Purpose:
To design and evaluate an optimised radiotherapy imaging beam, based on a prototype Elekta waveguide, with a novel coupling device (rotovane) allowing for a wide, continuously variable energy range.

Methods:
A waveguide test piece consisting of a buncher, rotovane and short relativistic section was used to investigate the performance of the novel continuously variable coupling device, and in particular investigate imaging at low megavoltage energies. An optimised imaging system utilising the lowest electron energy of the waveguide (1.4 MeV) was designed using BEAMnrc and implemented experimentally. Characterisation of the imaging beam was conducted experimentally and via Monte Carlo simulations. Cone beam computed tomography images (CBCT) were acquired using a Caesium Iodide imaging panel of humanoid anthropomorphic phantoms and a Catphan phantom. The contrast to noise ratio was assessed for CBCT and compared to kilo-voltage and megavoltage imaging systems.

Results:
The optimised imaging beam target assembly consisted of an electron window, 5 mm carbon electron absorber and 2.5 mm of Aluminium filtration. The x-ray beam had an average photon energy of 220 keV and a half value layer of 5.9 mm of Copper. Images with the same contrast to noise ratio as a 100 kVp CBCT system (XVI, Elekta) were obtained in doses less than 2 cGy; this is 11x higher than XVI but 150x lower than a megavoltage imaging system. Qualitatively, kilo-voltage equivalent images of head and pelvis phantoms were obtained in doses between 1 and 8 cGy.

Conclusions:
The prototype waveguide section was capable of producing electron energies from 1.4 to 9 MeV, suitable for imaging and therapy. The waveguide technology has the potential for producing near kilo-voltage equivalent images in acceptable dose from the therapy beam portal without the need for add-on x-ray systems. Additionally such a system could provide for enhanced target tracking during radiotherapy treatment.

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