

Search for invisible decays of dark photon at BESIII

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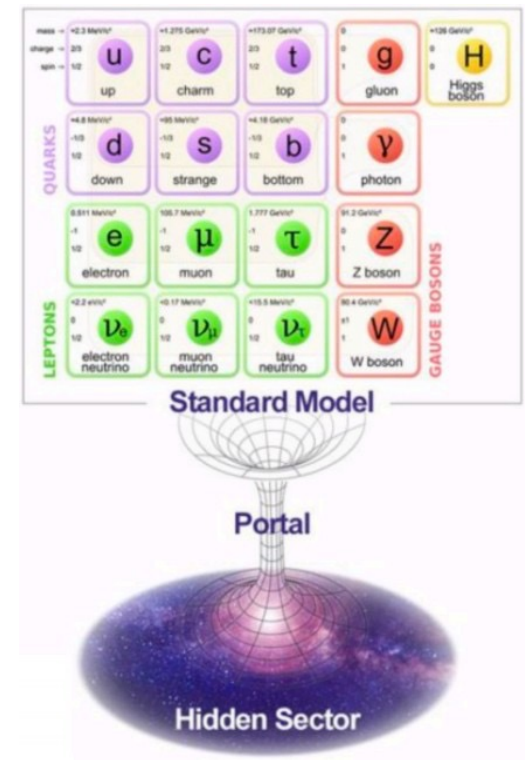


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Motivation

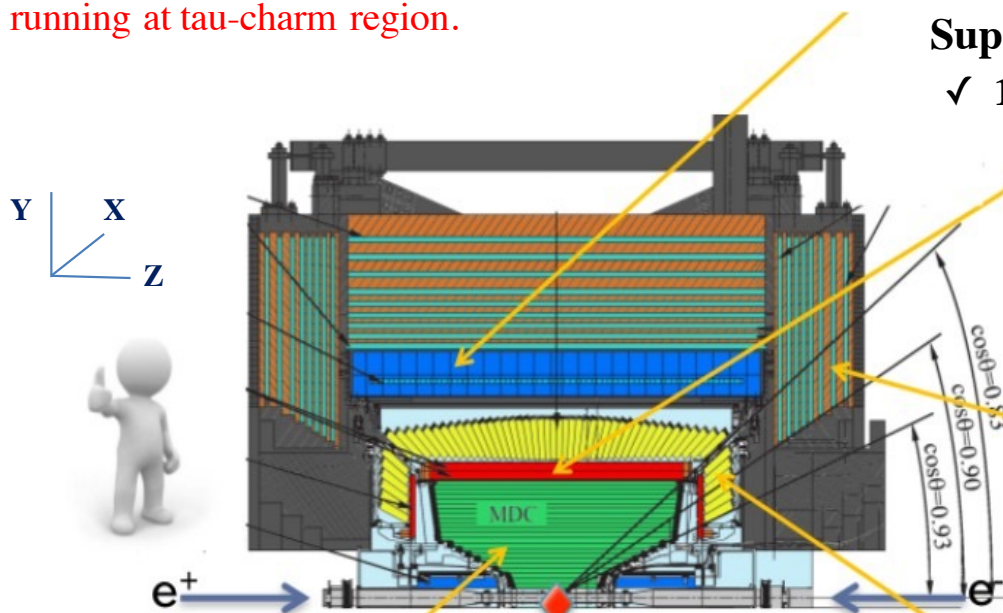
- Many extensions of the Standard Model (SM) introduce light weak interacting dark matter (DM) hidden sectors
 - ✓ Motivated by recent experimental anomalies and theoretical prejudice
 - ✓ The DM hidden sectors couple to the SM particles via the so called “portals” like the dark photons.
 - ✓ These new particles can be accessible by high intensity e^+e^- collider experiments, such as **BESIII experiment**, if their masses are in the MeV-GeV range.

R. Essig et al., arXiv: 1311.0029 (2013)



BESIII Experiment

BESIII experiment is a symmetric electron positron collider running at tau-charm region.



Super conducting magnet

✓ 1 Tesla

[Nucl. Instrum. Meth. A614, 345-399 (2010)]

Time of Flight (TOF)

- 2 layer plastic scintillators
- $\sigma_T \approx 80$ ps (barrel)
- $\sigma_T \approx 110$ ps (endcap) (**~ 65 ps after upgradation with MRPC**)
- Particle id

Muon system

- 9 layers of RPC
- $P > 400$ MeV/c
- $\delta R_\varphi \approx 1.4 - 1.7$ cm

Electromagnetic calorimeter (EMC) (CsI(Tl))

→ 6240 crystals overall

- $\sigma(E)/E \approx 2.5\%$
- $\sigma_{Z,\varphi}(E) \approx 0.5 - 0.7$ cm

Multilayer drift chamber (MDC)

- He/C₃H₈ (60/40)
- 43 layers
- Momentum resolution $\sigma_p/p \approx 0.5\%$ @ 1 GeV
- Spatial resolution $\sigma_{xy} \approx 130$ μm .

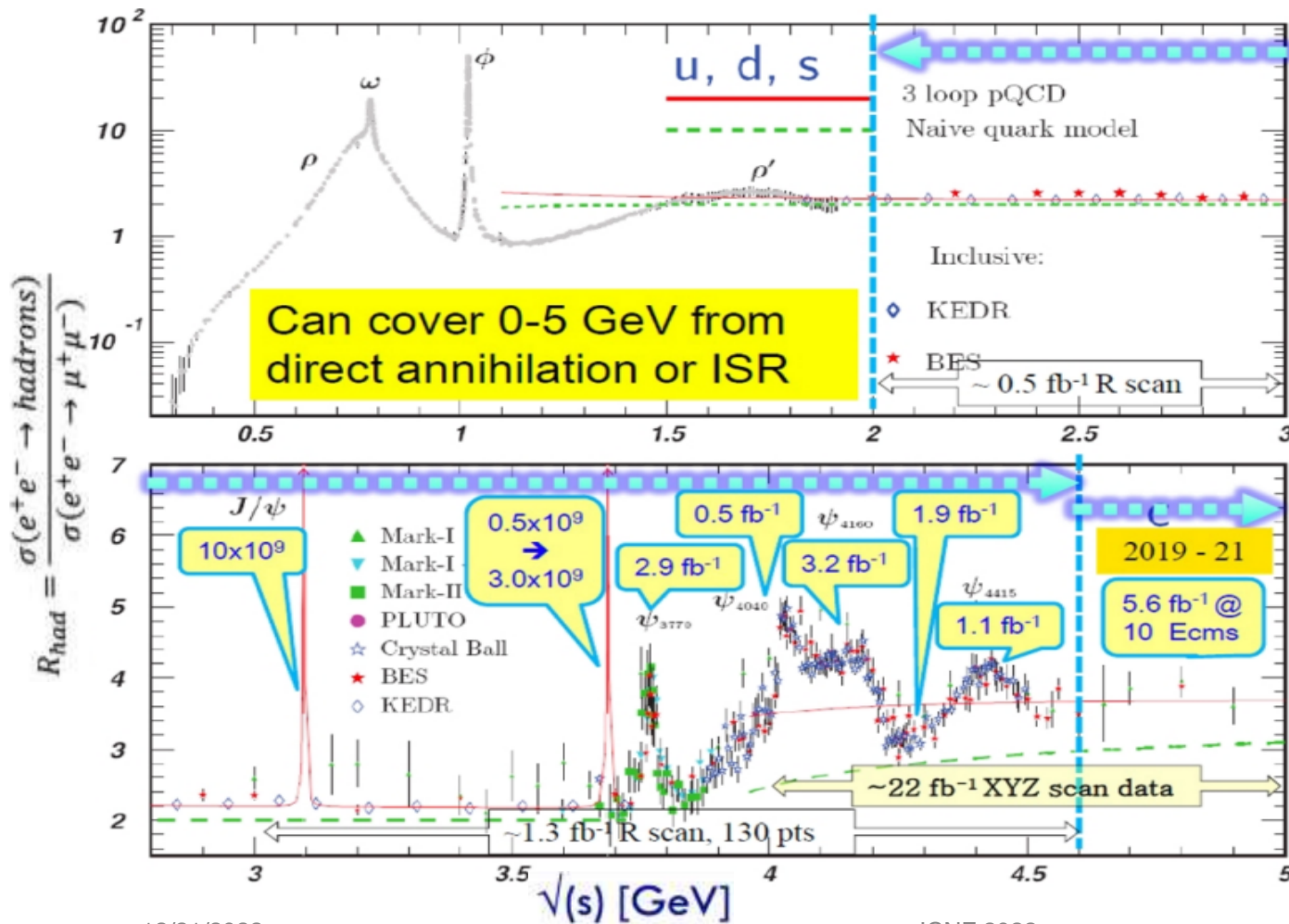
Will replace the inner part of the drift chamber by the three layers of CGEM detector.

12/21/2022

ICNF 2022

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BESIII Dataset



World largest data for

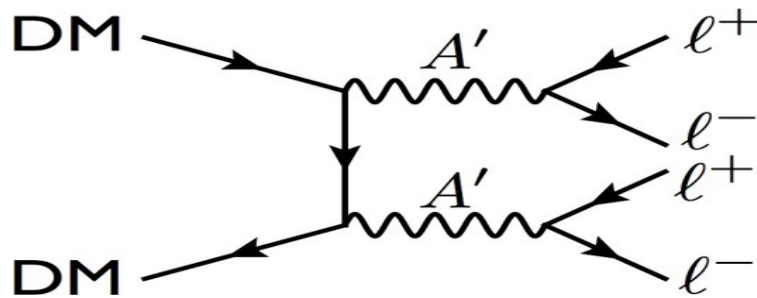
- ✓ Charmonium spectroscopy
- ✓ Charm physics
- ✓ Light hadrons
- ✓ New physics search

**IDEAL ENVIRONMENT TO
STUDY HADRON
SPECTROSCOPY & SEARCH
FOR NEW PHYSICS
PHENOMENA!!**

Dark photon

- New Models introduce new dark force carriers (e.g. dark-photon A' or γ') with light hidden sectors.

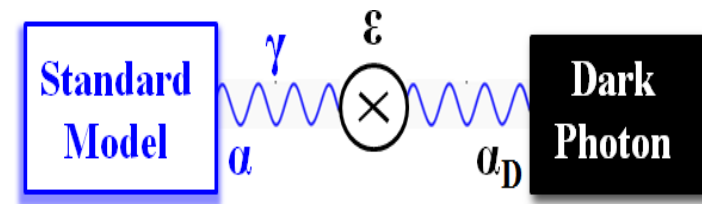
N. Arkani-Hamad et al, PRD 79, 015014 (2009)



$$m_{DM} \sim \text{TeV} \quad \text{MeV} \lesssim m_{A'} \lesssim \text{GeV}$$

- ❖ Produces high-energy (~ 100 GeV) cosmic-ray electrons and positrons.
- ❖ Could explain the features of astrophysical observations.

- ❖ Interaction with Standard Model via kinetic mixing with mixing strength (ϵ).



ϵ = hypercharge mixing strength.

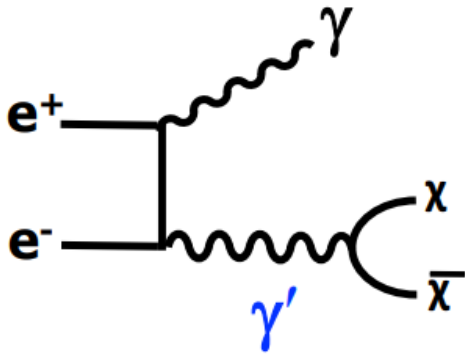
- ❖ Kinematic mixing generates non-zero coupling of SM fermions to A' : $\alpha_D = \alpha\epsilon$, where α_D and α are fine structure constants in dark and Standard Model sectors, respectively.

B. Batell, et al, PRD79, 115008 (2009);
R. Essig, et al, PRD80 015003 (2009)

Search for invisible decays of dark photon

Used 14.9 fb^{-1} of e^+e^- annihilation data taken at center-of-mass energies from 4.13 to 4.60 GeV to perform this search

Search is performed via Initial-State-Radiation (ISR) production ($e^+e^- \rightarrow \gamma_{\text{ISR}}\gamma'$), where γ_{ISR} is an ISR photon.

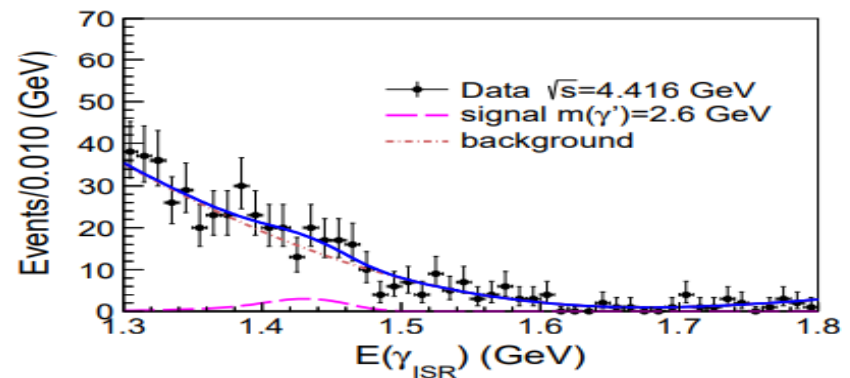
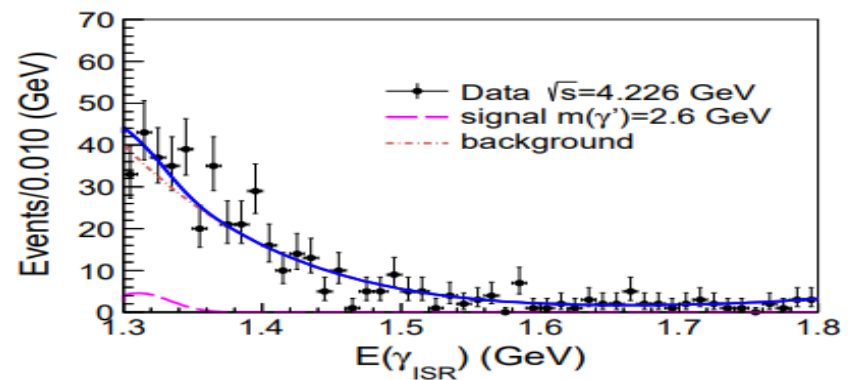


Energy of monochromatic photon:

$$E_{\text{ISR}} = \frac{s - m_{\gamma'}^2 c^4}{2\sqrt{s}},$$

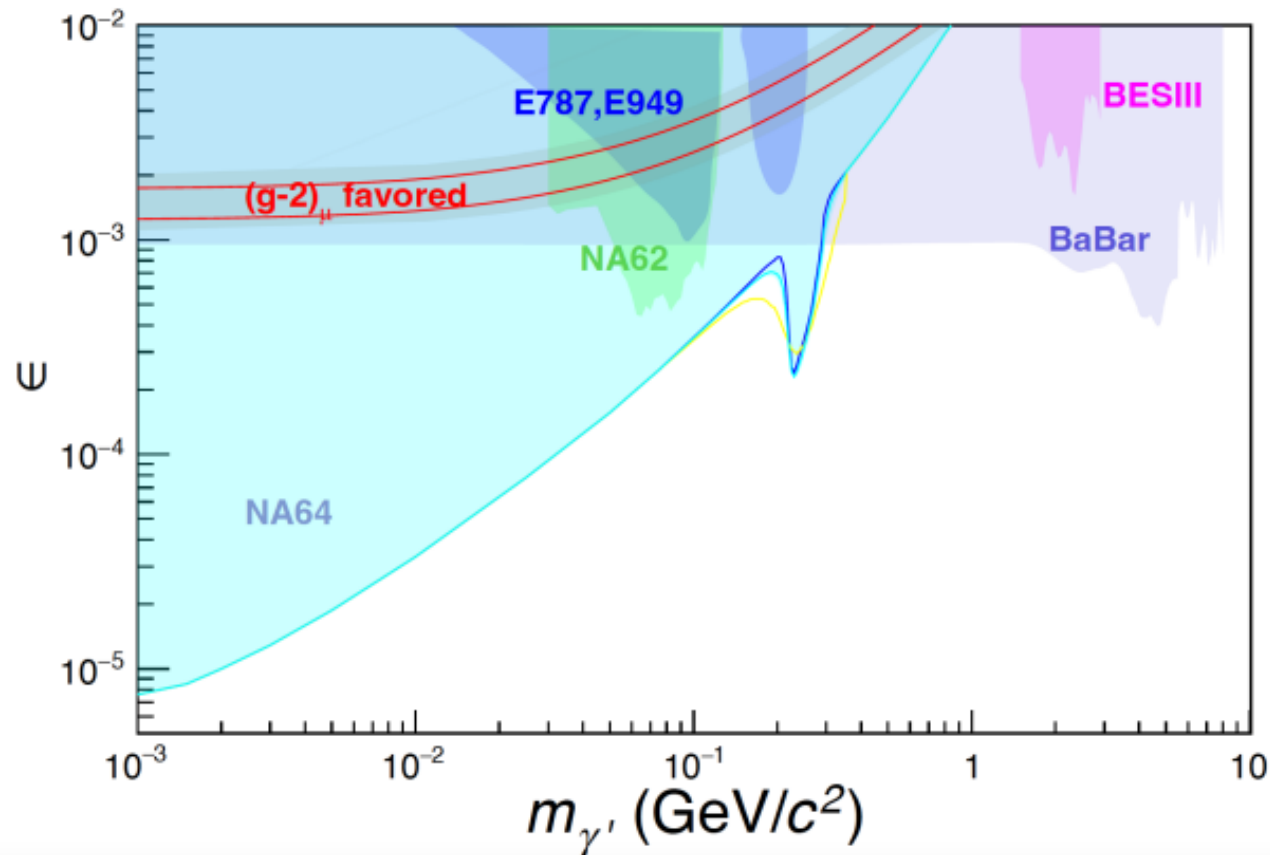
No evidence of dark photon production is found.

12/21/2022



90% confidence level upper limit on ϵ

ϵ = hypercharge mixing strength between Standard Model and dark sectors



- Our limit is comparable with the BaBar measurement.
Phys. Rev. Lett. **119**, 131804 (2017)
- Future BESIII data may improve sensitivity.
- Submitted to **Phys. Lett. B**, arXiv: **2209.13893** (2022)

Summary and conclusion

- We search for invisible decays of a dark photon via initial State Radiation $e^+e^- \rightarrow \gamma\gamma'$ process using the data –sets taken at center-of-mass energies from 4.13 to 4.60 GeV by the BESIII detector .
- We find no evidence of dark photon production.
- Set 90% confidence upper limit on the kinematic mixing strength between Standard Model and dark sectors.
- Our limit is comparable with the BaBar measurement.
- Submitted to **Phys. Lett. B, arXiv:2209:13893 (2022)**