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M E M O R A N D U M

Copy to/Copie à:

To/A : ISRC, K. Potter, Secretary

From/De : G. Jarlskog, D. Rahm and W. Willis WJW

Subject/: R806-R807 Single Photon Correlation Studies
Objet

The purpose of this note is to describe the present situation of our studies of direct single photons and their correlations with particles observed in R807, and to propose certain extensions of these studies.

The results of the 1979 run of R806, which ended on July 17, were first presented at the Lepton-Photon Conference in August. They confirmed the results of our first paper, which is due to appear soon in Physics Letters. The paper presenting the 1979 data is about to be submitted for publication. The correlations of charged particles registered in the R807 scintillator hodoscope with single photons and neutral pions in R806 have been analyzed, and will be reported in the Open Session of the ISRC. They will be reported in a R806-R807 collaborative paper to be submitted for publication jointly with the R806 1979 results.

The measurement of the correlations with the R807 hodoscope proved much more informative than we expected. We were able to see the differences between pi-zeros and single photons over the whole azimuthal range, despite the dilution due to integrating over a wide rapidity interval. In particular, we observe the single photon events to have a lower multiplicity on the trigger side, as expected on the basis of gluon absorption which is the leading QCD diagram. On the away side, the expected high jet multiplicity is observed for both pion and photon triggers, with a small difference in the average multiplicity which can be explained by well-known trigger bias effects, and possibly some genuine jet composition differences.

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Since this information is available now, rather than after the November-December runs, we have re-evaluated our program. For example, the general features of the toward side multiplicity seem clear, though the effects should be still more striking with charged particles observed in the drift chamber. The correlations on the away side are also understood at the simplest level. The next step should be to study those effects which are particularly suitable for separating quark and gluon jets. The leading diagram to produce single photons should be $gq \to \gamma q$, so that the recoil should be a quark jet, whereas the jets recoiling against neutral pions may be a mixture of quarks and gluons with comparable probabilities.[1] The best tool for identifying the quark jet is the charge asymmetry of the leading pion. The photon coupling is primarily to the u -quark, favouring u -quark recoil jets. However, as shown in Figure 1, the asymmetry is only large for fractional momenta $X_E = p_T^i / p_T^{trigger}$ close to one.[2] These events, with $X_E > .7$, only account for $\sim 1\%$ of the triggers. Gluon fragmentation gives no charge asymmetry.

Our event rate for single photon candidates (about 60% pure) with $p_T > 5$ GeV/c is about 250/day for an average luminosity of $10^{31}/s\text{-}cm^2$. This gives about 50 charged pions with large X_E, correlated with a single photon candidate, per ISR period. We feel that a satisfactory quantitative analysis requires about 200 events. Since the November period will be the first in which the large R807 drift chamber has been run, it is not sure that it can be counted as a full data taking period. Therefore we conclude that this program will require data taken in the first two or three periods of 1980.

Our goal is to use the charge asymmetry data for pion and photon triggers to determine the gluon-quark probabilities in the jets recoiling against pions, and to compare other features such as multiplicity, X_E distribution, and particle composition using the drift chamber-particle identification arm. Our trigger condition requires a trigger particle of $p_T > 3$ GeV in the R806 calorimeters, in coincidence with a "single particle trigger" in the particle identification arm of R807. The latter is a rather loose requirement for a candidate of moderate p_T in the particle identification arm. This reduces the trigger rate to a convenient value, adding negligibly to the R807 dead time. For this reason, there will be no interference with the previously

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foreseen program of R807 during this period, the measurement of the inclusive spectrum of identified particles in the very high p_T range.

The configuration of the R806 calorimeters has been altered since the running in the first half of 1979. One module is in the horizontal plane, directly facing the particle identification arm, with another mounted immediately below. This leaves a large angular region above the beam plane free for the installation of R807 calorimeters, Figure 2.

The implication of these measurements for the R806 computing budget at CERN and elsewhere are set forth in the enclosed memo to COCOTIME, as well as those associated with a new investigation contemplated using the 1978 R806 data. Since the latter program requires a substantial computing allotment, it may be appropriate to describe its physics justification here.

Part of our study of single photon measurements in the so-called "retracted configuration" run in 1977 and 1978 involved a comparison with the "normal configuration", especially the 1978 running. In the normal configuration, the angular resolution does not allow good resolution of the two photons from π^0 decay above p_T of about 4 GeV/c. However, these studies showed, both on the basis of Monte Carlo shower simulation computations and tests on data, that pion decays can be recognized by measuring the apparent shower radius even when they are not resolved as two showers. This technique works up to about 7 GeV/c. Correct values of the single photon production can be obtained from the normal configuration data over this p_T range, though we prefer to base our published measurements on the data with better angular resolution. However, only the normal configuration offers us the possibility of measuring the π^0-γ and γ-γ correlations for near 180^0. In the 1978 running four calorimeter modules were used, in a back-to-back configuration in the center of mass. One of the triggers was the detection of two shower clusters, each of more than 2 GeV p_T.

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The results which might be expected can be described in terms of the away side correlations, given a trigger which is a single photon candidate. The single photons produced by the $gq \to \gamma q$ diagram are anti-correlated with a second single photon: the away side showers should consist of π^0 and only background single photon candidates from meson decay, on this model. This would be a rather striking effect. There would be about twice as many single photon candidates with π^0 triggers as with single photon triggers, for the case where both showers have $7 > p_T > 5$ GeV/c. On the other hand, we may consider the triggers of 2.5 - 3.5 GeV, where almost all the single photon candidates are explained by meson decay background. There the background rejection obtained in selecting two single photon candidates is substantial and by now well understood in this apparatus. It ought to be possible to reach background levels where γ-γ pairs are expected, from $q\bar{q} \to \gamma\gamma$ for example. The number of pairs expected should be of the order of the Drell-Yan lepton pairs. There should be enough to be observable for masses around 7 GeV. The p_T range where substantial fractions of single photons are observed corresponds to masses around 12 GeV, where the number of lepton pairs is small. Thus a possible result is a shift from a positive γ-γ correlation for $p_T \sim 3$ to a negative correlation for $p_T \sim 6$ GeV/c. (This measurement was proposed in CERN/ISRC/76-15, but had to await clarifications of single photon production.)

This program seems to us very much worth-while. The considerable computing budget required will be used to select the relatively small number of events passing the tight cuts used to select single photon candidates from some 3×10^7 processed events on 250 Data Summary Tapes, and to obtain a sufficiently large sample of shower simulation events using the EGS program. The results should be obtained by March 1980.

REFERENCES

1. M. Jacob and F. Paige, BNL preprint.

2. R. Baier, J. Engels, B. Petterson, University of Bielefeld preprint.

FIGURE CAPTIONS

1. The positive to negative ratio recoiling against a single photon of 6 GeV at 90^0, from Ref. 2.

2. The present R806-R807 set-up.

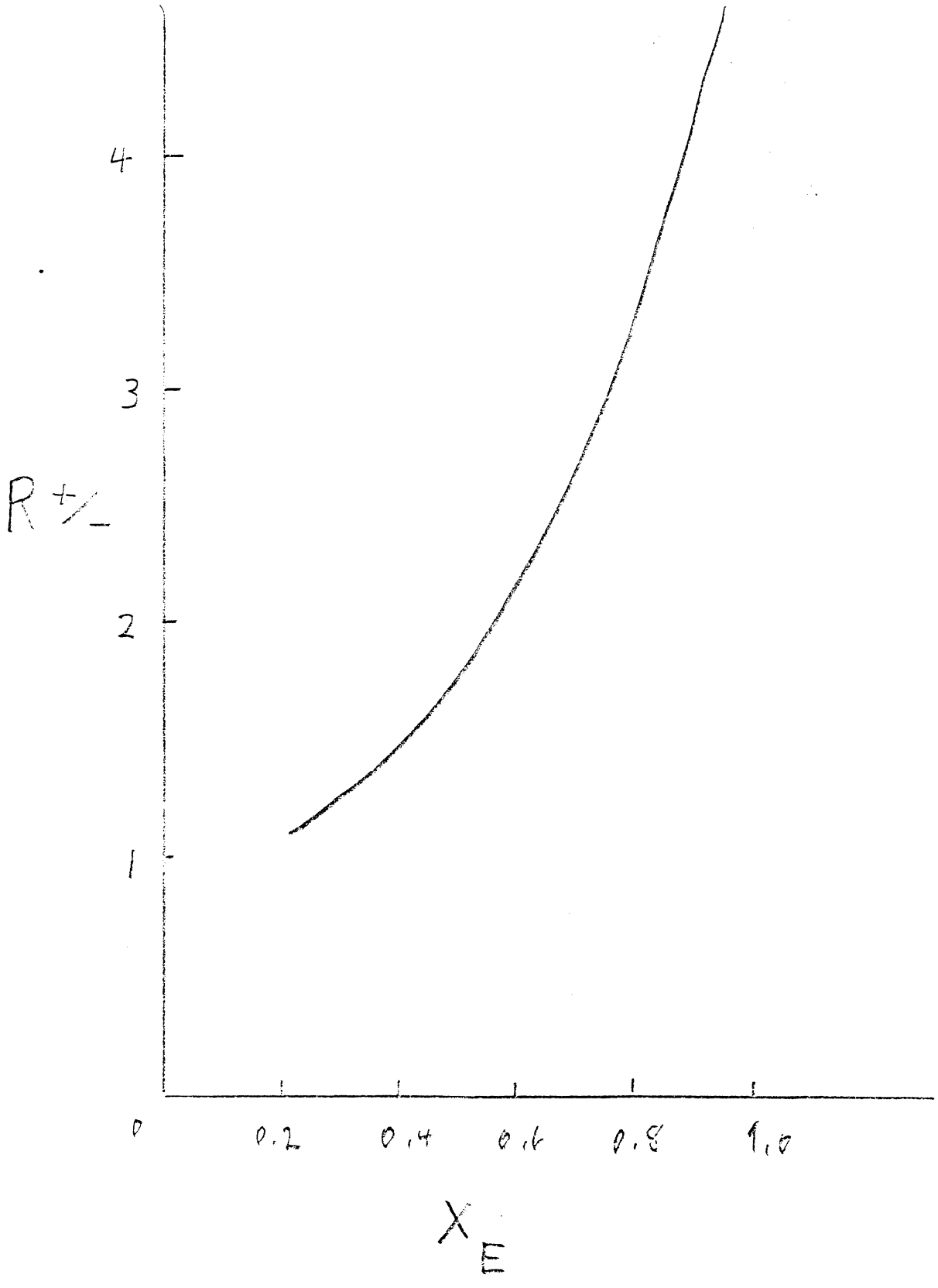

FIGURE 1

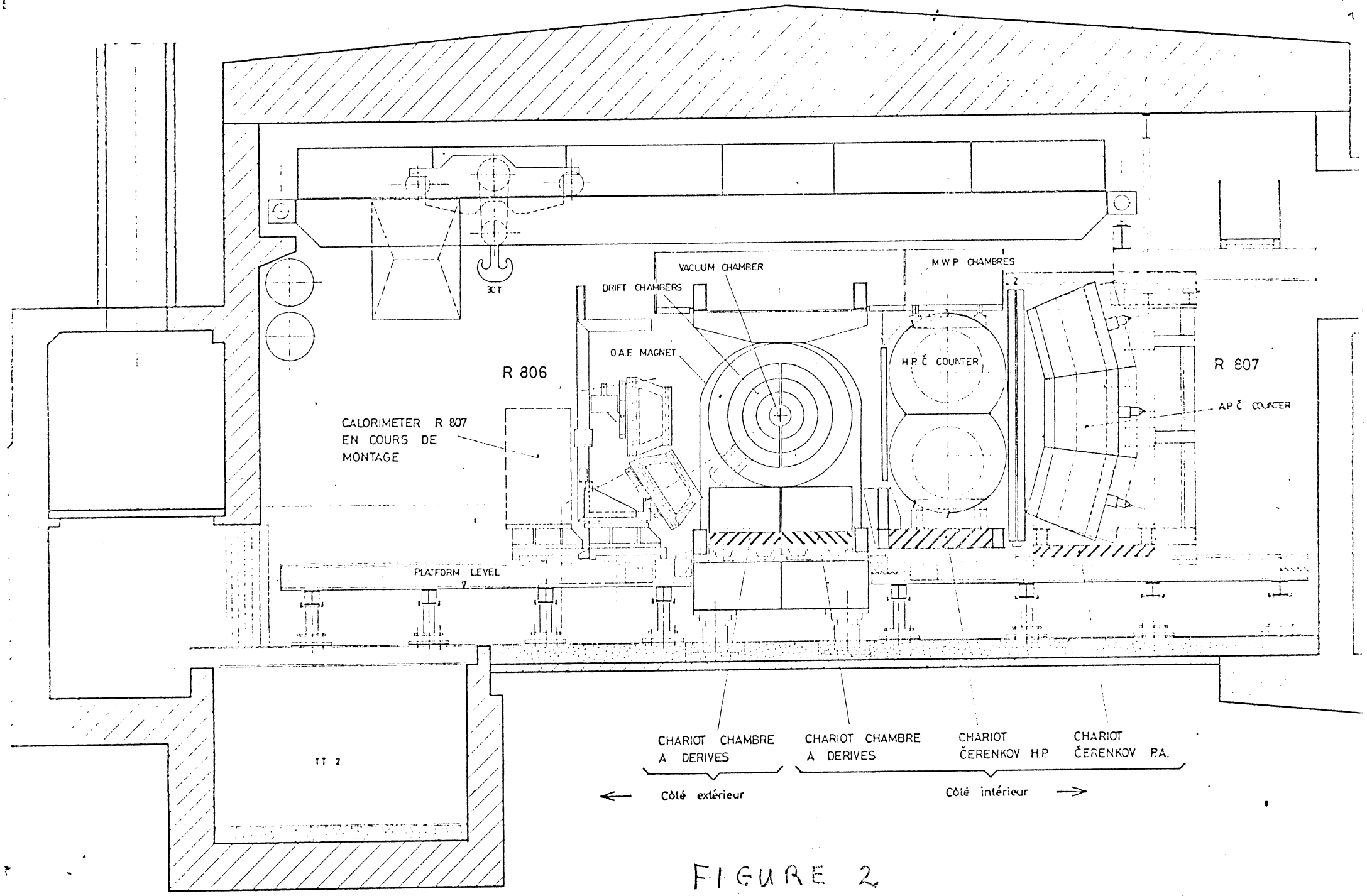
30T
VACUUM CHAMBER
DRIFT CHAMBERS
M.W.P. CHAMBRES
O.A.E. MAGNET
R 806
H.P.Č. COUNTER
R 807
A.P.Č. COUNTER
CALORIMETER R 807
EN COURS DE
MONTAGE
PLATFORM LEVEL
TT 2
CHARIOT CHAMBRE
A DERIVES
CHARIOT CHAMBRE
A DERIVES
CHARIOT
ČERENKOV H.P.
CHARIOT
ČERENKOV P.A.
Côté extérieur
Côté intérieur

FIGURE 2

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M E M O R A N D U M

Copy to/Copie à:

To/A : COCOTIME, L. Griffiths, Secretary

From/De : W. Willis Bill Willis

Subject/: R806 Computing
Objet

The R806 computing has evolved approximately as foreseen this year. Computation was finished for these papers, all published, submitted or in final draft stages :

(published)
- production of resolved pions up to p_T = 6 GeV/c;
- production of unresolved pions up to p_T = 16 GeV/c;
- eta production up to p_T = 12 GeV/c;
- two pair correlation over full azimuth;
- pion and eta angular correlations at very high p_T;
- pion and eta fragmentation distribution;
- direct single photon production from first retracted configuration run;

(about to be submitted)
- final paper on resonances decaying to e -pairs;
- final paper on e -pair continuum;
- production of η' and ω^0 at high p_T;
- final paper on pion production, including resolved pions up to 10 GeV/c, and final data on unresolved pions;
- three pion correlations;
- direct single photon inclusive spectra from 1979 running;
- charged particle correlations with direct single photon and π^0 triggers.

The last paper is a collaboration with the R807 team, but the computation was done on the R806 computer budget.

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We propose to carry out two further projects, which will continue the R806 computing into 1980. The first is an extension of the R806-R807 correlation studies during the first two or three periods of next year, in order to measure well the jets recoiling against single photons and π^0's, in particular, the charge asymmetry of the leading pions. The strategy for computation is to process the R806 data tapes first, since they require less computing time per event, then abstract the R807 events of interest from the data tape and process them with the R806 information added onto the Data Summary Tape.

The second project involves data which already exists, on the 1978 DST's. This is a measurement of $\gamma\pi^0$, $\pi^0\pi^0$ and $\gamma\gamma$ correlations. The physics motivations have been described in our recent ISRC document (CERN/ISRC/79-34). About 250 DST's must be reabstracted and large data samples manipulated to perform this analysis. Also, our present knowledge of the meson decay background in the single photon candidates is limited in an important way by the statistical errors on the EGS shower simulation events. We need to increase their number considerably, and to simulate some new categories.

In the past, Brookhaven has supported the R806 computing at or considerably above the CERN level. We expect this to be true in the present case. If we are able to carry out both of the above projects, we would change our plans somewhat from those previously stated, doing processing of new data at CERN, to avoid a double shipping of tapes, and assign BNL more of the simulation studies. The CERN share for 1980 would be 400 KSF on the 7600, about equally split between processing the new data and carrying out the $\gamma\gamma$ correlation study on the 1978 data.