

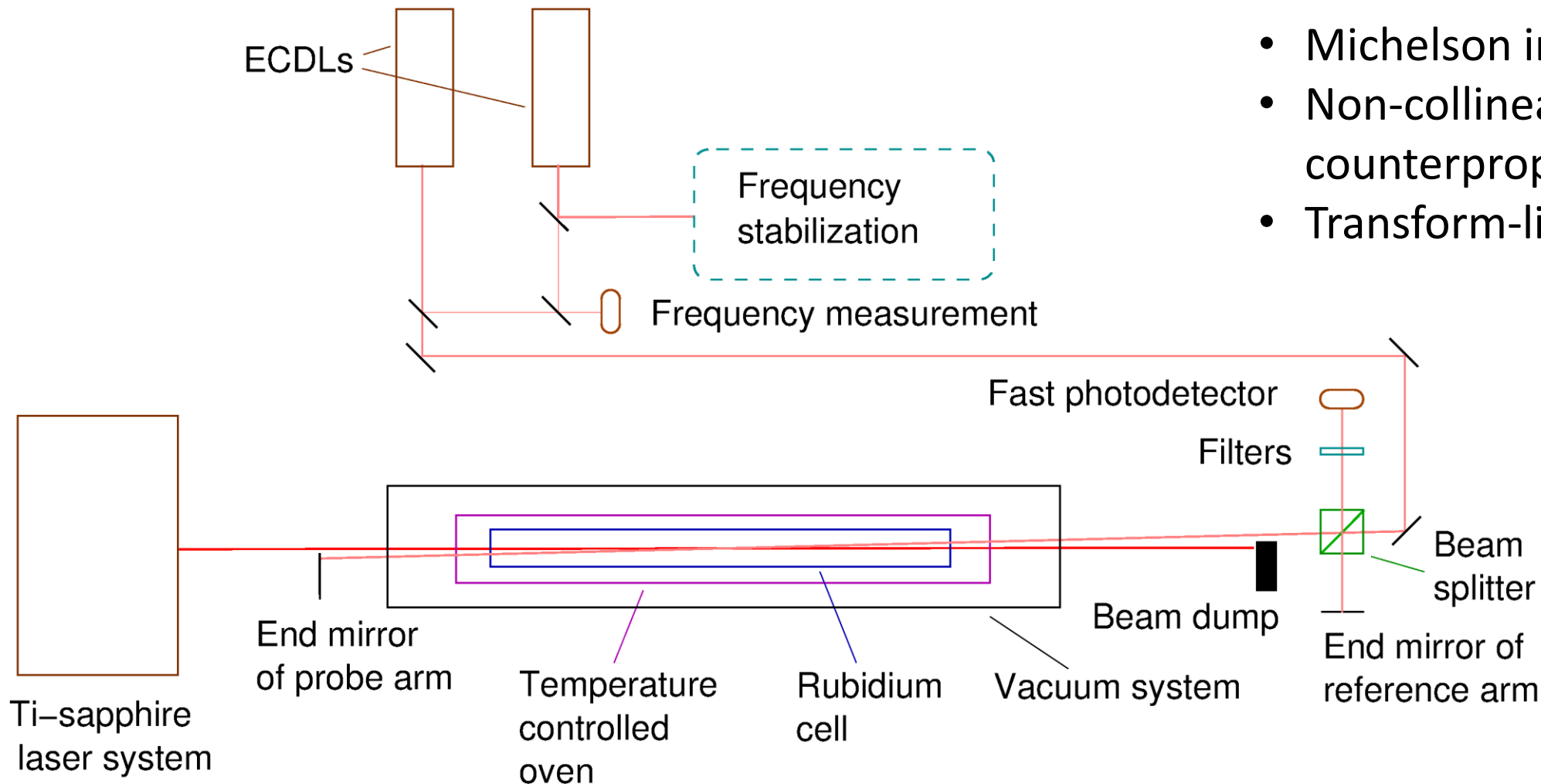
Longitudinal absorption and interferometric measurements at Wigner RCP

SCHEME

- Ti-Sapphire laser beam propagating longitudinally through the Rb-cell
- Counterpropagating quasi-resonant diode laser beam
- Detection of absorption (transmission) and interferometric signals:
 - Vs time: fast photodetector
 - Lateral distribution: gated camera

1. Temporal dependence of absorption and interferometric signals measured with the Legend laser (3 mJ, 40 fs)

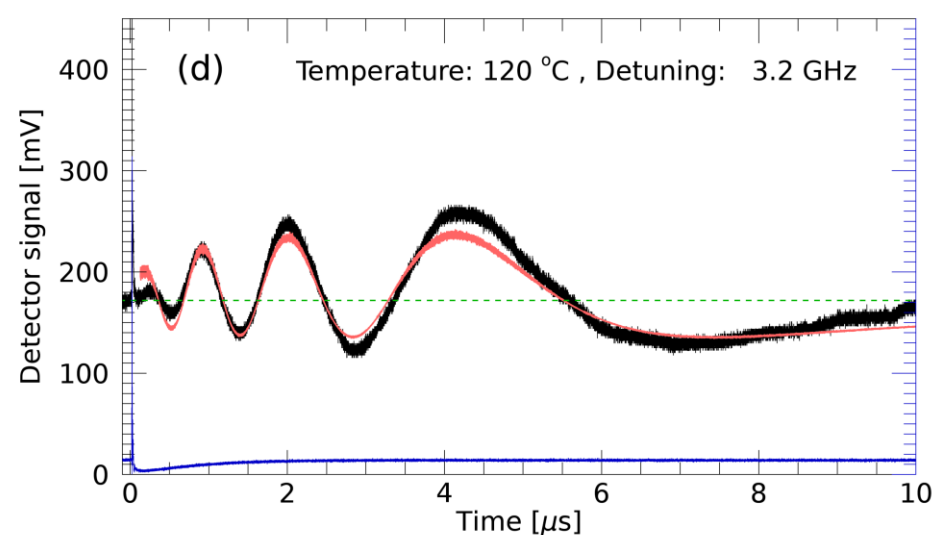
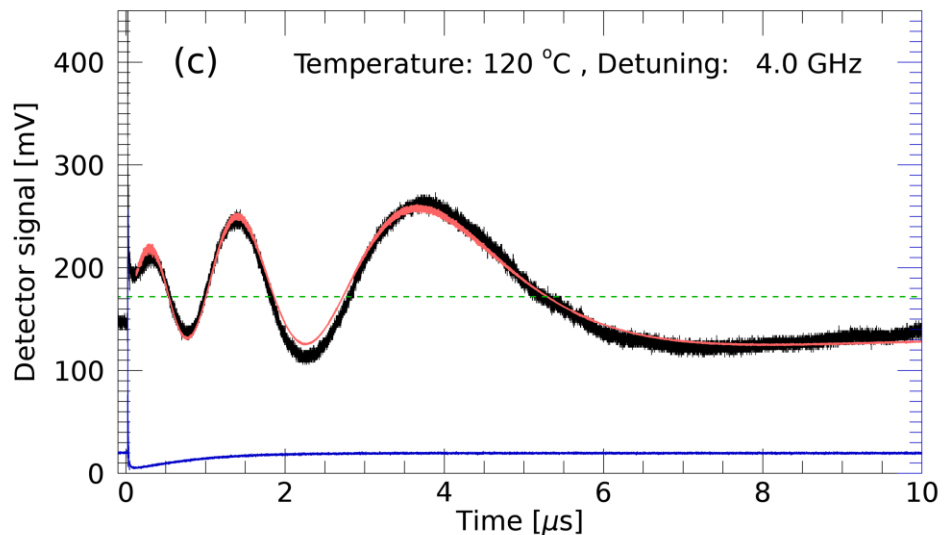
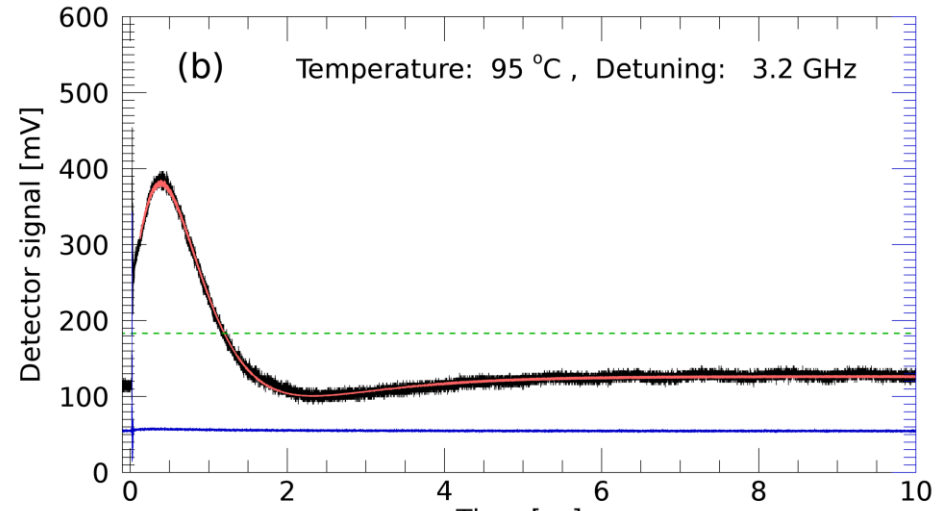
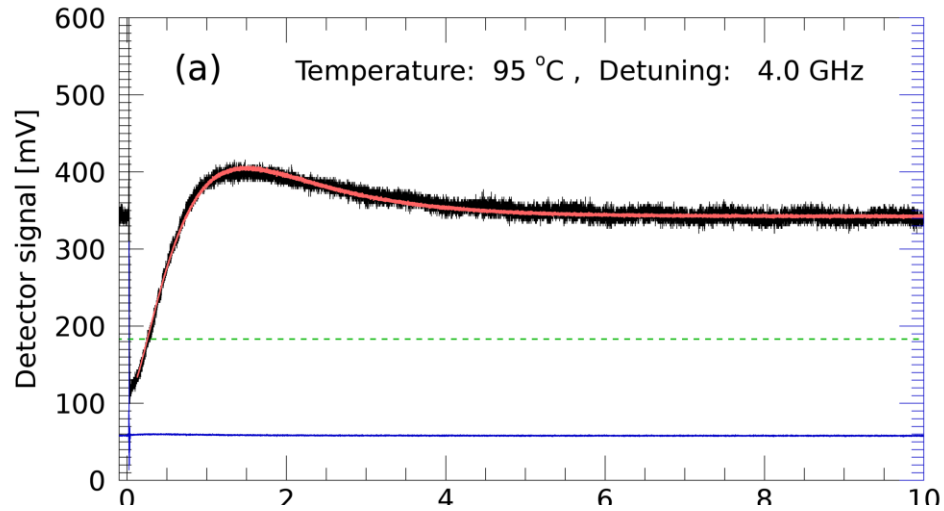
(G.P. Djotyan et al., Nucl. Instr. Meth. A 884 (2018) 25-30)



- Michelson interferometer
- Non-collinear counterpropagating beams
- Transform-limited pulses

Interferometric signals with fitted exponentially decaying phase difference

$$I_{\text{interf}}(t) = I_{\text{tr}}(t) + I_{\text{ref}} + 2\epsilon\sqrt{I_{\text{tr}}(t)I_{\text{ref}}} \cdot \cos(\varphi_0 + \varphi_1(t)) \quad \varphi_1(t) = \varphi_1^{(0)}e^{-t/\tau}$$

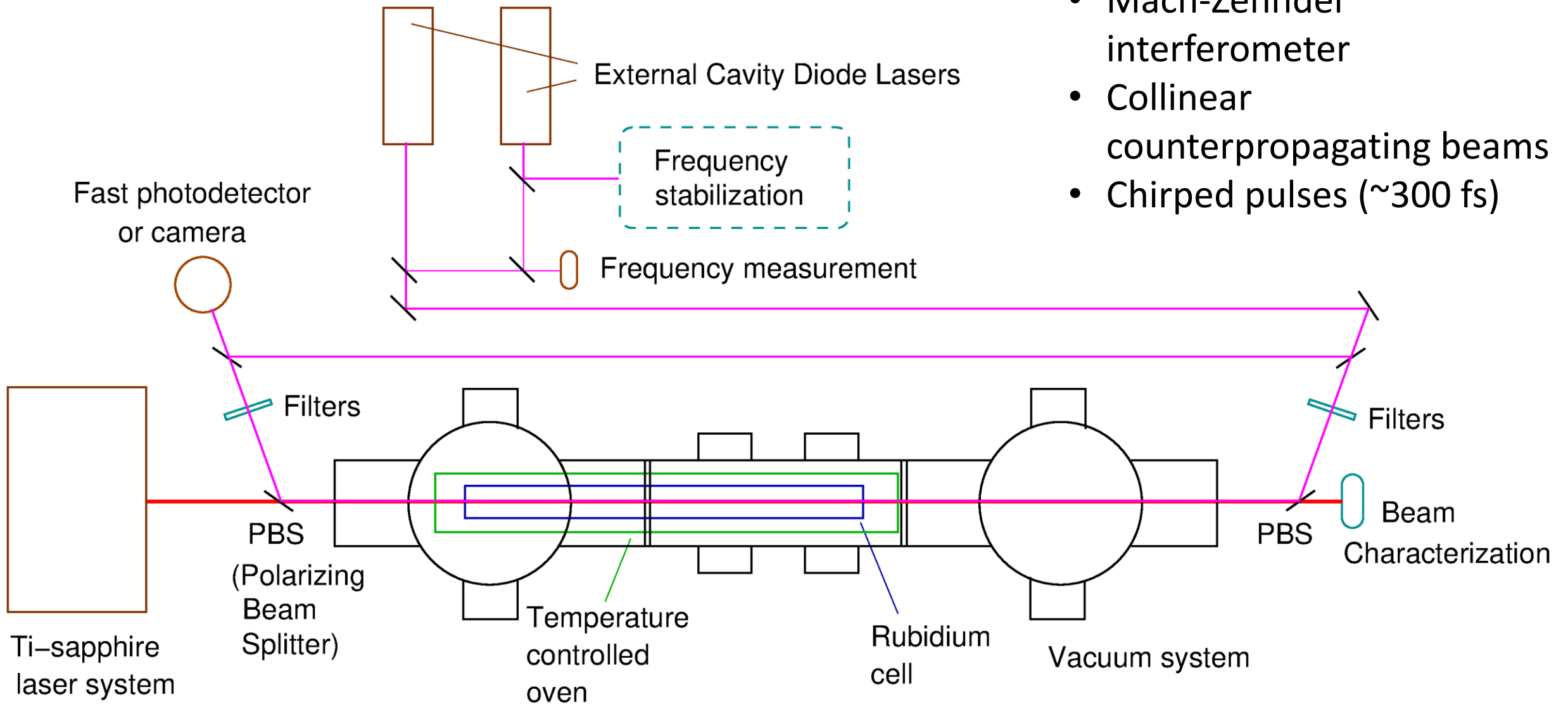


Results of the density calculations

$$\Delta N_p(t)L = \varphi_1(t) \frac{\lambda_L m}{\pi^2 f e^2} \left[\sum_{i=1}^2 p_i \sum_{j=1}^2 \frac{\Delta\omega_j^{(i)}}{\omega_{0j}^{(i)} (\Delta\omega_j^{(i)2} + \Gamma^2)} \right]^{-1}$$

Temperature (°C)	95		120	
Detuning (GHz)	4.0	3.2	4.0	3.2
$\varphi_1^{(0)}$ (rad)	3.59	5.41	18.3	24.8
τ (μ s)	1.08	1.07	2.28	2.31
ΔN_p (cm^{-3})	3.5×10^{11}	4.6×10^{11}	1.8×10^{12}	2.1×10^{12}
$\Delta N_p/N$ (%)	8.1	10.6	8.8	10.4

2. Experiments with the Hydra laser (30 mJ, 40 fs)



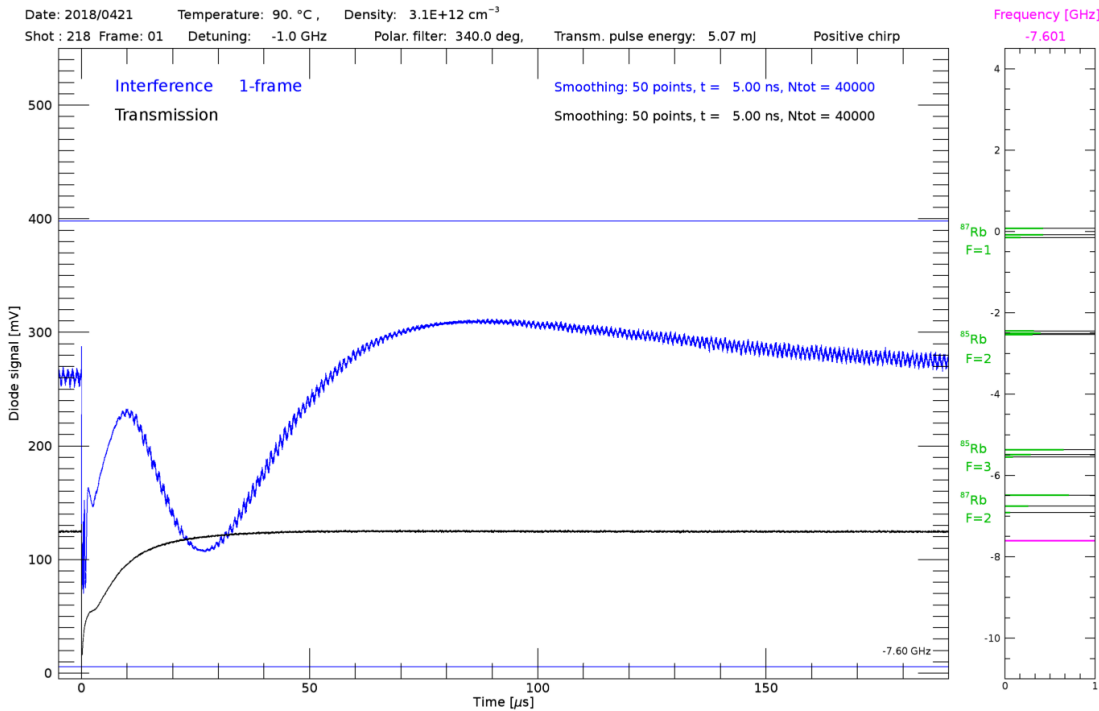
- Mach-Zehnder interferometer
- Collinear counterpropagating beams
- Chirped pulses (~ 300 fs)

Temporal dependence of the transmission and **interference** signals

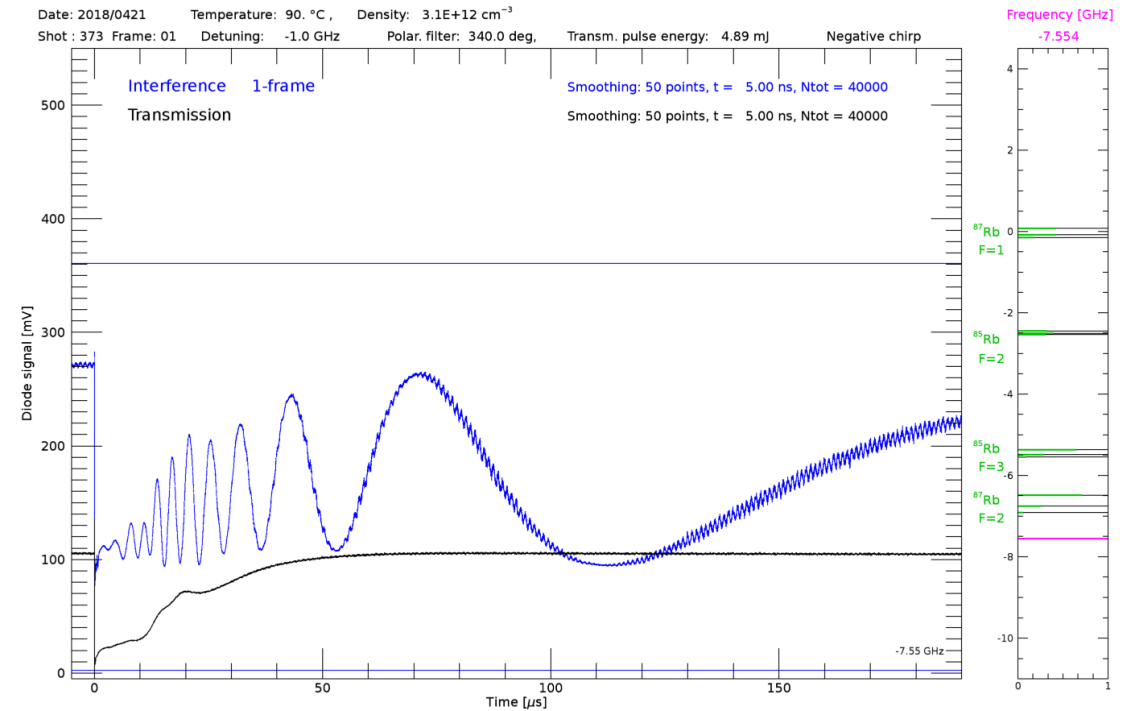
Difference between the efficiency of the pulses with positive and negative chirp: **NEGATIVE CHIRP** is more efficient

Ti:Sa laser pulse energy: 13.5 mJ; Diode laser detuning: -1 GHz

Positive chirp



Negative chirp



Transmission signals are different for positive and negative diode laser detuning

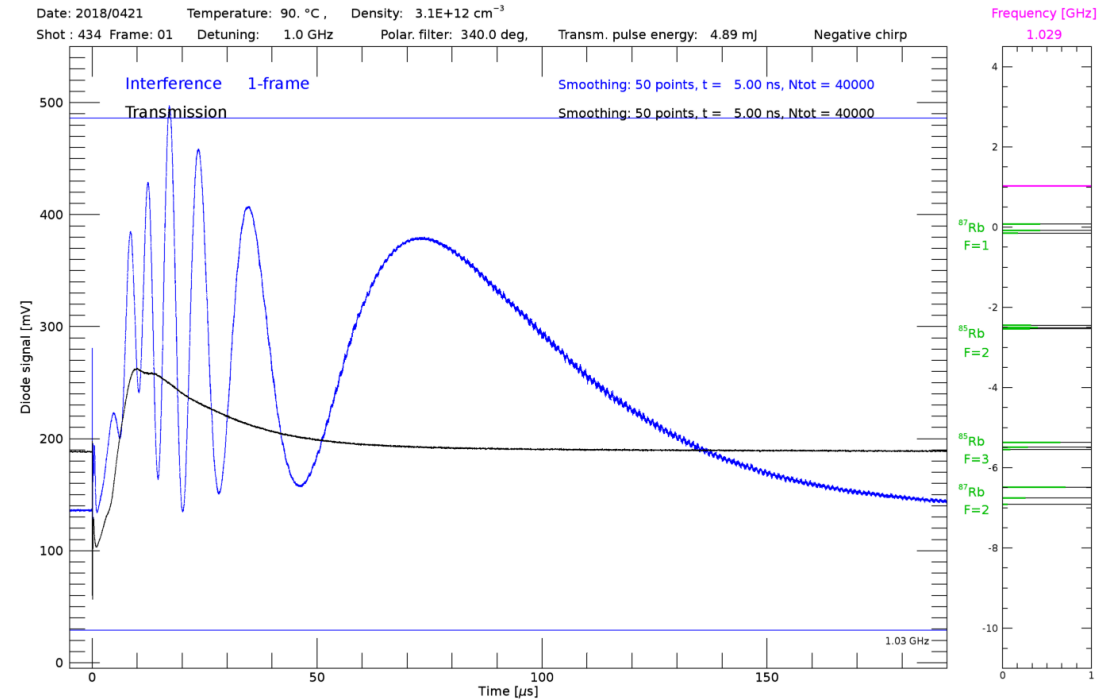
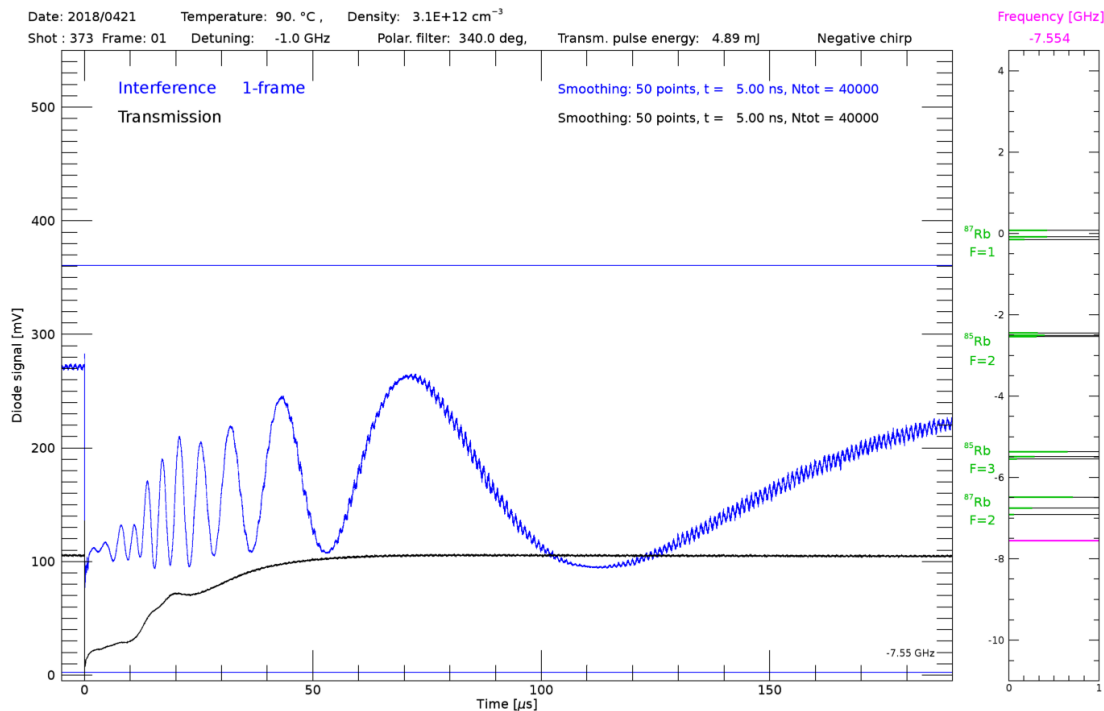
→ focusing / defocusing of the transmitted beam ?

Ti:Sa laser: pulse energy: 13.5 mJ, negative chirp

Diode laser:

Negative detuning: -1 GHz

Positive detuning: +1 GHz



Measurement of the lateral distribution of the transmitted diode laser beam intensity and interferograms with a gated camera at different delay times after the Ti:Sa pulse

(Exposure time of the image intensifier: 200 ns)

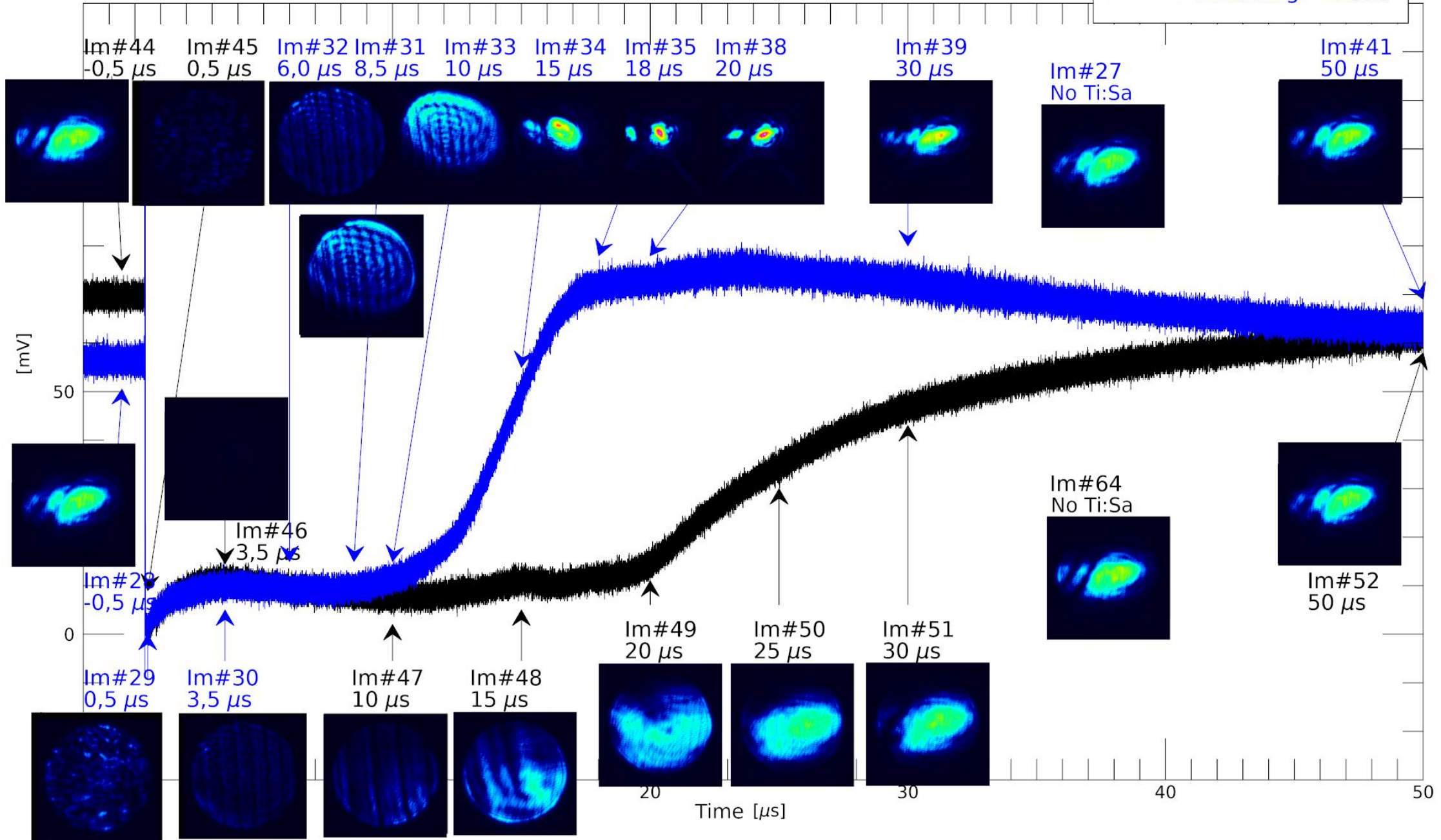
Positive detuning → lower refractive index of the vapor
density is lower at the middle → positive lens → focusing

Negative detuning → higher refractive index of the vapor
density is lower at the middle → negative lens → defocusing

Interference signals → ring structure varying in time → calculation of the density distribution

Longitudinal transmission signals, Rb-vapor temp = 120 C, density = $2 \times 10^{13} / \text{cm}^3$
Ti-sapphire pulse energy: 12.6 mJ, negative chirp; diode laser detuning: -4 and +4 GHz.

— Detuning: -4 GHz
— Detuning: 4 GHz



Longitudinal transmission and interference signals, Rb temp = 120 C, density = $2 \times 10^{13} / \text{cm}^3$
Ti-sapphire pulse energy: 12.6 mJ, negative chirp. Diode laser detuning: -4 GHz

