



Optical binding dynamics of gold nanoparticles with linearly patterned gold nanodisks

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Introduction

Optical matter of gold nanoparticles

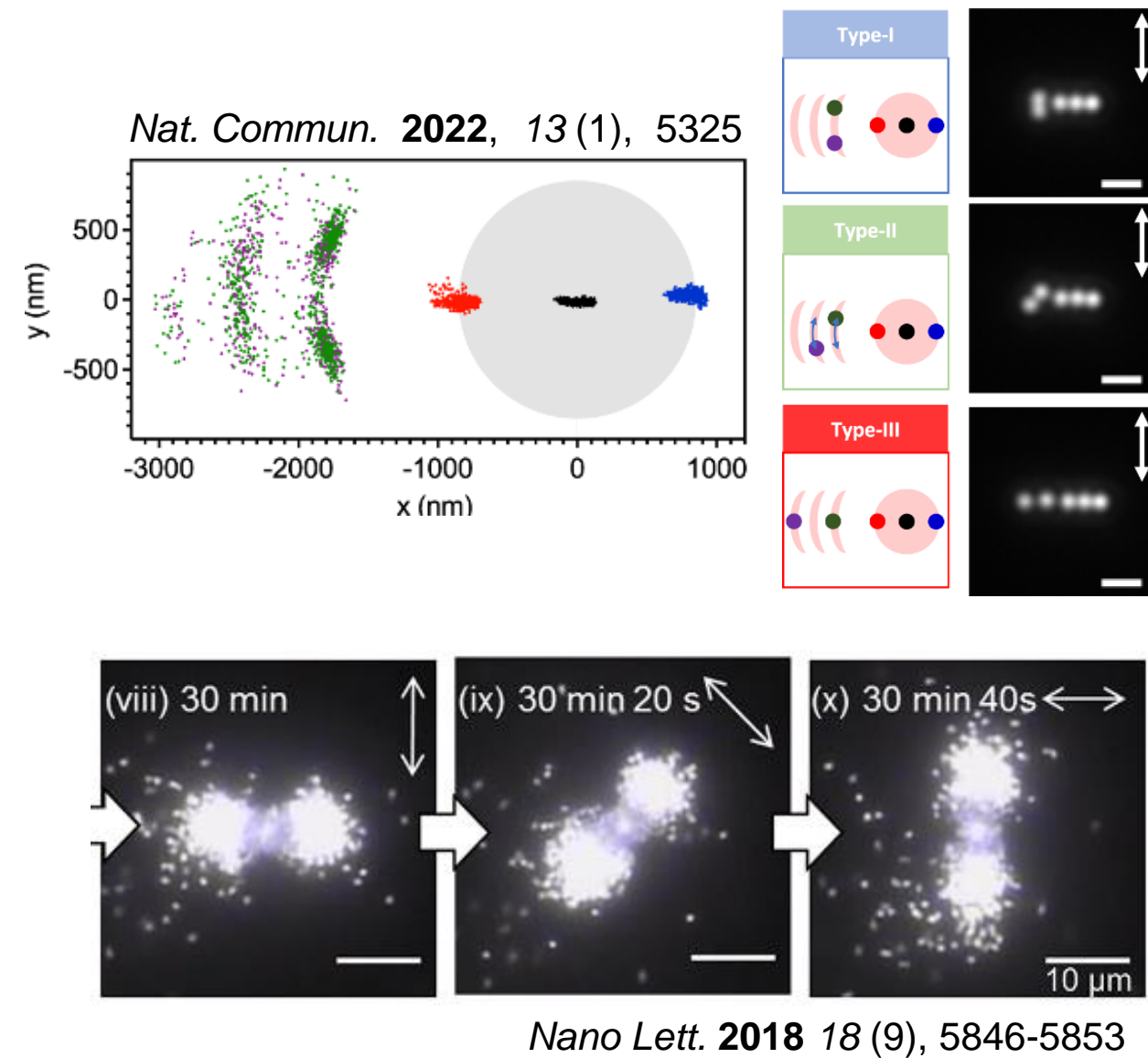
The gold (Au) nanoparticles (NPs) assembly was formed by focusing a linearly polarized 1064 nm laser at the glass/solution interface.

At the Individual stage:

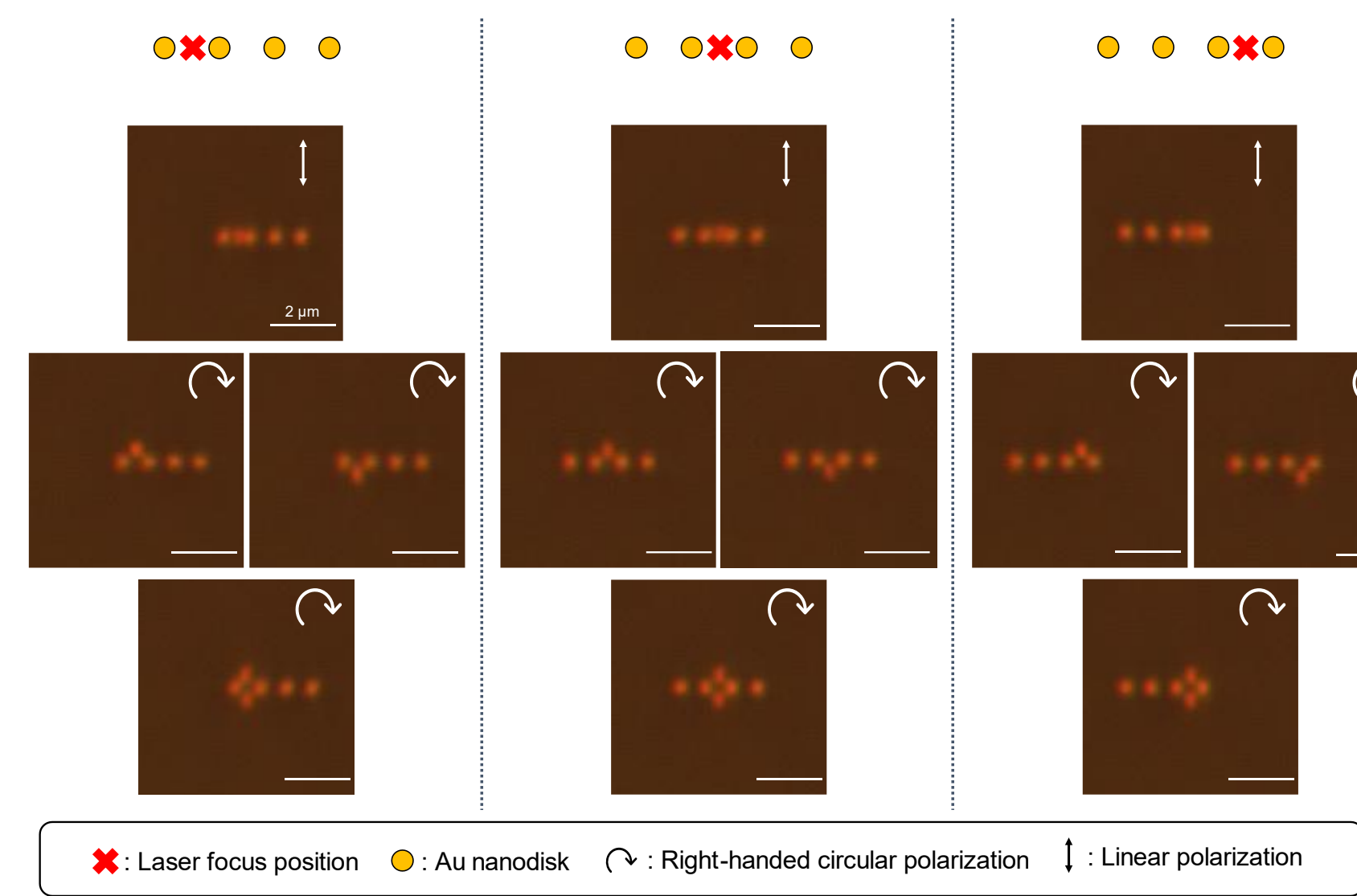
Au NPs { irradiated : Separated with a wavelength
non-irradiated : Half-wavelength periodicity

At the ensemble stage:

Morphology control { Polarization of the laser
Incident photon momentum
Excited scattering mode of Au NP



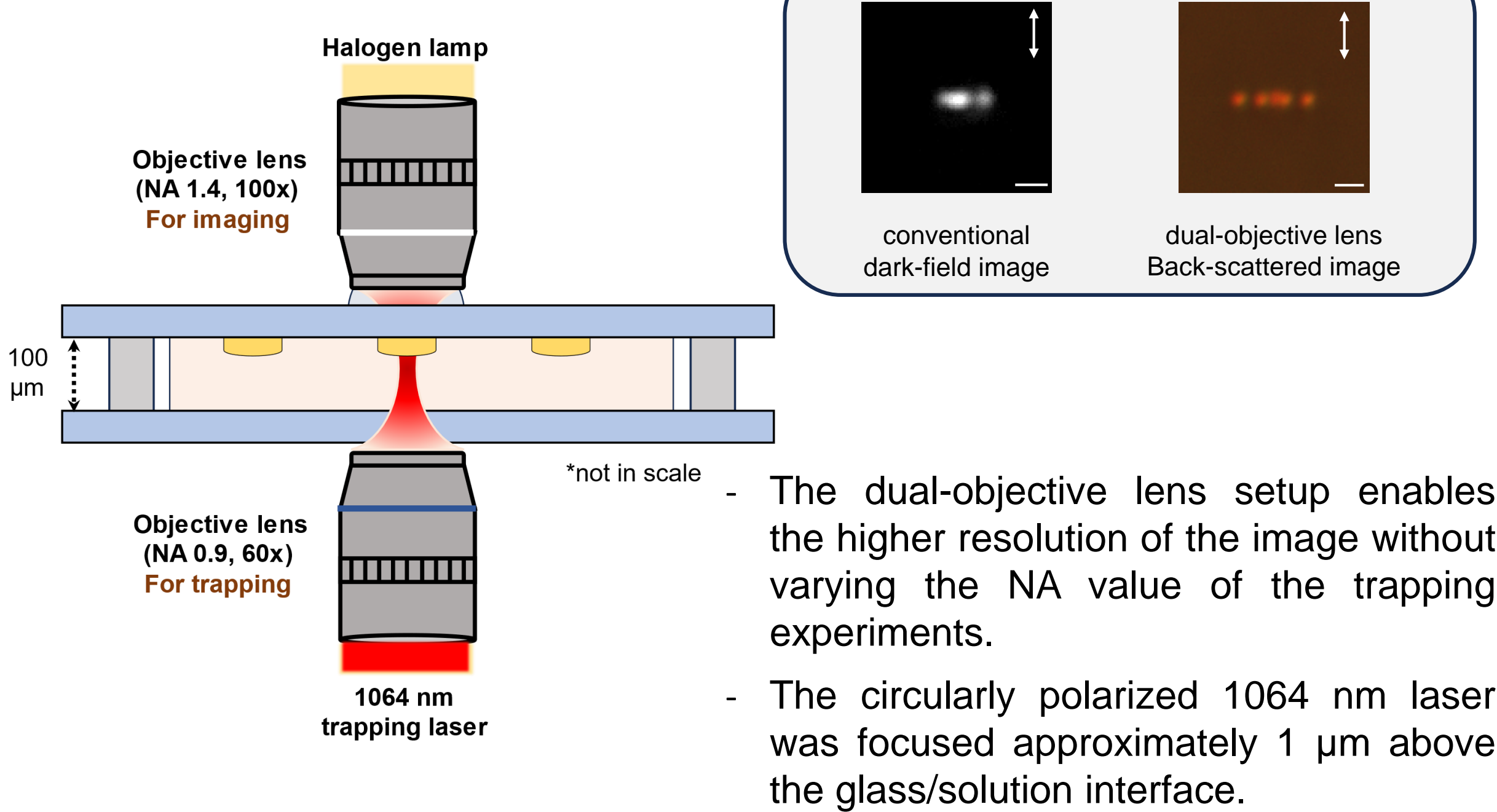
Previous work: Polarization dependent optical trapping dynamics



- The design of the Au nanodisk (ND) pattern was inspired by the optical binding linear assembly inside the laser focus.
- The Au NPs were trapped at a position with a displacement to the laser focus when a circularly polarized laser was introduced.
- The occupation of the top or bottom site were stochastic for the upcoming Au NP.
- Our attention shifted from the dynamics of Au NPs under linearly polarized irradiation to those under circularly polarized irradiation.

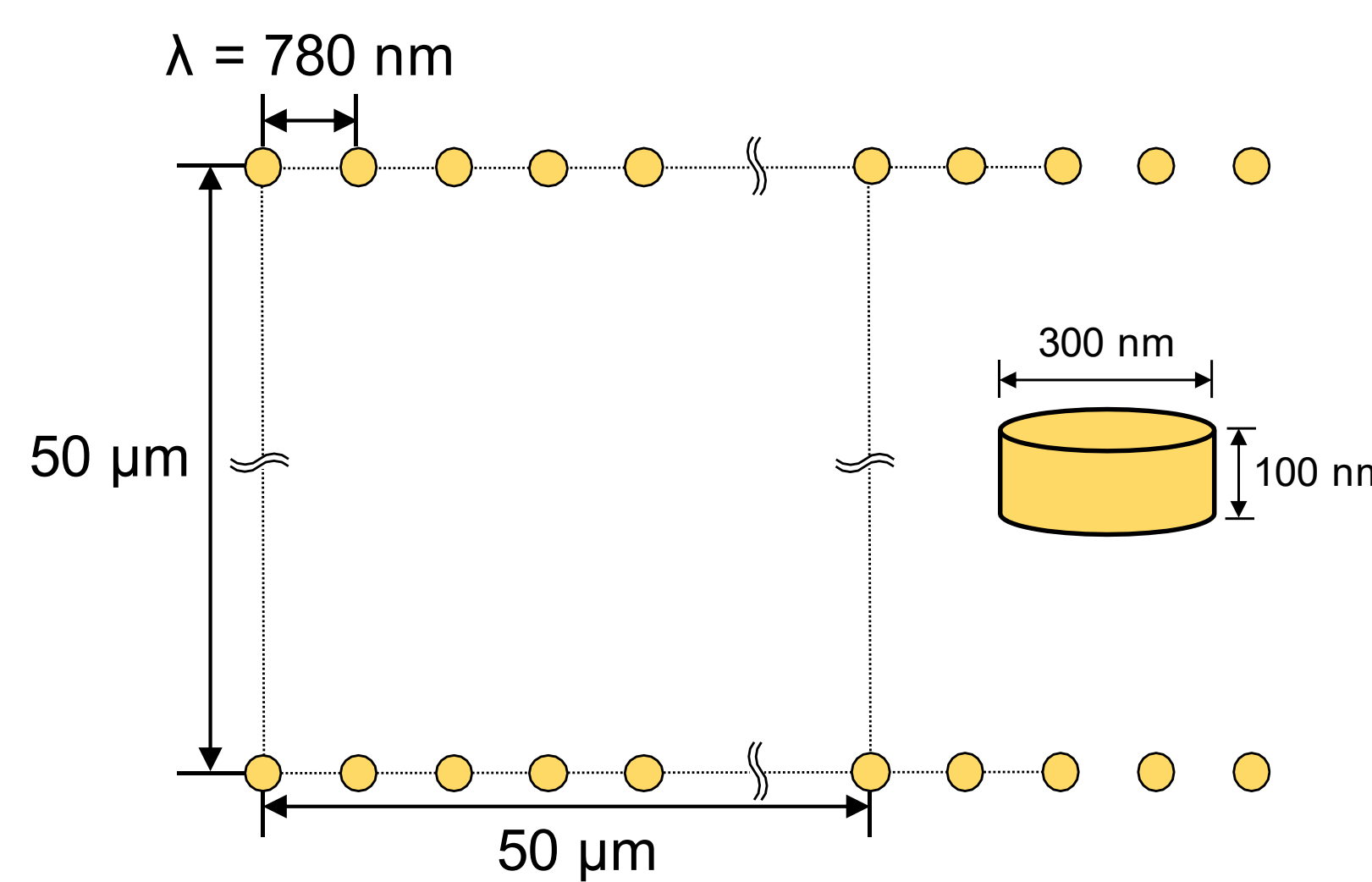
Experimental

Optical trapping setup

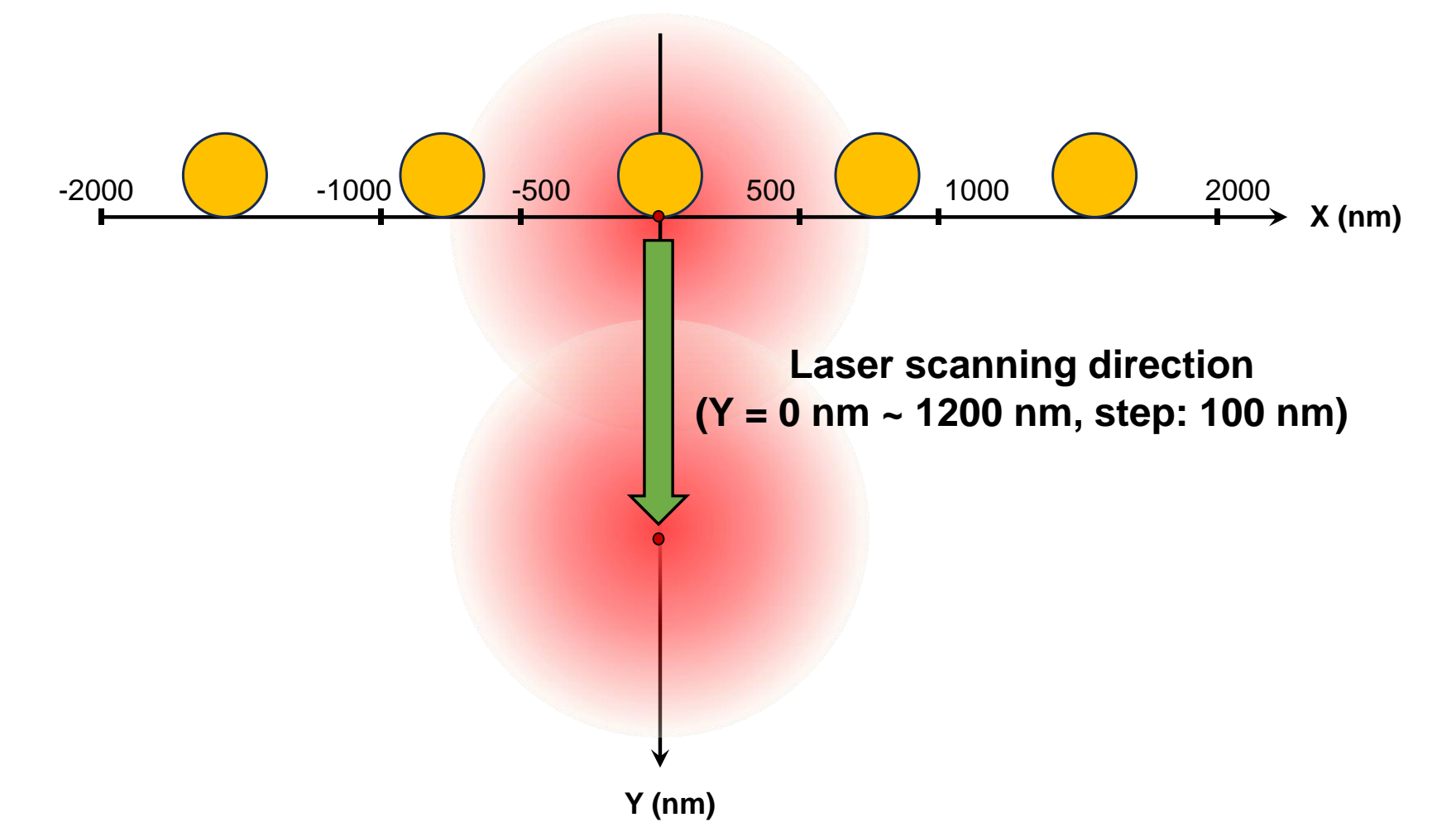


- The dual-objective lens setup enables the higher resolution of the image without varying the NA value of the trapping experiments.
- The circularly polarized 1064 nm laser was focused approximately 1 μ m above the glass/solution interface.

Design of the Au ND pattern



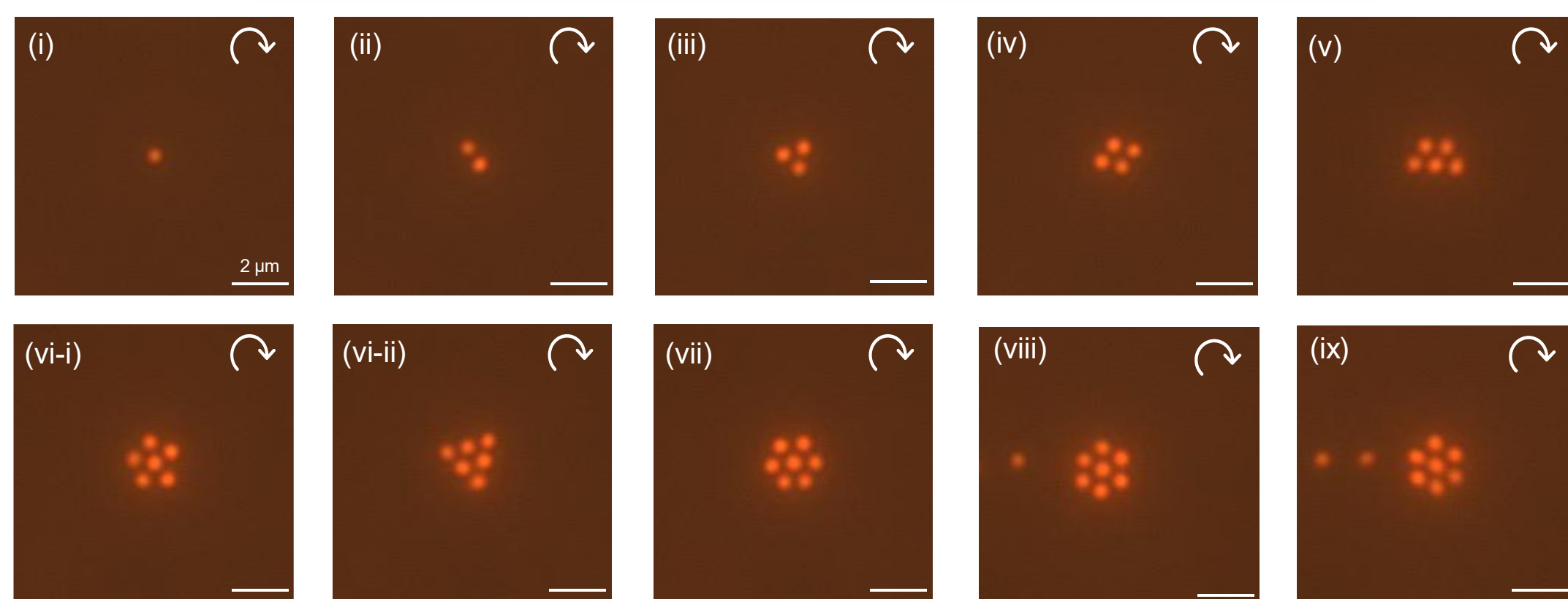
Experimental scheme



- The circularly polarized laser beam was scanned starting from the edge of the Au ND and extended up to 1200 nm away from it.
- The focal spot size was estimated around 1500 nm experimentally and theoretically.

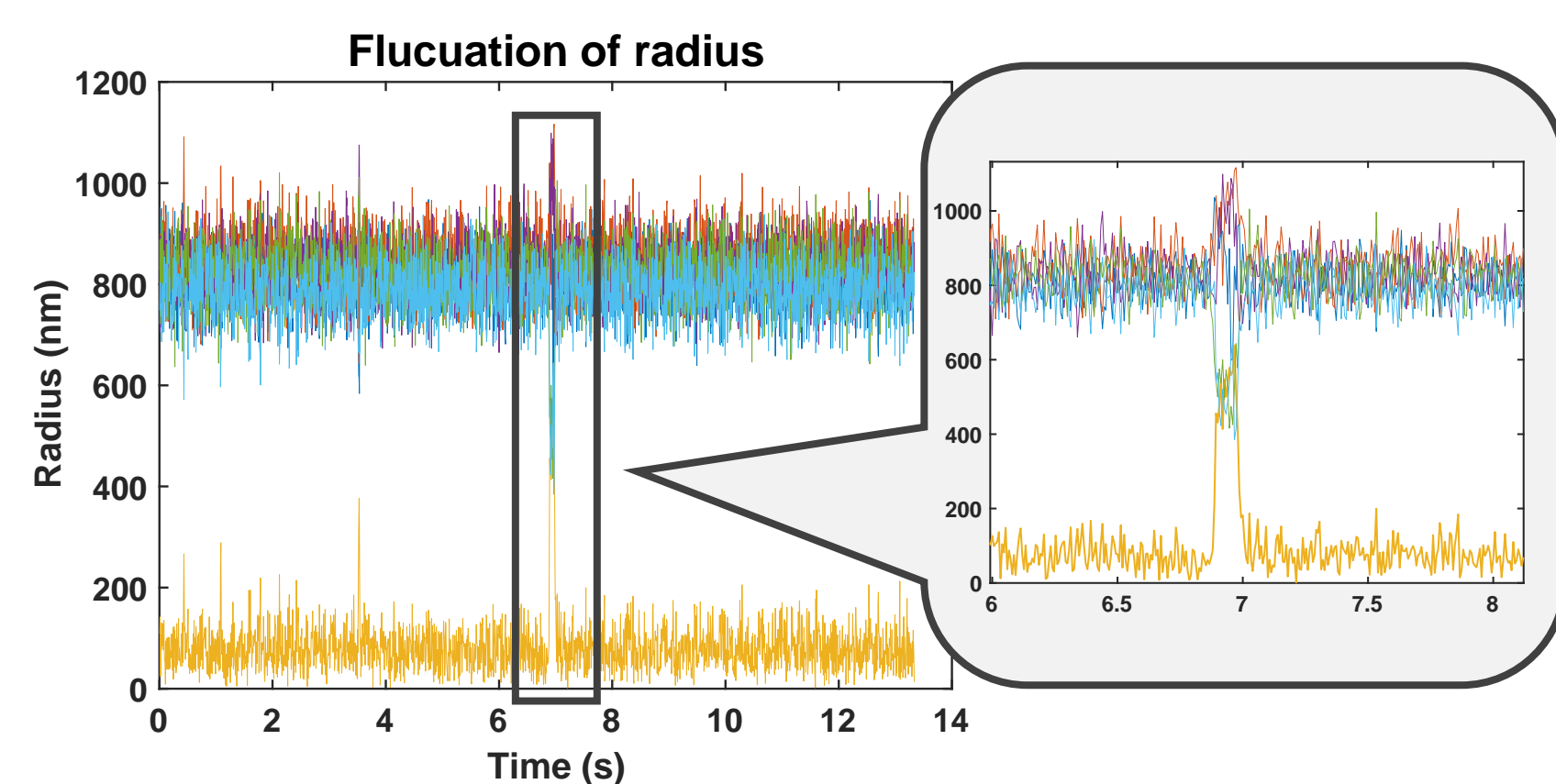
Results and Discussion

Au NP assembly at the Individual level



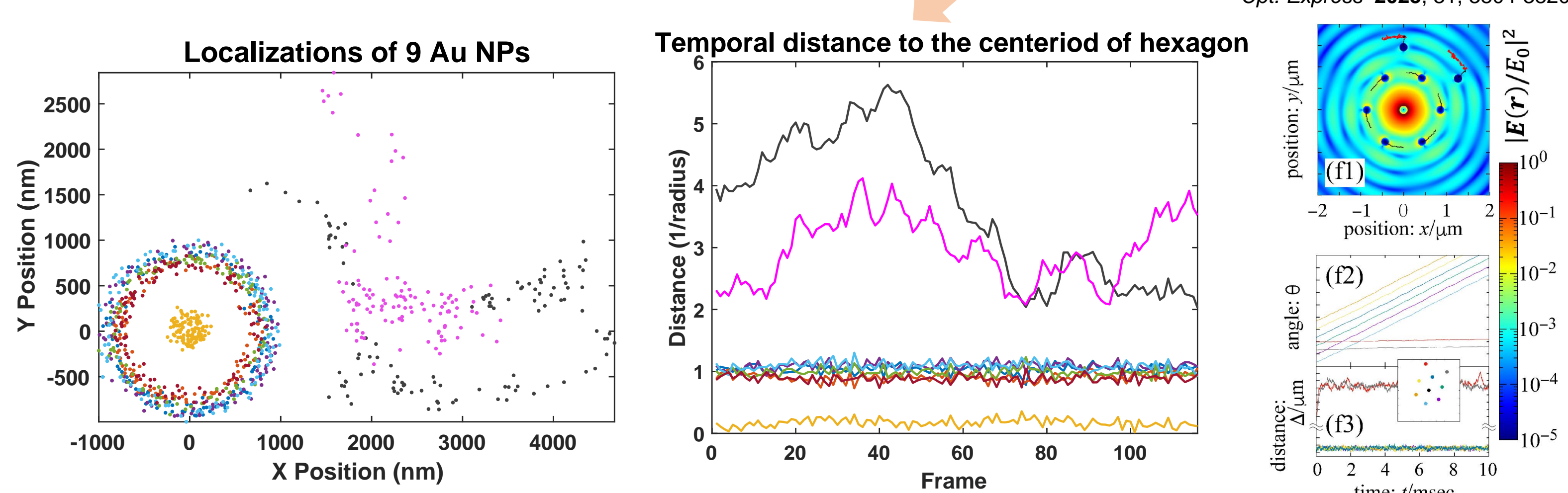
- Rotational motion of the Au NPs were observed → circular polarization
- The largest ordered assembly is the hexagon → focal spot size

Configuration change of 6 NP assembly



- The pentagon is more commonly observed.
- The configuration change was studied by investigating the geometry of the assembly.
- The emergence of triangle is associated with:
(i) 5 NP → 6 NP
(ii) rearrangement of the pentagon

Optical binding outside the irradiation area

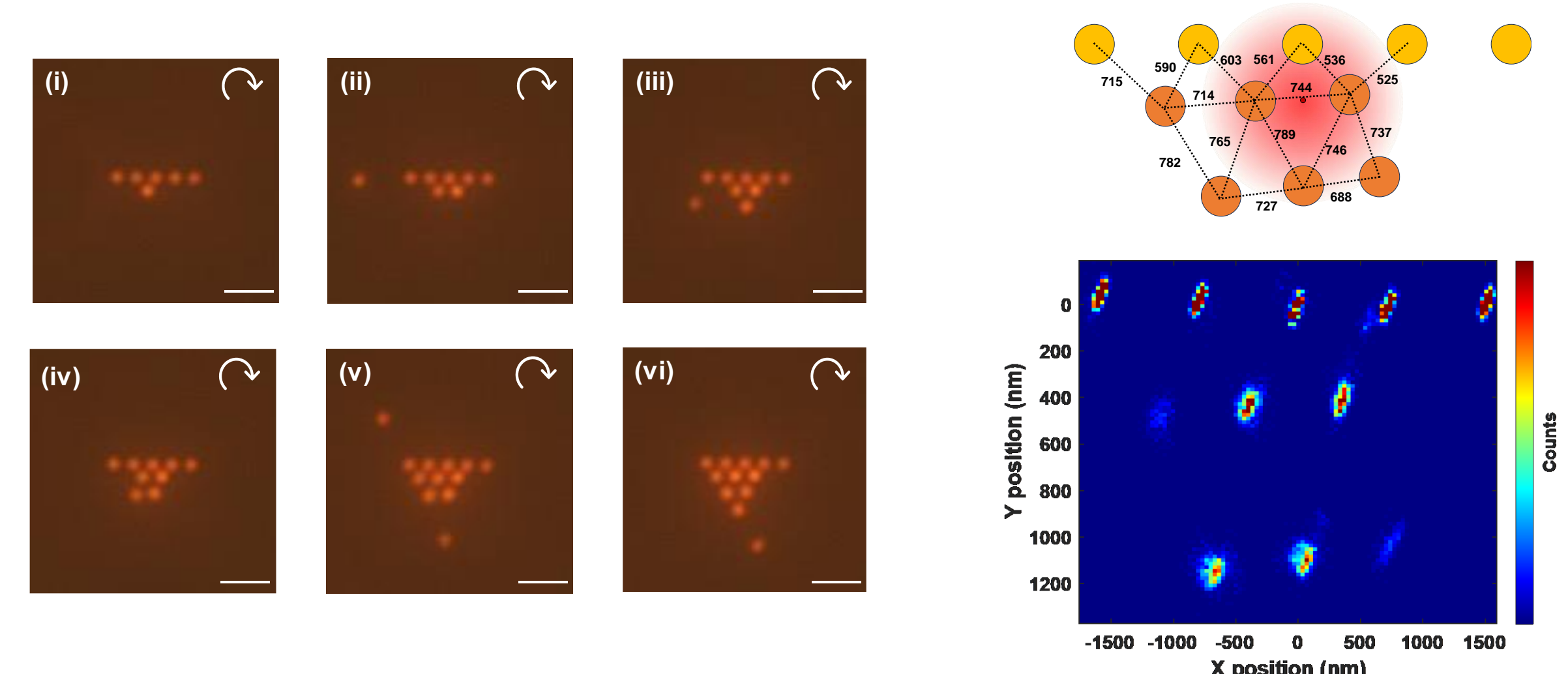


Summary

- The dynamics of optical matter and its coupling with lithographical pattern was extensively studied under circular polarization. The non-irradiated Au NPs exhibits the arc-shaped distribution with a half-wavelength periodicity, which realized the optical binding outside the irradiation area experimentally.
- The coupling of Au ND and Au NPs provides a new approach to prepare ordered optical matter with rotational suppression even with circular polarization. The distance between Au NPs and Au ND determines the strength of the coupling (far-field interaction).

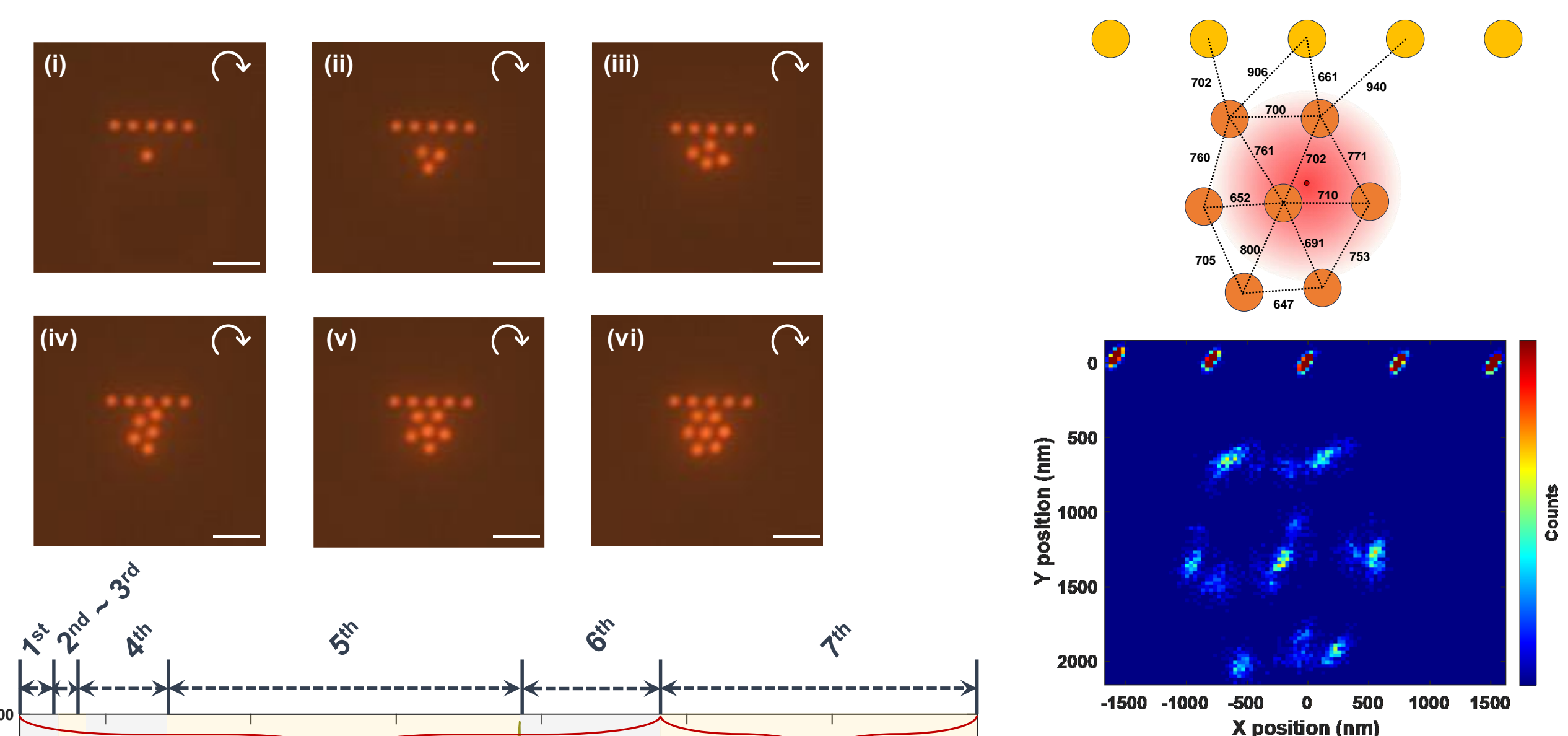
Far-field trapping enhancement of Au ND pattern

Laser positioned at Y = 300 nm (strong mutual interaction)



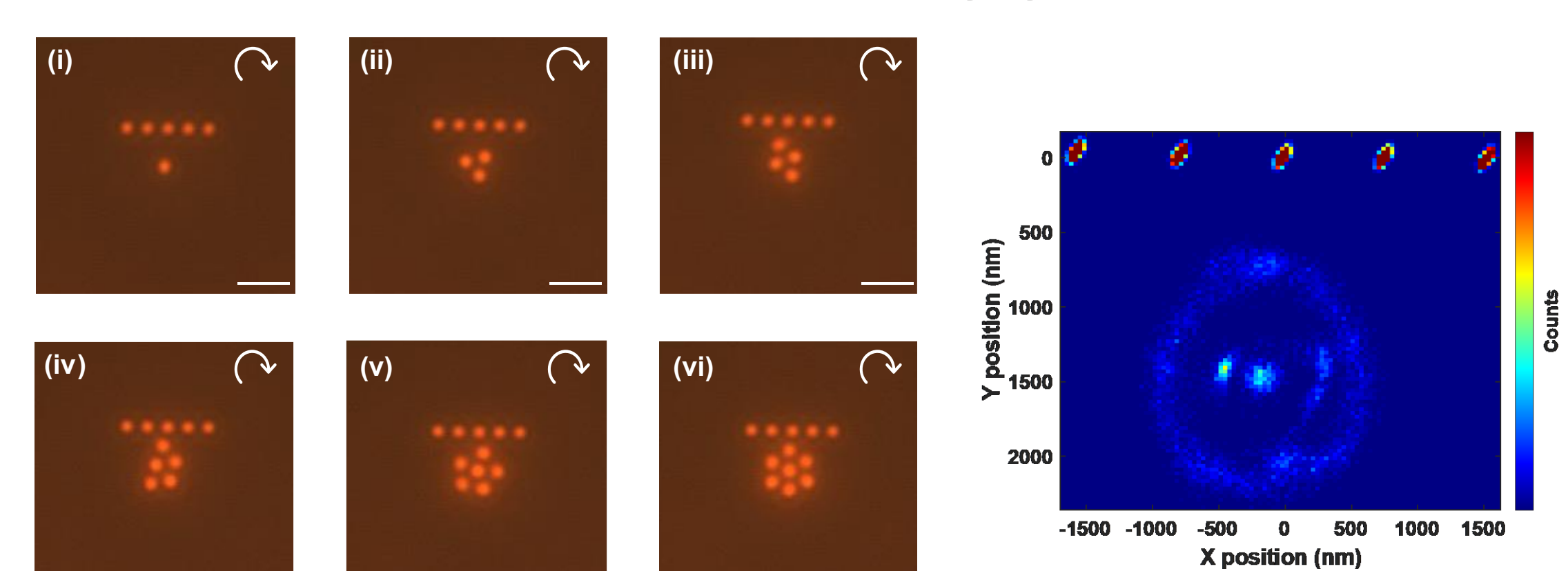
- Au NPs were **stably confined** near the Au ND pattern, forming a triangle configuration

Laser positioned at Y = 900 nm (weakened mutual interaction)



- The rotational motion of the assembly was **suppressed** when the fourth Au NP joined.
- The intrinsic configuration of the assembly was observed instead of the triangle one.

Laser positioned at Y = 1200 nm (negligible mutual interaction)



- The rotational **suppression was not observed** for the 7 NP assembly.