

# Applications of time and frequency signals on the fiber

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In the last 10 years, time and frequency transfer techniques over optical fibres have demonstrated results beyond time and frequency community, opening new venues for innovation and science. Coherent laser interferometry over fibre enables to compare optical clocks beyond their accuracy [1].

In Europe, Italy, France, Germany, UK, Check Republic, and Poland developed coherent optical links with hauls even longer than 2000 km. Italy, France, Germany, and UK implemented the first continental optical and microwave clocks comparisons [2, 3], enabling the first demonstrations of chronometric levelling in real filed [2, 4].

In Italy, INRIM realized a multi-purpose research optical fibre infrastructure, the Italian Quantum Backbone, 1850 km long, connecting the main towns and labs all over the country [5]. Coherent frequency and time transfer coexist, the latter uses the White Rabbit technique. INRIM explored the use of laser interferometry over fibre for new applications, not only in time and frequency. We demonstrated the use of ultrastable lasers and T/F methods for geophysics [6], for Earthquakes detection in submarine and terrestrial cables [7]. The use of submarine cables proved the feasibility of intercontinental clock comparisons, and a transatlantic optical link was realized [8]. The dissemination of frequency references via fibre was used in radioastronomy, for better measurements [5], demonstrating also new methods for intercontinental clock comparisons [9]. Last, coherent interferometry and phase noise control demonstrated to be useful in quantum communication, e.g. in effective Twin Field Quantum Key Distribution [10].

Time and Frequency Distribution, Clock Comparisons, Geophysics sensing and geodesy, Quantum communication can be all implemented at the same time on the Italian Quantum Backbone, thanks to its architecture, designed for multiapplication purposes, exploiting both T/F and single photon methods. Indeed, the Italian Quantum Backbone is the core of the QUID (Quantum Italy Deployment), the Italian realization of the initiative European Quantum Communication Infrastructure. At the Symposium, all this results will be shown and the forthcoming perspectives will be presented.



Fig.1. The Italian Quantum Backbone fibre research infrastructure for quantum technologies

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