ALR calculations with ReneSANCe

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ReneSANCe

- ReneSANCe is a new MC generator, published June 2020
  - Renat Sadykov, Vitaly Yermolchyk, *Polarized NLO EW e+e– cross section calculations with ReneSANCe-v1.0.0* (2020); DOI:10.1016/j.cpc.2020.107445
- Capable of calculating cross-sections and 4-vectors for bhabhas, muons, taus
- Supports beam polarization in each beam
- Has special ALR modes which calculate ALR numerator and denominator in 2 cases
  - Case 1: Both beams are polarized
  - Case 2: Only the e- beam is polarized (Added at our request)
- Much quicker to calculate ALR with these modes than through event generation

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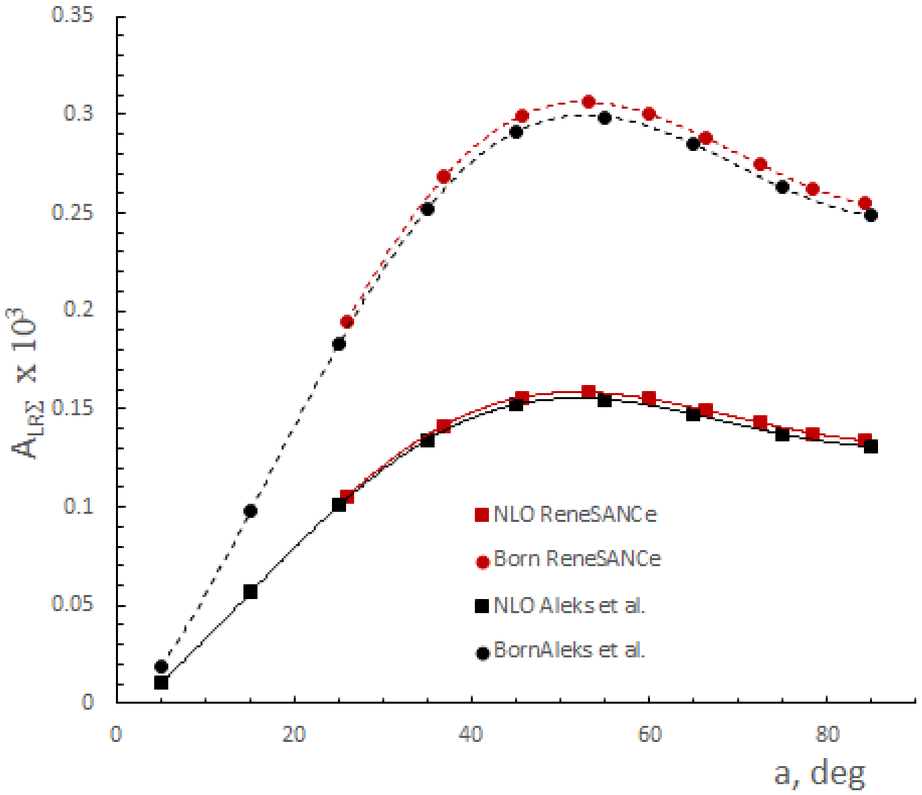
ALR in Bhabha's

- Some theoretical work already published on ALR in Bhabha's
  - A.G. Aleksejevs, S.G. Barkanova, Y.M. Bystritskiy and V.A. Zykunov, "Electroweak Corrections with Allowance for Hard Bremsstrahlung in Polarized Bhabha Scattering". *Phys. Atom. Nuclei* **83,** 463–479 (2020). https://doi.org/10.1134/S1063778820030035

- A_{LR} is calculated from electrons integrated between –cos(a) and cos(a)

- Positron is restricted to 0.94 > |cosθ| in ReneSANCe



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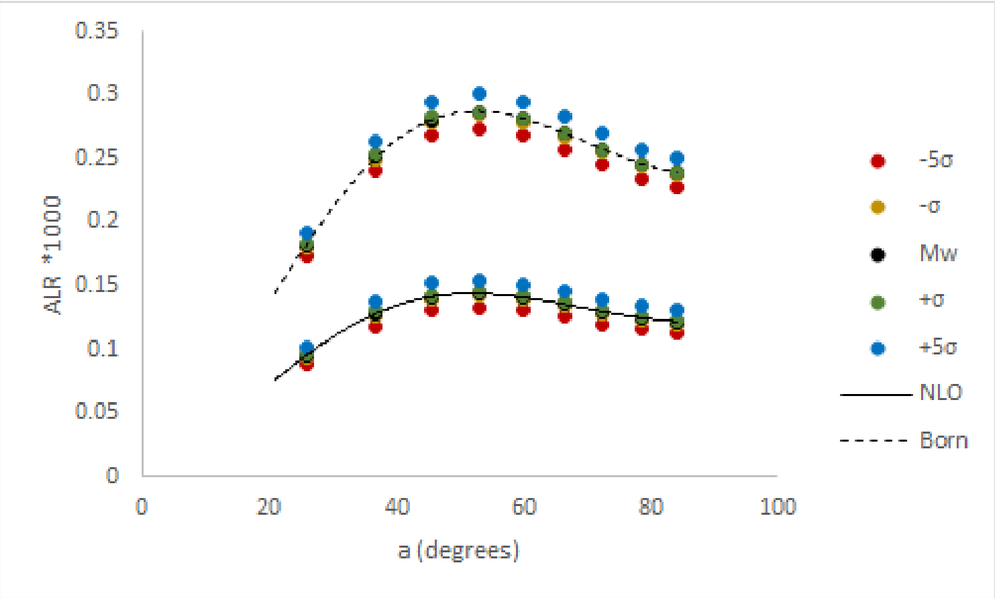
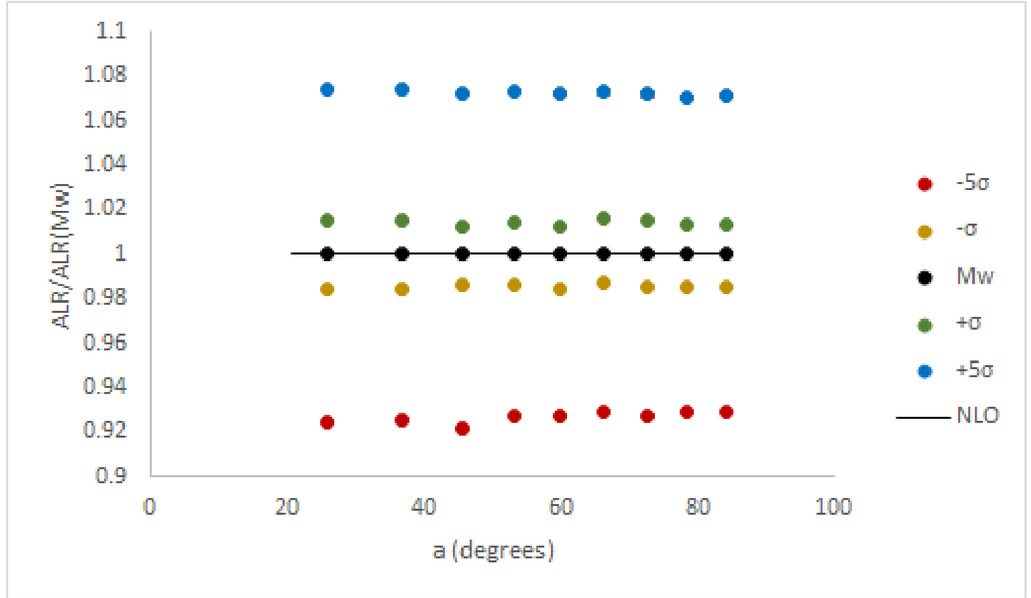
ALR Calculations

$$\sin^2\theta_W = 1 - \frac{M_W^2}{M_Z^2}$$

- Running ReneSANCe with the ALR modes
- Positron within |cosθ|<0.94, Electron integrated between –cos(a) and cos(a)
- Adjusted value of M_W as a proxy to $\sin^2\theta_W$
- 1 sigma(12 MeV) and 5 sigma shifts in M_W correspond to ~2 and 11 in $\sin^2\theta_W$ (based on pdg uncertainty)





- Plot on right shows relative shift across parameter space
- Shift is on the order of 1.5%, for 2 sigma shift in $\sin^2\theta_W$

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ALR Calculations

- Using the A_{LR} formula we can calculate expected sensitivities

$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} = \frac{4}{\sqrt{2}}\left(\frac{G_f s}{4\pi\alpha Q_f}\right) g_A^e g_V^f \langle P \rangle \propto T_3^f - 2Q_f \sin^2\theta_W$$

- $\Delta\sin^2\theta_W/\Delta A_{LR} \approx 100$, $\Delta g_V^e/\Delta A_{LR} \approx 200$
- Compared two angular acceptances: $|\cos\theta| < 0.90$, and $|\cos\theta| < 0.82$ (Belle II Lumi Paper acceptance)

	A_{LR}	σ(nb)
$\|\cos\theta\| < 0.90$	0.00010	40.8
$\|\cos\theta\| < 0.82$	0.00015	17.4

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	Acceptance	N	$\sigma\sin^2\theta_W$	σg_V^e
20 ab^{-1}	$\lvert\cos\theta\rvert < 0.90$	2.9×10^{11}	0.0003	0.0006
	$\lvert\cos\theta\rvert < 0.82$	1.3×10^{11}	0.0004	0.0009
40 ab^{-1}	$\lvert\cos\theta\rvert < 0.90$	5.8×10^{11}	0.0002	0.0004
	$\lvert\cos\theta\rvert < 0.82$	2.5×10^{11}	0.0003	0.0006
World Averages			**0.00016**	**0.00047**

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Conclusions

- Working to understand difference between Aleks *et al.* and ReneSANCe at Born level
- ReneSANCe calculates a cross-section of 17.4 nb for angular acceptance of 35°-145°, in agreement with BABAYAGA@NLO as used in Belle II luminosity paper
- Generator authors are interested in our use case
    - Planning to add asymmetric beam energies in the future
- Planning to release paper on study and expected sensitivity reach at Chiral Belle
- ReneSANCe will eventually be added to basf2 framework

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