Absolute Energy Calibration and Use of Time Information of the BESIII EMC

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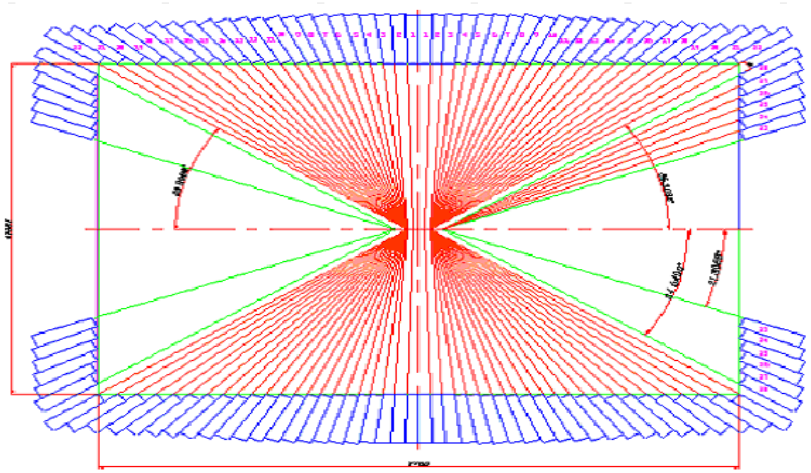
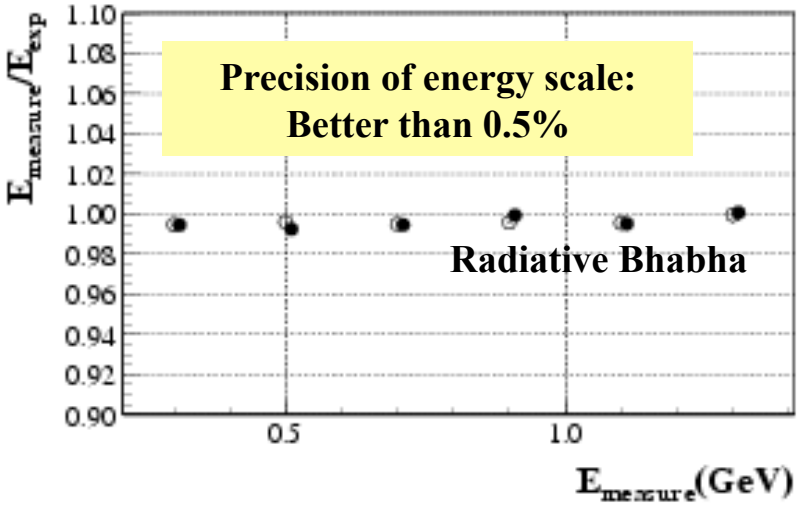
Outline

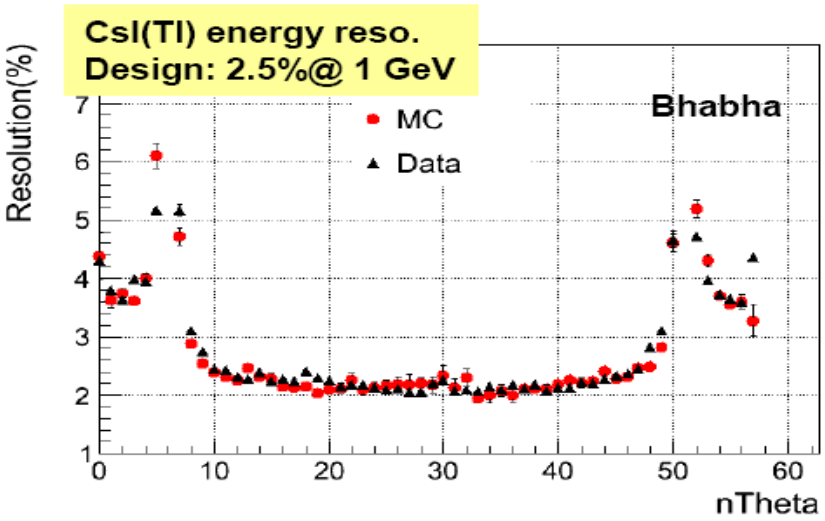
- BESIII Electro-Magnetic Calorimeter (EMC)
- Absolute photon energy calibration
- Use of time information of EMC for beam-related background veto
- Summary

BESIII Electro-Magnetic Calorimeter (EMC)



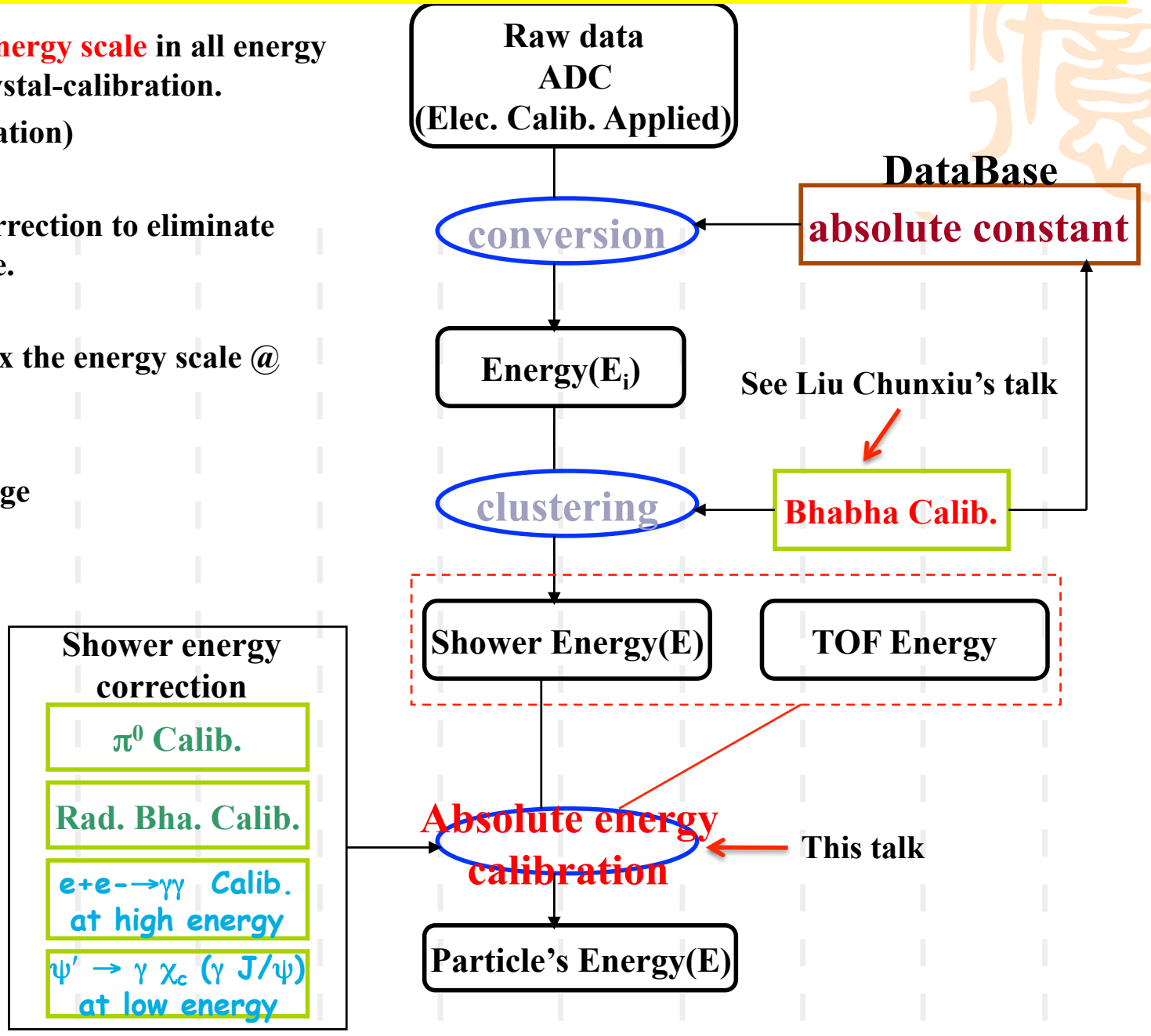


- Based on CsI(Tl) crystal
- Used to measure energy and position for electrons and photons
- Designed performance
  - Energy range：20MeV — 2GeV
  - Energy resolution: 2.5%@1GeV/c
  - Position resolution: 0.6 cm @ 1GeV/c
  - Provide neutral energy trigger
  - Good e/π identification above 200MeV/c
  - Equivalent electronics noise for each channel is less than 200KeV

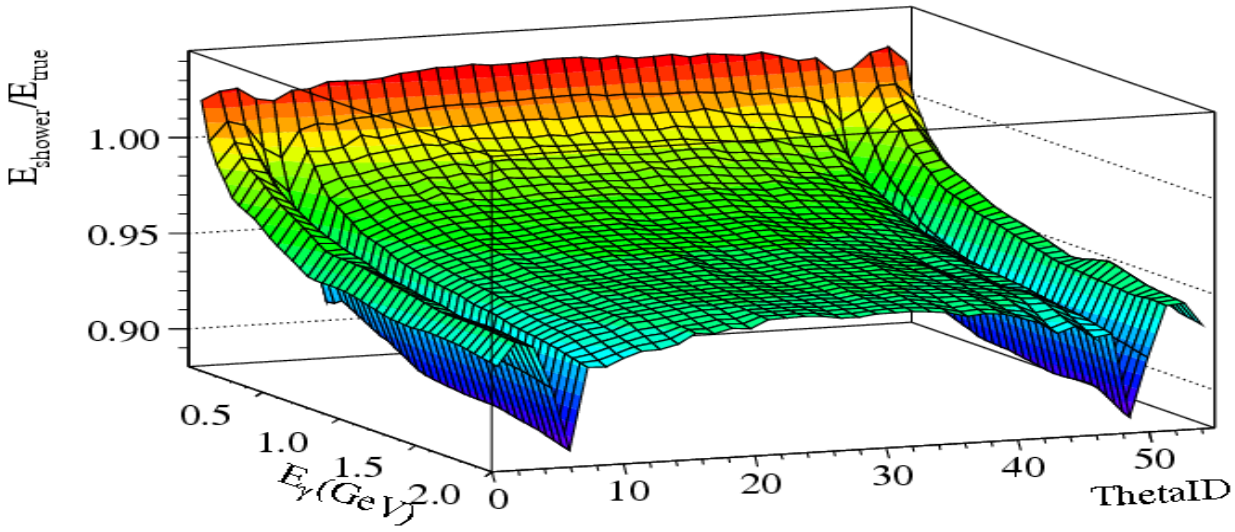


EMC Calibration Flow

- Purpose : to obtain energy scale in all energy range after single-crystal-calibration.
  (Bhabha - digi calibration)
- MC single photon correction to eliminate geometry dependence.
- Using di-gamma to fix the energy scale @ 1.843GeV.
- π^0 for low energy range
- Performance check:
  - $\psi' \rightarrow \gamma\chi_{c1,2}$
  - $e^+e^- \rightarrow e^+e^-\gamma$
  - $\psi' \rightarrow \pi^0\pi^0 J/\psi$



MC single photon correction



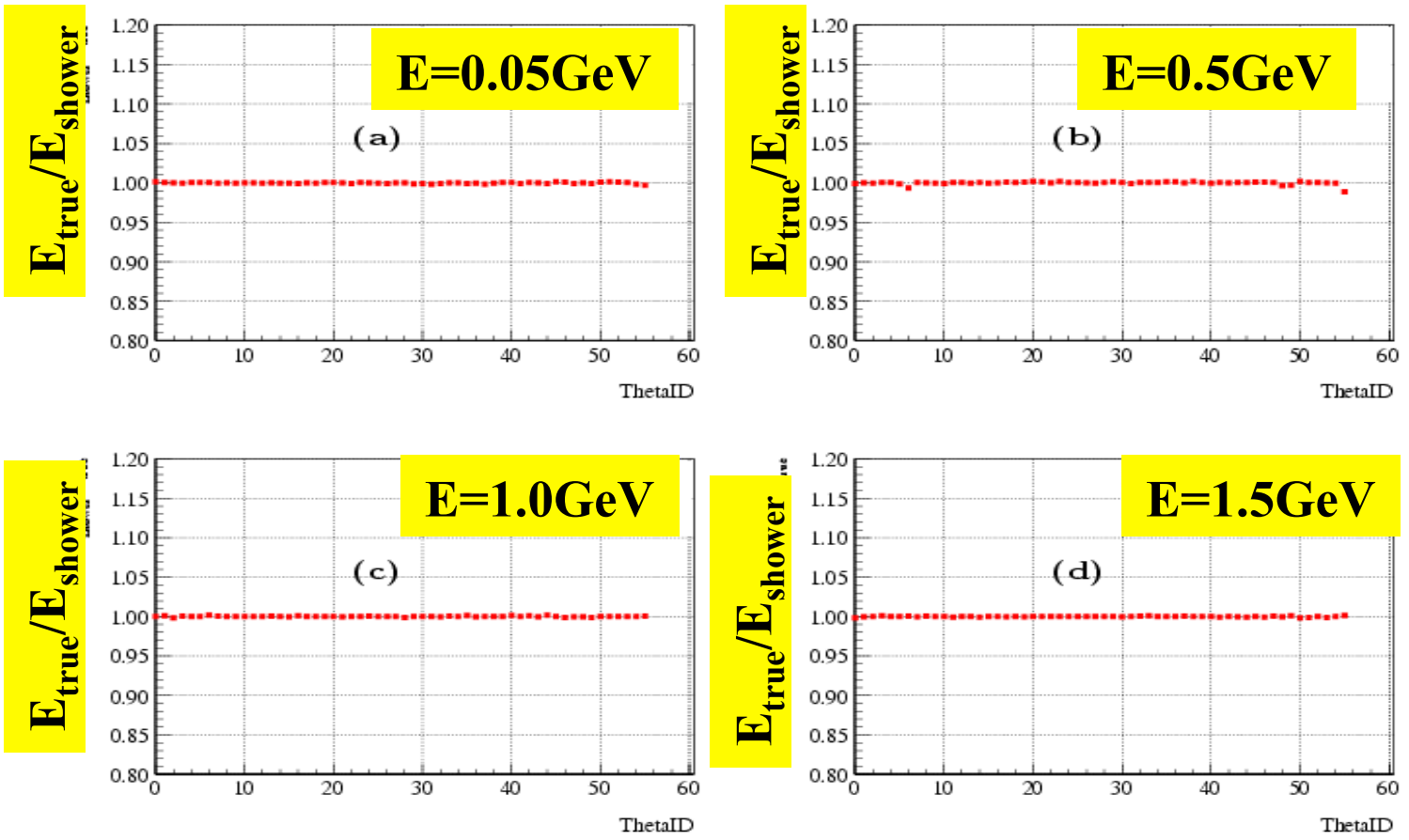
Correct MC shower energy peak to it's true value

Correct geometry dependence both in MC and DATA

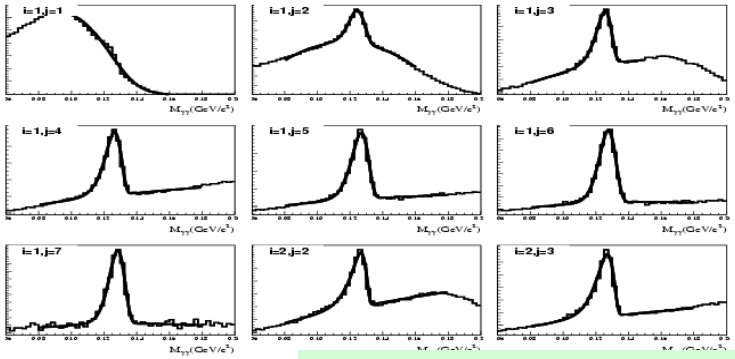
Use MC single photon from 0-2.0GeV to obtain correction factors and save them in a 2-D graph. Do an interpolation to obtain correction factors when reconstruct EMC shower energy

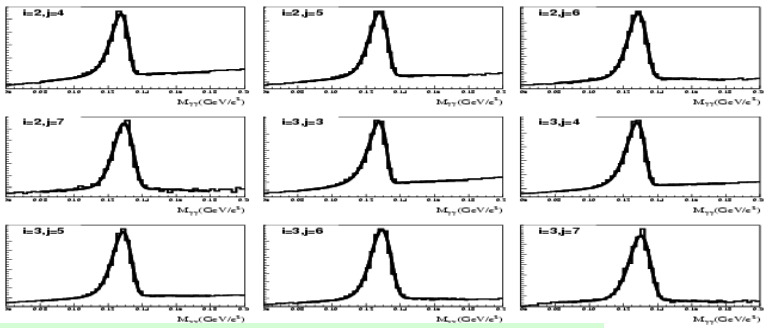
After MC correct for the geometry dependence, we further use $\pi^0 \rightarrow \gamma\gamma$ and $e^+e^- \rightarrow \gamma\gamma$ to correct energy dependence of the DATA/MC discrepancy

Theta dependence after MC single photon correction

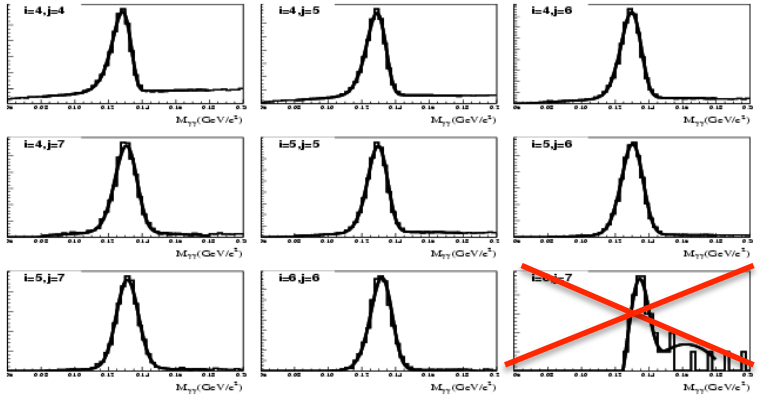


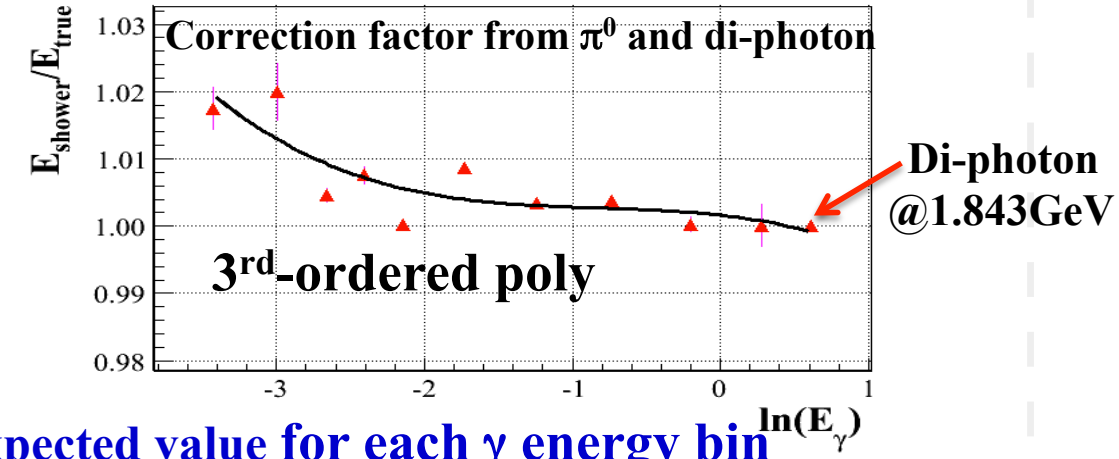
Calibration with $\pi^0 \rightarrow \gamma\gamma$ and $e^+e^- \rightarrow \gamma\gamma$





π^0 in different gamma energy bin combinations





- "Pull" the π^0 invariant mass to its expected value for each γ energy bin combination to extract photon energy scale
- Not sensitive to background.
- Not sensitive to resolution of photon.

Performance

Energy scale and resolution

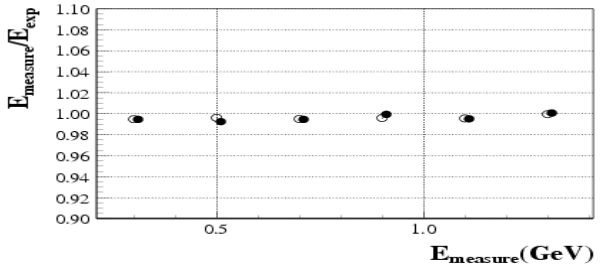
Fit result of $\psi' \to \gamma\chi_{c2} \to \gamma\gamma J/\psi$

	MC	DATA
E_γ(MeV)	127.48 ± 0.20	127.98 ± 0.14
σ_E(MeV)	3.71 ± 0.11	3.80 ± 0.07
σ_E/E_γ(%)	2.91 ± 0.08	2.97 ± 0.07

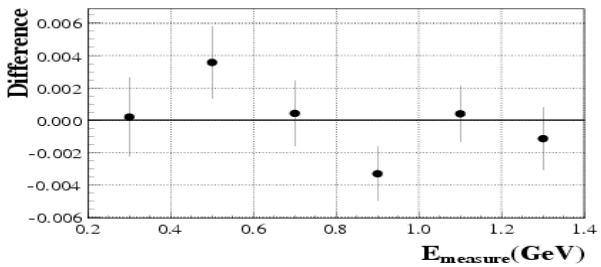
Fit result of $\psi' \to \gamma\chi_{c1}$

	MC	DATA
E_γ(MeV)	171.19 ± 0.10	171.36 ± 0.12
σ_E(MeV)	4.79 ± 0.06	5.00 ± 0.07
σ_E/E_γ(%)	2.80 ± 0.04	2.91 ± 0.04

$E_{measure}/E_{exp}$ in radative Bhabha (solid-data, circle-MC)

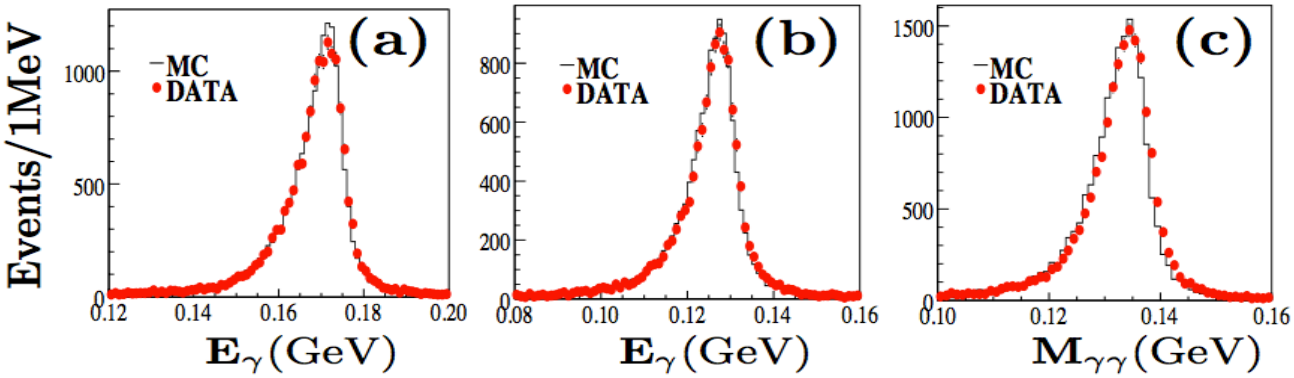


Difference in $E_{measure}/E_{exp}$ between DT/MC



DATA/MC
Energy scale ~0.5%
Energy resolution ~5%

Lineshape of γ and π^0

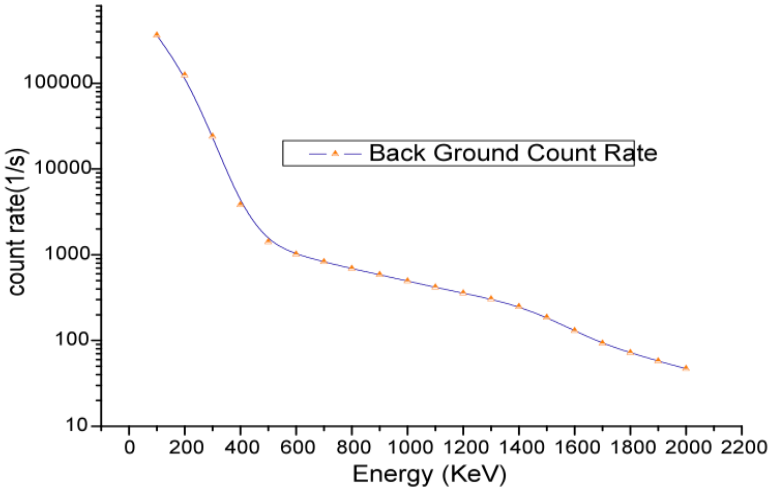


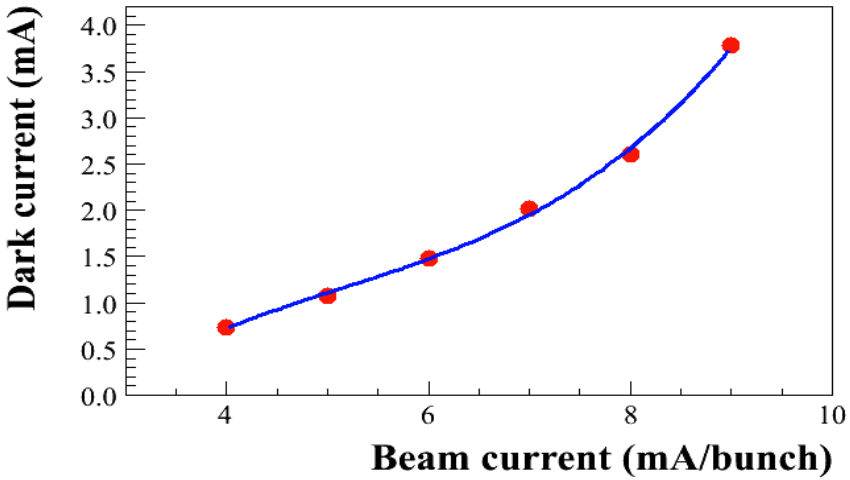
γ in $\psi' \to \gamma\chi_{c1}$ γ in $\psi' \to \gamma\chi_{c2}$ π^0 in $\psi' \to \pi^0\pi^0 J/\psi$

Use of EMC time information

- Physics analyses of BESIII which involve low energy photon such as $\psi' \rightarrow \pi^0 h_c$ ($p(\pi^0)$=84MeV), $\psi' \rightarrow \gamma \eta_c(2S)$ (E_γ=47MeV) need good photon-ID in low energy region.
- BEPC/BESIII has high luminosity, so it has relatively high beam-related background which is need to be suppressed when study low-energy photon.
- The peaking time of the energy deposit in the EMC is recorded in readout FADC of EMC with a precision of 50ns. Such a time stamp can be used to identify the energy deposit in coincidence with the beam-crossing, hence significantly reduce the backgrounds.

Beam-related background





Background count rate for one crystal as a function of energy.

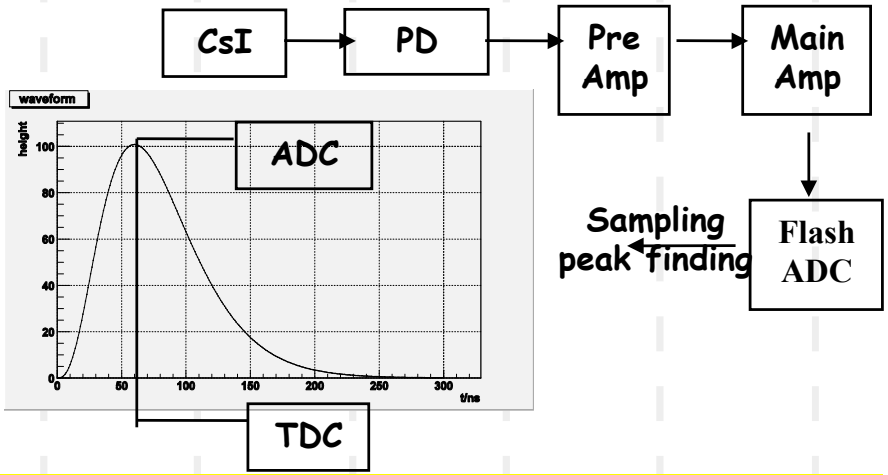
Dark current in MDC as a function of beam current.

High luminosity

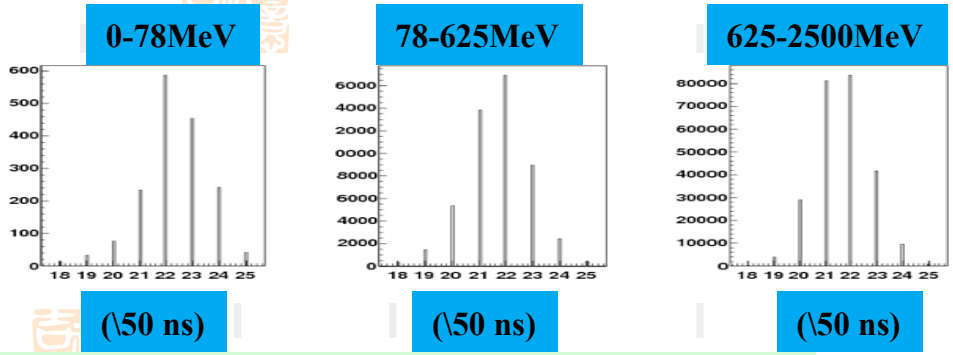
Low energy range

high beam-related background

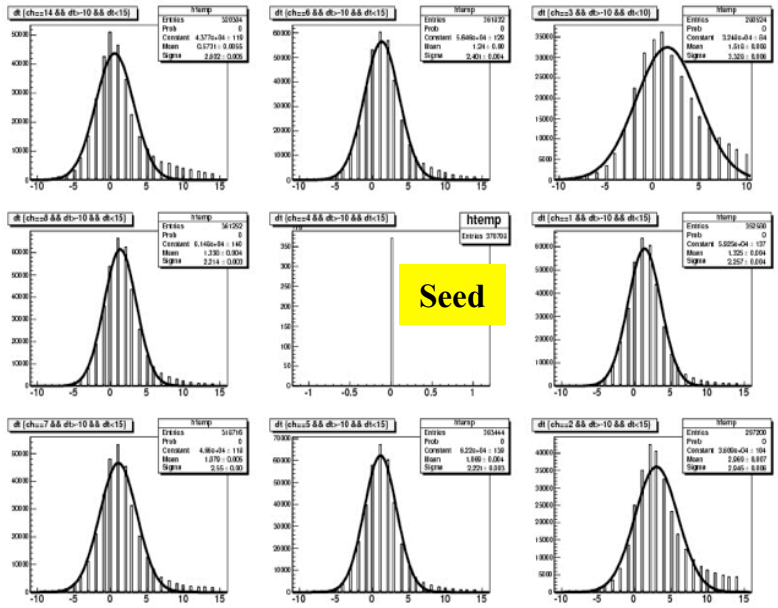
EMC time information of a crystal



The read out system of BESIII-CsI(Tl) calorimeter is based on FADC. The energy corresponds to the peak of signal waveform obtained by the scanning. In order to reduce the incoherent noise counts a time information can also be fetched by counting the timing step number in FADC with a precision of 50ns besides the read out of energy information.



The resolution of the time information for single-crystal in different energy ranges



The time difference between the seed crystal and other crystals in a 3X3 shower.

The time information of the seed will be reconstructed as the EMC time information of a shower

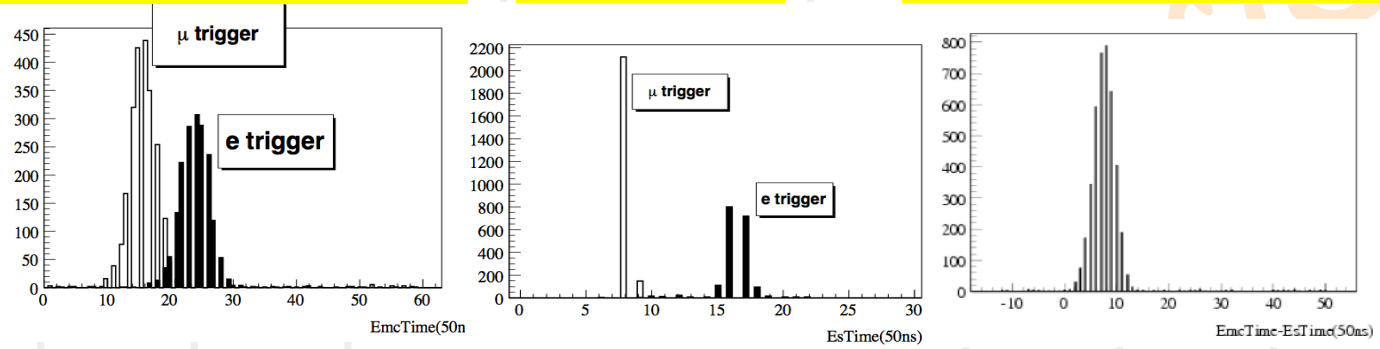
Time information of EMC shower

EMC TDC time (before subtract evt start time)

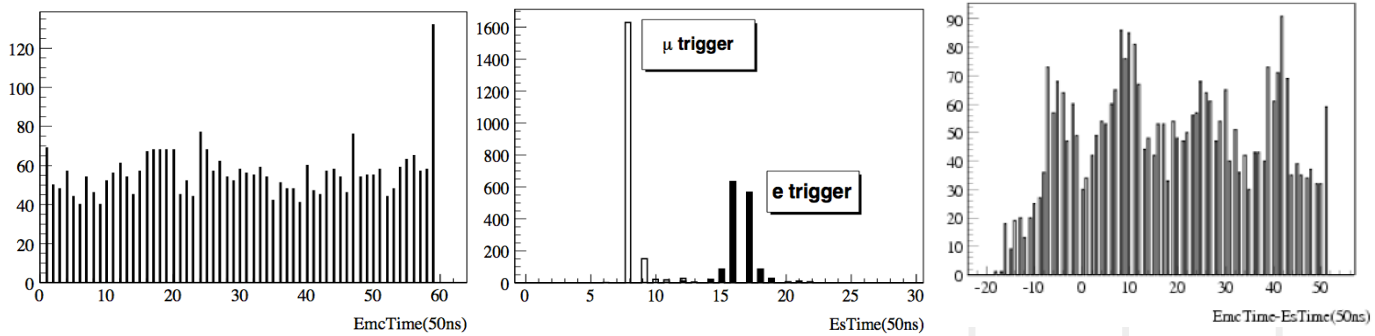
Event start time

EMC time used for physics analysis Emc TDC time – evt start time

Good photons



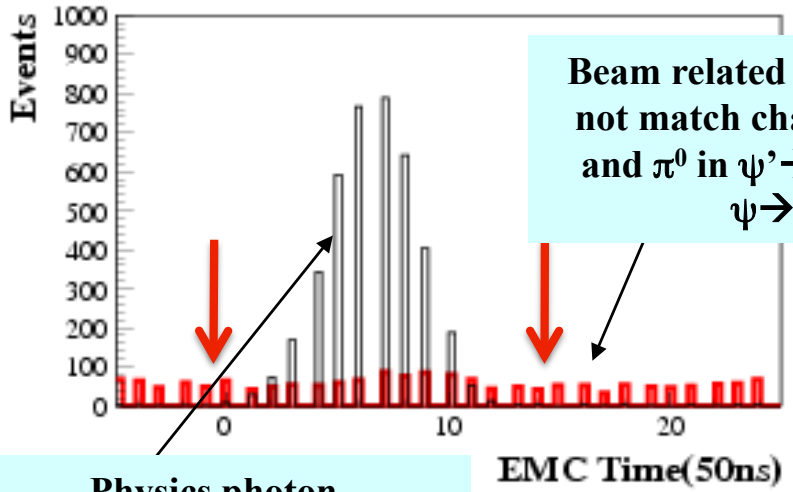
Fake photons



The raw EMC time is shifted by the trigger type, we use EMC Time minus Event Start Time to cancel this effect. The subtracted EMC time is used to distinguish physic photon and beam related bkg for physics analysis.

Use of time information for physics analysis

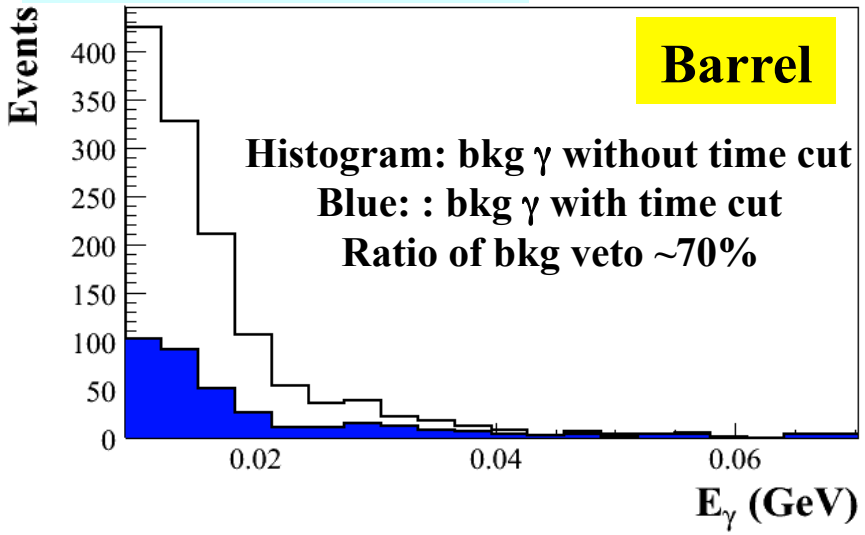
Cut: 0<=time<=14 * 50 ns

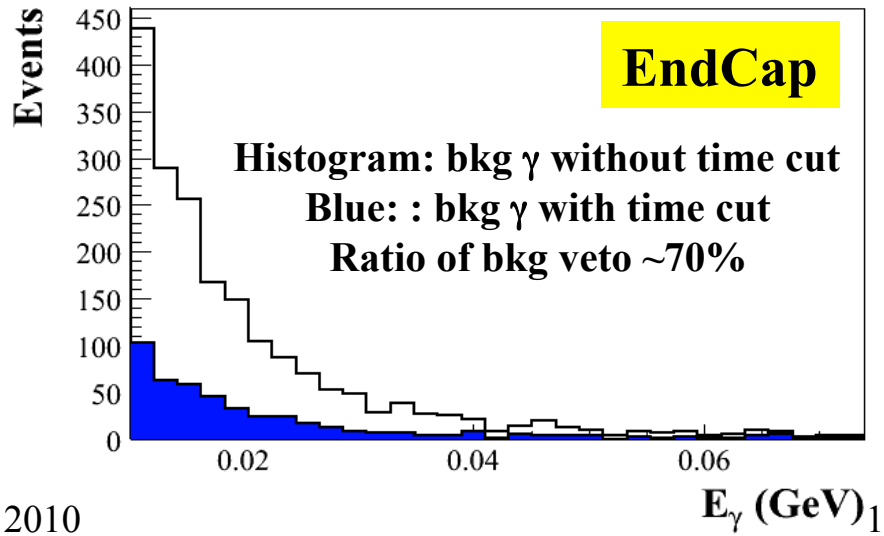


Beam related bkg, clusters not match charged tracks and π^0 in $\psi' \rightarrow \pi^0\pi^0 J/\psi$, $J/\psi \rightarrow l^+l^-$

Physics photon, from $\psi' \rightarrow \pi^0\pi^0 J/\psi$, $J/\psi \rightarrow l^+l^-$

The beam-related background can be suppressed significantly with a cut for time information.

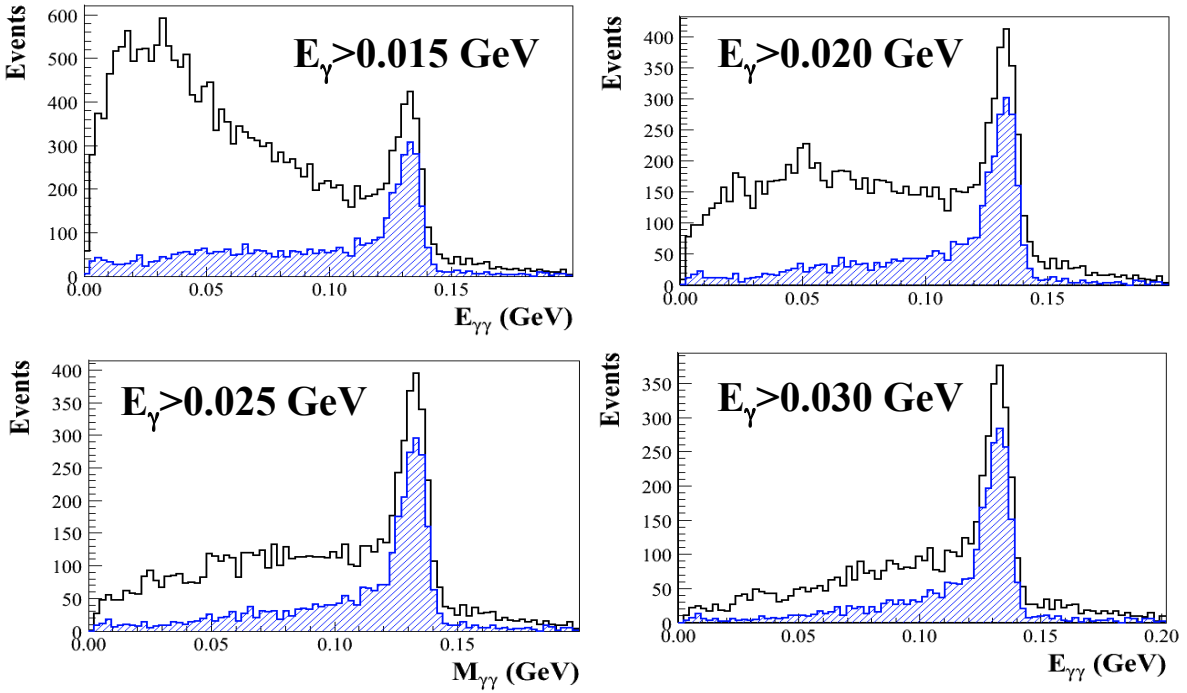




Low momentum π^0 in $\psi' \rightarrow \pi^0\pi^0 J/\psi$ process before/after using the time information cut

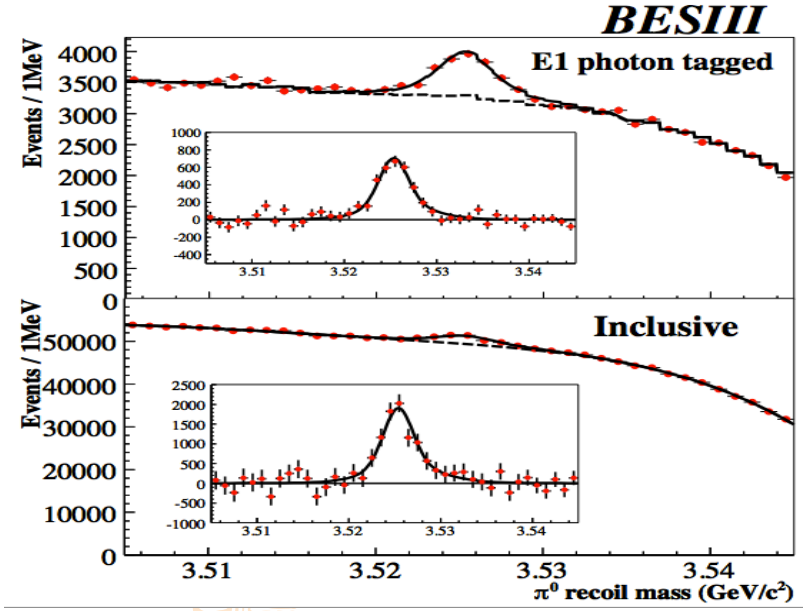
Cut: 0<=time<=14 * 50ns
Histogram: without time cut
Blue shade :applying time cut

$P(\pi^0)$ = 0.05 – 0.2 GeV
For different photon energy cuts random combination bkg. of π^0 can be suppressed significantly



Physics applications

Inclusive analysis of $\psi' \rightarrow \pi^0 h_c$
PRL104,132002(2010)



The use of time is crucial for us to solve the beam related background in EMC due to the high luminosity at BESIII

With the help of the time information, we have performed the inclusive analysis of $\psi' \rightarrow \pi^0 h_c$ which includes a very low momentum π^0 ($p(\pi^0)$ ~84MeV).
The exclusive analysis of $\psi' \rightarrow \pi^0 h_c$ and
the analysis of $\psi' \rightarrow \gamma \eta_c(2S)$ (E_γ=47 MeV) are ongoing

Summary

- After absolute energy calibration, precision of energy measurement reaches 0.5%.
- Energy scales and lineshapes of neutral tracks have good DATA/MC agreements.
- Time information is very useful for beam-related bkg veto at BESIII.

Thank You!