Measurement of the cross section of $e^+e^- \to \Omega^-\bar{\Omega}^+$

Bin Wang, Xin Mo, Matt Kurth, Xinchou Lou

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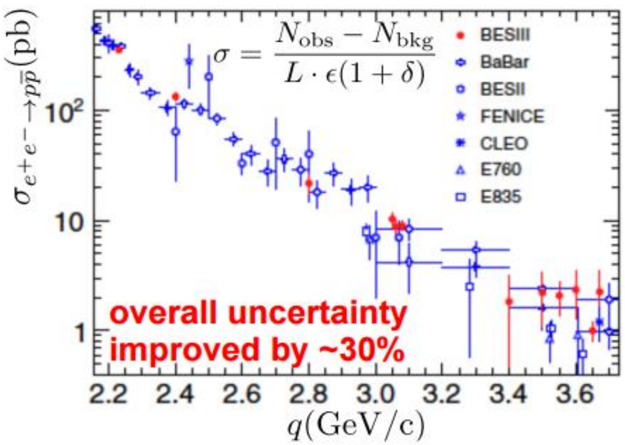
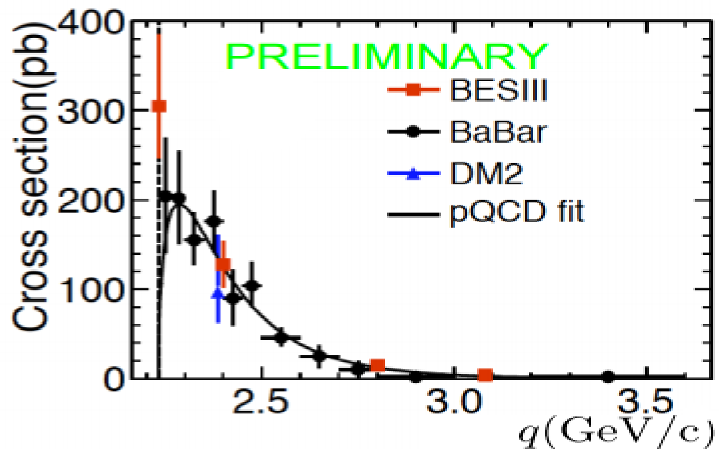
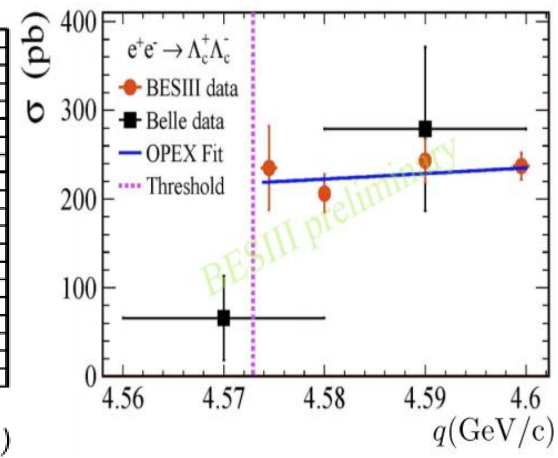
Motivation I

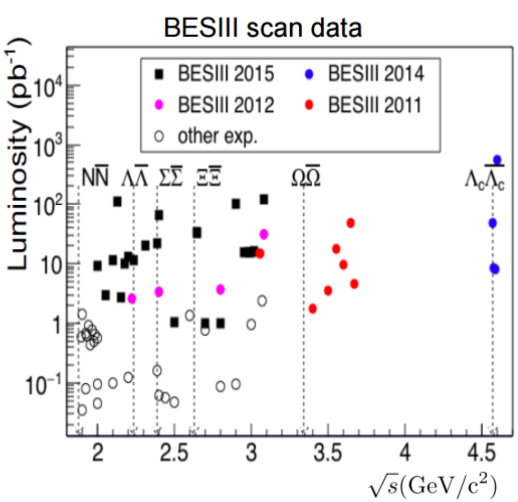
- BESIII has measured the cross section of $e^+e^- \to p\bar{p}$, $\Lambda\bar{\Lambda}$, and $\Lambda_c^+\bar{\Lambda}_c^+$.







All of plots in this page are from BESIII particle talks



What about other baryon pair production?

- Measurement of the cross section of $e^+e^- \to \Omega^-\bar{\Omega}^+$ at BESIII data.
- It is the first measurement of $e^+e^- \to \Omega^-\bar{\Omega}^+$.

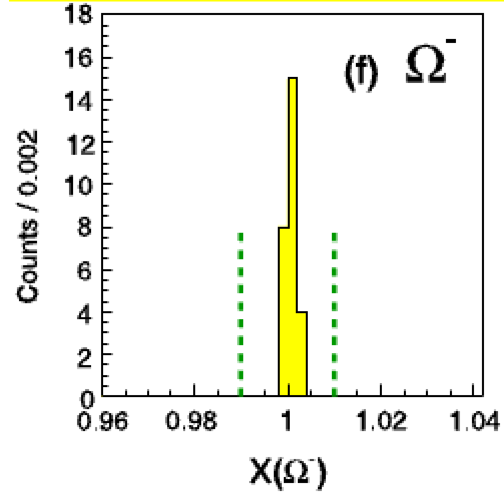
Motivation II

$\Gamma(\Omega^-\overline{\Omega}^+)/\Gamma_{total}$ — $\psi(2S) \to \Omega^-\overline{\Omega}^+$ result at PDG 2016 — Γ_{40}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.47±0.09±0.05		27	[1] DOBBS	14		$e^+e^- \to \psi(2S) \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.5	90		ABLIKIM	12Q	BES2	$e^+e^- \to \psi(2S) \to$ hadrons
<1.6	90		PEDLAR	05	CLEO	$e^+e^- \to \psi(2S) \to$ hadrons
<0.73	90		[2] BAI	01	BES	$e^+e^- \to \psi(2S) \to$ hadrons

[1] Using CLEO-c data but not authored by the CLEO Collaboration.
[2] Estimated using $B(\psi(2S) \to J/\psi\pi^+\pi^-) = 0.310 \pm 0.028$.

S. Dobbs *et al*., Physics Letters B 739 (2014) 90–94



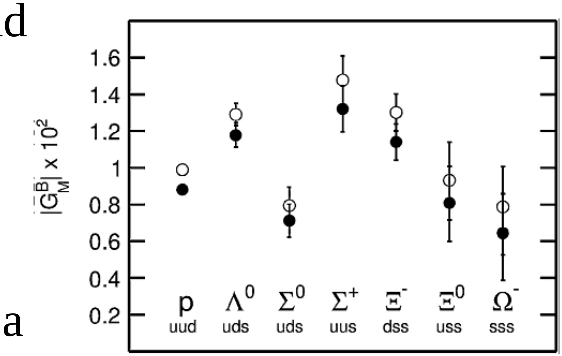


Fig. 4. Magnetic form factors $|G_M^B| \times 10^2$ for proton and hyperons for $|Q^2| = 14.2\ \mathrm{GeV}^2$. The closed circles correspond to the assumption $|G_M^B| = |G_E^B|$, and the open circles to the assumption $|G_E^B| = 0$.

- There is few results of $\Omega^-\overline{\Omega}^+$ production. CLEO-c and BESII have measured this process, while few signal events are extracted.
- BESIII has collected large integrated luminosities of $\psi(2S)$, $\psi(3770)$ and XYZ data samples, we can get a more precise result and measure the cross section of $\Omega^-\overline{\Omega}^+$ process above 4.0 GeV.

Data and MC samples

- Data samples:

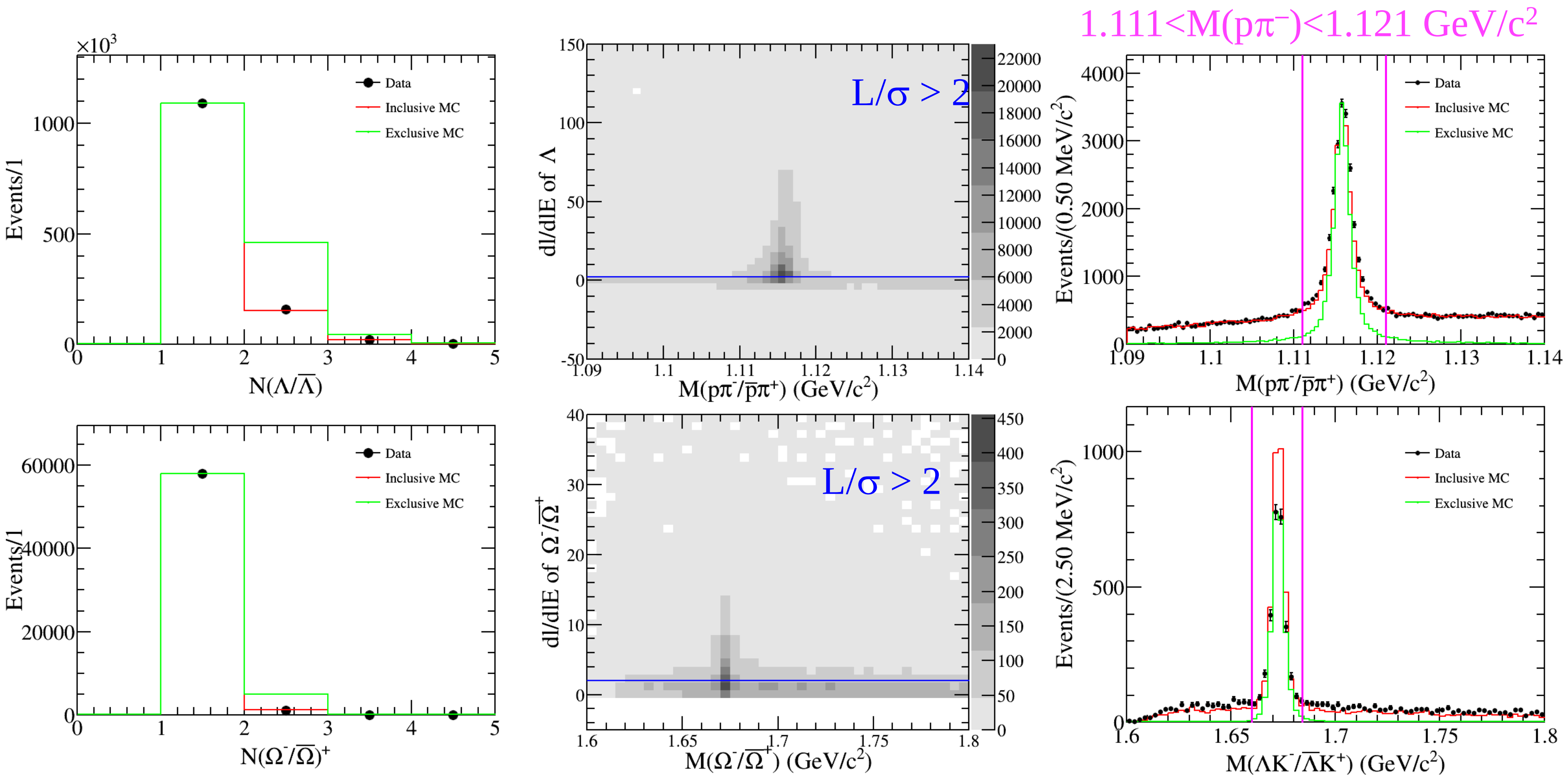
Energy (MeV)	Luminosity (pb^{-1})	Analysis Environment	Energy (MeV)	Luminosity (pb^{-1})	Analysis Environment
$\psi(3686)$	2012	BOSS6.6.4.p01	4226.3	1091.7	BOSS6.6.4.p01
$\psi(3770)$	2.93	BOSS6.6.4.p02	4237	529.0	BOSS7.0.2.p01
4007.6	481.96	BOSS6.6.4.p01	4247	?	BOSS7.0.2.p01
4180	3160	BOSS7.0.2.p01	4258	825.7	BOSS6.6.4.p01
4190	517.5	BOSS7.0.2.p01	4358.3	539.8	BOSS6.6.4.p01
4200	519.4	BOSS7.0.2.p01	4415.6	1073.6	BOSS6.6.4.p01
4210	509.0	BOSS7.0.2.p01	4599.5	566.9	BOSS6.6.4.p01
4220	508.5	BOSS7.0.2.p01			

- MC samples:
  - Inclusive MC: $\psi(3686)$ and $\sqrt{s}$=4.2263 GeV.
  - Exclusive MC (0.1M): $e^+e^- \to \Omega^-\bar{\Omega}^+, \Omega^- \to \Lambda K^-, \bar{\Omega}^+ \to anything$, [PHSP/J2BB2, optimize in the future].

Event selection

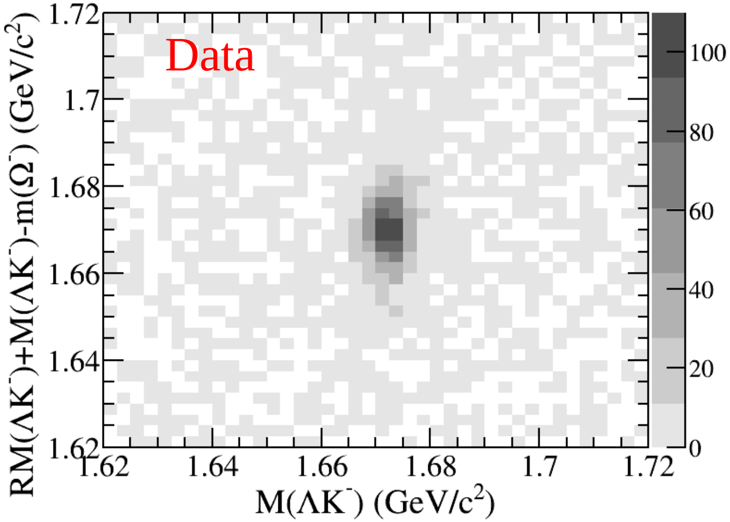
- At least three charged tracks are required and their polar angles θ must satisfy $|\cos\theta| < 0.93$;
- $K^{\pm}$ list: $\mathcal{L}$(K) > $\mathcal{L}(\boldsymbol{\pi})$, $\mathcal{L}$(K) > 0;
- Proton list: $\mathcal{L}$(p) > 0, $\mathcal{L}$(p)>$\mathcal{L}$(K) and $\mathcal{L}$(p)>$\mathcal{L}(\boldsymbol{\pi})$;
- Loop the remaining charged tracks to find an charged pion and then reconstruct the $\Lambda/\overline{\Lambda}$;
- Loop all of $K^{\pm}$ and $\Lambda/\overline{\Lambda}$ candidates and perform a vertex fit for $K^{\pm}\Lambda$ (include the wrong sign (WS) candidates) and a secondary vertex fit for Ω^{-};
- The decay lengths of $\Lambda/\overline{\Lambda}$ and Ω^{-} must satisfy L/σ > 2;
- If there is more than one Ω^{-} candidates, the candidate with minimum χ^2 is selected.

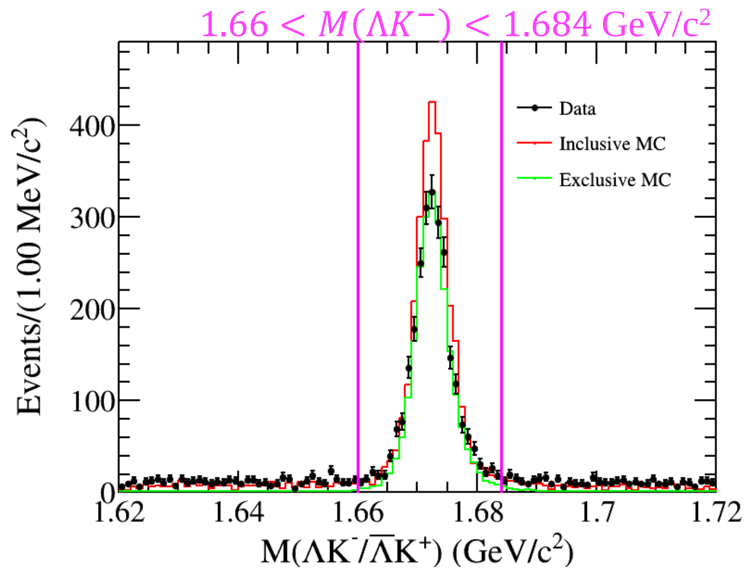
Event selection

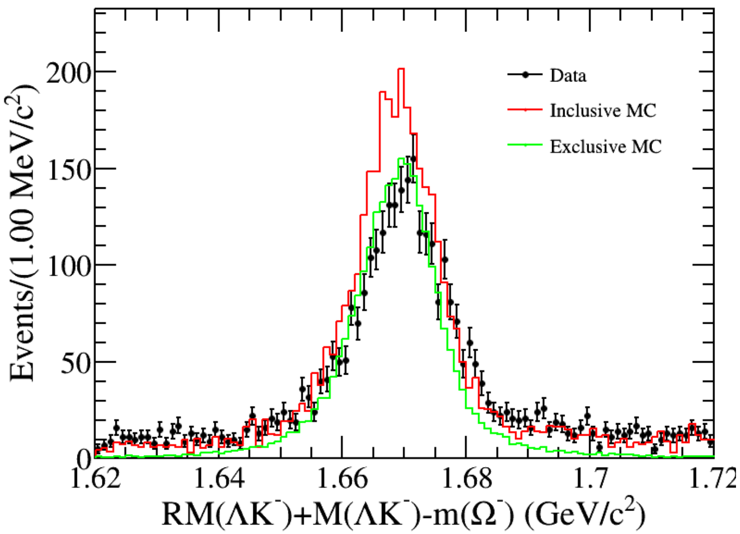


- Ω^- peak is clearly visible in the distributions of $M(\Lambda K^- \,/\, \bar{\Lambda} K^+)$ for data and MC samples.
- It has an enhancement near the threshold of $\Lambda K^- \,/\, \bar{\Lambda} K^+$ system for data.

Event selection

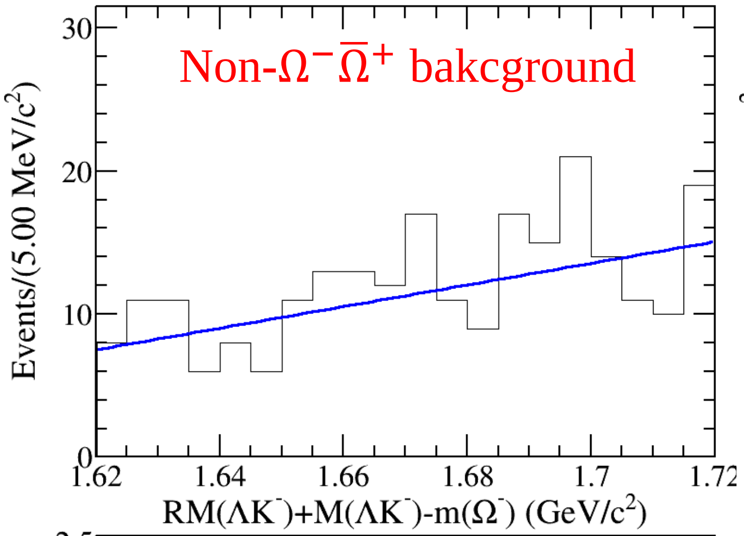


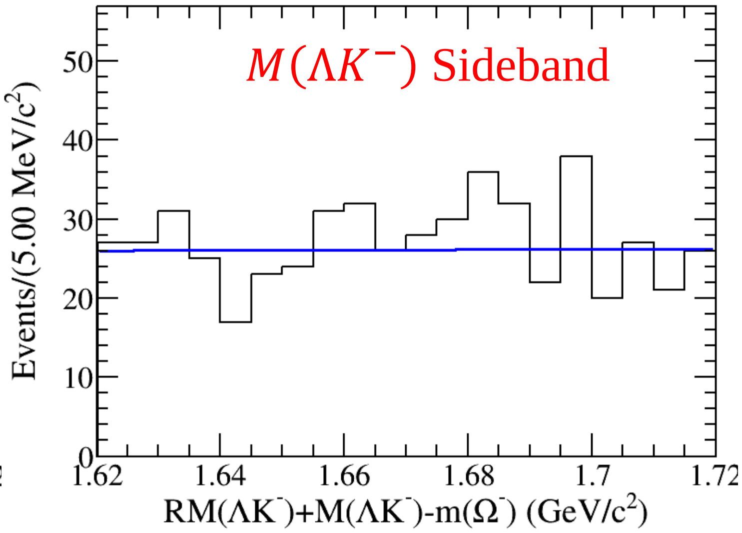


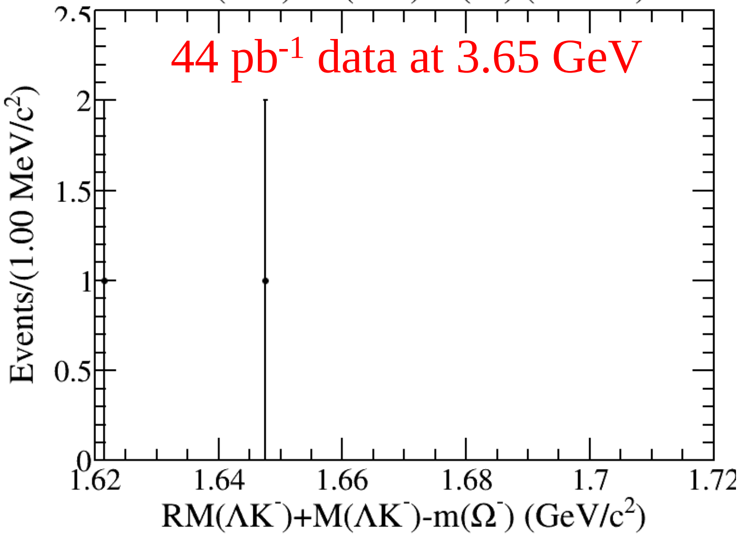


There is an enhancement corresponding to $e^+e^- \to \Omega^-\bar{\Omega}^+$ in the 2D plots $M(\Lambda K^-)$ versus R$M(\Lambda K^-) + M(\Lambda K^-) - m(\Omega^-)$ for data and inclusive MC, where R$M(\Lambda K^-)$ is the recoil mass of ΛK^-, $m(\Omega^-)$ is world average value of Ω^- mass.

Background study

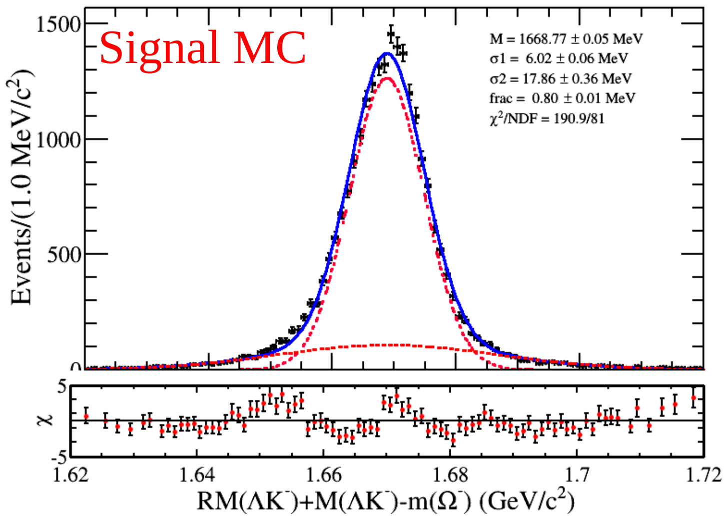


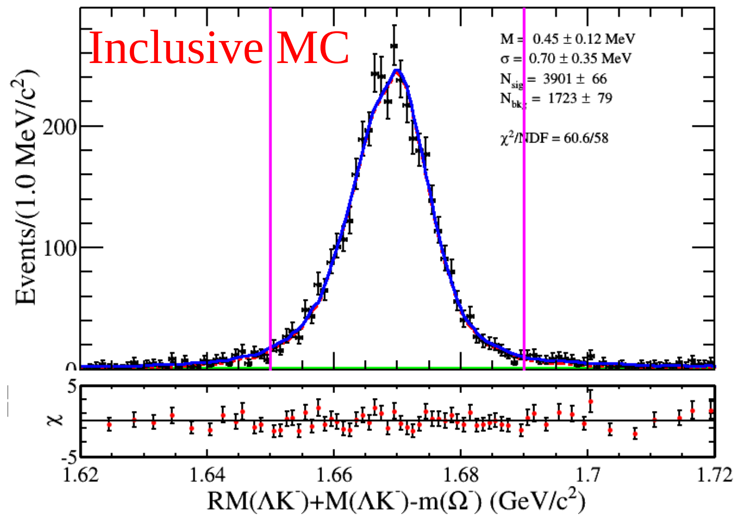


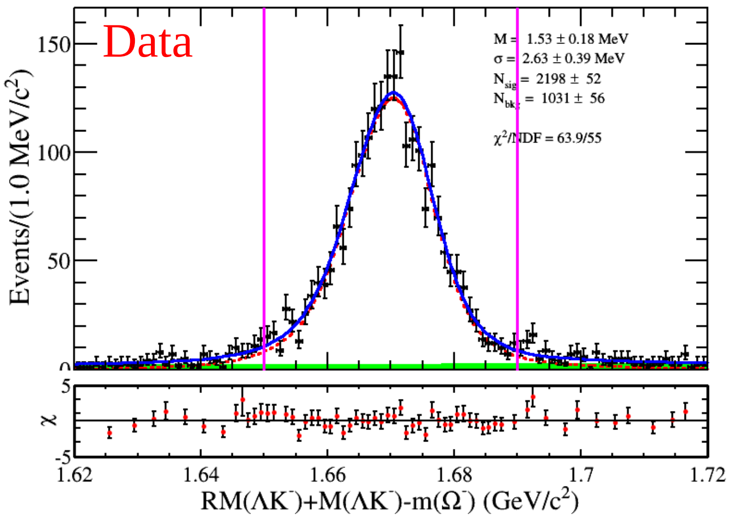


The background events have a smooth shape and can be describe by an first order polynomial function.

Signal extraction

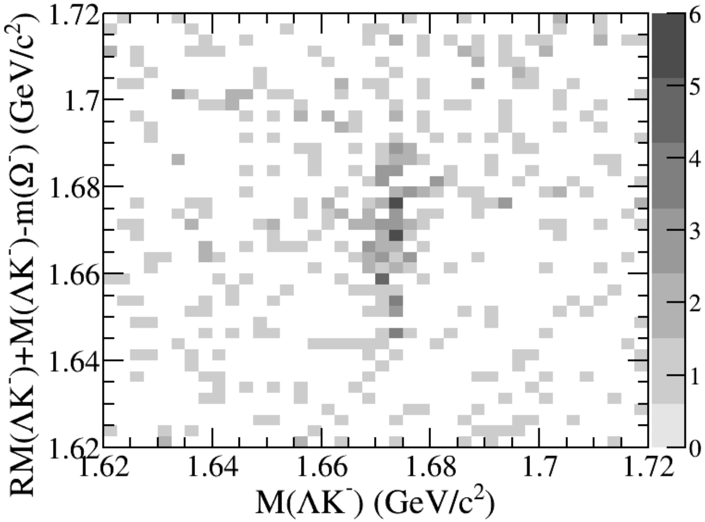


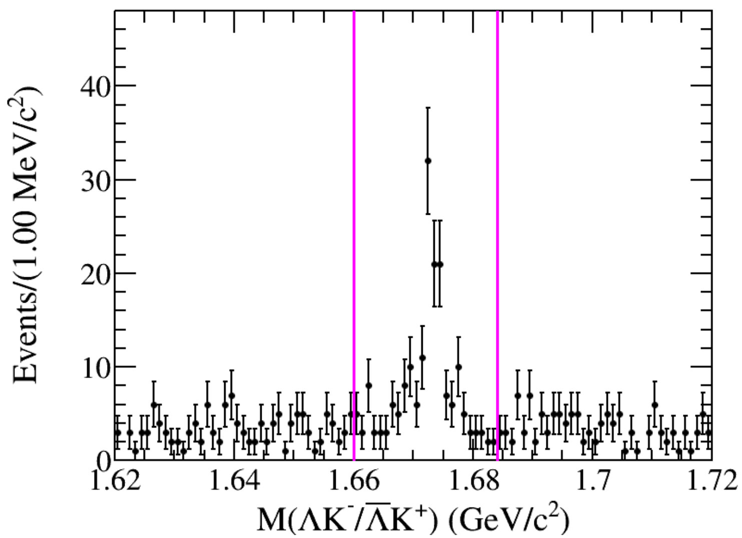


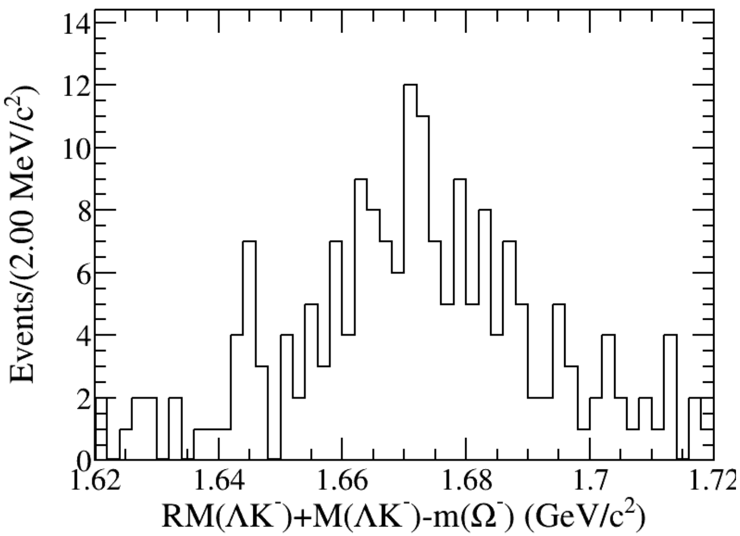


- Signal shape: Signal MC convoluted with a Gaussian function
- Background shape: 1st order polynomial
- Signal mass window: [1.65, 1.69] GeV/c^2
- Fit to inclusive MC: 3901$\pm$66 [Expected: 3984].
- Fit to data sample: 2198$\pm$52

Signal extraction for other data





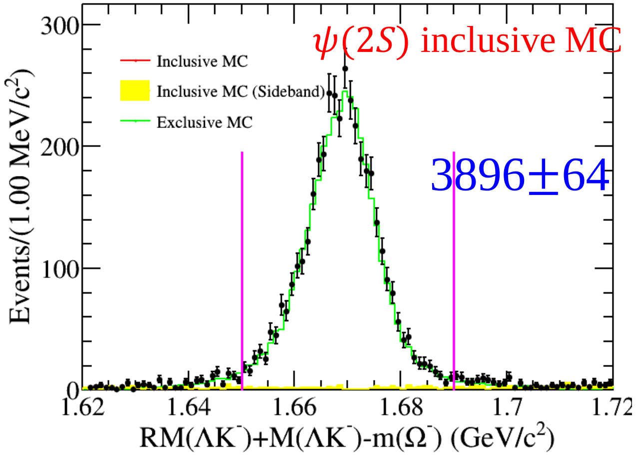


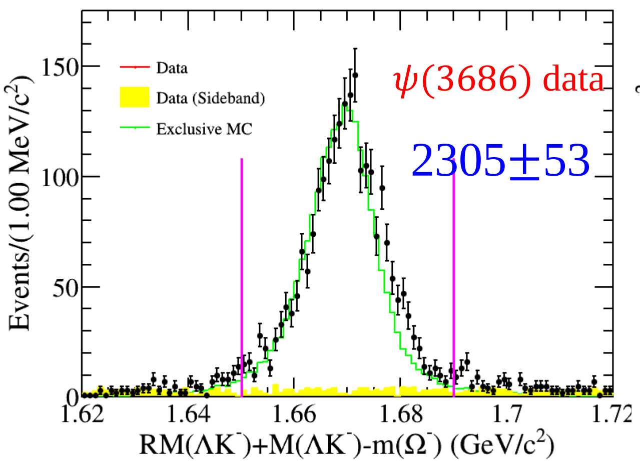
$e^+e^- \to \Omega^-\overline{\Omega}^+$ process is clearly visible in the $M(\Lambda K^-)$ and R$M(\Lambda K^-) + M(\Lambda K^-) - m(\Omega^-)$ distributions.

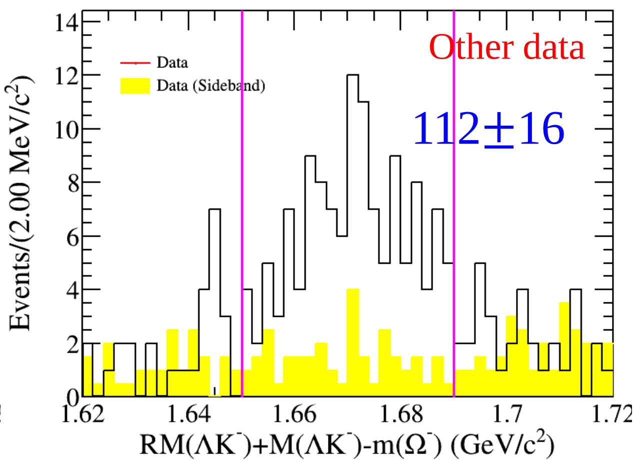
Signal extraction for other data

$$N^{sig}_{\Omega^-\bar{\Omega}^+} = N^{signal} - f \cdot N^{sideband}$$

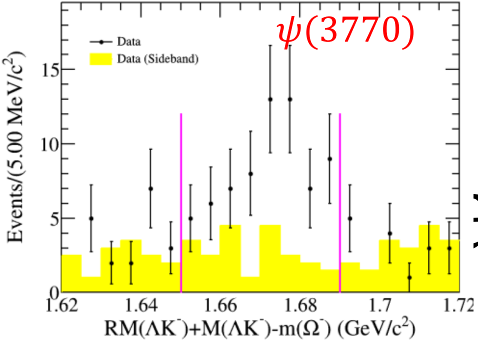
- $N^{sig}_{\Omega^-\bar{\Omega}^+}$ is the signal yield of $e^+e^- \to \Omega^-\bar{\Omega}^+$;
- N^{signal} is the number of events in R$M(\Lambda K^-) + M(\Lambda K^-) - m(\Omega^-)$ signal region;
- $N^{sideband}$ is the number of events in $M(\Lambda K^-)$ sideband region, which is [1.62, 1.644] GeV/c^2 and [1.696, 1.72] GeV/c^2;
- f is the scale factor (0.5).







Using the counting method, the signal yield of $e^+e^- \to \Omega^-\bar{\Omega}^+$ at $\psi(3686)$ data and other data sets are 2305$\pm$53 and 112 $\pm$ 16, respectively.



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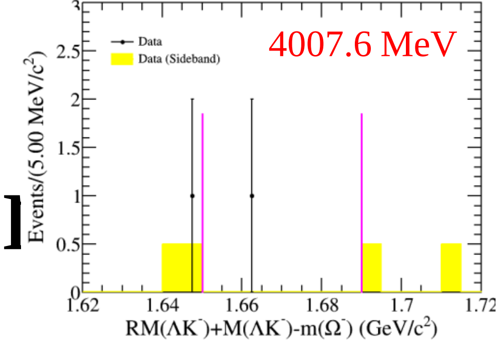
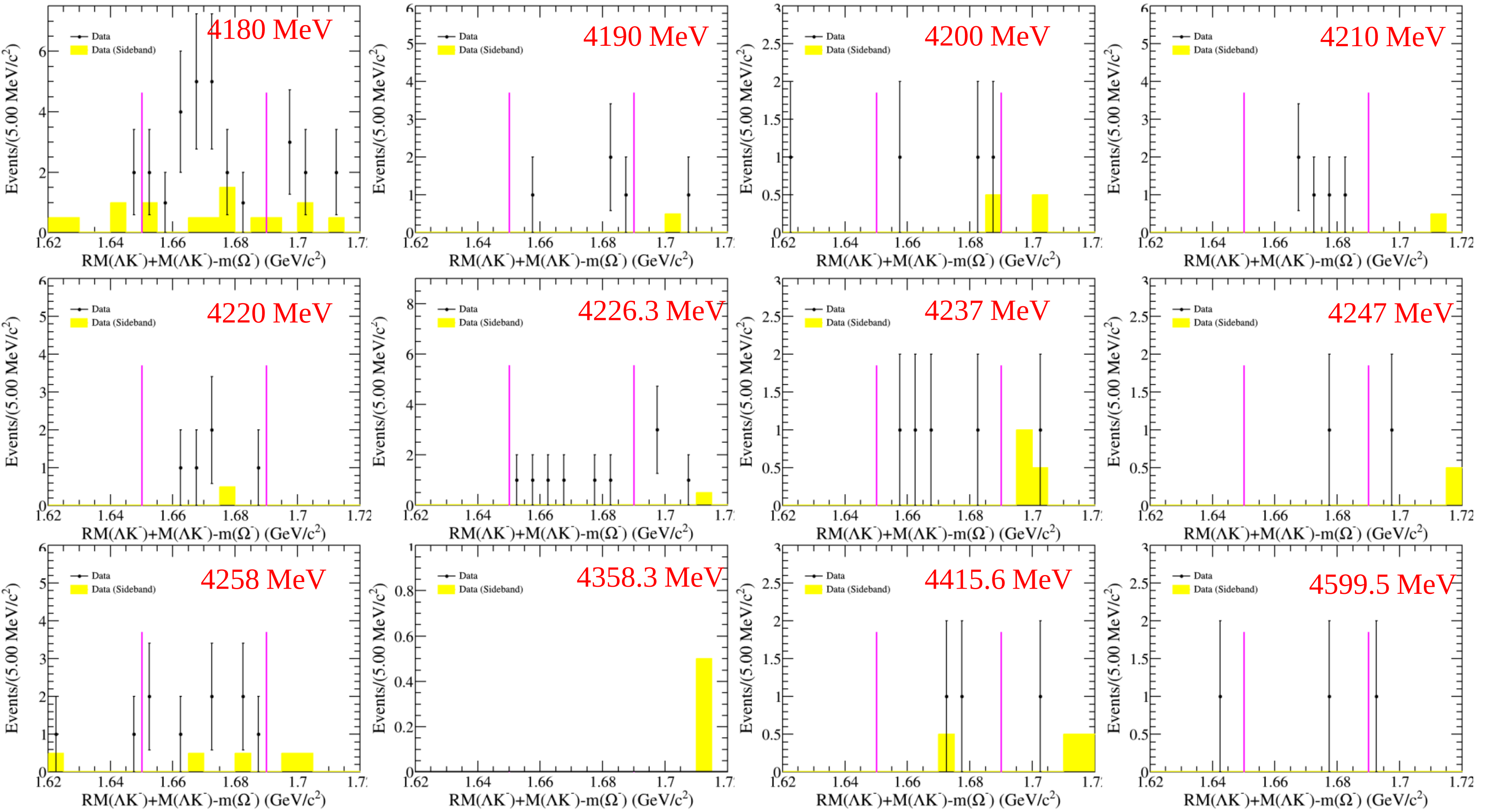




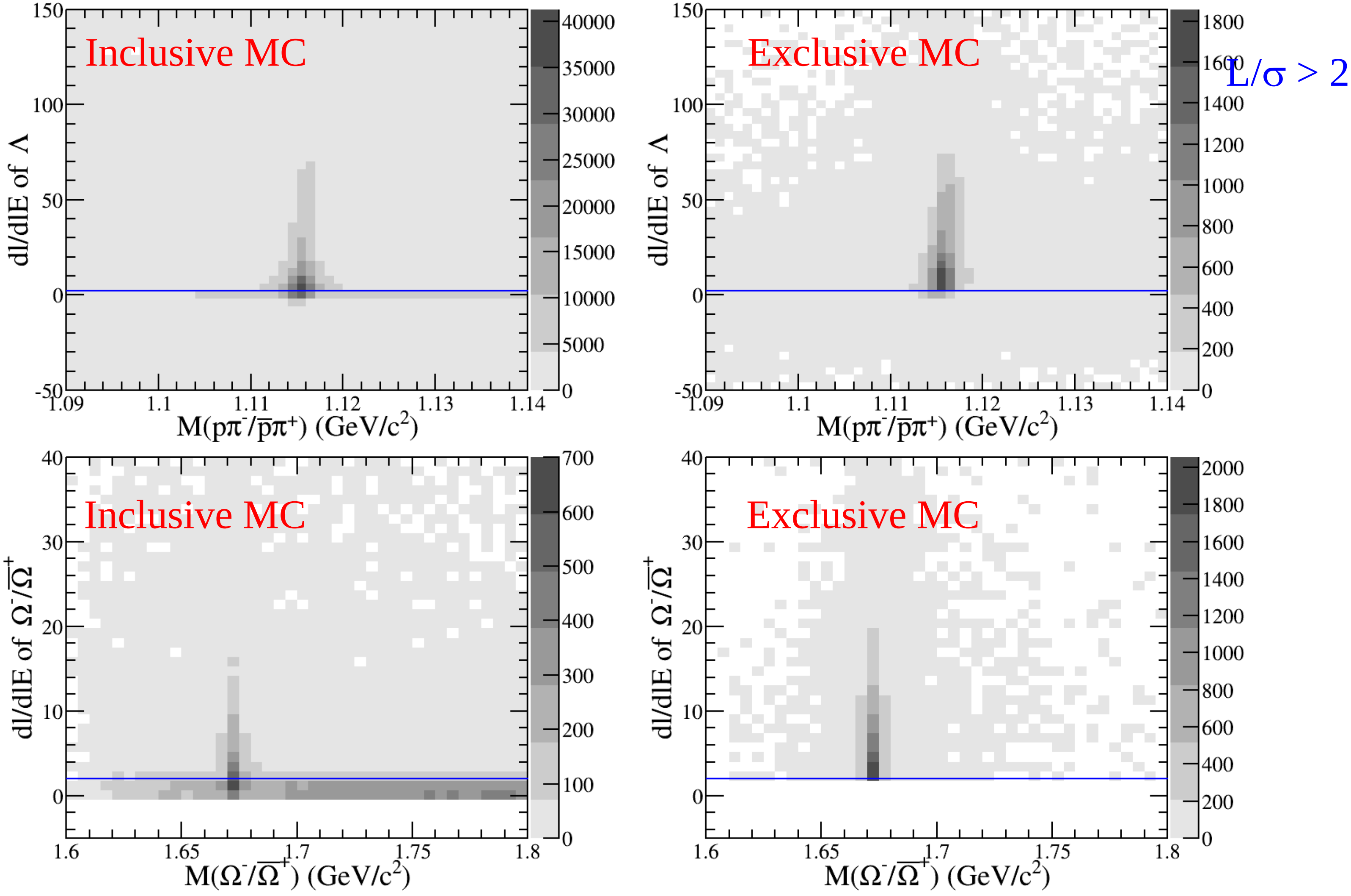
Summary and to do list

- $\psi(3686) \to \Omega^- \overline{\Omega}^+$ is observed.
- $e^+e^- \to \Omega^- \overline{\Omega}^+$ is first observed in data at BESIII.
- Using the counting method, the signal yield of $e^+e^- \to \Omega^- \overline{\Omega}^+$ at $\psi(3686)$ data and other data sets are 2305 ± 53 and 112 ± 16, respectively.

- [ ] Optimize the signal extraction
- [ ] Study the decay model of $e^+e^- \to \Omega^- \overline{\Omega}^+$ and determine the efficiency of each energy points;
- [ ] Measure the cross section of $e^+e^- \to \Omega^- \overline{\Omega}^+$.

backup

Event selection



Event selection