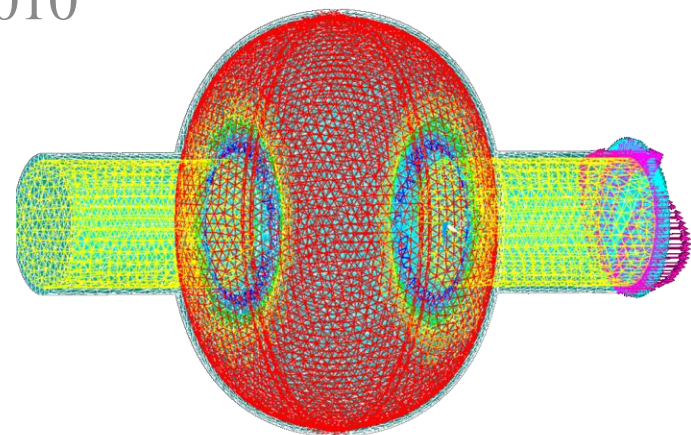
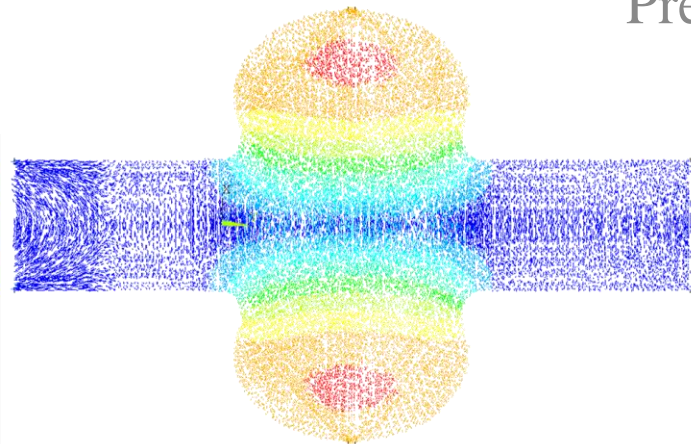
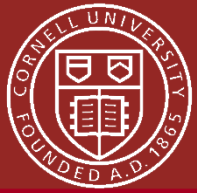


HOM Simulations with ANSYS

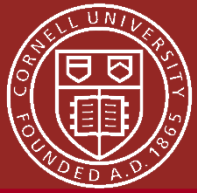
Sam Posen
Cornell University
Presented October 13th 2010
at HOM10
In Ithaca, NY





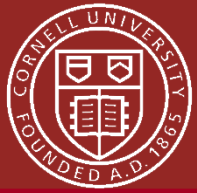
ANSYS

- ANSYS is a finite element analysis package developed for engineering applications
- ANSYS recently acquired several companies and now owns some industry-leading codes (HFSS, ICEM CFD, CFX, FLUENT)
- Has several types of analysis for different kinds of physics
- Can send results from one analysis to another
- Can couple some analyses together directly

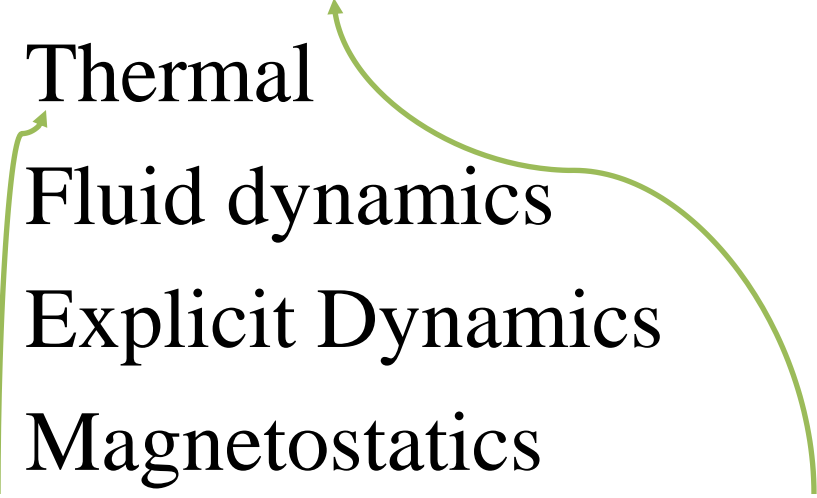


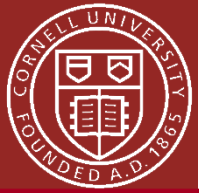
Analysis Types

- Structural
- Thermal
- Fluid dynamics
- Explicit Dynamics
- Magnetostatics
- High Frequency EMAG
- Low Frequency EMAG
- Joule Heating
- Directly coupled analyses



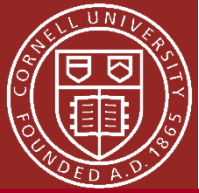
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 - Directly coupled analyses
- 
- A green arrow originates from the "High Frequency EMAG" item and points upwards and to the left, ending near the "Thermal" and "Structural" items.



Capability Comparison

| Capability | ANSYS | MWS | ACE3P |
|-------------------------------|-------|-----|---------|
| Eigenmode Solver | ★ | ★ | ★ |
| Time Domain (wakefields) | | ★ | ★ |
| S-Parameters | ★ | ★ | ★ |
| Multipacting | | | ★ |
| Coupled EM-Thermal-Structural | ★ | ★ | Not Yet |
| Complex μ and ϵ | ★ | ★ | ★ |
| Parallel Computing | ★ | ★ | ★ |



Capability Comparison

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| Coupled EM-Thermal-Structural | ★ | ★ | Not Yet |
| Complex μ and ϵ | ★ | ★ | ★ |
| Parallel Computing | ★ | ★ | ★ |

Excellent for thermal, structural analyses!

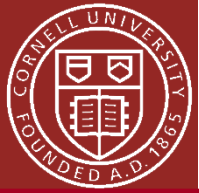
Not capable of introducing particles.

Not intended for accelerator applications!



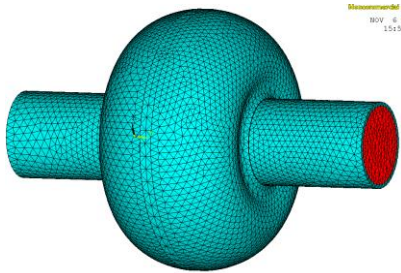
Benefits of ANSYS

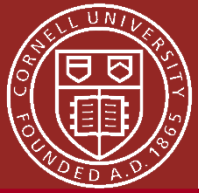
- Excellent support, documentation
- Low cost academic license for universities
- Well benchmarked
- Versatile – can easily access data at any selection of nodes, load any elements



Benefits of ANSYS

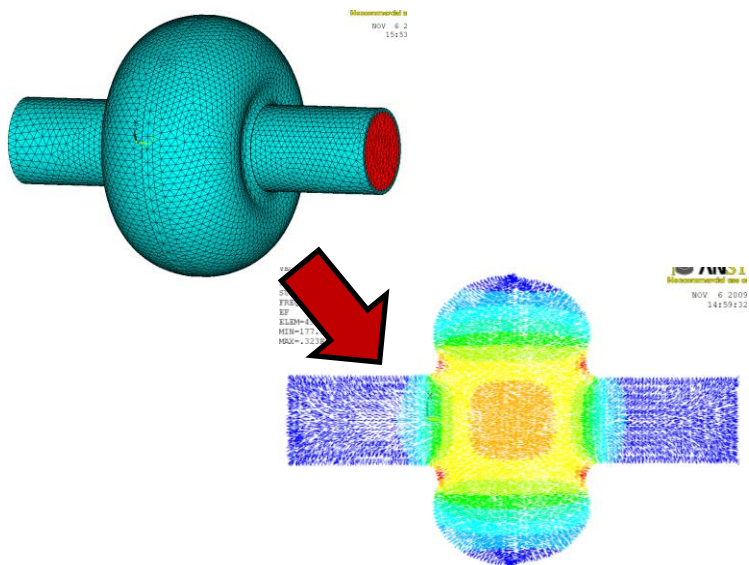
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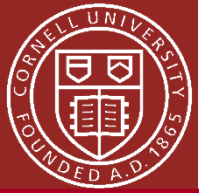




Benefits of ANSYS

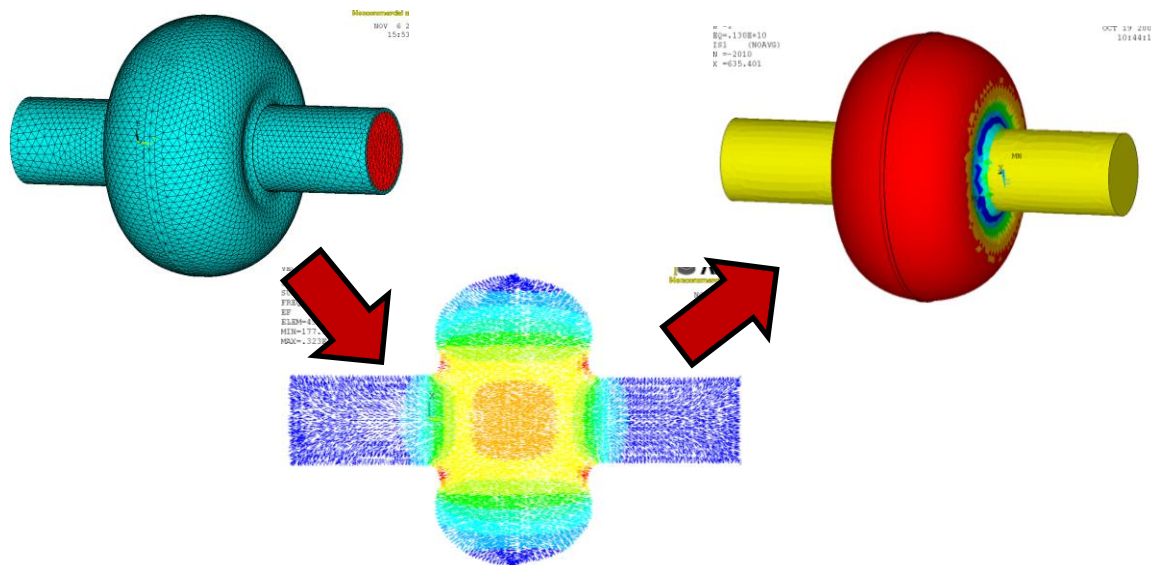
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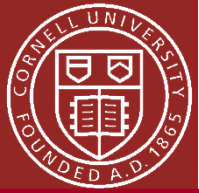




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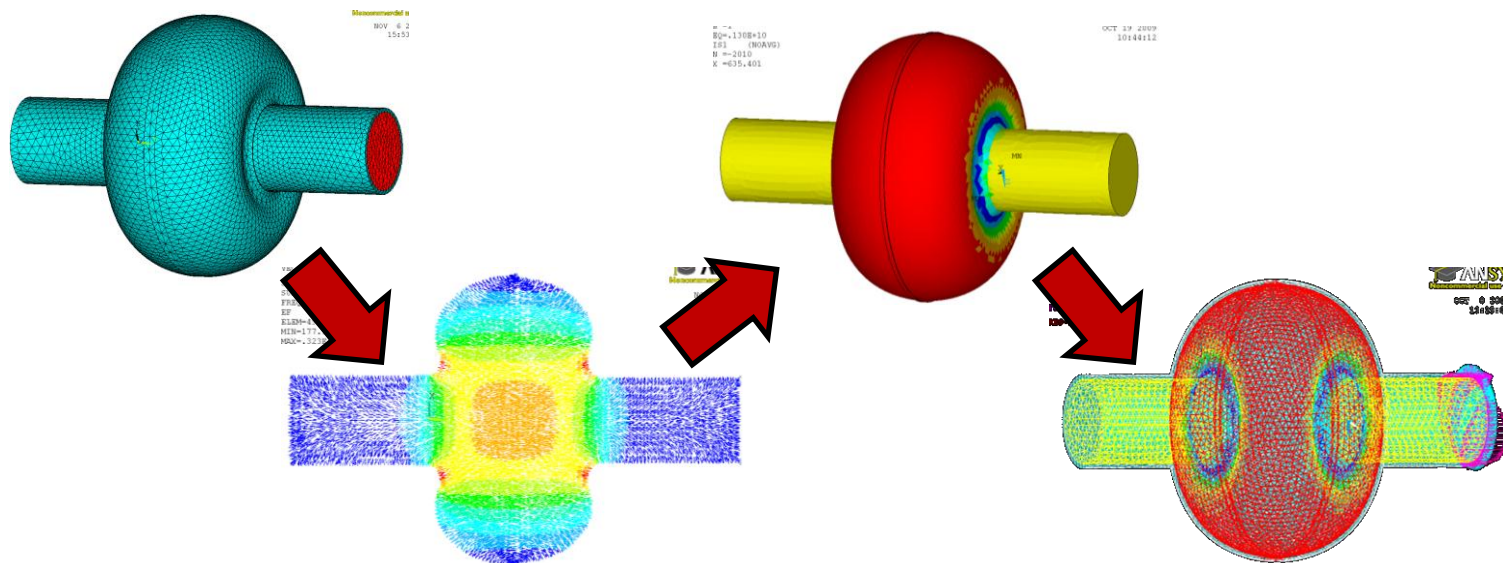
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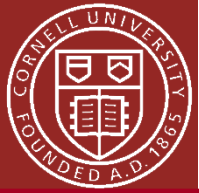




Benefits of ANSYS

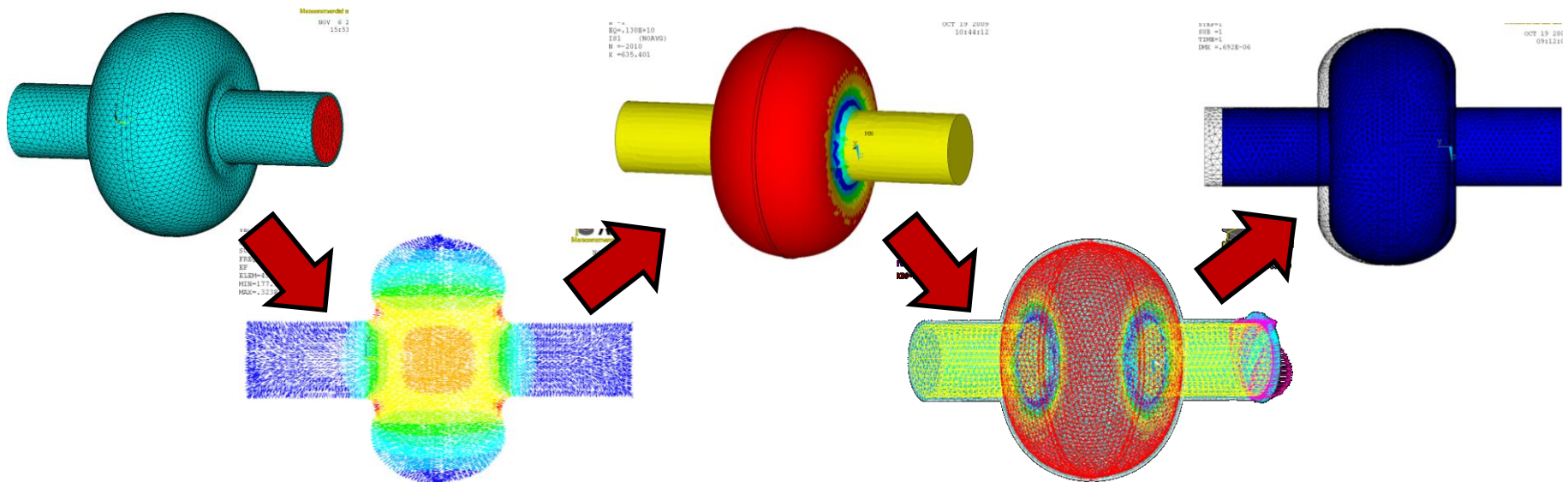
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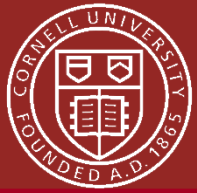




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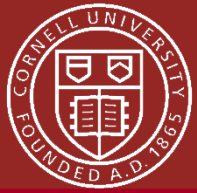
- Excellent support, documentation
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- Well benchmarked
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Drawbacks of ANSYS

- Program issues (issues as of right now—I'll talk about the future)
 - Interface not very user friendly
 - Mesher takes a long time
- Requirements of accelerator community not likely to influence development of code



Plans for ANSYS

- ANSYS is switching from its arcane FORTRAN-based system to new “Workbench” environment
- Much more user friendly, fast mesher
- Strong CAD model compatibility
- Built-in optimization algorithms
- Current WB 12.0 no HF simulations, but planned for 13.0 (January) or 14.0 (~1 year later)



Workbench Environment

B : Steady-State Thermal (ANSYS) - Mechanical [ANSYS Academic Research]

File Edit View Units Tools Help Solve Mesh Update Mesh Mesh Control Options

Outline

- Project
 - Model (B4)
 - Geometry
 - Coordinate Systems
 - Connections
 - Mesh
 - Steady-State Thermal (B5)
 - Initial Temperature
 - Analysis Settings
 - Internal Heat Generation
 - Temperature
 - Heat Flow
 - Heat Flux
 - Solution (B6)
 - Solution Information
 - Temperature
 - Temperature Probe

Details of "Mesh"

Defaults

| | |
|--------------------|------------|
| Physics Preference | Mechanical |
| Relevance | 0 |

Sizing

Inflation

Advanced

Pinch

Statistics

Messages

Text

Geometry | Worksheet | Print Preview | Report P...

0.000 0.025 0.050 (m)

0.013 0.038

Y Z X

Timestamp

1 Steady-State Thermal (ANSYS)

2 Engineering Data

3 Geometry

4 Model

5 Setup

6 Solution

7 Results

8 Parameters

Steady-State Thermal (ANSYS)

Parameter Set

1 Mechanical APDL

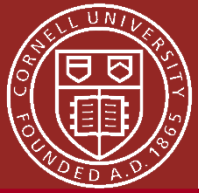
2 Analysis

Mechanical APDL

Timestamp

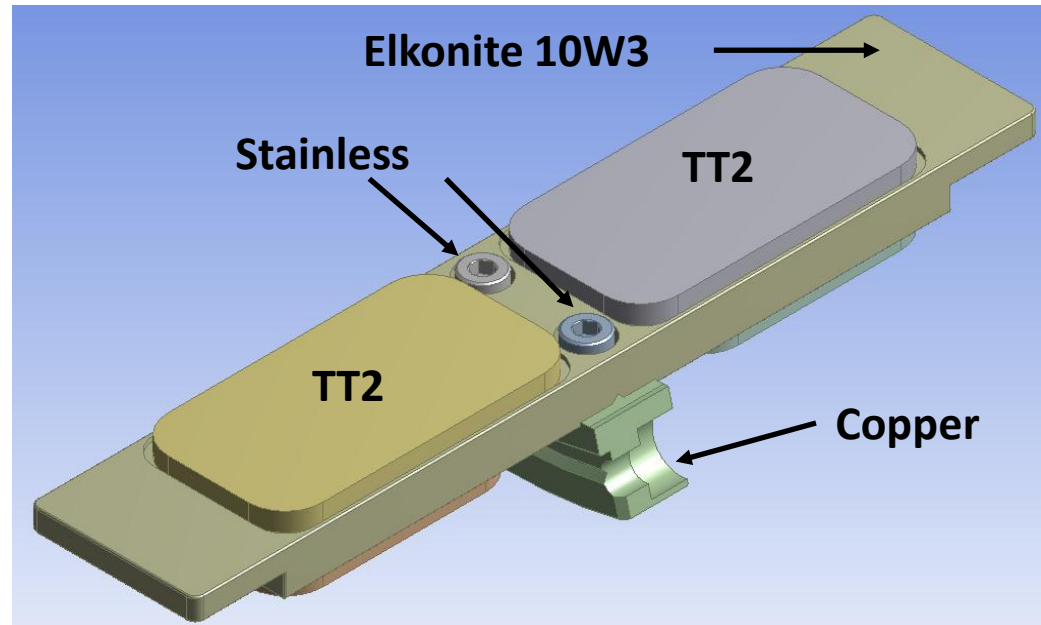
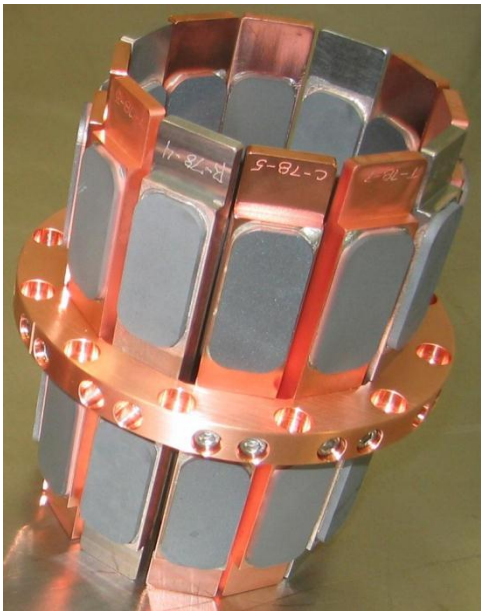
N, s, v, A) Degrees rad/s Celsius

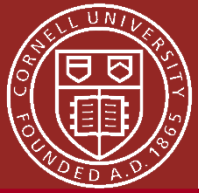
Press F1 for Help No Messa



ANSYS Example: ERL HOM Tile

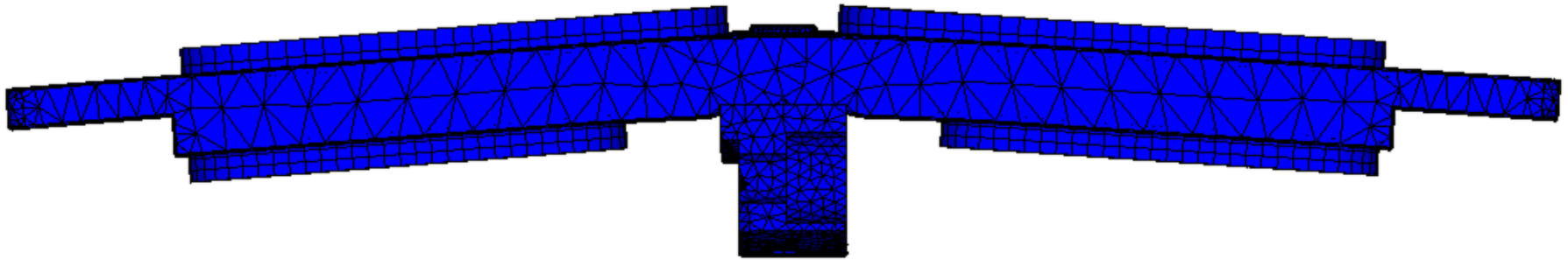
- ERL HOM absorbing tiles had been found cracked and fallen off assembly
- Thought to be thermal expansion mismatch causing stresses when assembly was cooled



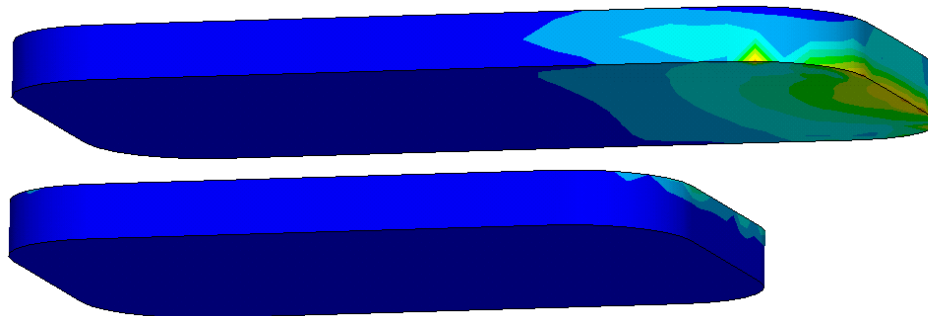


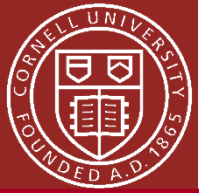
ANSYS Example: ERL HOM Tile

- Found small deflection in assembly when cooled



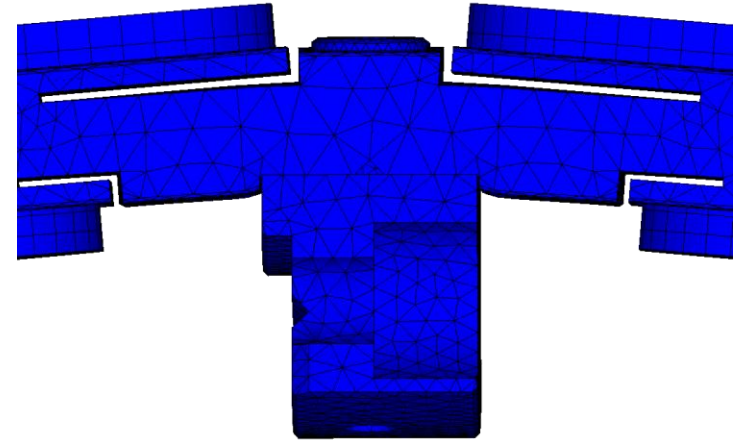
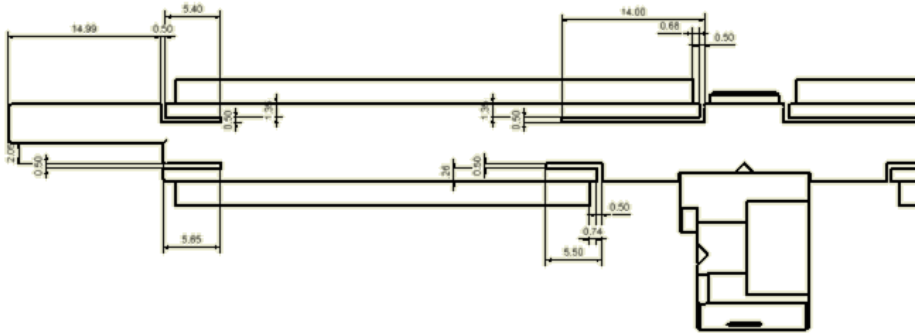
- large concentration of stress at edge of tile, near pivot point



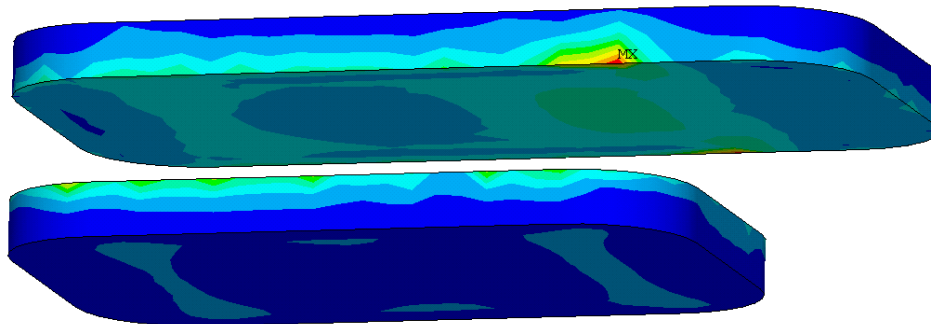


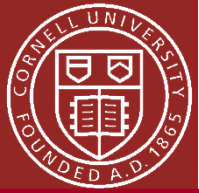
ANSYS Example: ERL HOM Tile

- Came up with series of stress relieving cuts



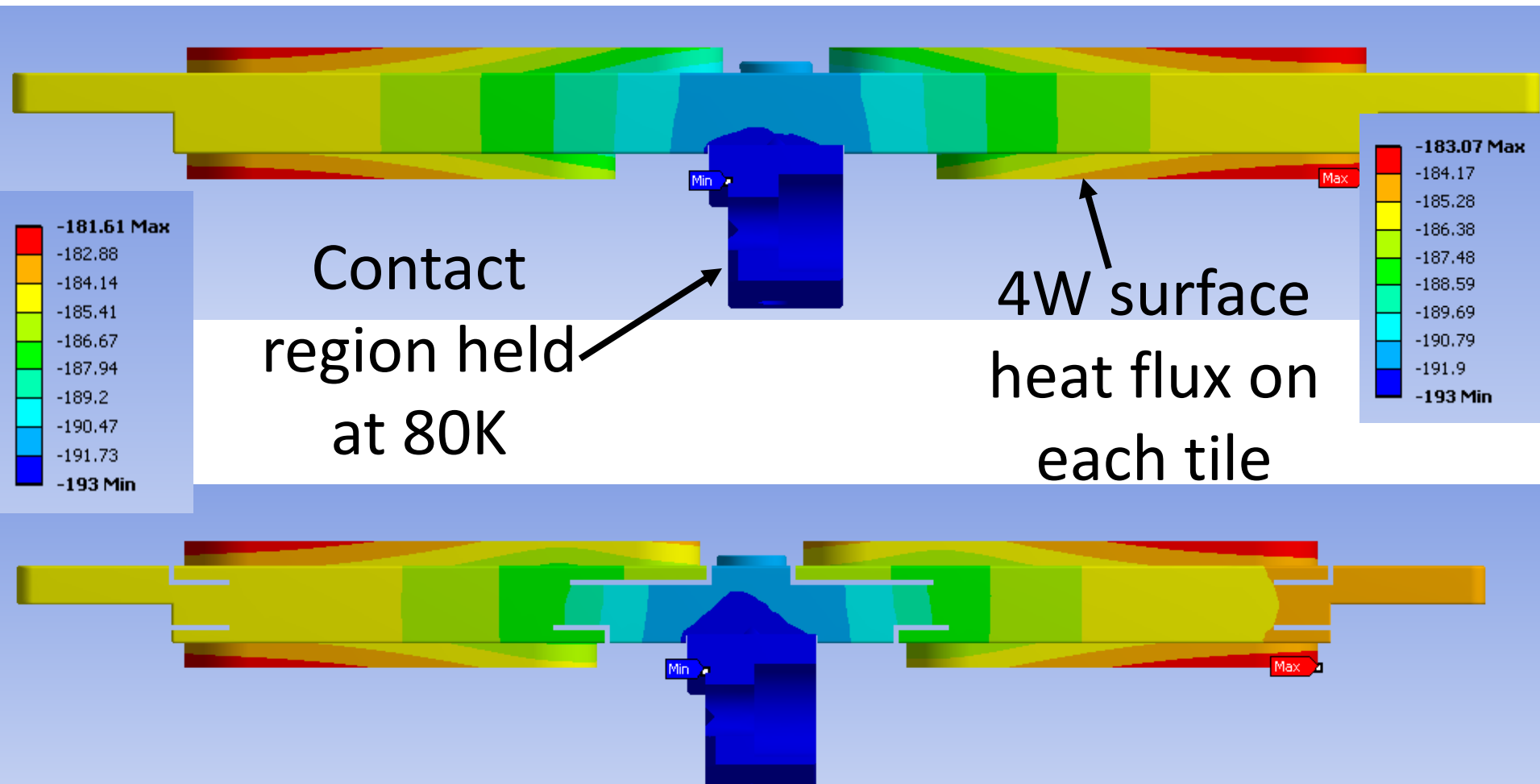
- Cuts reduced maximum calculated stress by more than 80%

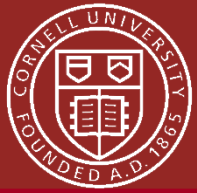




ANSYS Example: ERL HOM Tile

- Simulations show negligible effect on heat transport





Summary

- ANSYS is useful for multiphysics studies
- Not good for particles (wakefields, multipacting)
- Good documentation, support, benchmarks; small \$ for universities, versatile
- Upcoming versions of ANSYS supposed to have user-friendly HF simulation capabilities