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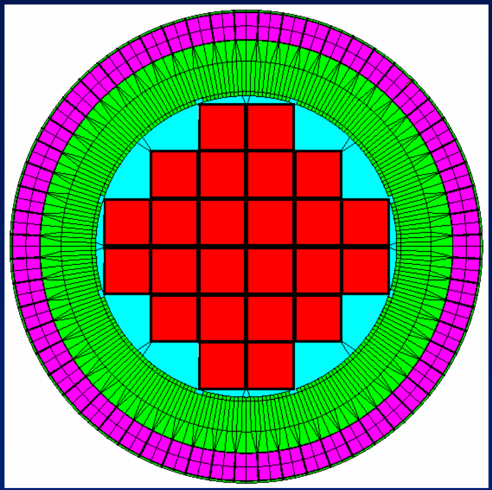

BENCHMARKING OF A THERMAL FINITE ELEMENT APPROXIMATION SCHEME FOR EXTERNALLY COOLED SPENT FUEL STORAGE CASKS

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Outline of Presentation

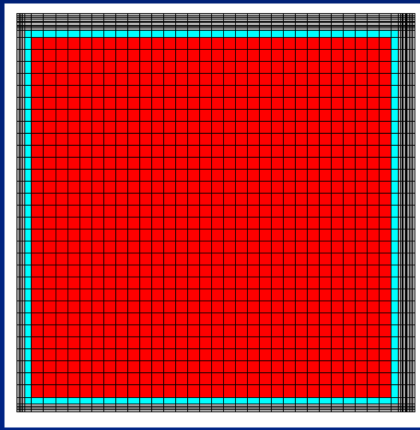
- Background
- Methodology and Assumptions
- Thermal Model
- Comparison of Results
- Conclusion
- Future Work

Background

- NRC licenses spent fuel storage casks under title 10 of the Code of Federal Regulations Part 72 (10 CFR Part 72)
- Thermal analysis is performed to ensure that materials will remain below their design basis temperature
- Pacific Northwest National Lab performed experimental measurement of temperature in TN-24P spent fuel cask (as well as other systems)
- NRC constructed a thermal finite element model to evaluate an approximation methodology

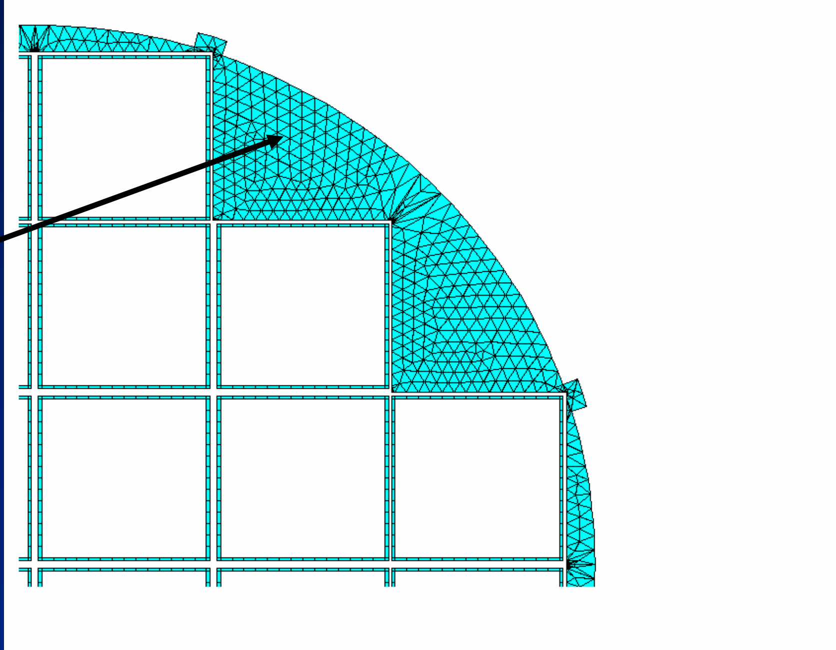
Spent Fuel Effective Conductivity Model

- Homogenized region
- Gap between fuel and basket compartment wall
- Model developed for 15x15 fuel assembly
- Internal convection captured via conduction multiplier



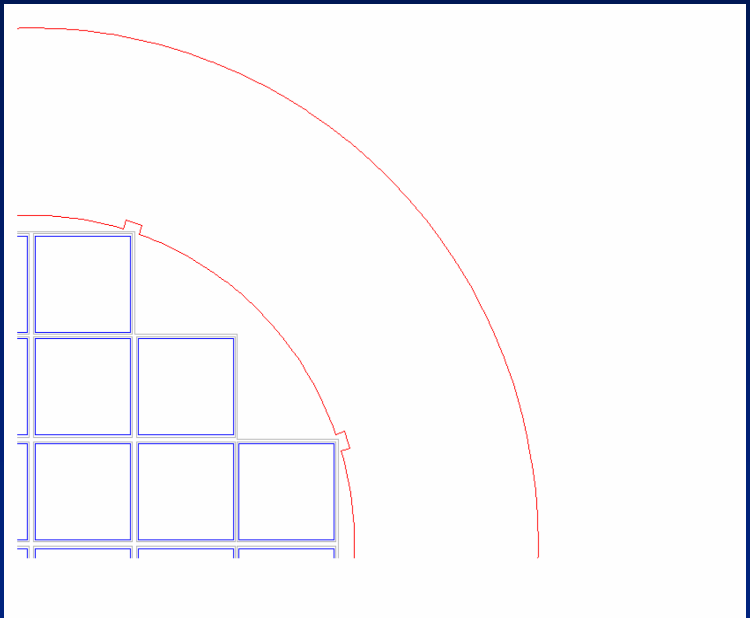
Internal Convection

- Vertical orientation
- Nusselt Number multiplier (3.66)
- Convection in downcomer region also captured



Boundary Conditions

- Heat generation (20.6 kW)
- Radiation internal and external
- No solar insolation (like tested)
- External natural convection correlation
- Ambient 100°F
  - Per 10 CFR 71



Internal Pressure and Gaps

- Internal Pressurization
  - Pressurization effect on gas conductivity
  - Effect on different gases
- Gaps in basket
  - Gap between basket and cask inner shell
  - Gaps between plates

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Analysis Input File

- APDL parametric design and build of model
- Clear and transparent history
- Easily adjustable and reconfigurable
- Enables sensitivity studies

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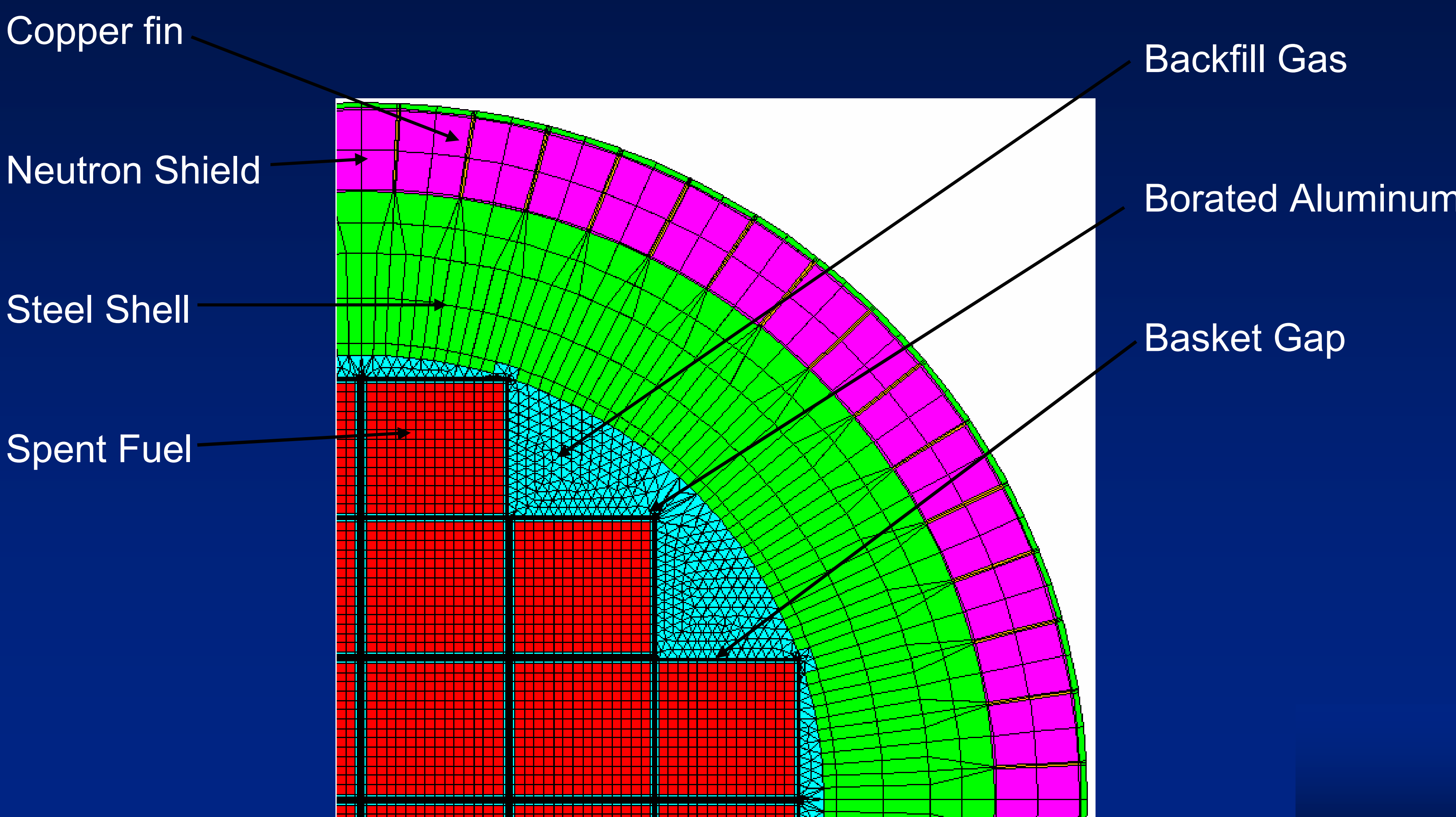
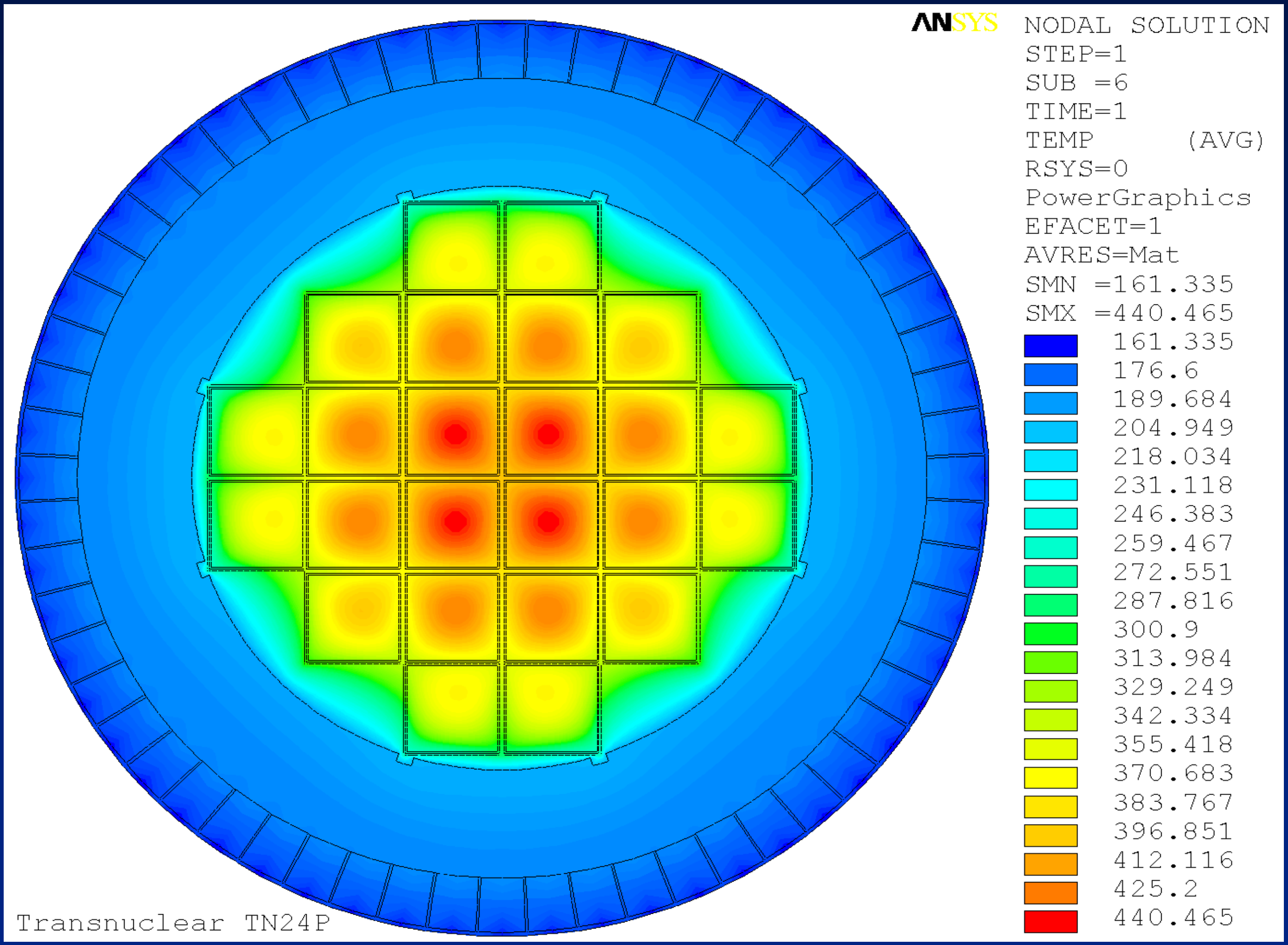
Thermal Model

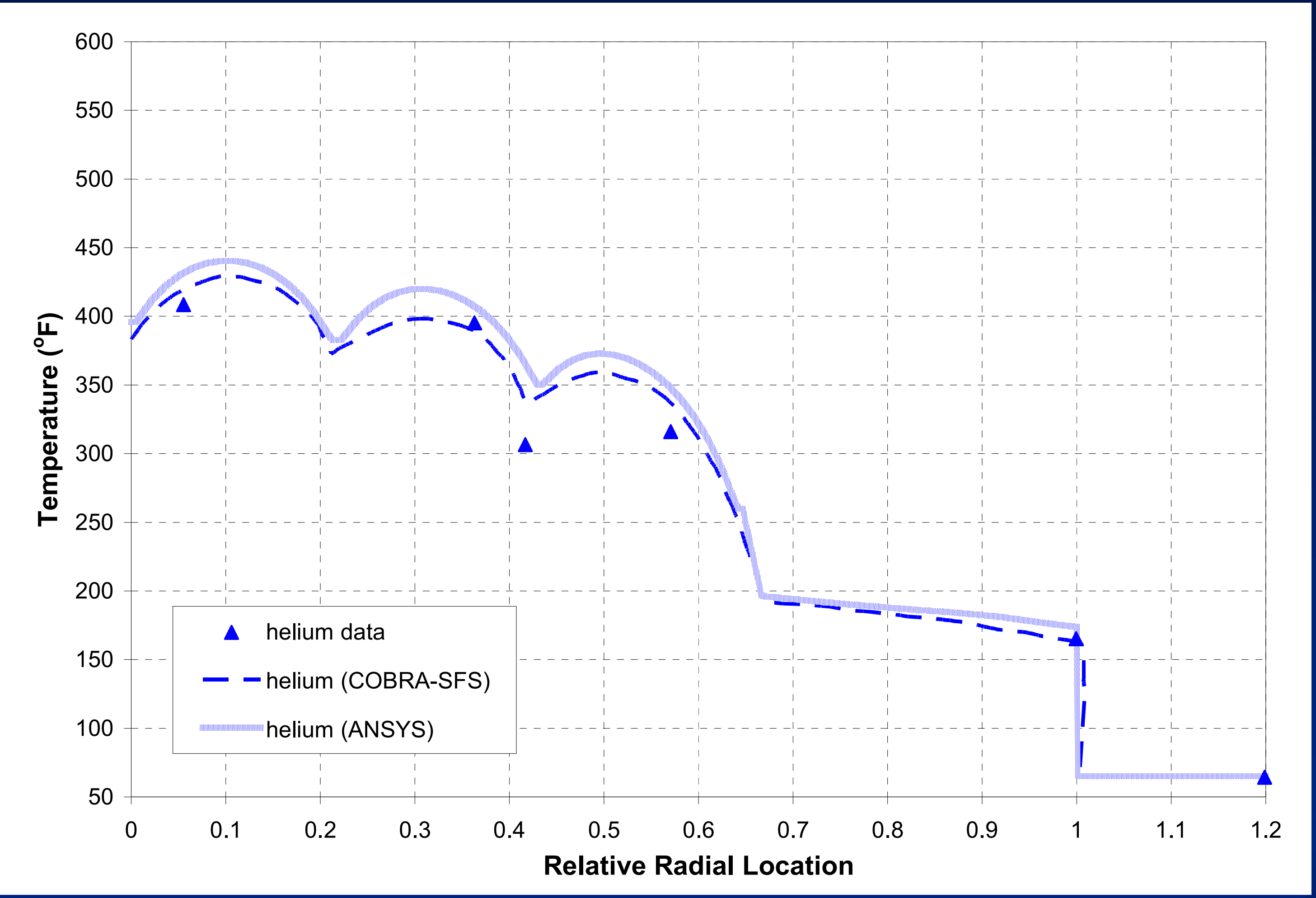


Results

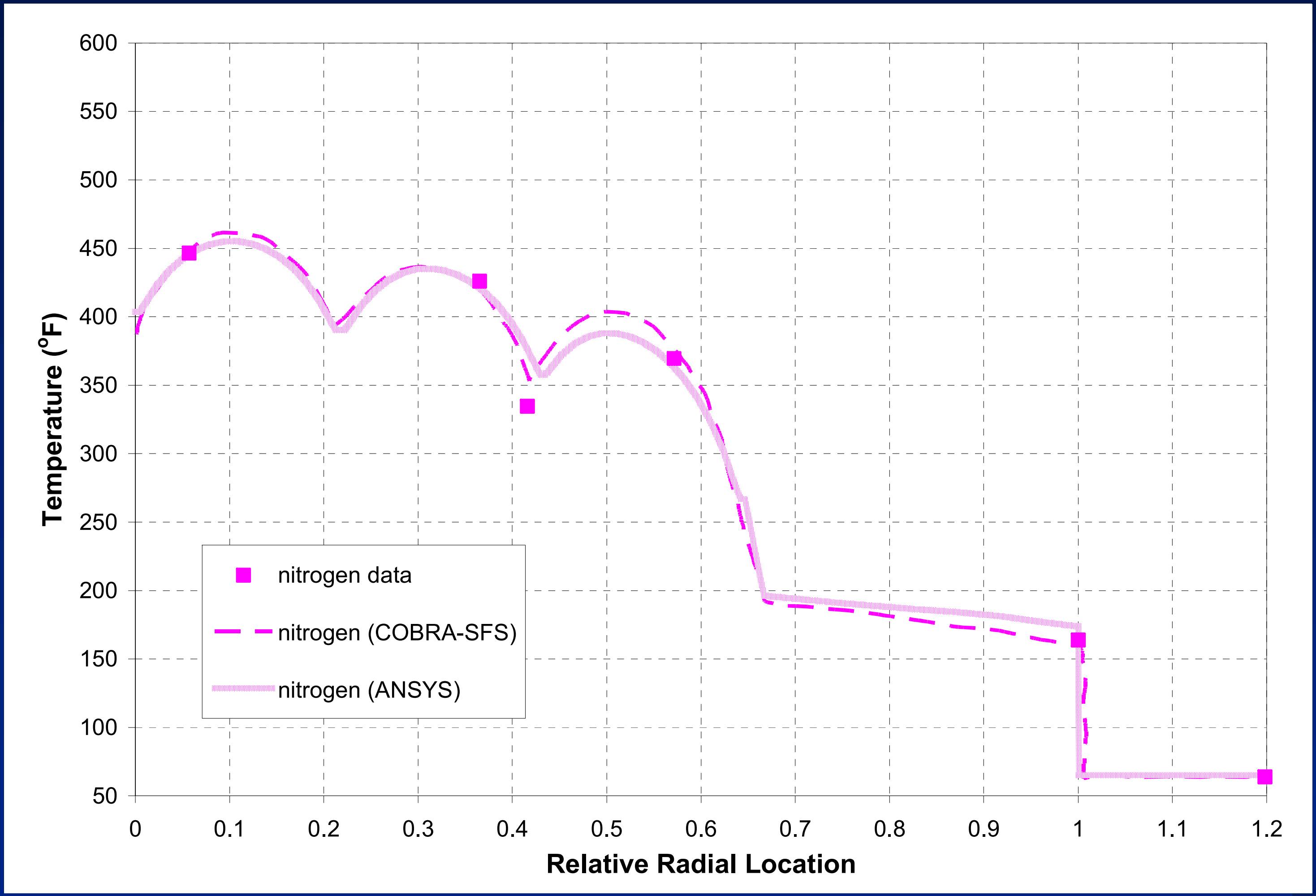


ANSYS
NODAL SOLUTION
STEP=1
SUB =6
TIME=1
TEMP (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
SMN =161.335
SMX =440.465
161.335
176.6
189.684
204.949
218.034
231.118
246.383
259.467
272.551
287.816
300.9
313.984
329.249
342.334
355.418
370.683
383.767
396.851
412.116
425.2
440.465
Transnuclear TN24P

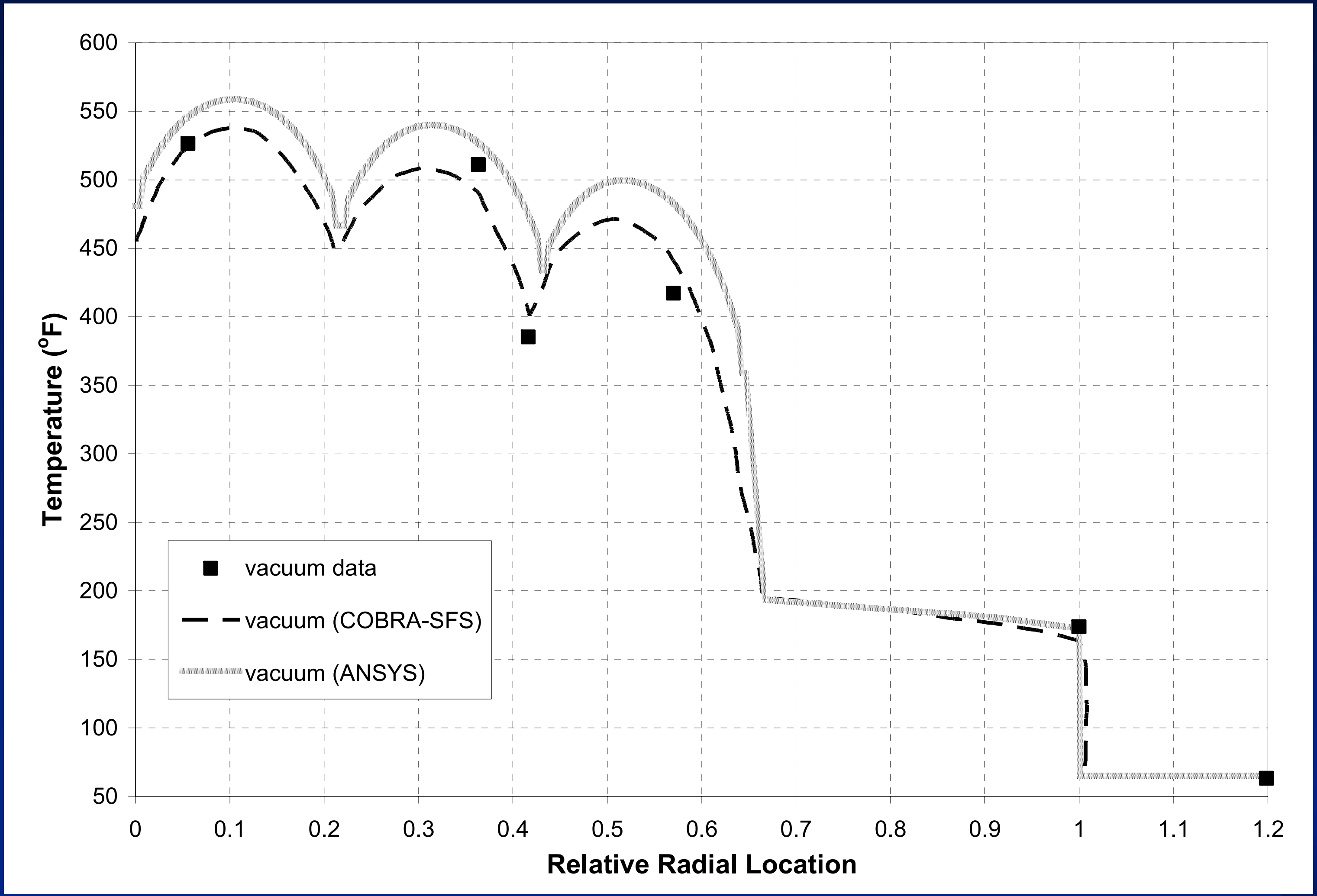
Comparison of Results - Helium



Comparison of Results - Nitrogen



Comparison of Results - Vacuum



Comparison of Results

Helium

Relative Radial Location	Description of Location	Measured Temperature (ºF)	COBRA-SFS Temperature (ºF)	ANSYS Temperature (ºF)
0.06	central fuel assembly	411.1	419.5	423.2
0.36	inner fuel assembly	396.0	389.7	399.9
0.42	basket plate	307.2	338.4	335.6
0.57	outer fuel assembly	319.3	337.3	332.7
1.00	cask surface	172.2	162.9	169.6

Nitrogen

Relative Radial Location	Description of Location	Measured Temperature (ºF)	COBRA-SFS Temperature (ºF)	ANSYS Temperature (ºF)
0.06	central fuel assembly	448.9	446.5	434.9
0.36	inner fuel assembly	426.9	421.0	411.9
0.42	basket plate	335.5	357.0	342.4
0.57	outer fuel assembly	371.5	376.8	357.6
1.00	cask surface	162.3	160.7	169.6

Vacuum

Relative Radial Location	Description of Location	Measured Temperature (ºF)	COBRA-SFS Temperature (ºF)	ANSYS Temperature (ºF)
0.06	central fuel assembly	527.5	522.9	532.6
0.36	inner fuel assembly	510.3	490.0	509.9
0.42	basket plate	386.1	408.7	443.9
0.57	outer fuel assembly	419.0	440.7	465.5
1.00	cask surface	173.8	163.4	169.6

Conclusions

- In general, acceptable thermal results can be obtained using this approximation methodology for spent fuel casks if:
  - An attempt is made to realistically account for all of the significant heat transfer mechanisms.
  - Convection (internal to the basket) is considered for vertical orientations (where the design permits!!)
  - The cask system’s physical attributes are accurately captured in the modeling.

Conclusions, Cont.

- A gap is modeled between the homogenized fuel compartment wall as part of the k-effective approach presented in this analysis (different than previous approach).
- Heat generation is applied only to the homogenized fuel region (geometrically represented).
- Empirical or experimental data on natural convection for internal and external regions of the cask is carefully verified for applicability and accuracy.
- Internal pressurization effects on gas convective coefficient of conductance are carefully considered and verified with relevant correlations and/or data.

Future Work

- Develop de-coupled model for internally cooled cask
- Develop additional fuel models