Experimental studies of the $\Lambda(1405)$

physics654 – Seminar on exotic multi-quark states

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Motivation

What is special about the $\Lambda(1405)$?

- its mass does not fit well into constituent quark models which do predict baryon masses well for other baryons
- invariant mass distribution (line shape) differs significantly from usual Breit-Wigner shapes
- candidate for an exotic multiquark state (bound system of $\overline{K}N$) since its mass lies just below threshold

There are (very) many different theoretical approaches to explain this behavior
$\rightarrow$ There is need for more experimental data!

some plots/pictures?

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Continuous Electron Beam Accelerator Facility (CEBAF)

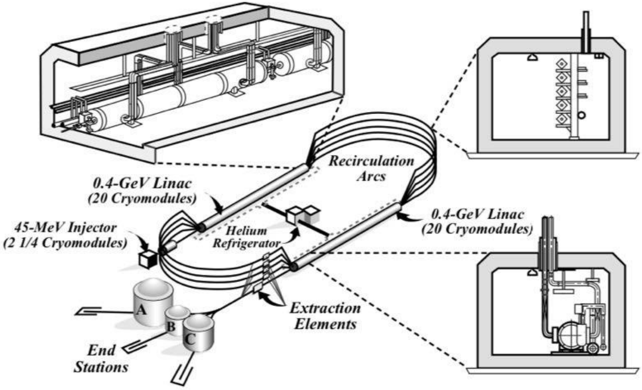

Figure 1: CEBAF layout at Jefferson Lab, [Mecking et al. 2003]

CEBAF Large Acceptance Spectrometer (CLAS)

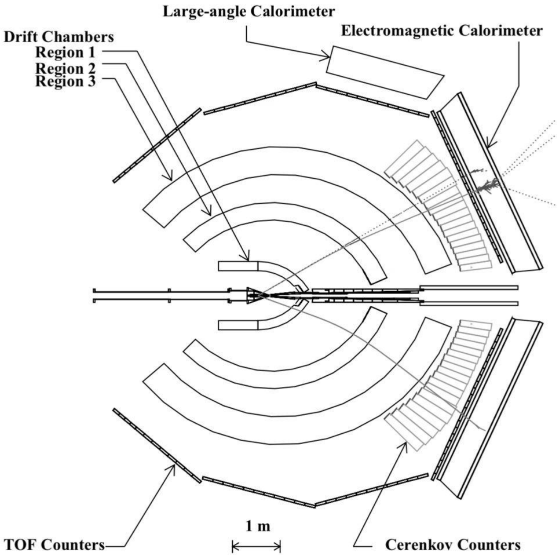

Figure 2: CLAS layout at Jefferson Lab, [Mecking et al. 2003]

Theoretical basics

The $\Lambda(1405)$ is so far (mostly) assumed to have $J^P = \frac{1}{2}^-$, but this has not been determined experimentally

Measuring spin

- consider the strong decay $Y^* \to Y\pi$, with J^P the spin and parity of Y^*
- the $Y\pi$ angular distribution will only depend on J

$$
\begin{aligned}
I(\theta_Y) &= \text{const.} && J = 1/2 \\
I(\theta_Y) &\propto 1 + \frac{3(1-2p)}{2p+1}\cos^2\theta_Y && J = 3/2,
\end{aligned}
$$

where θ_Y is the polar angle of the decay direction of Y in the Y^* rest frame, p describes the fraction of spin projections along the z axis

- uniform decay pattern is best evidence for spin $J = 1/2$

[Moriya et al. 2014]

1. Experimental setup
2. Spin-parity measurement
3. Line-shape measurement
4. Conclusion