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Hunt for X(17)

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2025-10-20 @ 南京师范大学，南京

Jun Jiang, Cong-Feng Qiao (UCAS), Yu-Han Zhao (SDU),
arXiv: 2511.xxxx

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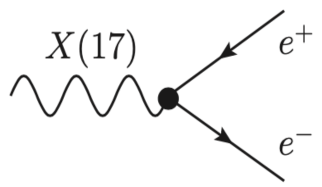
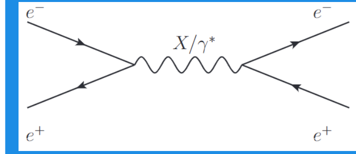
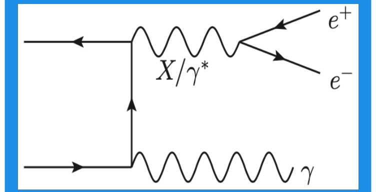
Motivation



Constraints on Xe^+e^- coupling



X(17) @ PADME



Revisit X(17) @ BESIII

Summary

Observation of Anomalous Internal Pair Creation in Be8 : A Possible Indication of a Light, Neutral Boson

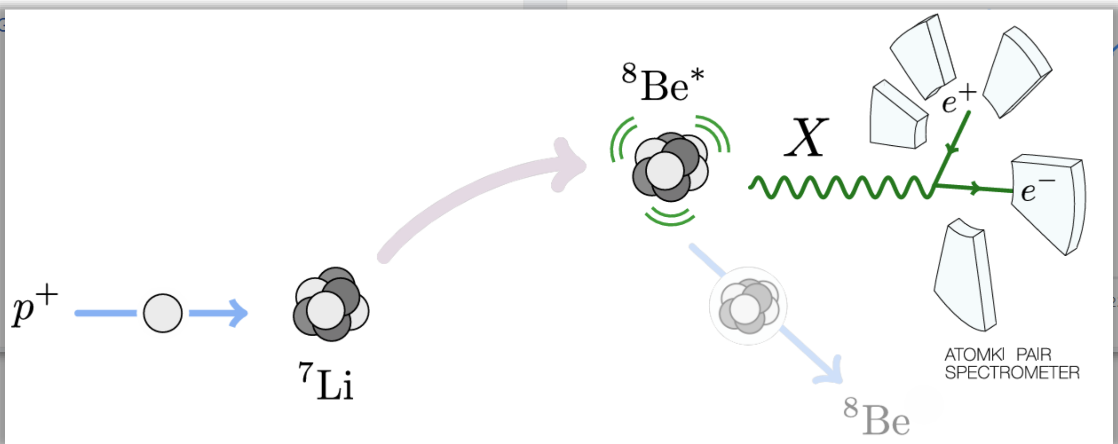
A. J. Krasznahorkay (Debrecen, Inst. Nucl. Res.), M. Csatlós (KLTE-ATOMKI), L. Csige (KLTE-ATOMKI), Z. G

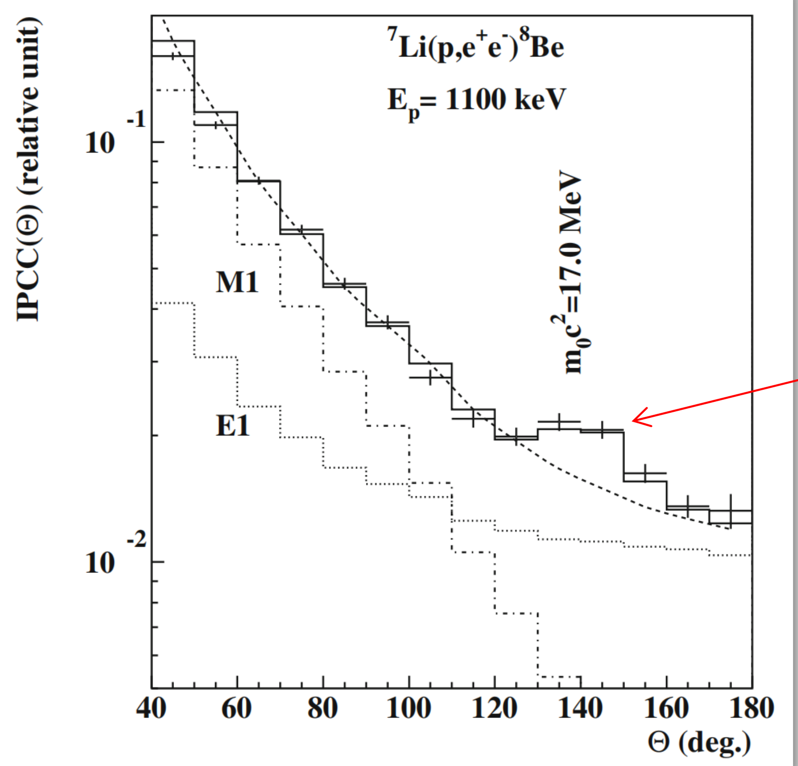
Apr 7, 2015

5 pages
Published in: *Phys.Rev.Lett.* 116 (2016) 4, 042501
Published: Jan 26, 2016
e-Print: 1504.01527 [nucl-ex]
DOI: 10.1103/PhysRevLett.116.042501
PDG: Heavy Particle Production Cross Section
View in: CERN Document Server, ADS Abstract Service, Nuclear Science References

pdf   links   cite   claim

Citations per year





electron–positron invariant mass and opening angle are related by

$$m_{ee}^2 = 2E_{e^+}E_{e^-} - 2\sqrt{E_{e^+}^2 - m_e^2}\sqrt{E_{e^-}^2 - m_e^2}\cos\theta + 2m_e^2$$
$$= (1-y^2)E^2\sin^2\frac{\theta}{2} + 2m_e^2\left(1 + \frac{1+y^2}{1-y^2}\cos\theta\right) + \mathcal{O}(m_e^4)$$

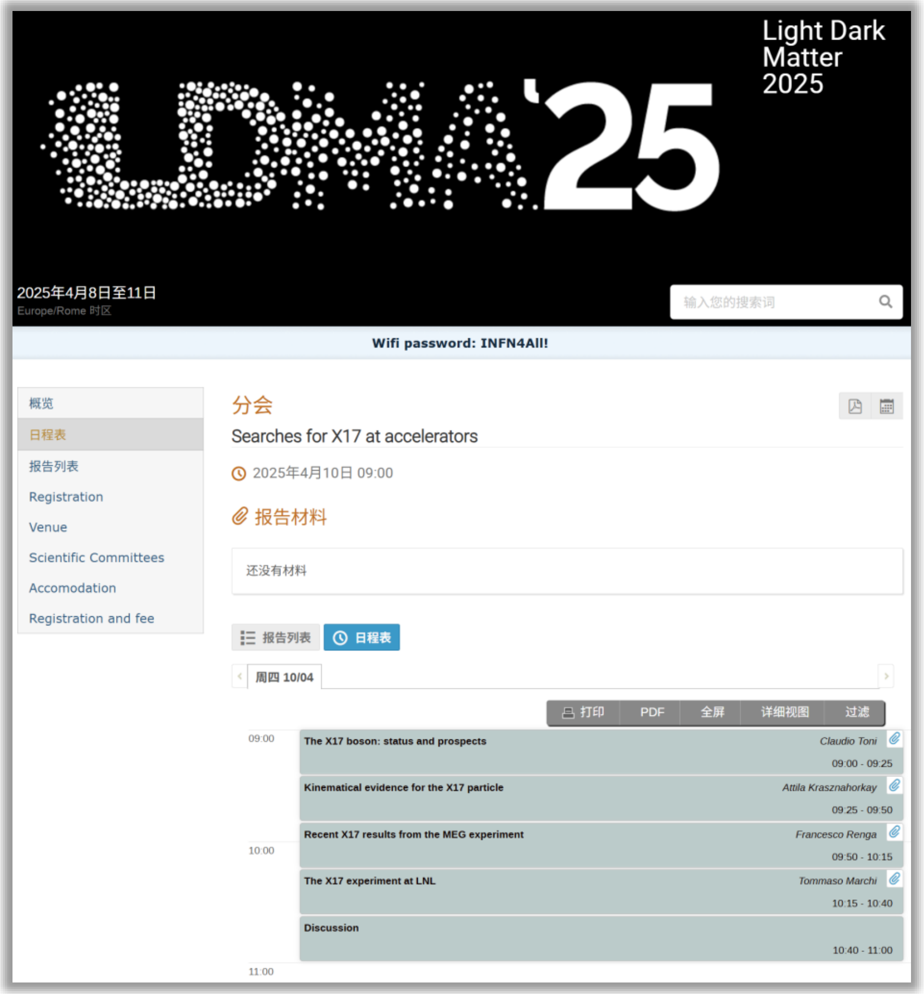
where

$$E \equiv E_{e^+} + E_{e^-} \qquad \text{and} \qquad y \equiv \frac{E_{e^+} - E_{e^-}}{E_{e^+} + E_{e^-}}$$

Phys. Rev. Lett. 116, 042501 (2016)
Eur. Phys. J. C (2023) 83 :230
Phys.Rev.D 95 (2017) 3, 035017

Nucleus (MeV)	m_X (MeV)	Experiment	Ref.
^{8}Be*(18.15)	$16.86 \pm 0.06 \pm 0.50$	Atomki	[2, 6]
^{8}Be*(18.15)	$17.17 \pm 0.07 \pm 0.20$	Atomki	[6]
^{4}He*(20.21/21.01)	$16.94 \pm 0.12 \pm 0.21$	Atomki	[9]
^{12}C*(17.23)	$17.03 \pm 0.11 \pm 0.20$	Atomki	[10]
^{8}Be*(GDR)	$16.95 \pm 0.48 \pm 0.35$	Atomki	[11, 12]
^{8}Be*(18.15)	$16.66 \pm 0.47 \pm 0.35$	VNU-UoS	[13]
^{8}Be*(17.64/18.15)	< 16.81 $[R_{Be} = 6 \cdot 10^{-6}]$	MEG II	[17]
$e^+e^- \to X_{17}$	$16.90 \pm 0.02 \pm 0.05$	PADME	[20, 21]

<u>More expeiments are on the way</u>:
Mu3e experiment
Montreal Tandem accelerator
New JEDI experiment at GANIL
nTOF collaboration at CERN
PRad experiment at JLab
...



arXiv:2504.11439
Universe 10 (2024) 11, 409
Phys. Rev. C 14, 28 (1976)
https://agenda.infn.it/event/43758/sessions/32329/#20250410

1 Motivation

J. L. Feng et al., "Protophobic **Fifth-Force Interpretation** of the Observed Anomaly in Be^8 Nuclear Transitions"

Phys. Rev. Lett. 117(2016), 071803
Phys.Rev.D 95 (2017), 035017
Phys.Rev.D 102 (2020), 036016

A. C. Hayes et al., "Angular correlations in the e^+e^- decay of excited states in Be^8"

Phys.Rev.C 105 (2022), 055502

- this resonance is dominated by M1 and E1 decay
- the existence of a 'bump' in the measured angular distribution is strongly dependent on the assumed M1/E1 ratio, which is a strong function of energy, while it was was assumed to be a constant in the Atomki experiments.

Xilin Zhang et al., "Can nuclear physics explain the anomaly observed in the internal pair production in the Beryllium-8 nucleus?" "Can a protophobic vector boson explain the ATOMKI anomaly?"

- study the possibility of using the nuclear transition form factor to explain the anomaly
- The net result is that X production is dominated by direct transitions induced by $E1^X$ and $L1^X$ (transverse and longitudinal electric dipoles) and $C1^X$ (charge dipole) without going through any nuclear resonance (i.e. Bremsstrahlung radiation) with a smooth energy dependence that occurs for all proton beam energies above threshold. This contradicts the experimental observations and invalidates the protophobic vector boson explanation.

Phys.Lett.B 773 (2017) 159-165
Phys.Lett.B 813 (2021) 136061

More Info.


Eur. Phys. J. C (2023) 83:230
https://doi.org/10.1140/epjc/s10052-023-11271-x

THE EUROPEAN PHYSICAL JOURNAL C

Check for updates

Review

Shedding light on X17: community report

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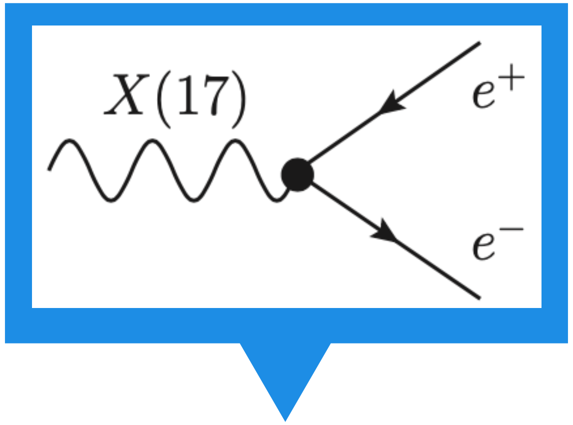
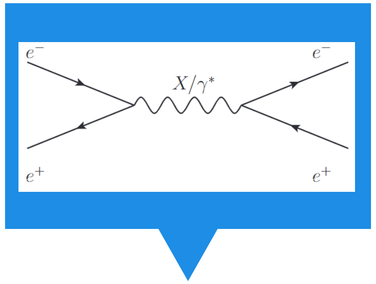
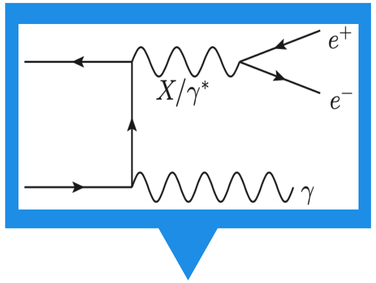
Motivation



Constraints on Xe^+e^- coupling



X(17) @ PADME

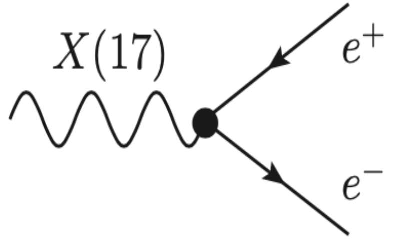


Revisit X(17) @ BESIII

Summary

■ Mixing of V +/- A model:

$$\mathcal{L}_X = -\frac{1}{4}X_{\mu\nu}X^{\mu\nu} + \frac{1}{2}m_X^2 X_\mu X^\mu - \sum_f e\bar{f}\gamma_\mu(\varepsilon_f^v - \varepsilon_f^a\gamma_5)fX^\mu$$



With such model, we suggest identifying X(17) in **(1) e^+e^- → X(17) + g ,**
(2) J/ψ → X(17)+ g at BESIII, where X(17) is reconstructed by e^+e^- pairs.

Eur. Phys. J. C 78, 456 (2018)
Eur. Phys. J. C 79, 404 (2019)

➢ Scalar X(17) hypothesis is excluded by parity conservation in ^{8}Be experiment; while a pseudoscalar state can explain only the ^{8}Be and ^{4}He anomaly, but not the ^{12}C one.

JHEP 02 (2023) 154,
JHEP 07 (2023) 168 (erratum)

➢ N.V. Krasnikov, "Implications of last NA64 results and the electron g_e−2 anomaly for the X(16.7) boson survival"

- The combination of latest NA64 experiment and recent value of the electron anomalous magnetic momentum exclude the pure vector and axial-vector couplings of X(17) boson to electrons at the 90% C.L.,
- but the model with "V ± A" interaction still survives and can further explains both the electron and muon anomalous magnetic momentum.

Mod.Phys.Lett.A 35 (2020), 2050116

- Atomki experiments

Decay length

$$L = \frac{\hbar \times c}{\Gamma(X \to e^+e^-)} \times \frac{v}{\sqrt{1-v^2}},$$

$$\Gamma(X \to e^+e^-) \approx \frac{\alpha m_X}{3}\left((\varepsilon_e^v)^2 + (\varepsilon_e^a)^2\right),$$

$$\mathcal{O}\left(\frac{m_e^2}{m_X^2}\right) \approx 0.1\%$$

2016, ^{8}Be; 2019/2021, ^{4}He; 2022, ^{12}C

Requiring L < 1 cm

$$m_X = 16.7 \pm 0.35(\text{stat.}) \pm 0.5(\text{sys.})\ \text{MeV},$$
$$\frac{\Gamma\left({}^8Be^* \to {}^8\ BeX\right) \text{Br}\left(X \to e^+e^-\right)}{\Gamma\left({}^8Be^* \to {}^8\ Be\gamma\right)} = 5.8 \times 10^{-6}.$$

$$\to (\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \gtrsim 1.8 \times 10^{-10}.$$

$$m_X = 16.94 \pm 0.12(\text{stat}) \pm 0.21(\text{sys})\ \text{MeV},$$
$$\frac{\Gamma\left({}^4He^* \to {}^4\ HeX\right) \text{Br}\left(X \to e^+e^-\right)}{\Gamma\left({}^4He^* \to {}^4\ He\gamma\right)} = (5.1 \pm 0.13) \times 10^{-6}.$$

$$\to (\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \gtrsim 3.5 \times 10^{-10}.$$

$$m_X = 17.03 \pm 0.11(\text{stat}) \pm 0.20(\text{sys})\ \text{MeV},$$
$$\frac{\Gamma\left({}^{12}C^* \to {}^{12}CX\right) \text{Br}\left(X \to e^+e^-\right)}{\Gamma\left({}^{12}C^* \to {}^{12}C\gamma\right)} = (3.6 \pm 0.3) \times 10^{-6}.$$

$$\to (\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \gtrsim 7.7 \times 10^{-11}.$$

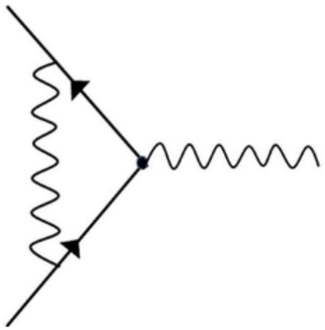
2 Constraints on Xe^+e^- Coupling

■ Electron anomalous magnetic momentum

- In 2022, an improved determination of the electron anomalous magnetic momentum (AMM) is obtained, a^{exp} =0.00115965218059(13), which is 2.2 times more accurately than the value in 2008.
- In comparison with the SM prediction in 2018, a^{SM} = 0.00115965218161(23) , we have the negative 3.9σ discrepancy between the measurement and the SM prediction

$$\Delta a_e \equiv a_e^{\rm exp} - a_e^{\rm SM} = (-1.02 \pm 0.26) \times 10^{-12}.$$

Phys.Rev.Lett. 130 (2023), 071801
Science 360 (2018), 191



➢ X(17) boson contributes to Δa_e through the leading one-loop triangle diagram

$$a_e^X = \frac{\alpha}{3\pi}(\frac{m_e}{m_X})^2[(\varepsilon_e^v)^2 - 5(\varepsilon_e^a)^2].$$

Nucl.Phys.B 137 (1978) 63-76

To diminish the 3.9σ discrepancy between the measurement and SM prediction,

$$\boxed{(-1.5 \pm 0.4) \times 10^{-6} \lesssim (\varepsilon_e^v)^2 - 5(\varepsilon_e^a)^2 \lesssim 0}.$$

The pure vector hypothesis of X(17) boson will enlarge the discrepancy of electron AMM!

Beam dumb experiments

- Bremsstrahlung reaction $e^- Z \to e^- Z X$, X(17) is produced by initial or final state radiation off a single electron.
- Within the errors of $\mathcal{O}\left(\frac{m_e^2}{m_X^2}\right) \approx 0.1\%$, the production rate depends on the coupling parameters only through $(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2$

➢ Recently, NA64 collaboration searched for X(17) twice and set limits on the Xee coupling parameter at the 90% C. L.

Excluded region: $1.3 \times 10^{-4} < \sqrt{(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2} < 4.2 \times 10^{-4}$

Excluded region: (2017&2018 data combined) $1.2 \times 10^{-4} < \sqrt{(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2} < 6.8 \times 10^{-4}$

Phys. Rev. Lett. 120 (2018), 231802
Phys. Rev. D 101 (2020) 7, 071101

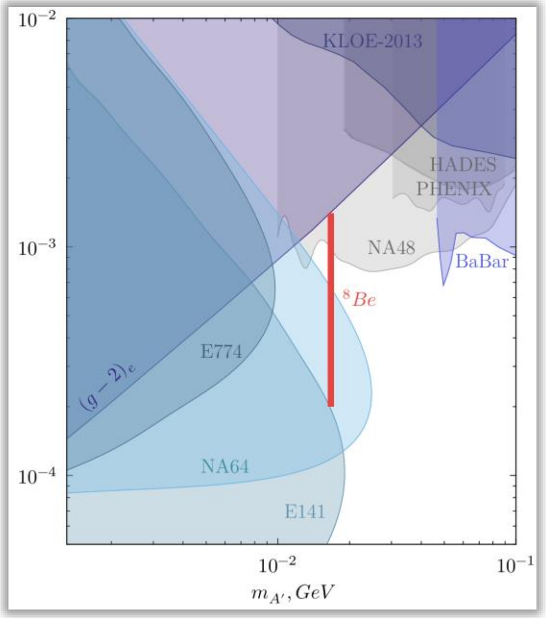
➢ Around 17 MeV, E137, E144 Beam dumb experimets
Excluded region:

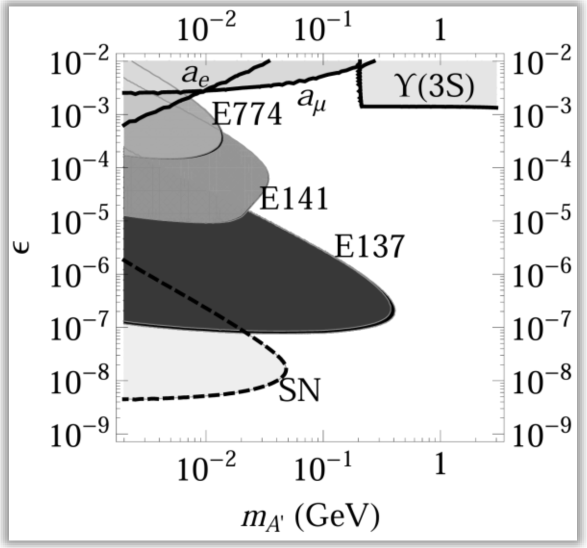
$$8 \times 10^{-8} < \sqrt{(\varepsilon_e^v)^2 + (\varepsilon_e^v)^2} < 3 \times 10^{-4}$$

Survival region:

$$(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \gtrsim 4.6 \times 10^{-7}.$$

We do not discuss the $< 6.4 \times 10^{-15}$ region.





Phys.Rev.D 80 (2009) 075018

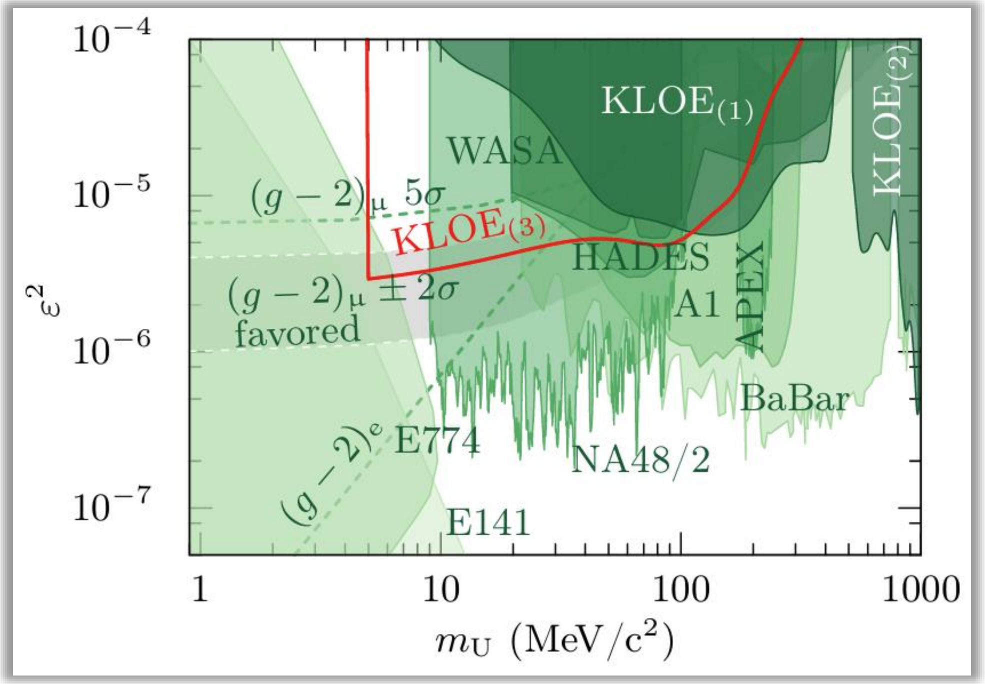
2 Constraints on Xe^+e^- Coupling

■ KLOE-2 experiment

- The KLOE-2 experiment searched for a low-mass vector boson U in $e^+e^- \to U\gamma,\ U \to e^+e^-$.
- Within the errors of $\mathcal{O}\left(\frac{m_e^2}{m_X^2}\right) \approx 0.1\%$, the production rate depends on the coupling parameters only through $(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2$

➢ An upper bound on Xee coupling around 17 MeV can be set at the 90% C. L.,

$$(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \lesssim 4 \times 10^{-6}.$$



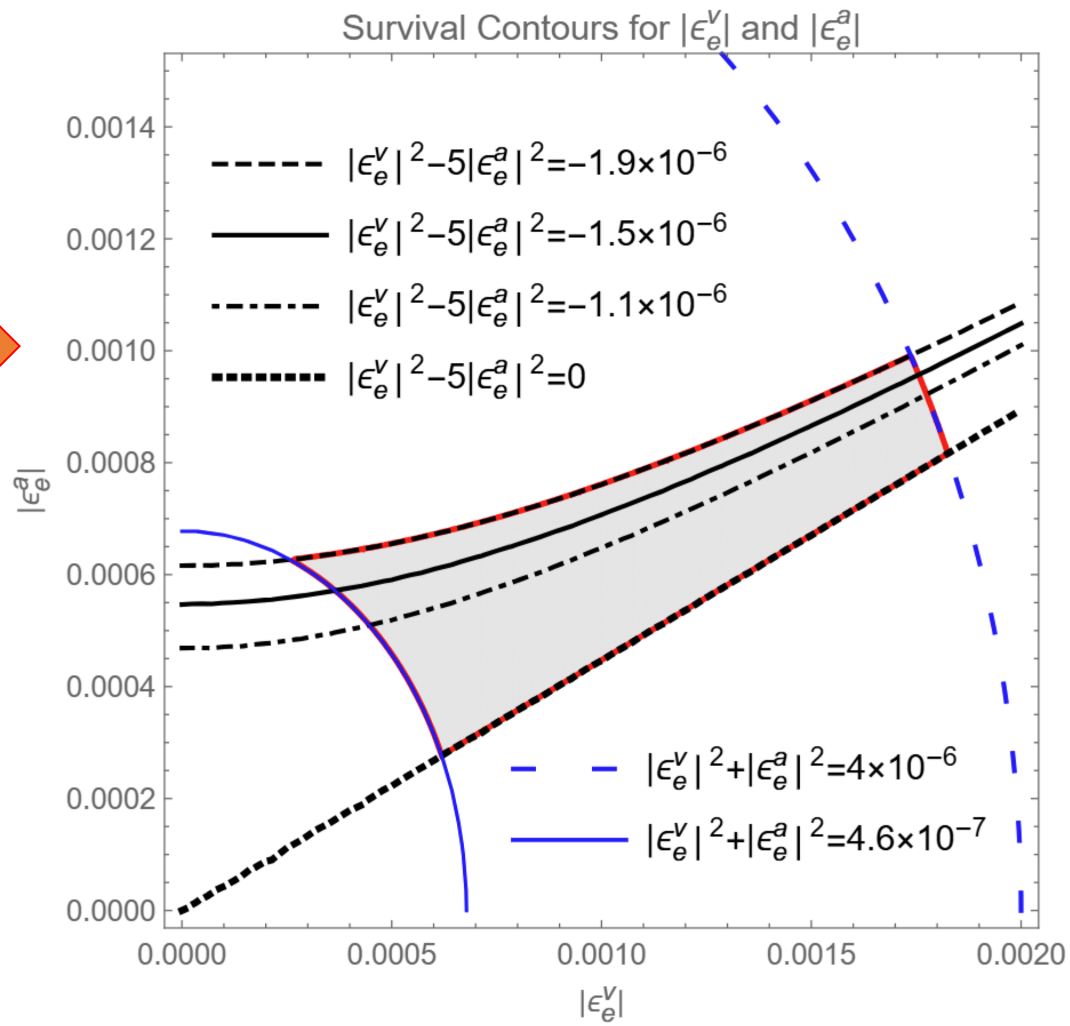
■ Survival regions for Xe^+e^- coupling

Beam dumb experiments

KLOE-2 experiment

$$4.6 \times 10^{-7} \lesssim (\varepsilon_e^v)^2 + (\varepsilon_e^a)^2 \lesssim 4 \times 10^{-6},$$
$$(-1.5 \pm 0.4) \times 10^{-6} \lesssim (\varepsilon_e^v)^2 - 5(\varepsilon_e^a)^2 \lesssim 0,$$

Electron AMM



- Pure V hypothesis: disfavored by Electron AMM.
- Pure A hypothesis: $6.8 \times 10^{-4} \lesssim |\varepsilon_e^a| \lesssim (5.4 \pm 0.7) \times 10^{-4}.$

  Pure axial-vector coupling is excluded.

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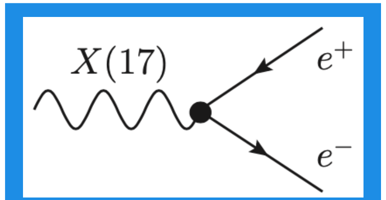
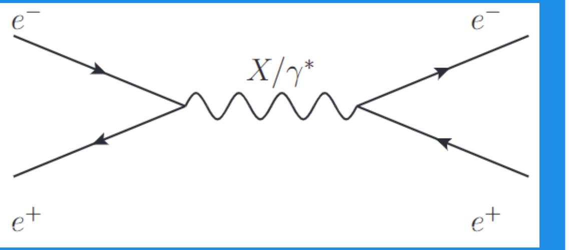
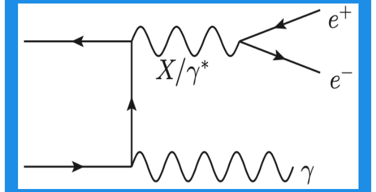
Motivation



Constraints on Xe^+e^- coupling



X(17) @ PADME



Revisit X(17) @ BESIII

Summary

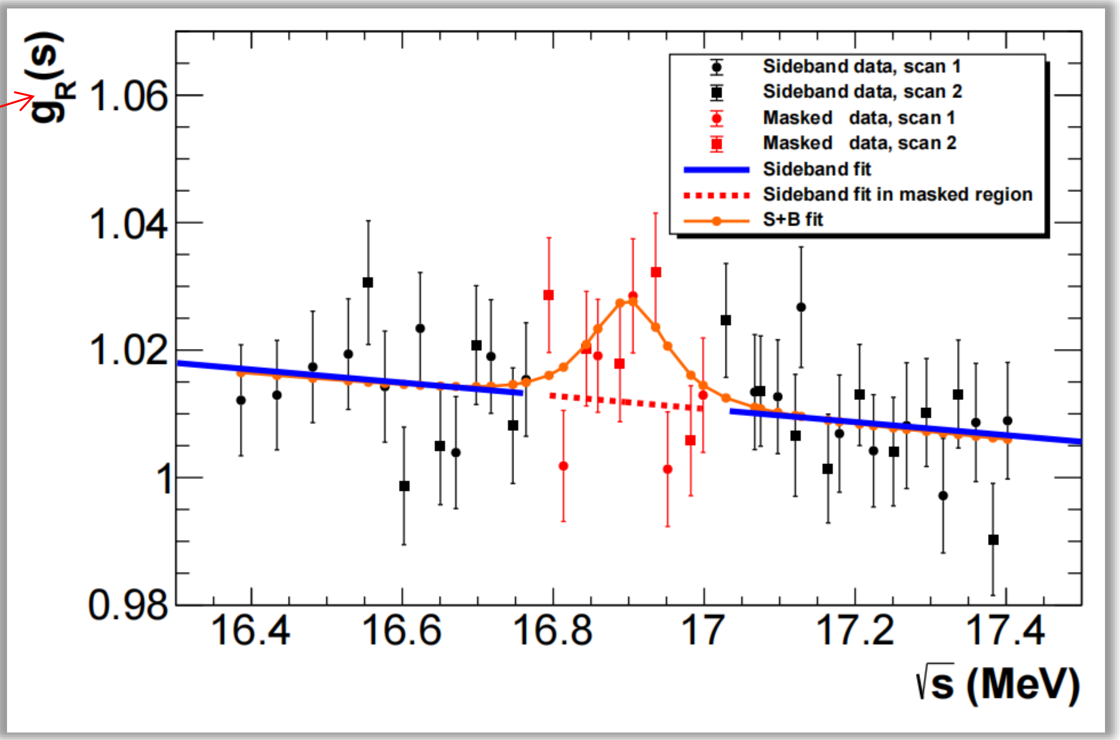
3 X(17) @ PADME

- PADME Experiment at the Frascati DAΦNE LINAC searched for X(17) using a positron beam incident on a fixed target
- The production rates of the Bhabha scattering $e^+e^- \to e^+e^-$ and the $e^+e^- \to \gamma\gamma$ process have been measured

within the beam energy between 262 and 296 MeV, corresponding to center-of-mass energies $16.4 < \sqrt{s} < 17.4$ MeV

$$g_R(s) = K(s)\left[1 + \frac{S(s; M_X, g_{ve})\varepsilon_{\rm sig}(s)}{B(s)}\right]$$

Terms linearly dependent on √s and are collectively referred to as K(s)



- ➢ Significant deviation is found at $\sqrt{s} \simeq 16.90$ MeV, with local significance of 2.5 σ and global significance of (1.77 ± 0.15) σ.
- ➢ By assuming the pure vector coupling, the upper limit $|\varepsilon^{v}_{e}| \lesssim 5.6 \times 10^{-4}$ is obtained at 90% C.L.

■ $e^+e^- \to X(17)$

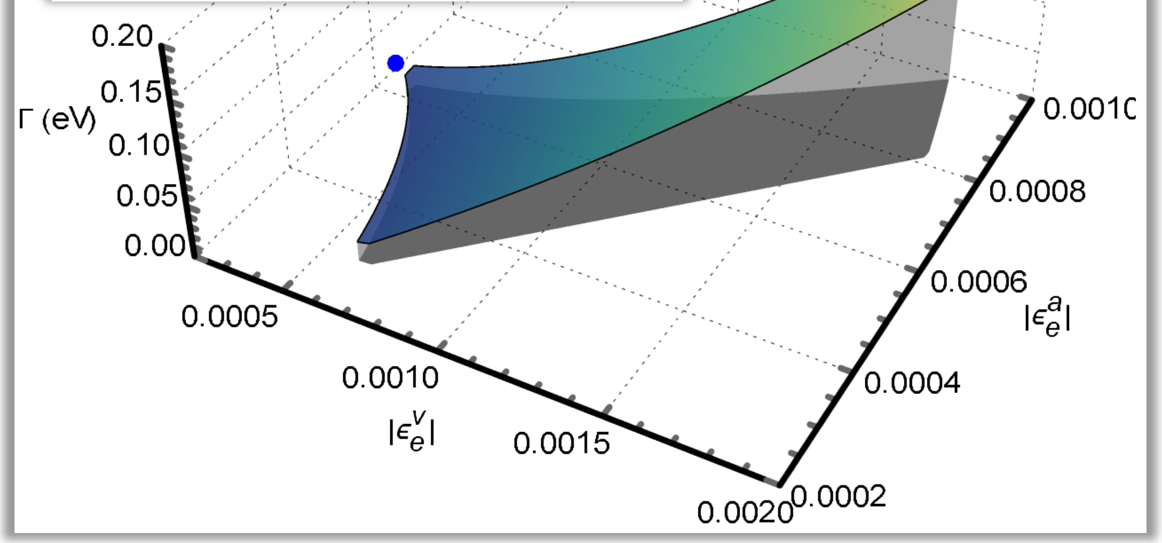
$$\sigma = \frac{2\pi^2\alpha}{s}((\varepsilon_e^a)^2 + (\varepsilon_e^v)^2)\delta(1 - \frac{m_X}{\sqrt{s}}) + \mathcal{O}((\frac{m_e}{\sqrt{s}})^2).$$

Cross section: 89 ~ 777 nb

■ $X(17) \to e^+e^-$

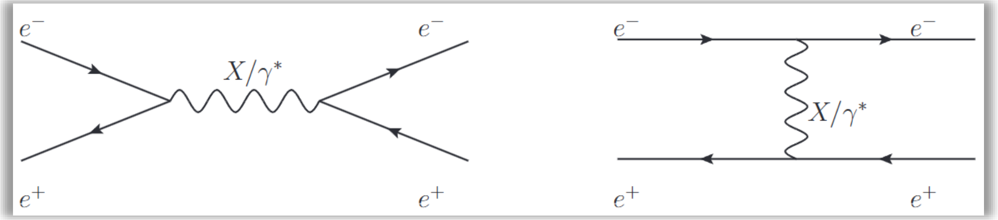
$$0.018\ \mathrm{eV} \lesssim \Gamma(X \to e^+e^-) \lesssim 0.16\ \mathrm{eV},$$

$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\max}^{\Gamma\to e^+e^-} \simeq (1.8, 0.84) \times 10^{-3},$$
$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\min}^{\Gamma\to e^+e^-} \simeq (2.4, 6.3) \times 10^{-4}.$$



Lifetime of X(17) at rest frame: 4~36 fs.

- $e^+e^- \to X(17)/\gamma^* \to e^+e^-$



Background (B)

$$\frac{d\sigma_B}{d\cos\theta} = \frac{\pi\alpha^2}{2s}\left(\frac{3+\cos^2\theta}{1-\cos\theta}\right)^2 + \mathcal{O}((\frac{m_e}{\sqrt{s}})^2).$$

$$\sigma_B = \frac{\pi\alpha^2}{2s}\left(I(\theta_2) - I(\theta_1)\right) + \mathcal{O}((\frac{m_e}{\sqrt{s}})^2),$$
$$I(\theta) \equiv \frac{\cos^3\theta}{3} + \cos^2\theta + 9\cos\theta + \frac{16}{1-\cos\theta} + 16\log(\cos\theta - 1) - \frac{31}{3},$$

divergent at $\cos\theta$=1 (t=0)

Signal (S)

$$\begin{aligned}\frac{d\sigma_S}{d\cos\theta} = & \frac{\pi\alpha^2 s}{2(s-m_X^2)^2(s+2m_X^2-s\cos\theta)^2}\left(((\varepsilon_e^v)^4+(\varepsilon_e^a)^4)\right.\\ & \times\left(s^2(\cos^2\theta+3)^2 - 6m_X^2 s(\cos^2\theta+3)(\cos\theta+1) + 2m_X^4(\cos\theta(5\cos\theta+6)+9)\right)\\ & +2(\varepsilon_e^v\varepsilon_e^a)^2\left(s^2\left(\cos\theta\left(\cos\theta\left(\cos\theta(\cos\theta+8)+6\right)+8\right)-7\right)\right.\\ & \left.\left.-2m_X^2 s(\cos\theta+1)\left(\cos\theta(5\cos\theta+16)-1\right)+2m_X^4\left(\cos\theta(11\cos\theta+26)+7\right)\right)\right)\\ & +\mathcal{O}((\frac{m_e}{\sqrt{s}})^2). \end{aligned} \tag{30}$$

$$\begin{aligned}\sigma_S = & \frac{4\pi\alpha^2}{3m_X^2 s(s+m_X^2)(s-m_X^2)^2}\\ & \left(s\left(((\varepsilon_e^v)^4+(\varepsilon_e^a)^4)\left(3s^3+4m_X^2s^2+m_X^4 s-6m_X^6\right)\right.\right.\\ & \left.+2(\varepsilon_e^v)^2(\varepsilon_e^a)^2\left(3s^3+22m_X^2s^2-5m_X^4 s-18m_X^6\right)\right)\\ & \left.+6\left((\varepsilon_e^v)^4+(\varepsilon_e^a)^4+6(\varepsilon_e^v)^2(\varepsilon_e^a)^2\right)m_X^2(m_X^2-s)(m_X^2+s)^2\log\left(\frac{m_X^2+s}{m_X^2}\right)\right)\\ & +\mathcal{O}((\frac{m_e}{\sqrt{s}})^2). \end{aligned}$$

- $e^+e^- \to X(17)/\gamma^* \to e^+e^-$

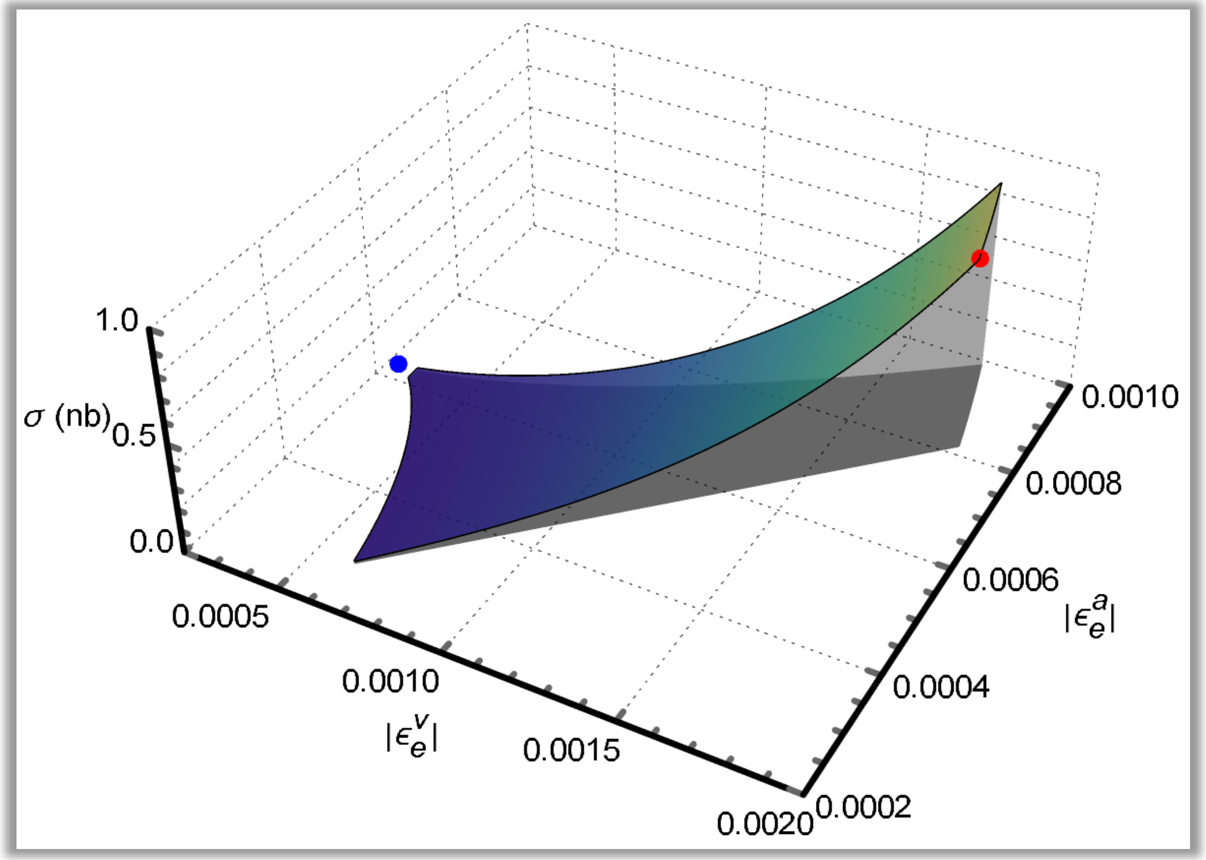
m_X=17 MeV, $\sqrt{s}$ = 17.02 MeV, Γ_X = 0.089 eV

$$0.011 \text{ nb} \lesssim \sigma(e^+e^- \to X \to e^+e^-) \lesssim 0.87 \text{ nb},$$

$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\text{max}}^{e^+e^- \to X \to e^+e^-} \simeq (1.8, 0.82) \times 10^{-3},$$
$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\text{min}}^{e^+e^- \to X \to e^+e^-} \simeq (2.4, 6.3) \times 10^{-4},$$

Cross sections depends on $|\sqrt{s} - m_X|$ strongly.

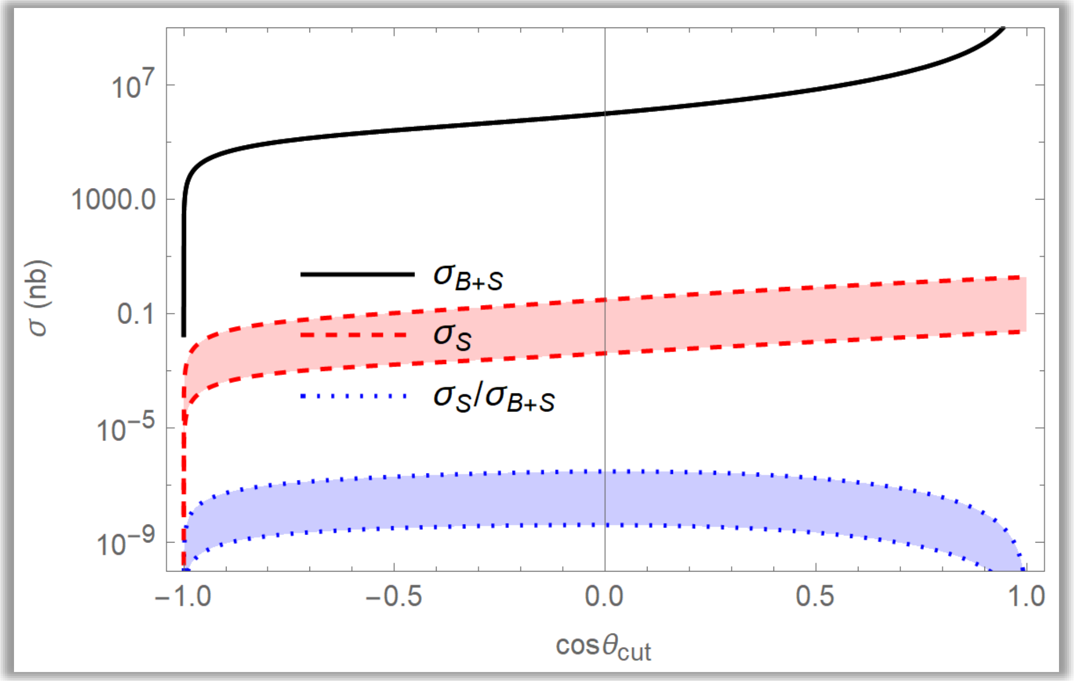
$\sqrt{s}$ (MeV)	σ_{min} (nb)	σ_{max} (nb)
17.02	0.011	0.87
17.05	0.0017	0.14
17.10	0.00043	0.035
17.20	0.00011	0.0086



- $e^+e^- \to X(17)/\gamma^* \to e^+e^-$

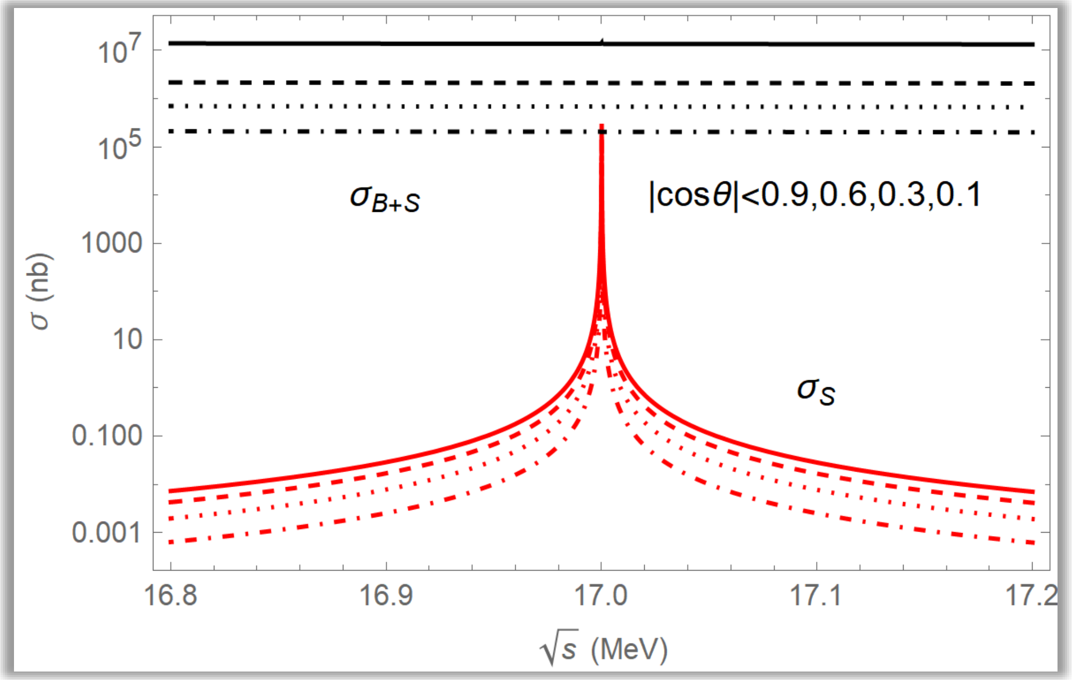
m_X=17 MeV, $\sqrt{s}$ = 17.02 MeV, Γ_X = 0.089

The range of integration is $\cos\theta \in [-1, \cos\theta_{cut}]$



Proper cuts on |cosθ| improve the signal-to-noise ratio

Cross section $\sigma(e^+e^+ \to X(17))$: 89 ~ 777 nb

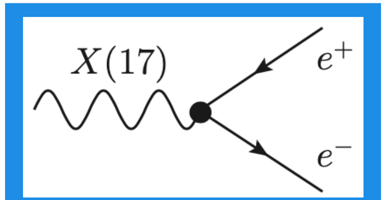


PADME: Scan energy steps 1.5 MeV; beam energy spread 0.75 MeV; ECal hit reconstruction threhold 1 MeV

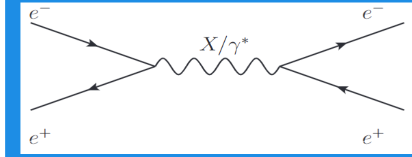
Due to the extremely low signal-to-noise ratio, I am pessimistic about detecting X(17) in the PADME experiment (Bhabha scattering).

CONTENTS

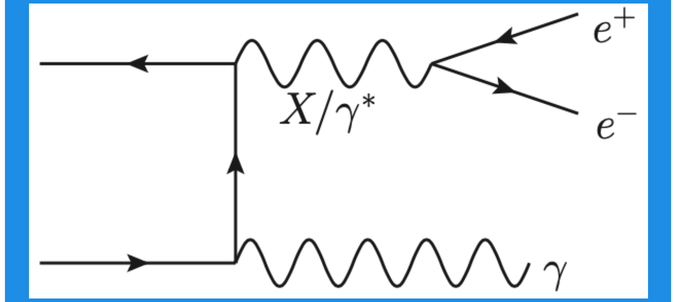
Motivation



Constraints on Xe^+e^- coupling



X(17) @ PADME

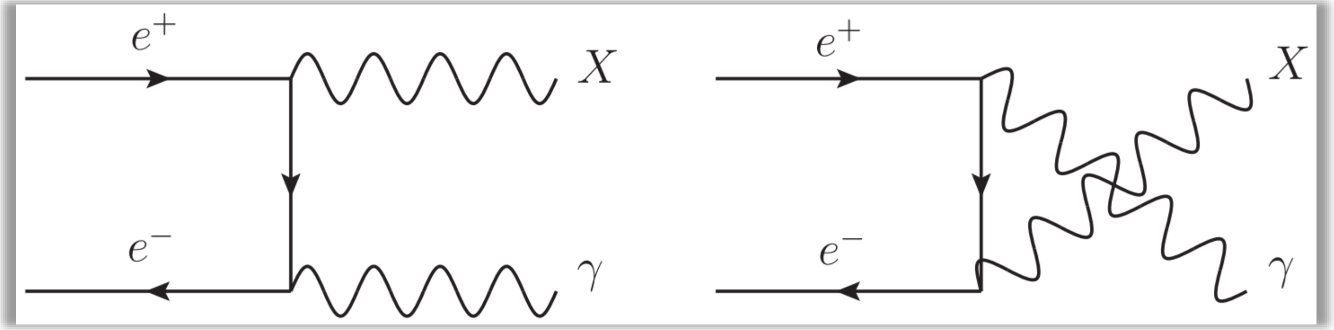


Revisit X(17) @ BESIII

Summary

- $e^+e^- \rightarrow X(17)+\gamma$

Within the errors of $\mathcal{O}\left(\frac{m_e^2}{m_X^2}\right) \approx 0.1\%$, the differential cross section depends on the coupling parameters only through the argument $(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2$



$$\frac{d\sigma}{d\cos\theta} = \frac{2\pi\alpha^2}{s}\left((\varepsilon_e^v)^2 + (\varepsilon_e^a)^2\right)\left(\frac{1+cos^2\theta}{1-cos^2\theta}\right) + \mathcal{O}\left(\left(\frac{m_e}{m_X}\right)^2, \left(\frac{m_X}{\sqrt{s}}\right)^2, \left(\frac{m_e}{\sqrt{s}}\right)^2\right).$$

The integrated cross section:

$$\sigma = \frac{4\pi\alpha^2}{s}\left((\varepsilon_e^v)^2 + (\varepsilon_e^a)^2\right)\left(\mathrm{Log}\left[\frac{s}{m_e^2}\right] - 1\right) + \mathcal{O}\left(\left(\frac{m_e}{m_X}\right)^2, \left(\frac{m_X}{\sqrt{s}}\right)^2, \left(\frac{m_e}{\sqrt{s}}\right)^2\right).$$

The leading order results are the argument $(\varepsilon_e^v)^2 + (\varepsilon_e^a)^2$ times the differential and total cross sections of $e^+e^- \rightarrow \gamma\gamma$

- $e^+e^- \rightarrow X(17)+\gamma$

At $\sqrt{s}$ = 3.7 GeV, the integrated cross section:

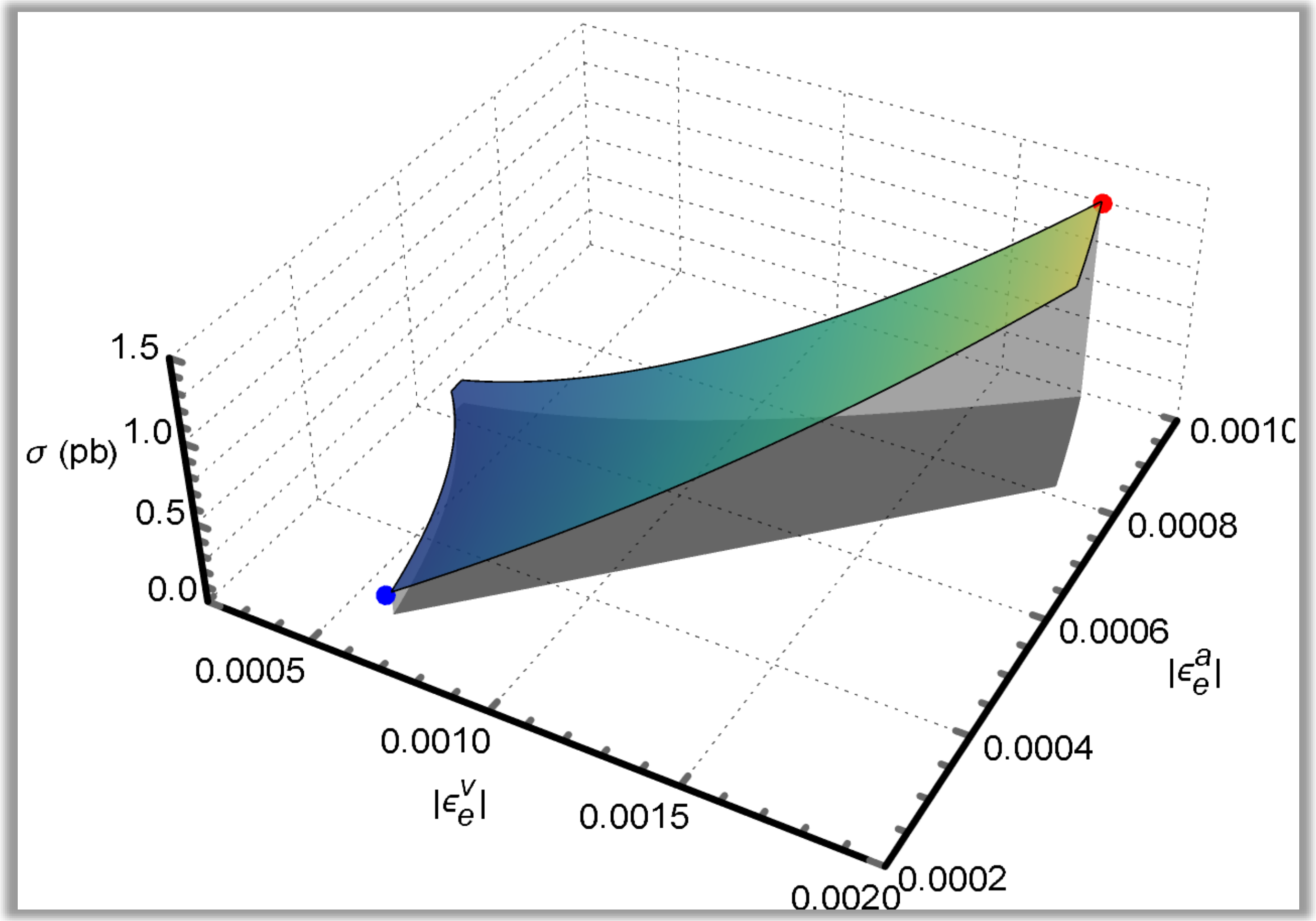
$$0.144 \text{ pb} \lesssim \sigma(e^+e^- \rightarrow X\gamma) \lesssim 1.28 \text{ pb},$$

with maximum and minimum coupling points

$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\max}^{e^+e^-\rightarrow X\gamma} \simeq (1.7, 0.99) \times 10^{-3},$$
$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\min}^{e^+e^-\rightarrow X\gamma} \simeq (6.1, 2.7) \times 10^{-4}.$$

Given the luminosity of BESIII at $\sqrt{s}$ = 3.7 GeV $\mathcal{L} = 10^{33} cm^{-2} s^{-1} \approx 10^4 pb^{-1} year^{-1}$ and BESIII cover 93% solid angle,
we roughly estimate X(17) events per year:

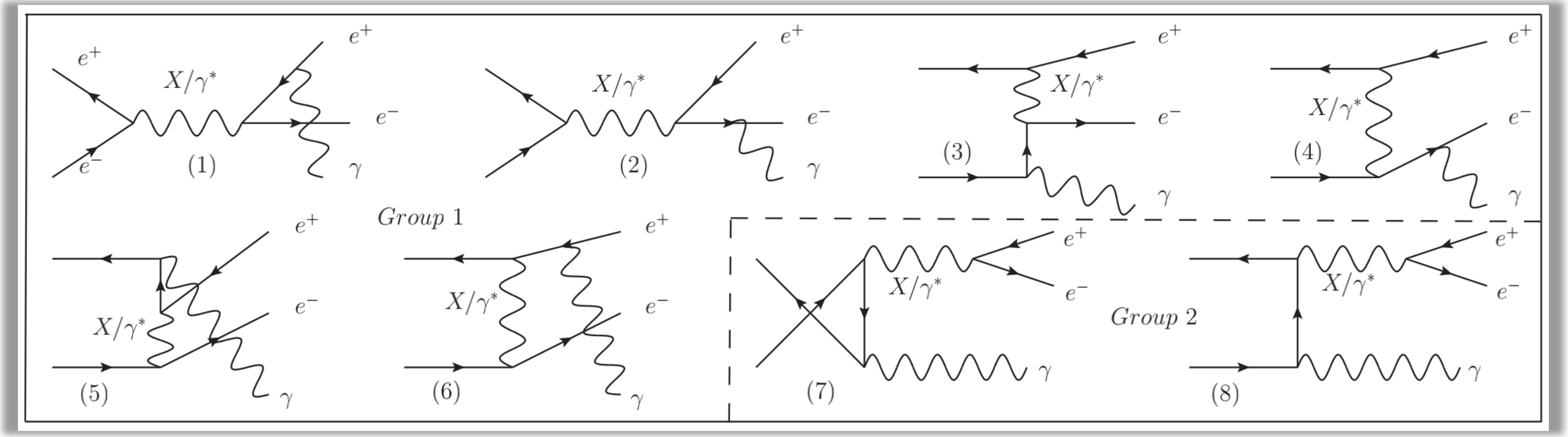
$$(1.3 \sim 12) \times 10^3$$



In e^+e^- c.m.s., the lifetime of X(17) at √s = 3.7 GeV is boosted by about two orders to 0.44~3.9 ps.
Decay length of X(17): L ≈ 0.13 ~ 1.2 mm, which implies X(17) created at the primary vertex in chamber.

4 Revisit X(17) @ BESIII

- Identify X in $e^+e^- \to e^+e^- \gamma$



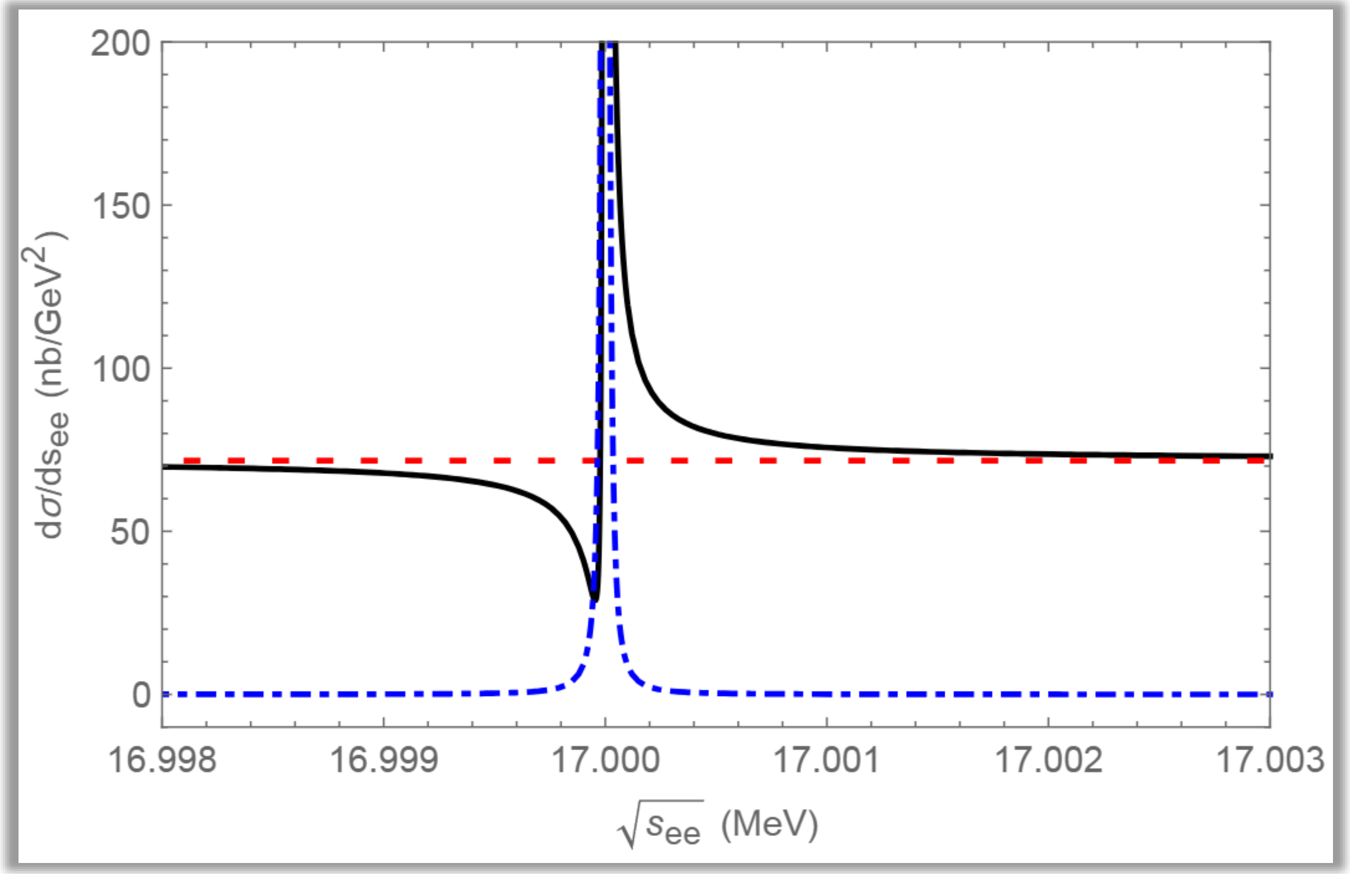
The differential cross section of $e^+(p_a)e^-(p_b) \to e^+(p_1)e^-(p_2)\gamma(p_3)$ can be formulated as

$$d\sigma = \frac{(2\pi)^4}{4\sqrt{(p_a \cdot p_b)^2 - m_e^4}} \bar{\sum} |\mathcal{M}_{\text{sg}} + \mathcal{M}_{\text{bg}}|^2 \, d\Phi_3, \tag{39}$$

where $\bar{\sum}$ stands for the average on initial spins and sum over final spins, $\mathcal{M}_{\text{sg}}$ and $\mathcal{M}_{\text{bg}}$ are the amplitudes of the signal and background Feynman diagrams respectively, and $d\Phi_3$ is the three-particle phase space.

- Identify X in $e^+e^- \to e^+e^-$ g

Differential distribution of e^+e^- invariant mass spectrum



$$(|\varepsilon_e^v|, |\varepsilon_e^a|)_{\max}^{e^+e^-\to X\gamma} \simeq (1.7, 0.99)\times 10^{-3},$$

$|cos\alpha| < 0.93$ for electrons/positrons,

$|cos\alpha| < 0.8$ and $E_\gamma > 25$ MeV for photons,

4 Revisit X(17) @ BESIII

- Identify X in $e^+e^- \to e^+e^- g$

Energy resolution at 20 MeV: $\delta(E)/E = 9\%$ ⇨ $\delta(17MeV) \approx 1.5MeV$

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Energy resolution (MeV)	1	1.5	3
Mass ranges (MeV)	[14, 20]	[12.5, 21.5]	[8, 26]
B ($\times 10^4$ year^{-1})	14.8	22.5	48.8
S ($\times 10^4$ year^{-1})	1.2 (0.13)		
$S/\sqrt{S+B}$	30 (3.4)	25 (2.7)	17 (1.9)

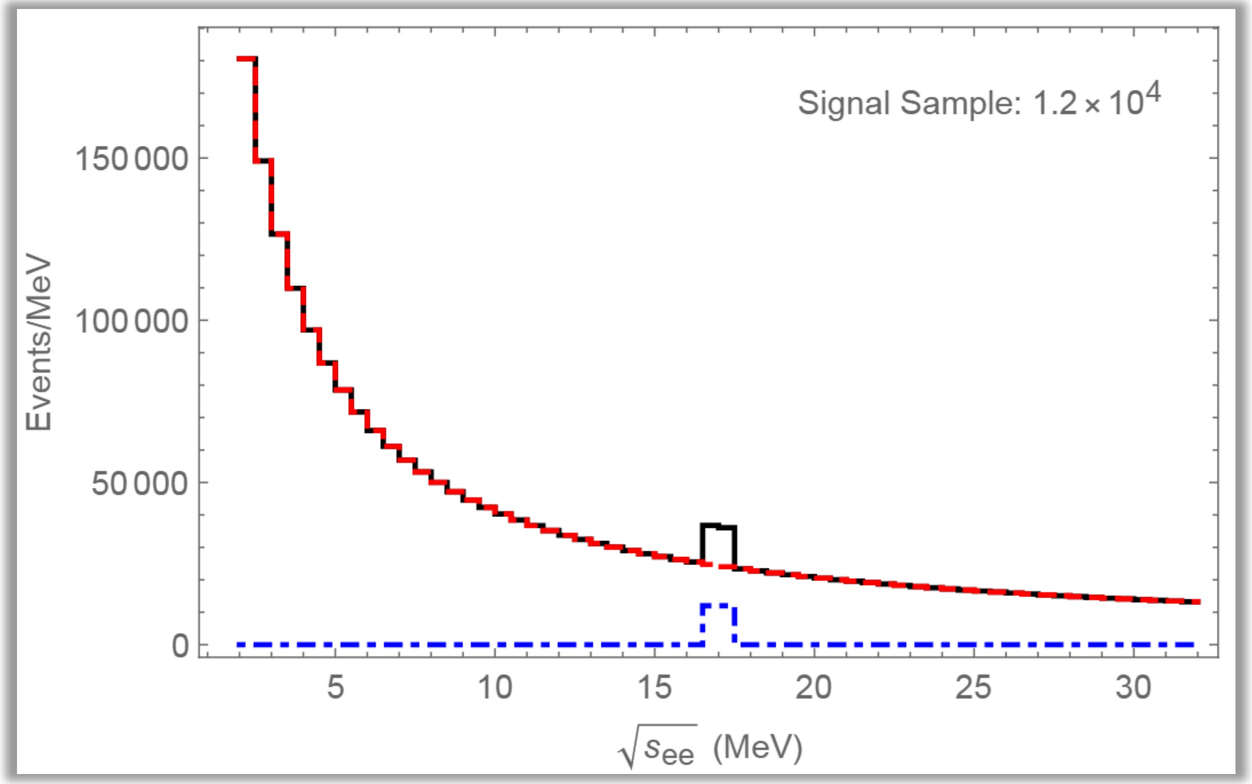
For the Gaussian distribution, 3σ deviation away from the expectation account for 99.73% of the set.

Values outside (inside) the parentheses are for the maximum (minimum) events in $e^+e^- \to X g$.

The number of events and signal-to-noise ratio data indicate that it is feasible to detect/exclude X(17) in the BESIII experiment.

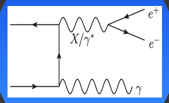
■ Identify X in $e^+e^- \to e^+e^-$ g

Invariant mass spectrum distribution **before smearing**



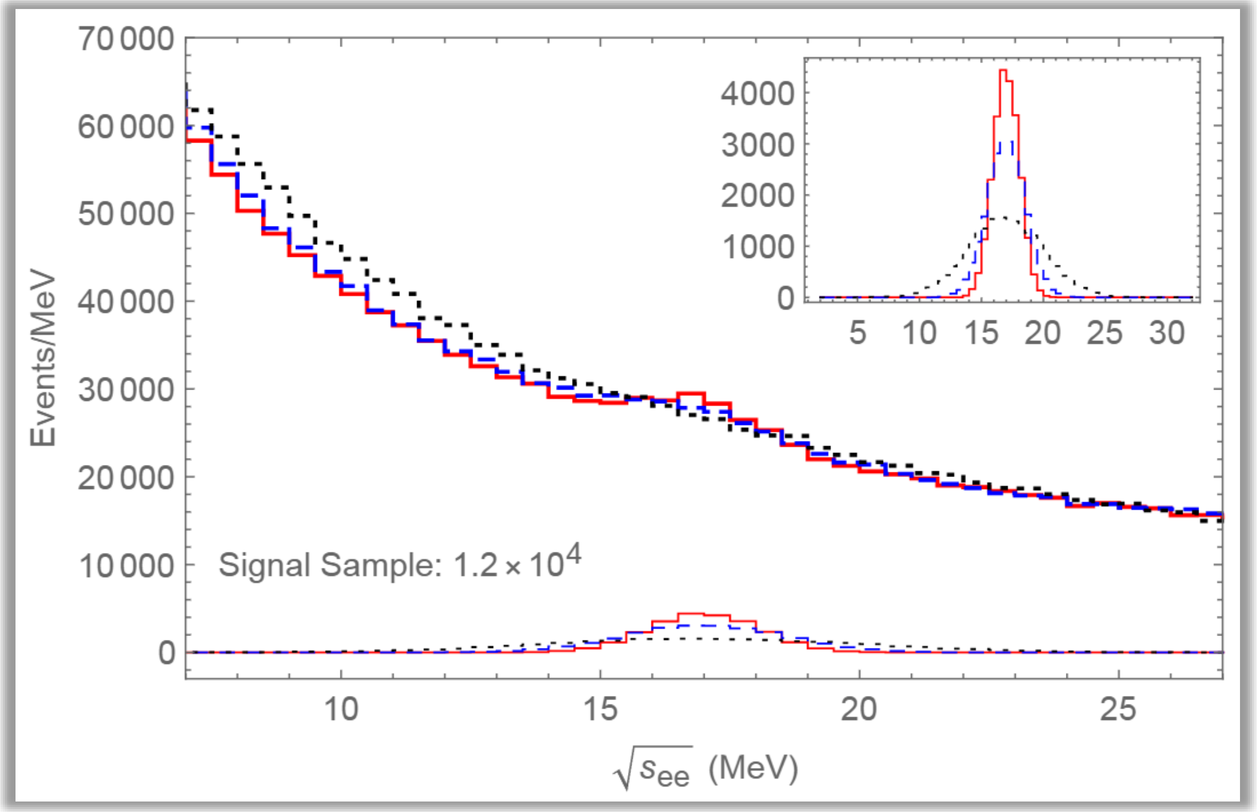
- The bin size: 0.5 MeV
- Maximum Sample: 1.2×10^4

If the minimum sample (0.13×10^4) was adopted, the height of X(17) bump will be about 10% of that and become a shoulder unless we adopt smaller bin size.



■ Identify X in $e^+e^- \to e^+e^- \gamma$

Invariant mass spectrum distribution **After smearing**



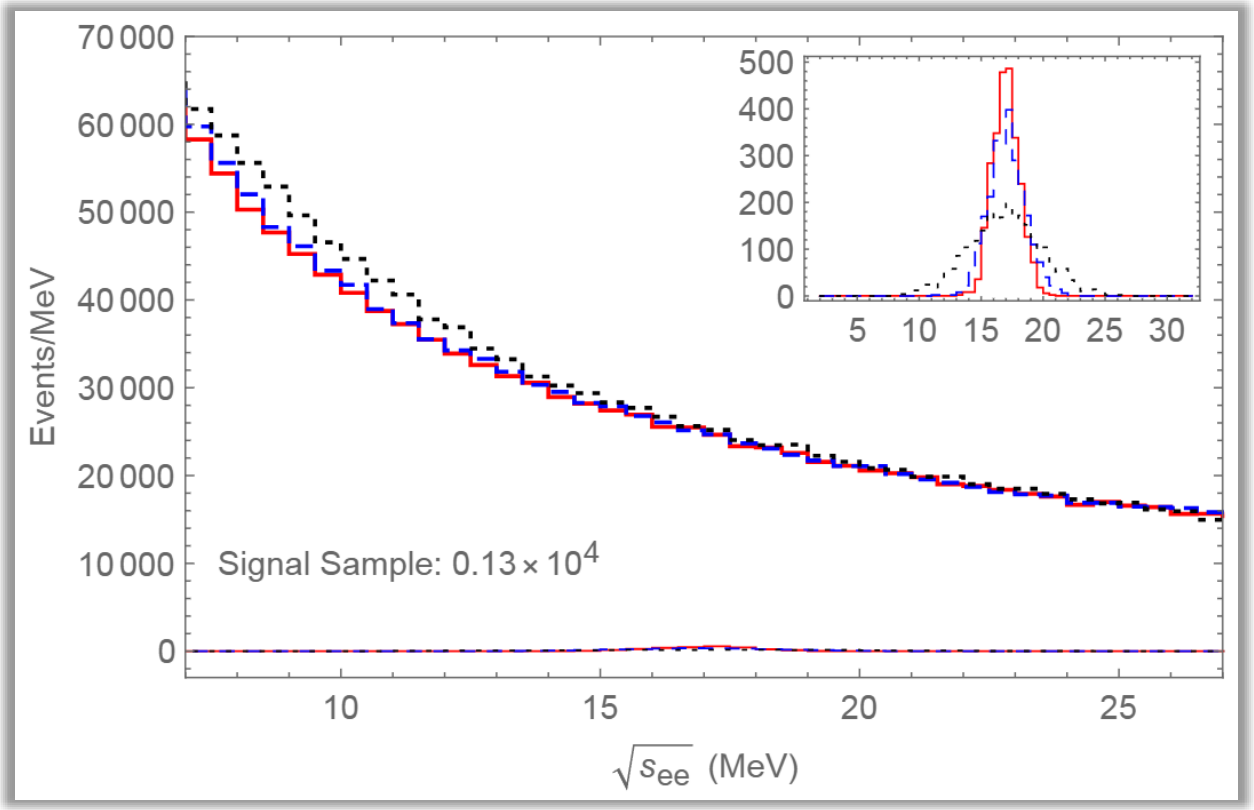
- The bin size: 0.5 MeV
- Maximum Sample: 1.2×10^4
- Energy resolutions: 1, 1.5, 3 MeV for different legends

93% coverange of solid angle is considered, but efficiencies etc. are not taking into account.

Modifying the bin size will not make the bump sharper after smearing.

- Identify X in $e^+e^- \rightarrow e^+e^- \gamma$

Invariant mass spectrum distribution **After smearing**



- The bin size: 0.5 MeV
- Maximum Sample: 0.13×10^4
- Energy resolutions: 1, 1.5, 3 MeV for different legends

Height of the bump decreases by about 90% in comparison with the maximum sample, and we can not identify the X(17) signals over the background events.

- ◆ The Atomki anomalies can be explained by introducing the X(17) boson with V±A interaction
- ◆ Bosed on exiting experimental data, **constraints on the couplings of X(17) to electrons within this V± A model** are obtained, while pure V and A couplings are disfavored.
- ✓ Pessimistic for $e^+e^- \to X(17) \to e^+e^-$ at PADME, but optimistic for $e^+e^- \to X(17)+\gamma \to e^+e^-\gamma$ at BESIII
- ✓ **BESIII experiment has the ability to give a decisive conclusion on X(17)**

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Thank You!

Hunt for X(17)

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