$\gamma^{(*)}\gamma^{(*)} \rightarrow \pi^+\pi^-$ at BESIII

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SFB 1044
THE LOW-ENERGY FRONTIER OF THE STANDARD MODEL

EINN2013 parallel session
"Photon-photon physics and its implications for the Muon's (g-2)"
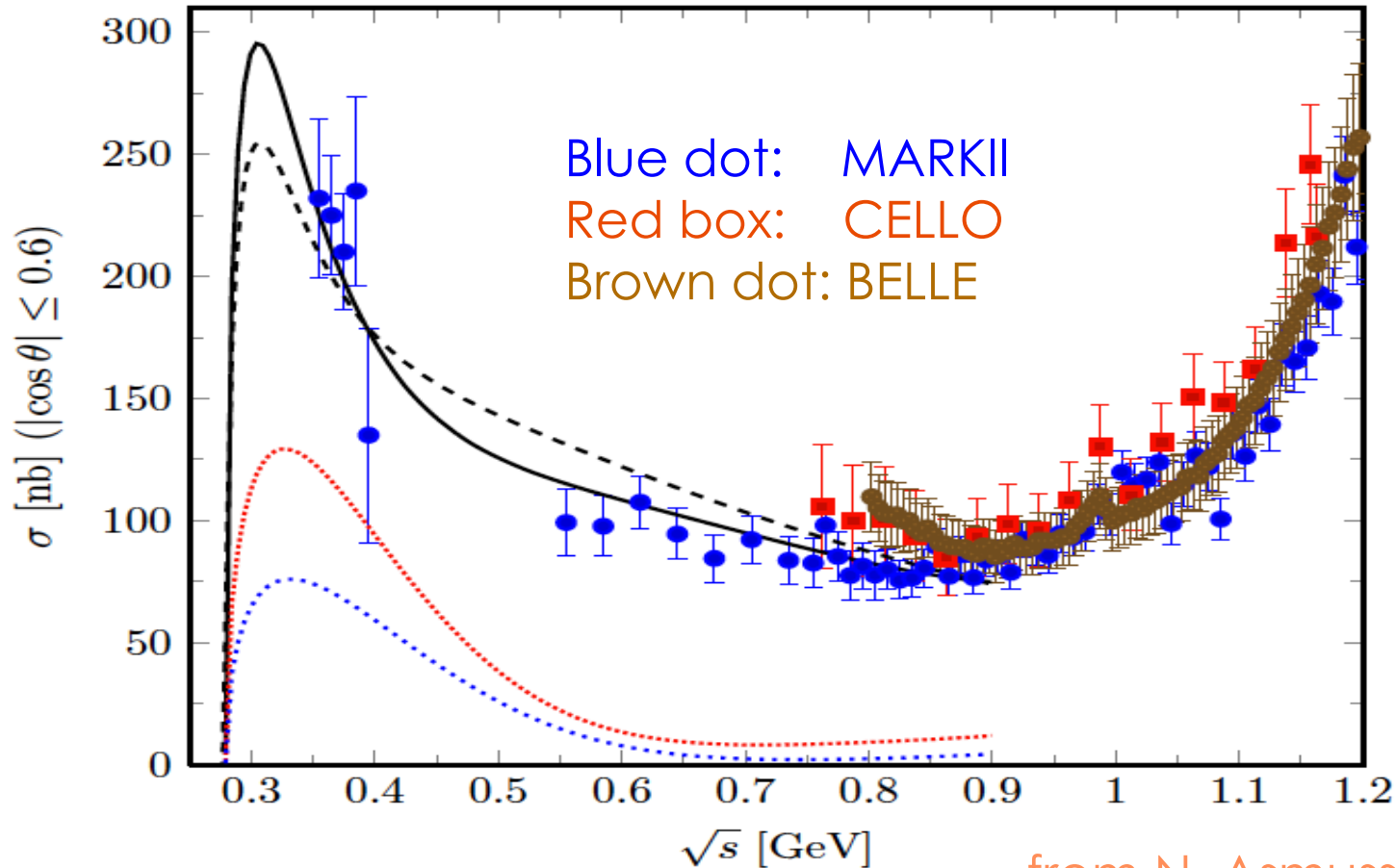2013-10-29

Outline

- Motivation

- BESIII detector

- Possibility of $\gamma^{(*)}\gamma^{(*)} \rightarrow \pi^+\pi^-$ at BESIII
  - MC generator
  - Event selection
  - Expected accuracy

- Summary and outlook

Motivation

- Physics at $\gamma^{(*)}\gamma^{(*)} \rightarrow \pi^+\pi^-$ process
  - $\sigma(\gamma^{(*)}\gamma^* \rightarrow \pi^+\pi^-)$ as a function of Q^2 → extract hadron form factor $|F(Q_1^2,Q_2^2)|$, $|F(Q_1^2,0)|$
    - provide information to light-by-light scattering contribution to g-2
  - $\sigma(\gamma\gamma \rightarrow \pi^+\pi^-)$
  - resonance parameter measurement
  - polarizabilities of pions, probe the structure of pion
  - previous measurements:
    - MarkII: 209 pb^{-1} @ 29 GeV cover W from 0.35 ~1.60 GeV [PRD42, 5, 1990]
    - BELLE: 85.9 fb^{-1} @ 10.52~10.58 GeV cover W from 0.8 ~1.5 GeV [PRD75, 051101(R), 2007]
    - CELLO: 86 pb^{-1} cover W from 0.75~1.9 GeV [Z.Phys.C56, 381, 1992]

Theoretical expectation

Blue dot: MARKII
Red box: CELLO
Brown dot: BELLE

from N. Asmussen (JGU)

Black line: untag
Red line: single tag $Q_1^2 = 0.5$ GeV^2
Blue line: double tag $Q_1^2 = Q_2^2 = 0.5$ GeV^2

Method used in experimental

- double tag:
  - two leptons with non-zero Q^2
  - tag the hadron products in the final states as well as both leptons

- single tag:
  - tag the hadron products in the final states and only one lepton
  - require the direction of the missing momentum to be at small angle, $Q^2_{untagged} \approx 0$

- untag:
  - only tag the hadron products in the final states
  - require the p_T-balance of the hadron products,
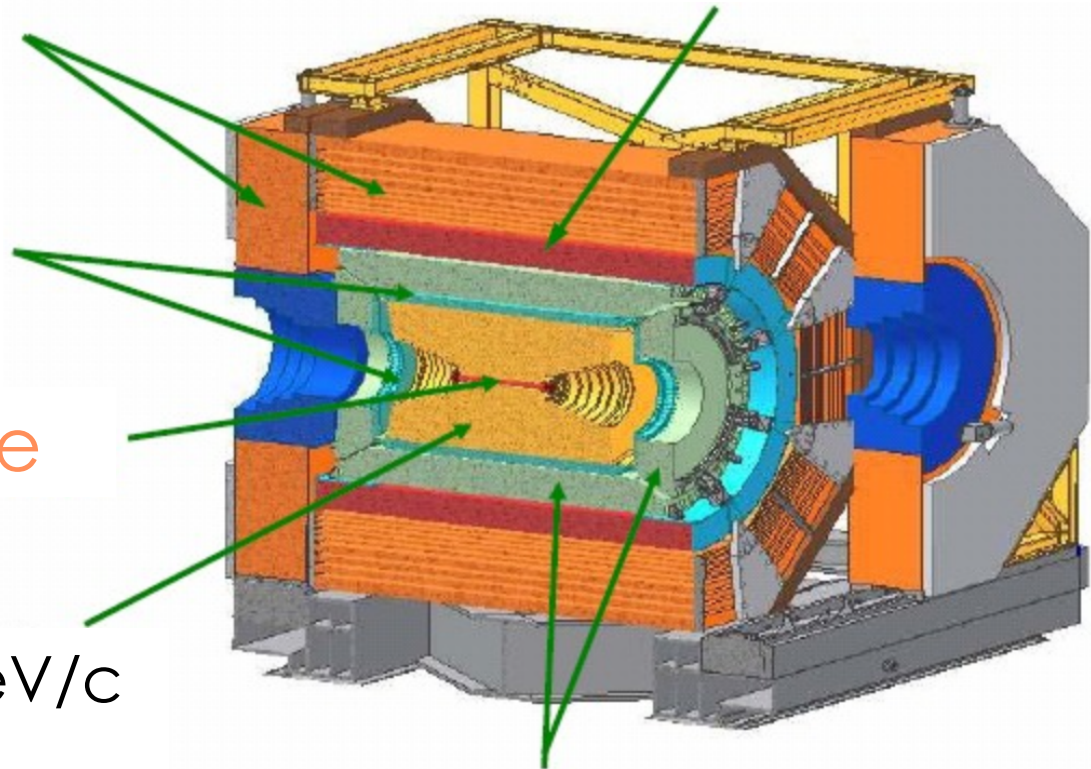
The BESIII detector

SC Magnet: 1Tesla

Magnet yoke

TOF: (σ_T)

Barrel: 80 ns

Endcap:110 ns

Beam pipe

MDC:

σ_p/p: 0.5% at 1GeV/c

σ_{xy}: 130 μm

dE/dx: 6%

CsI calorimeter:

ΔE/E: 2.5% / 5.0% at 1 GeV; σ_Z: 0.6 cm/$\sqrt{E}$

Data collected at BESIII

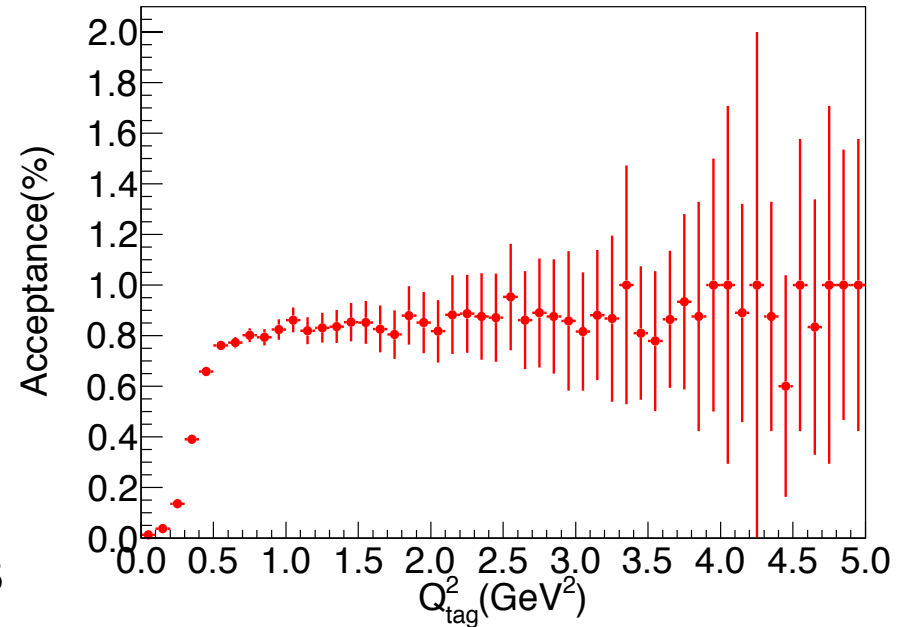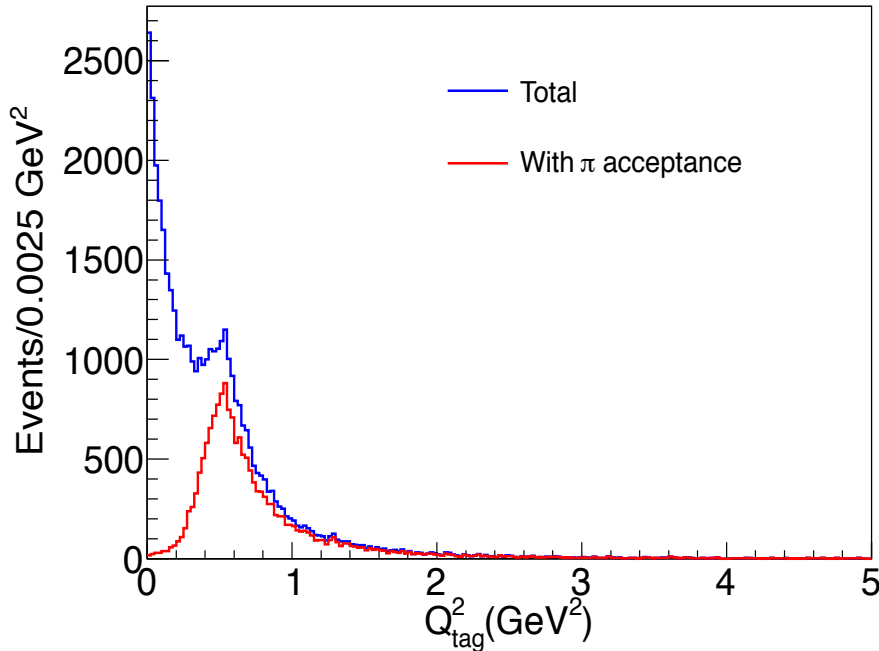| CMS	Previous data	BESIII data
J/ψ	58 M (BESII)	1.2 B
$\psi(3686)$	28 M (CLEO)	0.5 B
$\psi(3770)$	0.8 fb^{-1} (CLEO)	2.9 fb^{-1}
$\psi(4040)/$ Y(4260)/Y(4360)	0.6 fb^{-1} @ 4170 (CLEO)	0.5 fb^{-1} @ 4009; 2.0 fb^{-1} @ 4230+4260; 0.5 fb^{-1} @ 4360; 50 pb^{-1} @ other 10 scan energy points
R scan/τ scan		25 pb^{-1} τ scan; R scan @ 2230, 2400, 2800, 3400

More data for R scan and high mass resonances in the coming run period

Available two gamma generators

- Galuga 2.0 (revised by V.Bytev and A. Zhemchugovz (JINR))
  - based on improved equivalent photon approximation (EPA) approach
  - modified to included charged and neutral pion pair and kaon pair production based on ChPT prediction

- EKHARA (by H. Czyz and S. Ivashyn).
  - good description for the pseudoscalar final states
  - include pion pair production soon

- BesTwogam
  - inclusive generator, can be used to estimate background process, need further tests
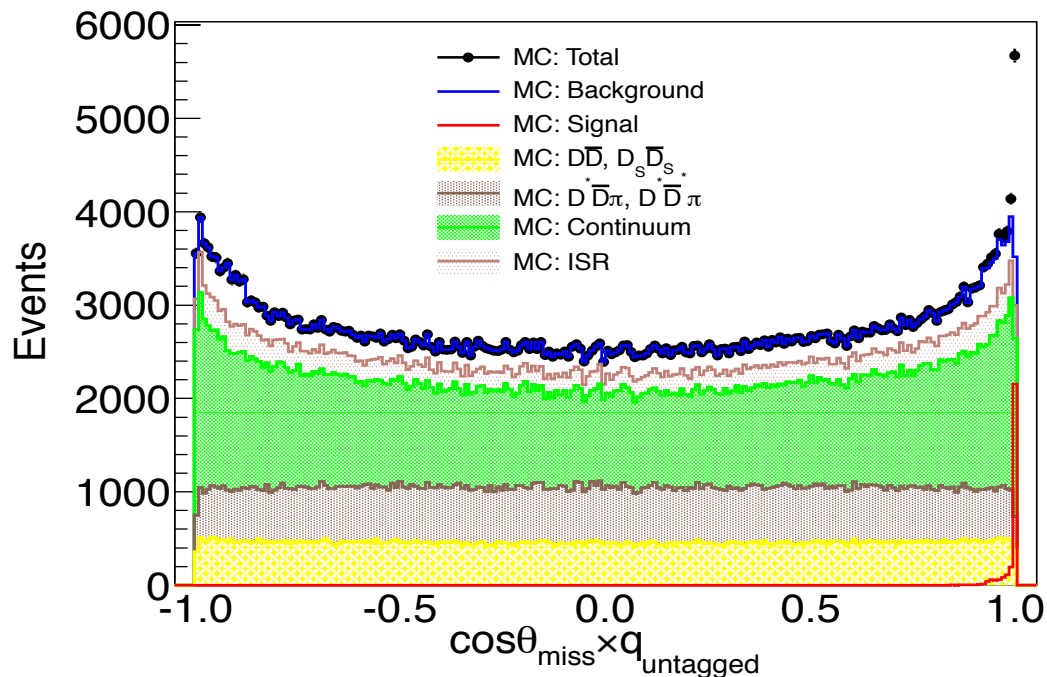
Acceptance at BESIII

- $\sqrt{s}$ = 4230 MeV, events not scaled

- Truth information with or without acceptance requirement

- Possible resonance not included in the generator

- High acceptance above 0.5 GeV^2

Selection study

- Signal MC: Galuga 2.0

- Background MC: 500 pb^{-1} at 4260 MeV
  - QED events: $e^+e^- \rightarrow e^+e^-(\gamma)$, $e^+e^- \rightarrow \mu^+\mu^-(\gamma)$, etc.
  - ISR processes: J/ψ, $\psi(3686)$, $\psi(3770)$, $\psi(4040)$
  - Hadronic final states;
  - Continuum;

- Basic event selection
  - Three charged tracks
  - Use dE/dx and TOF information to identify pions
  - Two pions with opposite charge
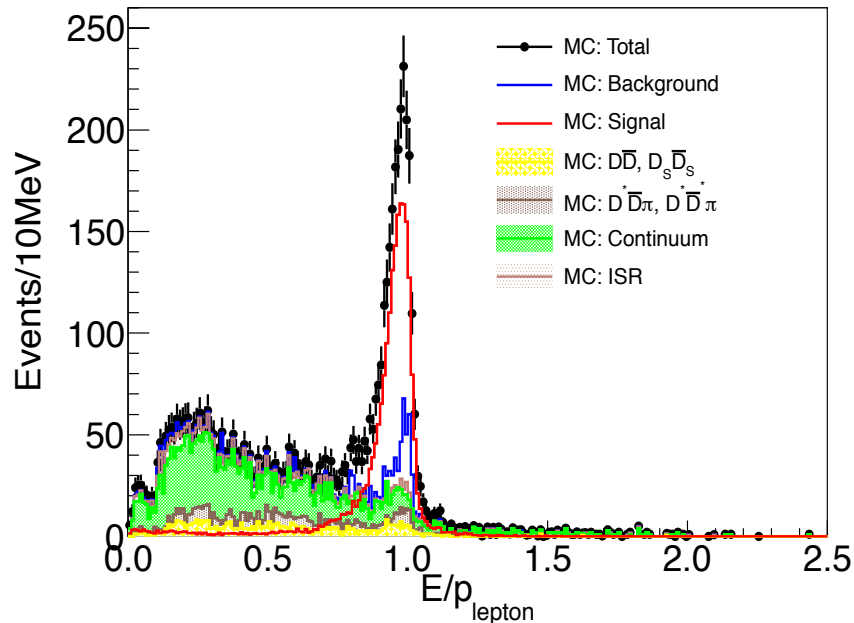 - No requirement on photon

Selection study

- Low Q2 for the untagged lepton
  - reconstructed using 4-momentum conservation
  - cut on the angular distribution of the missing momentum
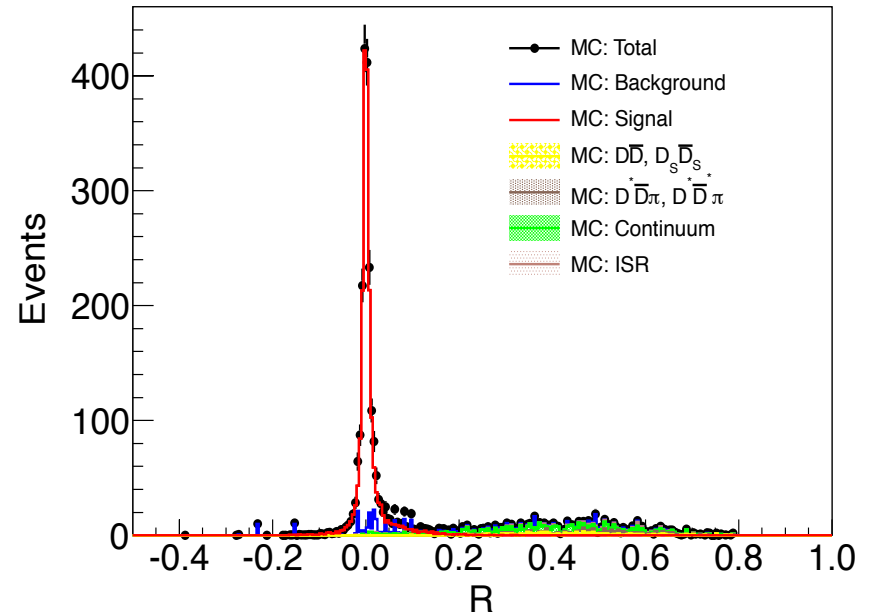

- cut:
  - $\cos\theta_{miss} > 0.99$
- efficiency loss about 20%
- Background suppress two orders of magnitude

Selection study
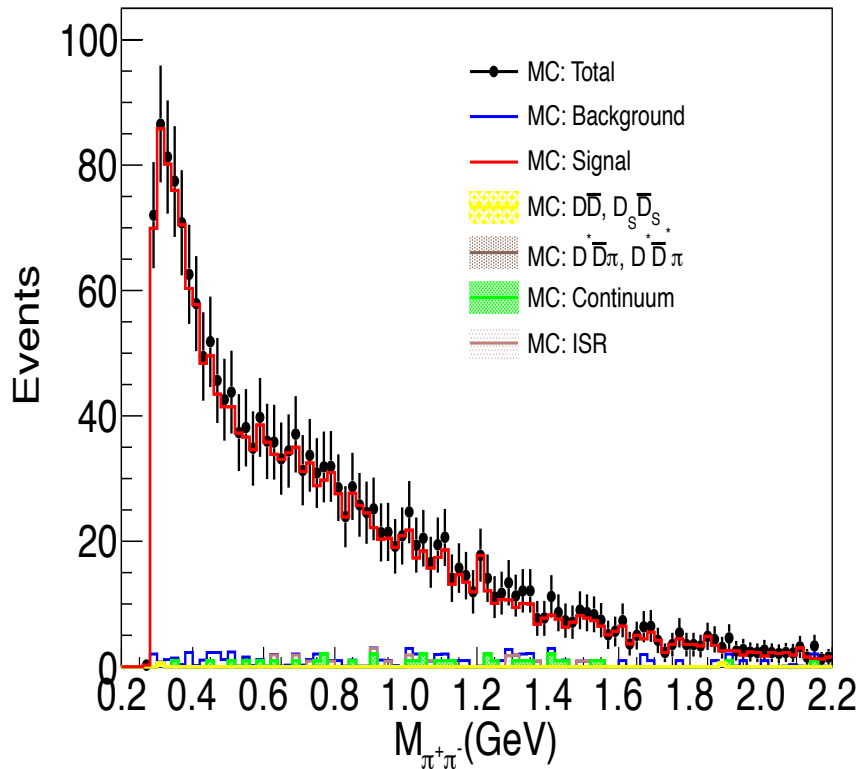
- Tagged lepton
  - E/p>0.8
  - efficiency lost about 15%
  - background rejected 69%

- R distribution
  - $R = (\sqrt{s} - E_{\pi\pi e} - P_{\pi\pi e})/\sqrt{s} < 0.15$
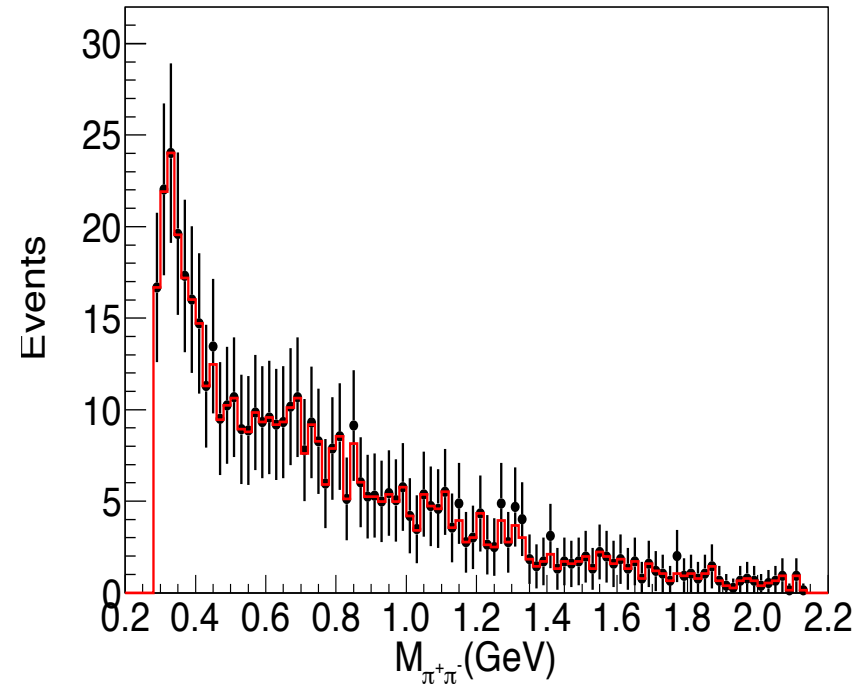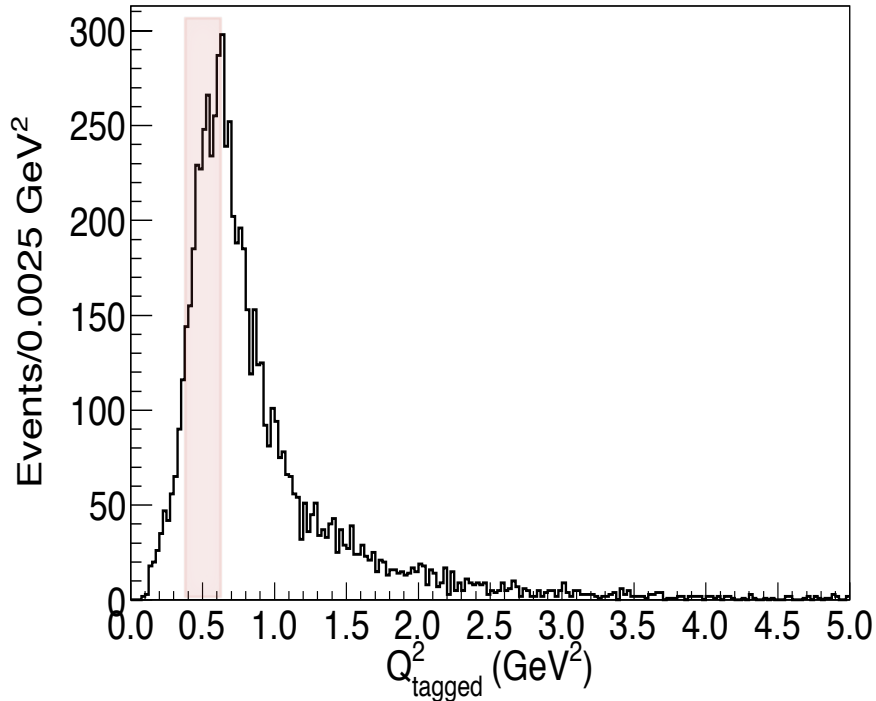 - useful to further reject ISR events and events with hadronic final states

Events after selection

- Background level: 10%
- Main background:
  - Bhabha events
    → larger MC sample
    → better MC generator
  - Dimu events
    →add selection to separate π/μ
  - continuum events
- Potential background:
  - $\gamma\gamma$ process, $\gamma\gamma$→e^+e^-. $\gamma\gamma$→$\mu^+\mu^-$

- 13,000 events generated @ 4230 for L_{int} = 500 pb^{-1}
- Efficiency about 15% after selection

$M_{\pi\pi}$ distribution at Q^2=0.5 GeV^2

- 500 signal events at 500 pb^{-1} 4230 data
- provide information in low W region and low Q^2

Summary and outlook

- Study of $\gamma\gamma \to \pi\pi$ just started at BESIII

  - start with single tag method

  - Q^2 from 0.3 to 3.0 GeV^2

  - cross section at low $M_{\pi\pi}$ mass region available (from 0.3 GeV)

  - currently: signal MC generator test and background study

- Plan

  - finalize event selection and look at data

  - extract cross section and form factor

THANK YOU FOR YOUR ATTENTION!