Searching for New Physics at the intensity frontier

(at low energies with lots of particles)
Part IV

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Overview

Why and where to search for new physics:

- Triumph and tragedy of the Standard Model

Proton decay:

- Watching lots of water

Proton radius, neutron lifetime:

- Puzzling discrepancies

Muon magnetic moment:

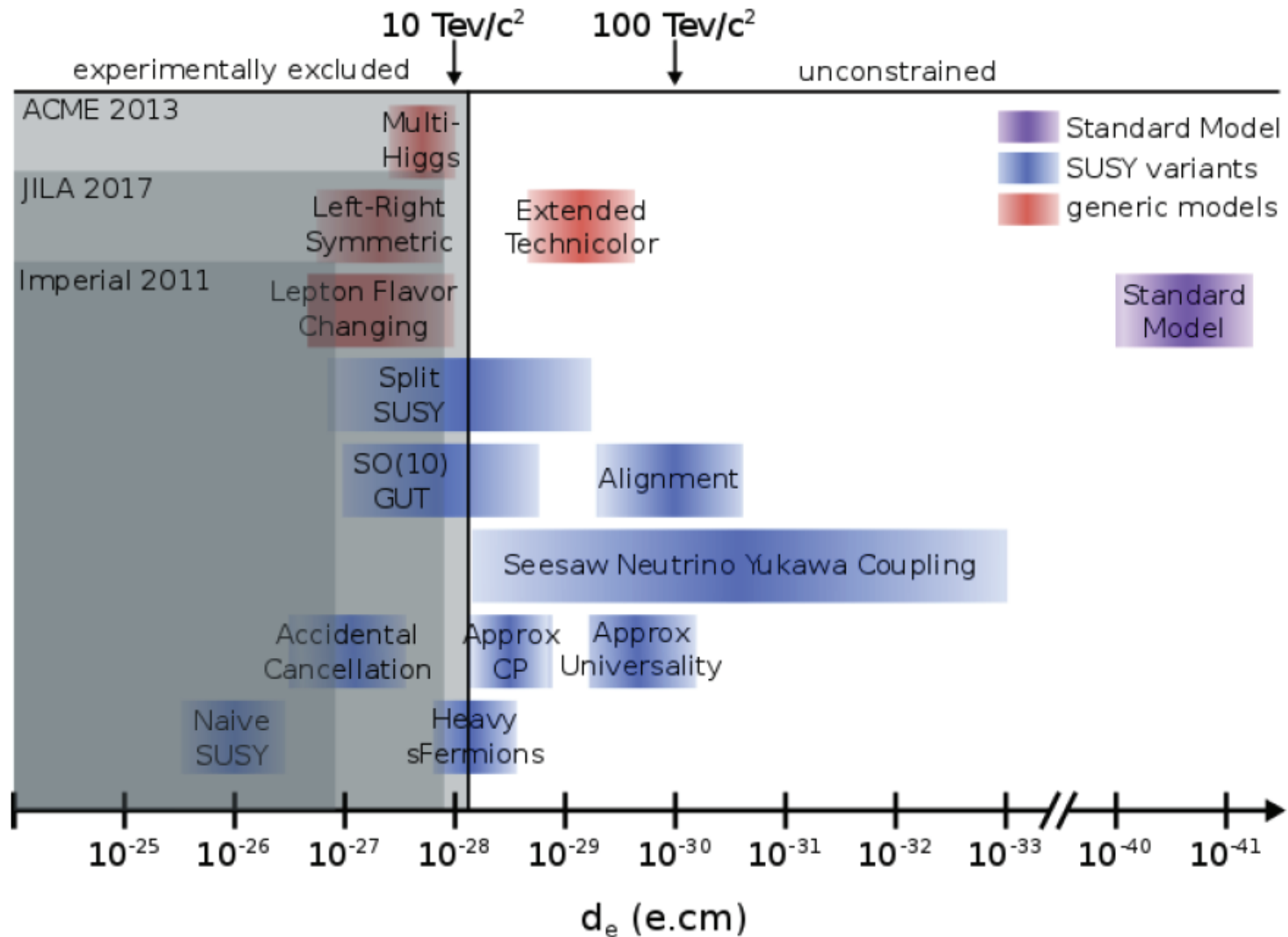- Measuring and calculating at the precision limit

The electric dipole moment of the neutron:

- Particles in a bottle
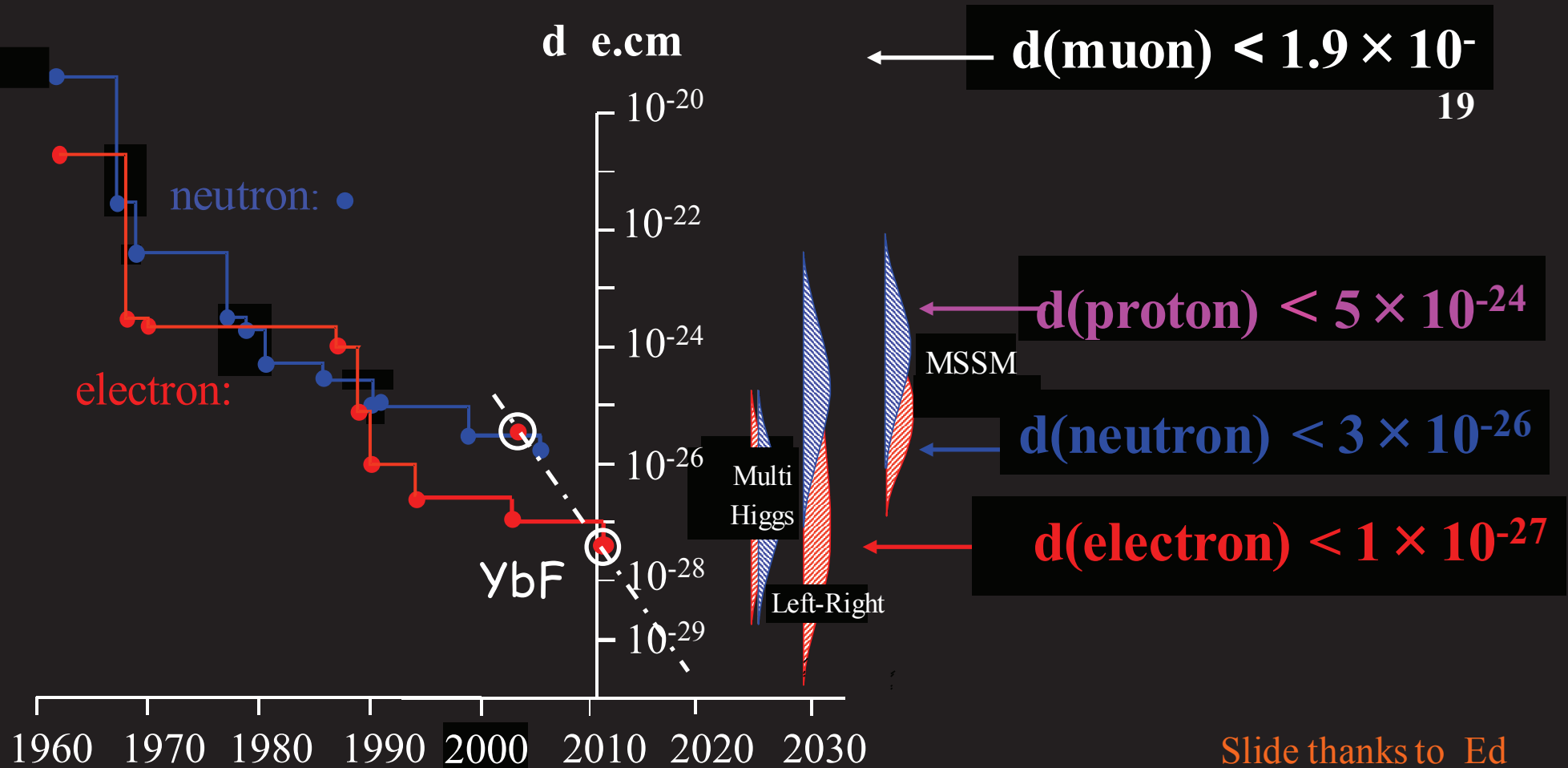
The weak mixing angle:

- New Physics in tiny differences between left- and right-handed
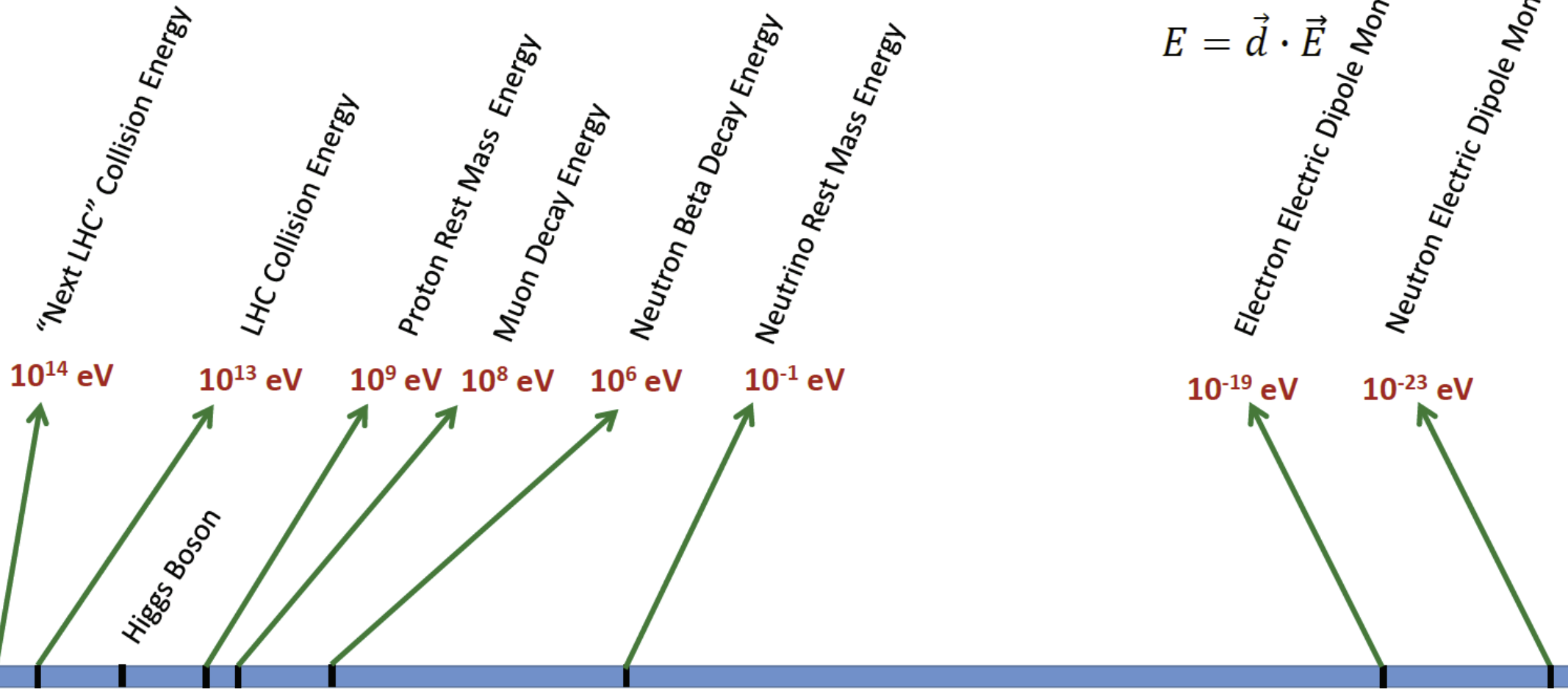
EDMs and new physics (here: electron EDM)

Imperial: Nature **473** 493 (2011), ACME: Science **343** 269 (2014), JILA: PRL **119** 153001
Figure adapted from Ben Spaun, PhD Thesis, Harvard University, (2014).

And in another graph...

d e.cm

10^{-20}

10^{-22}

10^{-24}

10^{-26}

10^{-28}

10^{-29}

neutron:

electron:

YbF

MSSM

Multi Higgs

Left-Right

1960 1970 1980 1990 2000 2010 2020 2030

d(muon) < 1.9×10^{-19}

d(proton) < 5×10^{-24}

d(neutron) < 3×10^{-26}

d(electron) < 1×10^{-27}

Physics at different Energy Scales

$$E = \vec{d} \cdot \vec{E}$$

"Next LHC" Collision Energy — 10^{14} eV

LHC Collision Energy — 10^{13} eV

Proton Rest Mass Energy — 10^9 eV

Muon Decay Energy — 10^8 eV

Neutron Beta Decay Energy — 10^6 eV

Neutrino Rest Mass Energy — 10^{-1} eV

Higgs Boson

Electron Electric Dipole Moment — 10^{-19} eV

Neutron Electric Dipole Moment — 10^{-23} eV

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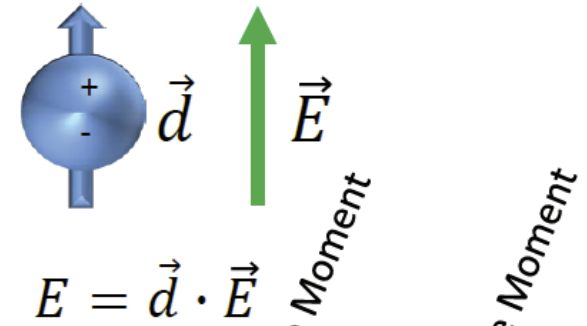
Connections...

The SM is almost unreasonably efficient

- Describes all experiments with fundamental particles

- Exception: Neutrino oscillations
        but: massive neutrinos can be dealt with

- Many few sigma hints out there (enough, if we consider trial factors?)

- Some large discrepancies with composite systems
  (proton radius, neutron lifetime ...)

- To get back to the beauty discussion:
  - Can we ask from our BSM extensions to be at least as efficient?
  - Is efficiency a indicator for beauty? (or understanding?)

Predictions... (2016 for the next three years)

- There will be 3 major intriguing BSM results:

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    1. One will be a statistical fluctuation

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    3. One will be a **Discovery !**

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Predictions... (2016 for the next three years)

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    1. One will be a statistical fluctuation
    2. One will be a new systematic effect
    3. One will be a **Discovery !**

Of course any decent theoretical prediction should include an error bar: = ± 1

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