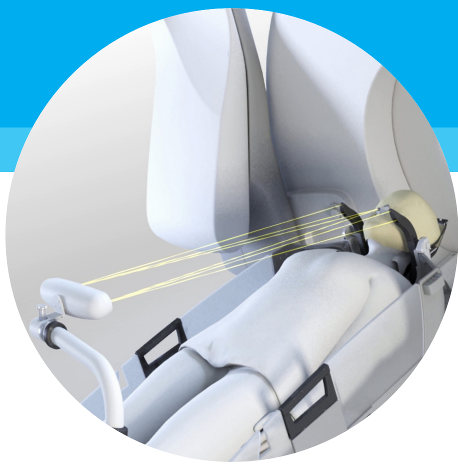
# High Definition Motion Management - enabling stereotactic Gamma Knife® radiosurgery with non-rigid patient fixations



WHITE PAPER

## Introduction

In this paper, a real-time patient tracking system for Leksell Gamma Knife® Icon™ is analyzed. This system monitors patient movements with sub-millimeter accuracy in 3D and enables the use of non-rigid fixations, whilst keeping high treatment accuracy and confidence.

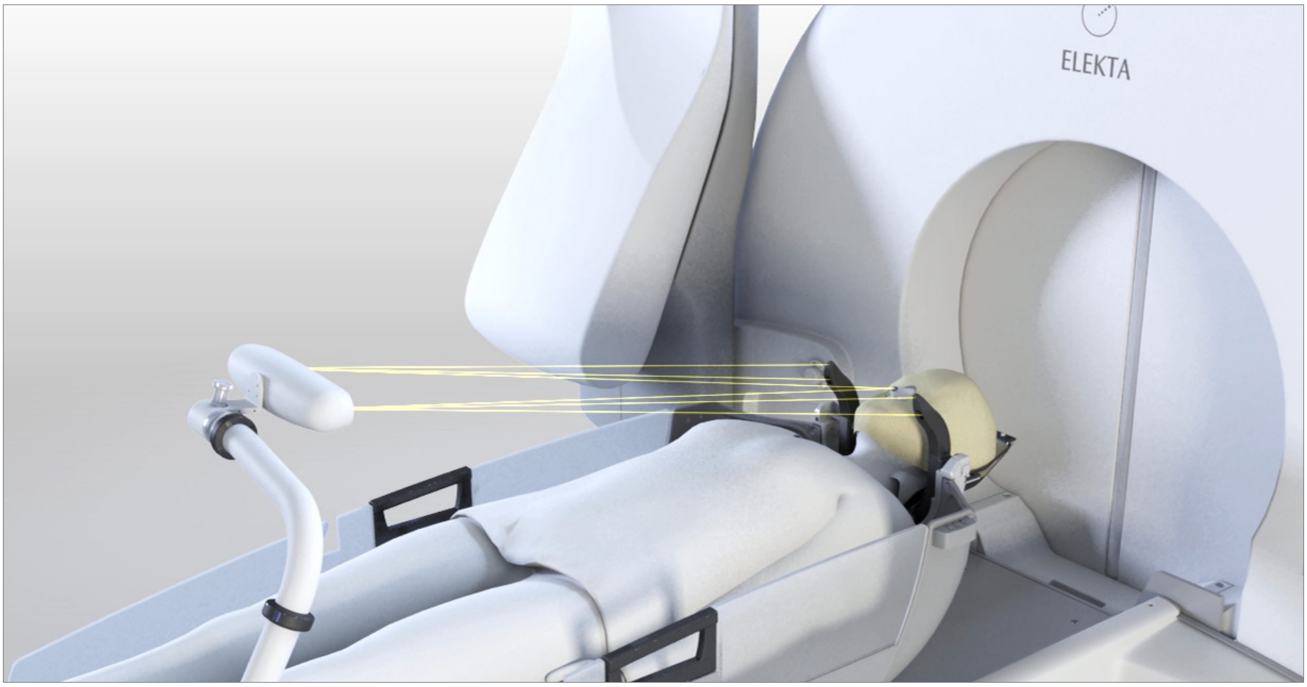



*Figure 1. The HDMM system*

**System description**

The High Definition Motion Management (HDMM) system consists of an infrared stereoscopic camera, a set of reference markers, and a patient marker. The system continuously tracks the movements of the patient during treatment with non rigid fixations. If large movements are detected sources are moved to an off position and the operator is alerted. The treatment can be resumed again when the patient has returned to the initial position.

The infrared camera is mounted onto an arm on the couch. This arm can be folded up when the HDMM system is used and folded down to stow away the camera when not in use, see Figure 2.

The camera tracks at a frequency of 20Hz a number of markers attached to the mask adapter, see Figure 3. These markers define a reference coordinate system in which the patient movements are measured. This reference system is necessary to reduce noise and any effect of camera movements. The patient movement is presented as a graph that is updated in real-time, see Figure 4.

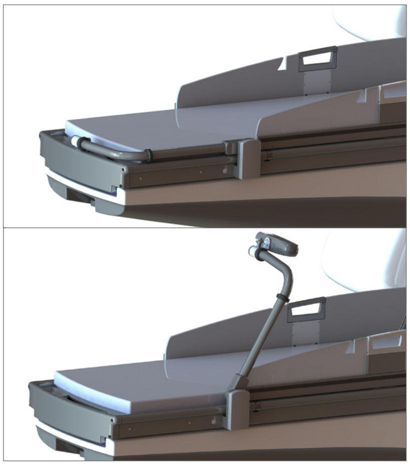


*Figure 2. HDMM arm with the infrared stereoscopic camera stowed away and folded up.*

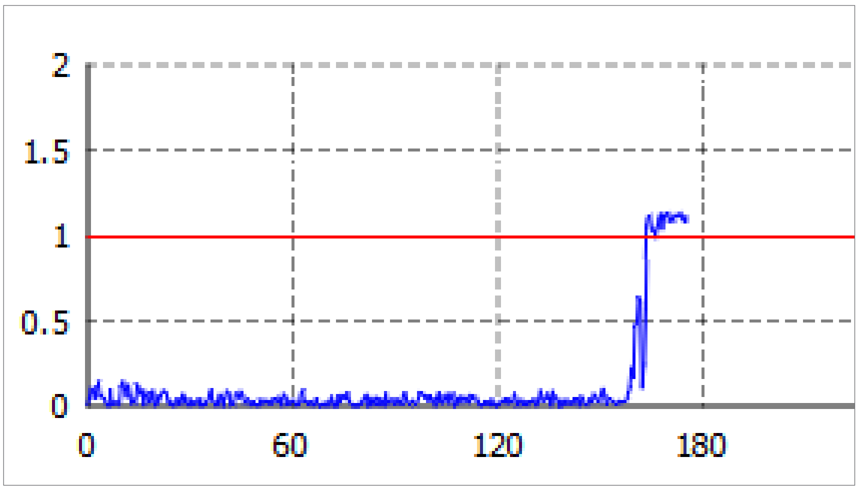



*Figure 4. HDMM GUI.  The red line marks the user defined maximum movement allowed.*

*Figure 3. The mask adapter, the integrated markers are highlighted with green circles.*

The patient marker is attached to the nose of the patient with adhesive, see Figure 5. The patient is immobilized with a thermoplastic mask over the face. To gain access to the nose, the mask has a nose opening which is sufficiently large to reduce any influence of the mask on movements of the nose.

*Figure 5. Patient with marker in mask adapter.*

### Accuracy

The accuracy of the method was studied by moving the patient marker, positioned as on a patient's head during a treatment, in steps of 0.1mm. The position was controlled by an independent measuring device with a guaranteed accuracy of 0.01mm and compared with the movement measured by the camera. The result is shown in Figure 6.

Figure 6 shows that the patient can be tracked with an accuracy of 0.1mm, or better in ideal conditions. The accuracy may become 0.15mm when including disturbances e.g. those caused by couch movements and vibrations of HDMM arm.

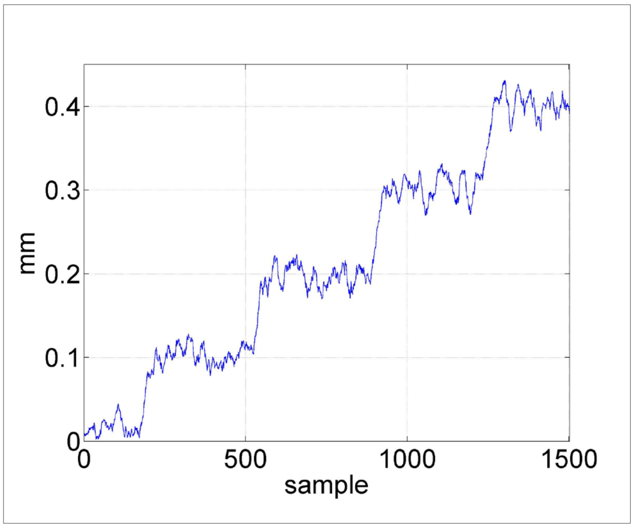



*Figure 6. The plot shows the 0.1mm steps measured with the HDMM system. The 0.1mm steps can clearly be distinguished in the plot.*

### Correlation between nose and target movement

Using nose movements as an approximation of target movements assumes that nose movements are well correlated with, and have larger amplitude than target movements. This hypothesis has been investigated in a prospective clinical study performed at Princess Margaret Cancer Centre [1]. In this study, patients were tracked using both this HDMM system and Cone Beam CT (CBCT). The movement of the target inside the skull was calculated in CBCT images taken before and after fractions and compared to HDMM measurements of nose movements. The study concluded that the movements detected with the HDMM system and CBCT correlates well and that these movements are generally larger or equal to actual target movements.

### Summary

Investigations show that tracking the movements of a patient's nose using an infrared stereoscopic camera is a feasible HDMM method to track sub-millimeter target movements during Gamma Knife® radiosurgery with mask immobilization.

## ABOUT ELEKTA

A human care company, Elekta pioneers significant innovations and clinical solutions harnessing both external and internal radiation therapy for treating cancer and brain disorders. Elekta provides intelligent and resource-efficient technologies that improve, prolong and save patient lives. We go beyond collaboration, seeking long-term relationships built on trust with a shared vision, and inspiring confidence among healthcare providers and their patients.

## REFERENCES

[1] Clinical Evaluation of a Novel Thermoplastic Mask System with Intrafraction Motion Monitoring using IR Tracking and Cone-beam CT for Gamma Knife® Radiosurgery. C. Chung[1], W. Li[2], G. Bootsma[1], Y. Cho[1], O. von Schultz[3], P. Carlsson[3], D. A. Jaffray.
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