14. International cosmic ray conference
Garching, near Munich (F.R.Germany), 15-29 Aug. 1975

OG 1.4

CEA-CONF--3076

DIFFUSE GAMMA RAY MEASUREMENT ABOVE 20 MeV WITH A BALLOON BORNE EXPERIMENT

B. Parlier, M. Forichon, T. Montmerle, B. Agrinier, Centre d'Etudes Nucléaires de Saclay, France

G. Boella, L. Scarsi, C.N.R. (Italy), M. Niel, C.E.S.R. (France) and R. Palmeira, I.N.P.E. (Brazil)

During two balloon flights of a spark chamber gamma ray telescope launched from Sao José dos Campos (Brazil) in 1973, we monitored the growth of the secondary gamma rays in function of the atmospheric pressure. The extrapolation to zero residual atmosphere giving evidence of an extraterrestrial flux is discussed.

1. Introduction. A series of observations of celestial gamma rays has been carried out by means of balloon flights of a spark chamber telescope sensitive to photon energies above ~ 20 MeV.

The anti-center region of the galaxy was surveyed from Aire-sur-l'Adour (France) (Parlier et al., 1973). A program for the observation of the galactic center region included two succesful balloon flights, which have been carried out from Sao José dos Campos (Brazil) in March 1973. The results of the observation of the galactic center gamma ray emission will be published elsewhere.

Preliminary results concerning the diffuse cosmic gamma ray background have been given at the 13th International Cosmic Ray Conference held in Denver, U.S.A. in 1973. Here we report the final result concerning this last subject.

2. Experimental details. The telescope used a 13 plates spark chamber with a total thickness of 0.43 radiation length, triggered by a Cerenkov detector scintillator coincidence system (Leray et al., 1972). The same instrument was used throughout the 3 flights considered in this analysis.

Information on the relevant flights is shown in table I. The analysis procedure, identical for the three flights, takes into account all the events which are recognized as downward moving electron pairs.

The sensitive area of the detection of gamma rays versus angle, has been obtained with the isotropic atmospheric flux, the result is shown in fig. 1.

N° and date	Launching site	Average ceiling altitude	Ascent		Geomagnetic cut-off rigidity
			free rotation	Oriented South East	
14 24.9.1971	Aire-sur-l'Adour (France) lat. 43°5 long. 0°2	2. mb		3h05 UT 5h 23 mb 2 mb $b^{II} \simeq -10°$	5.4 GV
CG1 11.3.1973	Sao José dos Campos (Brazil) lat. - 23° long. + 46° W	2.3 mb	5h18 UT 6h05 6h40 10 mb 2.2 mb 2.2 mb $51° > b^{II} > 25°$		12 GV
CG2 22.3.1973	id.	5.5 mb	5h01 5h50 UT 28 mb 11 mb $50° > b^{II} > 22°$		id.

TABLE I

The data used to derive the isotropic flux was obtained when the distance of the axis of the telescope was larger than 25° from the galactic disk in the flights CG1 and CG2 ; for the flight 14 the data used for the ascent and ceiling fluxes correspond to galactic latitudes $b_{II} \simeq -10°$ but this flight will only be useful as a comparison of atmospheric and local effect at medium geomagnetic latitude. The trajectories of the axis of the telescope used for ascent and ceiling point are shown in Table I.

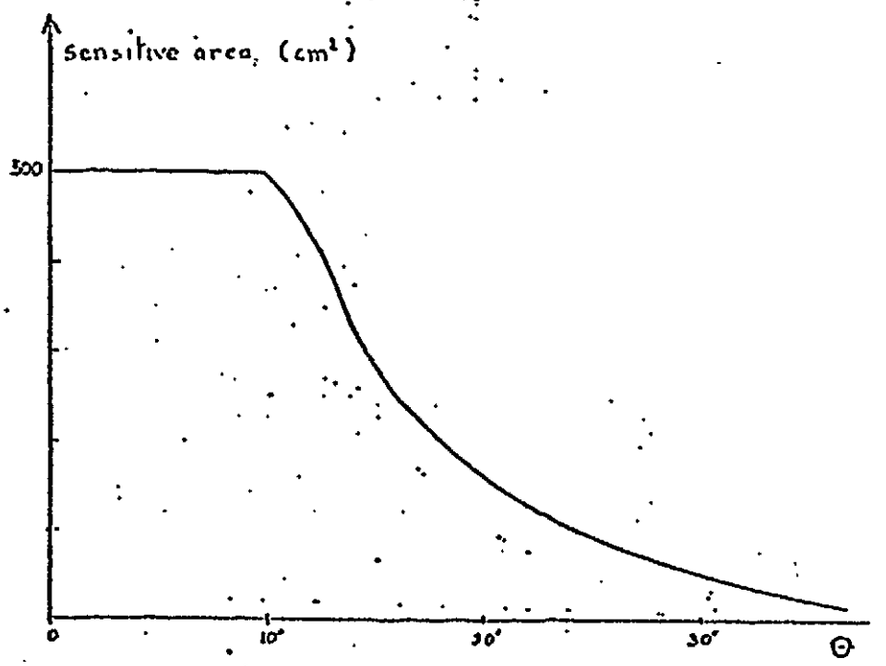

Fig. 1. Gamma ray telescope sensitive area as function of the angle with the axis of the telescope for an isotropic atmospheric flux.

3. Analysis of the data. The method employed to reveal the presence of a possible extra-terrestrial isotropic flux is the well-known construction of a growth-curve of the counting rate in function of the residual atmospheric pressure during the ascent of the balloon. The

pressure was monitored in all flights with the same instrument of the type improved aneroid capsule, the lecture of the deformation of the capsule is obtained by a standard pen and printed rotating drum system. This instrument has been built by one of us, B. Mougin, with standard parts commercialy available. This barometer was calibrated before each series of flights and proved to be very stable: hysteresis is nearly absent and temperature effect has been taken into account.

Fig. 2 shows the counting rate of the events within the full aperture of the telescope in function of the atmospheric pressure. Fig. 3 shows the counting rate of the events incoming within 12° of the axis of the telescope. On the two figures the straight line shows the expected counting rate computed from the work of Daniel and Stephens (1974) and the known efficiency in function of energy of our telescope.

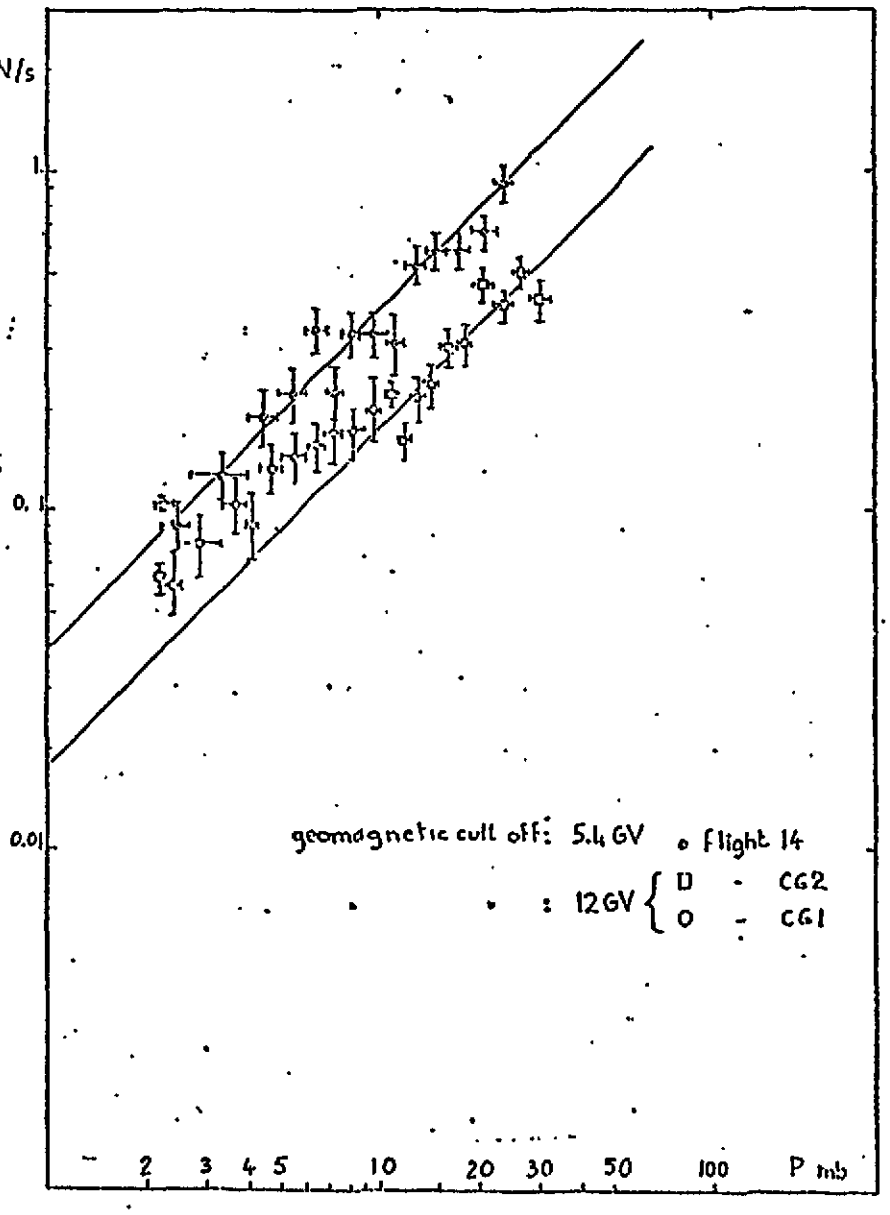

Fig. 2. Gamma ray counting rate versus the atmospheric pressure ; the straight line shows the expected count from the atmospheric residual pressure.

The experimental points at the two rigidity cut-off seems to fit very well the theory excepted for the low pressure points (< 10 mb) of the Brasilian flights. In order to give an interpretation to this last fact we used the property of the very good fit of the experiment with theory above 10 mb to compute the locally producted gamma ray on the basis of this linear law of production in

function of the atmospheric pressure. Although the computation can be done for the two. populations of events the thickness of local matter and the geometrical factor is more precisely known with the 12° cone restriction of fig. 3. The thickness of the thermal shield was 0.16 g of polystyren (styrofoam) for the flight 14 and 0.35 g for the flights CG1 and CG2. The result of this evaluation is shown by dashed lines on the figure 3. Still the experimental points of the flight CG1 shows an excess for the low pressure values (<10 mb). The amount of the excess above the atmospheric plus local production is equivalent to about 1 g of air with a confidence level of 2.5 σ for the ceiling point alone.

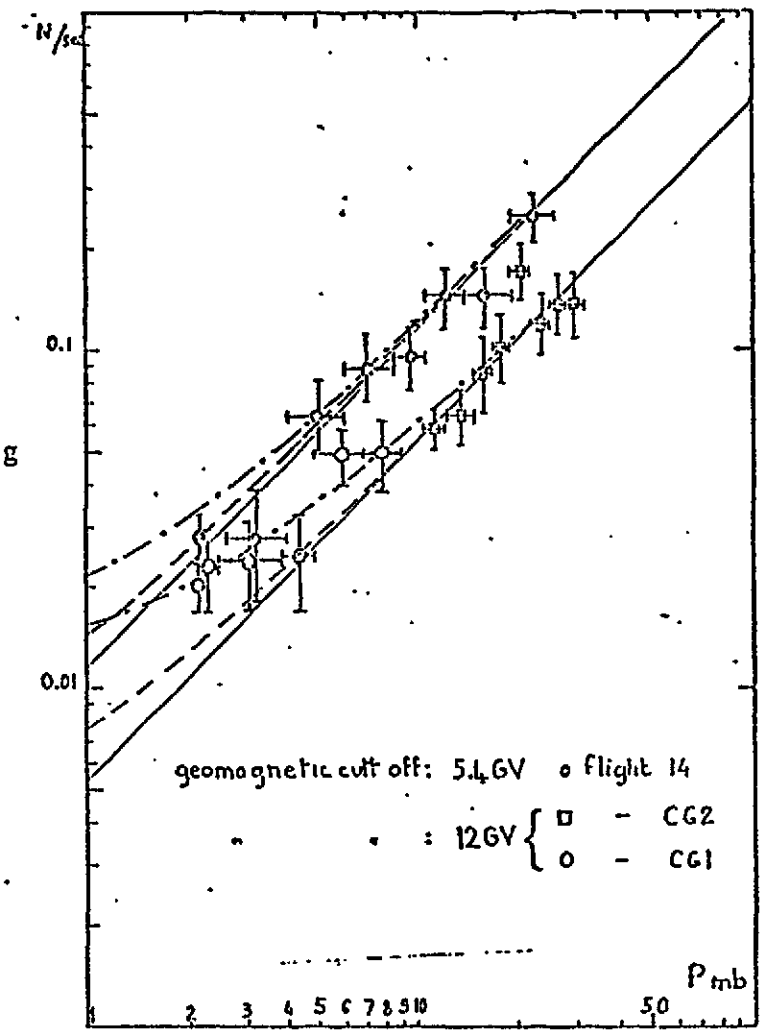

Fig. 3. Gamma ray incoming within 12° of the axis of the telescope : - the dashed line shows the local contribution ; - the dot-dashed line shows the atmospheric background plus the local background plus the diffuse cosmic radiation deduced from the data at 12 GV.

4. Flux evaluation.

Taking the data of fig. 3 and assuming an E^{-2} spectral shape for an isotropic component and taking 66.5 cm^2 st. for the geometric factor above 20 MeV, we get

$$I > 20 \text{ MeV} = 3.5 \pm 1.5 \ 10^{-3} \text{ photons/cm}^2 \text{. s. st. (see fig. 4)}$$

5. Discussion of the results. The presence of an excess of isotropic flux supposed to be of an extraterrestrial origin is figured by the dot-dashed line on the growth-curve of the Brasilian flights (fig. 3) ; it is clear that this flux is not resolved at the high latitude of the flight 14 due to higher background level.

Should this excess be due to an unknown atmospheric contribution it would have been about twice stronger in the flight 14 than in the flight CG1, inspection of the fig. 2-3 indicates that this time it would have been resolved from the background.

It remains the local production which due to the factor 1/2 in the shield thickness and to the factor 2 in the cosmic ray fluxes between the two observations would have given the same contributions for the two sets of flights, but the effect observed in the flight CG1 is larger by a factor 3 than the computed value of this contribution. The method used for this computation is based on the straight line fit with theory above 10 mb, if it is valid for air widely distributed above the detector we do not see why it would not for matter closer to the telescope. More since this matter is in the vicinity of the anti-coincidence counter this local production is certainly over estimated.

The flux is much higher than the value given above 30 MeV by SAS II (Fichtel, 1975)(fig. 4)then an underestimate of the efficiency may be invoked but we recall that during the first set of flights we observed the Crab Nebula (Parlier et al., 1973) at a level of flux confirmed by other experiments and in the second set of flights the galactic center region was clearly observed with about the flux given by SAS II.

The confidence in our result is based almost uniquely on the flight CG1 the other flights proving the reliability of the experiment in various situations. Then it needs to be confirmed and we suggest that the flux value given here be considered as an upper limit.

In conclusion of this experiment it seems that further observations of the diffuse background with high altitude balloon ≤ 1 mb, would be very valuable particularly because all the data is obtained at constant geomagnetic cut-off and that theoretical expectation of its effect exist (Daniel, 1974) and are well

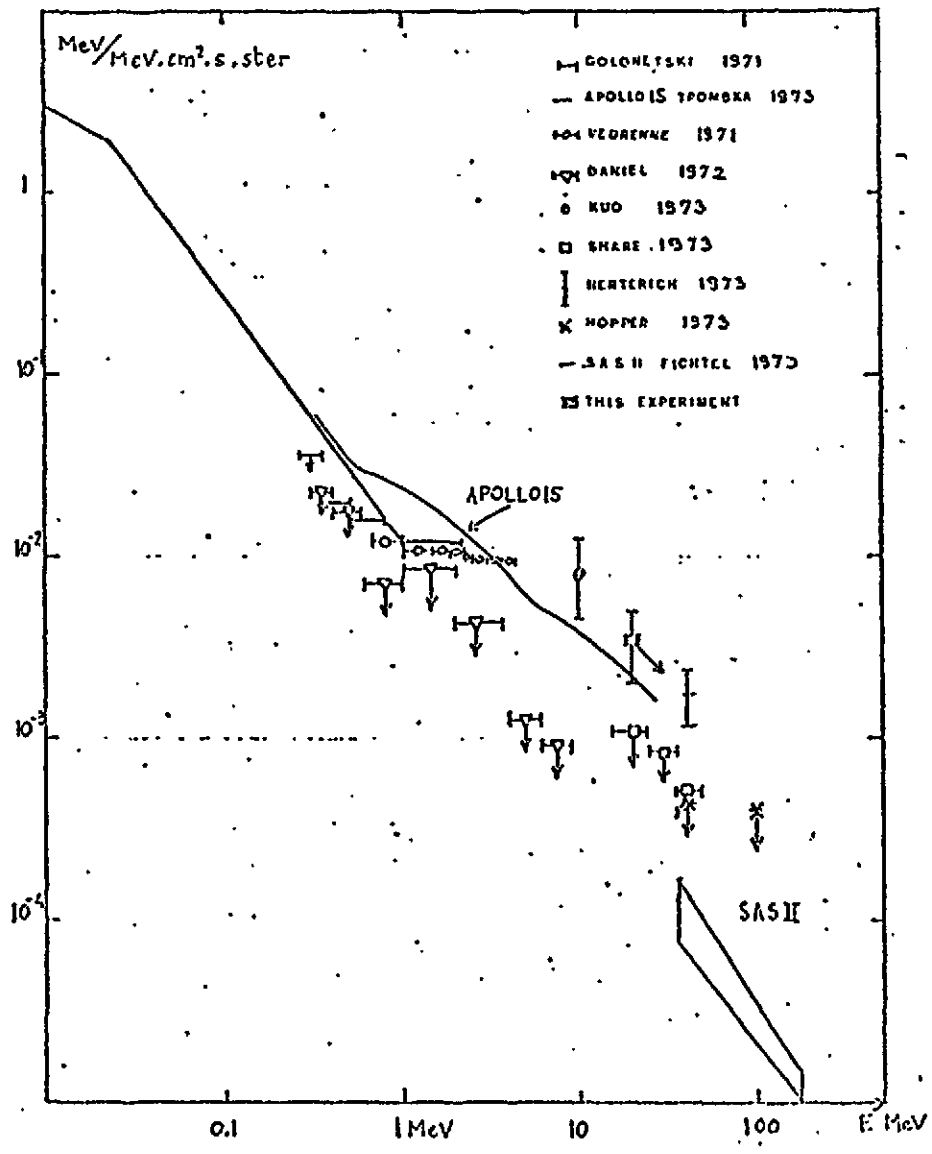

Fig. 4. Diffuse cosmic radiation spectrum observed by several experiments.

verified by the experiment:

Acknowledgements. This experiment was carried out under a C.N.E.S-C.E.A. collaboration and was financed in part by the Italian Consiglio Nazionale delle Ricerche and by the Brasilian Instituto de Pesquisas Espaciais. We acknowledge the collaboration of the C.N.E.S. and I.N.P.E. balloon launching departments.

References

Daniel, R.R. and Stephens, S.A. 1974, Tata Institute of Fundamental Research, report nr CR/NE-73/5.

Daniel, R.R., Joseph, G., and Lavakare, P.J. 1972, Tata Institute of Fundamental Research TIFR report nr CR/NE-72-3, I.A.U./Cospar Symposium nr 55, Madrid 11-13th May 1972.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A., Thompson, D.J., and Bignami, G.F. 1975, Ap.J. 198:163-182, May 15.

Golonetski, S.V., Mazets, E.P., Il'Inskii, V.N., Aptekar, R.L., Bredov, M.M., Gur'Yan, Y.U.A., and Panov, V.N. 1971, Ap.J. Letters vol. 9, p.69.

Herterich, W., Pinkau, K., Rothermel, H., Sommer, M. 1973, 13th International Cosmic Ray Conference, paper OG 31, p.21.

Hopper, V.D., Mace, O.B., Thomas, J.A., Albatz, P., Frye, G.M., Thomson Jr and G.B., Ap.J. 186 : 55-58, December 1973.

Kuo Fu Shong, Frye, G.M., Zych, A.D., 1973, Ap.J. vol 186, nr 2, part 2, Dec. 1.

Leray, J.P., Vasseur J., Paul, J., Parlier, B., Forichon, M., Agrinier, B., Boella, G., Maraschi, L., Treves, A., Buccheri, L., Cuccia, A., and Scarsi, L., 1972, Astron. and Astrophys. 16, 443-458.

Parlier, B., Agrinier, B., Forichon, M., Leray, J.P., Boella, G., Maraschi, L., Buccheri, R., Robba, N.R., and Scarsi, L., 1973 Nature Physical Science 242 nr 121.

Share, G.H., Kinzer, R.L., and Seeman, N., 1973, Paper OG 138, 13th International Cosmic Ray Conference, Denver, USA.

Trombka, J.L., Metzger, A.E., Arnold, J.R., Matteson, J.L., Reedy, R.C., and Peterson, L.E., 1973, Ap.J. 181, 737.

Vedrenne, G., Albernhe, F., Martin, I., Talon, R., 1971, Astron. and Astrophys. 15, 50-54.