BABAYAGA@NLO vs. BHWIDE

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LNF Frascati
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Luminosity needs

Two main motivations for a precision measurement of the integrated luminosity with a precision <1%

1) σ_{hadr} with so far typical precisions >5%;
cross check normalization to rad. muon pairs with the normalization to luminosity x radiator function

2) high-precision τ-analyses
which need as a normalization the $\tau^+\tau^-$ cross section AND the integrated luminosity

Luminosity needs

Normalitzation:

1) **Integr. Luminosity L_{int} x Radiator Function H**

   → Large angle Bhabhas → LO-Theory (analytic formula)

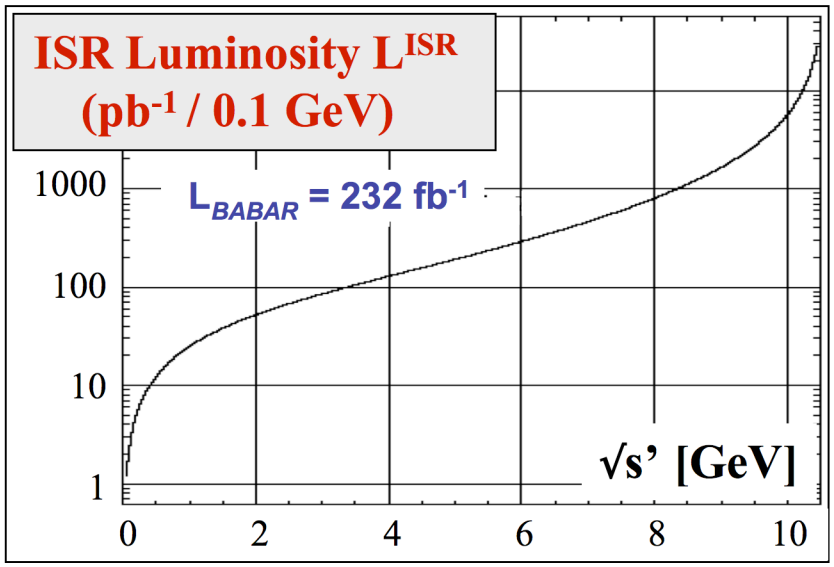
OR

2) **Use $e^+e^- \to \mu^+\mu^-\gamma$ events**

$$dL^{ISR}(M) = \frac{dN_{\mu\mu\gamma}(M)}{\varepsilon_{\mu\mu\gamma}(M)(1+\delta_{FSR}(M))\sigma^{Born}_{\mu\mu}(M)} = L_{int} x dH$$

Up to ca. 3% difference btw. 1) and 2)

Reasons?!



- Luminosity measurement using Large-Angle-Bhabha ca. 1% precision
- Radiator function @ Born level only
- Muon efficiency determination highly non-trivial, up to now precision ca. 2-3% (high-precision determination underway)

Luminosity measurement

$e^+e^- \rightarrow$	exp. error	theo. error	total error	event-generator
$e^+e^-(\gamma)$	0.7%	0.7%	1.0%	**BHWIDE** (S.Jadach, W.Placzek and B.F.L. Ward, Phys.Lett.B390 (1997) 298)
$\mu^+\mu^-(\gamma)$	0.5%	1.4%	1.5%	**BKQED** (F.Berends and R. Kleiss, Nucl.Phys.B228 (1983) 537)
$\gamma\gamma$	1.6%	2.0%	2.6%	

Luminosity measurement

Selection cuts on Bhabha sample:

- two tracks with net charge zero
- $\cos(\theta_{1,CMS}) < 0.7$ & $\cos(\theta_{2,CMS}) < 0.65$
- $P_{1,CMS}/E_{Beam} > 0.75$ & $P_{2,CMS}/E_{Beam} > 0.50$
- |3-d acollinearity -180°| < 30°
- EMC, $E_1/P_1 > 0.7$ and ($E_2/P_2 > 0.4$ OR $E_2/P_2 = 0$)

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↓

Luminosity determination with a precision of 0.94%

(Ref.: BaBar Analysis Document #229)

New event generator Babayaga@NLO

Bhabha-Scattering:
$e^+e^- \rightarrow e^+e^- (\gamma)$

Theoretical precision

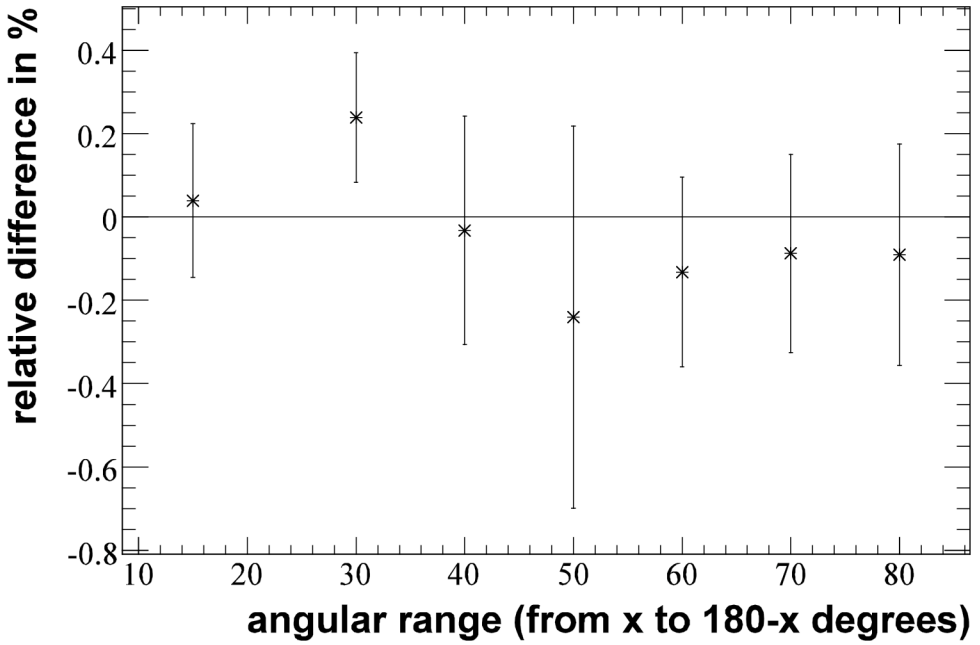
- BHWIDE (leading log) ~0.5%
- Babayaga@NLO (parton shower) ~0.1%
- Babayaga (version 3.5) ~0.5%

Authors of Babayaga@NLO: G. Balossini, C.M. Carloni Calame, G.Montagna, O.Nicrosini, F.Piccinini ([hep-ph/0607181])

Total σ_{eff}

θ = polar angle between incoming an outgoing lepton ($x < \theta < 180°-x$)

Angular range of outgoing leptons (CMS)	cross section / [nb]	
	BHWIDE	**Babayaga@NLO**
15°-165°	124.89±0.08	124.85±0.15
30°-150°	25.568±0.016	25.507±0.024
40°-140°	12.363±0.008	12.367±0.026
50°-130°	6.690±0.005	6.706±0.026
60°-120°	3.784±0.003	3.789±0.006
70°-110°	2.060±0.002	2.062±0.003
80°-100°	0.881±0.001	0.881±0.002



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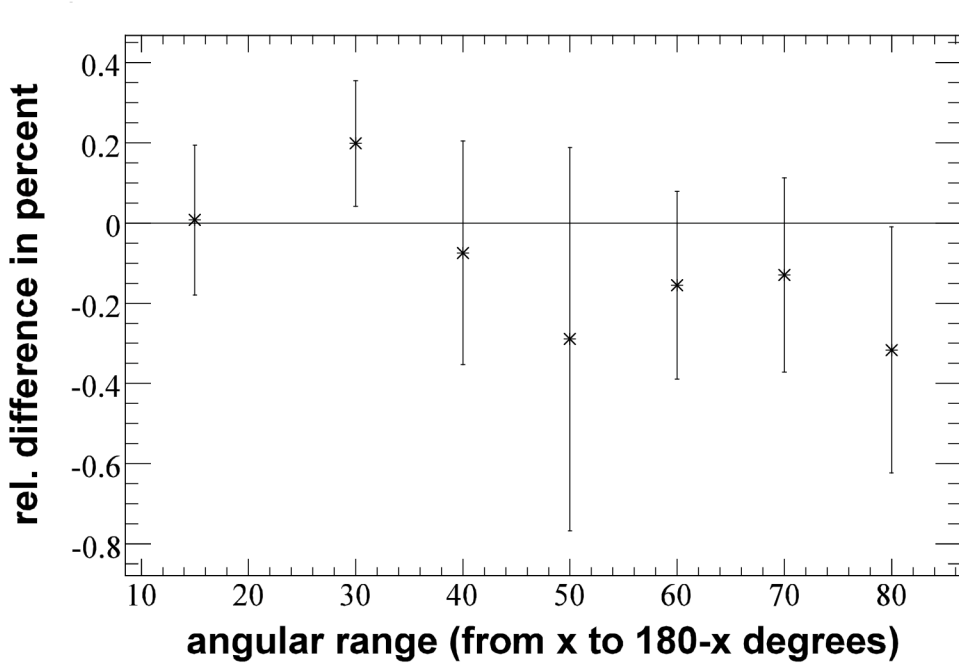
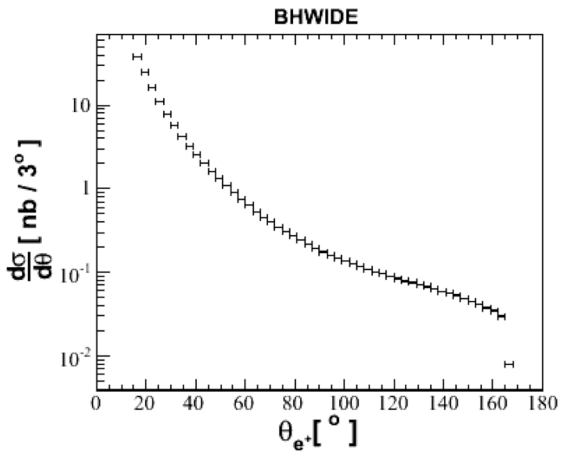
30°-150°	24.22±0.016	24.17.±0.02
40°-140°	11.660±0.008	11.67±0.03
50°-130°	6.289±0.004	6.31±0.03
60°-120°	3.549±0.003	3.554±0.006
70°-110°	1.928±0.002	1.931±0.003
80°-100°	0.822±0.001	0.824±0.002

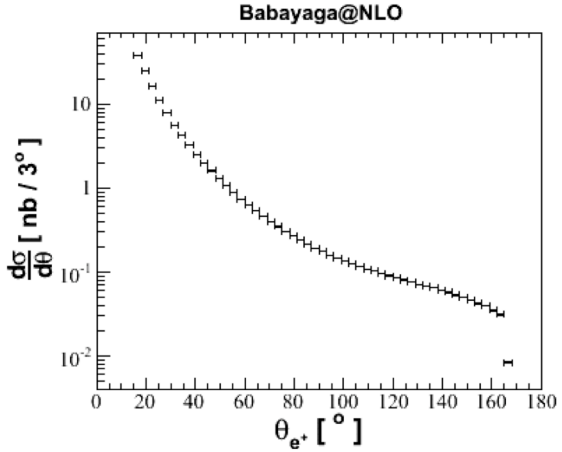


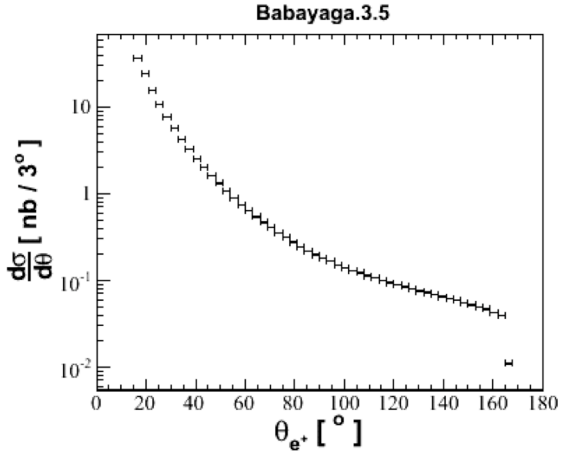
without vacuum polarization

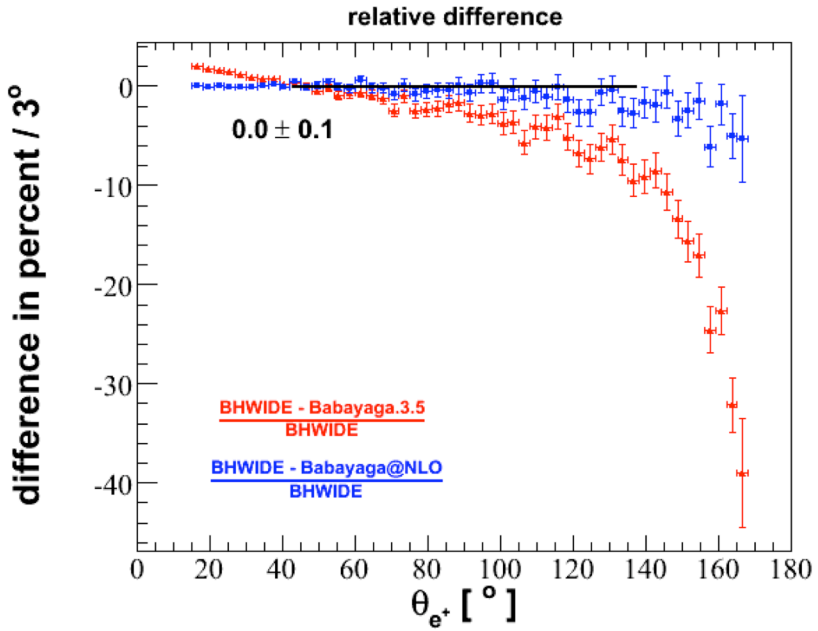
σ_{eff} as a function of θ_{e^-}

$15° < \theta_{lep} < 165°$









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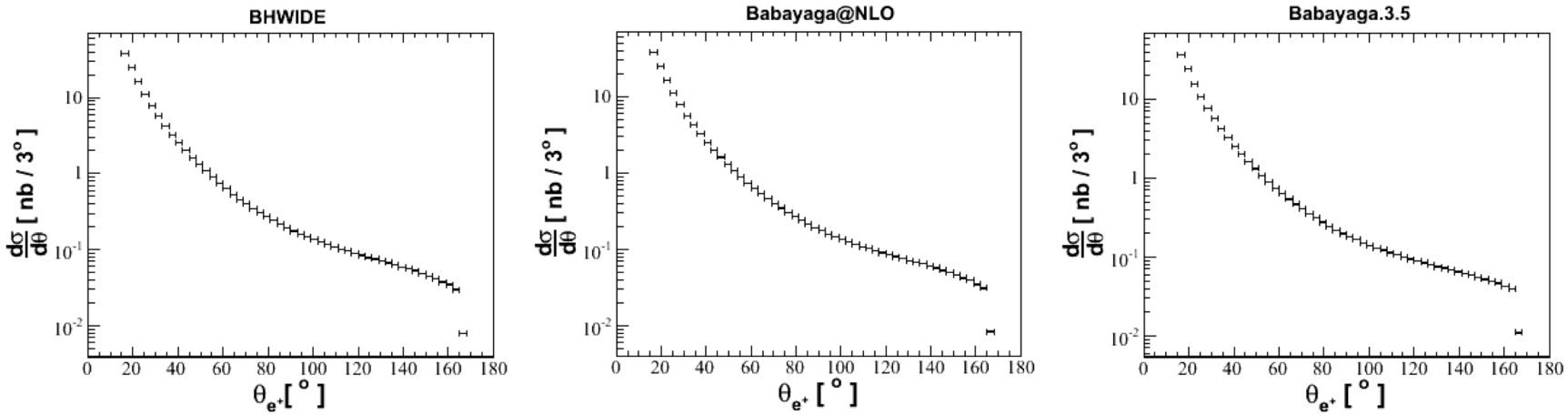
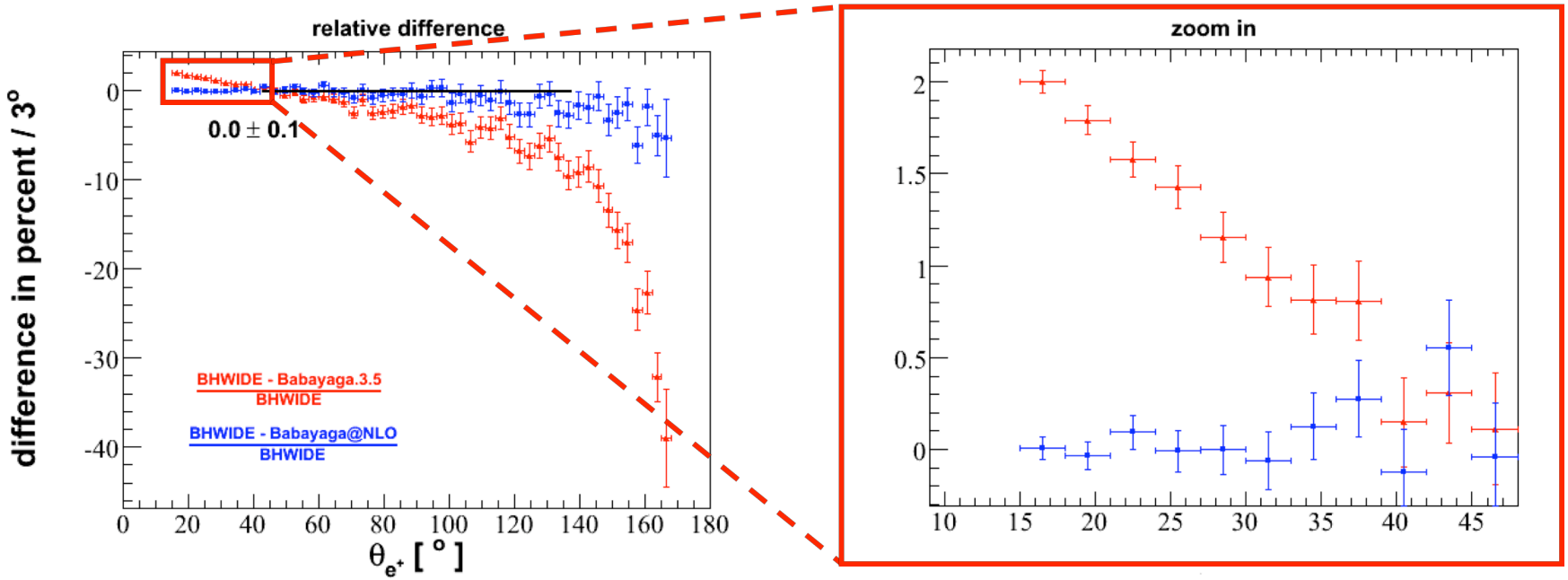
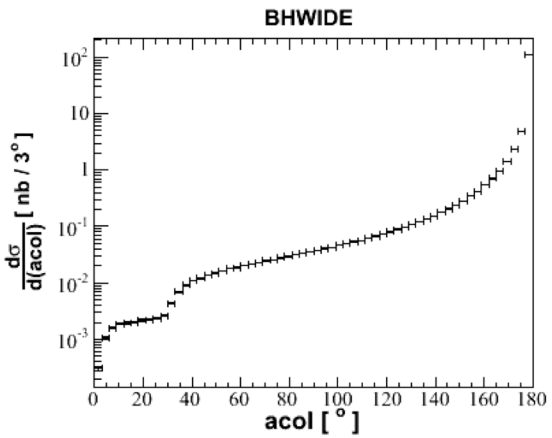
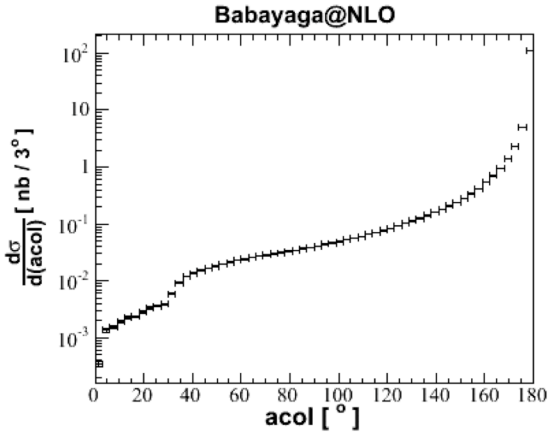


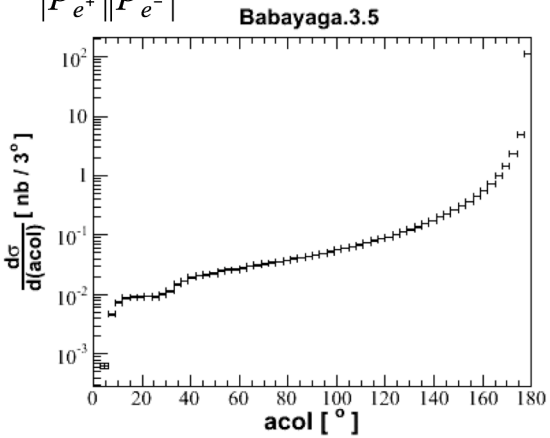


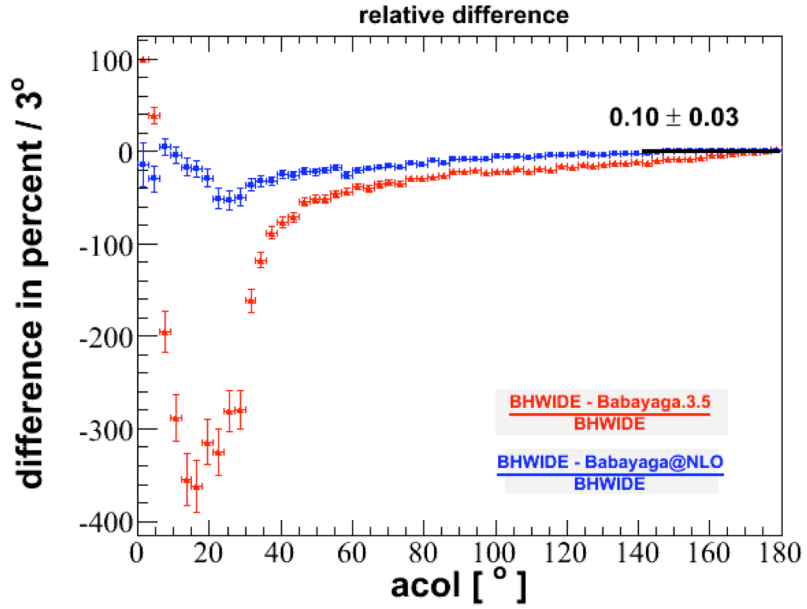
σ_{eff} as a function of *acol*

$$acol = a\cos\left(\frac{\vec{p}_{e^+} \cdot \vec{p}_{e^-}}{\left|\vec{p}_{e^+}\right|\left|\vec{p}_{e^-}\right|}\right)$$









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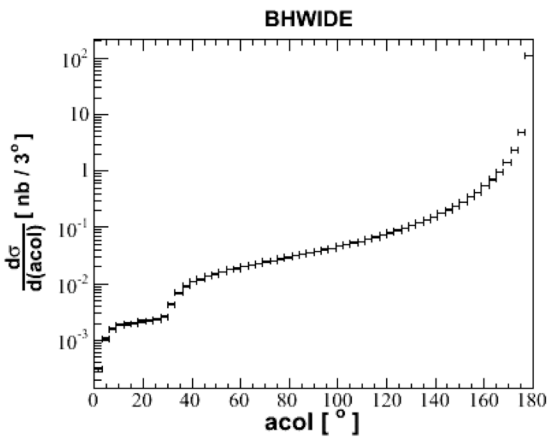
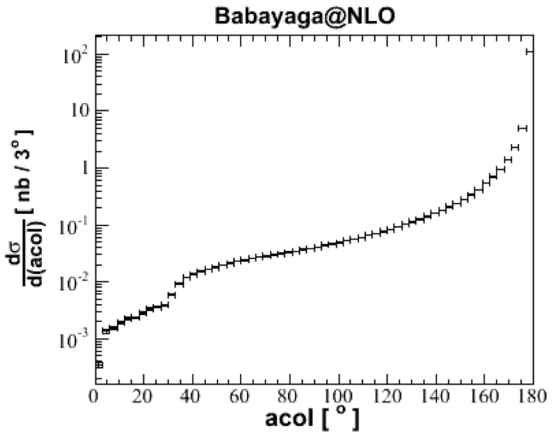
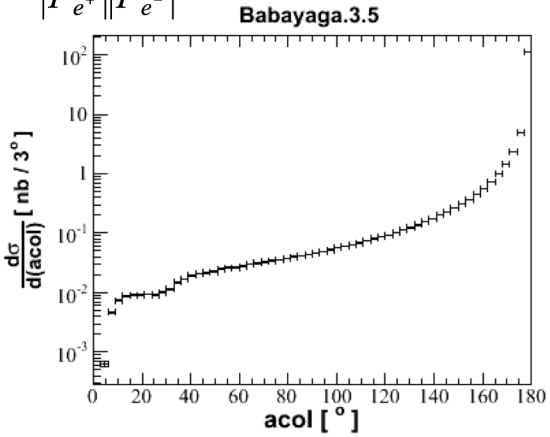
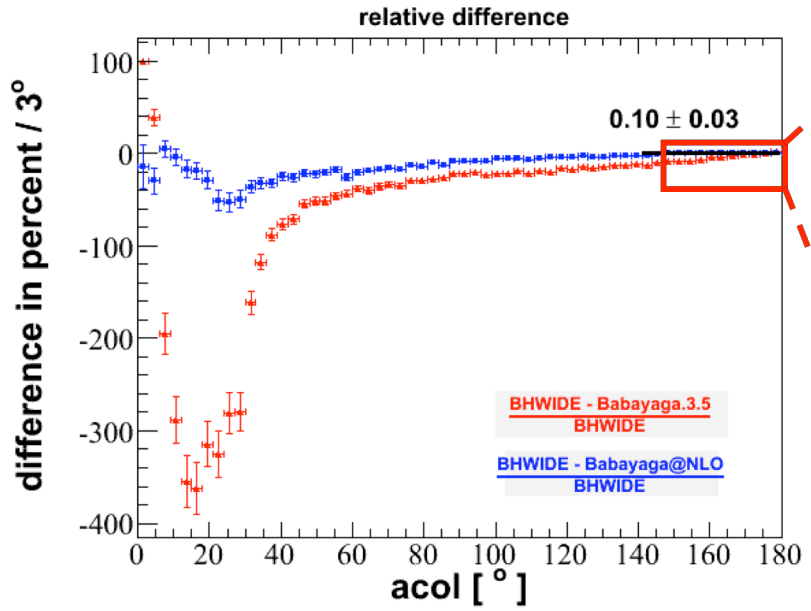
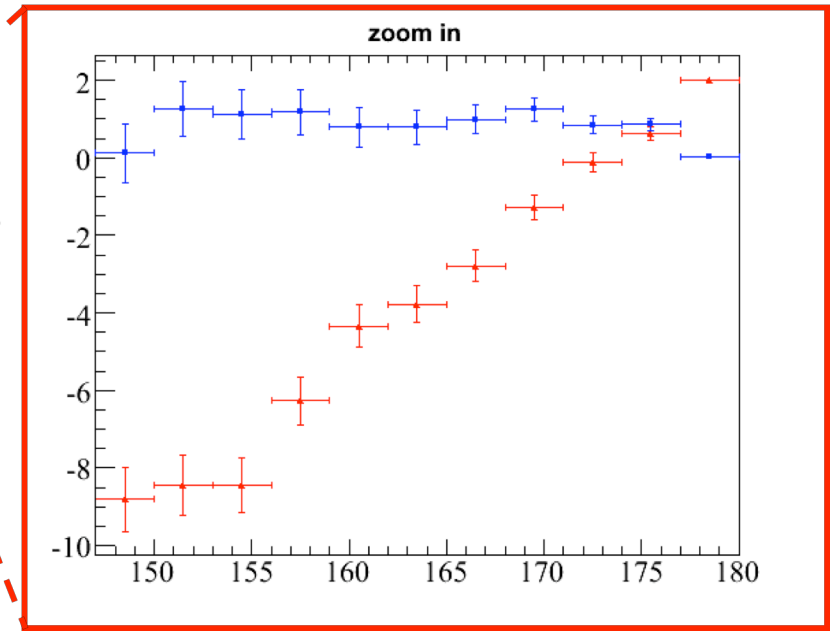




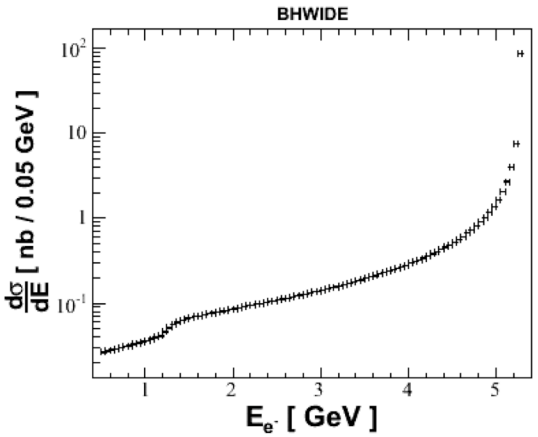


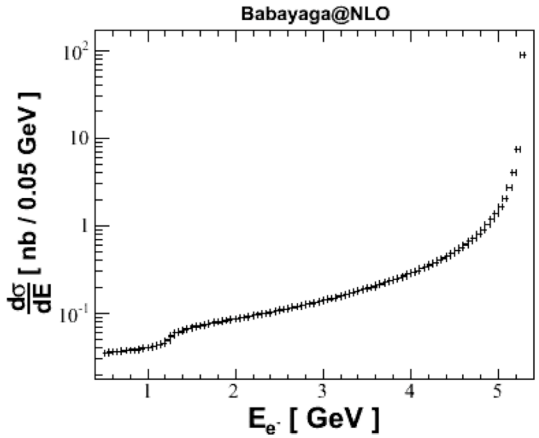


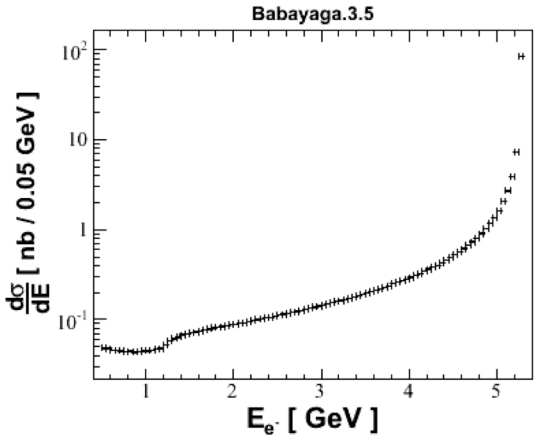


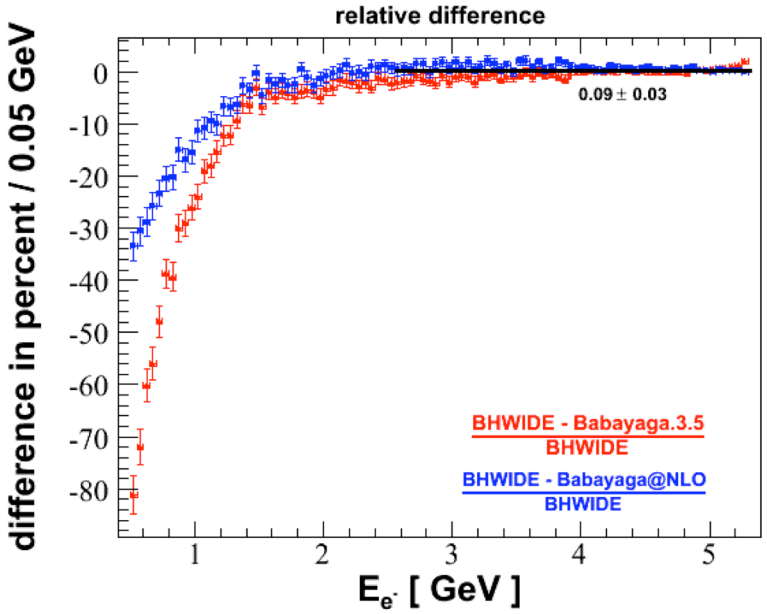
σ_{eff} as a function of E_{e^-}

$E_{e^-,min}$=0.5 GeV









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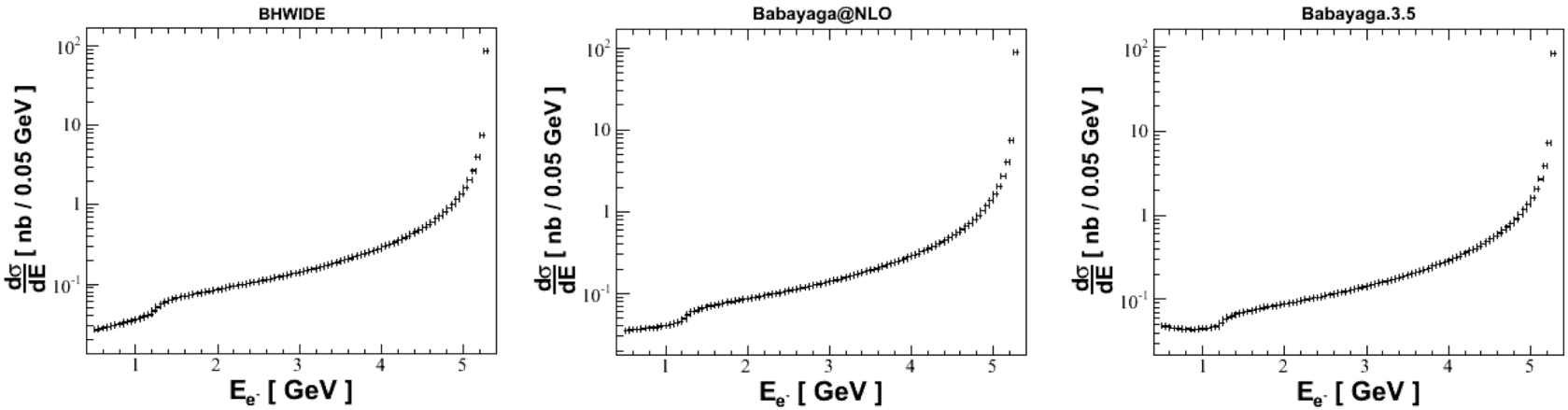
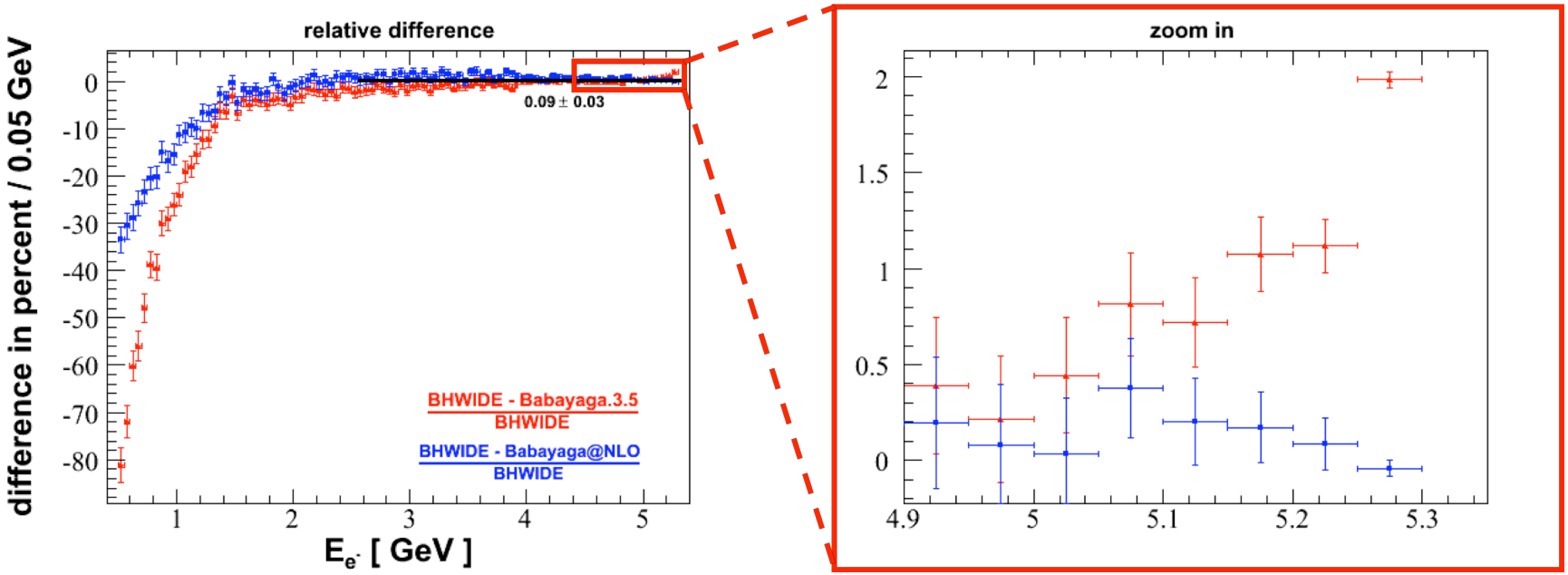
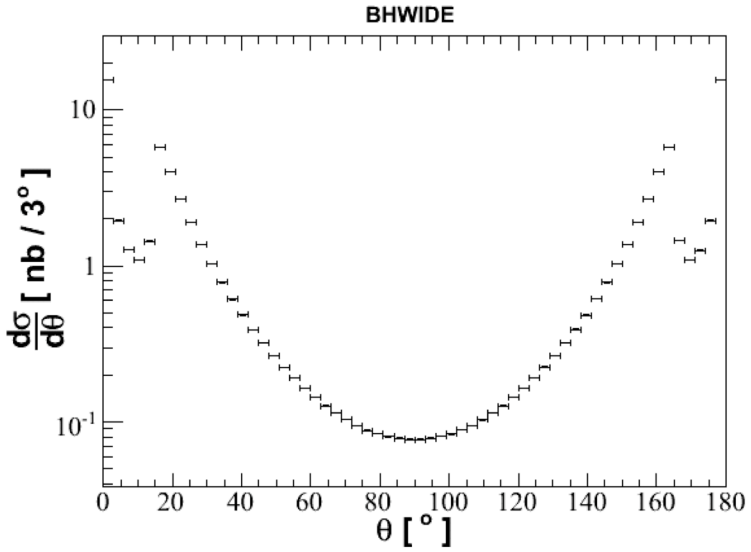
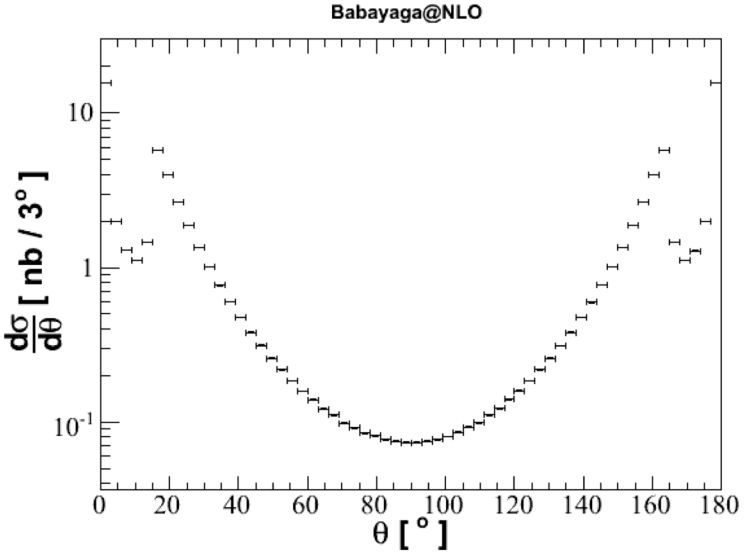
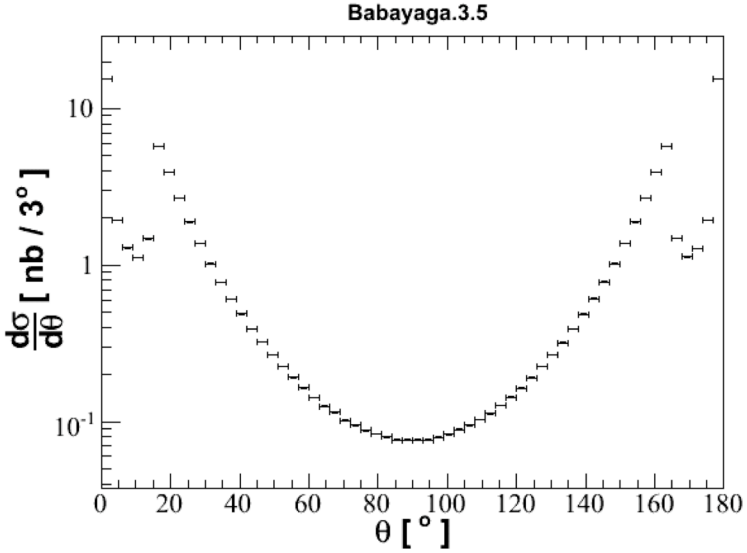


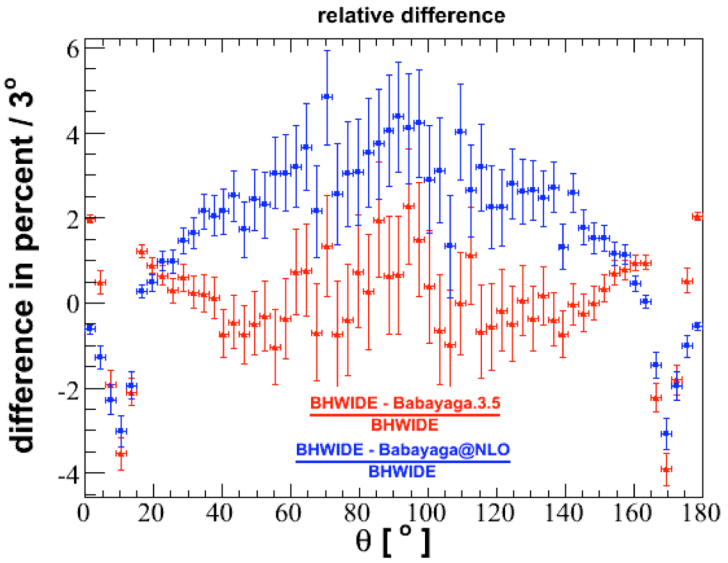


Hardest photon









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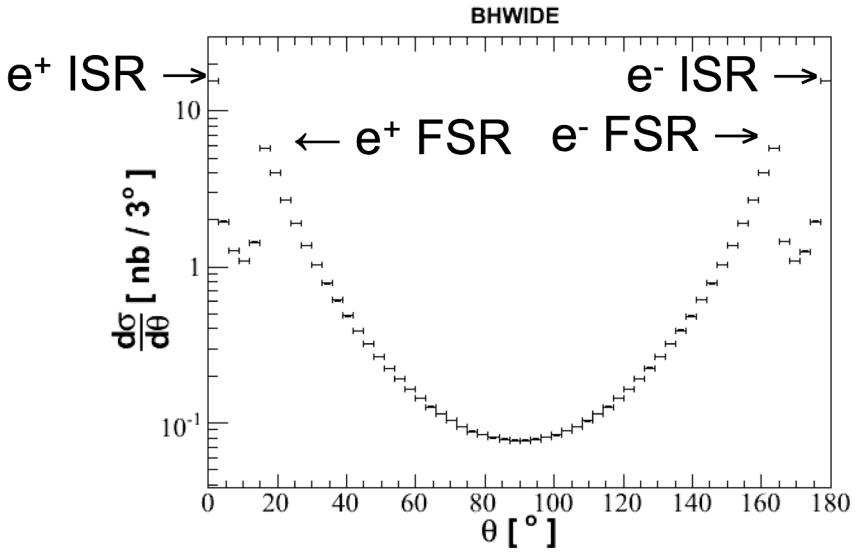

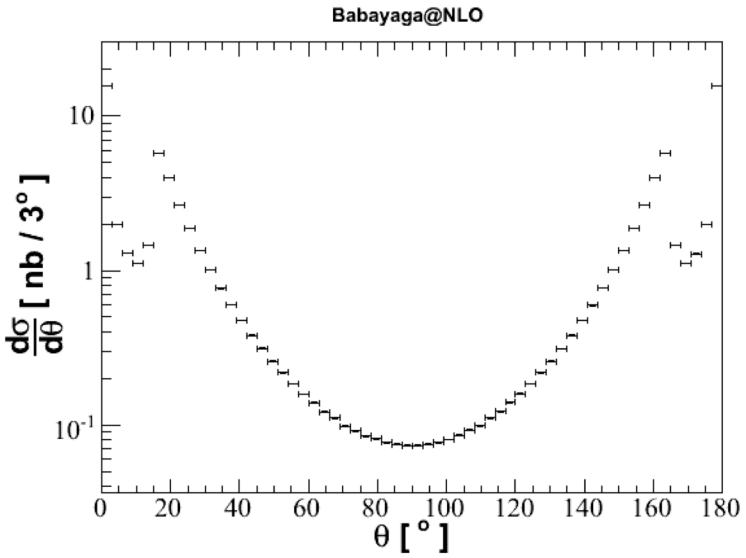

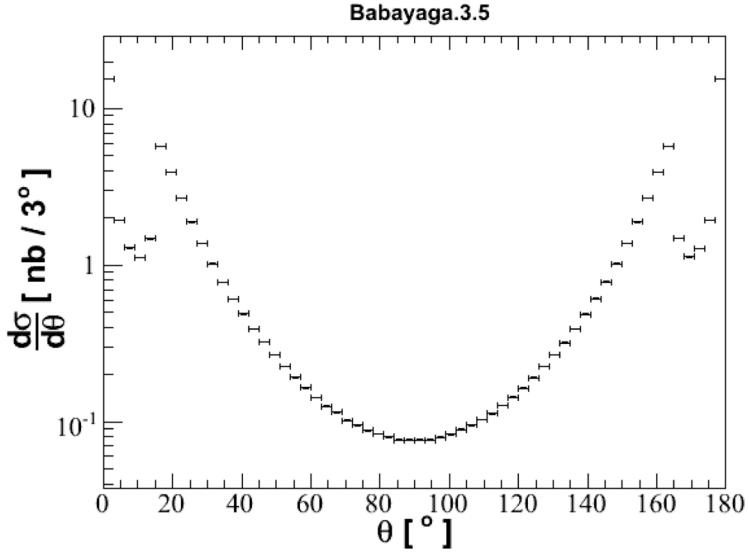

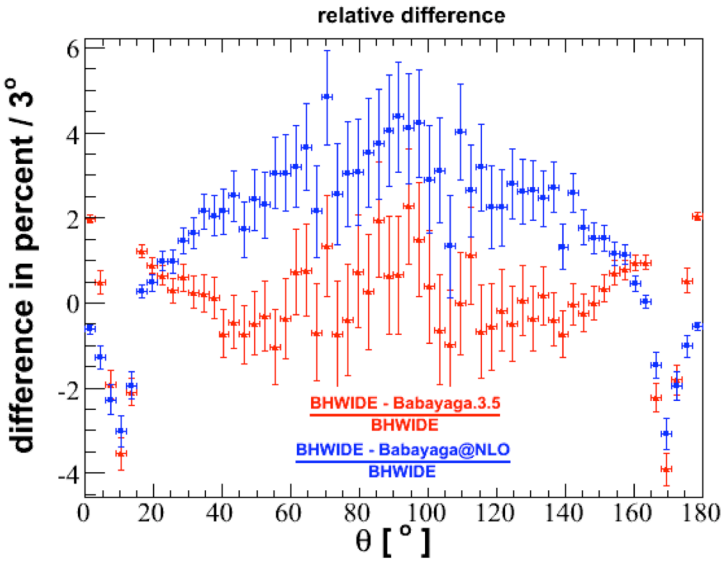

total σ_{eff}

with cuts of the luminosity determination:

- BHWIDE: $\sigma_{eff} = (6.815 \pm 0.009_{stat})$nb
- Babayaga: $\sigma_{eff} = (6.793 \pm 0.013_{stat})$nb

rel. difference of ~ $0.29\% \pm 0.24_{stat}\%$

Conclusions

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Arxiv:0706.3235

Motivation: tau analyses @ BaBar, which are limited in precision by both the $e^+e^- \to \tau^+\tau^-$ cross section as the luminosity, i.e. the $e^+e^- \to \mu^+\mu^-$ cross section

Tau and muon pair production cross-sections in electron-positron annihilations at $\sqrt{s} = 10.58$ GeV

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[2] *Laboratoire d'Annecy-le-Vieux de Physique des Particules LAPP, IN2P3/CNRS, Université de Savoie, F-74019 Annecy-le-Vieux cedex, France*
[3] *Institute of Nuclear Physics, P.A.N. ul. Radzikowskiego 152 PL-31342 Kraków, Poland*

(Dated: June 21, 2007)

The calculational precision of $e^+e^- \to \tau^+\tau^-$ and $e^+e^- \to \mu^+\mu^-$ production cross-sections in electron-positron annihilations at $\sqrt{s} = 10.58$ GeV are studied for the KKMC Monte Carlo simulation program. We determine $\sigma(e^+e^- \to \tau^+\tau^-) = (0.919 \pm 0.003)$ nb and $\sigma(e^+e^- \to \mu^+\mu^-) = (1.147 \pm 0.004)$ nb, where the error represents the precision of the calculation.

0.31% error

0.35% error

Arxiv:0706.3235

- Comparison $\tau^+\tau^-$ cross section btw. **KKMC and KORALB**

NNLO by exponentiation

NLO

--> validate KKMC and obtain then $\mu^+\mu^-$ cross section

- Checks done in **collaboration btw. theory & experiment**

  - treatment of vacuum polarization (± 0.18, ± 0.22)
  - treatment of ISR/FSR corrections (± 0.20, ± 0.20)
  - interference effects (γ-Z^0) and box diagrams (± 0.04, ± 0.04)
  - add. lepton pair, lepton pair vertex correction (± 0.15, ± 0.15)
  - impact of resonances (± 0.04, ± 0.10)

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