SWTW

IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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Thermal Analysis of Wafer Level Probes for Final Test

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Johnstech International

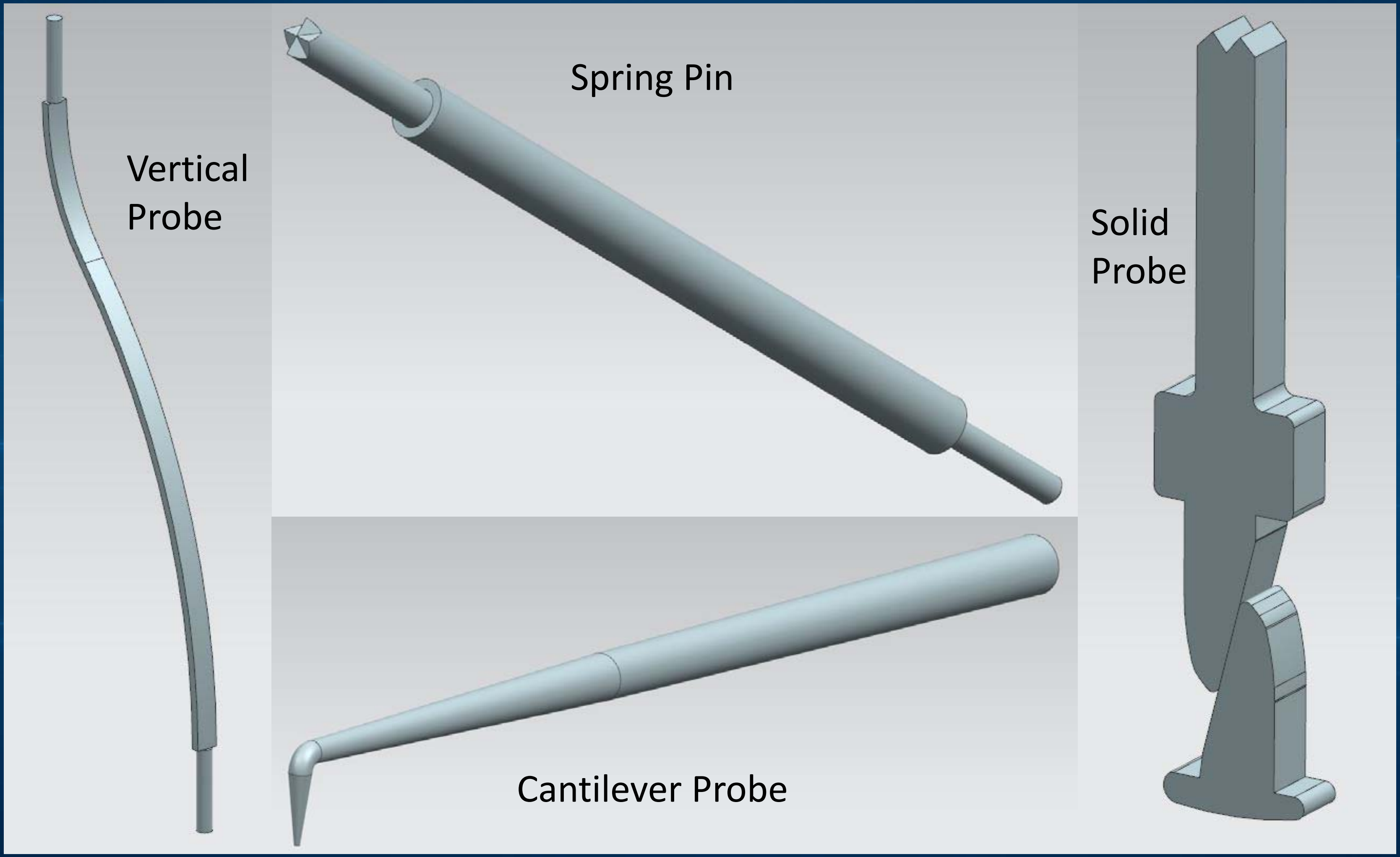
Computational Modeling With ANSYS®

- In this tutorial you will learn how to setup up and run a computational thermal analysis
- ANSYS ICEPAK
  - Electronics thermal management
- Joule Heating / Resistive Heating
- Computational Fluid Dynamics

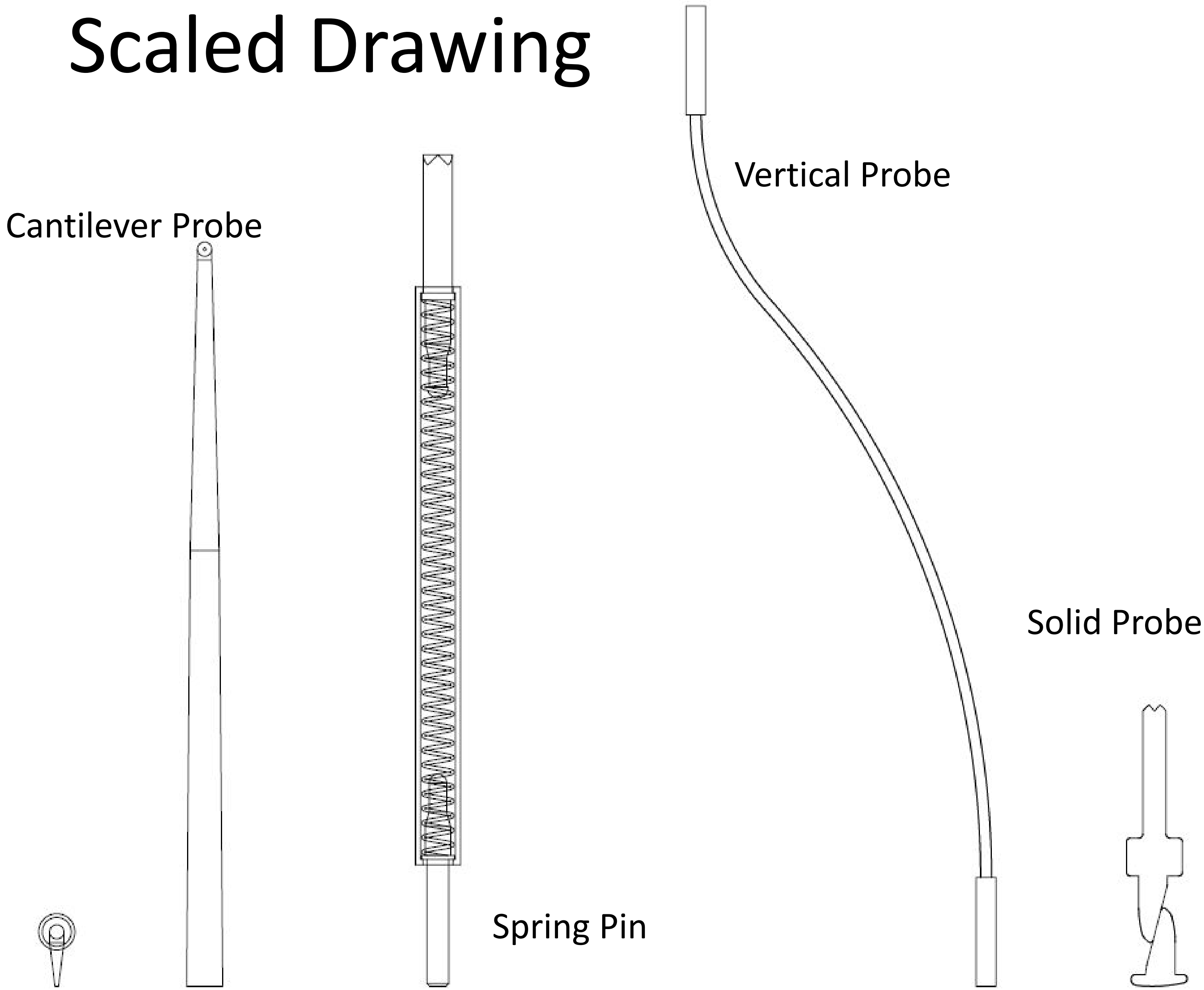
Assumptions

- 400 micron Pitch Probe Geometry
- Generic Probe Design
- Joule Heating Along One Axis
- Heat Sinks have constant temperature
  - 50˚C DUT temp
  - 20˚C LBD temp
- Material is Beryllium Copper

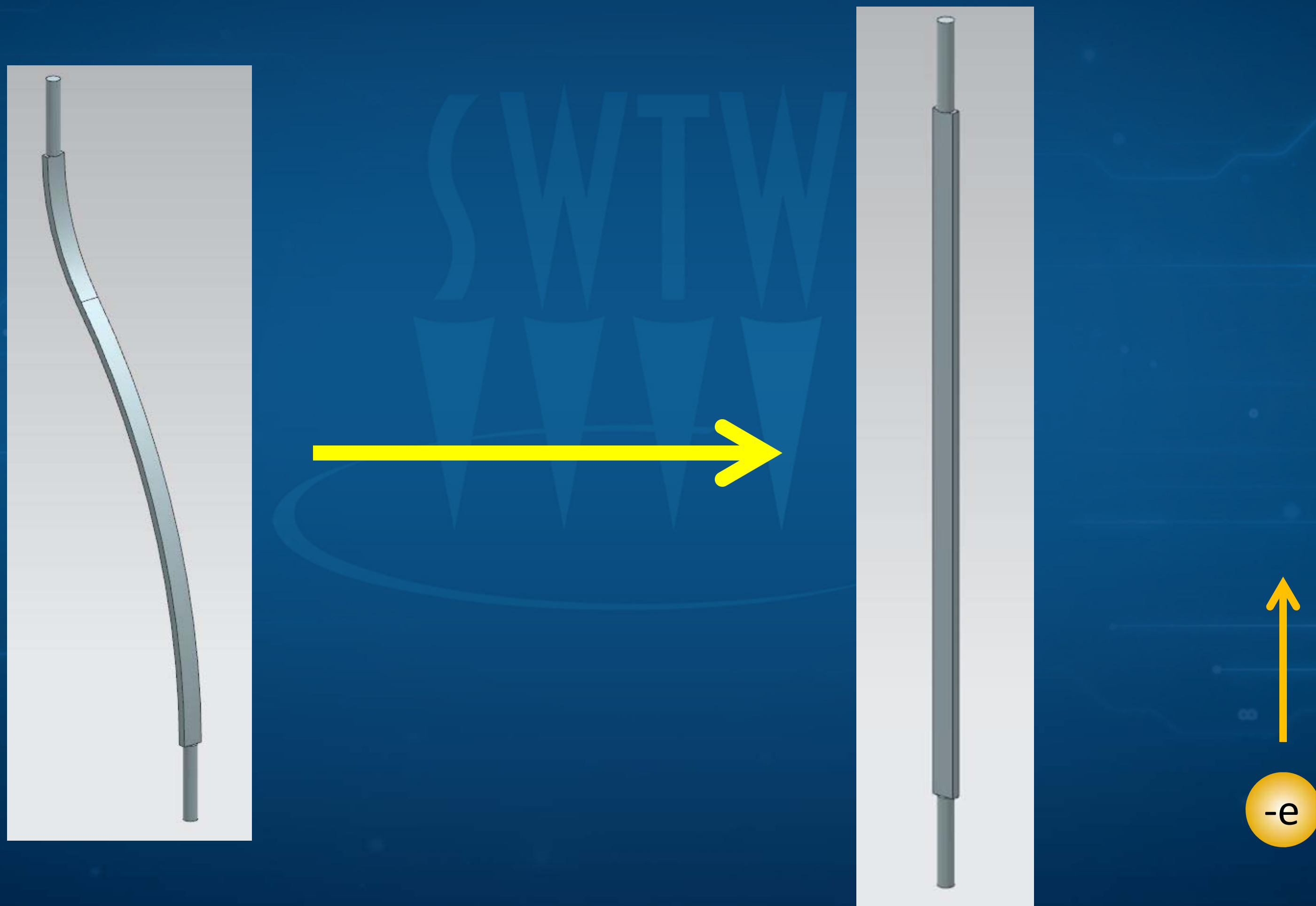
Probe Types



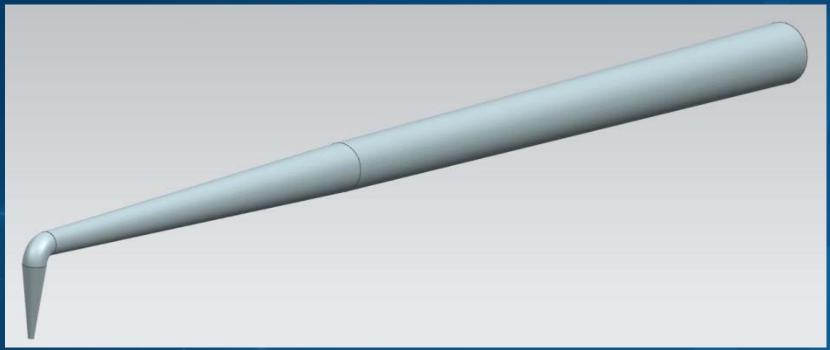
Scaled Drawing



Real Geometry vs. Physics Geometry

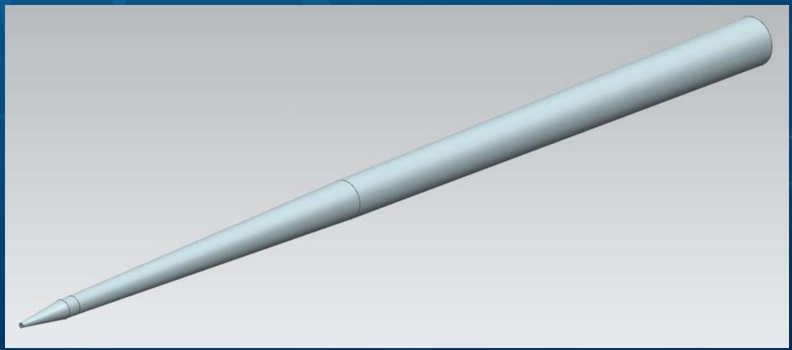


Real Geometry vs. Computational Geometry



Real Geometry

Computational Geometry



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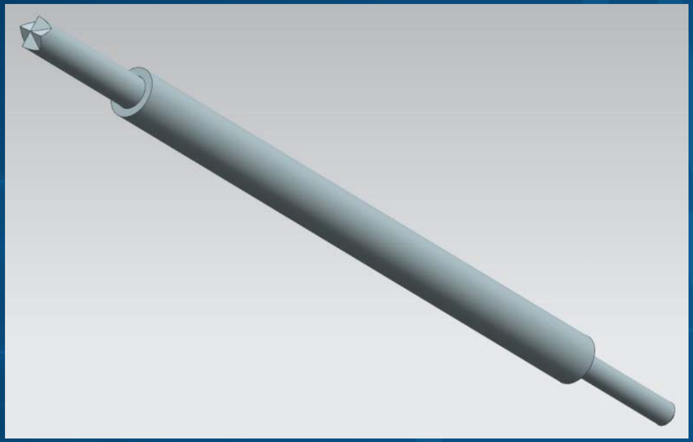
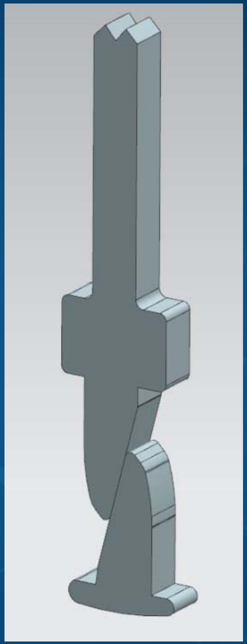
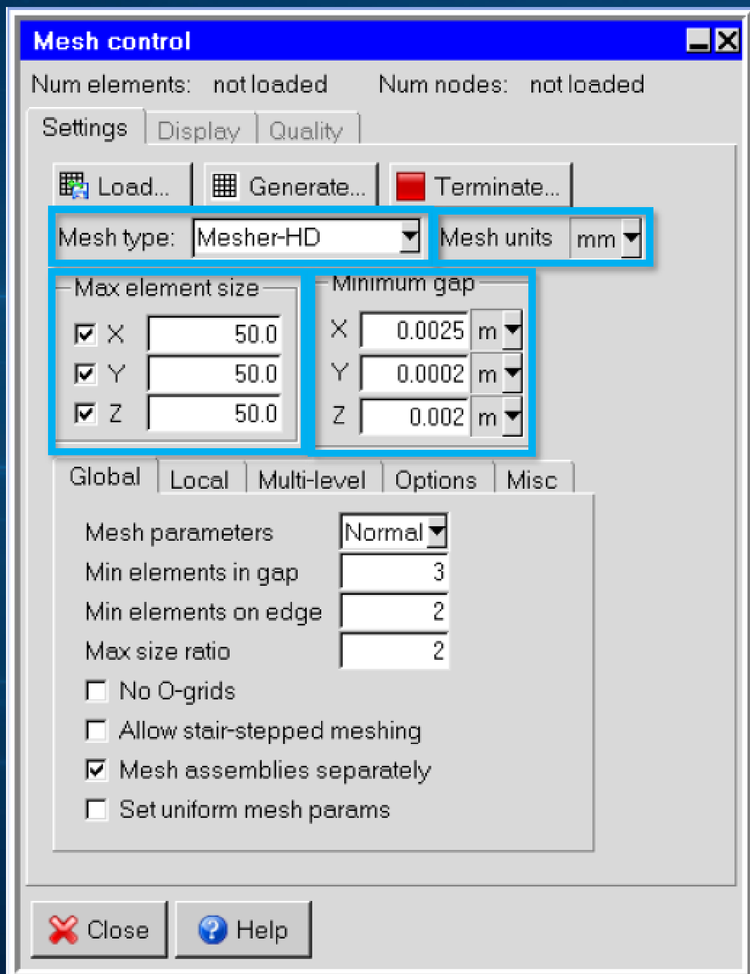
Real Geometry vs. Computational Geometry





Spring pins and solid probes all have electrons traveling in one axis and no changes are required for the computational model

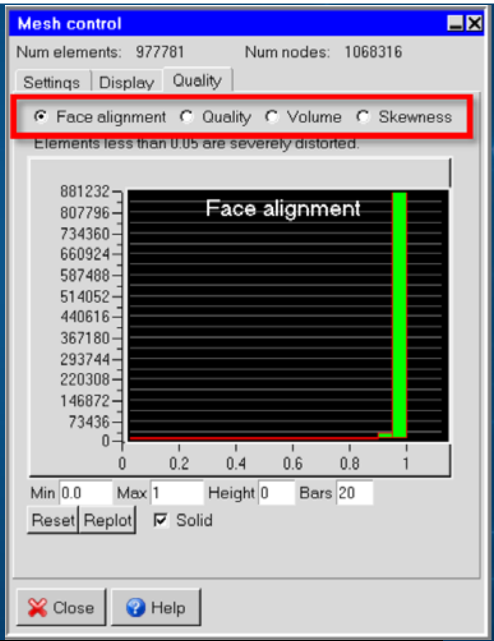
Mesh Settings

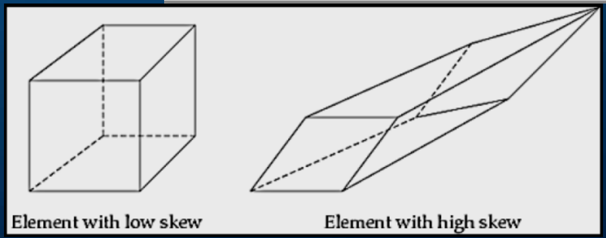


- Mesh Type
  - Mesher-HD ⟶ CAD Geometry
- Max element size
  - X,Y, and Z directional sizes of the background mesh
  - Balance between accuracy and runtime
- Minimum Gap
  - All geometries below this tolerance will be ignored by the mesher

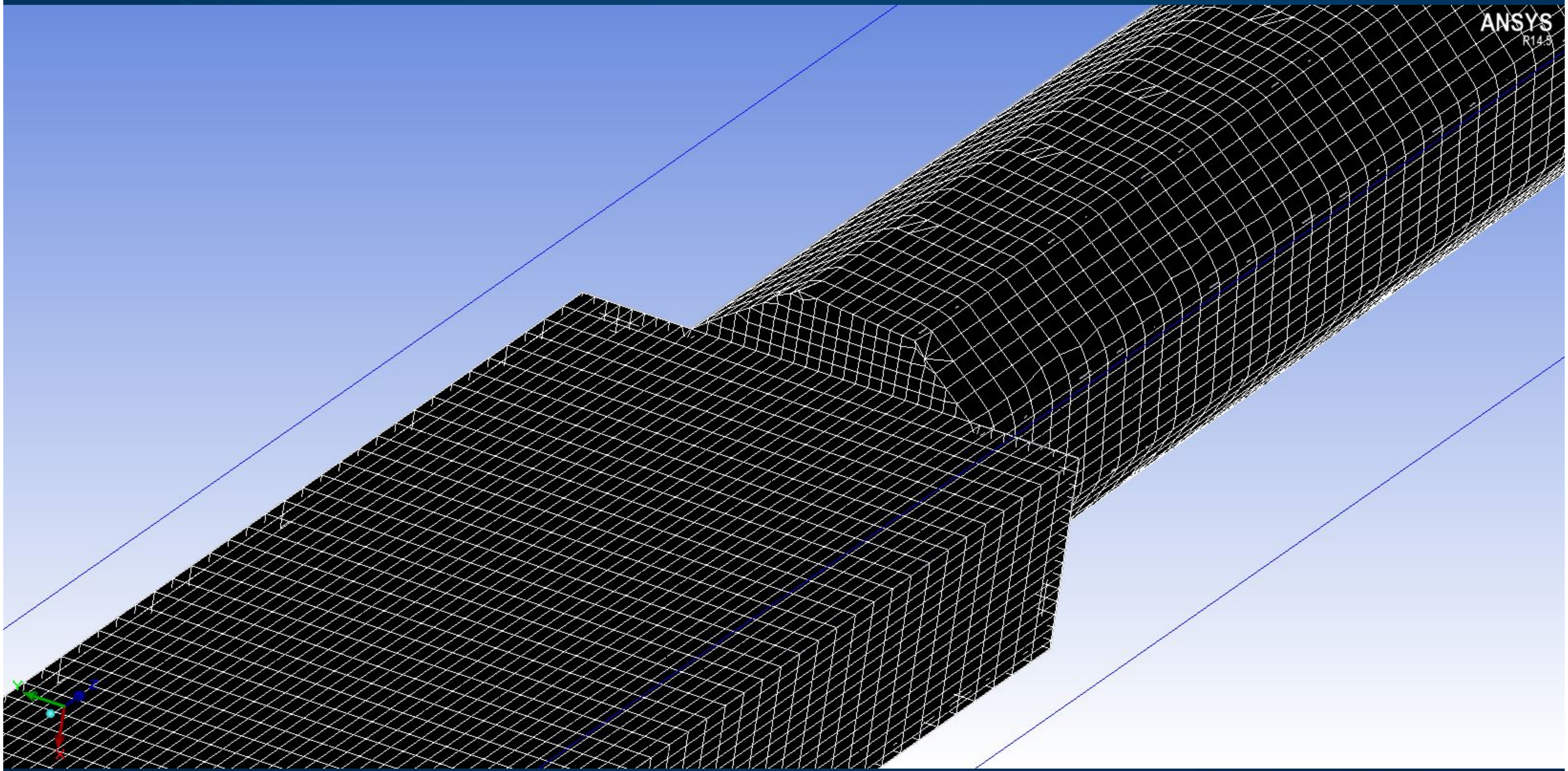
Meshing Verification

- Face Alignment
  - Range from 0 (bad) to 1 (good)
  - Face alignment must be greater than 0.05
  - Best results above 0.15
- Volume
  - Determines if you use double or single precision solver (1e-13)
- Skewness
  - Skewness determines how close to ideal a face or cell is
  - Should be above 0.02

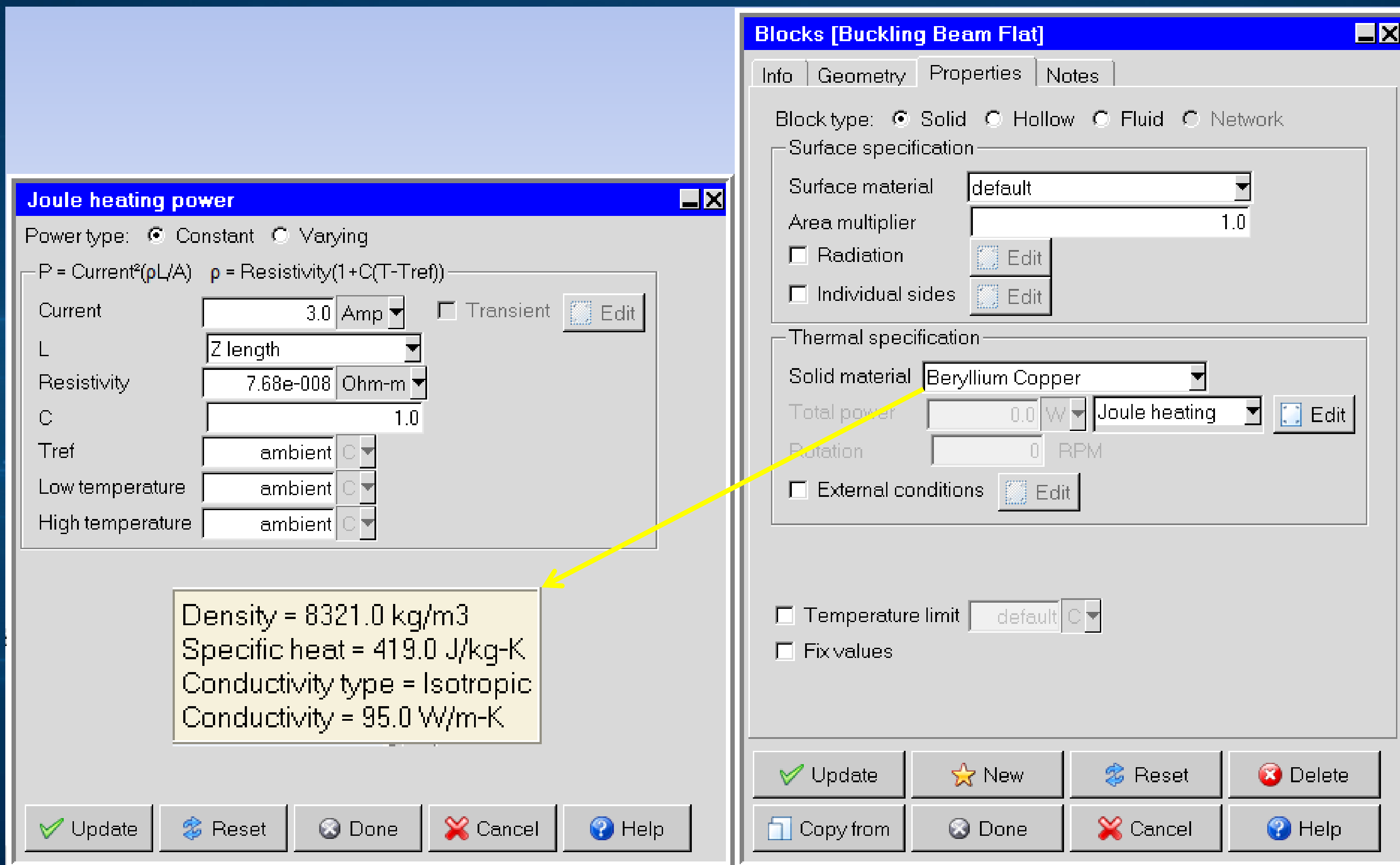




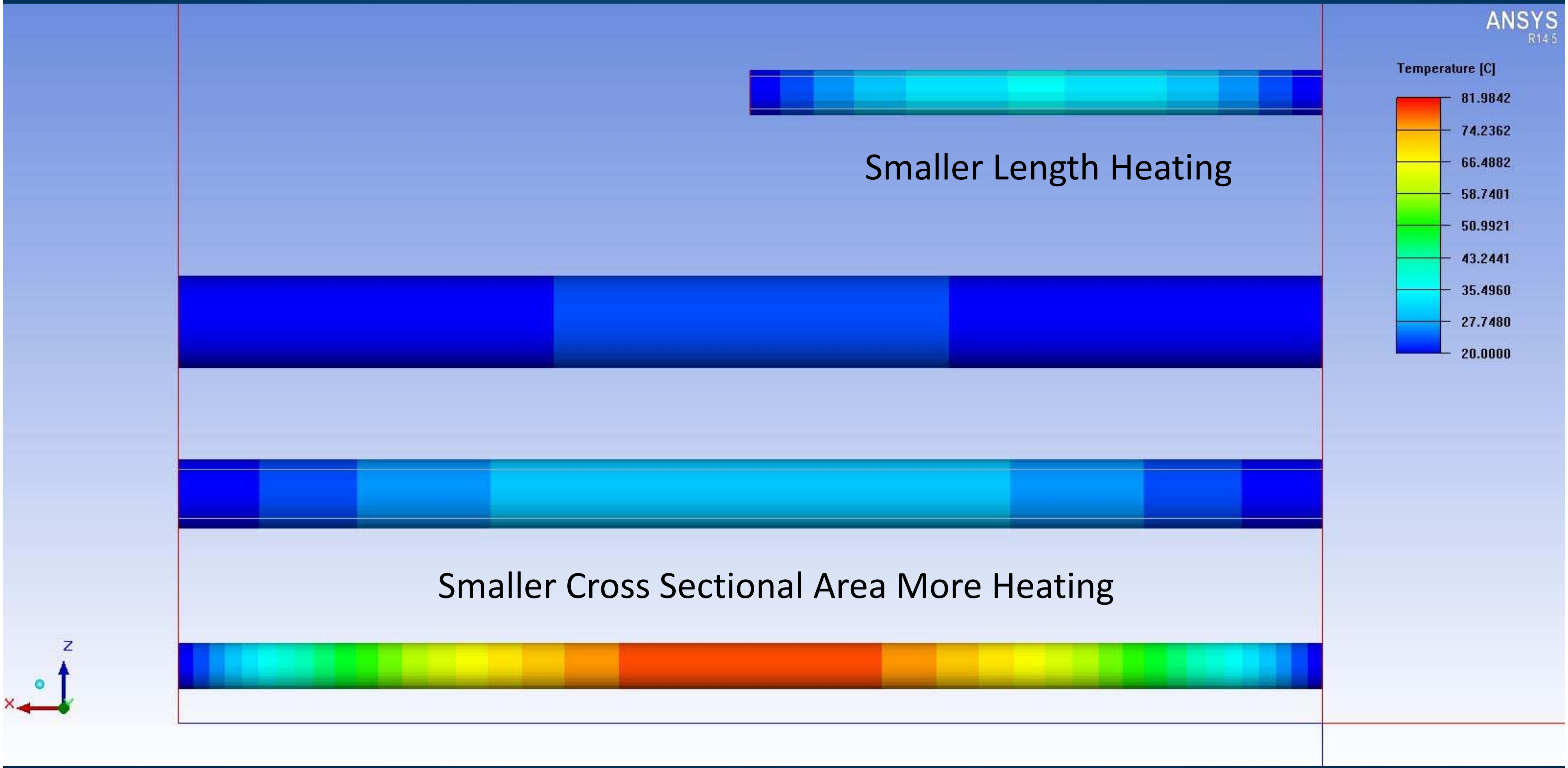
Visual Inspection of the Mesh



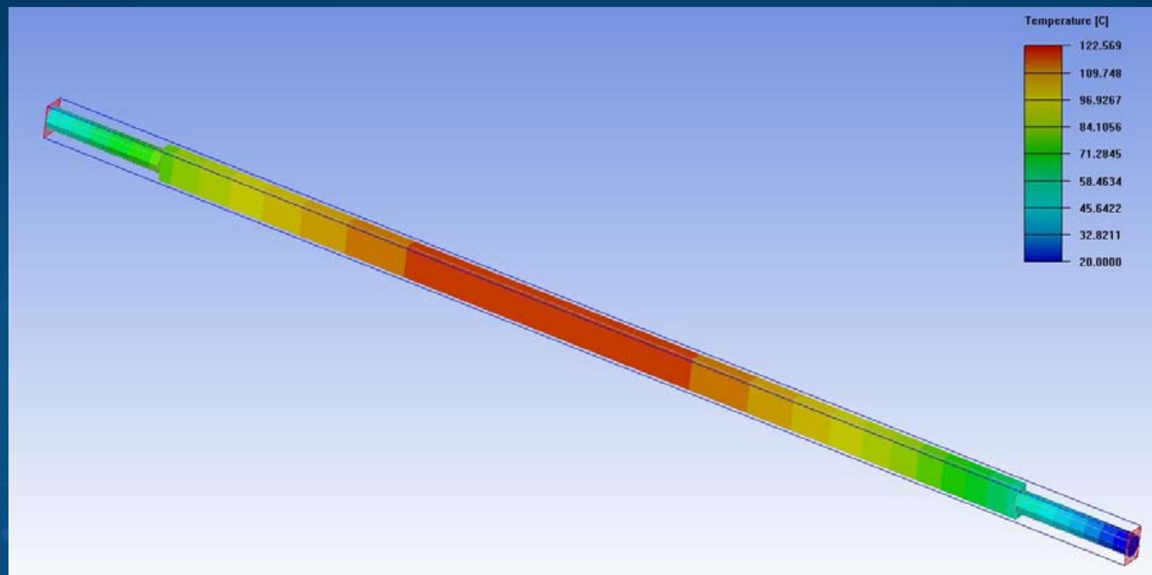
Material Properties and Joule Heating



Joule Heating of a Physics Rod

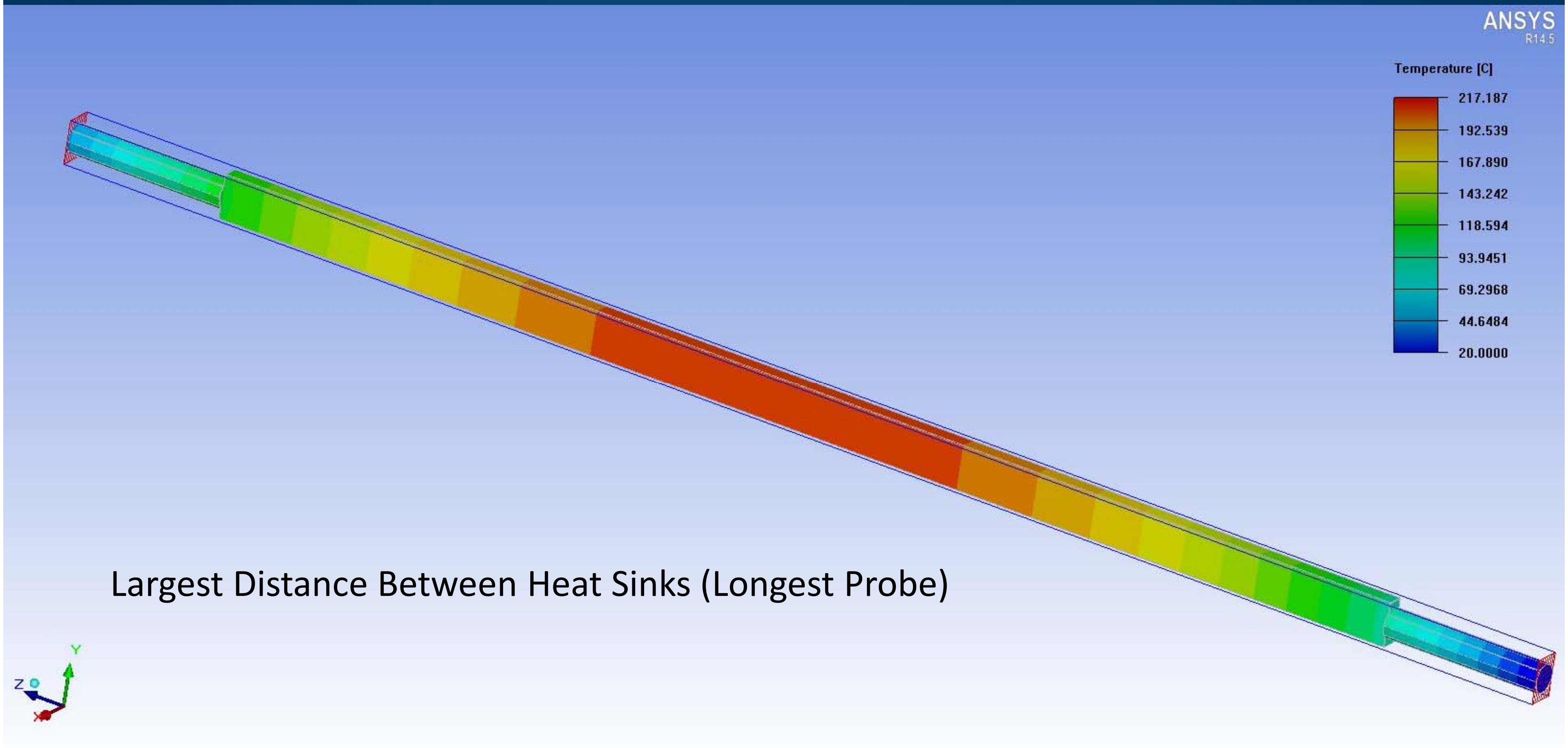


Adding Heat Sinks



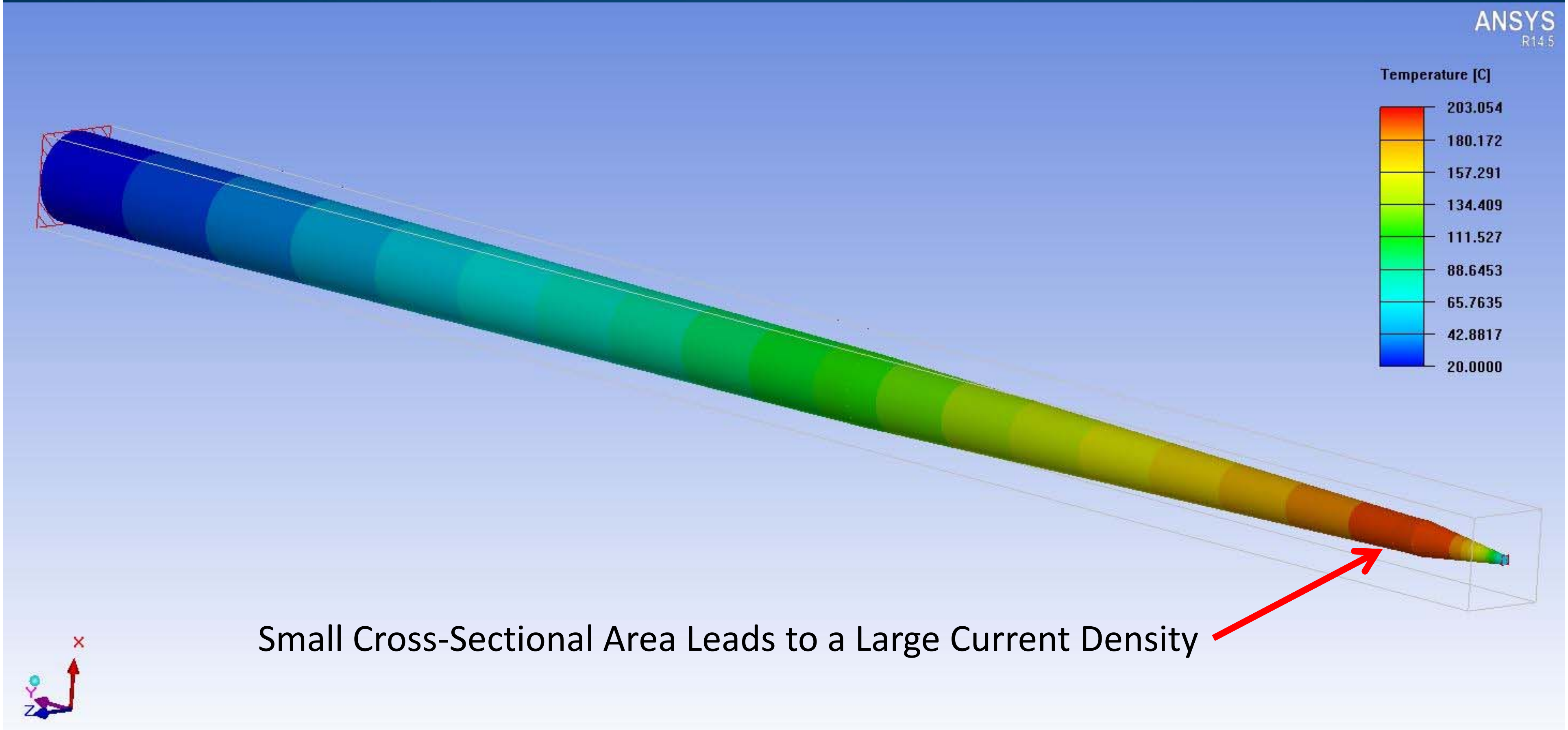
- Heat sinks being applied
  - 50˚C DUT temperature
  - 20 ˚C Load board trace temperature

Vertical Probe



Largest Distance Between Heat Sinks (Longest Probe)

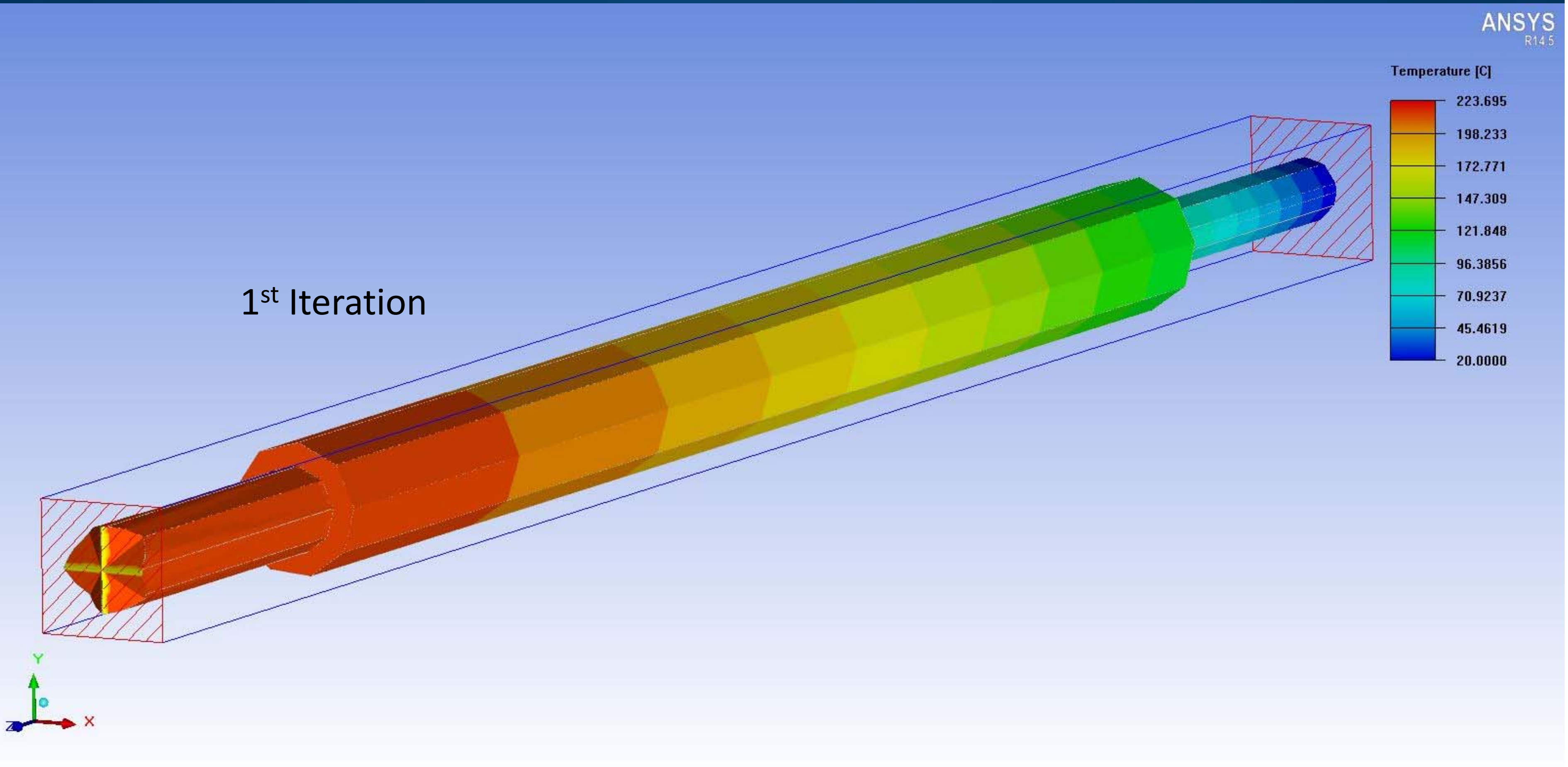
Cantilever Probe



Small Cross-Sectional Area Leads to a Large Current Density

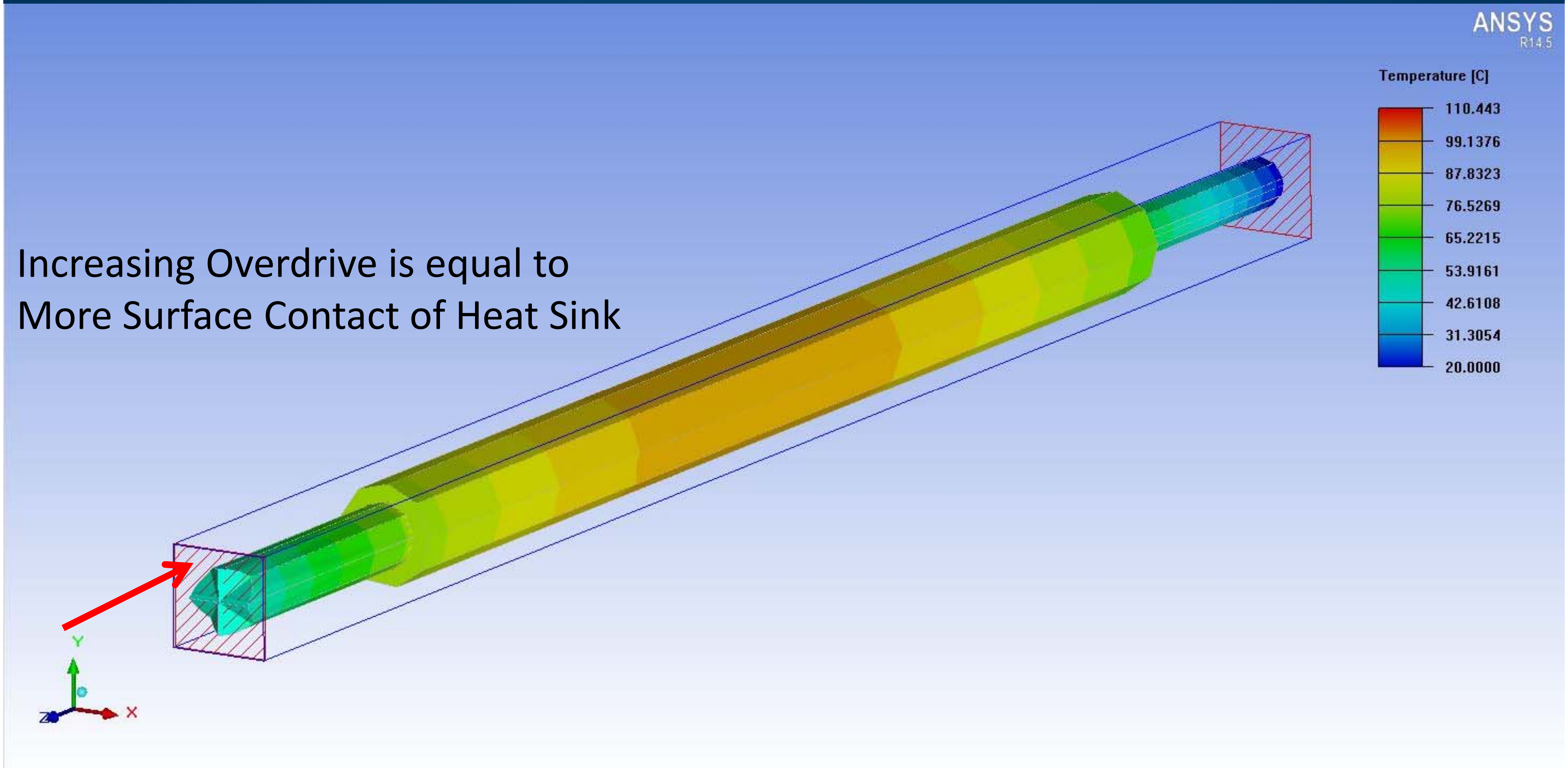
Spring Pin

1st Iteration

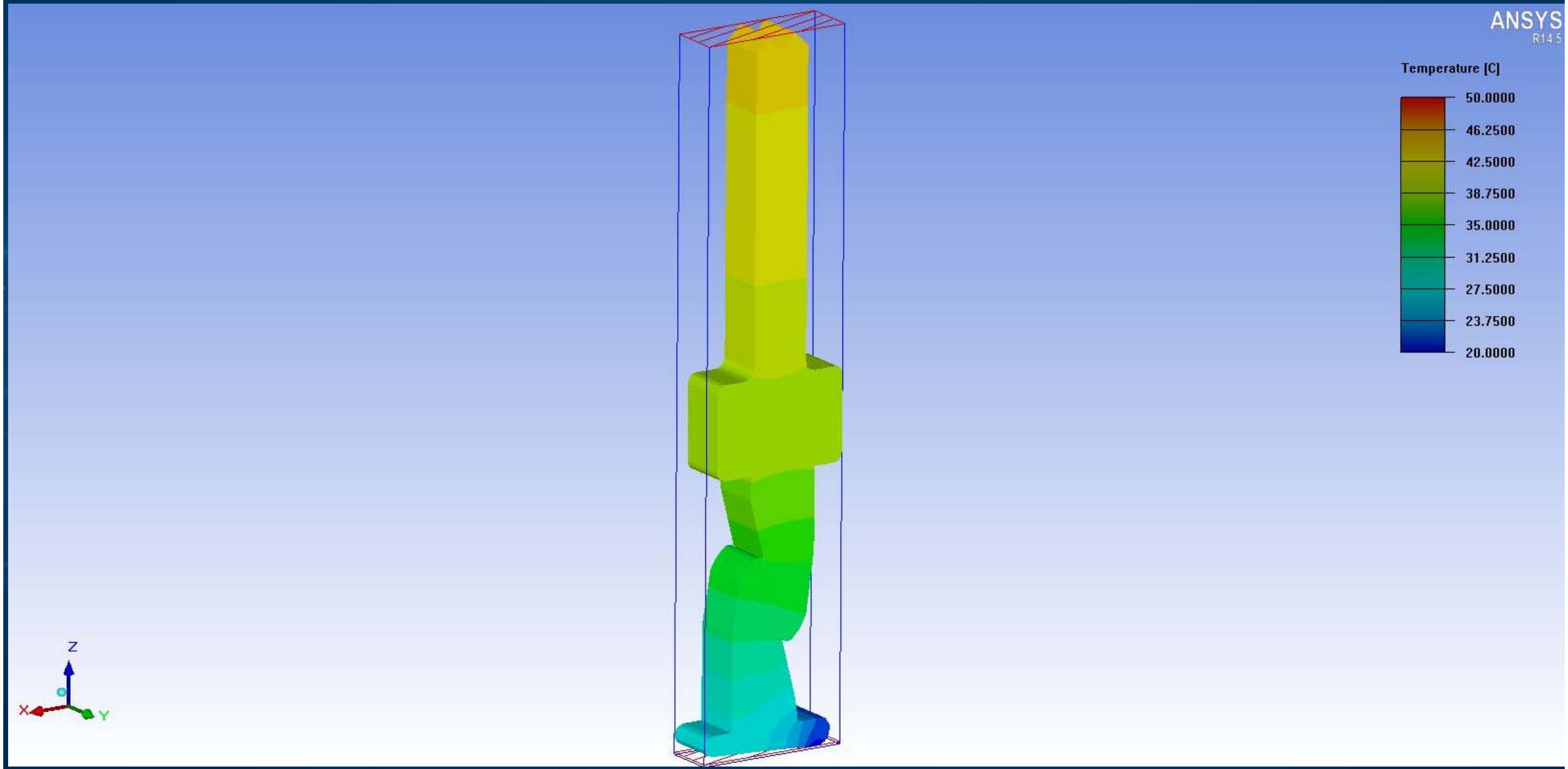


Improved Accuracy

Increasing Overdrive is equal to
More Surface Contact of Heat Sink

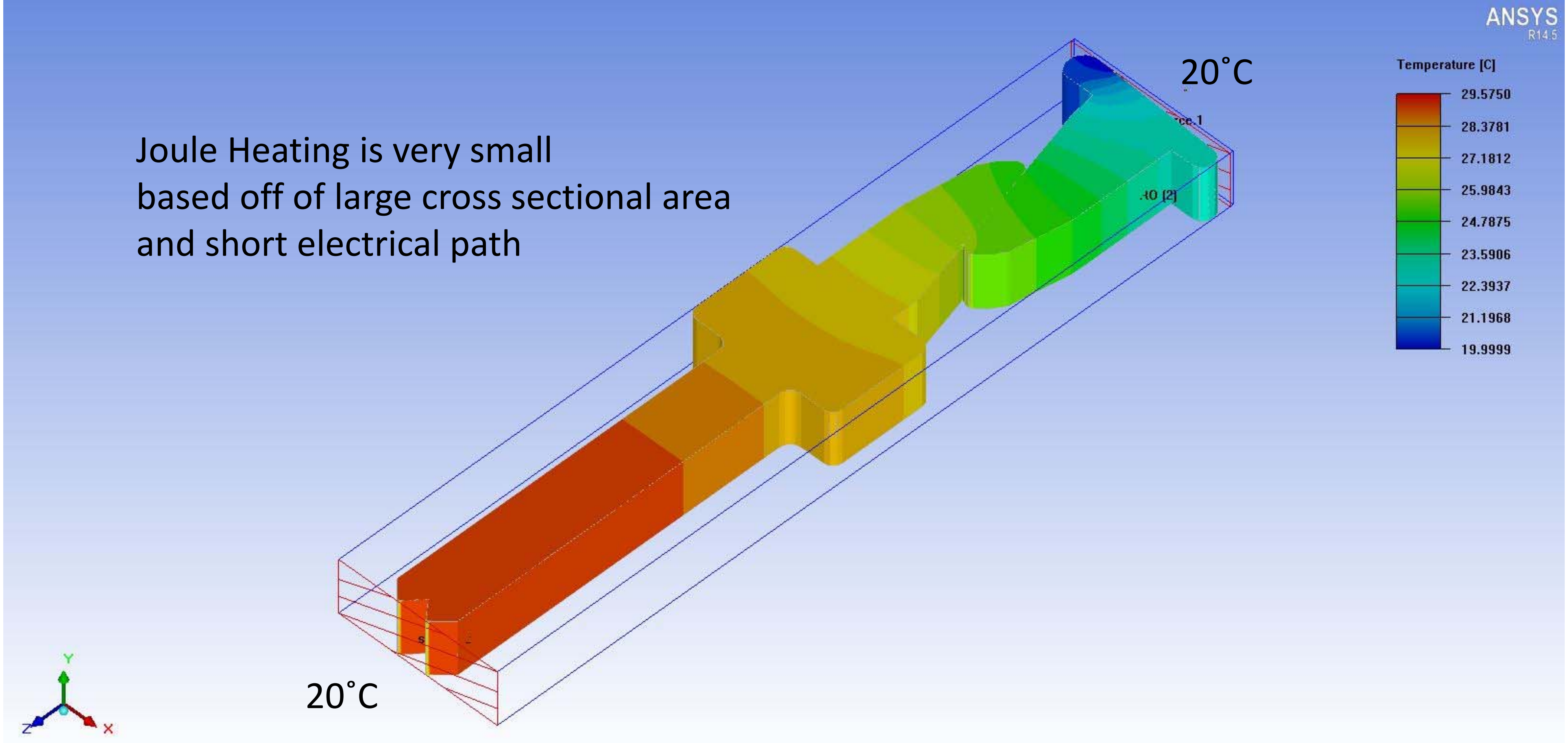


Solid Probe


ANSYS
R14.5
Temperature [C]
50.0000
46.2500
42.5000
38.7500
35.0000
31.2500
27.5000
23.7500
20.0000
Z
X
Y

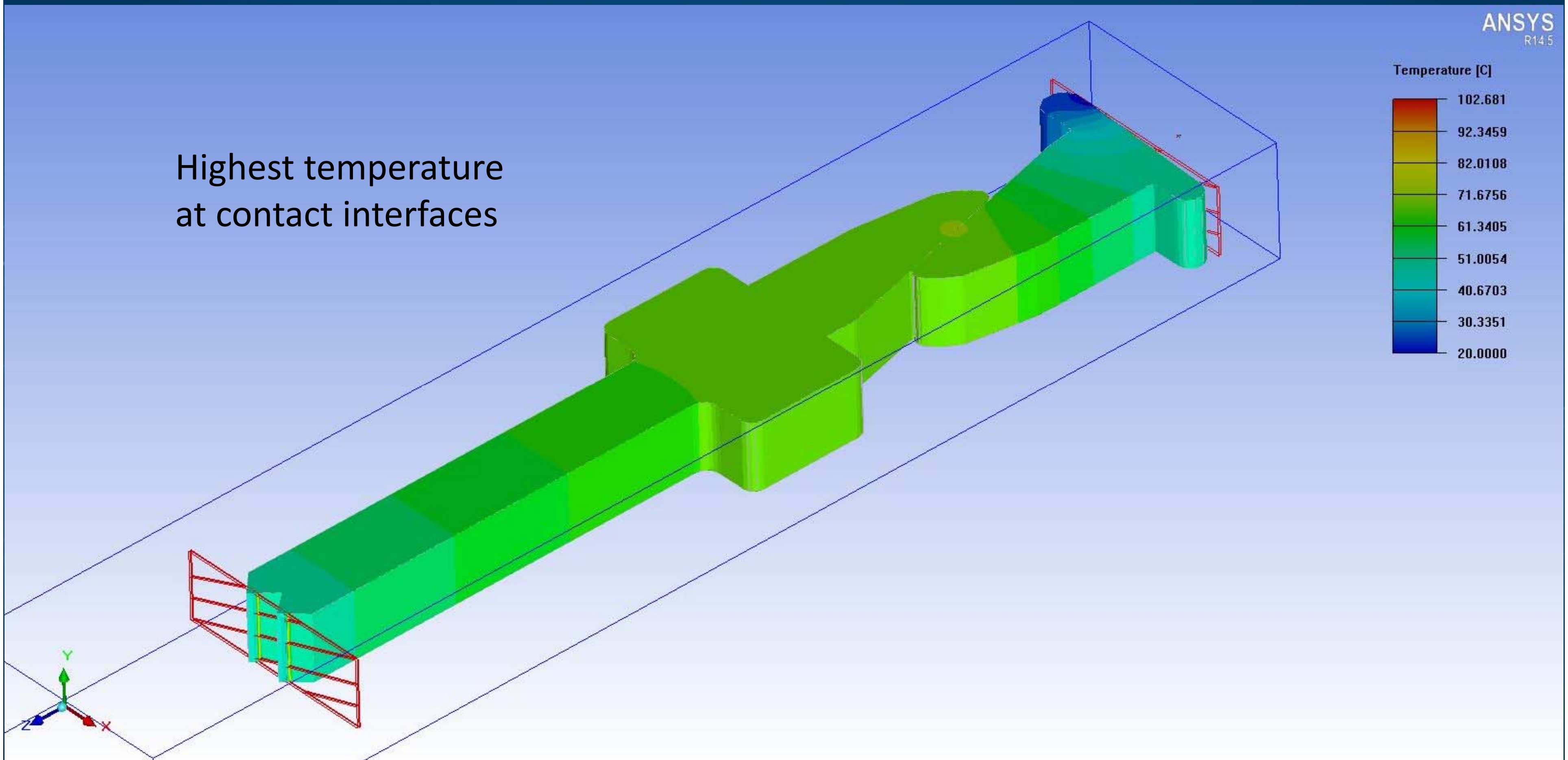
2nd Iteration

Joule Heating is very small
based off of large cross sectional area
and short electrical path

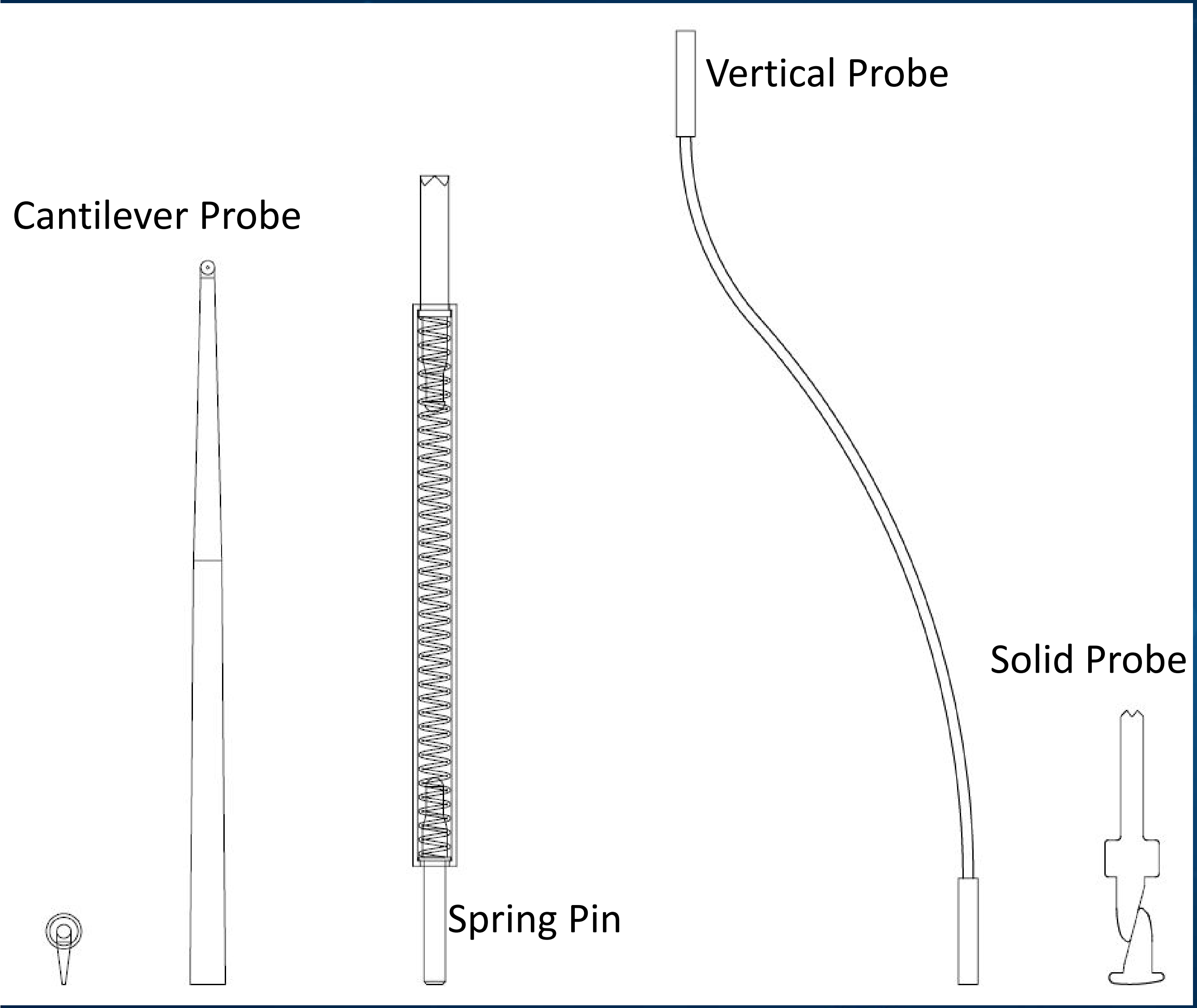


Adding Contact Resistance and Natural Convection

Highest temperature at contact interfaces



Probe Type Conclusions



- Vertical Probe has a the longest length leading to higher temperatures
- The cantilever probe has a small cross sectional area leading to high current density
- The Spring Pin has a contact resistance between the tips and the barrel leading to increased heating
- Solid Probe has the lowest Joule heating effect, but has internal contact resistances

Increasing Accuracy

- Adding Real Heat Sinks
  - Active DUT Heating
  - Conduction to Retaining Features
  - Natural Convection
  - Contact Resistance
  - Load Board Trace Cooling

Computational Conclusion

- Generate physical geometry for computational requirements
- Conduct accurate meshing and validate
- Review results and iterate with increasing complexity for best correlation to reality

Why Should You Care?

- Tomorrows devices will have higher transistor density and run hotter. We must address that today.

- Leveraging computational thermal analysis at the wafer scale will create better and faster designs pushing innovative solutions

Questions?