

Call 2021
Final Evaluation



Mf-QDS

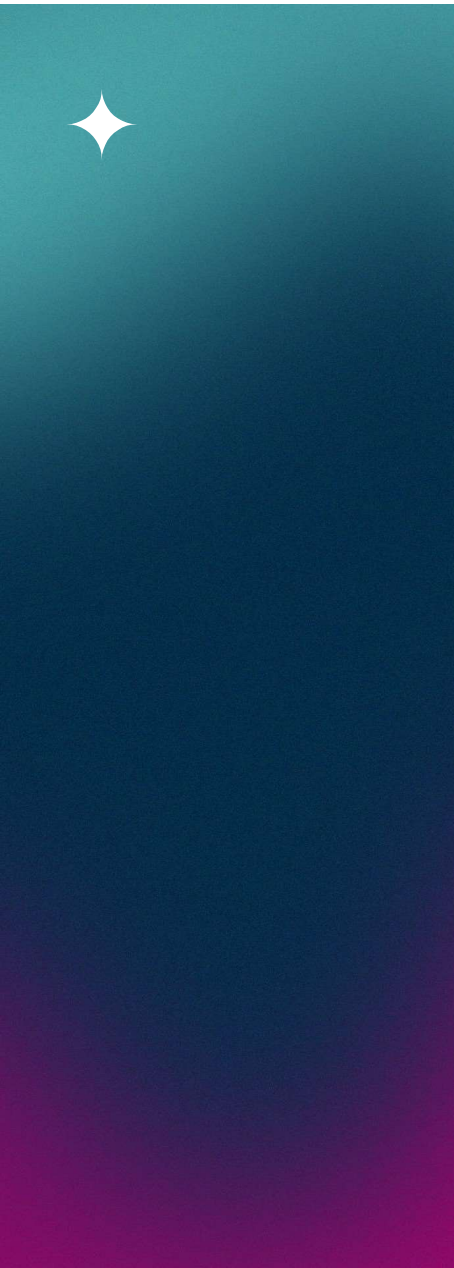
Microfluidics Quantum Diamond Sensor
Javier Prior

webs.um.es/javier.prior/



@prior.quantum





COLLABORATION



GEOGRAPHICAL BREADTH

(any Widening Countries?)



VARIETY OF SECTORS, DISCIPLINES –

complementarity of stakeholders (any private sector partners?)

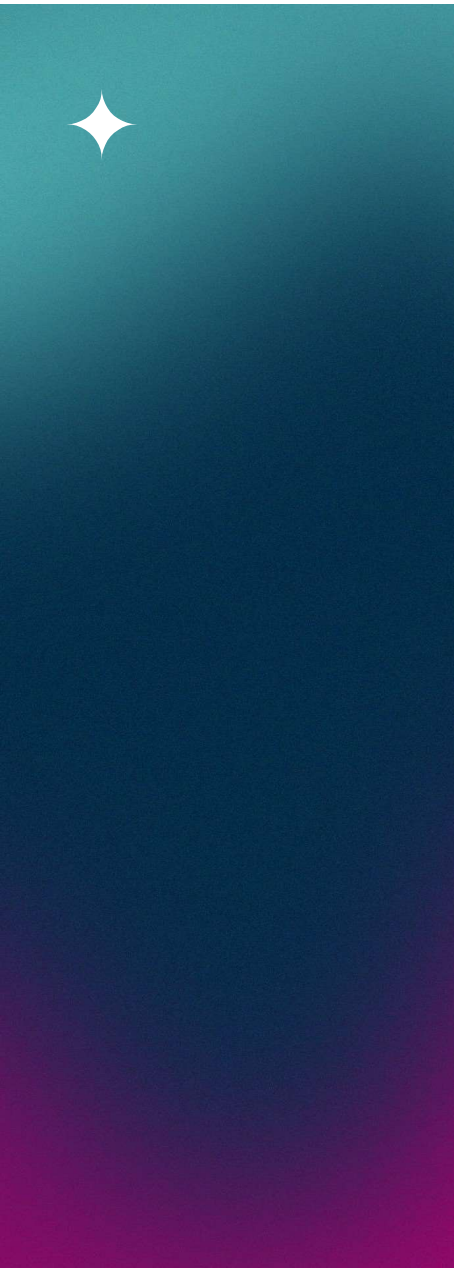


QUALITY OF COOPERATION – effectiveness, coordination, meetings, mobility activities



INFRASTRUCTURE SHARING within the project consortium





COLLABORATION



GEOGRAPHICAL BREADTH



JAGIELLONIAN
UNIVERSITY
IN KRAKÓW



universität
uulm

UNIVERSIDAD
DE MURCIA

THE HEBREW
UNIVERSITY
OF JERUSALEM



QuantERA Call 2021 Final Evaluation



COLLABORATION



VARIETY OF SECTORS, DISCIPLINES

- Companies: LightFab (DE), Element 6 (USA), Micrux (ES), Nanores (PL).



- Collaborations: Interlab-UMU, UGR,

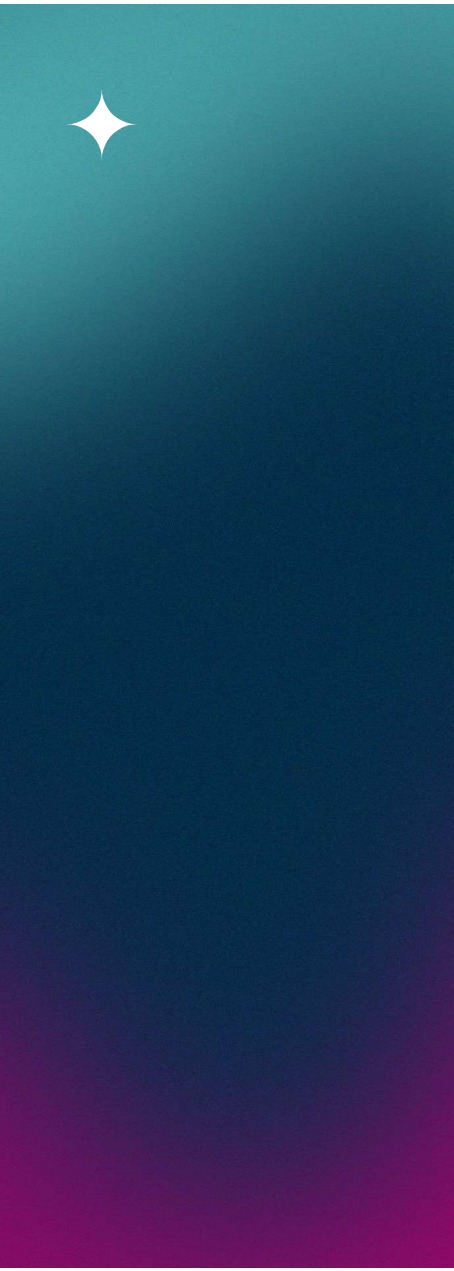
University of Melbourne.



UNIVERSIDAD
DE GRANADA

- Disciplines involved: Quantum Sensing, Quantum Control, Microfluidics, Nanotechnology, Numerical Modelling, Materials Sciences, Biomedical Applications, Theoretical/Experimental Collaboration.





COLLABORATION



QUALITY OF COOPERATION

- Regular meetings
- Sharing of procols and discoveries
- Researcher mobility and visits.

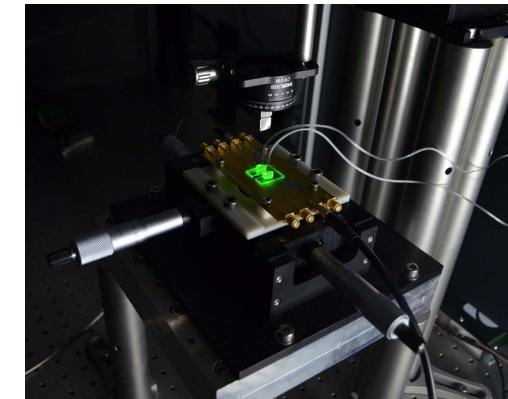
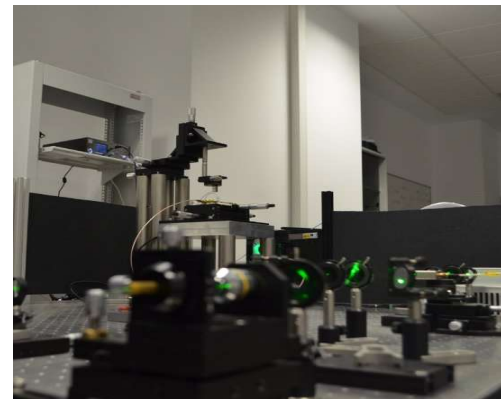


COLLABORATION



INFRASTRUCTURE SHARING

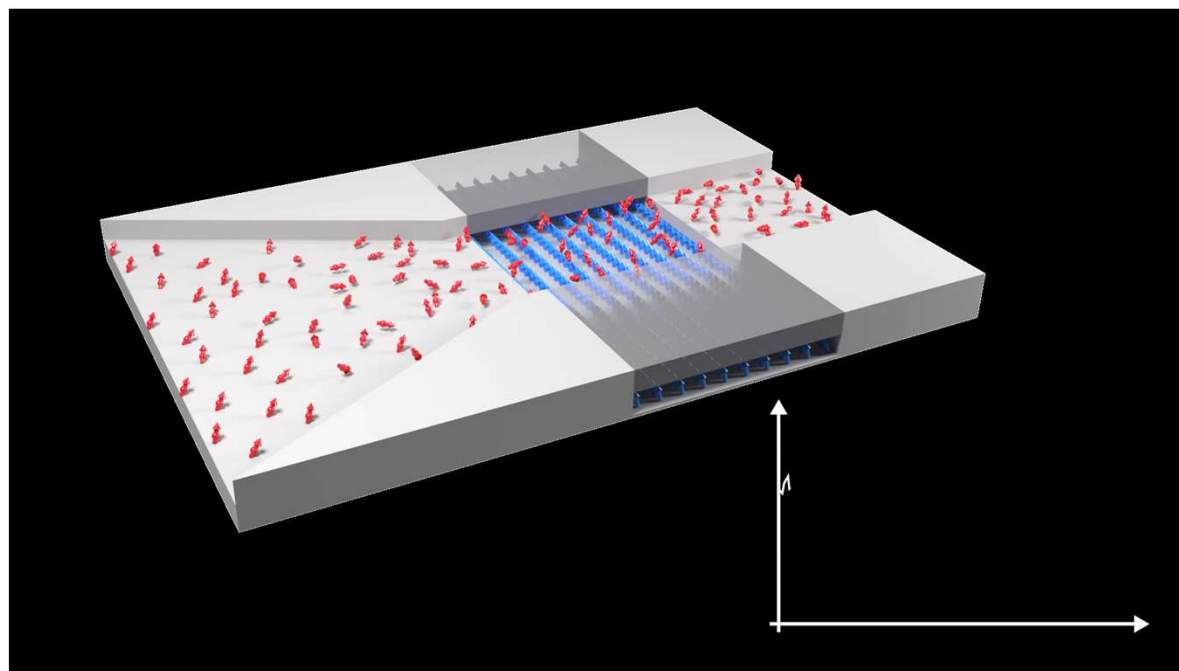
- Printed circuit boards
- Chip prototypes
- Diamonds
- Tubing and other microfluidics materials



SUCCESS STORY



CHALLENGE – Microfluidic measurements using a Quantum Diamond Sensor





SUCCESS STORY



SOLUTION – The research plan was divided in four objectives:



Accurate model
of the magnetic
noise induced to
the sensor



Design and
implementation
of a functionable
microfluidic
sensing platform



Experimental
measurement of
fluid velocity



Application:
detection of free
radicals in clinical
samples

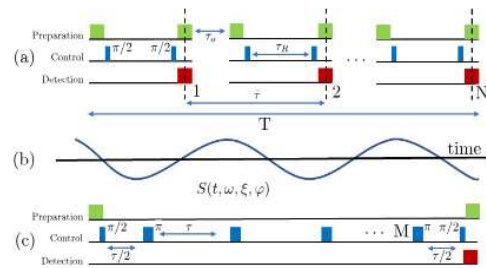


SUCCESS STORY



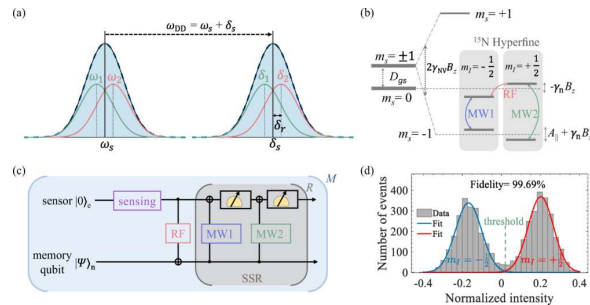
OUTCOMES – Objective 1. Accurate model of the magnetic noise induced to the sensor

Low frequency signal detection via correlated Ramsey measurements



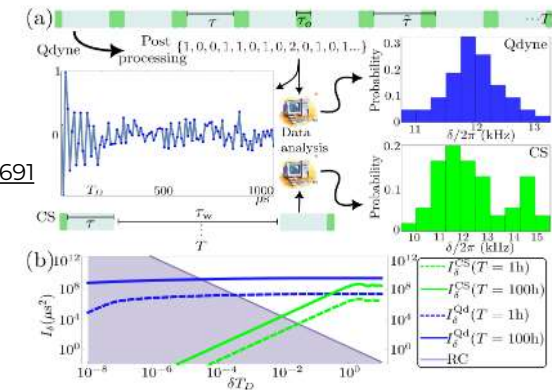
Journal of Magnetic Resonance
2024, 363, 107691.
DOI:
<https://doi.org/10.1016/j.jmr.2024.107691>

Overcoming Frequency Resolution Limits Using a Solid-State Spin Quantum Sensor



Phys. Rev. Lett. 135, 250806
DOI: <https://doi.org/10.1103/PhysRevLett.135.250806>

Optimal Sensing Protocol for Statistically Polarized Nano-NMR with NV Centers

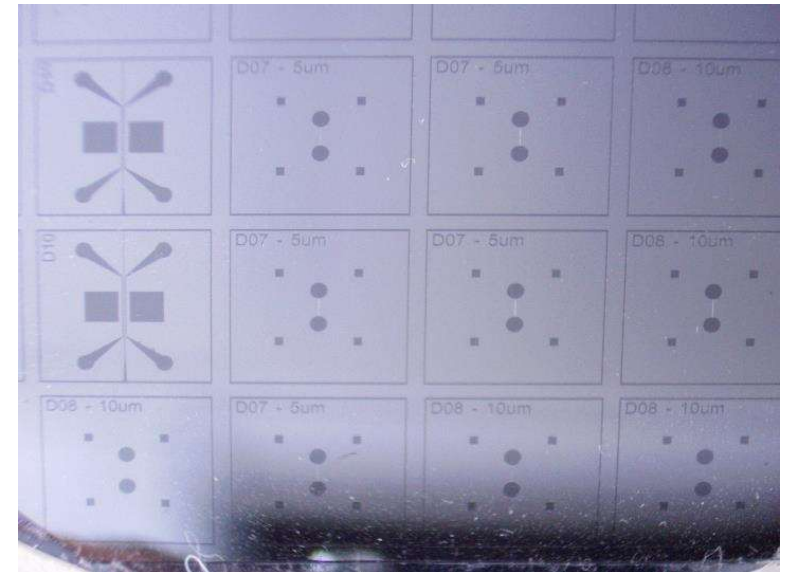
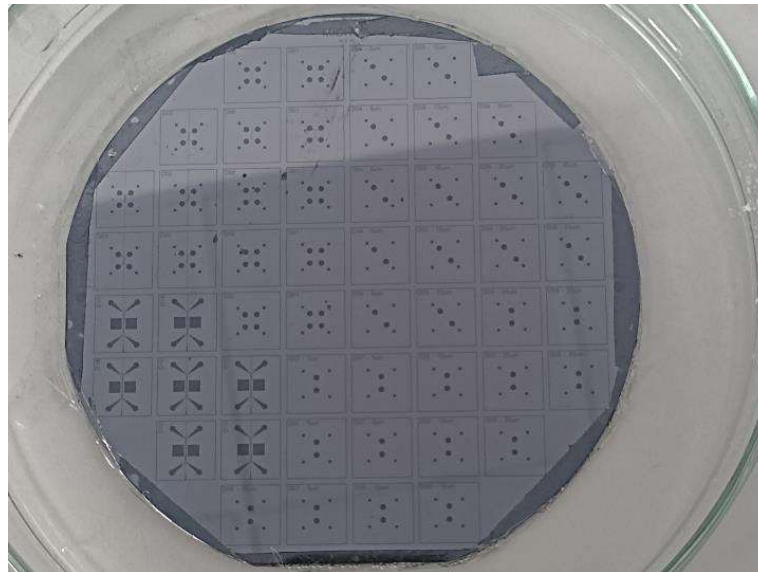


Phys. Rev. Lett. 131, 150801.
DOI: <https://doi.org/10.1103/PhysRevLett.131.150801>

SUCCESS STORY



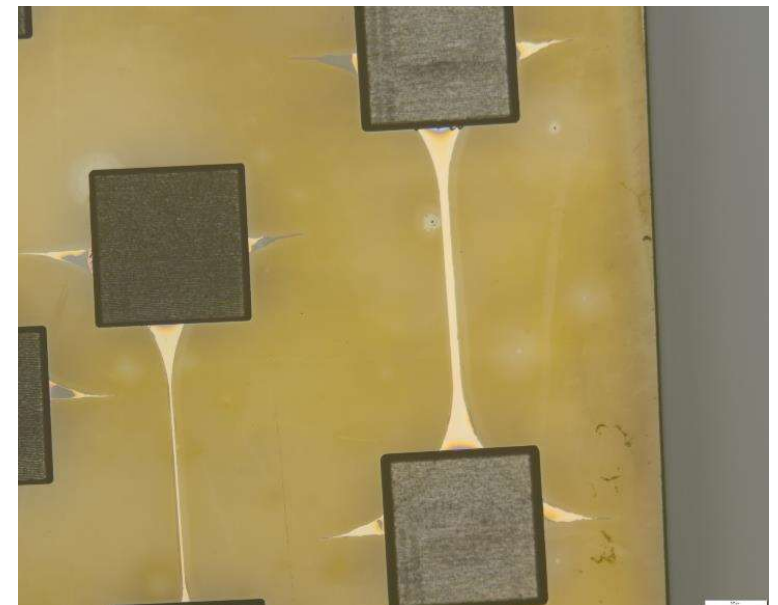
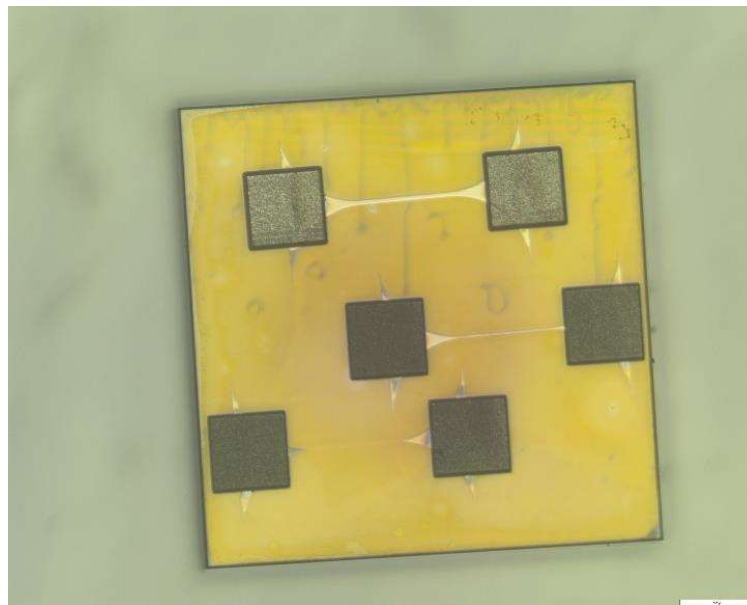
OUTCOMES - Objective 2. Design and implementation of a functionable microfluidic sensing platform



SUCCESS STORY



OUTCOMES - Objective 2. Design and implementation of a functionable microfluidic sensing platform



SUCCESS STORY



OUTCOMES - Objective 2. Design and implementation of a functionable microfluidic sensing platform

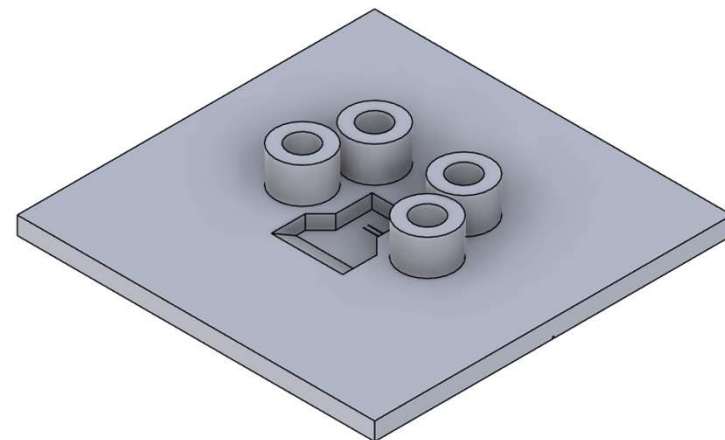
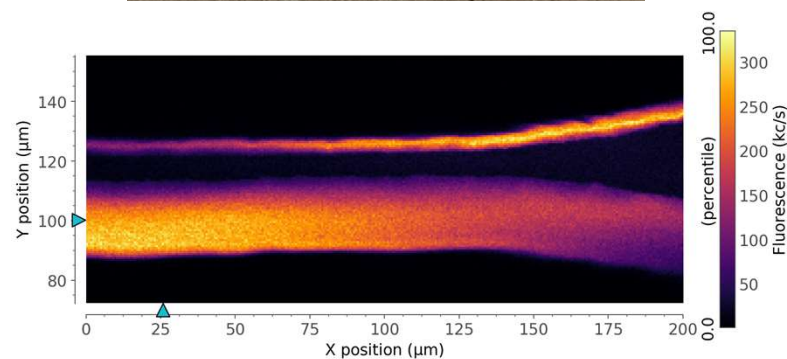


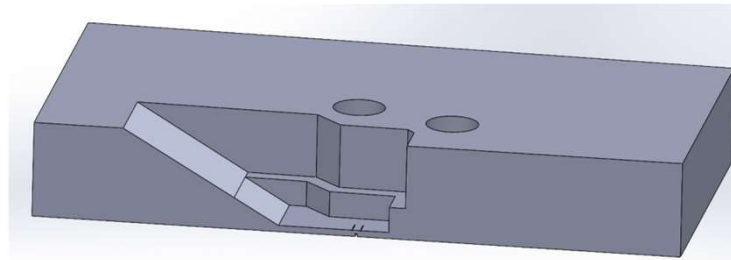
FIG. 15. Confocal imaging of single NVs in a microfluidic device. On the left, a silica glass chip for microfluidic experiments mounted on top of a gold PCB. The chip is illuminated with a green laser. Two needles installed on the inlet and outlet entries lead a flow of the studied fluid through the tubes into the chip. On the center, a microscope image of the $2 \times 2 \text{ mm}^2$ CVD-grown diamond installed on top of the microfluidic channels. On the right, an XY scan of single NV centers at a concentration of 10^{11} cm^{-2} . The NVs appear distinguishable despite the changes of the refractive index between surfaces.



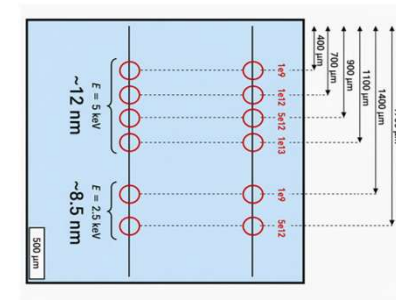
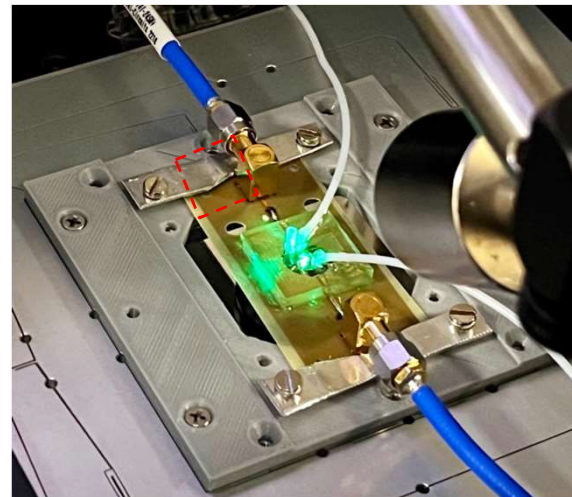
SUCCESS STORY



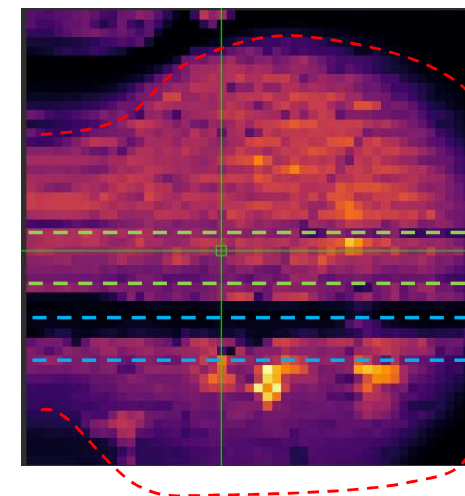
OUTCOMES - Objective 2. Design and implementation of a functionable microfluidic sensing platform



Microfluidic spectrometer



Near-surface NV diamond sample



Dense NV ensemble

Glass microchannel

Diamond microchannel



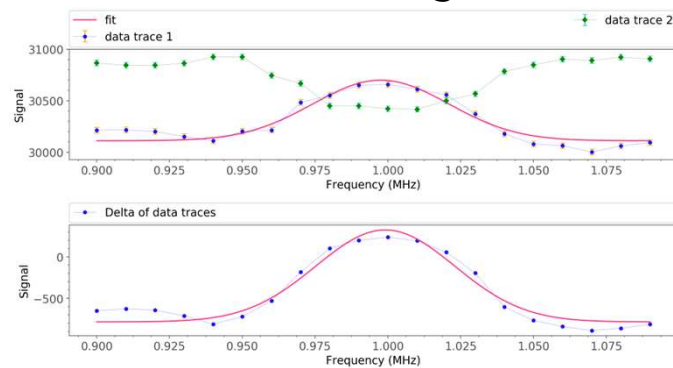
SUCCESS STORY



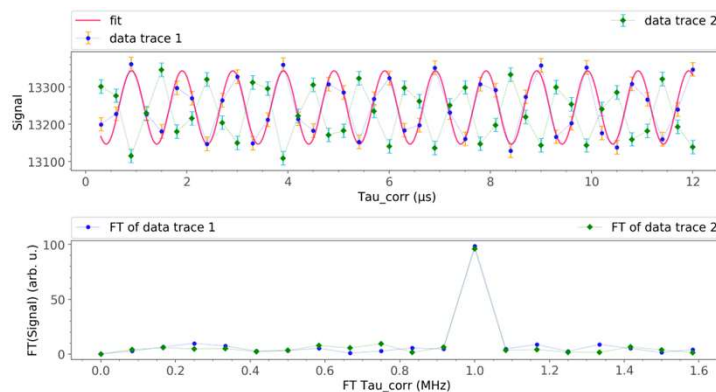
OUTCOMES - Objective 3. Experimental measurement of fluid velocity

Dynamical decoupling

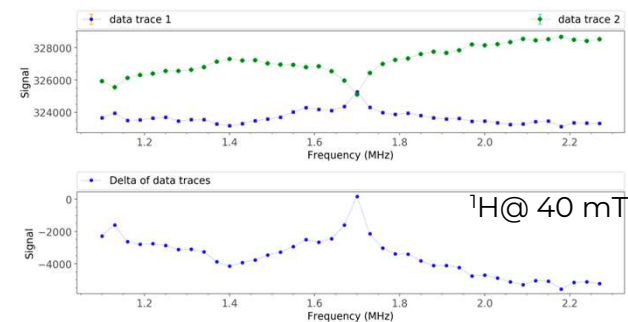
1 MHz test signal



Correlation spectroscopy

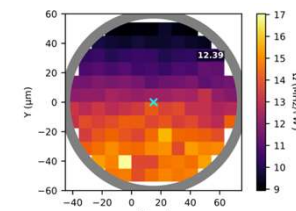
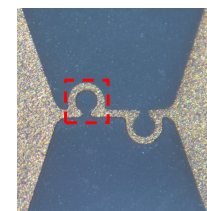


Protons in the microfluidic channel



$^1\text{H}@ 40 \text{ mT}$

- Higher lead fields are needed to distinguish ^1H signals from transient correlations.
- Higher lead field $\rightarrow$ stronger Rabi drive needed



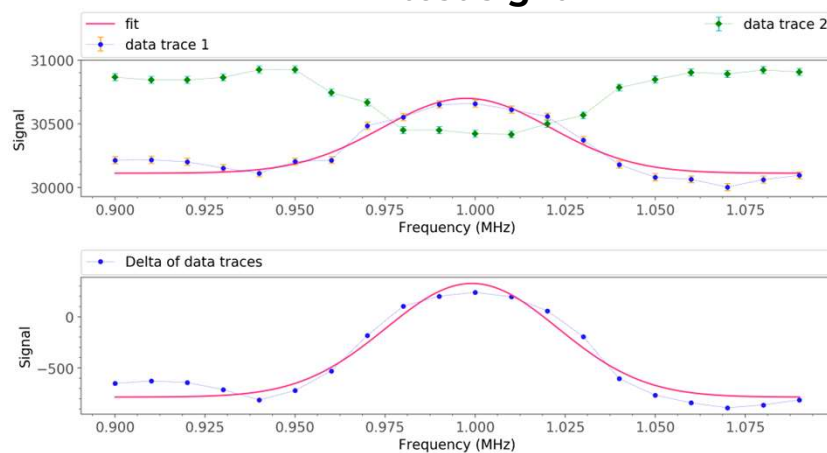
QuantERA Call 2021 Final Evaluation

Sensing modality for nanoscale noise spectroscopy

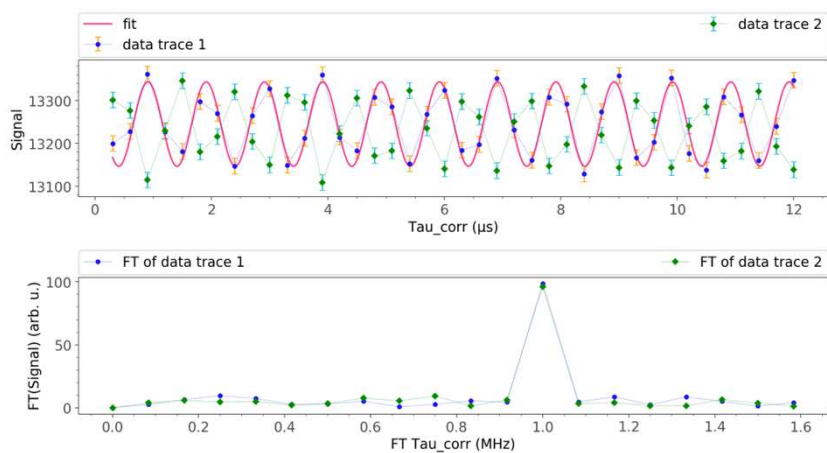
Sensing modality for nanoscale noise spectroscopy

Dynamical decoupling

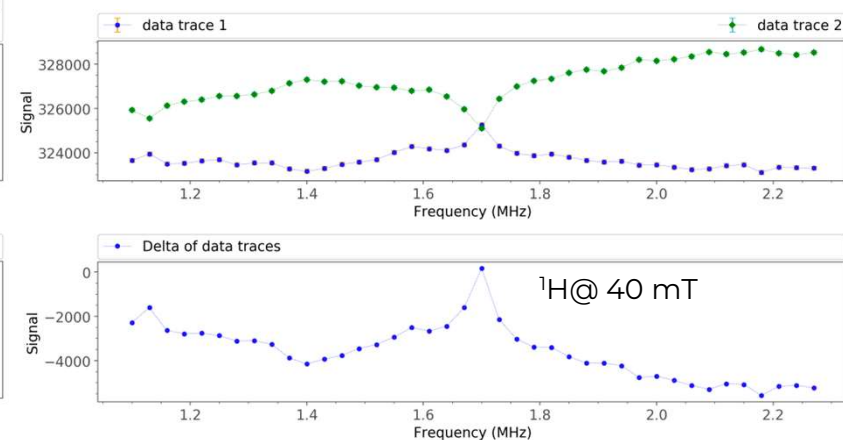
1 MHz test signal



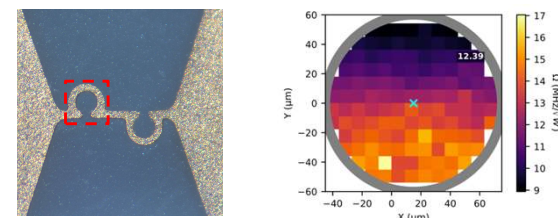
Correlation spectroscopy



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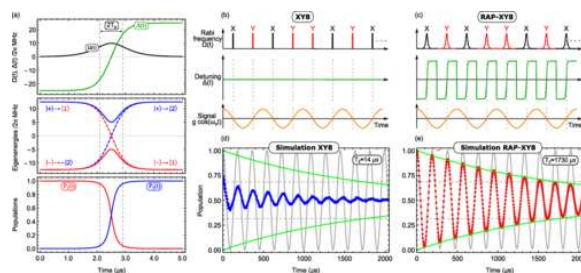
QuantERA Call 2021 Final Evaluation

SUCCESS STORY



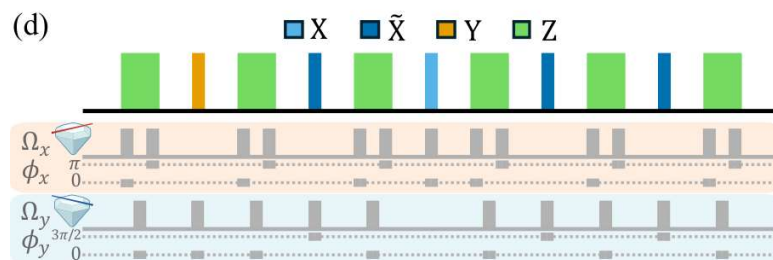
OUTCOMES - Objective 3. Experimental measurement of fluid velocity

Robust gigahertz-range ac magnetometry with an ensemble of N-V centers in diamond using concatenated continuous dynamical decoupling



Phys. Rev. Applied 26, 024018. DOI: <https://doi.org/10.1103/8zf5-1zyj>

Zero-field dipolar decoupling of color center ensembles via universal qutrit control



ArXiv.2605.26863

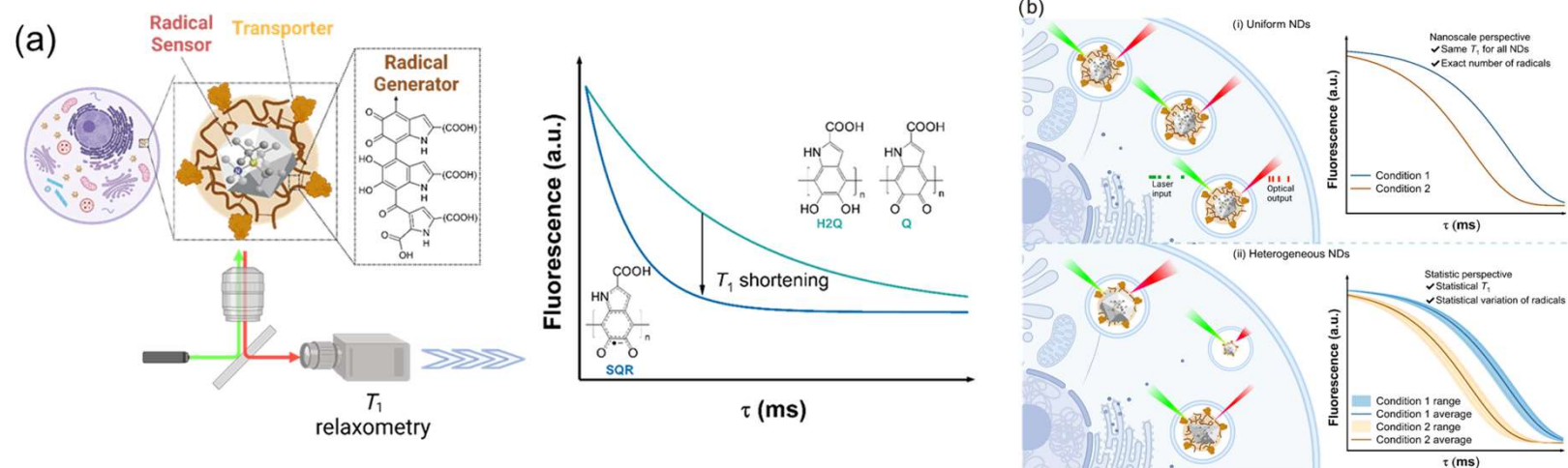


SUCCESS STORY



OUTCOMES - Objective 4. Application: detection of free radicals in clinical samples

Unraveling Eumelanin Radical Formation by Nanodiamond Optical Relaxometry in a Living Cell



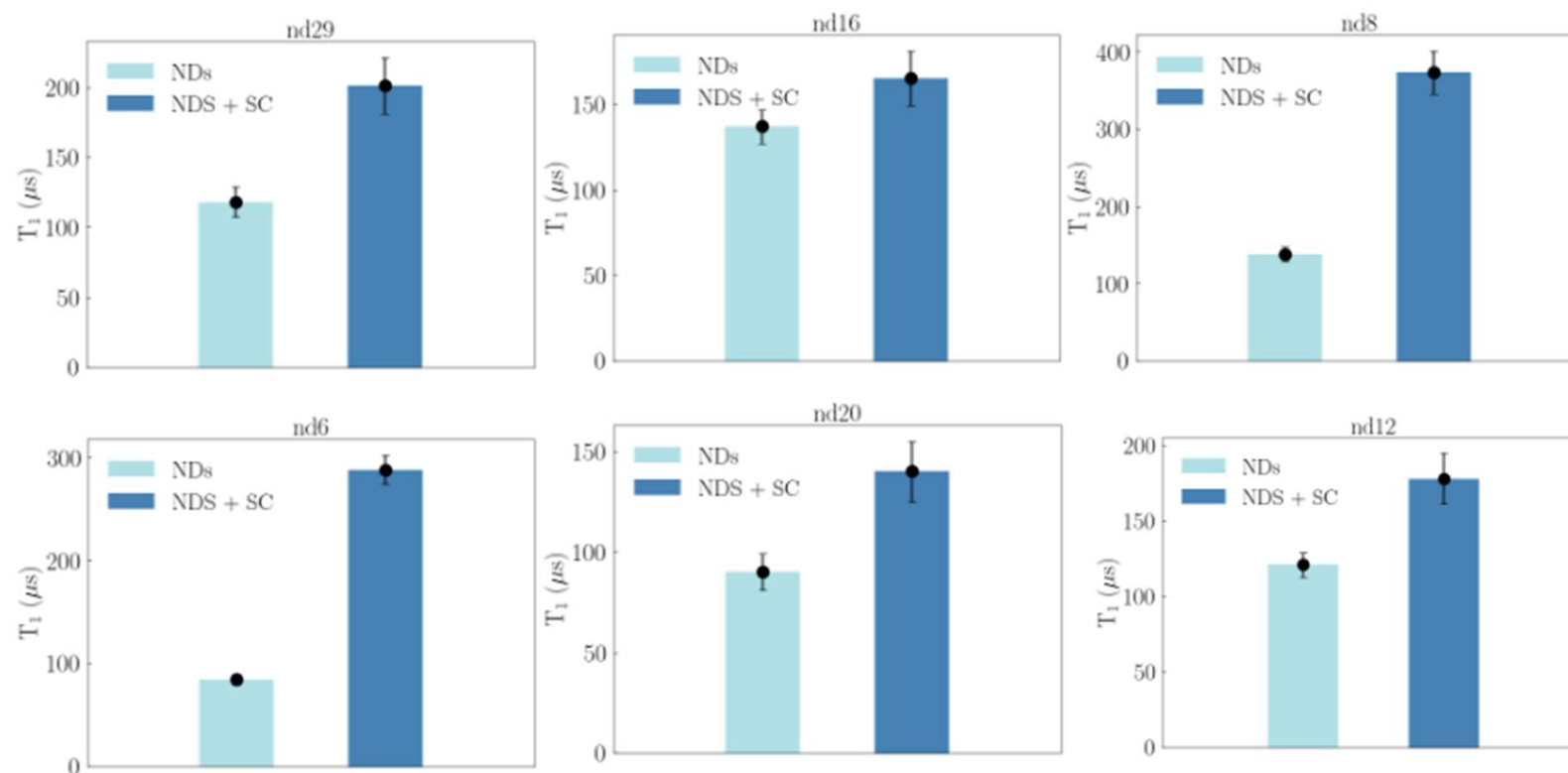
Journal American Chemical Society. 2024;146(11):7222-7232. doi:10.1021/jacs.3c07720

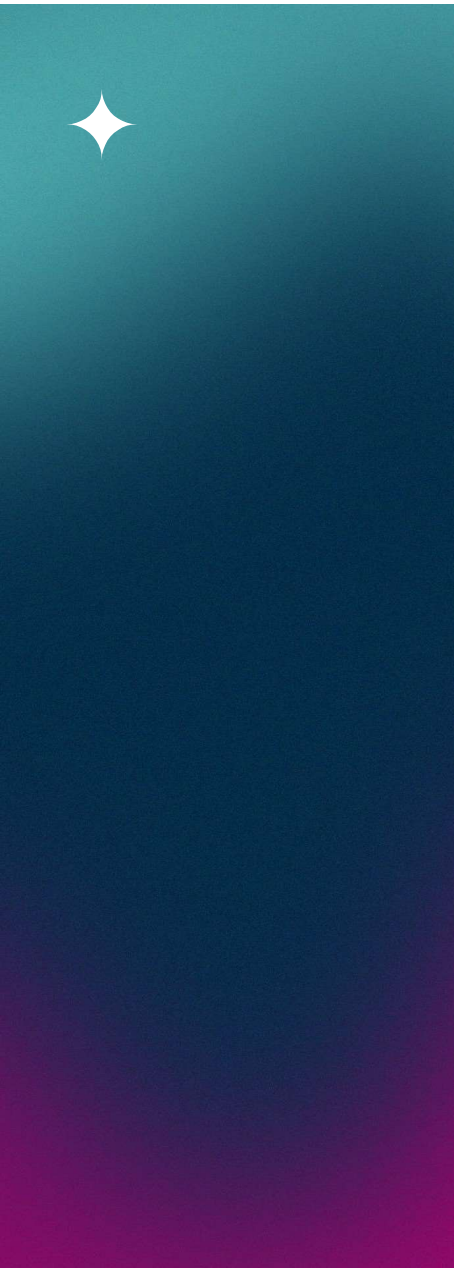


SUCCESS STORY



OUTCOMES - Objective 4. Application: detection of free radicals in clinical samples





SCIENTIFIC OUTPUTS



PUBLICATIONS AND PRESENTATIONS (highlights)

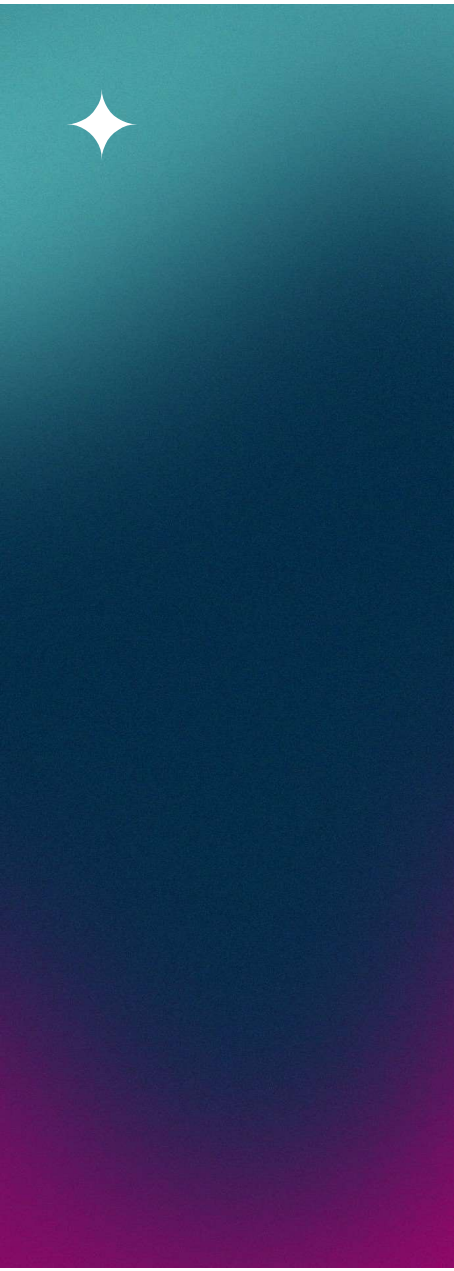


PATENTS (obtained and pending)



NUMBER OF BACHELOR, MASTER AND PhD THESES
prepared under the QuantERA Project





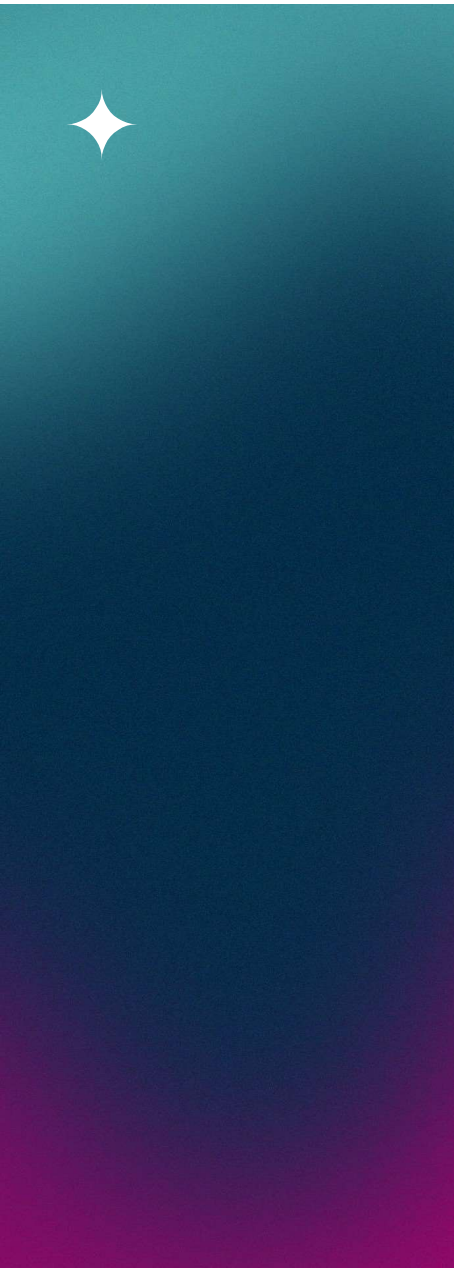
SCIENTIFIC OUTPUTS



PUBLICATIONS AND PRESENTATIONS

- Physical Review Letters 131(15), 150801. DOI: 10.1103/PhysRevLett.131.150801
- Journal of Magnetic Resonance 2024, 363, 107691. <https://doi.org/10.1016/j.jmr.2024.107691>
- Phys. Rev. Lett. 135, 250806 DOI: <https://doi.org/10.1103/lifg-s4rr>
- Science Advances 11(9) (2025). DOI: 10.1126/sciadv.adq6836
- Journal of Applied Physics 139 (5) <https://doi.org/10.1063/5.0293773>
- Journal American Chemical Society. 2024;146(11):7222-7232. doi:10.1021/jacs.3c07720
- Physical Review Research. DOI: 10.1103/6z22-4z36
- Advanced Science 12(45) (2025). DOI: 10.1002/adv.202511670
- Physical Review Applied 23, 034001 (2025). DOI: 10.1103/PhysRevApplied.23.034001
- Rev. Mod. Phys. 96, 025001. DOI: <https://doi.org/10.1103/RevModPhys.96.025001>
- ArXiv: arXiv.2605.26863
- Phys. Rev. Applied 26, 024018. DOI: <https://doi.org/10.1103/8zf5-1zyj>





SCIENTIFIC OUTPUTS



PATENTS

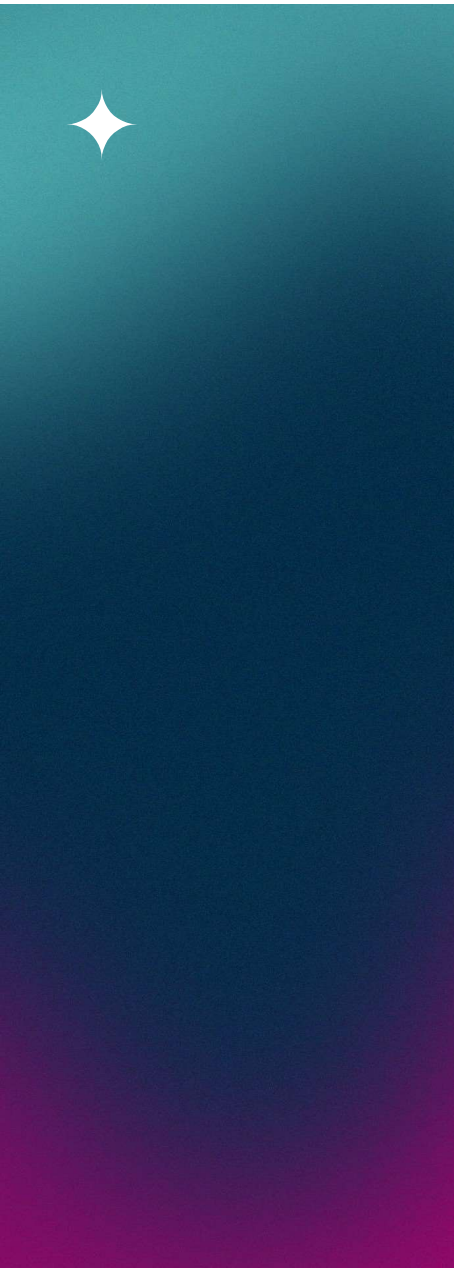
- US Patent 12,380,354 (2025)



NUMBER OF BACHELOR, MASTER AND PhD THESES

- 1 PhD thesis defended in 2025 at the University of Ulm
- 6 Master's theses completed at the University of Murcia
- 6 PhD theses in progress at the University of Murcia
- 2 PhD theses in progress at the Jagiellonian University in Krakow





IMPACT (potential users)



RELEVANT **INDUSTRY BRANCH**



KEY COMMERCIALY RELEVANT **APPLICATIONS**

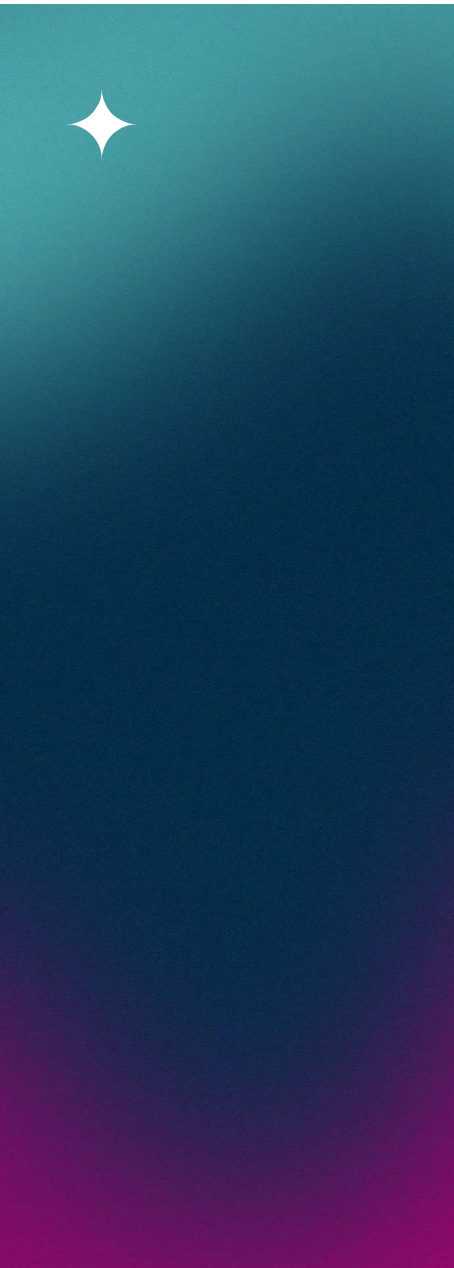


EXISTING/POTENTIAL **END USERS**



COOPERATION WITH THE **QUANTUM FLAGSHIP**
OR OTHER QUANTUM INITIATIVES (if applicable)





IMPACT (potential users)



RELEVANT **INDUSTRY BRANCH:**

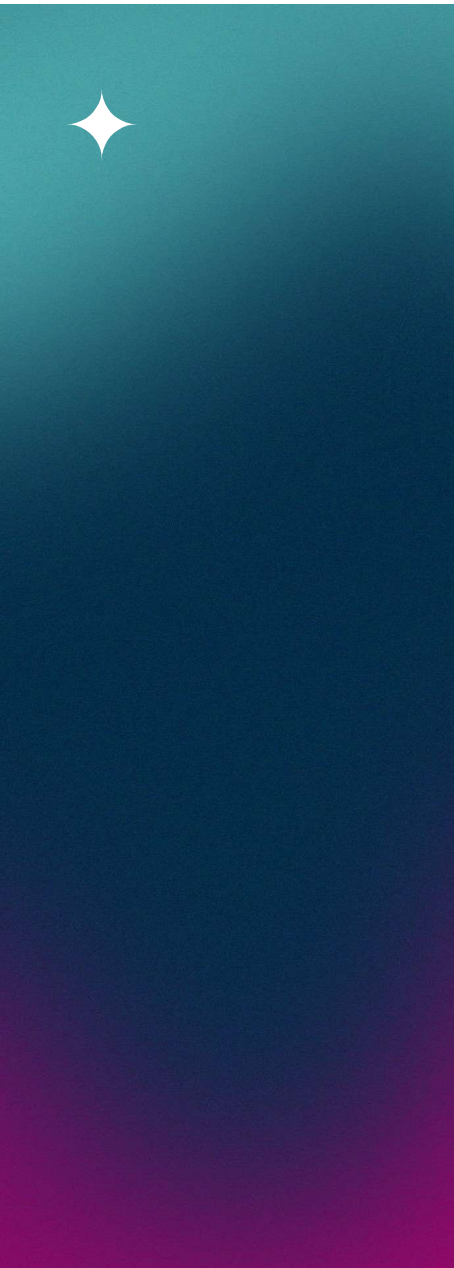
- Microfluidic and LOC
- Quantum Sensing and Quantum Technologies
- Biomedical and/or biochemical analysis



KEY COMMERCIALY RELEVANT **APPLICATIONS:**

- Integrated microfluidic platform for quantum sensing
- Free radicals detection on clinical samples
- Miniaturized sensing platforms market
- Biochemical/biomedical purposes





IMPACT (potential users)



EXISTING/POTENTIAL **END USERS:**

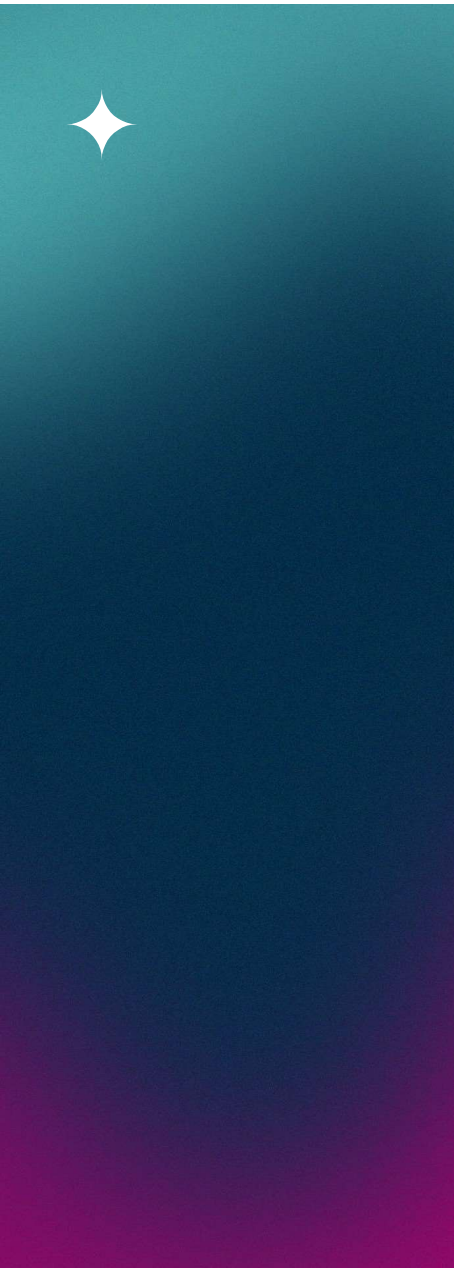
- Navantia (UMU)
- Discussions with Bosch (Ulm-UMU)
- Collaboration with IMIB (UMU)



COOPERATION WITH THE **QUANTUM FLAGSHIP** OR OTHER QUANTUM INITIATIVES:

- H2020 ERC HyperQ Project
- EU QCIRCLE
- QuMicro
- FLORIN





IMPACT (RRI aspects)



GENDER: Fostering gender balance and promoting female researchers.



OPEN SCIENCE: all the papers are available on ArXiv.



SCIENCE EDUCATION:

- Máster Interuniversitario en Tecnologías Cuánticas (UIMP, Universidad de Murcia, et. Al.) New official master 2024-2025.
- Quantum Engineering M. Sc. (University of Ulm)
- Talks in public schools and high schools
- Guided visits to the Qtech laboratory for Physics students from University of Murcia

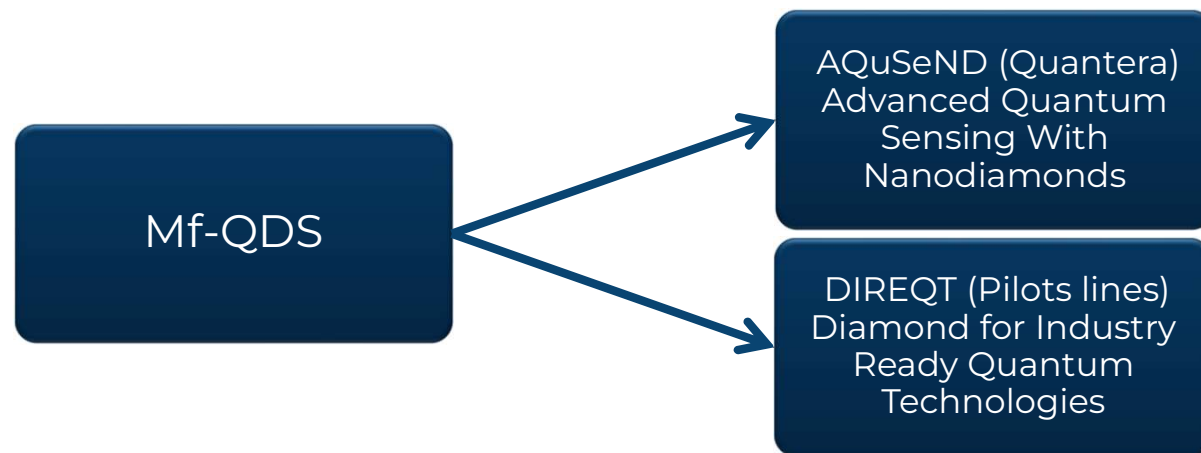


PUBLIC ENGAGEMENT:

- *Ministerio para la Transformación Digital y de la Función Pública*
- *Instituto de Fomento de la Región de Murcia*



WHAT'S NEXT



Call 2021
Final Evaluation



Thank you!

Mf-QDS

Microfluidics Quantum Diamond Sensor
Javier Prior

webs.um.es/javier.prior/



@prior.quantum

