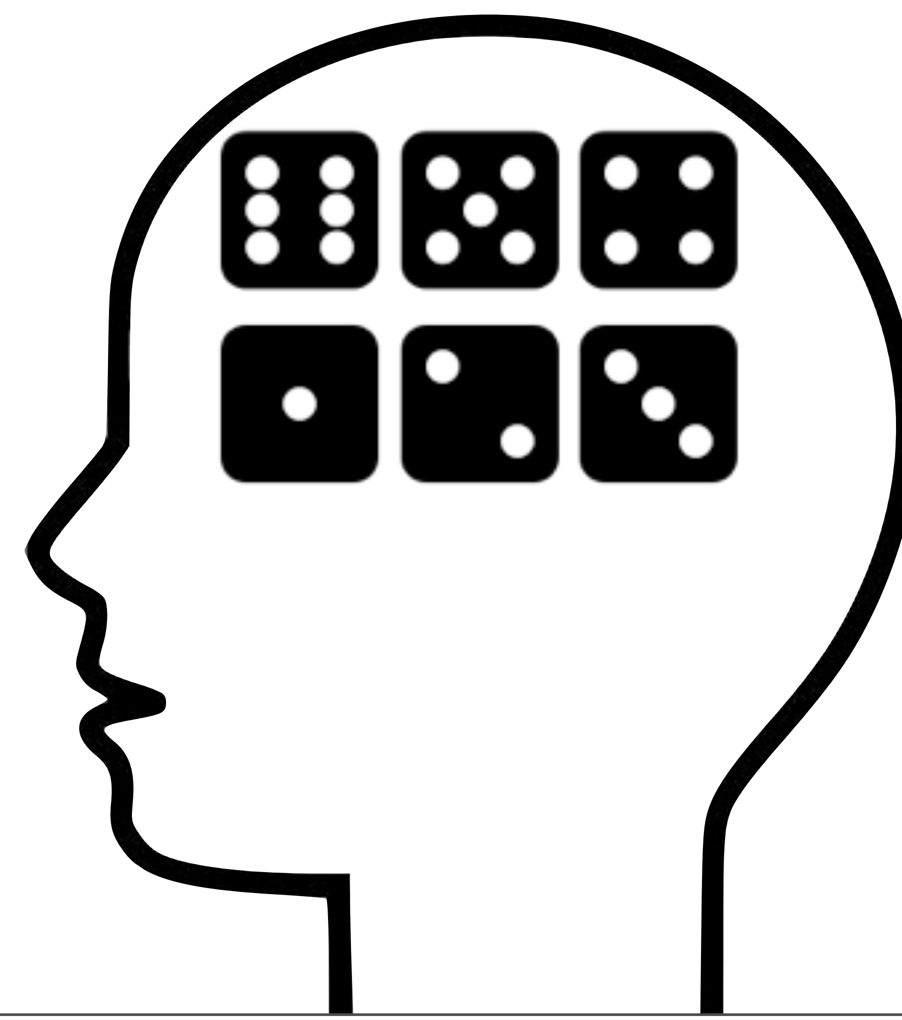
Why Monte Carlo generators?
Theory point of view

A. Bacchetta
“TMD Monte Carlo”
Frascati, 7 Nov 2011



Two types of generators

Two types of generators

- Full event generators (Pythia, Lepto...)
  All final-state particles are generated

Two types of generators

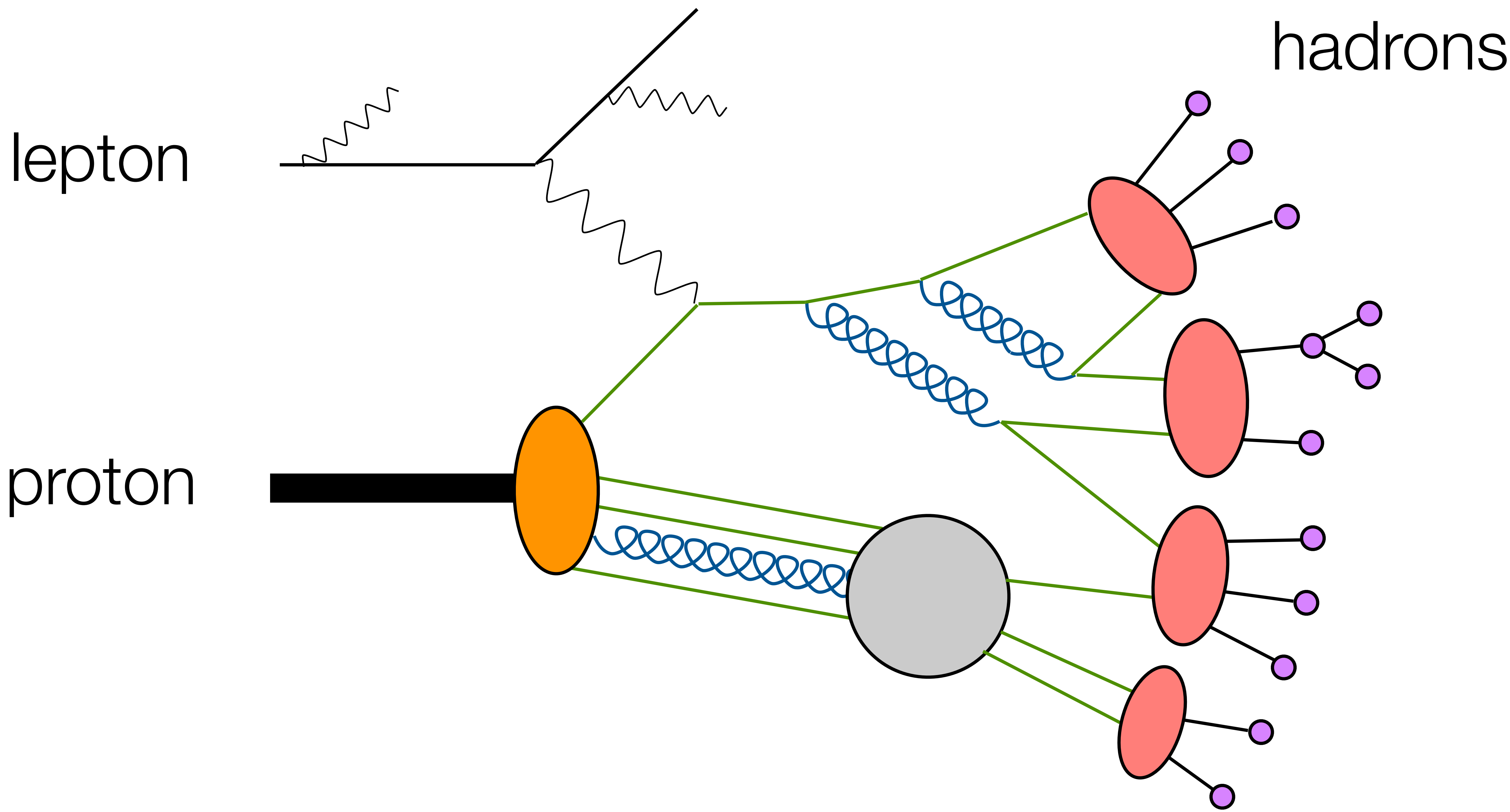
- Full event generators (Pythia, Lepto...)
  All final-state particles are generated

Two types of generators

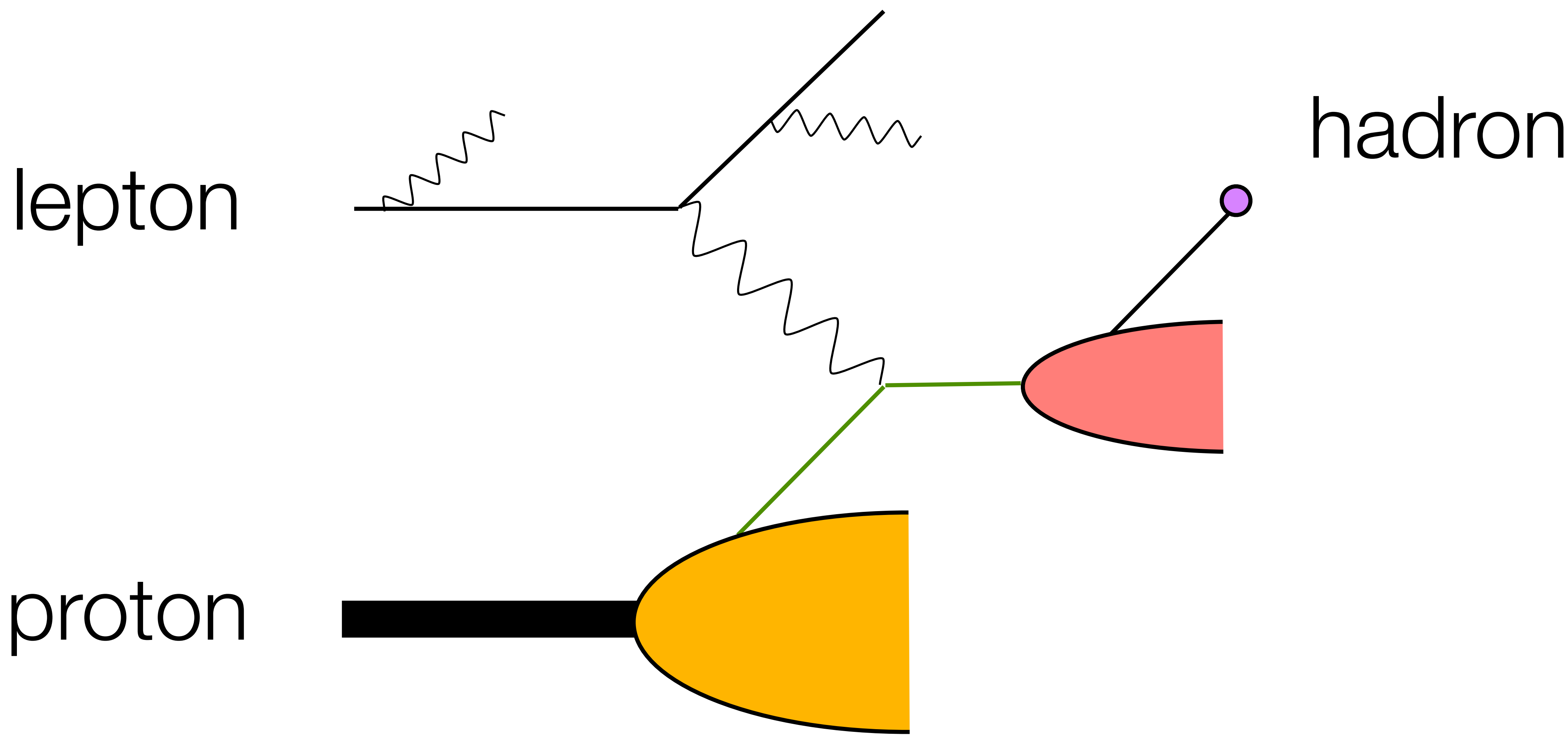
- Full event generators (Pythia, Lepto...)
  All final-state particles are generated

- Generators for single-particle (or two-particle) inclusive DIS (gmc_trans, TMDgen, ResBos...)
  Only one or two final-state particles are generated

Full event generator

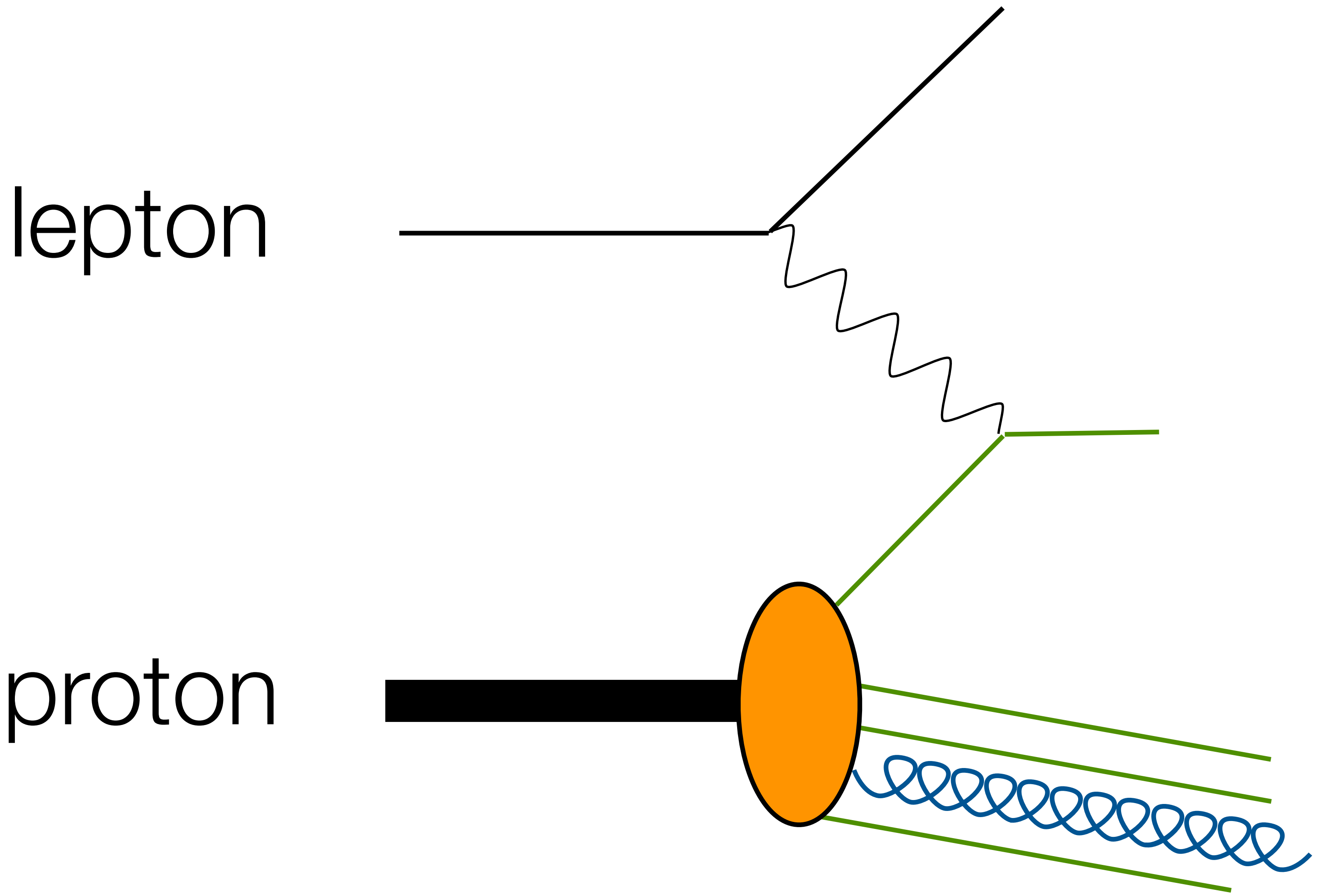


Single-particle DIS generator

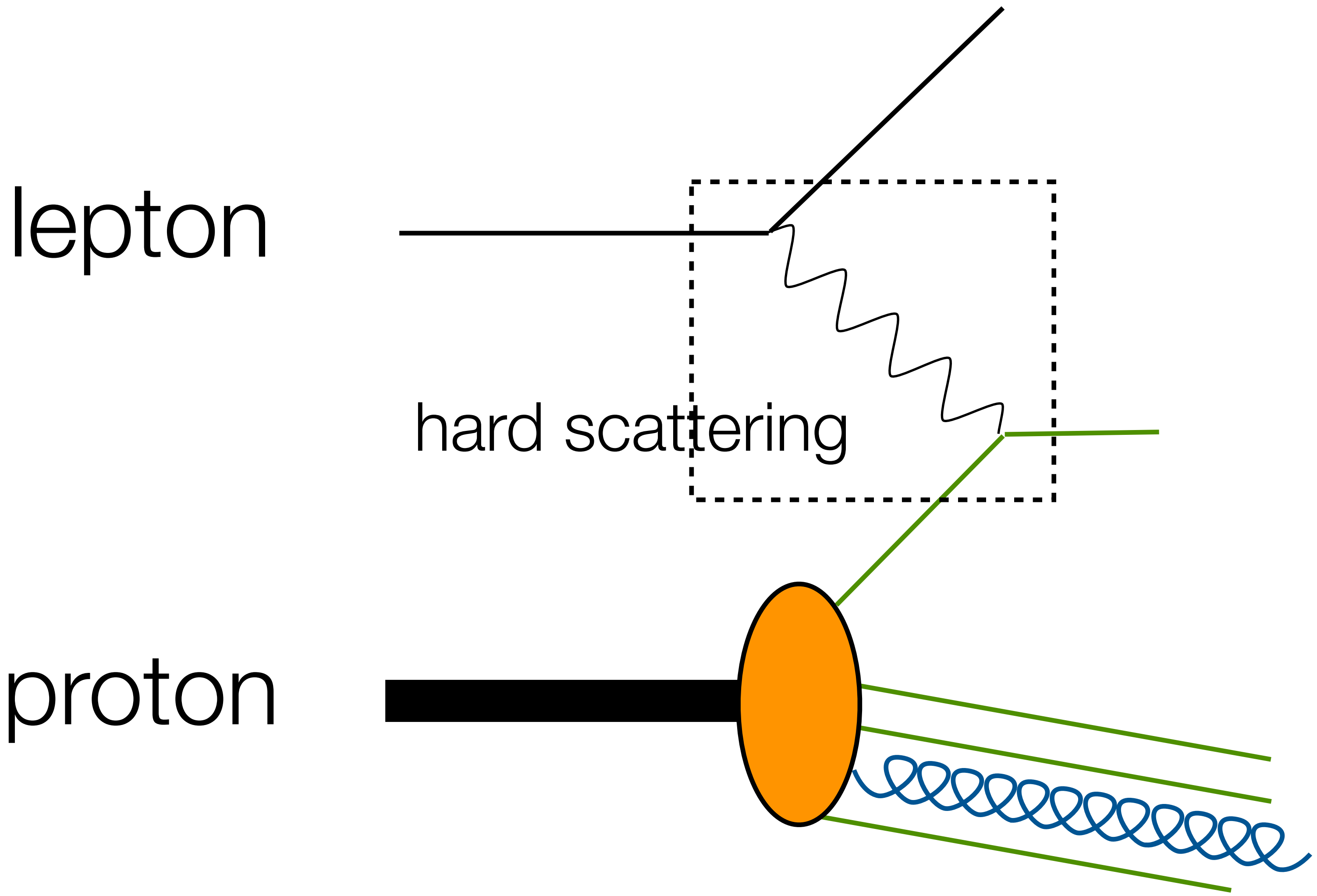


Something about full event generators

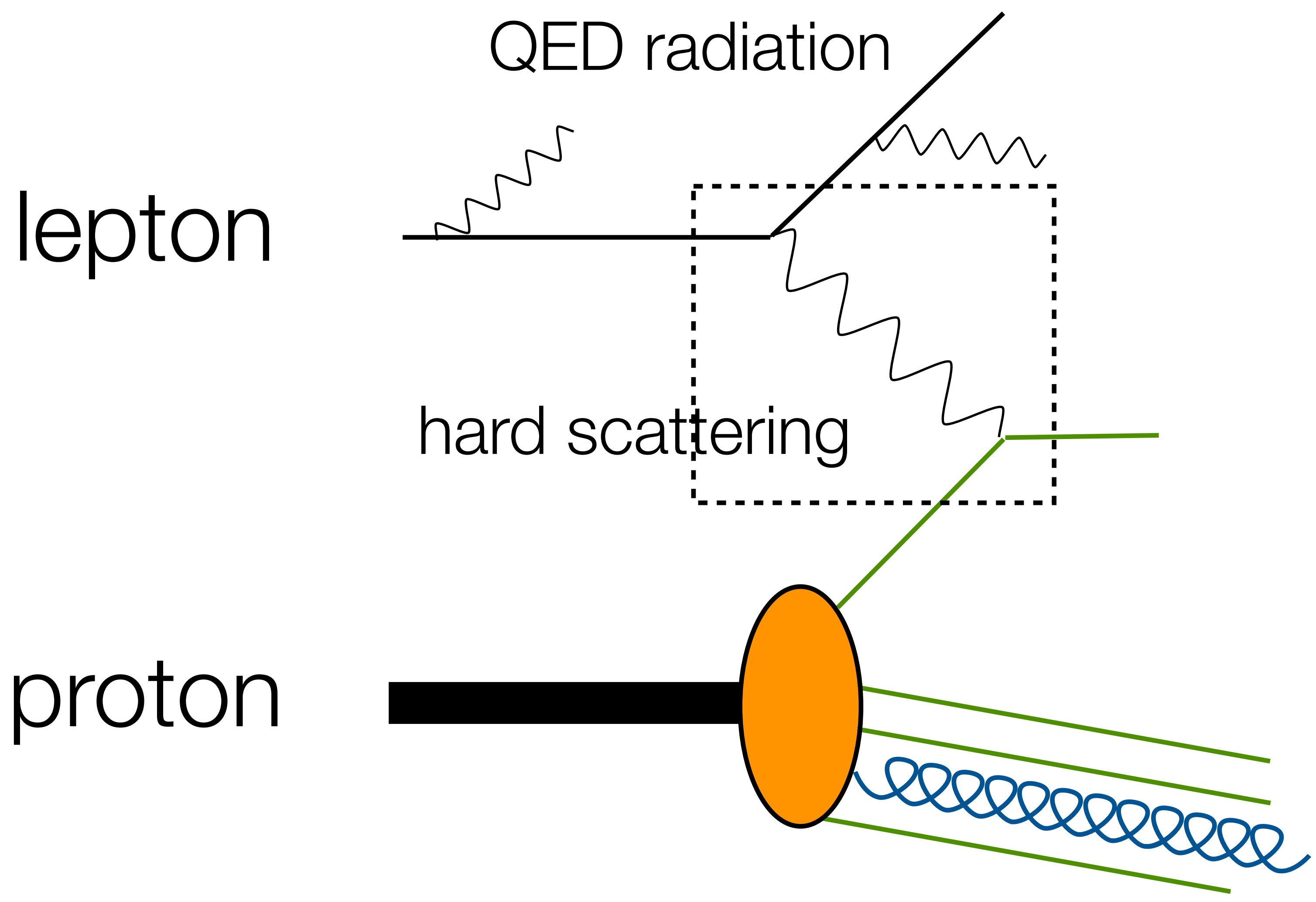
Full event generator



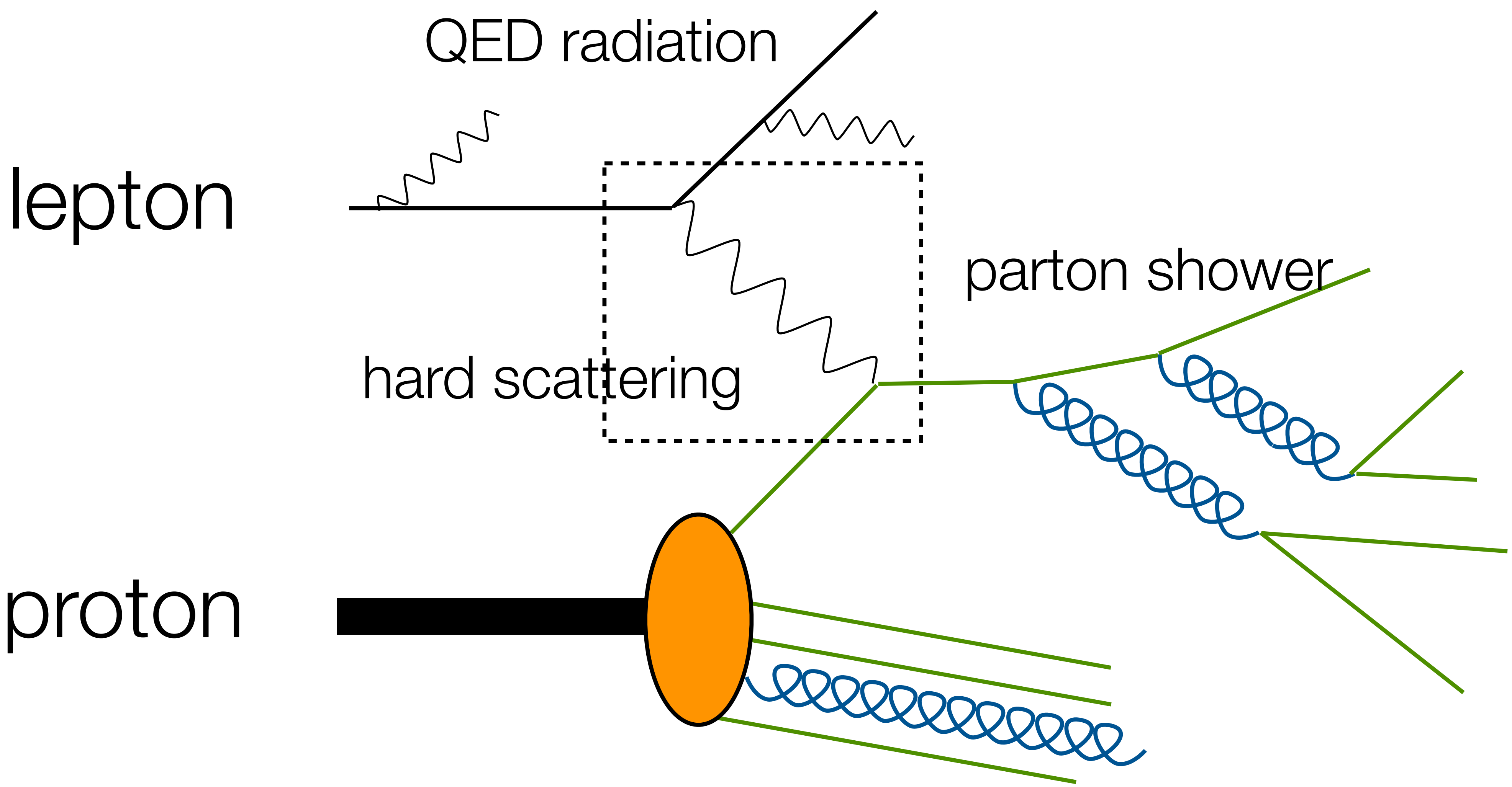
Full event generator



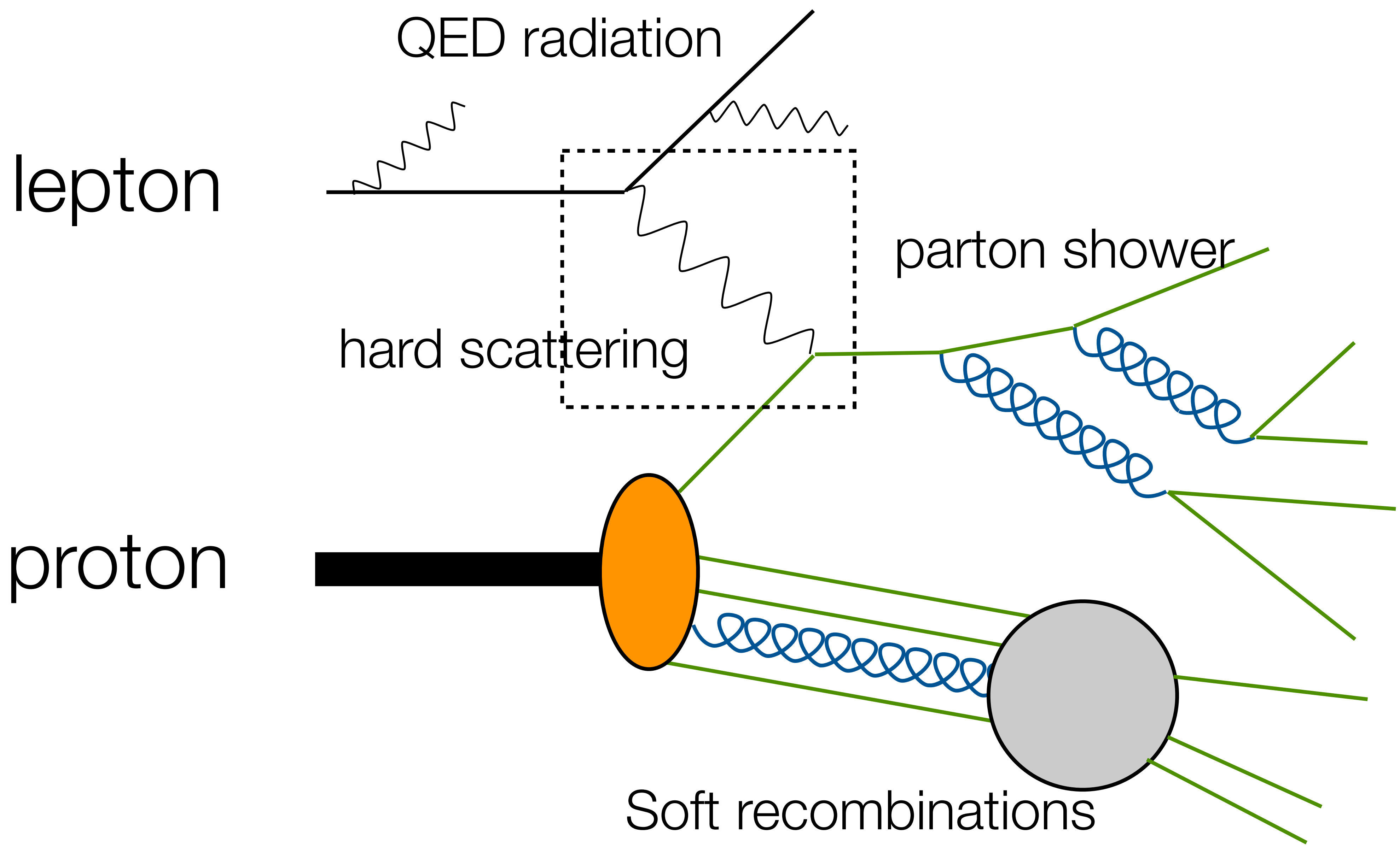
Full event generator



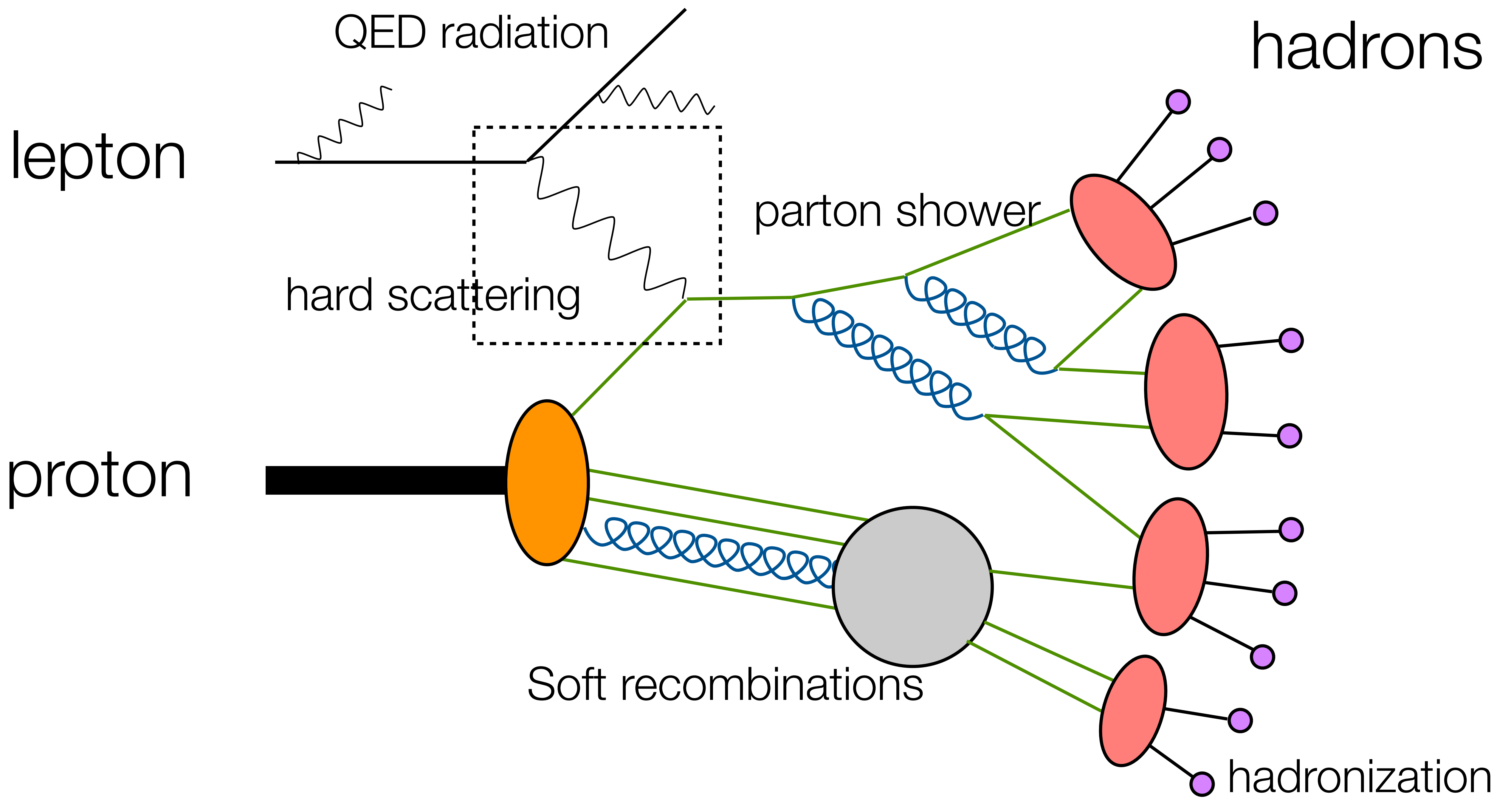
Full event generator



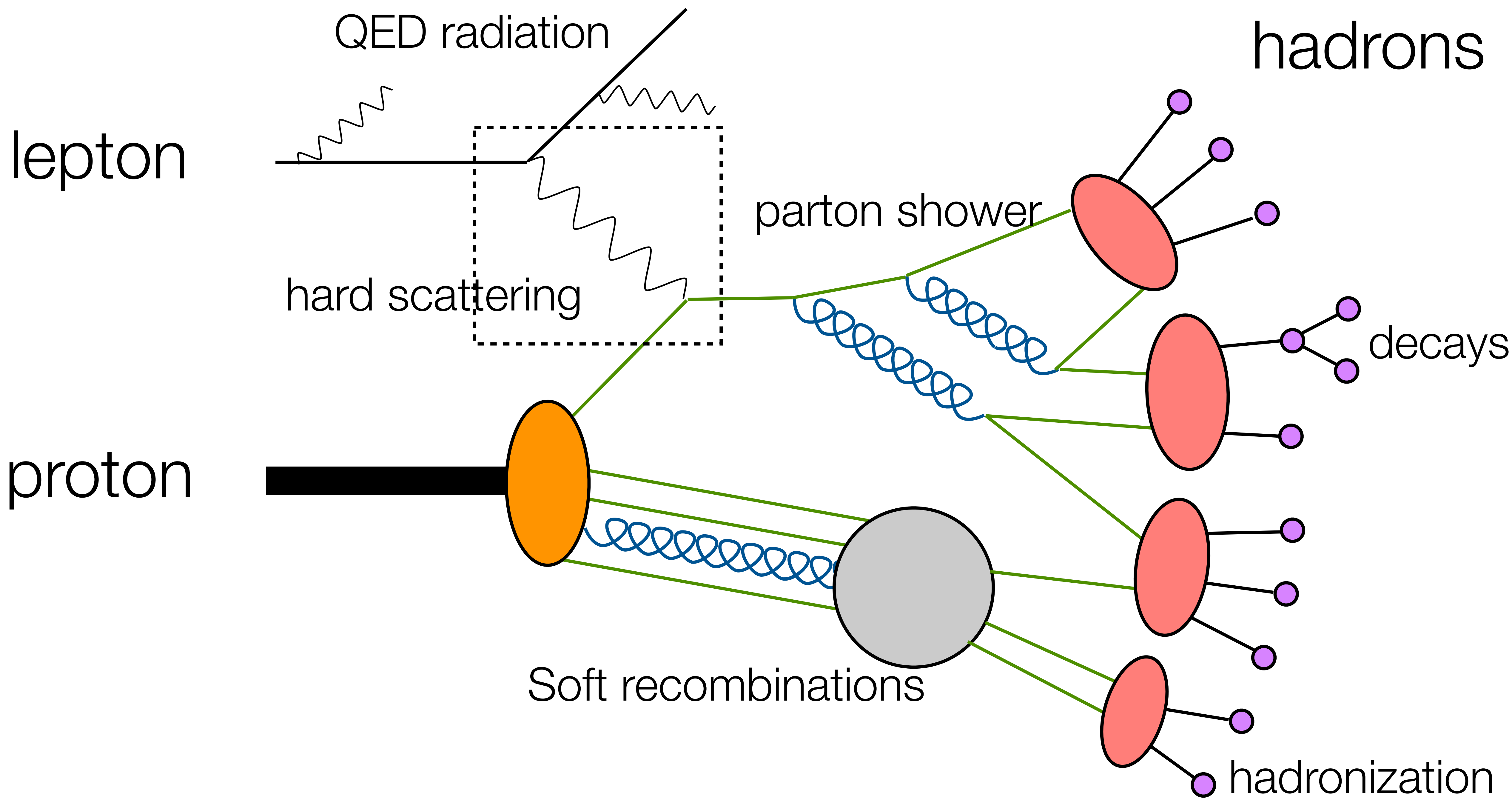
Full event generator



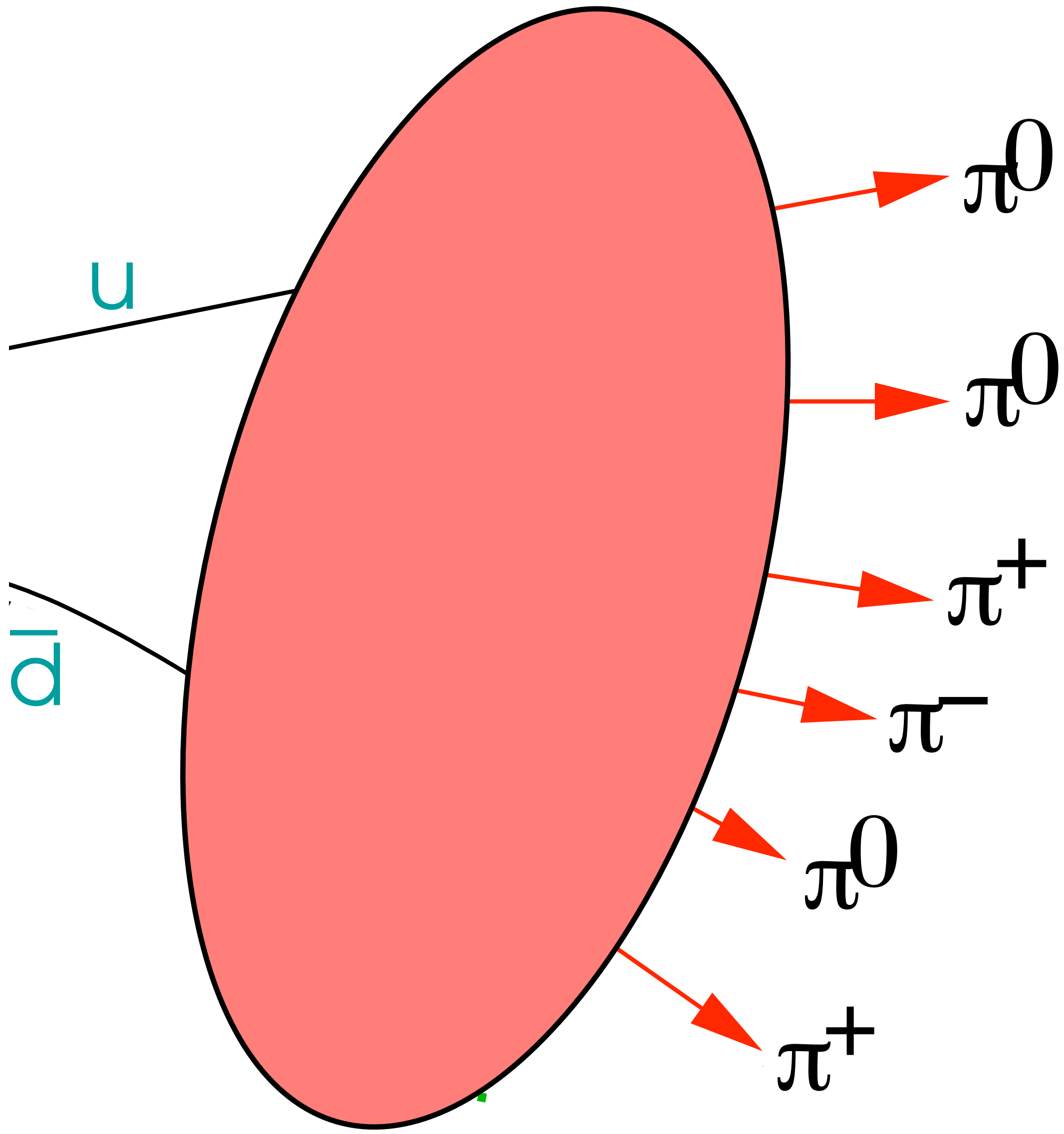
Full event generator



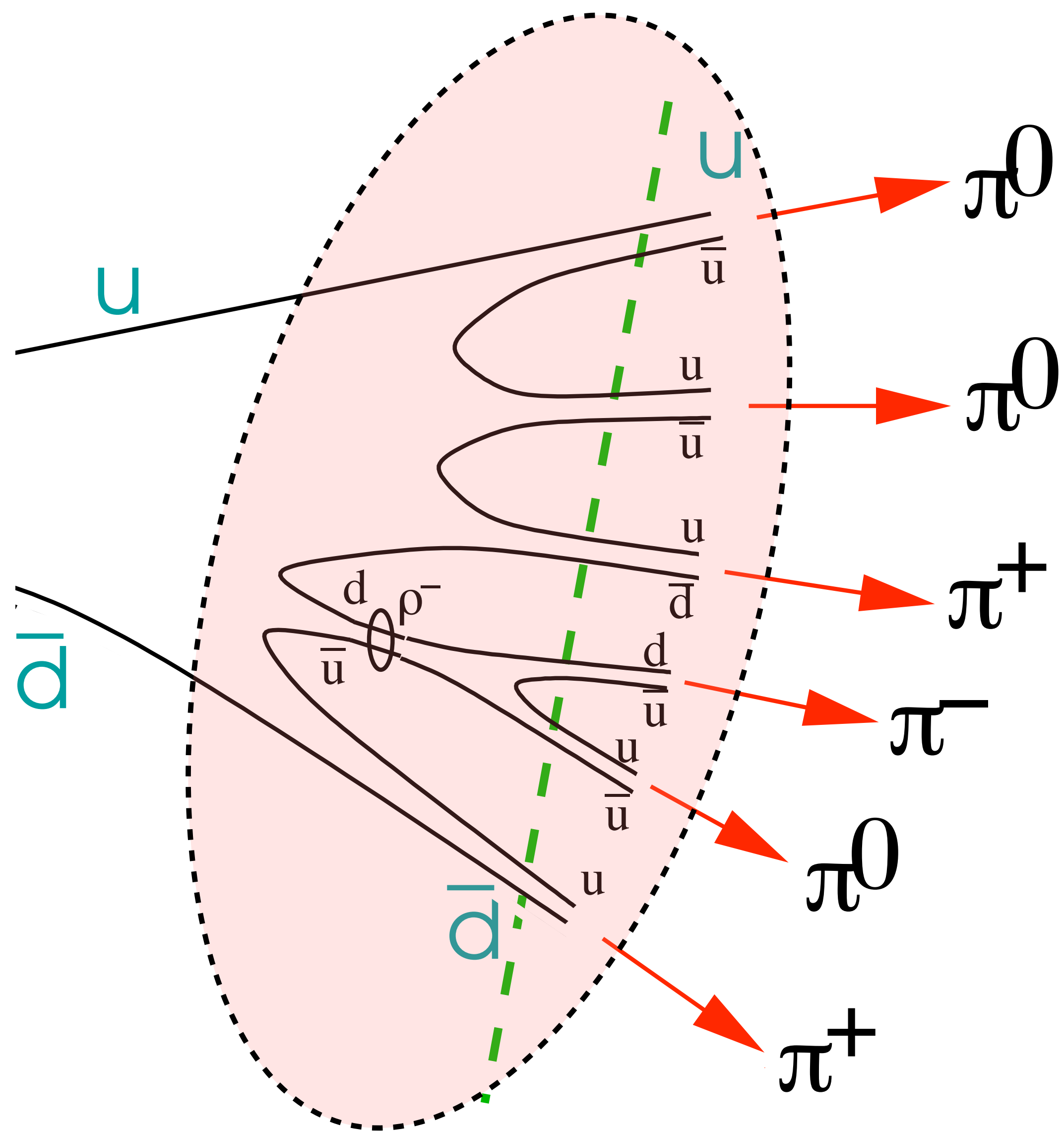
Full event generator



Example of fragmentation model



Example of fragmentation model



What are they used for?

What are they used for?

- Predictions of unmeasured cross sections

What are they used for?

- Predictions of unmeasured cross sections
- Systematic studies

What are they used for?

- Predictions of unmeasured cross sections
- Systematic studies
- Search for new physics

What are they used for?

- Predictions of unmeasured cross sections
- Systematic studies
- Search for new physics
- Access to quantities that are not directly measurable (i.e., W-boson mass)

Strong points of event generators

Strong points of event generators

- Gives a full description of the final state, in all kinematic regions

Strong points of event generators

- Gives a full description of the final state, in all kinematic regions

- Very sophisticated implementations, containing many ingredients

Strong points of event generators

- Gives a full description of the final state, in all kinematic regions

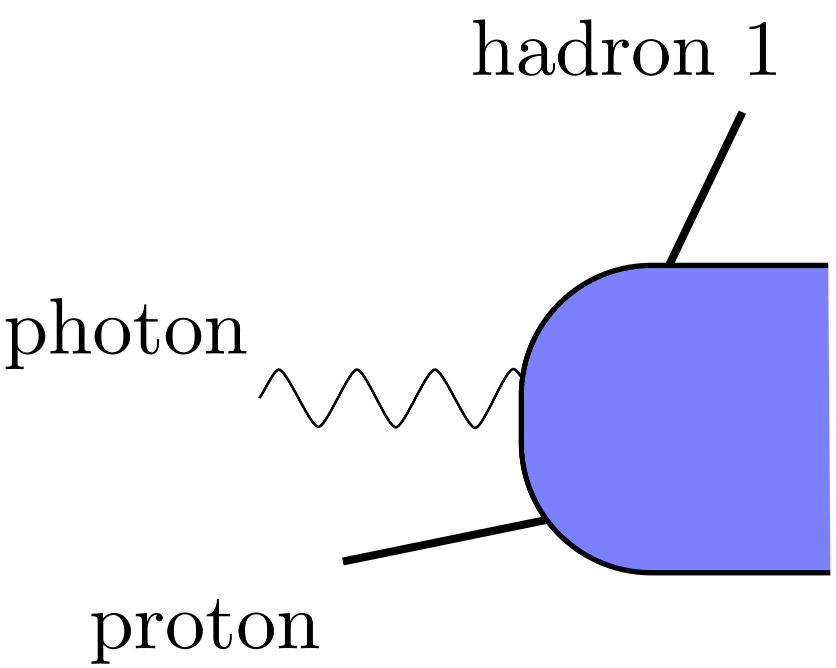
- Very sophisticated implementations, containing many ingredients

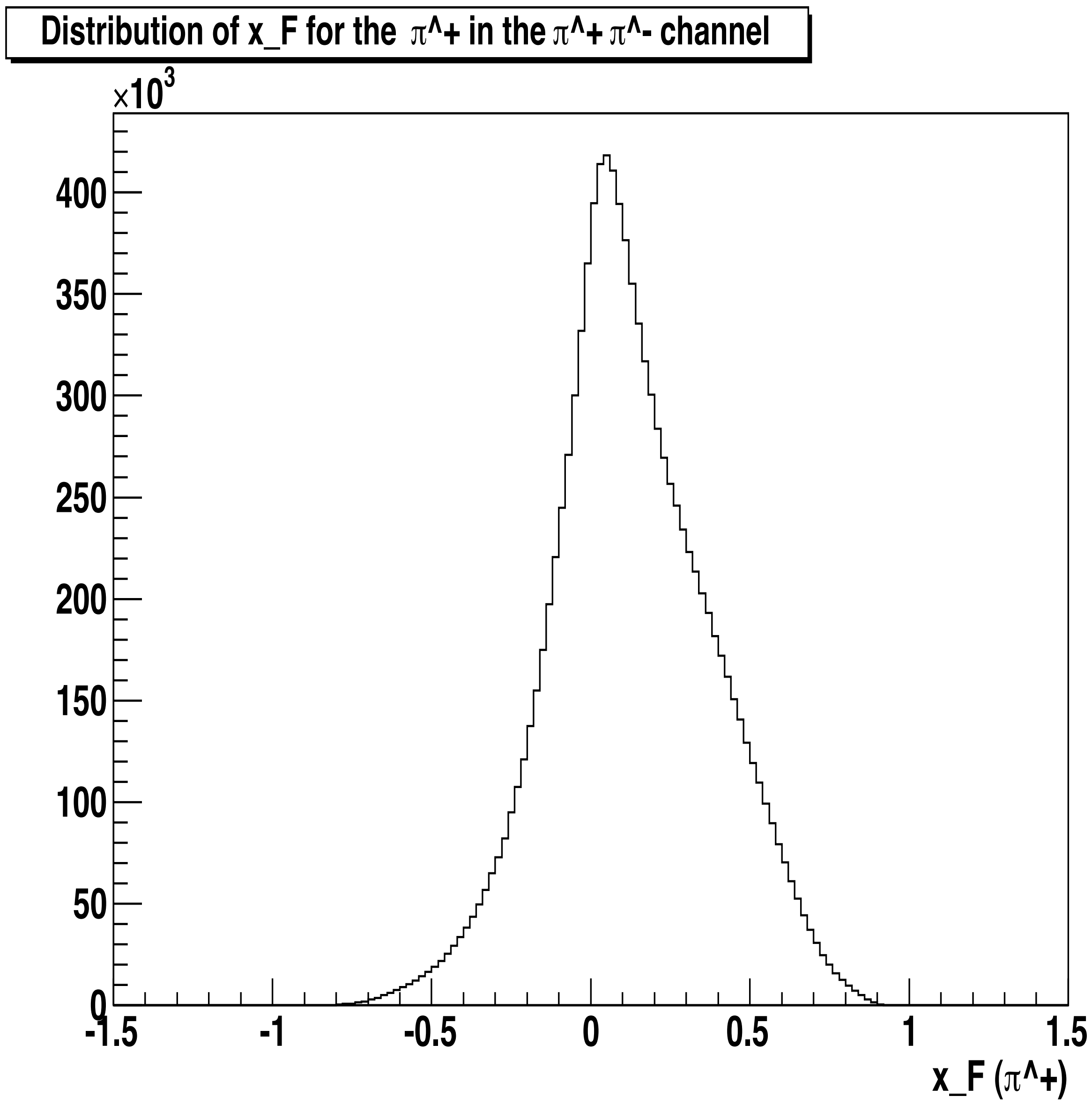
- Parameters well tuned

Strong points of event generators

- Gives a full description of the final state, in all kinematic regions
- Very sophisticated implementations, containing many ingredients
- Parameters well tuned
- Excellent coding, based on years of experience

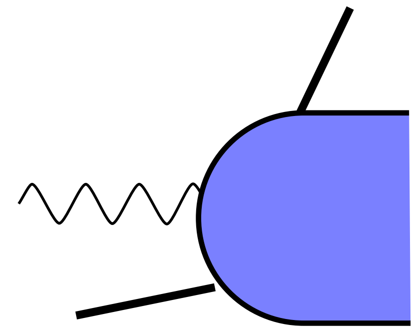
Full description of the final state

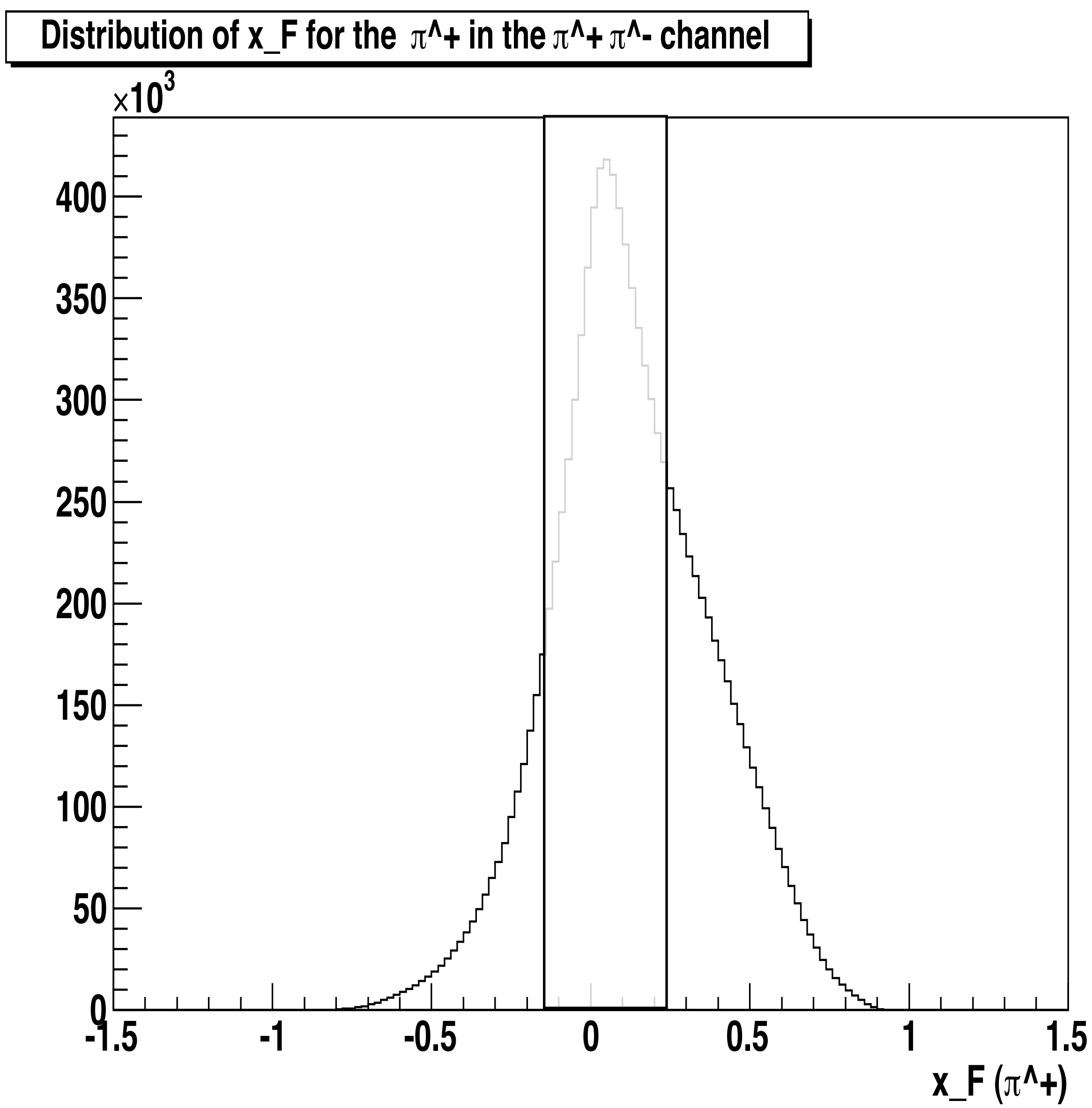




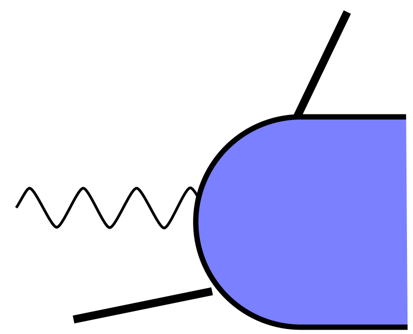
simulation for CLAS12

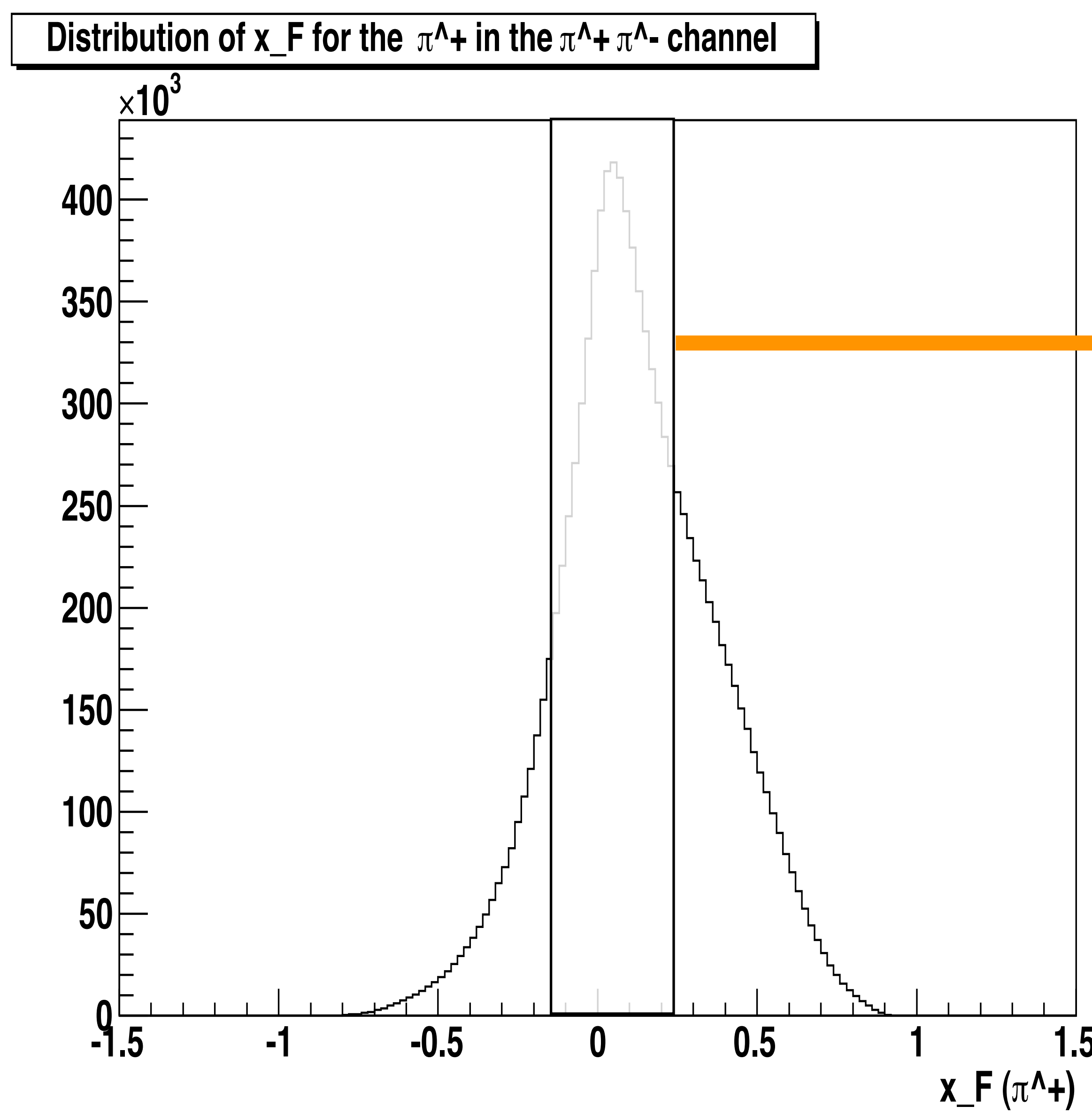
Comparison with SIDIS generators



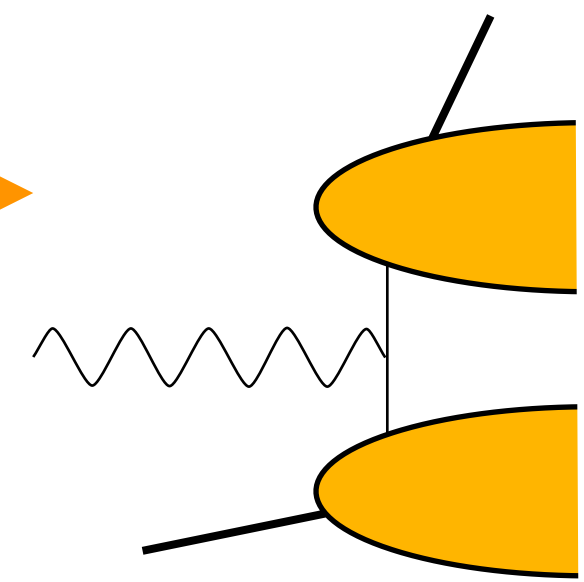


Comparison with SIDIS generators



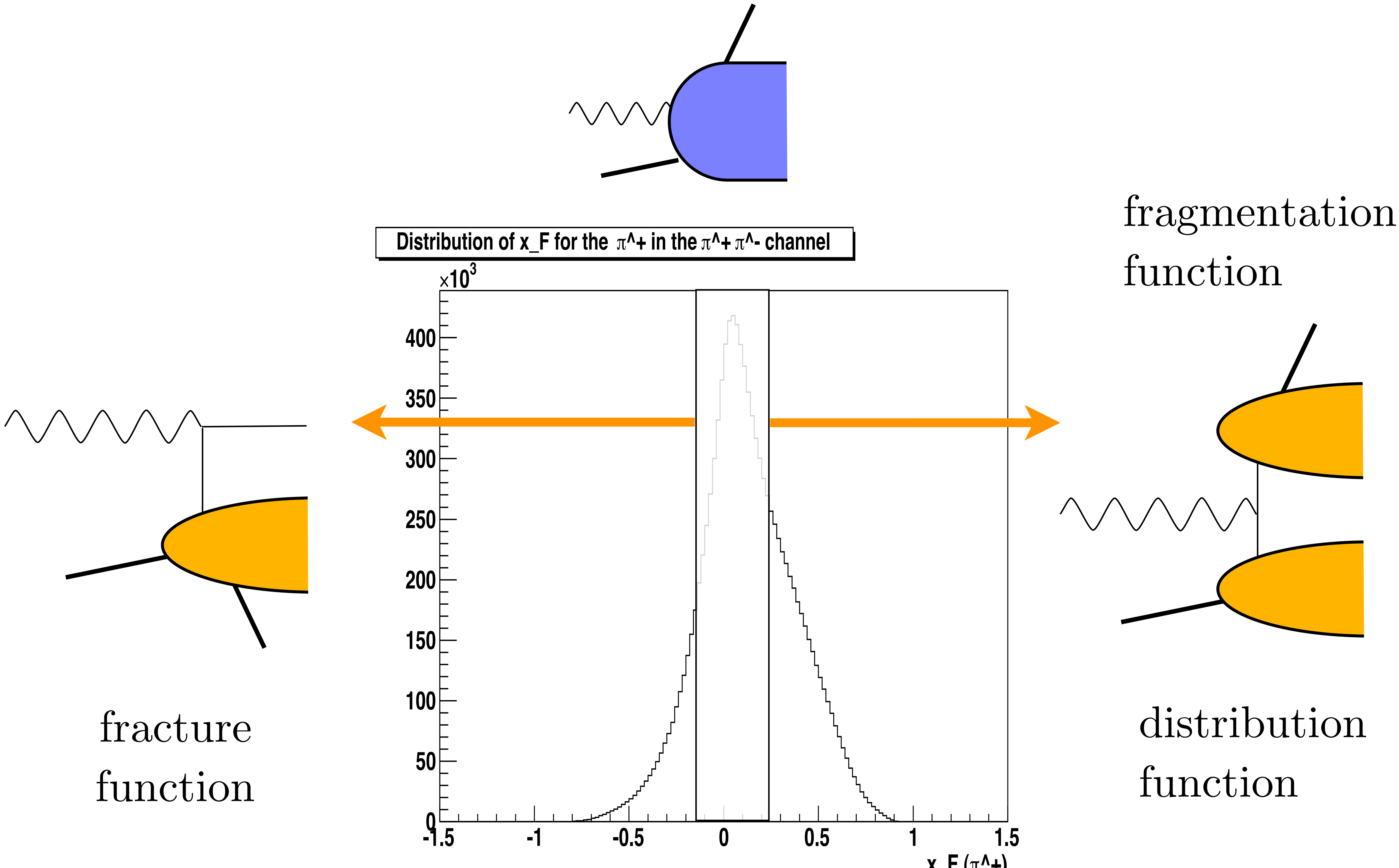


fragmentation function



distribution function

Comparison with SIDIS generators



Example of results

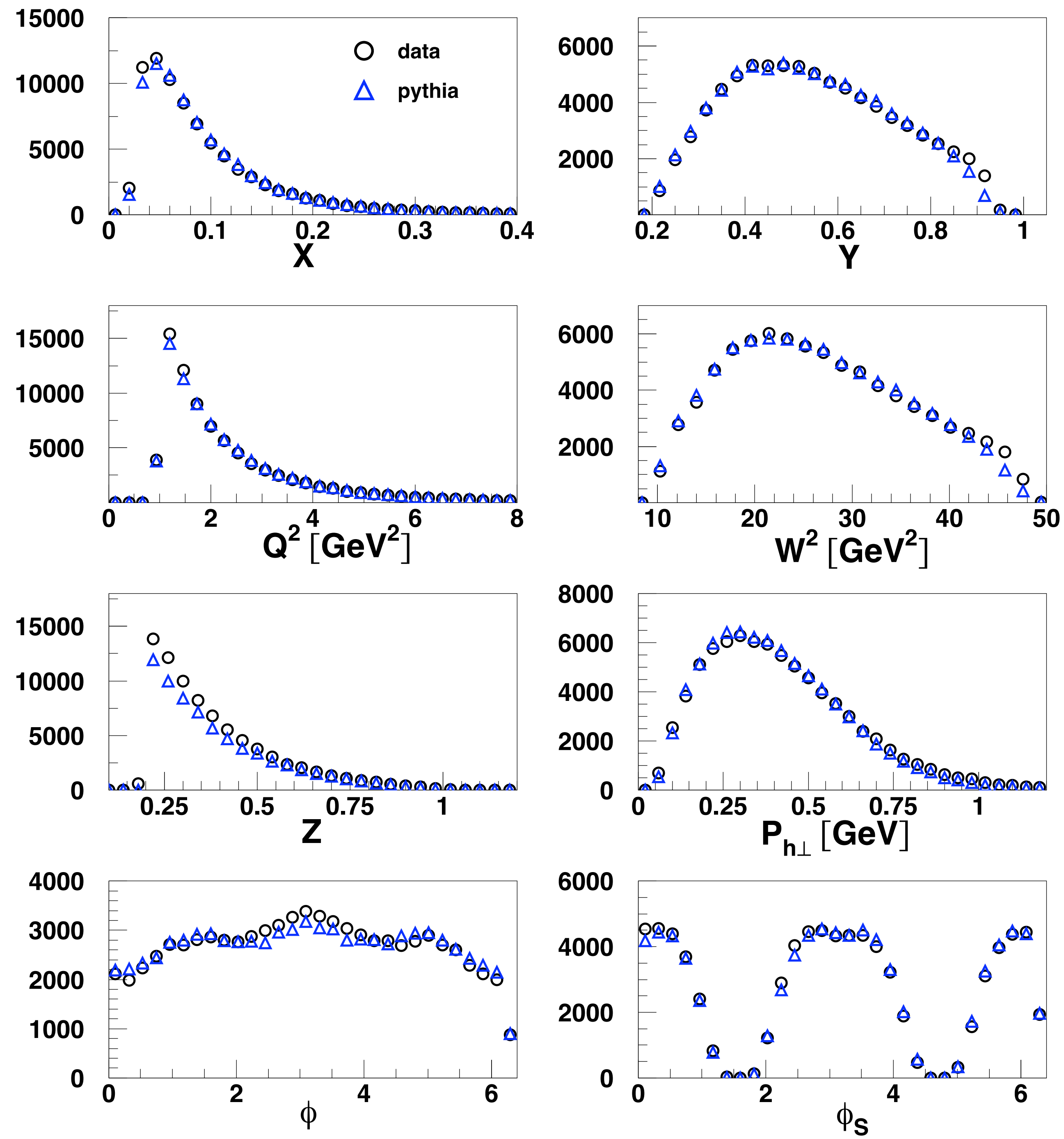


Figure 6.1: Comparison between the distributions of selected DIS and SIDIS kinematic variables obtained from real events and from events generated by PYTHIA.

Thesis of L. Pappalardo

Some limitations of full event generators

Some limitations of full event generators

- Do not include spin

Some limitations of full event generators

- Do not include spin
- Based on semi-classical picture (difficult to include quantum interference)

Some limitations of full event generators

- Do not include spin
- Based on semi-classical picture (difficult to include quantum interference)
- Difficult to modify

Some limitations of full event generators

- Do not include spin
- Based on semi-classical picture (difficult to include quantum interference)
- Difficult to modify
- Semi-inclusive DIS is not their main focus

Some limitations of full event generators

- Do not include spin
- Based on semi-classical picture (difficult to include quantum interference)
- Difficult to modify
- Semi-inclusive DIS is not their main focus
- Computationally intensive

Possible developments

Possible developments

- Inclusion of spin into the microscopic fragmentation mechanism
  Artru, arXiv:1001.1061; Bianconi, arXiv:1109.0688, Kotzinian, hep-ph/0510359

Possible developments

- Inclusion of spin into the microscopic fragmentation mechanism
  Artru, arXiv:1001.1061; Bianconi, arXiv:1109.0688, Kotzinian, hep-ph/0510359

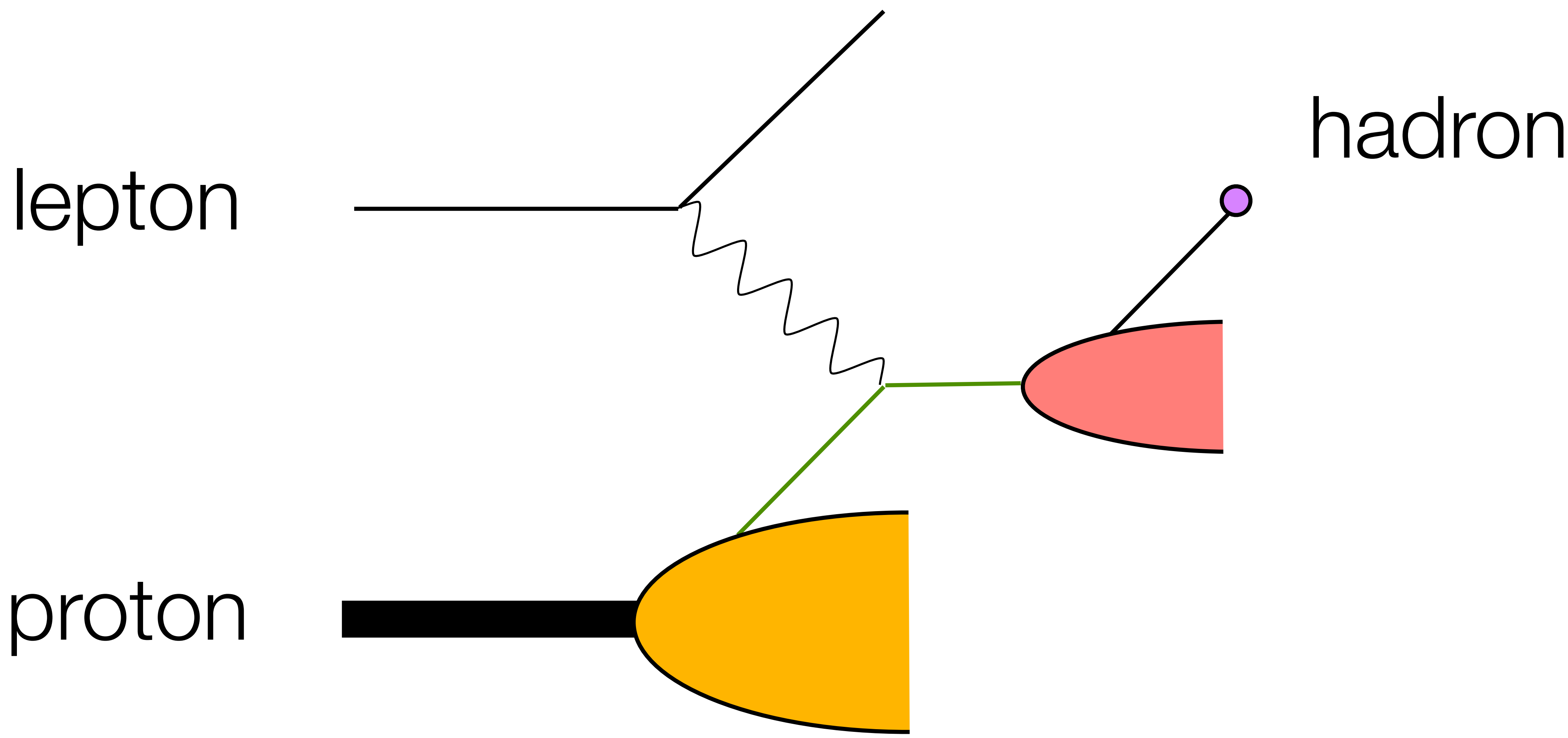
Possible developments

- Inclusion of spin into the microscopic fragmentation mechanism
  Artru, arXiv:1001.1061; Bianconi, arXiv:1109.0688, Kotzinian, hep-ph/0510359

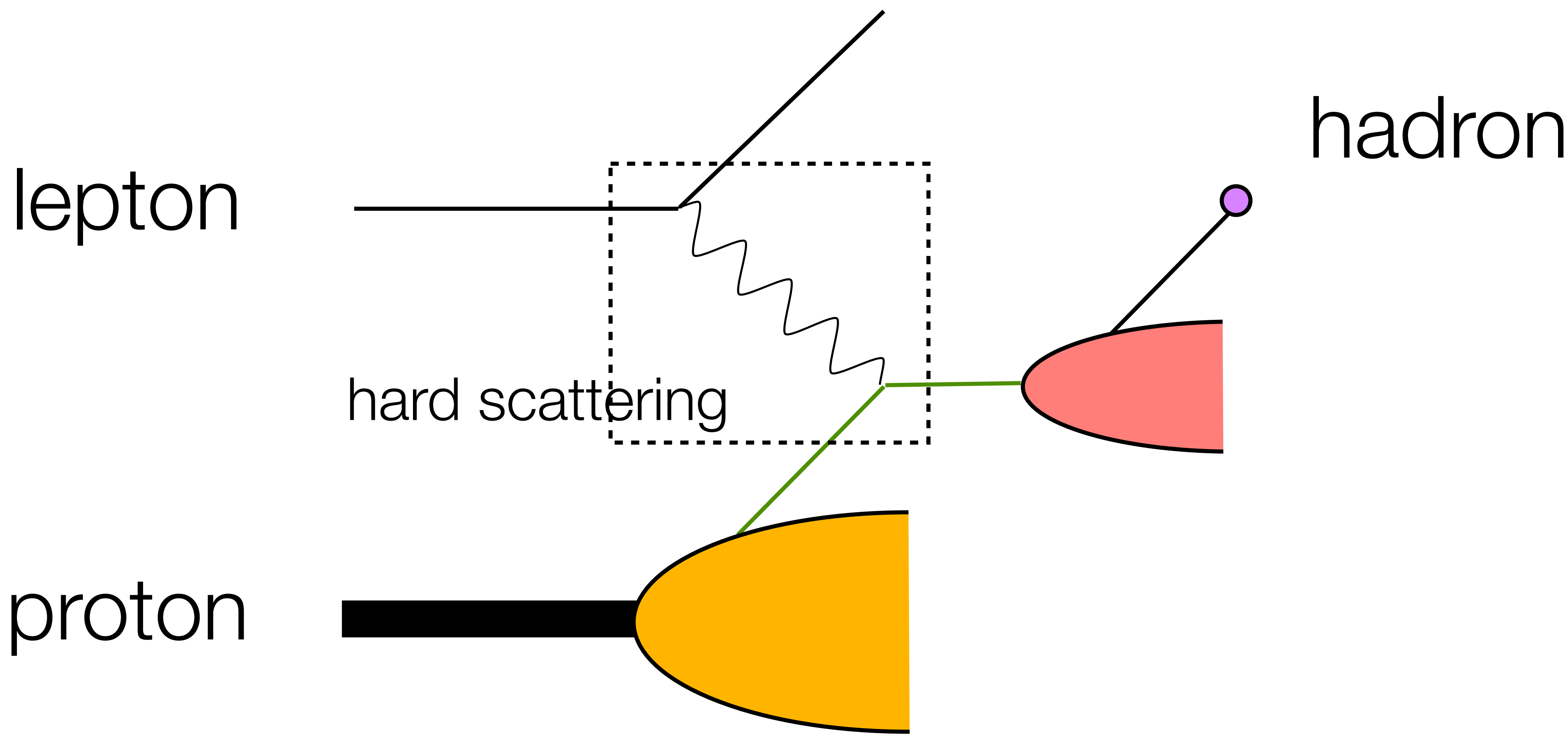
- Artificial modulation of the final cross section based on polarized cross-section (reweighting). Often used by experimental collaborations. No publication?

Something about SIDIS generators

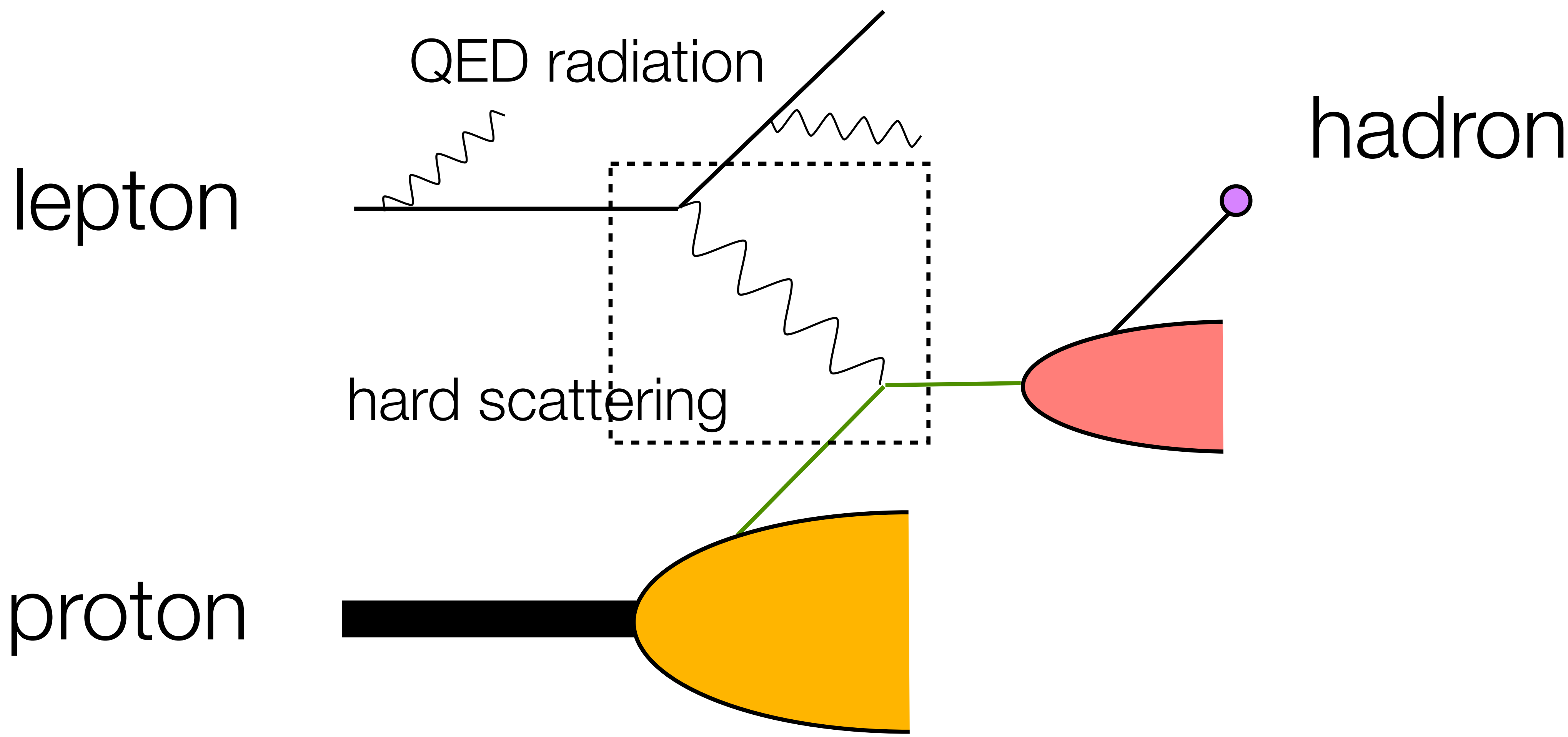
Single-particle DIS generator



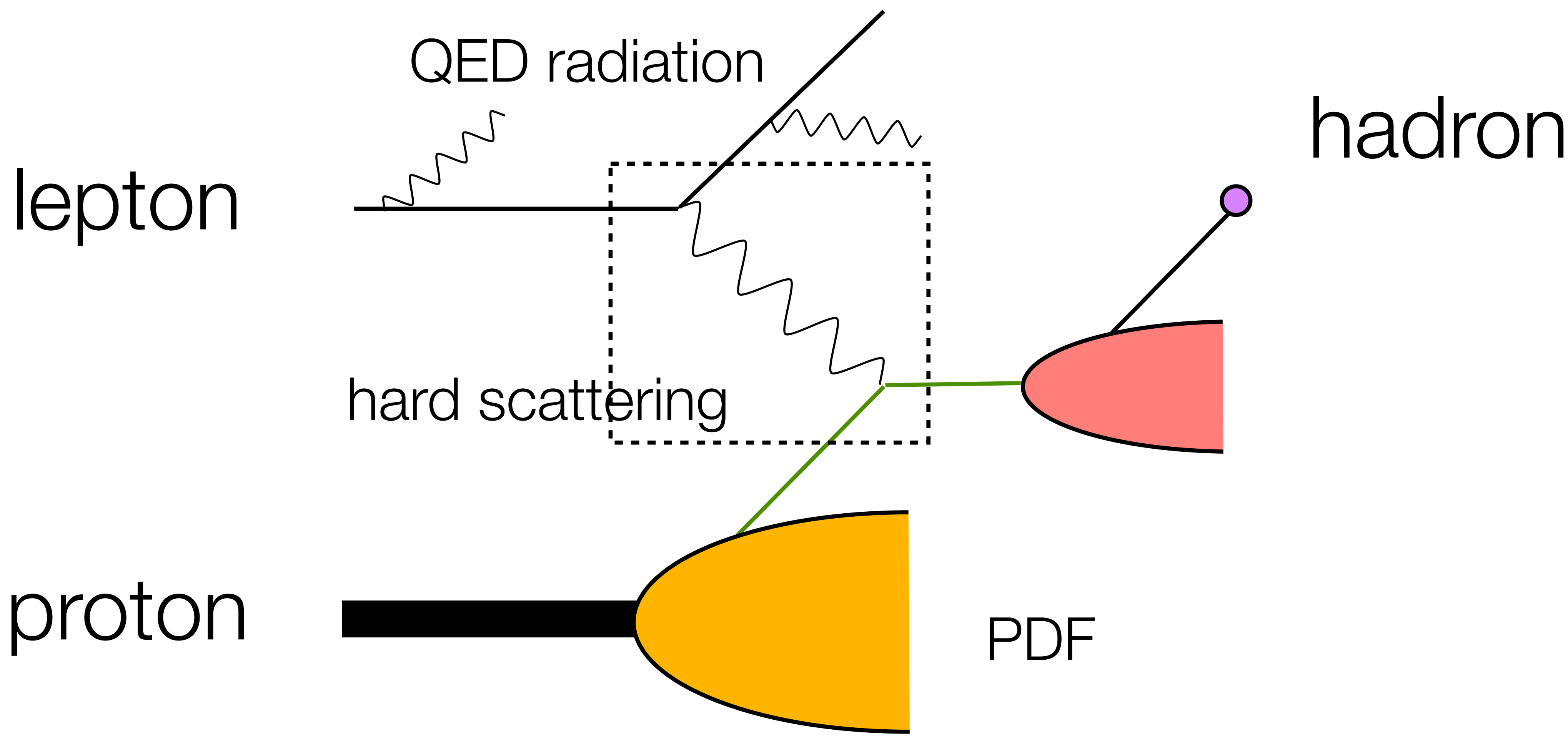
Single-particle DIS generator



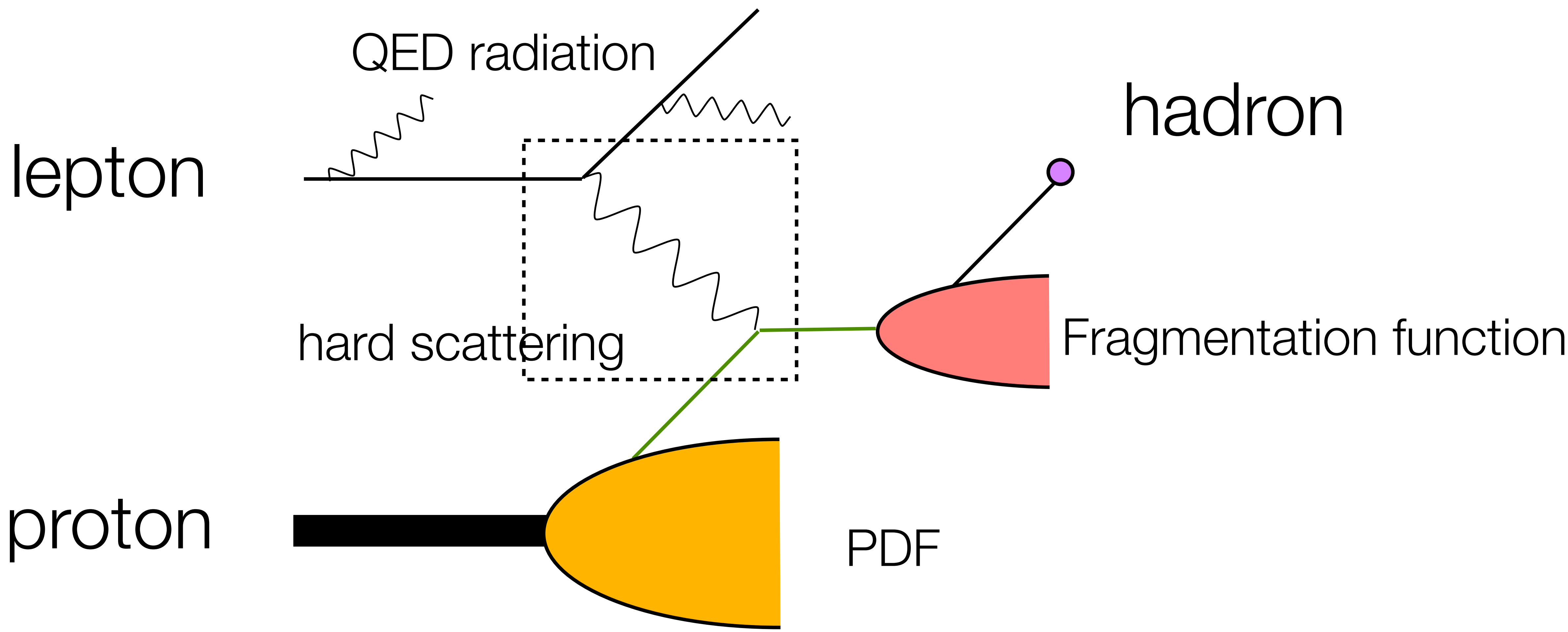
Single-particle DIS generator



Single-particle DIS generator



Single-particle DIS generator



Strong points of SIDIS generators

Strong points of SIDIS generators

- All kinds of signals can be introduced in principle

Strong points of SIDIS generators

- All kinds of signals can be introduced in principle
- Simple and fast

Strong points of SIDIS generators

- All kinds of signals can be introduced in principle
- Simple and fast
- Very close to theoretical formulas and theoretical parametrizations

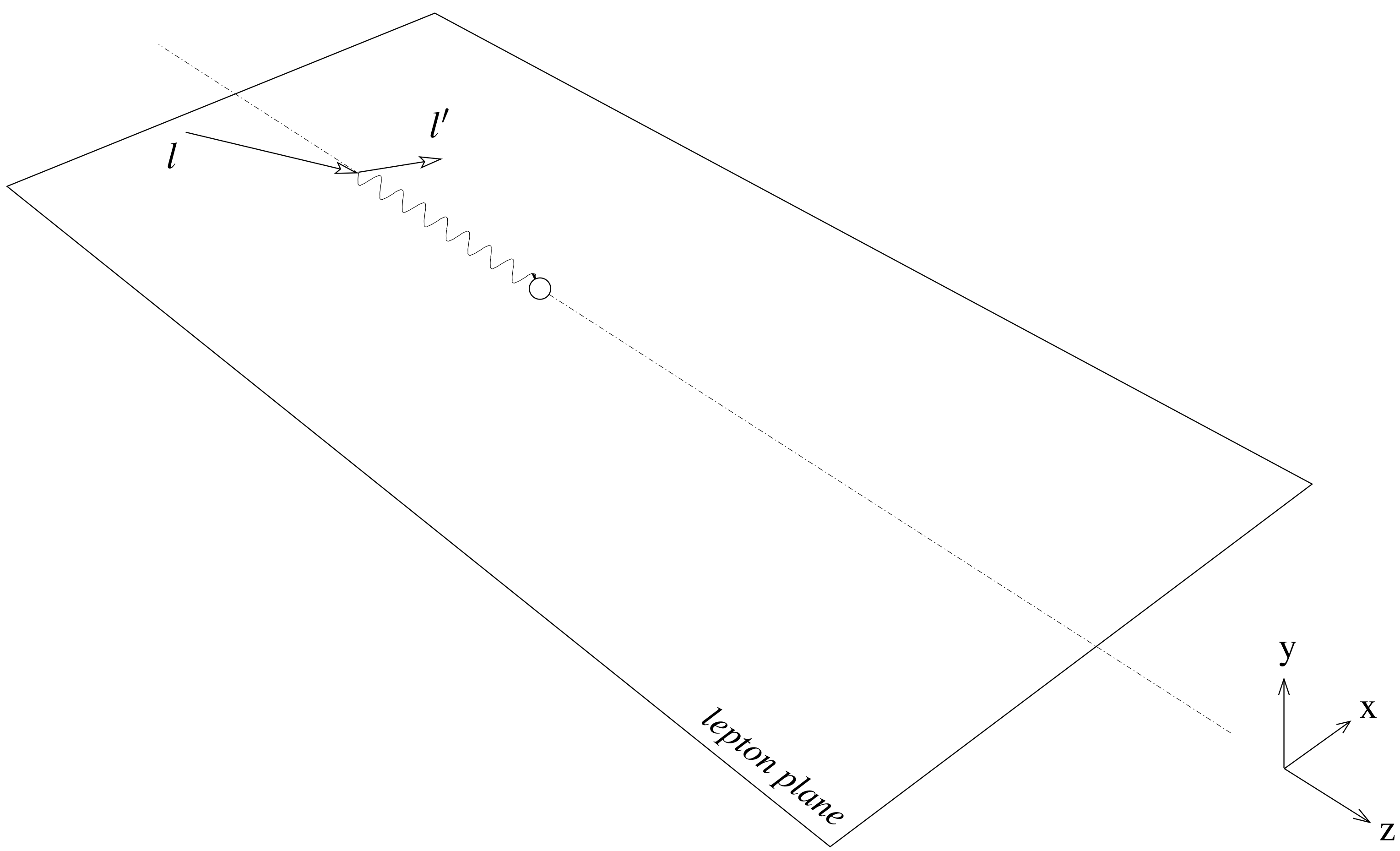
Strong points of SIDIS generators

- All kinds of signals can be introduced in principle
- Simple and fast
- Very close to theoretical formulas and theoretical parametrizations
- Can be in principle extended to higher orders

Inclusive DIS

$$\ell(l) + N(P) \to \ell(l') + X$$

$$x_B = \frac{Q^2}{2\,P\cdot q}, \qquad\qquad y = \frac{P\cdot q}{P\cdot l}$$



Structure functions

$$\frac{d\sigma}{dx_B\,dy\,d\phi_S} = \frac{2\alpha^2}{x_B y Q^2}\left\{\left(1-y+\frac{y^2}{2}\right)F_{UU,T} + (1-y)\,F_{UU,L} + S_L\lambda_e\,y\left(1-\frac{y}{2}\right)\,F_{LL} \right.$$
$$\left. + |\boldsymbol{S}_T|\lambda_e\,y\sqrt{1-y}\,\cos\phi_S\,F_{LT}^{\cos\phi_s}\right\}$$

see, e.g., A.B., Diehl, Goeke, Metz, Mulders, Schlegel, JHEP093 (07)

Structure functions

$$F_{UU,T}(x, Q^2)$$

$$\frac{d\sigma}{dx_B\, dy\, d\phi_S} = \frac{2\alpha^2}{x_B y Q^2} \bigg\{ \Big(1 - y + \frac{y^2}{2}\Big) F_{UU,T} + (1-y)\, F_{UU,L} + S_L \lambda_e\, y \Big(1 - \frac{y}{2}\Big)\, F_{LL}$$

$$+ |\boldsymbol{S}_T| \lambda_e\, y \sqrt{1-y}\, \cos\phi_S\, F_{LT}^{\cos\phi_s} \bigg\}$$

see, e.g., A.B., Diehl, Goeke, Metz, Mulders, Schlegel, JHEP093 (07)

Results for inclusive DIS

Results for inclusive DIS

$$F_{UU,T} = x_B \sum_a e_a^2 \, f_1^a(x_B)$$

$$F_{UU,L} = 0$$

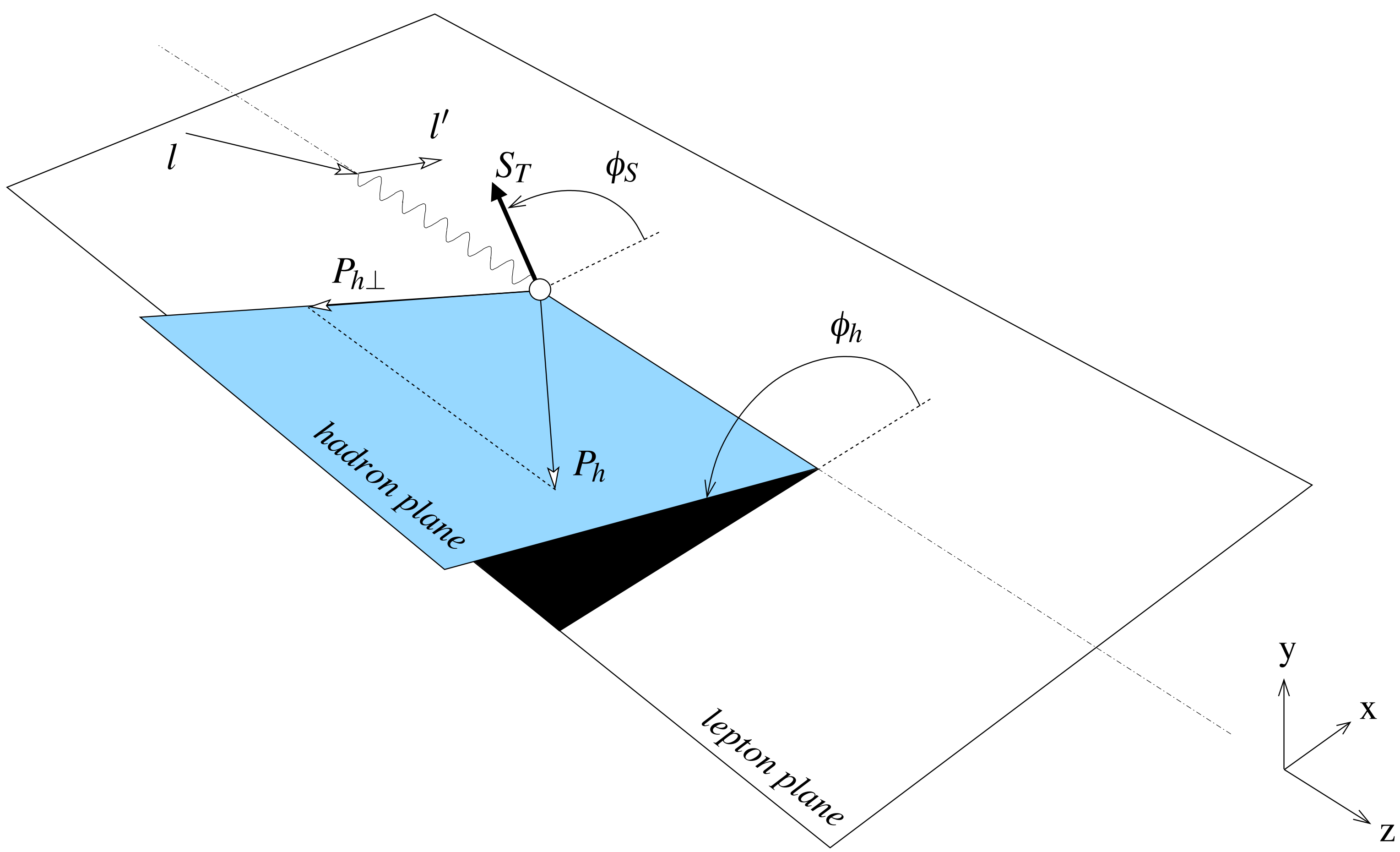
$$F_{LL} = x_B \sum_a e_a^2 \, g_1^a(x_B)$$

$$F_{LT}^{\cos\phi_S} = -\gamma x_B \sum_a e_a^2 \, g_T^a(x_B)$$

Semi-inclusive DIS

$$\ell(l) + N(P) \to \ell(l') + h(P_h) + X,$$

$$x_B = \frac{Q^2}{2\,P\cdot q}, \qquad y = \frac{P\cdot q}{P\cdot l}, \qquad z_h = \frac{P\cdot P_h}{P\cdot q}.$$



A.B., D'Alesio, Diehl, Miller, PRD70 (04)

Structure functions

$$
\begin{aligned}
&\frac{d\sigma}{dx\,dy\,d\phi_S\,dz\,d\phi_h\,dP_{h\perp}^2} \\
&= \frac{\alpha^2}{x\,y\,Q^2}\,\frac{y^2}{2\,(1-\varepsilon)}\Bigg\{ F_{UU,T} + \varepsilon\,F_{UU,L} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h} \\
&\quad + \lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h} + S_L\left[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,F_{UL}^{\sin\phi_h} + \varepsilon\sin(2\phi_h)\,F_{UL}^{\sin 2\phi_h}\right] \\
&\quad + S_L\,\lambda_e\left[\sqrt{1-\varepsilon^2}\,F_{LL} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\right] \\
&\quad + S_T\Bigg[\sin(\phi_h-\phi_S)\left(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon\,F_{UT,L}^{\sin(\phi_h-\phi_S)}\right) + \varepsilon\,\sin(\phi_h+\phi_S)\,F_{UT}^{\sin(\phi_h+\phi_S)} \\
&\qquad + \varepsilon\,\sin(3\phi_h-\phi_S)\,F_{UT}^{\sin(3\phi_h-\phi_S)} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_S\,F_{UT}^{\sin\phi_S} \\
&\qquad + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin(2\phi_h-\phi_S)\,F_{UT}^{\sin(2\phi_h-\phi_S)}\Bigg] + S_T\lambda_e\Bigg[\sqrt{1-\varepsilon^2}\,\cos(\phi_h-\phi_S)\,F_{LT}^{\cos(\phi_h-\phi_S)} \\
&\qquad + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_S\,F_{LT}^{\cos\phi_S} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos(2\phi_h-\phi_S)\,F_{LT}^{\cos(2\phi_h-\phi_S)}\Bigg]\Bigg\}
\end{aligned}
$$

see e.g. AB, Diehl, Goeke, Metz, Mulders, Schlegel, JHEP093 (07)

Structure functions

$$F_{UU,T}(x, z, P_{h\perp}^2, Q^2)$$

$$\frac{d\sigma}{dx\,dy\,d\phi_S\,dz\,d\phi_h\,dP_{h\perp}^2}$$

$$= \frac{\alpha^2}{x\,y\,Q^2}\,\frac{y^2}{2\,(1-\varepsilon)}\Bigg\{F_{UU,T} + \varepsilon\,F_{UU,L} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h}$$

$$+ \lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h} + S_L\Bigg[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,F_{UL}^{\sin\phi_h} + \varepsilon\sin(2\phi_h)\,F_{UL}^{\sin 2\phi_h}\Bigg]$$

$$+ S_L\,\lambda_e\Bigg[\sqrt{1-\varepsilon^2}\,F_{LL} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\Bigg]$$

$$+ S_T\Bigg[\sin(\phi_h-\phi_S)\left(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon\,F_{UT,L}^{\sin(\phi_h-\phi_S)}\right) + \varepsilon\,\sin(\phi_h+\phi_S)\,F_{UT}^{\sin(\phi_h+\phi_S)}$$

$$+ \varepsilon\,\sin(3\phi_h-\phi_S)\,F_{UT}^{\sin(3\phi_h-\phi_S)} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_S\,F_{UT}^{\sin\phi_S}$$

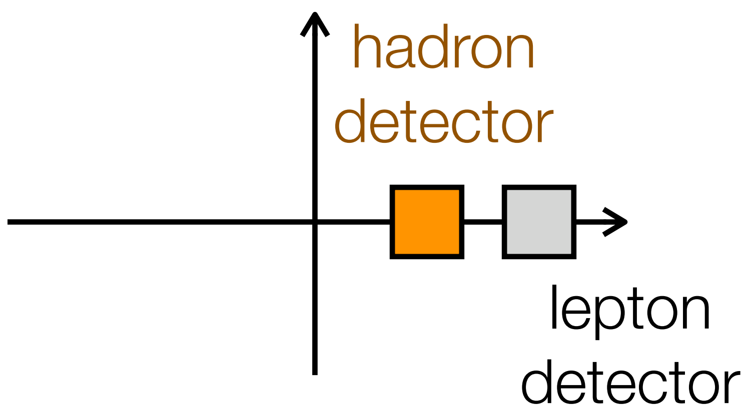
$$+ \sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin(2\phi_h-\phi_S)\,F_{UT}^{\sin(2\phi_h-\phi_S)}\Bigg] + S_T\lambda_e\Bigg[\sqrt{1-\varepsilon^2}\,\cos(\phi_h-\phi_S)\,F_{LT}^{\cos(\phi_h-\phi_S)}$$

$$+ \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_S\,F_{LT}^{\cos\phi_S} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos(2\phi_h-\phi_S)\,F_{LT}^{\cos(2\phi_h-\phi_S)}\Bigg]\Bigg\}$$

see e.g. AB, Diehl, Goeke, Metz, Mulders, Schlegel, JHEP093 (07)

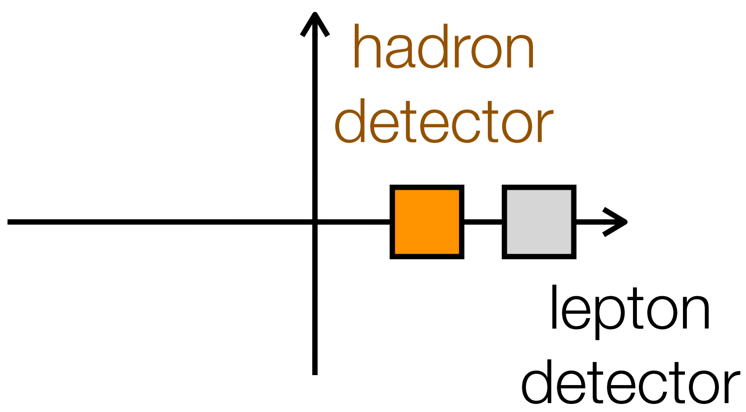
Beware: azimuthal coverage

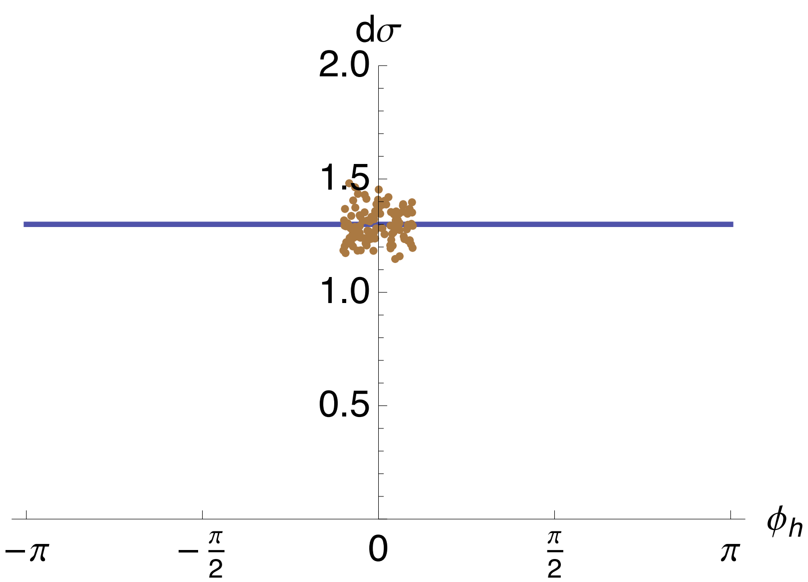
$$d\sigma = A$$



Beware: azimuthal coverage

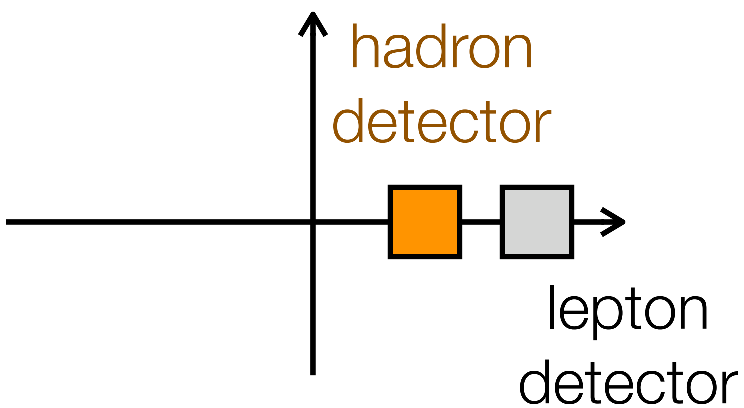
$$d\sigma = A$$

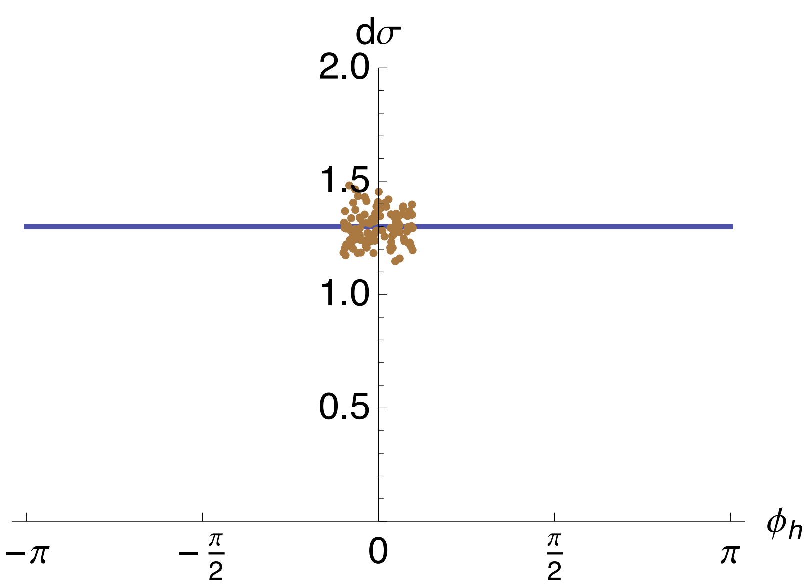




Beware: azimuthal coverage

$$d\sigma = A$$

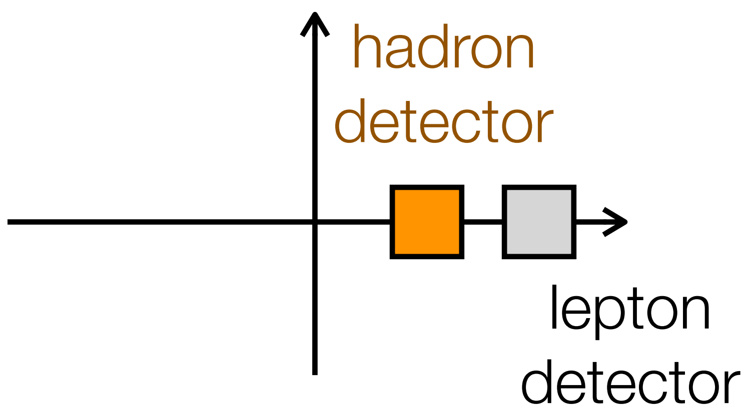


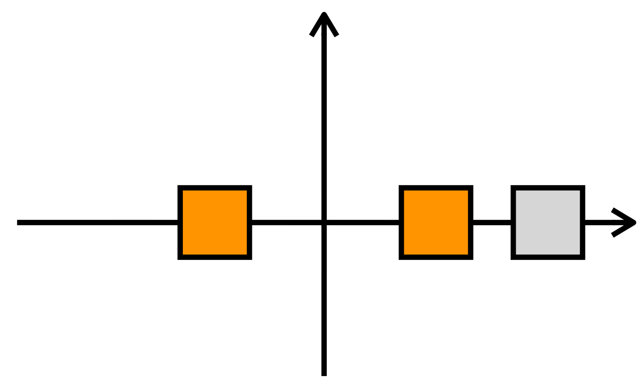


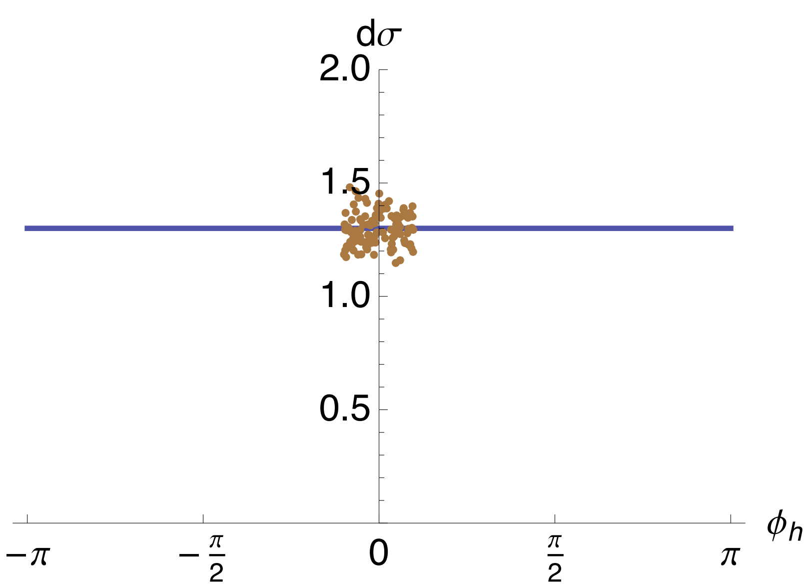
$$A = 1.3$$

Beware: azimuthal coverage

$$d\sigma = A$$



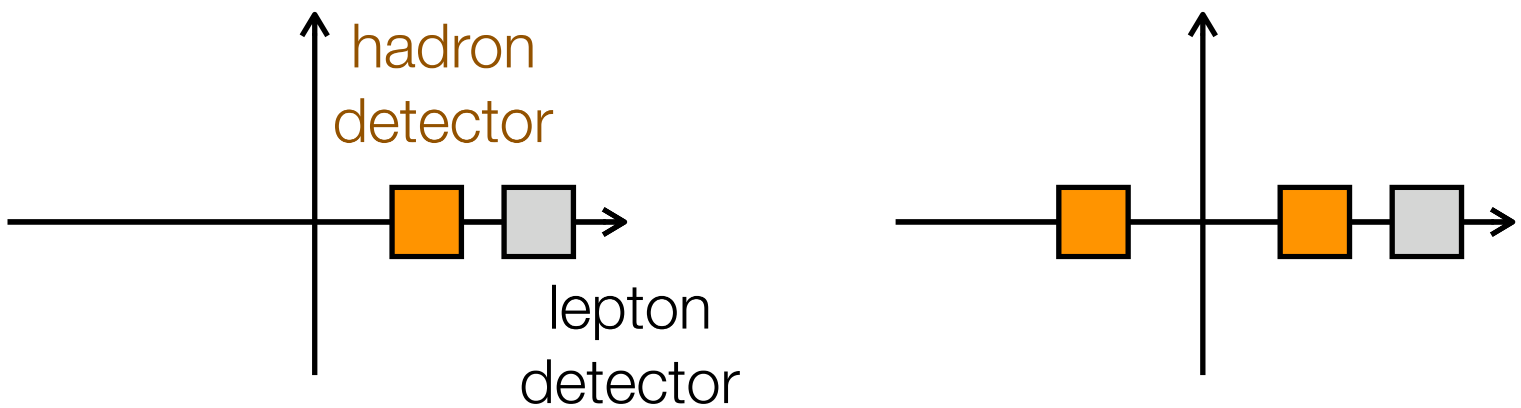


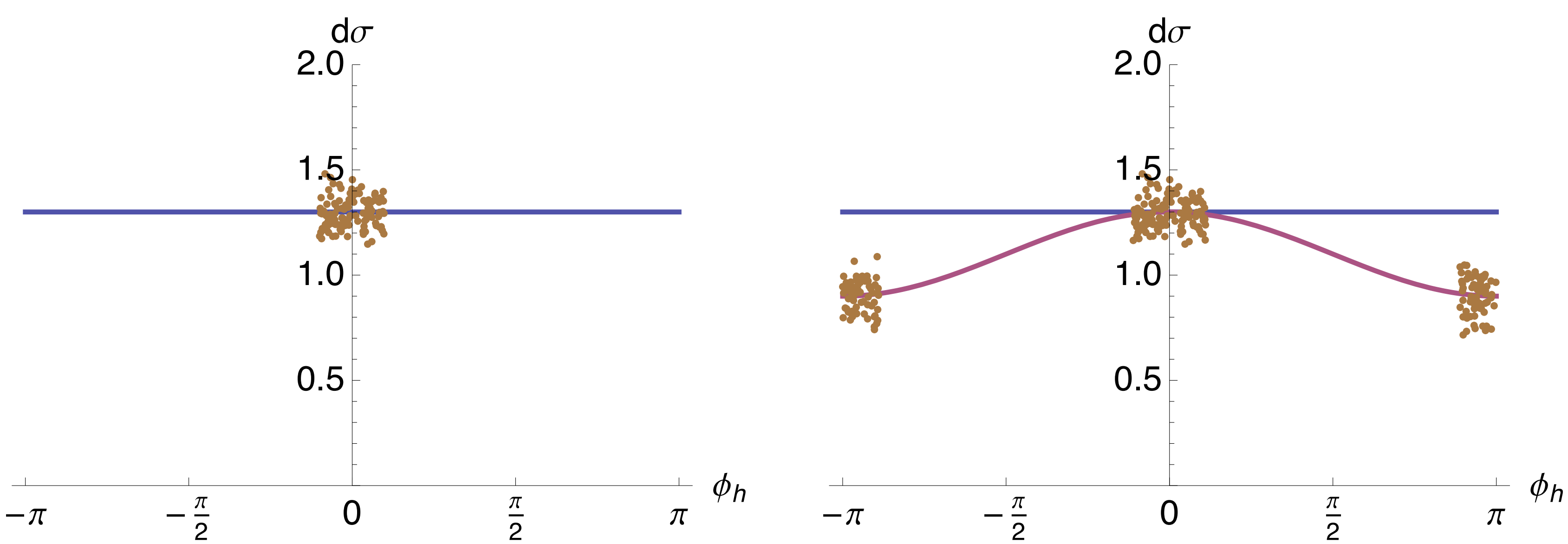


$$A = 1.3$$

Beware: azimuthal coverage

$$d\sigma = A$$

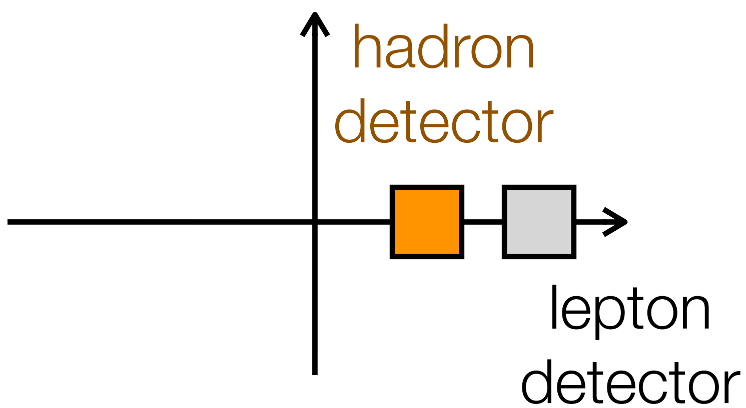


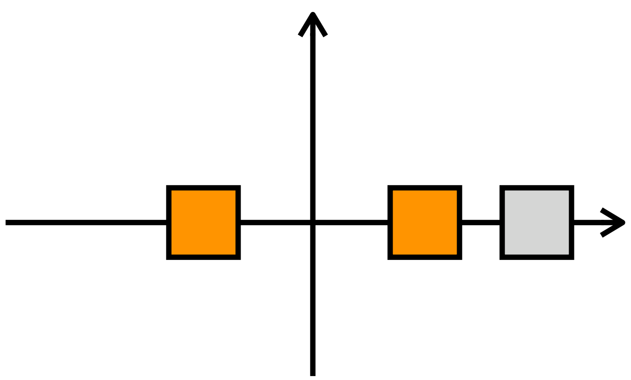


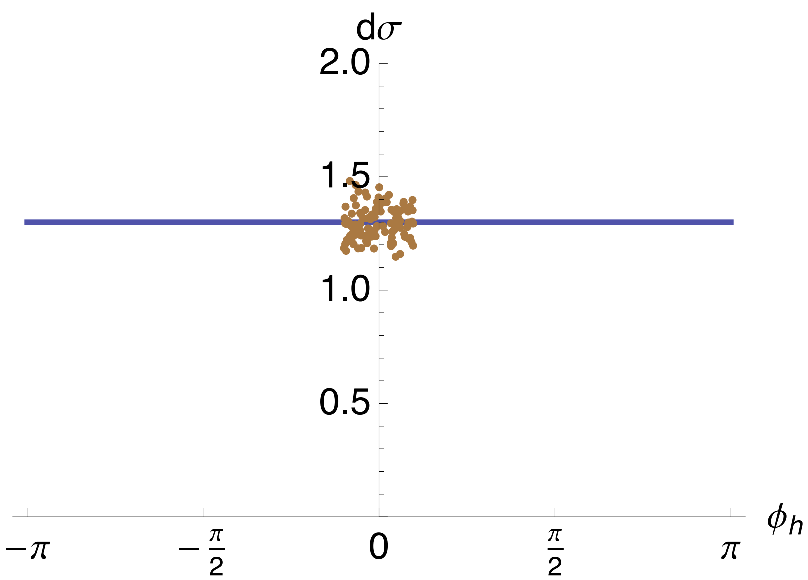
$$A = 1.3$$

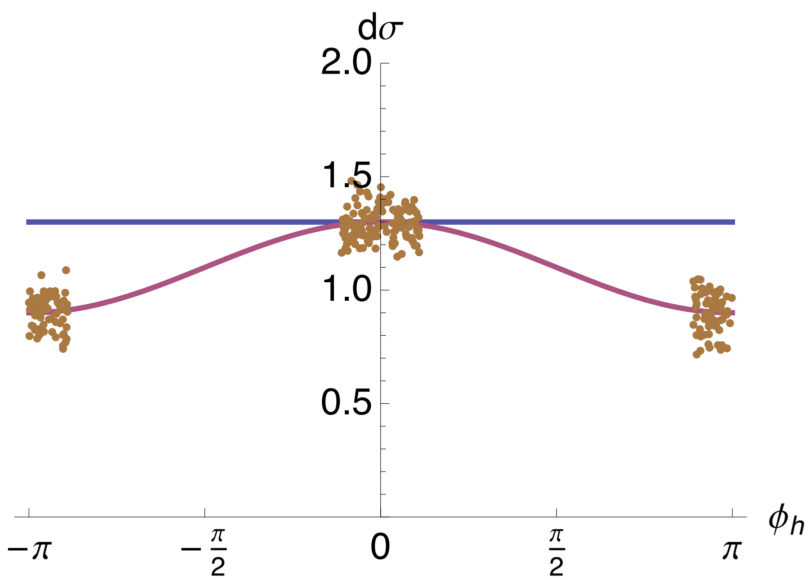
Beware: azimuthal coverage

$$d\sigma = A + B\cos\phi$$





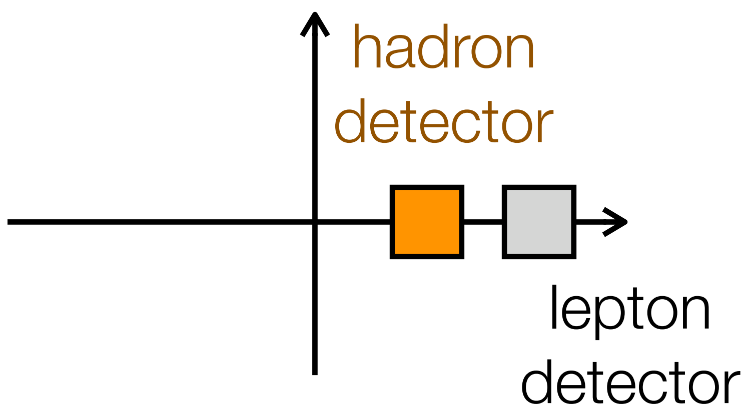


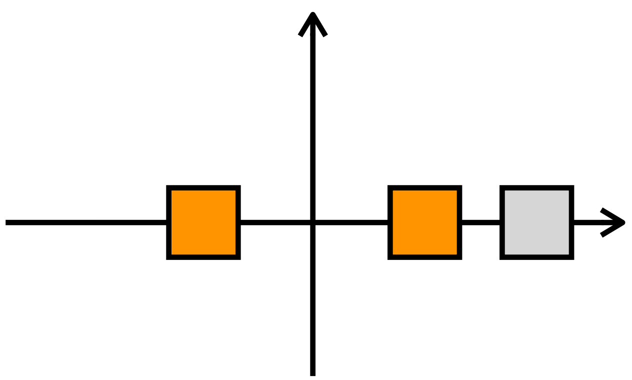


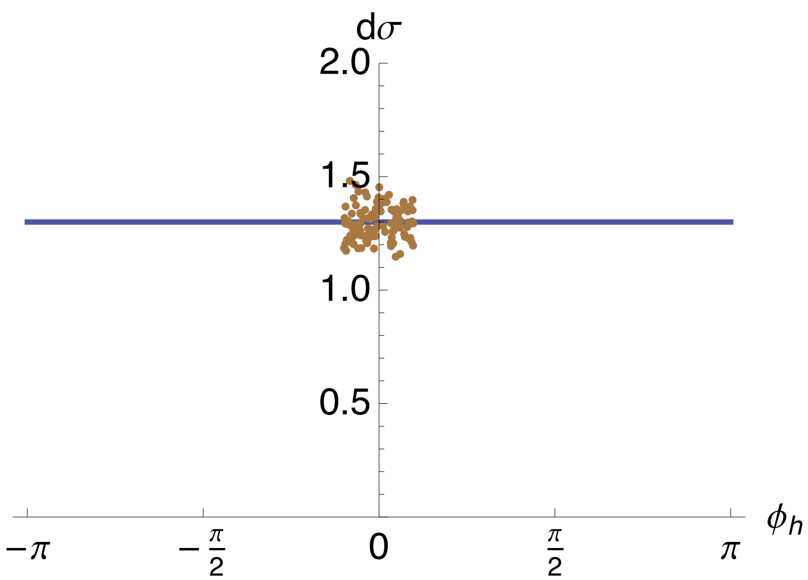
$A = 1.3$

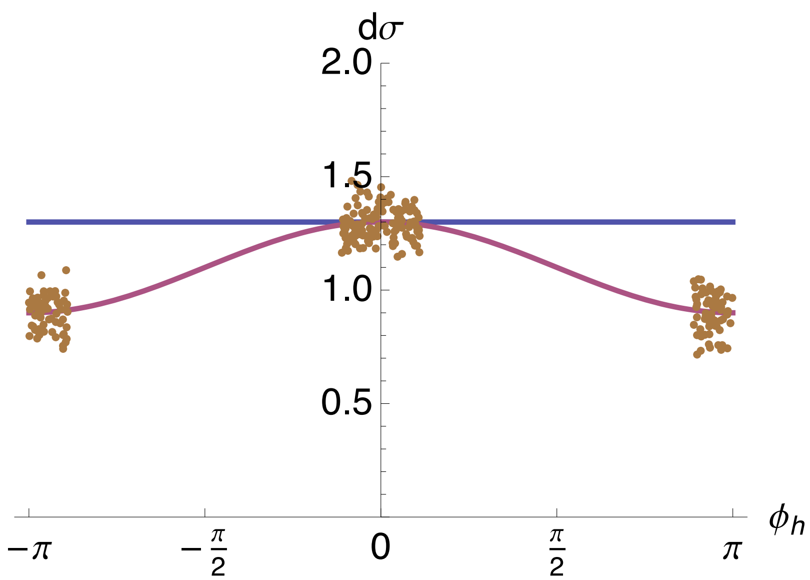
Beware: azimuthal coverage

$$d\sigma = A + B\cos\phi$$







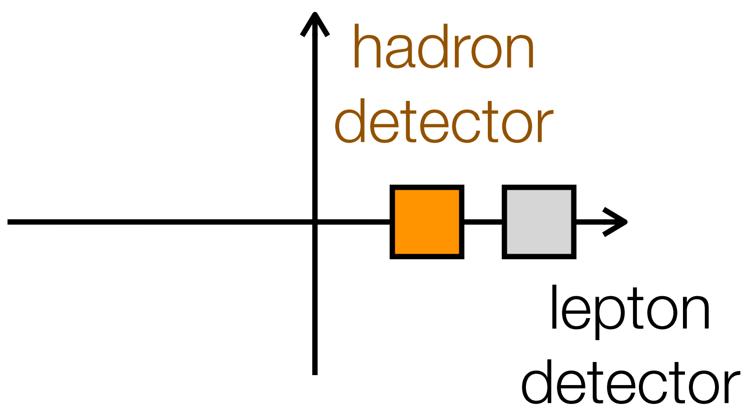


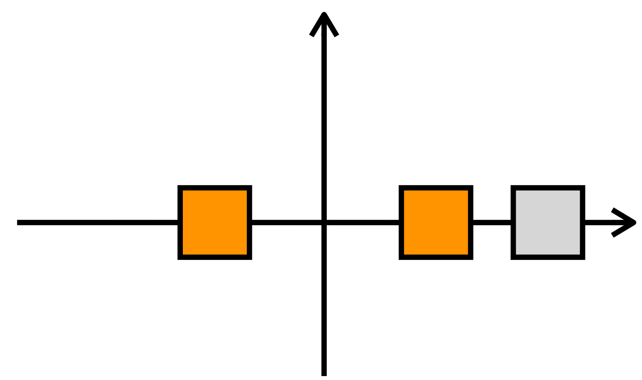
$A = 1.3$

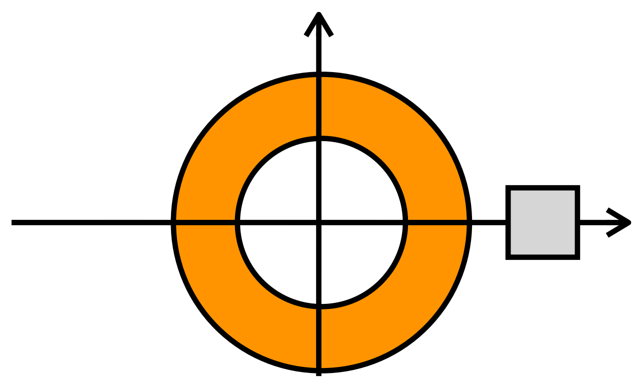
$A = 1.1, \quad B = 0.2$

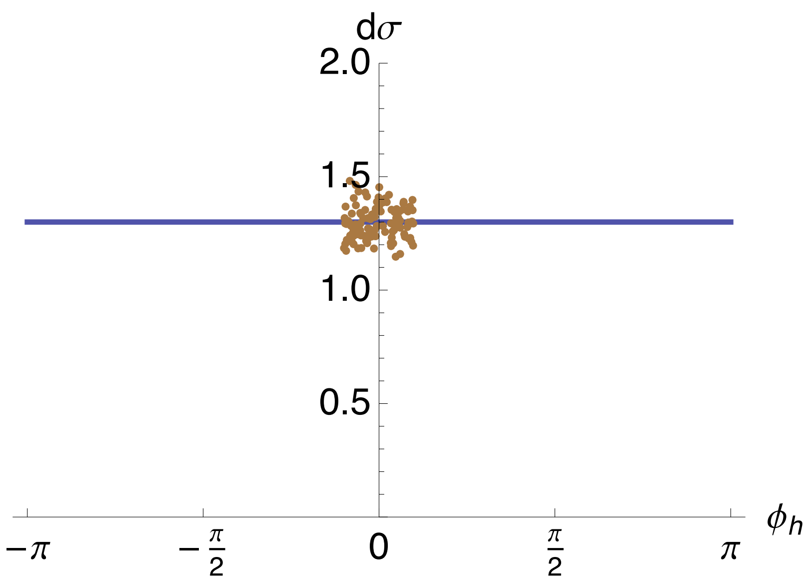
Beware: azimuthal coverage

$$d\sigma = A + B\cos\phi$$

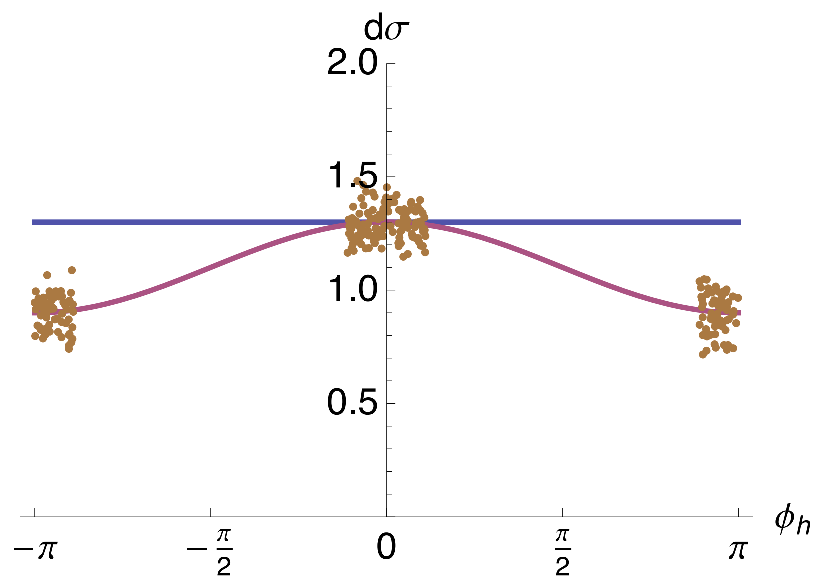








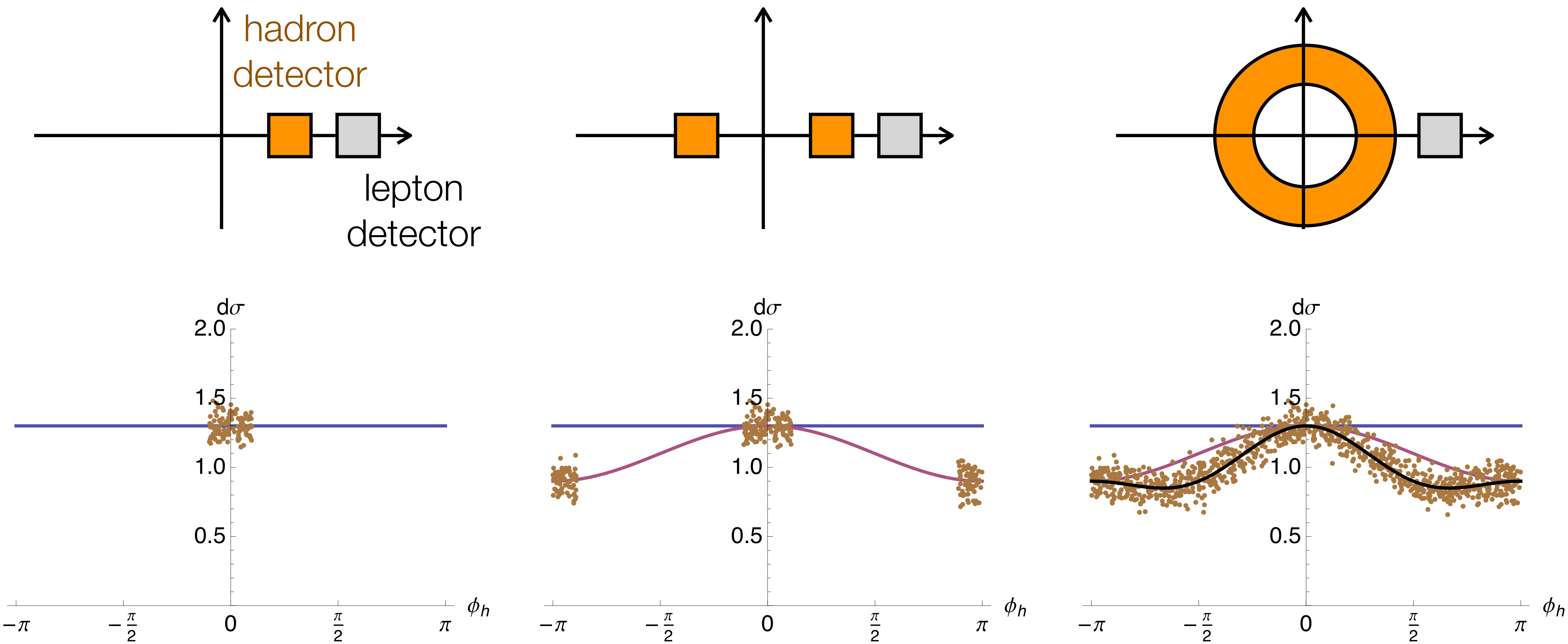
$A = 1.3$



$A = 1.1, \quad B = 0.2$

Beware: azimuthal coverage

$$d\sigma = A + B\cos\phi$$

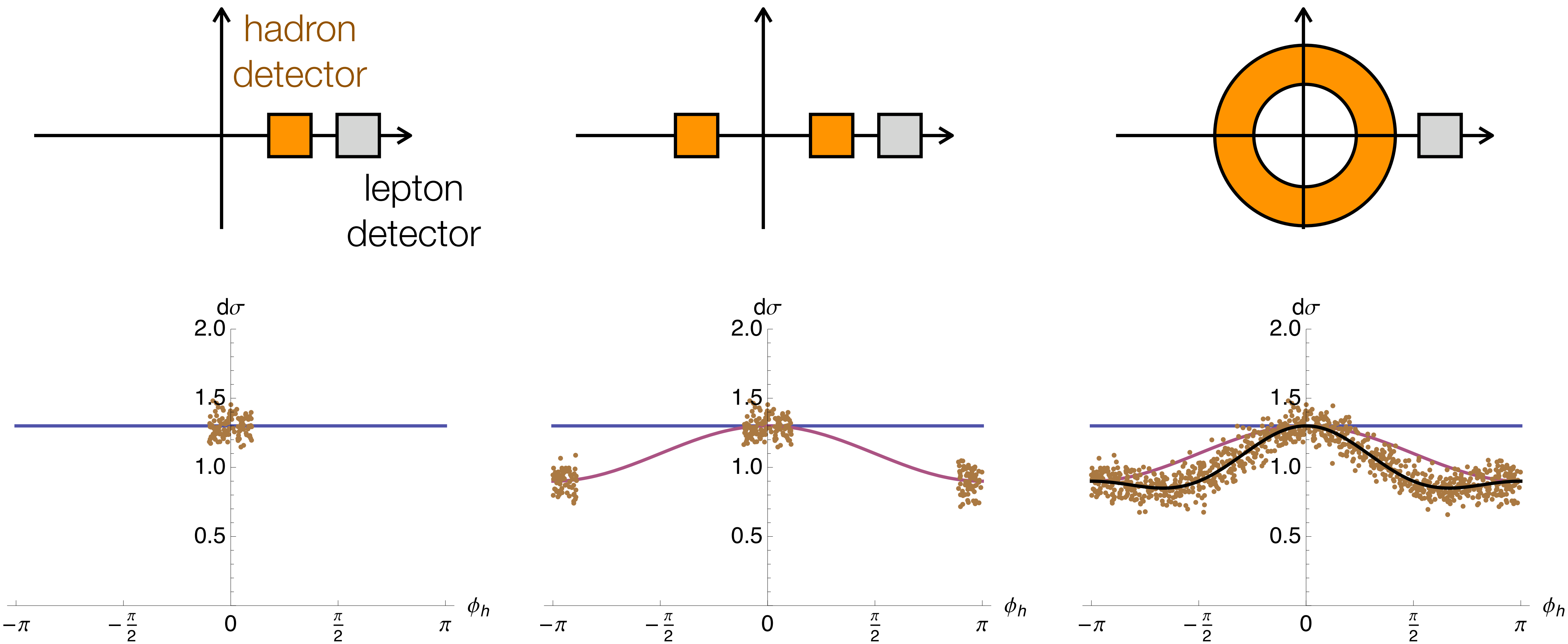


$A = 1.3$

$A = 1.1, \quad B = 0.2$

Beware: azimuthal coverage

$$d\sigma = A + B\cos\phi_h + C\cos 2\phi_h$$



$A = 1.3$ $\quad$ $A = 1.1, \quad B = 0.2$ $\quad$ $A = 1, \quad B = 0.2, \quad C = 0.1$

Unpolarized sector

$$F_{UU,T} = \mathcal{C}\big[f_1 D_1\big],$$

$$F_{UU,L} = \mathcal{O}\left(\frac{M^2}{Q^2}, \frac{q_T^2}{Q^2}\right),$$

$$F_{UU}^{\cos\phi_h} = \frac{2M}{Q}\,\mathcal{C}\left[-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M_h}\left(xh\,H_1^{\perp} + \frac{M_h}{M}\,f_1\frac{\tilde{D}^{\perp}}{z}\right) - \frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M}\left(xf^{\perp}D_1 + \frac{M_h}{M}\,h_1^{\perp}\frac{\tilde{H}}{z}\right)\right],$$

$$F_{UU}^{\cos 2\phi_h} = \mathcal{C}\left[-\frac{2\,\big(\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T\big)\,\big(\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T\big) - \boldsymbol{k}_T\cdot\boldsymbol{p}_T}{M M_h} h_1^{\perp} H_1^{\perp}\right],$$

$$\mathcal{C}\big[wfD\big] = \sum_a x\,e_a^2 \int d^2\boldsymbol{p}_T\,d^2\boldsymbol{k}_T\,\delta^{(2)}\big(\boldsymbol{p}_T - \boldsymbol{k}_T - \boldsymbol{P}_{h\perp}/z\big)\,w(\boldsymbol{p}_T, \boldsymbol{k}_T)\,f^a(x, p_T^2)\,D^a(z, k_T^2),$$

List of structure functions

	observable	twist
"SIDIS F_T"	$F_{UU,T}$	2
"SIDIS F_L"	$F_{UU,L}$	4
"Cahn"	$F_{UU}^{\cos\phi_h}$	3
"Boer-Mulders"	$F_{UU}^{\cos 2\phi_h}$	2
	$F_{LU}^{\sin\phi_h}$	3
	$F_{UL}^{\sin\phi_h}$	3
"Kotzinian-Mulders"	$F_{UL}^{\sin 2\phi_h}$	2
"SIDIS g_1"	F_{LL}	2
"Polarized Cahn"	$F_{LL}^{\cos\phi_h}$	3
"Sivers"	$F_{UT,T}^{\sin(\phi_h-\phi_S)}$	2
	$F_{UT,L}^{\sin(\phi_h-\phi_S)}$	4
"Collins"	$F_{UT}^{\sin(\phi_h+\phi_S)}$	2
"Pretzelosity"	$F_{UT}^{\sin(3\phi_h-\phi_S)}$	2
	$F_{UT}^{\sin\phi_S}$	3
	$F_{UT}^{\sin(2\phi_h-\phi_S)}$	3
"Worm gear"	$F_{LT}^{\cos(\phi_h-\phi_S)}$	2
"SIDIS g_2"	$F_{LT}^{\cos\phi_S}$	3
	$F_{LT}^{\cos(2\phi_h-\phi_S)}$	3

Unpolarized structure function

$$F_{UU,T} = \mathcal{C}[f_1 D_1]$$

$$\mathcal{C}\big[wfD\big] = \sum_a x\, e_a^2 \int d^2\boldsymbol{p}_T\, d^2\boldsymbol{k}_T\, \delta^{(2)}\big(\boldsymbol{p}_T - \boldsymbol{k}_T - \boldsymbol{P}_{h\perp}/z\big)\, w(\boldsymbol{p}_T, \boldsymbol{k}_T)\, f^a(x, p_T^2)\, D^a(z, k_T^2),$$

Gaussian ansatz

$$F_{UU,T} = \mathcal{C}[f_1 D_1]$$

$$\mathcal{C}\big[wfD\big] = \sum_a x\, e_a^2 \int d^2\boldsymbol{p}_T\, d^2\boldsymbol{k}_T\, \delta^{(2)}\big(\boldsymbol{p}_T - \boldsymbol{k}_T - \boldsymbol{P}_{h\perp}/z\big)\, w(\boldsymbol{p}_T, \boldsymbol{k}_T)\, f^a(x, p_T^2)\, D^a(z, k_T^2),$$

$$f_1^a(x, p_T^2) = \frac{f_1^a(x)}{\pi\langle p_T^2\rangle} e^{-\boldsymbol{p}_T^2/\langle p_T^2\rangle}, \qquad D_1^a(z, k_T^2) = \frac{D_1^a(z)}{\pi\langle K_T^2\rangle} e^{-z^2\boldsymbol{k}_T^2/\langle K_T^2\rangle}$$

$$\mathcal{C}[f_1 D_1] = \sum_a x e_a^2 \frac{f_1(x) D_1(z)}{\pi(z^2\rho_a^2 + \sigma_a^2)}\, e^{-\boldsymbol{P}_{h\perp}^2/(z^2\rho_a^2+\sigma_a^2)}$$

$$f_1^a(x, p_T^2) = \frac{f_1^a(x)}{\pi\langle p_T^2(x)\rangle^a} e^{-\boldsymbol{p}_T^2/\langle p_T^2(x)\rangle^a}, \quad D_1^a(z, k_T^2) = \frac{D_1^a(z)}{\pi\langle K_T^2(z)\rangle^a} e^{-z^2\boldsymbol{k}_T^2/\langle K_T^2(z)\rangle^a}$$

gmc_trans

gmc_trans

- Based on Gaussian ansatz. Cannot use non-Gaussian distributions (thus, many models cannot be implemented)

gmc_trans

- Based on Gaussian ansatz. Cannot use non-Gaussian distributions (thus, many models cannot be implemented)
- Implements several leading-twist terms of the cross section

gmc_trans

- Based on Gaussian ansatz. Cannot use non-Gaussian distributions (thus, many models cannot be implemented)
- Implements several leading-twist terms of the cross section
- First attempt at tuning the parameters of the unpolarized TMDs

gmc_trans

- Based on Gaussian ansatz. Cannot use non-Gaussian distributions (thus, many models cannot be implemented)

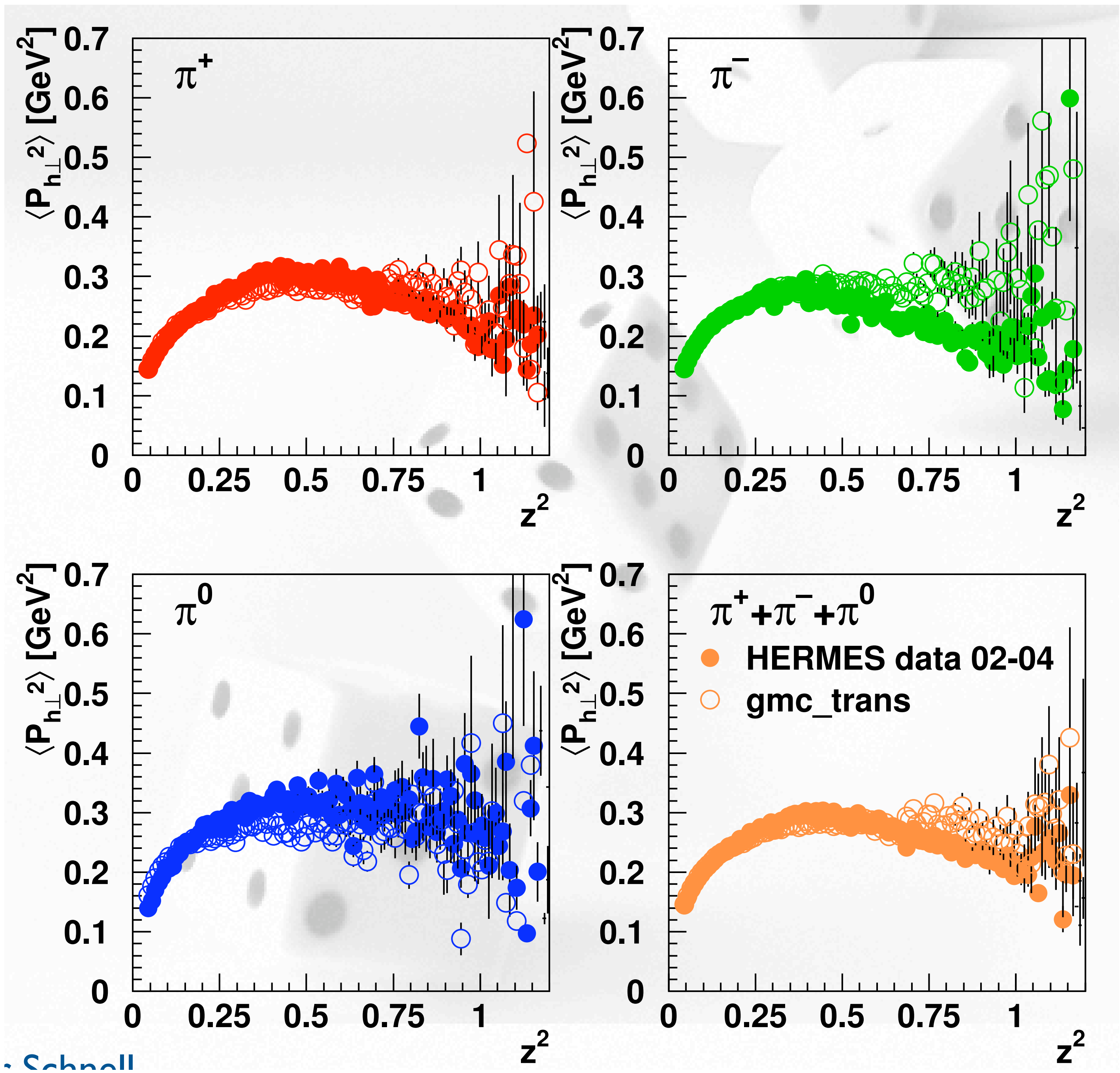
- Implements several leading-twist terms of the cross section

- First attempt at tuning the parameters of the unpolarized TMDs

- Careful implementation of positivity bounds

Comparison with data

$$\langle k_\perp^2 \rangle = 0.14 \text{ GeV}^2, \quad \langle P_\perp^2 \rangle = 0.42\, z^{0.54}(1-z)^{0.37} \text{ GeV}^2.$$



unpublished!

TMDgen

TMDgen

- Extension of gmc_trans done by Steve Gliske

TMDgen

- Extension of gmc_trans done by Steve Gliske
- Includes non-Gaussian distributions

TMDgen

- Extension of gmc_trans done by Steve Gliske
- Includes non-Gaussian distributions
- Includes two-hadron inclusive DIS

TMDgen

- Extension of gmc_trans done by Steve Gliske
- Includes non-Gaussian distributions
- Includes two-hadron inclusive DIS
- Written in C++

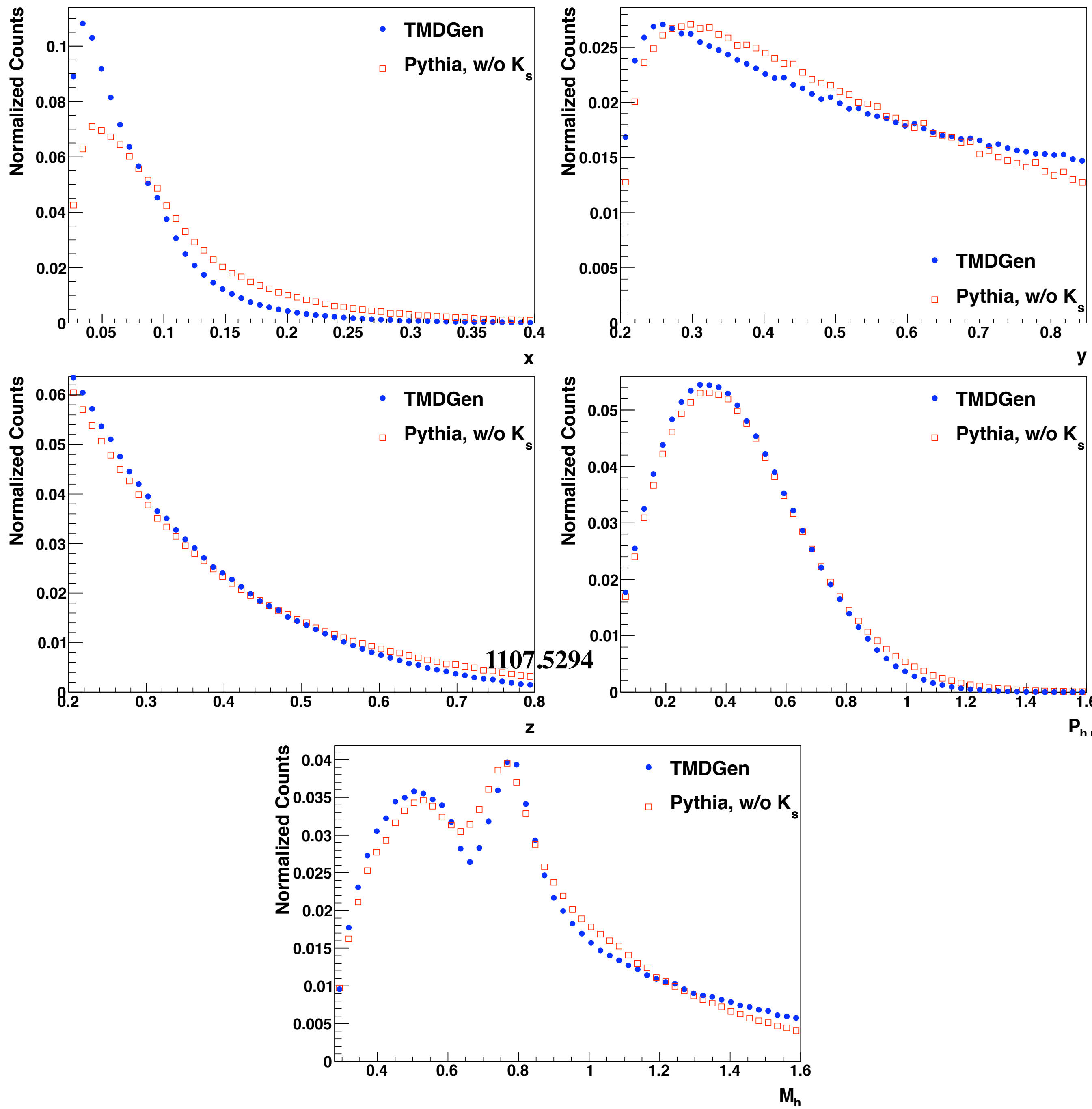


Figure 3.1: Comparison of 1D kinematic distributions from `TMDGen` and `Pythia`, in 4π, for $\pi^+\pi^0$ dihadrons. Listing the rows from top to bottom, and within each row from left to right, the panels are respectively the x, y, z, $P_{h\perp}$, and M_h distributions. `TMDGen` data is designated with blue circles, and `Pythia` data designated with red open squares.

Thesis of S. Gliske

TMDgen: still missing

TMDgen: still missing

- Lacks all subleading twist

TMDgen: still missing

- Lacks all subleading twist
- No TMD flavor dependence

TMDgen: still missing

- Lacks all subleading twist
- No TMD flavor dependence
- No QED radiative corrections

TMDgen: still missing

- Lacks all subleading twist
- No TMD flavor dependence
- No QED radiative corrections
- No TMD evolution

Unpol. TMD "state of the art"

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-ik_T \cdot b_T} \left[C \otimes f_1\left(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\right)\right] e^{-S'(b_T, Q)} \, e^{-S'_{\mathrm{NP}}(x, b_T, Q, \alpha_i)}$$

T. Rogers, M. Aybat, arXiv:1101.5057

Unpol. TMD “state of the art”

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-i k_T \cdot b_T} \left[C \otimes f_1\Big(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\Big)\right] e^{-S'(b_T,Q)} \, e^{-S'_{\rm NP}(x,b_T,Q,\alpha_i)}$$

collinear PDF

T. Rogers, M. Aybat, arXiv:1101.5057

Unpol. TMD "state of the art"

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-ik_T \cdot b_T} \left[C \otimes f_1\left(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\right)\right] e^{-S'(b_T,Q)}\, e^{-S'_{\rm NP}(x,b_T,Q,\alpha_i)}$$

collinear PDF

pQCD

T. Rogers, M. Aybat, arXiv:1101.5057

Unpol. TMD "state of the art"

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-ik_T \cdot b_T} \left[C \otimes f_1\left(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\right)\right] e^{-S'(b_T,Q)}\, e^{-S'_{\mathrm{NP}}(x,b_T,Q,\alpha_i)}$$

collinear PDF

pQCD

nonperturbative part of TMD

T. Rogers, M. Aybat, arXiv:1101.5057

Unpol. TMD "state of the art"

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-ik_T \cdot b_T} \left[C \otimes f_1\left(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\right)\right] e^{-S'(b_T,Q)}\, e^{-S'_{\rm NP}(x,b_T,Q,\alpha_i)}$$

collinear PDF

pQCD

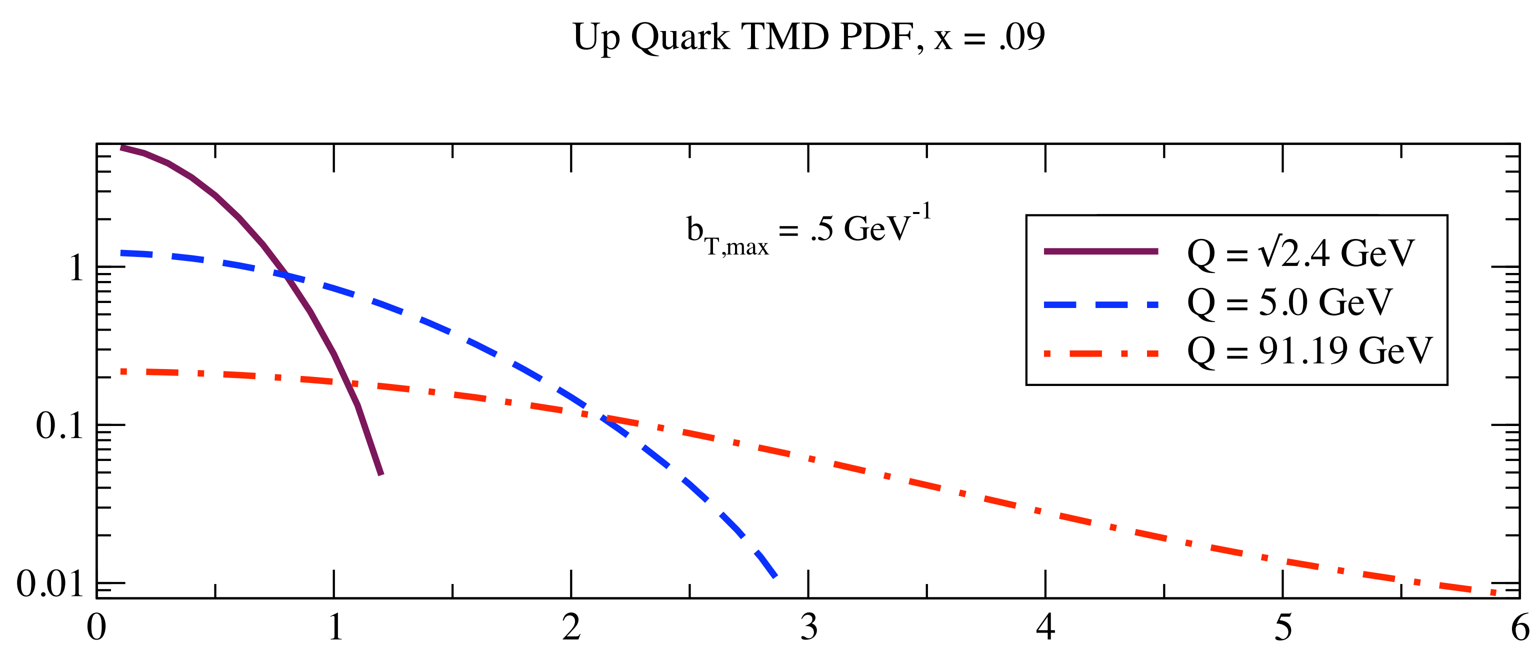
nonperturbative part of TMD

Fourier-transform of the TMD

T. Rogers, M. Aybat, arXiv:1101.5057

Unpol. TMD "state of the art"

$$f_1(x, k_T; Q) = \frac{1}{2\pi} \int d^2 b_T e^{-i k_T \cdot b_T} \left[C \otimes f_1\left(\hat{x}; \frac{2e^{-\gamma_e}}{b_T}\right)\right] e^{-S'(b_T, Q)}\, e^{-S'_{\rm NP}(x, b_T, Q, \alpha_i)}$$



T. Rogers, M. Aybat, arXiv:1101.5057
Landry, Brock, Nadolsky, Yuan, PRD67 (03)
P. Schweitzer, T. Teckentrup, A. Metz, PRD81(10)

ResBos

ResBos

- Already implements effect of gluon resummation, which is another way of including TMD evolution

ResBos

- Already implements effect of gluon resummation, which is another way of including TMD evolution
- It’s a generator “family” with several processes

ResBos

- Already implements effect of gluon resummation, which is another way of including TMD evolution
- It’s a generator “family” with several processes
- http://hep.pa.msu.edu/resum/index.html#SIDIS

Fourier-transformed TMDs

Fourier-transformed TMDs

- Since the TMD evolution formalism is done in bT space, it may be useful to implement the Fourier-transformed formulas in the MC generator

Fourier-transformed TMDs

- Since the TMD evolution formalism is done in bT space, it may be useful to implement the Fourier-transformed formulas in the MC generator

Fourier-transformed TMDs

- Since the TMD evolution formalism is done in bT space, it may be useful to implement the Fourier-transformed formulas in the MC generator

- This may also useful to study Bessel-weighted extraction methods
  Boer, Gamberg, Musch, Prokudin, arXiv:1107.5294

Conclusions

Conclusions

- There is a lot to do.

Conclusions

- There is a lot to do.
- Every collaboration and even every analysis group uses its own different solution.

Conclusions

- There is a lot to do.
- Every collaboration and even every analysis group uses its own different solution.
- Not enough attention is devoted to publishing the ideas and share them.

Conclusions

- There is a lot to do.
- Every collaboration and even every analysis group uses its own different solution.
- Not enough attention is devoted to publishing the ideas and share them.
- I would personally focus first on SIDIS generators, although I think the effort of modifying full event generators is extremely interesting