Lane #1 “Boomerang” Core Design:

Manipulating Rg Contours, Axis Migration and Ball Motion

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Over the years Lane #1 has designed and developed many different versions of their patented diamond core shape that has been highly successful on the lanes. From the first 8-sided true diamond all the way through the Timebomb’s Inverted Diamond, each step in design progression led to a unique ball motion. Lane #1 has taken the next step in design by contorting the diamond shape into an 8-sided “boomerang” diamond core. Countless research and testing with engineers at 900 Global have led to this unique shape and its properties. The new “boomerang” design allows the Radius of Gyration (Rg) contours to be manipulated from their normal orientations within a ball. The adjusted Rg contours allows for a change in typical axis migration which thus yield a unique ball motion. The following explanations offer an insight as to how, why, and what is to be seen with the new design.

For starters one must understand the concept of Rg and how it is perceived and connected to the bowling ball. The pure technical definition of Rg is defined as the square root of the moment of inertia divided by the mass of the object. The moment of inertia for any particular object is the ratio of applied torque and the resultant angular acceleration of the object. In laymen’s terms, the moment of inertia measures how easy it is for an object to rotate. Thus, the Rg determines how easy it is for a bowling ball of certain mass to rotate about a given axis. It is a measure of where the mass is located inside the ball. To help explain this concept, imagine a figure skater twirling on the ice. If the skater spins on the ice with arms extended out, the rate of rotation is slower than if the arms are pulled inward towards the body. The same applies for a designed core inside of the bowling ball. For a given core shape, the more dense (heavier) the inner core becomes, the more the bowling ball will simulate rotation like a figure skater with arms tucked close the body. In other words, the core will have a low Rg and will help the ball rev up in a quick manner. The less dense (lighter) the inner core is, the more the ball will behave as a spinning figure skater with arms extended out and it will take longer for the ball to rev up as it travels down the lane, thus, having a higher Rg.

In bowling the published Rg of a bowling ball is the lowest Rg of the ball. However, it must be understood that a ball has not only a low Rg location but also has a high Rg location and anywhere in-between those locations on the ball other Rg values will exist in-between the high and low. 900 Global design engineers use a software extension to the 3D-CAD Pro-Engineer program called “BMX Modeling” to map the different Rg values across every location on the bowling ball can be depicted. This map contains a representation of what is called “Rg Contours” of the ball. An example can be seen below in Figure 1. Each different colored band represents a different Rg value. Each contour is either in a circular or elliptical shape and the values are often differentiated in the third decimal.

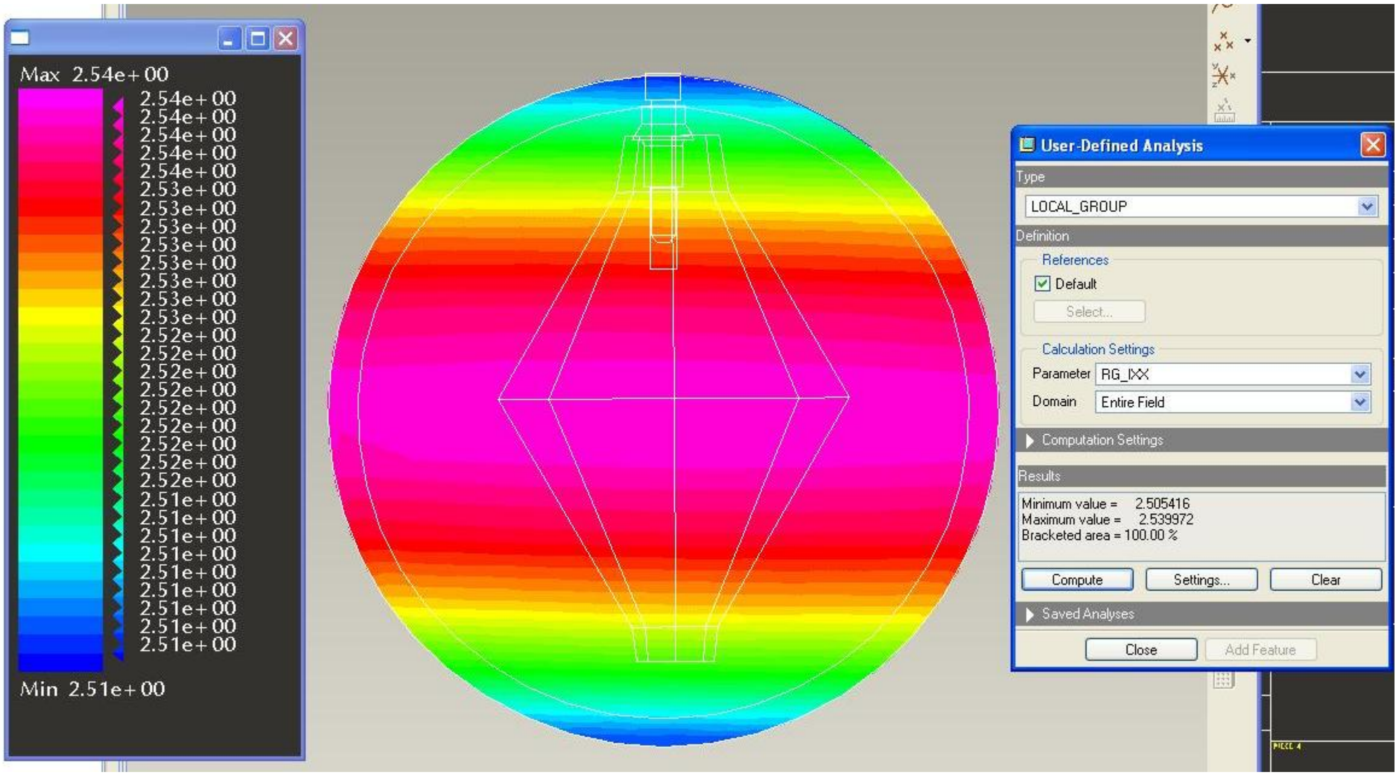

Figure 1: Generic Lane #1 Diamond Core w/ Plotted Rg Contours

The specific Rg contours and position of the contours are based upon the shape and mass of the core. Typically, the core is designed to have the lowest Rg positioned beneath the "Pin" of the bowling ball. It is common knowledge that using different drilling techniques to move the "Pin" around to different locations in relation to a bowlers' Positive Axis Point (PAP) will yield different ball motions on the lane due to the different flare patterns and amounts.

To further understand how these Rg contours play a part in determining ball motion a greater understanding of a term called "Axis Migration" must be investigated. An in depth study of axis migration was completed in 2007 and the results were released in a USBC technical article titled "*Marketing vs. Physics: The Real Truth about Axis Migration and Core Dynamics*". One part of the study aimed at determining and relating many different flare patterns to core dynamics and determined what influenced flare patterns as the ball rolled down the lane. The study incorporated 23 bowling balls with several different pin positions in relation to the PAP. As stated in the article:

> "*when a bowler releases a ball during delivery, the ball will first begin rotating about what is called his or her positive axis point (PAP). Simply defined, the positive axis point serves as the initial point of rotation. Then, due to the influence of ball properties, bowler attributes, lane conditions and the laws of physics (unstable to stable), new axis of rotation will exist as the ball travels down the lane. This change from the initial point of rotation to each subsequent*

point of rotation is called "Axis Migration." The migration of axis points can be determined and traced for a bowler by locating the axis of rotation for each flare ring as the ball rolls down the lane. Each flare ring will have an individual axis that the ball has rotated about to create that particular flare ring. The migration of axis points can be plotted on the ball and, depending upon certain characteristics, will yield different shapes (curved vs. straight line) due to the drilling pattern used. The plots will be at different distances away from the pin of the bowling ball."

An example of axis migration points that correspond to flare rings is shown below in Figure 2. The first point of rotation is on the PAP and matches with flare ring #1. The second axis of rotation corresponds with flare ring #2. Each subsequent axis rotation point has an individual flare ring as stated above. The axis points together form the Axis Migration path.

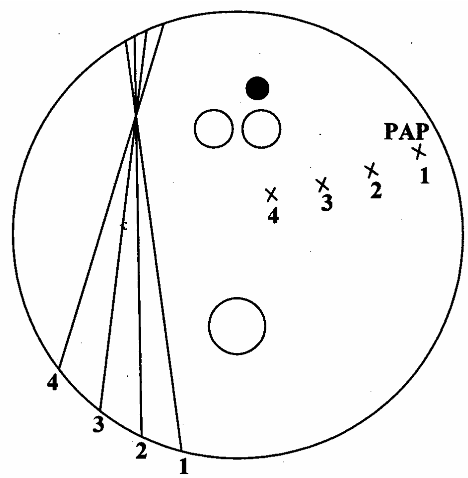

Figure 2: Axis Migration and Flare Rings

After 5 different types of extensive testing the Axis Migration study concludes that:

*"All testing shows the same trends and indicates that on-lane Axis migration is **DEPENDENT** upon the following two things:*

1) Physics

a. While on the lane, the bowling ball did not migrate to an axis that had a higher RG value (ball did not end up rotating about the mass bias spot or high RG axis).

2) Radius of Gyration

a. While on the lane, the USBC approved ball always flared and migrated toward an axis of rotation that was approximately equal in the RG value of the starting PAP (measured and rounded to the second decimal point)."

In summary, the Axis Migration study confirmed that regardless of many variables that a bowling ball (while on the lane) always created a flare path with axis points within the same Rg contour/band as initially started on dictated by the bowlers PAP at release.

With an understanding that the Rg contours control and determine the flare path that the ball is going to migrate through, one can now relate the influence of core shape in creating the Rg contours. Unique core shapes help in manipulating the Rg contour locations in relation to the “Pin”. After using “pin” to PAP distances for drilling patterns, one can see the change in flare pattern for this particular ball which ultimately influences the overall ball motion.

To physically show the differences in Rg contours and how it relates to ball motion let’s look at an example of two cores shapes given the same mass properties (Rg & Differential Rg). Figure 3 below is a Rg contour map of an un-drilled Chainsaw Massacre core shape while Figure 4 is a Rg contour map of the un-drilled new design “Boomerang” core. Both cores have the same low Rg of 2.53 and the same differential Rg(flare potential) of .040. Undoubtedly it can visually be seen the differences in Rg contour orientations. Using the “pin” as a reference the Rg contours of the Chainsaw Massacre core shape are horizontal and at 90 Degree bands from the “Pin”. The Rg contour bands of the “Boomerang” core shape are tilted in comparison. Due to the unique contorted Boomerang shape the contours are actually tilted at angle of 22 degrees as shown in the figure.

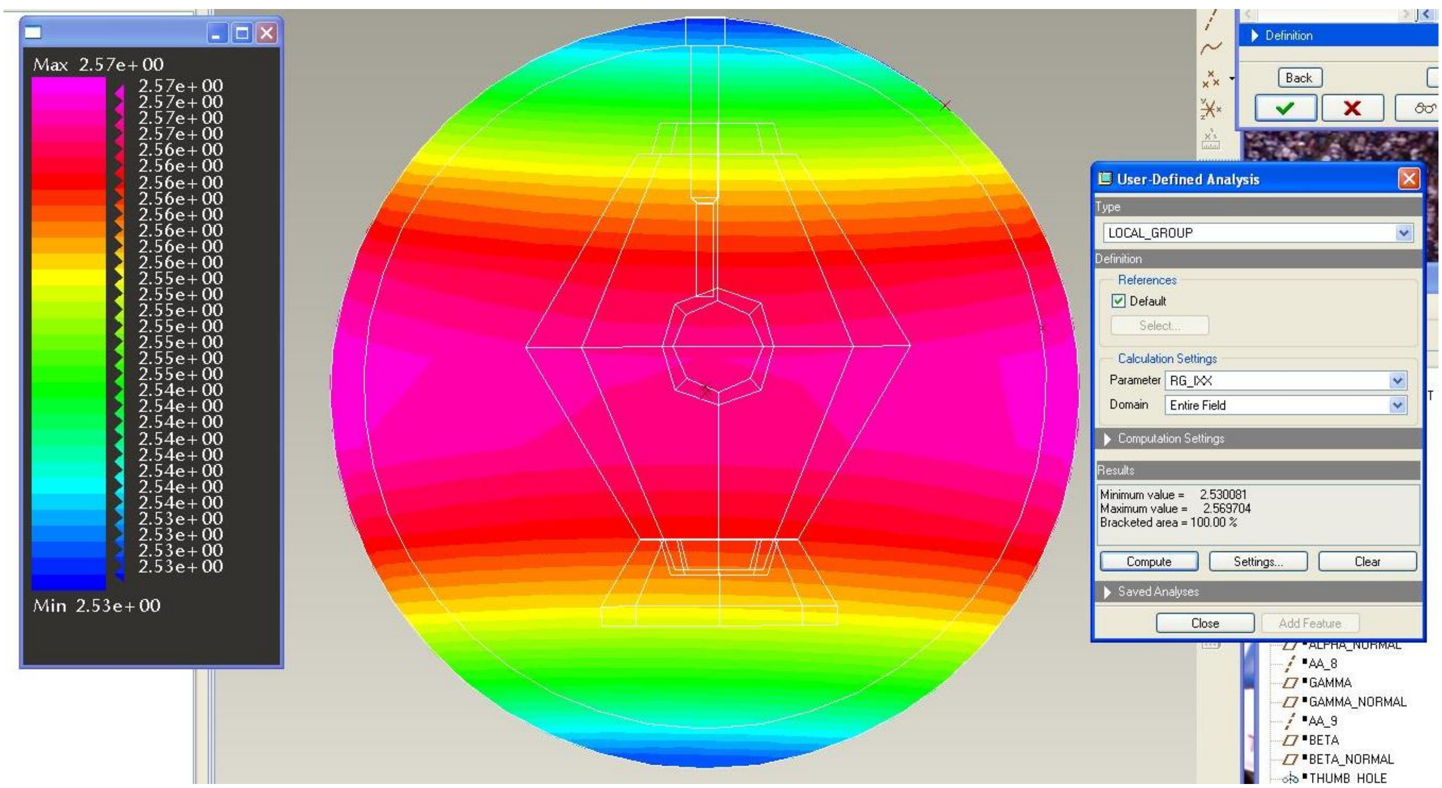

Figure 3: Un-Drilled Chainsaw Massacre w/ Plotted Rg Contours (2.53/.040)

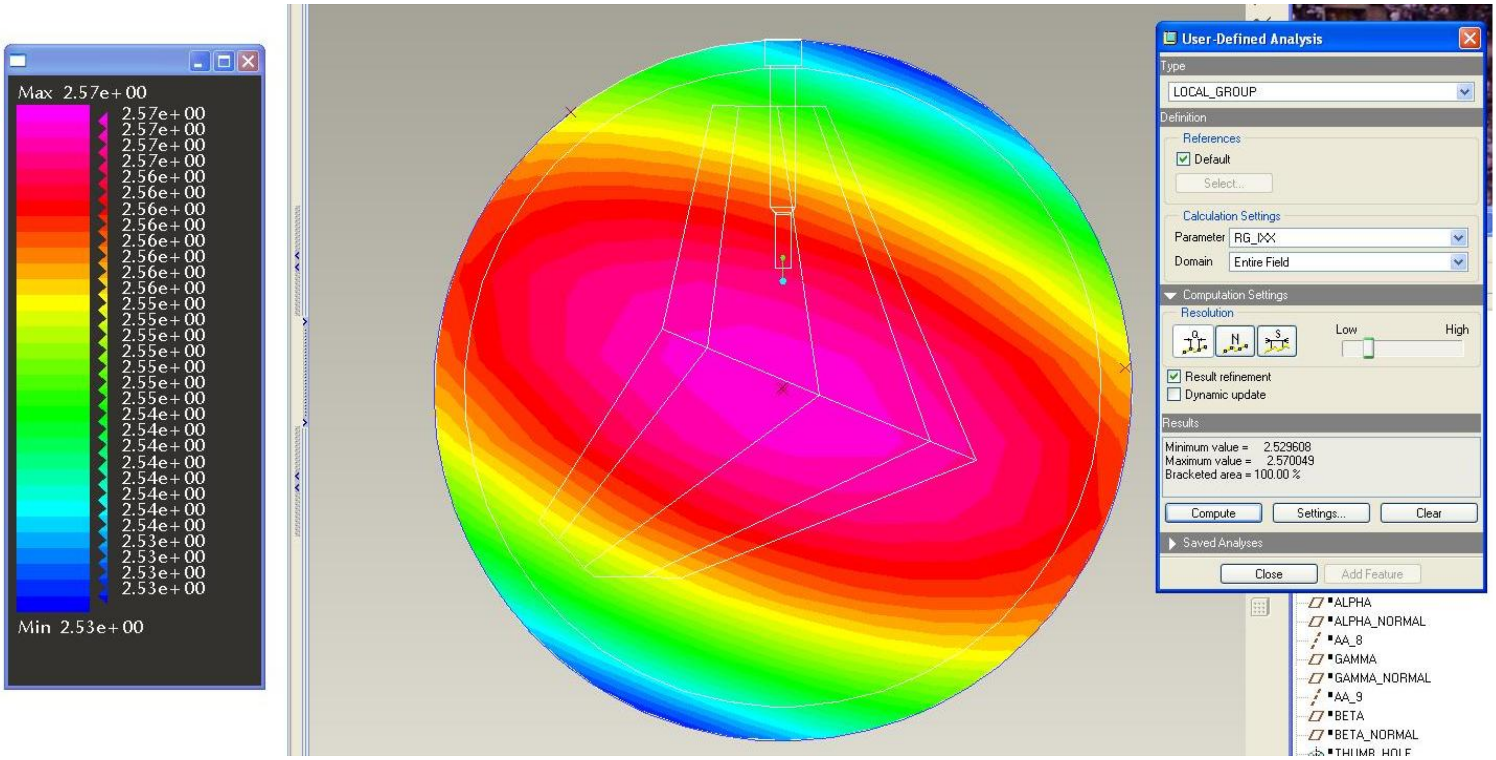

Figure 4: Un-drilled “Boomerang” Core Shape w/ Plotted Rg Contours (2.53/.040)

The initial Rg value about the PAP can now be compared between these two core shapes that have the same Rg and Diff. Rg. For this example, a “pin up” drilling that places the pin 5 – ½’’ from the PAP and swinging the center of gravity out ~ 1’’ from the center of grip on both core shapes was used for a direct analytical comparison. It is important to note that several drill patterns can be compared with the same trends in results. Figure 5 below shows that on the drilled Chainsaw Massacre the initial Rg about the PAP is 2.55’’ while Figure 6 below shows the same drill pattern on the “Boomerang” core but the starting PAP Rg is 2.56’’. Another interesting characteristic is seen by following the Rg contours towards the center of grip line. The high Rg (pink color band) contour is above the thumb hole in the “Boomerang” core and below the thumb hole in the Chainsaw Massacre. Therefore as seen, the actual Axis Migration Rg contour on the “Boomerang” core arc’s in a direction higher towards the finger holes compared to the Chainsaw Massacre Axis Migration path. This trait is due to the tilting of the Rg contours caused from the uniqueness of the core design. These differences combine to differ the resulting ball path and ball motion generated by each ball. If the same shell is placed around both cores the “Boomerang” core would have enhanced angle coming off the spot, become more continuous down lane, and also react slightly further down lane compared with a typical core design with the same mass properties.

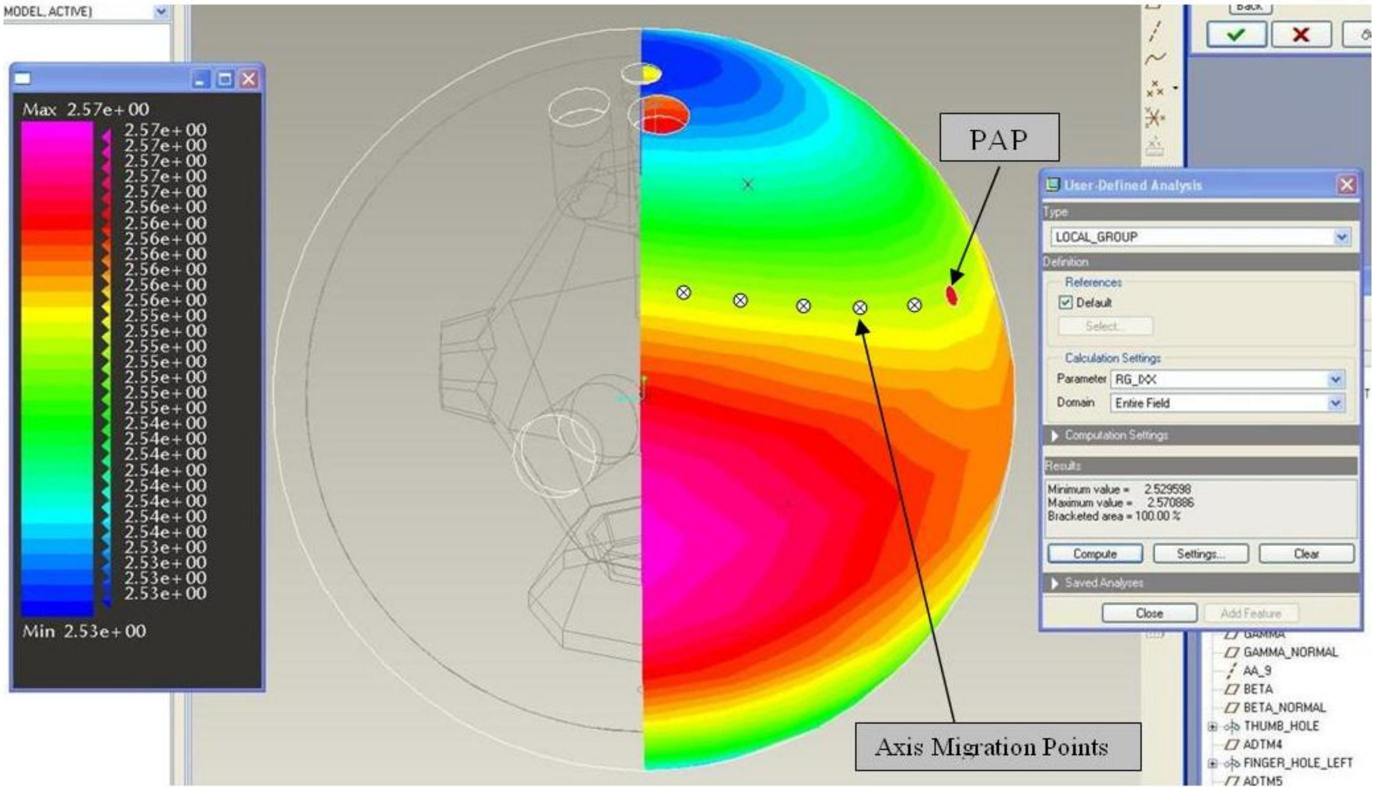

Figure 5: Drilled Chainsaw Massacre w/ Resulting Rg Contours (PAP Rg = 2.55)

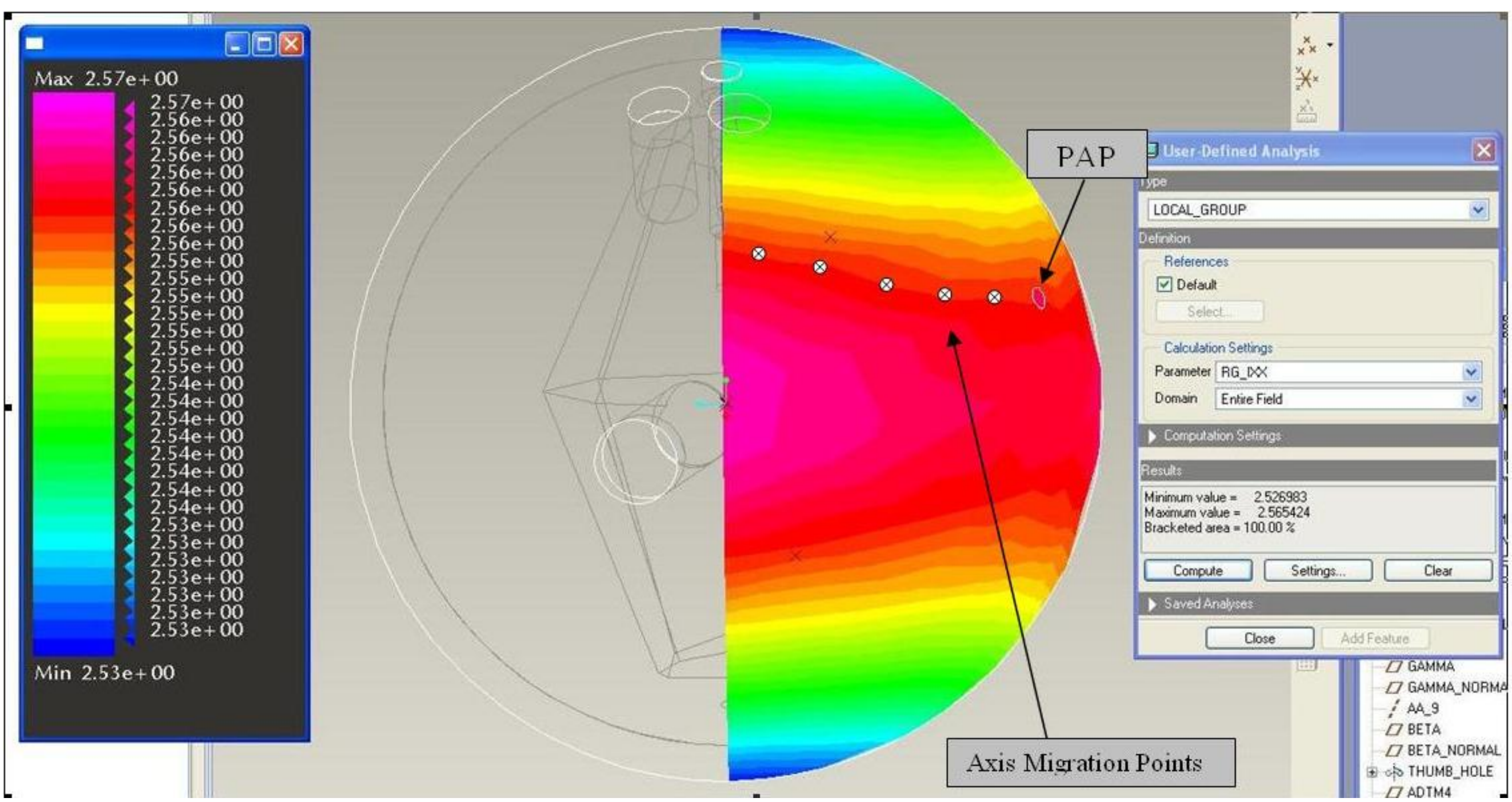

Figure 6: Drilled “Boomerang” w/ Resulting Rg Contours (PAP Rg = 2.56)

In conclusion, various versions of the diamond shape have proven success on the lanes. The next step in the ever evolving diamond technology has now been developed. Using contorted and stretched methods in design this new “Boomerang” core allows for significant alterations in Rg contours. These altered and shifted Rg bands allow for a different axis migration path with the “Boomerang” core creating a unique ball motion that can be added to expand Lane #1’s ball motion characteristics. The “Boomerang” core will enhance both the motion down the lane and the drive through the pins. Check out the latest addition to the Lane #1 diamond core family!