Quantum Integrated Light and Matter Interface - QuILMI

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PostDoc and PhD positions available !!! – Experiment & Theory

Goals of the QuILMI consortium

- to prepare a **degenerate cold atom cloud** in an optical lattice on a **chip surface**
- to implement **waveguides in the atom chip surface**
- to achieve **quantum control of tailored photon states** for guiding their propagation through the integrated circuit structure and for later analysis of the coupling fidelities
- to demonstrate and characterize coherent **photon-atom coupling** and **(single-)photon storage** in the ultracold atomic ensemble
- to develop an **integrated detector** for single-photon measurements
- to devise **new protocols and methods for creating entangled photon states** based on atomic interactions

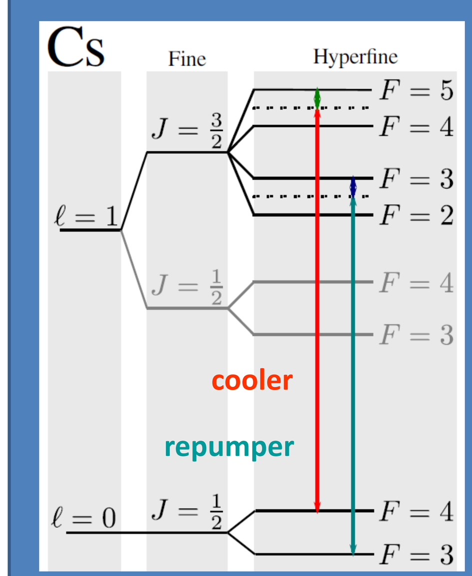
Funding

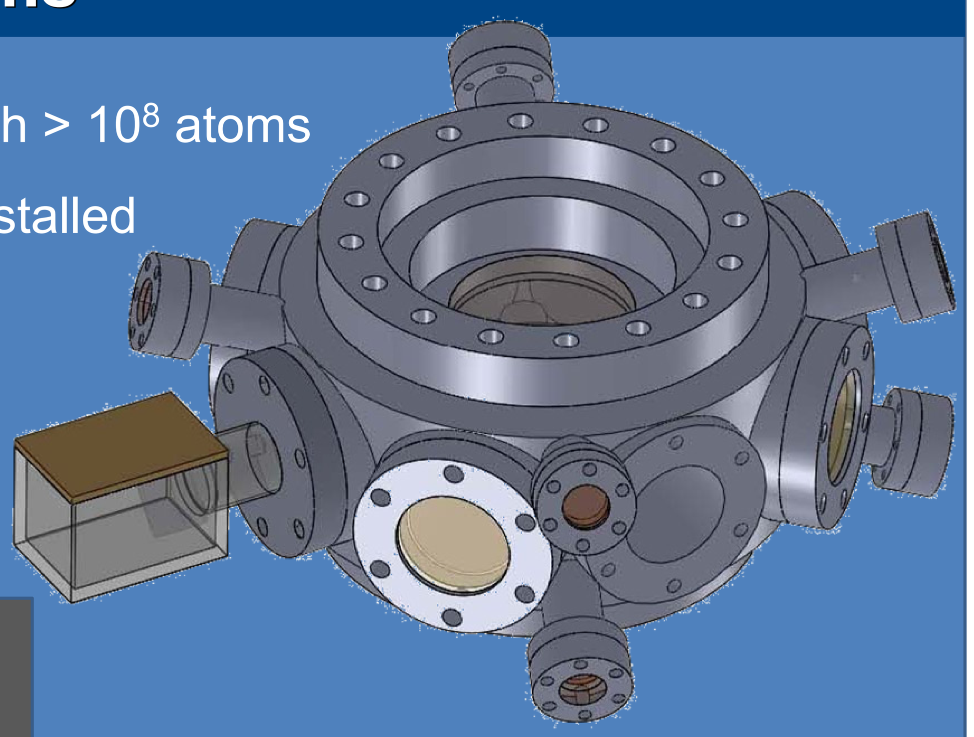
- effort is funded by the European Commission through the **FET-Open: Young Explorers** Call (FP7-ICT-2011-C)
- Total budget: 1.2 Mio EUR
- Funding period: 3 years, starting October 2012

SEVENTH FRAMEWORK PROGRAMME

Experiment – Cold atoms

- **Progress to date:** Cs-Mot with > 10^8 atoms
- crossed dipole trap (100W) installed

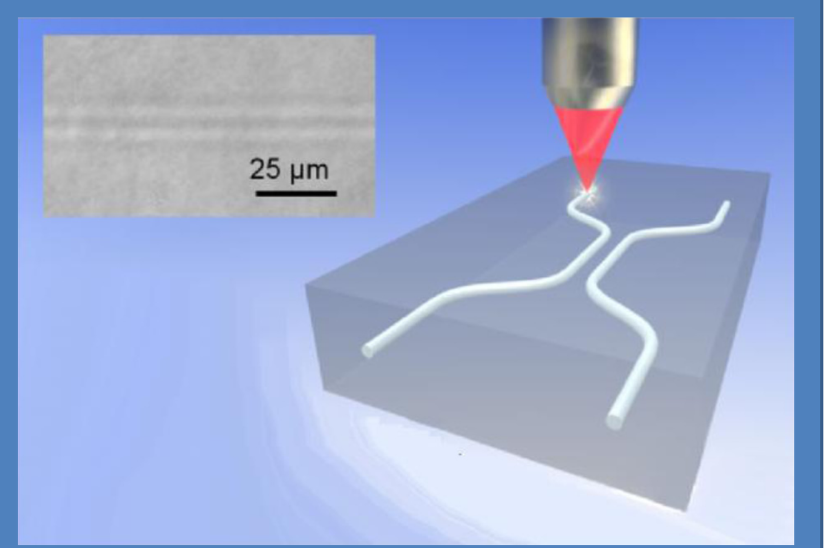




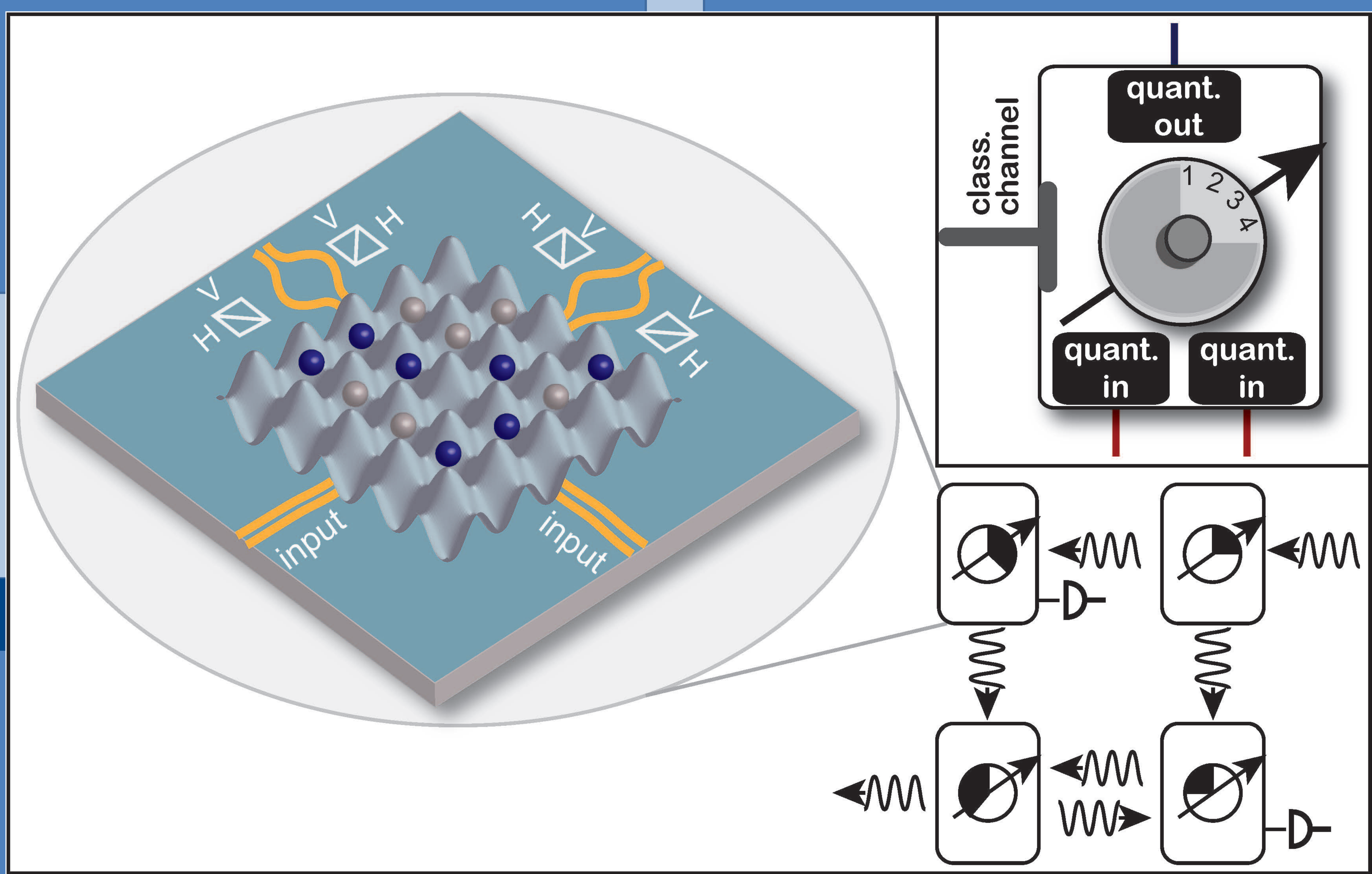
- **Next steps:** create Cs BEC below chip surface

Experiment – Photonics

- design of the chip structure
- characterization of waveguides
- generation of narrow-bandwidth entangled photons
- demonstration and manipulation of photonic entanglement on the chip
- test efficient photonic on-chip detectors



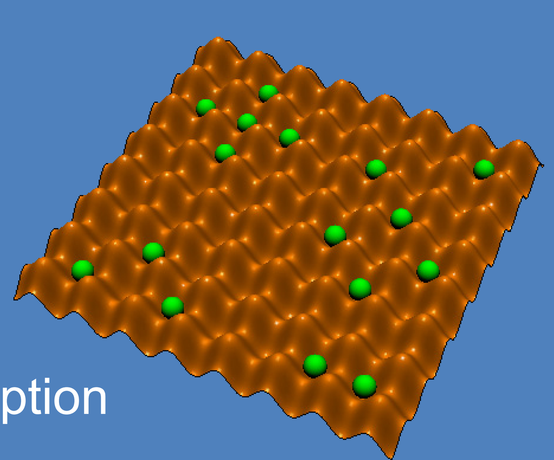
adapted from L. Sansoni *et al.*, Phys. Rev. Lett. **105**, 200503 (2011)



Vision of a complex hybrid light-matter network for quantum information processing based on integrated chip devices. Each device combines the coherent manipulation of a cold atom ensemble in a lattice with single-photon detection and manipulation on an integrated chip. Quantum states of an ensemble of ultracold atoms are mapped onto and controlled by photons guided by integrated waveguides. Schematically such a device has several quantum input/output channels, a classical output channel and an external control field.

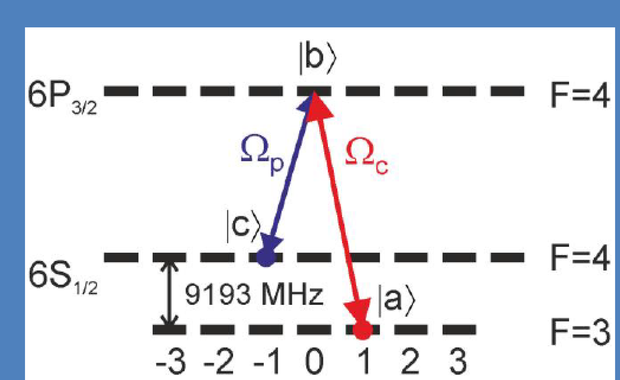
Theory

- atoms in an optical lattice will form the centrepiece of the envisioned hybrid device
- theory groups of I. Lesanovsky (Nottingham) and T. Pohl (Dresden) will
  - quantify storage and retrieval efficiencies of photons (atom-waveguide interface)
  - identify and quantify decoherence sources
  - deliver a theoretical framework for the description of atom chip quantum memories
  - identify mechanisms for non-linear quantum memories and effective photon-photon interactions for quantum gates



Combined setup

- photonic chip constructed in Vienna will be incorporated in the Nottingham experiment
- **Goal:** perform a read-write process with atoms emitted from wave-guide



Photons will be stored in the hyperfine states |a>=|3,1> and |c>=|4,-1> of the 6S1/2 state. Storage and retrieval of the photons is achieved by an appropriate switching of the control and probe lasers (with Rabi frequencies Ω_c and Ω_p).