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Letter of Intent

PRECISE MEASUREMENT OF THE PROTON-ANTIPROTON TOTAL CROSS-SECTION AT THE ISR OF CERN

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According to the possibility of running the ISR with protons and antiprotons in 1981-1982, we wish to outline here the experimental programme which we envisage to pursue.

Our main aim is the measurement of the proton-antiproton total cross-section ($\sigma_{\bar{p}p}$) in the new energy range available at the ISR. This measurement is important expecially if one considers that a direct comparison with the corresponding proton-proton cross-section (σ_{pp}) is possible.

Measurements of $\sigma_{\bar{p}p}$ at FNAL have been performed up to 200 GeV/c incident momentum.[1] The results (see Fig.1) show a rate of decrease less pronounced than at lower energies. Both theoretical arguments and comparison with the other particle-antiparticle cross-sections[2] suggest that in the ISR energy range $\sigma_{\bar{p}p}$ should reverse its dependence on energy and should start to increase, approaching σ_{pp}. If this effect does occur, $\sigma_{\bar{p}p}$ rises by at least 1.5 mb over the full ISR energy range.

An accurate study of $\sigma_{\bar{p}p} - \sigma_{pp}$ is interesting also when analysed in terms of topological cross-sections and correlation functions.[2] The difference between the two cross-sections is expected to become small ($\Delta\sigma$=2-0.6 mb over the ISR energy range as shown in Fig.2). For these reasons the measurement of $\sigma_{\bar{p}p}$ has to be performed with a relative error of $<$1%.

Our past experience with pp total cross-section measurement at the ISR as members of the Pisa-Stony Brook Collaboration (experiment R801) makes us confident that this high precision is attainable by measuring the total interaction rate R and the luminosity L. Therefore we are considering employing the same or a similar apparatus to that used in R801 to measure $\sigma_{\bar{p}p}$ and σ_{pp}. This apparatus, which is schematically shown in Fig.3, would comprise scintillation counter hodoscopes covering essentially the full solid angle; the basic trigger requires at least a charged particle in both hemispheres.

The main factor limiting the precision of the measurement is the precision of the Van der Meer (VDM) method used to measure the luminosity.[4] All other uncertainties in computing the total rate which are due to extrapolation of elastic and diffractive events, corrections for dead-time and trigger losses are well below 0.5%. In R801 we proved that the error in the

VDM method was below 1%.[5] Recent mesurements with this method[6] make us confident that the error on luminosity can be further reduced to less than 0.5% for proton and antiproton stacks.

The $\bar{p}p$ interaction can produce (in contrast to pp) final states consisting of all neutral particles or charged particles in one hemisphere only (by annihilation or charge exchange). These reactions escape the basic left-right charged-particle trigger and moreover they cannot be accounted for by extrapolation techniques. Although these processes are expected to give negligible contributions at ISR energies, it would be possible to recuperate in part these reactions by using lead converters in front of the hodoscopes, by employing a "one arm only" trigger (particle tracking would be crucial in this respect), and by tagging neutrons and antineutrons at small angle. For these purposes an upgrading of the basic scintillation counter set-up can be envisaged, using drift-chamber telescopes in an arrangement similar to the one that we are using at present in R209.[7] The facility of tracking charged particles and identifying the origin of the interaction, which is essential for background rejection in the $\sigma_{\bar{p}p}$ measurement with a "one arm only" trigger would make careful studies of inclusive physics possible (topological cross-sections, correlation functions) thus continuing and improving the same line of physics already followed in R801.[8] The experience in drift-chamber techniques gained in R209 would allow us to handle the difficult problem of efficiency and multiparticle pattern recognition.

In order to make measurements at small polar angles possible, the experiment would have to be installed in an even numbered intersection region.

Since the data collection rate is very high in this experiment, luminosity is not a problem. However, in order to keep single-beam background as low as possible, the intensities of the two beams should be, in principle, the same. In practice, operation with $I_{\bar{p}}$=250 mA and I_p=3 A should provide a luminosity of $\simeq 10^{28}\ cm^{-2} sec^{-1}$, with small background, quite adeguate for this experiment. In order to allow measurements of $\sigma_{\bar{p}p}$ and σ_{pp} with the minimum relative systematic error, one would also have to alternate frequently $\bar{p}p$ and pp runs at similar intensities. Accurate rate and VDM luminosity measurements would be needed on both $\bar{p}p$ and pp stacks.

For the time being, we are working on a detailed design of the experiment, and we are fully open to contributions by other interested physicists.

REFERENCES

1) A.S.Carroll et al., Phys. Letters 61B, 303 (1976).

2) J.G.Rushbrooke et al., Phys. Reports 44, 1-92 (1978).

3) S.R.Amendolia et al., Proc. Internat. Conf. on Instrumentation for High Energy Physics, Frascati 1973, (Lab. Naz. del CNEN, Frascati 1973) p.397.

4) S.Van der Meer, CERN Internal Report ISR-PO/68-31.

5) U.Amaldi et al., CERN Preprint to be published in Nuclear Physics.

6) K.Brand and J.P. Gourber, CERN Internal Report ISR-BOM/77-3.

7) A.Bechini et al., Paper presented at the Wire Chamber Conf., Vienna, Austria, 14-15 February 1978.

8) S.R.Amendolia et al., Phys. Letters 48B, 359 (1974).
S.R.Amendolia et al., Nuovo Cimento 31, 17 (1976).

Figure captions

Fig. 1 : $\bar{p}p$, pp, π^-p, π^+p, K^-p and K^+p total cross-sections versus $\sqrt{s}$ (GeV) and p_{lab} (GeV/c), as compiled by U.Amaldi, CERN.

Fig. 2 : $\sigma_{\bar{p}p} - \sigma_{pp}$ versus p_{lab} (GeV/c).
Data have been taken from:
W.Galbraith et al., Phys. Rev. 138B, 913 (1965).
S.P.Denisov et al., Phys. Letters 36B, 415 and 528 (1971).
J.Allaby et al., Phys. Letters 30B, 500 (1969).
A.S.Carroll et al., Phys. Letters 61B, 303 (1976).

Fig. 3 : Schematic layout of R801 experiment.

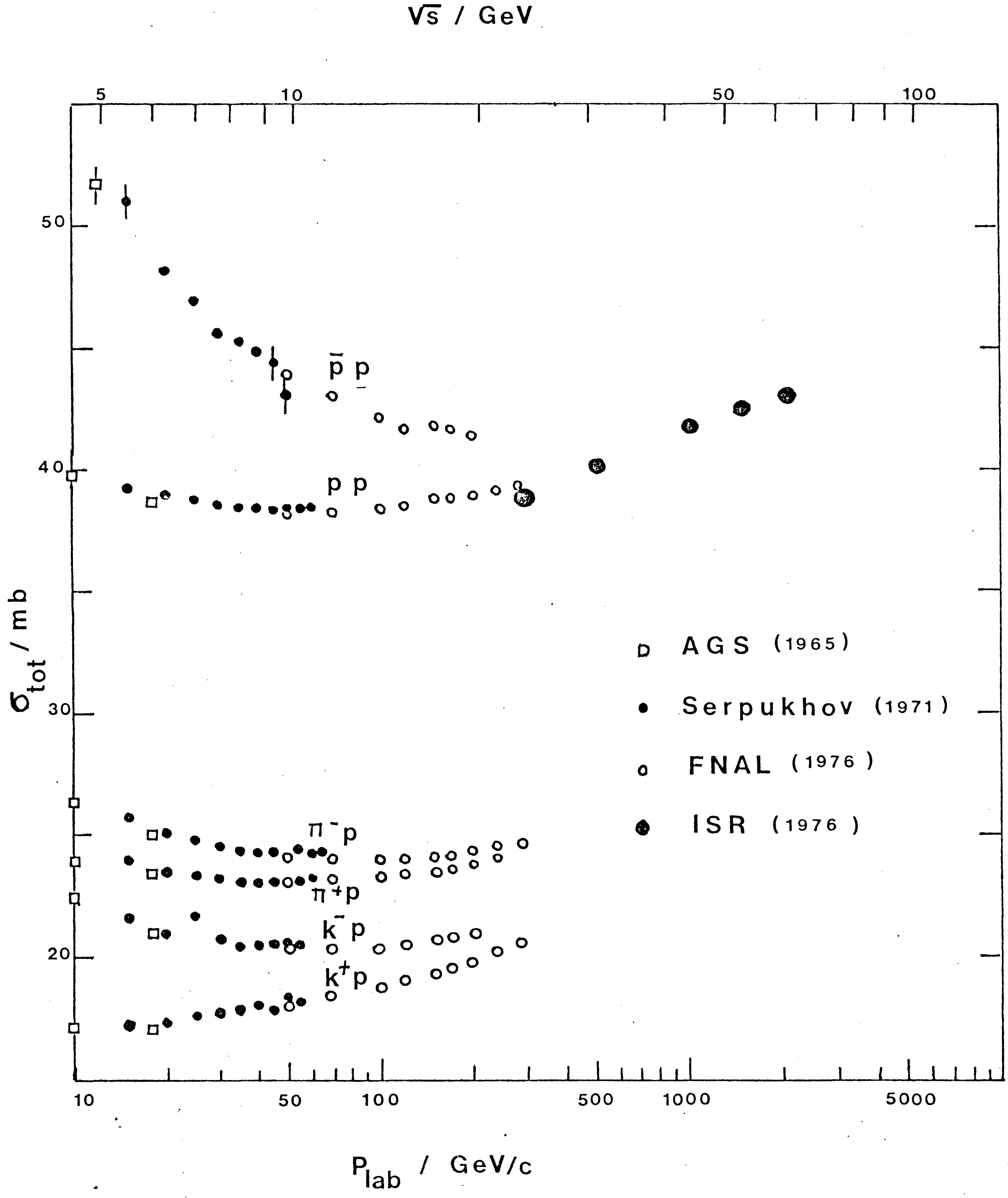
√s / GeV
5
10
50
100
50
40
30
20
σtot / mb
p̄ p
p p
π⁻p
π⁺p
k⁻p
k⁺p
AGS (1965)
Serpukhov (1971)
FNAL (1976)
ISR (1976)
10
50
100
500
1000
5000
Plab / GeV/c

fig 1

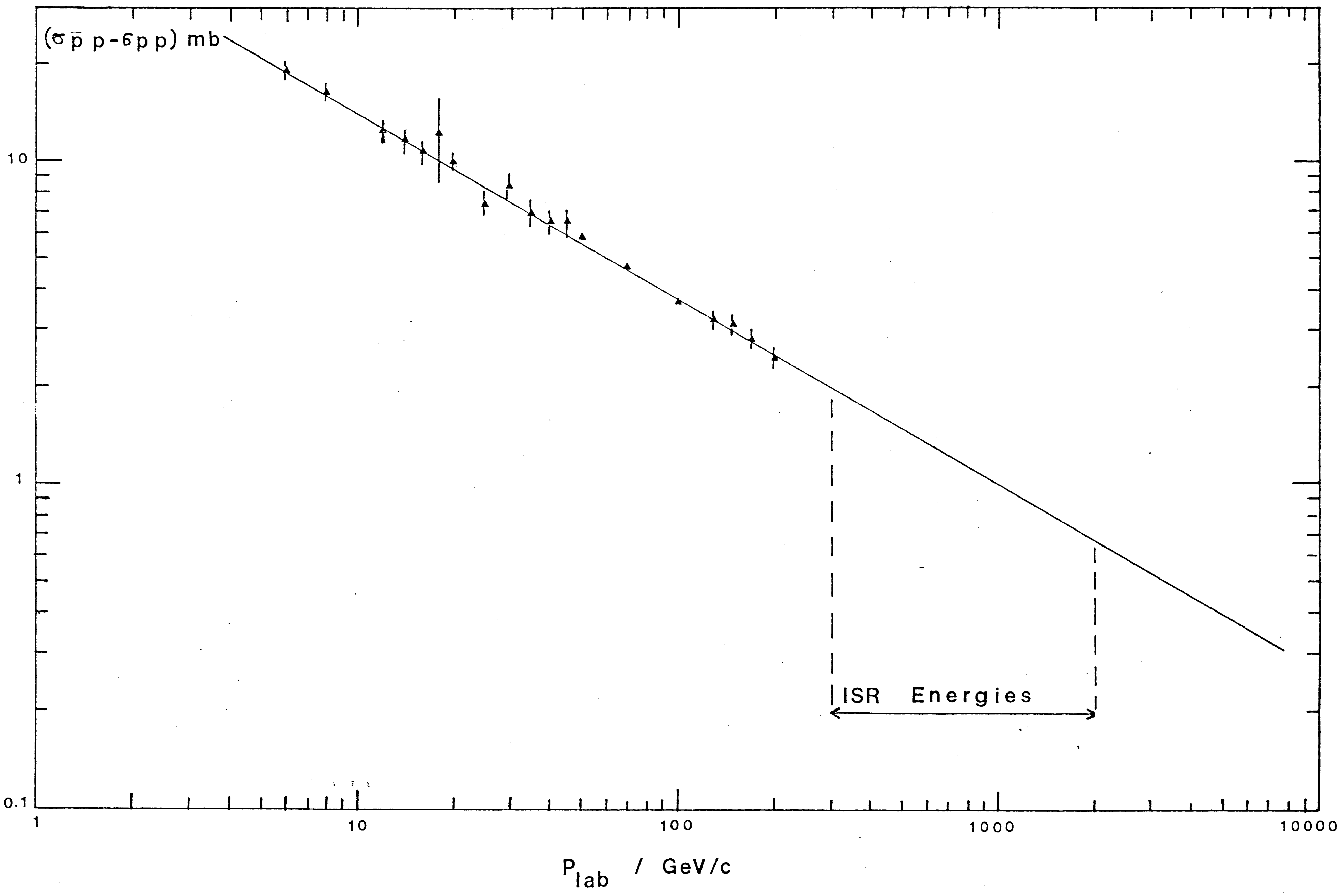

fig 2

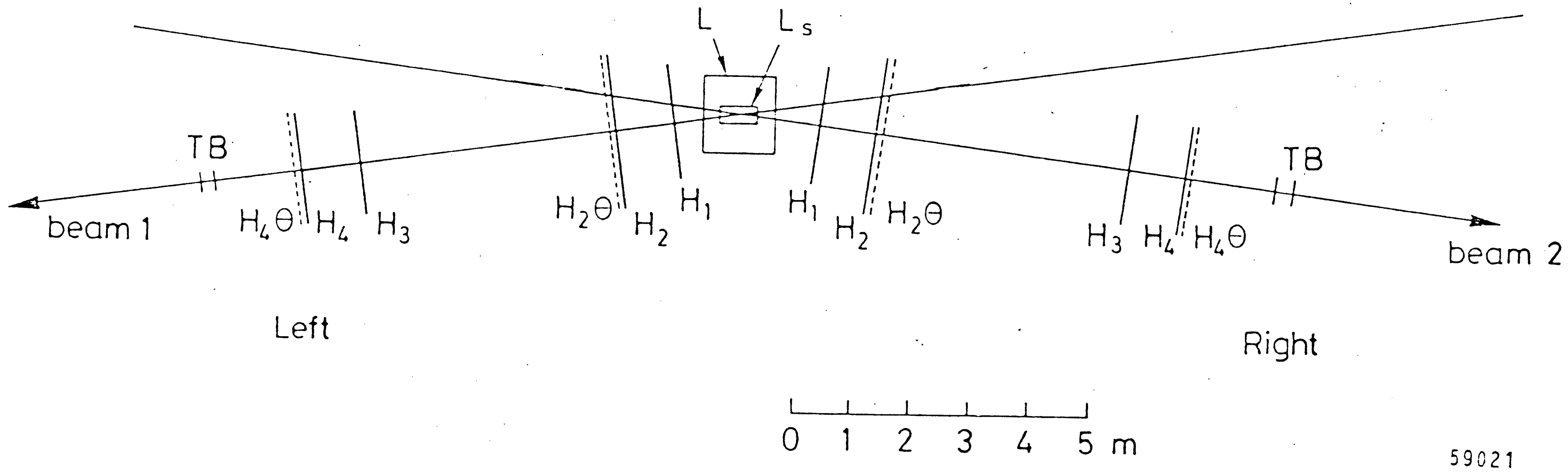
L
Ls
TB
TB
beam 1
beam 2
H4Θ
H4
H3
H2Θ
H2
H1
H1
H2
H2Θ
H3
H4
H4Θ
Left
Right
0 1 2 3 4 5 m
59021

Fig. **3**