

# DISQO: DISorder-Tailored Quantum Optical Sensor

Hugo Defienne (CNRS, Paris, France)

Andrei Nomerotski (Czech Technical University in Prague, Czech Republic)

Nicolas Joly (FAU Erlangen-Nürnberg, Germany)

Raj Pandya (Cambridge University, United Kingdom)

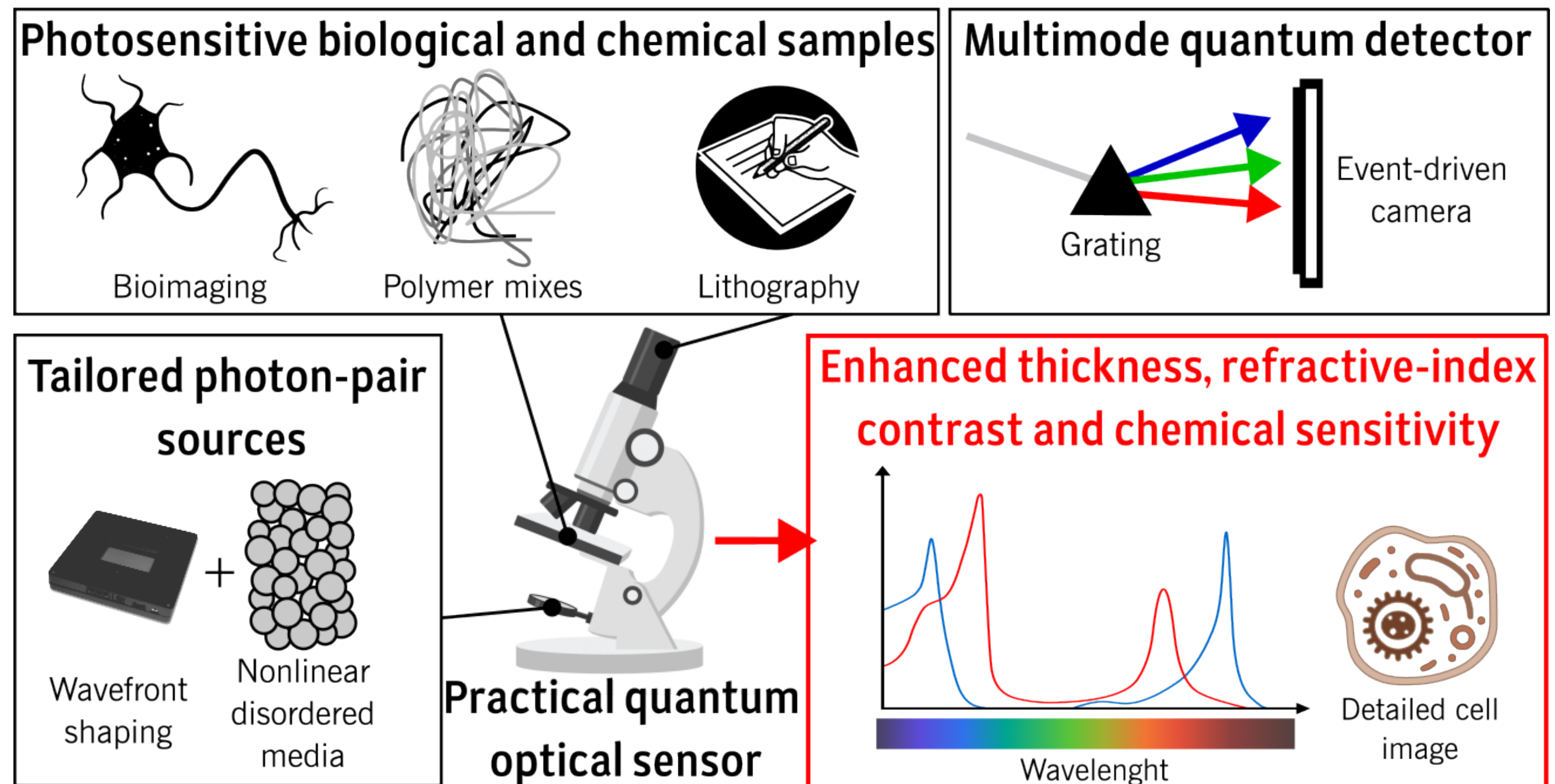
Emilie Kernén, Dmitri Orlov (Photonis/EXOSENS, Netherlands)

## What problem are we solving?

Quantum optical sensing offers measurement precision **beyond classical limits** and is rapidly becoming a key tool in biology and chemistry. However **non-ideal detectors, and noisy, lossy environments dilute the performance**.

### Example:

- **Entangled-photon-based sensing promises high sensitivity** to phase or optical thickness, sub-shot-noise measurements, and enhanced spatial resolution **at extremely low photon flux**, making it ideal for characterizing photosensitive samples, living cells, and chemical reactions.
- However, limited source tunability - **especially spectrally** - and the challenges of photon-pair detection constrain practical sensitivity and applicability.

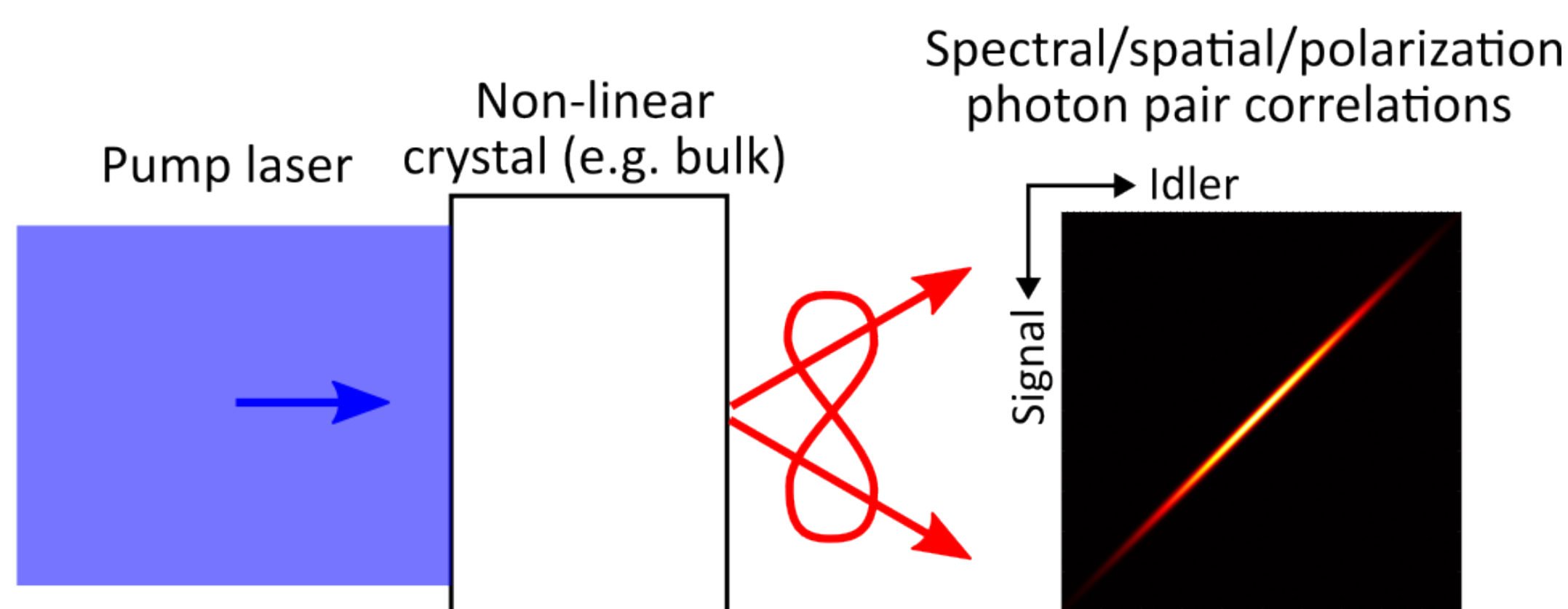


## How will it be done?

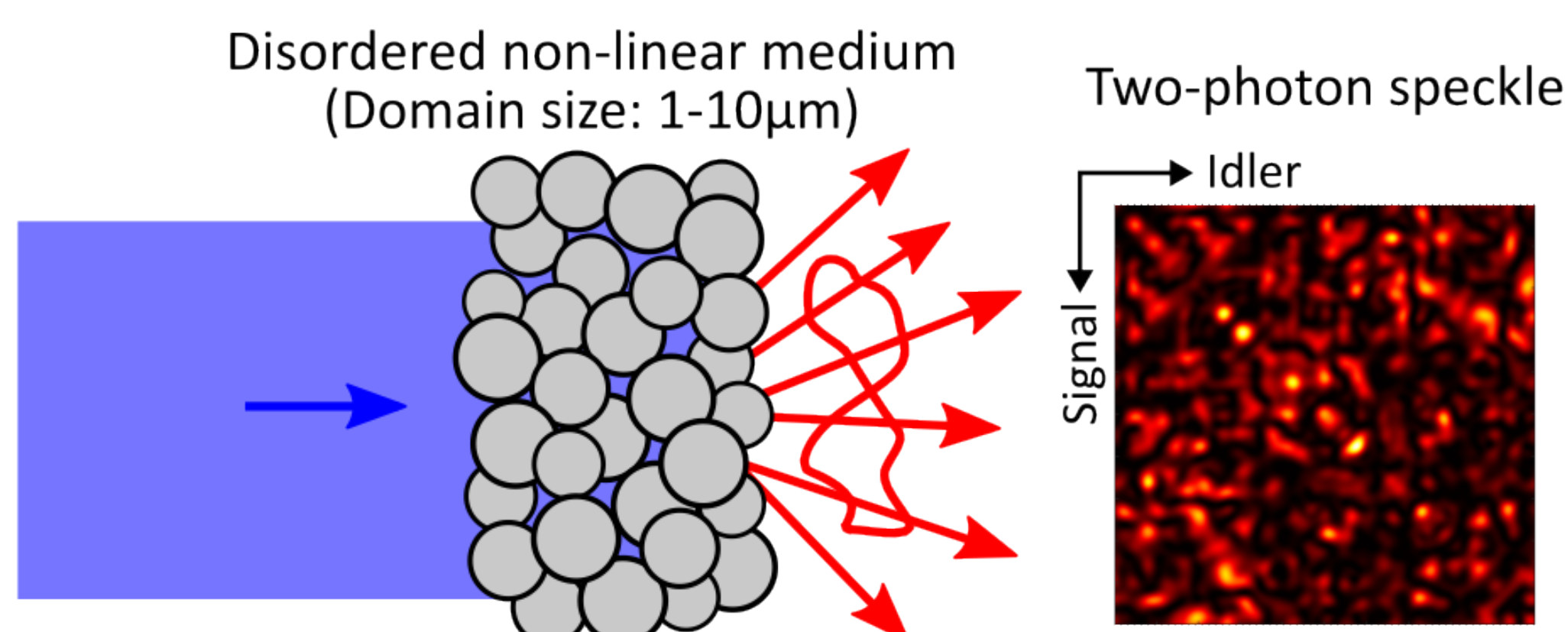
**DISQO** addresses these limitations by developing ‘disorder-tailored’ photon-pair sources, engineered and optimized for specific sensing and imaging systems under realistic conditions.

- These sources will be integrated into a next-generation photon-pair-based sensor that adapts the probe state to experimental conditions.
- Based on spontaneous parametric down-conversion (SPDC) and four-wave mixing (FWM) in nonlinear disordered media.
- Pumping these systems with wavefront-shaped laser beams will control the **spectral properties** of the photons [1].

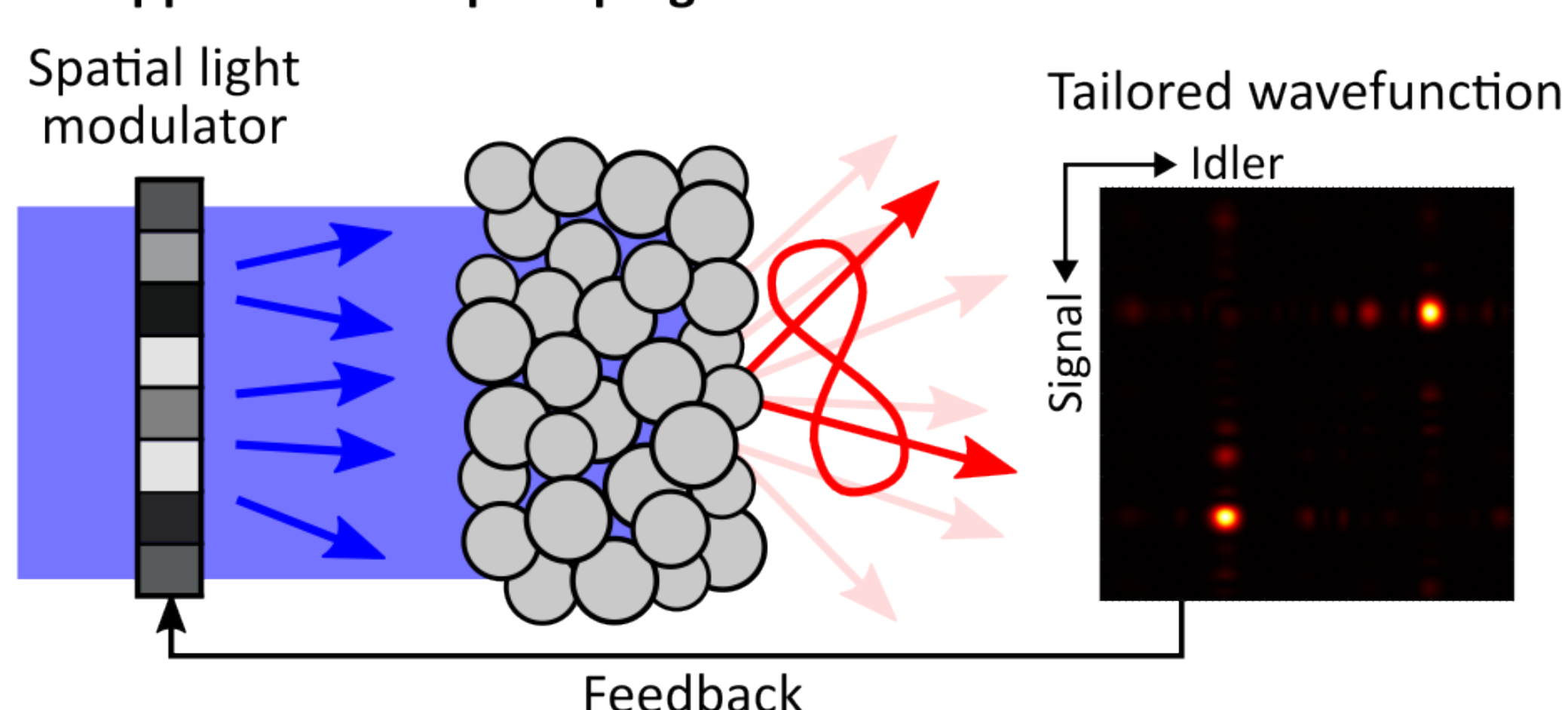
### a. Conventional photon-pairs generation (SPDC)



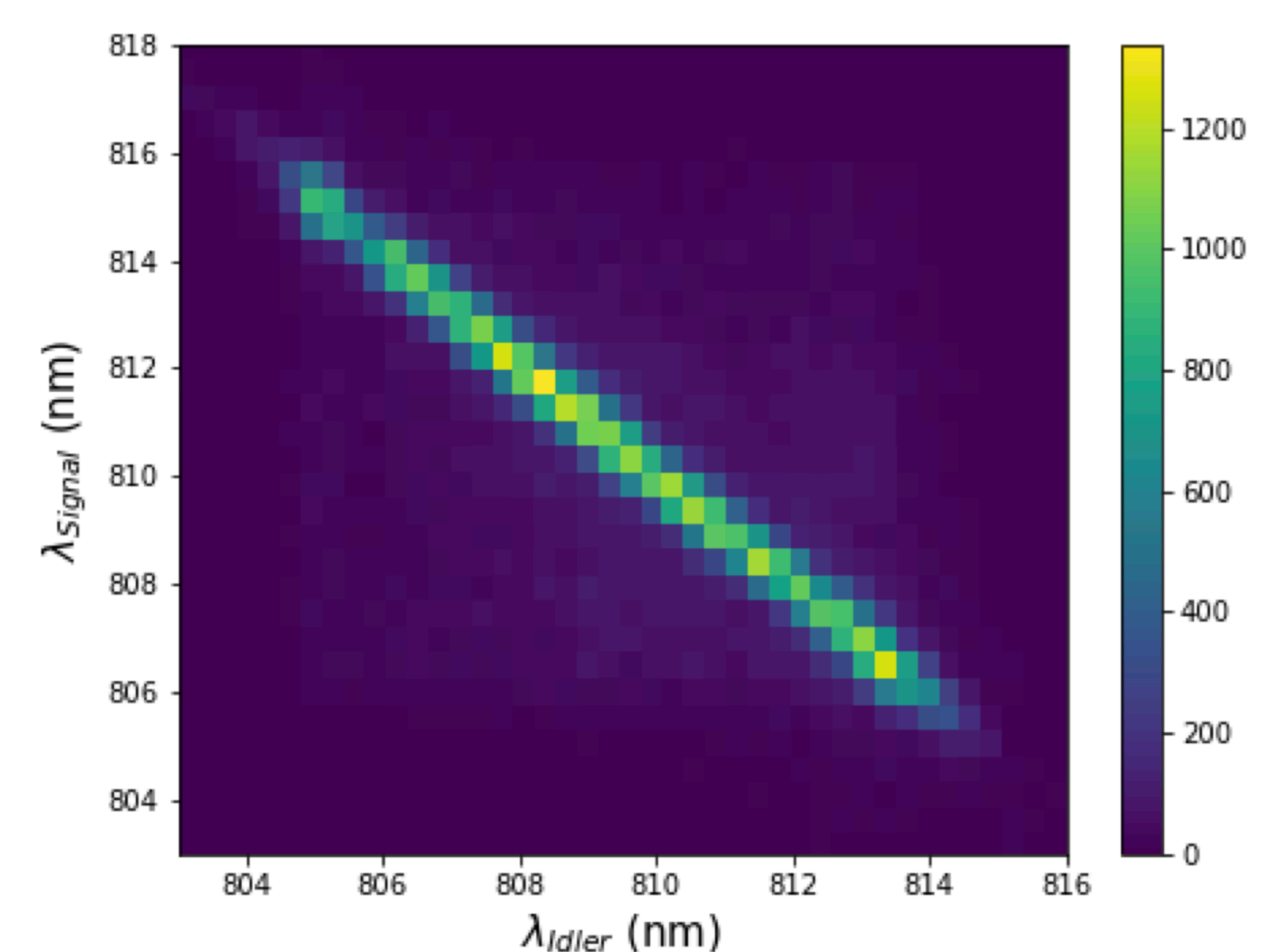
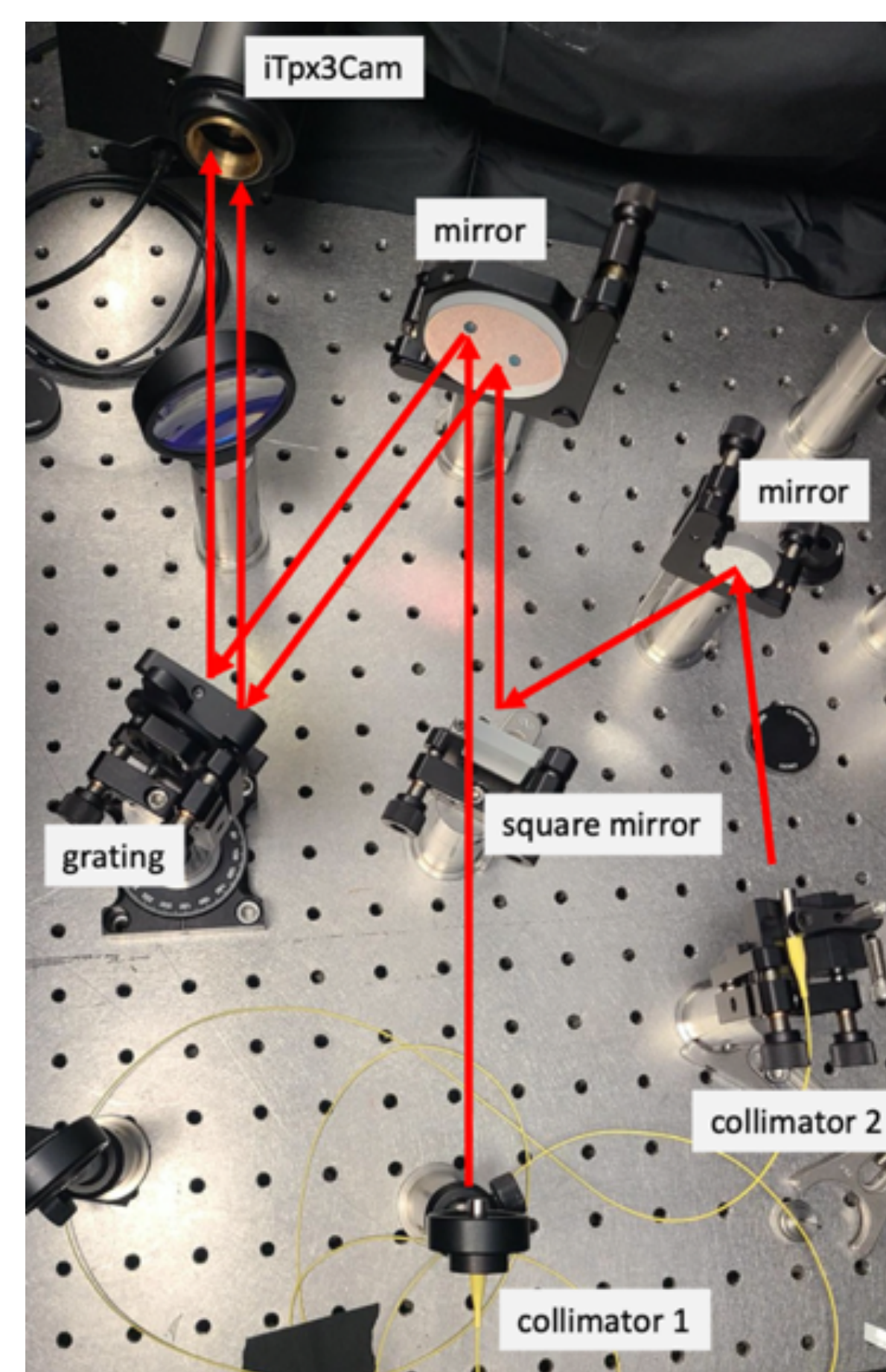
### b. Generation in disordered non-linear medium



### c. Our approach: Pump shaping + non-linear disorder

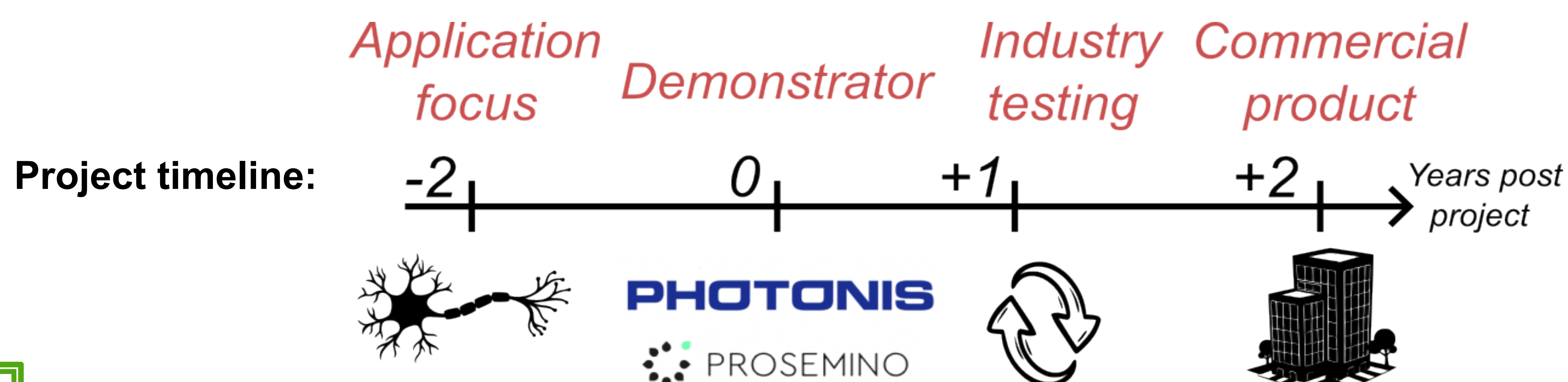


- **Quantum imaging spectrometer** based on data-driven Tpx4 camera will be developed
- **Will validate the advantages of these sources**, optimizing the probe quantum state to approach ultimate precision in practical sensing scenarios.



Spectrometer based on Tpx3 camera [2]

Pilot applications will involve **biological samples, chemical species and photosensitive materials**



[1] P. Cameron, B. Courme, C. Vernière, R. Pandya, D. Faccio, and H. Defienne, Science 383, 1142 (2024).

[2] B. Farella, G. Medwig, R. A. Abrahao, and A. Nomerotski, AIP Advances 14, 045034 (2024).