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

YUPING GUO

(g-2): Quo vadis?

7-10 April 2014 Institut für Kernphysik, Uni Mainz

OUTLINE

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

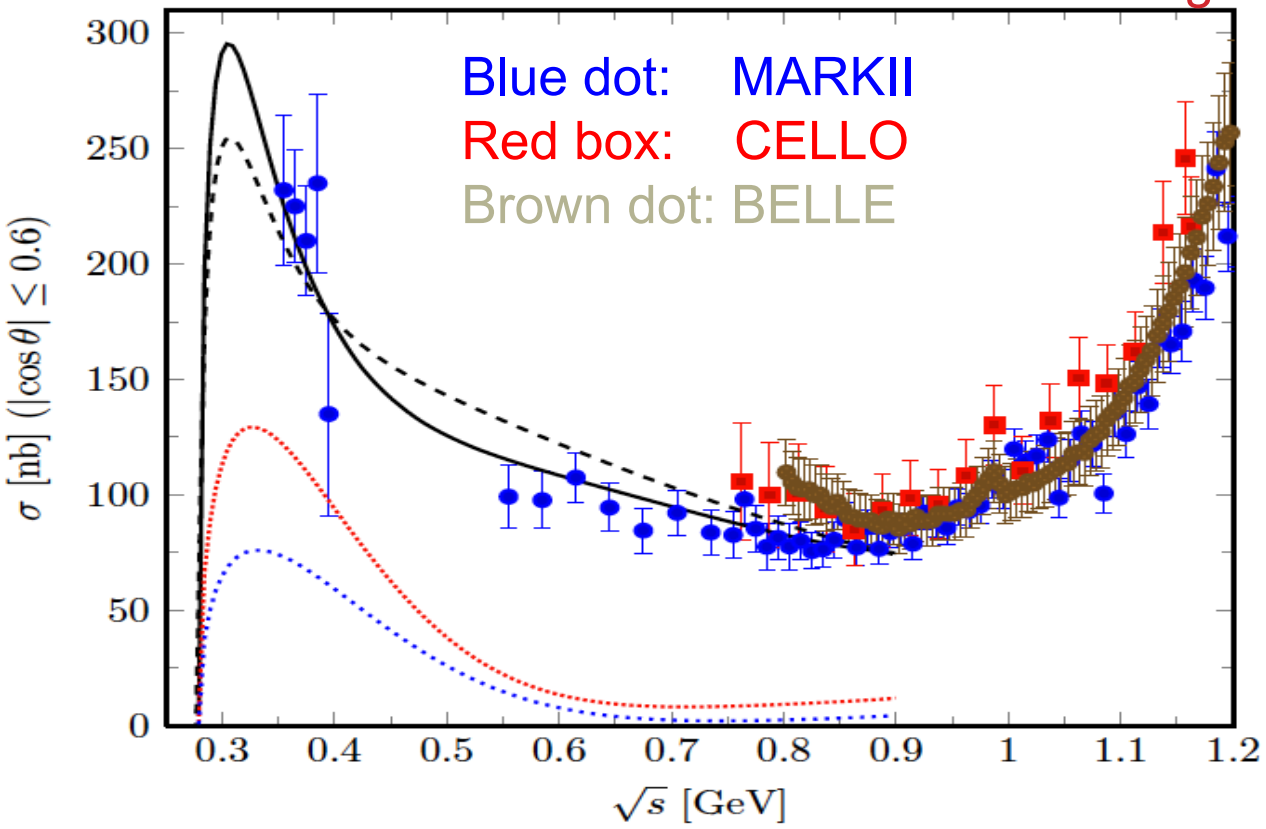
Motivation

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

- 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
- Resonance parameters for $0^{\pm+}$, 2^{++} states
- Pion polarizability, probe the structure of pion
- Re-scattering effect study at low mass region
- Previous measurements:
  - MarkII: 209 fb^{-1} @ 29 GeV cover W from 0.35 to 1.60 GeV [PRD42, 5, 1990]
  - Cello: 86 fb^{-1} cover W from 0.75 to 1.9 GeV [Z.Phys.C56, 381, 1992]
  - Belle: 85.9 fb^{-1} @10.52-10.58 GeV cover W from 0.8 to 1.5 GeV [PRD75, 051101(R), 2007]

Theoretical expectation

Nils Asmussen, Pere Masjuan, Marc Vanderhaeghen



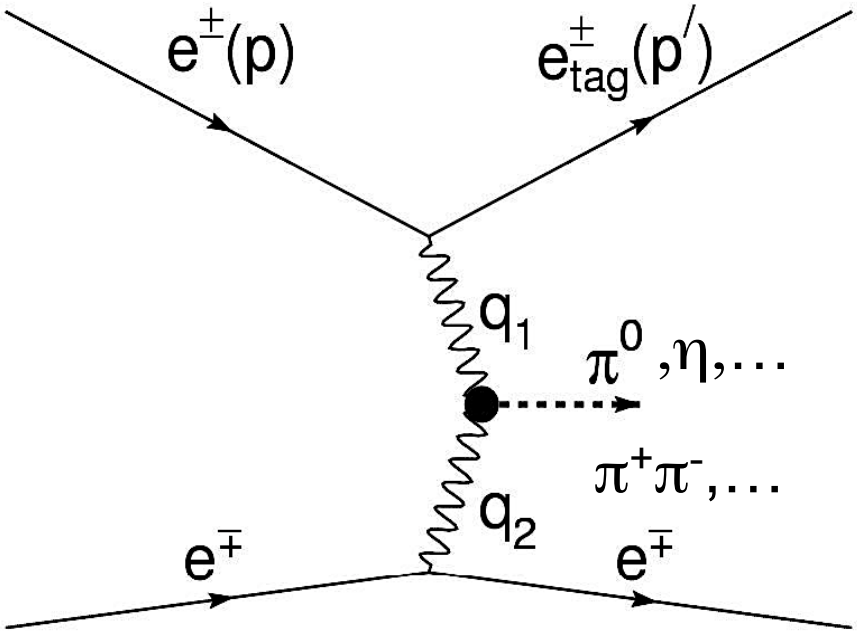
Black line: untag

Red line: single tag Q_1^2=0.5 GeV^2

Blue line: double tag Q_1^2=Q_2^2=0.5GeV^2

Method used experimentally

- Double tag method
- Single tag method
- Untag method



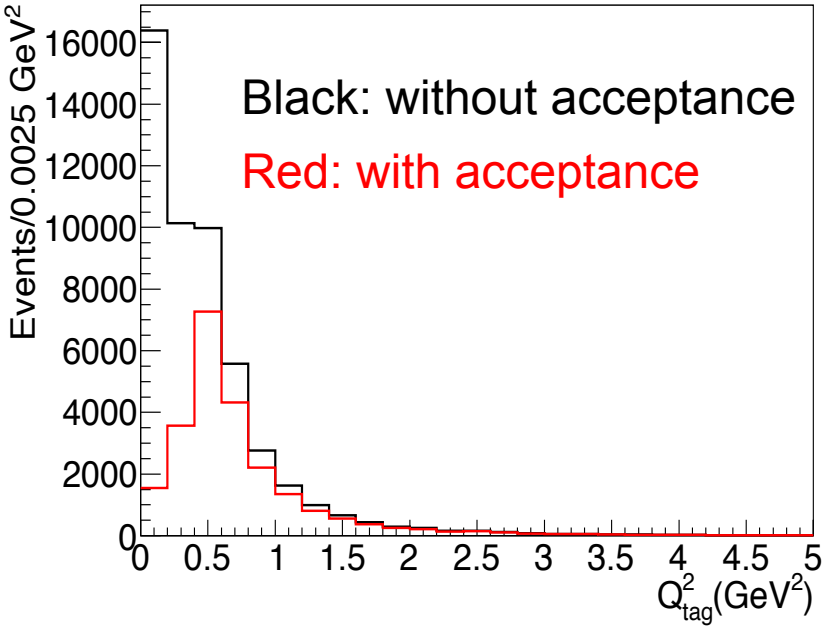
BESIII DATA SAMPLES

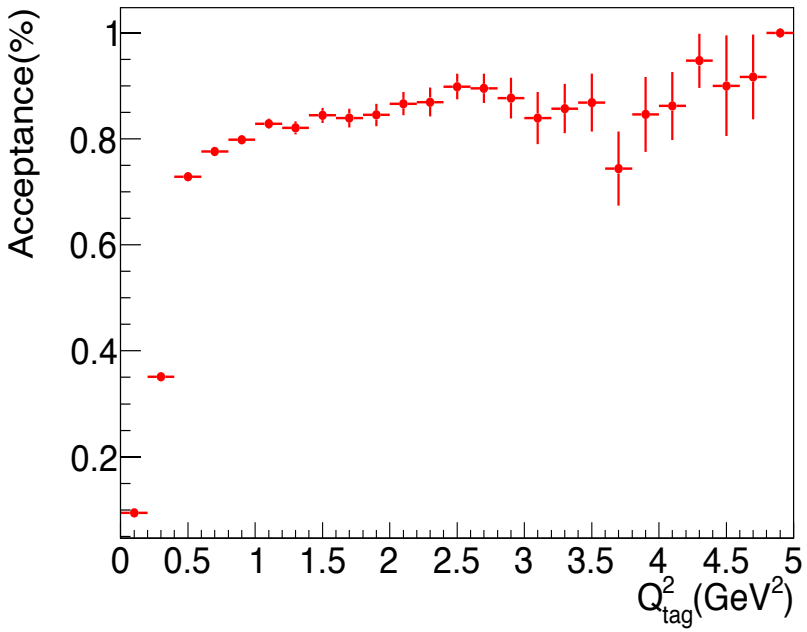
CMS	Previous data	BESIII data
J/ψ	58 M (BESII)	1.2 B
ψ(3686)	28 M (CLEO)	0.1 B + 0.4 B
ψ(3770)	0.8 fb^{-1} (CLEO)	2.9 fb^{-1}
ψ(4040)/ Y(4260)/Y(4360)	0.6 fb^{-1} @ 4170 (CLEO)	0.5 fb^{-1} @ 4009; 1.8 fb^{-1} @ 4230+4260; 0.5 fb^{-1} @ 4360; 50 pb^{-1} @ other 10 scan energy points
R scan/τ scan		25 pb^{-1} τ scan; R scan @ 2230, 2400, 2800, 3400, 107 energy points above 3850

MC simulations

- Signal MC:
  - generated using modified Galuga2.0 (ChPT prediction), no structures included
  - full space cross section: 5.2 nb
- Background MC: ($\gamma\gamma^* \rightarrow \mu^+\mu^-$)
  - generated using BesBdkRC (originate from RADCOR, written by F.A. Berends, P.H. Daverveldt, and R. Kleiss)
  - full space cross section: 33.6 nb
- Inclusive MC:
  - 500 pb^{-1} @ 4260 MeV
  - QED processes; ISR processes; DD final states; Hadronic final states; Continuum process

Acceptance





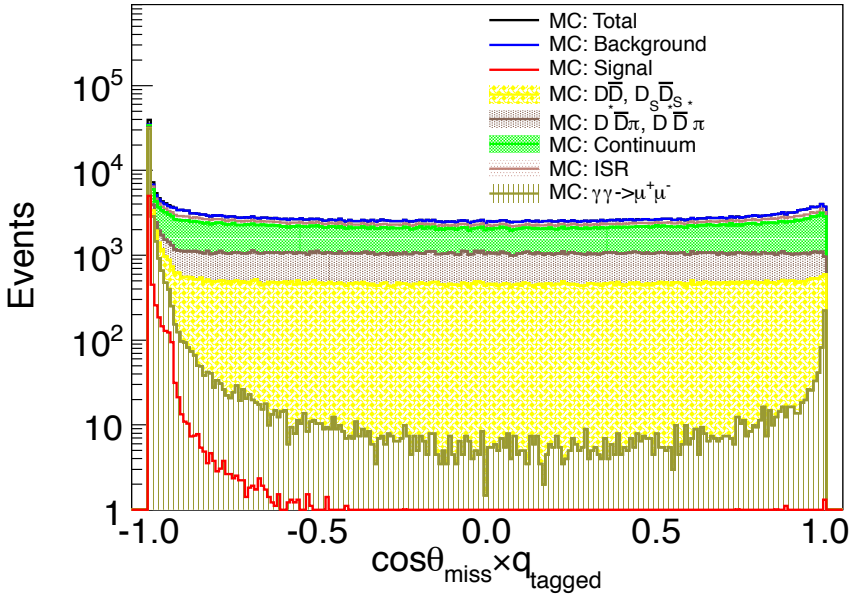
- $\sqrt{s}$ = 4230 MeV, single tagged
- Truth information with or without acceptance requirement
- High acceptance above 0.5 GeV^2

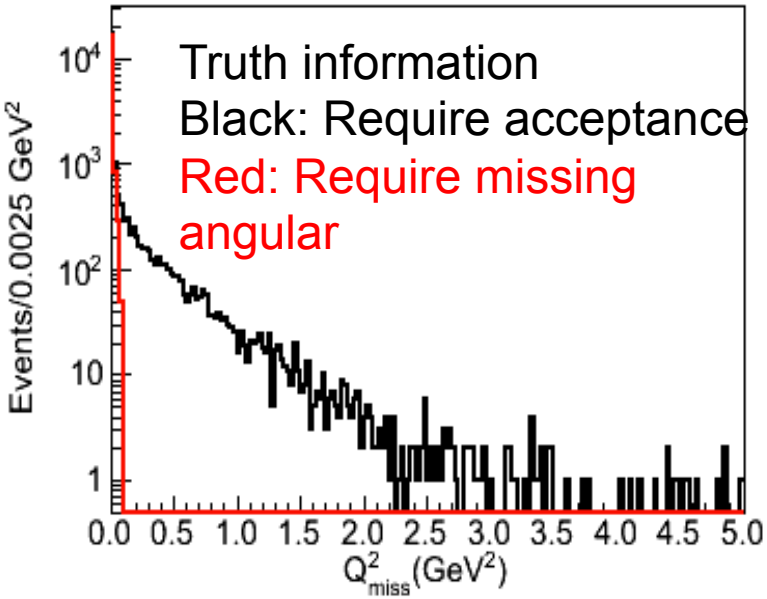
Event selection

- Three charged tracks reconstructed using MDC
- Pion identification:
  - Use dE/dx and TOF information
  - Prob(π)>Prob(K), Prob(π)>Prob(e), Prob(π)>Prob(p)
- Two pions with opposite charge
- No requirement on photon
- The missing momentum along the beam direction

Selection study

- Low Q^2 for the photon associated to the untagged lepton
  - reconstructed using 4-momentum conservation
  - cut on the angular distribution of the missing momentum



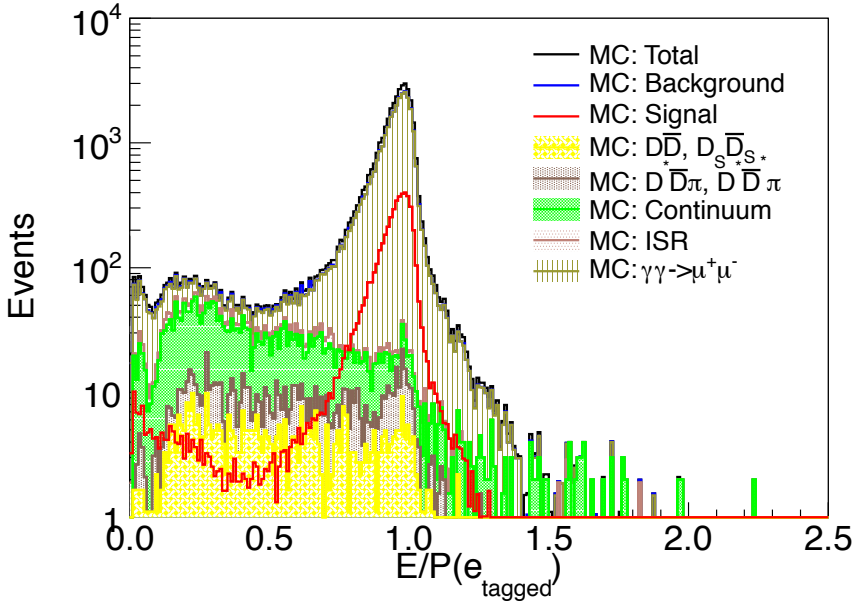


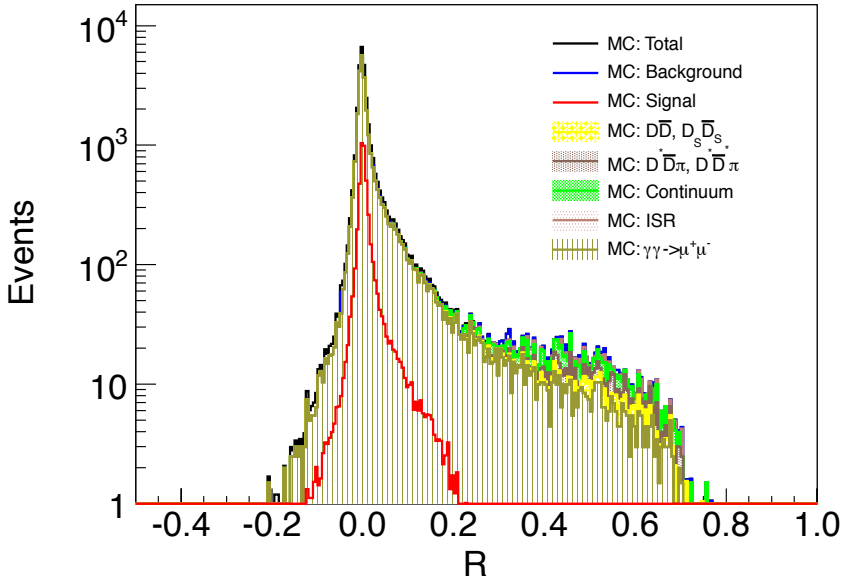
- Efficiency loss about 20%
- Background suppress two orders of magnitude

Selection study

- Tagged lepton
  - E/p>0.8
  - efficiency lost about 15%

- 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



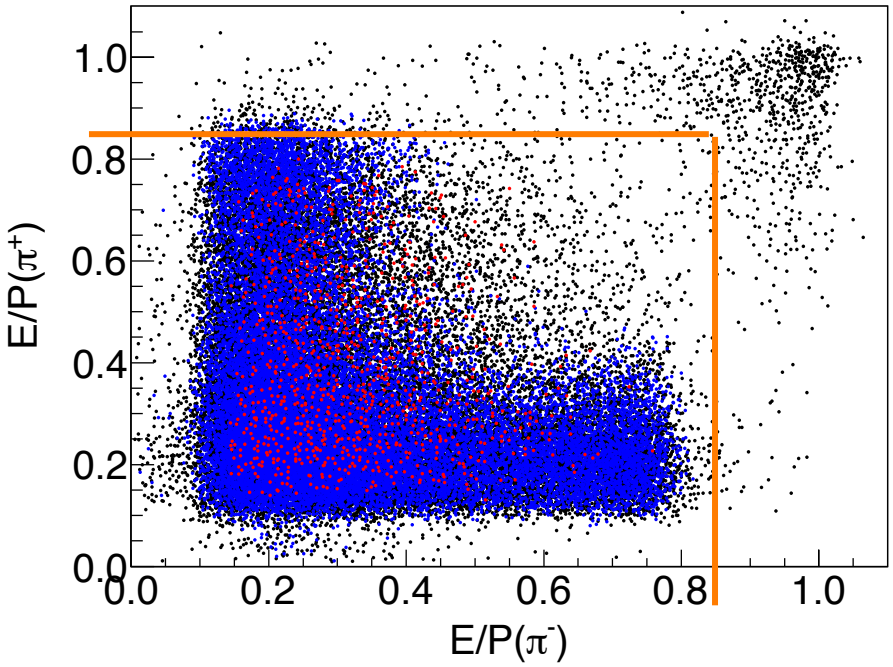


Background study

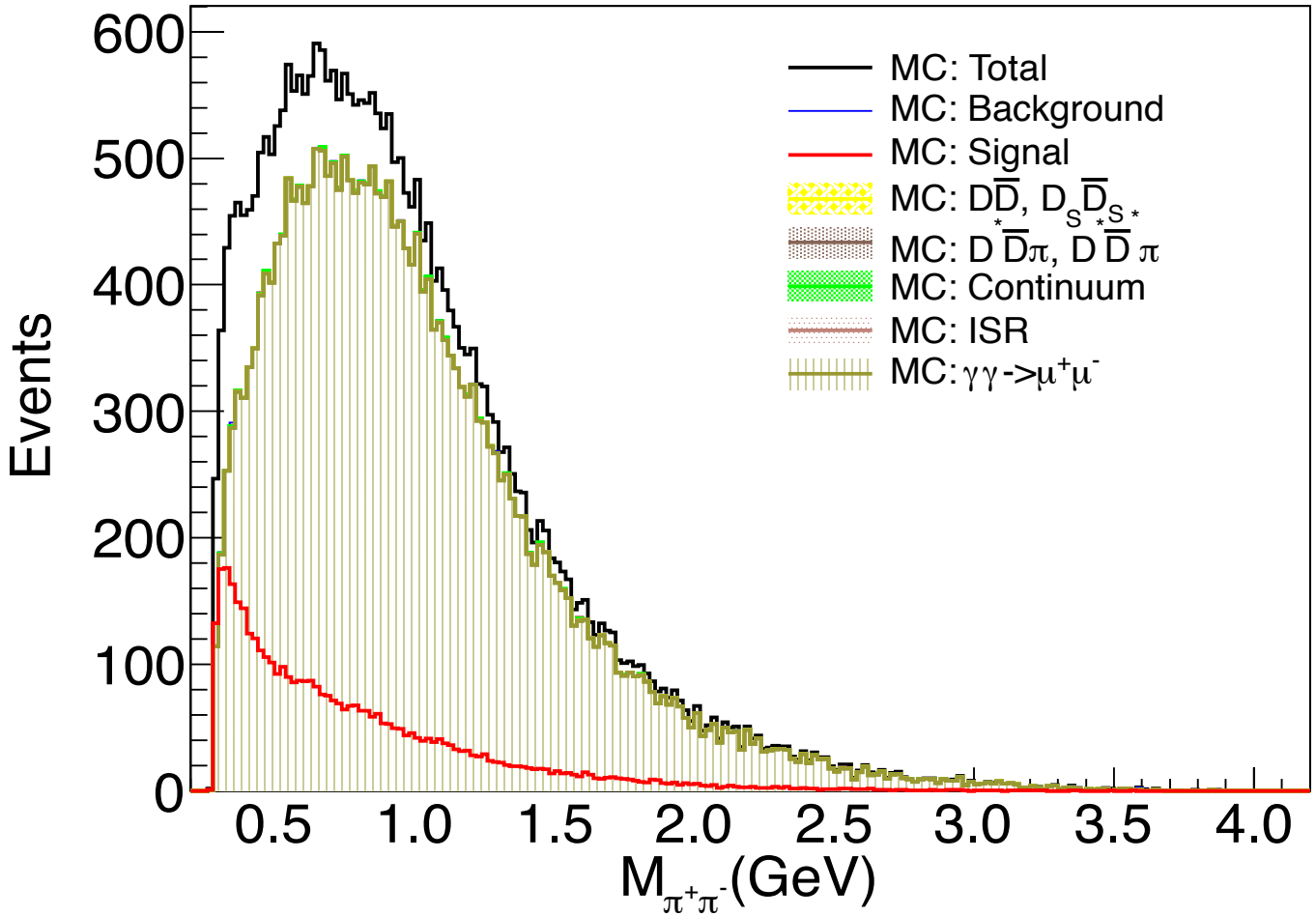
- Background from vector meson decay is at ~1% level
- Background from continuum process is at ~2% level
- Potential background:
  - $\gamma\gamma$ process, $\gamma\gamma \rightarrow e^+e^-$, $\gamma\gamma \rightarrow \mu^+\mu^-$, have much higher cross section at low mass region
  - $e^+e^- \rightarrow e^+e^-\pi^+\pi^-$, not through $\gamma\gamma$ process, contribute on the ρ peak

Background study

- $\gamma\gamma^{(*)} \rightarrow e^+e^-$
  - e^+/e^- deposited almost all the energy in EMC
  - E/P around 1
  - events remained need further check using MC simulation



Events after pre-selection

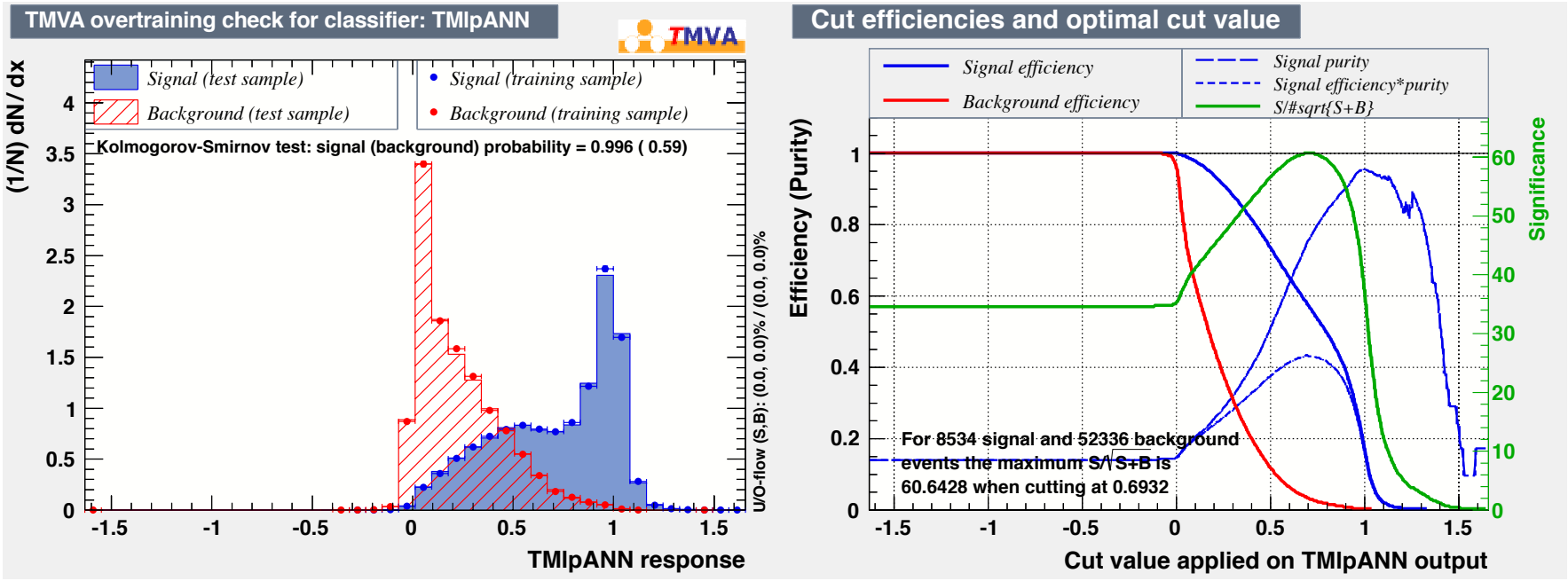


Background study: $\gamma\gamma^{(*)} \rightarrow \mu^+\mu^-$

- difficult to identify pions from muons
- A lot of low momentum tracks
- Artificial Neural Network (ANN) may help

- Input variables:
  - MDC: dE/dx
  - EMC: energy and shower shape
  - TOF: flight time
  - MUC: depth

Background study: $\gamma\gamma^{(*)} \rightarrow \mu^+\mu^-$

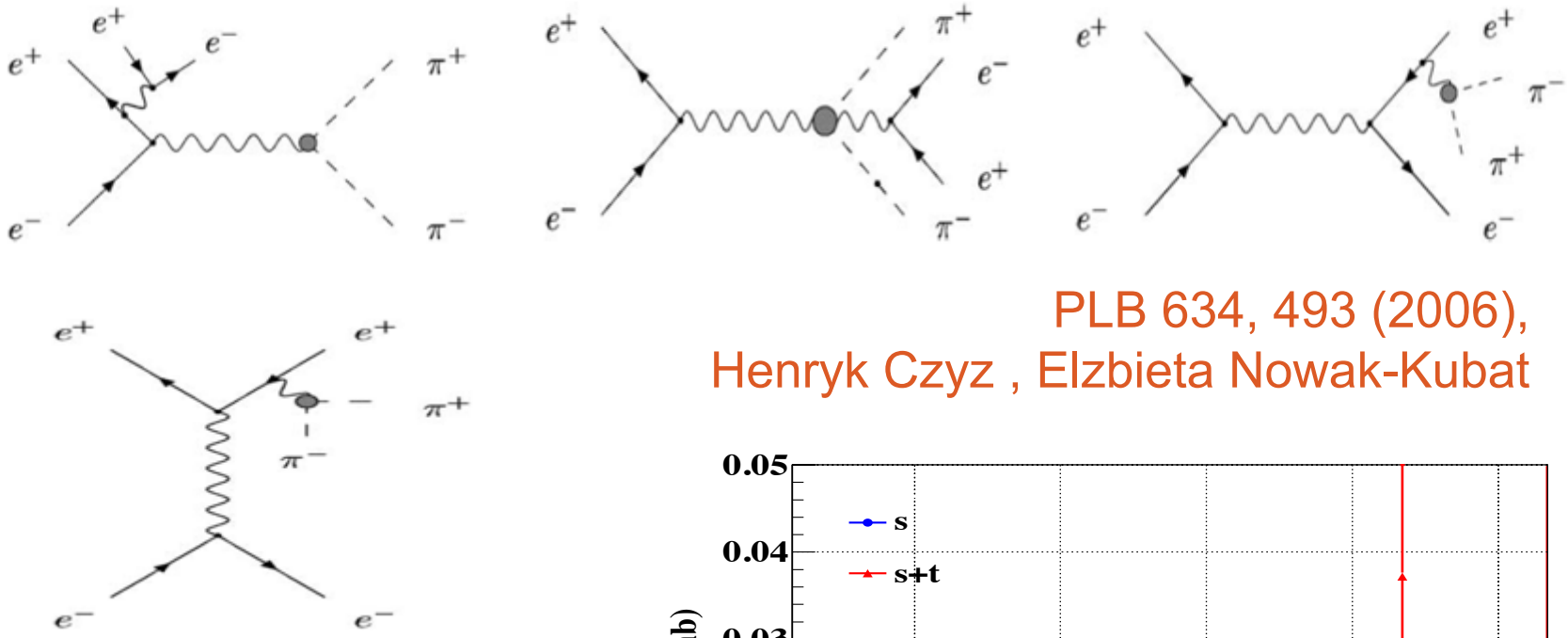


Cut on: 0.69

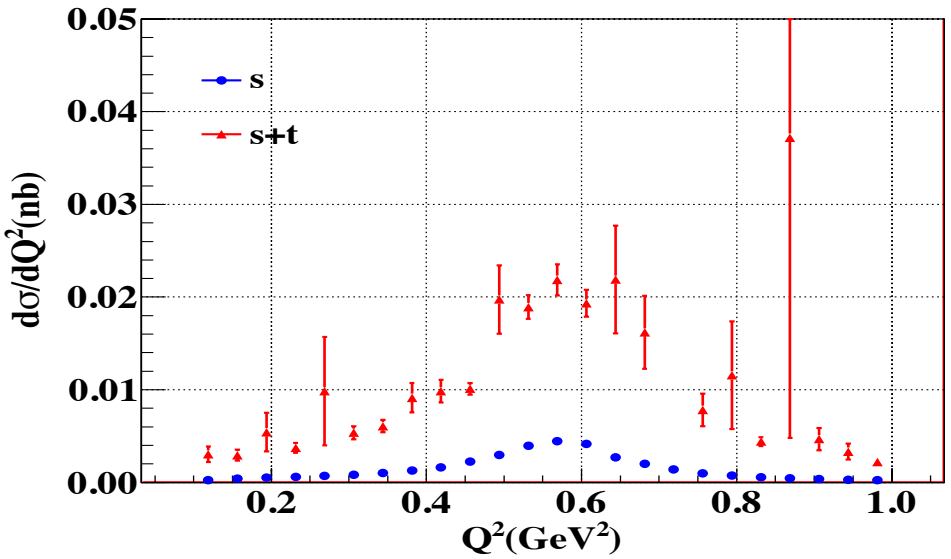
Background rejected: about 97% ; Signal loss: about 40%

Change the ratio of signal to background from 1:6 to 3:1

Background study: $e^+e^- \rightarrow e^+e^-\pi^+\pi^-$



PLB 634, 493 (2006),
Henryk Czyz , Elzbieta Nowak-Kubat



- Could be generated by EKHARA2.1
- Improvement needs

SUMMARY

- **First single tagged analysis launched at BESIII**
- **Get access to**
  - low Q^2 (from 0.2 GeV^2 to 2.0 GeV^2)
  - Low $\pi^+\pi^-$ mass region, starts from threshold up to 2.0 GeV
- **Roughly 9,000 signal events at 1 fb^{-1} 4230 data, expected accuracy 5-10%**
- **4 times larger data sample at the end of this run period**
- **Current status:**
  - Background understanding and signal events extraction

THANK YOU FOR THE ATTENTION!