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Luminosity measurement without using EMC

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March 12, 2025

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Motivation

- Luminosity ($\mathcal{L}$) is an important input for many measurement. So, precise measurement of luminosity is highly desired.

- In e^+e^- collider, the precise measurement is achieved due to the well-understood QED processes $e^+e^- \to e^+e^-$, $e^+e^- \to \gamma\gamma$, and $e^+e^- \to \mu^+\mu^-$.

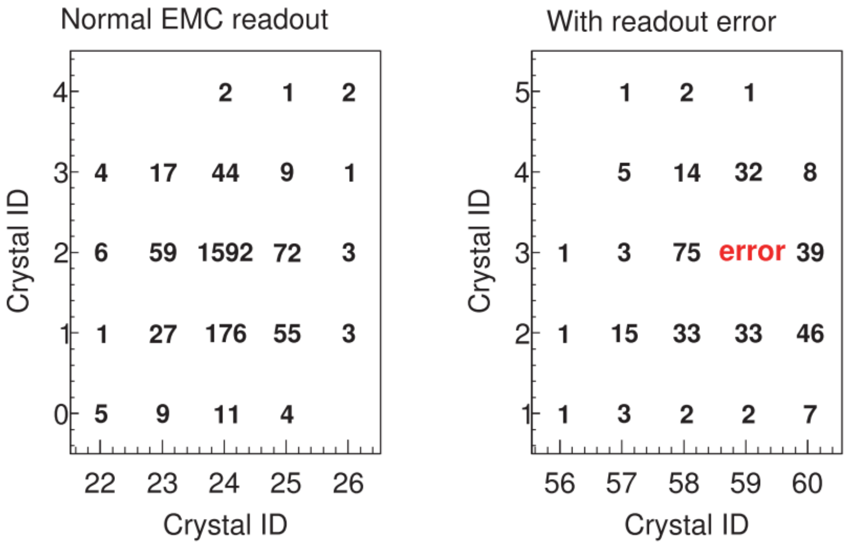
- For a specific process, the luminosity is usually determined as

$$\mathcal{L} = \frac{N}{\epsilon \times \sigma}$$

where N is the number of event, σ is cross section of the physical process and ϵ denotes the detection efficiency.

Motivation

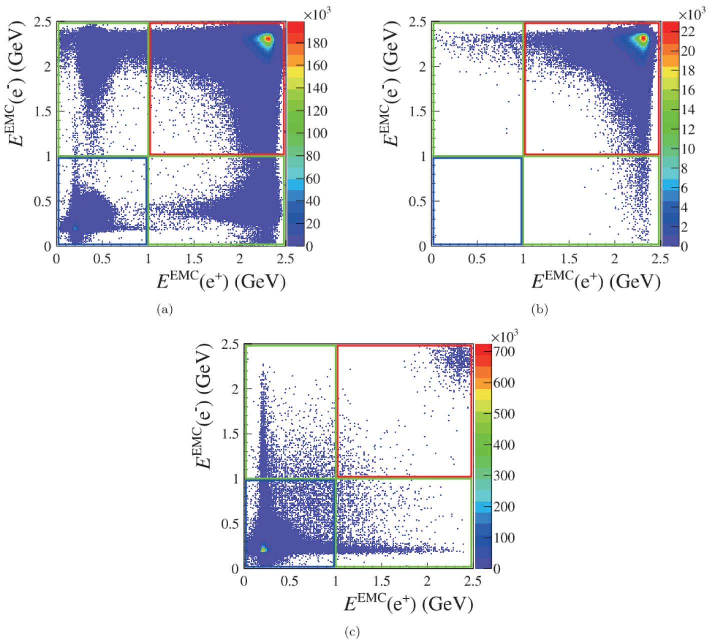
- In a study of high energy EMC showers, it was found that the EMC electronics occasionally failed to provide valid signals for crystals with high deposited energy. (See Tang Guangyi's report)



- The left plot shows the EMC energy deposition of a typical high energy (approximately 2 GeV) electron or positron shower, where no problem occurs.

- The right plot shows an example of a shower missing the readout of the EMC energy deposition from one crystal.

Motivation



Plots from BESIII work (CPC 46, 113003 (2022))

- In the plots, two abnormal accumulations can be found for the data samples, which are not present for the MC sample
- These accumulations are formed by events in which the reconstructed energy deposition by the charged track in the EMC is missing the readout signal from one crystal
- The 3% data events in green square region are saturation events

- The existence of saturation effects was not known previously: CPC 41,063001 (2017)
- Yield loss caused by saturation effects has been recovered in CPC 46, 113002 (2022) and CPC 46, 113003 (2022) .

Motivation

- To avoid the impact of saturation and other possible imperfect simulation of EMC showers, we propose a luminosity measurement method using MDC only.

- The luminosity is calculated by following formula

$$\mathcal{L} = \frac{N_{ee}}{\epsilon_{ee} \times \sigma_{ee}} = \frac{N_{\mu\mu}}{\epsilon_{\mu\mu} \times \sigma_{\mu\mu}} = \frac{N_{ee}+N_{\mu\mu}}{\epsilon_{ee}\times\sigma_{ee}+\epsilon_{\mu\mu}\times\sigma_{\mu\mu}} = \frac{N_{\mathrm{obs}}-N_{\mathrm{bkg}}}{\epsilon_{ee}\times\sigma_{ee}+\epsilon_{\mu\mu}\times\sigma_{\mu\mu}}$$

where N_{obs} is the total number of observed signal events, cross section σ is given by accurate QED theoretical calculation and ϵ denotes the detection efficiency which is estimated by signal MC.

- This method is applicable across all energy ranges and serves as a cross-check of the previously published luminosity results.

- Potentially identify other issues with EMC, and we do find an inefficiency of 1%!

Data Sets

- 2013-2014 R-scan data (BOSS 7.0.3)

  104 energy points in total, ranging from 3.8500 to 4.5900 GeV

- 2020 XYZ data (BOSS 7.0.6)

  7 energy points in total, ranging from 4.6000 to 4.7000 GeV

- 2021 XYZ data (BOSS 7.0.7)

  6 energy points in total, ranging from 4.7400 to 4.9500 GeV

Data Sets

- MC samples:

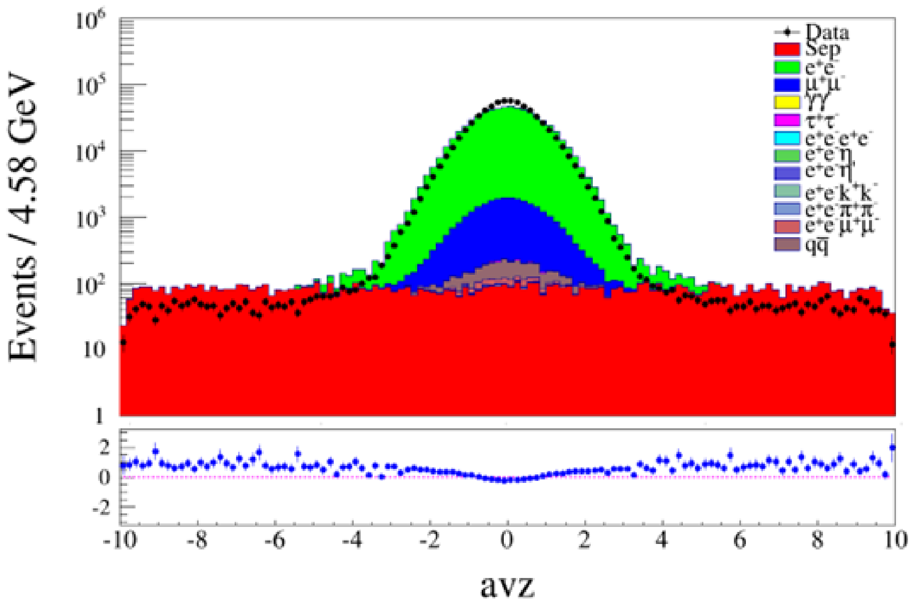
Process	Generator
e^+e^-	BABAYAGA NLO
$\gamma^+\gamma^-$	BABAYAGA NLO
$\mu^+\mu^-$	BABAYAGA NLO
$e^+e^-e^+e^-$	DIAG36
$e^+e^-\eta$	EKHARA
$e^+e^-\eta'$	EKHARA
$e^+e^-K^+K^-$	GALUGA
$e^+e^-\pi^+\pi^-$	GALUGA
$e^+e^-\mu^+\mu^-$	DIAG36
$q\bar{q}$	Hybrid

Selection Criteria

- $N_{\text{good}} = 2$, $Q_{\text{tot}} = 0$ ($V_{\text{r}} < 1$ cm, $|V_{\text{z}}| < 10$ cm, $|\cos\theta| < 0.8$)
- $0.2E_{beam} < P_{\ell^{\pm}} < 1.1E_{beam}$
- Back-to-back, $|\Delta\theta_{\ell^{\pm}}| = |\theta_1 + \theta_2 - 180°| < 10°$, $|\Delta\phi_{\ell^{\pm}}| = ||\phi_1 - \phi_2| - 180°| < 5°$

Background study

- Taking 4.58 GeV as an example, to remove the beam-associated and cosmic ray background, we use the sideband method.



- avz is defined as V_z of a event, average of tracks.
- In this plot, the beam-associated background is represented by the red histogram. Normalization is done according to data-taking time.
- The Bhabha and Dimu signal processes are represented by the green and blue histograms, respectively.
- For the sideband method, we choose |avz| < 3 as our signal region and 6 < |avz| < 9 as our background region.
- Bhabha events account for 95% of the total events, while Dimu events account for 4% of the total events.

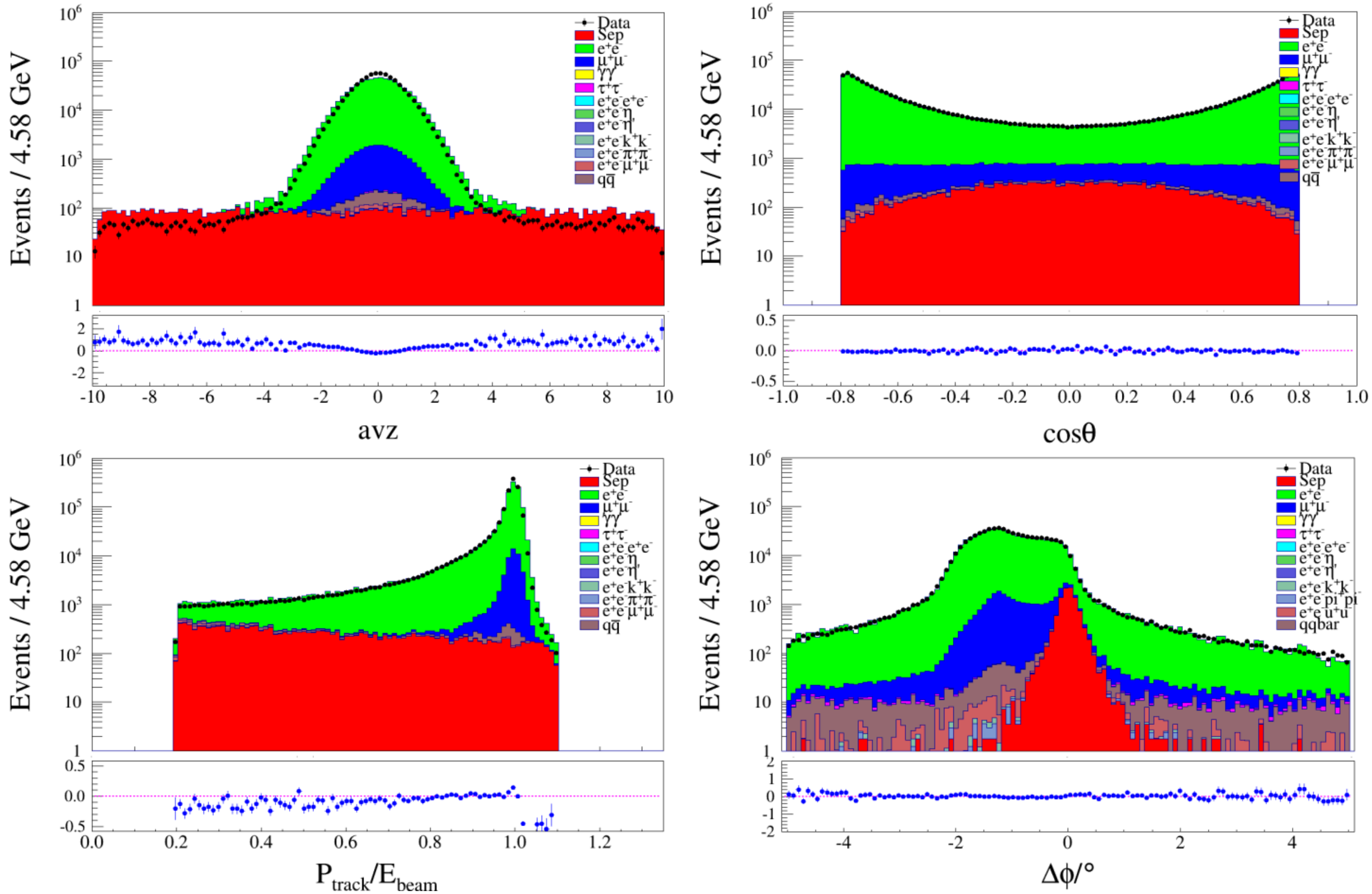
Background study

- For other background processes, we use MC to simulate the residual events in data

Background	N_{total}	N_{sur}	Scale factor	N_{scaled}	Ratio (%)
$\gamma\gamma$	1000000	11	0.188	2	0
$\tau^+\tau^-$	300000	1211	0.100	121	0.02
$e^+e^-e^+e^-$	200000	1724	0.006	10	0
$e^+e^-\eta$	100000	1	0.032	0	0
$e^+e^-\eta'$	100000	3	0.031	0	0
$e^+e^-K^+K^-$	40000	571	0.059	33	0
$e^+e^-\pi^+\pi^-$	40000	81	0.631	51	0.01
$e^+e^-\mu^+\mu^-$	400000	358	0.816	292	0.04
$q\bar{q}$	500000	4111	0.342	1405	0.20

Comparison between data and MC

- Taking 4.58 GeV as an example



BABAYAGA NLO simulated MC events agree with data quite well

Measured integrated luminosities

$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})
3.8500	8.118±0.009	3.9550	8.306±0.009	4.0160	6.721±0.008	4.1000	7.413±0.009
3.8900	7.963±0.009	3.9600	8.658±0.009	4.0180	7.148±0.009	4.1100	7.350±0.009
3.8950	7.741±0.009	3.9650	7.911±0.009	4.0200	6.873±0.008	4.1200	7.857±0.009
3.9000	7.758±0.009	3.9700	7.491±0.009	4.0250	6.697±0.008	4.1300	7.411±0.009
3.9050	7.842±0.009	3.9750	8.206±0.009	4.0300	16.727±0.013	4.1400	7.466±0.009
3.9100	7.398±0.009	3.9800	8.018±0.009	4.0350	6.876±0.009	4.1450	8.023±0.009
3.9150	7.645±0.009	3.9850	8.152±0.009	4.0400	6.704±0.008	4.1500	7.867±0.009
3.9200	6.978±0.008	3.9900	8.187±0.009	4.0500	6.744±0.008	4.1600	8.194±0.010
3.9250	6.848±0.008	3.9950	8.134±0.009	4.0550	7.063±0.009	4.1700	18.452±0.014
3.9300	6.873±0.008	4.0000	7.903±0.009	4.0600	6.471±0.008	4.1800	7.523±0.009
3.9350	7.311±0.009	4.0050	7.693±0.009	4.0650	7.169±0.009	4.1900	7.779±0.009
3.9400	7.407±0.009	4.0100	7.333±0.009	4.0700	7.446±0.009	4.1950	7.740±0.009
3.9450	7.738±0.009	4.0120	7.064±0.009	4.0800	7.906±0.009	4.2000	7.785±0.009
3.9500	7.912±0.009	4.0140	6.836±0.008	4.0900	7.765±0.009	4.2030	7.038±0.009

Measured integrated luminosities

$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})
4.2060	7.874±0.010	4.2650	8.867±0.010	4.3800	8.440±0.010	4.5400	9.834±0.011
4.2100	7.938±0.010	4.2700	8.834±0.010	4.3900	7.718±0.010	4.5500	9.138±0.011
4.2150	7.987±0.010	4.2750	8.823±0.010	4.3950	8.025±0.010	4.5600	8.670±0.011
4.2200	8.093±0.010	4.2800	8.984±0.010	4.4000	7.423±0.010	4.5700	8.825±0.011
4.2250	8.442±0.010	4.2850	8.800±0.010	4.4100	7.263±0.010	4.5800	8.995±0.011
4.2300	8.430±0.010	4.2900	9.267±0.011	4.4200	7.816±0.010	4.5900	8.650±0.011
4.2350	8.505±0.010	4.3000	8.705±0.010	4.4250	7.677±0.010		
4.2400	8.826±0.010	4.3100	9.195±0.011	4.4300	7.046±0.009		
4.2430	8.808±0.010	4.3200	9.640±0.011	4.4400	7.910±0.010		
4.2450	8.726±0.010	4.3300	8.930±0.010	4.4500	7.983±0.010		
4.2480	8.829±0.010	4.3400	8.968±0.010	4.4600	9.081±0.011		
4.2500	8.860±0.010	4.3500	8.786±0.010	4.4800	8.544±0.011		
4.2550	8.909±0.010	4.3600	8.346±0.010	4.5000	8.345±0.010		
4.2600	9.148±0.010	4.3700	8.773±0.010	4.5200	9.046±0.011		

Measured integrated luminosities

$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})
4.6000	589.73 ± 0.09
4.6120	103.70 ± 0.04
4.6200	524.96 ± 0.09
4.6400	559.73 ± 0.09
4.6600	532.21 ± 0.09
4.6800	1673.30 ± 0.1
4.7000	538.50 ± 0.09
4.7400	166.24 ± 0.05
4.7500	370.44 ± 0.07
4.7800	516.81 ± 0.09
4.8400	530.63 ± 0.09
4.9180	209.98 ± 0.06
4.9460	160.94 ± 0.05

Systematic Uncertainty

- nGood requirement
- $\Delta\theta$ cut range
- $\Delta\phi$ cut range
- $\cos\theta$ cut range
- Momentum cut range
- MC statistic
- Beam energy
- Background estimation
- Tracking efficiencies
- Uncertainty of Generator

Systematic Uncertainty

Control samples are selected to study the following systematic uncertainties.

- nGood requirement
  - $N_{\text{good}} \geq 2$ ($V_r < 1$ cm, $|V_z| < 10$ cm, $|\cos\theta| < 0.8$, $0.2 < P_{\ell^\pm}/P_{beam} < 1.1$)
  - $|\Delta\theta_{\ell^\pm}| < 10°$ and $|\Delta\phi_{\ell^\pm}| < 5°$ for the two tracks with largest momentum
  - The efficiency difference between data and MC with $N_{\text{good}} = 2$ are taken as systematic uncertainties.
- $\Delta\theta$ cut range
  - $N_{\text{good}} = 2$ ($V_r < 1$ cm, $|V_z| < 10$ cm, $|\cos\theta| < 0.8$, $0.2 < P_{\ell^\pm}/P_{beam} < 1.1$)
  - $|\Delta\theta_{\ell^\pm}| < 20°$ and $|\Delta\phi_{\ell^\pm}| < 5°$ to guarantee the control sample is pure
  - The efficiency difference between data and MC with $|\Delta\theta_{\ell^\pm}| < 10°$are taken as systematic uncertainties.
- $\Delta\phi$ cut range
  - $N_{\text{good}} = 2$ ($V_r < 1$ cm, $|V_z| < 10$ cm, $|\cos\theta| < 0.8$, $0.2 < P_{\ell^\pm}/P_{beam} < 1.1$)
  - $|\Delta\theta_{\ell^\pm}| < 10°$
  - The efficiency difference between data and MC with $|\Delta\phi_{\ell^\pm}| < 5°$ are taken as systematic uncertainties.

Systematic Uncertainty

- $\cos\theta$ cut range

- $N_{\text{good}} = 2\ (V_{\text{r}} < 1\text{ cm},\ |V_{\text{z}}| < 10\text{ cm},\ |\cos\theta| < 0.82,\ 0.2 < P_{\ell^\pm}/P_{beam} < 1.1)$
- $|\Delta\theta_{\ell^\pm}| < 10^\circ$ and $|\Delta\phi_{\ell^\pm}| < 5^\circ$
- The efficiency difference between data and MC with $|\cos\theta| < 0.8$ are taken as systematic uncertainties.

- Momentum cut range

- $N_{\text{good}} = 2\ (V_{\text{r}} < 1\text{ cm},\ |V_{\text{z}}| < 10\text{ cm},\ |\cos\theta| < 0.8,\ 0.2 < P_{\ell^\pm}/P_{beam} < 1.1)$
- $|\Delta\theta_{\ell^\pm}| < 10^\circ$ and $|\Delta\phi_{\ell^\pm}| < 5^\circ$
- The efficiency difference between data and MC with $0.2 < P_{\ell^\pm}/P_{beam} < 1.1$ are taken as systematic uncertainties.

- MC statistic

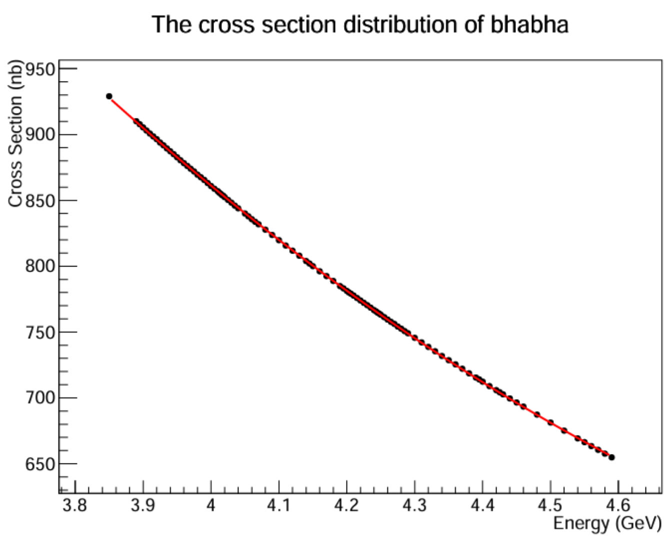
The systematic uncertainty of MC statistics is estimated by:

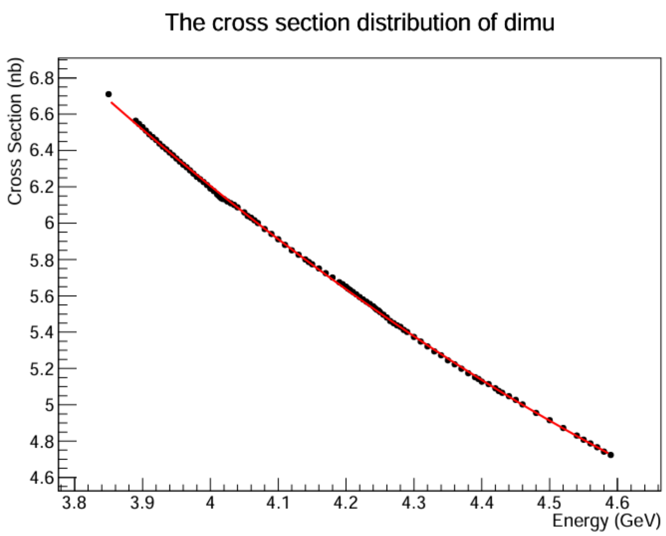
$$\frac{\sqrt{(1-\epsilon)*\epsilon}}{\sqrt{N}}$$

Systematic Uncertainty

- Beam energy

We use the BabayagaNLO generator to obtain the cross section and fit the cross section lineshape as shown in Figure. By changing the beam energy within 0.5 MeV, the impact of variations in center-of-mass energy on the luminosity results can be observed, which is considered as a systematic uncertainty.



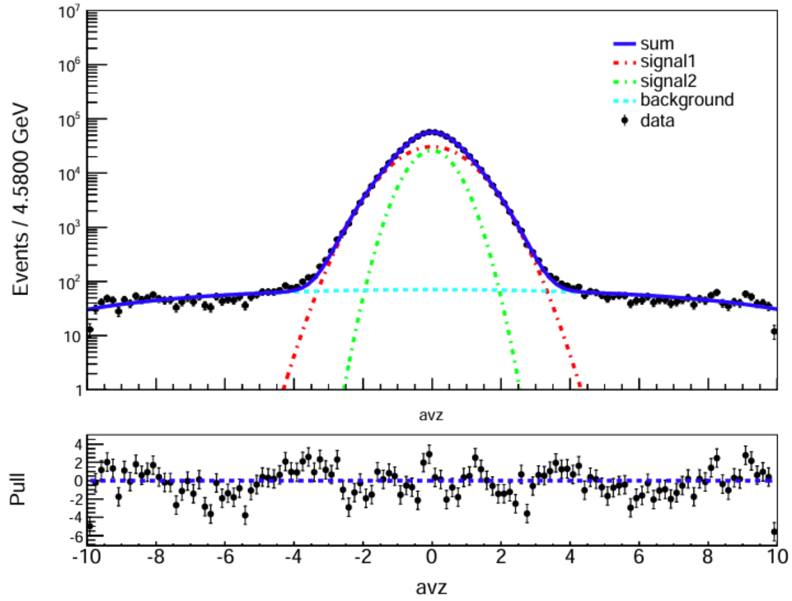


Systematic Uncertainty

- Background estimation

The ratio of the physical background to signal is very small, at about 0.2%. Therefore, the uncertainty due to background estimation for the physical process is neglected.

Regarding the beam-associated background, it is previously selected using the sideband method and can also be estimated by using a fit method. The difference between the two methods is considered as a systematic uncertainty. Taking 4.58 GeV as an example.



Systematic Uncertainty

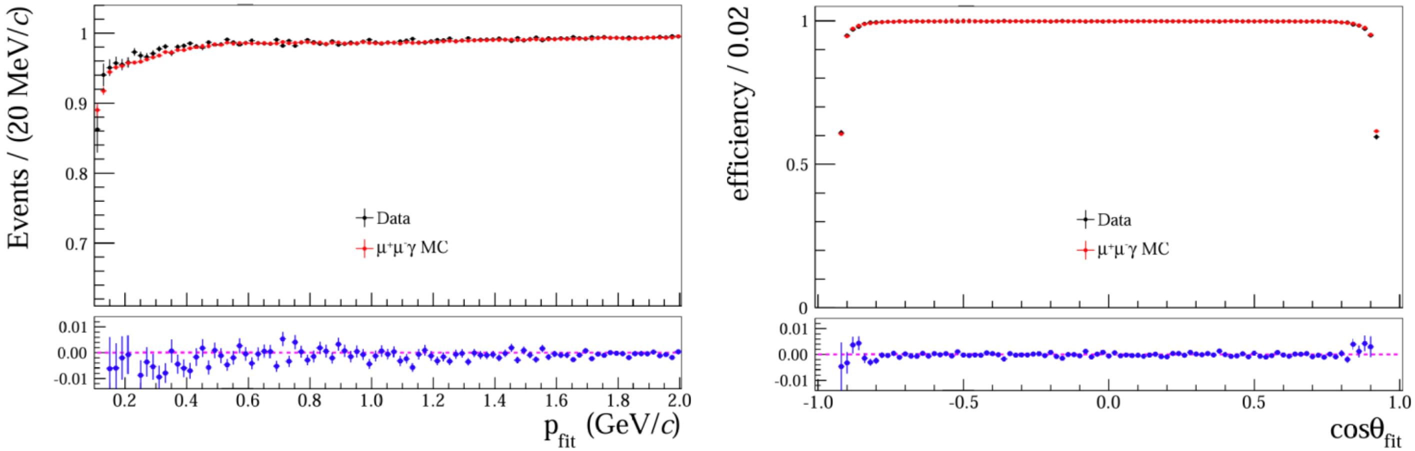
- Uncertainty of Generator

In this analysis, the generator of signal events is BabayagaNLO, according to the document of Babayaga generator, the estimated theoretical accuracy is about 0.1%.(Phys. Lett. B663, 209 (2008))

- Tracking efficiency

The uncertainty of the tracking efficiency has been studied using the $e^+e^- \to e^+e^-$. For each electron, the uncertainty is 0.15%. (CPC 46, 113003 (2022))

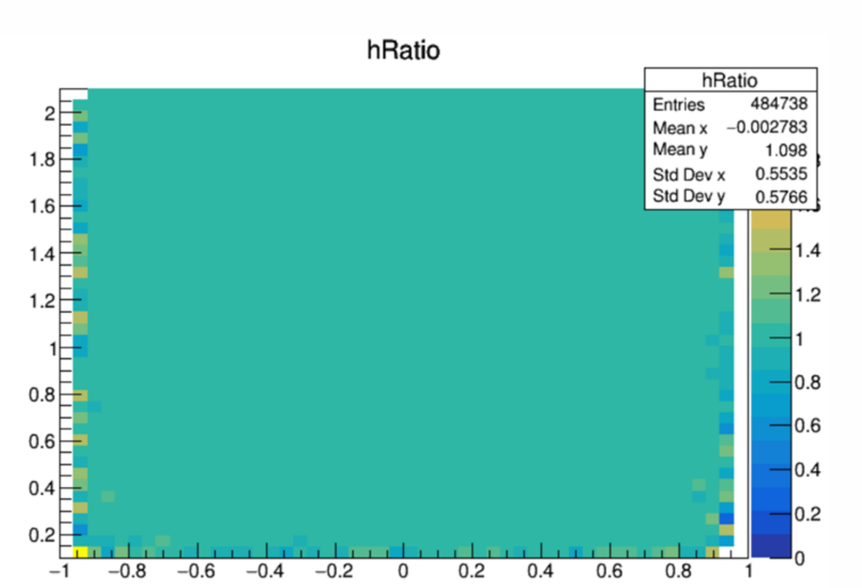
For each muon, at 4.178 GeV, select the control sample $e^+e^- \to \mu^+\mu^-\gamma$, and compare the data and MC distributions in momentum and $\cos\theta$.

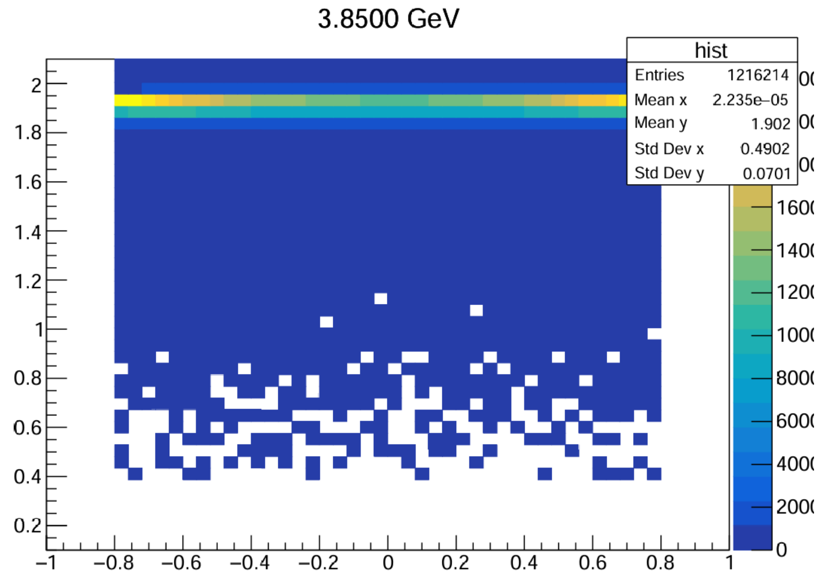


Systematic Uncertainty

The ratio of selection efficiencies between data and MC at 4.178 GeV is obtained. The cos θ ranges from -1 to 1, divided into 50 bins, and the momentum ranges from 0.1 to 2.1 GeV/c, divided into 42 bins.

For each muon track in the MC sample, the corresponding ratio is found based on its cos θ and momentum values, and this ratio is used as the weight for the track. The corrected selection efficiency is obtained, and the difference in the luminosity result is treated as a systematic uncertainty, the uncertainty is 0.02%.



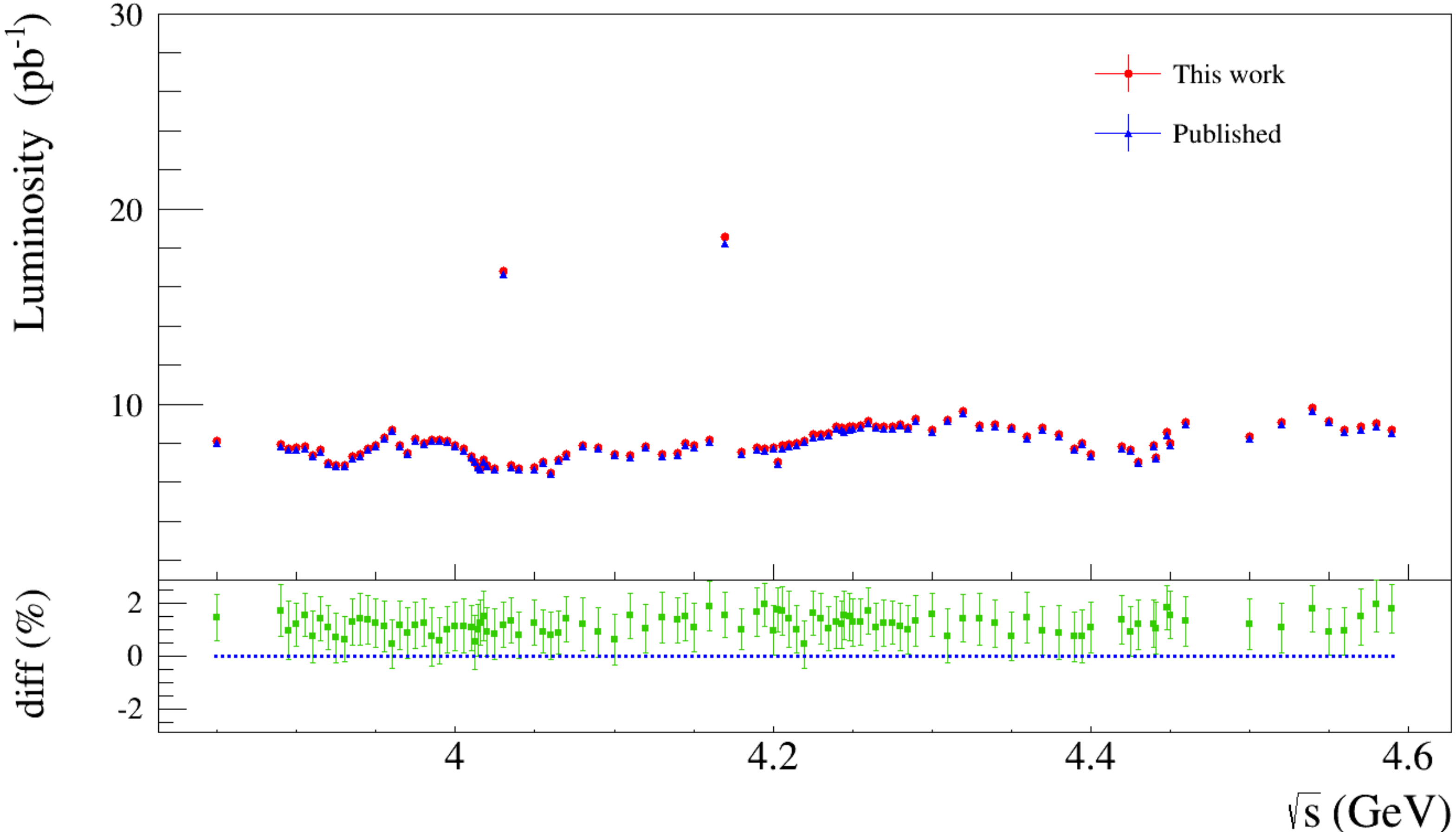


Systematic Uncertainty

Taking 4.60 GeV as an example, the summary of the systematic uncertainties is shown in Table.

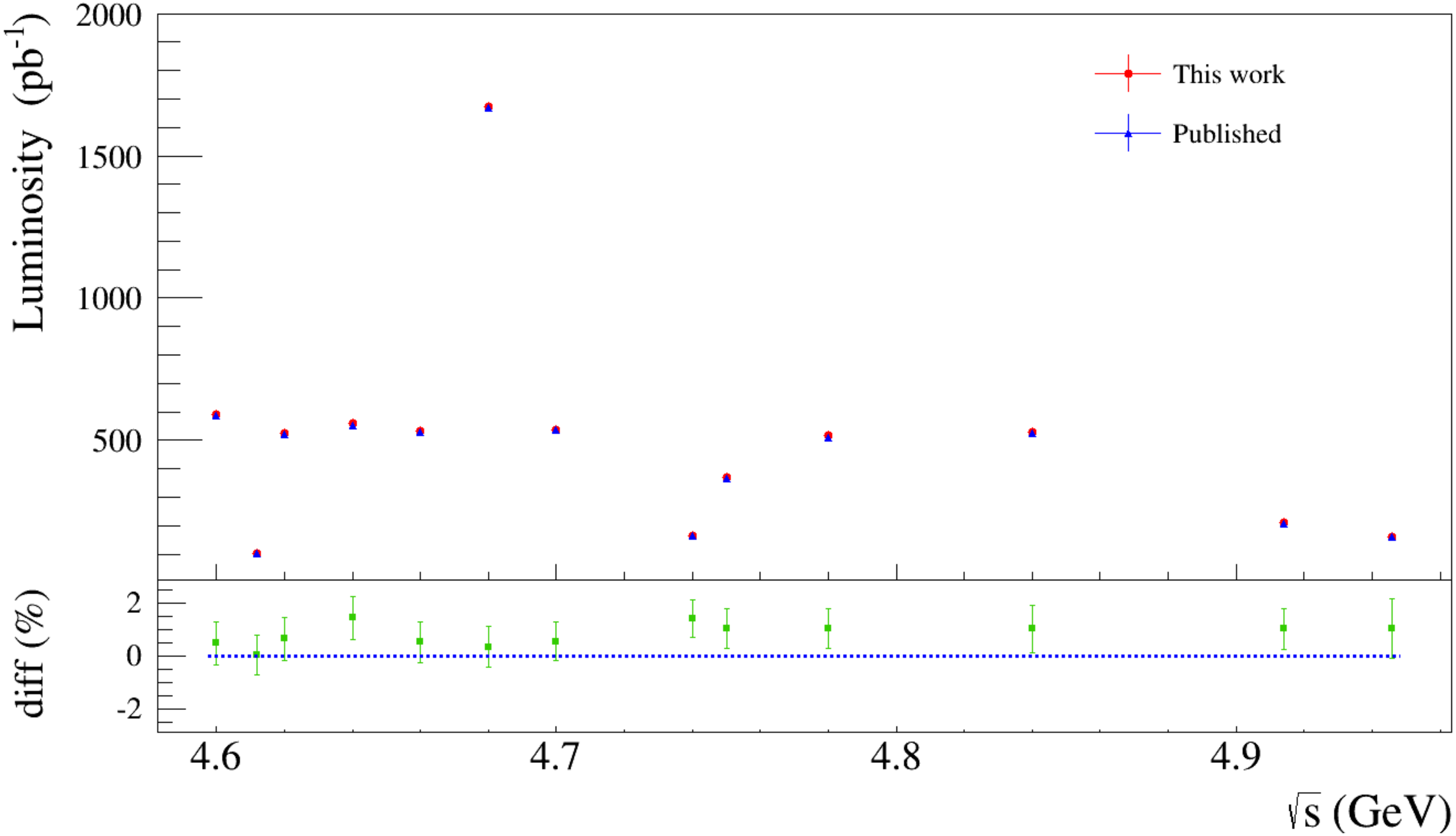
Source	Systematic Uncertainty(%)
nGood requirement	0.04
$\Delta\theta$ cut range	0.10
$\Delta\phi$ cut range	0.01
$\cos\theta$ cut range	0.01
Momentum cut range	0.04
MC statistic	0.27
Beam energy	0.04
Background estimation	0.23
Tracking efficiencies of e^+e^-	0.30
Tracking efficiencies of $\mu^+\mu^-$	0.02
Uncertainty of Generator	0.10
Total	0.50

Comparisons with published results: 3.85~4.59 GeV



The luminosity obtained by this work is systematically higher than the published result by 1.5%.

Comparisons with published results: 4.60~4.95 GeV



The luminosity obtained by this work is systematically higher than the published result by 1.0%.

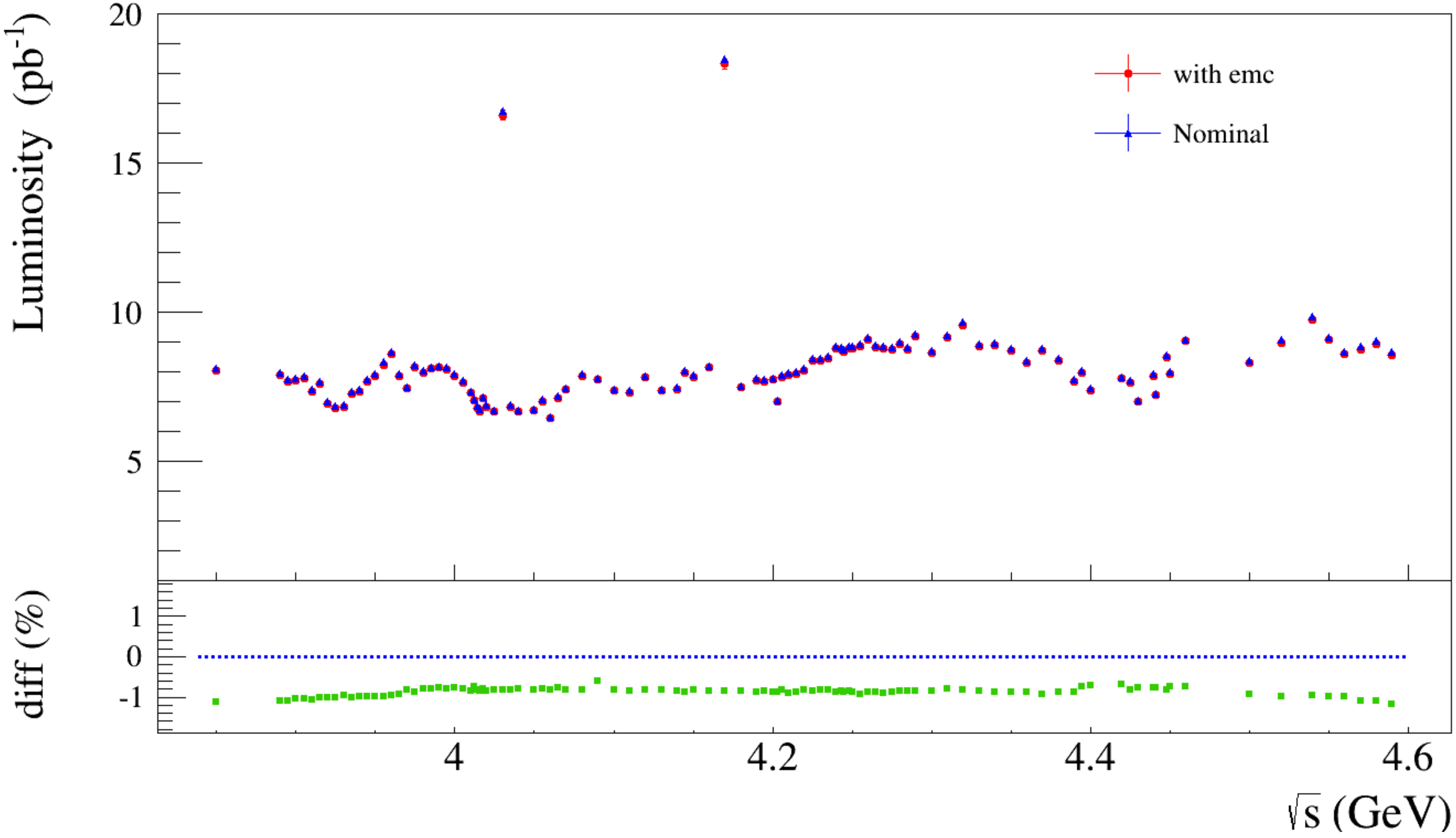
Comparisons with published results

After further investigations, the differences are primarily attributed to two sources.

- For the previous analysis from 3.85 to 4.59 GeV, Babayaga3.5 has been used as signal MC model. Now, with the BabayagaNLO, the previous results are found to be underestimated by 0.5%. Additionally, it is found that when both good charged tracks are required to deposited energy in the EMC, there is 1% efficiency difference between the signal MC and data.

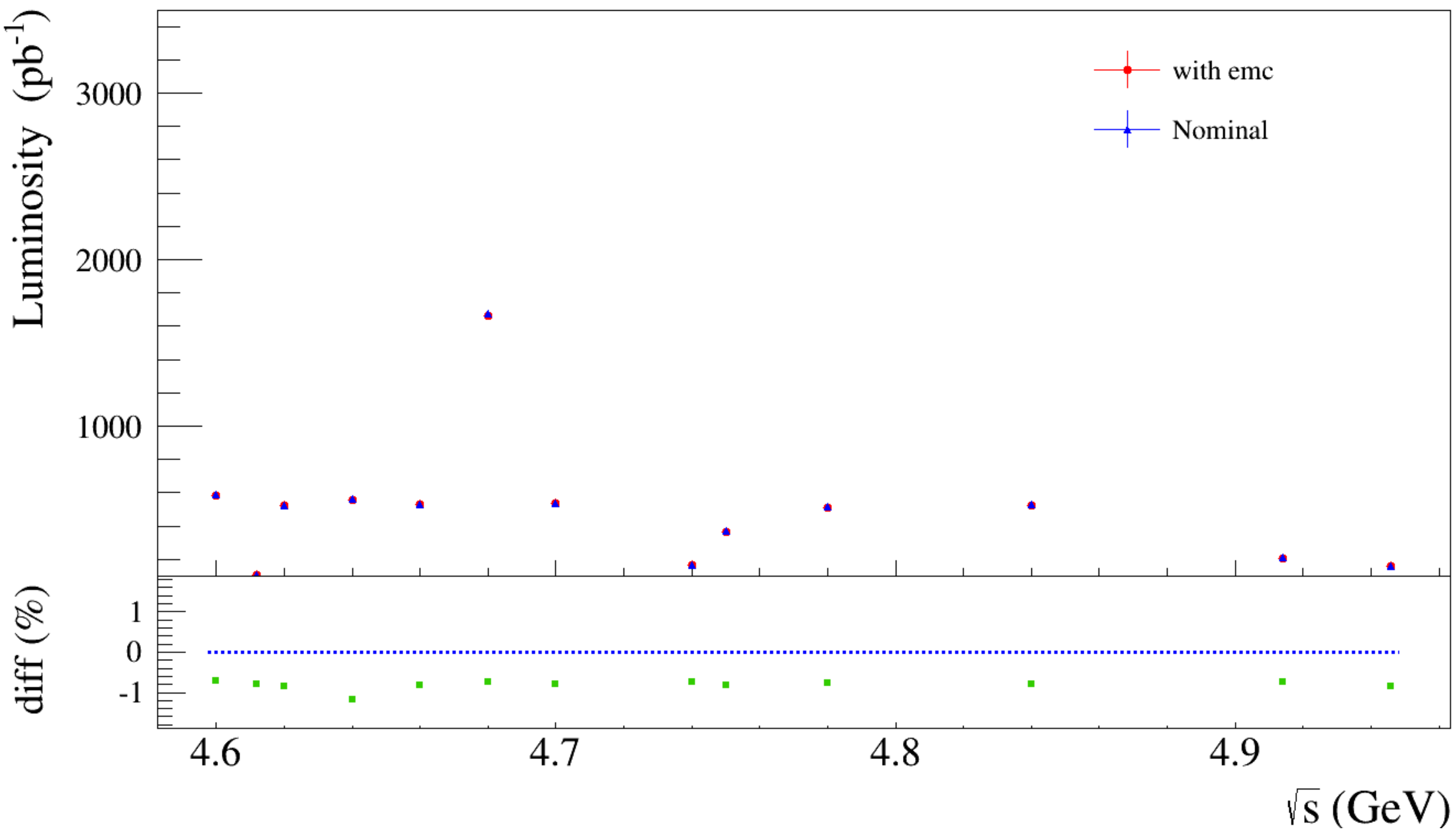
- For the previous analysis from 4.60 to 4.96 GeV, it is found that when both good charged tracks are required to deposited energy in the EMC, there is 1% efficiency difference between the signal MC and data.

Comparisons with published results : 3.85~4.59 GeV



The luminosity obtained by requiring both charged tracks have EMC shower information is systematically lower than the nominal result by 1%, and there is no energy-dependence in these differences.

Comparisons with published results : 4.60~4.95 GeV



The luminosity obtained by requiring both charged tracks have EMC shower information is systematically lower than the nominal result by 1%, and there is no energy-dependence in these differences.

Summary

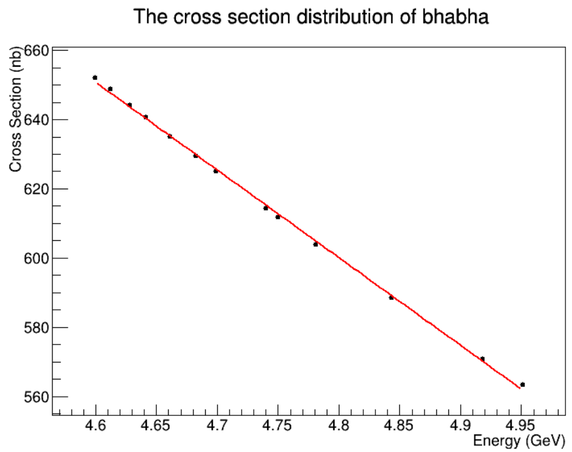
- The luminosity is measured from 3.85 to 4.95 GeV using only the MDC information.
- Our results are systematically higher than the published ones by 1.5% and 1.0% at (3.85, 4.59) GeV and (4.60, 4.95) GeV, respectively.
- There is a 0.5% difference between Babayaga3.5 and BabayagaNLO.
- An inefficiency of 1% is found in data compared with MC.

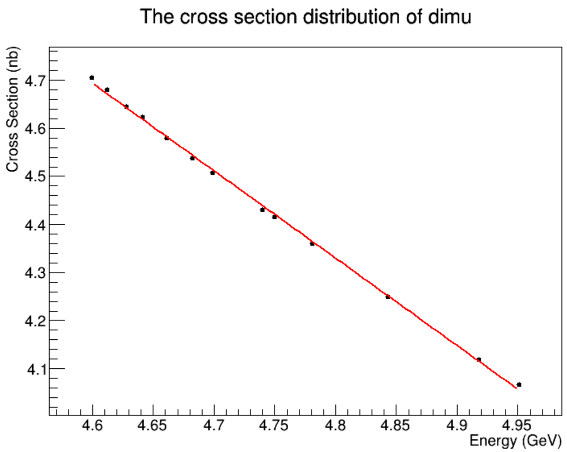
Thanks for your attention!

Back up

Systematic Uncertainty

- Cross section





$$\sigma^{obs}_{e^+e^-\to e^+e^-} = -253.272 * E_{cm} + 1815.82$$

$$\sigma^{obs}_{e^+e^-\to \mu^+\mu^-} = -1.81825 * E_{cm} + 13.0575$$

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
3.8500	7.999±0.009±0.058	8.118±0.009±0.04
3.8900	7.826±0.009±0.057	7.963±0.009±0.05
3.8950	7.666±0.009±0.054	7.741±0.009±0.07
3.9000	7.665±0.009±0.054	7.758±0.009±0.04
3.9050	7.720±0.009±0.054	7.842±0.009±0.04
3.9100	7.344±0.009±0.056	7.398±0.009±0.03
3.9150	7.538±0.009±0.054	7.645±0.009±0.04
3.9200	6.903±0.008±0.053	6.978±0.008±0.03
3.9250	6.800±0.008±0.050	6.848±0.008±0.04
3.9300	6.829±0.008±0.048	6.873±0.008±0.03
3.9350	7.216±0.009±0.053	7.311±0.009±0.04
3.9400	7.303±0.009±0.056	7.407±0.009±0.04
3.9450	7.632±0.009±0.063	7.738±0.009±0.03

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
3.9500	7.813±0.009±0.057	7.912±0.009±0.04
3.9550	8.212±0.009±0.066	8.306±0.009±0.04
3.9600	8.619±0.010±0.066	8.658±0.009±0.04
3.9650	7.818±0.009±0.058	7.911±0.009±0.04
3.9700	7.426±0.009±0.057	7.491±0.009±0.03
3.9750	8.111±0.009±0.057	8.206±0.009±0.04
3.9800	7.916±0.009±0.059	8.018±0.009±0.04
3.9850	8.092±0.009±0.077	8.152±0.009±0.04
3.9900	8.139±0.009±0.061	8.187±0.009±0.04
3.9950	8.052±0.009±0.057	8.134±0.009±0.04
4.0000	7.814±0.009±0.060	7.903±0.009±0.04
4.0050	7.605±0.009±0.056	7.693±0.009±0.05
4.0100	7.255±0.009±0.053	7.333±0.009±0.04

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.0120	7.027±0.009±0.058	7.064±0.009±0.04
4.0140	6.768±0.009±0.055	6.836±0.008±0.03
4.0160	6.636±0.008±0.048	6.721±0.008±0.03
4.0180	7.040±0.009±0.058	7.148±0.009±0.03
4.0200	6.810±0.009±0.050	6.873±0.008±0.04
4.0250	6.642±0.008±0.048	6.697±0.008±0.04
4.0300	16.639±0.013±0.118	16.837±0.013±0.08
4.0350	6.783±0.009±0.050	6.876±0.009±0.03
4.0400	6.651±0.009±0.048	6.704±0.008±0.03
4.0500	6.659±0.009±0.048	6.744±0.008±0.03
4.0550	6.997±0.009±0.052	7.063±0.009±0.03
4.0600	6.421±0.008±0.048	6.471±0.008±0.03
4.0650	7.105±0.009±0.052	7.169±0.009±0.03

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.0700	7.341±0.009±0.053	7.446±0.009±0.04
4.0800	7.810±0.009±0.065	7.906±0.009±0.04
4.0900	7.695±0.009±0.057	7.765±0.009±0.04
4.1000	7.366±0.009±0.060	7.413±0.009±0.04
4.1100	7.238±0.009±0.054	7.350±0.009±0.04
4.1200	7.775±0.009±0.061	7.857±0.009±0.04
4.1300	7.302±0.009±0.055	7.411±0.009±0.04
4.1400	7.364±0.009±0.054	7.466±0.009±0.04
4.1450	7.904±0.010±0.064	8.023±0.009±0.04
4.1500	7.781±0.009±0.057	7.867±0.009±0.04
4.1600	8.039±0.010±0.059	8.194±0.010±0.05
4.1700	18.246±0.015±0.131	18.534±0.014±0.08
4.1800	7.447±0.009±0.053	7.523±0.009±0.03

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.1900	7.650±0.009±0.061	7.779±0.009±0.04
4.1950	7.589±0.009±0.054	7.740±0.009±0.04
4.2000	7.709±0.010±0.059	7.785±0.009±0.04
4.2030	6.915±0.009±0.050	7.038±0.009±0.03
4.2060	7.740±0.010±0.060	7.874±0.010±0.04
4.2100	7.827±0.010±0.067	7.938±0.010±0.05
4.2150	7.906±0.010±0.062	7.987±0.010±0.04
4.2200	8.057±0.010±0.058	8.093±0.010±0.04
4.2250	8.305±0.010±0.064	8.442±0.010±0.04
4.2300	8.310±0.010±0.070	8.430±0.010±0.04
4.2350	8.416±0.010±0.063	8.505±0.010±0.04
4.2400	8.713±0.010±0.066	8.826±0.010±0.05
4.2430	8.703±0.010±0.071	8.808±0.010±0.04

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.2450	8.591±0.010±0.071	8.726±0.010±0.04
4.2480	8.698±0.010±0.068	8.829±0.010±0.04
4.2500	8.747±0.010±0.071	8.860±0.010±0.04
4.2550	8.794±0.010±0.064	8.909±0.010±0.05
4.2600	8.990±0.010±0.065	9.148±0.010±0.04
4.2650	8.770±0.010±0.068	8.867±0.010±0.04
4.2700	8.724±0.010±0.064	8.834±0.010±0.05
4.2750	8.712±0.010±0.062	8.823±0.010±0.04
4.2800	8.884±0.010±0.070	8.984±0.010±0.04
4.2850	8.711±0.010±0.065	8.800±0.010±0.04
4.2900	9.142±0.011±0.079	9.267±0.011±0.04
4.3000	8.568±0.010±0.062	8.705±0.010±0.04
4.3100	9.125±0.011±0.081	9.195±0.011±0.05

Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.3200	9.502±0.011±0.071	9.640±0.011±0.04
4.3300	8.805±0.010±0.077	8.930±0.010±0.04
4.3400	8.857±0.011±0.066	8.968±0.010±0.04
4.3500	8.721±0.011±0.066	8.786±0.010±0.04
4.3600	8.223±0.010±0.069	8.346±0.010±0.04
4.3700	8.690±0.011±0.071	8.773±0.010±0.04
4.3800	8.365±0.010±0.070	8.440±0.010±0.05
4.3900	7.661±0.010±0.056	7.718±0.010±0.04
4.3950	7.964±0.010±0.067	8.025±0.010±0.04
4.4000	7.342±0.010±0.055	7.423±0.010±0.03
4.4410	7.186±0.010±0.058	7.263±0.010±0.03
4.4200	7.707±0.010±0.059	7.816±0.010±0.04
4.4250	7.606±0.010±0.056	7.677±0.010±0.03

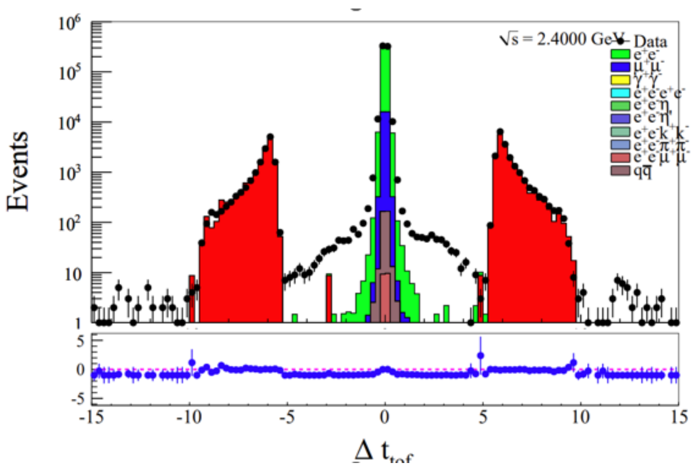
Result

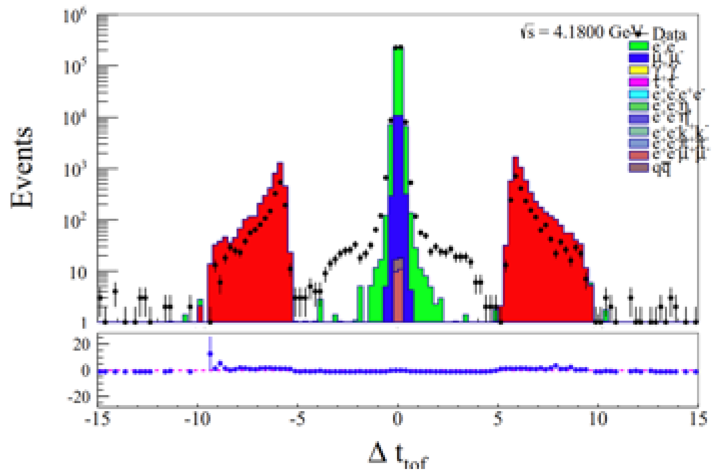
E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.4300	6.962±0.010±0.058	7.046±0.009±0.03
4.4400	7.813±0.010±0.063	7.910±0.010±0.04
4.4500	7.859±0.010±0.064	7.983±0.010±0.04
4.4600	8.961±0.011±0.065	9.081±0.011±0.04
4.4480	8.387±0.011±0.061	8.544±0.011±0.04
4.5000	8.243±0.011±0.068	8.345±0.010±0.04
4.5200	8.949±0.011±0.070	9.046±0.011±0.04
4.5400	9.657±0.011±0.074	9.834±0.011±0.04
4.5500	9.053±0.011±0.074	9.138±0.011±0.04
4.5600	8.588±0.011±0.064	8.670±0.011±0.05
4.5700	8.693±0.011±0.076	8.825±0.011±0.04
4.5800	8.837±0.011±0.075	9.013±0.011±0.05
4.5900	8.495±0.011±0.068	8.650±0.011±0.04

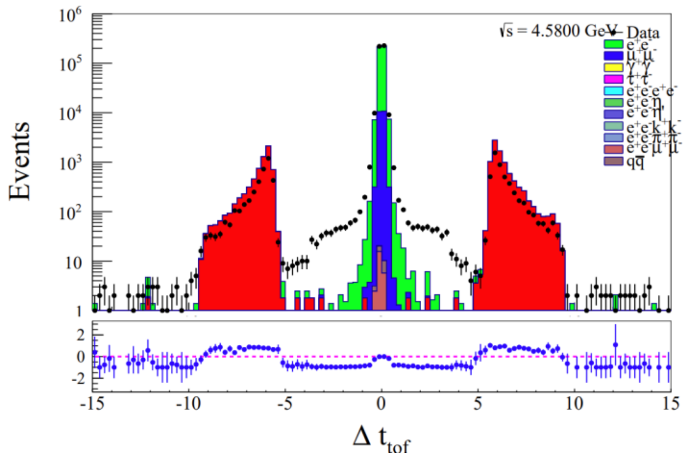
Result

E_{cm} (GeV)	$\mathcal{L}(pb^{-1})$ (publish)	$\mathcal{L}(pb^{-1})$ (this work)
4.6000	586.9±0.1±3.9	589.73±0.09±2.92
4.6120	103.65±0.05±0.55	103.70±0.04±0.55
4.6200	521.53±0.11±2.76	524.96±0.09±3.32
4.6400	551.65±0.12±2.92	559.73±0.09±3.49
4.6600	529.43±0.12±2.81	532.21±0.09±2.89
4.6800	1667.39±0.21±8.84	1673.30±0.15±9.70
4.7000	535.54±0.12±2.84	538.50±0.09±2.73
4.7400	163.87±0.07±0.87	166.24±0.05±0.84
4.7500	366.55±0.10±1.94	370.44±0.07±2.17
4.7800	511.47±0.12±2.71	516.81±0.09±2.82
4.8400	525.16±0.12±2.78	530.63±0.09±3.91
4.9180	207.82±0.08±1.10	209.98±0.06±1.19
4.9460	159.28±0.07±0.84	160.94±0.05±1.61

Cosmic background







- $\Delta t_{tof} = t_+ - t_-$
- The concentration of separate is distributed between 5-10 absolute values

EMC rec

- EmcRecAlg.TimeMax=60;

Table: The results at 4.58 GeV.

	Without EMC	With EMC	ratio
TimeMax=60	666810	666672	99.98%
TimeMax=35	666272	658934	98.90%
ratio	99.92%	98.84%	