

Some physics in the galacticextragalactic transition region

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Start with low-energy data





1		4.0
Element	Z	fraction at 10 ¹³ eV
hydrogen	1	0.3019
helium	2	0.4104
carbon	6	0.0388
oxygen	8	0.0745
neon	10	0.0153
magnesium	12	0.0293
silicon	14	0.0308
sulfur	16	0.0082
argon	18	0.0043
calcium	20	0.0070
iron	16	0.0800

Interpolated flux at 10¹³ eV from Figure 29.1 Particle Data Book

<u>C. Patrignani *et al.* (Particle Data Group)</u>, Chin. Phys. C, **40**, 100001 (2016).

http://pdg.lbl.gov/2016/reviews/rpp201 6-rev-cosmic-rays.pdf

Simple Model: Galactic Flux



- Include only 11 elements from Fig 29.1 of PDB neglect all others
- Composition at 10¹³ eV given by interpolation of Fig. 29.1 PDB
- Same power law extrapolated with index $\alpha = 2.80$.
- Protons cut off at $E_p = 10^{15.60} \text{eV}$, AND others at $Z \cdot E_p$
- Steeper power law above cut-off energies index unknown β=???



Simple Model: Extra-galactic



- Assume single light component up to just below the "ankle" with power law of index γ=3.24
- Low energy cut-off of this power law:
- Overall form (where $x = \log_{10} E$) $\log_{10} J = B + [1 - e^{-(c-x)/d}] - \gamma x$ chosen for its simplicity $\log_{10}[E^3 J(E)]$ **γ=3.24 γ=3.24** c = 16.4d = 0.55 $Z \cdot E_p$ $\log_{10} E$ Oct 12, UHECR 2018













Note



- Start with Balloon data
- assume nothing special happens except for a rigidity cut-off cycle starting at the knee
- Can comfortably fit TALE spectrum
- Composition (prediction from model + TALE data) upcoming soon!
- The extrapolation ONLY above 10¹⁴eV
- ISSCREAM will fill in the gap to 10¹⁵eV
- Not a new Idea: extend TALE or something equivalent by another order of magnitude down to 10¹⁴eV – will provide overlap and calibration for Xmax composition measurement

Some unfermented ideas



- Move TALE to 3000-3500m in altitude: can improve signal-to-noise by factor 3-4 in the 10¹⁴eV decade (by being closer to the shower maximum)– NOT good enough
- Will need at least another factor 3-4: a smaller pixel size will help (SNR improves roughly linearly with decrease in pixel size) → go to 0.2-0.3° pixels!
- Can an adaptation of a prototype/developmental EUSO camera be used for this measurement?
- A non-imaging Cherenkov detector?
- Both?
- Radio? Andreas says it's not possible

HAWC: 0.022 km², E>1-10 TeV, \$6M Optical V-ray Cosmic Ray 331 Non-imaging Counters. Observator Ogre-Crow 62 m spacing 8" PMTs \$ 40° Winst. 2 per counter 6 Fixed IACT stations 30°+30° 45°-75° elevition (e.g. 4xHikes) Cost (Conservative) Flok NI canter: \$3.3M \$ Sook IACT site: \$3.0M \$6.3M Area: 1 km² Doity Factor: 10% Threshold: SOTEV

AROJECT

Doug Bergman's hybrid imaging + non-imaging Cherenkov detector



End



Reserve Slides

Fit Spectrum



- A fairly wide range of the post-break power index β can be accommodated by this basic scheme
- We also show that the spectra obtained from assuming H4a Xmax distribution and assuming protons can both be fitted with β =4.2
- 5 cases:

symbol	Ι	II	III	IV	V
α	2.8	2.8	2.8	2.8	2.8
β	4.2	5.0	3.5	4.2	4.2
$\log_{10} E_p/\mathrm{eV}$	15.6	15.6	15.4	15.5	15.6
γ	3.24	3.24	3.24	3.24	3.24
d	0.56	0.70	0.36	0.78	0.71
C	16.38	16.24	16.53	16.45	16.31