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SAND2019-9815C

EDSR of a single heavy hole in a lateral GaAs/AlGaAs double quantum dot device

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Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Acknowledgement

- National Research Council of Canada
  - ✓Sergei Studenikin
  - ✓Guy Austing
  - ✓Alex Bogan
  - ✓Louis Gaudreau
  - ✓Marek Korkusinski
  - ✓Piotr Zawadzki
  - ✓Andy Sachrajda

National Research Council Canada

- Tohoku University
  - ✓Yoshiro Hirayama

GP Spin

TOHOKU UNIVERSITY

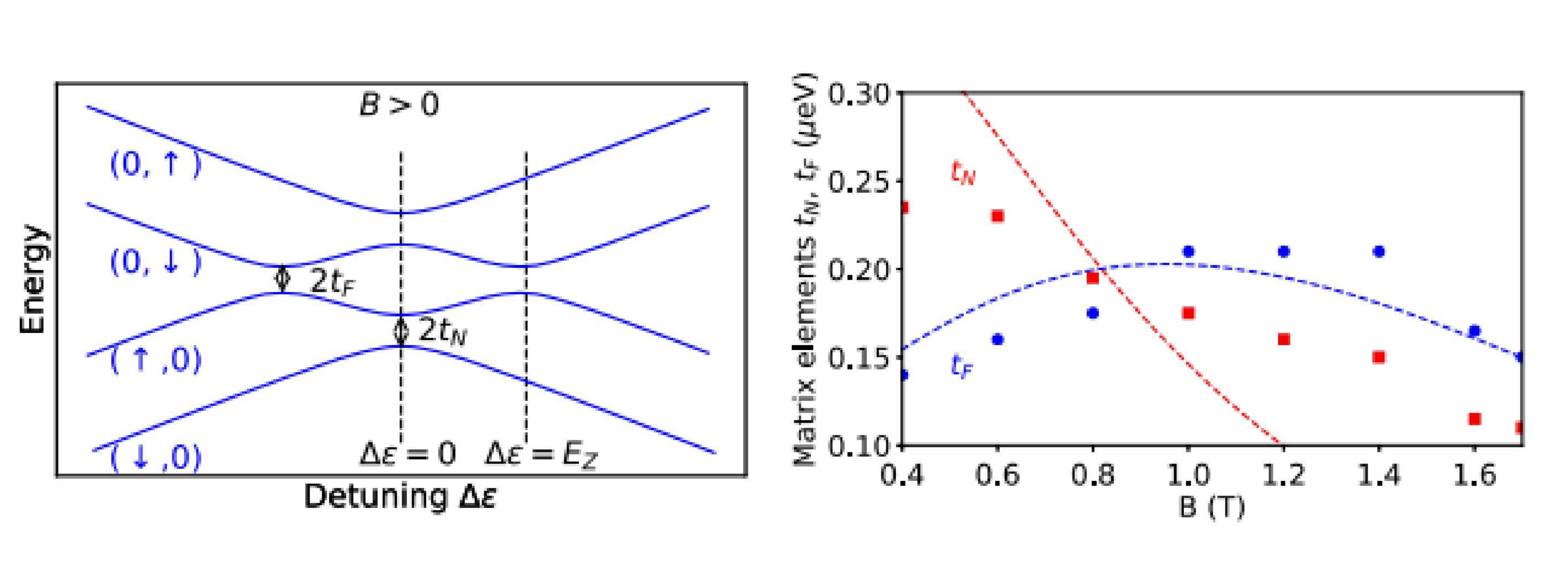
- Sandia National Laboratories
  - ✓Lisa Tracy
  - ✓John Reno
  - ✓Terry Hargett

Sandia National Laboratories

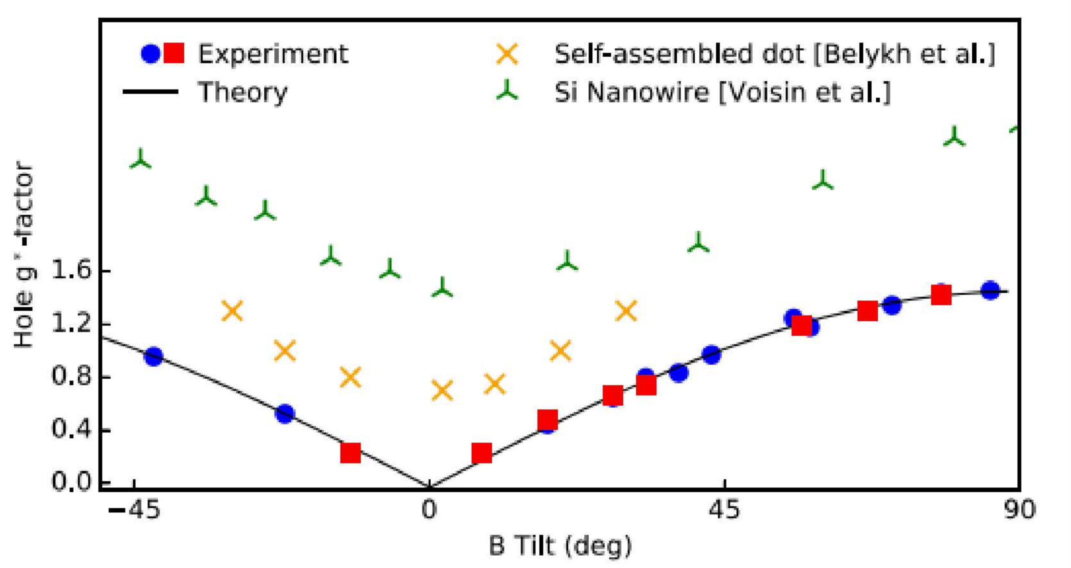
This work was performed at the Center for Integrated Nanotechnologies, a U.S. DOE, Office of Basic Energy Sciences user facility, and Sandia National Laboratories, a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Motivation

- Advantage of hole system
  - ✓ Reduced hyperfine interaction for improved coherence (T_1, T_2^*).
  - ✓ Large spin-orbit interaction for fast spin manipulations.
  - ✓ Effective heavy hole g-factor that is in-situ tunable with B-field direction-useful for spin-photon hybrid devices in direct bandgap materials such as GaAs.
  - ✓ No valley degeneracy issue as with conduction band electrons in Si & Ge.



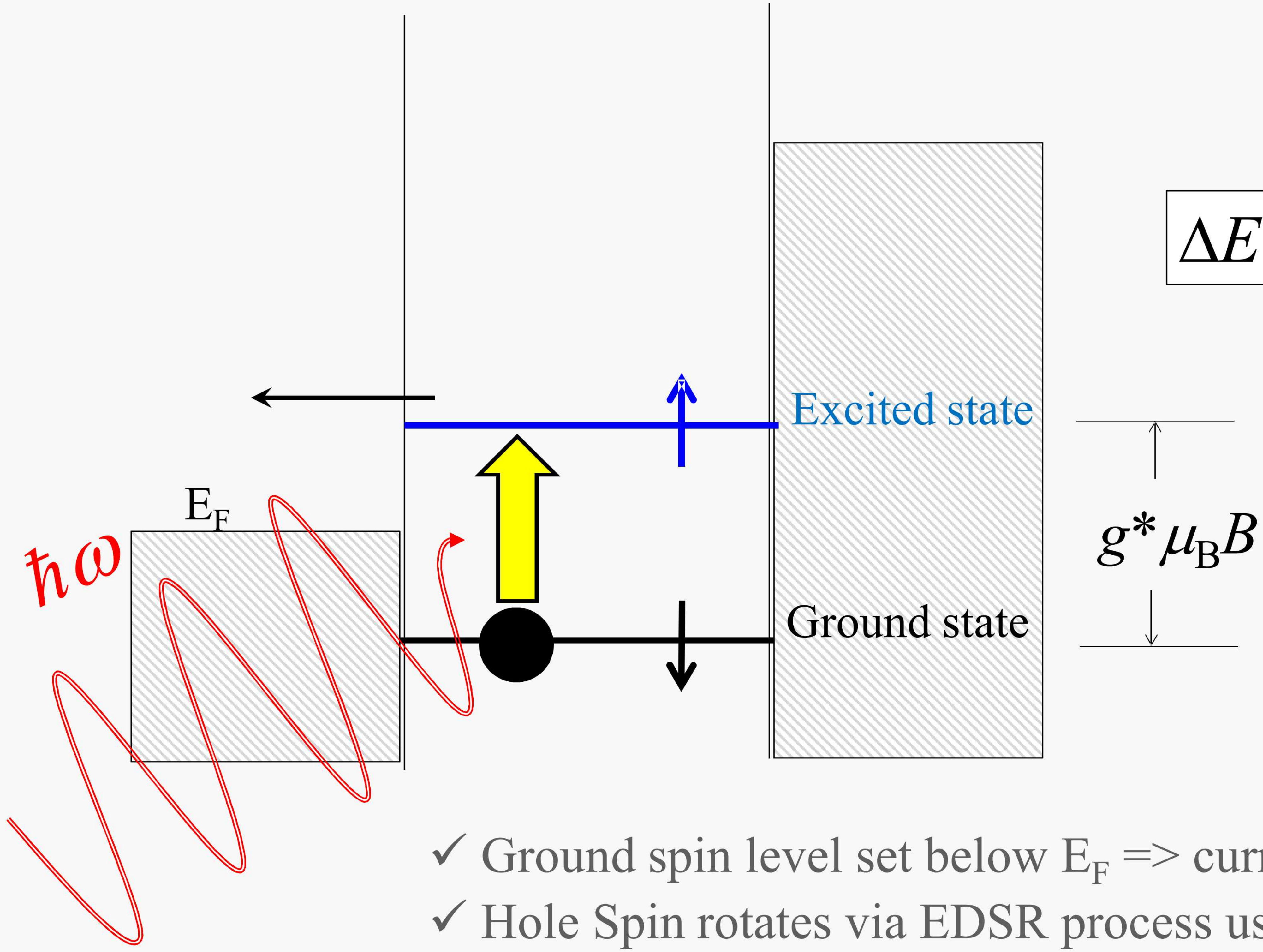
A. Bogan, et al., Phys. Rev. Lett. **120** 207701 (2018)



A. Bogan, et al., Phys. Rev. Lett. **118** 167701 (2017)

Method of measurement

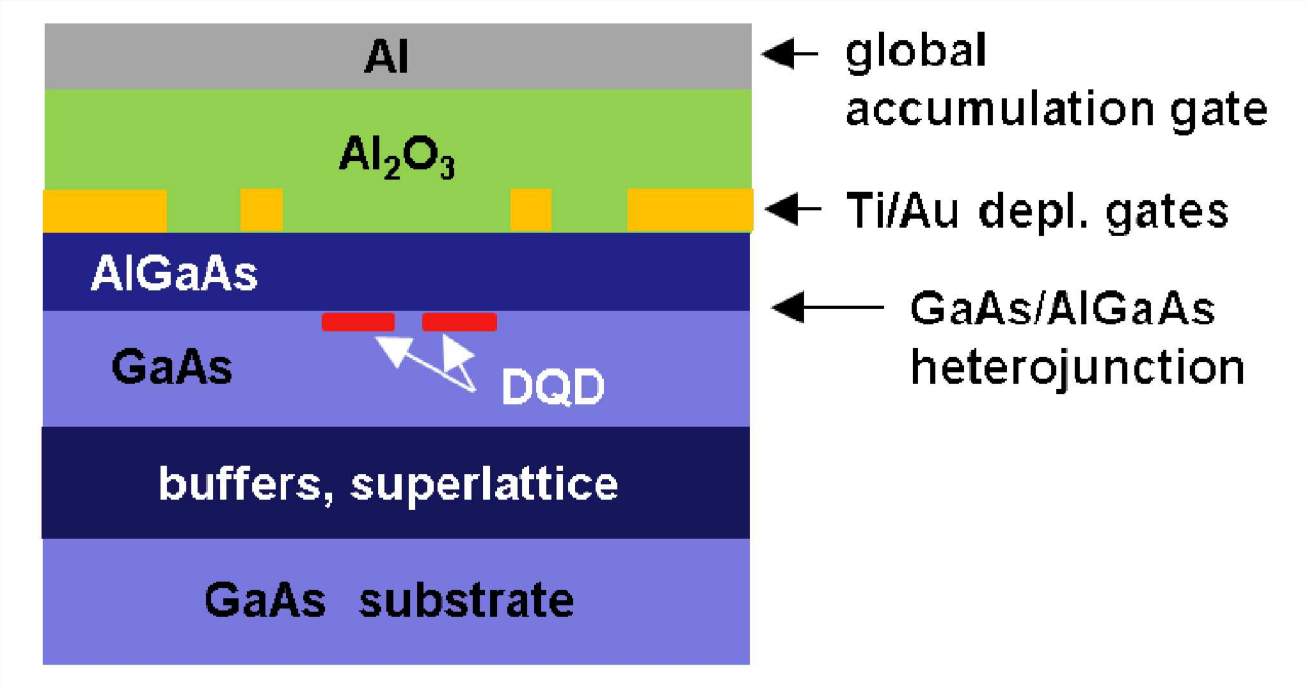
- EDSR (electric dipole spin resonance)

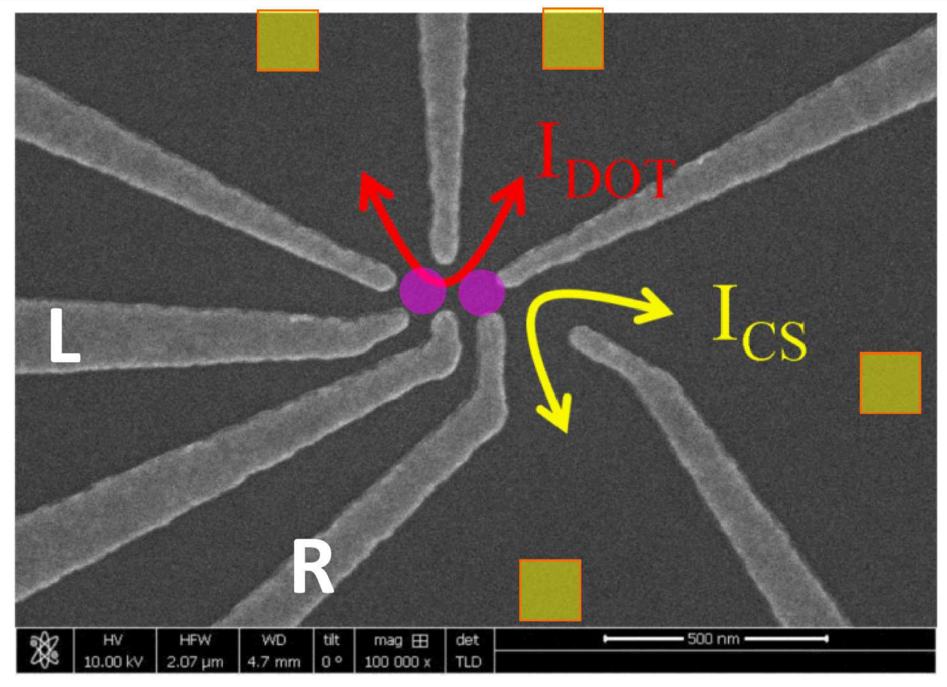


$$\Delta E = \hbar\omega = g^* \mu_B B$$

✓ Ground spin level set below E_F => current is blocked.
✓ Hole Spin rotates via EDSR process using local gate.

Sample structure





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Cross section and SEM image of the DQD device.

- Double Quantum Dot (DQD) device

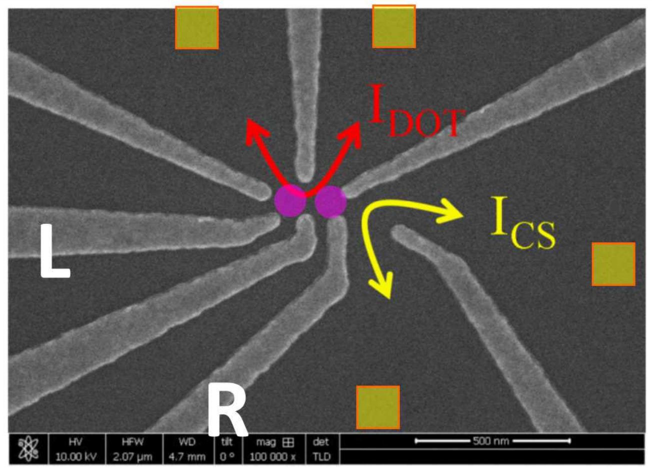
  ✓ 2D hole gas is generated at the GaAs/AlGaAs heterojunction using accumulation gate.

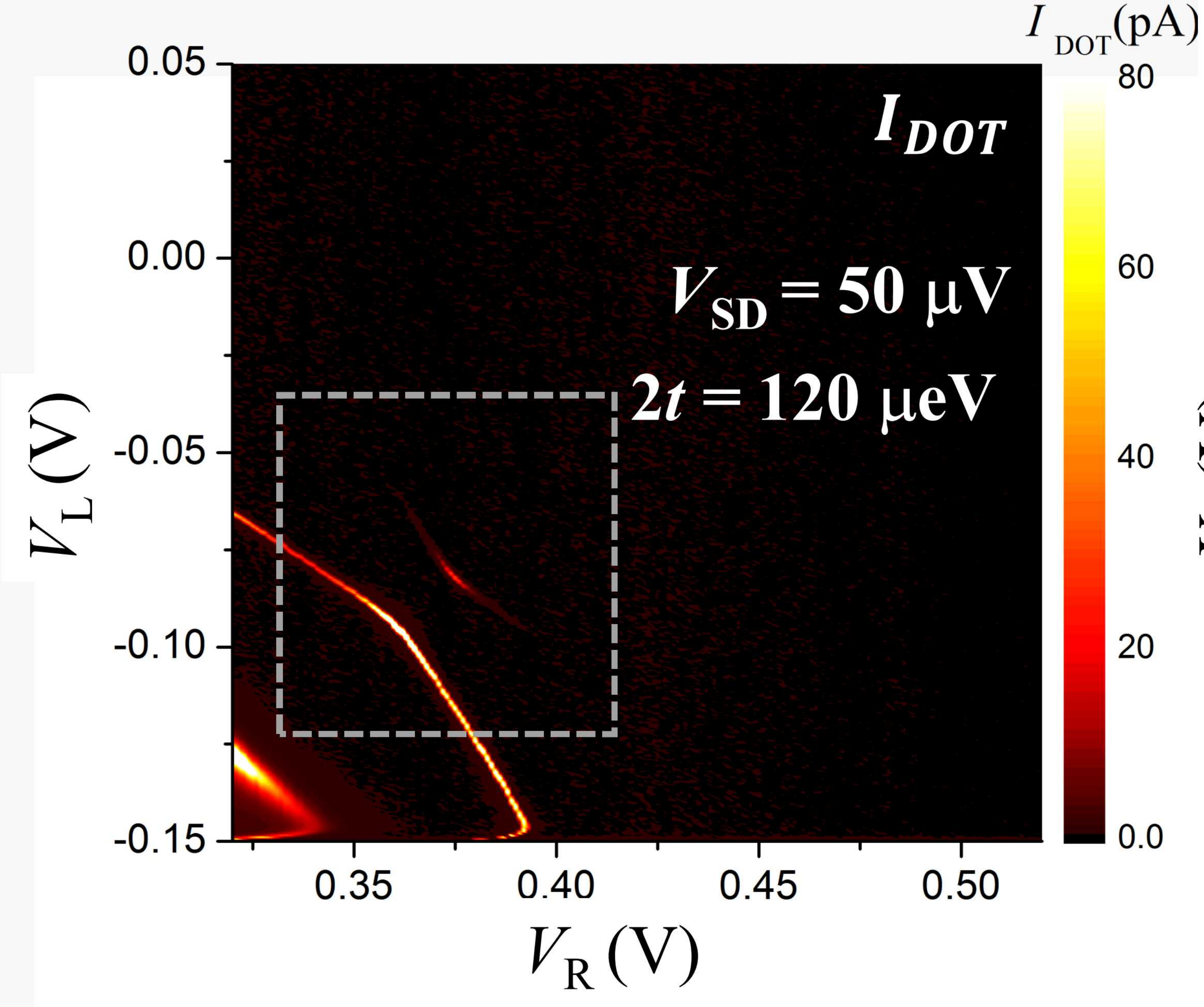
  ✓ Lateral DQD is formed using surface depletion gates (SEM).

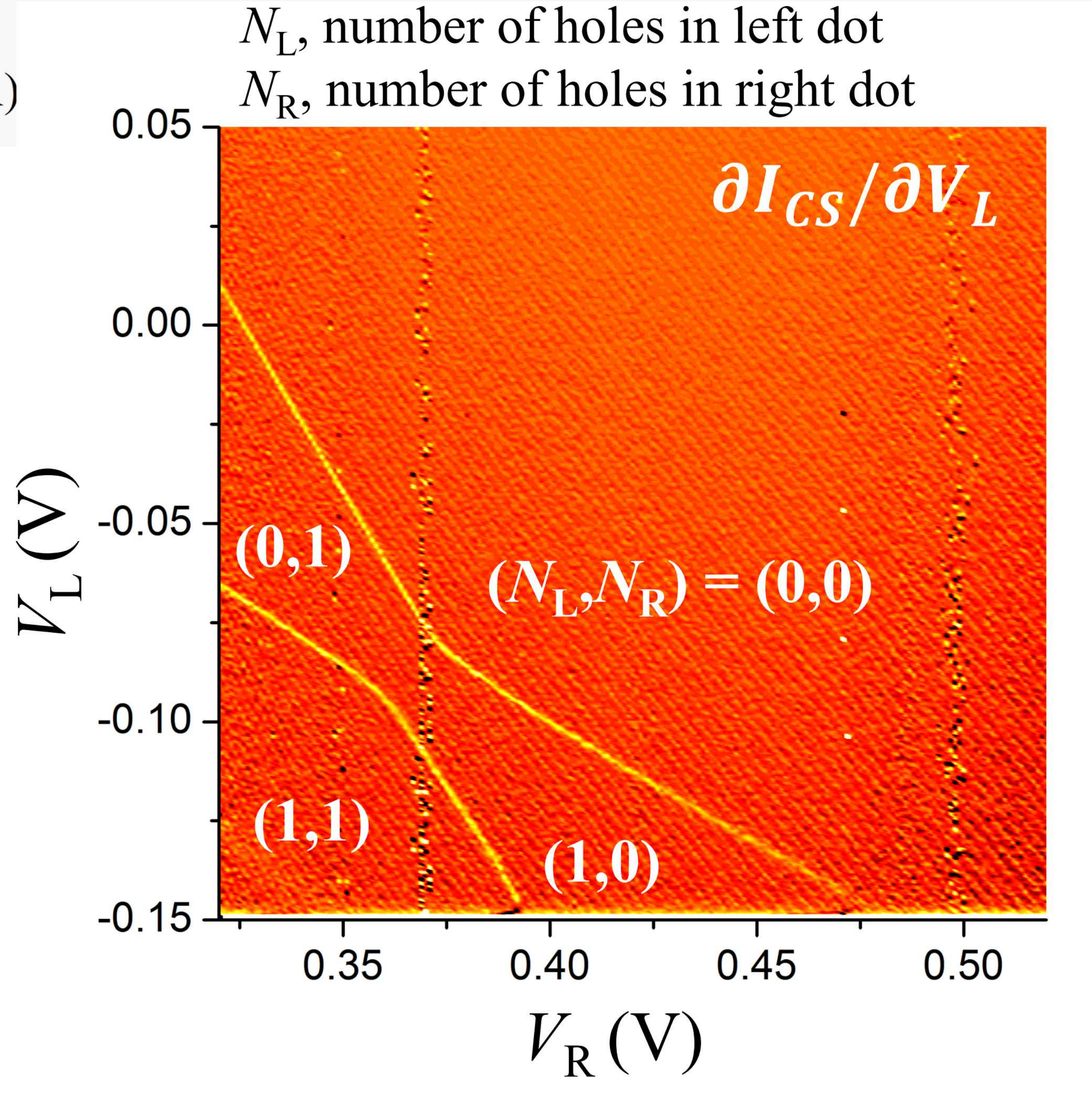
  ✓ DQD can be studied using current I_{DOT} and/or I_{CS} (QPC charge detector).

Transport & charge sensor measurements

- One-hole regime identified
  - ✓Stability diagram by transport I_{DOT}
  - ✓Stability diagram by charge sensor, I_{CS}

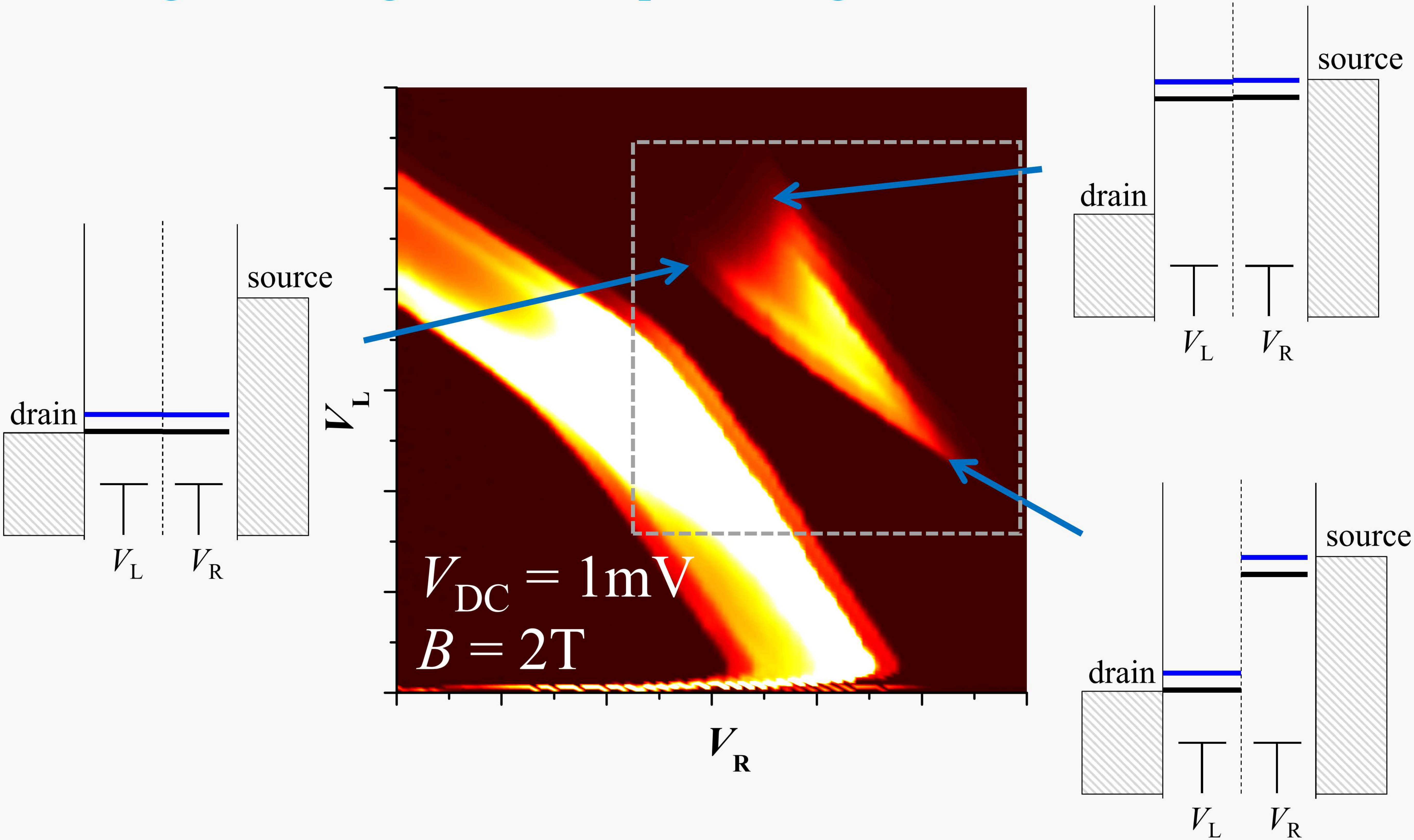




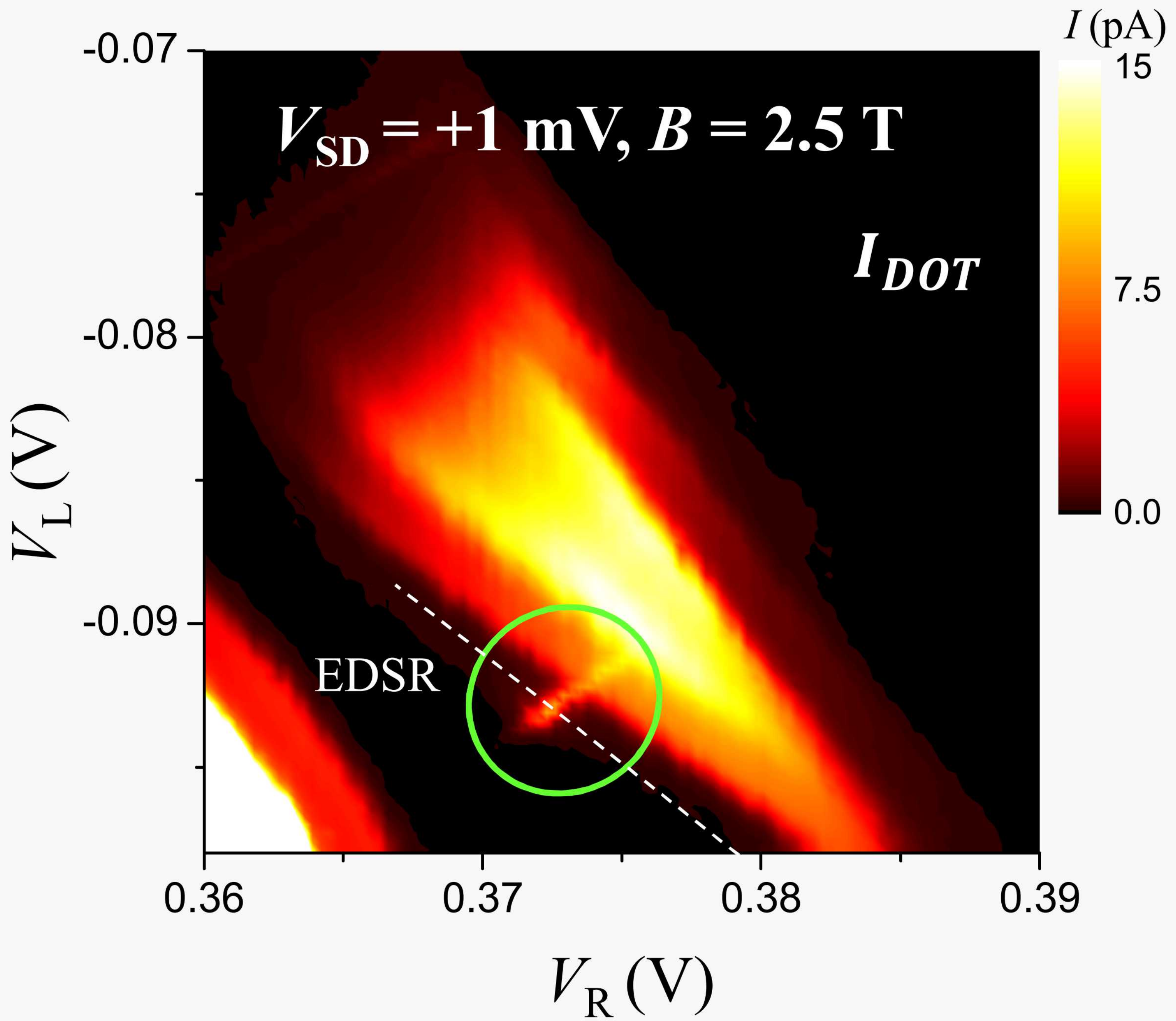


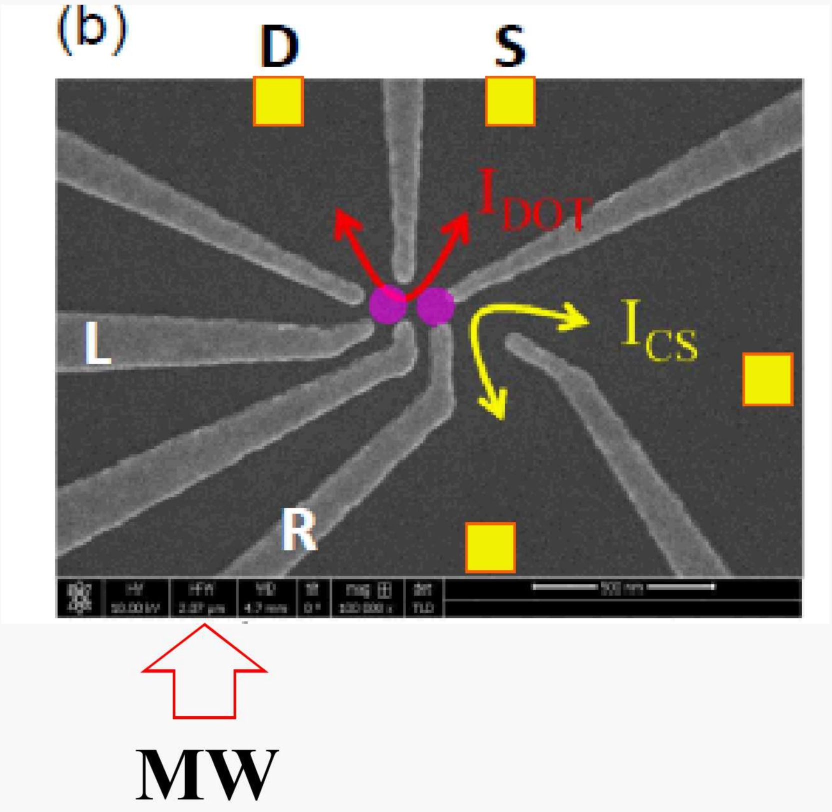
Energy diagram

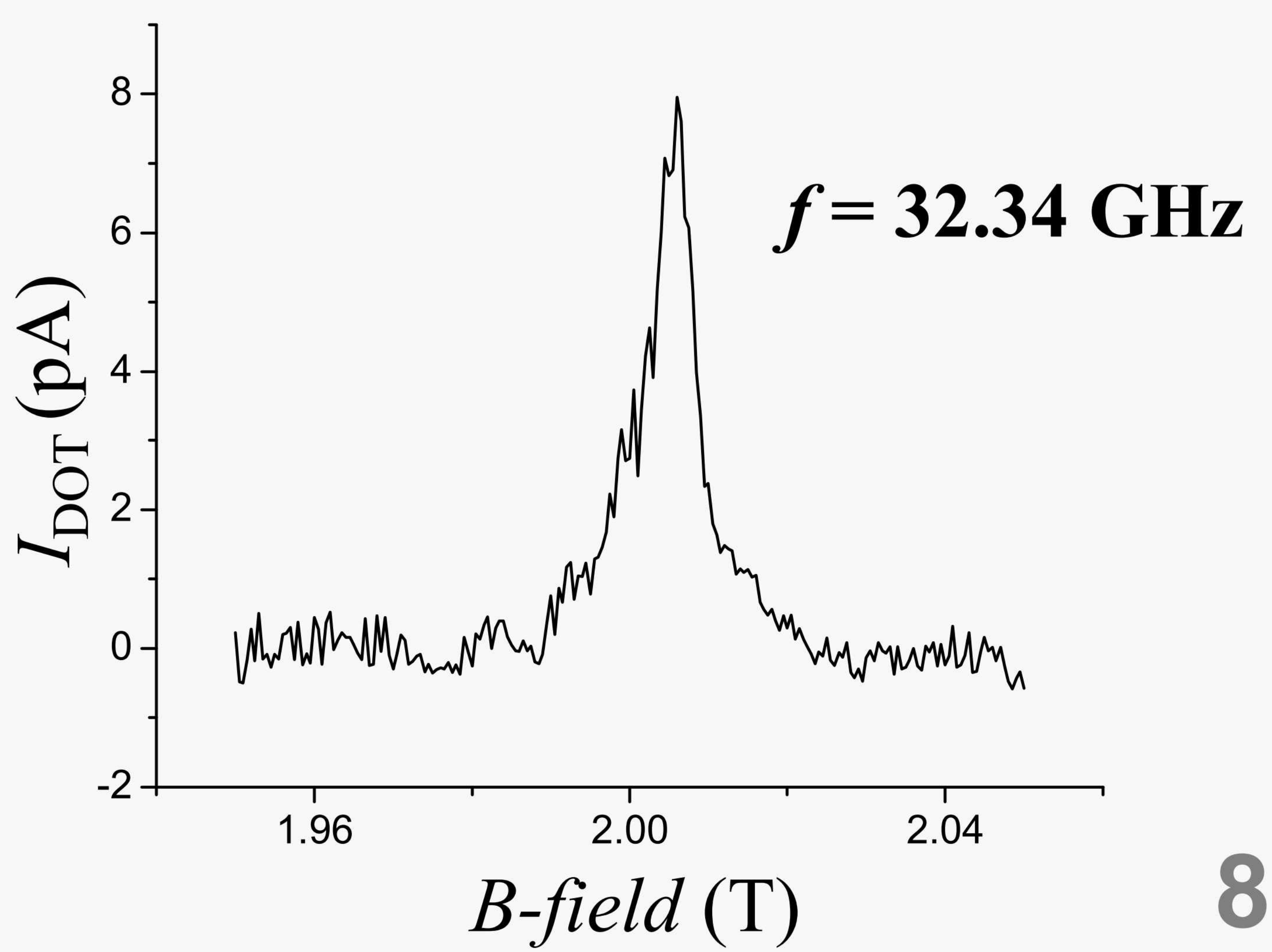
- Single-hole high-bias transport triangle



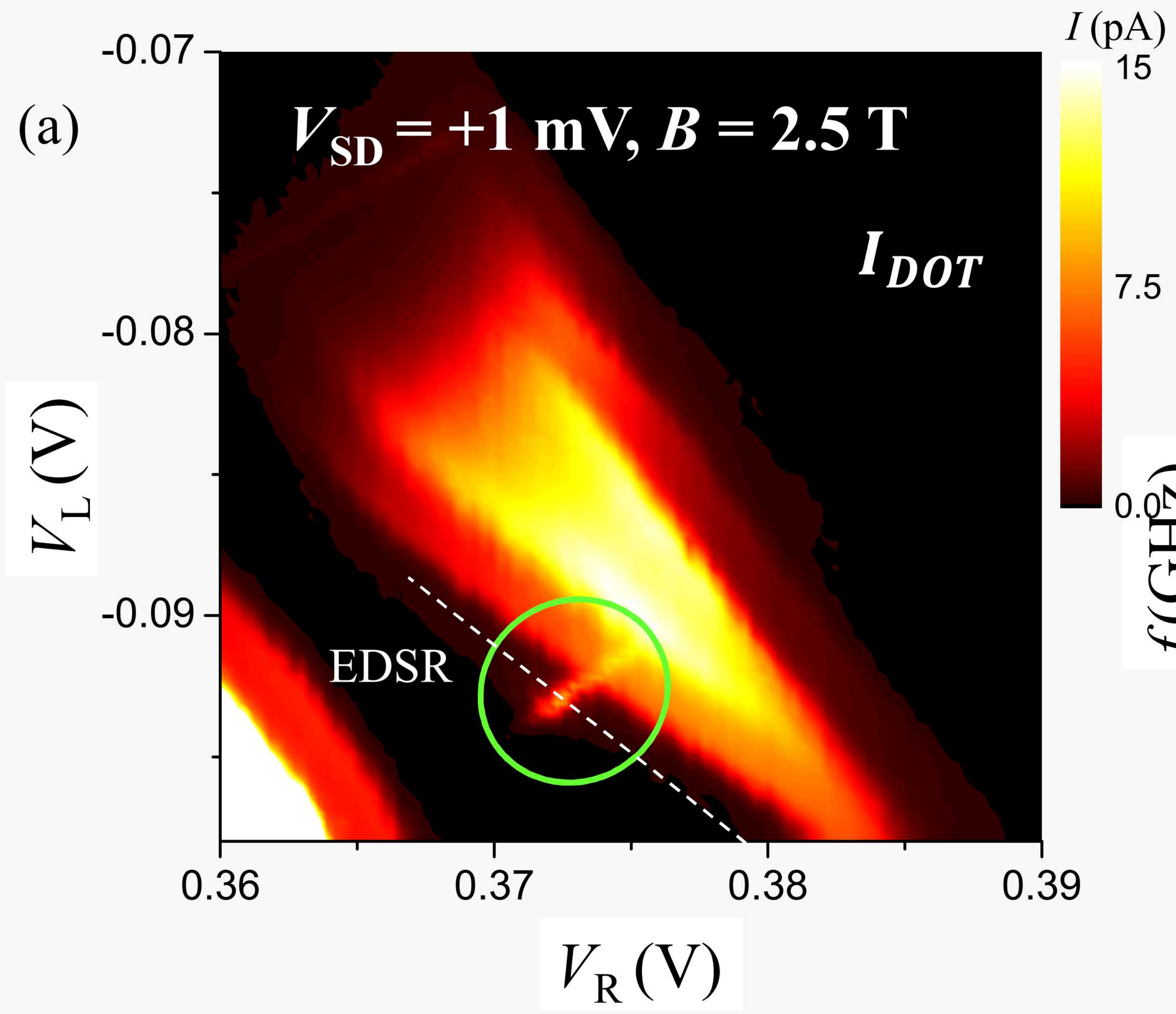
EDSR Line within high bias triangle

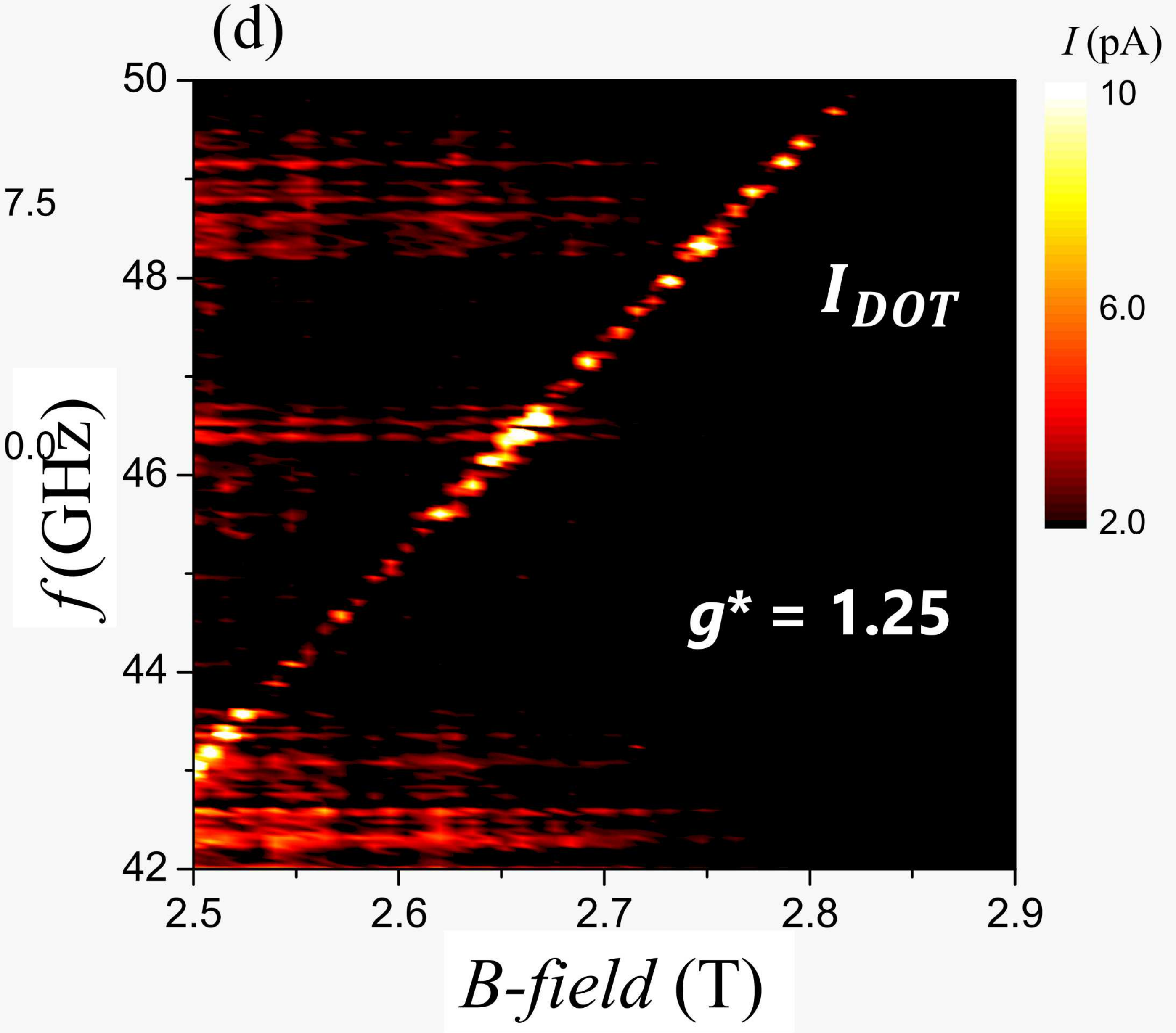




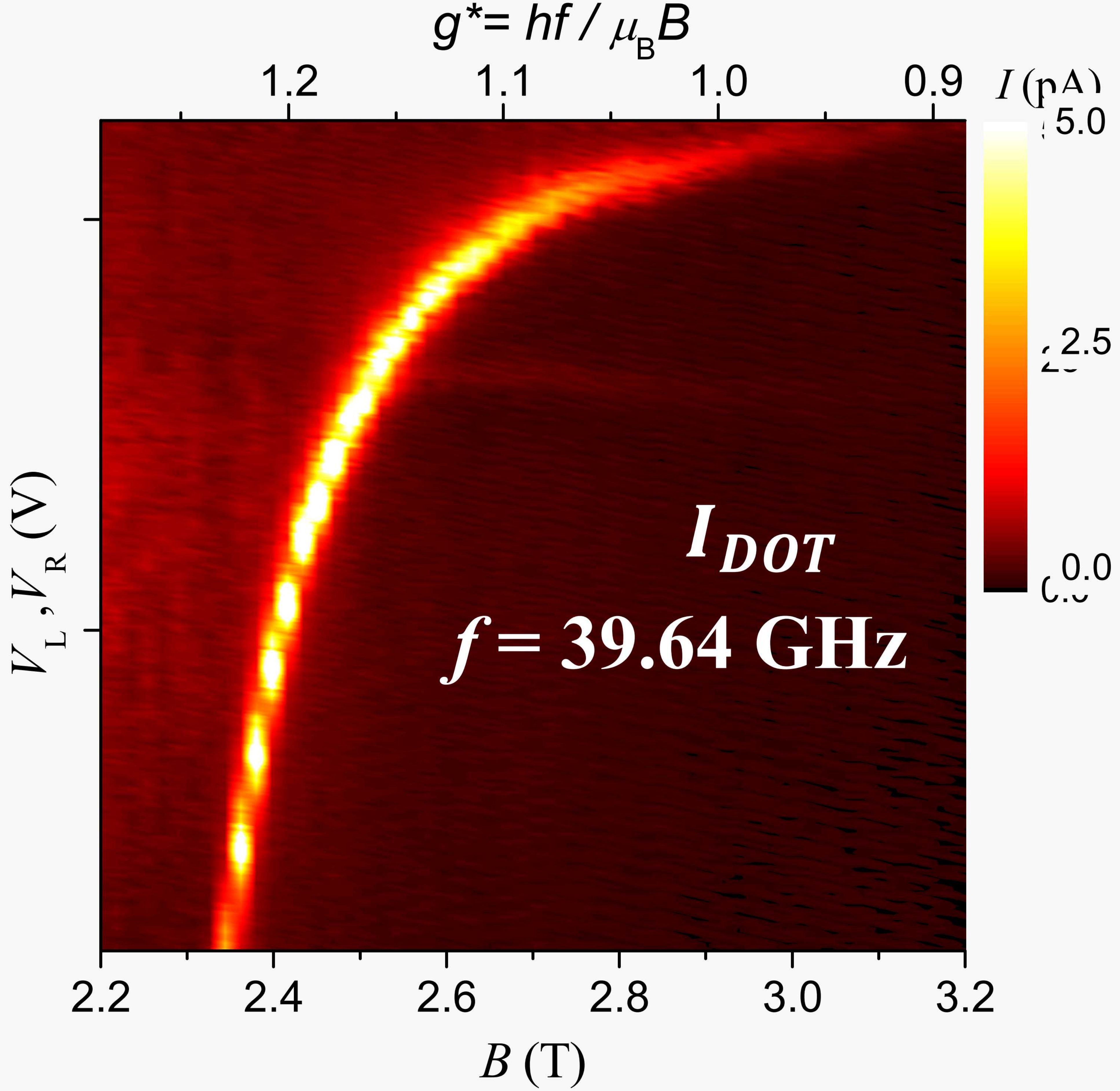


EDSR Line within high bias triangle

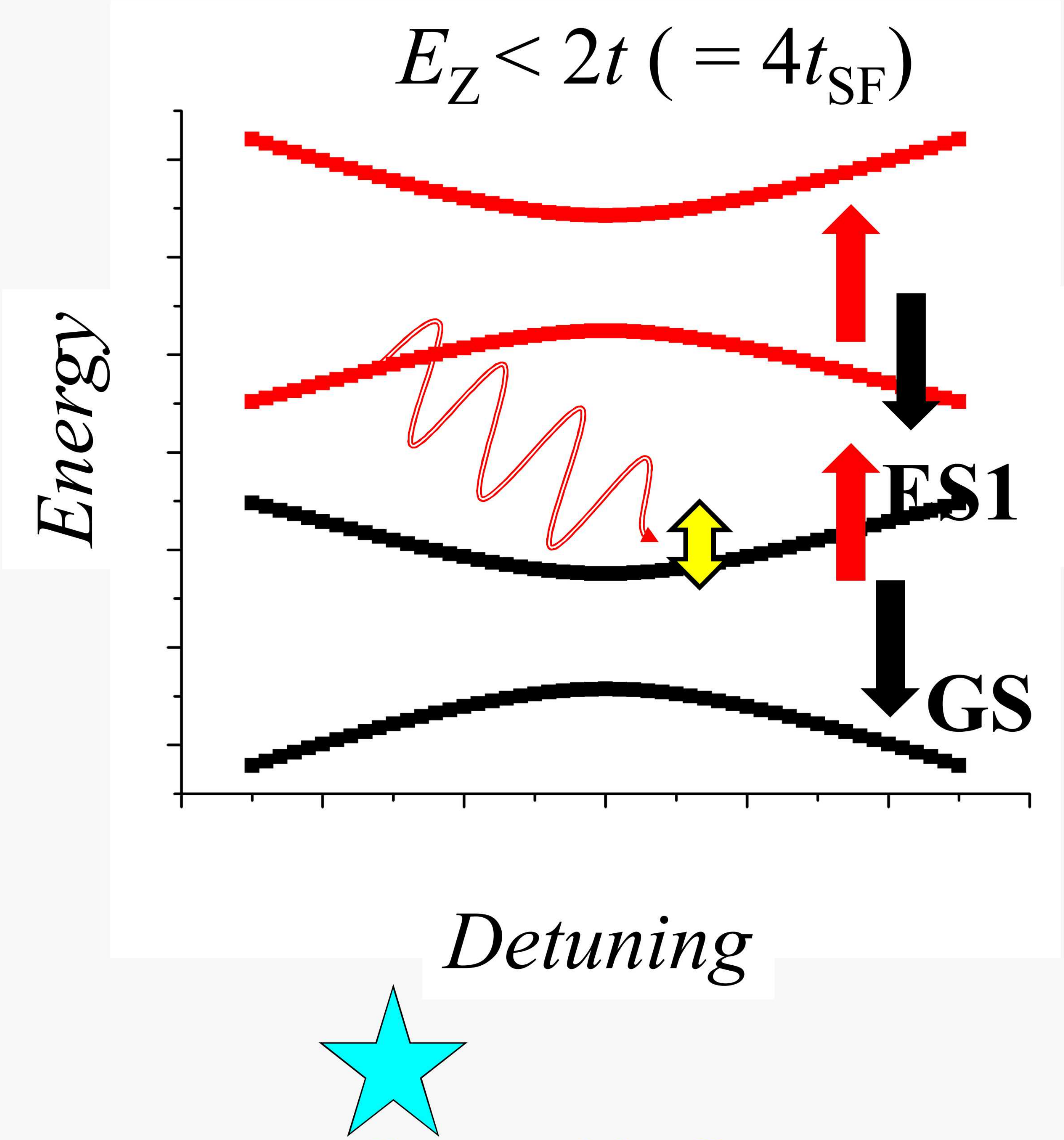


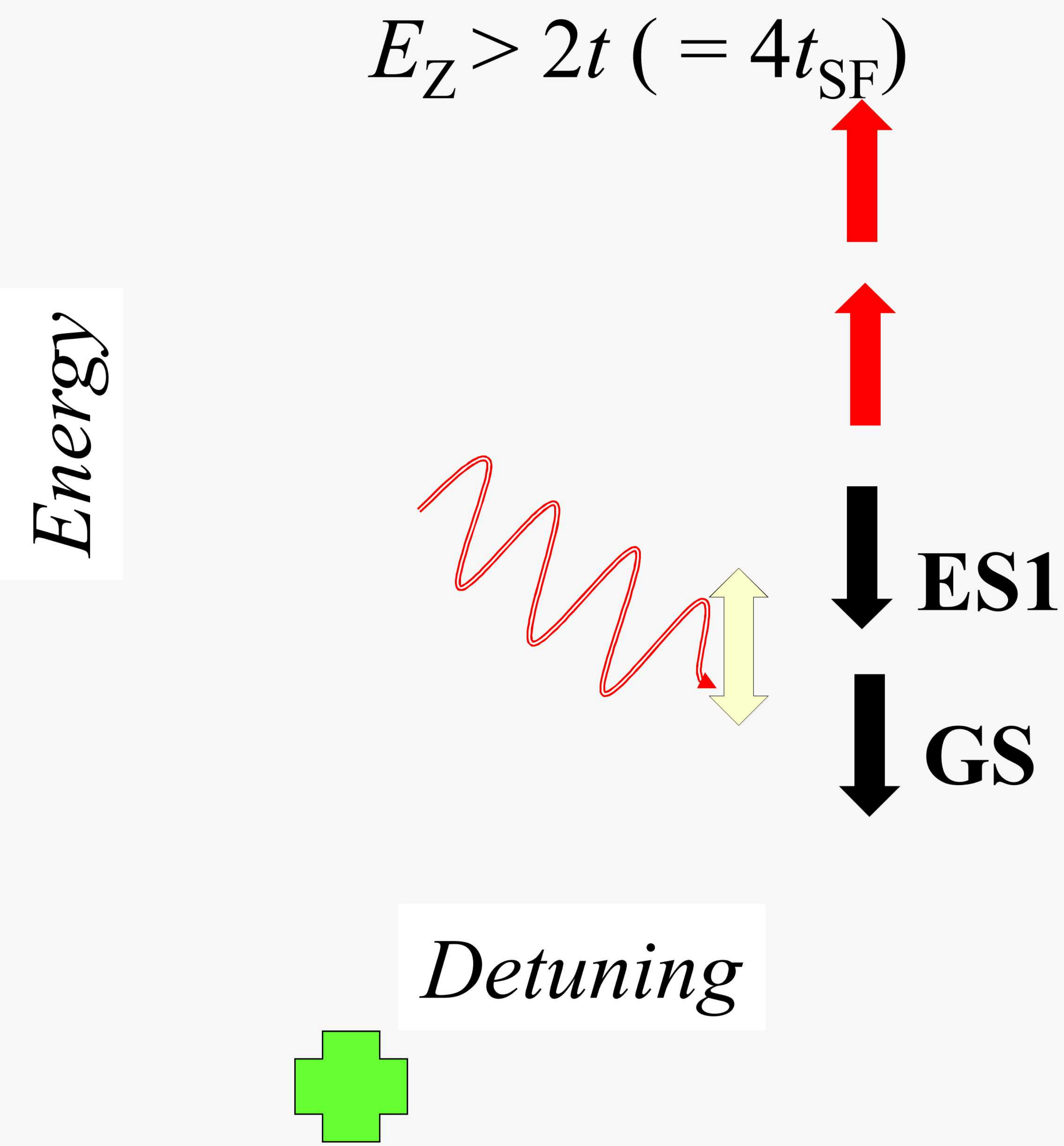


Magnetic field dependence of EDSR peak



Simulated single-hole energy levels

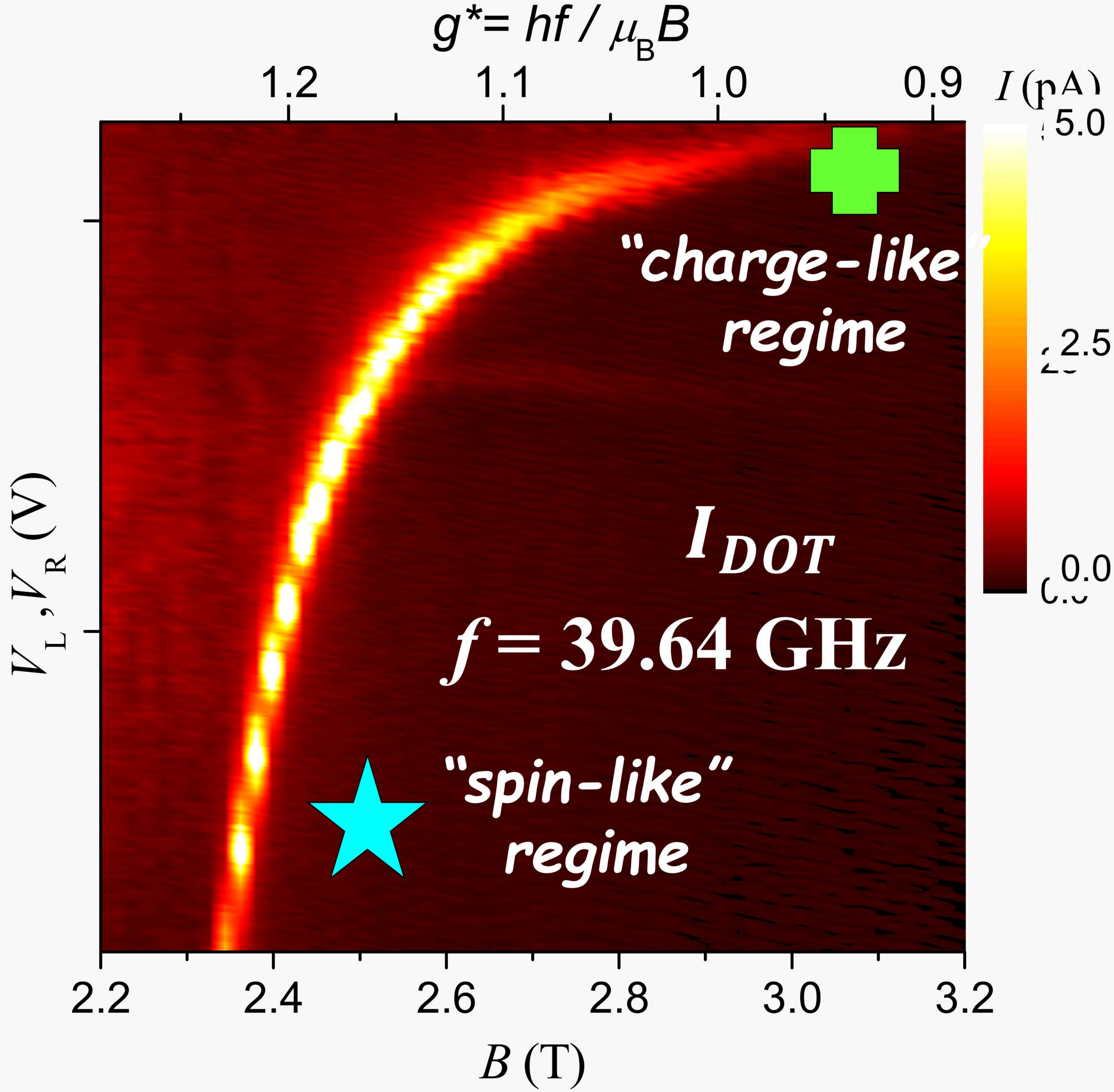




"spin-like" regime

"charge-like" regime

Magnetic field dependence of EDSR peak



Summary

- A single heavy hole spin system has been realize in the strong tunnel coupling regime and EDSR has been observed. The characteristics are strongly influenced by the spin-orbit interaction which induces spin-flip resonance.
  - ✓ Single heavy hole EDSR demonstrated in gated DQD device
  - ✓ Demonstrated that heavy hole effective g-factor can be tuned by a gate
  - ✓ A hybrid spin-charge system is realized where the EDSR can be continuously tuned from "spin-like" to "charge-like“ regime.