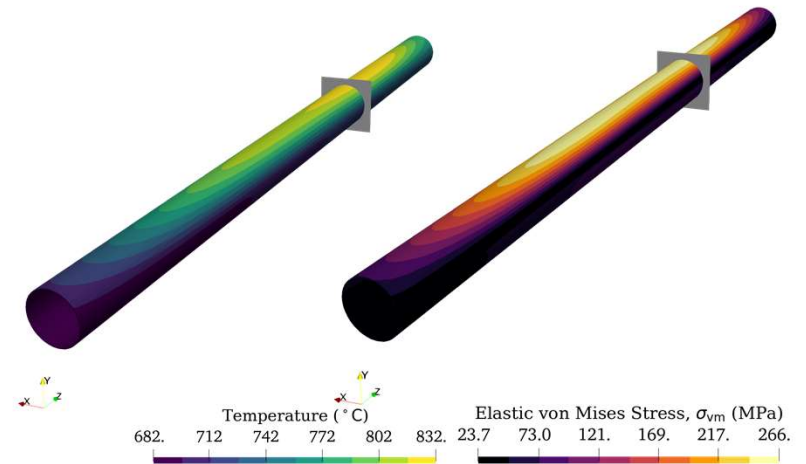


WE START WITH YES.



HIGH TEMPERATURE RECEIVER DESIGN AND ANALYSIS PACKAGE



MARK MESSNER
Argonne National Laboratory

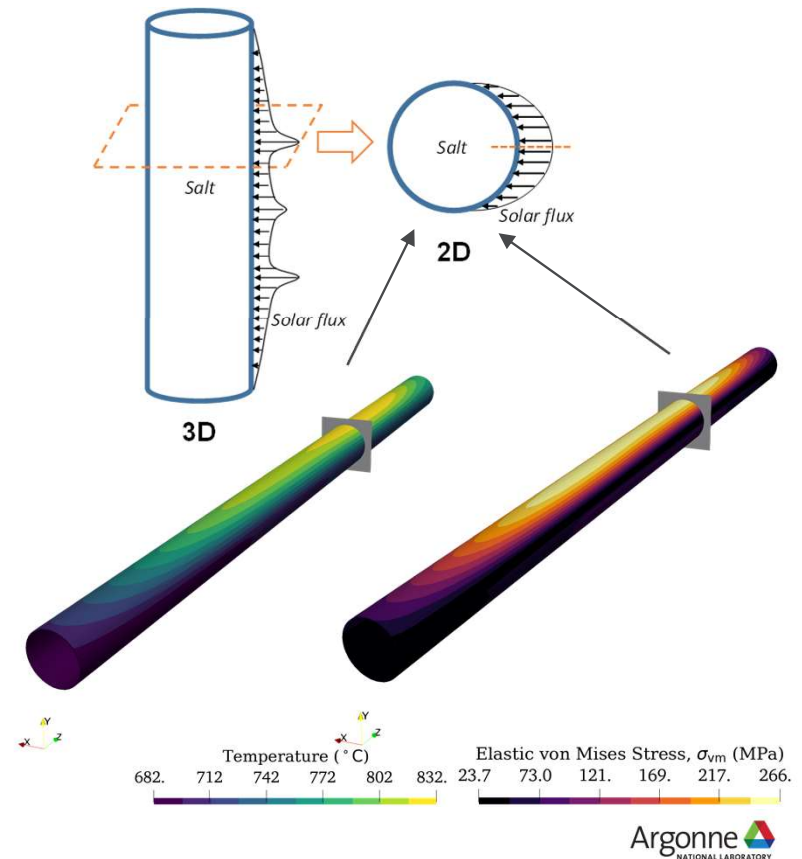
BIPUL BARUA
Argonne National Laboratory

MIKE MCMURTREY
Idaho National Laboratory

Gen 3 CSP Summit 2021
August 26th, 2021

FAST, ACCURATE RECEIVER LIFE ESTIMATION

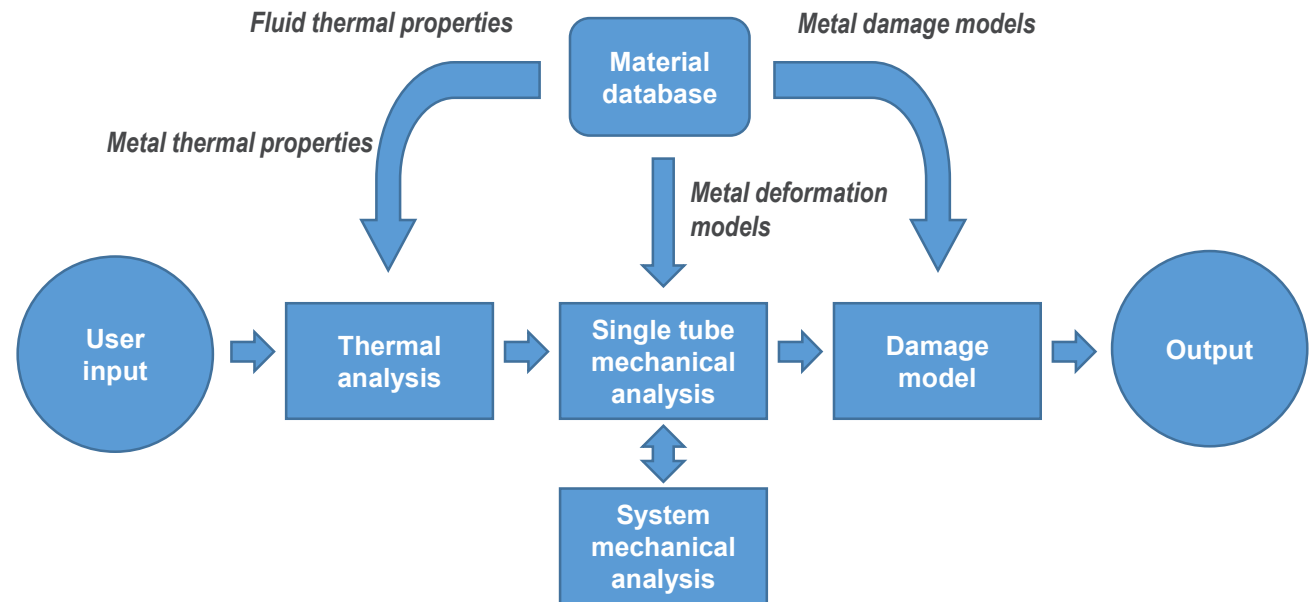
- **Designing a durable metallic receiver is challenging at Gen 3 conditions**
 - Max metal temperature $> 800^{\circ}\text{C}$ – even Ni-based alloys have diminished strength
 - Solar flux in non-uniform panel-to-panel, tube-to-tube, and both circumferentially and axially in each tube – leads to large thermal stresses
 - An accurate model is nonlinear and state-dependent
 - Approximate models typically neglect:
 - Thermal stress – not accurate for CSP systems
 - Alternating load – ignores the detrimental effect of creep-fatigue and potential for resetting thermal stress
 - Creep deformation/stress relaxation – actually too conservative
- **A fast, accurate means to estimate the life of a receiver could reduce risk and cost of next-gen systems**



APPROACH AND OPEN SOURCE SOFTWARE PACKAGE

Input: receiver materials, geometry, incident flux, fluid temperatures, and pressures

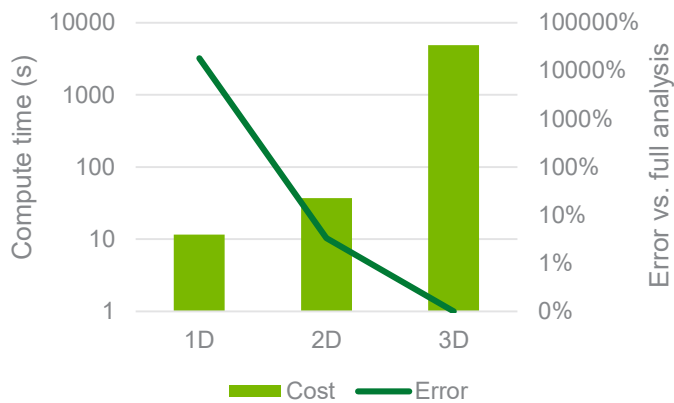
Output: estimated life



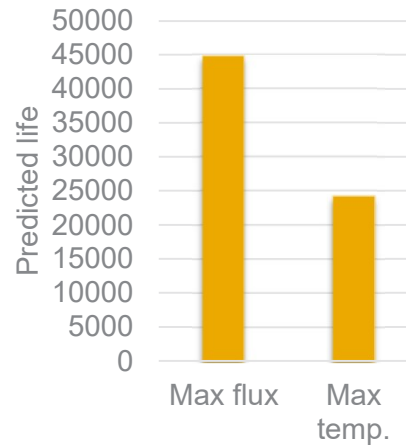
Complete version available as open source software: <https://github.com/Argonne-National-Laboratory/srlife>

HEURISTICS TO REDUCE THE TIME REQUIRED TO GET A LIFE PREDICTION

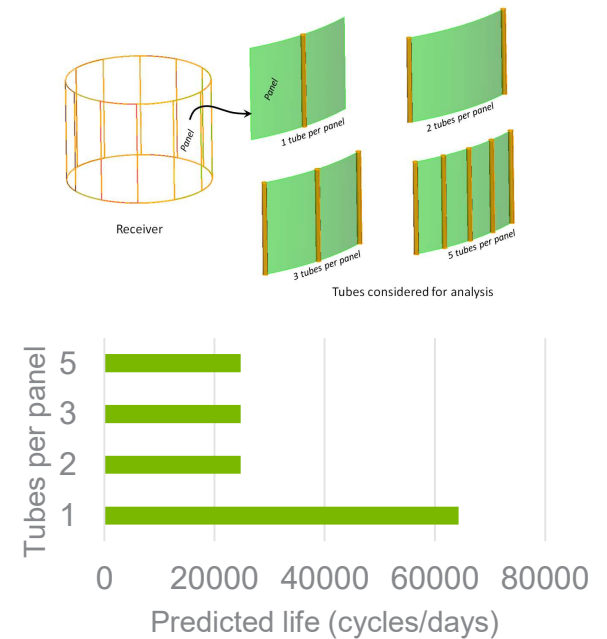
Cost versus accuracy of 1D/2D/3D analysis



Where should I slice the tube?



How many tubes to analyze per panel?



These (and other) studies inform our choice of heuristics to reduce the cost of a full 3D, every tube, every panel analysis

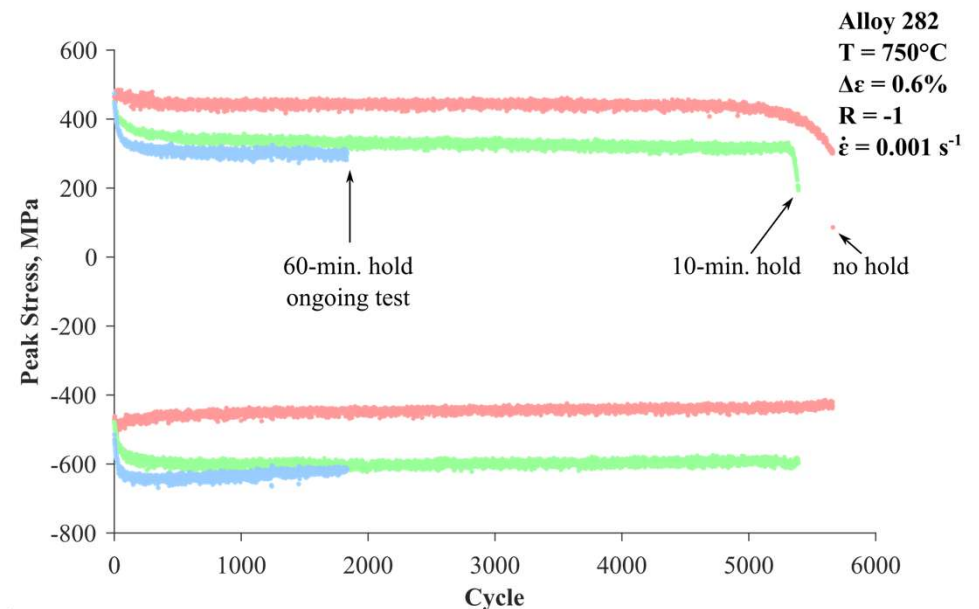
MATERIAL DATA AND ALLOY 282 TESTING

- Material database:

- 316H
- Alloy 740H
- Alloy 800H
- Alloy 617
- Alloy 230*
- Alloy 282*

* Provisional models

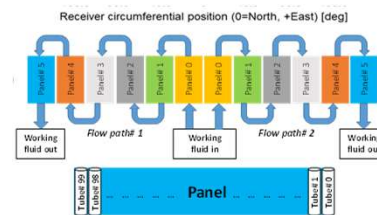
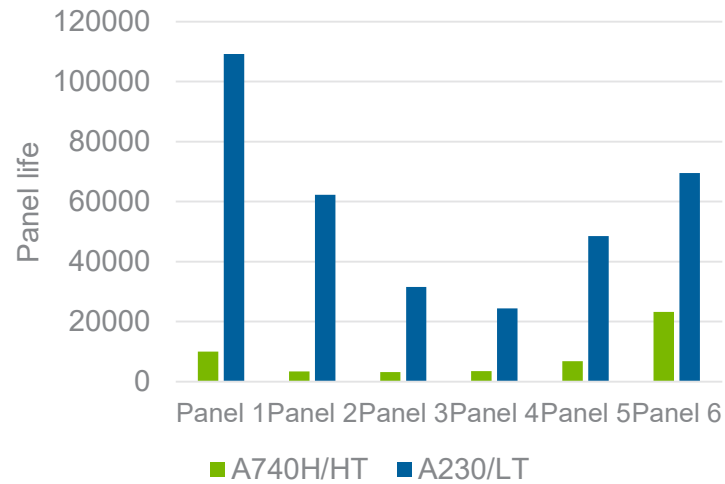
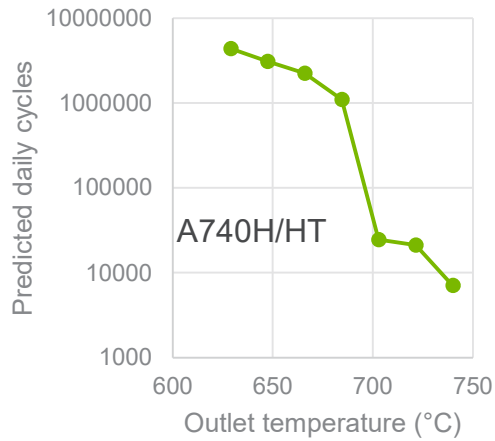
- Project includes a testing component at INL to determine complete properties for wrought 282 and look at cast and weld



Preliminary creep-fatigue test results suggest Alloy 282 may have better creep-fatigue resistance compared other Ni-based alloys

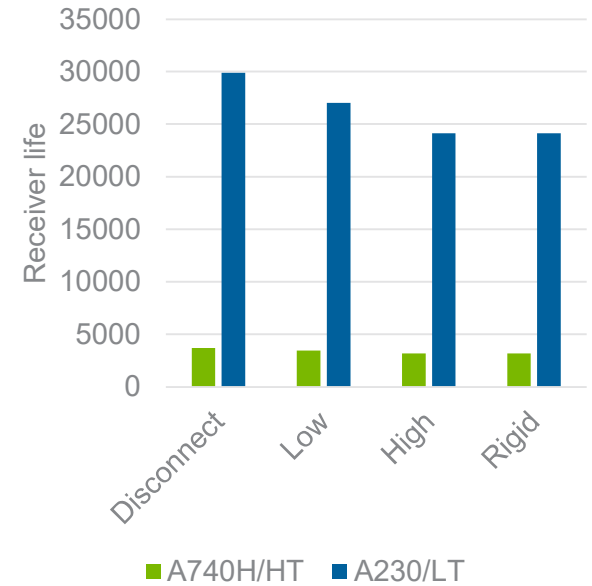
A FEW INTERESTING RESULTS

Effect of outlet temperature on predicted receiver life



Panel residual life

Effect of manifold stiffness



CONCLUSIONS AND FUTURE PLANS

- **Immediate plans:**

- Usability improvements: better windows support and automatic integration of heuristics
- Complete A282 testing and provide final recommended wrought properties
- Provide a strength reduction for cast A282

- **Longer term:**

- Integrate receiver thermohydraulic analysis into package – better integration with rest of software stack
- Design optimization studies – what performance is possible given constraints
- New materials – as required