Almost half a century in the making, the ‘Gravity Probe B’ space mission got within a month of launch late last year, only to be delayed again for repairs to its super-sensitive navigation system. When it is eventually launched, it will be measuring not stars or planets or even radiation in space, but the very fabric of space-time.

Called a “relativity gyroscope experiment” and developed by NASA and Stanford University, it will test two unverified predictions of Albert Einstein's general theory of relativity about “gravitomagnetism” and the “geodetic effect”. The probe’s super-cooled gyroscopes will measure how space and time are warped by the presence of the Earth, and how the Earth's rotation drags space-time around with it. These tiny effects require unprecedented precision because they are so small near Earth – but if verified (or more exciting, if NOT verified), they have profound implications for the nature of matter and the structure of the Universe.

Using a space gyroscope for this purpose was first proposed in 1959, and in 1971 NASA began engineering studies of the required technology. The precision was so far beyond available state-of-the-art that decades were spent building and testing prototypes (including a sub-orbital ‘Gravity Probe A’ mission in 1976). Over the years, Stanford University awarded 72 Doctorates and 20 other degrees for research on how to build and utilize such a probe.

Developing a reference platform against which the relativistic ‘drift’ would be detectable was literally an astronomical challenge. It wasn’t enough to select any random ‘guide star’ for the craft’s star tracker to observe. The problem was, astronomers didn’t know the angular position of any star to the accuracy needed to differentiate a true signal from background noise.

From its polar orbit, Gravity Probe B will lock on to the star IM Pegasi, which is barely bright enough to be visible to the naked eye under perfect observing conditions. But it has the immense invisible advantage that it’s a significant microwave emitter. This makes it possible to use very-long-baseline interferometry (VLBI) to plot its position in relation to some nearby quasars. Every few months over the last six years, astronomers have used the radio antenna arrays and dishes around the world to measure the star’s shifting position relative to two quasars. Analysis of these observations will allow determination of the star’s proper motion to an accuracy of about 0.1 milliarcseconds per year, which is comparable to the intended accuracy of the measurement of the mean rate of change of the gyro spin directions with respect to IM Pegasi. Combined, these measurements will determine the relativistic effects with respect to the distant universe.