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Poster P1.060

Neutronic effects of the ITER Upper Port environment update in C-Model

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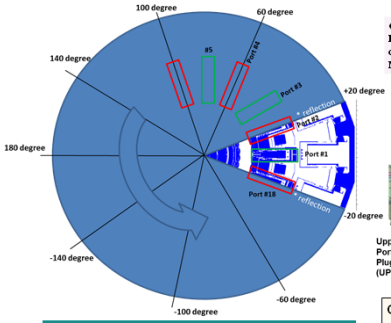
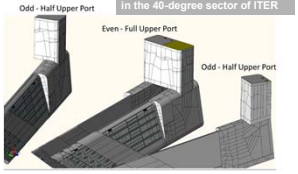
Main objectives of this work

- **Development of the new 3D MCNP model of the ITER Upper Port (UP) environment** integrated into the neutronics C-Model of the ITER tokamak machine.
- **Neutronics analysis** of the newly updated **C-Model Release 180430** issued on 30/04/2018 with Shut-Down Dose Rate (SDDR) calculations at 12 days of cooling. Comparison the SDDR with the previous MCNP model of ITER called **C-lite V2R150304MOD**.

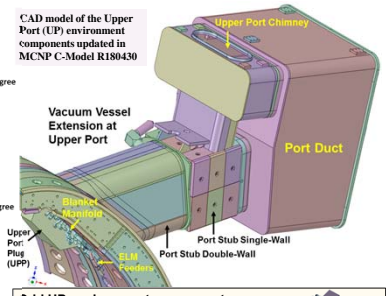
C-Model in 40-degree toroidal sector symmetrically represents the whole 360 degrees of ITER machine. It is copying 9 times by using the reflective boundary conditions. as shown in the simulated 9-sector pie:



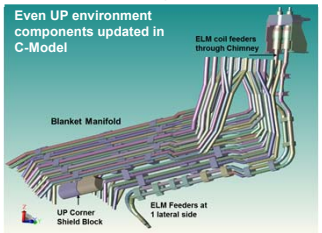
CAD view of C-Model envelopes in the 40-degree sector of ITER



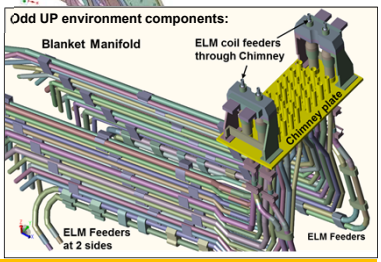
CAD model of the Upper Port (UP) environment components updated in MCNP C-Model R180430



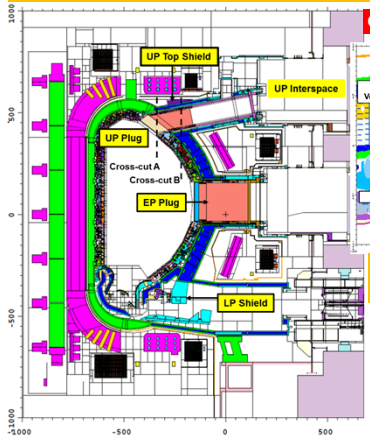
Even UP environment components updated in C-Model



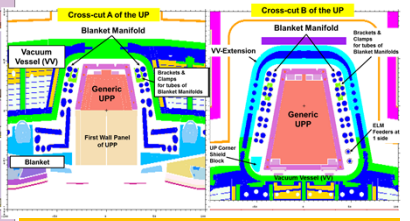
Odd UP environment components:



Development of the MCNP model of the UP environment



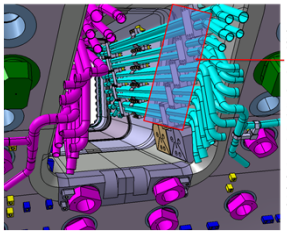
C-Model Release 180430 of 2018 – ITER Reference



State-of-the-art codes for ITER applications:

- SpaceClaim software for CAD processing;
- SuperMC (FDS, China) for CAD-to-MCNP conversion;
- Activation and SDDR calculations
  - FISPACT-2007 (CCFE) inventory code;
  - R2SMesh interface (KIT) for MCNP-FISPACT;
  - D1S-UNED v.3.1.2 for transport and SDDR;
- Radiation transport calculations (n/gamma fluxes)
  - MCNP5 v1.60, MCNP6 (LANL) code;
  - FENDL-2.1 and 3.1 neutron cross-section libraries.

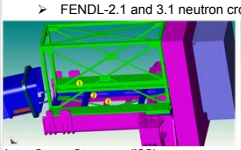
Potential shielding improvements at UP blanket manifolds, UP Stub, and UP Duct

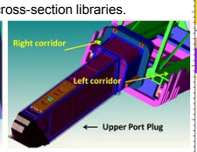


1) Additional customized plates thickness of **10 mm** proposed to be added over Manifolds.

The design has to be studied how to attach the plates to Manifolds supports (brackets, clamps).

2) **Insert shielding plates called "shielding belts"** around the UP single-wall stub and UP Duct.





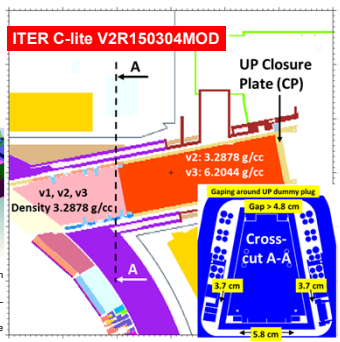
Inter-Space Structure (ISS)

(1) ISS X-shape beams and platform made of **aluminum type 6061** (IO PIM-169) with impurities of **Co=0.025 wt.%, Ni=0.025 wt.%** - GREEN color;

(2) ISS bogie with main structures made of steel **SS316L(N)-IG, Co 0.03 wt.%** - BLUE color – Diagnostics-grade steel modified according to IO PIM-169;

(3) ISS maintenance rails made of steel **SS316L(N)-IG, Co 0.05 wt.%** - horizontal structure with MAGENTA color – standard ITER-grade steel used.

ITER C-lite V2R150304MOD

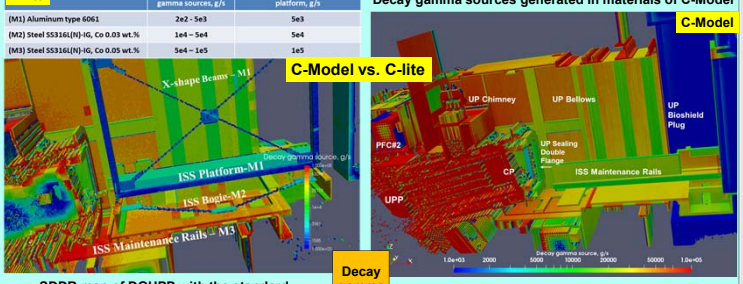


Neutronic effects of UP update in C-Model 2018

C-lite

Material	Range of decay gamma sources, g/s	Decay gamma source in mid of ISS platform, g/s
(M1) Aluminum type 6061	2e2 - 5e3	5e3
(M2) Steel SS316L(N)-IG, Co 0.03 wt.%	1e4 – 5e4	5e4
(M3) Steel SS316L(N)-IG, Co 0.05 wt.%	5e4 – 1e5	1e5

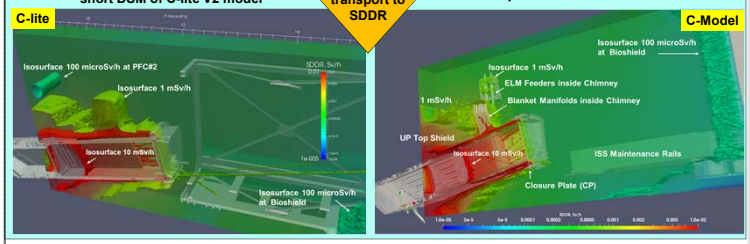
Decay gamma sources generated in materials of C-Model



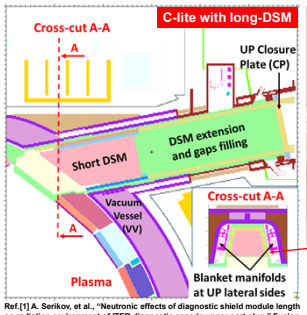
SDDR map of DGUPP with the standard short DSM of C-lite V2 model

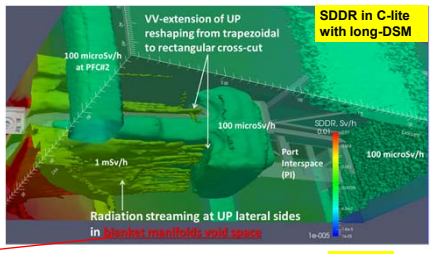
Decay gamma transport to SDDR

SDDR map of UP in C-Model R180430



Investigation Ref. [1] the Long-DSM option and filling the UP-VV gaps in C-lite V2





SDDR effect of n-streaming in gaps around the DGUPP is 77 microSv/h for both the models with or without the neutron cross-talks from EP & LP.

Neutron cross-talk from Equatorial & Lower Ports (EP & LP): effect of activation by neutrons from EP & LP is 75 microSv/h.

Ref.[1] A. Serikov, et al., "Neutronic effects of diagnostic shield module length on radiation environment of ITER diagnostic generic upper port plug," Fusion Engineering and Design (2018).

Conclusions and future work

MCNP tally Location Upper Port Interspace	Short DSM of C-Model R180430, microSv/h	Short DSM of C-lite V2R150304MOD, microSv/h	Long DSM of C-lite V2R150304MOD, microSv/h	Long DSM, filled DGUPP-VV gaps C-lite V2R150304MOD, microSv/h
UP Closure Plate (CP)	**1350**	1293	393	45
UP ISS Front of Left & Right Corridors	**266**	254	227	150

- Based on the performed neutronics analysis, we conclude that the updated ITER UP environment in the MCNP **C-Model Release 180430** demonstrated **similar SDDR** in relation to the previous version model **of ITER C-lite** V2R150304MOD with its short DSM.
- Small increase by 5% of SDDR in UP interspace corridors C-Model is explained by compensating effects of additional streaming (removed shielding "cigar racks" and widening by 1.5 cm the gaps around UPP) and absence of radioactive sources in parts of ISS. To provide personnel access to the ISS corridors, further improvement of the shielding performance is expected by increasing the length of the DSM, in case of long-DSM the SDDR is decreased by ~11% in corridors. If a design solution could be found how to fill the DGUPP-VV gaps, then reduction of 41% could be inferred, resulting ~150 microSv/h.
- **Following the ALARA principle**, if it would be possible to isolate UP environment from radiation exposure from other ports and mitigate streaming inside the UPP-VV gaps, then the SDDR limit of 100 microSv/h will be met.
- **Engineering design development** of the ITER Generic Upper Port Plug (GUPP) is still in progress. A possibility to insert shielding plates to the lateral sides of the rectangular part of UP extension is a subject of future work.

Acknowledgment & Disclaimer

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The views and opinions expressed herein do not necessarily reflect those of the ITER Organization. This paper does not commit the IO as a nuclear operator.

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