Study of the interaction of η and η' mesons with protons.

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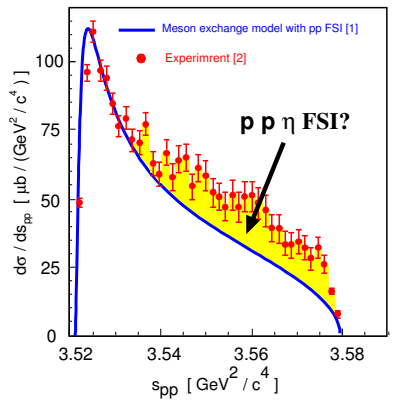
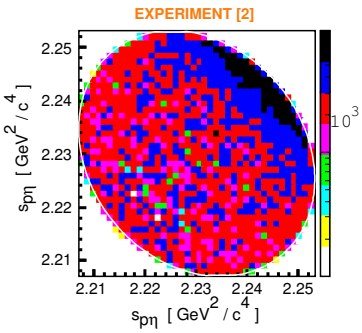
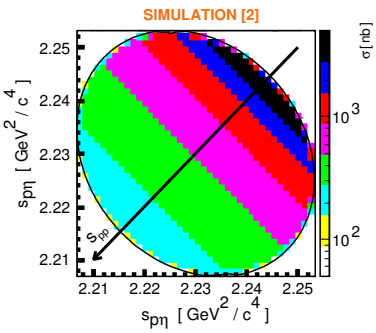
The interaction of hadrons - being the reflection of the strong force acting between their constituents - provides information about their structure and the strong interaction itself. Creation of mesons in the vicinity of nucleons with low relative velocities facilitates the study of meson-nucleon interactions. The best suited is the production close to threshold or in kinematical regions where the outgoing particles possess low relative velocities and hence remain in distance of few Fermi long enough to experience the hadronic interaction. The determined energy dependence of the total cross sections for η' and η mesons production in proton-proton collisions are presented in the figure on the rigth side. Comparing the data to the arbitrarily normalized phase space integrals (dashed lines) reveals that the ppη FSI enhances the total cross section by more than an order of magnitude for low excess energies. One recognizes also that in case of the η' meson the data are described very well (blue solid line) assuming that the on-shell proton-proton amplitude exclusively determines the phase space population. In the case of η meson production the interaction between nucleons is evidently not sufficient to describe the increase of the total cross section for very low and very high excess energies, as can be concluded from the comparison of the data and the upper blue line.The enhancement of the total cross section for higher energies can be assigned to the outset of higher partial waves, and the discrepancy visible closer to the threshold can be plausibly explained by the influence of the attractive interaction between the η meson and the proton.

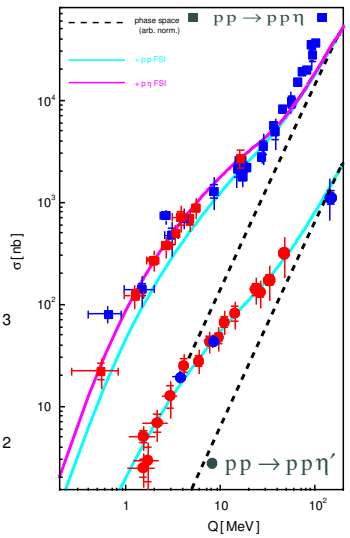


Experimentally determined background-free distribution of the square of the proton - proton (s_{pp}) invariant mass for the pp ->ppη reaction at an excess energy of Q = 15.5 MeV reveals an unexpectedly large signal from the ppη interaction.





The strenght of the interaction between particles depends on their relative momenta or equivalently on the invariant masses of the two-particle subsystem. Therefore it should show up as a modification of the phase space abundance in the kinematical regions where the outgoing particles possess small relative velocities. The above Dalitz plots show that the experimentally determined distribution remains rather homogeneous outside the region of the small proton-proton invariant masses, whereas the simulated abundance decreases gradually with growing proton-proton invariant mass (as indicated by the arrow). The increase of the population density at regions corresponding to the small pη relative momenta is better seen in the projection of the Dalitz plot onto the s_{pp} axis.



Total cross section for the reactions pp -> pp η' (circles) and pp -> pp η (squares) as a function of the centre-of-mass excess energy Q. Red points indicate the results of the COSY - 11 collaboration [3-6] and blue were determined at the SATURNE and CELSIUS laboratories [8-12].

A remarkable difference beteween the shape of the excitation functions of the pp -> ppη and pp -> ppη' reactions allowed to conclude that the interaction between the η' meson and the proton is significantly weaker than the analogous interaction between the η meson and the proton.

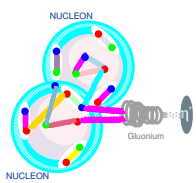
Isospin dependence of the η' meson production in nucleon - nucleon collisions: a window to study the reaction mechanism and the η' meson structure.

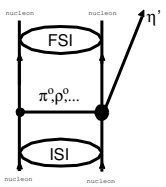
POSSIBLE STRUCTURE OF THE η' MESON

The most remarkable feature - in the frame of the quark model - distinguishing the η' meson from all other pseudscalar and vector ground state mesons, is the fact, that the η' is predominantly a flavour-singlet combination of quark-antiquark pairs and therefore can mix with purely gluonic states.

$$\eta' = \alpha \,|\text{quark-antiquark}\rangle + \beta \,|\text{gluons}\rangle$$

POSSIBLE MECHANISM OF THE REACTION

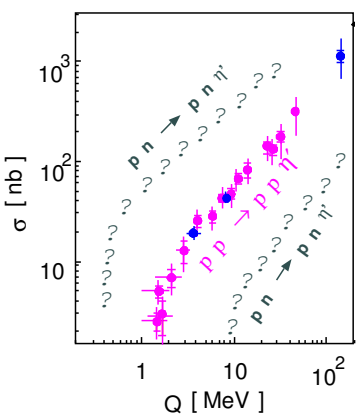




A comparison of the close-to-threshold total cross section for the η' meson production in both the pp -> pp η' and pn -> pn η' reaction constitutes a tool to investigate the η' meson structure and the reaction mechanism and may provide insight into the flavour-singlet (perhaps also into gluonium) content of the η' meson and the relevance of quark-gluon or hadronic degrees of freedom in the creaction process.

$$R \equiv \frac{\sigma(p\,n \dashrightarrow p\,n\,\eta')}{\sigma(p\,p \dashrightarrow p\,p\,\eta')} = ?$$

By the analogy to the η meson production - in case of the dominant isovector meson exchange we can expect that the ratio R should be about 6,5 [13]. If however η' meson is produced via its flavour - blind gluonium component from the colour - singlet glue excited in the interaction region the ratio should approach unity after corrections for the initial and final state interactions [14].



Excitation function for the pp -> pp η' reaction. Red points COSY-11 [3,4,6], blue pionts [11,12].

COSY-11 collaboration has so far determined the close-to-threshold excitation function for the pp -> pp η' reaction [3,6] whereas the total cross section for η' meson production in the proton-neutron interaction is still unknown. The analysis of such data taken at COSY -11 is in progress [7]

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