# Cosmic-ray Elemental Spectra Measured with ISS-CREAM 

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## Cosmic rays

All-particle spectrum


- Possible origin of galactic cosmic rays is thought as supernova remnants.
- The "knee" structure in allparticle spectrum shows possible acceleration limit signature.
- Direct measurements of individual elemental spectra can test the supernova acceleration model.


## Cosmic ray spectrum hardening





- Hardening above ~200GeV/nucleon
- Needs extension to higher energies by measurements with more statistics


## ISS-CREAM experiment



- Launched and started observation from August 2017.
- Measure cosmic rays up to ${ }^{\sim} 10^{15} \mathrm{eV}$

- Silicon Charge Detector (SCD): charge measurement (Sungkyunkwan Univ.)
- Calorimeter (CAL): energy measurement (Univ. of Maryland)
- Top/Bottom Counting Detector: e/p separation by shower shape (Kyungpook National Univ.)
- Boronated Scintillator Detector: e/p separation by neutron detection (Penn State Univ., NASA GSFC, Northern Kentucky Univ.)


## ISS-CREAM Collaboration

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## ISS-CREAM SCD and CAL



See G. Choi's poster for SCD See K. Kim's poster for CAL


- SCD is 4 layers silicon pixel detector (2688 channel/layer).
- SCD signals are proportional to square of cosmic ray charge.
- CAL consists of 20 tungsten layers and scintillating fiber ribbons, oriented alternately in $x$ - and $y$-directions.


## Sample cosmic ray events

- 20171116 02:26:43

FULL


SCD

CAL, T/BCD
BSD

Date: 11/16/2017
Time: 2:34:2


| ZCLB: 1 |
| :--- |
| EHIGH: 1 |
| ELOW: 1 |

- 20170910 SCD event hit map



## Charge distribution with sample data




## Analysis condition

- Reconstructed energy > 10 TeV

Data:

- 20170822-20190212 (540 days)
- Data collection time: ~1 year
- Physics trigger events provided by CAL or T/BCD
- Use layer 1 for SCD (since charge change in layers is under study)

Monte-Carlo:

- Geant3 MC toolkit
- Power-law energy distribution with index-2.7


## Event selection and tracking

Hit positions are determined using highest energy and neighboring ribbons, then fit them by linear line

Selection condition (based on [CREAM collaboration, ApJ 728:122 (2011); ApJ 839:5 (2017)])

- $\geqq 6$ consecutive layers have hits
- $\geqq 1$ channel of above hits have energy deposit $>45 \mathrm{MeV}$
- Track fit line: $\chi^{2} / n d f<10$

See J. P. Lundquist's poster for improved tracking study

Example event of CAL tracking


## Charge determination

- Reconstructed track is extrapolated to SCD.
- Highest signal pixel is searched within $7 \times 7$ pixel area.
- After path length is corrected, incident charge is determined.




## Energy Measurement

- CAL ADC signals are converted to energy deposits using calibration beam test data [CREAM collaboration, Proc. ICRC2017, 247, Proc. ICRC2011, 392, Nucl. Phys. B (Poc. Suppl.) 150, 272 (2006)]
- CAL has three gain ranges, and only low range is used in this work. Other ranges will be included soon.
- Extended to higher energies by MC.

Energy deposit - incident energy relation


## Elemental spectra




- Power-law shapes with indexes close to 2.5-2.7.
- More corrections are still to be made, but data reach about 1 PeV .


## Summary

- We presented preliminary analysis methods and elemental spectra observed with ISS-CREAM.
- They showed reasonable power-law shapes and highest energy for proton is about 1 PeV .
- The calibration and analysis are preliminary, which will be completed soon.
- The analysis results will constrain particle acceleration models more.


## Charge determination

- Select $0.7<Z<1.7$ as $p, 1.7<Z<2.7$ as $\mathrm{He}, 5.5<Z<6.5$ as $C$, $7.5<Z<8.5$ as 0 .


Carbon


## SCD analysis: Charge resolution for heavy nuclei

- Fit hits in SCD layer 1, 2, 3 by linear line
- Calculate average signal ADC value of the hits
- Convert ADC to charge

Analysis condition for charge $Z>4$ :


- Fit line is within TCD area.
- $\chi^{2}$ / ndf < 10
- Charge difference: within $\pm 0.5$
- SCD layer 4 is excluded due to power was on/off in the analysis period (will be added later).


## Charge distribution

## ISS-CREAM

$Z$ is calculated from $A D C\left(A D C \cos \theta \propto Z^{2}\right)$


## Charge resolution (SCD 3 layers)



We fit large peaks by Gauss distribution.

Charge resolution is $0.1 \mathrm{e}-0.3 \mathrm{e}$ for all peaks.

We have still a lot of rooms to improve it by using channel-tochannel correction ( $\sim 0.18 \mathrm{e}$ at charge = 10).

## Charge distribution calculation

20170827-20180619
Signal distribution



Charge distribution for CREAM-balloon


