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HAL Authorization

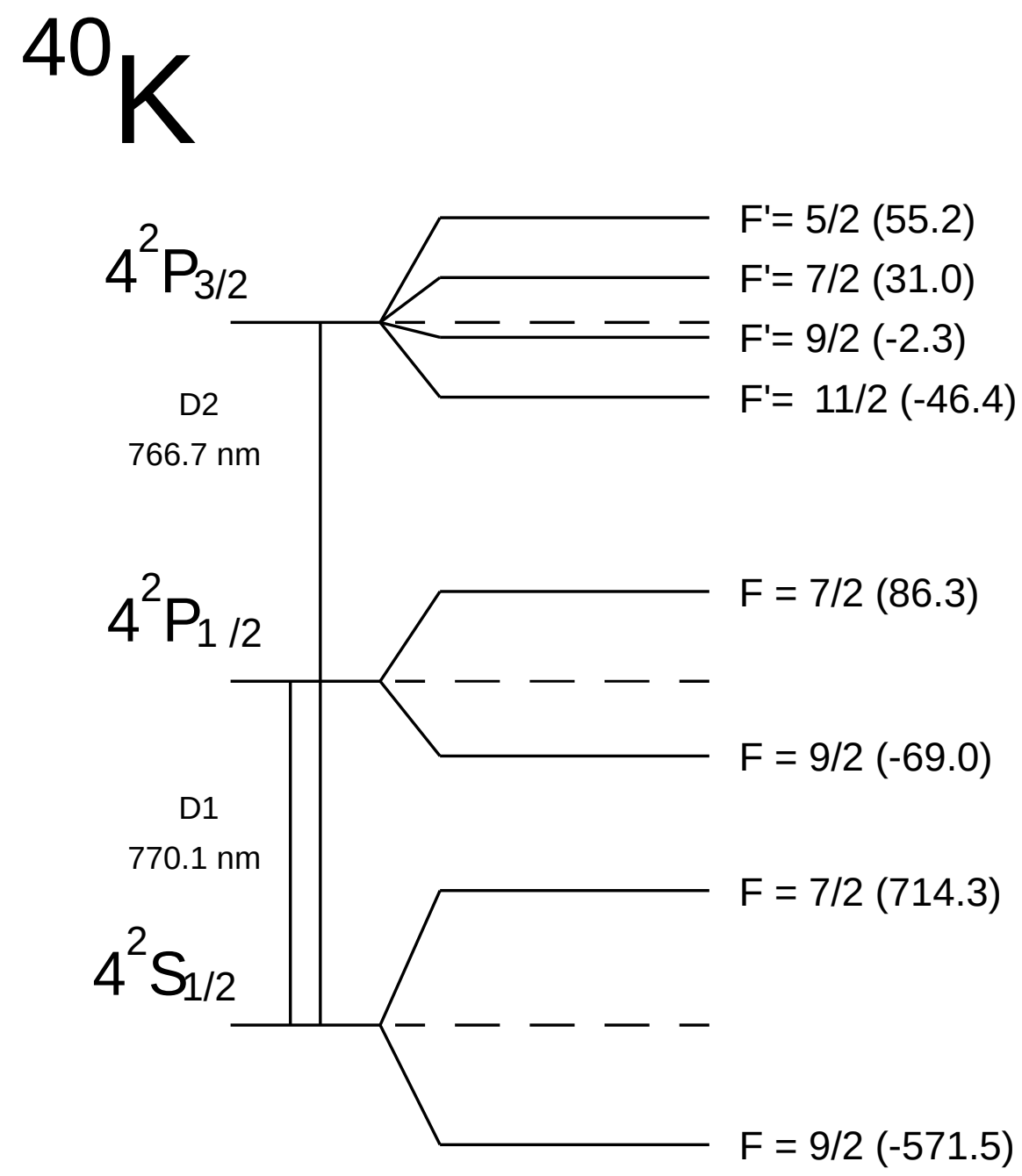
# Towards laser locking in the telecom range by spectroscopy of molecular gases

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## Motivation

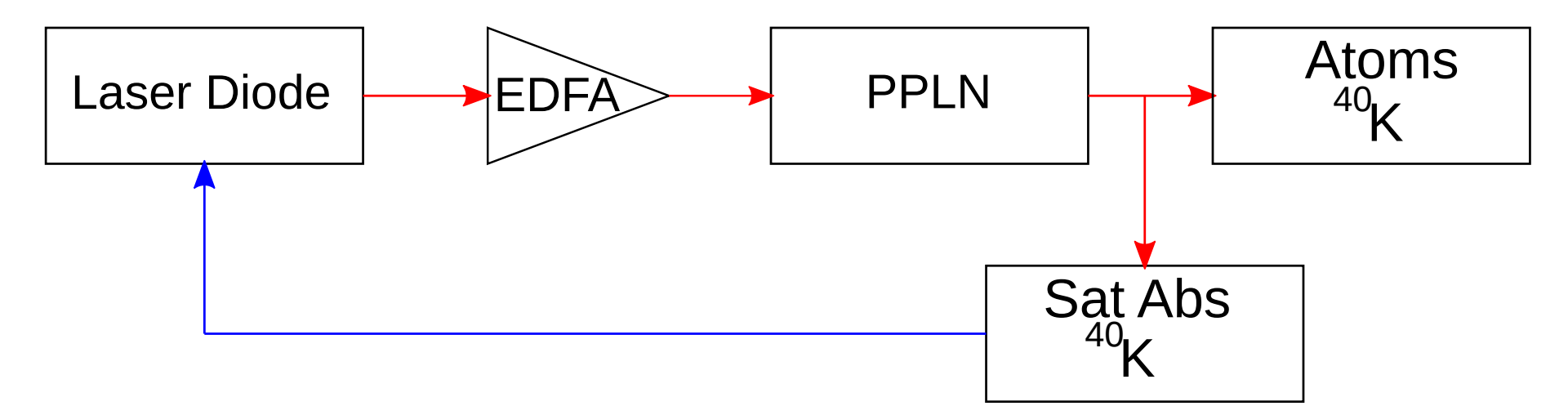
The AUFRONS (Ultra cold atoms in nanostructured optical potential) project aims at building near field optics / Ultra cold atoms hybrid systems to achieve stronger interaction between solid state and cold atoms physics. One of our goals is to manipulate cold fermionic species at the vicinity of a surface.



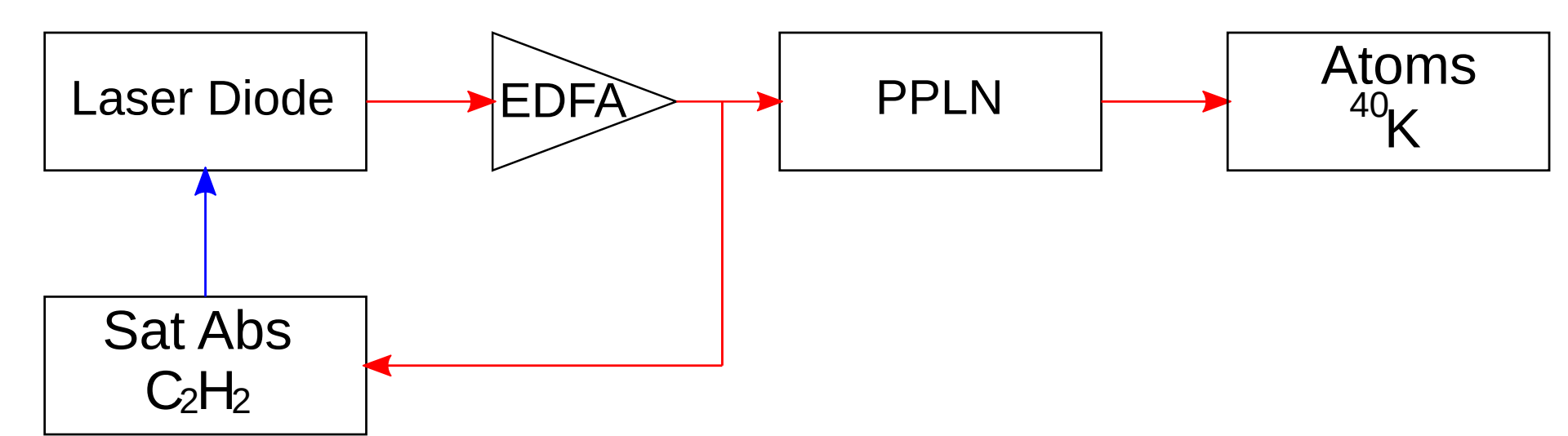
$^{40}\text{K}$ : + transition frequency close to  $^{87}\text{Rb}$   $\rightarrow$  doubled telecom laser diodes  
 + sympathetic cooling with  $^{87}\text{Rb}$   
 [1] + low field Feshbach resonances  
 – isotopic ratio (0,012 %)  
 – hyperfine lines are close, difficult to lock onto

$\text{C}_2\text{H}_2$  as rovibrational lines close to half the  $^{40}\text{K}$  transition frequency  
 + metrological transitions  
 [2] + narrow lines  
 + can work at room temperature  
 – low absorption

Potassium setup:

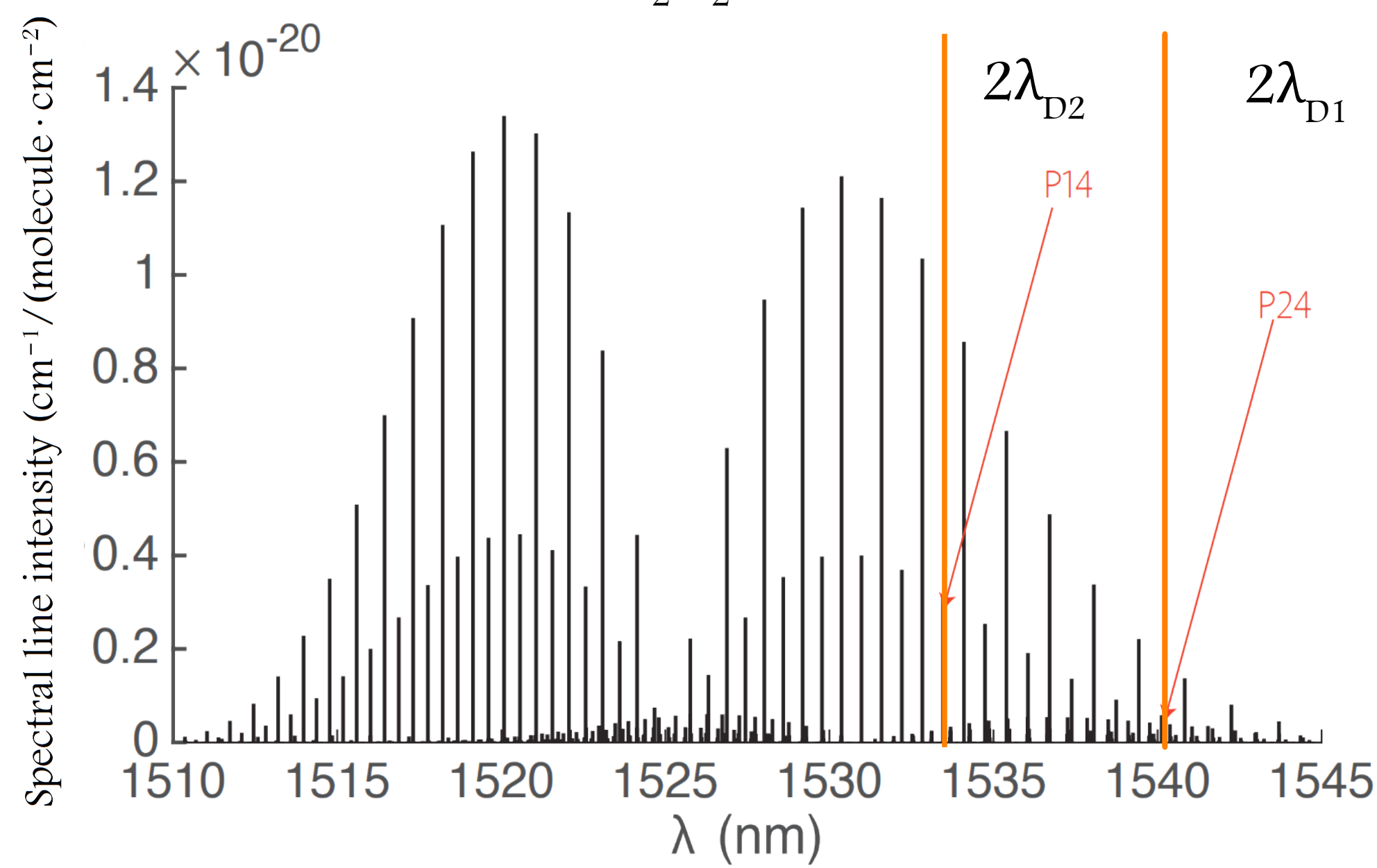


Acetylene setup:



## Molecular Gases: Acetylene

Lines of interest for Potassium cooling (D1 and D2) using acetylene ( $\text{C}_2\text{H}_2$ ) [2]



	$2\lambda_{D1,D2}$ (nm)	$\lambda_{C_2H_2,P24/P14}$ (nm)	Frequency Gap (GHz)
D1/P24 Transition	1540.216	1540.125	11.456
D2/P14 Transition	1533.402	1533.461	7.522

## Acetylene Spectroscopic Parameters

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

$$S = \underbrace{\text{wavenumber}} \times \underbrace{\text{Column density}}$$

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

$$\Gamma_{\text{tot}} = \Gamma_{\text{nat}} + \Gamma_{\text{pressure}} + \Gamma_{\text{transit}}$$

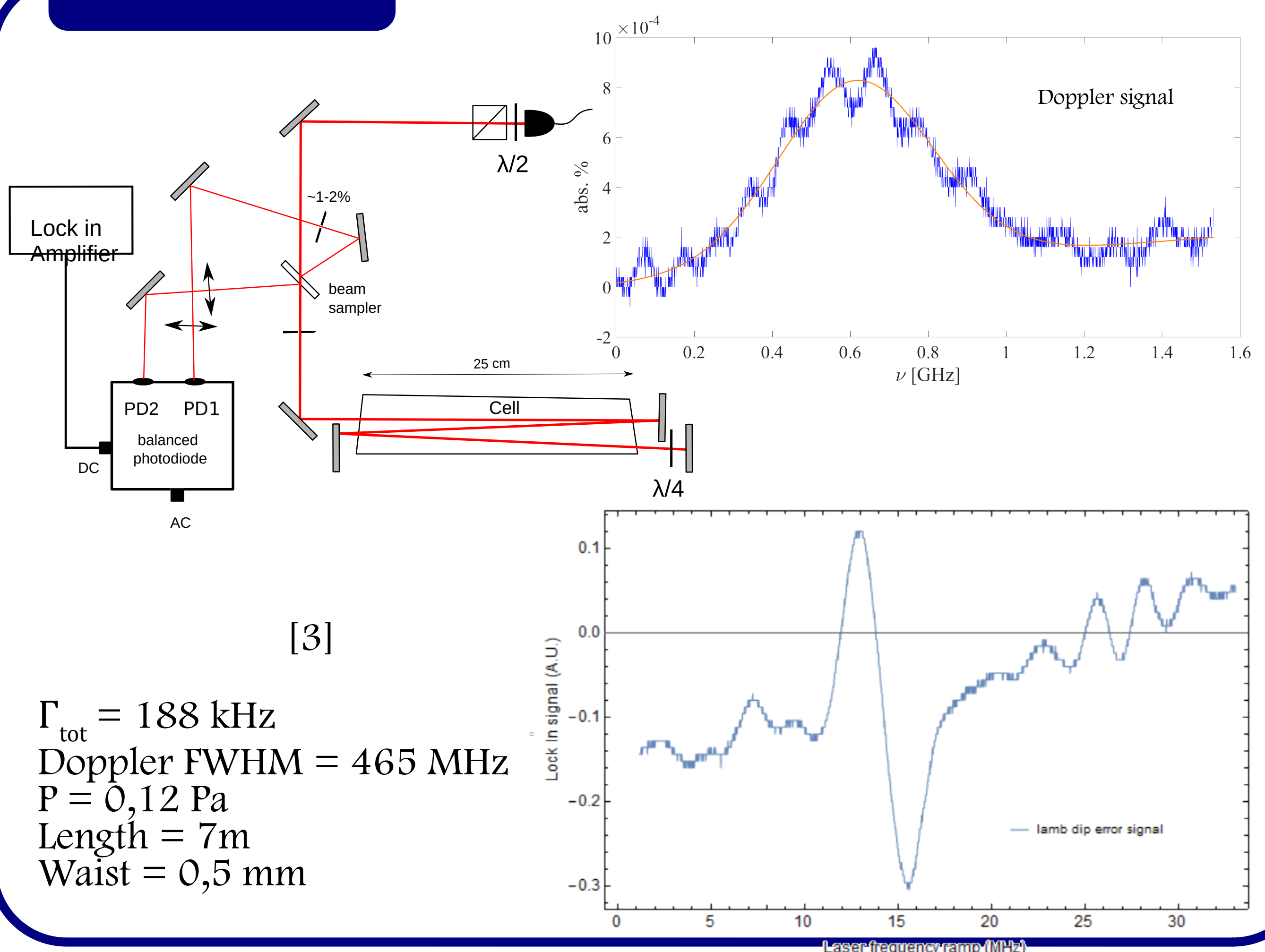
$$I_{\text{sat}} \propto \Gamma_{\text{tot}}^2$$

$$\Gamma_{\text{nat}} = 5 \text{ Hz}$$

$$\Gamma_{\text{pressure}} = (234 \text{ kHz/Pa}) \times P$$

$$\Gamma_{\text{transit}} = \frac{0,19}{w_0} \sqrt{\frac{2k_B T}{m_{C_2H_2}}}, w_0 \text{ waist radius}$$

## Bulk Cell



## Fiber Cell [4]

Length = 7m

MFD = 22  $\mu\text{m}$

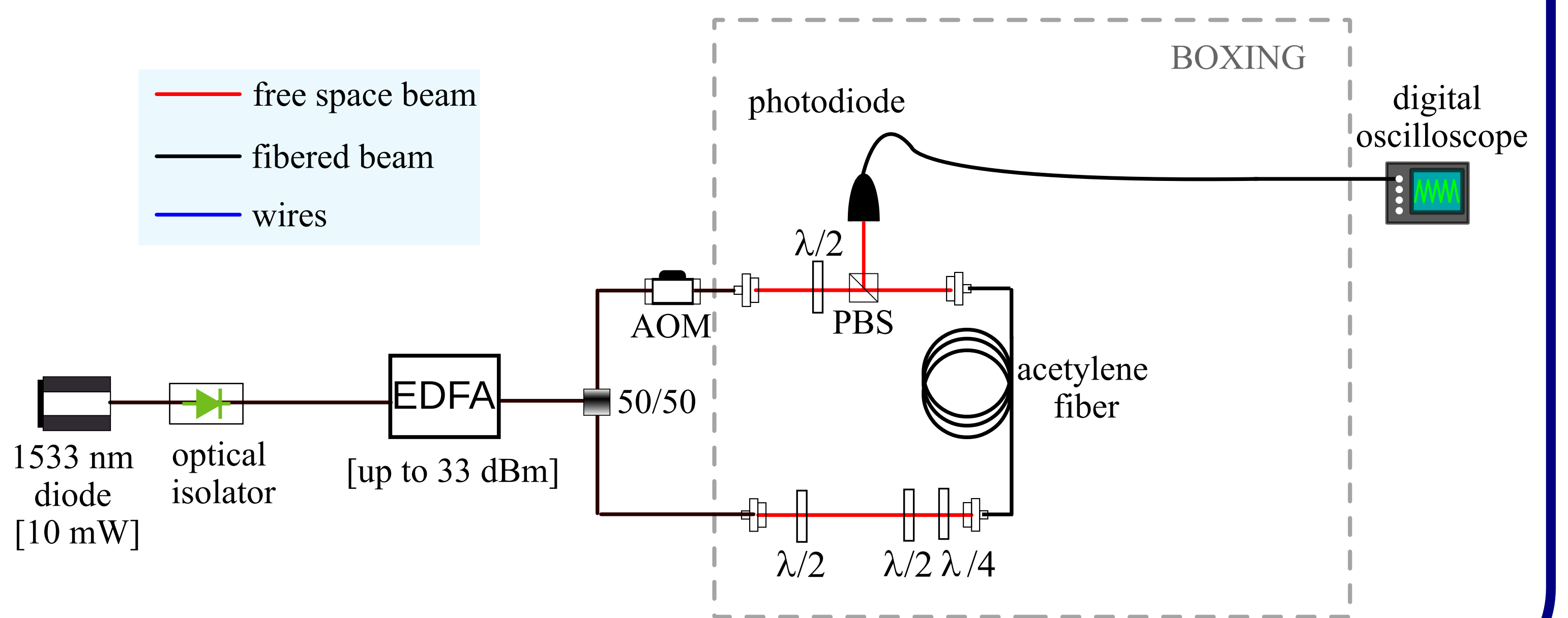
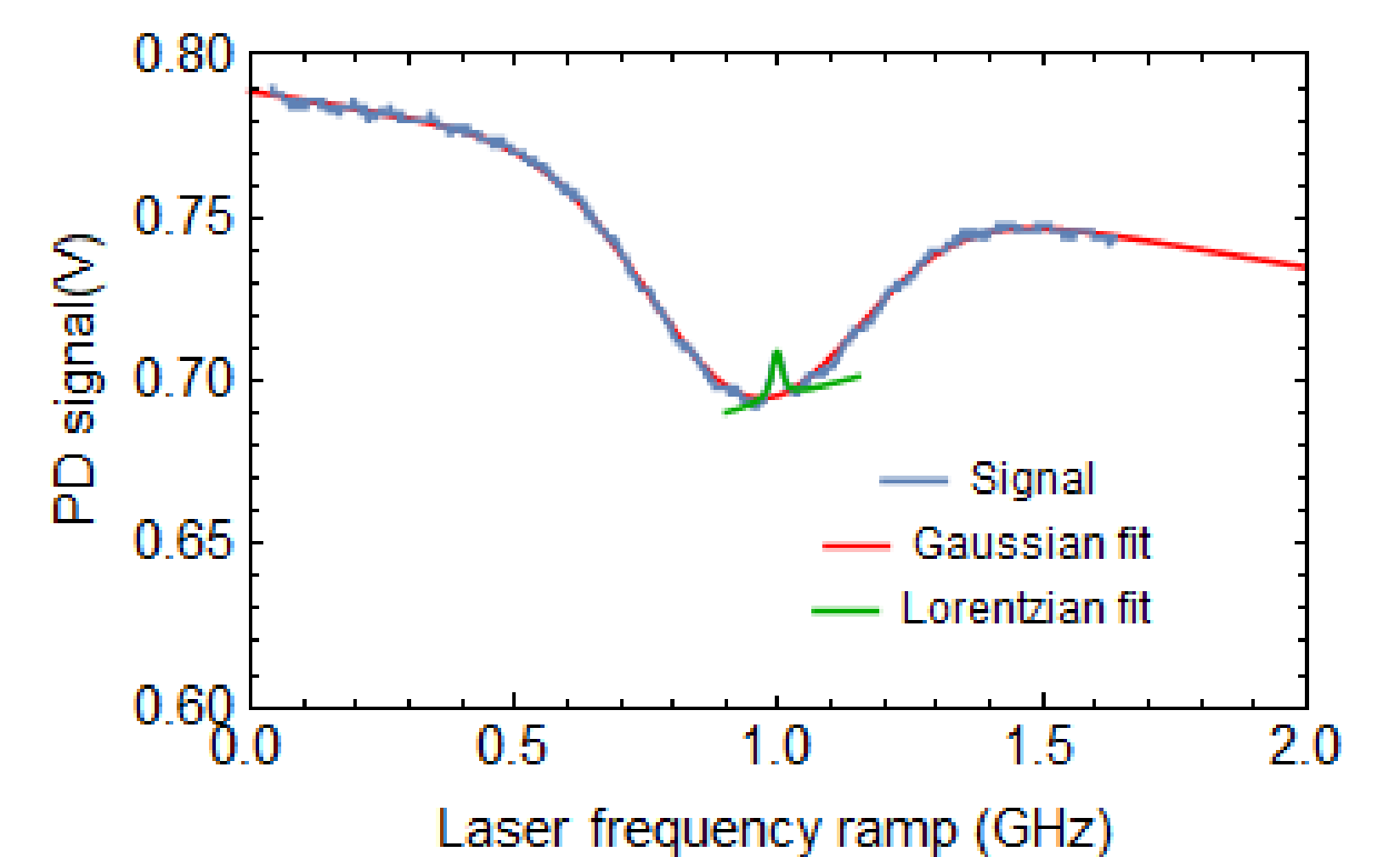
$P = 6$  Pa

$\Gamma_{\text{tot}} = 6$  MHz

$\Gamma_{\text{meas}} = 22$  MHz

Sat Abs Amplitude: 16% of Doppler

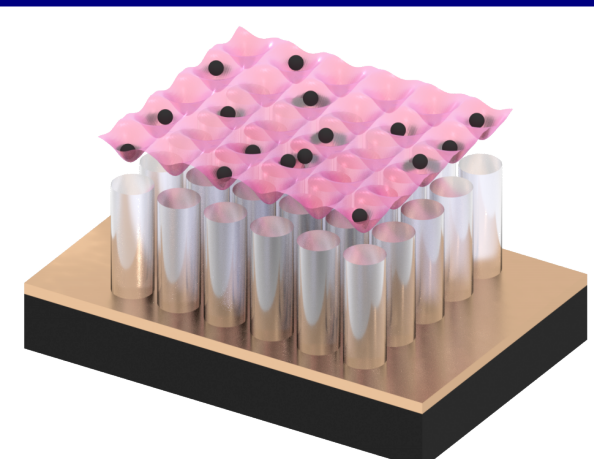
$P_{\text{sat}} \approx 20$  mW [5]



## Perspectives

Experiment :

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



## 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