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A saturation boiling model for an elongated boiling water target operating at a high pressure

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Abstract content
   (Max 300 words)

The majority of second-generation water targets for fluorine-18 production contains about 2 – 5 cubic cm of water with an oxygen-18 enrichment of typically 97%. They operate in the boiling regime at pressures of typically 20 – 50 bar. It is not unusual for these targets to occasionally fail catastrophically during bombardment. Proton beams with energy between 11 and 18 MeV are usually supplied by a cyclotron. Fast interlocks on beam current and target pressure are essential.

Recently, elements of a model which successfully describes the thermal behaviour of a boiling water reactor (BWR) were applied to such a water target. One may appreciate the enormous difference in scale between these two diverse systems. Those authors pointed out that elevated pressures and temperatures in excess of the saturation conditions may exist. Superheated regions in the water volume will certainly develop, however, they are likely to rapidly decay (on a time scale of a few milliseconds). This rapid decay is because of the small size of the liquid volume and fast mixing as a result of bulk boiling, enhanced by bulk radiation-induced nucleation. One concern may be unstable behaviour, e.g. cycles of rapid vaporization and condensation, which may lead to large pressure fluctuations.

At iThemba LABS, we modelled an elongated boiling water target by assuming the entire water volume to be at a constant temperature (for a constant beam current) and that a single overall convection heat-transfer coefficient applies to the target cooling. These approximations may seem severe for a system with such complex boiling behaviour, however, it may perhaps be justified due to the presence of fast mixing mechanisms in a small liquid volume. It will be shown that the measured pressure versus beam current curve of the target can be reproduced by such a simple model, assuming that the majority of the system operates at saturation conditions as given by the standard steam tables.

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