# Dark Sector Searches at BESIII

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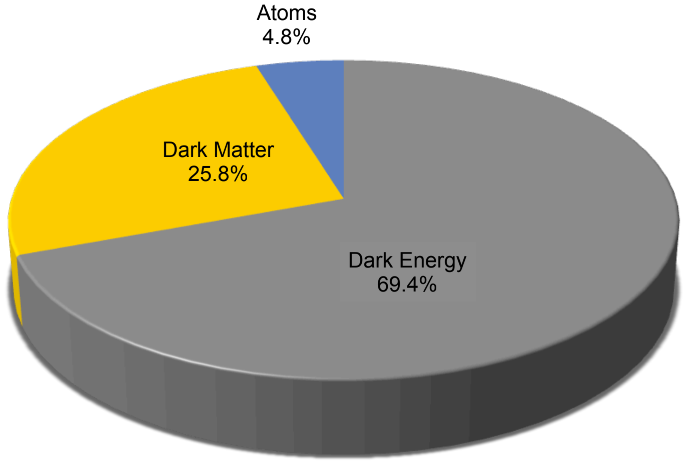
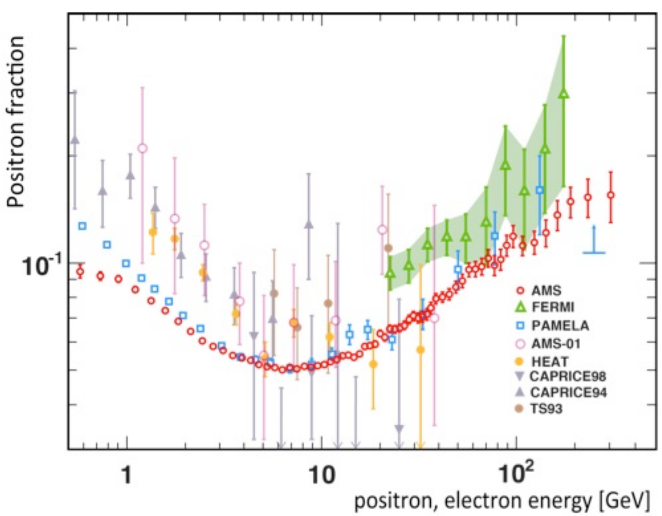
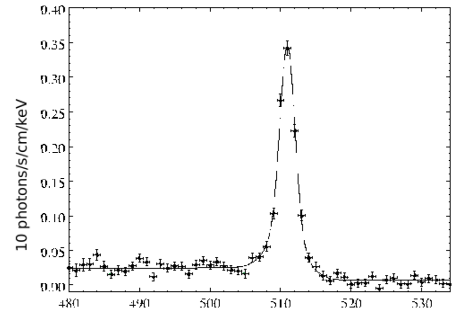
Flavour and Dark Matter Workshop

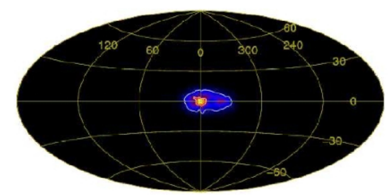
Heidelberg, Sep 27 2017

# Observational motivations for Dark Sector models



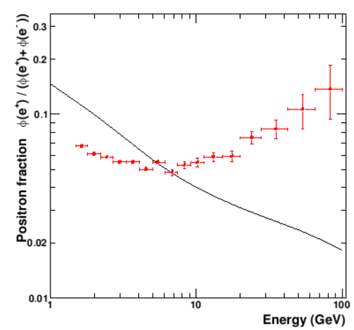



*511 keV line - sky map*

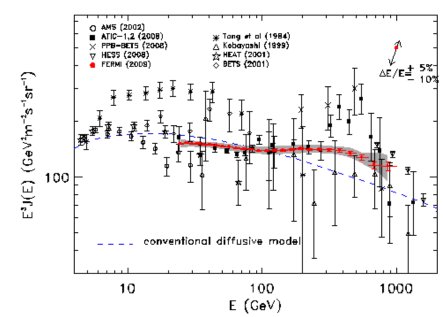
*G. Weidenspointner et al., Nature* **451** *(2008) 159*




*PAMELA: positron fraction*

*(confirmed by Fermi)*

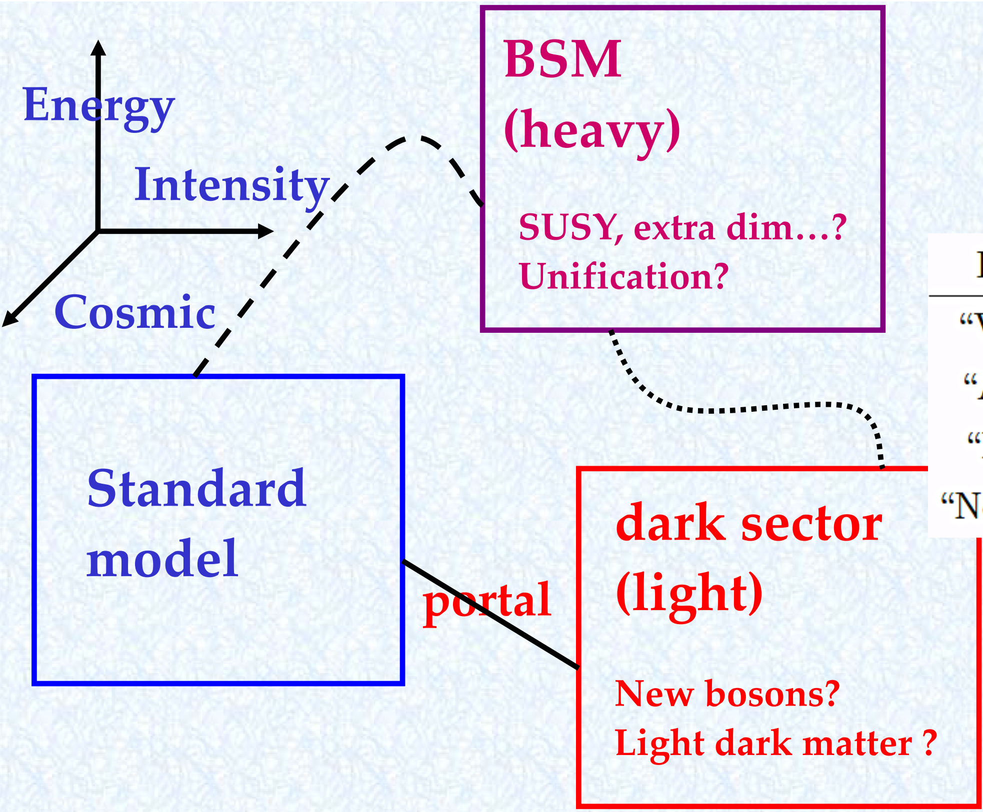
*O. Adriani et al., Nature* **458** *(2009) 607*




*Fermi: $e^+ + e^-$ spectrum*

*A.A. Abdo et al., Phys. Rev. Lett.* **102** *(2009) 181101*

# Dark sector and portal



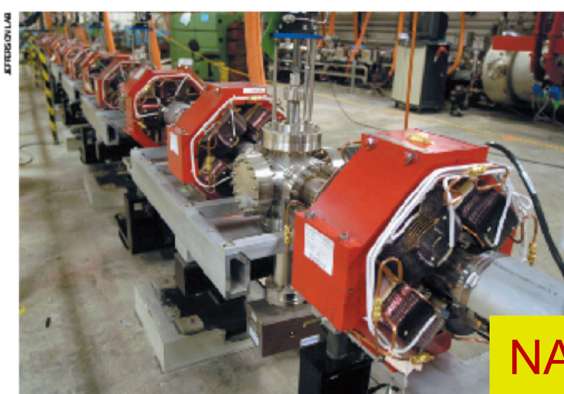

It is also referred as to heavy photon, hidden photon, A', γ' or U boson in the literature

| Portal | Particles | Operator(s) |
| --- | --- | --- |
| "Vector" | Dark photons | $-\frac{\epsilon}{2\cos\theta_W} B_{\mu\nu} F'^{\mu\nu}$ |
| "Axion" | Pseudoscalars | $\frac{a}{f_a} F_{\mu\nu} \widetilde{F}^{\mu\nu}$, $\frac{a}{f_a} G_{i\mu\nu} \widetilde{G}_i^{\mu\nu}$, $\frac{\partial_\mu a}{f_a} \overline{\psi}\gamma^\mu\gamma^5\psi$ |
| "Higgs" | Dark scalars | $(\mu S + \lambda S^2) H^\dagger H$ |
| "Neutrino" | Sterile neutrinos | $y_N LHN$ |

**Dark Sectors 2016 Workshop: Community Report**

Jim Alexander (VDP Convener),[1] Marco Battaglieri (DMA Convener),[2] Bertrand Echenard (RDS Convener),[3] Rouven Essig (Organizer),[4,*] Matthew Graham (Organizer),[5,†] Eder Izaguirre (DMA Convener),[6] John Jaros (Organizer),[5,‡] Gordan Krnjaic (DMA Convener),[7] Jeremy Mardon (DD Convener),[8] David Morrissey (RDS Convener),[9] Tim Nelson (Organizer),[5,§] Maxim Perelstein (VDP Convener),[1] Matt Pyle (DD Convener),[10] Adam Ritz (DMA Convener),[11] Philip Schuster (Organizer),[5,6,¶] Brian Shuve (RDS Convener),[5] Natalia Toro (Organizer),[5,6,**] Richard G Van De Water (DMA Convener),[12] … ,[15] David

arxiv: 1608.08632



The Jefferson Lab's Free-Electron Laser is a low-cost option in the bid to discover dark-se…

PARTICLE PHYSICS

**Physicists hunt for dark forces**

NATURE 2012.4

# Dark photon: characteristics

$$SU(3)_C \otimes SU(2)_L \otimes U(1)_Y \otimes U(1)_{DM} \otimes \ldots$$

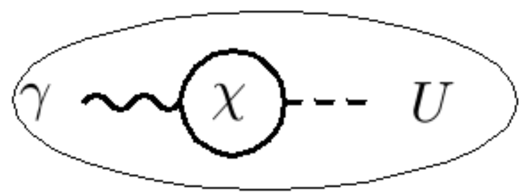
$$\mathcal{L}_{SM} = \mathcal{L}^F_{SM} + \mathcal{L}^B_{SM} + \mathcal{L}^H_{SM}$$

$$\mathcal{L}_{DM} = \mathcal{L}^F_{DM}(\chi) \Rightarrow M_\chi \sim 100 - 1000 \text{ GeV WIMP}$$

$$+ \mathcal{L}^B_{DM}(\mathbf{U}) \Rightarrow m_U \sim \text{GeV}$$ **Dark Photon U or $V$, $A'$...**

$$+ \mathcal{L}^B_{DM}(h') \Rightarrow \text{Higgs potential breaking } U(1)_{DM}$$

$$\mathcal{L}_{mix} = \epsilon F^{\mu\nu DM} F^{EM}_{\mu\nu}$$

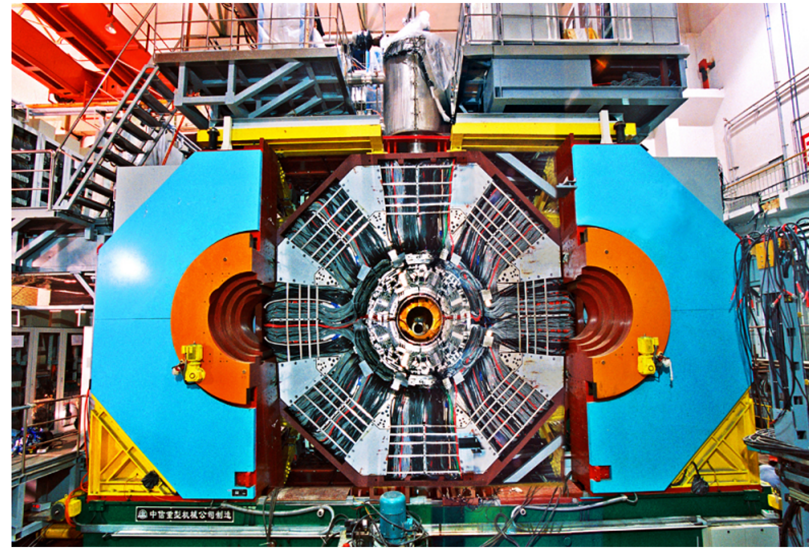



$$+ \text{ Higgs–Dark Photon int.} + \ldots$$

$\epsilon$ (or $\kappa$): **kinetic mixing parameter** $\epsilon \sim 10^{-3} \longrightarrow$ milli–charged SM fermions with coupling $\epsilon e$ to the dark photon (neglecting mixing with the $Z$)

Low energy, high luminosity e+ e- colliders are believed to be good places to search new physics models with dark sector phenomenology.

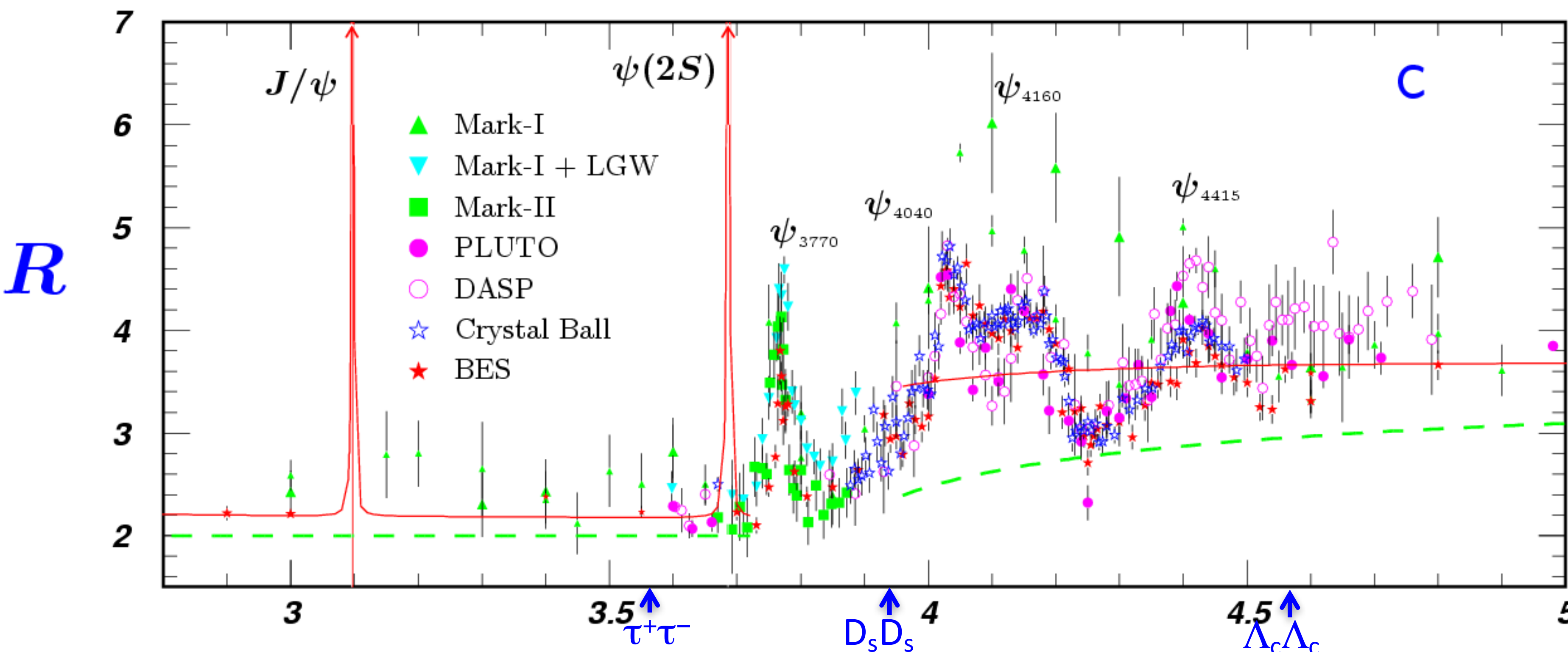
# BEPCII and BESIII Exp



- BEPCII is the only collider currently running at τ-charm energy
- First collision in 2008, physics run started in 2009
- **BEPCII reached peak lumi of $1 \times 10^{33}$ $cm^{-2}s^{-1}$@1.89GeV in April 2016**
- BESIII collaboration includes 61 institutes: 36 Chinese institutes，14 European ones，5 US ones and 6 from other Asian countries
- Secured the running for another 7-8 years, with small(but critical) energy increase and lumi upgrade

# BEPCII: a τ-c Factory

- Rich of **resonances**, charmonia and charmed mesons.
- **Threshold** characteristics (pairs of τ, D, $D_s$, charmed baryons…).
- **Transition** between perturbative and non-perturbative **QCD**.
- New hadrons: glueballs, hybrids, multi-quark states
- **New Physics:** high lumi, large datasets, hermetic detector with good performance



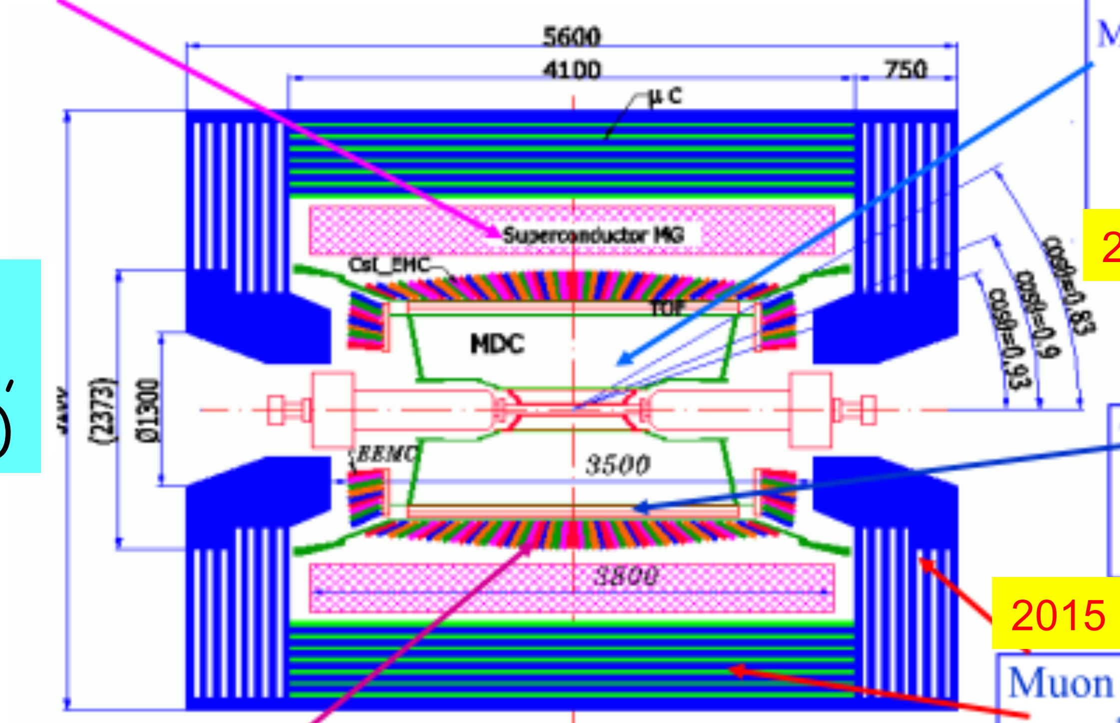
# BESIII Detector

Solenoid Magnet: 1 T Super conducting

MDC: small cell & He gas
$\sigma_{xy}$=130 μm
$\delta p/p$ = 0.5% @1GeV
dE/dx=6%

2018: Inner upgrade

Ref:
NIM A614, 345 (2010)




TOF:
$\sigma_T$ = 90 ps Barrel
110 ps Endcap

2015 ETOF upgrade: 60ps

Muon ID: 8~9 layer RPC
$\sigma_{R\Phi}$=1.4 cm~1.7 cm

EMCAL: CsI crystal
$\Delta E/E$ = 2.5% @1 GeV
$\sigma_{\varphi,z}$ = 0.5~0.7 cm/$\sqrt{E}$

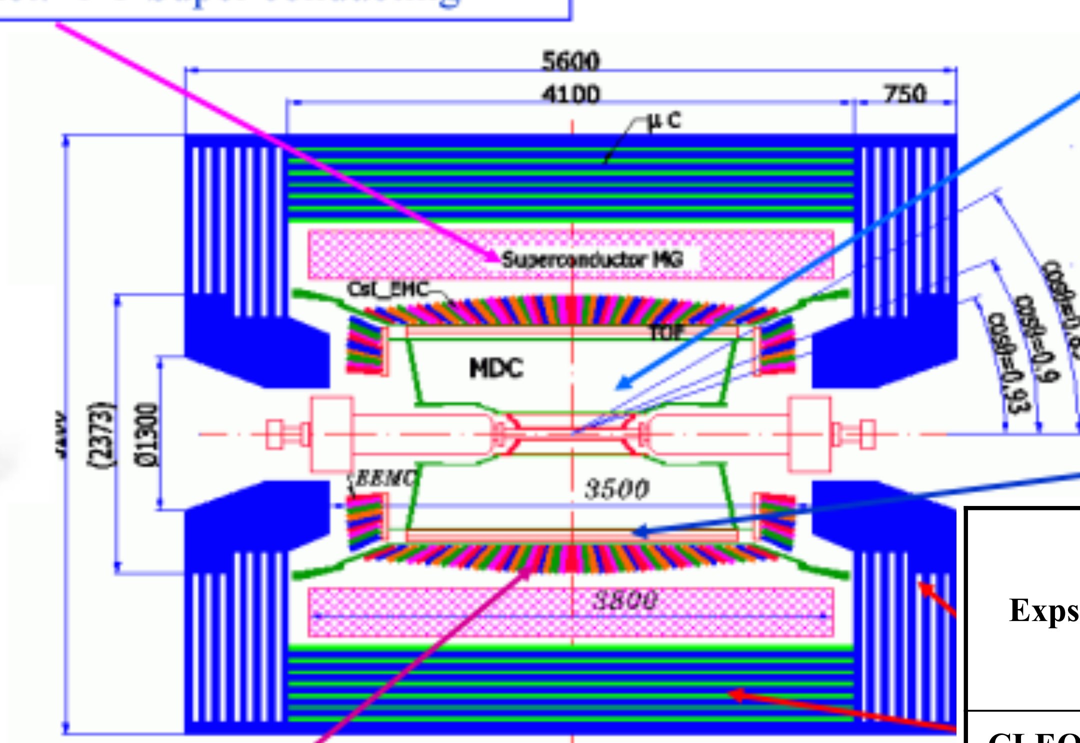
Data Acquisition:
Event rate = 3 kHz
Throughput ~ 50 MB/s

Trigger: Tracks & Showers
Pipelined; Latency = 6.4 μs

Clean environment and high luminosity at BESIII are helpful for indirect probe of new physics

# BESIII Detector

Magnet: 1 T Super conducting




Ref: NIM A614, 345 (2010)

2015 ETOF upgrade: 60ps

2018: Inner upgrade?

| Exps. | MDC Spatial resolution | MDC dE/dx resolution | EMC Energy resolution |
|---|---|---|---|
| CLEO-c | 110 μm | 5% | 2.2-2.4 % |
| BaBar | 125 μm | 7% | 2.67 % |
| Belle | 130 μm | 5.6% | 2.2 % |
| BESIII | 115 μm | <5% (Bhabha) | 2.4% |

Clean environment and high luminosity at BESIII are helpful for indirect probe rare/forbidden decays

# BESIII data samples

~ 0.5 B  $\psi(3686)$ events  ~ 24×CLEO-c

~ 1.3 B  $J/\psi$ events  ~ 21×BESII

~ 2.9/fb  $\psi(3770)$  ~ 3.5×CLEO-c  yellow book: 90M DDbar

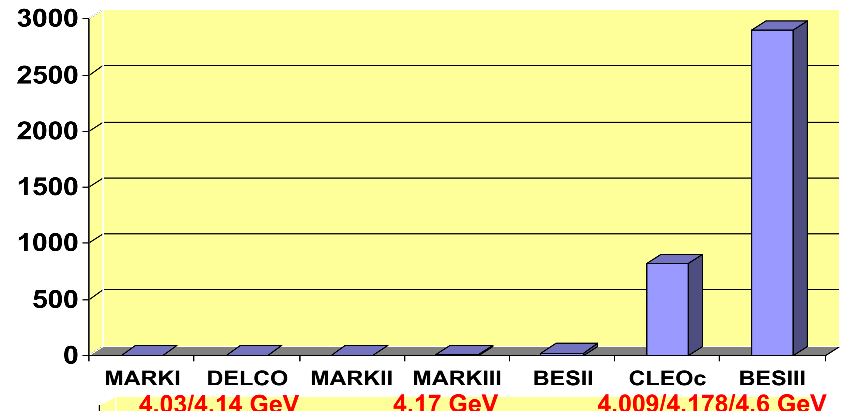
~ 0.482/fb  4.009  Ds study

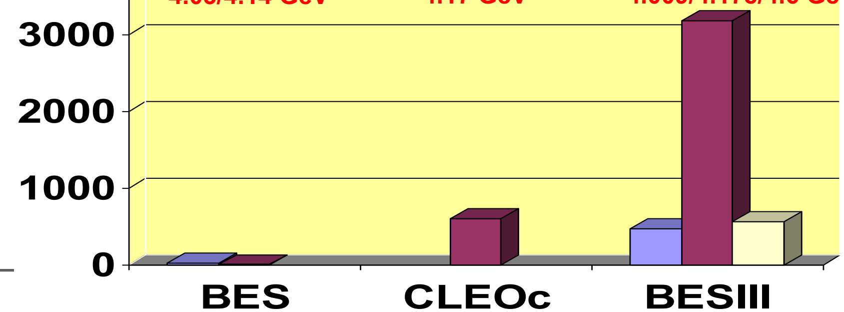
~ 0.6/fb  $\Lambda_c$ pairs at threshold  Unique

~ 9/fb  **XYZ** above 4 GeV

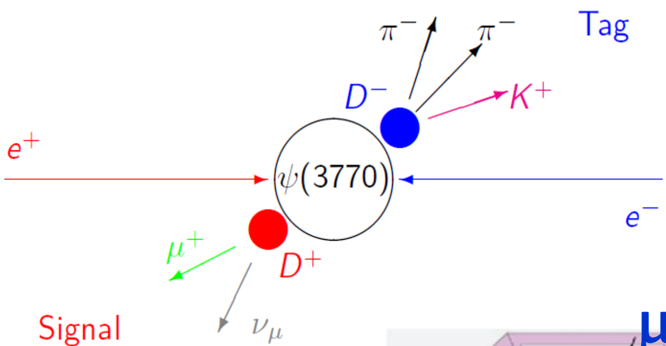
- 20 points for R &QCD Scan: 500/pb finished in May 2015
- Y(2175) resonance: 100 /pb
- 2016: 3/fb Ds data at 4170 MeV
  ~ 5×CLEO-c
- 2017: Y(4260), X(3872)
- 2018: 6-8B $J/\psi$ (NEW)

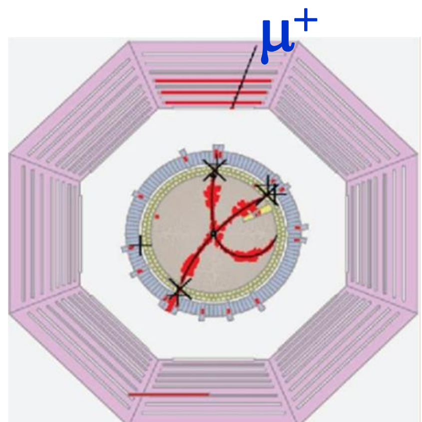
~ other data sets: tau, resonance scan and continuum, etc.



# Tagging technique at threshold




$D^- \to K^+\pi^-\pi^-$ vs. $D^+ \to \mu^+\nu$

- $e^+e^- \to D\bar{D}$ ($\Lambda_c^+\Lambda_c^-$), near Thrs.
- Double tag analysis
  - ✓ Tagging $D^-$ ($\bar{D}^0$), $\Lambda_c^-$ from hadronic decay modes

$$M_{BC} = \sqrt{E^2_{\rm beam} - p^2_{\bar{D}_{\rm tag}}}$$

  - ✓ (semi-)leptonic decay event can be well reconstructed in the recoil side of the tagged $\bar{D}$ ($\Lambda_c^-$)

$$M^2_{\rm missing} = E^2_{\rm miss} - p^2_{\rm miss} \sim 0$$

$$U_{\rm miss} \equiv E_{\rm miss} - |\vec{p}_{\rm miss}| \sim 0$$

- ☐ Event is very clean
- ☐ High tagging efficiency
- ☐ Most systematic uncertainties can be cancelled
- ☐ Could measure absolute BFs

# Reach of rare charm decays

Haibo Li

**SM predictions**

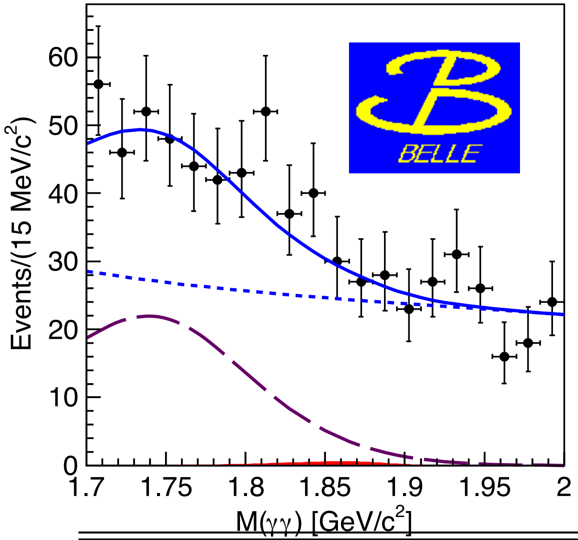
**Experimental reaches**

| | | | |
|---|---|---|---|
| $10^{-1}$ | | | |
| $10^{-2}$ | Cabibbo favored | | |
| $10^{-3}$ | Singly Cabibbo suppressed | | |
| $10^{-4}$ | Doubly Cabibbo suppressed | | CLEO-c |
| $10^{-5}$ | | | |
| $10^{-6}$ | Radiative decays | $D^0 \to \overline{K}^{*0}\gamma / \phi\gamma / \rho\gamma / \omega\gamma$ | BESIII |
| $10^{-7}$ | | $D^+ \to K^{*+}\gamma / \rho^+\gamma \quad D_S^+ \to K^{*+}\gamma / \rho^+\gamma$ | BESIII final/B factory |
| $10^{-8}$ | Long distance: Vector meson Dominance | $D^0 \to \gamma\gamma / VV'(\to ll) / hV(\to ll) / hh'V(\to ll)$ | LHCb |
| $10^{-9}$ | | | Super-B |
| $10^{-10}$ | | | Super-τ-charm |
| $10^{-11}$ | Short distance FCNC | $D^0 / D^+ \to \gamma\gamma / Vl^+l^- / hl^+l^- / hh'l^+l^-$ | |
| $10^{-12}$ | | $D^0 \to \mu^+\mu^-$ | |
| $10^{-13}$ | | $D^0 \to e^+e^-$ | |
| $10^{-14}$ | | | |
| $10^{-15}$ | | $D \to (h)\mu^+e^-$ | |
| | Forbidden decays: LNV, LFV, BNV | $D \to (hh)e^+e^+ / (hh)\mu^+\mu^+$ | |

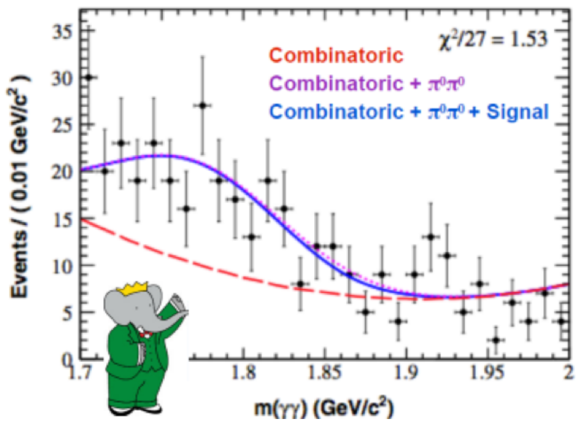
BESIII is more competitive in channels with low energy electron/photons, neutrons, pi0's

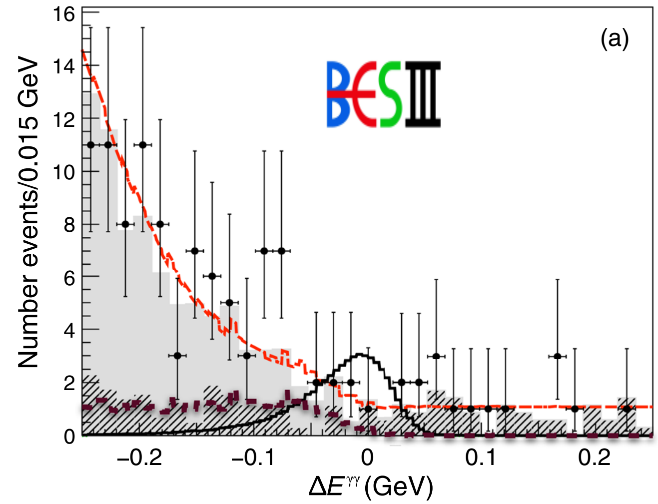
# $D^0 \to \gamma\gamma$: Comparisons

PhysRevD(2016).93.051102




Phys. Rev. D 85 (2012) 091107R




| Source | Contribution |
|---|---|
| Cut variation | $\pm 6.8\%$ |
| PDF shape | $^{+4.0}_{-2.4}$ events |
| Photon detection | $\pm 4.4\%$ |
| $K^0_S$ reconstruction | $\pm 0.7\%$ |
| $\pi^0$ identification | $\pm 4.0\%$ |
| $\mathcal{B}(D^0 \to K^0_S \pi^0)$ | $\pm 3.3\%$ |

Uncertainties independent of fitting procedure

| Source | Relative uncertainty (%) |
|---|---|
| Photon reconstruction | 2.0 |
| $M_{\rm BC}^{\gamma\gamma}$ requirement | 3.1 |
| ST $D^0$ yields | 1.0 |
| Total | 3.8 |

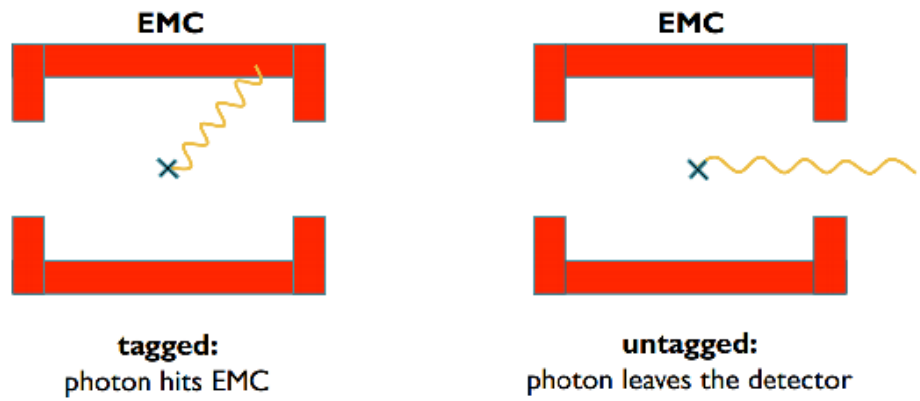
- BESIII has the least background contamincation
- and very good control of systematics
- Could still be competitive with the final DDbar sample
- Detailed projection study is needed to check what is the critical points for DDbar sample size

# Dark photon search with ISR

Search for narrow structure on top of the continuum QED background

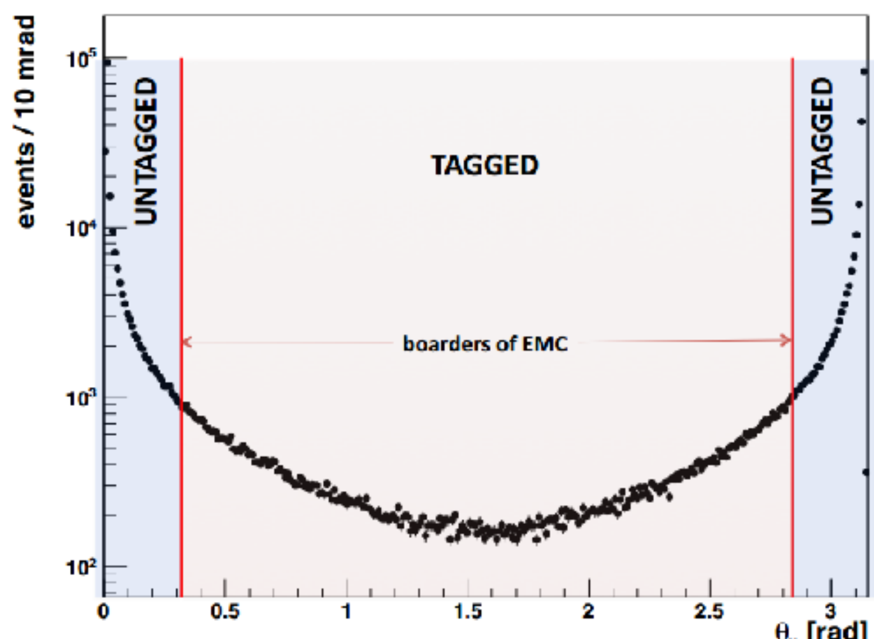
$e^+ e^- \to \gamma_{ISR} l^+ l^-$

- Use an untagged photon method to perform this analysis.



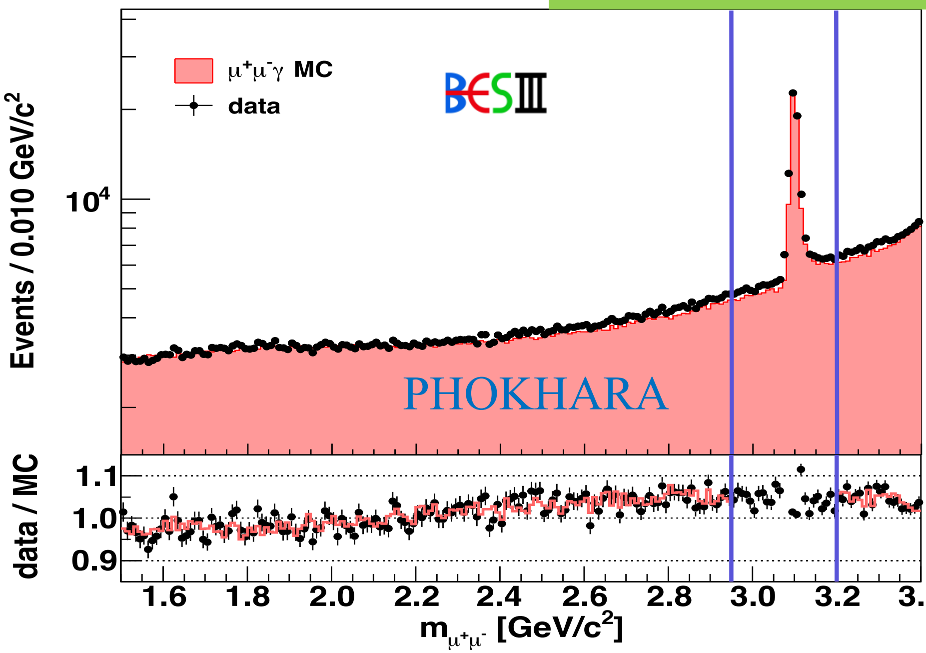

Event selection: $e^+e^- \to \mu^+\mu^-\gamma_{ISR}$ and $e^+e^- \to e^+e^-\gamma_{ISR}$

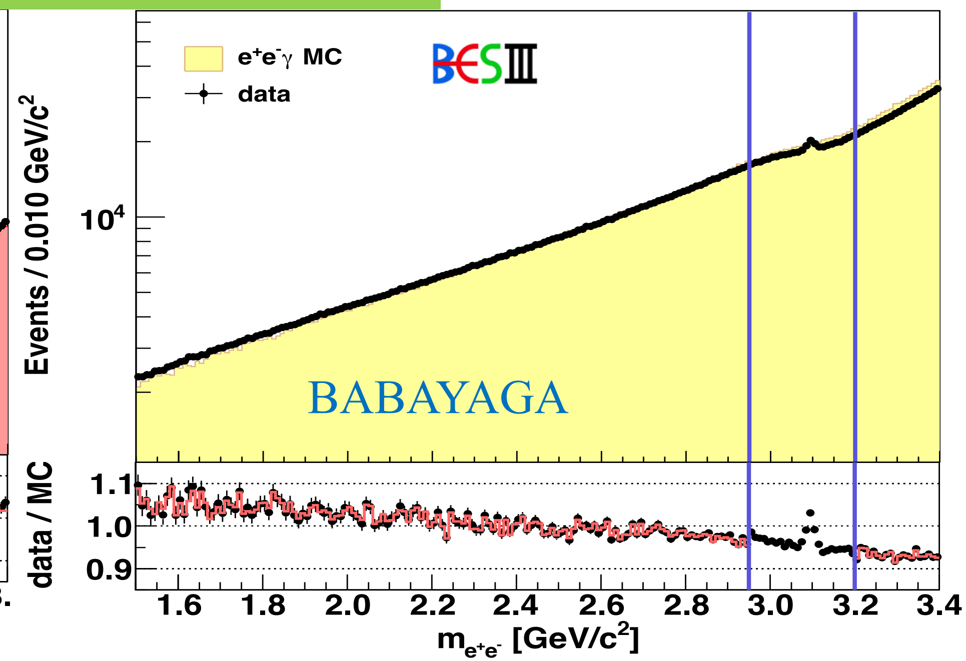
| | |
|---|---|
| distance to interaction point | $R_{xy} < 1.0$ cm<br>$R_z < 10.0$ cm |
| acceptance | 0.4 rad < $\theta$ < π – 0.4 rad |
| to supress background | PID |
| # charged tracks | = 2 |
| total charge | = 0 |
| # photons | = 0 (untagged analysis) |
| missing photon angle | < 0.1 rad or >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



# Mass spectrum of mumu and ee

**2.9fb$^{-1}$ psi(3773) dataset(2010+2011)**



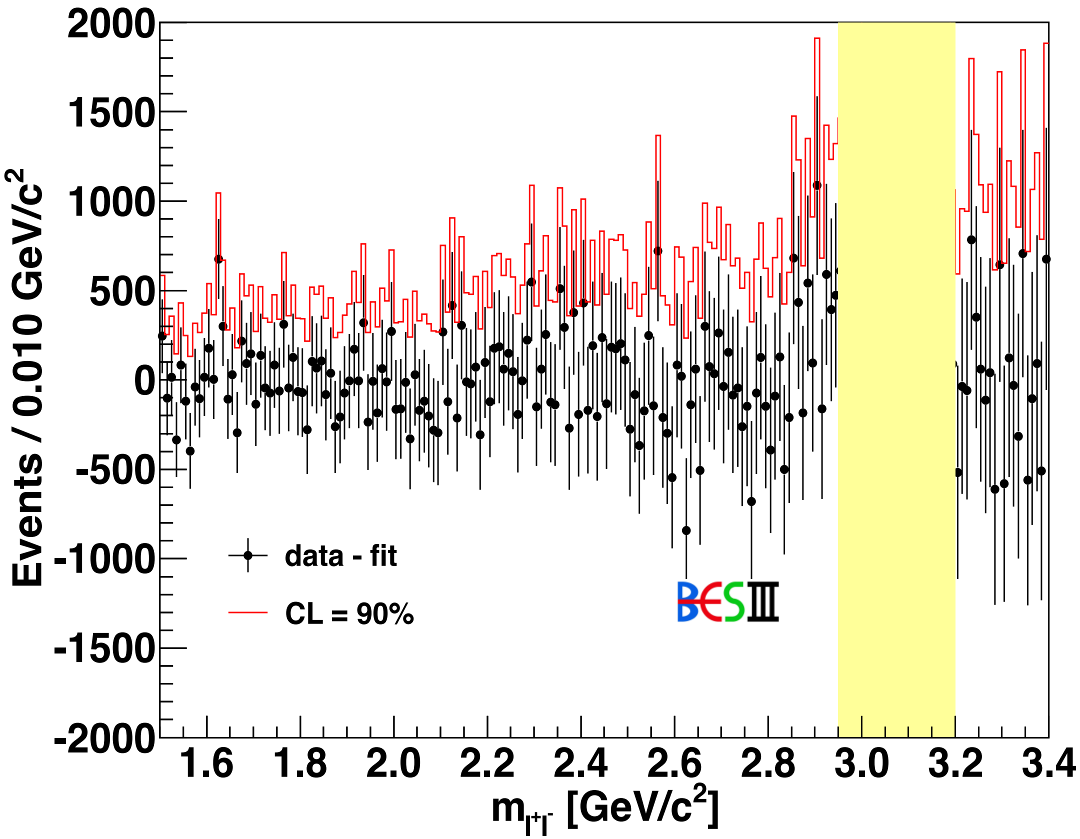




Cover mass region: 1.5 GeV/c 2 ~ 3.4 GeV/c

- <1.5 GeV/c 2 : $\pi^+\pi^-$ background dominates
- >3.4 GeV/c 2 : hadronic qq-bar process

**arXiv:1705.04265,**
**Accepted by Phy. Lett. B**

# Number of signal events

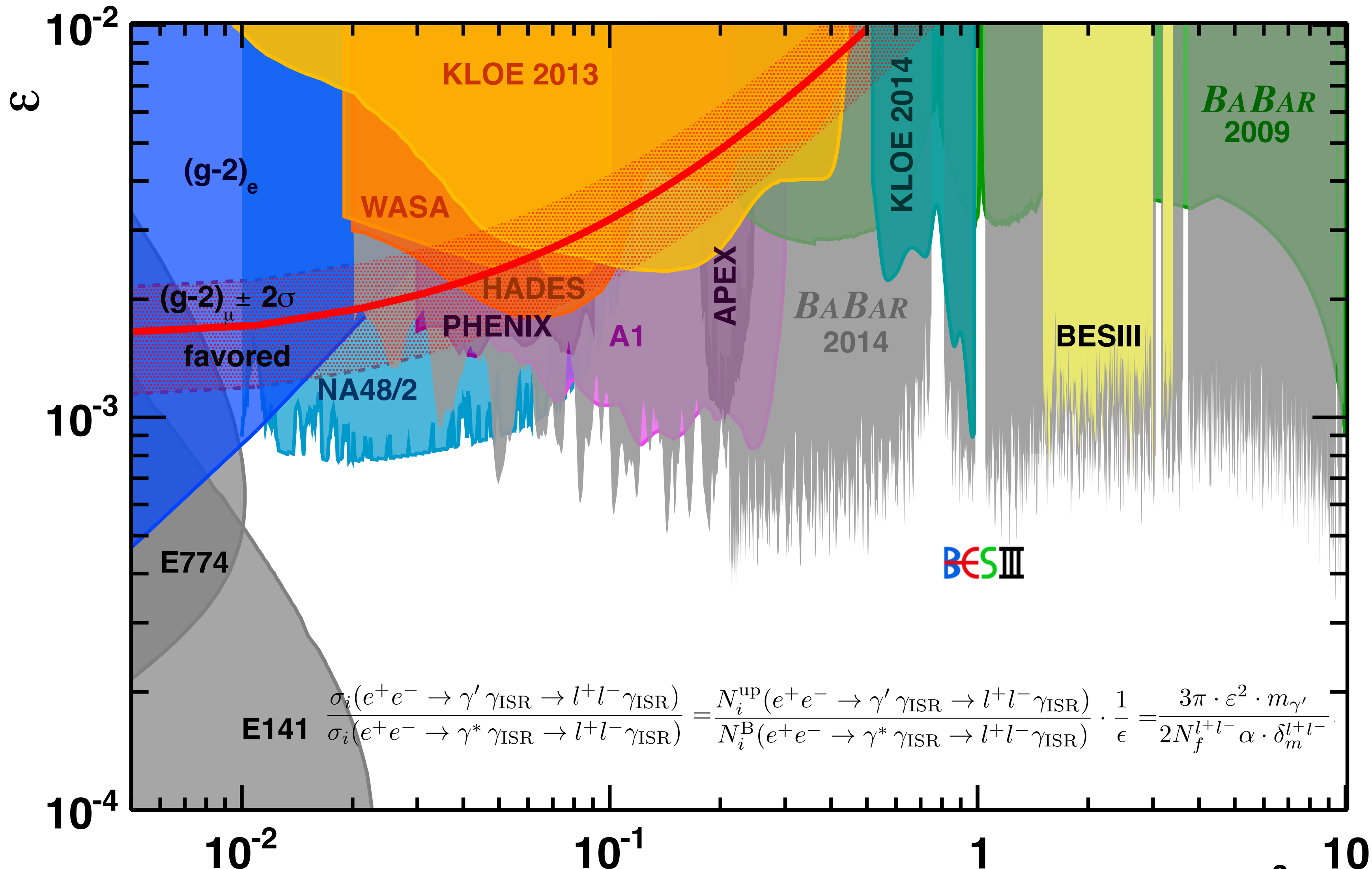



- Fit QED background with 4 order polynomial
- No peaking structure observed
- Combined statistical significance less than 3 σ
- 90% confidence level limit obtained
  - with profile likelihood approach

    W. Rolke et al., NIM A 551, 493 (2005)
  - systematic uncertainty included

arXiv:1705.04265, to appear in Phy. Lett. B

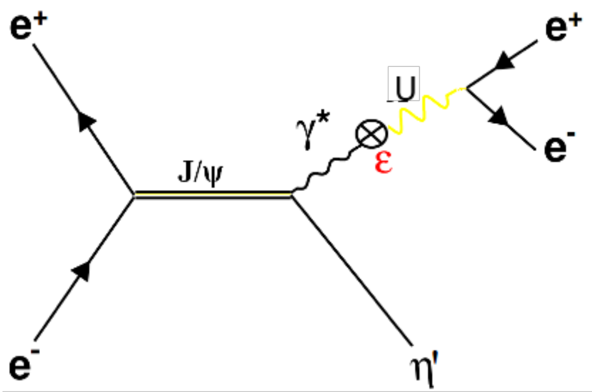
# BESIII ISR search results

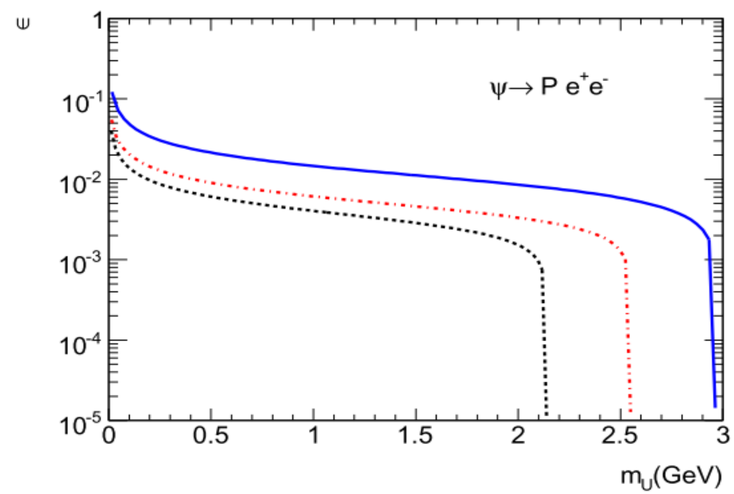



arXiv:1705.04265, to appear in Phy. Lett. B

# DP search through meson decays

Theoretical prediction for the reach of dark photon.
The black dashed line represents P= $\eta'$




J Fu et al.,
Mod. Phys. Lett. A 27, 1250223 (2012)

$$\frac{d\Gamma(\psi \to P l^+ l^-)}{dq^2 \Gamma(\psi \to P\gamma)} = \frac{\alpha}{3\pi}\left|\frac{f_{\psi P}(q^2)}{f_{\psi P}(0)}\right|^2 \frac{1}{q^2}\left(1-\frac{4m_l^2}{q^2}\right)^{\frac{1}{2}}\left(1+\frac{2m_l^2}{q^2}\right)$$
$$\times\left[\left(1+\frac{q^2}{m_\psi^2-m_P^2}\right)^2-\frac{4m_\psi^2 q^2}{(m_\psi^2-m_P^2)^2}\right]^{\frac{3}{2}}$$
$$= |F_{\psi P}(q^2)|^2 \times [\mathrm{QED}(q^2)]\,,$$

This process was first observed by BESIII with 225M $J/\psi$ sample
**Phys. Rev. D 89, 092008 (2014)**

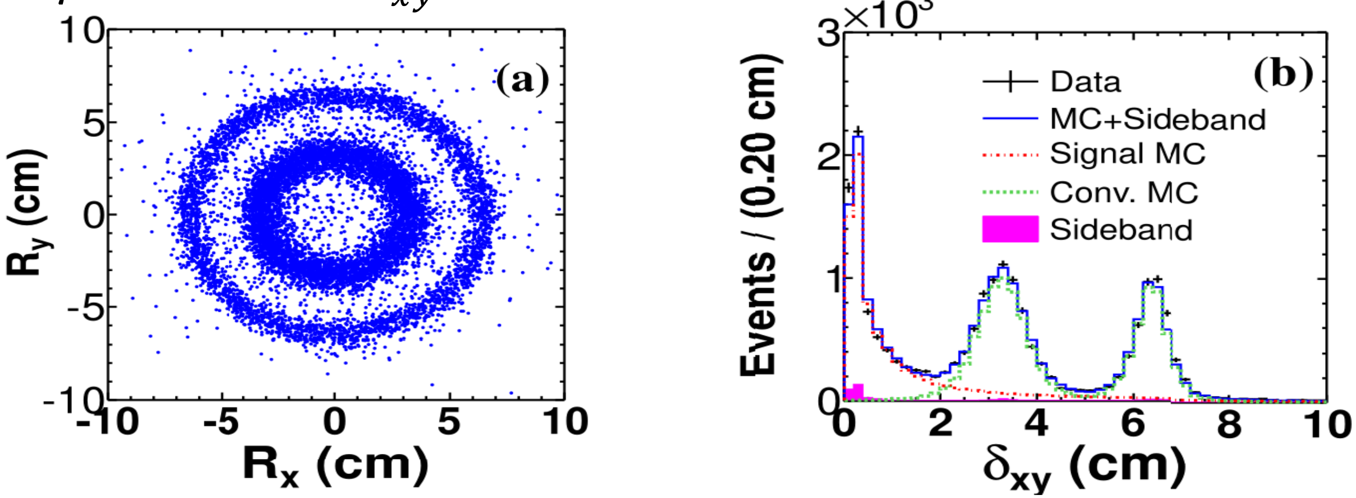
With 1.3 billion $J/\psi$ data, it is a good opportunity to improve the precision of B($J/\psi \to \eta' e^+ e^-$) and search for the dark photon through decays $J/\psi \to \eta' \mathrm{U}, \mathrm{U} \to e^+ e^-$ at BESIII.

#  $J/\psi \to \eta' e^+ e^-$ Event selection

- Selection of $\gamma e^+e^-\pi^+\pi^- / \gamma\gamma e^+e^-\pi^+\pi^-$
  - Four good charged tracks with $e^+e^-$ identified successfully
  - At least one/two good photons in EMC
  - $e^+e^-\pi^+\pi^-$ successful vertex fit
  - $\gamma e^+e^-\pi^+\pi^- / \gamma\gamma e^+e^-\pi^+\pi^-$ 4C fit with $\chi^2_{4c} < 100$

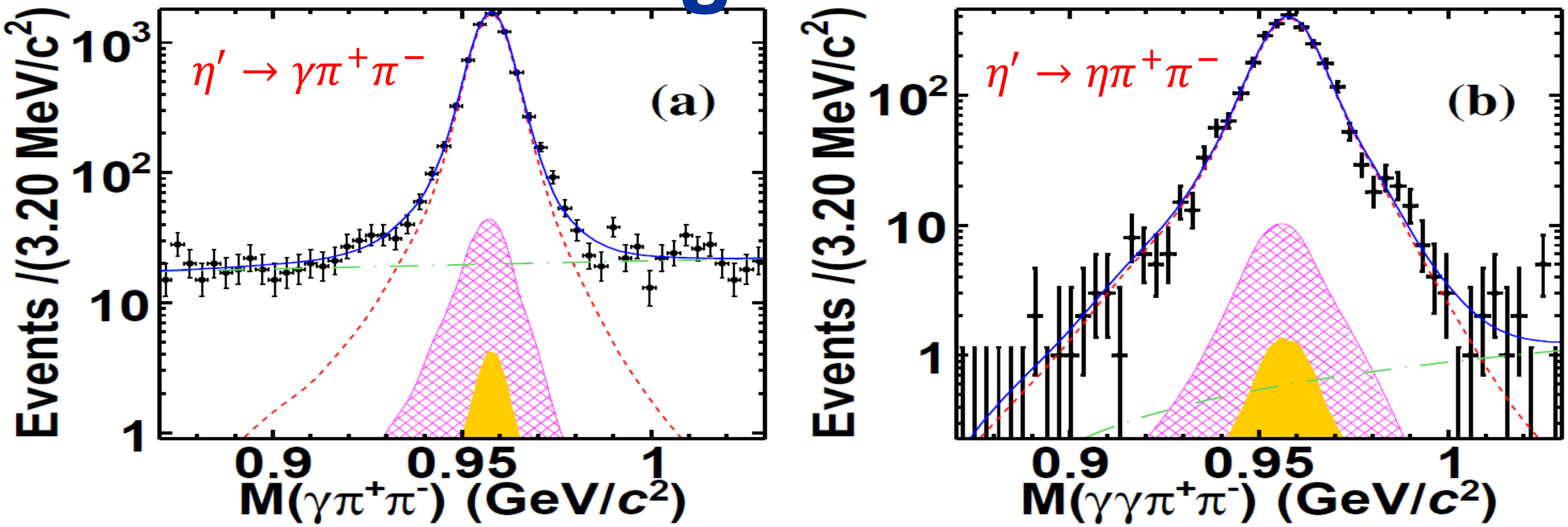
**1.3B J/psi dataset(2009+2012)**

- Veto of $\gamma$ conversion : $\delta_{xy}$ < 2cm




- Addition selection for each mode
  - $\eta' \to \gamma\pi^+\pi^-$
    Veto $\pi^0$: M($\gamma e^+e^-$) $\notin$ (0.10,0.16) GeV/c²
  - $\eta' \to \eta\pi^+\pi^-$
    Select $\eta$: M($\gamma\gamma$) $\in$ (0.48,0.60) GeV/c²

# Branching fraction result




- Signal: MC shape ⊗ Gaussian
- Non-peaking background: Chebychev Polynomial
- Peaking background: MC shape ($\gamma$ conversion/ $J/\psi \to \Phi\eta'$ )

| | $\eta' \to \gamma\pi^+\pi^-$ | $\eta' \to \eta\pi^+\pi^-$ |
|---|---|---|
| Signal Yield | $6436.9 \pm 87.1$ | $2494.4 \pm 51.3$ |
| Background Yield | $981.4 \pm 43.8$ | $27.3 \pm 10.0$ |
| Efficiency (%) | 28.21 | 19.94 |
| B($J/\psi \to \eta' e^+ e^-$) ($10^{-5}$) | $5.98 \pm 0.08_{stat} \pm 0.32_{syst}$ | $5.65 \pm 0.12_{stat} \pm 0.33_{syst}$ |
| Combined result($10^{-5}$) | $5.81 \pm 0.07_{stat} \pm 0.29_{syst}$ | |

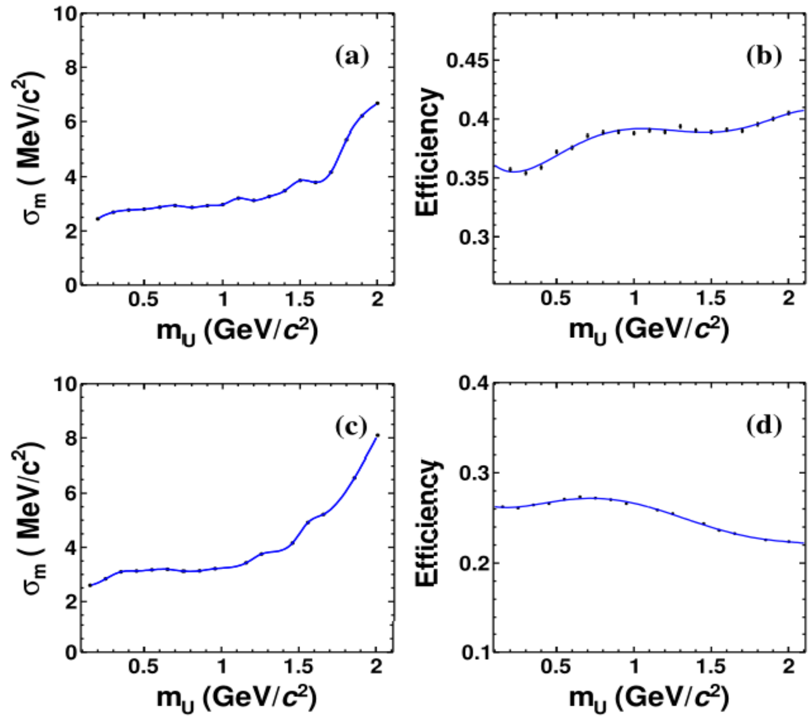
BESIII **Preliminary**

Improves on the previous BESIII measurement of B($J/\psi \to \eta' e^+ e^-$)

Phys. Rev. D 89, 092008 (2014)

# DP ana: selection,resol.,eff.

- Additional event selection criteria
  1. Without $\gamma$ conversion veto
  2. $\eta'$ signal region [0.93,0.98] GeV
  3. $M(e^+e^-) > 70$ MeV/c$^2$
- Resolution and selection efficiency from signal MC
  - The resolution $\sigma_m$ of dark photon signal and selection efficiency depend on dark photon mass $m_U$.




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

- $\sigma_m$ : 2 - 7 MeV
- Efficiency: 35 - 41 %

$\eta' \to \eta\pi^+\pi^-$

- $\sigma_m$ : 2 - 8 MeV
- Efficiency: 22 - 28 %

# Dark photon search strategy

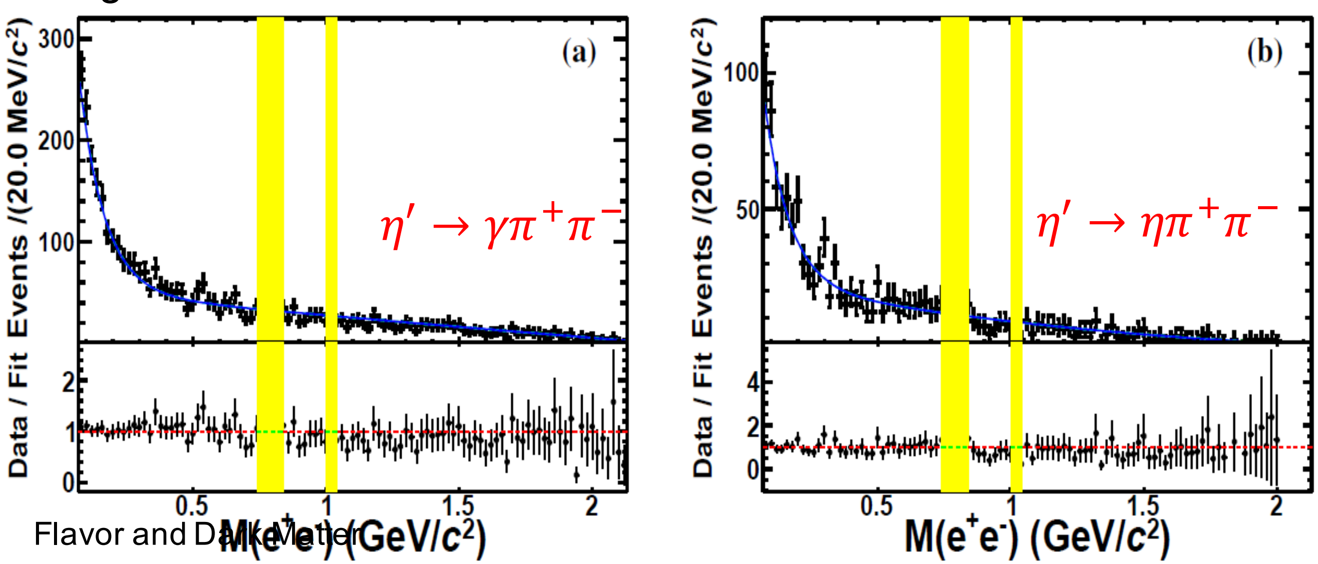
- Strategy:
  - Assuming the background is smooth, dark photon would appear as a narrow peak on the top of the background.
  - We look for a narrow peak signal on invariant mass of $e^+e^-$ by a step of 2 MeV in [0.1, 2.1] GeV range.
- Signal description:
  - Shape: A sum of two Crystal Ball (CB) functions with opposite tails.

$$y = CB_1(x;\mu,\sigma_1,n1,\alpha_1) + f * CB_2(x;\mu,\sigma_2,n2,\alpha_2)$$

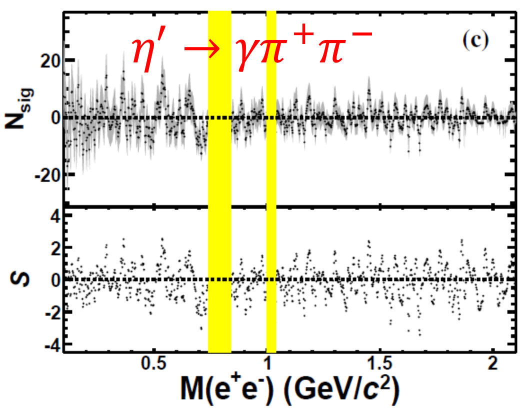
  - Parameters are interpolated based on signal MC samples generated with different $m_U$ hypotheses.
- Background description:
  - Shape: A sum of $2^{nd}$ order polynomial and exponential, parameters are determined from data fit.

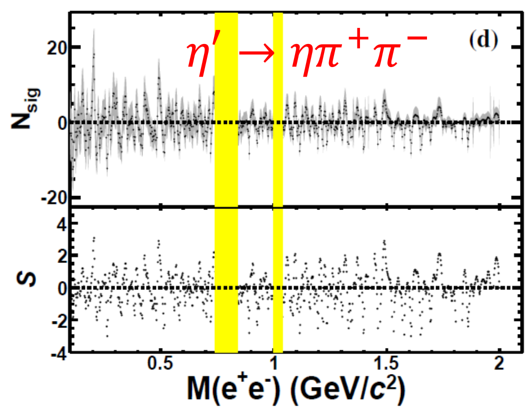
$$y = p0 + p1 \cdot x + p2 \cdot x^2 + e^{\tau \cdot x}$$

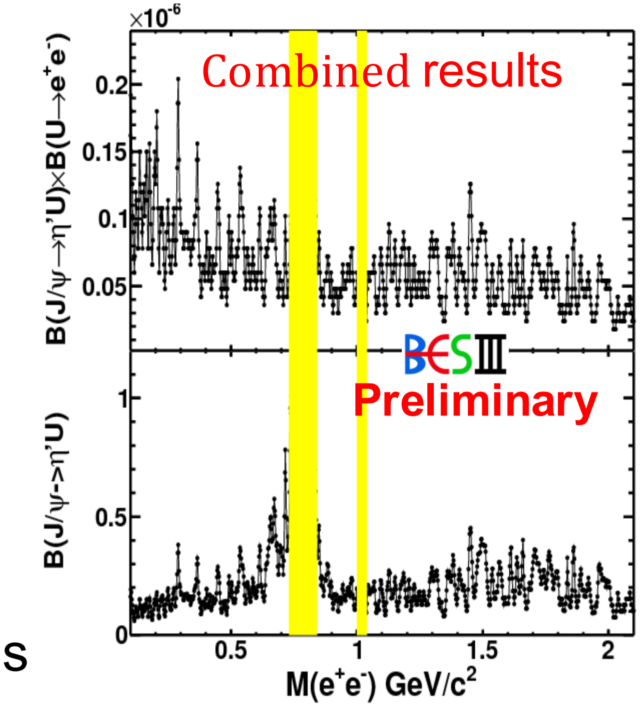
  - $\omega$ and $\Phi$ regions are excluded.



# Dark photon search results




- $N_{sig}$ : Number of signal yield.
- $S$ : Statistical significance of signal , defined as

$$\mathcal{S} = \text{sign}(N_{\text{sig}})\sqrt{-2\ln(\mathcal{L}_0/\mathcal{L}_{\max})}.$$

- No significant dark photon signal is observed.
- Set combined limits @ 90% C.L. on the branching fractions
  1. B( $J/\psi \to \eta'$U) ×B( U → $e^+e^-$)
  2. B( $J/\psi \to \eta'$U): B( U → $e^+e^-$) is considered as a function of $m_U$ from Phys. Rev. D 79, 115008 (2009).

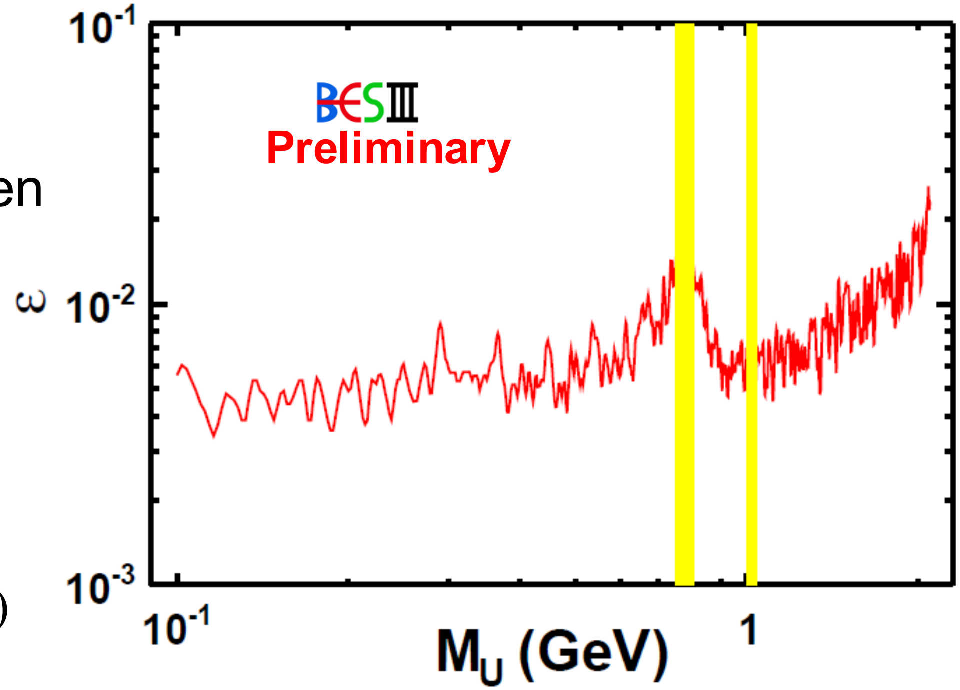
# Exclusion limit on mixing strength $\varepsilon$

$$\frac{\mathcal{B}(J/\psi \to \eta' \mathrm{U})}{\mathcal{B}(J/\psi \to \eta' \gamma)} = \varepsilon^2 |F(m_{\mathrm{U}}^2)|^2 \frac{\lambda^{3/2}(m_{J/\psi}^2, m_{\eta'}^2, m_{\mathrm{U}}^2)}{\lambda^{3/2}(m_{J/\psi}^2, m_{\eta'}^2, 0)}$$

$m_X$ :Mass of particle $X$

arXiv: 0904.1743

$\mathcal{B}$ :Branching fraction




$\varepsilon$ :Kinematic mixing strength between SM photon and dark photon

$F$ :Form factor

$$|F(q^2)| = 1/(1 - q^2/\Lambda^2)$$

$\Lambda$= 3.686 GeV

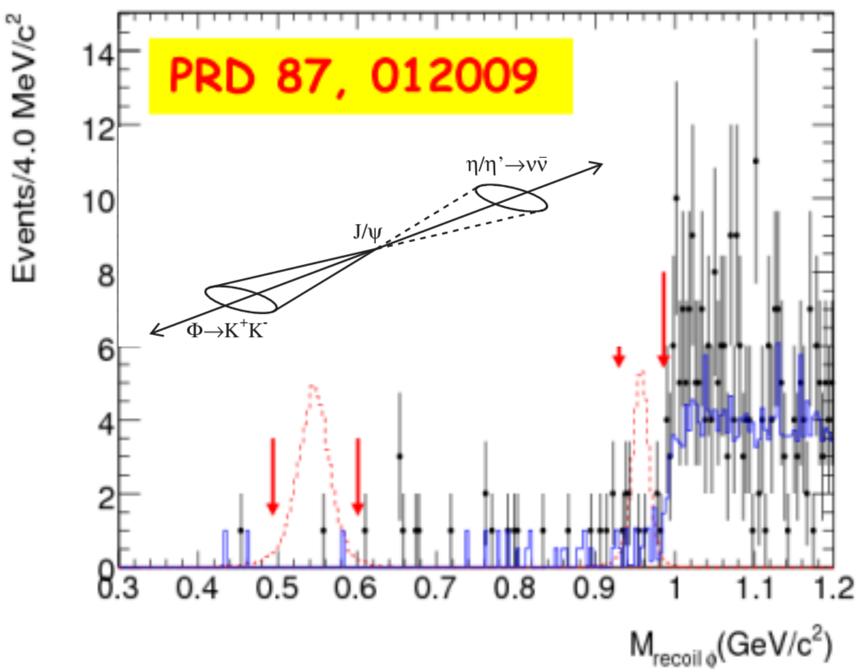
Mod. Phys. Lett. A 27, 1250223 (2012)

$\lambda$ : Kinematic factor

$$\lambda(m_1^2, m_2^2, m_3^2) = (1 + \frac{m_3^2}{m_1^2 - m_2^2})^2 - \frac{4m_1^2 m_3^2}{(m_1^2 - m_2^2)^2}$$

# Search for η /η′ invisible decays

- 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.




$Br(\eta'\to invisible)/Br(\eta'\to\gamma\gamma)<2.39\times10^{-2}$
$Br(\eta\to invisible)/Br(\eta\to\gamma\gamma)<2.58\times10^{-4}$

$Br(\eta'\to invisible)<5.21\times10^{-4}$ @90%C.L.
$Br(\eta\to invisible)<1.01\times10^{-4}$ @90%C.L.
Improved PDG Values

PDG : $Br(\eta'\to invisible)<9\times10^{-4}$ @90%C.L
$Br(\eta\to invisible)<6\times10^{-4}$ @90%C.L.

Theory : $Br(\eta'\to\chi\chi)\sim8.1\times10^{-7}$
$Br(\eta\to\chi\chi)\sim7.4\times10^{-5}$
B. McElrath, PRD 72, 103508 (2005)

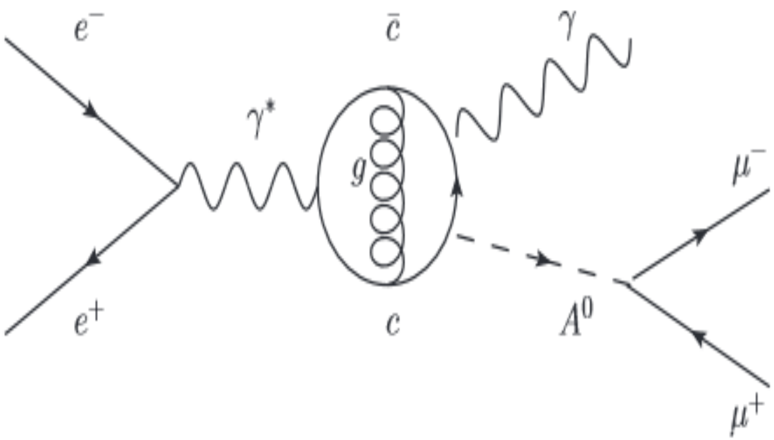
➢ Coupling of fermions and the CP-odd Higgs $A^0$ in the NMSSM:

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

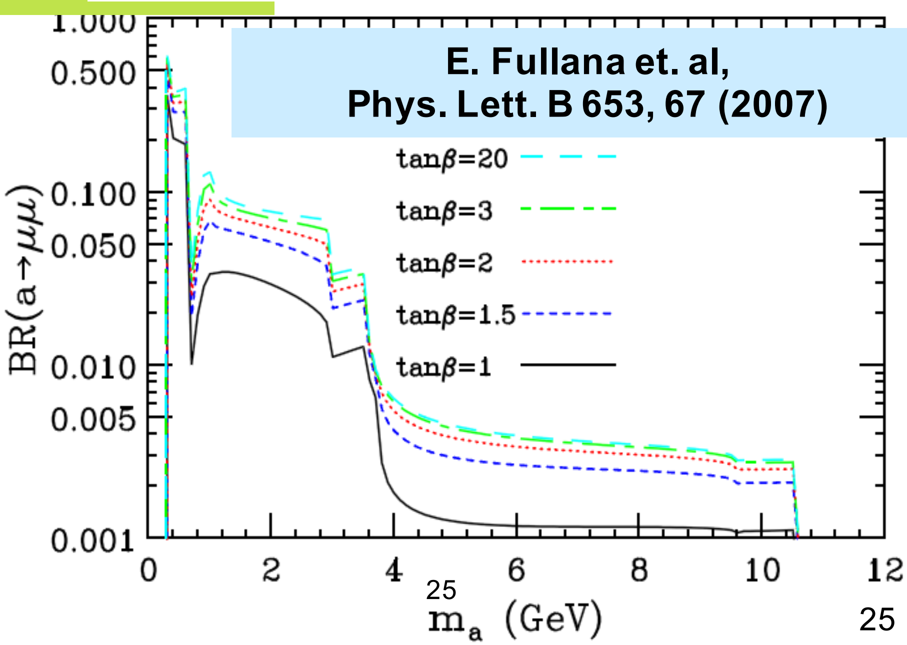
$d = d, s, \mathbf{b}, e, \mu, \tau$

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

$u = u, \mathbf{c}, t, \nu_e, \nu_\mu, \nu_\tau$



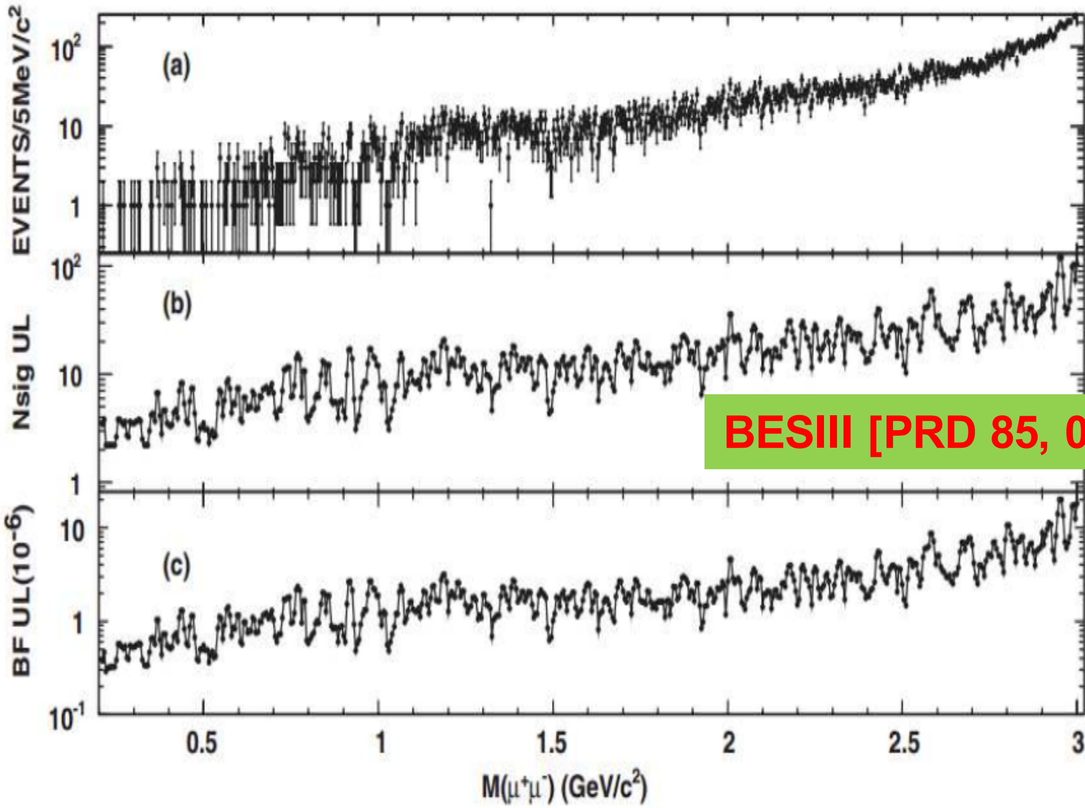
$$\tan\beta = \frac{v_u}{v_d}$$




E. Fullana et. al,
Phys. Lett. B 653, 67 (2007)

# Results with ψ' data in published in 2012

ψ'->pipi J/ψ, J/ψ→γ$A^0$, $A^0$→$\mu^+\mu^-$




BESIII [PRD 85, 092012 (2012)]

Coupling of c-quark to the $A^0$:

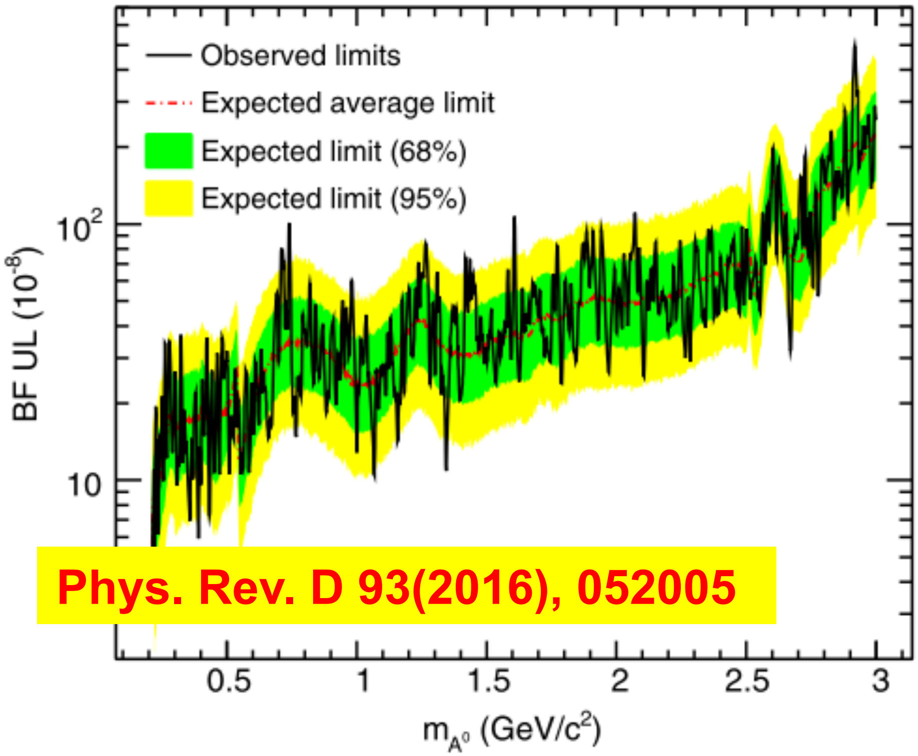
Expected BF: $10^{-7}$ -$10^{-9}$

[PRD 76, 051105 (2007)]

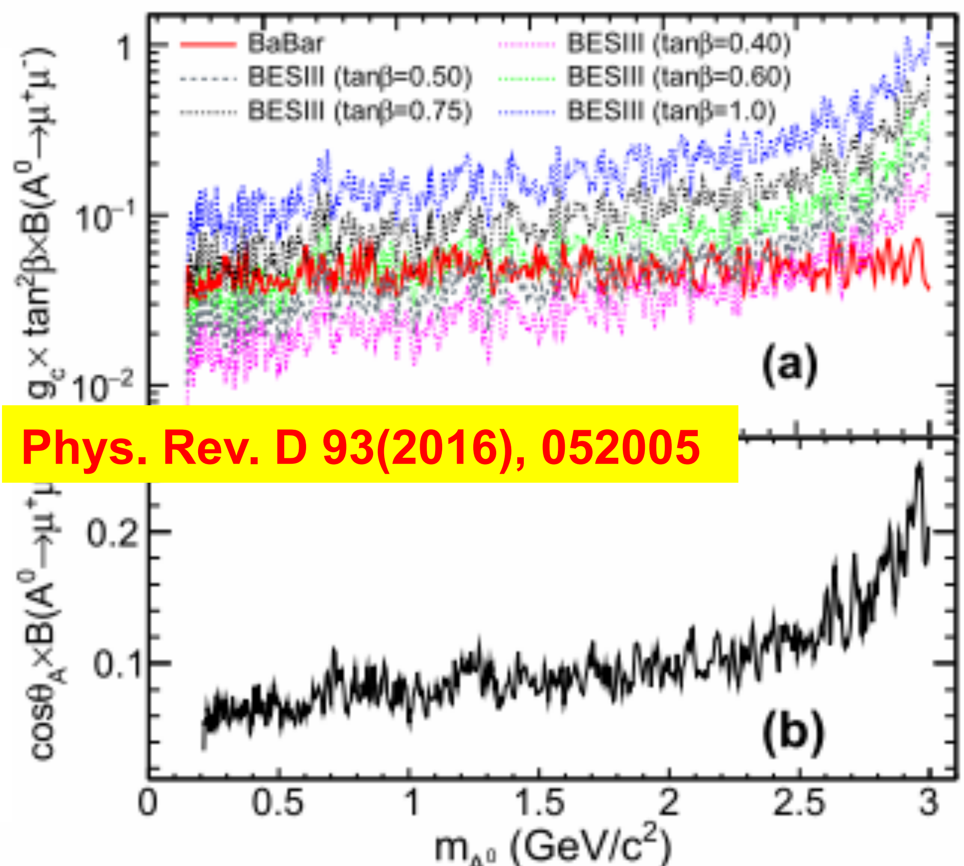
106M psi' data

**BESIII exclusion limit ranges from 4×$10^{-7}$ - 2.1×$10^{-5}$ depending on $A^0$ mass points.**

# New BESIII Results(225M J/ψ)




Phys. Rev. D 93(2016), 052005




Phys. Rev. D 93(2016), 052005

PRD 87, 031102 (R) (2013) (BaBar experiment)

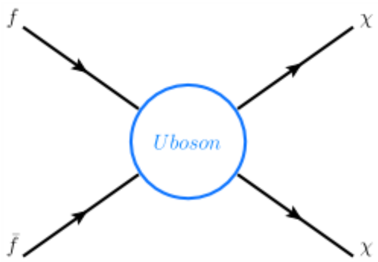
**The new limits are five times below our previous results (2012, Psip)**

BESIII [PRD 85, 092012 (2012)]

**BESIII vs. BaBar measurements comparison and combination,A0 is mostly singlet**

# Extenstion of the analysis

- **Meson invisible decays**
  - Jpsi -> inv,
  - Jpsi -> gam+inv
  - phi/omega -> inv: first search




- **Ongoing related DP search channels**
  - Invisible DP in ISR process: to come soon, competitive
  - LUV dark scalar search with e+e->mu+ mu- Z'
  - DP search with $J/\psi \to \eta e^+e^-$
  - … and more

# Summary

- **BESIII has joined the world wide efforts of dark sector search and is probing other new physics .**
- **DP search with untagged ISR events in 1.5 GeV/$c^2$ ~ 3.4 GeV/$c^2$ set competitive limit on the mixing strength between $10^{-3}$ and $10^{-4}$ in this region**
- **The branching fraction of $J/\psi \to \eta' e^+e^-$ is updated with 1.3 billion $J/\psi$ data to be $(5.81 \pm 0.07_{stat} \pm 0.29_{syst})\times 10^{-5}$.**
- **DP is searched $J/\psi \to \eta' \mathrm{U},\ \mathrm{U} \to e^+e^-$. Upper limits on B( $J/\psi \to \eta' \mathrm{U}$) ×B( $\mathrm{U} \to e^+e^-$) and B( $J/\psi \to \eta'$U) is set for the first time, the mixing strength $\varepsilon$ constrained**
- **BESIII has great potential with unique (and increasing) datasets and analysis techniques:**
  - **More to come, stay tuned!**
  - **More ideas from you are welcome!**

# Thanks!

**Extra slides…**