Update on Bhabha A_{LR} Studies

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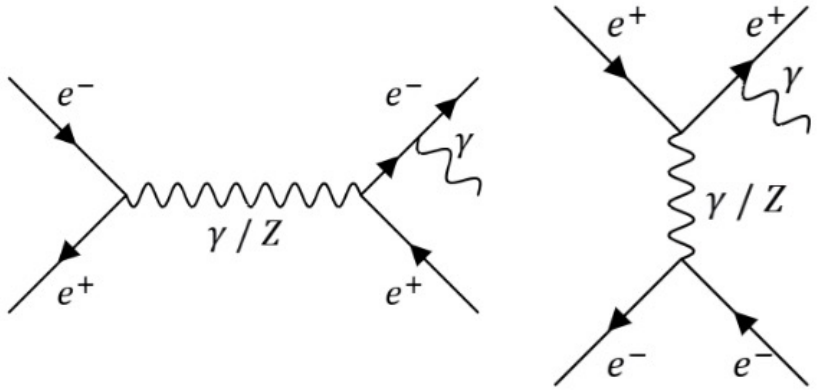

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Comparing Two NLO Theory Calculations of A_{LR}

We compare calculations of the ReneSANCe Monte Carlo generator

[R. Sadykov and V. Yermolchyk, *"Polarized NLO EW cross section calculations with ReneSANCe",* Computer Physics Communications 256, 107445 (2020)]

with those of an independent NLO calculation

[A. G. Aleksejevs, S. G. Barkanova, Y. M. Bystritskiy, and V. A. Zykunov, *"Electroweak Corrections with Allowance for Hard Bremsstrahlung in Polarized Bhabha Scattering",* Physics of Atomic Nuclei 83, 463 (2020)]

and determine the level of agreement

Comparing Two NLO Theory Calculations of A_{LR}

To compare ReneSANCe calculations to those of Aleksejevs *et al* the following ReneSANCe default SM parameters were changed to correspond to those in Aleksejevs *et al:*

widths of the W boson and the top quark are set to 0,
M_{Higgs}=125GeV, M_Z =91.1876, M_W=80.4628GeV,
M_u=69.83MeV, M_d=69.84MeV, M_S=0.15GeV, M_c=1.2GeV,
M_b=4.6GeV, M_t=174GeV
CM energy = 10.577 GeV
soft photon cutoff, *ome,* set to 0.002
(Note that earlier comparisons had different *ome* following advice of A. Aleksejevs, likely a misunderstanding.)

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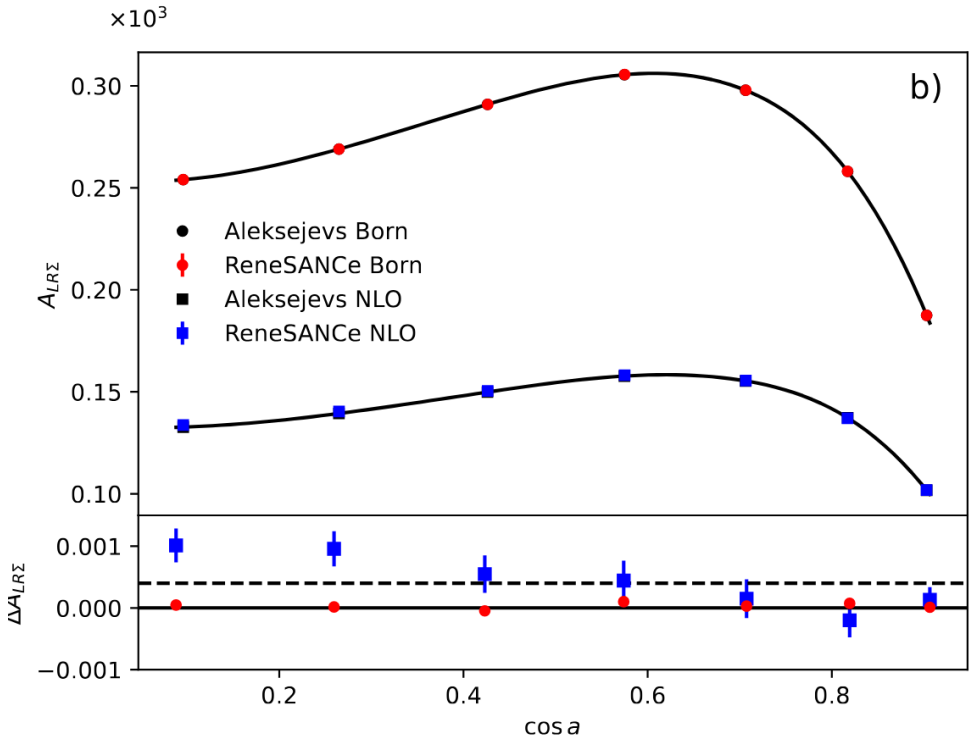


- Comparison of calculations of integrated A_{LR} in Bhabhas from Aleksejevs *et al* and ReneSANCe for an angular acceptance of final-state electron angle "a" integrated between a and 180°-a. Line is a cubic spline.
- The average absolute difference between the calculations is 4.4×10^{-7} equivalent to a relative difference of 0.3%

Sensitivity to A_{LR}

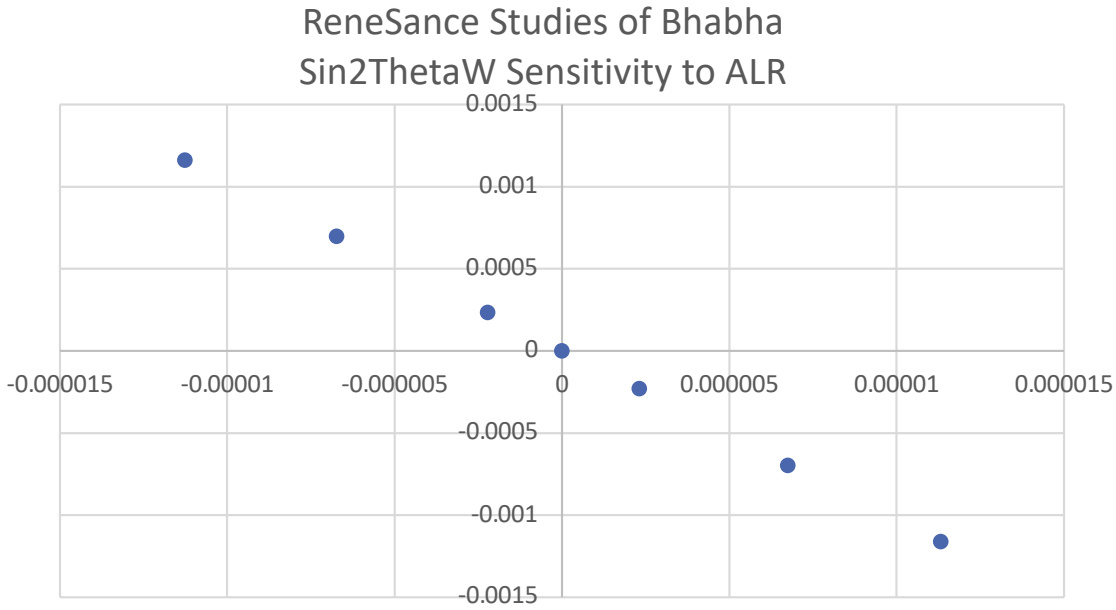
Assuming Chiral Belle achieves it's goal of a 70% polarization, and taking $A_{LR} = 0.00012$ from ReneSANCe for the angular acceptance of

$|\cos\theta| < 0.819$, a measured $A_{LR}\langle Pe\rangle = 0.000098$ is predicted, with a statistical uncertainty of 2.3% for 40 ab^{-1} of data.

Dominant systematic uncertainties are expected to arise from knowledge of the beam polarization (0.4%), background modeling (0.07%), angular acceptance (1.1% assuming 0.50^{o} systematic, probably conservative), and knowledge of the center-of-mass energy of the collisions (0.7%)

$\sin^2\theta_W$ Sensitivity to A_{LR}

As suggested by authors of ReneSANCE, we shift values of M_w in ReneSANCE generator to determine $\sin^2\theta_W$ sensitivity to A_{LR}



$\sin^2\theta_W$ Sensitivity

Using the published Belle II efficiency for selecting Bhabha events from our luminosity paper:
"Measurement of the integrated luminosity of the Phase 2 data of the Belle II experiment", Chinese Physics C 44, 021001 (2020).
and assuming a $40ab^{-1}$ dataset having 70% polarization, projected uncertainty on the $\sin^2\theta_W$ using ReneSANCe is ± 0.00032

Comparable to combined SLD-LEP uncertainty of ± 0.00024 on $\sin^2\theta_W$ at the Z^0 pole involving only the Z^0-electron couplings
(Note: recent CMS result for $\sin^2\theta_W$ from $Z^0 \to e^+e^-$ is ± 0.00041)

Also comparable to the MOLLER experiment's projected uncertainty of (± 0.00028) at the lower 100 MeV energy scale

Chiral Belle including tau and muons – assuming lepton universality gives an uncertainty of ± 0.00019 - would be single most precise measurement of $\sin^2\theta_W$ (NB: ± 0.00016(LEP + SLC))

What is size of NNLO Contributions

The change from Born-level to NLO is large

Next Steps:

In progress of getting estimated projections of size of NNLO contributions