

classical  
optics



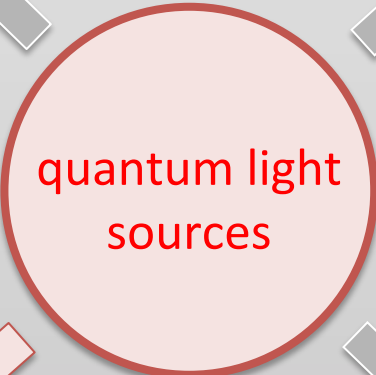
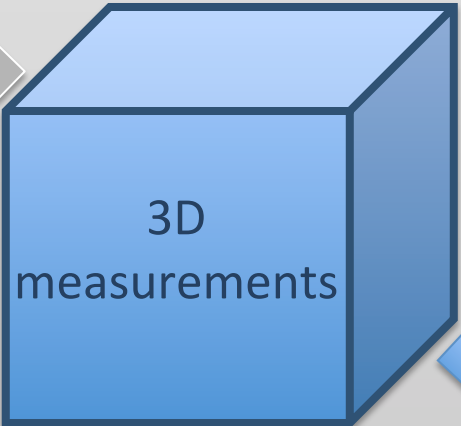
quantum optics

- linear and nonlinear interaction between light and matter
- ... → topological 3D information
- ... → quantum light sources / quantum communication
- ... → efficient coupling to matter, micro & nano

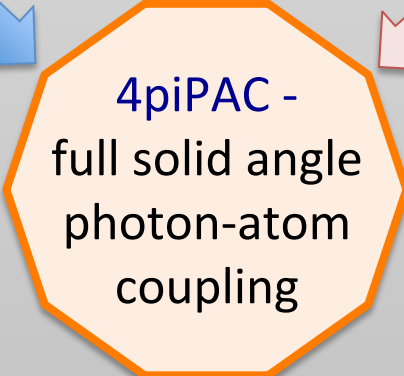
flying triangulation

cluster states

probabilistic protocols



interferometry



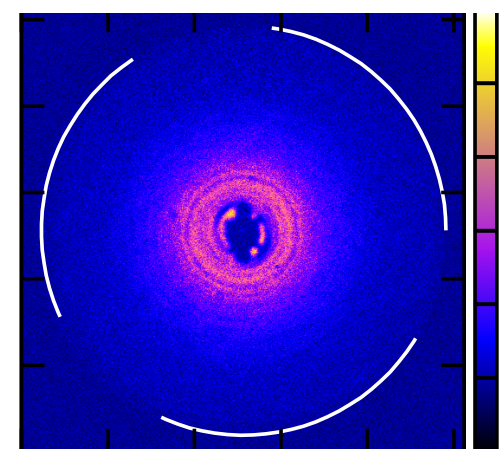
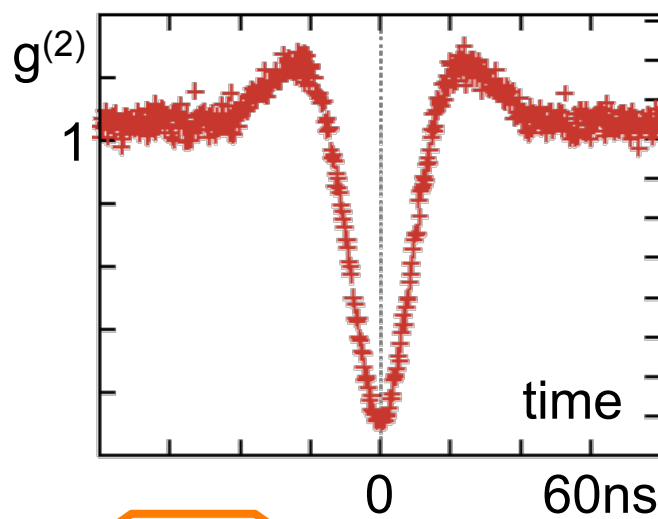
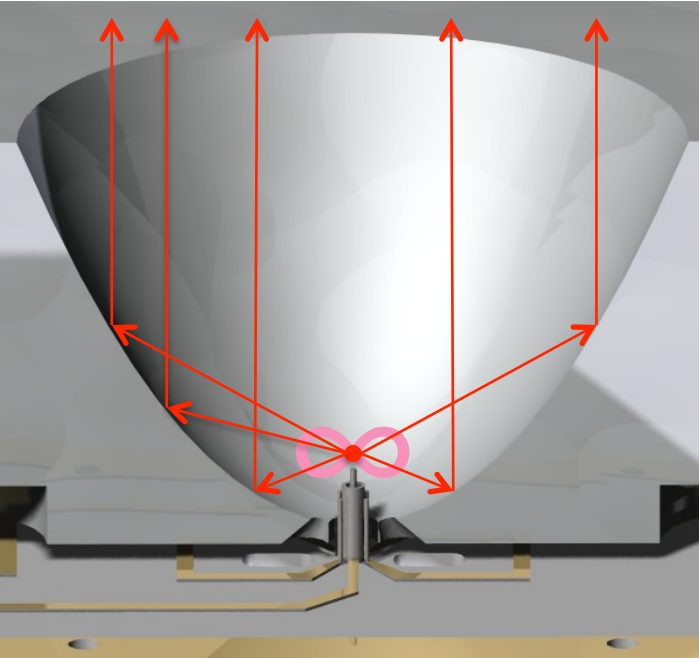
quantum/classical communication

higher order modes



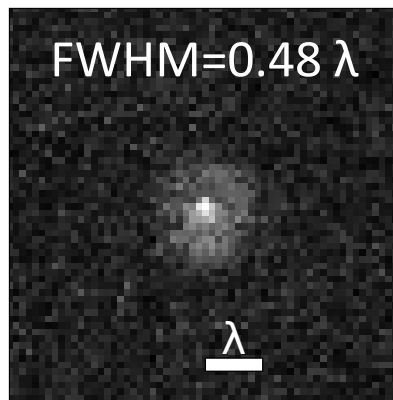
interaction with nano particles

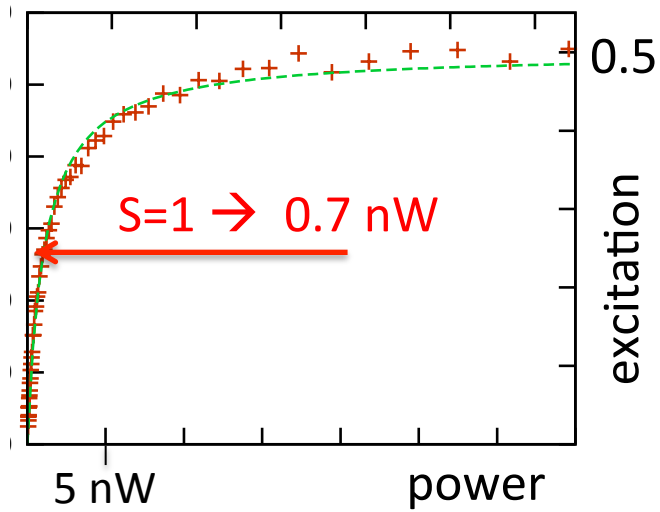
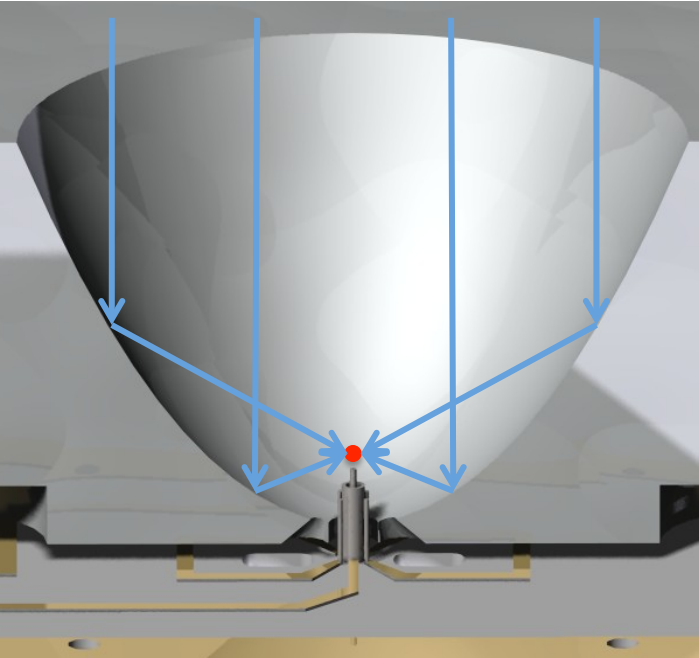
characterization



4piPAC -  
full solid angle  
photon-atom  
coupling

R. Maiwald et al.,  
Phys. Rev. A 86, 043431 (2012)

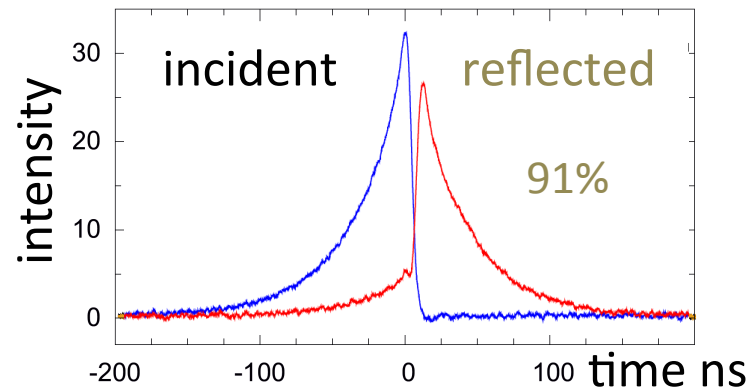




excitation with coherent beam

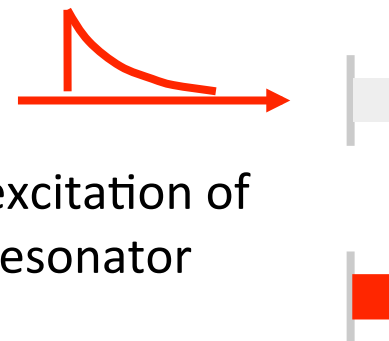
4piPAC -  
full solid angle  
photon-atom  
coupling

“absorption”



Marianne Bader et al., *unpubl.*

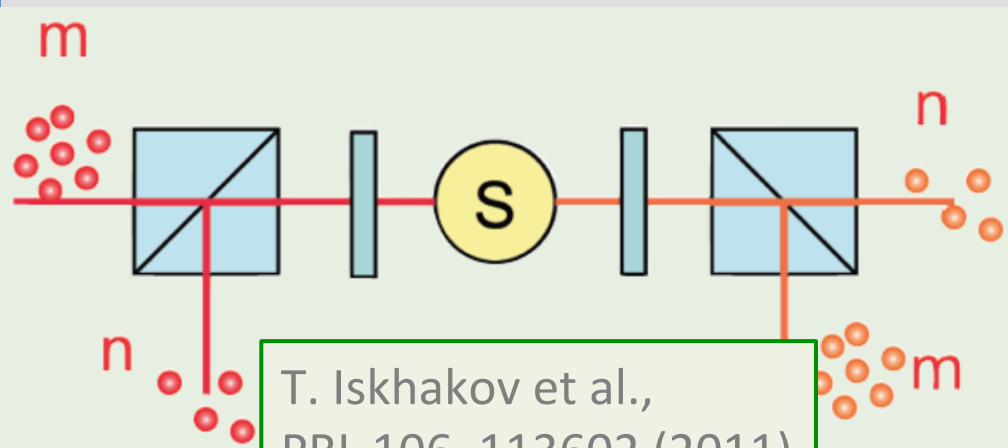
test



theory:  
S. Heugel et al.,  
*Laser Physics* 20, 100 (2010)

→ goal:  
same for atom

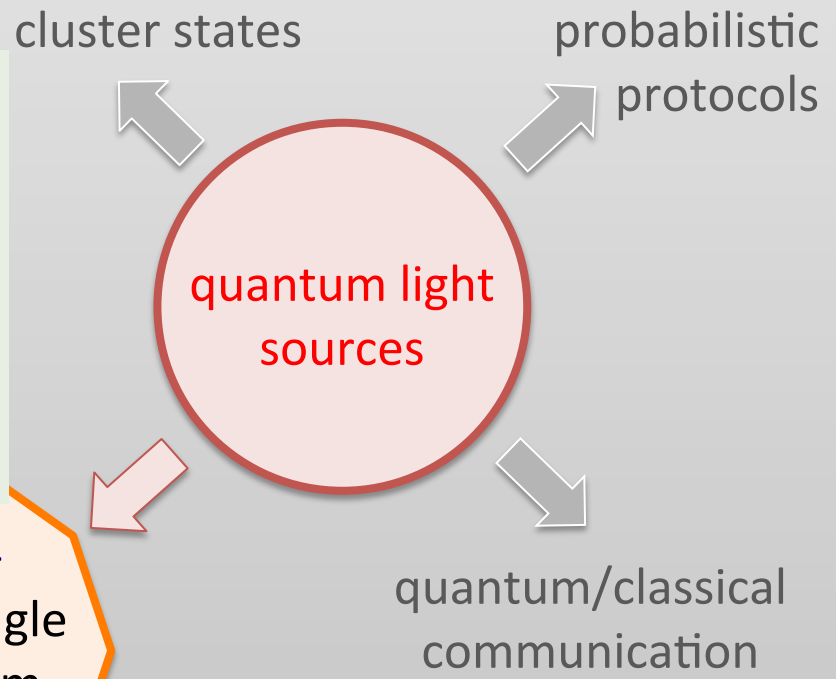
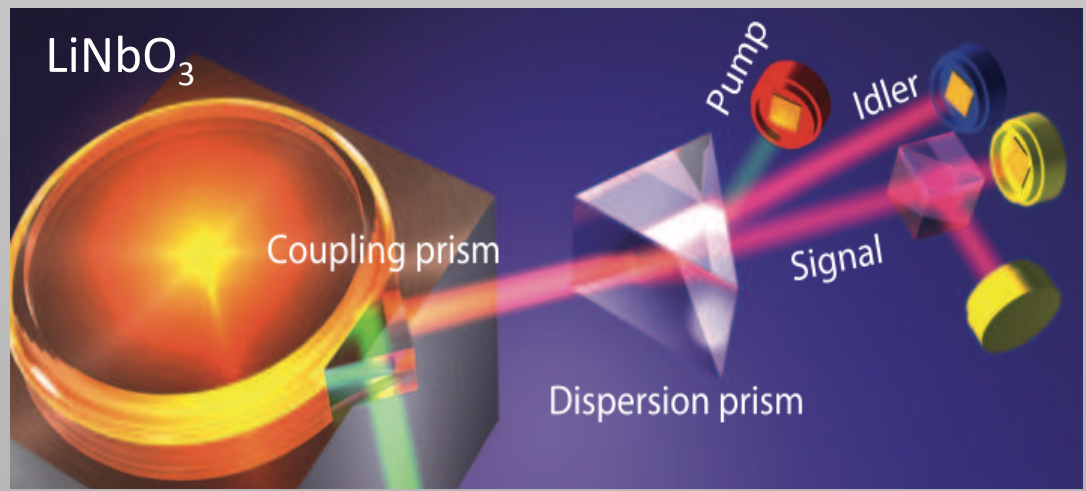
# 1-, 2-, & 4-mode squeezing



T. Iskhakov et al.,  
PRL 106, 113602 (2011)  
PRL 109, 150502 (2012)

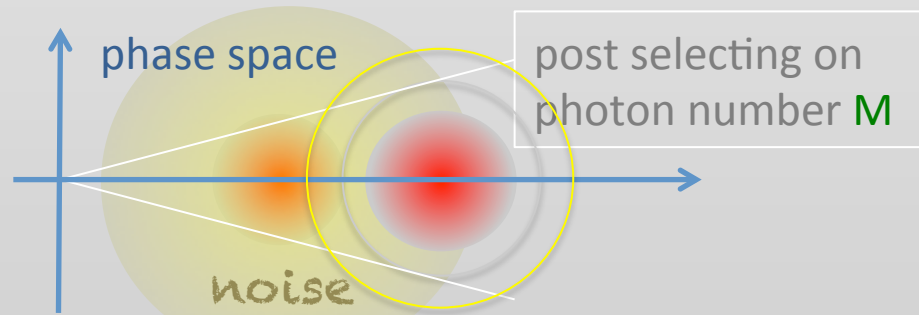
4piPAC -  
full solid angle  
photo-atom  
coupling

whispering gallery mode optical  
parametric oscillator  
M. Förtsch et al., arXiv:1204.3056

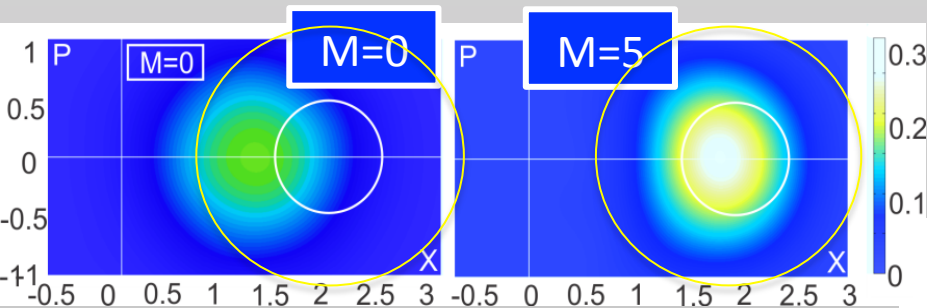


- heralded single photons
- few MHz linewidth
- large spectral separation (10 GHz)

# Probabilistic Cloning

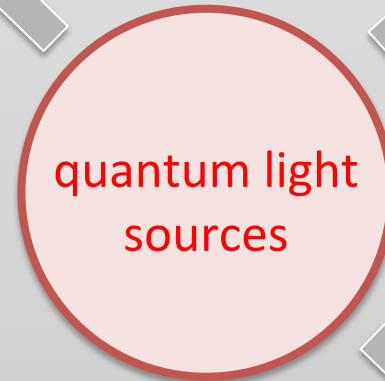


C. R. Müller et al., Phys. Rev. A 86, 010305(R) (2012)



cluster states

probabilistic protocols

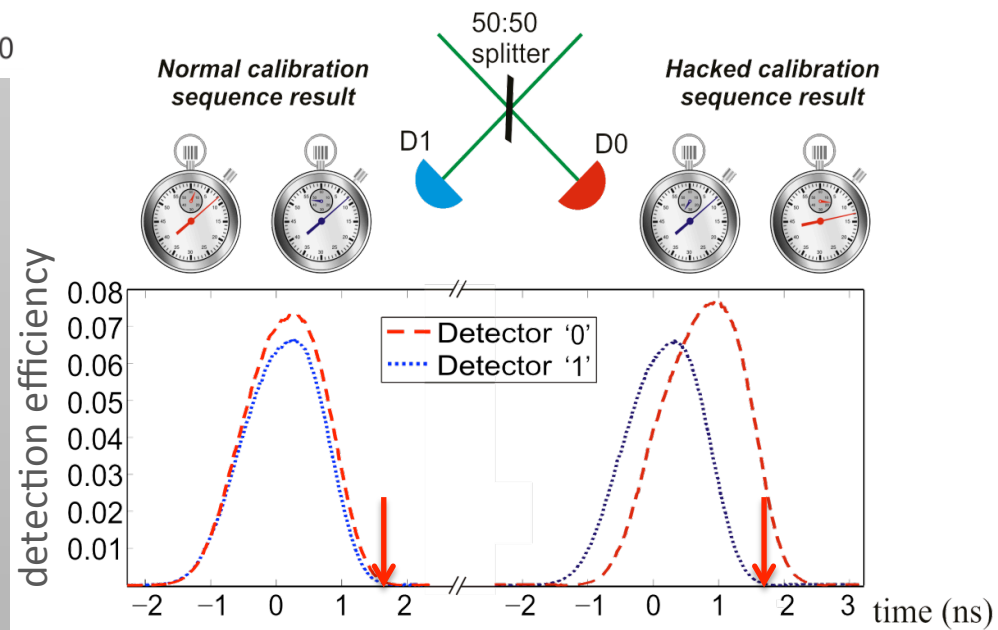


quantum/classical communication

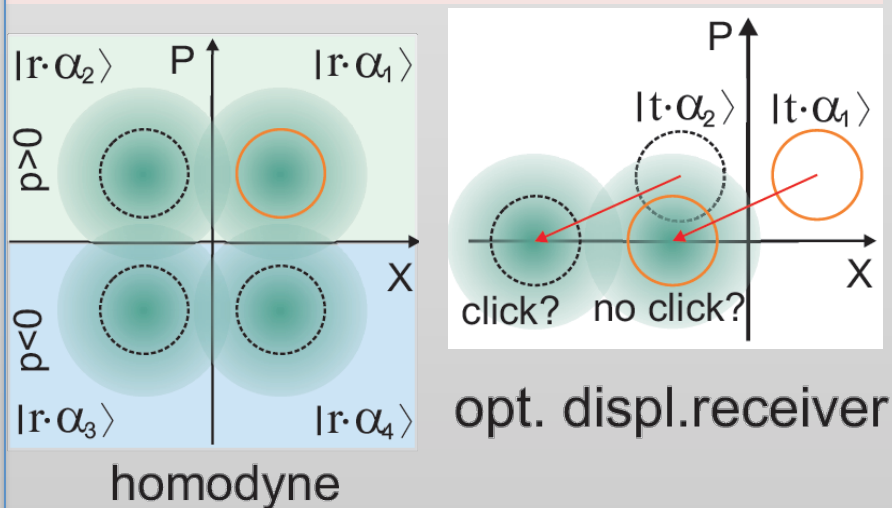
## quantum hacking

N. Jain et al., Phys. Rev. Lett. 107, 110501 (2011)

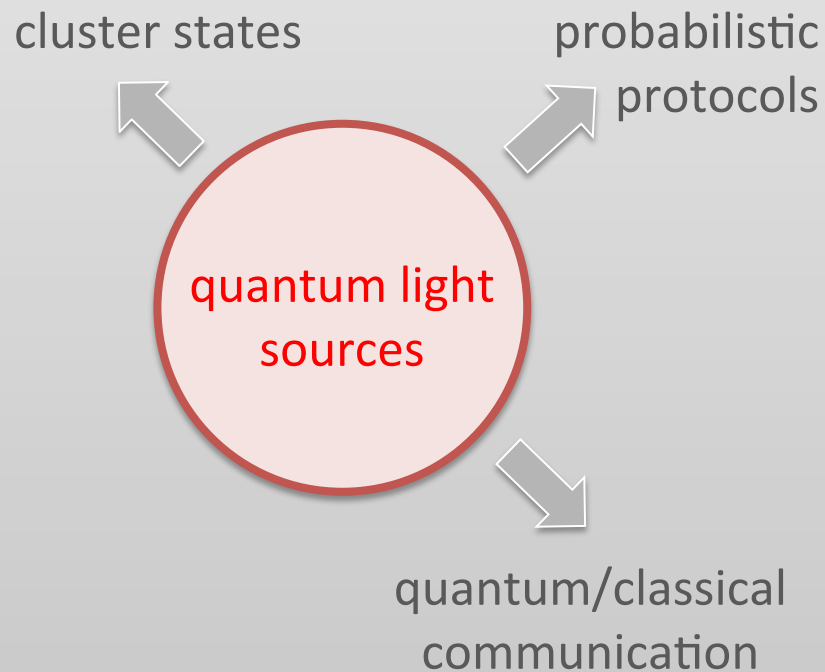
→ taking advantage of a vulnerable calibration routine



## quantum receiver – coherent states



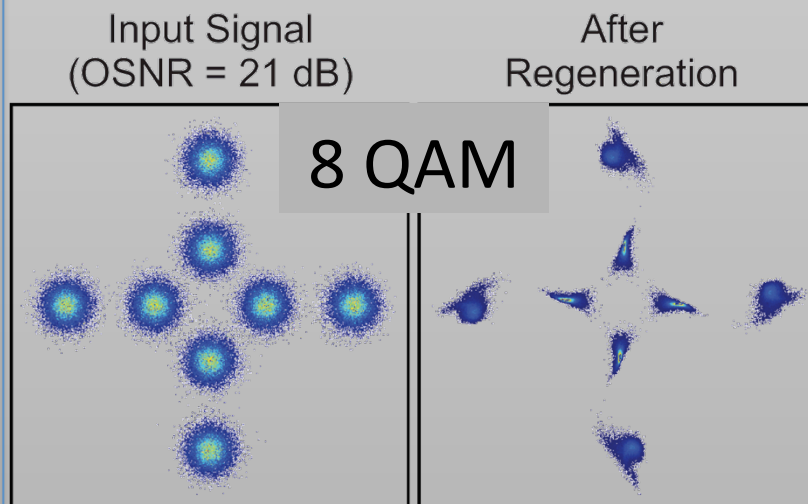
C.R. Müller et al., NJP 14, 083009 (2012)



↑ quantum

classical →

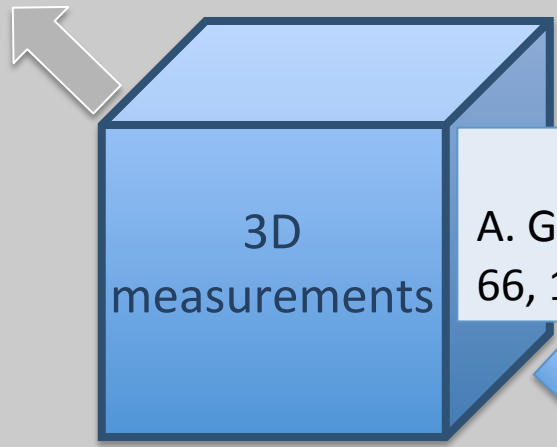
## Quadrature amplitude modulation QAM



simultaneous amplitude and phase regeneration in a nonlinear interferometer

T. Röhlingshöfer et al., ECOC 2012

flying triangulation

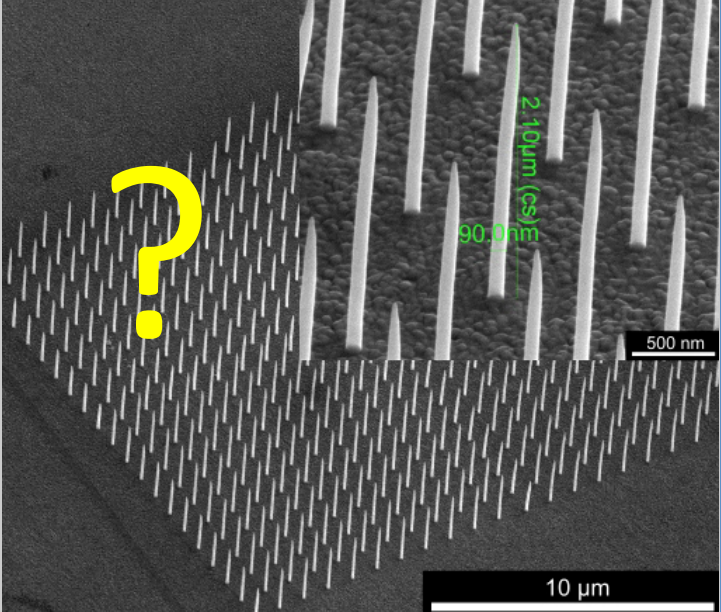


3D measurements

parabolic mirror  
A. Golla et al., Eur. Phys. J. D 66, 190 (2012)

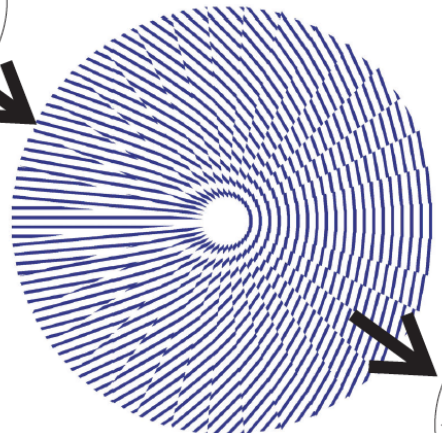
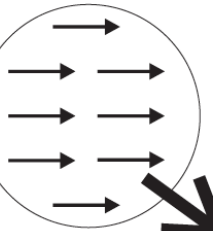
4piPAC -  
full solid angle  
photon-atom  
coupling

interferometry

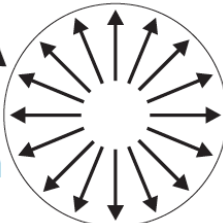


electron beam induced deposition  
K. Höflich et al. Nanotechnol. 23, 185303 (2012)

linear polarization

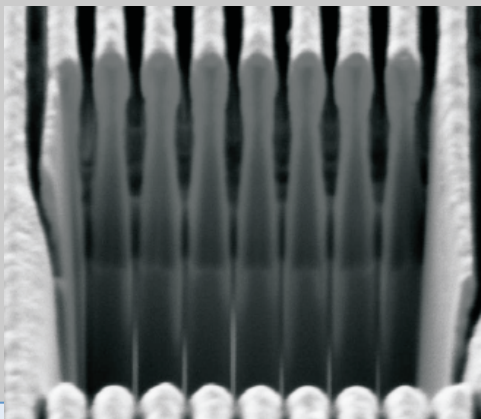


radial polarization



300 nm

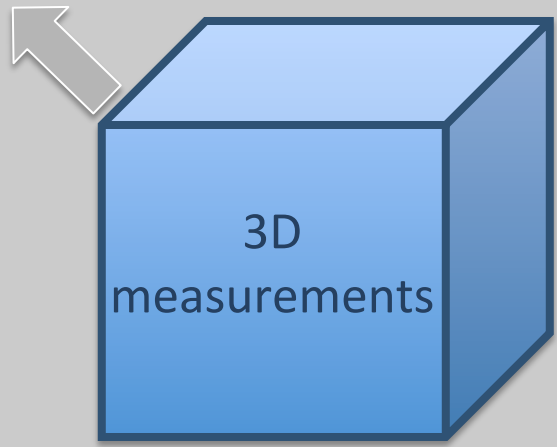
lithography



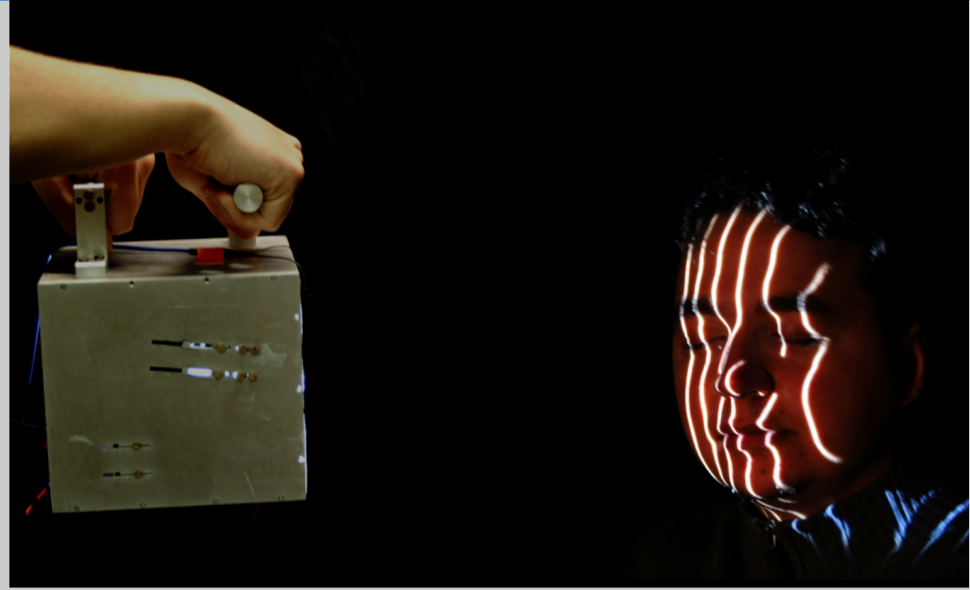
Z. Ghadyani et al., Appl. Opt. 50, 2451 (2011)



flying triangulation

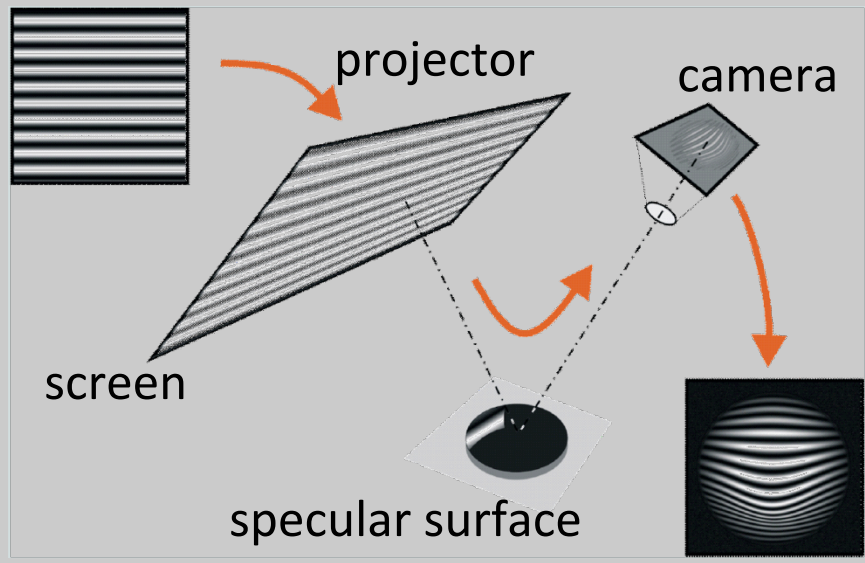


interferometry



MACRO & micro

S. Ettl et al.,  
Appl. Opt. 51, 281 (2012)



4piPAC -  
full solid angle  
photon-atom  
coupling

developing schemes for generating  
radial polarization  
→ the challenge : uv

higher order  
modes



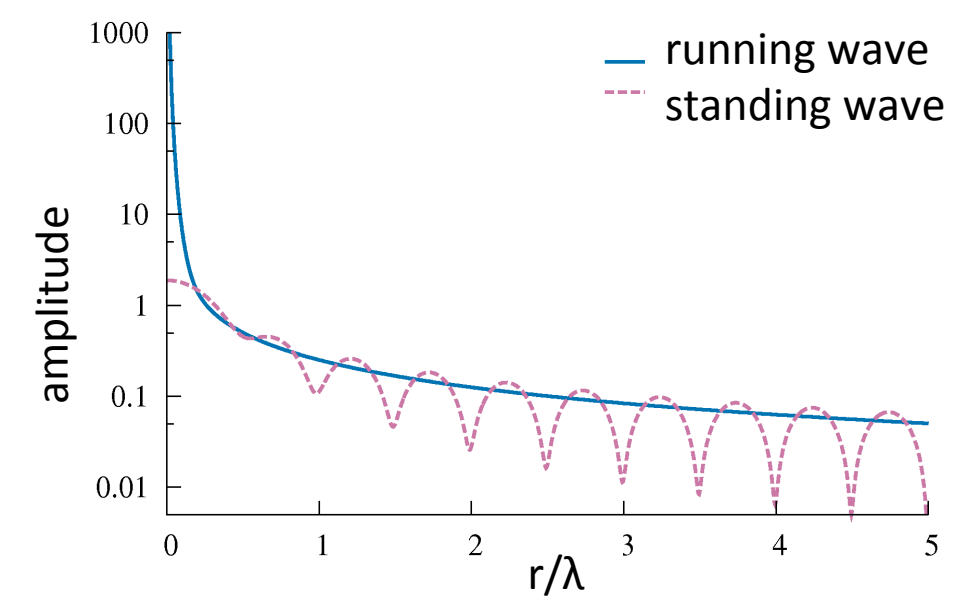
interaction with  
nano particles

characterization

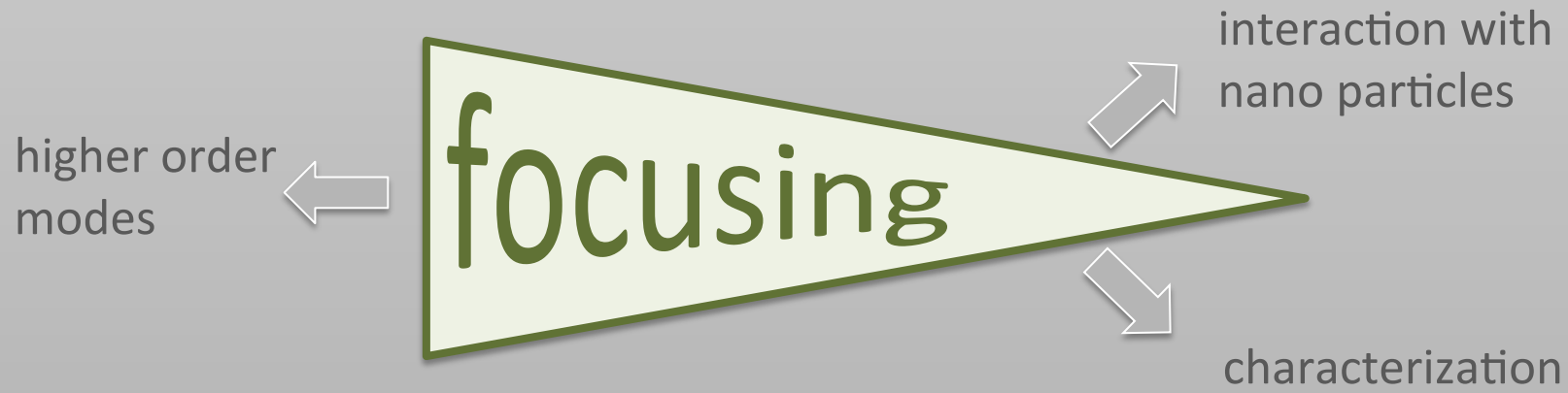
$$\vec{E} = \vec{E}_{0, far} \frac{e^{-ikr}}{r} + \vec{E}_{0, near} \left( \frac{1}{r^3} + \frac{ik}{r^2} \right) e^{-ikr}$$

on resonance field enhancement !

off resonant field enhancement ???

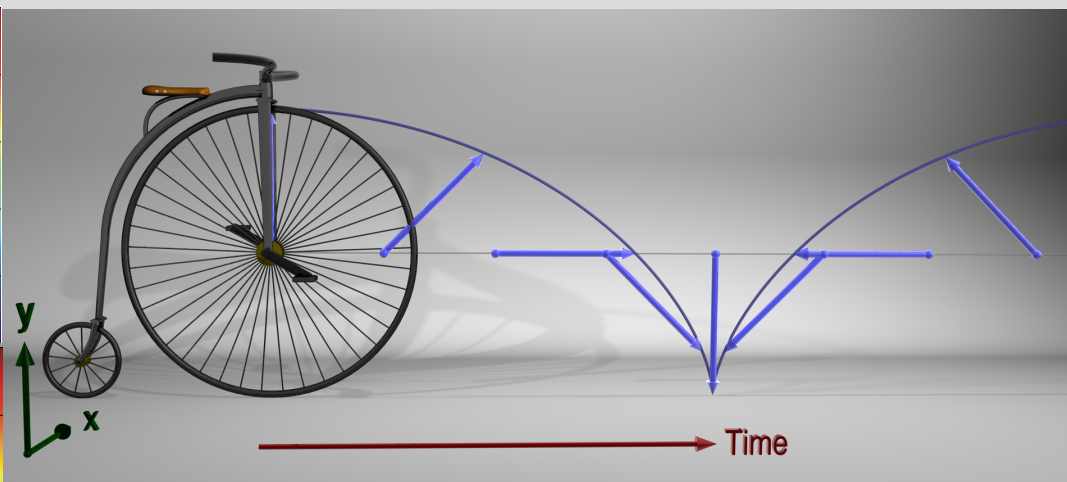
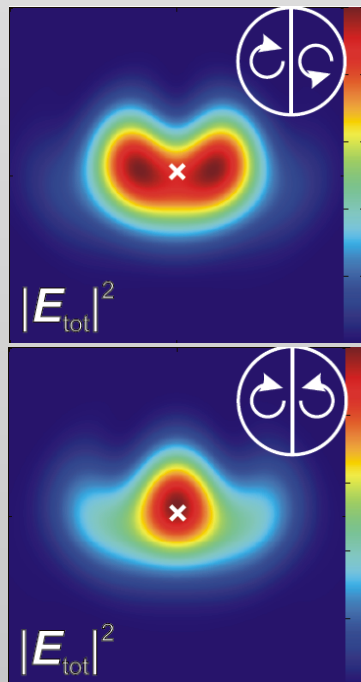
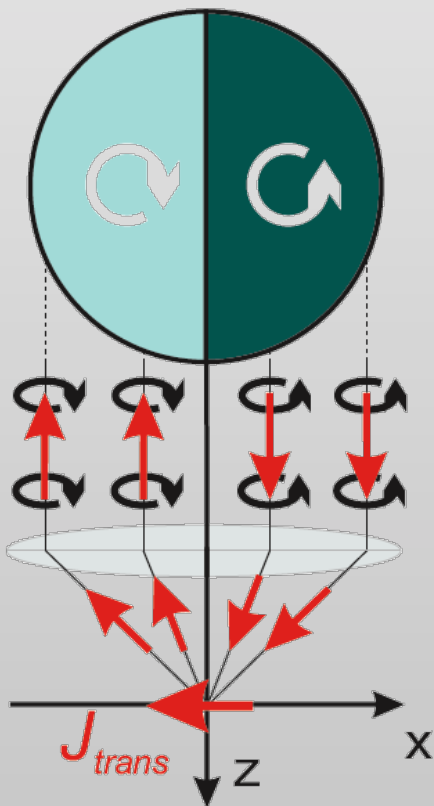


→ → field enhancement for ultra short pulses focused in free space  
 I. Gonoskov et al. Phys.Rev.A86, 053836 (2012)



P.Banzer et al.  
arXiv:1210.1772

transverse angular momentum  
→ photonic wheel



higher order modes

focusing

interaction with  
nano particles

characterization