QUANTUM MEMORY PROTOTYPE FOR SPACE

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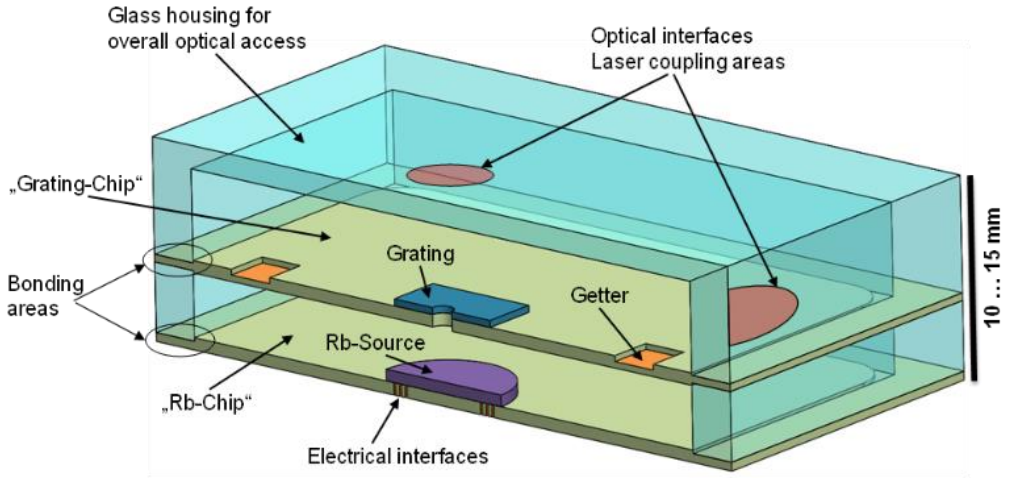
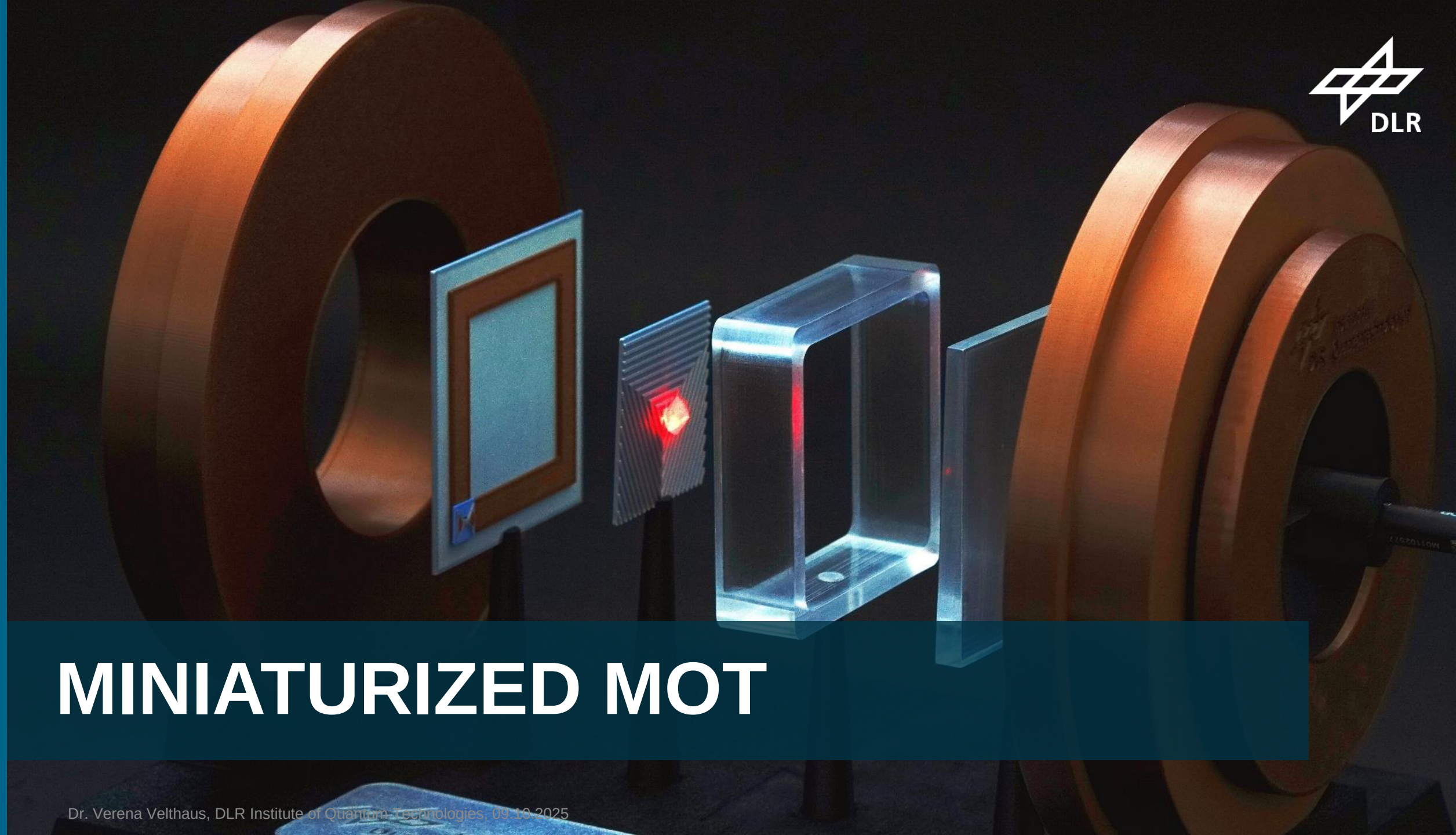
Agenda

- Scope
- Miniaturized Magneto-optical Trap (MOT)
- MOT Test System
- Memory System
- Roadmap

Scope

- Develop miniaturized magneto-optical trap (MOT) as a prerequisite for compact quantum memory for space applications (ESA-founded project QMEM)
- Requirements for space:
  - Low size, weight and power
  - High system stability
- Our approach:
  - Miniaturization of science chamber to chip-size
  - Compact and stable light-conditioning system in elegant breadboard design (FORTH)
  - Include space readiness requirements into design and run first thermal-vacuum tests (TESAT)
- Setup of non-miniaturized MOT Test System and Memory System (DLR-founded project RoGloQuaN)

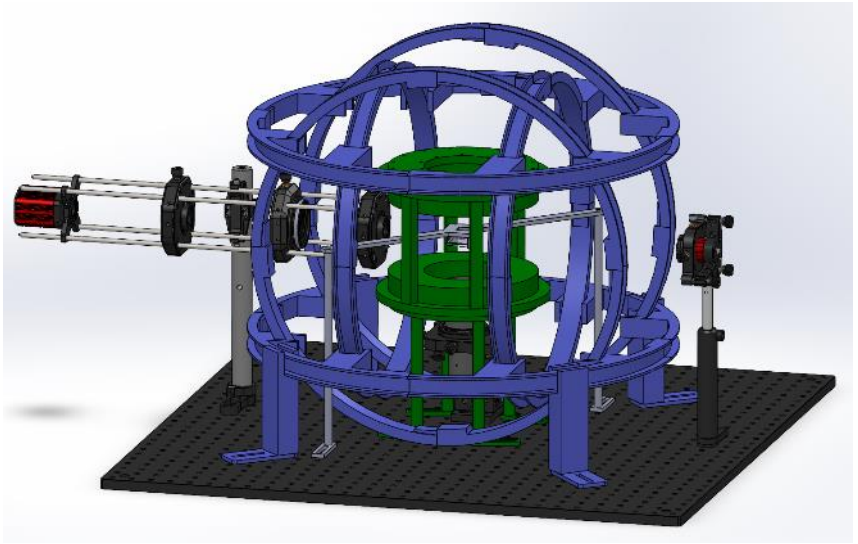




MINIATURIZED MOT

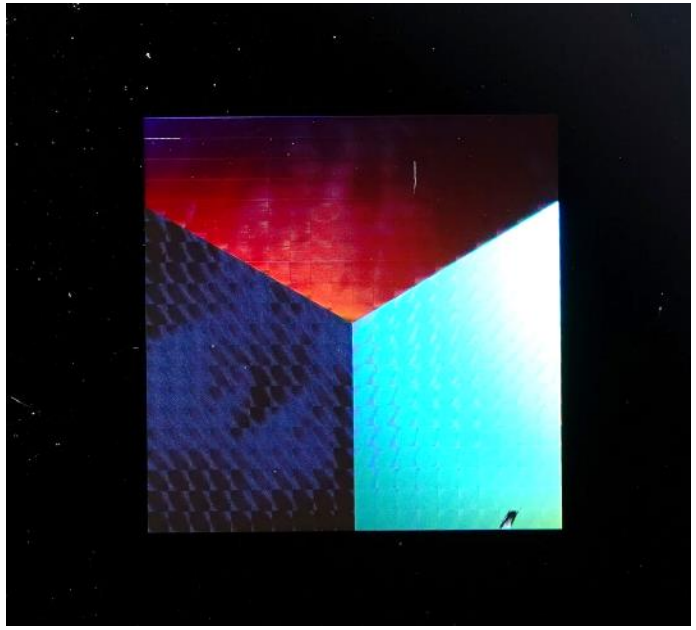
System Overview

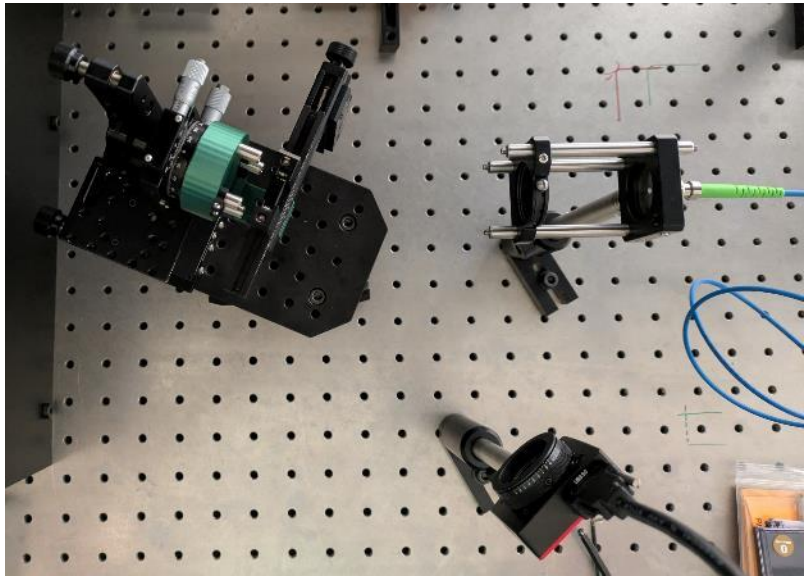
- Grating MOT with only one incident cooling beam
- Compact laser system with flat-top beam collimator as final optics
- Miniaturized glass cell with Rb source and getter pump
- Pair of anti-Helmholtz coils to provide trapping field
- 3 pairs of Helmholtz coils for compensation of external fields
- Fluorescence and absorption imaging system



Grating Chip

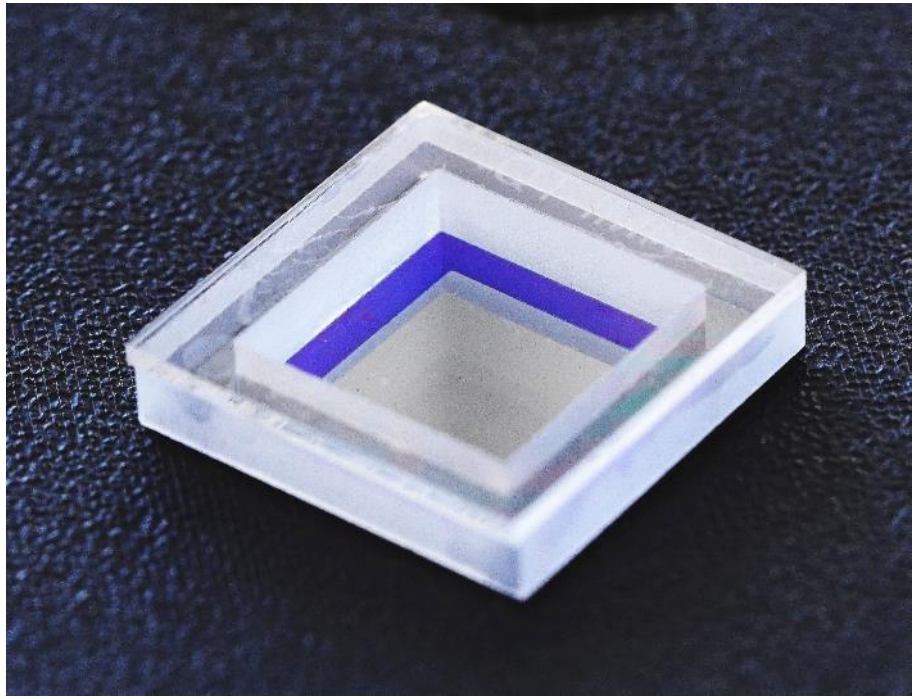
- Triangular grating with Al coating
- Production by electron beam lithography, dry etching and metal coating
- Optimization of manufacturing process in progress
- Build up of optical characterization setup for chip





Ultra-high Vacuum Cell

- Target pressure < $1 \cdot 10^{-8}$ mbar
- Sealing by chip bonding methods
  - Process for sealing of vacuum cells by anodic bonding is established
  - Helium leak rate < $8 \cdot 10^{-13}$ mbar·l/s
- Vacuum will be maintained by getter material
  - No power consumption and easy to miniaturize
  - Deposition on base chip with structuring by lithography
- Evaluation of vacuum quality in cells with miniaturized high vacuum sensors in preparation

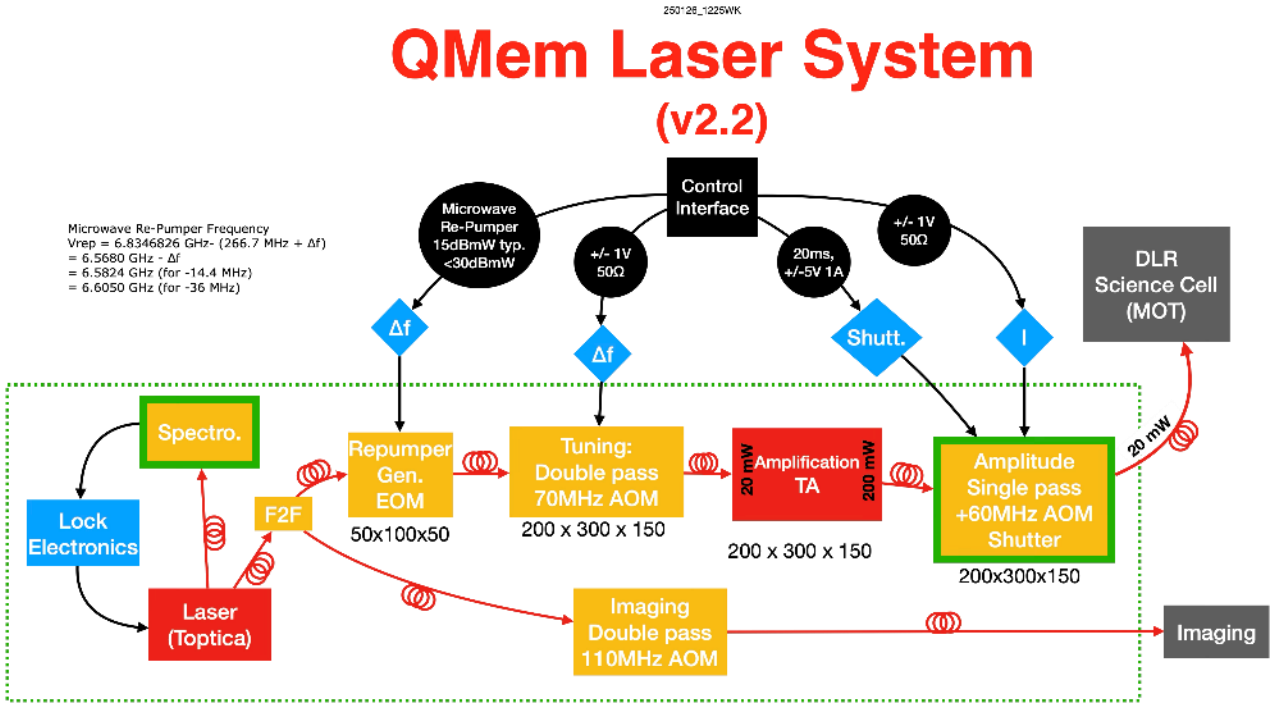


Miniaturized Rubidium Source

- Resistive heating of metallic Rb (30-60 °C)
- Production by lithography and dry etching methods
- Cavity filling with micro-dispensing systems
- Development of filling and sealing process in progress

Cooling Laser System

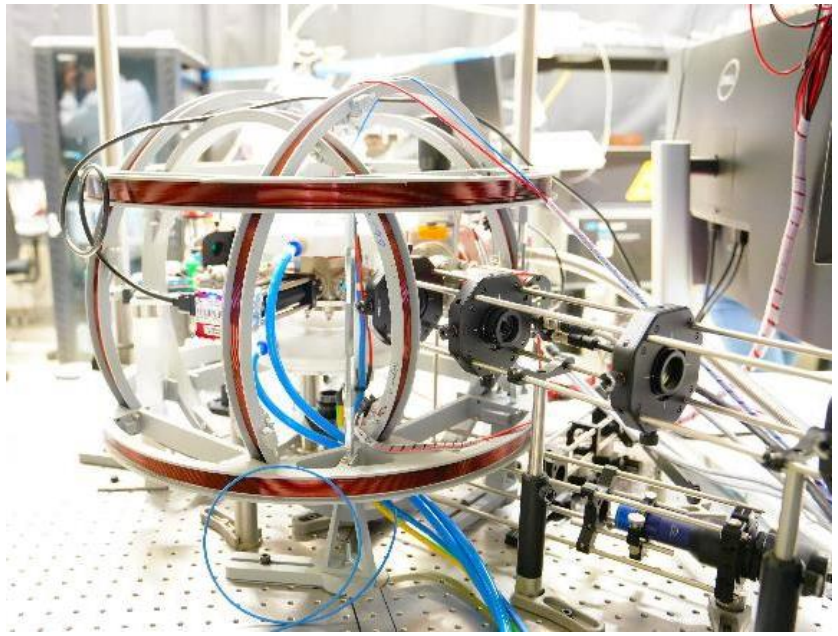
- Contribution from the Space Optics Laboratory @ FORTH-IESL
- Provide cooling, repumper and imaging beam
- Light-conditioning and spectroscopy will be space-ready (elegant bread board design)
- Protype (not space-ready) already installed at DLR
- Output power cooling beam: ≥ 50 mW
- Frequency tuning range: ~ 50 MHz

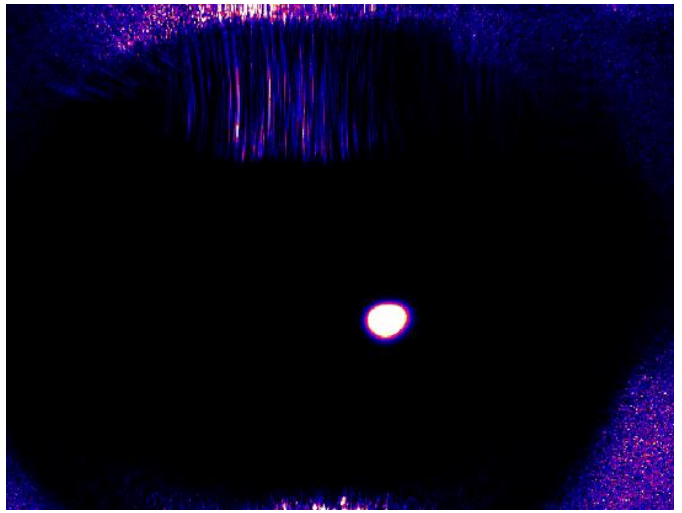


MOT TEST SYSTEM

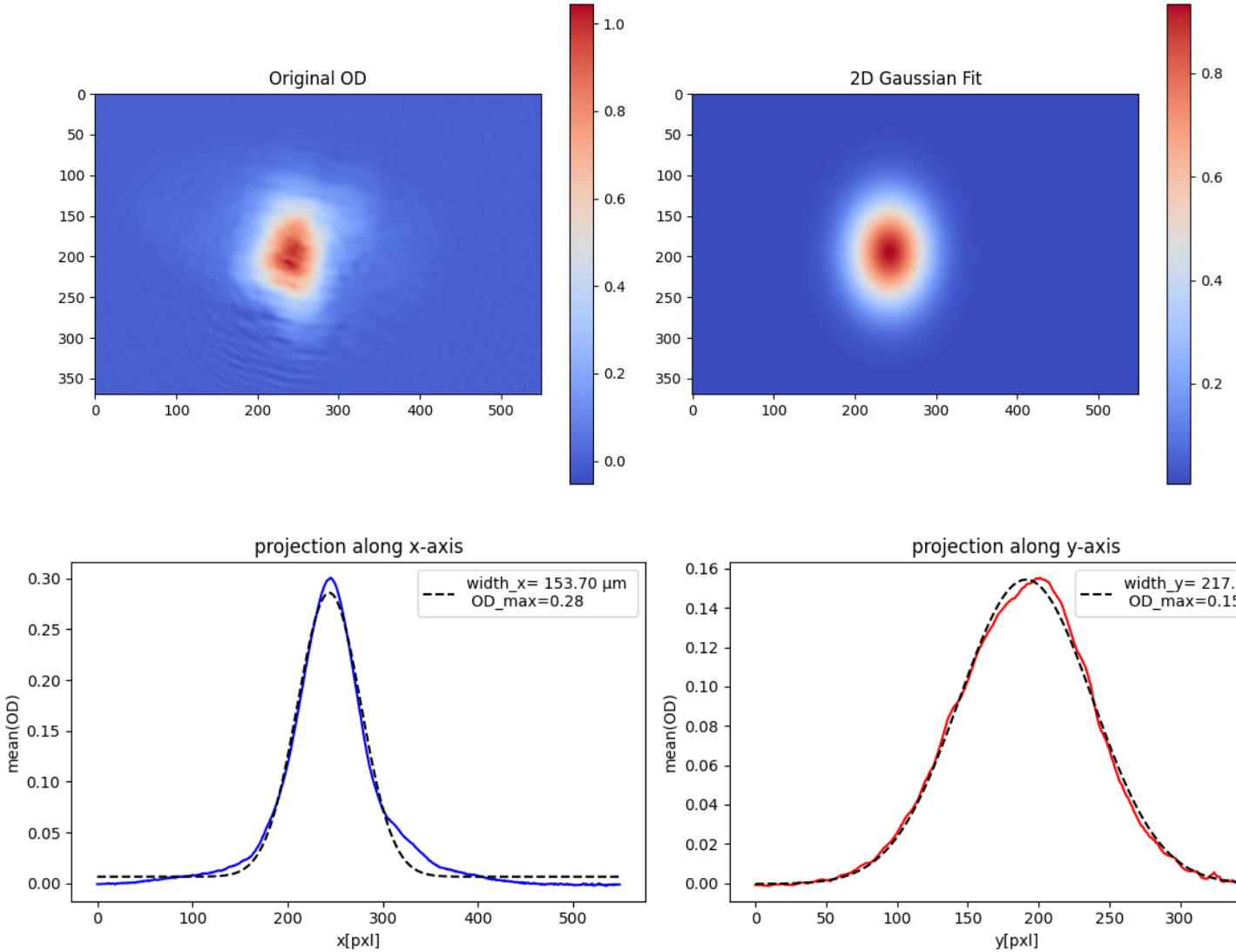
MOT Test System

- Non-miniaturized system with commercial vacuum chamber, NEG/turbo pump and Rb dispenser
- As close as possible to miniaturized system
- Same periphery for miniaturized MOT and Test System
- Optimization of MOT parameters in progress





MOT Test System



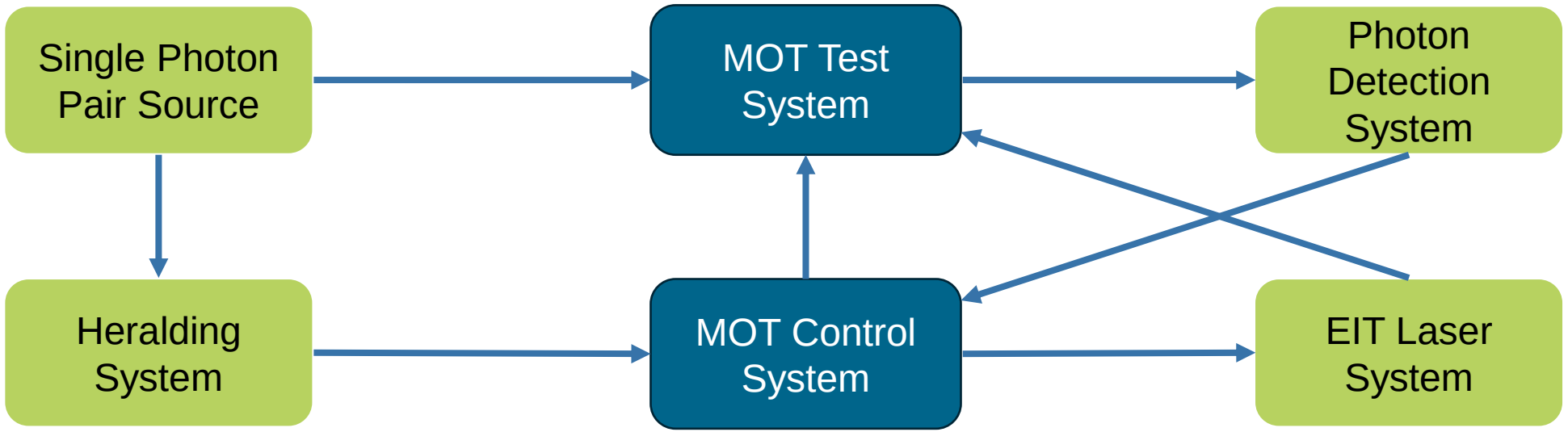
MEMORY SYSTEM

Warm Vapor Memory

- Storage medium: Rubidium vapor
- Memory protocol: Electromagnetically induced transparency (EIT)

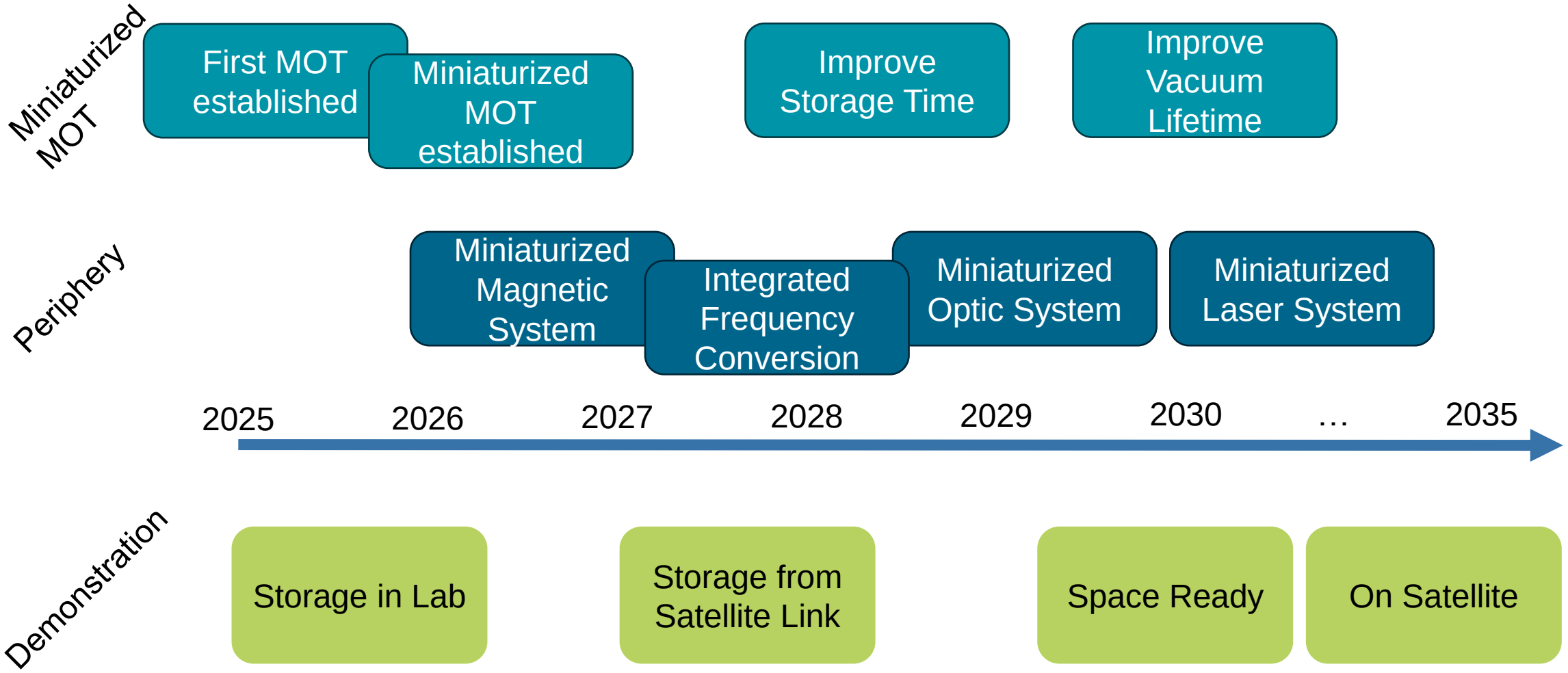
Cold Atomic Gas Memory

- Next step: Combine **MOT Test System** and **EIT Memory System**
- Demonstrate single photon storage in cold atomic gas



ROADMAP

Roadmap for DLR Cold Gas Quantum Memory



THANK YOU FOR YOUR ATTENTION