Expression of Interest

Total Cross Section, Elastic Scattering and Diffraction Dissociation at LHC

2 March 1992

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We wish to express our interest to perform the following measurements at LHC.

Elastic Scattering. Elastic scattering events will be observed with high-resolution detectors placed inside "Roman pots" in an insertion having high-value of β, the betatron function at the crossing point. This technique was pioneered at the CERN ISR many years ago and then successfully employed at the $S\overline{p}pS$ Collider by experiment UA4 and at Fermilab by experiment E710. The extrapolation to the LHC from present Collider energies was already discussed in some detail in the LHC Workshops [1,2].

We plan to make use of a "mini" version of the standard "Roman pots" with scintillating fibers, silicon pixels or gaseous microstrips. These detectors have already sufficient spatial resolution. The choice will be imposed by the requirement of radiation hardness and operational reliability. One has in fact to keep in mind that the detectors for this experiment must be operated very close (distance of the order of 1 mm) to an intense proton beam.

The basic requirements on the high-β insertion were defined at the Aachen Workshop [2] and recently discussed at the Experimental Requirement Committee [3]. We expect that an insertion with $\beta = 1 \div 2\ km$ should be suitable to detect elastic scattering down to a momentum transfer squared $-t = 5.10^{-3} GeV^2$. A first study of a high-β insertion with $\beta = 750m$ was presented at the Aachen Workshop [4]. In order to measure elastic scattering in the Coulomb interference region, an insertion with higher β is needed. The β of the insertion should be tunable, the high-β mode allowing detection of low-t events with low

luminosity and the medium or low-β mode of large-t events with high luminosity.

Total Cross Section. The total cross section will be obtained with the so called luminosity independent method, i.e. by a simultaneous measurement of elastic scattering at low-t and of the rate of the inelastic interactions. With minimum momentum transfer of $5.10^{-3} GeV^2$, assuming a forward slope $b \approx 20 GeV^{-2}$, the extrapolation to the optical point will be of only 10%. As discussed in ref. 2, the measurement of the inelastic rate should be done with a vertex detector which observes charged tracks and reconstructs the interaction point. Extrapolating from UA4[5] and E710[6] to LHC, one finds that the coverage of the vertex detector should be at least three pseudorapidity units (from 6 to 9), corresponding to production angles in the range from 0.25 mrad up to about 6 mrad.

In practice the design of the detectors to measure the inelastic rate will follow the final design of the insertion itself.

The error on the measurement of σ_{tot} could be of $2-3\%$. Because the LHC beams cross each other at an angle, the feasibility of implementing the Van der Meer method to measure the luminosity as at the ISR, is worth studying. The measurement of σ_{tot} would be considerably simplified.

Diffraction Dissociation. We plan to study the process $pp \rightarrow pX$ by detecting the proton scattered quasi-elastically with the "Roman pots" and measuring the decay products of the system X in a vertex detector. The mass distribution of X will be measured together with the pseudorapidity distribution of its decay products.

Diffraction dissociation was extensively studied at the ISR and at the $S\overline{p}pS$ Collider by UA4 and UA8. It has a substantial cross section, $\sigma_{SD} \approx 0.2\ \sigma_{inel}$, but the basic mechanism and its connection with elastic scattering still remain rather obscure today.

Very Forward Particle Production. The centre-of-mass energy of the LHC is equivalent to $1.4 * 10^{17}\ eV$ incident $p-p$ interaction, which corresponds to the high energy tail of the cosmic ray spectra. The cosmic ray experiments are mostly sensitive to particles produced very forward. As shown by UA7 [7], the measurement in an accelerator experiment of the particles produced at $y \approx y_{beam}$, is useful to fix the energy scale for the cosmic ray experiments allowing a much better understanding of the production mechanism. In addition the amount of scaling violation in the rapidity distribution in the forward region can be measured. We then propose to install in the "Roman pots" at the LHC small calorimeters to measure particle production, in particular photons and electrons at very small angles.

References.

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