

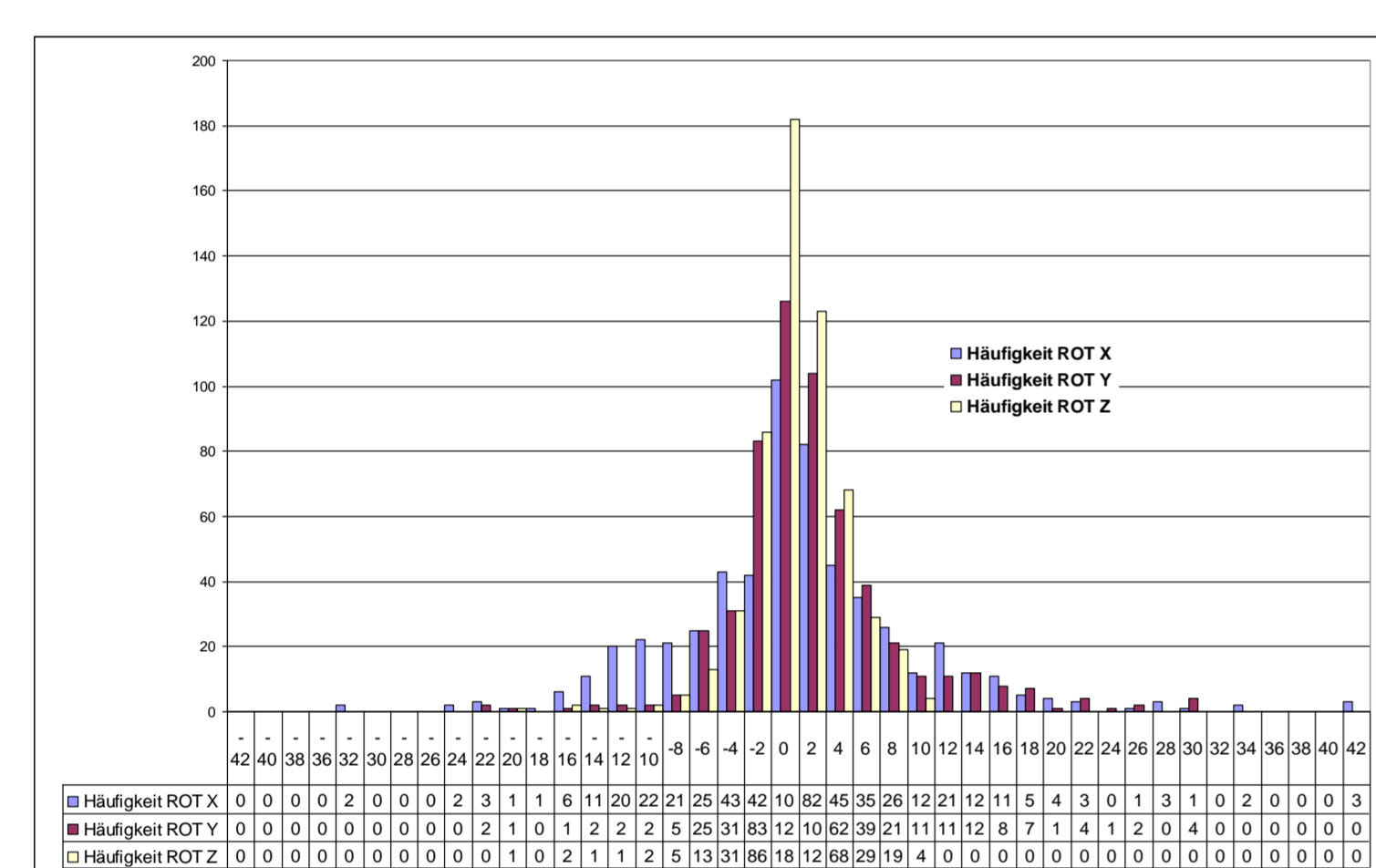
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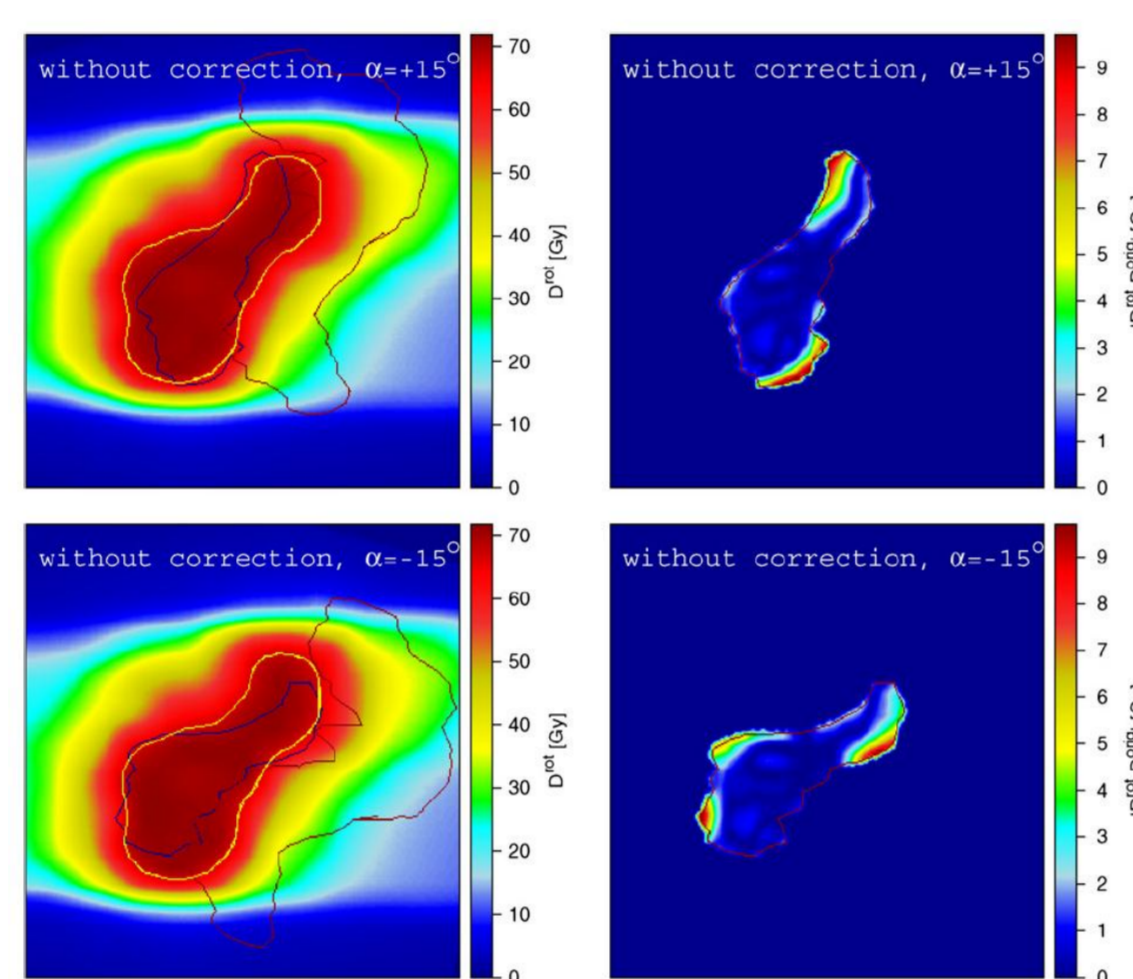
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## Introduction

A recent study at our institution has confirmed that a considerable number of the patients suffering from prostate cancer shows a significant inter-fractional prostate motion. In 12 % of 567 analyzed fractions we discovered rotational prostate misalignments of 14 degrees and more, in 1.4 % we even found rotations of 30 degrees and more. Undetected rotational prostate motion potentially jeopardizes the success of radiotherapy as it can lead to local underdosing in tumor regions (Rijkhorst et al., IJROBP 2008).



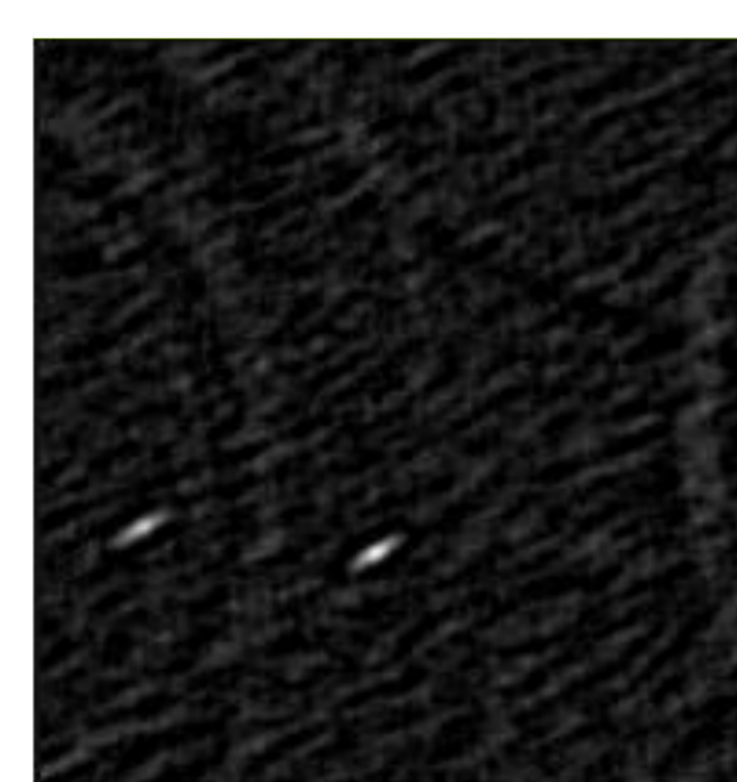
Picture 1: Results of the study; axis of abscissae: degrees of rotations, ordinate: Number of Persons (H. Deutschmann <sup>1),2)</sup>)



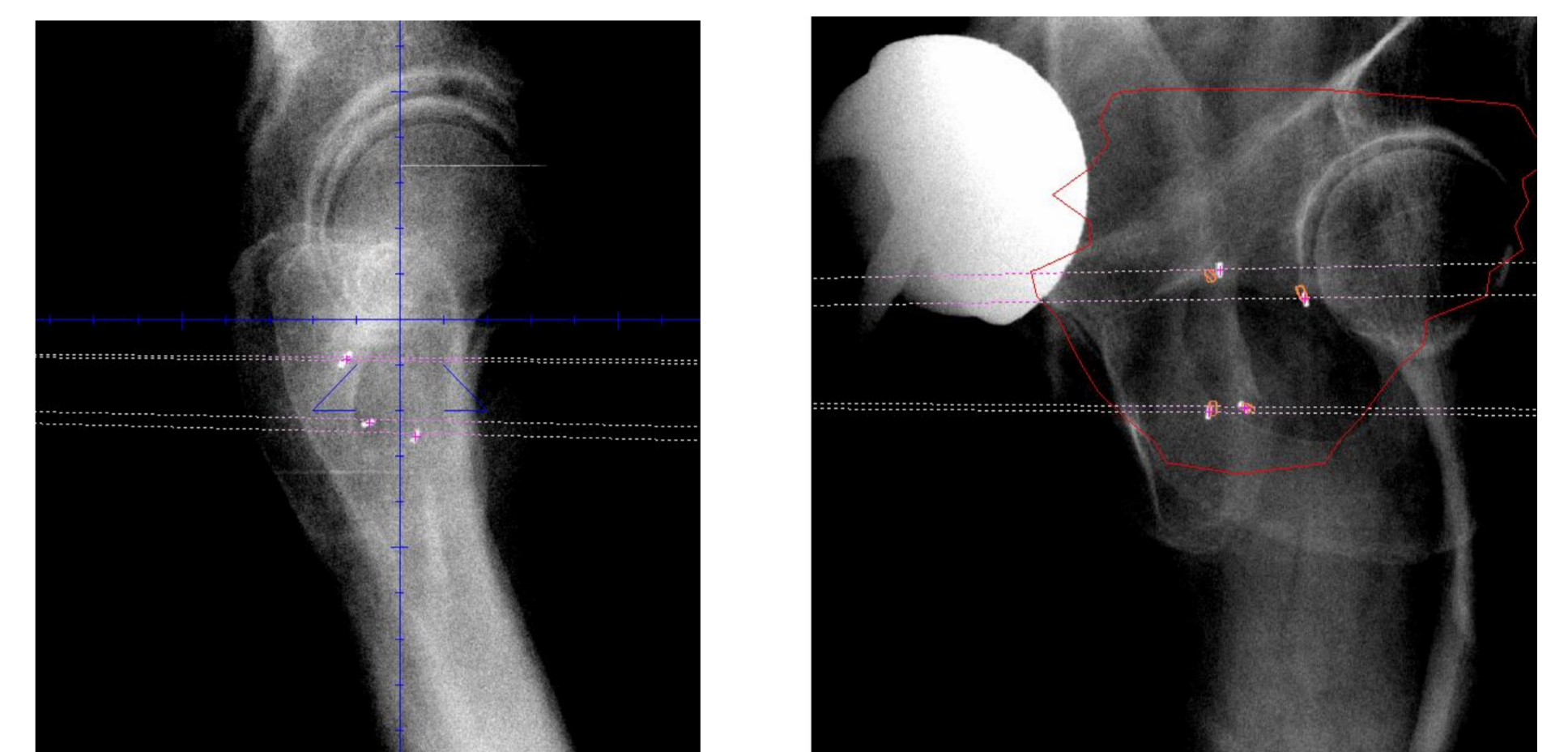
IJROBP 2008: ERIK-JAN RIJKHORST, PH.D., MARCEL VAN HERK, PH.D., JOOS V. LEBESQUE, M.D., PH.D., AND JAN-JAKOB SONKE, PH.D.: Margin CTV-PTV 6 mm, after CB-Recon. and x/y/z couch-corrections

## Results

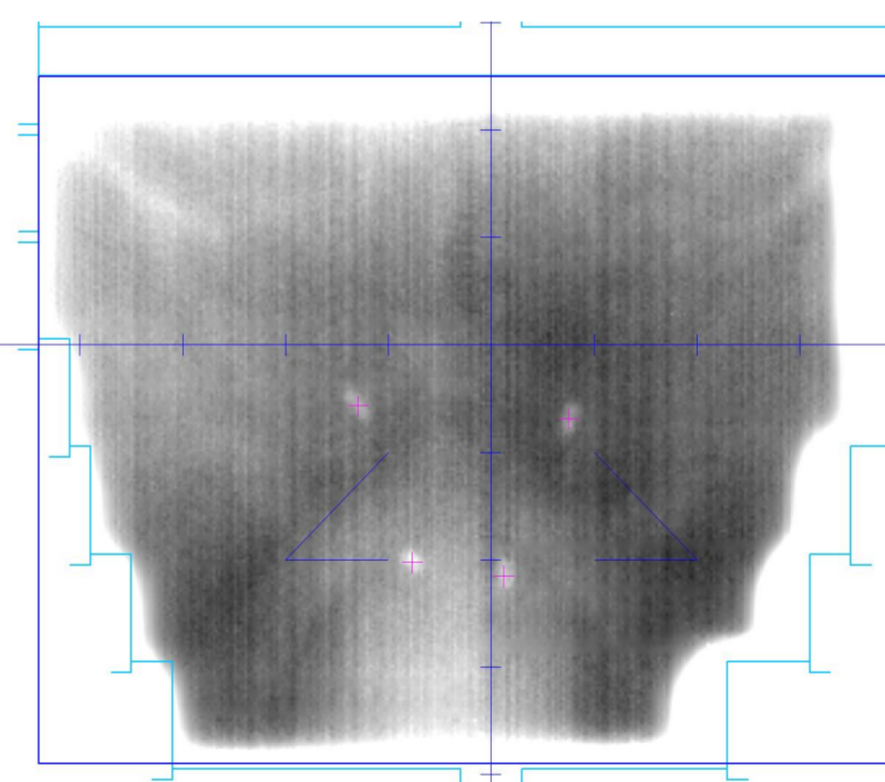
First results of our GPU marker detection approach show that we are able to accelerate the process by a factor of 15 compared to the traditional algorithm. In clinical images the gold seeds are reliably detected in 0.8 s on average. Using these inferred positions we can compute the actual prostate rotation and translation, and adapt the treatment plan to the actual situation in the course of our aperture-based image-guided radiotherapy approach.



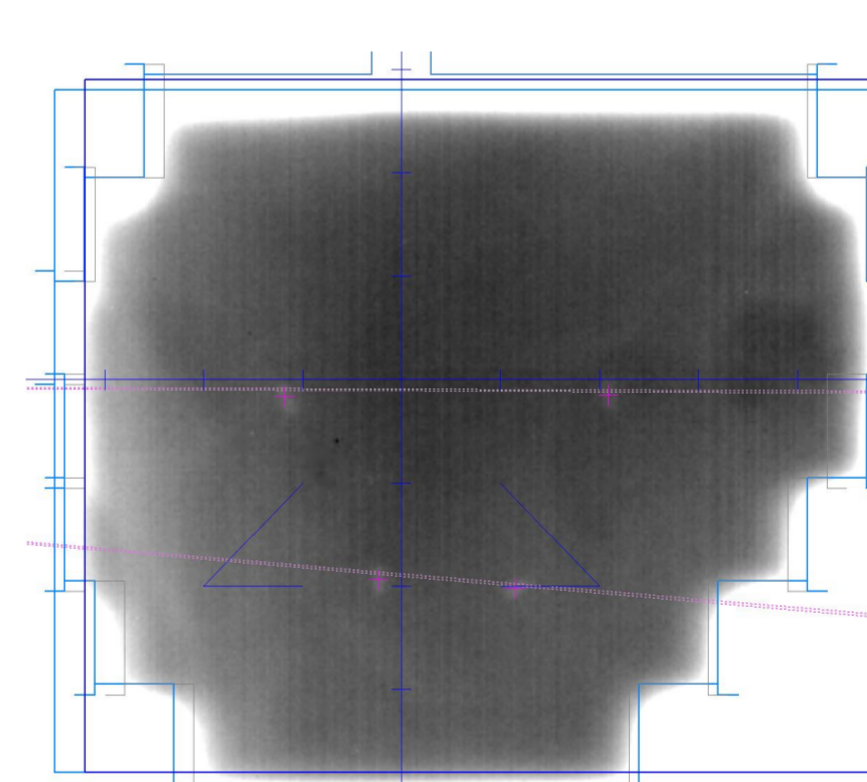
Result of the Convolution



Detected Markes in kV-Images



Detected Markes in MV-Images

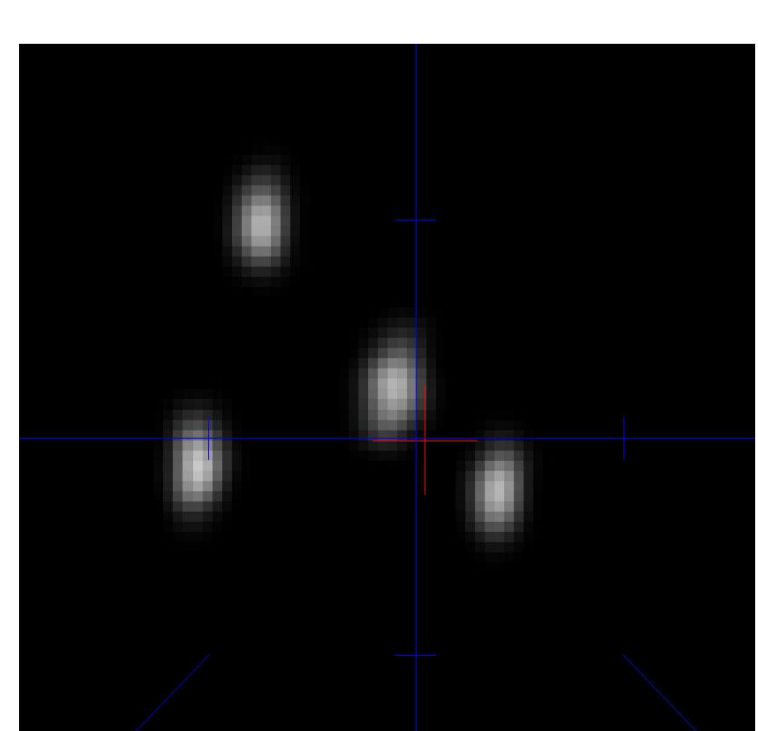


MV-Image with wedge

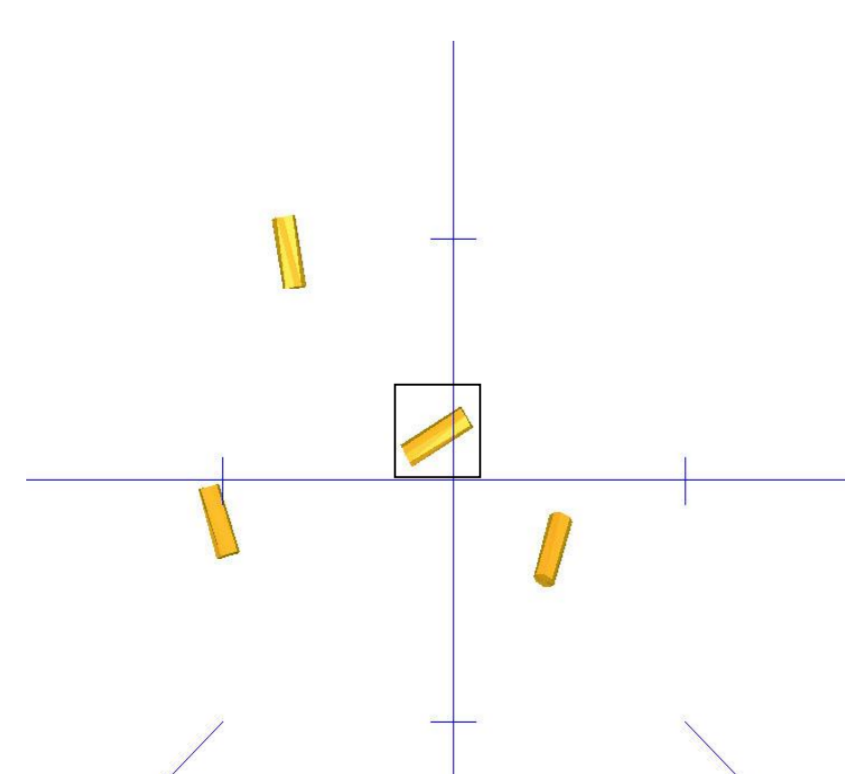
## Materials and Methods

In order to overcome this fundamental risk we apply a minimally invasive procedure. Four gold seeds are implanted into the cancerous prostate tissue. These fiducial markers are pre-interventionally imaged and spatially localized using CT. Right before each treatment fraction X-rays (kV-images) and portal images (MV-images) are acquired from the patient lying on the linear accelerator couch. These images show the markers and therefore enable inference of the actual prostate position and pose.

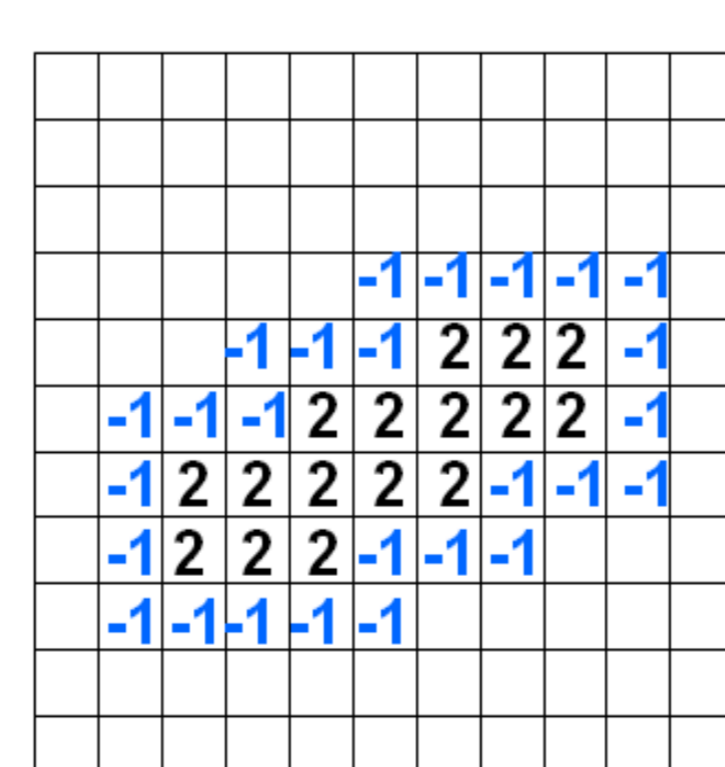
Basically the computational detection of the fiducial markers in the acquired images is required to be fast and reliable. Using the imaging geometry the theoretical marker positions can be computed. These positions are consulted as initial guess for a subsequent local image analysis that employs a so-called Mexican-Hat-filter combining both smoothing and edge detection for finding the real marker positions. However, large image search areas for robust marker detection imply increased computation time. In order to accelerate this process we implemented the algorithm on the graphics card (GPU) which usually has a large number of parallel processing units. The GPU algorithm allows us to analyze multiple regions of the image at the same time.



DRR: localized Markers using CT



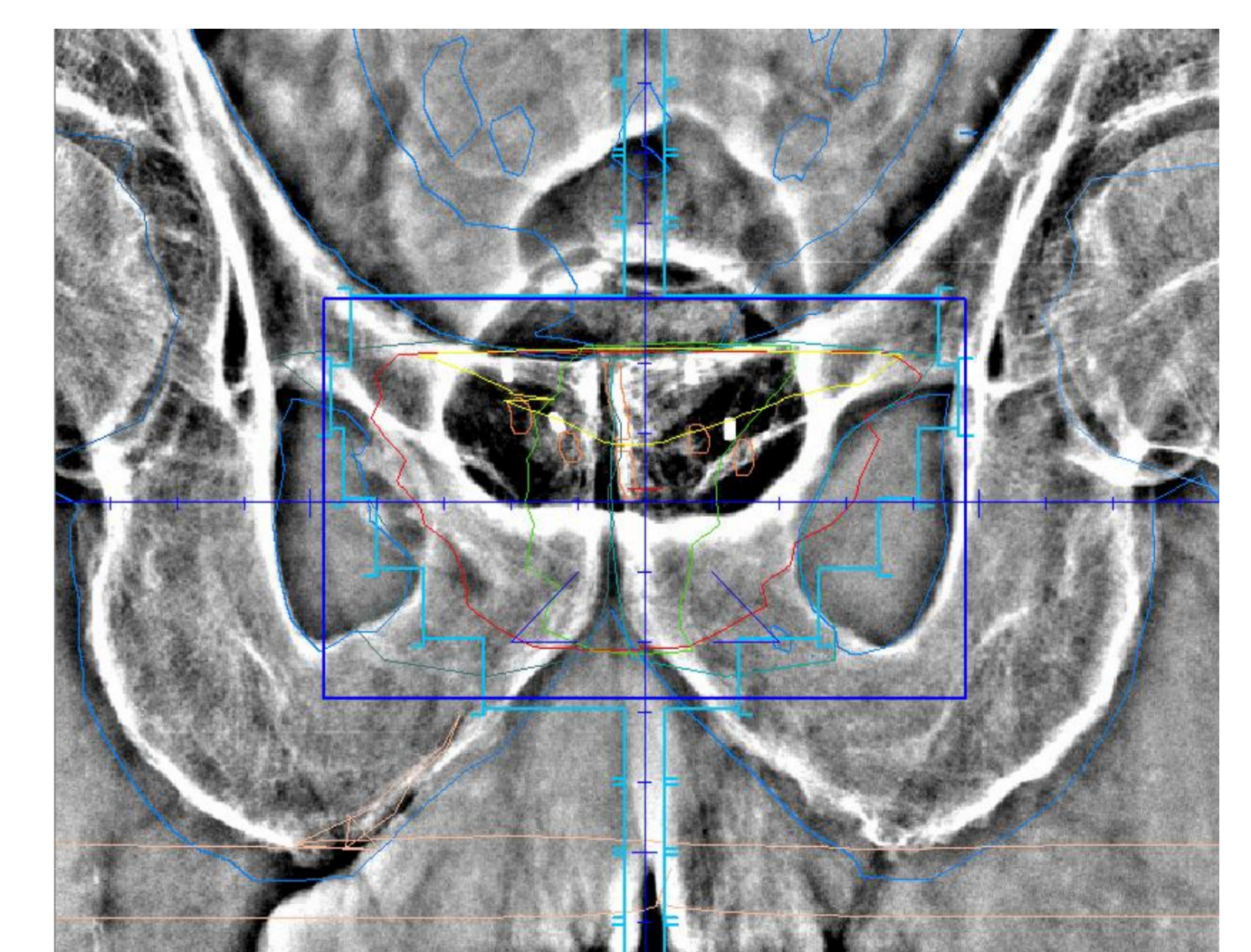
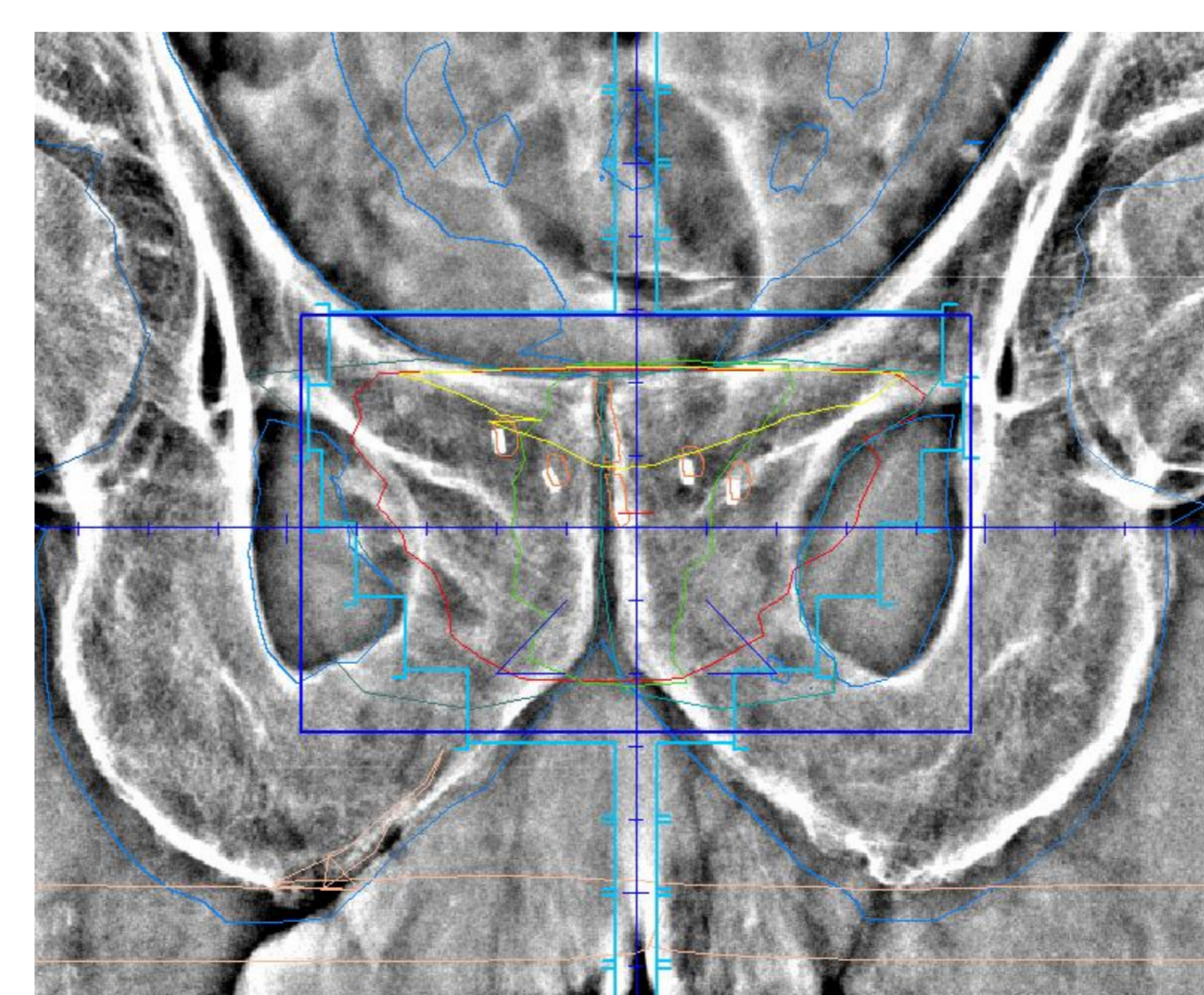
3D surface model



Mexican - Hat - Filters

## Outlook

Currently inter-fractional corrections are performed by applying this method. Furthermore the detection of markers in MV-images is possible too, so intra fractional corrections can be done without additional kV-Images. This procedure is not confined to the prostate.



Intra fractional motion of the prostate : 2 minutes difference between this images