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PROPOSAL FOR A PEDAGOGIC EXPERIMENT BY
MEANS OF PP COLLISIONS IN THE HBC 200

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Abstract

We propose to use bubble chamber pictures of p p collision to transmit some basic concepts of physics to high school and University students.

As many severe cuts are necessary for this purpose , we request at least 100.000 pictures of p at 2 GeV/c in order to get an adequate sample (about 200) of useful events before the shutting down of the HBC 200.

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1) Purpose of the operation

We have proposed two exercises for students of the last class of high school. These students are 16-17 years old, and at this time they know, as elementary particle, only p, n, e. They will discover the π meson at the end of the second exercise, and this is why we recommend using the pp interaction.

- a) first exercise : on an elastic event, they check the validity, and the necessity of the relativistic mechanics.
- b) second exercise : on an inelastic event, by using the relativistic mechanisms formula, that they have checked in the previous exercise, they find that a new particle is produced and consequently that a part of the incident energy was converted into matter.

2) Method of measurement in High School

- The method of measurement should be cheap because the device should be multiplied by the number of High School times the number of student-pairs in the class, and we have proposed to use large pictures (100 x 70 cm) and templates.

- Students do their measurement on one view only, because the geometrical reconstruction is complicated for them, and does not bring anything in the knowledge of the relativistic mechanics. This requires that every track should have a dip smaller than 11° ($\cos \delta \leq .98$).

3) Choice of incident momentum

To be measurable by this rough device, the curvature should be quite large, that means that the momentum should be as low as possible. On the other hand, the proton, and specially the secondary protons should be relativistic, because we make this exercise in order to check the relativistic mechanics, and consequently the incident momentum should have some GeV/c. We have chosen a compromise between the possibilities of measurement and the significance of relativity and we will take pictures at 2 GeV/c.

4) Pictures selection

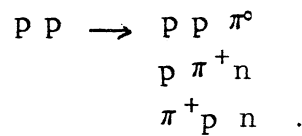
- . In october 74, in a pirate experiment, we took 12000 pictures of proton at 2 GeV/c. The average number of incident tracks was 5. These pictures were scanned, selecting flat events, and 500 were measured on a spiral reader, and those events passed through Thresh-Grind, as in a real experiment.
- . Various cuts were made along this procedure
 - cut in dip
 - cut in fiducial volume. Our fiducial volume was very small in the center of the chamber to get a good length of tracks for measurability.
 - cut in quality of the pictures : no parasite, no superposition, etc..
 - cut in transverse momentum
- . for elastic event, the most interesting is the symmetric event, when the momenta of secondary tracks are quasi equal. Indeed, if one secondary proton has a momentum roughly equal to incident momentum, in energy balance the main part of the outgoing energy comes from this fast proton and we find that the outgoing energy is equal to the ingoing, independantly of the $E = f(p)$ formula.
- . for inelastic event, the most interesting is the non symmetric event. To avoid the π -p ambiguity for the two positive tracks, it is necessary to have an asymmetric event since otherwise the interchange $p_2 \leftrightarrow p_3$ does not change the energy equation and thus is insensitive to the mass permutation.

After these cuts, we get only about ten of each category of events, elastic and inelastic.

5) The two exercises

Elementary ideas on relativity have already been tough. Momentum conservation tests first establish whether the event is elastic or inelastic. Energy conservation tests are carried out on the elastic events using non-relativistic and relativistic formulae. This demonstrates the necessity and validity of relativistic mechanics.

For the inelastic events, the missing momentum is calculated by the plot and several hypotheses are compared and checked by energy conservation.



Only one of them fits the energy balance. This demonstrates particle creation and the energy matter relationship.

6) Providing the High-Schools, and results.

Seven schools were involved in the 74-75 school year and nineteen schools in the present school year.

In 1975 we provided each test high school with four different events (two elastic and two inelastic) on large pictures and with a set of templates.

No practical problems have been encountered during the experiment so far. The students seem to have no difficulty in establishing that the relativistic approach is more exact than the non relativistic, or in selecting from amongst the possible particle creation hypotheses.

In the 1976 school year, twelve events are tested.

7) Developments

- As we have said, with 12 000 pictures of proton we got at the utmost twenty useful events, this is why we request to increase our stock by a factor ten. We are therefore proposing to take at least 100.000 pictures of proton-proton collisions before the shutting down of the HBC 200.

- As an aside let us state that the same pedagogic tests can clearly be made in the University as illustrations of lectures on relativity ; but incident proton is no longer necessary since the students know other particles .

- Of course the twelve tested events, with their Grind out-put are available to every one who is interested as will be the future events if this proposal is accepted.

8 - Reference

- Bubble chamber film in education.
CERN courrier-n° 11-vol 15 (352) Nov 75.