

Secondary beam @ JLAB

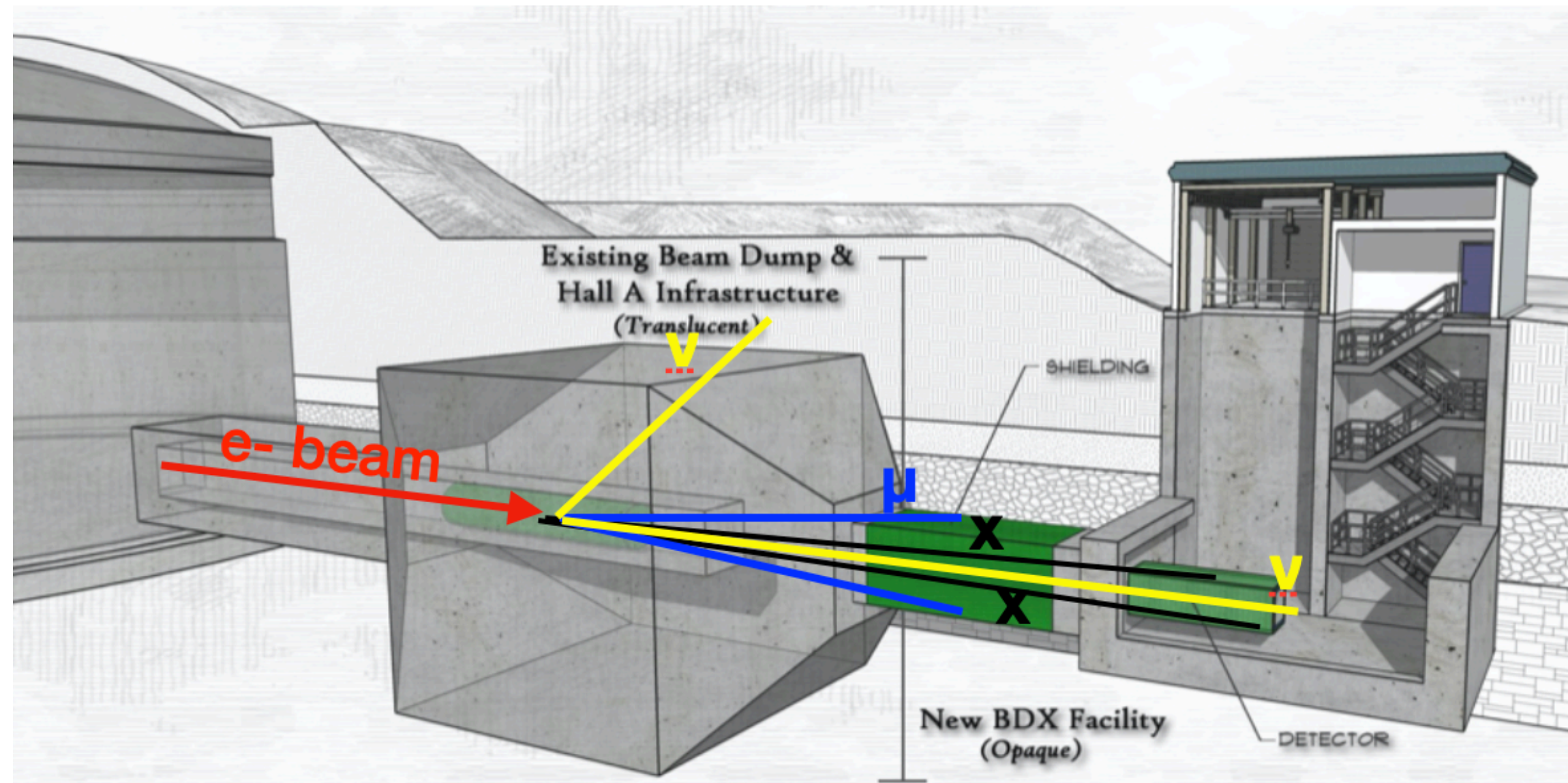
Mariangela Bondi and Marco Battaglieri



CSN3 Referee's Meeting - July 10, 2024

New physics perspective at JLAB with secondary beams

- CEBAF provides a high-intensity e- beam for extracted-beam experiments
 - The machine can sustain up MW power (100 uA @10GeV, 200uA @5GeV)
- High-intensity secondary beams are produced in the dump(s) fully parasitically
 - Muons, Neutrinos and LDM (if it exists)



■ 2 PhD thesis:

- S. Grazi thesis : “ ν BDX a Coherent Elastic Neutrino Nucleus Scattering (CEvNS) experiment at Jefferson Lab”
- A. Fulci thesis: “Secondary Beams at JLAB”

Milestone 2024: 100%



instruments



Article

Secondary Beams at High-Intensity Electron Accelerator Facilities

Marco Battaglieri¹, Andrea Bianconi^{2,3}, Mariangela Bondi⁴, Raffaella De Vita¹, Antonino Fulci^{4,5,*}, Giulia Gosta², Stefano Grazi^{1,5}, Hyon-Suk Jo⁶, Changhui Lee⁶, Giuseppe Mandaglio^{4,5}, Valerio Mascagna^{2,3}, Tetiana Nagorna¹, Alessandro Pilloni^{4,5}, Marco Spreafico^{1,7}, Luca J. Tagliapietra⁸, Luca Venturelli^{2,3} and Tommaso Vittorini^{1,7}

- ¹ Istituto Nazionale di Fisica Nucleare, Sezione di Genova, 16146 Genova, Italy; tetiana.nagorna@ge.infn.it (T.N.); tommaso.vittorini@ge.infn.it (T.V.)
 - ² Istituto Nazionale di Fisica Nucleare, Sezione di Pavia, 27100 Pavia, Italy; andrea.bianconi@unibs.it (A.B.)
 - ³ Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, 25123 Brescia, Italy
 - ⁴ Istituto Nazionale di Fisica Nucleare, Sezione di Catania, 95125 Catania, Italy; giuseppe.mandaglio@unime.it (G.M.); pillaus@jlab.org (A.P.)
 - ⁵ Dipartimento di Scienze MIFT, Università degli Studi di Messina, 98166 Messina, Italy
 - ⁶ Department of Physics, Kyungpook National University, Daegu 41566, Republic of Korea
 - ⁷ Dipartimento di Fisica, Università degli Studi di Genova, 16126 Genova, Italy
 - ⁸ NEVNUCLAB, 123 W Nye Lane, Carson City, NV 89706, USA; lucaj@nevnuclab.com
- * Correspondence: antonino.fulci@unime.it

Abstract: The interaction of a high-current $O(100 \mu\text{A})$, medium energy $O(10 \text{ GeV})$ electron beam with a thick target $O(1\text{m})$ produces an overwhelming shower of standard model particles in addition to hypothetical light dark matter particles. While most of the radiation (gamma, electron/positron) is contained in the thick target, deep penetrating particles (muons, neutrinos, and light dark matter particles) propagate over a long distance, producing high-intensity secondary beams. Using sophisticated Monte Carlo simulations based on FLUKA and GEANT4, we explored the characteristics of secondary muons and neutrinos and (hypothetical) dark scalar particles produced by the interaction of the Jefferson Lab 11 GeV intense electron beam with the experimental Hall-A beam dump. Considering the possible beam energy upgrade, this study was repeated for a 22 GeV CEBAF beam.



Citation: Battaglieri, M.; Bianconi, A.; Bondi, M.; De Vita, R.; Fulci, A.; Gosta,

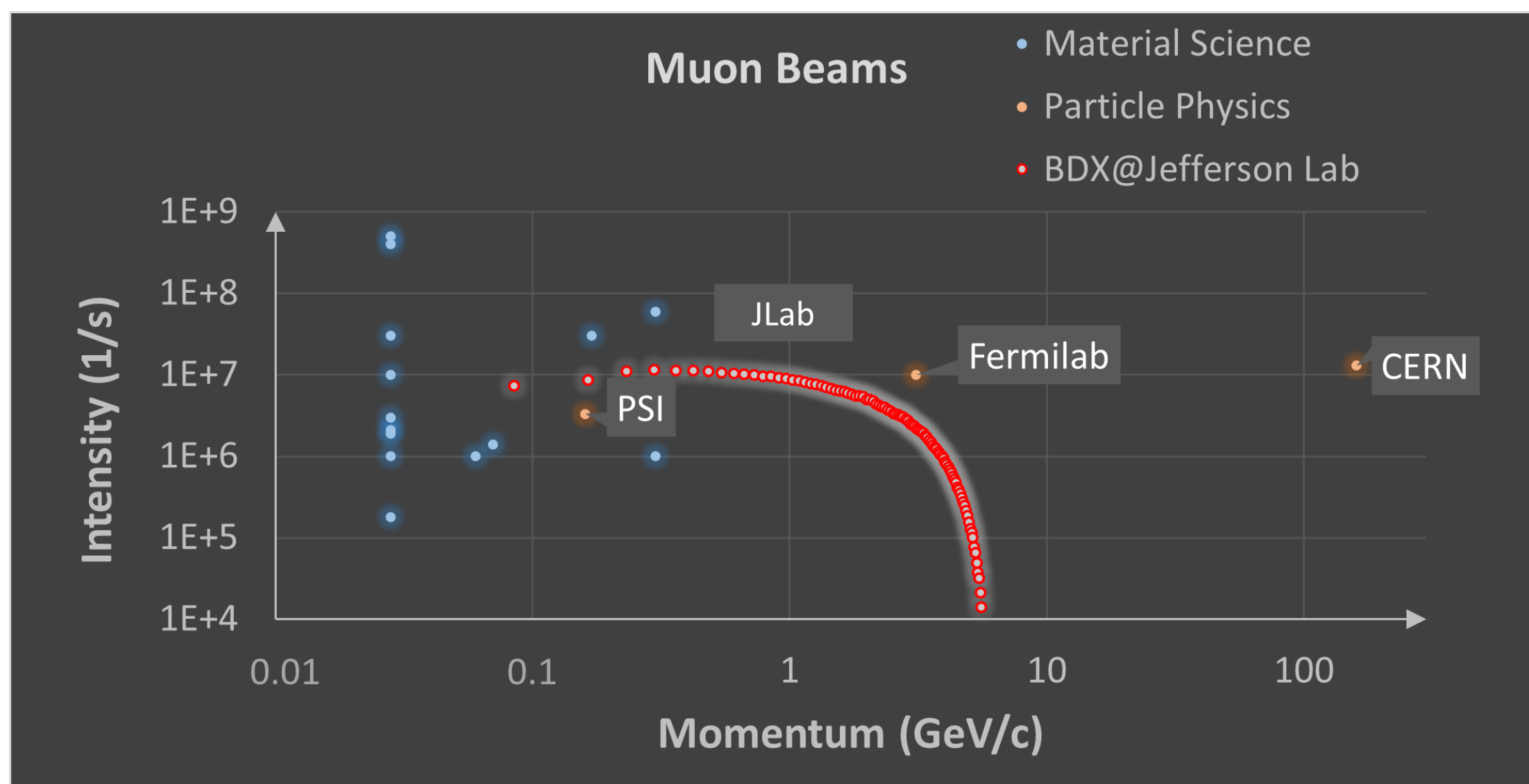
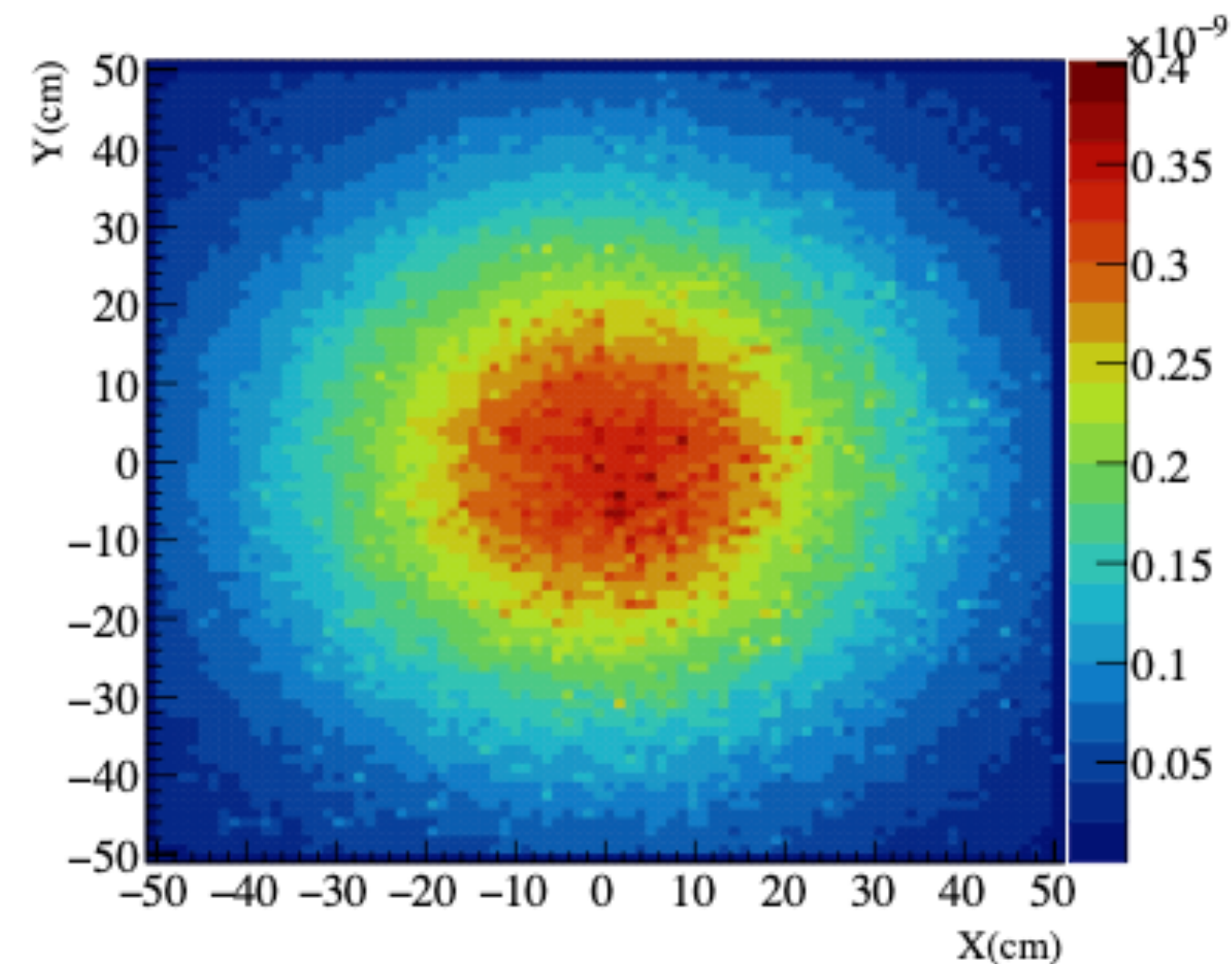
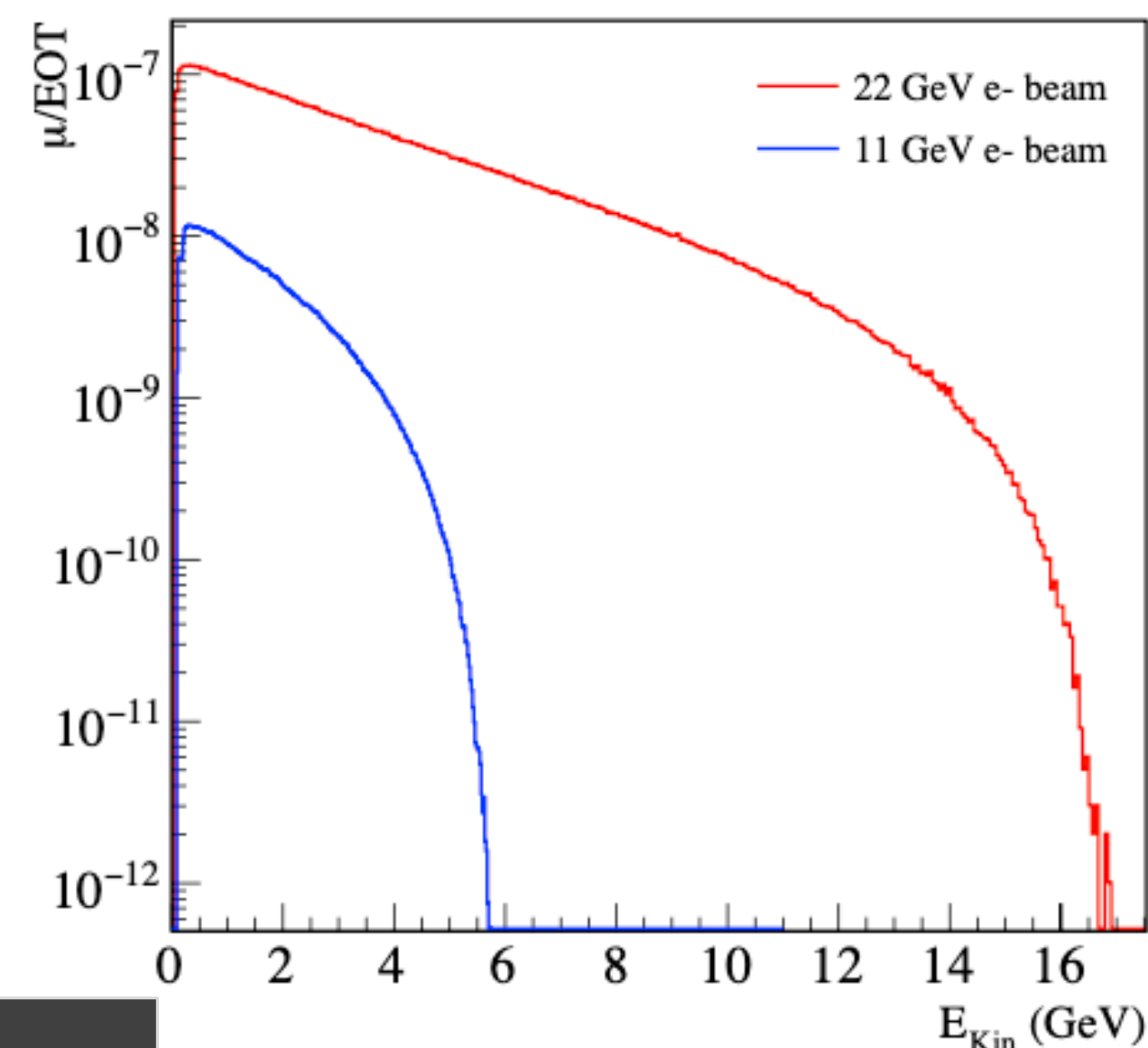
Keywords: intensity frontier; neutrino interaction; dark matter; BSM physics; muon beam

■ Simulation Framework:

- FLUKA/GEANT4: interaction of 11 GeV (22 GeV) e- beam with Hall-A BD and subsequent transportation of the secondary particles

Muon flux @ JLAB-HALL-A

- The flux increases with the energy of primary beam:
 - Muon flux (11 GeV e- beam): $9E-7 \mu/EOT$
 - Rate $\sim 3E8 \mu/s$
 - Muon flux (22 GeV e- beam): $5E-6 \mu/EOT$
 - Rate $\sim 2E9 \mu/s$
 - Muon flux profile σ_x and $\sigma_y \sim 20 \text{ cm}$

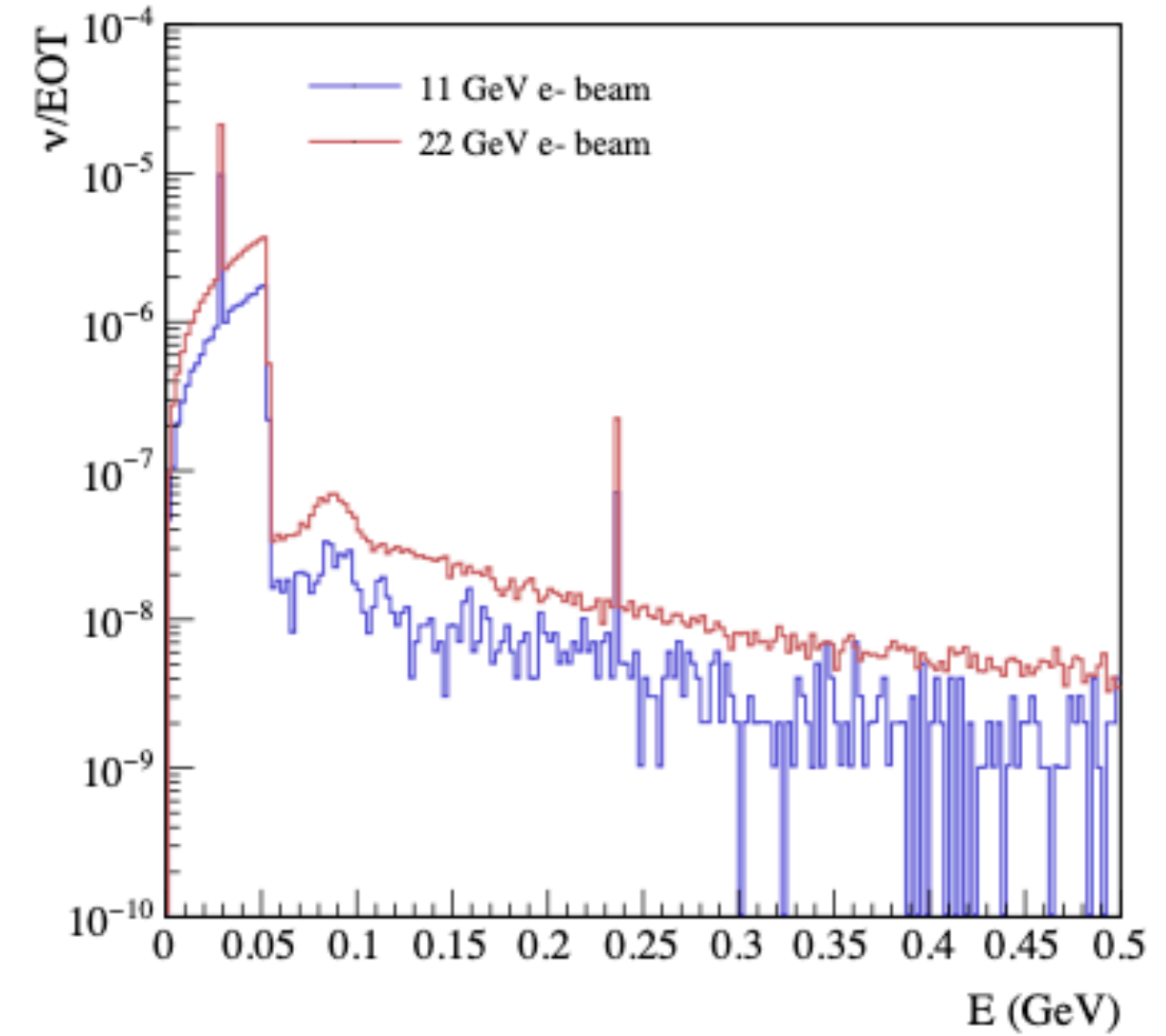
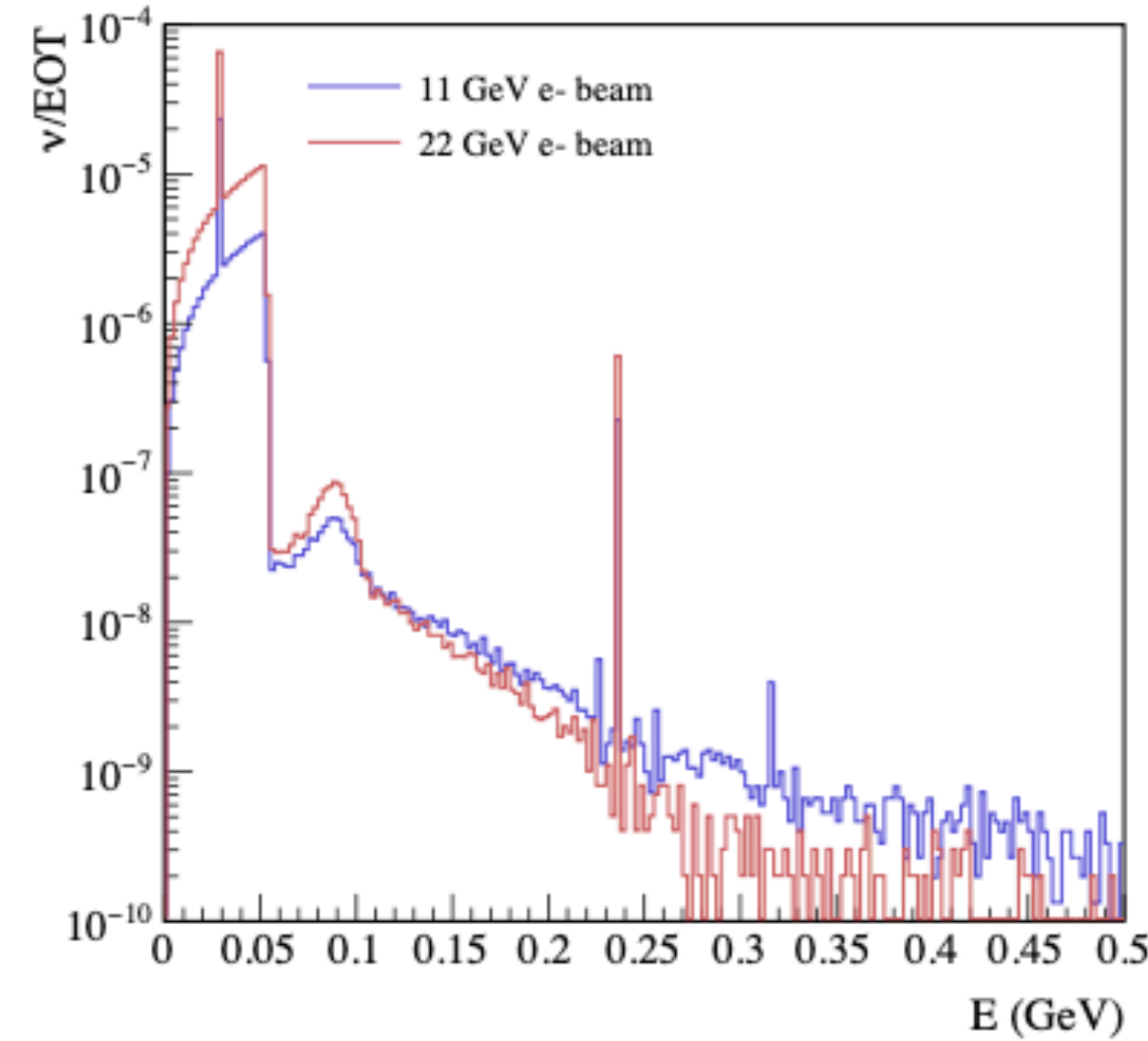


Physics case:

- Probing muon-philic forces: Use the secondary muon beam to produce exotic particles accounting for g-2 anomaly
- Proton radius measurement with muon beam

We plan to organize a dedicated Workshop @ JLAB

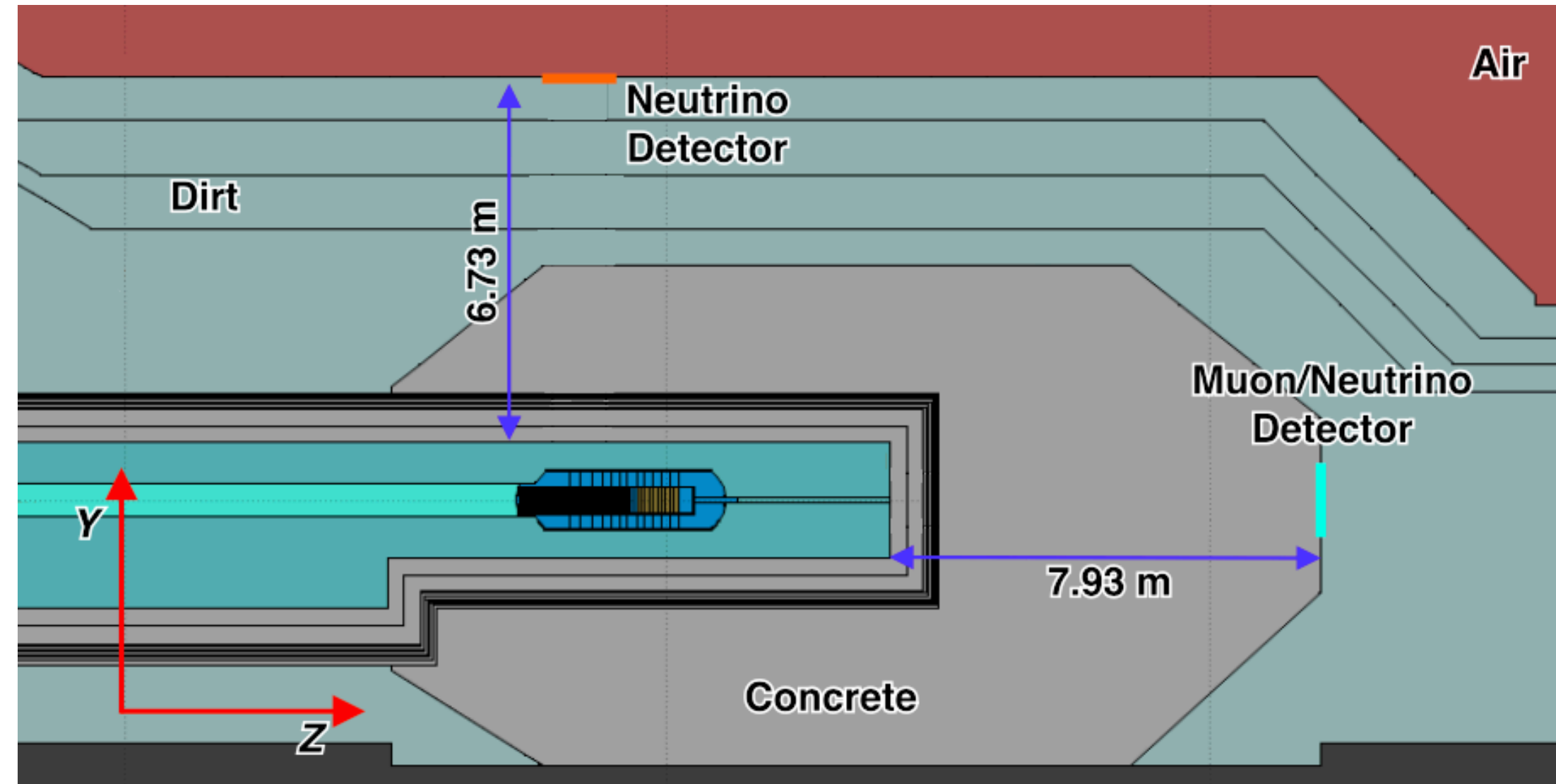
- Neutrino flux estimated using FLUKA for 11 GeV and 22 GeV primary e- beam on Hall-A BD
- Flux on-axis scored on a plane downstream Hall-A dump
- Flux off-axis scored on a plane perpendicular to the dump



Beam Energy	Off-Axis Flux [$\nu/EOT/m^2$]	On-Axis Flux [$\nu/EOT/m^2$]
11 GeV	6.7×10^{-5}	2.9×10^{-5}
22 GeV	1.9×10^{-4}	6.3×10^{-5}

- Physics case:
- CEvNS measurement using flux-off axis

We plan to organize a dedicated Workshop @ JLAB



- This project is a spin-off of BDX: from the beam-related backgrounds to the secondary beams exploration
- The article “ M. Battaglieri et al, Secondary Beams at High-Intensity Electron Accelerator Facilities, *Instruments* 2024, 8(1), 1; <https://doi.org/10.3390/instruments8010001>" has been published
 - **Milestone 2024 : 100%**
- JLAB management is demonstrating a keen interest in the exciting potential of secondary beams
 - JLAB management wants to organize, with our support, a workshop “BDX and Beyond” dedicated to explore new opportunities triggered by secondary beams
 - Goal of the workshop: to attract “new” communities and shape a well-defined physics program

LB