DARK PHOTON SEARCH AT BELLE

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ON BEHALF OF THE BELLE COLLABORATION, 2012/JULY/7

Mass Range of Dark Photon:

0.27 - 3 GeV/c^2

Mass Range of Dark Higgs:

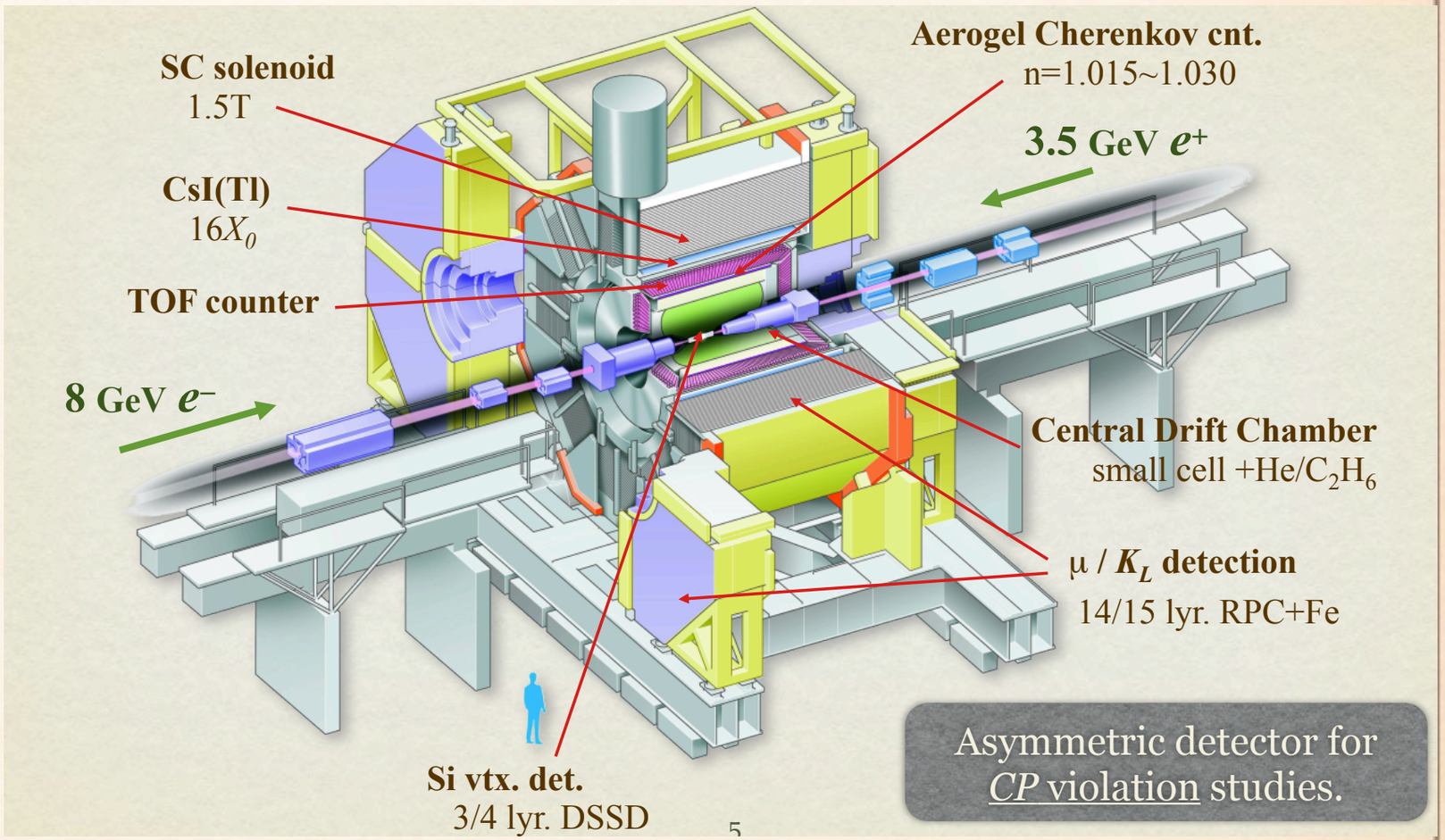
0.54 - 10.86 GeV/c^2

MELBOURNE, ICHEP 2012

OUTLINE

- Motivation
- Strategy
- Signal Efficiency
- Background
- Preliminary Results

Belle Detector

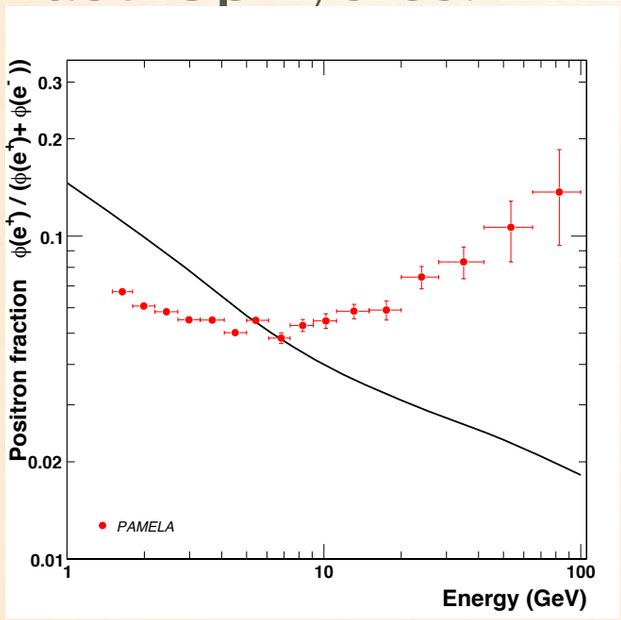


Asymmetric detector for *CP* violation studies.

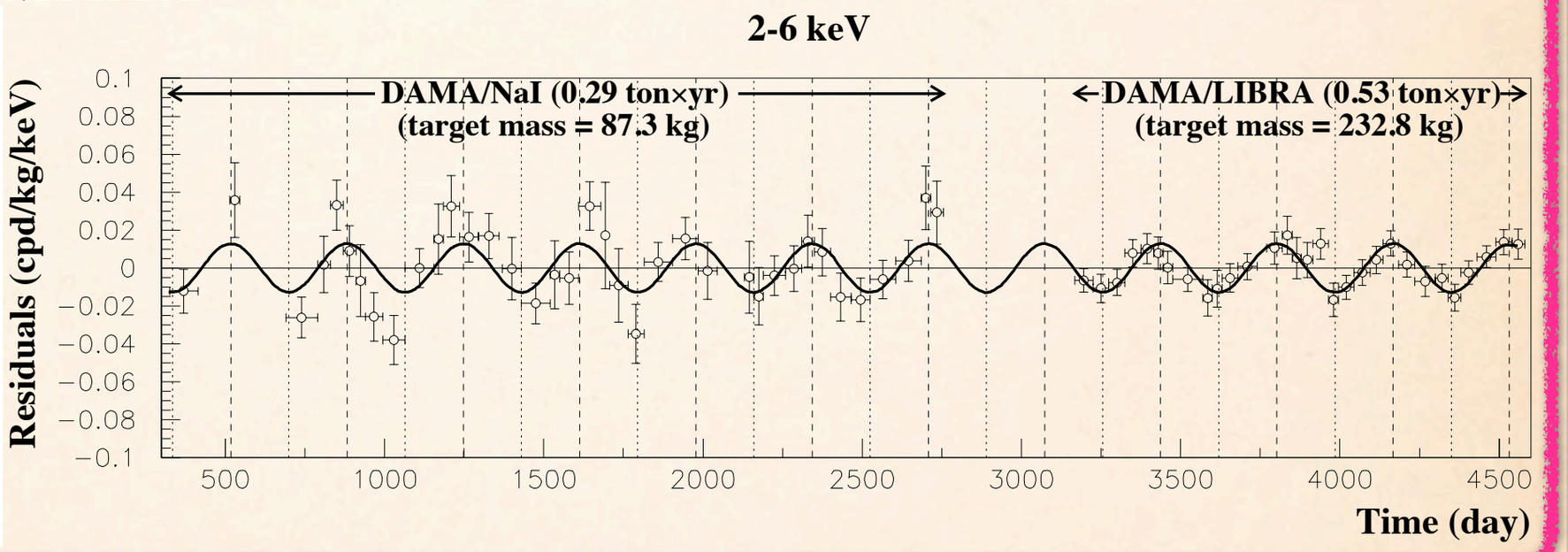
MOTIVATION

- Dark photon and Dark Higgs are coupled through the dark sector.
- This theory may explain the inconsistencies observed in astrophysical data and dark matter experiments.

- astrophysics: PAMELA



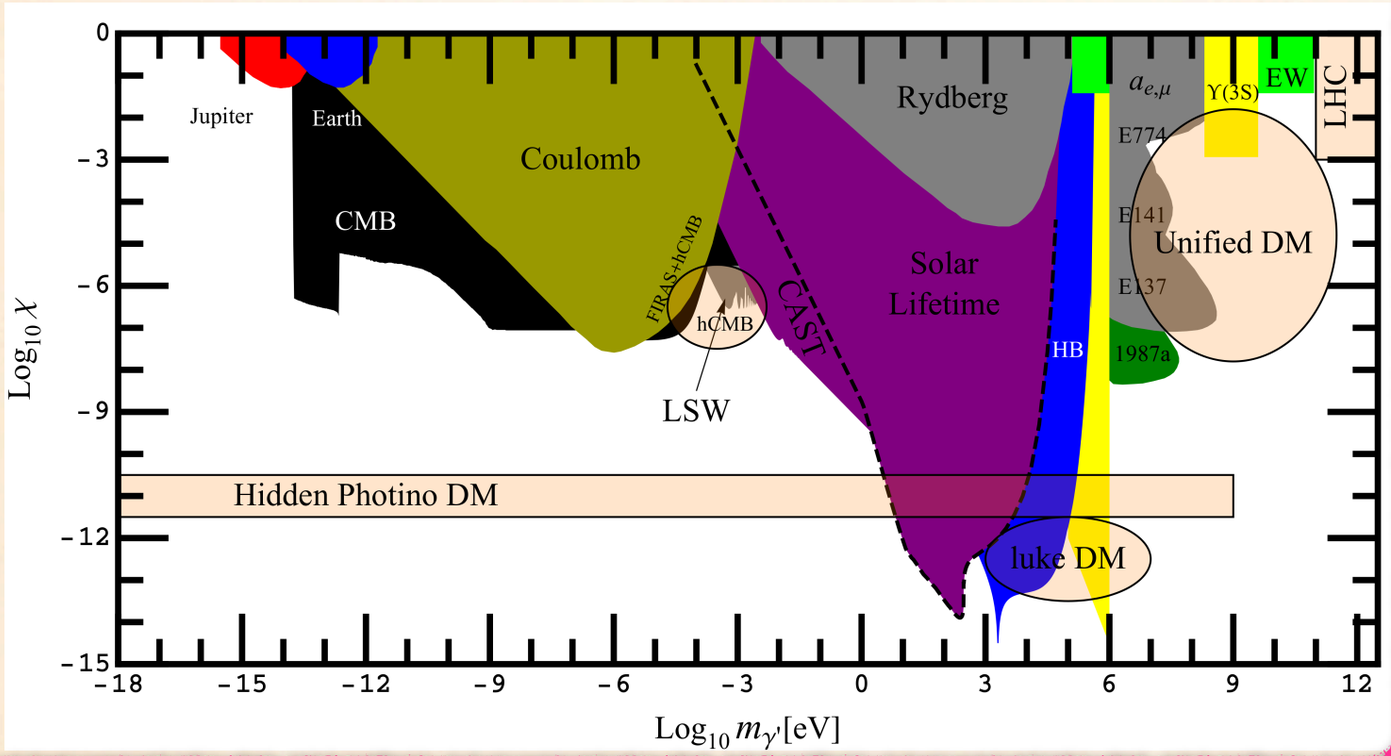
- dark mater: DAMA/LIBRA



- PAMELA: O. Adriani et al., Nature 458, 607-609 (2009)
- DAMA/LIBRA: R. Bernabei et al., Eur. Phys. J. C (2008) 56: 333-355.

PREVIOUSLY AND RECENTLY

- Summary of astrophysical and cosmological constrains and experimental limits



J. Jaeckel and A. Ringwald, arXiv:1002.0329

BaBar Collaboration, PRL 108, 211801 (2012)

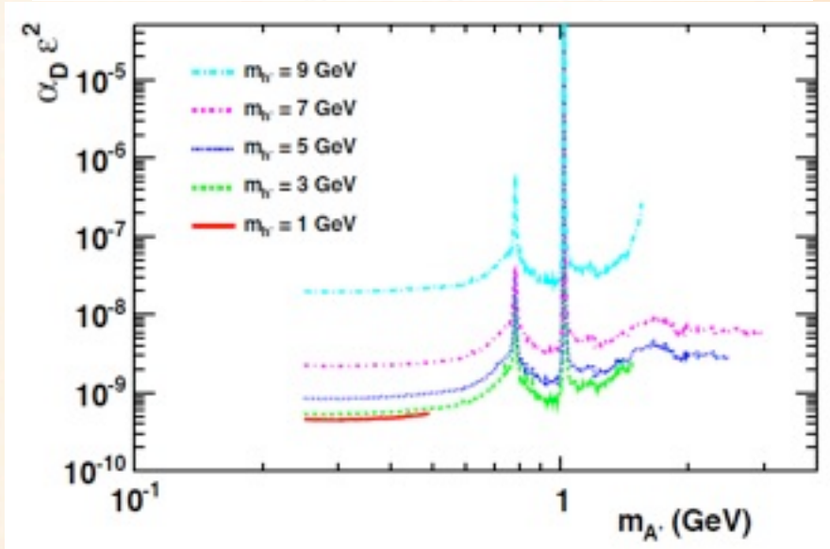
y-axis: kinetic mixing, x-axis: dark photon mass

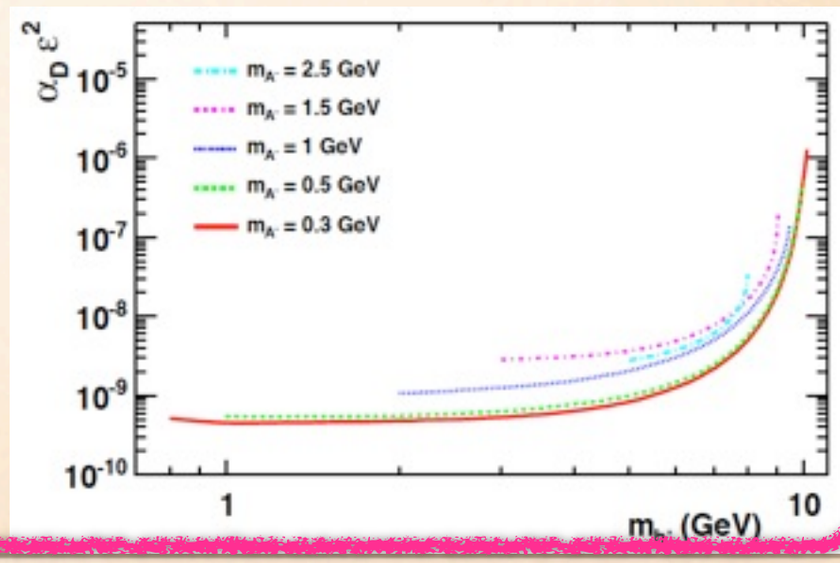
- BaBar Results:

($L = 521\ \mathrm{fb}^{-1}$ at $\Upsilon(2S, 3S, 4S)$):

★ $e^+e^- \to Ah'(\to AA)$

with $A \to l^+l^-$ (l=e or μ) or hadrons



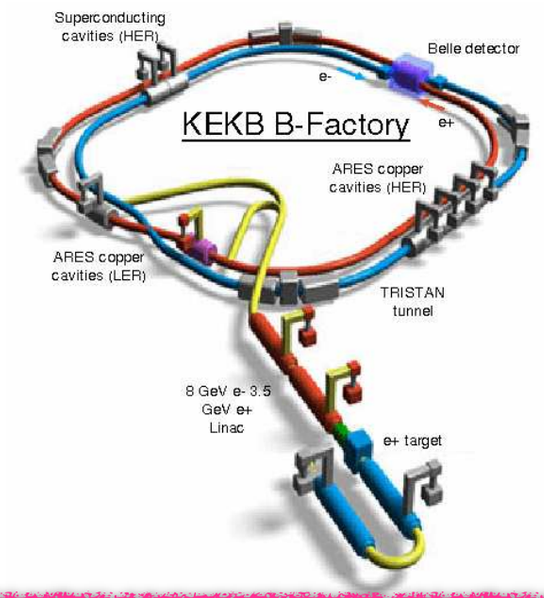


SEARCH FOR THE DARK PHOTON AND DARK HIGGS AT BELLE

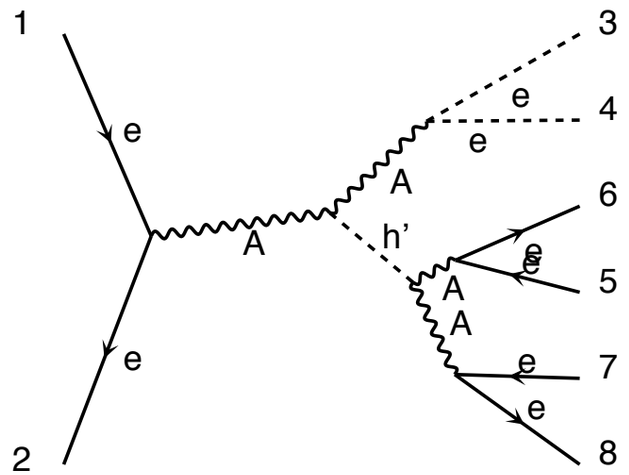
$e^+e^- \to Ah' \to AAA$ with $A \to l^+l^-$ (l=e or μ) or hadrons

B. Batell, M. Pospelov, and A. Ritz arXiv:0903.0363 (2009).

- Belle Exp. at KEK B-factory
- L = 1021 fb^{-1} at $\Upsilon(1S, 2S, 3S, 4S, 5S)$ and continuum



- channels presented today
  - $e^+e^- \to 3e^+3e^-$
  - $e^+e^- \to 3\mu^+3\mu^-$



- $0.27 < m_A < 3$ GeV/c^2
- $0.54 < m_{h'} < 10.86$ GeV/c^2

SIGNAL MC

Strategy

The combinations with three masses

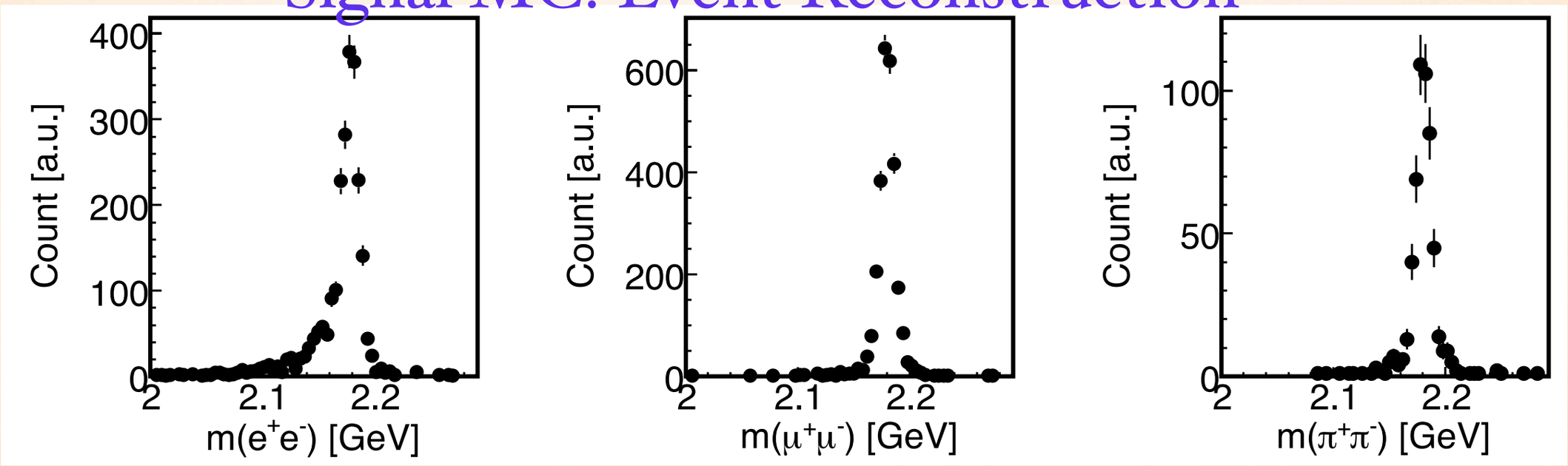
$(m_A^1,\ m_A^2$ and $m_A^3)$

"equal" and

$m_{h'} > 2m_A$

are chosen.

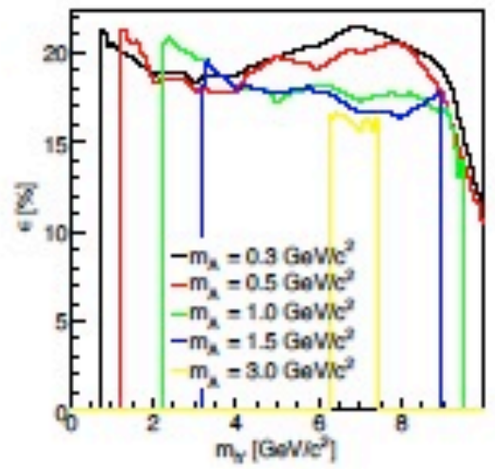
Signal MC: Event Reconstruction

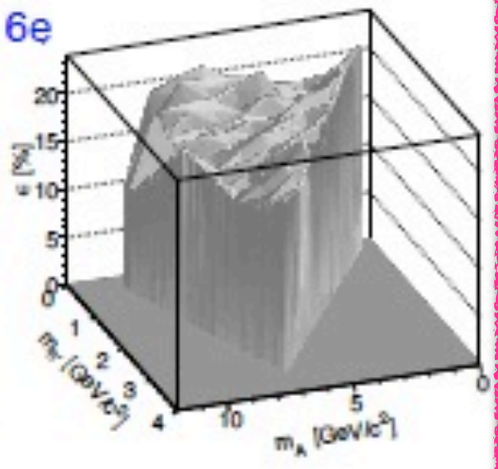


DETECTION EFFICIENCY

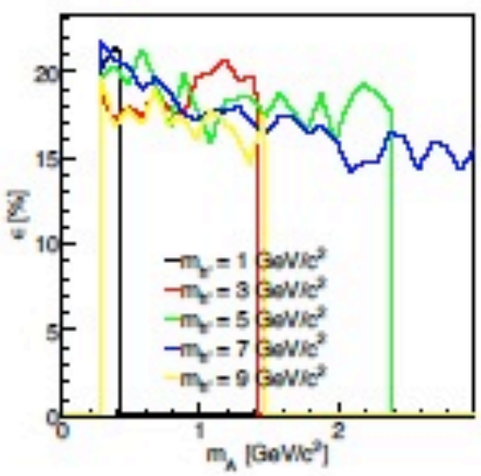
$e^+e^- \to Ah' \to AAA \to 3l^+3l^-$

- $e^+e^- \to 3e^+3e^-$

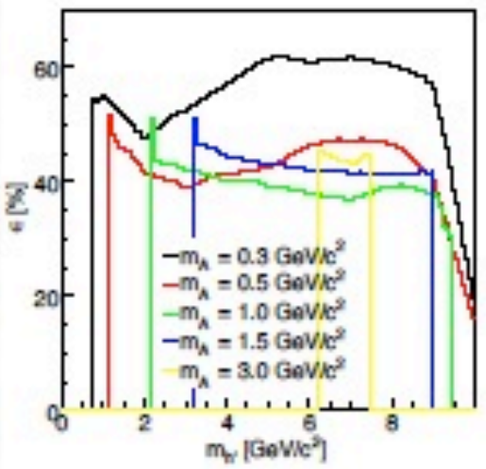


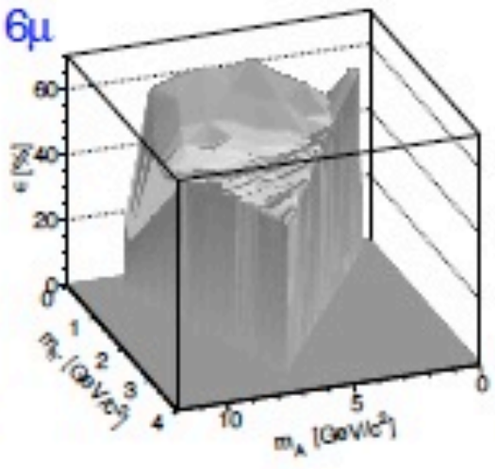


efficiency:
about 18%

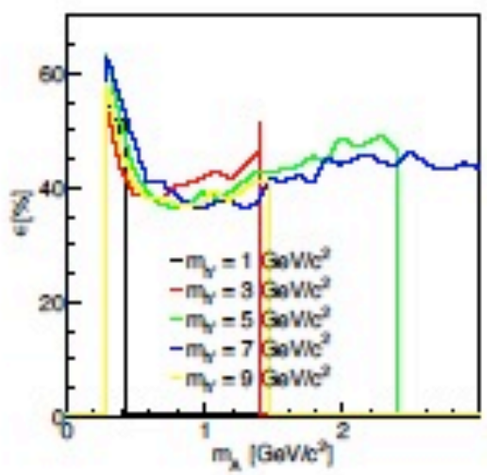


- $e^+e^- \to 3\mu^+3\mu^-$





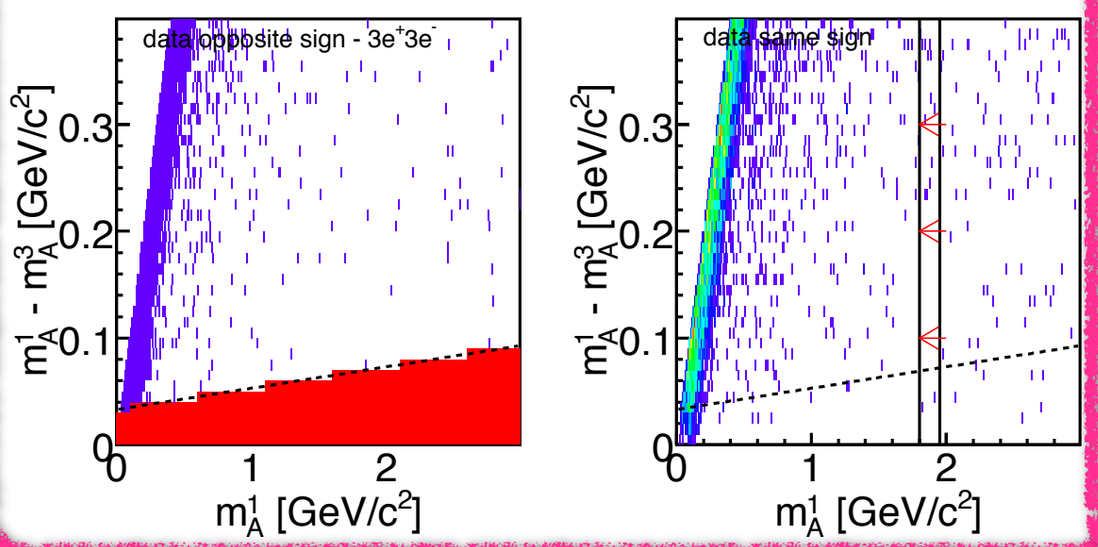
efficiency:
about 40%



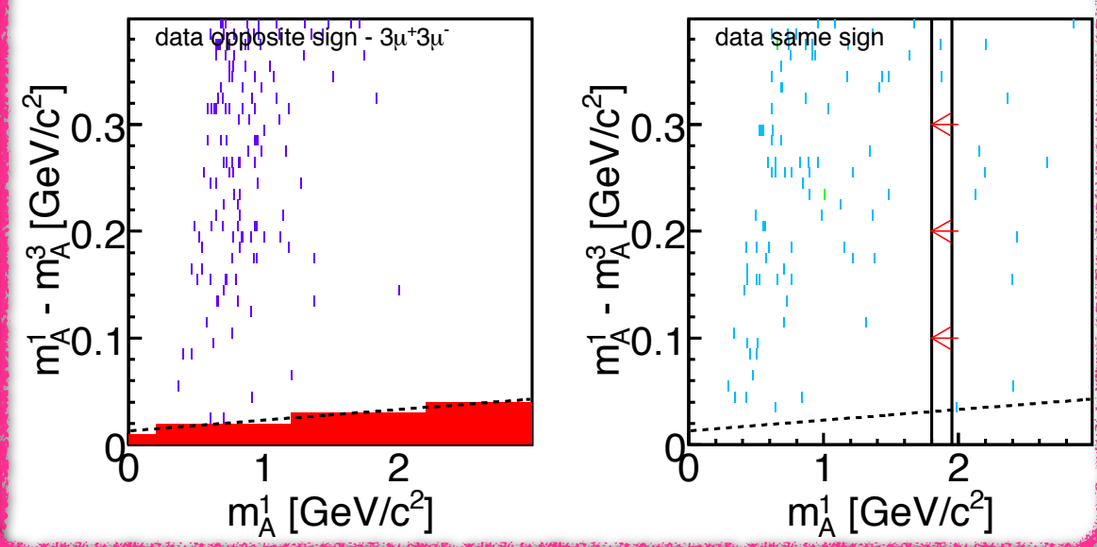
BACKGROUND ESTIMATION

- No realistic background model is available. Data driven background estimation: one pair of opposite sign and two pairs of the same sign are calculated.
  - estimate background using "same sign" events
    $e^+e^- \to Ah' \to A(l^+l^-)A(l^+l^+)A(l^-l^-)$
  - order masses of lepton pairs $m_A^1 > m_A^2 > m_A^3$ and plot $m_A^1 - m_A^3$ vs. m_A^1

- $e^+e^- \to 3e^+3e^-$

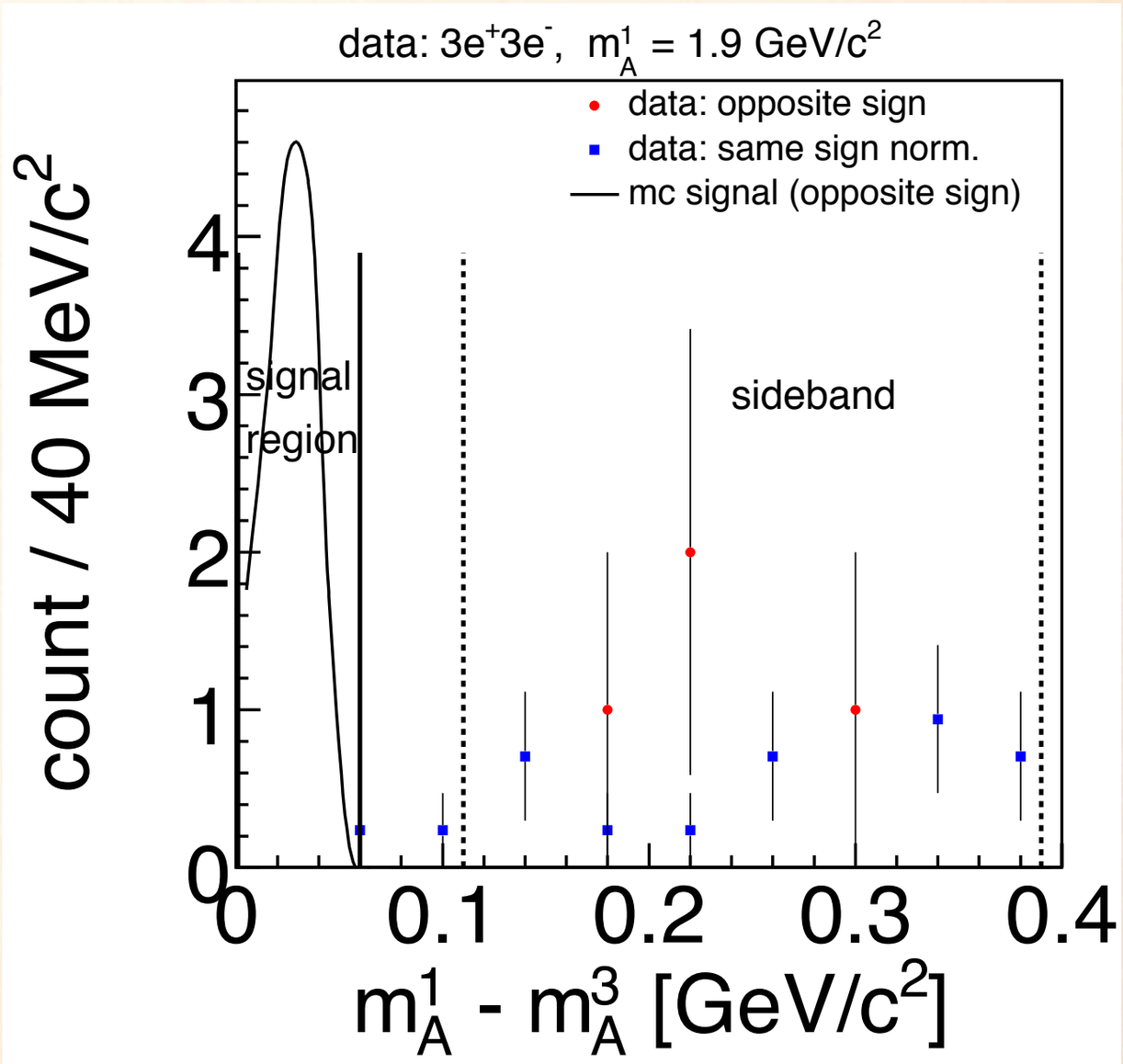


- $e^+e^- \to 3\mu^+3\mu^-$



BACKGROUND ESTIMATION: NORMALIZATION

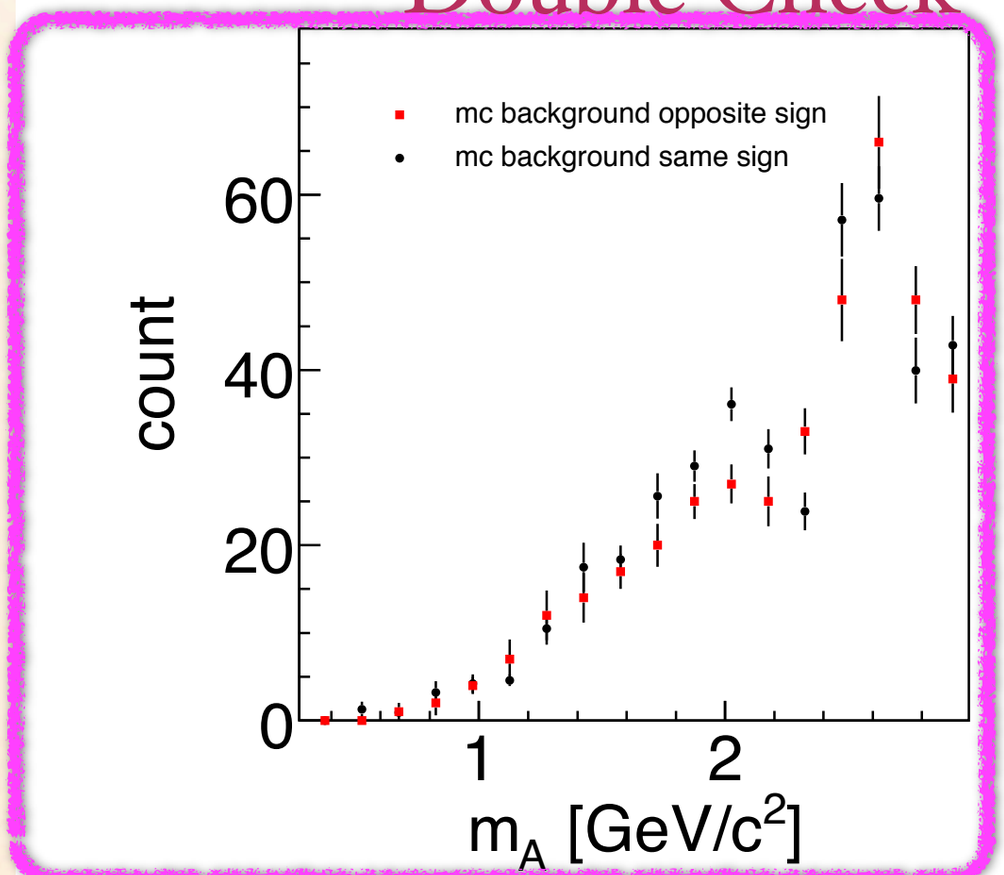
1. sideband events are used to normalize same sign to opposite sign.
2. background estimated from the number of counts in the signal region of the same sign distribution.



BACKGROUND ESTIMATION: MC TEST, PREDICTION

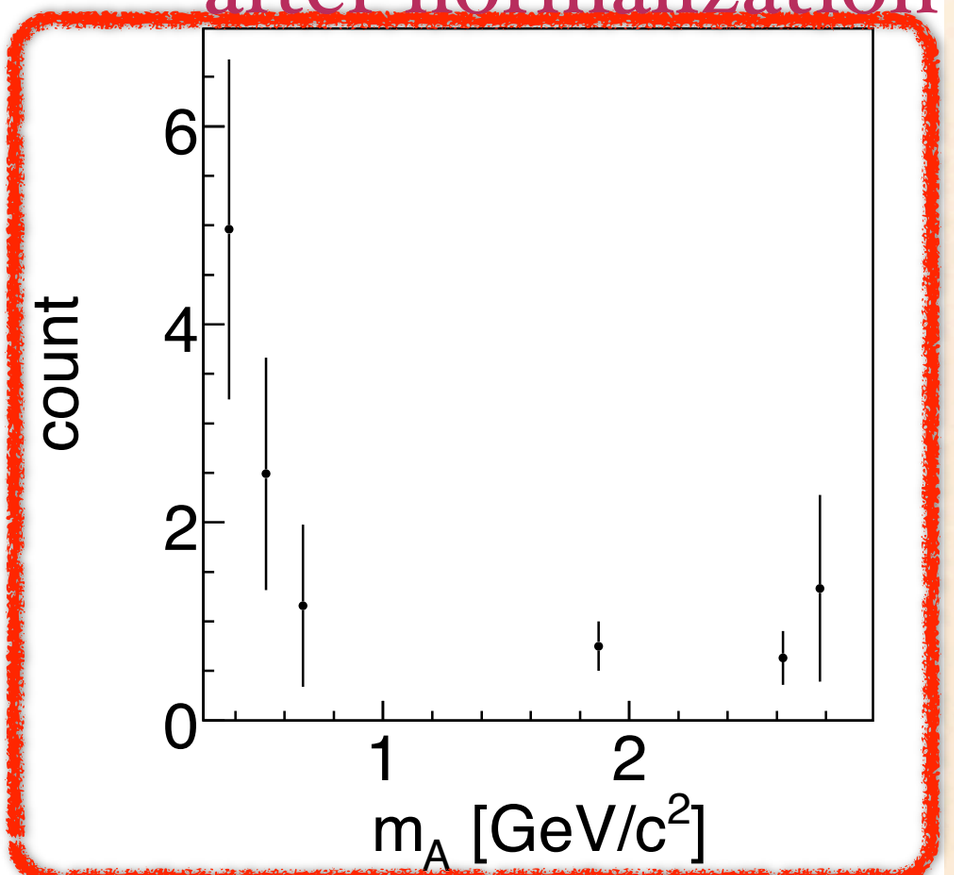
- MC test

Double Check



- data: $e^+e^- \to 3e^+3e^-$

after normalization

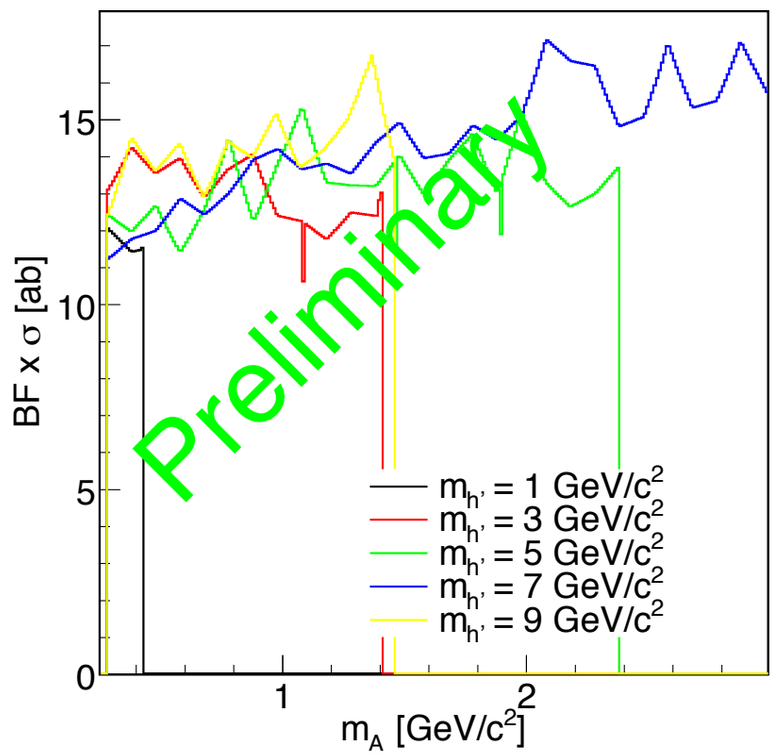


- background estimation method verified successfully with MC
- for experimental data, predicted BG is
  - $>$ 20 events for electron final state (see plot)
  - 0 event for muon final state

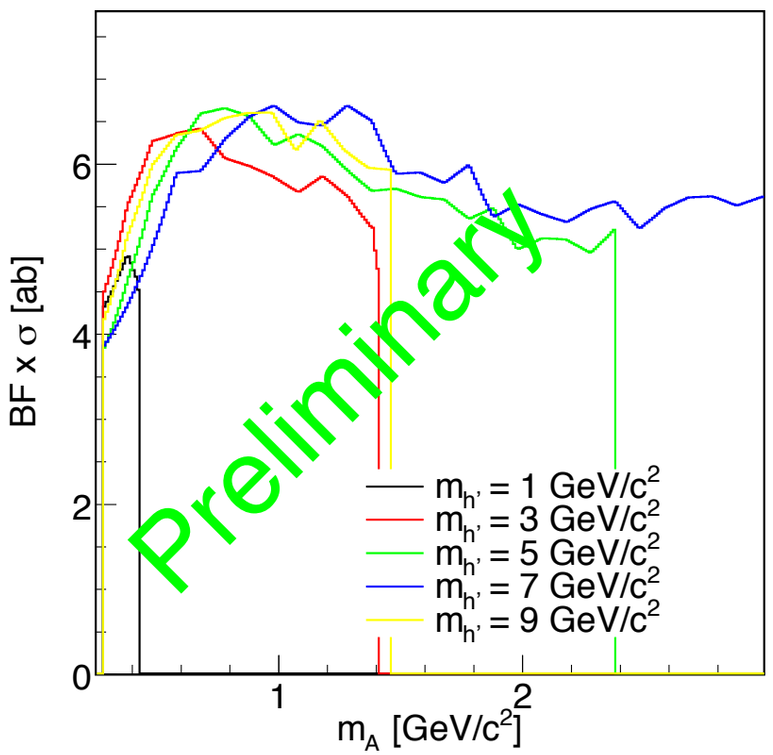
PRELIMINARY RESULTS

- Assume number of events observed = number of background
- Upper Limit (90% C.L.) determined by Feldman-Cousins method
- Sensitivity scales nearly linearly with integrated luminosity

- $e^+e^- \to 3e^+3e^-$



- $e^+e^- \to 3\mu^+3\mu^-$



SUMMARY

Mass Range of Dark Photon:

0.27 - 3 GeV/c^2

Mass Range of Dark Higgs:

0.54 - 10.86 GeV/c^2

- From our control data sample, we found that: background is estimated to be small, implying Sensitivity scales nearly linearly with integrated luminosity

- The results will be unblinded soon.

THANK YOU~