THE BUCKLAND PARK AIR SHOWER ARRAY

R.W. Clay, C.L. Corani, J.R. Patterson, B.R. Dawson, P.G. Edwards, A.G. Gregory, J.R. Prescott, S.D. Elton, and D. Ciampa.

Physics Department, University of Adelaide,
Adelaide, South Australia. 5000.

ABSTRACT

The new Buckland Park Air Shower Array has been producing analysed shower data since July 1984. The array is described and some preliminary performance figures are presented.

1. Introduction. The Buckland Park array has recently been upgraded with the addition of new scintillators with the result that its shower size response has been extended to $\sim 10^4$ particles at threshold. The array now detects events at a mean rate of ~ 1/10s. The main purposes of the new array are to continue the study of point sources of ultra high energy gamma rays[1,2] in the southern hemisphere and the properties of cosmic ray air showers with sizes less than 10^5 particles.

2. Array Description. The design considerations and predictions are given in ref. 4. Briefly, the major considerations in optimizing the rates of detection of small air showers were the need to increase the ground area covered by closely-spaced detectors and to increase the individual detector areas so as to minimize sampling fluctuations.

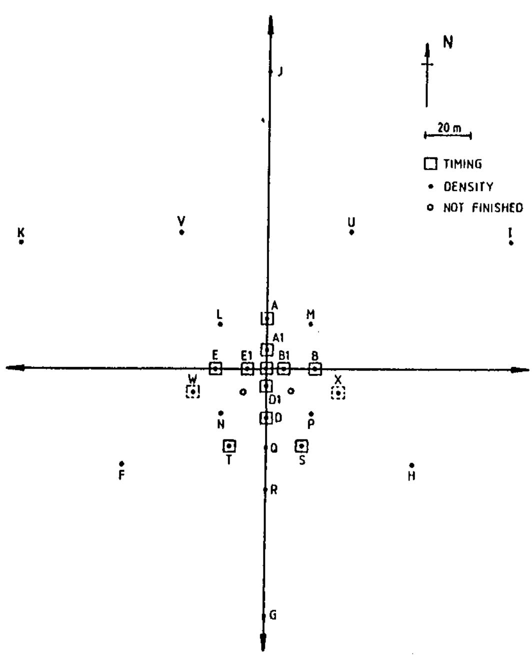

Fig. 1 Array layout

The array consists of 27 scintillators arranged as shown in figure 1. New scintillators have been added to the old array[3] to increase the density of detectors near the centre where eight detectors A1, B1, C, D1, E1, D, S and T have also been increased in size from 1 m^2 to 2.25 m^2.

The detectors are scintillators of 50 mm thickness housed in pyramidal enclosures[4] which are then housed in thermally insulated galvanised iron huts. All detectors contain a particle density measuring photomultiplier (RCA 8055 general purpose 120 mm tube or equivalent) which feeds a pre-amplifier at the detector before signal transmission to the central laboratory. Saturation occurs at ~ 300 particle level Eleven of the detectors have, in addition, a fast timing photo-multiplier (Philips XP2040) which directly drives 50 ohm cable (RG8) to the central laboratory. Fast timing detectors were added at sites S and T to enable directions to be found for small showers falling nearby and to improve the angular accuracy in the north-south plane for medium and larger showers falling near the centre. Two further slow detectors will soon be added as indicated in figure 1 and fast timing introduced in X and W detectors to improve directional measurement of showers in the east-west plane.

An event is recognized when any two of the 19 inner amplitude measuring detectors trigger at the threshold of 2 particles, (each of which has an individual rate ~ 0.5 Hz) and any two of the fast timing detectors also trigger. (Their individual rates are ~ 100Hz). The slow system thresholds are set well above those in the fast system to ensure that, in most cases, the fast detectors trigger as closely as possible to the start of the photomultiplier pulse and reduce timing uncertainties associated with the fast system rise time ($\sigma_t \sim 5$ns). A further result is that except for the smallest of showers, there are normally many more than two fast detectors triggered and directions can be found with timing redundancy. The final trigger rate is ~ 8000 events day^{-1}.

The density measuring channels have final pulse shapes which are quite long (rise ~ 100ns, fall ~ 5μs) and these pulses are fed to CAMAC Peak-sensing ADCs (LeCroy 2259A) which are gated by the array trigger. The array data is calibrated and partly analyzed (for angles of incidence) by a Nova mini-computer system. Output is presently recorded on magnetic tape for later analysis and one 2400 foot tape lasts about five days. The resolved single particle peaks of all detectors are monitored regularly, normally when each tape is changed.

The relative times of arrival of the fast timing pulses are measured with ~ 1 ns bit resolution using a CAMAC Time to Digital Convertor (LeCroy 2228A). Our previous practice had been to start the TDC off using a discriminator output from the central detector, the others being delayed a fixed amount to act as stops. With our more loose coincidence system we now do not specify any particular fast channel to be the TDC start channel. Instead the fast coincidence output triggers the TDC start. In order to ensure that all pulses will be within the range of the TDC, there is a further monostable delay of ~ 200 ns in each channel after the discriminator and before the TDC stop. These delays appear to be inherently quite stable and do not suffer from any bandwidth limitations of delay cable.

Any combination of fast timing detectors may trigger on a given event. We need to find one timing detector which has been triggered and calculate all usable (non-collinear) time differences after subtraction of the known delays. It is then straightforward to calculate the zenith and azimuth angles for the shower axis. At the same time, right ascension, declination and Julian time are calculated for the event. The chi-square fitting parameter for a planar shower front is consistent with a directional accuracy ~ 2.5/cos θ degrees where most detectors are triggered. The worst cases will be for small showers triggering only our inner 2.25 m^2 detectors. In these cases, we have a detector spacing of only 8m and directions are expected to have uncertainties $\gtrsim$ 10°.

3 Preliminary Results. The array detects showers with analysed sizes down to 10^4 particles and with our present preliminary shower analysis we have a median shower size ~ 0.9×10^5 particles. Figure 2 shows a preliminary graph of the size distribution for analysed showers over the whole array and compares it to the performance of the old array. We are beginning to develop our directional analysis system and Table 1 shows a sky map with the accumulation of events for several sidereal days in which only showers with at least five measured times are used. The map shows the extent of sky coverage available from Buckland Park.

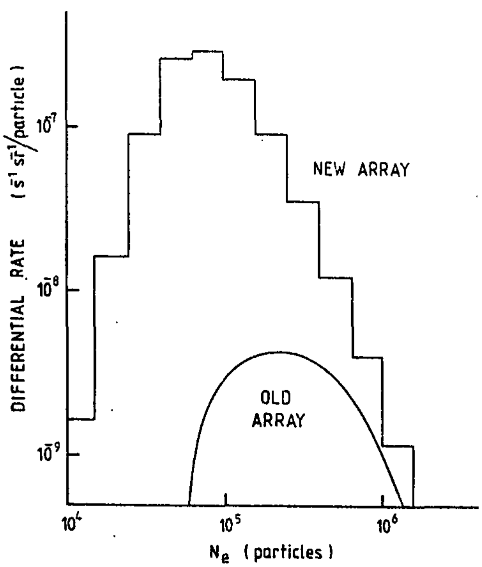

Fig. 2 Size Distribution for all events accepted by whole array. The events are analysed using the NKG function and MINUIT[5] program package.

References

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RIGHT ASCENSION (HOURS)	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
0	0	3	5	14	38	43	103	141	187	235	272	257	268	240	197	151	100	66	24	10	7	8	1	0	0	1	1
0.5	0	0	10	16	23	70	109	144	178	231	245	308	237	235	181	152	93	70	33	14	5	3	1	0	0	0	0
1.0	0	2	4	15	29	56	100	136	186	218	270	295	269	256	197	139	102	66	37	26	7	6	2	1	0	0	0
1.5	0	2	4	20	31	67	96	143	203	230	259	265	257	256	199	153	91	61	37	19	9	2	0	1	0	0	0
2.0	0	1	12	8	31	39	102	150	182	239	250	274	255	266	200	137	98	68	24	17	7	4	2	1	0	0	0
2.5	0	3	5.	8	26	65	115	153	174	173	253	285	279	237	216	140	113	57	37	18	9	2	0	1	0	0	0
3.0	0	2	5	9	25	68	106	143	177	246	281	272	246	218	205	136	104	57	20	8	0	1	1	1	0	1	0
3.5	0	1	8	16	36	62	87	149	197	237	239	285	250	250	186	143	80	67	25	16	6	2	1	1	0	0	0
4.0	0	1	6	20	36	42	80	144	187	210	258	265	262	259	183	162	90	69	20	13	8	2	0	0	1	0	0
4.5	0	0	5	17	26	50	101	131	194	228	283	248	234	238	184	160	98	53	52	17	8	4	1	0	0	0	0
5.0	1	2	7	18	35	51	95	140	205	253	254	264	294	245	162	156	104	57	29	22	10	3	1	1	0	0	0
5.5	1	4	5	12	25	67	88	141	193	258	246	261	269	229	191	148	88	63	29	14	4	2	1	2	0	0	0
6.0	0	1	2	15	39	48	95	137	210	240	276	291	278	244	181	144	98	59	37	8	11	4	1	0	1	2	0
6.5	0	2	3	14	26	77	81	141	180	254	245	269	258	226	215	145	98	66	27	12	6	1	2	1	0	0	1
7.0	0	3	6	12	39	55	87	153	209	220	272	264	255	258	212	159	84	61	30	13	6	5	1	1	0	0	1
7.5	1	3	3	18	25	50	102	146	198	263	268	261	259	239	191	155	108	54	37	12	8	5	1	0	0	0	0
8.0	0	2	6	16	32	58	102	129	190	249	275	278	248	244	182	158	96	65	30	15	12	1	1	0	0	0	0
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9.5	0	2	3	18	28	50	100	122	161	228	255	314	266	243	199	145	82	57	29	12	4	5	1	1	0	0	0
10.0	1	3	5	10	34	56	109	159	202	230	263	257	260	250	192	161	94	64	26	12	5	2	0	0	0	0	0
10.5	0	2	4	13	26	57	97	144	191	227	271	282	280	244	213	138	105	52	37	13	3	3	2	1	1	0	0
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12.0	0	3	3	12	29	46	97	153	174	233	275	249	259	228	194	145	103	41	26	24	5	2	1	0	1	0	0
12.5	0	2	6	13	37	60	92	134	194	238	255	253	308	225	196	178	104	59	25	15	3	4	0	1	0	1	1
13.0	0	2	4	16	30	58	93	144	160	190	269	283	260	218	193	139	106	58	38	17	5	3	2	2	0	0	0
13.5	0	0	4	17	39	45	106	144	192	241	274	288	261	230	199	131	101	52	34	15	7	3	1	0	1	0	0
14.0	0	2	6	12	26	62	74	132	165	229	266	280	272	255	210	134	107	53	28	20	6	3	1	1	0	0	1
14.5	0	2	6	12	24	62	102	151	191	219	244	287	249	246	202	150	92	58	37	16	6	3	1	0	0	1	0
15.0	0	1	2	22	39	58	90	133	207	259	273	264	282	253	210	146	114	64	34	19	3	2	0	0	1	1	0
15.5	0	0	7	15	30	51	104	142	187	205	293	276	262	237	195	144	103	54	31	11	7	6	2	0	0	0	0
16.0	0	1	11	22	29	69	108	139	207	234	233	269	293	246	182	157	100	64	23	18	5	5	3	1	0	0	0
16.5	0	0	5	16	24	55	96	147	205	235	252	267	264	246	199	145	99	80	33	12	1	3	1	0	0	0	0
17.0	0	0	7	10	32	50	103	149	185	231	277	276	254	228	217	167	108	63	36	30	4	3	2	0	1	0	0
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19.5	0	1	7	9	29	63	102	141	180	248	267	279	265	241	200	161	109	65	33	12	6	3	1	0	1	0	0
20.0	1	2	6	12	31	58	96	145	170	218	250	310	291	238	201	141	95	64	22	9	7	2	1	0	0	0	0
20.5	0	2	7	13	24	51	90	129	165	237	249	267	259	249	206	150	110	69	29	14	5	5	2	0	0	0	0
21.0	2	0	6	17	28	53	83	149	193	216	281	279	272	237	197	148	101	59	24	19	5	4	0	0	0	0	0
21.5	1	1	2	14	26	66	105	120	186	233	252	271	251	233	194	161	108	72	37	19	5	4	5	1	0	0	0
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22.5	0	5	7	12	28	61	110	137	188	242	262	269	232	221	219	158	115	57	31	20	4	2	0	1	0	0	0
23.0	2	1	3	19	39	50	106	138	199	212	259	244	289	261	205	145	92	61	28	12	7	2	1	0	0	1	0
23.5	0	1	6	15	27	62	99	125	196	205	248	301	283	247	193	161	104	50	21	18	7	3	2	0	0	0	0

DECLINATION (DEGREES)

TABLE 1

Sky map showing typical coverage of the southern sky. The median shower size is $0.9x10^5$ particles.