Summary of MASCO Meeting June 18 - 19, 2012

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Presented at:
Fusion Materials Science – Plasma Facing Components Coordination Meeting
Princeton Plasma Physics Laboratory
Princeton, NJ
June 20, 2012

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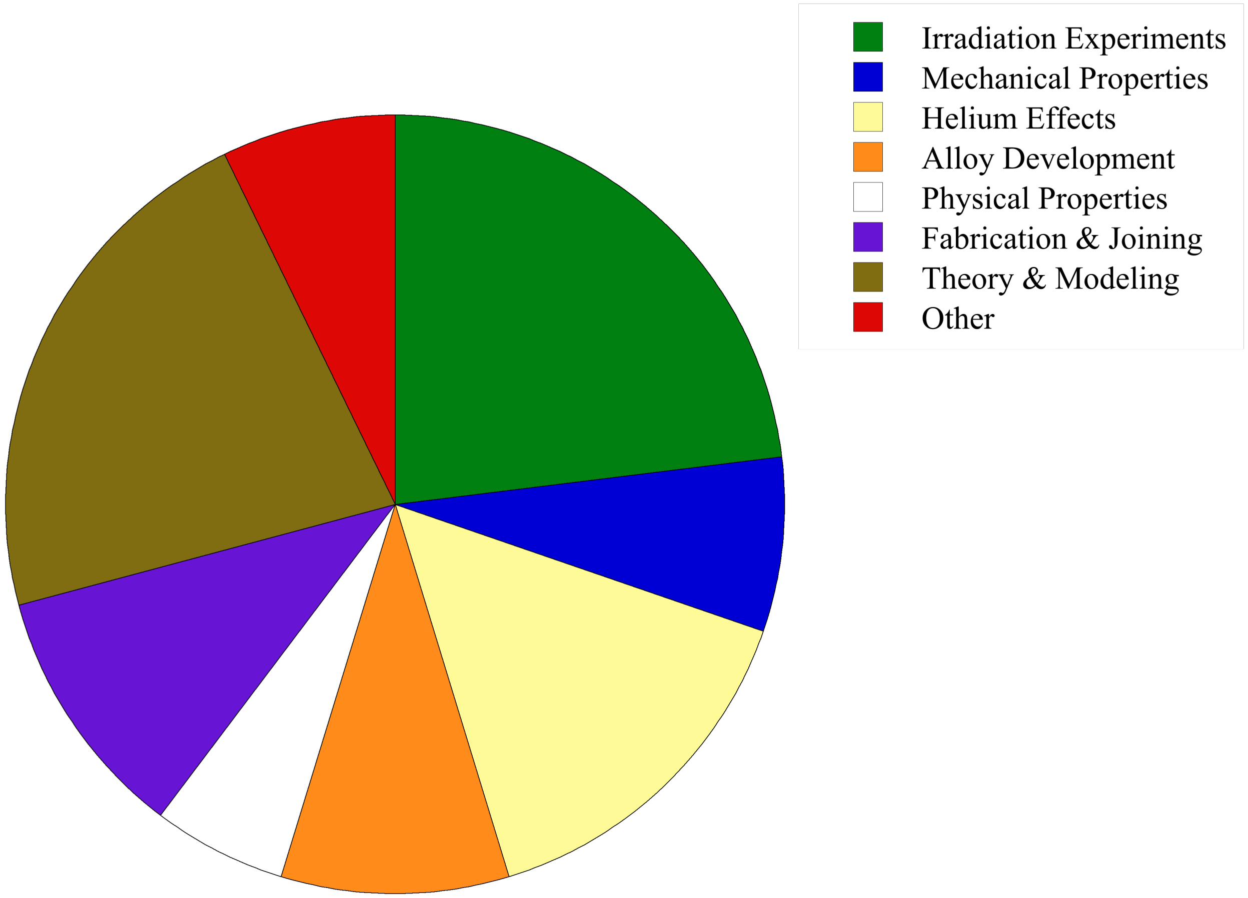
Pacific Northwest NATIONAL LABORATORY

Program Organization

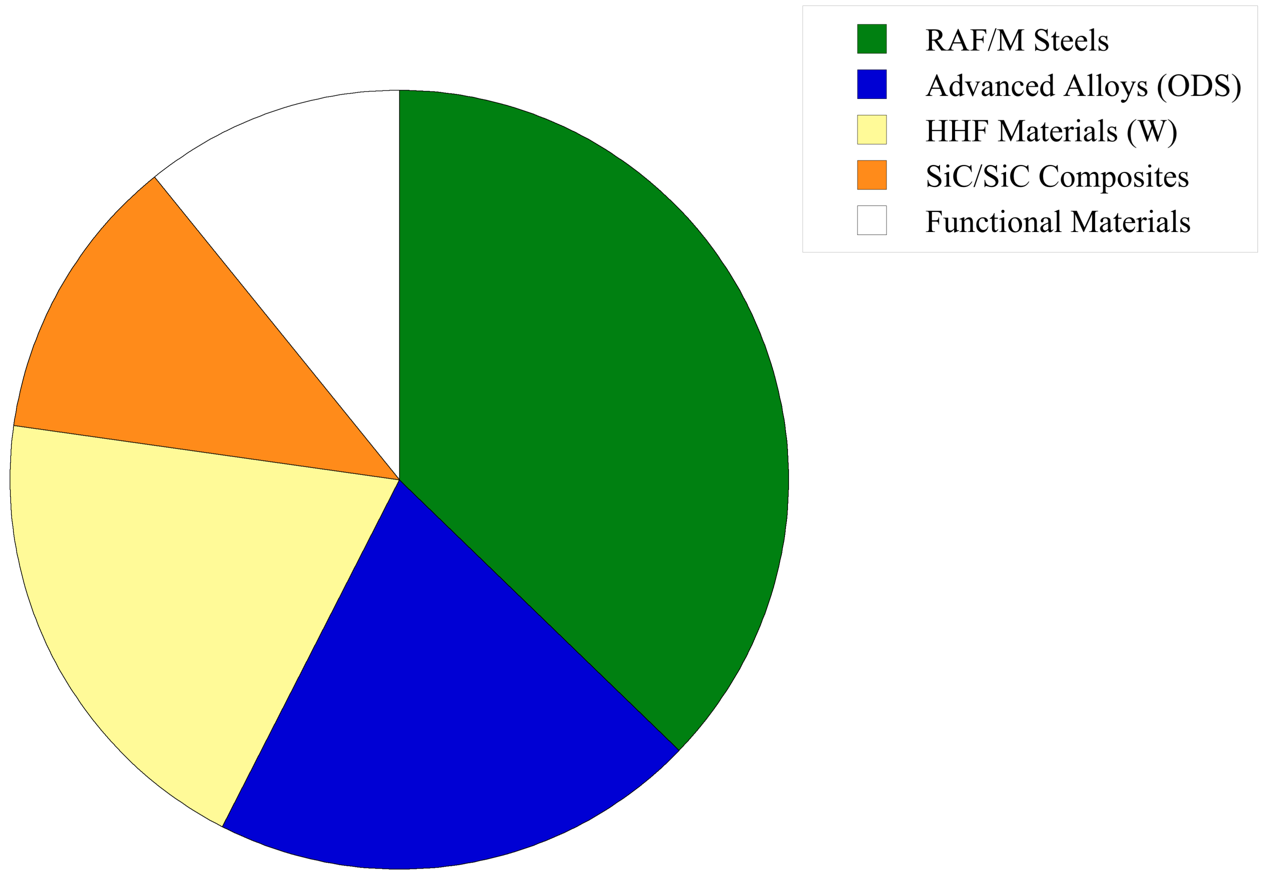
- Integrated, science based, national level program involving LLNL, ORNL, PNNL, UCLA, UCSB, and UTK.
- International fusion materials programs are coordinated through IEA Implementing Agreements involving Canada (inactive), China, European Union, India, Japan, Korea, Russian Federation, Switzerland and United States.
- The Fusion Materials Sciences Program is involved in strong, well-established international collaborative programs:
  - DOE/JAEA (irradiation experiments in HFIR for structural materials development).
  - DOE/MEXT TITAN (irradiation experiments in HFIR and complementary non-irradiation tests using unique U.S. facilities for structural and functional materials development).
  - EU (e.g. PSI, Riso, irradiation experiments in HFR-Petten).

Budget Distribution by Research Topic

- Current budget allocation: ~$5,000K
- Early Career Award:
  - J. Marion, LLNL
  - $500K
- Outcome of materials solicitation will be known soon (~2 weeks):
  - $2,600K
  - New institutions
  - New research topics
  - Reorganization under discussion



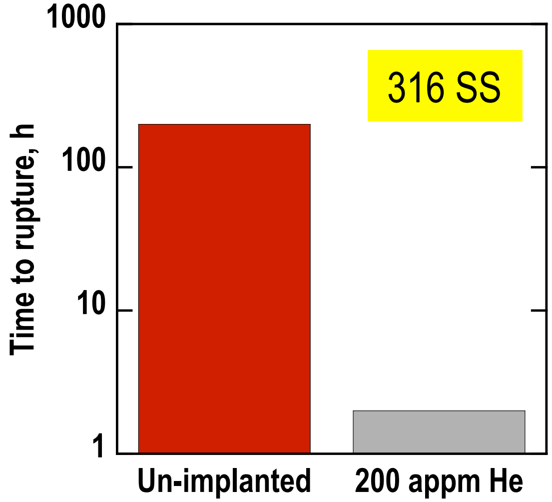
Budget Distribution by Material System

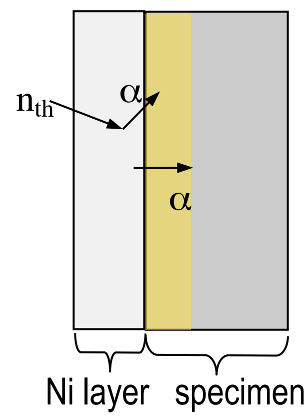


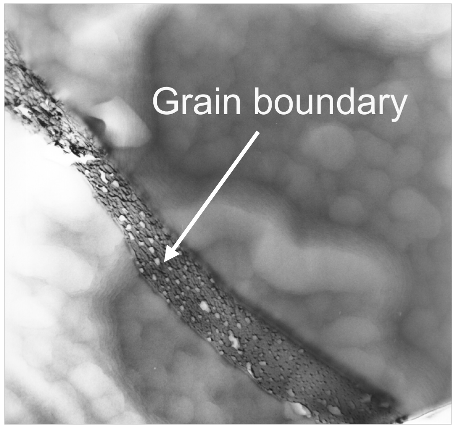
Impact of He-Rich Environment on Neutron Irradiated Materials

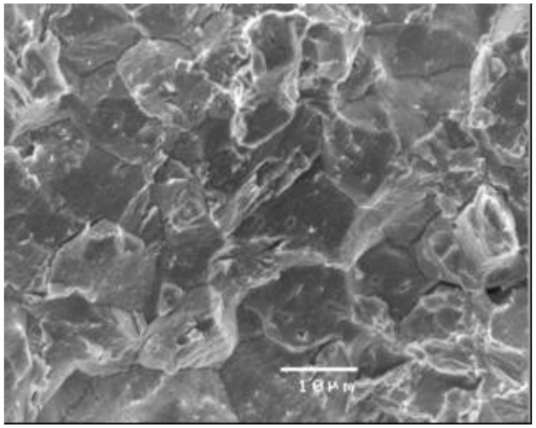
- A unique aspect of the DT fusion environment is substantial production of gaseous transmutants such as He and H.
- Accumulation of He can have major consequences for the integrity of fusion structures such as:
  - Loss of high-temperature creep strength.
  - Increased swelling and irradiation creep at intermediate temperatures.
  - Potential for loss of ductility and fracture toughness at low temperatures.
- TMS appear to be more resistant to He embrittlement, but He can reach and damage grain boundaries. Property changes under prototypical conditions (T, He/dpa, ϕt, etc.) have not been fully explored.

Schroeder & Batfalsky, 1983



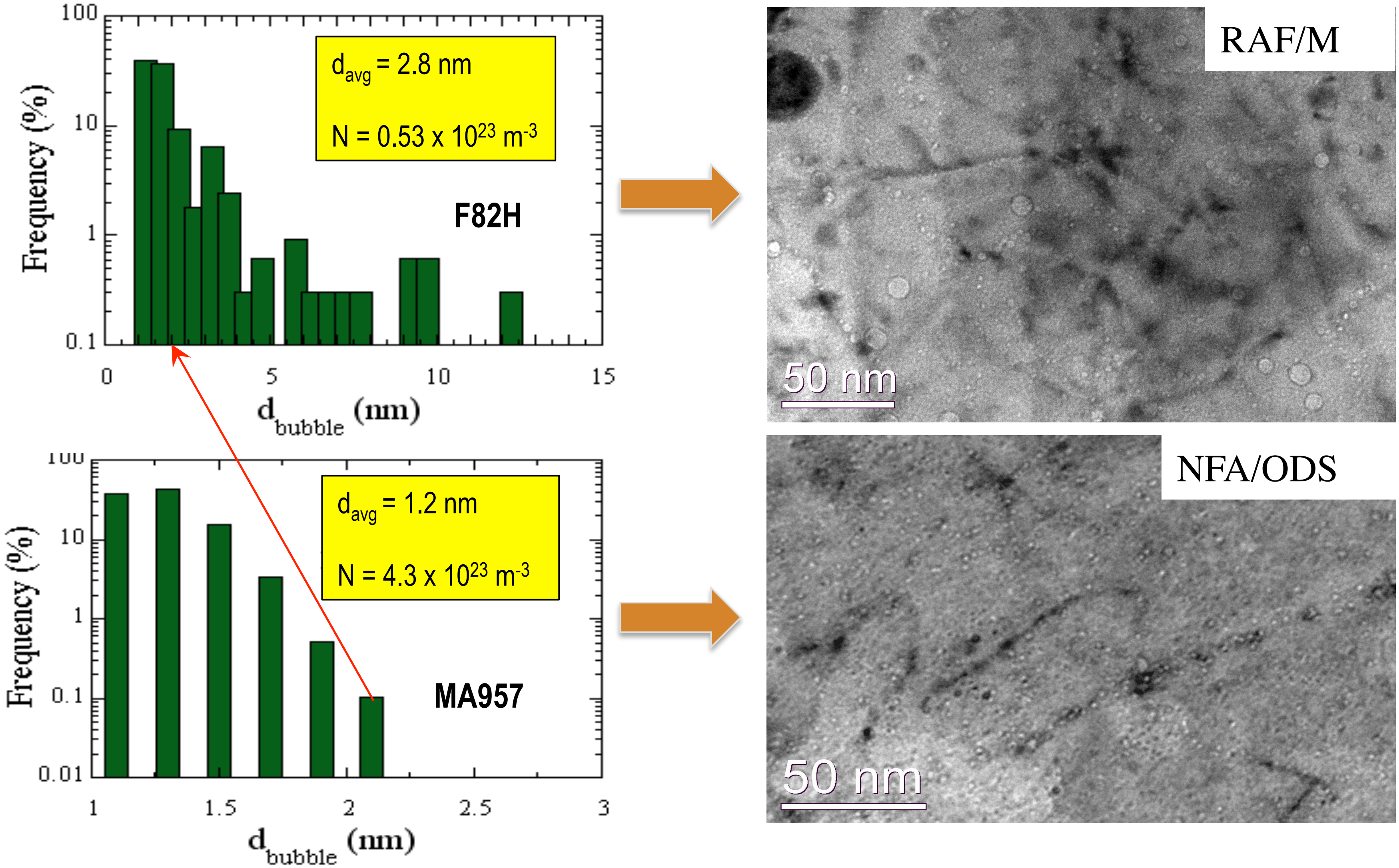






Helium Bubble Size and Number Density at 500°C, 380 appm He/9 dpa

NFA provide radiation damage resistance by promoting vacancy-interstitial recombination & trapping of He.

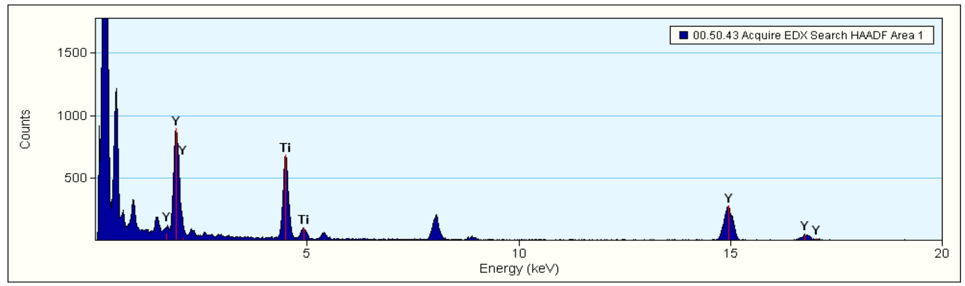


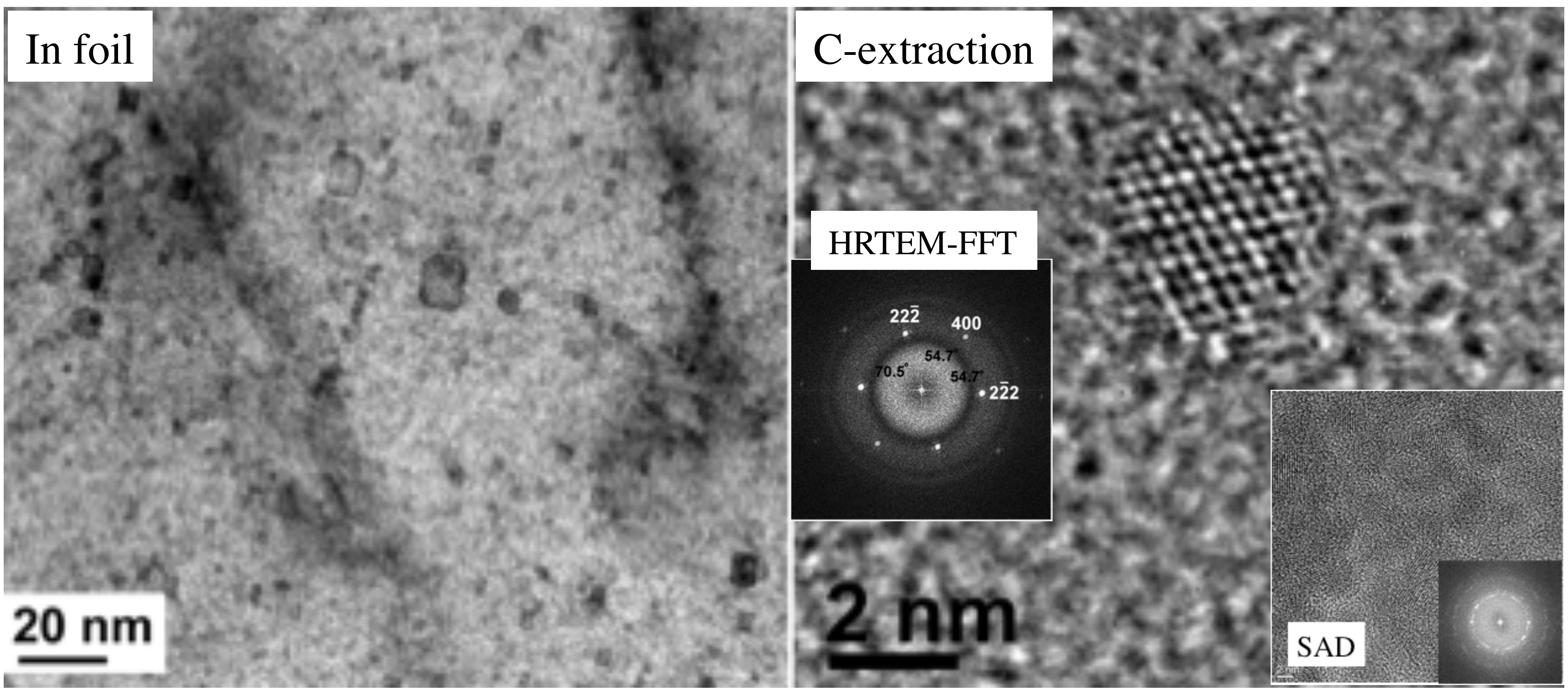
NFA - What Are NF?

- $10^{23\text{-}24}/m^3$ of 1 to 4 nm $Y_2Ti_2O_7$ (mostly)

G. R. Odette and D. T. Hoelzer, JOM 62-9 (2010) 84; Yu et al, Act Mat 60-8 (2012) 356

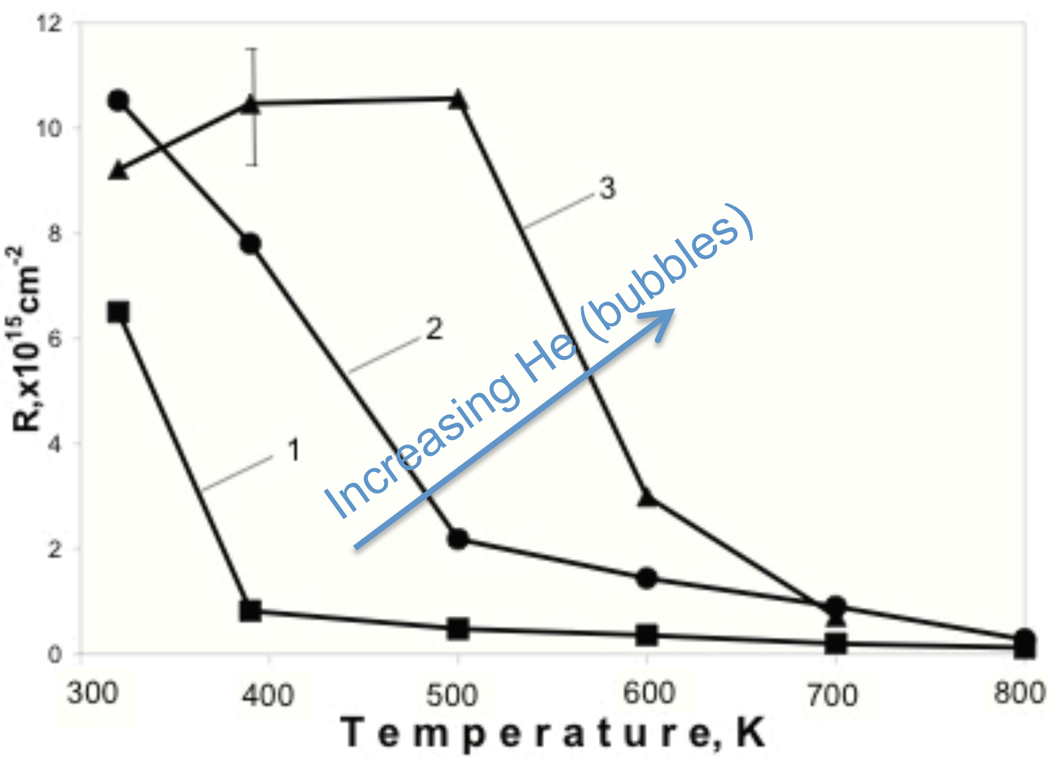
Element	At%
O	68
Ti	15.4
Cr	1.1
Y	15.5





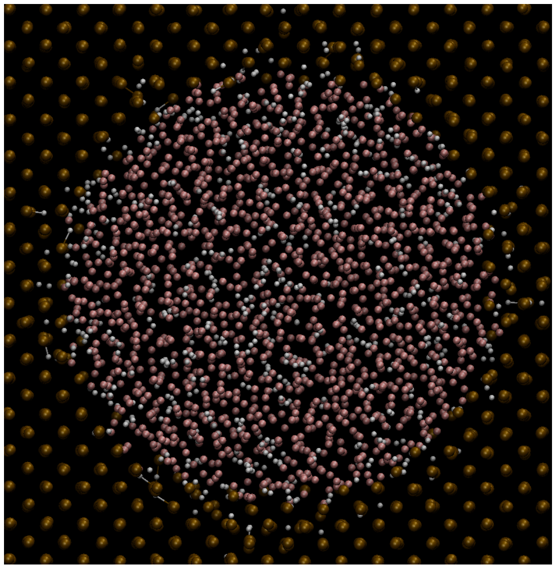
Strategies to Improve Radiation Resistance may Cause Enhanced Tritium Retention

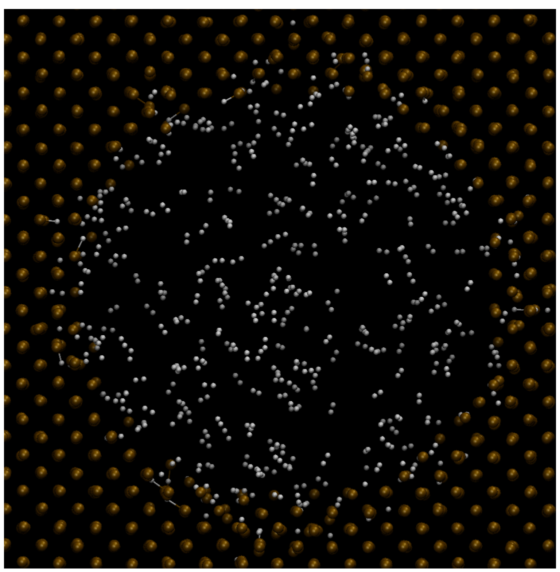
G.D. Tolstolutskaya et al., 12th Int. Conf. on Environmental Degradation of Materials in Nucl. Power System (TMS, 2005), p. 411



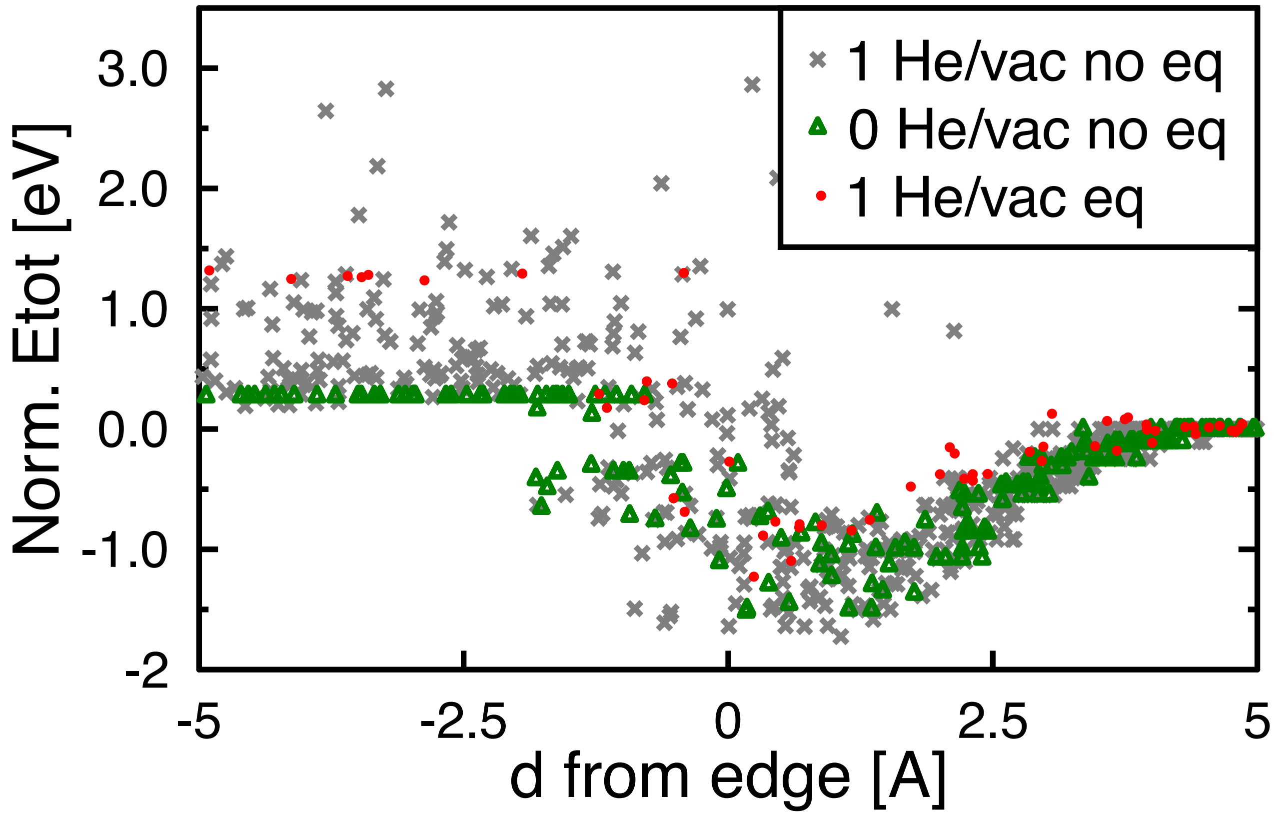
Deuterium retention in 18Cr10NiTi steel implanted to 1×10^{16} cm^{-2} without He (1) and with He to 5×10^{15} cm^{-2} (2) and 5×10^{16} cm^{-2} (3)

He-H behavior at bubbles in Tungsten





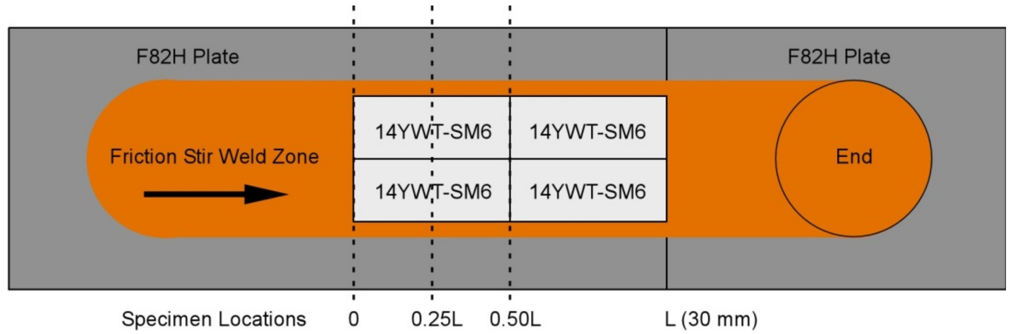
At larger He bubbles H segregates to the bubble/matrix interface



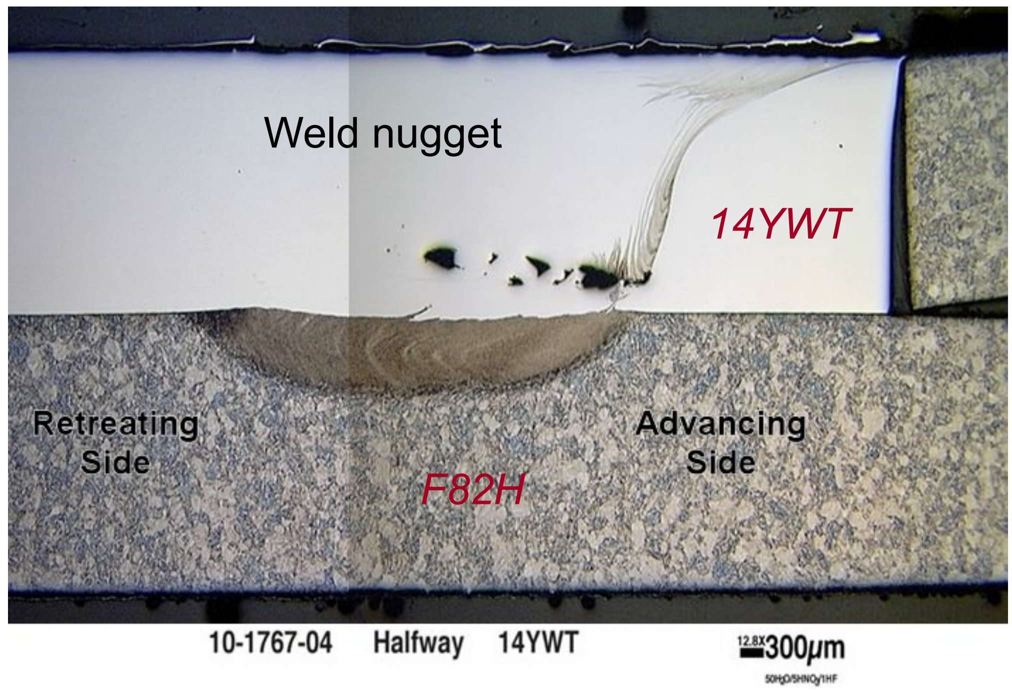
B.D. Wirth et al, UTK

Joining of Advanced Steels : ODS to RAF

- Ends cut from previously tested fracture toughness dual notch bend bars of 14YWT-SM6 and welded into slot in F82H plate



Specimen at 0.25L location

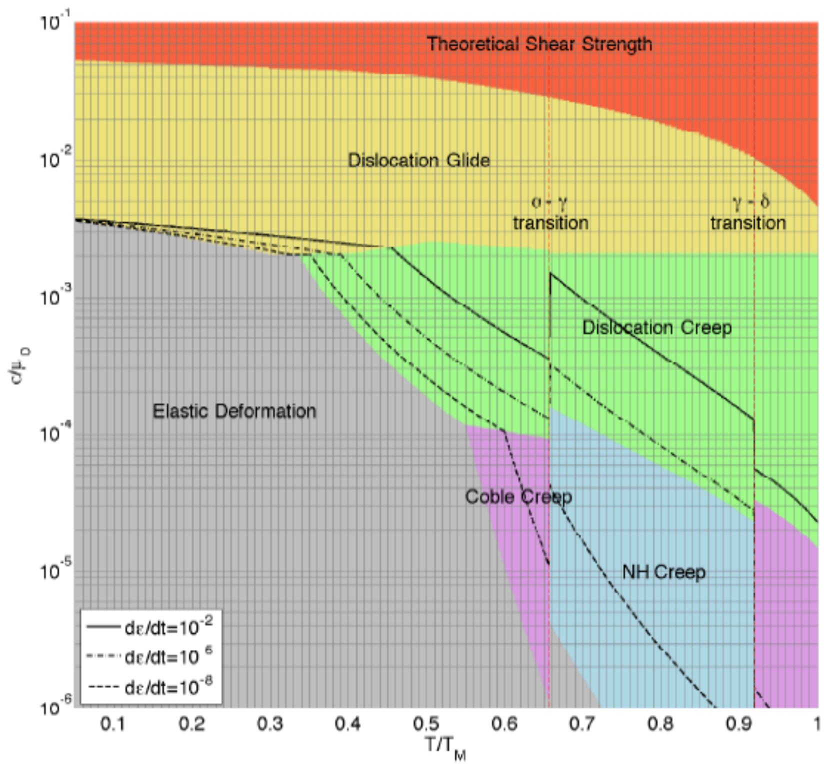


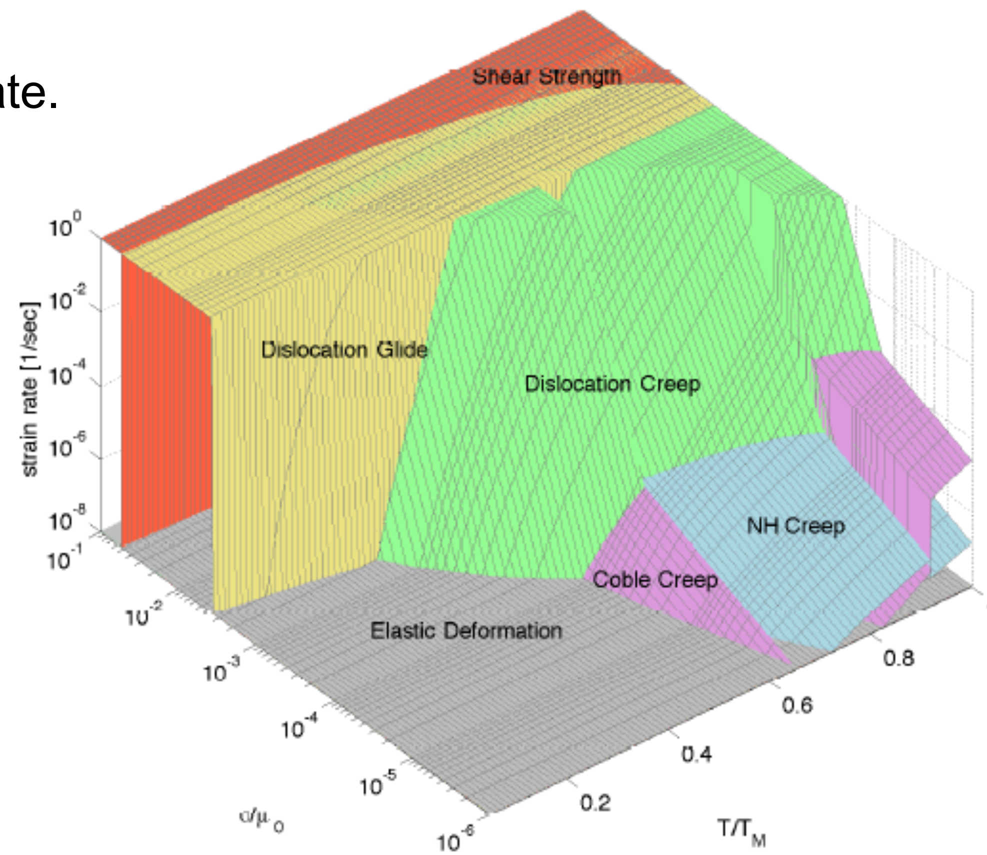
- Joining of sample by FSW was successful!
  - Good overall consolidation of 14YWT
  - Good bonding between 14YWT and F82H
  - Voids present at the bottom of the weld - need to refine the process conditions
- PCBN (Polycrystalline Boron Nitride) pin tool did not fracture!

Z. Feng and D.T. Hoelzer, ORNL

Materials Engineering & Design Interface: Empirical Data Extrapolation

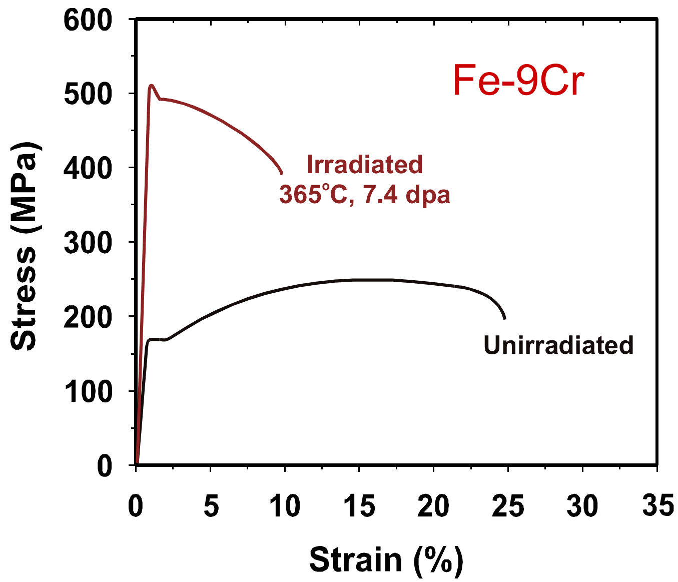
- Empirical Determination of deformation mechanisms of F82H steels as a function of temperature and strain rate.



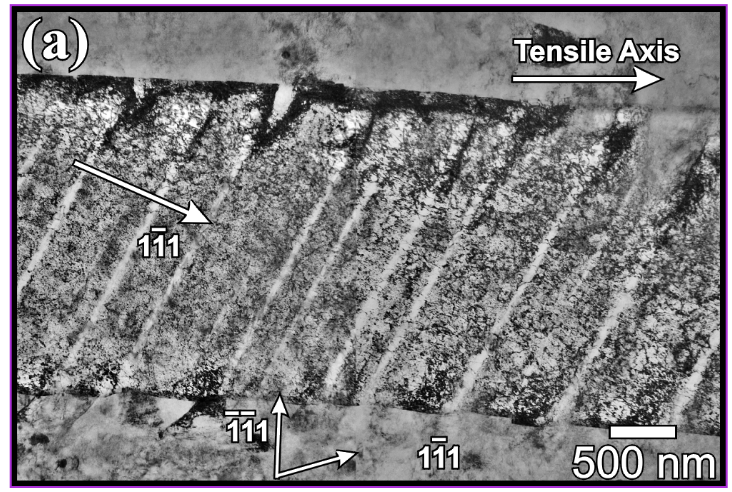


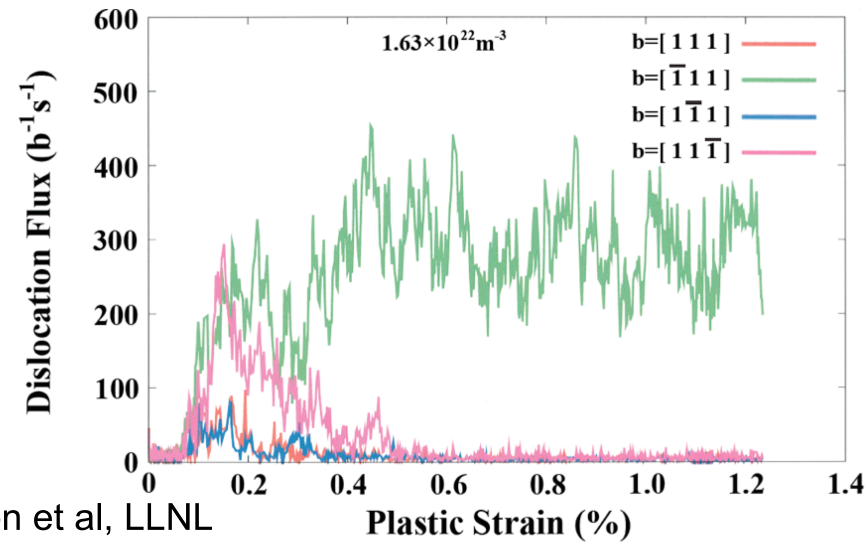
N.M. Ghoniem et al, UCLA

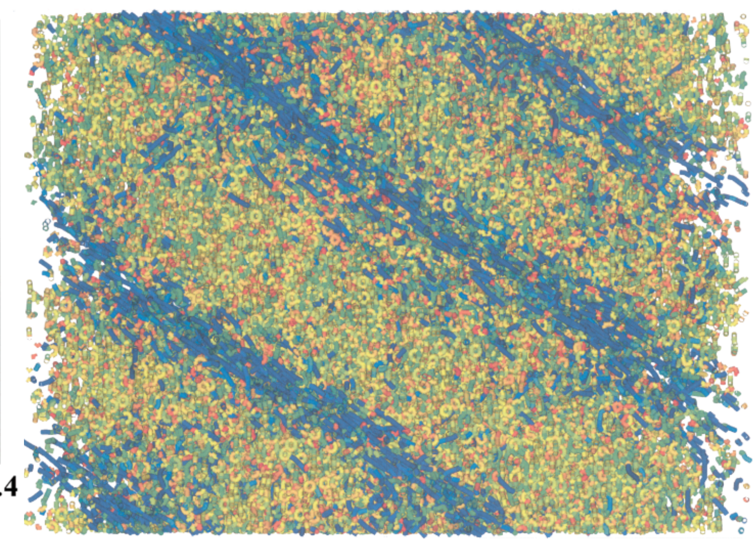
Experiments & Modeling of Ductility Loss in Steels



Edwards, 2001







J. Marion et al, LLNL