

Coherent space-gated microscopy: a step towards deep-tissue phase imaging of biological cells

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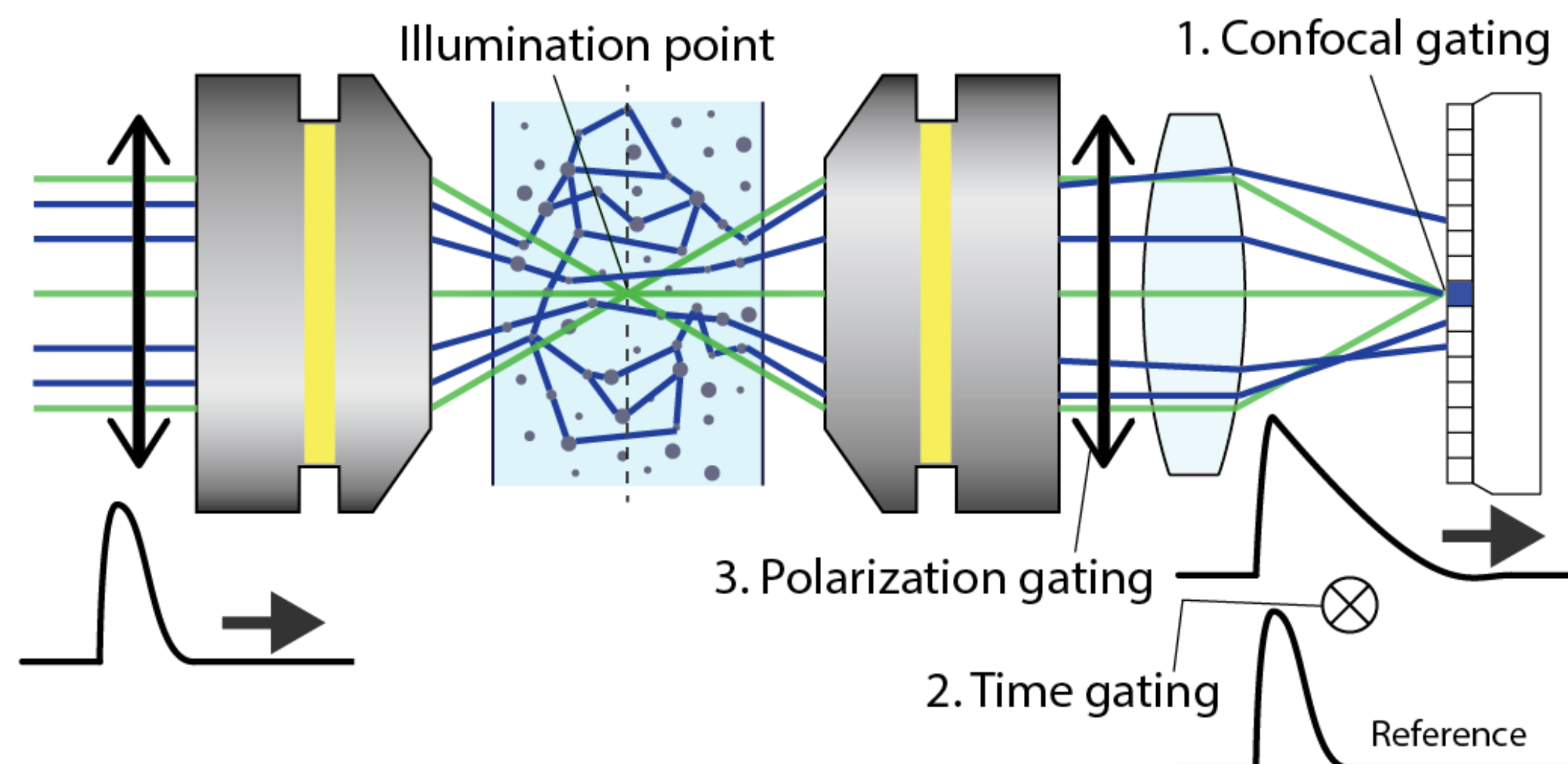
[†] Equal Contribution



Abstract

Here, we present a new gating scheme, called ‘space’ gating that rejects the multiply scattered wave directly at the object plane located inside the scattering medium. This method allows the rejection of the multiply scattered wave, which existing gating methods cannot filter out.

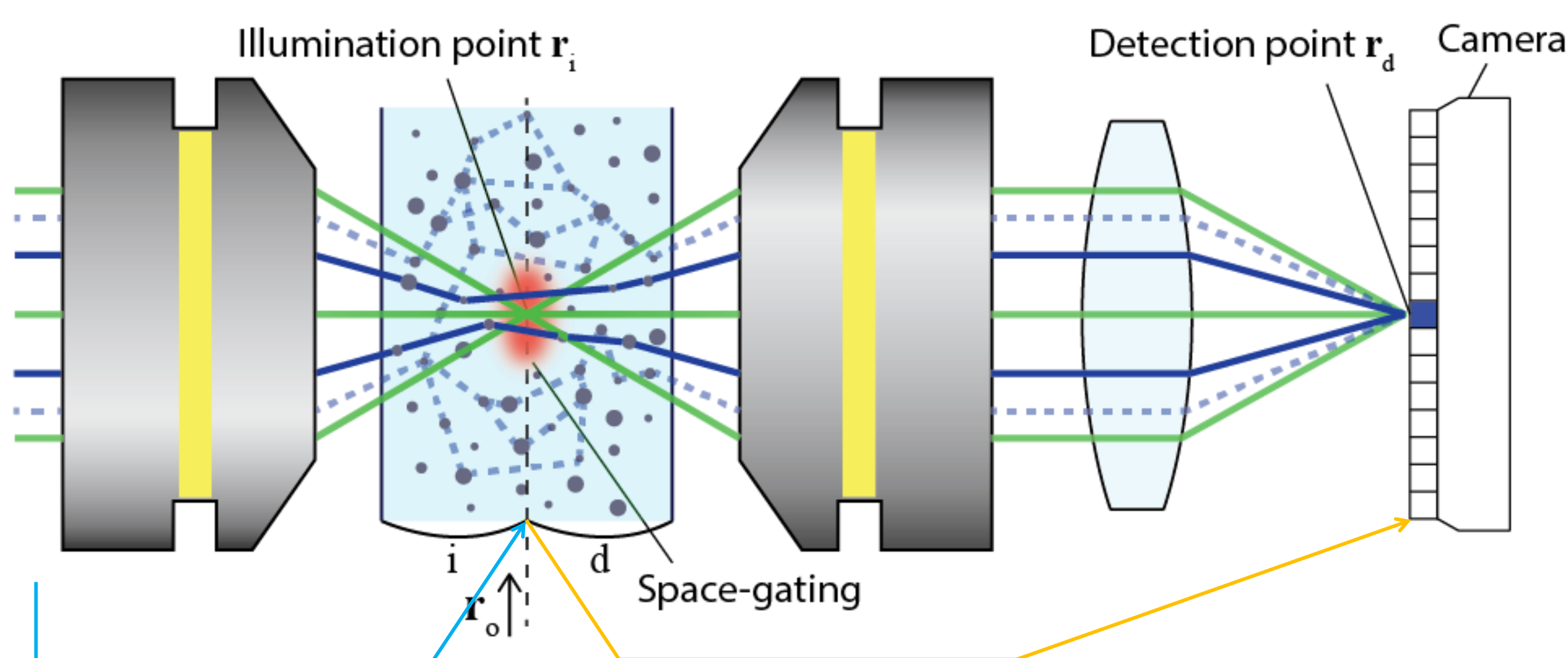
Conventional Gating Schemes



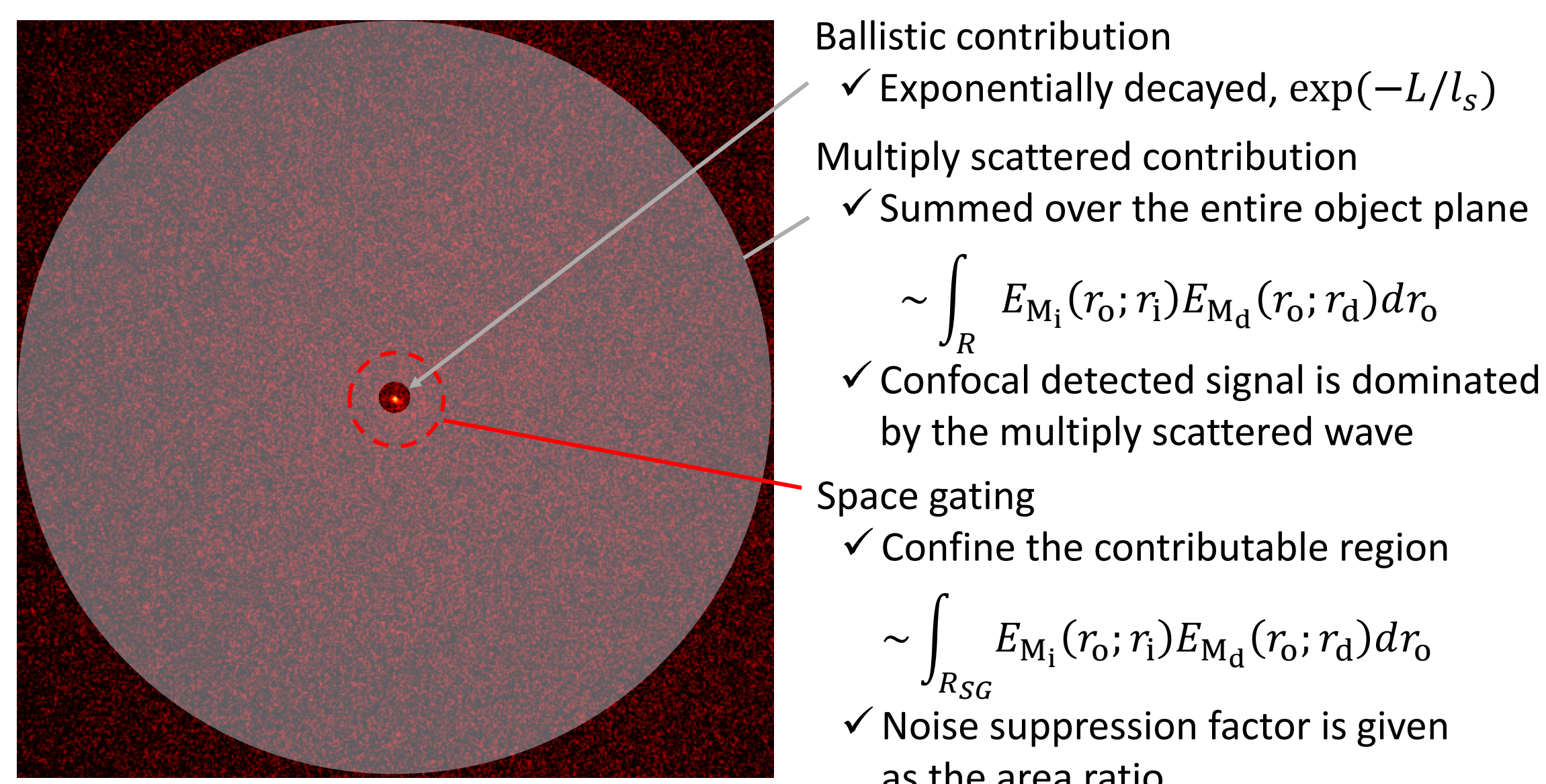
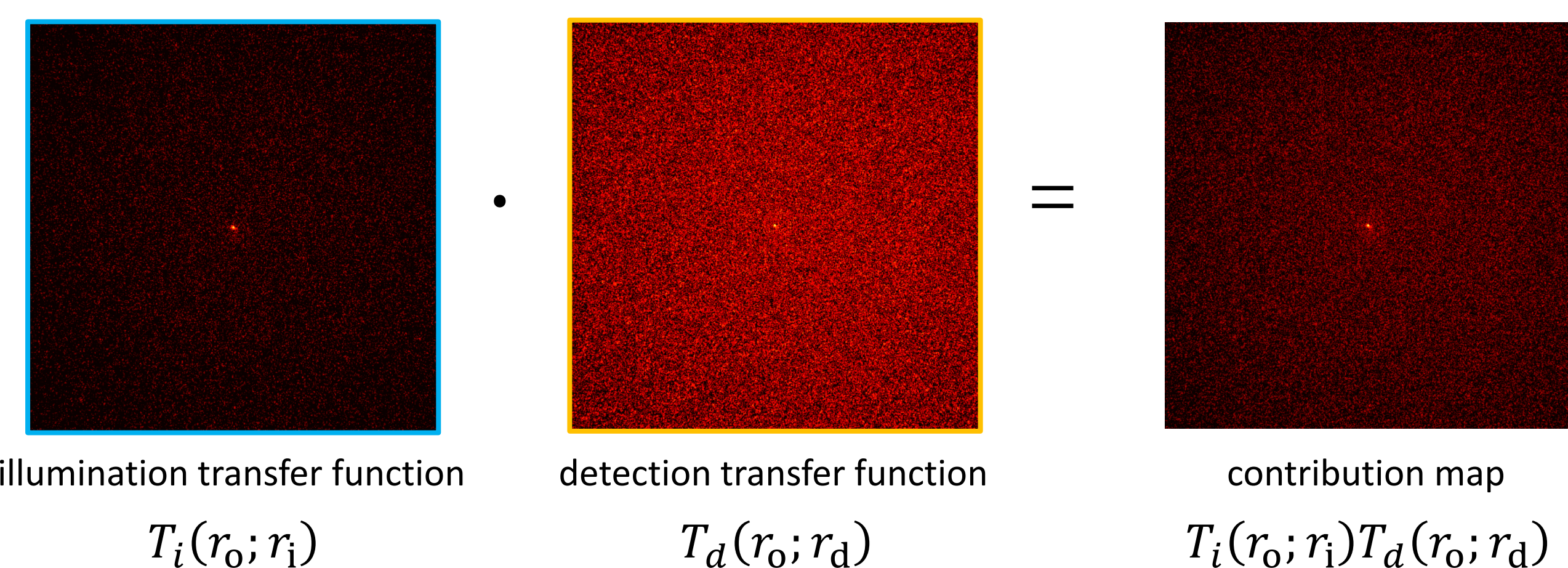
To extend imaging depth in scattering media, various gating operations – **confocal**, **coherence**, and **polarization gating** – have been devised to filter out the multiply scattered wave. Typically, those gating methods are combined to optimize the gating efficiency (e.g. optical coherence tomography). However, these gating methods are imperfect as they **all act at the detection plane located outside the scattering medium**.

Space Gating

Space gating is a new gating scheme applied ‘**inside**’ scattering media.

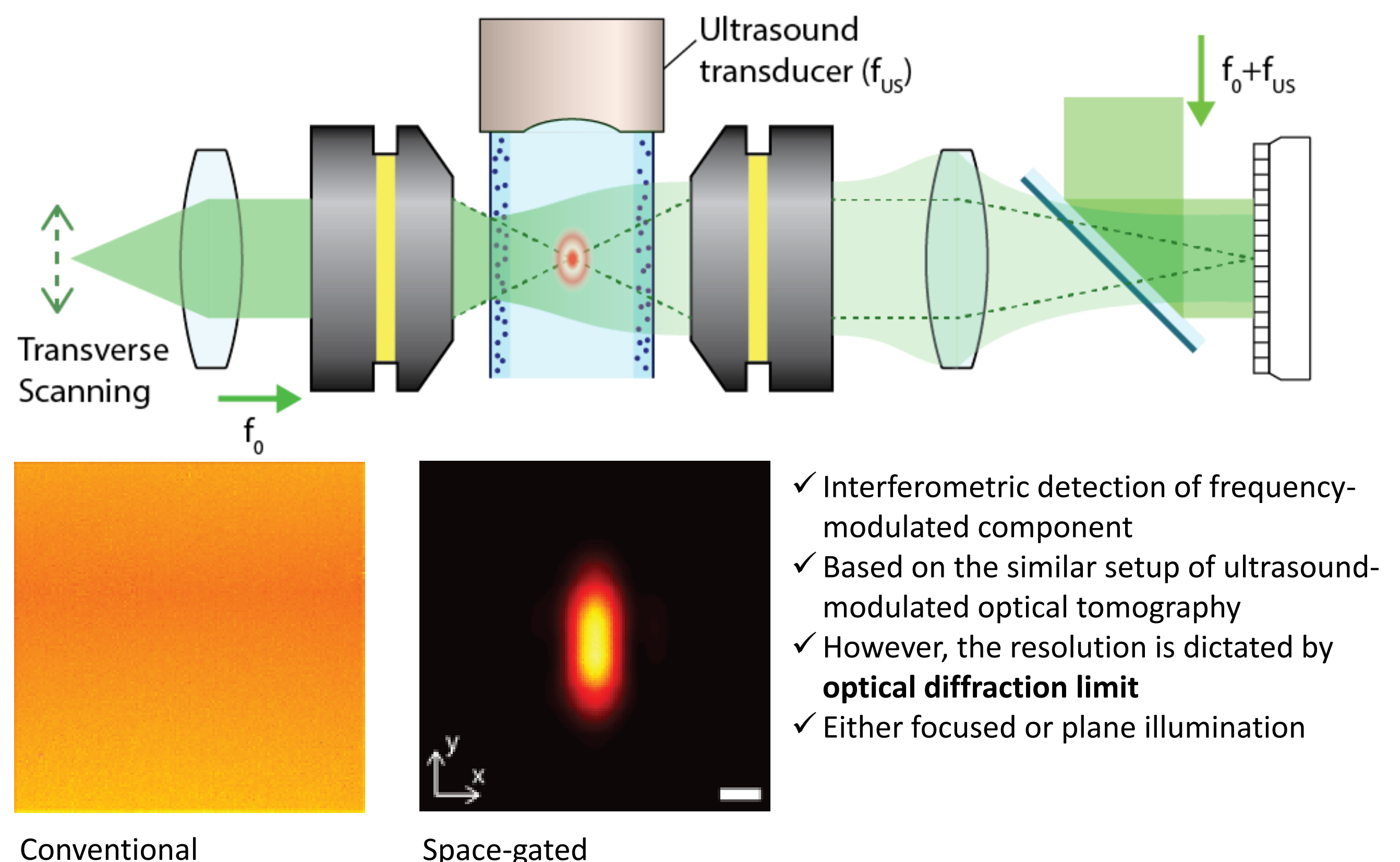


Transfer Functions and Contribution Map on the Object Plane

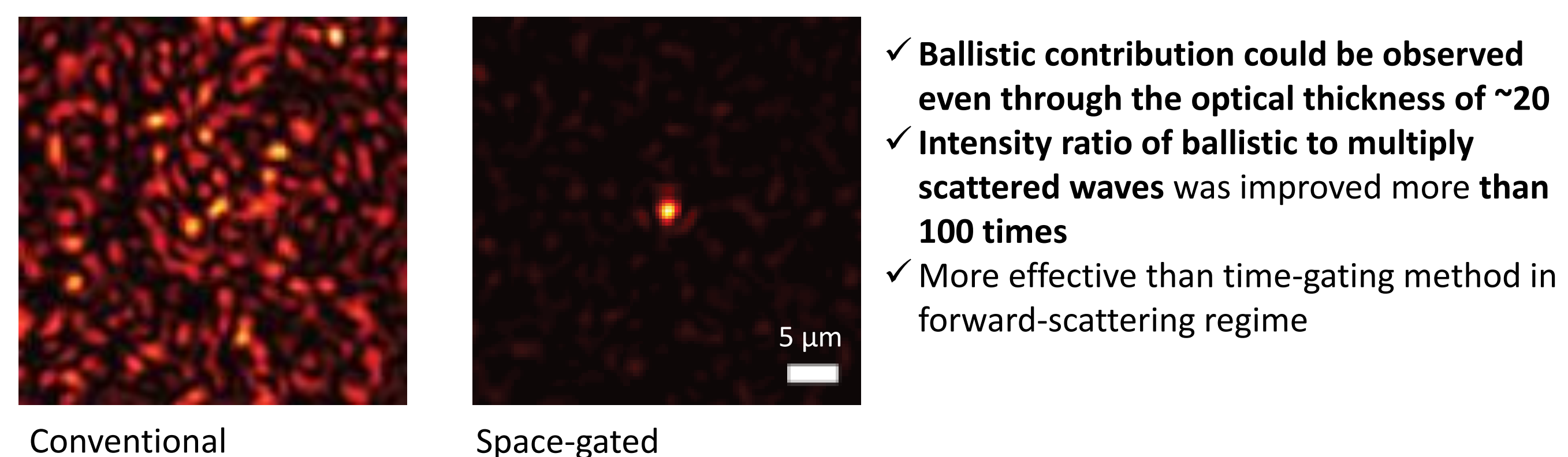


Implementation of Space Gating

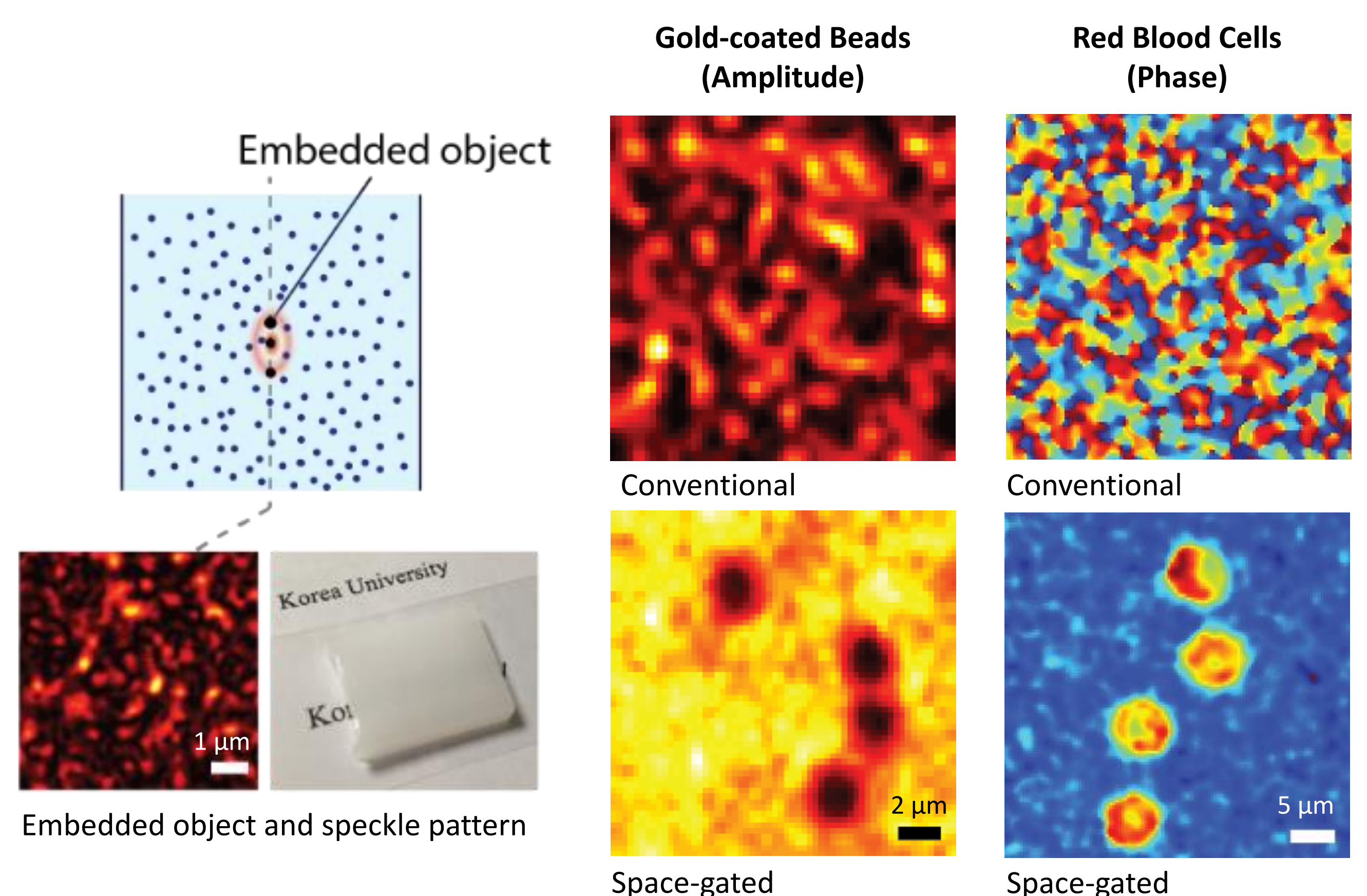
Acousto-optic effect enables space-gating.



Imaging PSFs on the Detection Plane



Imaging Cells Embedded within Scattering Media



Conclusions

- A new gating mechanism, called ‘space’ gating, has been proposed.
- Space gating rejects the multiply scattered wave whose optical path spreads beyond the extent of the ultrasound focus.
- In contrast to the conventional gating methods – confocal, time, and polarization gating, space gating operates ‘inside’ scattering media.
- Space-gated imaging is an optical diffraction-limited coherent imaging method for both amplitude and phase objects.
- Space gating can suppress the multiply scattered wave by more than 100 times.
- Space gating is more effective than time-gating method in forward-scattering regime.
- Phase imaging through scattering media is a unique imaging capability of space gating.

Acknowledgements

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