Radiation Source Terms Downstream of JLab's High Power Beam Dumps

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17 January 2017

Jefferson Lab's experimental Halls A and C each employ a high power beam dump (HPBD) capable of absorbing up to 1 MW beam power [1]. The 1 MW limit will remain during CEBAF's 12 GeV operations, with the HPBDs receiving electron beams with energies up to 11 GeV [2]. The radiation source terms downstream of the dumps are of great interest to some experimental proposals, such as the Dark matter search in a Beam-Dump eXperiment (BDX) [3].

Each beam dump consists of an aluminum pressure vessel with an aluminum plate heat exchanger core, as shown in Figure 1. The heat exchanger (Figure 2) is made of a total of 20.8 rl of aluminum and 3.1 rl water so that 70 % of the power is absorbed directly in the aluminum [1].

Interaction of 11 GeV electron beam with the HPBD was modeled using FLUKA-2011.2c.5 [4]. Figure 3 presents a 3-dimentional representation of the FLUKA model with a cutout showing the internal structure of the vessel model.

Particle fluences were calculated at the end of the dump, 411.2 cm downstream of the beam window, through the back of the 11.58 cm diameter cooling water supply line.

Differential fluences of photons, electrons, positrons, muons, μ^+, μ^-, protons, and neutrons are presented in Figures 5-12.

Figure 1: Beam dump vessel assembly - DWG. NO. 27020-E-0001

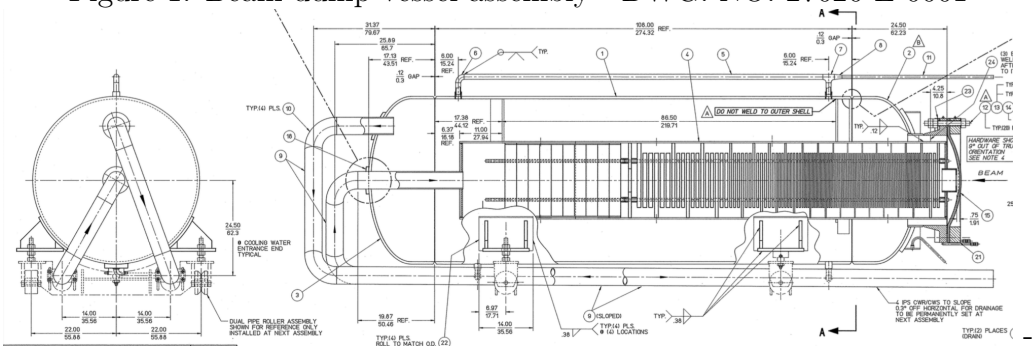

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Figure 2: Plate exchanger assembly - DWG. NO. 27020-E-0016

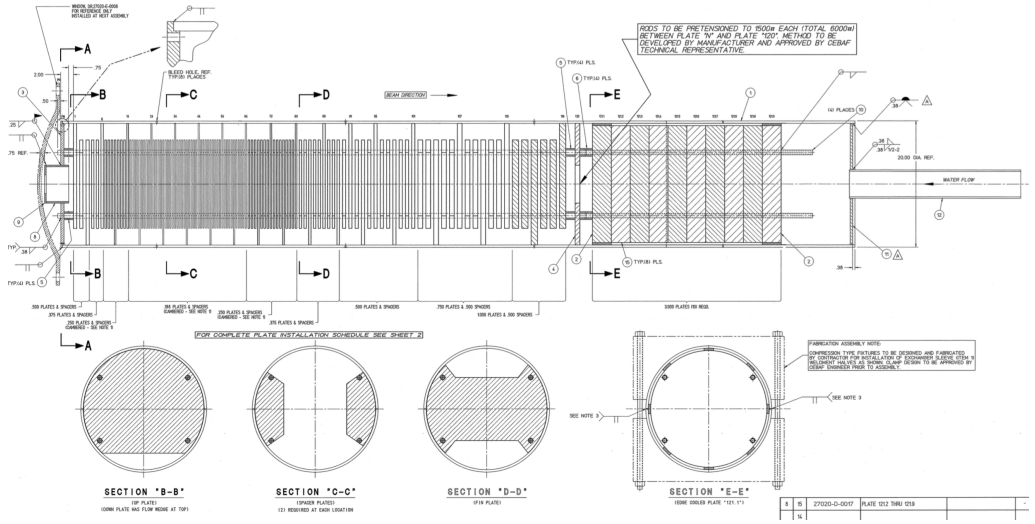

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Figure 3: 3D representation of HPBD FLUKA model

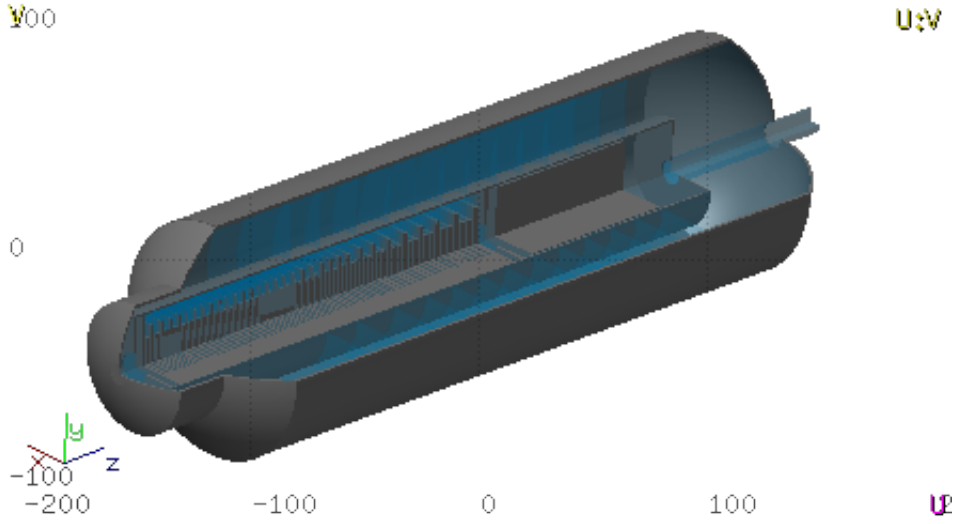


Figure 4: YZ cross section of HPBD model

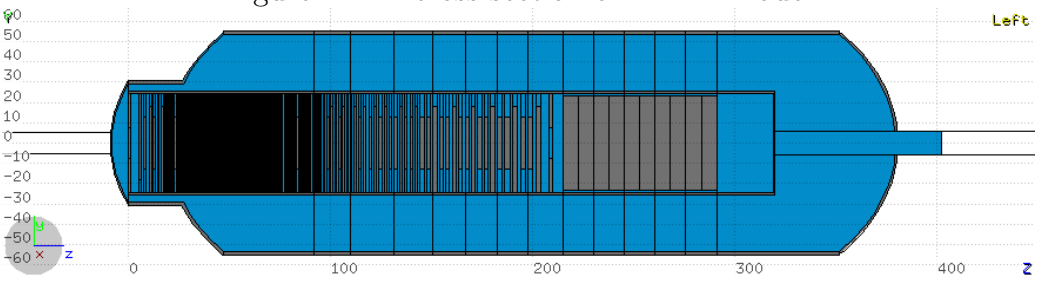


Figure 5: Photon differential fluence downstream of HPBD

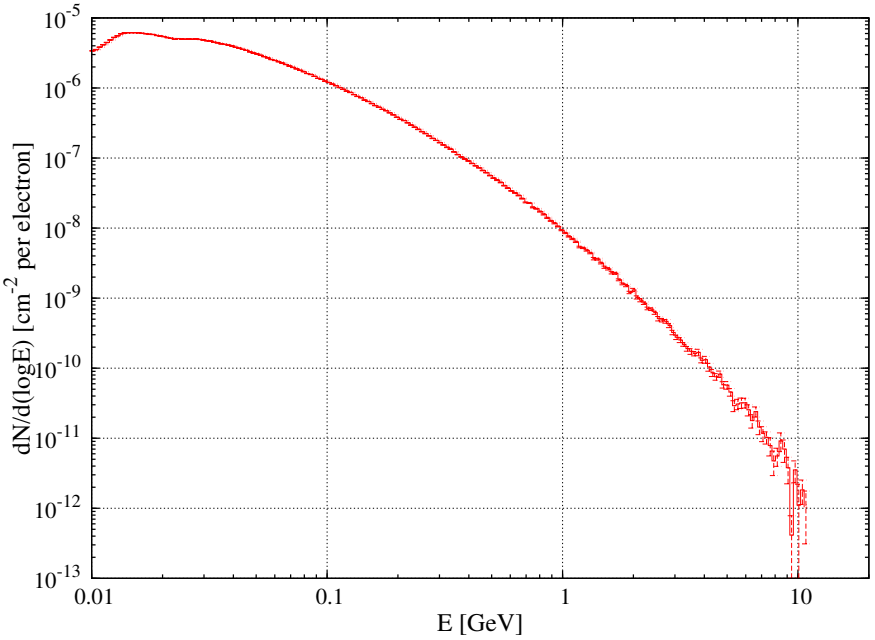


Figure 6: Electron differential fluence downstream of HPBD

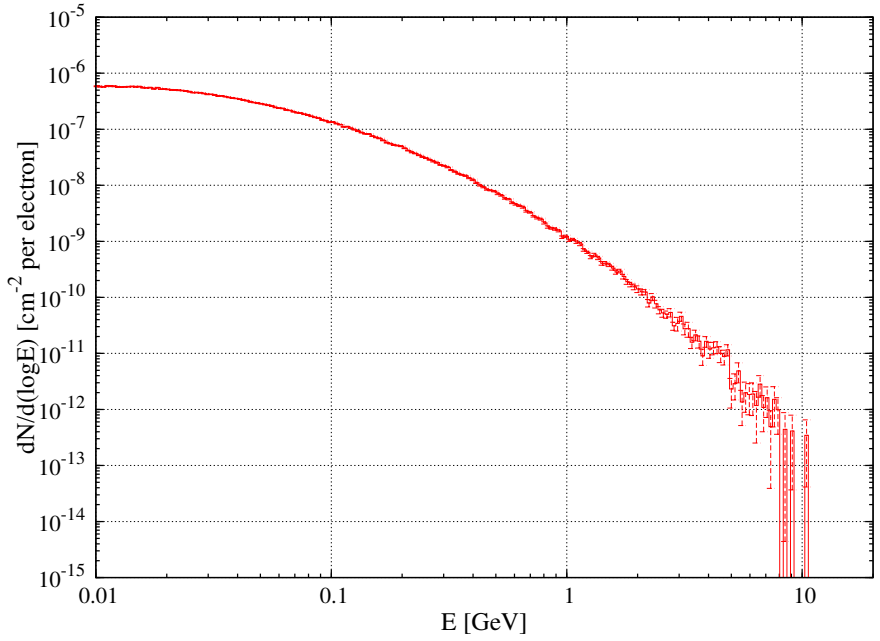


Figure 7: Positron differential fluence downstream of HPBD

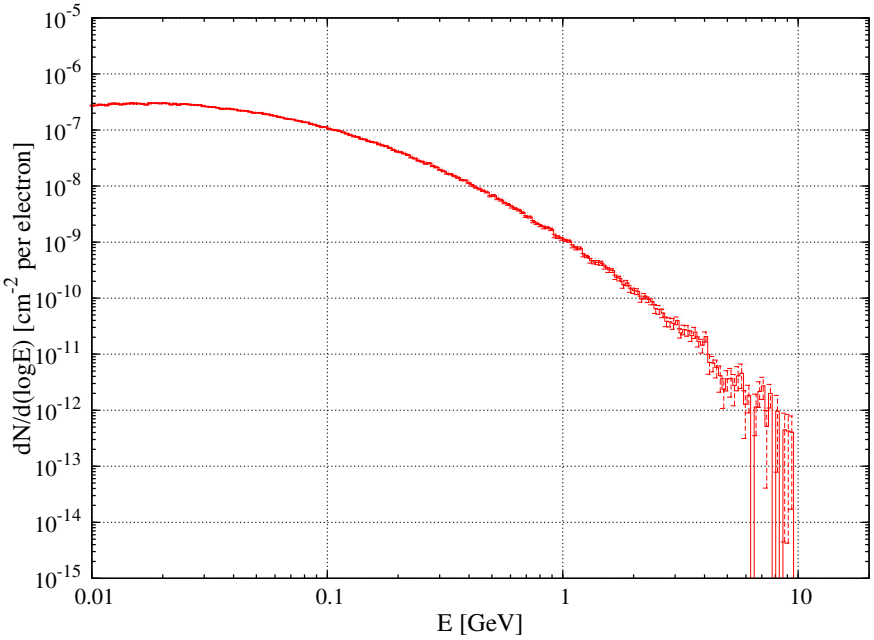


Figure 8: Muon differential fluence downstream of HPBD

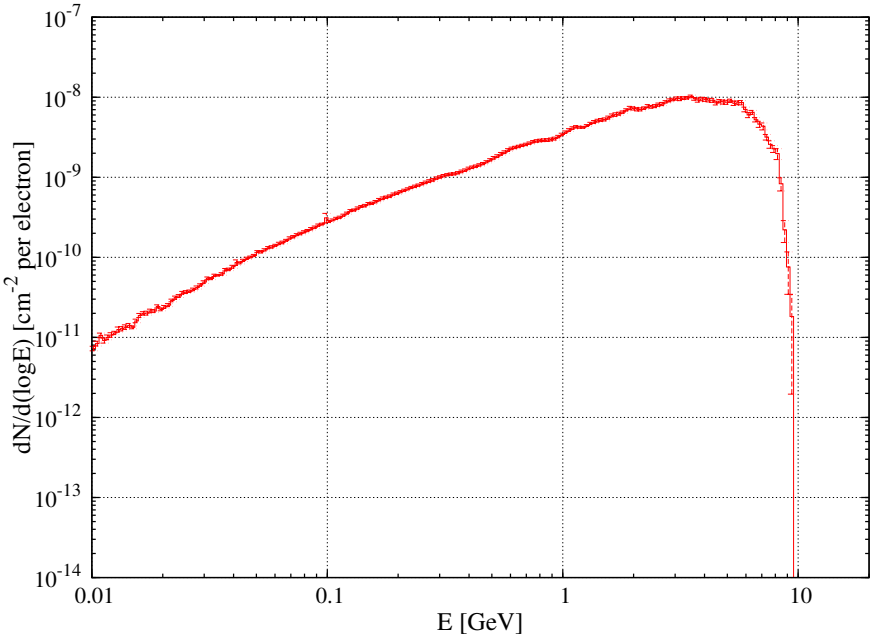


Figure 9: μ^+ differential fluence downstream of HPBD

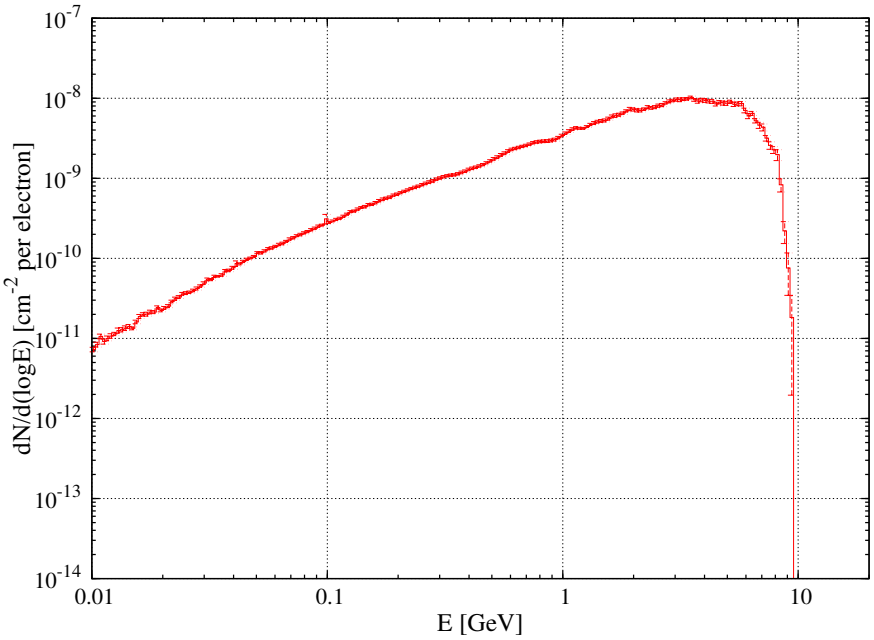


Figure 10: μ^- differential fluence downstream of HPBD

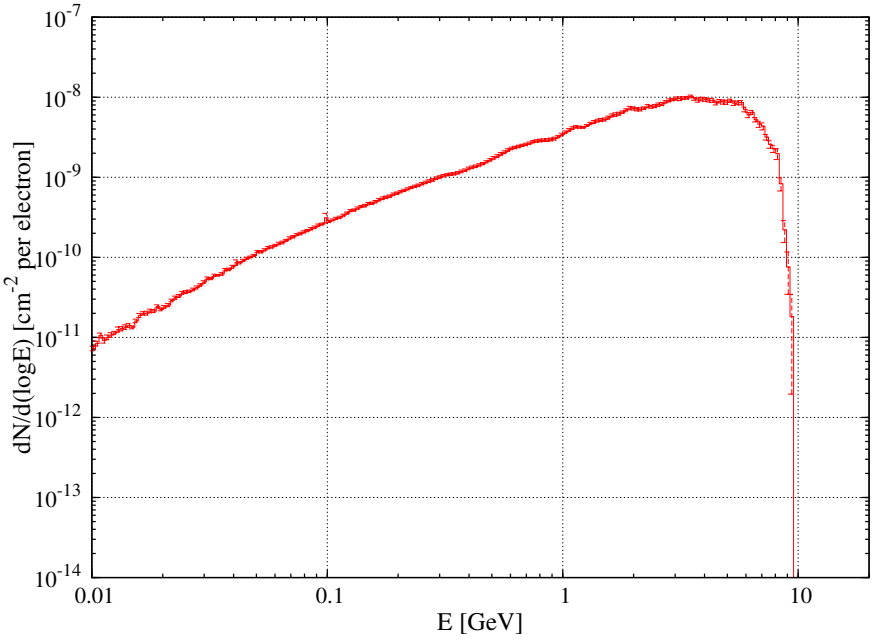


Figure 11: Proton differential fluence downstream of HPBD

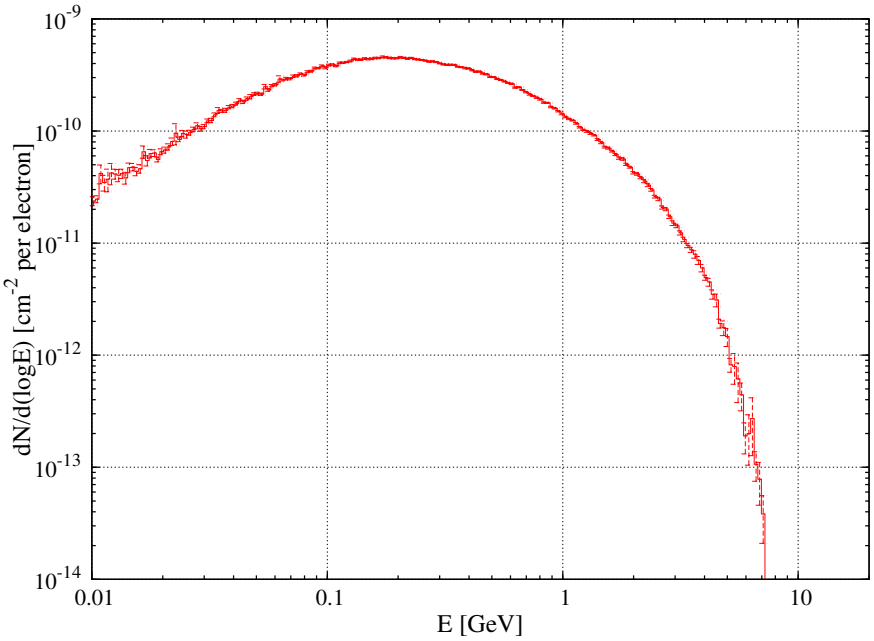
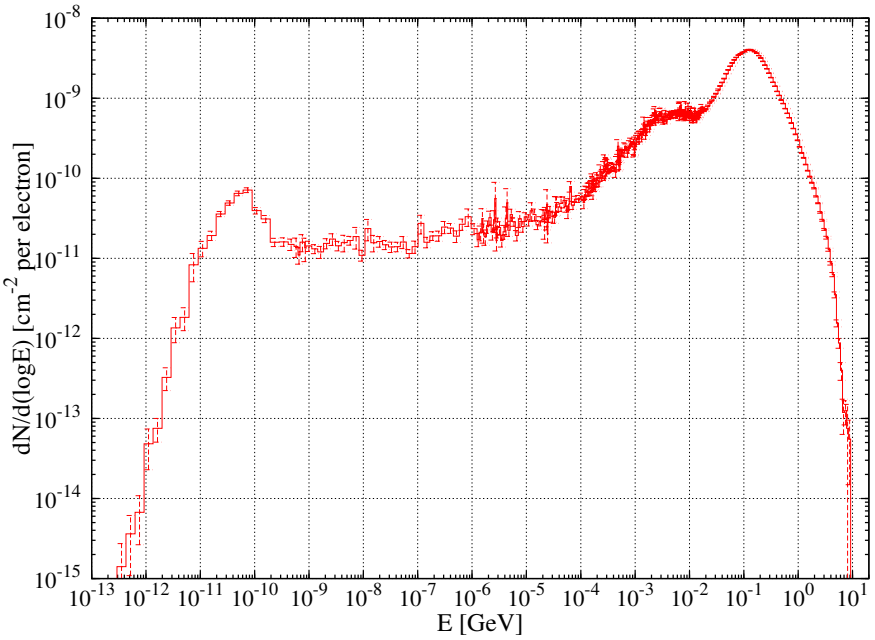


Figure 12: Neutron differential fluence downstream of HPBD



References

[1] M. Wiseman, C. K. Sinclair, R. Whitney, M. Zarecky. *"High Power Electron Beam Dumps at CEBAF"*, PAC'97 Proceedings, 3761-3763, 1997.

[2] Jay Benesch, Arne Freyberger, Geo Kraft, Yves Roblin, Mike Spata, Michael Tiefenback *"As Built 12GeV CEBAF Energy and Current Limits"*, JLAB-TN-13-001, 2013.

[3] M. Battaglieri *et al. "Dark matter search in a Beam-Dump eXperiment (BDX) at Jefferson Lab"*, Proposal submitted to the 44th JLab PAC, arXiv:1607.01390, 2016.

[4] T.T. Bohlen, F. Cerutti, M.P.W. Chin, A. Fassò, A. Ferrari, P.G. Ortega, A. Mairani, P.R. Sala, G. Smirnov, and V. Vlachoudis."The FLUKA Code: Developments and Challenges for High Energy and Medical Applications", Nuclear Data Sheets 120, 211-214, 2014.