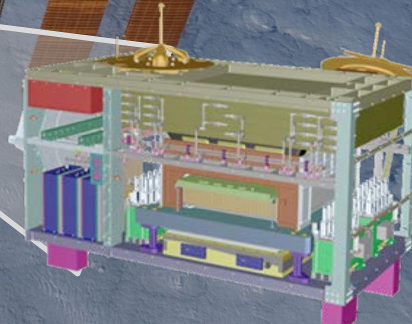
27–31 August 2018 | Berlin
2018 TeV Particle Astrophysics
TeVPA

Cosmic Ray Energetics And Mass
CREAM for the ISS (ISS-CREAM)



Eun-Suk Seo
University of Maryland
for
the CREAM Collaboration

CREAM Collaboration

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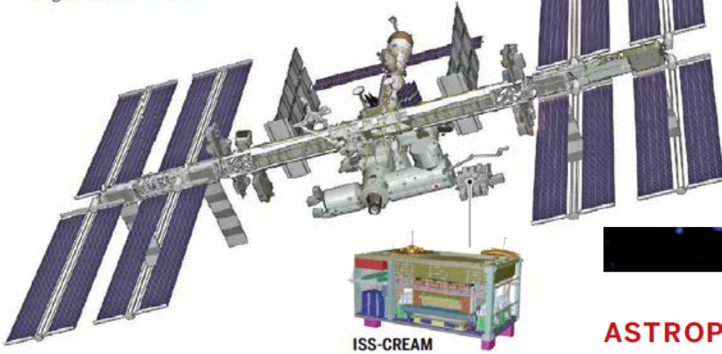
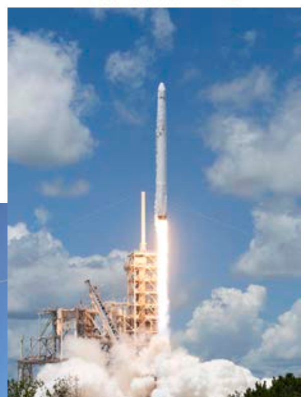
Thanks to NASA HQ/GSFC WFF/JSC/MSFC/KSC, SpaceX and JAXA

On the News: ISS-CREAM launch on SpaceX-12, 8/14/17

Aiming high

From the International Space Station (ISS), the Cosmic Ray Energetics and Mass (CREAM) instrument will trace the energy at which cosmic rays become very rare, revealing the limits of the supernova shock waves thought to accelerate them.





ASTROPHYSICS

Cosmic ray catcher will probe supernovae from new perch

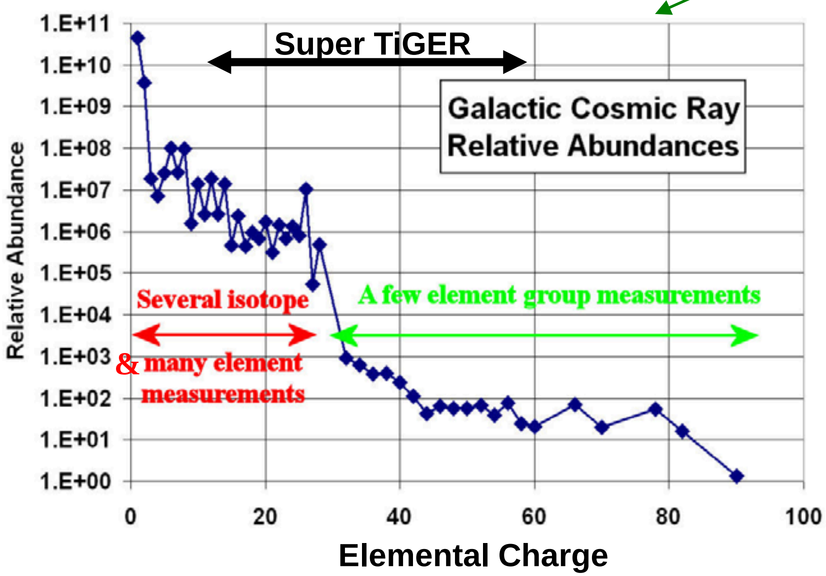
Balloon-borne detector moves to space to trap rare, high-energy particles that carry clues to their origin

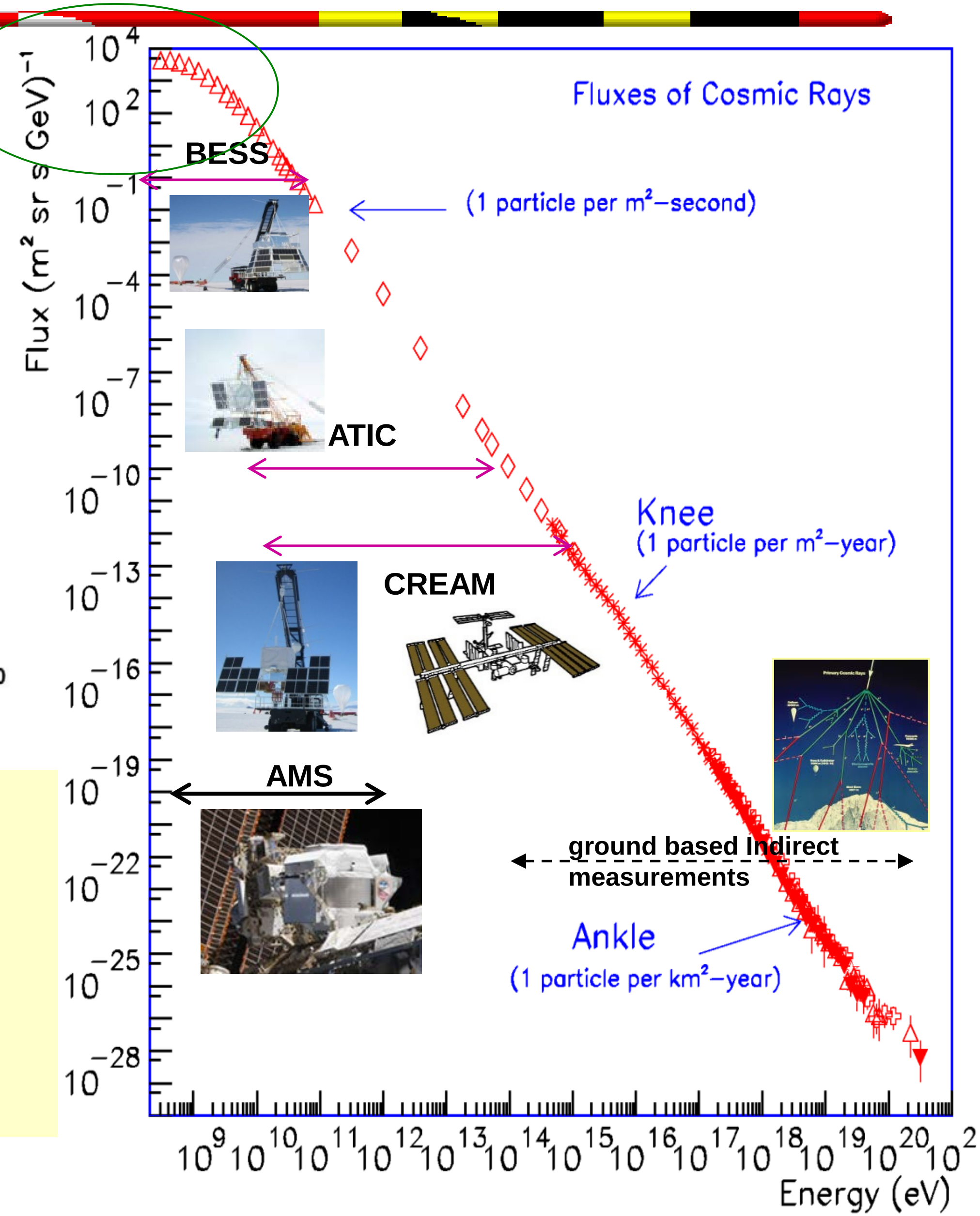
By **Eric Hand**

After 191 days aboard balloons sailing the stratosphere, an experiment designed to probe the galaxy's natural particle accelerators will move to higher ground: the International Space Station (ISS). The Cosmic Ray Energetics and Mass (CREAM) instrument and its successors floated above Antarctica seven times to collect high-energy cosmic

that a few smash into Earth with extraordinarily high energies—higher than today's most powerful atom smashers can generate. Their abundance drops sharply with increasing energy, following what's known as a power law distribution. In 1949, Italian-American physicist Enrico Fermi came up with a mechanism that could explain that and the cosmic rays' mind-boggling energies: supernova shock waves. In the centuries after a supernova,

How do cosmic accelerators work?





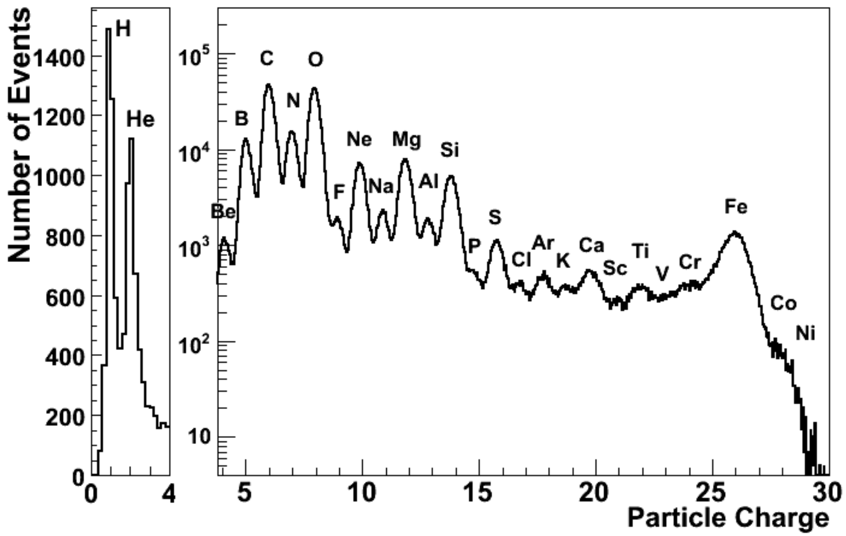
Mission Goal

Extend the energy reach of direct measurements of cosmic rays to the highest energy possible to investigate cosmic ray origins, acceleration and propagation.

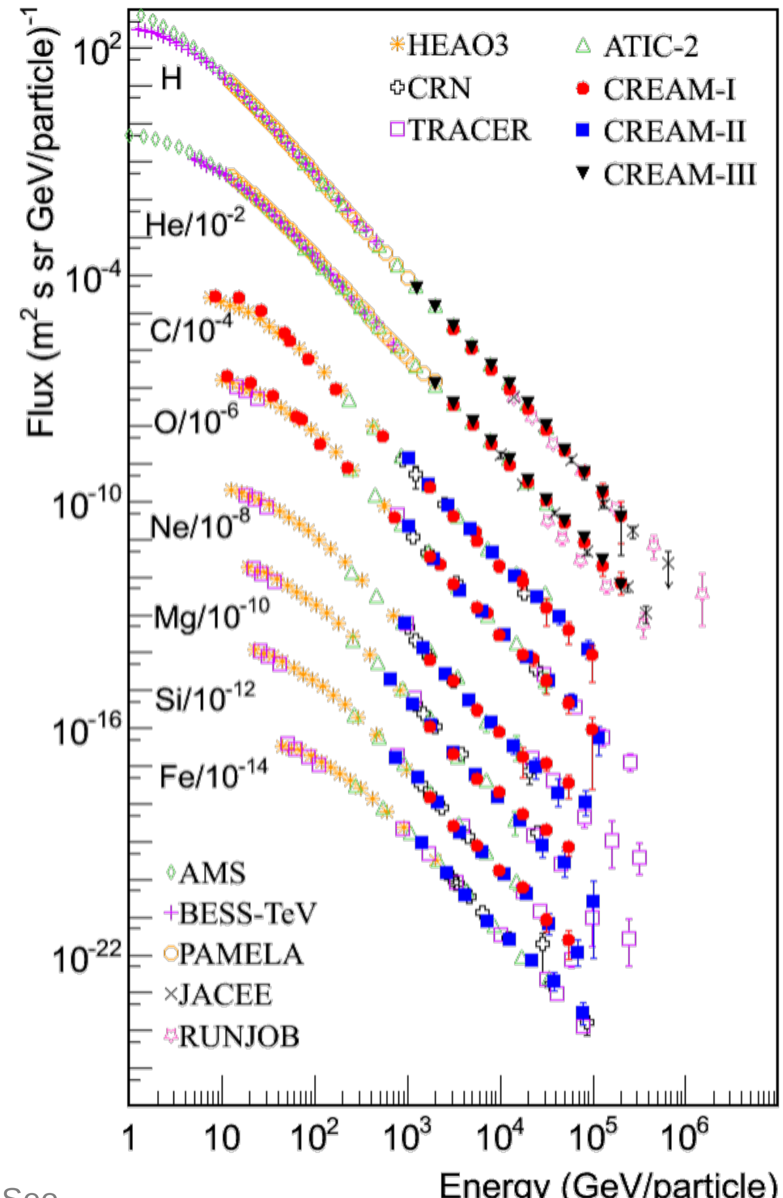
Elemental Spectra over 4 decades in energy

Yoon et al. ApJ **728**, *122*, 2011; Ahn et al., ApJ **715**, *1400*, 2010; Ahn et al. ApJ **707**, *593*, 2009

Excellent charge resolution from SCD

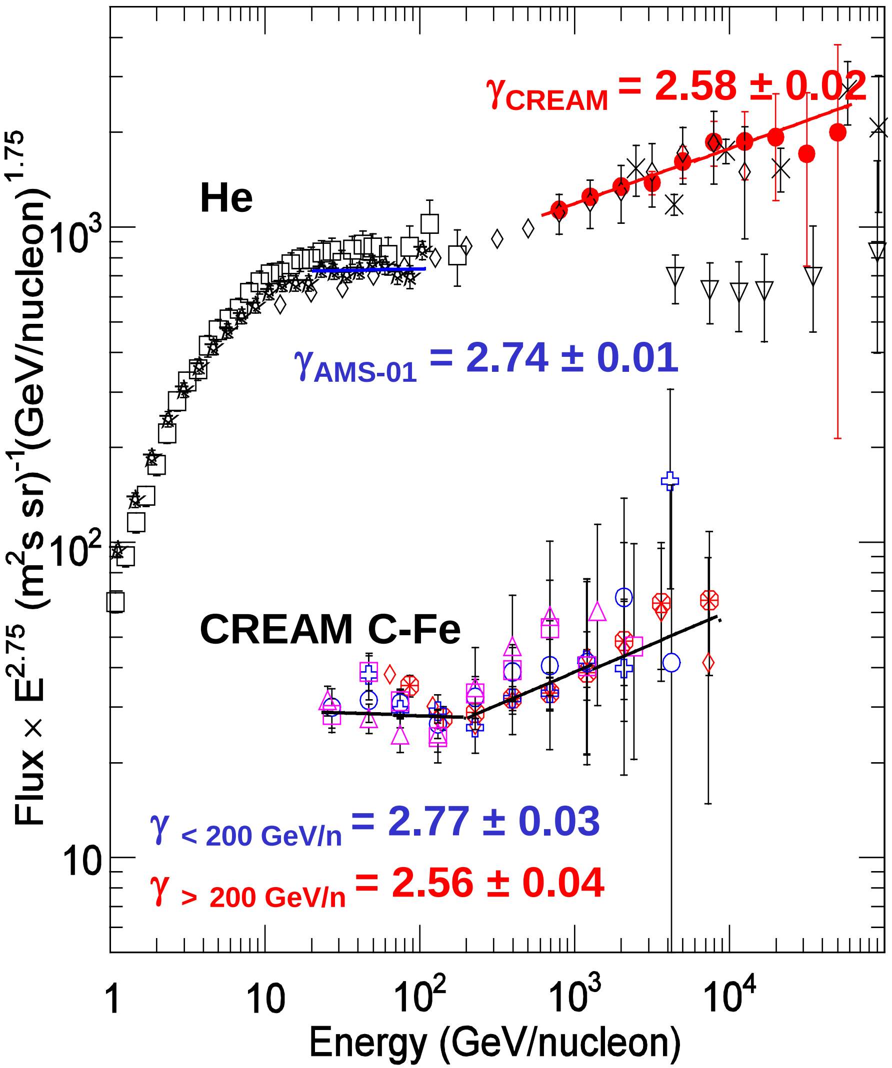


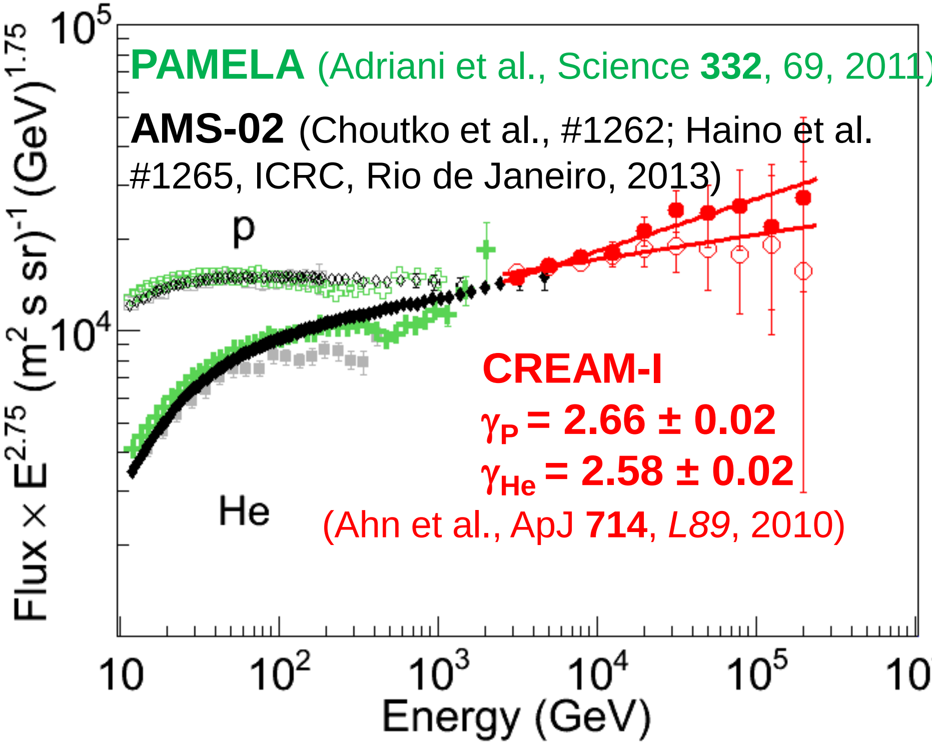
Distribution of cosmic-ray charge measured with the SCD. The individual elements are clearly identified with excellent charge resolution. The relative abundance in this plot has no physical significance.



CREAM spectra harder than prior lower energy measurements

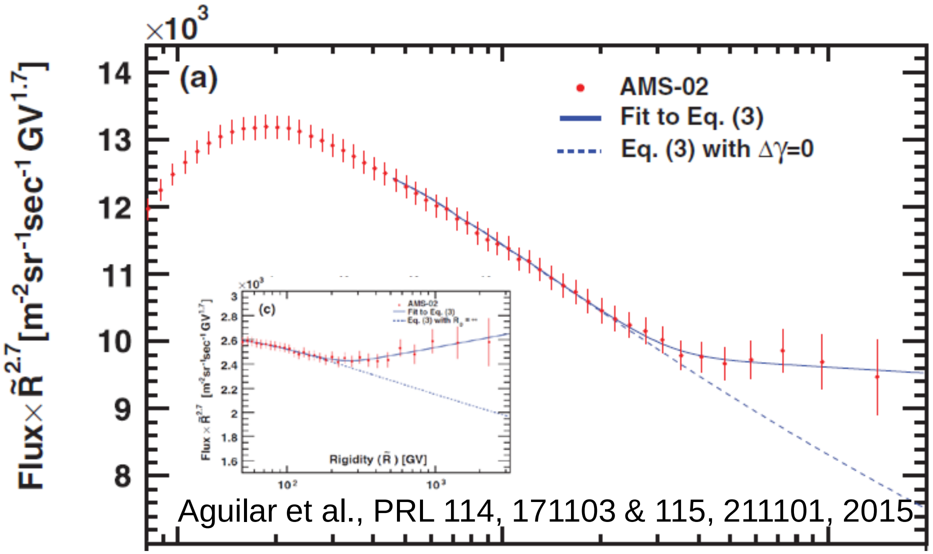
Yoon et al. ApJ **728**, *122*, 2011; Ahn et al. ApJ 714, L89, 2010

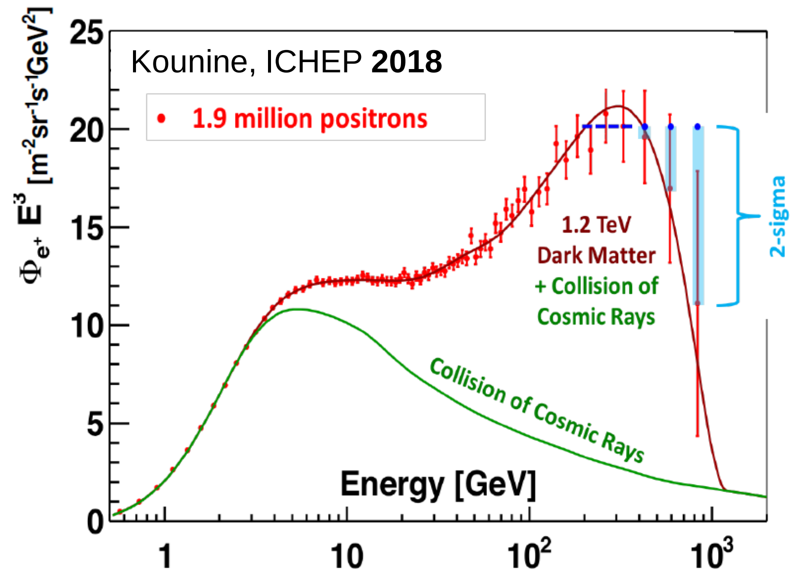


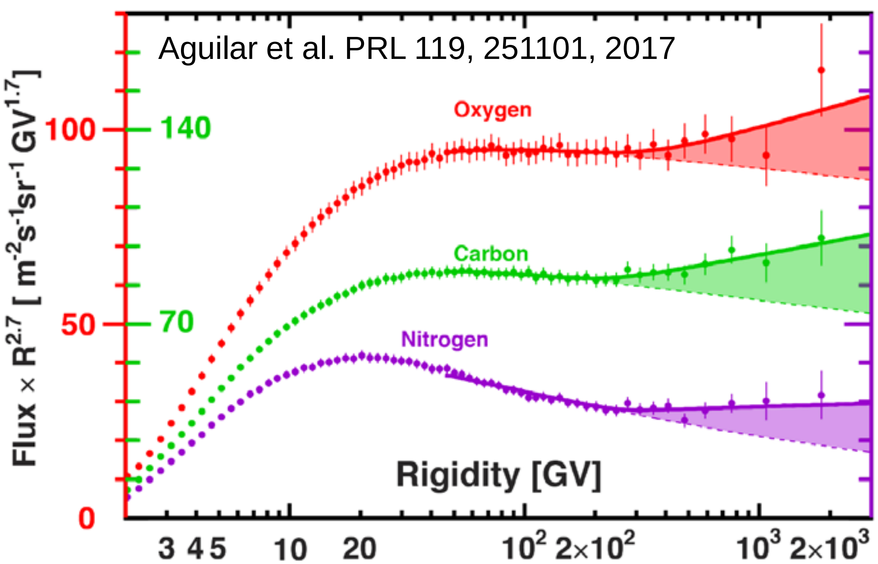


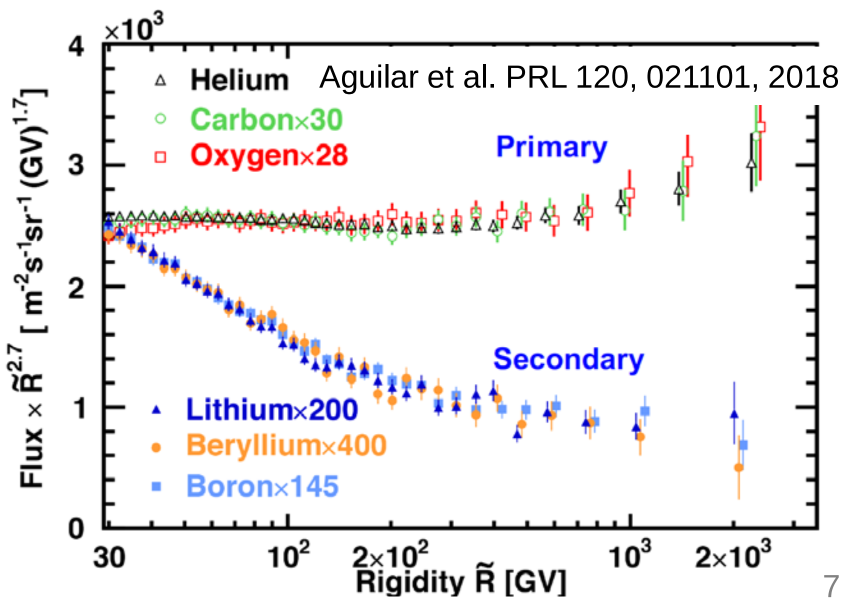
It provides important constraints on cosmic ray acceleration and propagation models, and it must be accounted for in explanations of the e^+e^- anomaly and cosmic ray "knee."

Spectral Hardening Confirmed



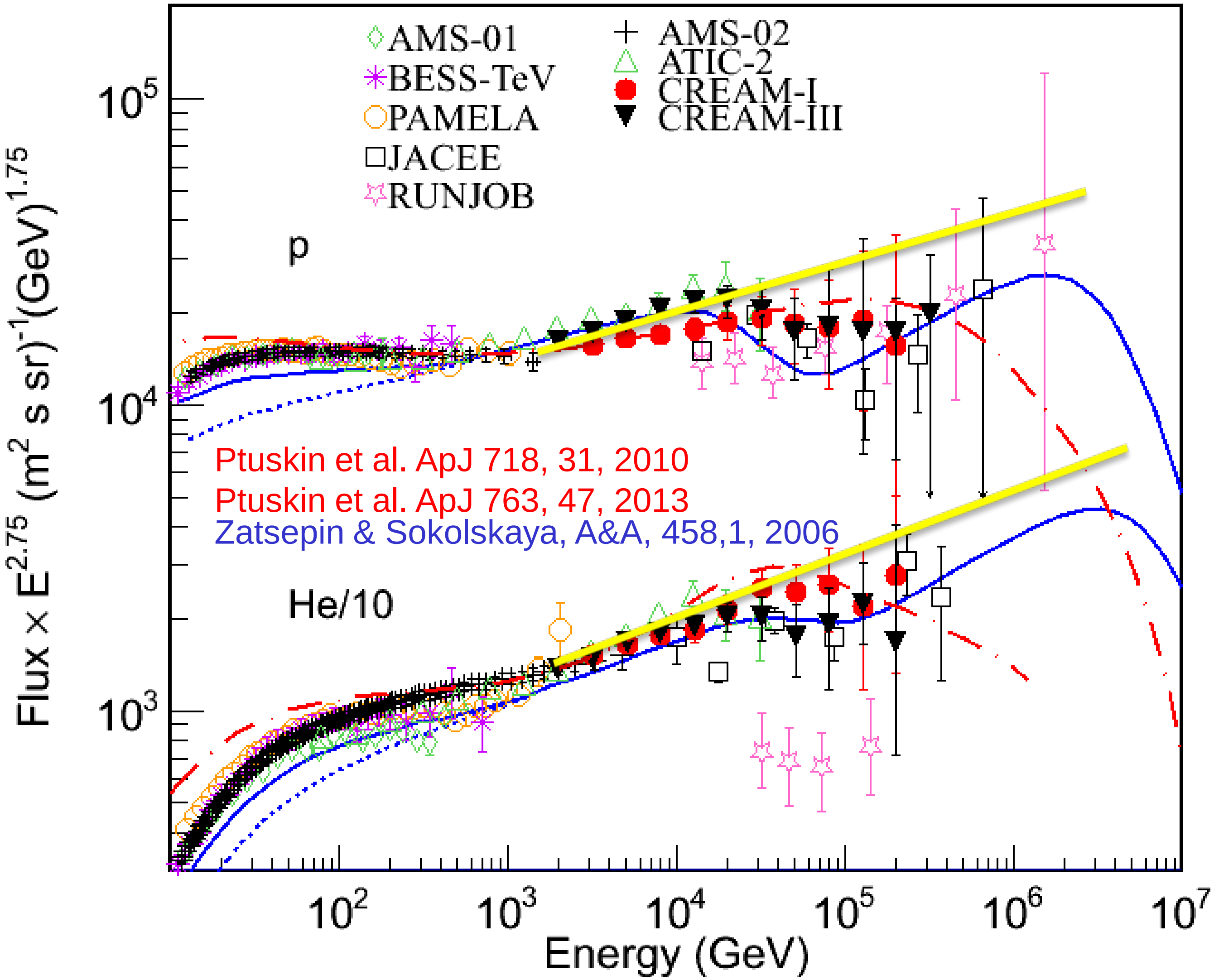






Need to extend measurements to higher energies

Yoon et al. (CREAM Collaboration) ApJ 839:5, 2017

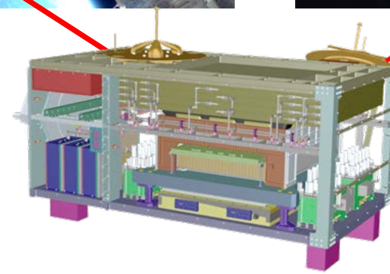


ISS-CREAM: CREAM for the ISS

E. S. Seo et al, Advances in Space Research, **53**/10, *1451*, 2014

SpaceX-12 Launch on 8/14/2017

ISS-CREAM installed on the ISS 8/22/17



Mass: ~1258 kg
Power: ~ 415 W
Data rate: ~500 kbps

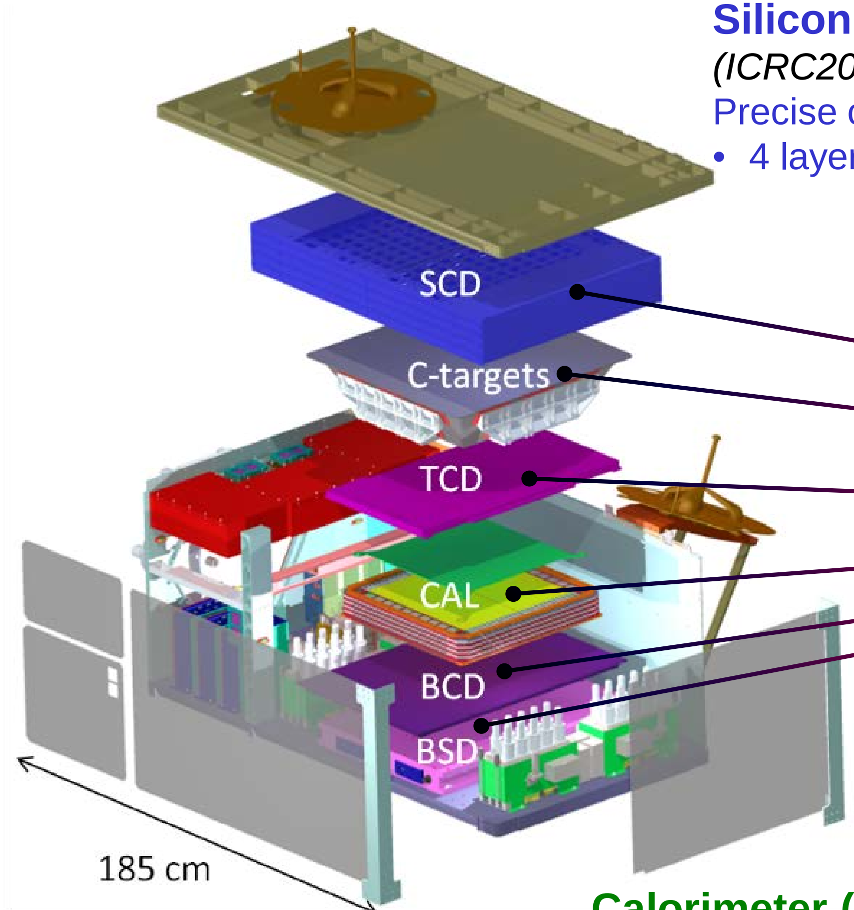
- Building on the success of the balloon flights, the payload has been transformed for accommodation on the ISS (NASA's share of JEM-EF).
  - Increase the exposure by an order of magnitude
- ISS-CREAM will measure cosmic ray energy spectra from 10^{12} to $>10^{15}$ eV with individual element precision over the range from protons to iron to:
  - Probe cosmic ray origin, acceleration and propagation.
  - Search for spectral features from nearby/young sources, acceleration effects, or propagation history.

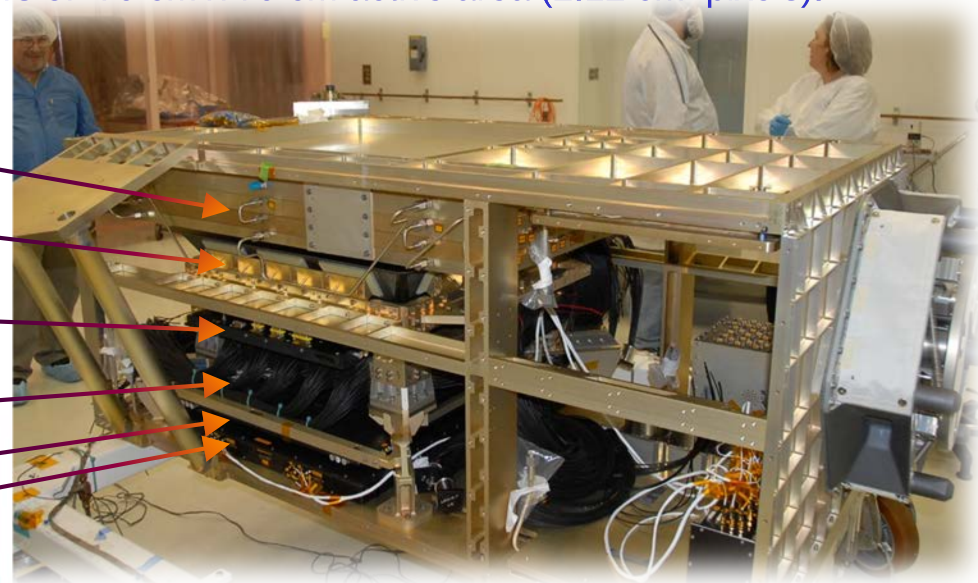
ISS-CREAM Instrument

Seo et al. Adv. in Space Res., **53**/10, *1451*, 2014; Smith et al. PoS(ICRC2017)199, 2017

Silicon Charge Detector (SCD) *Lee et al. PoS (ICRC2017)244, 2017; Hong et al. PoS(ICRC2017)229, 2017.*
Precise charge measurements with charge resolution of ~ 0.2e.

- 4 layers of 79 cm x 79 cm active area (2.12 cm^2 pixels).





Boronated Scintillator Detector (BSD) *Link et al. PoS(ICRC2015)611, 2015.*

- Additional e/p separation by detection of thermal neutrons.

Calorimeter (CAL) *Picot-Clemente et al. PoS(ICRC2017)247, 2017.*

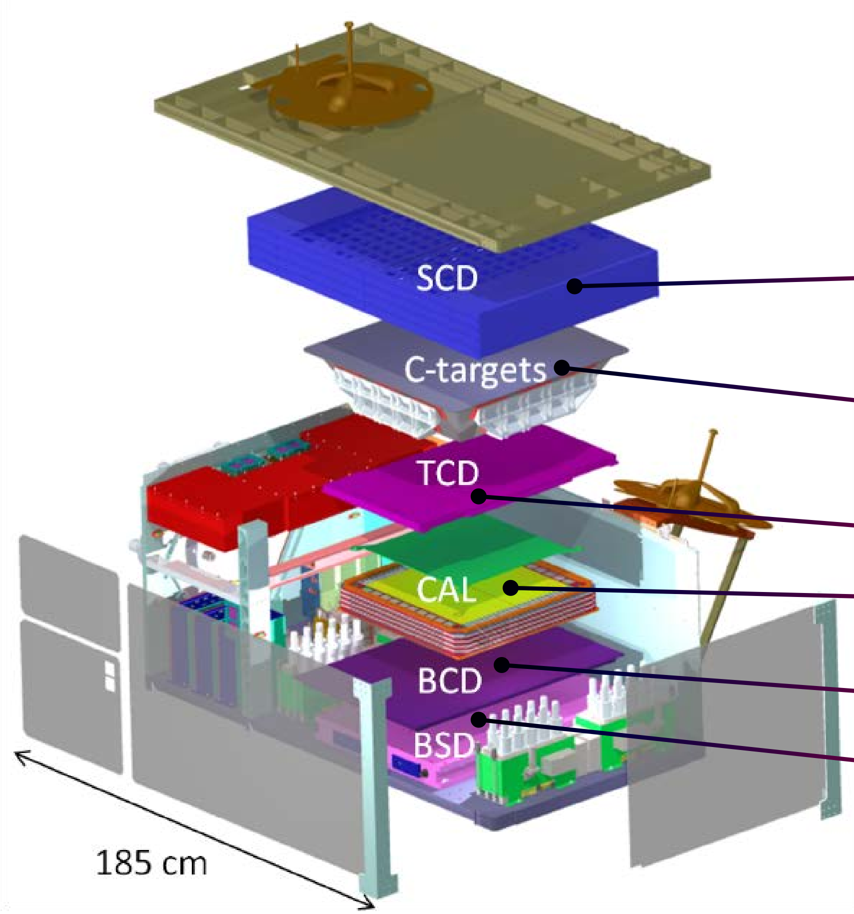
- 20 layers of alternating tungsten plates and scintillating fibers.
- Determines energy.
- Provides tracking and trigger.

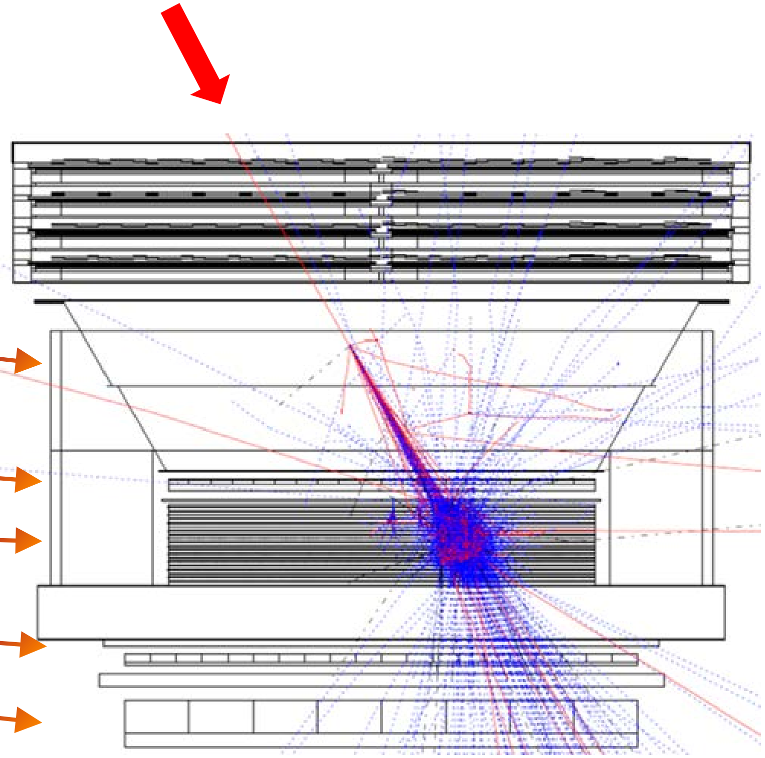
Top/Bottom Counting Detector (T/BCD) *Kang et al. PoS(ICRC2017)250, 2017; Hwang et al. JINT10 (07), P07018, 2015.*

- Plastic scintillator instrumented with an array of 20 x 20 photodiodes for e/p separation.
- Independent trigger.

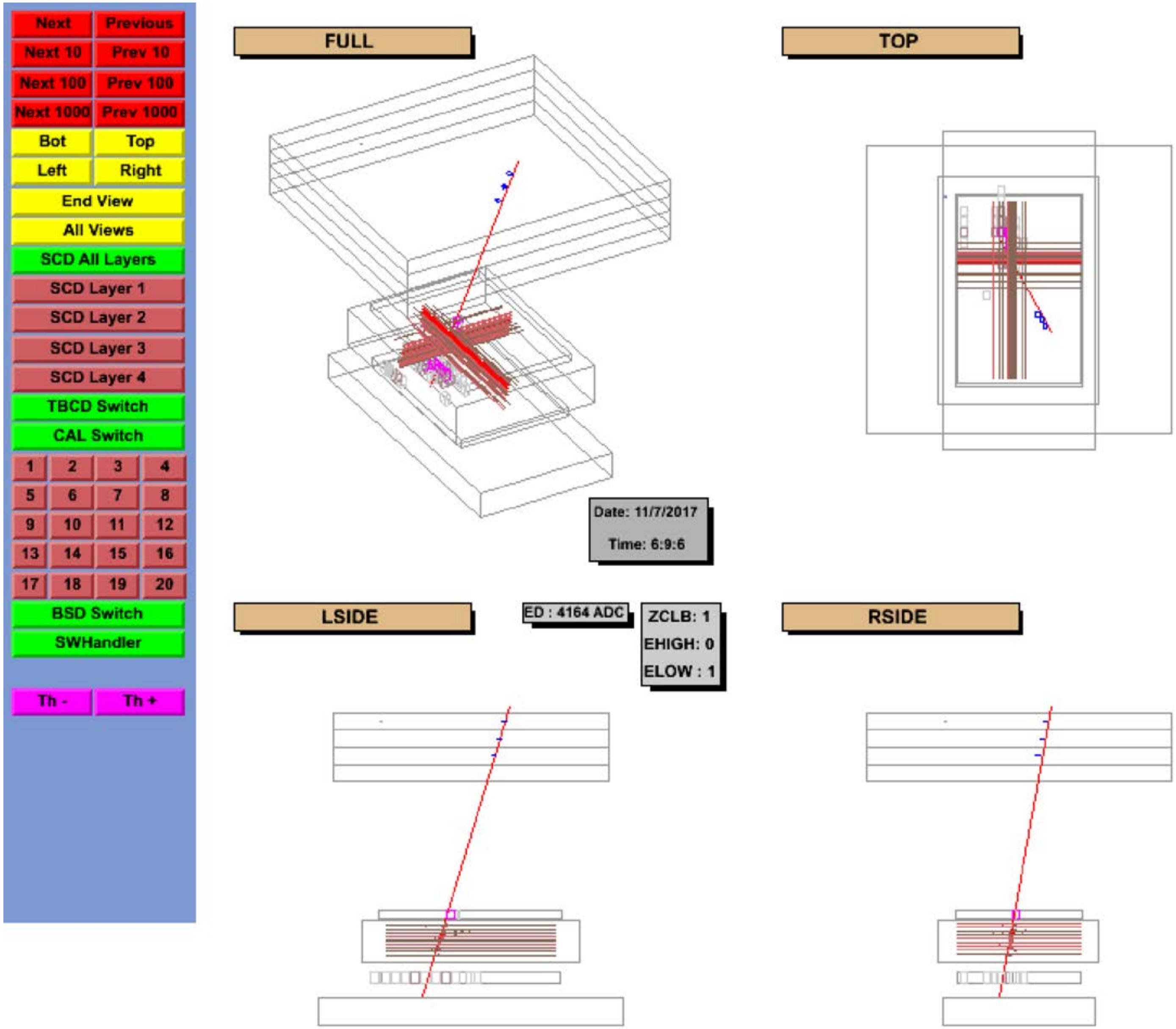
Cosmic Ray Event Simulation

Seo et al. Adv. in Space Res., **53**/10, *1451*, 2014; Smith et al. PoS(ICRC2017)199, 2017

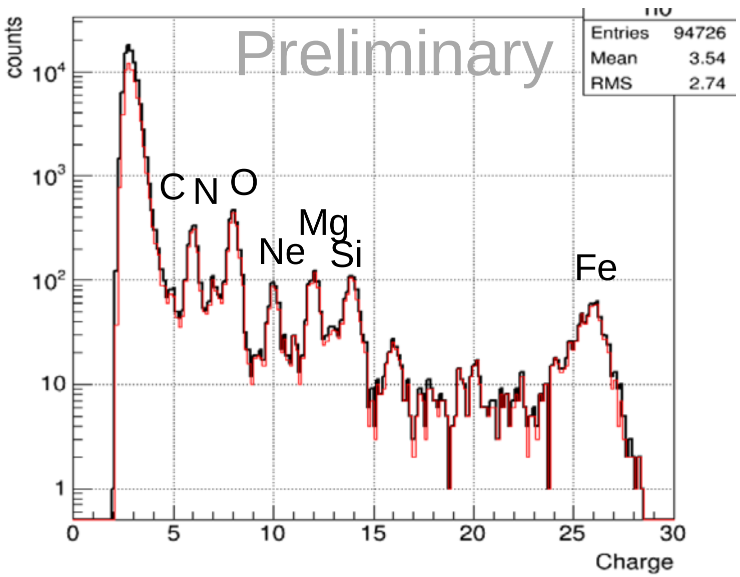


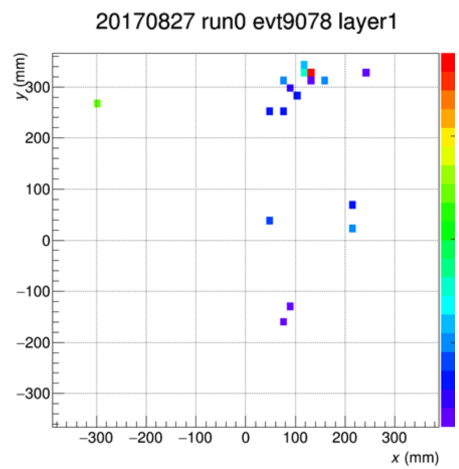


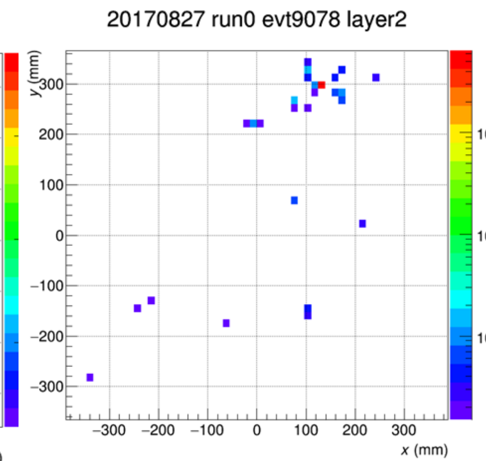
Flight data: Cosmic Ray Detection

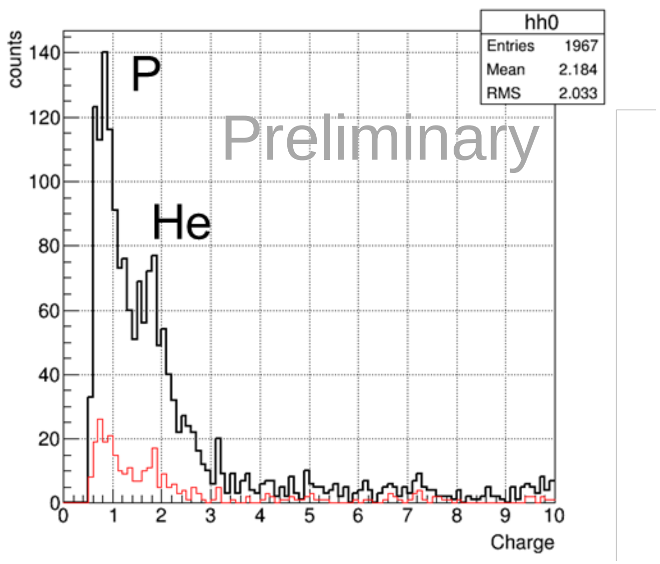


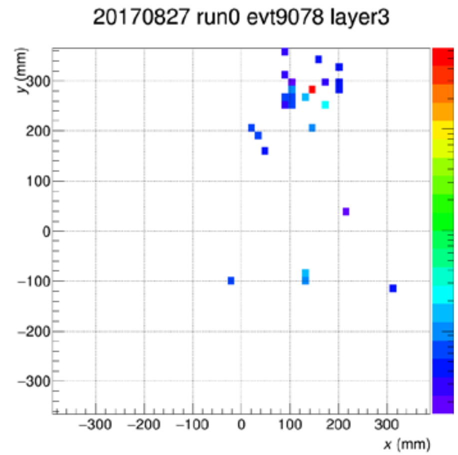
SCD: individual elements are clearly identified

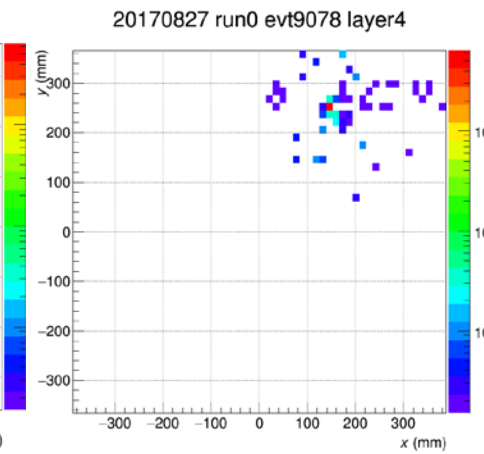






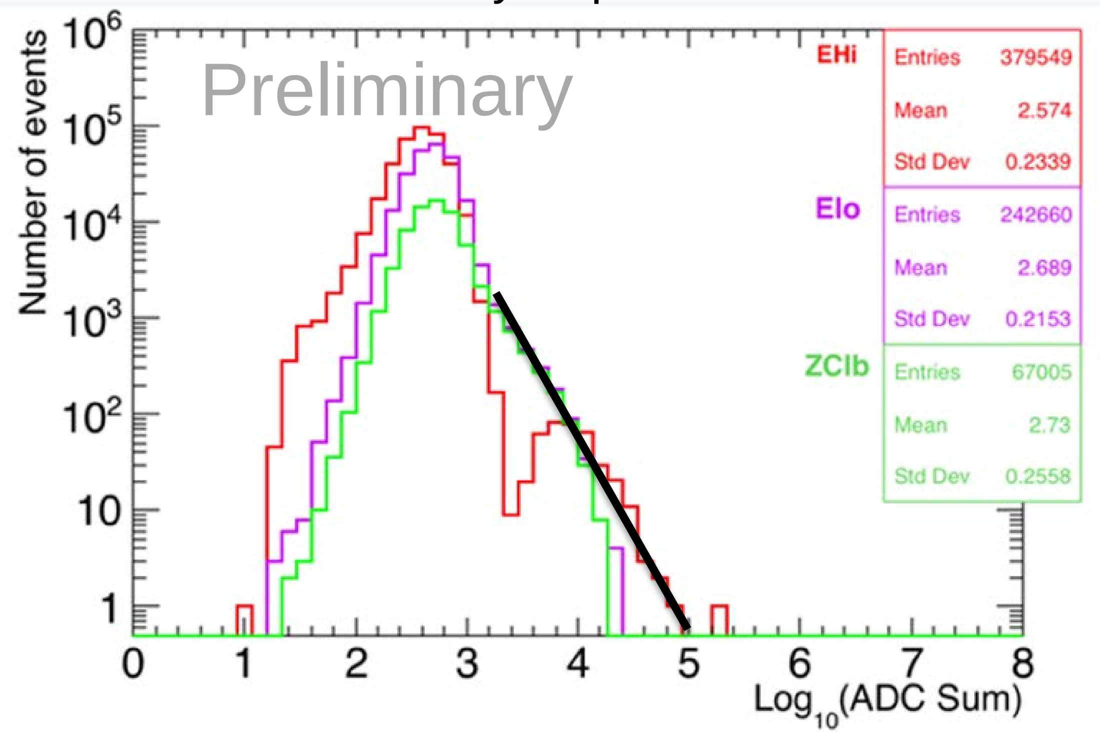




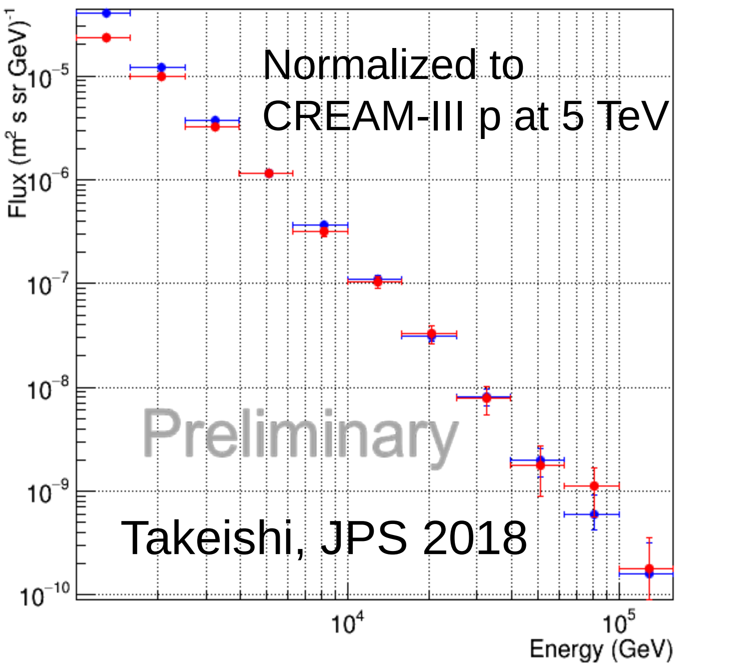


CAL provides energy measurements

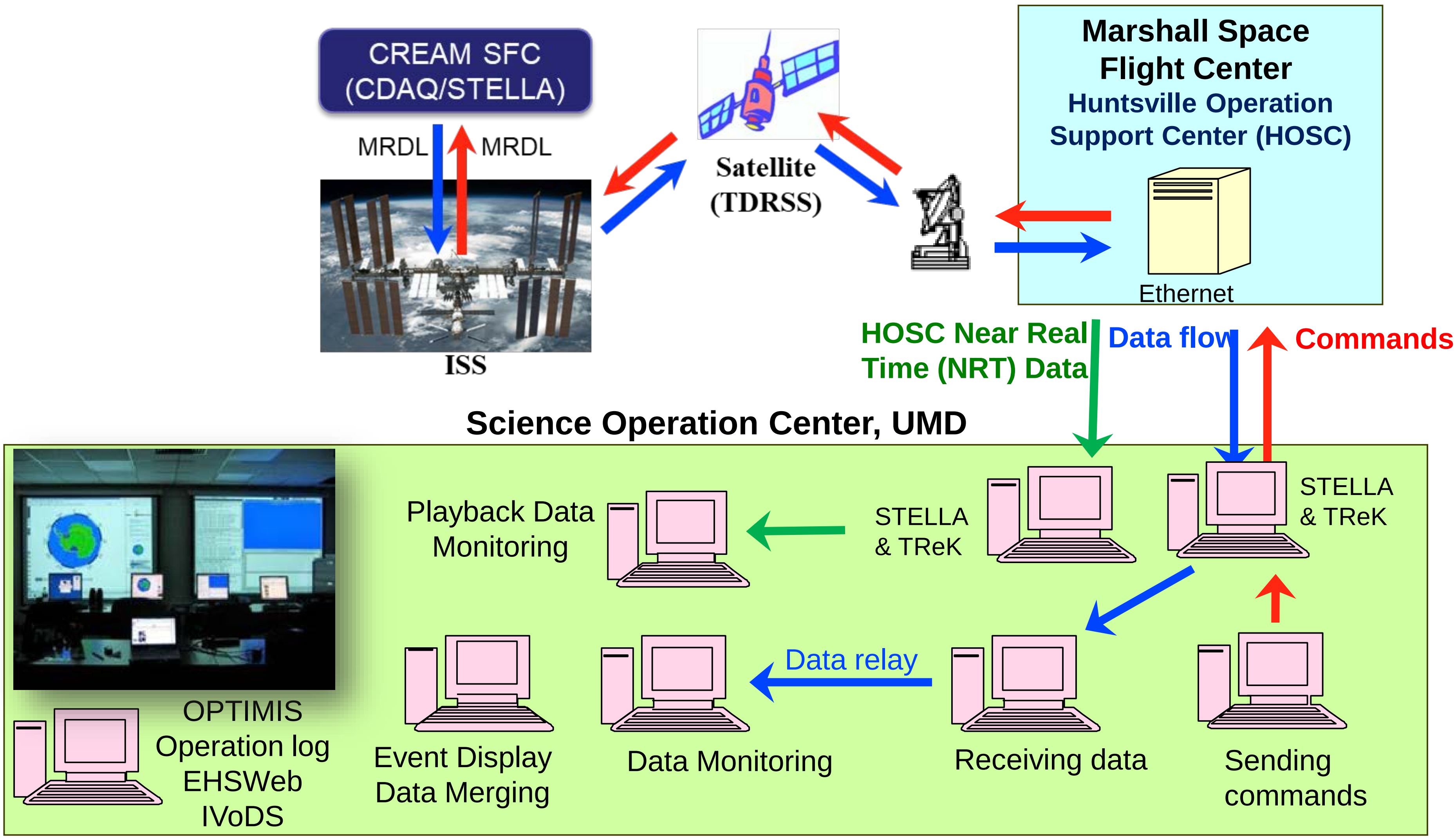
Cosmic ray all particle counts



Spectrum Consistency Check



CREAM Science Operation

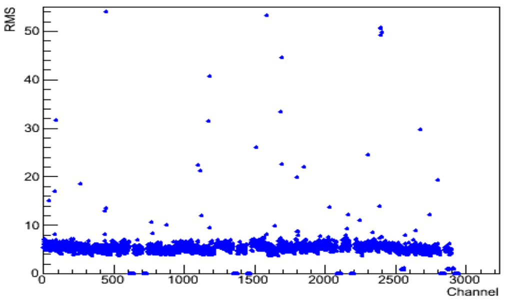


Web Monitoring and Data Distribution

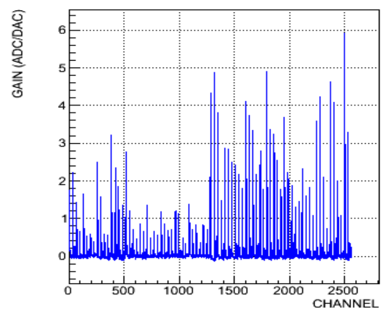
http://cosmicray.umd.edu/iss-cream/data

- Monitor performance of CREAM instrument using in-flight calibration data
  - Every hour: Noise level (pedestal runs) of Calorimeter, SCD, and TCD/BCD
  - Every two hours: Charge gain, HPD aliveness etc.
- Relay the housekeeping data to a web server for worldwide monitoring
  - 1558 housekeeping parameters every 5 sec
  - Provides warning by color display when values are out of range.
- Visualize interactions of cosmic rays in CREAM by generating event display plots of science events.
- Process all data and distribute them in ROOT format for analysis.
  - Refine the initial pre-launch detector calibrations channel by channel to reflect the actual flight conditions, including time-dependent effects

Noise level of one layer of SCD

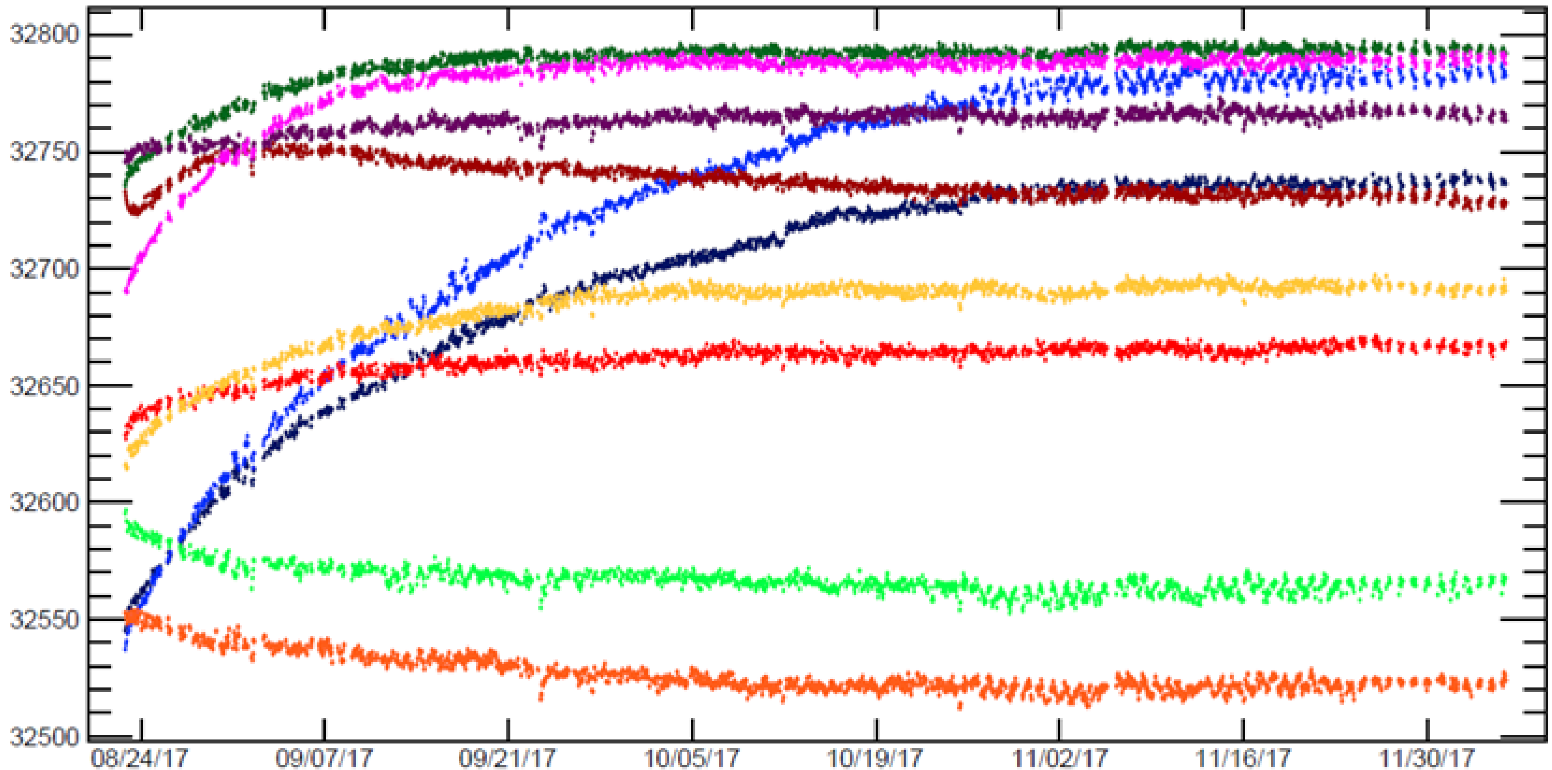


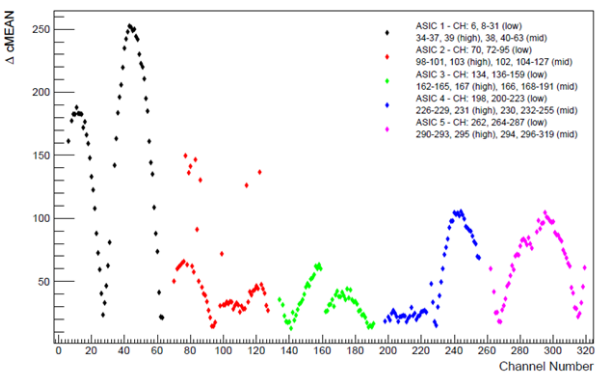
HPD aliveness of CAL

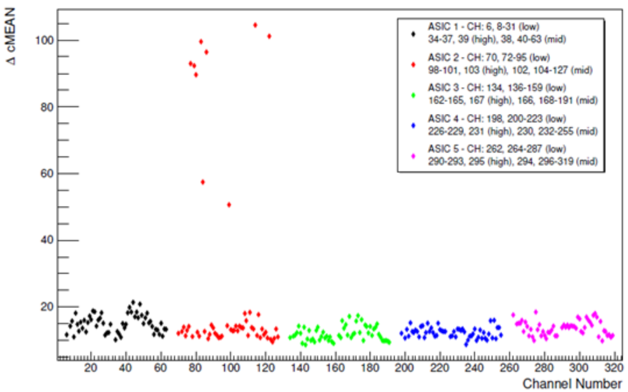


EvtTime	11:37:45	CalHV6a	-0.08	HPD12	26.27
RawClb	0.00	CalHV6b	-0.05	HPD78	27.94
RawExt	0.00	CalHV7a	-0.08	HPD34	26.68
RawCD1	0.00	CalHV7b	-0.06	HPD56	25.91
RawCal	0.00	CalHV8a	-0.08	SFC-A	26.20
RawCD2	0.00	CalHV8b	-0.06	ColdPla2	26.08
TrgTime	18:00:00	CalBias1	55.96	ColdPla3	-74.84
TrgTotal	0.00	CalBias2	55.44	ATCS3	27.18
TrgExt	0.00	CalBias3	56.11	ATCS4	26.39
TrgClb	0.00	CalBias4	55.35	ATCS5	25.98
TrgEHi	0.00	CalBias5	56.18	SFC-B	26.33
TrgELow	0.00	CalBias6	55.44	RedPM	25.93
TrgZClb	0.00	CalBias7	56.16	+X-YCP	23.88
NioTime	11:37:47	CalBias8	55.40	HKBox	24.80
NioTRate	1.93	BsdRet1	0.02	BottPla	23.62
NioNRate	0.00	BsdRet2	0.02	ATCS6	24.68
CMDQ	0.00	BsdTQB	26.49	+3o3VC	3.30
HKQ	0.00	BsdTQA	26.83	+5o2VC	5.00
EVTQ	0.00	BsdTQC	25.21	+12VC	12.12
DAT0	0.00	BsdTQD	24.66	m5o2VC	-4.99
DAT1	0.00	Bsd-12V	-11.76	TempC	32.79
PKT0	0.02	Bsd+1o5V	1.52	5o2cCl	0.69

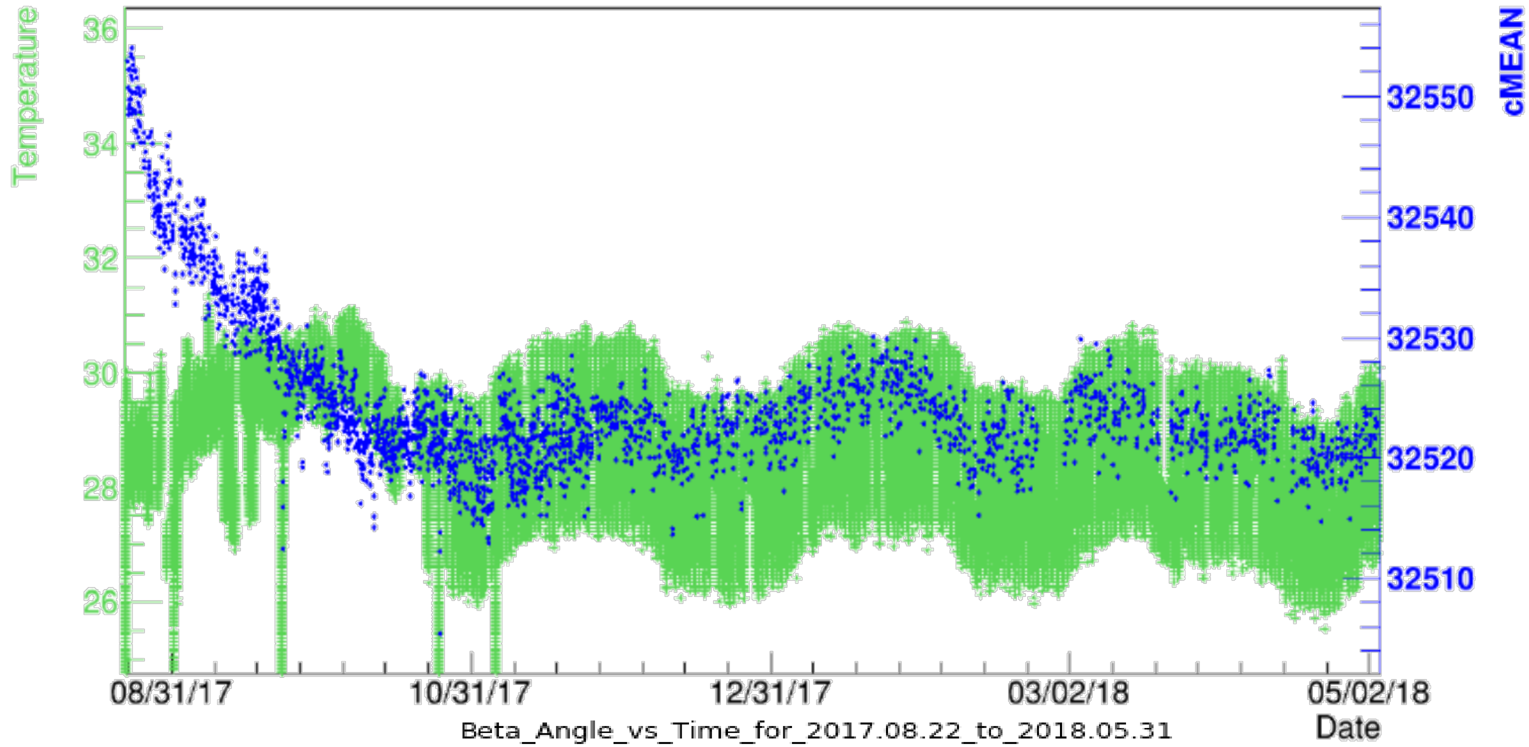
CAL pedestal reached a plateau in November 2017

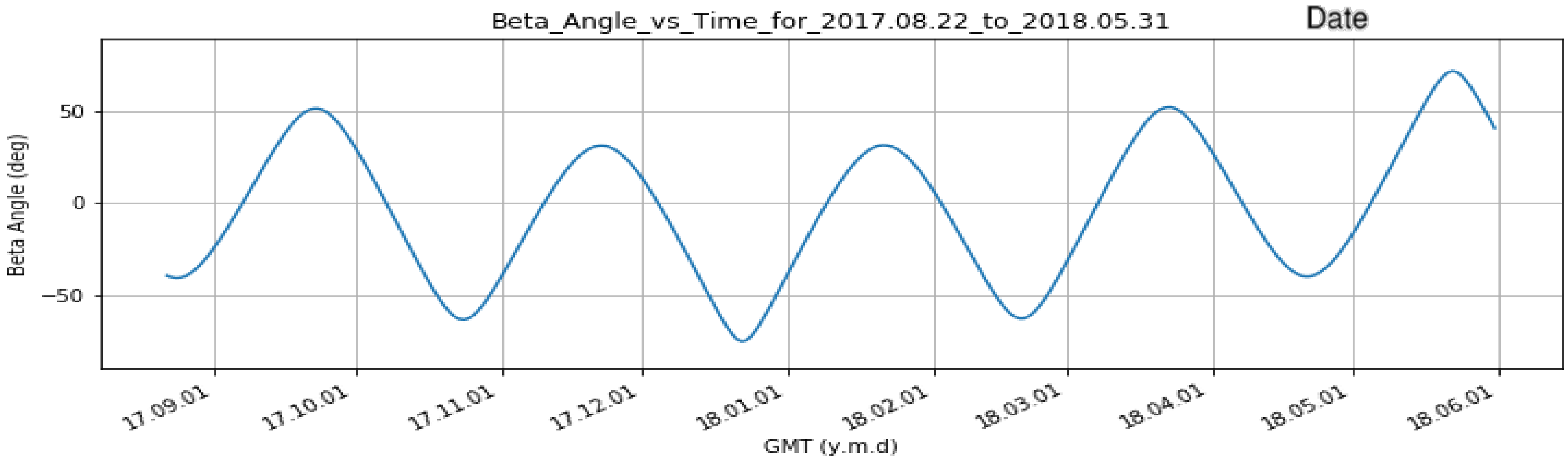






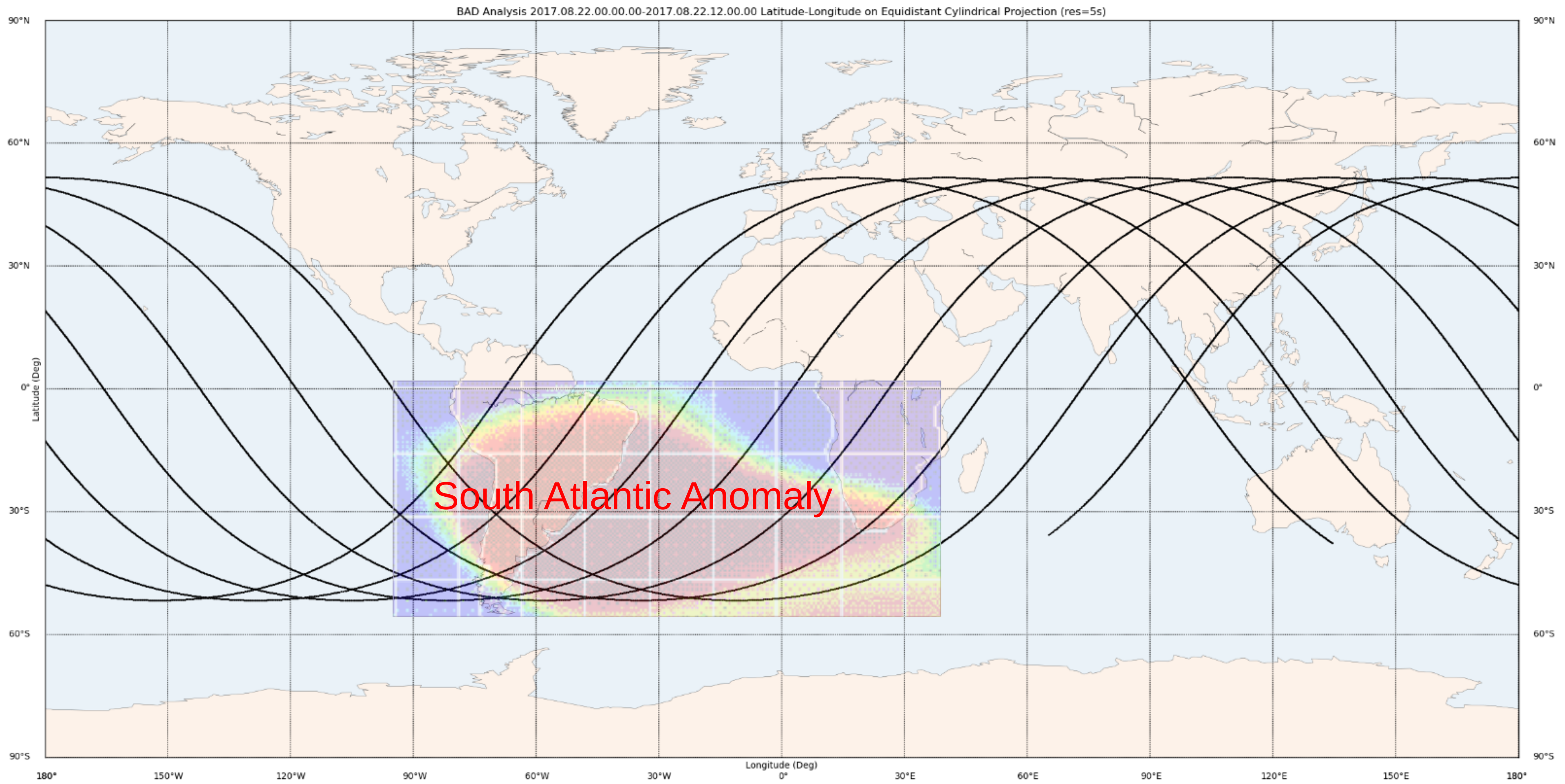
Temperature Dependence





Currently taking data only during non-SAA orbit

To avoid radiation damage to the instrument



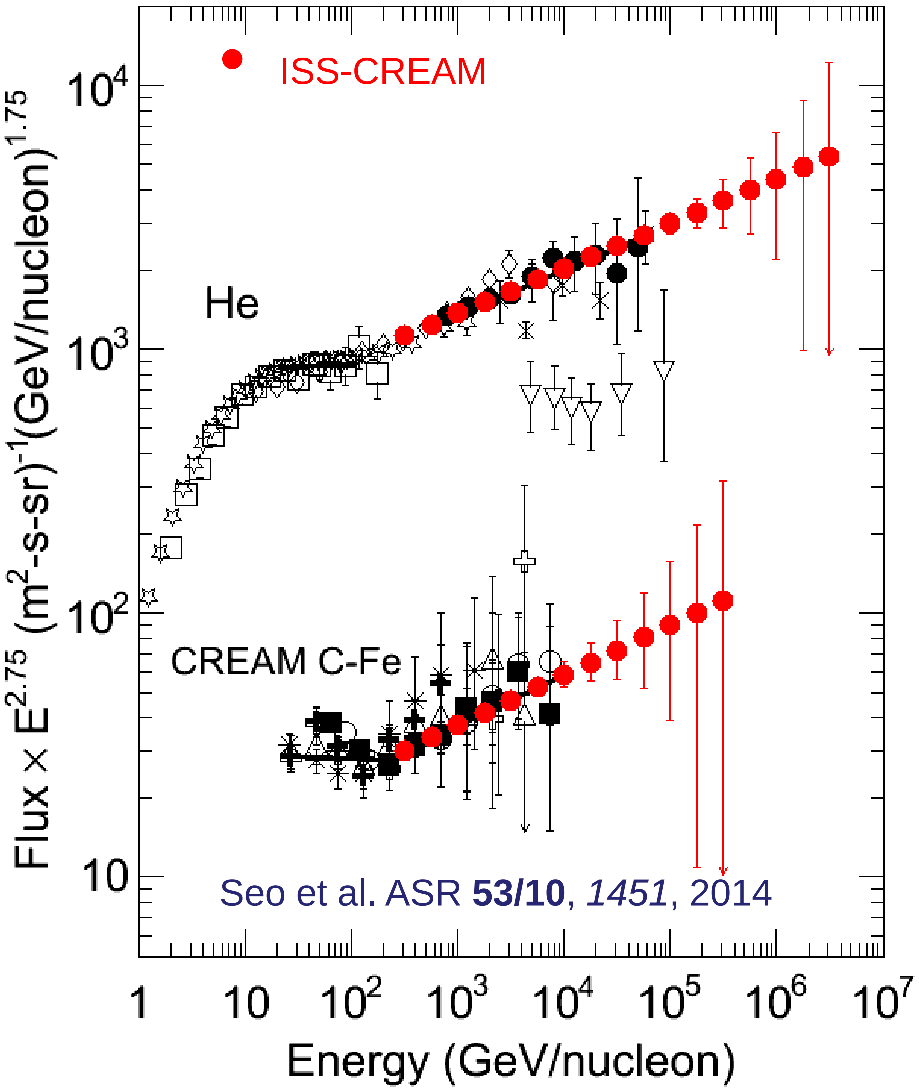
Detector and instrument checkouts are completed, and the entire instrument is taking data in a stable configuration in non-SAA orbits.

ISS-CREAM takes the next major step

Increases the exposure by an order of magnitude!

- The ISS-CREAM space mission can take the next major step to 10^{15} eV, and beyond, limited only by statistics.

- The 3-year goal, 1-year minimum exposure would greatly reduce the statistical uncertainties and extend CREAM measurements to energies beyond any reach possible with balloon flights.




ISS-CREAM