SIRADGEN: Monte Carlo generator for simulation of radiative events in polarized SIDIS

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Modern Monte Carlo simulation of radiative events for polarized SIDIS

Nowadays for simulation of radiative events Monte Carlo generators RADGEN and DJANGOH is used both for DIS and SIDIS. However even in unpolarized case the structure both DIS and SIDIS cross section is quite different:

$$\sigma_{SIDIS} \sim A_{SIDIS} + B_{SIDIS} \cos\phi_h + C_{SIDIS} \cos 2\phi_h$$

$$\sigma_{SIDIS} \sim \int d\phi_h \sigma_{SIDIS}$$

For description of polarized DIS 4 structure functions (2 unpolarized and 2 polarized ones) are used.
For description of polarized SIDIS 18 structure functions (2 unpolarized and 2 polarized ones) are used.
Unfortunately Monte Carlo generators RADGEN and DJANGOH cannot account ϕ-dependence anywhere.

Modern Monte Carlo simulation of radiative events for polarized SIDIS

Basing on the equations from
I.Akushevich, A.Ilyichev. Phys.Rev. D100 (2019) no.3, 033005
and WW-SIDIS model for the structure functions
S. Bastami et al., JHEP 1906, 007 (2019)
a new Monte Carlo generator SIDIS-RC EvGen
D. Byer et al., Comput.Phys.Commun. 287 (2023) 108702
has been developed.
SIDIS-RC EvGen includes ϕ-dependence but does not take into account exclusive radiative tail.

Radiative, exclusive and non-radiative contribution

After IRD cancellation by Bardin-Shumeiko approach radiative corrected cross section reads

$$\sigma_{obs} = (1+\delta)\sigma_{Born} + C_1 \int\limits_{\tau_{min}}^{\tau_{max}} d\tau \int\limits_0^{2\pi} d\phi_k \int\limits_0^{R_{max}} dR \left[\sigma_R - \sigma_R^{IR}\right] + \sigma_R^{ex}$$

$$\sigma_R^{ex} = C_2 \int\limits_{\tau_{min}}^{\tau_{max}} d\tau \int\limits_0^{2\pi} d\phi_k \sigma_R^{ex}$$

3 photonic variables are associated with photon energy (R), polar (τ) and azimuthal (ϕ_k) photon angles.

To start the simulation of the unobservable hard real photon emission it is necessary to introduce the minimum photon energy $E_\gamma^{min} = R_{min}/M$.

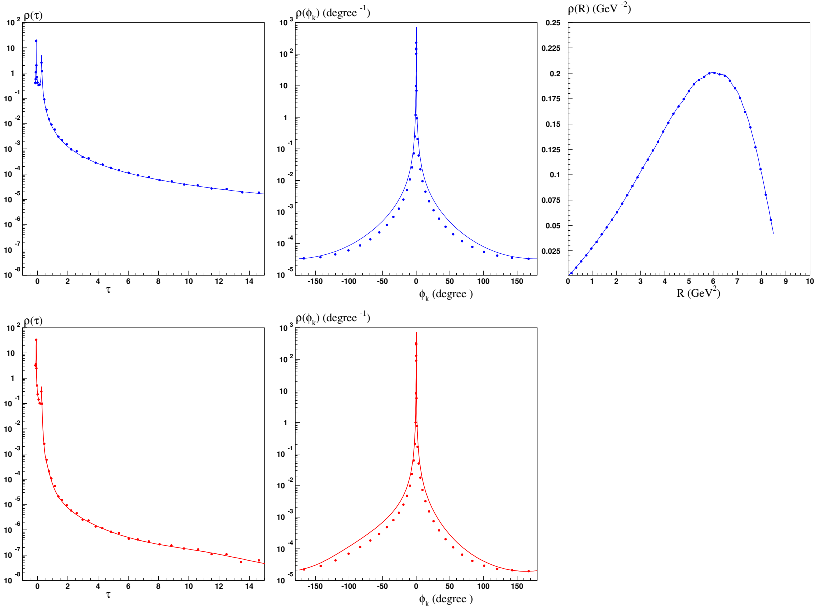
$$\sigma_{obs} = \sigma_{non-rad}(R_{min}) + \sigma_{rad}(R_{min}) + \sigma_R^{ex}$$

$$\sigma_{rad}(R_{min}) = C_1 \int\limits_{\tau_{min}}^{\tau_{max}} d\tau \int\limits_0^{2\pi} d\phi_k \int\limits_{R_{min}}^{R_{max}} dR \sigma_R$$

Strategy for simulation of one event

- For the fixed initial energy and six variables (x, y, z, p_t, ϕ_h and ϕ) the contribution $\sigma_{non-rad}(R_{min})$, $\sigma_{rad}(R_{min})$ and σ_R^{ex} are calculated. Note, that together with Born subprocess, the contributions of loop effects and soft photon radiation are also included into the non–radiative part.
- The channel of scattering is simulated for this event in accordance with partial contributions of these three positive parts into the total cross section.
- For SIDIS or exclusive radiative event the corresponding photonic kinematic variables are simulated in accordance with their calculated distribution
- The four–momenta of all final particles in the required system form are calculated.
- If the initial SIDIS variables have not a fixed value but are instead simulated according to some probability distribution (for example, the Born cross section) then the cross sections have to be stored for reweighting. The SIDIS variables are simulated over the Born cross section, and realistic observed distribution over these variables is calculated as sum of weights, they are ratios of the total and Born cross sections.

Numerical test: probability distribution $ep \to e\pi^+X$



Conclusions

- Recently we start to develop Monte Carlo generator SIRADGEN for simulation of unobserved real photon emission in polarized SIDIS taking exclusive radiative tail.
- Preliminary numerical tests show good agreement between calculated numerically and simulated probabilities over each photonic variables.
- We hope that this generator will be completely tested checked and finished rather soon.
- We also hope that this generator will be used in different collaborations such as Jlab and COMPASS.