Search for Dark Sectors at BESIII

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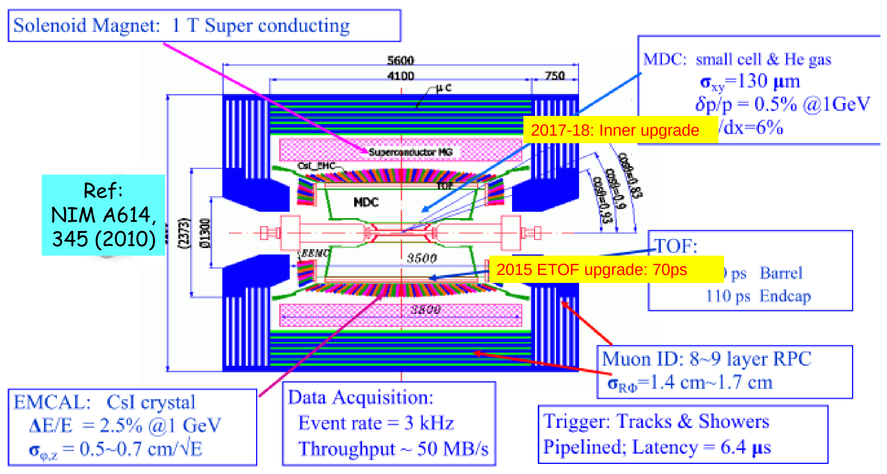
Introduction

Low energy, high luminosity e+ e- colliders are believed to be good places to search for some exotic particles predicted in new physics models with dark sector phenomenology. BESIII as the only currently running tau-charm factory has great potential to probe these particles and models, with the largest samples of directly produced charmonia and some other unique datasets. Here describes some of such searches and related results including search for di-muon decays of a CP-odd light Higgs boson(A^0) in the radiative decay of J/ψ , dark photon searches using both the initial state radiation and pseudoscalar meson decays and the study of meson invisible decays.

BESIII detector and data sets

- BEPCII is the only collider currently running at τ-charm energy
- First collision in 2008, physics run started in 2009
- BEPCII reached peak luminosity of 1×10^{33} $cm^{-2}s^{-1}$@1.89GeV in April 2016
- BESIII collaboration includes 31 Chinese institutes，13 European ones，6 US ones and 6 from other Asian countries, totally ~400 collaborators
- Clean environment and high luminosity at BESIII are helpful for indirect probe of new physics
- BESIII has accumulated huge datasets (those used in this presentation):
  - 1.3B J/ψ events, which is 21 times of BESII
  - 0.45B $\psi(3686)$ events , which is 24 times of CLEO_c
  - 2.9/fb at $\psi(3770)$, which is 3.5 times of CLEO_c
  - And many more: >5/fb above 4 GeV, 3/fb Ds data at 4170 MeV, R&QCD scan data etc



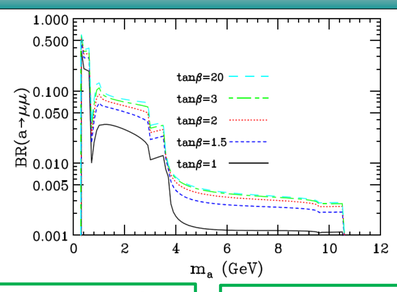
Light Higgs searches

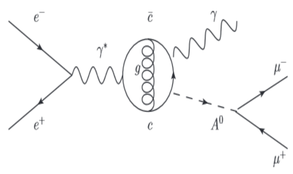
Coupling of fermions and the CP-odd Higgs A^0 in the NMSSM

$$L_{int}^{f\bar{f}} = -\cos\theta_A \tan\beta \frac{m_f}{v} A^0 \bar{d}(i\gamma_5)d,$$

$$L_{int}^{f\bar{f}} = -\cos\theta_A \cot\beta \frac{m_f}{v} A^0 \bar{u}(i\gamma_5)u,$$

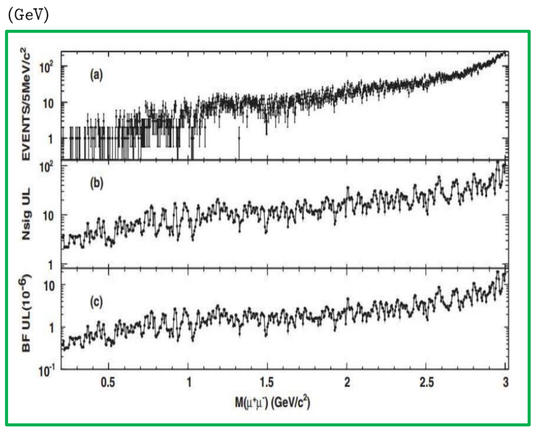
$$\tan\beta = \frac{v_u}{v_d}$$

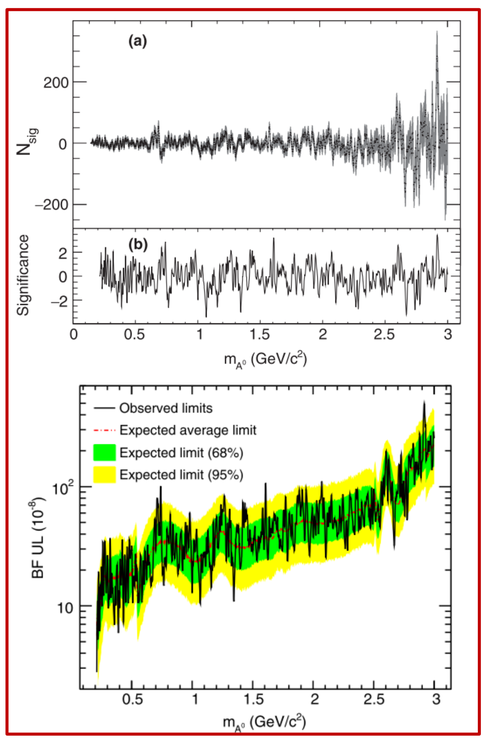




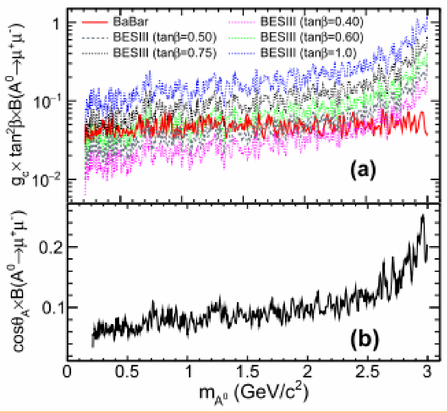
Using a data sample of 106M ψ'events, we search for ψ'-> π π J/ψ, J/ψ→γA^0, A^0→$\mu^+\mu^-$, and find no evidence for any $\mu^+\mu^-$ mass peak between the mass threshold and 3.0 GeV/c^2. The 90% CL upper limits on the product branching ratio, depending on the mass of A^0

We also directly search for J/ψ→γA^0, A^0→$\mu^+\mu^-$, with 225M J/ψ events and find no evidence in the same mass range. The new 90% CL upper limits on the product branching ratio are five times below the previous results.



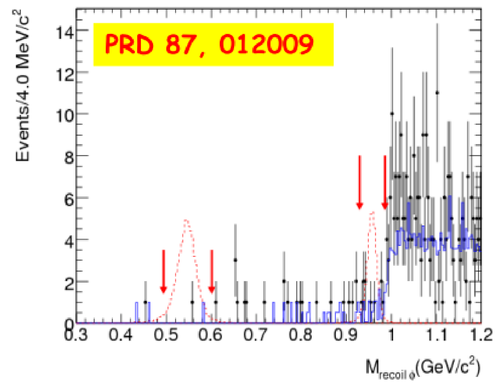


This new result is complementary to those obtained by considering the b-quark and it seems better than the BABAR measurement in the low-mass region for tan β ≤ 0.6 [Fig(a)]. Both types of constraints may then be combined to obtain an upper limit on cos θ_A, independently of tan β. The results [Fig(b)] reveal that the A0 is constrained to be mostly singlet.



Search for η /η′ invisible decays with J/ψ→φη(η'), φ →K^+K^-

- η/η′ decay play special role in low energy scale QCD theory.
- Invisible and radiative decays offer a window for new physics beyond the SM.
- The observation of the invisible final states provide information for light dark matter states χ, spin-0 axions, and light spin-1 U bosons.
- Huge J/ψ sample, large branching fraction of J/ψ→(γ/φ)η/η′ and narrow intermediate meson widths provide clean, large η/η′ sample.



Br(η′→invisible)/Br(η′→γγ)<2.39×10^{-2}
Br(η →invisible)/Br(η→γγ)<2.58×10^{-4}

Br(η′→invisible)<5.21×10^{-4}@90%C.L.
Br(η →invisible)<1.01×10^{-4}@90%C.L.
Improved PDG Values

Theory : Br(η′→χχ) ~8.1×10^{-7}
Br(η →χχ)~7.4×10^{-5}
B. McElrath, PRD 72, 103508 (2005)

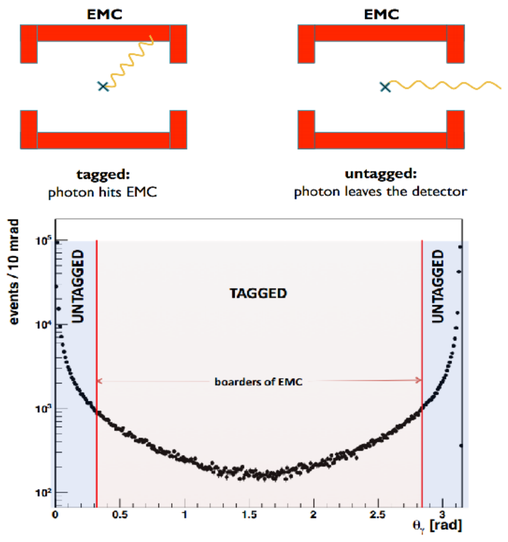
Dark photon search with ISR events

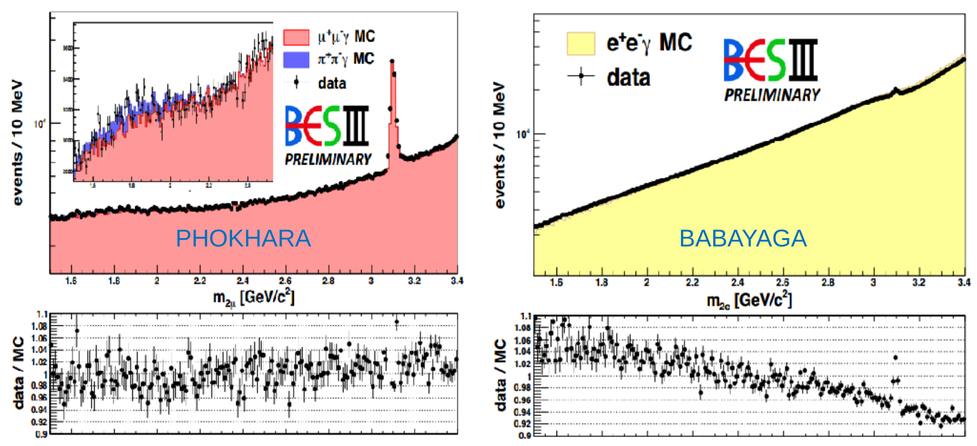
Dark Photon (A') as dark-force carrier is EM-equivalent expected in the dark sector. It couples to SM particles via kinetic mixing. The idea sparked world-wide efforts. Here we are using 2.9fb^{-1} data taken at 3.773GeV

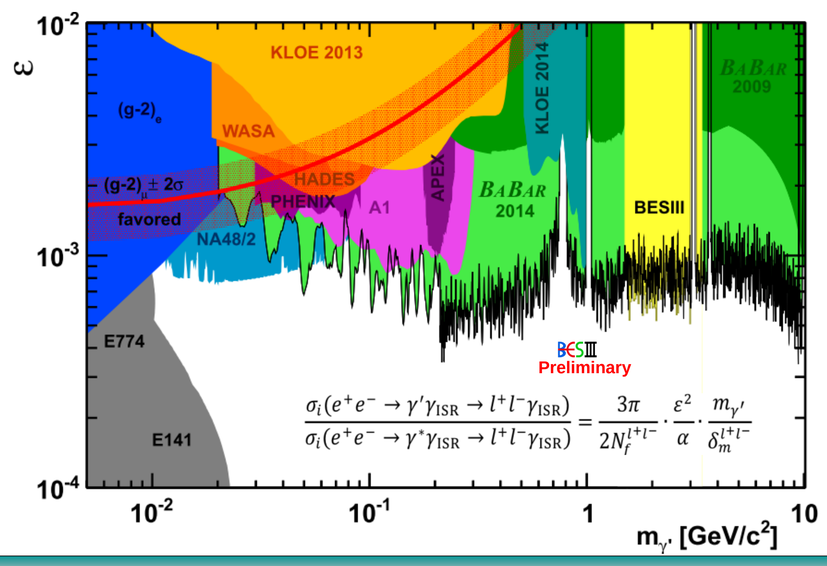
- Use an untagged photon method to perform this analysis.

Event selection: $e^+e^- \to \mu^+\mu^-\gamma_{ISR}$ and $e^+e^- \to e^+e^-\gamma_{ISR}$

distance to interaction point	R_{xy} < 1.0 cm R_z < 10.0 cm
acceptance	0.4 rad < θ < π – 0.4 rad
to supress background	PID
# charged tracks	= 2
total charge	= 0
# photons	= 0 (untagged analysis)
missing photon angle	< 0.1 rad or > π – 0.1 rad
1C kinematic fit	χ^2_{1C} < 20







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