ENEA possible activity in the HEHIHB network

Presentation of an exemplar activity performed in the laboratories of ENEA Frascati, which can be interesting to HEHIHB network

Prepared by L. PETRIZZI and P. BATISTONI, ENEA (Frascati)

- National institute for the New Technologies, the Energy, the Environment

- Frascati is one of the 11 ENEA research centers. Half of Frascati ENEA center manpower is devoted to the research in the field of Thermonuclear Fusion Technology (ca. 200 professionals)

- Frascati center is further divided in divisions. Our laboratory (10 professionals) is under the FUS(ion) TEC(hnology) Division, and it is called Neutronics Laboratory

- The neutronics laboratory performs calculations and experimental activities: in support of the design of the next fusion machine like ITER (the International Thermonuclear Reactor) or in support of the management and physics studies of the existing machines like the JET (Joint European Torus in UK) or the small FTU in Frascati.

- The activities are in collaborations with other international research centres (mainly European) financed in the EURATOM programme of the actually 6th FP (Framework Programme 2002-2006)

The shielding benchmark experiment

- The so called Shielding Benchmark Experiment is an exemplary experiment directed by Frascati in which both experimental and calculation expertise worked together for the improvement of the design tools used in ITER
- The focal issue was the assessment of the reliability of the calculations tools to predict the heating in the Superconducting Coils of ITER machine

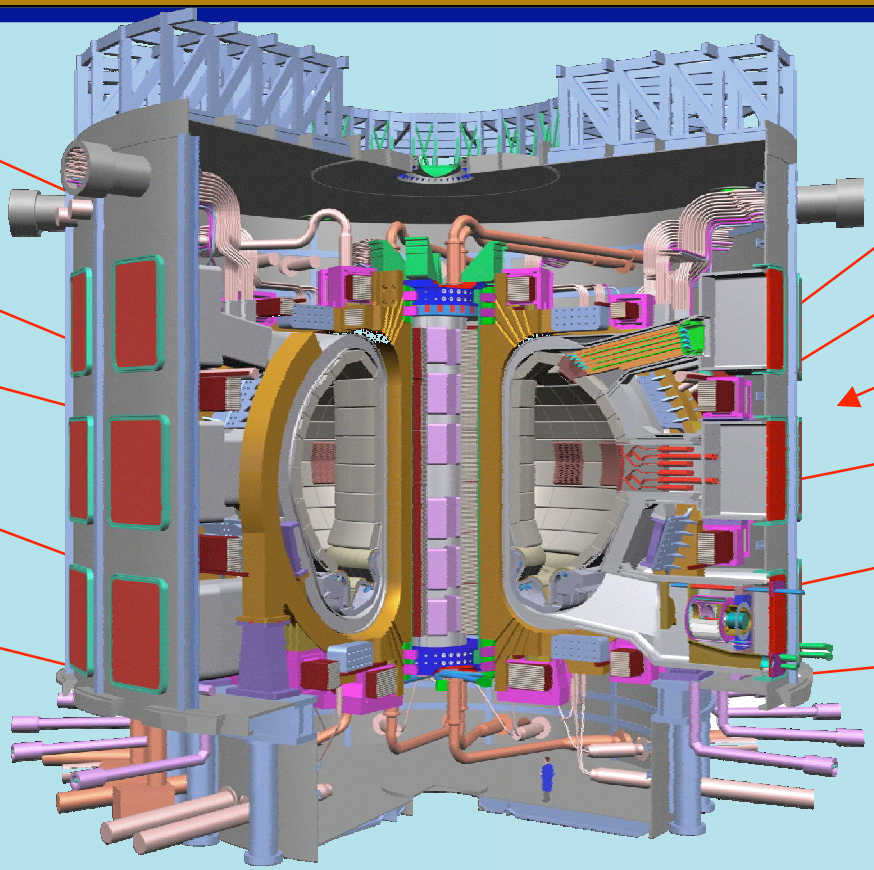
Why the shield in ITER is needed

- In ITER plasma chamber in the D-T fusion reactions, 14 MeV neutrons are emitted. The plasma is confined in a stable way with the help of a Toroidal Field (ca. 10 Tesla) created by external Superconducting Magnets. Total fusion power is 500 MW.
- The TF coils, for a proper functioning, should not be under a combined n and gamma radiation field such that:
  - Max nuclear heating on the conductor — 1 mW/cm^3
  - Max nuclear heating on the case — 2 mW/cm^3
  - Dose to the insulator — 10 Mgray
  - Total fluence to the insulator — 10^{18} n/cm^2
  - Total nuclear heating on the 16 coils — 14 KW

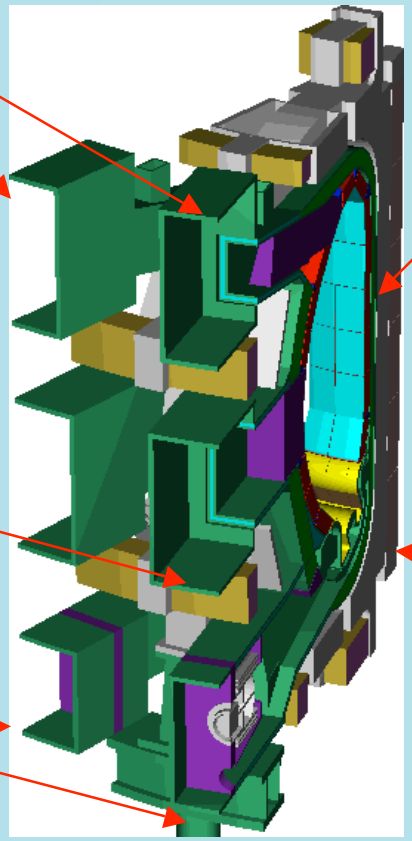
The reliability of calculation tools

- A proper shield is needed to dump the neutrons
- The shield is designed according to the available tools. For the radiation transport MCNP version 4C3 is now used, with nuclear data coming from FENDL1 (now updated to 2), a special library created by an IAEA committee for ITER purpose.
- The 3-D model can be accurate, but what about code and nuclear data?
- The shielding benchmark experiment was financed by ITER to give answer to that, performed in 4 years 1995-98 and it costed in the actual currency 200 K (no inflation taken into account)

ITER- Main Features



ITER MCNP BASIC Model

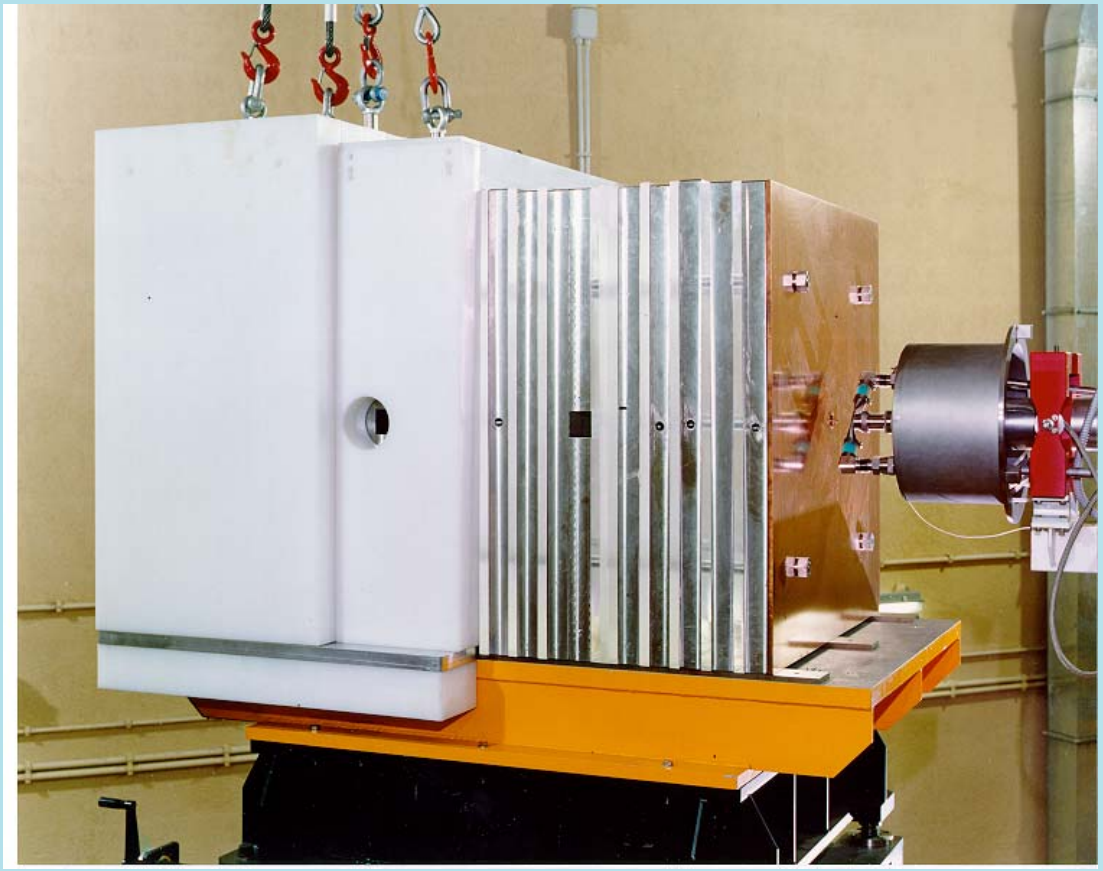


The ITER Basic Model (~2500 cells) can be very detailed

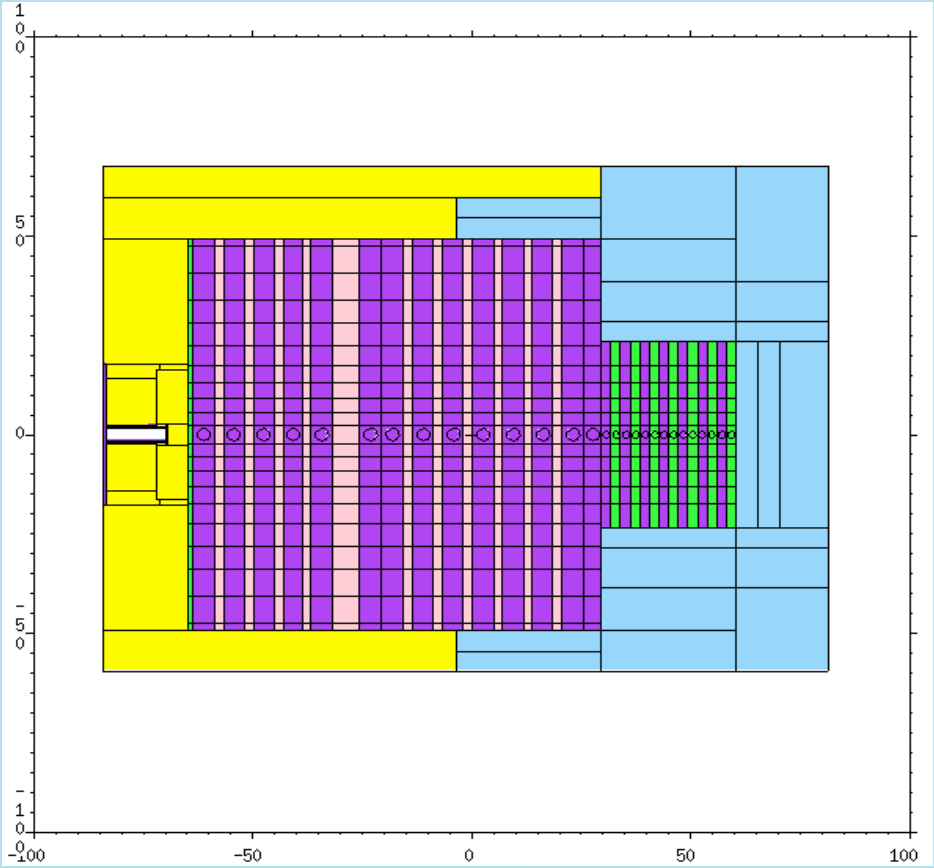
The shielding benchmark experiment

- A mock-up of the ITER inboard shield, including first wall, vacuum vessel and Toroidal Field Coil, has been assembled at the 14 MeV Frascati Neutron Generator (FNG) of ENEA Frascati.
- The FNG facility is 14 MeV n source able to give 10^{11} n/sec at 14 MeV.
- Neutron and gamma ray spectra and nuclear responses have been measured inside this mock-up.
- Measured data have been compared with calculated data to validate transport codes and nuclear data that are being used in the design of the ITER system.

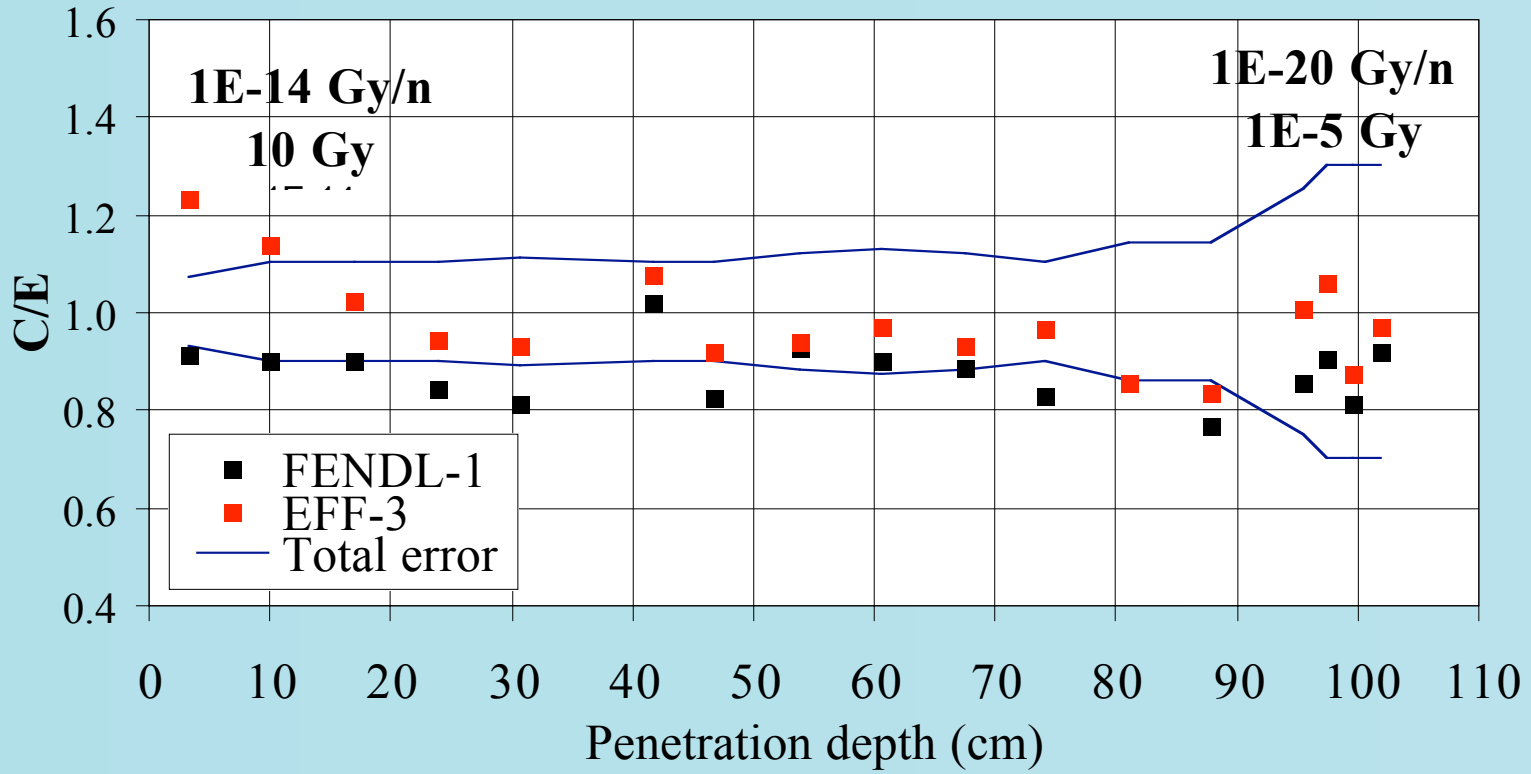
The FNG facility with the mockup



Geometrical model of the bulk shield mock-up and the FNG target in MCNP



C/E ratios of calculated over measured nuclear heating obtained using FENDL-1 and EFF-3 nuclear data libraries



Condensed conclusions of the benchmark

- The use of MCNP code and the FENDL-1 nuclear data library can describe satisfactorily the neutron and gamma flux attenuation in the large stainless steel/water ITER shield system up to about 1 m of penetration depth.
- It is noted, however, that in general a slight underestimation of the nuclear responses is observed all along the penetration depth. For the nuclear heating this underestimation amounts to 10% -20%.

For more info

- L. Petrizzi

- Phone +39 06 9400 5741
- E-mail petrizzi@frascati.enea.it
- Website :www.fusione.enea.it (under construction, info limited)