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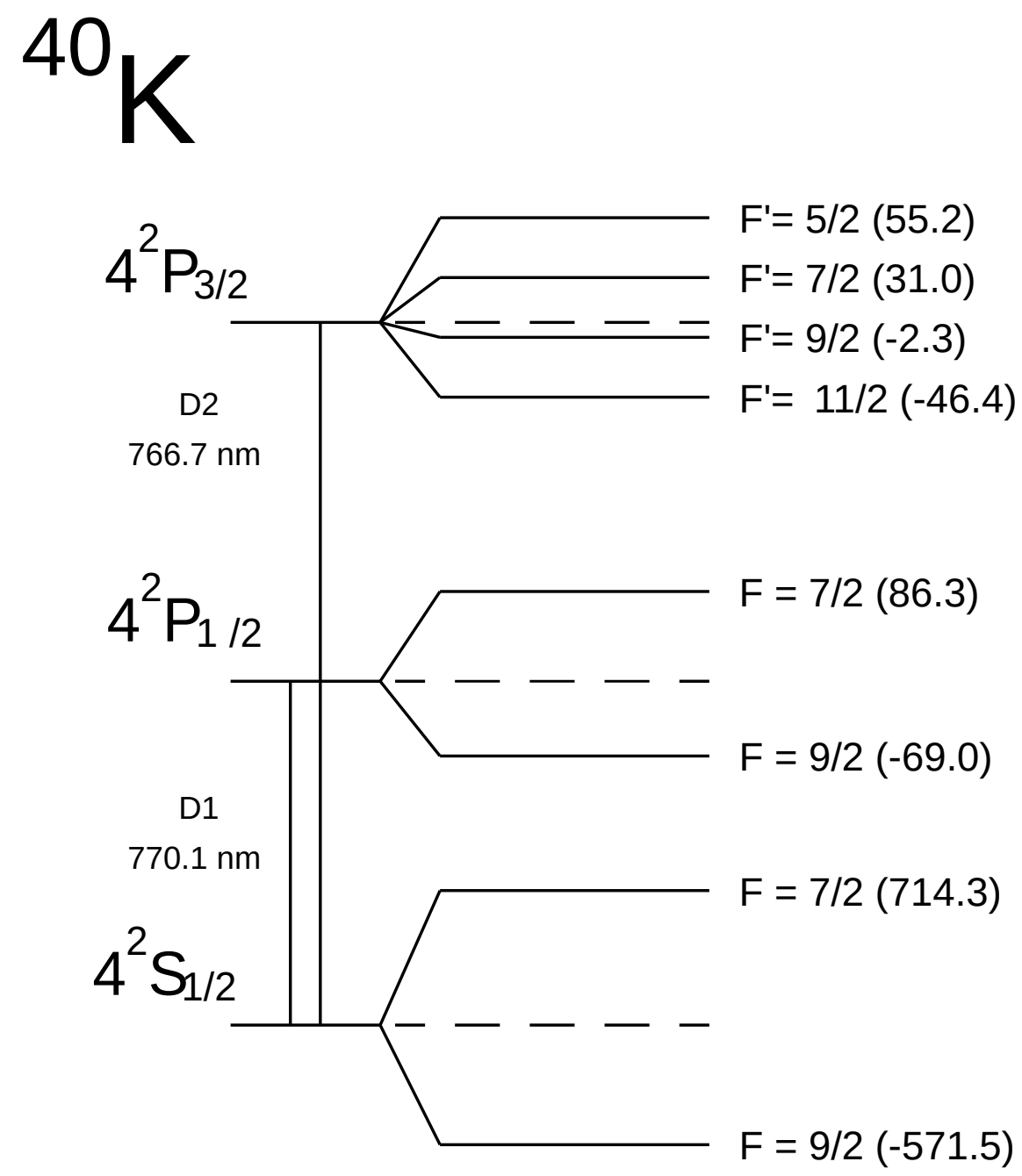
Towards laser locking in the telecom range by spectroscopy of molecular gases

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Motivation

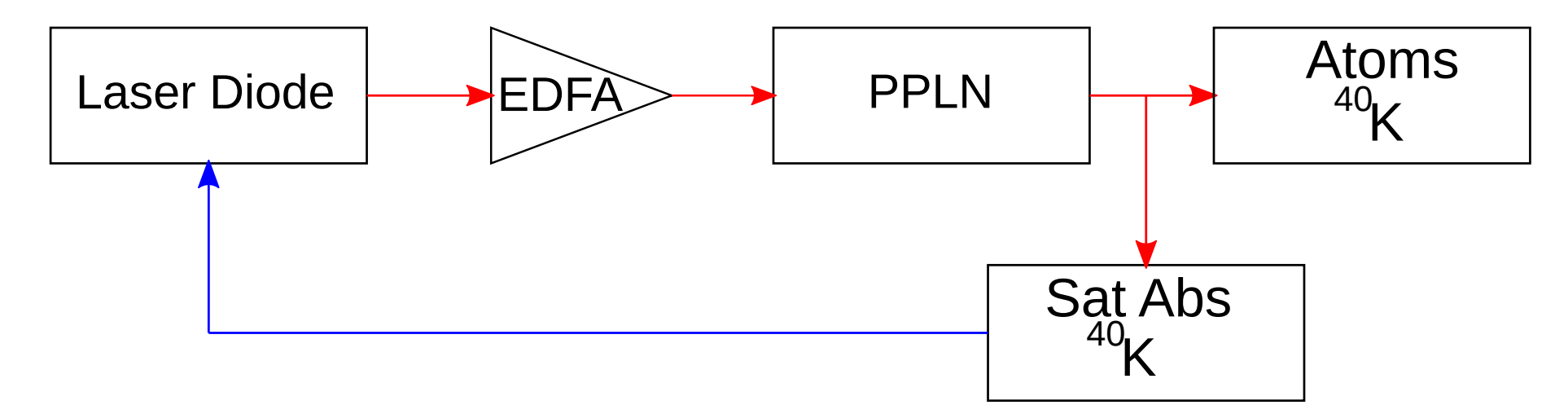
The AUFRONS (Ultra cold atoms in nanostructured optical potential) project aims at building near field optics / Ultra cold atoms hybrid systems to achieve stronger interaction between solid state and cold atoms physics. One of our goals is to manipulate cold fermionic species at the vicinity of a surface.



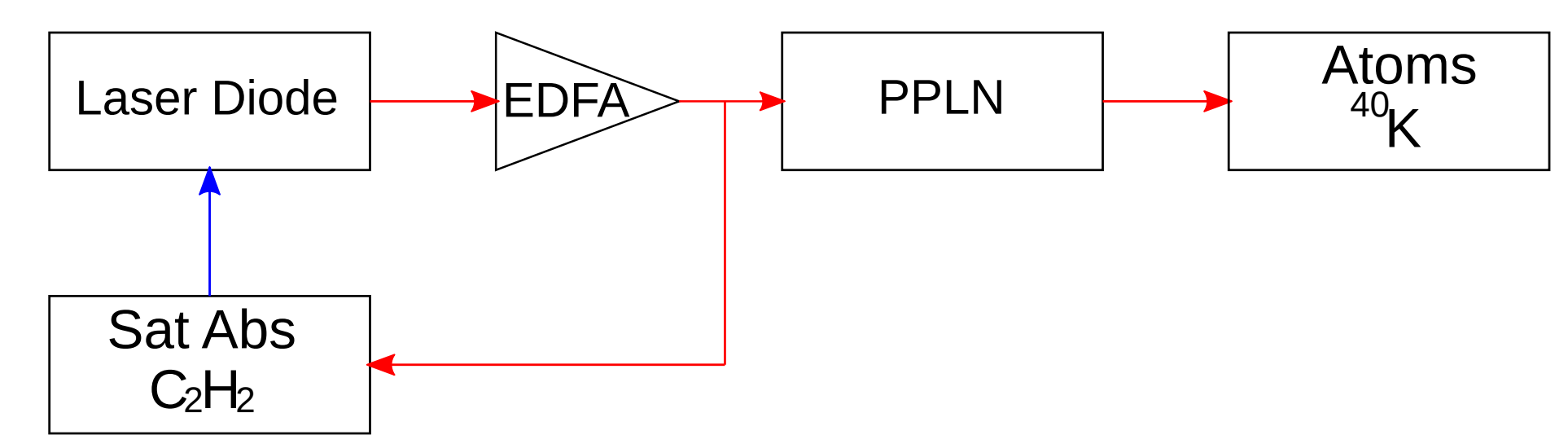
- ^{40}K : + transition frequency close to ^{87}Rb → doubled telecom laser diodes
 + sympathetic cooling with ^{87}Rb
 [1] + low field Feshbach resonances
 – isotopic ratio (0,012 %)
 – hyperfine lines are close, difficult to lock onto

- C_2H_2 as rovibrational lines close to half the ^{40}K transition frequency
 + metrological transitions
 [2] + narrow lines
 + can work at room temperature
 – low absorption

Potassium setup:

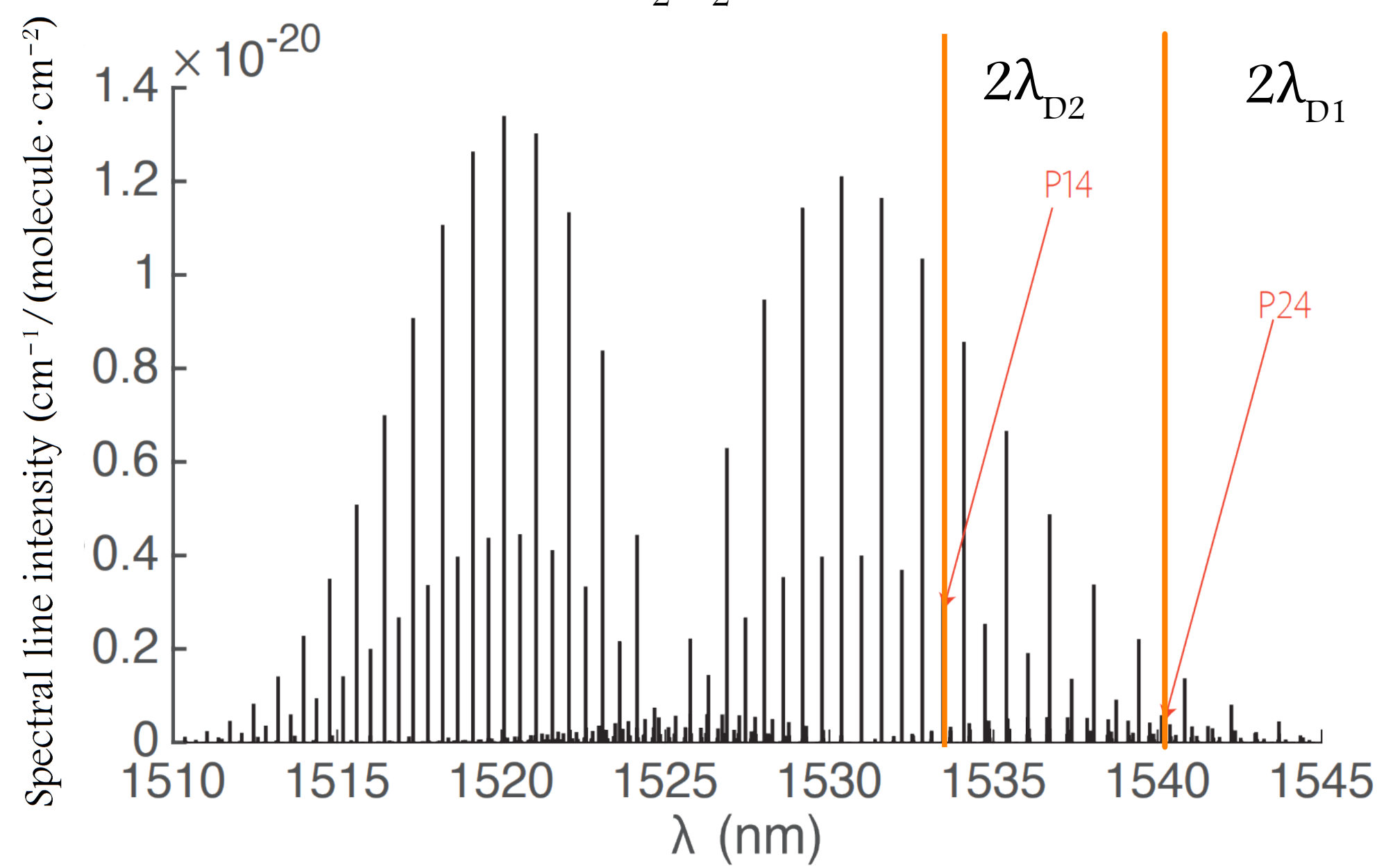


Acetylene setup:



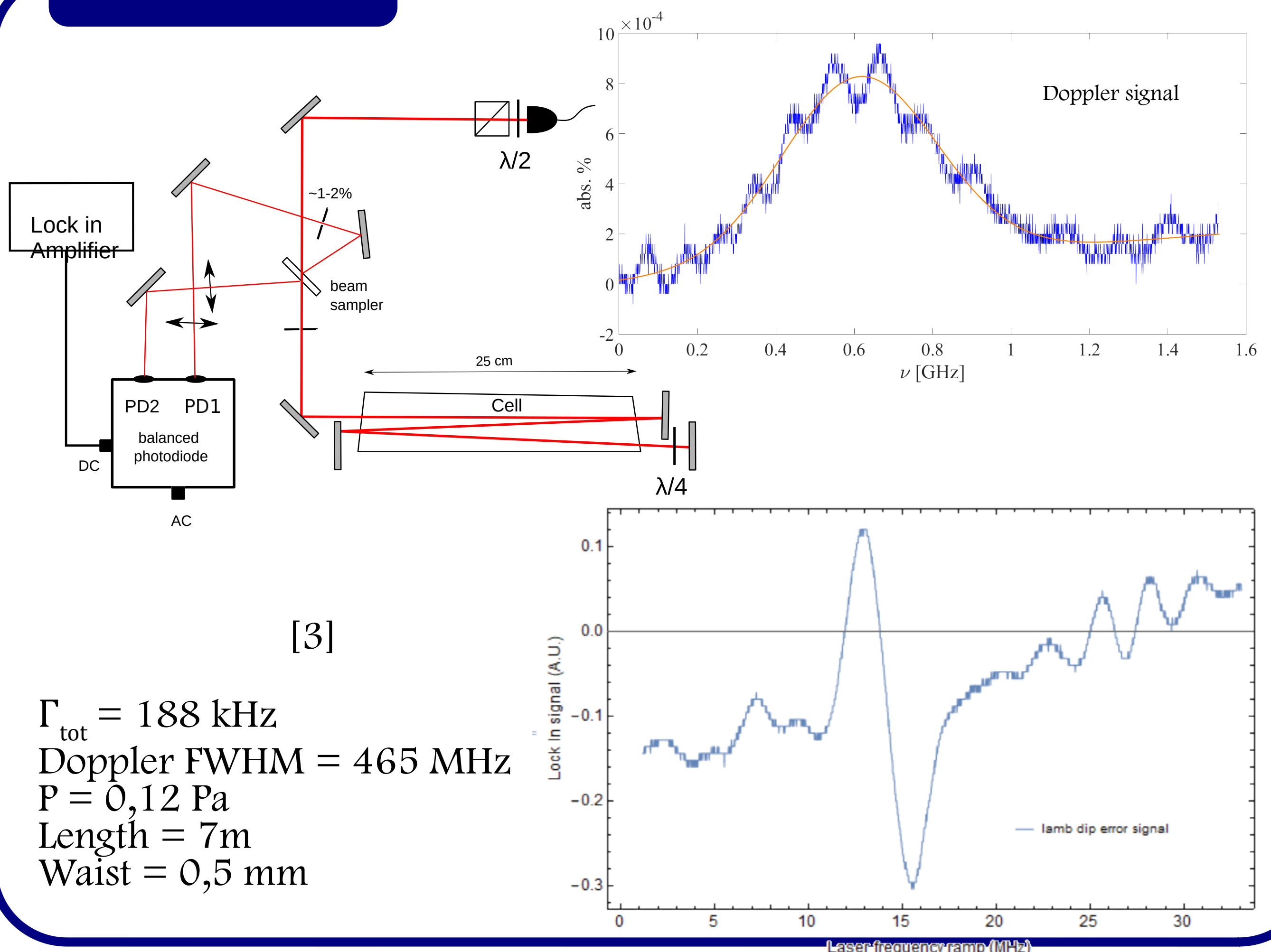
Molecular Gases: Acetylene

Lines of interest for Potassium cooling (D1 and D2) using acetylene (C_2H_2) [2]



	$2\lambda_{D1,D2}$ (nm)	$\lambda_{C2H2,P24/P14}$ (nm)	Frequency Gap (GHz)
D1/P24 Transition	1540.216	1540.125	11.456
D2/P14 Transition	1533.402	1533.461	7.522

Bulk Cell



Acetylene Spectroscopic Parameters

- S = Spectral line intensity ($\text{cm}^{-1}/(\text{molecules} \cdot \text{cm}^{-2})$) [2]
 wavenumber Column density

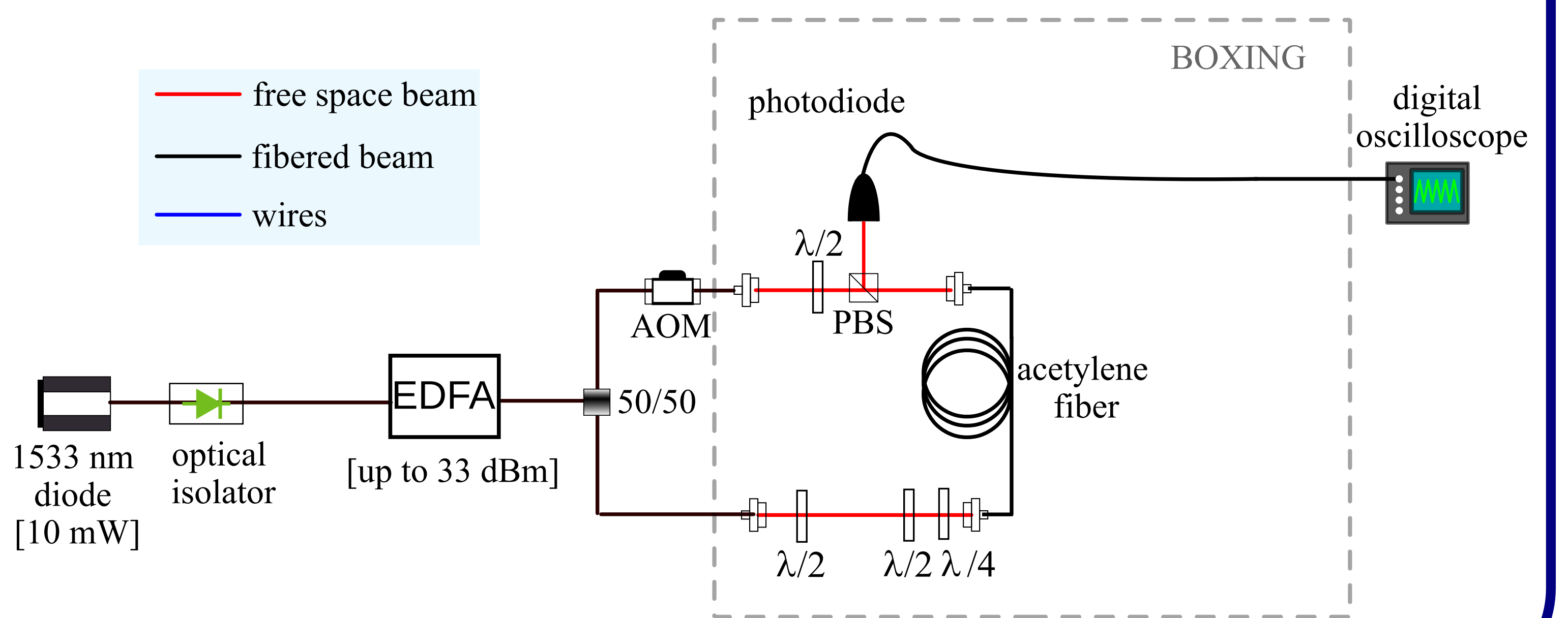
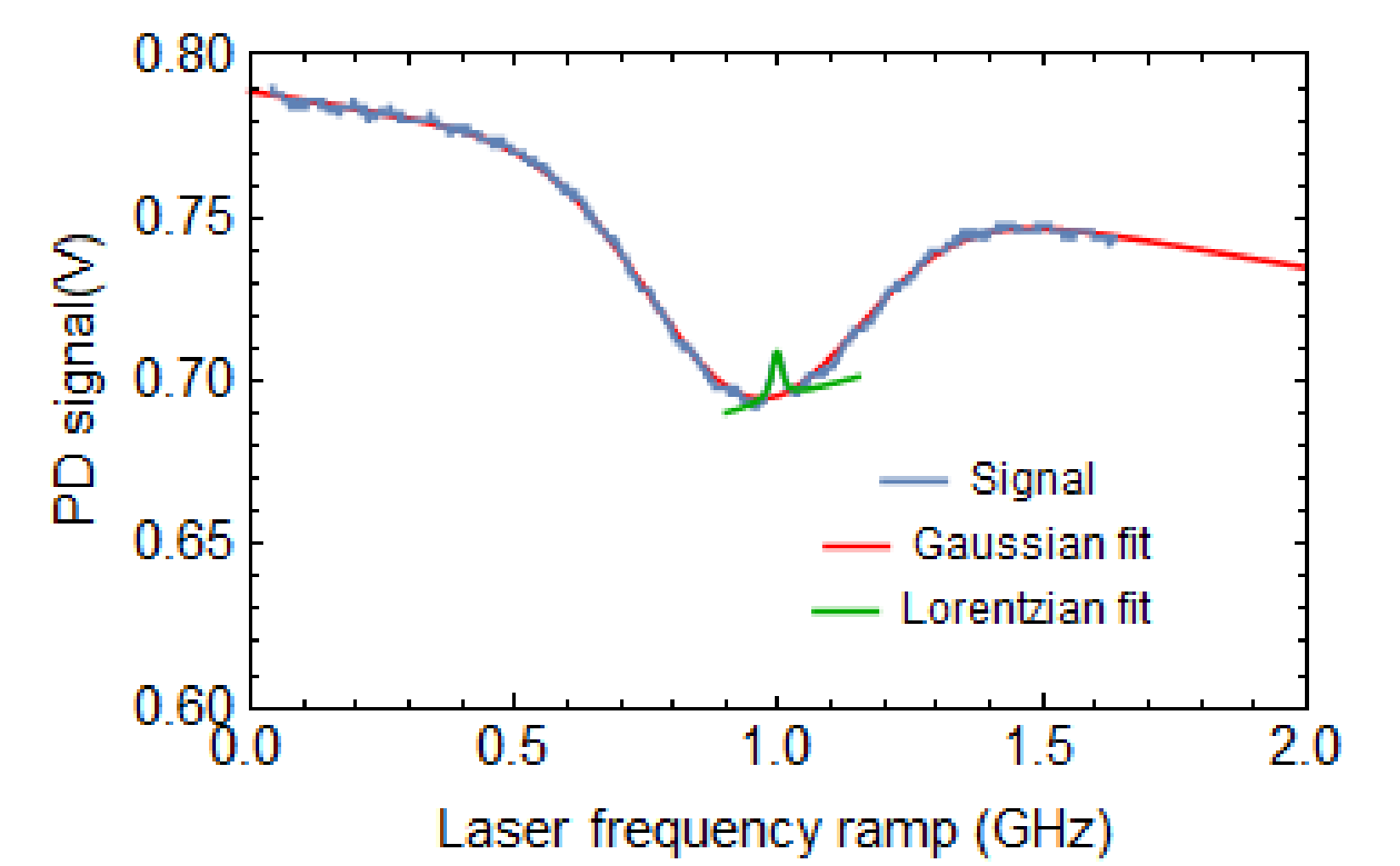
Optical Density is given by $OD = S \times \text{line profile} \times \frac{P}{k_B T} L$ Doppler FWHM $\approx 472 \text{ MHz}$

$\Gamma_{\text{tot}} = \Gamma_{\text{nat}} + \Gamma_{\text{pressure}} + \Gamma_{\text{transit}}$
 $I_{\text{sat}} \propto \Gamma_{\text{tot}}^2$

$\Gamma_{\text{nat}} = 5 \text{ Hz}$
 $\Gamma_{\text{pressure}} = (234 \text{ kHz/Pa}) \times P$
 $\Gamma_{\text{transit}} = \frac{0,19}{w_0} \sqrt{\frac{2k_B T}{m_{C_2H_2}}}$, w_0 waist radius

Fiber Cell [4]

- Length = 7m
- MFD = 22 μm
- $P = 6 \text{ Pa}$
- $\Gamma_{\text{tot}} = 6 \text{ MHz}$
- $\Gamma_{\text{meas}} = 22 \text{ MHz}$
- Sat Abs Amplitude: 16% of Doppler
- $P_{\text{sat}} \approx 20 \text{ mW}$ [5]



References

- [1] T. Tiecke. Properties of Potassium. <http://www.tobiastiecke.nl/archive/PotassiumProperties.pdf>, (2011).
- [2] HITRAN. Data base spectroscopy
- [3] J. Hald et al, Opt. Lett. **19**(3), 2052–2063 (2011)
- [4] M.Triches et al, Opt. Lett. **23**(9), 11227–11241 (2015)
- [5] J. Henningsen et al, Opt. Exp. **13**(26), 10475–10482 (2005)

Collaborations

Xlim:
 Fetah Benabid, Benoît Debord, Thomas Billotte

Perspectives

Experiment :

- Comparing bulk and fiber cells
- Herriott Cell
- Comparing the setups with ^{87}Rb reference via frequency comb
- Application for Potassium cooling

