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GUESS: a 3D crustal model of Central Italy for geoneutrino physics

Virginia Strati[1,2], Lorenzo Rossi[3], Alberta Albertella[3], Mauro Buttinelli[4], Martina Capponi[5], Paolo Conti[6], Andrea Ermini[6,7], Francesco Emanuele Maesano[4], Roberta Maffucci[4], Fabio Mantovani[1,2], Luca Pagano[1,2], Sabah Ramouz[3], Kassandra Giulia Cristina Raptis[1,2], Mirko Reguzzoni[3], Riccardo Salvini[6], Daniele Sampietro[5], Pegah Solemani Dinani[6], and Mara Monica Tiberti[4]

[1]University of Ferrara, Physics and Earth Sciences Department, Ferrara, Italy (strati@fe.infn.it)

[2]INFN, Ferrara Section, Ferrara, Italy

[3]Politecnico di Milano, Milan, Italy

[4]National Institute of Geophysics and Volcanology (INGV), Rome, Italy

[5]Geomatics Research & Development s.r.l., Lomazzo (CO), Italy

[6]Department of Physical Sciences, Earth and Environment and Centre of Geotechnologies (CGT), University of Siena, San Giovanni Valdarno (AR), Italy

[7]University of Trento - National PhD Program in Space Science and Technology, Trento, Italy

Geoneutrinos, electron antineutrinos produced by the radioactive decay of Uranium (U) and Thorium (Th), offer a unique real-time window into the Earth's interior composition and radiogenic heat budget. These particles are detected by large-volume underground scintillators where cosmic ray backgrounds are minimized. However, the lack of directional sensitivity in current liquid scintillator detectors, such as Borexino (Gran Sasso massif, Italy), results in a signal degeneracy that necessitates highly accurate models of the local lithosphere to isolate the mantle contribution.

In the framework of the GUESS project (GeoneUtrinos: mESSengers of the Earth's interior), we present a high-resolution 3D geophysical model of Central Italy specifically tailored for geoneutrino signal prediction. Addressing the limitations of previous models, this work adopts a joint multi-disciplinary approach.

The "GUESS model" is computed inverting ground gravity data integrating heterogeneous datasets as prior information in a Bayesian framework. The geological and geophysical prior datasets include: 1D stratigraphic data from deep exploration wells; 2D interpreted seismic profiles and geological cross-sections; 3D passive seismic data (receiver functions) to constrain the Moho discontinuity. This probabilistic framework discretizes the crust into six lithological units, from Quaternary volcanics to the Lower Crust, and explores high-dimensional solution spaces in terms of both geometry and density distribution via simulated annealing. This methodology not only optimizes mass and volume estimates according to both gravity and geophysical data but also provides a quantification of estimation uncertainties by Monte Carlo samples. This workflow demonstrates how the integration of potential field data with seismic and geological constraints provides a robust, geodynamically realistic architecture, advancing both neutrino geoscience and

our understanding of complex lithospheric structures.

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