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Poster P3.125

Complete Neutronic Analysis for the Edge Charge Exchange Recombination Spectroscopy in Equatorial Port of ITER

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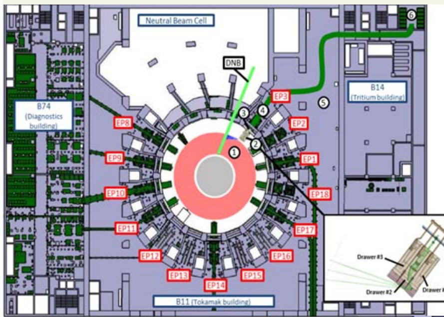
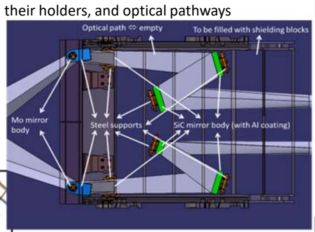
Main objectives of this work

- **Neutronics support for designing** the Charge Exchange Recombination Spectroscopy (CXRS) system viewed Edge plasma from the ITER Equatorial Port #3 (EP3).
- **Creating MCNP neutronics model** of CXRS-Edge installed inside the DSM #1 and #2 of EP3 as part of ITER tokamak C-Model, without any other Diagnostic systems planned for EP3 (MSE, GDC, and VisIR) – because engineering designs of these systems are not matured enough. The model does not include Diagnostics Neutral Beam (DNB), no any Neutral Beam Injectors (NBI) in the adjacent ports.
- **Local approach was applied for neutronics analysis,** it is aimed on investigation of the impact of CXRS-Edge system on radiation environment inside the Inter-Space Structure (ISS) area of EP3 and to study radiation effects for the CXRS-Edge components themselves.
- **The CXRS-Edge design** is developed by RF-DA, it provides design data and CAD models.

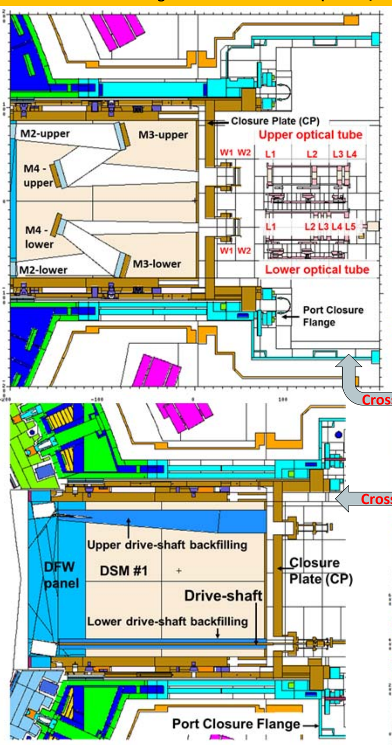


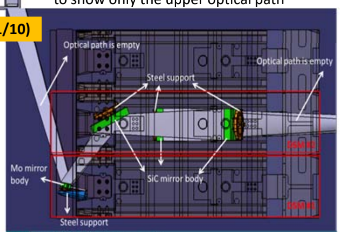
Side view of the CXRS Edge with mirrors made of molybdenum (Mo) and silicon carbide (SiC), their holders, and optical pathways

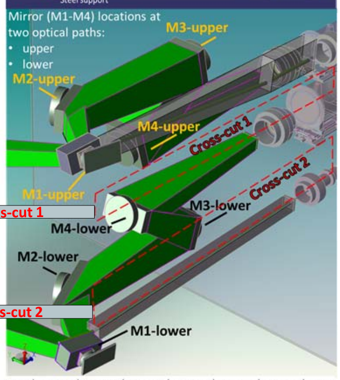


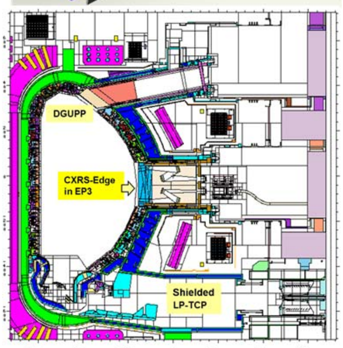
Top view of the EPP3 CXRS Edge assembly - to show only the upper optical path

MCNP model of CXRS-Edge in C-MODEL R181031 (Rev.19/01/10)





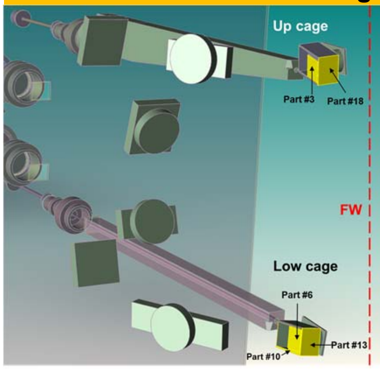




State-of-the-art codes and data for ITER applications:

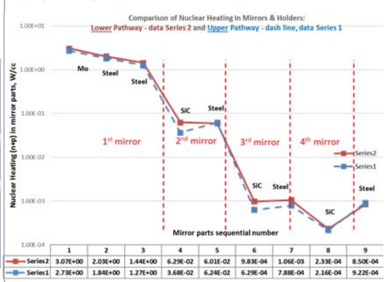
- SpaceClaim software for CAD processing;
- SuperMC (FDS, China) for CAD-to-MCNP conversion;
- Shut-Down Dose Rate (SDDR) calculations:
  - D1S-UNED v.3.1.2 for transport and activation inventory;
- Radiation transport calculations (neutron and gamma fluxes)
  - C-MODEL R181031 (Revision 190110), MCNP6 code;
  - FENDL-2.1 and 3.1 neutron cross-section libraries.

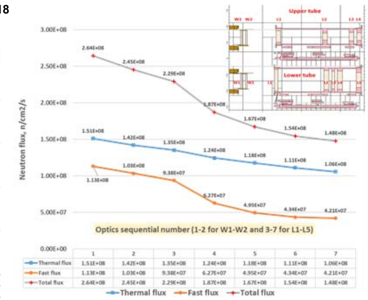
Peaks of nuclear heating in Mo parts of M1 cages



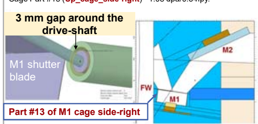
Sequential number of the Mo cage part	Location in Mo cage	Total (n+p) heat in Mo per MCNP cell volume, W/cc
1	Up_mirror_M1	2.73E+00
2	Low_axis	3.24E+00
3	Up_Shutter Blade_and part_of_its axis	4.20E+00
4	Up_axis	2.96E+00
5	Up_axis	2.89E+00
6	Low Shutter Blade	5.05E+00
7	Low_mirror_M1	3.07E+00
8	Low_cage_back	3.89E+00
9	Low_cage_side-up	3.59E+00
10	Low_cage_front	4.49E+00
11	Low_cage_side-left	2.28E+00
12	Low_cage_side-bottom	3.70E+00
13	Low_cage_side-right	6.39E+00
14	Up_cage_back	3.47E+00
15	Up_cage_side-left	1.99E+00
16	Up_cage_side-bottom	3.20E+00
17	Up_cage_side-up and front	3.35E+00
18	Up_cage_side-right	5.48E+00

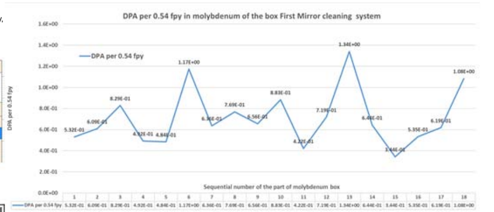
Closest to FW: Part #13 (cage side-right at Lower path) and **Part #18** ((cage side-right at Upper optical pathway)





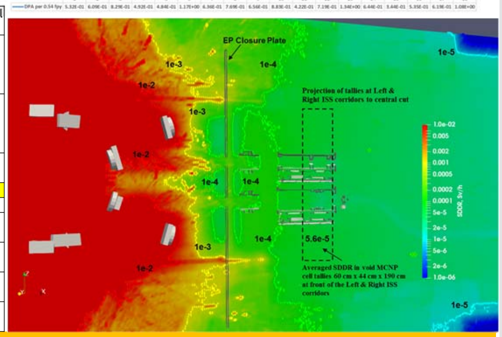
Maximum values found in the following Mo components:
Cage part #13 (**Low_cage_side-right**) equaled 1.34 dpa per 0.54 fpy,
Shutter Part #6 (**Low Shutter Blade**) = 1.17 dpa/0.54fpy,
Cage Part #18 (**Up_cage_side-right**) =1.08 dpa/0.54fpy.





Total (neutron + photon) heating in materials of the CXRS mirrors and holders

Mirror number	Mirror Material	Heating (n+p) per cell volumes, W/cc
M1 upper	Molybdenum mirror	2.73E+00
	steel disk	1.84E+00
	steel plate	1.27E+00
M1 lower	Molybdenum mirror	3.07E+00
	steel disk	2.03E+00
	steel plate	1.44E+00
M2 upper	SiC mirror	3.68E-02
	steel disk	6.24E-02
M2 lower	SiC mirror	6.29E-02
	steel disk	6.01E-02
M3 upper	SiC mirror	6.29E-04
	steel disk	7.88E-04
M3 lower	SiC mirror	9.83E-04
	steel disk	1.06E-03
M4 upper	SiC mirror	2.95E-04
	steel disk	9.22E-04
M4 lower	SiC mirror	2.97E-04
	steel disk	8.50E-04



Conclusions and future work

- **Maximum nuclear heating** in molybdenum M1 cleaning cage at the side close to FW is **6.39 W/cc**, heating of the M1 Mo mirror is **3.07 W/cc**.
- **Maximum neutron damage** of **1.34 dpa/0.54fpy** in molybdenum was found at the first mirror M1-cleaning cage, in location closest to plasma FW.
- **SDDR assessment** with local approach for the EP3 ISS corridors does not reveal contribution from CXRS-Edge, indicated the optimal shieldings performance of the doglegs.
- **Local SDDR** in the EP3 ISS corridors is **~56 microSv/h** with or without CXRS.
- **Designing work is in progress.** This work is an initial contribution to the complete neutronic analysis. Adding second bend to the CXRS lower shaft could slightly reduce activation of the CXRS-Edge components in EP3 of ITER.
- **It would be recommended** to investigate whether the first mirrors can be moved further away from the plasma FW to reduce nuclear heat load and neutron damage.

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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