# Spin-Enhanced Lateral Flow Immunoassay Using Fluorescent Nanodiamonds for Dengue Fever Detection

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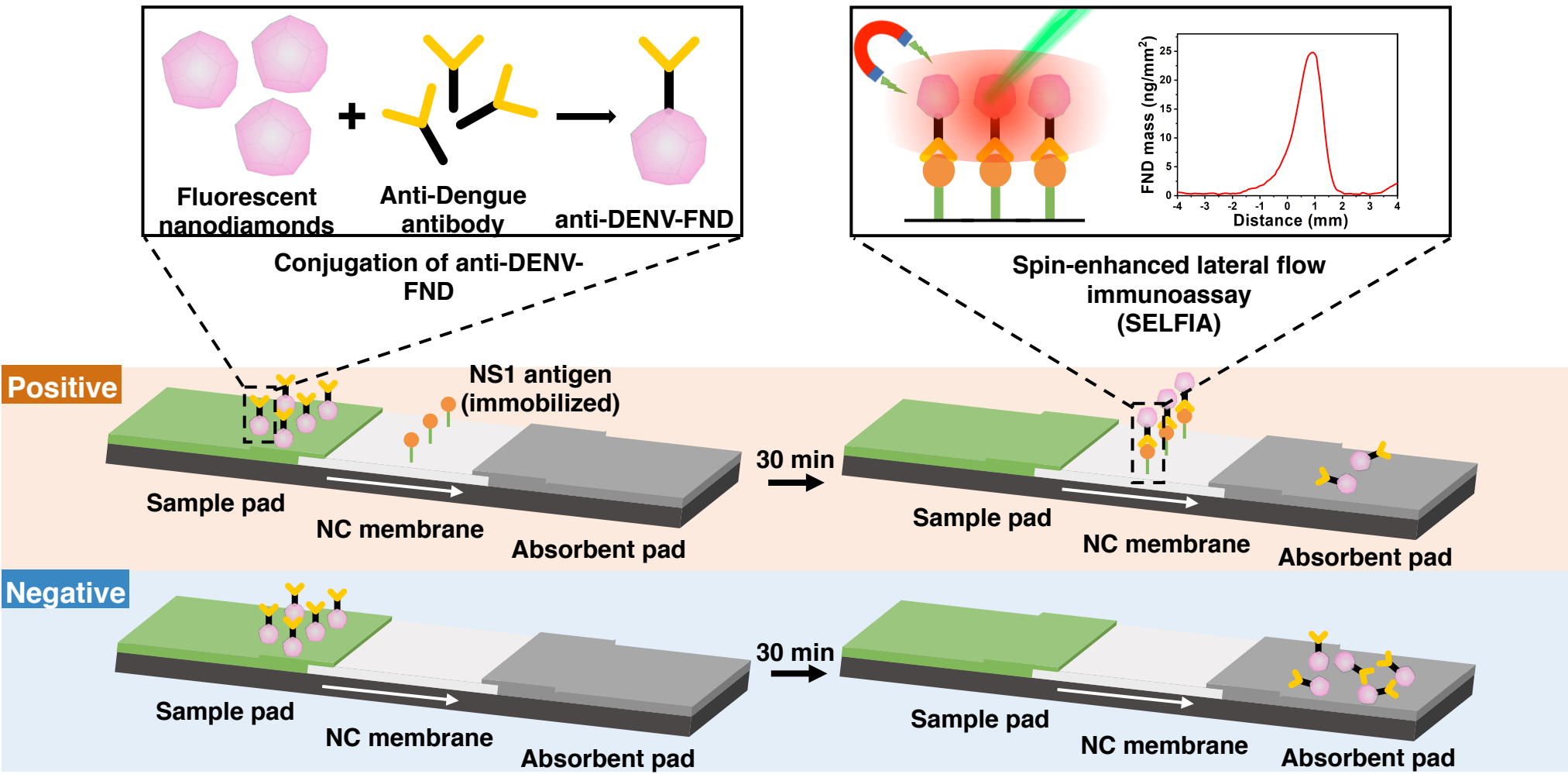[3] Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei 10617, Taiwan, Republic of China.
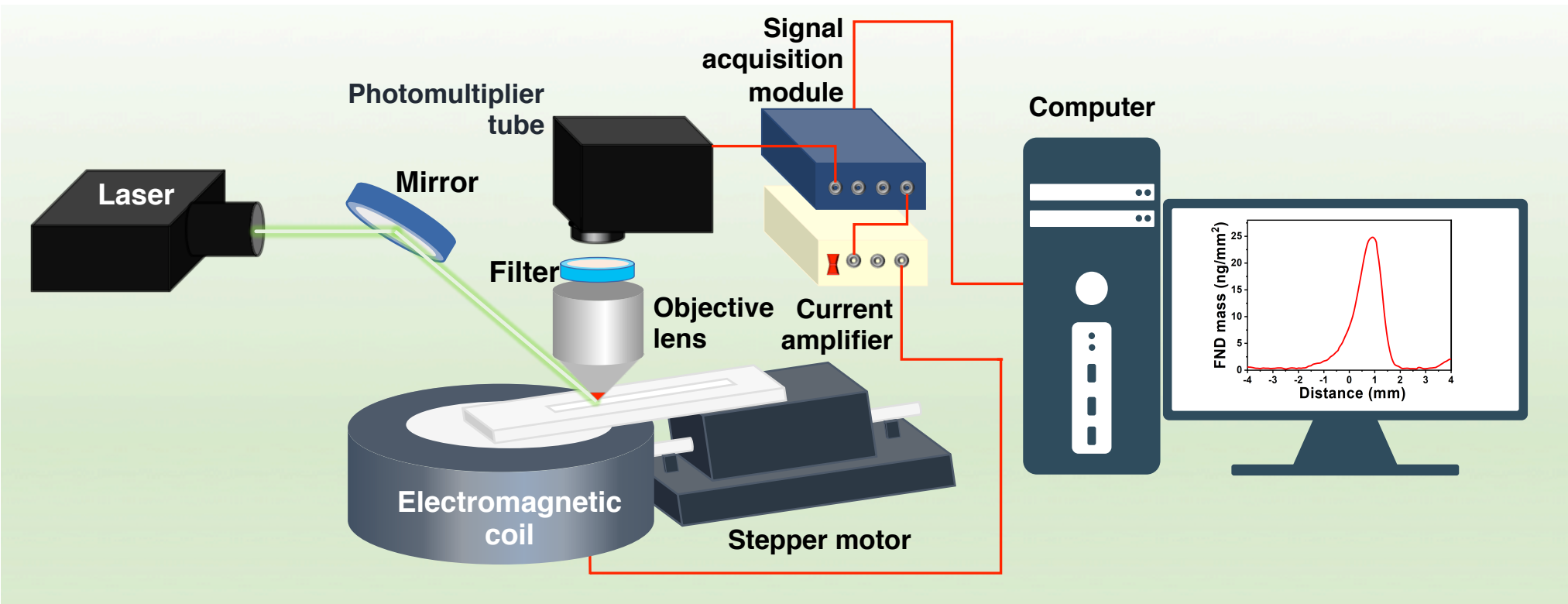
## Abstract

Dengue Fever, a global disease transmitted by mosquitoes, has wreaked havoc in nations across the globe. The lack of vaccination and directed treatment for dengue fever makes detection at the infection's early stages extremely important for disease prevention and clinical care. In this report, a new model of diagnosis is proposed: Spin-Enhanced Lateral Immunoassay (SELFIA). Associating lateral flow immunoassay (LFIA) with an alternative diagnostic marker Fluorescent Nanodiamond (FND), SELFIA utilizes electromagnetic fields to modulate the signals from the FND and provides accurate and sensitive results, replacing the conventional but flawed diagnostic method of colloidal gold LFIA. We discovered the application of FND-based SELFIA on Dengue Fever diagnosis not only accurately detects the Dengue virus NS1 antigen of all four serotypes (DV1, DV2, DV3, DV4), but it also provides signals with the detection limit of 0.01-0.02 ng/mm², which is approximately 100 times more sensitive than those of colloidal gold-based LFIA. In conclusion, SELFIA is an improved diagnostic tool for Dengue Virus, which can potentially be applied to other viruses such as Zika virus and Coronavirus in the near future.
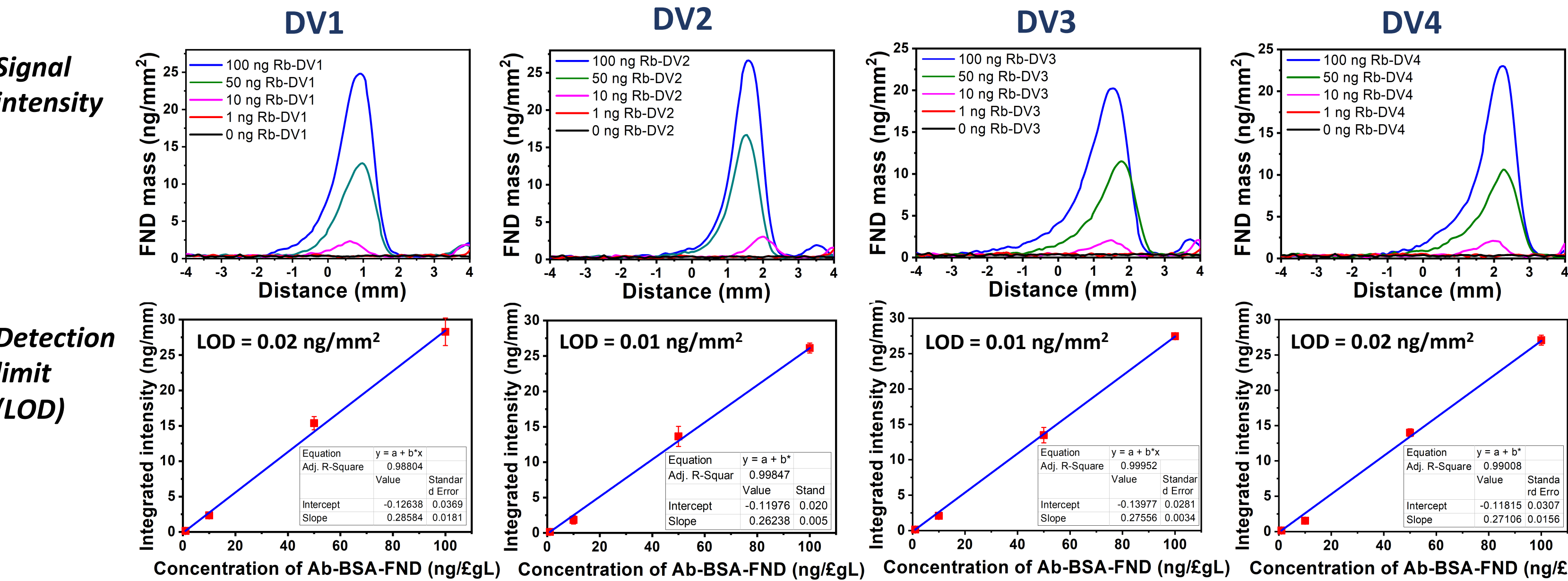
## Introduction



## Spin-Enhanced Lateral Flow Immunoassay (SELFIA)



## Motivation



**The dengue fever epidemics in Taiwan.** (A) Accumulated dengue fever (DF) case numbers reported annually in Taiwan during 2005–2015. (B) Geographic distribution of DF cases in the dengue outbreak in Taiwan in 2015. (C) The incidence of DF at different ages. (D) The incidence of DF and dengue hemorrhagic fever (DHF) and the DHF death rate (%) in 2005–2015. (Wang et al., *Int. J. Infect. Dis.* **2019**, 88, 88-99)

## Comparison

| Characteristic | LFIA | SELFIA (Our study) |
|---|---|---|
| Reporter | Nanogold | Fluorescent Nanodiamond |
| Observation method | Visual | Magnetic Modulation |
| Detection time | ~20 min | ~30 min (including scanning) |
| Sensitivity | 75% | ~100% |
| Specificity | 98% | 100% |
| Detection limit | 1 ng/μL | 0.01-0.1 ng/μL |

## Results - Detection of Dengue Serotypes Using SELFIA

### DV1     DV2     DV3     DV4

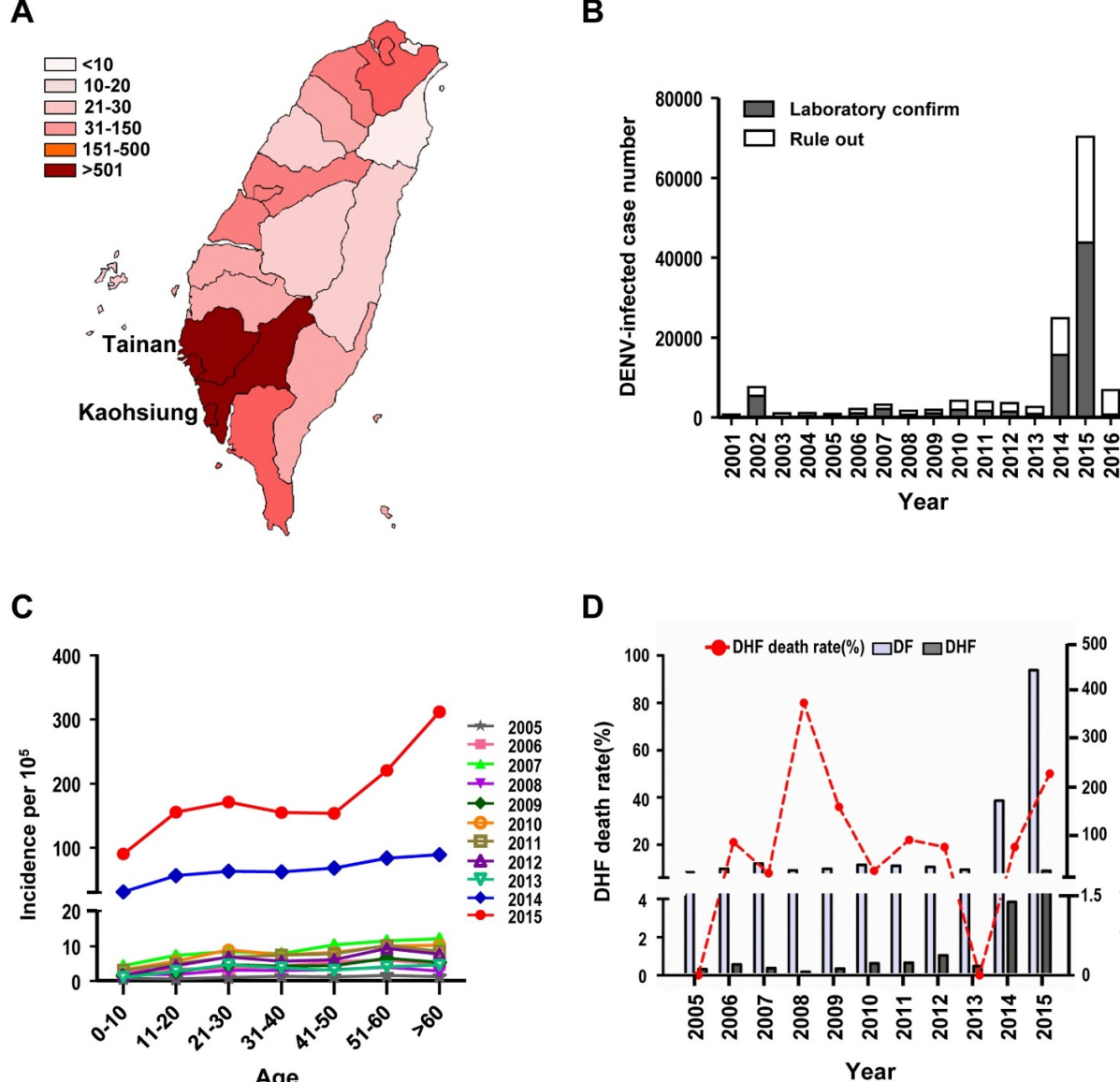*Signal intensity*

*Detection limit (LOD)*



## Conclusion

Taking advantage of the unique magneto-optical properties of negatively charged nitrogen-vacancy centers in FND, the SELFIA utilizes electromagnetic fields to modulate FND's fluorescence signals to provide ultra-sensitive and specific results, especially when compared to the conventional colloidal gold LFIA. The NS1 antigens of four distinct serotypes (DV1, DV2, DV3, DV4) at different concentrations were evaluated to determine the detection limit compared to the conventional nanogold-based LFIA. The distinct peaks of FND mass are observed in all groups of four NS1 serotypes with the detection limit range 0.01-0.02 ng/mm², indicating the specific detection of the Dengue virus antigen NS1. Moreover, the application of FND-based SELFIA also provided signals that are approximately 100-time more sensitive than those produced by the conventional nanogold-based LFIA. To summarize, the SELFIA is an innovative and improved diagnostic tool. In addition to the dengue virus, it could also potentially be incorporated with artificial intelligence (AI) image recognition to detect other viruses and other health issues, such as cancer and other chronic diseases, in the near future.

## References

• Anal. Chem. 2021, 93, 18, 7140–7147
• WHO, Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. Geneva, (2009) 1-147