Long Term Inclinometer Monitoring – An Update

D. Martin
ESRF, Grenoble, BP 220, Grenoble, F-38043, France

Although Hydrostatic Levelling Systems are remarkably precise, certain applications may be better served using high precision bi-axial inclinometers. Two years ago at the last IWAA held at CERN, results of tests made with two inclinometer systems, the Leica Level 20 and the Wyler Zeromatic 2/2 were presented[1]. Since January 2004 the Leica Level 20 inclinometer has been installed in the ESRF Storage Ring (SR) tunnel gathering data. Since January 2005 the Wyler Zeromatic 2/2 has also been installed in the ESRF SR tunnel. This paper will give an update of the performance of these instruments under real accelerator operating conditions.

1. INTRODUCTION

In a classical setup such as at the ESRF, a magnet support girder is equipped with three hydrostatic leveling system (HLS) sensors. This permits the measure of three degrees of freedom, the two tilts, pitch and roll, and the height with respect to another HLS or a reference. A dual axis inclinometer can replace two of these HLS sensors.

The most sensitive direction to tilt errors, at least at the ESRF, is across the magnet support in the radial direction. This is commonly referred to as the roll of the magnet support. Taking advantage of the very short lever arm and the inclinometer angle precision, the roll of these supports, which are generally long and narrow, can be measured more accurately by a precise inclinometer than by an HLS. Naturally, the accuracy in the other direction (i.e. the pitch) is reduced with respect to that of the HLS. Nonetheless, this may be acceptable for most applications (Table 1).

Table 1 The main interest in using bi-axial inclinometers is: first to replace two HLS sensors by one instrument and second to increase precision in the determination of roll error

	Separation Distance		
	2 m	1 m	0.5 m
HLS with resolution of 1 µm	1 µm or ½ µradian	1 µm or 1 µradian	1 µm or 2 µradian
Inclinometer with a resolution of 1 µradian	2 µm or 1 µradian	1 µm or 1 µradian	½ µm or 1 µradian

2. RESULTS AND DISCUSSION

The HLS, the Wyler Zeromatic 2/2, the HLS system and the independent tilt and tilts derived from leveling all agree remarkably well over the full study period for the G20 Radial Tilt (Roll) and G20 Longitudinal Tilt (Pitch). (see Figure 1 and Figure 2 below) The Leica Level 20 inclinometers agree less well with the HLS installed on the G10 and G30 girders. The independent tilt and leveling measurements tend to follow more closely the HLS. One has the impression there is a slightly non-linear response of the Leica Level 20 on G10 girder while there appears to be a simple offset error on the G30 girder. These errors could possibly be calibrated and corrected for. Maximum differences are in the order of 20 micro-radians or roughly 60 µm for the pitch and less than 10 µm for the roll.

3. CONCLUSIONS

Tests over a 20 month period under real accelerator operating conditions have shown that high precision inclinometers such as the Leica Level 20 or the Wyler Zeromatic 2/2 can be used to measure magnet support tilts reliably with the same order of magnitude precision as the most precise HLS systems thus providing an alternative level sensing system.

References

1. Martin, D. Inclinometer Comparison in Eighth International Workshop on Accelerator Alignment. 2004. CERN, Geneva Switzerland.

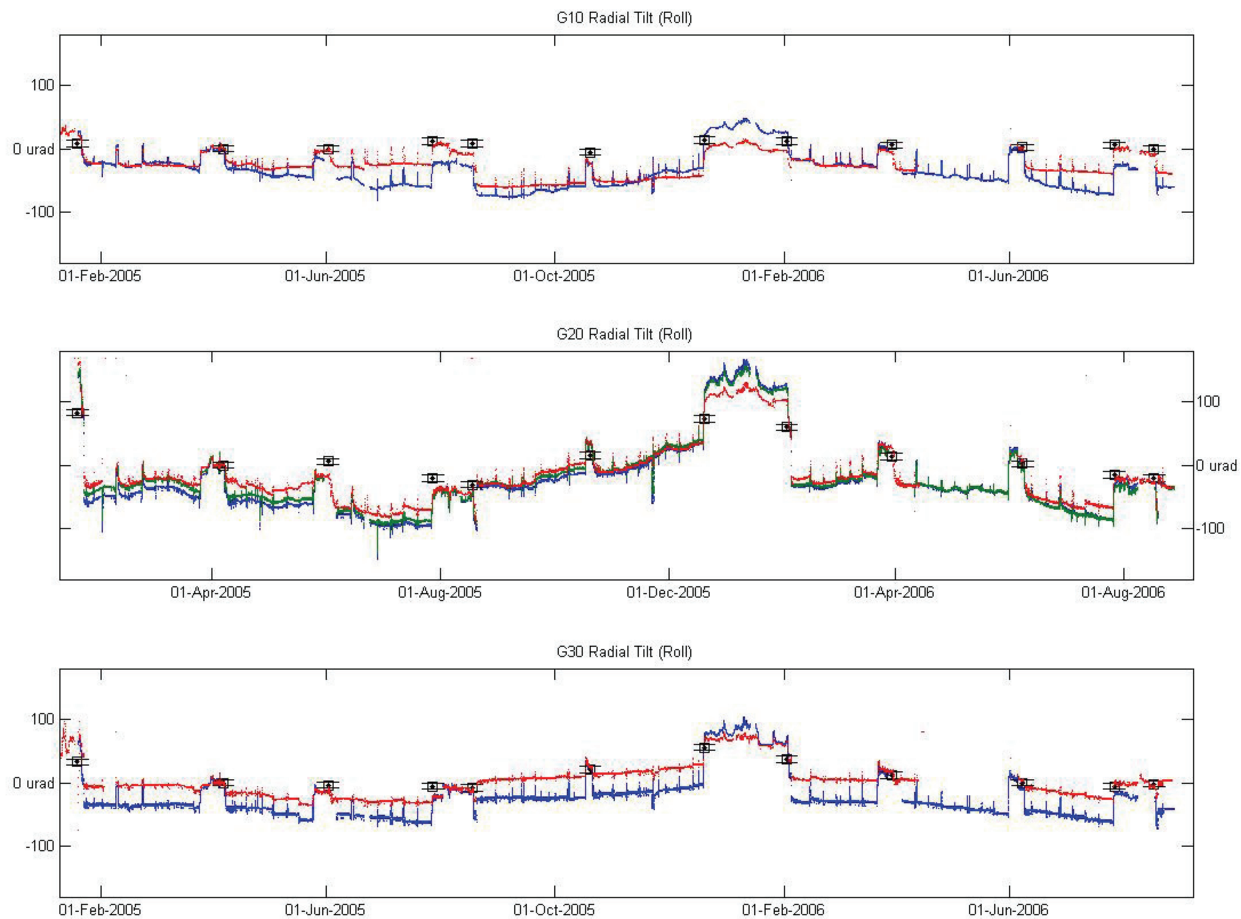

Figure 1 This graph presents the roll of three ESRF girders observed by the Leica Level 20 inclinometer (in blue), the Wyler Zeromatic 2/2 inclinometer (in green - for the G20 middle graph only) and an ESRF HLS system (in red). Punctual independent tilt measurement and their uncertainties (represented as error bars) are also shown.

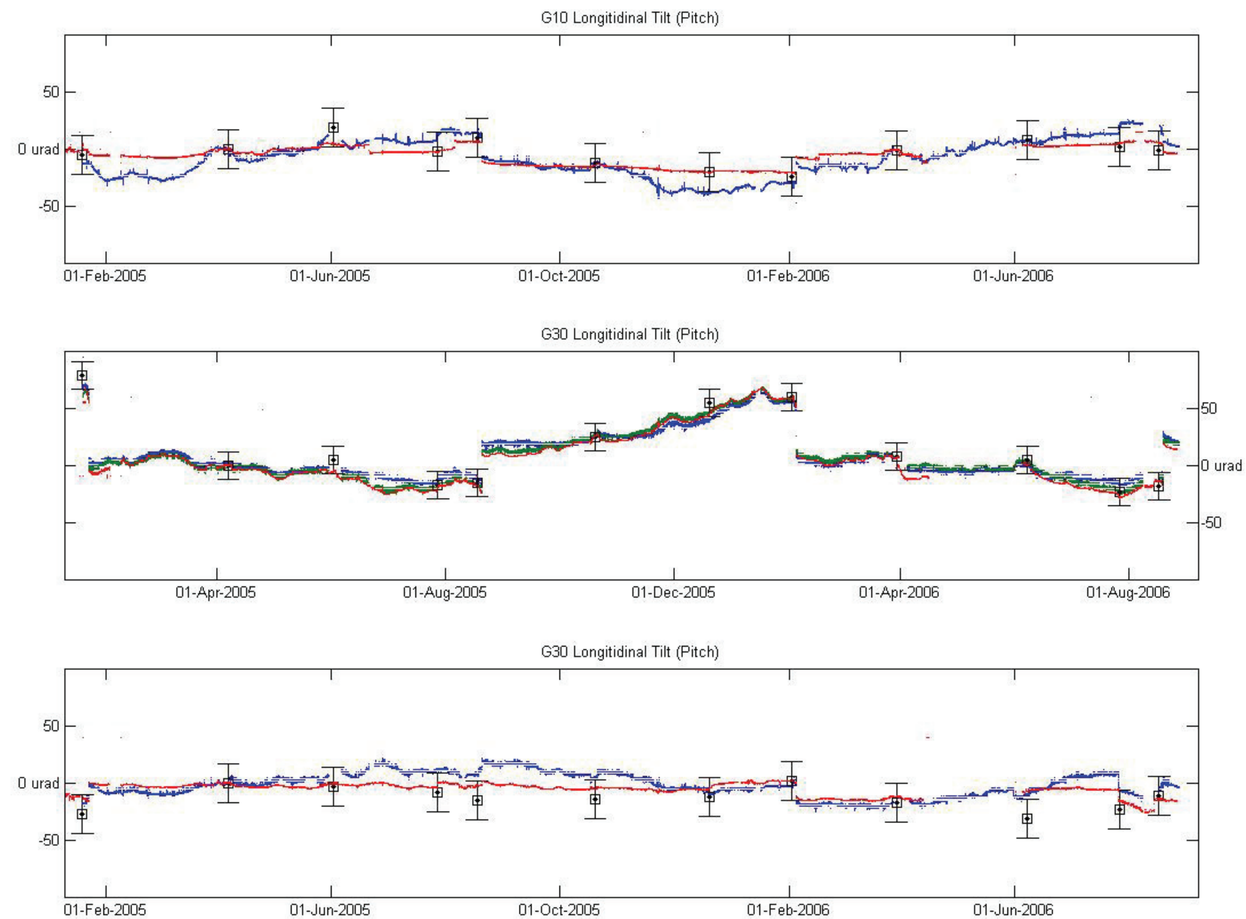

Figure 2 This graph presents the pitch of three ESRF girders observed by the Leica Level 20 inclinometer (in blue), the Wyler Zeromatic 2/2 inclinometer (in green- for the G20 middle graph only) and an ESRF HLS system (in red). Punctual independent tilts and their uncertainties (represented as error bars) as determined by levelling are also shown.