Experimental Characterization of Frequency Dependent Squeezed Light

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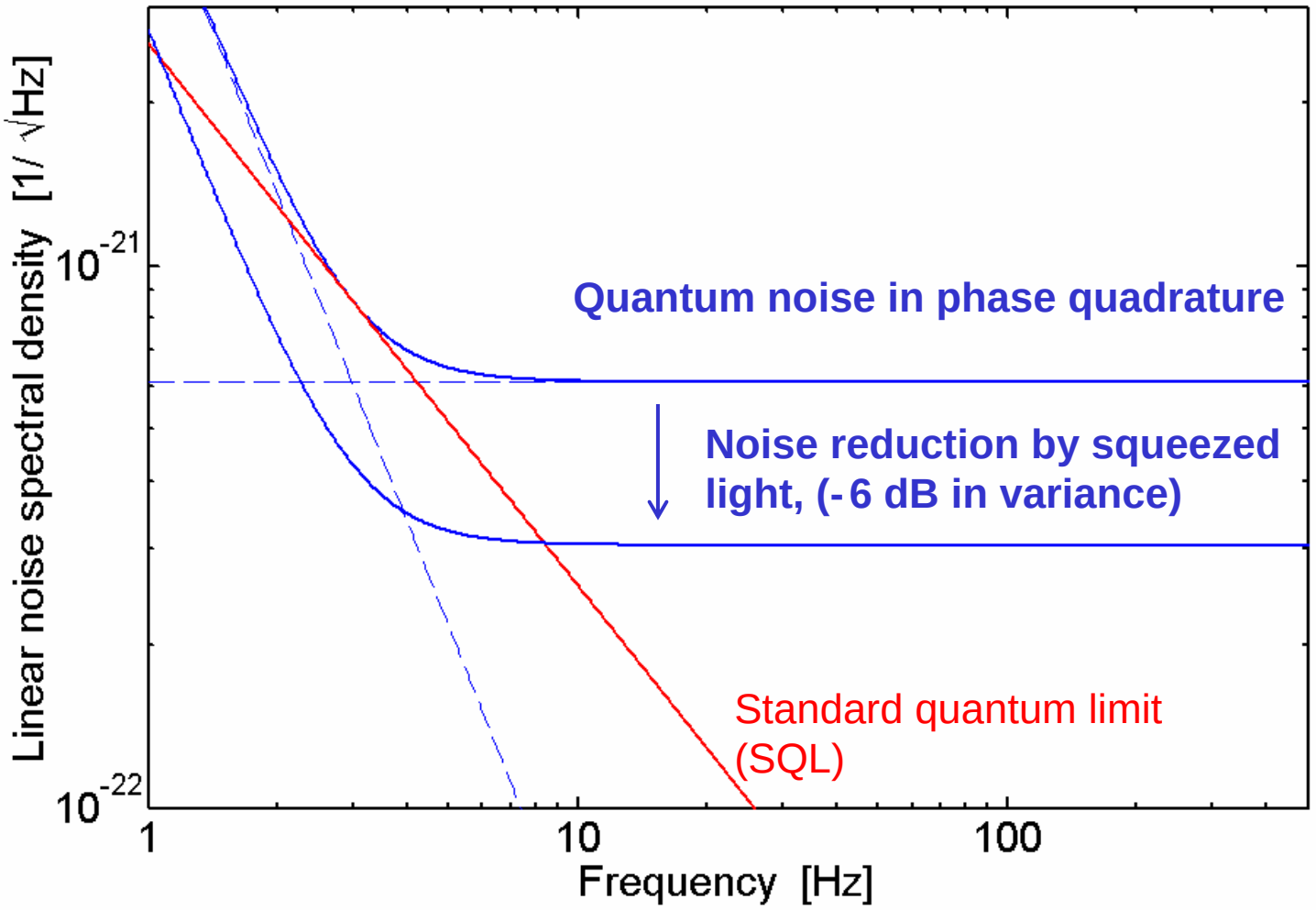
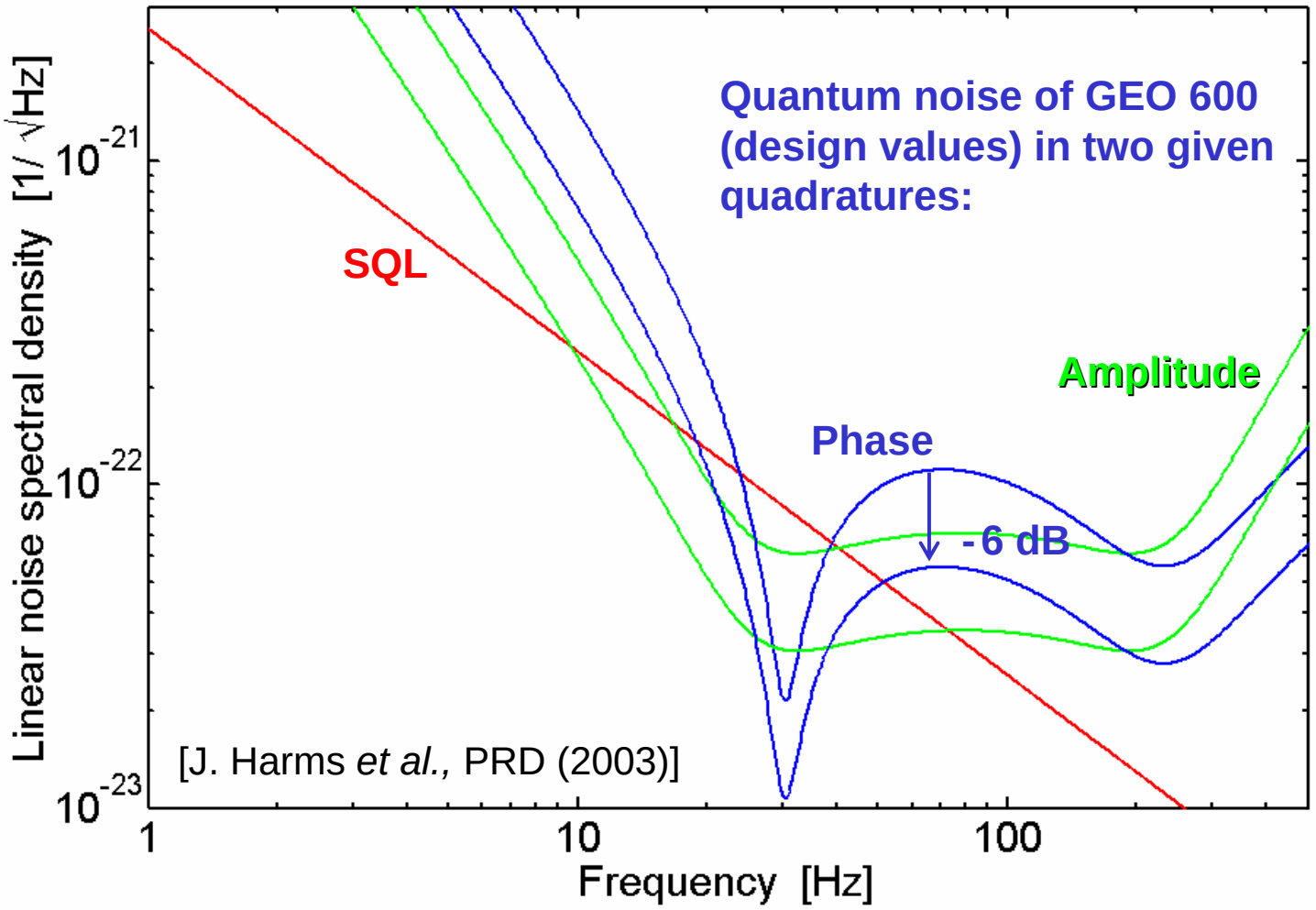
Simple MI plus Squeezed Light Input

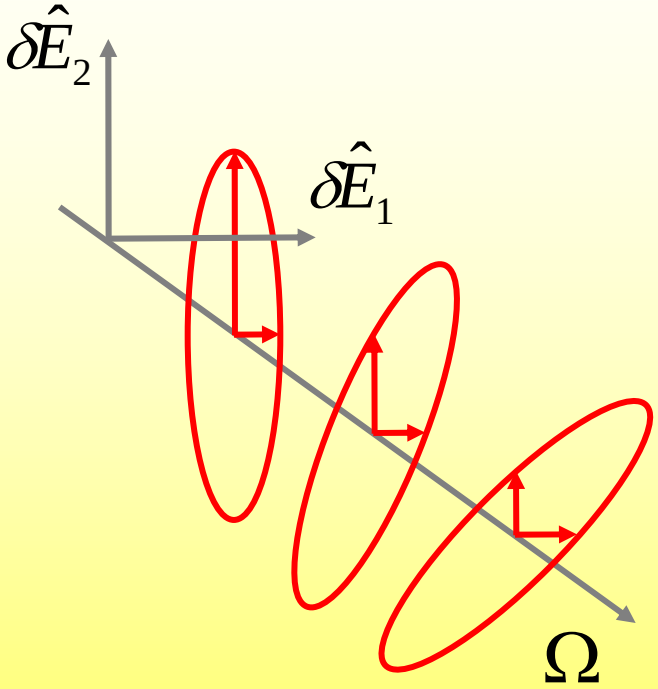


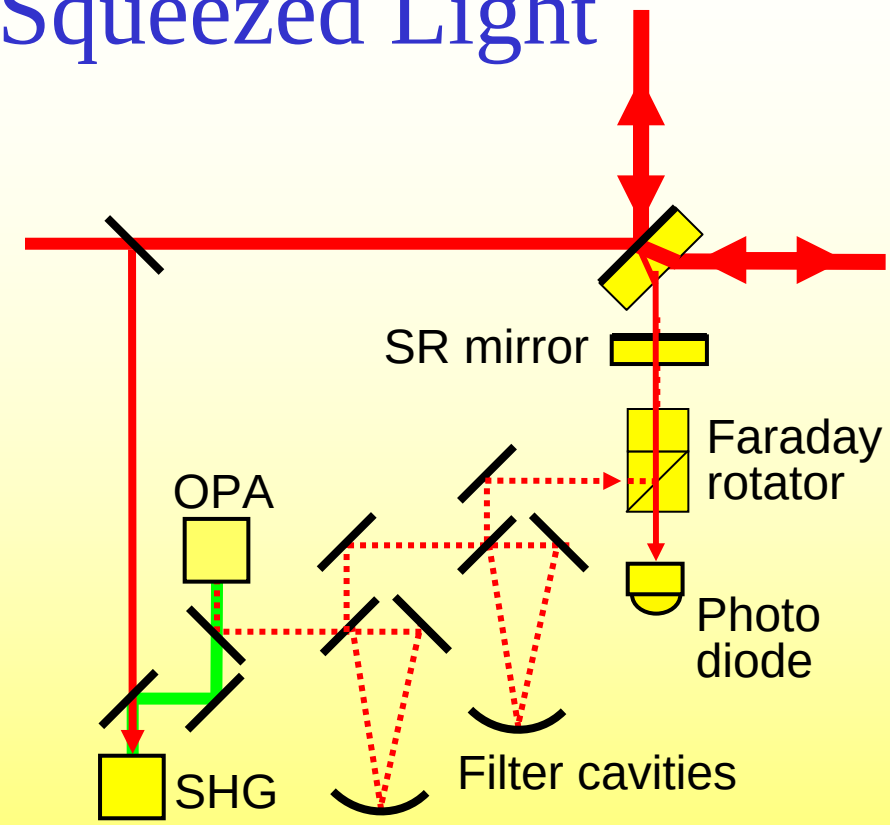
Optical Spring SR Interferometer

Optical Spring SR Interferometers



Frequency Dependent Squeezed Light

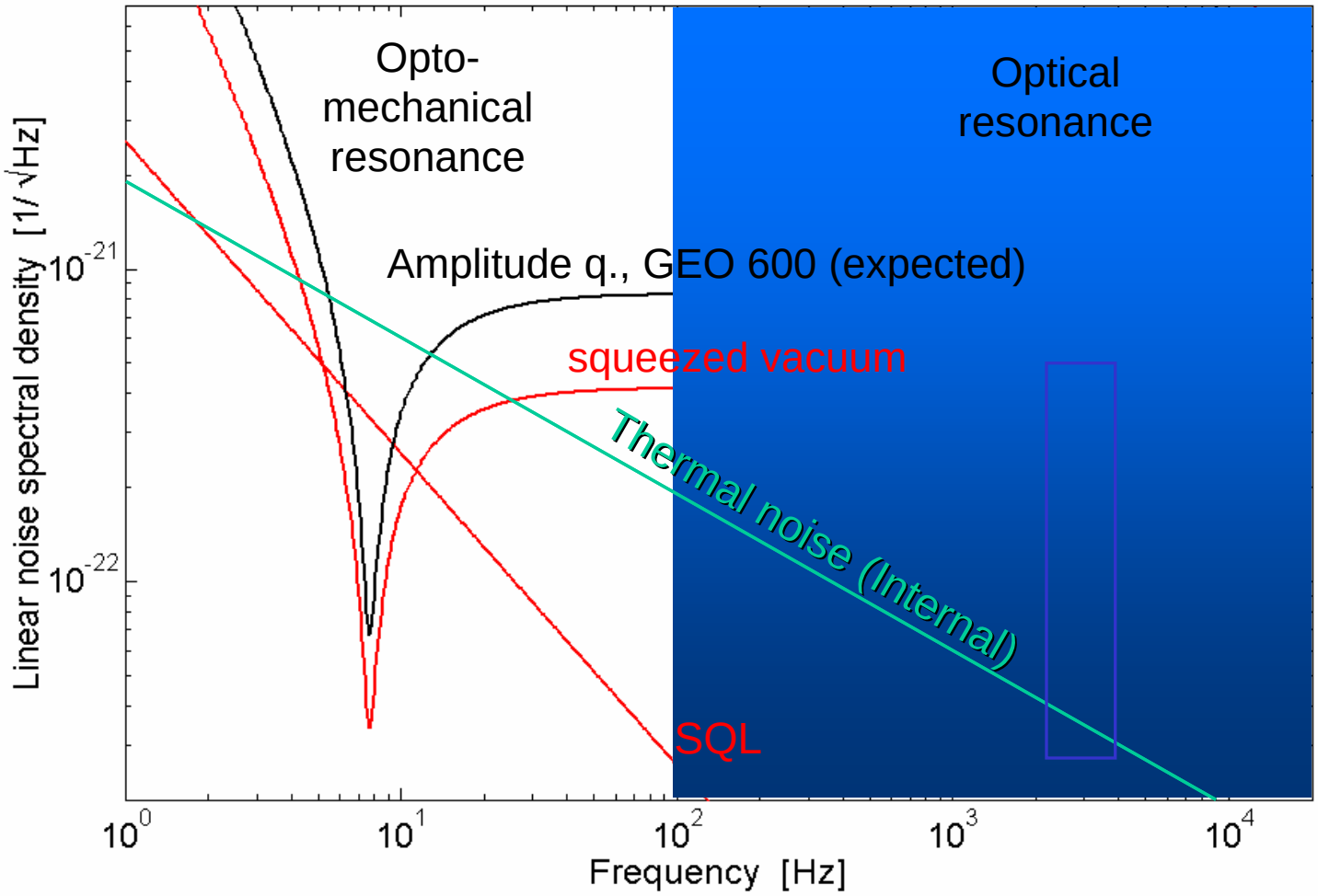




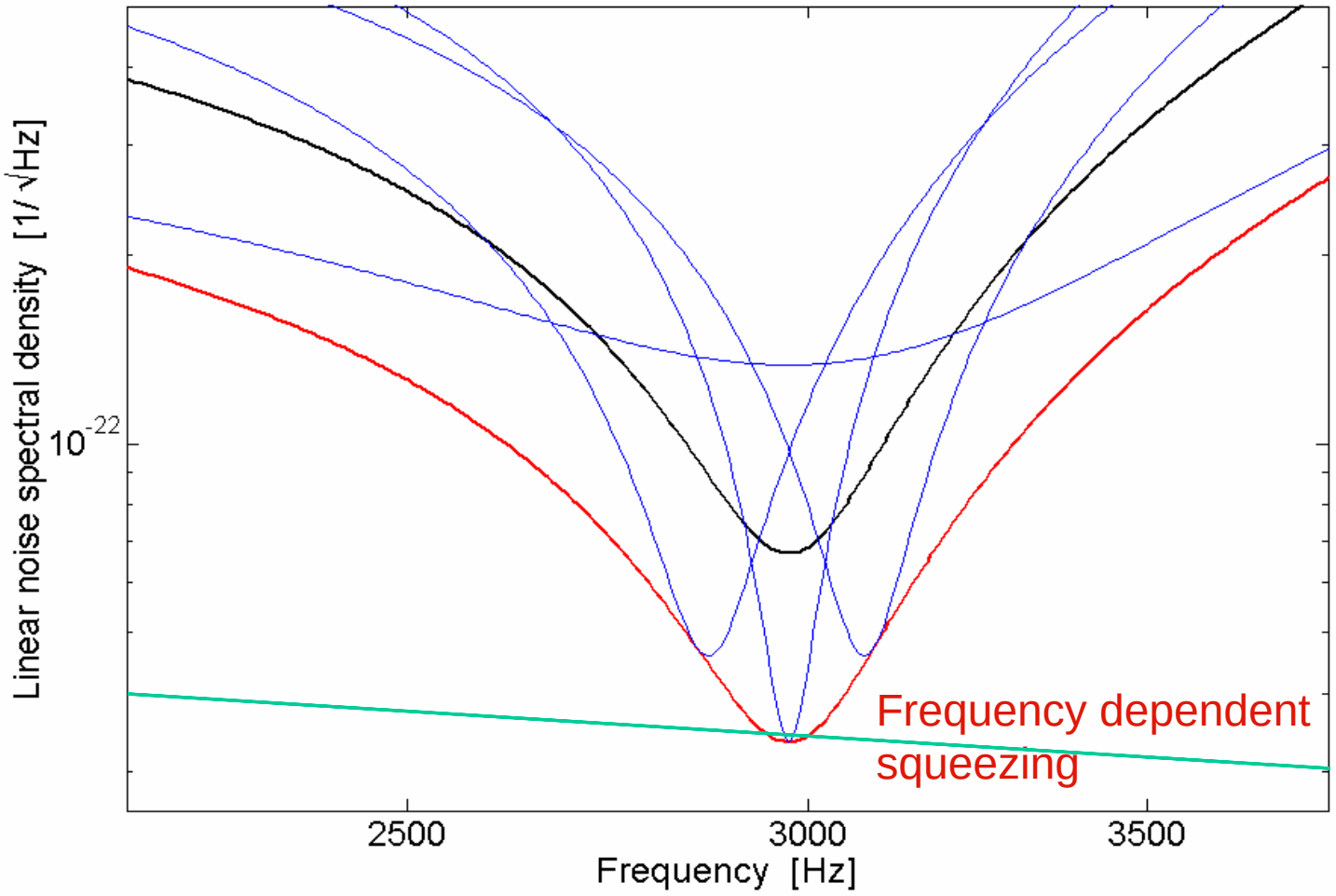
Reflecting squeezed light at two subsequent filter cavities provide the desired frequency dependence in the generic case (for fixed angle homodyne detection).

[Kimble *et al*., Phys. Rev. D 65, 022002 (2001)], [Harms *et al*., Phys. Rev. D 68, 042001 (2003)].

Frequency Dependent Squeezing of Shot-noise



Frequency Dependent Squeezing of Shot-noise



Rotation of Quadrature Amplitudes

$$\hat{a}_1 = \frac{\hat{a}(\omega_0+\Omega)+\hat{a}\ (\omega_0-\Omega)}{\sqrt{2}}$$ Amplitude quadrature

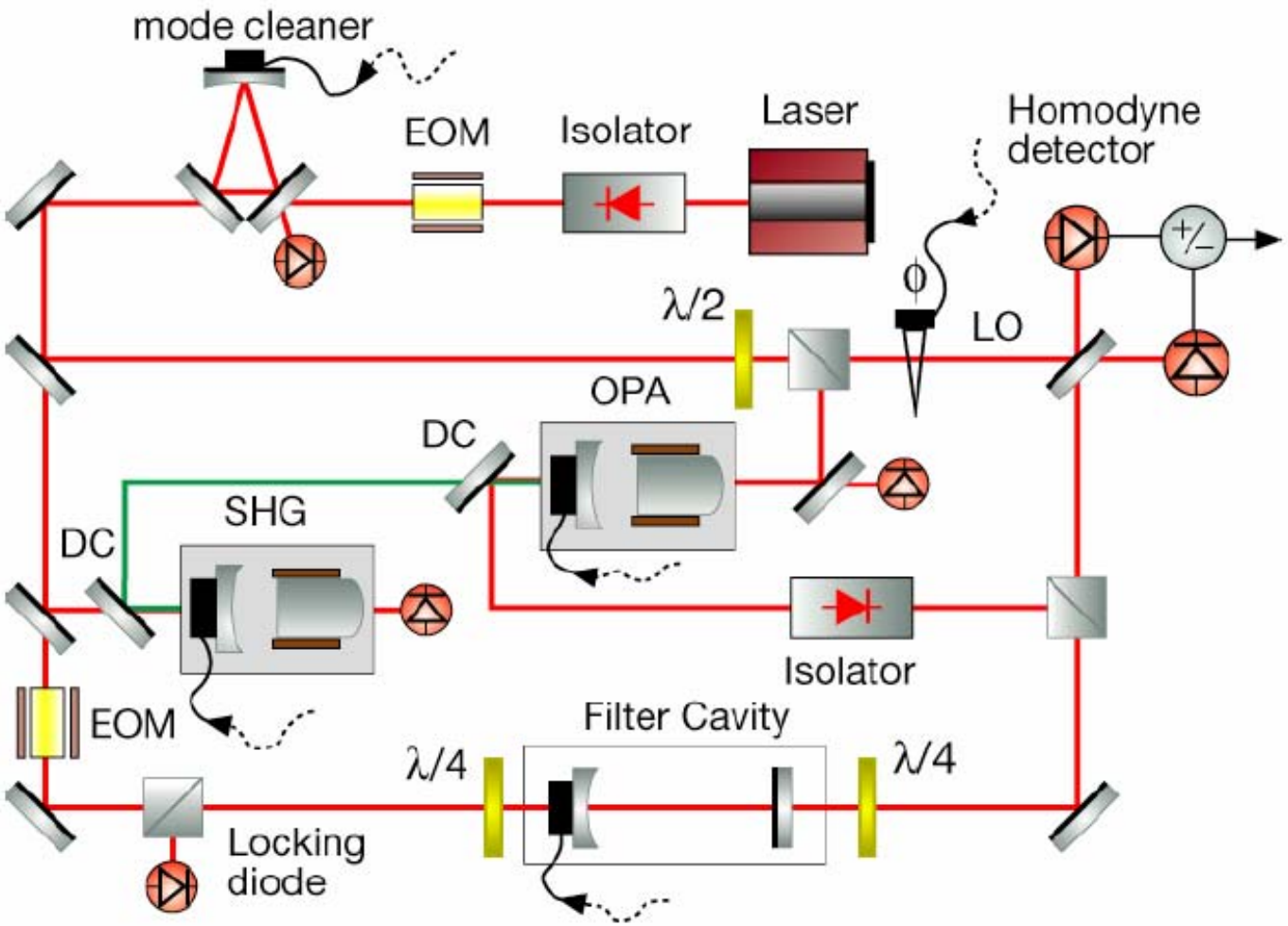
$$\hat{a}_2 = \frac{\hat{a}(\omega_0+\Omega)-\hat{a}\ (\omega_0-\Omega)}{i\sqrt{2}}$$ Phase quadrature

$$\hat{a}_\theta = \frac{\hat{a}(\omega_0+\Omega)e^{+i\theta}+\hat{a}\ (\omega_0-\Omega)e^{-i\theta}}{\sqrt{2}}$$ θ quadrature

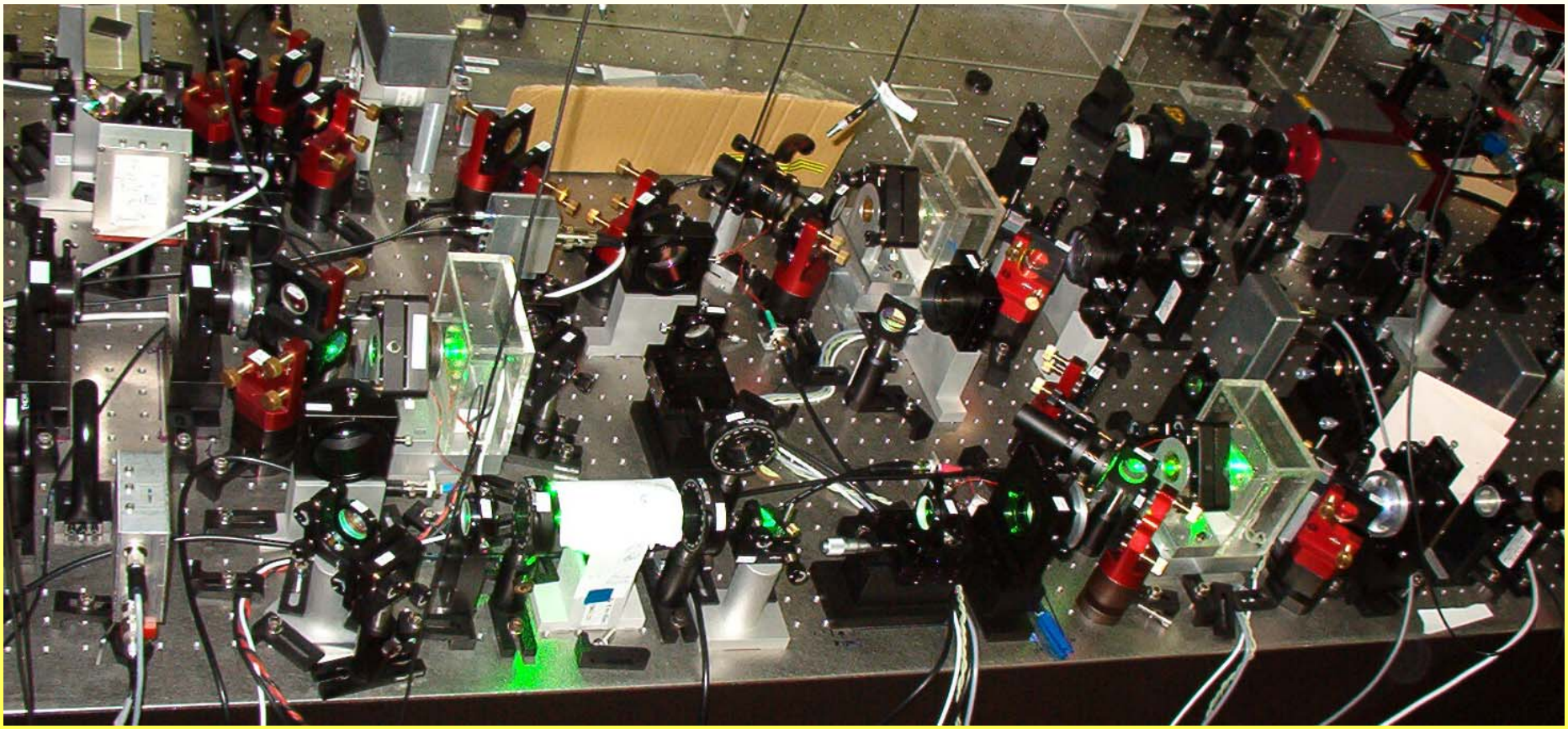
$$\hat{a}_{\theta'} = \frac{\hat{a}(\omega_0+\Omega)e^{+i\theta}+\hat{a}\ (\omega_0-\Omega)e^{-i(\theta+\Phi)}}{\sqrt{2}}$$ Angle rotated by Φ/2

$$= \frac{e^{-i\Phi/2}}{\sqrt{2}}\left(\hat{a}(\omega_0+\Omega)e^{+i\theta'}+\hat{a}\ (\omega_0-\Omega)e^{-i\theta'}\right) \quad , \quad \theta' = \theta+\Phi/2$$

Generation of Frequency Dependent SQZ



Squeezed Light Generation



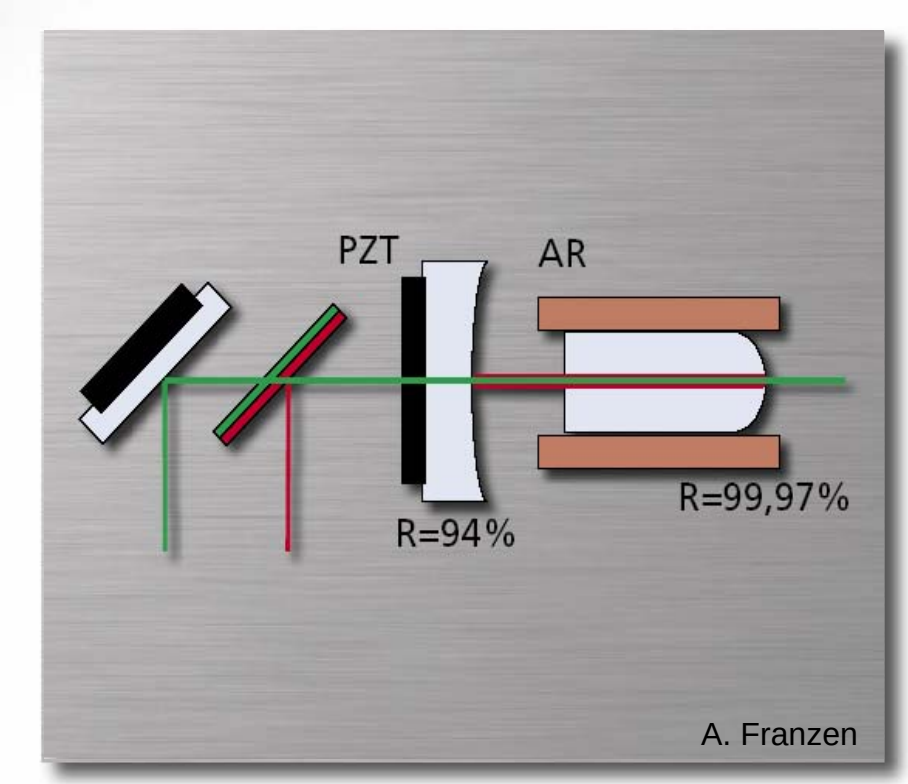
Squeezed Light Generation

OPA layout

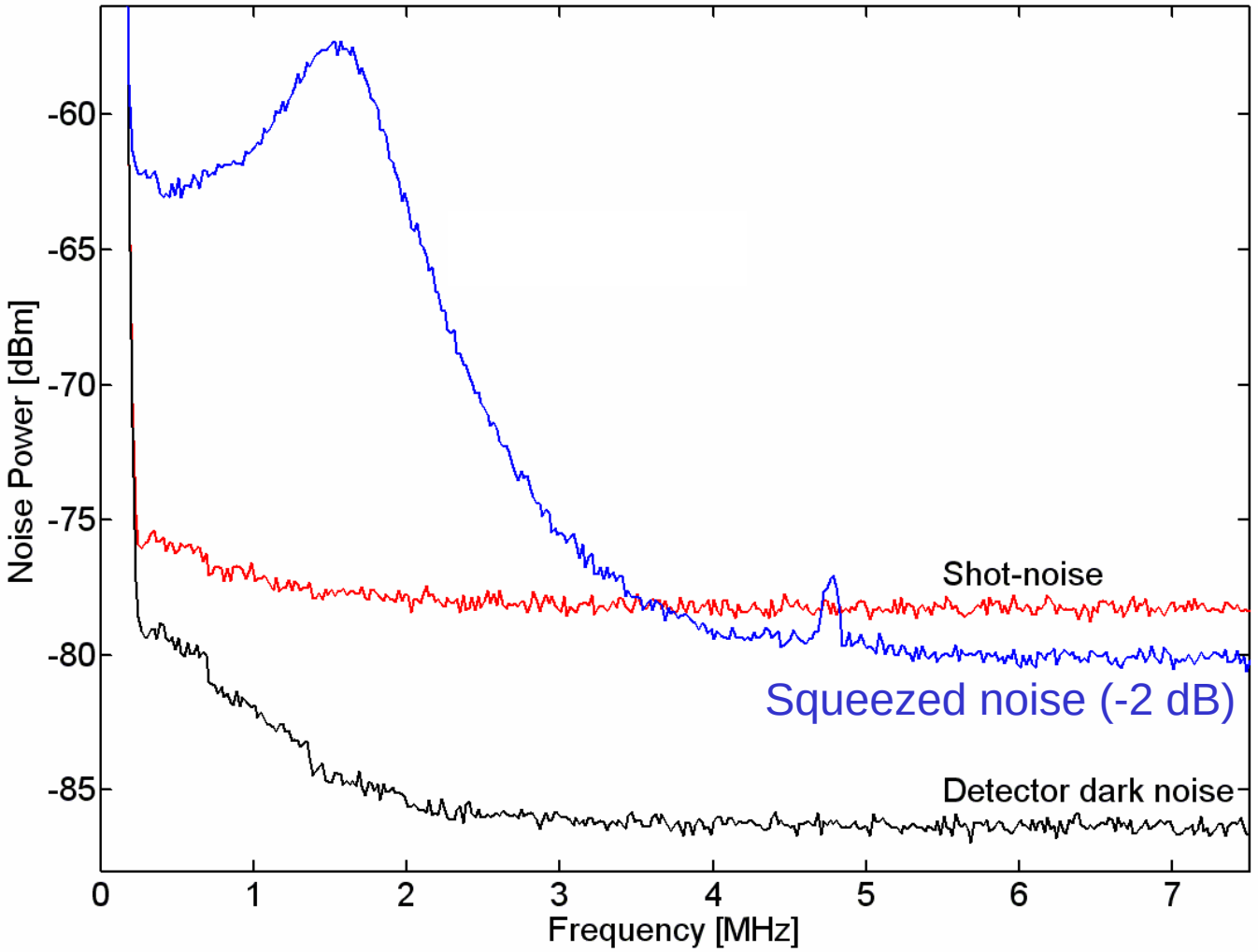
MgO LiNO – hemilithic crystal
7.5mm x 5mm x 2.5 mm

Radius of curvature: 10 mm
HR=99.97% at 1064 nm
Flat surface
AR at 1064 nm and 532 nm

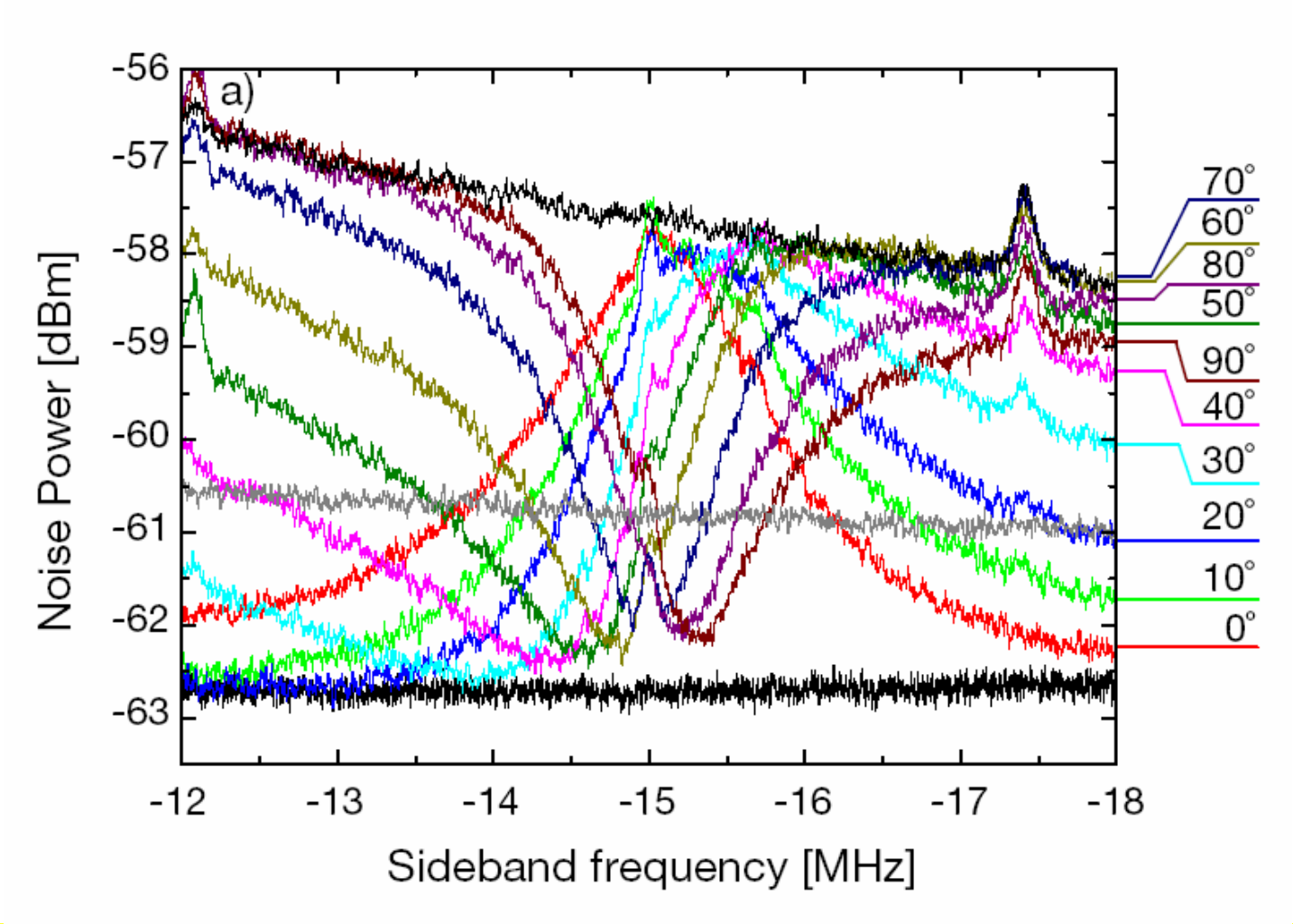
Output coupler:
R=94% at 1064 nm
Finesse ~ 100
Waist ~ 32 μm
FSR ~ 9 GHz
γ = 90 MHz



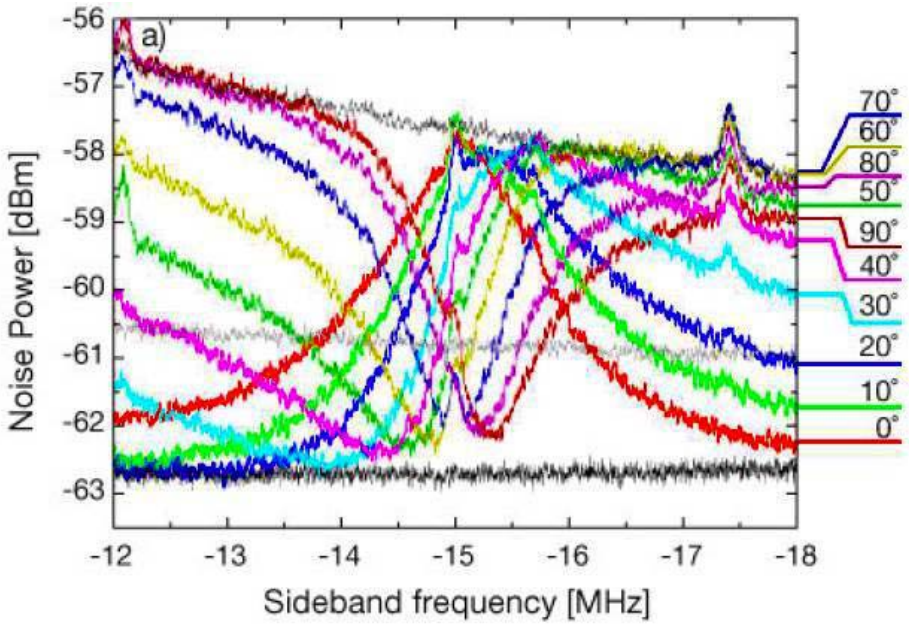
Locked Amplitude Squeezed Spectrum

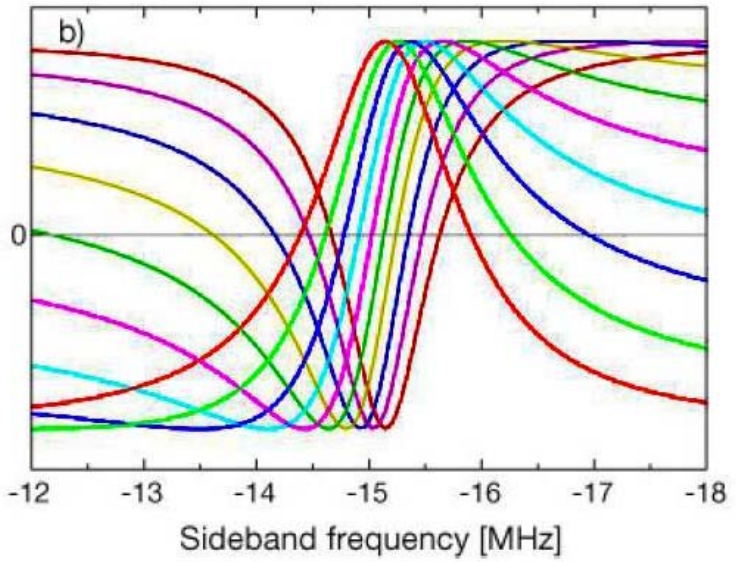


Frequency Dependent Squeezing Spectrum

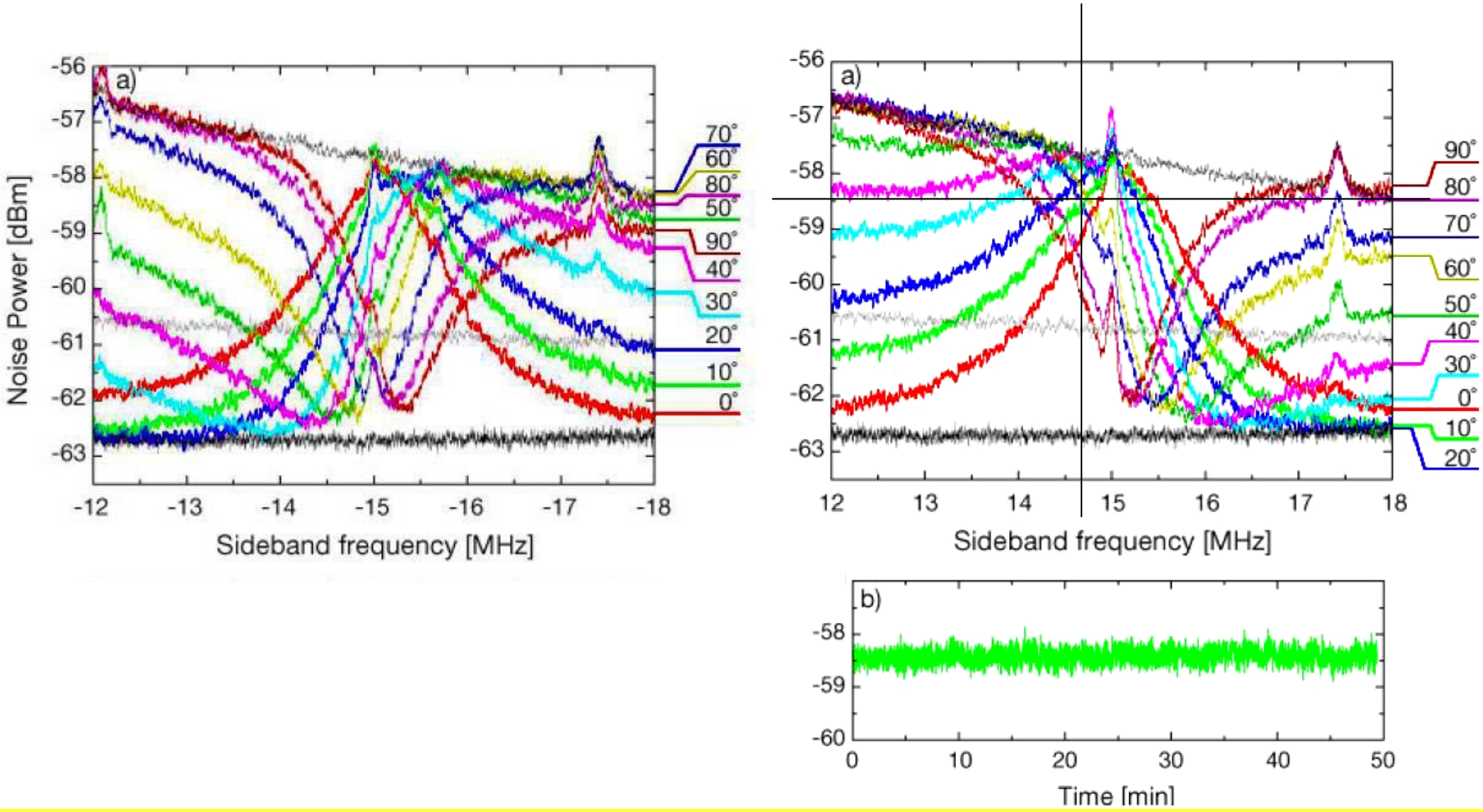


Frequency Dependent Squeezing Spectrum

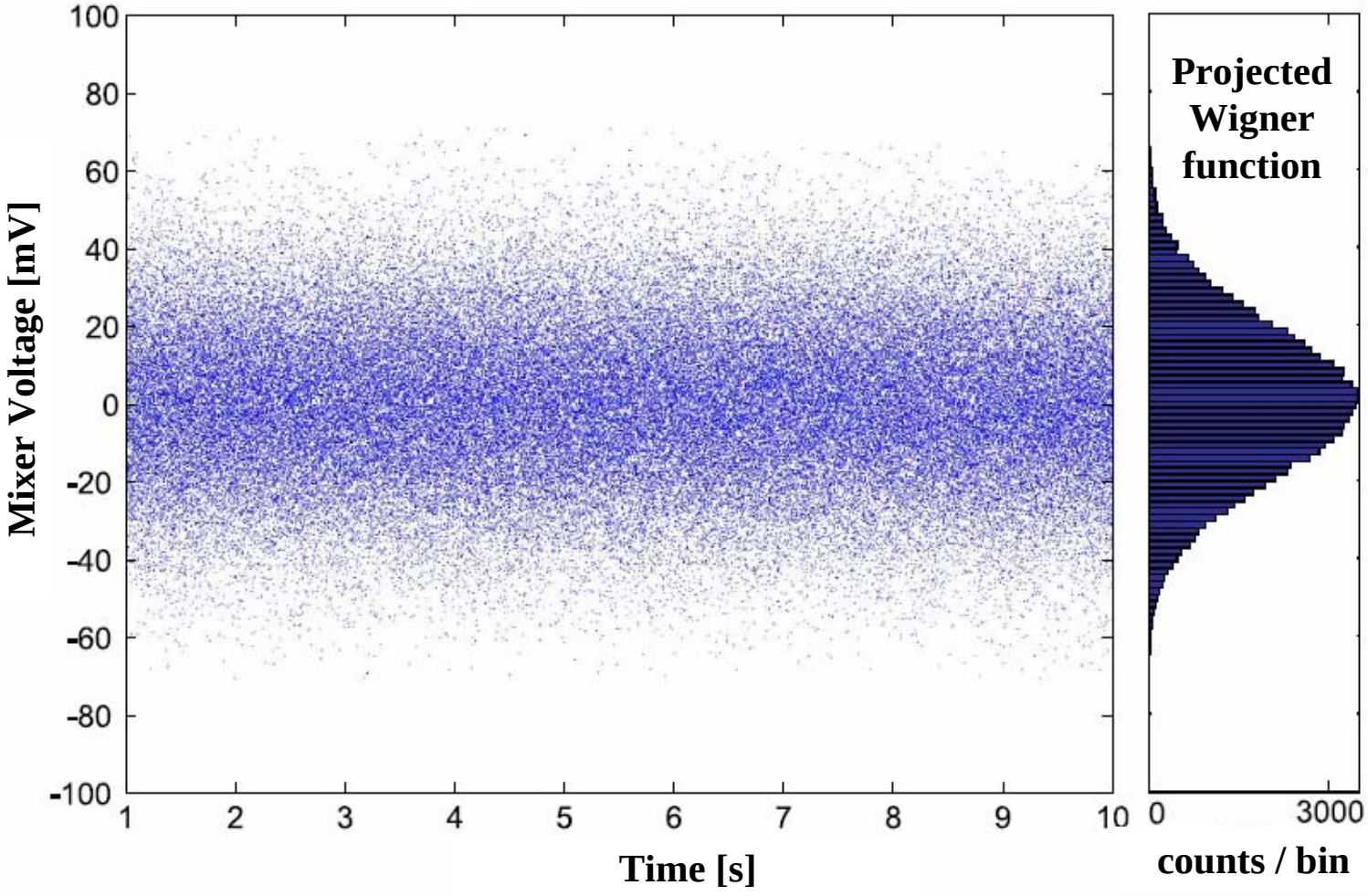




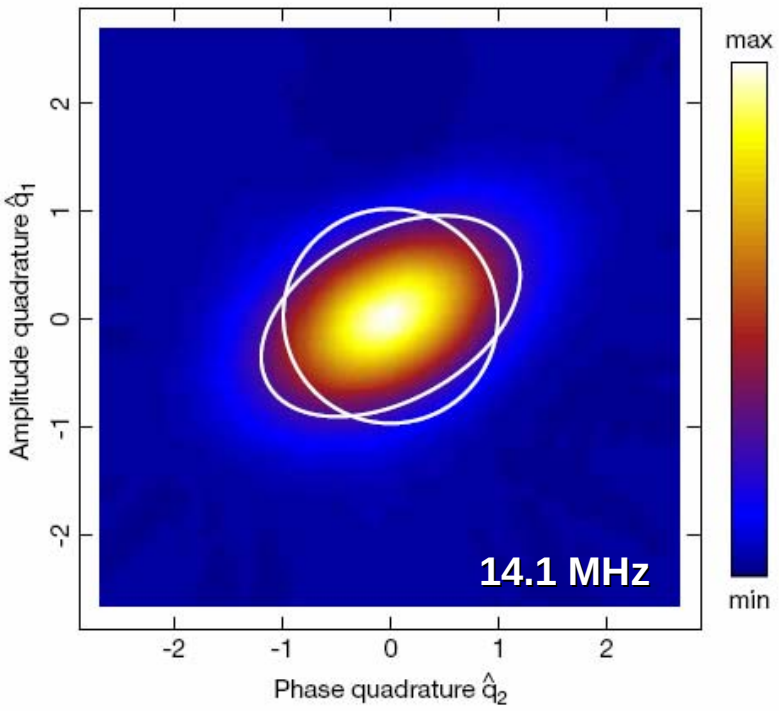
Frequency Dependent Squeezing Spectrum

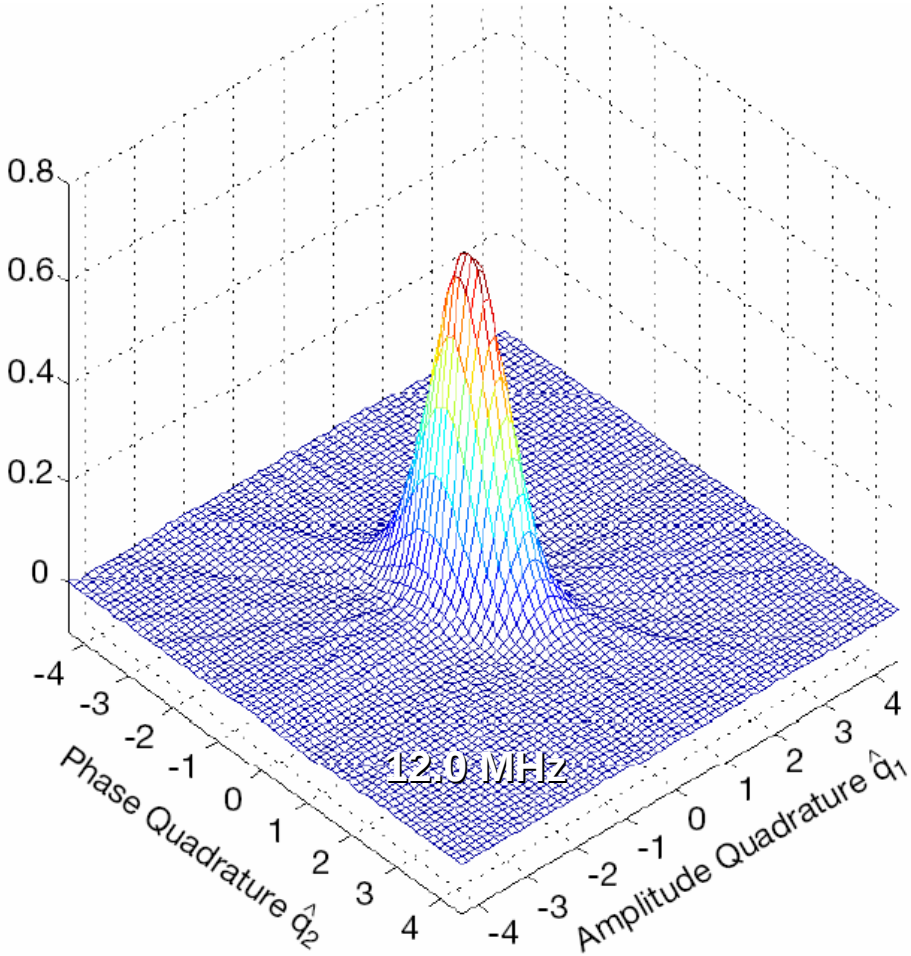


Tomography - Quadrature Noise Histogram

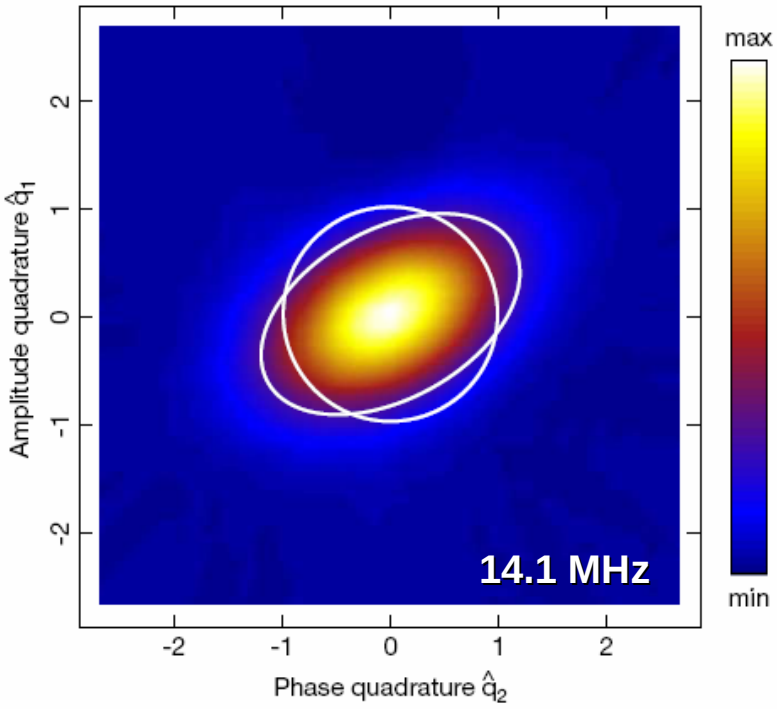


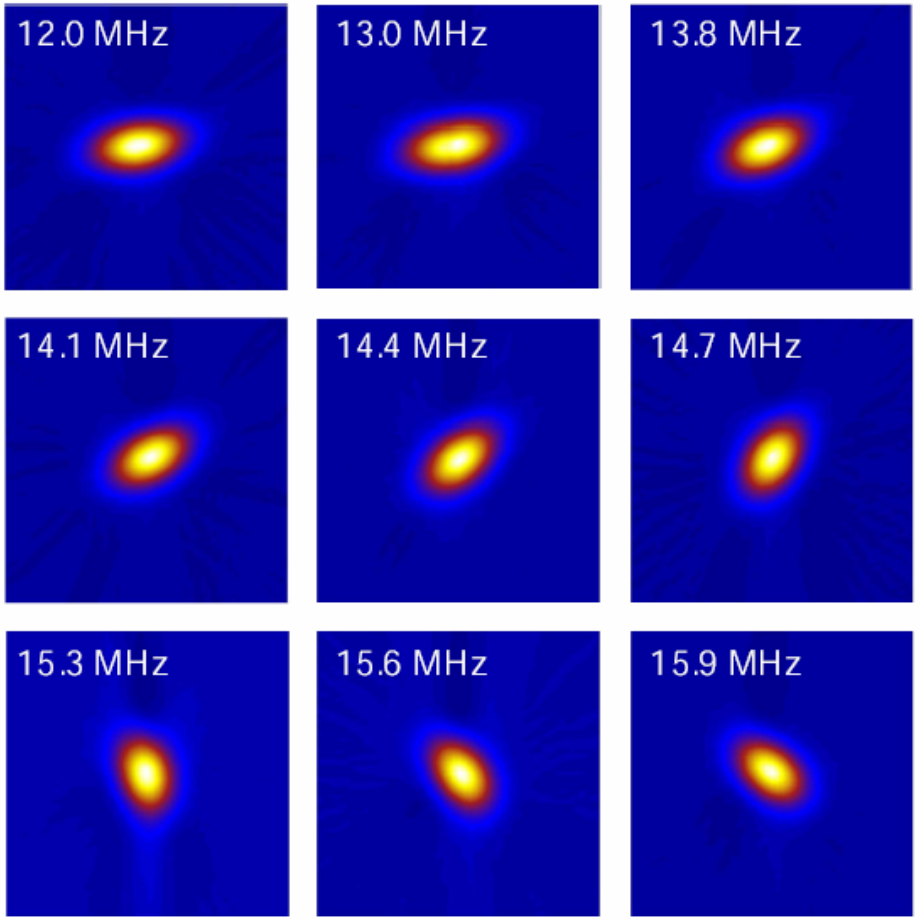
Tomography - Wigner Function Plots





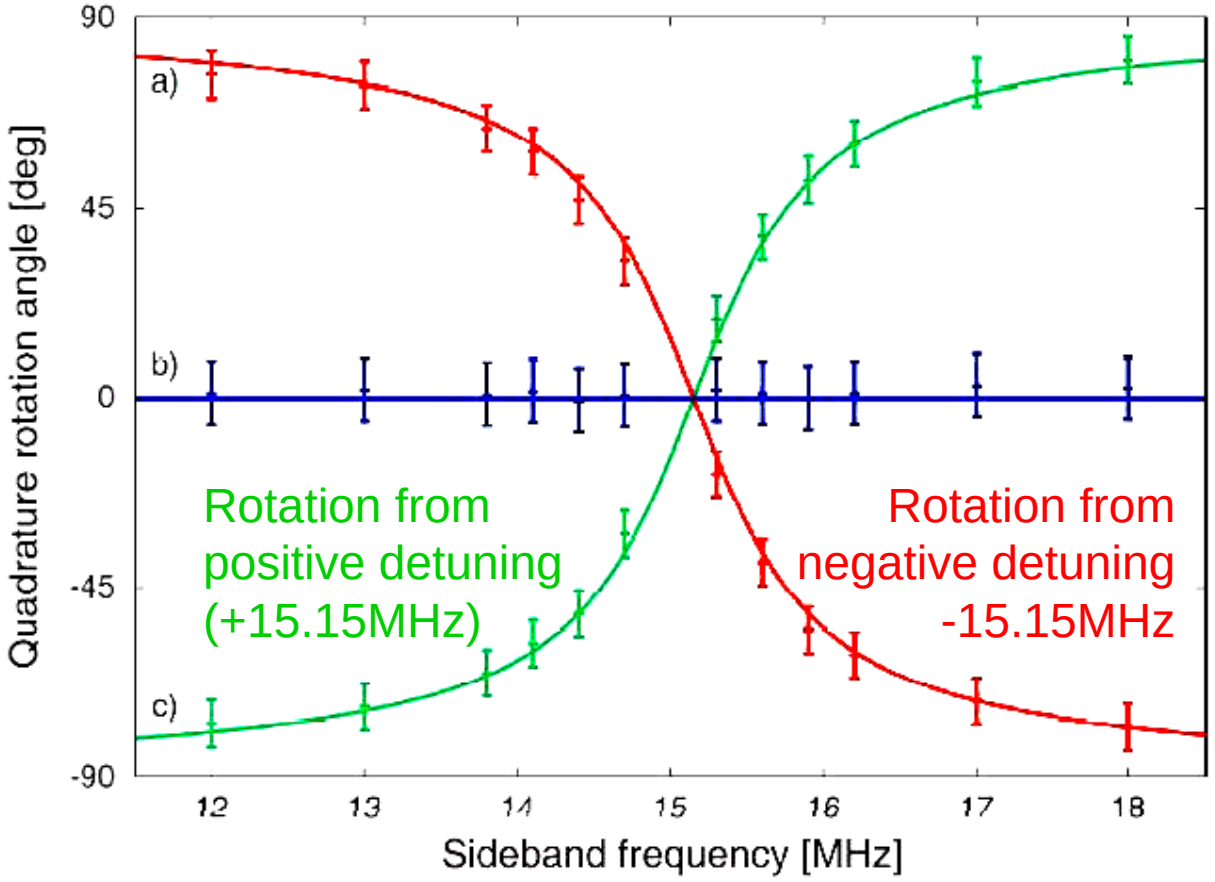
Tomography - Wigner Function Plots





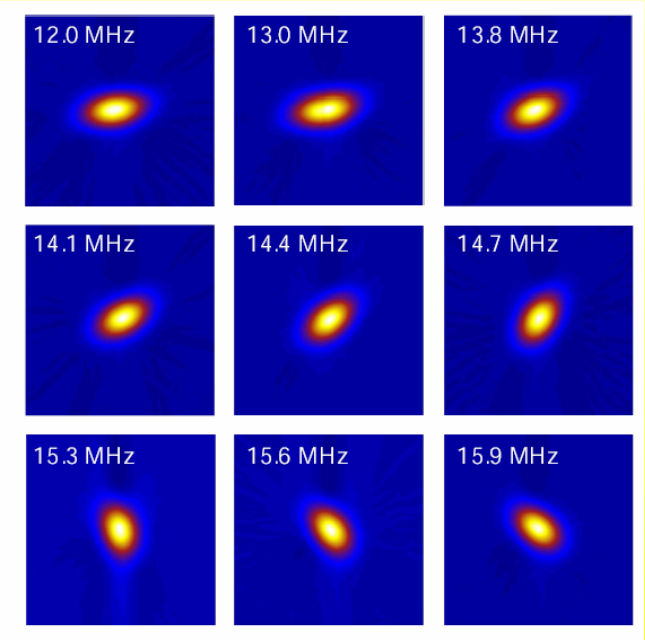
[Chelkowski *et al.*, Phys. Rev. A 71, 013806 (2005)].

Cancellation of Frequency Dependence



Summary

- Demonstration of frequency dependent squeezed light in a fully controlled (locked) setup
- Characterization using quantum state tomography (also locked)
- Cooperation of two identical cavities with opposite detunings (filter cavity plus signal recycling cavity) has been inferred leading to a broadband noise reduction.



[Chelkowski *et al*., Phys. Rev. A 71, 013806 (2005)].