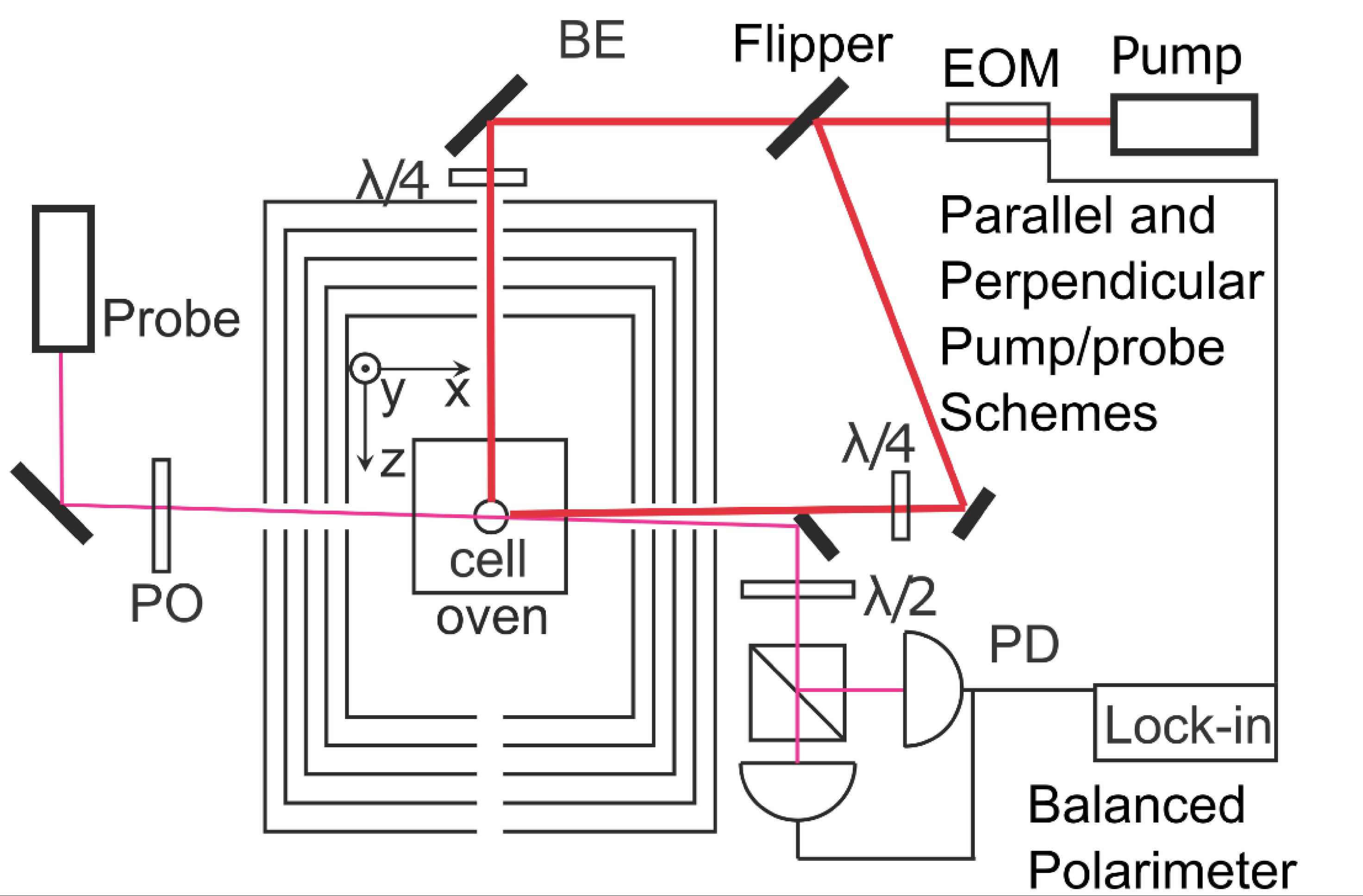
A ^{3}He-^{129}Xe co-magnetometer with ^{87}Rb magnetometry

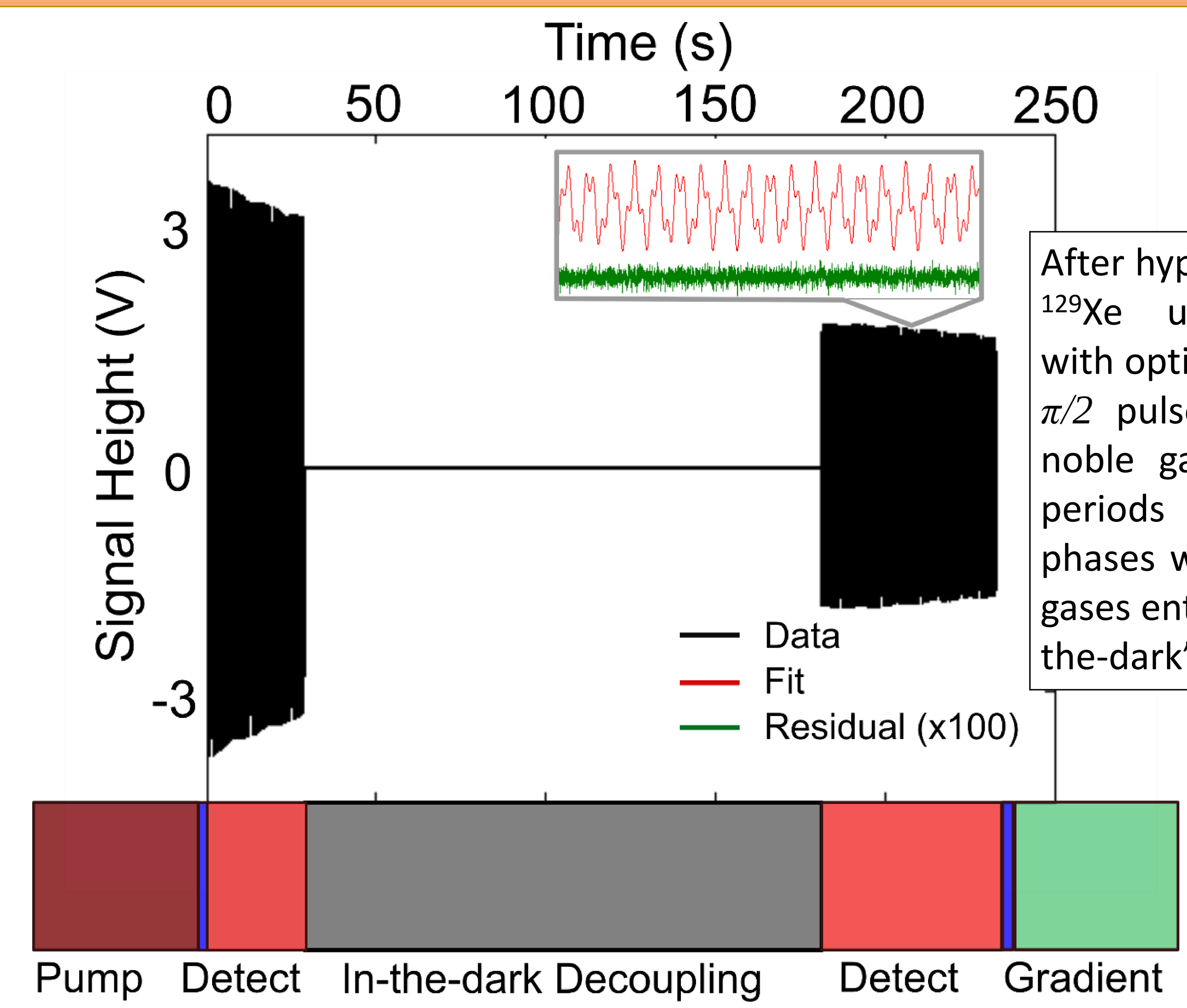
PRINCETON UNIVERSITY

Mark Limes, Dong Sheng, Mike Romalis

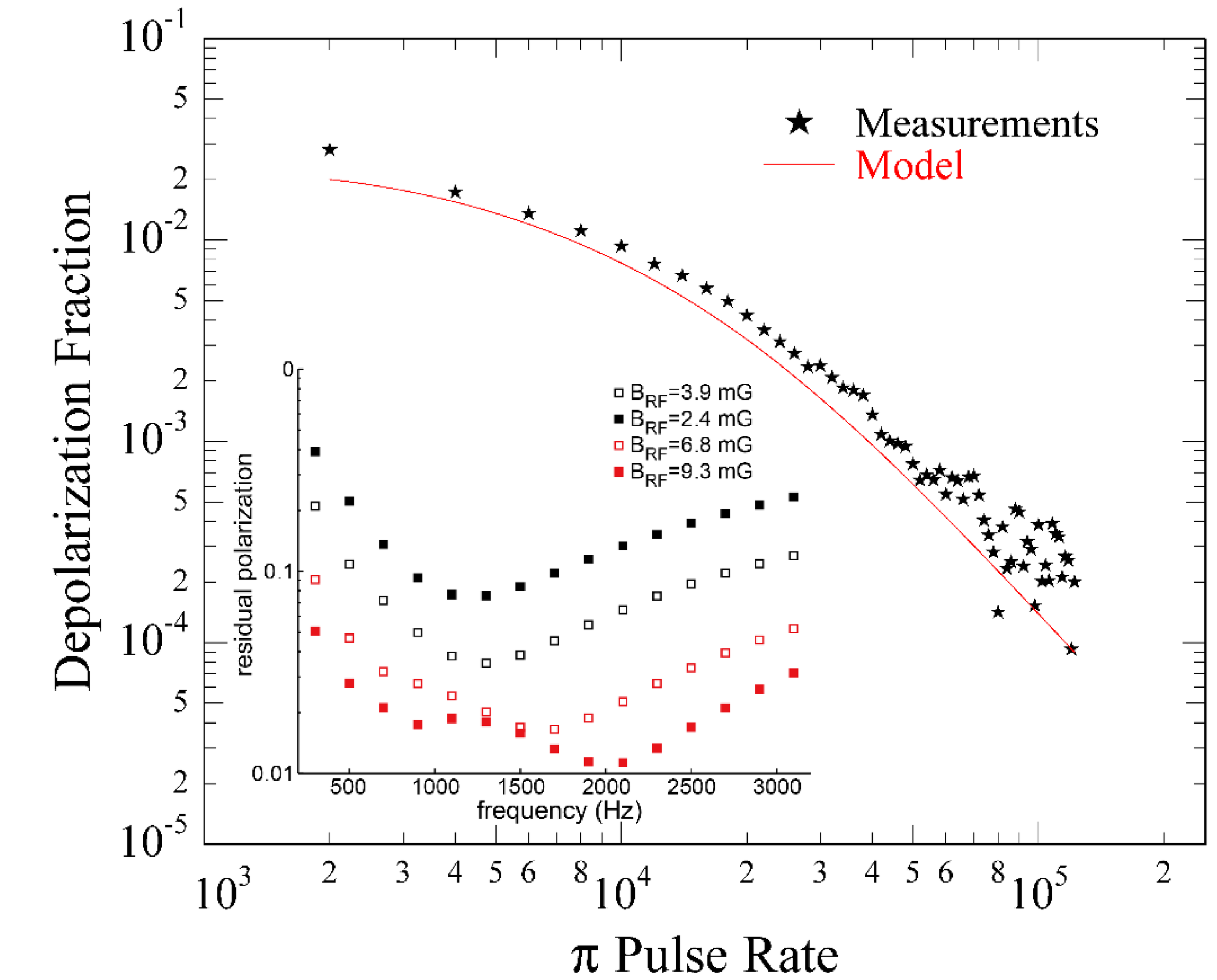
DARPA NSF



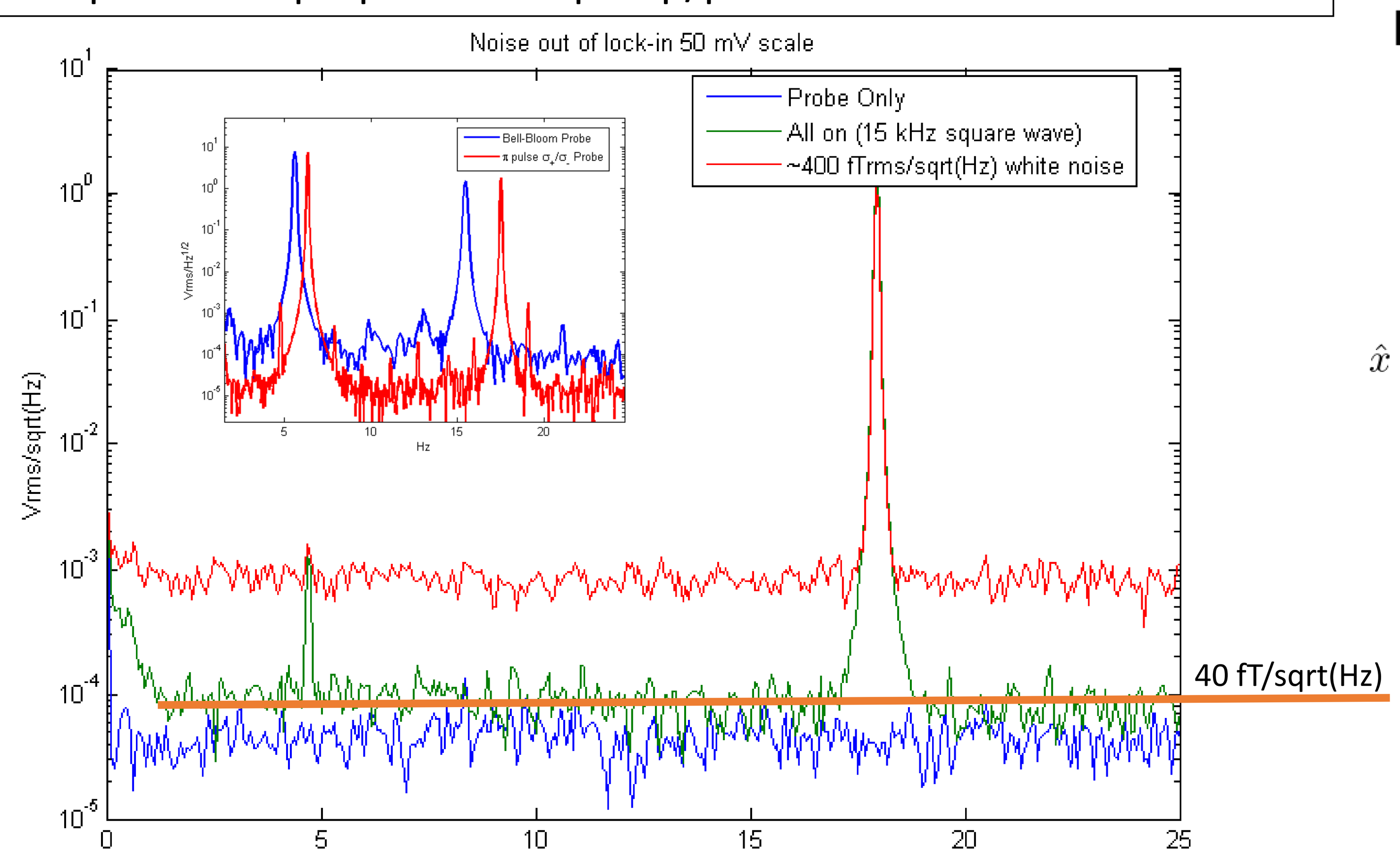
^{3}He and ^{129}Xe are read out by probing polarized ^{87}Rb by Faraday rotation. The spins are manipulated using a ^{87}Rb pump laser and magnetic field coils, with parallel or perpendicular pump/probe beams.



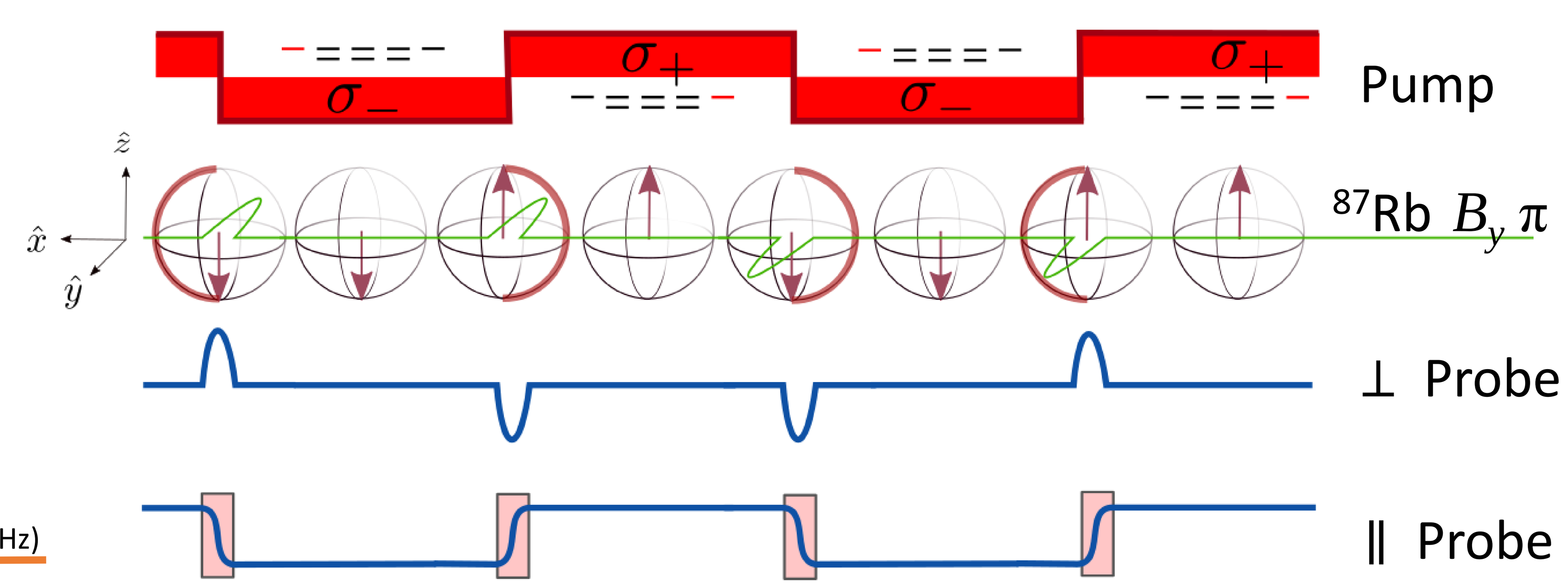
After hyperpolarizing ^{3}He and ^{129}Xe using spin-exchange with optically pumped ^{87}Rb, a $\pi/2$ pulse is applied to the noble gases. Two detection periods then determine the phases with which the noble gases enter and leave the "in-the-dark" decoupling period.



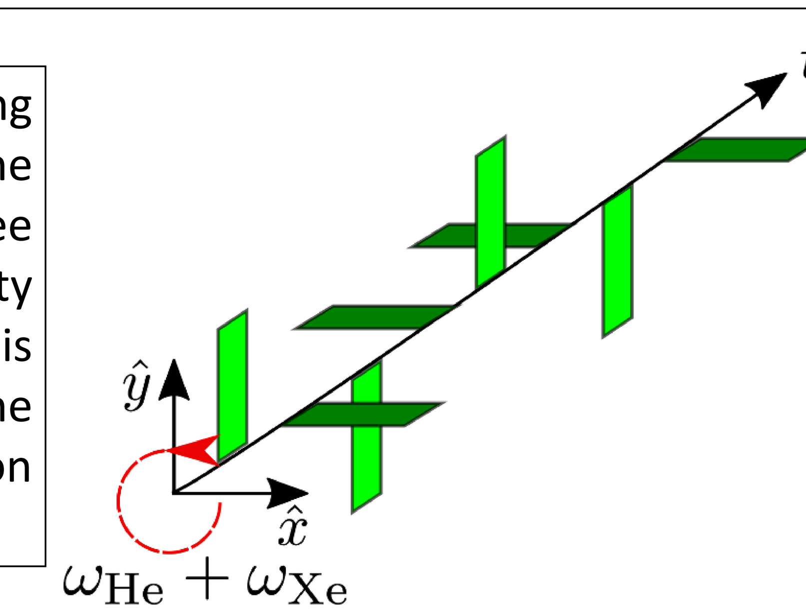
Rb π pulses gives decoupling of the Rb-Xe Fermi-contact interaction along a single axis by a factor approaching 10^4, a factor of 10^2 better than sine-wave depolarization schemes [1] (inset).

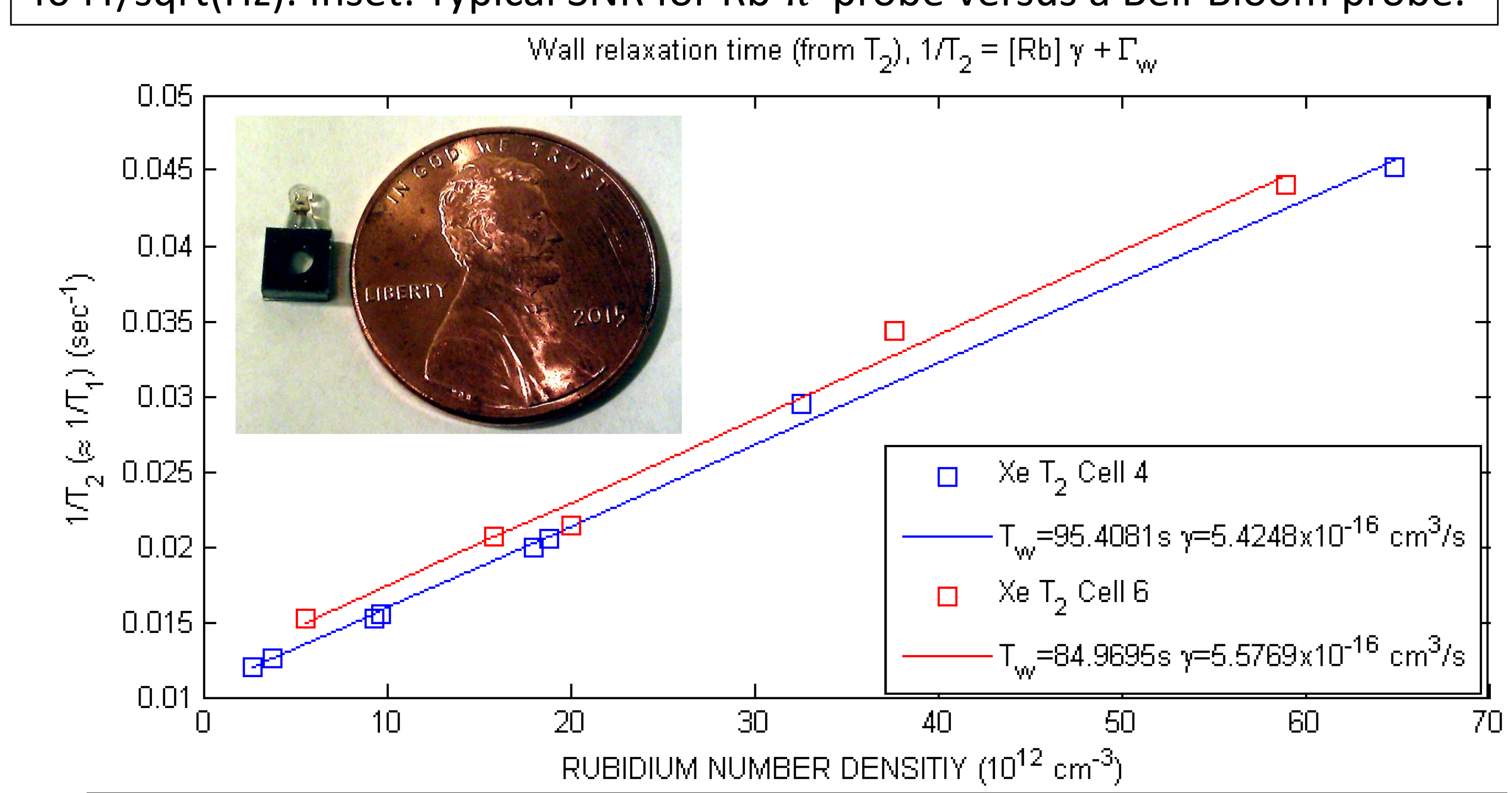


The ^{87}Rb magnetometer using π pulse detection has a sensitivity of 40 fT/sqrt(Hz). Inset: Typical SNR for Rb π probe versus a Bell-Bloom probe.

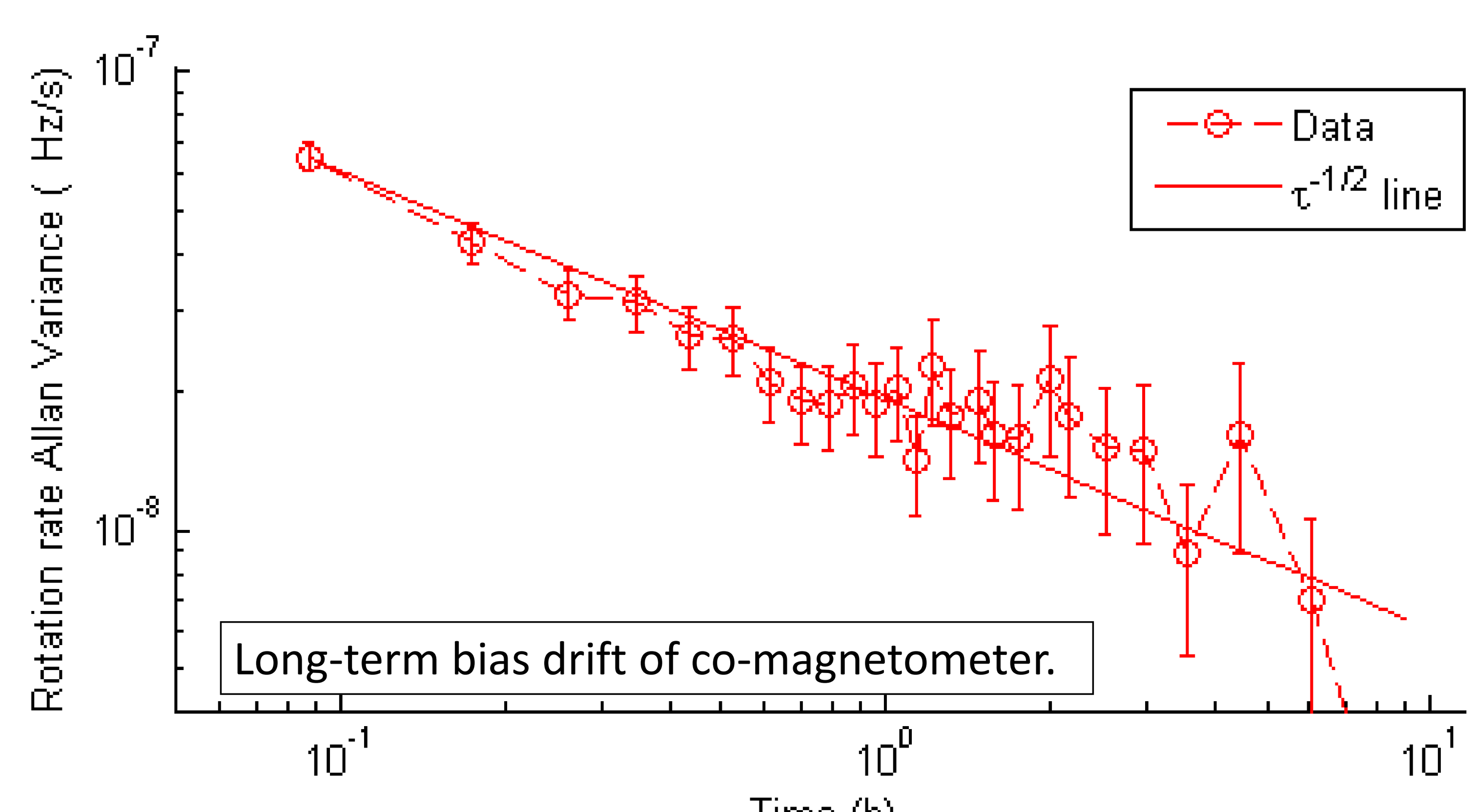


An "in-the-dark" decoupling pulse scheme averages the ^{87}Rb polarization along three axes, introduces no net helicity of the field pulses, and is rotated to null the effect of the sequence on the precession frequency ratio.

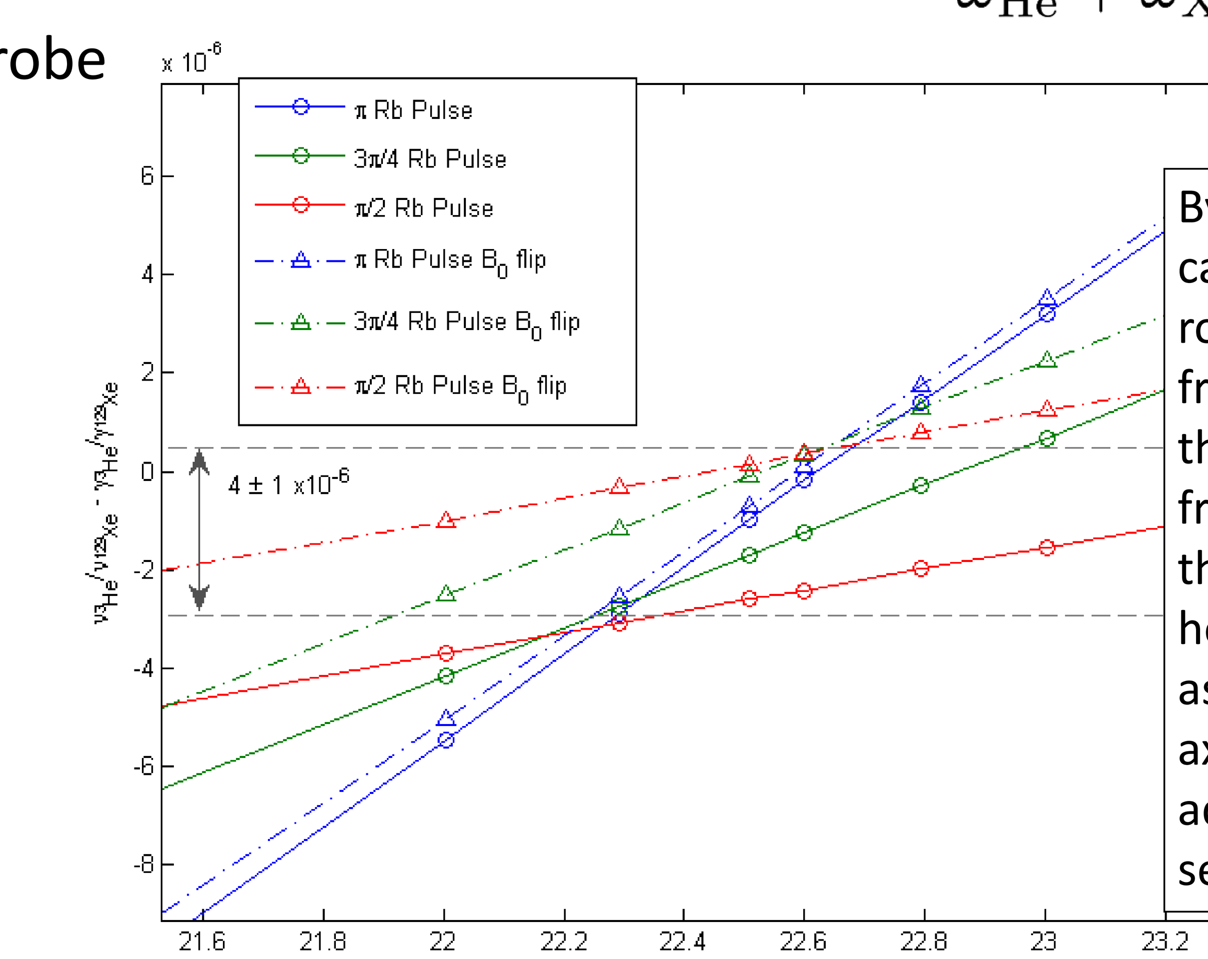




Anodically bonded cells have a ^{129}Xe Wall Relaxation time of $T_w \approx 100s$.



Long-term bias drift of co-magnetometer.



By flipping the bias field, we can calibrate our system using Earth's rotation. A pulse rotation frequency equal to the sum of the He and Xe precession frequencies gives a measurement that is insensitive to Rb π pulse height. Small imperfections, such as time delays between the pulse axes, can lead to artificial additions to the x-y pulse sequence rotation.

References:
[1] New classes of systematic effects in gas spin comagnetometers, D. Sheng, A. Kabcenell, M. V. Romalis, Phys. Rev. Lett. **113**, 163002 (2014).
[2] Nuclear spin gyroscope based on an atomic comagnetometer, T. W. Kornack, R.K. Ghosh, M. V. Romalis, Phys. Rev. Lett. **95**, 230801 (2005).
[3] NMR detection with an atomic magnetometer, I. M. Savukov and M. V. Romalis, Phys. Rev. Lett. **94**, 123001 (2005).