Precision Measurement of the η Mass at COSY

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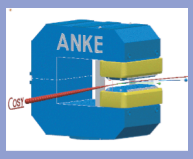
Supported by the COSY-FFE program



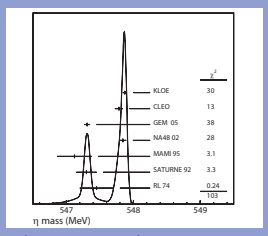
Motivation

$$
\begin{array}{lcllcll}
m_\eta^{SATN} & = & 547.3 & \pm & & \pm & 0.15_{total} \quad \mathrm{MeV/c^2} \\
m_\eta^{NA48} & = & 547.843 & \pm & 0.030_{stat} & \pm & 0.041_{syst} \quad \mathrm{MeV/c^2} \\
m_\eta^{GEM} & = & 547.311 & \pm & 0.028_{stat} & \pm & 0.032_{syst} \quad \mathrm{MeV/c^2} \\
m_\eta^{KLOE} & = & 547.874 & \pm & 0.007_{stat} & \pm & 0.031_{syst} \quad \mathrm{MeV/c^2} \\
m_\eta^{CLEO} & = & 547.785 & \pm & 0.017_{stat} & \pm & 0.057_{syst} \quad \mathrm{MeV/c^2} \\
m_\eta^{MAMI} & = & 547.76 & \pm & 0.10_{stat} & \pm & 0.07_{syst} \quad \mathrm{MeV/c^2}
\end{array}
$$

KLOE unpublished
MAMI preliminary

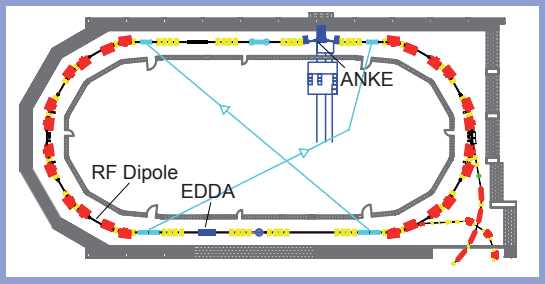
A precise knowledge of the η-mass is relevant for various fields of particle physics. However, the current data base on the η-mass is inconsistent with respect to the quoted uncertainties (see left). Therefore, a precision measurement using the two-body reaction d+p→^{3}He+η will be performed at COSY-ANKE.

The idea of this experiment is to identify the reaction threshold (Q=0) as function of the deuteron beam momentum with high accuracy. With the new possibility at COSY to determine the absolute beam momentum with high quality, the η mass can be measured with high precision.

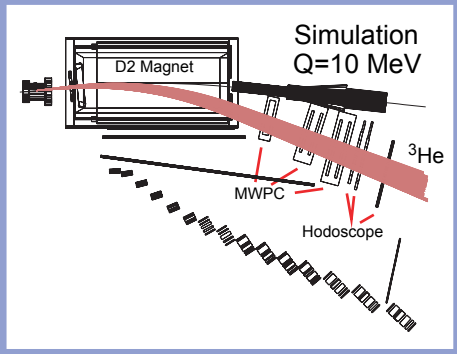


http://arxiv.org/abs/0707.4616

Experimental Setup



The reaction d+p→^{3}He+η will be investigated at the ANKE spectrometer, located at the COSY synchrotron (left).
The ^{3}He-nuclei can be identified using the forward part of the ANKE detector setup, which consists of the spectrometer magnet D2, three MWPCs and three layers of scintillation hodoscopes (right). This setup provides full acceptance over the whole excess engergy range (Q=-5 MeV to 10 MeV) of interest. The η-meson will subsequently be identified via the momentum determination of the ^{3}He-nuclei and the missing mass technique.

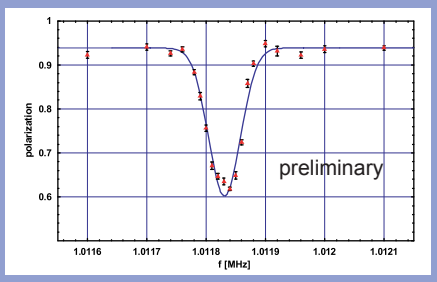


Determination of the Beam Momentum

Using a polarized deuteron beam, a spin resonance can be induced by an rf dipole or rf solenoid.
The number of spin precessions of a circulating beam particle in a storage ring is given by: $\nu_s = G \cdot \gamma$
The vertical polarization can be distorted by a horizontal rf magnetic field. For a beam circulating with f_0 the spin flip resonance frequencies are: $f_{res} = f_0(k \pm \nu_s), \quad k = 0, 1, 2...$

This leads to $\gamma = \frac{1}{|G|} \cdot \left(1 - \frac{f_{res}}{f_0}\right)$

Measurements performed recently at COSY (October 23th, 2007)

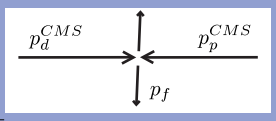


γ = 1.93906 ± 0.00004
p_d = 3.11598 ± 0.00009 GeV/c

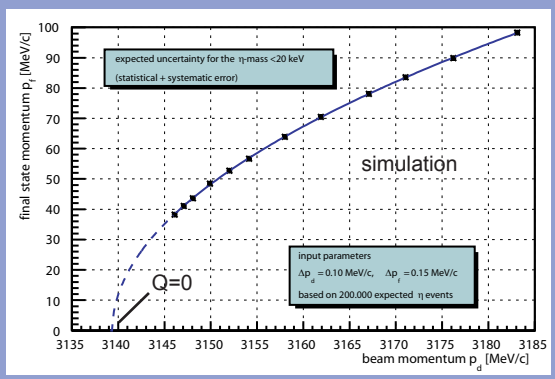
Extraction of the η Mass

For the two-body reaction d+p→ ^{3}He+η the relation between the final state momenum p_f and the center-of-mass energy is given by:

$$\sqrt{s}(p_d) = \underbrace{\frac{p_f^2(p_d, m_\eta)}{2 \cdot m_{\mathrm{red}}}}_{Q} + m_{^3\mathrm{He}} + m_\eta$$



at threshold (Q=p_f=0): $m_\eta = \sqrt{s} - m_{^3\mathrm{He}}$



all uncertainties based on previous measurements

Summary and Status

It is possible to measure the η mass using the reaction d+p→ ^{3}He+η with a precision in the order of 20 keV at COSY-ANKE. The beam momentum can be determined with high precision using the spin resonance method. Subsequently, the η mass can be measured via the determination of the reaction threshold.

The discussed measurements are currently running (March '08!) with three weeks of scheduled beam time.
The results will shed new light on the η mass situation and the question:

m_η = 547.3 MeV/c^2 or m_η = 547.8 MeV/c^2 ?