NAL PROPOSAL No. 163

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PROPOSAL FOR A STUDY OF THE INTERACTION OF HIGH ENERGY π^- WITH NEON

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December 1, 1971

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NAL Directors Office

PROPOSAL:

To study high energy π interactions in the 30" bubble chamber filled with a hydrogen-neon mixture.

PURPOSE:

The purpose of the exposure is several fold.

1) To determine the multiplicity distribution in neon and compare this with data obtained in hydrogen.
2) To look for relatively stable particles produced at very high energies.
3) To look at the inclusive momentum distributions of produced pions and compare hydrogen and neon
4) Quark search.
5) To search for Electromagnetic showers.

METHOD:

We propose to use the 30" MURA-NAL chamber filled with an H_2 - Ne mixture ($\rho \sim .25 - .3$) to give a radiation length of about 1 meter. We also propose to use the MAMI wide gap chamber system downstream.

MOTIVATION:

The purpose of the experiment is to study the effects of very high energy cascading in a heavy nucleus. This cascading makes it possible to reach states that are not readily available in a single pion-nucleon collision. It was pointed out over a year ago[1] that it was possible to reach much higher mass complexes than can be readily reached in single collisions. Likewise, it is possible to reach states of high strangeness or high angular momentum in multi-particle collisions.

In collisions at 100 BeV and above the cascade should not behave at all like the cascades that one is used to thinking of in electron-photon showers. This is caused by the fact that the Lorentz contraction causes the products of the cascade to remain well inside of the range of their nuclear forces. Thus the energy of the incoming particle will remain well collimated as it progresses through the nucleus. The drawing in Fig. 1 shows a cross section of a neon nucleus. The lines show the characteristic cones for particles of 100, 50, 25, 12.5, 6.25 BeV. If a shower really started at a point as indicated then only 3 nucleons would be involved in the cascade. The products of momenta more than 6 BeV would be in the outside cone. All of the produced particles would essentially simultaneously interact with each of the three nucleons successively. It might be that the multiplicity of produced particles would be the same as in a single π-nucleon collision. Who knows?

The first thing to look at in this experiment would be the multiplicity and momentum distribution of individual particles. This information alone will give interesting insights into the physics of the situation. If we find dramatically higher multiplicities or a few events of dramatically higher multiplicities (40 pions for example), it would be a strong indication of new sorts of particles being produced or basically new processes going on.

PARTICLE SEARCH

We would also use the pictures for doing the sort of search carried out in emulsion 15 - 20 years ago. That is a search for stable super-strange particles. The neon in the chamber enhances the stopping power of the chamber by a factor of 5 at least. It is admittedly a long shot, but it would be simple to try.

ELECTROMAGNETIC EFFECTS

We propose to run the chamber with an H-neon density of about .3 g/cm^2. This gives a radiation length of 1 meter, which means a conversion probability of $\sim$.4 in the chamber. In looking at γ-rays at high energies, it is important not to have too short a radiation length since the first conversion tends to wipe out the downstream part of the chamber. The proposed radiation length would be useful for looking at events with large numbers of relatively low energy γ-rays which are produced over a large solid angle. The chamber is unfortunately too small really to look very effectively for several very high energy photons.

APPARATUS REQUIRED:

We propose to use the 30" MURA-NAL chamber filled with a Neon-hydrogen mixture to give a density of not more than .3 g/cm^3. We also propose to use the wide-gap spark chamber spectrometer to make measurements on high momentum particles.

We would like to use π^- in the 100 - 200 BeV range with a $\Delta P/P$ of not more than 1 percent.

We would require 50 K pictures with $\sim$5 π^- tracks per picture. On the basis of multiplicities expected from hydrogen, we would expect the order of 10 events having 20 π's or more produced. Thus we should have a meaningful number of events to make a Neon-hydrogen comparison so far as particle spectra and multiplicities.

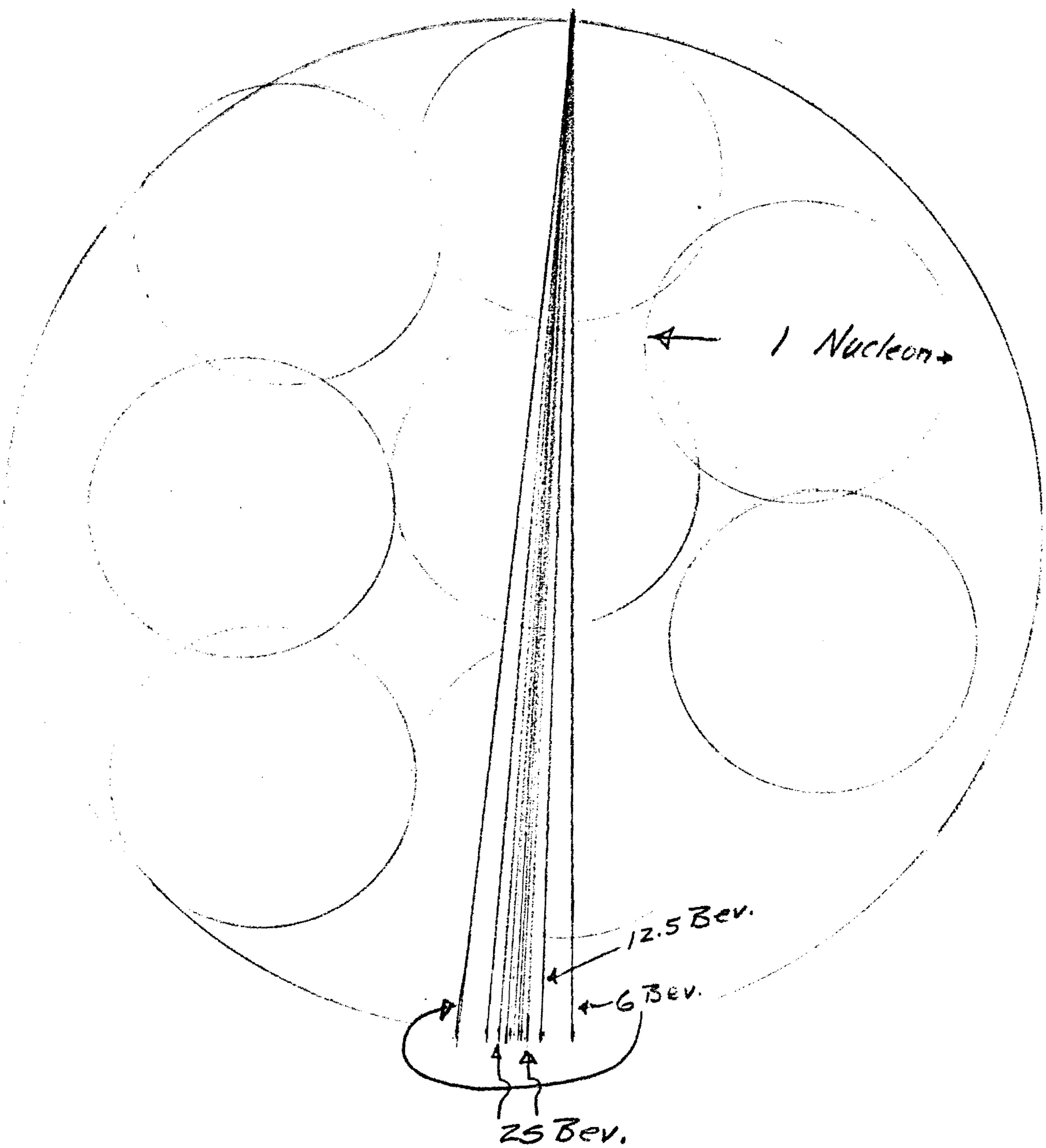

Fig. 1 - Cascade in Neon

Proposal No. 163A
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PROPOSAL FOR A STUDY OF THE INTERACTION OF HIGH ENERGY $\pi^{\pm}$ WITH NEON

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Revised May 18, 1973

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PROPOSAL:

To study high energy π interactions in the 30" bubble chamber filled with a hydrogen-neon mixture.

PURPOSE:

The purpose of the exposure is several fold.

1) To determine the multiplicity distribution in neon and compare this with data obtained in hydrogen.
2) To study the multiplicity of π^0's produced in π^--p interactions.
3) To look at the inclusive momentum distributions of produced pions and compare hydrogen and neon.
4) Quark search.
5) To search for Electromagnetic showers.
6) To look at diffraction dissociation on neon.
7) To look at the properties of stopping tracks -- to see whether exotic stable particles are produced.

METHOD:

We propose to use the 30" MURA-NAL chamber filled with an H_2-Ne mixture ($\rho \sim .2$) to give a radiation length of about 2 meters. We also propose to use the MAMI wide gap chamber system downstream.

MOTIVATION:

The purpose of the experiment is to study the effects of very high energy cascading in a heavy nucleus. This cascading in principle makes it possible to reach states that are not readily available in a single pion-nucleon collision. It was pointed out over three years ago[1] that it was possible to reach much higher mass complexes than can be readily reached in single collisions. Likewise, it is possible to reach states of high strangeness or high angular momentum in multi-particle collisions.

In collisions at 100 BeV and above the cascade should not behave at all like the cascades that one is used to thinking of in electron-photon showers. This is caused by the fact that the Lorentz contraction causes the products of the cascade to remain well inside of the range of their nuclear forces. Thus the energy of the incoming particle will remain well collimated as it progresses through the nucleus. The drawing in Fig. 1 shows a cross section of a neon nucleus. The lines show the characteristic cones for particles of 100, 50, 25, 12.5, 6.25 BeV. If a shower really started at a point as indicated then only 3 nucleons would be involved in the cascade. The products of momenta more than 6 BeV would be in the side cone. All of the produced particles would essentially simultaneously interact with each of the three nucleons successively. It might be that the multiplicity of produced particles would be the same as in a single π-nucleon collision. Who knows?

In a study which we are doing with 10 GeV π^+ we seem to find evidence for a sizable class of interactions in which multiplicities of 2x , the average hydrogen multiplicity, are found. It would be interesting to see if this effect persists at higher energies.

Also at 10 GeV we find that π-nucleus collisions are a very copious source of very low energy (20 - 40 MeV) pions. It will be interesting to see if this effect persists or increases.

The first thing to look at in this experiment would be the multiplicity and momentum distribution of individual particles. This information alone will give interesting insights into the physics of the situation. If we find dramatically higher multiplicities or a few events of dramatically higher multiplicities (40 - 100 pions for example), it would be a strong indication of new sorts of particles being produced or basically new processes going on.

PARTICLE SEARCH:

We would also use the pictures for doing the sort of search carried out in emulsion 15 - 20 years ago. That is a search for stable super-strange particles. The neon in the chamber enhances the stopping power of the chamber by a factor of 3 at least. It is admittedly a long shot, but it would be simple to try.

ELECTROMAGNETIC EFFECTS:

Our experience using 10 BeV π^+ in neon shows that we can separate Neon and hydrogen events on the basis of topology with some precision. There are hydrogenic type collisions in neon which will contaminate the hydrogen sample. These events are apparently similar to hydrogen events in all respects. We thus should be able to do a study of hydrogen interactions in the neon-hydrogen (with this $\sim$ 20 per cent background from neon). What makes this unique is that we will be able to study π^o and η^o production much better (better statistics and precision) than any other experiment to be done until an H_2 target is placed in the 15' chamber. The radiation length should be about 2 meters as compared to 9 meters in pure hydrogen.

We propose to run the chamber with an H-neon density of about .2 g/cm^2. This gives a radiation length of $\sim$ 2 meters, which means a conversion probability of $\sim$.2 in the chamber. In looking at γ-rays at high energies, it is important not to have too short a radiation length since the first conversion tends to wipe out the downstream part of the chamber. It is also important to minimize the numbers of secondary interactions in the chamber. The proposed radiation length would be useful for looking at events with large numbers of relatively low energy γ-rays which are produced over a large solid angle. The chamber is unfortunately too small really to look very effectively for several very high energy photons.

APPARATUS REQUIRED:

We propose to use the 30" MURA-NAL chamber filled with a Neon-hydrogen mixture to give a density of not more than .2 g/cm^3. We also propose to use the wide-gap spark chamber spectrometer to make measurements on high momentum particles.

We would like to use π^- in the 100 - 200 BeV range with a $\Delta P/P$ of not more than 1 per cent.

We would require 50K pictures with $\sim 4\ \pi^-$ tracks per picture. On the basis of multiplicities expected from hydrogen, we would expect the order of 10 events having 20 π's or more produced. Thus we should have a meaningful number of events to make a Neon-hydrogen comparison so far as particle spectra and multiplicities.

REFERENCES

1. W. D. Walker, Phys. Rev. Letters 24, 1143 (1970).

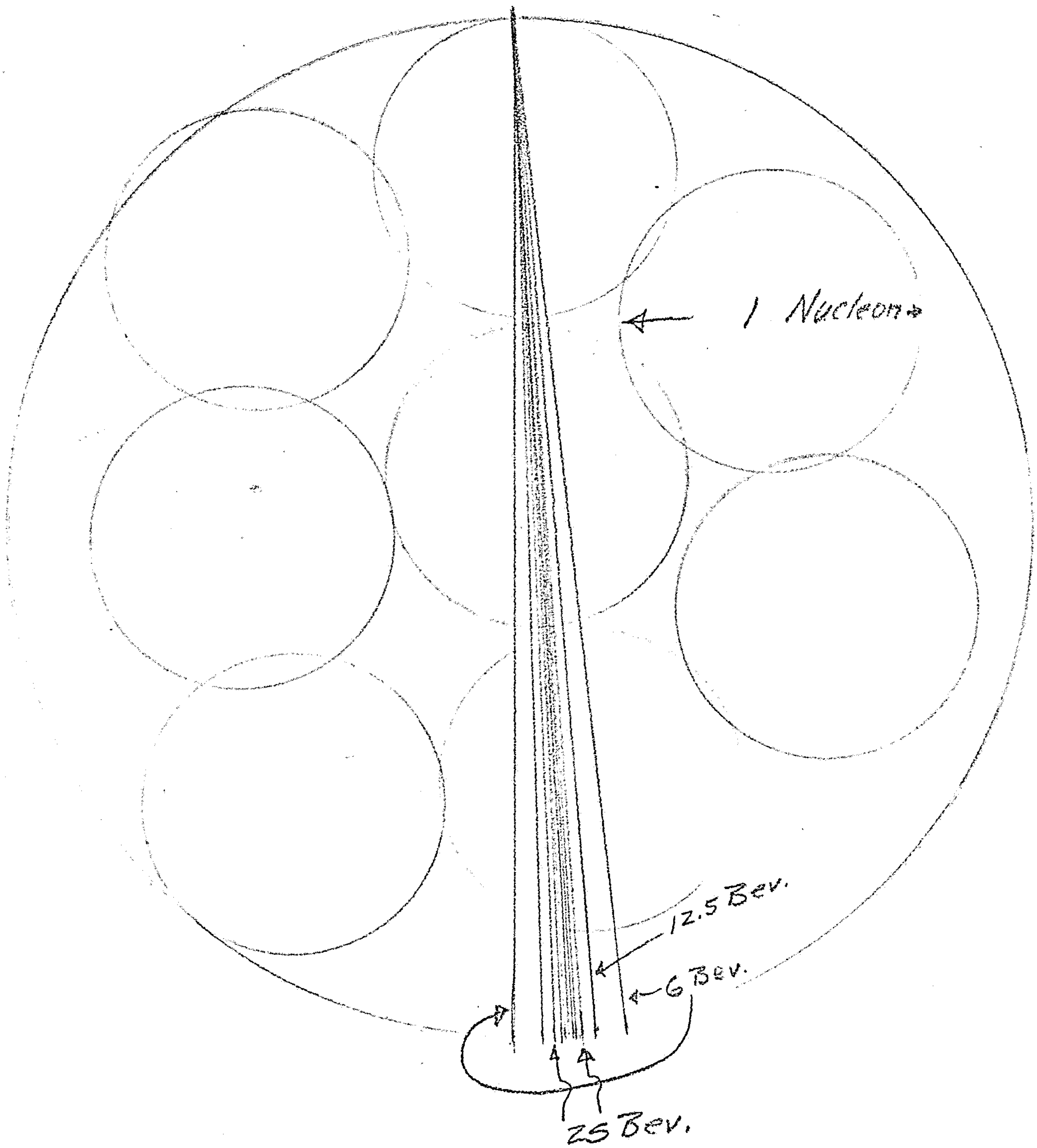

Fig. 1 – Cascade in Neon