Report on ME-1514

High energy, high spatial resolution imaging of ITER toroidal field conductors

The beamtime on station ID19 (just before the EBS shutdown) was very successful. We took a 1m long section of the electrical conductor used for plasma containment at ITER and imaged sections as a function of temperature down to 77k. The idea was to follow the stresses likely to be caused by strand movements for different conductor production mechanisms. The experiment was only just possible with 8-9% transmission through the object. Nevertheless some excellent images were obtained and after image processing and digital image correlation we can now make some definitive conclusions regarding the longevity and use of these conductors. We are currently submitting this work to Nature.

Preliminary reconstructions were performed on the raw images acquired at beamline ID19. Reconstructions were performed using filtered back-projection, producing 400 image slices across a 1 cm thick section of the samples, with a voxel size of 21.8 μm when accounting for geometric and optical magnification of the sample. During post-processing, a Paganin filter was applied to both sets of reconstructed volumes. The Paganin filter is a phase retrieval algorithm, which aims to find the optimum phase that satisfies a set of constraints. The filter was applied due to its ability to boost contrast via noise reduction, particularly in parallel beam, tomographic images. Prominent ring artefacts were observed in the image slices, potentially due to erroneous pixel values. These were in part reduced upon application of the filter. Upon filtering, improved contrast was achieved, with each conductor component easily distinguished. In particular, the two types of strand (solid copper and Nb3Sn) offered improved contrast, allowing observation of distributions within each section of the conductor. **Figure 1** illustrates the application of the post-processing filter for a single reconstructed slice of the heat-treated conductor.

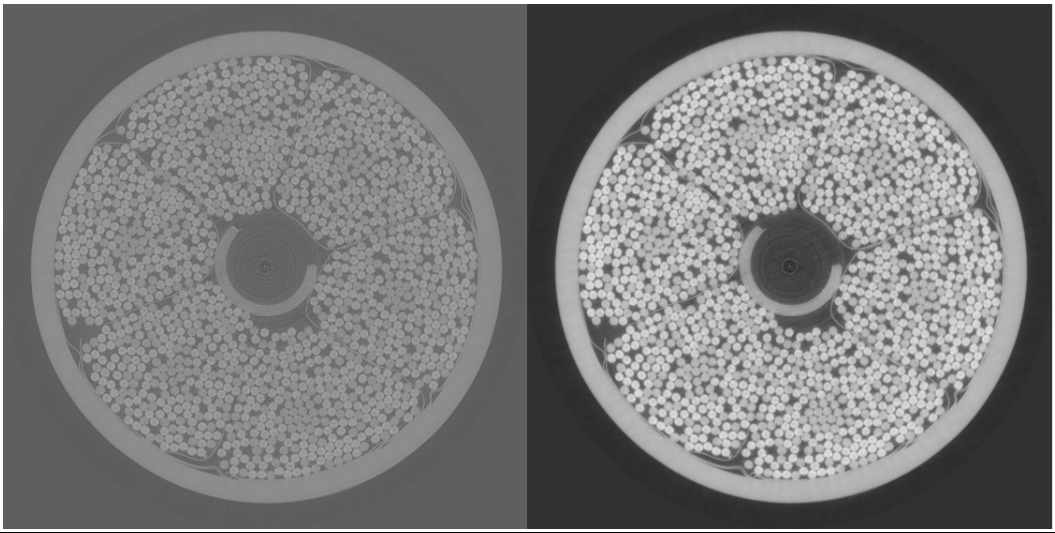

Figure 1: **Application of a noise reduction filter.** Left, original reconstructed image slice of the conductor prior to filtration. Right, identical image slice upon application of the phase retrieval filter based on Paganin's approach.

Analysis

Two reconstructed image slices from each conductor were taken for further analysis. These corresponded to depths of approximately 2 mm and 5 mm into the reconstructed image volume. In order to isolate individual fibres, a thresholding regime was implemented, such that all other components of the conductor (including the steel cooling spiral, outer jacket and petal envelopes) were removed. **Figure X**2 below illustrates an example of the thresholding technique, producing a binarised image from a reconstructed slice. Image s corresponding to the same slice at each temperature were checked to correct for possible sample misalignments between sequential scans.

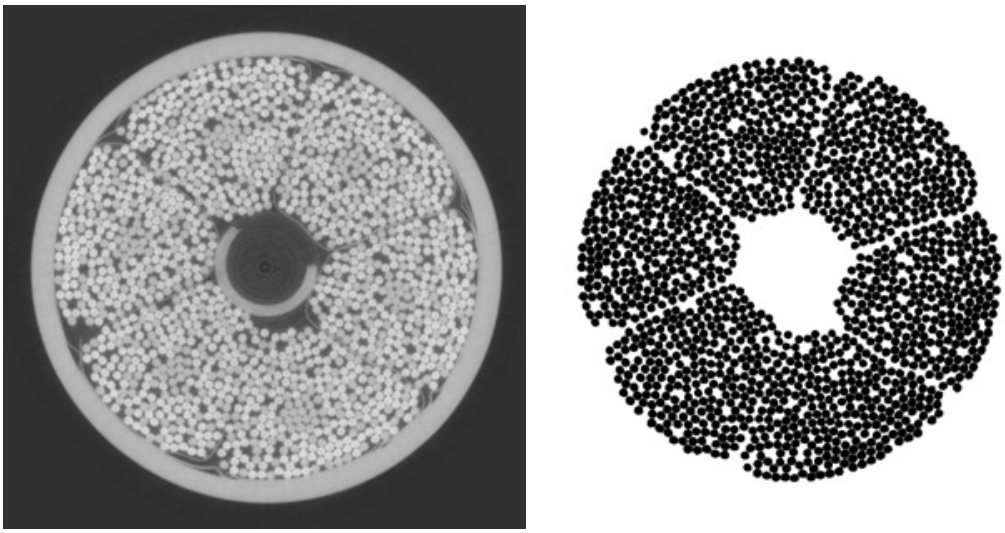

Figure 2: **Thresholding and segmentation procedure of conductor.** Left, reconstructed image slice of the conductor, prior to thresholding. Right, binarised image of the superconducting bundles, isolated from all other components.

After processing we have many maps which show how and where the wire move when cooled, these will all be displayed in DIC maps in our publication