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Proposal

A search for centrally produced non-$q\overline{q}$ mesons in proton proton interactions at 450 GeV/c using the CERN Ω Spectrometer and GAMS-4000

(Extension of the WA91 and NA12/2 experiments)

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Abstract

During the last decade evidence for non-$q\overline{q}$ mesons has grown due to experiments having high statistics in various decay modes. However there are still many channels which have promising signals but any definite conclusion is limited by the available statistics. In order to make a significant contribution to this field we propose to perform two 100 day runs combining the efficient multiphoton detection of GAMS-4000 with the good charged particle detection of the Omega Spectrometer to search for other non-$q\overline{q}$ mesons in the reaction $pp \rightarrow p_f X^0 p_s$ at 450 GeV/c. Although many final states will be studied those decaying to $\eta\eta$, $\eta\eta'$ and $\eta'\eta'$ are of particular interest and the statistics in these channels will be greatly enhanced. This study will act as an important input in helping to understand non-perturbative QCD.

1 Introduction to the proposed experiment

During the past ten years WA76, WA91 and NA12/2 have searched for non-$q\overline{q}$ mesons in the mass range up to 2.5 GeV. Both experiments, as well as others, have found evidence for such states.

Quantum ChromoDynamics (QCD) predicts the existence of a whole spectra of non-$q\overline{q}$ mesons, but their levels cannot be calculated through perturbative methods. In fact, at present there is no reliable way to predict accurately the mass and width of the nonet members and so it is not possible to definitely assign experimentally observed mesons to a nonet position based on their masses.

What is clear is that in order to help solve this problem of the light meson spectrum and hence increase our understanding of non-perturbative QCD a systematical experimental study is required of as many decay modes and production mechanisms as possible.

WA76, WA91 and NA12/2 have already contributed to this program through studies of charged (WA76, WA91) and neutral (NA12/2) decay modes of light mesons produced in central collisions. This mode of production, that enhances Double Pomeron Exchange (DPE) and is likely to involve preferentially gluon collisions, should favour the production of gluon-rich states.

In order to study channels that at present do not have sufficient statistics and hence detect states not yet observed by previous experiments, we propose to make a more complete study of the mass region from 1.2 to 2.5 GeV using the "gluon-rich" production mechanism (DPE), which has already shown that it produces interesting states, by now combining the charged particle reconstruction of the Omega Spectrometer with the multiphoton detection of GAMS-4000.

This will significantly improve the statistics in many final states, especially final states involving ηs and η's, which are of particular interest since glueballs are likely to decay preferentially with the emission of these mesons [1].

This is the aim of the present proposal. GAMS has already been moved behind the Omega Spectrometer and was operated successfully during the 1994 run of the WA91 experiment. Although this run was optimised for charged particle detection it acted as a successful test of the GAMS integration into the Omega setup.

2 An introduction to non-$q\overline{q}$ mesons

2.1 Non-$q\overline{q}$ mesons

QCD not only describes how quarks and antiquarks interact, but also predicts that the gluons which are the quanta of the field will themselves interact to form mesons. If the object formed is composed entirely of valence gluons the meson is called a glueball, however if it is composed of a mixture of valence quarks, antiquarks and gluons (i.e. $q\overline{q}g$) it is called a hybrid. In addition, $q\overline{q}q\overline{q}$ states are also predicted.

Perturbative QCD has been very successful in describing many hadronic reactions especially at high P_T. However, although several non-$q\overline{q}$ candidates have emerged, as will be described later, none of these have definitively been identified as being a glueball.

Since QCD cannot predict the spectrum of the non-$q\overline{q}$ states we have to resort to various models [2-8]. All models predict a rich spectrum of non-$q\overline{q}$ states with various quantum numbers including those which cannot be realised by $q\overline{q}$ states.

2.2 Mass estimations

Most of the models converge in assigning quite low masses to these new states some of which should have masses in the 0.5 to 2.0 GeV region [2, 3]. However, predictions have been made using lattice gauge theory [4] and flux tube models [5] which indicate that the lowest states could be higher in mass.

The masses of the lowest lying two gluon glueballs have been calculated using lattice gauge theory. Recent predictions [6] show that

$$m(2^{++})/m(0^{++}) = 1.5$$

and using a string constant of $\kappa = 400$ MeV that

$$m(0^{++}) = (1240 - 1600)\mathrm{MeV}.$$

The flux tube model has been used to calculate the masses of the lowest lying hybrid states and recent predictions [7] are that

$$m(1^{--}, 0^{-+}, 1^{-+}, 2^{-+}) \approx 1900 \text{ MeV}.$$

Bag model calculations of $qq\overline{qq}$ states show that most fall apart into two colour singlet mesons and thus have a decay width of the order of their mass, too wide to be detected as resonances.

The only four-quark states that may be observable are those whose nominal mass is below threshold for their principal fall-apart decay mode. It has been argued [8] that $f_0(980)$ and $a_0(980)$ are candidates for the $I = 0$ $s\overline{s}(u\overline{u} + d\overline{d})$ and $I = 1$ $s\overline{s}d\overline{u}$ states of the lowest lying scalar four-quark nonet. Because of their quark content these states will couple strongly to $K\overline{K}$. However, being below the $K\overline{K}$ threshold these decays are strongly suppressed by phase-space. For the $f_0(980)$ the remaining dominant channel is $\pi\pi$ which requires an OZI violation to annihilate the $s\overline{s}$ pair.

There is a similar possibility that $qq\overline{qq}$ states can also be observed near $K^*\overline{K}$ threshold.

2.3 How to look for non-$q\overline{q}$ states

The following have been suggested as possible ways to identify gluonic states.

1. To look for "oddballs", states with J^{PC} quantum numbers not allowed for normal $q\overline{q}$ states, for example $J^{PC} = 1^{-+}$.
2. To look for extra states, that is states that have quantum numbers of an already completed nonet and that have a mass which is sufficiently low that it is unlikely to be a member of the radially excited nonet and hence it cannot be described as being a pure $q\overline{q}$ state.
3. To look for states with branching ratios that are not compatible with $q\overline{q}$ mesons.
4. To look for states preferentially produced in gluon-rich processes. Some of these processes are described below.

Figure 1 summarises several dynamical configurations which have been suggested as possible sources of gluonium and where experiments have been performed.

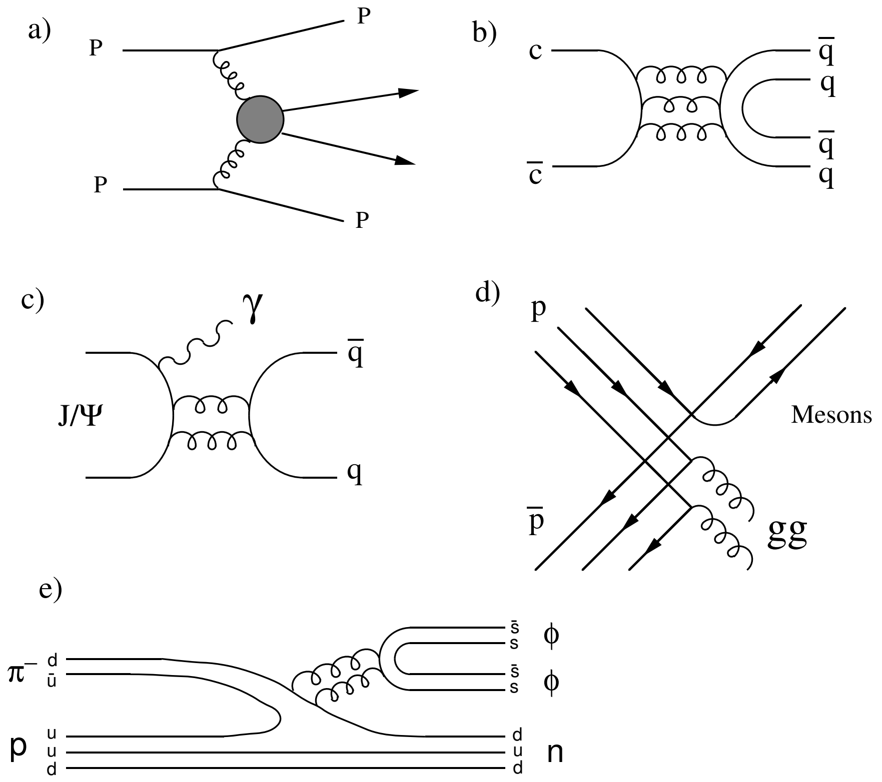

Figure 1: Examples of the gluon-rich channels. Some dynamical configurations that have been used in a search for non-$q\overline{q}$ states.

1. Pomeron-Pomeron scattering is shown in fig. 1a). The Pomeron is an object which can be described as a multi-gluon state, and is thought to be responsible for the

large cross sections of diffractive reactions. Consequently DPE is considered to be a possible source of glueballs.

2. The J/ψ decay is believed to be a highly glue rich channel either via the hadronic decay shown in fig. 1b), or via the radiative decay shown in fig. 1c).

3. Figure 1d) shows proton antiproton annihilation; the annihilation region of quarks and antiquarks is a source of gluons where glueballs and hybrids could be produced.

4. Special hadronic reactions, an example of which is shown in fig. 1e) where the $\phi\phi$ system is thought to be produced via an intermediate state containing gluons. Reactions of this kind which have disconnected quark lines are said to be OZI violating [9].

The first reaction is the one which has been studied by experiments WA76, WA91 and NA12/2.

3 The WA76 and WA91 experiments

3.1 Introduction

Experiment WA91 is a continuation of the WA76 experiment which was designed to study exclusive final states formed in the reaction

$$pp \rightarrow p_f(X^0)p_s \tag{1}$$

where the subscripts f and s indicate the fastest and slowest particles in the laboratory respectively and X^0 represents the central system that is presumed to be produced by a double exchange processes.

Experiment WA76 was performed at two incident beam momenta, 85 and 300 GeV/c and WA91 at 450 GeV/c, corresponding to centre-of-mass energies of $\sqrt{s} = 12.7$, 23.8 and 29.1 GeV. Having data at different centre-of-mass energies has allowed a study of the energy dependence of the observed mesons to be performed and hence, given some insight into their nature since the cross section for DPE produced states is expected to be effectively constant with energy whereas the cross section for mesons produced via Regge exchange decrease with increasing energy ($1/\sqrt{s}$ for Regge-Pomeron and $1/s$ for Regge-Regge).

Several interesting non-$q\overline{q}$ candidate states have already been observed in these experiments and are described below.

3.2 The $E/f_1(1420)$

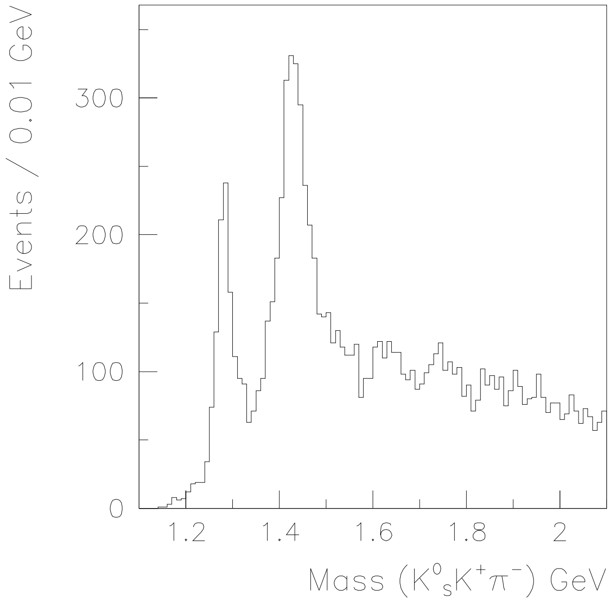

Figure 2: The $K^0_S K^\pm \pi^\mp$ mass spectrum from WA76 and WA91

The $E/f_1(1420)$ has been observed in the reaction $pp \rightarrow p_f(K^0_S K^\pm \pi^\mp)p_s$ by both the WA76 and WA91 experiments [10]. Figure 2 shows the $K^0_S K^\pm \pi^\mp$ mass spectrum from WA76 and WA91 where two peaks are seen. The $f_1(1285)$ which is the $(u\overline{u} + d\overline{d})$ member of the 1^{++} nonet and the $E/f_1(1420)$.

A spin parity analysis of the $K^0_S K^\pm \pi^\mp$ system using Zemach tensors shows that the $E/f_1(1420)$ decays predominantly to $K^*(892)\overline{K}$ and has $J^{PG} = 1^{++}$. The observation of $E/f_1(1420)$ in the $K^0_S K^0_S \pi^0$ shows that its C parity is positive and hence its quantum numbers are determined to be $I = 0$, $J^{PC} = 1^{++}$. A search for other decay modes of the $E/f_1(1420)$ was performed but none found [11].

Initially the $E/f_1(1420)$ was thought to be the $s\overline{s}$ member of the 1^{++} nonet. If so then it would be expected that it should be produced in K^-p interactions. However, it was not observed in these interactions, instead another $J^{PC} = 1^{++}$ state, the $f_1(1530)$, was observed [12].

Therefore, there are 10 candidate members for the groundstate $J^{PC} = 1^{++}$ nonet. Since the $E/f_1(1420)$ decays predominantly to $K^*(892)\overline{K}$ but is not produced in K^-p interactions it has been suggested that the $E/f_1(1420)$ could be a hybrid [13], four-quark [14], or $K^*\overline{K}$ molecule-like state [15].

3.3 The X(1450) and X(1900)

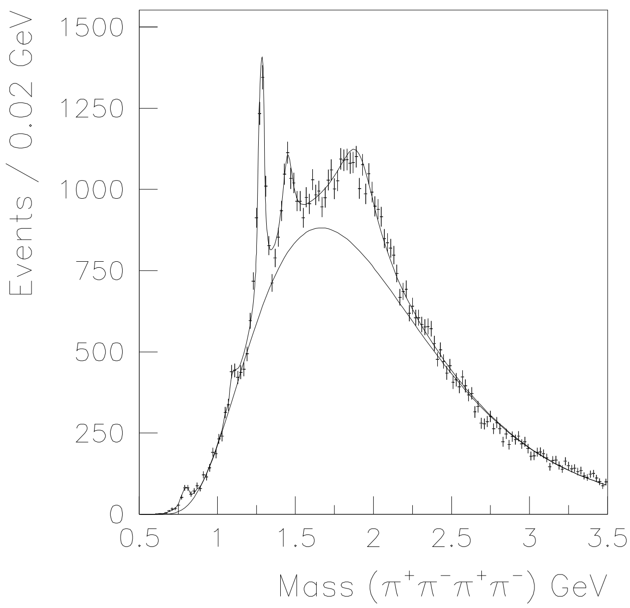

Figure 3: The $\pi^+\pi^-\pi^+\pi^-$ mass spectrum from WA91

The WA76 collaboration reported the observation of two previously unobserved mesons, which it called the X(1450) and X(1900), decaying to $\pi^+\pi^-\pi^+\pi^-$ in the reaction

$$pp \rightarrow p_f(\pi^+\pi^-\pi^+\pi^-)p_s \tag{2}$$

at 300 GeV/c [16]. In contrast, no clear evidence was seen for the X(1450) or X(1900) in the 85 GeV/c data of the same experiment. This increase in signal to background ratio with increased incident energy [16] is consistent with the formation of these states via a double Pomeron exchange mechanism, which as mentioned above is predicted to be a source of gluonic states [17]. It is also of interest to note that the X(1450) state has not been observed in any other production mechanism even though this mass region has been studied thoroughly in the past in other reaction mechanisms. One of the main aims of the WA91 experiment therefore was to confirm the existence of these states and to determine their quantum numbers.

Figure 3 shows the $\pi^+\pi^-\pi^+\pi^-$ mass spectrum from WA91 which again shows evidence of these new states and with the increased statistics a determination of the spin of the states was possible. The analysis of the X(1450) shows that it is a relatively narrow state ($\Gamma = 56 \pm 12$ MeV) with $I^G(J^{PC}) = 0^+(0^{++})$ which decays to $\rho^0\pi^+\pi^-$. The X(1900) could either be a single broad state ($\Gamma = 370 \pm 70$ MeV) with $I^G(J^{PC}) = 0^+(2^{++})$ or possibly two separate narrower states.

4 The NA12/2 experiment

4.1 Introduction

The aim of the NA12 experiment and a similar ongoing experiment at IHEP, Protvino was to make a systematic study of neutral states produced in the exclusive charge exchange (CEX) π^-p reaction and which decayed into pseudoscalar mesons. Several non-$q\overline{q}$ candidates were observed in these experiments and two are described below.

- The **G/f_0(1590)** scalar meson was discovered in a partial wave analysis of the $\eta\eta$ system produced in the π^-p CEX reaction at 38 GeV/c (IHEP)[18] and 100 GeV/c (CERN)[19]. Its unusual decay properties : BR(G$\rightarrow$ $\eta\eta'$) > BR(G$\rightarrow$ $\eta\eta$) > BR(G$\rightarrow$ $4\pi^0$) >> BR(G$\rightarrow$ $\pi\pi$,KK) favours its interpretation as a 0^{++} glueball candidate [1].
- The **X(1910)** meson was observed in the π^-p$\rightarrow$ $\eta\eta'$n reaction at high $|t|$ where the one-pion-exchange mechanism (OPE) becomes negligible [20]. This meson was not observed in the symmetrical decay channels like $\eta\eta$, $\pi^0\pi^0$, $K^0_S K^0_S$. Its unusual decay properties and the fact that it is not produced via OPE as well as its small width suggest a possible non-$q\overline{q}$ interpretation.

The NA12/2 experiment continued these studies by searching for non-$q\overline{q}$ states produced in gluon-rich central collisions. The GAMS spectrometer was used to detect the $\eta\eta$ and $\eta\eta'$ multiphoton decay modes as well as other multiphoton final states. The measurements were performed using a 300 GeV/c π^- beam and a 450 GeV/c proton beam.

4.2 The $\eta\eta$ final state

The first data obtained in the NA12/2 300 GeV/c π^- run showed that the $\eta\eta$ system could be isolated from the 4γ final state. A new tensor state, the $f_2(2175)$, was observed (fig. 4) [21].

The centrally produced $\eta\eta$ mass spectrum observed in the 450 GeV/c proton run (fig. 5) again shows evidence for the $f_2(2175)$. The mass ratio of $f_2(2175)$ and $G/f_0(1590)$ is close to 1.5, the value predicted for the tensor and scalar glueballs.

The structure in the 1.4 to 1.8 GeV region has been interpreted as being due to the $f_2'(1525)$ and $G/f_0(1590)$ mesons. However, the $\theta/f_2(1720)$ meson is also expected to decay through $\eta\eta$ but due to the lack of statistics in this region it is impossible to make a definite statement on this.

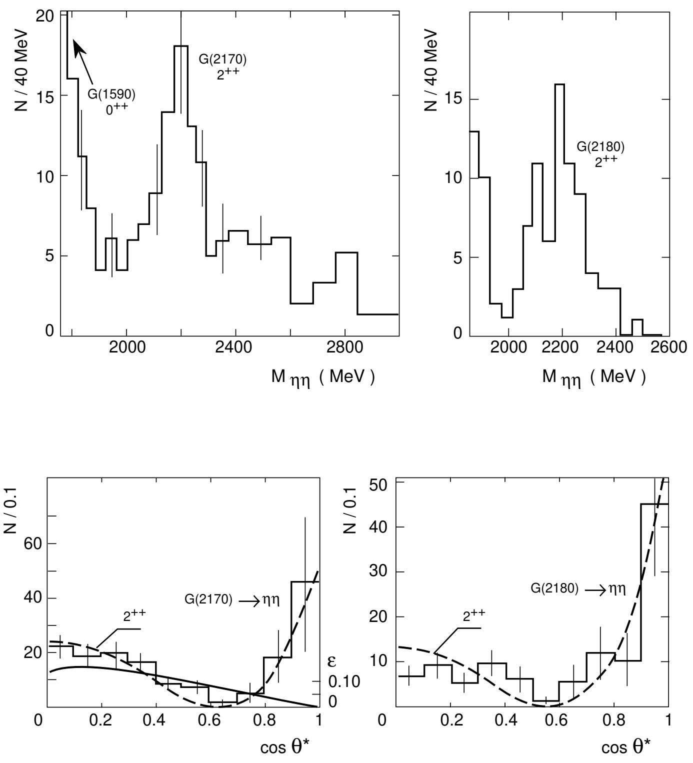

Figure 4: The $\eta\eta$ mass spectrum above 1.7 GeV obtained in the NA12/2 experiment at 300 GeV/c pion beam (left) and 450 GeV/c proton beam (right). Below the angular distributions of the G/f_2(2175) decay are shown in the Gottfried-Jackson frame.

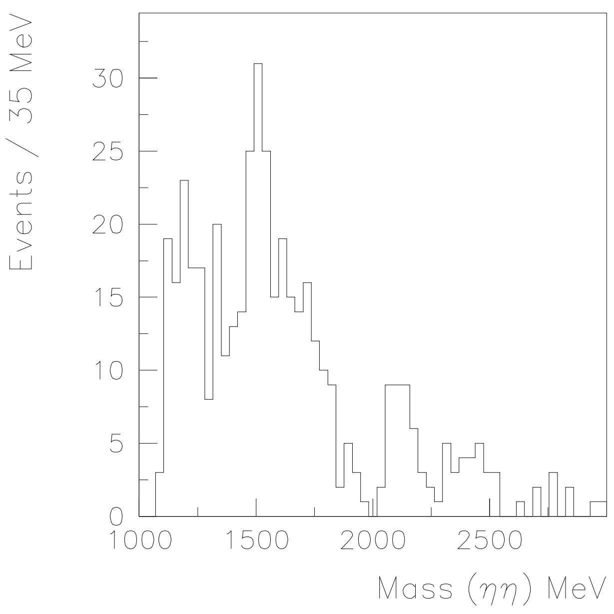

Figure 5: Preliminary $\eta\eta$ mass spectrum from the last NA12/2 proton run.

5 The proposed experiment

5.1 Introduction

Experiments WA76, WA91 and NA12/2 performed a dedicated search for non-$q\overline{q}$ mesons in centrally produced exclusive events and it is important to note that in all channels where the statistics were sufficient to do a proper spin analysis interesting candidates have been found. Another interesting point is that the candidates found to date have the same spin quantum numbers as existing nonets.

We now propose to make a more complete study of the mass region from 1.2 to 2.5 GeV using the "gluon-rich" production mechanism (DPE) and the charged particle reconstruction of the Omega Spectrometer combined with the multiphoton detection of GAMS-4000. This will greatly improve the statistics in many final states and of particular interest will be final states involving ηs, η's and ωs.

In the following we will discuss the $\eta\eta$, $\eta\eta'$ and $\eta'\eta'$ final states. Although we are interested in many final states these are particularly interesting since for a glueball G there exists the prediction that $\Gamma(G \rightarrow \eta'\eta') > \Gamma(G \rightarrow \eta\eta') > \Gamma(G \rightarrow \eta\eta)$ [1].

5.1.1 The $\eta\eta'$ final state

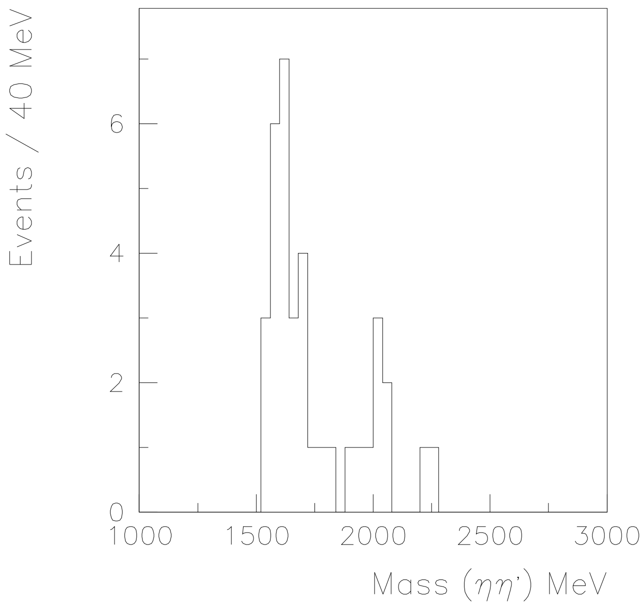

Figure 6: The $\eta\eta'$ mass spectrum from one run of the NA12/2 experiment

The GAMS collaboration using the charge exchange reaction have reported a large branching ratio of the $G/f_0(1590)$ to $\eta\eta'$ [19]. In order to understand the nature of this state high statistics data are required in central production.

Figure 6 shows the $\eta\eta'$ mass spectrum from NA12/2 in central production observed in the 8γ decay mode. The channel is clean but the statistics are poor.

5.1.2 The $\eta'\eta'$ final state

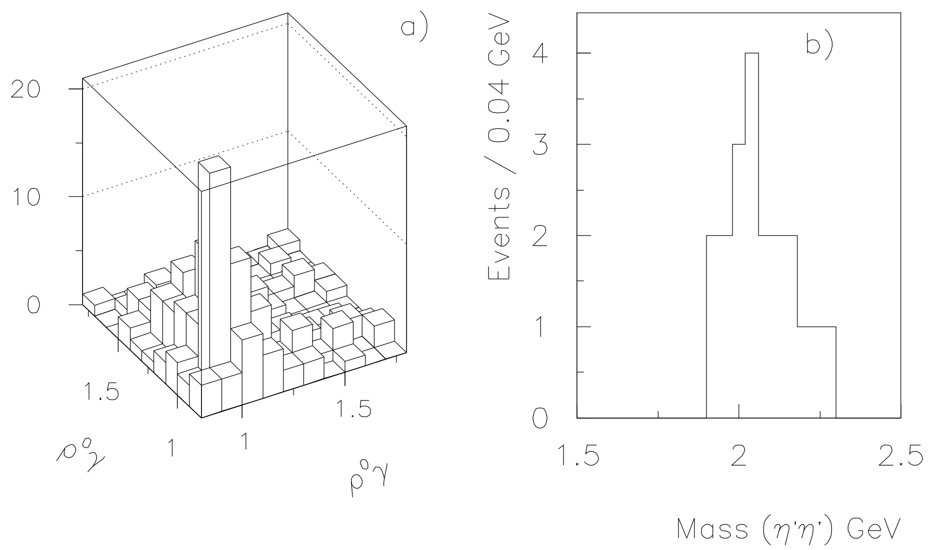

Figure 7: a) Lego plot of $\rho^0\gamma$ versus $\rho^0\gamma$ and b) the $\eta'\eta'$ mass spectrum from the WA91 experiment

If a state, for example the $f_2(2175)$ described above, is observed in $\eta\eta$ and $\eta\eta'$, it is necessary in order to test its "glueball" nature to measure its branching rate to $\eta'\eta'$.

NA12/2 have not observed the $\eta'\eta'$ final state since the all photon decay rate of $\eta'\eta'$ is very low. Figure 7a) shows the $\rho^0\gamma$ versus $\rho^0\gamma$ scatter plot from WA91 where a clear excess is observed due to the $\eta'\eta'$ final state. This is the first observation of the $\eta'\eta'$ final state and the mass spectrum is shown in figure 7b). The statistics are poor because of the poor two photon and hadron-photon space resolution in the OLGA calorimeter used in WA91. With the combination of GAMS plus Omega, as will be shown later, the statistics will be greatly increased.

5.1.3 Summary

To date the statistics in these channels have been limited since the NA12/2 only had access to a low branching ratio as the charged tracks where not detected. In the case of WA91 events were lost due to photon and hadron shower overlap in the OLGA calorimeter. The proposed setup solves these problems by combining the best features of each experiment.

In addition to these channels many other channels, for example $\omega\omega$, $\eta\pi$, $\eta'\pi\pi$, and $\pi^+\pi^-\pi^0\pi^0$, will have greatly increased statistics and allow us to search for new states in a large number of decay modes.

5.2 Layout and trigger conditions

The proposed layout of the experiment is similar to that used for phase one of the WA91 experiment and is shown in fig. 8. The main modification is the replacement of the OLGA calorimeter with that of the GAMS multiphoton detector.

The layout of the Omega Spectrometer for this experiment is briefly described below.

- The direction of the beam (450 GeV/c incident protons) will be measured using 10 (5y and 5z planes) 20 μm pitch microstrip detectors. The track finding will have a backup of 4 (1/3 mm logical spacing) scintillation hodoscopes (2y and 2z planes).
- Target: 60 cm of liquid hydrogen.
- The slow proton will be defined by requiring one hit on one side of the box counters surrounding the target, one hit on a single y plane of the C MWPCs and one hit on one of the slabs of the slow proton counter (SPC). The pulse-height recorded on the SPC will allow discrimination between π^+ and protons.
- No other particle will be required on the other three sides of the Box counter which surrounds the target system to veto backward diffractive events.
- The fast proton will be triggered by two scintillation counters A1 and A2 of (2.5x2.5 cm^2) and (5x5 cm^2) respectively. The A2 counter will be split vertically in half, called A2(L) and A2(R) to help veto elastic events (as described below).
- The fast protons direction outside the field will be measured by two sets of 4 planes of microstrip detectors (5x5 cm^2) at 6 and 10 metres from the centre of Omega. A system of 1 mm pitch MWPCs will be used at 20 m to help in resolving ambiguities in the microstrip system. In addition the UK microstrip gas chamber group is planning to supply 2 gas microstrip planes of 200 μm pitch to be used at 20 m.
- GAMS-4000 will be used for the measurement of γs.

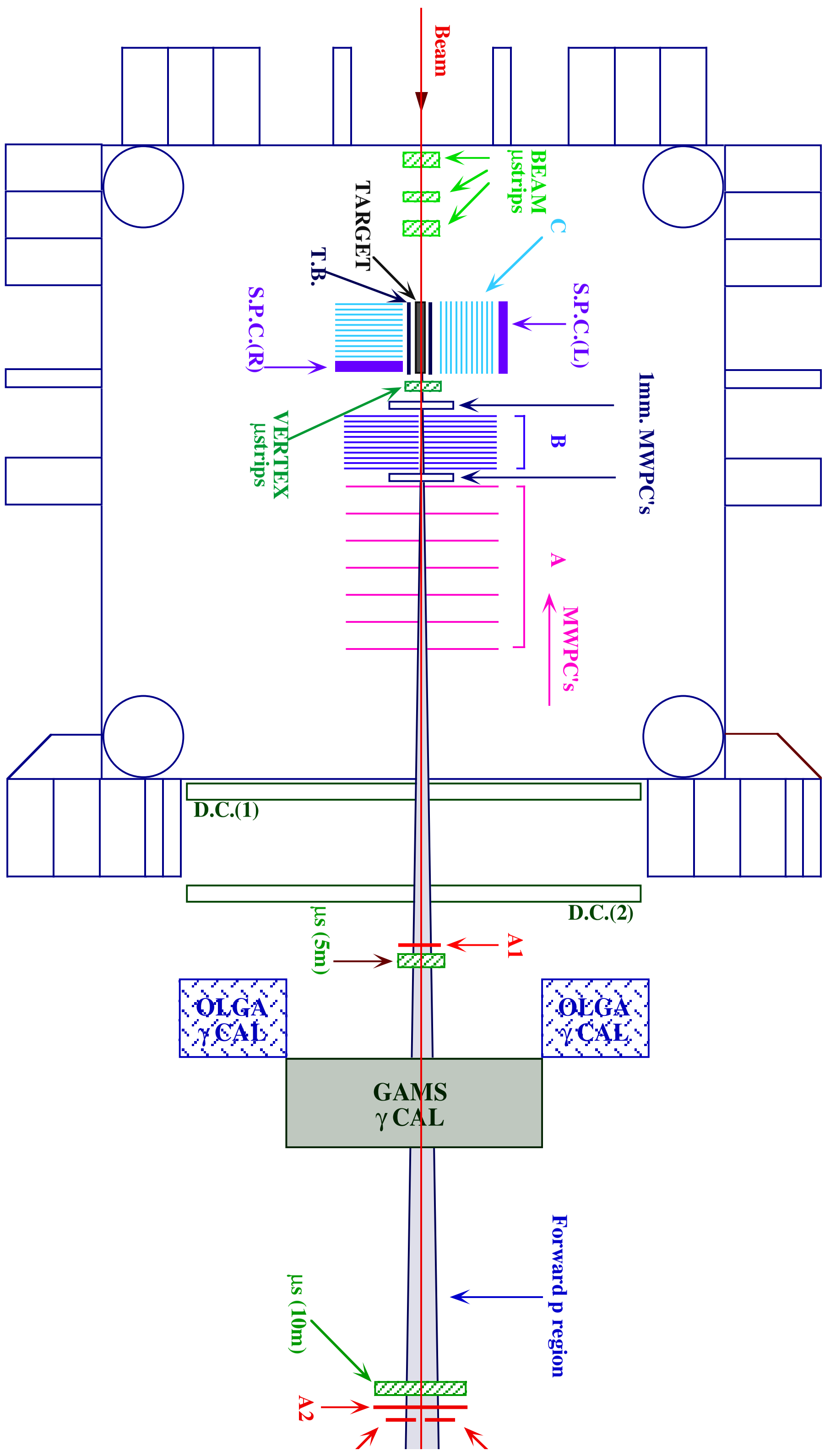

Figure 8: Proposed layout of the Omega Spectrometer.

The trigger of the experiment will require :

1. A fast particle crossing the downstream microstrip telescope. This requirement will be fulfilled by asking for a coincidence between two scintillation counters (A1 and A2) placed close to the microstrip detectors at 5 and 10 m.
2. A slow particle left [right] will be defined by requiring one hit on any of the fourteen slabs of the Slow Proton Counter Left (SPC(L)) [Right (SPC(R))] in coincidence with a hit in the left [right] box counter (TB) and ≥ 1 hit in 2 planes of the C MWPCs on the left [right] side of the target.
3. In order to reduce backward diffraction or excitation events no hit will be required in the other three sides of the box counter (TB) which is left open at its front end to allow particles produced centrally to escape downstream.

Elastic scattering events are automatically rejected when the slow proton and fast proton are on the same side i.e. a slow proton left and a hit in the A2(L) counter or a slow proton right together with a hit in A2(R). However the other combinations are dominated by elastic scattering. Therefore for the combinations slow proton left and A2(R) or slow proton right and A2(L) we will reduce the number of elastic scattering events triggered on by asking that either energy is seen in the calorimeter, using a fast analog signal summation system, or that there are 2 or more hits in an A MWPC outside the fast track region.

The alignment of the microstrip system which is critical for the isolation of momentum balancing events will be performed on a run by run basis using beam triggers which will be taken interleaved with the physics triggers.

5.3 Rates

The event rate for WA91 was 600 events for 5×10^6 incident protons per burst. With 60 % machine efficiency this would give us 2 million events per day. With two periods of 100 days each, which would be divided into 10 days of setting up and 90 days of effective data taking, we would reach 360 million events on tape.

The data would be processed on a system of HPs at CERN and in the host institutes and no problem with available computer power is foreseen.

5.4 Acceptances

In order to detect multiphoton final states in phase one of the WA91 experiment the OLGA calorimeter was used which was the best available calorimeter in 1992. However, for the 1994 run the GAMS-4000 detector, which is far superior to the OLGA calorimeter, was used. This run was not optimised for photon detection, nevertheless it was very useful for integrating GAMS-4000 into the Omega setup.

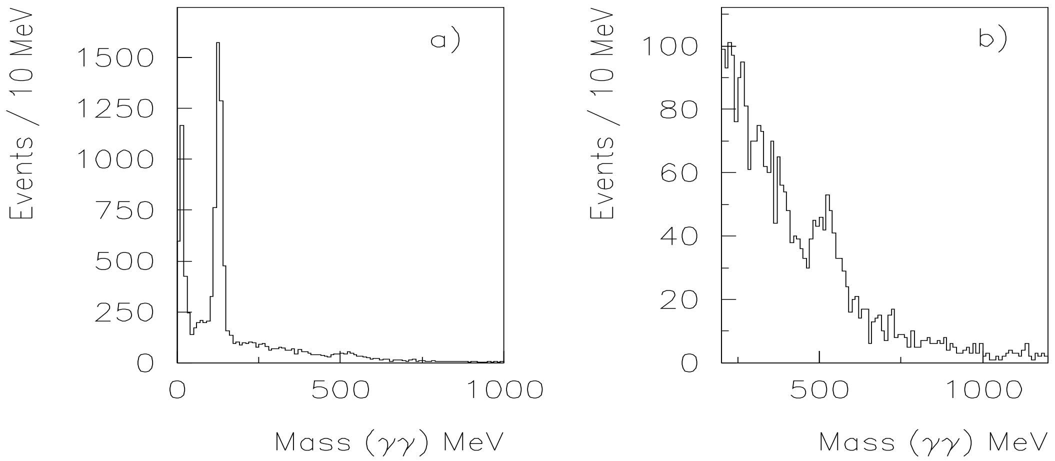

Figure 9: On-line $\gamma\gamma$ mass spectrum from GAMS-4000 in the 1994 WA91 run.

Figure 9 shows the on-line $\gamma\gamma$ effective mass spectrum from GAMS during the 1994 run where clear π^0 and η peaks are observed showing that this detector works well inspite of the fact that it was placed behind the Cerenkov detectors.

The aim is now to take data optimised for photon detection in order to combine the charge particle tracking of Omega with the multiphoton detection of GAMS. This will lead to an increase of statistics by more than an order of magnitude.

In order to calculate the number of events we expect to record in a 180 day run we have performed a Monte Carlo simulation of the combined Omega plus GAMS setup including geometrical effects, reconstruction efficiencies and analysis cuts. In order to calculate a cross section for the processes we have used the number of events observed by NA12/2 in the run of 30 days in 1991.

NA12/2 observed 1000 centrally produced $\eta\eta$ events in the 4γ decay mode and 100 $\eta\eta'$ events in all final states. No signal has been observed for the $\eta'\eta'$ final state. If it is assumed that the cross section for $\eta'\eta'$ production is the same as that for $\eta\eta'$ then taking into account the small η' branching fraction available to NA12/2 they would have only expected to have seen 2 events in the $\eta'\eta'$ channel. Using the same cross section for $\eta'\eta'$ production and the Monte Carlo for the 1992 run of the WA91 experiment predicts 30 events in the $\rho^0\gamma$ $\rho^0\gamma$ final state to be compared with the 20 events observed in fig. 7.

Using the cross sections obtained from these observed events and the proposed beam flux, target, acceptances and data analysis cuts the number of events that could be observed in the proposed 180 day run have been calculated.

Table 1: Centrally produced $\eta\eta$

Decay mode	Event topology	Expected number of events
$\eta \to \gamma\gamma$ $\eta \to \gamma\gamma$	4γ	5800
$\eta \to \gamma\gamma$ $\eta \to \pi^+\pi^-\pi^0$	$\pi^+\pi^-4\gamma$	6010
$\eta \to \pi^+\pi^-\pi^0$ $\eta \to \pi^+\pi^-\pi^0$	$2\pi^+2\pi^-4\gamma$	1530

Table 1 shows the expected number of events for the $\eta\eta$ channel as a function of decay mode considered. Tables 2 and 3 give the number of events expected in the decay modes considered for the $\eta\eta'$ and $\eta'\eta'$ channels respectively. It is clear that simultaneous good detection of several charged tracks and several photons is extremely important. Table 4 summarises the number of events observed to date by the GAMS collaboration and compares them to the number of events predicted in the proposed 180 day run.

In the proposed run we should observe 13000 $\eta\eta$ decays, 5000 $\eta\eta'$ decays and 2500 $\eta'\eta'$ decays which is an order of magnitude larger than currently published statistics. This increase is due mainly to the addition of decay modes involving charged particles as well as γs in the final state, which were not observable in the NA12/2 experiment.

6 Conclusion and requests

The results from the analysis of the WA76, WA91 and NA12/2 data, when compared with the results from other experiments, provide evidence for the existence of states which do not fit into the conventional pattern of $q\overline{q}$ nonets. The existence of these states could only be demonstrated because we obtained sufficient statistics in certain channels in order to do a complete spin analysis.

In order to find more candidates and therefore to help establish the nature of the non-$q\overline{q}$ spectrum we need high statistics for as many channels as possible. We therefore propose to combine the high quality charged particle tracking of Omega with the high quality multiphoton detection of GAMS.

In summary, we request two periods of 90 days of effective data taking in 1995 and 1996, preceded by a 10 day setting up period each year, in the H1 beam at 450 GeV/c and the use of the Omega Spectrometer.

Table 2: Centrally produced $\eta\eta'$

Decay mode	Event topology	Expected number of events
$\eta \to \gamma\gamma\ \eta' \to \gamma\gamma$	4γ	210
$\eta \to \gamma\gamma\ \eta' \to \pi^0\pi^0\eta,\ \eta \to \gamma\gamma$	8γ	210
$\eta \to \gamma\gamma\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma$	$\pi^+\pi^-4\gamma$	1115
$\eta \to \gamma\gamma\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \pi^+\pi^-\pi^0$	$2\pi^+2\pi^-4\gamma$	560
$\eta \to \gamma\gamma\ \eta' \to \rho^0\gamma$	$\pi^+\pi^-3\gamma$	1565
$\eta \to \pi^+\pi^-\pi^0\ \eta' \to \gamma\gamma$	$\pi^+\pi^-4\gamma$	110
$\eta \to \pi^+\pi^-\pi^0\ \eta' \to \pi^0\pi^0\eta,\ \eta \to \gamma\gamma$	$\pi^+\pi^-8\gamma$	105
$\eta \to \pi^+\pi^-\pi^0\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma$	$2\pi^+2\pi^-4\gamma$	560
$\eta \to \pi^+\pi^-\pi^0\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \pi^+\pi^-\pi^0$	$3\pi^+3\pi^-4\gamma$	200
$\eta \to \pi^+\pi^-\pi^0\ \eta' \to \rho^0\gamma$	$2\pi^+2\pi^-3\gamma$	775

Table 3: Centrally produced $\eta'\eta'$

Decay mode	Event topology	Expected number of events
$\eta' \to \gamma\gamma\ \eta' \to \gamma\gamma$	4γ	10
$\eta' \to \gamma\gamma\ \eta' \to \pi^0\pi^0\eta,\ \eta \to \gamma\gamma$	8γ	20
$\eta' \to \gamma\gamma\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma$	$\pi^+\pi^-4\gamma$	150
$\eta' \to \gamma\gamma\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \pi^+\pi^-\pi^0$	$2\pi^+2\pi^-4\gamma$	80
$\eta' \to \gamma\gamma\ \eta' \to \rho^0\gamma$	$\pi^+\pi^-3\gamma$	140
$\eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma\ \eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma$	$2\pi^+2\pi^-4\gamma$	550
$\eta' \to \pi^+\pi^-\eta,\ \eta \to \gamma\gamma\ \eta' \to \rho^0\gamma$	$2\pi^+2\pi^-3\gamma$	1080
$\eta' \to \rho^0\gamma\ \eta' \to \rho^0\gamma$	$2\pi^+2\pi^-2\gamma$	505

Table 4: Summary of expected number of events

	$\eta\eta$	$\eta\eta'$	$\eta'\eta'$
NA12/2	1000	100	2 predicted
Proposed experiment	13340	5410	2535

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