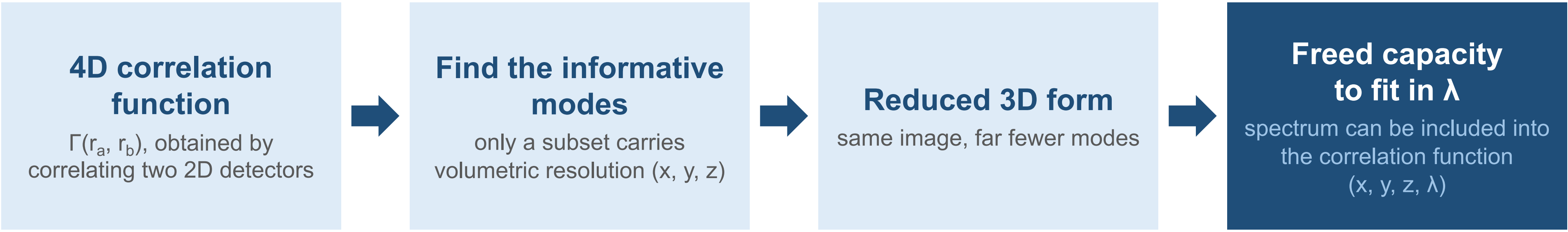


THE CHALLENGE

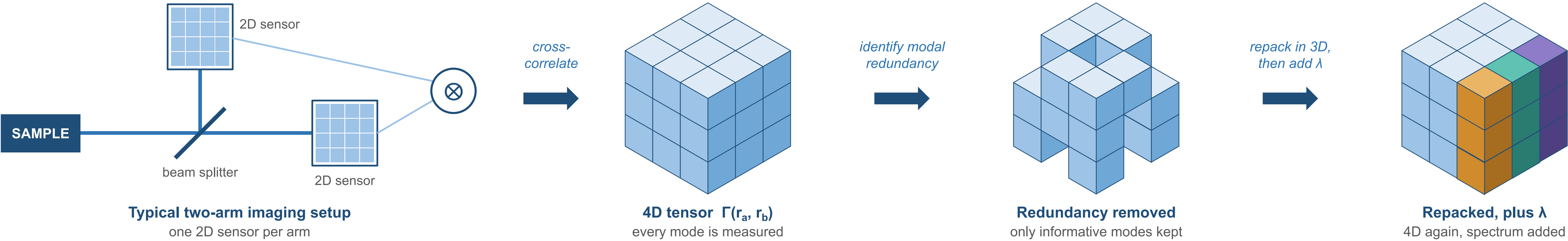
- Quantum imaging relies on a large number of transverse spatial modes, which limits signal-to-noise ratio, acquisition speed and data-processing load.
- No device, classical or quantum, retrieves x , y , z and λ together without mechanical scanning.
- Conventional systems are constrained by an inherent trade-off between spectral resolution, volumetric reconstruction and acquisition speed.

THE CONCEPT



Removing modal redundancy frees degrees of freedom inside the measured correlation function. That freed room is exactly what is needed to fit spectral information into a 4D correlation function. Same dimensionality as before, to achieve spectroscopy resolved in 3D space

STEP BY STEP



Cross-correlating the two sensors yields the full 4D correlation tensor. Most of its modes are redundant: removing them and repacking leaves the same image information in a smaller volume, and the freed capacity carries the spectral dimension.

OBJECTIVE 1
FEWER MODES, SAME RESOLUTION

Identify and isolate the small set of resolution-bearing spatial modes, then reformulate the 4D correlation function into a redundancy-free 3D representation. Validated on ghost imaging and correlation plenoptic imaging (CPI) [1] with pseudo-thermal and SPDC sources.

Lead: Bari · WP3 · M1–24

OBJECTIVE 2
ESTIMATION AT THE QUANTUM LIMIT

One validated framework for comparing and optimising spatial mode demultiplexing (SPADE) [2], CPI and Hong-Ou-Mandel interferometry (HOM) [3] built on Fisher-information analysis and new phase-retrieval algorithms.

Lead: LKB Paris · WP2 · M1–36

OBJECTIVE 3
SCAN-LESS SPECTRAL 3D IMAGING

The first class of devices to deliver x , y , z and λ in a single acquisition, built on the re-engineered correlation function and on detection strategies designed for noise reduction.

Lead: Glasgow · WP4 · M1–36

TARGETS

$x \cdot y \cdot z \cdot \lambda$ in a single acquisition, no moving parts	3–10× signal-to-noise gain in ghost imaging	10–50× resolution gain in CPI from phase retrieval	TRL 4 two demonstrators benchmarked by M36
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HOM DEMONSTRATOR

Glasgow

HOM interferometry with SPDC sources and the latest single-photon avalanche array cameras turns photon arrival time into micron-scale depth. Spectral-temporal mapping adds λ . First build at month 6.

Delivers: micron-scale depth and λ together, widefield and scan-less.

LIGHT-FIELD DEMONSTRATOR

Bari

Correlation plenoptic imaging under pseudo-thermal illumination, with correlation hyperspectral imaging [4] folded into the same architecture. Works with self-emitting fluorescent samples.

Delivers: x , y , z and λ from one acquisition, compatible with fluorescent samples.

PARAMETER ESTIMATION

LKB Paris

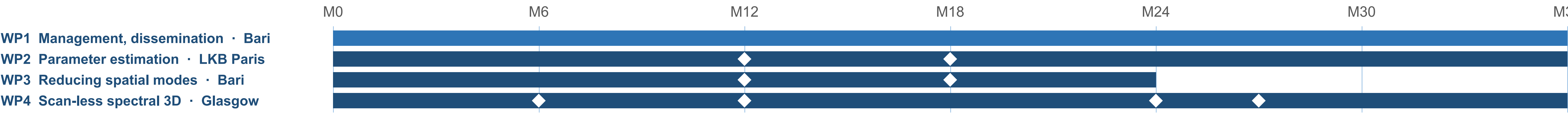
Spatial mode demultiplexing (SPADE), CPI and HOM benchmarked through Fisher-information analysis, with new phase-retrieval algorithms to approach the quantum limit.

Delivers: one validated framework for comparing and optimising the three schemes.

WHERE IT LANDS

- Fluorescence microscopy and tissue characterisation
 - Remote sensing and atmospheric monitoring
 - Cultural-heritage diagnostics
 - Industrial inspection and machine vision
- Routes out:** at least one patent, a Bari spin-off launching in 2026, and MPLC manufacturing.

WORK PLAN · 36 MONTHS



CONSORTIUM

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REFERENCES

[1] M. D'Angelo, F. V. Pepe, A. Garuccio, G. Scarcelli, Correlation plenoptic imaging, *Phys. Rev. Lett.* **116**, 223602 (2016)

[2] C. Rouvière et al., Ultra-sensitive separation estimation of optical sources, *Optica* **11**, 166–170 (2024)

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[4] G. Massaro, F. V. Pepe, M. D'Angelo, Correlation hyperspectral imaging, *Phys. Rev. Lett.* **133**, 183802 (2024)