The Multi-channel High Precision ATLAS SCT Alignment Monitoring System: A Progress Report

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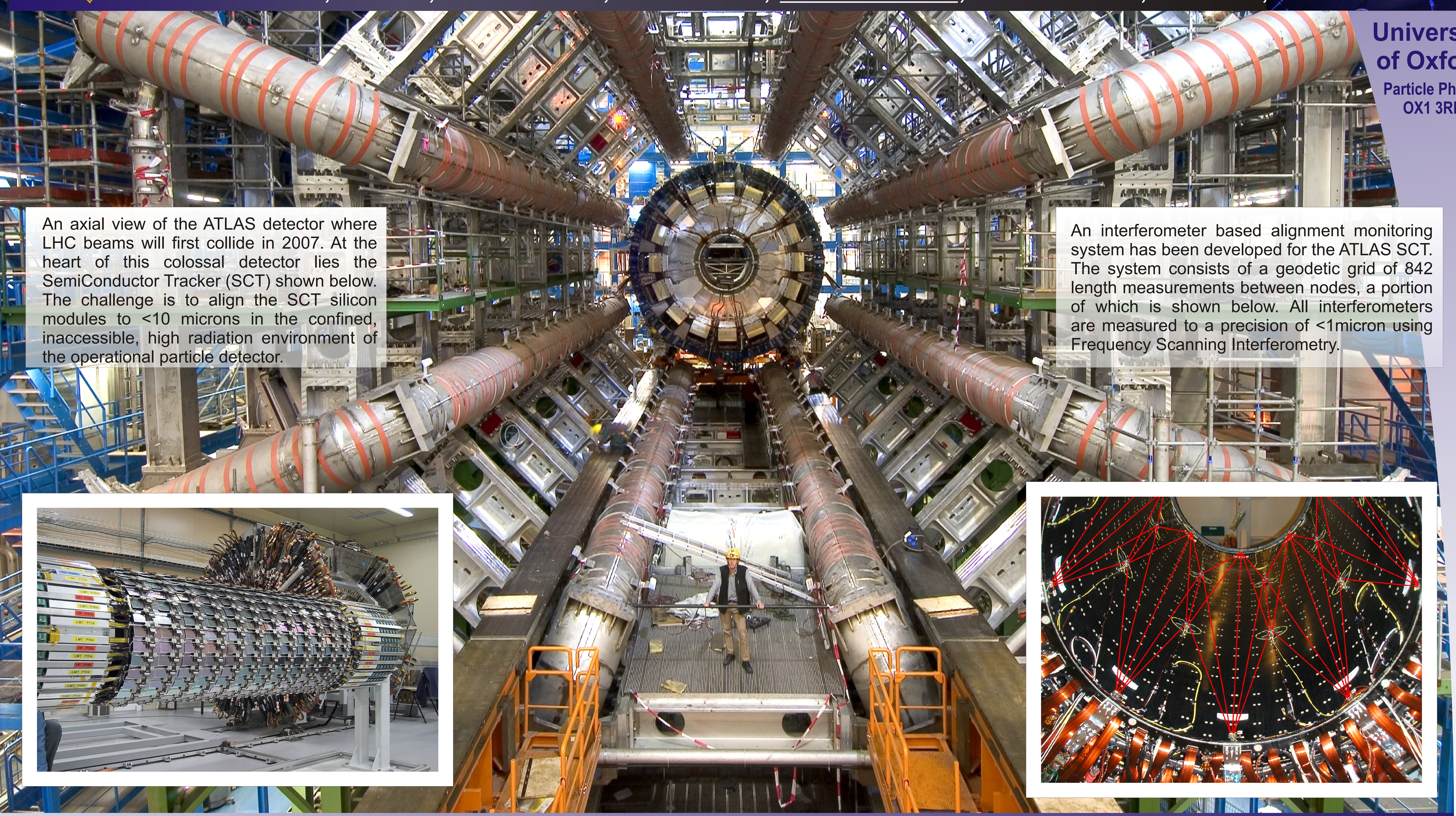
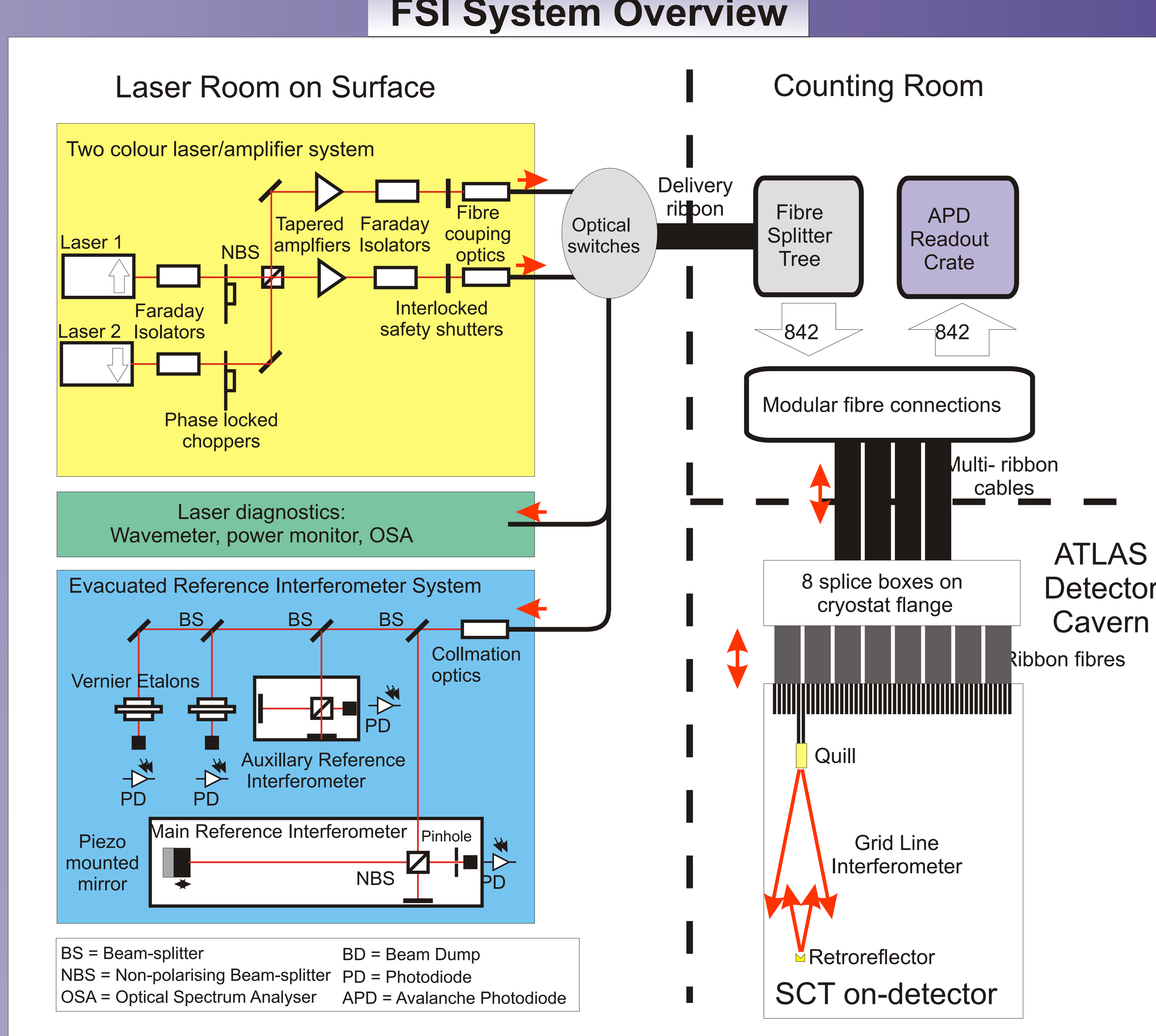


An axial view of the ATLAS detector where LHC beams will first collide in 2007. At the heart of this colossal detector lies the SemiConductor Tracker (SCT) shown below. The challenge is to align the SCT silicon modules to <10 microns in the confined, inaccessible, high radiation environment of the operational particle detector.

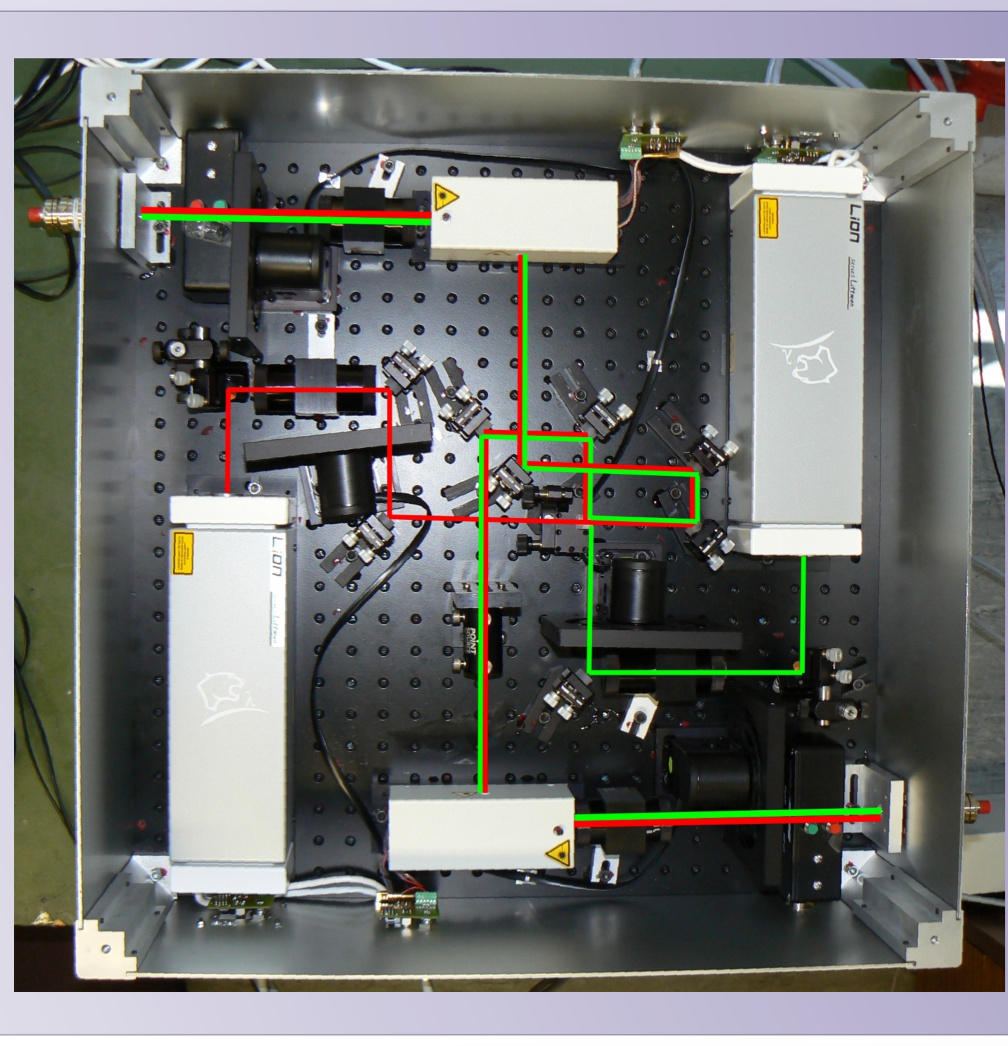
An interferometer based alignment monitoring system has been developed for the ATLAS SCT. The system consists of a geodetic grid of 842 length measurements between nodes, a portion of which is shown below. All interferometers are measured to a precision of <1micron using Frequency Scanning Interferometry.

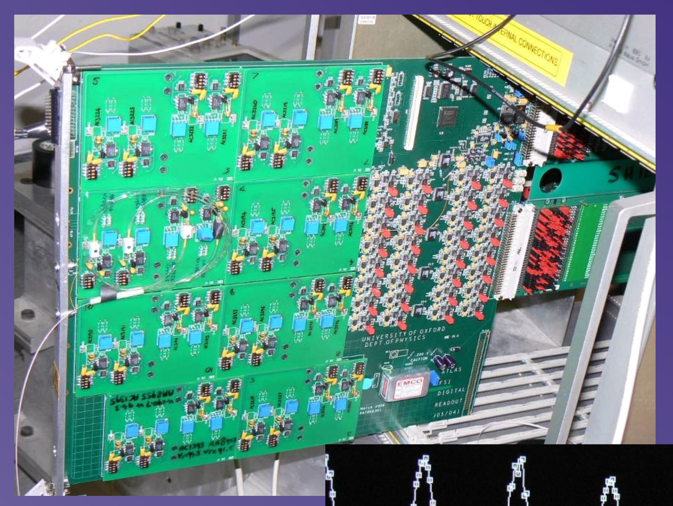
FSI System Overview

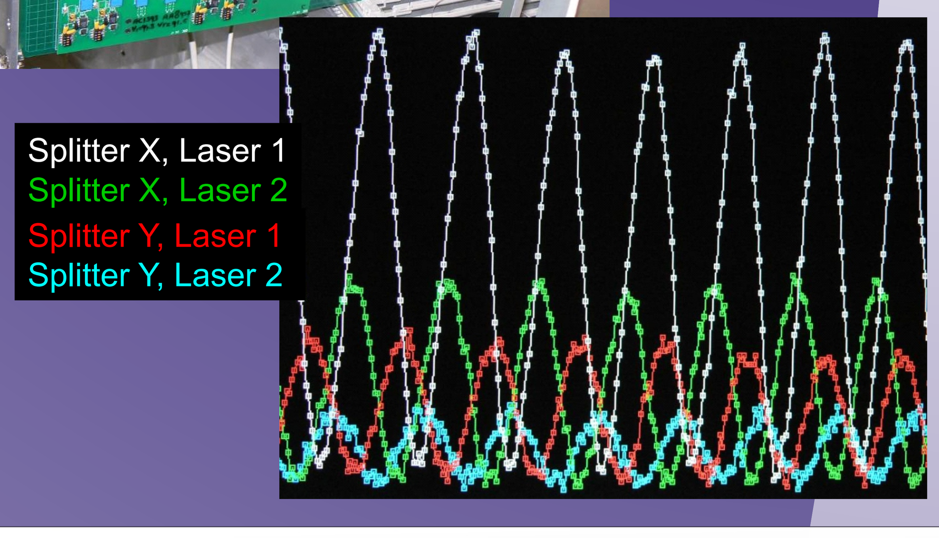
Frequency Scanning Interferometry is a technique for multiple, simultaneous and precise distance measurements in a hostile environment. A tunable laser illuminates a reference interferometer and multiple interferometers to be measured. As the optical frequency is scanned, a phase shift is induced in all interferometers, at a rate that is proportional to the length of each interferometer. The phase shifts are compared to determine the ratio of interferometer lengths to <1ppm.



The Grid Line Interferometers are fibre coupled and use retro-reflectors so they can operate remotely inside ATLAS without the need for adjustment. The GLI design tolerates misalignment by using a divergent beam from a single mode fibre. As a trade off the return signal is only a few pW per mW of input power. All GLIs are now installed and developments are in progress for the off-detector lasers, diagnostic and read-out system.

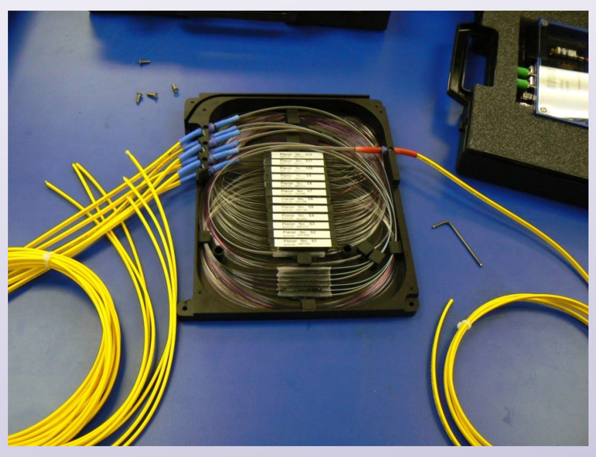


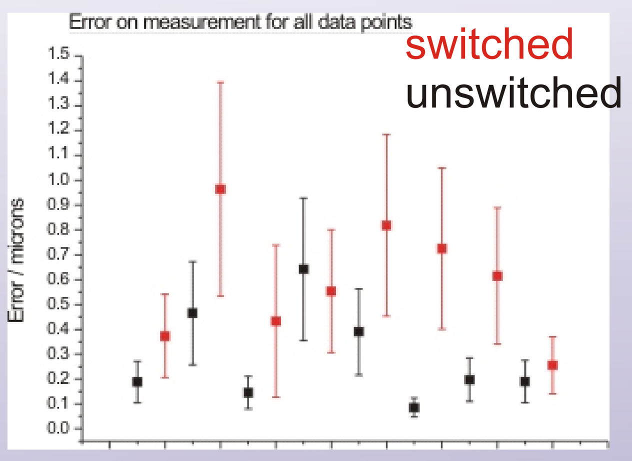




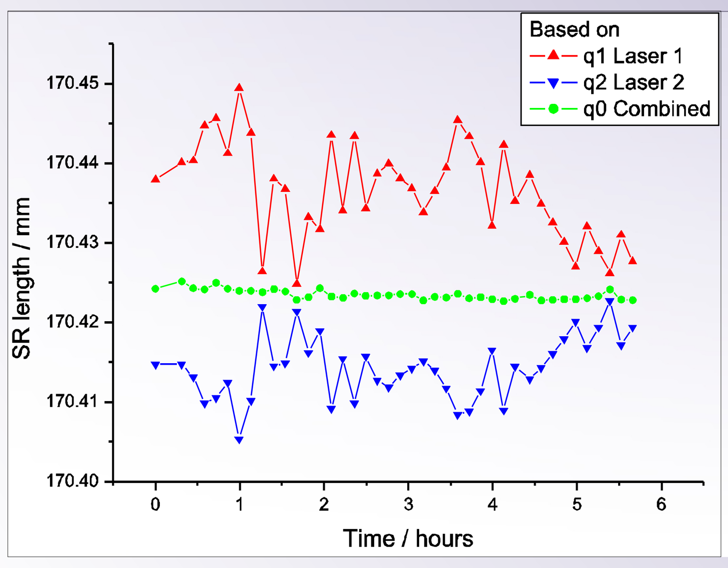
The laser light is conveyed to the GLIs via a fibre-splitter-tree of fused taped couplers. Recently available IR MEMs optical fibre switches enable the optical power delivered to the GLIs to be cost-effectively doubled. Tests in Oxford show precise FSI measurements using an active optical switch are possible, as plotted below.

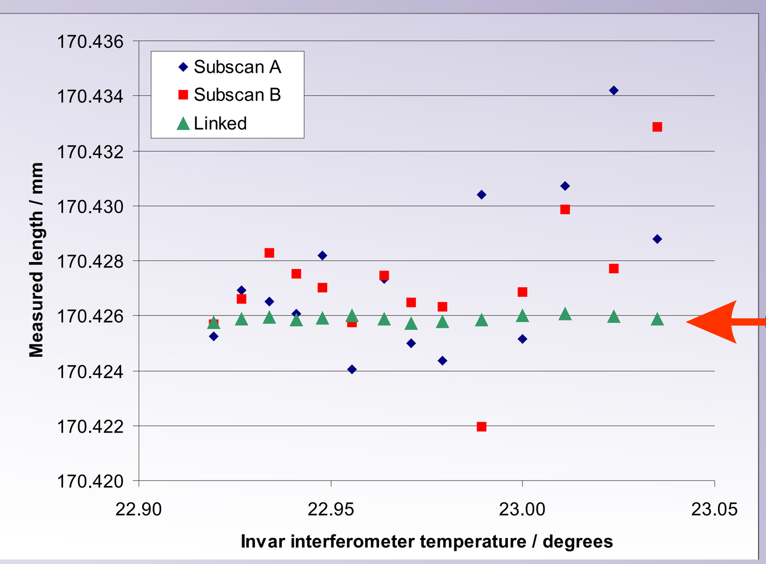
The above two-colour laser-amplier system illuminates all 842 interferometers. The two lasers are tuned in opposite directions to reduce the effects of drift in the interferometer length during a frequency scan, as shown in the plot below. The remaining error in the phase measurement is minimised by rapid scans and by scanning over a large frequency range. A precision of <100nm has already been achieved with this system.





A multi-channel read-out system has been developed that uses sensitive avalanche photo-diodes (APDs) to detect the pW return signals. A series of 9U VME cards shown above each read out 64 fibre-coupled interferometers. The read-out is multiplexed so that signals from two optical switched interferometers reach one APD in alternate time slots. The plot shows four intensity signals for the two lasers and two GLIs that were read out successfully by one APD as the optical frequency was scanned.





σ=96nm precision

References:
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