Fermilab-TM-2679-APC

Accident scenarios for IOTA ring and dose distributions calculated with MARS15 code

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June 14, 2018

The Integrable Optics Test Accelerator (IOTA) at Fermilab's Accelerator Science and Technology (FAST) facility [1] is a storage ring for advanced high intensity beam physics research. Layout of the ring is shown in Fig. 1. A plan view of the ring with enclosure walls are shown in Fig. 2. The entire beam, stored in the IOTA ring, is assumed to be completely lost at either of the three locations shown in Fig. 2. Therefore, we will consider three separate corresponding accident scenarios. The maximal amount of electrons stored in the IOTA ring is estimated to be 2×10^{10} electrons with energy of 150 MeV. At locations 1 and 2 the beam is lost on 60-deg dipole walls, while at location 3 the beam is lost on Lambertson magnet wall.

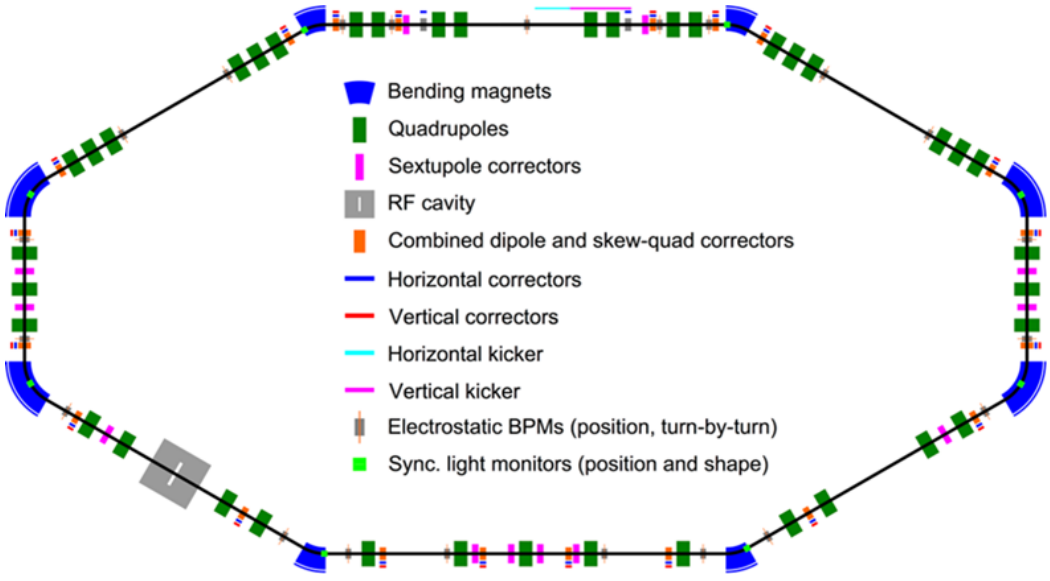


Figure1. Layout of the IOTA ring.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

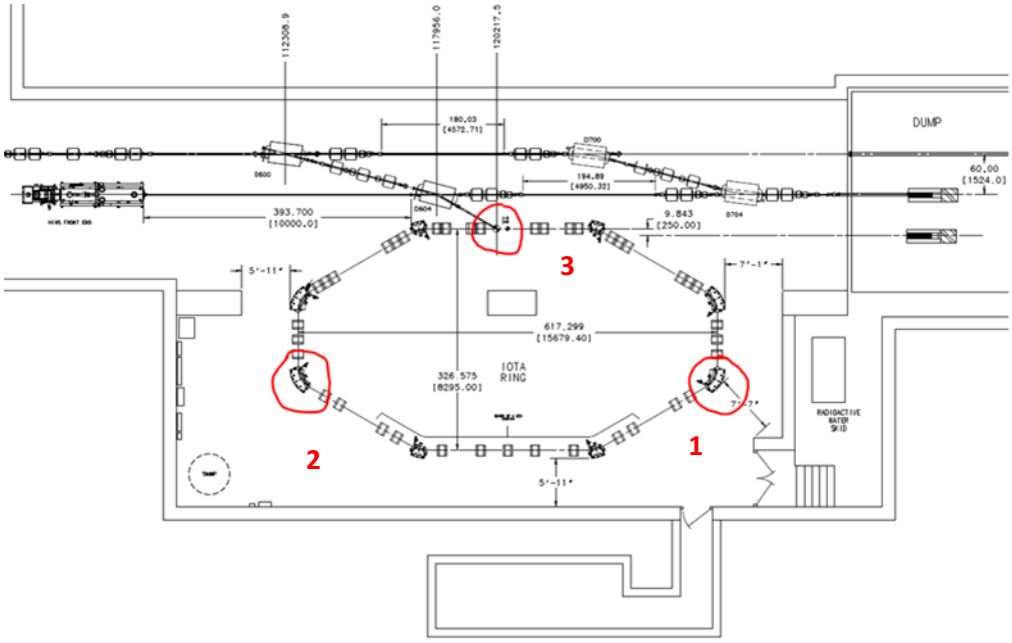


Figure 2. A plan view of the ring with the enclosure walls (at beamline elevation). The red circles indicate the three selected locations of tentative beam incidents with corresponding numbers also shown in red.

The calculations have been performed with MARS15 Monte Carlo code [2, 3]. In addition to calculated two-dimensional prompt dose distributions, the dose was calculated also in a human phantom and in five locations around the facility where corresponding detectors (chipmunks) are located (see Table 1). The phantom is represented by a sphere filled with water and with R=27 cm.

Table 1. calculated dose (mrem/2. $\times 10^{10}$ electrons) in chipmunks and human phantom for the three accident scenarios in IOTA ring.

Detector	Location	Description	Accident 1	Accident 2	Accident 3
Human phantom	A	Outside ECB door upstairs	8.6×10^{-7}	1.7×10^{-8}	7.7×10^{-8}
Chipmunk 1	B	Near ECB door upstairs	5.2×10^{-6}	8.6×10^{-8}	3.4×10^{-7}
Chipmunk 2	C	Staircase, downstairs	4.0×10^{-2}	1.5×10^{-5}	7.2×10^{-4}
Chipmunk 3	D	In ECB, on the floor	6.5×10^{-10}	1.6×10^{-13}	2.0×10^{-11}
Chipmunk 4	E	In ECB, on the floor	1.9×10^{-9}	1.0×10^{-12}	1.5×10^{-10}
Chipmunk 5	F	In beam enclosure, under ceiling	1.5×10^{-6}	8.1×10^{-6}	4.6×10^{-6}
The calculated statistical uncertainty (1σ) for the human phantom and chipmunks 1, 2 and 5 does not exceed 10%, while for chipmunks 3 and 4 the 1σ is about 50%.					

A plan view of the computer model and locations of the chipmunk and phantom are shown in Figs. 3 and 4, respectively. The calculated dose distributions are shown in Figs. 5 thru 7.

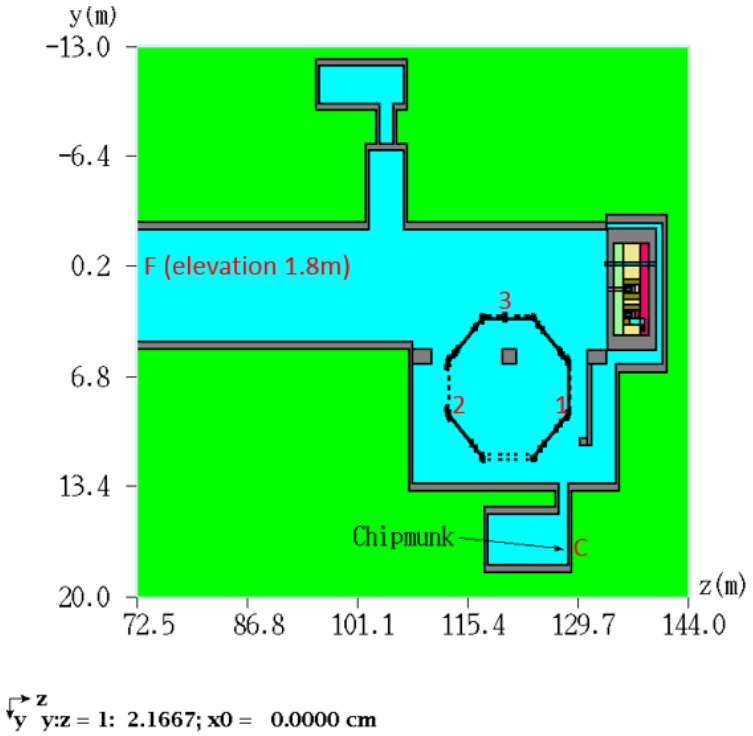


Figure 3. A plan view of the MARS15 geometry model at beamline elevation (x = 0) that shows also locations of two detectors (see Table 1).

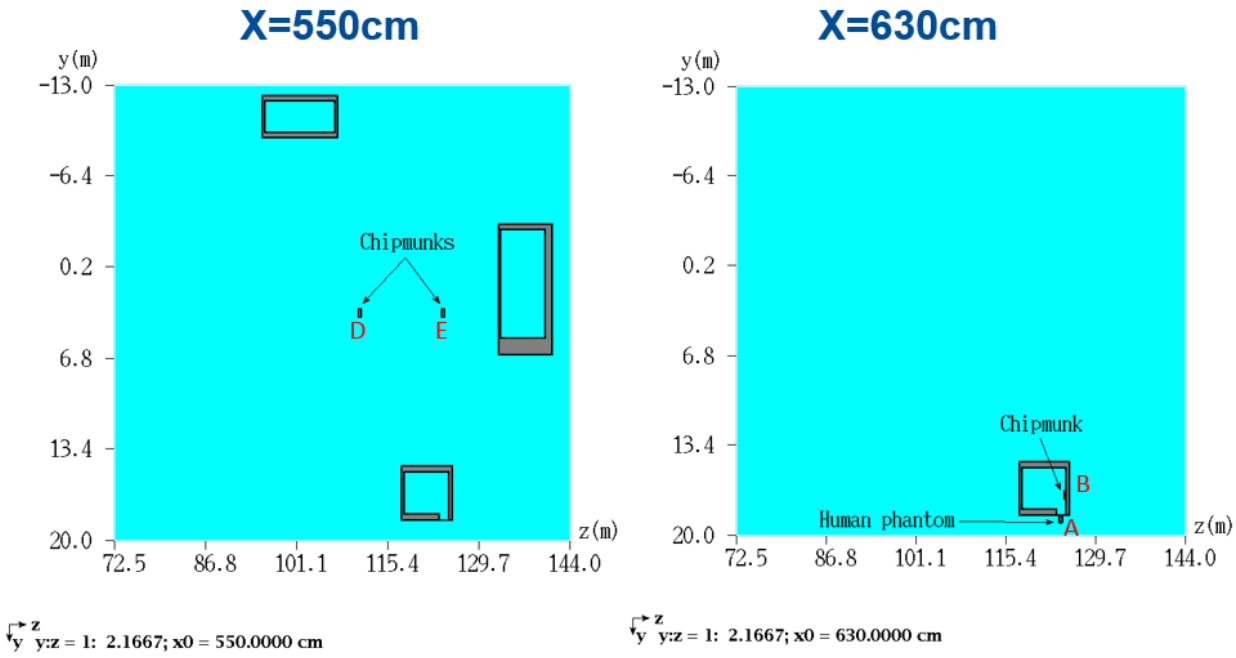


Figure 4. A plan view of the MARS15 geometry model at two different elevations (x = 550 and 630 cm) that shows also locations of three detectors and a human phantom (see Table 1).

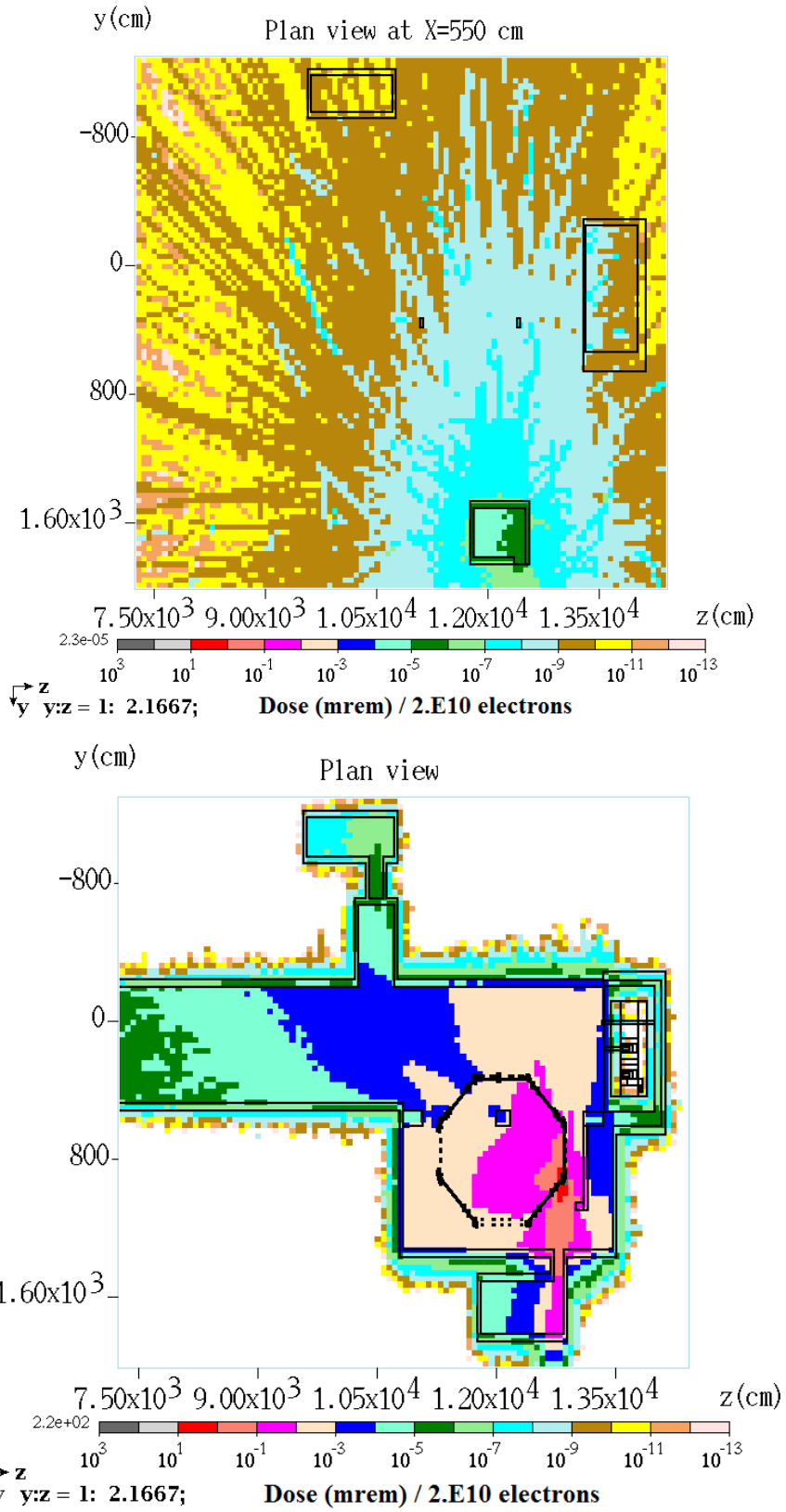
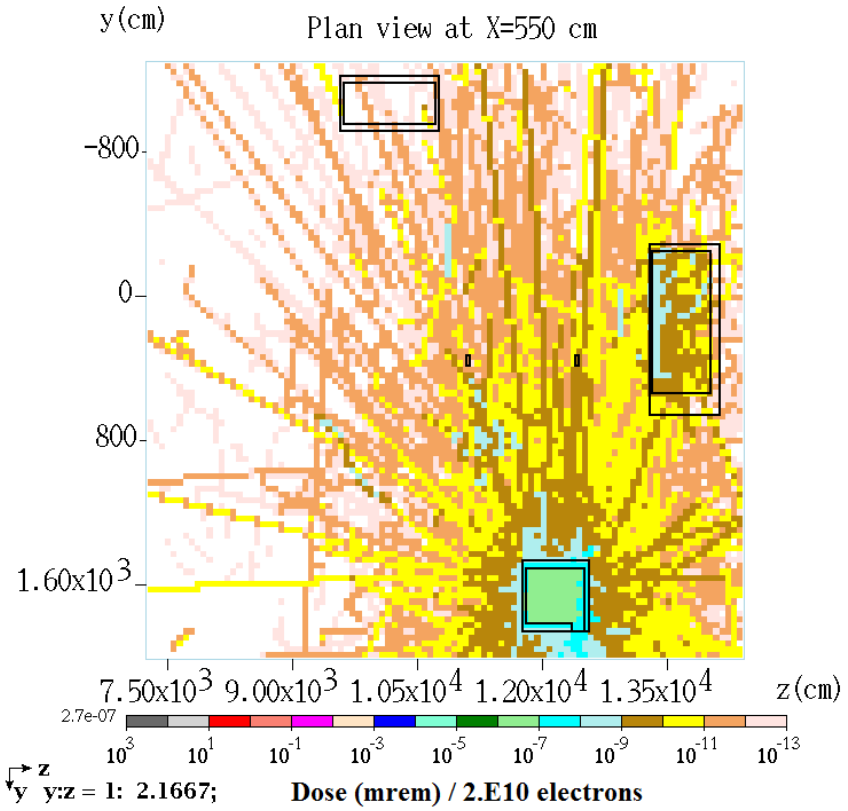


Figure 5. Calculated dose distributions for accident scenario 1 in IOTA ring at beamline elevation (bottom) and at elevation X=550cm (top).



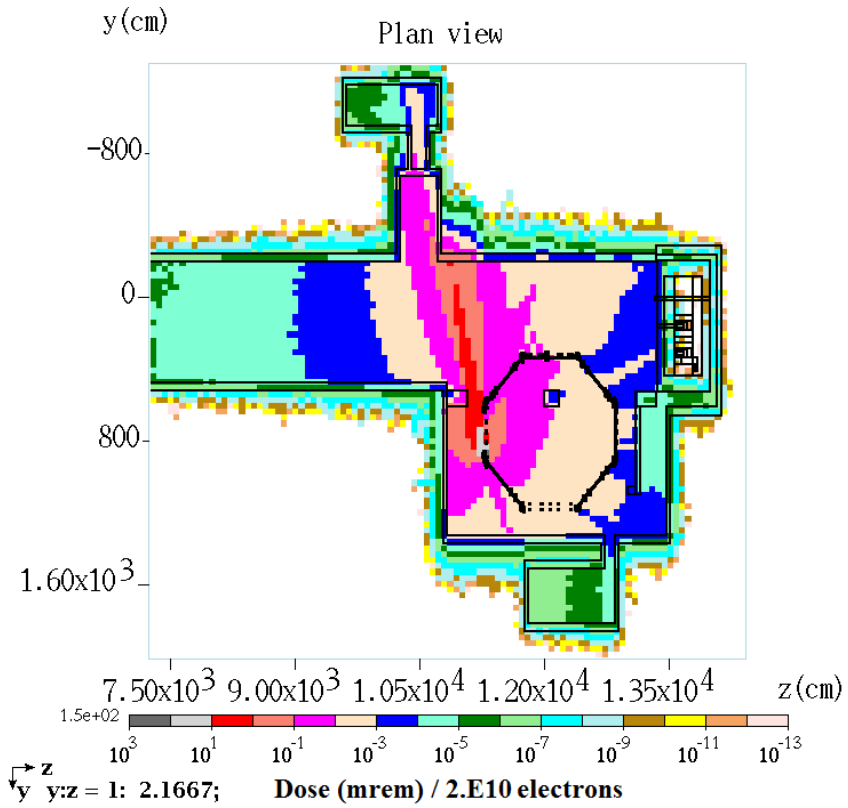


Figure 6. Calculated dose distributions for accident scenario 2 in IOTA ring at beamline elevation (bottom) and at elevation X=550cm (top).

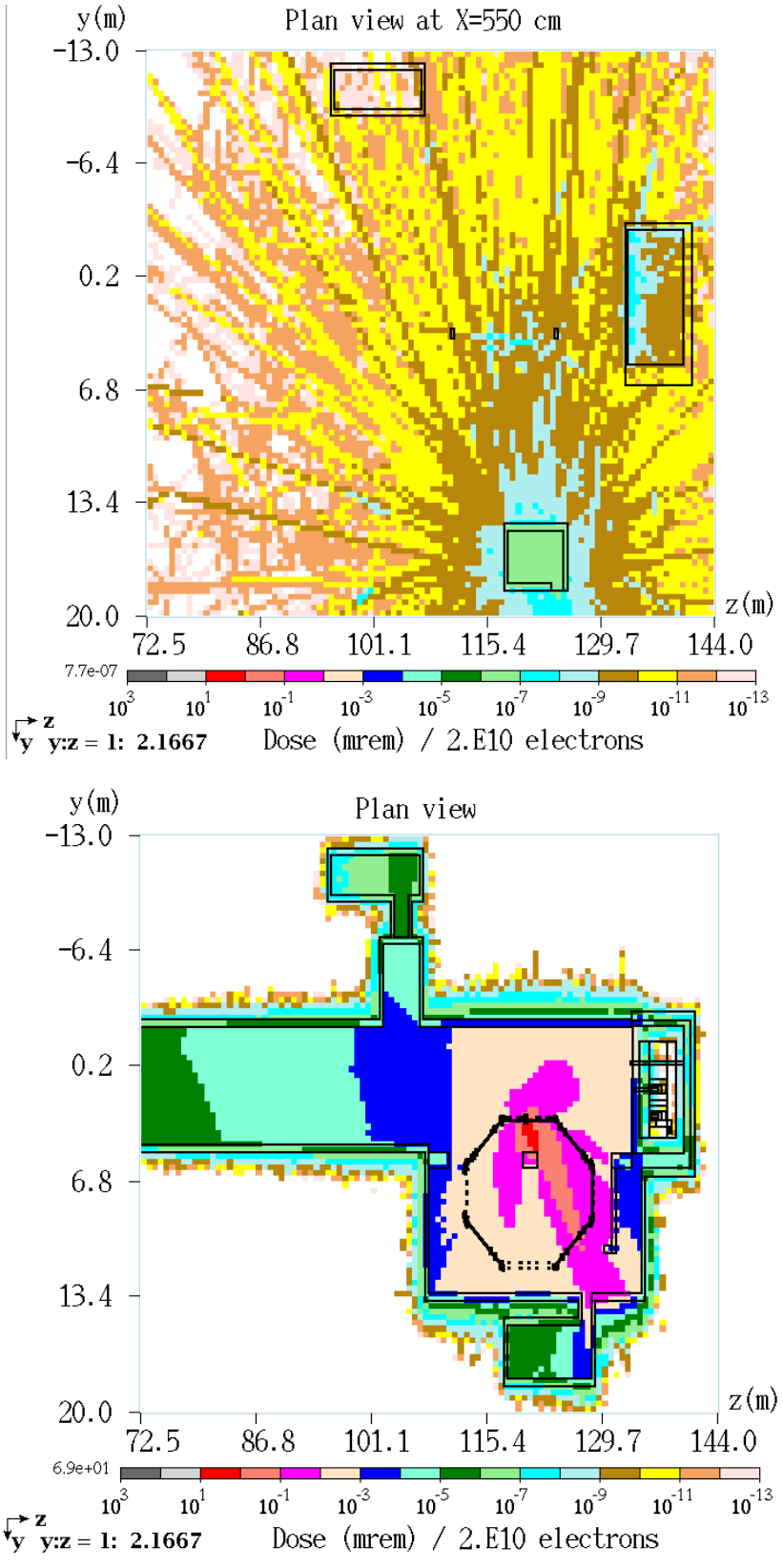


Figure 6. Calculated dose distributions for accident scenario 3 in IOTA ring at beamline elevation (bottom) and at elevation X=550cm (top).

Acknowledgments

This work used a Director's Discretionary Allocation at Argonne Leadership Computing Facility.

References

[1] M. Church *et al.*, "Proposal for an Accelerator R&D; User Facility at Fermilab's Advanced Superconducting Test Accelerator (ASTA)," 2013.

[2] N. V. Mokhov, "The MARS Code System User's Guide, Version 15 (2018)", Fermilab-FN-1058-APC (2018); https://mars.fnal.gov/

[3] N. V. Mokhov *et al.*, "MARS15 code developments driven by the intensity frontier needs", Progress in Nuclear Science and Technology, **v.4**, 496 (2014).