

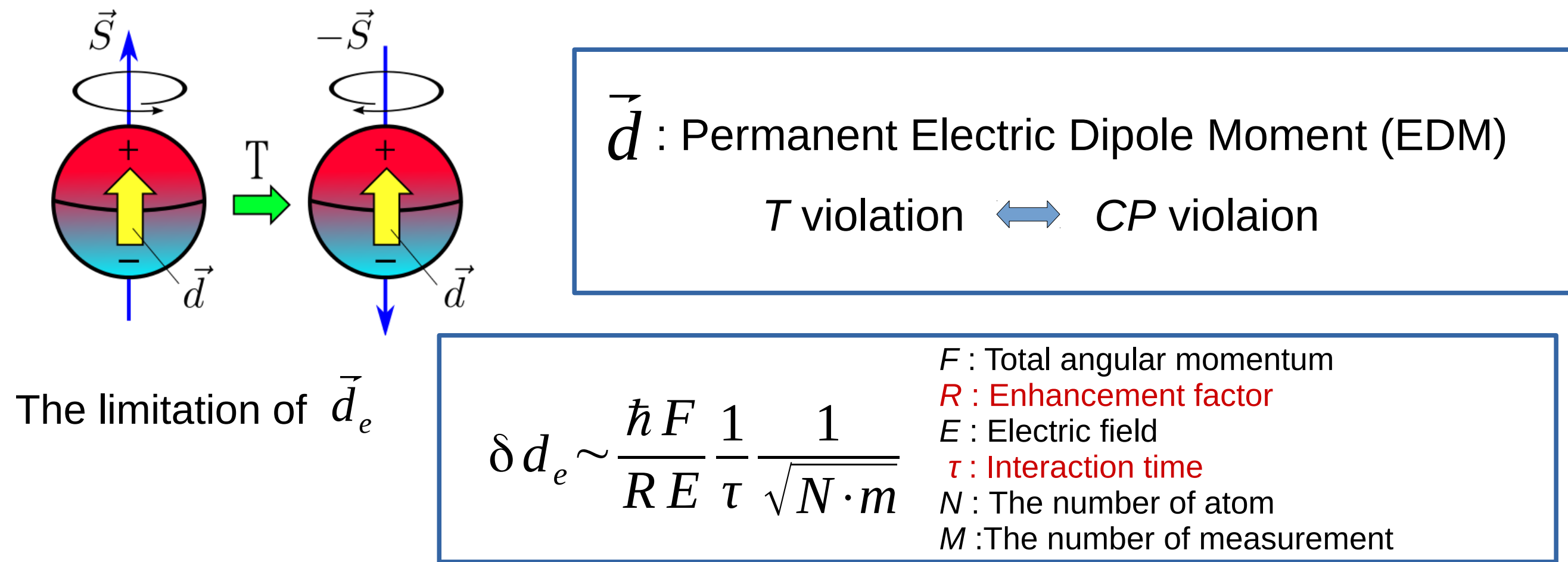
Development of an optical dipole force trap system towards search for an electron EDM using laser-cooled francium

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A permanent electric dipole moment (EDM) of the electron which violates time reversal symmetry is a sensitive tool for exploring the new physics beyond the Standard Model. At CYRIC, Tohoku University, we are constructing experimental apparatuses to search for the electron EDM using laser-cooled francium (Fr). Since Fr is unstable element, we are developing these apparatus using rubidium (Rb) which has similar chemical properties to that of Fr.

1. Search for an electron EDM

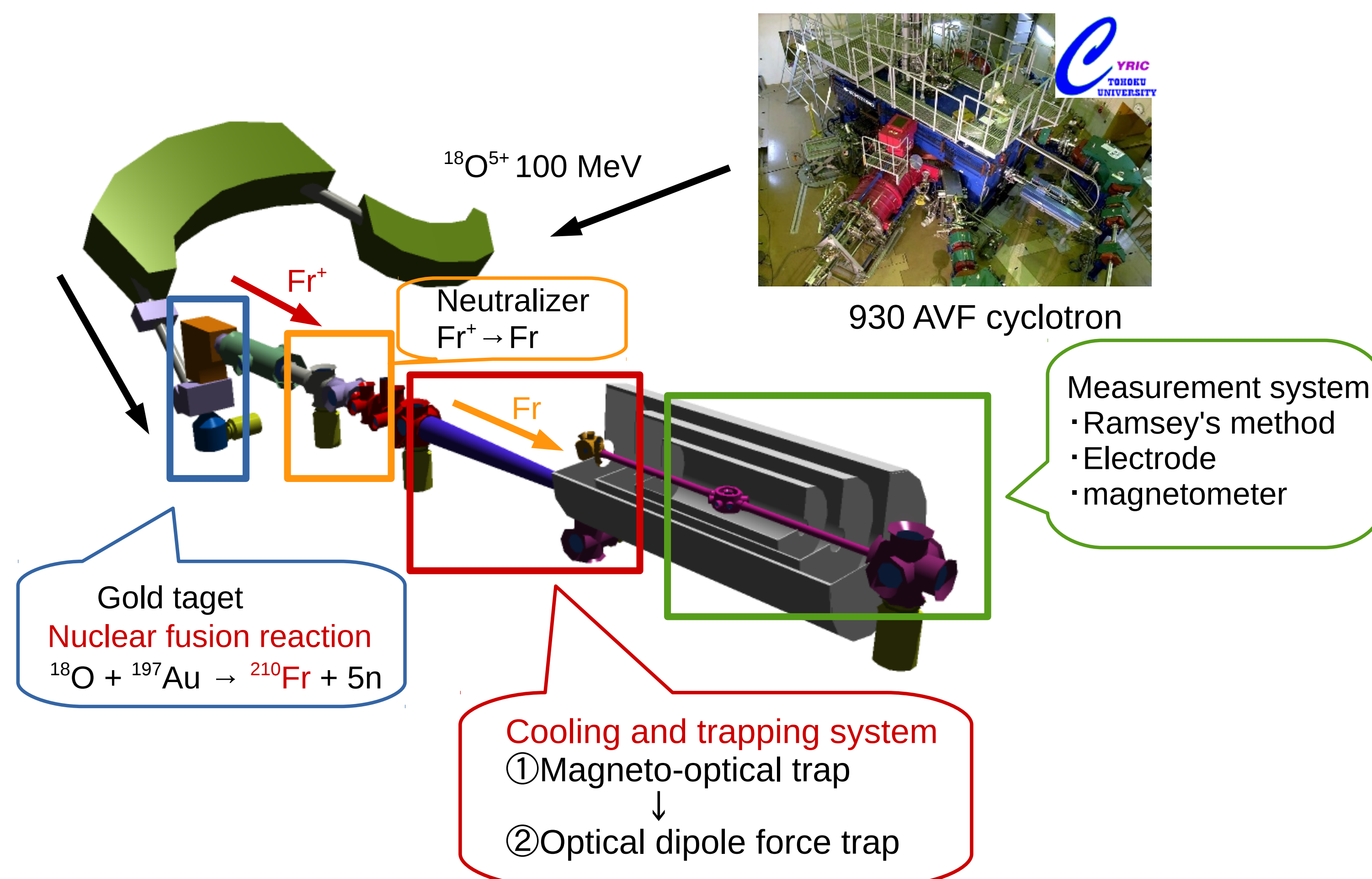


• **Francium (Fr)** has a large enhancement factor $R \sim 900$ [1, 2] for electron EDM

• Laser cooling and trapping \rightarrow Long interaction time

\rightarrow Search for the EDM using laser-cooled Fr atoms!

2. Plan to search for the EDM at CYRIC



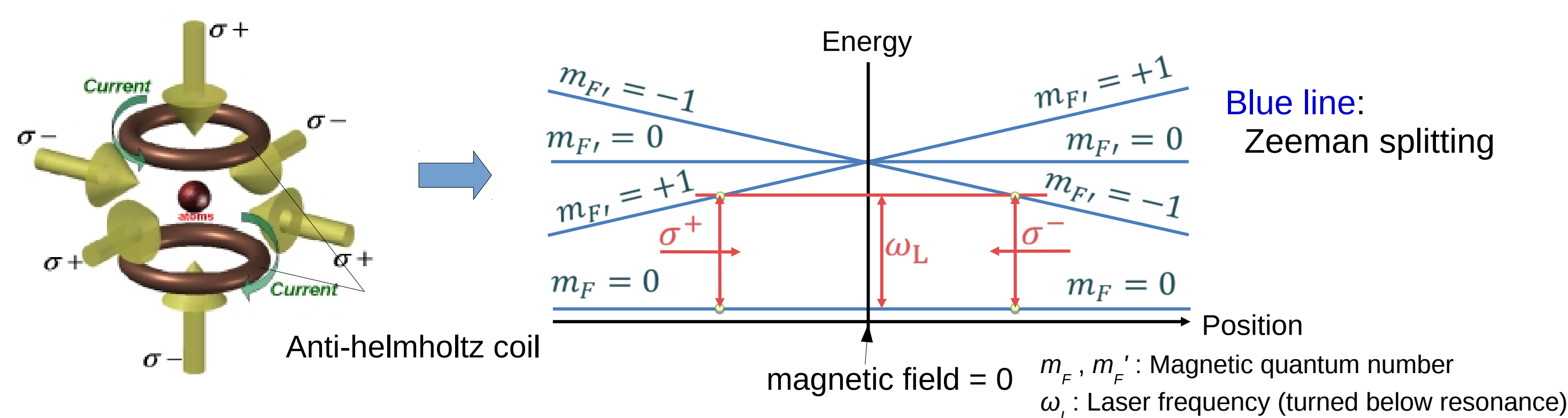
Rubidium (Rb) is used for developing these apparatuses.

Why Rb? \rightarrow This is also alkali metal and has similar chemical properties to that of Fr.

3. Laser cooling and trapping ~ MOT & ODT ~

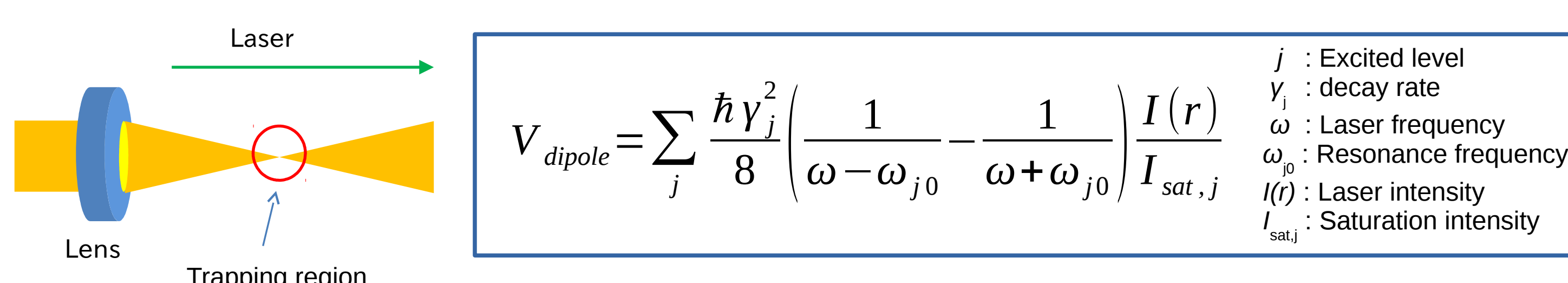
① Magneto-optical trap (MOT)

Cooling and trapping technique using radiation pressure of laser lights and Zeeman splitting caused by quadrupole magnetic field.

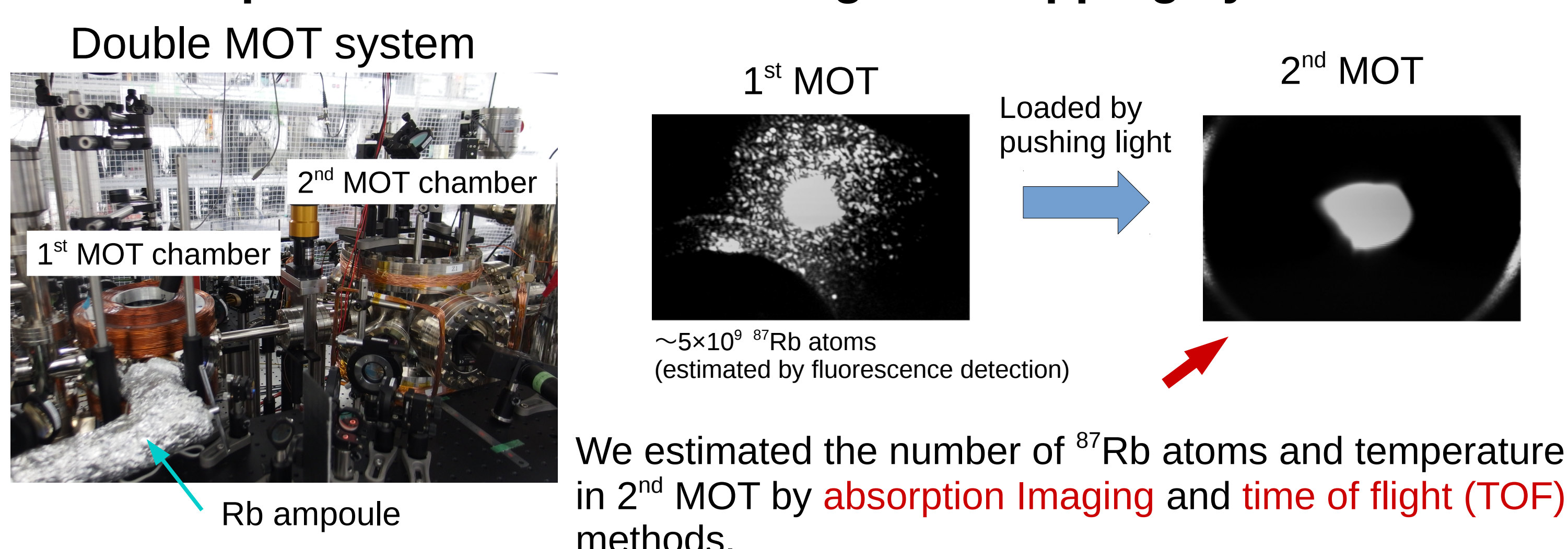


② Optical dipole force trap (ODT)

Trapping technique using an electric dipole force which is caused by the interaction between an induced electric dipole moment and an electric field of non-resonant laser light.

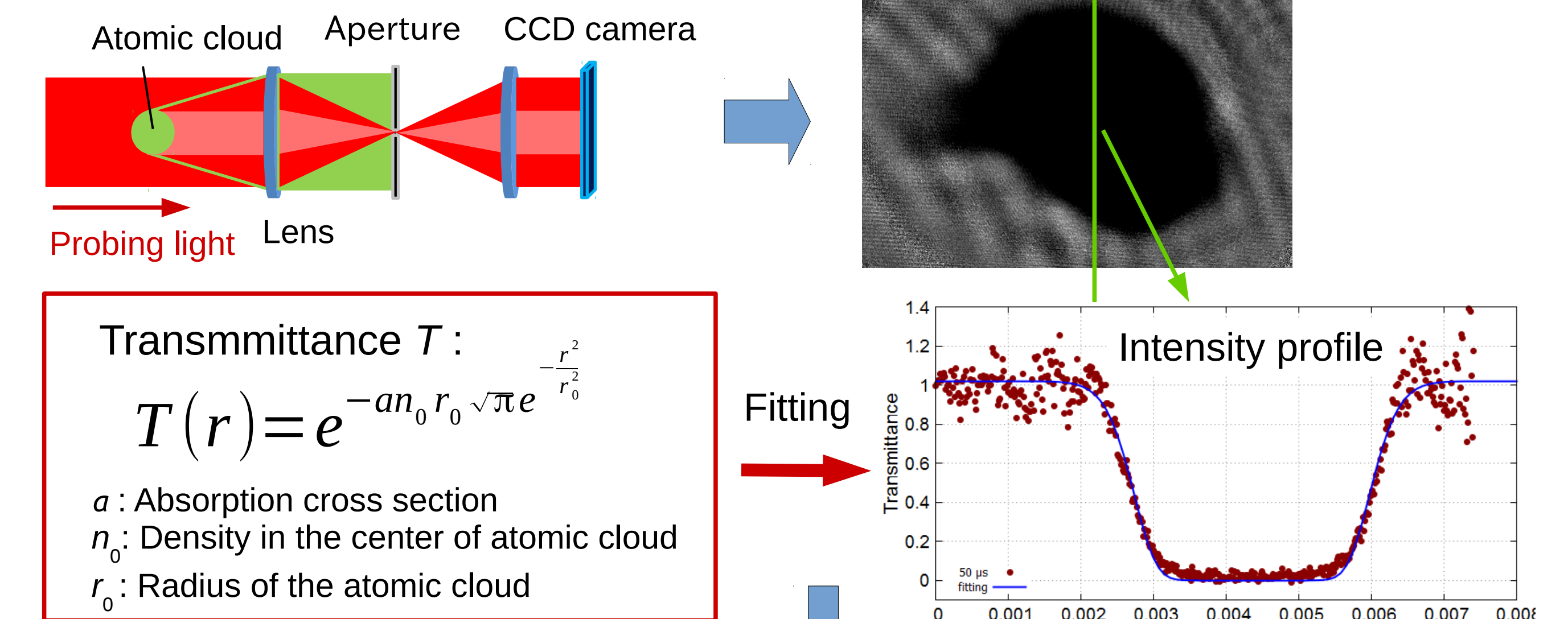


4. Development of the laser cooling and trapping systems



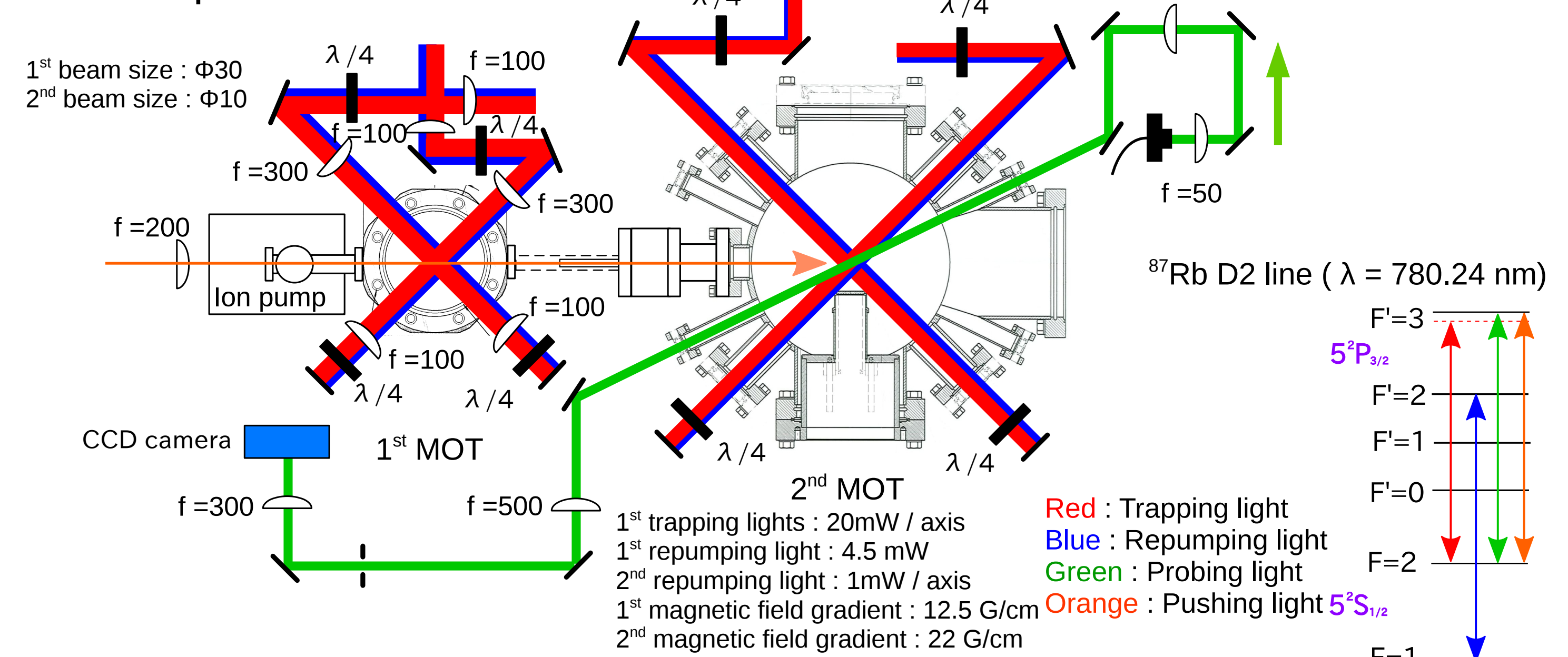
5. Absorption Imaging and time of flight

• Absorption Imaging



The number of trapped Rb atoms N : $N = \pi^{3/2} n_0 r_0^3$

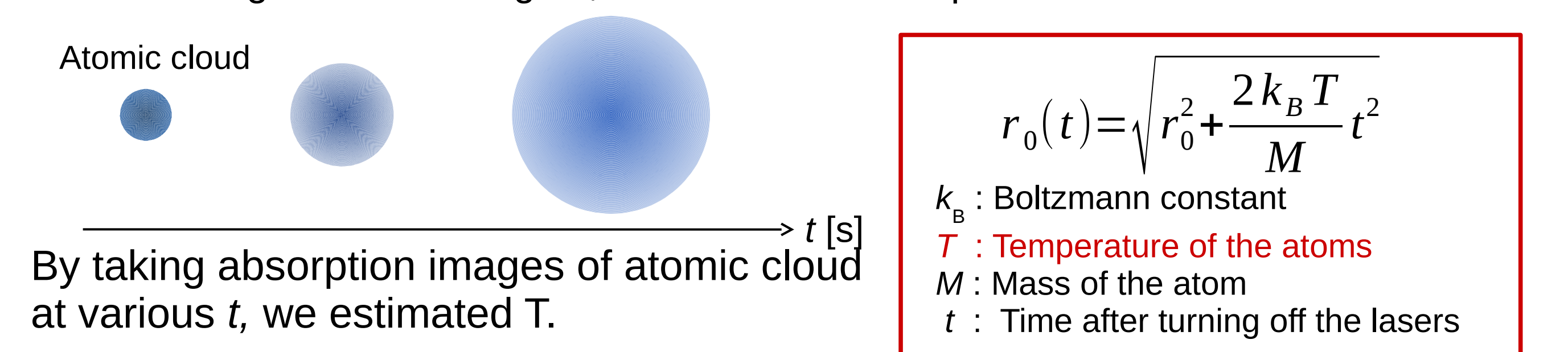
• Setup and results



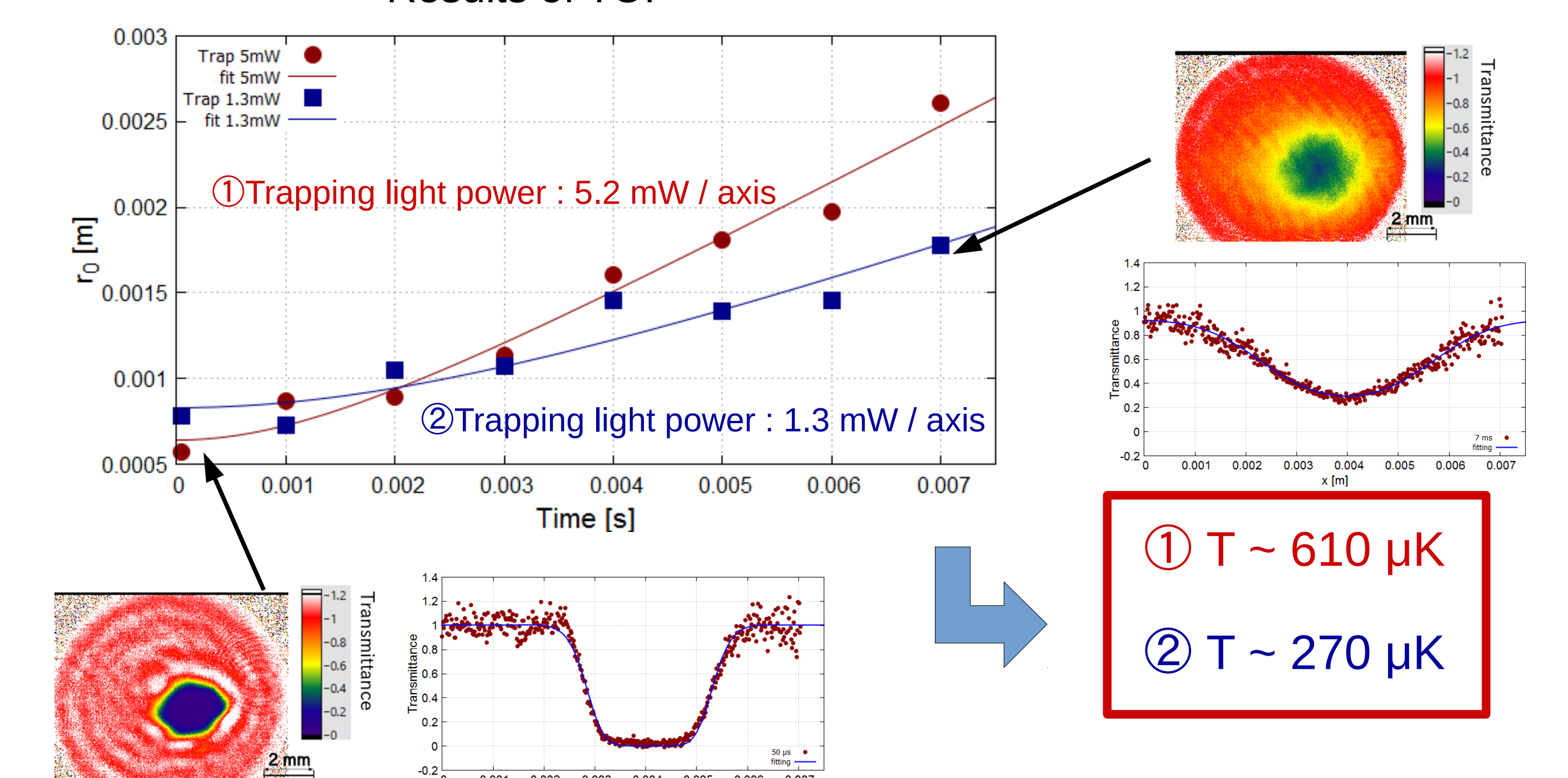
In 2nd MOT
 Trapping laser power of 5.2 mW / axis : $N = 4.8 \times 10^9$
 Trapping laser power of 1.3 mW / axis : $N = 1.8 \times 10^8$

• TOF

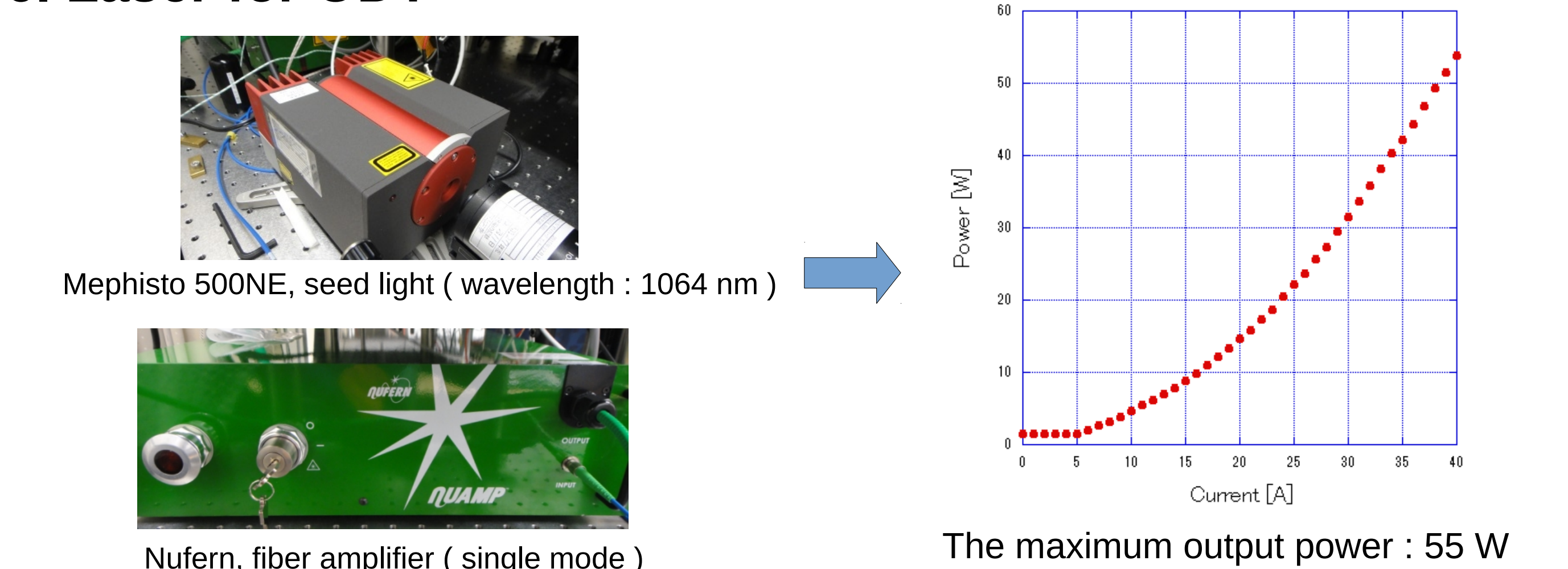
After turning off the laser lights, the atomic cloud expands.



Results of TOF



6. Laser for ODT



The potential depth estimated at the power of 30 W theoretically is about 3 mK $>$ T estimated from TOF method!

7. Summary

- We developed laser cooling and trapping system using Rb atoms.
- We measured the number of the atoms and temperature of the atomic cloud in 2nd MOT.
- We introduced new seed light and fiber amplifier and obtained the maximum output power of 55 W for ODT.