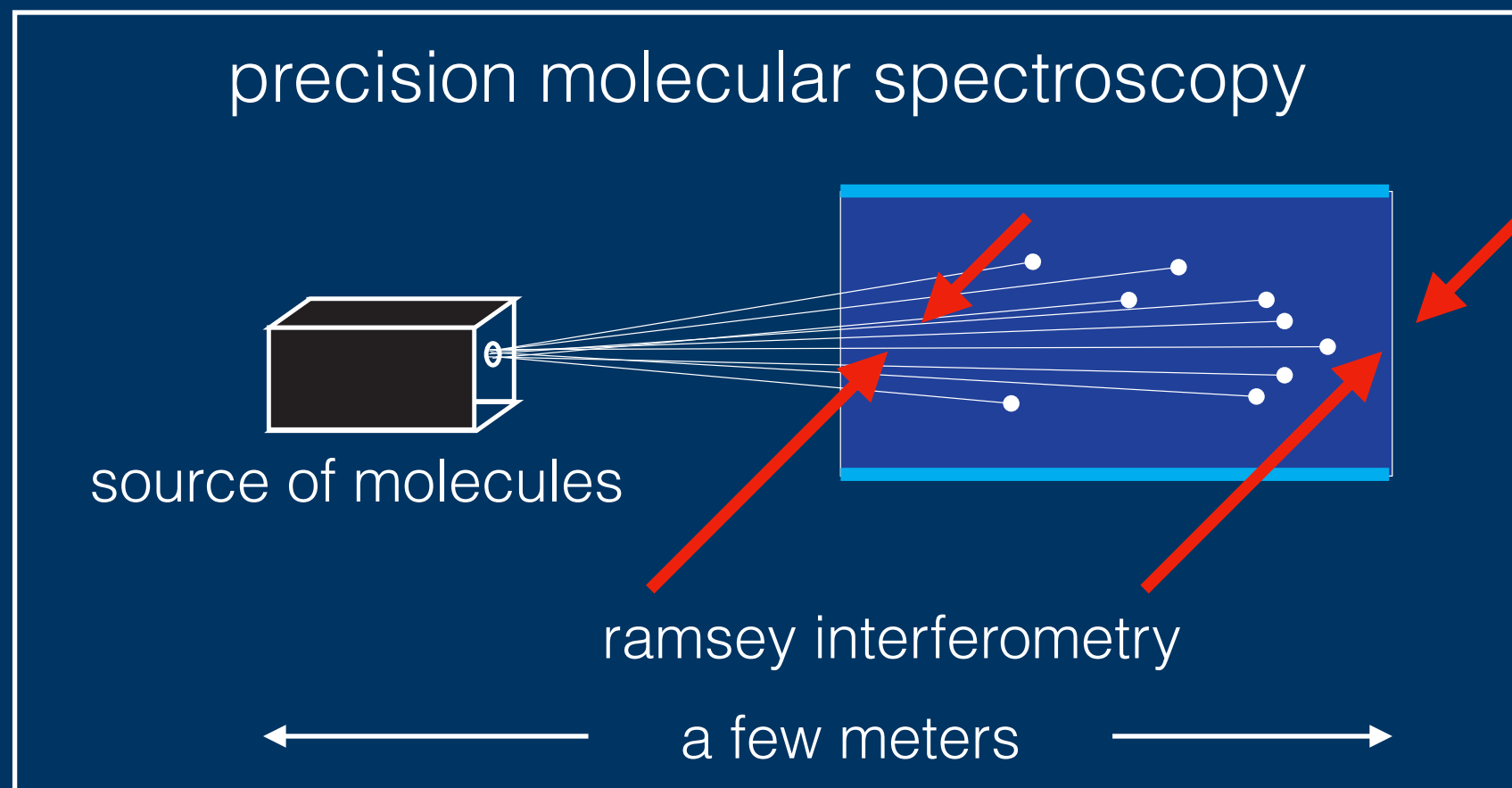


Table-top particle physics

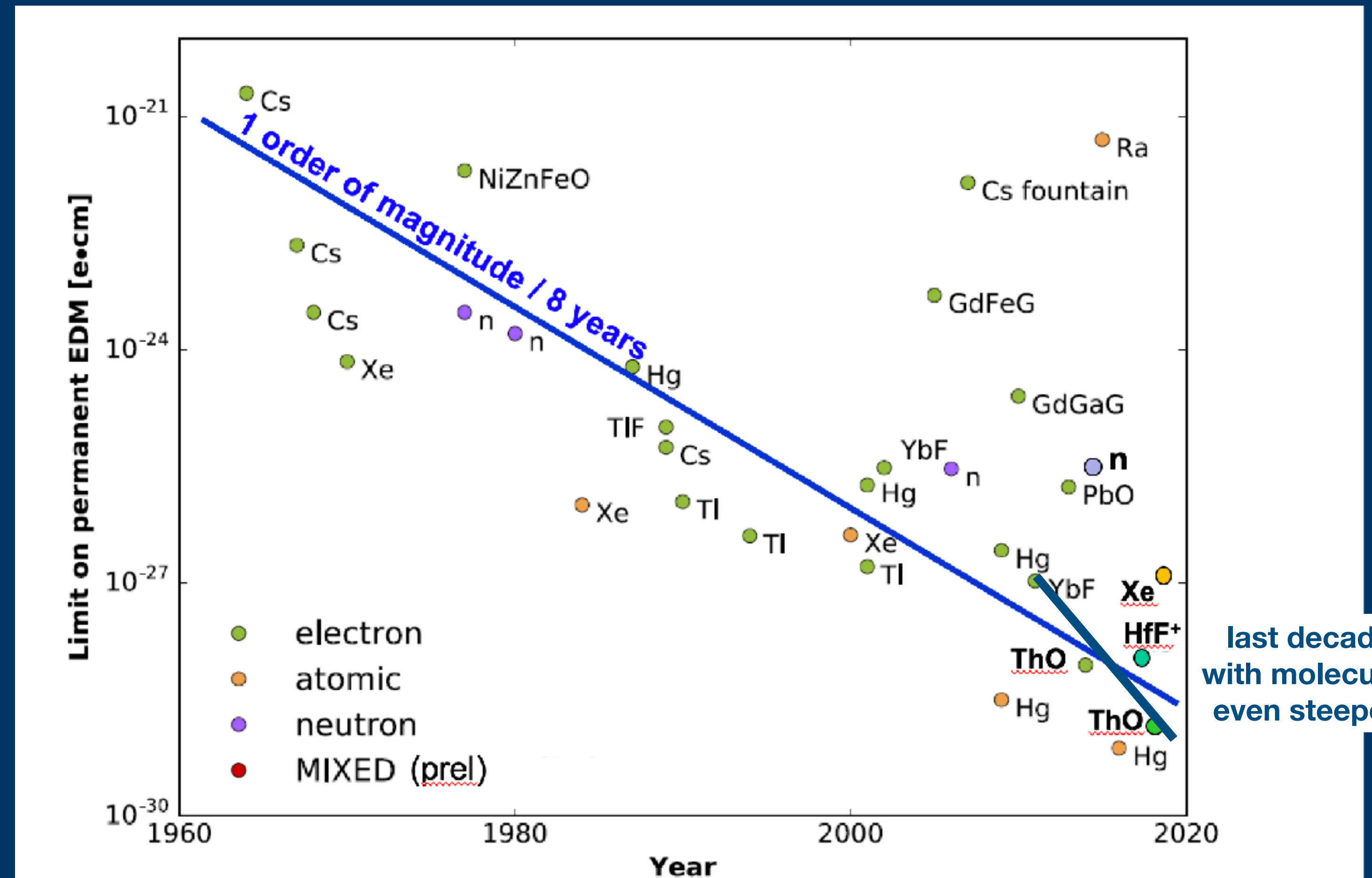
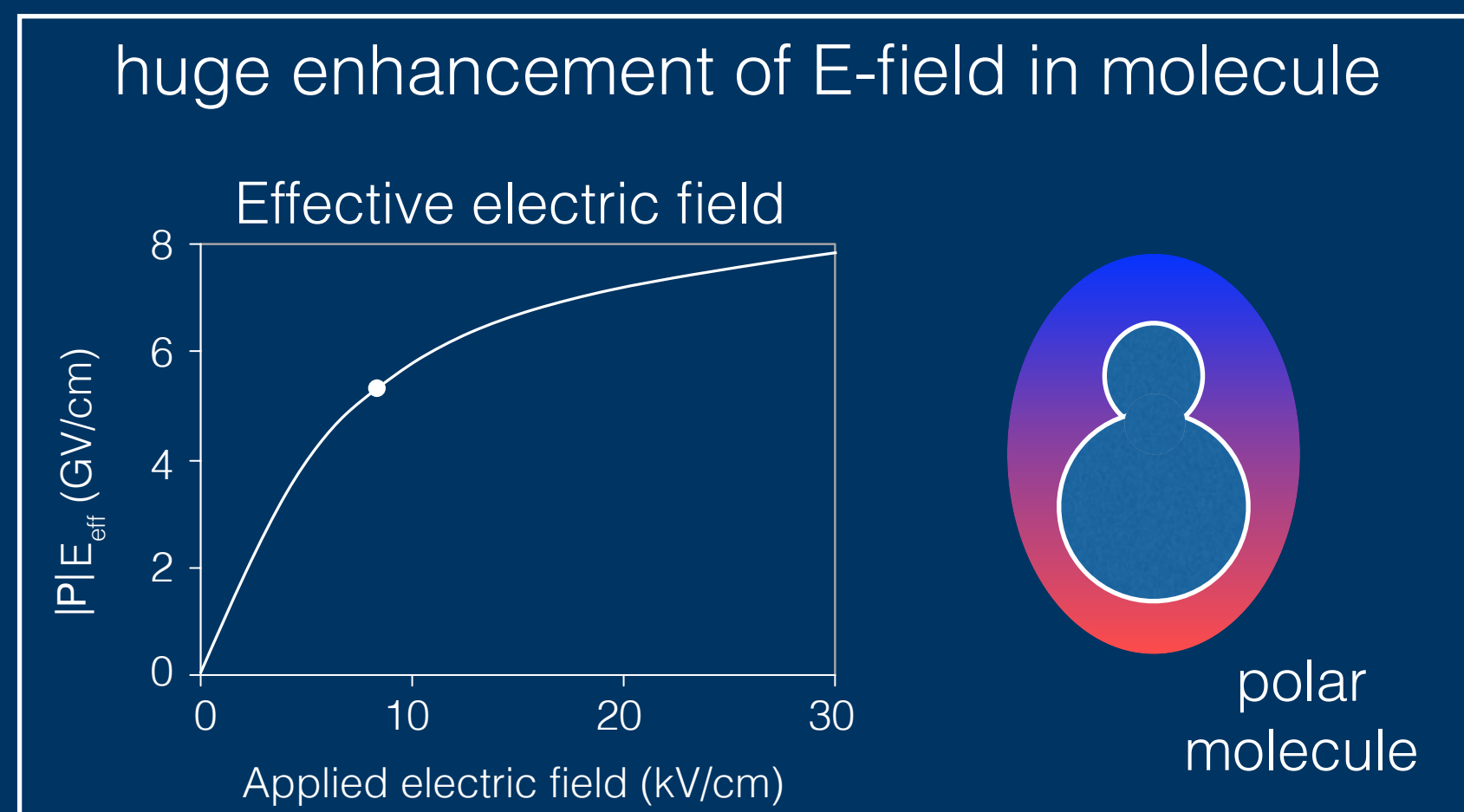
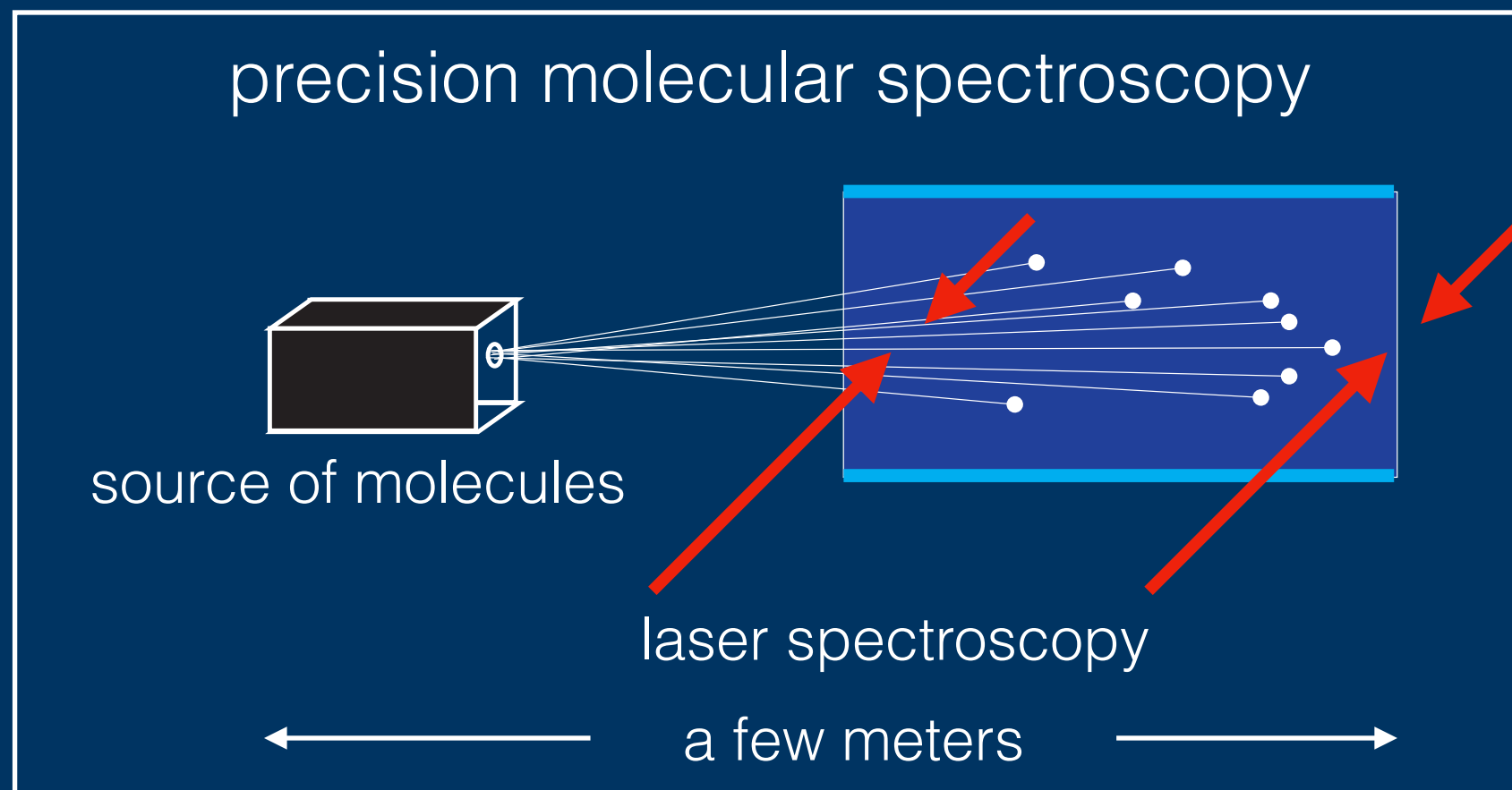
TeV physics through incredible precision and huge enhancements



eEDM sensitivity gain of factor 100 \rightarrow factor 10 increase in probed energy scale!

Table-top particle physics

TeV physics through incredible precision and huge enhancements

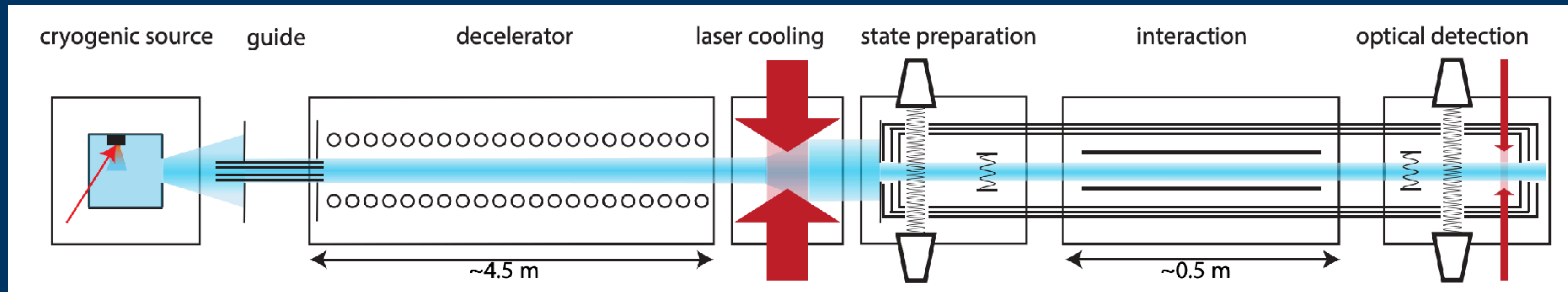


eEDM sensitivity gain of factor 100 → factor 10 increase in probed energy scale!

What we work on now

manipulation of molecules to reach highest sensitivity

Slow, intense and cold beam of BaF molecules



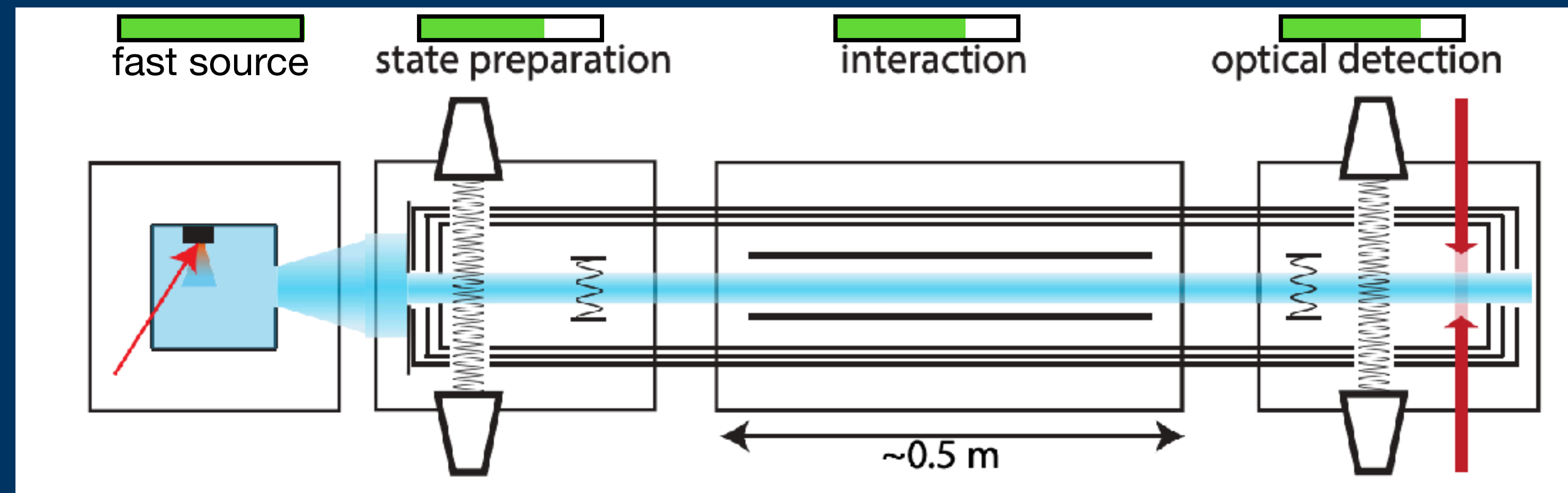
important role of theory: selection of molecules, interpretation of spectra, translation of spectroscopy to eEDM limit

What we work on now

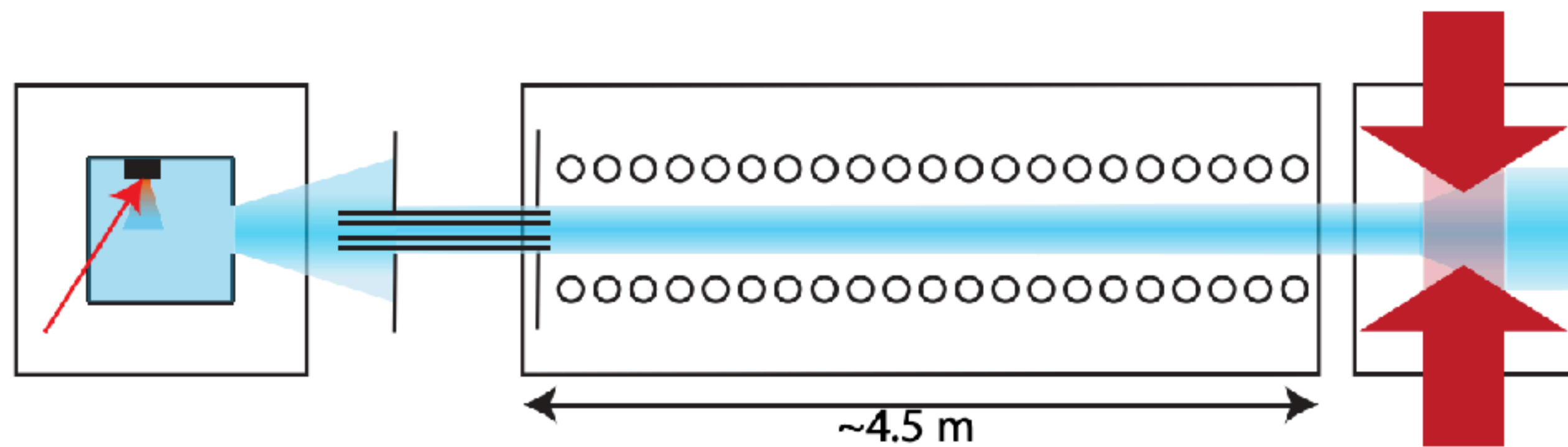
manipulation of molecules to reach highest sensitivity

fast beam eEDM

show systematics under control



cryogenic source guide decelerator laser cooling



slow and cold beam

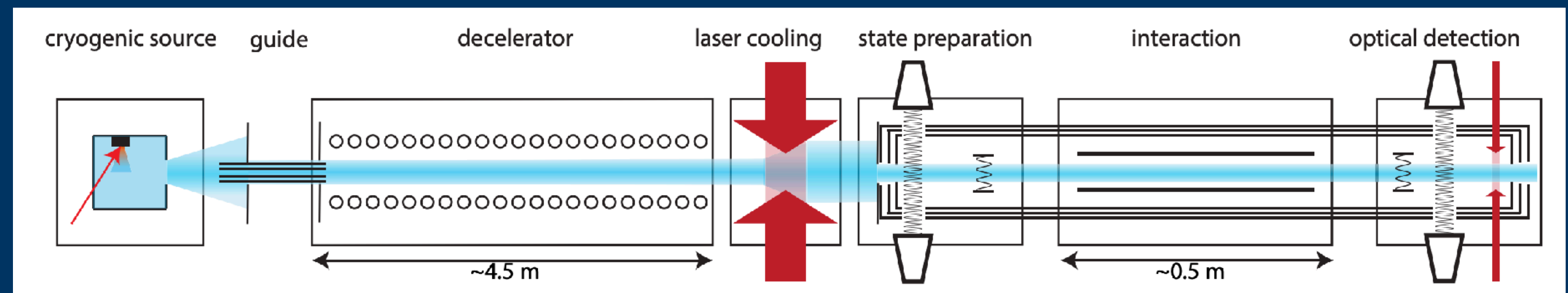
show full statistics can be reached

Extrapolating eEDM - 5 and 10 years

optimise, collect data, and improve

5 years

combine, optimise, collect data



10 years

significant (1-2 orders of magnitude) improvement possible:

- **coherence time** (slower particles)
- **statistics** (beam intensity, light collection)
- **systematics** (comagnetometer states)

Beyond eEDM

connections to other experiments and programs

not only *electron-EDM*

Also: oscillating EDMs for axion searches!

Physics beyond colliders at CERN: beyond the Standard Model working group report

J Beacham¹, C Burrage^{2,30}, D Curtin³, A De Roeck⁴,
J Evans⁵, J L Feng⁶, C Gatto^{7,8}, S Gninenko⁹, A Hartin¹⁰,
I Irastorza¹¹, J Jaeckel¹², K Jungmann^{13,30}, K Kirch^{14,30},
F Kling⁶, S Knapen¹⁵, M Lamont⁴, G Lanfranchi^{4,16,30,31},
C Lazzeroni¹⁷, A Lindner¹⁸, F Martinez-Vidal¹⁹,
M Moulson¹⁶, N Neri²⁰, M Papucci^{4,21}, I Pedraza²²,
K Petridis²³, M Pospelov^{24,30}, A Rozanov^{25,30}, G Ruoso^{26,30},
P Schuster²⁷, Y Semertzidis²⁸, T Spadaro¹⁶, C Vallée²⁵ and
G Wilkinson²⁹

J. Phys. G: Nucl. Part. Phys. 47 (2020) 010501

J Beacham *et al*

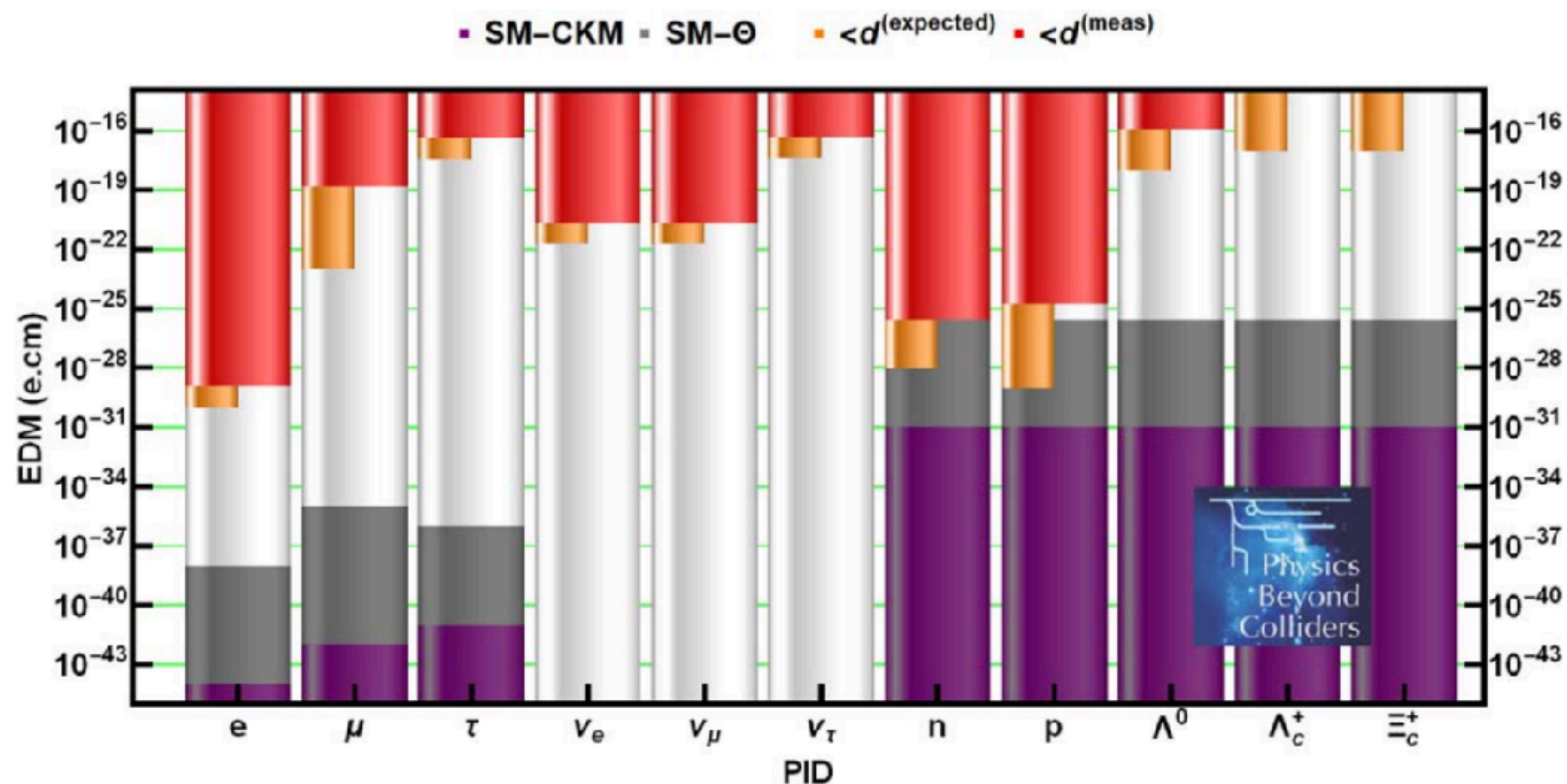


Figure 13. Overall status of EDM measurements: current limits on EDMs of fundamental particles are displayed as red bars from the top. From below come the SM estimates from CKM CP violation and Θ_{QCD} (assuming it takes the maximal value allowed by the neutron EDM). White regions indicate safe BSM discovery territory for the experiments.

Beyond eEDM

connections to other experiments and programs

**Fundamental physics
impact through low-energy
precision studies**

Testing QED

e.a. determination of alpha using Cs and Rb atoms

Lepton universality

H atom, Muonic Hydrogen, emerged from 'proton-size puzzle'

Determination (and variation?) of constants

e.a. HD+ lab spectra for m_p/m_e , compare with astrophysical observations, optical clocks

Parity violation

Anapole moments, chirality

Beyond eEDM

connections to other experiments and programs

R&D

photon detection, electronics, custom hardware, optical lab

**eEDM interconnections
with Nikhef programs**

LHCb

CP violation

Theory

Quantum chemistry and particle physics EFT

Gravitational waves

Lasers, cavities, shot-noise limited photon detection, state squeezing, 'AMO tricks'

Concluding

Exciting times ahead!



university of
groningen
van swinderen institute for
particle physics and gravity

Nikhef

Dutch National Institute for (astro)Particle Physics



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