Precision Measurements of the Electromagnetic Properties of Pseudoscalar Mesons at Jlab via the Primakoff Effect

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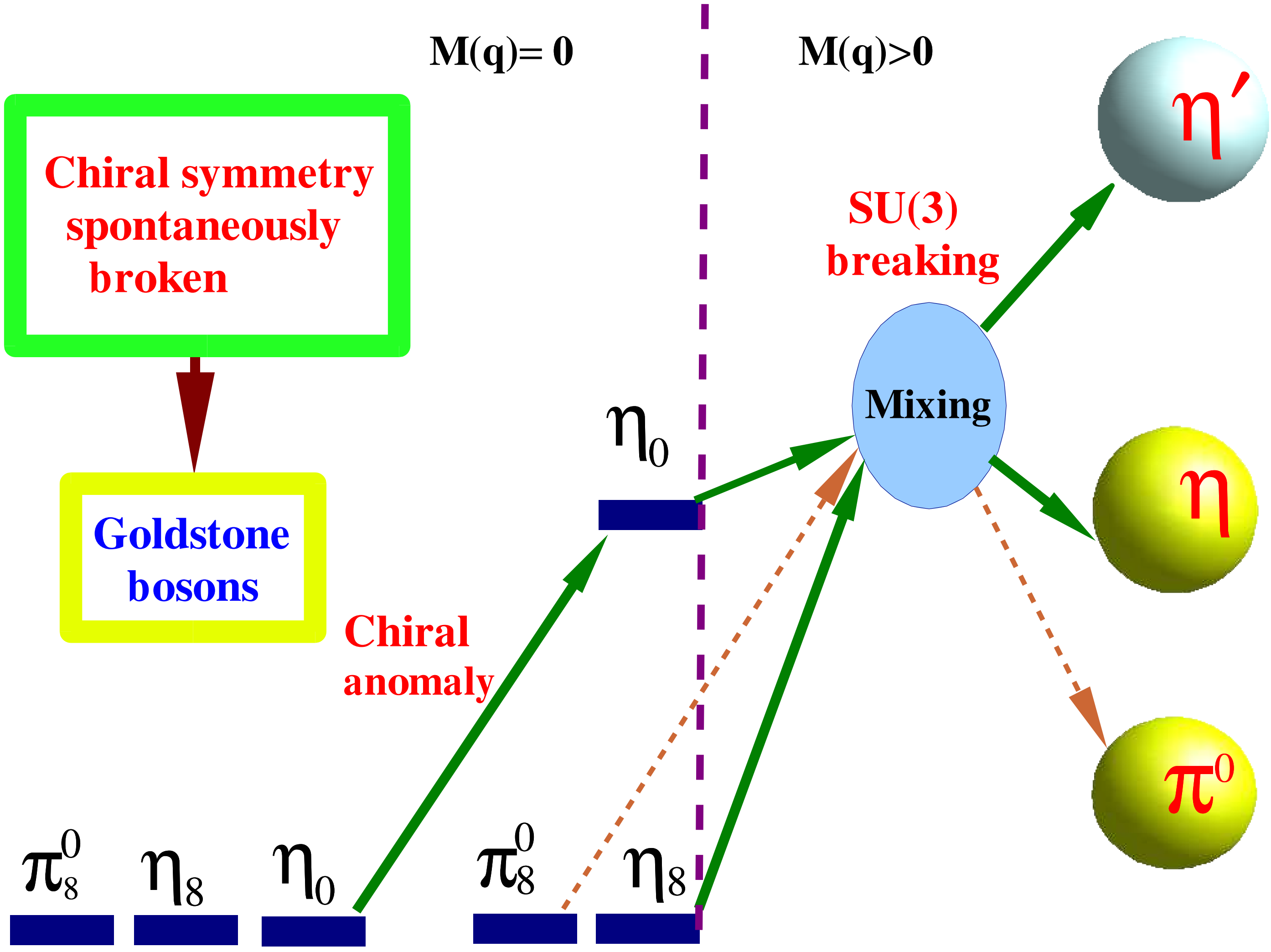
PrimEx Collaboration

Physics Motivation



Chiral anomaly $\Longrightarrow \pi^0, \eta, \eta' \rightarrow \gamma\gamma$

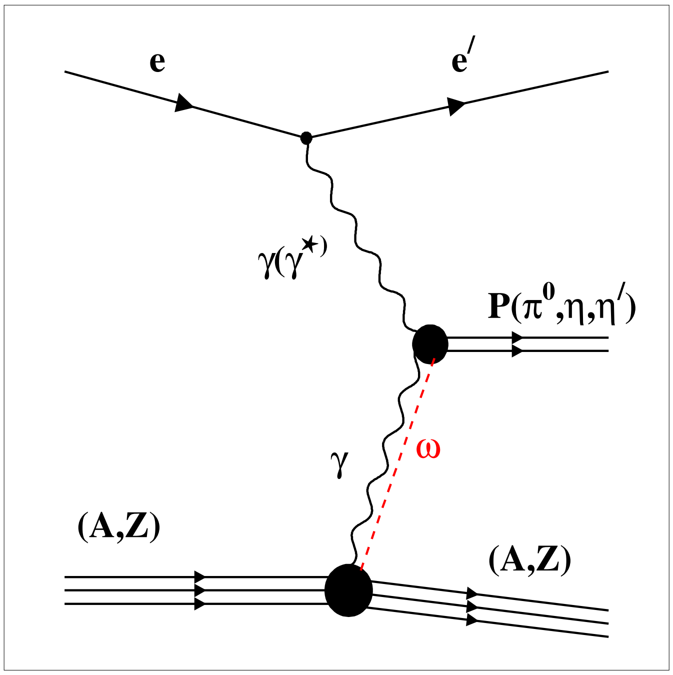
A study of π^0, η, η' meson system provides a powerful tool to understand the fundamental aspects of low energy QCD .

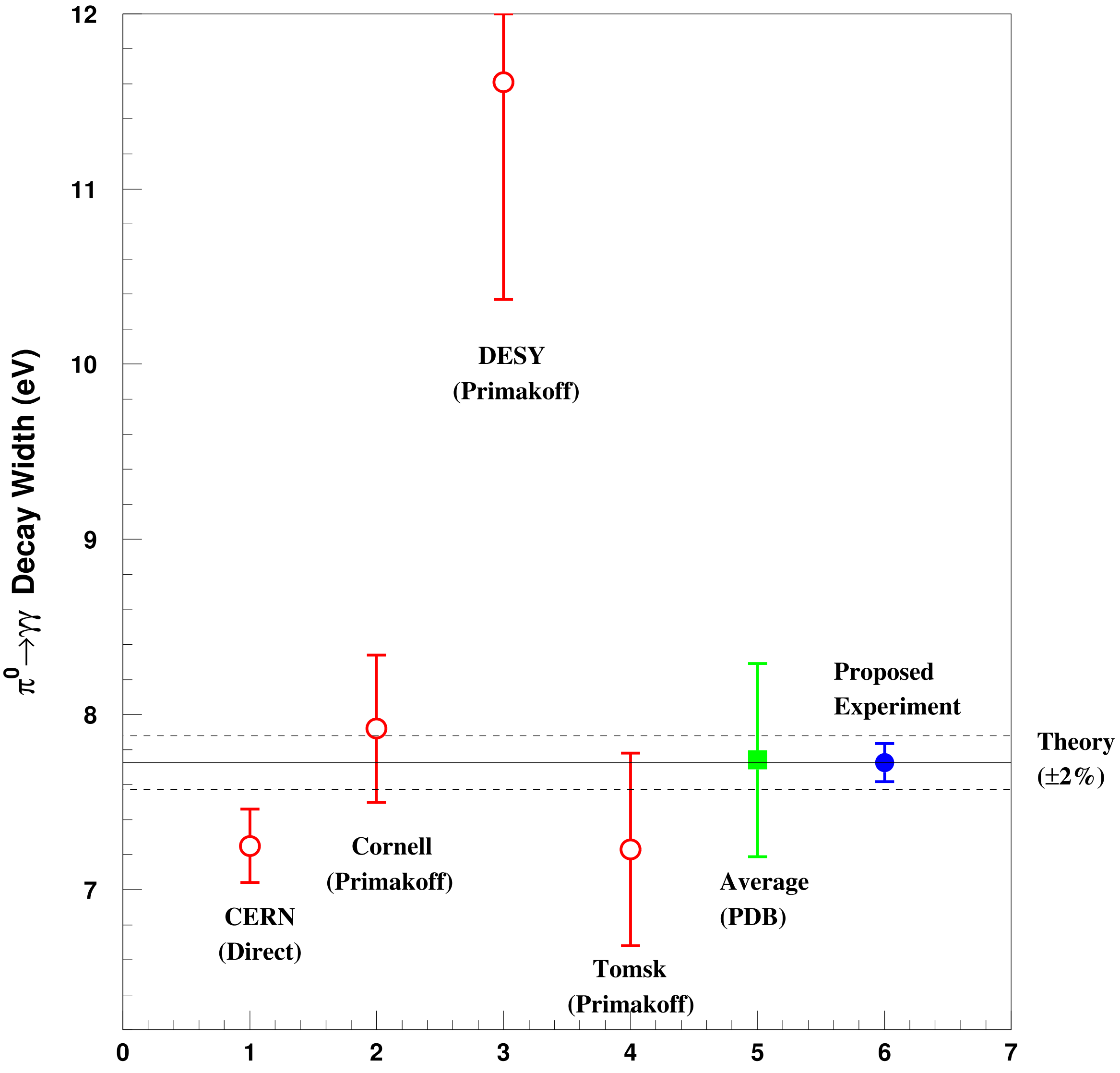
What and how to measure?

High precision measurements of:

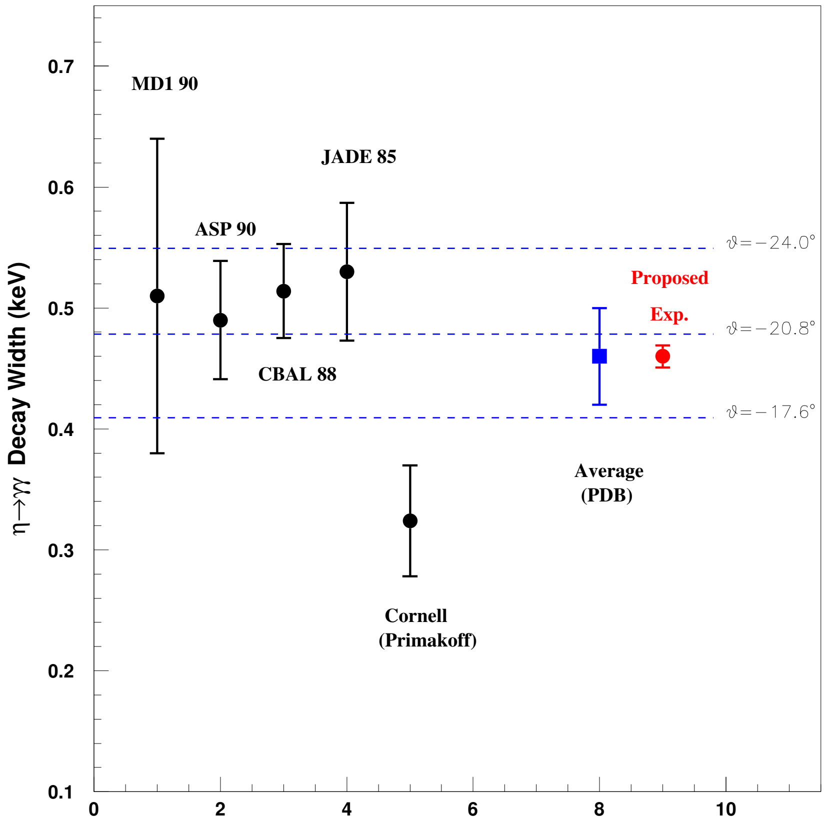
- $\Gamma(\pi^0 \rightarrow \gamma\gamma)$ **at 6 GeV** ($\sim 1.4\%$)
- $\Gamma(\eta \rightarrow \gamma\gamma)$, $\Gamma(\eta' \rightarrow \gamma\gamma)$ **at 12 GeV** ($\sim$ 2–3%)
- **Transition Form Factor** $F_{\gamma\gamma^* P}(Q^2)$ **of** π^0, η, η' **at low** Q^2 **(** **0.001–0.5** GeV^2**)**

through ***Primakoff effect*** **.**

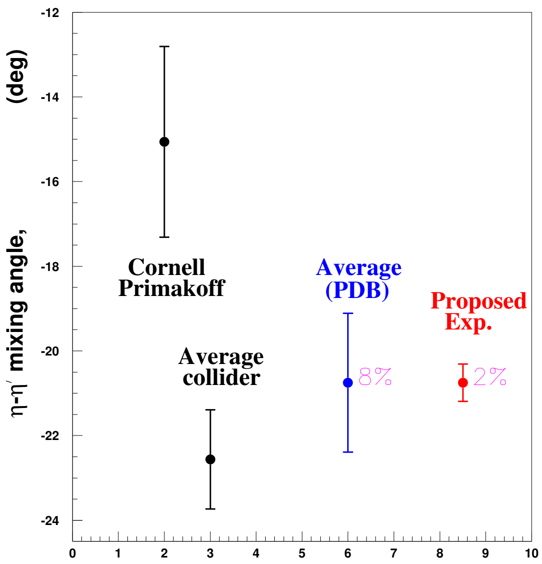




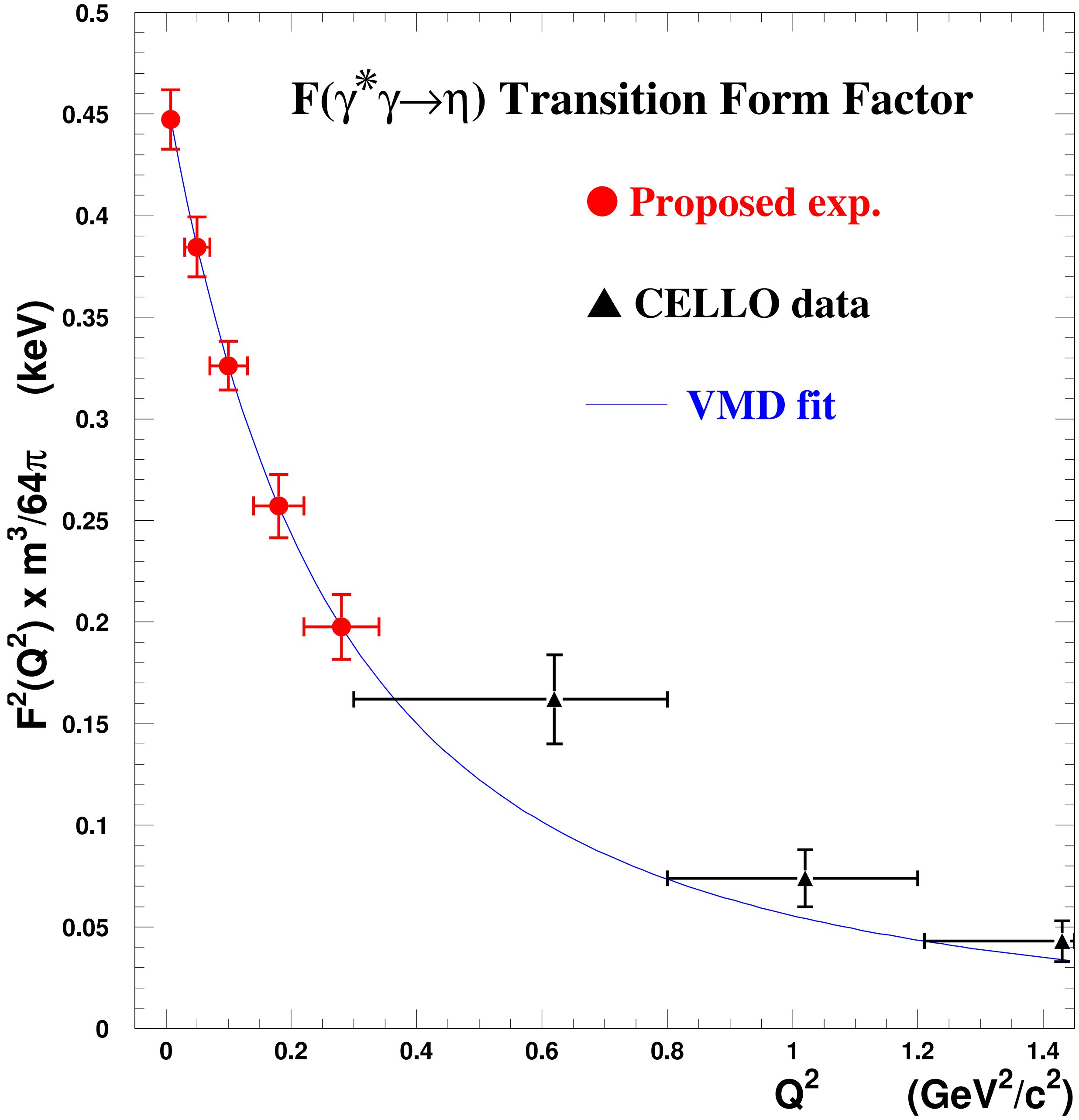
$\pi^0 \rightarrow \gamma\gamma$ Decay Width (eV)
12
11
10
9
8
7
0
1
2
3
4
5
6
7
DESY
(Primakoff)
Proposed
Experiment
Theory
(±2%)
Cornell
(Primakoff)
CERN
(Direct)
Tomsk
(Primakoff)
Average
(PDB)



0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
4
6
8
10
η→γγ Decay Width (keV)
MD1 90
JADE 85
ASP 90
CBAL 88
Cornell
(Primakoff)
Average
(PDB)
Proposed
Exp.
ϑ=−24.0°
ϑ=−20.8°
ϑ=−17.6°



-12
-14
-16
-18
-20
-22
-24
0
1
2
3
4
5
6
7
8
9
10
η-η′ mixing angle, (deg)
Cornell
Primakoff
Average
collider
Average
(PDB)
Proposed
Exp.
8%
2%


F(γ*γ→η) Transition Form Factor
Proposed exp.
CELLO data
VMD fit
F²(Q²) x m³/64π (keV)
Q² (GeV²/c²)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fundamental input to physics:

- **Test chiral anomaly predictions**

$$\Gamma(\pi^0 \rightarrow \gamma\gamma) = \frac{\alpha^2 m_{\pi^0}^3 N_c^2}{576\pi^3 f_\pi^2}$$

- **Determine the η–η' mixing angle and the decay constant $\bar{f}_{\eta 0}$**

- **Determine the slopes of $F_{\gamma\gamma^* P}(Q^2)$ (P: π^0, η, η')**
  $\Longrightarrow$ **electromagnetic interaction radii of π^0, η, η'**
  $\Longrightarrow$ **determine $\mathcal{O}(p^6)$ LEC in Chiral Lagrangian**
  $\Longrightarrow$ **test QCD based models**

- **Improve determination of decay width $\Gamma(\eta \rightarrow 3\pi)$ ($\Gamma(\eta \rightarrow 3\pi) \propto (m_d - m_u)^2$)**

- **Help further understand the role of glue in η'**