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Bison-TRACE Coupling

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Outline

- Review of the Comprehensive Reactor Analysis Bundle (CRAB)
- Bison-TRACE coupling approach
- Initial validation against Loss Of Flow Test (LOFT) L2-5
- Full-length rod Loss Of Coolant Accident (LOCA) demonstration with Zry and FeCrAl cladding
- Conclusions, collaborations and future planned work

Comprehensive Reactor Analysis Bundle (CRAB)

CRAB is a proposed suite of codes coupled through the MOOSE framework, allowing existing NRC codes to be integrated with advanced DOE codes

- This presentation will focus on Bison-TRACE only

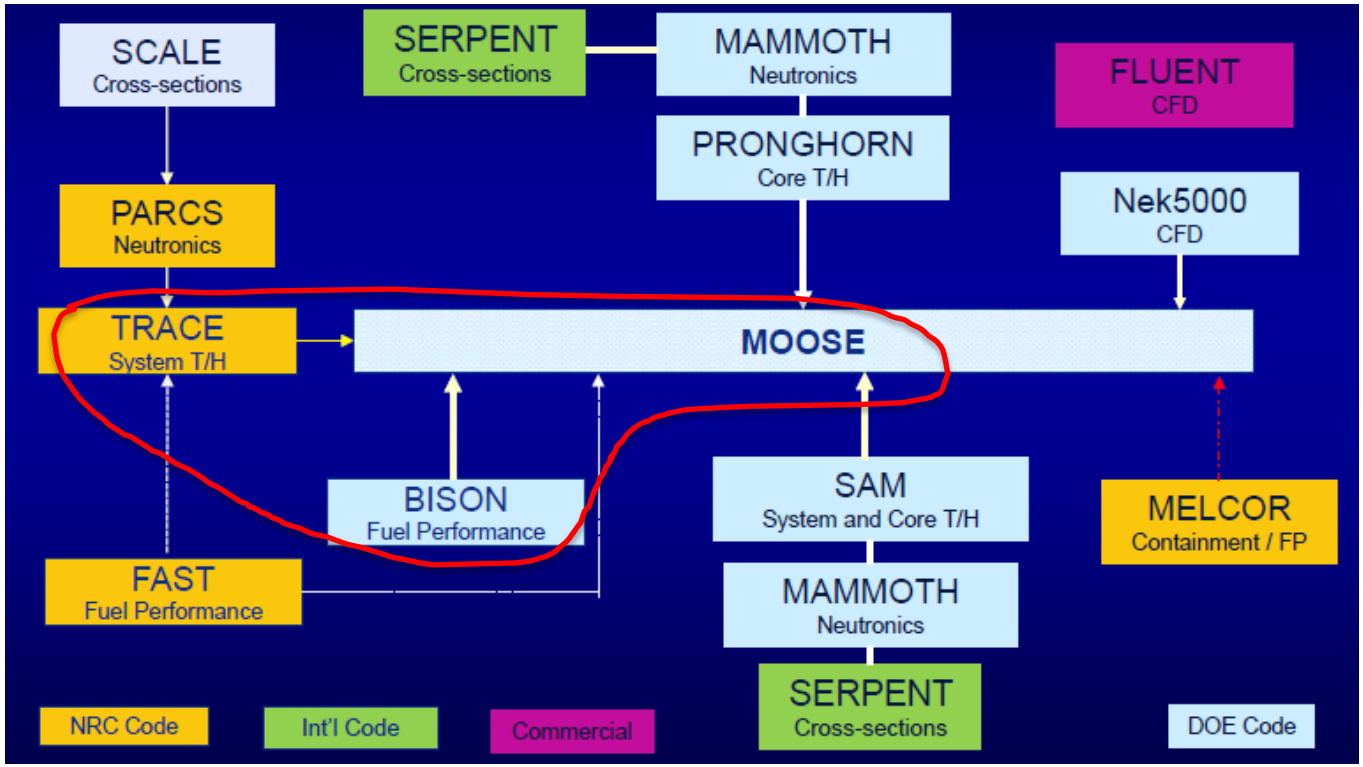
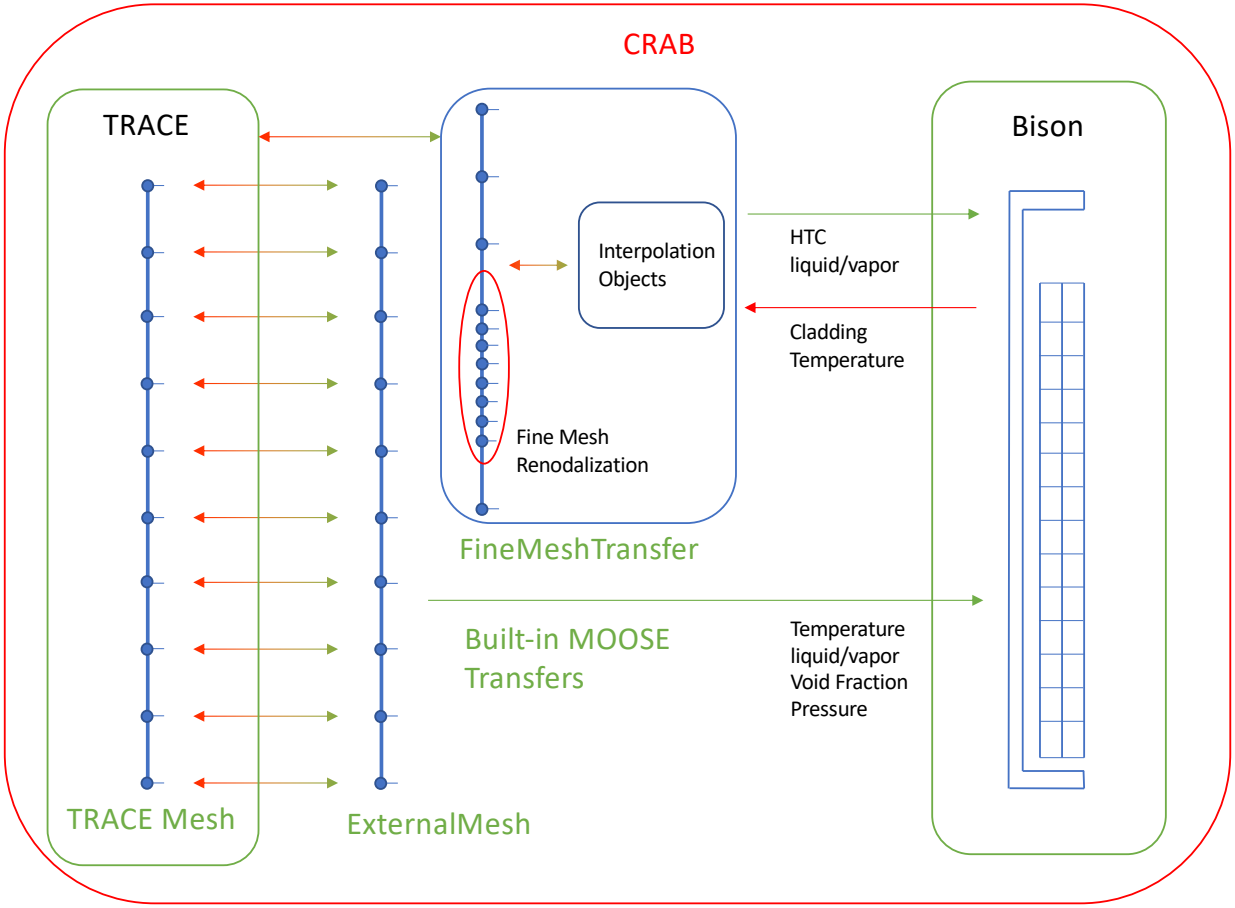


Figure c/o NRC

Bison – TRACE Spatial Coupling Approach

Initial results identified that a sophisticated two-level transfer approach was needed

- The MOOSE ExternalMesh object replicates the TRACE mesh inside the MOOSE framework. This allows for a 1:1 transfer space to leverage preexisting MOOSE internal transfers to and from Bison.
- A FineMeshTransfer object was developed to transfer parameters that are subject to TRACE's fine mesh renodalization. A MOOSE interpolation object then passes the data to and from the Bison mesh.



Bison – TRACE Temporal Coupling Approach

A time step synchronization scheme allows Bison and TRACE to take different timesteps based on individual physics. With this approach, Bison provides TRACE a target step end time and then TRACE solves to that point.

Challenges that exist:

- TRACE's ability to restart a calculation from a previous time (Auto)
- Manual time stepping is currently required to adequately resolve the progression of the quench front during the LOCA.
- Solutions to both issues are under development

```
Solve Converged!

Time Step 2, time = 200
            dt = 100

 time-step    problem    time-step   outer-it.    cpu       save point
  number      time (s)    size (s)    number    time (s)   nstep    time(s)
   2204     100.040228    0.040228       1     1.70E+01   2199   9.98E+01

 restart dump generated at problem time   100.040228 s after 2204 time steps

 time-step    problem    time-step   outer-it.    cpu       save point
  number      time (s)    size (s)    number    time (s)   nstep    time(s)
   2221     100.585976    0.046102       2     1.70E+01   2199   9.98E+01

 restart dump generated at problem time   100.585976 s after 2221 time steps

 ....

 time-step    problem    time-step   outer-it.    cpu       save point
  number      time (s)    size (s)    number    time (s)   nstep    time(s)
   4192     199.134383    0.050000       1     2.10E+01   4178   1.98E+02

 restart dump generated at problem time   199.134383 s after 4192 time steps

 time-step    problem    time-step   outer-it.    cpu       save point
  number      time (s)    size (s)    number    time (s)   nstep    time(s)
   4202     199.634383    0.050000       1     2.10E+01   4178   1.98E+02

restart dump generated at problem time   199.634383 s after 4202 time steps
```

Initial Validation Against LOFT L2-5 Experiment

The LOFT experiments were conducted at INL between 1976-1983

- LOFT was a ½ scale PWR with system conditions that closely mimicked a commercial PWR
- Initial validation against the L2-5 experiment was suggested by the NRC, who provided TRACE inputs

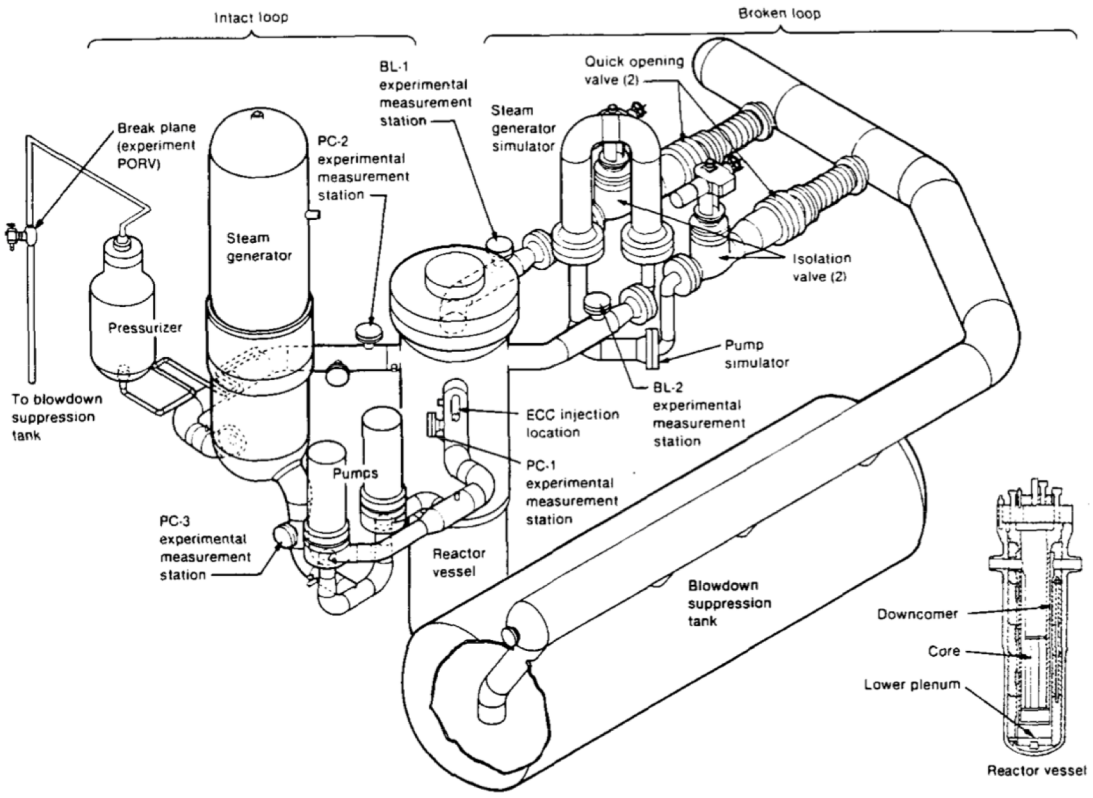


Figure c/o Technical Report NUREG/CR-3214

Initial Validation Against LOFT L2-5 Experiment

- Comparisons made to cladding temperature measurements on rod 5H06
  - Coupled approach clearly improves temperature prediction
  - Timestep sensitivity observed during quench and is under investigation

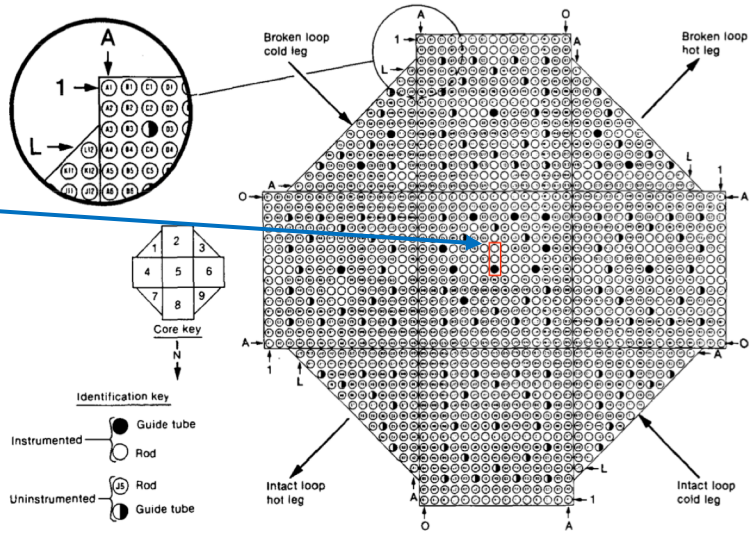
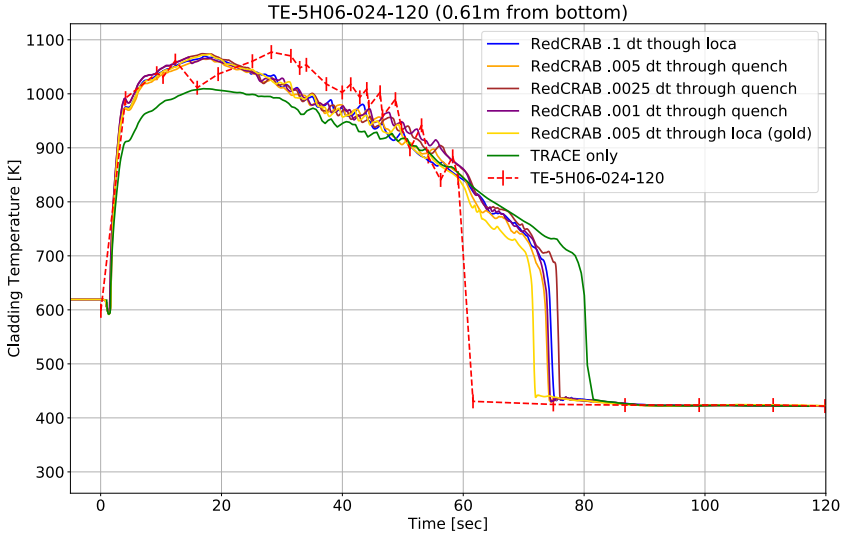
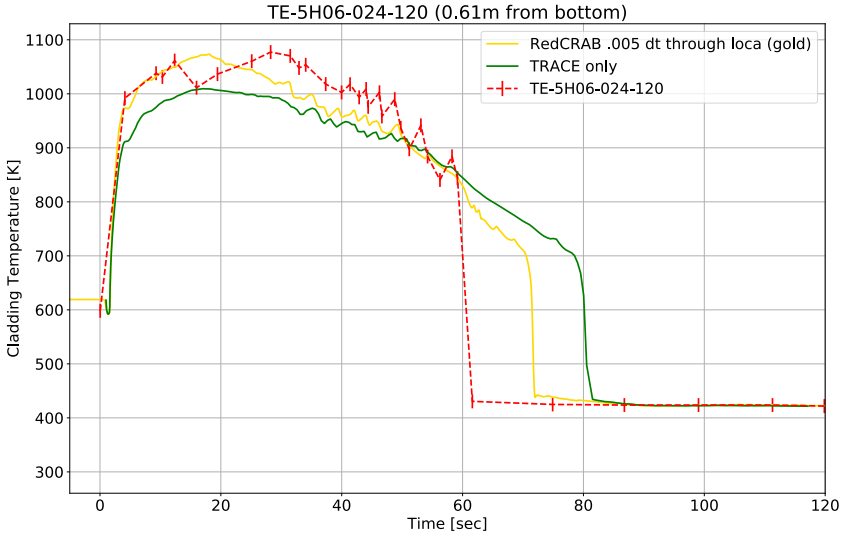


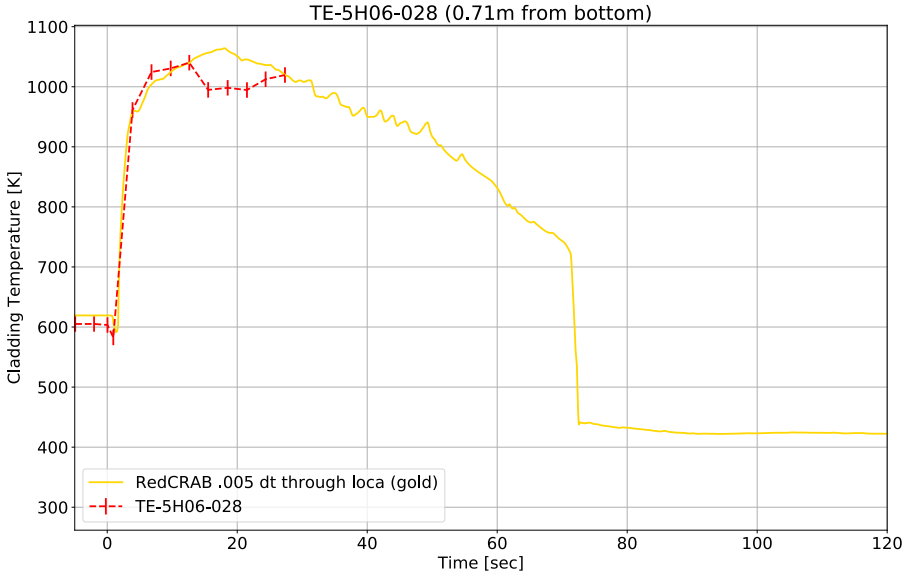
Figure c/o Technical Report NUREG/CR-3214

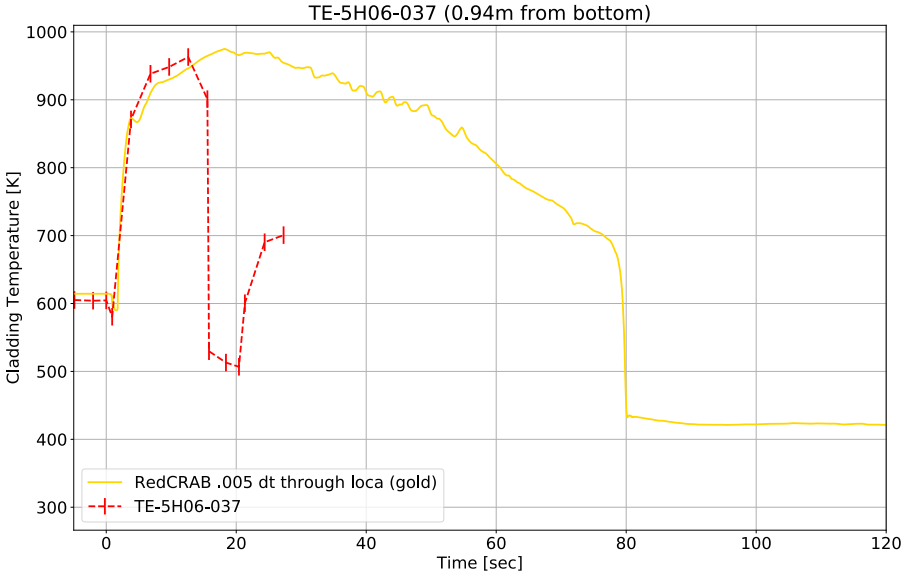




Initial Validation Against LOFT L2-5 Experiment

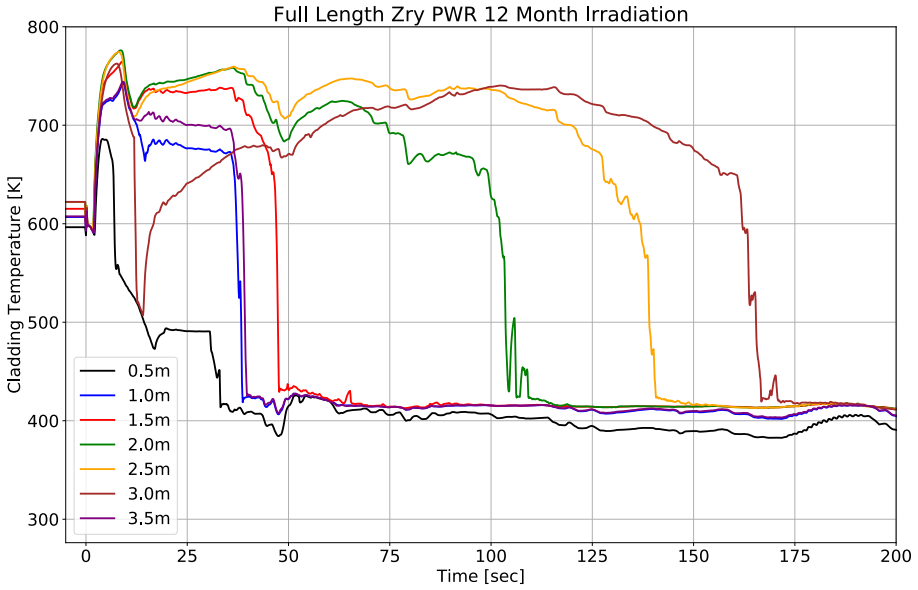
- Additional temperature comparisons at higher axial positions on the same rod
  - Most of the LOFT thermocouples only recorded data for 30 seconds into the LOCA, which is why the red line stops.
  - TC-037 experienced a 5 second top-down quench that was is not currently captured in the TRACE model

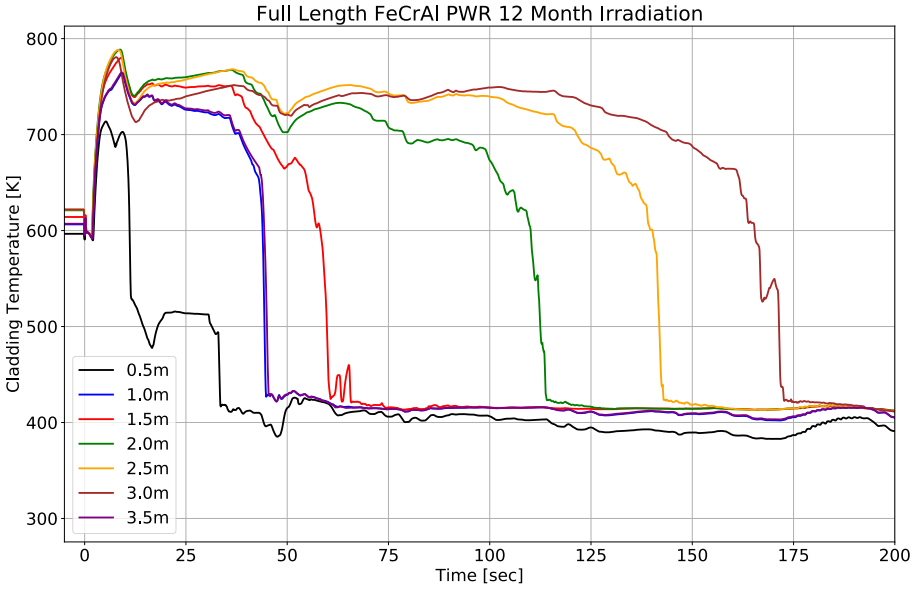




Full Length Rod LOCA Demonstration with Zry and FeCrAl Cladding

- Work is continuing on the full-length rod demonstration simulations using experience gained from the LOFT case
  - Results shown are from the initial fully-coupled simulations. The LOCA was initiated after a 12 months of steady operation.
  - TRACE inputs were, once again, provided by the NRC. For this simulation a lower power rod was selected.
  - Propagation of a quench front is obvious

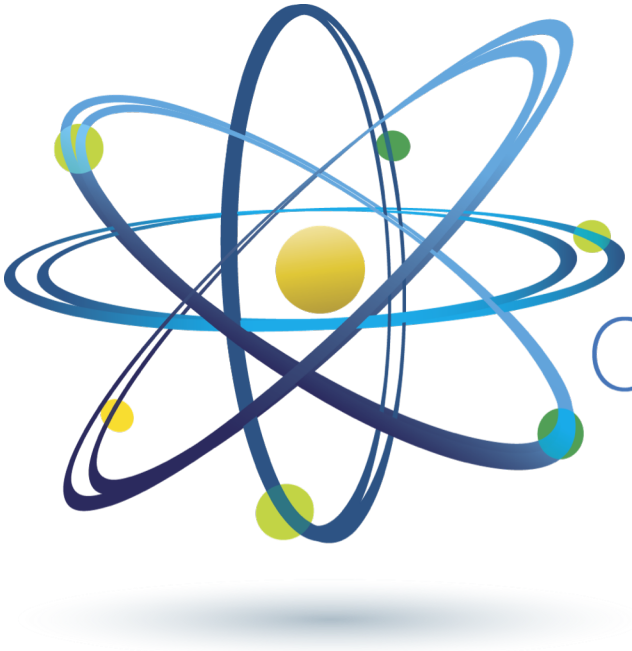




Conclusions, Collaborations and Future Work

- **Conclusions**
  - Coupled Bison-TRACE capability has been established and represents an initial demonstration of NRC's CRAB concept
  - The codes can be run stand alone or in either a one-way or fully-coupled manner
  - An initial validation case (LOFT L2-5) has been completed, with the coupled codes resulting in an improved prediction of cladding temperature
  - Coupling of Bison and TRACE combines the strengths of both codes, resulting in a significantly improved simulation capability
- **Collaboration**
  - Very good working relationship has been established between the INL and NRC
  - Periodic site visits and cross training on codes is planned
- **Future Work**
  - Further investigation and simulation with the full-length rods
  - While the MOOSE framework can handle a variety of subcycling solves with failure, further development is needed to fully support TRACE's Auto stepping capability
  - A parameter has been identified to gage coupled solution convergence. Development is underway to make this TRACE parameter available to MOOSE, allowing for tighter coupling and removing the need for user imposed, very small, timesteps

Questions?



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