The Arrival Direction of EAS Observed by Kinki Array with Energy Around 10^{15} eV (II)

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Abstract

We have reported a seriese of asearch for the directional analysis of EAS for the Kinki data concerning on the galactic coordinates with energy range between 10^{14} and 10^{17}eV at sea level.

In this report, I will present some basic results about the distribution of arrival distribution of EAS in the galactic coordinates. No strong statistical significance of deviation from isotropy was found for the galactic plane enhancemcnt. Concerning on the galactic enhancement tactor f_e a comparison with some other higher energy experiment is also presented.

Key words: EAS, the galactic plane enhancement, Durham formulation.

1 Introduction

There has been published many papers on the arrival directional analysis of extensive cosmic rays various energy range[1]. Approximately 296k events in the period between 1989 and 1995 of the Kinki data are analysed [2]. An anisotropic distribution for the galactic plane was investigated for these data. We also

compare from our low energy EAS to most high energy ones[3]. We have already reported some results elsewhere[4].

2 The Galactic Plane Enhancement of EAS

We especially take notice of an analysis on the galactic plane enhancement of the arrival direction of Cosmic rays. The galactic latitude enhancement factor, fe values were calculated from ratio of the number of observed events to expected events, n_{obs}/n_{exp}. n_{obs} is the number of observed events and n_{exp} is the number of expected ones which are take into account of correction of observation efficiencies using Monte Carlo generated events and observed a real celestial declination(δ) distribution. The f_e values for the directions of the galactlc centre and anti-centre are compared. These distributions are evaluated with the fit of Durham formulation[5]:

$$I(b)/I_o=n_{obs}/n_{exp}$$
$$=(1-f_e)\ (\text{const})\ f_e\ e^{-b2},$$

where I(b) is the observed cosmic rays intensity at the galactic latitude b, I_o is the overall average intensity, and 'const' is a correct average intensity for normalisation which is currently taken to be 1.4. And calculations were done for the data dividing into two direction concerning on the galactic longitude l, i.e.,the galactic 'centre' and the galactic 'anti-centre', corresponding to $270<l<90$ and $90<l<270$ in unit of degrees, respectively. Calculation results for our data with cut of these directional criteria are shown in Table-1. Fig-1 is shown their plot with other experimental data for the 'uncut' distribution.

3 Results

1. We analyse about 300k EAS events, however, this number of events isn't enough to recognise of anisotropy less than 0.1% in this energy region.

2.Following f_e values are obtained for the data of the Kinki array:

f_e(uncut)=0.014 ± 0.007,
f_e(centre)=0.011 ± 0.010,
f_e(anti-centre)=0.016 ± 0.010.

It seems that the distribution of arrival direction of EAS suggests isotropic our low energy region.

A comparison with the energy dependence of some higher energy experiments shown in the figures, in the view of the f_e are summarised as following for 'uncut', 'centre' and 'anti-centre' distributions:

- seems very weak energy dependences,
- this weak dependence is not evident,
- need more accurate analyisis.

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Table Captions

Table-1 Calculation results of the galactic latitude b vs. n_{obs}/n_{exp} and their errors for the Kinki data.

Table-2 Asummary of f_e values of our data and some other experiments.

Figure Caption

Fig.-1 The galactic enhancement factor f_e for the 'uncut' distribution. Closed circle are our data and cross for Akeno, asterisc for Volcano Ranch, triangle for Yakutsk, square for SUGER, and open circle for Haverah Park.

*** uncut 241591 evs ***

b	obs	error	exp(int)	exp	error	obs/exp	error
-85	0.00	+/- 0.00	0.00	0.00	+/- 0.00	0.000	+/-0.000
-75	5.00	+/- 2.24	0.00	0.00	+/- 0.00	0.000	+/-0.000
-65	15.00	+/- 3.87	14.10	14.10	+/- 0.97	1.064	+/-0.284
-55	710.00	+/-26.65	806.72	792.62	+/- 8.68	0.896	+/-0.035
-45	5320.00	+/-72.94	6389.64	5582.92	+/- 26.25	0.953	+/-0.014
-35	13619.00	+/-116.70	20371.04	13981.40	+/- 42.89	0.974	+/-0.009
-25	22238.00	+/-149.12	42669.80	22298.77	+/- 55.08	0.997	+/-0.007
-15	25466.00	+/-159.58	68256.66	25586.85	+/- 57.44	0.995	+/-0.007
-5	23849.00	+/-154.43	91859.27	23602.61	+/- 52.07	1.010	+/-0.007
5	19928.00	+/-141.17	111732.91	19873.65	+/- 41.87	1.003	+/-0.007
15	18472.00	+/-135.91	130134.52	18401.61	+/- 38.03	1.004	+/-0.008
25	17801.00	+/-133.42	147716.77	17582.25	+/- 36.19	1.012	+/-0.008
35	17401.00	+/-131.91	164820.03	17103.27	+/- 35.17	1.017	+/-0.008
45	17176.00	+/-131.06	182200.06	17380.03	+/- 35.93	0.988	+/-0.008
55	18119.00	+/-134.61	200321.98	18121.92	+/- 38.19	1.000	+/-0.008
65	19200.00	+/-138.56	219483.05	19161.07	+/- 41.18	1.002	+/-0.008
75	15665.00	+/-125.16	235114.50	15631.46	+/- 35.20	1.002	+/-0.008
85	6607.00	+/- 81.28	241556.42	6441.92	+/- 18.61	1.026	+/-0.013

*** centre : 88581 evs ***

b	obs	error	exp(int)	exp	error	obs/exp	error
-85	0.00	+/- 0.00	0.00	0.00	+/- 0.00	0.000	+/-0.000
-75	3.00	+/- 1.73	0.00	0.00	+/- 0.00	0.000	+/-0.000
-65	2.00	+/- 1.41	0.21	0.21	+/- 0.05	9.747	+/-7.280
-55	29.00	+/- 5.39	28.33	28.12	+/- 0.79	1.031	+/-0.194
-45	390.00	+/-19.75	452.76	424.43	+/- 3.58	0.919	+/-0.047
-35	1661.00	+/-40.76	2226.02	1773.27	+/- 7.84	0.937	+/-0.023
-25	3899.00	+/-62.44	6160.48	3934.45	+/- 12.29	0.991	+/-0.016
-15	6034.00	+/-77.68	12564.11	6403.64	+/- 16.02	0.942	+/-0.012
-5	7906.00	+/-88.92	20544.95	7980.84	+/- 17.75	0.991	+/-0.011
5	8677.00	+/-93.15	29395.68	8850.73	+/- 18.65	0.980	+/-0.011
15	8876.00	+/-94.21	38341.42	8945.74	+/- 18.50	0.992	+/-0.011
25	8853.00	+/-94.09	47024.84	8683.42	+/- 17.90	1.020	+/-0.011
35	8536.00	+/-92.39	55527.11	8502.26	+/- 17.49	1.004	+/-0.011
45	8386.00	+/-91.58	64082.50	8555.39	+/- 17.66	0.980	+/-0.011
55	8224.00	+/-90.69	72342.38	8259.87	+/- 17.20	0.996	+/-0.011
65	7503.00	+/-86.62	79941.59	7599.22	+/- 16.74	0.987	+/-0.012
75	6582.00	+/-81.13	86515.63	6574.03	+/- 16.38	1.001	+/-0.013
85	3020.00	+/-54.95	89477.73	2962.11	+/- 9.40	1.020	+/-0.019

*** anti-centre : 153010 evs ***

b	obs	error	exp(int)	exp	error	obs/exp	error
-85	0.00	+/- 0.00	0.00	0.00	+/- 0.00	0.000	+/-0.000
-75	2.00	+/- 1.41	0.00	0.00	+/- 0.00	0.000	+/-0.000
-65	13.00	+/- 3.61	13.89	13.89	+/- 0.95	0.936	+/-0.267
-55	681.00	+/- 26.10	778.39	764.50	+/- 8.29	0.891	+/-0.035
-45	4930.00	+/- 70.21	5936.87	5158.48	+/- 24.48	0.956	+/-0.014
-35	11958.00	+/-109.35	18144.98	12208.11	+/- 39.12	0.980	+/-0.009
-25	18339.00	+/-135.42	36509.24	18364.26	+/- 49.51	0.999	+/-0.008
-15	19432.00	+/-139.40	55692.37	19183.13	+/- 49.16	1.013	+/-0.008
-5	15943.00	+/-126.27	71314.02	15621.66	+/- 40.98	1.021	+/-0.009
5	11251.00	+/-106.07	82336.81	11022.79	+/- 26.07	1.021	+/-0.010
15	9596.00	+/- 97.96	91792.54	9455.72	+/- 20.31	1.015	+/-0.011
25	8948.00	+/- 94.59	100691.23	8898.69	+/- 18.63	1.006	+/-0.011
35	8865.00	+/- 94.15	109292.10	8600.87	+/- 17.96	1.031	+/-0.011
45	8790.00	+/- 93.75	118116.60	8824.50	+/- 18.87	0.996	+/-0.011
55	9895.00	+/- 99.47	127978.52	9861.92	+/- 23.26	1.003	+/-0.010
65	11697.00	+/-108.15	139540.25	11561.73	+/- 28.22	1.012	+/-0.010
75	9083.00	+/- 95.30	148597.59	9057.34	+/- 22.22	1.003	+/-0.011
85	3587.00	+/- 59.89	152077.36	3479.77	+/- 10.63	1.031	+/-0.017

Table-1

Summary of fe values of experiments

	<Eshw>(EeV)	fe	err	events
*** uncut ***				
HP	1.361	0.032	0.032	7320
	2.628	0.084	0.060	2443
	5.437	0.204	0.104	706
	10.861	0.100	0.176	249
	22.125	0.316	0.240	99
	63.789	-0.644	0.324	66
SUGER	11.04	0.364	0.192	183
	22.08	0.100	0.292	114
	54.93	0.332	0.272	84
YAKUTSK	17.43	0.368	0.184	233
Volcano Ranch	27.96	-0.24	0.48	44
Akeno	0.018	0.006	0.017	
	0.058	0.024	0.036	
	0.135	0.000	0.025	
	0.234	0.006	0.041	
	0.407	-0.060	0.020	
	0.741	-0.018	0.027	
	1.315	0.006	0.030	
	2.410	-0.072	0.081	
	4.236	0.163	0.111	
	7.621	0.121	0.216	
	17.22	0.195	0.148	
Kinki	0.003	0.014	0.007	298395 evs
*** centre ***				
SUGER	10.88	0.272	0.252	115
	21.58	0.244	0.352	75
	54.35	-0.076	0.340	51
YAKUTSK	17.30	0.452	0.264	57
Kinki	0.003	0.011	0.0103	109066 evs
*** anti-centre ***				
SUGER	11.33	0.636	0.260	68
	22.97	-0.692	0.468	39
	55.77	0.792	0.440	33
YAKUTSK	17.47	0.468	0.224	176
Kinki	0.003	0.016	0.010	189329

Table-2

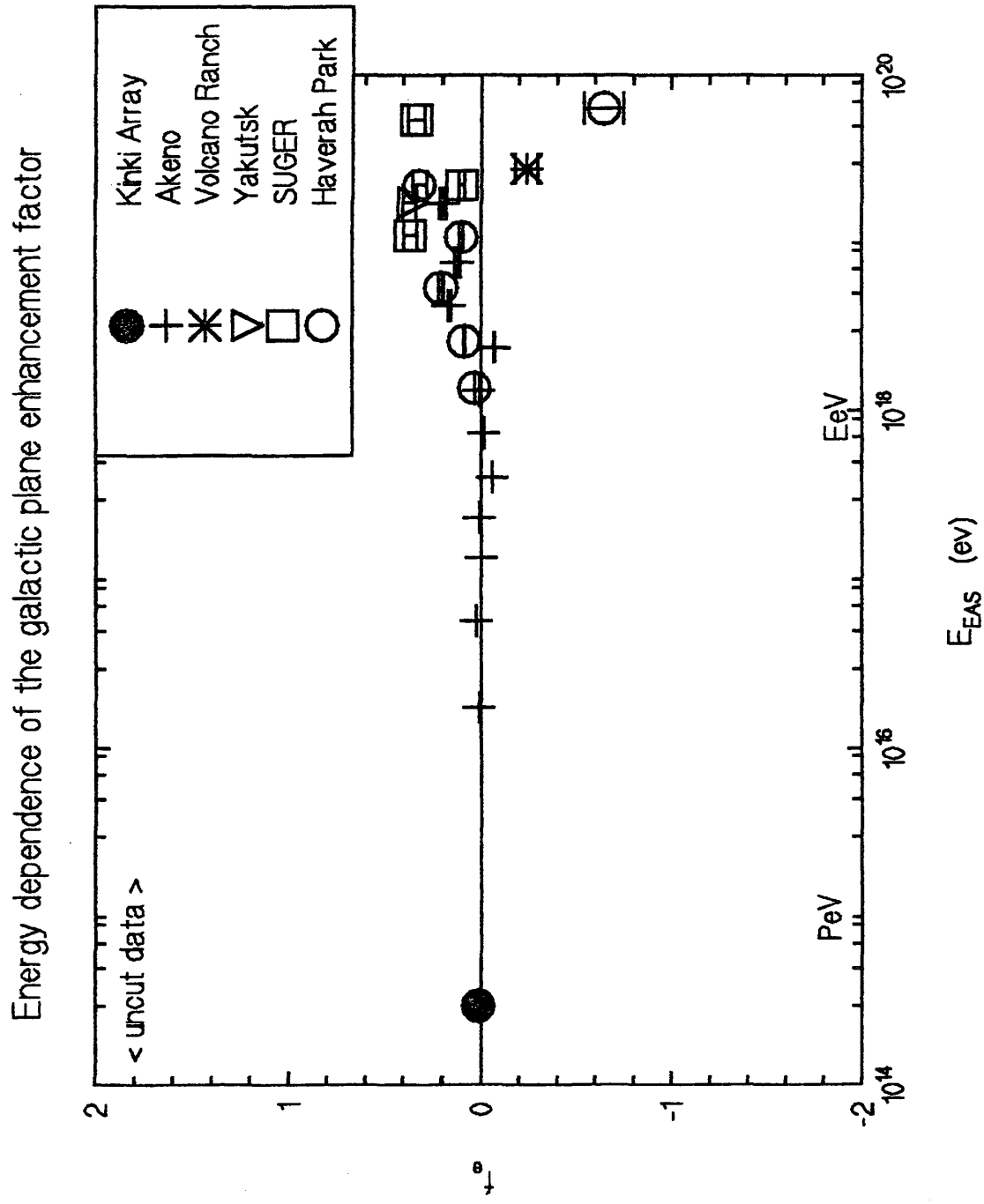
Energy dependence of the galactic plane enhancement factor
Kiki Array
Akeno
Volcano Ranch
Yakutsk
SUGER
Haverah Park
< uncut data >
PeV
EeV
E_{EAS} (ev)
f_e
2
1
0
-1
-2
10^{14}
10^{16}
10^{18}
10^{20}

Fig.-1