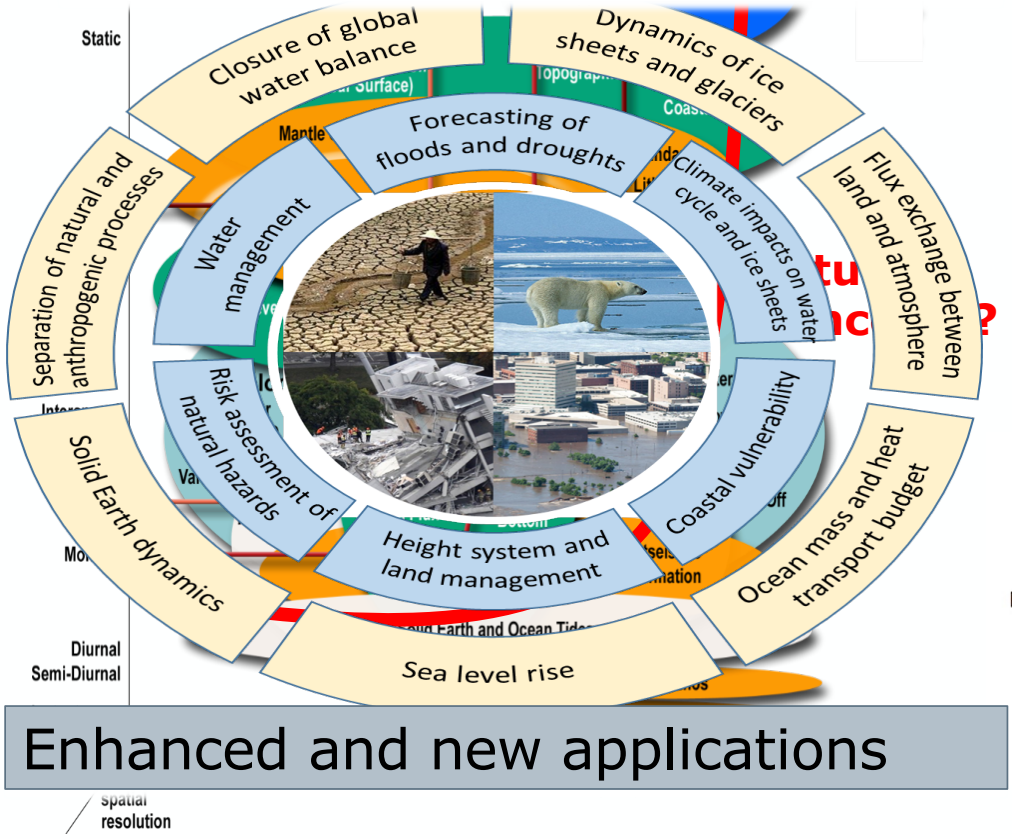
From classical to quantum space gravimetry

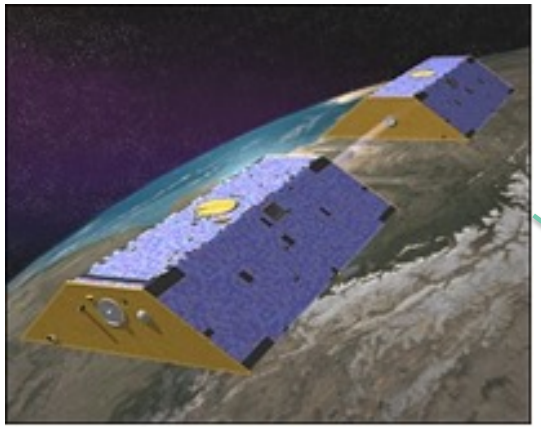
Olivier Carraz, Luca Massotti, Ilias Daras, Roger Haagmans, and Pierluigi Silvestrin

Earth Observation Future needs

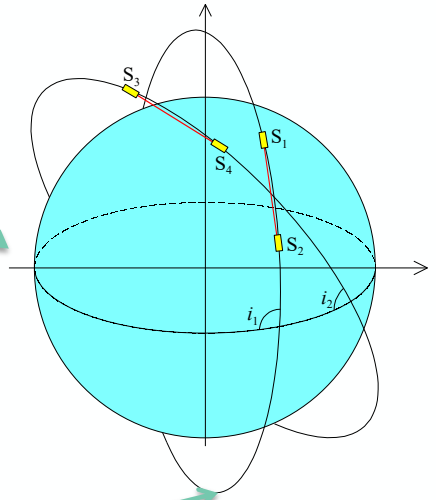
Enhanced and new observations at short and long time scales



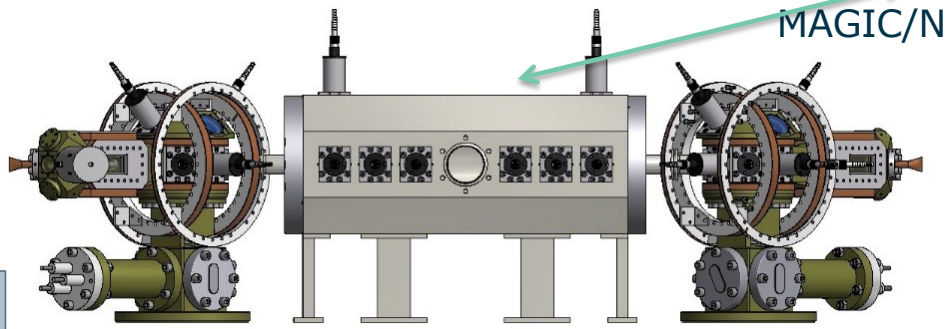
Enhanced and new applications



GRACE FO



MAGIC/NGGM

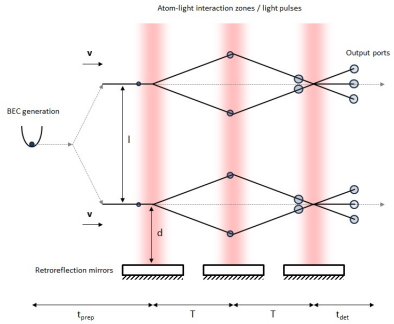


Cold Atom Interferometry

Space Quantum Gravimetry

- Absolute measurements based on fundamental quantum physics
- No drifts, no mechanisms
- In space: long atom interferometry time, but cannot be tested on ground ➔ need in-orbit experiment

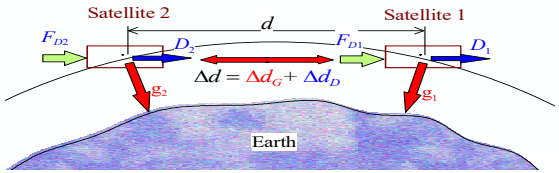
1. Cold Atom Interferometer (CAI) interleaved quantum gravity gradiometer (QGG)

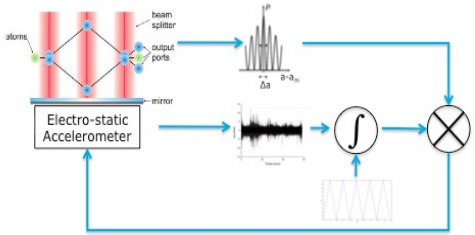


GOCE mission evolution goals:

- one order of magnitude lower error in gradients
- no drag compensation necessary

2. Hybridization classical accelerometers/CAI for SST



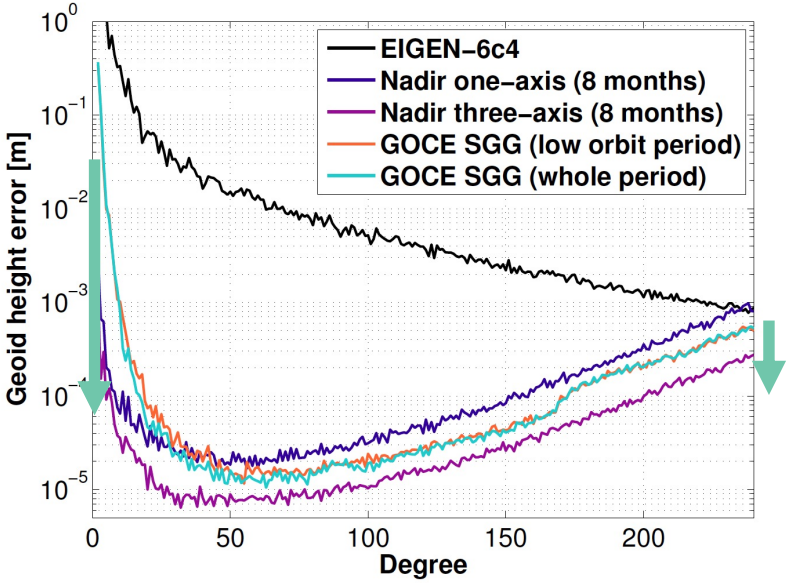


- improve “classical” space accelerometers at low frequencies (no drifts in principle)
- raise ‘hybrid accelerometer’ performance to match that of laser interferometer for much better gravimetry data
- Can be implemented as add-on to existing accelerometer

From classical to quantum gravimetry

1. Cold Atom Interferometer (CAI) interleaved quantum gravity gradiometer (QGG)

- Static field already improved in 8 months mission (Lifetime for GOCE: 3 years)
- Time variable: Needs 1-2 orders magnitude improvement (Sensitivity enhancement, multiple S/C)

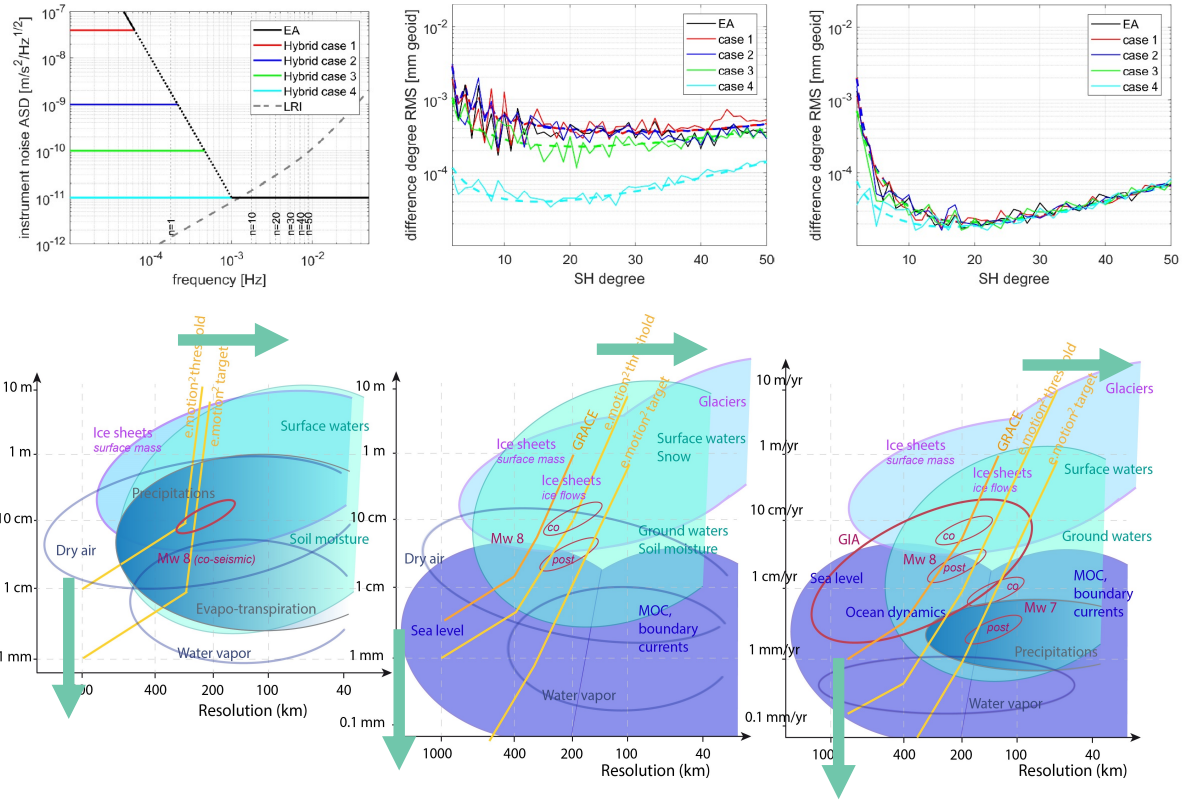


2. Hybridization classical accelerometers/CAI for SST

- Drag compensation relaxation
- Low degree improvement (also in Bender configuration)

GRACE-type

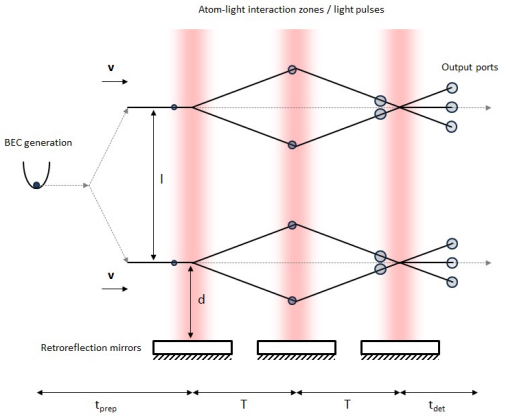
Bender-type



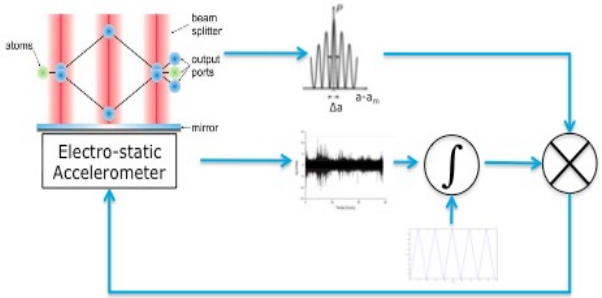
Cold Atom Interferometer (CAI) for EO

Concepts for Earth Geodesy

1. CAI interleaved gravity gradiometer

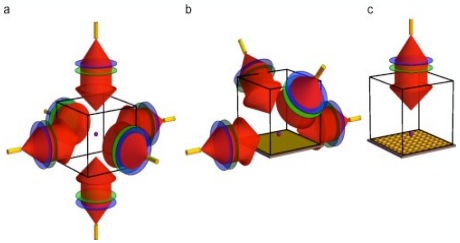


2. Hybridization classical accelerometers/CAI

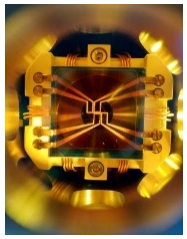


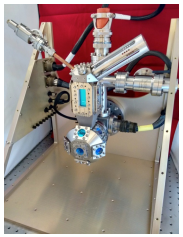
Hardware developments

1. Grating Magneto Optical Trap (MOT)

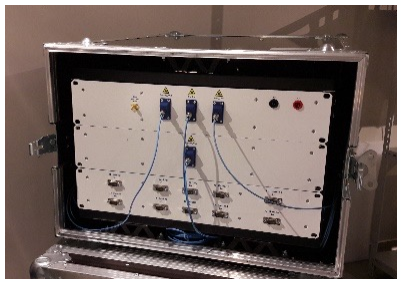


2. Compact Vacuum Chamber for BEC



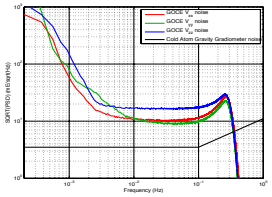


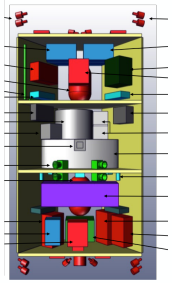
3. Agile and compact laser system for CAI

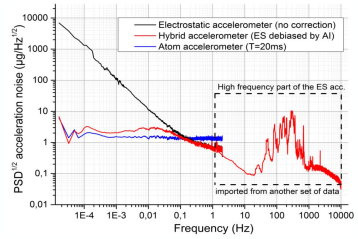


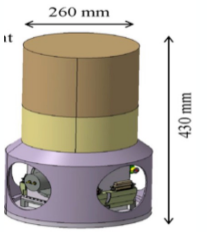
Results

1. Mission and instrument concepts validated



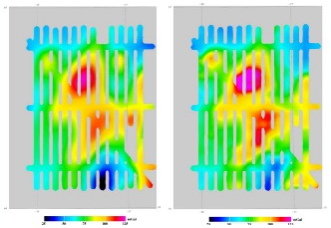


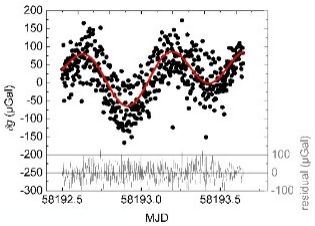




2. On-ground validation

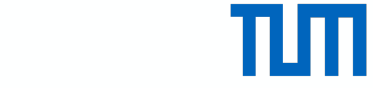
CAI Classical Laser System





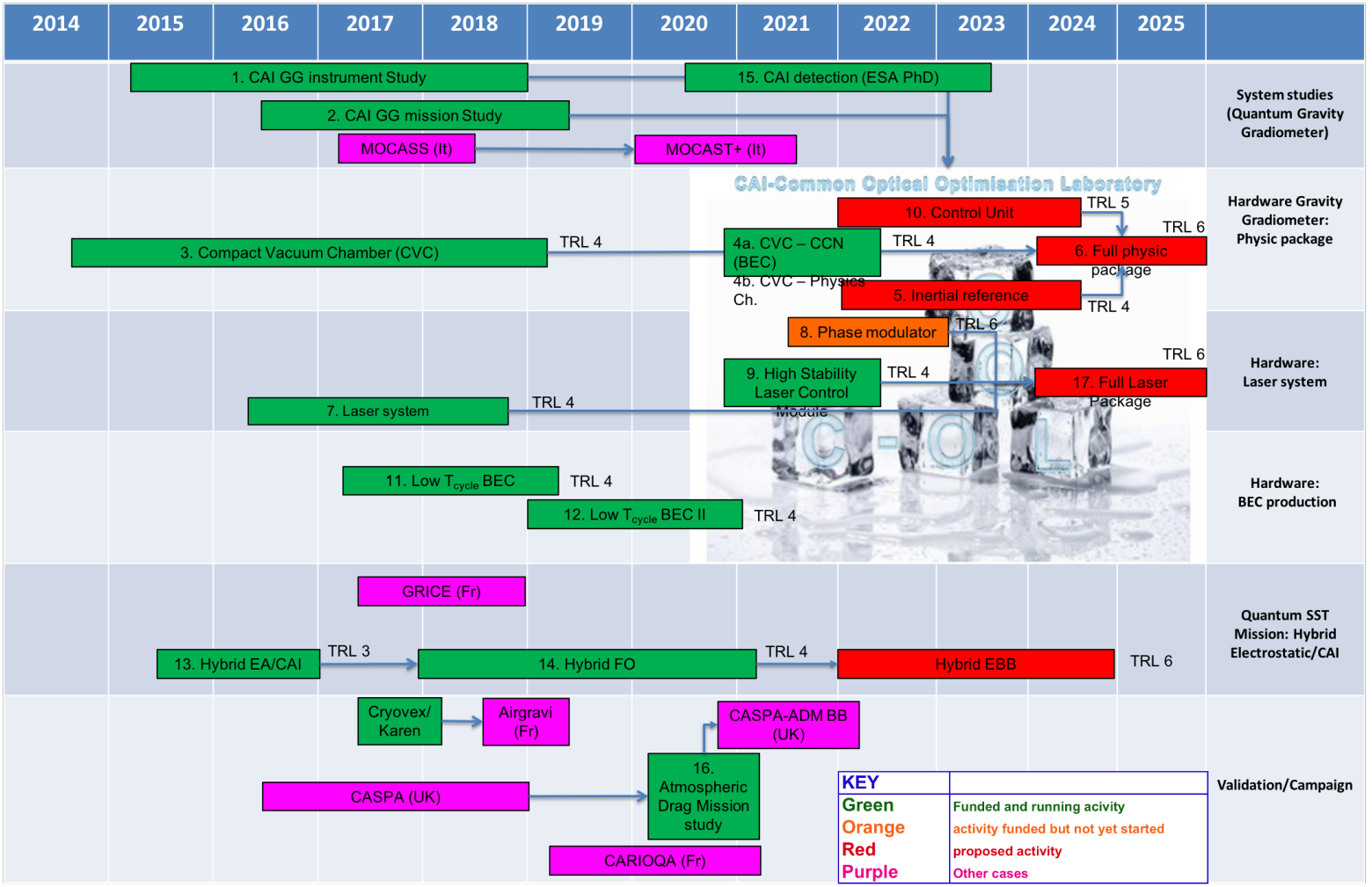
Airborne campaign

Industry and Academic Partners



Preliminary timeline for EBB development

1. Quantum SST: Hybrid concept validated on ground and in airplane. Next step is the development of an EBB (and further of a mission demonstration)
2. Quantum GG: Path toward an EBB by 2025. Some sub-systems need to be developed (modular to any concept).
3. Technology based on BEC generation



Concepts for future missions: first outlook