Parasitic Material Irradiation Studies for Accelerator Facilities in ISAC

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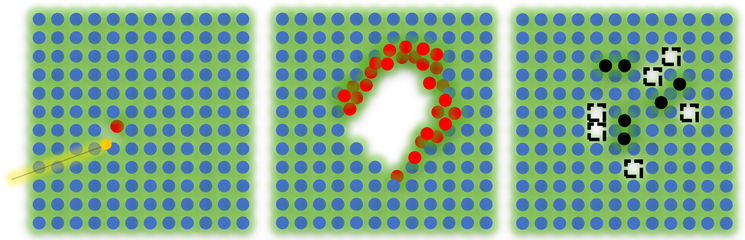
Context of the research

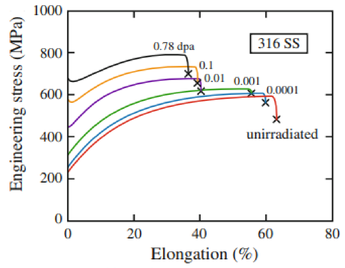
Future accelerator facilities aim to increase the power of their driver beam to rise the number of nuclear reactions or have a more favorable cross section to produce particles of experimental interest. Consequently, new target stations need to accommodate larger thermomechanical stresses in higher radiation fields for which little amount of experimental data is available. In that scenario, a main concern is an increase in the radiation damage that will accumulate in the materials of the target stations. Mainly on beam intercepting components such as beam windows and beam dumps but also radiation weak components such as vacuum seals.

Radiation damage in materials

Radiation damage is a phenomenon occurring to materials exposed to radiation fields in which some macroscopic property (i.e., yield strength, thermal conductivity, density...) is negatively altered as consequence of the interaction of its atomic structure with energetic particles; any atomic, subatomic, or elementary particle with sufficient kinetic energy to at least ionize or displace an atom forming the target material.

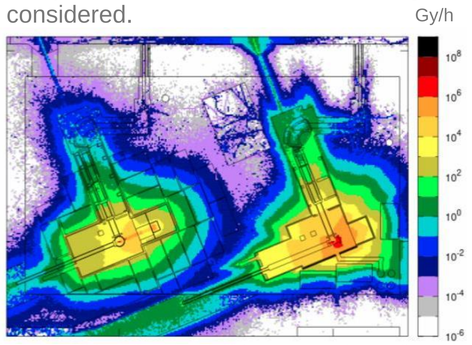
Primary knock-out atom in crystal lattice ➡ Collision cascade ➡ Recombination and resulting defects ➡ 316SS mechanical properties degradation under neutron flux[1]





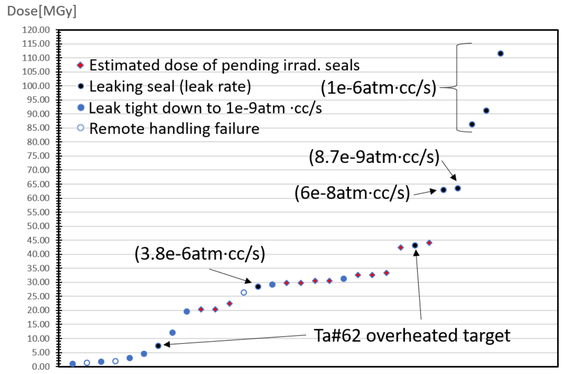
Radiation damage in ARIEL

- High ambient doses during operation.
- Complex cooling loops for in beam components, additive manufacturing considered.



Ambient doses H*(10) in APTW and AETE[2]

Early results on radiation resistance of seals

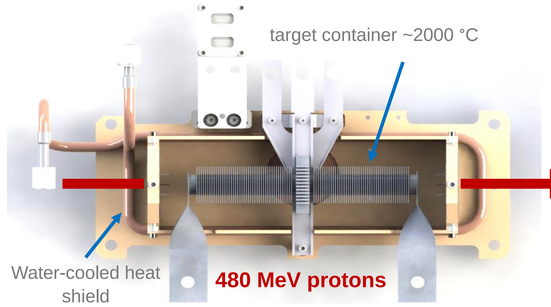


Radiation resistance of spring energized PEEK seals

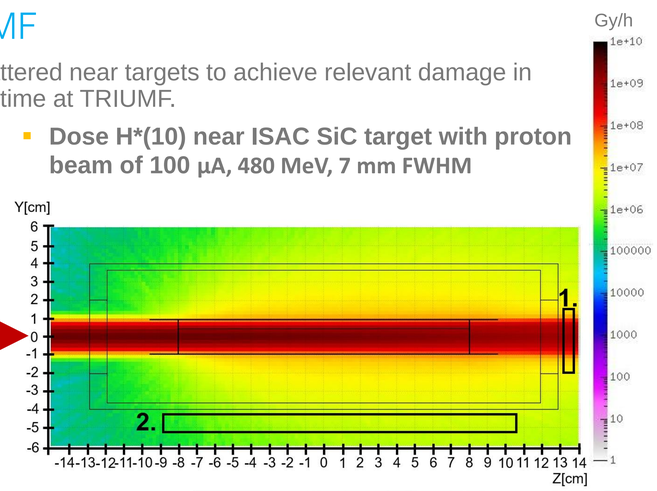
Parasitic irradiations at ISAC-TRIUMF

Parasitic irradiations profit from beam particles scattered near targets to achieve relevant damage in material samples without consuming experimental time at TRIUMF.

- **ISAC ISOL target**



- **Dose H*(10) near ISAC SiC target with proton beam of 100 µA, 480 MeV, 7 mm FWHM**

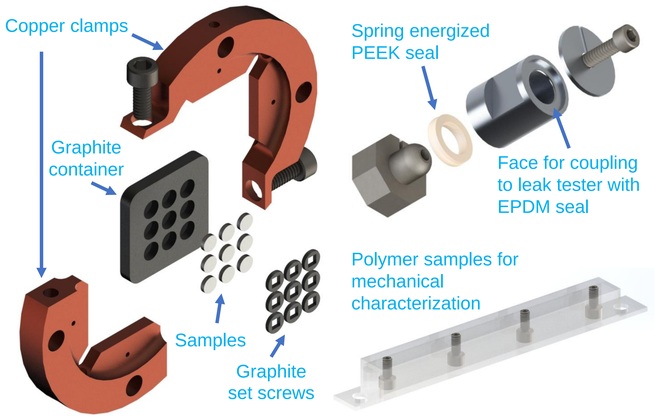


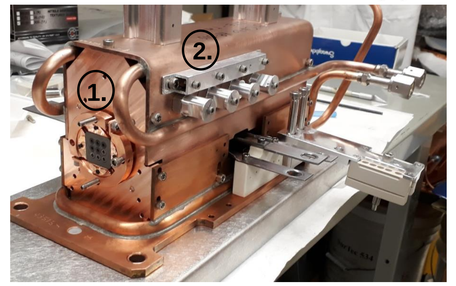
1. In-beam parasitic targets:

- 0.1-1 DPA/ISOL target (accumulative up to 5DPA/year)

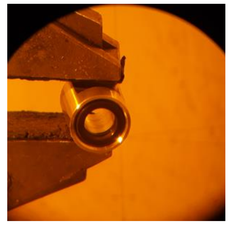
2.Scattered beam parasitic assemblies:

- 1-200 MGy/ISOL target

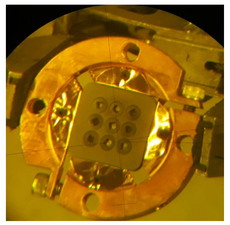




Assembled ISAC target with parasitic additions



Seal after 43MGy irradiation



Parasitic target after 6000 µAh irradiation at max I= **95µA**

Conclusions/Summary

The design of future high power accelerator facilities requires more experimental data on radiation resistance of the materials used in target stations. Within that context, a parasitic irradiation setup capable of routine irradiation of components and material samples has been commissioned at ISAC-TRIUMF. Single to iterative irradiations can qualify new materials and techniques for new high-power target stations.

References

1. Was, G. S. Fundamentals of Radiation Damage Materials Science, 2nd edition. Fundamentals of Radiation Materials Science (2017). doi:10.1007/978-1-4939-3438-6_1
*2. Augusto, R. S. et al. An overview of the shielding optimization studies for the TRIUMF-ARIEL facility. Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip. **1005**, 165401 (2021).*

Discovery, accelerated