EURAMET workshop

Future in Neutron Dosimetry

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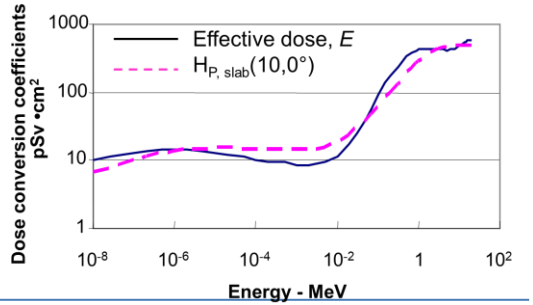
Challenges in neutron dosimetry

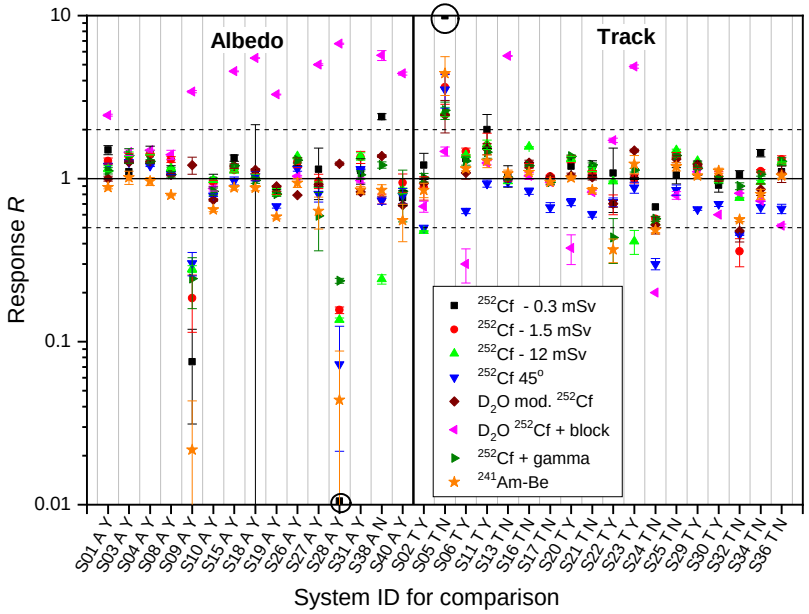
- More than 60 000 radiation workers are exposed in Europe to neutron (or mixed n,g) radiation
  - Nuclear energy applications (Pu/U, reactors, fuel, spent fuel), accelerators, industry (use of sources)
  - New applications arise: high energy fields (laser facilities, proton therapy facilities,…)
  - Important for space and aircrew
- Individual dosimetry for neutrons is far less established than for photons
  - Devices with non-ideal response characteristics: use of field-specific correction factor
- Neutrons always together with (mostly strong) gamma fields
- Large energy range: 10 orders of magnitude
- Need to measure dose equivalent:
  - Weighting factor dependent on neutron energy



Status neutron dosimetry

EURADOS Intercomparison exercises for neutron neutron dosemeters provided by individual monitoring services

- Held in 2012 / 2017 / 2022
- Way to have an overview of the current performances of neutron dosemeters



- Dominating techniques: track etched / albedo dosemeters
- Many services need information on neutron field to estimate the doses
- 2017: 21 out of 33 services had maximum 2 outliers

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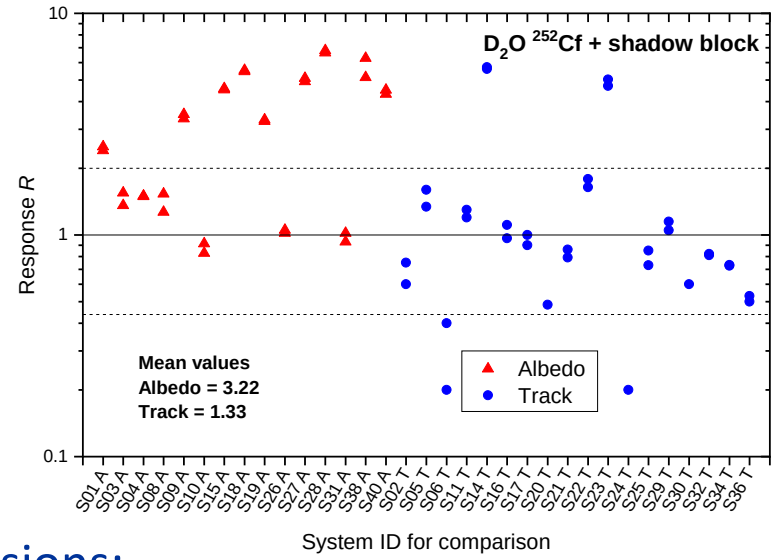
Status neutron dosimetry



S. Mayer, M-A. Chevallier, E. Fantuzzi, M. Hajek, M. Luszik-Bhadra, R. Tanner, D.J. Thomas, F. Vanhavere: **EURADOS Report 2021-06, EURADOS Intercomparison IC2017n for Neutron Dosemeters",** Nov. 2021.

Main conclusions:

- the energy and angle dependence of the response is definitely the most challenging issue for neutron dosimetry systems
- The hardest configurations to measure are the workplace fields
- The neutron calibration fields are not representative of the field encountered in routine at workplaces

Challenges - ISO standards

- **This issue has also had to be addressed in ISO 21909 standard**: giving type tests for the performance of passive neutron dosemeters
  - Part 1: mandatory for all dosemeters – performance tests and criteria
  - Part 2: dedicated for the ones that could not comply to energy and angular criteria (only).
    - "Methodology and criteria for the qualification of personal dosimetry systems in workplaces"

  - **Very challenging series to make type tests and criteria aligned with situations of use at the workplaces (dose level + energy)**

- **Needs to have running facilities with reference simulated workplace fields**
  - Also need for a standard to quantify properly how the reference simulated workplace field is representative of the workplace field

EURADOS Strategic Research Agenda

Challenge 5.3: To develop neutron dosimetry techniques

- Better understanding of neutron workplace fields with a strong focus on the direction dependence of the field.
- Extension of neutron personal dosimetry to novel and high-energy fields.
- New, improved neutron dosemeters (including active dosemeters)
- Better performance in the workplace from the main types of dosemeters currently used.
- Estimation of neutron risk via direct assessment of effective dose.

- Improvement of the quality of the PADC material for track etched detectors
  - EURADOS WG2 CR-39 quality task

- Development of other techniques
  - AI for track recognition
  - Computational dosimetry

Challenges – improvement of PADC material

The *CR-39 Quality* task aims at improving the quality, and thus the performance, of the CR-39 (PADC) material used as neutron detector/dosimeter through the collaboration among:

- Individual Monitoring Services (IMSs);
- CR-39 Manufacturers;
- Researchers.

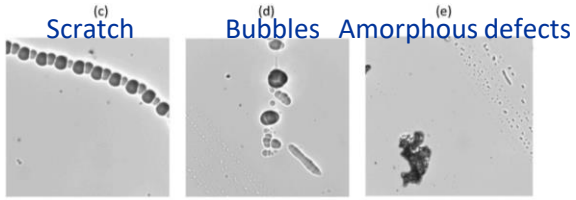
Main problematics:

1. high and variable intrinsic background across a batch/sheet of CR-39s;
2. variable CR-39 sensitivity across batches;
3. variable ageing and fading phenomena across batches

➢ State of the art paper published

https://doi.org/10.1016/j.physo.2022.100114

➢ Experimental campaign will start this October



M. Bolzonella, I. Ambrozova , M. Caresana, N. Gibbens, P. Gilvin, F. Mariotti, A. Savary, A. Stabilini, F.A. Vittoria, E.G. Yukihara, M.-A. Chevallier: **Neutron personal dosimetry using polyallyl diglycol carbonate (PADC): Current status, best practices and proposed research**, Physics Open 12 (2022)

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Computational dosimetry

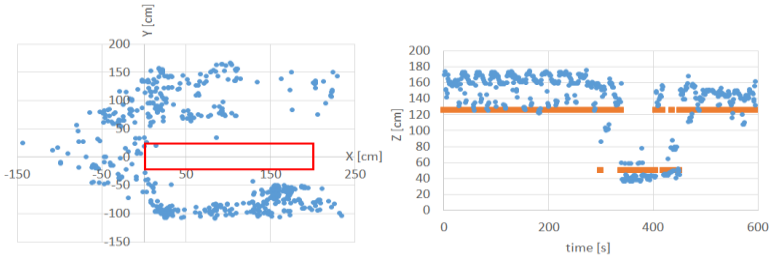
Podium project

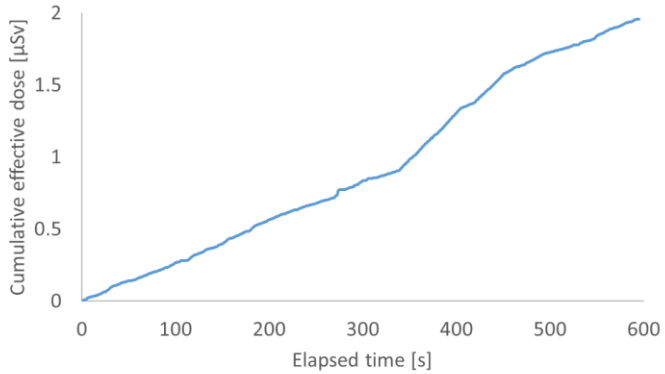
- Improvement of worker dosimetry by replacing personal dosimeters by computational dosimetry
- Combination of worker tracking with 3D cameras and Monte Carlo radiation transport simulation

Two stage approach

- Effective dose rate map based on simulations and/or measurements
  - No problems with changing quantities
- Worker tracking to select appropriate dose rates from map
  - Can be done on-line

Effective dose assessment





First successful test at well-characterized simulated neutron workplace field

Challenges:

- Dosimetry uncertainty versus characterisation accuracy/time
- Characterisation both in energy and angle
- Traceability