§28. Optimization of Two Color Poloidal Interferometer/Polarimeter for ITER

Pavlichenko, R., Kawahata, K.

Control of the current density profile becomes a paramount issue for the modern tokamak experiments. The polarimeter under study is based on the system that was originally proposed for previous ITER designs[1-2]. The modified system featured a fan of chords viewing the plasma through an equatorial port. The updated system will be operating at a wavelength of 48 or 57 μm (instead of originally proposed 118 μm). This allows increasing the maximum number (because of smaller diameters of the waveguides / delivering tubes in the blanket shield modules (BSM)) of chords via the equatorial port (EQ port) up to 12, which was limited to 9, viewing the plasma via penetration through the BSM. For the best optimization of the plasma coverage up to six chords in vertical direction via an upper plug are proposed. The beams are reflected back along the same path through the plasma by means of 38 mm wide circular shaped retroreflectors indented about 25 cm deep at the bottom of remote handling grips in the blanket modules opposing the ports.

The base issue for the optical system design is the retroreflectors fault tolerance in respect to vignetting. This brings of the optical system starting point to comply the diameter limit of the retroreflectors with the well known formula: D_{min}.>2.2d, where d the 1/e width of the laser Gaussian beam intensity distribution. This corresponds to a ~99% transmission (reflection) by (through) the optical system. Optimization of the diameter for the dielectric waveguides is shown at the Fig. 1. For the chosen waveguide diameter of 40 mm shorter wavelength has about 10% higher waveguide transmission coefficients.

The calculated values of the Faraday rotation angle are in the range of ±35° (see Fig. 2) and can be easily measured with high accuracy. Similar conclusions can be made for the upper chord and for the other plasma scenarios.
The data from the horizontal polarimeter fan give a substantial improvement of the q-profile determination in the plasma center. Including the chords via the upper port gives a further, but smaller, improvement.

The beam displacement due to refraction varies from chord to chord and is typically between 0.5 and 2.2 mm for the equatorial (circles) and upper chords (crosses) and the flat density profile (see Fig. 3). The refraction for the peaked profile and for the vertical chords, with a much longer line of sight through the plasma is somewhat larger (up to 3.5 mm in the worst case). It is important to note that the difference in the beam displacements calculated for the peaked profile is typically different between 0.25 and 0.5 mm (depending on the chord length).

Utilization of the short wavelength laser sources will give a clear advantage for the beam targeting into the retroreflectors. Installation of additional channels in the UPPER port will not give desired improvement of the current profile inversion.

References
1) A. J. H. Donné, A. J. H. et al. : Rev. Sci. Instrum. 70 (1999) 726.
2) A. J. H. Donné, A. J. H. et al. : Rev. Sci. Instrum. 75 (2004) 4694.

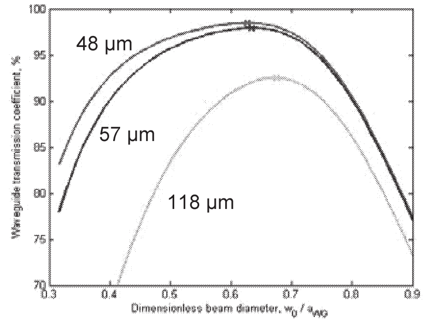

Fig.1. Calculated optimized waveguide diameter of 40 mm for the dielectric waveguides for 48,57 and 118 μm.

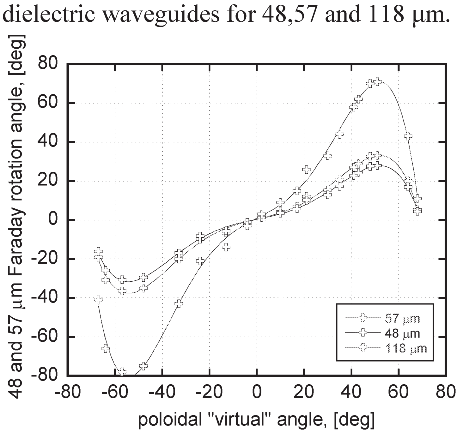

Fig.2. Calculated Faraday rotation angles for horizontal chords (EQ port) for laser wavelength 48, 57 and 118 μm.

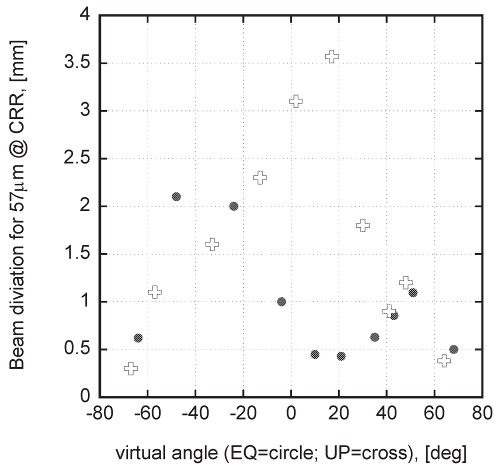

Fig.3. The beam displacement for EQ and UP port 'fun-like' beams, for the 57μm due to refraction varies from chord to chords.