



# The search for the nEDM

How the nEDM can probe why we live in a matter dominated universe.

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**ENERGY**

Office of  
Science

# Outline

## ■ Motivation

- What is the nEDM?
- How is it related to the baryon asymmetry problem?

## ■ Theory

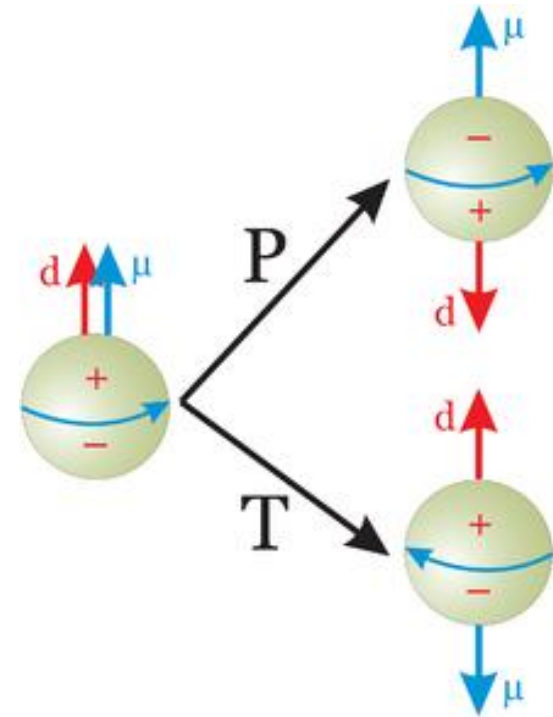
- What is predicted by the standard model?
- What does theory predict for beyond standard model?

## ■ Experiment

- What are the status of current measurements?
- What is planned for the future?

# What is the nEDM?

- Neutron electric dipole moment (nEDM) arises from an anisotropic charge distribution
- Aligned with spin
- Non-zero nEDM has symmetry implications
  - Violates T (CP)
  - Violates P



Andreas Knecht

# Baryon Asymmetry and the nEDM

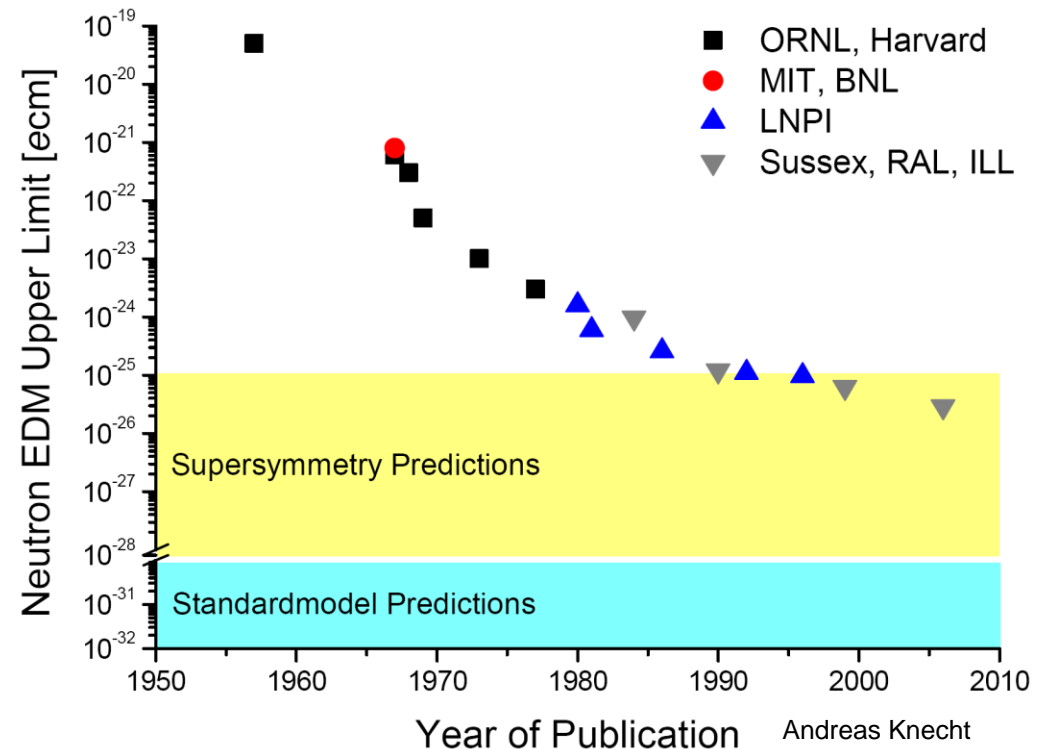
- Why is our world made of matter?
- Sakharov conditions
  - Baryon number violation
  - C and CP violation
  - Interactions out of thermal equilibrium
- Standard model fails at explaining baryogenesis
  - Violation from electroweak processes
  - Known violation not strong enough
- Beyond Standard Model (BSM) required to meet observations
- nEDM probes additional sources of CP violation

$$\begin{array}{l} \text{SM Prediction} \\ \frac{n_B - n_{\bar{B}}}{n_\gamma} \sim 10^{-18} \end{array}$$

$$\begin{array}{l} \text{Observed} \\ \frac{n_B - n_{\bar{B}}}{n_\gamma} \sim 10^{-10} \end{array}$$

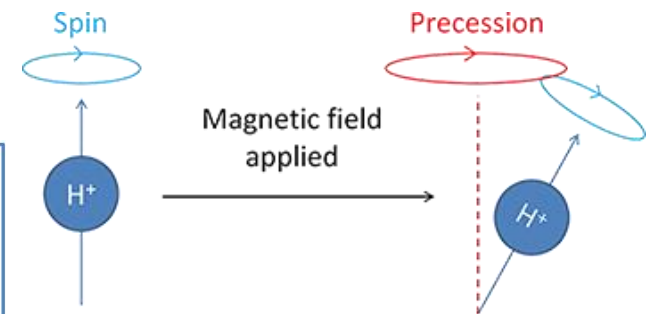
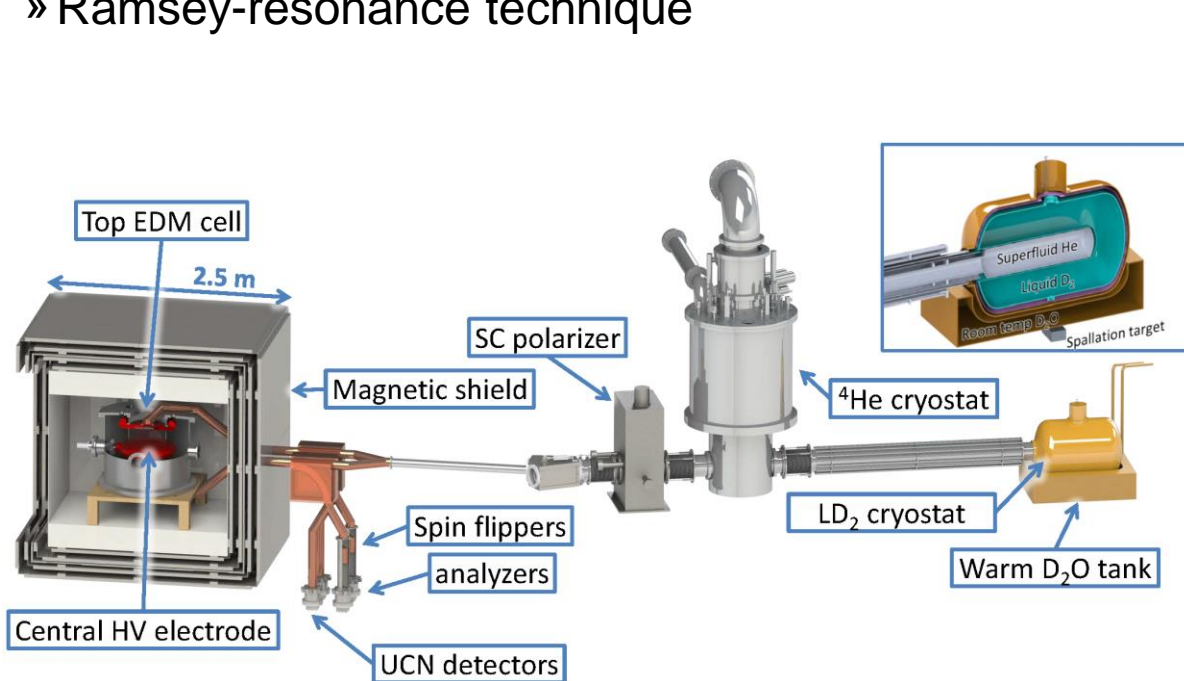
# Theory Predictions

- CP violation in SM from phase in CKM matrix
  - Leads to nEDM of  $O(10^{-31})$
  - Suppressed QDC sources
- Most BSM theories provide additional channels for CP violating processes
- Lattice QCD often used to calculate the effect of these additional processes
  - If nEDM found, can help limit potential theories



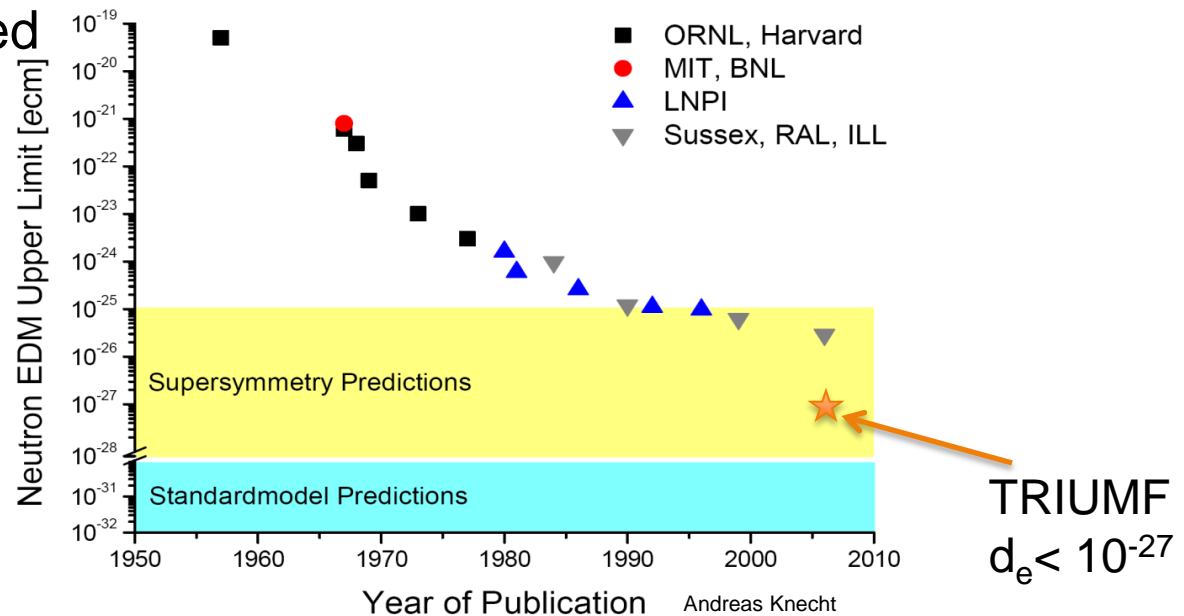
# Current Measurements

- Primary method of measurement is Ultra Cold Neutron
  - Total reflection => storable in bottle
  - $E < 300 \text{ neV}$  ( $< 7 \text{ m/s}$ )
  - Apply B/E field and measure Larmor precession  $h\nu = 2\mu_n B \pm 2 d_n E$ 
    - » Ramsey-resonance technique



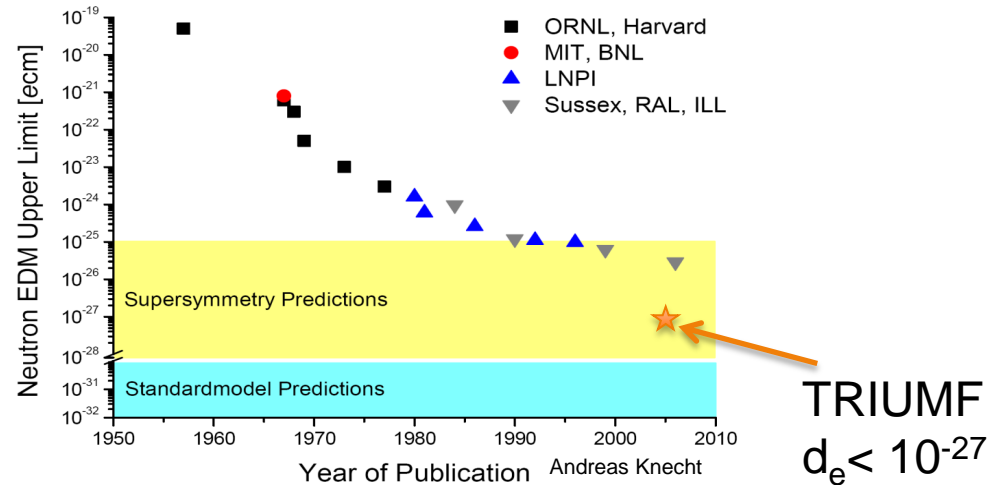
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- Next generation at TRIUMF
  - First UCN Nov 2017
  - nEDM experiment to run by 2020
  - Should push limit to  $d_e < 10^{-27}$





# The Future

- Continue to search for CP violating processes
- Theory
  - Lattice QCD will give better predictions as computing power increases
- Experiment
  - TRIUMF will provide the best bound yet on the nEDM

# Sources

- [1] R. Picker, JPS Conf.Proc. 13 010005 (2017)
- [2] R. Gupta, et al., arXiv:1701.04132 [hep-lat] (2017)
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- [4] L. Altarev, et al., Physica B: Condensed Matter 406(12): 2365-2369 (2012)
- [5] “TRIUMF's (ultra)cool experiment fires up,” TRIUMF <http://www.triumf.ca/first-triumf-ucns> (2017)

