

Status of the U.S. CALET Effort

T.G. Guzik, Louisiana State University

CALET TIM – Florence, Italy

February 2020

The U.S. Proposal to NASA

- Proposed to continue support for the U.S. CALET effort
 - Proposal submitted to NASA on 22 March 2019
 - Selection letter was received on 21 August 2019
 - Budget negotiations were successfully completed by 18 December 2019
- Anticipated major task items for 2020 - 2024
 - Continue U.S. CDC operations at LSU
 - Work to archive CALET data at HEASARC (GSFC)
 - Analysis of UH cosmic rays (WUSTL)
 - Gamma ray analysis using CAL and coordinate with CGBM
 - Work on “Space Weather” / low energy particle analysis
 - Assist international collaboration with e, p, He, nuclei spectrum analysis
 - Continue to add to the CALET instrument simulated dataset

U.S. Participants

- U.S. team structure similar to that of prior cycle
 - LSU lead organization – T.G. Guzik, U.S. PI
 - WU St. Louis – B. Rauch, Institution PI
 - GSFC – J.W. Mitchell, Deputy PI, Institution PI, J.F. Krizmanic, Co-I
- Louisiana State University (LSU)
 - T.G. Guzik, M.L. Cherry, J.P. Wefel, Y. Kawakubo, D. Granger, A. Ficklin, A. Ryan, E. Western, ~2 undergraduates
- Washington University at St. Louis (WUSTL)
 - B.F. Rauch, J.H. Buckley, H.S. Krawczynski, M. Israel, W.R. Binns, Post-Doc (TBD), W. Zober, ~2 undergraduates
- NASA Goddard Space Flight Center (GSFC)
 - J.W. Mitchell, G. de Nolfo, J.F. Krizmanic, Y. Akaike, A. Bruno, N. Cannady, T. Hams, J. Link, A. Moiseev, M. Sasaki, K. Sakai, Programmer (TBD)

U.S. CALET Data Center (USCDC)

- USCDC Cluster
 - Main Storage and Distribution Server to GSFC and WUSTL
 - Dataset Conversions
 - Large Simulations
- “Dany” Test Cluster
 - New server with 96 Xeon Processing Nodes
 - Supplement computational tasks performed by USCDC
 - Targeted data analysis tasks and test new packages
- HPC facilities external to the USCDC at LSU
 - Massive scale simulations
 - Requires simulation plan and proposal for usage
- USCDC Storage Capabilities
 - Expanding the USCDC storage capability to accommodate larger dataset requirements

Storage Capability	Current Total	w/ New Disk Server	Future Reconfiguration with existing hardware
USCDC Storage	110 TB	230 TB	270TB

U.S. Supporting CALET Flight Ops

- Several U.S. participants will directly assist CALET flight operations at the WCOC
 - Y. Akaike (GSFC) will move to Waseda in ~April 2020
 - Y. Kawakubo (LSU) will assist at the WCOC from March through August 2020 and then return to LSU
- U.S. contributes to shift work monitoring CALET flight data
 - Remotely review Data Quality Check (DQC) plots at the WCOC everyday to monitor CALET performance
 - Shift schedule involves personnel at LSU and GSFC
 - Monday: A. Ficklin
 - Tuesday: A. Ryan
 - Wednesday: E. Western
 - Thursday: N. Cannady
 - Friday: N. Cannady
 - Saturday: Y. Kawakubo
 - Sunday: Y. Kawakubo
- Issues uncovered during the DQC monitoring include:
 - GPSR Raw packets (not an issue for now)
 - Missing plots (issue with the webserver)
 - Obstruction in CALET field of view deduced from GAM and ASC plots

Other contributions to collaboration

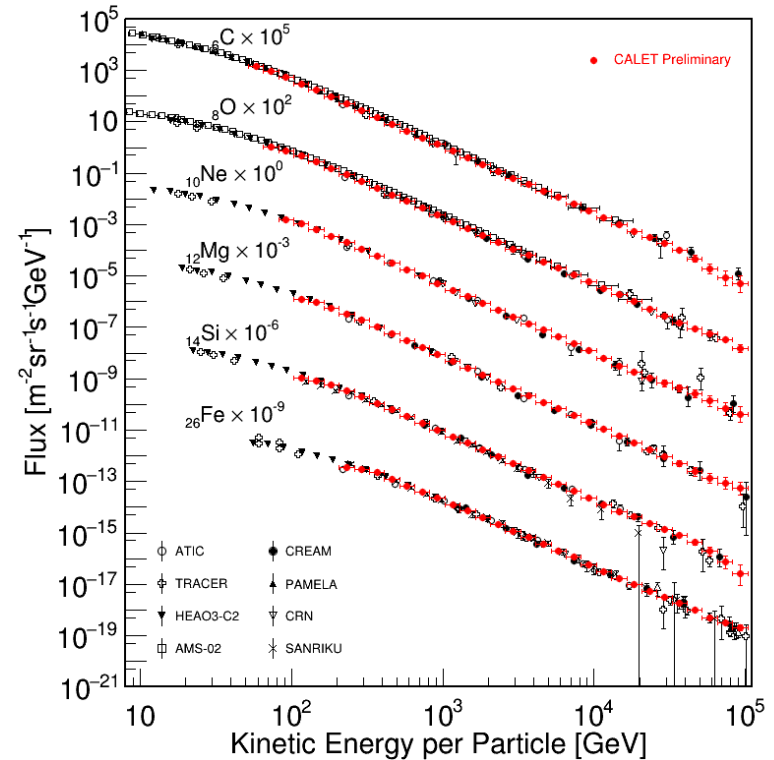
- Distribution of MSS KOZ table describing planned SSRMS operations to CALET members
- HEASARC Data archiving (presentation on 5 Feb)
 - CHD count rate to FITS format, initial HEASARC site developed
 - Iterating update of FITS files for CGBM archive with ISAS/DARTS
 - HEASARC archiving of CALET published spectra still work in progress
- Epics Simulations (presentation on 5 Feb):
 - 2.5 additional families of ^4He generated (UnifiedOutput uploaded to Waseda Archive)
 - Heavy nuclei runs to 1 PeV
 - High statistics runs for gammas & electrons
 - Runs to assess incorporation of direct electron production in Epics 9.28

U.S. Talks at this TIM

- 4 Feb 10:10 Analysis of B/C ratio and energy spectra of heavy nuclei measured by CALET – Y. Akaike (UMBC-NASA/GSFC)
- 4 Feb 11:20 Analysis status of low-Z particles stopping in CALET – A. Ryan (LSU)
- 4 Feb 14:00 CALET ultra-heavy cosmic-ray observations incorporating trajectory dependent geomagnetic rigidities – B. F. Rauch (WU St. Louis)
- 4 Feb 14:30 Determining angle dependent effective rigidity cutoffs for ISS-CALET ultra-heavy cosmic-ray analysis – W. Zober (WU St. Louis)
- 4 Feb 14:50 CALET solar gamma-ray measurement – N. Cannady (NASA/GSFC)
- 4 Feb 16:20 Analysis for GW events and GRBs – Y. Kawakubo (LSU)
- 5 Feb 10:15 HEASARC CALET archive status (teleconference) – L. Angelini (HEASARC/GSFC)
- 5 Feb 13:30 US CALET simulation status – J. F. Krizmanic (USRA/CRESST/GSFC)
- 5 Feb 14:45 REP measurements with CALET (teleconference) – A. Ficklin (LSU), A. Bruno (GSFC)

Highlights of High-Z Analysis

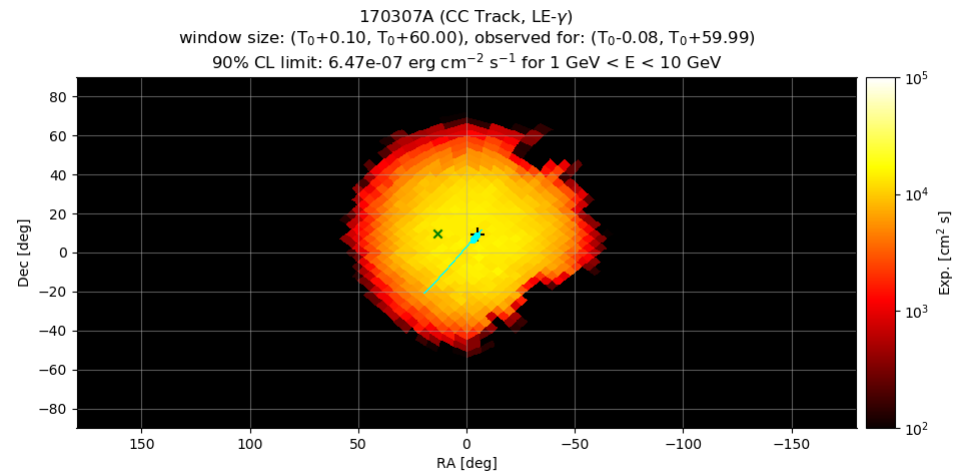
- The charge calibration was performed and a good charge resolution was achieved on flight data, 0.18 for carbon, which is equivalent with the beam test result.
- A large amount of the simulation data was produced with the CALET EPICS simulation using the GSFC ADAPT cloud computing system and used to evaluate systematic uncertainties.
- The systematic studies include trigger efficiency, charge selection efficiency, energy unfolding, beam test results, difference among the simulations packages used by CALET: Cosmos/Epics, Fluka, and GEANT4.
- Most studies of these have been completed, the improved results such that for the boron-to-carbon ratio measurements will be reported.



Preliminary energy spectra of carbon, oxygen, neon, magnesium, silicon and iron as a function of kinetic energy per particle after 962 days of CALET operation compared with previous observations. Only statistical errors are shown.

Highlights of Gamma-Ray Analysis

- Finalized methodology for GRB counterpart searches and setting corresponding upper limits (Figure shows an example)
- Baseline analysis of quiescent solar gamma-ray emission completed, spend time at Waseda working with Asaoka-san to finalize journal paper
- Improved rejection of ISS structure contamination in the CALET field of view, code written to standardize FoV masking where ISS structure interferes, will be useful for UH analysis,
- Unification of exposure generation software code into common utility for collaboration use.



CALET LE- γ follow-up observation of GRB 170307A detected by Swift. The cyan line shows the path of the CALET zenith pointing on the sky. The source position reported by Swift is shown as the green \times . The exposure is shown by the pixel color. There is no prompt counterpart candidate: a corresponding upper limit is calculated.

Search for EM counterparts of GW

- The LIGO & Virgo third observation run started on April 1, 2019.
- 48 (+ Fermi GBM-190816) GW events have been reported in O3.
- Updated pipelines for GWs & GRBs and searched for signals.

CAL statistics

1 : HV off *
24 : Outside of the FOV
24 : No detection

CGBM statistics

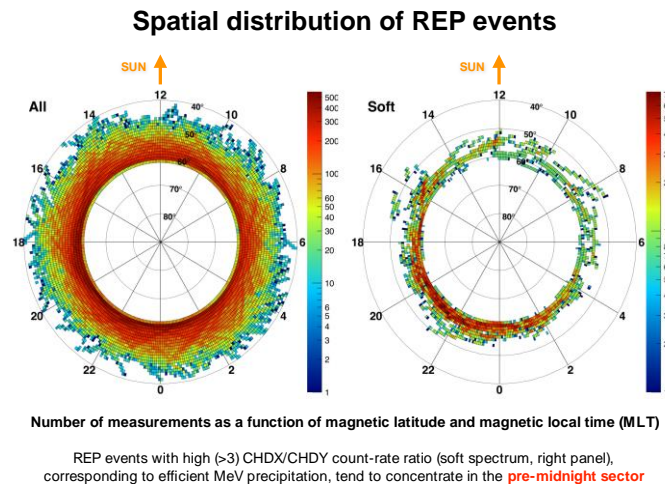
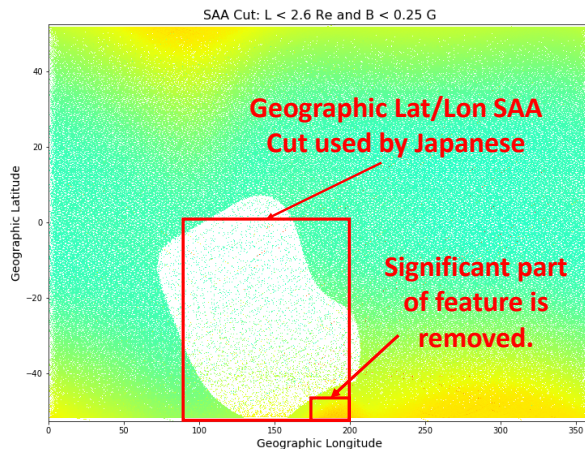
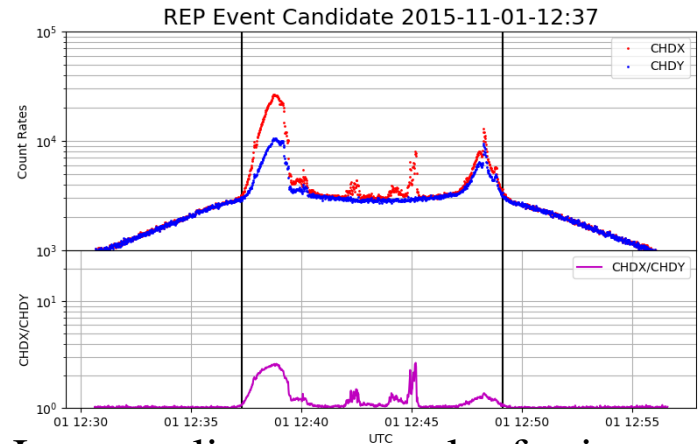
17 : HV off
3 : Outside of the FOV
29 : No detection

* For safety during a special ISS activity

- **CALET has found no counterpart candidate so far.**
- **We have reported our analysis for 46 events to GCN circular.**
(Except for S190412m, S190421ar, Fermi GBM-190816)

Highlights of “Space Weather” Analysis

- Developed analysis procedure using CHDx and CHDy count rates to catalogue REP events
- Search resulted in the identification of 1020 REP event candidates between November 2015 and September 2019, with 848 being found in the time covered by the Japanese search (November 2015-March 2018).
- The 86 excess events found when compared to the Japanese list are a result of using a less conservative SAA cut. Having the cut be defined by B and L, instead of geographic latitude and longitude, allows for a more accurate cut and prevents incorrect removal of events underneath the SAA.
- Space Weather/Geomagnetic analysis ongoing with comparison to other measurements, including those from Van Allen Probes.



Number of measurements as a function of magnetic latitude and magnetic local time (MLT)

REP events with high (>3) CHDX/CHDY count-rate ratio (soft spectrum, right panel), corresponding to efficient MeV precipitation, tend to concentrate in the **pre-midnight sector**

Investigating Nuclei that Stop in the CAL

- Potential new application of CALET flight data
 - Lower energy nuclei entering the geomagnetic field at high latitude could potentially “stop” rather than interact in the TASC.
 - Would add a lower energy (< few GeV) flux measurement to the CALET data products.
 - Interaction probability increases with Z , so analysis might be “restricted” to light nuclei ($Z < 10$)
- Possible LSU graduate student thesis study
- Initial search is currently focused on $Z \sim 2$
 - Selected LEE Run for event search based on orbital operation
 - Simulated low energy protons and helium-4 in EPICS for development of selection parameters
 - Currently comparing flight data with simulation results and Bethe-Bloch calculation
 - Will utilize LSU HPC allocation to generate additional statistics as well simulation of heavier isotopes for further study and efficiency calculation

U.S. CALET Collaboration Summary

- Completed major review by NASA and are now fully funded for next four years (2020 – 2024)
- Continuing with identical collaboration organization and familiar participants
- The U.S. is contributing to the success of CALET in many areas including flight operations and data analysis
- Working on nuclear abundances and spectrum, secondary / primary ratios, ultra-heavy composition, gamma-ray, transient gamma-ray events, space weather
- NASA is ready to extend the existing JAXA / NASA LOA
- U.S. participants are ready to continue our successful scientific collaboration with Japan and Italy