

# Comparison of the generators

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## Some conditions

- ▶ To compare  $\pi^+\pi^-$  CMD-2 pion form factor has been used.
- ▶ Several options of Phokhara6.0 generators has been tested (MCGPG is set to match these options).
- ▶ To compare  $\mu^+\mu^-$  and  $e^+e^-$  no vacuum polarization has been included.
- ▶ Comparision in several energy points have been done ( $\phi$ -factory,  $\tau/c$ -factory and  $B$ -factory).
- ▶ To get total cross section two types of selections criteria have been used (“ISR” mode and “Luminosity” mode).

# Selection criteria

Loose cuts used for “ISR” mode.

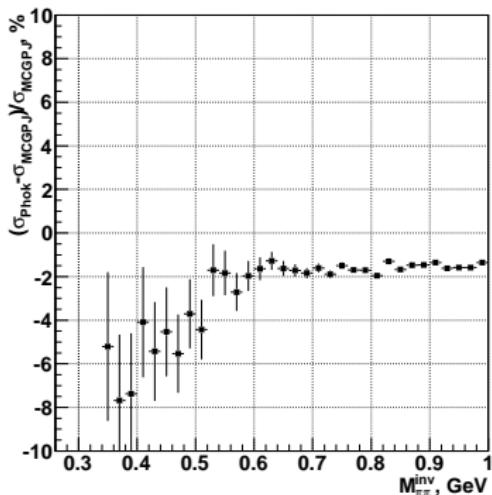
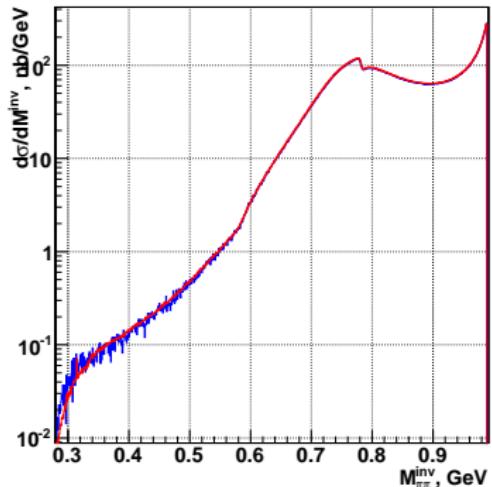
- ▶  $1 < \theta_{+,-} < \pi - 1$
- ▶  $p_\perp > 90 \text{ MeV}/c$

More strong cuts used for “Luminosity” mode.

- ▶  $|\theta_+ + \theta_- - \pi| < 0.25 \text{ rad}$
- ▶  $||\phi_+ - \phi_-| - \pi| < 0.15 \text{ rad}$
- ▶  $E_{+,-} > E_{\text{beam}}/2$

# Comparision of Phokhara6.0 & MCGPJ for $\pi^+\pi^-$

$E_{cm} = 1$  GeV ISR selection mode & Phokhara options =  
nlo+isr+fsr+nfsnlo  $\Sigma E_\gamma > 0.01$  GeV



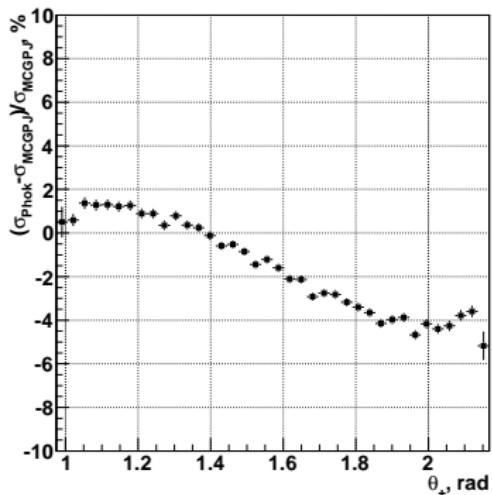
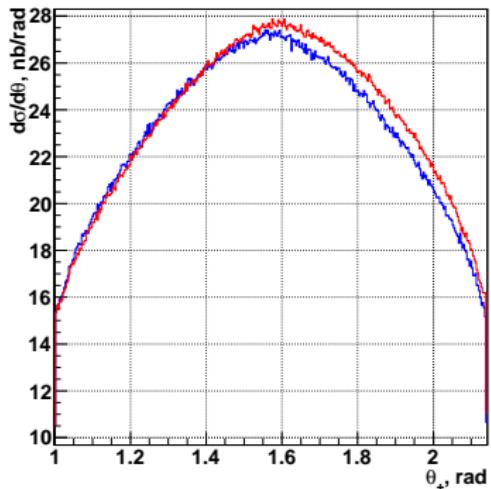
$$\sigma_{\text{MCGPJ}} = 26.8084 \pm 0.00584868 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 26.3799 \pm 0.00734057 \text{ nb}$$

$$\delta\sigma/\sigma = -1.59833 \pm 0.0350102 \%$$

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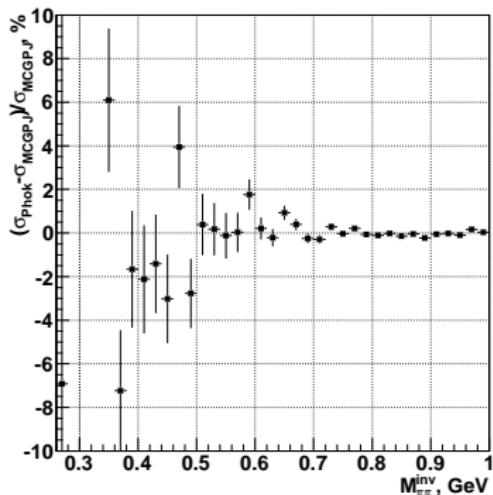
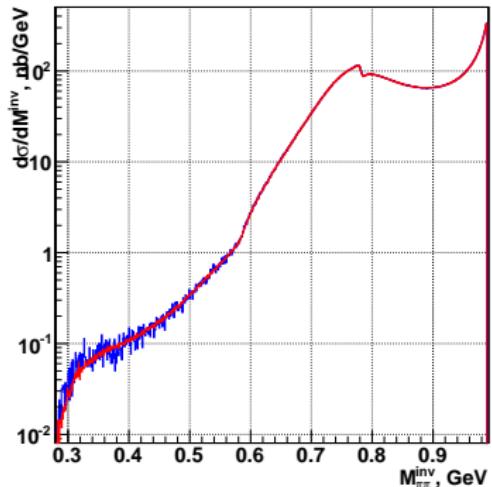
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# Comparision of Phokhara6.0 & MCGPJ for $\pi^+\pi^-$

$E_{cm} = 1$  GeV ISR selection mode & Phokhara options =  
born+isr+fsr+int  $\Sigma E_\gamma > 0.01$  GeV



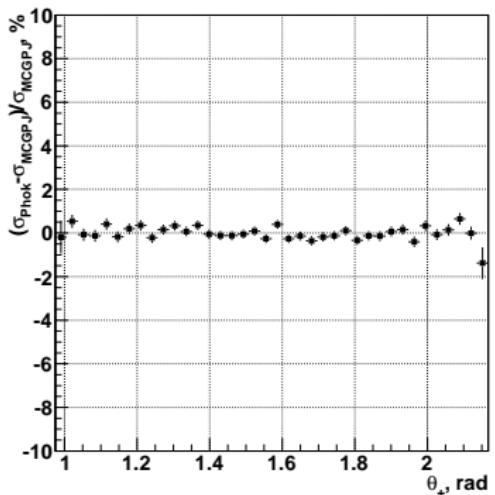
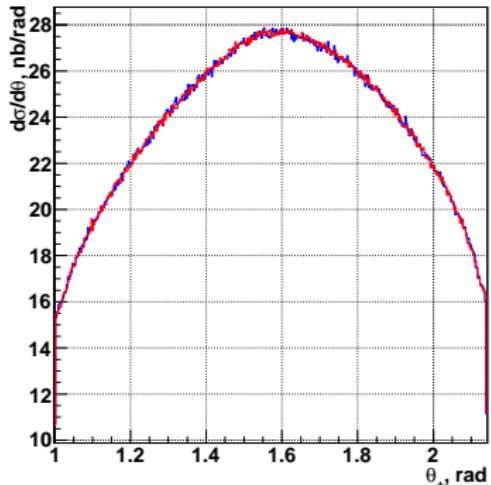
$$\sigma_{MCGPJ} = 27.015 \pm 0.00596421 \text{ nb}$$

$$\sigma_{Phokhara6.0} = 27.017 \pm 0.00598027 \text{ nb}$$

$$\delta\sigma/\sigma = 0.00754742 \pm 0.0312643 \text{ \%}$$

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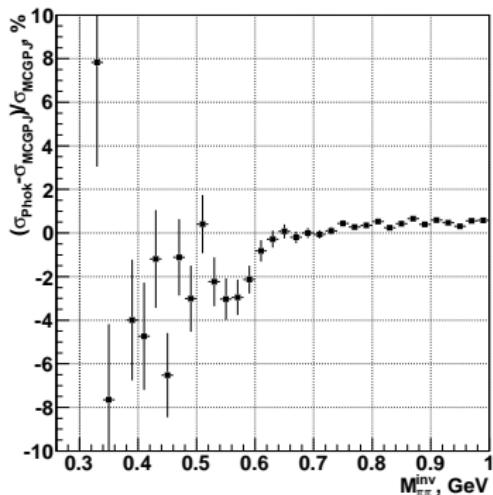
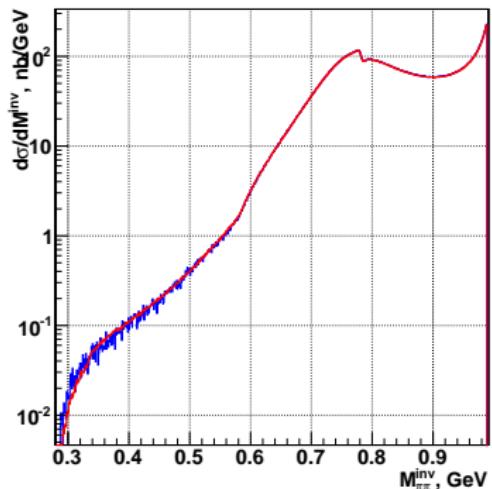
$$\sigma_{\text{MCGPJ}} = 27.015 \pm 0.00596421 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 27.017 \pm 0.00847872 \text{ nb}$$

$$\delta\sigma/\sigma = 0.00754742 \pm 0.0383725 \text{ %}$$

# Comparision of Phokhara6.0 & MCGPJ for $\pi^+\pi^-$

$E_{cm} = 1$  GeV ISR selection mode & Phokhara options =  
nlo+isr+nfsnlo  $\Sigma E_\gamma > 0.01$  GeV



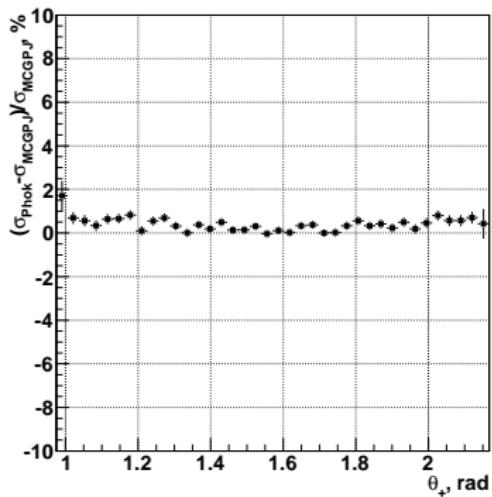
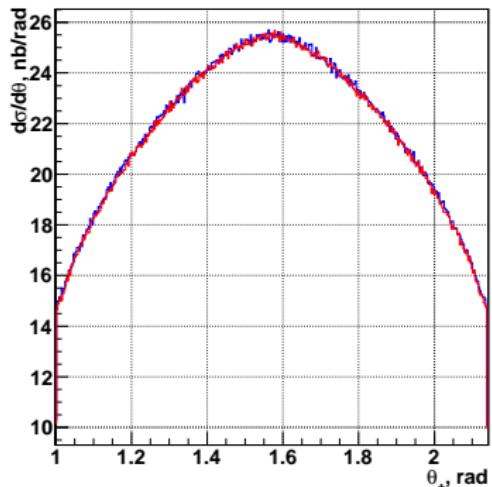
$$\sigma_{MCGPJ} = 24.7287 \pm 0.00582484 \text{ nb}$$

$$\sigma_{Phokhara6.0} = 24.8171 \pm 0.00613383 \text{ nb}$$

$$\delta\sigma/\sigma = 0.357461 \pm 0.0342067 \text{ \%}$$

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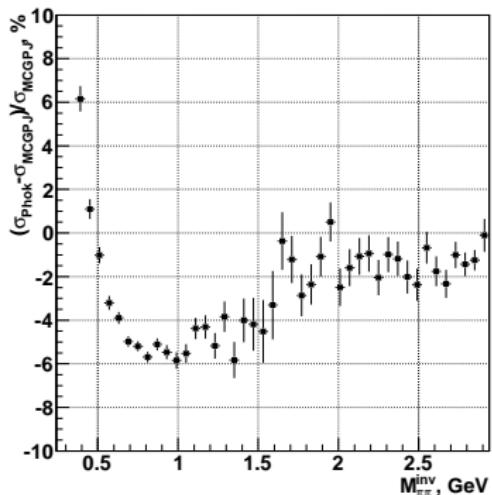
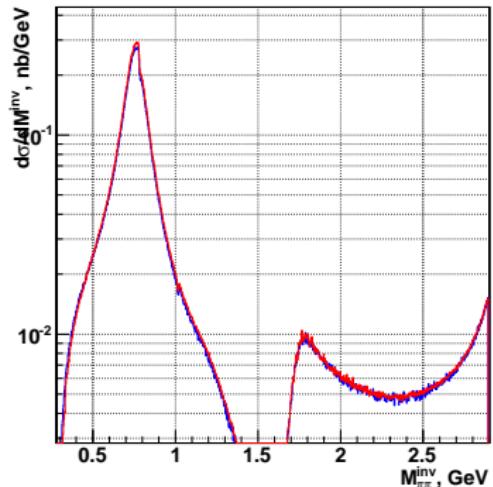
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# Comparision of Phokhara6.0 & MCGPJ for $\pi^+\pi^-$

$E_{cm} = 3 \text{ GeV}$  ISR selection mode & Phokhara options =  
nlo+isr+fsr+nfsnlo  $\Sigma E_\gamma > 0.1 \text{ GeV}$



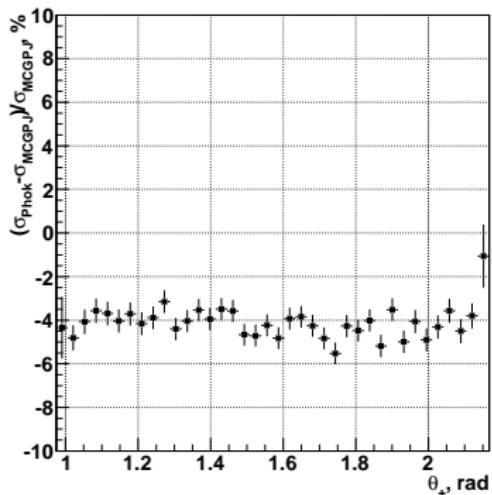
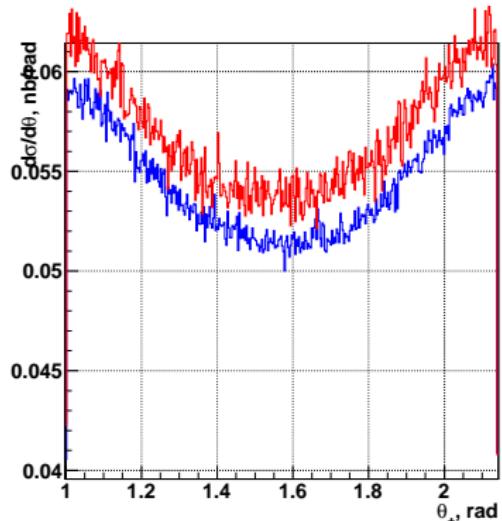
$$\sigma_{\text{MCGPJ}} = 0.0649594 \pm 5.06701e-05 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 0.0622538 \pm 2.90324e-05 \text{ nb}$$

$$\delta\sigma/\sigma = -4.16494 \pm 0.0898995 \%$$

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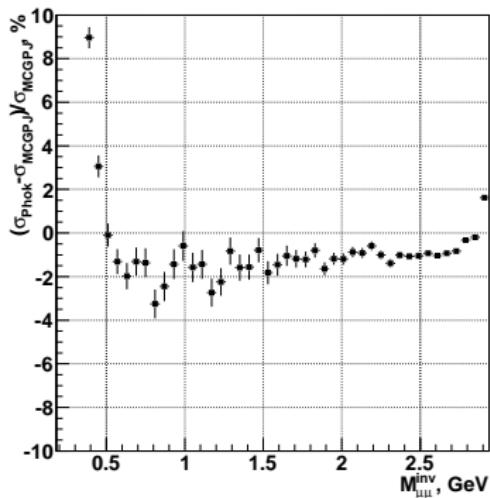
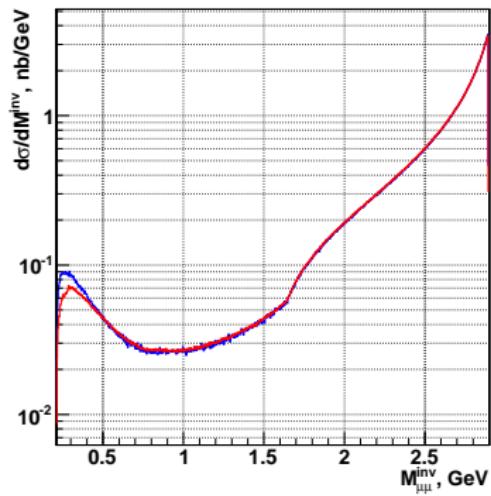
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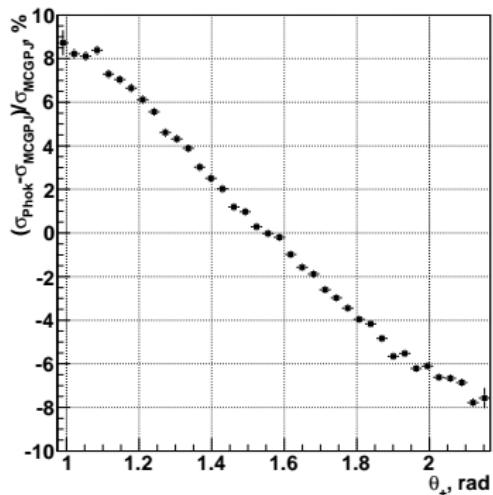
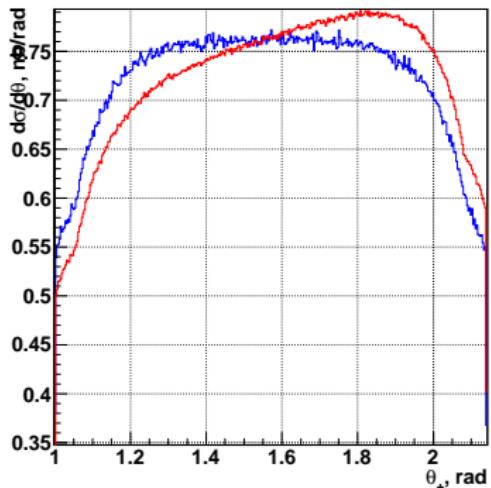
$$\sigma_{\text{MCGPJ}} = 0.822978 \pm 0.000112059 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 0.821332 \pm 0.000226267 \text{ nb}$$

$$\delta\sigma/\sigma = -0.200005 \pm 0.0306807 \%$$

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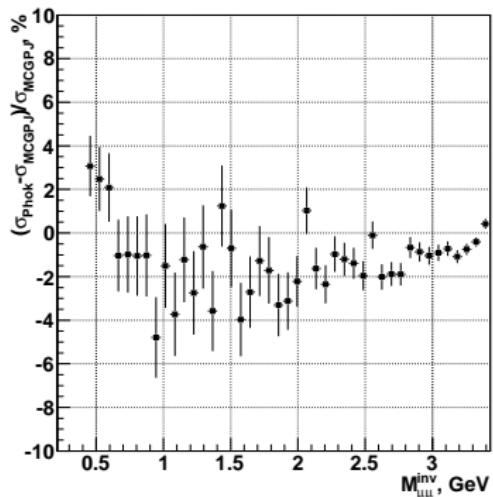
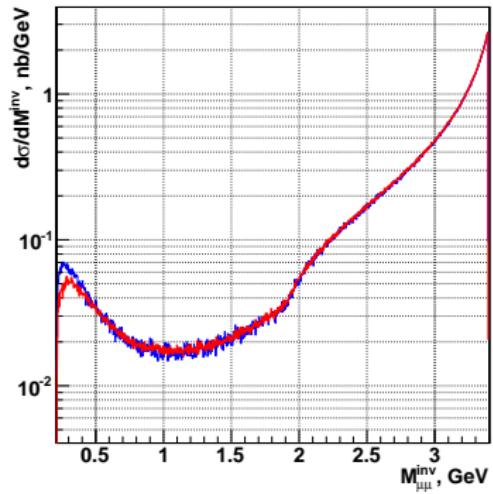
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# Comparision of Phokhara6.0 & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 3.5$  GeV ISR selection mode & Phokhara options =  
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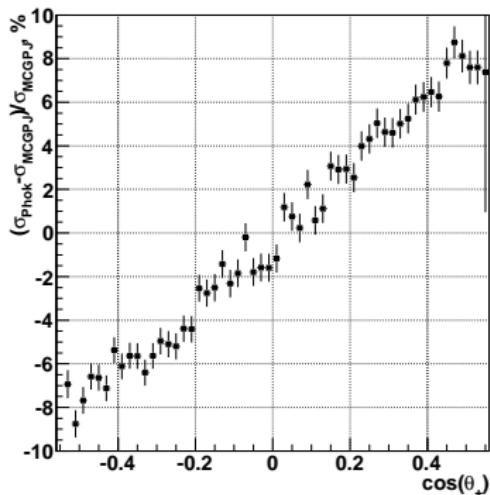
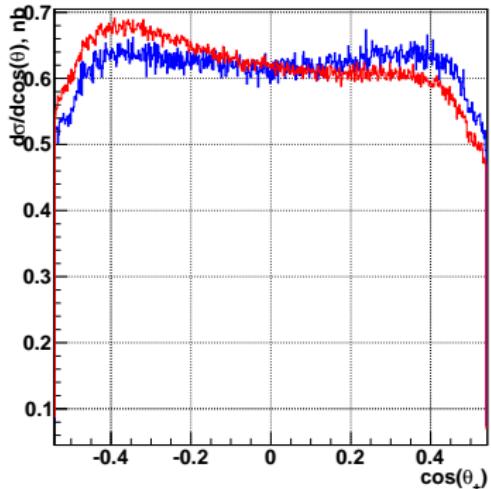
$$\sigma_{\text{MCGPJ}} = 0.668487 \pm 0.000323837 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 0.665983 \pm 0.000492604 \text{ nb}$$

$$\delta\sigma/\sigma = -0.374663 \pm 0.0881866 \text{ \%}$$

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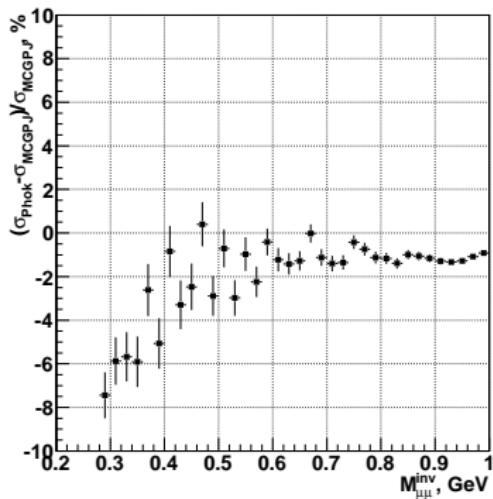
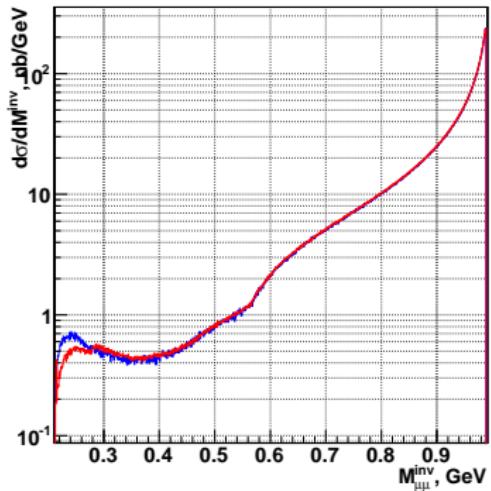
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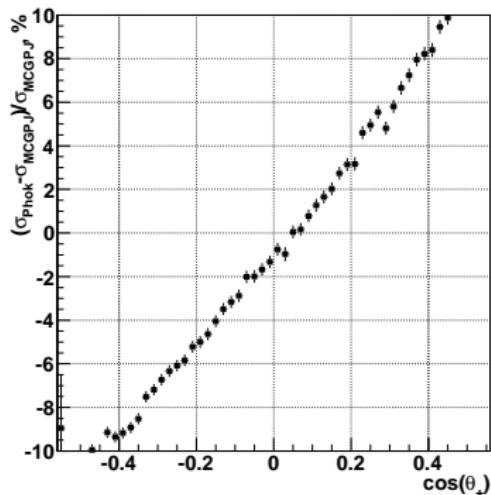
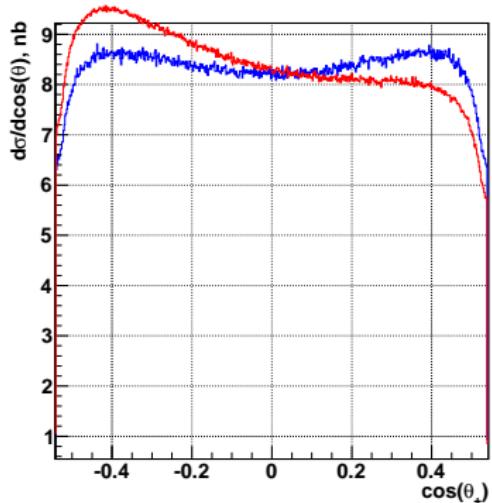
$$\sigma_{\text{MCGPJ}} = 9.07261 \pm 0.00191914 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 8.97855 \pm 0.00299017 \text{ nb}$$

$$\delta\sigma/\sigma = -1.03673 \pm 0.0391625 \%$$

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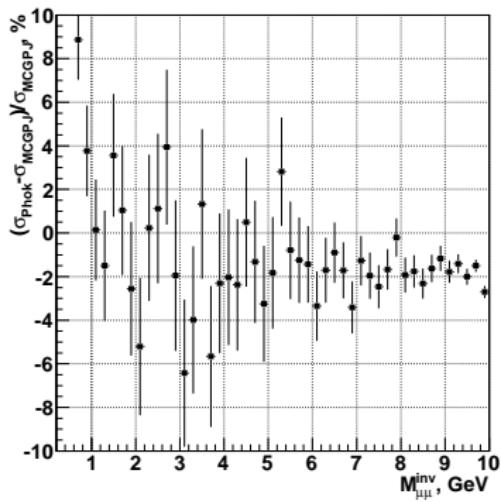
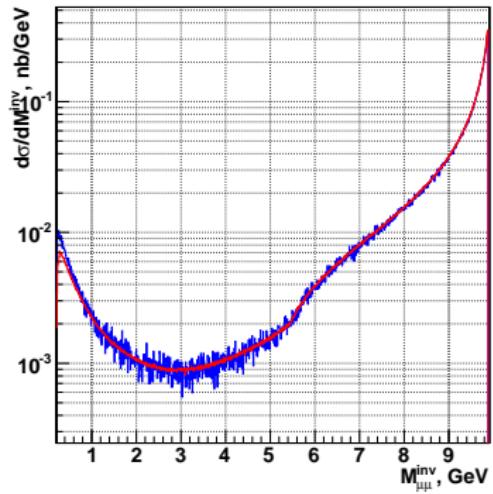
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# Comparision of Phokhara6.0 & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 10$  GeV ISR selection mode & Phokhara options =  
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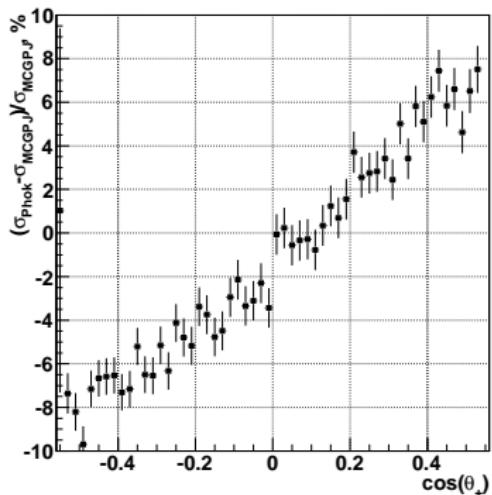
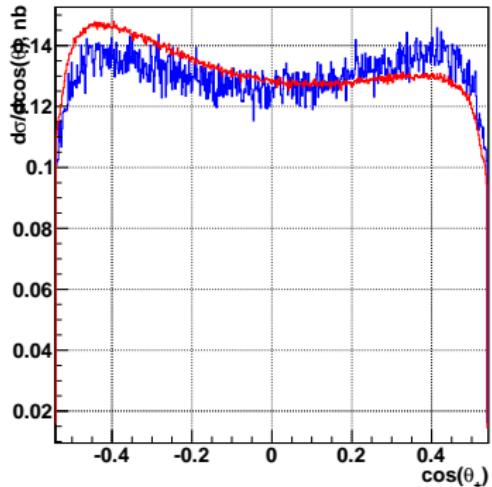
$$\sigma_{\text{MCGPJ}} = 0.142606 \pm 3.31935e-05 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 0.140715 \pm 0.000172945 \text{ nb}$$

$$\delta\sigma/\sigma = -1.32597 \pm 0.123488 \%$$

# Comparision of Phokhara6.0 & MCGPJ for $\mu^+\mu^-$

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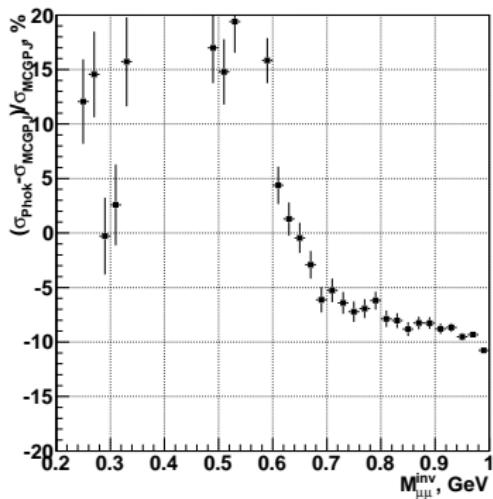
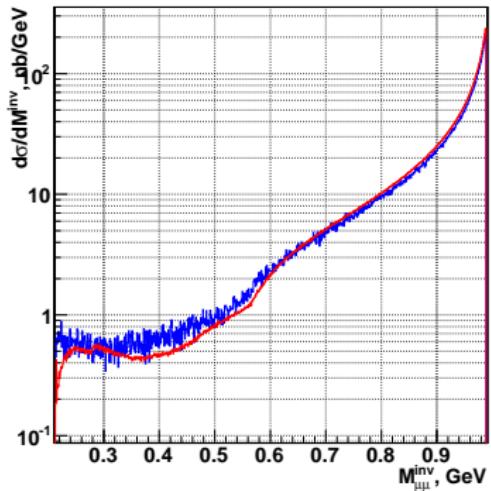
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$$\delta\sigma/\sigma = -1.32597 \pm 0.123488 \%$$

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$E_{cm} = 1$  GeV ISR selection mode & Phokhara options =  
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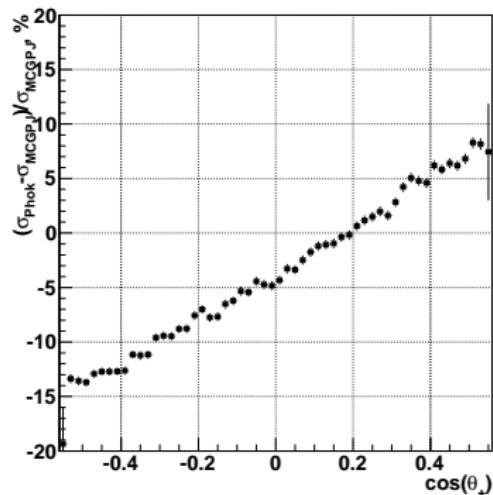
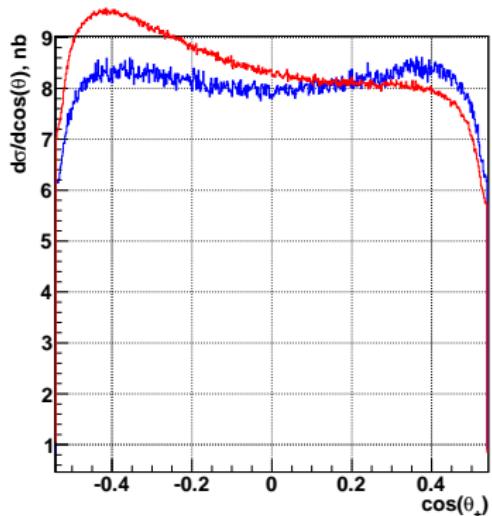
$$\sigma_{MCGPJ} = 9.07261 \pm 0.00191914 \text{ nb}$$

$$\sigma_{Phokhara6.0} = 8.70536 \pm 0.0106992 \text{ nb}$$

$$\delta\sigma/\sigma = -4.04786 \pm 0.119811 \%$$

# Comparision of Phokhara6.0 & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 1$  GeV ISR selection mode & Phokhara options =  
nlo+isr+fsr+fsnl  $\sum E_\gamma > 0.01$  GeV



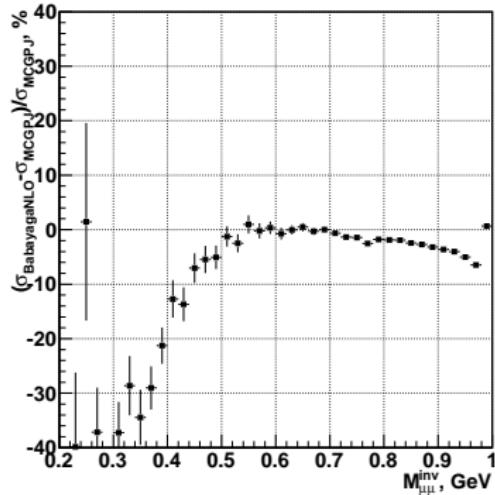
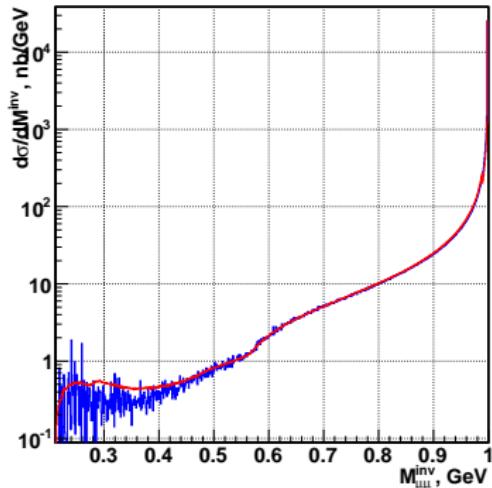
$$\sigma_{\text{MCGPJ}} = 9.07261 \pm 0.00191914 \text{ nb}$$

$$\sigma_{\text{Phokhara6.0}} = 8.70536 \pm 0.0047957 \text{ nb}$$

$$\delta\sigma/\sigma = -4.04786 \pm 0.0569346 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 1$  GeV ISR selection mode



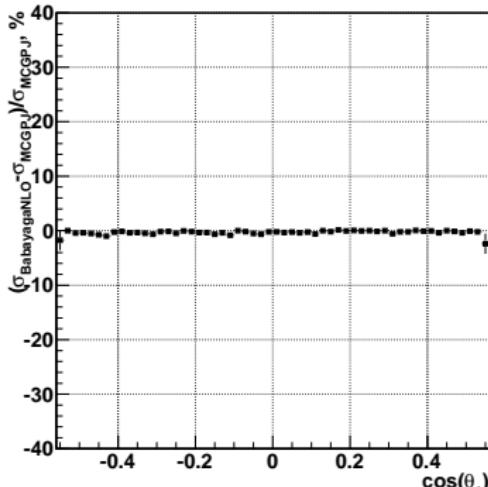
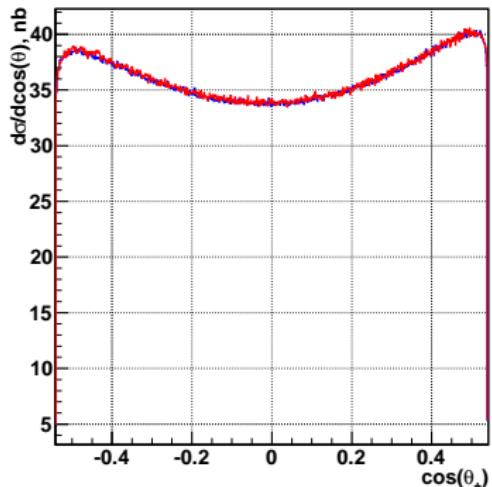
$$\sigma_{\text{MCGPJ}} = 39.1238 \pm 0.00998487 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 39.02 \pm 0.00614031 \text{ nb}$$

$$\delta\sigma/\sigma = -0.265265 \pm 0.0299609 \text{ \%}$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 1$  GeV ISR selection mode



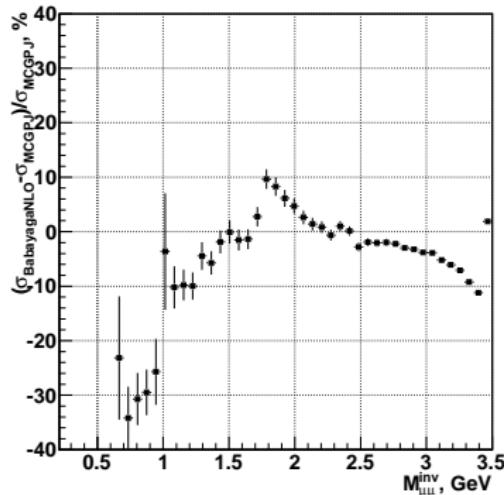
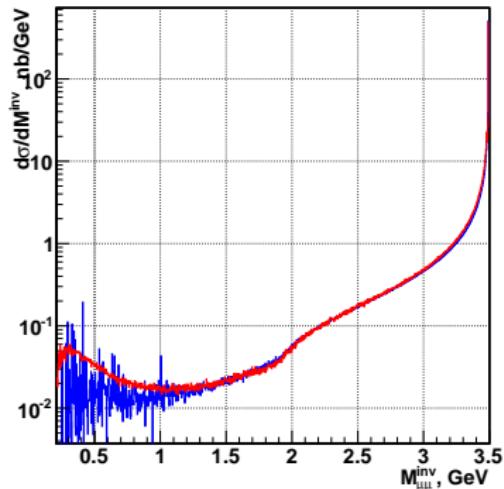
$$\sigma_{\text{MCGPJ}} = 39.1238 \pm 0.00998487 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 39.0168 \pm 0.00672788 \text{ nb}$$

$$\delta\sigma/\sigma = -0.273274 \pm 0.0307742 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 3.5$  GeV ISR selection mode



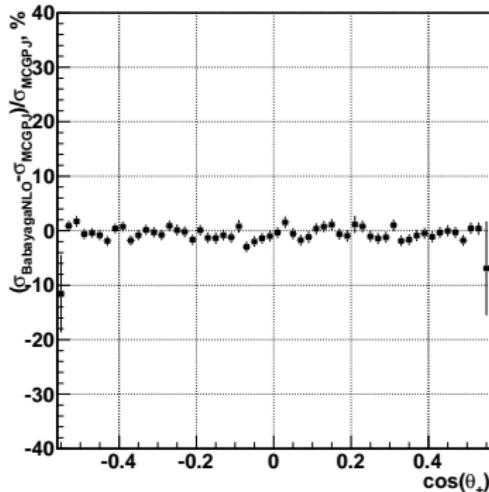
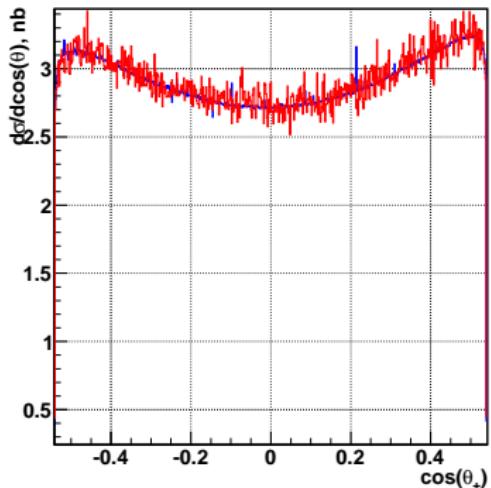
$$\sigma_{\text{MCGPJ}} = 3.16922 \pm 0.00426541 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 3.15397 \pm 0.00107068 \text{ nb}$$

$$\delta\sigma/\sigma = -0.481028 \pm 0.138764 \text{ \%}$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 3.5$  GeV ISR selection mode



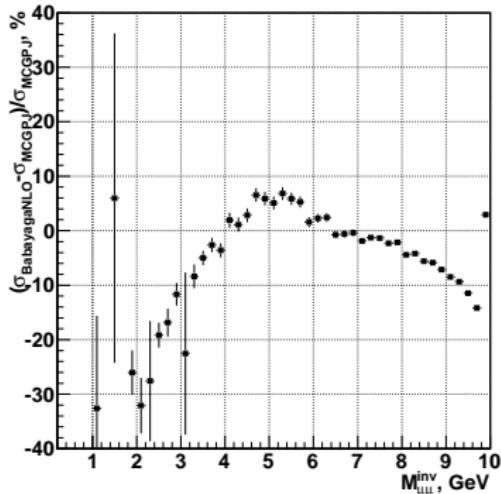
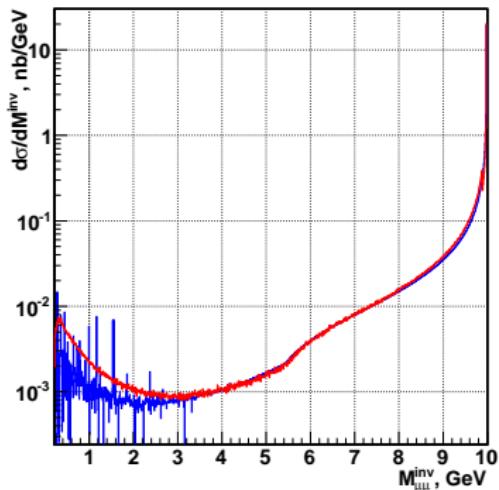
$$\sigma_{\text{MCGPJ}} = 3.16922 \pm 0.00426541 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 3.15381 \pm 0.0010614 \text{ nb}$$

$$\delta\sigma/\sigma = -0.486279 \pm 0.138693 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 10$  GeV ISR selection mode



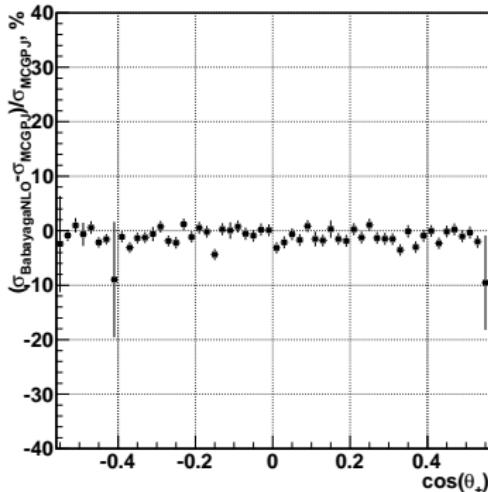
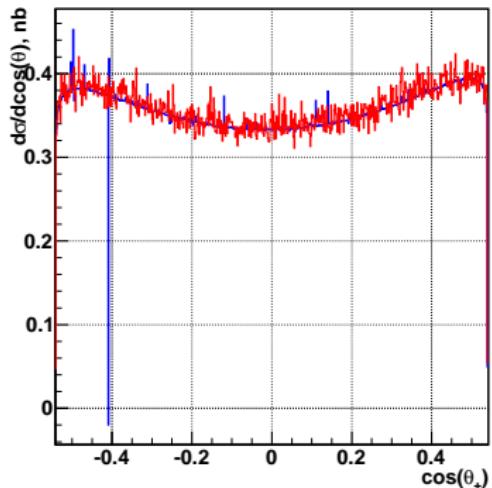
$$\sigma_{\text{MCGPJ}} = 0.390082 \pm 0.000561087 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 0.38578 \pm 0.000821413 \text{ nb}$$

$$\delta\sigma/\sigma = -1.10285 \pm 0.255012 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 10$  GeV ISR selection mode



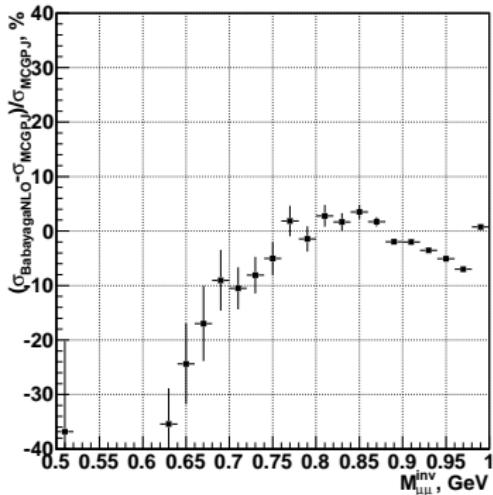
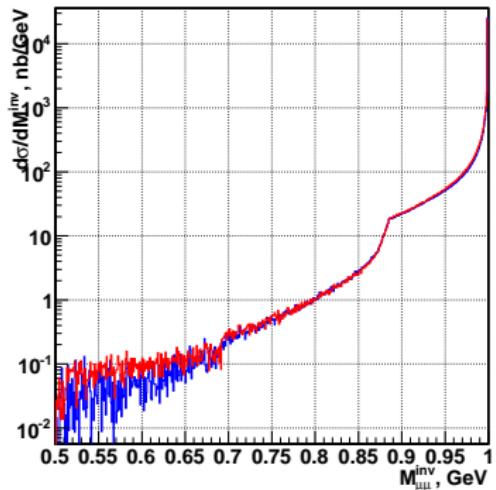
$$\sigma_{\text{MCGPJ}} = 0.390082 \pm 0.000561087 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 0.385773 \pm 0.000820712 \text{ nb}$$

$$\delta\sigma/\sigma = -1.10455 \pm 0.254863 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 1$  GeV Luminosity selection mode



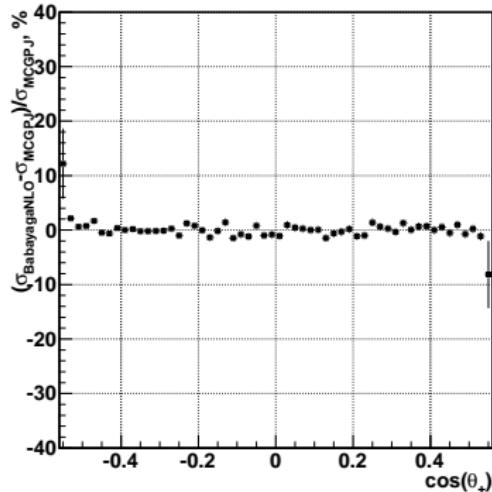
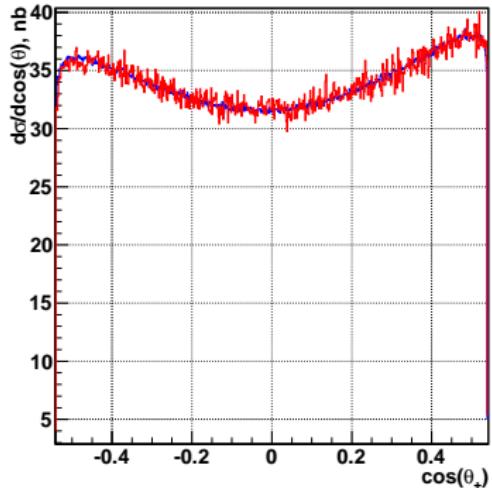
$$\sigma_{\text{MCGPJ}} = 36.7799 \pm 0.033169 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 36.7878 \pm 0.00632931 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0213953 \pm 0.0918096 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 1$  GeV Luminosity selection mode



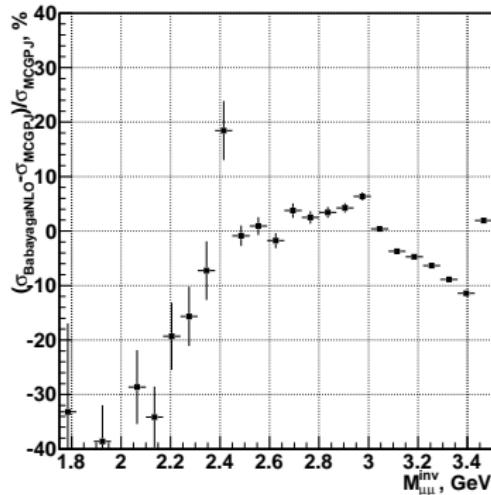
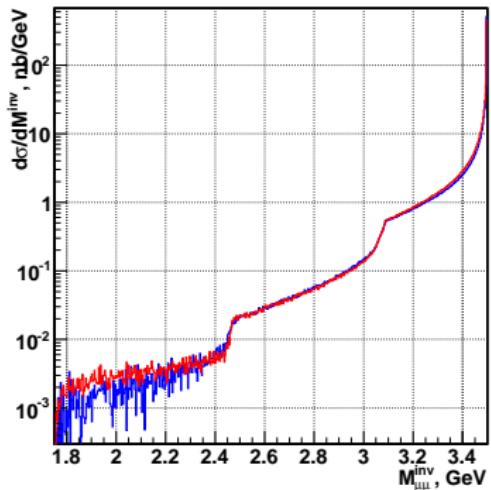
$$\sigma_{MCGPJ} = 36.7799 \pm 0.033169 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 36.787 \pm 0.00743065 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0192286 \pm 0.0924176 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 3.5$  GeV Luminosity selection mode



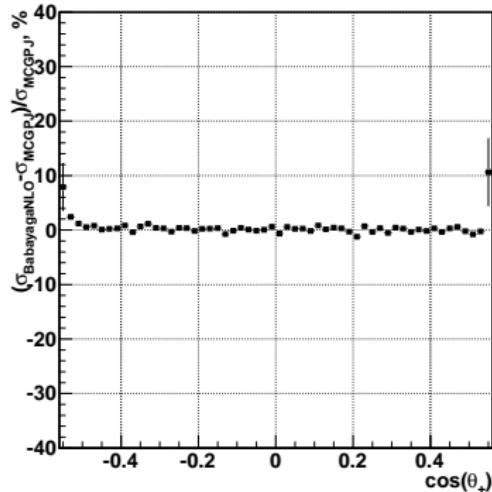
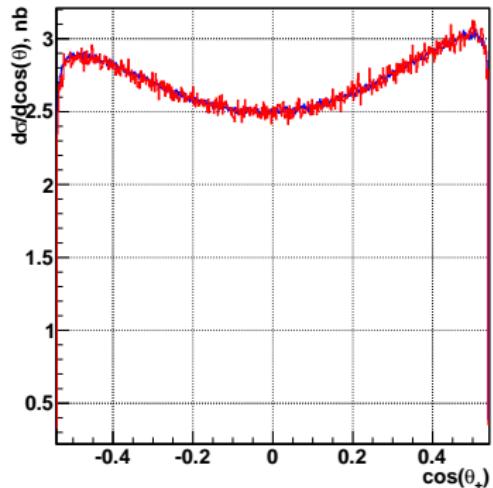
$$\sigma_{\text{MCGPJ}} = 2.91885 \pm 0.00189376 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 2.92443 \pm 0.000548279 \text{ nb}$$

$$\delta\sigma/\sigma = 0.191023 \pm 0.0675446 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 3.5$  GeV Luminosity selection mode



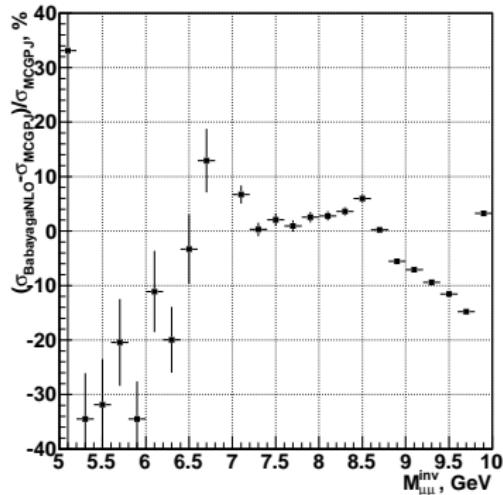
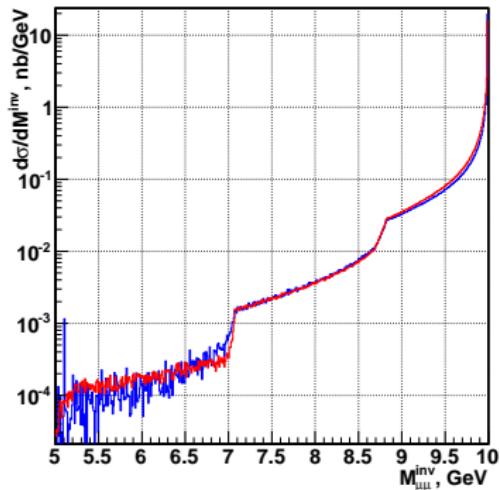
$$\sigma_{\text{MCGPJ}} = 2.91885 \pm 0.00189376 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 2.92437 \pm 0.000621559 \text{ nb}$$

$$\delta\sigma/\sigma = 0.188964 \pm 0.0682854 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 10$  GeV Luminosity selection mode



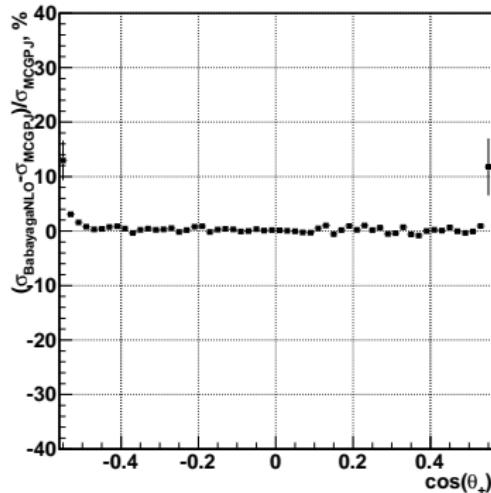
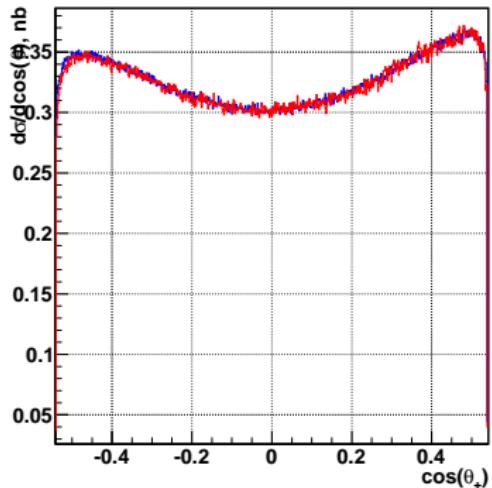
$$\sigma_{MCGPJ} = 0.352467 \pm 0.000162458 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 0.353556 \pm 9.317e-05 \text{ nb}$$

$$\delta\sigma/\sigma = 0.308951 \pm 0.0531335 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $\mu^+ \mu^-$

$E_{cm} = 10$  GeV Luminosity selection mode



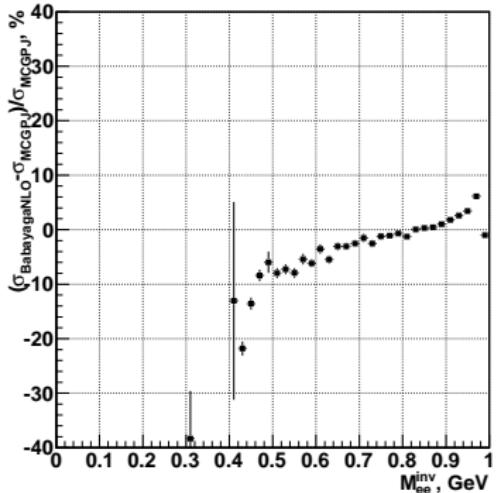
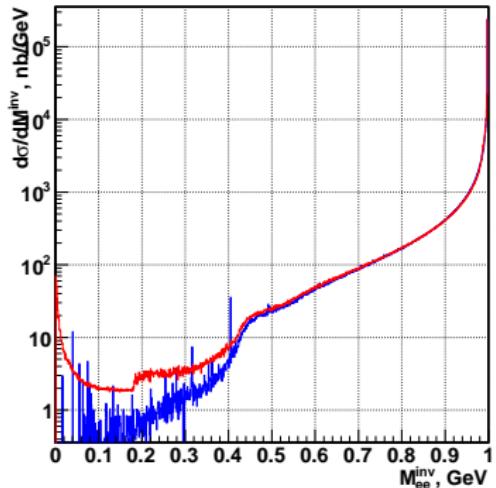
$$\sigma_{MCGPJ} = 0.352467 \pm 0.000162458 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 0.353537 \pm 0.00010246 \text{ nb}$$

$$\delta\sigma/\sigma = 0.303548 \pm 0.0544928 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 1$  GeV ISR selection mode



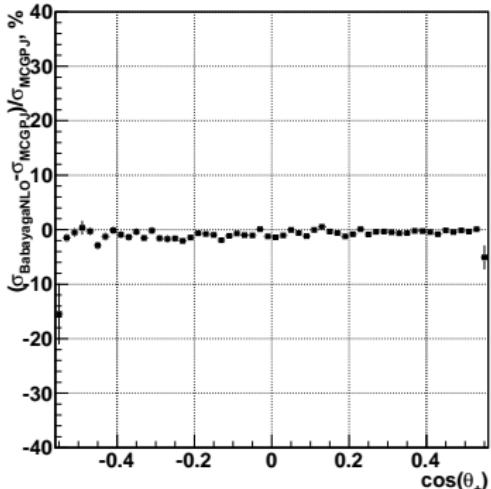
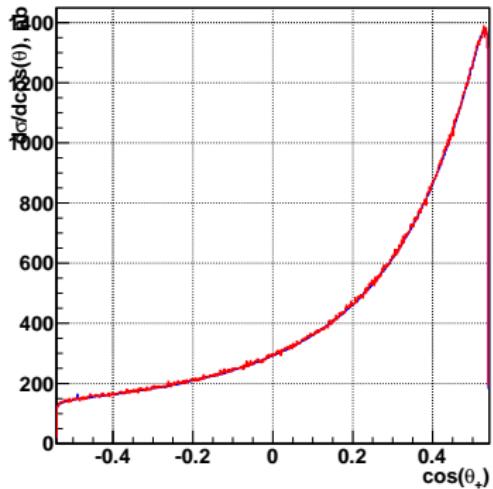
$$\sigma_{\text{MCGPJ}} = 467.168 \pm 0.273953 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 464.549 \pm 0.0725169 \text{ nb}$$

$$\delta\sigma/\sigma = -0.560579 \pm 0.0606608 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 1$  GeV ISR selection mode



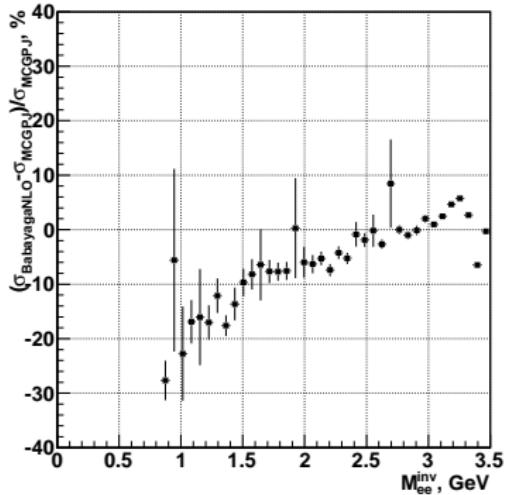
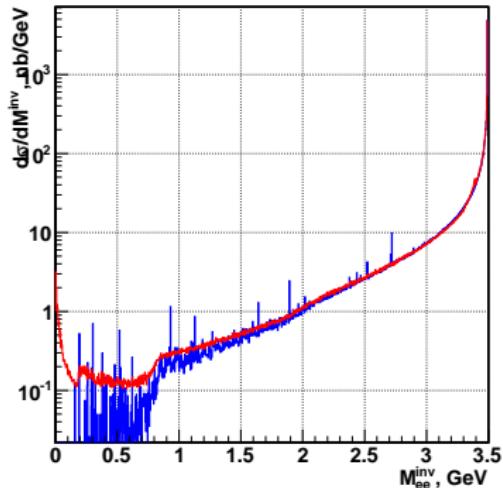
$$\sigma_{\text{MCGPJ}} = 467.168 \pm 0.273953 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 464.537 \pm 0.0763951 \text{ nb}$$

$$\delta\sigma/\sigma = -0.563152 \pm 0.0608785 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 3.5$  GeV ISR selection mode



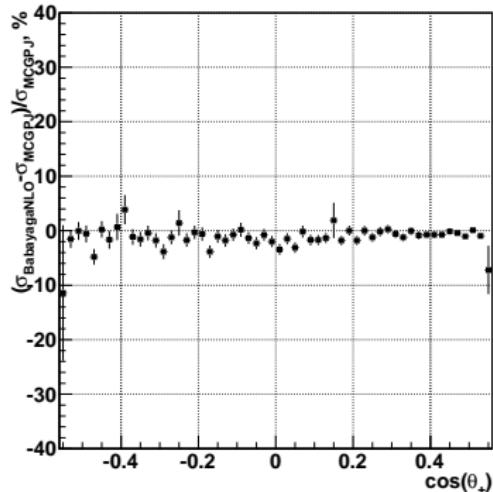
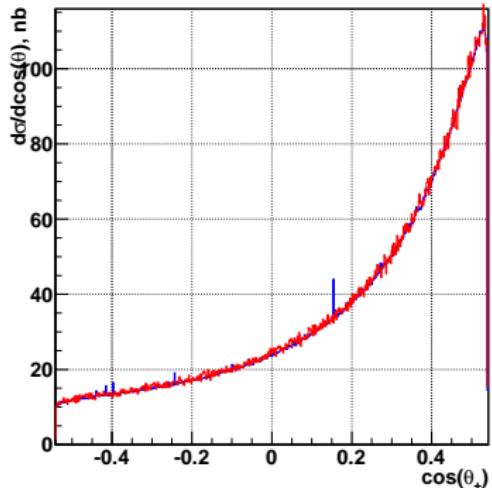
$$\sigma_{MCGPJ} = 38.1785 \pm 0.0462963 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 37.8674 \pm 0.0274266 \text{ nb}$$

$$\delta\sigma/\sigma = -0.814793 \pm 0.140945 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 3.5$  GeV ISR selection mode



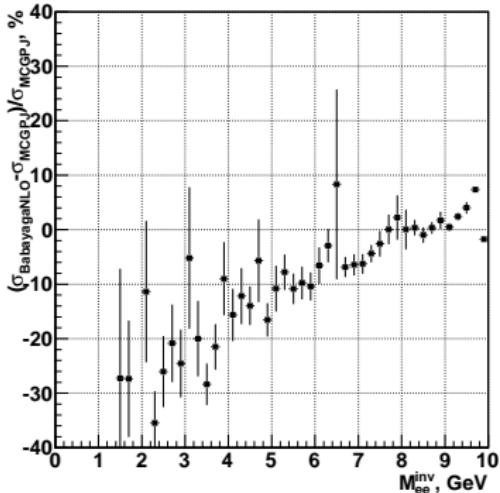
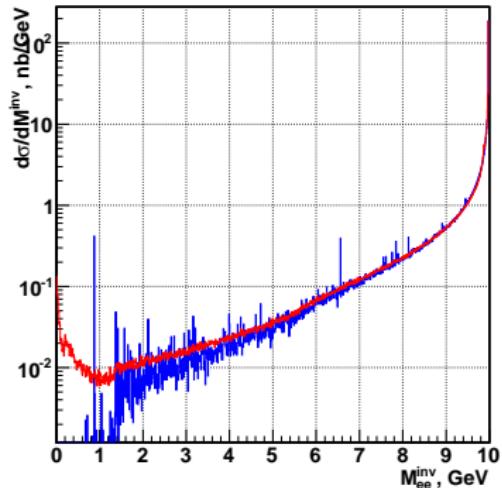
$$\sigma_{\text{MCGPJ}} = 38.1785 \pm 0.0462963 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 37.865 \pm 0.0277406 \text{ nb}$$

$$\delta\sigma/\sigma = -0.821047 \pm 0.141366 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 10$  GeV ISR selection mode



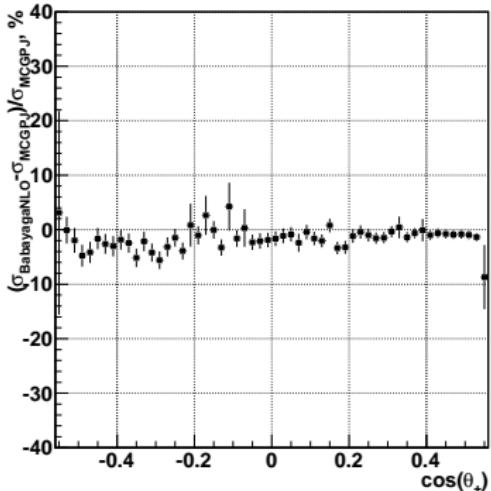
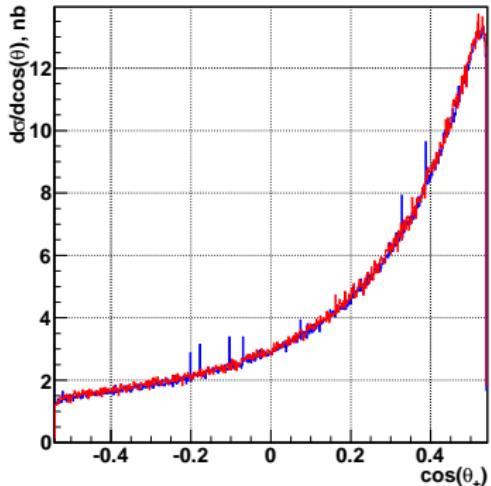
$$\sigma_{\text{MCGPJ}} = 4.67064 \pm 0.00656641 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 4.61716 \pm 0.0074765 \text{ nb}$$

$$\delta\sigma/\sigma = -1.14496 \pm 0.213047 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 10 \text{ GeV}$  ISR selection mode



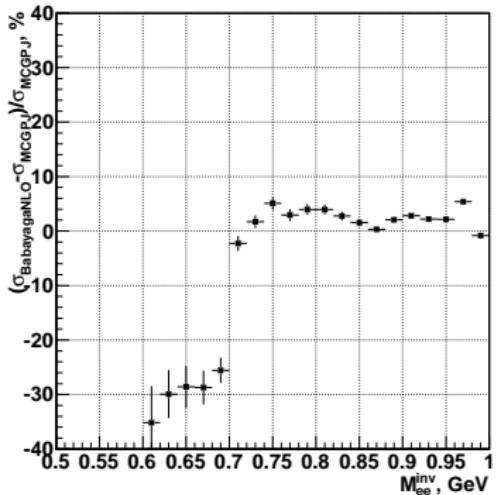
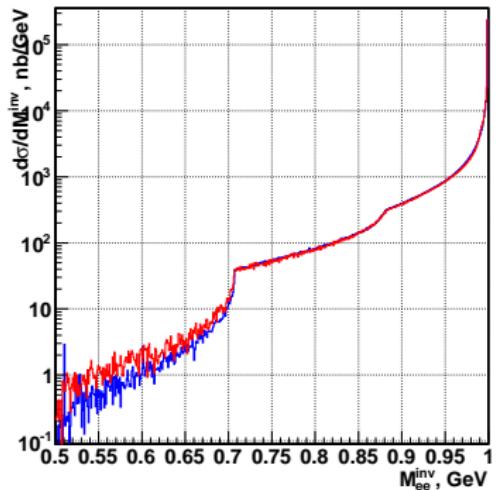
$$\sigma_{\text{MCGPJ}} = 4.67064 \pm 0.00656641 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 4.61451 \pm 0.00675714 \text{ nb}$$

$$\delta\sigma/\sigma = -1.20159 \pm 0.201731 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 1$  GeV Luminosity selection mode



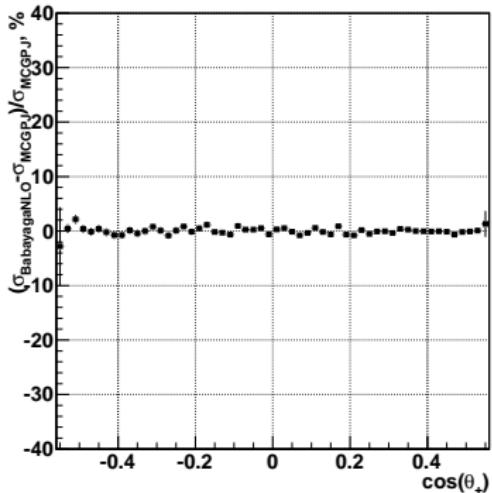
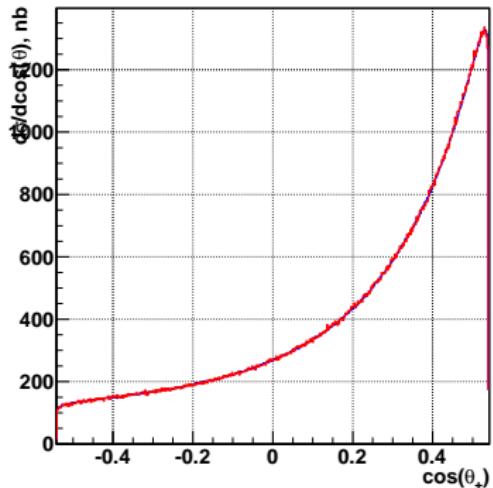
$$\sigma_{MCGPJ} = 438.249 \pm 0.252148 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 438.05 \pm 0.0737916 \text{ nb}$$

$$\delta\sigma/\sigma = -0.0453247 \pm 0.0599485 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 1$  GeV Luminosity selection mode



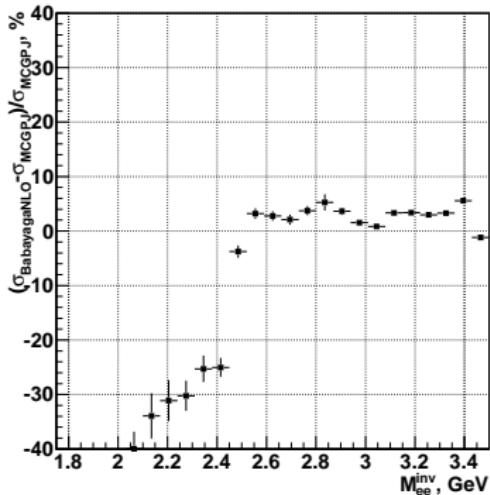
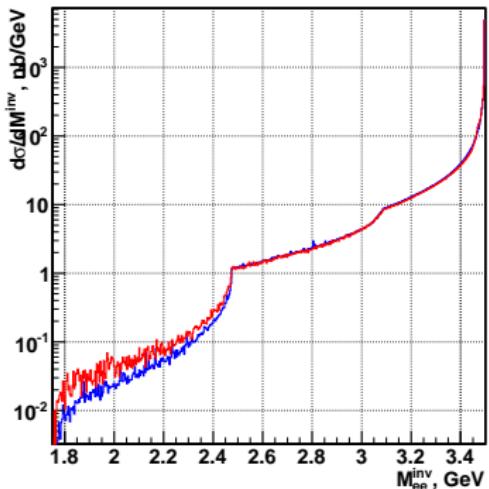
$$\sigma_{MCGPJ} = 438.249 \pm 0.252148 \text{ nb}$$

$$\sigma_{Babayaga@NLO} = 438.046 \pm 0.0826323 \text{ nb}$$

$$\delta\sigma/\sigma = -0.0462621 \pm 0.0605461 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 3.5$  GeV Luminosity selection mode



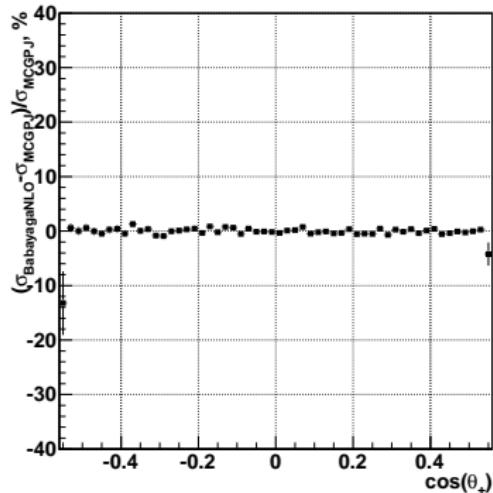
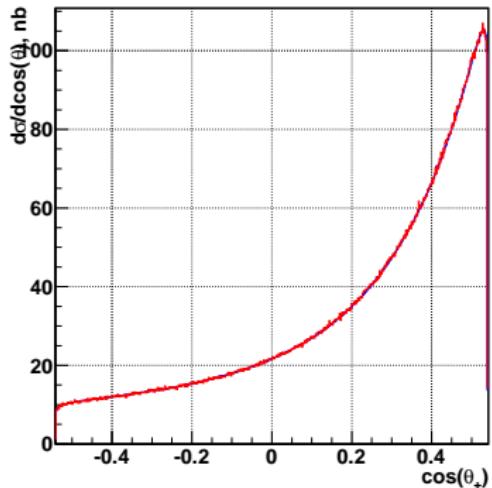
$$\sigma_{\text{MCGPJ}} = 35.2009 \pm 0.0194035 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 35.1812 \pm 0.0044 \text{ nb}$$

$$\delta\sigma/\sigma = -0.0558374 \pm 0.0565217 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 3.5$  GeV Luminosity selection mode



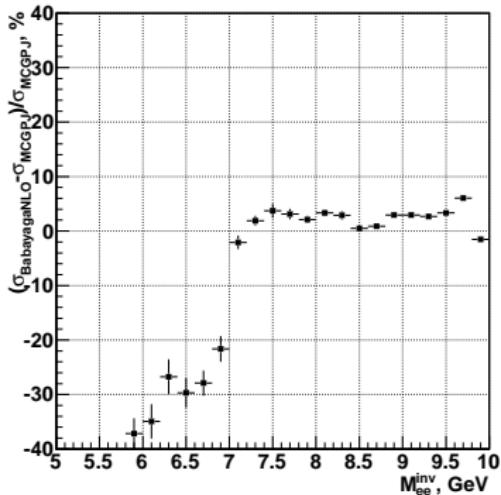
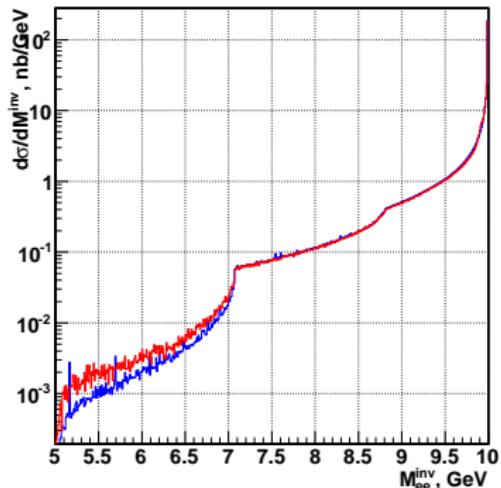
$$\sigma_{\text{MCGPJ}} = 35.2009 \pm 0.0194035 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 35.1812 \pm 0.00460139 \text{ nb}$$

$$\delta\sigma/\sigma = -0.0559143 \pm 0.056651 \%$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 10 \text{ GeV}$  Luminosity selection mode



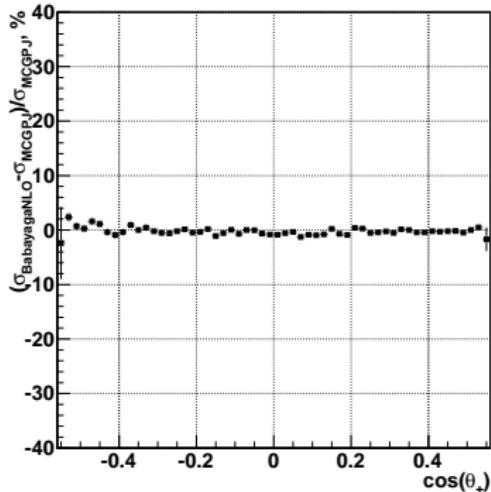
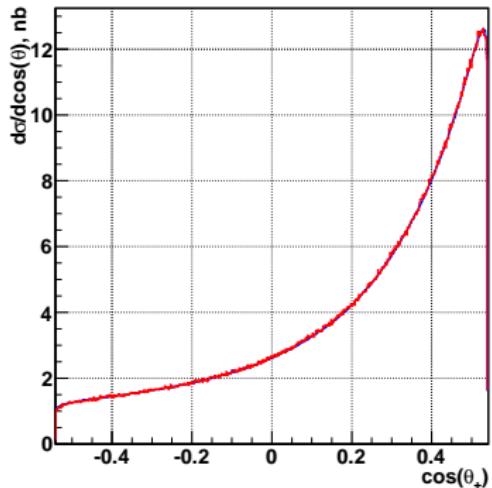
$$\sigma_{\text{MCGPJ}} = 4.25529 \pm 0.00227632 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 4.24566 \pm 0.000608743 \text{ nb}$$

$$\delta\sigma/\sigma = -0.226331 \pm 0.0553736 \text{ \%}$$

# Comparision of Babayaga@NLO & MCGPJ for $e^+e^-$

$E_{cm} = 10 \text{ GeV}$  Luminosity selection mode



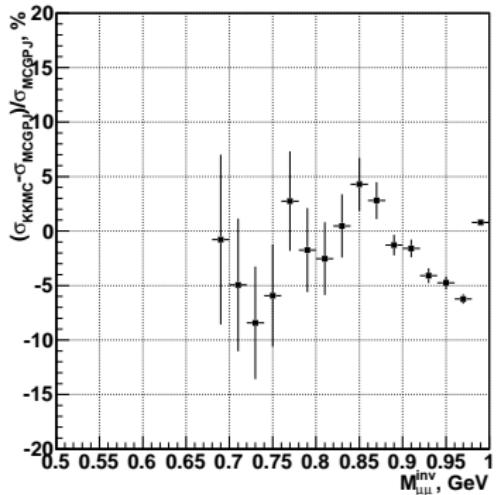
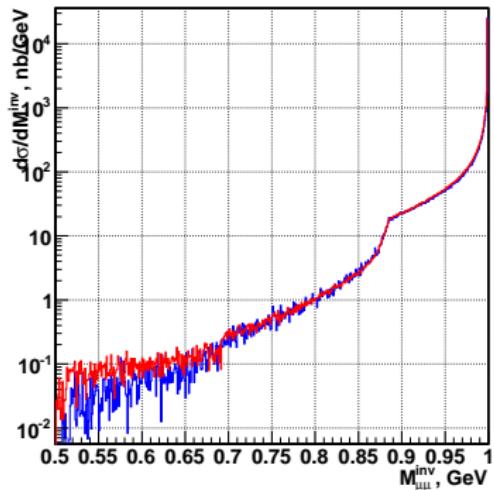
$$\sigma_{\text{MCGPJ}} = 4.25529 \pm 0.00227632 \text{ nb}$$

$$\sigma_{\text{Babayaga@NLO}} = 4.24565 \pm 0.000624257 \text{ nb}$$

$$\delta\sigma/\sigma = -0.226424 \pm 0.0554689 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 1$  GeV Luminosity selection mode



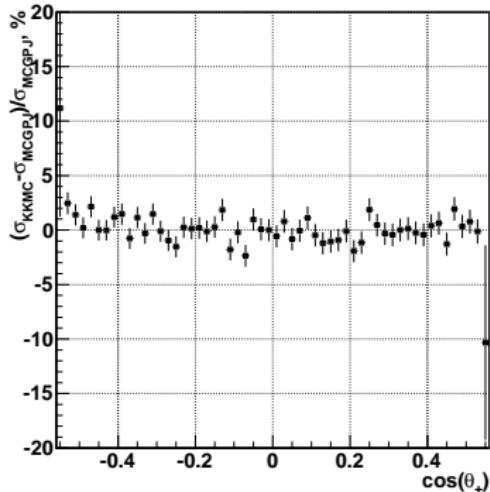
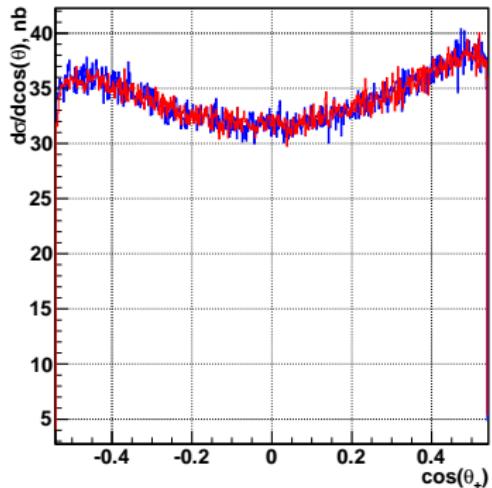
$$\sigma_{\text{MCGPJ}} = 36.7799 \pm 0.033169 \text{ nb}$$

$$\sigma_{\text{KKMC}} = 36.8126 \pm 0.0387473 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0889476 \pm 0.138677 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 1$  GeV Luminosity selection mode



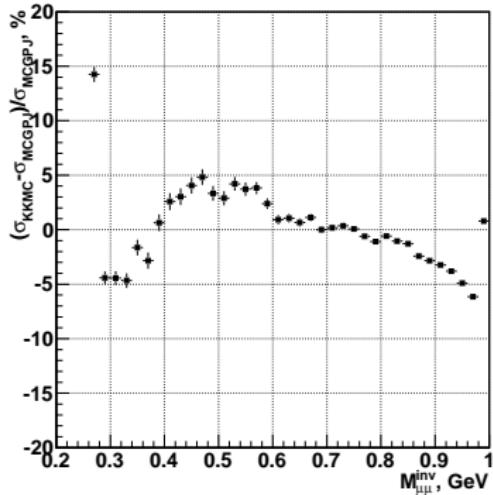
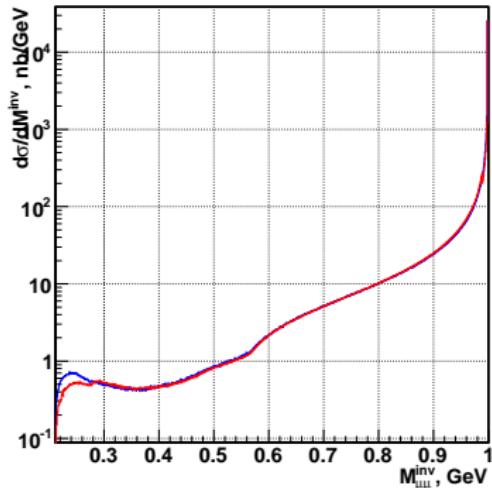
$$\sigma_{MCGPJ} = 36.7799 \pm 0.033169 \text{ nb}$$

$$\sigma_{KKMC} = 36.8126 \pm 0.0387473 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0889475 \pm 0.138677 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 1$  GeV ISR selection mode



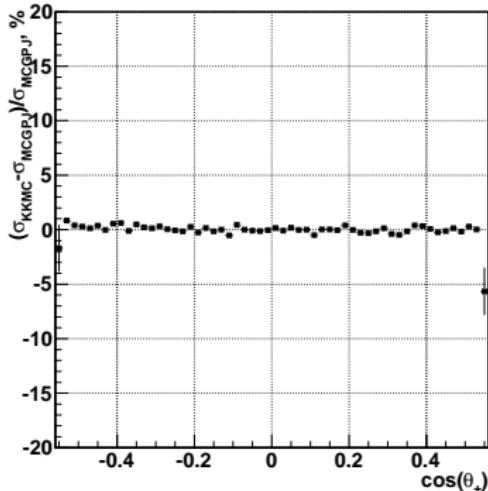
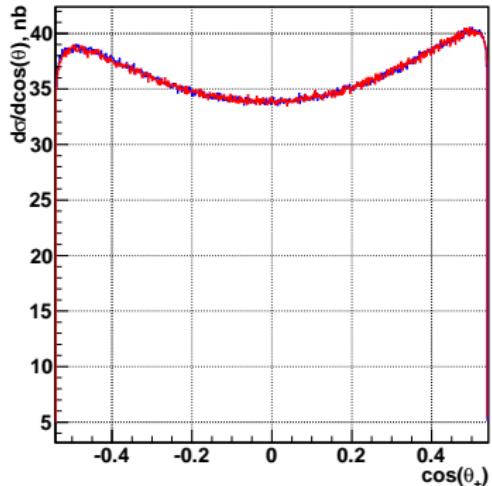
$$\sigma_{\text{MCGPJ}} = 39.1238 \pm 0.00998487 \text{ nb}$$

$$\sigma_{\text{KKMC}} = 39.1455 \pm 0.00906285 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0556258 \pm 0.0344664 \text{ \%}$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 1$  GeV ISR selection mode



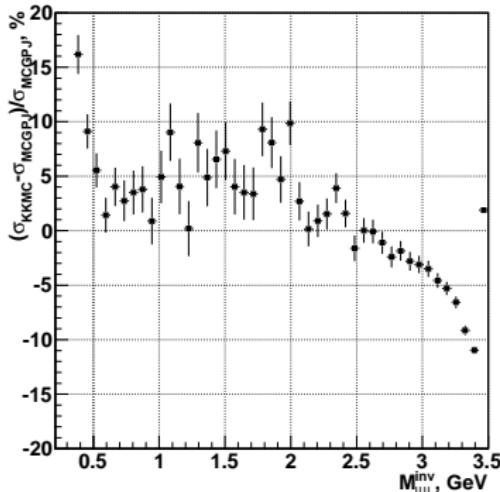
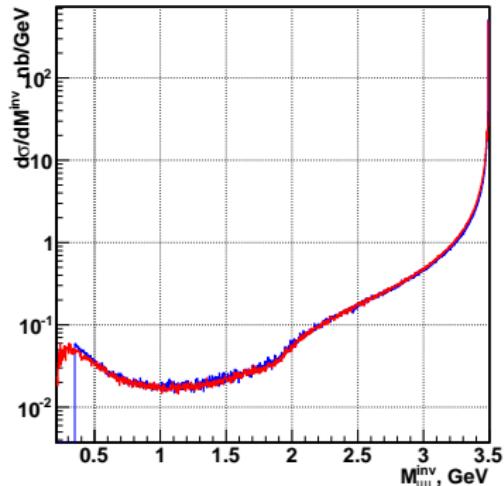
$$\sigma_{MCGPJ} = 39.1238 \pm 0.00998487 \text{ nb}$$

$$\sigma_{KKMC} = 39.1455 \pm 0.00906285 \text{ nb}$$

$$\delta\sigma/\sigma = 0.0556257 \pm 0.0344664 \text{ \%}$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 3.5$  GeV ISR selection mode



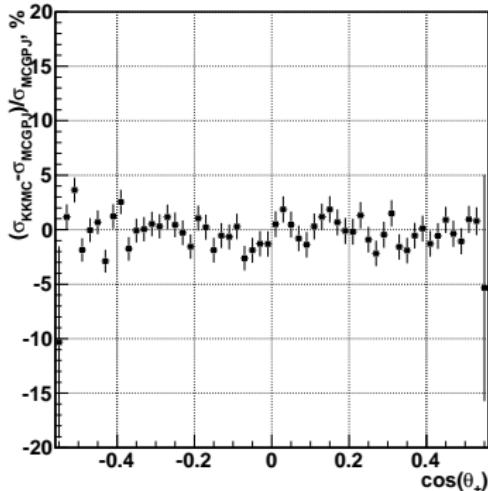
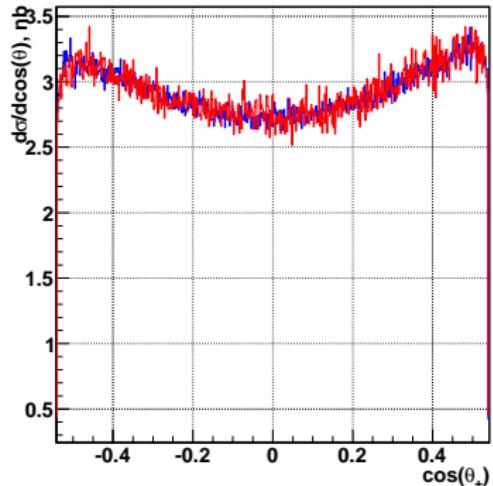
$$\sigma_{MCGPJ} = 3.16922 \pm 0.00426541 \text{ nb}$$

$$\sigma_{KKMC} = 3.16525 \pm 0.0026585 \text{ nb}$$

$$\delta\sigma/\sigma = -0.125326 \pm 0.15859 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 3.5$  GeV ISR selection mode



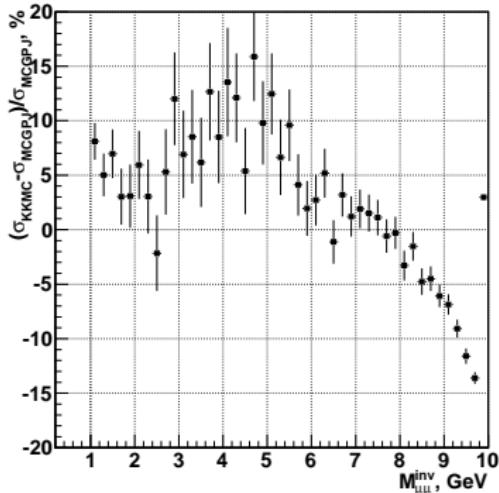
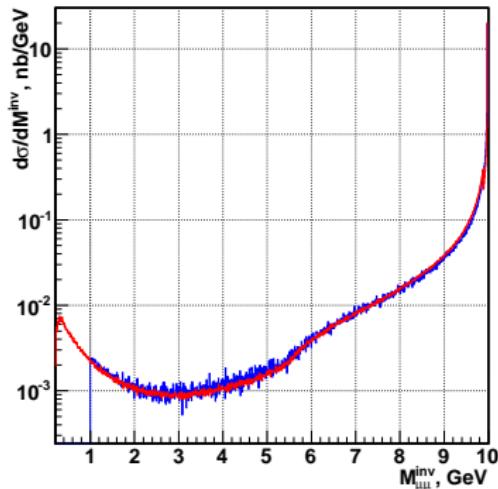
$$\sigma_{MCGPJ} = 3.16922 \pm 0.00426541 \text{ nb}$$

$$\sigma_{KKMC} = 3.16525 \pm 0.0026585 \text{ nb}$$

$$\delta\sigma/\sigma = -0.125327 \pm 0.15859 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 10$  GeV ISR selection mode



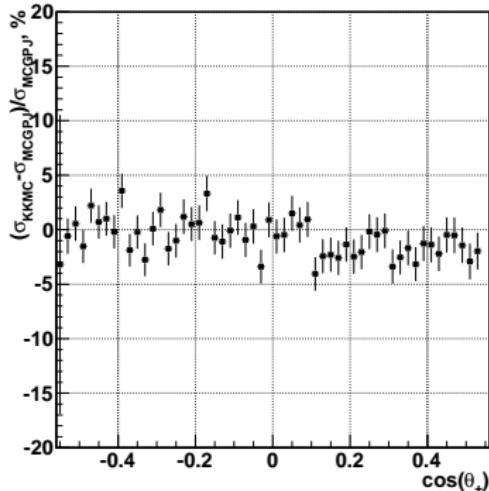
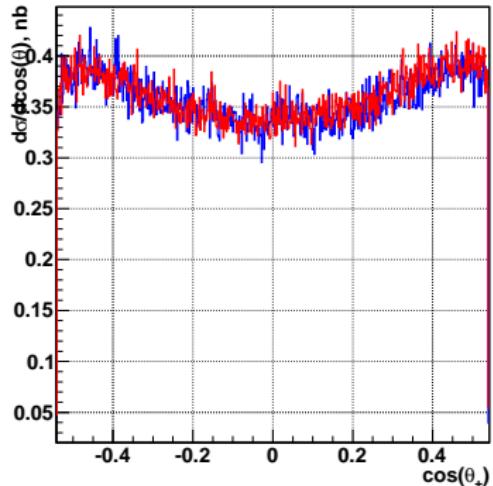
$$\sigma_{\text{MCGPJ}} = 0.390082 \pm 0.000561087 \text{ nb}$$

$$\sigma_{\text{KKMC}} = 0.387288 \pm 0.000628677 \text{ nb}$$

$$\delta\sigma/\sigma = -0.716311 \pm 0.216018 \%$$

# Comparision of KKMC & MCGPJ for $\mu^+\mu^-$

$E_{cm} = 10$  GeV ISR selection mode



$$\sigma_{MCGPJ} = 0.390082 \pm 0.000561087 \text{ nb}$$

$$\sigma_{KKMC} = 0.387288 \pm 0.000628677 \text{ nb}$$

$$\delta\sigma/\sigma = -0.716311 \pm 0.216018 \%$$

# Conclusions

- ▶ MCGPJ generator has been compared with other precise generators (Phokhara6.0, Babayaga@NLO, KKMC) for different processes ( $\pi^+\pi^-$ ,  $\mu^+\mu^-$ ,  $e^+e^-$ ).
- ▶ Some deviations have been observed.
- ▶ Let us start discussion!