Threshold experiments of the COSY type at higher energies

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Recent results from measurements at IUCF, Bloomington [1, 2] and CELSIUS, Uppsala [3] have revealed that $pp \to pp\pi^0$–production has been described in a too simple framework [4, 5, 6]. Only when taking heavy meson exchange into account the theoretical predictions agree to the experimental situation in the threshold region [7, 8]. Similarly, investigations of threshold $pp \to pp\eta$–production reveal effects not considered before, this time due to strong η–nucleon final state interaction [9]. At COSY–Jülich measurements of the $s\bar{s}$–dissociation in threshold regions have just started, namely the $pp \to pK\Lambda$–reaction at TOF [10] and the $pp \to ppK\overline{K}$ and $pp \to pp\phi$–reactions at COSY-11 [11]. Here, new and unforeseen effects might occur also. Since strange quarks are not existing as valence quarks in the entrance channel, these production experiments isolate the pure $s\bar{s}$–dissociation process. Moreover, hyperon decay in the exit traces back to the polarization of the strange quark directly [12].

A simple analogy of arguments leads to the importance of and interest in charm production. The $c\bar{c}$–dissociation manifests in charm–anticharm meson pair or charmed meson–charmed baryon production. Due to the high mass of the charm quark, model calculations are easier since they can be performed in a non–relativistic approximation. There is no doubt that also hidden charm states can be precisely studied with cooled proton beams, without restrictions to 1^-–states. The two protons allow tagging of the charmonium mass, this together with the characteristic leptonic decay provides a clean sample.

Reaction	Threshold momentum	
$pp \to d\pi^{\pm}$	0.789	GeV/c
$pp \to pp\,\pi^0$	0.777	GeV/c
$pp \to pp\,\eta$	1.986	GeV/c
$pp \to p\Lambda K^+$	2.339	GeV/c
$pp \to pp\,K^+K^-$	3.302	GeV/c
$pp \to pp\,p\bar{p}$	6.501	GeV/c
$pp \to pp\,\Lambda\overline{\Lambda}$	7.999	GeV/c
$pp \to pp\,\Xi^-\overline{\Xi^-}$	9.901	GeV/c
$pp \to pp\,\Omega^-\overline{\Omega^-}$	13.558	GeV/c
$pp \to pp\,J/\Psi$	12.207	GeV/c
$pp \to p\Sigma_c D^0$	13.750	GeV/c
$pp \to pp\chi_{c2}$	14.760	GeV/c
$pp \to pp\,D^+D^-$	15.837	GeV/c

Table 1: Examples of threshold momenta

Another experimental topic which extends the quark–antiquark production not to higher quark masses but to higher complexity is the baryon–antibaryon production at threshold. The underlying $3q$–$3\bar{q}$–dissociation is a basic process in hadronic physics which opens a wide field of interesting experiments.

For instance, examining the $pp \to pp\,p\bar{p}$–reaction below the threshold of the $pp \to pp\,p\bar{p}\pi^0$–reaction provides an extremely clean sample, firstly because one can identify the antiproton by its annihilation signature, secondly due to the fact that all ejectiles stay at angles which are quite low in the laboratory system ($< 15^\circ$). This allows measurements using an installation like the TOF detector in its longest version or a setup similar to COSY-11.

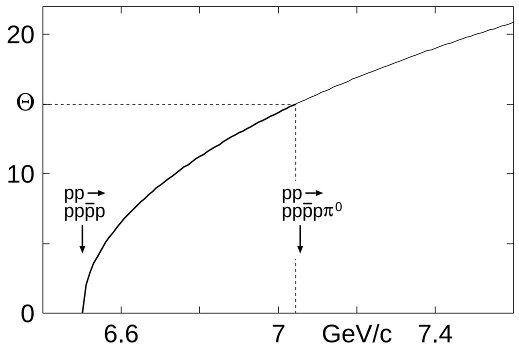

Figure 1: Maximum opening angle of the (anti)protons in $pp \to pp\,p\bar{p}$

At 7.05 GeV/c, i.e. just below the $pp \to pp\,p\bar{p}\pi^0$–threshold, the TOF setup would cover 100 % of the reaction. Monte Carlo calculations show that 99.86 % of the events would contain at least one baryon with $\beta < 0.88$ which would allow time-of-flight reconstruction leading to an overdetermined offline evaluation.

In the baryon–antibaryon production ($pp \to ppB\overline{B}$) it seems interesting to compare dissociation reactions with no ($p\bar{p}$), one ($\Lambda\overline{\Lambda}$), two ($\Xi\overline{\Xi}$), or even three ($\Omega^-\overline{\Omega^-}$) $s\bar{s}$–pairs. Especially the $Y\overline{Y}$–production provides easy access to polarization and spin correlation information like in our PS185 experiment at LEAR [12], where we study the same system in a different hadronic surrounding ($\bar{p}p \to \overline{\Lambda}\Lambda$). Extensions to higher energies were already considered there [13].

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