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

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Outline

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2) Non−$q\bar{q}$ candidates from
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   b) NA12

3) The proposed experiment

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An introduction to non–$q\bar{q}$ mesons

QCD not only descibes how quarks and
antiquarks interact by the exchange of gluons

– it also predicts a rich spectrum of non–$q\bar{q}$ states

gg, ggg	Glueballs
$q\bar{q}g$	Hybrids
$q\bar{q}q\bar{q}$	4–quark states

Mass estimations

Naive estimates from the Bag model a few years ago predicted

$$M_{gg}(0^{++}) = 1 \text{ GeV}$$

However, new Lattice Gauge calculations

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

and that depending on the choice of constant

$$M(0^{++}) = 1240 - 1600 \text{ MeV}$$

The ggg states are higher in mass and the lightest $q\bar{q}$ hybid has

$$M(q\bar{q}g) > 1.5 \text{ GeV}$$

How to look for non–$q\bar{q}$ mesons ?

1) Look for Oddballs

– states with J^{PC} not allowed for $q\bar{q}$ states

2) Look for extra states

– states with quantum numbers of an already completed nonet

3) Look for states with unusual branching ratios

4) Look for states preferentially produced in gluon rich processes

Experiments WA76, WA91 and NA12/2 have studied

exclusive final states in the reactions

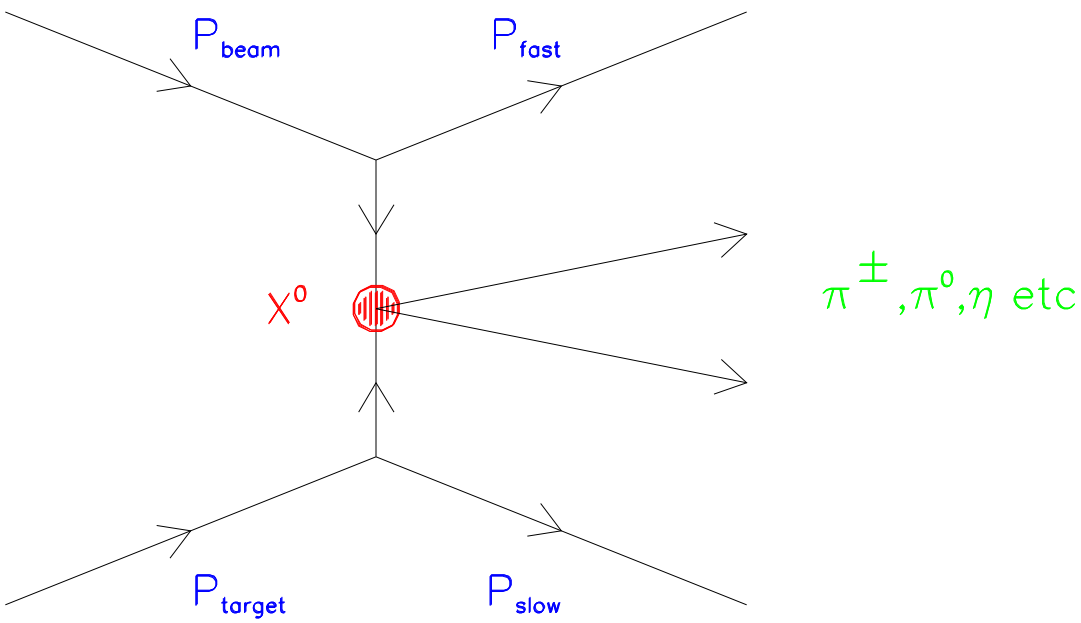
$$pp \rightarrow p_f p_s(X^0)$$

and

$$\pi^+ p \rightarrow \pi_f^+ p_s(X^0)$$

at 85, 300 and 450 GeV/c

Centre of mass view



Experiments WA76 and WA91

Good charged particle detection

Experiment NA12/2

Good neutral particle detection

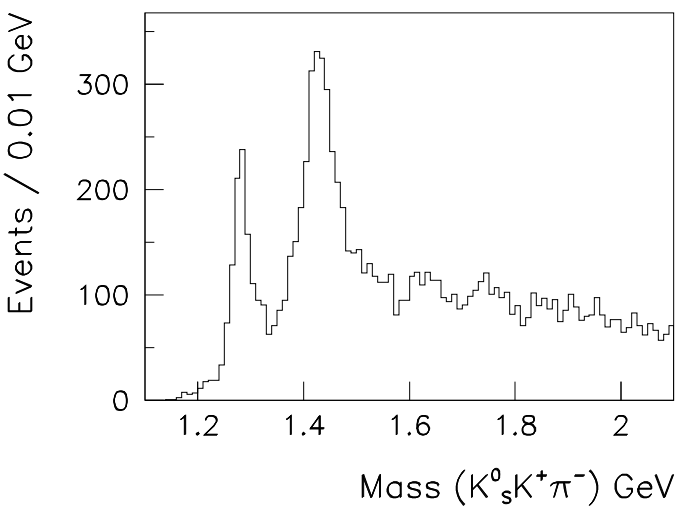
Both experiments have found evidence for non–$q\bar{q}$ states since there are too many states for the available nonet places

However their classifcation is not easy

We now propose to combine the best parts of each experiment to perform a more complete search for non–$q\bar{q}$ mesons

In particular by studying final states involving ηs and η's

The E/$f_1(1420)$



Only observed decaying to $K^*\bar{K}$

Dalitz plot analysis $\rightarrow$ $J^{PG} = 1^{++}$

Observation in $K^0_S K^0_S \pi^0$ $\rightarrow$ $I = 0$

and hence $I^G J^{PC} = 0^+ 1^{++}$

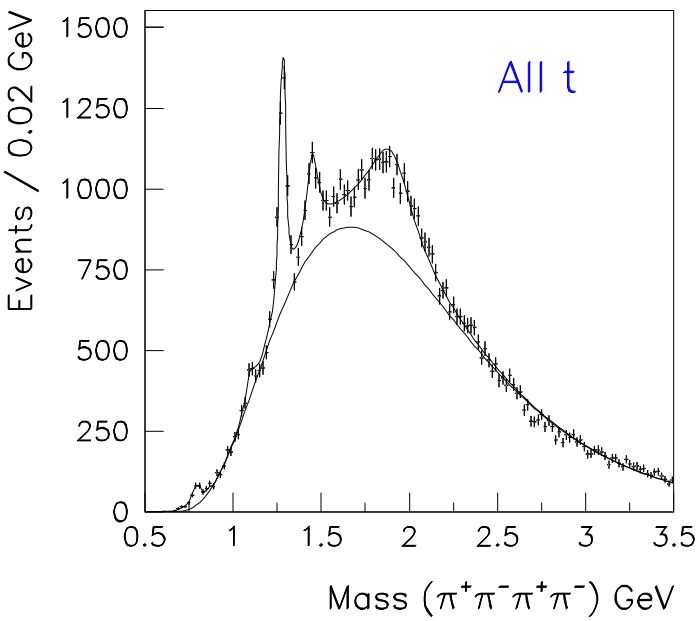
The E/f_1(1420) was thought to be the $s\bar{s}$
member of the 1^{++} nonet

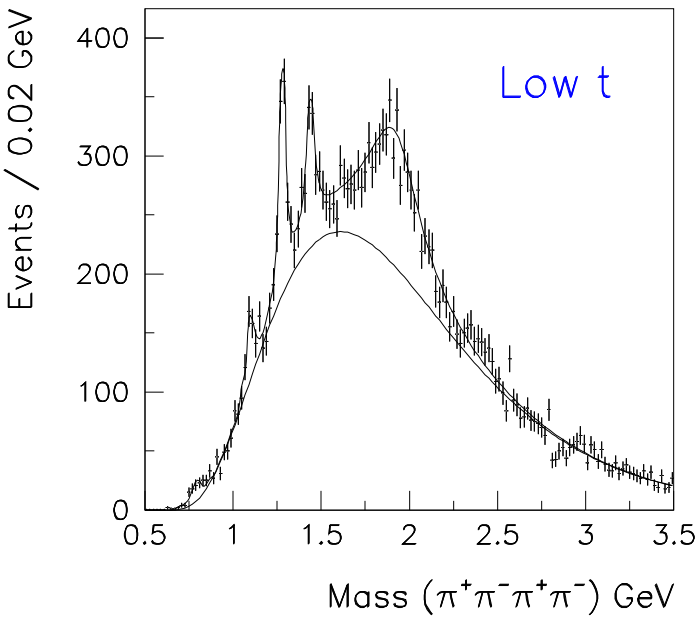
However it was not observed in K^-p reactions
where $s\bar{s}$ states should be observed
Instead another state the f_1(1530) was observed

Therefore the E/f_1(1420) is an extra state
which only decays to $K^*\bar{K}$near to
$K^*\bar{K}$threshold

Whatever its classification there are
10 states where the $q\bar{q}$ nonet would
predict that there should only be 9

The X(1450) and X(1900)





X(1450) and X(1900) were first observed by experiment WA76 in the 300 GeV/c run (not observed in 85 GeV/c data)
One of the main motivations of the WA91 experiment was to confirm these states and get enough statistics to determine their quatum numbers

WA91 confirmed both of these states

X(1450) decays to $\rho^0\pi^+\pi^-$
and has $I^GJ^{PC} = 0^+0^{++}$

X(1900) decays to $a_2(1320)\pi$ and $f_2(1270)\pi^+\pi^-$
and has $I^GJ^{PC} = 0^+2^{++}$

Their prominence at the higher energies suggests that they are produced by DPE and it not easy to accomodate into a $q\bar{q}$ nonet

Summary

WA76, WA91 and NA12/2 performed a dedicated search for non−$q\bar{q}$ mesons in central production In channels where the statistics have been sufficient to perform a spin analysis interesting states have been observed

Although their now appears to be evidence for non−$q\bar{q}$ mesons there are still several questions to be answered

Why do all the states observed to date have the same quantum numbers as $q\bar{q}$ nonets ?

How do we reconcile states observed in different experiments ?

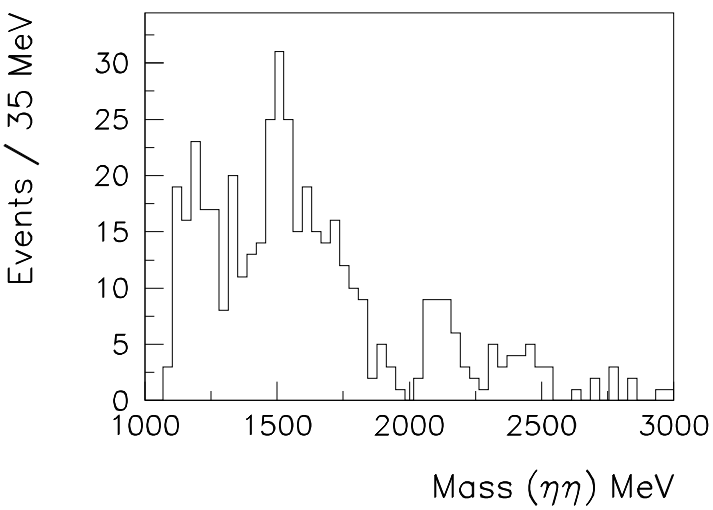
The proposed experiment

In order to try to answer these questions
we propose to study those channels which to date
have poor statistics, in particular those
final states involving charged and neutral particles
for example ηs, η' and ωs,

By combining the charge particle reconstruction of
Omega with the multiphoton detection of GAMS−4000

Although we wish to study many final states
of particular interest will be the $\eta\eta$,
$\eta\eta'$ and $\eta'\eta'$ systems which at
present are the two body pseudoscalar final states
with the poorest statistics and also glueballs are
predicted to decay preferentially into them
For a Glueball G
$\Gamma(G \rightarrow \eta'\eta') > \Gamma(G \rightarrow \eta\eta') > \Gamma(G \rightarrow \eta\eta)$

The $\eta\eta$ final state from NA12/2

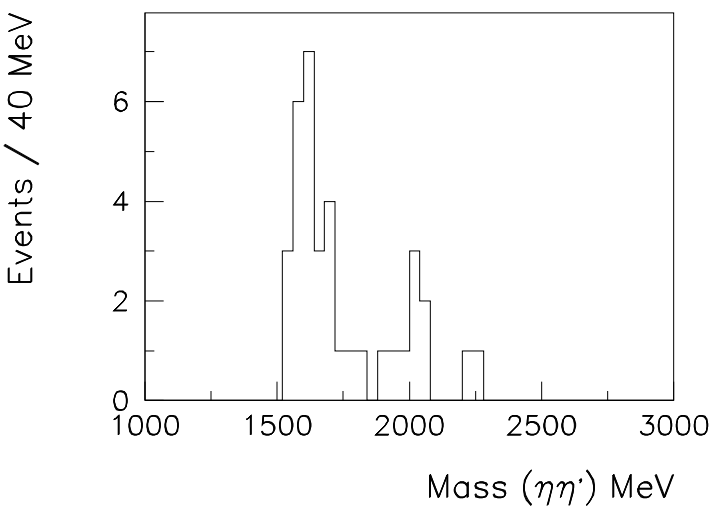


Observation of $G/f_0(1590)$ and

$f_2(2175)$

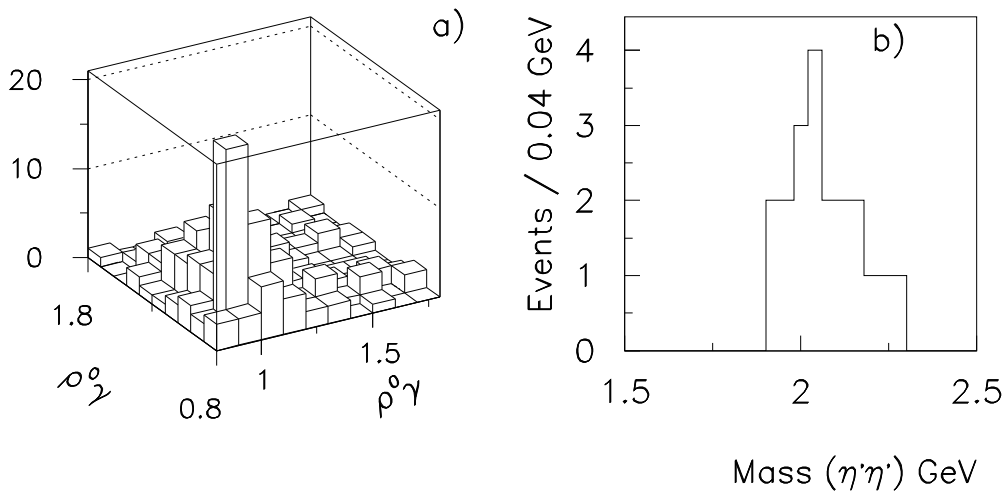
Is there any $\vartheta/f_2(1720)$?

The $\eta\eta'$ final state from NA12/2



Need to determine the Branching Ratio of $G/f_0(1590)$ and $f_2(2175)$ to $\eta\eta'$

The $\eta'\eta'$ final state from WA91



The first observation of the

$\eta'\eta'$ final state

Can be isolated even in

this difficult decay mode