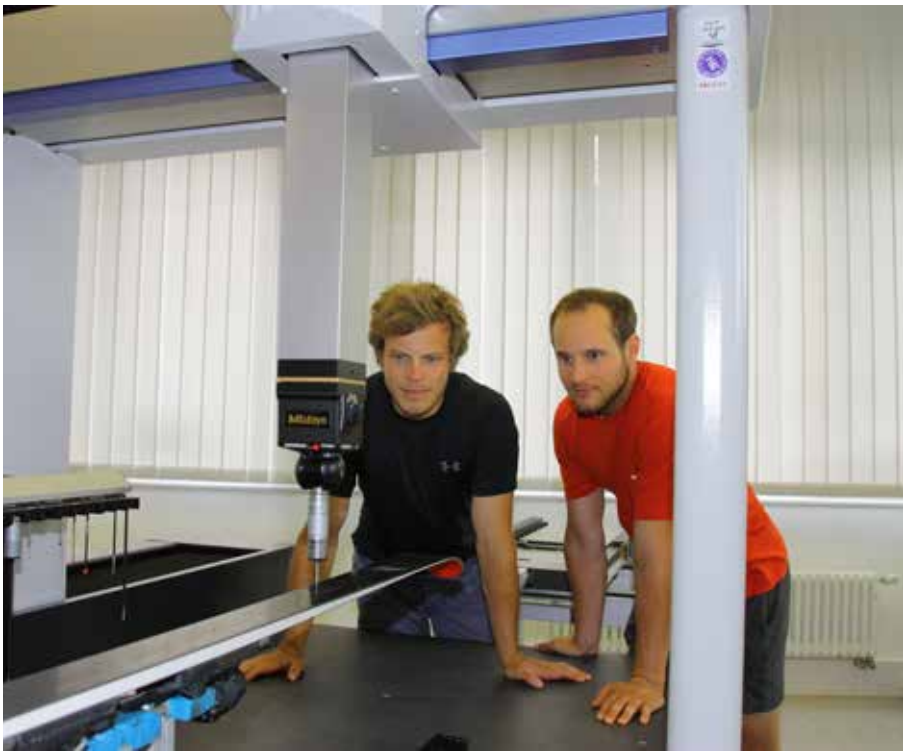
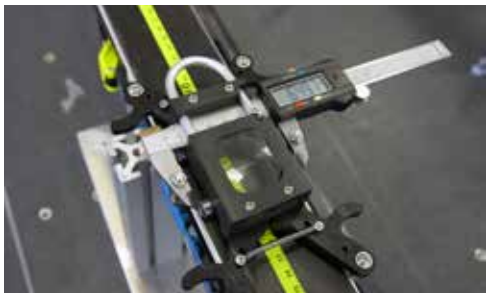
Coordinate measurement simply different
Racing skis to the test bench





Left: Mario Lazzeri (l.) and Johannes Brunner check the carving of racing skis with a Mitutoyo Crysta-Apex S CMM.

Above: The measurement method of the Ski Federation FIS provides for measurement with a caliper.

Below: Edge detection with the Crysta-Apex S.

Fancier workpieces have rarely been measured by a coordinate measuring machine: Two Austrian students have been checking, as part of a student research project, the carving of GS (Giant Slalom) racing skis with a Mitutoyo Crysta-Apex S.

Their passion for the project is easy to see in Mario Lazzeri and Johannes Brunner, because the two Austrian students have devised a more than exotic theme for their student research project. They measure GS racing skis. Their goal is to find out whether the relatively simple method of measurement of the international ski federation, FIS, is feasible and provides realistic results, or not. To be exact, this has to do with the carving of the skis, i.e. the concavity of the ski edges. Modern "planks" are namely wider at the leading and trailing ends than in the middle. This special "carved" form facilitates and speeds up cornering - for both hobby skiers as well as for World Cup Professionals.

The FIS regulations stipulate an average radius of curve of at least 35 meters in the giant slalom. Although tighter radii comply with the dynamics they do, however, pose an increased risk of injury to the skier. Furthermore, the skis must be at least 1.95 meters long. The skis are measured in the developed length by the FIS with a steel measuring tape, the zero point of which is attached to the end of the ski.

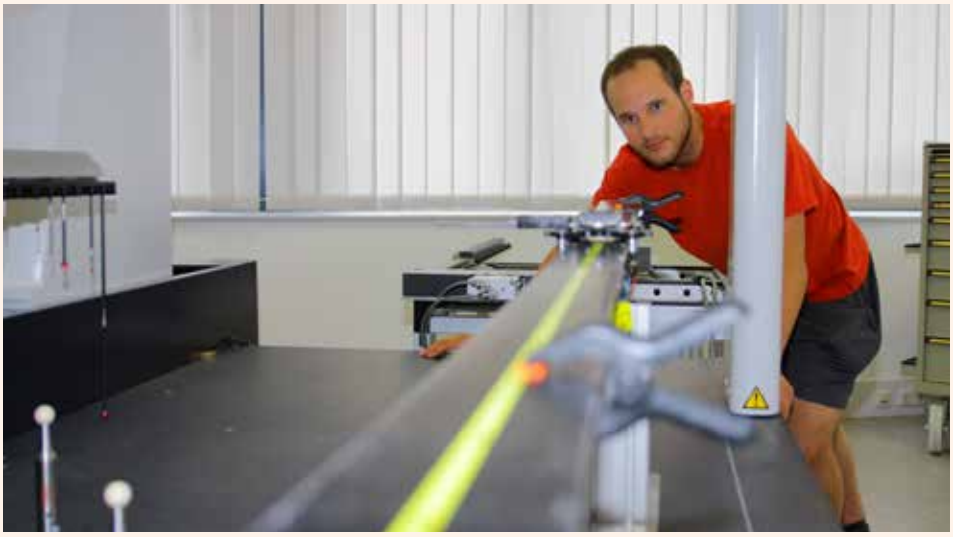
The length of the ski is then measured from the narrowest point of the ski to the leading and trailing ends. In order that the entire ski waist radius is not distorted by the different geometries of the ski tails and ski tips, the rear ski width is measured for 90% of the rear ski length and the leading ski width for 80% of the front ski length. In order to determine the sidecut the width of the ski is measured – at predetermined points – using a movable device with a built-in sliding caliper. Using an integrated magnifying glass with a marking line, the measurement position can be read from the measuring tape. From this, the mean radius of the sidecut is calculated.

If the sidecut radius is found to be under the permitted limit after a single measurement, the measurement and calculation has to be repeated twice. From the thus determined three sidecut radii the arithmetic mean, XR, is generated. To allow for measurement errors in the length and the width the sidecut radius is defined as 1.015 XR. This corresponds to an average measurement error of 1.5%. 1.015 XR must be greater than or equal to the applicable radius limitation.

"Measuring with a caliper at different positions has enormous potential for error," said Lazzeri. "We want to know if the results are useful and reliable or not," says the trained machinist. Thus was born the idea for the student research project for the seminar "Problem Analysis in Biomechanics" at the Institute of Sports Sciences at the University of Innsbruck in Univ.-Prof. Mag. Dr. Werner Nachbauer.

The issue is dynamite, because a supposedly too small a radius may result in a disqualification by the FIS – and can result in a tremendous setback both sportswise and financially for the athlete and his team.

Since Lazzeri had worked half his life with Mitutoyo manual measurement tools, the 31-year-old knew that the Japanese are the benchmark worldwide in terms of dimensional metrology. A phone call was enough: Mitutoyo Austria was in on the party and supported the project with help and advice. The skis were measured in the Mitutoyo branch at Eisenach. Together with Mitutoyo engineer, Friedrich Schinko, the skis were harnessed to a coordinate measuring machine of the type Mitutoyo Crysta-Apex S 9168 with a tactile scanning probe SP25. To fix the skis on the granite working table of the Crysta the Austrians had specially converted a mount for ski bindings, similar to that used by the service staff to grind the steel edges.



Left: Skis were positioned on the CMM using a mount for ski bindings.
Above: Using a tape measure, the measurement positions of the FIS are tracked.

After a pre-probing from above for each measuring point, the Crysta-Apex S executed the edge point measurement with a travel speed of 520 mm/s and a digital step of 0.1 microns, with a cylindrical stylus tip of four millimeters diameter. With the extremely powerful Mitutoyo CMM software MCOSMOS, Lazzeri, Brunner and Schinko collected and analysed the data, because MCOSMOS is ideal for this purpose with the universal geometry measurement program GEOPAK with macros for the automatic measurement of all control geometries and the 2D evaluation module SCANPAK.

The software depicted graphically every single one of the probe starting points together with all the relevant data. From all the individual data delivered by the Crysta-Apex S it was not only the overall radius of the ski that could be reliably calculated, but also the pretension of the ski, the tip radius, any form deviations of the overall radius and individual radii from at least 3 points in each case.

After two days of testing and a meticulous data analysis, the verdict of the students was made. With regard to the carving there are serious differences between the different racing skis. Within the limitations of the regulations every manufacturer is obviously trying, with his own design, to optimise the dynamic behavior of his skis. The FIS method of using calipers showed, with respect to a calculated average sidecut radius, no significant deviation from the measurement with the Mitutoyo Crysta-Apex S and thus serves its purpose. Statements about sidecut development cannot, however, thus be met. For this, measurement by coordinate metrology would be indispensable.