Collaborations on satellite laser ranging research with Frascati National Labs

Esperimento: MoonLIGHT-2 (CSN2)

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QuantumFuture Research Group

Founded in 2003 and headed by **Paolo Villoresi** at the Dept. of Information Engineering of the UniPD

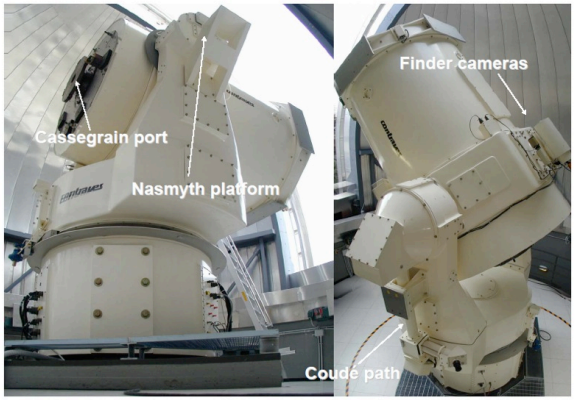
Interdisciplinary expertise: Quantum and Classical Optics, Quantum communications engineering, Quantum Control theory and Quantum Astronomy.

Fundend by Italian Space Agency, European Space Agency, UniPD, and industrial research contracts

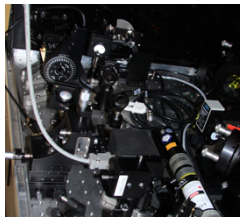
Strategic Res. Project of UniPD 2009-2013 (35 man-years PhD and Assegnisti)

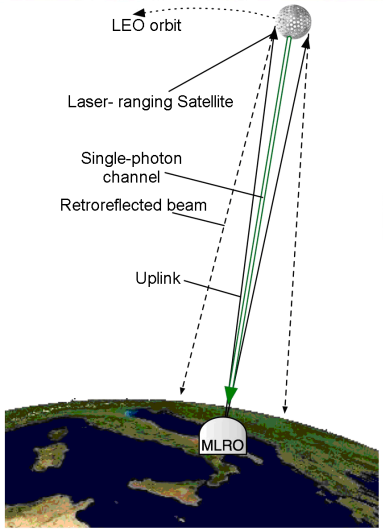
Currently 8 Faculties+6 PhD Students+5 Assegnisti and Post-Docs+ undergraduates

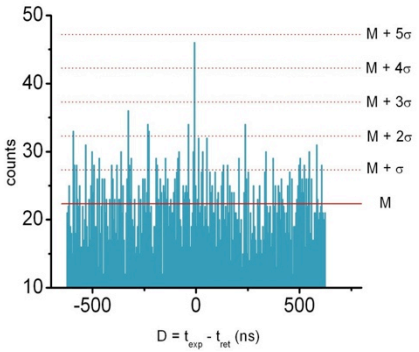
Space QComms timeline

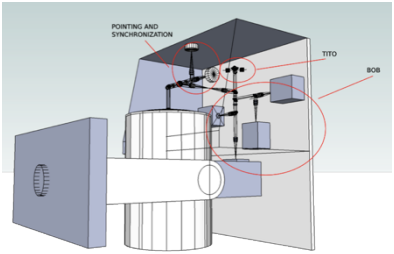


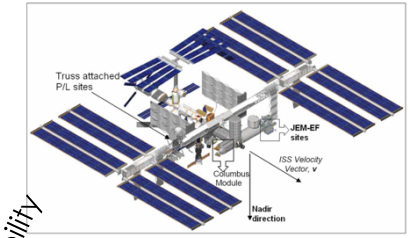
The Matera Laser Ranging Observatory, Italian Space Agency, with its1.5 m telescope an millimeter resolution in SLR located in Matera is our research hub for Space Quantum Communications since 2003.

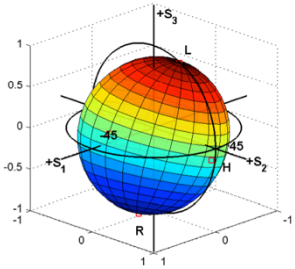


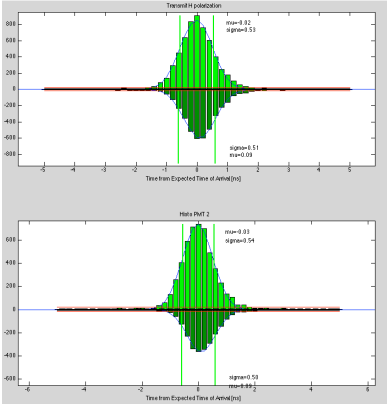












2003 – Research agreement with ASI

Optical front-end, high rep rate laser installed and single photon receiver @ MLRO

Setup for the returns search

2008 – first single-photon return from Ajisai announced

2009 - Feasibility study for a quantum payload for the ISS

Design and test of setup for polarization analysis

Characterization of MLRO Mueller Matrix

2012 - Analysis of response for different satellites CCR

2013 – state preparation, state analysis – satellite synchronization

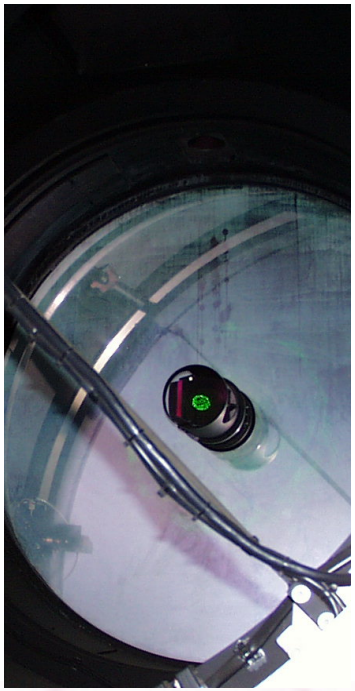
2014 – Q-Comm with different satellites

Multi wavelengths state analyzer

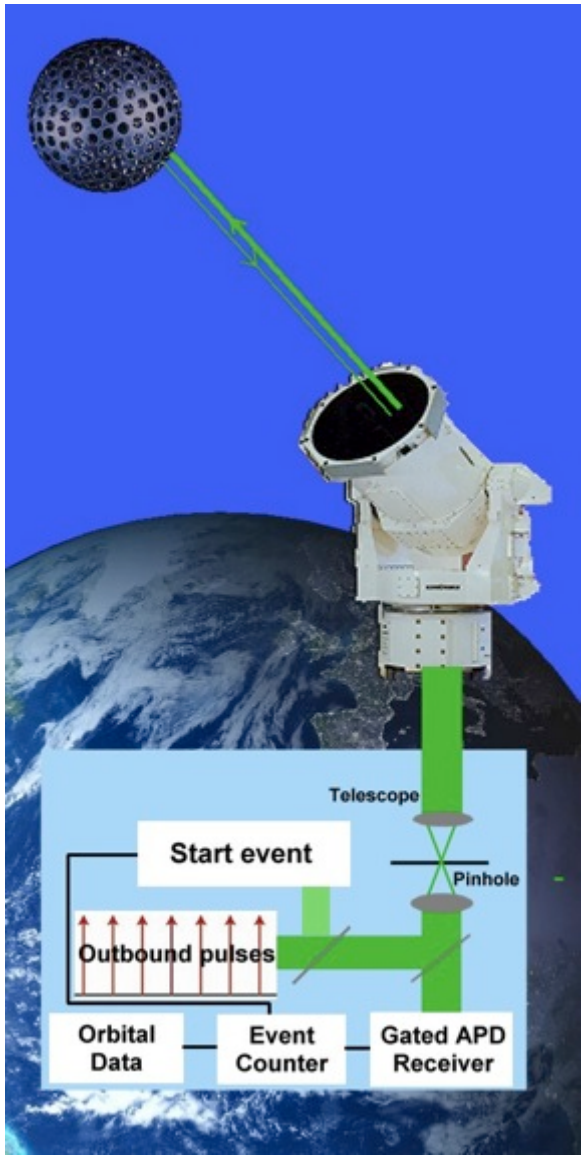
Definition of next generation payload for Q-Comm in Space

Q-Comm with satellites under Scientific collaboration

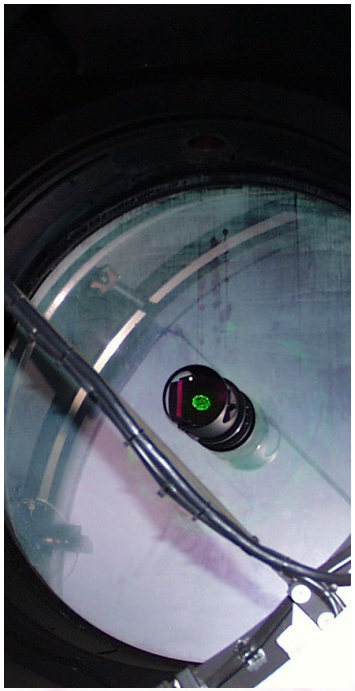
Synergy with the LNF team



- Il Gruppo di ricerca SCF_Lab coordinato da S. Dell'Agnello è attivo da anni nello studio dei retroriflettori spaziali (CCR) per laser ranging. **SCF_Lab group has ~17FTE.**
- QuantumFuture ha utilizzato studiato canali di comunicazione ottica nello Spazio utilizzando CCR dal 2003 presso ASI-MLRO a Matera.



MoonLIGHT-2 @ LNF – CSN2

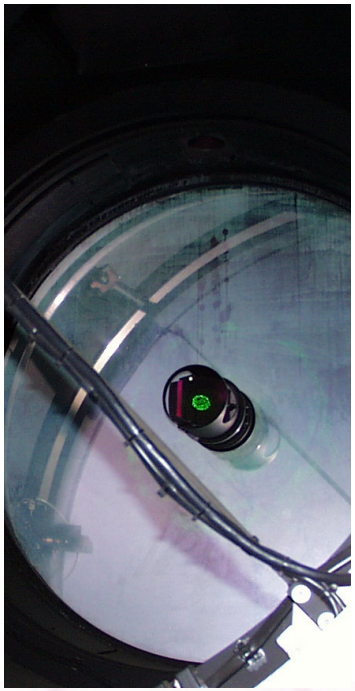


Da Simone Dell'Agnello LNF
Esperimento di test previsione Rel. Gen., esplorazione e Geodesia spaziale

Descrizione contributi gruppo Pd: Studi sistematici sull'influenza della polarizzazione del laser su **Lunar Laser Ranging (LLR)** return, o cosiddetto laser-link budget, per riflettori Apollo, Lunokhod, e MoonLIGHT
Uni-Pd ha esperienza unica della stazione MLRO ed in particolare della gestione della polarizzazione.

1. Studio della polarizzazione ottimale da usare per LLR su MoonLIGHT
2. Campagne misure sperimentali a MLRO del link budget in funzione di varie stati di polarizzazione, con satelliti e la Luna
3. Studi sistematici sull'influenza della durata dell'impulso laser, della scelta dei filtri, della banda; studio dell'effetto della dispersione in lambda per impulsi corti, studio della diffrazione dell'impulso in funzione della durata impulso.
4. *test di ottiche dello SCF_Lab* (e.g. ottiche con aperture CA fino a 200 mm) alle Canarie
5. presa dati LLR a MLRO assieme con INFN-LNF SCF_Lab, Apollo/ Lunokhod adesso e MoonLIGHT dal 2016.

Contribution to MoonLIGHT-2



- Design of optical interface, detectors and synchronized acquisition for polarization analysis in Lunar ranging, 3 months.
- Collaboration in the design and field tests for a modulated retro-reflector, MRR, 2 years.
- Realization and Lab tests of the optical interface, 4 months.
- Experiment on polarization effect on Lunar Ranging – Comparison with targeted satellites; 12 months.
- Design of high performance laser/telescope interface for high accuracy Lunar laser ranging with Moonlight-2, 5 months.

Total duration of the program 24 months.

Participating personnel 4 FTE, request for 1 Post-Doc biannual grant (additional 2 FTE). 2+1 FTE/year + 20% of Paolo Sartori

Total costs:

Equipment (complete optical interface, MRR assembly and FPGAs): 80 k – Polarimeter detectors (5 x 15k€)

Travels to MLRO Matera and the Observatories OGS-JKT at the Canary Islands – including instrument transportation and logistics: 40 k€

Personnel : 24 months of post-doc