Light Meson Decays at BESIII

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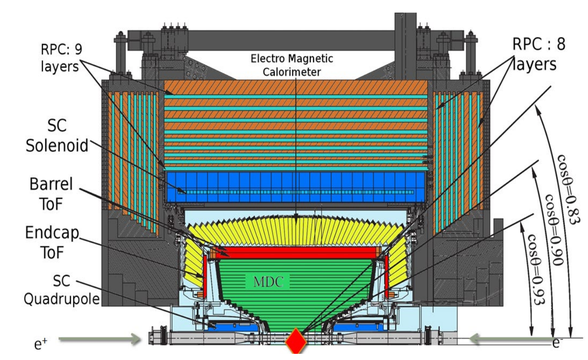
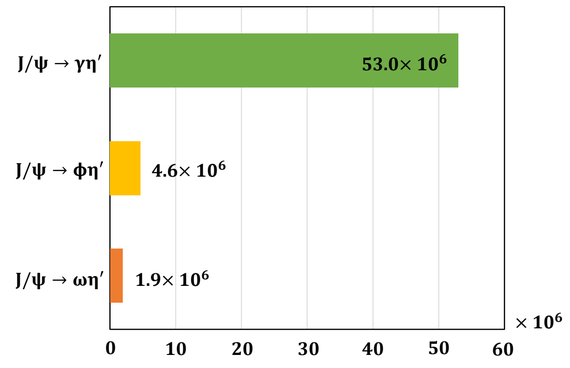
η' Physics

- η' play an important role in understanding the low energy QCD.
- η' decay:
  - Search for processes beyond the Standard Model;
  - Offer unique opportunities to investigate decay dynamics;
  - Probe a wide variety of physics issues: pion-pion scattering, CP-violating asymmetry…
  - Test theoretical model: the vector meson dominance (VMD) models, the non-relativistic effective field theory (NREFT)…

BESIII Experiment at BEPCII

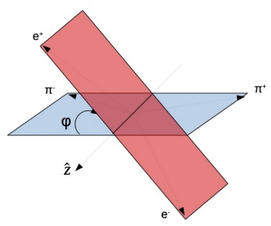
- The BESIII detector[1] records symmetric e^+e^- collisions provided by the BEPCII storage ring.
- $(10087 \pm 44) \times 10^6$ J/ψ events (collected in 2009~2019)

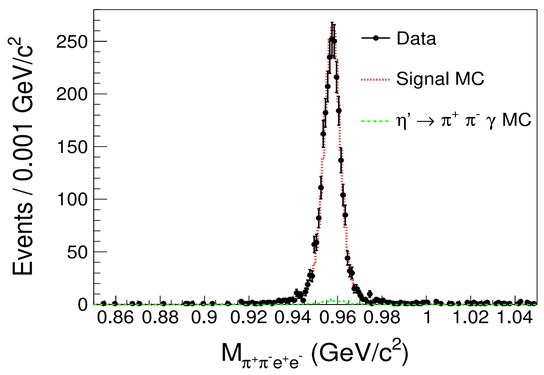




Search for a CP-Violating Asymmetry in $\eta' \to \pi^+\pi^-e^+e^-$

- Possible CP-violating contribution
  - Manifested as asymmetry in angle φ
  - $\mathcal{A}_{CP} = \frac{N(sin2\varphi>0)-N(sin2\varphi<0)}{N(sin2\varphi>0)+N(sin2\varphi<0)} = (2.9 \pm 3.7 \pm 1.1)\%$
- $\mathcal{B} = (2.42 \pm 0.05 \pm 0.08) \times 10^{-3}$





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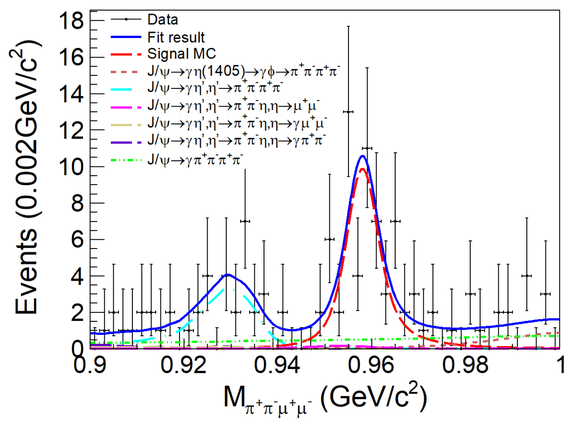
Observation of $\eta' \to \pi^+\pi^-\mu^+\mu^-$

- First observation of $\eta' \to \pi^+\pi^-\mu^+\mu^-$



  - $\mathcal{B} = (1.97 \pm 0.33 \pm 0.18) \times 10^{-5}$
  - Statistical significance: 8σ

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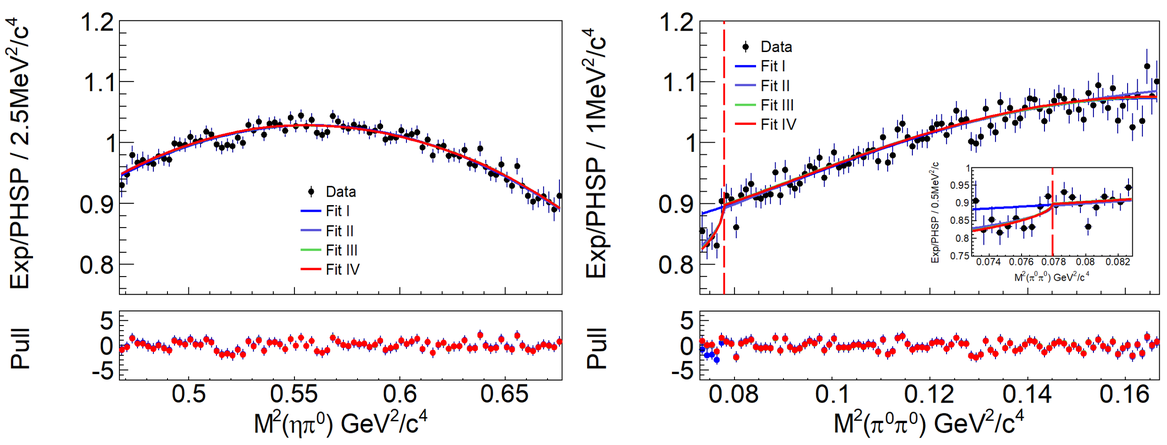
Evidence for The Cusp Effect in $\eta' \to \pi^0\pi^0\eta$

- Evidence for the cusp effect in η'



$$\mathcal{M} = \mathcal{M}^{tree} + \mathcal{M}^{one-loop} + \mathcal{M}^{two-loop} + \cdots$$

■ **Fit I**: Only the tree level contribution is included. (no cusp effect)

■ **Fit II, III, IV**:

- Including the one- and two-loop levels contribution. (have cups effect)
- The $\pi\pi$ scattering length combination:

$$a_0 - a_2 = 0.226 \pm 0.060 \pm 0.012$$

arXiv: 2207. 01004 [hep-ex]

Summary

- Large J/ψ decay sample at BESIII provides an excellent laboratory to study light meson decays.
- Compared with different theoretical predictions:

$\mathcal{B}$	Hidden gauge[2]	VMD[2]	ChPT[3]	BESIII results
$\eta' \to \pi^+\pi^-e^+e^-(10^{-3})$	2.17±0.21	2.27±0.13	$2.13^{+0.17}_{-0.31}$	2.42±0.05±0.08
$\eta' \to \pi^+\pi^-\mu^+\mu^-(10^{-5})$	2.20±0.30	2.41±0.25	$1.57^{+0.97}_{-0.75}$	1.97±0.33±0.18

  - First observation of $\eta' \to \pi^+\pi^-\mu^+\mu^-$
- $\eta' \to \pi^+\pi^-e^+e^-$
  - $\mathcal{A}_{CP} = (2.9 \pm 3.7 \pm 1.1)\%$, no CP-violation.
- $\eta' \to \pi^0\pi^0\eta$
  - Evidence for the cusp effect with a significance of around 3.5σ.
  - $a_0 - a_2 = 0.226 \pm 0.060 \pm 0.012$
- 10 billion J/ψ data collected will bring more exciting results in the future.

References

[1] Nucl. Instrum. Meth. A 614, 345 (2010).
[2] T. Petri, arXiv:1010.2378
[3] Eur. Phys. J. A 33, 95–106 (2007)