η-meson radiative decay width measurement

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Introduction

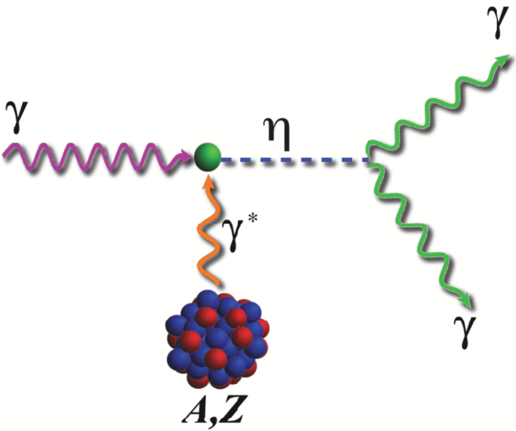
The SRC data set can be used to:

- Measure FCAL angular resolution by observing the Primakoff photoproduction of π^0
- Check if this measurement is possible with a Carbon target

But, the SRC data set cannot be used for a precise measurement

Measurement of the η radiative decay width

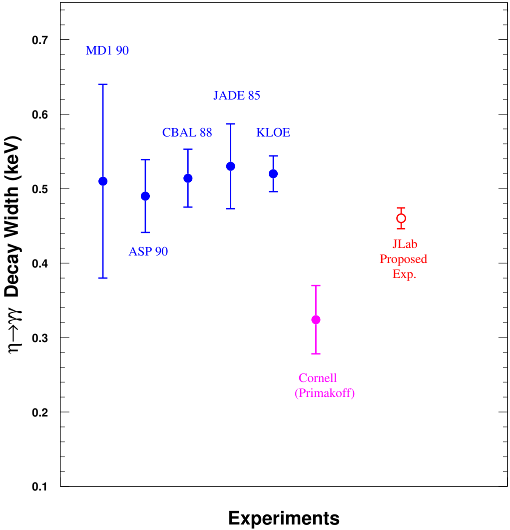
Via the Primakoff proceess



Primakoff photoproduction of an η-meson off a nucleus

PrimEx-eta experiment

Goal, 3.2% uncertainty: 1% statistical error and 3% systematic error

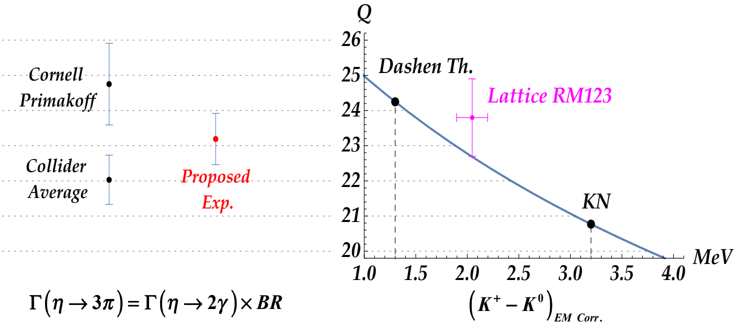


- Extraction of the η–η' mixing angle
- Impact on all other η partial decay and in particular $\eta \rightarrow 3\pi$
- Improve theoretical calculation of Hadronic Light-by-Light $(g-2)_\mu$

Sensitive probe to low-energy QCD

Precision determination of the quark mass double ratio Q

$\eta \to 3\pi$ decay used as input into Q calculation eg



- Primakoff (Browman et al) vs. collider average (Tanabashi et al)
- Kaon mass difference with theoretical estimatation for the electromagnetic corrections (Kastner et al and Giusti et al)

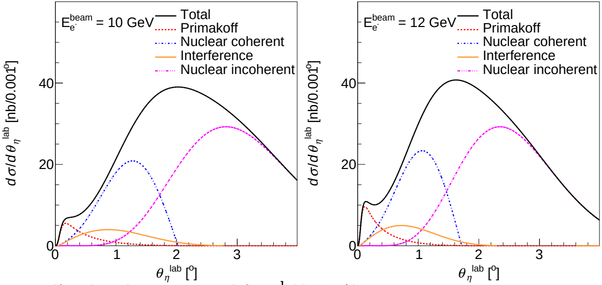
Test Standard Model

$\gamma + {}^4\text{He} \rightarrow \eta + {}^4\text{He}$

Theoretical differential cross-section known:

- $\frac{d\sigma_T}{d\Omega} = \frac{d\sigma_P}{d\Omega} + \frac{d\sigma_{NC}}{d\Omega} + 2\sqrt{\frac{d\sigma_P}{d\Omega}\frac{d\sigma_{NC}}{d\Omega}}\,cos(\phi) + \frac{d\sigma_{NI}}{d\Omega}$
- Primakoff contribution is directly proportional to the $\Gamma_{\eta\rightarrow\gamma\gamma}$ decay width

  $\frac{d\sigma_P}{d\Omega} = \boxed{\Gamma_{\eta\rightarrow\gamma\gamma}} \frac{8\alpha Z^2}{m_\eta^3} \frac{\beta^3 E^4}{Q^4} |F_{e.m.}(Q)|^2 \sin^2(\theta_\eta^{\text{lab}})$
- Expected cross-section for different accelerator electron beam energies ($\text{E}_{\text{e}^-}^{\text{beam}}$) but same:
  - Photon-beam energy ($\text{E}_\gamma^{\text{beam}}$) range relative to $\text{E}_{\text{e}^-}^{\text{beam}}$, $87.5\% \times \text{E}_{\text{e}^-}^{\text{beam}} \leq \text{E}_\gamma^{\text{beam}} \leq 97.5\% \times \text{E}_{\text{e}^-}^{\text{beam}}$
  - $\Gamma_{\eta\rightarrow\gamma\gamma} = 510$ eV and $\phi = 57.5^o$



- Primakoff contribution increases with $\text{E}_\gamma^{\text{beam}} \nearrow$
- Overlap between Primakoff and background (Coherent & Interference) decreases with $\text{E}_\gamma^{\text{beam}} \nearrow$
- But overlap will increase for heavier nuclei

$\gamma + {}^{12}\mathrm{C} \to \eta + {}^{12}\mathrm{C}$

As to be determined but compared to ^{4}He

- Primakoff yield/peak should increases by a factor $(6/2)^2$
- Coherent & Incoherent yield/peak should increases by a factor (12/4)

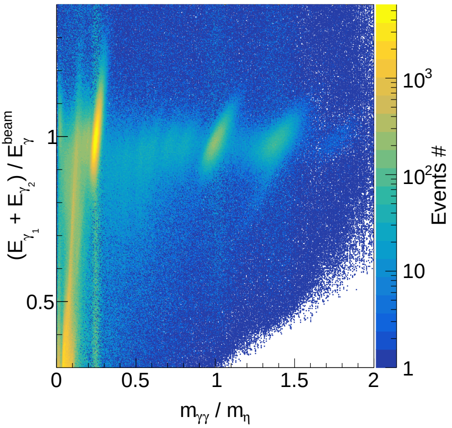
Since ratio between Primakoff peak and Coherent peak is 4 for ^{4}He, one can expect the a ratio of 1 between Primakoff and Coherent peak for ^{12}C

At this stage, systematic error on the integrated luminosity is known while systematic error on the Primakoff η yield has not been studied

$\eta(/\pi^0) \to \gamma\gamma$, selection criteria

Two clusters in Forward Calorimeter:

- Barrel Calorimeter used to veto hadronic backgrounds
- Time-Of-Flight wall used to veto charged particles
- Elasticity required

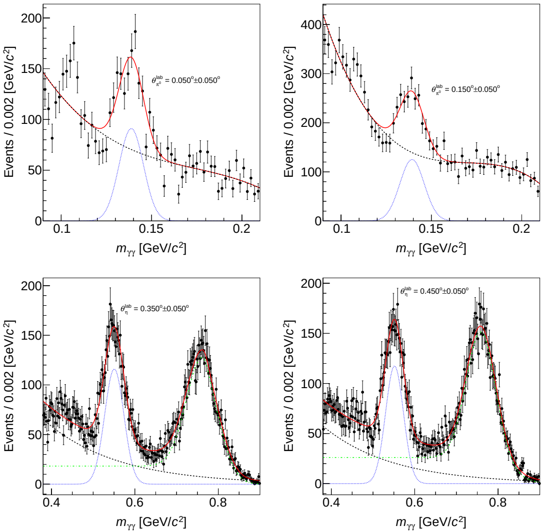


$\gamma_{\text{beam}}{}^{12}\text{C} \to \eta/\pi^{0\,12}\text{C}$ and $\eta/\pi^0 \to \gamma_1\gamma_2$
In Primakoff process, most of the energy is transfered to η-meson
=> $E_\gamma^{\text{beam}} - E_{\gamma_1}^{\text{cluster}} - E_{\gamma_2}^{\text{cluster}} \sim 0$ (elasticity)

Clear signal but includes Primakoff and (in)coherent events, and non-negligible backgrounds (mainly beamline and hadronic)

First look at the data

28638/28672 of the SRC Carbon data set have been analysed, fit not optimized



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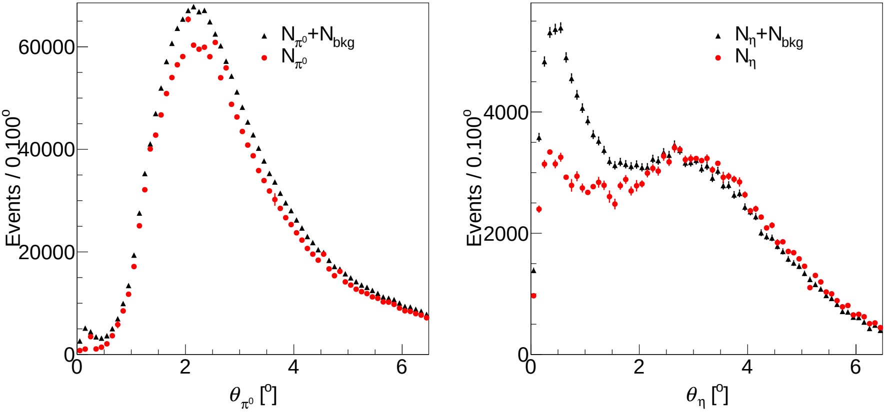
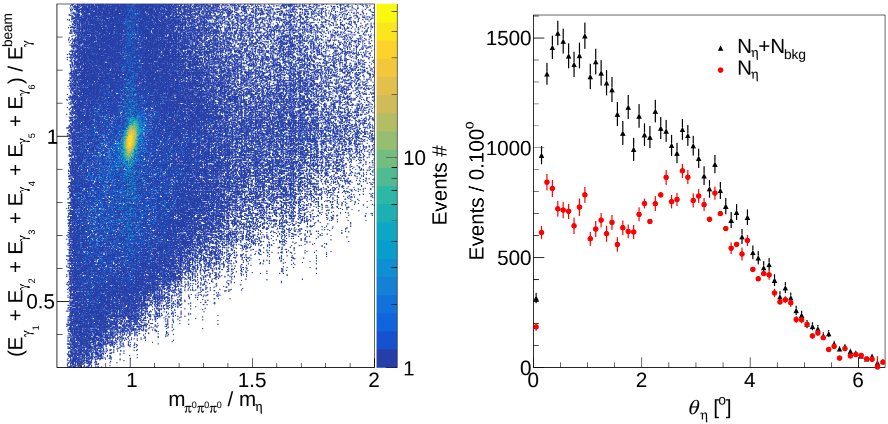


Below 0.2^o, $N_\eta \sim 3450$

Cross-checked of the η yield

Can be done with the $\eta \rightarrow \pi^0\pi^0\pi^0$

- 6 Forward Calorimeters clusters)
- BCAL veto
- Elasticity required



- Yield extracted per theta bin by a fit
- Lower statistic compared to $\eta \rightarrow \gamma\gamma$ but cleaner signal

Conclusion

This data set looks promising