Candidates of the quasi-molecular meson-baryon states and a related topic

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What's $S_{11}(1535)$?
Meson-*N* quasi-molecuar state
Missing states
Experimental apparatus
Radiative decay width of η

S_{11}(1535) resonance

Chiral symmetry with spontaneous breakdown: Important concept in the hadron dynamics

S_{11}(1535) :

- A candidate of a chiral partner
- of nucleon

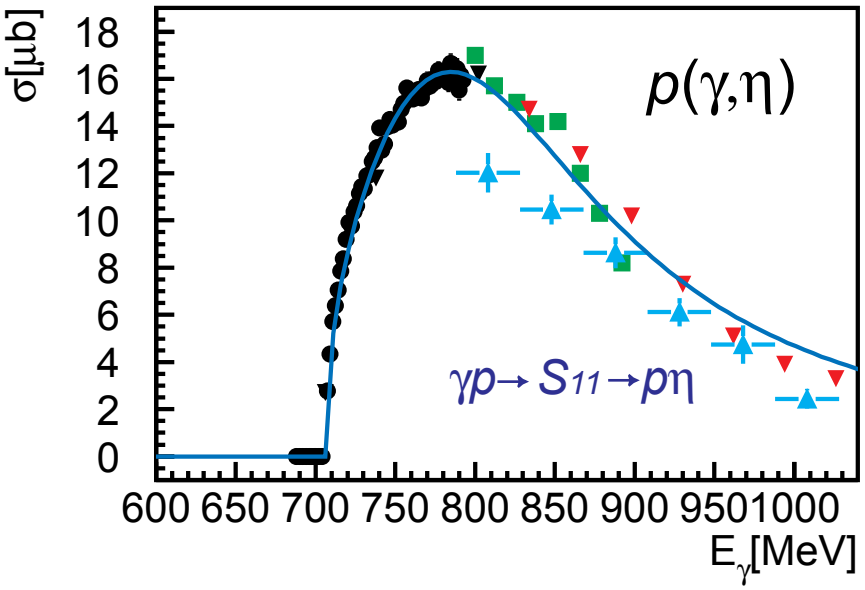
Partially restoration of chiral symmetry in nuclear medium

- Mass, coupling and so on

C. DeTar and T. Kunihiro Phys. Rev. D39 2805(1989),
D. Jido et al. Nucl. Phys. A671(2000)471

Mass and width of S_{11}
in Nuclei and vacuum?

Chiral structure of nucleon and nuclear resonance



[B. Krusche et al., Phys. Rev. Lett. 74 (1995) 3736]
[M. Wilhelm, Ph.D. Thesis, Bonn, BN-IR-93-43]
[S. Homma et al., J. Phys. Soc. JPN. 57 (1988) 828]
[D. Rebreyend et al., Nucl. Phys. A663&664 (2000) 436c]

Large branching ratio to N-η (35 ~ 55 %)

- Most of the η photoproduction occur
- via S_{11} resonance up to 1 GeV

S_{11} and CQM

Conventional 3*q* structure of S_{11} : $[70,1^{-}_{1}]$

Constituent Quark Model prediction

- Γ_η : less than 1 MeV for both resonance

*N*η decay branch of S_{11}

- $S_{11}(1535)$ Γ_η : 40 - 80 MeV
- $S_{11}(1650)$ Γ_η : non-zero but small
- Why large η-*N* decay width of $S_{11}(1535)$?

Quasi-molecular meson-baryon resonance?

- (R. Bijker et al., nucl-th/9608057)

Quasi-molecular meson-baryon resonance
exotic configuration of penta-quark
baryon - gluon resonance

Meson-*qqq* quasi-molecular states

(Coupled-channel analysis by N. Kaiser et. al. NPA612(1997)297)K

K-p elastic, inelestic scattering
photo-meson(η,*K*) production
pion induced meson(η,*K*) production

low energy cross section
baryon structure

$S_{11}(1535)$, $\Lambda(1405)$: quasi-bound states of $\bar{K}N$ and $K\Sigma$

Other candidates?

Candidates of η-*qqq* quasi-molecular states (simple model)

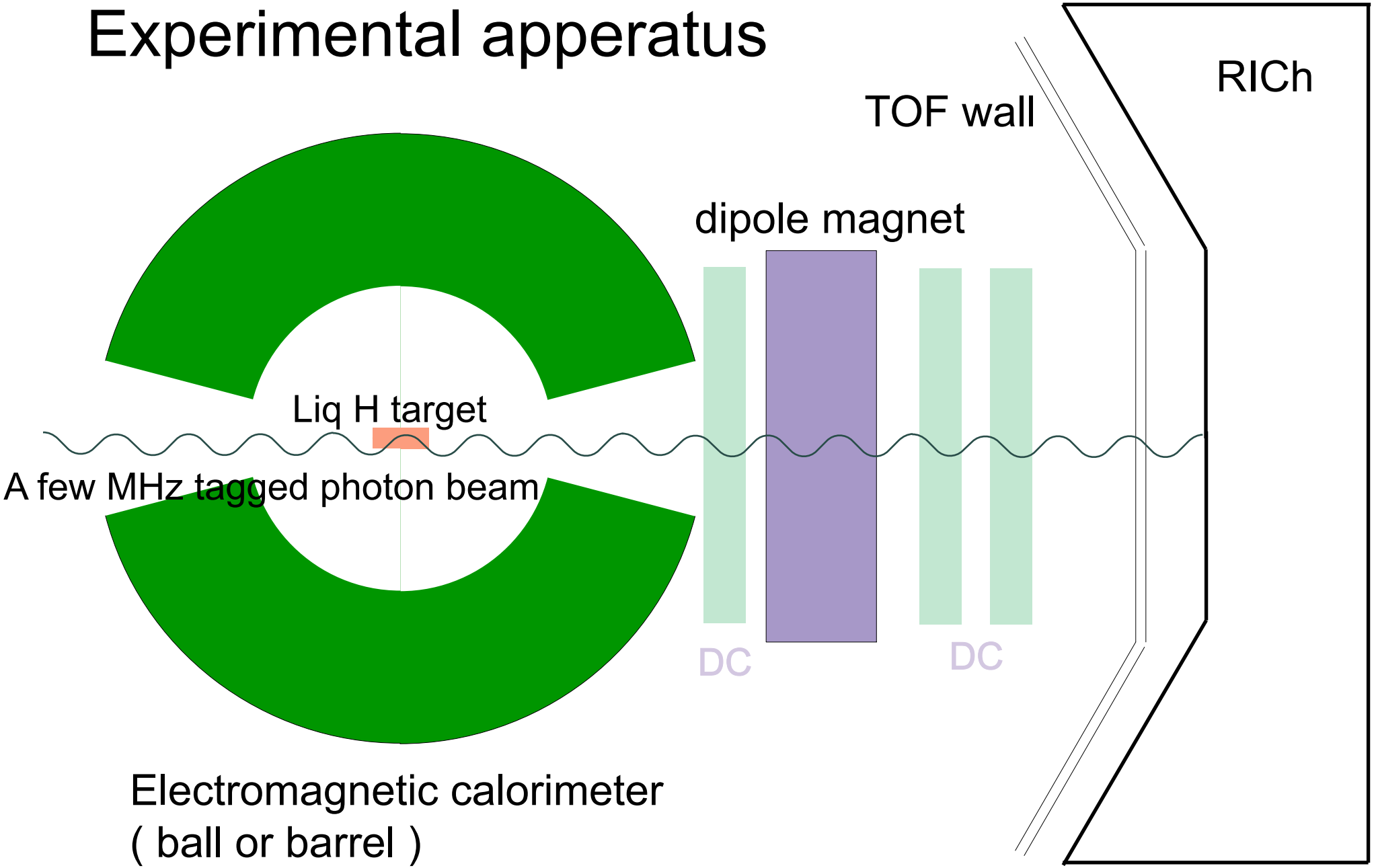
$M_{qqq\text{-}\eta} = M_B + M_\eta + \varepsilon$,

- $\varepsilon = \varepsilon_0$ + spin, iso-spin dependent terms (+20 MeV)

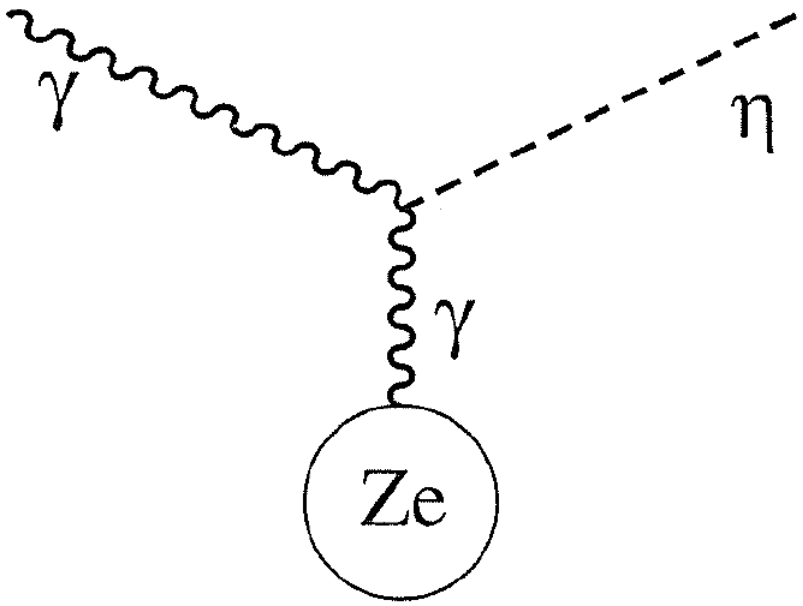
	M(th)	Mass	Width	$N\eta$ branch	status
$N(1535)S_{11}$	1506	1520 - 1555	~ 150	0.35 - 0.55	****
$\Lambda(1670)S_{01}$	1683	1660 - 1680	25 - 50	0.1 - 0.25	****
$\Sigma(1750)S_{11}$	1756	1730 - 1800	60 -160	0.15 - 0.55	***
$\Xi(++++)S_{11}$	1885	-	-	-	no exp
$\Delta(++++)P_{33}$	1800+α	-	-	$\Delta^* \rightarrow \Delta\eta$	no exp

Mass, Width, Photoexcitation amplitude ?
by using $(\gamma, K^+\eta)$, $(\gamma, K^+K^+\eta)$, $(\gamma, \eta\pi)$ reaction

Experimental apperatus



Primakoff(Coulomb) process



$$\frac{d\sigma^c}{d\Omega} = 8\,\alpha\,\Gamma\gamma\gamma\,Z^2\,\frac{\beta^3 E^4}{\mu^3}\,\frac{|Fc(Q)|^2}{Q^4}\sin^2\theta$$

α : fine structure constant
β, μ, θ : velocity, mass, angle of η
E : photon energy
Q : four momentum transfer
Z : target charge
Fc(Q) : target charge form factor
$\Gamma\gamma\gamma$: $\eta \rightarrow \gamma\gamma$ decay width

nuclear coherent incoherent

$$\frac{d\sigma^{all}}{d\Omega} = a_c \frac{d\sigma^c}{d\Omega} + a_{coh} \frac{d\sigma^{coh}}{d\Omega} + (a_c\, a_{coh})^{1/2} \frac{d\sigma^{int}}{d\Omega} + a_{incoh} \frac{d\sigma^{incoh}}{d\Omega}$$

Coulomb interference

$\Gamma\gamma\gamma$ from inverse reaction

$$e^+e^- \rightarrow e^+e^- \gamma^*\gamma^* \rightarrow e^+e^- \eta, \pi^0$$

Process	$\Gamma\gamma\gamma(\pi^0)$ (eV)	$\Gamma\gamma\gamma(\eta)$ (keV)
Inverse	7.7 +- 0.6	0.51 +- 0.03
Primakoff	8.02 +- 0.42	0.32 +- 0.05
status	agree	>30 % discrepancy

Uncertainties

- Bremsstrahlung spectrum ~ 12%
- F(Q), interference estimation ~ 2.5%

Tagged photon beam experiment

Cross section and more

Target : ^{89}Y
Detection angle : 1 deg
Charge form factor : experimental value

$$\frac{d\sigma^c}{d\Omega}$$ ~ □100 pb/sr□□ for 1 GeV
□ 100 μb/sr□□ for 3 GeV
□ 200 mb/sr□ for 8 GeV

Requirement
- □ ・Ultra-forward (less than 5 deg) angle
- □ electro-magnetic calorimeter
- □ ・Clean (low emittance) tagged photon beam