Measurement of $\sigma(e^+e^- \to \Lambda\bar{\Lambda})$ at the center-of-mass energy from 3.773 to 4.6 GeV

Xiongfei Wang(王雄飞)   Xinchou Lou

IHEP

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Charmonium group meeting

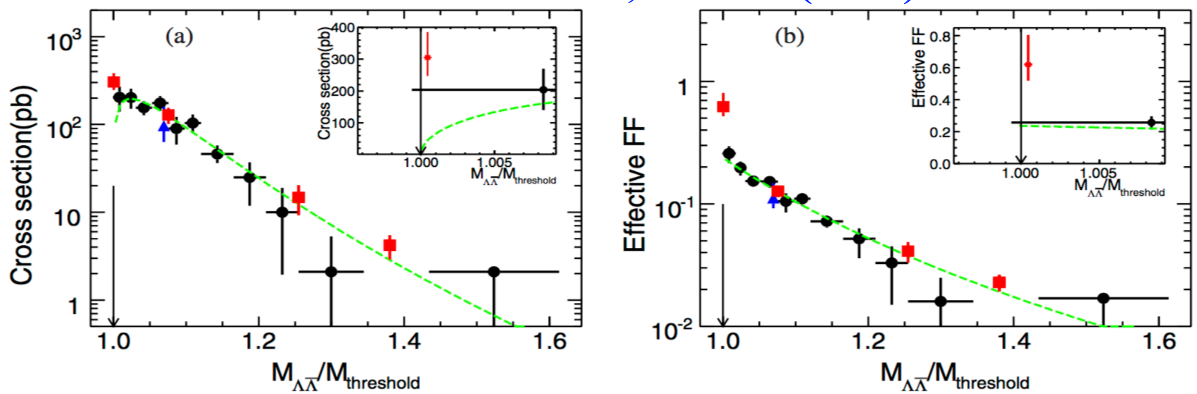
Outline

- Motivation
- Data sets
- Event selection
- Yield extraction (***counting***)
- Detection efficiency
- Born cross section &FFs calculation
- Systematic uncertainty
- Summary

Motivation

- The study of the production of Charmonium(-like) Y states in e^+e^- annihilations above open-charm threshold can provide a test for PQCD.
- The anomalous behavior differing from the pQCD prediction at threshold is observed.

PRD 97, 032013 (2018)



What's the situation far away from the threshold, which should be also an interesting topic.

- The unexpected features of baryon pair production have driven many theoretical interests in Ref.[PRC79, 054001 (2009) , PLB643, 29 (2006)], including scenarios that invoke $B\bar{B}$ bound states or unobserved meson resonances. To test the hypotheses, a precision measurement of $\sigma^B(e^+e^- \to \Lambda\bar{\Lambda})$ beyond the threshold is desired.

- BESIII so far has collected large data sample for above open charm threshold, it should be a good chance to measure cross section and form factor for $e^+e^- \to \Lambda\bar{\Lambda}$ beyond threshold, which may provide us more insights into the nature above the open charm region and experimental evidence .

Data sets

ID	$\sqrt{s}$ (MeV)	$L(pb^{-1})$
3773	3773.0	2917.0
4009	4007.6	482.0
4180	4178.0	3189.0
4190	4189.3	521.9
4200	4199.6	523.7
4210	4209.7	511.2
4220	4218.8	508.2
4230	4226.3	1047.3
4237	4235.8	508.9
4246	4243.9	532.7
4260	4258.0	825.7
4270	4266.9	529.3
4280	4277.8	174.5
4360	4358.3	539.8
4420	4415.6	1028.9
4600	4599.5	566.9

XYZ Data
16 energy points

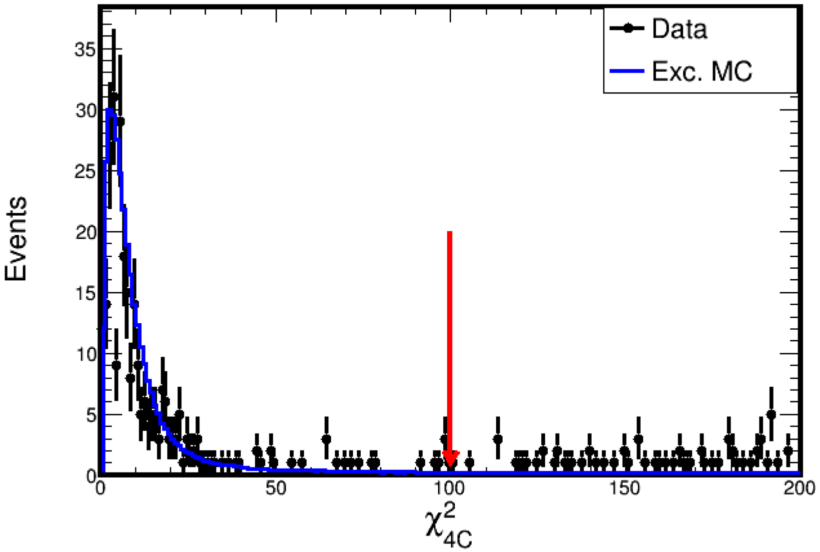
Exclusive MC (PHSP)
100k for each energy point

$$e^+e^- \to \Lambda\bar{\Lambda} \to p\bar{p}\pi^-\pi^+$$

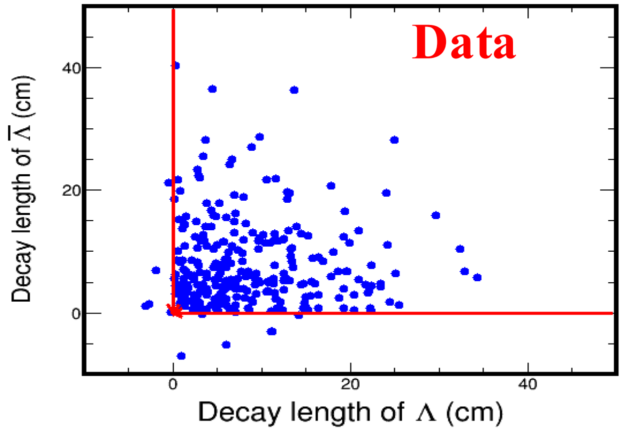
BOSS version: 703

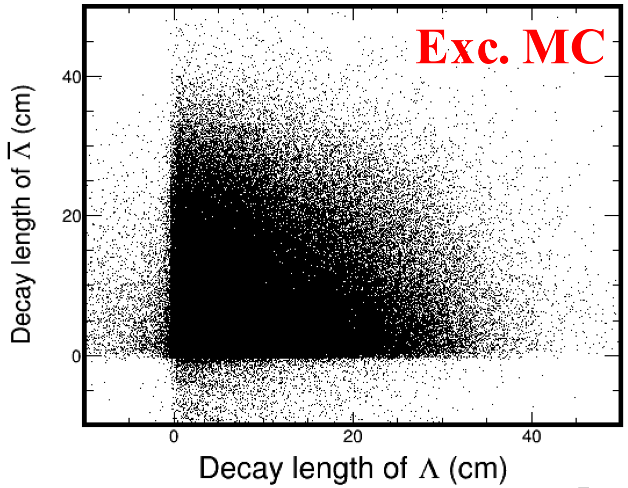
Event selection

- **Initial selection:**
  - **Charged track :**
    - ✓ $N_+ = 2 \& N_- = 2$
    - ✓ n(Charge) = 0
  - **PID: Yes!**
    - ✓ $N_p = 1 \& N_{\bar{p}} = 1 \& N_{\pi^+} = 1 \& N_{\pi^-} = 1$
  - **Λ reconstruction:**
    - ✓ Using secondary-vertex reconstruction strategy by looping $p\pi$ with combination of $\delta_{min} = |M_{p\pi} - M_\Lambda|$.
  - **4C kinematic fit ($\Lambda\bar{\Lambda}$ hypothesis)**



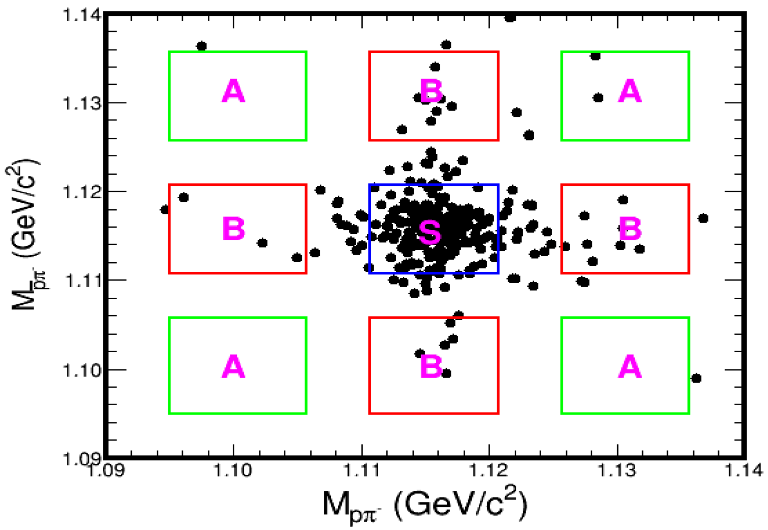
- **Further selection:**
  - $L_{\Lambda/\bar{\Lambda}} > 0$
  - $\chi^2_{4C} < 100$





Extraction of signal yields (counting)

$$N^{obs} = N^{S} - \frac{1}{2}N^{B} + \frac{1}{4}N^{A}$$



- The statistics significance for counting experiments can be calculated based on Poisson by

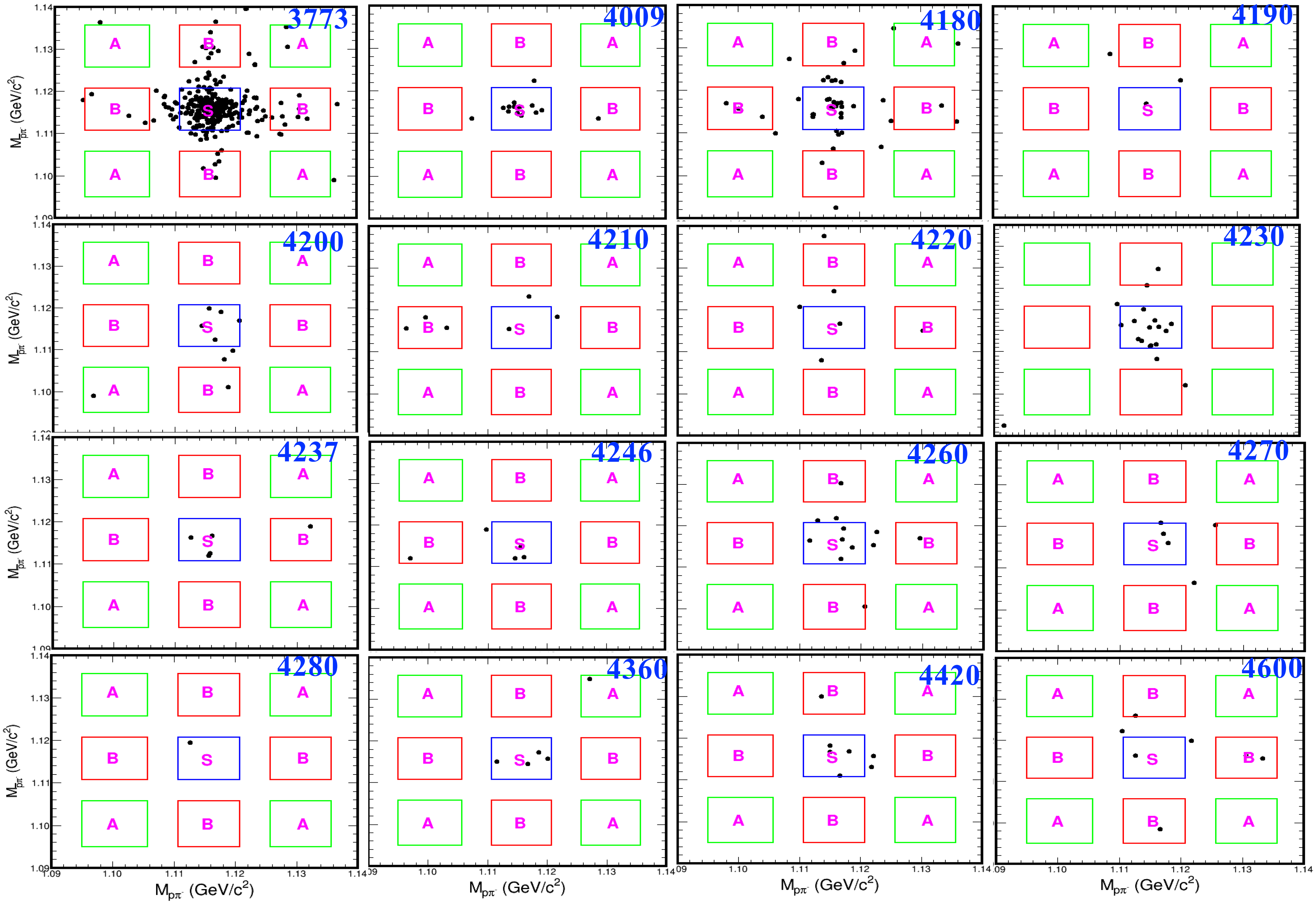
$$\sqrt{-2*\log\frac{\text{TMath::Poisson(S,b)}}{\text{TMath::Poisson(S,S)}}}$$

ID	N^S	N^B	N^A	$N^{\text{obs.}}$	S(σ)	N^{UP}
3773	$214.0^{+15.6}_{-14.6}$	$24.0^{+6.0}_{-4.9}$	$2.0^{+2.6}_{-1.3}$	$202.0^{+16.3}_{-15.0}$	29.1	--
4009	$12.0^{+4.6}_{-3.4}$	$1.0^{+2.3}_{-0.8}$	0	$11.5^{+4.9}_{-3.4}$	7.3	--
4180	$17.0^{+5.2}_{-4.1}$	$8.0^{+3.9}_{-2.8}$	$1.0^{+2.3}_{-0.8}$	$13.3^{+6.0}_{-4.6}$	5.0	--
4190	$1.0^{+2.3}_{-0.8}$	0	0	$1.0^{+2.3}_{-0.8}$	--	3.89
4200	$4.0^{+3.2}_{-2.0}$	$1.0^{+2.3}_{-0.8}$	$1.0^{+2.3}_{-0.8}$	$3.8^{+3.8}_{-2.1}$	3.8	--
4210	$1.0^{+2.3}_{-0.8}$	$3.0^{+2.9}_{-1.6}$	0	$-0.5^{+3.1}_{-1.4}$	0.5	2.60
4220	$1.0^{+2.3}_{-0.8}$	$1.0^{+2.3}_{-0.8}$	0	$0.5^{+2.8}_{-1.0}$	0.6	3.89
4230	$12^{+4.6}_{-3.4}$	$2.0^{+2.6}_{-1.3}$	0	$11.0^{+5.0}_{-3.5}$	6.1	--
4237	$4.0^{+3.2}_{-2.0}$	$1.0^{+2.3}_{-0.8}$	0	$3.5^{+3.6}_{-2.1}$	3.1	---
4246	$3.0^{+2.9}_{-1.6}$	$1.0^{+2.3}_{-0.8}$	0	$2.5^{+3.3}_{-2.1}$	2.4	6.68
4260	$5.0^{+3.4}_{-2.2}$	$2^{+2.6}_{-1.3}$	0	$4.0^{+3.9}_{-2.4}$	2.1	7.99
4270	$3.0^{+2.9}_{-1.6}$	0	0	$3.0^{+2.9}_{-1.6}$	--	6.68
4280	$1.0^{+2.3}_{-0.8}$	0	0	$1.0^{+2.3}_{-0.8}$	--	3.89
4360	$4.0^{+3.2}_{-2.0}$	0	$1.0^{+2.3}_{-0.8}$	$4.3^{+3.4}_{-2.0}$	3.8	--
4420	$4.0^{+3.2}_{-2.0}$	$1.0^{+2.3}_{-0.8}$	0	$3.5^{+3.6}_{-2.1}$	3.1	--
4600	$1.0^{+2.3}_{-0.8}$	$3.0^{+2.9}_{-1.6}$	0	$-0.5^{+2.8}_{-1.2}$	0.5	2.30

- Upper limit for counting experiment is estimated by statistics

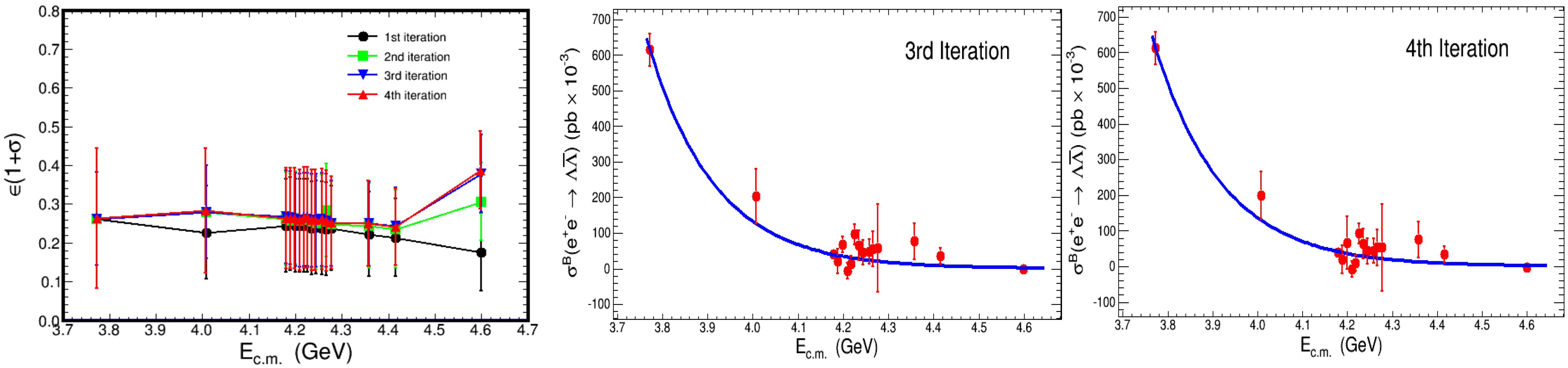
http://people.na.infn.it/~lista/Statistics/slides/06%20-%20upper%20limits.pdf

Signal yields extraction



Detection efficiency @ KKMC

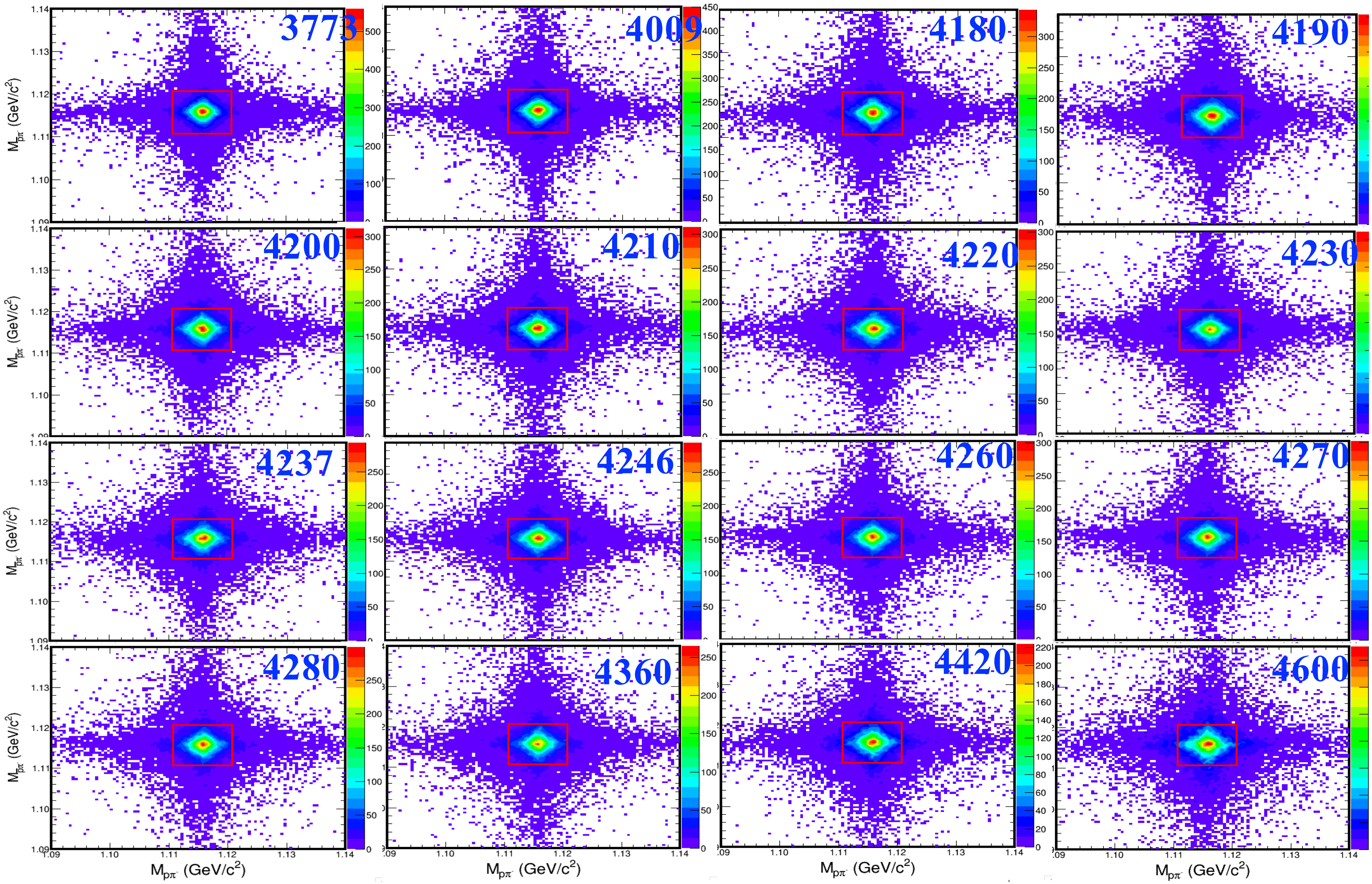
- **Iteration method**
- **Initial state radiation correction**
- **To be stable**



(a) The curve of $(1+\sigma)\cdot\epsilon$, (b) and (c) the Born cross section for last two iterations fitted by second polynomial.

The efficiency is defined by: $\epsilon = \frac{N_{\Lambda\bar{\Lambda}}^{detected}}{N_{\Lambda\bar{\Lambda}}^{generated}}$

Signal MC


3773
4009
4180
4190
4200
4210
4220
4230
4237
4246
4260
4270
4280
4360
4420
4600
$M_{p\pi^-}$ (GeV/c^2)
$M_{\bar{p}\pi^+}$ (GeV/c^2)

Calculation of Born cross sections and FFs

- **Experimentally, Born cross sections of $e^+e^- \to \Lambda\bar{\Lambda}$ are calculated by:**

$$\sigma^B = \frac{N_{obs}}{\mathcal{L}(1+\delta)(1+\Pi)\epsilon\mathcal{B}^2(\Lambda\to p\pi)},$$

where N_{obs} number of observed events, $\mathcal{L}$ luminosity, $1+\sigma$ ISR factor, $1+\Pi$ vacuum polarization factor, $\mathcal{B}$ the branching fraction.

- **Theoretically, Born cross section can be expressed as:**

$$\sigma^B = \frac{4\pi\alpha^2 C\beta}{3s}\left[|G_M|^2 + \frac{2m_\Lambda^2}{s}|G_E|^2\right].$$

- $G_{M/E}$: **electric/magnetic FF**
- $\beta = \sqrt{1-\frac{4m_\Lambda^2}{s}}$: **velosity**
- $\alpha = \frac{1}{137}$: **fine structure constant**
- s: the square of CM energy

Coulomb factor C =1 for neutral mode

The effective form factor defined by

$$|G_{eff}(s)| = \sqrt{\frac{|G_M|^2+\left(\frac{2m_\Lambda^2}{s}\right)|G_E|^2}{1+2m_\Lambda^2/s}}$$

is proportional to the square root of the baryon pair production cross section, to be

$$|G_{eff}(s)| = \sqrt{\frac{3s\sigma^B}{4\pi\alpha^2\beta(1+\frac{2m_\Lambda^2}{s})}}.$$

Numerical results

ID	$\sqrt{s}$ (MeV)	$L(pb^{-1})$	$\|1+\Pi\|^2$	$1+\delta$	$\epsilon(\%)$	S(σ)	N_{obs}	N^{UP}	σ^B ($pb\times10^{-3}$)	$\|G_{eff}(s)\|\times10^{-3}$
3773	3773.0	2917.0	1.06	0.79	33.12 ± 0.18	29.1	$202^{+15.2}_{-14.2}$	--	$611.9^{+46.0}_{-43.0}$	$10.3^{+2.8}_{-2.7}$
4009	4007.6	482.0	1.05	1.16	24.32 ± 0.16	7.3	$11.5^{+3.9}_{-2.9}$	--	$197.3^{+66.9}_{-49.7}$	$6.2^{+3.6}_{-3.1}$
4180	4178.0	3189.0	1.05	1.49	17.64 ± 0.13	5.0	$13.3^{+4.4}_{-3.0}$	--	$37.0^{+12.2}_{-8.3}$	$2.8^{+1.6}_{-1.3}$
4190	4189.3	521.9	1.06	1.52	17.32 ± 0.13	--	$1.0^{+2.3}_{-0.8}$	3.89	$16.8^{+38.7}_{-13.5}(<65.6)$	$1.9^{+2.8}_{-1.7}(<3.7)$
4200	4199.6	523.7	1.06	1.55	16.92 ± 0.13	3.8	$3.8^{+4.4}_{-3.0}$	--	$63.9^{+74.0}_{-50.5}$	$3.7^{+3.9}_{-3.3}$
4210	4209.7	511.2	1.06	1.57	16.38 ± 0.13	0.5	$-0.5^{+1.3}_{-0.5}$	2.60	$-8.8^{+22.8}_{-8.8}(<45.7)$	$-1.4^{+2.2}_{-1.4}(<3.7)$
4220	4218.8	508.2	1.06	1.60	16.49 ± 0.13	0.6	$0.5^{+1.3}_{-0.3}$	3.89	$8.6^{+22.4}_{-5.2}(<67.2)$	$1.3^{+2.2}_{-1.0}(<3.1)$
4230	4226.3	1047.3	1.06	1.63	16.28 ± 0.13	6.1	$11.0^{+3.4}_{-2.3}$	--	$91.4^{+28.3}_{-19.1}$	$4.4^{+2.4}_{-2.0}$
4237	4235.8	508.9	1.06	1.66	15.52 ± 0.13	3.1	$3.5^{+2.4}_{-1.4}$	--	$61.7^{+42.3}_{-18.5}$	$3.6^{+3.0}_{-2.3}$
4246	4243.9	532.7	1.06	1.68	$15.34.\pm0.13$	2.4	$2.5^{+2.1}_{-1.1}$	6.68	$42.1^{+35.3}_{-18.5}(<112.8)$	$3.0^{+2.7}_{-2.0}(<4.9)$
4260	4258.0	825.7	1.05	1.73	15.09 ± 0.13	2.1	$4.0^{+3.2}_{-2.0}$	7.99	$43.3^{+34.6}_{-21.6}(<86.6)$	$3.1^{+2.7}_{-2.2}(<4.3)$
4270	4266.9	529.3	1.05	1.76	14.48 ± 0.13	--	$3.0^{+2.9}_{-1.6}$	6.68	$51.9^{+50.1}_{-27.7}(<115.9)$	$3.3^{+3.3}_{-2.4}(<5.0)$
4280	4277.8	174.5	1.05	1.79	14.08 ± 0.12	--	$1.0^{+2.3}_{-0.8}$	3.89	$53.0^{+122.0}_{-42.4}(<206.8)$	$3.4^{+5.1}_{-3.0}(<6.7)$
4360	4358.3	539.8	1.05	2.18	11.42 ± 0.11	3.8	$4.3^{+2.9}_{-1.5}$	--	$74.6^{+50.33}_{-26.0}$	$4.1^{+3.4}_{-2.4}$
4420	4415.6	1028.9	1.05	2.55	9.44 ± 0.10	3.1	$3.5^{+2.4}_{-1.4}$	--	$33.0^{+22.6}_{-13.2}$	$2.8^{+2.3}_{-1.7}$
4600	4599.5	566.9	1.05	4.79	8.03 ± 0.10	0.5	$-0.5^{+1.3}_{-0.3}$	2.30	$-5.3^{+13.9}_{-3.2}(<24.6)$	$-1.2^{+1.9}_{-0.9}(<2.5)$

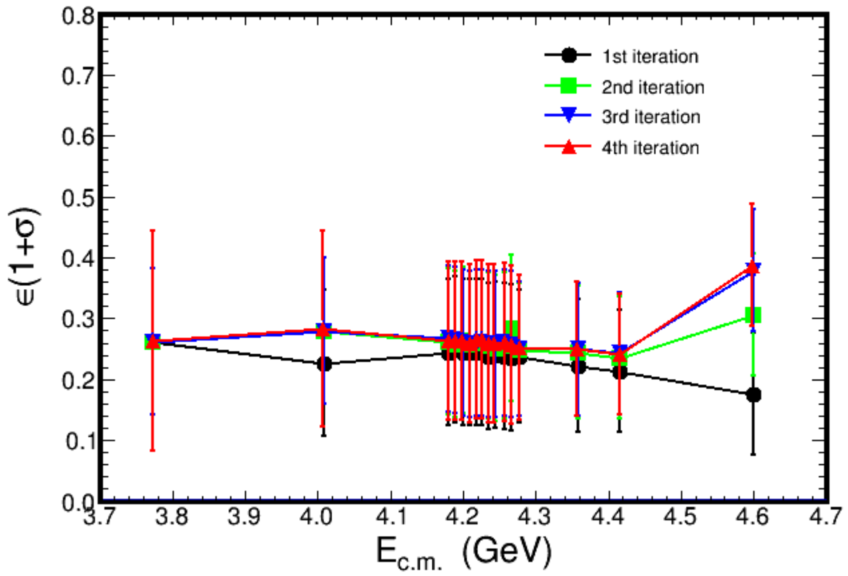
$$\boxed{\sigma^B(e^+e^- \to \Lambda\bar{\Lambda}) = \frac{N_{obs}}{\mathcal{L}\cdot\epsilon\cdot|1+\Pi|^2\cdot(1+\sigma)\cdot\mathcal{B}^2(\Lambda\to p\pi)}}$$

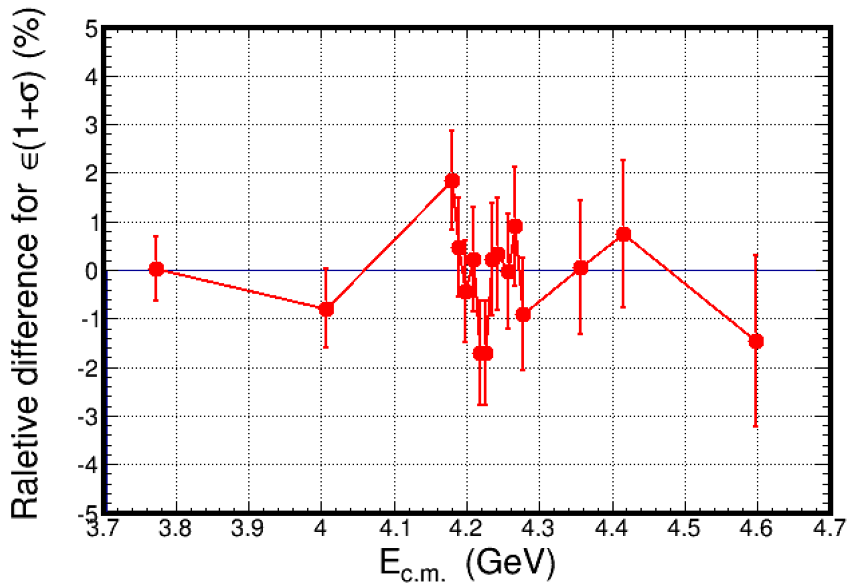
Systematic uncertainty

- **Luminosity: the published paper and BESIII preliminary measurement.**
- **Λ reconstruction: track, PID are proposed to be combined, quoted by published paper** Phys. Rev. D **87**, 032007 (2013).
- **Branching fraction for $\Lambda \to p\pi$: 1.1%.**
- **ISR factor: the difference for last two iteration.**
- **Λ decay length: the difference between the data and MC with and without requirement of Λ decay length based on the all data.**
- **Angular distribution: the difference between the data and PHSP MC**
- **4C kinematic fit: Done with control sample $\psi(3686) \to \Lambda\bar{\Lambda}$**

Source	Value(%)
Luminosity	1.0
Branching fraction of of $\Lambda \to p\pi$	1.1
ISR factor	1.8
Λ and $\bar{\Lambda}$ reconstruction	5.4
Λ and $\bar{\Lambda}$ decay length	1.8
4C kinematic fit	1.0
Angular distribution	6.3
Total	8.8

Systematic uncertainty (σ^B) for ISR factor



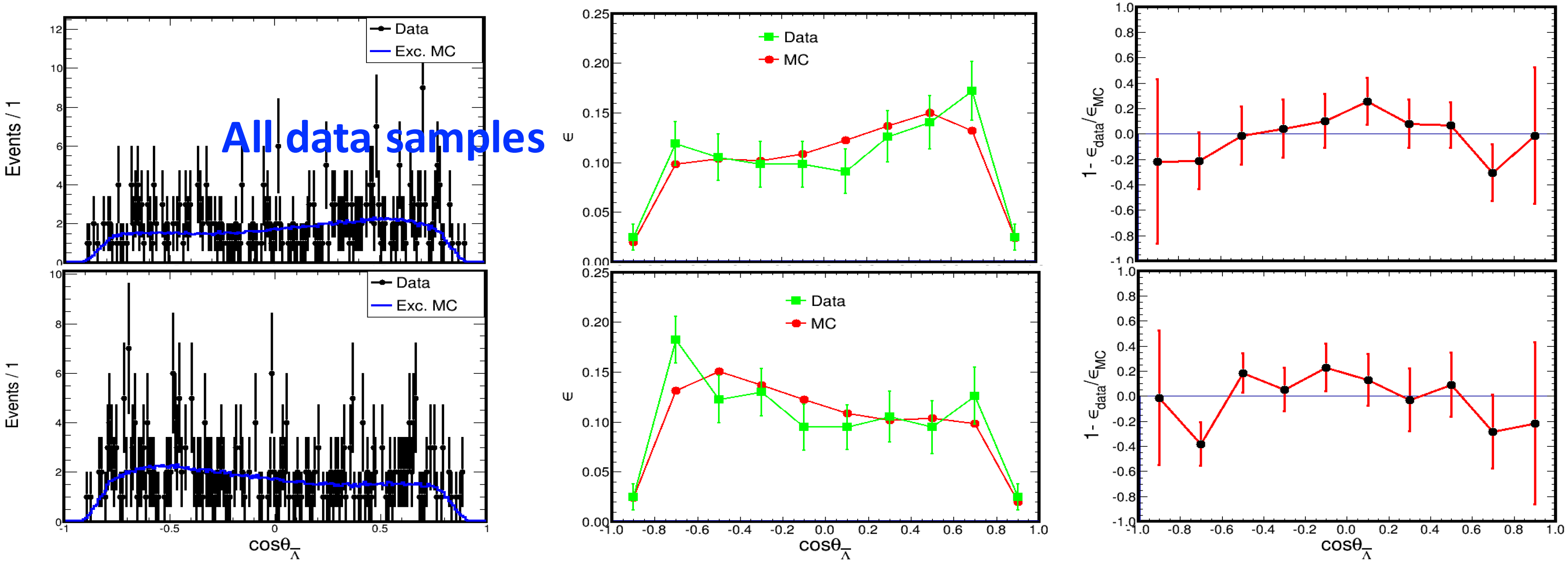


The relative difference of $\epsilon(1+\sigma)$ for each energy point.

3773	4009	4180	4190	4200	4210	4220	4230	4237	4246	4260	4270	4280	4360	4420	4600
0.0	0.8	1.8	0.5	0.5	0.2	1.7	1.7	0.2	**0.3**	0.1	0.9	0.9	0.0	0.7	1.5

Conservatively, we take the largest one 1.8% as the systematic uncertainty on the ISR factor for each energy point.

Systematic uncertainty (σ^B) for angular distribution



- The efficiency for each $\boldsymbol{cos\theta}$ interval is defined by $\epsilon_i = \frac{N_i^{obs}}{N_{all}^{obs}}$, where the subscript $\boldsymbol{i}$ runs over every $\boldsymbol{cos\theta}$ interval, N_i^{obs} number of events for each $\boldsymbol{cos\theta}$ interval, N_{all}^{obs} number of events for whole $\boldsymbol{cos\theta}$ interval.
- The efficiency difference is defined by $\sigma_i = 1 - \frac{\epsilon_{Data}}{\epsilon_{MC}}$.
- The weighted average difference is taken as the systematic uncertainty

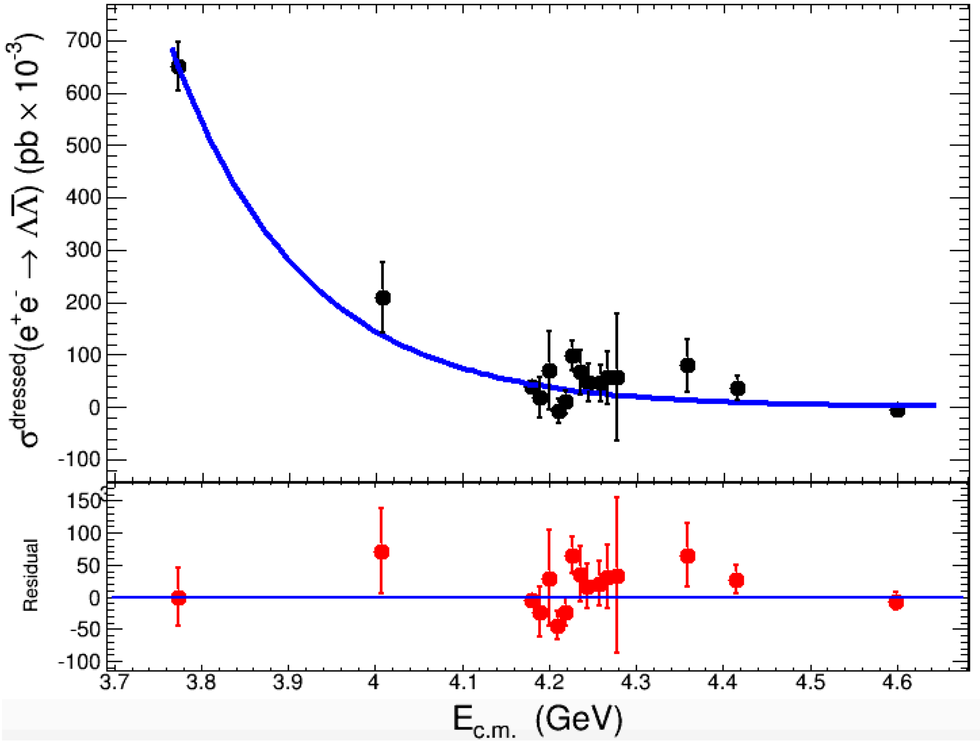
$$\delta_\Lambda = \sqrt{\sum_i \sigma_i^2 / N} = 5.1\%,$$

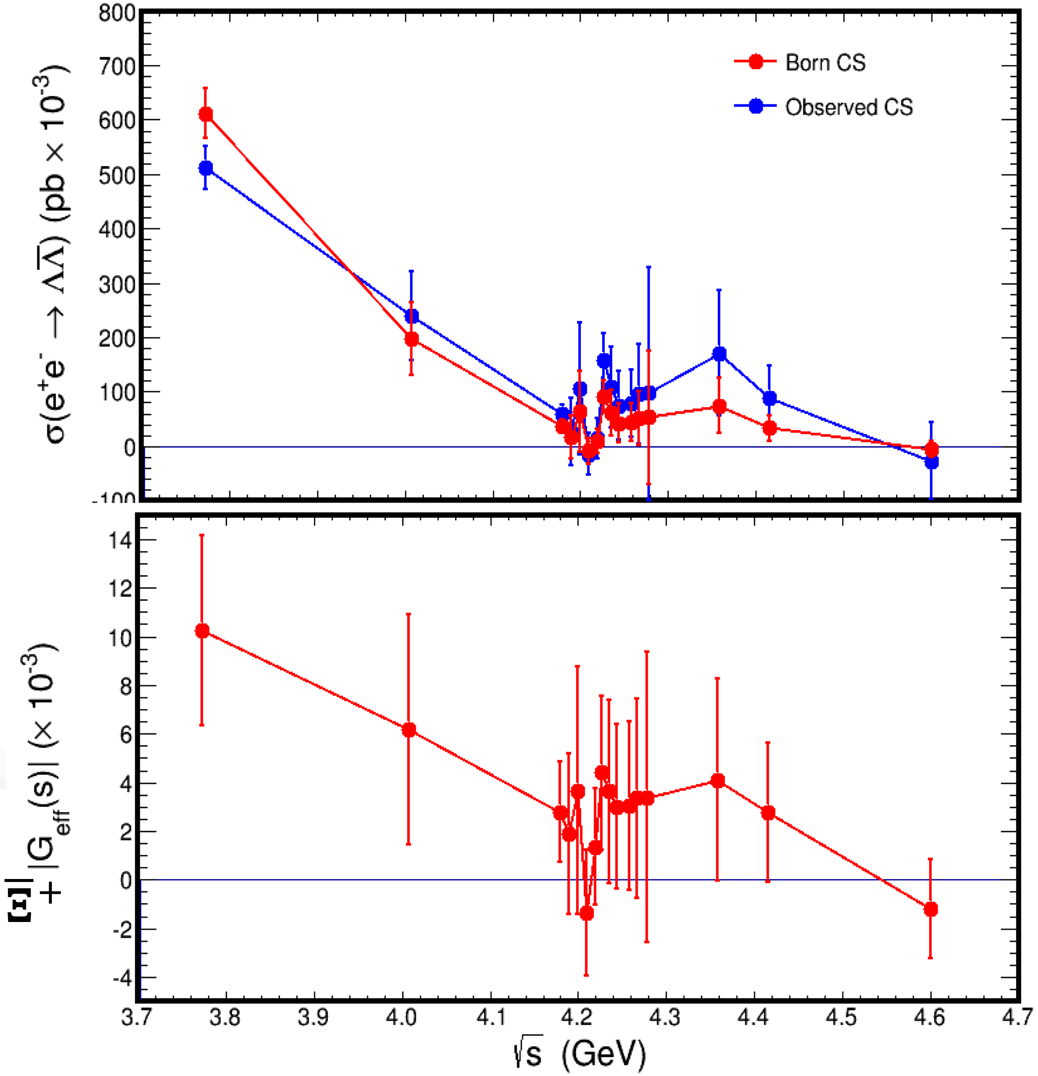
$$\delta_{\bar{\Lambda}} = \sqrt{\sum_i \sigma_i^2 / N} = 6.3\%,$$

N is the number of $\boldsymbol{cos\theta}$ intervals.

Conservatively, 6.3% is taken as the systematic uncertainty for angular distribution.

Line shape for Born cross section & FFs





- **The cross section and FFs for $e^+e^- \to \Xi^-\bar{\Xi}^+$ are measured for the first time between 3.773 and 4.6GeV**

- **Due to the limited statistics and energy points, we just perform a smooth fit to the dressed cross section (including the vacuum polarization effect).**

Summary

■ Summary

- ✓ Using XYZ data for 16 energy points, Born cross section & FFs for $e^+e^- \to \Lambda\bar{\Lambda}$ are measured for the first time in the center-of-mass energy between 3.773 and 4.6GeV/c^2.
- ✓ A fit to the dressed cross section is performed by **exponent function** without consideration of Charmonium(-like)Y states due to the limited statistics and energy points.

■ Next to do

- ✓ Improve the details
- ✓ Prepare the memo

Backup

Error calculation

Exact Binomial and Poisson Confidence Intervals

Revised 05/25/2009 -- Excel Add-in Now Available! (read below)

Binomial || Poisson || Set Conf Levels

This page computes exact confidence intervals for samples from the Binomial and Poisson distributions.

By default, it calculates symmetrical 95% confidence intervals, but you can change the "tail areas" to anything you'd like.

The formulas used in this web page are also available as Excel macros, which you can download in the file: confint.xls (85k long). This spreadsheet now includes an extra page that can generate a customized table of confidence limits around the observed numerator (x) and around the observed proportion (x/N), for any value of the denominator (N). My thanks to Prof. Patrick J. Laycock (University of Manchester) for that enhancement.

If you would like to have the six functions (BinomLow, BinomHigh, BinomP, PoisLow, PoisHigh, and PoisP) which appear in this spreadsheet available all the time (just as if they were built-in Excel functions), you can download and install the confint.xla Excel "add-in". Save the downloaded file in some reasonably "permanent" location on your computer's hard disk. Then install it, using the appropriate steps for your version of Excel (see Excel's Help section for "add-ins").

Note: Before using this page for the first time, make sure you read the JavaStat user interface guidelines for important information about interacting with JavaStat pages.

Binomial Confidence Intervals

Enter the observed numerator and denominator counts, then click the **Compute** button:

Numerator (x): 10

Denominator (N): 20

Compute

Proportion (x/N):

Exact Confidence Interval around Proportion: to

Numerical results

ID	$\sqrt{s}$ (MeV)	$L(pb^{-1})$	$\lvert 1+\Pi \rvert^2$	$1+\delta$	N_{obs}	σ	$\epsilon(\%)$	σ^B (pb)
3773	3773.0	2917.0	1.06	0.79	$202^{+15.2}_{-14.2}$	29.1	33.11±0.18	0.16±0.04
4009	4007.6	482.0	1.05	0.75	$11.5^{+3.9}_{-2.9}$	7.3	30.18±0.17	
4180	4178.0	3189.0	1.05	1.00	$13.3^{+4.4}_{-3.0}$	5.0	24.45±0.16	0.11±0.01
4190	4189.3	521.9	1.06	1.02	$1.0^{+2.3}_{-0.8}$	--	24.21±0.16	
4200	4199.6	523.7	1.06	1.02	$3.8^{+4.4}_{-3.0}$	3.8	23.78±0.16	
4210	4209.7	511.2	1.06	1.03	$-0.5^{+1.3}_{-0.5}$	0.5	23.55±0.16	
4220	4218.8	508.2	1.06	1.04	$0.5^{+1.3}_{-0.3}$	0.6	23.32±0.15	
4230	4226.3	1047.3	1.06	1.04	$11.0^{+3.4}_{-2.3}$	6.1	23.45±0.15	0.09±0.02
4237	4235.8	508.9	1.06	1.04	$3.5^{+2.4}_{-1.4}$	3.1	22.77±0.15	
4246	4243.9	532.7	1.06	1.05	$2.5^{+2.1}_{-1.1}$	2.4	22.75±0.15	
4260	4258.0	825.7	1.05	1.05	$4.0^{+3.2}_{-2.0}$	2.1	22.48± 0.15	0.10±0.03
4270	4266.9	529.3	1.05	1.05	$3.0^{+2.9}_{-1.6}$	--	22.34± 0.15	
4280	4277.8	174.5	1.05	1.07	$1.0^{+2.3}_{-0.8}$	--	22.12± 0.15	
4360	4358.3	539.8	1.05	1.15	$4.3^{+2.9}_{-1.5}$	3.8	19.26 ±0.14	
4420	4415.6	1028.9	1.05	1.19	$3.5^{+2.4}_{-1.4}$	3.1	17.96 ±0.13	0.04±0.02
4600	4599.5	566.9	1.05	1.26	$-0.5^{+1.3}_{-0.3}$	0.5	13.87 ±0.12	

The statistical significance is calculated to be $\sigma = s/\sqrt{s+b}$

$$\sigma^B(e^+e^- \to \Xi^-\bar{\Xi}^+) = \frac{N_{obs}}{2 \cdot \mathcal{L} \cdot \epsilon \cdot |1+\Pi|^2 \cdot (1+\sigma) \cdot \mathcal{B}(\Xi \to \pi\Lambda) \cdot \mathcal{B}(\Lambda \to p\pi)}$$

Numerical results

ID	$\sqrt{s}$ (MeV)	$L(pb^{-1})$	$\|1+\Pi\|^2$	$1+\delta$	N_{obs}	σ	$\epsilon(\%)$	$\sigma^B\ (pb)$
3773	3773.0	2917.0	1.06	0.79	$202^{+15.2}_{-14.2}$	14.3	33.12±0.18	0.16±0.04
4009	4007.6	482.0	1.05	1.15	$11.5^{+3.9}_{-2.9}$		24.26±0.16	
4180	4178.0	3189.0	1.05	1.45	$13.3^{+4.4}_{-3.0}$	3.8	18.03±0.13	0.11±0.01
4190	4189.3	521.9	1.06	1.46	$1.0^{+2.3}_{-0.8}$		17.60±0.13	
4200	4199.6	523.7	1.06	1.50	$3.8^{+4.4}_{-3.0}$		17.61±0.13	
4210	4209.7	511.2	1.06	1.52	$-0.5^{+1.3}_{-0.5}$		16.88±0.13	
4220	4218.8	508.2	1.06	1.54	$0.5^{+1.3}_{-0.3}$		16.75±0.13	
4230	4226.3	1047.3	1.06	1.55	$11.0^{+3.4}_{-2.3}$	3.4	16.76±0.13	0.09±0.02
4237	4235.8	508.9	1.06	1.58	$3.5^{+2.4}_{-1.4}$		16.06±0.13	
4246	4243.9	532.7	1.06	1.60	$2.5^{+2.1}_{-1.1}$		15.64.±0.13	
4260	4258.0	825.7	1.05	1.66	$4.0^{+3.2}_{-2.0}$	2.1	15.39± 0.13	0.10±0.03
4270	4266.9	529.3	1.05	1.68	$3.0^{+2.9}_{-1.6}$		16.90± 0.13	
4280	4277.8	174.5	1.05	1.71	$1.0^{+2.3}_{-0.8}$		14.47± 0.12	
4360	4358.3	539.8	1.05	2.03	$4.3^{+2.9}_{-1.5}$		11.99 ±0.11	
4420	4415.6	1028.9	1.05	2.35	$3.5^{+2.4}_{-1.4}$	1.6	10.00 ±0.10	0.04±0.02
4600	4599.5	566.9	1.05	3.59	$-0.5^{+1.3}_{-0.3}$		8.52 ±0.10	

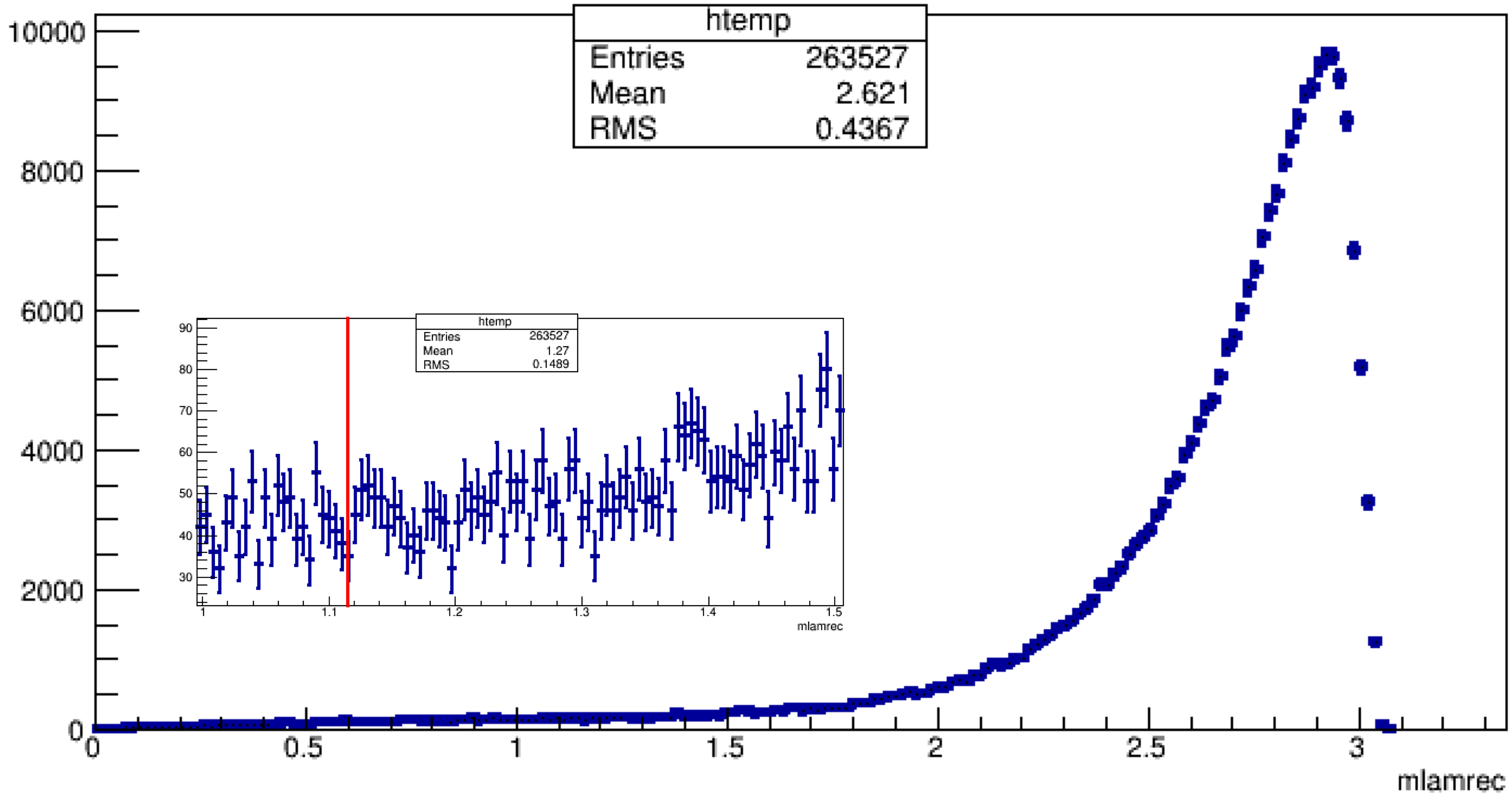
The statistical significance is calculated to be $\sigma = s/\sqrt{s+b}$

$$\boxed{\sigma^B(e^+e^- \to \Xi^-\bar{\Xi}^+) = \frac{N_{obs}}{2\cdot\mathcal{L}\cdot\epsilon\cdot|1+\Pi|^2\cdot(1+\sigma)\cdot\ \mathcal{B}(\Xi\to\pi\Lambda)\cdot\mathcal{B}(\Lambda\to p\pi)}}$$

Numerical results

ID	$\sqrt{s}$ (MeV)	$L(pb^{-1})$	$\lvert 1+\Pi \rvert^2$	$1+\delta$	$\epsilon(\%)$	$S(\sigma)$	N_{obs}	N^{UP}	σ^B (pb)
3773	3773.0	2917.0	1.06	0.79	33.12±0.18	29.1	$202^{+15.2}_{-14.2}$	--	0.16±0.04
4009	4007.6	482.0	1.05	1.16	24.12±0.16	7.3	$11.5^{+3.9}_{-2.9}$	--	
4180	4178.0	3189.0	1.05	1.49	17.96±0.13	5.0	$13.3^{+4.4}_{-3.0}$	--	0.11±0.01
4190	4189.3	521.9	1.06	1.52	17.40±0.13	--	$1.0^{+2.3}_{-0.8}$	3.89	
4200	4199.6	523.7	1.06	1.54	16.95±0.13	3.8	$3.8^{+4.4}_{-3.0}$	--	
4210	4209.7	511.2	1.06	1.56	16.52±0.13	0.5	$-0.5^{+1.3}_{-0.5}$	2.60	
4220	4218.8	508.2	1.06	1.58	16.41±0.13	0.6	$0.5^{+1.3}_{-0.3}$	3.89	
4230	4226.3	1047.3	1.06	1.62	16.10±0.13	6.1	$11.0^{+3.4}_{-2.3}$	--	0.09±0.02
4237	4235.8	508.9	1.06	1.64	15.74±0.13	3.1	$3.5^{+2.4}_{-1.4}$	--	
4246	4243.9	532.7	1.06	1.67	15.48.±0.13	2.4	$2.5^{+2.1}_{-1.1}$	6.68	
4260	4258.0	825.7	1.05	1.72	15.17± 0.13	2.1	$4.0^{+3.2}_{-2.0}$	7.99	0.10±0.03
4270	4266.9	529.3	1.05	1.76	14.61± 0.13	--	$3.0^{+2.9}_{-1.6}$	6.68	
4280	4277.8	174.5	1.05	1.78	14.03± 0.12	--	$1.0^{+2.3}_{-0.8}$	3.89	
4360	4358.3	539.8	1.05	2.16	11.53 ±0.11	3.8	$4.3^{+2.9}_{-1.5}$	--	
4420	4415.6	1028.9	1.05	2.50	9.70 ±0.10	3.1	$3.5^{+2.4}_{-1.4}$	--	0.04±0.02
4600	4599.5	566.9	1.05	4.65	8.15 ±0.10	0.5	$-0.5^{+1.3}_{-0.3}$	2.30	

$$\boxed{\sigma^B(e^+e^- \to \Lambda\bar{\Lambda}) = \frac{N_{obs}}{\mathcal{L}\cdot\epsilon\cdot|1+\Pi|^2\cdot(1+\sigma)\cdot\mathcal{B}^2(\Lambda\to p\pi)}}$$



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