Dark Photon Search at BESIII with ISR Method

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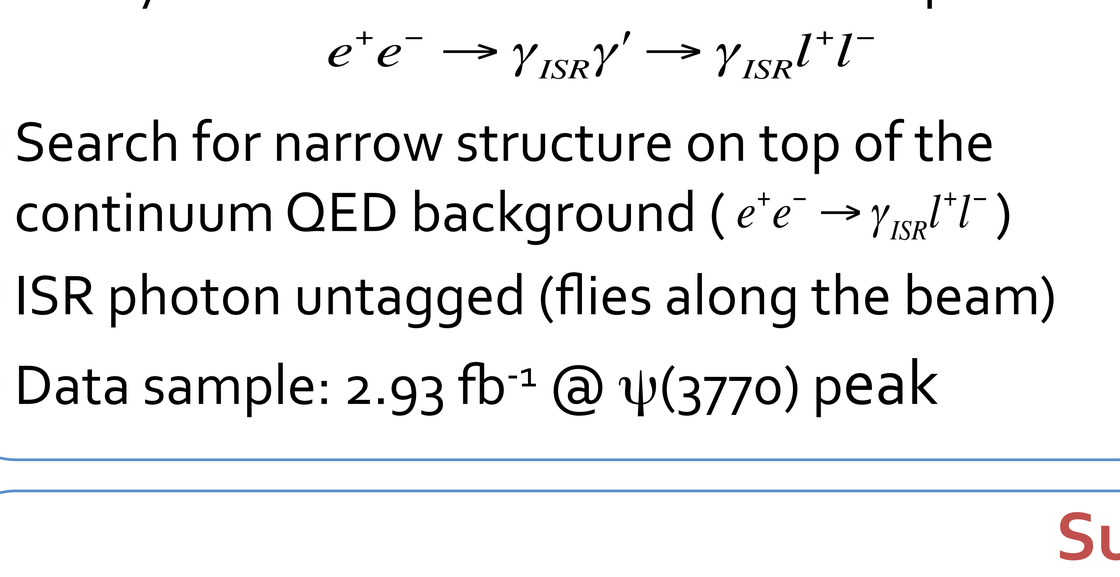
Dark Photon (γ′)

- New Abelian gauge group U(1) force carrier, kinetic mixing with SM U(1) with mixing coefficient ε
- Could explain deviation of muon anomaly $(g-2)_\mu$
  Also large number of astrophysical anomalies
- Typical mix strength: $10^{-2} \sim 10^{-5}$
- Expected mass scale: MeV/c² ~ GeV/c²

BEPCII and BESIII Dector

- Energy range: 2.0 ~ 4.6 GeV
- Design luminosity: 10^{33} cm^{-1}s^{-1}

Half plot



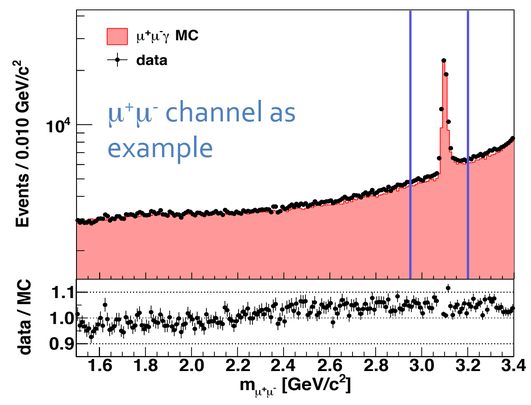
Search Strategy

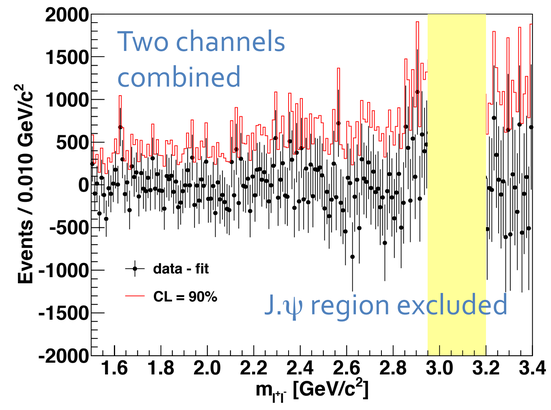
- Decay channel: Initial State Radiation process:

$$e^+e^- \to \gamma_{ISR}\gamma' \to \gamma_{ISR} l^+l^-$$

- Search for narrow structure on top of the continuum QED background ($e^+e^- \to \gamma_{ISR} l^+l^-$)
- ISR photon untagged (flies along the beam)
- Data sample: 2.93 fb^{-1} @ ψ(3770) peak

Number of Signal Events





- Fit the QED background with 4th order polynomial function
- Look for peaking structure in M(data-fit)
- Set 90% confidence level using profile likelihood approach

Calculation of ε

Mixing coefficient

Number of dark photon events

Dark photon mass

$$\frac{\sigma_i(e^+e^- \to \gamma'\gamma_{\mathrm{ISR}} \to l^+l^-\gamma_{\mathrm{ISR}})}{\sigma_i(e^+e^- \to \gamma^*\gamma_{\mathrm{ISR}} \to l^+l^-\gamma_{\mathrm{ISR}})} = \frac{3\pi}{2N_f^{l^+l^-}} \cdot \frac{\varepsilon^2}{\alpha} \cdot \frac{m_{\gamma'}}{\delta_m^{l^+l^-}}$$

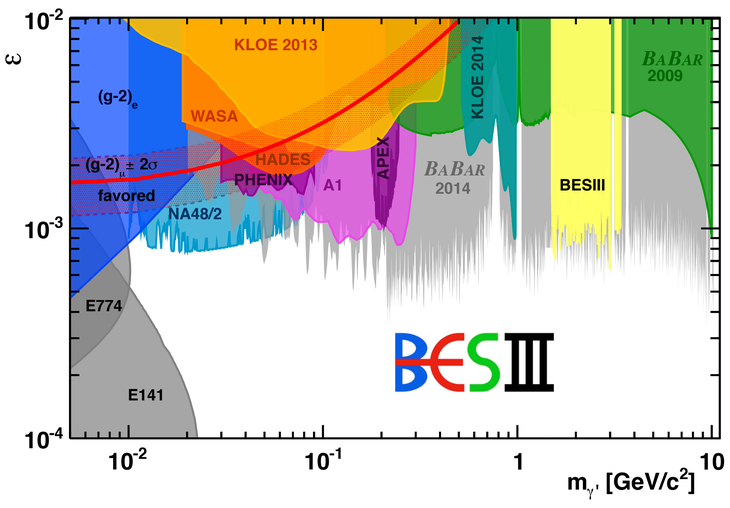
Number of QED events from annihilation process

Ratio of possible decay channels of the dark photon and the phase space

Fine structure constant

Bin width

$$N_f^{l^+l^-} = \frac{\Gamma_{\mathrm{tot}}}{\Gamma(\gamma' \to l^+l^-)} = 1 + \frac{\Gamma_{\mu\mu}}{\Gamma_{ee} + \Gamma_{\mu\mu}} \cdot (1 + R(\sqrt{s}))$$



Summary

- Dark photon search in mass region 1.5 GeV/c² ~ 3.4 GeV/c² with untagged method
- Analysis approach has no dependence on the radiator function
- No candidates with significance larger than 3σ found
- Mixing coefficient between 10^{-3} and 10^{-4}, competitive limit in this mass region

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SFB 1044 THE LOW-ENERGY FRONTIER OF THE STANDARD MODEL