Beam-time request for COSY experiment #55
"Study of $a_0^+(980)$ mesons at ANKE"

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Abstract

We request two weeks of beam time for a simultaneous measurement of the reactions $\mathrm{pp} \to \mathrm{d}\,\mathrm{a}_0^+ \to \mathrm{d}\,\mathrm{K}^+\overline{\mathrm{K}}^0$ and $\mathrm{pp} \to \mathrm{d}\,\mathrm{a}_0^+ \to \mathrm{d}\,\pi^+\eta$ with ANKE at maximum COSY-beam energy of $T \approx 2.6$ GeV. The data will be used to determine the branching ratio $\mathrm{a}_0^+ \to \mathrm{K}^+\bar{\mathrm{K}}^0/\pi^+\eta$ which is not well known so far.

Contents

1 Introduction

This beam-time request is based on COSY proposal #55 [1] which was approved during the 14^{th} meeting of the COSY-PAC. The proposal foresees the measurement of the reaction $pp \to d\,a_0^+ \to d\,K^+\overline{K}^0$ at various beam energies between threshold ($T = 2.48$ GeV, $p = 3.29$ GeV/c) and the maximum achievable COSY energy ($T \approx 2.6$ GeV). The goal of the measurements is to determine the mass distribution of the $a_0^+(980)$ with high statistical accuracy as a function of T which should allow to draw conclusions about the nature of this resonance.

The measurements proposed here are a natural extension of the original proposal. The simultaneous measurement of the two decay channels $a_0^+ \to K^+\bar{K}^0/\pi^+\eta$ seems to be suitable to shed light on the nature of the a_0^+ resonance. It is shown that the measurements can be performed within two weeks of beam time with the cluster-jet target which has been installed and successfully put into operation at ANKE in summer of 1999. Furthermore, the data on the a_0^+-production cross section obtained during this first beam time at maximum COSY energy will allow to determine the total beam time needed to perform the full measurements closer to threshold described in the original proposal.

This beam-time request updates the theoretical and simulation calculations of the original proposal and gives rate estimates on the $a_0^+ \to \pi^+\eta$ channel which has not been considered before. It is shown that also for this reaction channel the background can be sufficiently suppressed.

2 Physics case

The scalar meson sector plays a very important role in the physics of hadrons. Nevertheless, the structure of the lightest scalar mesons $a_0(980)$ and $f_0(980)$ is not understood yet and is one of the most important topics of hadronic physics (see e.g. [2, 3, 4, 5, 6, 7] and references therein). It has been discussed that they could be either "Unitarized $q\overline{q}$ states", "Four-quark cryptoexotic states", $K\overline{K}$ molecules or vacuum scalars (Gribov's minions) (see e.g. [6]). Nowadays theory gives some preference to the Unitarized Quark Model (UQM), proposed by Tornqvist [8] (see e.g. [6, 7]). However, other options cannot be ruled out completely. Moreover, there is a strong mixing between the uncharged $a_0(980)$ and the $f_0(980)$ due to coupling to $K\overline{K}$ intermediate states [9]. Therefore, it is of particular interest to study the charged components of the $a_0(980)$ which are not mixed with the $f_0(980)$ and preserve their original quark content.

Until now the charged components of the $a_0(980)$ were studied mainly in the $\eta\pi^+$ or $\eta\pi^-$ channels [10]. Recent experimental data from the E852 Collaboration at BNL yield for the charged a_0^+ meson a mass of (998.3 ± 4.0) MeV/c^2 and a width of (72 ± 10) MeV/c^2[11]. Note that the mass of the a_0 reported by the E852 Collaboration is significantly larger than the average value of 983.4 ± 0.9 MeV/c^2 quoted by the particle data group (PDG) [10].

The Branching Ratios (BR's) into the two main a_0 decay channels $\eta\pi$ and $K\overline{K}$ are still unclear: the $\eta\pi$ mode is quoted by the PDG [10] as "dominant" and the $K\bar{K}$ mode as "seen". The data from only two experiments [12, 13], where decay of the $a_0(980)$ into $K\overline{K}$ was observed, are used for the PDG analysis. The authors of [13] report a ratio of branching ratios

$$B(\bar{p}p \to a_0\pi; a_0 \to K\bar{K})/B(\bar{p}p \to a_0\pi; a_0 \to \pi\eta) = 0.23 \pm 0.05 \; . \tag{1}$$

However, the second branching ratio which they took from [14] may have a large systematic uncertainty stemming from a strong interference of the a_0 signal with a broad resonance $a_0(1450)$, which has a width of about 265 MeV. As a result the $a_0(980)$ distribution in the reaction $p\overline{p} \to \eta\pi^0\pi^0$ appeared to be distorted. Moreover, the invariant-mass resolution in [13, 14] is only ~ 27 MeV/c^2. Therefore, it is necessary to measure the relative fraction of the two main a_0 decay channels $\eta\pi$ and $K\overline{K}$ with high mass resolution $\Delta m < 10$ MeV/c^2 and lower background in an independent experiment (see also discussion in Sect.3.1). An important dynamical feature of this experiment at COSY is that the $a_0(980)$ will be produced not far from its threshold, thus the $a_0(980)$ signal will not be contaminated by the tails from higher resonances.

The comparison of the yields from both decay channels will be used for the determination of the relative BR's into $\eta\pi$ and $K\overline{K}$. This value as well as the width of the $a_0(980)$ in both decay channels will be important for further tests of the existing a_0 models, see Sect.3.1.

It should be noted that the a_0^+-production cross section in pp collisions at near-threshold energies is basically unknown. The model calculations presented in Sect.3.2 therefore may have substantial uncertainties. Thus, the determination of the production cross section alone already is an interesting task. This quantity is also sensitive to the nature of the $a_0(980)$ and will be a "by-product" of the measurements proposed here.

3 Theoretical considerations

3.1 Models and existing data on the strengths of the $\mathrm{K\overline{K}}$ and $\pi\eta$ decay channels

Within the framework of a coupled channel formalism the $\mathrm{a}_0(980)$ can be considered as a normal $\mathrm{q\overline{q}}$ resonance with a large admixture of $\mathrm{K\overline{K}}$ and $\eta\pi$ continuum

$$|\mathrm{a}_0\rangle = C_{\mathrm{q\overline{q}}}|\mathrm{q\overline{q}}\rangle + C_{\mathrm{K\overline{K}}}|\mathrm{K\overline{K}}\rangle + C_{\eta\pi}|\eta\pi\rangle \ . \tag{2}$$

Then an appropriate parametrization of the shape of the $\mathrm{a}_0(980)$ in each ($\eta\pi$ or $\mathrm{K\overline{K}}$) channel can be made in the form proposed by Flatté [15]:

$$|A_i|^2 = const. \cdot \frac{|\Gamma_i(M)|\ M_{\mathrm{r}}^2}{(M^2 - M_{\mathrm{r}}^2)^2 + M_{\mathrm{r}}^2|\Gamma_{\mathrm{tot}}^2(M)|} \tag{3}$$

where $\Gamma_{\mathrm{tot}}(M) = \Gamma_1(M) + \Gamma_2(M) = g_1\rho_1 + g_2\rho_2$; g_1 and g_2 are the coupling constants to the two final states and ρ_i can be expressed through the momenta of the final particles $\rho_i = 2q_i/M$; M_{r} is the K-matrix pole. Molecular or "threshold cusp" cases would imply a dominance of the $|\mathrm{K\overline{K}}\rangle$ component and, therefore, would correspond to a relatively large ratio $R = (g_2/g_1) \gg 1$. In the following table we present the most recent results for the $\mathrm{a}_0(980)$ parameters.

Reaction	R	M_{r} [GeV]	g_1 [GeV]
$\mathrm{p\overline{p}} \to \eta\pi^0\pi^0,\ \eta\eta\pi^0$ [16] $^{i)}$	1.05÷2.05	1.013÷1.058	0.241÷0.287
$\mathrm{p\overline{p}} \to \eta\pi^0\pi^0,\ \eta\eta\pi^0$ [16] $^{ii)}$	1.05÷1.45	1.004÷1.024	0.229÷0.312
$\mathrm{p\overline{p}} \to \eta\pi^0\pi^0,\ \eta\eta\pi^0$ [16] $^{iii)}$	1.12÷1.37	0.999÷1.006	0.211÷0.275
$\mathrm{p\overline{p}} \to \eta\pi^0\pi^0$ [14] $^{iv)}$	1.15 ± 0.10	0.999 ± 0.006	0.218 ± 0.020
$\mathrm{p\overline{p}} \to \mathrm{K_L K^\pm}\pi^\mp$ [13] $^{v)}$	1.03 ± 0.4	0.999 ± 0.002	0.324 ± 0.015
$\pi^-\mathrm{p} \to \mathrm{n}\eta\pi^-\pi^+,\ \mathrm{n}\eta\pi^0$ [11] $^{vi)}$	0.91 ± 0.10	1.001÷0.0019	0.122 ± 0.008

$^{i)}$ without any external constraint
$^{ii)}$ with constraint on $|A_i|^2$ at half-height from the reaction $\mathrm{p\overline{p}} \to \eta\omega\pi^0$
$^{iii)}$ with constraint on $|A_i|^2$ at half-height from the reaction $\mathrm{p\overline{p}} \to \eta\omega\pi^0$ and contribution from a hypothetical $\mathrm{a}_2'(1620)$
$^{iv)}$ solution B with constraint on the a_0 mass from the reaction $\mathrm{p\overline{p}} \to \eta\omega\pi^0$
$^{v)}$ with constraint that the ratio of integrated intensities in $\mathrm{K\overline{K}}$ and $\eta\pi$ channels is given by Eq.(1)
$^{vi)}$ the authors of [11] present the value $g_{\pi\eta} = 0.243 \pm 0.015$ which is related to g_1 by $g_{\pi\eta} = (2/M)\, g_1$

In [16] it was shown that if the fit of the $\eta\pi$-mass distribution is made without any additional constraint, the parameters M_{r}, R and g_1 cannot be determined very well. They are strongly correlated and if one of them is varied in steps, χ^2 changes rather slowly but M_{r}, R and g_1 move together. That is why additional constraints are used in most fits.

In [11] also a Breit-Wigner (BW) fit of the $\mathrm{a}_0(980)$ shape in the $\eta\pi$ channel was done. The mass and width of a_0^+ were determined to be (996.4 ± 1.6) and (62 ± 6) MeV/c^2, respectively. The two determinations of the a_0 mass and width (BW and Flatté) were found to be statistically consistent. As in a Breit-Wigner parametrization only two parameters enter, it is not sensitive at all to the value of R. Thus for a reliable determination of R the measurement of both channels is necessary.

Two zero's of the function $D(M) = M^2 - M_r^2 + iM_r(g_1\rho_1(M) + g_2\rho_2(M))$ define two T-matrix poles on sheet II and III. The position of the T-matrix pole in sheet II defines the mass m_0 and width Γ_0 of $a_0(980)$; m_0 is usually different from M_r. According to PDG [10] the average value of the measured $a_0(980)$ masses is equal to 983.4 ± 0.9 MeV/c^2 for the $\eta\pi$ final state (calculated without the new result of E852 [11]) and 980.8 ± 2.7 MeV/c^2 for the $K\overline{K}$ final state. The width of $a_0(980)$ is equal to 92 ± 8 MeV in the $K\overline{K}$ final state [13] and to 72 ± 10 MeV in the $\eta\pi$ final state [11]. In view of those differences it looks also important to perform new measurements of the $a_0(980)$ mass distribution in both decay channels at ANKE, where, as we already mentioned above, we expect better resolution and lower background.

The values of R presented in the table above are not favourable to a pure molecular or pure "threshold cusp" interpretation. Nevertheless, there still is a comparatively large uncertainty in g_1 and g_2: the values of g_1 can vary from 0.12 to 0.32 GeV and R can be between 0.9 and 2.05. A more precise knowledge of g_1 and g_2 would help us to better understand the $a_0(980)$ internal structure. For example, this information can be used to determine the relative weights of the different components in the state vector of $a_0(980)$ defined by Eq.(2).

3.2 Calculation of the a_0^+-production cross section

The missing mass spectrum of deuterons from the reaction $pp \to d\,X^+$ produced at 0° and incident momenta of 3.8, 4.5 and 6.3 GeV/c has been measured at Lawrence Radiation Laboratory (Berkeley) [17]. Apart from peaks corresponding to π^+ and ρ^+ production, there is a distinctive structure in the missing mass spectrum at 0.95 GeV^2 which was identified with a_0^+ production. The corresponding differential cross section for the forward a_0^+ production is shown by the open circles in Fig.1.

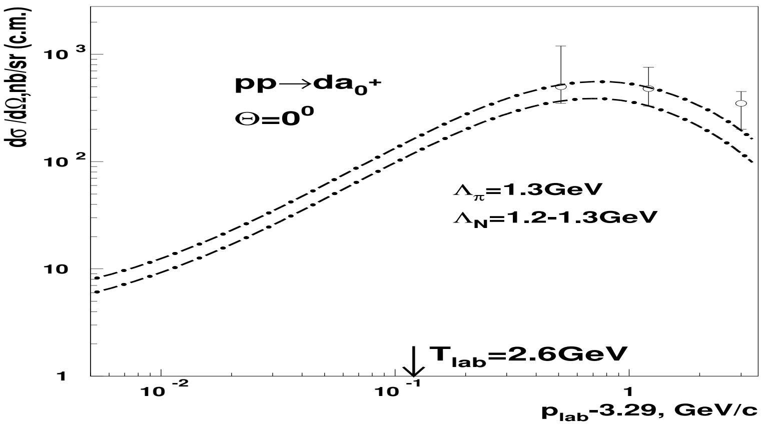

Figure 1: Forward differential cross section of the reaction $pp \to da_0^+$ as a function of $(p_{\rm lab} - 3.29)$ GeV/c. The empty circles are the experimental data from [17]. The two dashed-dotted curves describe the results of the TSM calculations at $\Lambda_N = 1.2$ and 1.3 GeV/c.

In order to estimate the cross section of the reaction $pp \to da_0^+$ at lower momenta which are available at COSY we use the two-step model (TSM) described by a triangle diagram [18]. We took into account three different contributions: i) a_0 coupling to two nucleons through $f_1(1285)$ and π-meson exchanges; ii) similar a_0 coupling through η- and π-meson exchanges; iii) production of a_0 through π exchange with an s- and u-channel nucleon current. The coupling constants and cut-off parameters Λ_i for π- and η-meson exchanges were taken from the Bonn-potential model. In the case of the a_0 and $f_1(1285)$ mesons we used the results from [19, 20]. The cut-off for nucleon exchange was considered as a free parameter within the interval 1.2–1.3 GeV. It appeared that mechanisms i) and ii) can be neglected and that the dominant contribution stems from the nucleon u-channel exchange. The results of our calculations for the forward differential cross section at various beam energies are presented in Fig.1. The two dashed-dotted curves describe the results of the TSM calculations at different values of the nucleon cut-off parameter: $\Lambda_N = 1.2$ and 1.3 GeV/c. Rather good description of the existing data has been reached for $\Lambda_N = 1.3$ GeV/c.

The angular dependence of the differential cross section of the reaction $pp \to da_0^+$ as a function of the c.m. angle $\Theta_{c.m.}$ can be parametrized as

$$\frac{d\sigma}{d\Omega_{c.m.}} = A + B \cdot \cos^2\Theta_{c.m.} + C \cdot \cos^4\Theta_{c.m.} \,. \tag{4}$$

The results of our calculations on the total a_0^+-production cross section for the reaction $pp \to da_0^+$ are presented in the following table:

T [GeV]	A [nb/sr]	B [nb/sr]	C [nb/sr]	σ_{tot} [nb]
2.52	21.3	15.3	−2.1	330
2.60	68	76	−22	1120
2.62	78	97	−31	1310

Note that an understanding of the $a_0^+(980)$-production mechanism may also yield information on its internal structure. For example, the WA57 collaboration measured inclusive photoproduction of $a_0^\pm(980)$ at photon energies 25–55 GeV [21]. It was found that the cross section of this process is relatively large with a value of $\sim 1/6$ of the cross sections for corresponding non-diffractive production of leading ρ^0, ω, ρ^+ and ρ^-. The authors interpreted this relatively strong production of the $a_0^\pm(980)$ as evidence that it is a $q\overline{q}$ state rather than $qq\overline{q}\overline{q}$. This argument can also be used in our case. In fact, in the LBL experiment [17] the measured values of $d\sigma/d\Omega$ for the reaction $pp \to da_0^+(980)$ are $\sim (1/4 \div 1/6)$ of the cross section for ρ^+ production:

	$d\sigma/d\Omega$ [μb/sr]	
p [GeV/c]	$pp \to d\rho^+$	$pp \to da_0^+$
3.8	3.2±0.5	$0.5^{+0.7}_{-0.15}$
4.5	2.0±0.4	$0.48^{+0.28}_{-0.15}$
6.3	0.5±0.5	$0.35^{+0.10}_{-0.15}$

If measurements made at ANKE will confirm a comparatively large value of the $a_0^+(980)$-production cross section presented in this section then this will be a good evidence that the $a_0^+(980)$ has an essential $q\overline{q}$ admixture.

4 Results of simulation calculations

4.1 Detection scheme

Figure 2 shows the trajectories of deuterons detected in coincidence with K^+ or π^+ mesons from the reaction $pp \to da_0^+$. It can be seen that the fast ($p \approx 2$ GeV/c) deuterons in both cases are detected in the forward detection system. Deuteron identification — mainly against fast protons, $p_p > 1.5$ GeV/c — is based on the measurement of time-of-flight (TOF) and energy losses. In addition the use of special inclined Čerenkov counters based on the principle of total reflection is foreseen [1, 22]. The kaons are detected and identified in the side telescopes whereas pions (which have slightly higher momenta) mainly hit the side-wall counters between the telescopes and the forward system. It has already been shown in the proposal [1] that for the case of the $a_0^+ \to K^+\overline{K}^0$ channel a sufficient background suppression can be achieved (see also [23] for the measured performance of the K^+ detectors). Therefore, in Sect.4.3 we focus on the $a_0^+ \to \pi^+\eta$ case.

The mass distribution of the a_0^+ mesons can be deduced as the missing mass of the deuterons detected with the forward counters, $m(a_0^+) = m.m.(pp, d)$. The momentum resolution for the deuterons is $\Delta p/p \approx 1.5\%$ leading to a mass resolution of $\Delta m \approx 7$ MeV/c^2 [1, 22] which is small in comparison with the natural width of the a_0^+ of 72 MeV/c^2 [11].

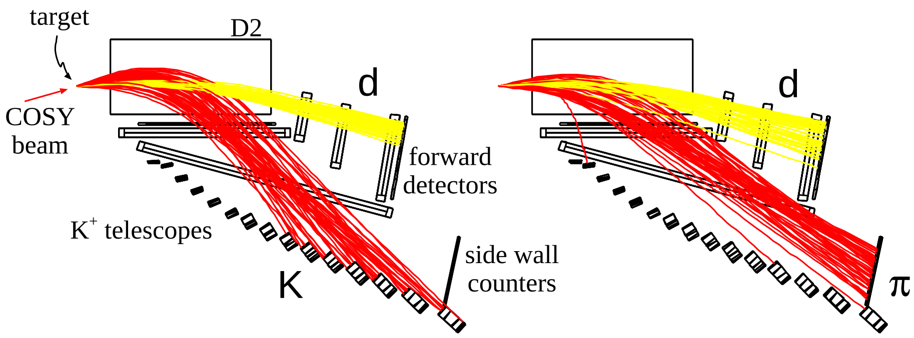

Figure 2: Ejectile trajectories in ANKE for the two decay branches $a_0^+ \to K^+\bar{K}^0/\pi^+\eta$. For the simulations a beam energy of $T = 2.62$ GeV and a field strength in D2 of $B = 1.57$ T was assumed. In the figure the field region of D2 is indicated as a rectangular box.

It is of great advantage that both decay channels can be measured simultaneously at ANKE. This allows to deduce from the measured d-K^+ and d-π^+ rates the ratio of the BR's avoiding systematical uncertainties e.g. from luminosity monitoring. The different detection efficiencies can be deduced from simulation calculations as presented here and from calibration measurements on the K^+-detection efficiencies in the telescopes [23].

4.2 Count-rate estimate

For the count-rate estimates of the two decay channels we *assume* a branching ratio of $\mathrm{BR}(a_0^+ \to K^+\bar{K}^0) = 12\%$ and $\mathrm{BR}(a_0^+ \to \pi^+\eta) = 88\%$. This value has been obtained by using the branching ratio from [13] and applying the phace-space corrections for $T = 2.6$ GeV where only a_0's with masses below 1022 MeV/c^2 can be produced[1]. With the cluster-jet target luminosities up to $L \approx 3\cdot 10^{30}$ cm^{-2}s^{-1} are achievable. From the simulation calculations geometrical detection efficiencies of $\varepsilon_{\mathrm{geo}} = 12\%$ (0.15%) for the detection of d-K^+ (d-π^+) pairs are deduced. About 70% of the kaons decay in flight between the target and the detectors whereas more than 90% of the pions reach the corresponding counters. For the detection efficiencies for kaons (pions, deuterons) in the telescopes (side-wall counters, forward detectors) we assume $\varepsilon_{\mathrm{det}} = 30\%$ (90%, 90%) which is in line with recent measurements. Thus the following count rates can be expected for d-K^+ coincidences:

$$
\begin{aligned}
\dot{n}_{\mathrm{dK^+}} &= L \cdot \varepsilon_{\mathrm{geo}} \cdot \varepsilon_{\mathrm{decay}} \cdot \varepsilon_{\mathrm{det}} \cdot \sigma \cdot \mathrm{BR} \\
&\approx 3 \cdot 10^{30}\ \mathrm{cm^{-2}s^{-1}} \cdot 0.12 \cdot 0.3 \cdot (0.3 \cdot 0.9) \cdot 1.12\ \mu\mathrm{b} \cdot 0.12 \\
&\approx 14\ \mathrm{h^{-1}}\ , \qquad (5)
\end{aligned}
$$

and for d-π^+ coincidences:

$$
\begin{aligned}
\dot{n}_{\mathrm{d\pi^+}} &= L \cdot \varepsilon_{\mathrm{geo}} \cdot \varepsilon_{\mathrm{decay}} \cdot \varepsilon_{\mathrm{det}} \cdot \sigma \cdot \mathrm{BR} \\
&\approx 3 \cdot 10^{30}\ \mathrm{cm^{-2}s^{-1}} \cdot 0.0015 \cdot 0.9 \cdot (0.9 \cdot 0.9) \cdot 1.12\ \mu\mathrm{b} \cdot 0.88 \\
&\approx 12\ \mathrm{h^{-1}}\ . \qquad (6)
\end{aligned}
$$

Thus, it is concluded that within one week of beam time more than 1000 events can be collected for each decay channel allowing to determine the branching ratio with high statistical accuracy and to distinguish between the predictions from different models given in Sect.3.1.

4.3 Background suppression

Three major sources of background have to be considered here:

$pp \to dX$ In this case, a fast deuteron is detected and correctly identified in the forward counters. In coincidence a K^+ or a π^+ meson not stemming from resonant production via the a_0^+ is detected in the telescopes or side-wall detectors, respectively. For the case of $pp \to dK^+X$ (and also $pp \to pK^+X$) it has already been shown in [1] that the background can be sufficiently reduced. In case of pion production our calculations show that the most dangerous background contribution stems from ρ^+ production, $pp \to d\rho^+ \to d\pi^+\pi^0$. Figure 3 shows a missing mass analysis for this reaction channel in comparison with a_0^+ production. It can be seen that due to the high mass resolution achievable at ANKE there is a clear separation between signal and background even if one takes into account the much larger cross section for ρ^+ production. For comparison, in the figure we also show the events where the a_0^+ decays into kaons. It

[1] In [11] a mass of 998.3 MeV/c^2 was found for the charged a_0 mesons which is significantly larger than the value of 983.4 MeV/c^2 quoted by PDG [10]. If this value is correct a larger fraction of the a_0^+ mesons can decay into $K^+\bar{K}^0$

can nicely be seen that only events above the $K\overline{K}$ threshold are detected. Thus the measurements will also give the oportunity to — for the first time — simultaneously observe the a_0^+-mass distribution in both decay channels.

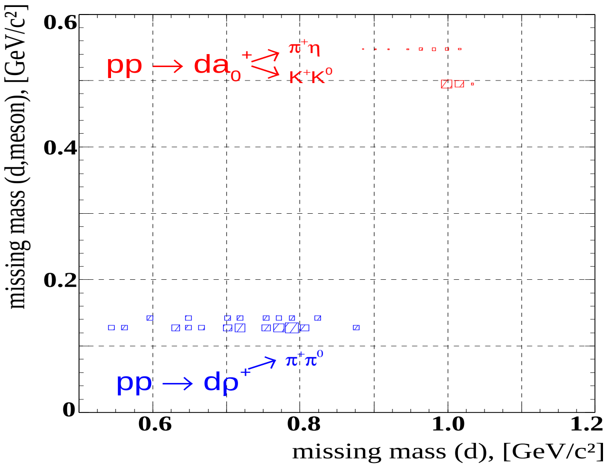

Figure 3: Missing mass distributions for a_0^+'s and for the background reaction $pp \to d\rho^+ \to d\pi^+\pi^0$. In the simulation the different production cross sections were taken into account, the box sizes represent the counting rates in a linear scale.

$pp \to p\pi^+X$ The background which demands the most thorough treatment during data analysis will be due to misidentification of fast protons as deuterons in the forward detectors. Figure 4 a) shows the detection time in the forward counters (deduced in an off-line analysis from the detection time for the coincident π^+ and the forward ejectile) vs. the deuteron or proton momentum (measured with the forward MWPC's). It is seen that for low momenta there is a good separation of the background, however, for $p > 2$ GeV/c the time differences get rather small. Taking into account the time resolutions of the scintillation counters and the much larger cross section for background production it can be deduced from the simulation calculations that in the high momentum region an additional background-reduction factor of ~ 10 is needed. One possibility for further background reduction is a missing mass analysis analogous to Fig.3 which is shown in Fig.4 b). It is seen that the a_0^+ events are concentrated around $m.m.(\mathrm{d, meson}) = m(\eta) = 547$ MeV/c^2 whereas the background from misidentified protons is spread out to different masses. It is expected that such a missing mass analysis will further suppress the background by roughly one order of magnitude. Further suppression by another order of magnitude will be supplied by the measurement of energy losses and with the use of inclined Čerenkov counters in the forward detection system. The latter are expected to yield a fast proton-to-deuteron suppression by at least one order of magnitude, see also [1, 22]. We conclude that background from proton misidentification can sufficiently be suppressed. Note that in our simulation calculations one- and multi-pion production were taken into account.

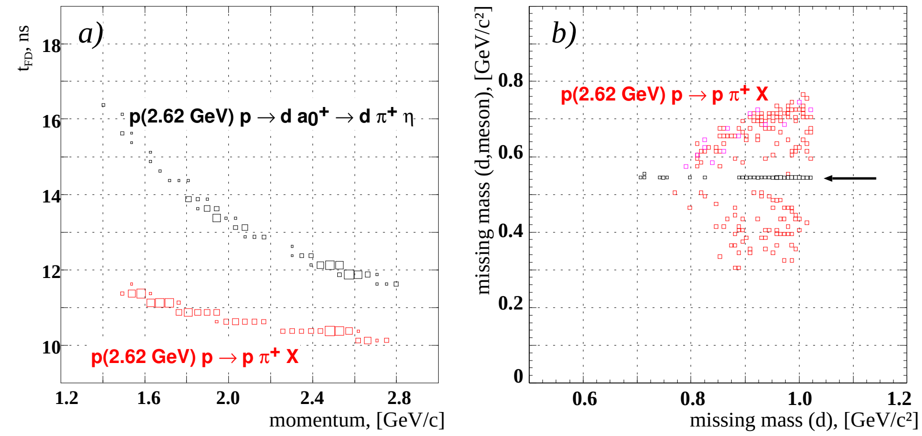

Figure 4: Detection time in the forward scintillators vs. ejectile momenta (left figure). The box sizes do *not* represent the realistic counting rates. Missing-mass distributions for the background reaction pp $\rightarrow$ pπ^+X where the proton is misidentified as a deuteron in the forward detection system. The position of 'real' a_0^+ events is indicated by the arrow (right figure).

Scattered background from the pole shoes of D2 and the vacuum chambers. According to our experience this background can very efficiently be suppressed using the wire-chamber information, even in cases of nuclear targets and subthreshold meson production where the background-to-signal ratio is much worse than in our case [23].

4.4 Data on the production of mesons other than a_0^+

It should be noted here that the data obtained from pp collisions at $T \approx 2.6$ GeV during two weeks of beam time will not only yield information on the a_0^+ meson but also on other reaction channels. Corresponding data analyses are foreseen. As example we quote following channels:

- **pp $\rightarrow$ dρ^+** In Fig.3 of Sect.4.3 this reaction channel is shown as possible background for a_0^+ production. According to our simulation calculations, the counting rate for this channel will be $\dot{n} \approx 30$ h^{-1}.

- **pp $\rightarrow$ ppϕ $\rightarrow$ ppK$^+$K$^-$** At ANKE all 4 outgoing particles can be detected and identified if appropriate detectors for negatively charged particles are placed in the return yoke of D2. Such a detection system is currently under construction. At the time of the proposed measurements prototype counters will be installed for testing purposes. Thus the data will allow tests of these detectors and development of the corresponding data-analysis software. A proposal for K$^+$K$^-$ production in pA collisions [24] for which the detectors will be used later has already been approved during an earlier meeting of the COSY-PAC.

5 Requested time for measurements

Summarizing, we apply for the following amount of beam time:

- **Two weeks** for the measurement of the branching ratio $a_0^+ \to K^+\bar{K}^0/\pi^+\eta$ using the cluster-jet target. Prefered time is November/December 2000 since then the tuning and test measurements of the ANKE forward-detection system will be finished. In order to minimize time losses due to setting up the spectrometer and the detection systems, the beam time should be a common 4 weeks block together with the measurements on deuteron breakup, see beam-time request to proposal #20 [22] presented during this PAC meeting. The two weeks of beam time include four days for the following preparatory tasks: two days of beam development including stochastic cooling at maximum COSY energy ($T \approx 2.6$ GeV) and beam intensity; one day of test measurements to optimize background conditions at ANKE (in particular in the forward counters), to adjust the degraders in the K^+ telescopes to the field strength in D2 of $B = 1.57$ T [2] and to optimize the DAQ electronics for K^+-d and π^+-d coincidence measurements; one day for the installation of the target-near semiconductor counters and for pumping of the target region.

- In a later stage of the proposed studies (see approved COSY proposal #55 [1]) it is planned to systematically study the a_0^+ production at various beam energies between threshold and the maximum COSY energy. Note that due to the lower cross sections closer to threshold these measurements will require the use of the frozen-pellet target which will offer 1–2 orders of magnitude higher luminosities. This target will be available not earlier than middle of 2001. The **estimated** beam time for these measurements is **2–3 weeks**. The actual time needed can only be estimated after the analysis of the data obtained during the beam time requested here. In this sense these measurements can be regarded as test measurements for a systematic study of the mass distribution of the a_0^+ meson.

[2] The procedure of degrader optimization is already well established since it has been developed and used for the subthreshold K^+ studies at $B = 1.30$ T. In order to keep the time needed for the optimization as short as possible a Cu-foil target will be used which provides much higher counting rates. Only after this optimization semiconductor counters for luminosity monitoring can be mounted close to the target region.

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