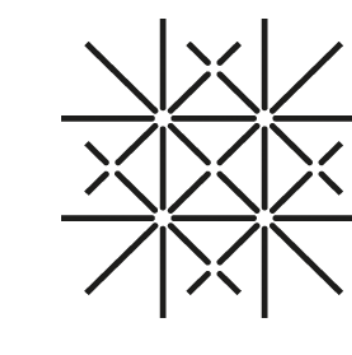
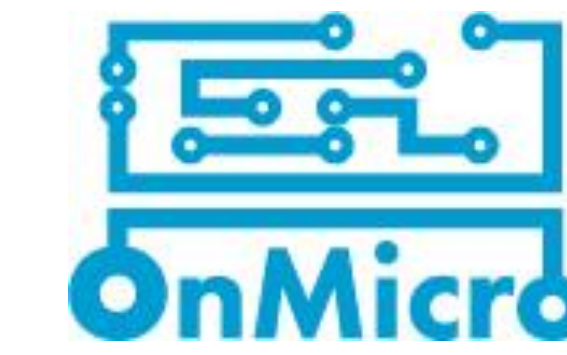
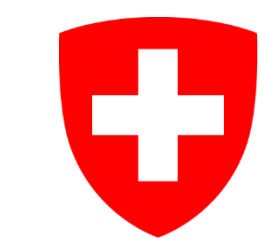


Quantum Metrology for High Frequency Electric Fields

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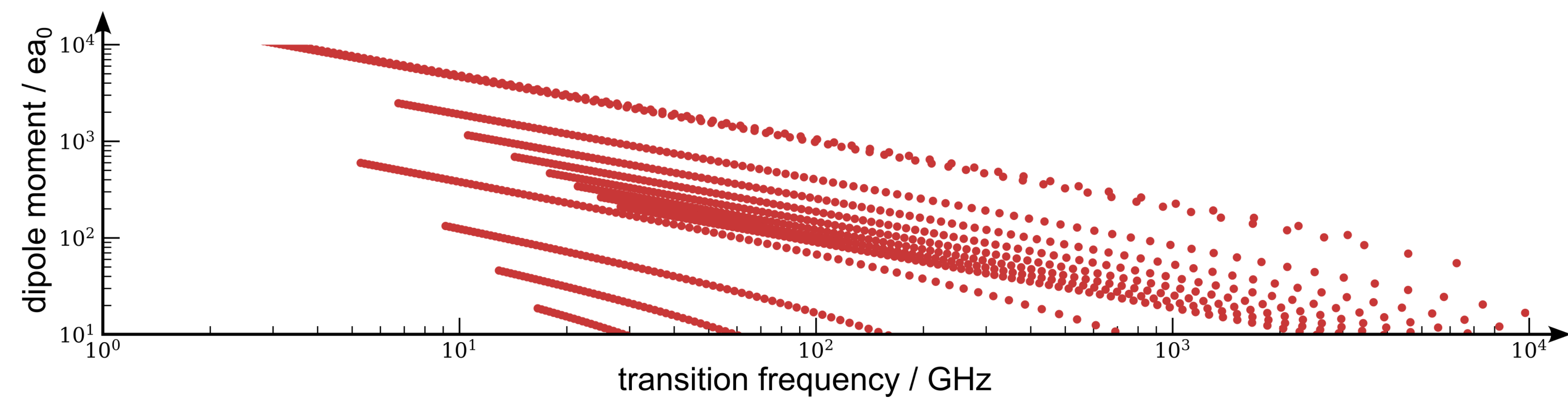
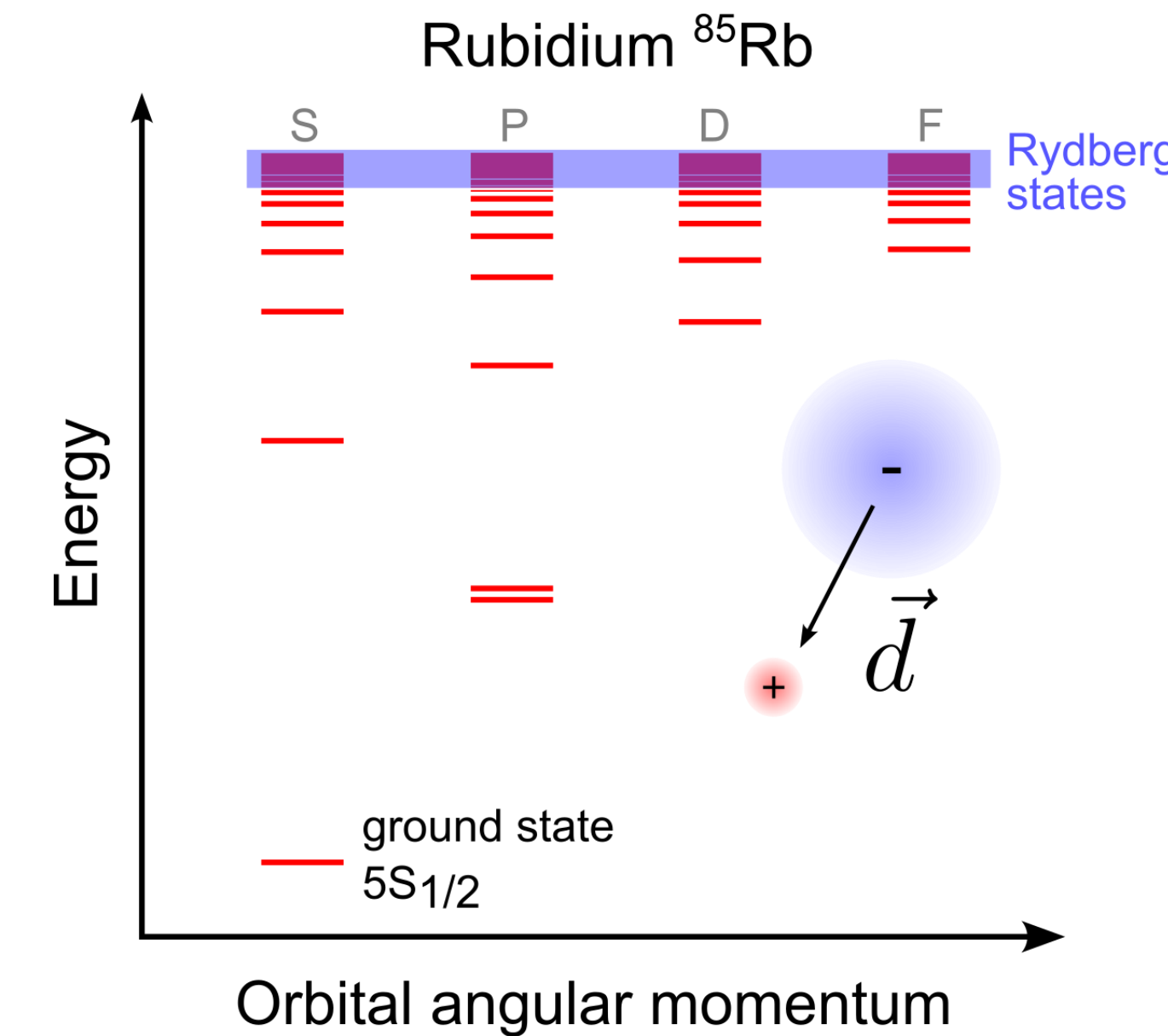


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We investigate the use of alkali atoms as electric field sensors for high frequency on-wafer measurements. These atoms are well-defined quantum systems and hold a promising potential for accurate and traceable measurements. The project aims to map electric fields above a coplanar waveguide and to determine microwave power and S-Parameters up to 50 GHz.

Rydberg Atoms as Field Sensors

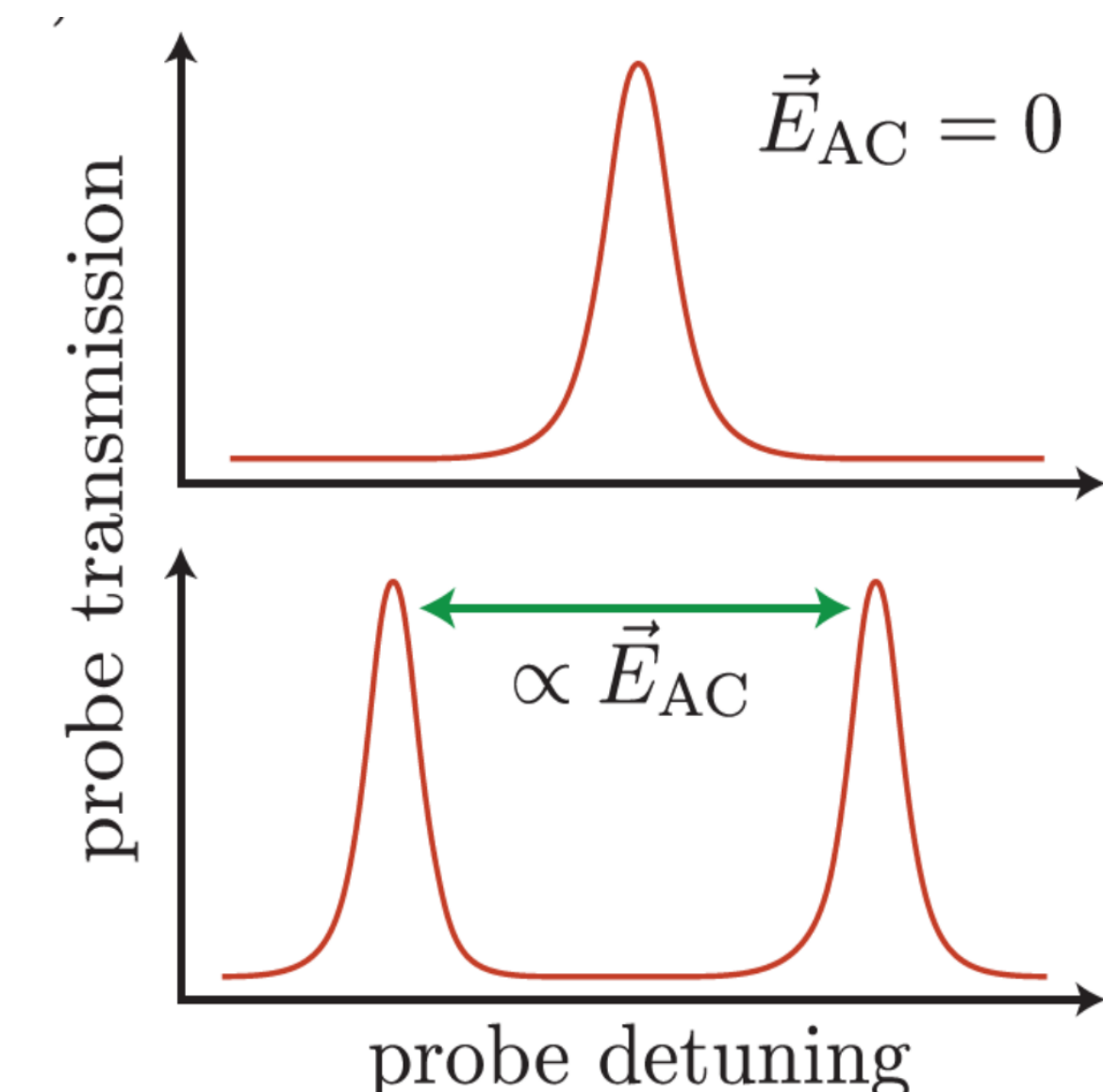
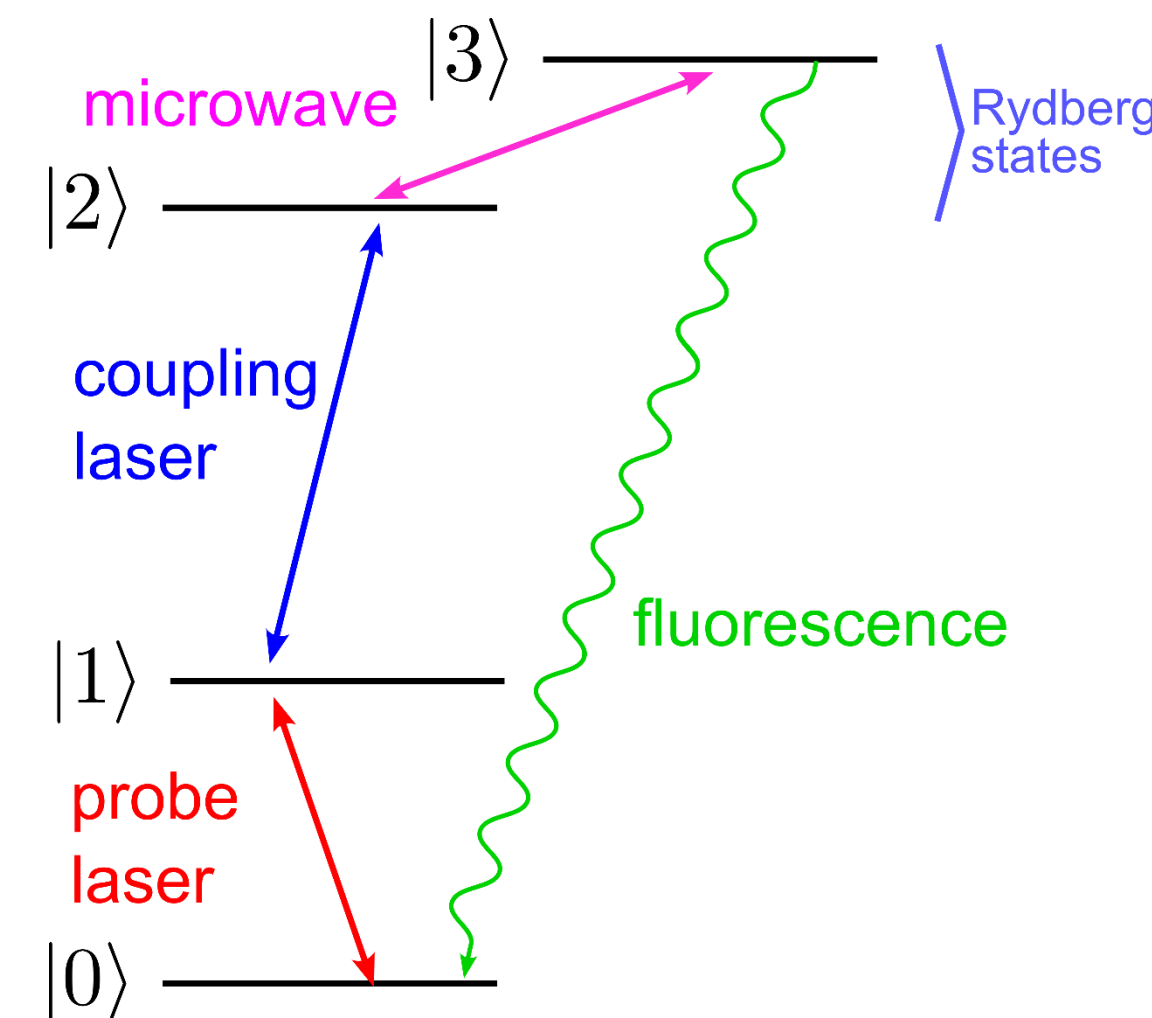
- Rydberg atoms are neutral atoms whose valence electron is excited to a high energy state – a *Rydberg state*.
- Alkali atoms have only one valence electron. In a Rydberg state, they become very similar to a hydrogen atom.
- In a Rydberg state, the valence electron is strongly delocalized from the core and the other electrons. A large dipole is formed.
- The large dipole moment makes these systems very sensitive to electric fields over a broad frequency range.
- Detailed knowledge of the atomic system makes Rydberg atoms a very promising toolset for metrological applications and SI-traceability.



Access to the Quantum World

To leverage the advantageous properties of quantum system, the microscopic quantum world must be connected to real-life macroscopic object. In this project, we employ an optical excitation scheme.

- A *probe laser* excites the atom from the ground state $|0\rangle$ to state $|1\rangle$.
- A *coupling laser* excites the atom to a high-lying *Rydberg state* $|2\rangle$.
- Electric fields at *microwave frequencies* can excite to a nearby *Rydberg state* $|3\rangle$.



Electro-magnetically induced transparency (EIT)

- The transmission of the probe laser is increased when the atoms couple in resonance to the probe and coupling lasers.
- This resonance condition is perturbed in the presence of an microwave field. The perturbation is directly proportional to the electric field strength.

Fluorescence decay

- The emitted *fluorescence* of the atoms is captured with a photodiode or camera.
- The captured fluorescence can be related to the electric field strength.

Rydberg Sensing for On-Wafer Measurements

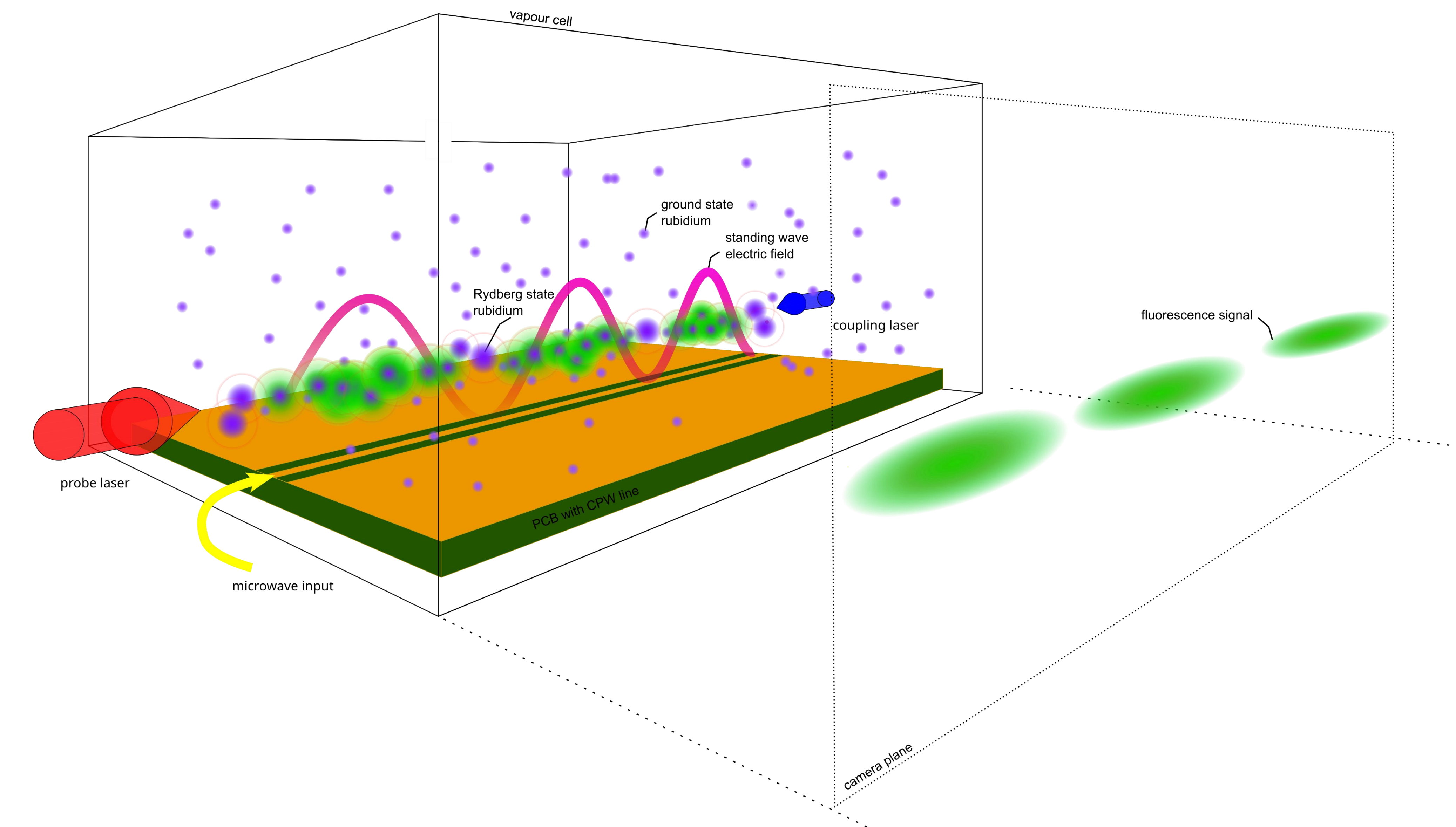
The project aims to explore Rydberg atoms as electric field sensors for on-wafer measurement. The targets are to

- map the electric fields above a CPW line,
- determine the microwave power within the CPW line
- measuring scattering parameters (S-Parameters) at the microwave output port.

The foreseen setup consists of a large vapor cell hosting

- optical access for the lasers and fluorescence observation,
- electrical feedthroughs for sending and receiving high-frequency signals,
- a printed circuit board (PCB) with CPW line or other standards (short, open, lines).

This approach ensures minimal perturbation of the electric field, as no metallic or dielectric probes are used. Instead, the atomic vapor is in direct contact with the unperturbed electric field.



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