NCTS Annual Meeting 2021

Machine optimization of optical nanofiber evanescent field trap for Rb atoms

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Collaboration work with CQC2T, Australian National University

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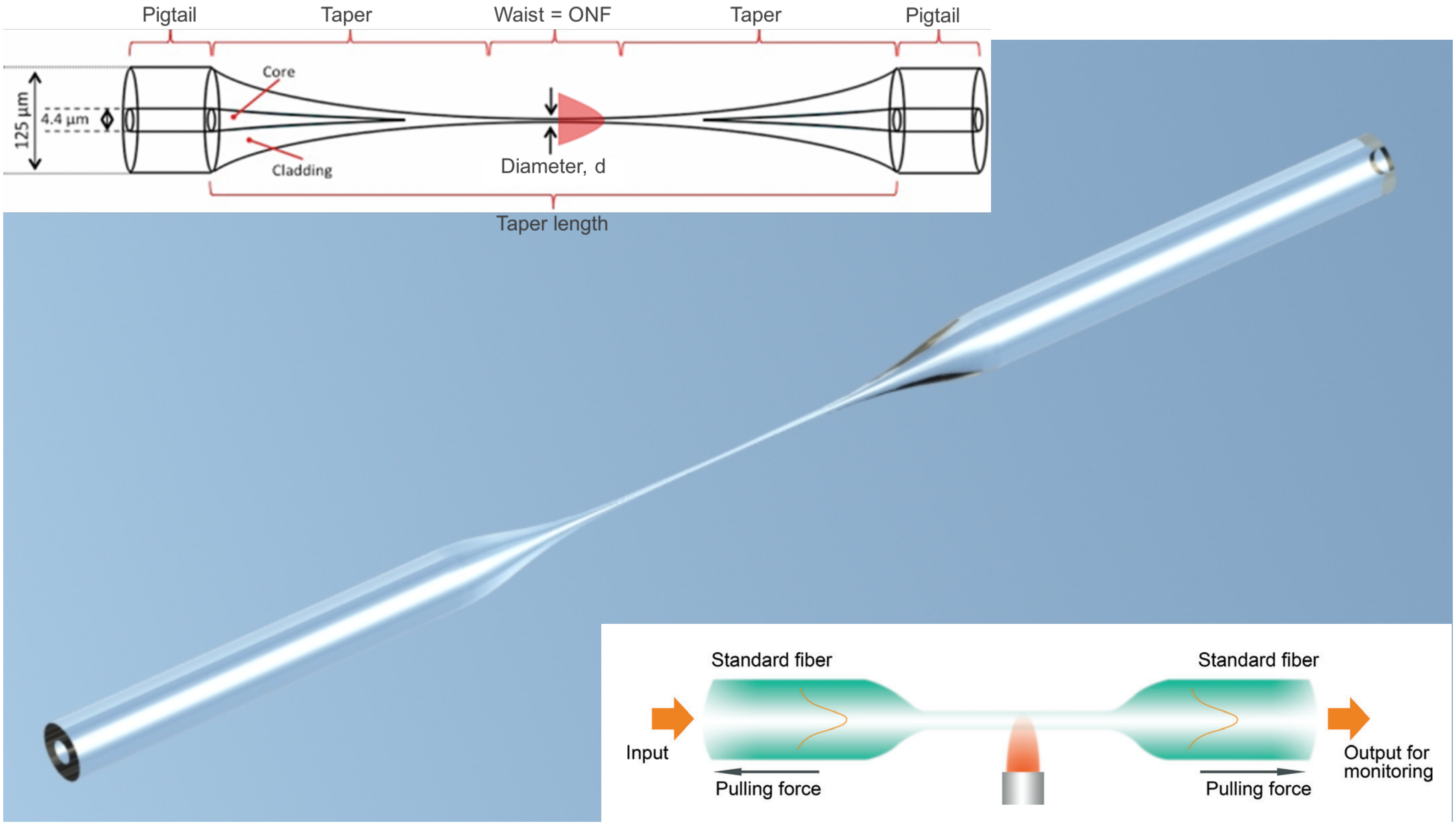
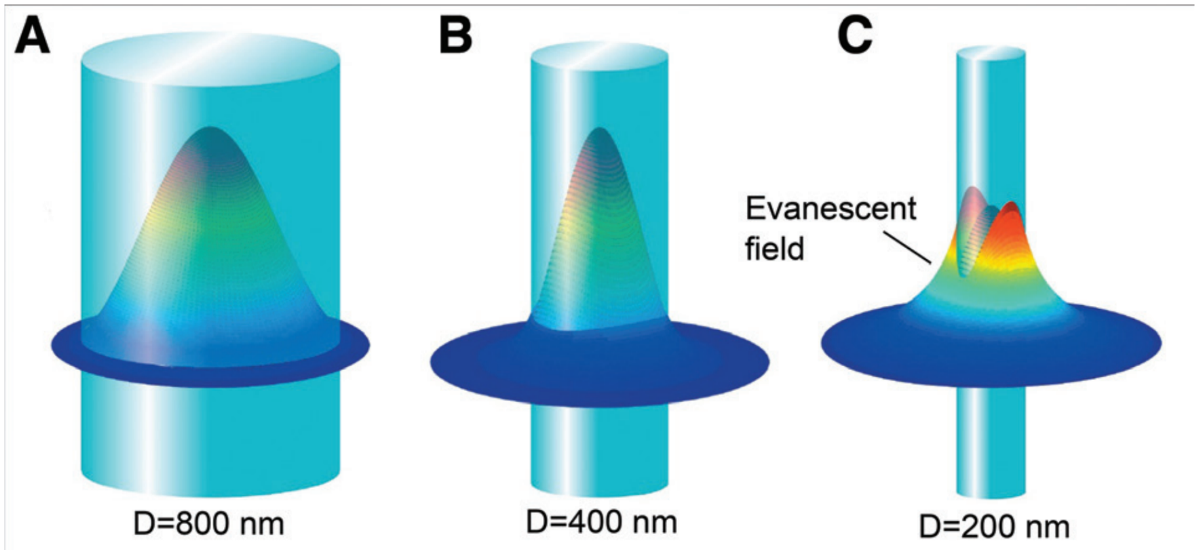
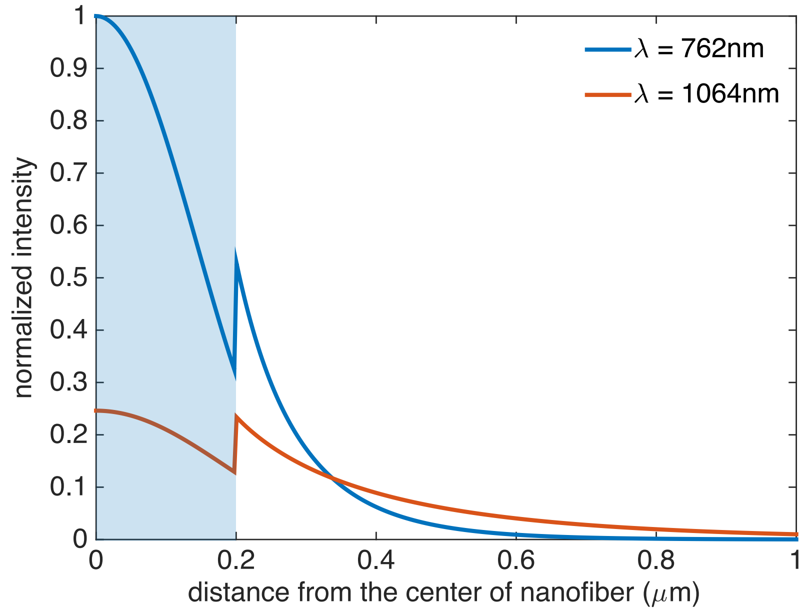
OKINAWA INSTITUTE OF SCIENCE AND TECHNOLOGY GRADUATE UNIVERSITY

Optical nanofiber (ONF)



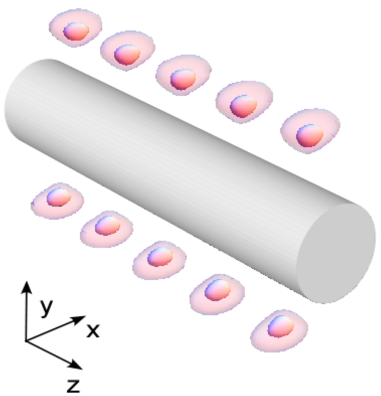
Evanescent field around ONF



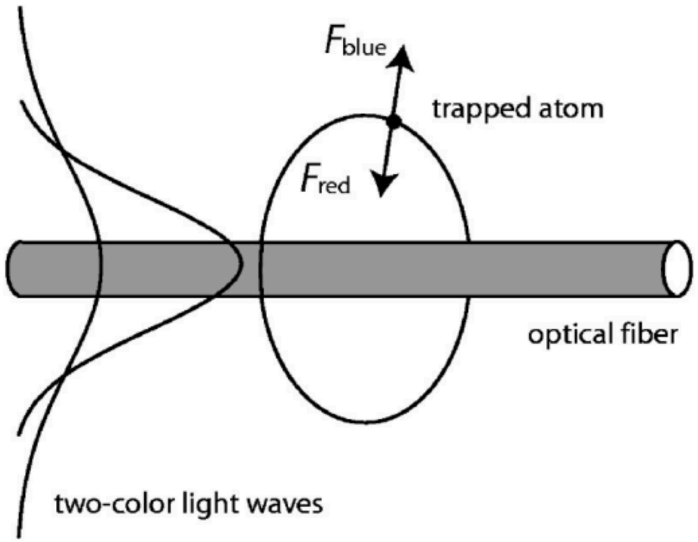


Wu et al., Nanophotonics **2**, 407 (2013)

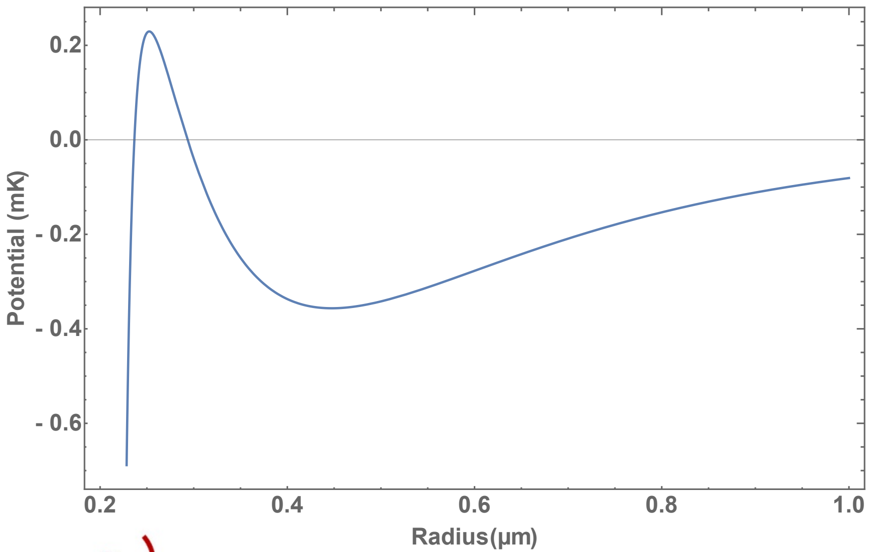
Two-color evanescent field trap

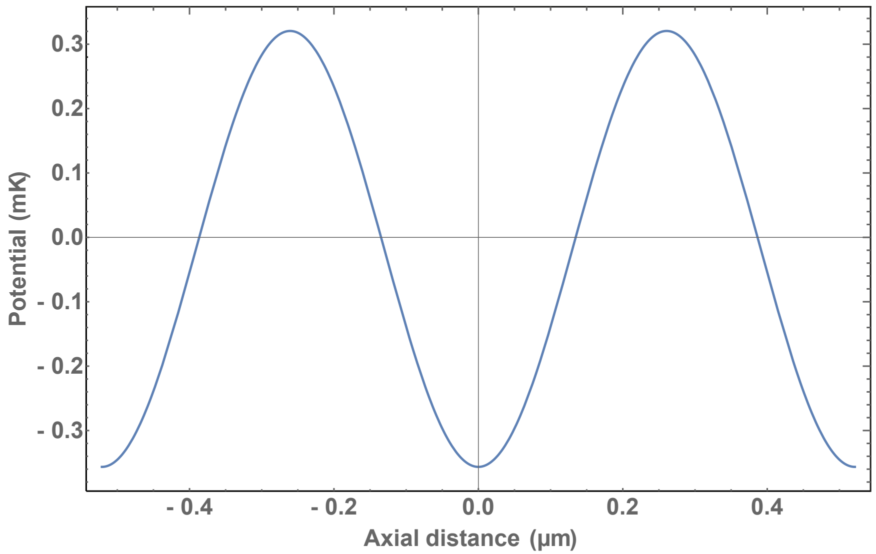


$$\Delta E_v = -\frac{1}{2}\alpha\mathcal{E}^2$$



Le Kien et al. Phys. Rev. A **70**, 063403 (2004)

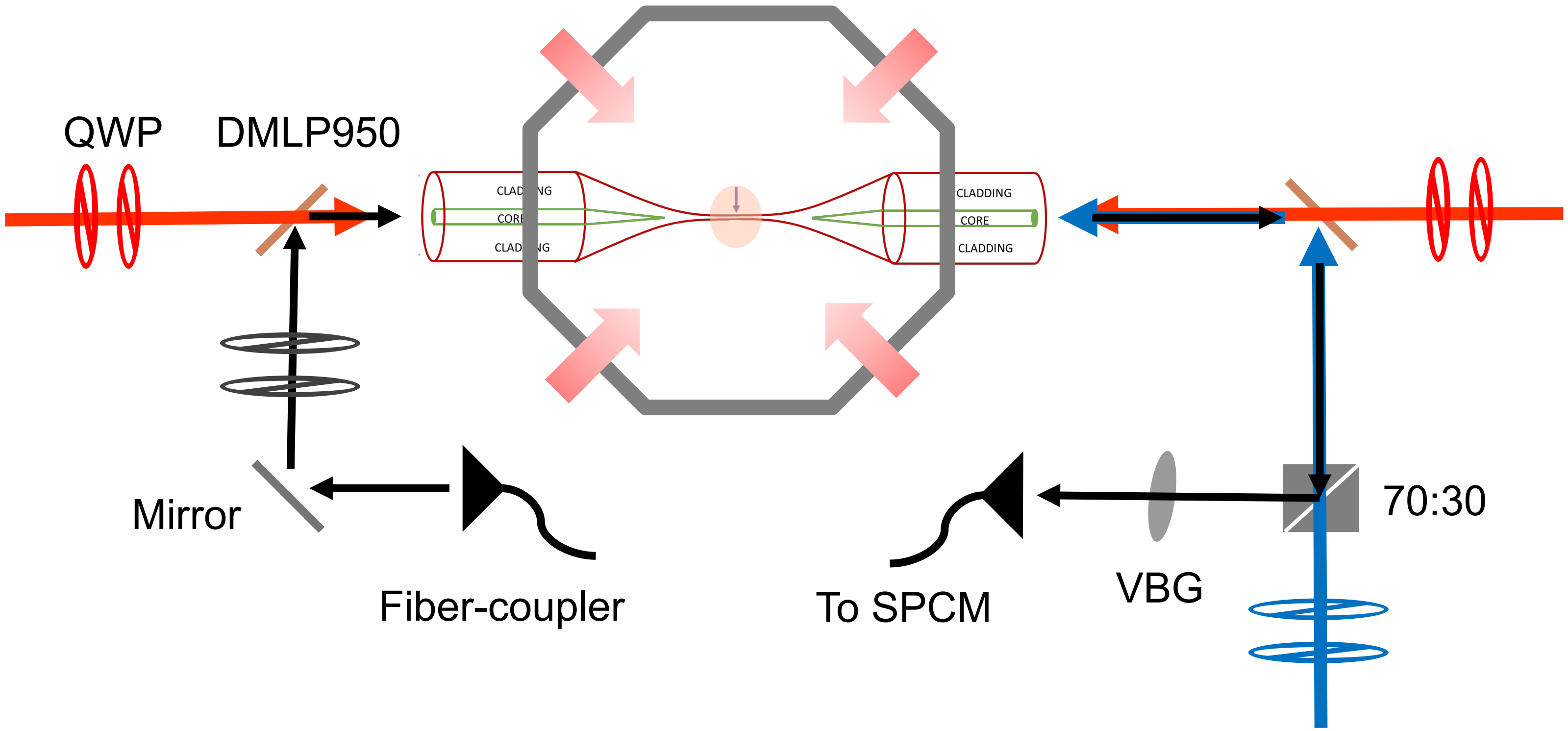




$$\lambda_{red} = 1064\ nm$$

$$\lambda_{blue} = 762\ nm$$

Two-color evanescent field trap



$$\lambda_{red} = 1064\, nm$$

$$\lambda_{blue} = 762\, nm$$

Experi…

LETTER

https://doi.org/10.1038/s41586-019-0902-3

Waveguide-coupled single collective excitation of atomic arrays

Neil V. Corzo[1,2], Jérémy Raskop[1], Aveek Chandra[1], Alexandra S. Sheremet[1], Baptiste Gouraud[1,3] & Julien Laurat[1]*

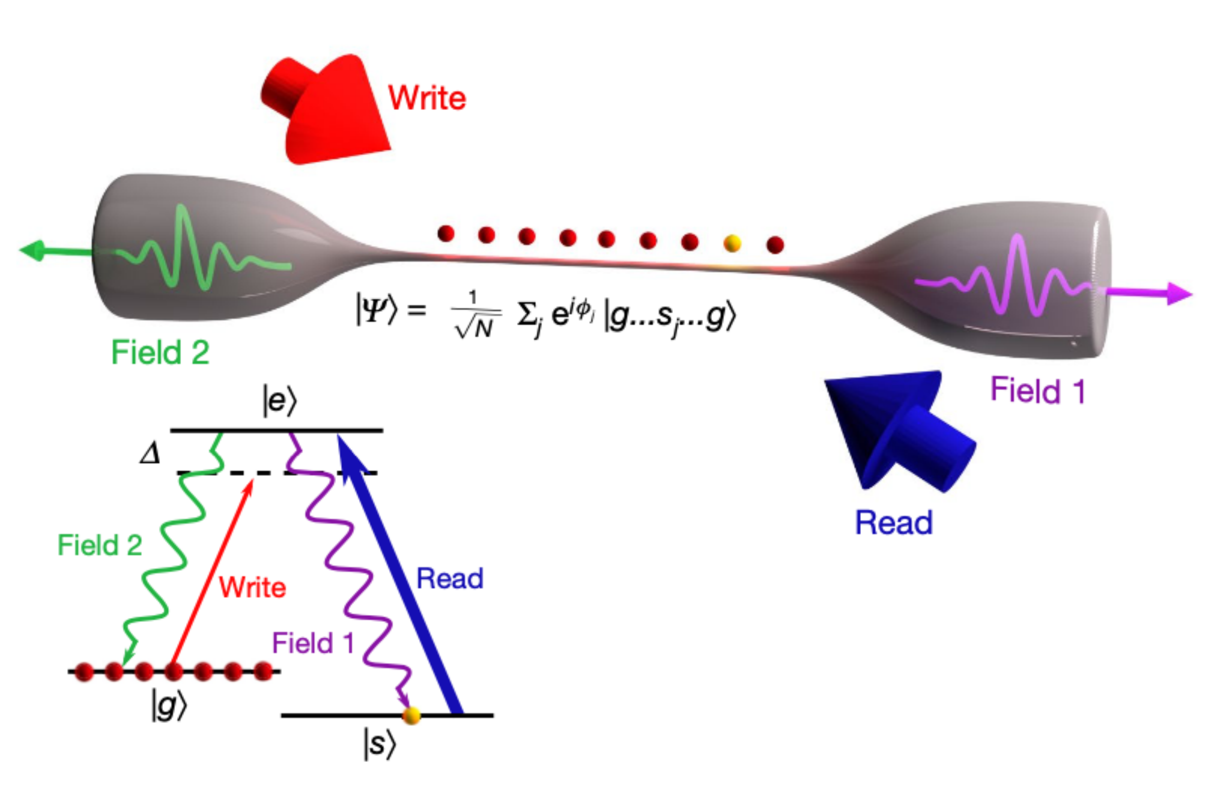


Fig. 1 | Waveguide-coupled collective excitation in an atomic register.

Observa… …terface

QUANT… …nmark

(R… …2018)

We observe colle… …nsional light-atom interface. Strings of… …ered nanofiber are prepared in a cohere… …um nondemolition measurement of on… …probe dispersively coupled to the collec… …nt of the same spin projection. For the c… …noise 40 dB above the detection noise v… …e negative Wigner function of nonclass… …inherent to atoms trapped and probed… …amics of quantum fluctuations relevant… …of thermal atomic motion. This work… …states and many-body interactions in…

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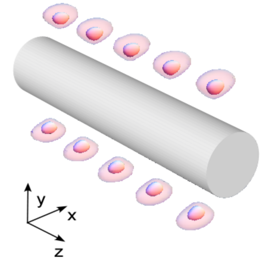
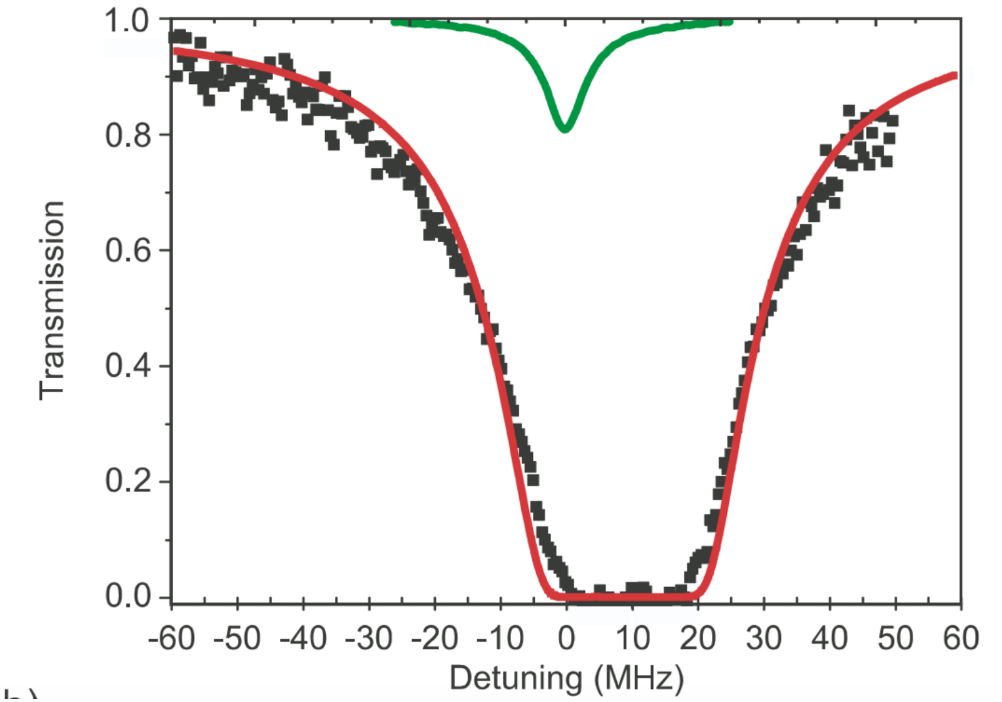
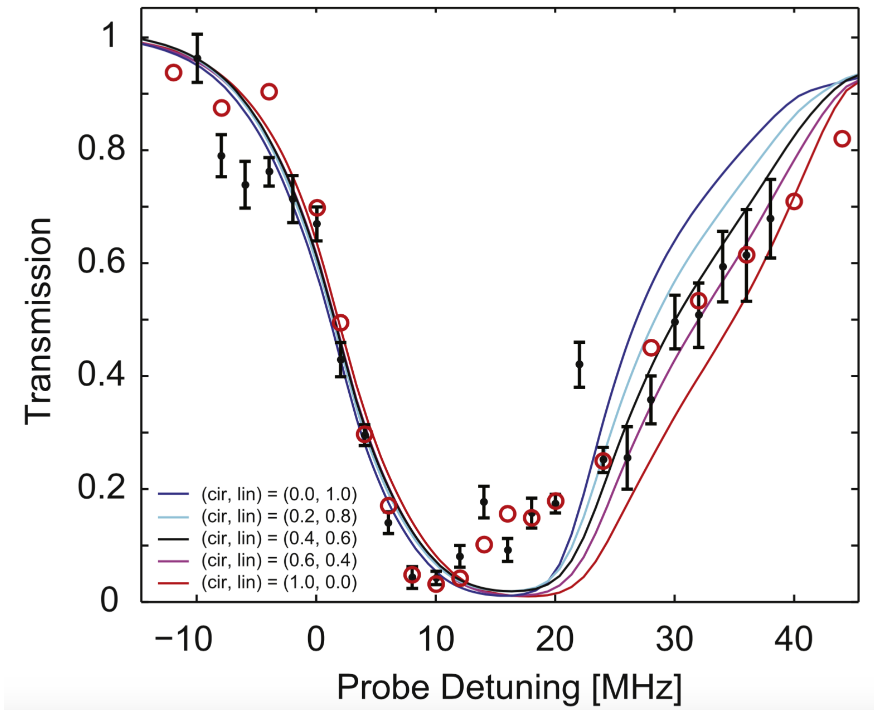
Atoms trapped in ONF evanescent field 1-d lattice





2000 trapped Cs atoms

Vetsch et al., Phys. Rev. Lett. **104**, 203603 (2010)

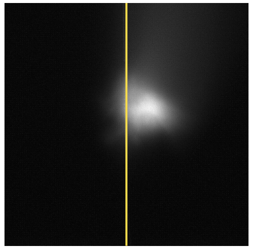


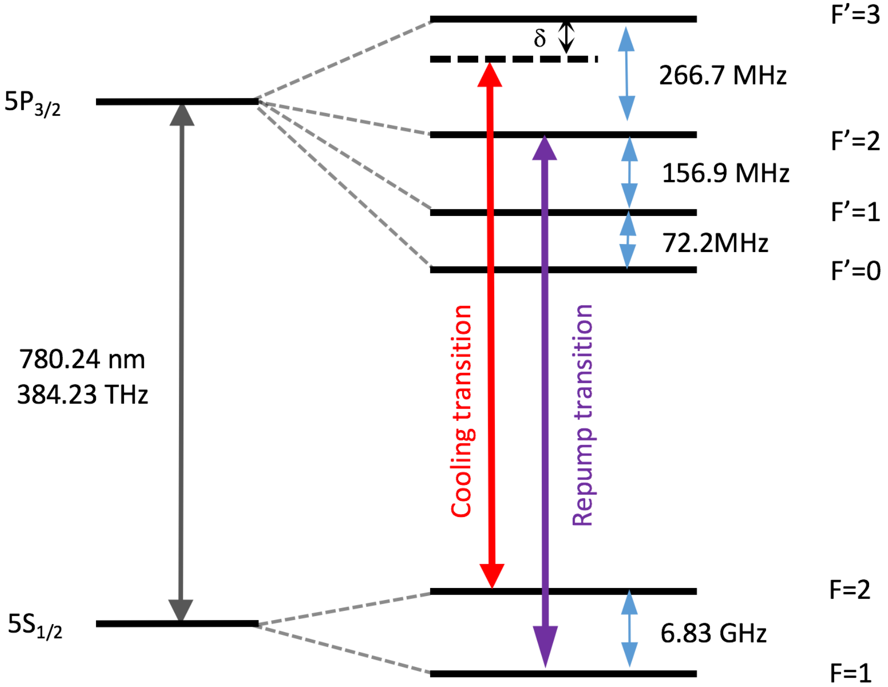
302 trapped Rb atoms

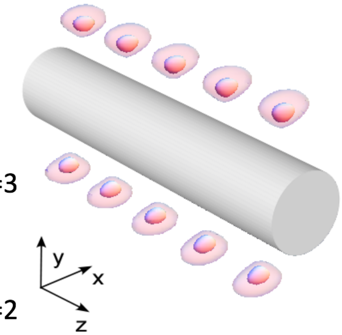
Lee et al., J. Phys. B: At. Mol. Opt. Phys. **48**, 165004 (2015)

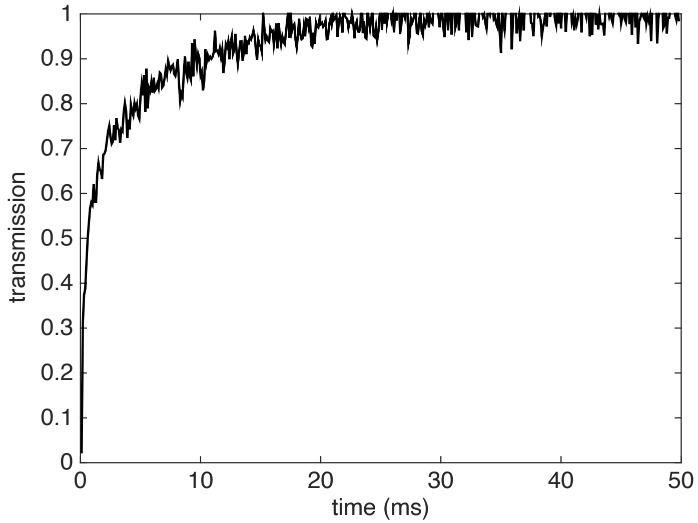
Experimental sequence

MOT (~1.6s)	Molasses t1~2.5ms	Molasses t2~2.5ms	Measurement window (~75ms)	Rest (~120ms)

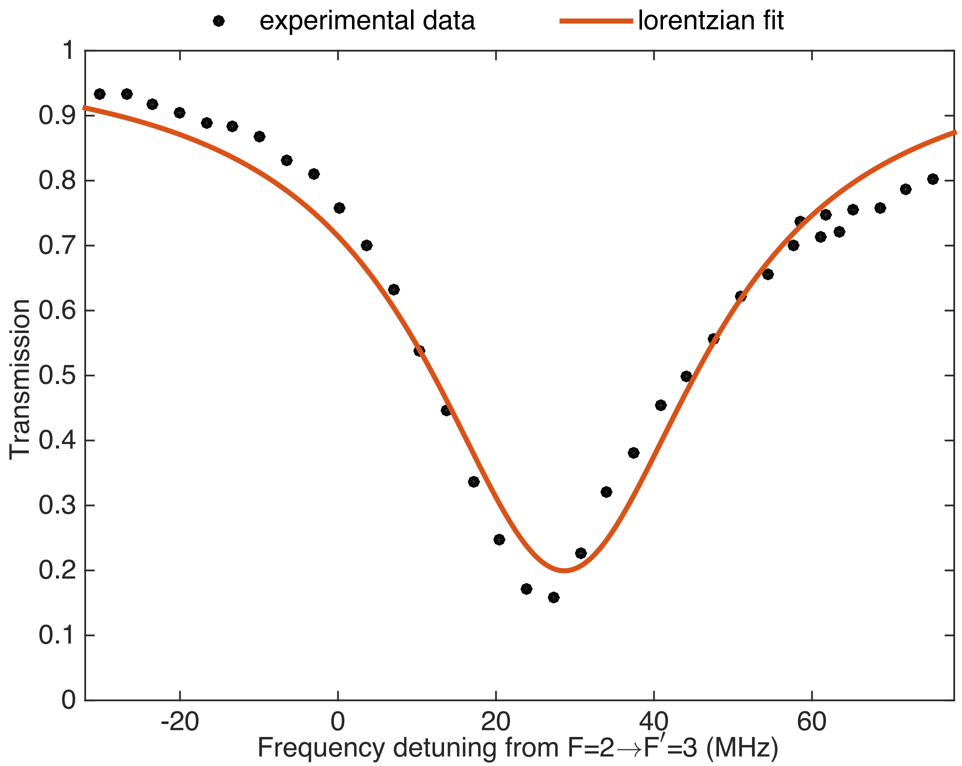




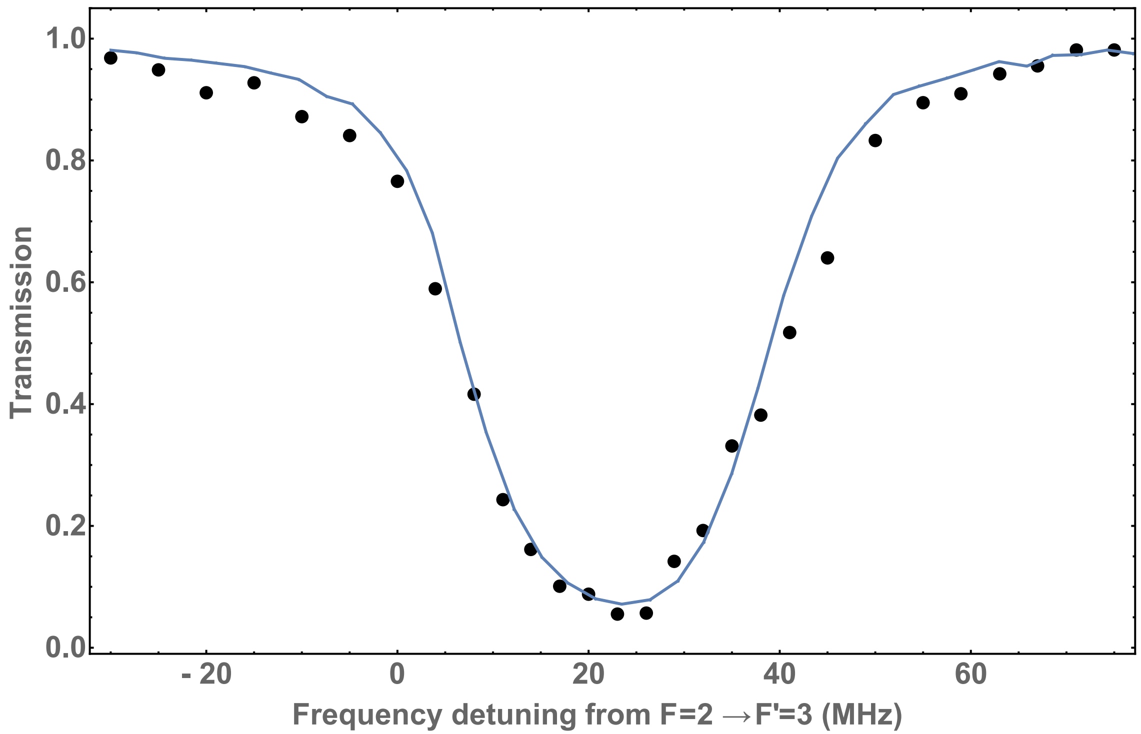




Absorption spectrum



No dipole trap

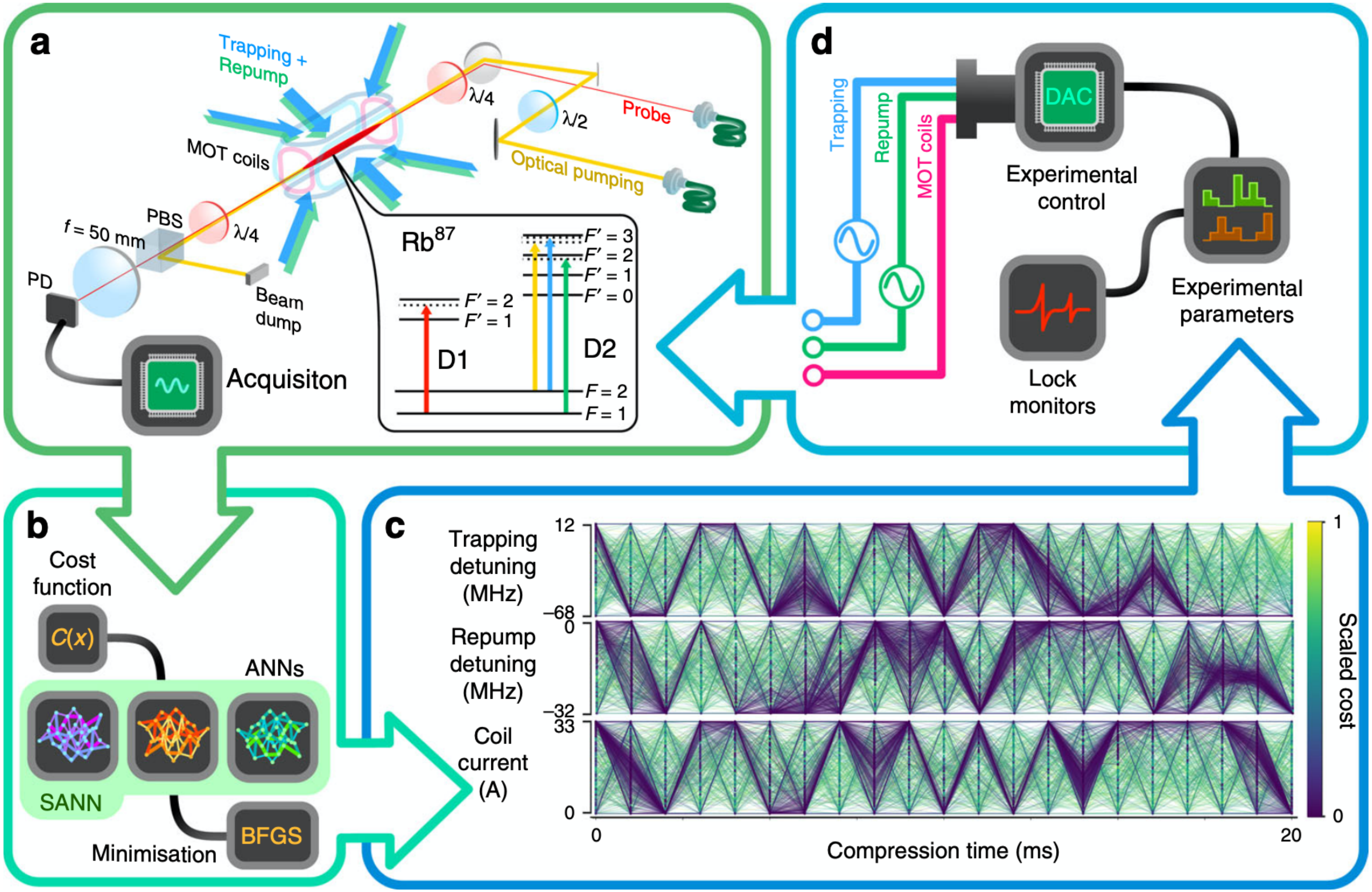


Atoms trapped in evanescent field dipole trap

450 atoms

Machine Learning (ML) scheme

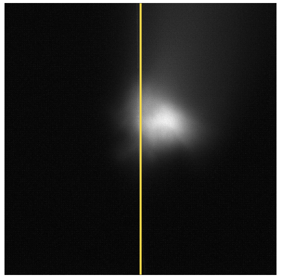
Tranter et al., Nat. Commun. **9**, 4360 (2018)



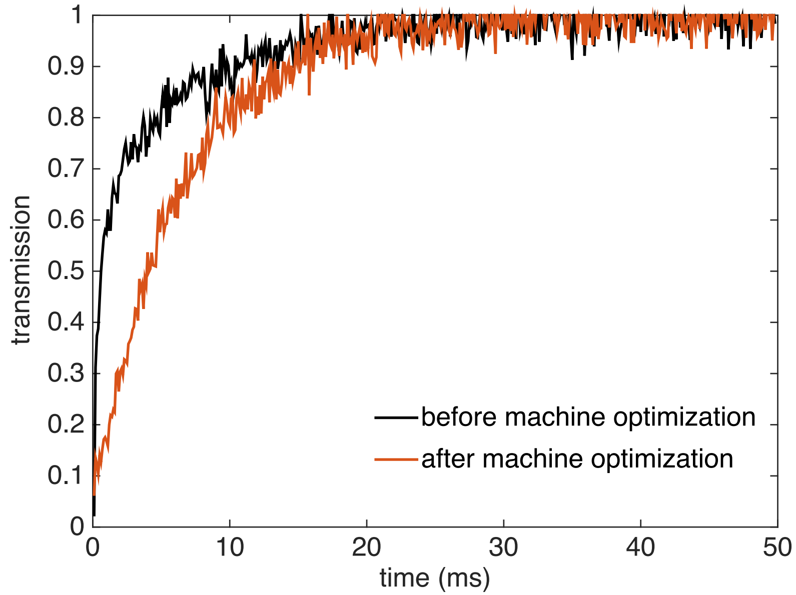
Cost function and the experimental controls

MOT (~1.6s)	Molasses t1~2.5ms	Molasses t2~2.5ms	Measurement window (~75ms)	Rest (~120ms)

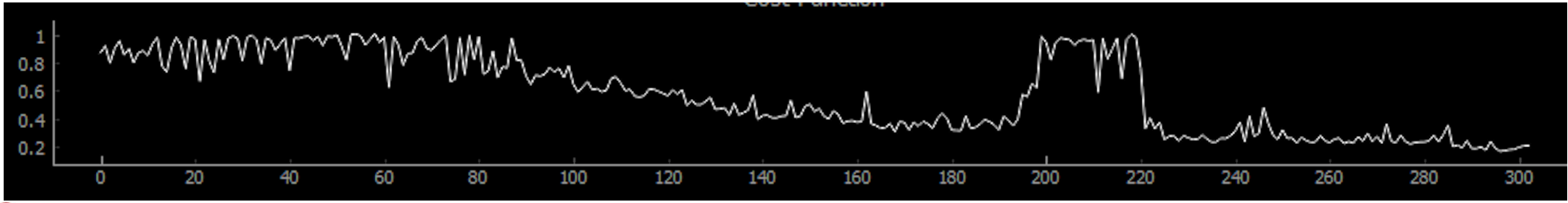
Magnetic fields



Cooling beam detuning
Cooling beam power
Repump beam power
Molasses times
Trapping power



Cost function = Average transmission

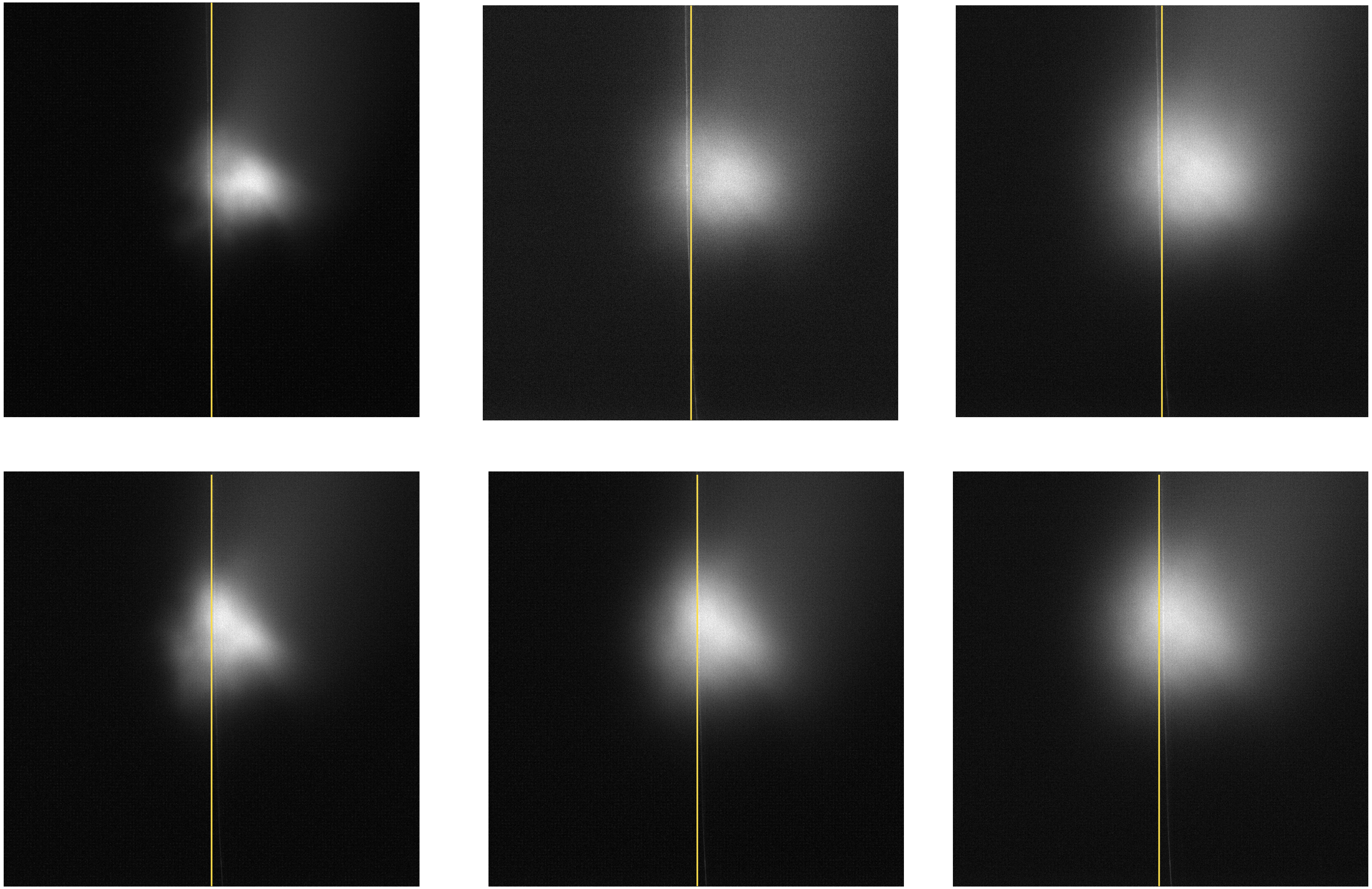


Atom cloud after ML optimization

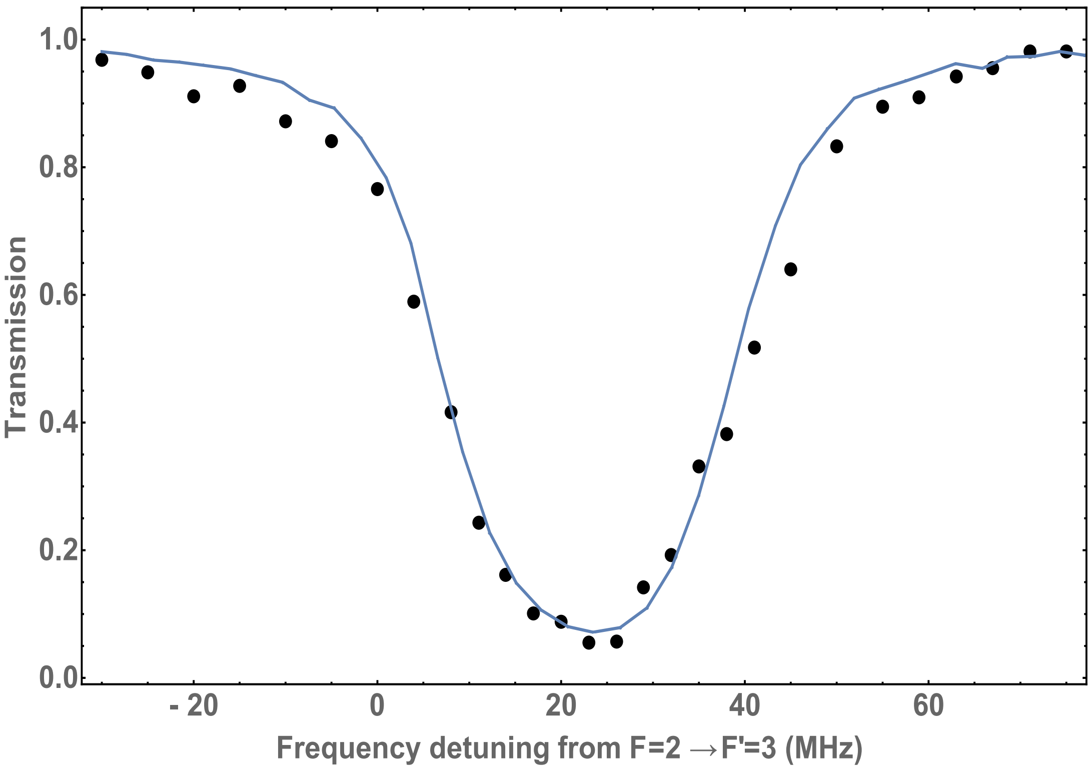
Time delays	$200\mu s$	$4200\mu s$	$5200\mu s$

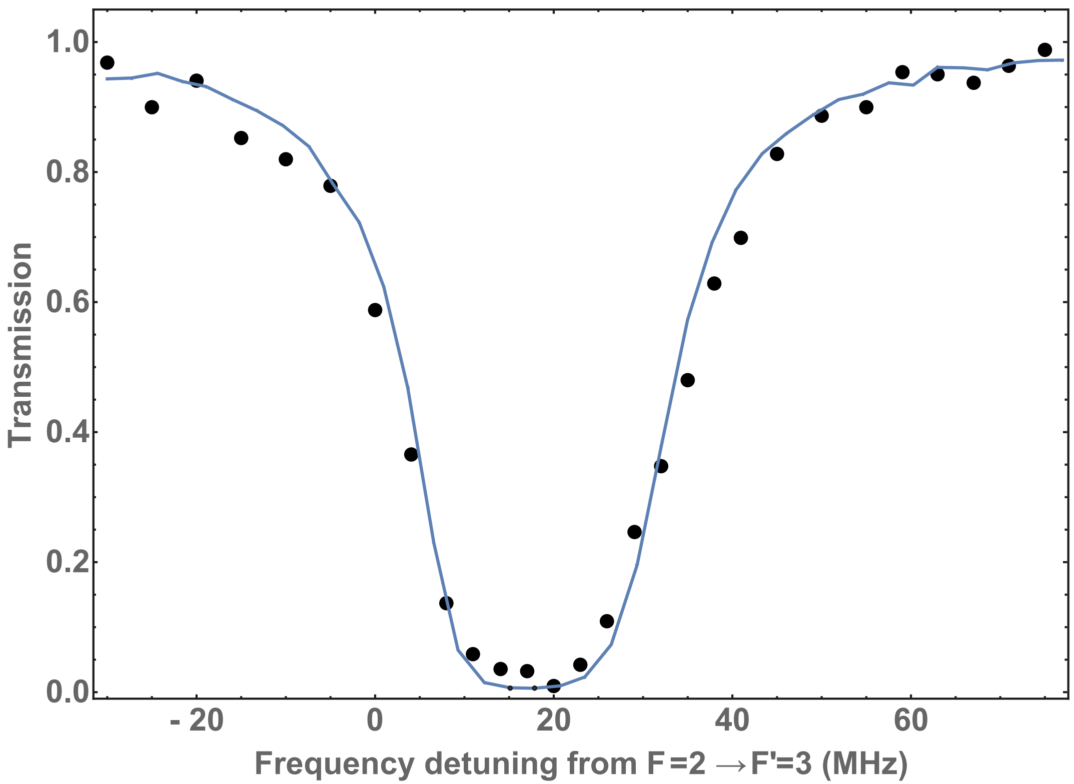
Before optimization

ML-optimized



Nearly two-fold increase in number of trapped atoms with ML





450 atoms **800 atoms**

Summary

- ONFs offer huge advantage for applications in quantum technologies
  - Easy integration of strongly interacting ensemble of atoms into the fiber network

- Atoms can be trapped in the evanescent field around the ONF with an appropriate combination of red- and blue-detuned light fields propagating through the ONF.

- Machine optimization can be used to improve the number of trapped atoms near the ONF. In our case, we observed an increase by 70%.

Thank you for your attention!