



# Diamond NMR Spectrometers

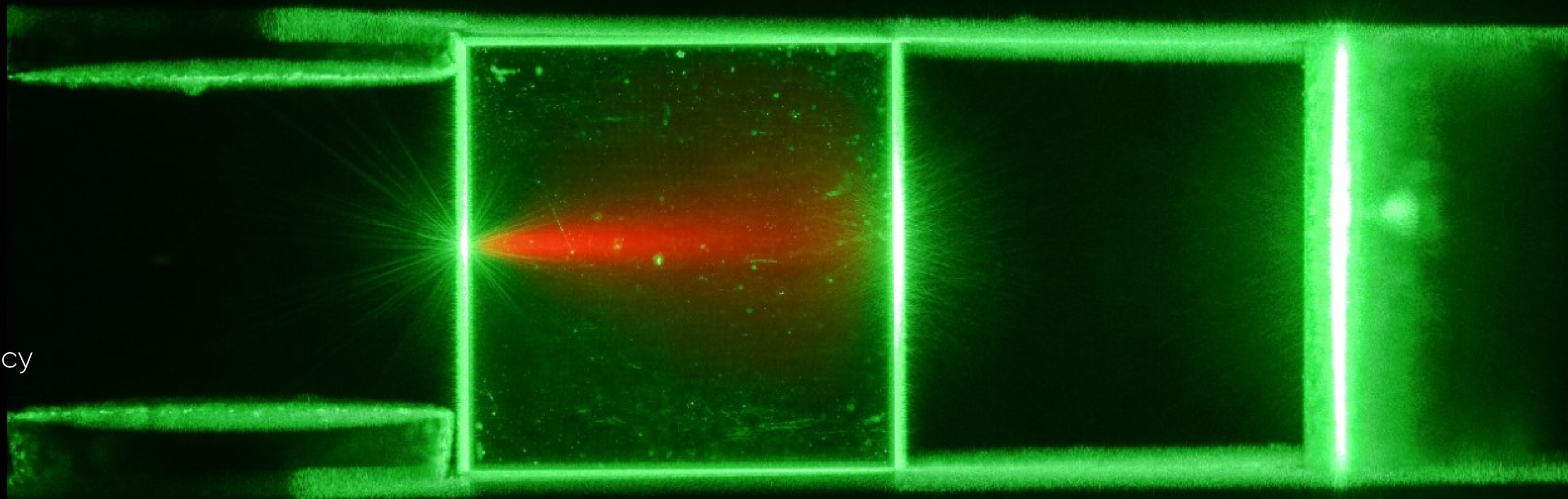
Sepehr Ahmadi

[sepehr.ahmadi@csiro.au](mailto:sepehr.ahmadi@csiro.au)

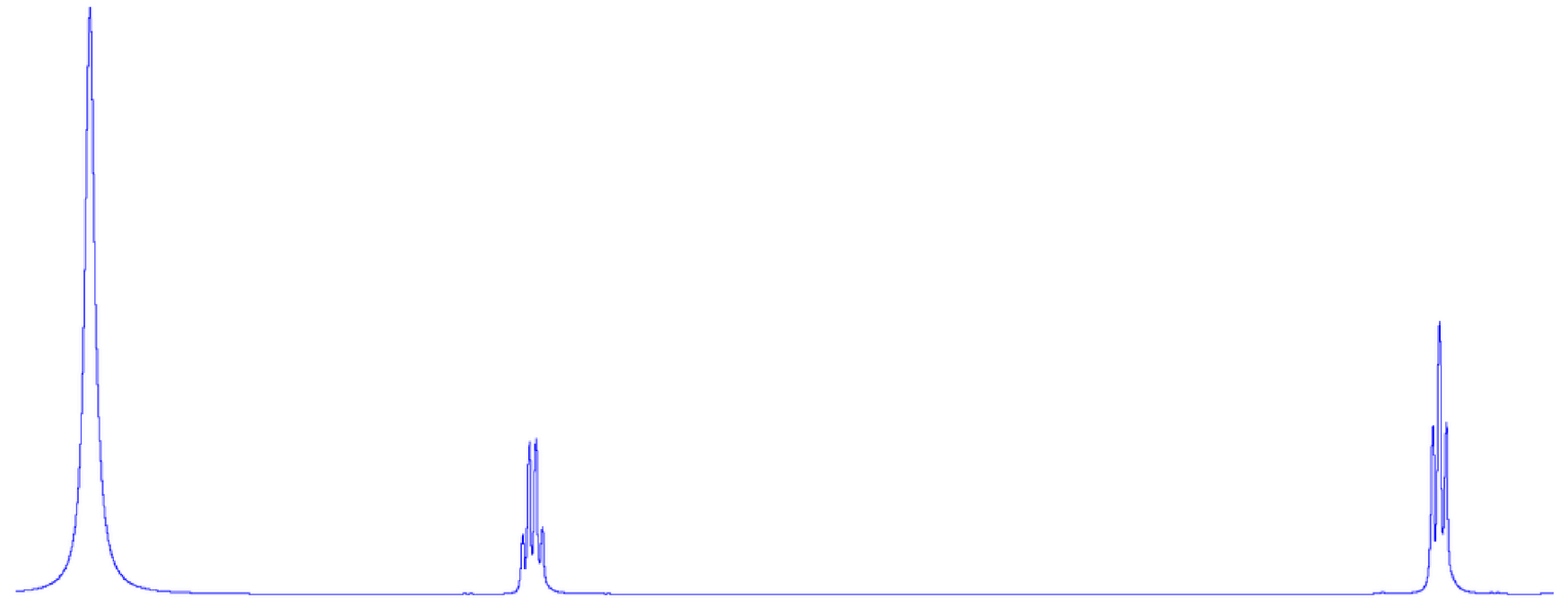
Emerging Energy Technologies

CSIRO Manufacturing

Australia's National Science Agency



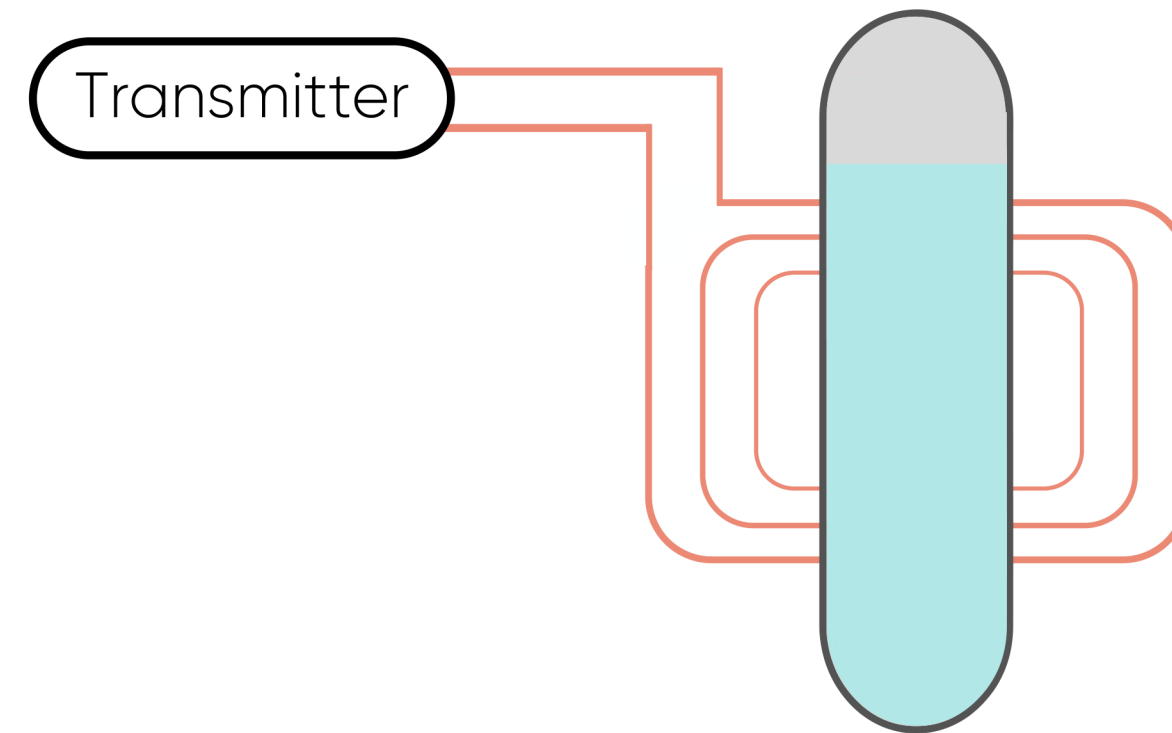
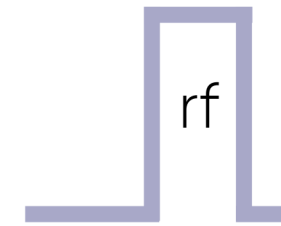
# NMR spectroscopy



# Conventional NMR



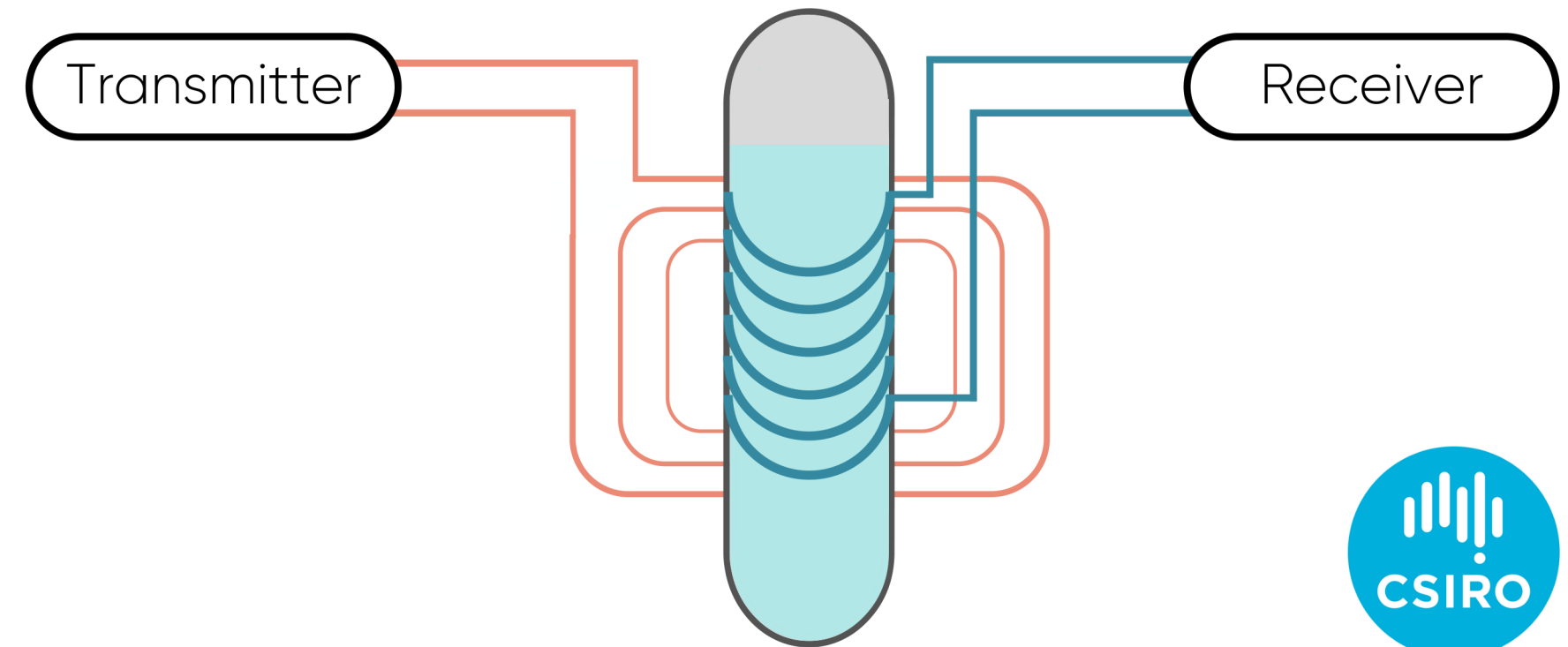
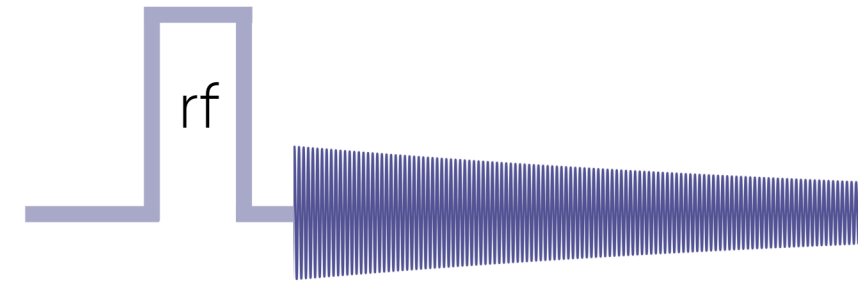
Basic pulse sequence



# Conventional NMR



Basic pulse sequence

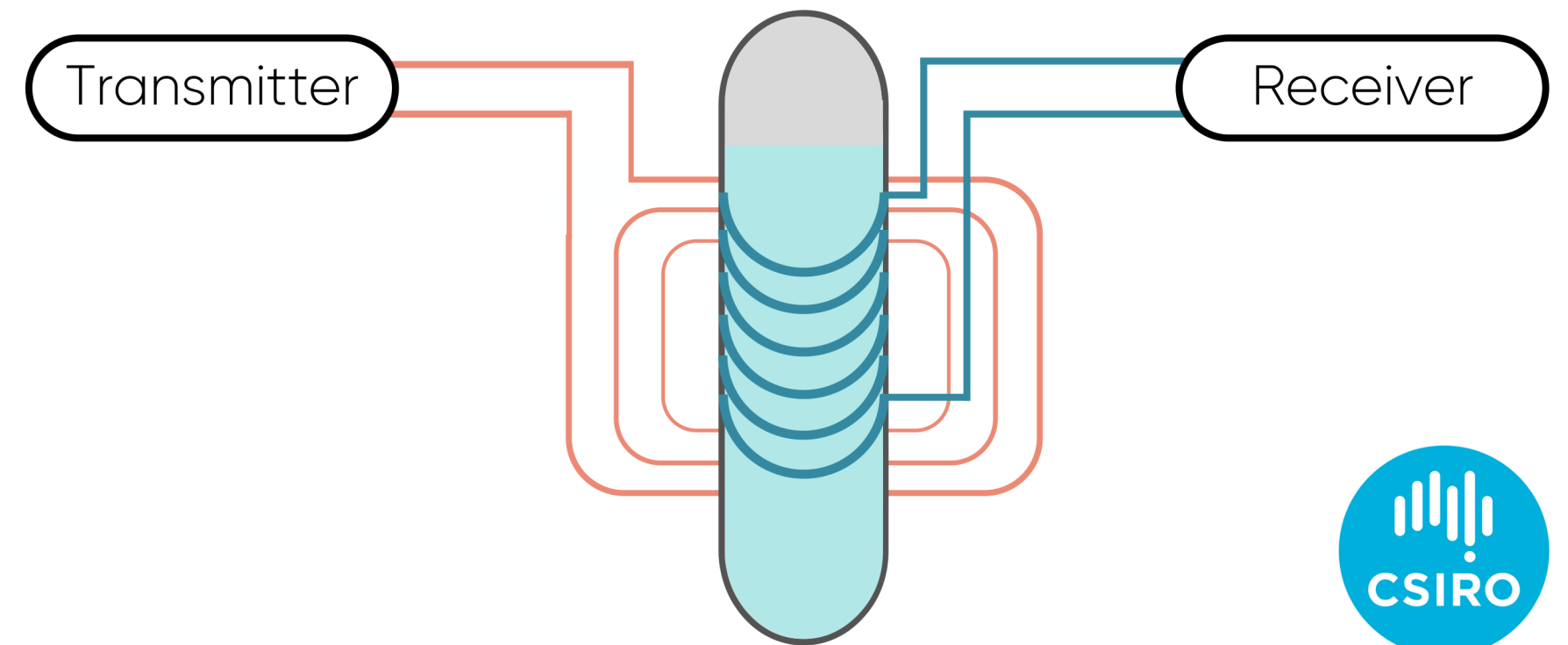


# Conventional NMR

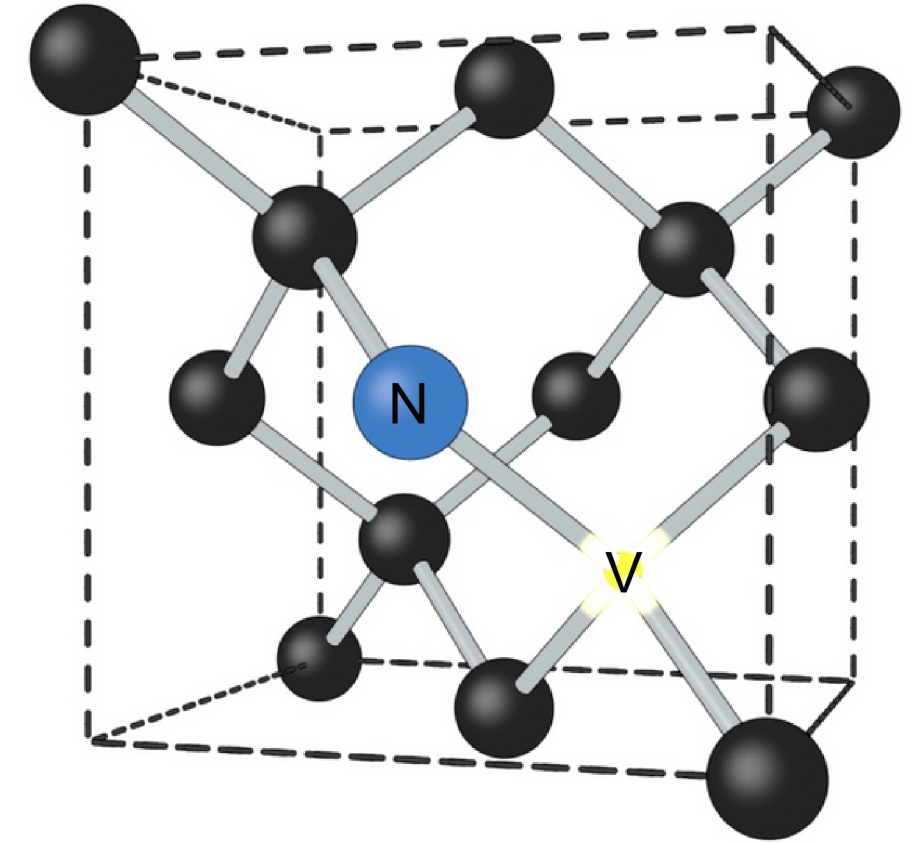


## Limitations:

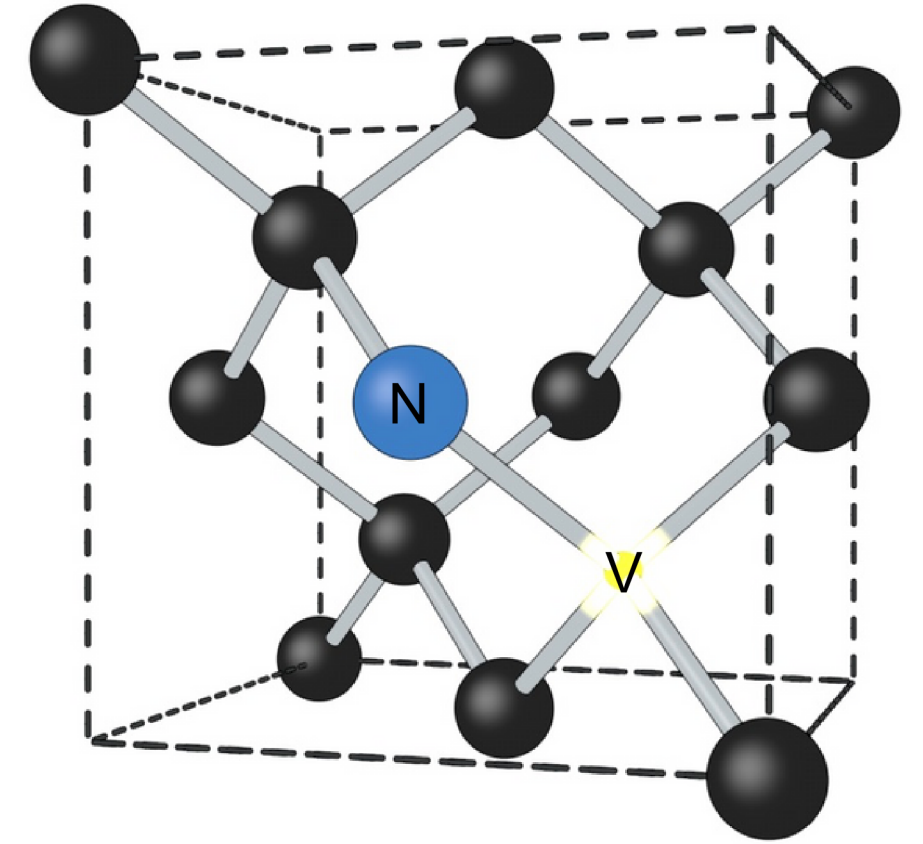
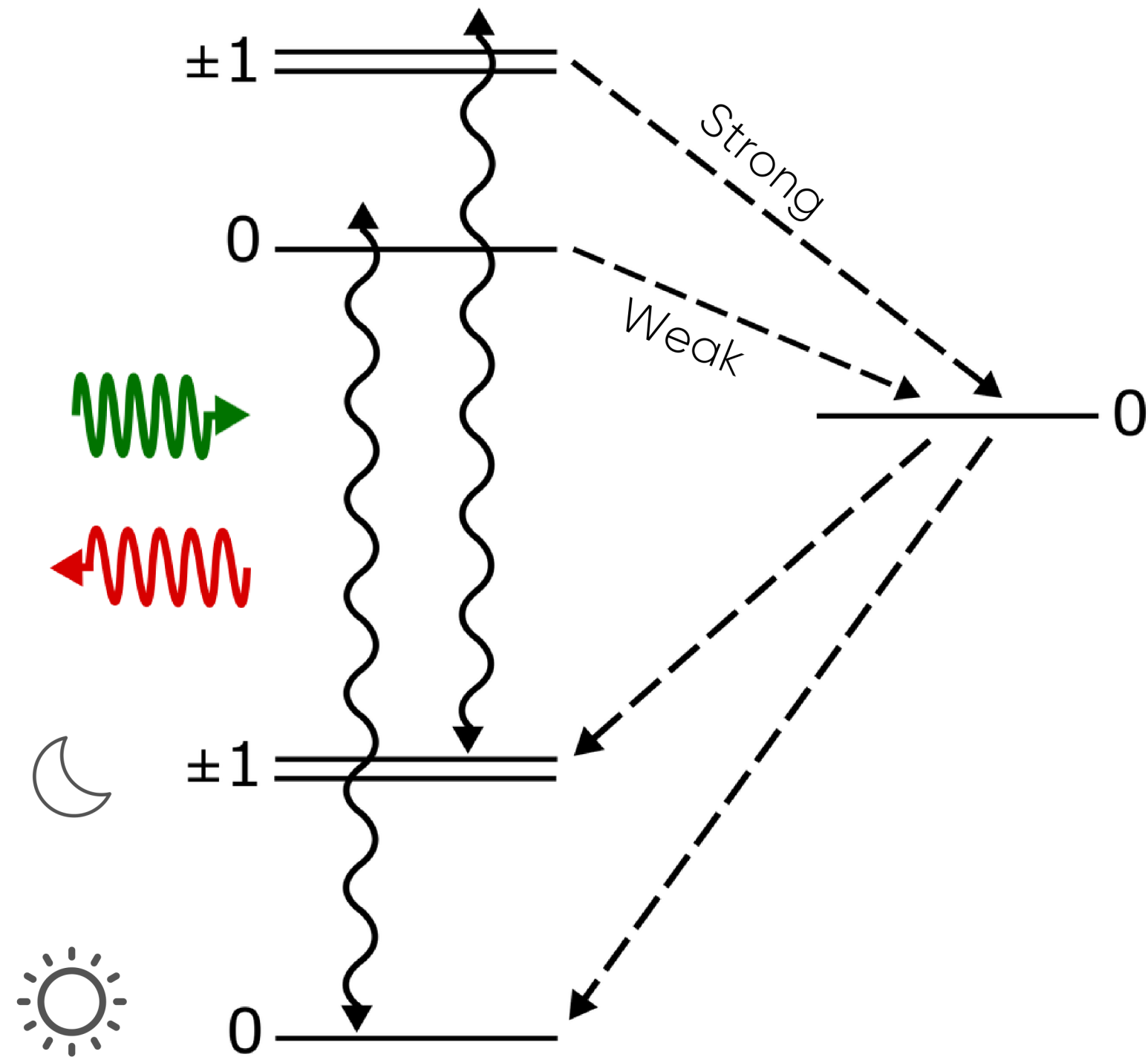
- Inductive detector noise
- Thermal polarisation
- Macroscopic sample
- Requires large and expensive magnets
- Limited spatial resolution



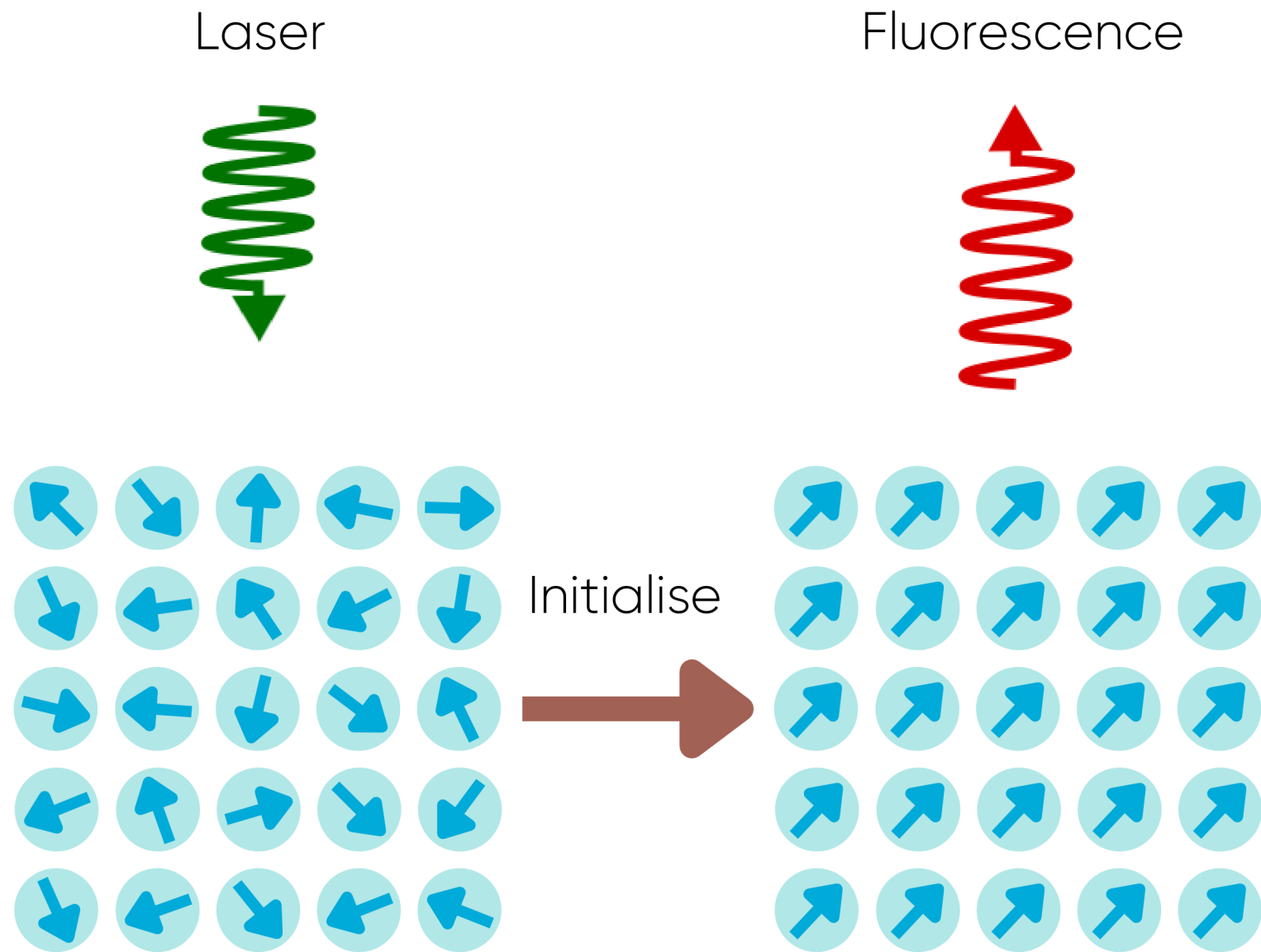
# Nitrogen-Vacancy Centre



# Electronic Structure

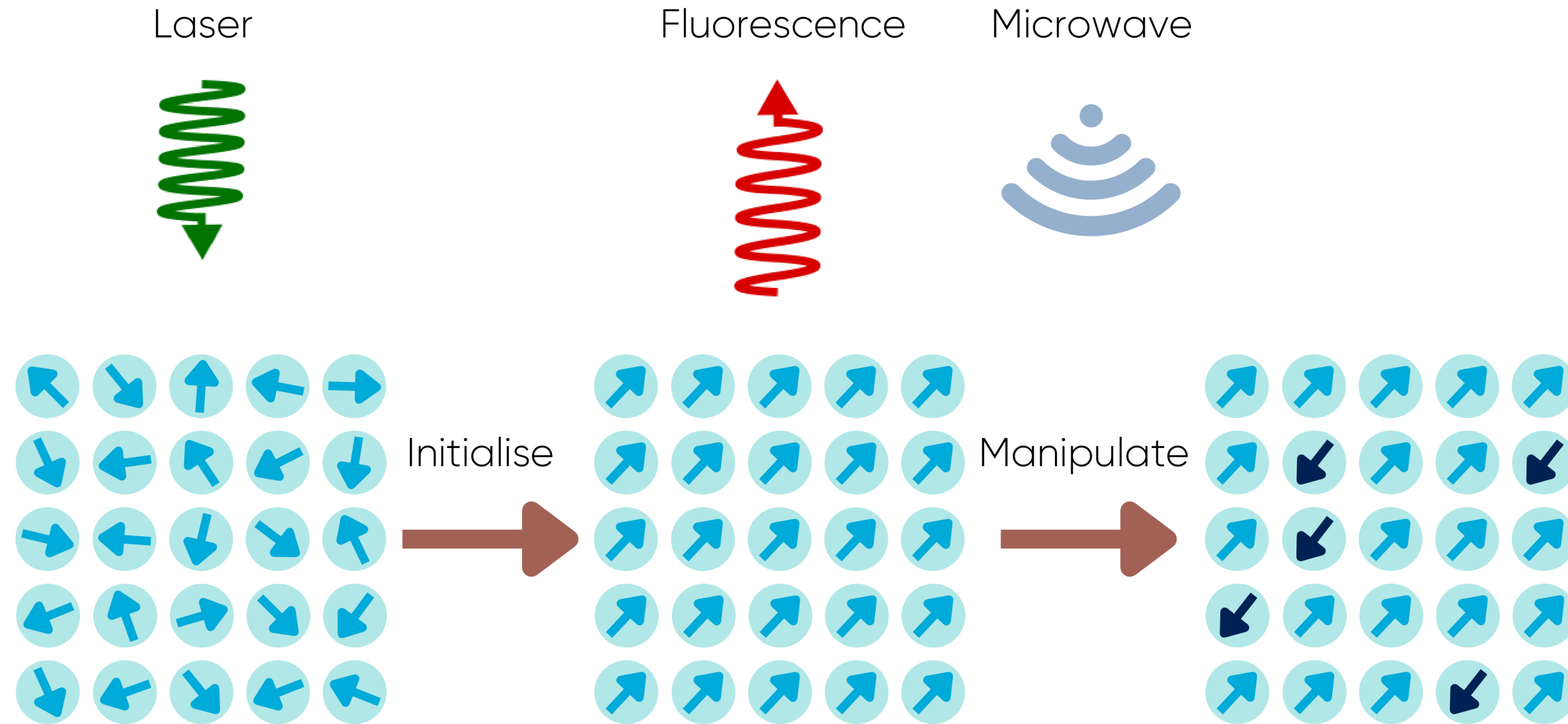


# Initialisation

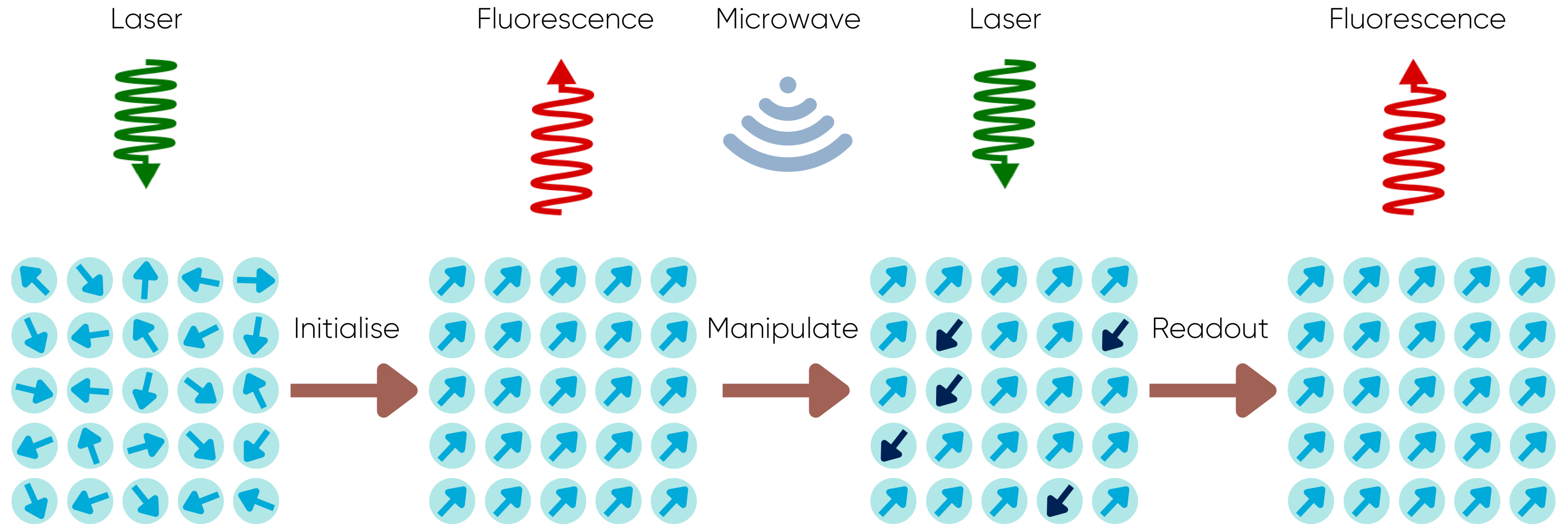




# Manipulation

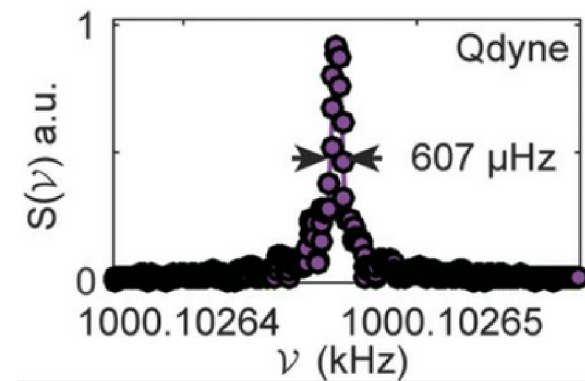


# Readout



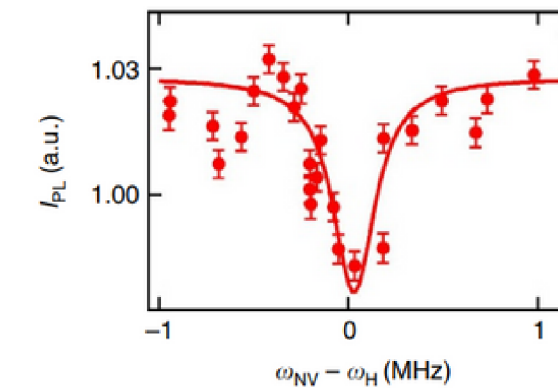
# Diamond-based NMR

## Submillihertz single NV NMR



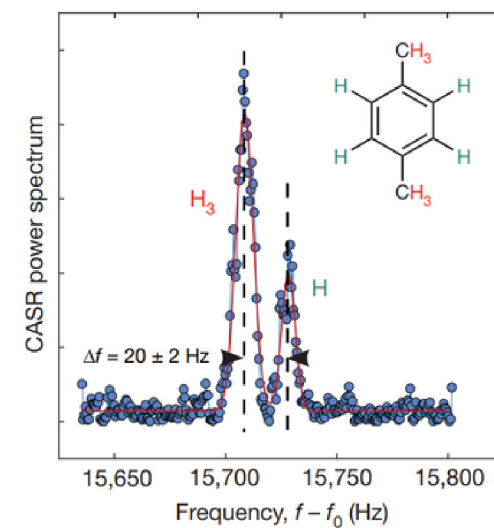
S. Schmitt et al., Science 356, 832–837 (2017)

## Microwave-free NMR



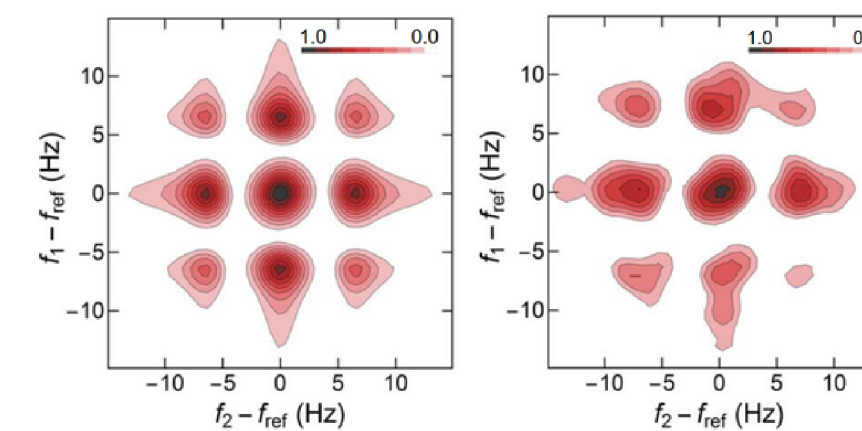
J.D.A. Wood et al., Nat. Commun. 8, 15950 (2017)

## High-resolution NV-ensemble NMR



D.R. Glenn, et al., Nature 555, 351–354 (2018)

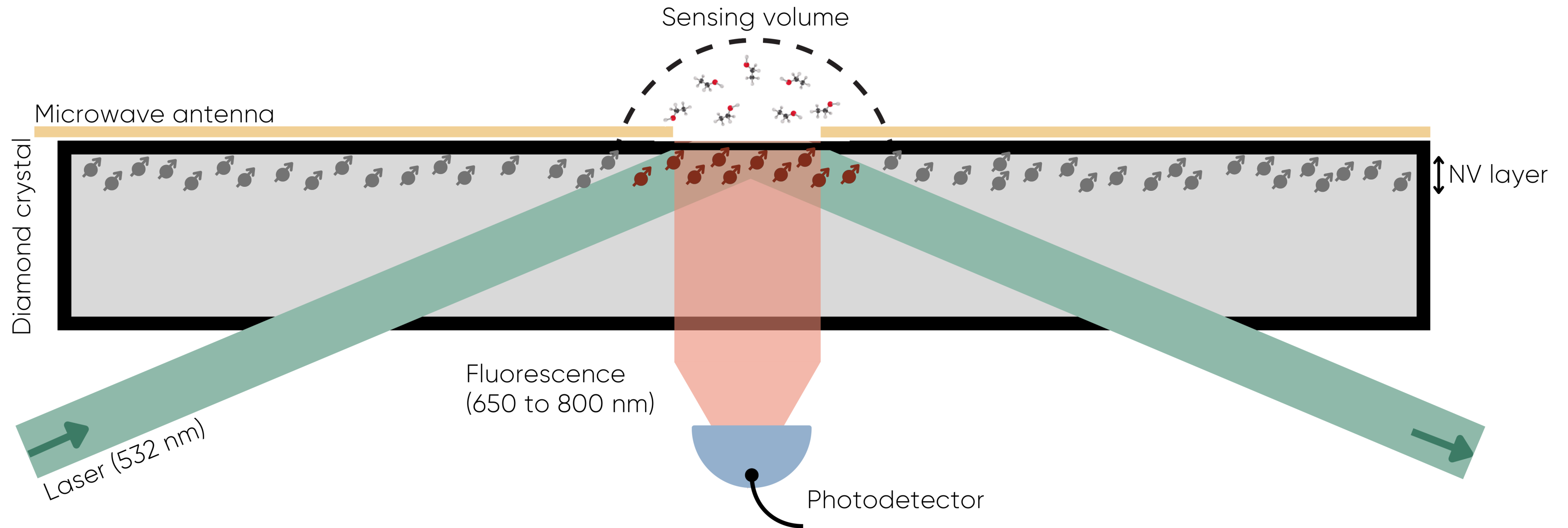
## Two-dimensional NMR



J. Smits et al., Science Advances 5, 7 (2019)



# Diamond sensor



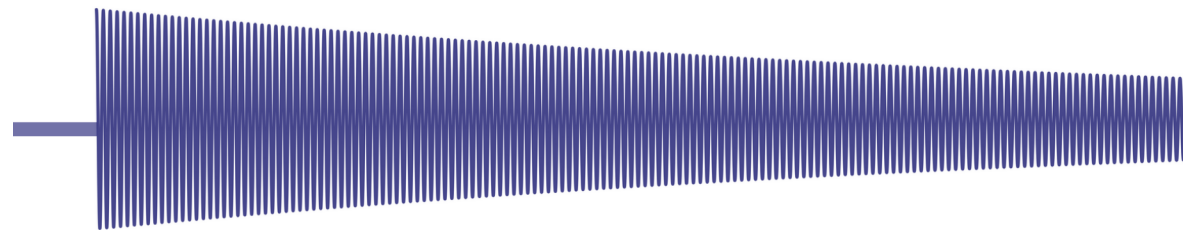
# NMR spectroscopy

## Pulse sequence

RF pulse



Nuclear magnetic field



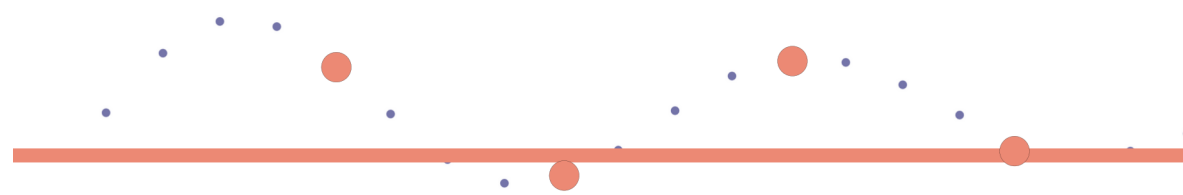
Microwave sequence (XY8)



Laser pulse

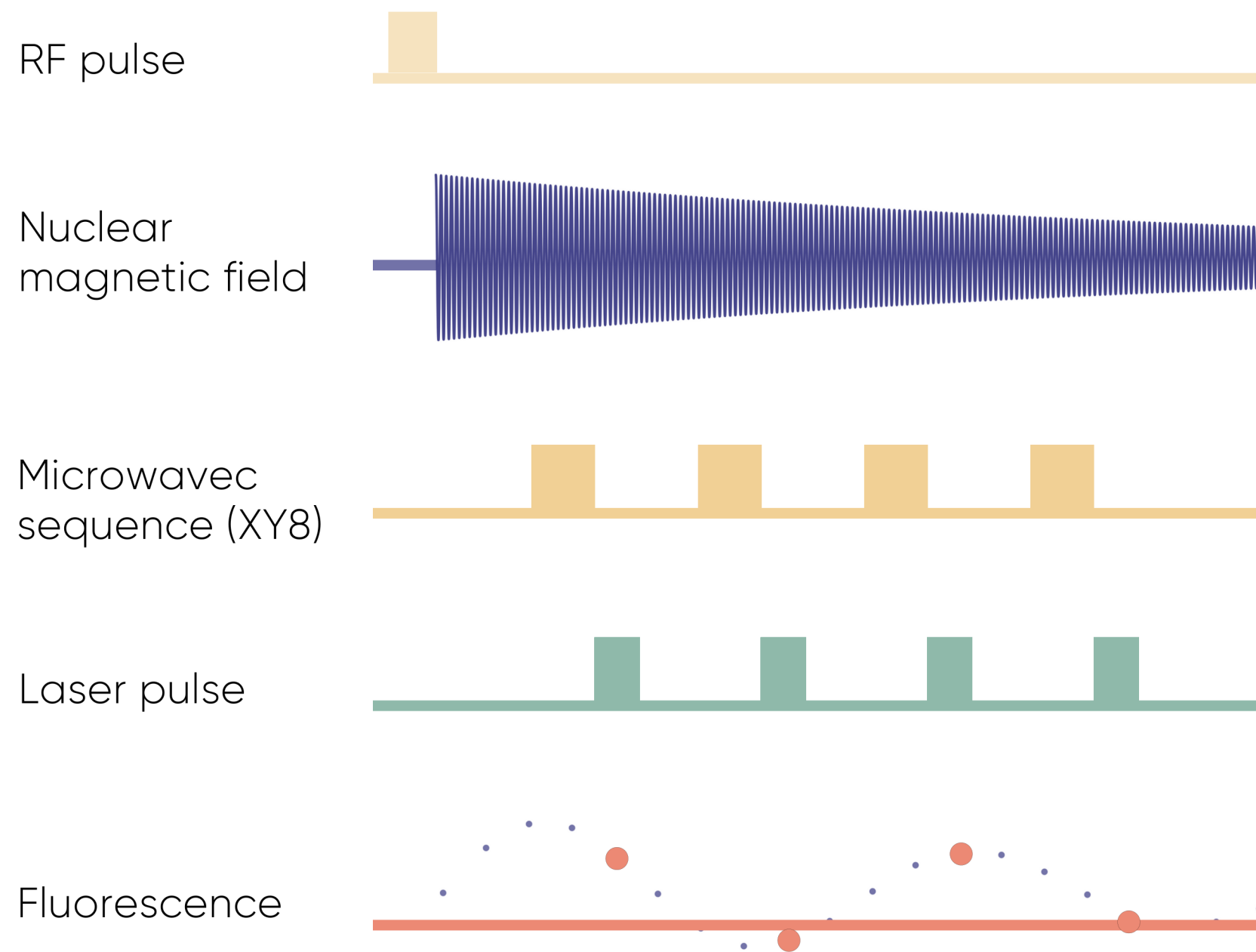


Fluorescence



# NMR spectroscopy

## Pulse sequence

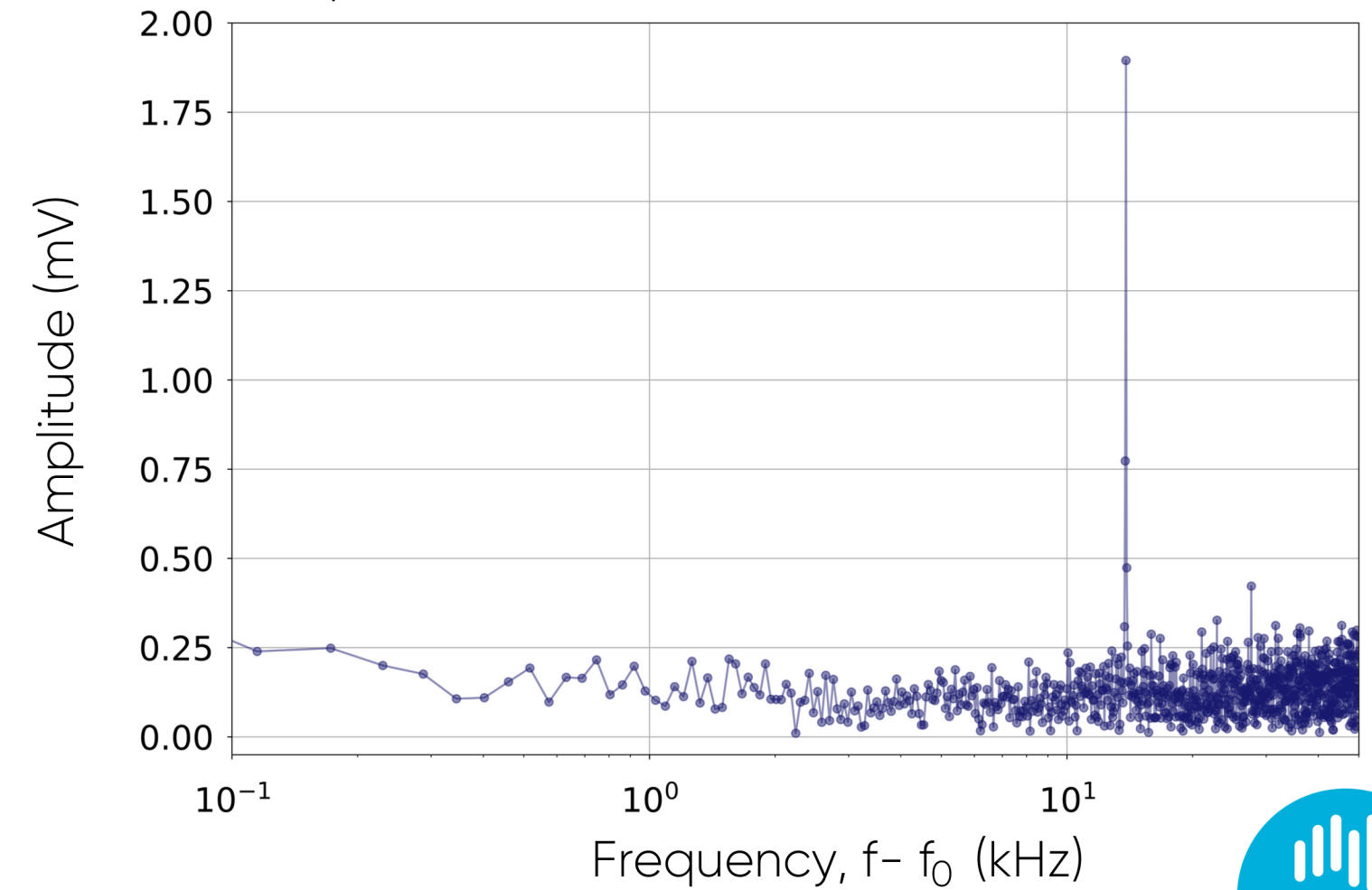


## Measured signal



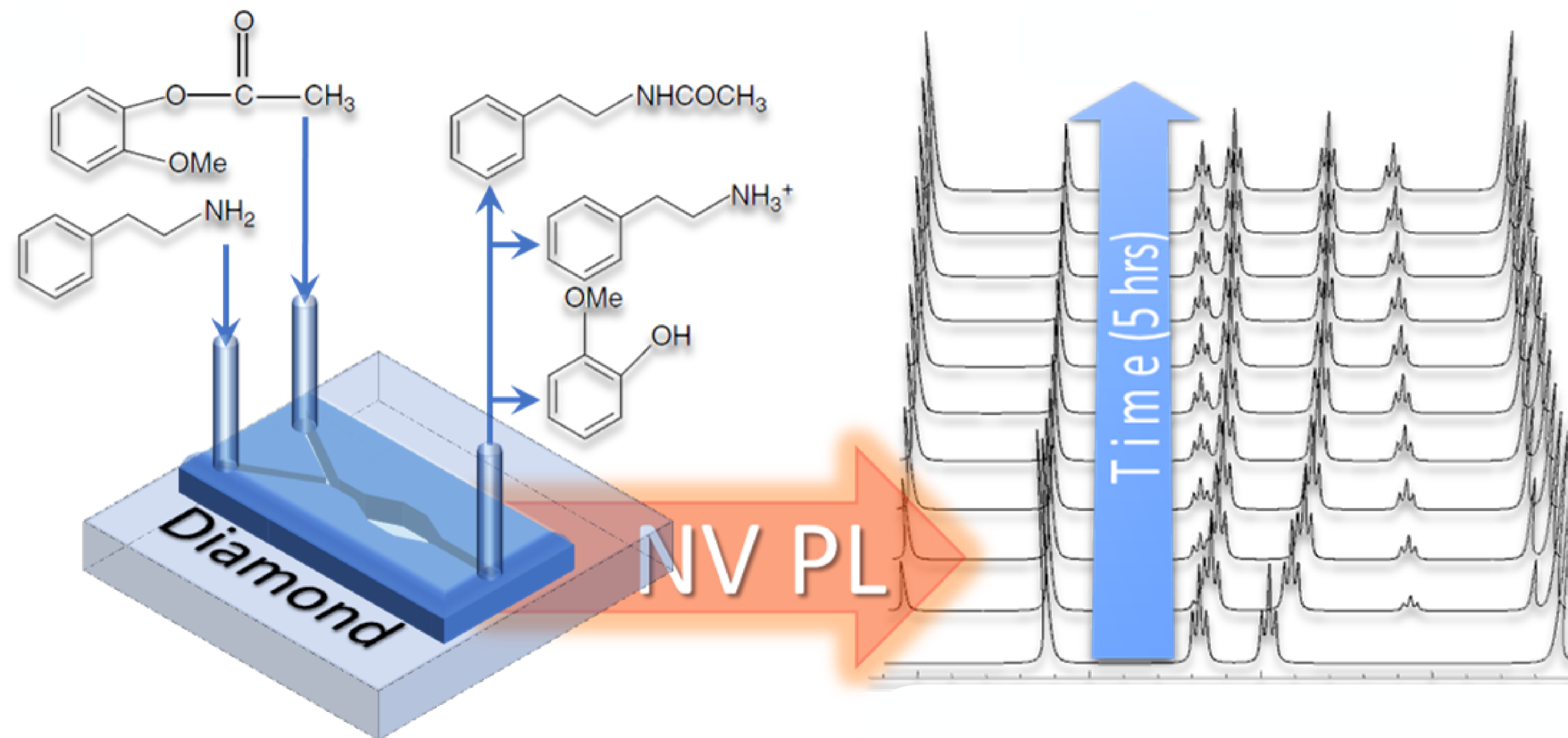
Di Wang

50 mT Static field  
Spectral resolution  $\sim 55$  Hz



# Application

## In situ monitoring of chemical reactions



Dr. Liam Hall

University of Melbourne





Dr. Anthony Chesman  
CSIRO Manufacturing



Dr. Liam Hall  
University of Melbourne



Dr. David Simpson  
University of Melbourne



Di Wang  
University of Melbourne



Ella Walsh  
University of Melbourne

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Emerging Energy Technologies

CSIRO Manufacturing

Australia's National Science Agency



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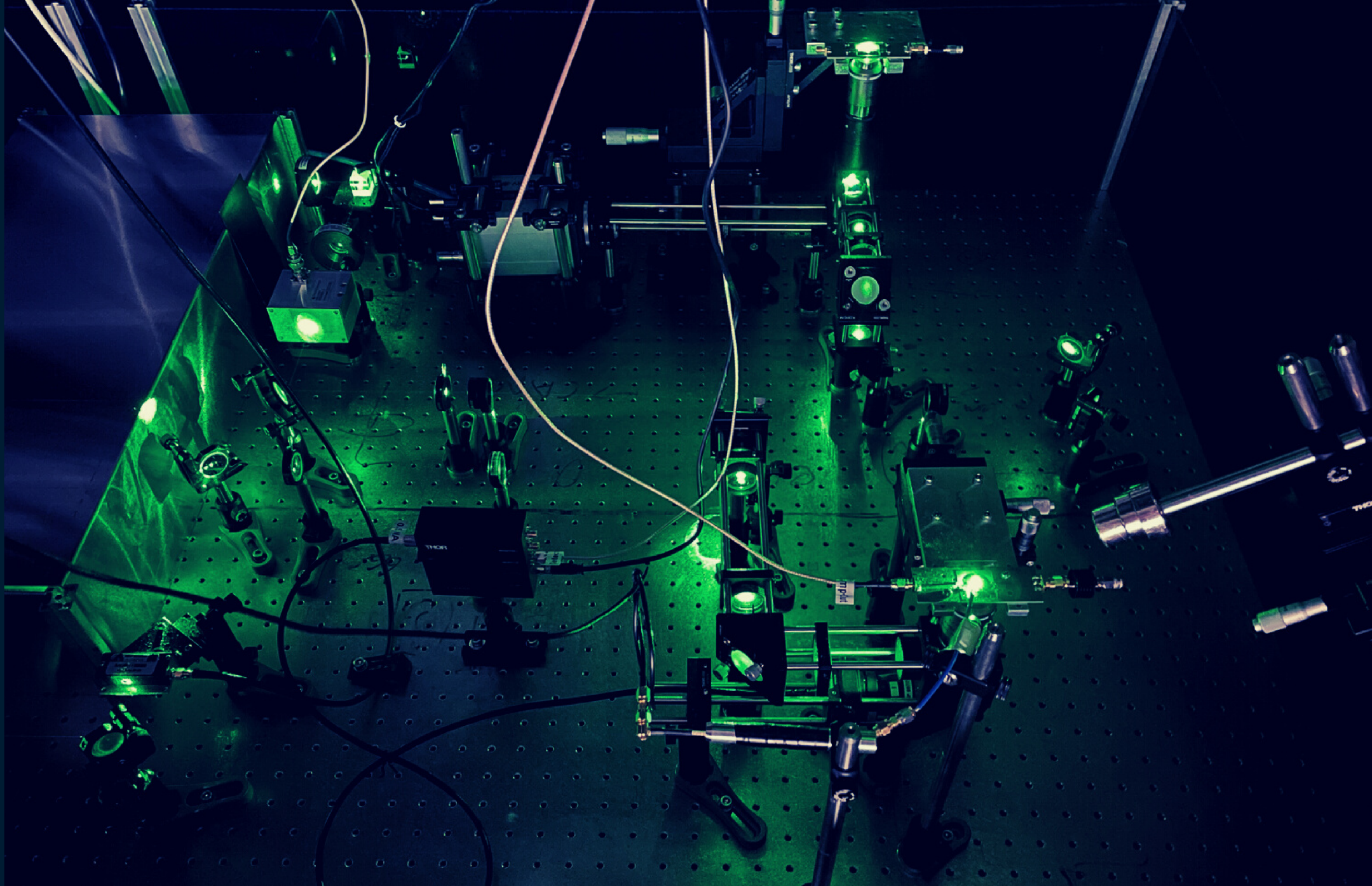


exciton  
science





# Thank you



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