

Photoproduction of the $b_1(1235)$ meson on the proton at $E=6-12$ GeV at the GlueX Experiment

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Faculty of
Science

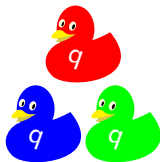


NSERC
CRSNG

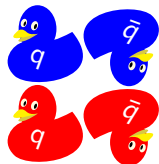
Quark Model



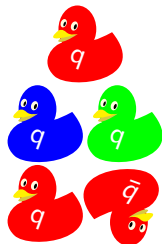
Meson



Baryon



Tetraquark



Pentaquark

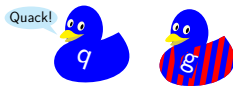
Exotics



Hybrid



Glueball

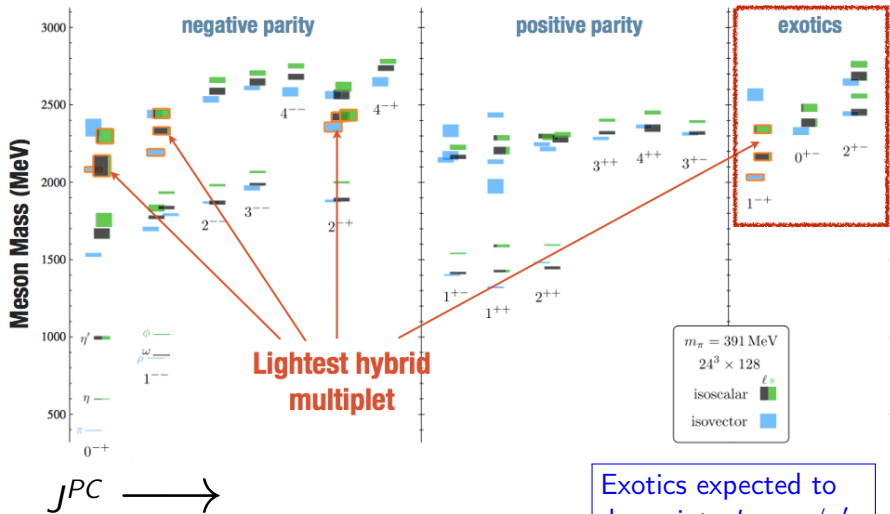


Quark

Gluon

Lattice QCD Predictions¹

$$\gamma \text{ Beam} \rightarrow J^{PC} = 0^{-+}, 1^{+-}, 2^{-+}, \boxed{0^{+-}, 1^{-+}, 2^{+-}}$$



¹Dudek et al. PRD 88 (2013) 094505.

Motivation & History for the b_1 meson

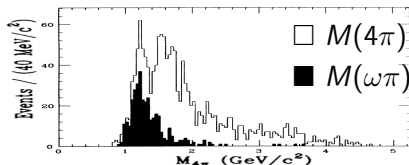
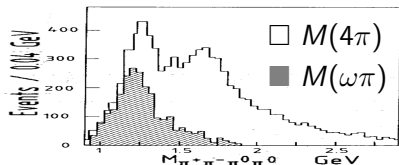
Motivation

Exotics $\pi_1(1600)^a$, $\pi_1(2015)^b$, $h_0(2400)$, $b_2(2500)$ could potentially decay to $b_1\pi$ which decays dominantly through $b_1 \rightarrow \omega\pi$. Precise measurement of the π_1 requires understanding the decay of the b_1 meson.

^aReported by E852, VES, COMPASS and CBAR

^bReported by E852

History of the $b_1(1235)$ Photoproduction (from the 1980s)



Invariant mass of $\pi^+\pi^-\pi^0$ and $\omega\pi^0$ from the Omega-Photon [1] (right) and SLAC-H-Photon experiments [2] (left).

Outline

$b_1(1235)$

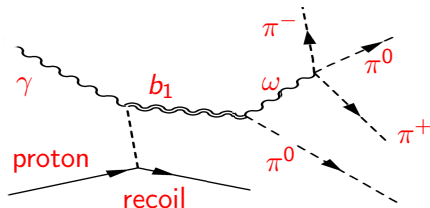
Flavorless meson

nomenclature: "b" a meson of spin zero and odd orbital angular momenta. The subscript is the total angular momenta of the $q\bar{q}$ system.

$b_1(1235)$	$J^{PC} = 1^{+-}$
Mass	1229.5 ± 3.2 MeV ($S = 1.6$)
Width	142 ± 9 MeV ($S = 1.2$)

Outline

- Invariant mass.
- Angular distribution.
- Total cross-section.
- Mandelstam-t dependence.
- Van Hove cut.



Event Selection

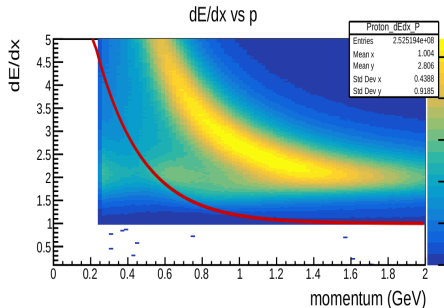
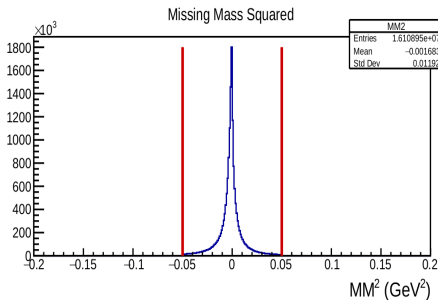
$$\gamma p \rightarrow pb_1(1235) \rightarrow p\omega\pi^0 \rightarrow p + \pi^+ + \pi^- + 2\pi^0$$

All Particles Detected

π^0 formed in the range [0.08,0.19] GeV.

$\sim 23 \times 10^6$ triggers (2016-2017)

Two sample cuts

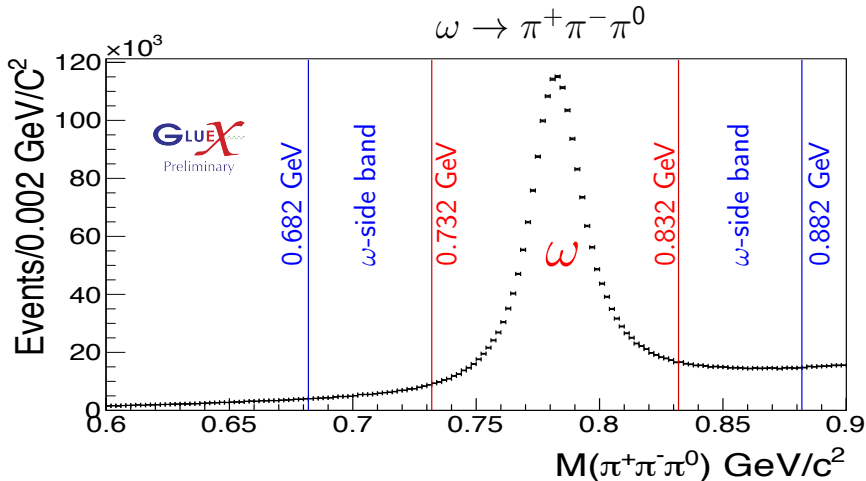


and many more cuts, most loose, then Kin fitter

ω -Side band (background under its peak)

$$0.732 < M(\omega) < 0.832 \text{ GeV}/c^2$$

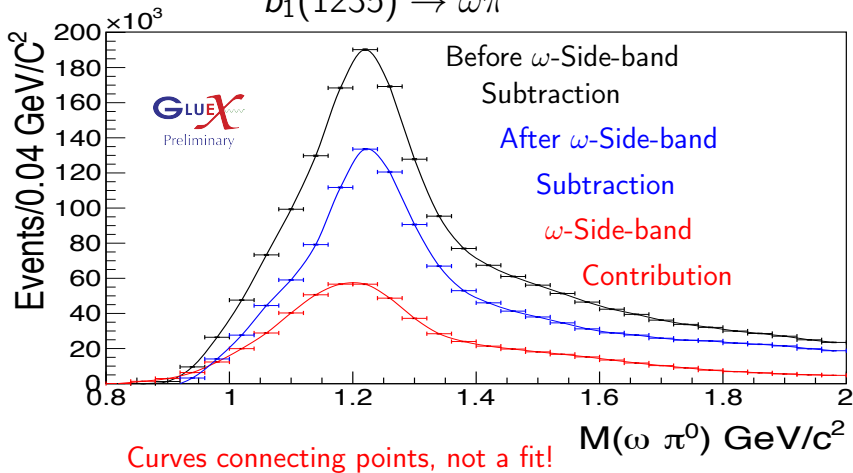
Vertical error bars within marker size.



$M(\omega\pi^0)$ ω -Side band Subtracted

$$0.732 < M(\omega) < 0.832 \text{ GeV}/c^2$$

$$b_1(1235) \rightarrow \omega\pi^0$$



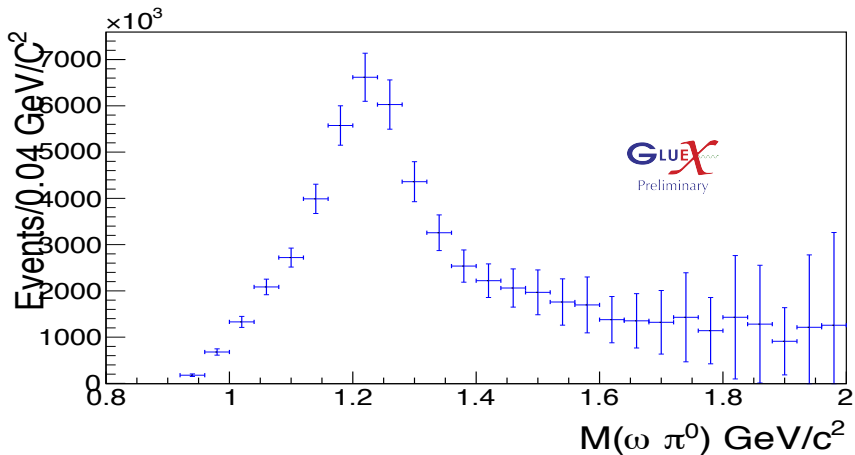
Monte-Carlo Simulation

- Moment analysis model used by previous experiments ^a.
- A basis set of 25 orthogonal moments.
- A set of 22 parameters obtained by fitting the data.
- Generating resonances with $J^P = 1^\pm, 0^-$.
- Sample used in this report: 5M events.
- MC subjected to same cuts as data.

^aOmega Photon Collab. M. Atkinson et al., Nucl.Phys. B243, 1-28, (1984).
SLAC-H Collab. J. E. Brau et al., Phys. Rev. D V37, (1988).

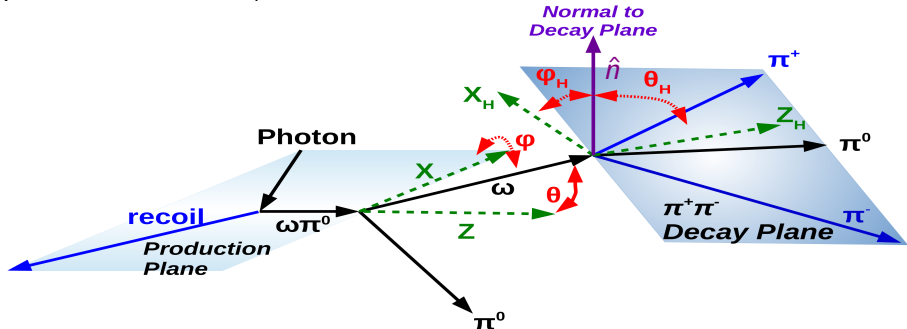
$M(\omega\pi^0)$ Acceptance Corrected

Blue curve from slide (9) with acceptance correction.



$\omega\pi^0$ Helicity Frame

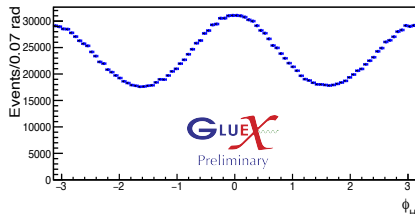
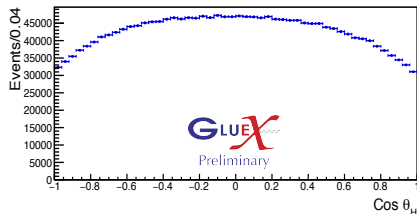
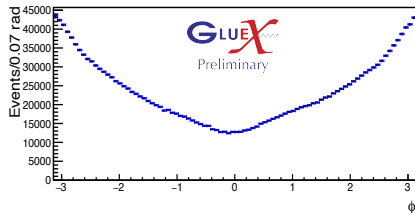
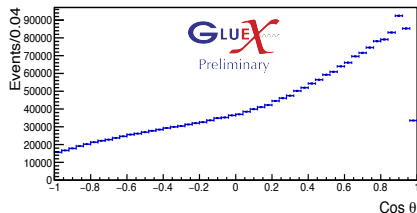
Angles (θ, ϕ) describe the direction of the ω meson in the b_1 helicity frame. Angles (θ_H, ϕ_H) describe the direction of the normal to the decay plane \hat{n} in the helicity frame of the ω meson.



Partial Wave Amplitude (PWA) analysis expands the resonance into a series of spin and parity states. **Spin-Density Matrix Elements (SDMEs)** analysis expands the resonance into density matrix elements. **Moments analysis** projects the resonance on a set of spherical harmonics.

Angular Distribution

Not corrected for acceptance.
 $1.185 < M(\omega\pi^0) < 1.285 \text{ GeV}/c^2$

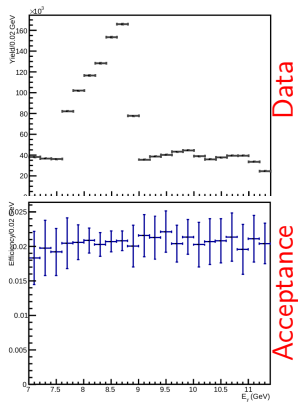
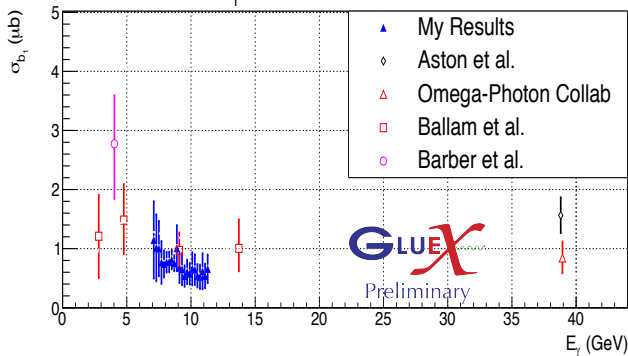


Total Cross-section for $b_1(1235)$

$$\sigma = \frac{N}{\text{Acceptance} \times N_\gamma \times \text{Target Thickness} \times BR}$$

$$BR = BR(b_1 \rightarrow \omega\pi^0) \times BR(\omega \rightarrow \pi^+\pi^-\pi^0) \times [BR(\pi^0 \rightarrow 2\gamma)]^2$$

b_1 Total Cross-Section



Comparing total cross-section results with previous experiments.
 Error bars represent only statistical error. Systematic studies to follow.

Summary & Future Work

- **GlueX** experiment is designed to map the meson spectrum and search for exotics. The $b_1(1235)$ meson is an important part of measuring the lightest hybrid multiplet.
- **Current Analysis:**
 - Invariant mass.
 - Mandelstam-t distribution.
 - Decay and production plane angles.
 - Total Cross-section.
 - MC set size is currently limiting. A larger set will become available soon.
- SDMEs could be calculated as a sum of moments which we can now extract.
- I am working on a new amplitude generator to allow extracting PWAs.

Thank You!