ALR calculations with ReneSANCe

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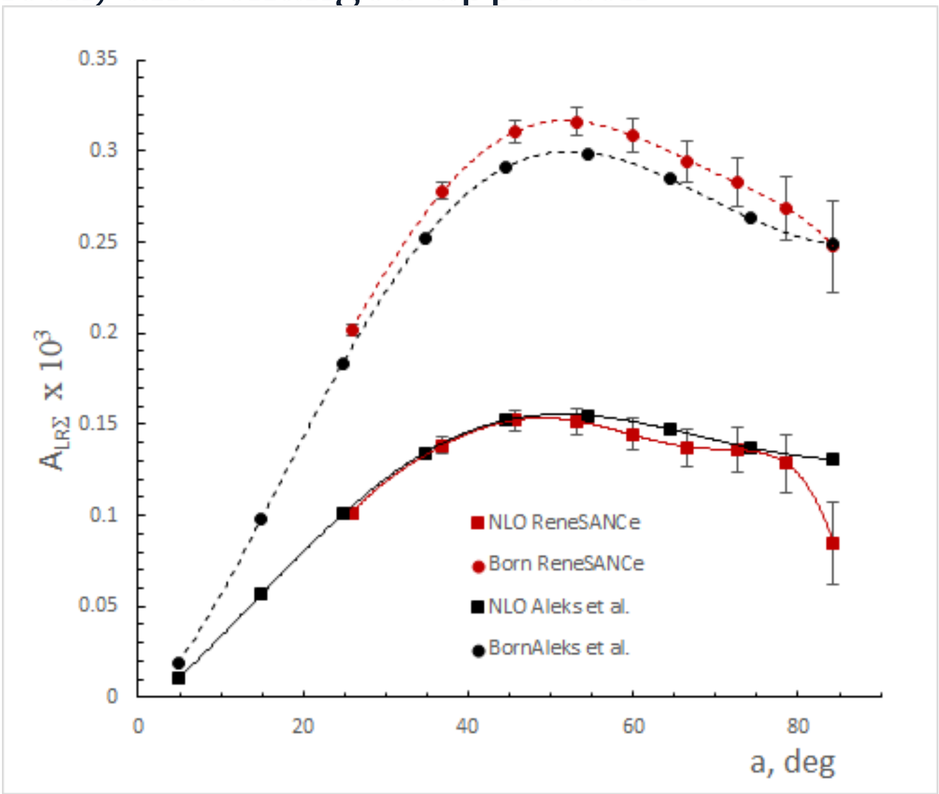
ReneSANCe

- ReneSANCe is a new MC generator, published last June
  - 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

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
- Working with Aleksejevs et al. to produce comparisons to ReneSANCe
- Ran into computing bottleneck, and changed approach



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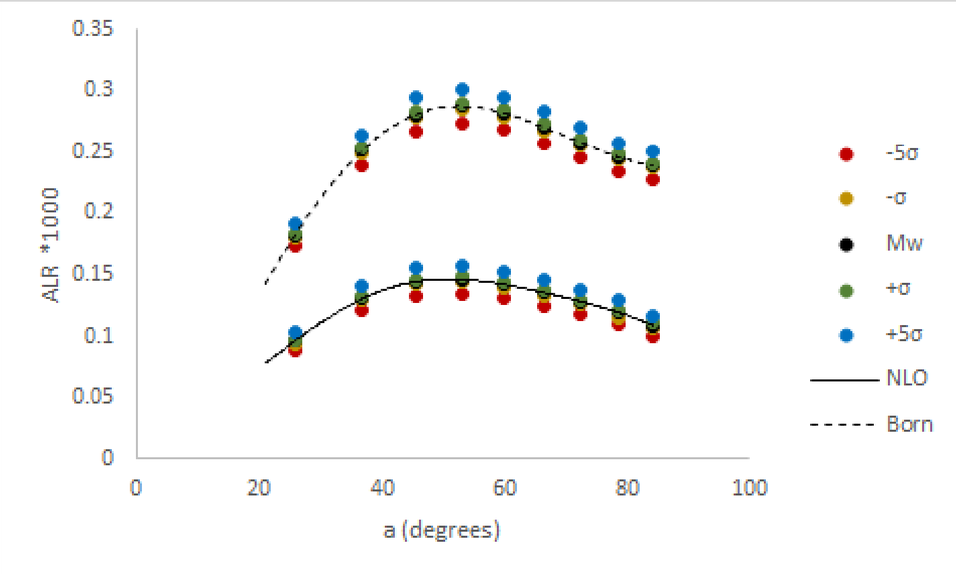
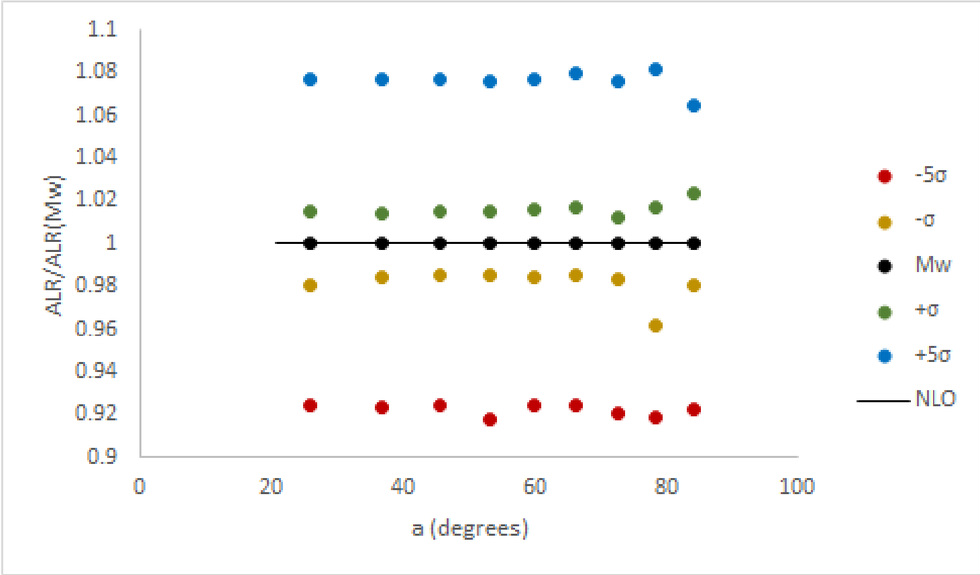
ALR Calculations

- Running ReneSANCe with the ALR modes
- Positron within $|\cos\theta|<0.94$, Electron integrated between $-\cos(a)$ and $\cos(a)$
- Adjusted value of M_W as a proxy to $\sin^2\theta_W$
- 1 sigma 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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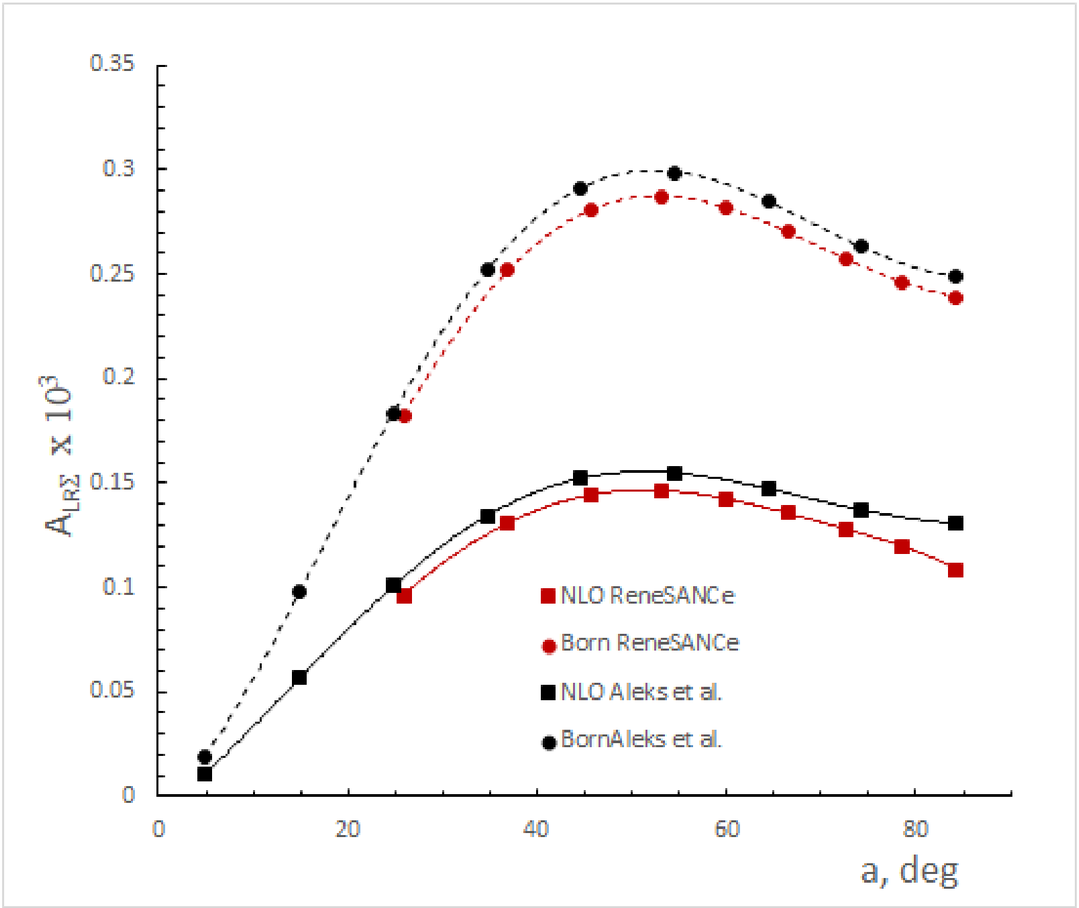
Comparison with Aleksejevs *et al.* v2

- Comparison with using the ALR modes
- Some differences in standard model parameters should explain shift
- Largest M_W used in sensitivity study was 80.439 GeV, Aleksejevs *et al.* use M_W=80.4628 GeV
- The difference in M_W should result in ~10% shift based on sensitivity study



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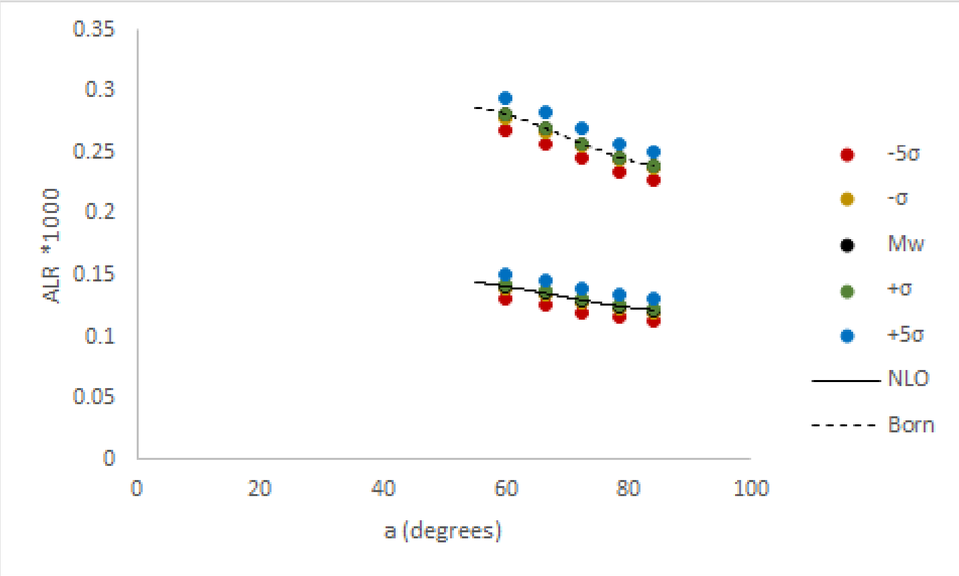
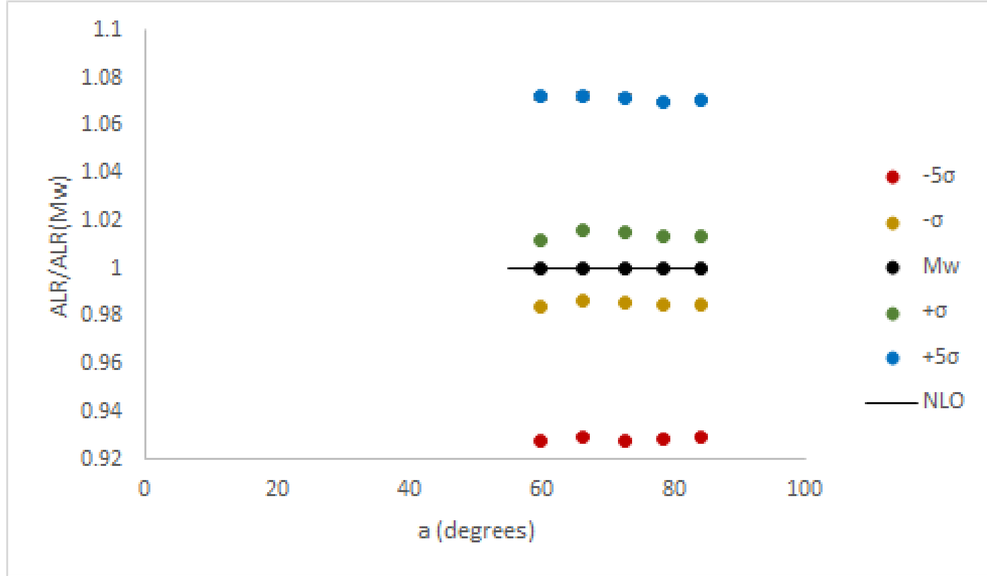
ALR Calculations

- Flucations in relative shifts tracked to imprecision in MC grid
- Authors suggested increasing grid generation parameters
- Grid generation takes ~20-40 hours, sampling is negligible
- Not all data points available yet, possibly by meeting tomorrow





- Error in ALR is ~10^{-4} (on plot, 10^{-7} absolute)
- Error in relative shift is ~10^{-3}

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Meeting the authors

- Met with ReneSANCe authors Vitaly Yermolchyk and Renat Sadykov last Friday via Zoom
- Confirmed varying M_W is the correct approach to study $\sin^2\theta_W$ sensitivity

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

- Vitaly and Renat are interested in continuing development for our use cases
  - Planning to add asymmetric beam energies
- They're interested in keeping track of our progress as one of the first users of the generator

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ReneSANCe at Belle II

- Working to add ReneSANCe as independent generator at Belle II
- LHE output can be read into Belle II via LHEInputModule
- Vitaly and Renat had a few suggestions
  - Suggested single generation of MC grid with very high settings
  - Event sampling on grid should be fast with no overlap
  - Authors also planning to add functionality for separate beam energies
- ReneSANCe complies and runs with no issues in the basf2 environment
- Working to understand if we can add built generator to basf2, or just source+build instructions
- Didn’t see generators session this B2GM so may end up emailing the WG list

Conclusions

- Finishing sensitivity study in the next few days
- A. Aleksejevs *et al.* have expressed interest in varying their calculations to match ReneSANCe variables
    - Planning short run to match their calculations
    - Allows for custom acceptance angles, plan to match published Belle II Lumi Paper
- Planning to release paper on study and expected sensitivity reach at Chiral Belle
- ReneSANCe will be available on basf2 (dev branch) in the near future