Light mesons and axions at BESIII

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- Examples of light meson studies: two pion system

  Prog.Part.Nucl.Phys. 120 (2021) 103884

- Axion and dark photon searches

Workshop at 1GeV scale: From mesons to axions

Kraków, September 20th, 2024

UPPSALA UNIVERSITET

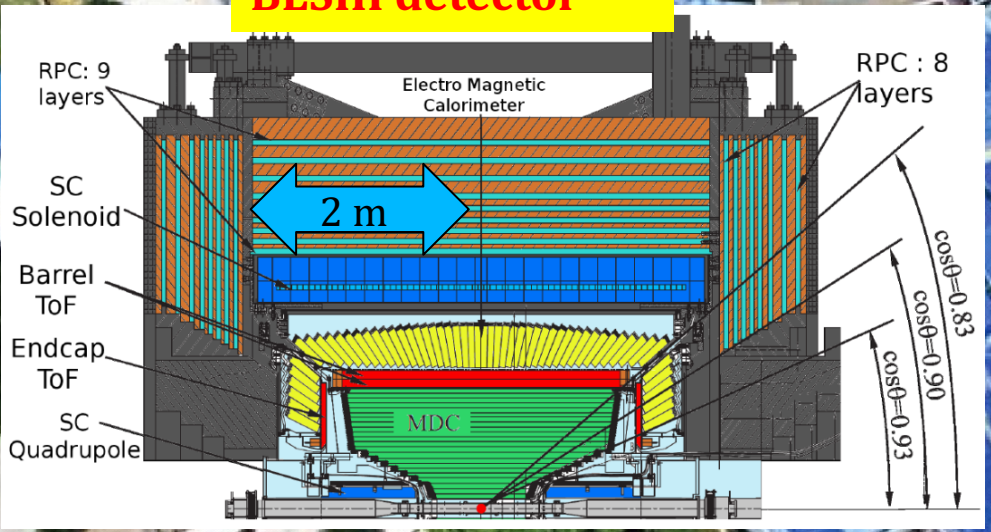
NCBJ ŚWIERK

BEPCII (Beijing)

Linac

Storage ring

BESIII detector

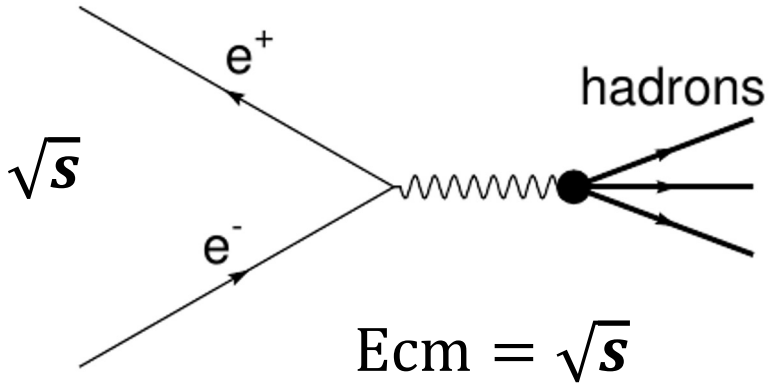


τ –charm factory $2<\sqrt{s}<4.95$ GeV:

- Charmonium spectroscopy/decays
- Light hadrons
- Charm
- τ physics
- R-scan

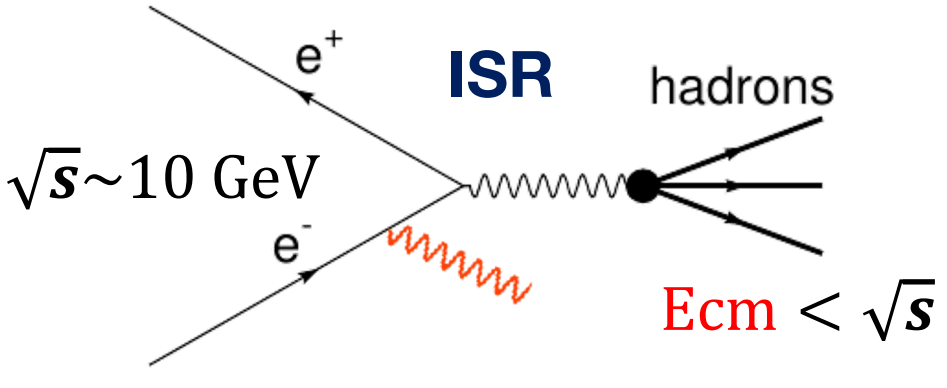
Hadrons at e^+e^- colliders

BESIII

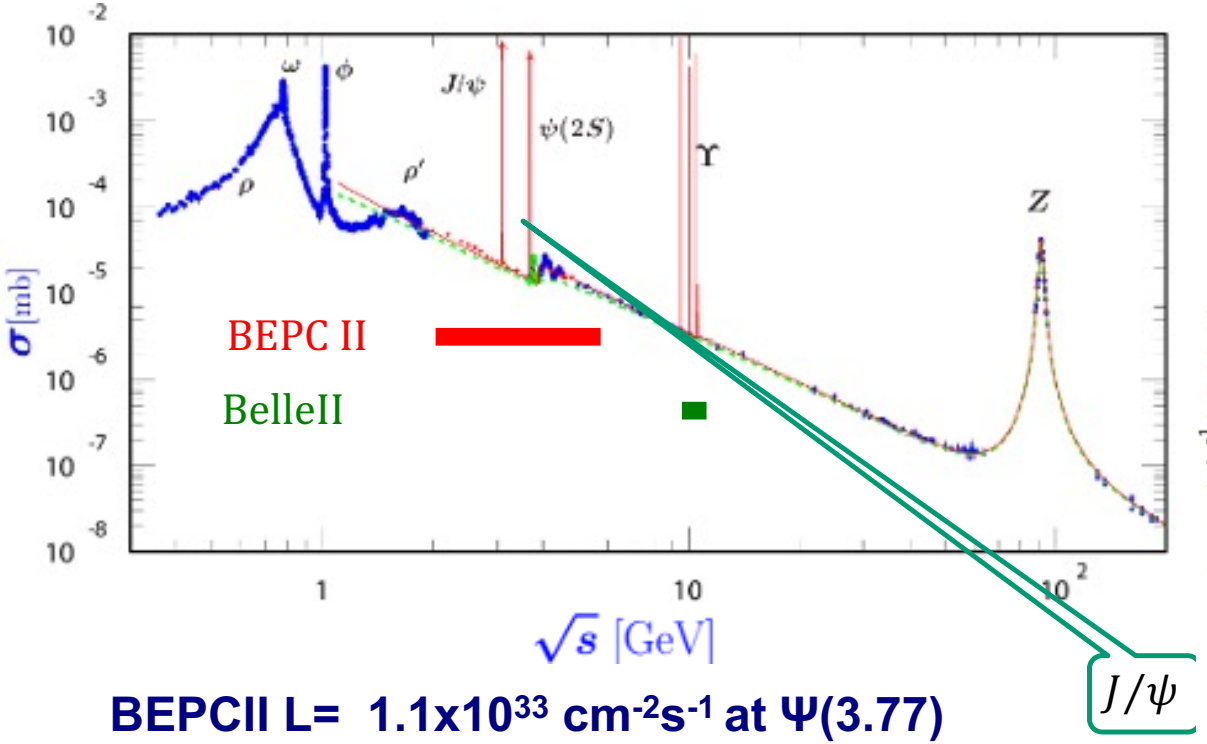


- ❑ (very) high luminosity at selected c.m. energies
- ❑ better resolution: at J/ψ 0.9 MeV

BelleII



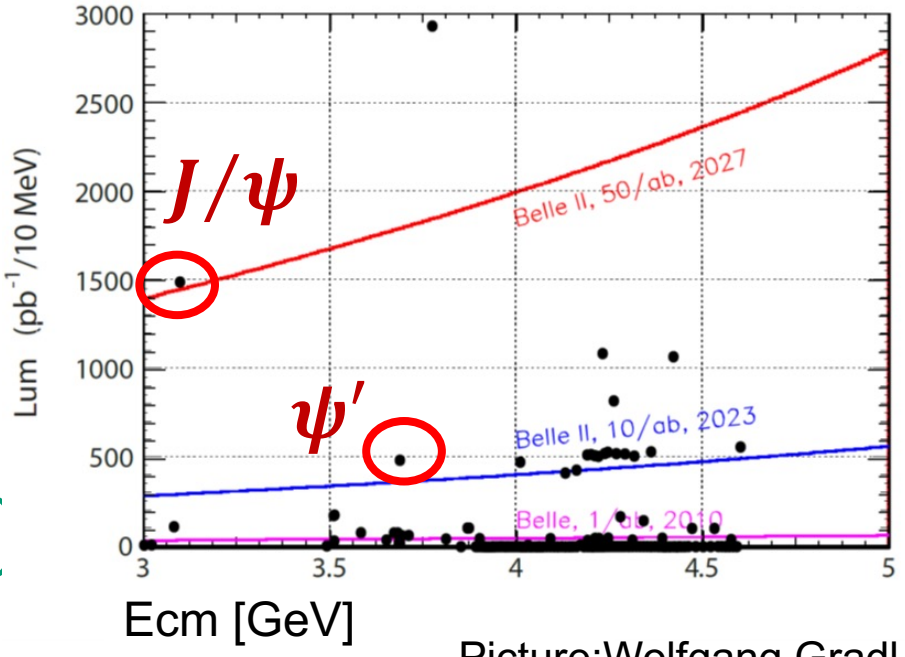
- ❑ ISR: many Ecm simultaneously
- ❑ also hadrons from B and τ decays



BEPCII L= 1.1x10^{33} cm^{-2}s^{-1} at Ψ(3.77)

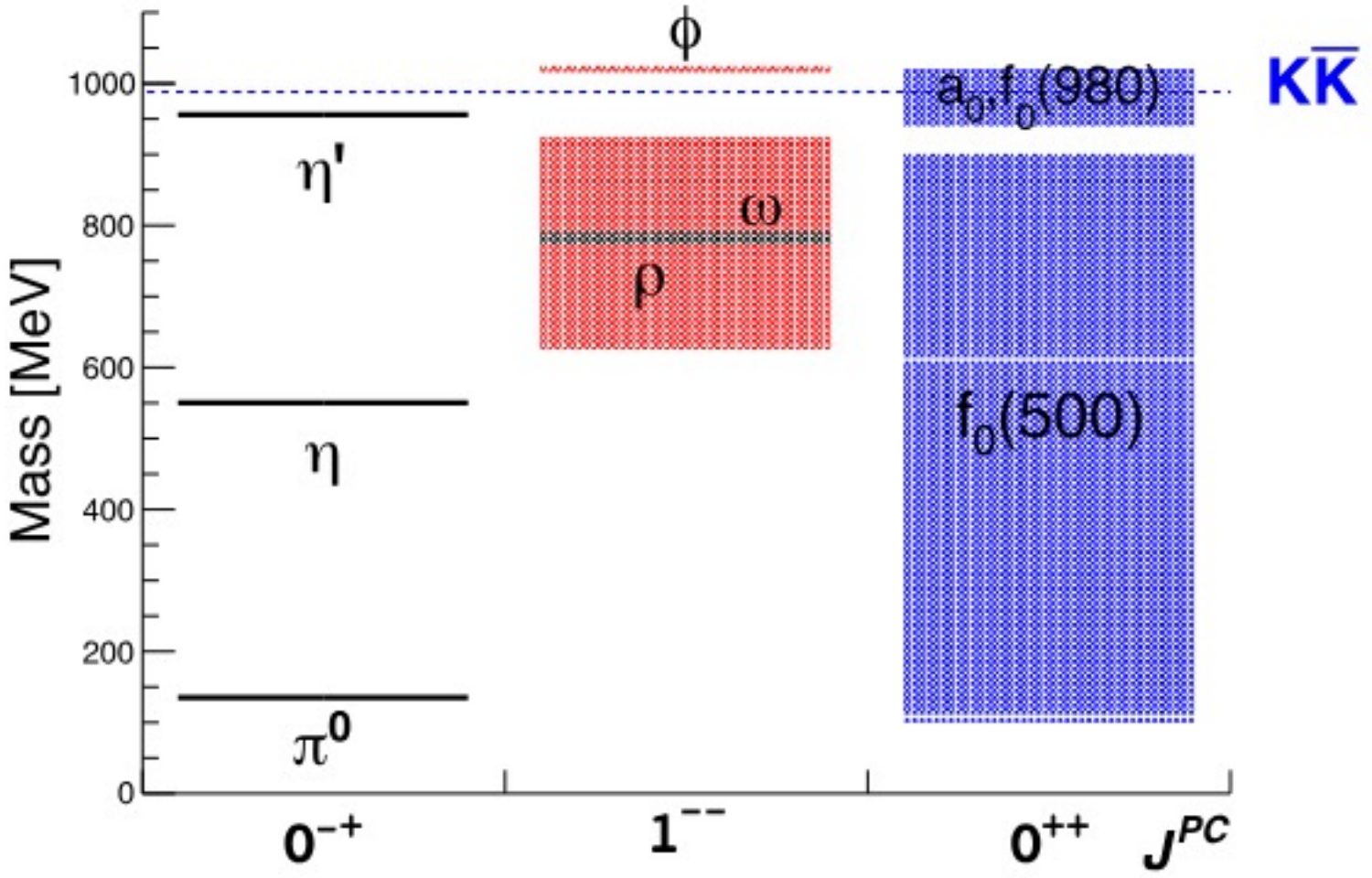
10^{10} J/ψ Feb 2019

$\psi(3770)20\ \text{fb}^{-1}$

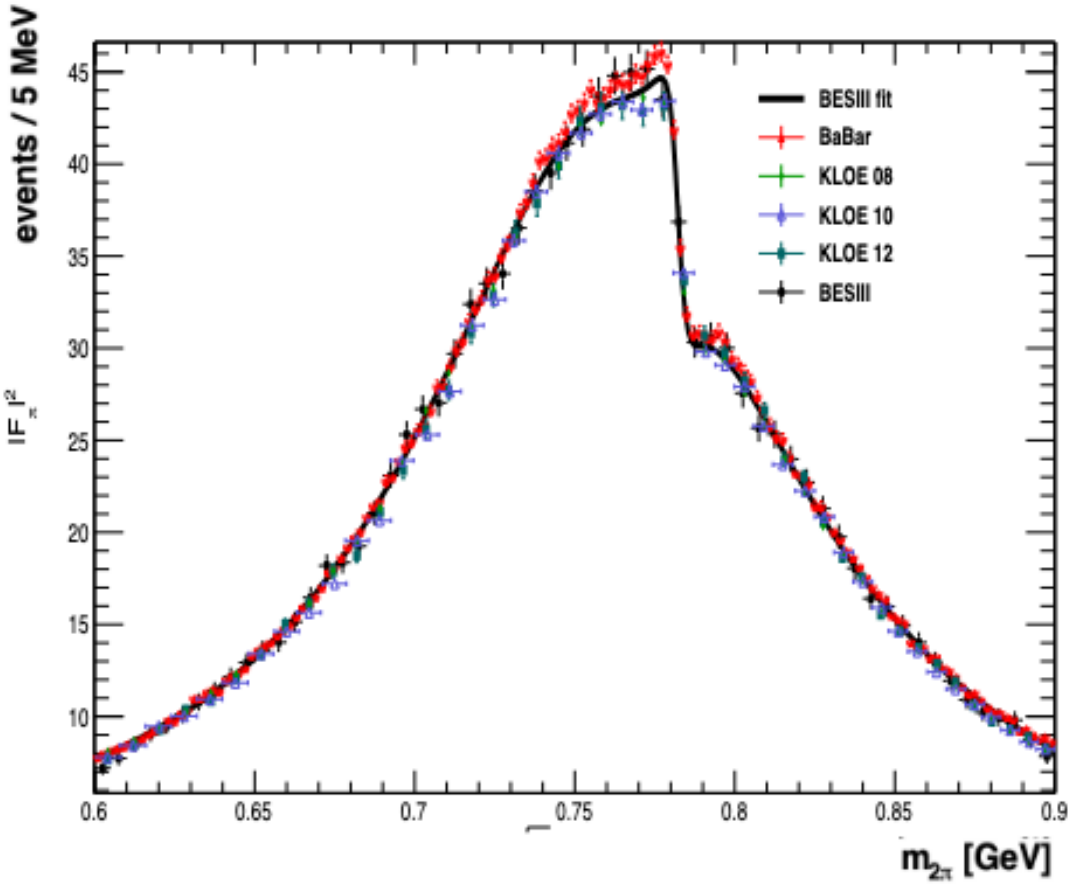


Picture:Wolfgang Gradl

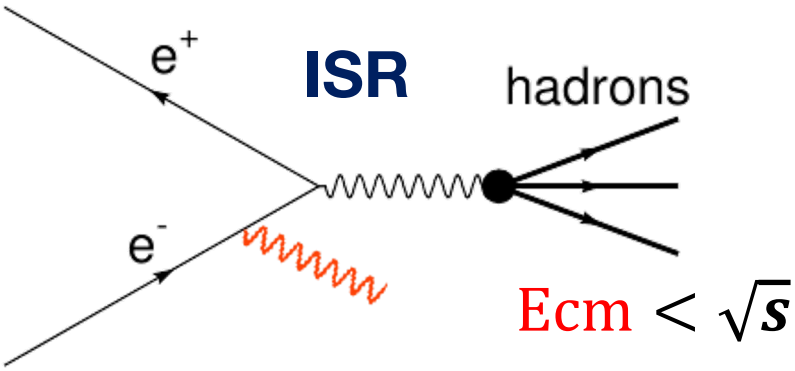
Neutral light mesons



$$e^+e^- \to \pi^+\pi^-\gamma_{ISR}$$



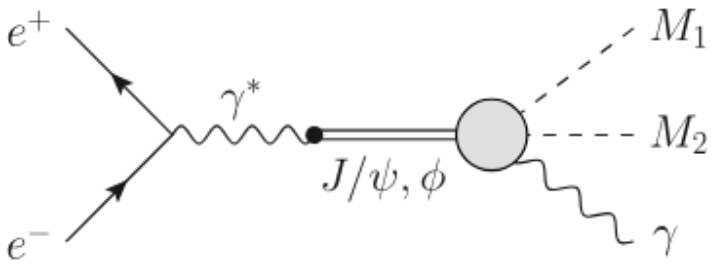
$\sqrt{s} = 3.77$ GeV



Crucial for hadronic contribution to muon g-2

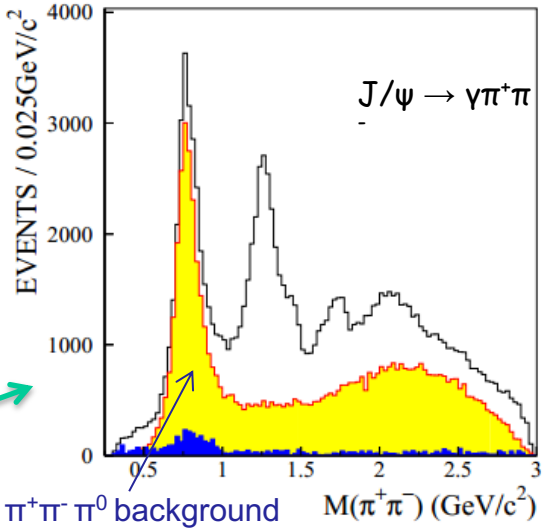
PLB753 (2016) 629
PLB812 (2021) 135982 (erratum)

Amplitude analysis of $J/\psi \to \gamma\pi^0\pi^0$



Radiative decays to two pseudoscalars, angular momentum + parity restricts the quantum numbers to $J^{PC}=0^{++},2^{++},4^{++}\ldots$

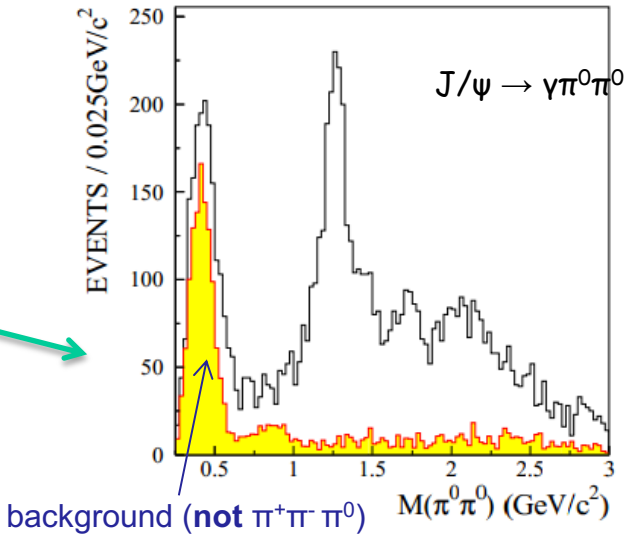
$\pi^0\pi^0$ is cleaner than $\pi^+\pi^-$



Amplitude analysis:

Mass independent fits → final state interactions of $\pi^0\pi^0$

Mass dependent fits → extracting masses, widths, etc. of intermediate states

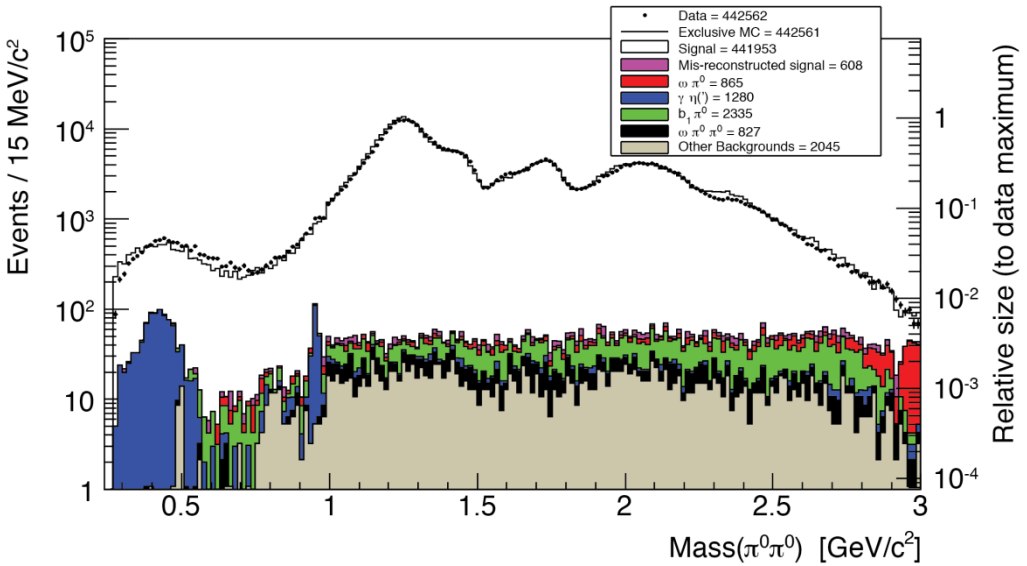


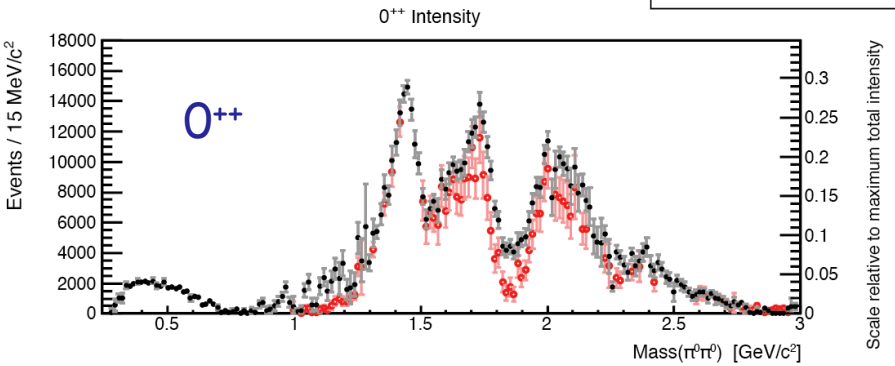
BESII: PLB 642,441 (2006)

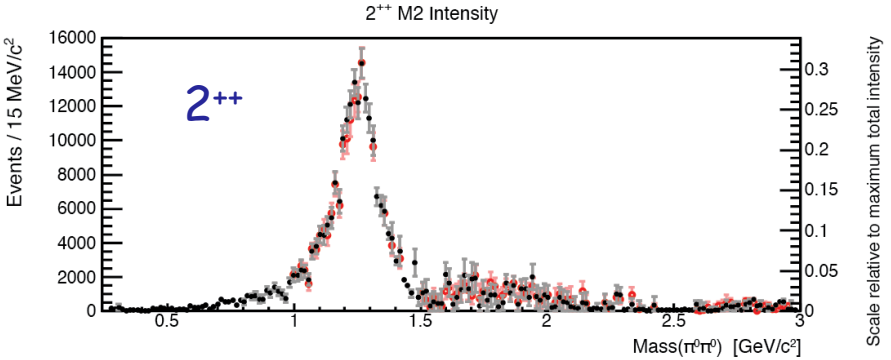
Amplitude analysis of $J/\psi \to \gamma\pi^0\pi^0$

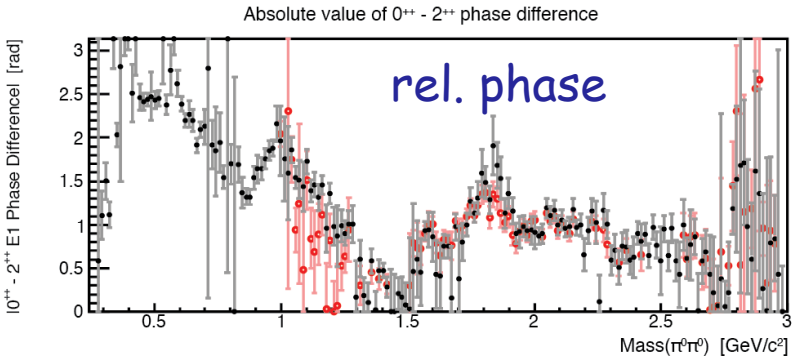
- Solution 1
- Solution 2

PRD92 (´15) 052003





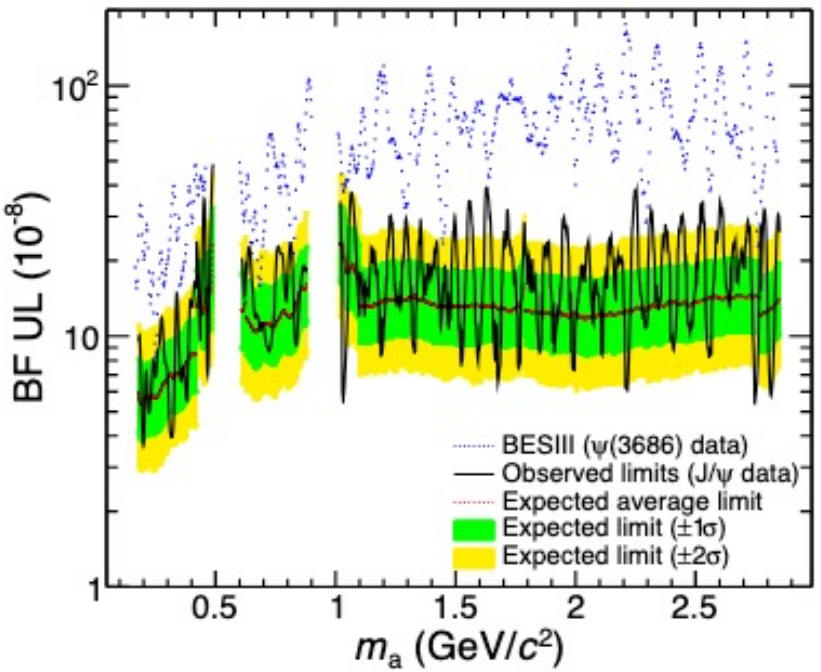


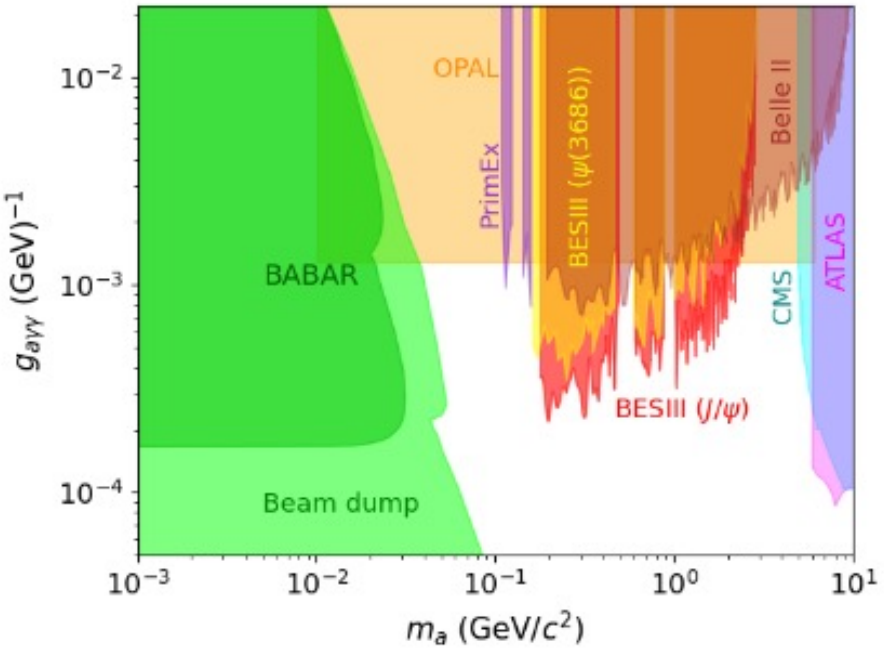


* Error bars are statistical only

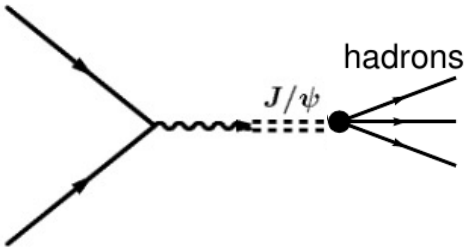
Search for ALP in $J/\psi \to \gamma(a \to \gamma\gamma)$

Phys.Rev.D 110 (2024) L031101





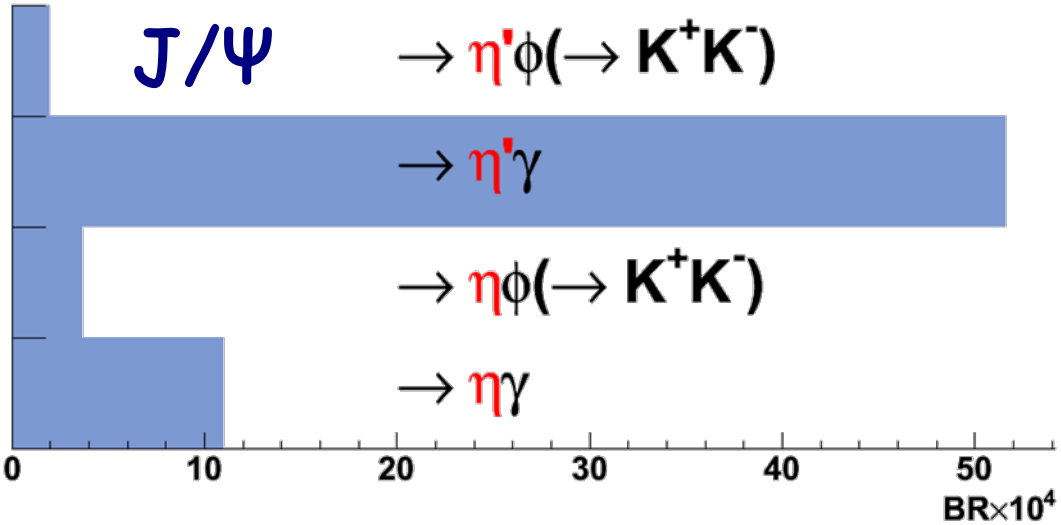
η, η' decays



10^{10} J/Ψ events ⇒ 45×10^{6} η'

Radiative Decays			
$\eta \to \gamma\gamma$	39%	$\eta' \to \rho^0\gamma$	29%
$\eta \to \pi^+\pi^-\gamma$	5%	$\eta' \to \omega\gamma$	3%
		$\eta' \to \gamma\gamma$	2%

BESIII

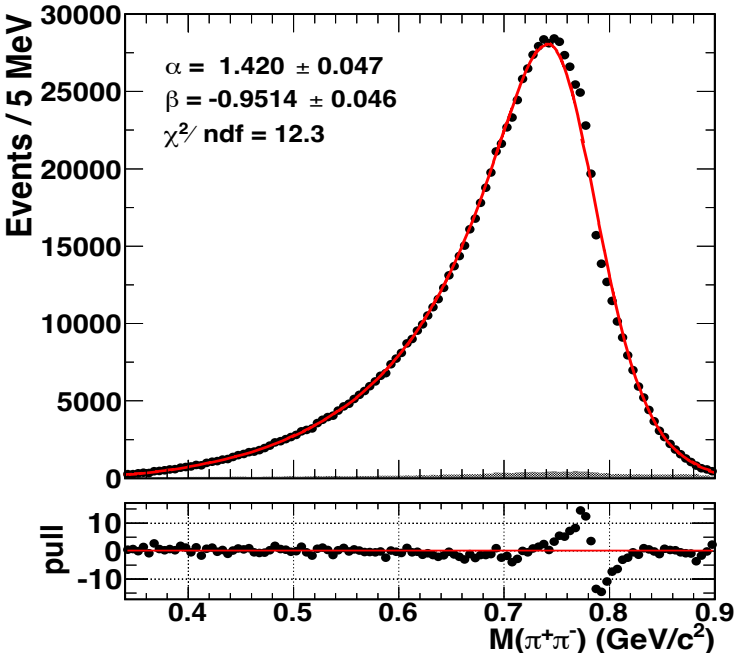


Study of $\eta' \to \pi^+\pi^-\gamma$

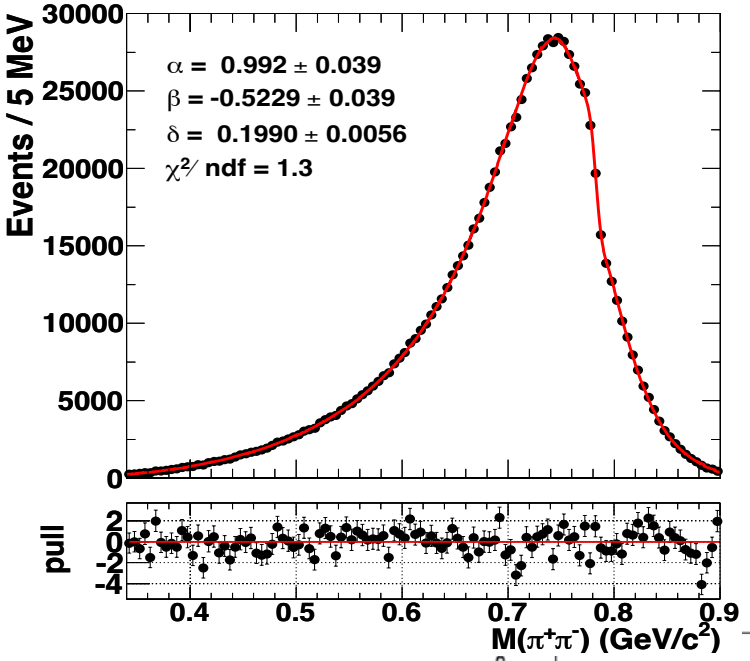
based on 0.9 x 10^6 η' → π+π-γ

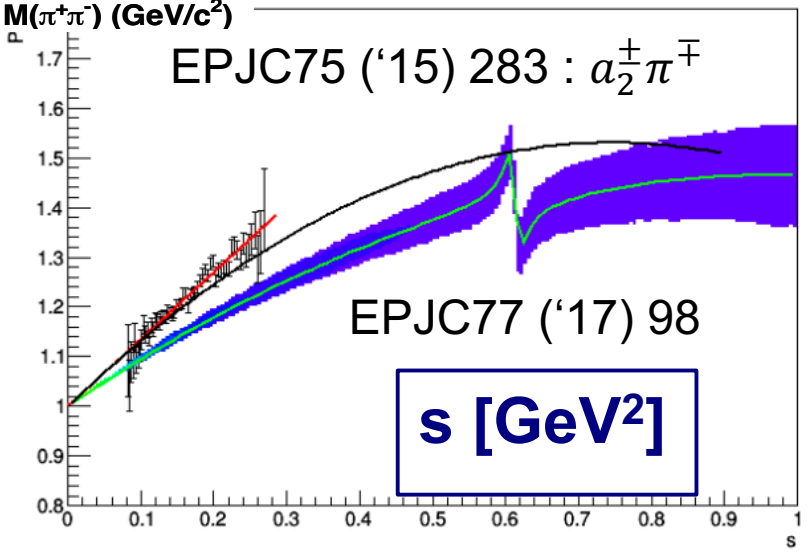
$$\frac{d\Gamma}{ds_{\pi\pi}} = |AP(s_{\pi\pi})F_V(s_{\pi\pi})|^2 \Gamma_0(s_{\pi\pi})$$

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



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

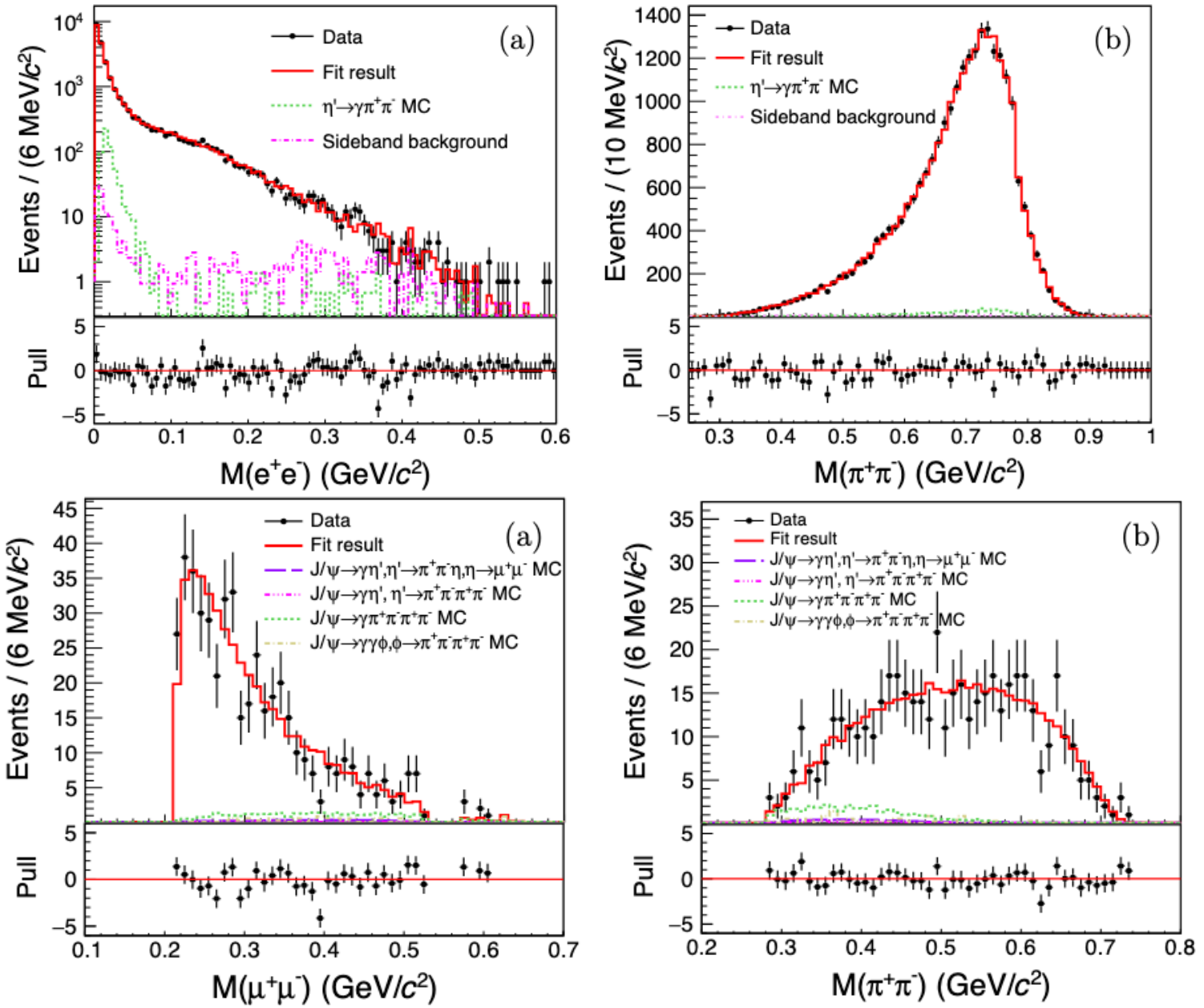




Phys.Rev.Lett. 120 (2018) 242003

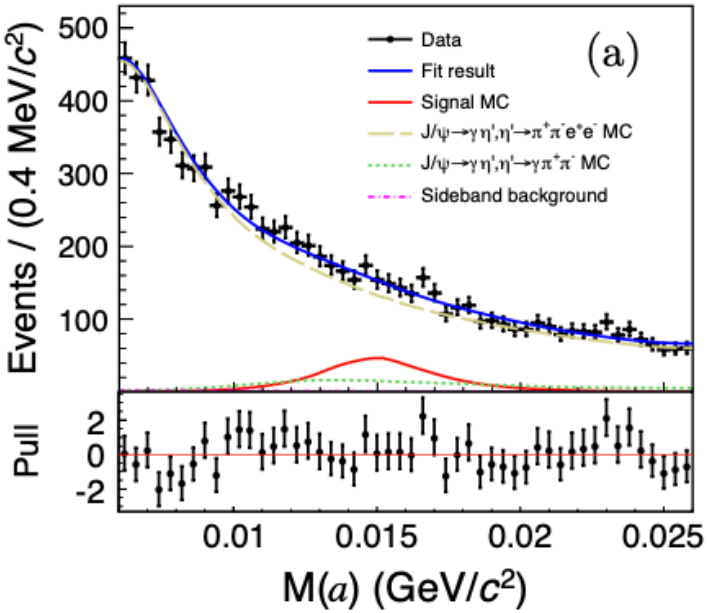
Study of $\eta' \to \pi^+\pi^-e^+e^-$

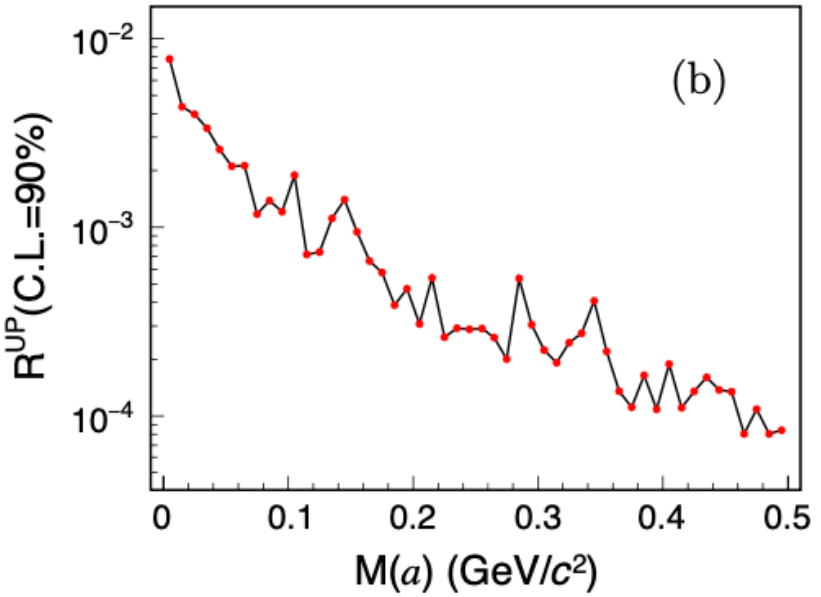
JHEP 07 (2024) 135



Search for ALP in $\eta' \to \pi^+\pi^- e^+ e^-$

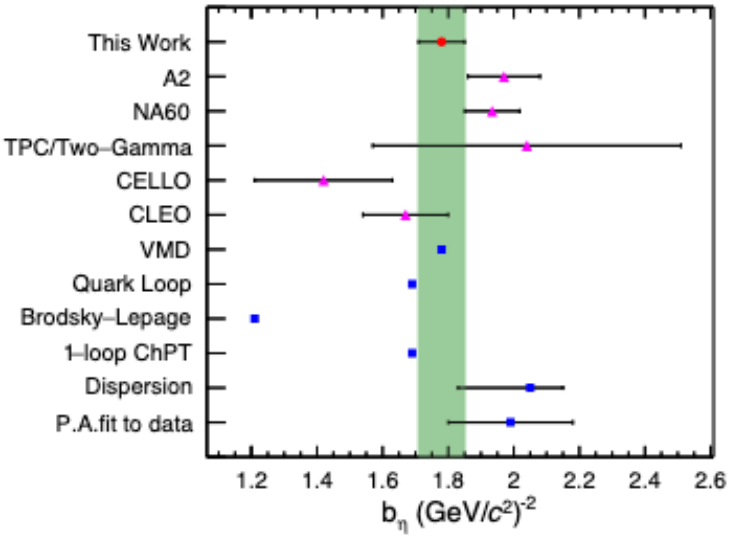
JHEP 07 (2024) 135

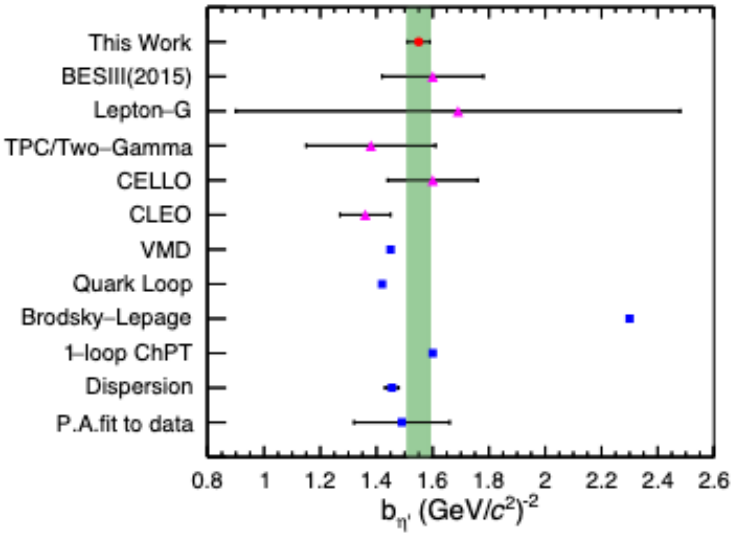




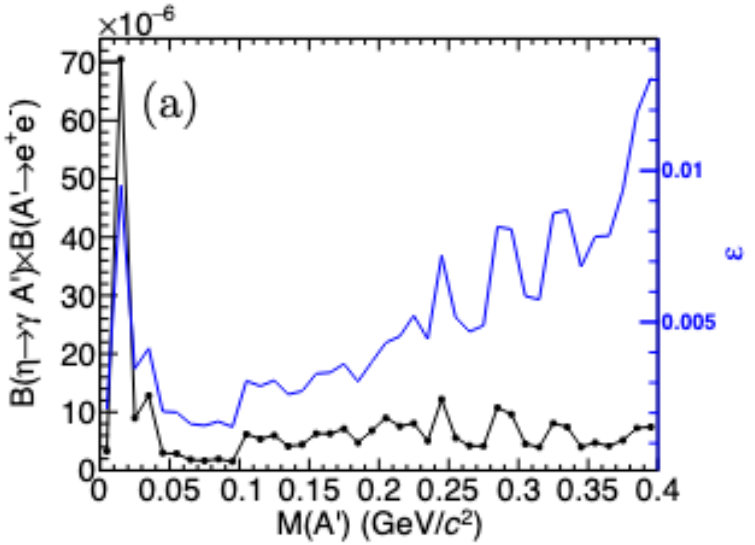
Study of $\eta' \to e^+e^-\gamma$

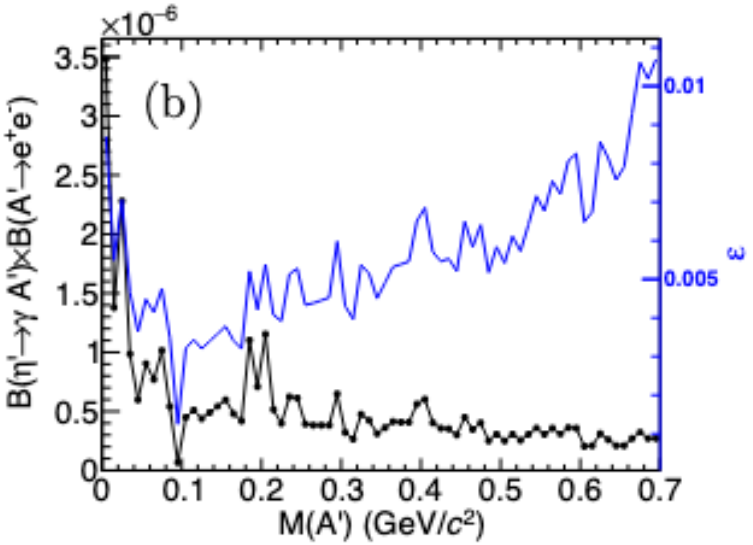
Phys.Rev.D 109 (2024) 7



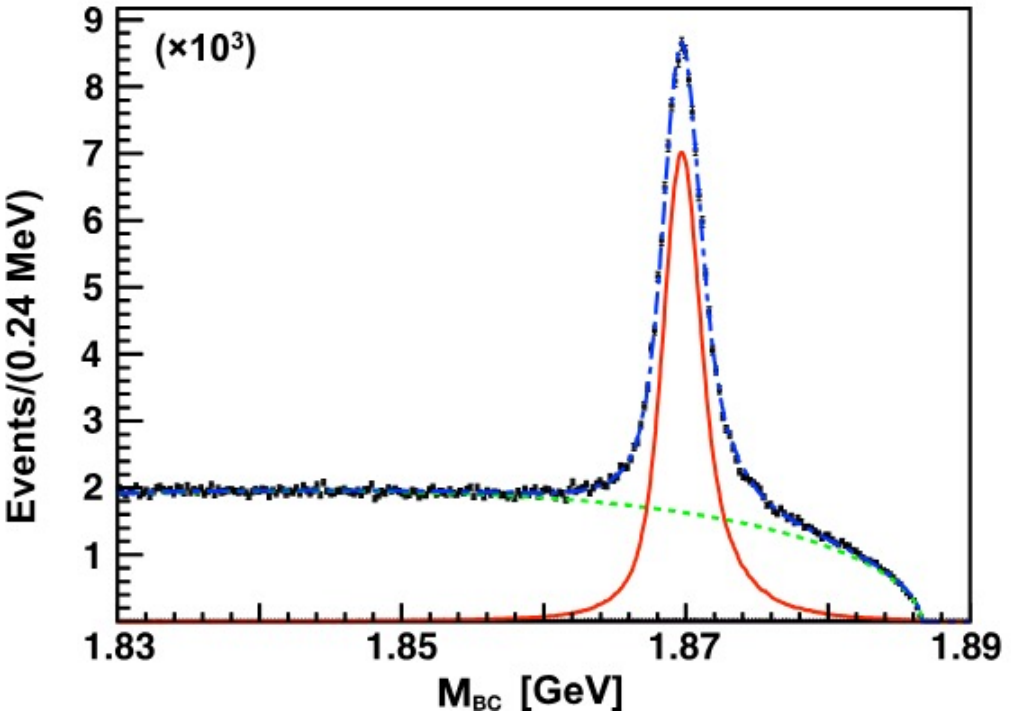


Search for dark photon A' in $\eta' \to e^+e^-\gamma$





Double Tag method for Dmeson decay studies at $\psi(3770)$



$$\psi(3770) \to D\bar{D}$$

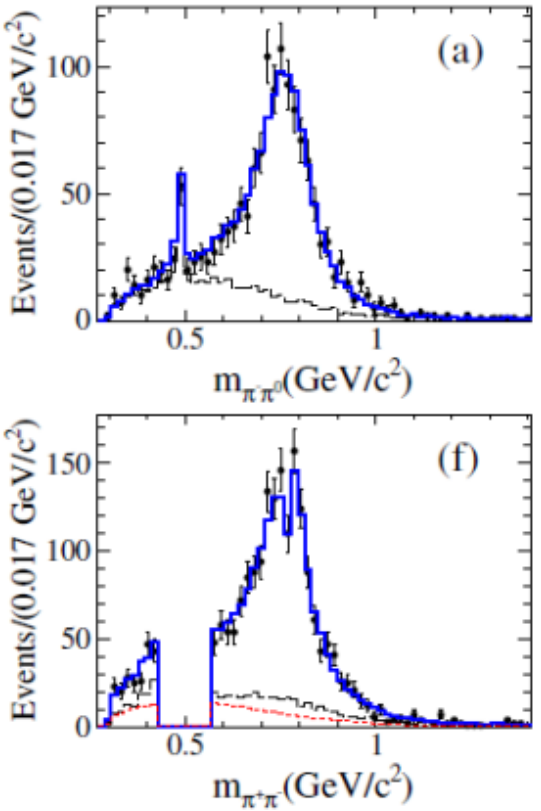
Channels used for D meson tagging in $e^+e^- \to D\bar{D}$ at the $\psi(3770)$ resonance. Single-tag efficiencies, ϵ_{tag}, are given. The efficiencies are corrected for $\mathcal{B}(K_S^0 \to \pi^+\pi^-)$. The number of events is for integrated luminosity of $2.9\,\text{fb}^{-1}$ and c.c. is implied.

Tag mode	N_{tag} $(\times 10^3)$	ϵ_{tag} (%)	Tag mode	N_{tag} $(\times 10^3)$	ϵ_{tag} (%)
$\bar{D}^0 \to K^+\pi^-$	520	64	$D^- \to K^+\pi^-\pi^-$	798	51
$\bar{D}^0 \to K^+\pi^-\pi^-\pi^0$	1080	35	$D^- \to K^+\pi^-\pi^-\pi^0$	245	25
$\bar{D}^0 \to K^+\pi^+\pi^-\pi^-$	699	39	$D^- \to K_S^0\pi^-$	93	51
			$D^- \to K_S^0\pi^-\pi^0$	206	26
			$D^- \to K_S^0\pi^-\pi^-\pi^+$	110	27
			$D^- \to K^+K^-\pi^-$	68	40

Semileptonic D meson decays

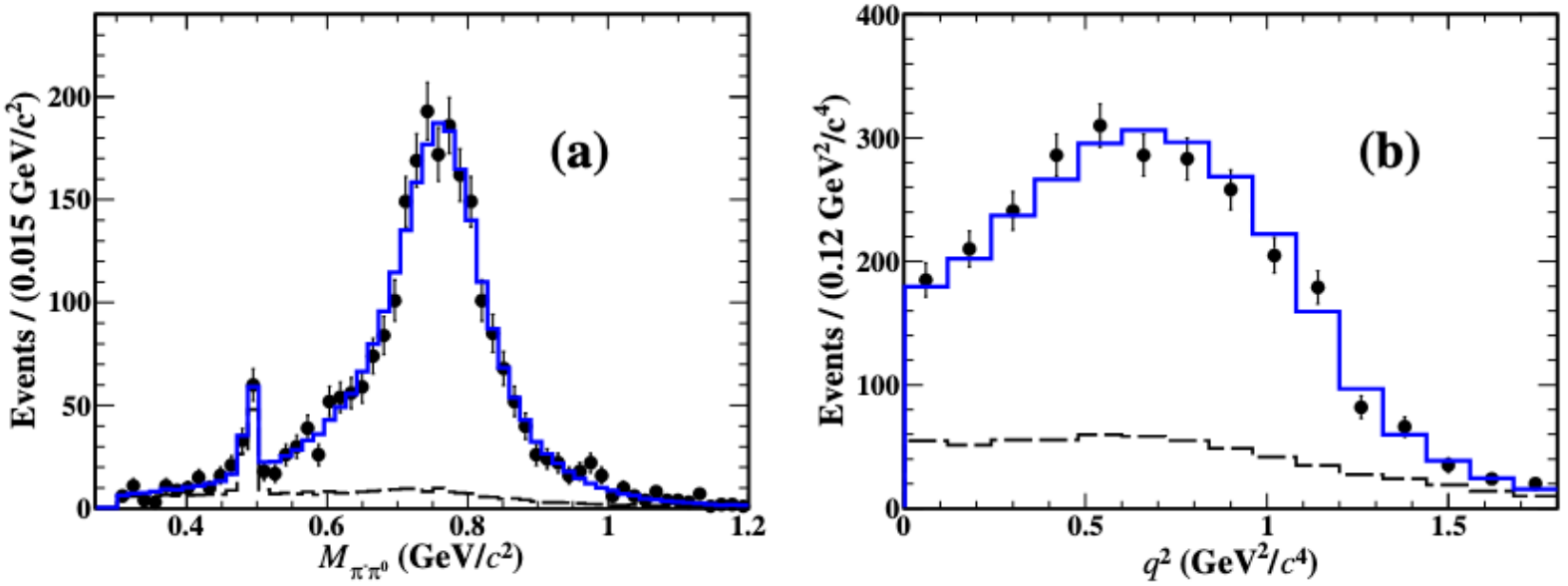
Phys.Rev.Lett. 122 (2019) 062001 3 fb^{-1}

Signal mode	This analysis ($\times 10^{-3}$)
$D^0 \to \pi^-\pi^0 e^+\nu_e$	$1.445 \pm 0.058 \pm 0.039$
$D^0 \to \rho^- e^+\nu_e$	$1.445 \pm 0.058 \pm 0.039$
$D^+ \to \pi^-\pi^+ e^+\nu_e$	$2.449 \pm 0.074 \pm 0.073$
$D^+ \to \rho^0 e^+\nu_e$	$1.860 \pm 0.070 \pm 0.061$
$D^+ \to \omega e^+\nu_e$	$2.05 \pm 0.66 \pm 0.30$
$D^+ \to f_0(500)e^+\nu_e,\ f_0(500) \to \pi^+\pi^-$	$0.630 \pm 0.043 \pm 0.032$
$D^+ \to f_0(980)e^+\nu_e,\ f_0(980) \to \pi^+\pi^-$	<0.028



2.76× 10^6 neutral and 1.57× 10^6 charged tags

Study of the decay $D^0 \to \pi^+\pi^0 e^+ \nu_e$

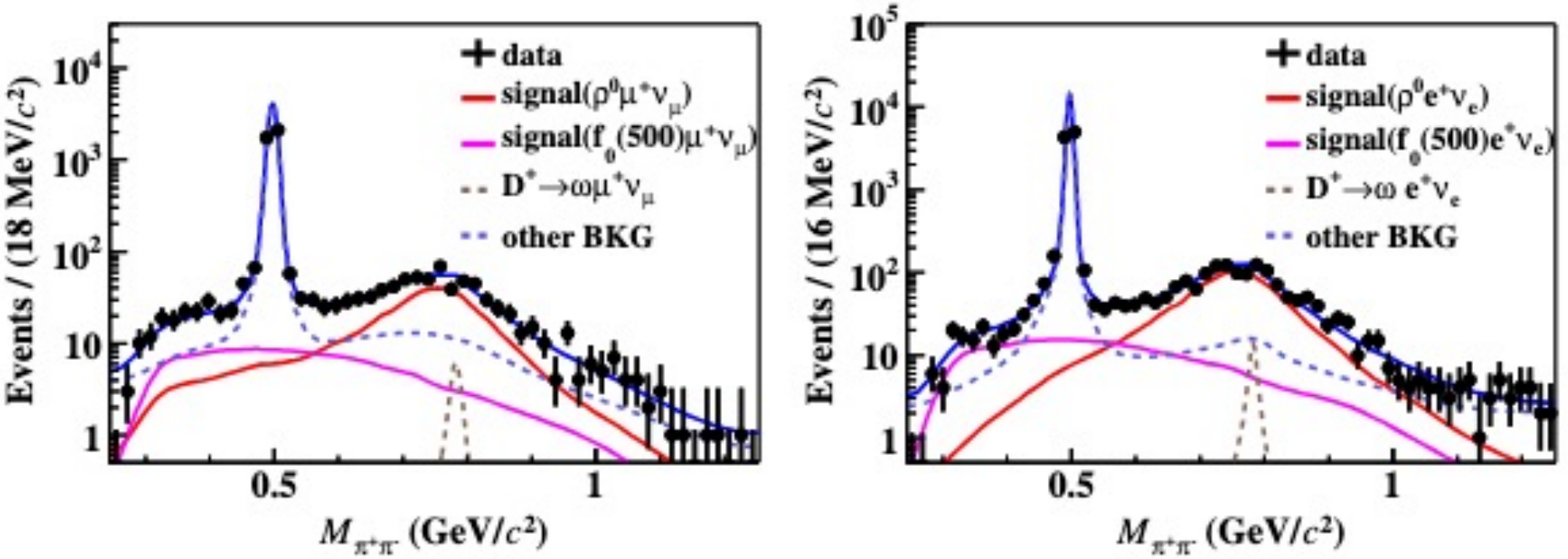


7.93 fb^{-1}

arXiv:2409.04276

Study of $D^+ \to \pi^+\pi^- l^+ \nu_l$

2.93 fb^{-1}



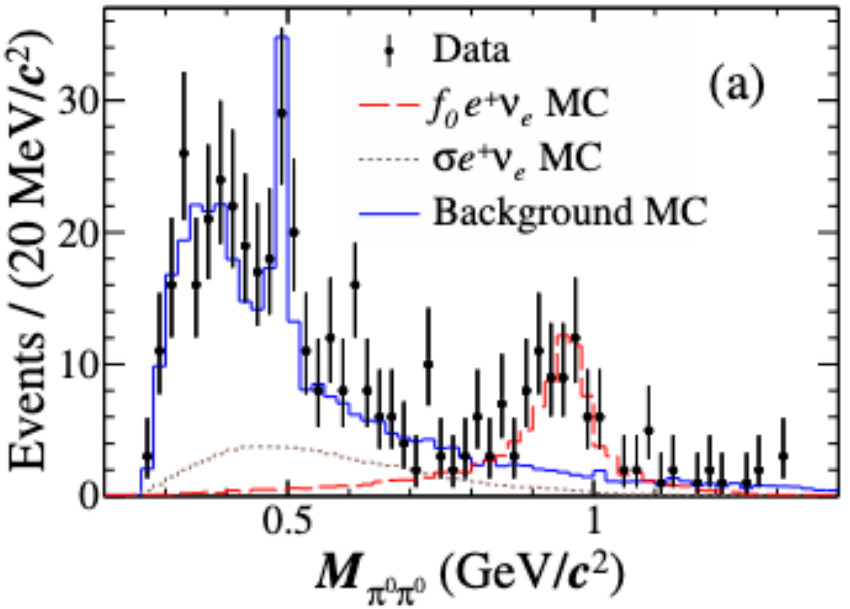
2401.13225

Study of $D_s^+ \to \pi^0\pi^0 e^+\nu_e$

$$e^+e^- \to D_s^{*\pm}D_s^{\mp} \to \gamma(\pi^0)D_s^{\pm}D_s^{\mp}$$

4.128 to 4.226 GeV.

6.32 fb^{-1}

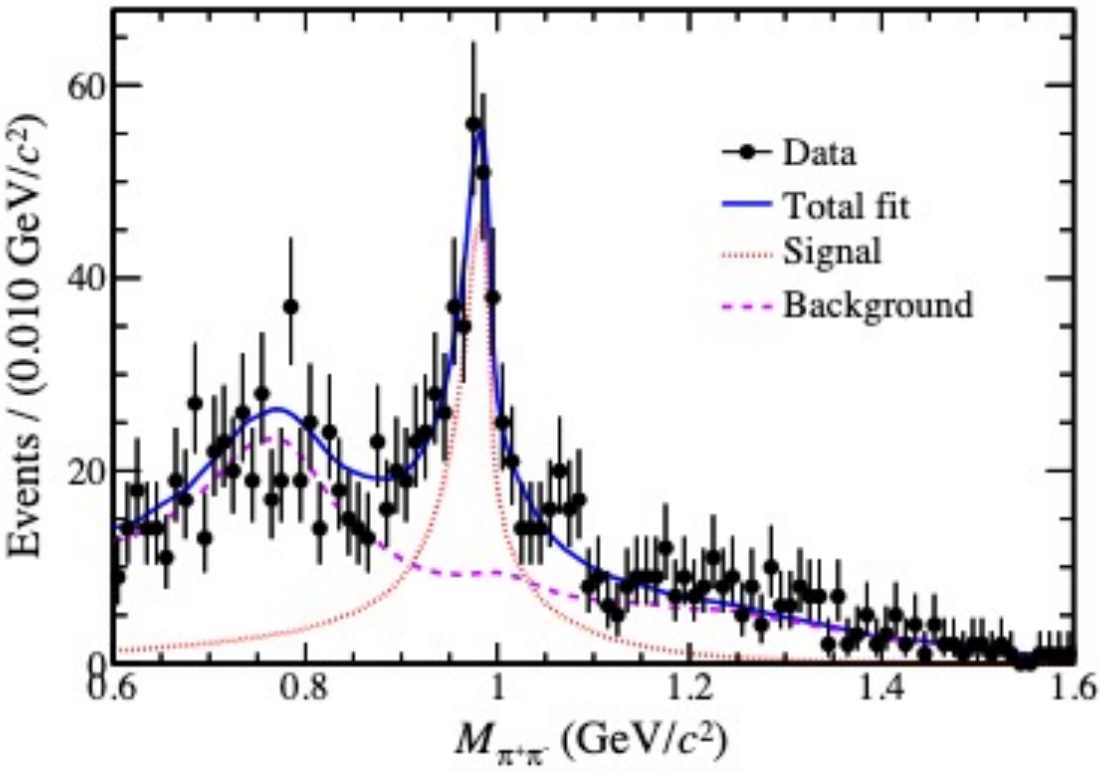


Phys.Rev.D 105 (2022) L031101

Study of $D_s^+ \to \pi^+\pi^- e^+ \nu_e$

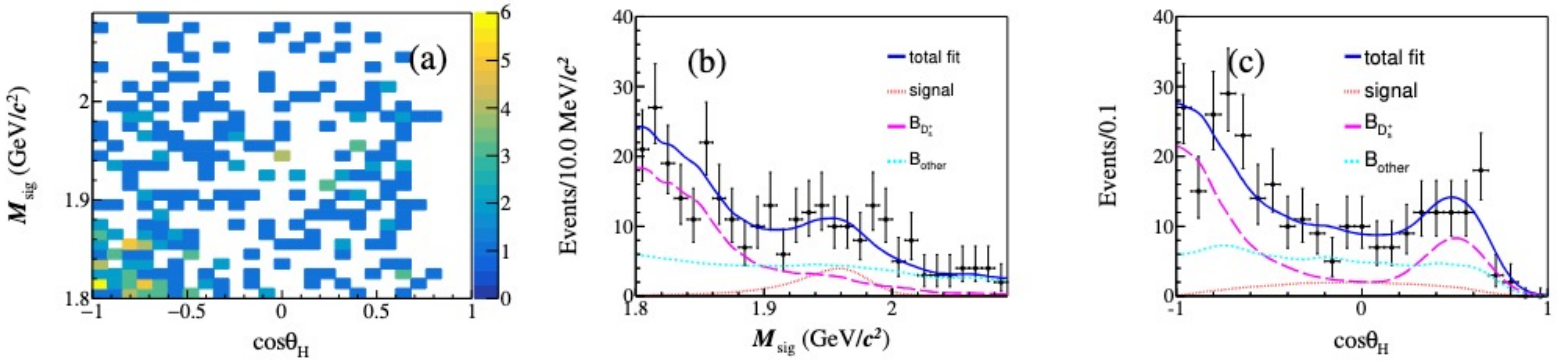
Phys.Rev.Lett. 132 (2024) 141901

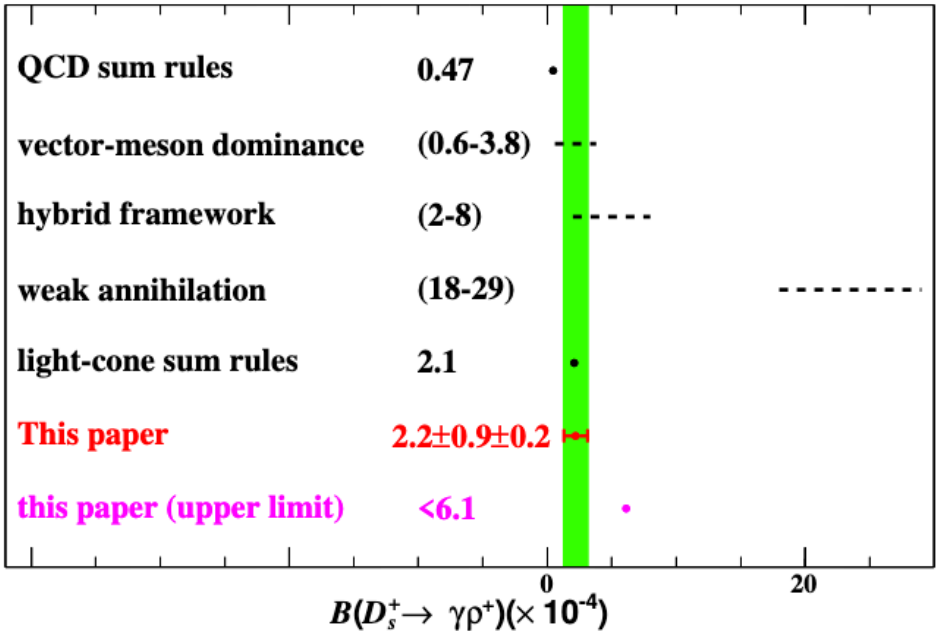
7.33 fb−1



4.128 to 4.226 GeV.

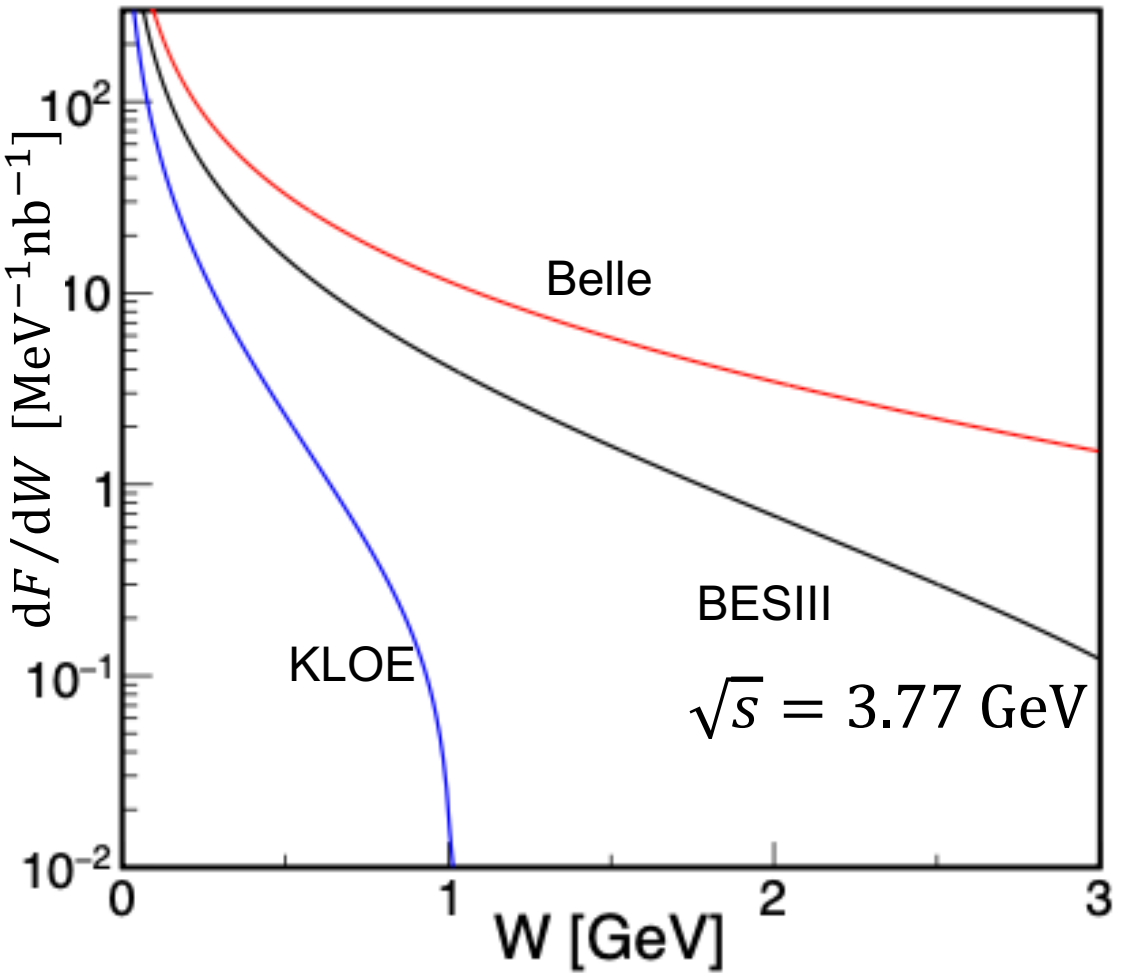
Search for weak radiative decay $D_s^+ \to \rho^+\gamma$

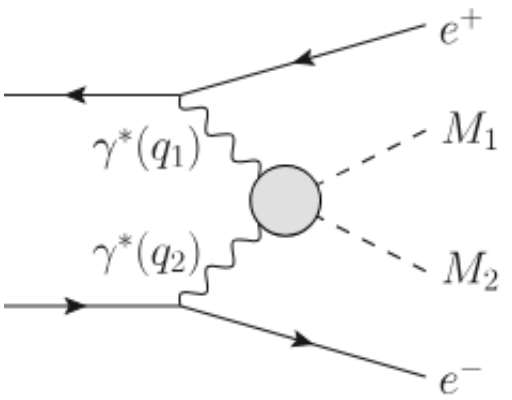




2408.03980 [hep-ex]

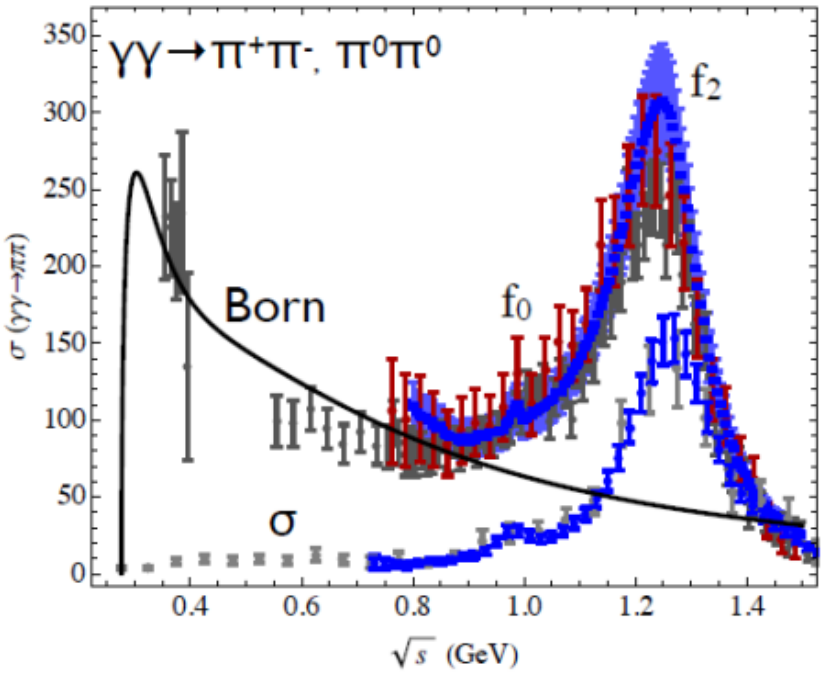
Two photon physics at BESIII

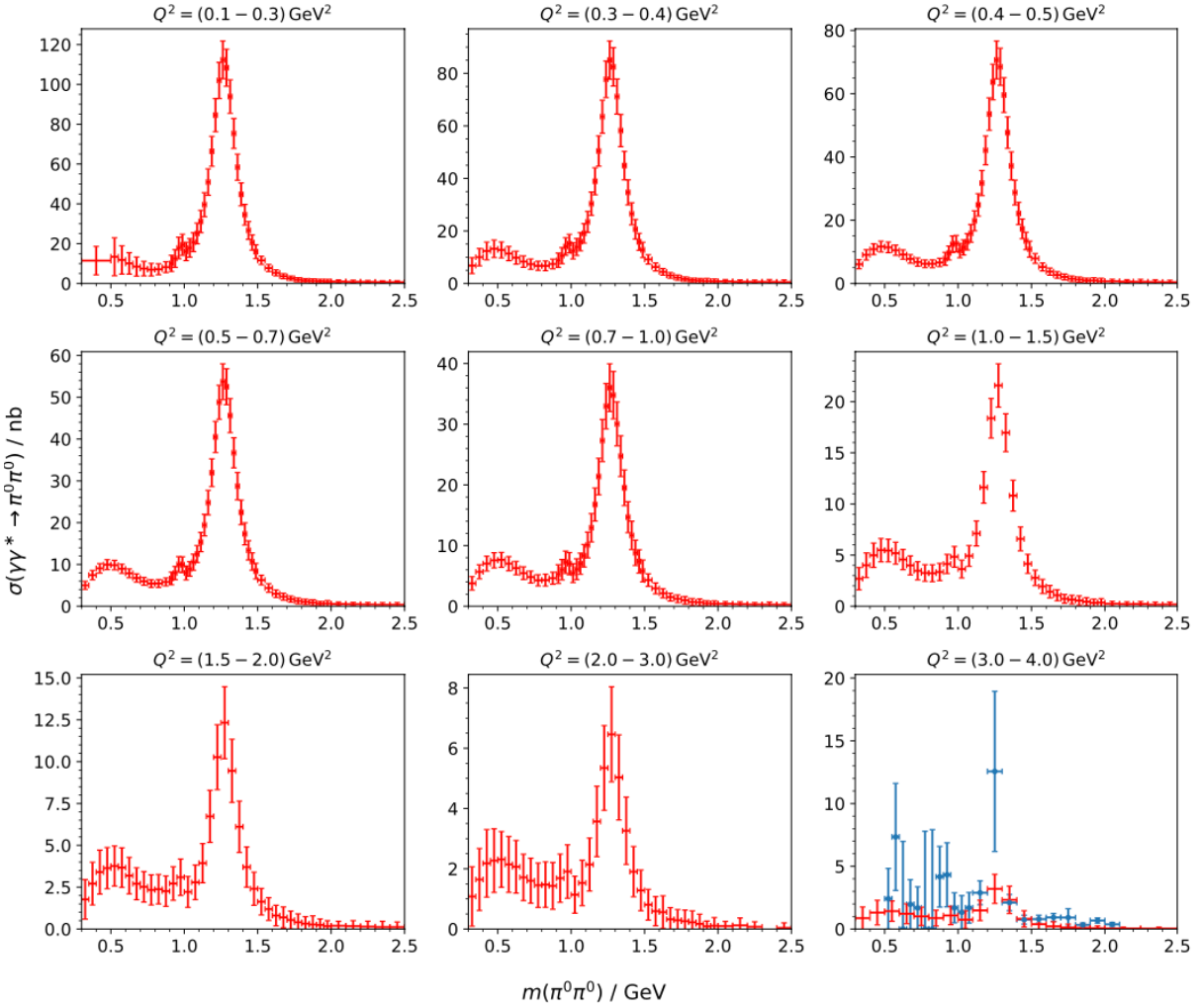




$$N_{eeX} = \mathcal{L} \int \frac{dF}{dW} \sigma_{\gamma\gamma \to X}(W)\, dW$$

γγ→ππ Belle





γγ*→ππ BESIII in progress MC plots
[Max Lellmann Mainz]

Summary

- ISR
- Radiative decays of J/ψ
- Semileptonic D,Ds decays using double tag
- Two gamma physics
- η' factory (4.5×10^7 events)
- New physics searches

Chin.Phys.C 44 (2020) 4, 040001