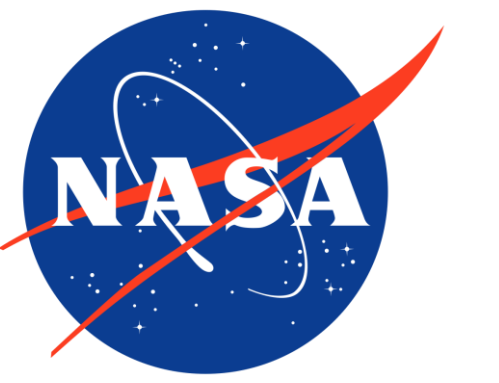


# Verification of Electron Beam Irradiation as a Lipid Decontamination Method for Life Detection Instrumentation



Denise Buckner (Blue Marble Space Institute of Science, [denise.buckner@und.edu](mailto:denise.buckner@und.edu)); Mary Beth Wilhelm (NASA-ARC); Michael Gaffey (University of North Dakota); Antonio Ricco (NASA-ARC); Margaret Abraham (Aerospace Corporation)

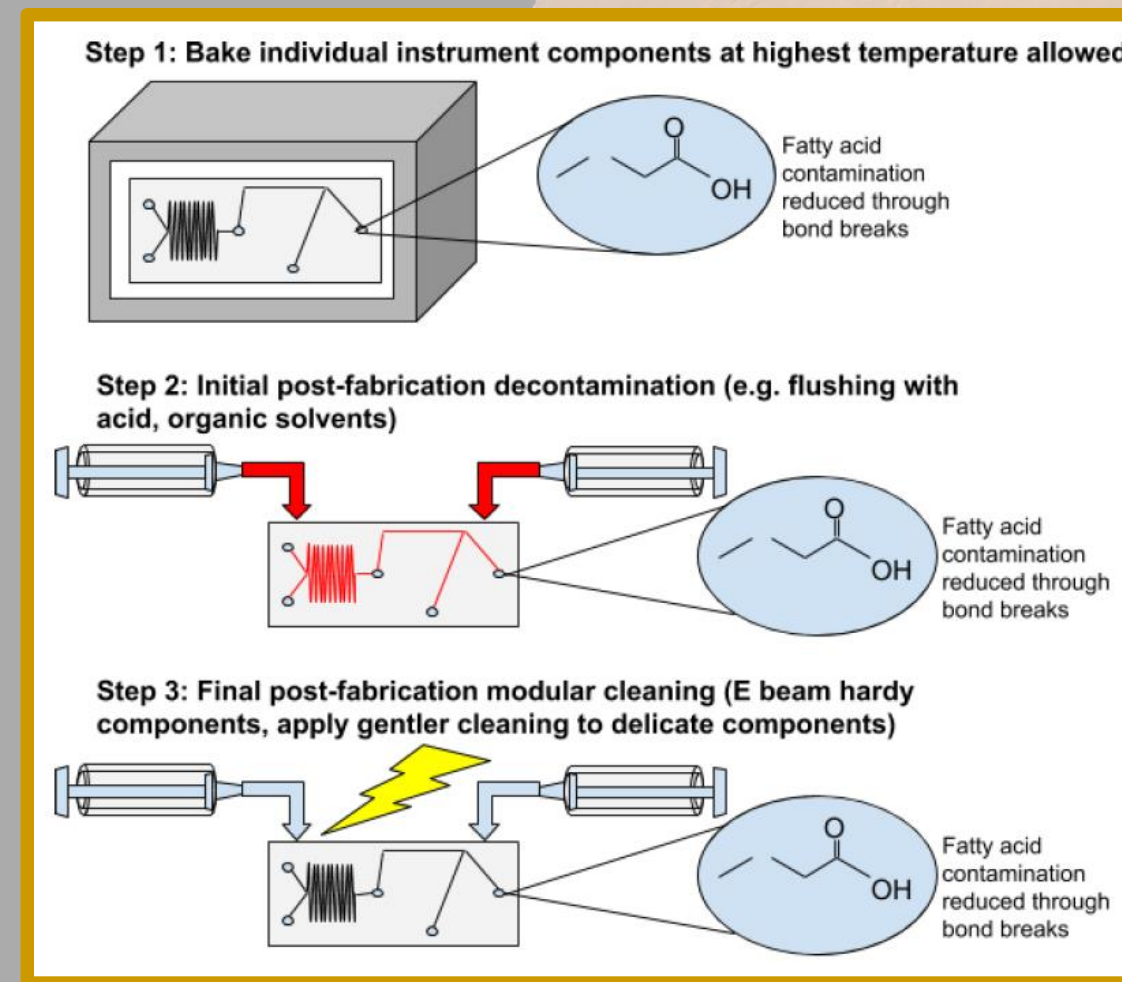


## OVERVIEW

We studied **Electron Beam Irradiation (EBI)** as a potential decontamination technique for destroying molecular lipid contaminants from the **Extractor for Chemical Analysis of Lipid Biomarkers in Regolith (ExCALiBR)**, our novel life detection instrument. We found EBI was unable to significantly degrade lipids at doses tolerable by instrument materials and should not be implemented for lipid CC. However, resistance to degradation suggests that lipids are an ideal biomarker, and further research is needed to determine longevity in planetary environments experiencing high electron fluxes. (Fig 1,2)



**Figure 1:** ExCALiBR prototype: our novel, non-aqueous lipid extractor for life detection missions



**Figure 2:** Hypothesized CC plan for ExCALiBR, with EBI as a final, whole-instrument cleaning step

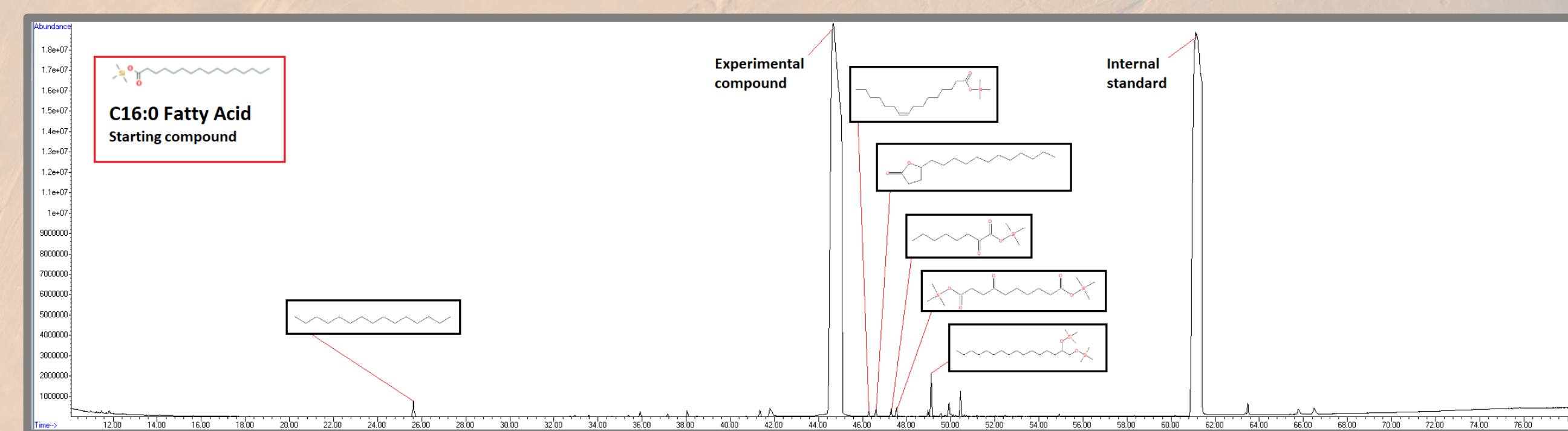
## METHODS

- Selected standards from representative classes of lipid biomarkers, including:
  - C16:0 saturated fatty acid (1-Pentadecanecarboxylic acid)**
  - C18:1 monounsaturated fatty acid (cis-9-Octadecenoic acid)**
  - C21 saturated alkane (Heneicosane)**
  - C27 saturated tetracyclitriterpene (5- $\alpha$ -Cholestane)**
  - C27 stanol (5 $\alpha$ -Cholestan-3 $\beta$ -ol)**
- Prepared samples for irradiation by dissolving lipids in  $\text{CH}_2\text{Cl}_2$ , partitioning aliquots into glass vials, and drying lipids down under pure  $\text{N}_2$  (Fig 3)
- Irradiated lipids at Steri-Tek<sup>TM</sup> expert sterilization services (Fig 4) under a DualBeam<sup>TM</sup> processor (10 MeV, 20 KW linear accelerator) at doses:
  - 5 kGy, 10 kGy, 25 kGy, 50 kGy, 100 kGy**
- Prepared samples for analysis by re-dissolving  $\text{CH}_2\text{Cl}_2$ , adding an internal standard, and derivatizing as needed
- Analyzed irradiated lipids via Gas Chromatography-Mass Spectrometry (GC-MS) (Fig 5-9)
  - Quantified percent reduction (Tables 1-5)
  - Identified radiolytic products

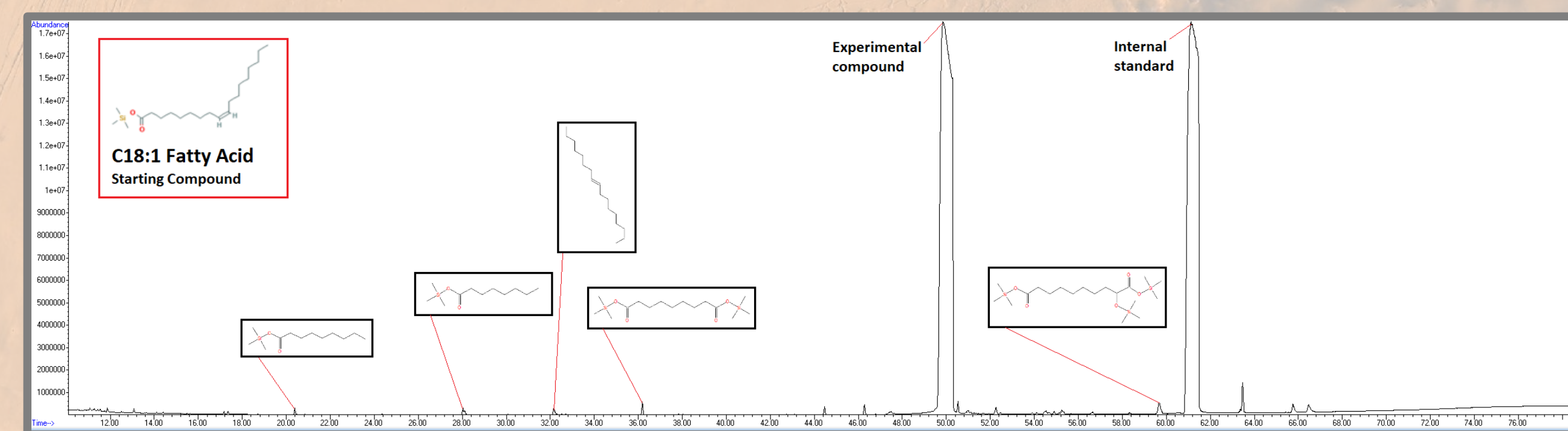
## LIPID BIOMARKERS

- Required for all life as we know it (primarily for comprising membranes that protect cells from water)
- Survive in the terrestrial geologic record for orders of magnitude longer than any other biomarker (~gyrs)
- Can form through biotic or abiotic processes
- Found on Earth, in meteorites, and likely on Mars and the moon
- Display origin-diagnostic features [1,2,3,4,5]

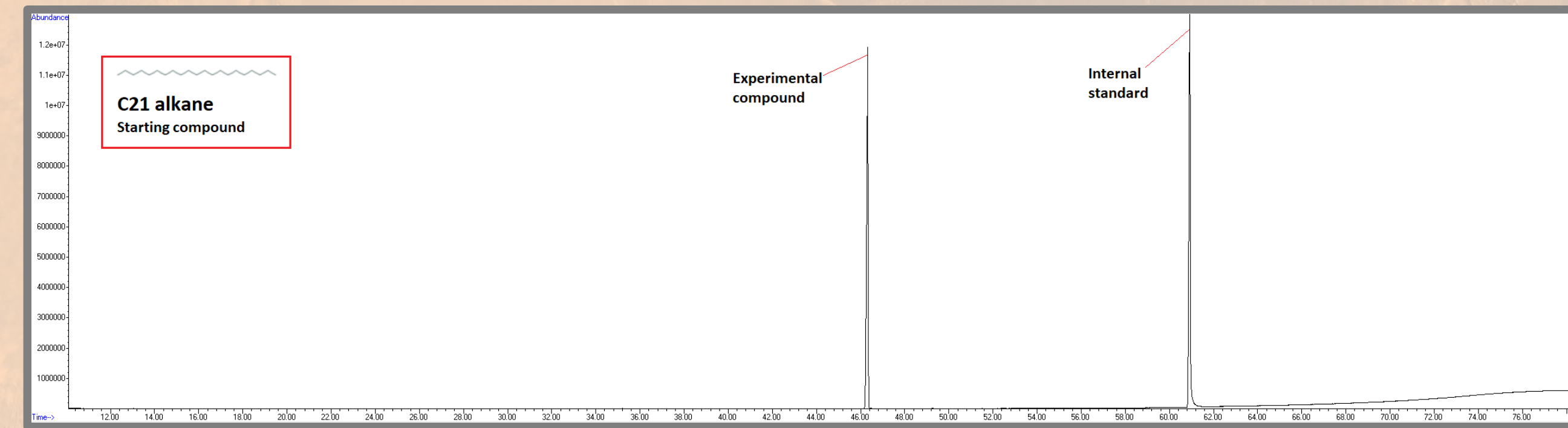
## RESULTS



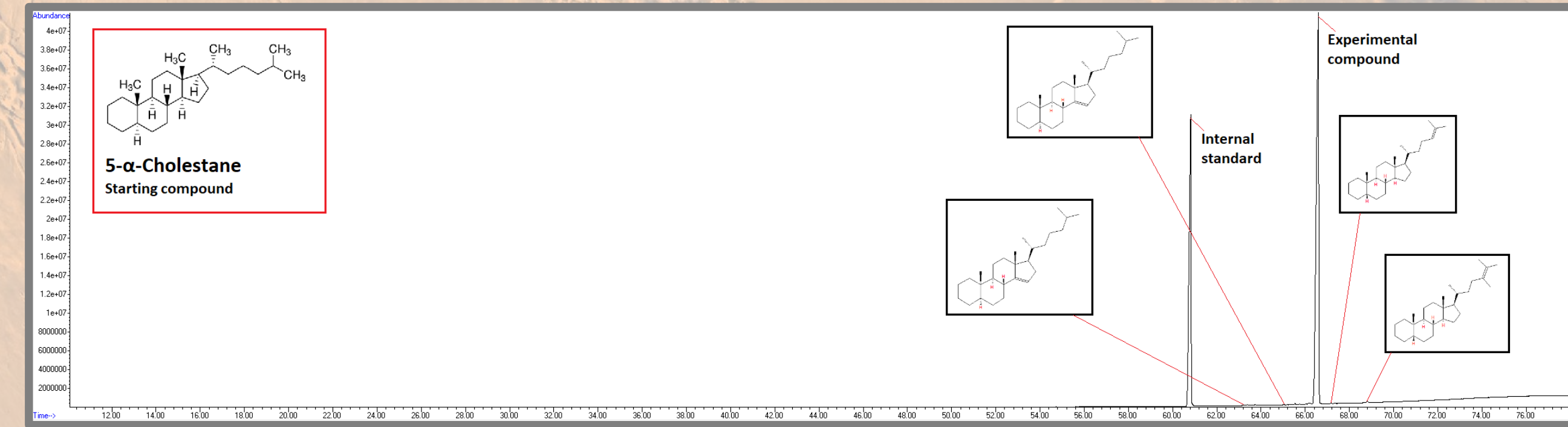
**Figure 5:** GC-MS chromatogram of C16:0 Fatty Acid standard following 100 kGy of irradiation; tallest peaks are experimental compound and internal standard by abundance, compounds in boxes are radiolytic products



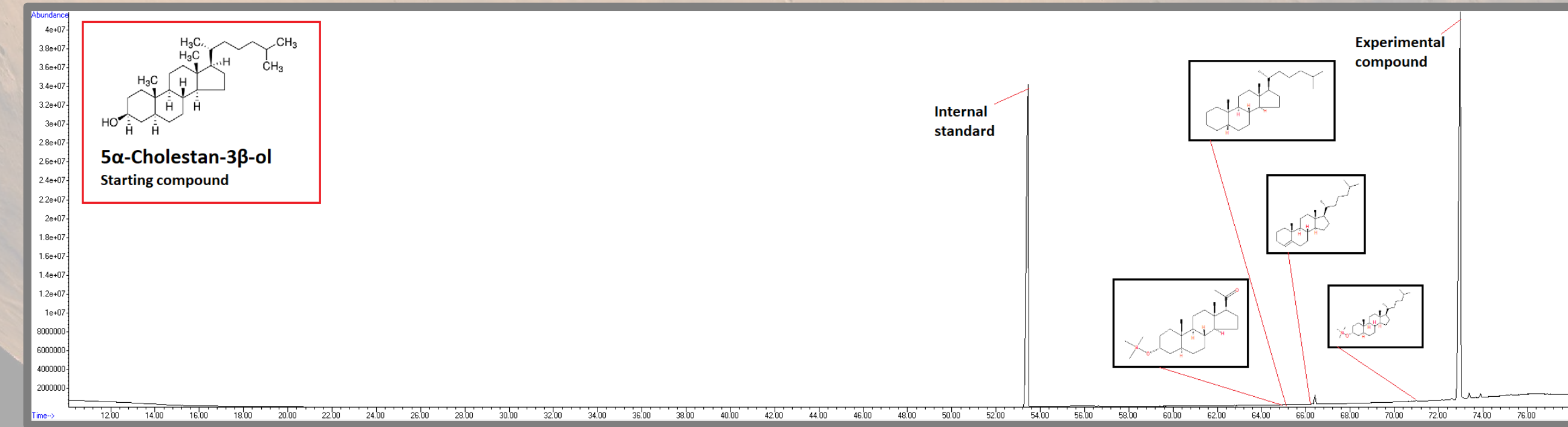
**Figure 6:** GC-MS chromatogram of C18:1 Fatty Acid standard following 100 kGy of irradiation; tallest peaks are experimental compound and internal standard by abundance, compounds in boxes are radiolytic products



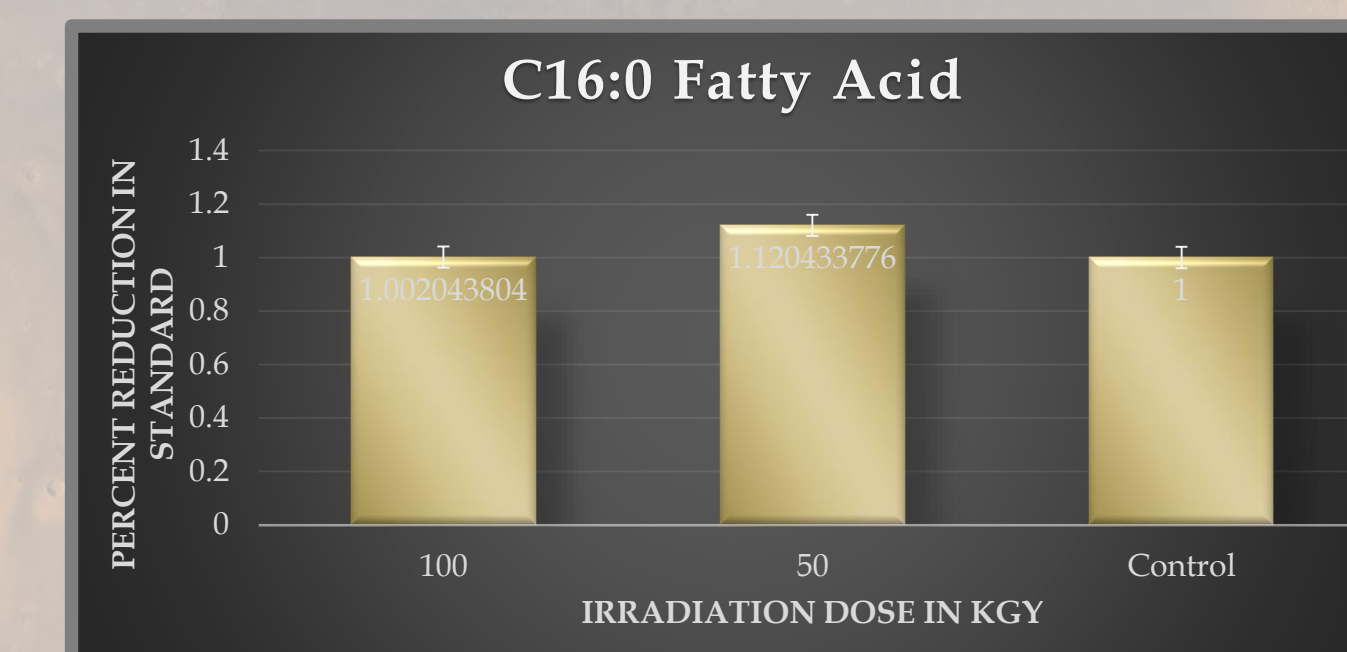
**Figure 7:** GC-MS chromatogram of C21 Alkane standard following 100 kGy of irradiation; tallest peaks are experimental compound and internal standard by abundance, no significant radiolytic products were resolved



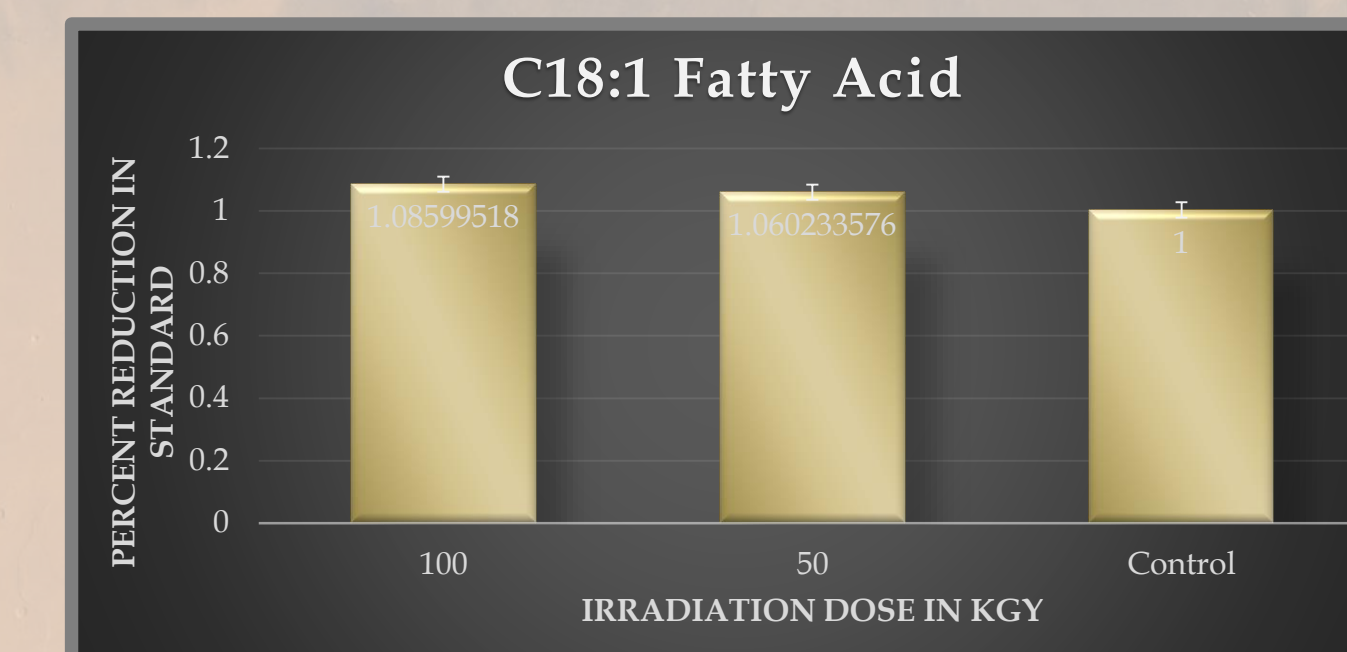
**Figure 8:** GC-MS chromatogram of C27 5- $\alpha$ -Cholestane standard following 100 kGy of irradiation; tallest peaks are experimental compound and internal standard by abundance, compounds in boxes are radiolytic products



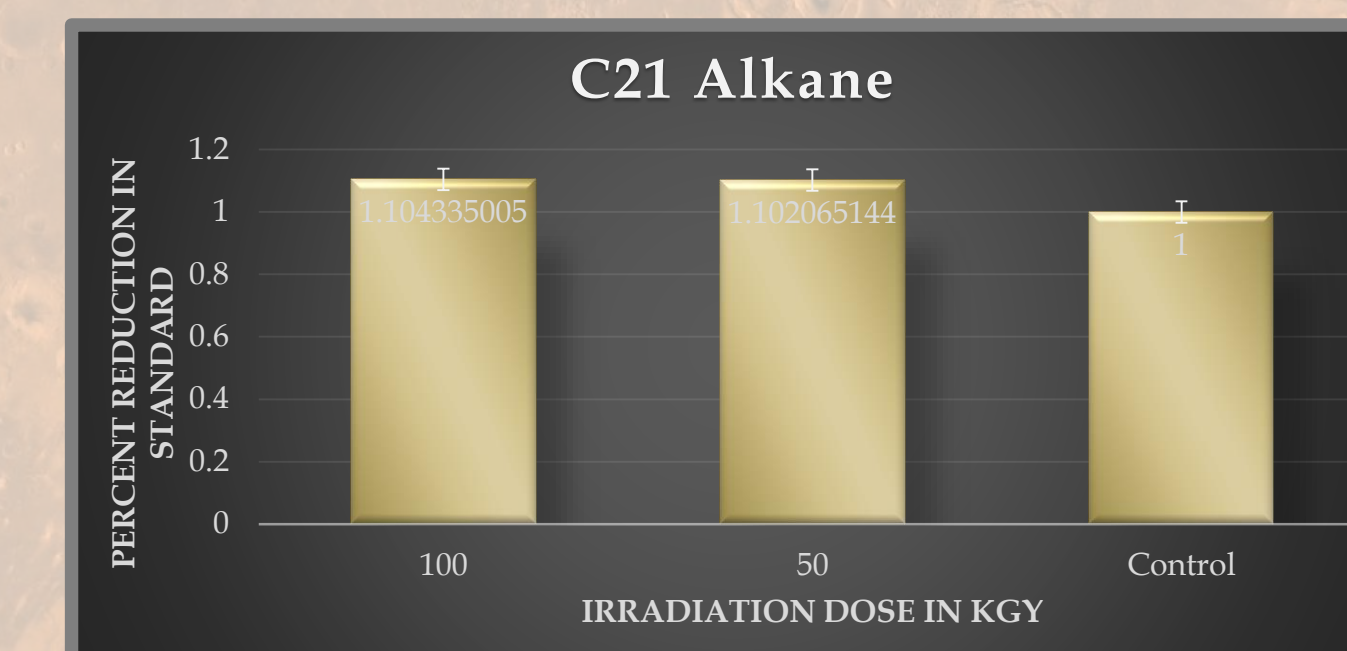
**Figure 9:** GC-MS chromatogram of C27 5 $\alpha$ -Cholestan-3 $\beta$ -ol standard following 100 kGy of irradiation; tallest peaks are experimental compound and internal standard by abundance, compounds in boxes are radiolytic products



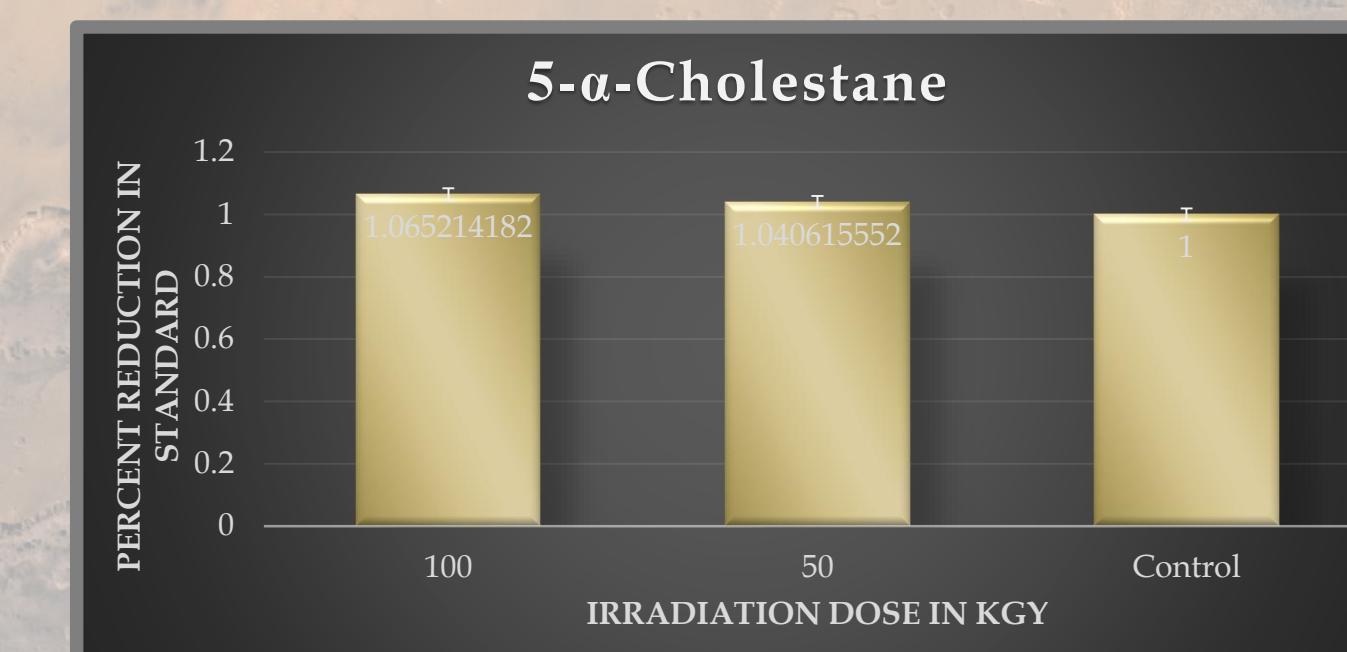
**Table 1:** Percent reduction in C16:0 Fatty Acid by EBI dose absorbed; no significant degradation observed



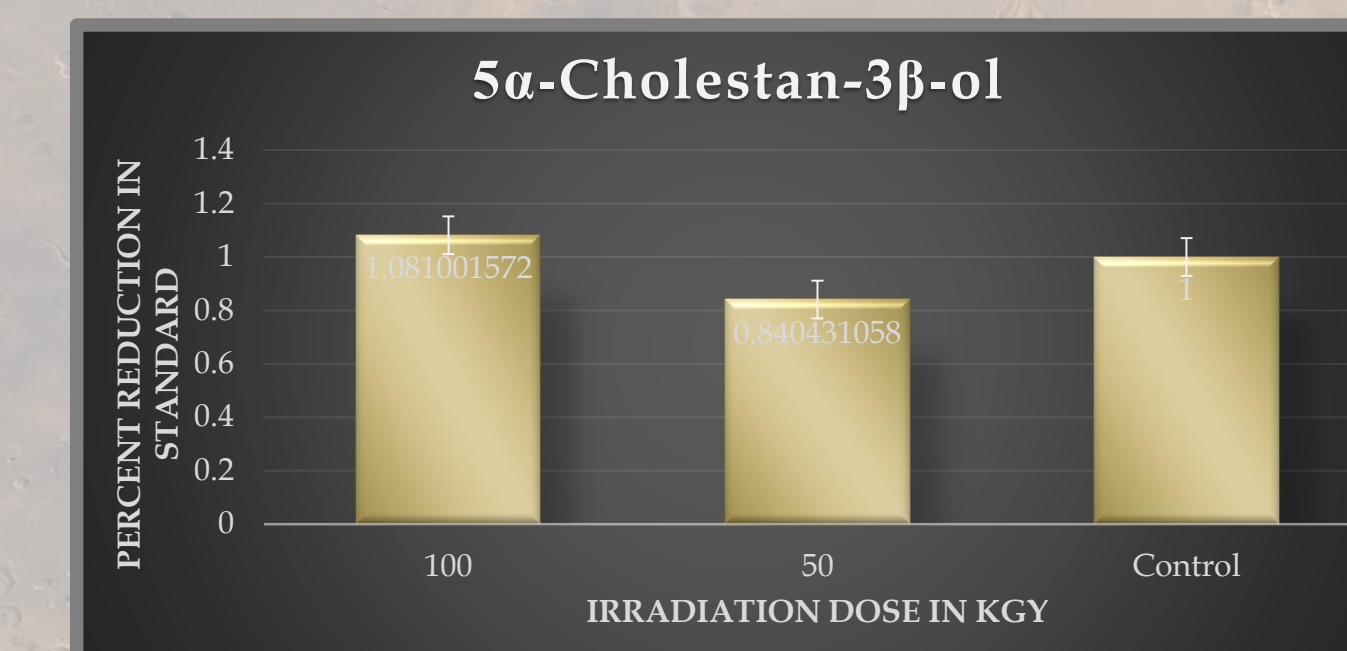
**Table 2:** Percent reduction in C18:1 Fatty Acid by EBI dose absorbed; no significant degradation observed



**Table 3:** Percent reduction in C21 Alkane by EBI dose absorbed; no significant degradation observed



**Table 4:** Percent reduction in Cholestane by EBI dose absorbed; no significant degradation observed



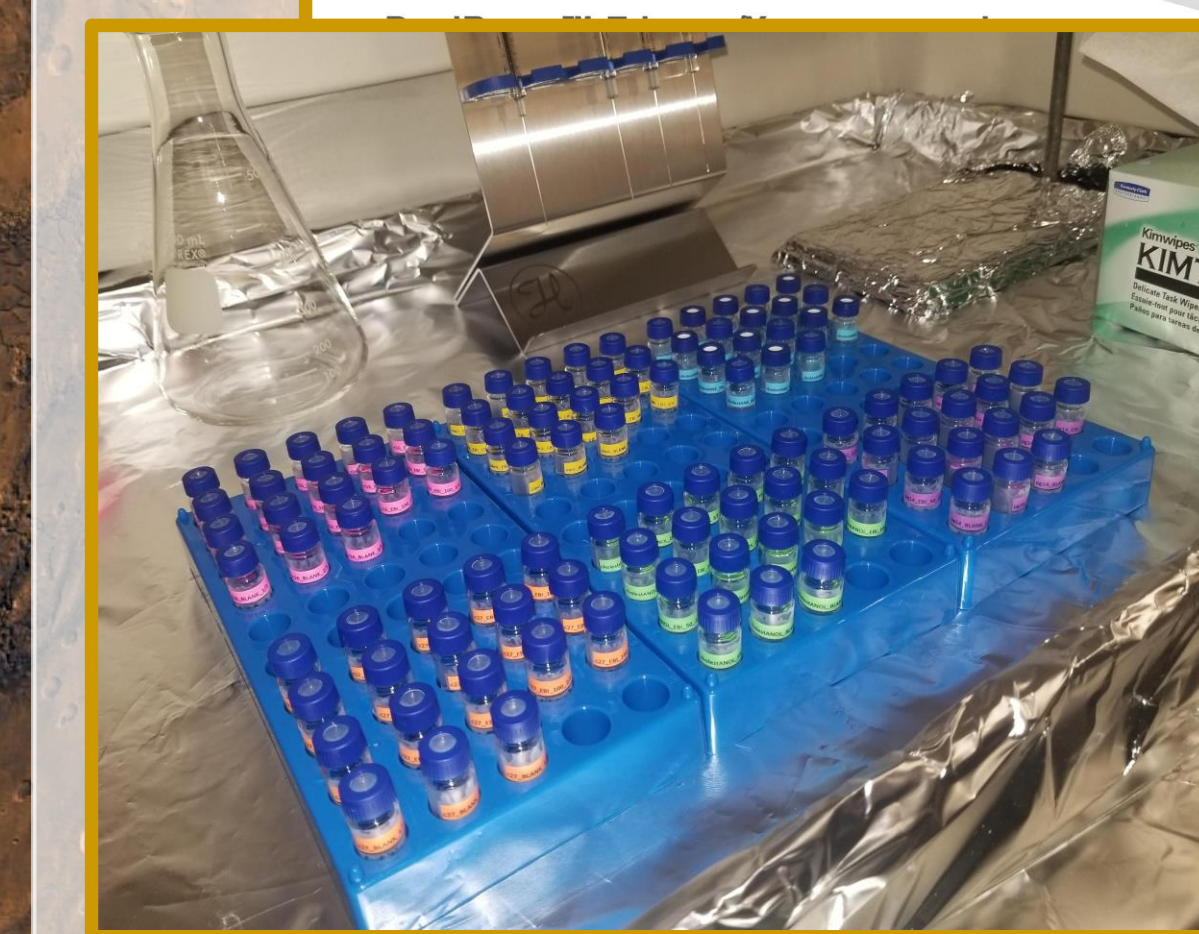
**Table 5:** Percent reduction in Cholestanol by EBI dose absorbed; no significant degradation observed

## DISCUSSION

- No significant lipid degradation observed at doses tested (5 kGy, 10 kGy, 25 kGy, 50 kGy, 100 kGy)
- Small quantities of radiolytic products observed
- Large diversity of radiolytic products observed
- Polycyclic compounds more resistant to breakdown than aliphatics
- Recombination (particularly in fatty acid compounds) observed
- Dicarboxylic acids observed following irradiation of monocarboxylic acids (similar to those found in carbonaceous meteorites, specimens that have experienced high levels of irradiation throughout the solar system's lifetime)



**Figure 3:** Steri-Tek EBI facility



**Figure 4:** Samples pre-irradiation

## FUTURE WORK

- Find and verify a contamination control method that will destroy lipids without harming the materials used to construct ExCALiBR
- Further explore lipid longevity under irradiation in simulated Mars, Europa, and Enceladus conditions

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