Control of dark state beating in PrYSO

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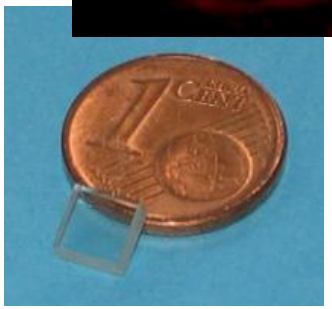
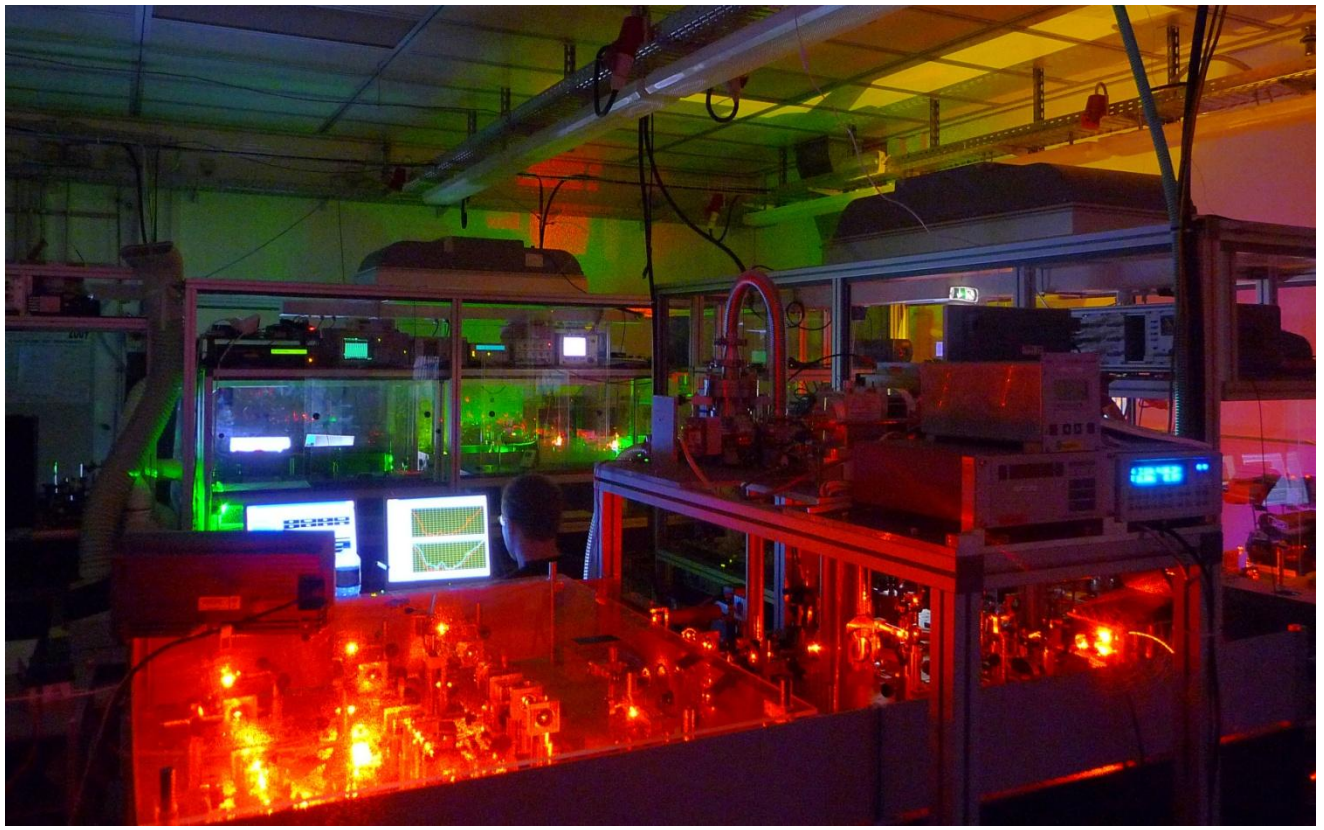


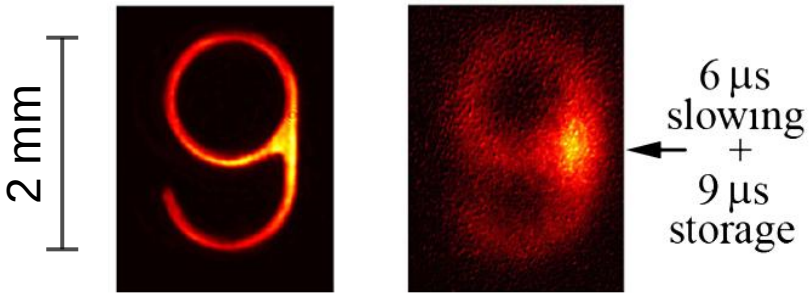


Motivation

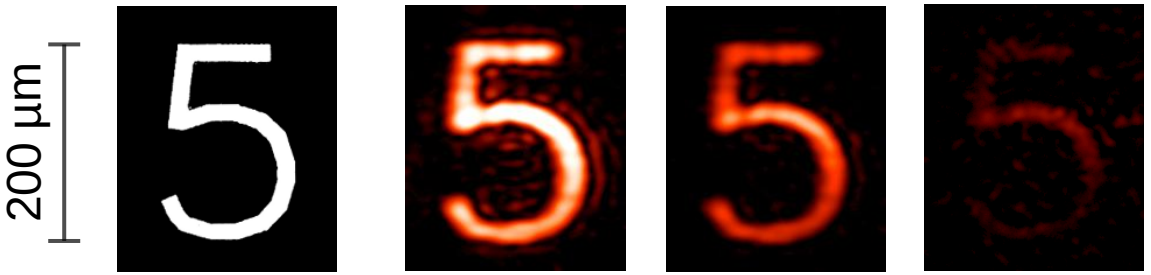
Remember: light / image storage by EIT

PRL 100, 223601 (2008)
PRA 81, 011401(R) (2010)

- Gas (Rb):

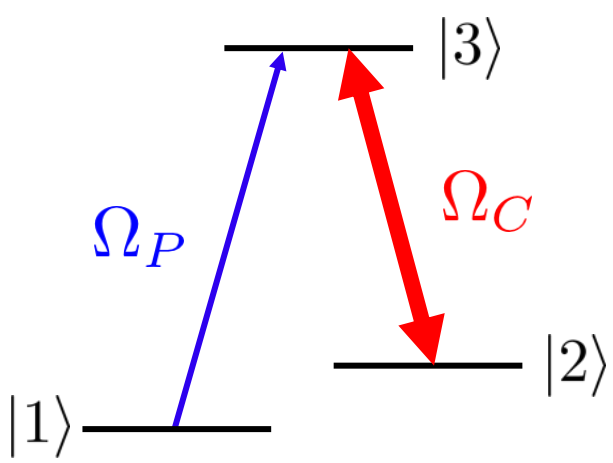


- PrYSO:

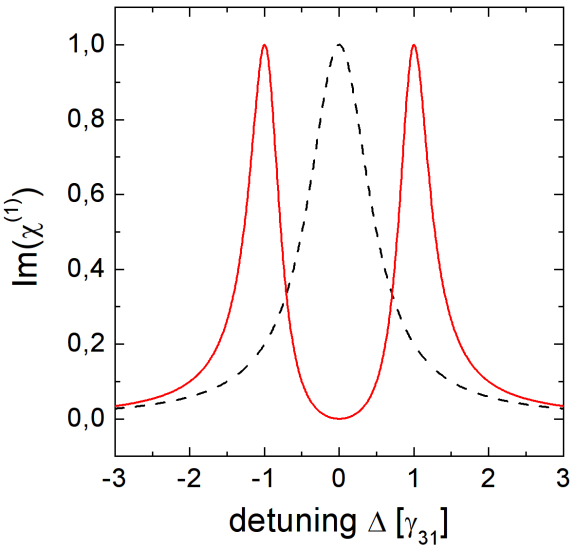


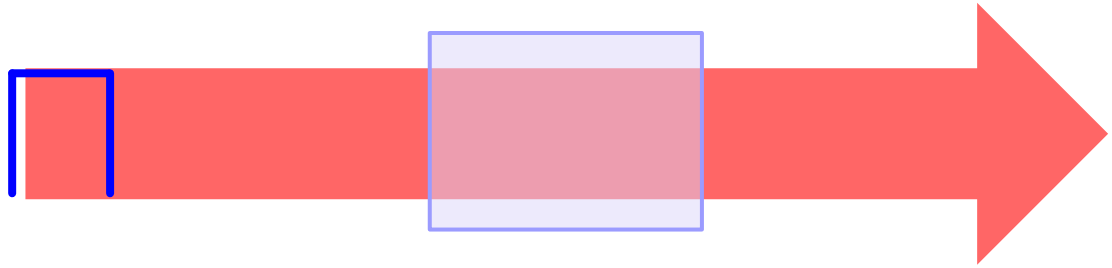
⇨ complete collapse at certain storage times
⇨ no simple exponential decay $\exp(-t/T_2)$

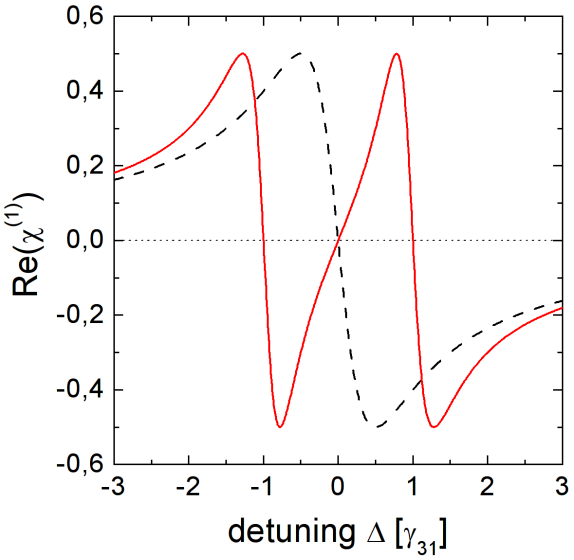
EIT & slow light



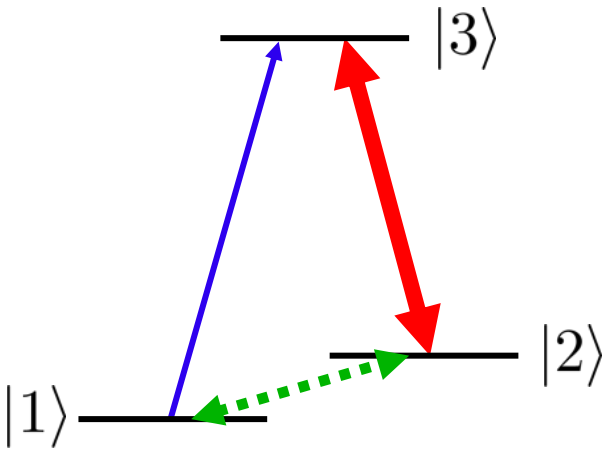
$$v_{gr} = \frac{c}{n + \omega \frac{\partial n}{\partial \omega}}$$







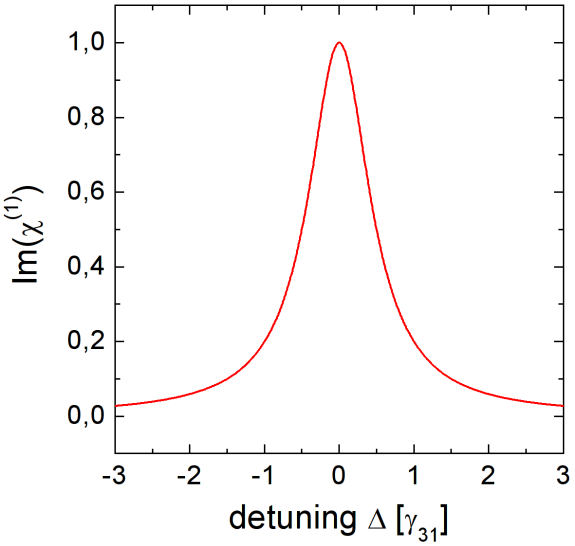
Light storage by EIT

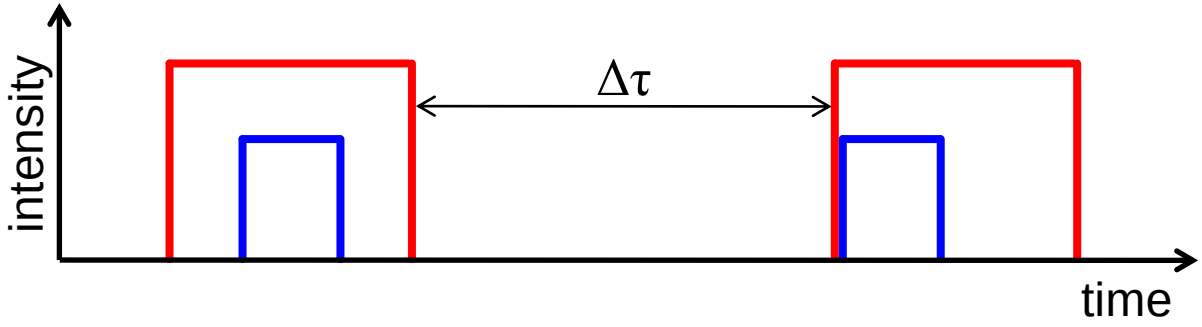


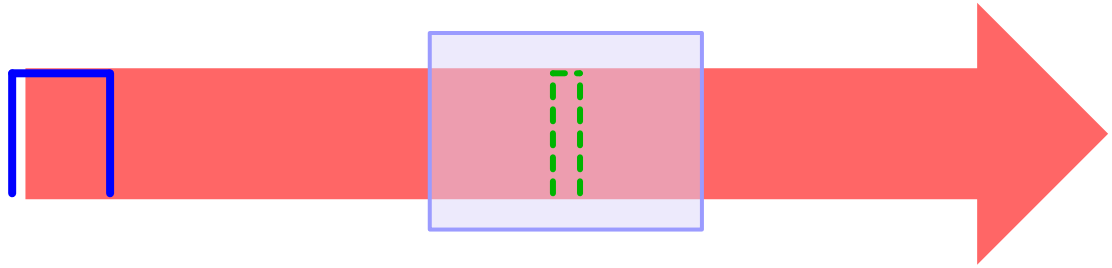
$$v_{gr} = \frac{c}{n + \omega \frac{\partial n}{\partial \omega}}$$

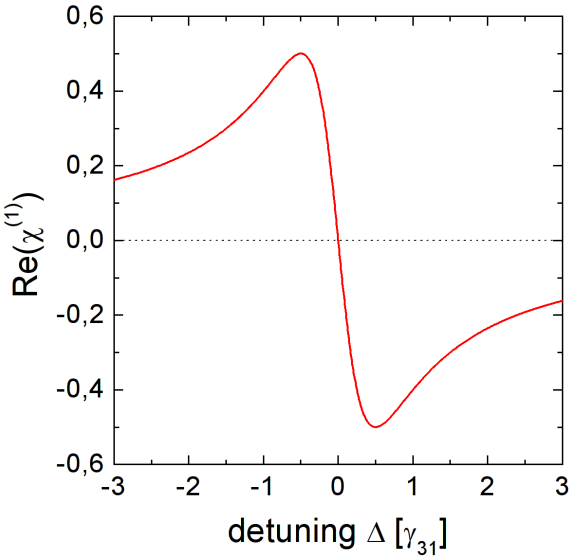
- coherence

$$\rho_{12} = \langle c_1^* c_2 \rangle$$

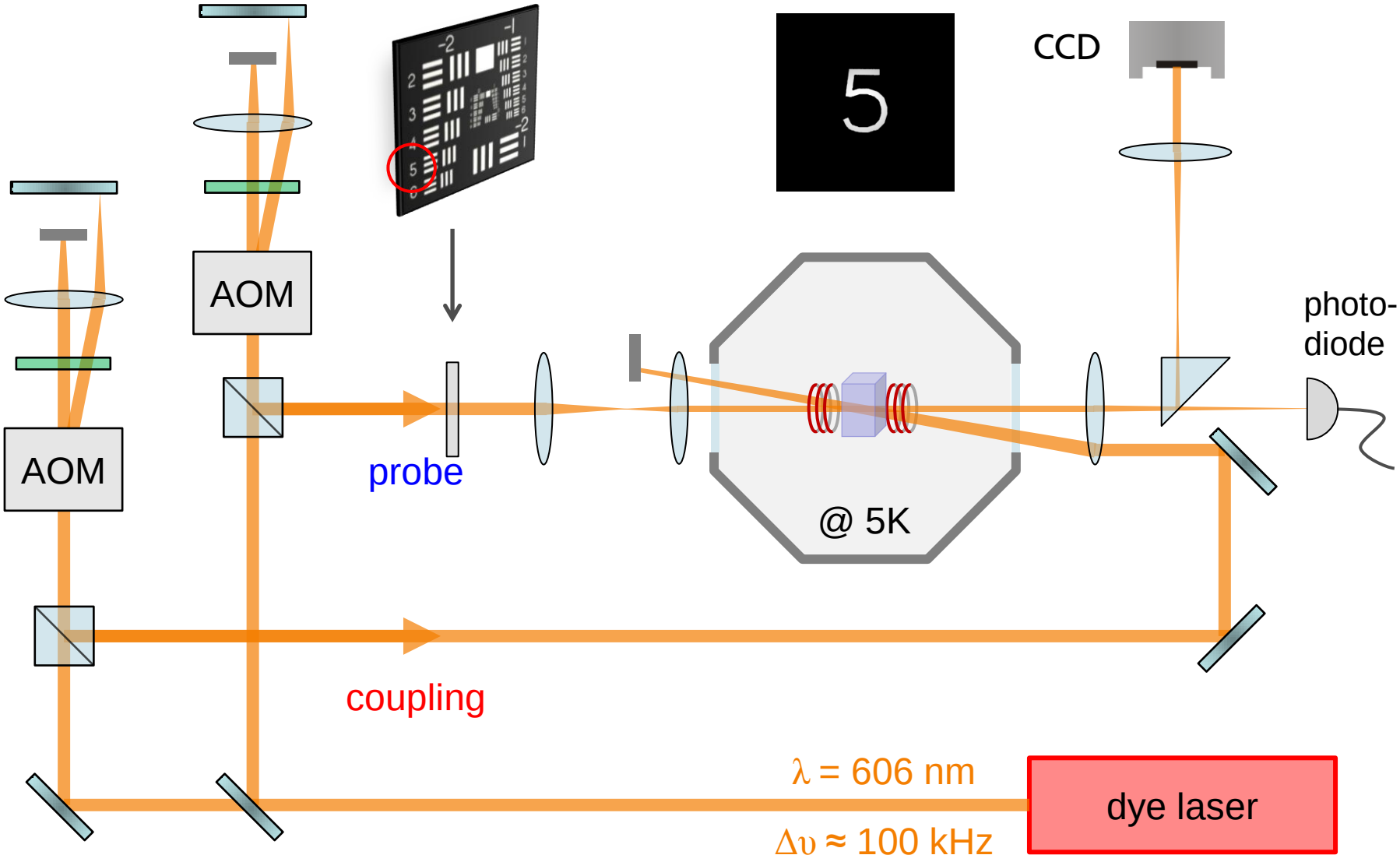






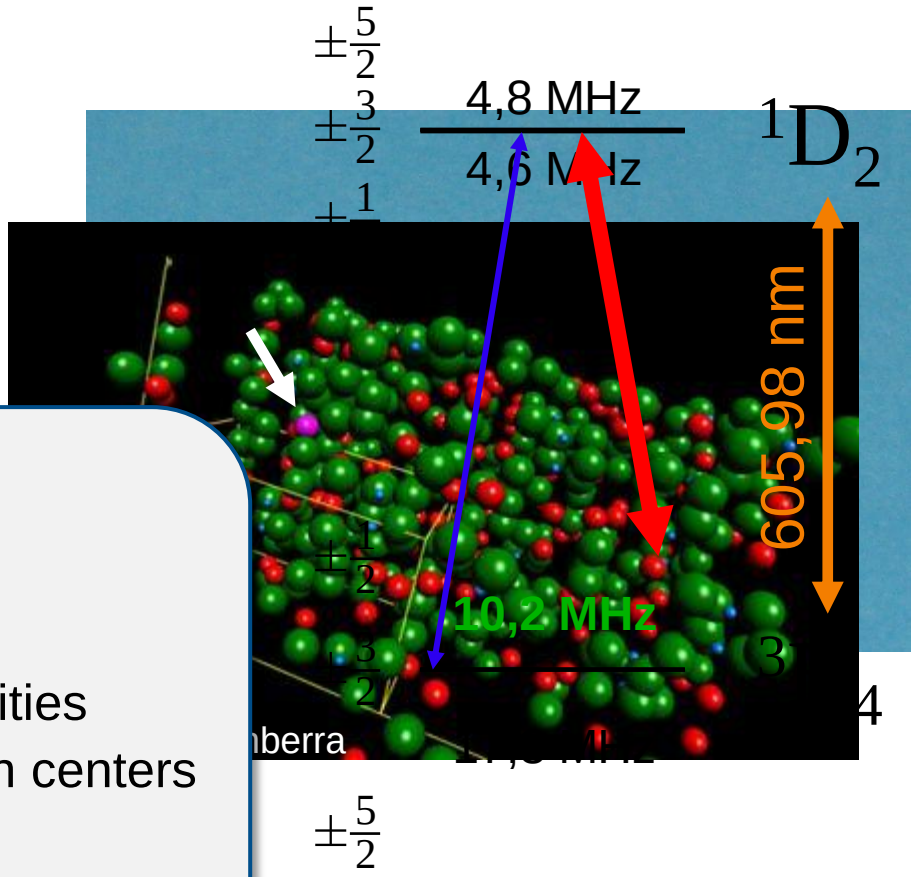


Experimental setup



The medium: $Pr^{3+}:Y_2SiO_5$

- $Pr^{3+}:Y_2SiO_5$ (0.02% dopant concentration)



timescales:

$T_1^* = 164\ \mu s$

$T_2^* = 111\ \mu s$

$T_1 \approx 100\ s$

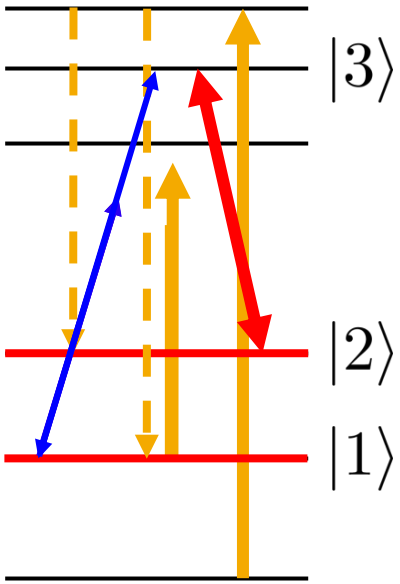
$T_2 \approx 500\ \mu s$

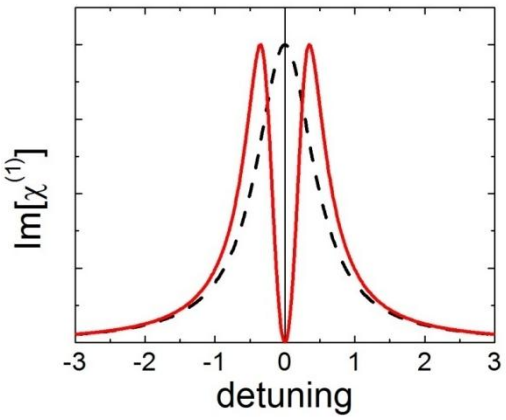
advantages:

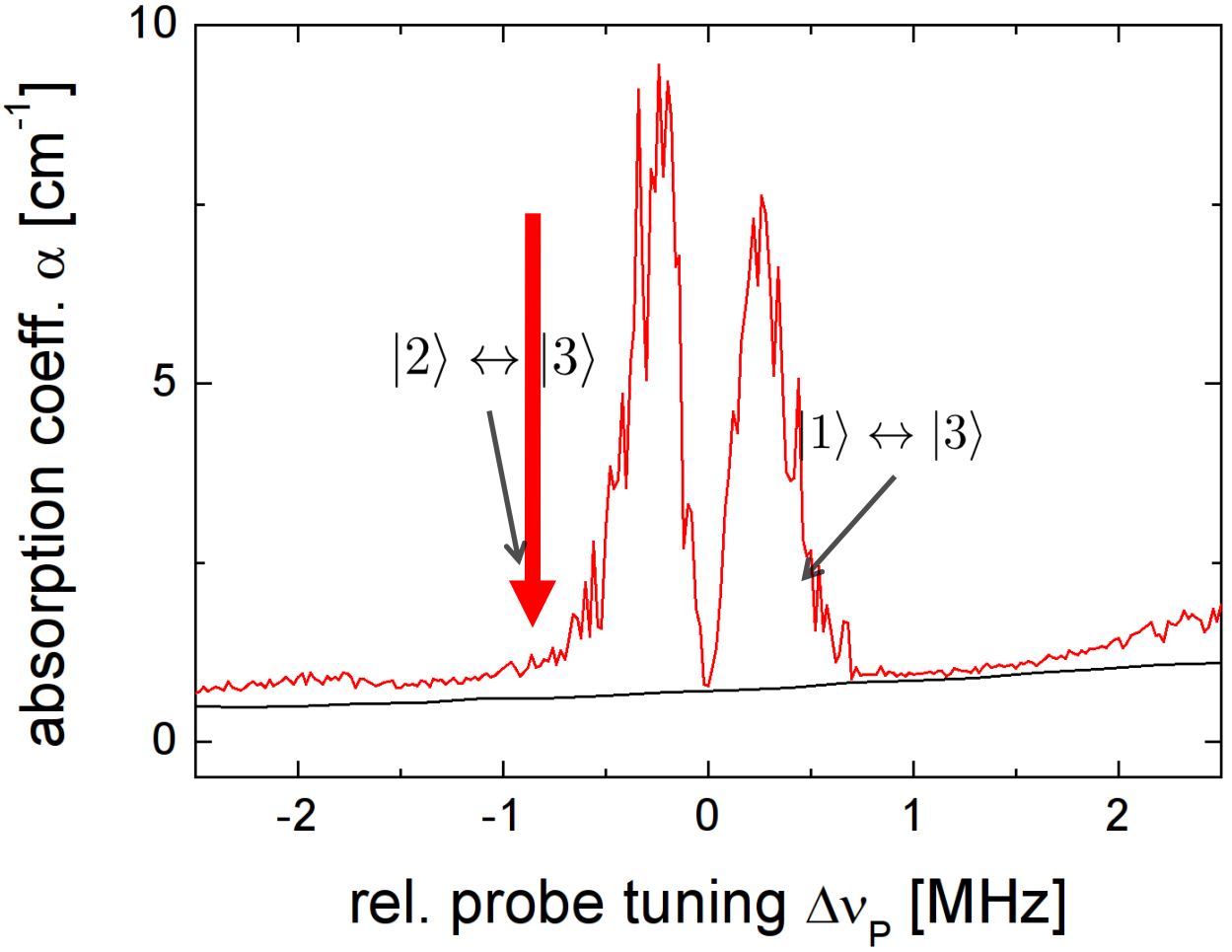
- high T_1 and T_2
- $\Delta\nu_{hom} \sim 3$ kHz
- large opt. densities
- fixed interaction centers

⇨ image storage

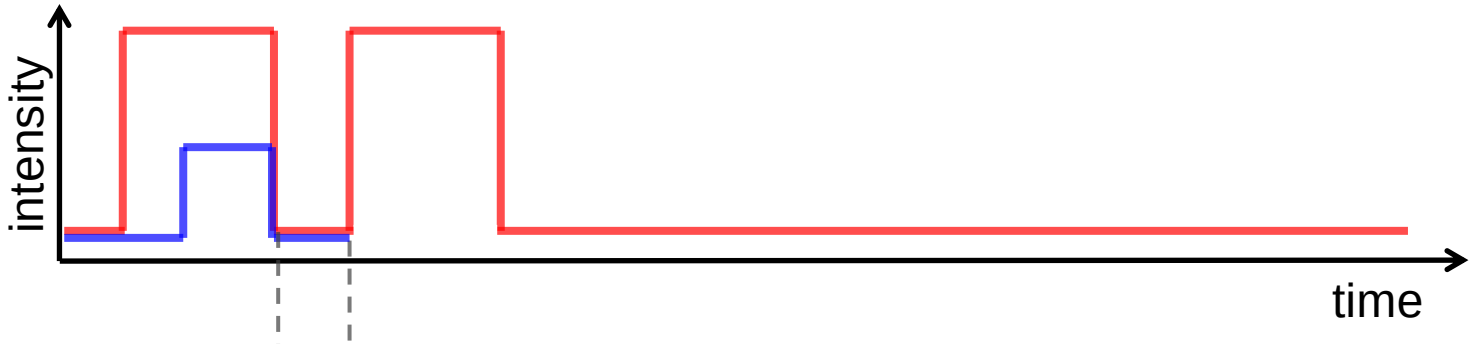
Preparation & EIT in $Pr^{3+}:Y_2SiO_5$

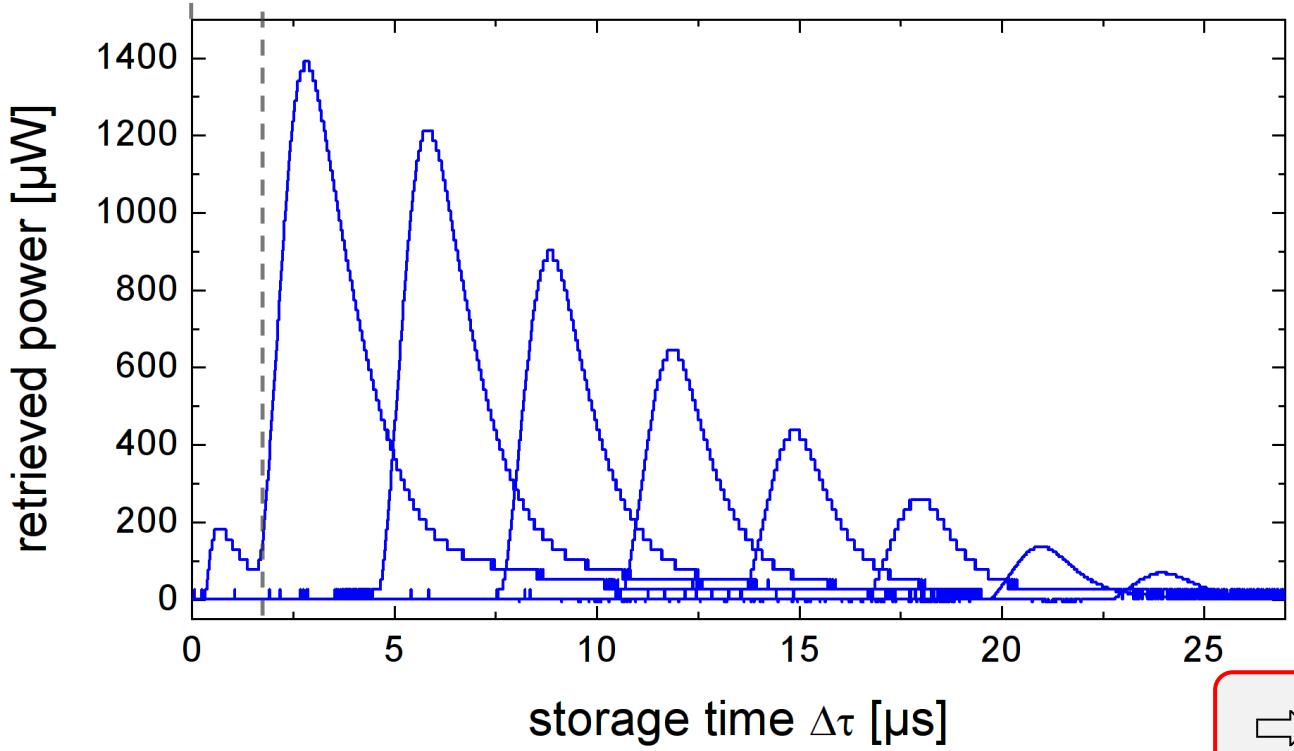


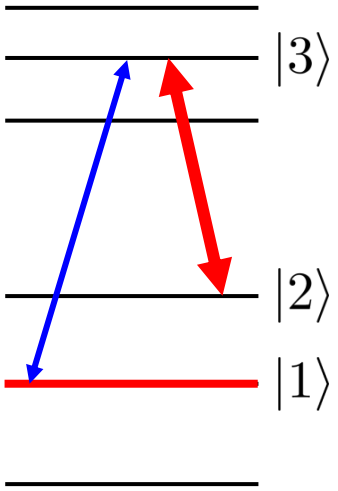




Light storage in $Pr^{3+}:Y_2SiO_5$

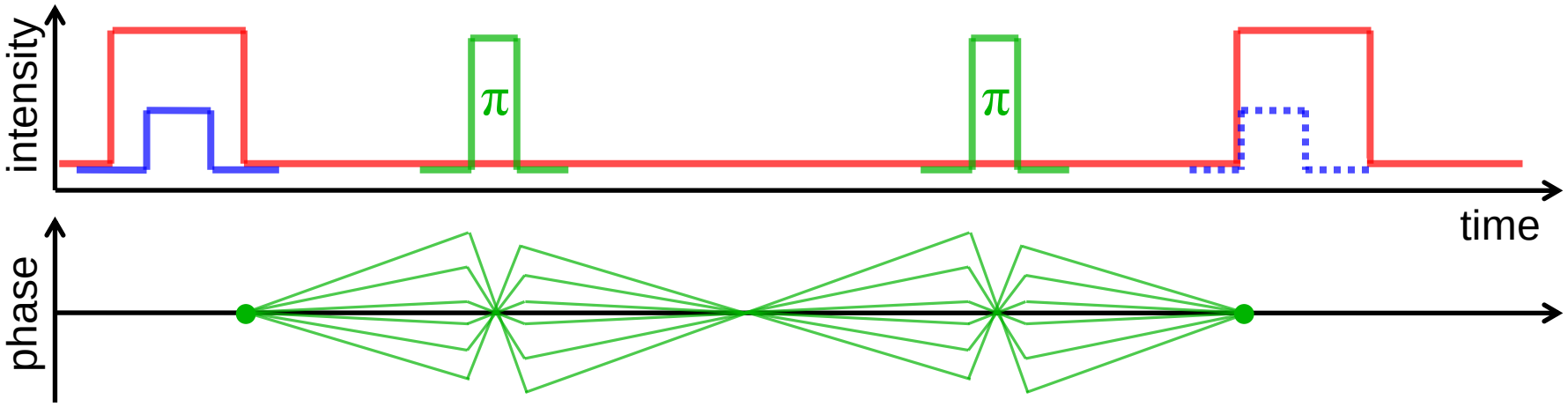






⇨ $\Delta\tau_{max} \approx 20\ \mu s$

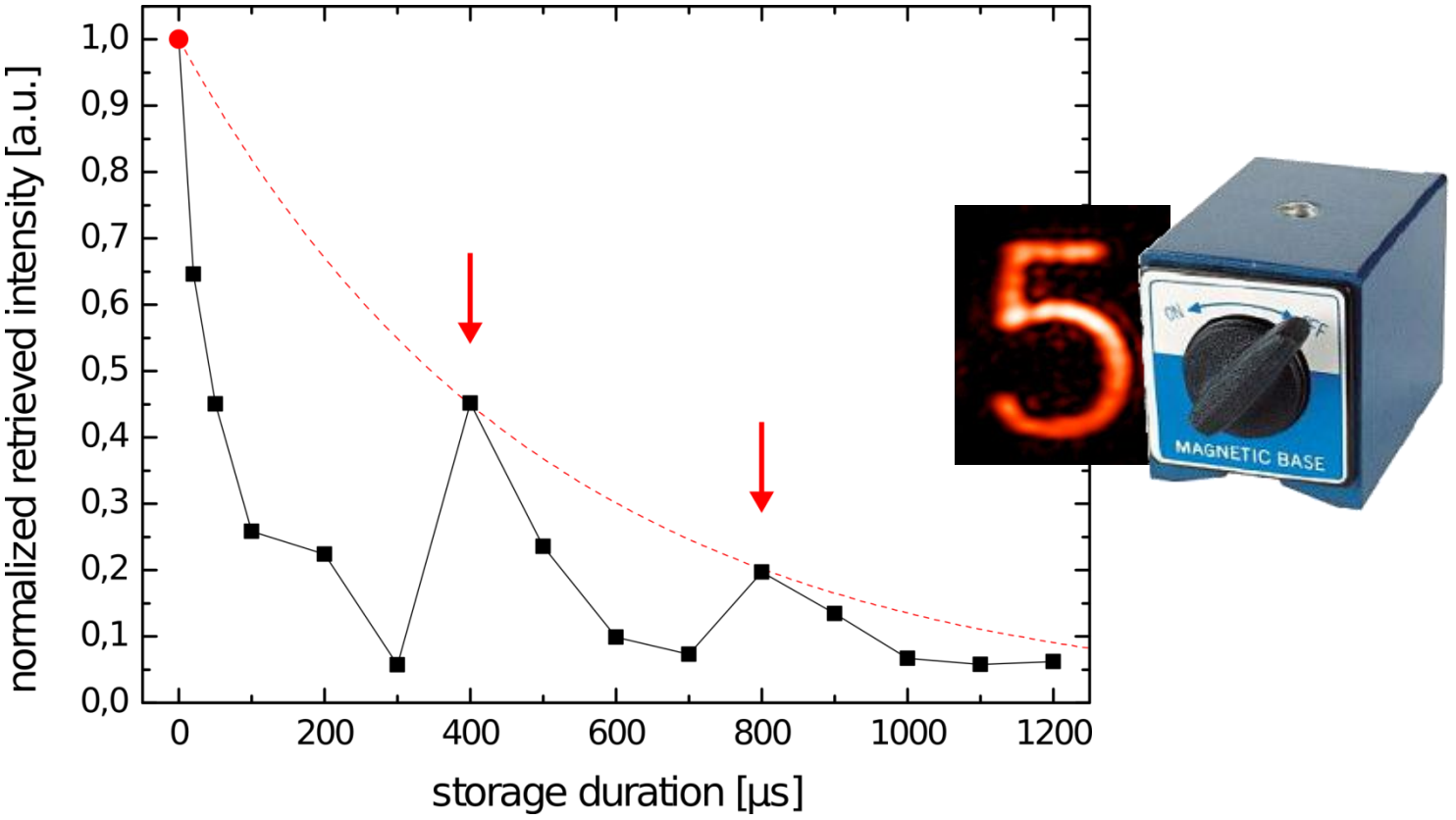
Image storage in PrYSO



direct image

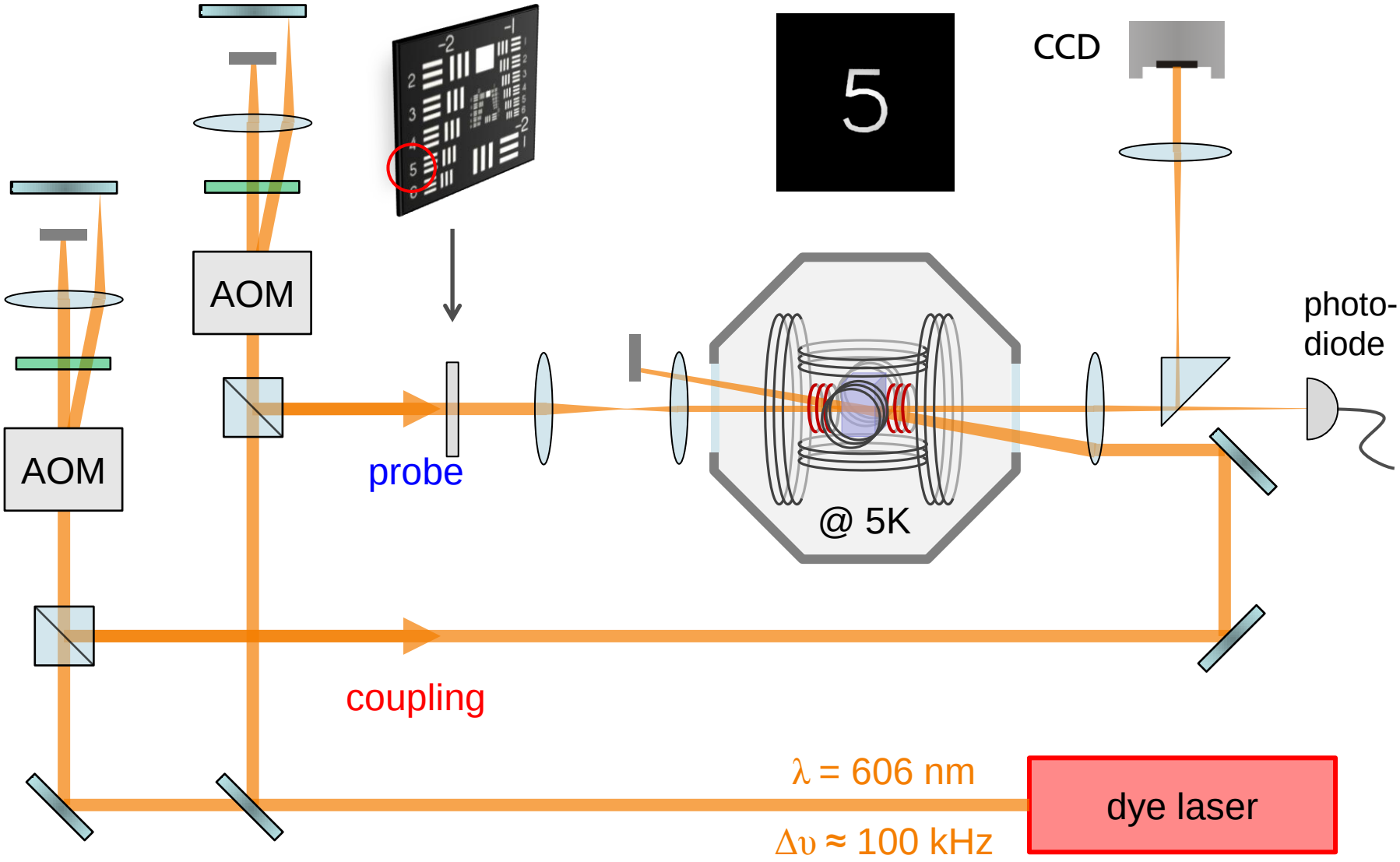
$\Delta\tau = 20\ \mu s$ (rephased!)

Time dependent readout

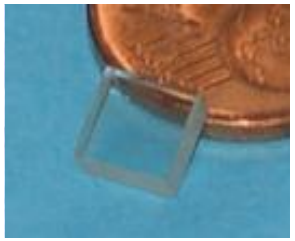


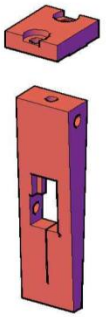
⇨ Oscillation of storage efficiency
⇨ dependent on magnetic fields !

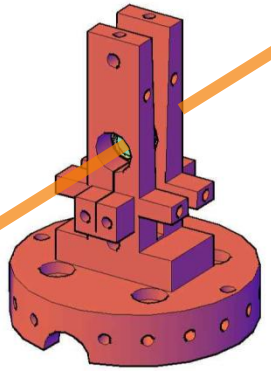
Experimental setup II

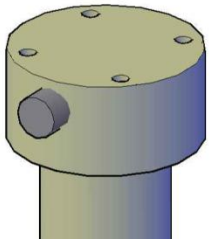


Inside the cryostat

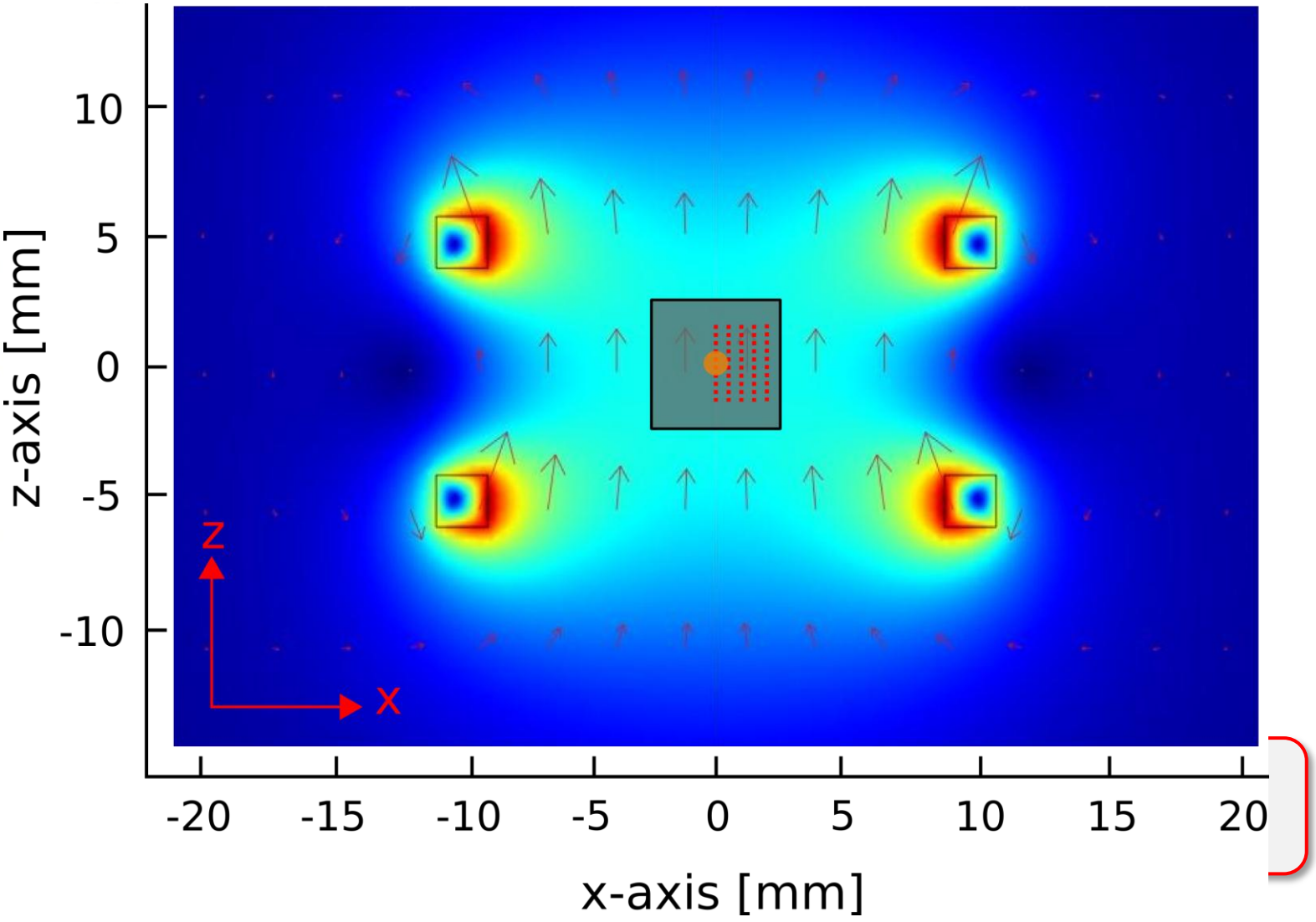




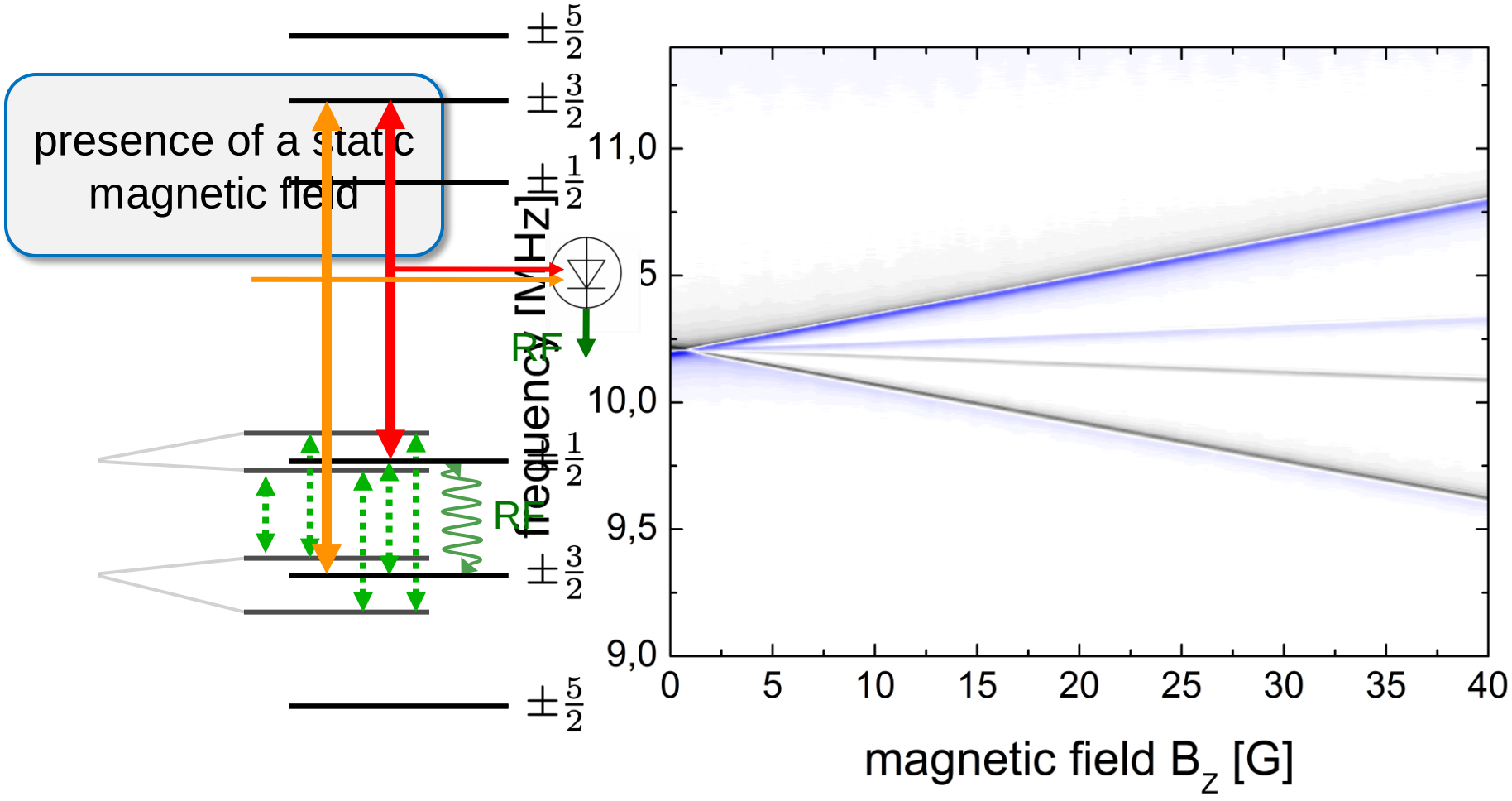




Inside the cryostat

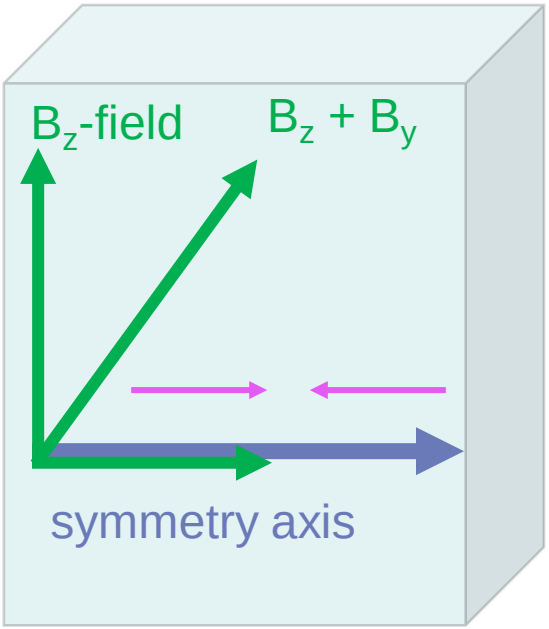


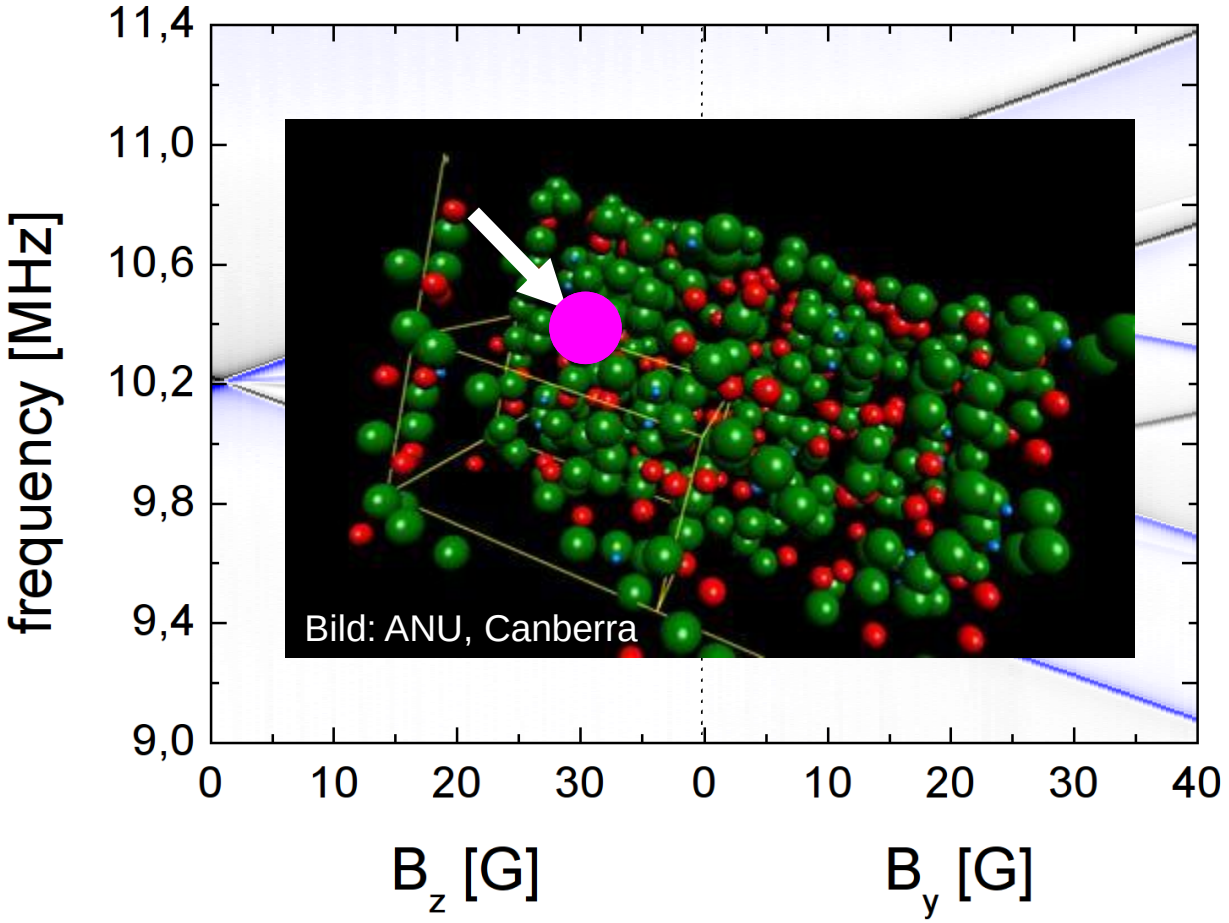
Spectroscopy of Hyperfinestates



Spectroscopy of Hyperfinestates

two magnetic sites



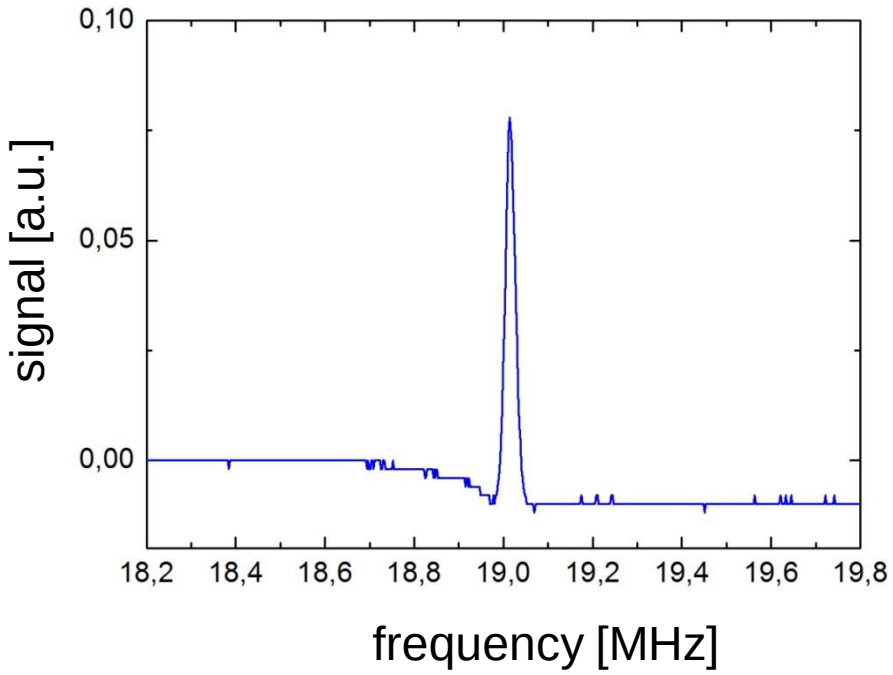


Spectroscopy of Hyperfinestates

resolution < 30 kHz

laserjitter ~ 100 kHz

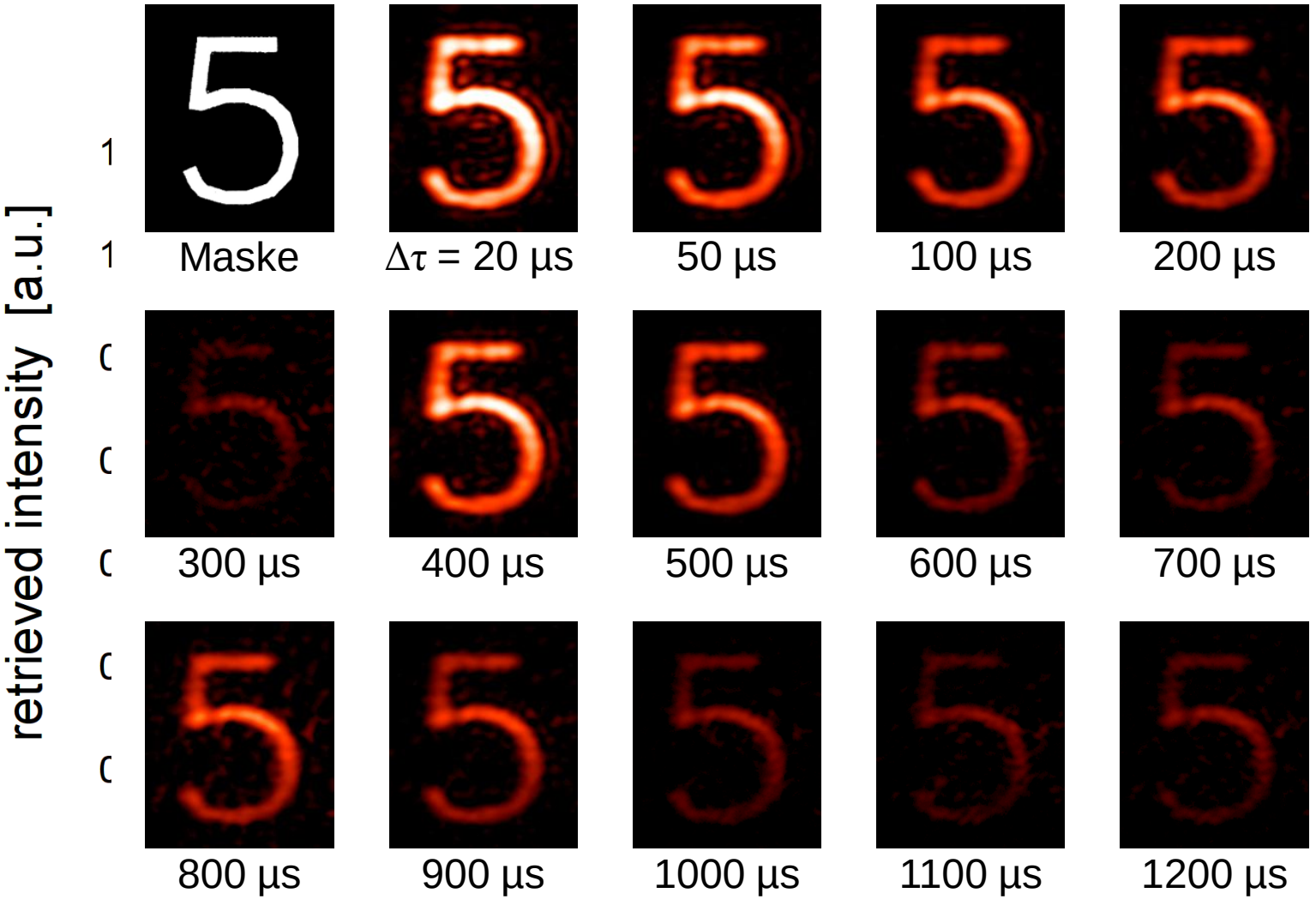
Γ_{inhom} ~ 30 kHz



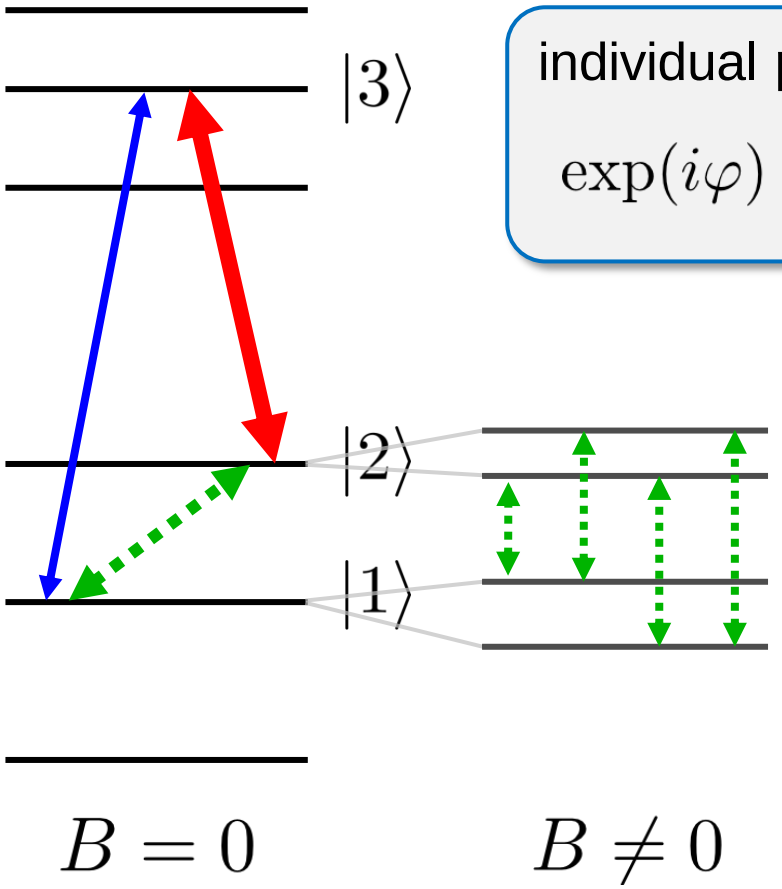
precise control through magnetic field

optimizing storage efficiency

Oscillation in storage efficiency

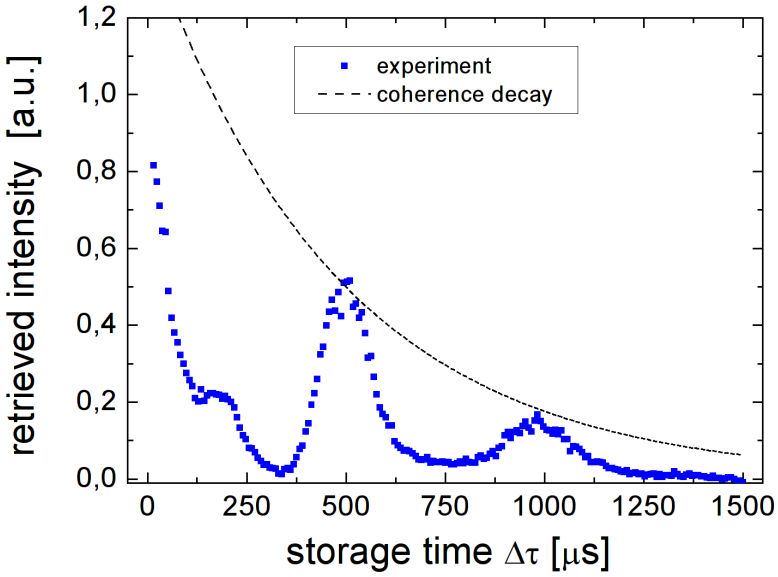


Light storage in degenerated Λ-systems



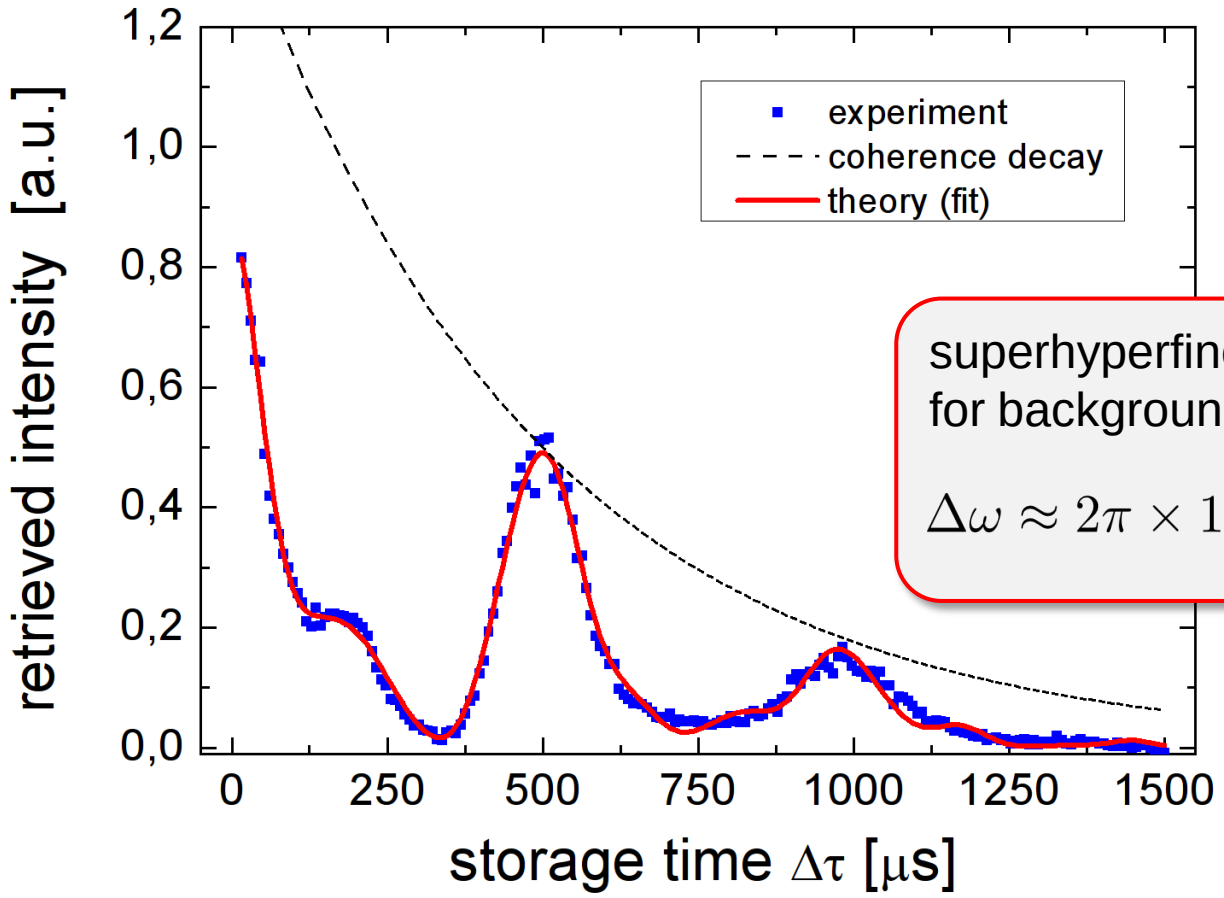
individual phases:

$$\exp(i\varphi) = \exp(i\omega_{ij}\Delta\tau)$$



$$S(\Delta\tau) = S(0)\left|\sum_{j=1}^{8} a_j \exp(i\omega_j\Delta\tau)\right|^2 \exp(-\Delta\tau/T_2)$$

Dark State Beating

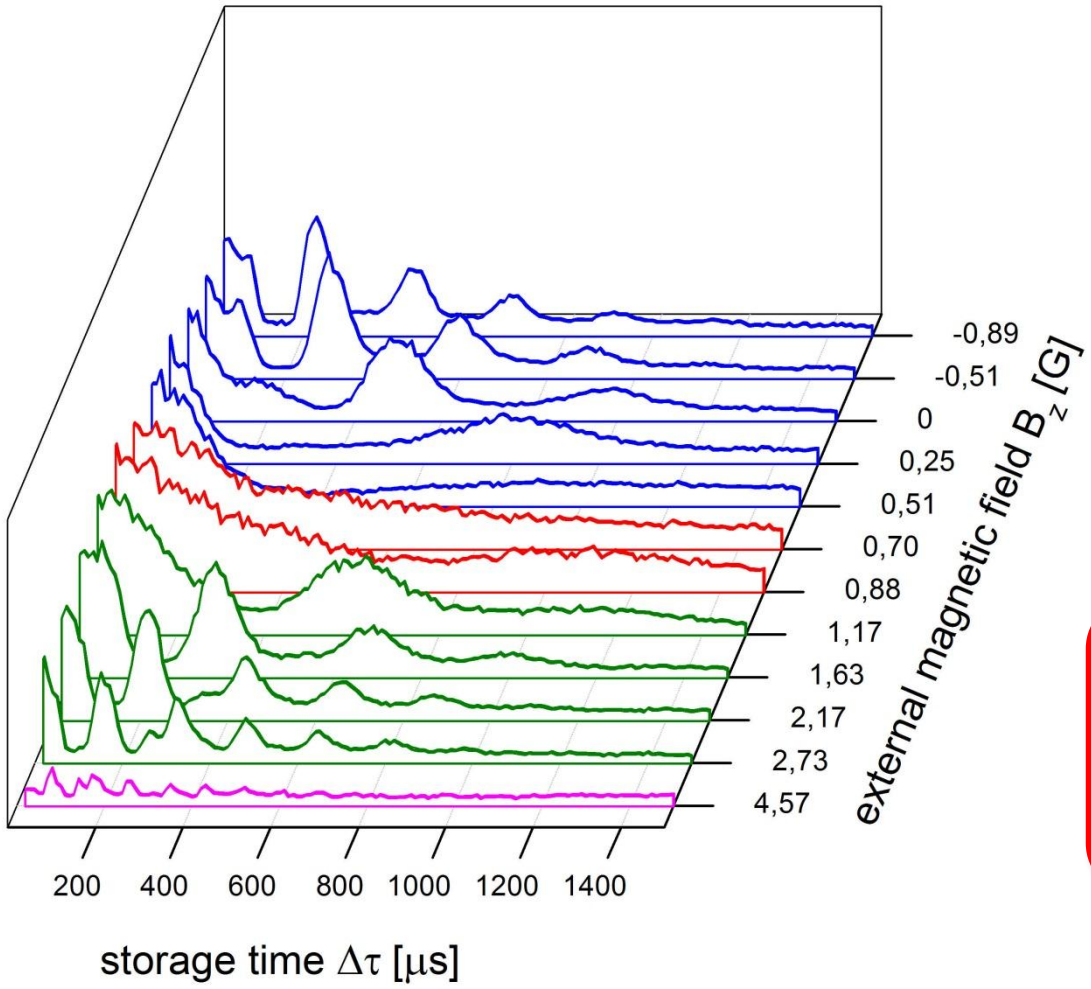


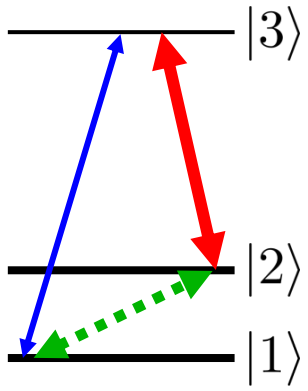
superhyperfine-splitting for background field:

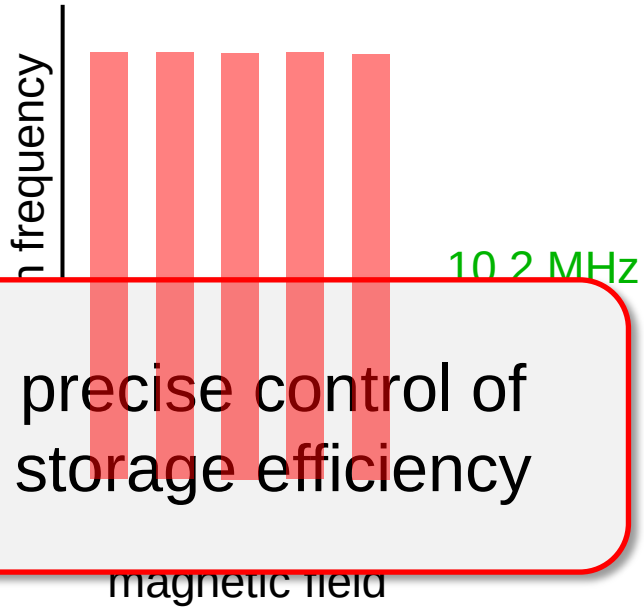
$$\Delta\omega \approx 2\pi \times 10 - 20\,\mathrm{kHz}$$

$$S(\Delta\tau) = S(0)\left|\sum_{j=1}^{8} a_j \exp(i\omega_j \Delta\tau)\right|^2 \exp(-\Delta\tau/T_2)$$

Control of Dark State Beating

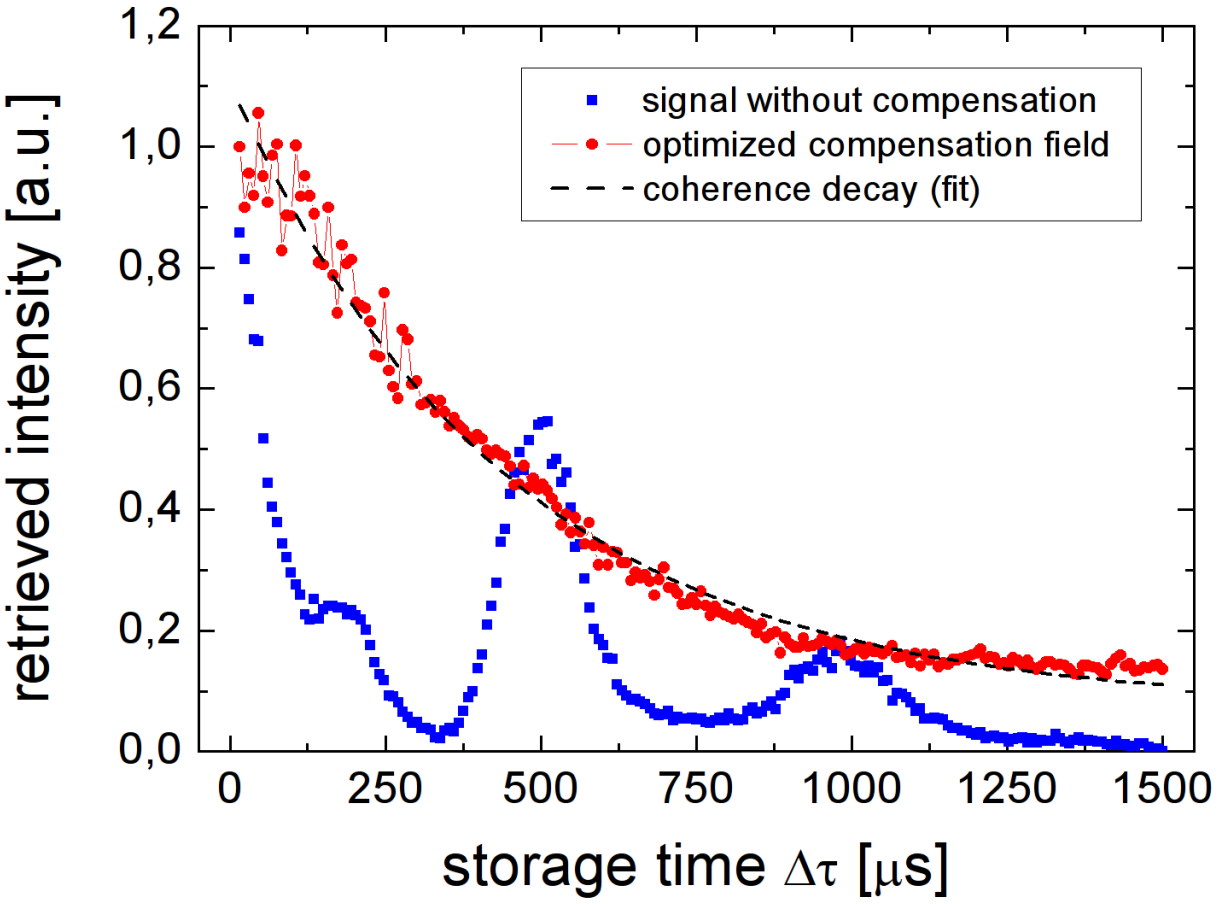






precise control of storage efficiency

Compensation of Dark State Beating



compensation B-field:

B_x = 0,37 G

B_y = -0,09 G

B_z = 0,43 G

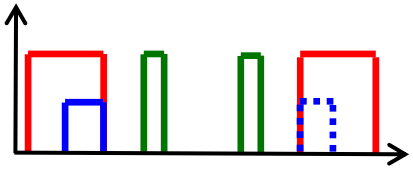
optimal light storage efficiency for every $\Delta\tau$

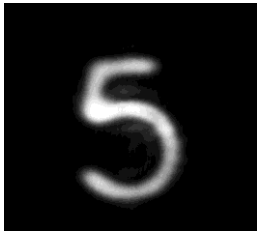
Summary

Control of Dark State Beating in $Pr^{3+}:Y_2SiO_5$

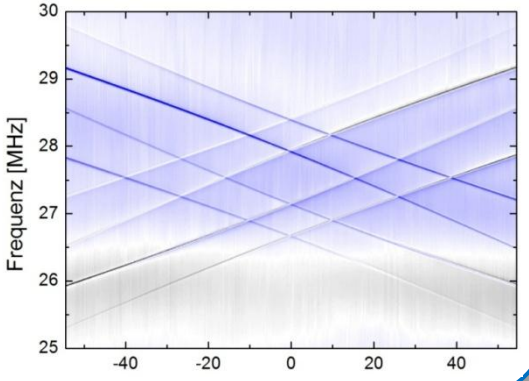
light / image storage

$\Delta\tau > 1ms$

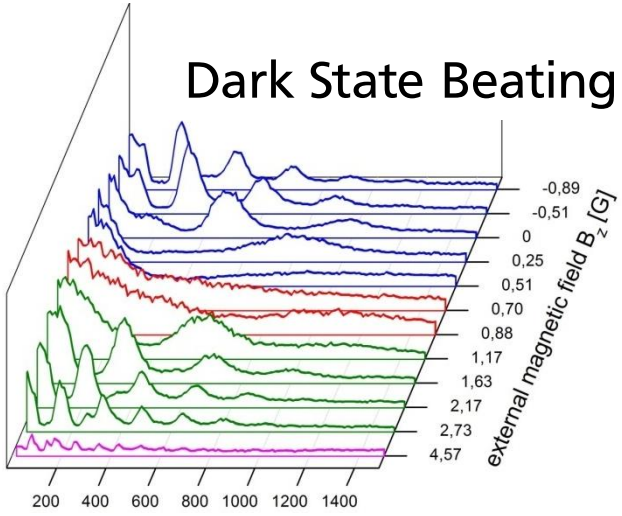




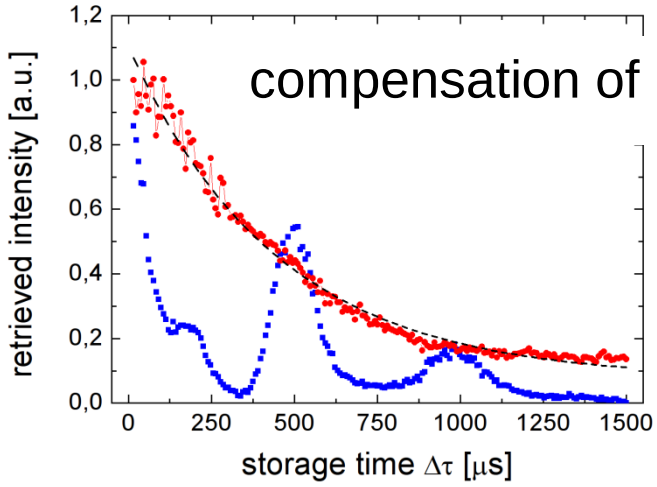
magnetic field and HFS



Dark State Beating



compensation of DSB



Thank you!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Andreas Rudolf
Nina Rentzsch
Damaris Zeitler
Moritz Wolf
Martin Buschbeck