CREAM:

at The High Energy Cosmic Ray Frontier

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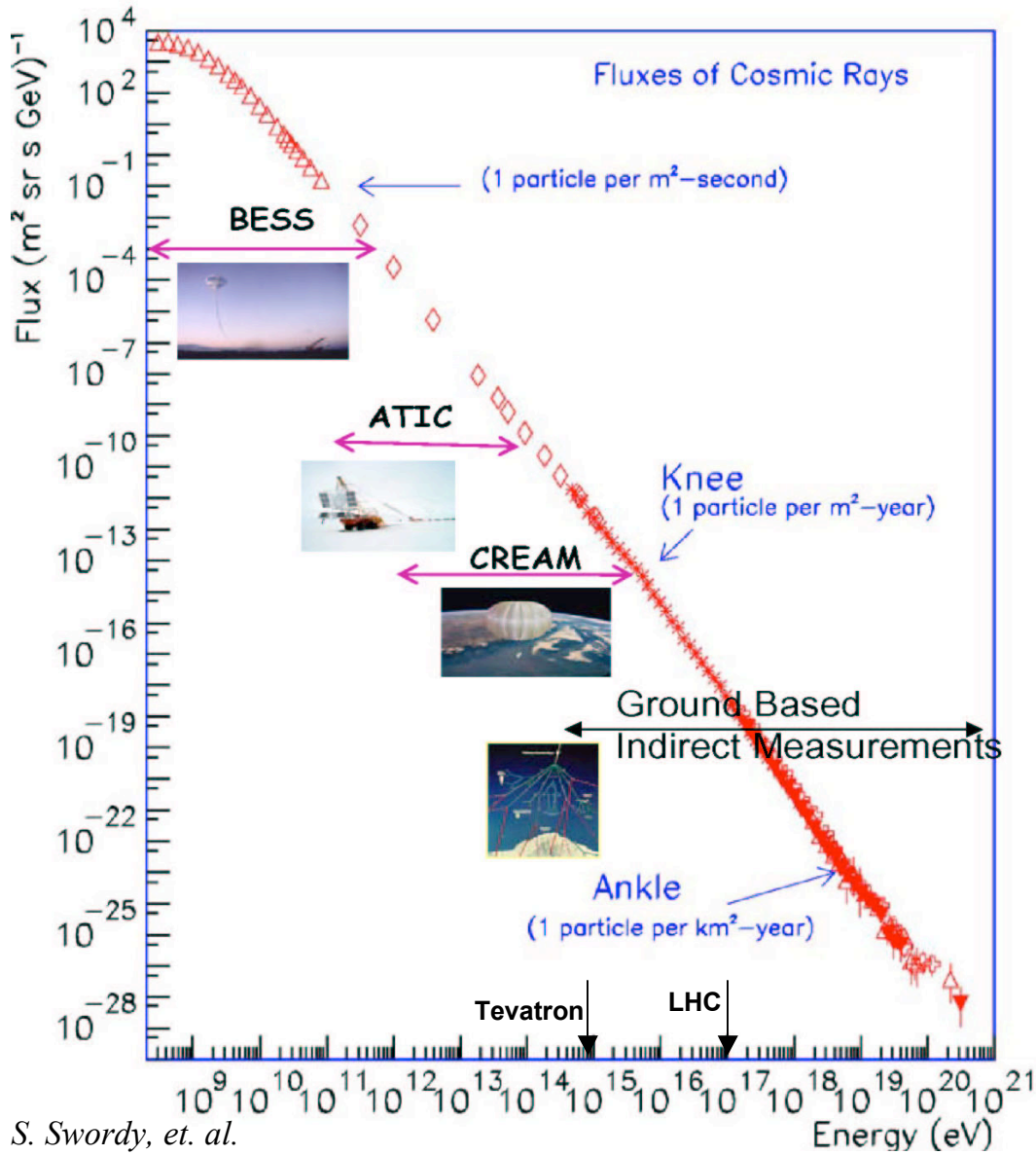
All-particle CR Spectrum



S. Swordy, et. al.

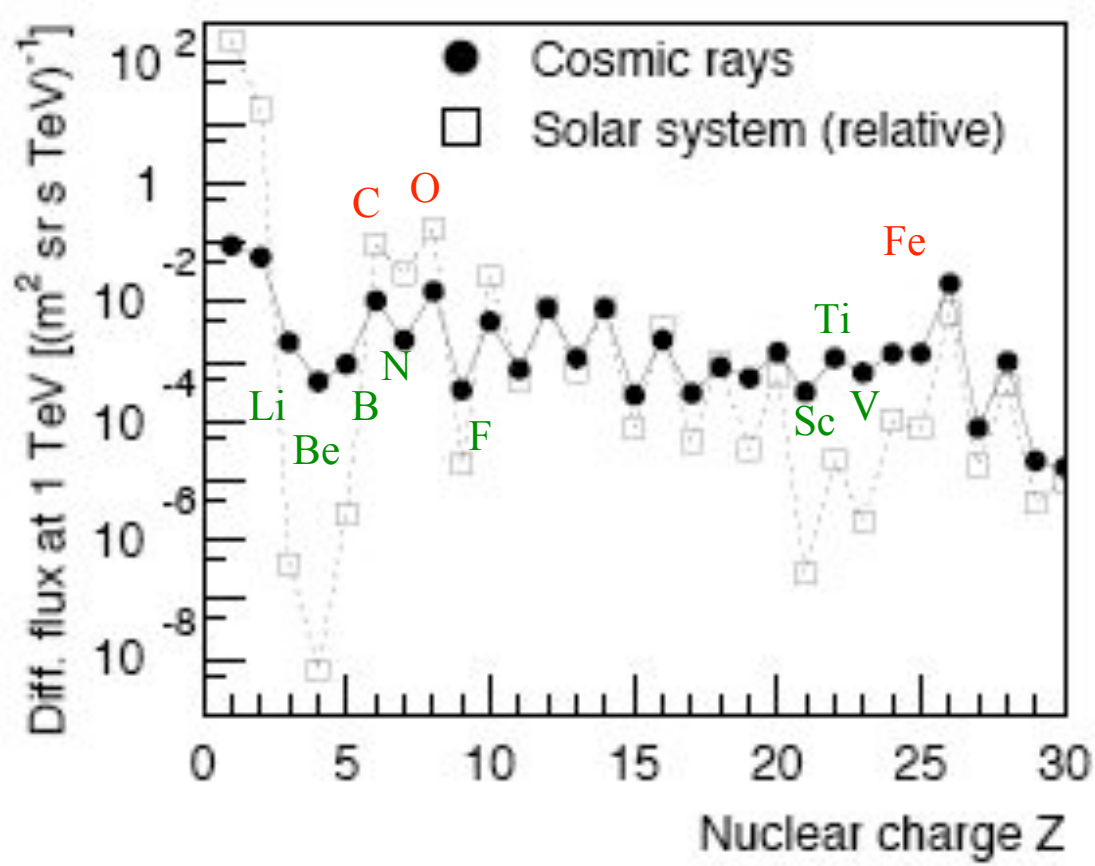
Abundance

Cosmic ray abundances

- trace solar system values
- implying stellar origin.

Even-odd effect:

- Even-charge elements more abundant due to stability in stellar nucleosynthesis.
- Over-abundance of unstable elements in CRs implies spallation of primaries during propagation.



Hörandel

Cosmic Ray Energetics and Mass

Particle Detector

Charge and Energy:

- $+1 \leq Z \leq 26$
- 10^{12} eV <~ E <~10^{15} eV

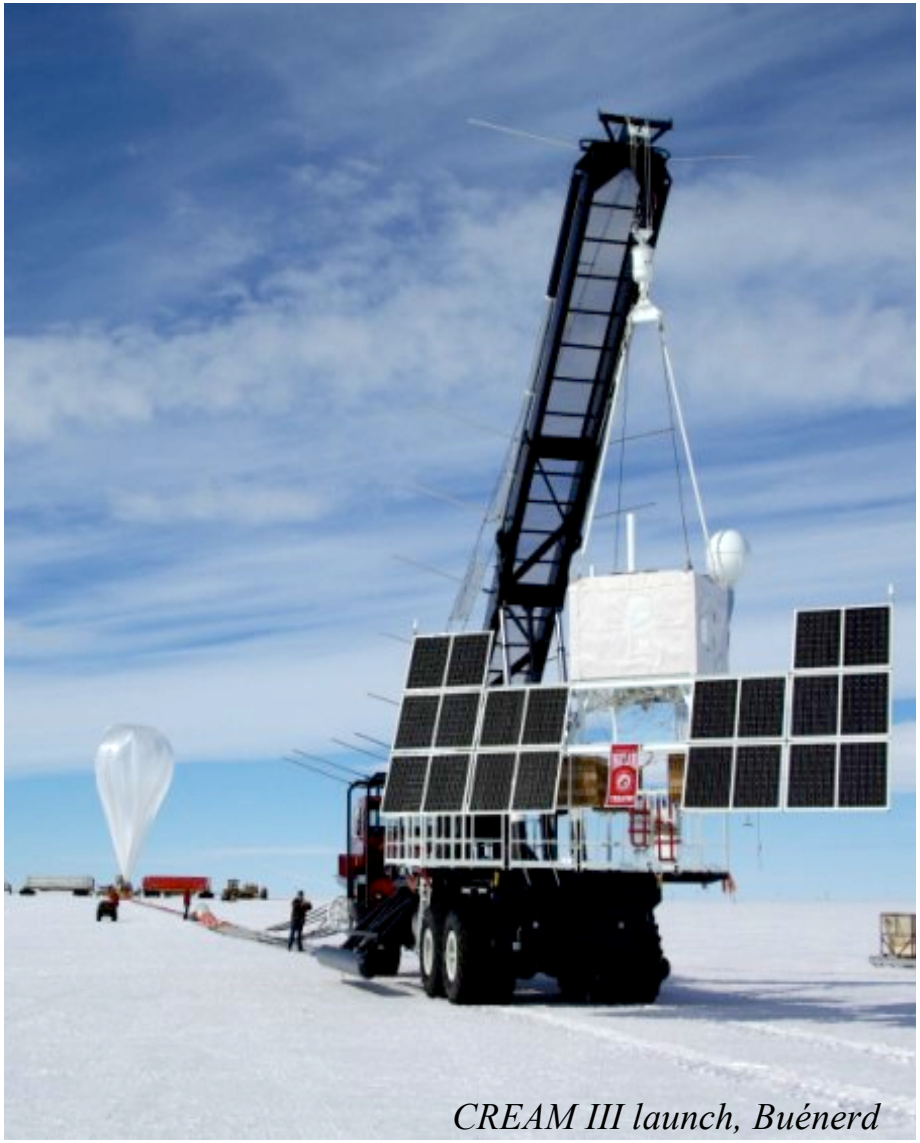
from 4 main subsystems:

- TCD (Z), TRD (E), SCD (Z), Cal (E)

Timing **C**harge **D**etector, **T**ransition **R**adiation **D**etector, **S**ilicon **C**harge **D**etector, and **Cal**orimeter

Flown on a Long-Duration Balloon over Antarctica

- CREAM I: 42 days
  (16 Dec 04 - 27 Jan 05)
- CREAM II: 28 days
  (16 Dec 05 - 13 Jan 06)
- CREAM III: 28 days
  (19 Dec 07 - 16 Jan 08)



CREAM III launch, Buénerd

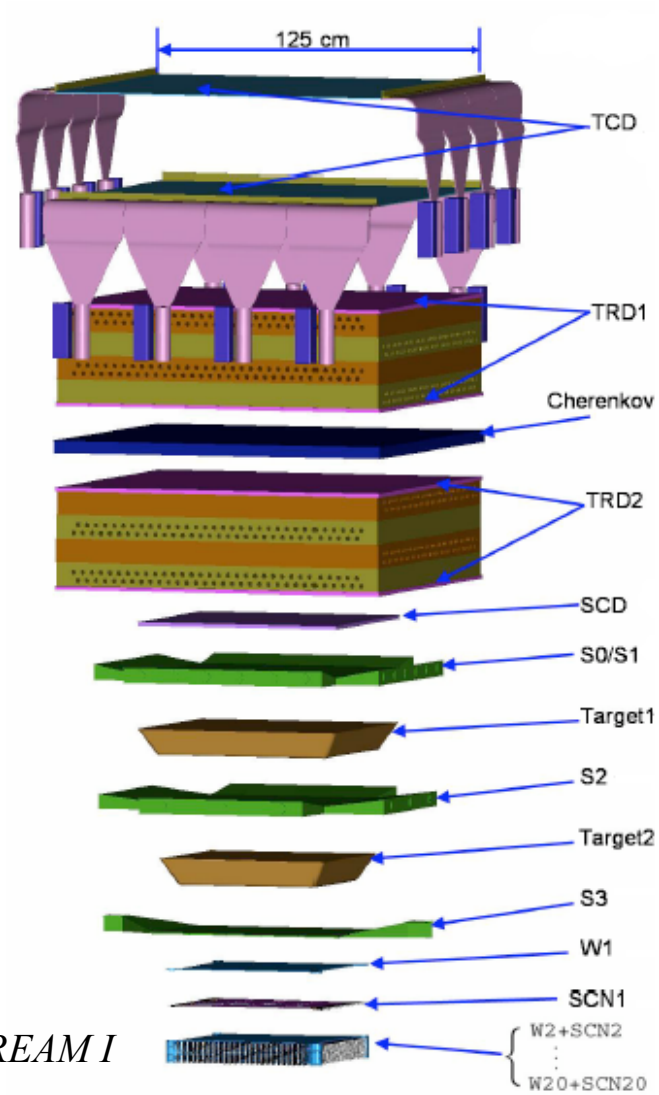
How CREAM (I) does all that.

Timing Charge Det.:

- Scintillation ⇒ Z, β
- $\sigma_Z \sim 0.2\text{-}0.35e$
- High Z trigger
- PMTs read out with v. fast electronics

Silicon Charge Det:

- Si ⇒ Z, E
- $\sigma_Z \sim 0.2e$
- smaller (area ~ half) acceptance than TCD



CREAM I

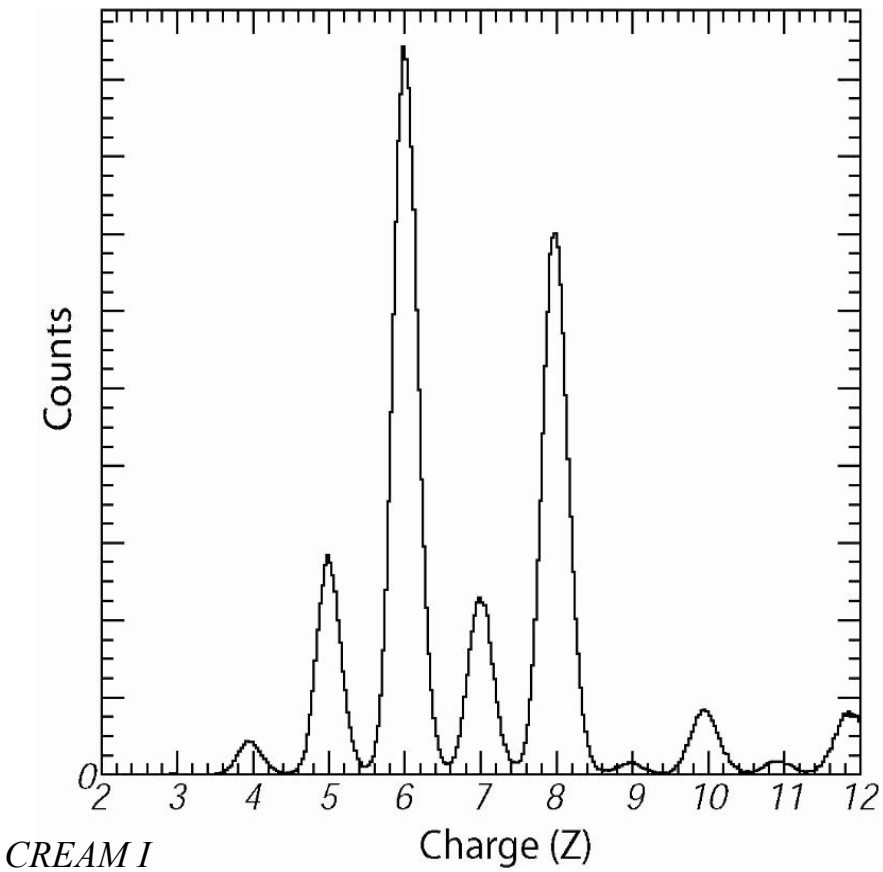
Transition Radiation Det. (+Cherenkov):

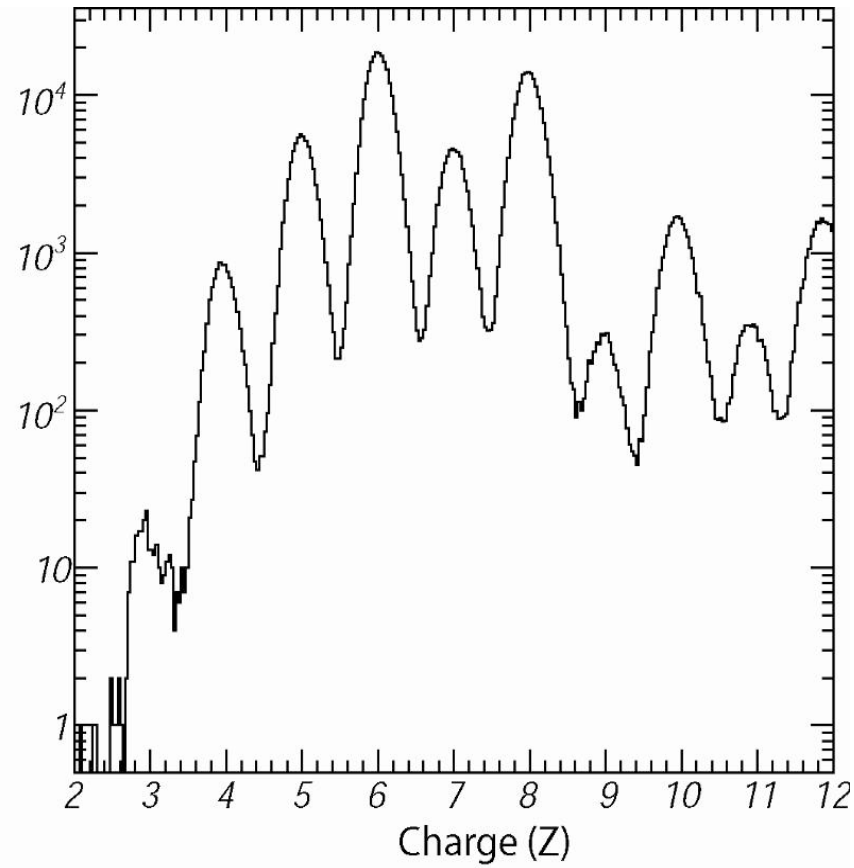
- Ionization & TR ⇒ γ, Z
- Tracking (mm) and E
- Threshold: Z>3
- Cher → γ → E

Calorimeter:

- Inelastic interactions in Carbon target
- Track secondaries
- W & Scin. fibers measure E_{dep}
- Hi E trigger

Charge





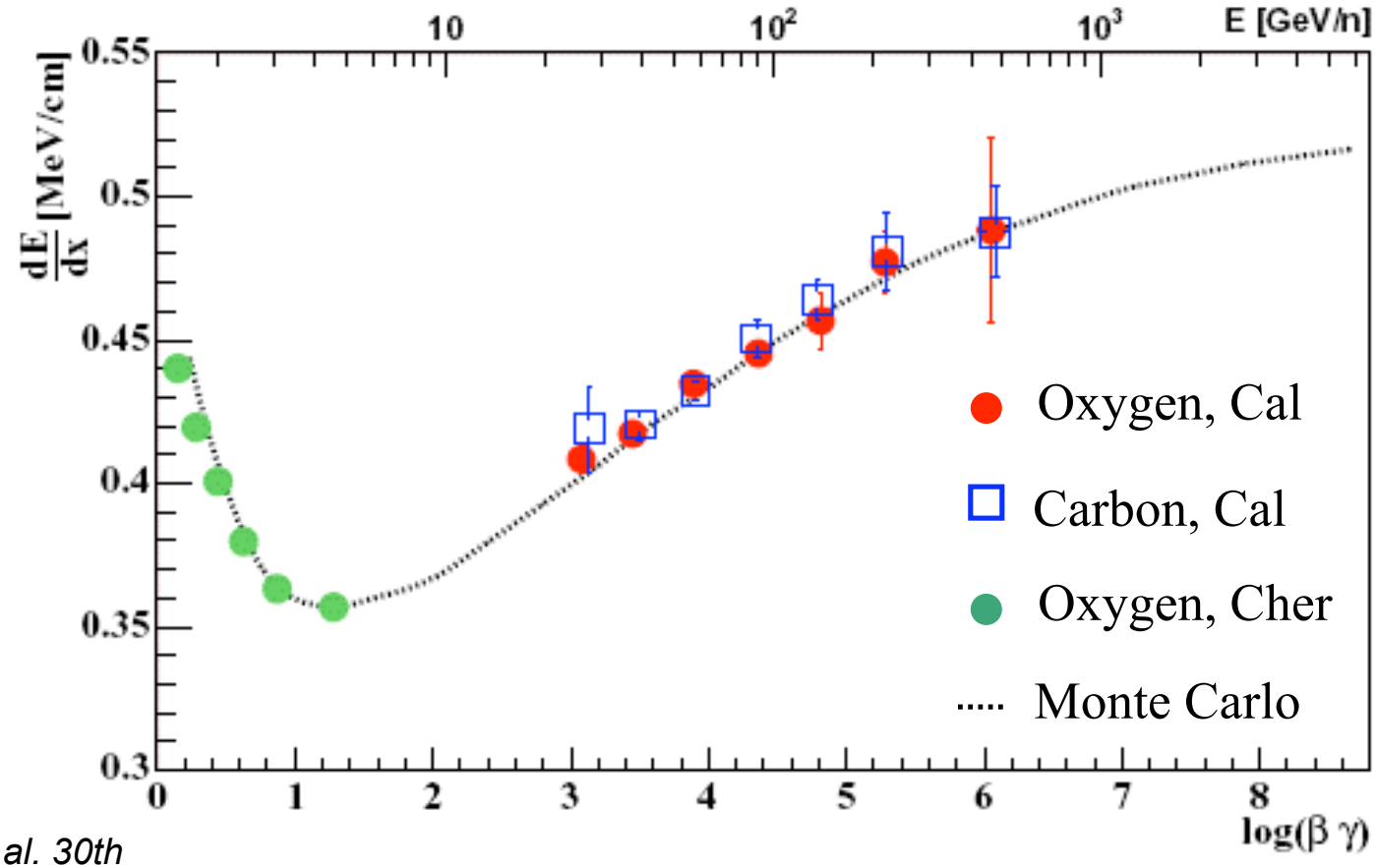
Carbon: $\sigma = 0.16$ e

Oxygen: $\sigma = 0.17$ e

from TCD and SCD

Energy

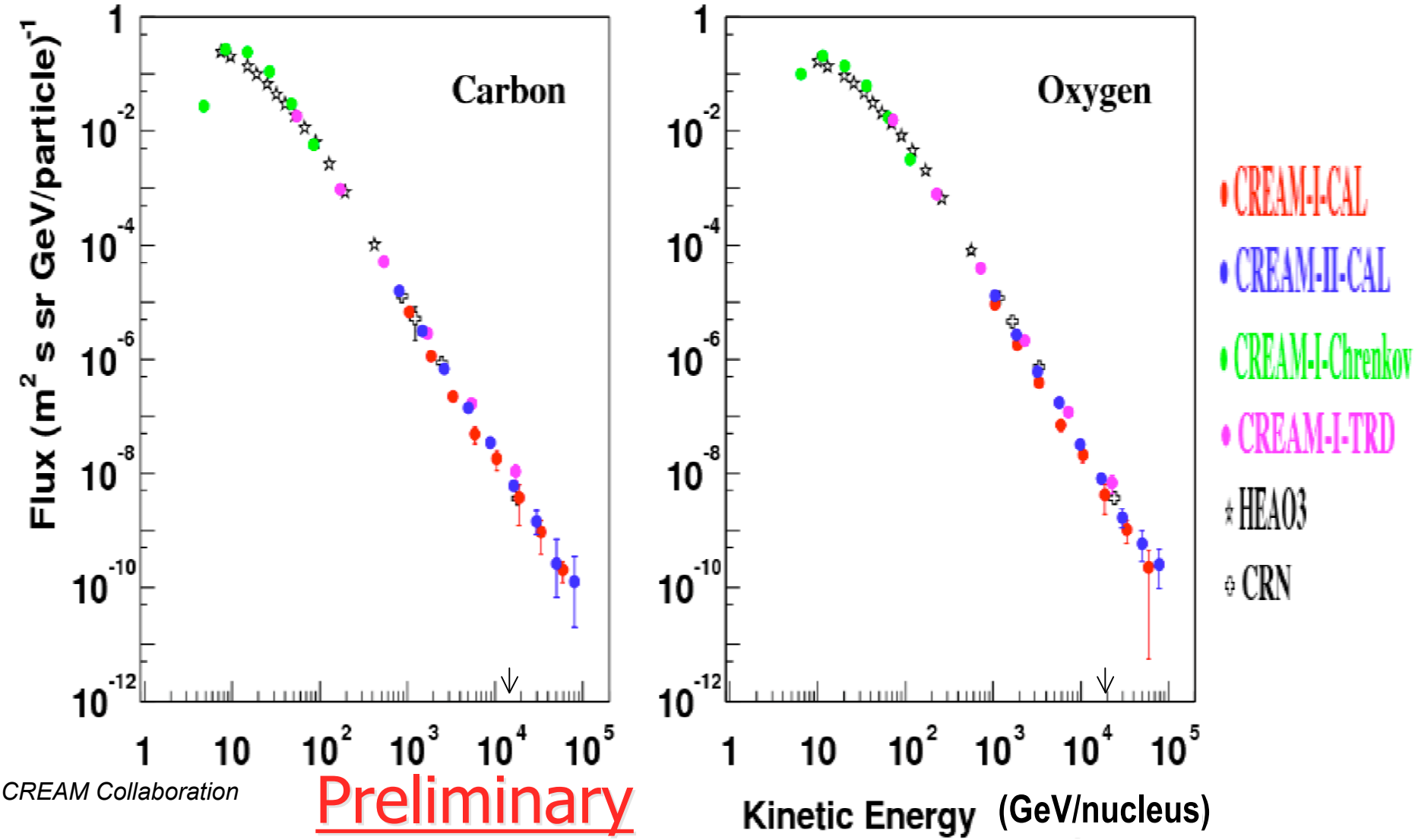
Cross-calibration of TRD and Calorimeter energy measurements



Maestro et al. 30th ICRC, Merida, 2007

Preliminary Results

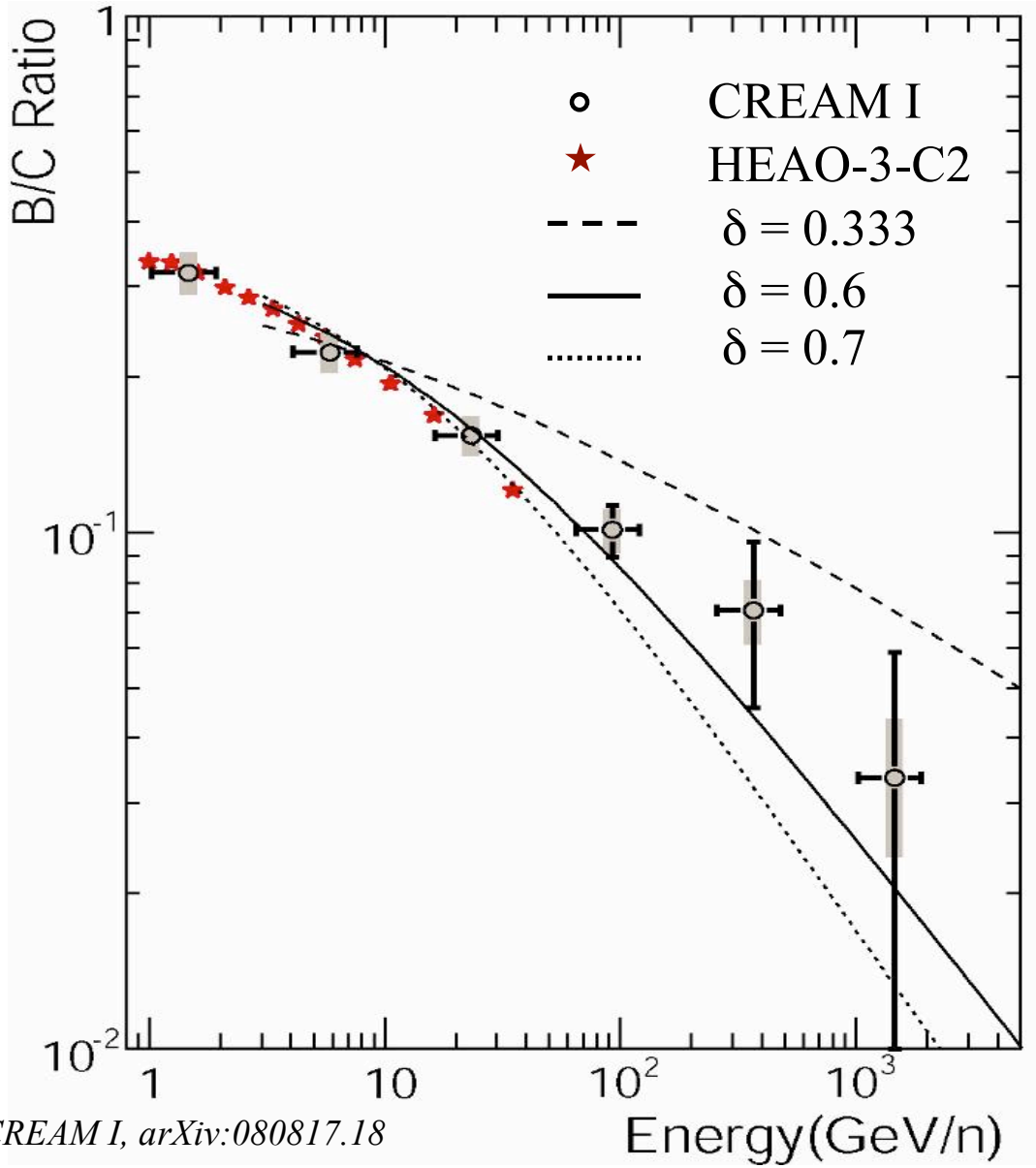
Carbon and Oxygen Spectra



CREAM Collaboration

Preliminary

Boron:Carbon



CREAM I, arXiv:080817.18

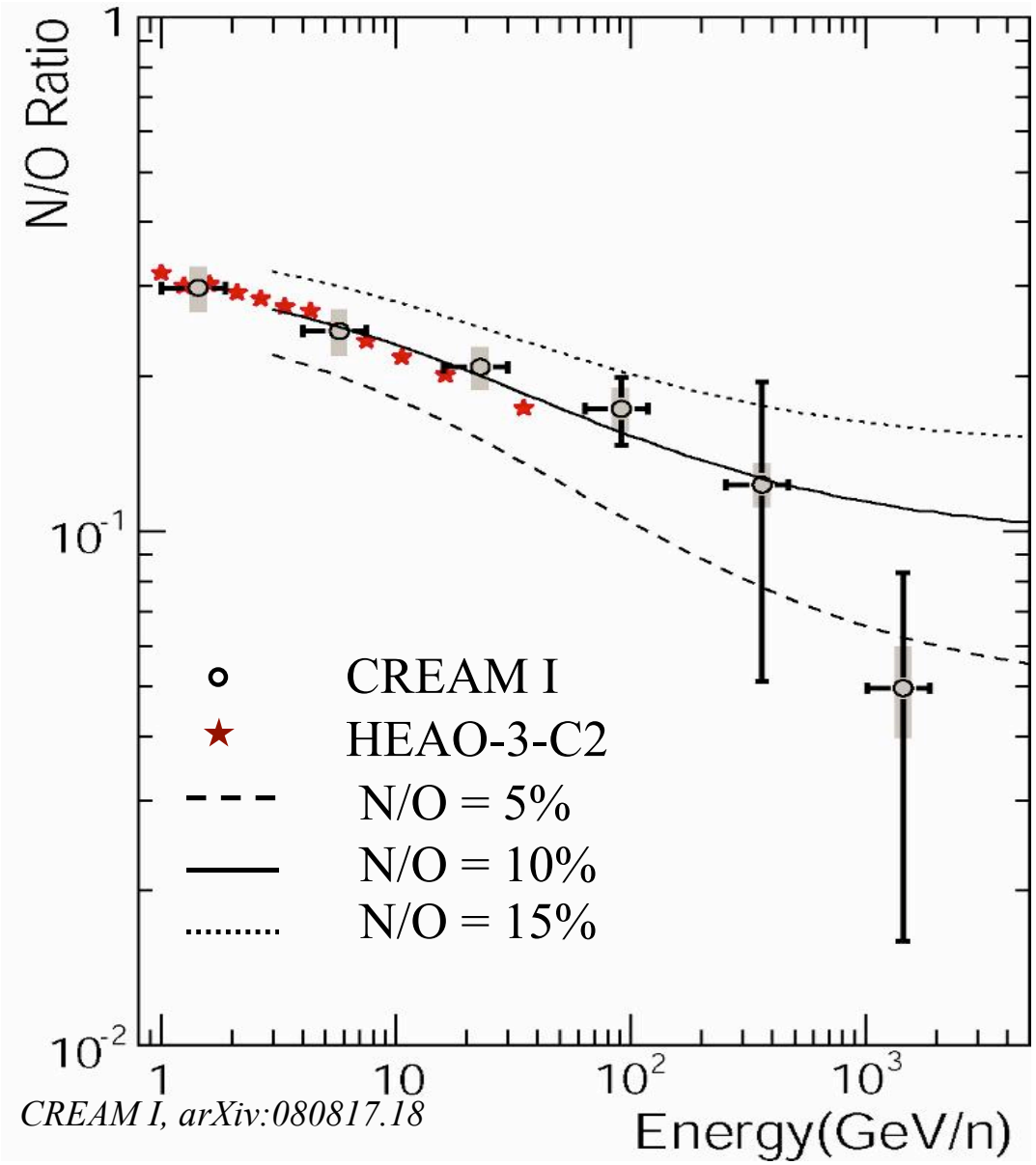
Lines:

- Simple Leaky-box model with range of propagation index δ

Error Bars: (Vertical)

- Line: Statistical
- Shaded: Systematic, dominated by uncertainties in atmospheric secondary production at E > 300GeV/n

Nitrogen:Oxygen



CREAM I, arXiv:080817.18

Lines:

- Simple Leaky-box model assuming $\delta = 0.6$ with range of N/O in source

Error Bars: (Vertical)

- Line: Statistical
- Shaded: Systematic, dominated by uncertainties in atmospheric secondary production at E > 300GeV/n

Conclusions

- CREAM data agrees with previous measurements and has extended the Carbon and Oxygen spectra in energy.

- CREAM has extended the Boron to Carbon and Nitrogen to Oxygen ratios with good statistics 2 orders of magnitude higher in energy.

- The galactic propagation index from B:C corresponds to a high energy propagation pathlength of ~1 g/cm^2 and, in conjunction with the N:O ratio, suggests a source N abundance at high energies of ~10%.

- CREAM II and III have increased our statistics; further analysis is forthcoming. Systematic errors can be reduced by improving our understanding of nuclei interactions.

- CREAM IV is being prepared to fly again this winter.