Characterization of waste by R2S methodology: SEACAB system

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25/11/2017, RADKOR2017, ANKARA

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Needs and objectives

-The maturity of light water reactors in Spain has a milestone with the shutdown of first PWR NPP (Zorita, 2006) and its level 3 decommisioning presently at final steps

-A significant quantity of activated waste (vessel and internals) routed to on-site temporal storage

-A high cost difference compared with low and intermediate radwaste storage (El Cabril: 300 years for site release, shorter than Cs137 decay, no alpha activity allowed)

-Need to rationalize costs by correctly splitting wastes

-Accurate tool required to evaluate long life isotopes (Ni59, Ni63, Nb94) relative to El Cabril limits in (low precision acceptable)

-Especial problem with Difficult or Impossible-to-measure nuclides (DTM,ITM)

Calculation Alternative

- Dose assays are very limited
  - ➔ Only representative for gamma-emitting isotopes
  - ➔ Blind to beta emitters (H3, C14) or soft X-ray (Fe55)
  - ➔ Expensive
- Calculation is therefore necessary

  (without forgetting its qualification by measurements)
  - ➔ Fortunately the neutron source is well known (power, time, axial-radial distribution)
  - ➔ Fortunately components associated to fuel can be quantified in terms of “burnup”
  - ➔ Fortunately advanced Monte Carlo methods and modern computers allow to determine the neutron intensity and spectrum for out-of-core components
  - ➔ Careful application of international standard ISO-16966

Standard's help and first applications

- ISO-16966 guides the use of calculation tools for assessment of the content of full set of nuclides
- Point method for small and well characterized components (surveillance capsules, jet pump brackets)
- Range method for large components with a single variable (position in core, distance to core, time of presence):
  - Conversion method (associated to local or average fuel burnup)
  - Correlation method (associating the DTM to key nuclides such as Co60)
  - Distribution evaluation method (distance along vessel height)
- Defines the qualification method for the calculation of DTM or ITM nuclides
- Pioneered application to the characterization of 3 types of assembly channels and 2 highly irradiated control rods

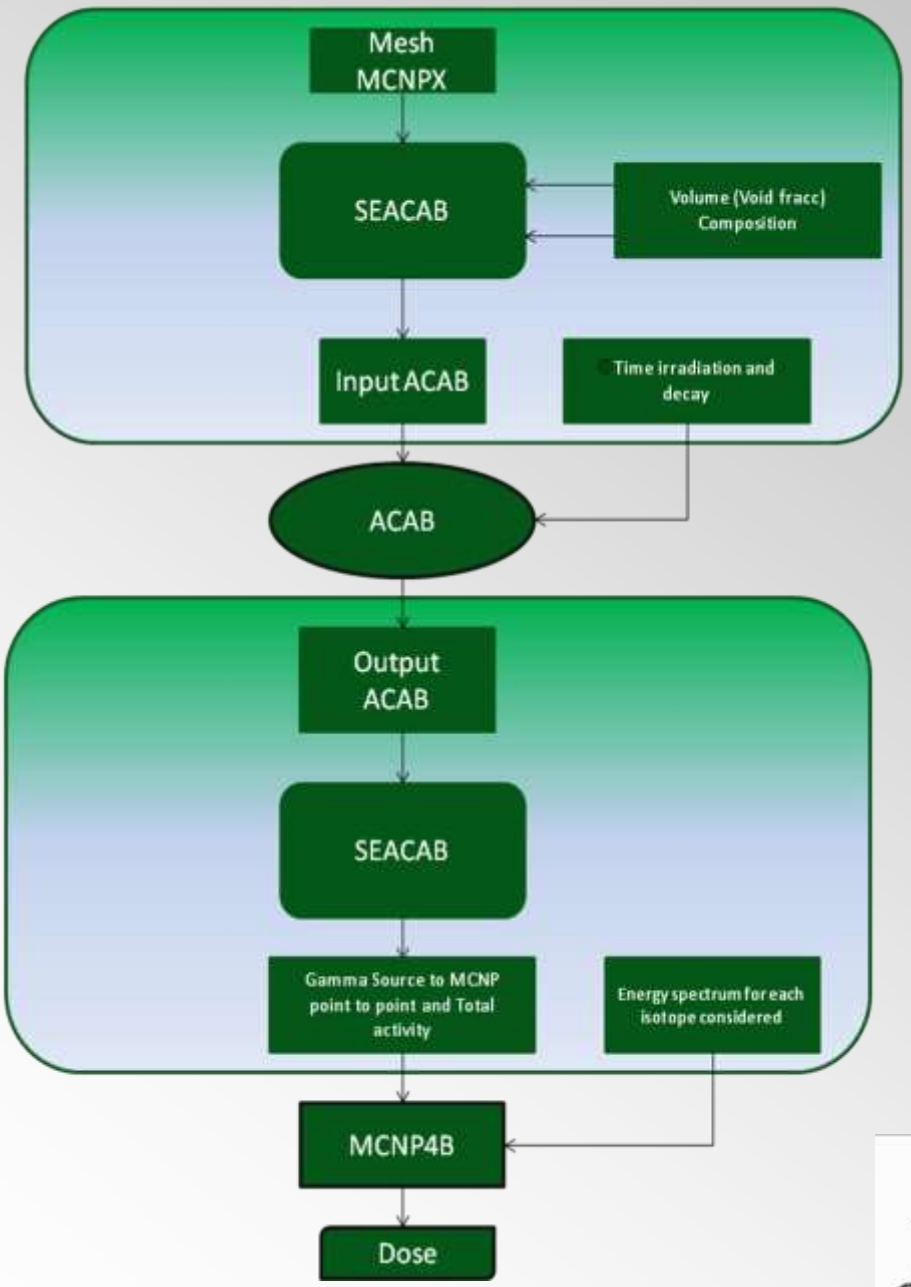
  (SEA in collaboration with Iberdrola Generación Nuclear)

Development of SEA-ACAB methodology

- ✓ "Virtue by need" (SEA involvement in the design of the shielding of Tritium Breeder Modules of ITER, F4E contract OMF-331 Lot 1)
- ✓ Three-step required in the method (Rigurous-two-step-method):

Neutron flux and spectrum in thousands points → Depletion calculation at each point with local composition → Gamma dose originated by the various gamma-emitting nuclides

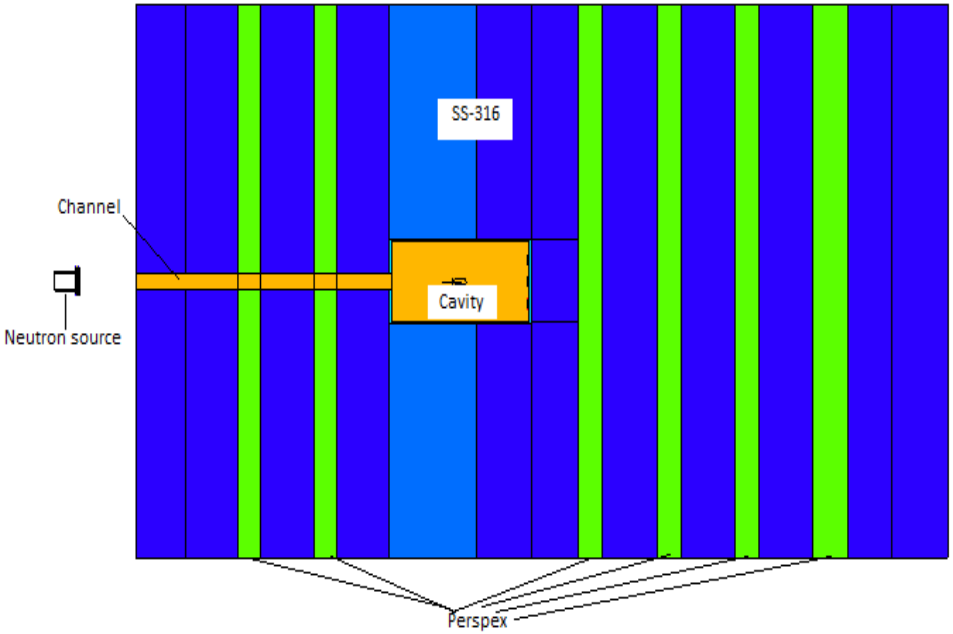
- ✓ New capabilities of MCNP version 5 (meshtally)
- ✓ International succes of depletion code ACAB (made by UNED, used by LLNL in Inertial Confinement Fusion)
- ✓ Simply putting together in a routine: SEACAB
- ✓ Intense qualification effort (FNG exp., FNS exp.)
- ✓ Several application projects (F4E, ITER and Cofrentes NPP)


Mesh
MCNPX
SEACAB
Volume (Void fracc)
Composition
Input ACAB
Time irradiation and
decay
ACAB
Output
ACAB
SEACAB
Gamma Source to MCNP
point to point and Total
activity
Energy spectrum for each
isotope considered
MCNP4B
Dose

Qualification of SEACAB

Frascati Neutron Generator residual dose measurements

- ✓ Comparison of residual dose at different times after an intense irradiation of a bulk of steel and plastic layers with DT neutrons
- ✓ Contribution of several nuclides (Co58, Mn54, Tc99, Mo99, Fe59, Co60, Ni57...) because of neutron energy larger than threshold for (n,p) (n,t)

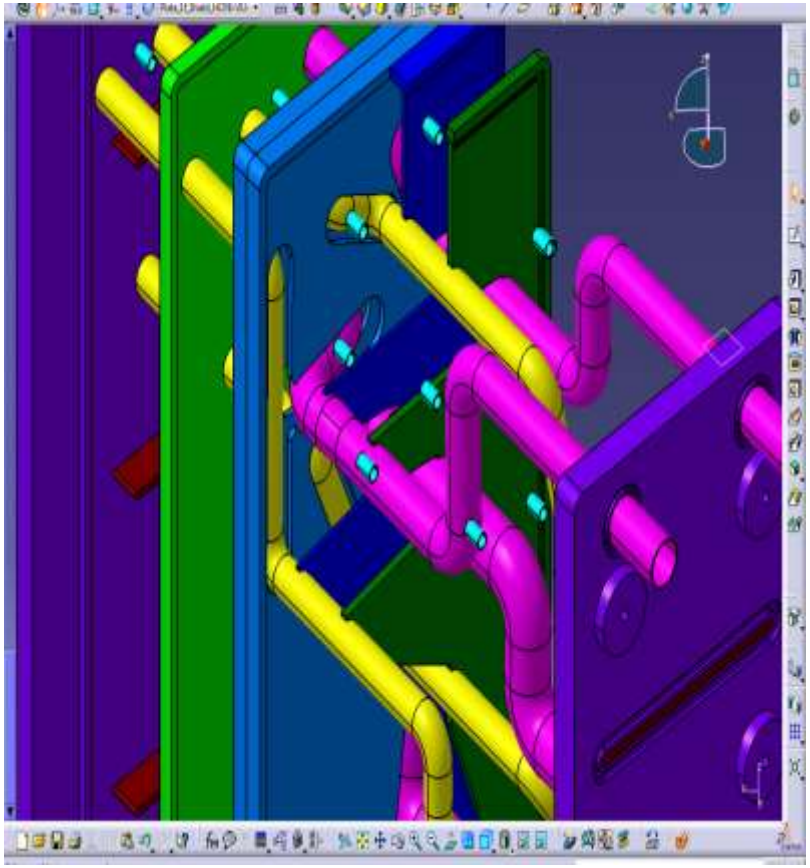


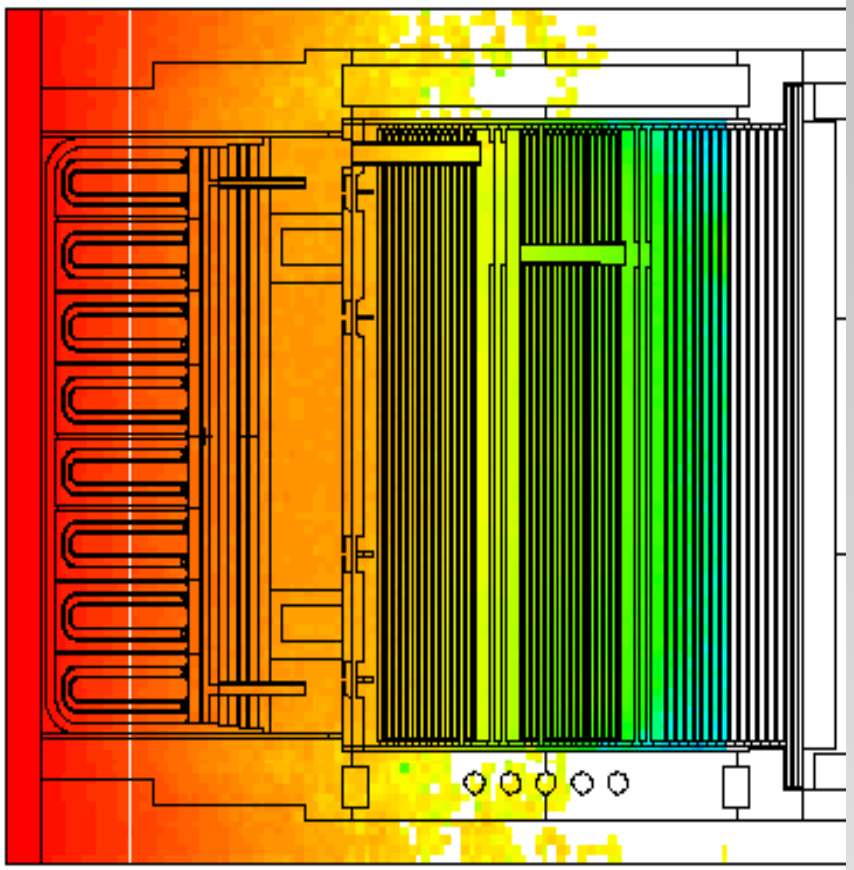
✓Results comparable to those obtained by other european institutions (KIT, ENEA, Culham, UNED)

❖ **Application of SEACAB**: ITER TBM shielding

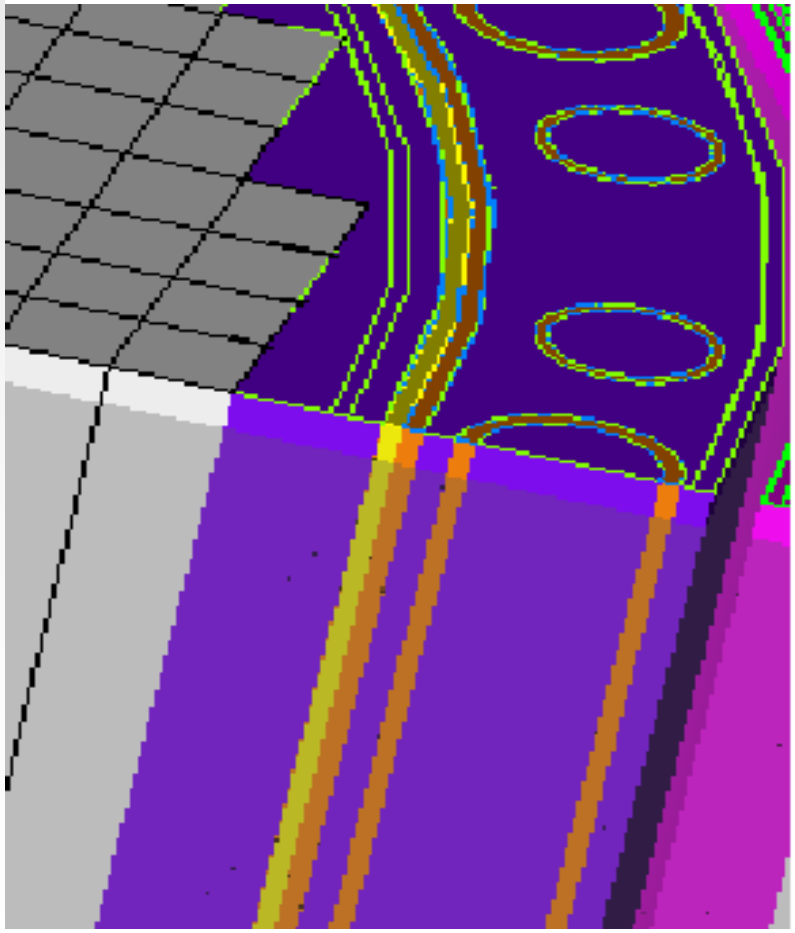
❖ F4E OMF-0331, Lote 1

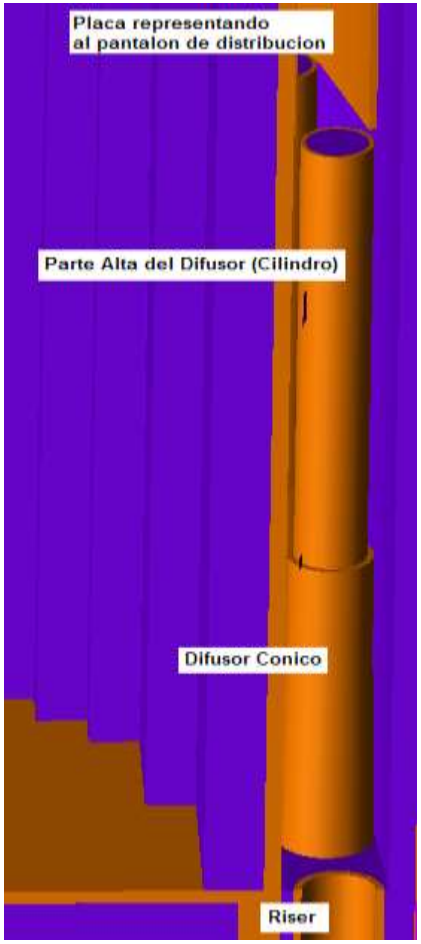
Residual dose 12 days after shutdown behind equatorial port #16 of ITER





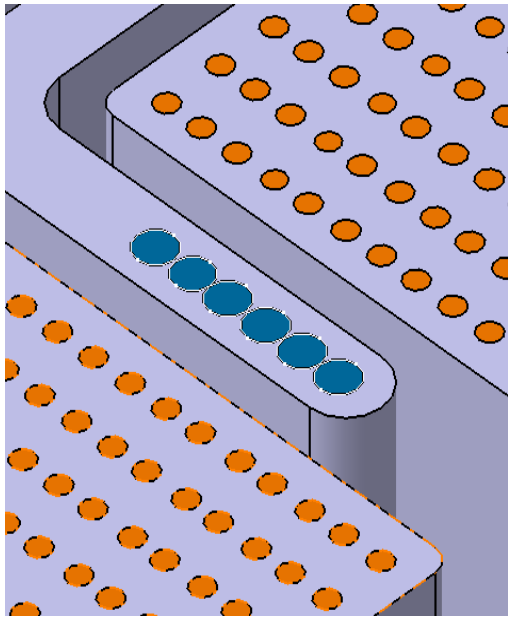
❖ **Application of SEACAB**: Dose to polymer plug used in the decontamination of a recirculation loop of Cofrentes NPP:

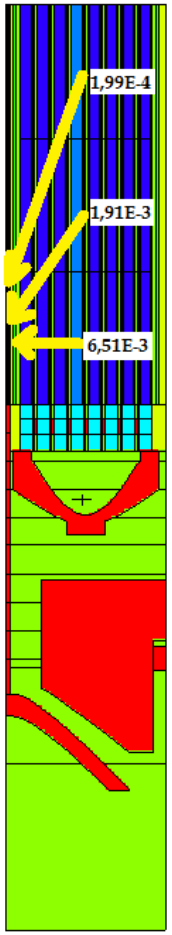


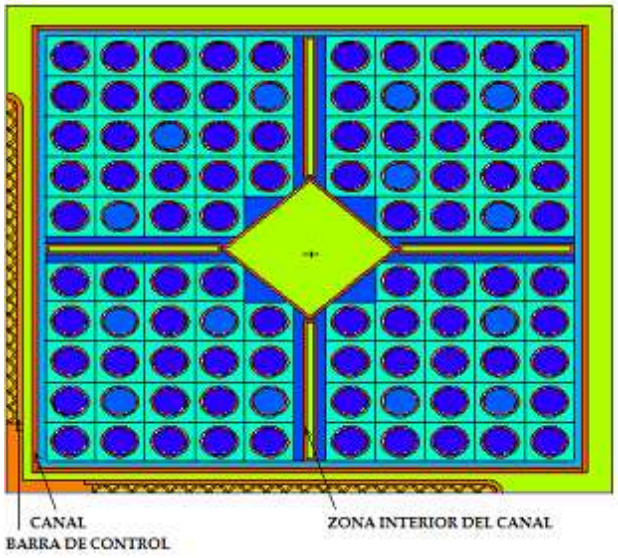


- The use of a lixiviant agent required
- Residual dose to the plug due to the vessel activation
- Residual dose to the limiting jet-pump entrance due to shroud activation
- Additional direct gamma dose along core loading

❖ **Application of SEACAB**:Characterization of assembly channels and control rods of Cofrentes NPP:







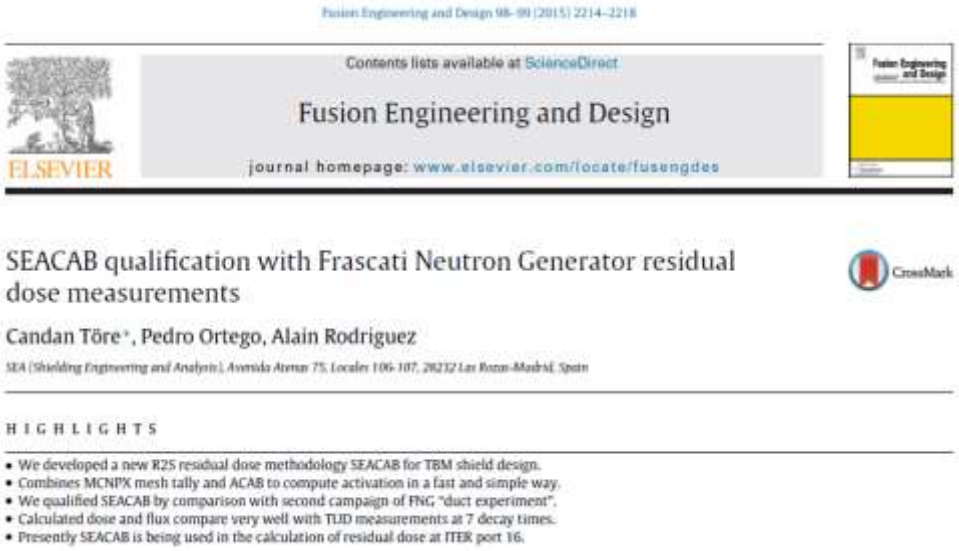
✓ Effort to minimize the storage room in the spent fuel pools occupied by assembly channels and control rods

Conclusion

SEACAB is a reliable methodology;

Validated with experimental measurements to support the NPP and ENRESA in dealing with "residuos especiales" i.e. activated wastes different than fuel (Spanish regulation) in order to:

- ✓ Rationalize the cost of waste management
- ✓ Free room in the spent fuel pools
- ✓ Minimize the need to use spent fuel casks and storage positions for intermediate or low activity waste



Fusion Engineering and Design 98–99 (2015) 2214–2218

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

SEACAB qualification with Frascati Neutron Generator residual dose measurements

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HIGHLIGHTS

- We developed a new R2S residual dose methodology SEACAB for TBM shield design.
- Combines MCNPX mesh tally and ACAB to compute activation in a fast and simple way.
- We qualified SEACAB by comparison with second campaign of FNG "duct experiment".
- Calculated dose and flux compare very well with TLD measurements at 7 decay times.
- Presently SEACAB is being used in the calculation of residual dose at ITER port 16.