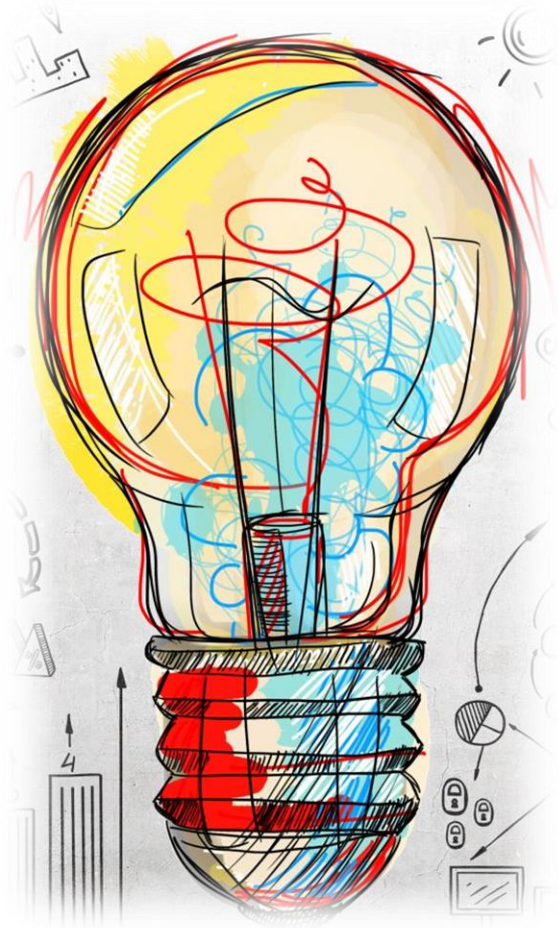
QI.AB



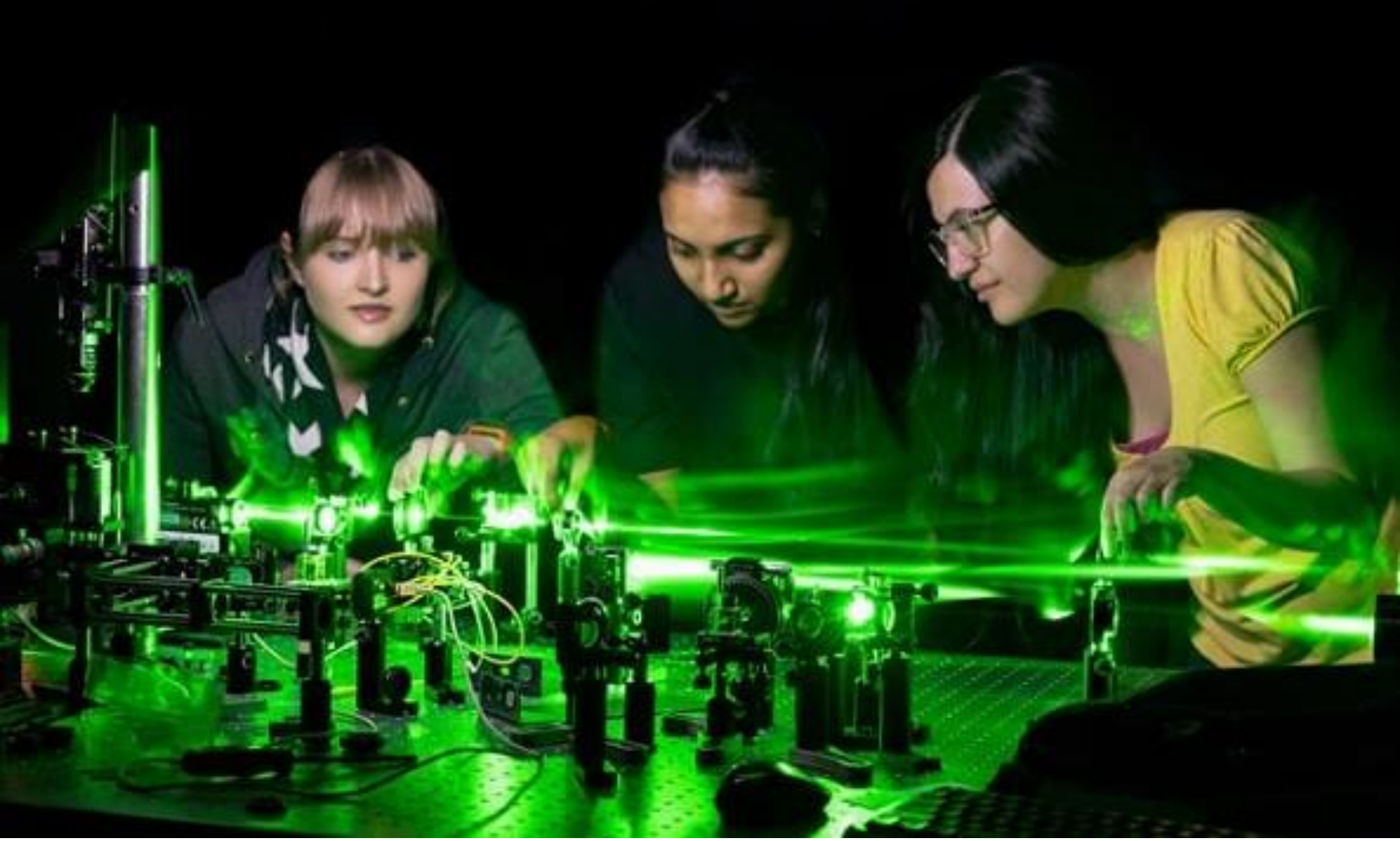
Capturing a quantum image without a camera

Structured Light Laboratory

WITS UNIVERSITY

RAPHTA

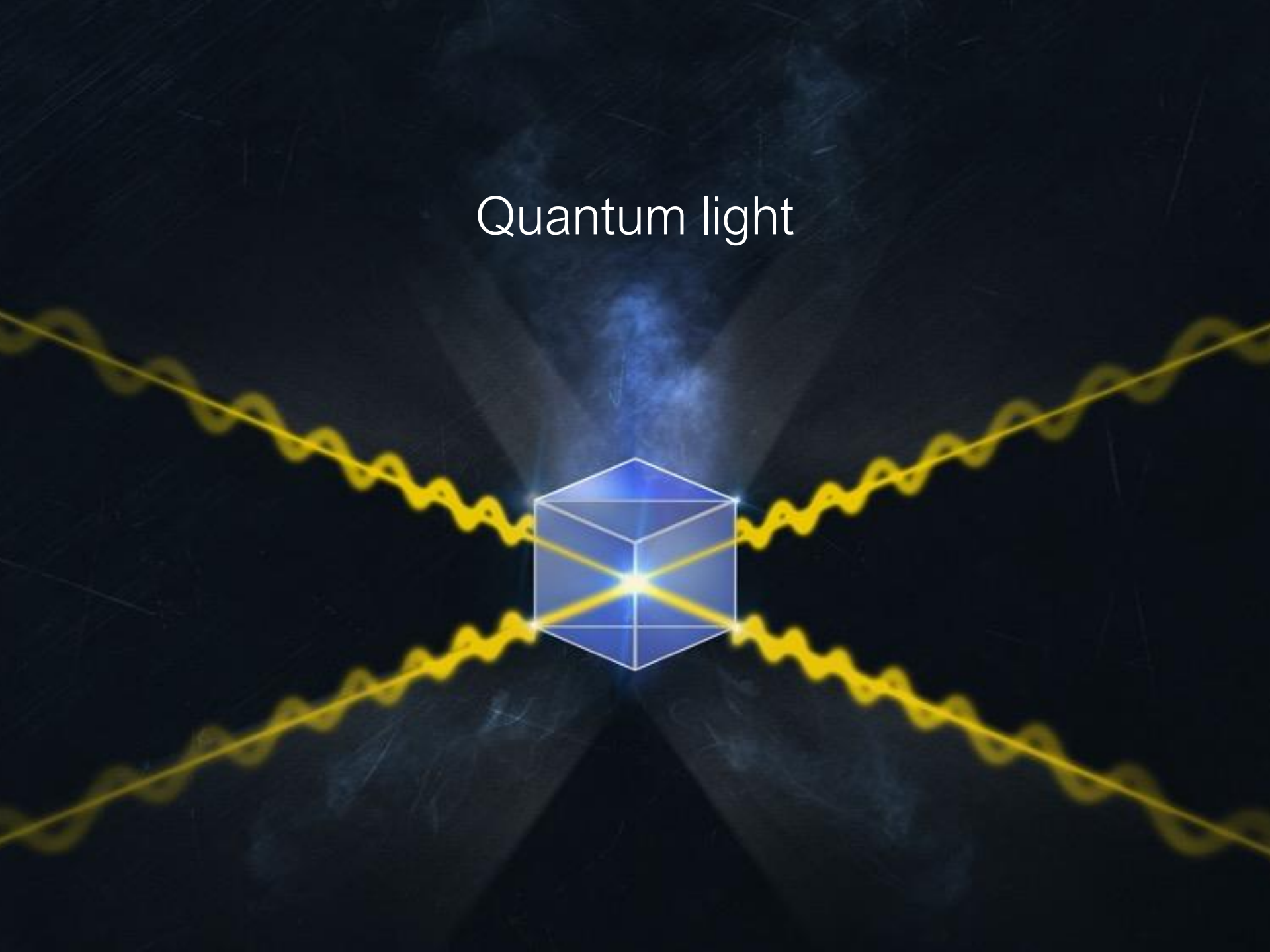
Dr. Chané Moodley

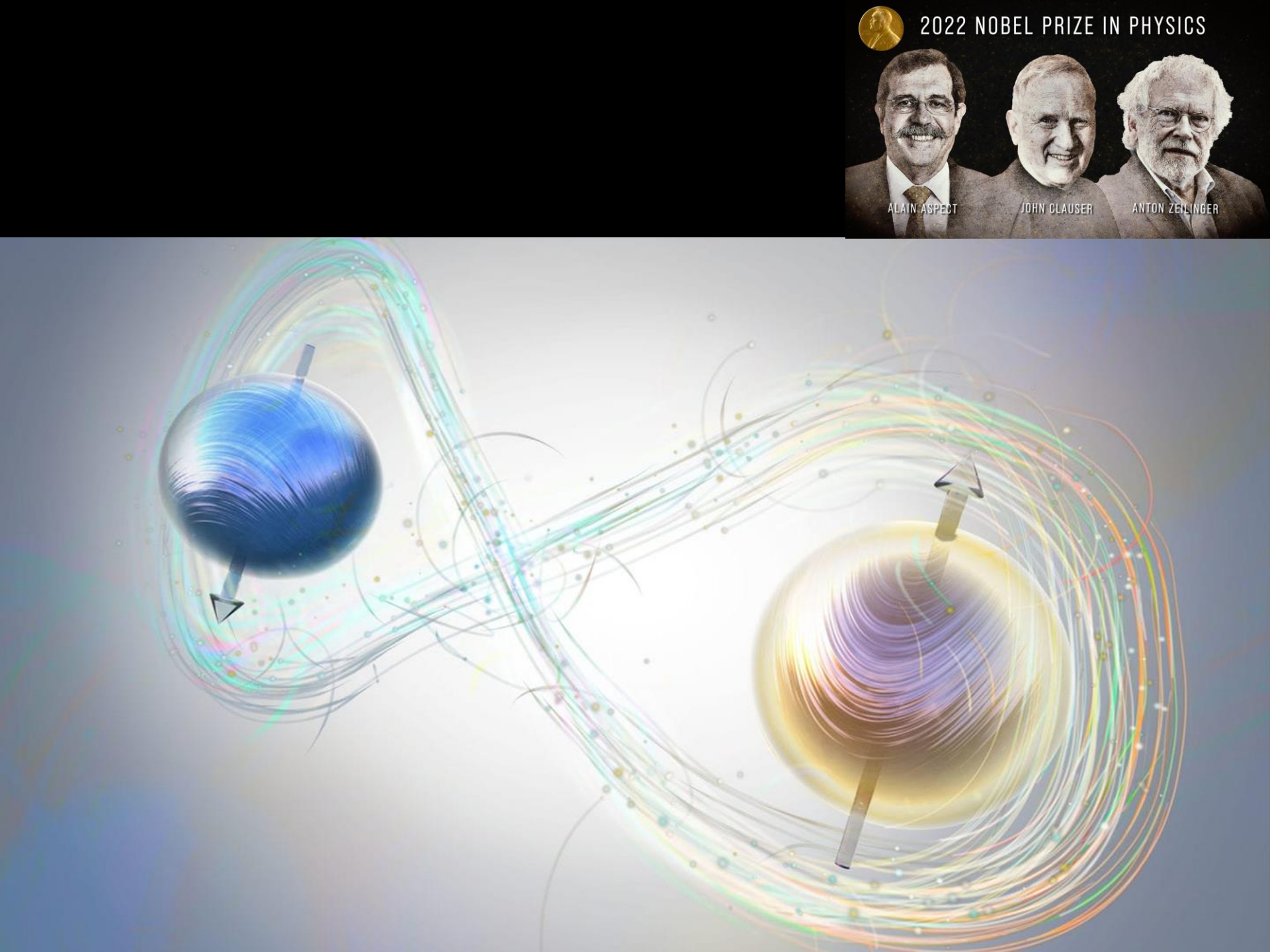


We tailor light, like cloth

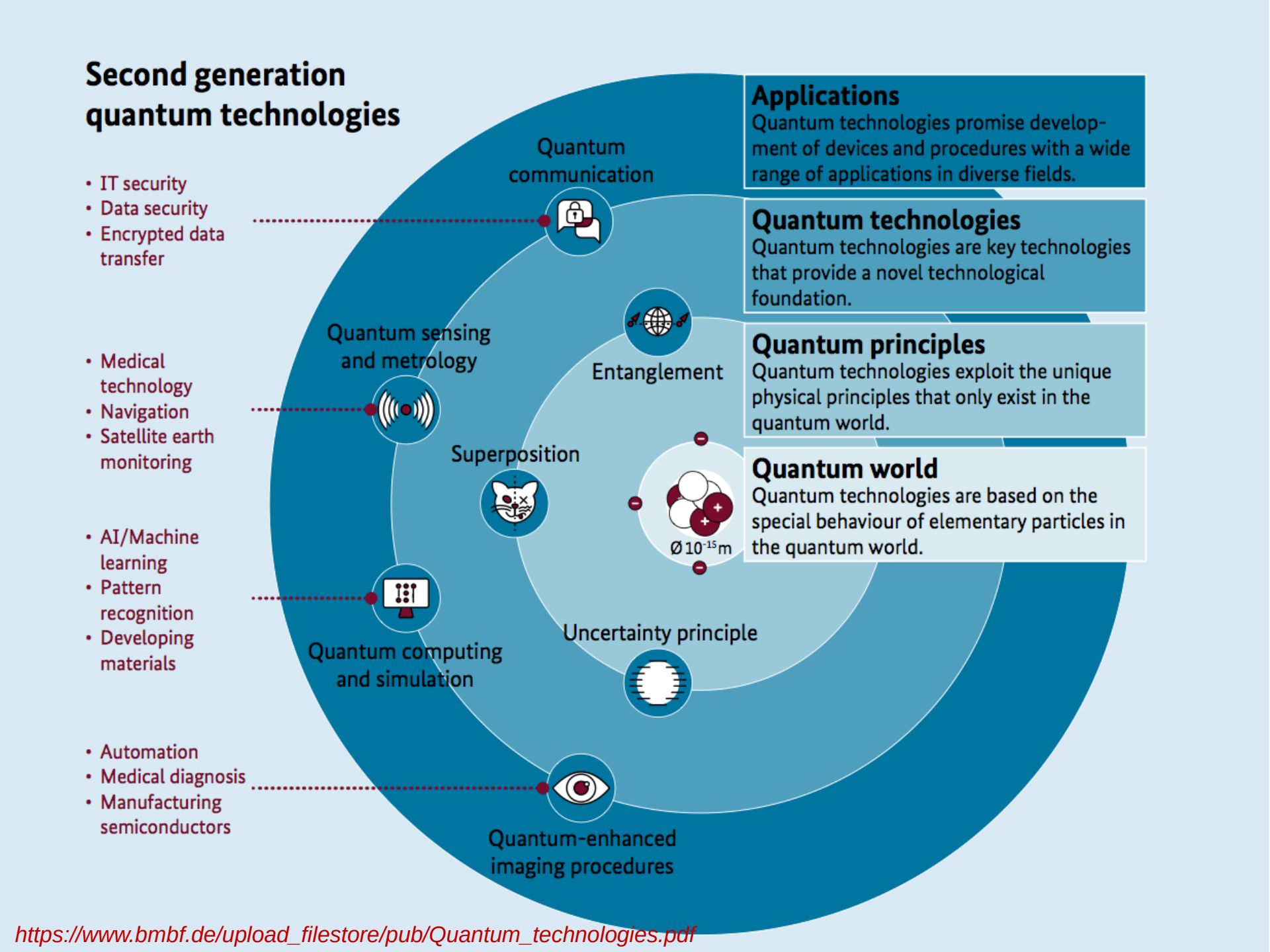
Including quantum light

Quantum light




2022 NOBEL PRIZE IN PHYSICS
ALAIN ASPECT
JOHN CLAUSER
ANTON ZEILINGER

Second generation quantum technologies



https://www.bmbf.de/upload_filestore/pub/Quantum_technologies.pdf

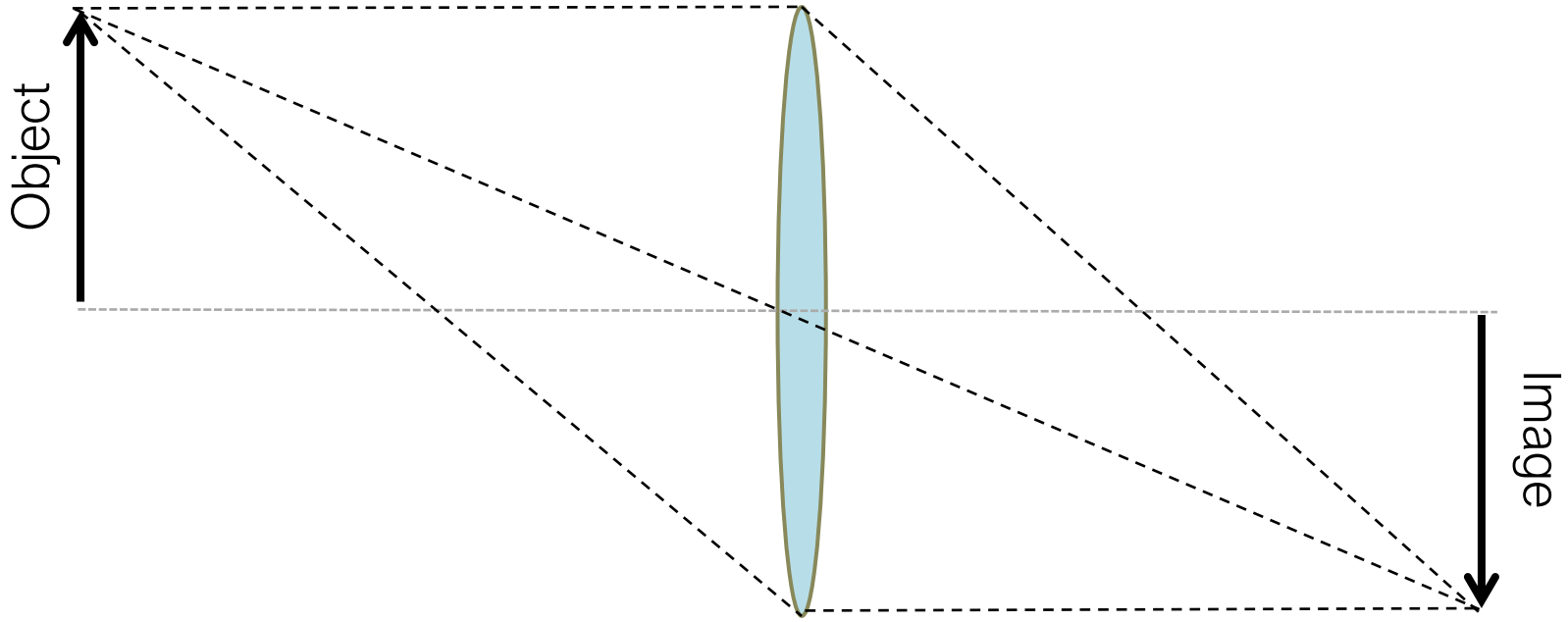
QI..AB

RAPHIA

Conventional Imaging

As we all know it

An image is information organised in space



How do images form?

By position correlations

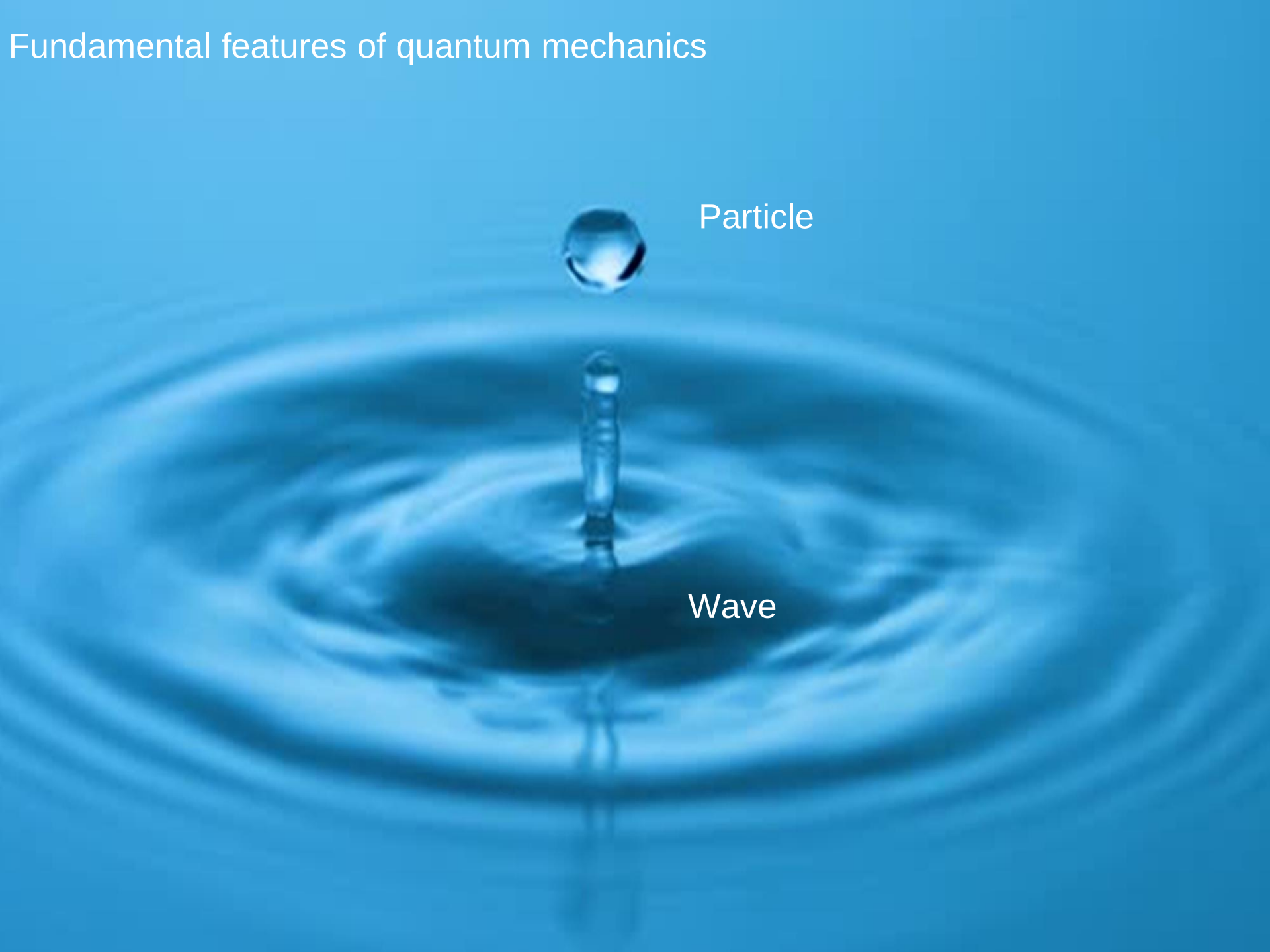
How do images form?

By position correlations

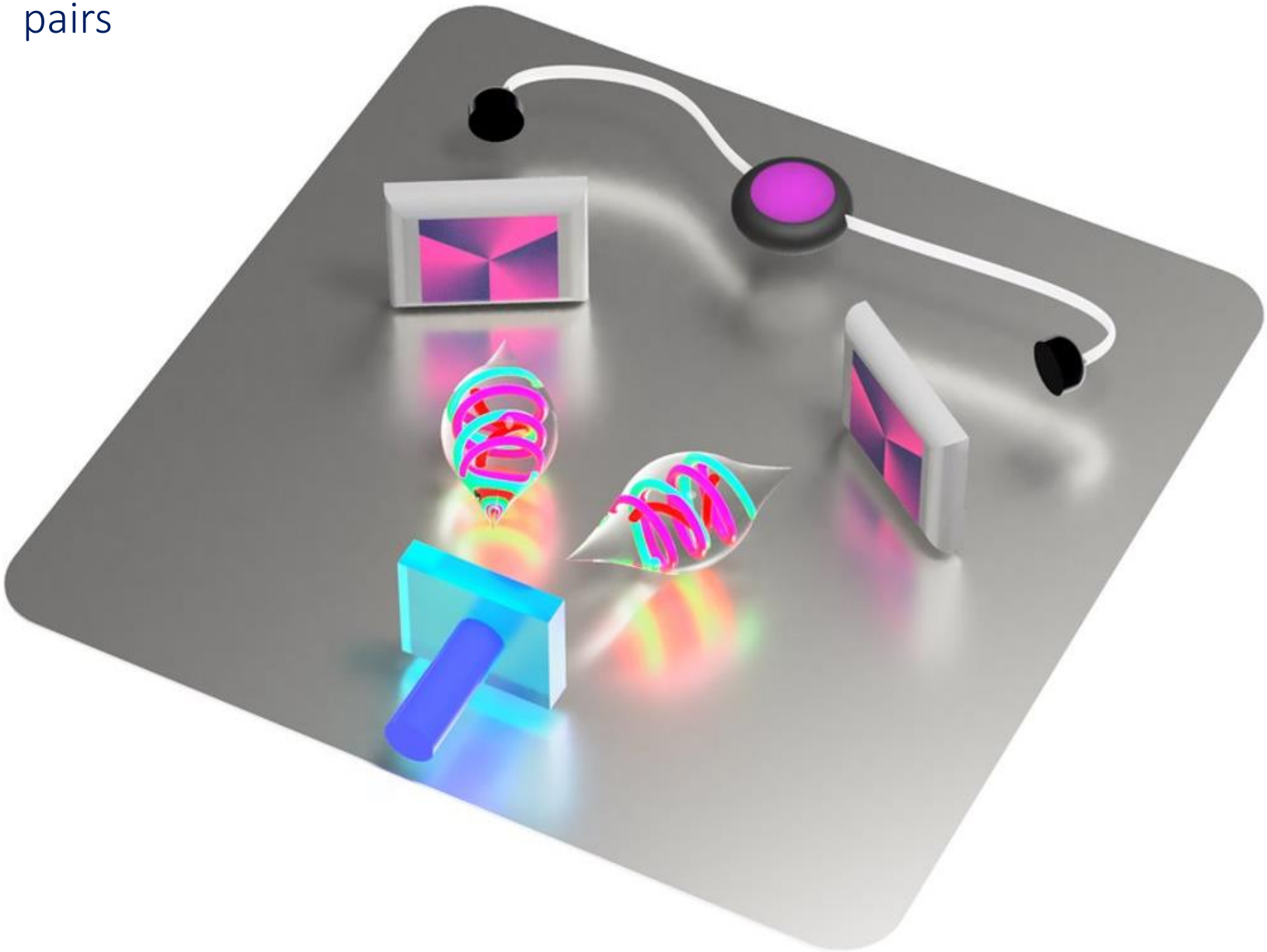
Conventional Imaging

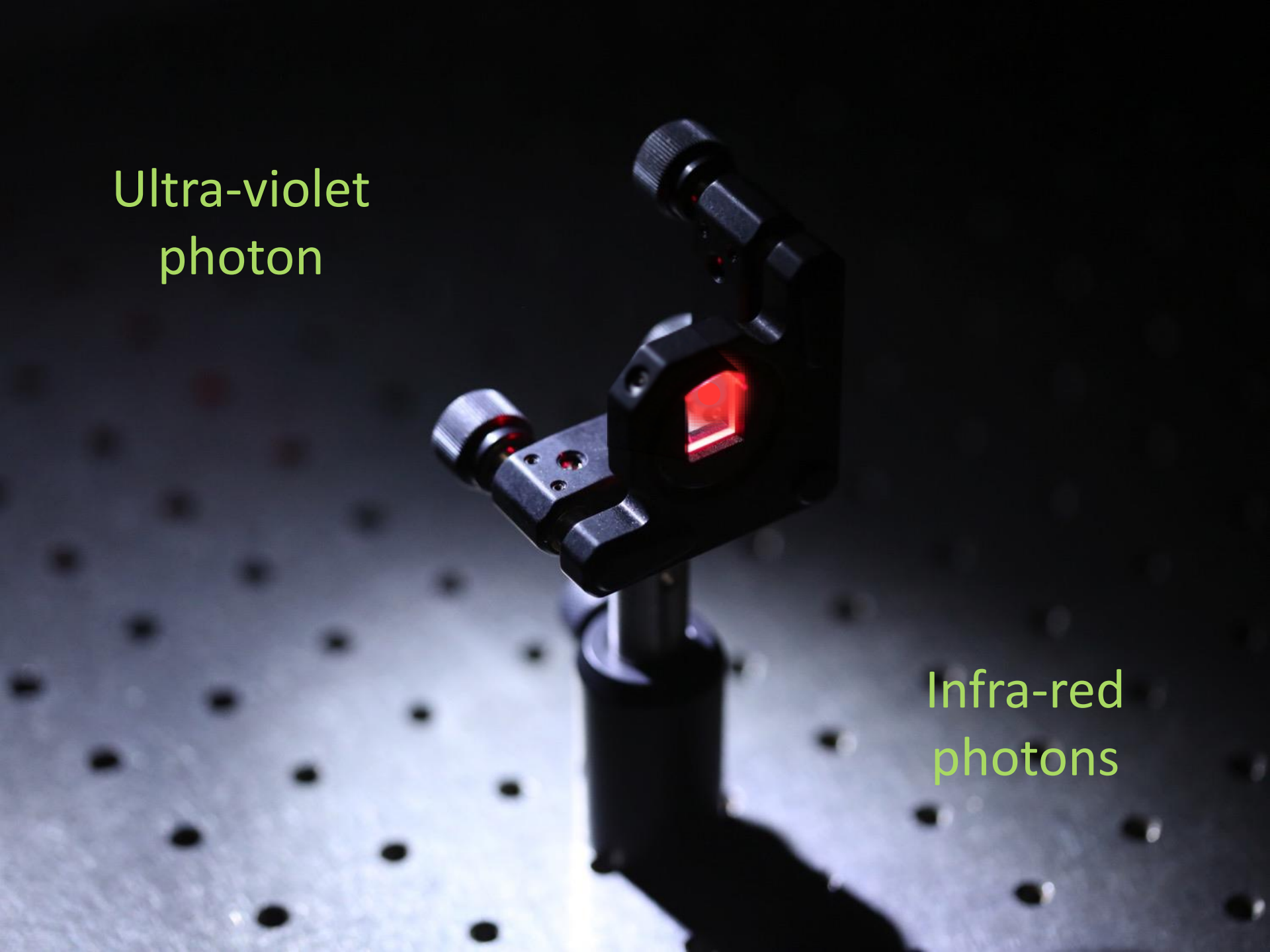
As we all know it

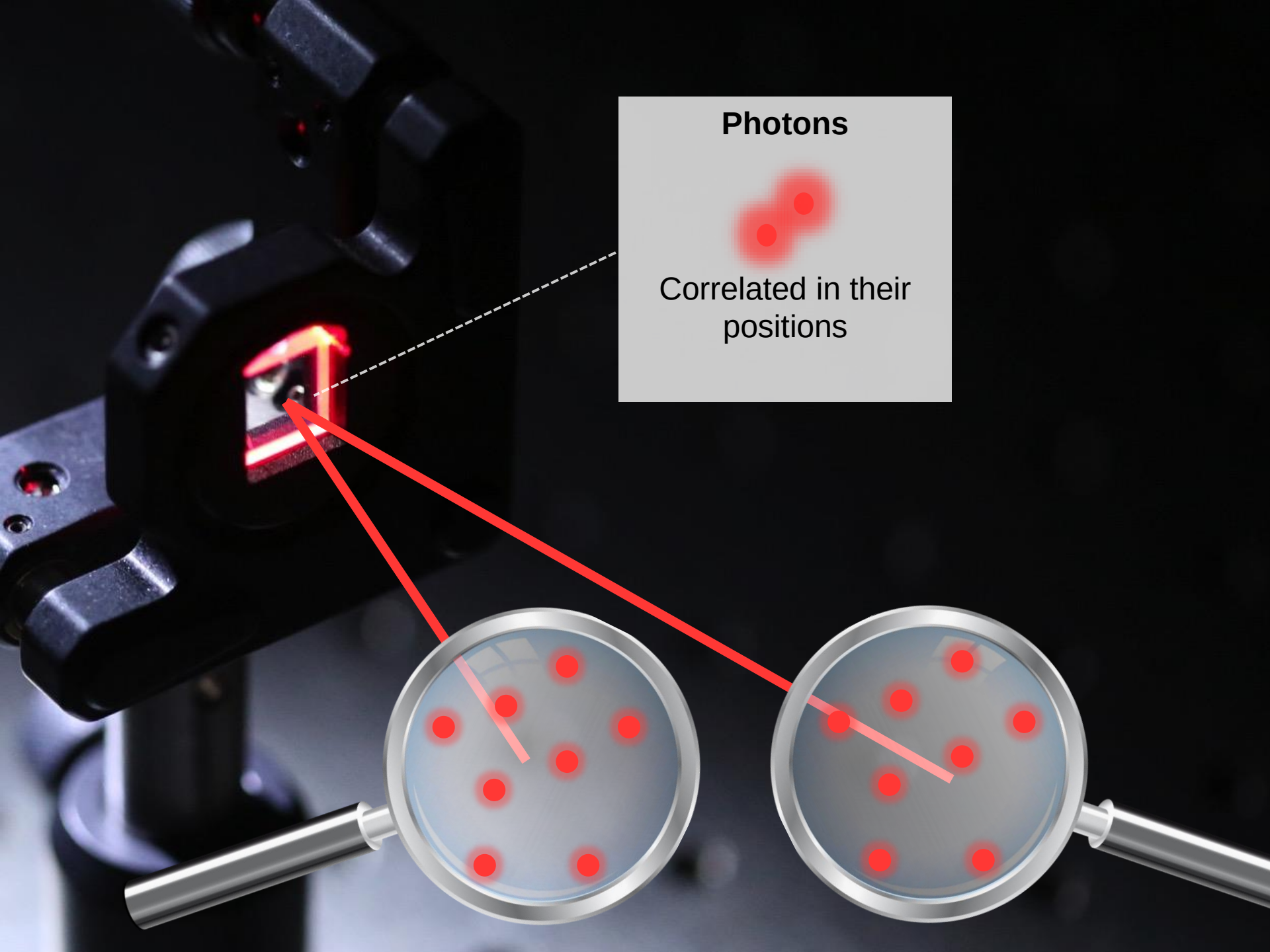
Fundamental features of quantum mechanics



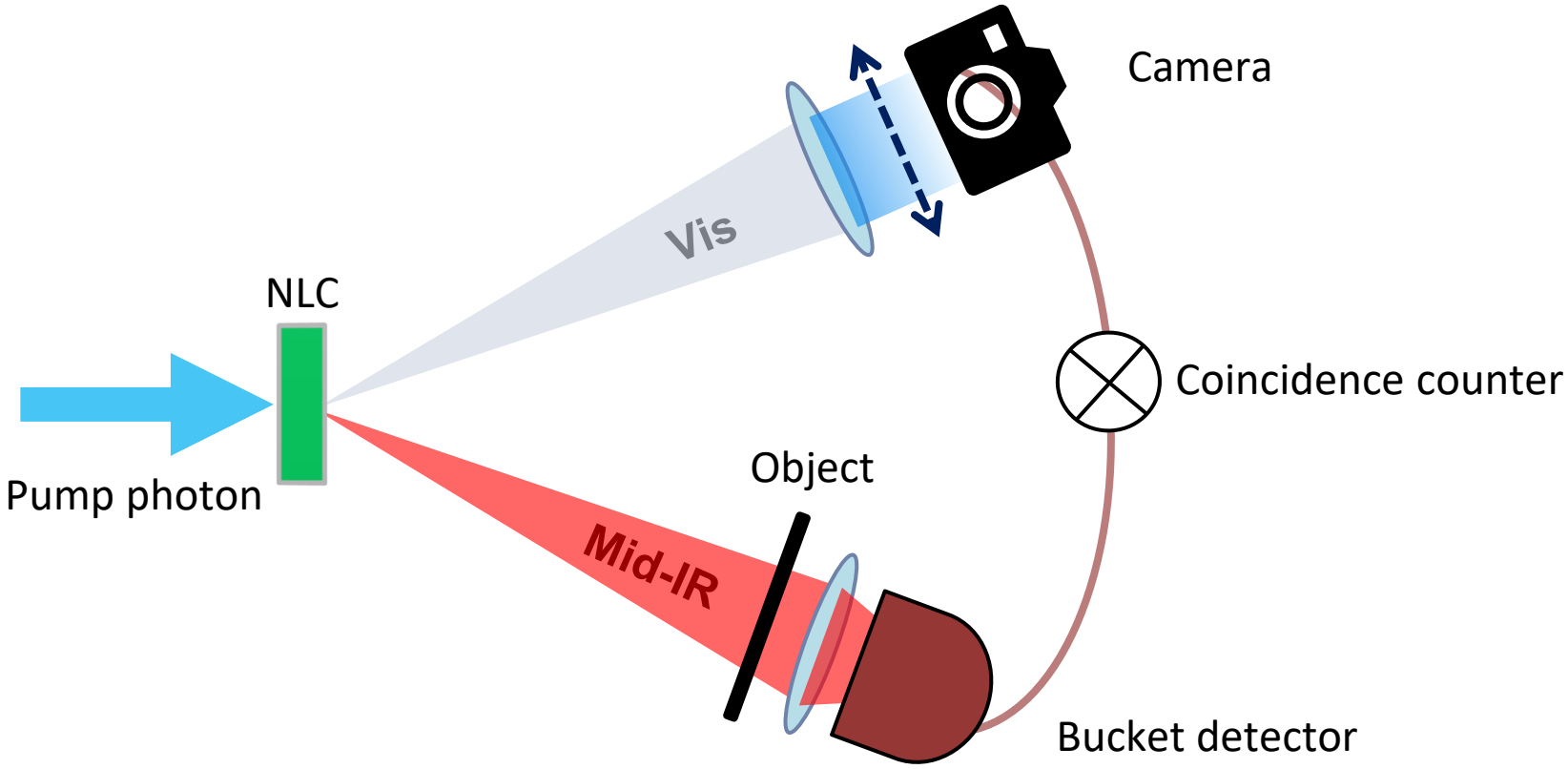
Non-linear crystals are employed to generate entangled photon pairs



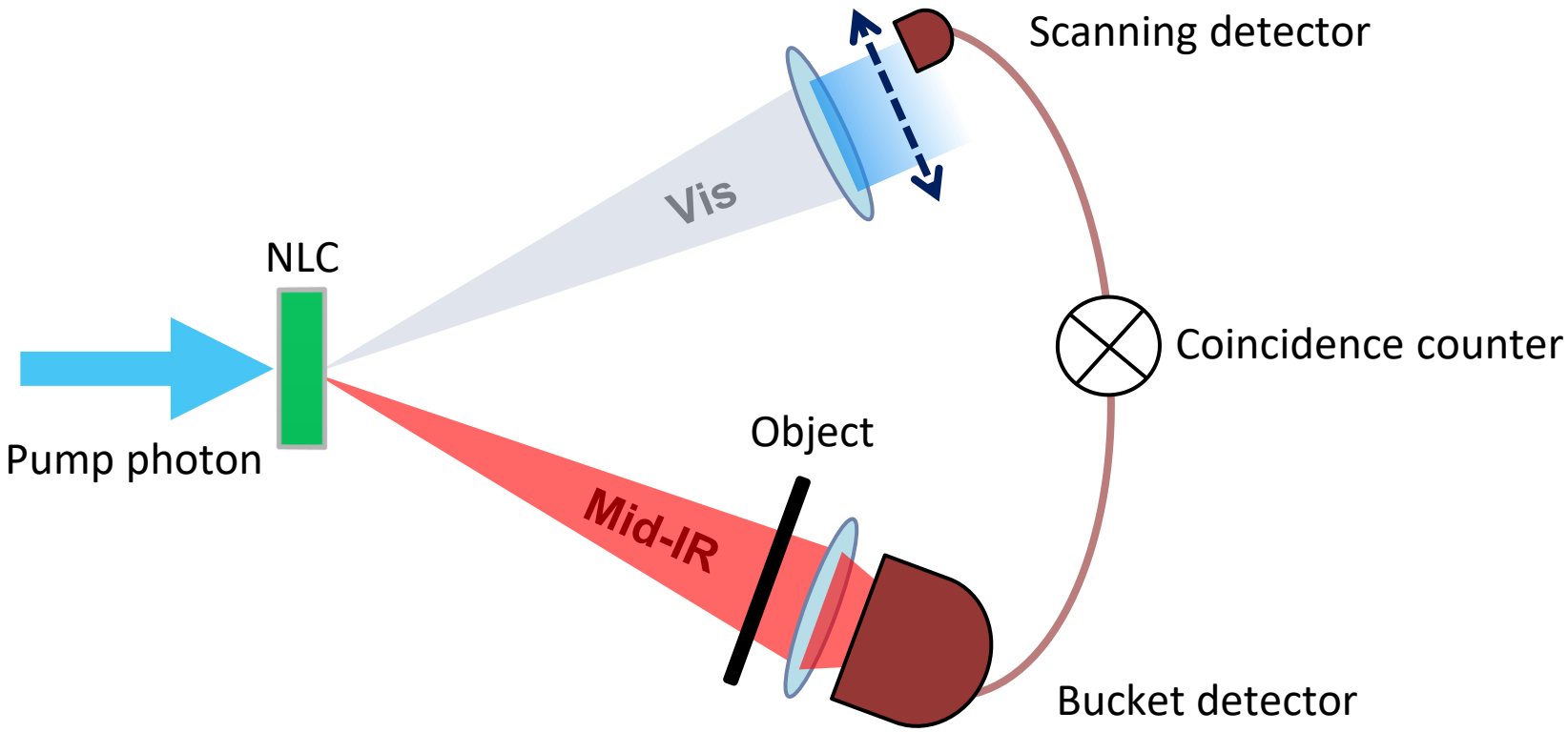

Ultra-violet
photon
Infra-red
photons


Photons
Correlated in their positions

Entangled photon pairs are employed in quantum ghost imaging to facilitate an alternative image acquisition method



Entangled photon pairs are employed in quantum ghost imaging to facilitate an alternative image acquisition method

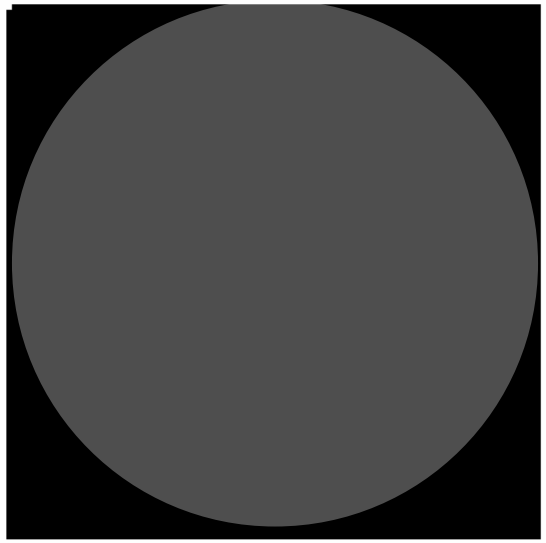


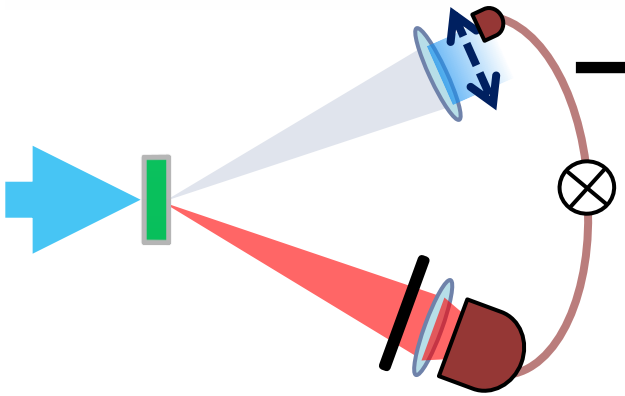
Spatially resolving detector is accomplished by a SMF physically translated throughout a transverse scanning area

Mid-IR photons

Visible photons

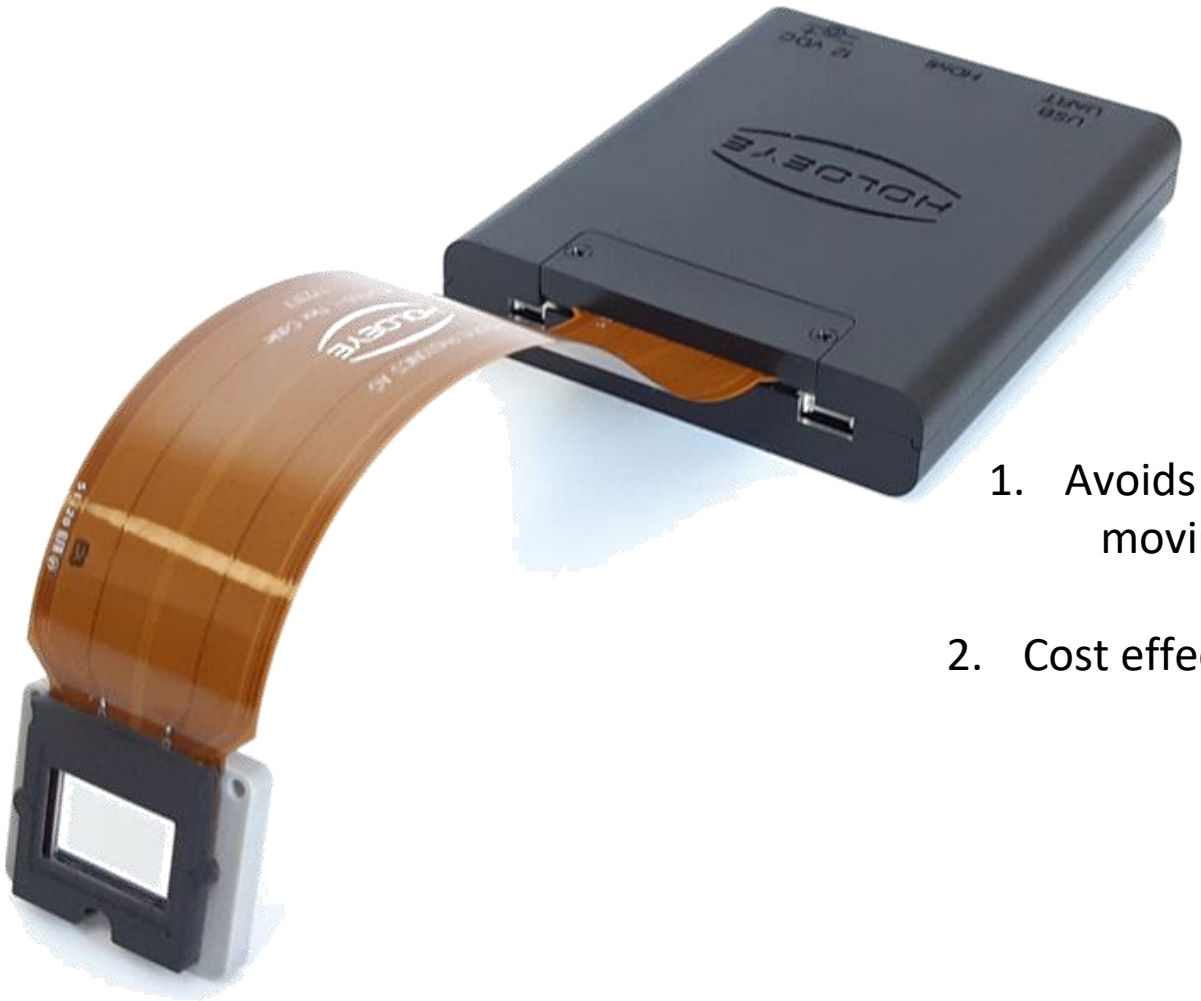
Image reconstruction





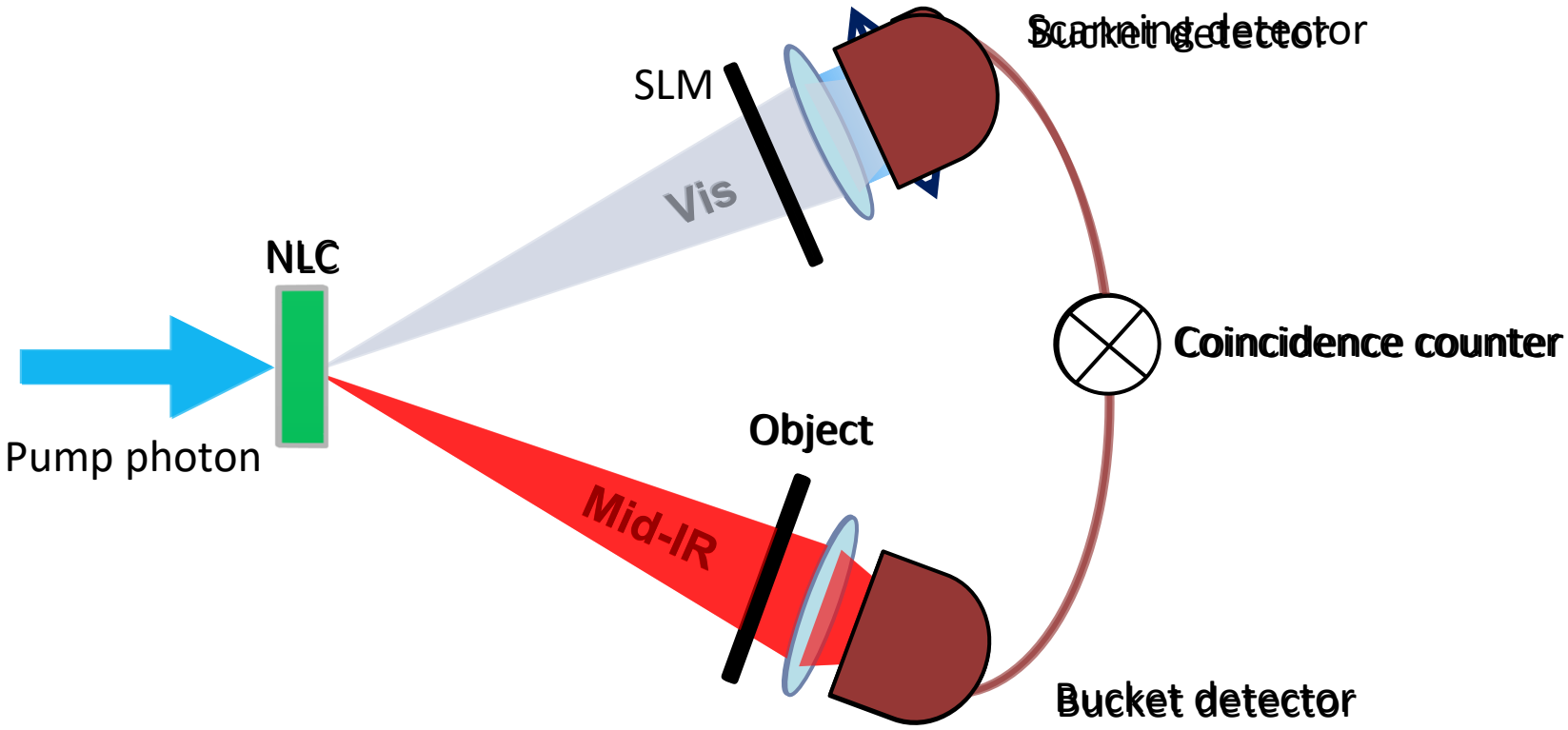
$$$

SLMs avoid the instability associated with a detector moving on a motorised translation stage



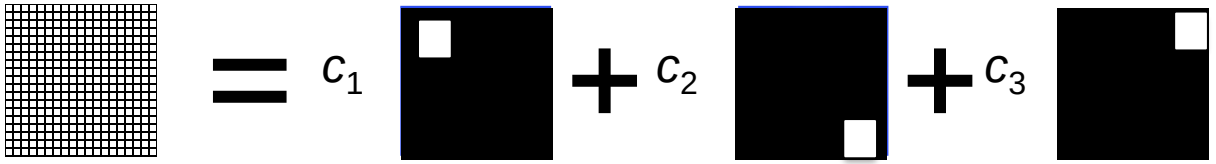
1. Avoids instability that comes with moving an optical element for detection
2. Cost effective alternative to advanced scientific cameras

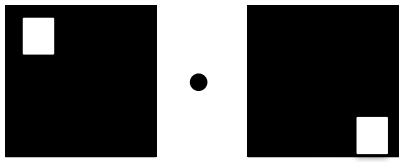
We replace the scanning detector by a SLM and a cheap bucket detector

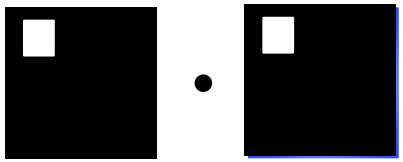


Now we want to remove the camera … to do this we “re-imagine” how pixels works …

$$U = \sum_{n=0}^{\infty} c_n \Psi_n$$

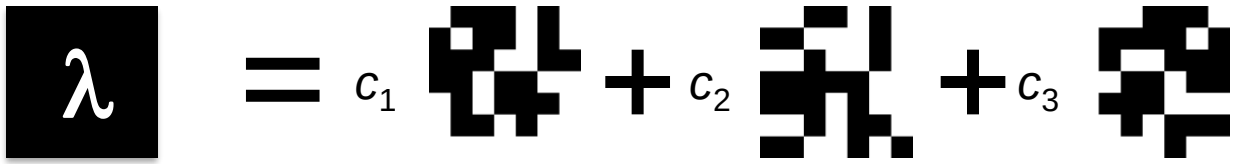


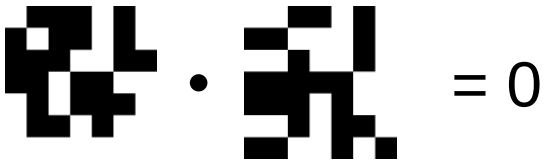


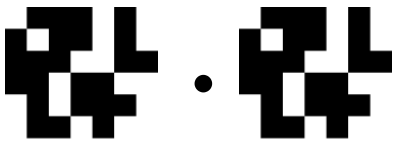


Now we can expand on the idea and use random patterns

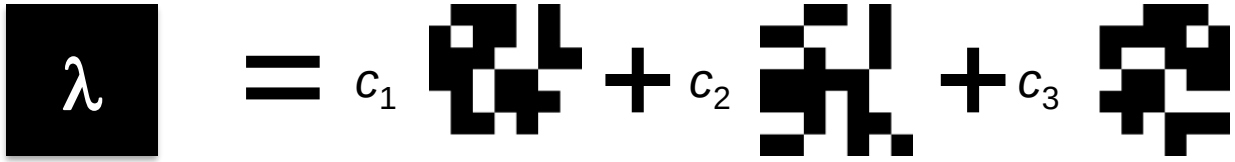
$$U = \sum_{n=0}^{\infty} c_n \Psi_n$$

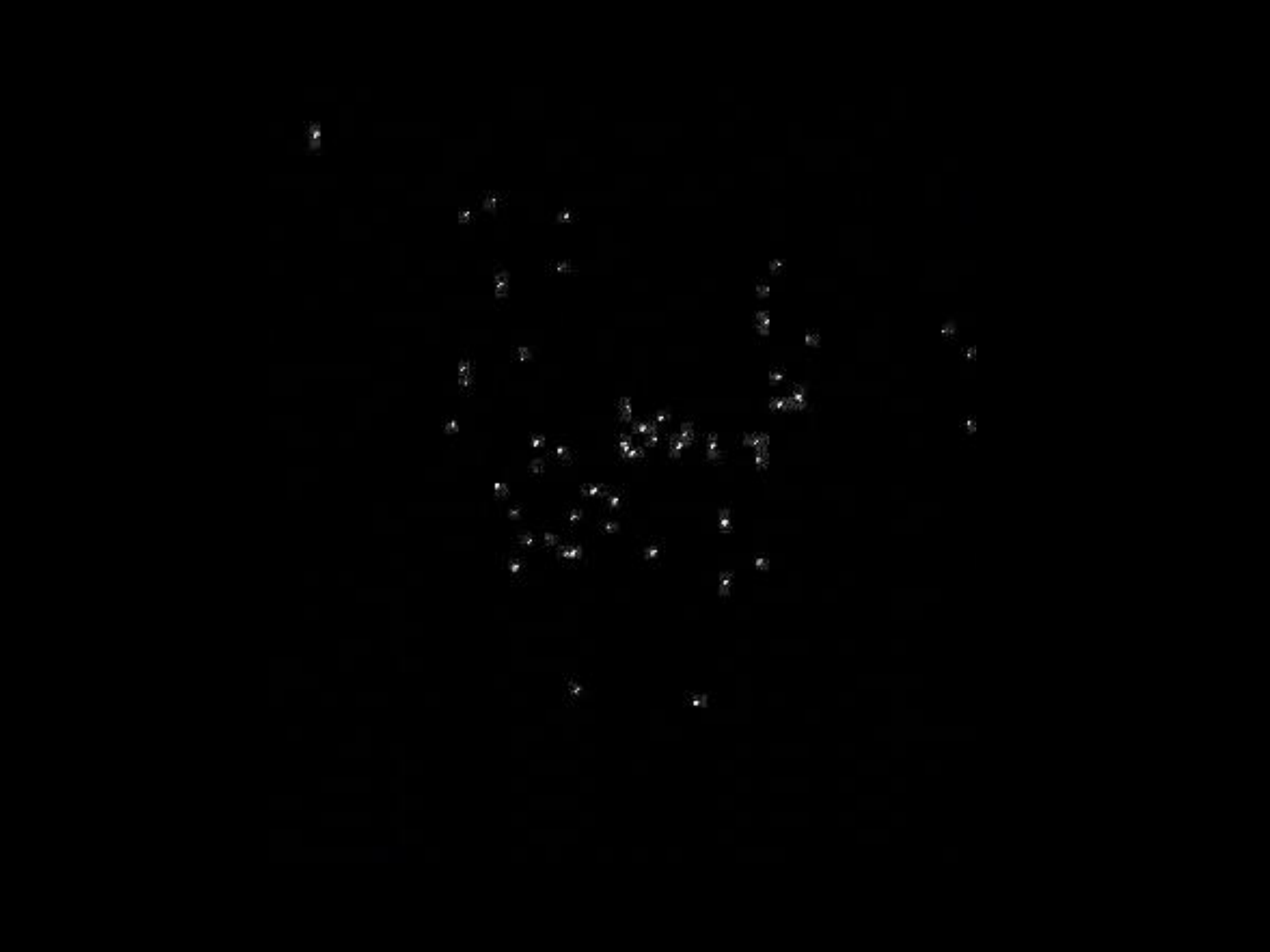






Now we can do ghost imaging using random masks and a single pixel detector

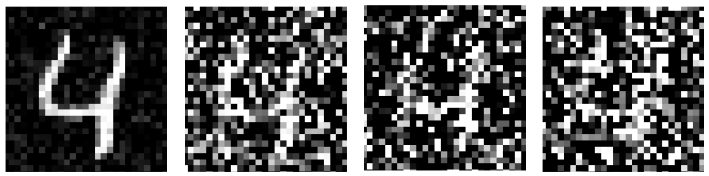


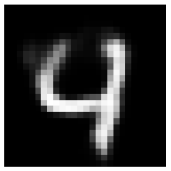


Two-step deep learning approach to establish early stopping point

Step 1 –
deep convolutional autoencoder

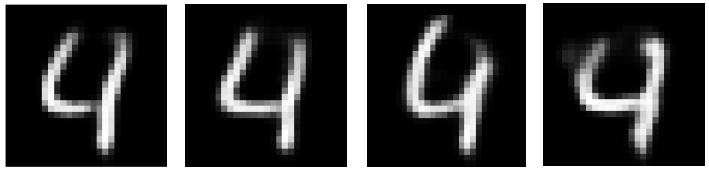
Step 2 – neural classifier





Autoencoder:
enhancement & denoising

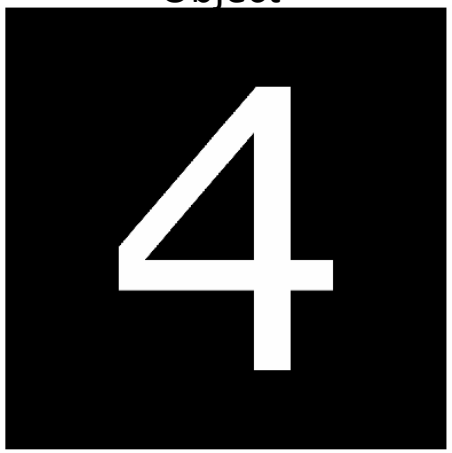
Classifier:
recognition & confidence



I am **98%** confident that this is a **number 4!**

Two-step approach process

Object



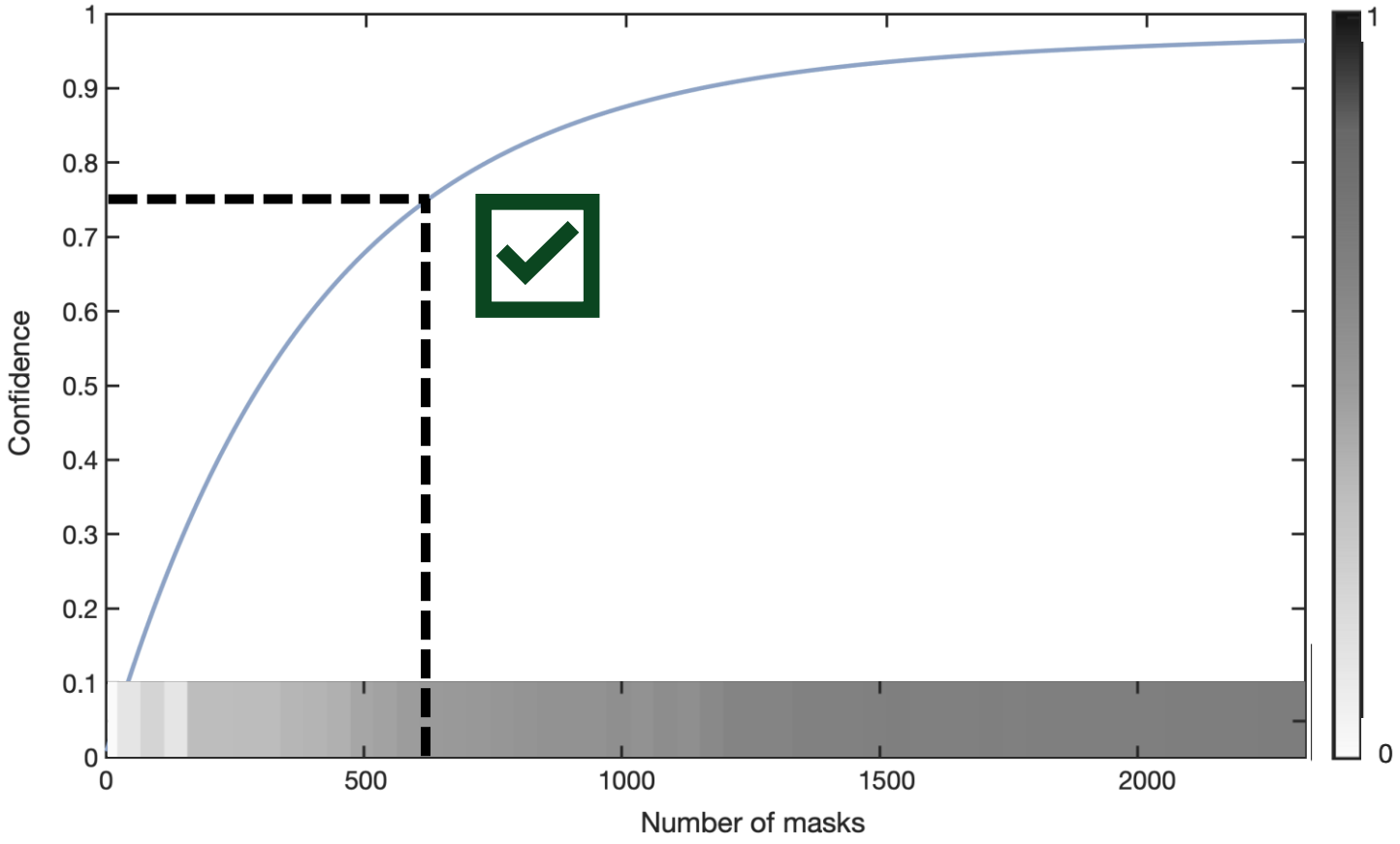
Mask

Image

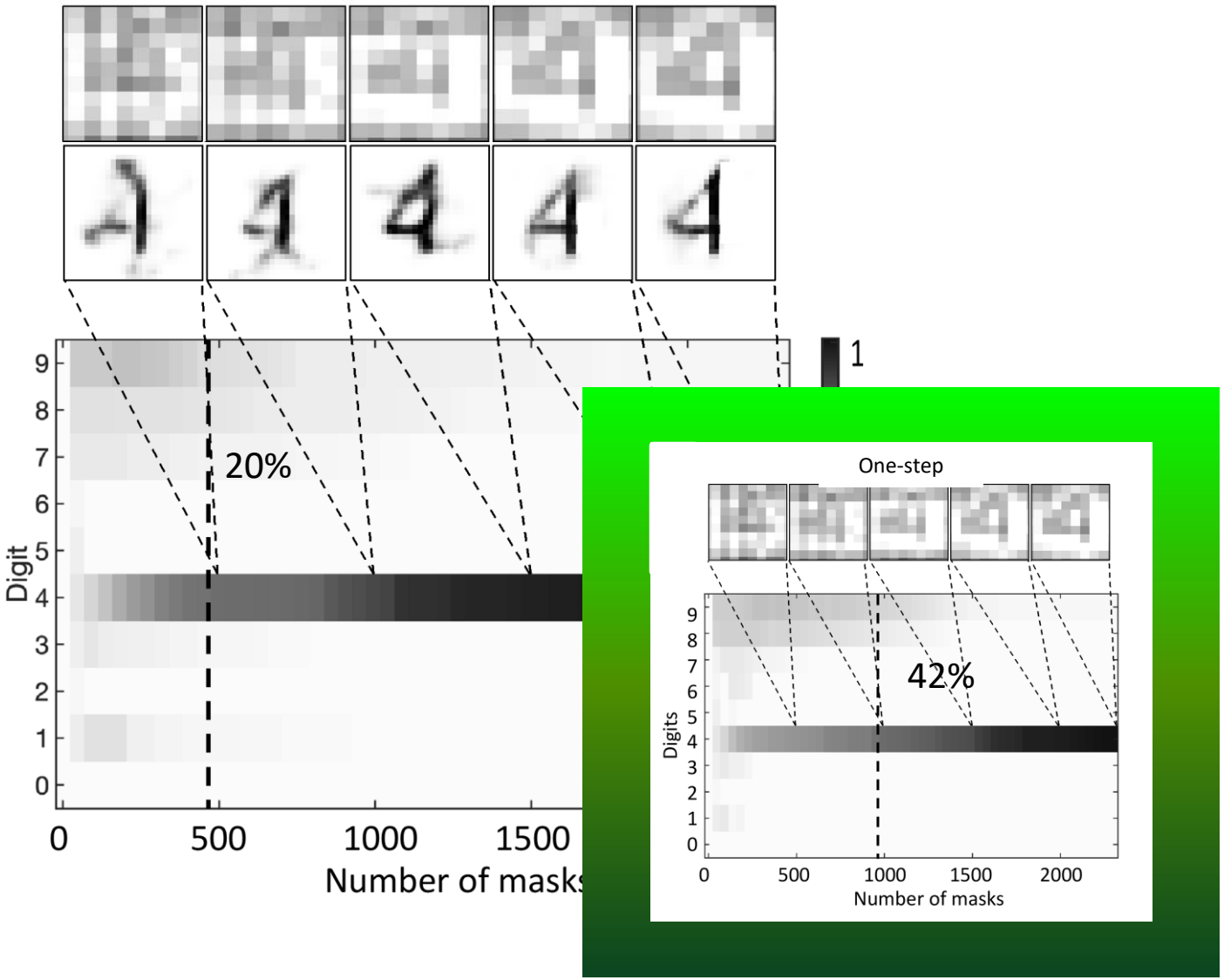
Autoencoder:
enhancing & denoising

Classifier:
recognition & confidence

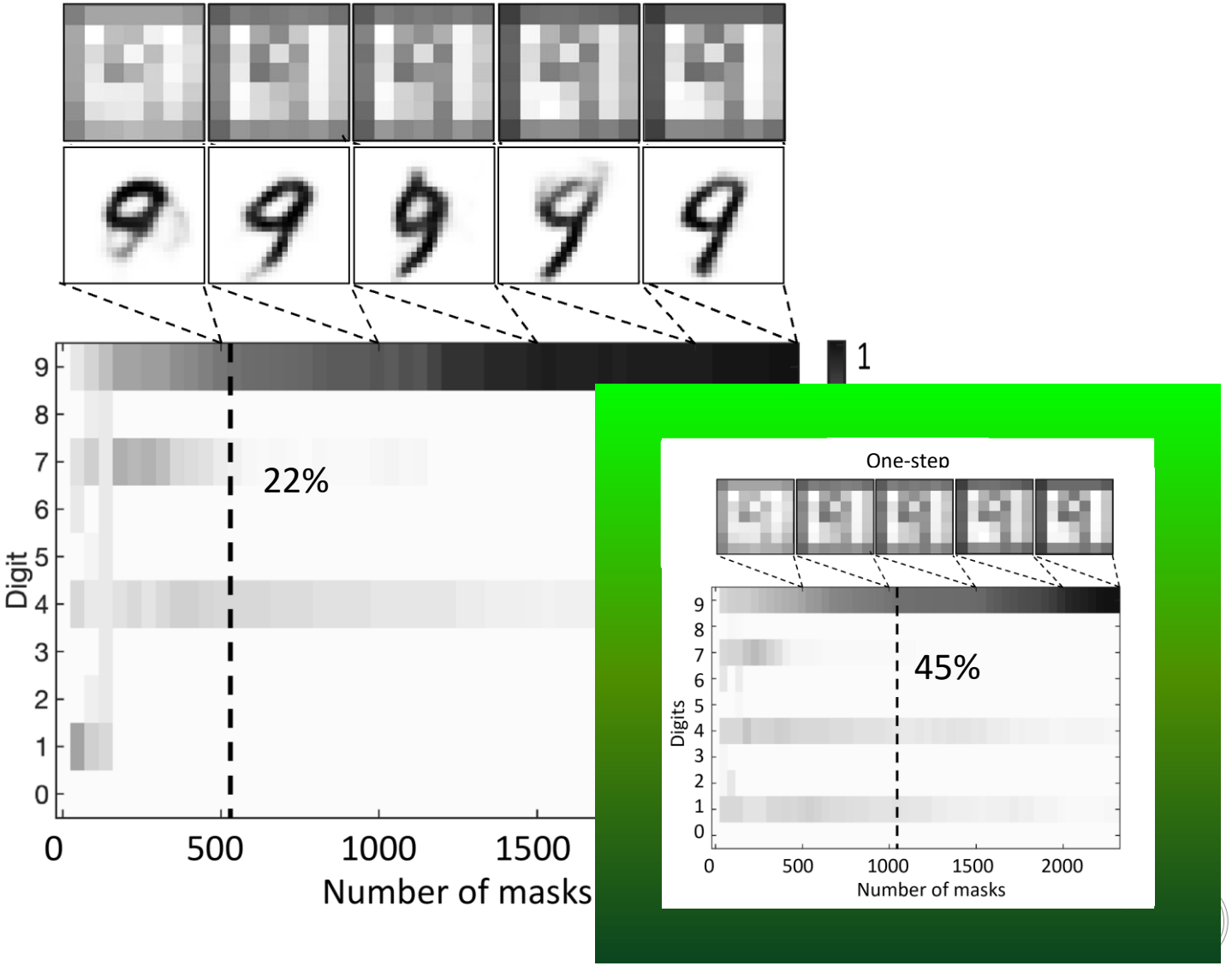
75% confidence must be achieved to stop the experiment



Two step approach speeds up image acquisition time – 5x faster



Two-step approach performs similarly for different objects



Summary

- Employing a SLM we developed a stable and cost-effective quantum ghost imaging experimental implementation.

- We varied physical parameters in the experiment by controlling what was displayed on the SLM.

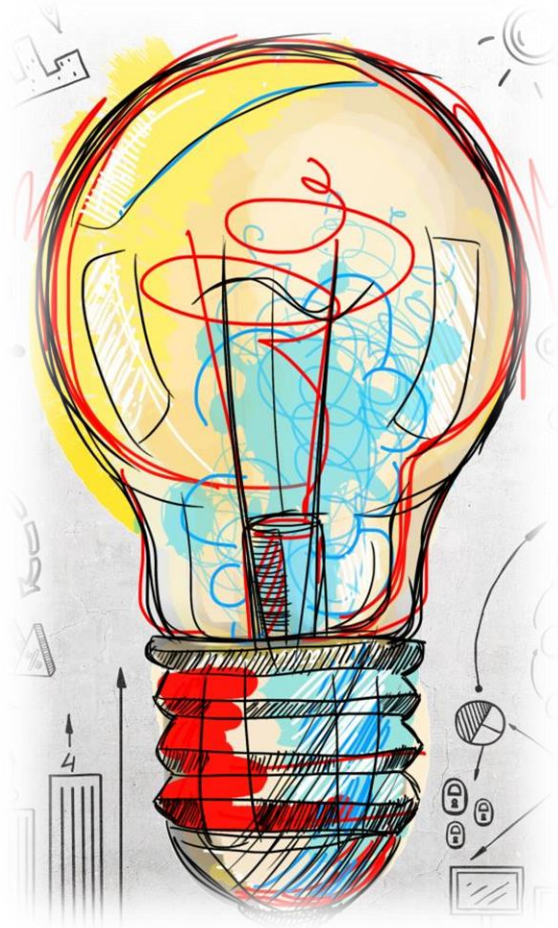
- We designed and implemented a two-step intelligent algorithm approach to establish an optimal early stopping point for ghost imaging experiments to reduce image acquisition time and to establish a more economical use of photons.

- Our novel intelligent ghost imaging approach achieves a 5-fold decrease in image acquisition time, utilising 5x less photons than conventional approaches.

Structured Light Laboratory

QI..AB

Thank you



Paper

Raphta

Structured Light Lab

RAPHTA