NEUTRON BEAM IRRADIATION OF NI-20CR FOIL IN MCNP

GABRIEL LEWIS
12.06.24
NE 585

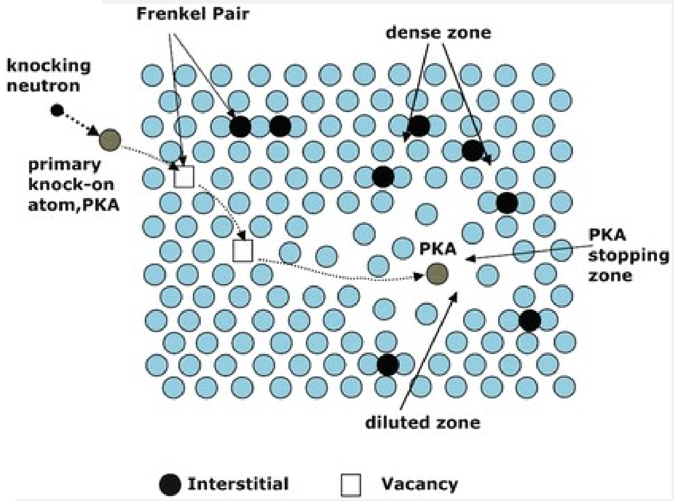
INTRODUCTION

- Project Synopsis
  - Rationale
- Geometrical Configuration
- MCNP: Flux Tallies?
- Displacement per atom (dpa)

PROJECT SYNOPSIS

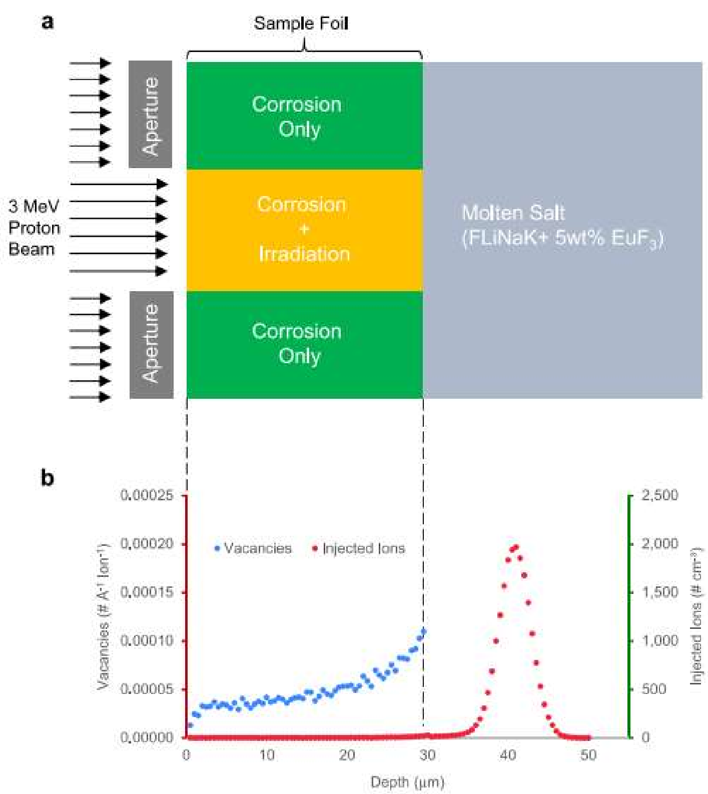
- Goal:

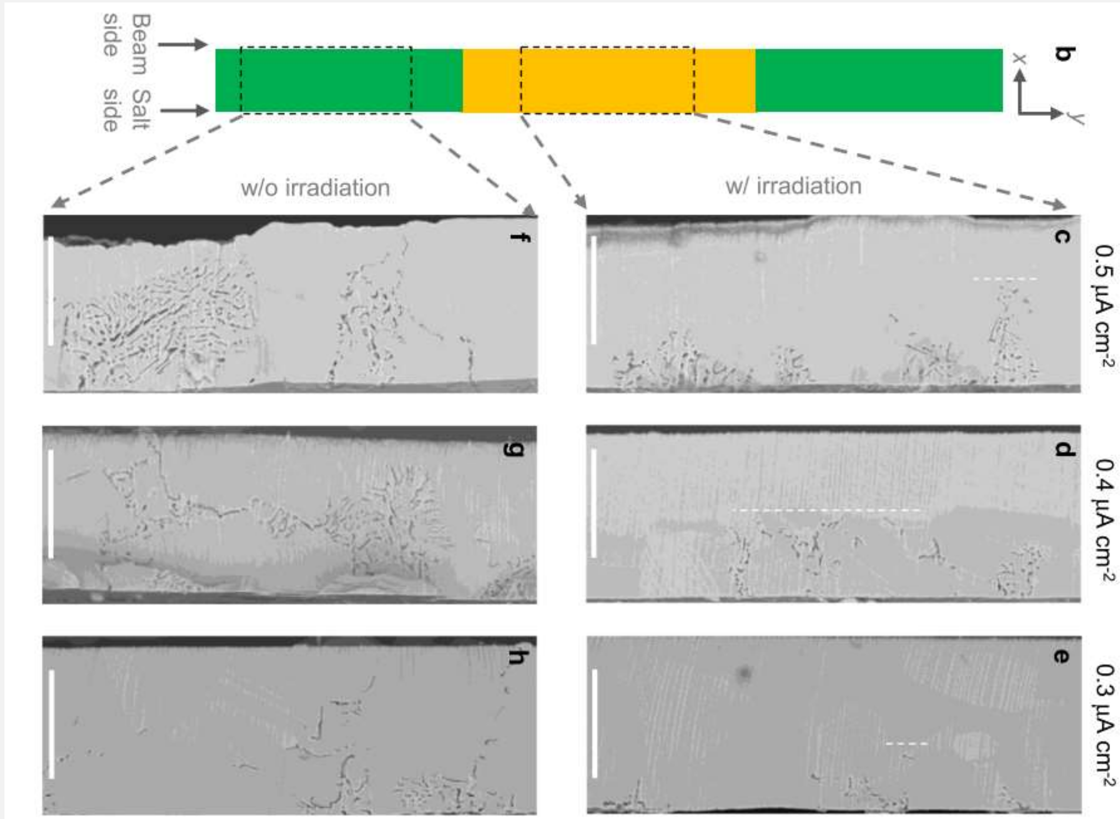
  Simulation of neutron damage on Ni-20Cr and subsequent analysis of displacements per atom and effect on corrosion control.



Handbook of Damage Mechanics. (2014).
Los Alamos National Laboratory. (2023).

RATIONALE





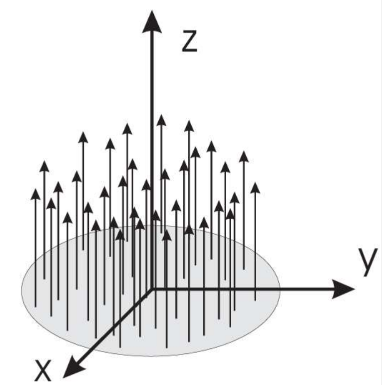
Nature Communications, 11(1), 3430-3430. (2020).

GEOMETRIC CONFIGURATION

3.3.4 Monodirectional and Collimated Sources

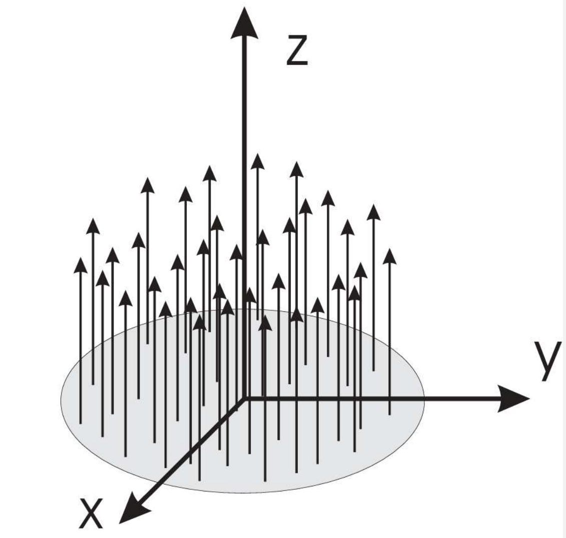
Monodirectional Disk Source

```
c --- Disk source perpendicular to z-axis uniformly emitting
c     1.2-MeV neutrons monodirectionally in the +ve z-direction.
c
SDEF  POS=0 0 0  AXS=0 0 1 EXT=0  RAD=d1  PAR=1  ERG=1.2
      VEC=0 0 1  DIR=1
SI1  0   15      $ radial sampling range: 0 to Rmax (=15cm)
SP1 -21  1       $ radial sampling weighting: r^1 for disk
```

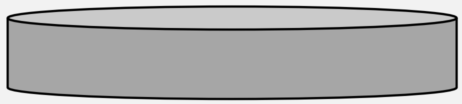


Kansas State University. (2004).

GEOMETRIC CONFIGURATION



First Layer: Radial, monodirectional source with r= 0.25cm



Second Layer: 30µm Ni-20Cr Disk with r= 1.4cm

Third Layer: 0.3cm Capsule of Salt with r=1.4cm

Kansas State University. (2004).

MCNP

```
c       ----------
c       data cards
c       ----------
MODE    n
f4:n    1             $ flux tally 4 at cell 1????
c       ---
c       end physics
c       ---
c
c       ---
c       ---Disk source perpendicular to z-axis uniformly emitting
c       3.0-MeV neutrons monodirectionally in the +ve z-direction
c
SDEF    POS=0 0 0.00001 AXS=0 0 1 EXT=1 RAD=d1 PAR=1 ERG=3.0
        VEC=0 0 1 DIR=1
SI1     0    0.25 $ radial sampling range: 0 to Rmax (=0.25cm)
SP1     -21 1     $ radial sampling weighting: r^1 for disk
c       ---
c
c       ---
c       end source
```

https://github.com/HeartUnderSnow/Salt-Disk

DPA CALCULATION VIA NEUTRON FLUX

Dislocated Atoms (DA) = $\eta_{\text{eff}} \sum_{i=1}^{nuclide} \frac{E_l^A}{E_l^D}$ (1)

E of a nuclide to displace atoms = $E_l^A = \Phi N_l \sigma_{da} V$ (2)

Displacement per atom per second =

$$\text{DPA/s} = \frac{DA}{V \cdot \sum_{i=1}^{nuclide} (N_l \times 10^{24})} \quad (3)$$

Transactions of the Korean Nuclear Society. (2023).
Nuclear Engineering and Design, vol 33, no.1. (1975). ← Had to pull some strings to find this

FUTURE WORK

- Actually getting the flux tallies from MCNP
- Introduce inert gas and salt into environment
- Obtaining σ_{da} data from ENDF/somewhere
- Calculating bulk diffusion changes to salt-alloy boundary

$$D_{total} = D_i C_i + D_v C_v$$

Nature Communications, 11(1), 3430-3430. (2020).

REFERENCES

Hoffelner, W. (2015). Irradiation Damage in Nuclear Power Plants. In: Voyiadjis, G. (eds) Handbook of Damage Mechanics. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-5589-9_36

Zhou, W., Yang, Y., Zheng, G., Woller, K. B., Stahle, P. W., Minor, A. M., & Short, M. P. (2020). Proton irradiation-decelerated intergranular corrosion of Ni-Cr alloys in molten salt. *Nature Communications*, *11*(1), 3430–3430. https://doi.org/10.1038/s41467-020-17244-y

Shultis, J.K., Faw, R. E. (2004). An MCNP Primer. *Department of Mechanical and Nuclear Engineering. Kansas State University.* *https://bl831.als.lbl.gov/~mcfuser/publications/MCNP/MCNP_primer.pdf*

Mai, N. Kim K., Lee D. (2023). Calculation of Displacement per Atom (DPA) in STREAM. Department of Nuclear Engineering, Ulsan National Institute of Science and Technology. *Transactions of the Korean Nuclear Society Spring Meeting.* Jeju, Korea, May 17-19. 2023. https://kns.org/files/pre_paper/49/23S-379-NguyenTrong.pdf

Norgett, M., Robinson, M., & Torrens, I. (1975). A proposed method of calculating displacement dose rates. Nuclear Engineering and Design., 33(1), 50–54. https://doi.org/10.1016/0029-5493(75)90035-7