Muon Study of Novel Quantum States in Thin-Film Superconducting Devices

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1 Scientific Motivation

Modern computing moves **electrical charge** through materials. As electrons scatter, energy is dissipated as heat, limiting how **powerful** devices can be and creating **energy waste**

We need ways to process information with less energy

- Spintronics uses **spin** to store and transport information
- **Superconductors**, such as Nb, can carry current without electrical resitance

Can superconductivity be engineered to carry spin?

Singlet Pairs in Superconductors | **Equal-Spin Triplet States**

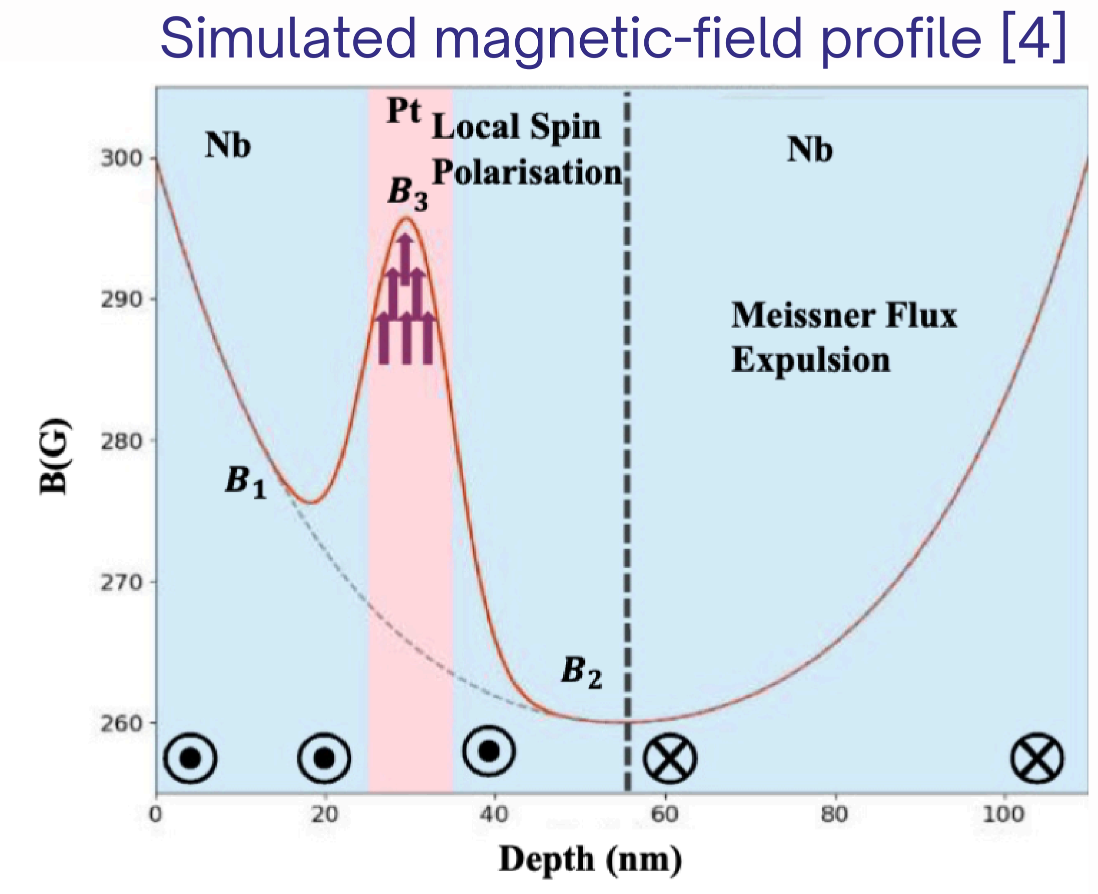
Opposite spins → no net spin | Parallel spins → can carry spin

2 The Research Question

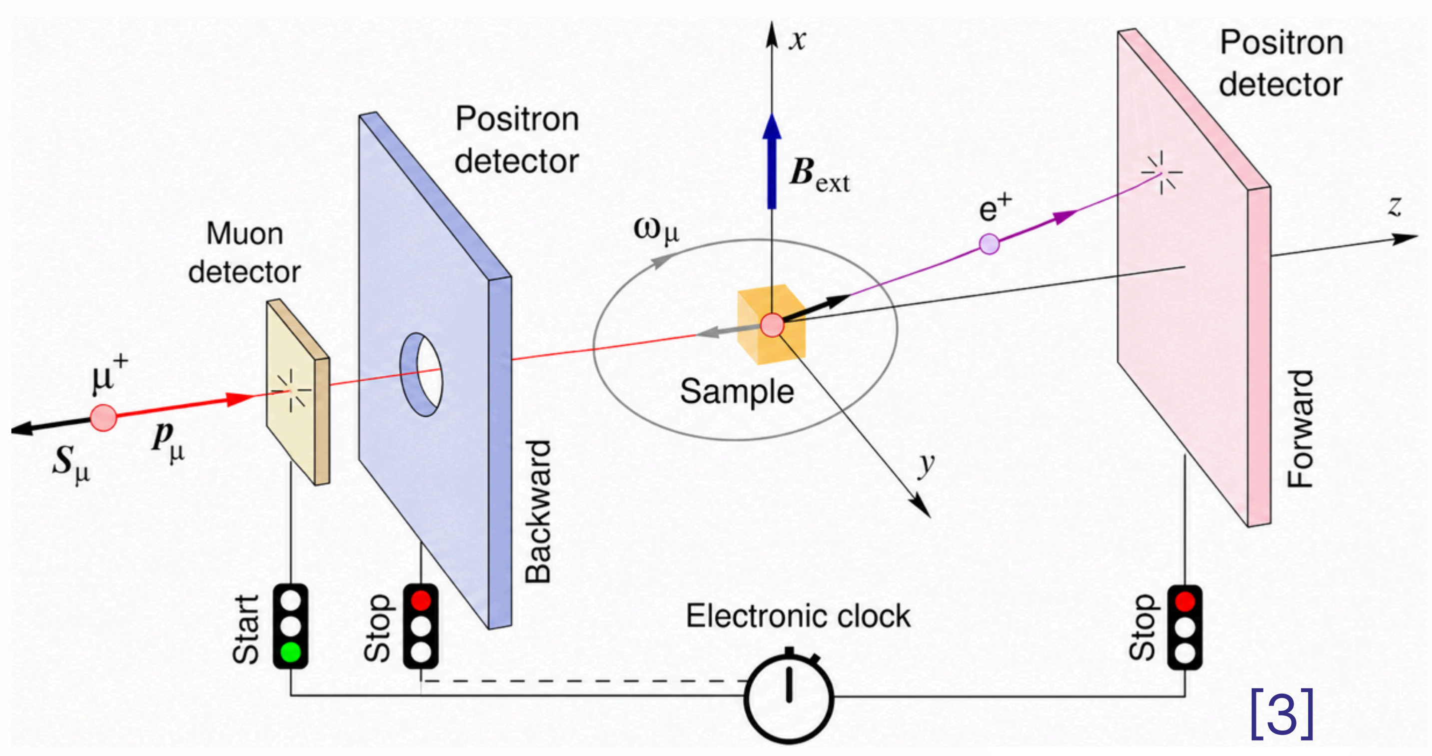
Can we generate spin-polarised triplet states at the Nb/Pt interface and transfer them into a normal metal (Au)?

- Previous studies observed an anomalous magnetic response at the Nb/Pt interface consistent with **triplet states**
- If these triplets can be transferred to a normal metal they could provide a **superconducting source of spin current**

Simulated magnetic-field profile [4]



3 How We Test It — LE-μSR



[3]

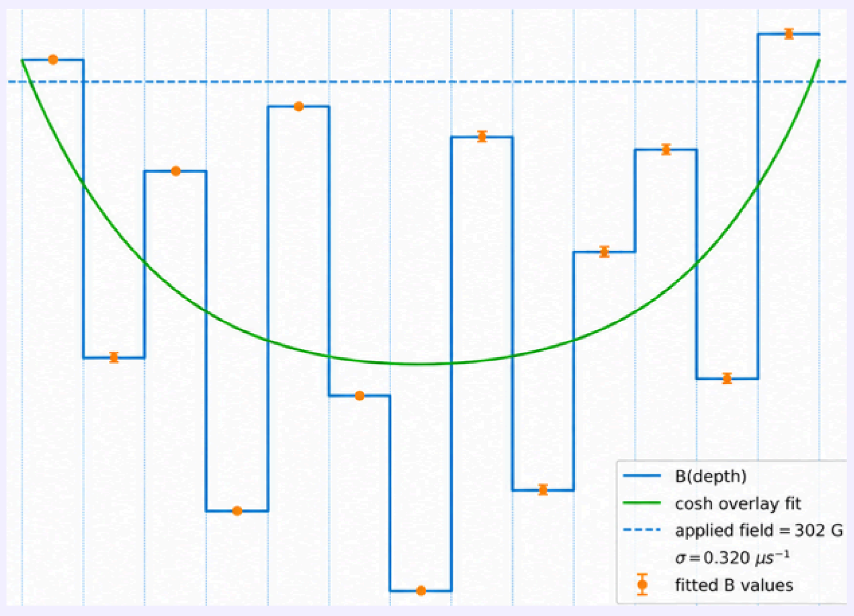
LE-μSR probes the magnetic field in a thin film

1. Implant spin-polarised mouons into the sample
2. Vary their energy to probe different depth ranges
3. Measure their spin precession to infer the local magnetic field

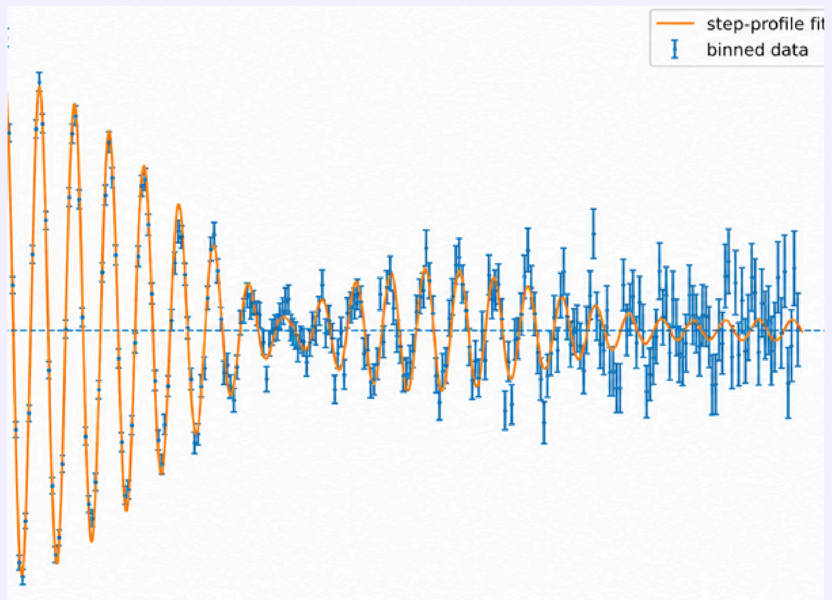
Reconstructing the magnetic field profile requires combining measurements across energies

4 Analysis & Outcomes

I developed a **new analysis framework** to reconstruct the magnetic field profile through the thin film



Reconstructed field profile



Example μSR fit

5 Next Steps

- Apply the new tools to the latest LE-μSR data
- Test whether spin-polarised triplets diffuse from Nb/Pt into Au

Success could open a route to low dissipation superspintronic devices

Interested? Read the full report

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Key References

[1] M. Eschrig, Rep. Prog. Phys. 78, 104501 (2015).
[2] M. Flokstra et al., Nat. Commun. 14, 5081 (2023).
[3] T. Shang and T. Shiroka, Front. Phys. 9, 651163 (2021)
[4] S. L. Lee, private communication.