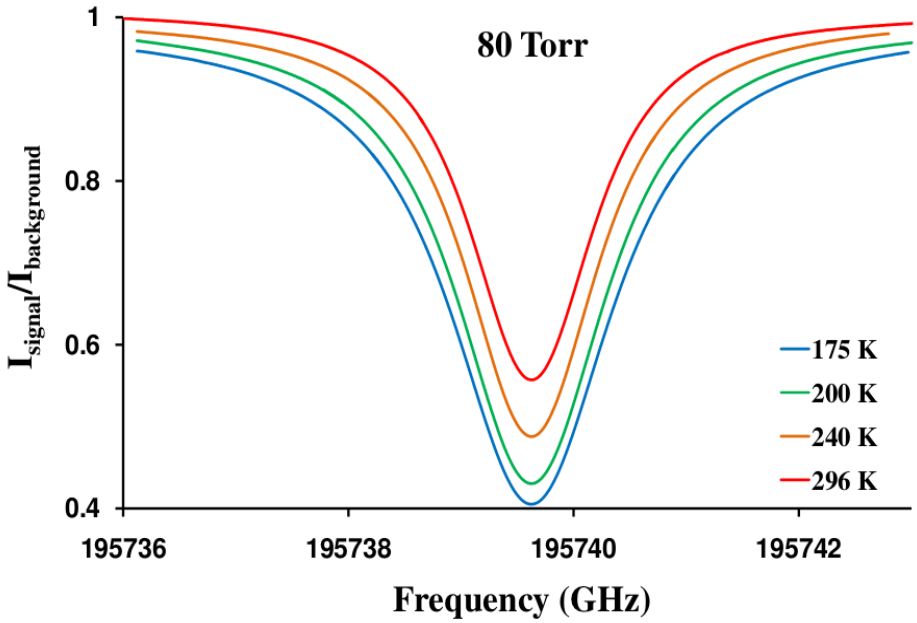
Frequency Comb-referenced Spectra in the $\nu_1+\nu_3$ Band of Acetylene

Matthew Cich, Damien Forthomme, Greg Hall, Chris McRaven, Trevor Sears, Sylvestre Twagirayezu



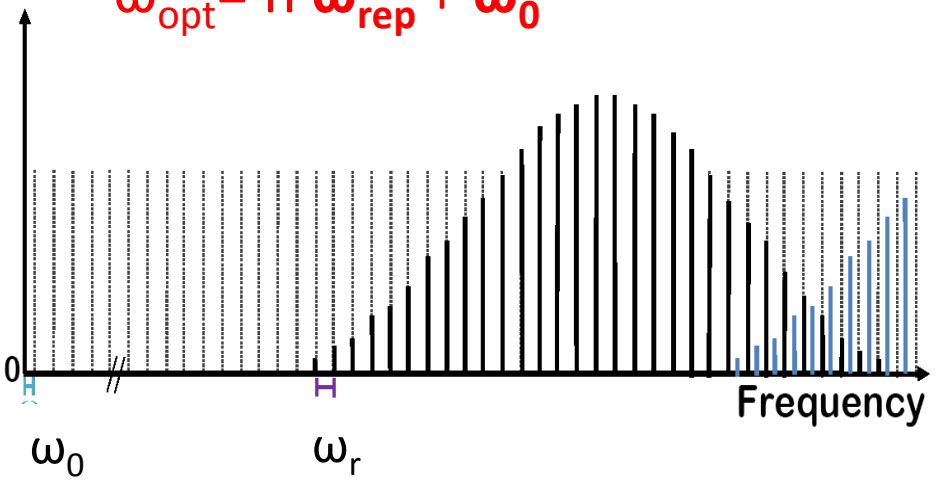
Frequency comb-referenced measurements

ω_{rep} and ω_o are fixed to the GPS atomic clock standard. Optical frequencies good to better than10^{-12}.

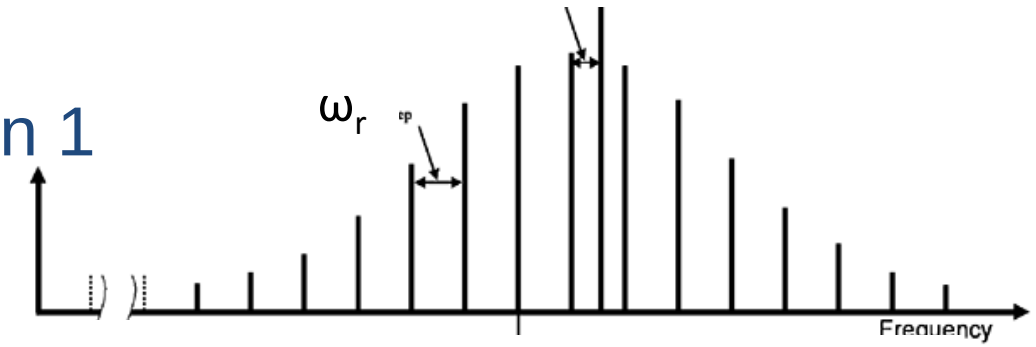
Use the comb as a frequency ruler by phase locking a spectroscopic laser to a single comb line.

We are currently limited to optical wavelengths between 1 and 2 microns.

$\omega_{opt} = n\,\omega_{rep} + \omega_0$



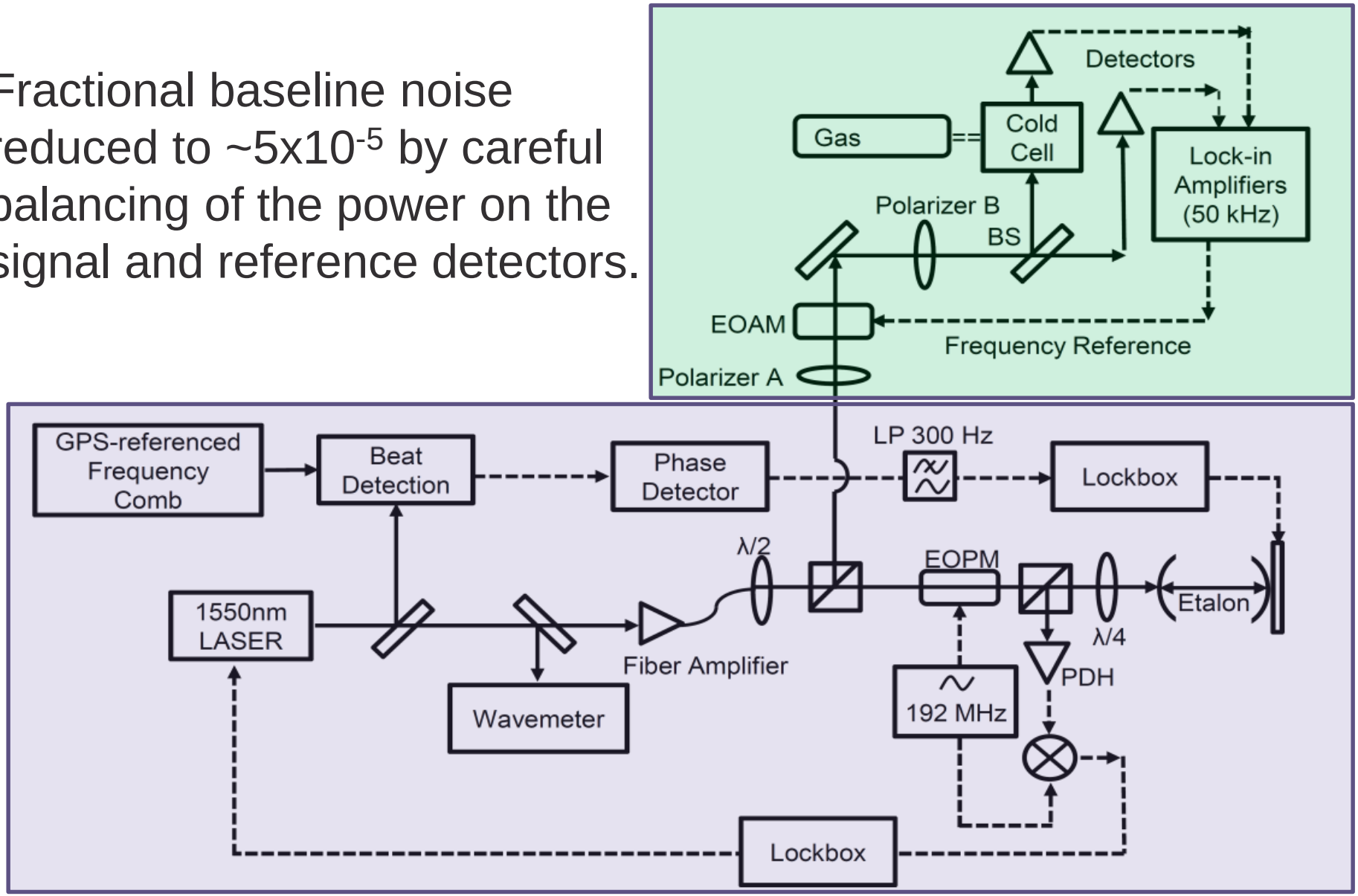
Lock external laser frequency to comb component



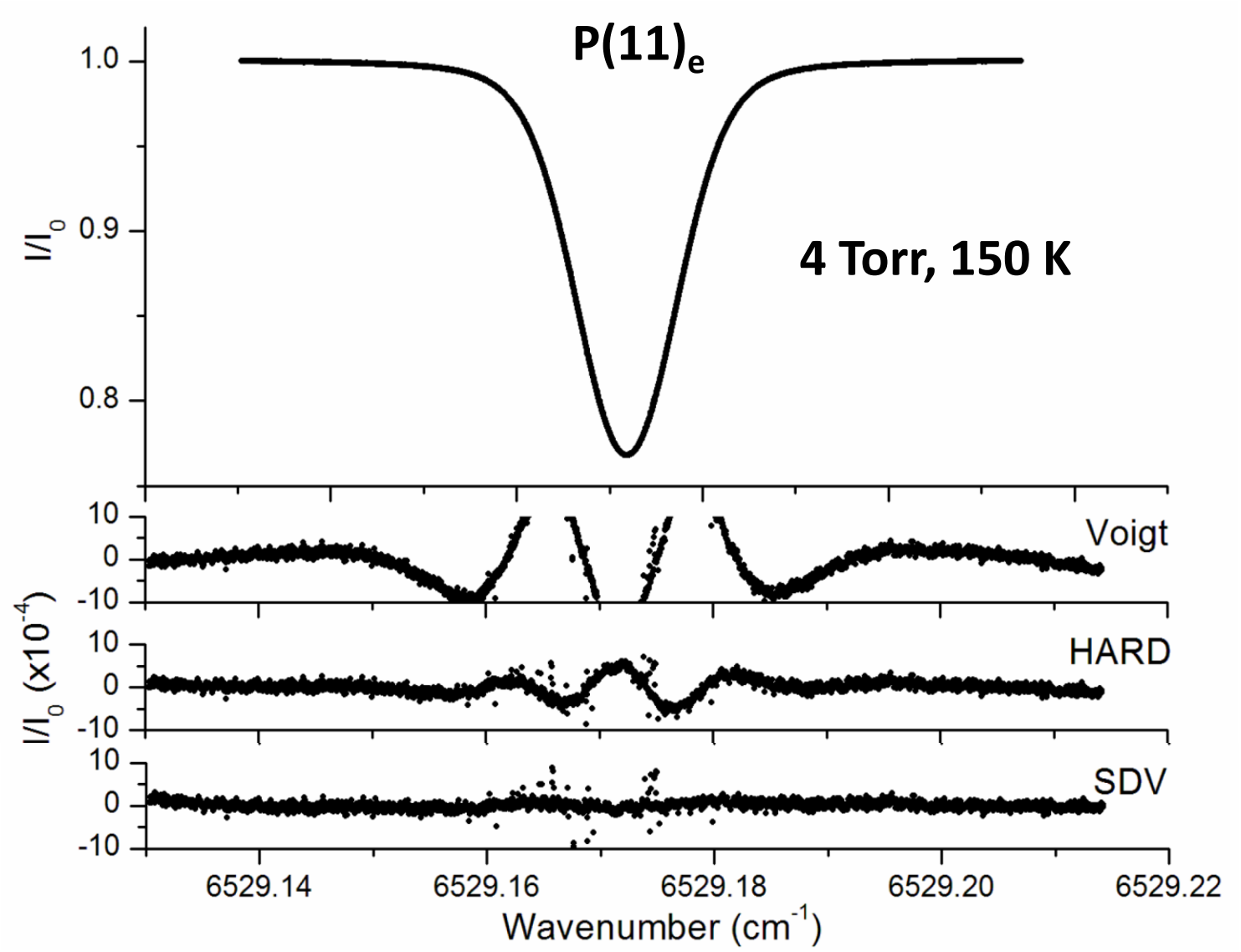
$\omega_{laser} = n\,\omega_{rep} + \omega_0 + \omega_{laser\text{-}off}$

Dual Beam Spectrometer

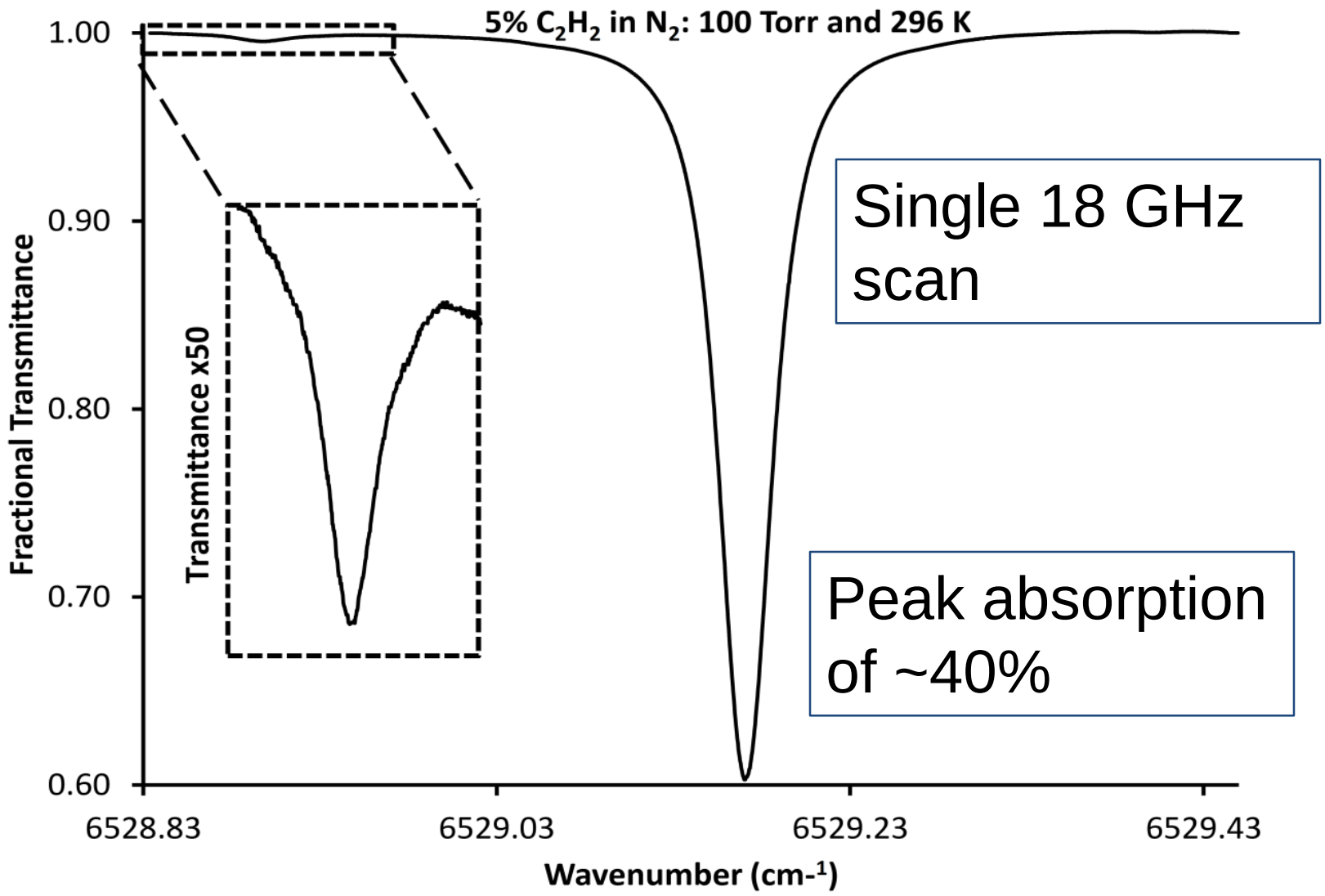
Fractional baseline noise reduced to ~5×10^{-5} by careful balancing of the power on the signal and reference detectors.



Line shape measurements



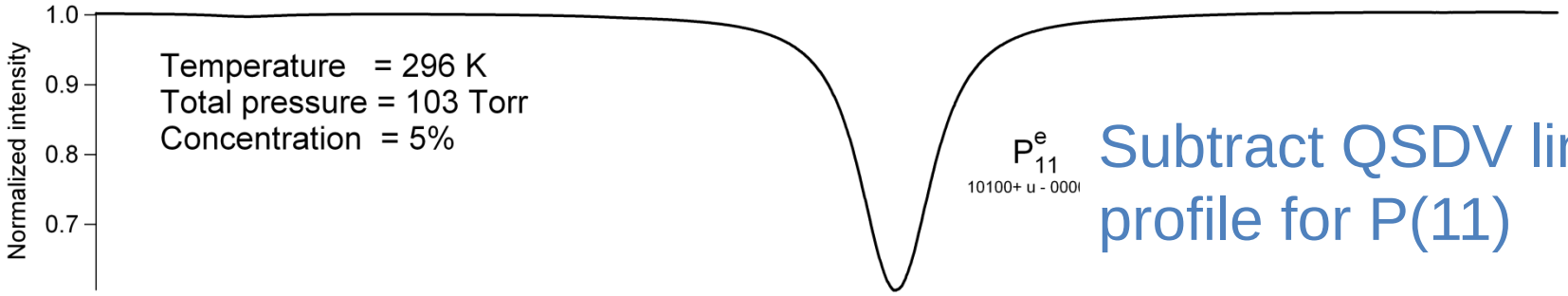
Single Line ($P(11)_e$)



Single 18 GHz scan

Peak absorption of ~40%

Isolated Lines?



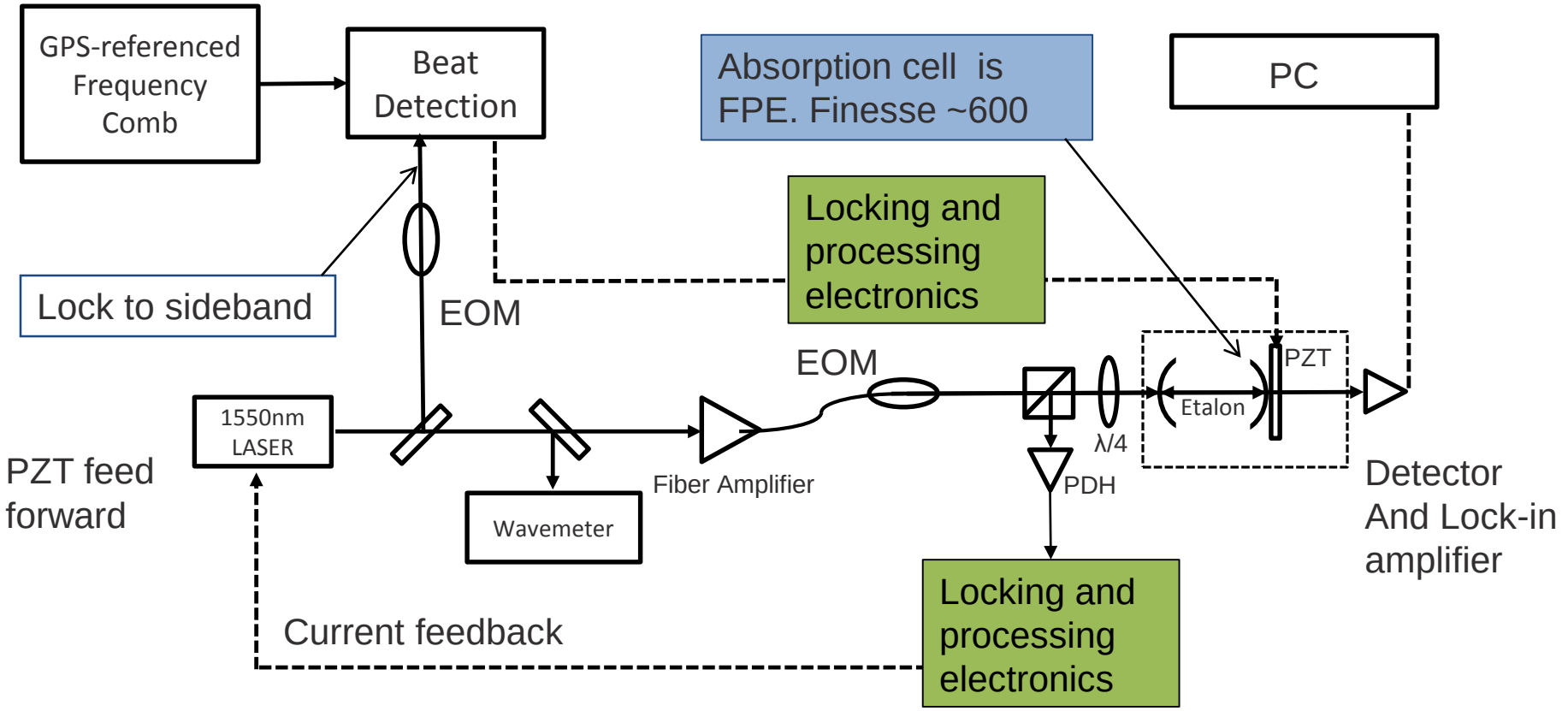
Subtract QSDV line profile for P(11)

Schematic background spectrum

Measure the line shape as a function of pressure and temperature. But weak underlying (hot band) lines blend with the main line in ways that are difficult to quantify-particularly if their positions are not well known. Need accurate rest frequencies…

Cavity-enhanced absorption

Sub-Doppler measurements in a cavity.
Laser locked to cavity; cavity referenced to comb; wavelength modulation detection.

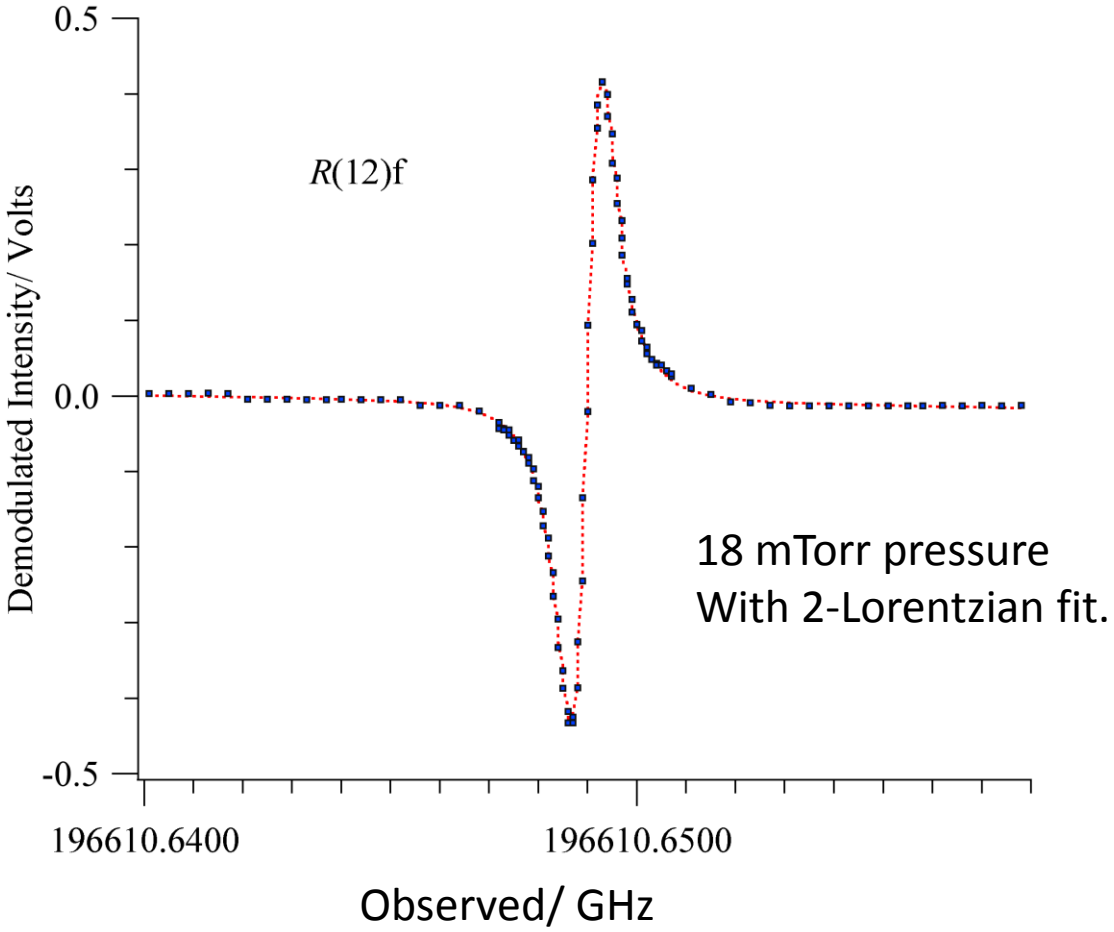


C_2H_2 sub-Doppler measurements

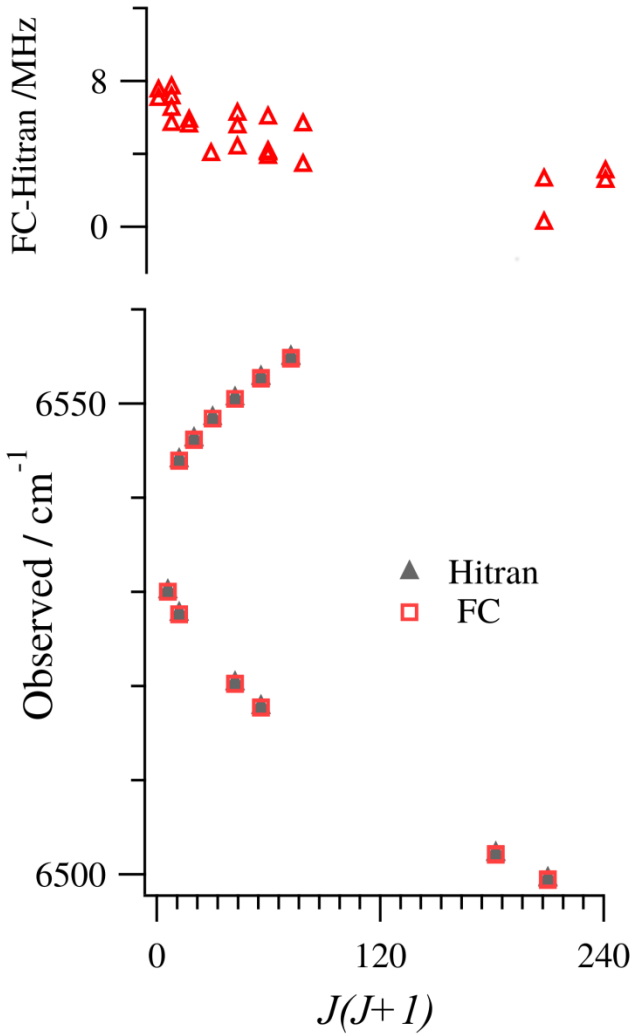
Most important are the v_4 and v_5 hot bands.

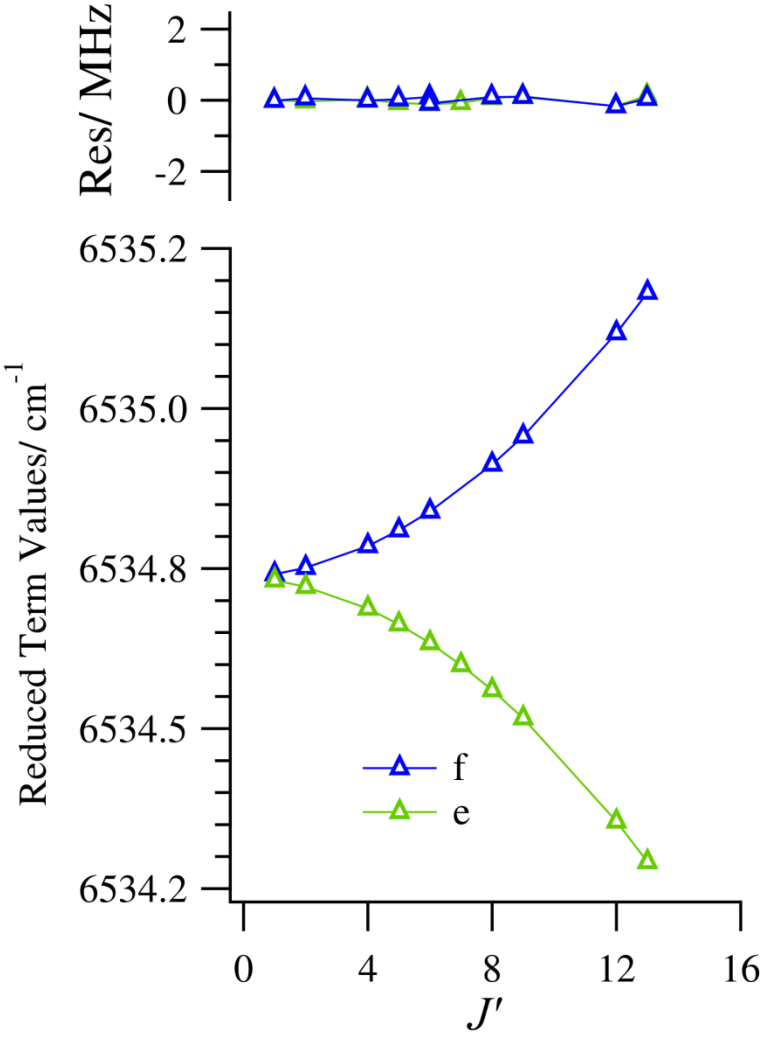
Example of 10110-00010 $R(12)_f$ hot band line:

196 610.648 976 5(17) GHz. Fractional uncertainty 8×10^{-12}.



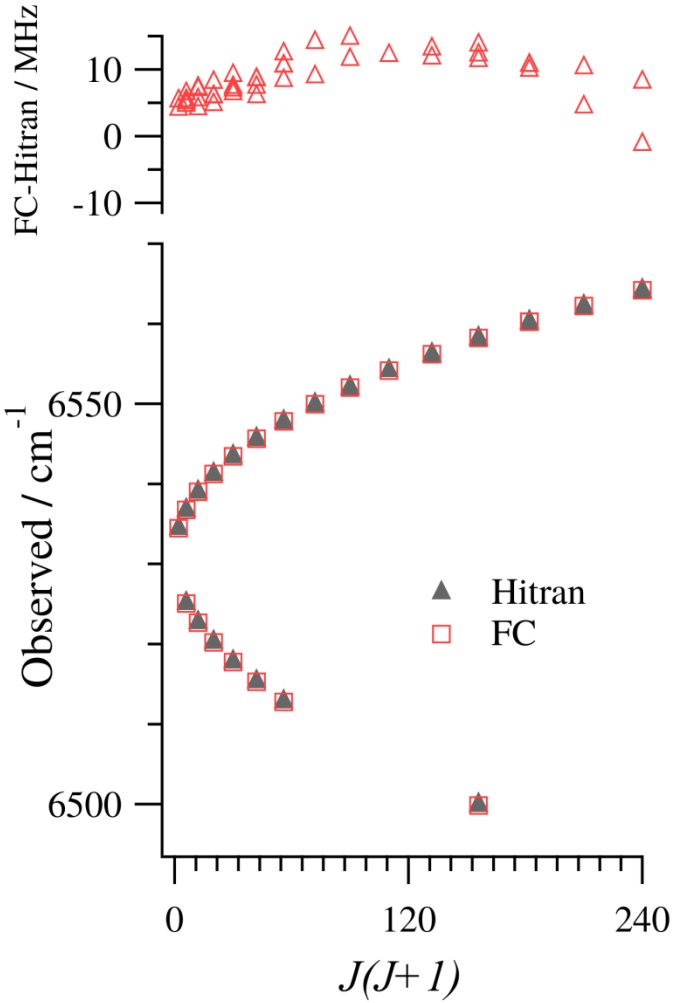
C_2H_2 ν_5 hot bands

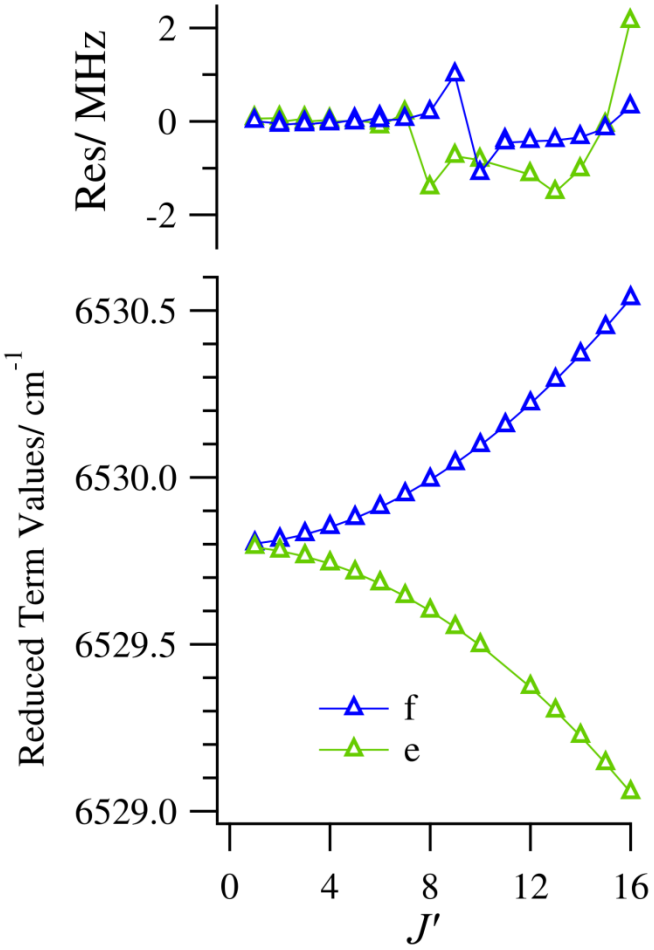




HITRAN has regular J-dependent errors. Upper level is regular.

C_2H_2 ν_4 hot bands

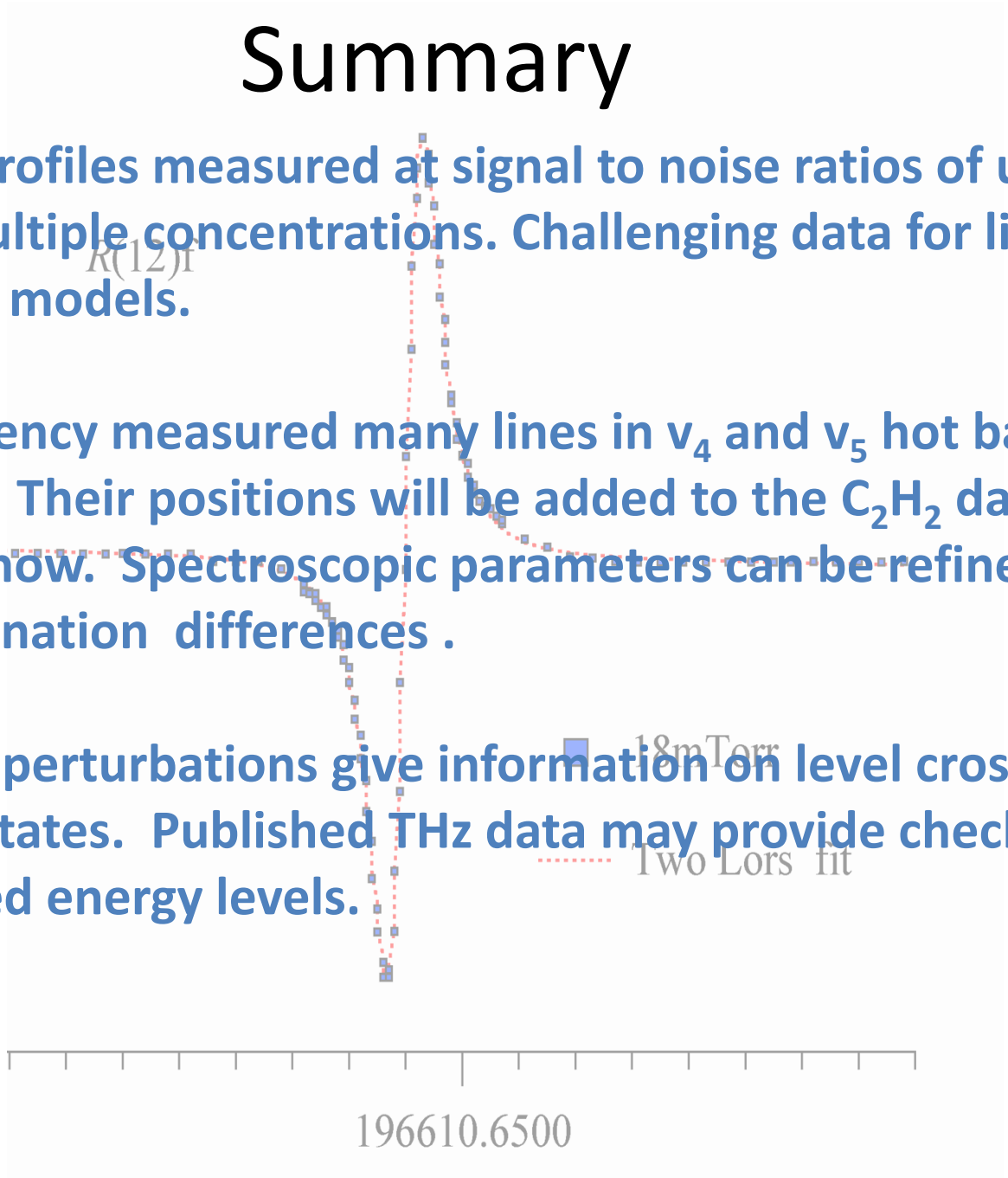




HITRAN has J-dependent errors. We measure some small perturbations that reflect level crossings of dark states

Summary

- Line profiles measured at signal to noise ratios of up to 10^5 for multiple concentrations. Challenging data for line shape models.
- Frequency measured many lines in v_4 and v_5 hot bands of v_1+v_3. Their positions will be added to the C_2H_2 data base somehow. Spectroscopic parameters can be refined from combination differences .
- Weak perturbations give information on level crossings of dark states. Published THz data may provide check on derived energy levels.



Acknowledgements

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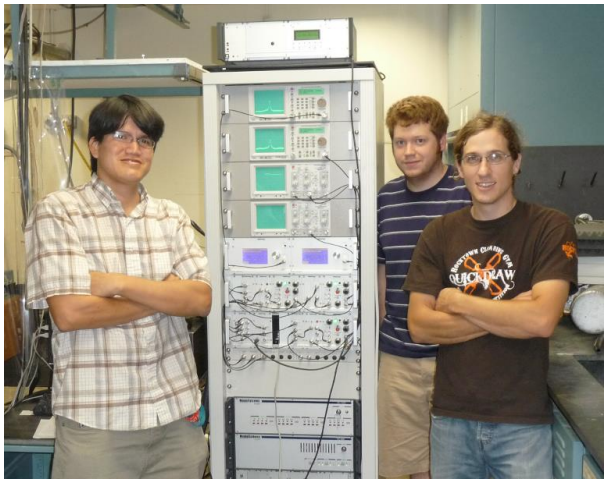

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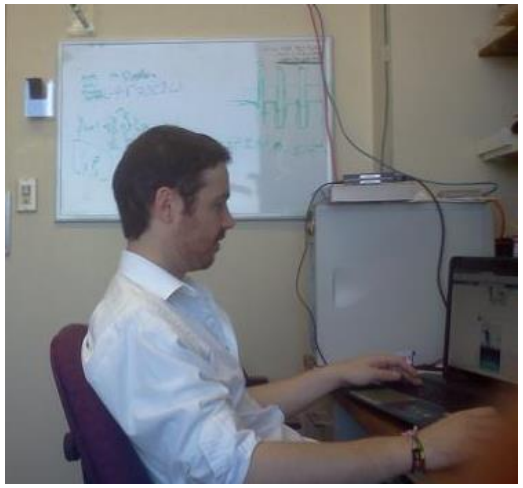
Gary Lopez



Damien Forthomme