Recent result on η/η′ physics at BESIII

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ECT workshop : precision tests of fundamental physics with light mesons

June12-16, 2023, ECT, Trento

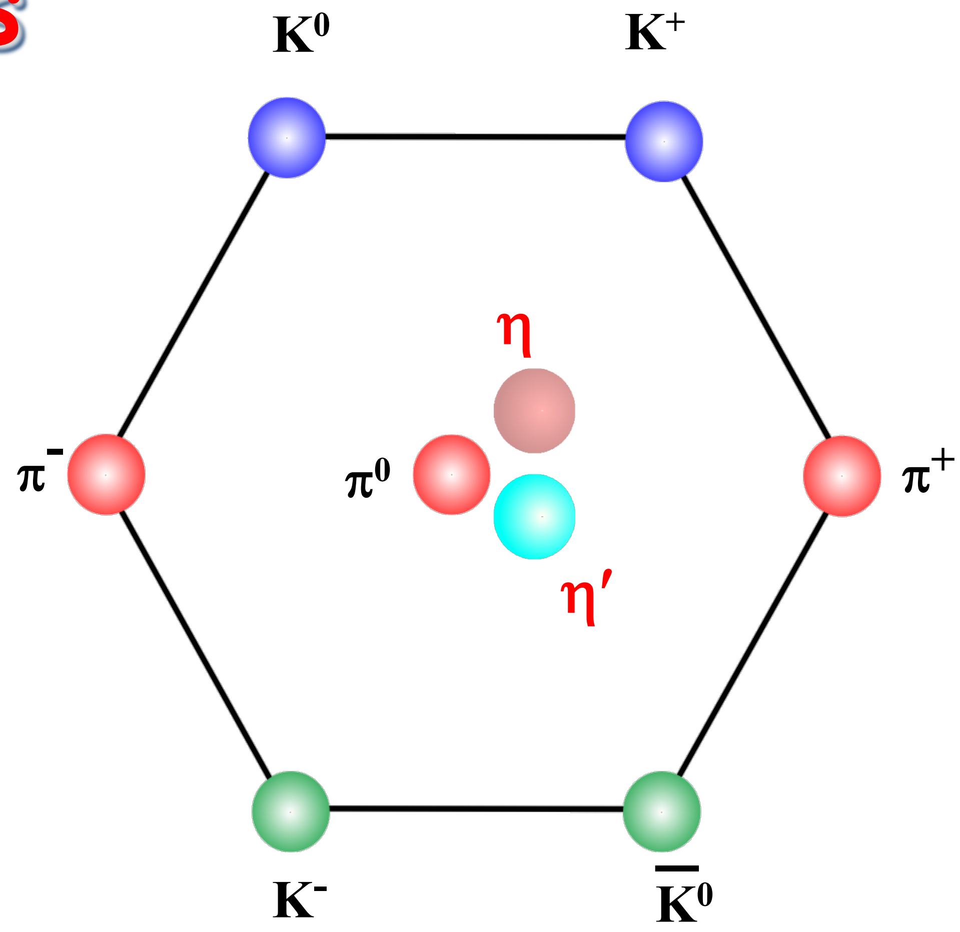
OUTLINE

- Light meson physics
- BESIII: a light meson factory
- Recent results on η/η' physics
  - Transition form factors
  - Dalitz plot analyses of $\eta' \to \pi^0\pi^0\eta$, $\eta \to 3\pi$
- Summary

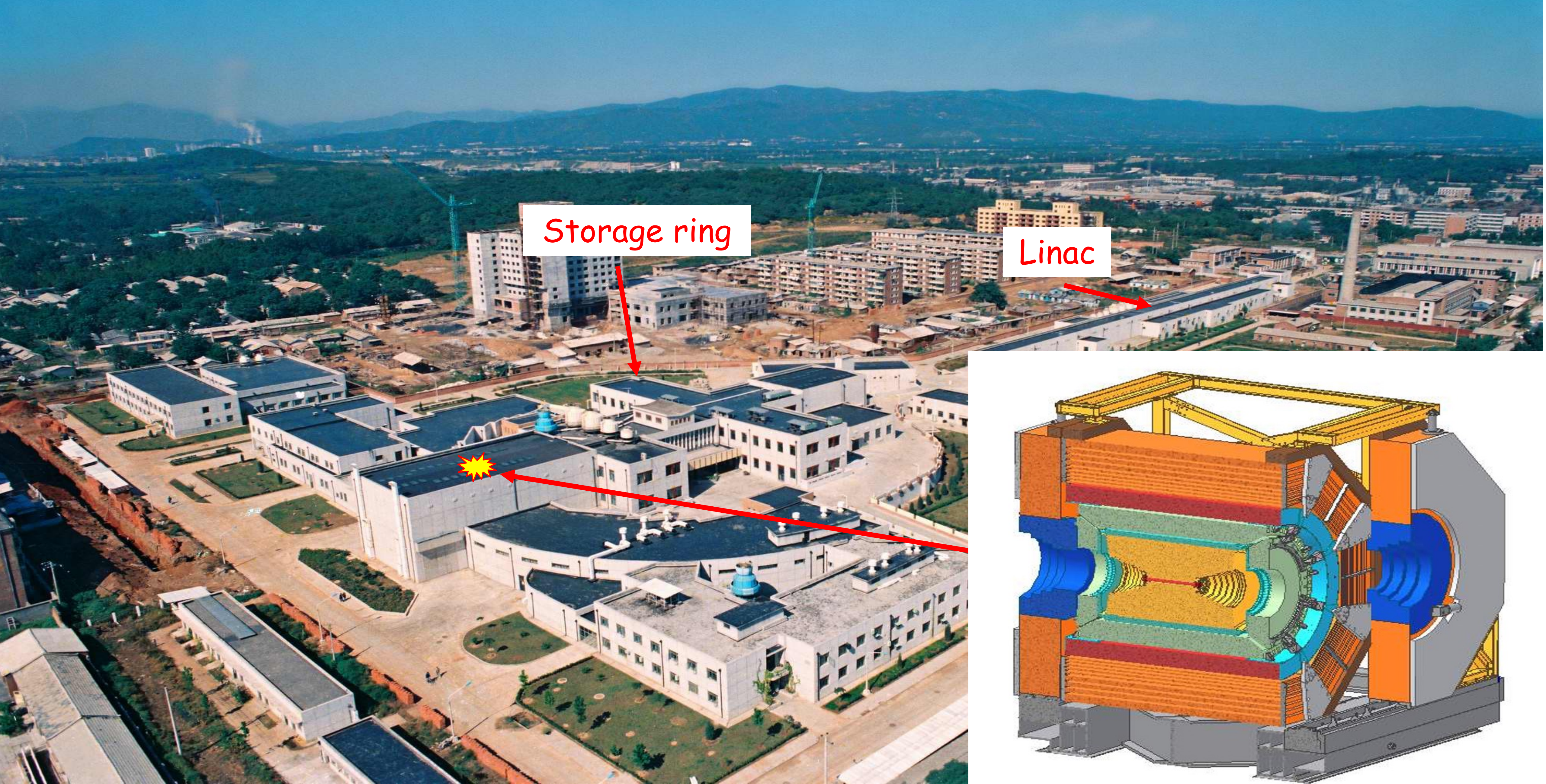
Light Meson Physics

- Light mesons
  - Important roles in particle physics, e.g. Quark Model, CP violation …
- Rich physics
  - Test ChPT predictions
  - Test fundamental symmetries
  - Probe new physics beyond the SM
  - EM Form factors: HLbL contributions to $(g-2)_\mu$
- Experiments: A2, KLOE-2, GlueX, BESIII, LHCb, CMS......

JEF, REDTOP, STCF

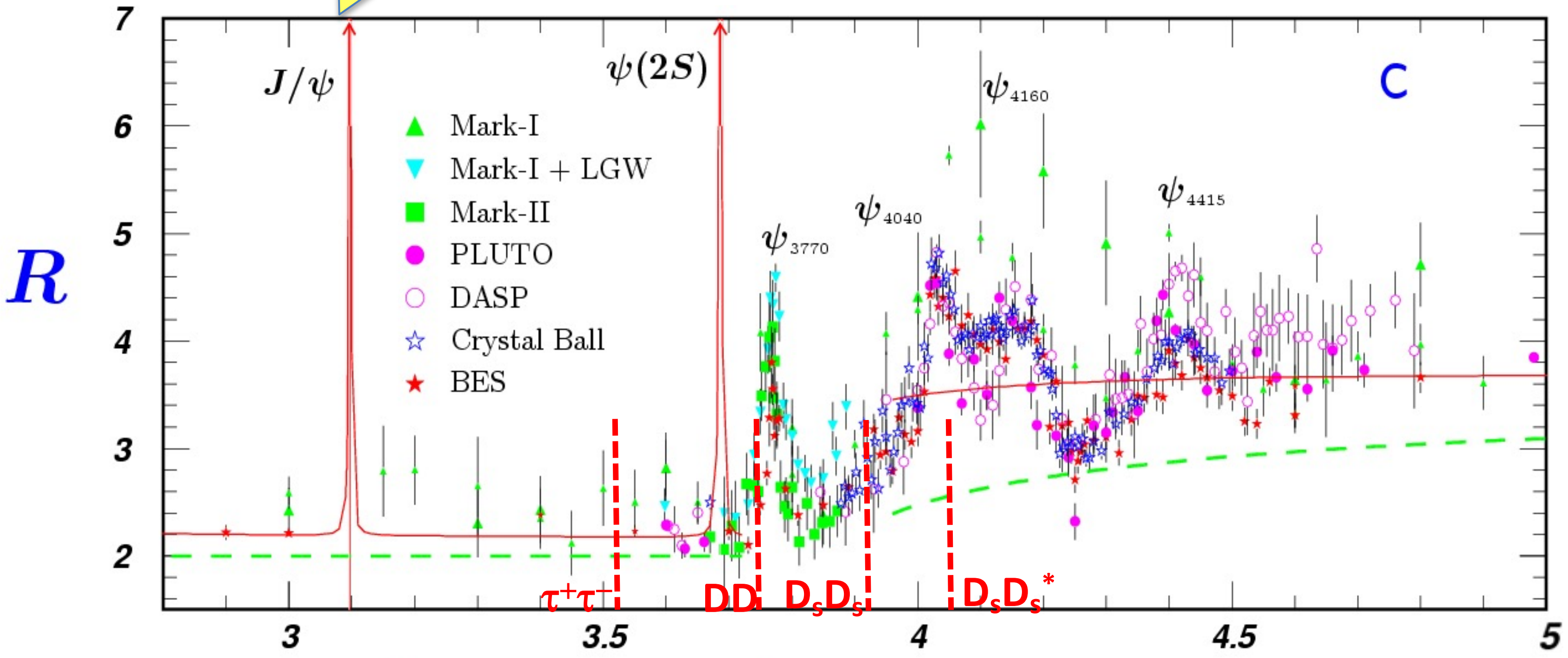


Bird view of BEPCII



World largest data sample directly collected in τ-charm region

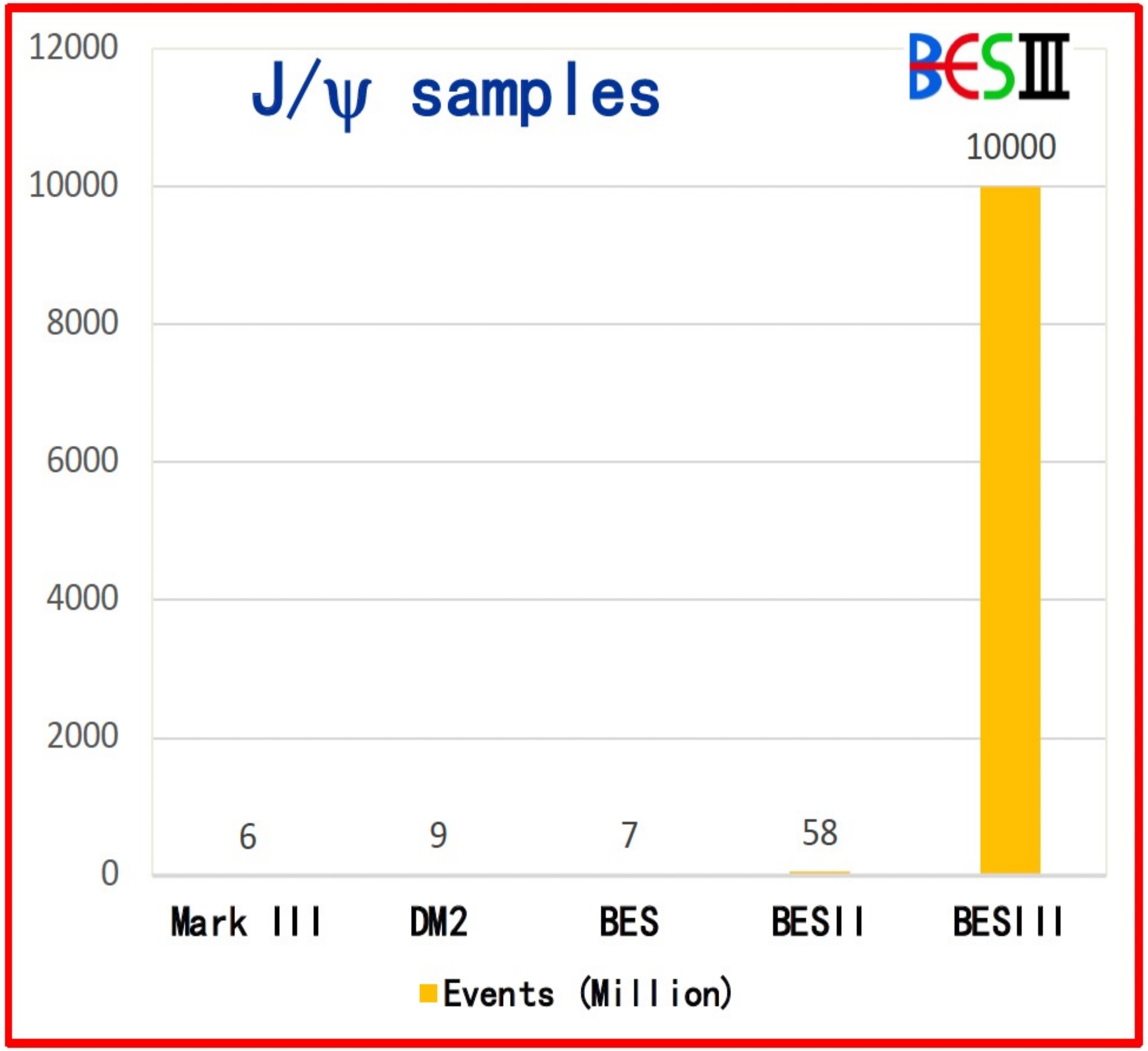
10x10^9 J/ψ
200 × BESII



- Charmonium physics
- Charm physics
- R-QCD physics
- Light hadron physics

2008-present: ~50 fb^{-1} data in E_{cm} = 2-4.95 GeV

Light mesons at BESIII



$J/\psi \to \gamma\eta$ → 1×10^7 η

$J/\psi \to \gamma\eta'$ → 5.2×10^7 η'

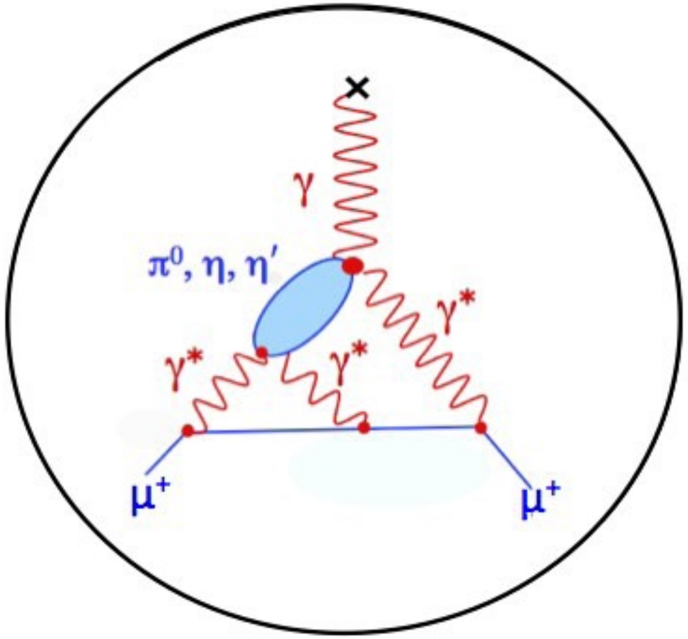
$J/\psi \to \omega\eta$ → 1×10^7 ω

$J/\psi \to \rho\pi$ → 2×10^8 π^0

……

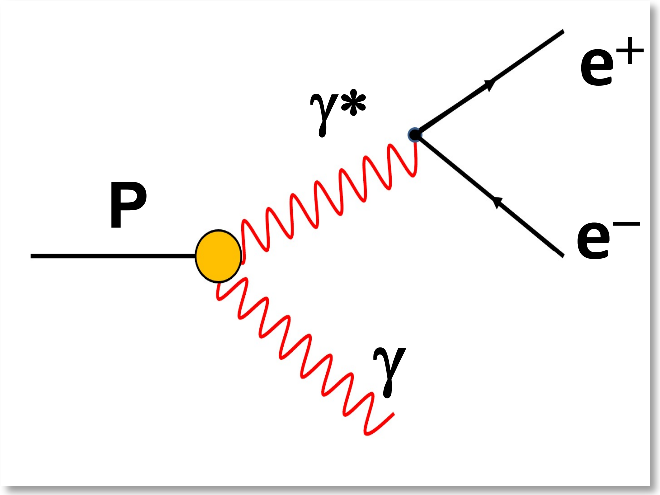
A light meson factory !

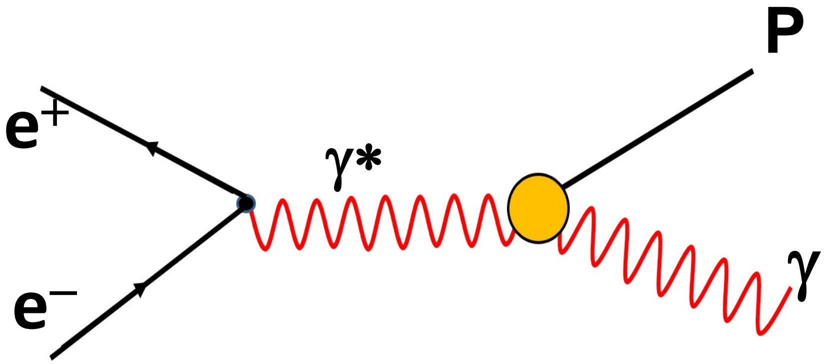
TFFs as experimental input @ BESIII

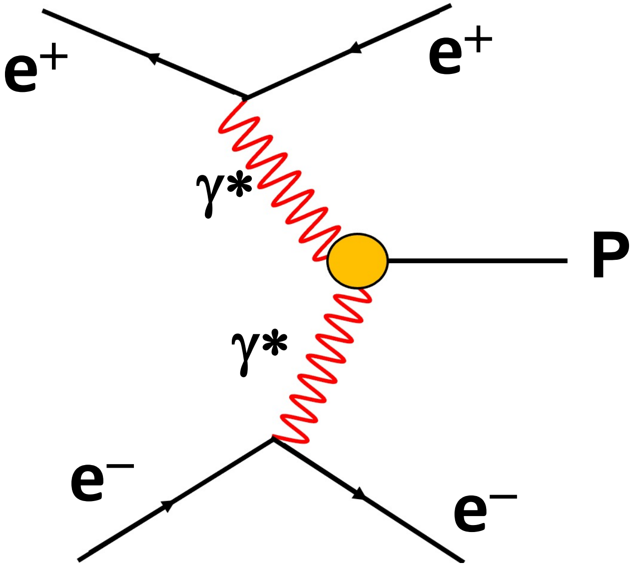


HLbL contributions

Pseudoscalar TFFs are experimentally accessible in three different processes





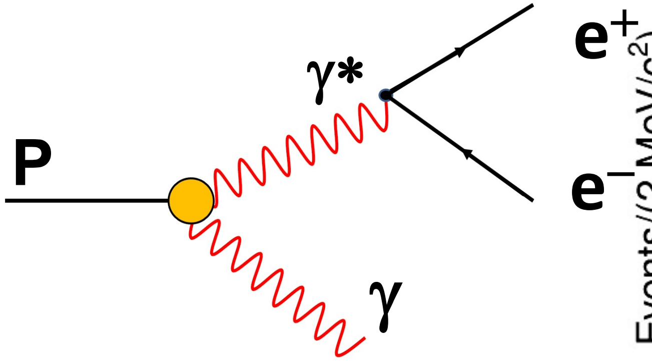


Dalitz decays $0 < q^2 < M^2$

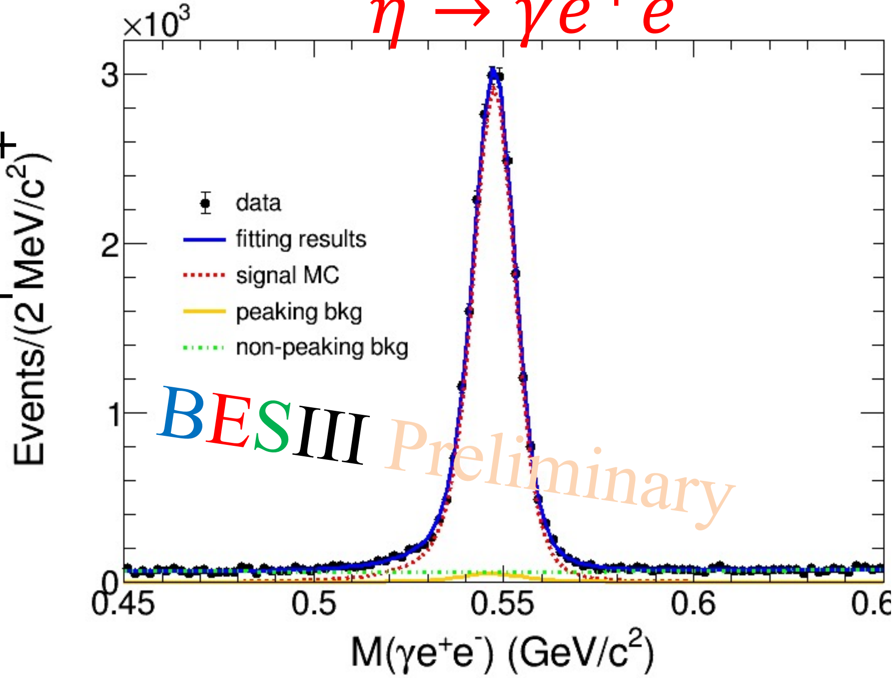
Annihilation process $q^2 = s > M^2$

Two photon process

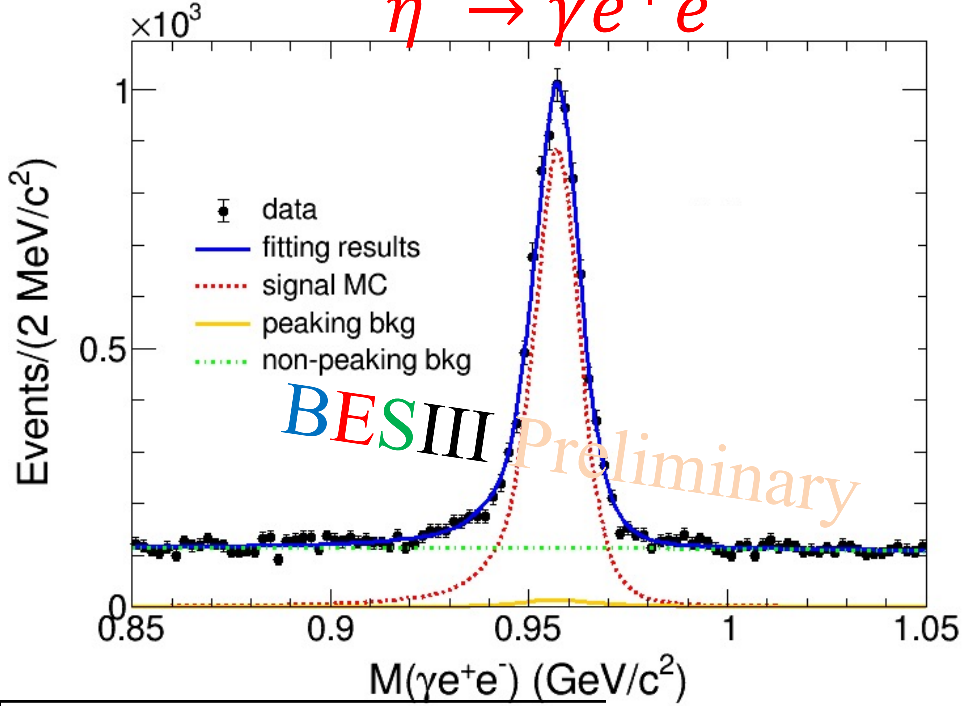
Single Dalitz decays η/η′ →γe⁺e⁻



$\eta \to \gamma e^+ e^-$



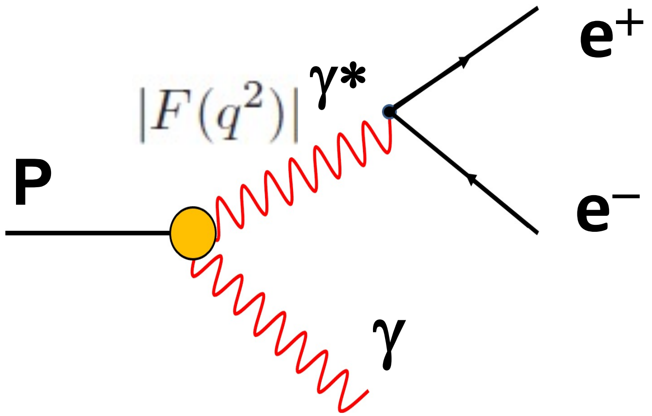
$\eta' \to \gamma e^+ e^-$



Mode	Yield	$\epsilon(\%)$	Branching fraction
$\eta \to \gamma e^+ e^-$	22907 ± 164	29.6	$(7.07 \pm 0.05(stat))\times10^{-3}$
$\eta' \to \gamma e^+ e^-$	7611 ± 108	29.8	$(4.83 \pm 0.07(stat))\times10^{-4}$

Consistent with the previous experimental works and theoretical predictions

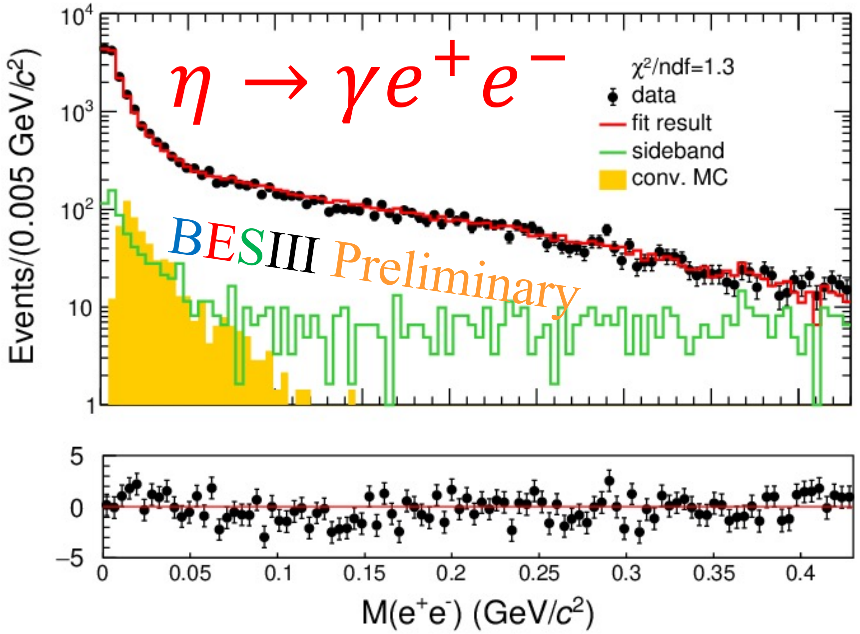
TTFs in η/η′ →γe⁺e⁻

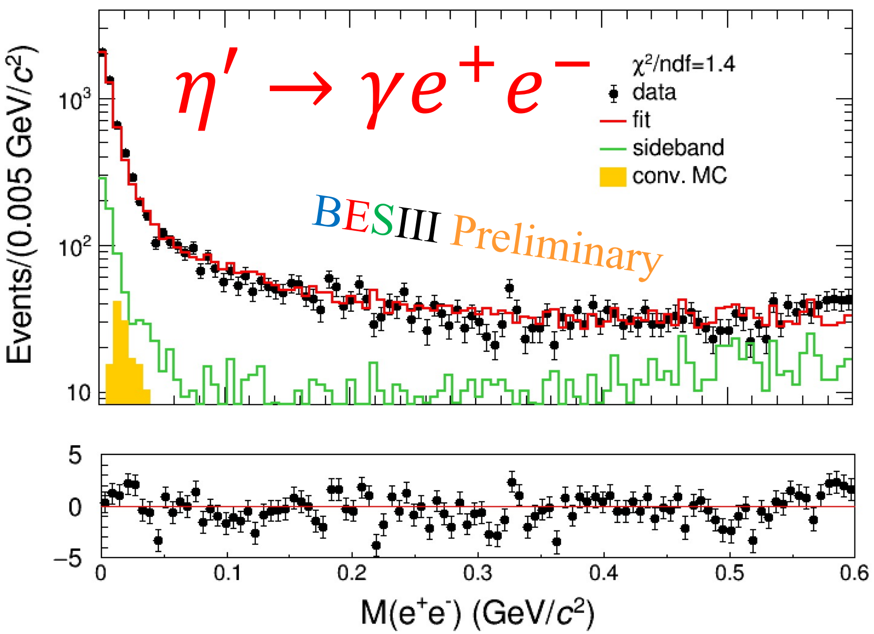


$$\frac{d\Gamma(P\to\ell^+\ell^-\gamma)}{dq^2\Gamma_{\gamma\gamma}} = \frac{2\alpha}{3\pi}\frac{1}{q^2}\sqrt{1-\frac{4m_\ell^2}{q^2}}\left(1+\frac{2m_\ell^2}{q^2}\right)\left(1-\frac{q^2}{M_P^2}\right)^3 |F_P(q^2,0)|^2$$

Single-pole: $F(q^2) = \frac{1}{1-q^2/\Lambda^2}$

$$b_P = \left.\frac{d\ln|F_P(q^2)|}{dq^2}\right|_{q^2=0}$$

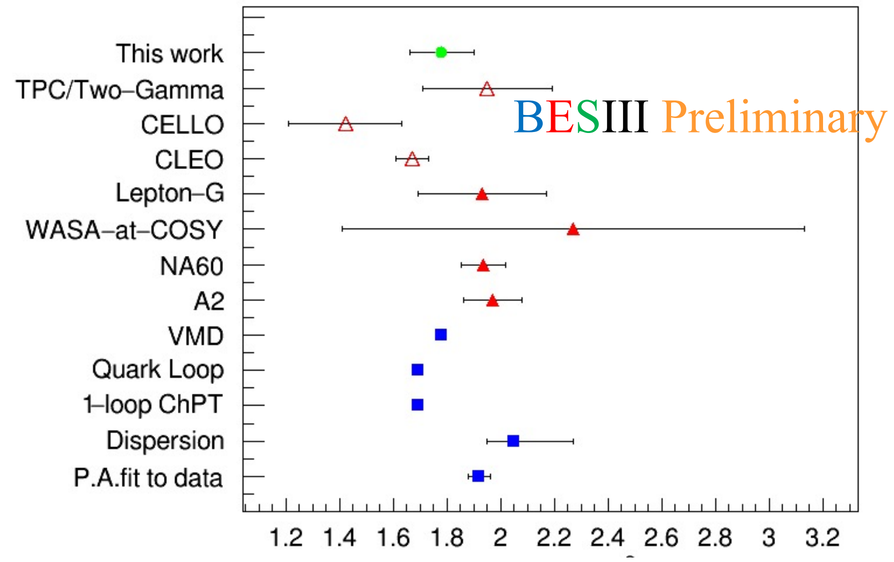


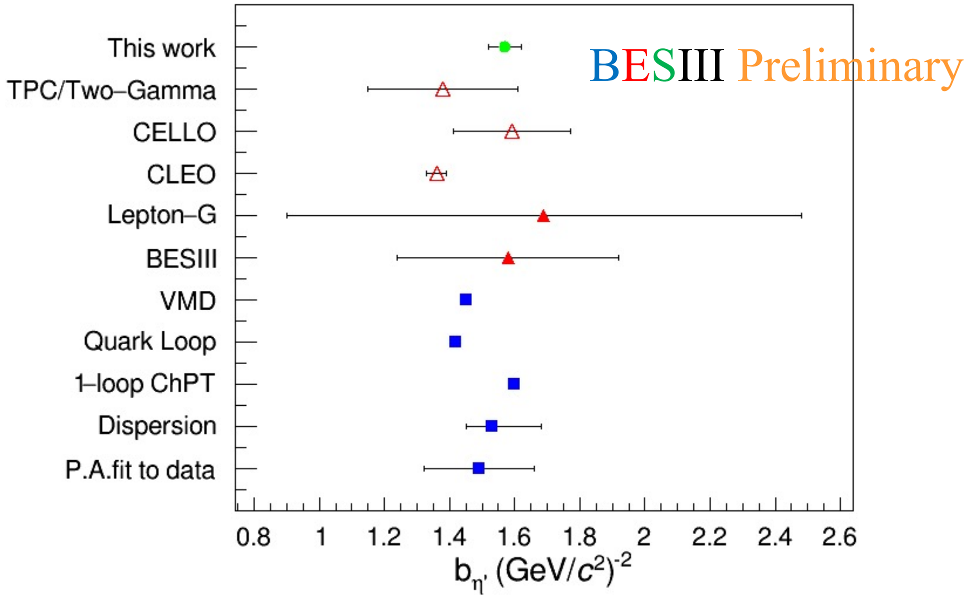


$b_\eta = (1.78 \pm 0.12(stat))\ (\mathrm{GeV}/c^2)^{-2}$

$b_{\eta'} = (1.57 \pm 0.05(stat))\ (\mathrm{GeV}/c^2)^{-2}$

Comparisons



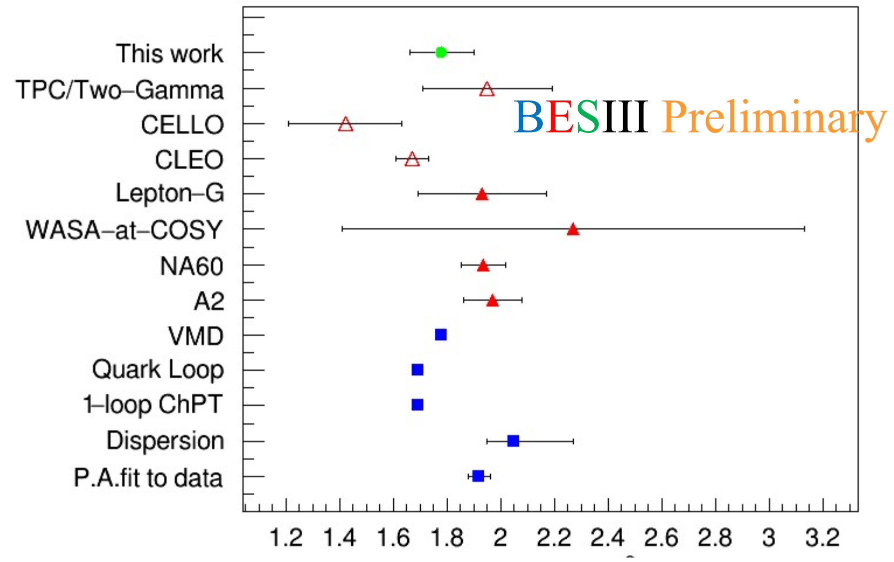


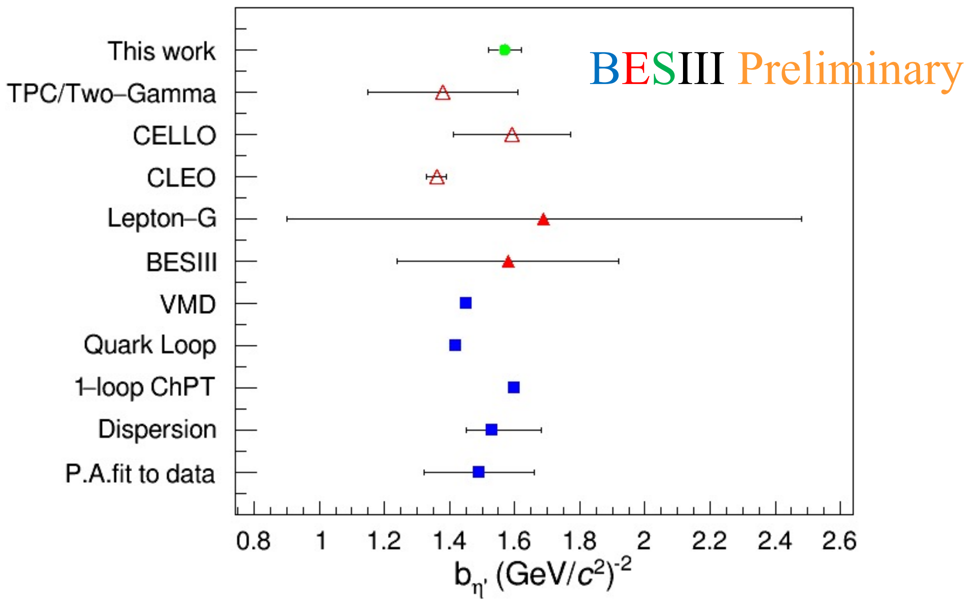
New parameterization ?

EPJC 82,434)2022) , see Simon's talk

$$
\begin{aligned}
F_{P\gamma^*\gamma^*}(s,0) = F_{P\gamma\gamma} &+ \left[1 + \frac{\epsilon_{\rho\omega} s}{M_\omega^2 - s - iM_\omega\Gamma_\omega}\right] \\
&\times \frac{s}{48\pi^2}\int_{4M_\pi^2}^{\infty} \mathrm{d}s' \frac{\sigma_\pi^3(s')P(s')|F_\pi^V(s')|^2}{s'-s-i\epsilon} \\
&+ \frac{F_{P\gamma\gamma} w_{P\omega\gamma} s}{M_\omega^2 - s - iM_\omega\Gamma_\omega}\left[1 + \frac{\epsilon_{\rho\omega} s}{48\pi^2 g_{\omega\gamma}^2}\right. \\
&\times \left.\int_{4M_\pi^2}^{\infty} \mathrm{d}s' \frac{\sigma_\pi^3(s')|F_\pi^V(s')|^2}{s'(s'-s-i\epsilon)}\right] \\
&+ \frac{F_{P\gamma\gamma} w_{P\phi\gamma} s}{M_\phi^2 - s - iM_\phi\Gamma_\phi},
\end{aligned}
\qquad (
$$

Comparisons





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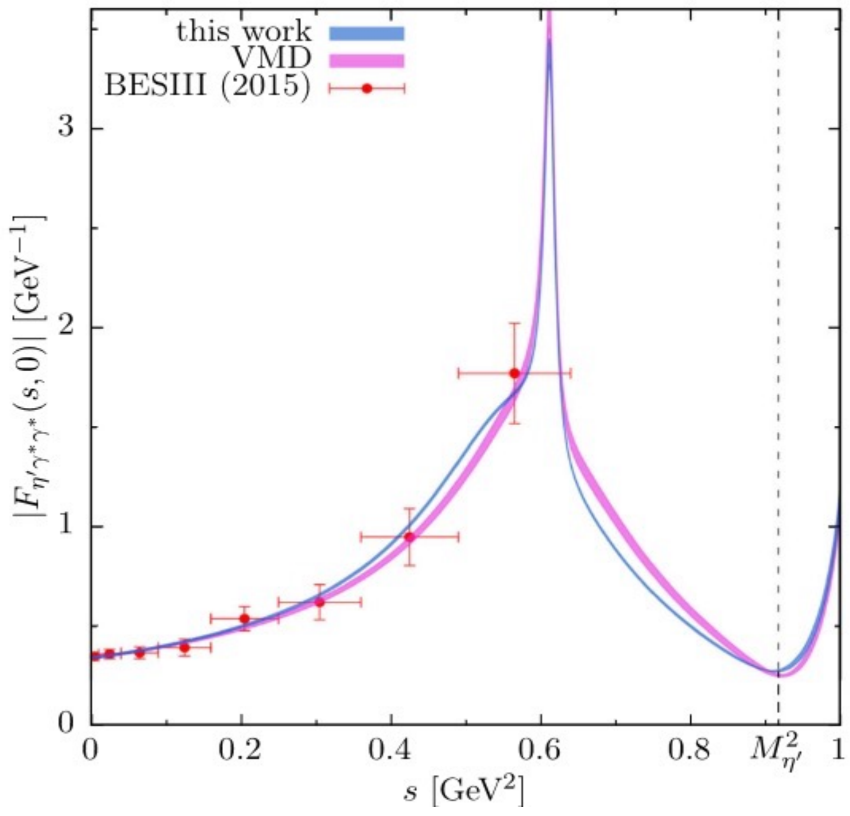
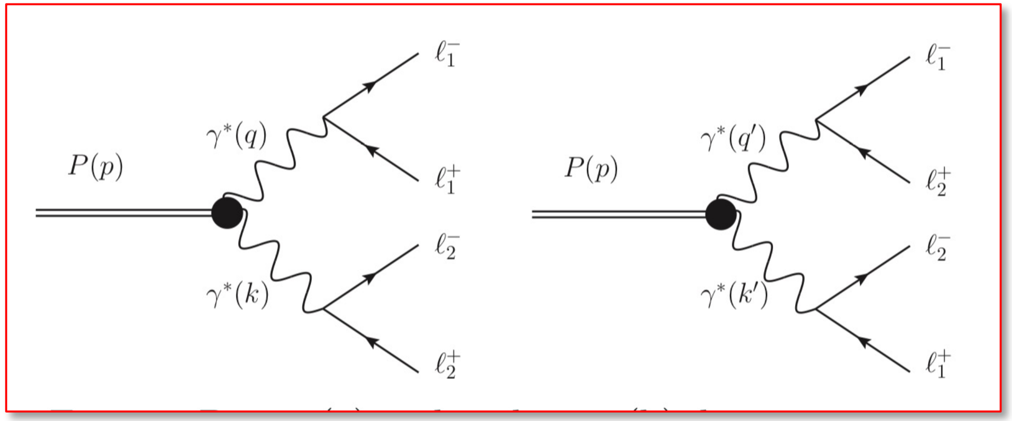


We may have a fit to data soon

Observation of $\eta' \to e^+e^-e^+e^-$



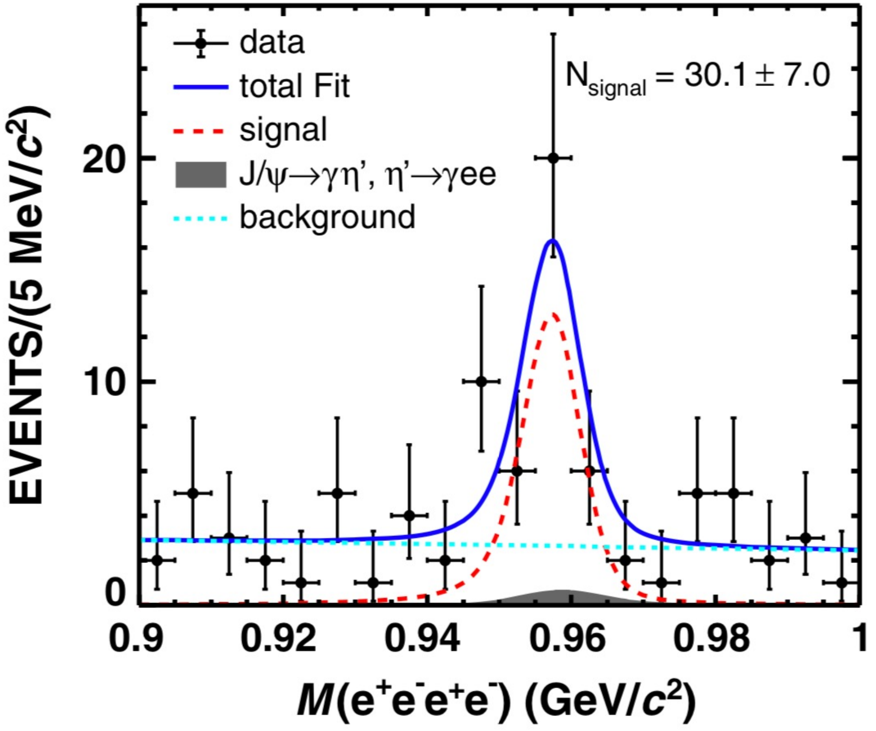
- Double virtual FFs?
- Statistics limited !

$B(\eta' \to e^+e^-e^+e^-) = (4.5 \pm 1.0 \pm 0.5) \times 10^{-6}$

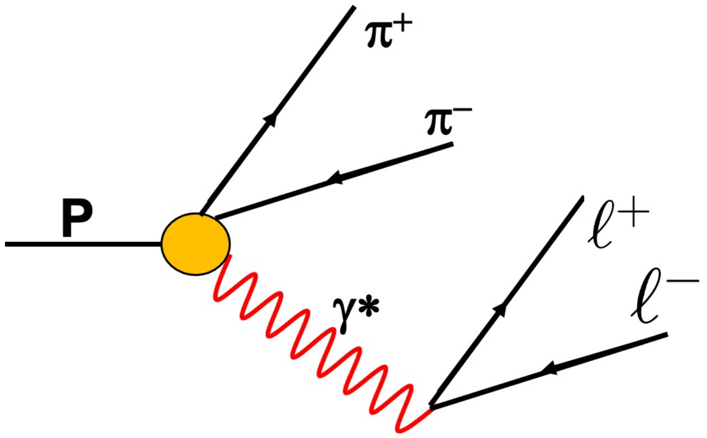
BESIII: PRD 105, 112010(2022)

Rafel, Sergi, Chinese Physics C42 (2018) 023109

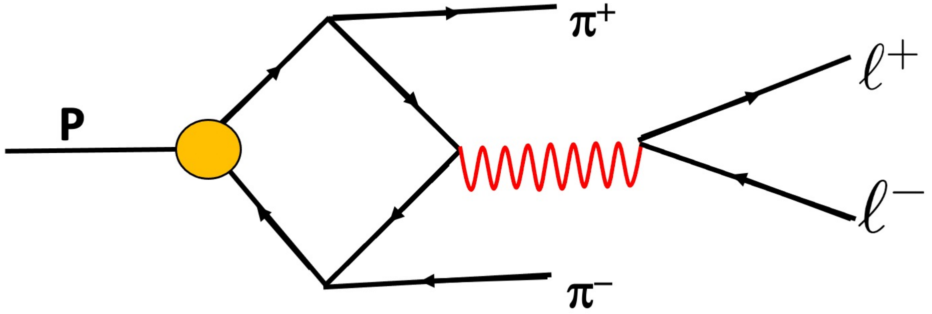
$\eta' \to e^+e^-e^+e^-$	$2.10(45) \times 10^{-6}$
$\eta' \to \mu^+\mu^-\mu^+\mu^-$	$1.69(36) \times 10^{-8}$
$\eta' \to e^+e^-\mu^+\mu^-$	$6.39(91) \times 10^{-7}$



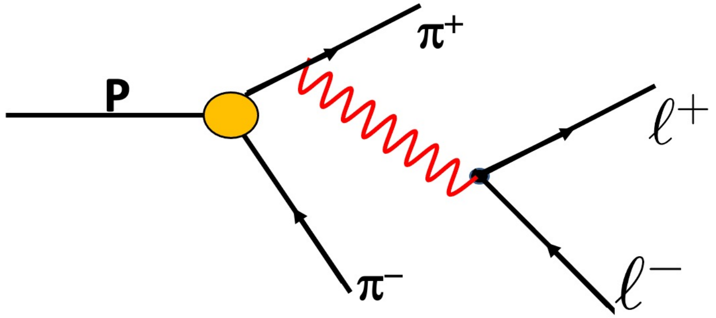
$\eta' \to \pi^+\pi^- l^+ l^-$



VMD



Box-anomaly

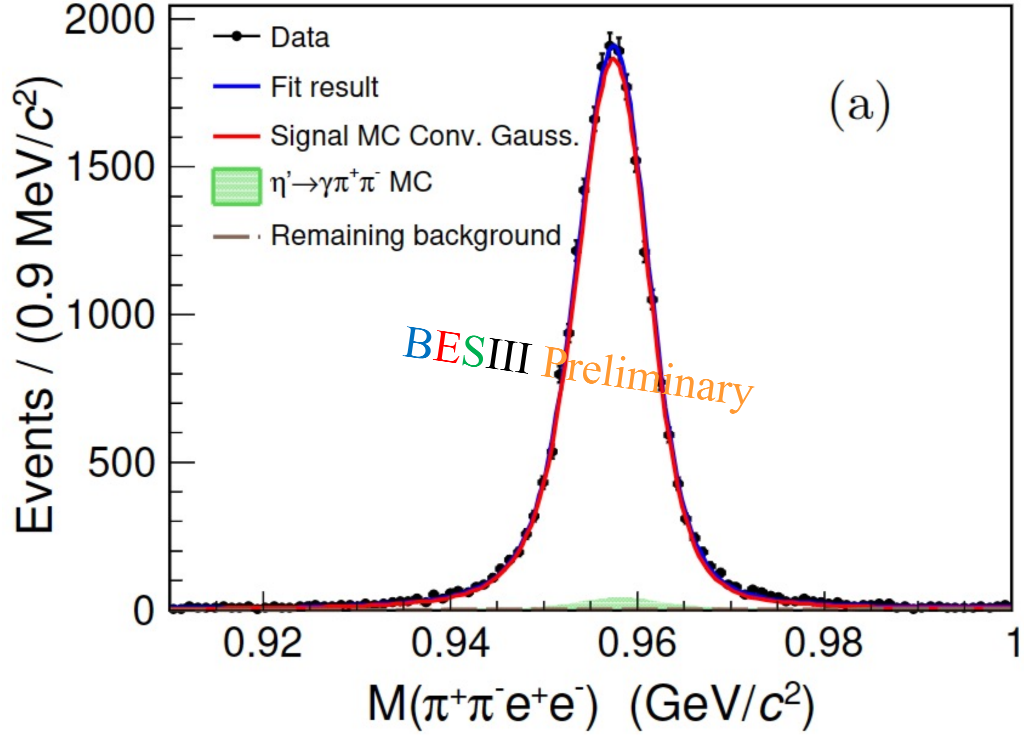


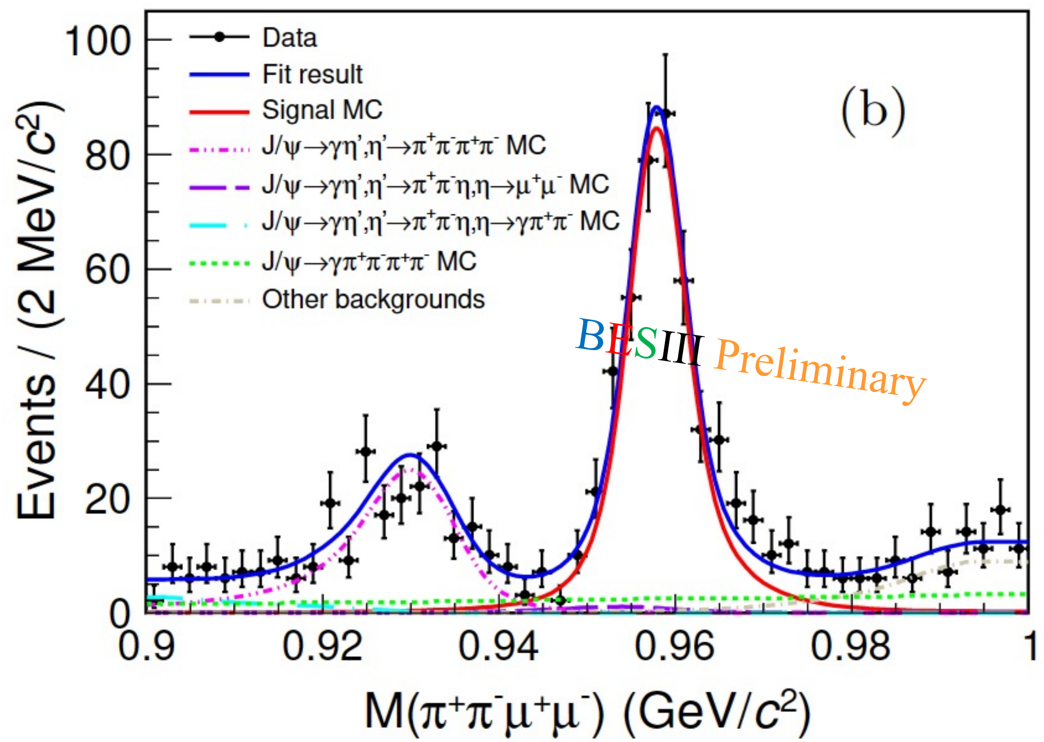
CP violation

	$\mathcal{B}(\eta' \to \pi^+\pi^- e^+e^-)$ (10^{-3})	$\mathcal{B}(\eta' \to \pi^+\pi^- \mu^+\mu^-)$ (10^{-5})
Hidden gauge*	2.17 ± 0.21	2.20 ± 0.30
Unitary χPT*	$2.13^{+0.17}_{-0.31}$	$1.57^{+0.96}_{-0.75}$
VMD*	2.27 ± 0.13	2.41 ± 0.25
BESIII (2013)$^\diamond$	$2.11 \pm 0.12 \pm 0.15$	< 2.9
BESIII (2021)$^\diamond$	$2.42 \pm 0.05 \pm 0.08$	$1.97 \pm 0.33 \pm 0.19$
CLEO$^\diamond$	$2.50^{+1.2}_{-0.9} \pm 0.5$	< 24

A. Faessler, C. Fuchs, and M. I. Krivoruchenko, PRC **61**, 035206 (2000).
B. Borasoy and R. Nissler, EPJA **33**, 95 (2007).
T. Petri, arXiv:1010.2378
………

BFs of $\eta' \to \pi^+\pi^-l^+l^-$





Decay Mode	N_{sig}	$\varepsilon(\%)$	Branching fraction
$\eta' \to \pi^+\pi^-e^+e^-$	22725±155	17.49±0.04	$(2.45 \pm 0.02(stat))\times 10^{-3}$
$\eta' \to \pi^+\pi^-\mu^+\mu^-$	434±25	37.95±0.07	$(2.16 \pm 0.12(stat))\times 10^{-5}$

Decay Amplitude

T. Petri, arXiv:1010.2378

- Decay amplitude

$$\overline{\left|\mathcal{A}_{\eta'\to\pi^+\pi^-l^+l^-}\right|}^2(s_{\pi\pi}, s_{ll}, \theta_\pi, \theta_1, \varphi) = \frac{e^2}{8k^2}|M(s_{\pi\pi}, s_{ll})|^2 \times \lambda\left(m_{\eta'}^2, s_{\pi\pi}, s_{ll}\right) \times [1 - \beta_1^2 \sin^2\theta_1 \sin^2\varphi] s_{\pi\pi}\beta_\pi^2 \sin^2\theta_\pi$$

- $M(s_{\pi\pi}, s_{ll})$ contains the information of the decaying particle and the VMD input ,

$$M(s_{\pi\pi}, s_{ll}) = \frac{e}{8\pi^2 f_\pi^3}\frac{1}{\sqrt{3}}\left(\frac{f_\pi}{f_8}\sin\theta_{mix} + 2\sqrt{2}\frac{f_\pi}{f_0}\cos\theta_{mix}\right) \times VMD(s_{\pi\pi}, s_{ll})$$

constant

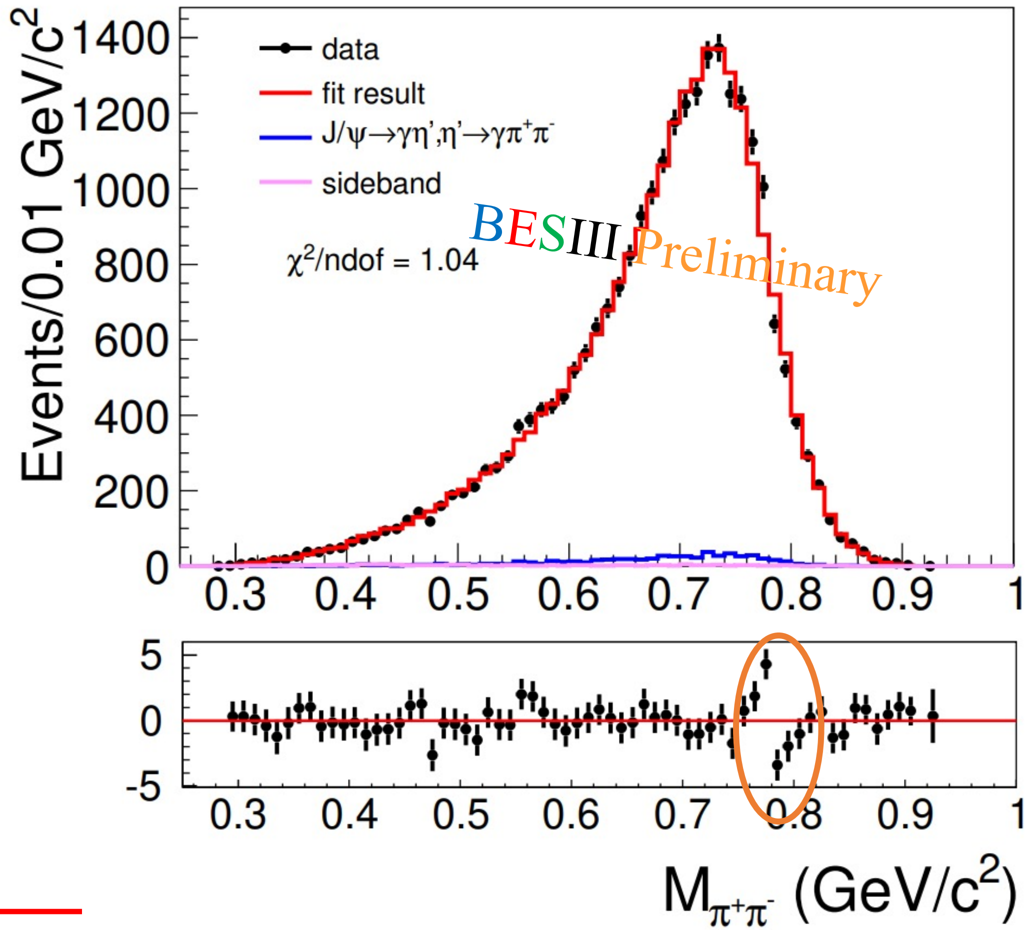
- Form Factor:

$$VMD(s_{\pi\pi}, s_{ll}) = 1 - \frac{3}{4}(c_1 - c_2 + c_3) + \frac{3}{4}(c_1 - c_2 - c_3)\frac{m_V^2}{m_V^2 - s_{ll} - i m_V \Gamma(s_{ll})} + \frac{3}{2}c_3\frac{m_V^2}{m_V^2 - s_{ll} - i m_V \Gamma(s_{ll})}\frac{m_{V,\pi}^2}{m_{V,\pi}^2 - s_{\pi\pi} - i m_{V,\pi}\Gamma(s_{\pi\pi})}$$

Box anomaly | VMD contribution | VMD contribution

✓ VMD models:

- Hidden gauge model (Model I): $c_1 - c_2 = c_3 = 1$
- Full VMD model (Model II): $c_1 - c_2 = 1/3,\ c_3 = 1$
- Modified VMD model (Model III): $c_1 - c_2 \neq c_3$



✓ ρ^0 only can not describe data

✓ $\omega \to \pi^+\pi^-$ decay is necessary !

$$\frac{m_{V,\pi}^2}{m_{V,\pi}^2 - s_{\pi\pi} - i m_{V,\pi}\Gamma(s_{\pi\pi})} + \beta e^{i\theta}\frac{m_\omega^2}{m_\omega^2 - s_{\pi\pi} - i m_\omega \Gamma_\omega}$$

box-anomaly?

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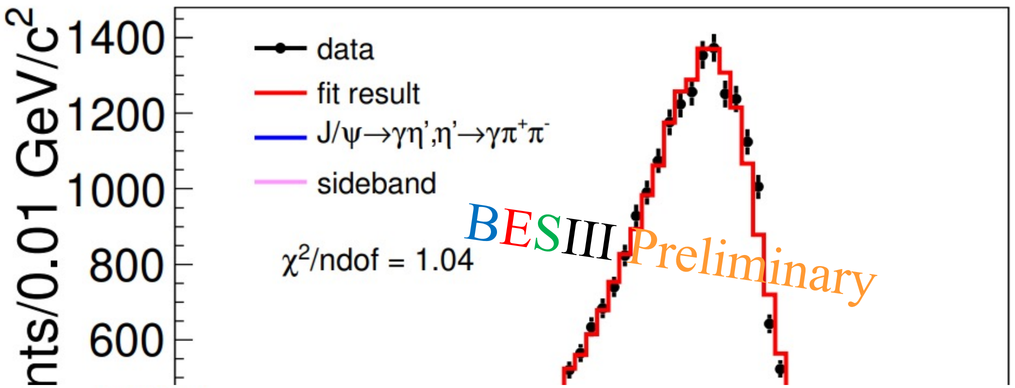
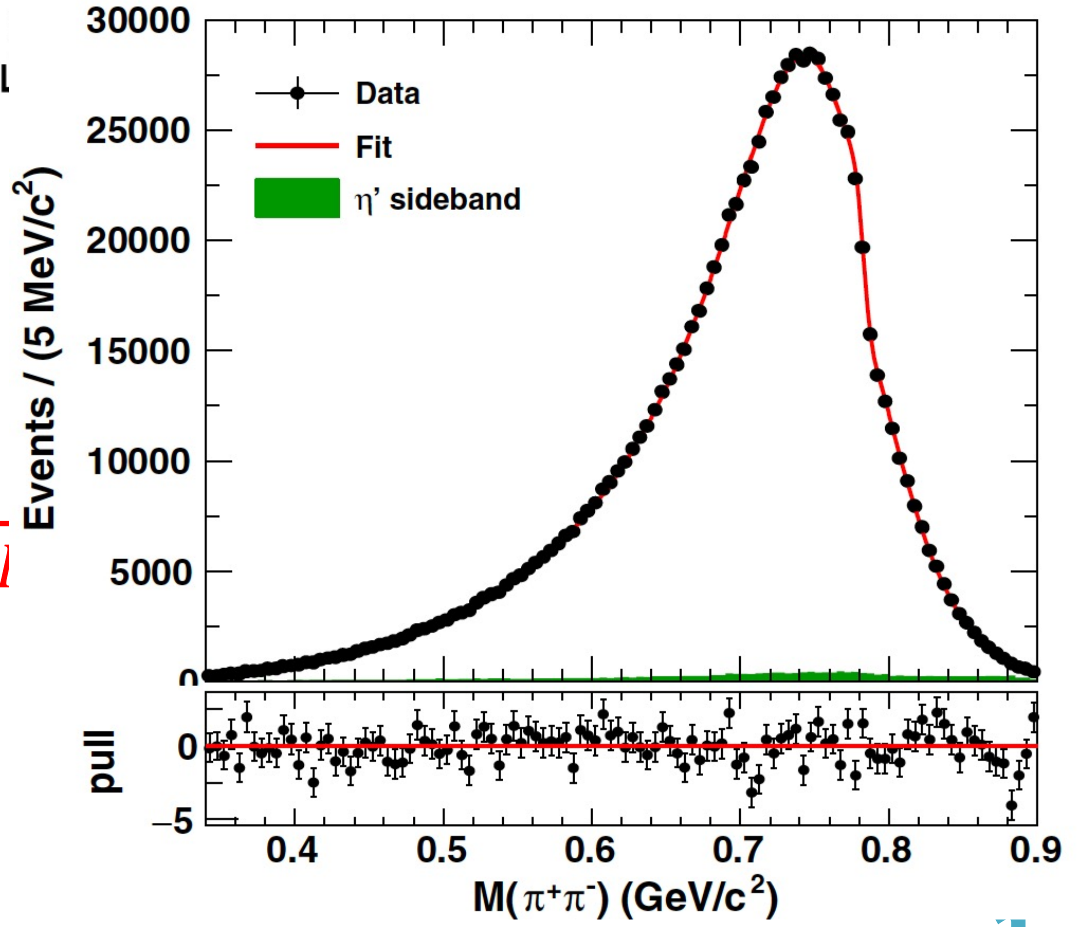


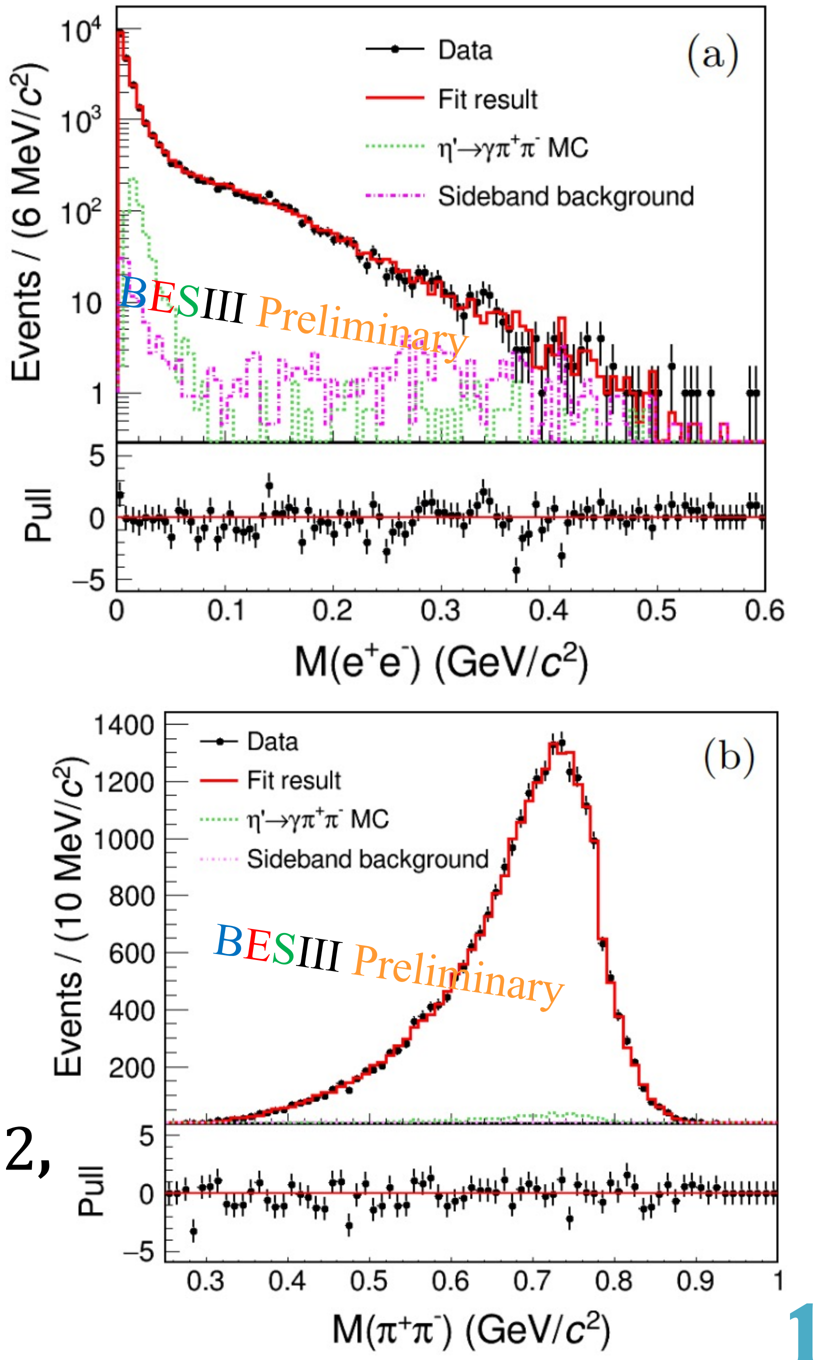


box-anomaly? $\eta' \to \gamma\pi^+\pi^-$ **, see Andrzej's talk**

BESIII:PRL120,242003(2018)

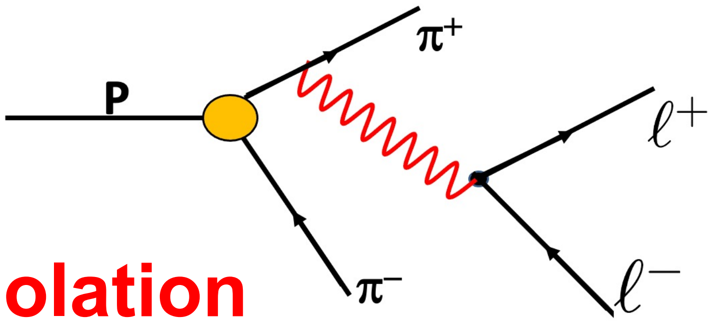
Amplitude analysis results

$\eta' \to \pi^+\pi^-e^+e^-$	Model I	Model II	Model III
	$c_1 - c_2 = c_3 = 1$	$c_1 - c_2 = 1/3, c_3 = 1$	$c_1 - c_2 \neq c_3$
$m_V\,(\mathrm{MeV}/c^2)$	954.26 ± 82.53	857.37 ± 74.31	787.53 ± 137.90
$m_{V,\pi}\,(\mathrm{MeV}/c^2)$	765.32 ± 1.12	765.35 ± 1.12	764.75 ± 1.25
$m_\omega\,(\mathrm{MeV}/c^2)$	778.69 ± 1.26	778.70 ± 1.26	778.70 ± 1.36
$\beta(10^{-3})$	8.53 ± 1.40	8.52 ± 1.40	8.11 ± 1.43
θ	1.43 ± 0.31	1.43 ± 0.31	1.44 ± 0.35
$c_1 - c_2$	1	1/3	-0.03 ± 0.87
c_3	1	1	1.03 ± 0.02

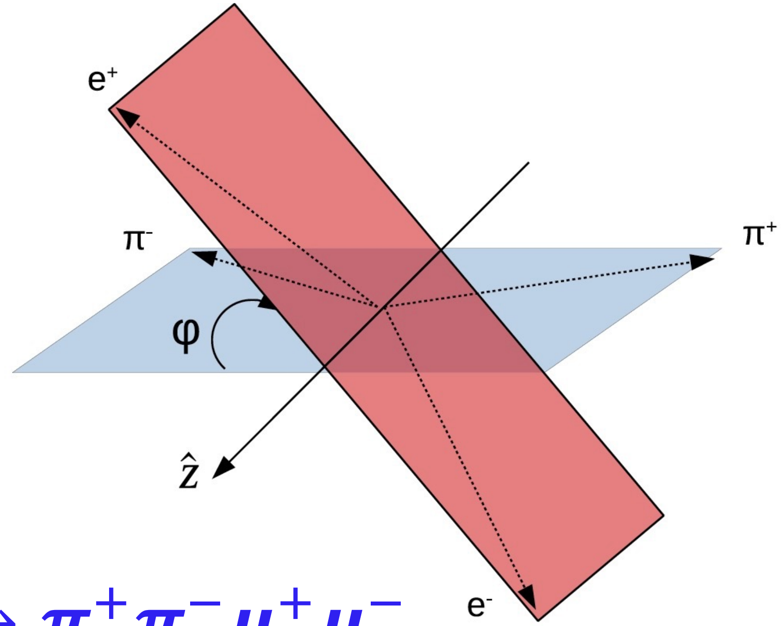


- ✓ **All the above cases provide good description of data**
- ✓ **Limited statistics at the high e^+e^- mass region**
  → Large statistical uncertainty
- ✓ **A test with $c_1 - c_2 = c_3$ gives $c_1 - c_2 = c_3 = 1.03 \pm 0.02$, which is consistent with Model I.**

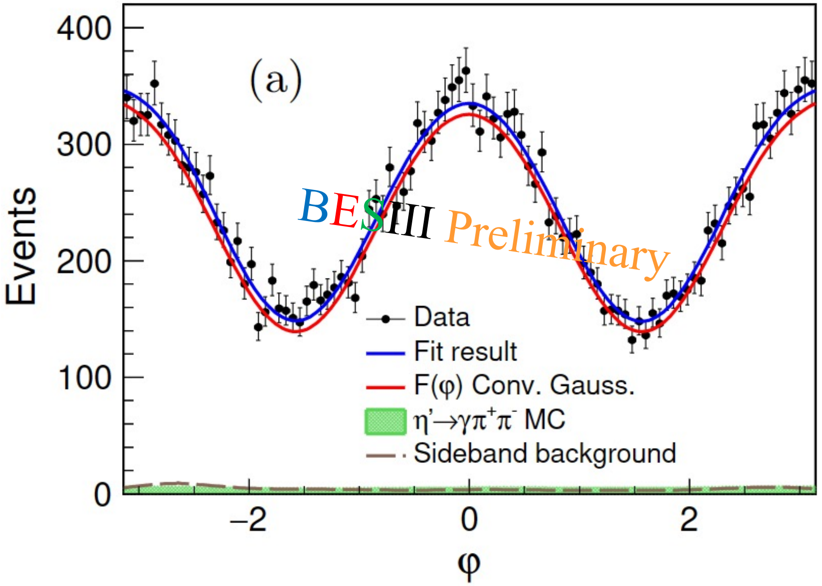
Search for *CP* Asymmetry



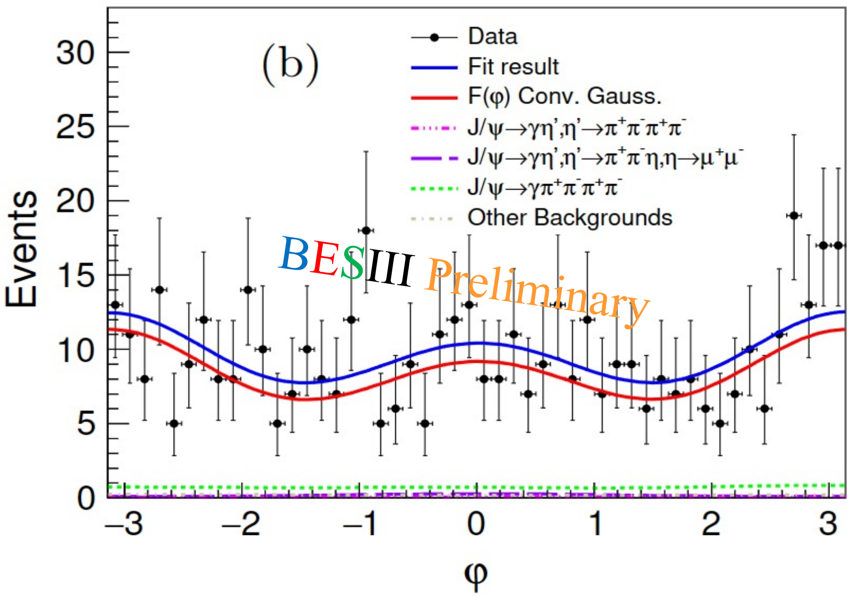
CP violation



$\eta' \to \pi^+\pi^-e^+e^-$

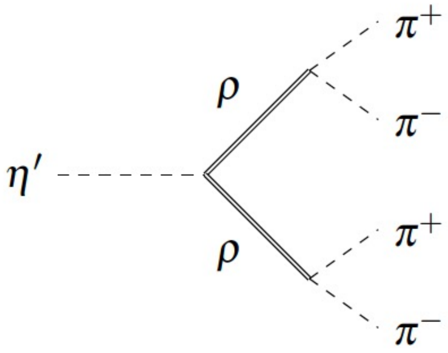


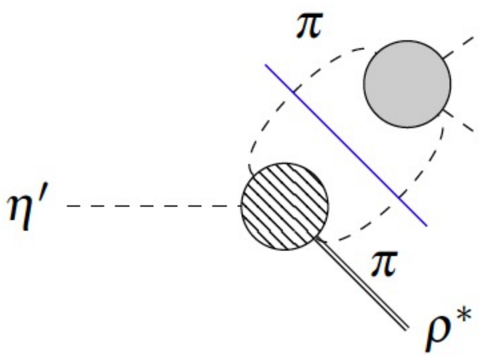
$\eta' \to \pi^+\pi^-\mu^+\mu^-$

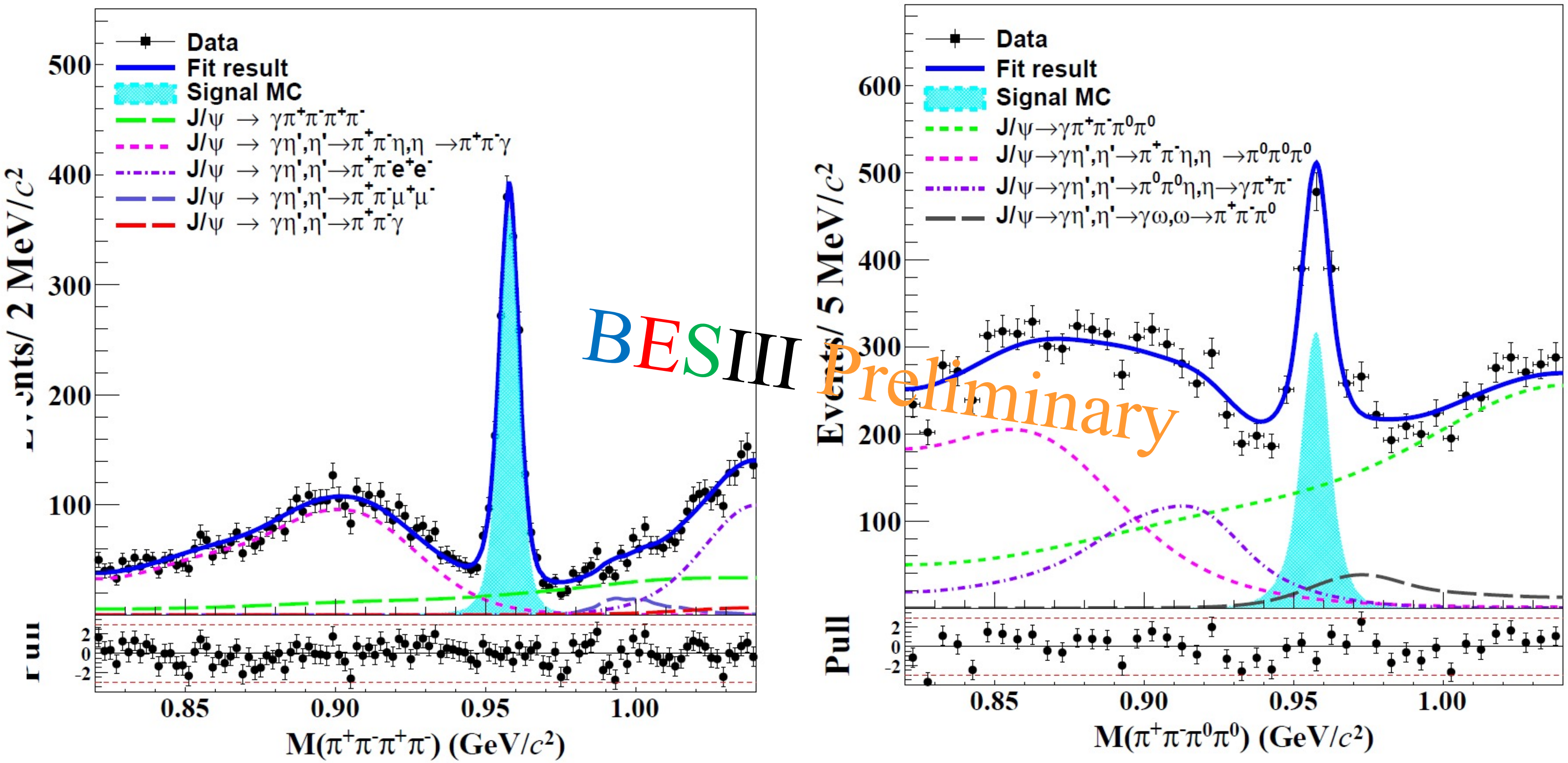


$\mathcal{A}_{CP} = \quad (-0.21 \pm 0.73(stat))\%.$ $\quad (0.62 \pm 4.71(stat))\%$

Branching fraction of $\eta' \to \pi^+\pi^-\pi\ \ \pi$







$B(\eta' \to \pi^+\pi^-\pi^+\pi^-) = (1.0 \pm 0.3) \times 10^{-4}$
$B(\eta' \to \pi^+\pi^-\pi^0\pi^0) = (2.4 \pm 0.7) \times 10^{-4}$

F.K. Guo et al ,PRD 85,014014 (2012)

see Simon's talk

Mode	N_{sig}	ε(%)	$\mathcal{B}(\times 10^{-5})$
$\eta' \to \pi^+\pi^-\pi^+\pi^-$	1650±48	36.4	8.56±0.25($stat$)
$\eta' \to \pi^+\pi^-\pi^0\pi^0$	865±49	7.8	2.12±0.12($stat$)

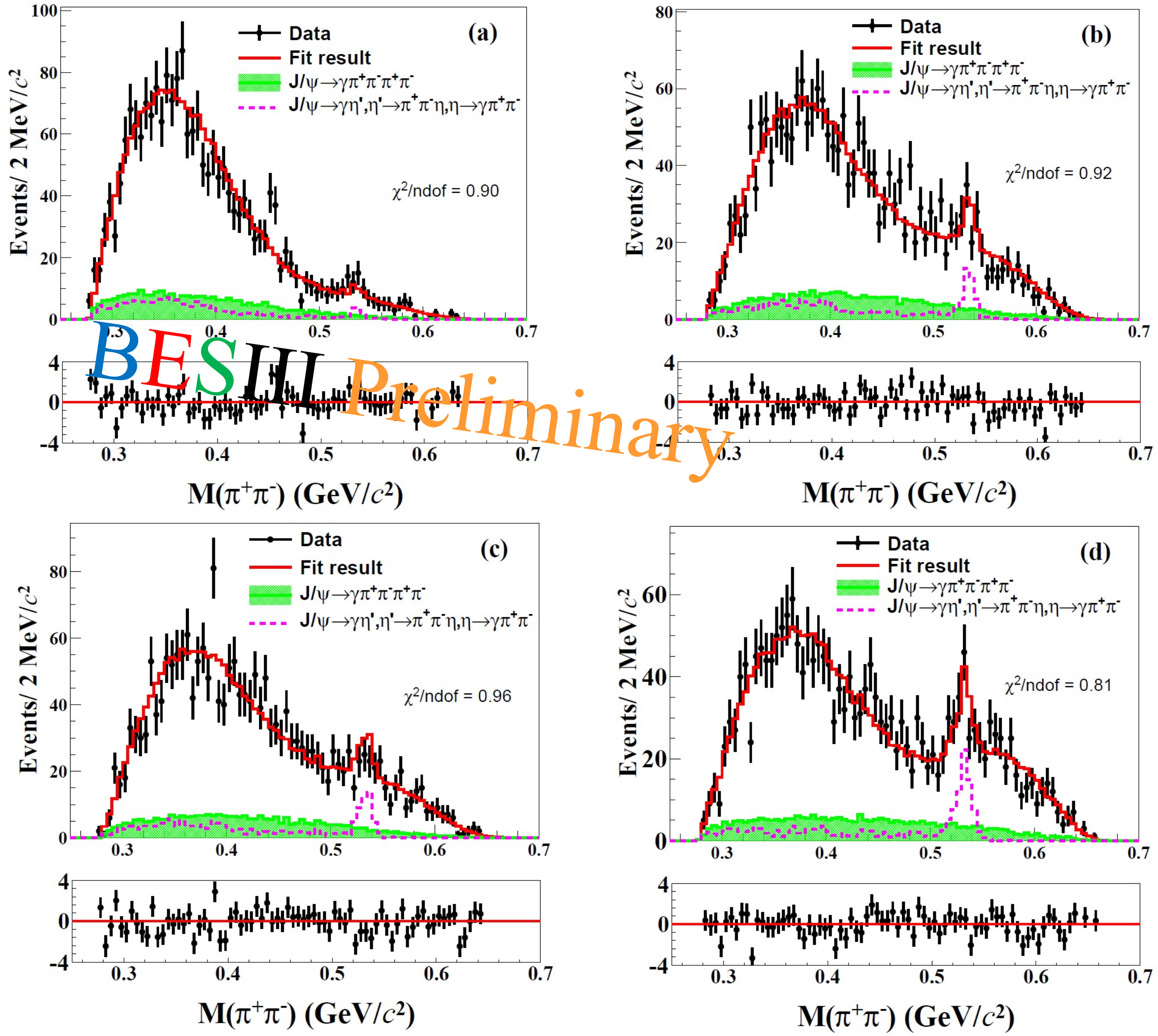
Amplitude analysis results

- **The decay amplitude based on the ChPT and VMD model** $\mathcal{A}_V(\eta_8 \to \pi^+\pi^-\pi^+\pi^-) =$

$$\simeq \frac{N_c \epsilon_{\mu\nu\alpha\beta}}{16\sqrt{3}\pi^2 F_\pi^5} p_1^\mu p_2^\nu p_3^\alpha p_4^\beta \left\{ (c_1 - c_2) \left[\frac{s_{12}}{D_\rho(s_{12})} + \frac{s_{34}}{D_\rho(s_{34})} - \frac{s_{14}}{D_\rho(s_{14})} - \frac{s_{23}}{D_\rho(s_{23})} \right] + c_3 \left[\frac{M_\rho^2(s_{12}+s_{34})}{D_\rho(s_{12})D_\rho(s_{34})} - \frac{M_\rho^2(s_{14}+s_{23})}{D_\rho(s_{14})D_\rho(s_{23})} \right] \right\}$$

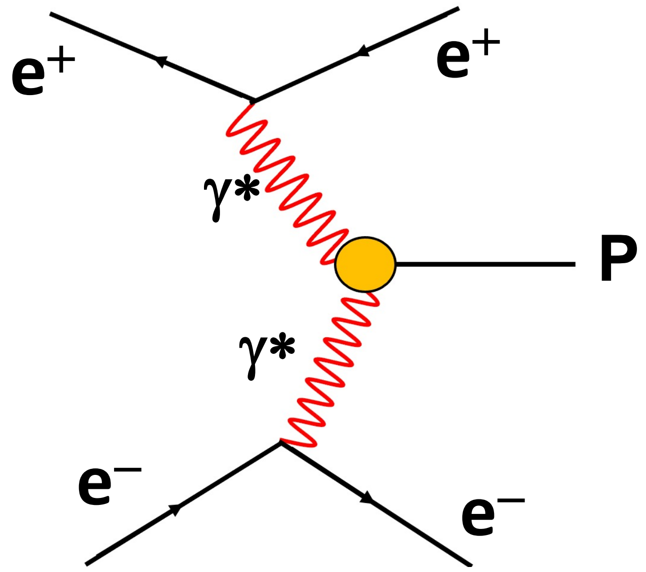
$$D_\rho(s) = M_\rho^2 - s - i\, M_\rho \Gamma_\rho(s) \ ,$$

$$\Gamma_\rho(s) = \frac{M_\rho}{\sqrt{s}} \left(\frac{s - 4M_\pi^2}{M_\rho^2 - 4M_\pi^2} \right)^{3/2} \Gamma_\rho$$

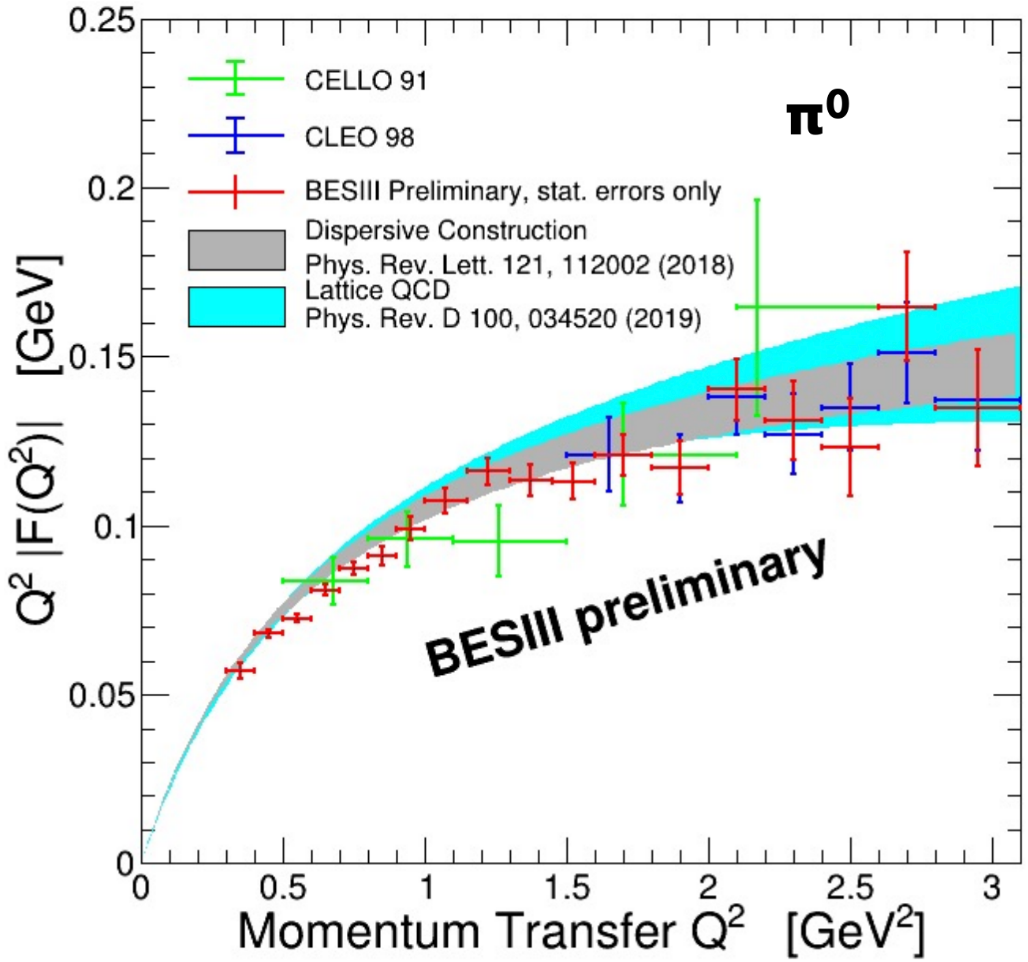


By assuming $c_1 - c_2 = 1$, the fit yields $c_3 = 1.22 \pm 0.29$, which is consistent with the theoretical expectation of $c_3 = 1$

Space-like π^0 TFF (preliminary results only)



[Prog.Part.Nucl.Phys. 107 (2019) 20-68]



- ~16fb^{-1} @3.773 GeV is available
- 5 times larger than that for "preliminary"

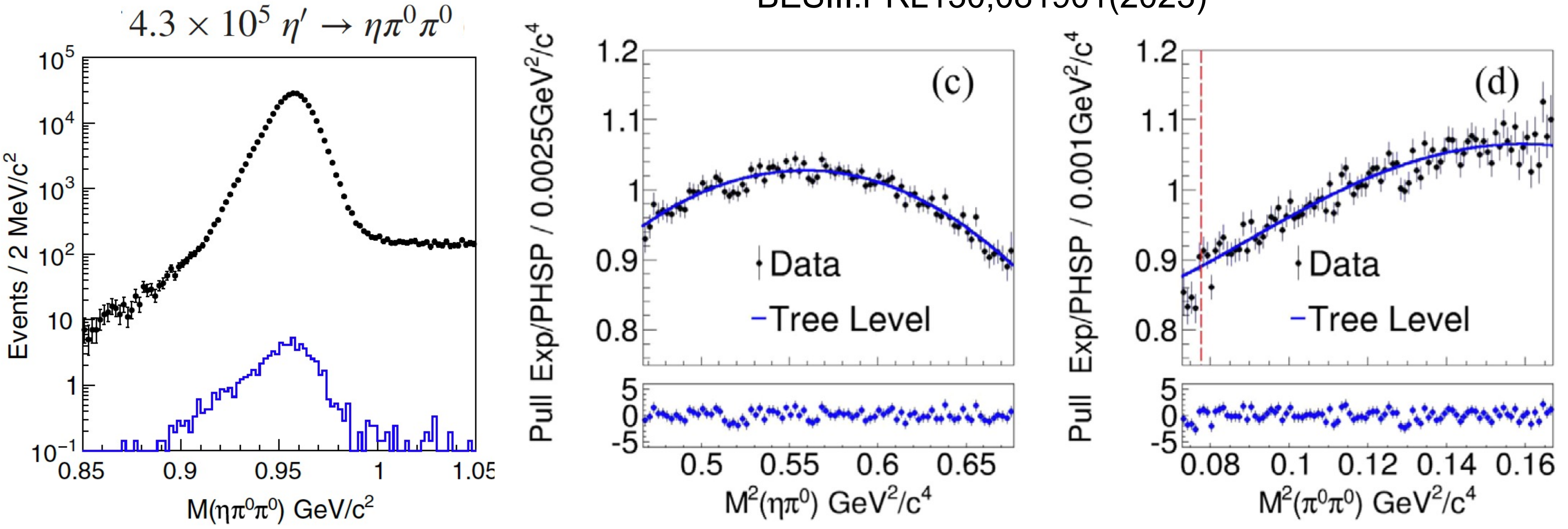
Evidence of the cusp effect in $\eta' \to \pi^0\pi^0\eta$

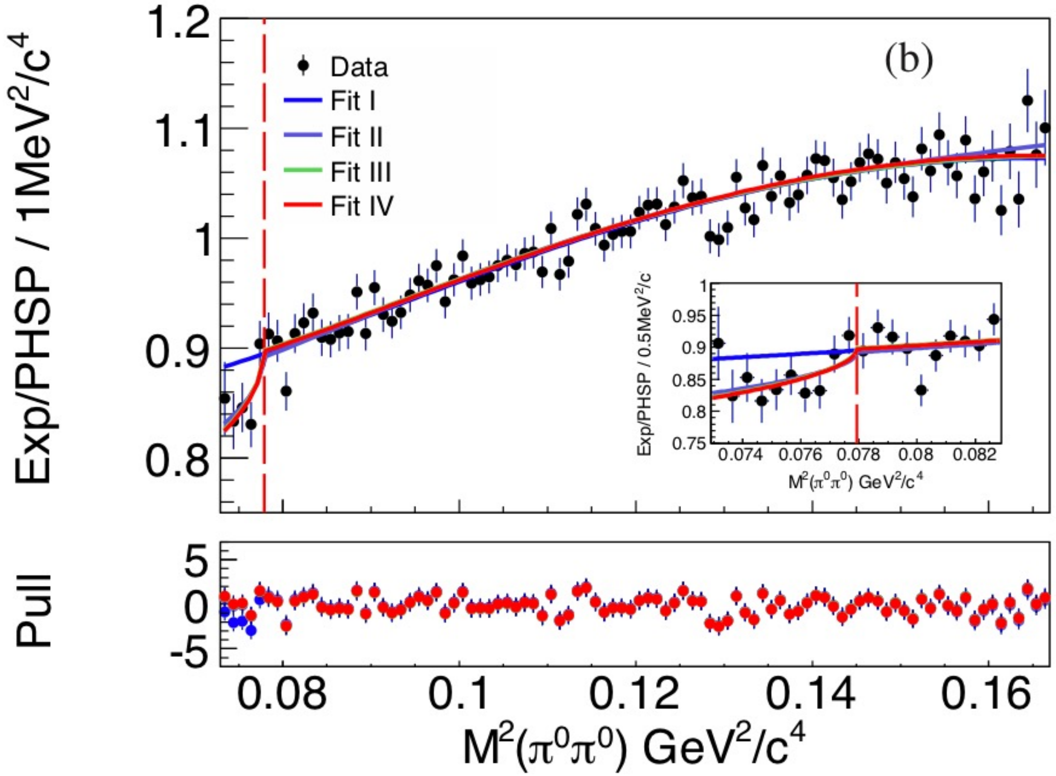
- Investigation on ππ and πη final interactions
- The cusp effect is sizeable in this decay

B. Kubis and S. P. Schneider, EPJC 62, 511 (2009)

S. Gonzalez-Solls, E. Passemar EPJC78, 758 (2018)

BESIII:PRL130,081901(2023)

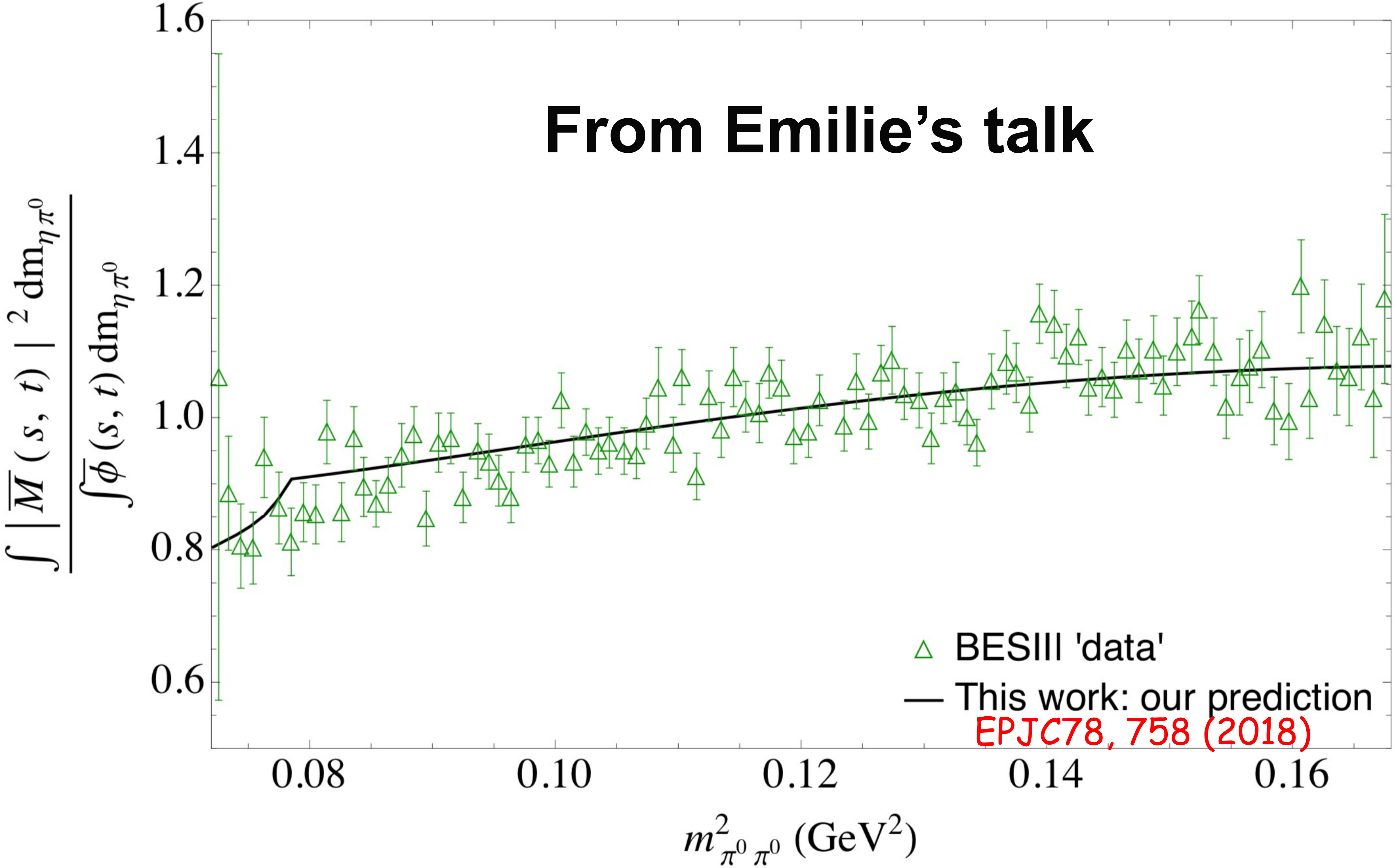




- Non-relativistic effective field theory
  B. Kubis and S. P. Schneider, EPJC 62, 511 (2009)
- Fits at different cases
- Evidence of the cusp effect @ 3.5σ
- $\eta\pi$ interaction not included!

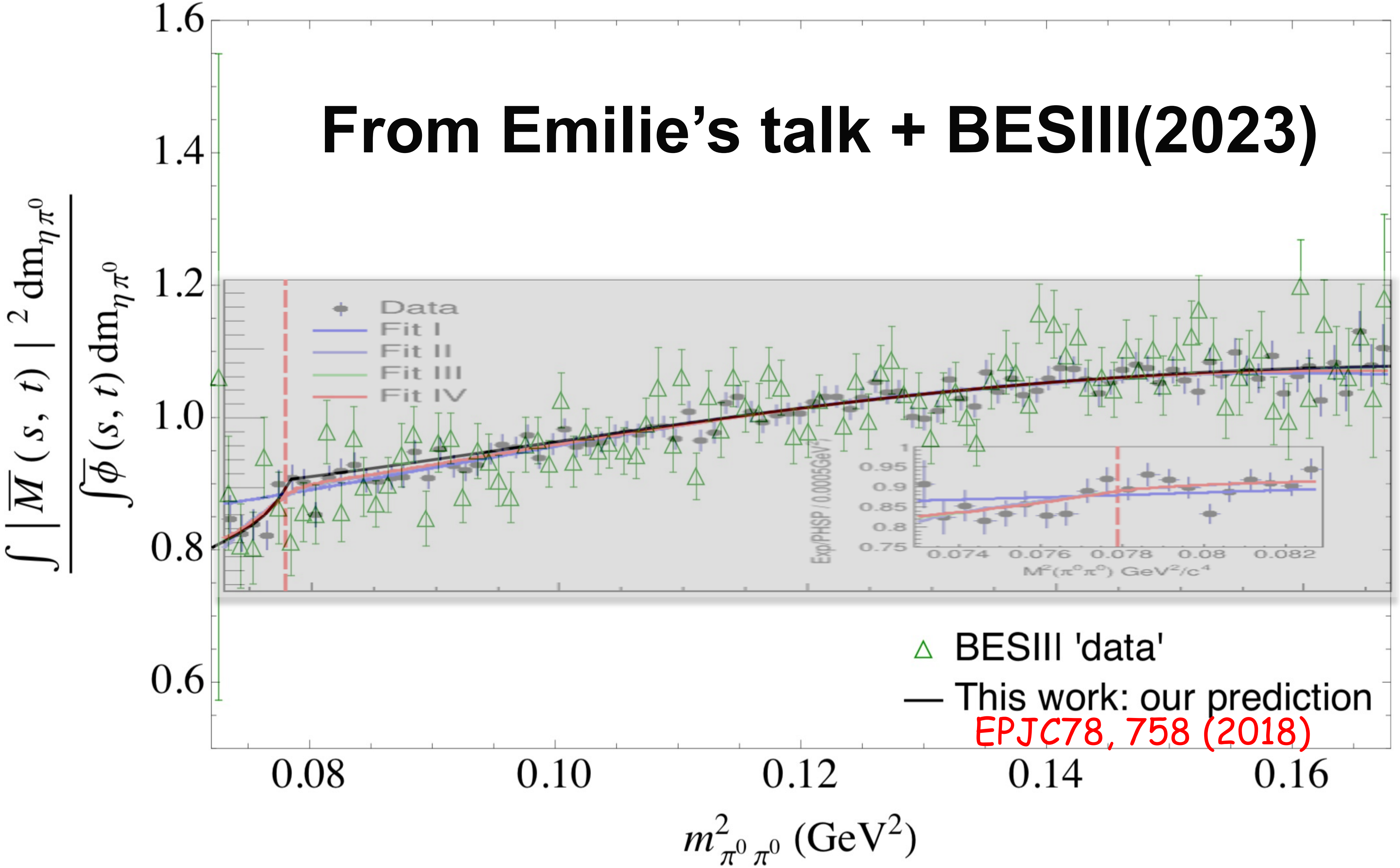
Parameters	Fit I	Fit II	Fit III	Fit IV
a	$-0.075 \pm 0.003 \pm 0.001$	-0.207 ± 0.013	-0.143 ± 0.010	$-0.077 \pm 0.003 \pm 0.001$
b	$-0.073 \pm 0.005 \pm 0.001$	-0.051 ± 0.014	-0.038 ± 0.006	$-0.066 \pm 0.006 \pm 0.001$
d	$-0.066 \pm 0.003 \pm 0.001$	-0.068 ± 0.004	-0.067 ± 0.003	$-0.068 \pm 0.004 \pm 0.001$
$a_0 - a_2$	-	0.174 ± 0.066	0.225 ± 0.062	$0.226 \pm 0.060 \pm 0.012$
a_0	-	0.497 ± 0.094	-	-
a_2	-	0.322 ± 0.129	-	-
Statistical Significance	-	3.4σ	3.7σ	3.6σ

From Emilie’s talk

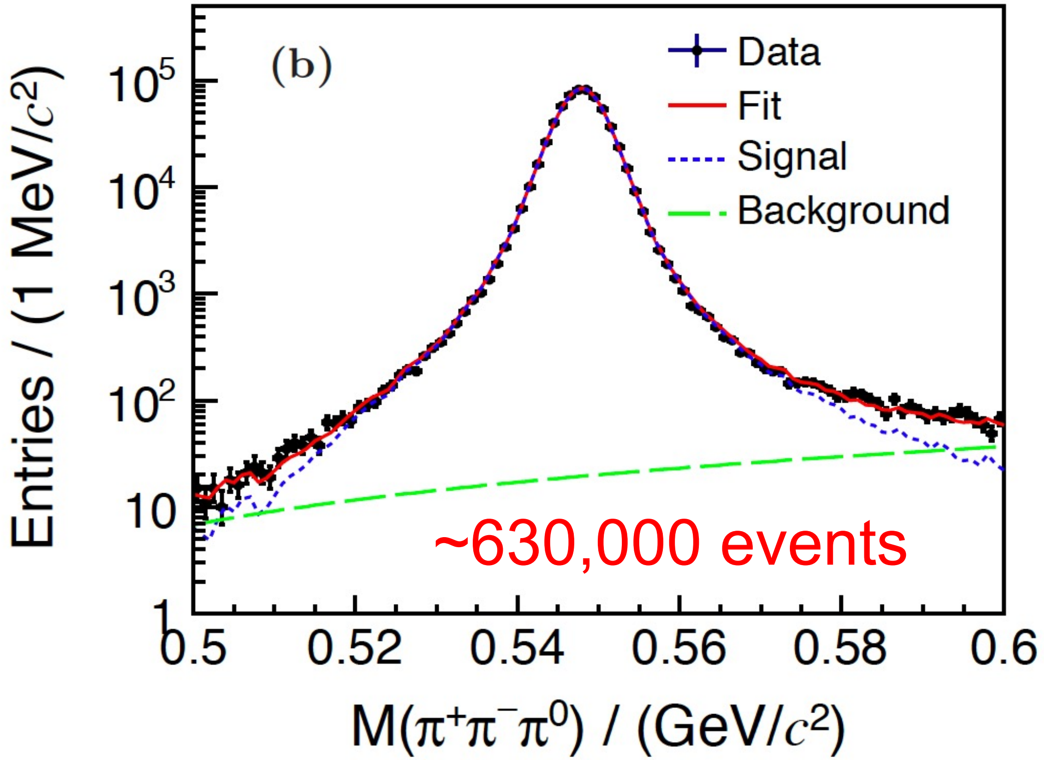


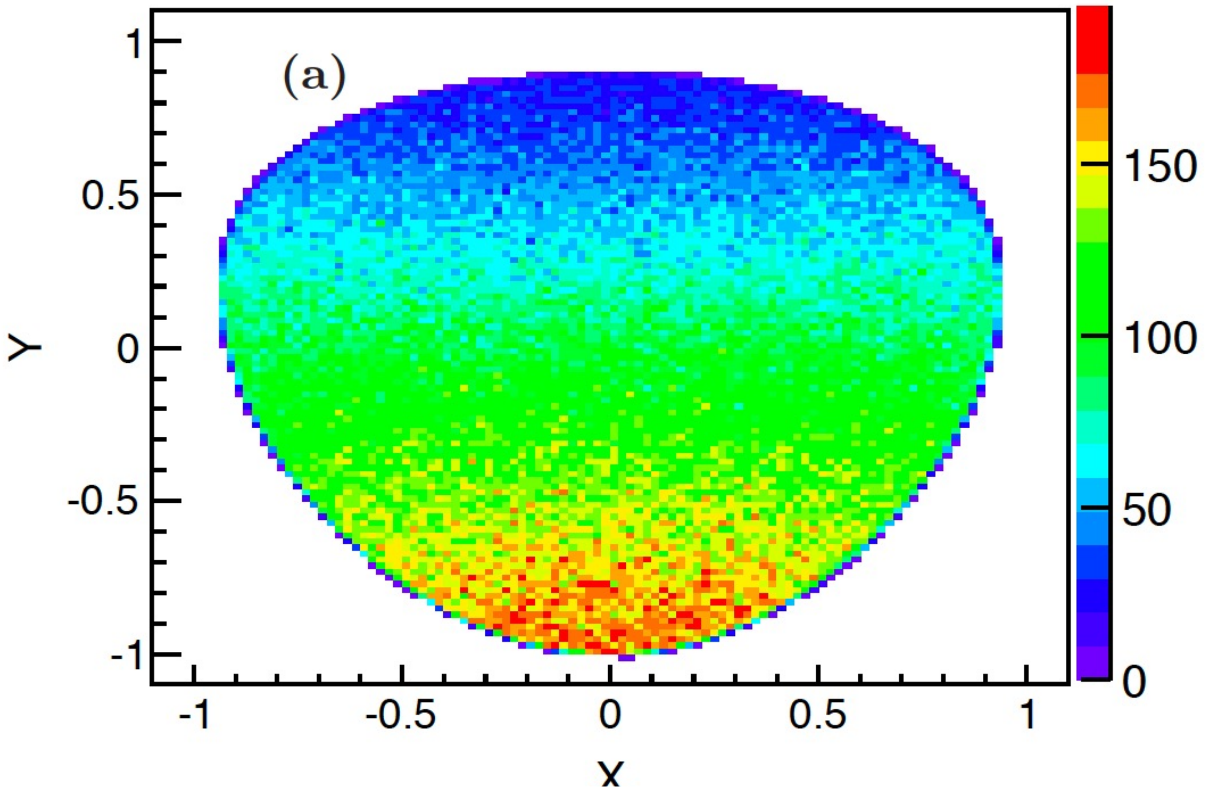
EPJC78, 758 (2018)

From Emilie's talk + BESIII(2023)



Updated results on $\eta\to\pi^+\pi^-\pi^0$, $\eta\to\pi^0\pi^0\pi^0$



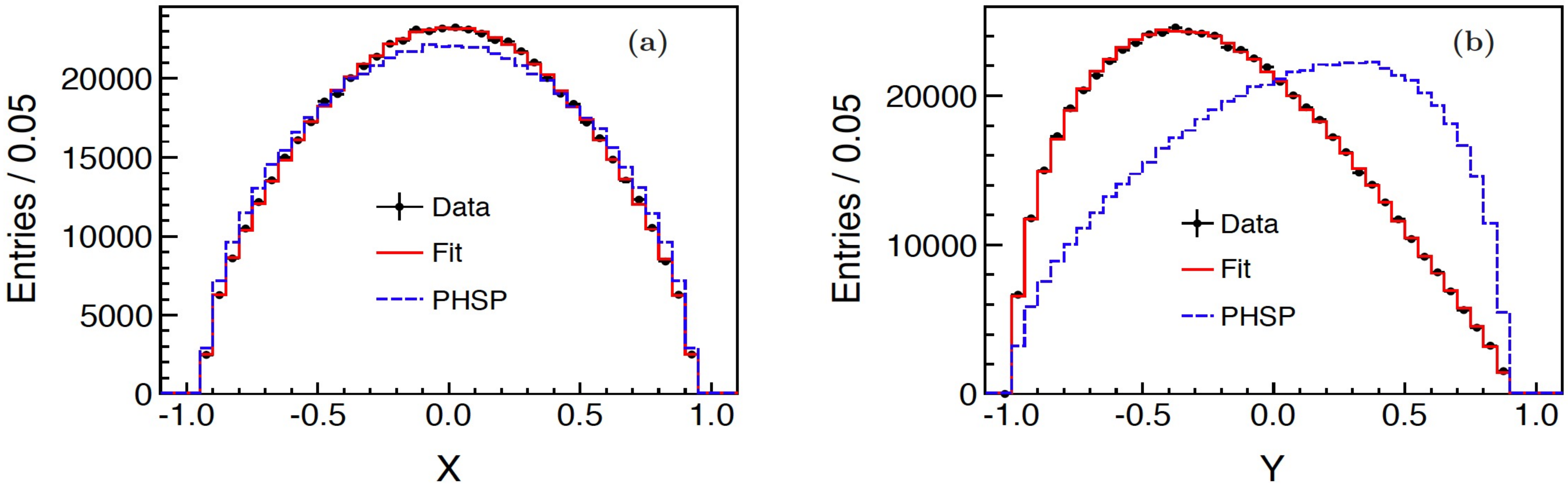


PRD107,092007(2023)

$$X=\frac{\sqrt{3}}{Q_\eta}(T_{\pi^+}-T_{\pi^-}),\qquad Y=\frac{3T_{\pi^0}}{Q_\eta}-1$$

$\eta \to \pi^+ \pi^- \pi^0$

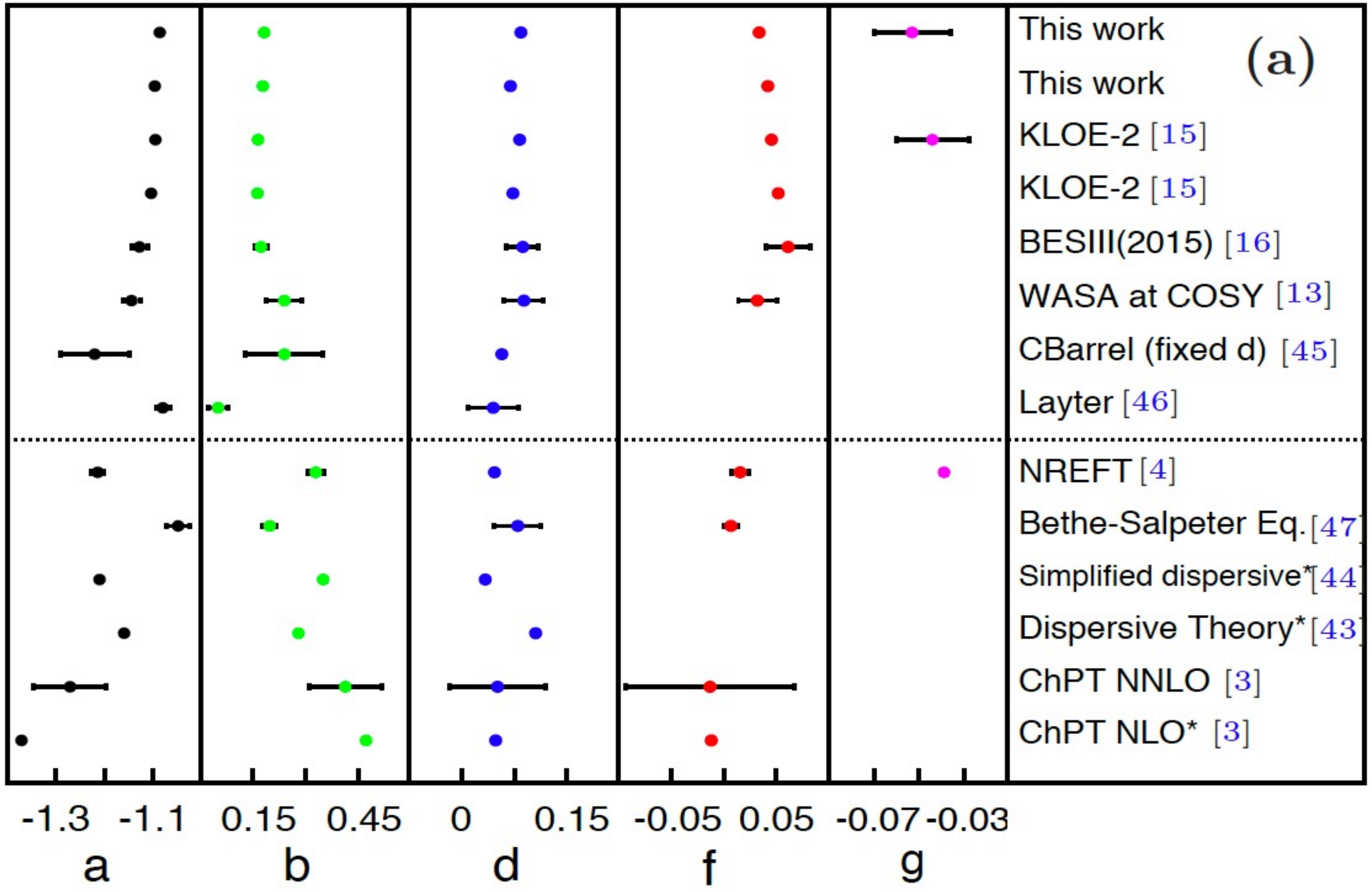
$$|A(X,Y)|^2 \propto 1 + aY + bY^2 + cX + dX^2 + eXY + fY^3 + gX^2Y + \cdots$$



Comparison to experimental and theoretical results

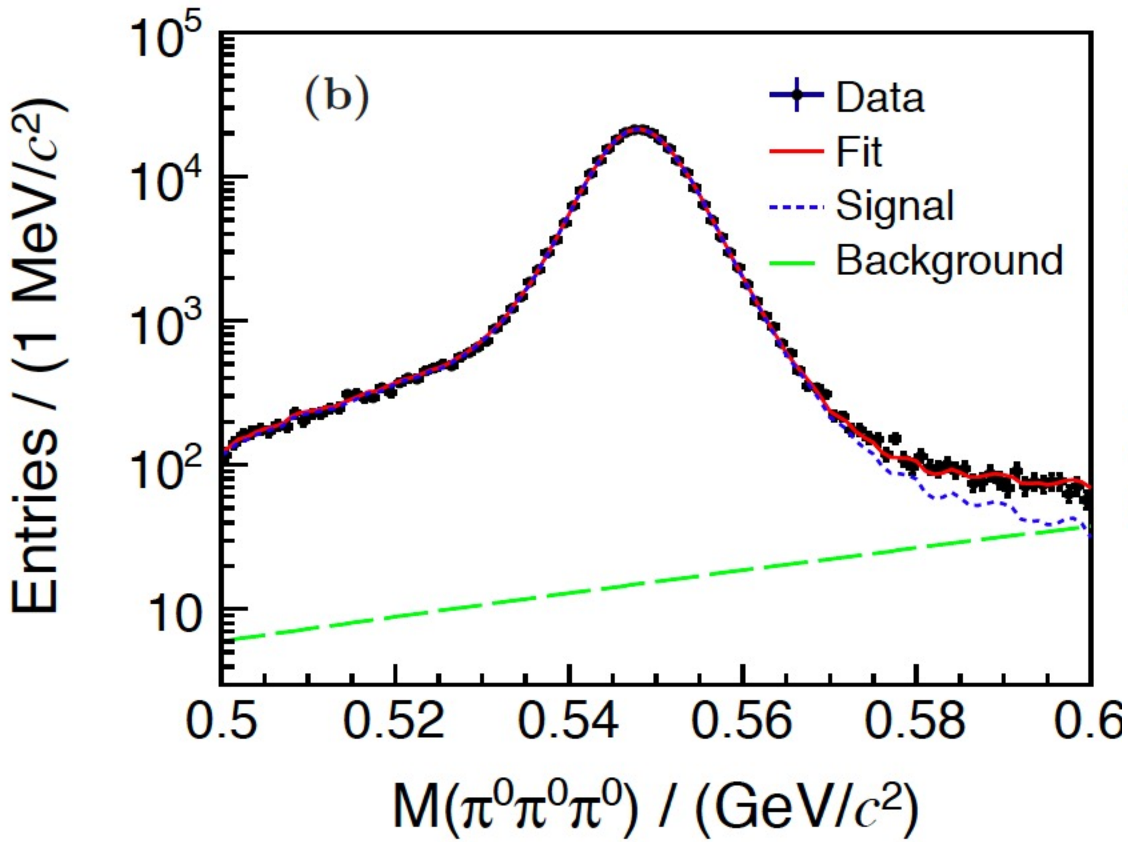
$$
\begin{aligned}
a &= -1.097 \pm 0.005 \pm 0.001 \\
b &= 0.158 \pm 0.006 \pm 0.003 \\
d &= 0.070 \pm 0.006 \pm 0.001 \\
f &= 0.134 \pm 0.010 \pm 0.003
\end{aligned}
$$

$$
\begin{aligned}
a &= -1.086 \pm 0.006 \pm 0.001 \\
b &= 0.162 \pm 0.006 \pm 0.003 \\
d &= 0.083 \pm 0.007 \pm 0.001 \\
f &= 0.118 \pm 0.011 \pm 0.003 \\
g &= -0.053 \pm 0.017 \pm 0.003
\end{aligned}
$$



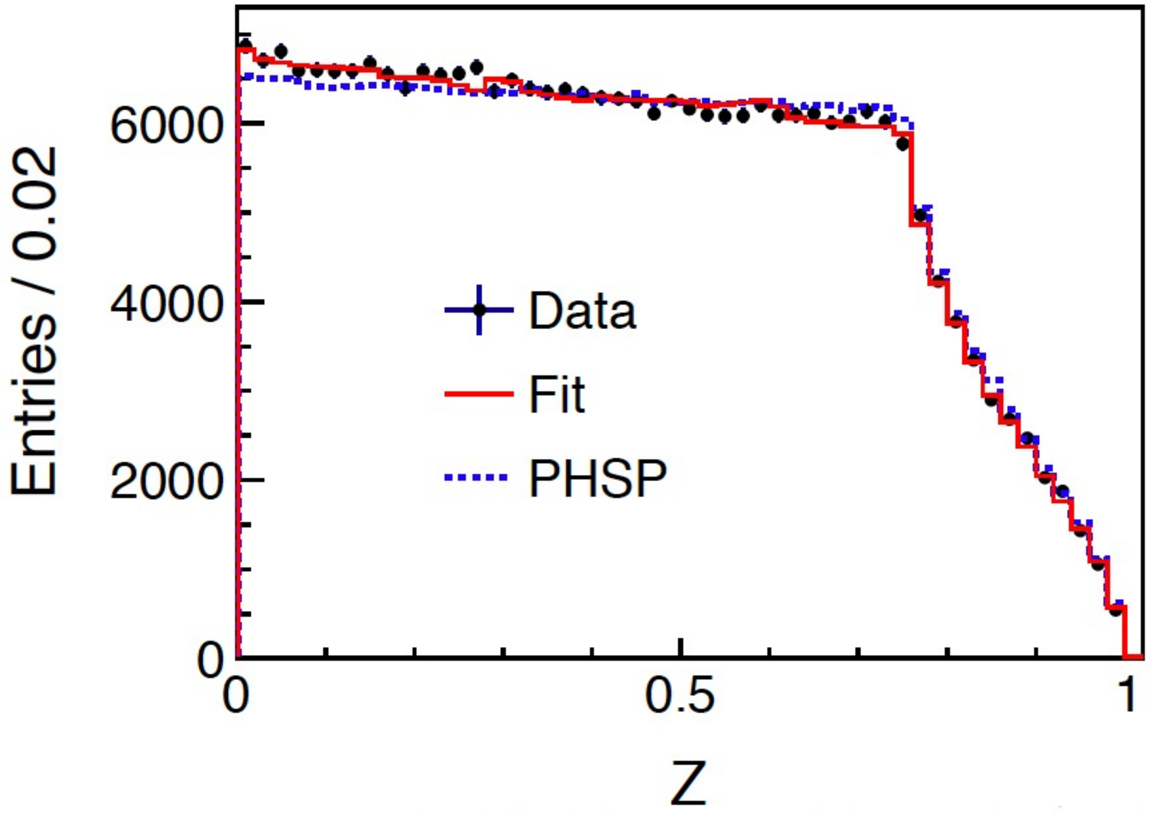
$\eta\to\pi^0\pi^0\pi^0$

~270,000 events



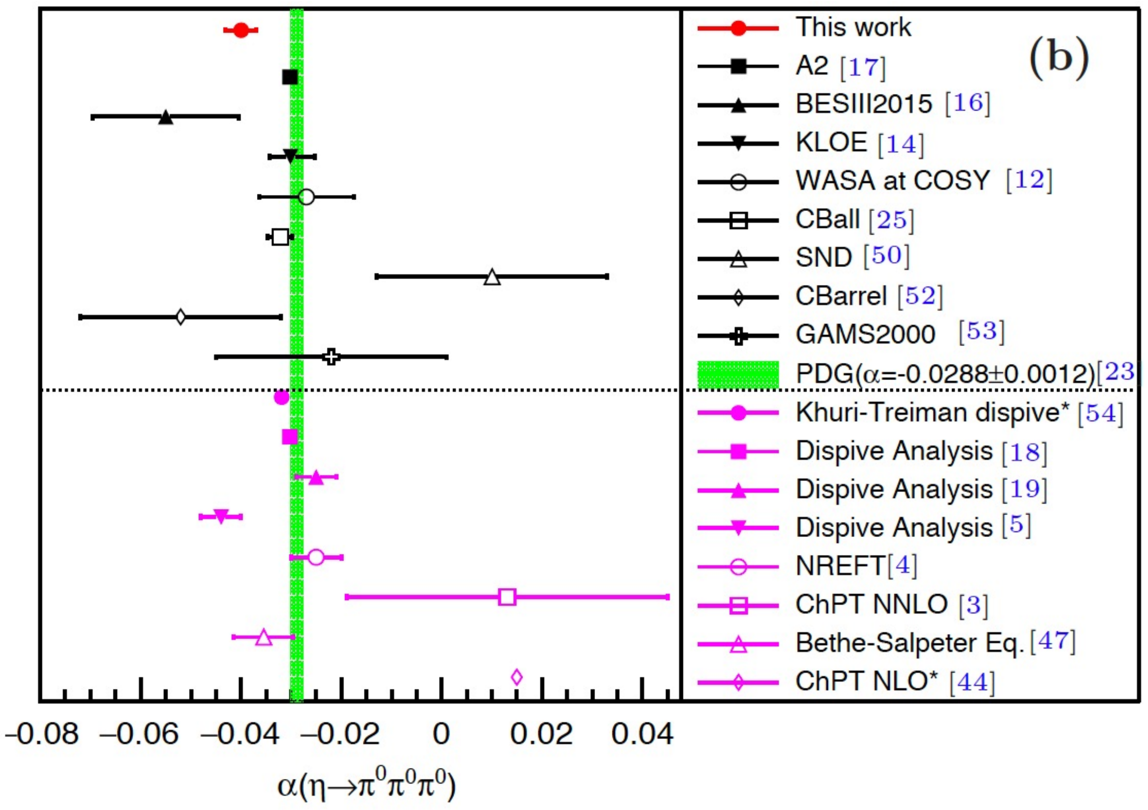
PRD107,092007(2023)

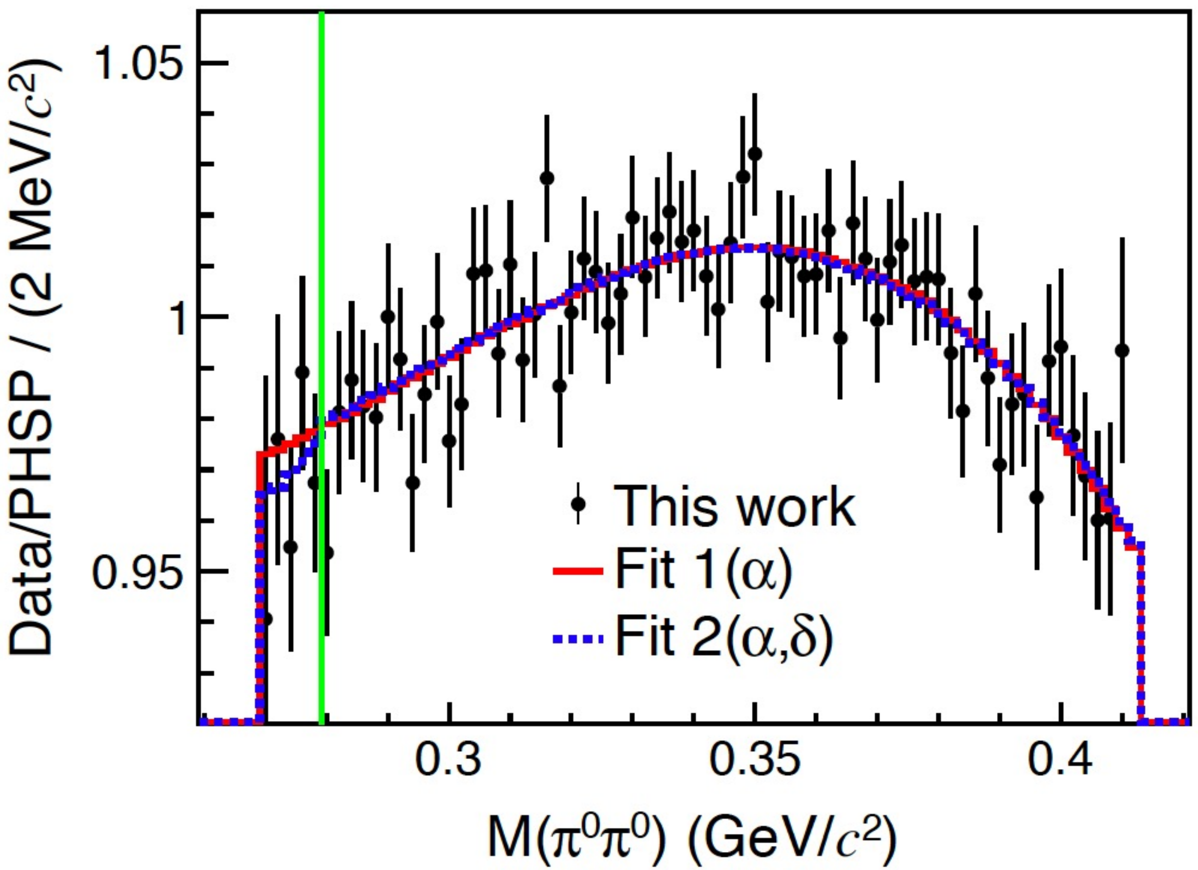
$$|A(X,Y)|^2 \propto 1+2\alpha Z$$



$$\alpha = -0.0406\pm0.0035\pm0.0008$$

$\eta \to \pi^0\pi^0\pi^0$





Deviations from A2: 2.8σ

No evident cusp effect

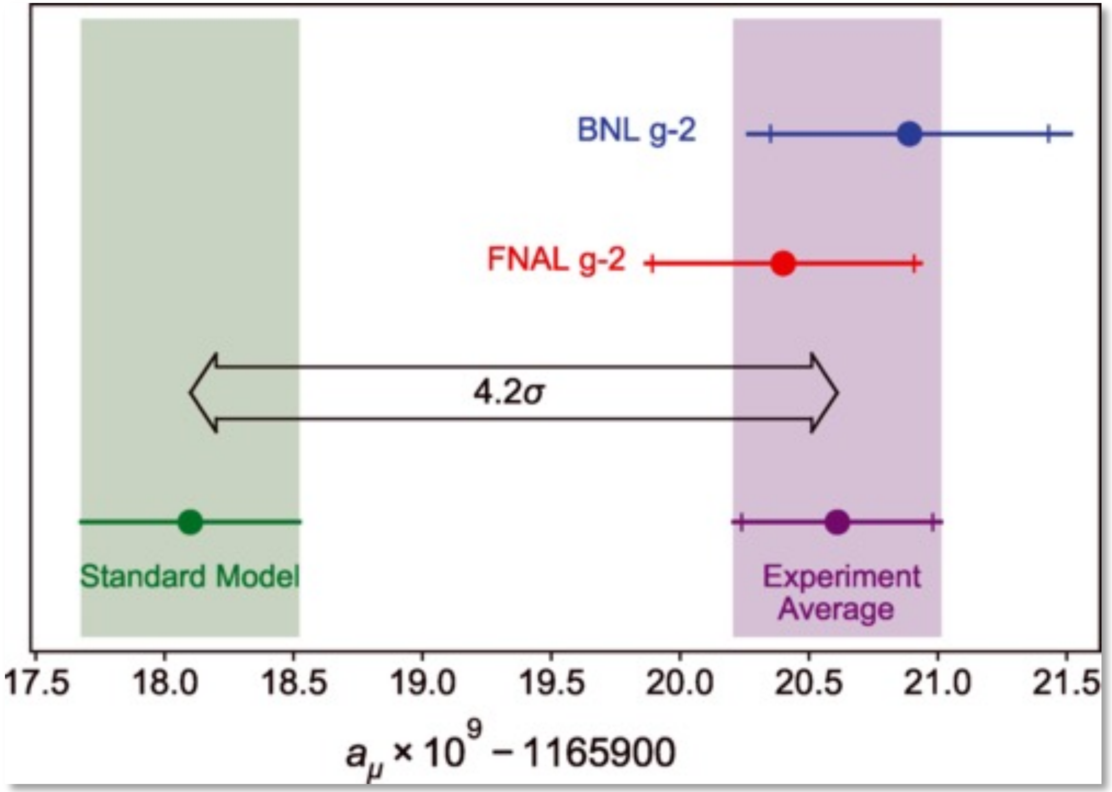
Summary and Prospects

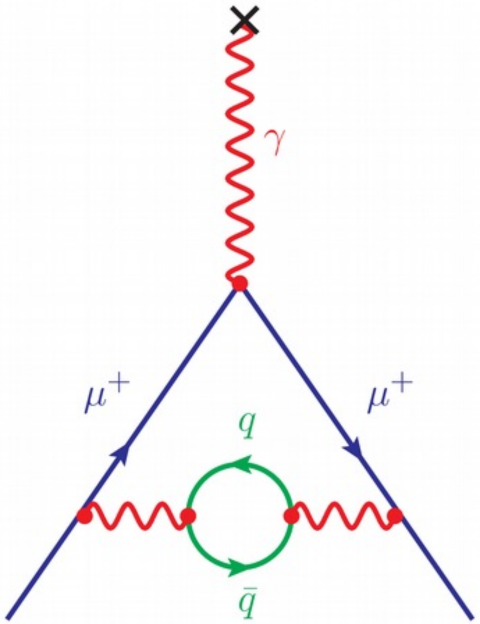
- BESIII: a light meson factory
  - Many progresses achieved on η/η′ decays
- With 10 billion J/ψ events
  - Allow to study light meson decays with high precision

    e.g.,~7 million $\eta' \to \gamma\pi^+\pi^-$ events, ~2 million $\eta' \to \eta\,\pi^+\pi^-$ events
  - New source of η: $\eta' \to \pi^+\pi^-\eta$ (arXiv:2306.02810)
- Space-like TFFs for π^0, η/η′
  - $20\,fb^{-1}$ @3.773 GeV expected by 2023 → space-like TFFs !

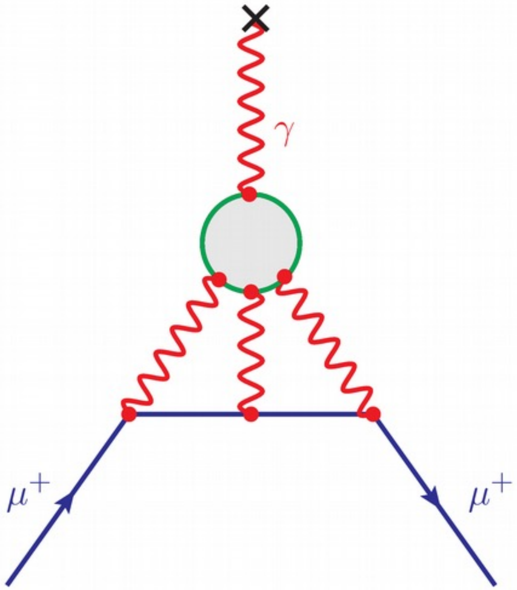
Many thanks!

$$a_\mu = \frac{g_\mu - 2}{2} = a_\mu^{QED} + a_\mu^{weak} + a_\mu^{hadr}$$





HVP

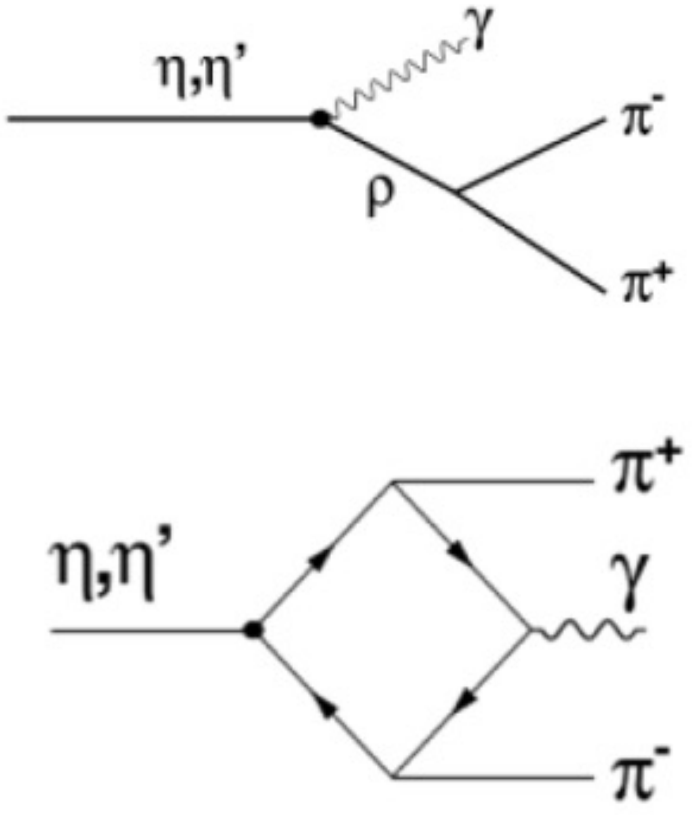


HLbL

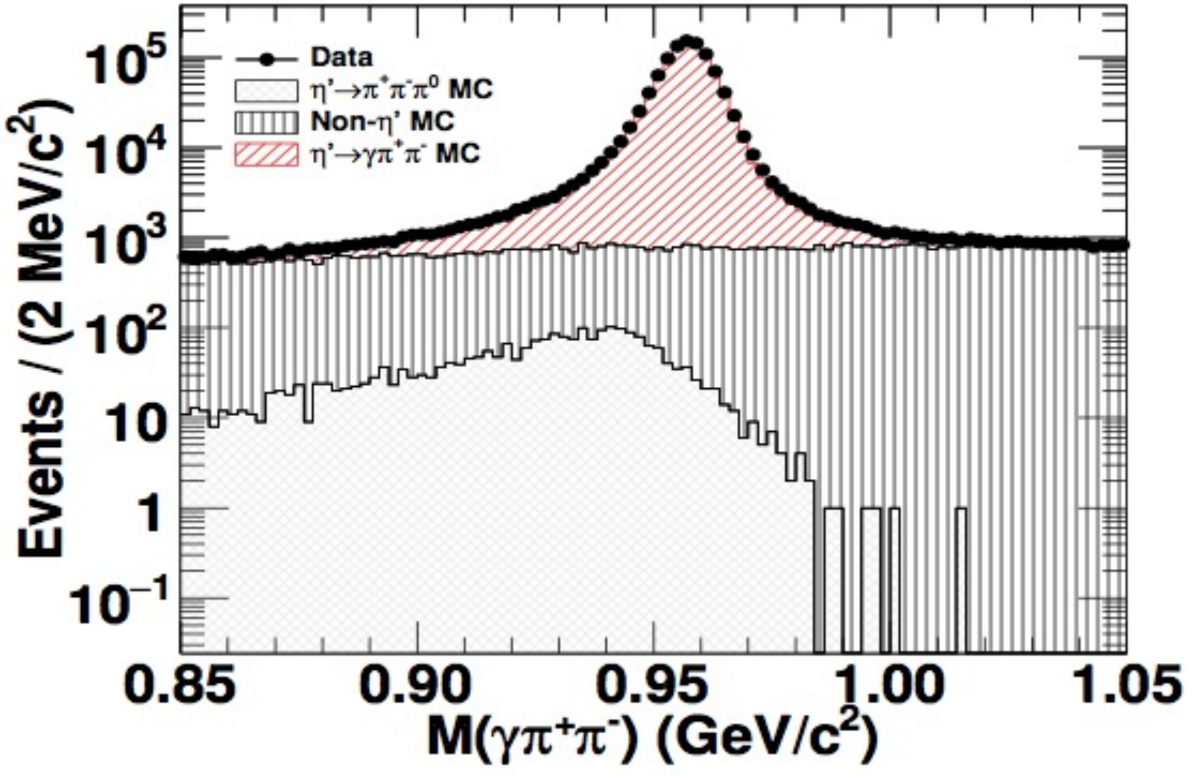
Prediction completely limited by hadronic contributions!

Use experimental input to improve theory!

$\eta' \to \gamma\pi^+\pi^-$ decay dynamics



~0.9M events



high term of ChPT→ box anomaly

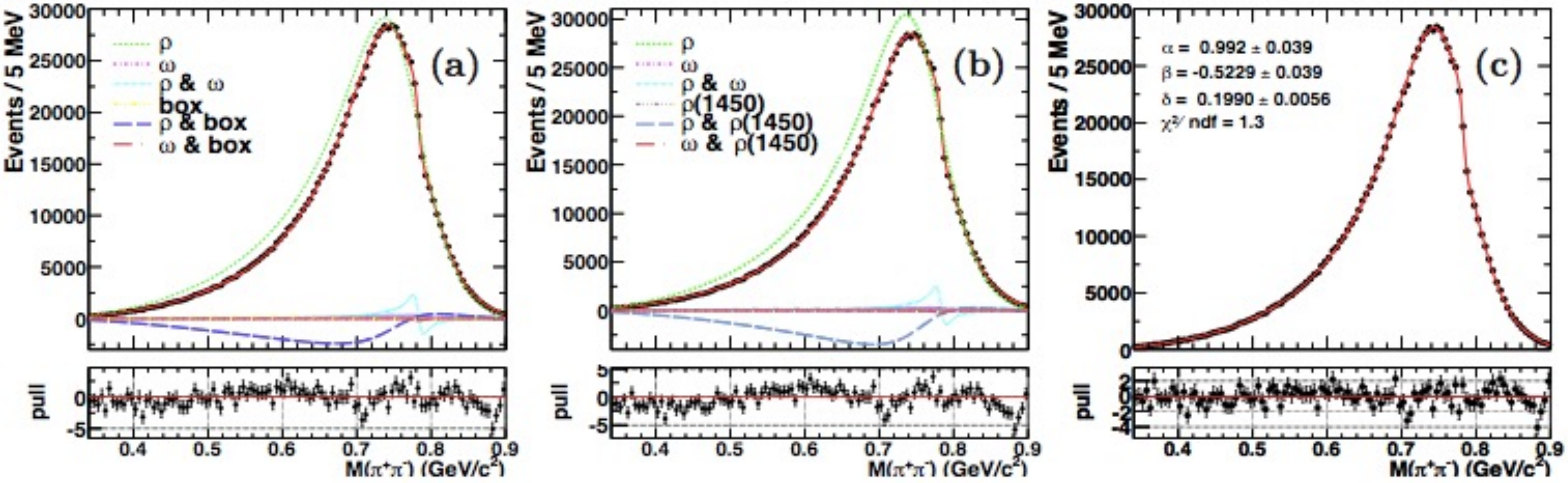
PRL120,242003(2018)

Model-(in)dependent fit

fit with $\rho(770)$-ω-box anomaly

fit with $\rho(770)$-ω-$\rho(1450)$

$P(s_{\pi\pi}) = 1 + \alpha\, s_{\pi\pi} + \beta\, O(s^2_{\pi\pi}) + \delta\, BW_\omega$



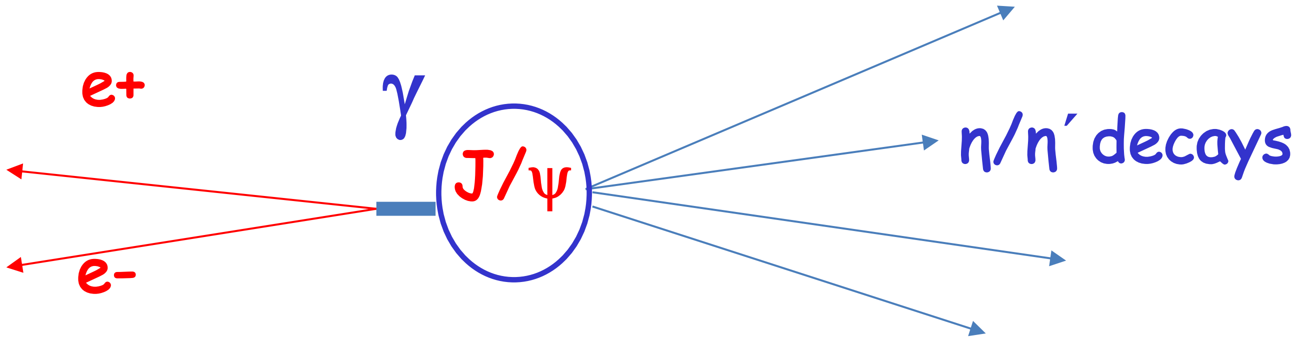
- ✓ $\rho(770)$-ω cannot describe data well
- ✓ Extra contribution (maybe $\rho(1450)$ or box-anomaly) is also necessary

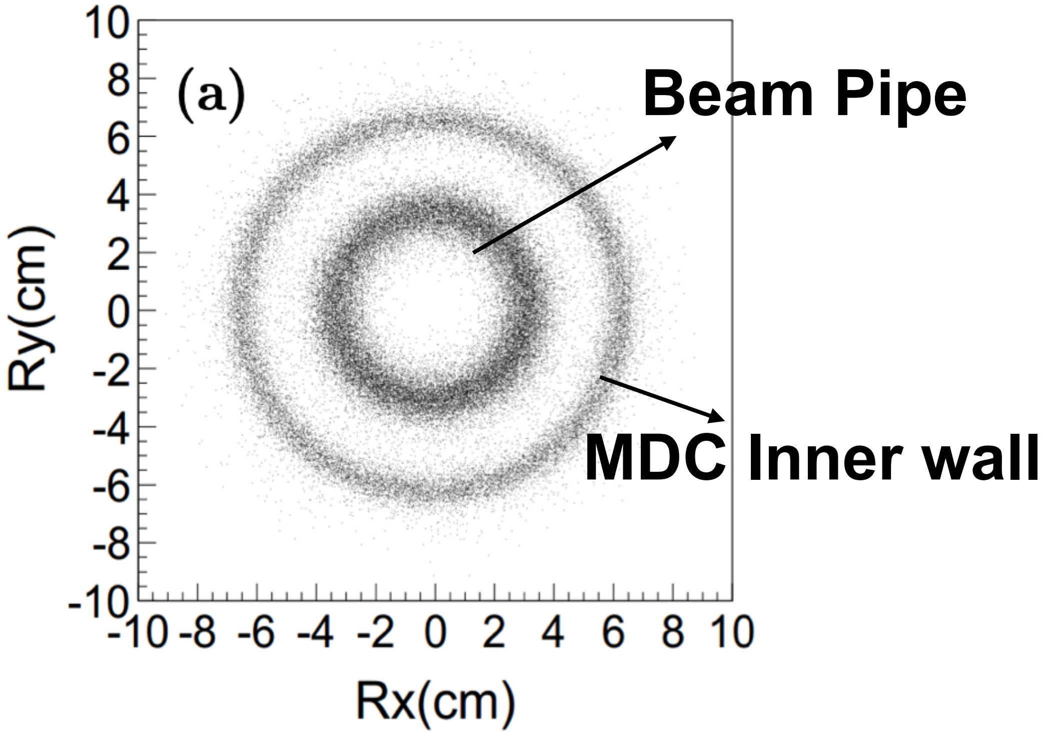
New approaches

Absolute Measurement of BFs of η′ decay modes	PRL122, 142002(2019)
Novel approach to investigate η decays	in progress

γ conversion: η/η' inclusive decays

- A novel way to measure the absolute BFs of η/η' decays
- Excellent momentum resolution for electrons @MDC

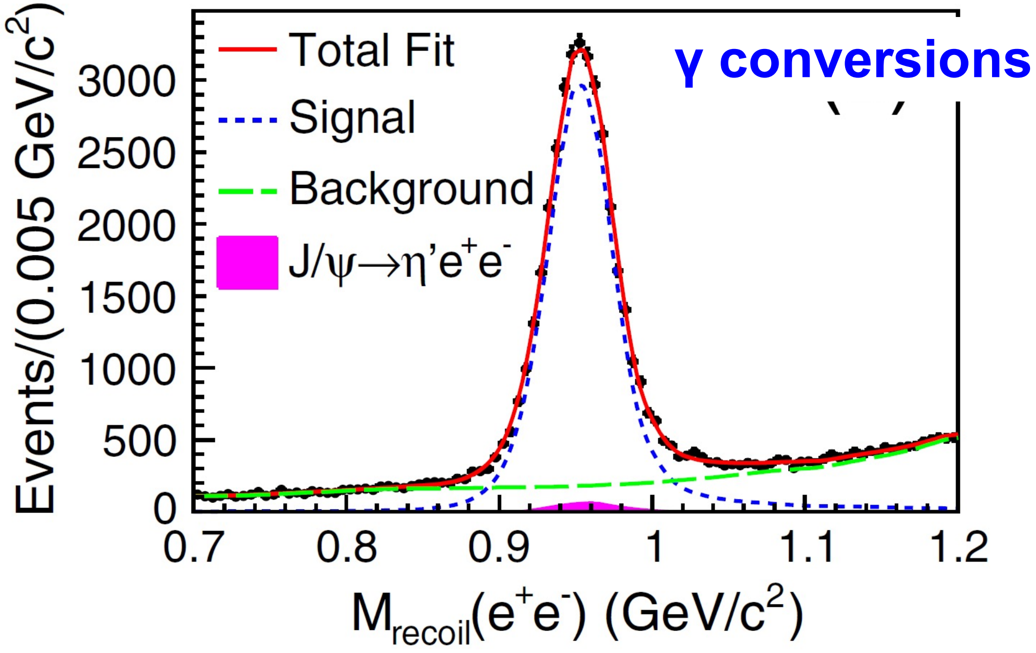




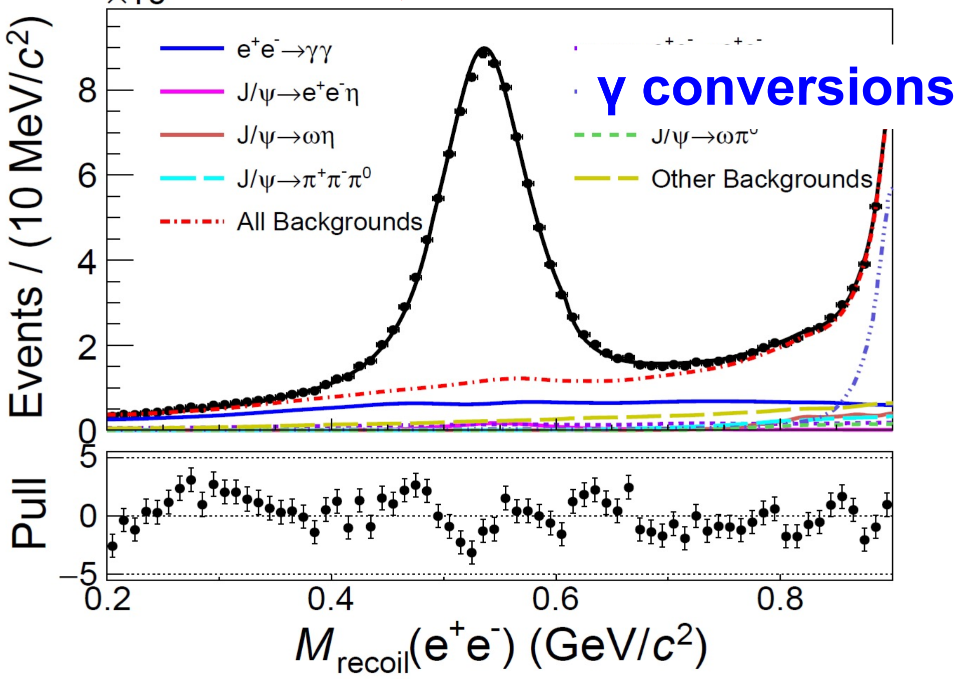
$$\mathcal{B}(\eta' \to X) = \frac{N^{\rm obs}_{\eta'\to X}}{\varepsilon_{\eta'\to X}} \frac{\varepsilon}{N^{\rm obs}_{J/\psi\to\gamma\eta'}}$$

First Measurement of Absolute BFs of η′ /η decays

PRL122, 142002 (2019)



PRD104, 092004 (2021)



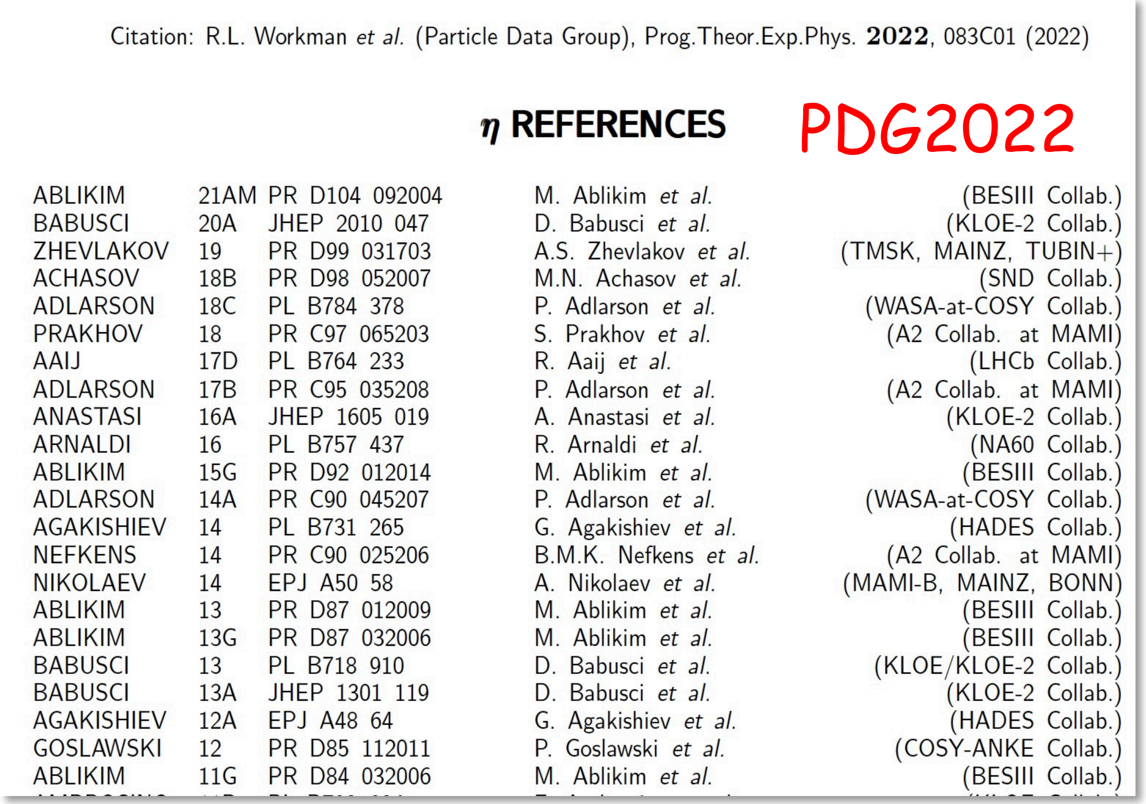
Decay mode	$\mathcal{B}(\eta' \to X)(\%)$ This measurement	PDG [7]
$\eta' \to \gamma\pi^+\pi^-$	$29.90 \pm 0.03 \pm 0.55$	28.9 ± 0.5
$\eta' \to \eta\pi^+\pi^-$	$41.24 \pm 0.08 \pm 1.24$	42.6 ± 0.7
$\eta' \to \eta\pi^0\pi^0$	$21.36 \pm 0.10 \pm 0.92$	22.8 ± 0.8
$\eta' \to \gamma\omega$	$2.489 \pm 0.018 \pm 0.074$	2.62 ± 0.13
$\eta' \to \gamma\gamma$	$2.331 \pm 0.012 \pm 0.035$	2.22 ± 0.08

B(J/ψ→γη′) = (5.27±0.03±0.05)×10^{-3}

X	This work	PDG
$\gamma\gamma$	$39.86 \pm 0.04 \pm 0.99$	39.41 ± 0.20
$\pi^0\pi^0\pi^0$	$31.96 \pm 0.07 \pm 0.84$	32.68 ± 0.23
$\pi^+\pi^-\pi^0$	$23.04 \pm 0.03 \pm 0.54$	22.92 ± 0.28
$\pi^+\pi^-\gamma$	$4.38 \pm 0.02 \pm 0.10$	4.22 ± 0.08

B(J/ψ→γη) = (1.067±0.005±0.023)×10^{-3}

New approach to investigate η decays with $\eta' \to \pi^+\pi^-\eta$



Citation: R.L. Workman *et al.* (Particle Data Group), Prog.Theor.Exp.Phys. **2022**, 083C01 (2022)

η REFERENCES PDG2022

ABLIKIM	21AM	PR D104 092004	M. Ablikim *et al.*	(BESIII Collab.)
BABUSCI	20A	JHEP 2010 047	D. Babusci *et al.*	(KLOE-2 Collab.)
ZHEVLAKOV	19	PR D99 031703	A.S. Zhevlakov *et al.*	(TMSK, MAINZ, TUBIN+)
ACHASOV	18B	PR D98 052007	M.N. Achasov *et al.*	(SND Collab.)
ADLARSON	18C	PL B784 378	P. Adlarson *et al.*	(WASA-at-COSY Collab.)
PRAKHOV	18	PR C97 065203	S. Prakhov *et al.*	(A2 Collab. at MAMI)
AAIJ	17D	PL B764 233	R. Aaij *et al.*	(LHCb Collab.)
ADLARSON	17B	PR C95 035208	P. Adlarson *et al.*	(A2 Collab. at MAMI)
ANASTASI	16A	JHEP 1605 019	A. Anastasi *et al.*	(KLOE-2 Collab.)
ARNALDI	16	PL B757 437	R. Arnaldi *et al.*	(NA60 Collab.)
ABLIKIM	15G	PR D92 012014	M. Ablikim *et al.*	(BESIII Collab.)
ADLARSON	14A	PR C90 045207	P. Adlarson *et al.*	(WASA-at-COSY Collab.)
AGAKISHIEV	14	PL B731 265	G. Agakishiev *et al.*	(HADES Collab.)
NEFKENS	14	PR C90 025206	B.M.K. Nefkens *et al.*	(A2 Collab. at MAMI)
NIKOLAEV	14	EPJ A50 58	A. Nikolaev *et al.*	(MAMI-B, MAINZ, BONN)
ABLIKIM	13	PR D87 012009	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	13G	PR D87 032006	M. Ablikim *et al.*	(BESIII Collab.)
BABUSCI	13	PL B718 910	D. Babusci *et al.*	(KLOE/KLOE-2 Collab.)
BABUSCI	13A	JHEP 1301 119	D. Babusci *et al.*	(KLOE-2 Collab.)
AGAKISHIEV	12A	EPJ A48 64	G. Agakishiev *et al.*	(HADES Collab.)
GOSLAWSKI	12	PR D85 112011	P. Goslawski *et al.*	(COSY-ANKE Collab.)
ABLIKIM	11G	PR D84 032006	M. Ablikim *et al.*	(BESIII Collab.)

- Production rate lower than η′
- Background from QED and J/ψ decays

$J/\psi \to \gamma\eta$ → 1×10^7 η

$J/\psi \to \gamma\eta'$, $\eta' \to \pi^+\pi^-\eta$ → 2.2×10^7 η

One more η′ constraint to suppress the background events !

$J/\psi \to \gamma\eta', \eta' \to \pi^+\pi^-\eta$

$J/\psi \to \gamma\eta$

- Help distinguish muons from pions
- Background level is low