In vivo measurement of Pb-210 activity in skull to reconstruct cumulative radon exposure by the TRACE group

Yuanyuan Liu[1,2,3*], Bin Wu[1,2,3*], Xiangpeng Meng[2,3,4], Yu Wang[2,3,5], Congchong Yan[6], Lai Zhou[1,2,3], Ju Ao[1,2,3], Jiali Qian[1,2,3], Sirun Gong[1,2,3], Jianping Cheng[1,2,3]

1 Joint Laboratory of Jinping Ultra-low Radiation Background Measurement of Ministry of Ecology and Environment Beijing Normal University, Beijing Normal University, Beijing, 100875, China

2 Jinping Deep Underground Frontier Science and Dark Matter Key Laboratory of Sichuan Province, Liangshan, 615000, China

3 Key Laboratory of Beam Technology of Ministry of Education, Beijing, 100875, China

4 Department of Engineering Physics, Tsinghua University, Beijing, 100084, China

5 School of Nuclear Science and Technology, University of South China, Hengyang, 421001, China

6 School of Radiation Medicine and Protection, Suzhou Medical College of Soochow University, Suzhou, 215031, China

Evaluating the health effects of low-dose ionizing radiation exposure in humans remains one of the major challenges in radiation protection. In particular, assessing health risks associated with chronic low-dose radon exposure is a key issue. Radon is the second leading cause of lung cancer after smoking. The World Health Organization reports that 3%-14% of lung cancer cases can be attributed to radon exposure. Previous studies suggest that lung cancer risk is associated with cumulative radon exposure. The accurate assessment of cumulative radon exposure remains challenging because related factors such as radon concentration, breathing rate, and residence time carry significant uncertainties. Since skeletal Pb-210 has been proposed as a potential biomarker of chronic radon exposure, in vivo measurement of Pb-210 activity in skull is being investigated as a promising approach to reconstruct cumulative radon exposure.

However, several challenges remain: (1) Pb-210 in skull exists at trace levels, resulting in a low signal-to-noise ratio (~1/100) in the detector and strong susceptibility to background interference; (2) inter-individual anatomical differences complicate accurate calibration of detection efficiency; and (3) Pb-210 originates from multiple intake sources and follows complex biokinetic processes, making the attribution of Pb-210 to radon exposure difficult. To address these challenges, in an ultra-low radiation background environment provided by the China Jinping Underground Laboratory, the TRACE (Trace-level RAdionuclides in vivo Counting Experiment) group has conducted a series of studies on background suppression, efficiency calibration for Pb-210 in skull, and the development of Pb-210 biokinetic model. In vivo measurements of Pb-210 activity in skull have also been performed in multiple volunteers. Moreover, data from TRACE studies have been adopted by the Chinese Center for Disease Control and Prevention as an important scientific basis for the national standard, *Diagnostic Standard for Lung Cancer Induced by Occupational Radon Exposure*.

*Corresponding author：Yuanyuan Liu, email: yyliu@bnu.edu.cn; Bin Wu, email: bwu6@bnu.edu.cn.

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