ARIES Project
Work Package 17 - 1st Workshop

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Marco G. Beghi – Carlotta Accettura

POLITECNICO
MILANO 1863

Possible contributions to WP 17 – Task 17.4

Task 17.4: Simulation of irradiation effects and mitigation methods

- Investigation and simulations of material damage induced by irradiation with protons and ions at various energies and doses
- Quantify Displacement per atom (DPA), gas production, nuclear transmutations for equipment in complex accelerator environments and provide a relationship with radiation experiments at lower energies and/or different particle species
- Ideally, relate radiation damage quantities (e.g. DPA) with change of relevant macroscopic material properties
- Open to co-operation with other international collaborations such as RaDIATE – (Radiation Damage In Accelerator Target Environment)

guidance of a doctoral thesis aiming at monitoring and characterizing the evolution of properties of materials, and at modeling it, in relation to the primary damage

Collimator performance

Collimators subjected to:

- continuous removal of halo particles
- beam impact in incidental conditions

Collimator performance depends on collimator materials properties:

- electrical conductivity
- thermal conductivity
- CTE
- specific heat
- melting/recrystallization temperatures
- stiffness
- toughness
- ….

resulting in

- mechanical integrity
- dimensional integrity
- resistance to stresses induced by energy deposition

Collimator performance prediction

How do collimator material properties evolve under irradiation by TeV protons ?

We ‘more easily’ measure the properties evolution due to swift ions (~ 100 MeV C, or Ca, or ~ GeV Xe, or Au, ….)

What does the knowlege of the evolution under swift ions tell us about prediction of the evolution under TeV protons ?

What does the knowlege of the evolution under swift ions tell us about prediction of the evolution under MeV neutrons ?

Prediction of evolution of material properties

For evolution under MeV neutrons,
dpa as single predictor (together with irradiation temperature)
turned out to be a more than reasonable predictor (not complete)

evolution of **metals** under **MeV neutrons** (and ~ ions):
evolution of a super-saturated solution of vacancies/interstitials (Frenkel pairs)
dpa ~ concentration of injected 'escaping' Frenkel pairs
(+ He production by (n,α) reactions, ….)

evolution of **non metallic materials** under neutrons & ions
- covalent bonds vs. metallic bonding: electron localization / relaxation
- defect mobility vs. temperature

evolution under >> **MeV particles**
- >> nuclear reactions, particle showers
- >> gas evolution
- tracks
- ….

Multi-scale modeling

evolution of **non metallic materials under >> MeV particles**
dpa **alone** no longer good predictor

- dpa: ‘primary damage’ in terms of # of atomic displacement
- spatial distribution of damage
- gas production
- ….

multi-scale / multi steps modeling

- interaction at nuclear/atomic level (primary) (FLUKA; SRIM ?)
- irradiation → evolution of properties

- irradiation → evolution of micro/meso-structure → evolution of properties
- structure / behaviour relationship

Conclusions ?

Not conclusions, a beginning !