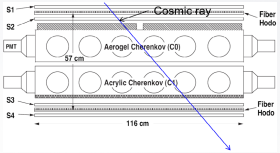
SuperTIGER Ultra-Heavy Galactic Cosmic Ray Atmospheric Propagation Corrections and Uncertainty Analysis

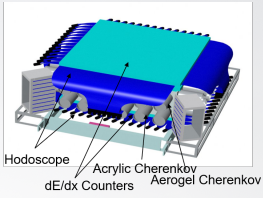
Brian F. Rauch[a], Nathan E. Walsh[a], and Wolfgang V. Zober[a] for the SuperTIGER Collaboration

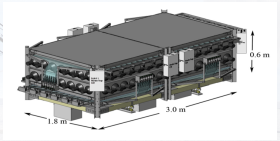
[a]Department of Physics and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130 USA

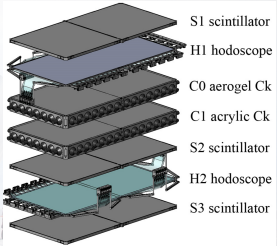
Instrument

Top: TIGER stack, TIGER technical model
Bottom: one of two SuperTIGER modules and SuperTIGER module expanded view.
Background: SuperTIGER-2 at launch

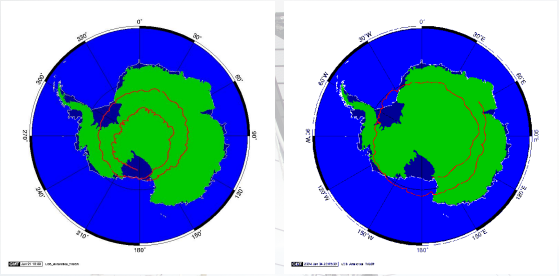


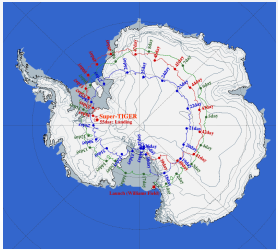


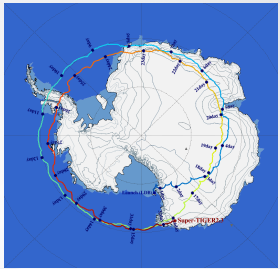




Flight History of TIGER and SuperTIGER

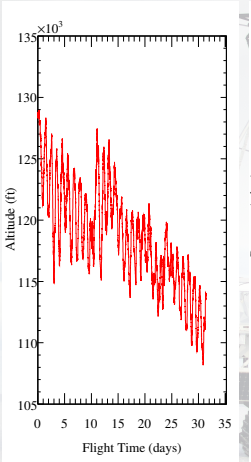


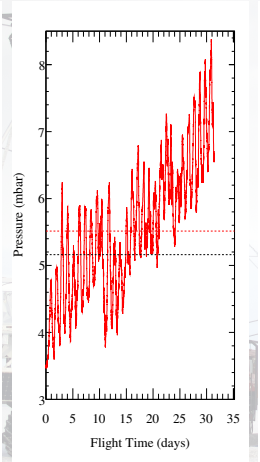


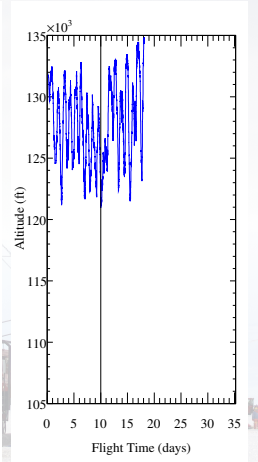


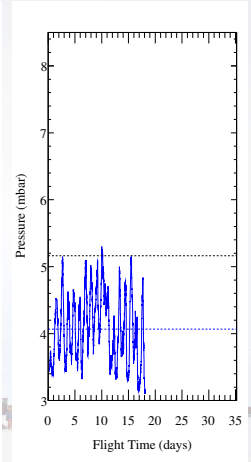
Left to right: TIGER 2001 from Dec 21, 2001 – Jan 21, 2002, TIGER 2003 from Dec 27, 2003 – Jan 4, 2004, SuperTIGER 2012 from Dec. 8, 2012 - Feb. 1, 2013, and SuperTIGER 2019 from Dec. 15, 2019 - Jan. 17 2020.

Tiger Altitude and Pressure Profiles



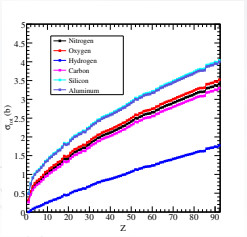


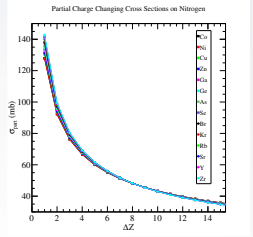


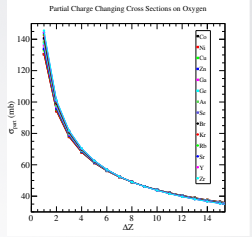


Charge Changing Cross Sections

Left to right: charge changing cross sections: total and partial on $^{14}_{7}$N and $^{16}_{8}$O.







The total charge changing cross sections are given by:
$\sigma_{tot}(P,T) = \pi[R_P + R_T - (3.20 \pm 0.05)]^2$,
where P and T refer to the projectile and target nuclei, and R_P and R_T are their respective nuclear radii.

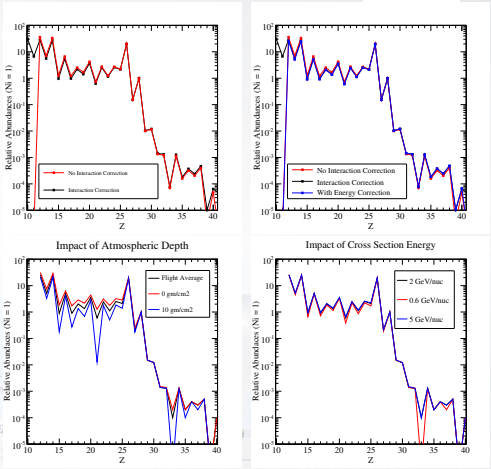
parameter	value
p_1	21.2 ± 0.5 mb
p_2	1.08 ± 0.15
p_3	$(0.485 \pm 0.014)A$ GeV
p_4	0.094 ± 0.013
p_5	1.11 ± 0.02
p_6	10.8 ± 1.6
p_7	$(0.85 \pm 0.03)A$ GeV
χ^2_ν	2.84
N	1741

The partial charge changing cross section is given by:

$$\sigma_{\Delta Z}(A_P, A_T, K, \Delta Z) = p_1(A_P^{1/3} + A_T^{1/3} - p_2)(1 + p_3/K)|\Delta Z|^{-p_4[1+A_P^{1/3}/p_5+A_T^{1/3}/p_6+p_7/K]}$$

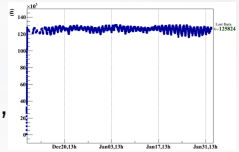
TIGER Systematics

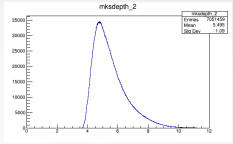
Top Left: impact of atmospheric interaction corrections on TIGER abundances,
Top Right: impact of interaction corrections with energy loss correction on TIGER TOA abundances,
Bottom left: sensitivity of TIGER TOA abundances to atmospheric depth,
Bottom right: sensitivity of TIGER TOA abundances to interaction cross section energy.

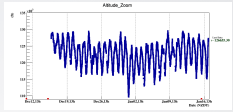


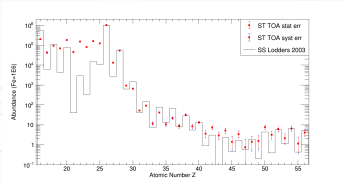
SuperTIGER Altitudes and Systematics

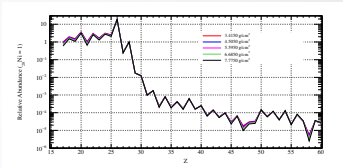
Top Row (Left to Right):
SuperTIGER 2012 altitude profile,
SuperTIGER 2012 atmospheric overburden distribution,
altitude profile at float.











Bottom row (Left to Right): SuperTIGER 2012 TOA relative abundances with systematic error bars based on scaling cross sections up and down by their uncertainties, SuperTIGER 2012 atmospheric propagation correction dependence on assumed depth.

Acknowledgements

SuperTIGER is supported by NASA under grant numbers NNX09AC17G, NNX14AB25G, NNX15AC23G, and 80NSSC20K0405 and the Peggy and Steve Fossett Foundation

The material contained in this document is based upon work supported by a National Aeronautics and Space Administration (NASA) grant or cooperative agreement. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author and do not necessarily reflect the views of NASA