Arc Splitting for VMAT Patient QA

Our center uses the MapCheck2 device of Sun Nuclear Corporation for our IMRT patient quality assurance. We've used it for a number of years, with excellent results, to check our 9-field sliding window plans. When we implemented modulated arc therapy about 15 months ago, we decided that rather than purchase a new cylindrical phantom, we would also use the flat MapCheck2. However, rather than irradiate it flat on the couch (which would involve the known directional dependence of the diodes), we used Sun's Isocentric Mounting Fixture, which attaches to the head of the gantry. With such a setup, the full fluence of an arc is delivered en face to the device, and directional dependence is not a factor. Now, prior to the release of Eclipse version 10.0, a modulated arc plan containing a full arc could only be checked with a verification plan that also consisted of the same full arc. The point was made that it could be theoretically possible for the full arc to pass our criteria (3%/3 mm, 10% threshold, 95% of points passing), but, if the arc could be split, for one or more partial arcs to fail. One scenario could be a certain point failing low on one partial arc, failing high on another, and passing on the full arc; in other words, there could be unseen cancellations. If this happened with enough points, there could possibly be failing partial arcs with the full arc passing, without knowledge of the failures. With the release of Eclipse version 10.0, it is now possible to split any arc into partial arcs for verification purposes; Varian recommends no more than 40 partial arcs, for limitations of computing speed. So now the environment is ripe for searching for the aforementioned failures or cancellations. To do so, 12 patient plans were investigated. These involved plans for treating the prostate only; the prostate and seminal vesicles; the prostate, seminal vesicles and pelvic lymph nodes; and the prostate bed. We used two full arcs clinically in all cases. Verification plans were created composed of the same two arcs; 8 partial arcs of 90° each; and 16 partial arcs of 45° each. The following show sample fluence patterns, all calculated from the same clinical arc:

After analyzing 288 partial arcs and 49,670 measured vs. calculated point pairs, there were a total of 100 failed points, representing 0.2% of the total. There was no evidence of cancellation; if a point failed, there was no corresponding point or points in other partial arcs that offset the failure. These failed points seemed pretty much random; sometimes they were in high dose gradients, sometimes not. With so few failures, no partial arc even came close to failing our 95% passing criterion. A fair number of failed points (61) arose from low-dose points; even though these were above the 10% threshold for their partial arc, because of the way the fluence split, they were less than, sometimes much less than, the 10% threshold for the full arc (some expected doses were as low as 3 cGy). If our average passing percentage per full arc was 96% and we saw 2% more failed points from the partial arcs, then there might be a cause for concern. Since our average percentage is in the 99% range, and we “discovered” 0.2% failed points from the partial arcs, this seems no cause for concern.