5s-6s Two-photon Spectroscopy in Rubidium 85 & 87

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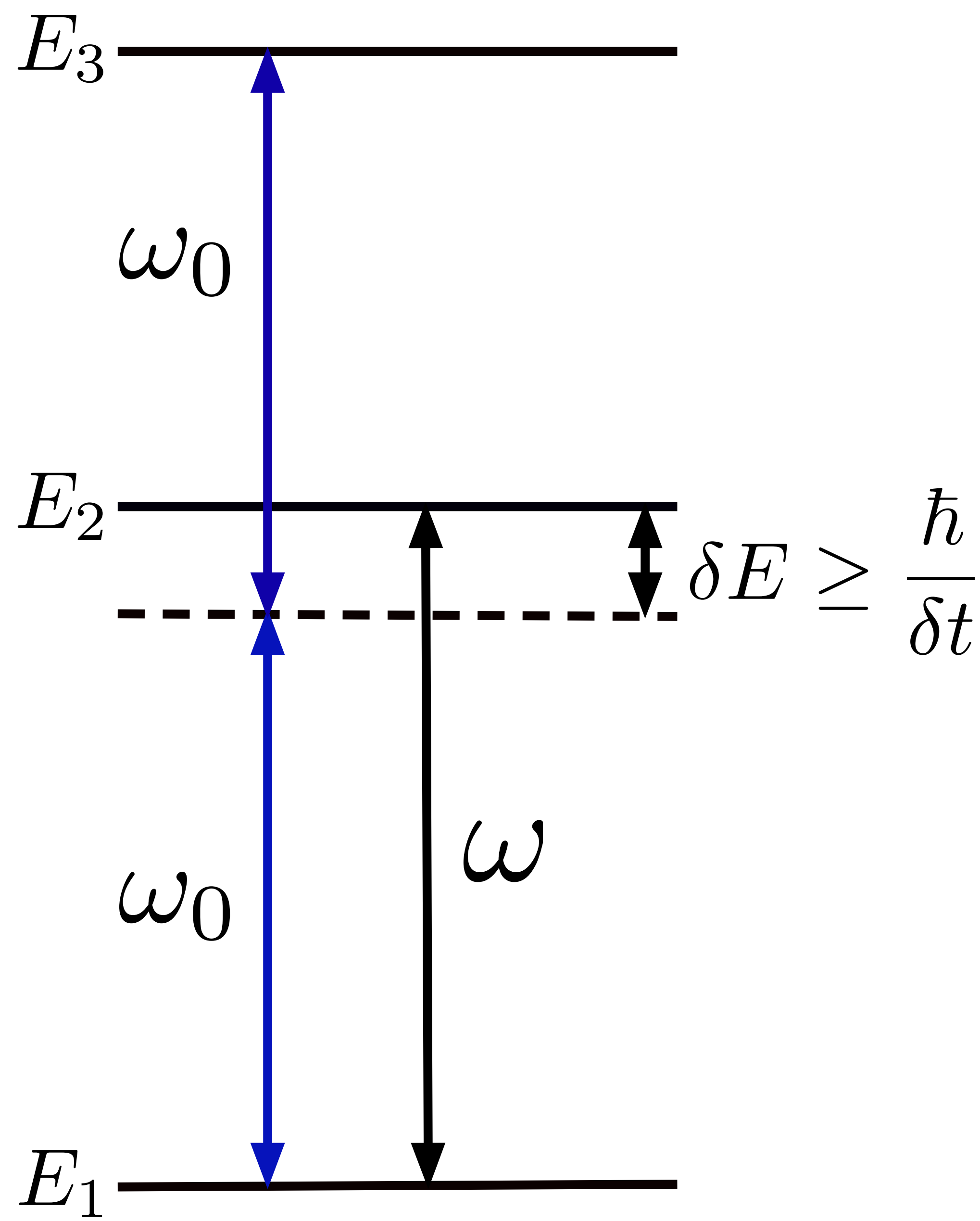
Quick Intro to 2-photon Transitions

Benefits:

- Stringent condition on required frequency means narrow resonances
- Prone to less systematic effects than Raman spectroscopy
- Potentially only need 1 laser, not 2+

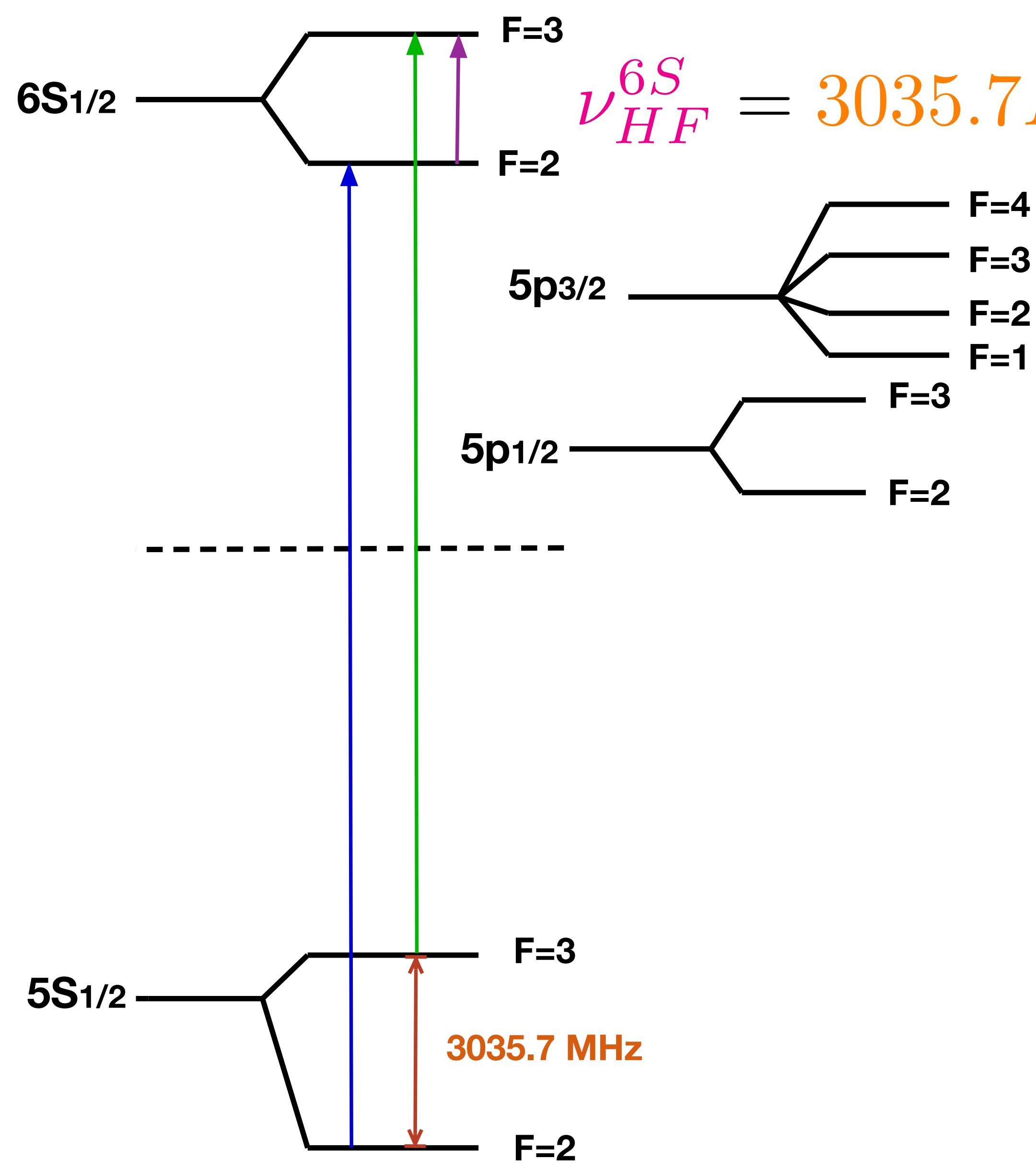


Measurement Plan

- Measure HF splitting of 6s levels in Rb85 and Rb87
- Measure their Isotope Shift (IS)
- All done with 2-photon spectroscopy

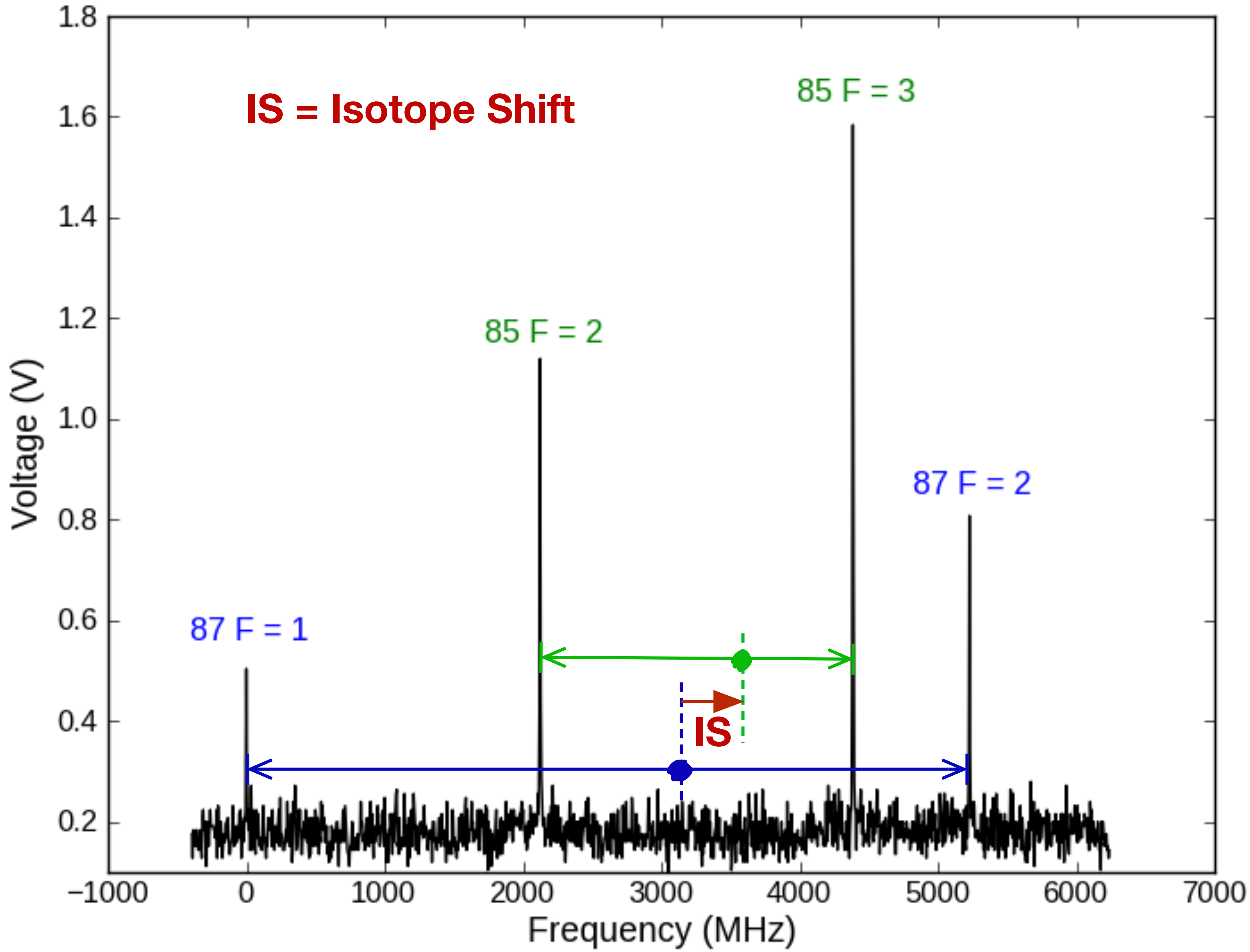
^{85}Rb

$I = \frac{5}{2}$

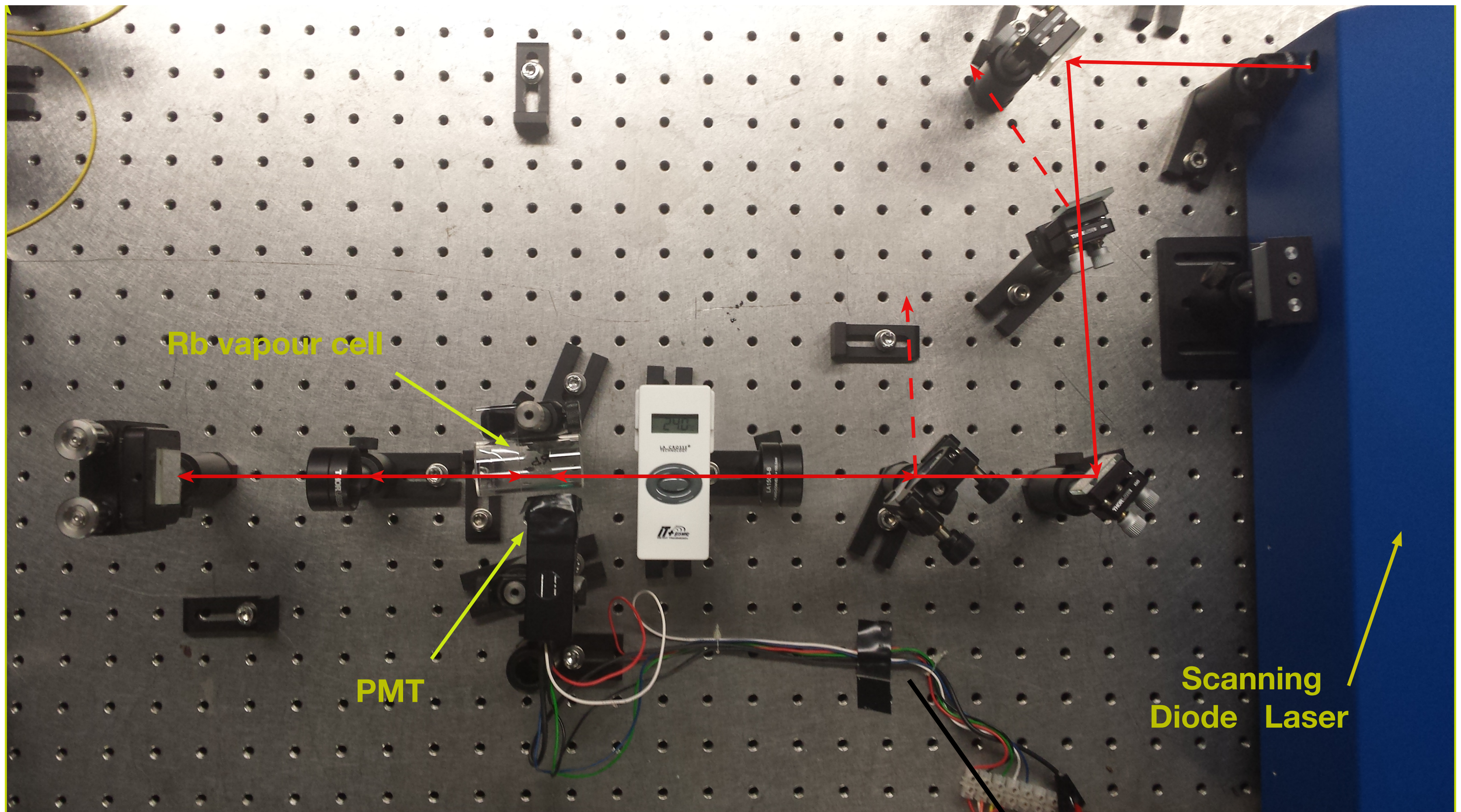


$$\nu_{HF}^{6S} = 3035.7MHz - (\nu_{3\to3} - \nu_{2\to2})$$

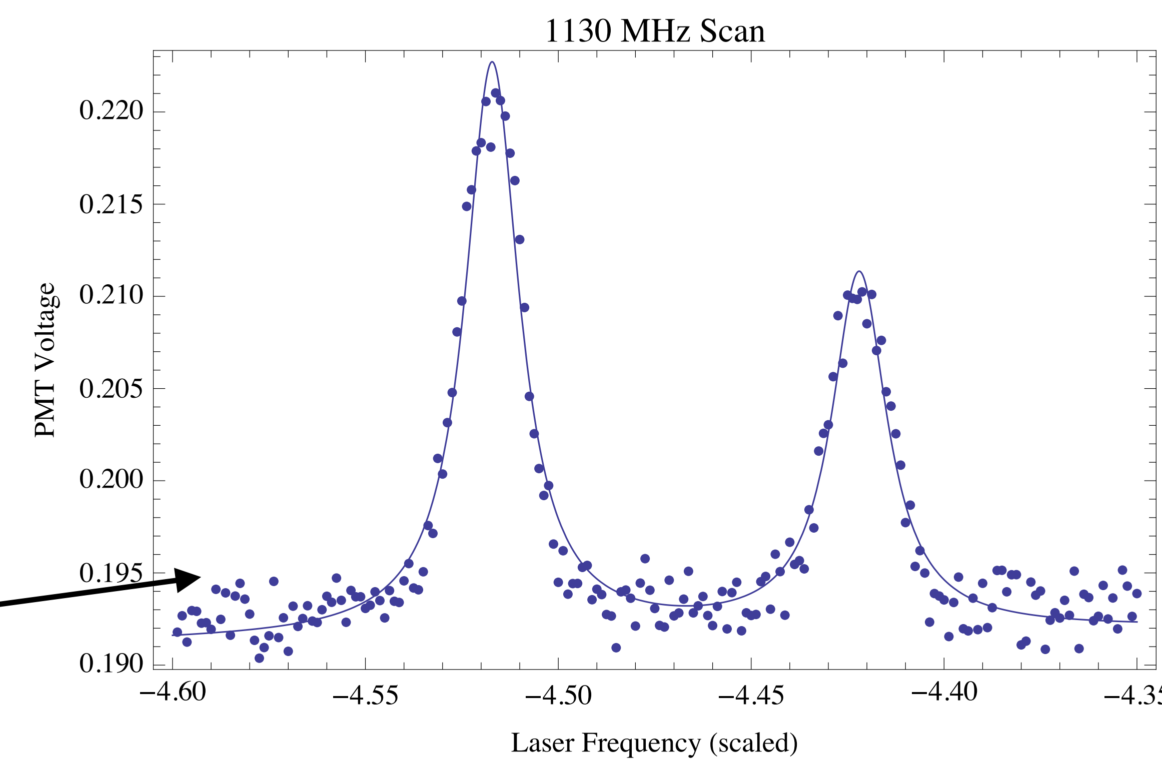
2-photon Transitions



Experimental Set-up



PMT signal

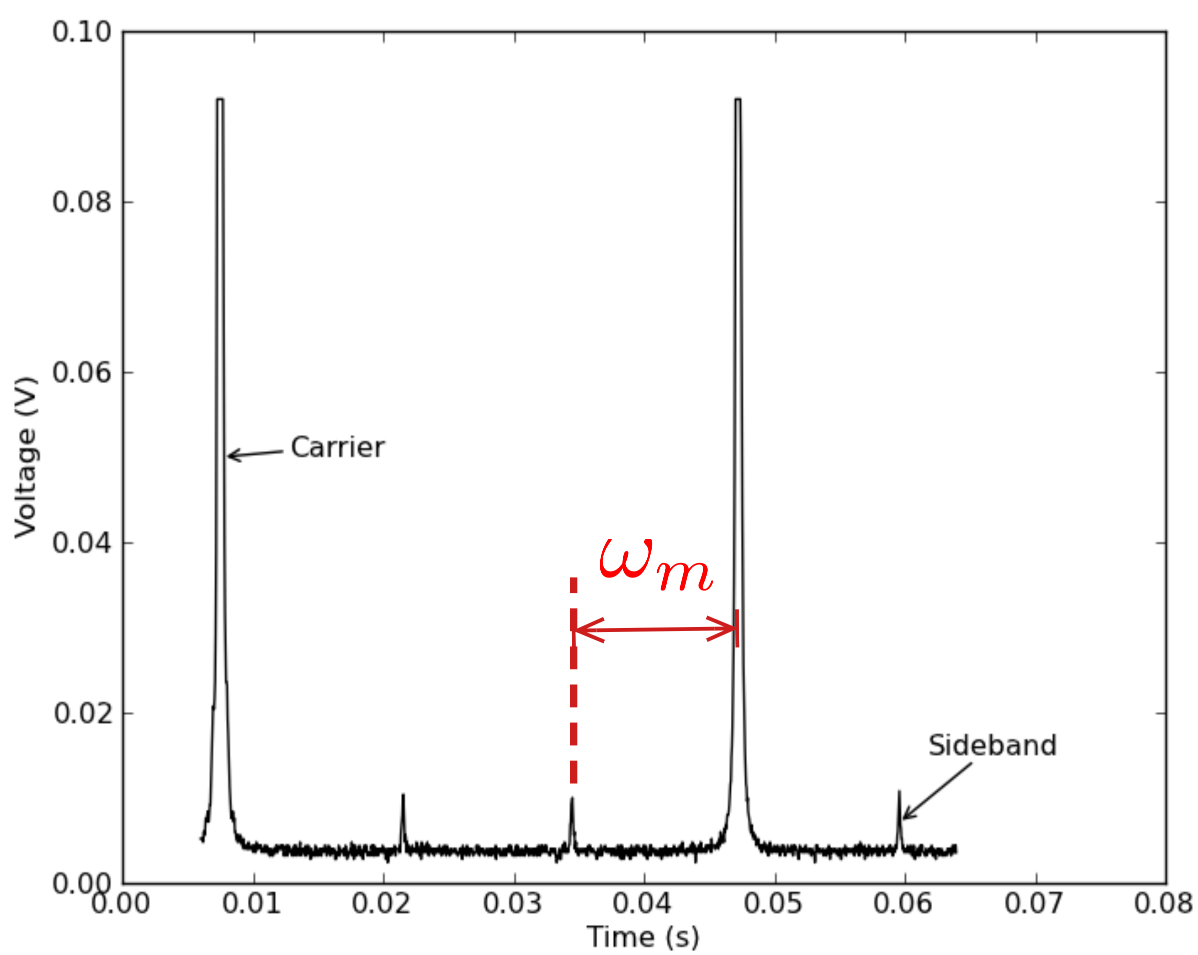


Lorentzian fitted Peaks
to find peak centres

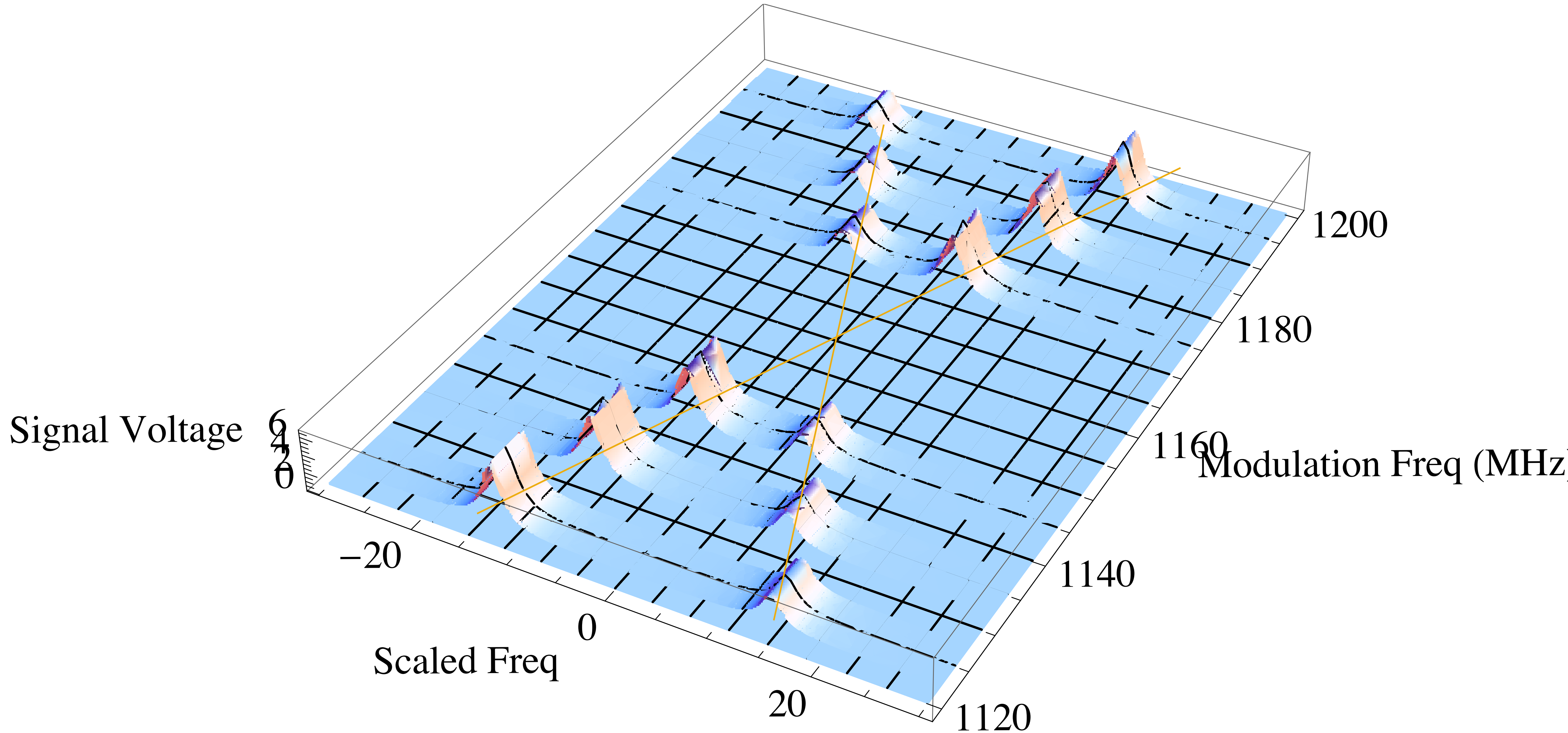
Experimental Technique

- Sideband Modulation Technique using a RF generator interfaced on lab computer
- Sideband frequencies known to the nearest kHz

$$E(t) = E_0 \left\{ \frac{M}{2} \exp[i(\omega_c - \omega_m)t] + \exp(i\omega_c t) + \frac{M}{2} \exp[i(\omega_c + \omega_m)t] \right\}$$



- Scanned sidebands 1000-3000 times and averaged them
- Quick 50 ms per scan to eliminate effects of laser drifts
- 200 data points per scan



Idea:

- **Scan sidebands at frequencies around the cross-over value**
- **Interpolate the frequency associated with the cross-over**

Systematic Effects

AC Stark Shifts:

- Energy levels in the atom shift under E1 transitions due to the LASER
- Effect is linearly proportional to laser intensity
- Absolute 5s and 6s AC shifts in Rb 2-photon transitions ~90kHz
- Differential AC stark shift on 6s HF splitting ~45kHz

$$\Delta E_n^{ac} = \frac{E_0^2}{4} \sum_j \frac{|\langle n|d_z|j\rangle|^2}{\Delta_j}$$

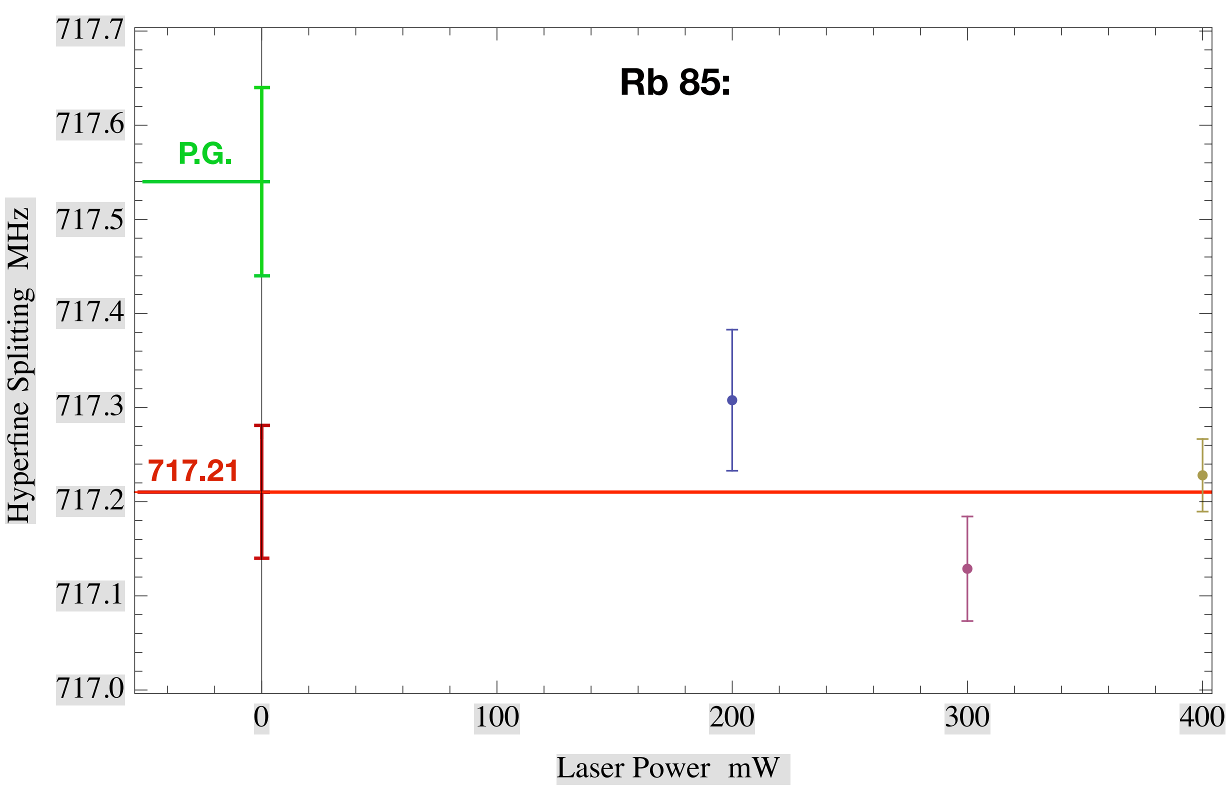
Zeeman Effect

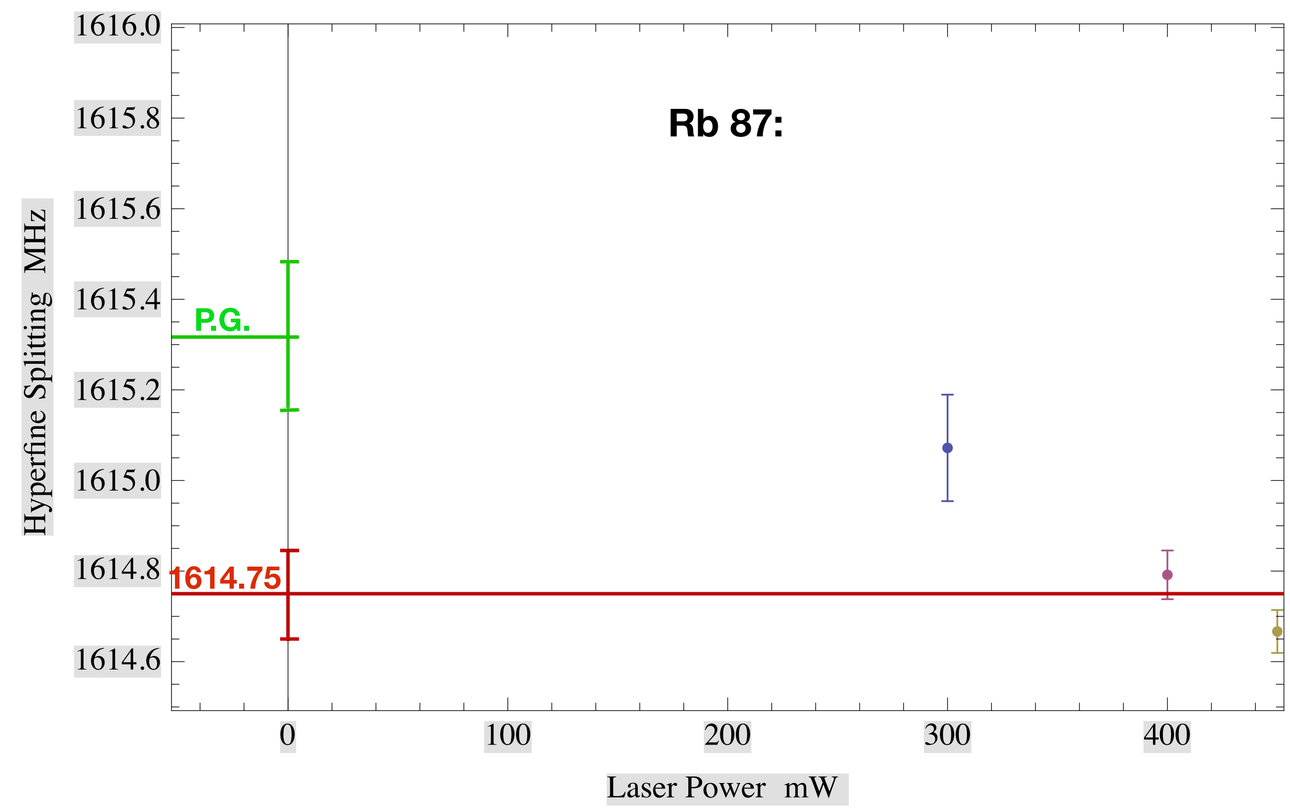
- With linearly polarized light Zeeman Shifts are zero to 1st order in 2-photon transitions where:

$$\Delta F = 0, \Delta m_F = 0$$

Results: HF Splittings

ISOTOPE	OUR 6S HF SPLITTING (2014)	P. GALVAN 6S HF SPLITTING (2008)
• Rb85	717.21(07) MHz	717.54(10) MHz
• Rb87	1614.75(08) MHz	1615.32(16) MHz

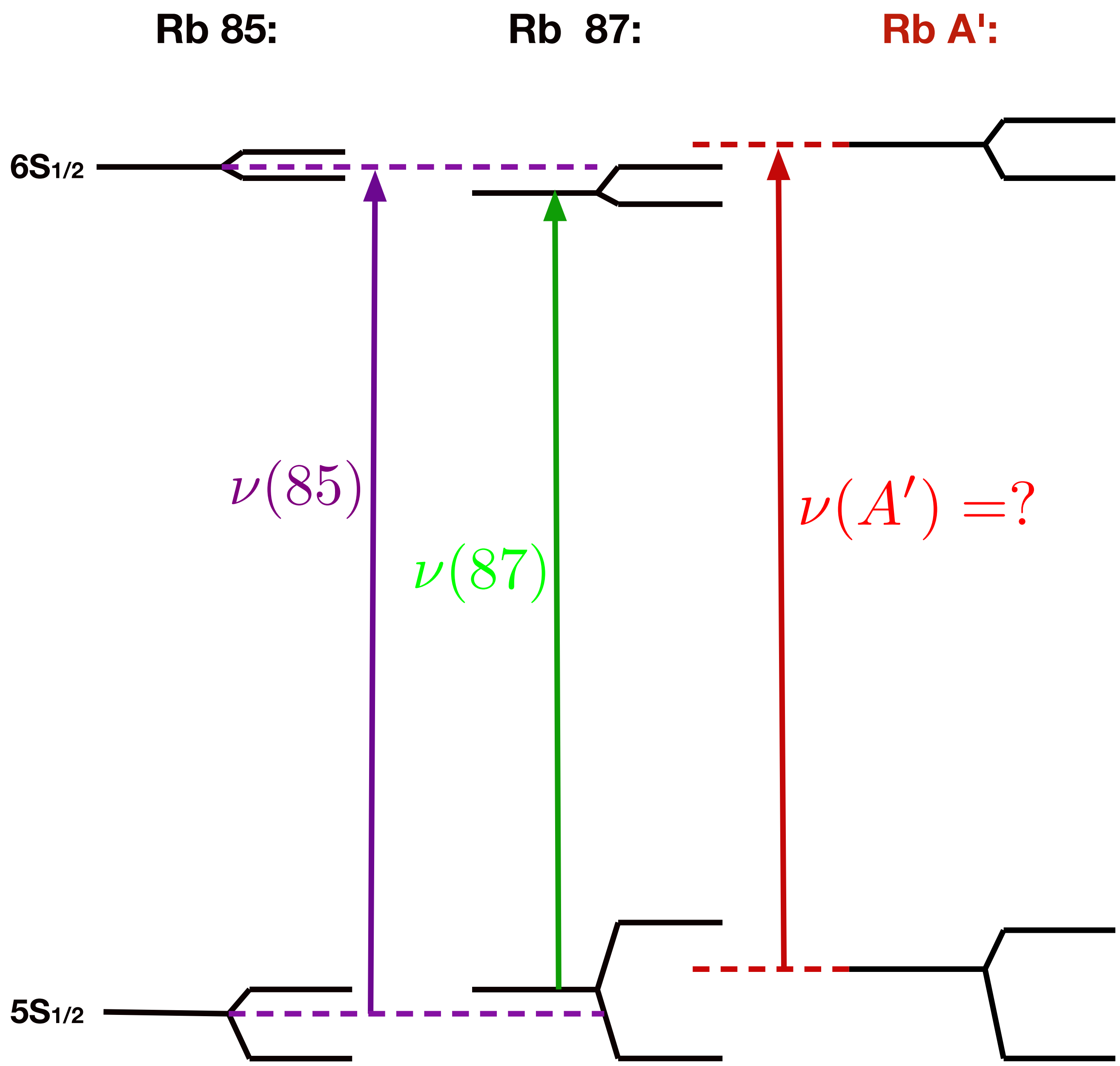




Results for the Isotope Shift

IS	99.17(09) MHz

$= \nu(85) - \nu(87)$

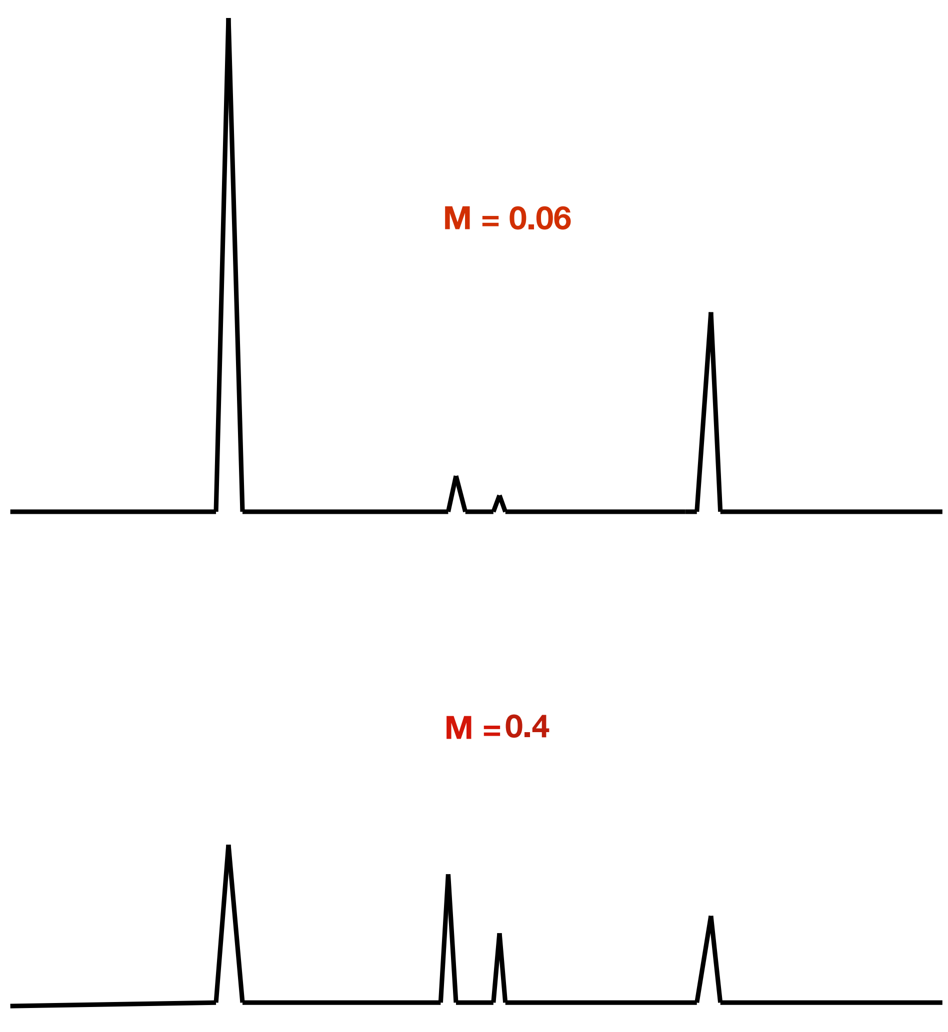


$$IS^{AA'} \sim \nu(A') \frac{M_A - M_{A'}}{M_A M_{A'}} + \delta \langle r^2 \rangle^{AA'}$$

- Isotope shifts must be measured with respect to a *reference isotope*
- All other isotopes of Rb are unstable/short-lived

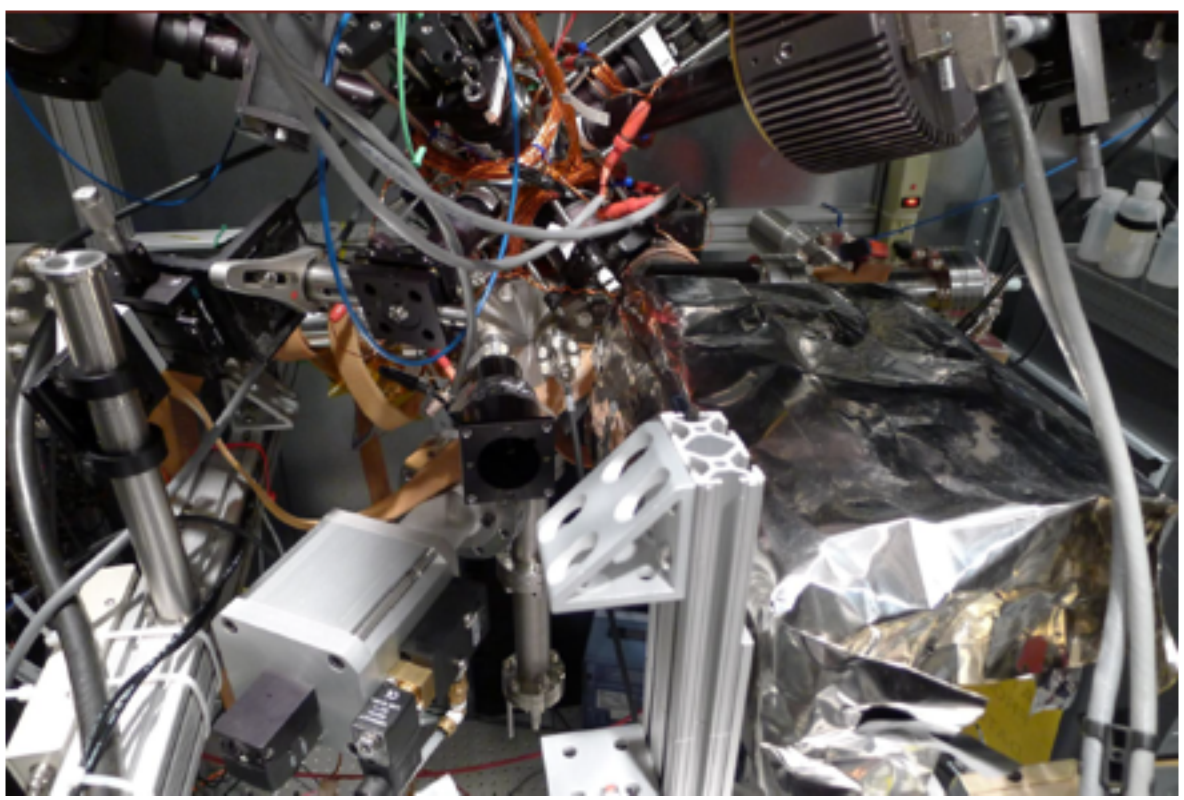
Improvements

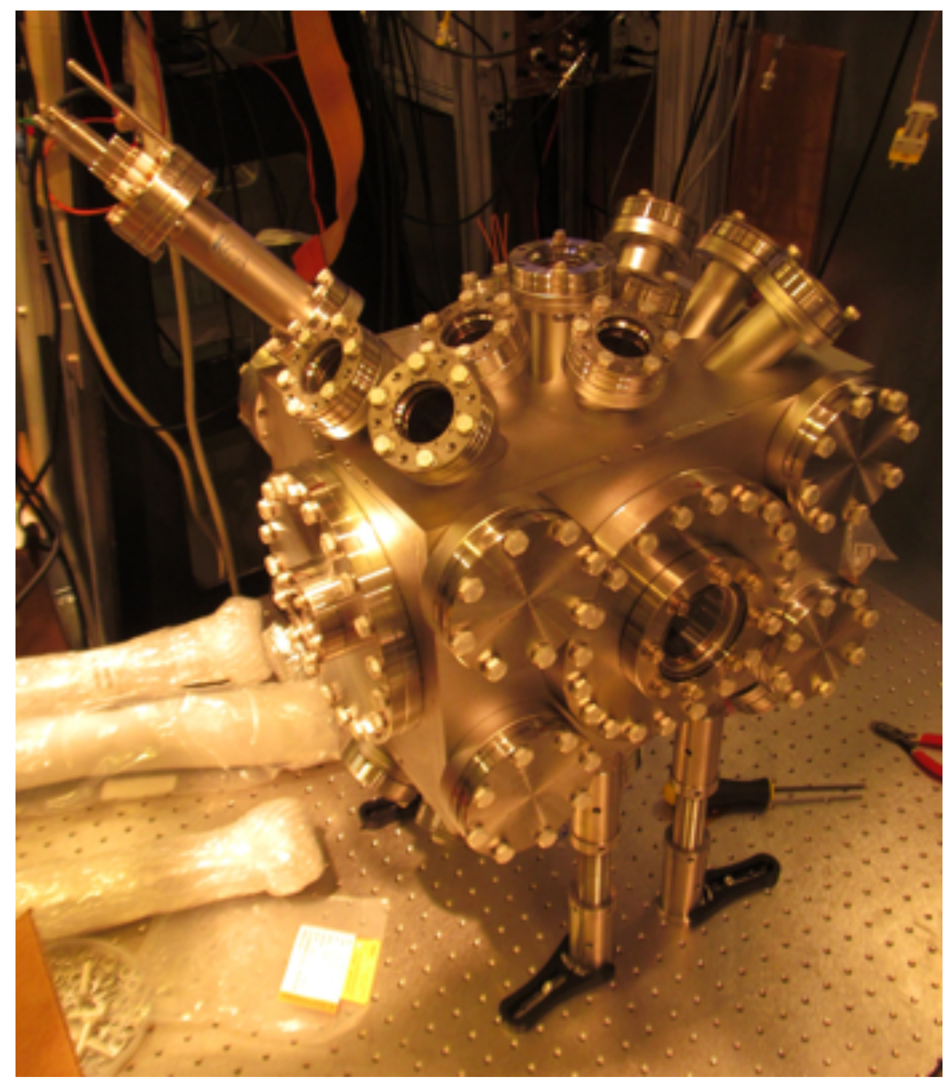
- Take measurements at a broader range of laser powers (100-600mW)
- Use a RF generator which can operate in a wider range of modulation frequencies and capable of **HIGHER POWER COUPLING TO SIDEBANDS**



Future Experiments

- 1-photon Stark-induced spectroscopy in Rb in a MOT
- Potentially get other isotopes of Rb at TRIUMF for other IS measurements
- Use same facility for APNC experiments of Fr at TRIUMF using a MOT and Ti-Sapph laser





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References

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