National Aeronautics and
Space Administration

Hardware Assembly Assurance Activities: Radiation Testing of the Handheld Universal Lunar Camera (HULC) for Artemis

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Outline

- Motivations
- Radiation test campaigns
- Assembly level risk quantification
- Takeaways for future endeavors

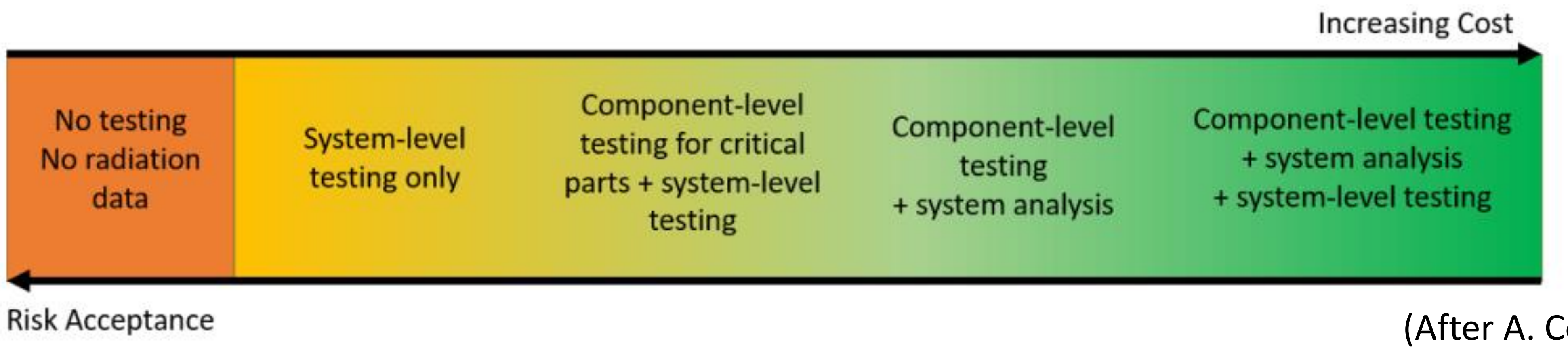
Earthrise Credit: NASA

Motivations

- The Handheld Universal Lunar Camera (HULC) is built on a COTS Nikon Z9 platform and will provide the next opportunity to capture the next *Earthrise* photo
- Radiation environments are challenging for modern electronics.
- While COTS products provide a cheap and easy solution for many space applications, most are susceptible to effects of ionizing radiation.
- Such COTS systems often require modification, yet programs do not want to incur large cost and schedule impacts.
- MSFC provides project and engineering support for the Handheld Camera Project, which covers ISS & Artemis IVA / EVA (used for still imagery and video)
- A common camera reduces mass and cost while also simplifying training, mission planning, and ground operations

Z9 Teardown Credit: Kolari Vision

Understanding return on investment

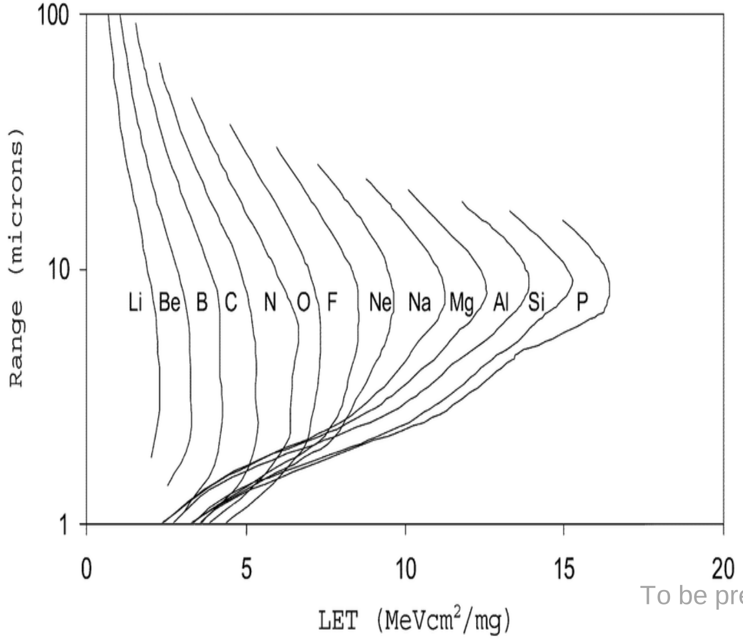


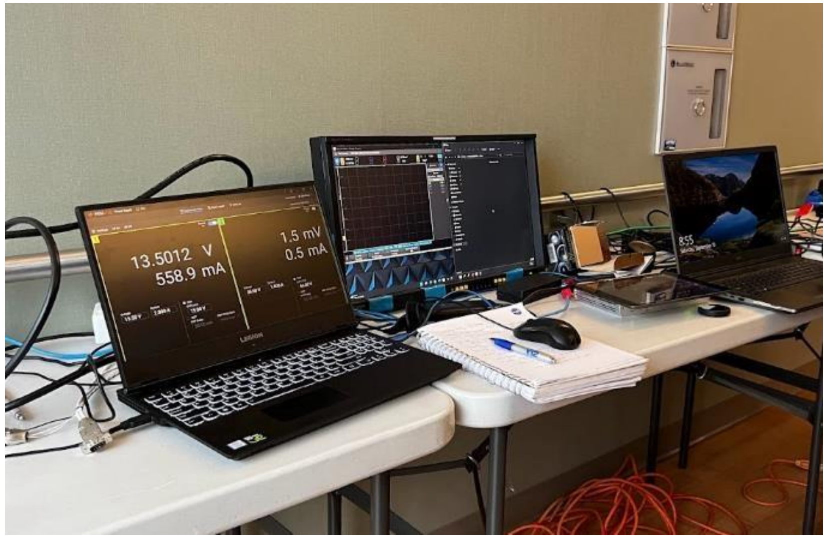
(After A. Coronetti)

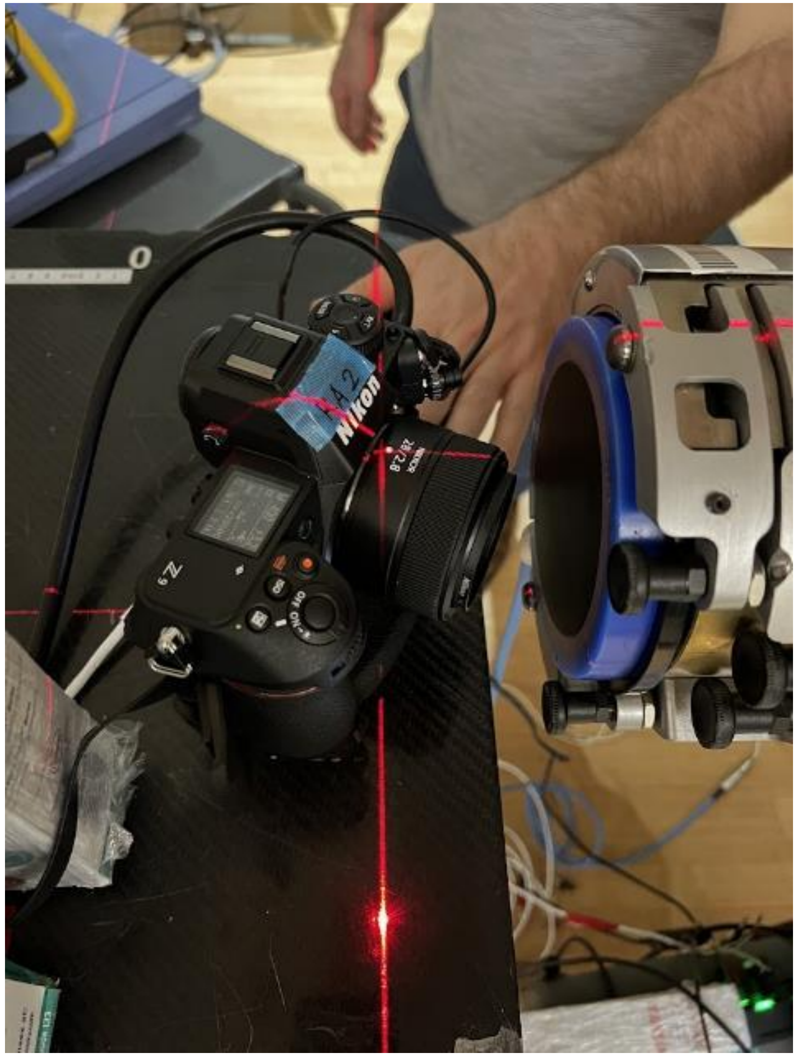
- For this program adoption of risk and cost savings are both necessary for mission success criteria
- One test does not answer the question or inform engineering trades sufficiently
- In order to most effectively gain insight and meet schedule, a tailored test campaign is necessary

Proton testing of the full assembly

- 200 MeV medical proton sources more available than heavy ions typically
  - Drawback: Certainty of LET that caused the effect?
  - Insight: Identification of softest components
- Feasibility study conducted by MSFC
  - Interruptions characterized
  - Failures found – post test failure analysis became necessary

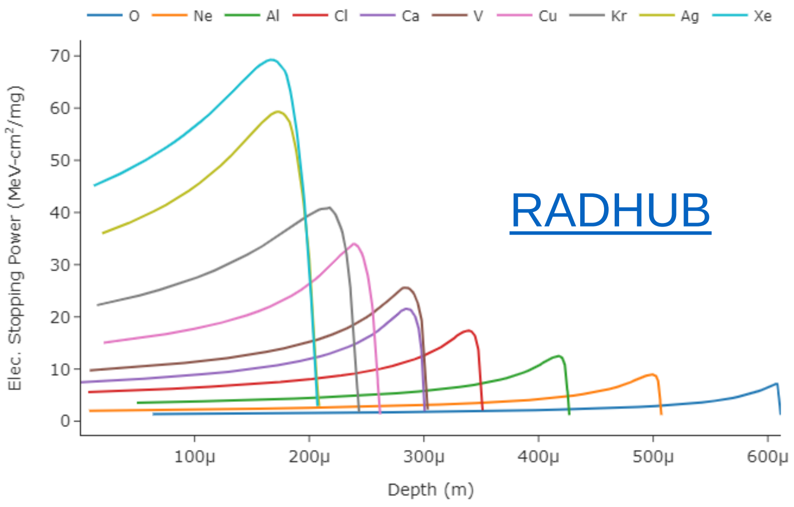




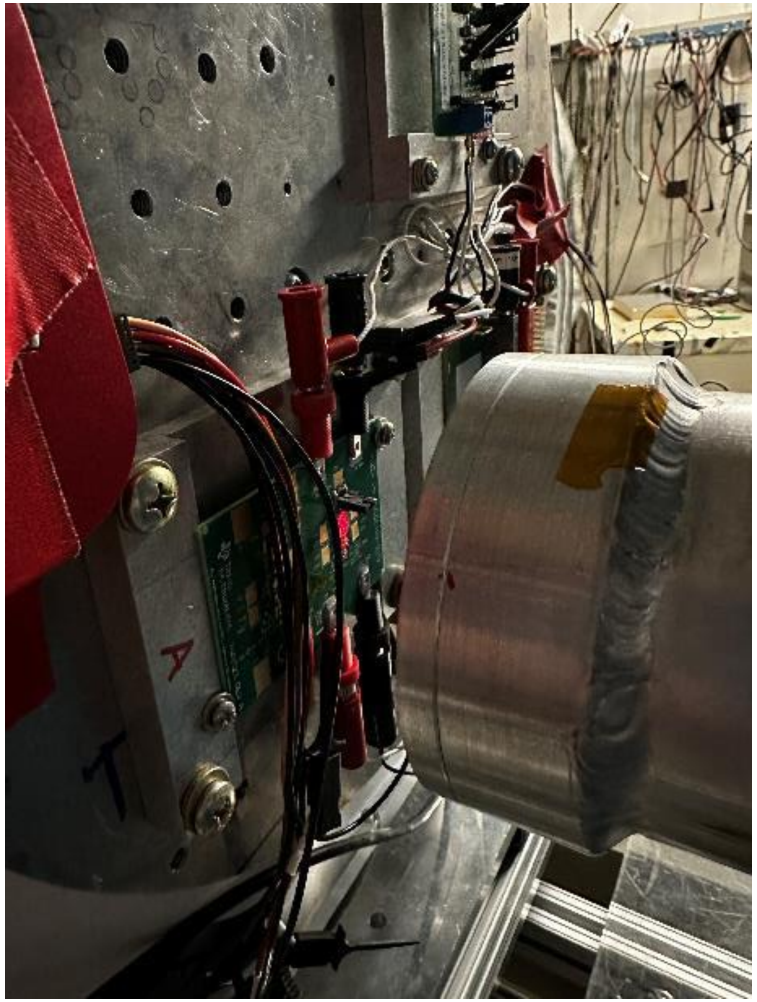


Heavy ion testing

- Lawrence Berkeley National Lab (LBNL) piece-part testing
  - Drawback: device under test preparation cost
  - Insight: rate predictions / comparison
- With manufacturer support
  - Focusing on candidate components for replacement and devices that could not be replaced
  - This will inform feedback into design change suggestions

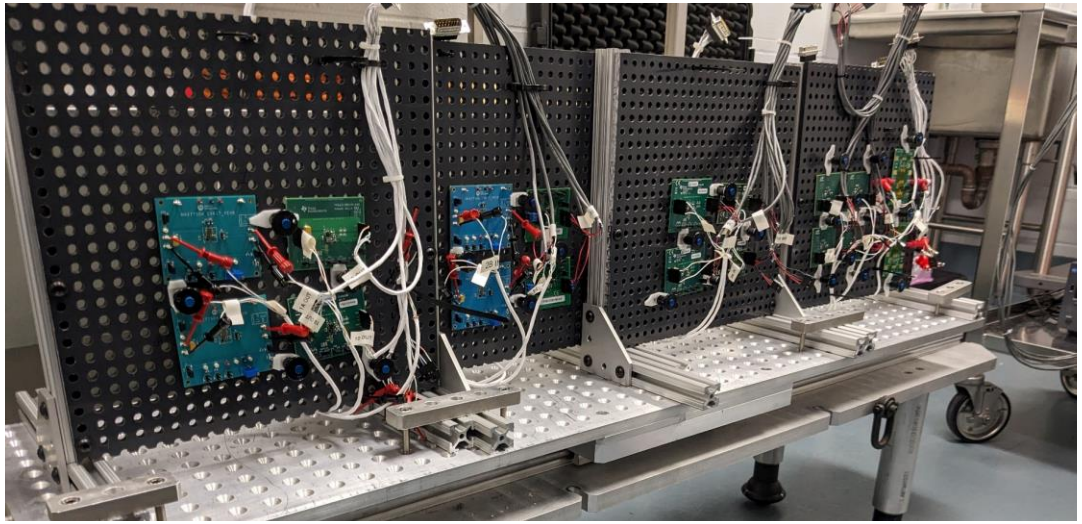


[RADHUB]

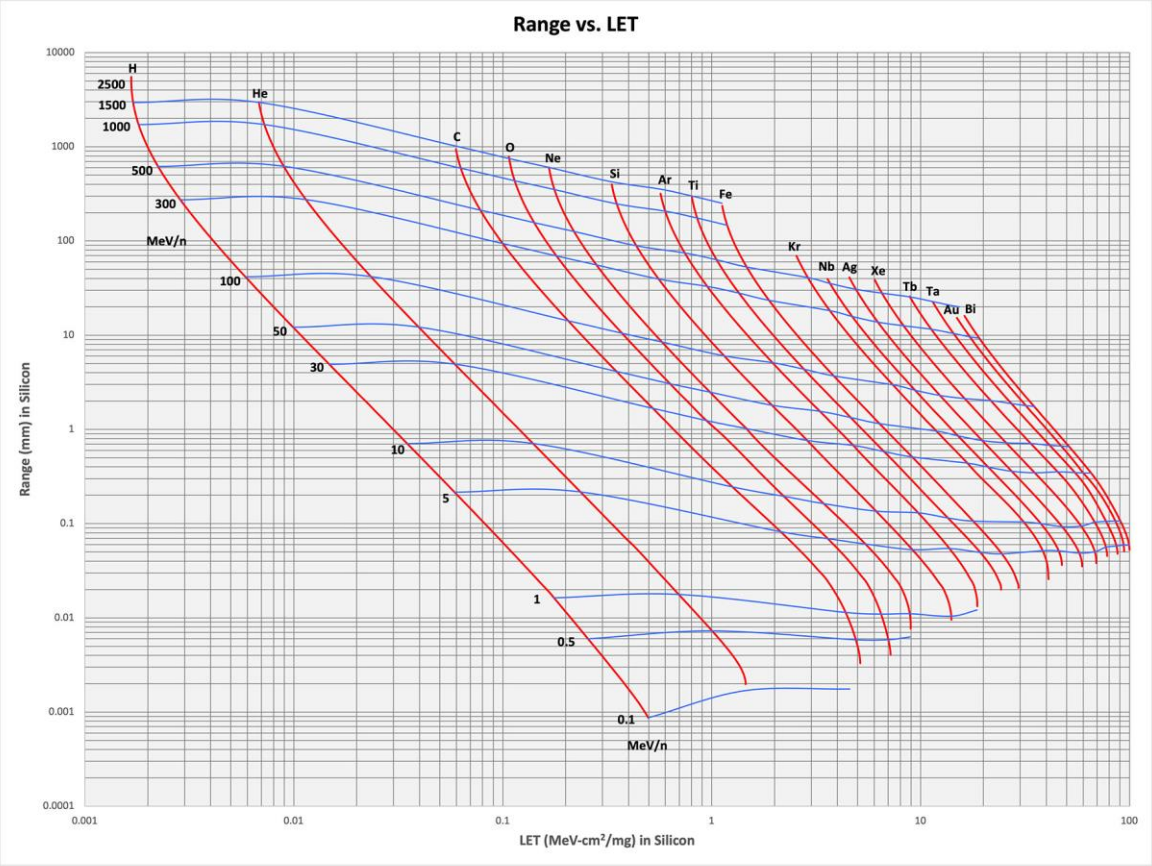


Piece-part testing refined

- NASA Space Radiation Lab (NSRL)
  - Drawback: expensive! Synchrotron vs. Cyclotron
  - Insight: ion energies and deposition most similar to space environment, no need to de-encapsulate
- Larger sample sizes of down-selected components
- Possible design changes (supply voltages, current)



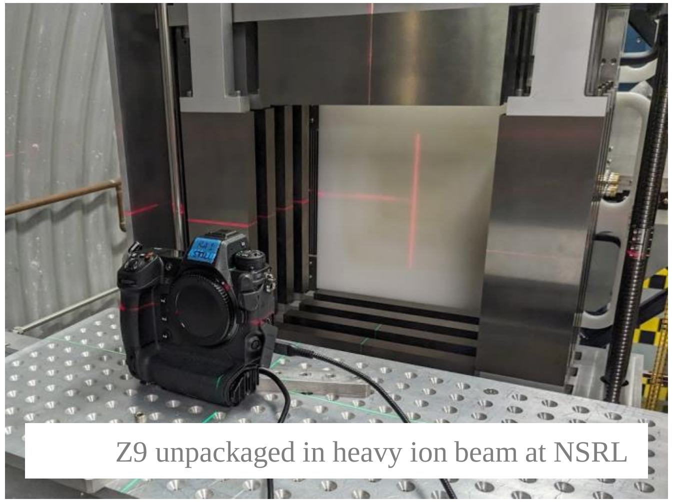
Piece-part heavy ion testing at NSRL



[BNL | NSRL User Guide]

Finalizing an assembly level test

- Challenge is design of test
  - Use case and availability constraints needed
  - Concept of operations and human interfacing
- Final test campaigns will include
  - Update to build, firmware
  - Exploration of operational modes
  - Down-selected choice for compact flash

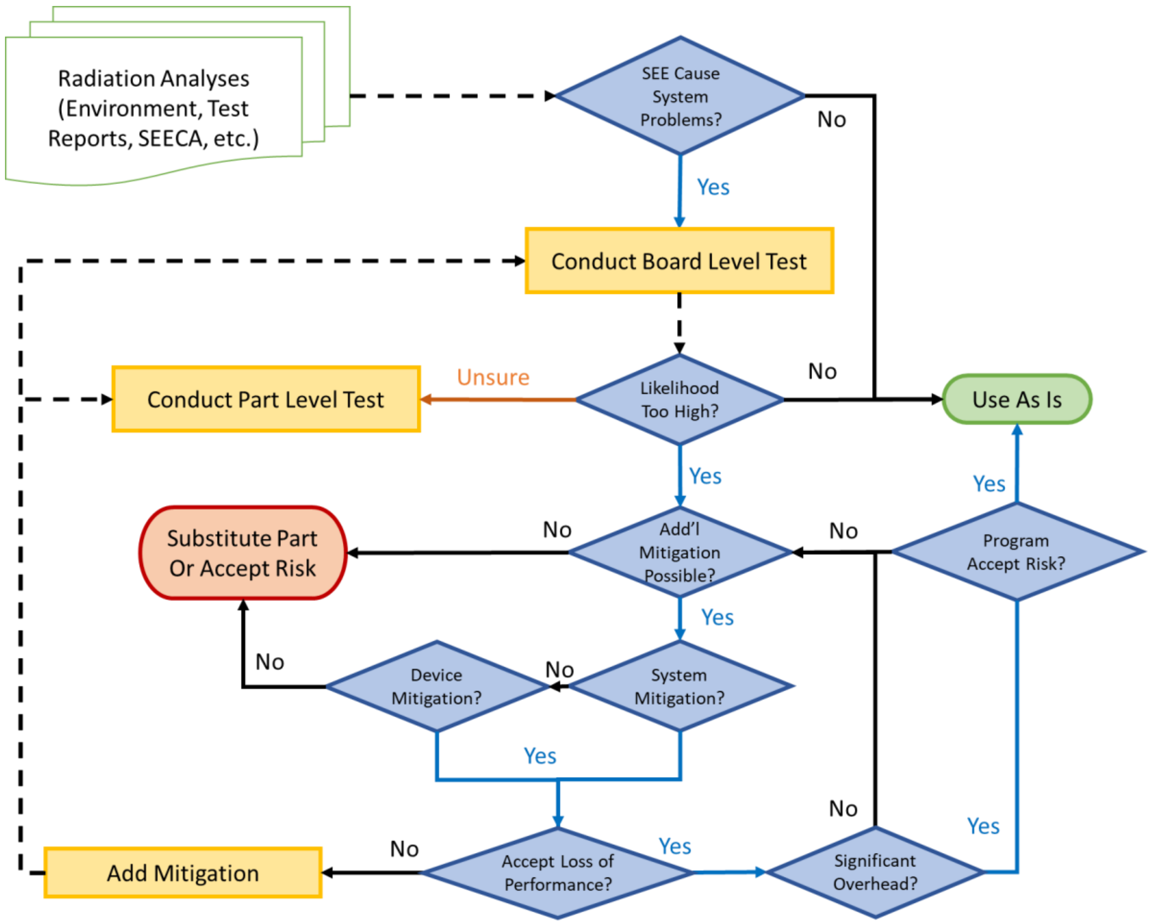


Z9 unpackaged in heavy ion beam at NSRL

Z9 unpackaged in heavy ion beam at GSI – Credit:MSFC

Decisions, decisions

- How do you go about testing a complex system of systems?
- Notional threats from commercially available components suggest that [no radiation data](#) is too high of a risk in the space radiation environment
- Published: [A Methodology for Cost Effective Radiation Characterization of COTS Hardware for Space Use](#)



Findings

- We had knowledge that our testing would be in search of an iterative solution from the start, but not how many
- System-level testing does not equate to cheaper alternative
- Highest susceptibility that will remain are tied to technologies that are unique to specific hardware like LCD screen driver IC
- Conservatism associated with full system results is dramatically improved by piece-part understanding

Thank you!