



# The Development of Compound Parabolic Concentrators (CPC)

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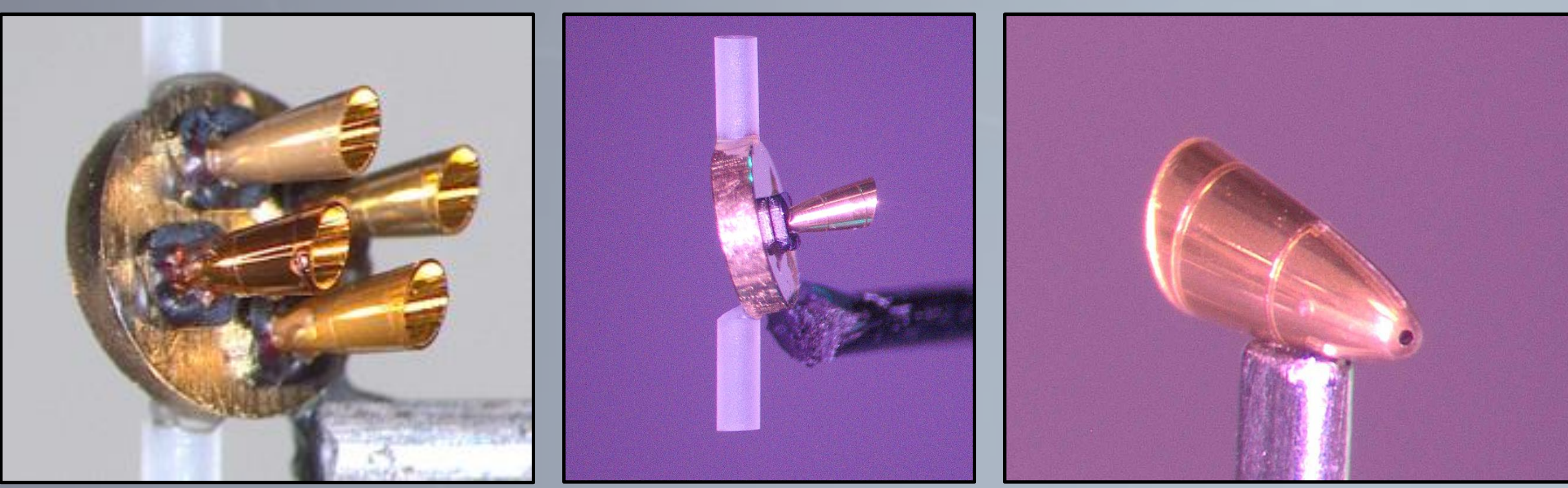
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## COMPOUND PARABOLIC CONCENTRATOR (CPC)

- CPCs are used at the National Ignition Facility's Advanced Radiography Capability (NIF-ARC) laser to enhance the acceleration of electrons and protons, and to produce high energy photons.
- CPCs have a parabolically curved design to redirect rays from the outer edges of the beam to the cone tip and improves energy concentration.
- The diameter opening of a CPC cone is 500um with a 50um diameter cone tip.



## SIZE OF CPC CONE

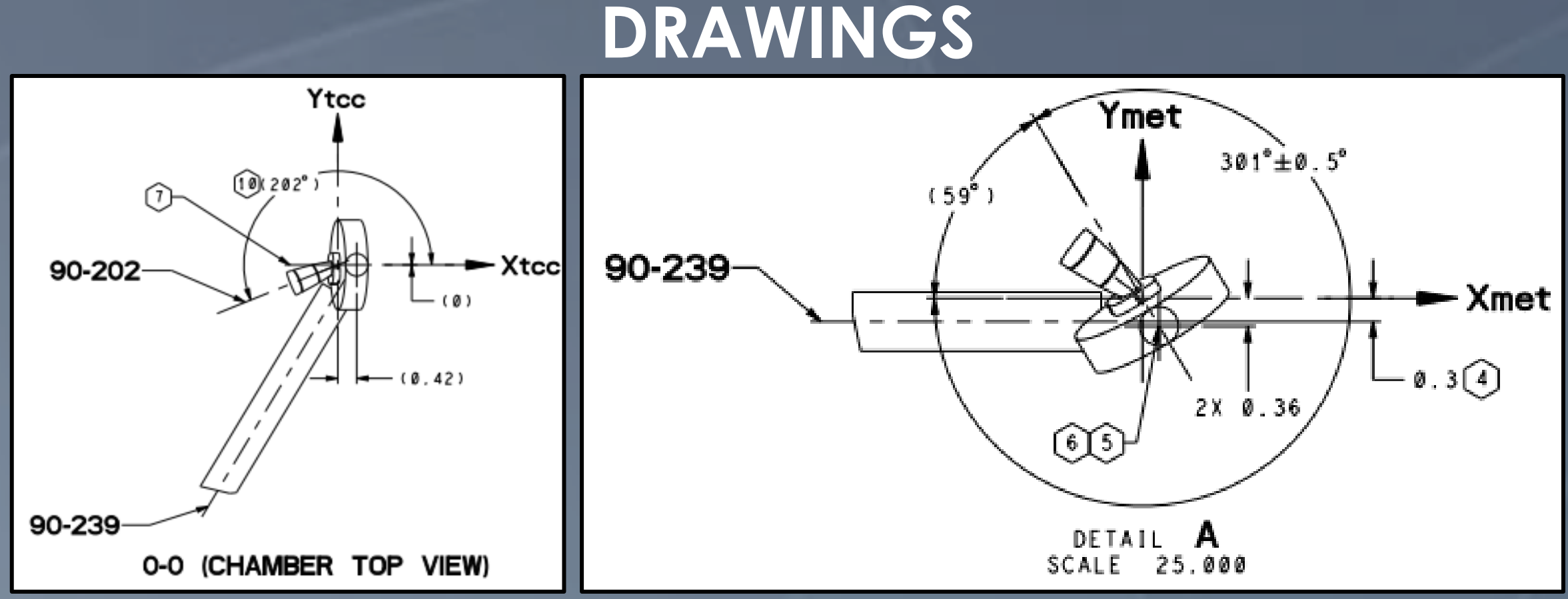


Dime vs CPC length:  
17.91mm vs 1.2mm

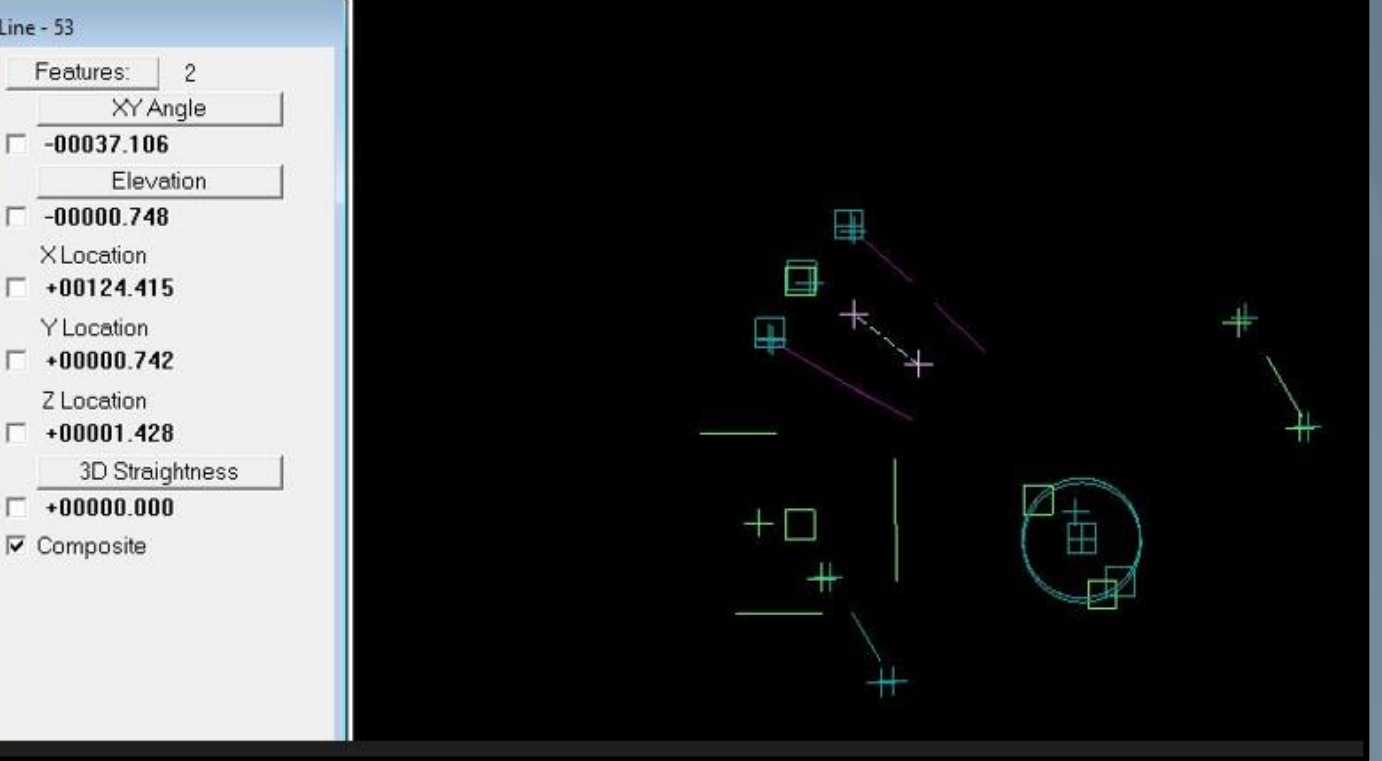
Can you find the CPC cone on the dime? That's how small it is!

The size of these CPC cones are super tiny, and this makes it really challenging to handle, maneuver, and assemble.

## CPC CONE ALIGNMENT CHALLENGES

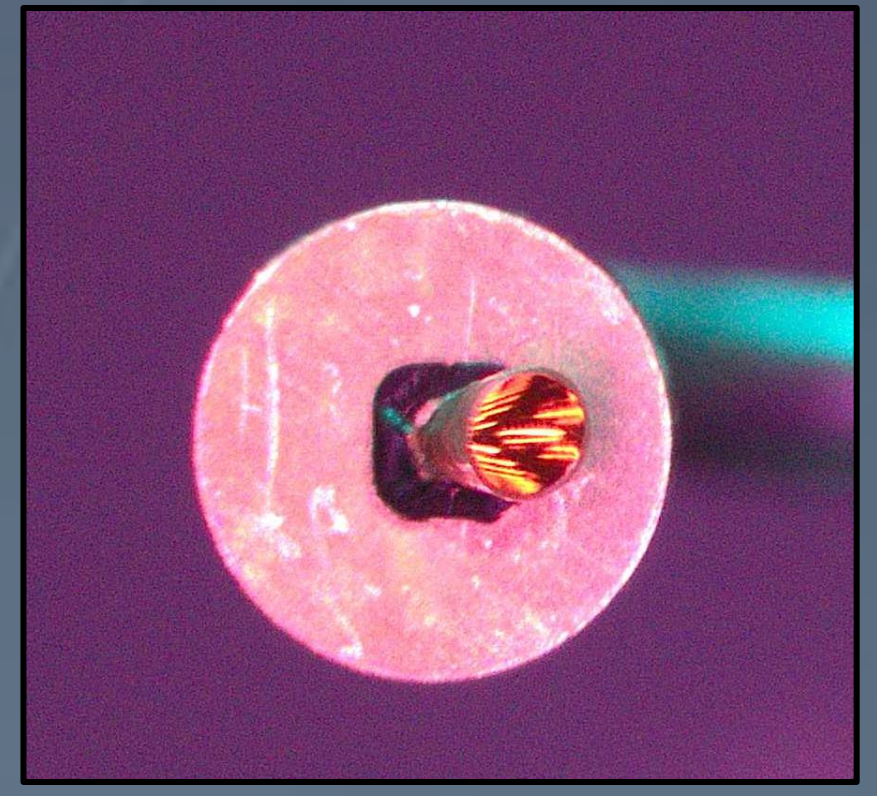


Precise angle alignment of the CPC cone to the drawing specification is challenging and resulted in various changes to CPCs and assembly methods.

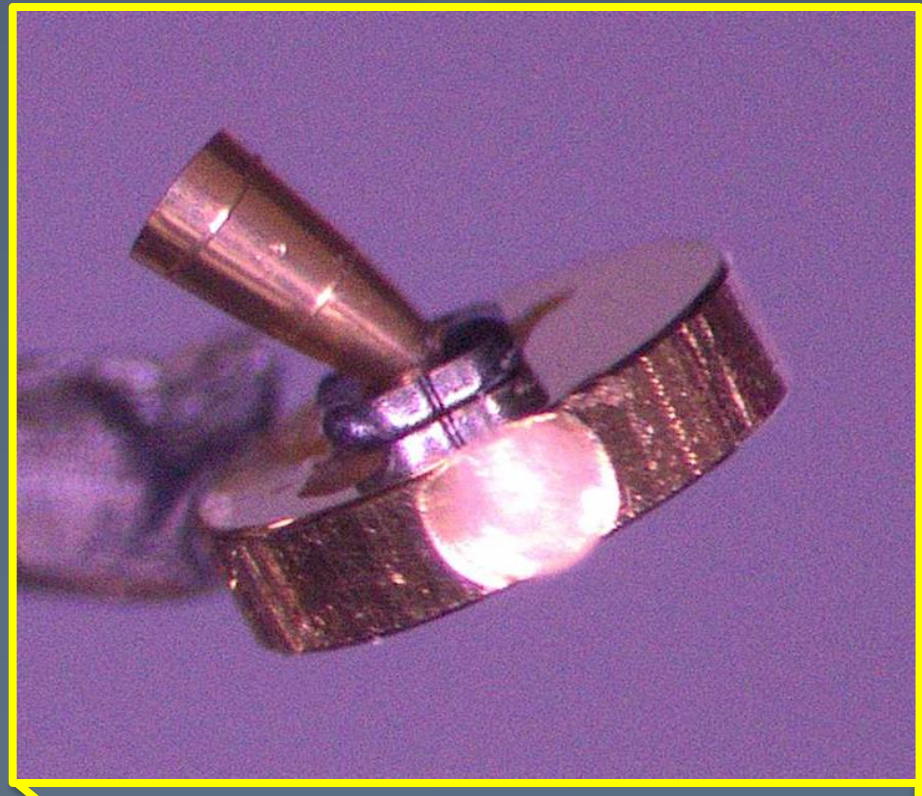


OPTICAL COORDINATE MEASURING MACHINE

## TARGET VIEWS



FRONT VIEW



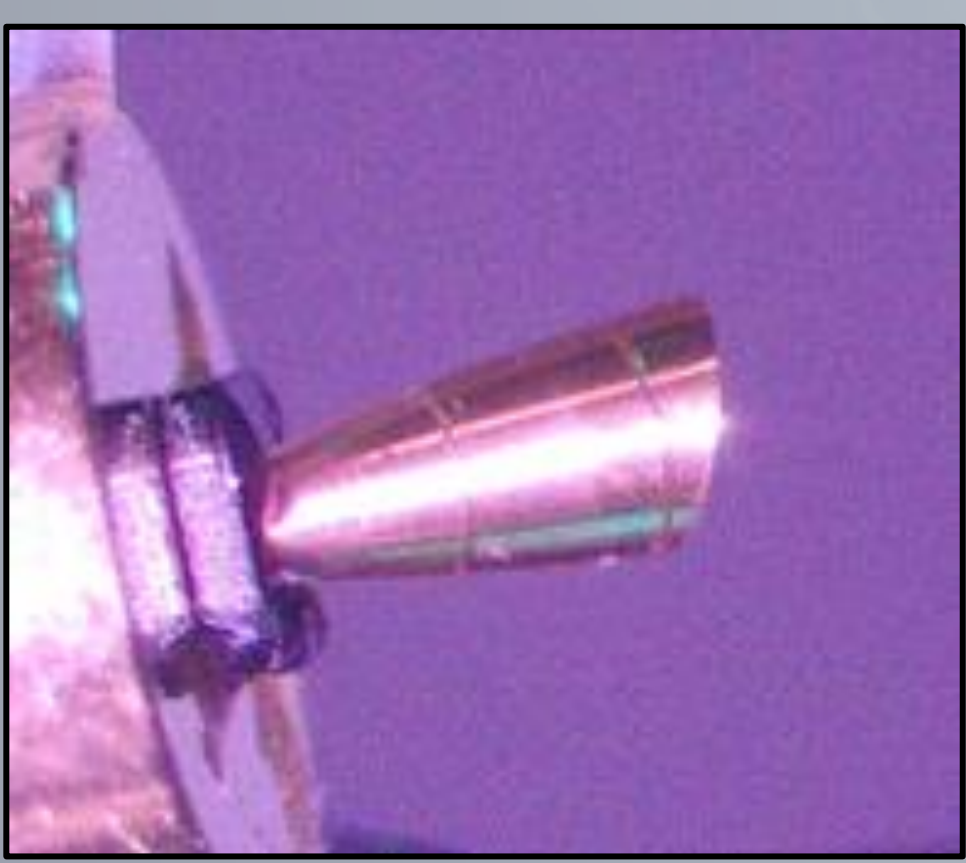
TOP VIEW



COMPLETED TARGET VIEW

## DEVELOPMENT AND IMPROVEMENTS OF CPCs

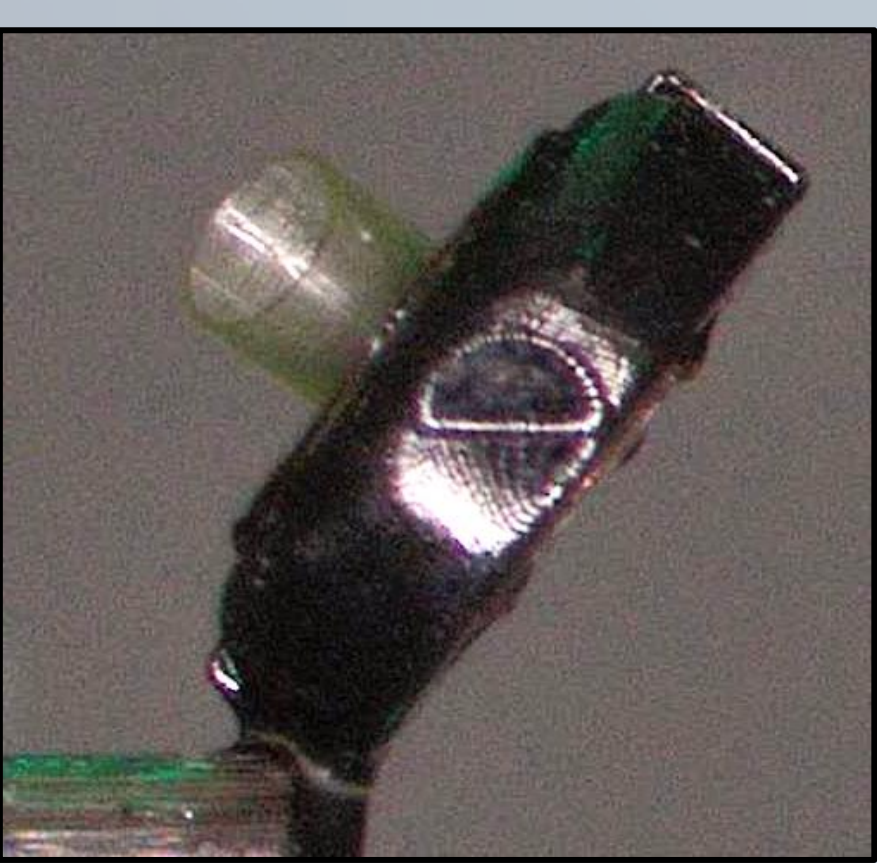
### Au CPC



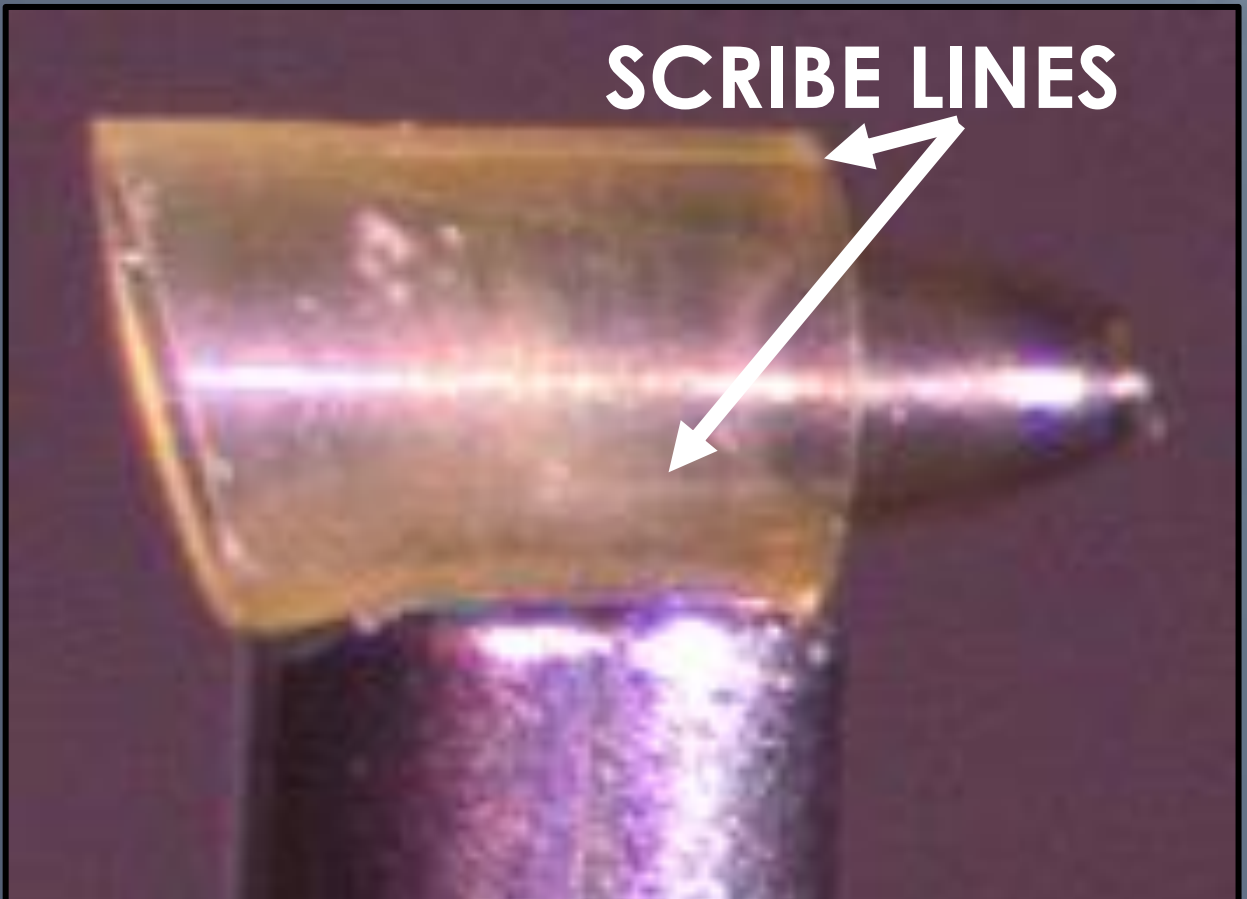
- Au cones are good x-ray producers.
- The parabolic shape is important for physics but made it a challenge to align the angle.
- Scribe lines were added to aid in angle alignment for metrology and assembly.



### EPOXY



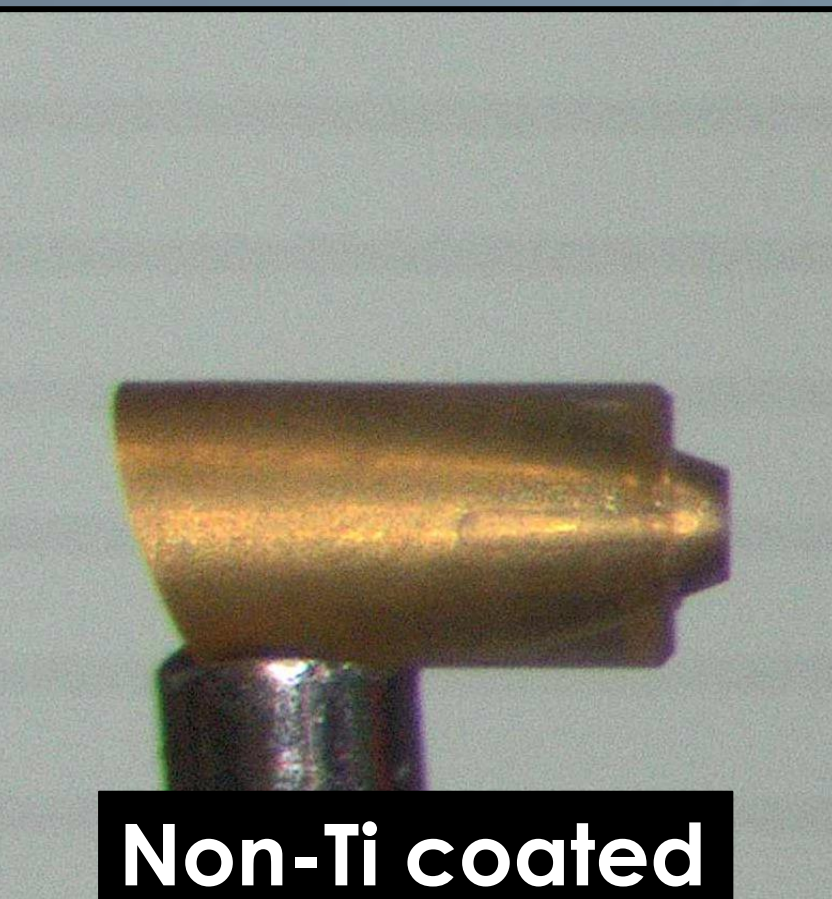
- Epoxy CPCs can be 3D printed.
- Produces fewer x-rays which can be unwanted backgrounds.
- Difficult to laser focus. Laser hits through epoxy and gives incorrect measurements.
- Scribe lines were less visible than on Au CPCs



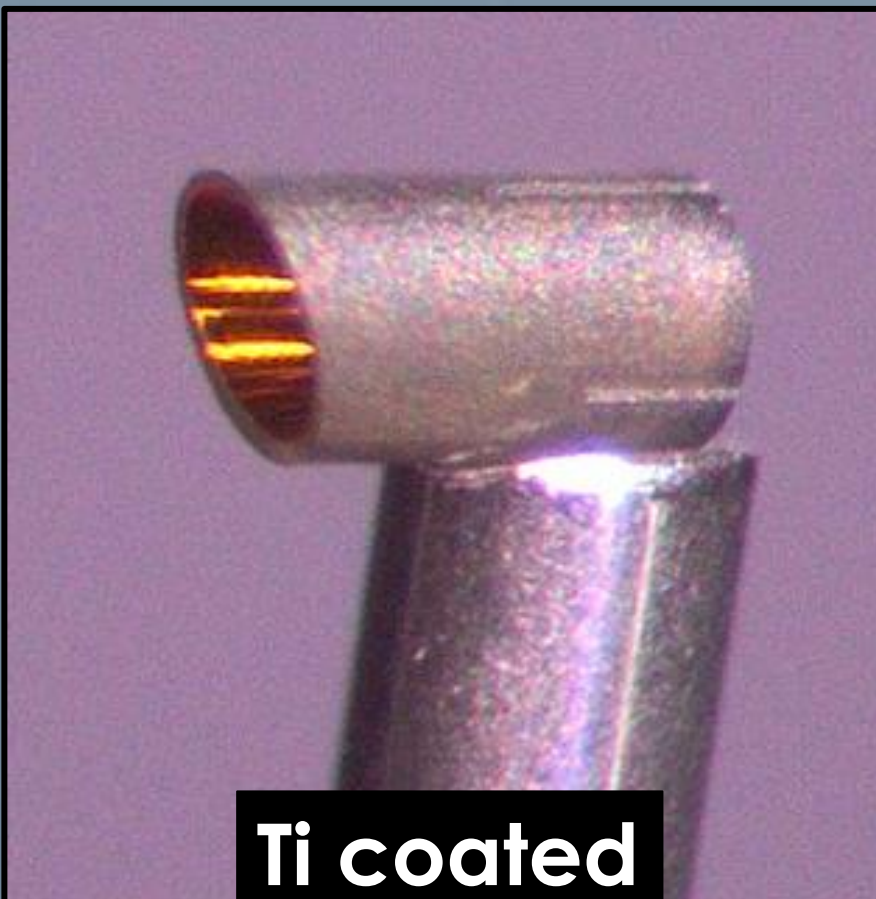
### CYLINDRICAL CPC



- Au parabolic CPC cones are coated with epoxy or Ti.
- Easier to handle with the improved design.
- Easier to perform metrology and measure precise angle alignments.
- Ti coated CPCs greatly improved laser focus issues and the visibility of scribe lines were more defined.



Non-Ti coated

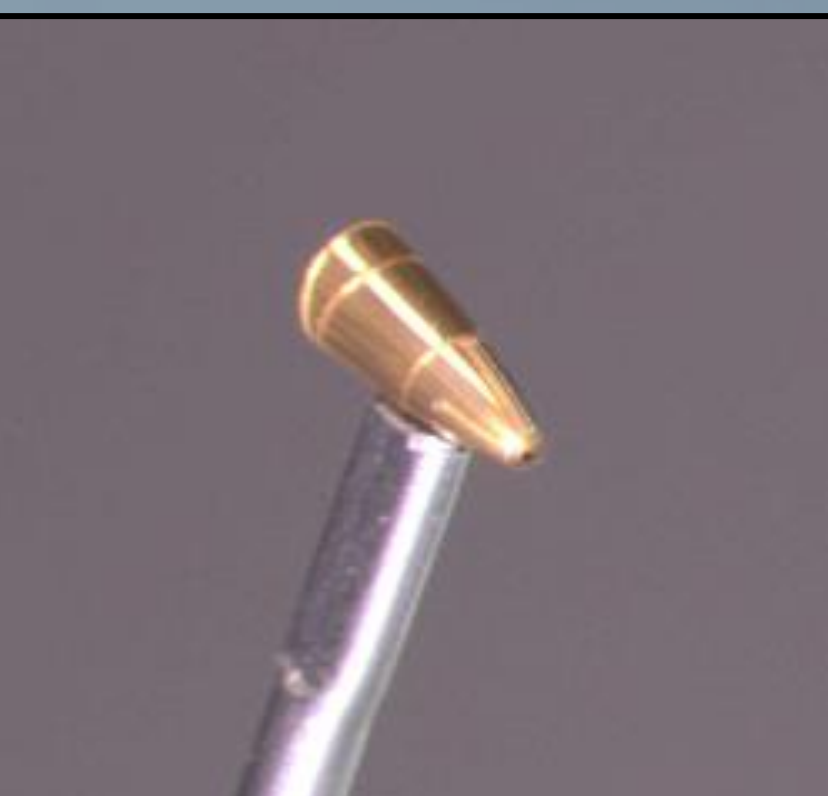


Ti coated

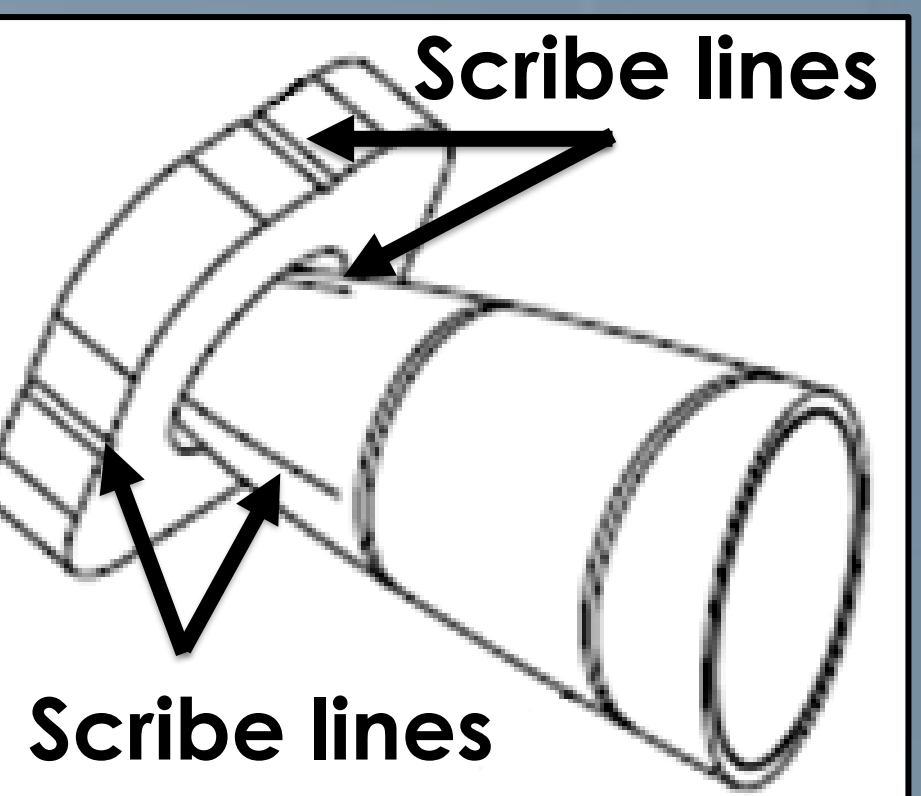
## ASSEMBLY CHALLENGES

### VACUUM TIP MODIFICATION

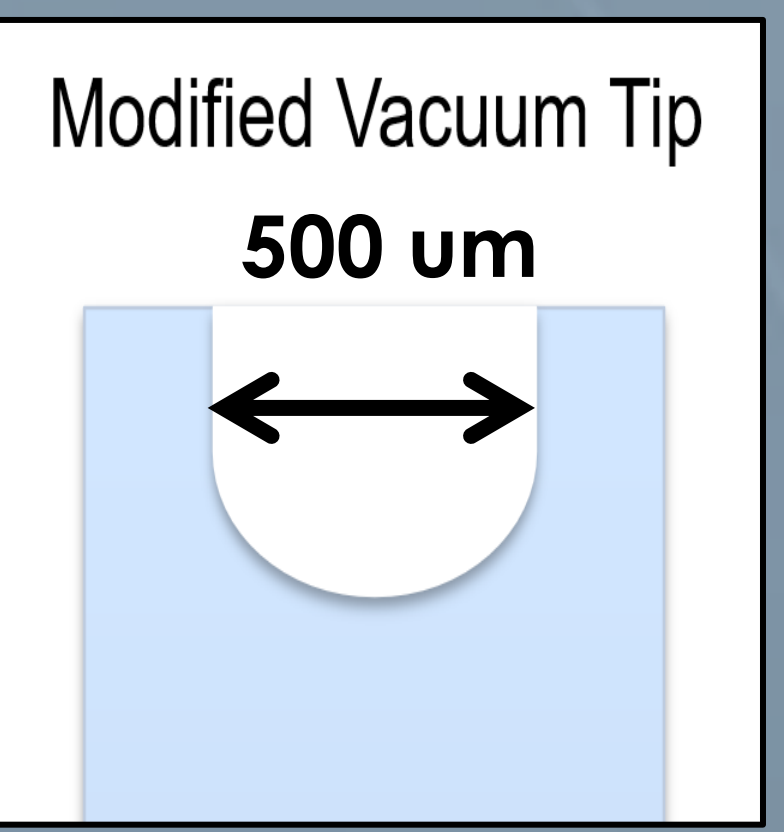
CPC cones had difficulty staying on vacuum tip while rotating cone to adjust the position of scribe lines for assembly.



FLATTENED VAC TIP



SCRIBE LINES



3D PRINTED VAC TIP

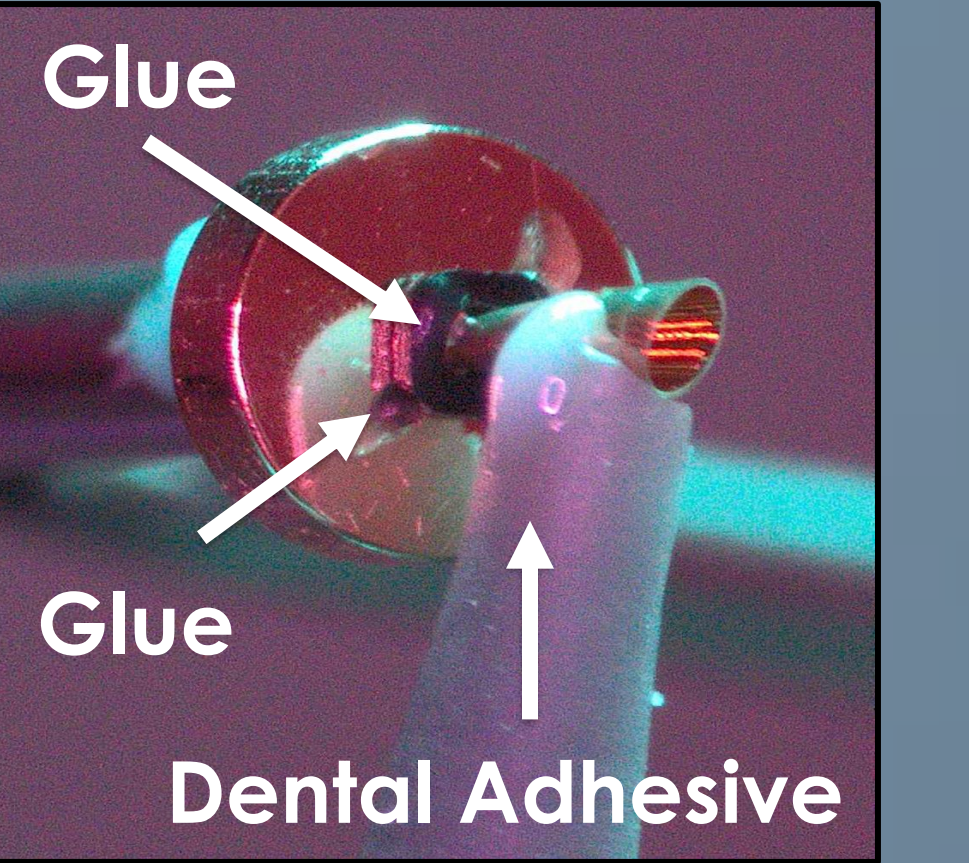
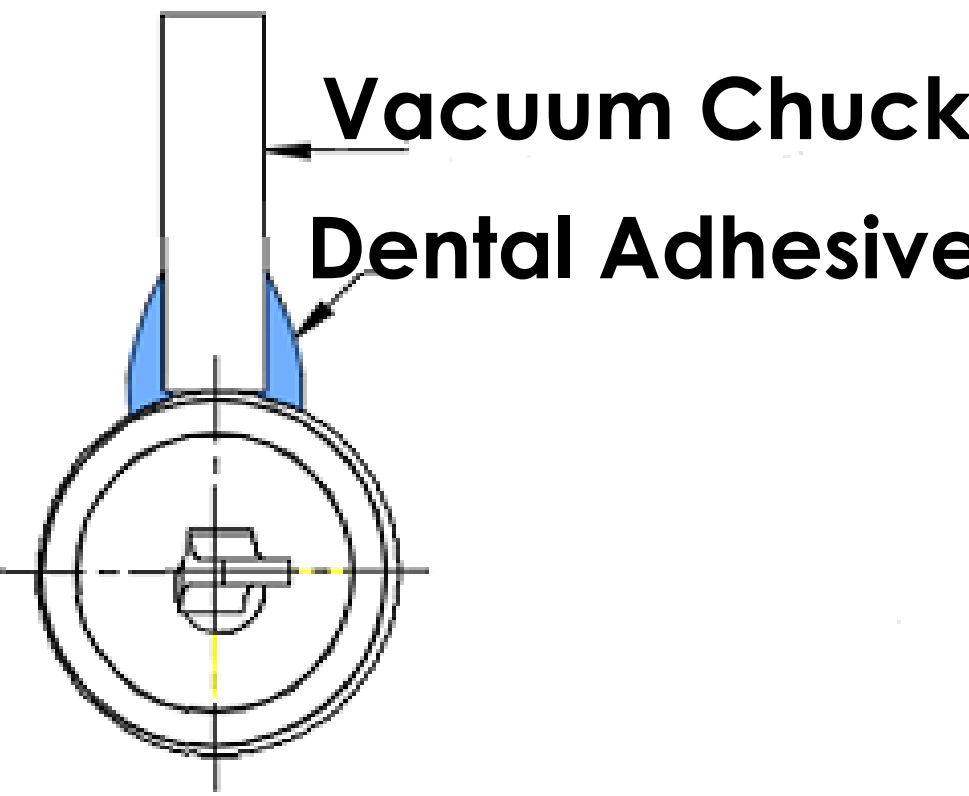
Various tips and tip modifications were tested. Laser cutting to the radius of the CPC cone improved handling and stability during rotation of cone the best.



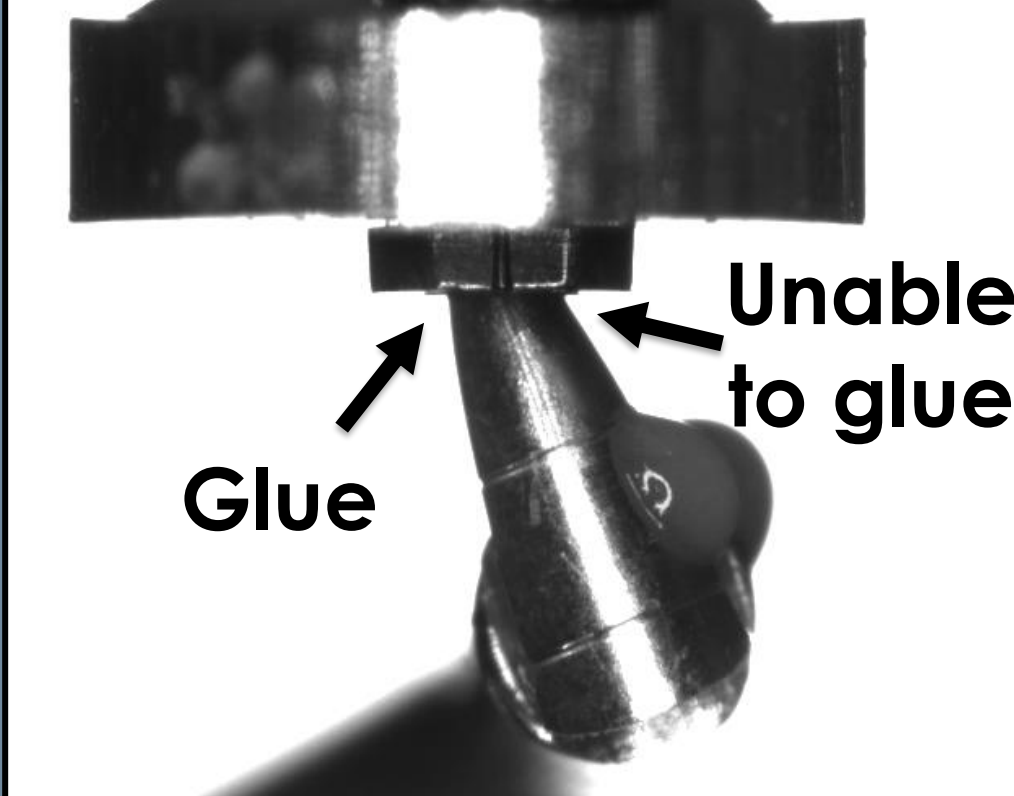
LASER CUT VAC TIP

### STABILITY DURING GLUE APPLICATION

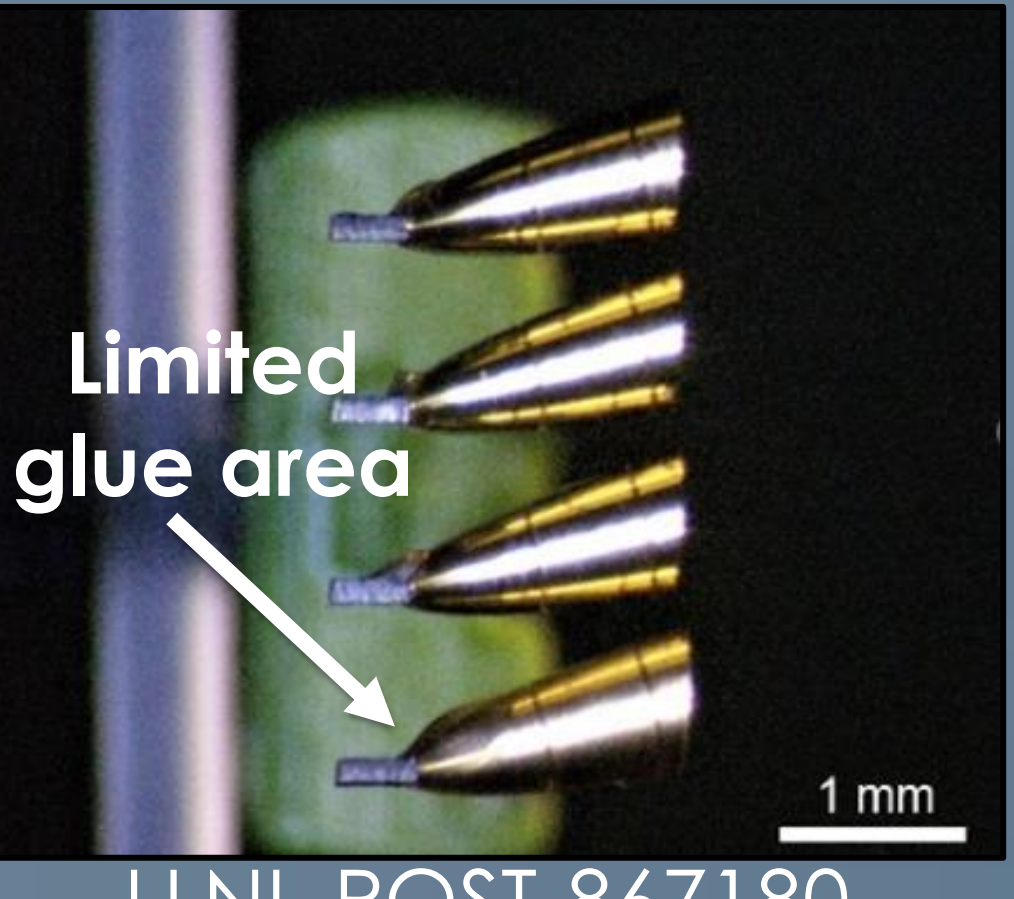
Dental adhesive aided in the stability of the cone during the gluing process.



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Gluing micro-sized parts precisely on the CPC cone is challenging due to limited glue areas and visibility during the glue application process.



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