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A LETTER OF INTENT

A STUDY OF $\bar{p}p$ INTERACTIONS AT 70 GeV/c ON WA-31 EXPERIMENT FILMS

by

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Collaboration will start hadron exp. only after 1980, because lepton goes slow as expected. Therefore this collaboration is welcomed.

→ OK.

Serpukhov, 1979

In this letter we present our interest in the study of $\bar{p}p$ interactions at 70 GeV/c on the films obtained from BEBC with neon-hydrogen mixture and a track sensitive target (TST) for the WA-31 experiment. This experiment is being performed by BHLMS collaboration to study the production of prompt leptons. But the large size of TST (Fig.1) gives also an opportunity to fulfil a certain program of hadron investigations.

Since the total number of the pictures is about 188 thousand and the experimental number of interactions per picture is 0.53[1] the sensitivity of the hadron experiment achieves ~2 ev./mb. But for $\bar{p}p$ study only a part of the total statistics can be effectively used mainly due to the background conditions.
Below we shall bear in mind the minimal statistics which is necessary for the hadron program.

As the main advantage of the large bubble chambers with neon-hydrogen mixture and TST is high efficiency of detecting gammas from π^0-decays we are mainly interested in hadron processes with π^0 production.

1. Measurement of the π^0, ω^0, η^0 Production Cross-Sections in Inclusive and Semi-Inclusive Reactions.

The γ-conversion probability in the 100 cm neon-hydrogen mixture behind the TST is $\varepsilon \approx 85\%$. But the experience in the -measuring in heavy liquids shows that the efficiency of π^0 reconstruction with measured γ's will be much less than ε^2. This is due to the following factors:

- losses of γ's (especially slow and asymmetric γ's) while scanning (10÷15%);
- energy and angle cuts ($E_\gamma > 70$ MeV) to throw away the bremstrahlung γ's (~10%);
- losses at the stage of measurements and geometric reconstruction (5÷10%);
- losses when associating γ's with the primary vertex (~5%);

Thus the Data Summary Tape (DST) will contain < 60% of all γ's. This will result in a certain problem in defining sources of γ's.

Another problem with γ's will be roughness of the measurements of the energies and angles ($\Delta E_\gamma/E_\gamma \leq 15\%$) and rather high uncertainty in combining γ-pairs which are produced from some π^o's (~50% for decay of $2\pi^o$).

To improve the accuracy of the angle measurements for the convensional e^+e^--pairs, it will be very desirable to fit them to the primary vertex (2C and 3C fits). But such a possibility in this experiment with TST has not yet been proved.

So in the first stage of the experiment we suggest that distributions of the effective $\gamma\gamma$-mass to find the production cross-sections of the neutral mesons to be used. Within the statistics of~10K events and under the "pessimistic" estimation of the probability for a γ to come to DST (50%) one can expect about 25K of γ's which are completely reconstructed and associated with primary vertices (see below point II). This will lead to 6÷7 thousand of π^o-mesons in the peak of $M(\gamma\gamma)$-distribution.

This level of statistics will also allow us to find π^o production cross-sections for the semi-inclusive reactions. Thus we

shall obtain the average value $\langle n_{\pi^0} \rangle$ as a function of charged multiplicity $n_{\pm}$, as well as $f_{2\,n^{\pm}}^{oo}$, $f_{2\,n^{\pm}}^{\pm o}$ and so on.

If the $\gamma\gamma$-pairs are correctly associated, the accuracy in determination of π^0 momentum will be sufficiently high ($\Delta p/p \leq 3\%$). So we shall be able to do the direct measurement of the ω^0 inclusive production cross-section using the decay mode:

$$\omega^0 \rightarrow \pi^+ \pi^- \pi^0 \ .$$

At present the estimations of ω^0-inclusive cross-section in the high energy $\bar{p}p$ interactions exist only for 32 GeV/c[2]. They were obtained by studying the ω^0-reflection into the $\pi^+\pi^-$ effective mass spectrum (see Fig.2). The 32 GeV/c data exhibit the approximate equality $\sigma(\omega^0) \approx \sigma(\rho^0)$ which is obtained in the simple additive quark model (Anisovich and Shekhter). But to solve the problem, we need direct measurements of ω^0-production which can be made in the proposed experiment in the most accurate way. Within the statistics of 10 thousand events the accuracy in determination of $\sigma(\omega^0)$ is expected to be $\sim$1mb, e.g. 10%.

One can attempt to estimate the $\eta^0(549)$ production cross-section, using the hadron decay mode

$$\eta^0 \rightarrow \pi^+ \pi^- \pi^0 \ .$$

Probably this will be possible if the cross section is higher than 1mb, but the background conditions are unknown.

II. Multiplicities

With high efficiency of γ detection one can also reconstruct the distributions in π^0-multiplicity by solving the equations which connect the observation frequency of $n\gamma$ with the probability of $m\pi^0$ to be produced[3]. Expected 25K of γ's will be enough

to reconstruct the π^0-multiplicity distribution in inclusive processes, although the problem will be complicated if the $\eta^0(549)$ production cross-section is large.

The π^0-multiplicity distributions $P_{n\pm}(n_{\pi^0})$ for various charged topologies are of most interest. The low energy data show that the cross-sections of the annihilation events with odd number of pions are bigger than with even one.[4] The energy increase eliminates this effect, but the distribution $P_{n\pm}(n_{\pi^0})$ is still far from the Poisson shape.

Table 1 represents the topological cross-sections in 70 GeV/c $\bar{p}p$ interactions which are obtained by interpolation in 9-100 GeV/c interval. They are compared with the pp experimental data at 69 GeV/c.[5] Assuming the average summary proton and antiproton multiplicity to decrease from 1.2 $(\bar{p}+p)$/event in four-prong events to 0.6 $(\bar{p}+p)$/event in sixteen-prong events due to the increasing probability of annihilation, one can estimate the average π^0 multiplicities in the various topologies if the equations $(\pi^-) = (\pi^+) = (\pi^0)$ hold.

The Table also shows how much γ's in the various topologies will be put on DST for 10K events. (The probability for γ to come to DST is assumed to be 50%). From these estimations one can deduce that the cross-sections of the events with $n_{\pi^0} < 4$ in the topologies $4 \leq n_\pm \leq 8$ are calculated with 5÷15% accuracy. But the analogous procedure in higher topologies ($n_\pm \geq 10$) requires the sufficiently larger statistics.

III. Annihilation

At present there is no data on the annihilation cross-section for the events with neutral pions ($n_{\pi^0} \geq 1$) above 12 GeV/c. The estimations and the preliminary experimental 32 GeV/c $\bar{p}p$ results on 1C-fit annihilation channels show that the cross-sections for the channels $\bar{p}p \rightarrow n(\pi^+\pi^-)\pi^0$ at n=3÷6 can achieve 100 mb. So the statistics 0.3 - 0.5 ev./mb can probably allow to get the cross-section rough estimates using events with one or two γ's:

$$\bar{p}p \rightarrow n(\pi^+\pi^-) + (\pi^0 \rightarrow \gamma_{vis} + \gamma_{unvis}) ,$$
$$\bar{p}p \rightarrow n(\pi^+\pi^-) + (\pi^0 \rightarrow \gamma_{vis} + \gamma_{vis}) .$$

The cross-sections for some non-annihilation 1C channels can also be found.

IV. Conclusion

The study of $\bar{p}p$ interactions with WA-31 experiment films can give some interesting information even on the 0.3 - 0.5 ev/mb level of statistics. Such an information cannot be obtained accurately in hydrogen bubble chambers.

Our group has experience in bubble chamber investigations being engaged in pp, K^-p and $\bar{p}p$ experiments on Mirabelle.

IHEP has all the necessary software for data handling and the adequate measuring equipment. For this particular experiment we suppose to use two precise projectors PUOS-4 (with the magnification x 60), projectors PUOS-2M and HPD. This experiment will allow us to scan and measure about 5000 events of all topologies during a year.

As we intend to perform some preliminary work, we would like to get one film (or more) from WA-31 experiment in autumn 1979.

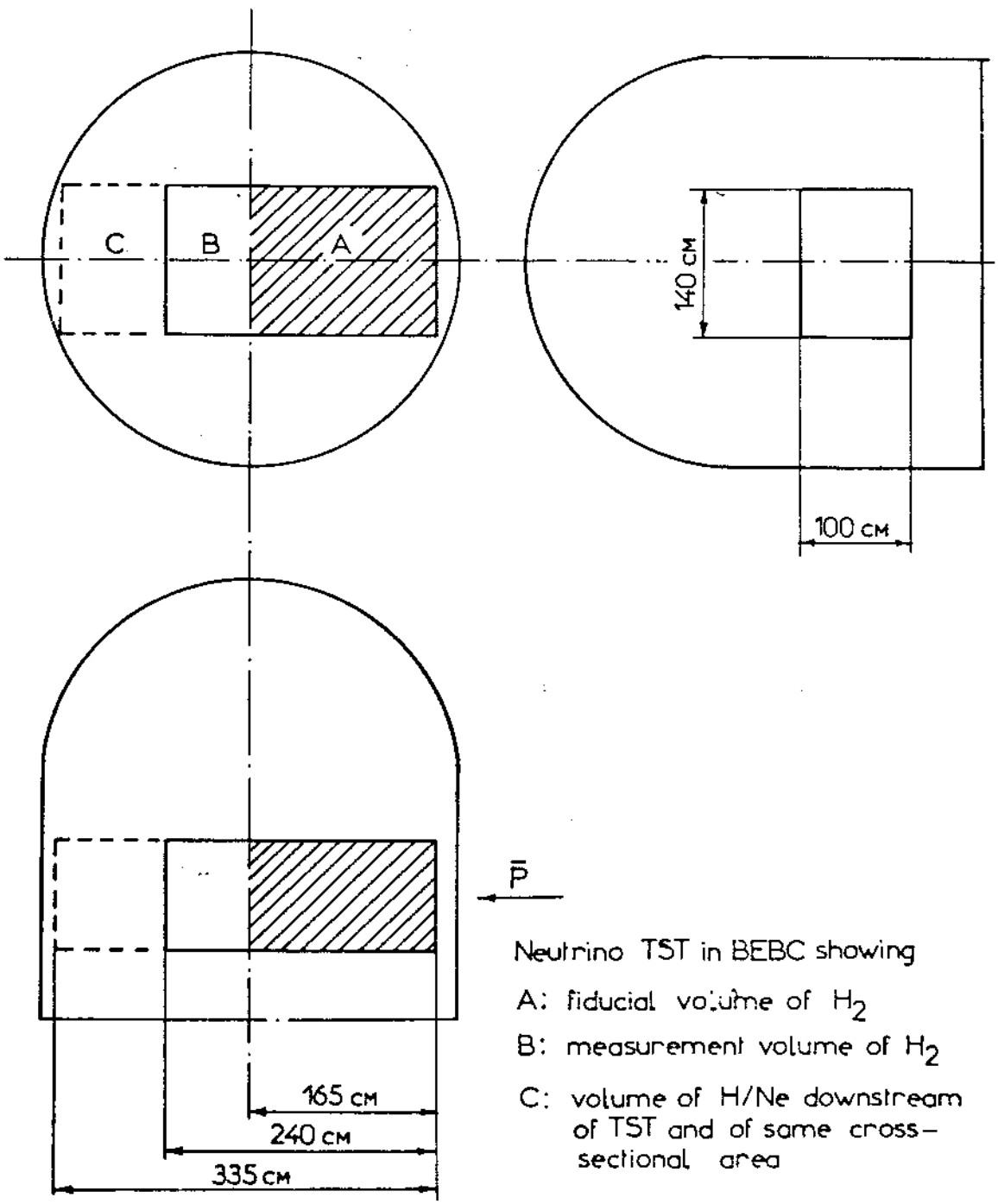
Table 1

Topological cross-sections and average π^0-multiplicities in $\bar{p}p$ interactions at 70 GeV/c (interpolation) and pp interactions at 69 GeV/c (experiment).

Topology	Cross-sections in mb		$\langle n_{\pi^0} \rangle$	n_γ per 10000
	$\bar{p}p$-70	pp-69	in $\bar{p}p$-70	of events
2(inel)	4.5	4.8 ± 0.6	-	-
4	9.1	8.8 ± 0.3	1.4	3300
6	8.9	7.8 ± 0.2	2.4	5300
8	6.5	5.4 ± 0.2	3.4	5400
10	3.3	2.7 ± 0.1	4.5	3600
12	1.5	1.14 ± 0.05	5.6	2200
14	0.6	0.37 ± 0.03	6.7	1000
16	0.2	0.08 ± 0.01	7.7	-

References

1. J.Lemonne. A private communication
2. Yu.I.Arestov et al., IHEP Preprint 79-22, SERP E-122,(1979)
3. J.R.Elliott et al., Nucl.Phys. B133, 1 (1977)
4. I.Bar-Nir et al., Nucl.Phys. B20, 45 (1970)
5. V.V.Babintsev et al., IHEP Preprint M-25, Serpukhov, 1976.



Neutrino TST in BEBC showing

A: fiducial volume of H_2

B: measurement volume of H_2

C: volume of H/Ne downstream of TST and of same cross-sectional area

Fig. 1

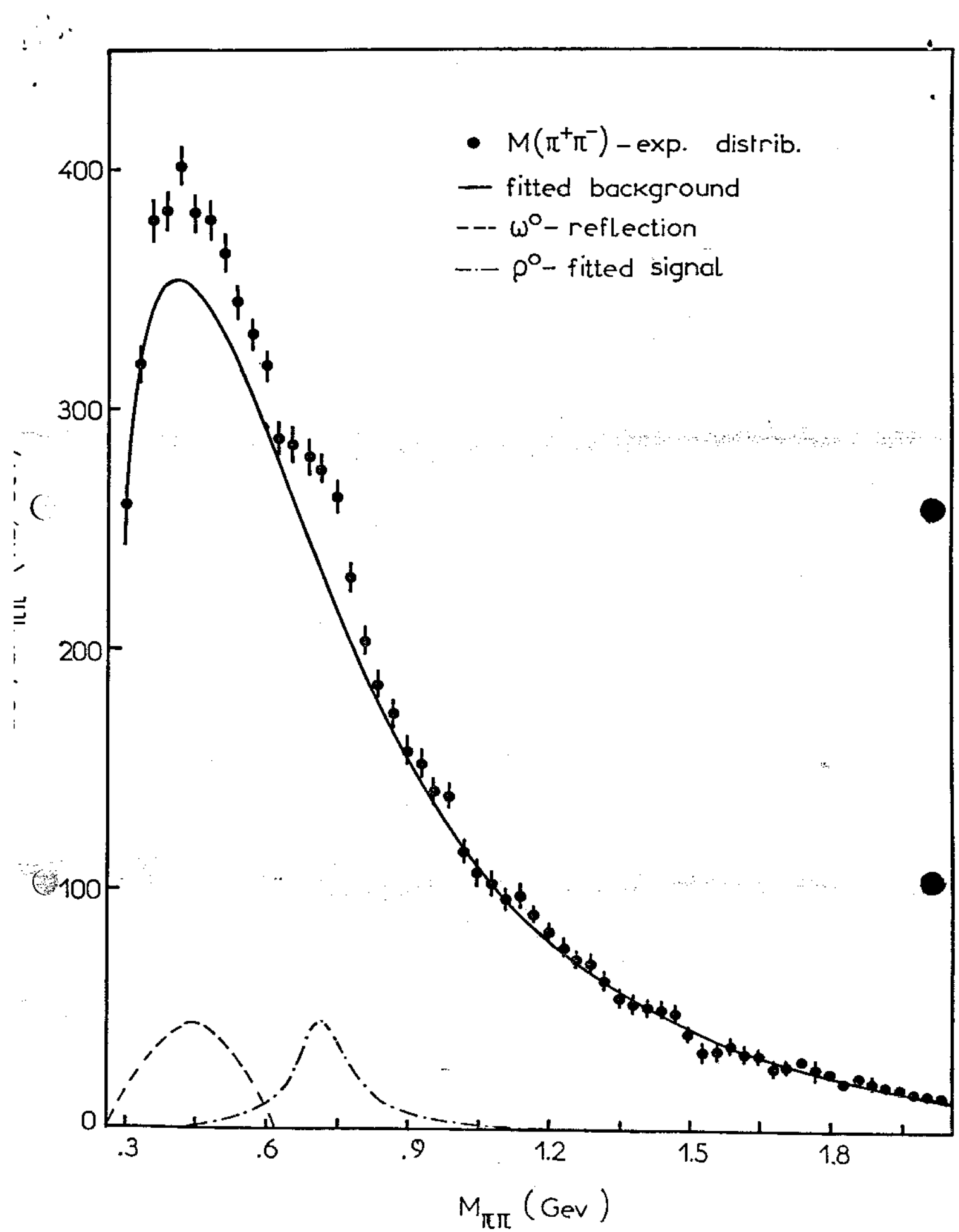

M(π⁺π⁻) – exp. distrib.
fitted background
ω°– reflection
ρ°– fitted signal
400
300
200
100
0
.3
.6
.9
1.2
1.5
1.8
M_ππ (Gev)

Fig. 2

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№ ——

"14" V 1979 г.

Dear Prof. Butterworth,

I send to You, as to the Chairman of SPSC, the Letter of Intent in which the group of IHEP physicists expresses its interest in participating in a "hadronic" phase of WA-31 experiment. Their group-leader Dr. A.Moiseev has already contacted with the spokesman of B-H-L-M-S-Collaboration Dr. J.Lemonne who after discussion of this problem in the Collaboration has informed us that there are no particular objections against the proposal of the IHEP group to join WA-31 exp. in its "hadronic" phase.

This Letter of Intent has been considered in our Institute from the point of view of expected physics as well as the ability of our measuring center to perform the required amount of measurements and has been approved.

This group has been involved for several years in a number of high energy experiments on MIRABELLE bubble chamber in the France-Soviet Union and CERN-Soviet Union Collaborations and now part of this group is involved in the $\bar{p}p$-experiment at 32 GeV/c with high statistics. So they are well acquainted with the problems of large bubble chambers and have a good experience in participation in big scientific Collaborations.

The possibility for IHEP physicists to work on films from BEBC with TST will be very useful also from the point of view of our plans to develop TST for MIRABELLE.

I hope that the continuation of our cooperation in the field of bubble chamber experiments, proposed in this Letter of Intent, will be as successful as it has been up to now.

Sincerely yours
Vice-director of IHEP

N.E.Tyurin

A copy to Dr. G.Fidecaro