Radiative corrections in SIDIS

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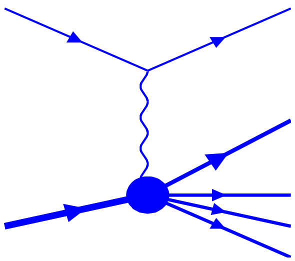
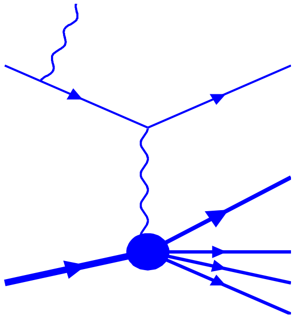
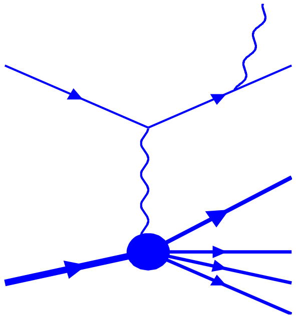
Contribution to RC in SIDIS

The Born cross section

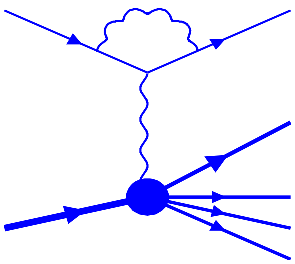


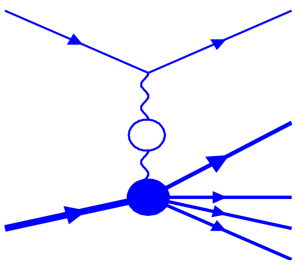
Emission of a radiated photon (semi-inclusive processes)



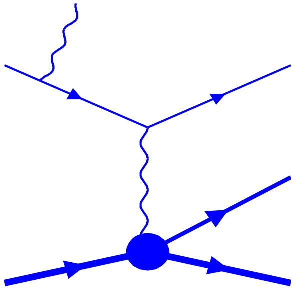


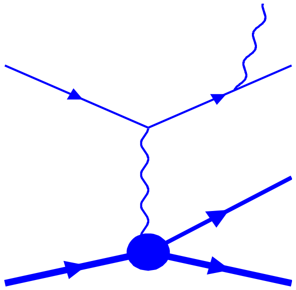
Loop diagrams





Emission of a radiated photon (exclusive processes)





Calculation of RC to SIDIS using POLRAD 2.0

- Option SIRAD has to be used.
- Simple QPM is assumed. The RC cross section is calculated in terms of parton distributions $f(x)$ and fragmentation functions $D(z)$.
- RC for unpolarized cross section and polarized part of the cross section are calculated.
- No exclusive radiative tail is separately calculated.
- Several models for parton distributions and fragmentation functions are implemented.
- RC has traditional form: a factorized part representing the contributions of loops and soft photon emission and the term in the form of two-dimensional integral representing the hard photon emission.
- Integration over p_t and ϕ_h is assumed, i.e., the RC to the three-fold cross section is calculated: $d\sigma/dxdydz$.

Numerical Estimates of RC to SIDIS using POLRAD 2.0

hadron	x	y	z	A_{born},%	A_{obs},%	δ_A	δ_u	δ_p
π^-	0.18	0.76	0.54	17.57	17.34	-1.34	-4.65	-5.93
	0.24	0.70	0.61	20.08	19.71	-1.87	-6.69	-8.43
	0.31	0.69	0.69	22.15	21.61	-2.40	-8.54	-10.74
	0.37	0.70	0.77	21.37	20.68	-3.24	-10.28	-13.18
π^+	0.18	0.76	0.54	39.70	40.08	0.95	-3.04	-2.11
	0.24	0.70	0.61	43.77	43.80	0.07	-5.07	-5.00
	0.31	0.69	0.69	49.07	48.83	-0.48	-7.03	-7.48
	0.37	0.70	0.77	53.90	53.34	-1.04	-8.92	-9.87
π^0	0.18	0.76	0.54	32.45	32.71	0.81	-3.57	-2.79
	0.24	0.70	0.61	37.13	37.13	0.00	-5.52	-5.52
	0.31	0.69	0.69	42.89	42.66	-0.53	-7.38	-7.87
	0.37	0.70	0.77	47.91	47.40	-1.07	-9.17	-10.14

δ_A *is the relative correction to polarization asymmetry,*

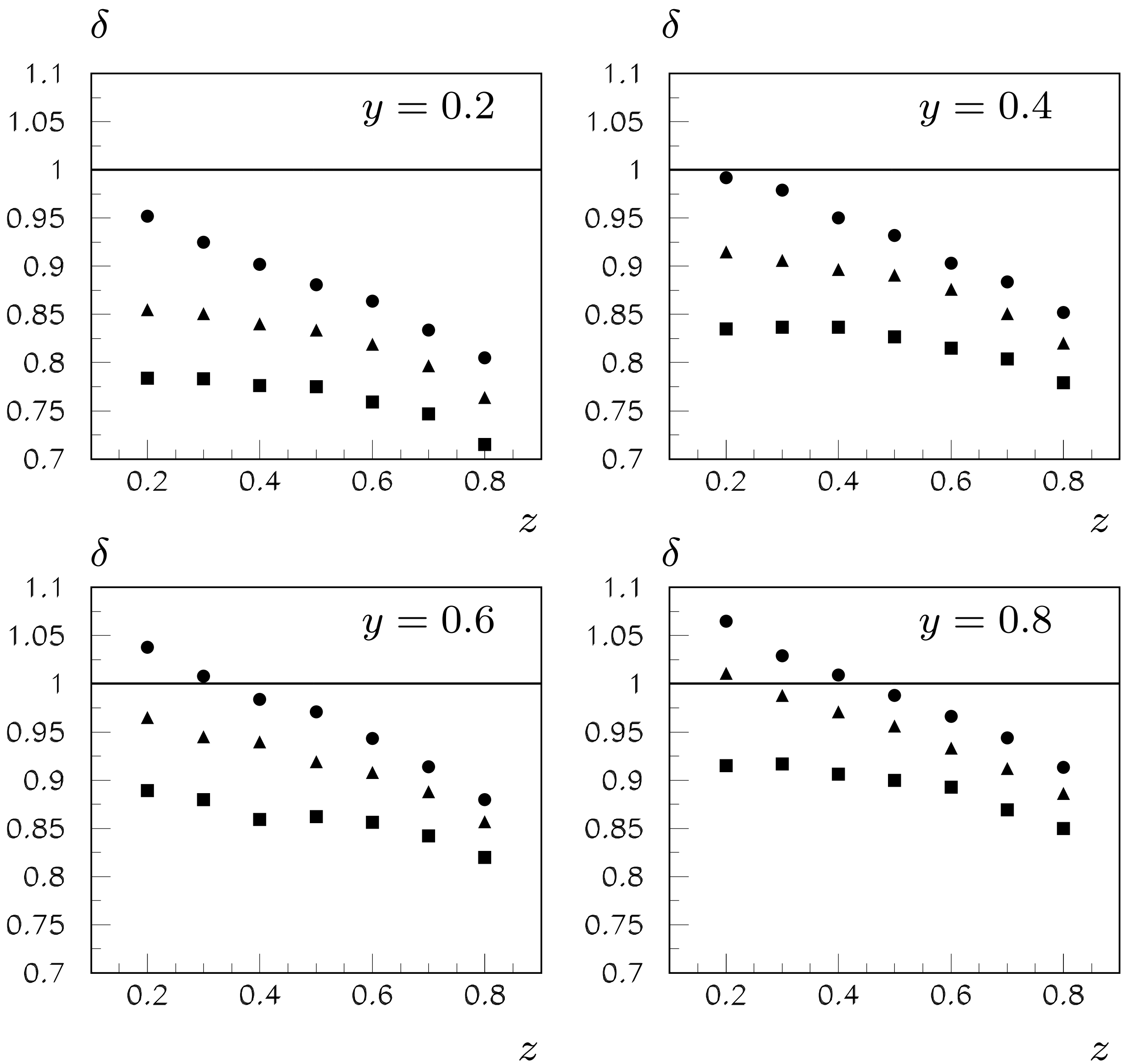
$\delta_{u,p}$ *are corrections to unpolarized and polarized parts of cross sections.*

Calculation of RC to SIDIS using HAPRAD

- Original version is based on the calculation in Akushevich, Soroko, Shumeiko EPJ C10(1999)681. In this paper an approach to calculate radiative corrections to unpolarized cross section of semi-inclusive electroproduction is developed.
- calculate the RC to five-dimensional cross section $d^5\sigma/dxdydzdp_t^2d\theta_h$ as well as to four- and three-dimensional cross sections (i.e., $d^4\sigma/dxdydzdp_t^2d$ and $d^3\sigma/dxdydz$).
- For the three-dimensional cross section the results for RC are close to that given by POLRAD 2.0 (SIRAD)
- The correction is of standard form:

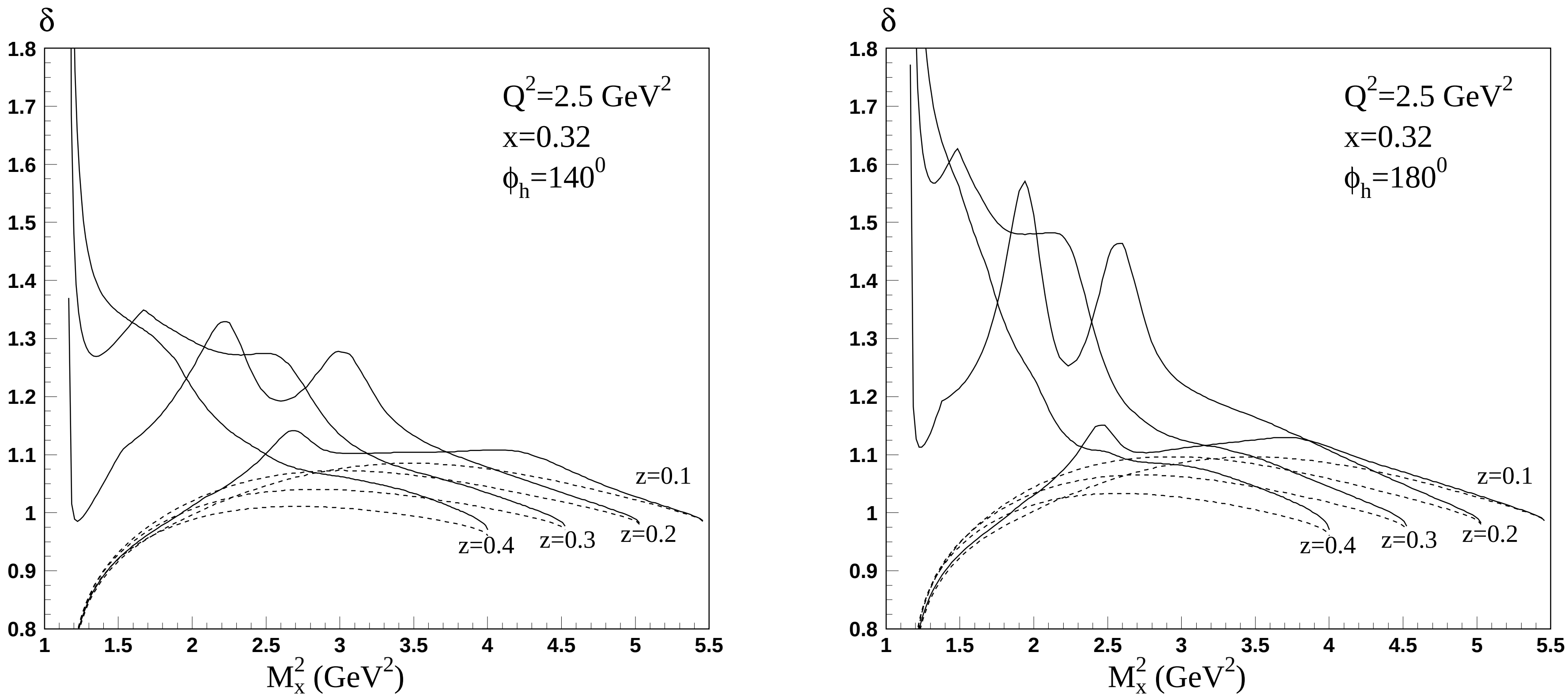
$$\sigma_{obs} = \sigma_0 e^{\delta_{inf}}(1 + \delta_{VR} + \delta_{vac}) + \sigma_F.$$

Numerical results



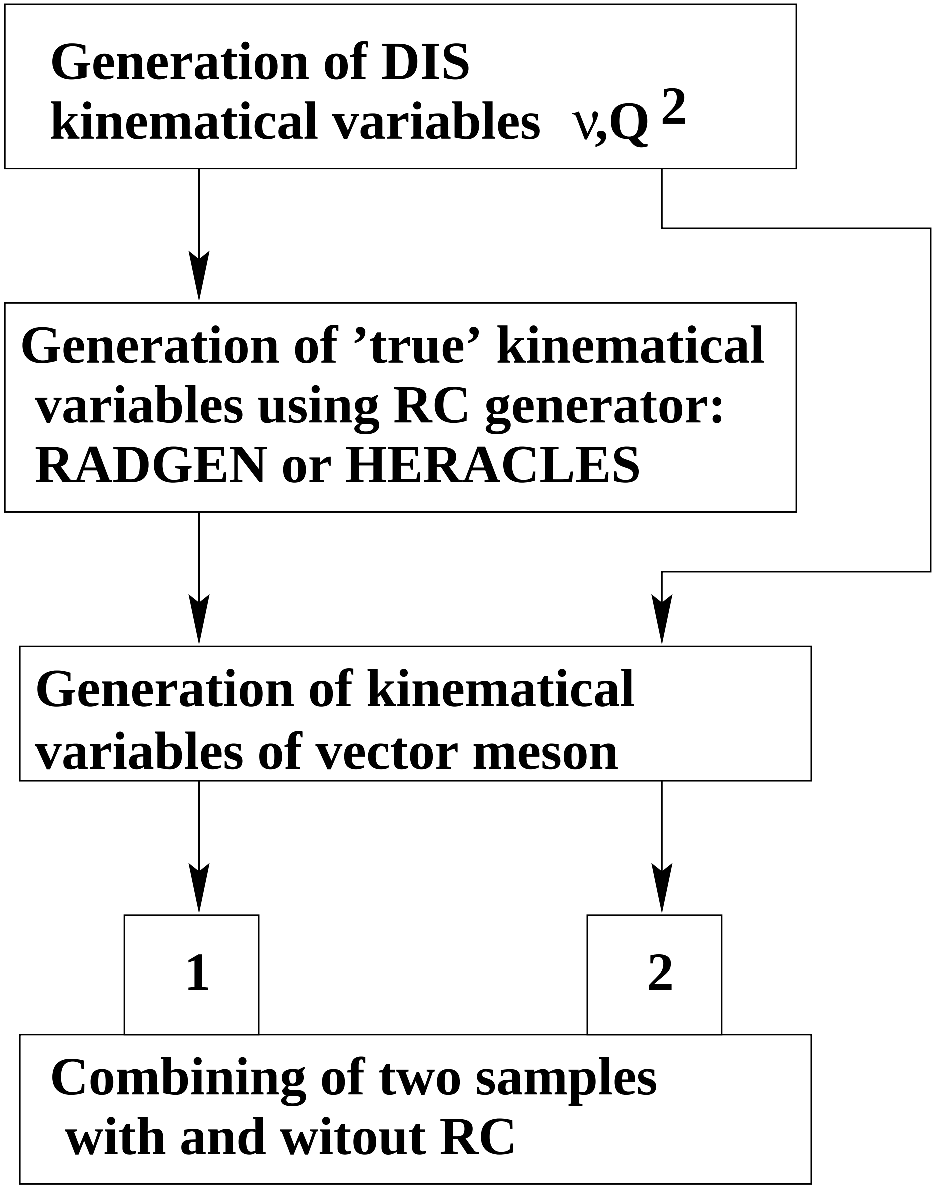
Radiative correction to the semi-inclusive cross section for kinematics of HERMES; $\sqrt{S}$=7.19 GeV. Symbols from top to bottom correspond to the x=0.05, 0.45 and 0.7. The results for x=0.15 are skipped, because they practically coincide with ones for x=0.05.

Importance of exclusive radiative tail



M_X^2-dependence of the RC factor for the semi-inclusive π^+ electroproduction at fixed proton for lepton beam energy 6 GeV: solid lines show the total correction, dashed lines represent the correction excluding the exclusive radiative tail (Akushevich, Ilyichev, Osipenko, Phys.Lett. B672(2009)35)

Calculation of RC to SIDIS using Monte Carlo generator



Possible scheme of Monte Carlo calculation of the RC factor (Akushevich, hep-ph/9906410)

General task for RC to SIDIS

General consideration of RC to SIDIS of polarized particles requires knowledge of 18 structure functions $\mathcal{H}_i(x, z, Q^2, t)$

- in semi-inclusive region and
- in exclusive region

Lack of this knowledge is the only obstacle in calculation of RC to SIDIS.

Possible alternative is the iteration procedure of RC implementation, when the structure functions are parametrized at each step of iteration procedure and then obtained parametrization is used for RC calculation.

RC to SIDIS: Current Approach

- Choose the leading contribution (e.g., twist-two contribution) to SIDIS cross section
- Use hadronic tensor defined as

$$2MW^{\mu\nu}(q,P,P_h) = \sum_q e_q \int \frac{d^2k_T}{(2\pi)^2}\frac{d^2p_T}{(2\pi)^2}\mathrm{Tr}(\Phi(p,P)\gamma^\mu\Delta(k,P_h)\gamma^\nu)\delta^{(2)}(zp_T+k_T-P_{h\perp})$$

where

$$\Phi(p,P) = \frac{1}{2}f_1(x,p_T^2)\hat{p}|_{p^+=xP^+,p_-=0} + \dots$$

$$\Delta(k,P_h) = \frac{1}{2}D_1(z,k_T^2)\hat{k}|_{k^-=P_h^-/z,k_+=0} + \dots$$

- Perform tensor integration to bring tensor structure out of the integral i.e., to have hadronic tensor in the form $W^{\mu\mu} = -g^{\mu\nu}H_1 + P^\mu P^\nu H_2 + (P^\mu P_h^\nu + P_h^\mu P^\nu)H_3 + \dots$
- calculate $L_{\mu\nu}W^{\mu\nu}$, where $L_{\mu\nu}$ is the leptonic tensor with RC.

Conclusion: RC to SIDIS

- Two basic contributions to RC in SIDIS needs to be separately calculated: the contribution from continuous spectrum (i.e., analog of inelastic radiative tail in DIS RC) and exclusive radiative tail (i.e., analog of elastic radiative tail in DIS or radiative tail from elastic peak).
- RC from continuous spectrum to the three-dimensional cross section $d\sigma/dxdydz$ is of order 5-15% with relatively strong dependence of x and z.
- Large effects are possible from exclusive tail for small M_x.
- Large correction is expected for p_t-distribution.
- Dependence on the model of SIDIS SF is expected (e.g., models for p_t-distribution).
- Only RC to continuous spectrum was evaluated for polarization asymmetry. No large correction was found.
- Important contributions to be calculated:
  - RC to polarization asymmetries due to inelastic radiative tail
  - exclusive radiative tail for polarized case
  - RC to dihadron SIDIS
- Models for 18 structure functions are required in the broad kinematical region including the region of exclusive scattering.