Simulations of A_{LR} and A_{FB} to NLO with ReneSANCe

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Asymmetries

- Due to γ-Z interference there are two major asymmetries present in $e^+e^- \to f\bar{f}$
- First, a left-right asymmetry, A_{LR}, caused by a difference in the cross-sections for left and right handed initial state electrons

$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} \tag{1}$$

- Secondly, a forward-backward asymmetry, A_{FB}, caused by a preference for the final state fermion being in the forward hemisphere vs the backward hemisphere.

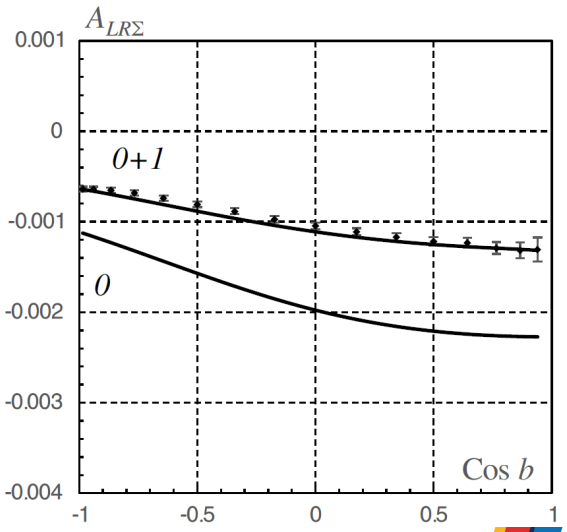
$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B} \tag{2}$$

Asymmetries

- Two recent theory papers calculate the asymmetries at fully NLO
- In Muons: Aleksandrs Aleksejevs, et al. DOI: 10.1103/PhysRevLett.124.141801
  - I provided a comparison to $\mathcal{KK}$MC in the paper
  - Results were presented in the 2019 fall B2GM
- In Bhabhas: A. G. Aleksejevs, et al. DOI:10.1134/S1063778820030035
- The bhabha paper has no simulation so I am working on a comparison
- In order to produce bhabha pairs for study I am using the new ReneSANCe generator (DOI: 10.1016/j.cpc.2020.107445)
- ReneSANCe is the only generator I found capable of using polarized beams for bhabha generation

A_{LR} in muons

- Points are integrated between 10° and b
- Experimental uncertainty is expected to be on the order of a pixel with 20 ab^{-1} of data



A_{LR} in bhabhas

- In Muons A_{LR} at the born level takes the form of:

$$A^0_{LR} = -\frac{2s}{m_Z^2}\left[a_e v_\mu + a_f v_\mu \frac{(1-2y)}{2(y-1)y+1}\right] \quad (y = -t/s) \tag{3}$$

- In Bhabhas the structure is quite different

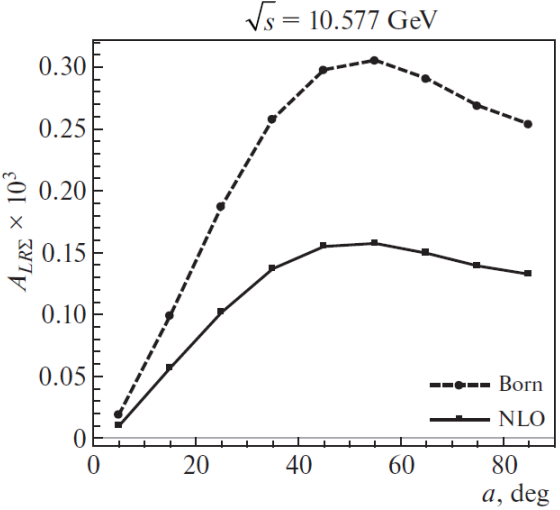
$$A^0_{LR} = \frac{8 v^Z a^Z s t u^3}{m_Z^2(s^4+t^4+u^4)} \tag{4}$$

- This manifests in a different A_{LR} sign

A_{LR} in bhabhas

Results from theory paper

- electrons are integrated from $-a$ to a
- positrons must have $|\cos\theta| < 0.94$
- large $\cos\theta$ are excluded as the cross sections become large

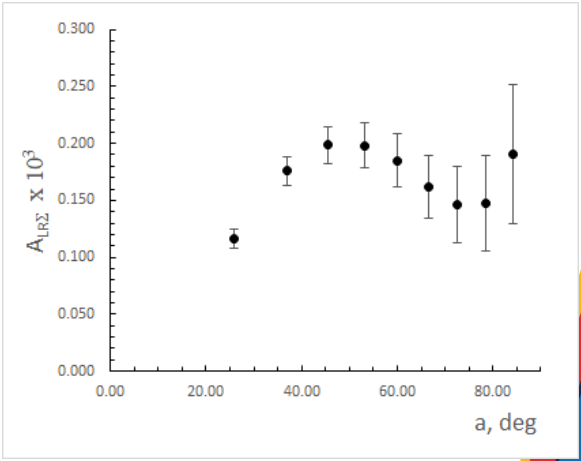


ReneSANCe

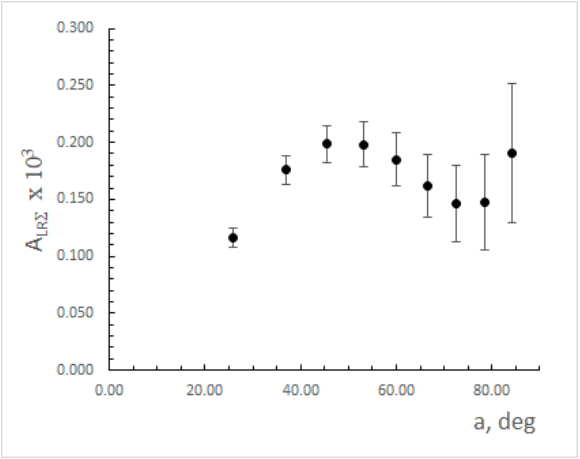
- Used the ReneSANCe generator to generate 10 billion bhabha events for each electron beam polarization
- Generator is setup to do studies on a variety of variables
- Currently working on getting born level numbers as well as studying $sin^2\theta_W$ sensitivity
- A_{LR} and A_{FB} from ReneSANCe has been calculated at NLO

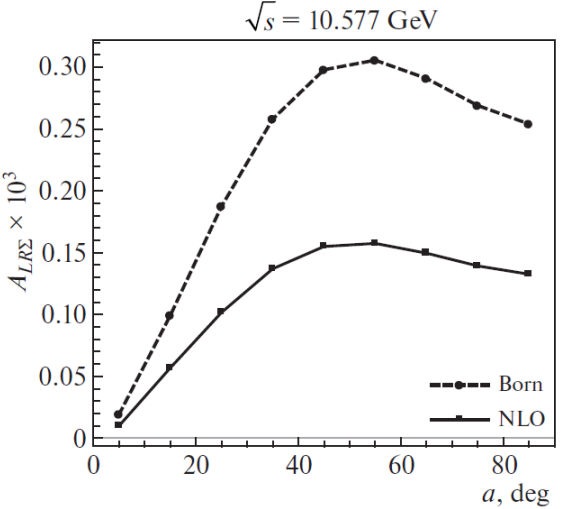
ALR in ReneSANCe

- electrons are integrated from $-a$ to a
- positrons have $|\cos\theta| < 0.93$
- $\sqrt{s} = 10.577$ GeV

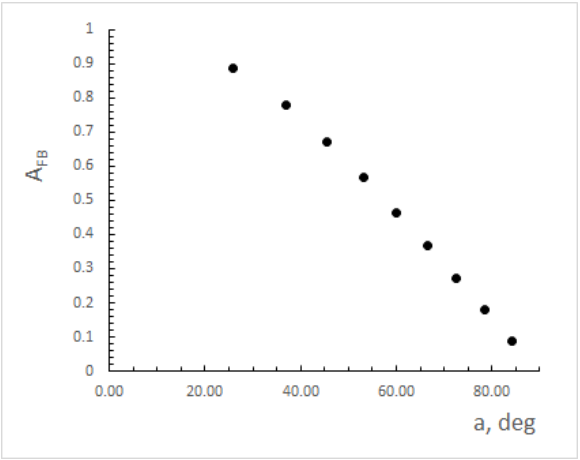


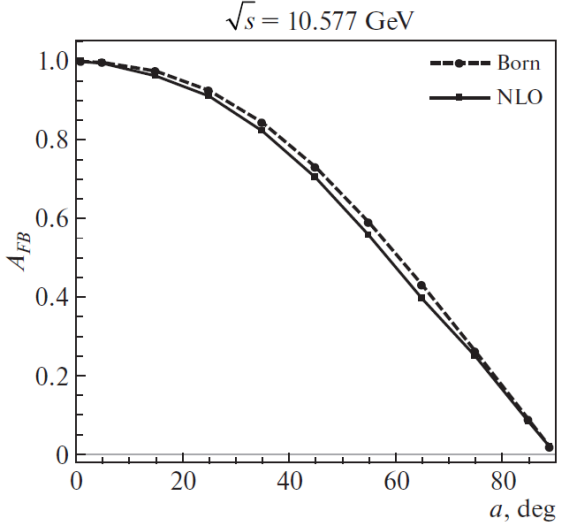
ALR in ReneSANCe





AFB in ReneSANCe





Conclusions

- ReneSANCe is showing relatively good agreement with the theory results
- Comparisons at the Born level almost ready
- Sensitivity to $\sin^2 \theta_W$ to follow