Tim Chupp

Recommended Reading; 2021 Summary by Chen-Yu (Les Houches)

https://lpsc-indico.in2p3.fr/event/2584/contributions/5103/

Thanks to!

- International committee: Bernhard Lauss, Brad Filippone, Jeff Martin
- Local oragnizers: Steven, Nguyen, Chen-Yu, TC
- Session chairs: Russ M, Brad P., Georg B, Bernhard, Jeff M., Austin, Wolfgang S., Andy S., Shinsuke, Steven C, Nguyen, Chen-Yu

Tito


MOST SPECIAL THANKS TO
Carrie Talus
Vanessa Tapia
!!!
Georgia O'keefe: Jimson Weed (Datura stramonium)

By the numbers

- 70 Participants
- 52 Contributions – 2 plenary talks; 4 overview talks
- 7 Coffee breaks – 30 minutes!
- 5 experiments/labs (full coverage or our field)
- 1 Bob
- 0 measured with grater and greater precision - Peter Geltenbort

Measure 0?

4,000,000 UCN/fill from Super Sun (Estelle)

10,000 MSR Shielding factor @ low *f* for TWO MSRs! (Maedeh)

54 Tiles of n2EDM active shield

7 layers of n2EDM MSR and 7th-order gradient corrections

10^{-11} T residual field in MSR (Felicity)

10^{-14} T minimum from Cs magnetometer (Victoria)

0 e-cm±… (Stephanie)

Dirac "discovered" EDMs

The Quantum Theory of the Electron.

By P. A. M. Dirac, St. John's College, Cambridge.

(Communicated by R. H. Fowler, F.R.S.—Received January 2, 1928.)

$$[-(p_0 + e'A_0)^2 + (\mathbf{p} + e'\mathbf{A})^2 + m^2c^2 + e'h(\boldsymbol{\sigma}, \mathbf{H}) + ie'h\rho_1(\boldsymbol{\sigma}, \mathbf{E})]\psi = 0$$

$i\gamma_5$

$g=2$

The electron will therefore behave as though it has a magnetic moment $eh/2mc \cdot \boldsymbol{\sigma}$ and an electric moment $ieh/2mc \cdot \rho_1 \boldsymbol{\sigma}$. This magnetic moment is just that assumed in the spinning electron model. The electric moment, being a pure imaginary, we should not expect to appear in the model. It is doubtful whether the electric moment has any physical meaning, since the Hamiltonian in (14) that we started from is real, and the imaginary part only appeared when we multiplied it up in an artificial way in order to make it resemble the Hamiltonian of previous theories.

$$H = -\vec{\mu} \cdot \vec{B} - \vec{d} \cdot \vec{E} = -\mu \vec{J} \cdot \vec{B} - d\vec{J} \cdot \vec{E}$$

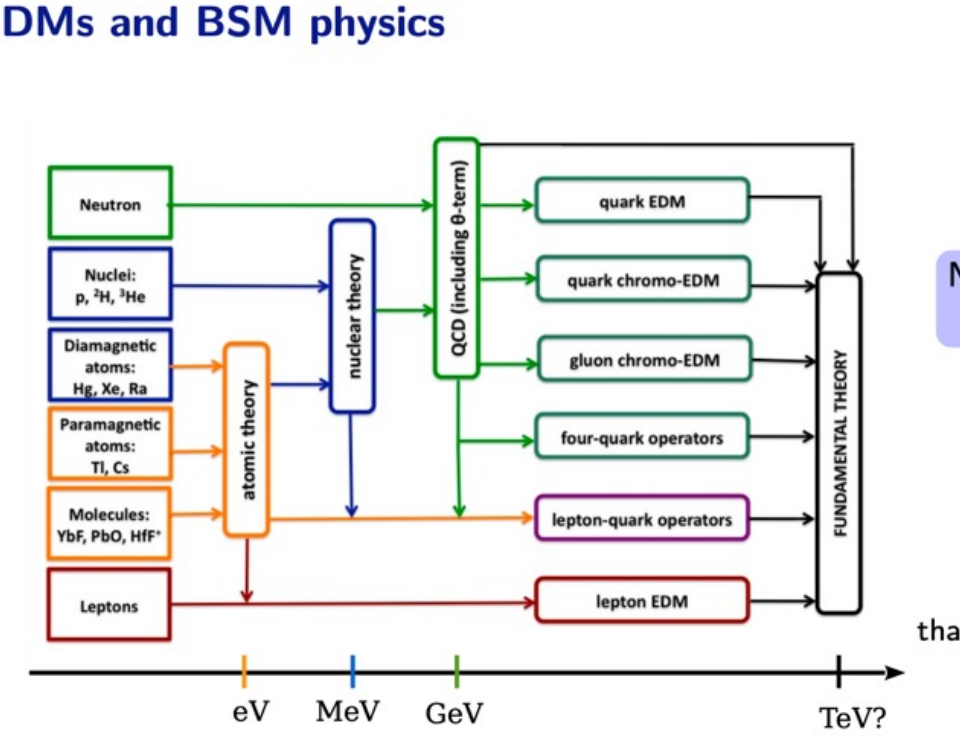
Where we (nEDM) stand

System	Result	95% u.l.	ref.
Paramagnetic systems			
Xe^m	$d_A = (0.7 \pm 1.4) \times 10^{-22}$	3.1×10^{-22} e-cm	a
Cs	$d_A = (-1.8 \pm 6.9) \times 10^{-24}$	1.4×10^{-23} e-cm	b
	$d_e = (-1.5 \pm 5.7) \times 10^{-26}$	1.2×10^{-25} e-cm	
Tl	$d_A = (-4.0 \pm 4.3) \times 10^{-25}$	1.1×10^{-24} e-cm	c
	$d_e = (6.9 \pm 7.4) \times 10^{-28}$	1.9×10^{-27} e-cm	
YbF	$d_e = (-2.4 \pm 5.9) \times 10^{-28}$	1.2×10^{-27} e-cm	d
ThO	$\omega^{NE} = -510 \pm 485$ μrad/s		e
	$d_e = (4.3 \pm 4.0) \times 10^{-30}$	1.1×10^{-29} e-cm	
	$C_S = (2.9 \pm 2.7) \times 10^{-10}$	7.3×10^{-10}	
HfF^+	$f^{BD} = -14.6 \pm 22.8_{\rm stat} \pm 6.9_{\rm syst}$ µHz.	2.1×10^{-29} $e$cm	f
Diamagnetic systems			
n	$d_n = (-0.0 \pm 1.1) \times 10^{-26}$	2.2×10^{-26} e-cm	g
^{199}Hg	$d_A = (2.2 \pm 3.1) \times 10^{-30}$	7.4×10^{-30} e-cm	h
^{129}Xe	$d_A = (1.4 \pm 6.9) \times 10^{-28}$	1.4×10^{-27} e-cm	i
^{225}Ra	$d_A = (4 \pm 6) \times 10^{-24}$	1.4×10^{-23} e-cm	j
TlF	$d = (-1.7 \pm 2.9) \times 10^{-23}$	6.5×10^{-23} e-cm	k
Particle systems			
μ	$d_\mu = (0.0 \pm 0.9) \times 10^{-19}$	1.8×10^{-19} e-cm	l
Λ	$d_\Lambda = (-3.0 \pm 7.4) \times 10^{-17}$	7.9×10^{-17} e-cm	m

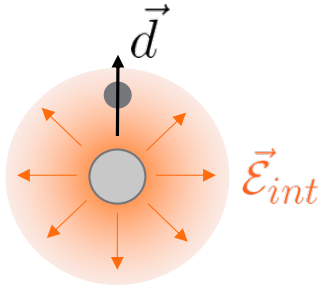
2017
2018 (8x)

2023 (8x) (90%cl)

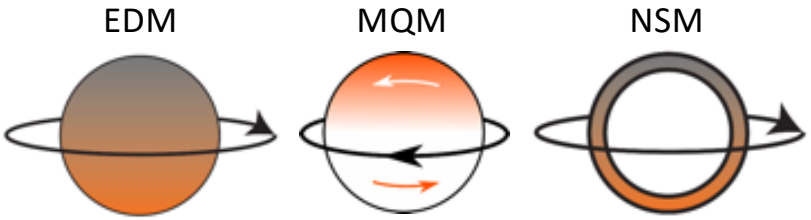
2020 (1.6x)
2017 (4x)
2019 (5x)
2016



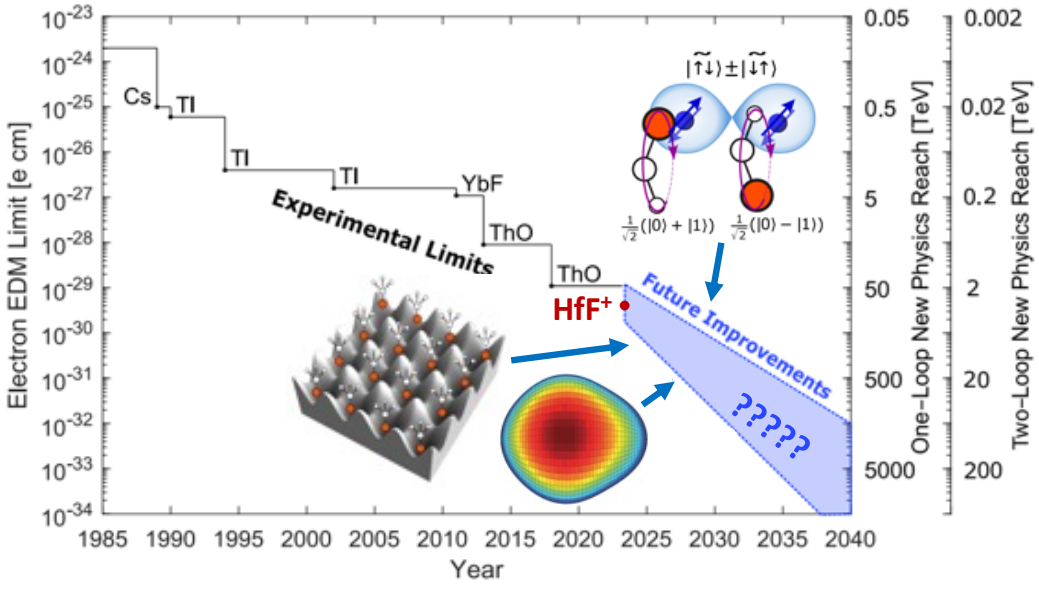
CPV with Atoms and Molecules - Hutzler



Atoms and molecules have large internal fields…



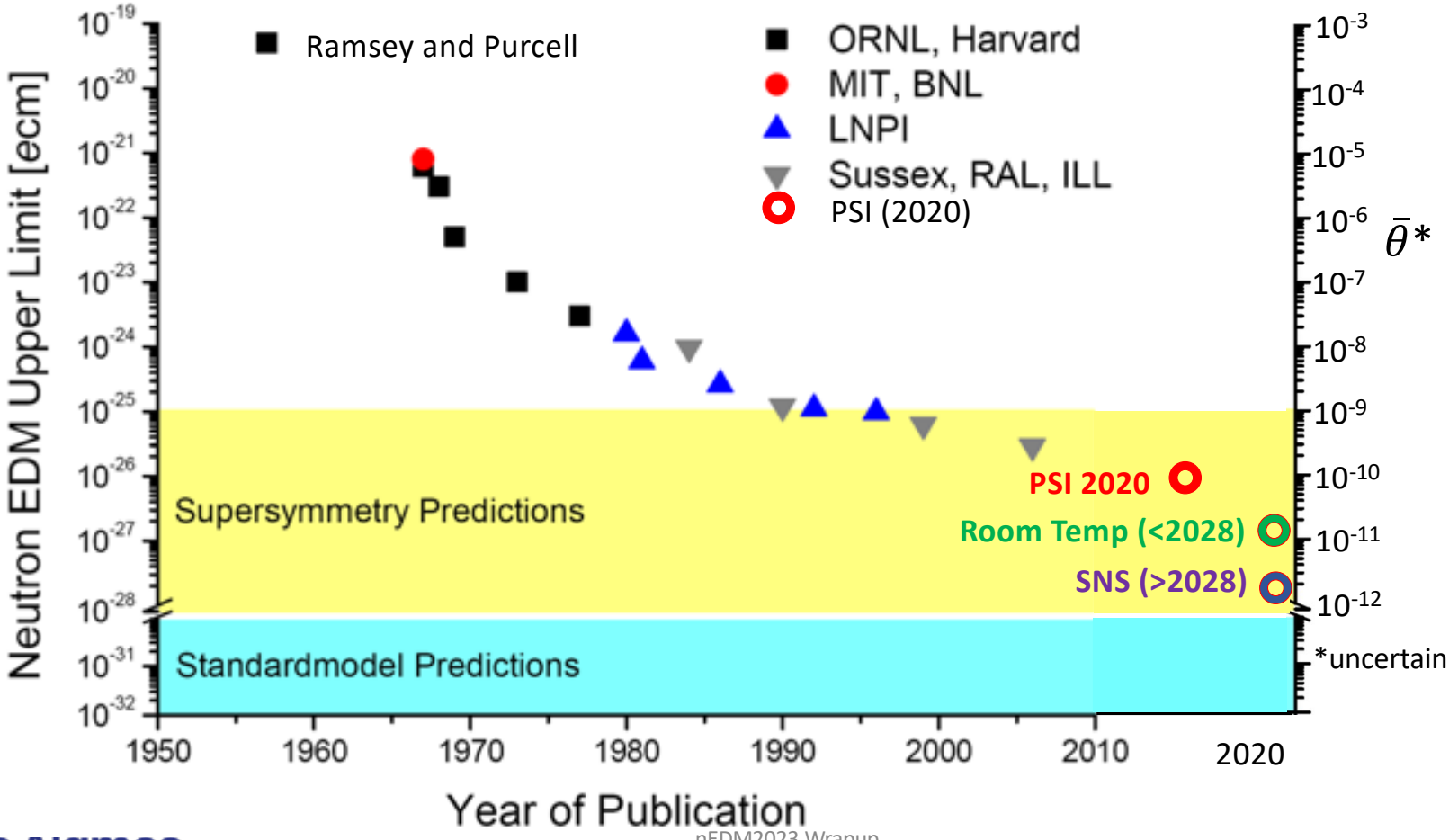
… which amplify signals from electronic and hadronic CPV



Many experiments are needed to explore the complex CPV parameter space $(d_e, C_S, \theta_{QCD}, g_i, d_q, \tilde{d}_q, \dots)$

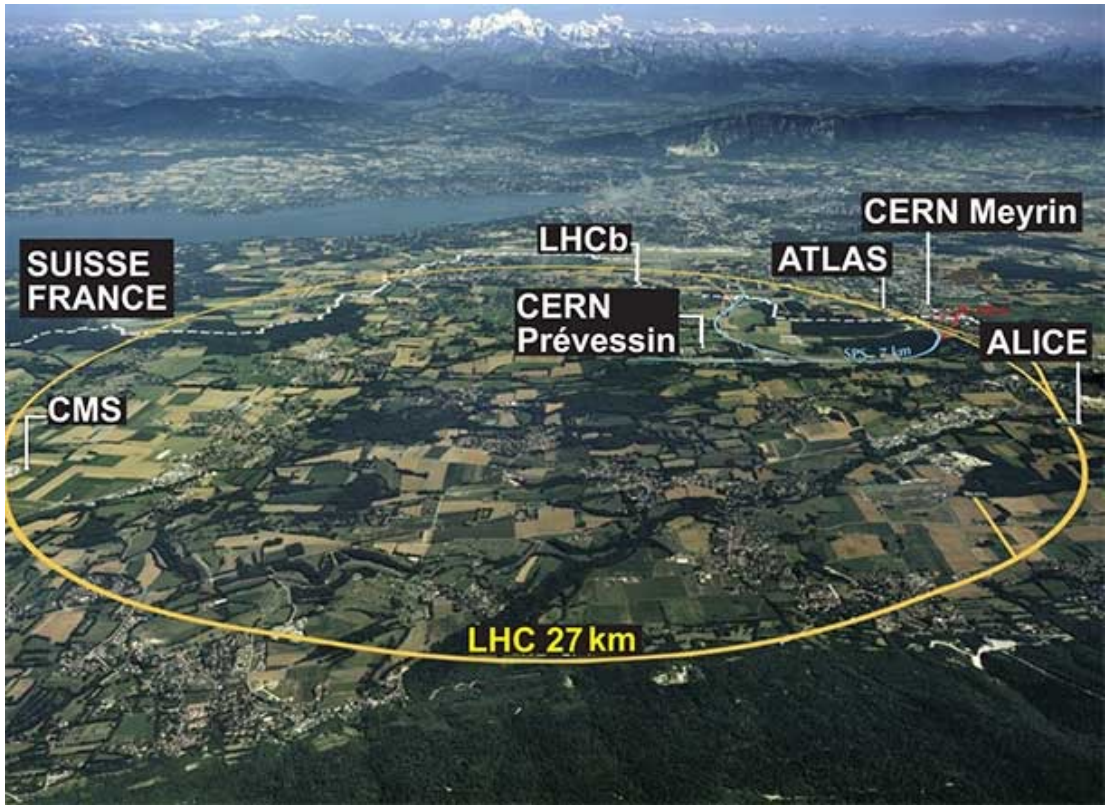
Many experiments are ongoing, and many new ones are underway!

Where we (nEDM) stand



*uncertain theory connection

EDM's probe TeV scale physics (dimension 6)



$$\mu \approx \frac{e\hbar}{2m} \qquad (\alpha = \frac{e^2}{\hbar c})$$

$$\frac{d}{\mu} \approx f^{2N} \left(\frac{m_q}{m_X}\right)^2 \sin\phi$$

$\sin\phi \approx 1$

$f \approx \alpha$

$\frac{d}{\mu} \approx 10^{-14}$

$$m_X \approx m_q \sqrt{10^{14}\,\alpha^N}$$

N: # loops

~ 10+ TeV LHC scale

or ϕ is small

Ways to organize a workshop wrap-up


TUCAN Collaboration

- by collaboration (see overview talks)
- by T-shirt

- by technical topic

  sources, guides, chambers, polarimetry, (co)magnetometers, MSRs, HV, simulations/systematics, analysis/blinding

- by participants

Participants - YOU

- Youth
- Diversity
- Talent
- Ambition
- Community

We don't know how large an nEDM nature is hiding from us, but if it's >10-28 e-cm YOU will find it.

nEDM 2026


PAUL SCHERRER INSTITUT
PSI
Hoping for a more peaceful world in 2026!

The Genesis Committee Meets Again – Tim Chupp

The Genesis committee was meeting again. The frequency of these meetings always increased as the deadline for unveiling the next universe approached. Much had already been settled – the basic building blocks, the forces between them, the spontaneous generation of ratios - all were routine.

So now it was time to make sure it would all work together. Too many times a new universe had just fizzled and turned into nothing more than it started with.
How boring!

The chair called on the first simulations group to report.

"Well we've been running this, and there's something we've never seen before in replicating life forms: some sort of intelligence."

"What do you mean?"

"Well they seem to learn, to investigate, to assemble things – edifices, machines."

"And?"

"And then they destroy everything they built. It seems that is the inevitable purpose"

"That's intelligence?"

"Well we have seen rare cases of collective efforts to figure it all out."

"And?" (This seems to be the chair's favorite word – used knowing that there is always more, always something new from the next random simulation.)

"And there's one successful case …. They figured it out!"
A gasp emerged from everyone, except the chair.

"Of course it's bound to happen. Should we make it harder?" Murmurs of ascent followed as the chair turned to the initial conditions group. "Double the number of basic building blocks; randomize the masses."

"Same forces?"

"Sure - give it a whirl." The simulations groups got busy and shortly someone called out, "Got one – a complete revelation."

"Hmm that was fast," mused the chair," Okay – add another generation – and another force – a weak one – that will slow things down." The silence endured, and after what seemed like an eternity, the chair again spoke out. "Nothing?"

"Group one report."

"Not yet,"

"Group two?"

"Nope, but we haven't even run the first Infinity of cases!"

"We don't have time for that," said the chair, "let's wrap this one up. It's time to move on to the next universe."