

Exploring Nanoparticles-Assisted Signal Amplification for QCM

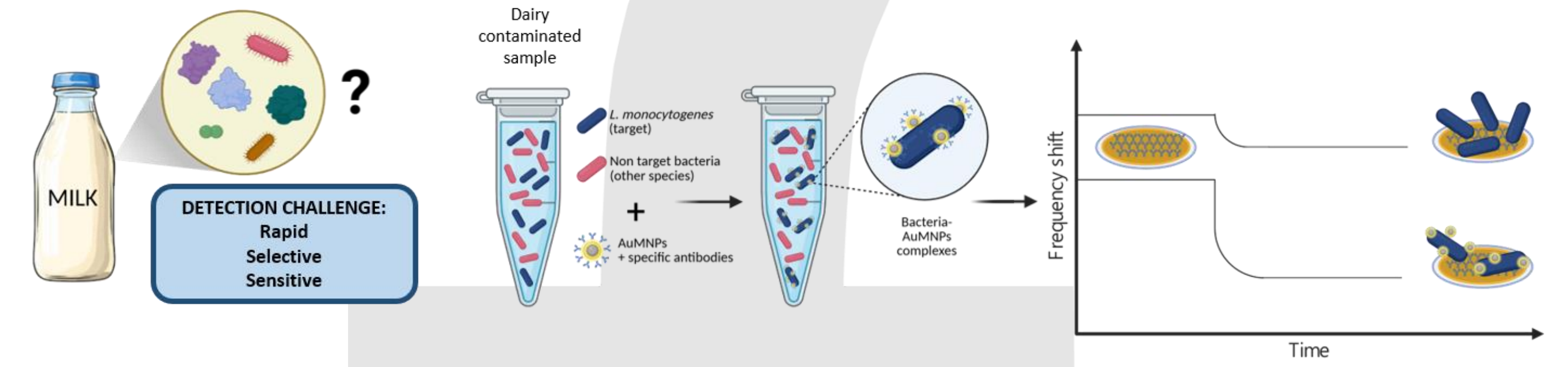
Detection of *Listeria monocytogenes*

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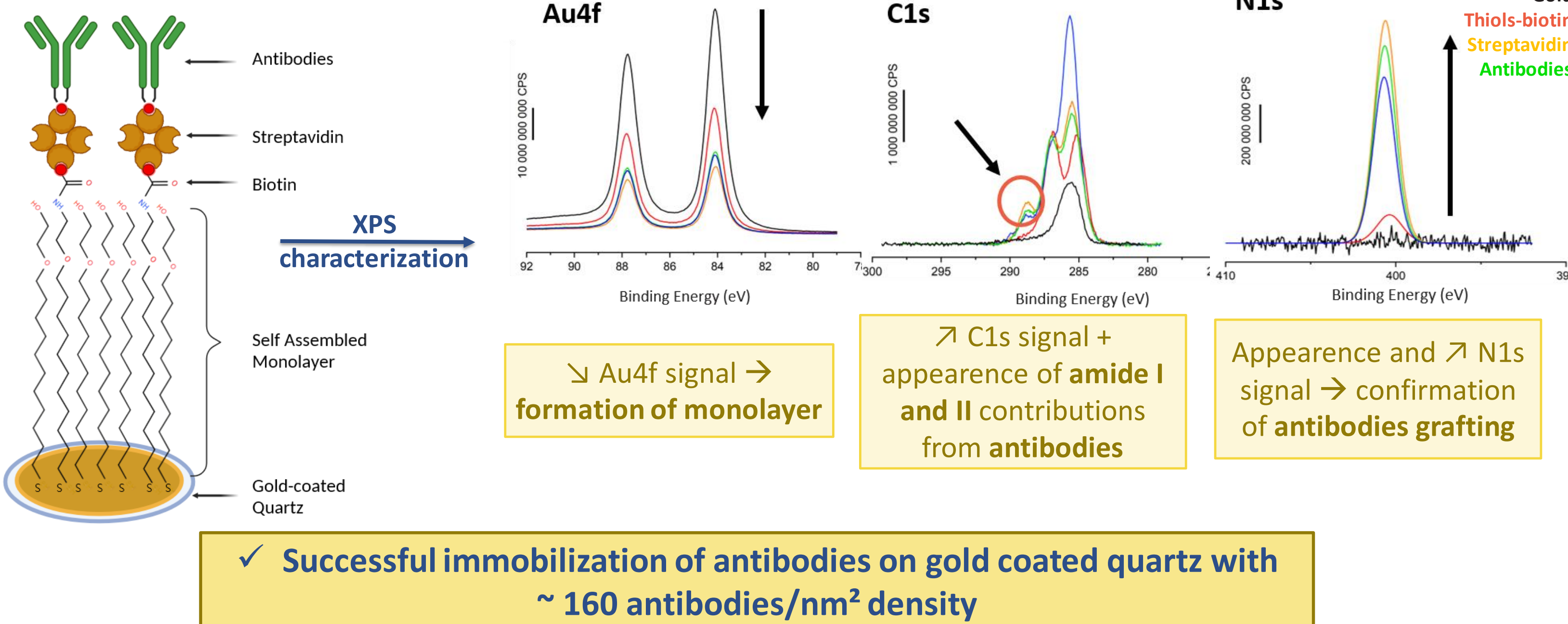
CONTEXT & OBJECTIVES

Listeria monocytogenes is a major foodborne pathogen requiring sensitive and rapid detection in dairy products. Conventional microbiological methods are reliable but time-consuming, highlighting the need for alternative biosensing strategies. **This work aims to develop a QCM biosensor combined with nanoparticles-assisted signal amplification for rapid and specific *L. monocytogenes* detection.**



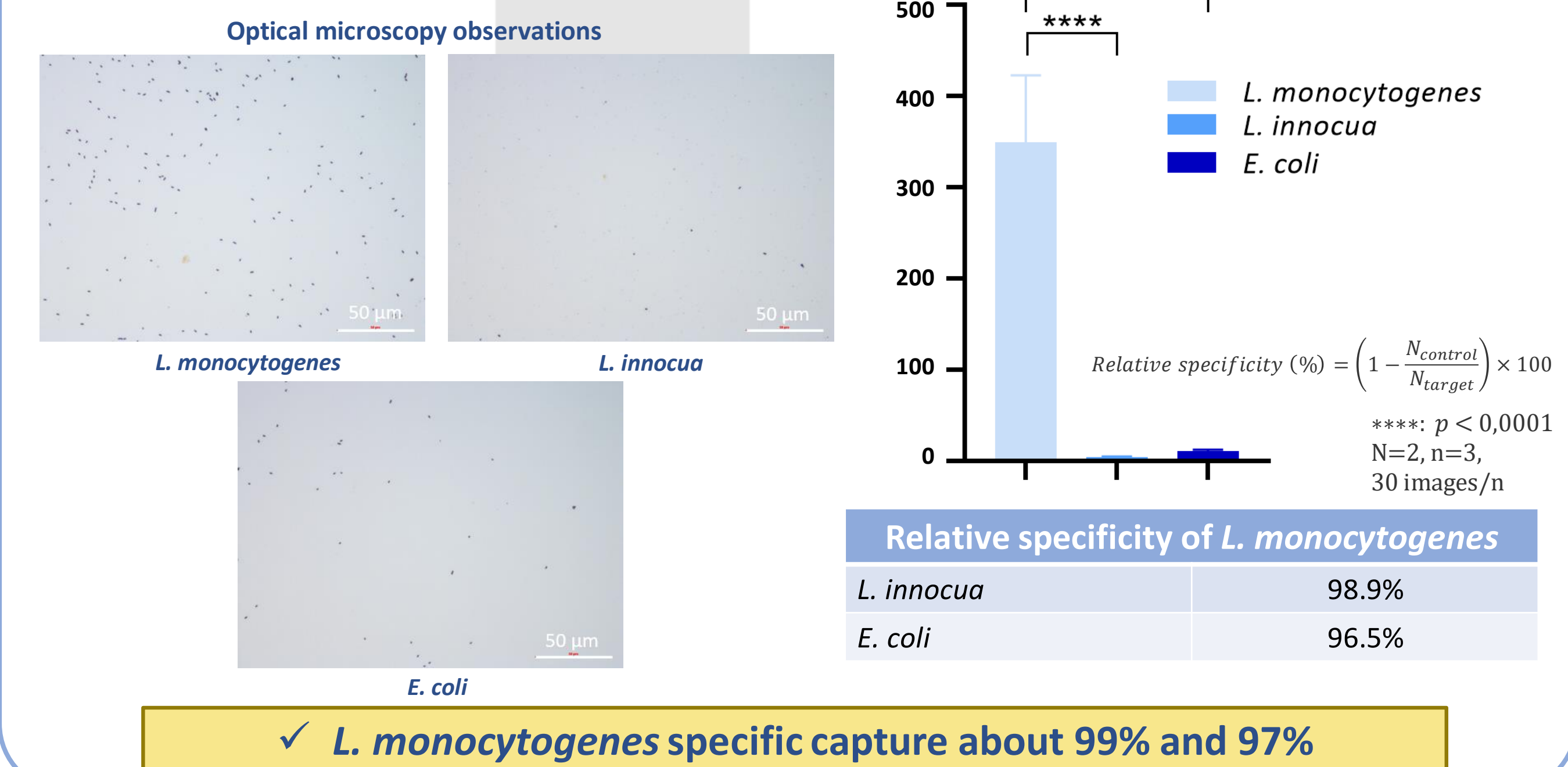
BIOSENSOR DESIGN

Gold-coated quartz crystals were functionalized with a thiols self-assembled monolayer allowing the immobilization of **anti-*L. monocytogenes* specific monoclonal antibodies**. The surface chemistry was optimized with biotin and streptavidin molecules to orient antibodies in a way that promotes bacterial recognition while limiting non-specific interactions.



SELECTIVE LIGAND

Selectivity of the biointerface was evaluated by comparing the capture of target bacterium, *L. monocytogenes*, with two non-target species, in static conditions at 10⁷ CFU/mL bacterial suspensions. *L. innocua* was selected as a closely related *Listeria* control, whereas *E. coli* was used as a phylogenetically distant non-target bacterium.

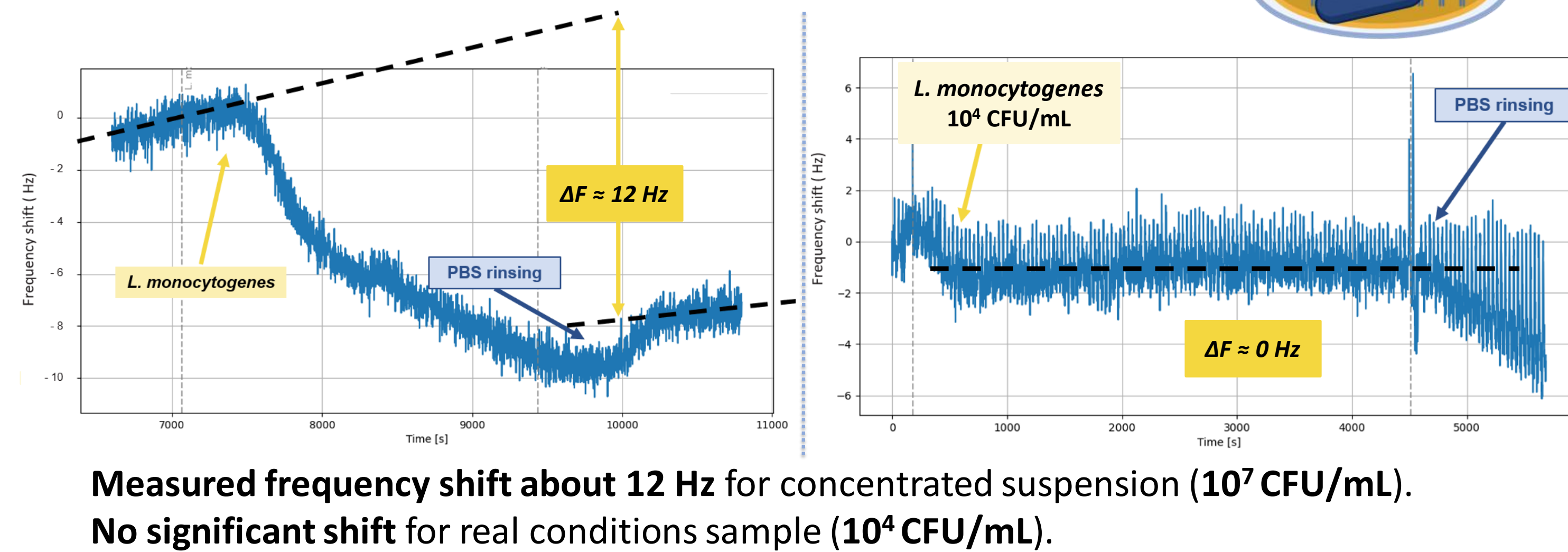


BACTERIAL DETECTION WITH QUARTZ CRYSTAL MICROBALANCE

Bacterial capture was monitored under dynamic conditions using quartz crystal microbalance measurements. Target bacteria binding on the functionalized quartz surface induces changes in the associated acoustic response. **QCM therefore enables real-time and label-free monitoring of the bacterial capture process.**

① QCM RESPONSE TO SIMPLE BACTERIAL SUSPENSION

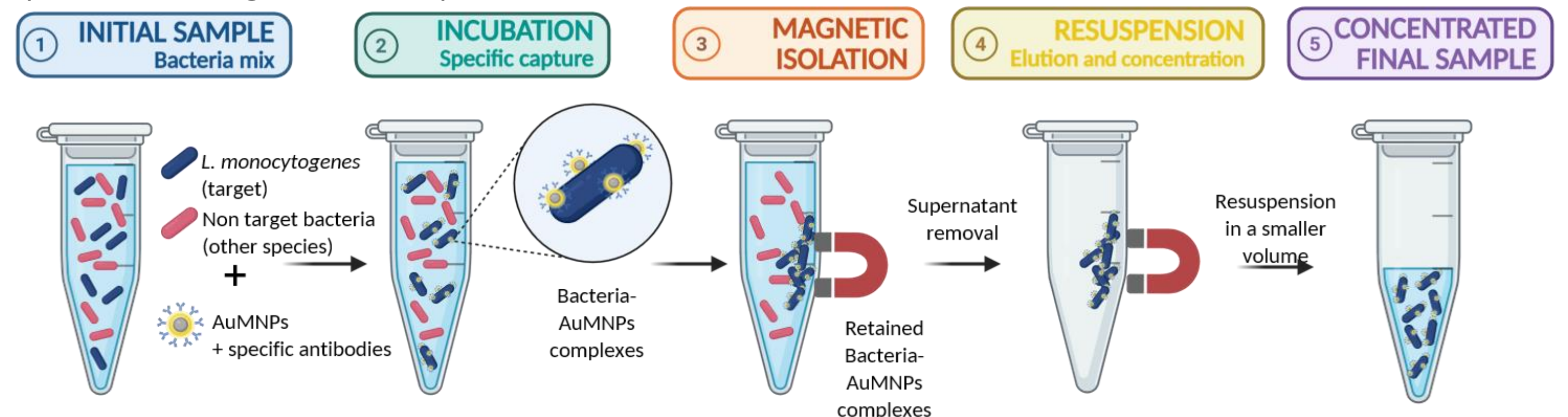
Injection of simple bacterial suspension in PBS, various concentrations.



- ✓ **Target bacteria captured**
- ✓ **Specificity maintained at the LOD of the QCM under ideal conditions**
- ✗ **Need to improve the capture at low and real concentrations**

② MAGNETIC CAPTURE AND CONCENTRATION

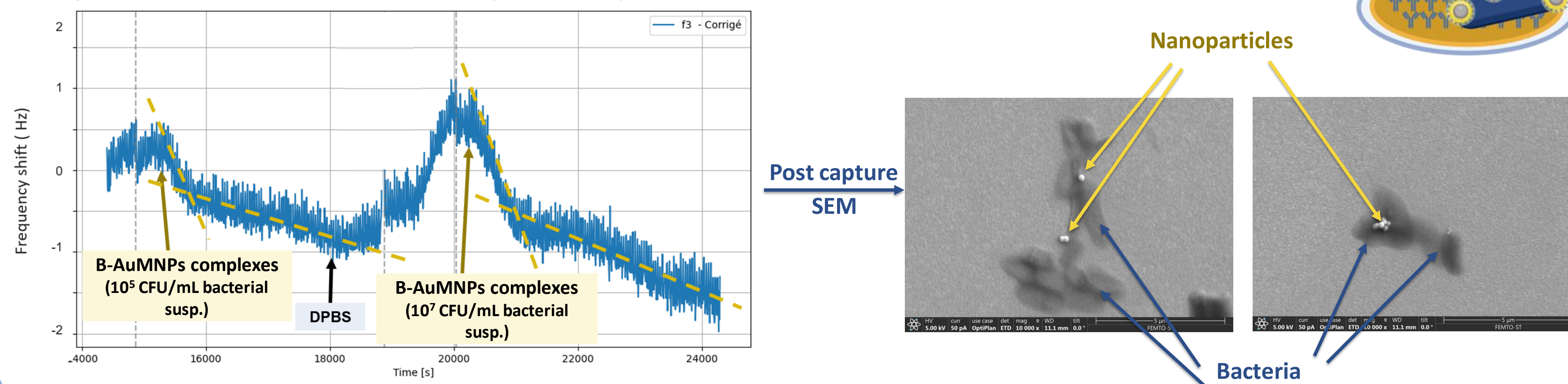
To enhance the response associated with bacterial capture, **functionalized magnetic nanoparticles were used as concentration tool and mass-amplification elements** to obtain more concentrated sample. The chemistry used for quartz surfaces was transposed to particles, using the same specific antibodies as surfaces.



Association of nanoparticles with *L. monocytogenes* will create Bacteria-Nanoparticles complexes, that will increase the perturbation generated upon capture at the QCM surface by increasing the mass of bacteria. **This strategy combines specific bacterial mass amplification with nanoparticles-assisted enhancement of the QCM response.**

③ QCM RESPONSE TO BACTERIA-NANOPARTICLE COMPLEXES

Injection of Bacteria-AuMNPs complexes suspensions in PBS, various concentrations.



Injection of **bacteria-nanoparticle complexes** induced a measurable **decrease** in QCM frequency. Post-QCM SEM imaging confirmed the **presence of bacteria associated with nanoparticles** on the sensor surface, demonstrating successful capture of the complexes. However, the **acoustic response remained lower than expected** and a **clear nanoparticle-induced signal enhancement could not yet be demonstrated**.

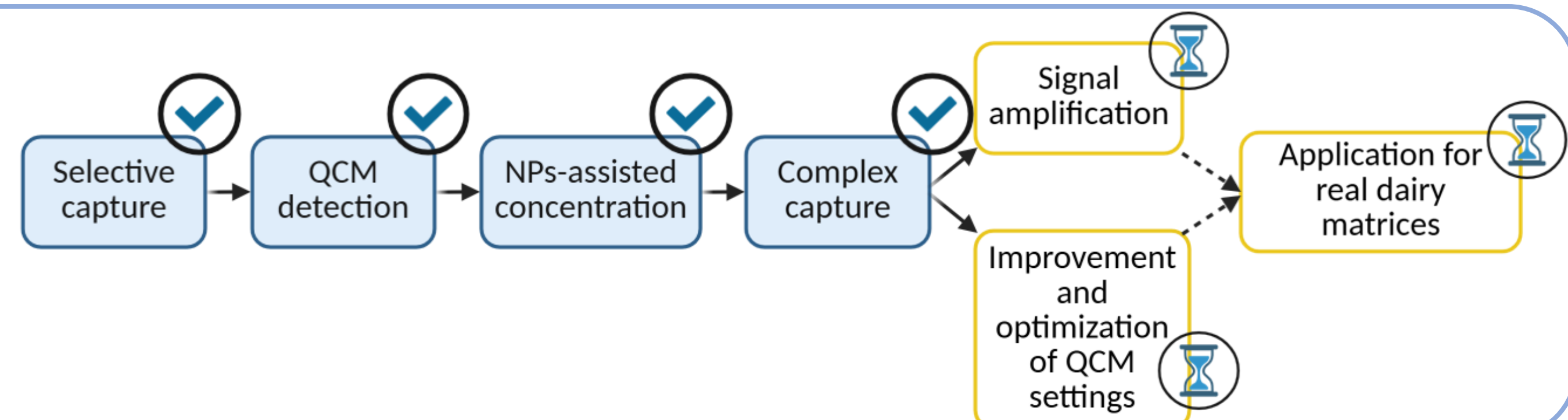
- ✓ **Complex capture confirmed**
- ✗ **Signal amplification not demonstrated**
- **further optimization required for complexes formation step**

CONCLUSION & OUTLOOKS

- ✓ **Selective and specific biointerface developed for *L. monocytogenes* capture.**
- ✓ **QCM enables real-time and label-free monitoring for bacterial detection.**
- ✓ **Capture of bacteria-nanoparticles complexes confirmed by post-capture SEM observation.**



Expected acoustic signal enhancement not yet achieved
→ **Optimization of QCM parameters (flow rate, ...)**
→ **Optimization toward magnetic concentration and detection in real dairy matrices**



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