Neutron Activation System

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Neutron Activation System

- Absolutely calibrated time integrated measurement of the total neutron yield with possibility of separation the DD and DT neutron fluxes
  - Total neutron yield determination
    - burn control, evaluation of α particles production, determination of the energy production
    - neutron loads studies,
    - calibration of the neutron diagnostics
    - validation the theoretical models and simulation codes
    - control of the neutron limit, evaluation of the safety risk
  - Separation of the total neutron yield connected to the DD and DT neutrons
    - triton burn-up studies
    - fuel ratio monitoring
  - Comparison of neutron loads in different positions (if various irradiations ends will be available)
    - studies neutron emission asymmetries connected to the ion transport

- Neutron emission spectroscopy by means of unfolding (application of different deconvolution methods)
    - studies the behavior of fast ions
    - triton burn up studies
    - detection of neutrons associated with runaway electrons

- Study of the different materials behaviour in the fusion reactor environment.
  - PFC's materials irradiation
  - ITER materials test
  - Testing new materials behaviour

Neutron Activation System

Activities done in 2021 - Preliminary feasibility study

Selection of the dosimetry foils for 2.5 MeV and 14.1 MeV neutrons monitoring

- The selection of threshold nuclear reactions has been done based on many parameters: threshold energy of reactions, the half-life of the reaction product, reaction cross-section, emission intensity of gamma quanta emitted from reaction products etc.
- Most of the proposed dosimetry reactions have been tested during DD experimental campaign at the JET tokamak.

Verification of threshold reactions

- Simulation of the neutron activation for two positions in JT-60SA was made by the FISPACT-II inventory code.
- The results obtained for the position in the first wall shows that selected foils provide the detectable activity and studies of the triton burn-up will be possible.

Foil	Reaction	Threshold [MeV]	Product half-life
Al	Al-27(n,p)Mg-27	1.9	9.5 min
Ti	Ti-47(n,p)Sc-47	1.9	3.3 d
Ni	Ni-58(n,p)Co-58	1.6	71 d
Zn	Zn-64(n,p)Cu-64	1.8	12.7 h
Y	Y-89(n,n')Y-89m	1.2	15.7 s
Cd	Cd-111(n,n')Cd-111m	0.5	49 min
In	In-115(n,n')In-115m	0.6	4.5 h
Au	Au-197(n,n')Au-197m	0.5	7.7 s

The selected threshold reactions and their parameters for the DD neutrons monitoring

Foil	Reaction	Threshold (MeV)	Product half-life
Al	Al-27(n,a) Na-24	3.3	15 h
Si	Si-28(n,p)Al-28	4	2.24 min
Fe	Fe-56(n,p)Mn-56	3	2.6 h
Co	Co-59(n,2n)Co-58	10.6	71 d
Cu	Cu-63(n,2n)Cu-62	11	9.7 min
Ni	Ni-58(n,2n)Ni-57	12.4	35.6 h
Zr	Zr-90(n,2n)Zr-89	12.1	78.4 h
Nb	Nb-93(n,2n)Nb-92m	8.9	10.25 d

The selected threshold reactions and their parameters for the DT neutrons monitoring

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Activities plan for 2022

1. Selection of the irradiation ends locations – **approximate positions were selected**
2. Activation simulations for the selected dosimetry foils that will be irradiated in selected irradiation ends locations (neutron spectrum and fluxes for selected positions from MCNP simulations required)
3. Gamma spectrometry measurements – optimisation of measurements sequence and the sample-detector distance for considered HPGe detector.
4. Evaluation of the possibility of triton burn-up studies due to variations in the 14 MeV neutrons quantity;
5. Analysis of the neutron spectrum deconvolution possibility based on activation measurements (testing of different algorithms)
6. Preparation of the recommended calibration procedure based on the activation system.