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Experimental Proposal

Inclusive Neutron Production by Protons on Protons and Nuclei

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May, 1975

SUMMARY

We propose to study the inclusive production of neutrons in the reaction $p + p \rightarrow n + x$ at 300 and/or 400 GeV using the external diffracted proton beam in the Meson Area M2 beam line. An ionization calorimeter neutron detector, previously built and used for experiment E4, would be used to determine the neutron spectrum. The neutron production angle relative to the incident proton direction would be varied over the range 0-10 mr by aiming the incident proton beam.

The physics studied would be the character of the exchange processes at the nucleon vertex in high energy interactions, and the mix between diffractive and non-diffractive processes.

Approximately 500 hours of beam would be required with testing included. The experiment will be compatible with other setups in the M2 beam.

Data from the CERN ISR and the 30-inch bubble chamber at FNAL have led to a rather detailed picture of inelastic proton production in p-p reactions. At least two components of the proton spectrum stand out. One component wherein the proton undergoes an inelastic diffractive collision with the target results in a broad peak at $x \geqslant 0.8$ with a t-distribution characteristic of elastic scattering. The other component contributes a broad continuum over $0 < x \leqslant .9$ and is considered to correspond to the proton coming from a more central collision including protons from decay of isobars or clusters. By a quantitative comparison of produced neutron and proton spectra (in P_T and P_L^* space) we can gain a better understanding of the role of nucleons in the inclusive reactions. Outstanding questions include the mix of $I = 0$ and 1 exchange, and role of P exchange. Some coarse data exists currently; from secondary interactions in the 30-inch HBC, the Caltech group has made a 10% determination of the inclusive neutron production cross section (integrated over all n energies) at 300 GeV. At CERN the CERN-Karlsruhe group (Engler et al.) have used a calorimeter to measure neutron production spectra, although these data are limited to larger neutron production angles by geometric constraints. At FNAL, our data from the M3 and M4 beams provide inclusive production data at two particular lab angles from a Be target. The detailed information from the proposed experiment would greatly and easily exceed the cumulative knowledge in this area.

The M2 beam can be steered vertically over the angular range 0 to 10 mr to strike a target ahead of E8's long sweeping magnet. We propose to put our E4 neutron calorimeter downstream of the E8 detection apparatus in line with the E8 neutral beam. Most tuneup could be done entirely parasitically on E8. By exploring the range of neutron energies and angles from 15 to 300 GeV and from 0 to 10 mr, a wedge in c.m. momentum space is scanned from $p_z^* = 0$, $p_T = 0.14$ GeV/c to $p_z^* = 14$ GeV $(x = 1)$, $p_T = 3$ GeV/c (for 300 GeV incident protons). The proton targets used by E8 would be perfectly appropriate for this experiment. A liquid hydrogen target would be desirable, but rates and fluxes appear to make CH_2-C subtraction adequate for good statistics. The neutron calorimeter was determined to have a resolution $\sim 13\%$ FWHM in the M3 beam, quite sufficient for the measurements proposed here. The required beam flux is modest, $\sim 10^7$ protons per pulse in M2. We had sufficient beam in M3 with 10^{11} protons on target and 5×10^{-11} steradians to accumulate $\sim 10^4$ neutrons per pulse. With the detector in the M2 beam, the solid angle subtended would be $\sim 10^{-6} - 10^{-7}$ sterads; hence we would obtain $\geq 10^6$ events with one hour of beam of $\sim 10^7$ on target. The spectra could easily be repeated at different production angles, in about 1 mr steps. Data could be taken from several different target elements in addition to hydrogen in order to explore the A dependence of forward inclusive spectra. This would increase the required time only slightly in view of the rapid data rate. A remotely controlled target changer already exists for E8.

A second calorimeter is currently under construction in Ann Arbor. By mid summer we will be able to have two calorimeters installed at FNAL, so that the need for a calorimeter in this experiment will not interfere with E248, E330, or other Michigan experiments.

No additional equipment is needed from FNAL for this experiment. Beam, floor space, electronics, targets, etc. all exist in the E8, E248, and E330 domains of the Michigan experimenters proposing this experiment.