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SUB-CM Ranging and other improvements in Graz

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1.0 Introduction

A lot of tests and experiments have been made in Graz during the last 2 years to increase performance and accuracy; using the SPAD from the Prag group as receiver, we have reached now about 5 mm RMS from the calibration target, and about 8 mm RMS from ERS1 and STARLETTE. In addition, routinely using the semitrain, the number of returns has been increased significantly for most satellites.

2.0 Experiments

In January 1991, together with the Prague group, we installed their streak camera as a receiver in the Graz laser telescope, and first echoes from AJISAI and STARLETTE could be recorded.

In December 1991, again together with the Prague colleagues, 2-color ranging experiments were performed, using Raman upshifted red (683 nm) and 532 nm wavelengths; returns of both colors from AJISAI and LAGEOS could be recorded. A detailed description of both experiments is given elsewhere in these proceedings.

3.0 Accuracy Improvements

As stated already during the Matera workshop, the contribution of the SPAD itself to the overall jitter can be decreased by using higher voltages above break (Vab). Modifications of the original SPAD electronics now allow us to increase this Vab to more than 10 V, resulting in a jitter of 5 mm RMS (fig. 1) from the calibration target. In this test, we used an SR620 counter, which also contributes to the lower RMS (the start input of the SR620 handles the output of the start Optoswitch significantly better than our HP5370A).

The well known disadvantage of the high Vab is the increase in noise; while a standard SPAD at 2.5 Vab at room temperature has an acceptable noise of about 200 kHz or less, this increases at 10 Vab to about 1 MHz (fig. 2). To reduce this, we cool the SPAD now with Peltiers to -25°C, reaching again about 200 kHz noise.

Short before the workshop, we had 4 different counters available for test purposes at the SLR Graz: HP5370A, HP5370B, and 2 SR620. The RMS values of these specific instruments are listed in table 1; RMS 1 is measured with asynchronous, random pulses, as it is the case during satellite ranging; RMS 2 is measured with pulses synchronous to the internal frequencies, and is listed here only for completeness.

	RMS 1	RMS 2	Remarks
HP 5370A	22 ps	10 ps	Our standard counter for SLR
HP 5370B	40 ps	12 ps	Available for tests
SR620/1	21 ps	8 ps	Our future counter for SLR
SR620/2	20 ps	8 ps	Same type, available for tests

Table 1: Counter Comparison

Using these counters in our station for calibration tests, we got the results shown in fig. 3. We measured all counters with "good alignment" (the returns focussed as good as possible on the center of the SPAD) and "weak alignment" (focussing of the returns on the SPAD far from optimum). It can be seen that good SPAD alignment (together with optimizing all start/stop input pulse rise times, pulse forms, trigger thresholds etc.) is of the same importance than selecting the proper counter.

4.0 Routine use of the Semitrain

Since summer 1991, we routinely use the second half of the pulse train (semitrain), delivered from our Nd:YAG laser, for all SLR measurements. The software has been modified to allow for automatic "folding" of the returns. Fig. 5 shows an example pass of LAGEOS, with totally 7 tracks (or pulses from the semitrain) identified later by the software.

By using all returns from the semitrain, the number of returns for most satellites could be increased significantly (fig. 6); for LAGEOS the increase in returns is more than 50%; for the ETALON's, it is more than doubled.

5.0 Acousto-Optic Modelocker

In February 1992, we installed an Acousto-Optic Modelocker in our old Nd:YAG laser oscillator, inceasing reliability and shot-to-shot reproducibility of the laser pulses. Besides increasing the number of valid shots from our previous average of about 70% (it was an old, purely passiv modelocked oscillator!) to more than 99%, the much better stability of the pulses had a noticeable effect on the jitter (Fig. 4); the routine cal. values showed better stability and even slightly lower RMS (the AO-Modelocker was installed after calibration number 98, in fig. 4).

The AO-Modelocker requires temperature stabilization; this is done by slighly heating it to 27°, using the hot side of Peltier elements; the cold side of these elements is used at the same time to cool the Dye Cell to about 10°, which should result in a longer lifetime of the Dye. Results are promising (we used the same dye from February to May), but still have to be verified during the next years.

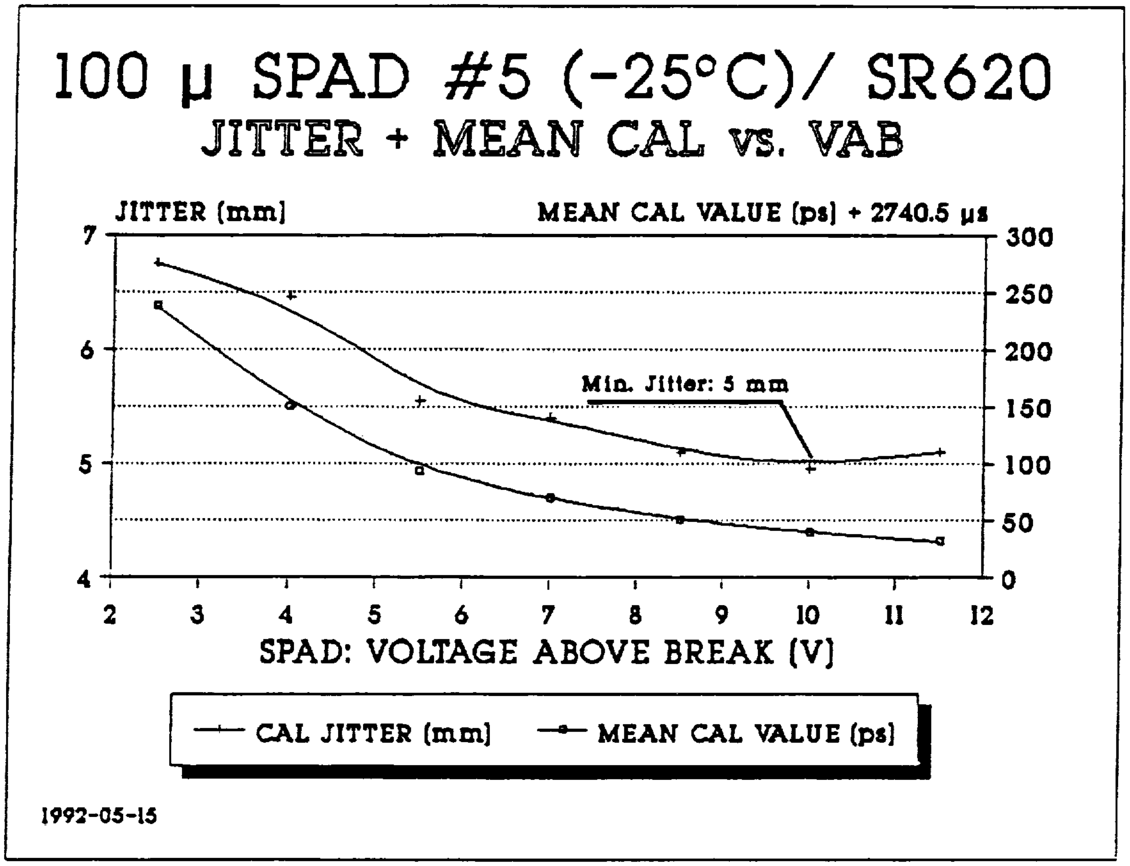

Figure 1: Minimum Jitter from Target is about 5 mm

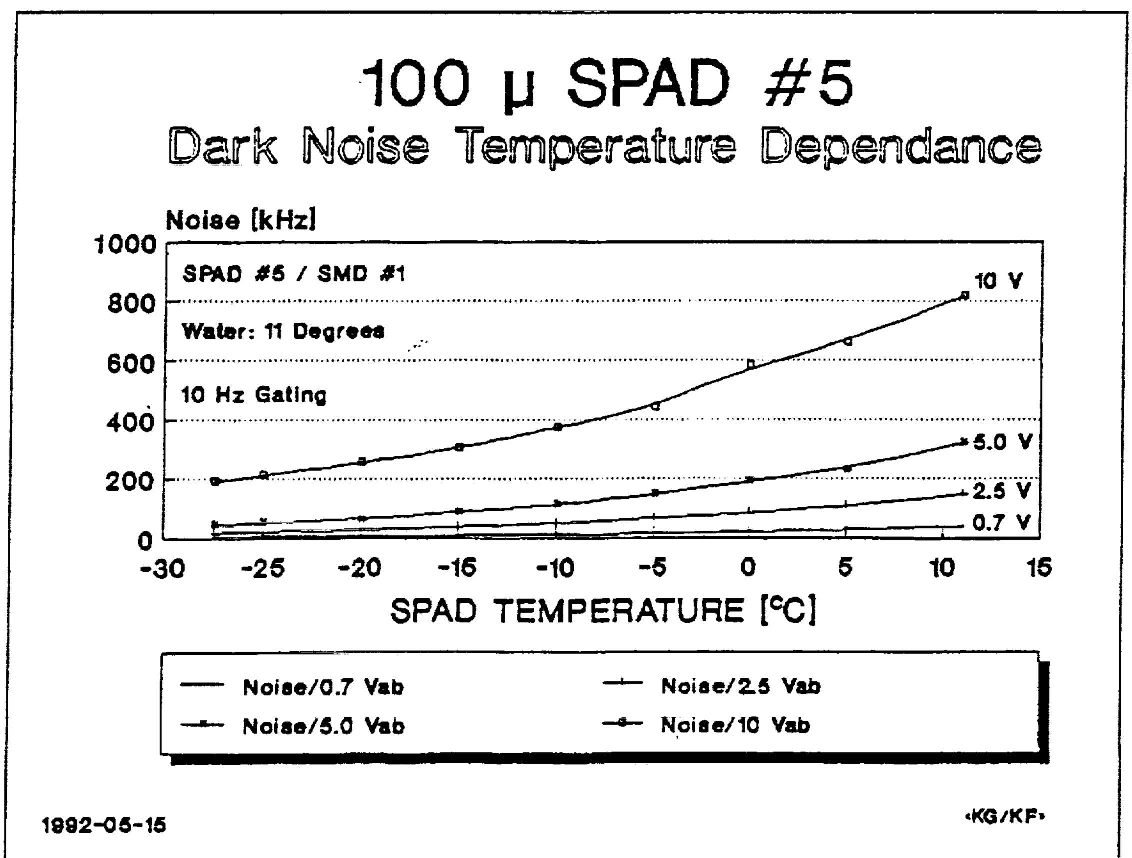

Figure 2: Noise depends on Voltage above break and temperature

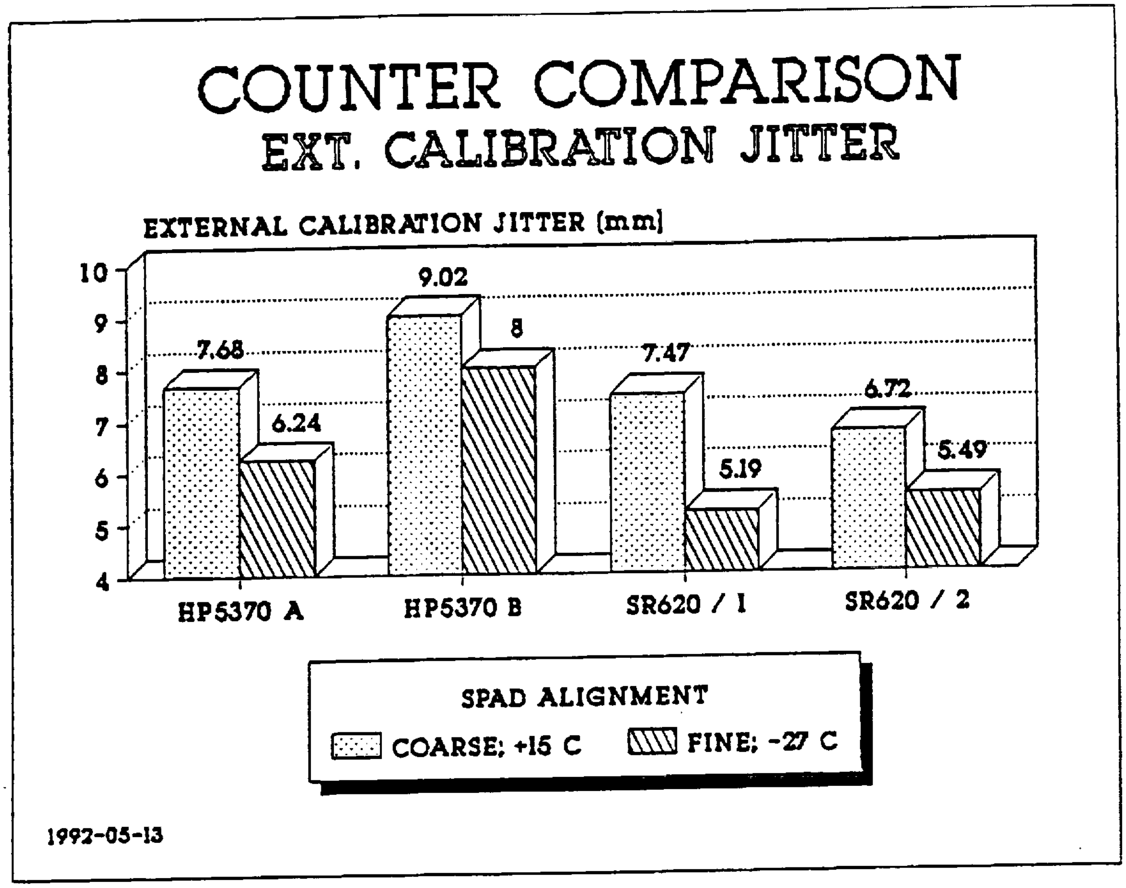

Figure 3: Calibration with different counters and alignments

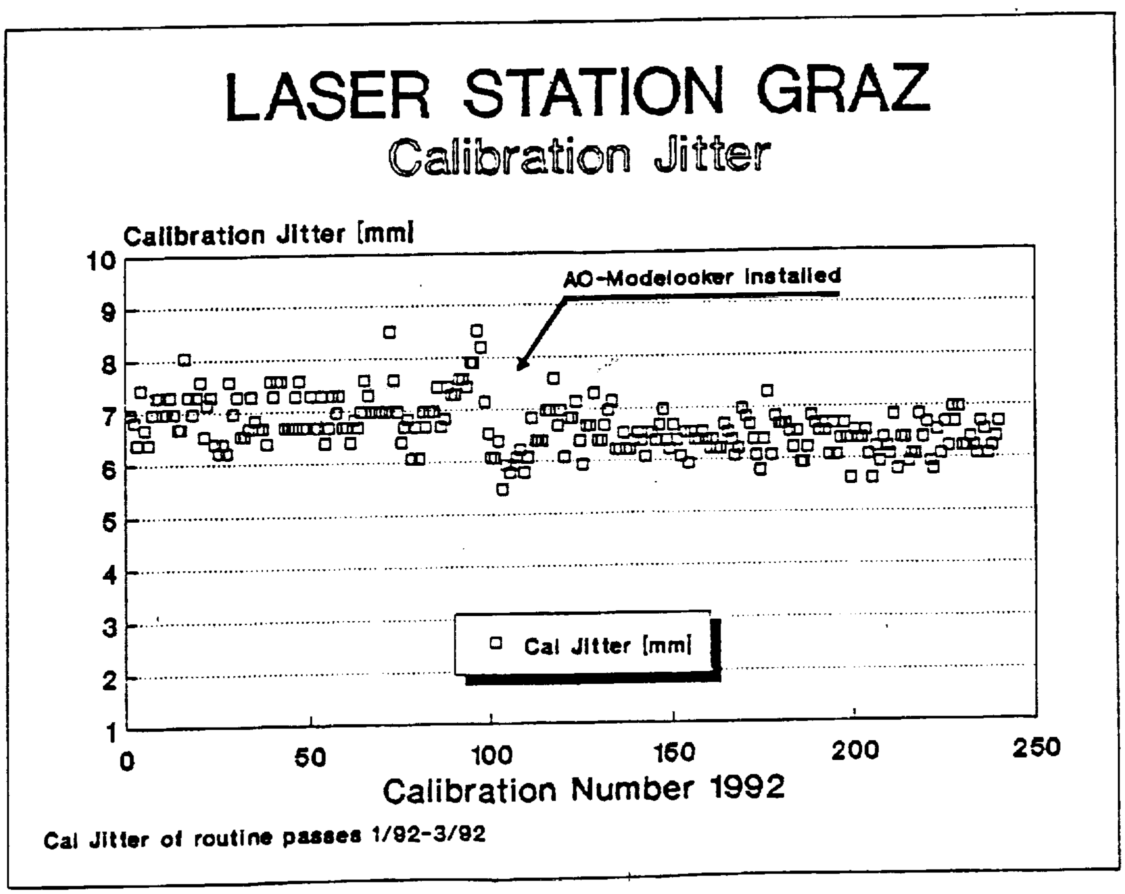

Figure 4: Effect of Acousto-Optic Modelocker on Cal stability

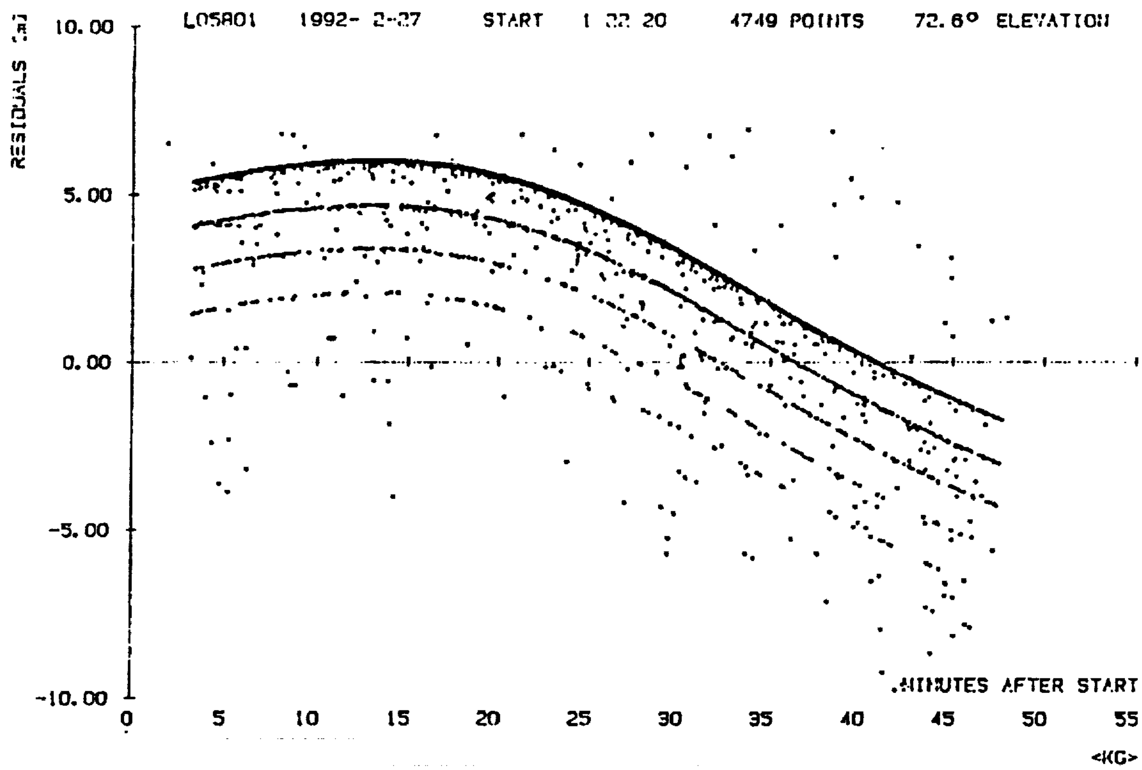

Figure 5: Typical LAGEOS pass, with semitrain returns

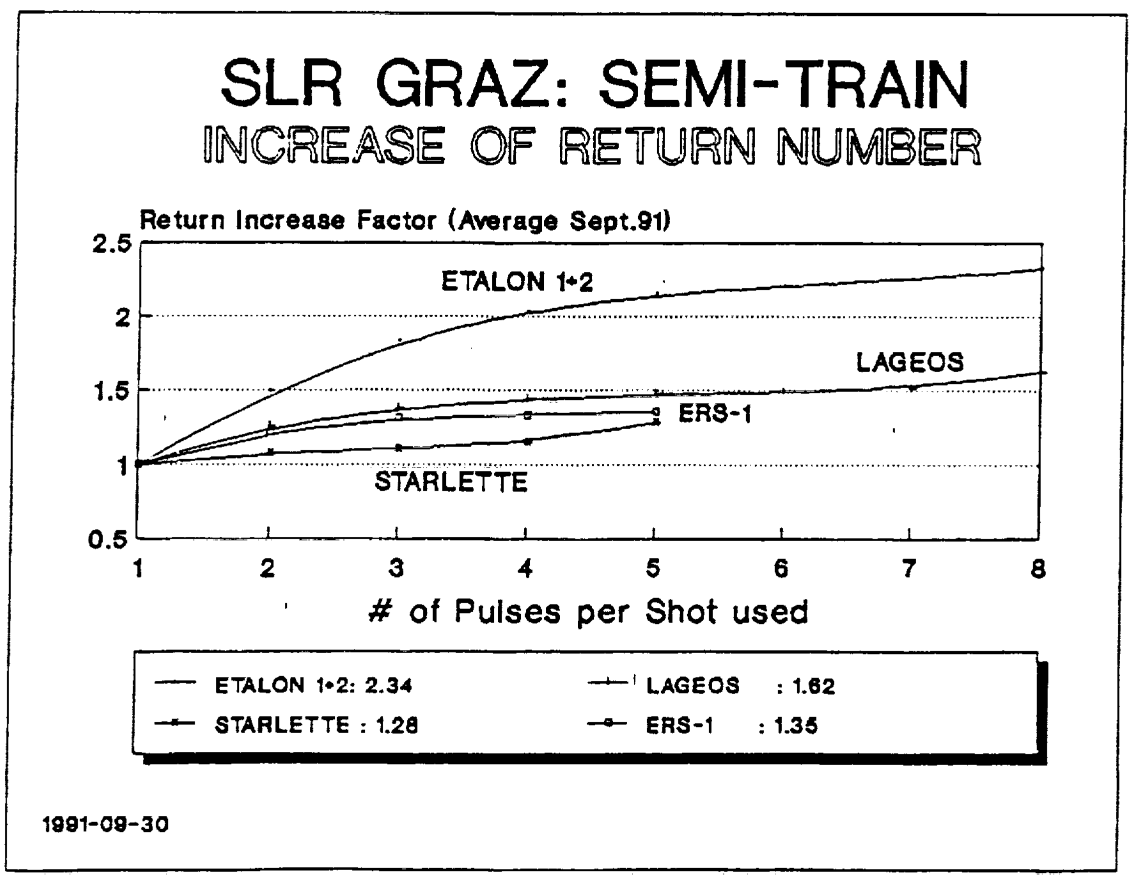

Figure 6: Increase of return number with semitrain