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PROPOSAL FOR A MEASUREMENT OF THE MULTIPLICITY AND RAPIDITY DISTRIBUTION OF SECONDARIES PRODUCED IN DIFFRACTIVE PROTON-PROTON COLLISIONS AT s = 500 and 1250 GeV^2

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CERN/Holland/Lancaster/Manchester Coll.

INTRODUCTION.

In this note it is proposed to study the multiplicity and angular distributions of secondaries associated with events in which one of the colliding protons is diffractively excited to a state of relatively high mass, while the other emerges from the collision area essentially unperturbed, i.e. with only a small change in momentum and direction. The measurements would centre on the following points.

1) The multiplicity as a function of missing mass, in particular a test of the statement that

$$< n_D(M^2) > = a_D + b \ln M^2$$

where b is the same number as in

$$< n(s) > = a + b \ln s.$$

Data from NAL indicate that this may be the case at $s < 600$ GeV^2. The experiment would aim at measuring this multiplicity at selected total energies $\sqrt{s}$ and momentum transfers $\sqrt{t}$ to the outpoing proton.

2) The distribution in $y = \ln tg\, \theta/2$ of the particles which decay from diffractively produced clusters of specified mass. For specified mass M, i.e. momentum and angle of the non-excited proton, the distribution in rapidity of the secondaries should centre at $y_C = \ln \sqrt{s}/M$ and should range from $y_C - \ln M$ to $y_C + \ln M$. The multiplicity (see 1)) and the rapidity distribution within the bunch on the rapidity plot are then related to the dynamics of the cluster producing process. The distribution could e.g. manifest the same short-range character as non-diffractive collisions appear to have. Fig. 1 shows the

missing mass spectrum produced in inelastic $pp \rightarrow pX$ collisions at fixed s and t (top graph). The MM resolution for $M^2 = 5$ and $M^2=15$ GeV^2 is indicated by the shaded areas; this MM resolution corresponds to a resolution in momentum of 0.8% (FWHM). The centre graph indicates schematically the expected grouping of secondaries on the rapidity plot for the two mass ranges, while the bottom graph illustrates the need for high resolution in momentum: integrated over all masses the rapidity distribution becomes flat and the structure is lost. (Le Bellac, Miettinen, Roberts, Berger, Fox).

3) The distribution in $y = \ln tg\, \theta/2$ of the particles which decay from clusters which are possibly left after removal of the "diffractive" clusters. Such central clusters are presumably responsible for the bulk of the short range correlations seen in non diffractive collisions. They may be distinct from their diffractive counter parts by their different charge content (v. Hove, Pokorski).

APPARATUS.

From the points above it follows that a combination of high precision equipment for determining the momentum and angle of the non-excited leading proton and large solid angle correlation equipment is required for these measurements. It is therefore proposed to use the CHLM spectrometer in essentially its present configuration to selectively (p_L, p_T, particle type) trigger on events in which the secondaries emerging over the entire rapidity range are recorded in hodoscopes of nearly 4π solid angle, placed close to the intersecting beams.

The hodoscopes would be designed and built in collaboration with the Daresbury, Liverpool, Rutherford collaboration which has proposed to use them in an experiment in which secondaries associated with high p_T triggers in the R203 spectrometer are recorded. We refer to that proposal (CERN/ISRC/73-27 and a further memo 6/11/73) for a description of the equipment. Detailed discussions between the two groups have resulted in a layout which is compatible with simultaneous data taking with both spectrometers. The layout is also complementary to the hodoscopes which have recently been installed along the downstream side of ring 2. This section, for which ISRC approval was obtained in April 1973 and which is now operational, would become integral part of the system; in particular, signals would be shared by the two collaborations. The two CHLM spark chamber/counter arrays at large angles which are now too restricted in angular coverage to be of further use have been shut down and will be removed from the tunnel.

MONEY,MANPOWER,COMPUTER REQUIREMENTS.

Estimates indicate that the hodoscopes plus cabling and electronics would cost approximately 200-250 KSFRS in "new" money, plus an additional 100-150 KSFRS from materials available or recovered from exp. R201. This is to be compared with the small angle spectrometer for which a total investment of approximately 3 MSFRS (5 magnets, 2 septa 2 20000A/30V supplies etc) has been made. Discussions as to how to share the cost in new money between the outside participants (Daresbury, Rutheford Laboratory, F.O.M.) are underway. Assistance from the ISR experimental support group will evidently be indispensable in making the device operational.

The CHLM group in its present configuration consists of 17 physicists and engineers. Approximately half of these are short-time participants (1-2 years), the other half has longer term arrangements. It is believed that in this way a suitable balance between stability, required for starting a new experiment with already operating equipment, and a useful rotation among physicists with interest in ISR physics is achieved.

The requirements for off-line computing remain essentially unaltered with respect to exp. R201. The hodoscope data are recorded in pattern units and analysed along with the tracking of the particle in the spectrometer. The 1973 request for R201 has been for 150 hr CP time 6600.

RUNNING TIME

The duration of the experiment is determined by the question as to what ranges in s, M^2 and t must be explored in order to arrive at conclusions of interest. NAL data suggest that energy dependence is of relatively little importance. We therefore propose to limit the experiment to two energies s = 550 GeV^2 (11.8/11.8 GeV) and s = 1250 GeV^2 (11.8/26.4 GeV). As to M^2 dependence, this is obviously the central issue. The spectrometer has an acceptance in momentum of $\pm$ 15%, largely sufficient to accept the entire M^2-range of interest in one setting of the fields, angles and heights of the elements of the spectrometer.

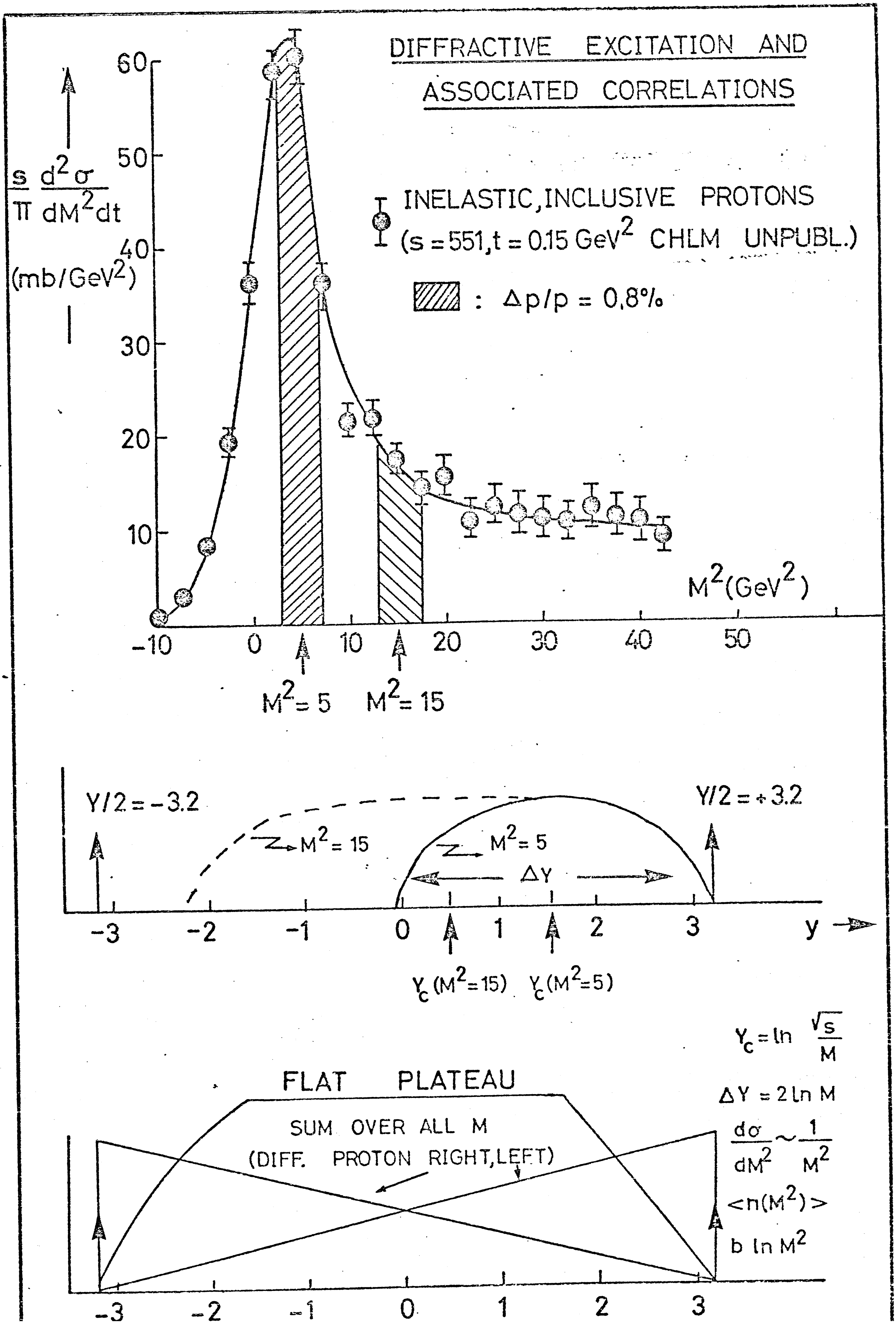
About the t-dependence there is little information and we propose to explore the range accessible with the spectrometer in some detail. From single particle runs over the same range (taking $\sim$ 60-80 hours at each energy) we estimate to require $\sim$200 hours/energy to get adequate statistics in the hodoscopes. A large fraction of this time the experiment would run in parallel with the one proposed by the Daresbury, Liverpool, Rutherford coll.

Average luminosity is sufficient to do the measurements. The experiment would run in optimum conditions with low current ($<$ 4A) in ring 1 and high ($>$ 7A) in ring 2.

OUTLOOK.

In order to investigate the feasibility of running with a large counter hodoscope placed very close to the crossing beams, tests have been made with a small 6 counter hodoscope covering the c.m. rapidity range - 1.6 to + 1.6. The hodoscope was triggered with high momentum protons in the spectrometer. It was found that 1) the rate of accidental coincidences with average beam qualities is a few per cent of the beam/beam rate; 2) the distribution in y is sensitive to the selection of M^2 in the spectrometer and also in agreement with model calculations. The latter point is illustrated in figure 2 where the rapidity distribution obtained with the test set-up is compared with a model calculation.

From these results we conclude that the experiment as proposed here should be feasible.



DIFFRACTIVE EXCITATION AND
ASSOCIATED CORRELATIONS
s/π d²σ/dM²dt (mb/GeV²)
INELASTIC, INCLUSIVE PROTONS
(s = 551, t = 0.15 GeV² CHLM UNPUBL.)
: Δp/p = 0,8%
M²(GeV²)
M² = 5   M² = 15
Y/2 = −3.2
Y/2 = +3.2
M² = 15
M² = 5
ΔY
y
Yc(M²=15)   Yc(M²=5)
Yc = ln √s/M
FLAT PLATEAU
SUM OVER ALL M
(DIFF. PROTON RIGHT, LEFT)
ΔY = 2 ln M
dσ/dM² ~ 1/M²
<n(M²)>
b ln M²

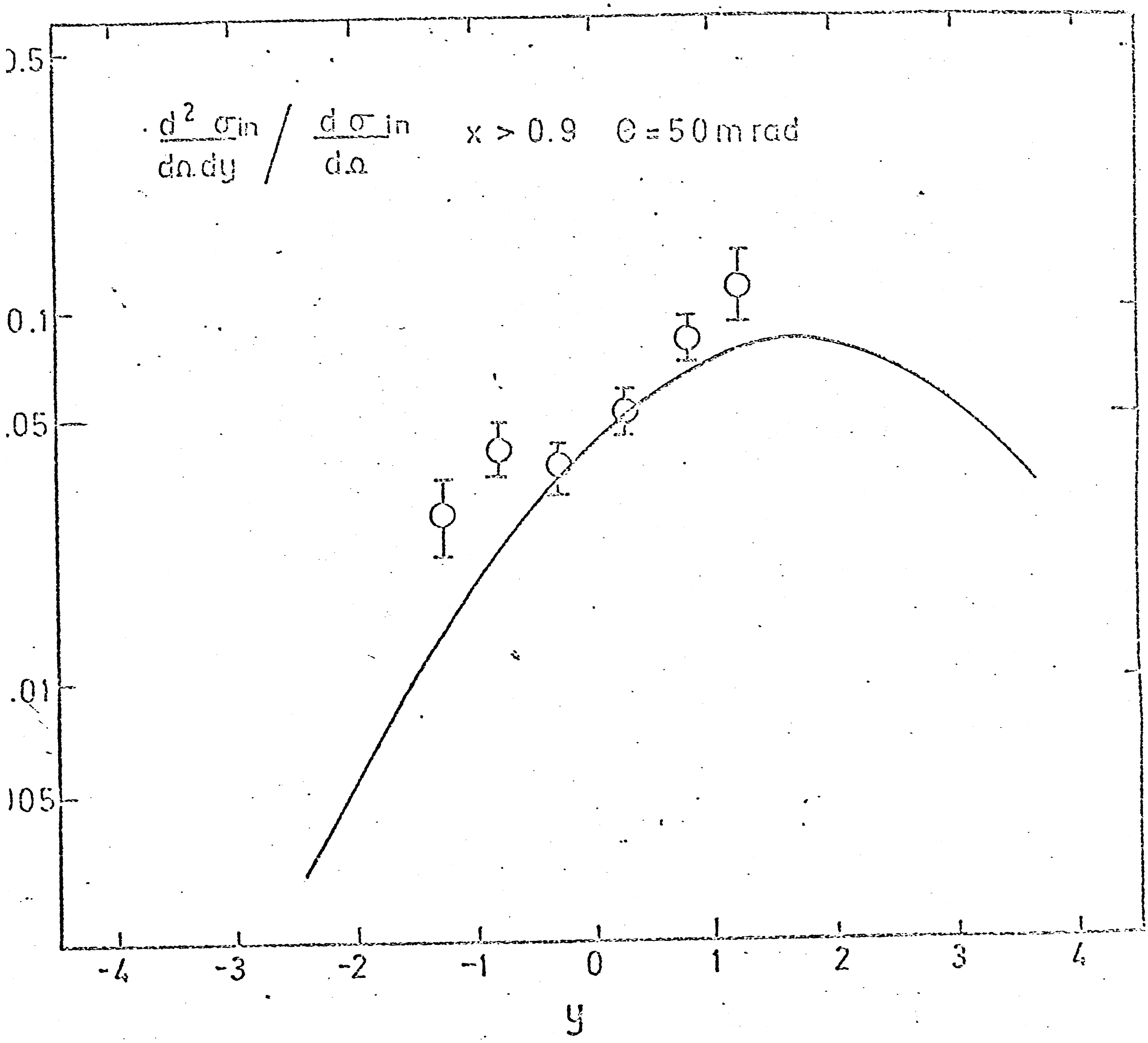


FIG. 2

Rapidity distribution of particles associated with high x protons at small angle. Data CHLM coll., test set-up. Solid line: rapidity distribution of decay products from diffractively produced clusters (Le Bellac, Miettinen, Roberts, RL-73-111). Without the high x proton trigger the distribution would be flat.