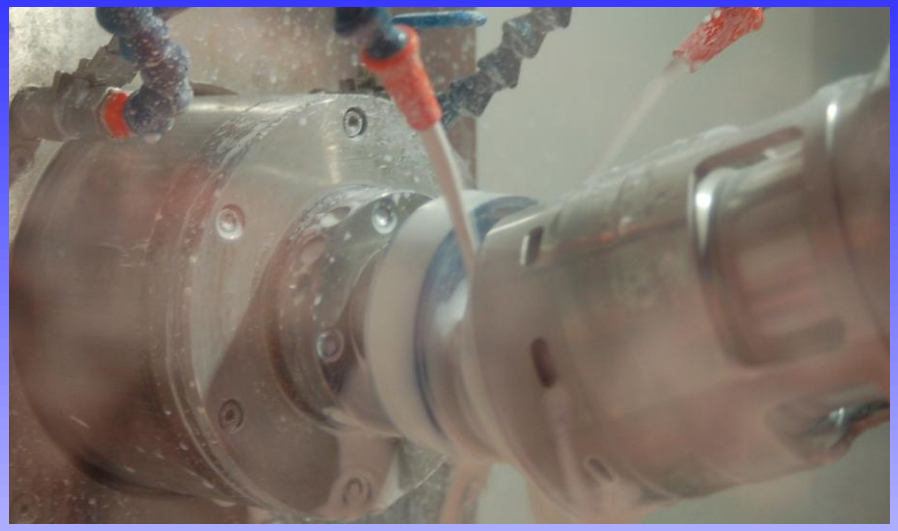

Active Methods to Control Edges on Segmented Mirrors

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TECHNOLOGIES

Importance of edges

- Segmented-mirror telescopes
- Instrumentation optics
  - e.g. image and pupil slicers

- Edge-roll degrades:-
  - Infrared emissivity
  - Stray light performance

Context for this work

- Develop a *generic* edge-control process
- Support a very challenging project:
  - Manufacture of seven prototype mirror-segments for the 42-metre European Extremely Large Telescope ('E-ELT').
  - 1.42m across-corners, hexagonal, off-axis aspheric mirrors
  - The telescope construction-phase will require **1,148 segments.**

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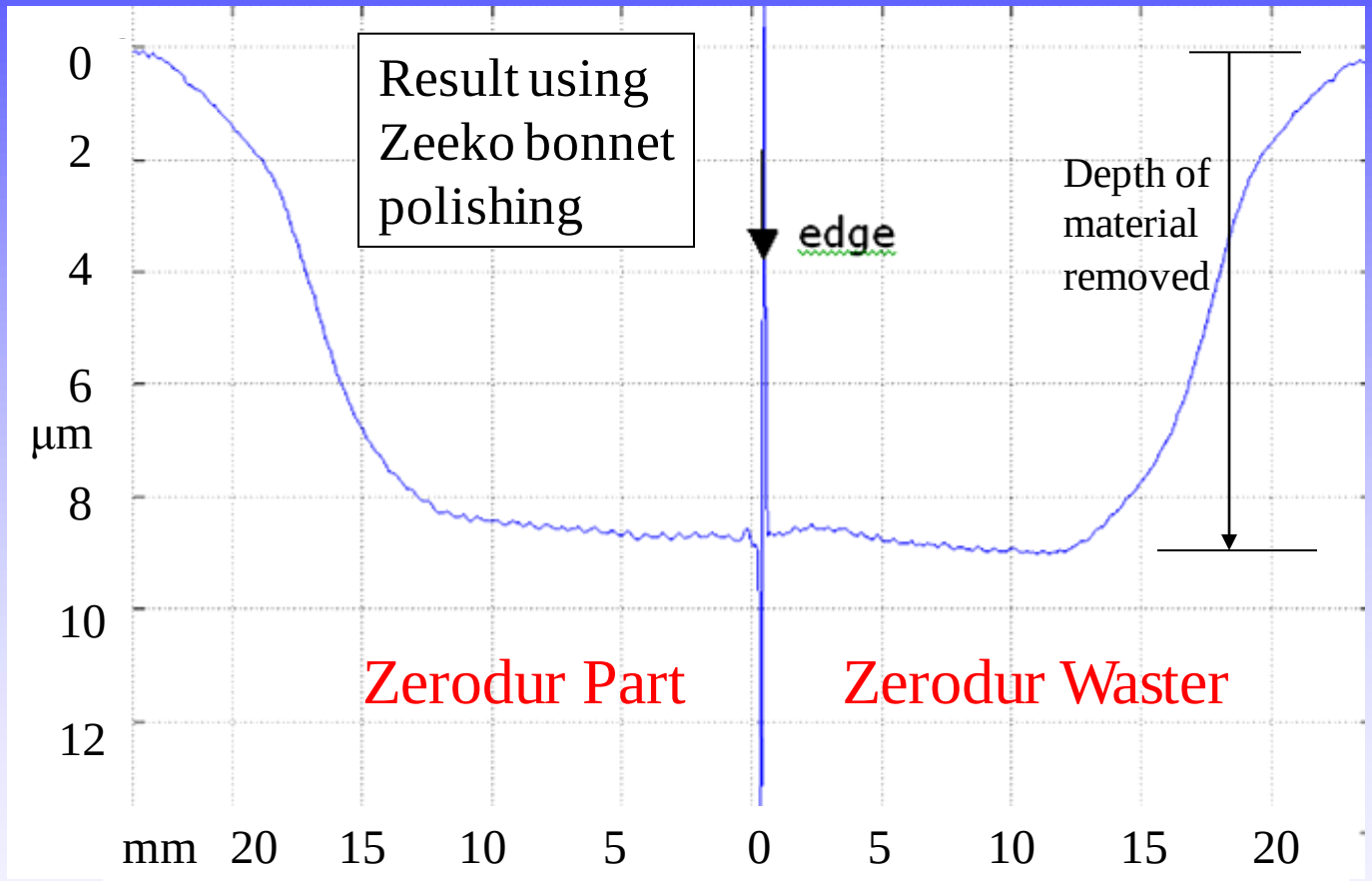
Basis of process

- Polish and rectify form with near-Gaussian influence-functions:-
  - Zeeko-classic bonnets
  - Potential for finishing with Zeeko-Jet
- But, how do we address the edges?

Standard technique – use of wasters

- Attach sacrificial strips around the part, to support the tool as it overhangs the edge.



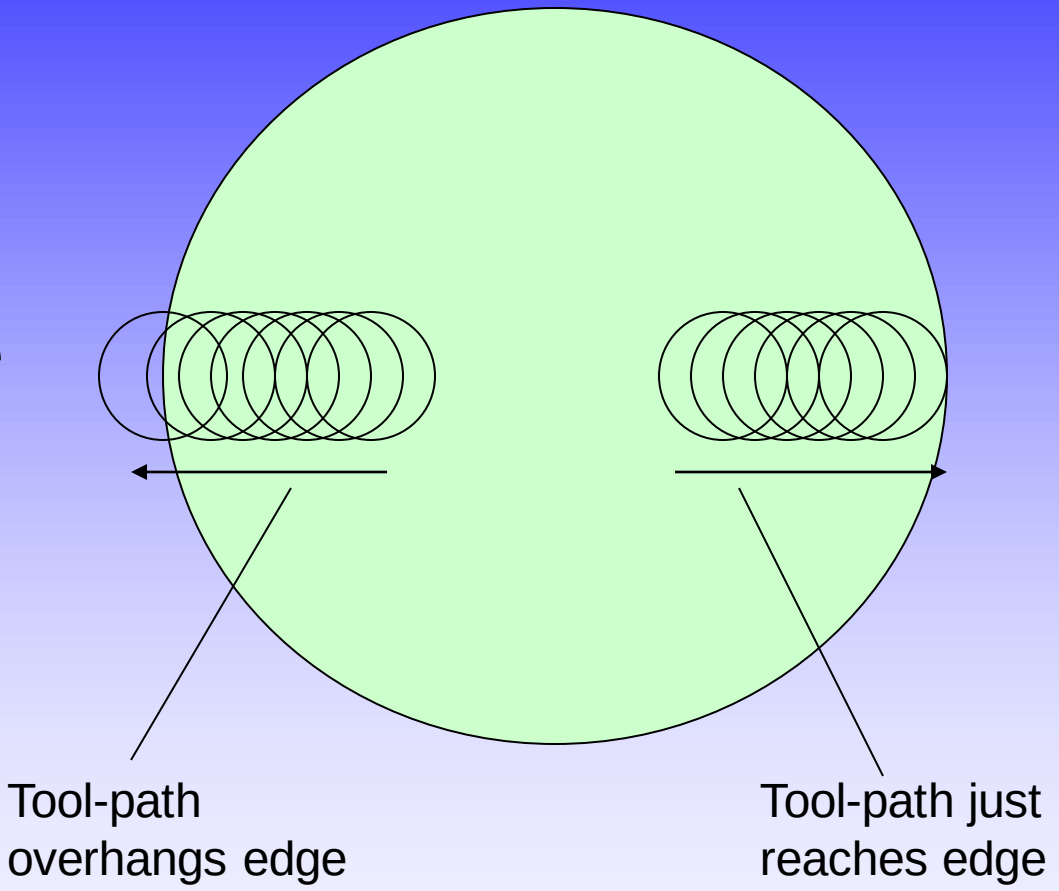
Issues with wasters

- For meter-scale mirrors:-
  - Expense of matching material
  - Adhesives can distort the mirror substrate
  - Manually-intensive with risk
- Prefer a direct ‘active’ approach… particularly for segment mass-production.

Overhang of Gaussian polishing spot at ends of raster tool-path

The polishing spot can:-

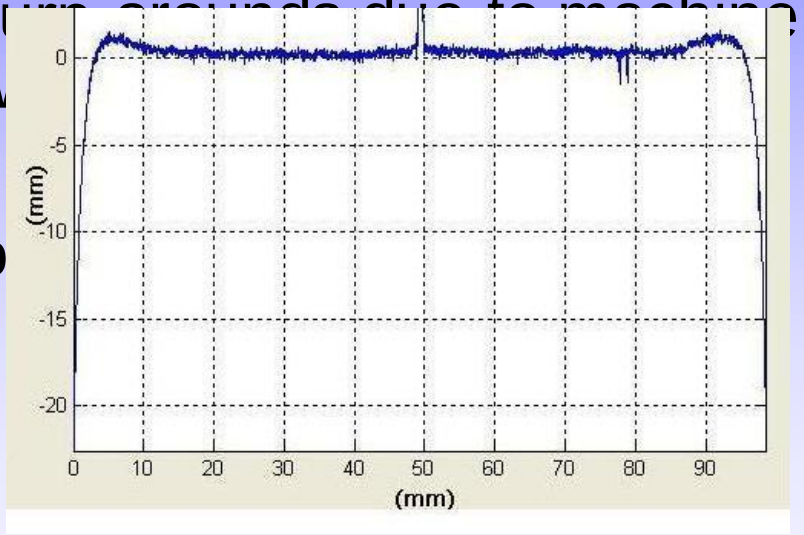
- Stop short of edge
- Reach edge
- Overhang edge



With no special precautions …

Three relevant effects regarding edge-profile:-

1. … where the tool-path turns around w.r.t. the edge
2. … extra removal at raster t… decelerations (increased dw…
3. Small spot sizes needed fo… polish global surface.



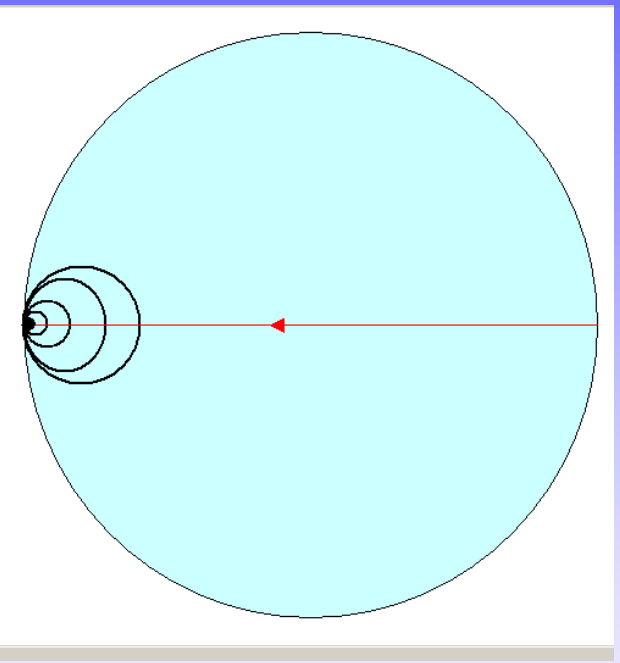
Preferred strategy

– Bulk surface-removal with big spots leaving a minimum turned-up edge

– Edge rectified with small spots in a separate operation.

How do we create the turned-up edge?

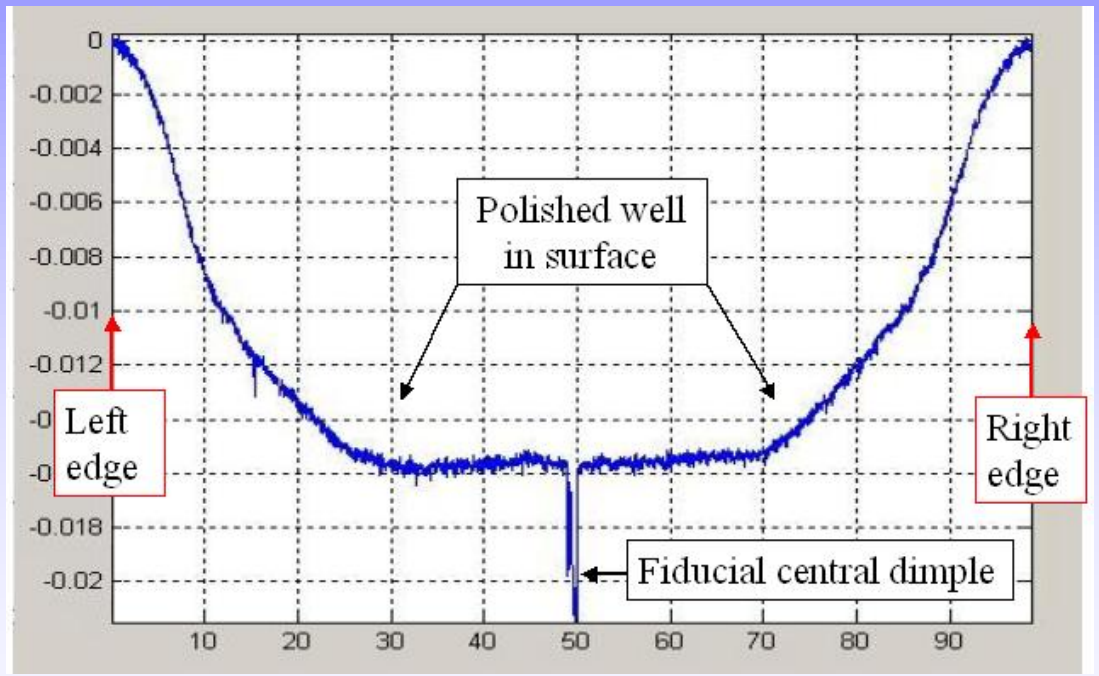
Linear tool-lift with raster tool-path



- The bonnet lifts as the leading-edge of the contact-spot reaches the edge of the part.
  - Reduces spot-size and removal-rate to zero at the edge
- The raster traverse decelerates
  - Increases effective dwell-times
  - Avoids extra dwells from raster turn-arounds

Current Software Implementation

- Linear 'lift-off' algorithm
- Linear deceleration of traverse-speed
- Both start at the same position



- No edge-roll, but-
- Removal is zero at edge of part

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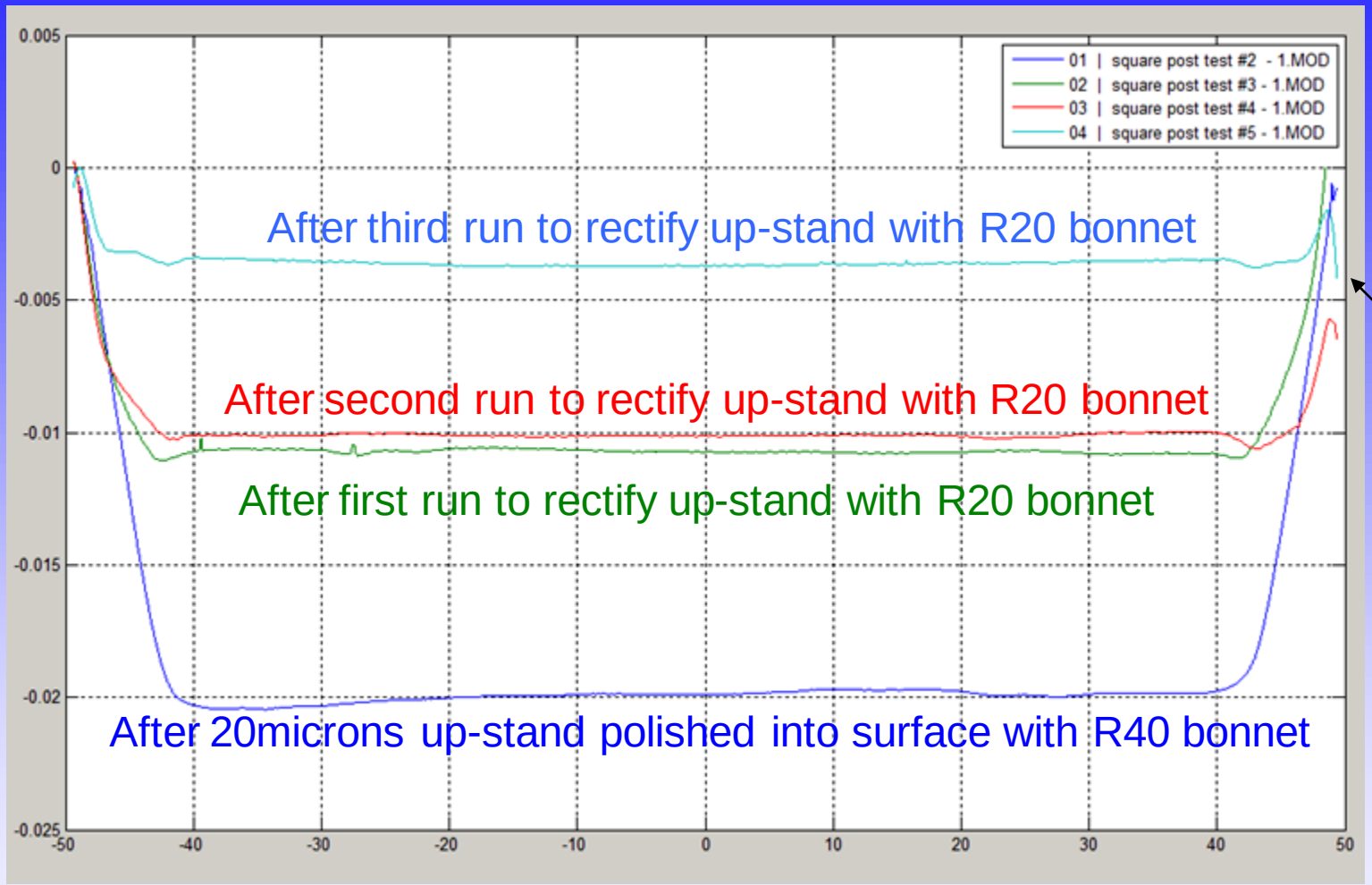
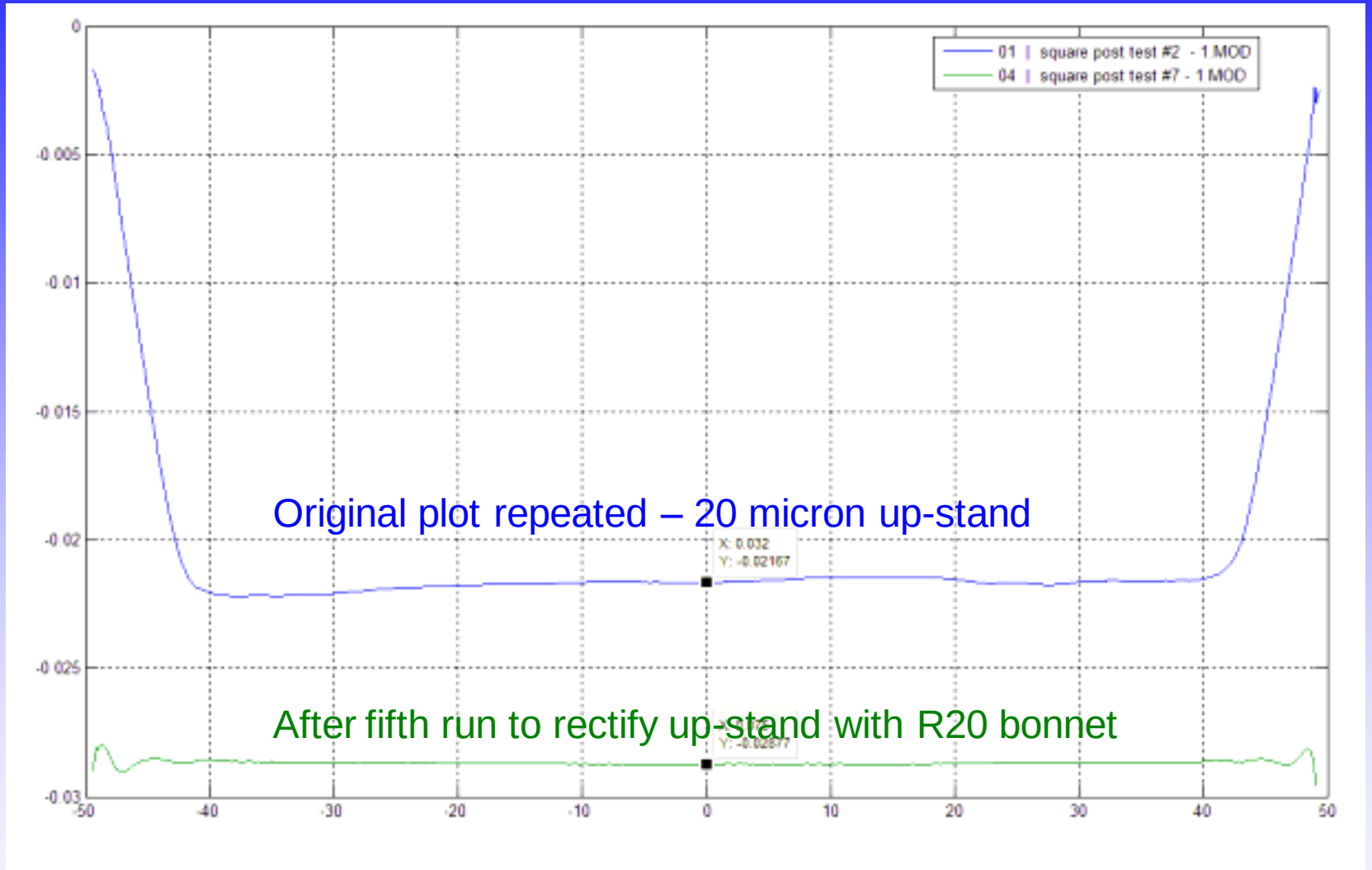
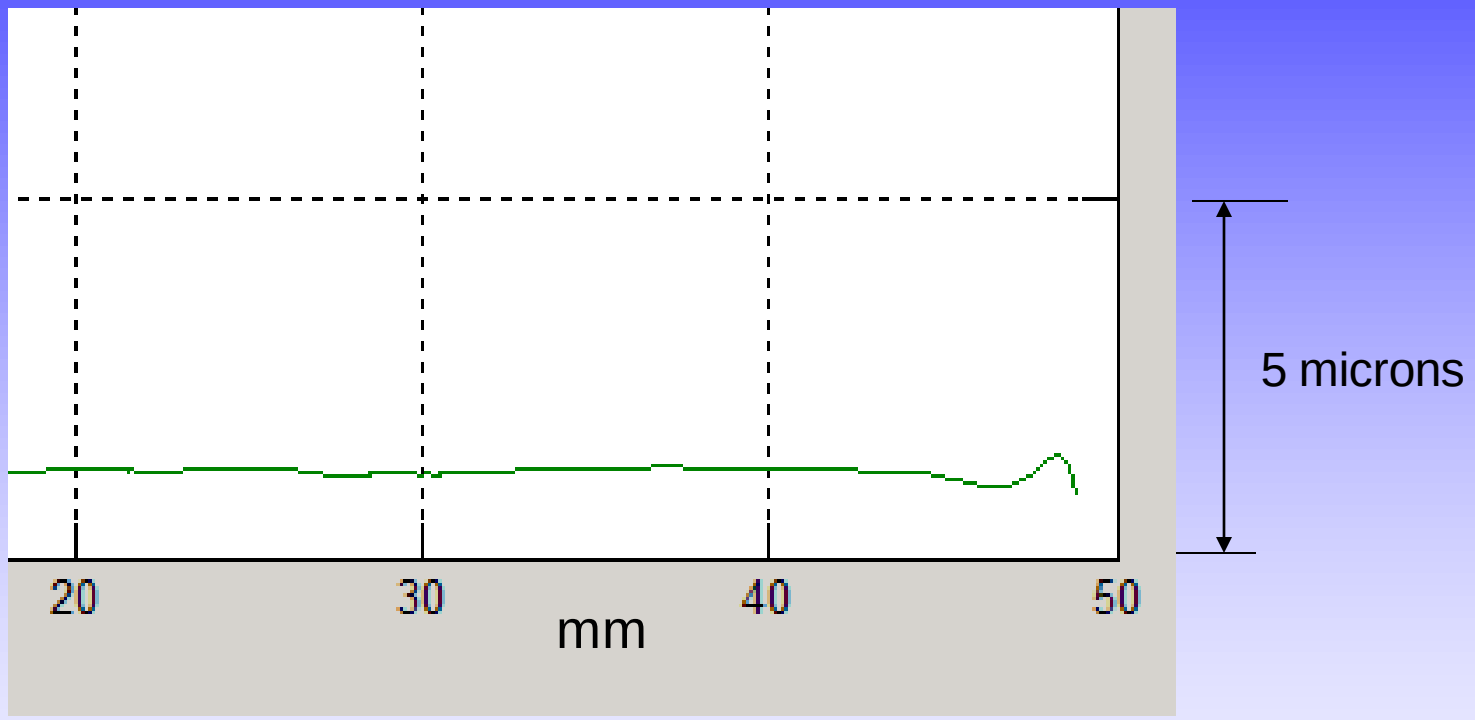
Edge up-stand and edge-rectification



After two more runs c.f. original profile

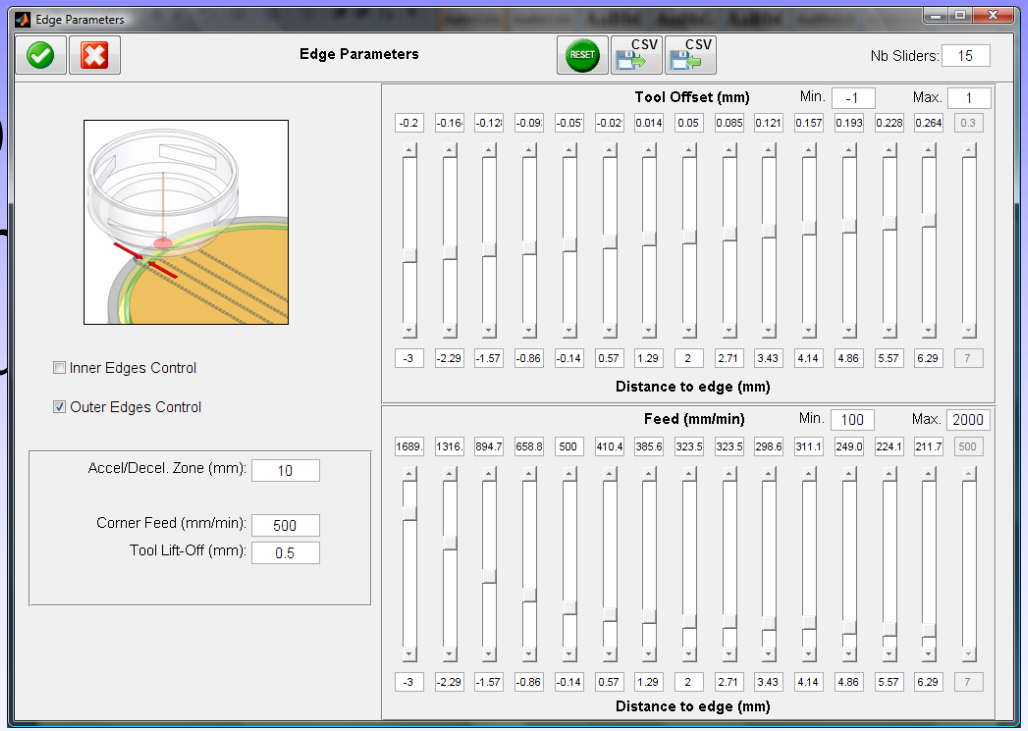


After pitch-loaded 20mm bonnet



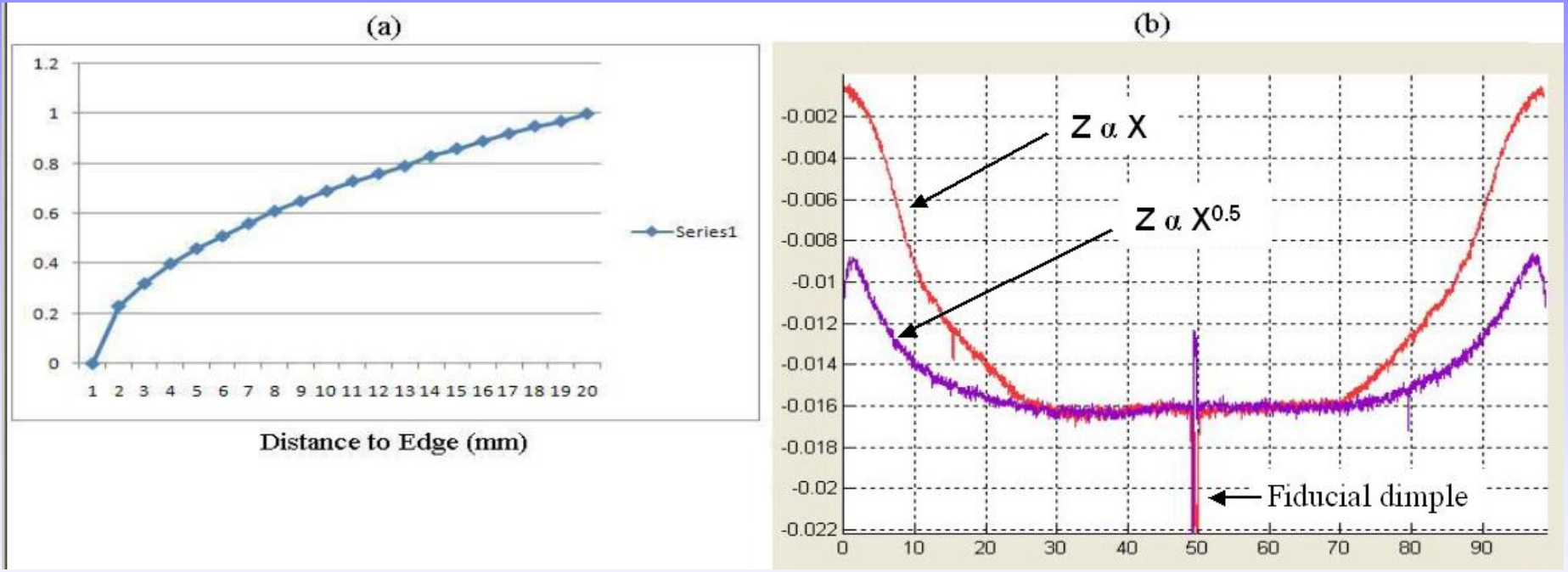
Revised Software Implementation

- Non-linear option for both ‘Lift-off’ and Deceleration.
- Can b
  - Mar
  - Inpu



Example – tool-lift using $Z=X^{0.5}$ function

- Significantly reduced up-stand without incurring edge-roll below the projected optical surface.



Next stages

- Reduce up-stand volume and speed the edge-rectification
  - Implement tool-lift within *Precessions* ™ numerical optimizer code
  - Explore pads/slurries for fast edge-rectification
  - Merge with empirical modeling of spot-evolution with part-overhang
- Amalgamate with the random tool-path

Conclusions

- Successful demonstration of the principle:
  1. Controlled peripheral up-stand, which allows fast global polishing & form-rectification.
  2. Separate pass with small spots to rectify up-stand.
- Considerable scope for further process optimization

Acknowledgements

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