

### Electron and Proton Separation Study Using the Top and Bottom Counting Detectors of ISS-CREAM Experiment

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Sinchul Kang, H.J. Kim, H. Park, J.M. Park, H.J. Hyun, Y.S. Hwang, H.B. Jeon Kyungpook National University (T/BCD group)

## **ISS-CREAM** Experiment



- ISS-CREAM (Cosmic Ray Energetics And Mass on the International Space Station)
  - It will be launched in August, 2017
  - It measures the energy spectral features from ~10<sup>11</sup> eV to > 10<sup>15</sup> and composition that might be related to the supernova acceleration limit
  - It provides keys to understand the origin, acceleration and propagation of cosmic







## **ISS-CREAM** Experiment



#### **ISS-CREAM Instrument**



- Silicon Charge Detector (SCD)
  - It provides precise charge measurements
- Sampling Calorimeter (CAL)
  - It determines energy of the cosmic rays and provides tracking and event trigger
- Top and Bottom Counting Detectors (TCD/BCD)
  - It provides shower profiles for electron and hadron separation
- Boronated Scintillator Detector (BSD)
  - It provides additional electron/hadron discrimination using thermal neutrons produced by the calorimeter

## Top and Bottom Counting Detector



#### ♦ Goals

- e/p separation for electron and gamma-ray physics
- Provide a redundant trigger in addition to the CAL trigger
- Provide a low energy electron trigger

#### ♦ Instrument

- Plastic scintillator coupled with 2-dimensional photodiode arrays
- $500 \times 500 \times 5 \text{ mm}^3$  and  $600 \times 600 \times 10 \text{ mm}^3$  plastic scintillator for TCD and BCD, respectively
- 23 mm × 23 mm × 650 μm photodiode

#### Method

 Electron and proton make different shower shapes (Electromagnetic vs. Hadronic showers)



# e/p Separation Study



Cut criteria for e/p separation

#### ♦ TCD

- 20 × 20 photodiodes + 5 mm plastic scintillator
- Shower + back scattering
- Cut methods
  - Number of hits
  - **RMS (ATIC analysis method)** RMS<sup>2</sup> =  $\Sigma$ Energy \_ TCD<sub>i</sub> × { $(x_i - x_c)^2 + (y_i - y_c)^2$ }  $x_i, y_i$  : coordinates of a sensor in the TCD

#### ♦ BCD

- 20 × 20 photodiodes + 10 mm plastic scintillator
- Transverse + Longitudinal shower
- Cut methods
  - Number of hits
  - f-factor = RMS<sup>2</sup> × Energy in BCD/Energy in CAL (similar to ATIC's)

 $x_c, y_c$  : coordinates of the center of the energy calculated Energy \_ TCD<sub>i</sub> : Energy deposited in the sensor i



- CAL trigger & 2MIP trigger
- High Energy Bin
- Hit distribution in the TCD/BCD
- Shower width distribution in the TCD/BCD

e/p Separation Study



#### **Result of e/p separation study**

Electron Ene

| n Energy [GeV] | Selected electron<br>(Total electron)<br>[Number of events] | Selected proton<br>(Total proton)<br>[Number of events] | Electron efficiency<br>[%] | Proton rejection power   | Incident<br>angle<br>[degree] | Accepted<br>electron<br>[number of<br>events] | Selected<br>proton<br>[number of<br>events] | Electron<br>efficiency<br>[%] | Proton<br>rejection<br>power  |
|----------------|---|---|----------------------------|--|-------------------------------|---|---|-------------------------------|-------------------------------|
| 150<br>300     | 29,129<br>(51,555)<br>9,253<br>(12,961)                     | 7,318<br>(2.92 × 10 <sup>7</sup> )                      | 56.5 ± 0.2<br>71.4 ± 0.4   | $(2.25 \pm 0.03) \times 10^{3}$<br>$(1.96 \pm 0.06) \times 10^{4}$ |                               |   |   |                               |                               |
|                |   |   |                            |  | 0 5517                        | 5517  | 6   | $55.2 \pm 0.5$                | $(9.19 \pm 3.75) \times 10^2$ |
|                |   |   |                            |  |                               |   |   |                               | $^{10}$                       |
| 600            | 1,226<br>(2,293)  | 702<br>(2.92 × 10 <sup>7</sup> )                        | 53.5 ± 1.0                 | (2.22 ± 0.12) × 10 <sup>4</sup>                                    | 15                            | 5822  | 9   | $58.2 \pm 0.5$                | $(0.47 \pm 2.10) \times 10^2$ |
|                |   |   |                            |  | 30                            | 6188  | 8   | 61.9 ± 0.5                    | $(7.74 \pm 2.73) \times 10^2$ |
| 1,200          | 205<br>(510)  | 5<br>(2.92 × 10 <sup>7</sup> )                          | 40.2 ± 0.8                 | (2.35 ± 1.07) × 10 <sup>6</sup>                                    | 45                            | 6422  | 7   | 64.2 ± 0.5                    | $(9.17 \pm 3.47) \times 10^2$ |
| 2,500          | 24<br>(62)  | 20<br>(2.92 × 10 <sup>7</sup> )                         | 39.9 ± 0.8                 | (5.65 ± 1.86) × 10 <sup>5</sup>                                    | 60                            | 4306  | 4   | <b>43.1 ± 0.5</b>             | $(1.08 \pm 0.54) \times 10^3$ |

#### Total events of proton and electron is 10<sup>4</sup>



## Thank you for your attention!