$^{13}C(\pi^+,\pi^-)$ **1993Wa07**

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1980Bu15: $^{13}C(\pi^+,\pi^-)$ E=180 MeV, θ=5°, measured $\sigma(\theta)$ and Q. Used the Energetic Pion Channel and EPICS spectrometer to separate pions.

1984Se15, 1985SeZY: $^{13}C(\pi^+,\pi^-)$ E=164, 292 MeV, measured $\sigma(E(\pi),\theta)$, missing mass spectrum. Used a 90% isotopic pure ^{13}C target. Normalized yields with $^1H(\pi^+,\pi^+)$ at 50° and compared with phase-shift anlaysis. Found $\Delta E \approx 0.9$ and 0.5 MeV FWHM resolution of missing mass spectra for thick and thin targets. The pions were separated using the EPICS spectrometer. Deduced ^{13}O levels. Excited state peaks appear significantly narrower than the ground state peak, which is surprising. The energies of the observed peaks appear to be shifted lower by $\approx$300 keV when compared with (1993Wa07), while the g.s. seems to have a high-energy tail. The ground state and other levels are reported at E_x=2.75 MeV 4, 4.21 MeV and 6.02 MeV 8.

1989Mo09: $^{13}C(\pi^+,\pi^-)$ E=292 MeV, θ=5°, measured $\sigma(\theta)$. ^{13}O deduced GDR built on IAS.

1990Gl09: $^{13}C(\pi^+,\pi^-)$ E=132 MeV, compiled data.

1990Mo02: $^{13}C(\pi^+,\pi^-)$ E=292 MeV, θ=5°, measured $\sigma(\theta)$. ^{13}O deduced GDR built on IAS. 90% enriched ^{13}C target.

1991Mo02: $^{13}C(\pi^+,\pi^-)$ E=292 MeV, θ=18°, measured $\sigma(\theta(\pi),E(\pi))$. 90% isotopic pure ^{13}C target. ^{13}O deduced giant resonances, Γ, ISPIN.

1993Wa07: $^{13}C(\pi^+,\pi^-)$ E=140-295 MeV, measured $\sigma(\theta)$ vs E using EPICS at LAMPF. 90% isotopic pure ^{13}C target. Deduced levels, Γ, configurations from mising mass spectra. Analyzed level structures at E_{π^+}=140, 180, 220, 260, 295 MeV. The ground state and other levels are reported at E_x=3.10 MeV 7, 4.50 MeV 9, 6.10 MeV 9 and 8.7 MeV 2. The ground state width is reported at Γ=0.40 MeV 6, even thought the state is known to have Γ<<1 eV. Other widths for the excited states are reported as Γ=0.6 MeV 4, 0.6 MeV 4, 0.6 MeV 4 and 3.1 MeV 5, respectively.

1994Mo04, 1994Mo44: $^{13}C(\pi^+,\pi^-)$ E=295 MeV, compiled, reviewed $\sigma(\theta)$. Deduced GDR excitation.

1996Mo03: $^{13}C(\pi^+,\pi^-)$ E=140-295 MeV, θ=18° measured $\sigma(\theta)$. Analyzed various results.

See theoretical analysis in (1991Ku07).

Discussion: The level structures observed in $^{13}C(\pi^+,\pi^-)$ are best resolved in (1984Se15), though they did not report uncertainties for some of their results. On the other hand, (1993Wa07) also utilized EPICS at LANSCE for their measurement, and they did report experimental uncertainties, but they reported rather unreliable width values such as $\Gamma_{g.s}$=400 keV 60. A further complication is that the reported excitation energies of (1984Se15) are systematically lower than those in (1993Wa07) suggesting the data sets should not simply be averaged. We select the excitation energies and widths of (1984Se15) for the lower-lying states since they appear better resolved, and we note that (1993Wa07) was focused on the E_x=8.7 MeV GDR⊗IAS resonance.

^{13}O Levels

E(level)†	J^{π}	$\Gamma^{\dagger}$	Comments
0	$(3/2^-)$		E(level): Q(g.s)=−18.9 MeV 1 (1993Wa07,1991Mo02). Γ: The value Γ=400 keV 60 is reported in (1993Wa07), but this would imply a particle unbound level.
2.75×10^3 4			Γ: NARROW. E(level): From E_x=2.75 MeV 4 in (1984Se15). See also E_x=3.10 MeV 9 from Q=−22.0 MeV 6 (1993Wa07). Γ: In (1984Se15) a peak with a narrower width than the g.s. is observed; subsequent results from (2021Ch45) $^9Be(^{13}O,^{13}O)$ support the existence of narrow states ($\approx$50 keV) in this region. The other width reported for this state is Γ=0.60 MeV 40 (1993Wa07).
4210	$(1/2^-)$		E(level): From (1984Se15). See also E_x=4500 keV 90 from Q=−23.4 MeV (1993Wa07). J^{π}: Based on similarities with $^{12}C(\pi^+,\pi^-)^{12}O$(g.s.) and $^{14}C(\pi^+,\pi^-)^{17}O$(5.9 MeV) (1984Se15). Γ: In (1984Se15) a peak with a similar width to the g.s. is observed. The only width reported for this state in $^{13}C(\pi^+,\pi^-)$ is Γ=0.60 MeV 40 in (1993Wa07).
6020 80		$\approx$1.2 MeV	E(level): From (1984Se15). See also E_x=6.10 MeV 9 from Q=−25.0 MeV 8 (1993Wa07) and see also 5.1 MeV from Q=−24.0 MeV 5 in (1991Mo02).

<u>^{13}C(π^+,π^-)   **1993Wa07** (continued)</u>

<u>^{13}O Levels (continued)</u>

E(level)[†]	Γ[†]	Comments
		Γ: From (1984Se15). The other width reported for this state is Γ=0.60 MeV *40* (1993Wa07).
8.7×10³ *2*	3.1 MeV *5*	E(level),Γ: From Q=−27.6 MeV *2* (1993Wa07). See also Q=−27.7 MeV *5* and Γ=3.0 MeV *6* (1991Mo02), and Q=−27.4 MeV *5* and Γ=2 MeV *1* (1989Mo09). Suggested GDR⊗IAS resonance.

[†] From (1984Se15).

<u>^{13}C(π^+,π^-)   **1993Wa07** (continued)</u>