Mineral Track Detection Activities at University College London

David Waters & Pieter Vermeesch
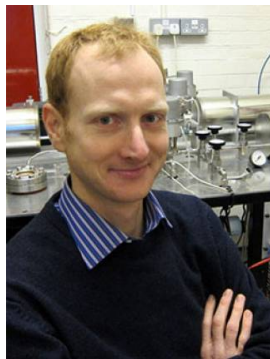
University College London

9 January 2024

Who Are We ?

Prof. David Waters

Head of High Energy Physics, Department of Physics & Astronomy, UCL

Prof. Pieter Vermeesch

Director, London Geochronology Centre, Department of Earth Sciences, UCL

Our Day Jobs …

- ▶ Neutrino physics.
- ▶ Low-background physics: SuperNEMO, LEGEND, radiopurity screening etc.

- ▶ Geochronology.
- ▶ Cosmogenic nuclides, fission tracks, U-Th-He dating, etc.

LOREX - see separate presentation.

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Solar Neutrinos: Proposal for a New Test

Abstract. *The predicted flux on the earth of solar neutrinos has eluded detection, confounding current ideas of solar energy production by nuclear fusion. The dominant low-energy component of that flux can be detected by mass-spectrometric assay of the induced tiny concentration of 1.6×10^7 year lead-205 in old thallium minerals. Comments are solicited from those in all relevant disciplines.*

$$^{205}\text{Tl}(\nu, e^-)^{205}\text{Pb}$$

$$t_{1/2}(^{205}\text{Pb}) = 16 \text{ Myr}$$

Determining erosion rates in Allchar (Macedonia) to revive the lorandite neutrino experiment

Pieter Vermeesch[1], Martin Rittner[1], Irene Schimmelpfennig[2], Lucilla Benedetti[2], ASTER Team[2,†]

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[2]Aix-Marseille Université, CNRS, IRD, Coll. France, UM 34 CEREGE, Technopôle de l'Environnement Arbois-Méditerranée, BP 80, 13545 Aix-en-Provence, France

MSci project 2021-22

1. Familiarise ourselves with the literature.
2. Get to grips with packages such as `SRIM` and reproduce many results from the existing papers.
3. Initiate feasibility studies for detecting neutrinos from an artificial source to validate the concept of paleo-neutrino detection.
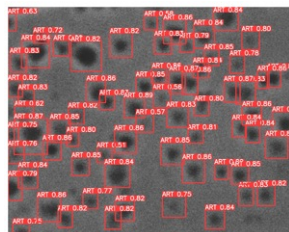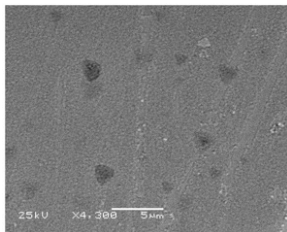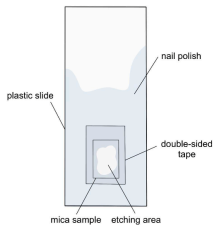
Nathan Higginbotham
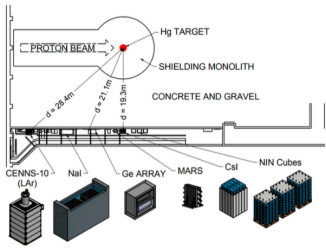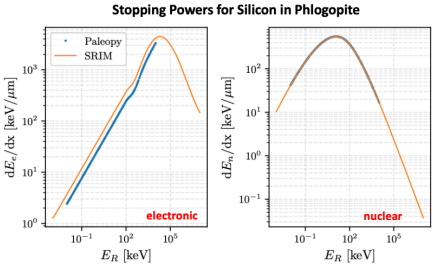
MSci project 2022-23

1. Perform some preliminary experiments with mica etching and microscopy. We are confident that we can see alpha recoil track signatures.
2. Initial attempts at machine-learning approaches to the analysis of microscope images.

Tiemothy Wuisan

UCL Facilities and Expertise

London Geochronology Centre

1. *Fission track analysis*
   Zeiss AxioImager M2m

2. *(U-Th)/He dating*
   IR laser extraction,
   ^{4}He/^{3}He-spike, Hiden
   quadrupole mass analyser

3. *U/Pb geochronology*
   UV laser ablation + Agilent
   7900x ICP-MS

4. *Noble gas geochemistry*
   Noblesse multicollector MS

5. Mineral separation facilities,
   Scanning Electron Microscope,
   ...

High-Energy Physics Group

1. Radiopurity assay facilities
   (ICP-MS, HPGe, radon and
   alpha-spectrometry). Some are
   local to UCL, others at the Boulby
   underground laboratory.

2. Centre for Doctoral Training in
   Data Intensive Science: big-data
   and machine-learning.

Other Scanning Facilities:

1. UCL : SAX, TEM, AFM, nano-CT

2. National : SAX (Diamond light
   source)

UCL Facilities
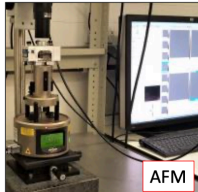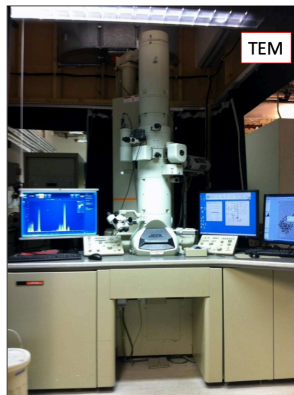
Our plans

1. Systematic investigation of scanning methodologies - the key to unlocking larger target masses with more precision:
    1.1 Using previously listed local/national facilities.
    1.2 Machine-learning enhanced analysis pipelines.
2. One scientist's background is another's signal:
    2.1 Expose samples to cosmic-rays/artificial sources. ART analysis.
    2.2 Assess the backgrounds to physics signals, while at the same time expanding their use as geochronological tools.
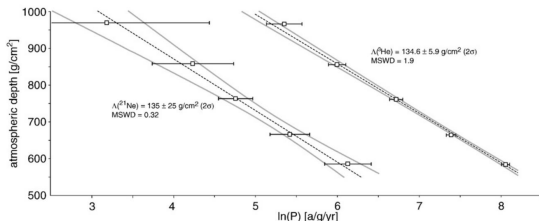
left: ARTs under the SEM, right: cosmogenic ^{3}He and ^{21}Ne in artificial quartz targets (http://dx.doi.org/10.1016/j.epsl.2009.05.007)