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Search for a permanent electric dipole moment on the electron (eEDM) using BaF molecules

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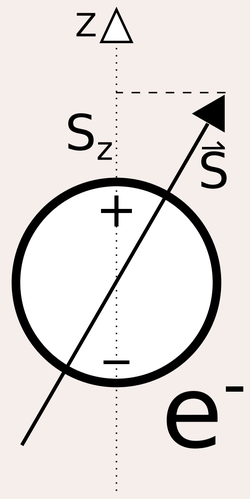
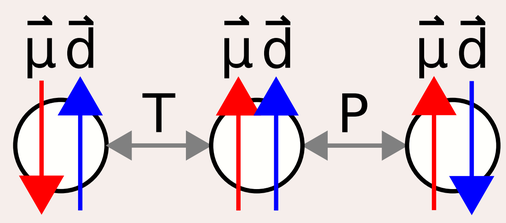
Electron Electric Dipole Moment (eEDM)



In electric field: causes spin precession.

$$H = -(\mu\vec{B} + d\vec{E}) \cdot \frac{\vec{S}}{|\vec{S}|} \qquad (1)$$

$$\text{where} \quad \vec{\mu} = \mu\vec{S} \quad \text{and} \quad \vec{d} = d\vec{S}. \quad (2)$$



Tests Standard Model extensions into TeV scale.

Measurement Sensitivity

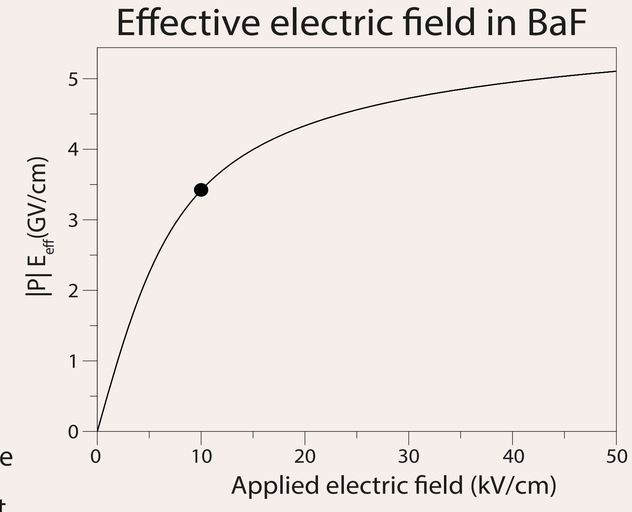
Sensitivity<10^{-28} e cm

$$\sigma_d = \frac{\hbar}{2|P|E_{\text{eff}}\tau\sqrt{\dot{N}T}}$$

Polarization of molecule
Effective electric field
Coherent interaction time
Particle rate and Measurement time
Statistical uncertainty in EDM measurement

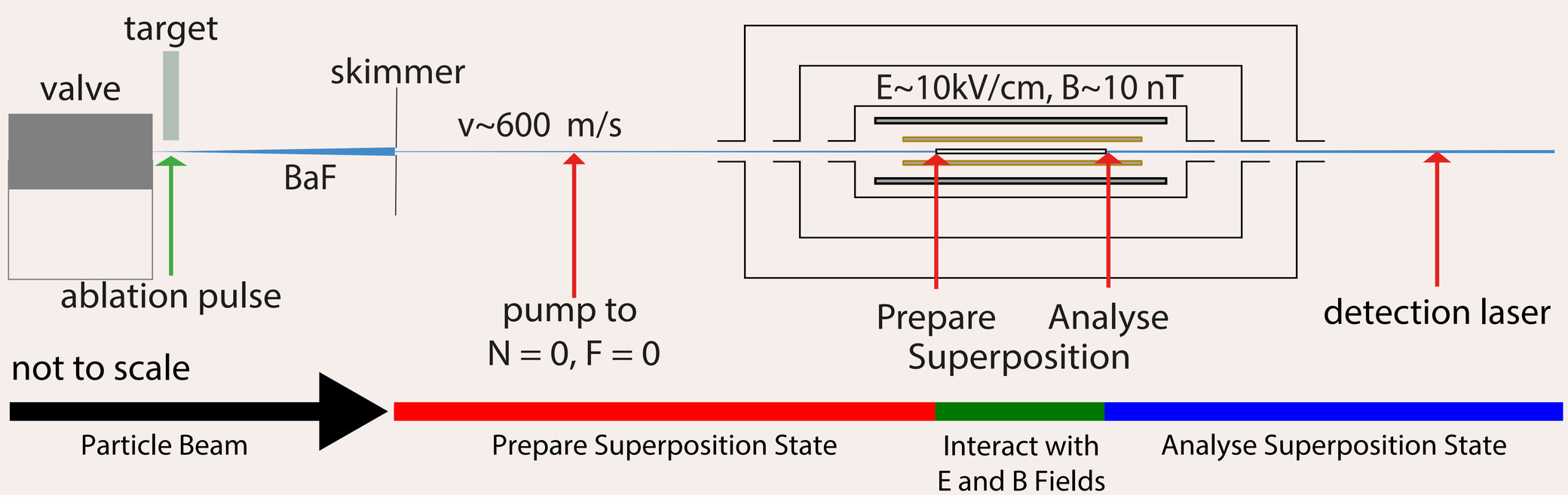
*P. Aggarwal, H. L. Bethlem et al., Eur. Phys. J. D 72 197(2018)

Effective electric field in BaF



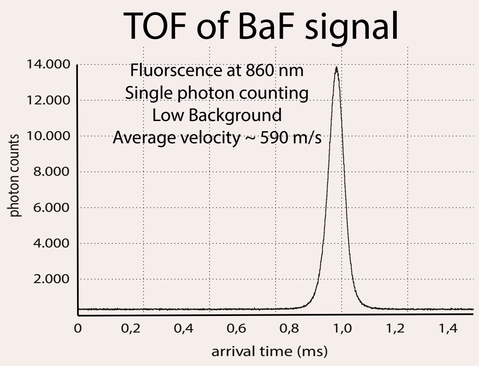
Electric field enhancement

Experimental Setup Phase 1: Supersonic Source + Interaction zone

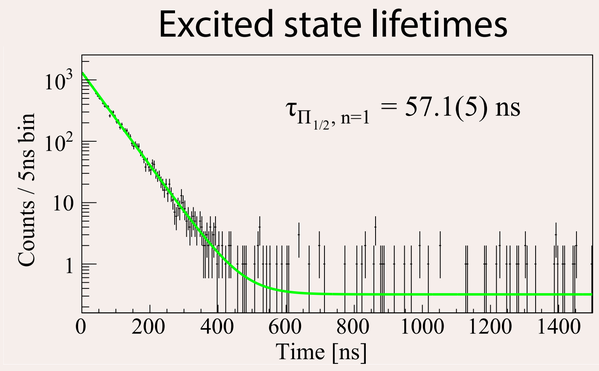


BaF Spectroscopy: towards state preparation

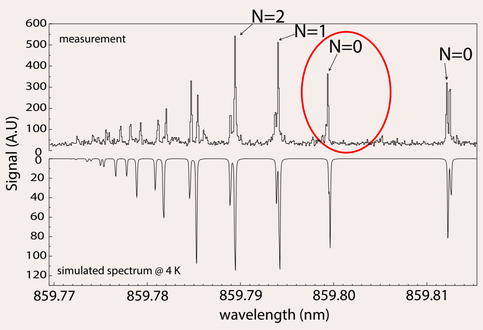
TOF of BaF signal



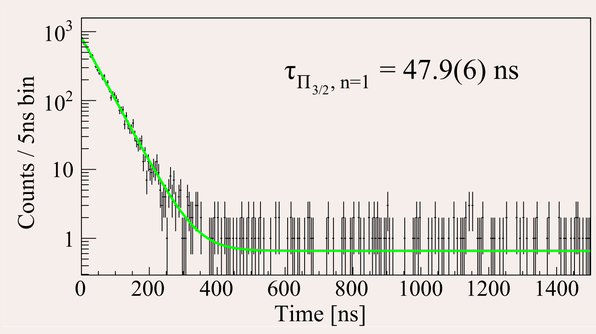
Excited state lifetimes



Rotational Spectrum



10 % in N=0 state.



*P. Aggarwal, V.R. Marshall et al., Phys Rev. A. (To be published)

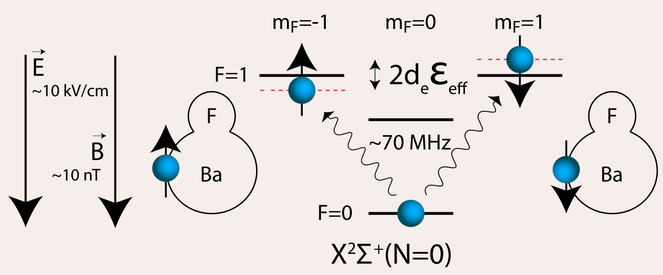
Best predictions from X2C-MRCI theory: 30% shorter lifetimes

*Y. Hao et al., J. Chem. Phys. (2019)

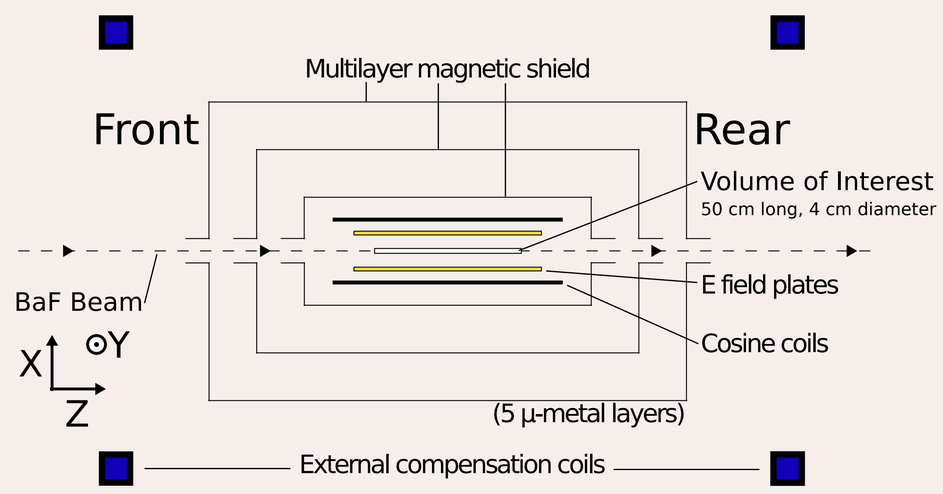
State Preparation

Transfer molecules from N=0 into eEDM-sensitive superposition state

$v = 0, N = 0, |m_F = -1\rangle \pm |m_F = +1\rangle$



Interaction Zone: E, B fields



E = 10 kV/cm, B = 10 nT, both homogeneous to 1%.

Outlook: Phase 2

Phase 2: Cryo-Source + Molecule Decelerator + Laser Cooling + Interaction Zone

eEDM sensitivity < 5 x 10^{-30} e cm

B = 600 pT