Four Wave Mixing (FWM) in alkali atom vapors - Numerical method

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Abstract. Four Wave Mixing (FWM) in alkali atom vapors exists only under very specific conditions, it is necessary that density of alkali vapor, intensities and frequencies of pump and probe laser beams, have their values within rather narrow ranges. FWM is nonlinear phenomena that can be regarded as scattering of laser beams on nonlinear index grating, generated by the same laser beams. Such scattering results in conversion of two pump photons to additional probe photon, and to conjugate photon at frequency (much) different form the pump and probe frequencies.The interaction of coherent radiation with atomic pairs was analyzed using the Maxwell-Bloch equations. Codes have been developed to numerically solve this system, including the Doppler effect and relaxation processes.

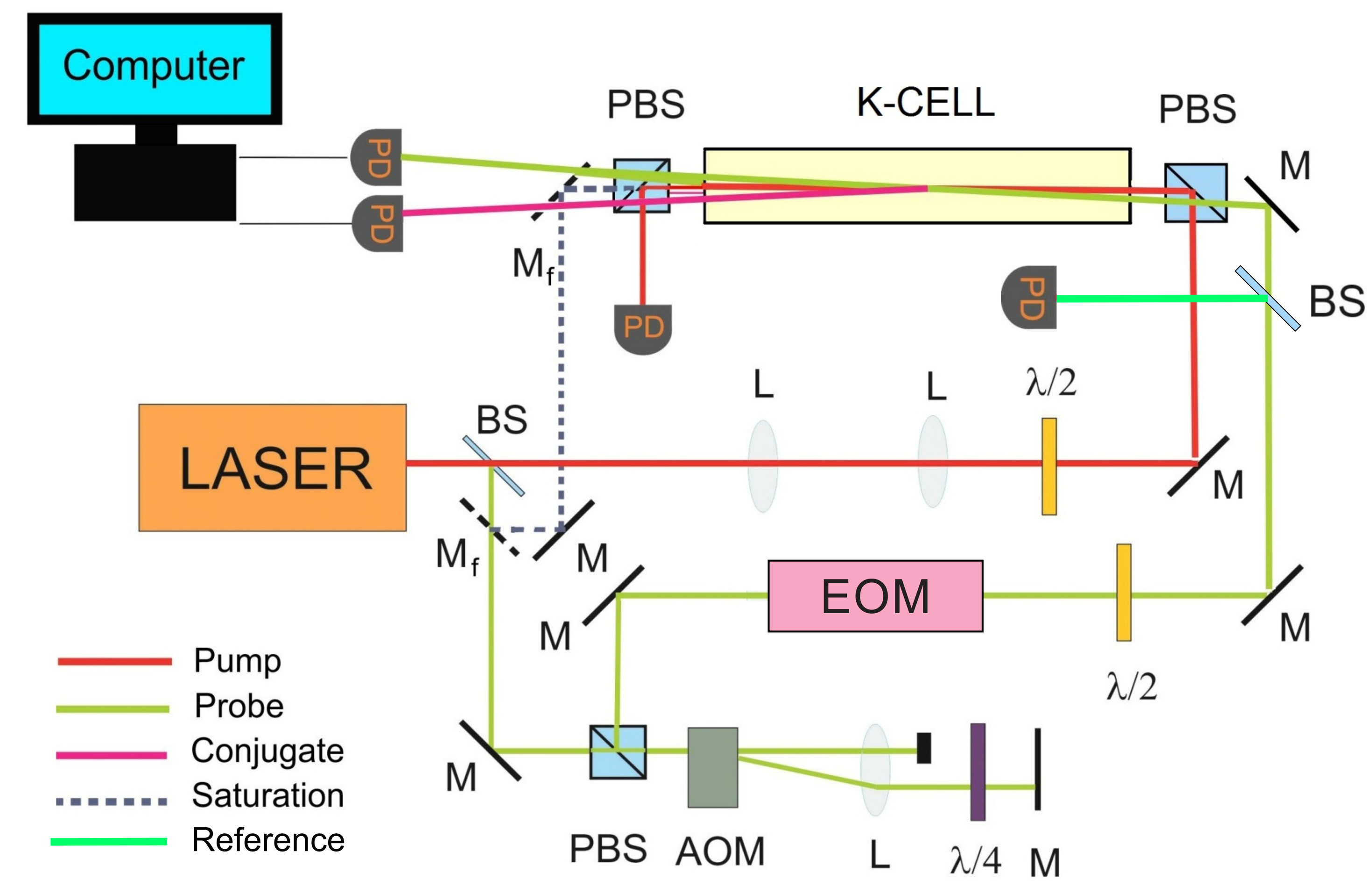

Fig.1 Experimental setup:

BS - beam splitter, L - lenses
PBS - polarizing beam splitter
M - mirrors, M_f - flip mirrors
λ/4 - lambda-quarter wave plate
λ/2 - lambda-half wave plates
AOM - acousto-optic modulator
PD - photodiodes
EOM - electrooptic modulator

Flip mirrors are used to switch between the configuration for four wave mixing and saturation spectroscpy, changing the role of the probe and the pump

Experimental parameters: Pump intensity ~200mW, initial probe intensity 20uW,angle between the pump and the probe 3 mrad, diameter of the pump 1 mm, diameter of the probe 0.8 mm.

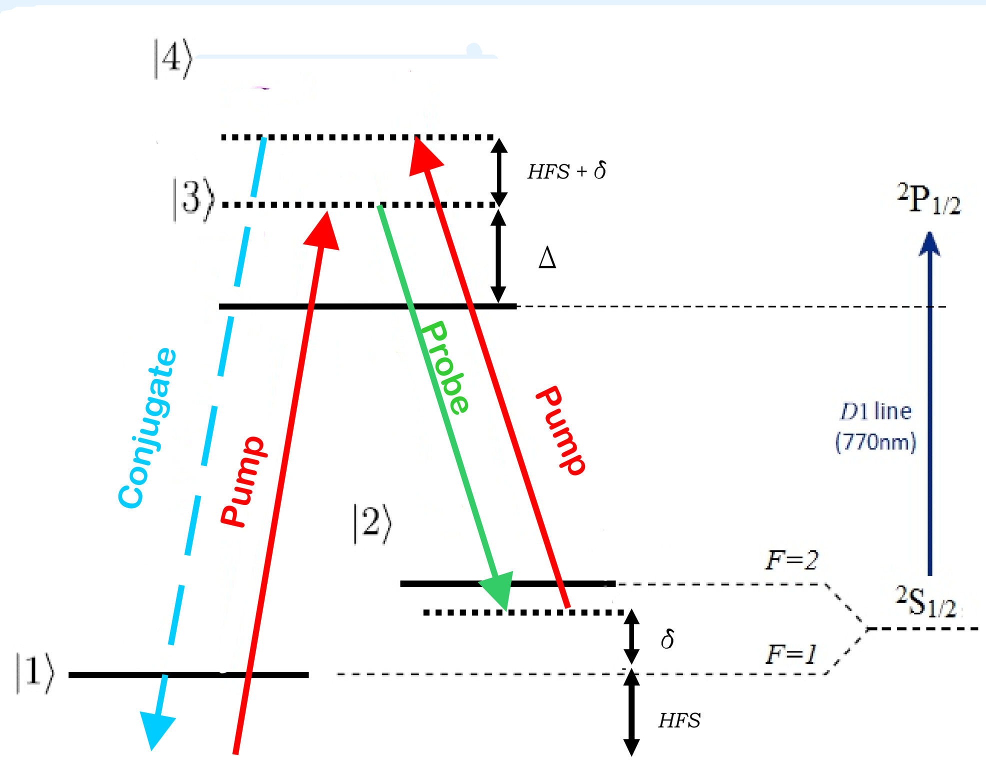

Fig.2 Double-Λ scheme: Double-Λ scheme is realized on D1 line of ^{39}K. The hyperfine splitting of the level $^2P_{1/2}$ is neglected. Δ - One-photon detuning, δ - Two-pfoton detuning, *HFS* - Hyperfine splitting

Delay is defined as the difference between the peaks of the probe and reference pulses. **Fractional delay** is defined as the ratio of the delay and the width of the reference pulse (Width R). **Broadening** is defined as the ratio (in percentiles) of the width of the probe pulse (Width P) and the width of the reference pulse (Width R).

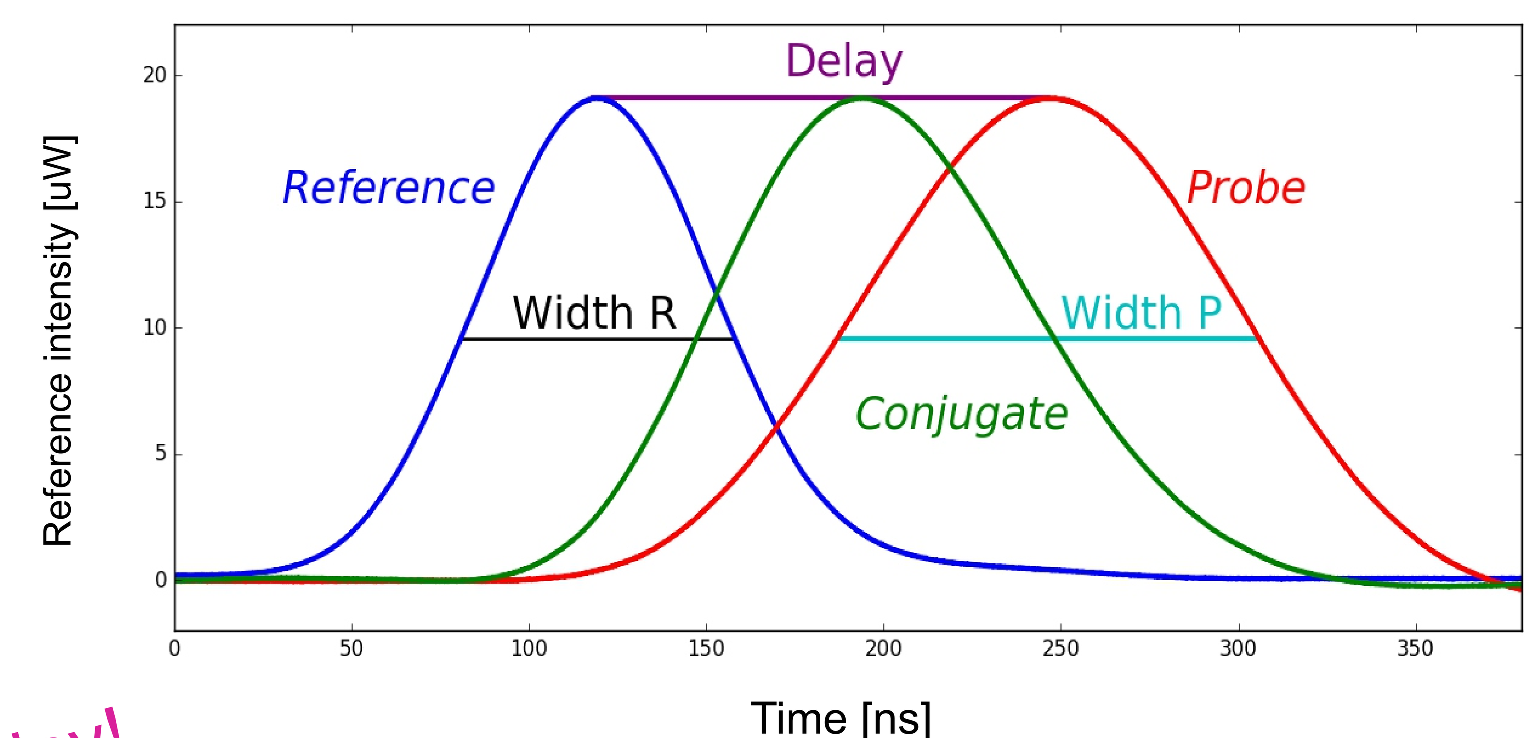

Fig.3 What do we measure?: Probe and conjugate pulses in time domain with measured quantities drawn

Wanted:
Large fractional delay!
Small broadening!

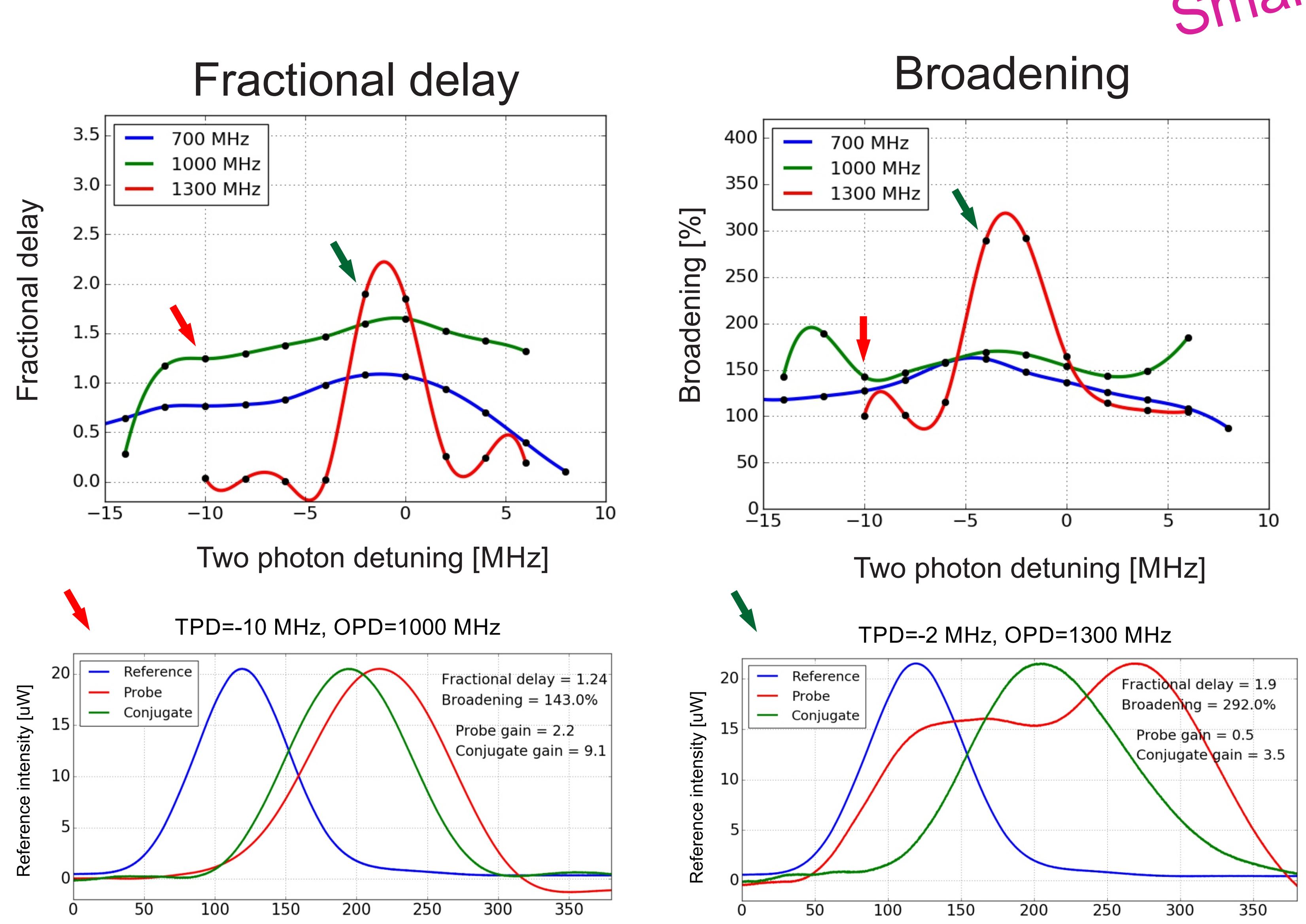

Fig. 4 Two-photon detuning: Fractional delay and broadening of the probe versus two-photon detuning for various values of one-photon detuning and temperarture of 120 C.

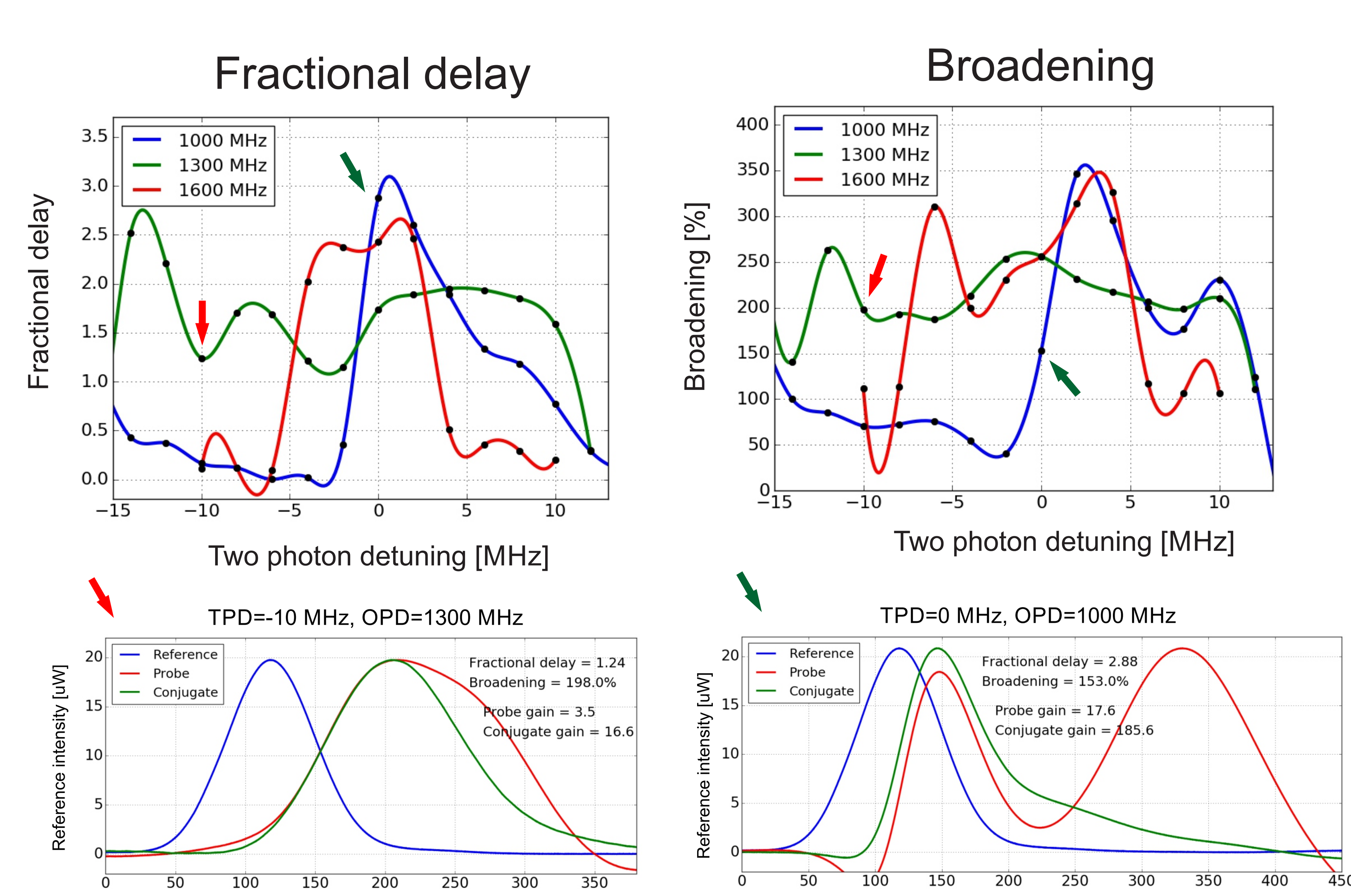

Fig. 5 Two-photon detuning: Fractional delay and broadening of the probe versus two-photon detuning for various values of one-photon detuning and temperarture of 140 C.

References.

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[2] J.Okuma, N. Hayashi, A. Fujisawa, M. Mitsunaga, Optics Letters, Vol. 34, Issue 11, pp. 1654-1666 (2009)
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Conclusion. We have demonstrated for the first time the slowing of optical pulses in hot potassium vapor . The effect was comprehensively studied by varying most of the parametrs important for FWM phenomena. The delay of optical pulses and its broadening, in general, change with these parameters simultaneously. The best trade off between the two was found at T=120 C, OPD=1000 MHz and TPD=-10 MHz.