# NOTE ON AREA FOR P-P EXPERIMENTS WITH INTERNAL TARGET

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August 11, 1967

One of the interesting experiments that might be done on the 200 GeV accelerator is proton proton elastic scattering at very high transverse momentum. This experiment gives the most sensitive measurement of what is (in some sense) the structure of strongly interacting material in the proton. Unfortunately the differential cross section becomes very small at high transverse momenta, making measurements very difficult. Recent experiments[1,2,3] have indicated that the cross section appears to go as

$$\frac{d\sigma}{dt} = 7\, e^{-1.51 P_\perp^2}\ \mu b/[GeV/c]^2$$

This leads to the expression

$$\left(\frac{d\sigma}{d\Omega}\right)_{cm} \approx T_o 10^{-.65 P_\perp^2}\ \mu b/sr$$

If this trend continues we will get the following cross sections at 50, 100 and 200 GeV.

| $T_o$(GeV) | 50 | | 100 | | 200 | |
|---|---|---|---|---|---|---|
| $P_\perp^2$(GeV/c)$^2$ | $\theta_{cm}$ | $\frac{d\sigma}{d\Omega})_{cm}$ | $\theta_{cm}$ | $\frac{d\sigma}{d\Omega})_{cm}$ | $\theta_{cm}$ | $\frac{d\sigma}{d\Omega})_{cm}$ |
| 10 | 39° | 1.5 $10^{-35}$ | 26° | 3 $10^{-35}$ | 18° | 6 $10^{-35}$ |
| 15 | 50° | $10^{-38}$ | 33° | 1.7 $10^{-38}$ | 22° | 3 $10^{-38}$ |
| 20 | 62° | 5 $10^{-42}$ | 39° | $10^{-41}$ | 26° | 2 $10^{-41}$ |
| 30 | -- | --- | 50° | 3 $10^{-48}$ | 33° | 6 $10^{-48}$ |

Of course it is possible that the cross section will break again in which case $d\sigma/d\Omega$ will be considerably larger for $P_\perp^2 = 15$, 20 and 30. It is unlikely that they will be smaller.

The counting rate for an elastic scattering experiment is given by

$$N(\text{events/hour}) = I_o(\rho N_o t) \frac{d\sigma}{d\Omega} \Delta\Omega$$

We choose $I_o$ the incident proton flux to be $I_o = 10^{13}$ protons/pulse x $10^3$ pulses/hour = 3 $10^{16}$ proton/hour. Avogadro's number is $N_o = 6\ 10^{23}$ and $\rho = .07$ is the density of liquid hydrogen, which is the best target for such low rate experiments. The c.m. solid angle $\Delta\Omega$ should be no more than $10^{-3}$ sr to insure rejection of inelastic events. The length of the target t should be no more than 30 cm to insure both good geometry and less than 10% rescattering of the scattered protons. Then we have

$$N(\text{events/hour}) = 3\ 10^{16}(.07 \times 6\ 10^{23} \times 30)\frac{d\sigma}{d\Omega})_{cm} \times 10^{-3}$$

If we set a lower limit of 1 event/hour as the lowest acceptable counting rate we obtain

$$\left[\frac{d\sigma}{d\Omega})_{cm}\right]_{min} \approx 2\ 10^{-38}$$

This cross section is about $10^2$ below the smallest cross sections that have presently been measured. As can be seen from the table this will allow measurements out to about $P_\perp^2 \approx 15(\text{GeV/c})^2$. The measurements would be likely to determine if another break exists in this cross section. At present there are few points beyond $P_\perp^2 = 9$ with reasonable errors. If $d\sigma/d\Omega$ does break then the measurements could be extended well beyond $P_\perp^2 = 15$. In 1000 hours of running ($\sim$ 2 months) about 10-15 points could be measured with errors from 5 $\rightarrow$ 10%.

The experiment described above could be done on the extracted proton beam. To extend the range of measurements further it would be necessary to run with an internal target. This would increase the counting rate by about a factor of 10 due to multiple traversals through a thin target; the beam keeps passing through the target until all the protons interact strongly. If this experiment were run for 1000 hours targeting 1-2 $10^{13}$ protons/pulse, then the set of 10% measurements could be extended down to $d\sigma/d\Omega \sim 10^{-39}$ $cm^2$/sr.

If the run were significantly shorter or of significantly lower intensity, then there would be no point in using the internal rather than external beam.

## Conclusion

I believe that a run of this length and intensity on an internal target would be unacceptable to the NAL administration because of the severe radiation problems involved. A run of significantly less intensity would offer no advantage over a run on the external beam. Consequently I would recommend that no specific provisions be made for experiments of this type on an internal target. Instead it should be insured that such experiments could be run on the external proton beam.

## References

1. G. Cocconi *et al.*, Phys. Rev. **138**, B165 (1963).
2. C. W. Akerlof *et al.*, Phys. Rev. Letters **17**, 1105 (1966);
   C. W. Akerlof *et al.*, Phys Rev. **159**, (1967).
3. J. V. Allaby *et al.*, CERN preprint NP 67-8 (1967).