

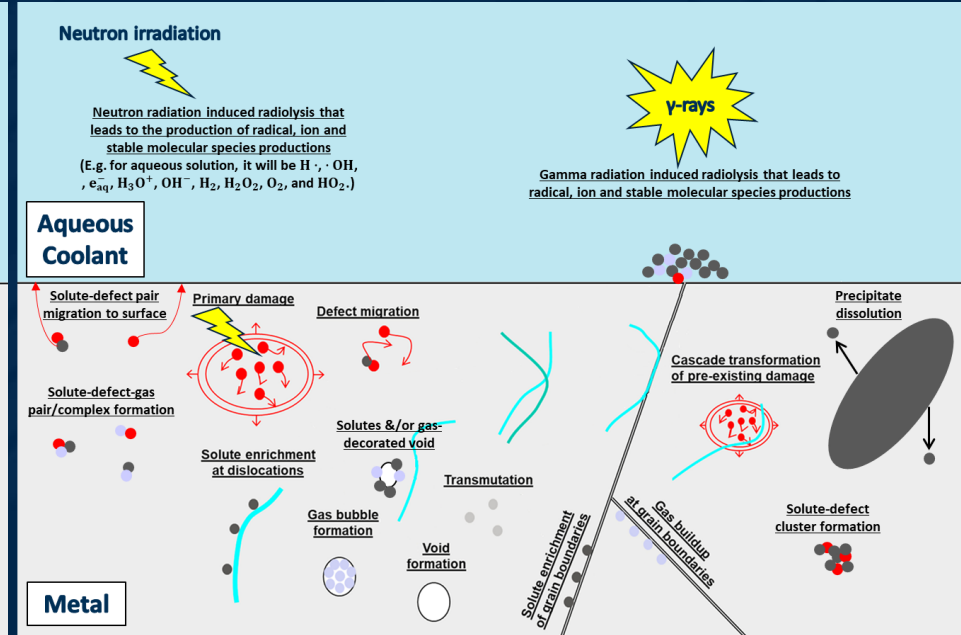
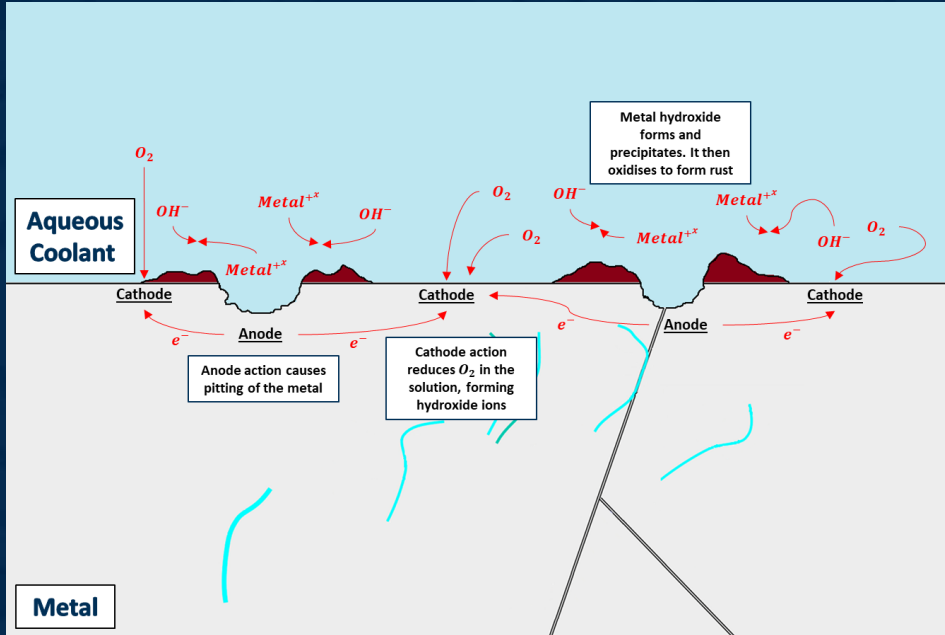


In-situ Proton Irradiation-Corrosion Studies at Michigan Ion Beam Laboratory

P. Wang, S. Raiman, K. Field, G. Was
University of Michigan

NSUF Annual Program Review, April 18, 2024





Common/simplified localized corrosion events that occur in metal under aqueous coolant under **no-radiation** scenario.

General events that occur in a metal and in an aqueous coolant **under an irradiation environment**



Corrosion behaviour

Radiation environment \neq Without radiation

Type of surface oxides

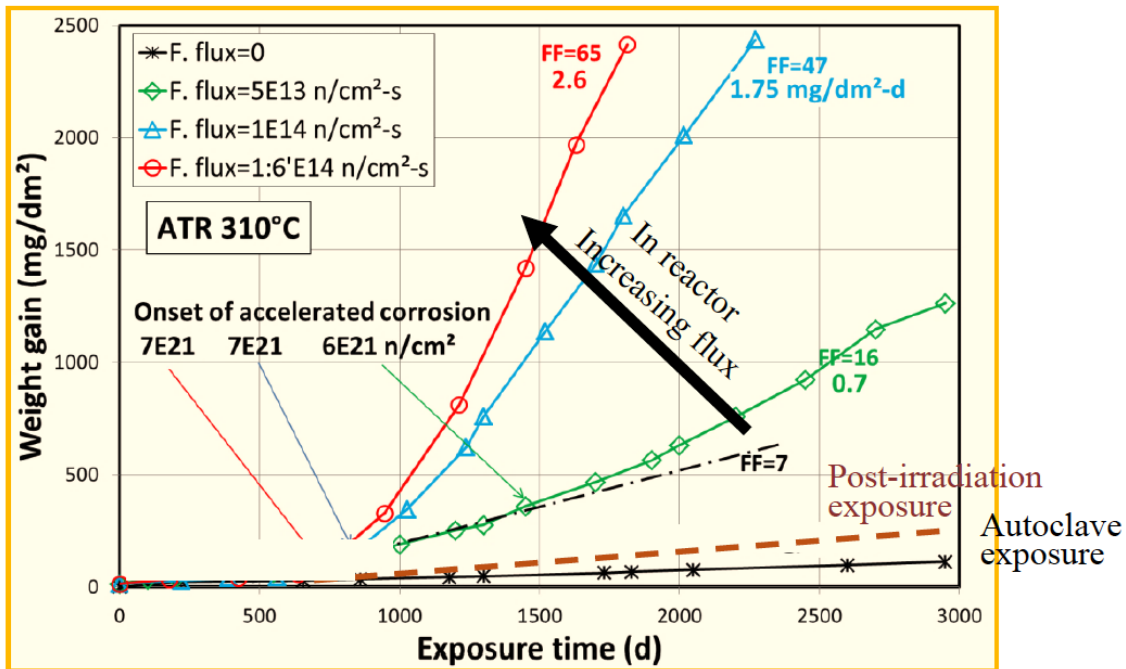
Radiation environment \neq Without radiation

Oxides growth rate

Radiation environment $>$ Without radiation

Density of Oxide/s layer

Radiation environment \neq Without radiation



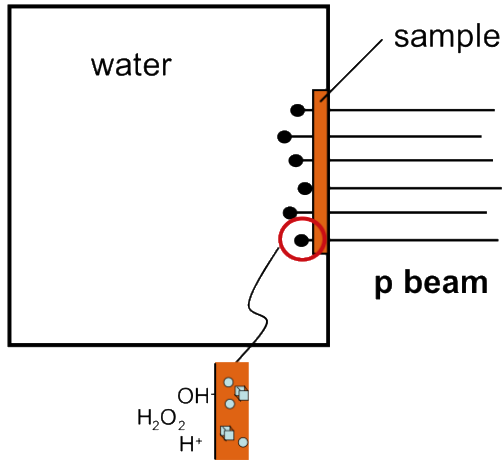
Simultaneity of corrosion and radiation => 40x increase in corrosion rate

B. Kammenzind, Zr ASTM conference, 2016

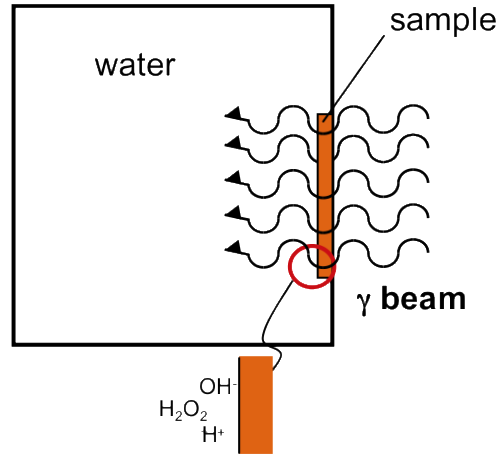


Irradiation-Accelerated Corrosion of Reactor Core Materials, NEUP Project # 10-677

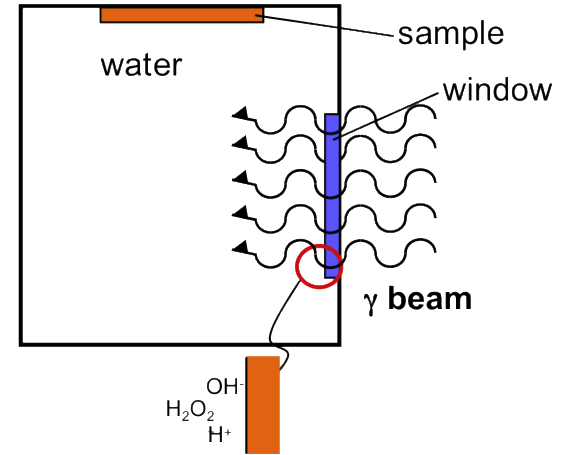
Combined effects experiment
in water

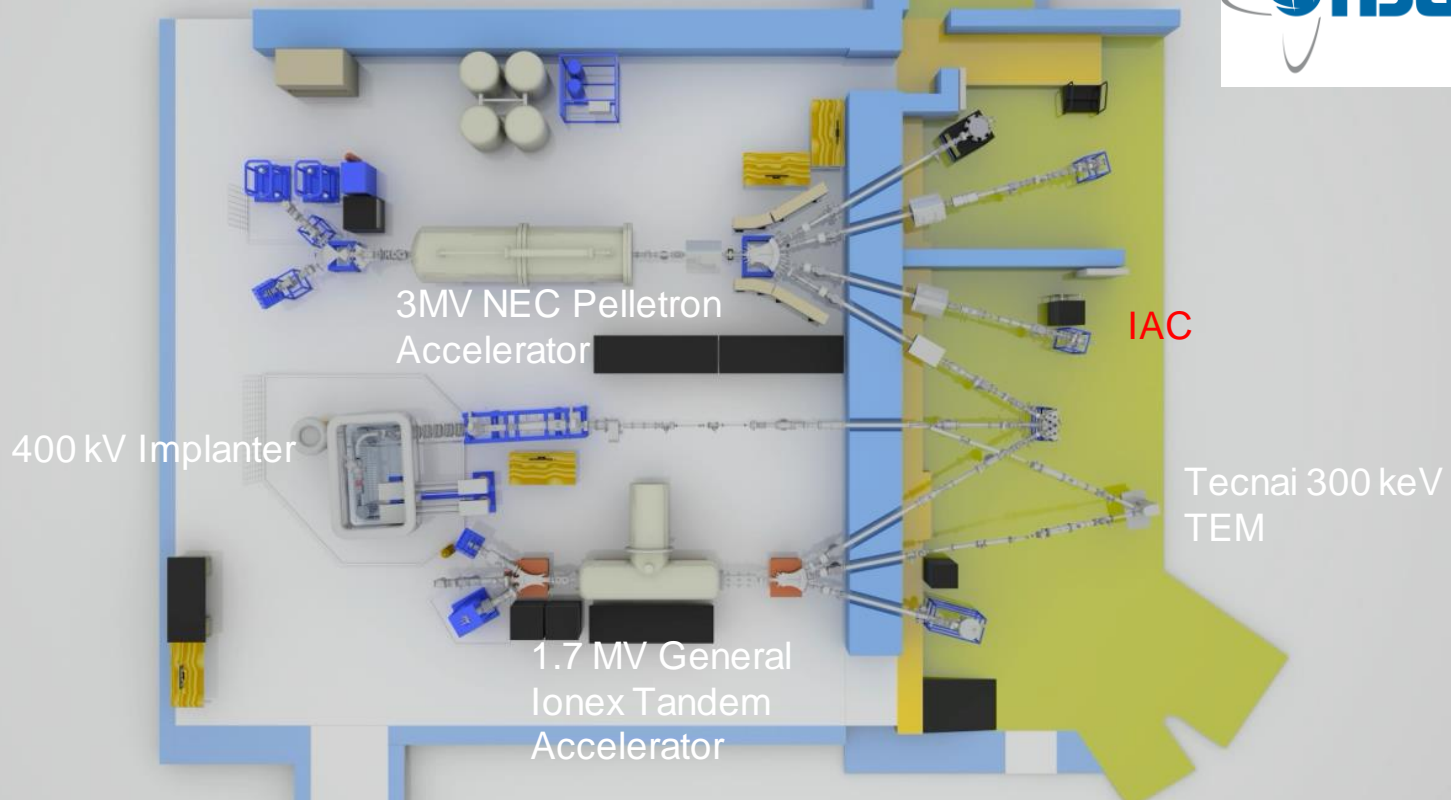


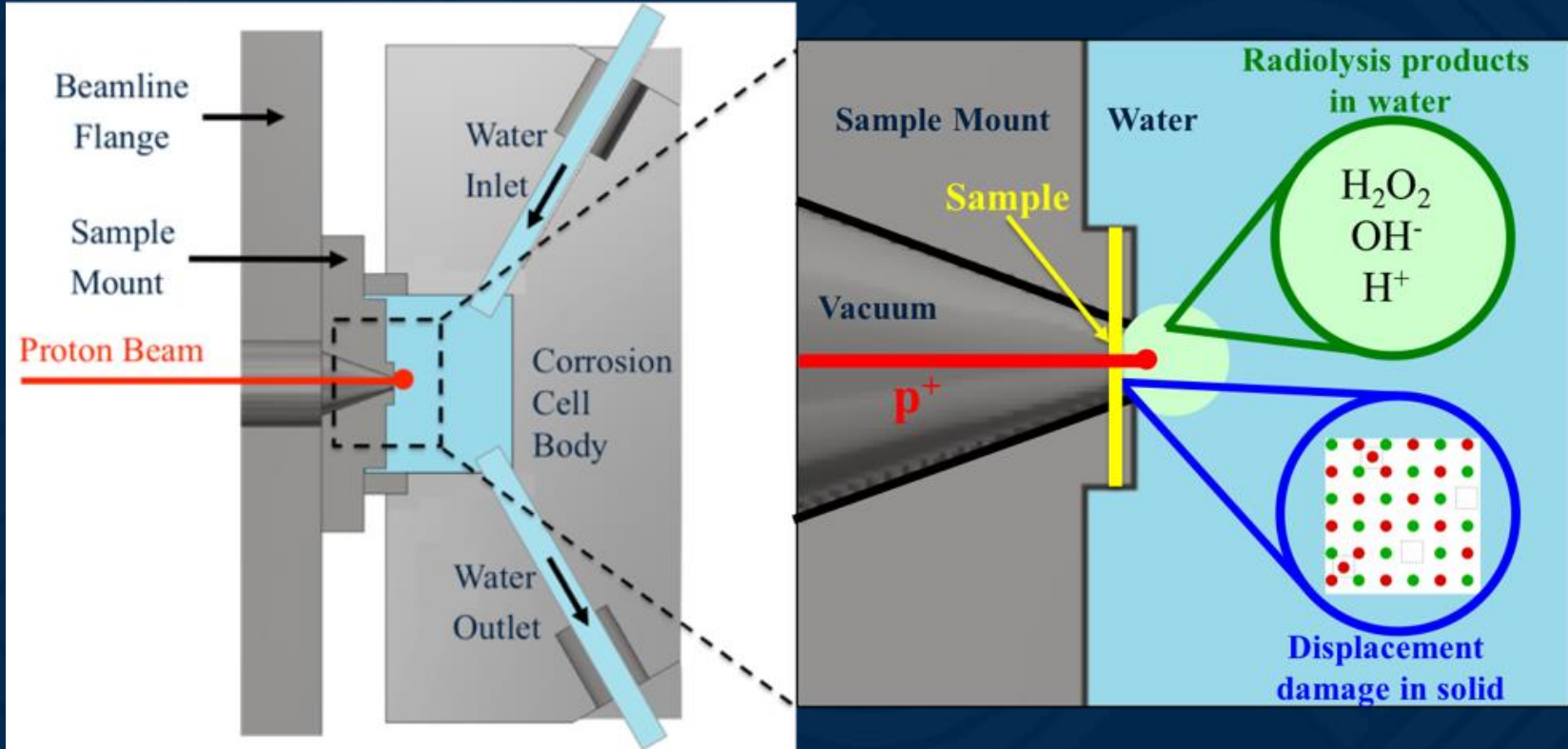
Effect of excitons
and radiolysis

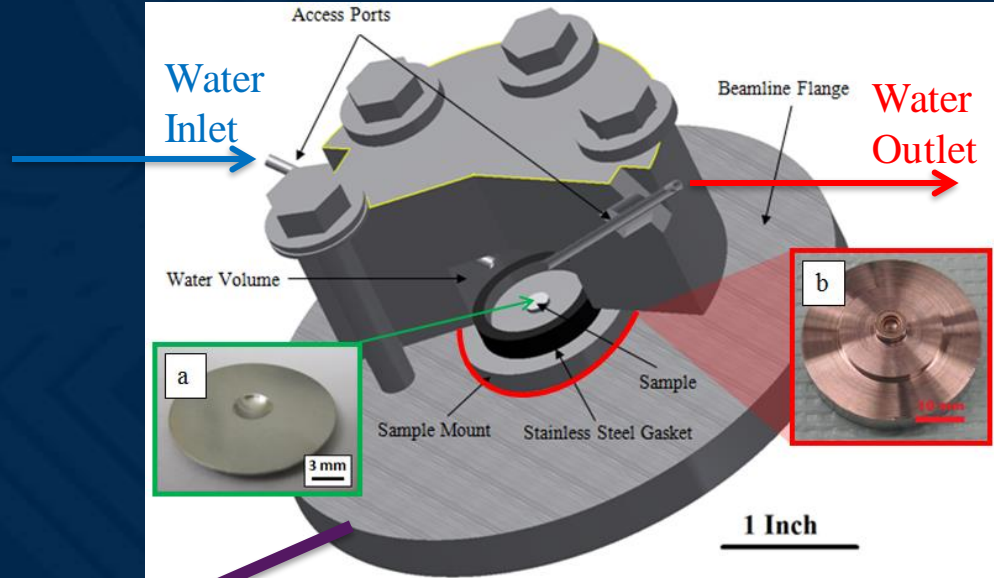


Effect of radiolysis







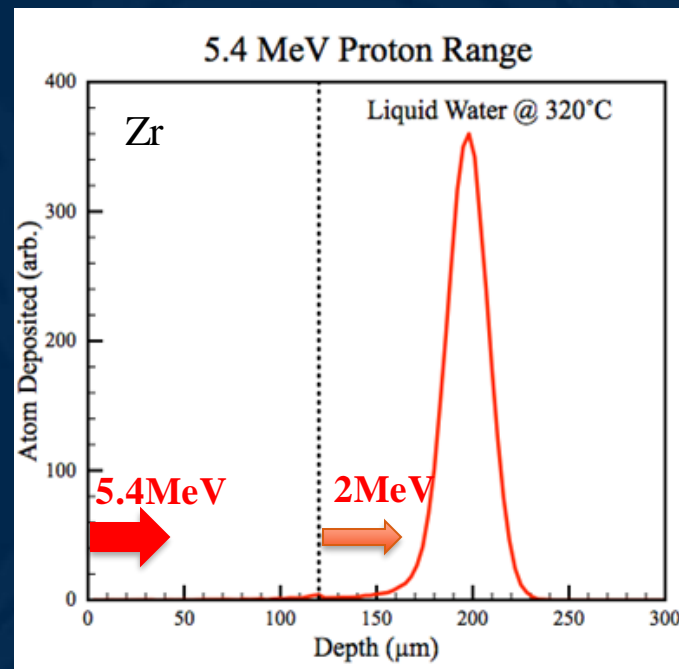
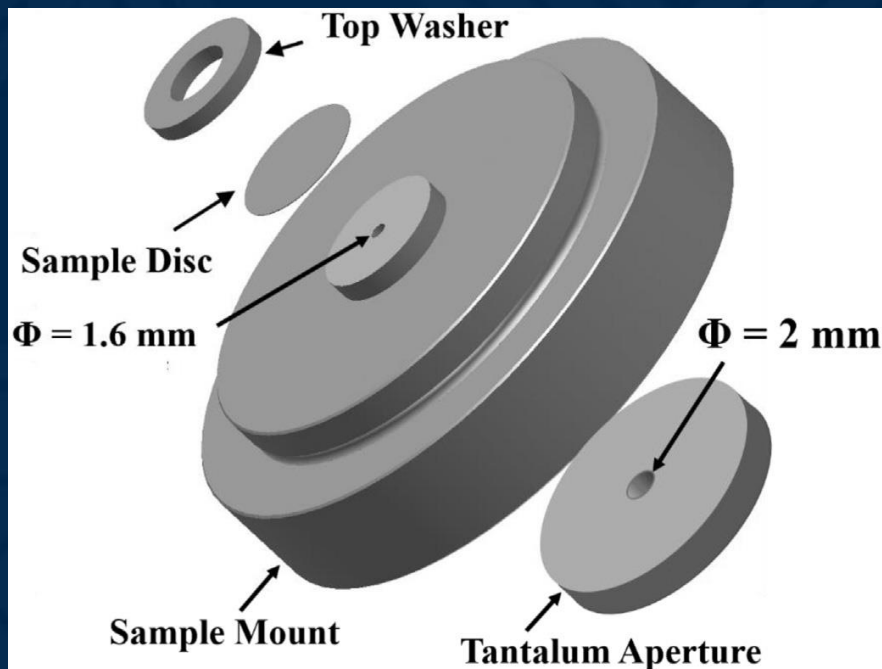


To 1.7 MV
tandem accelerator



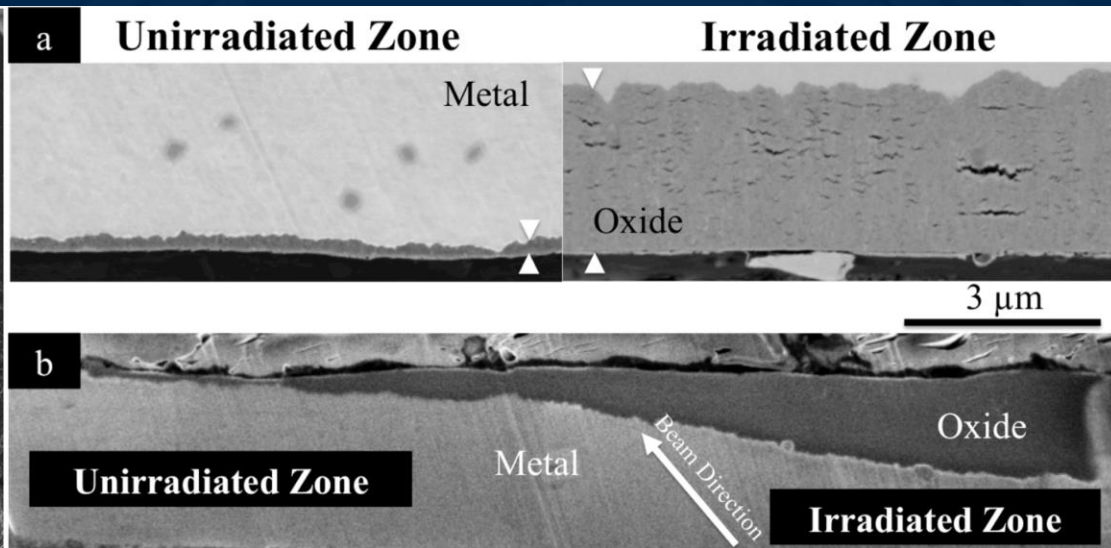
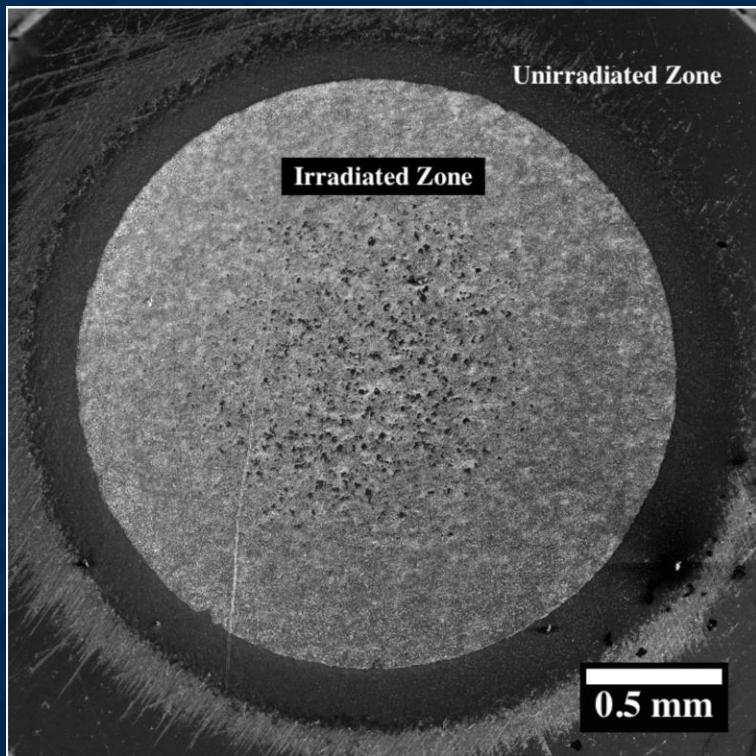


Metallic Samples



Water pressure and temperature: 2000 psi @ 320°C
Current density: up to 10 $\mu\text{A}/\text{cm}^2$

Fluence: $\sim 6 \times 10^{13}$ ions/cm²-s
Dose rate: ~ 1500 kGy/s (typical LWR ~ 5 -10 kGy/s)



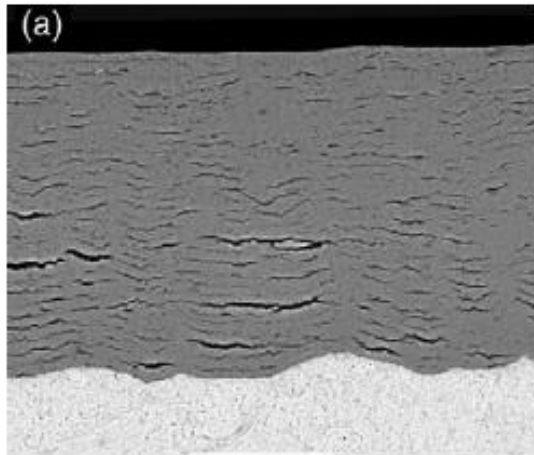
3.4 MeV proton through 50 μ m Zircaloy-4 over 24 h
in 320C pure water with 3wt ppm H₂, 4E-7 dpa/s



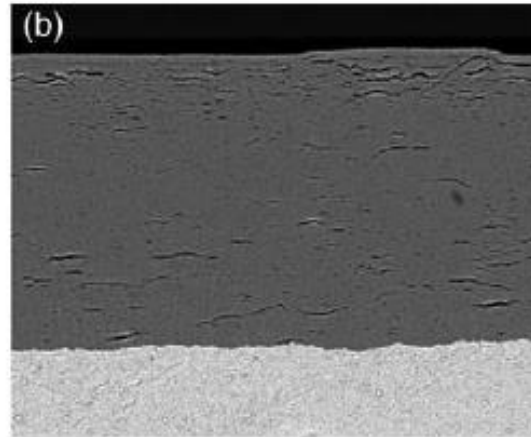
Non-irradiated 360C autoclave
grown film

Oxide film grown in irradiation
environment (300C, 90×10^{20}
neutron/cm², ~15 dpa)

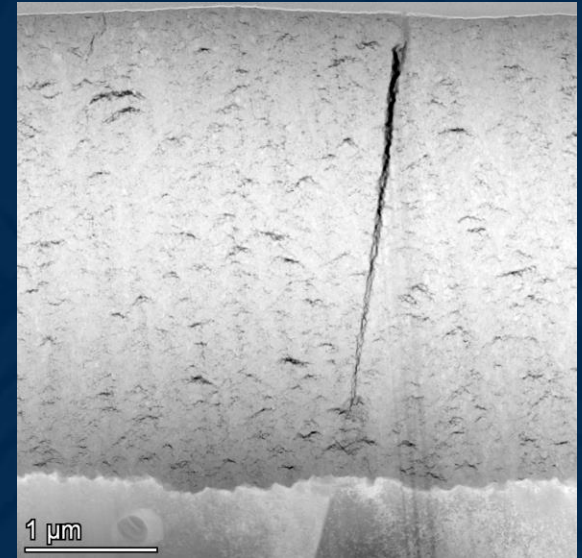
Proton in-situ irradiation-corrosion
in Hydrogenated water
(320C, pre-irradiated 5 dpa
Zircaloy-4)



25 μm



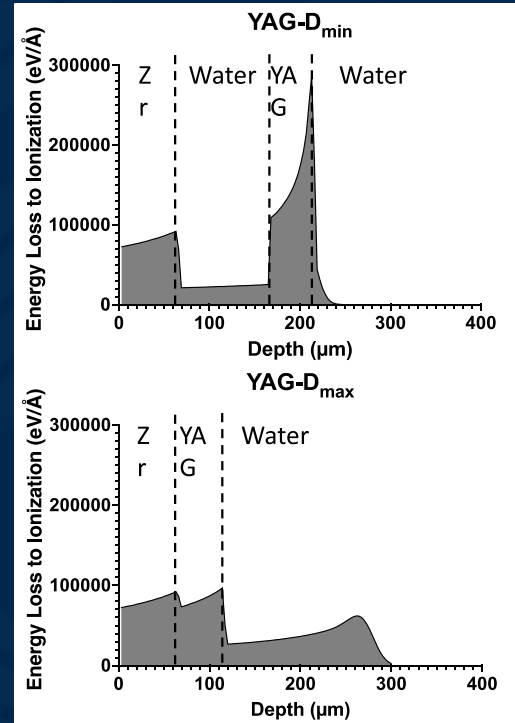
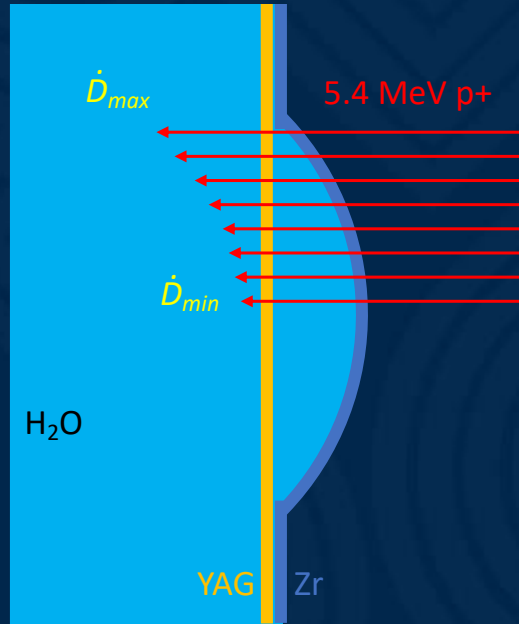
25 μm



1 μm

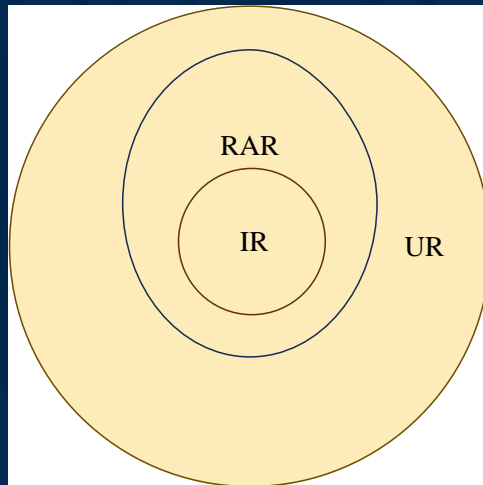
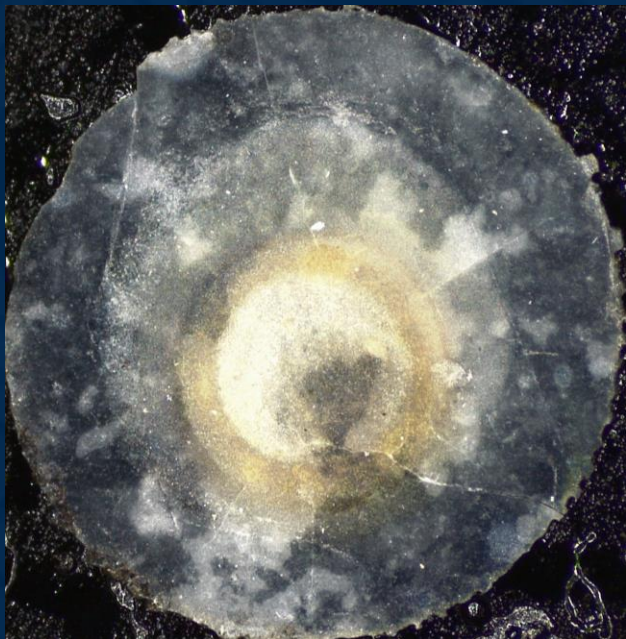


Ceramic Samples

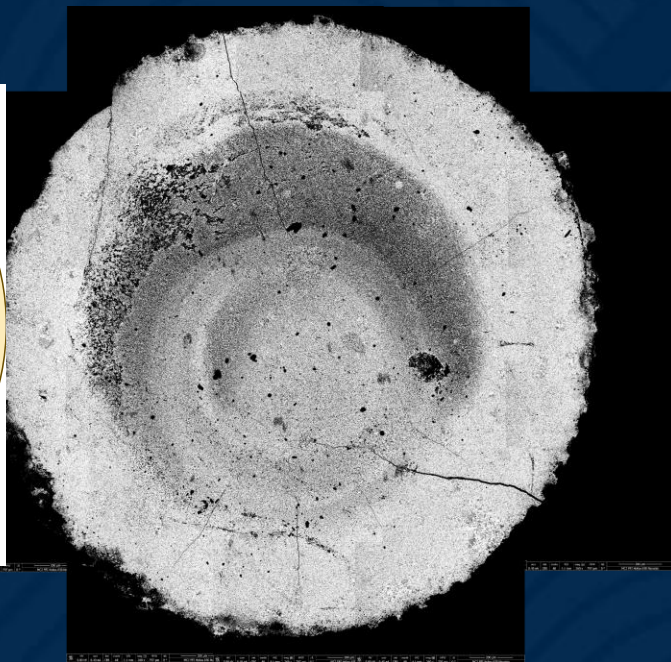




Optical



SEM (BSC)





MIBL(<https://mibl.engin.umich.edu>)

