Radiative DIS and SIDIS

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FF2019 16 March 2019

Workshop on Novel Probes of the Nucleon Structure in SIDIS, e+e- and pp

- The role of input SFs in RC
- Comparing RCs in DIS
- Radiative correction in SIDIS
- Tests and validation
- Summary

Radiative DIS

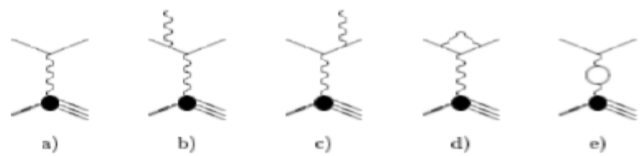


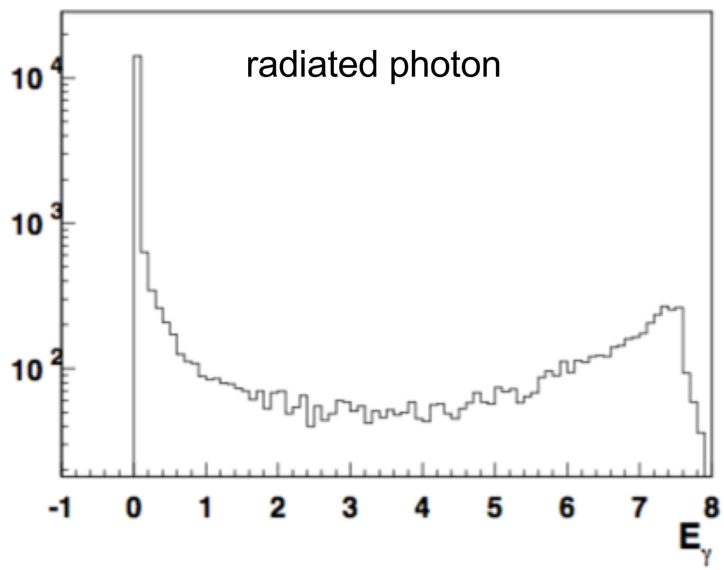
Figure 1: Feynman diagrams contributing to the Born and the radiative correction cross sections in lepton-nucleus scattering.

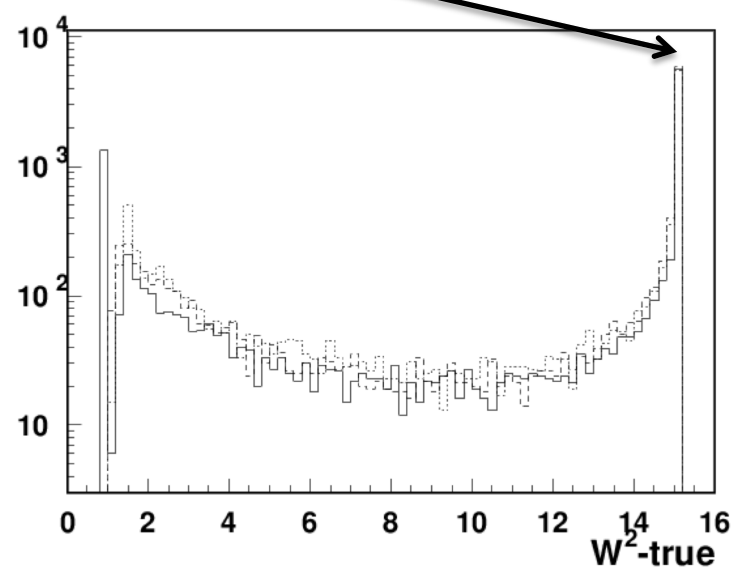
Akushevich et al. http://www.jlab.org/RC/radgen/

For SIDIS we need x-sections/SFs in the full W range, including exclusive part

generate a single kinematical point at E_b=10.6 GeV with e'=2.0 GeV, θ=0.3
→ **x,y,Q^2,W^2(0.12,0.8,1.9,15.1)**
Integrated over all **Eγ** **$\sigma_{Rad}/\sigma_{Born}$=1.24**

original W^2





From SIDIS to DIS

$$\boxed{\frac{d\sigma}{dx\,dQ^2\,d\psi\,dz\,d\phi_h\,d|\boldsymbol{P}_{h\perp}|^2} = \frac{\alpha^2}{xQ^4}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\left\{F_{UU,T}+\varepsilon F_{UU,L}\right\}}$$

3D SIDIS

$$F_{UU,T}(x,z,Q^2) = \int d^2\vec{P}_{h,\perp}F_{UU,T}(x,z,P^2_{h,\perp},Q^2)$$

$$\frac{d\sigma(lN\to lX)}{dx\,dQ^2\,d\psi} = \frac{1}{\nu+M}\sum_h\int E_h\,dE_h\frac{d\sigma(lN\to lhX)}{dx\,dQ^2\,d\psi\,dE_h} = \frac{\nu}{\nu+M}\sum_h\int z\,dz\boxed{\frac{d\sigma(lN\to lhX)}{dx\,dQ^2\,d\psi\,dz}}$$

1D SIDIS

$$\frac{d\sigma}{dx\,dQ^2\,d\psi} = \frac{2\alpha^2}{xQ^4}\frac{y^2}{2(1-\varepsilon)}\left\{F_{UU,T}(x,Q^2)+\varepsilon F_{UU,L}(x,Q^2)\right\}.$$

$$\boxed{\frac{d\sigma}{dx\,dQ^2\,d\psi} = \frac{2\alpha^2}{xQ^4}\frac{y^2}{2(1-\varepsilon)}\left\{2(1-\varepsilon)xF_1(x,Q^2)+\varepsilon(1+\gamma^2)F_2(x,Q^2)\right\}}$$

DIS

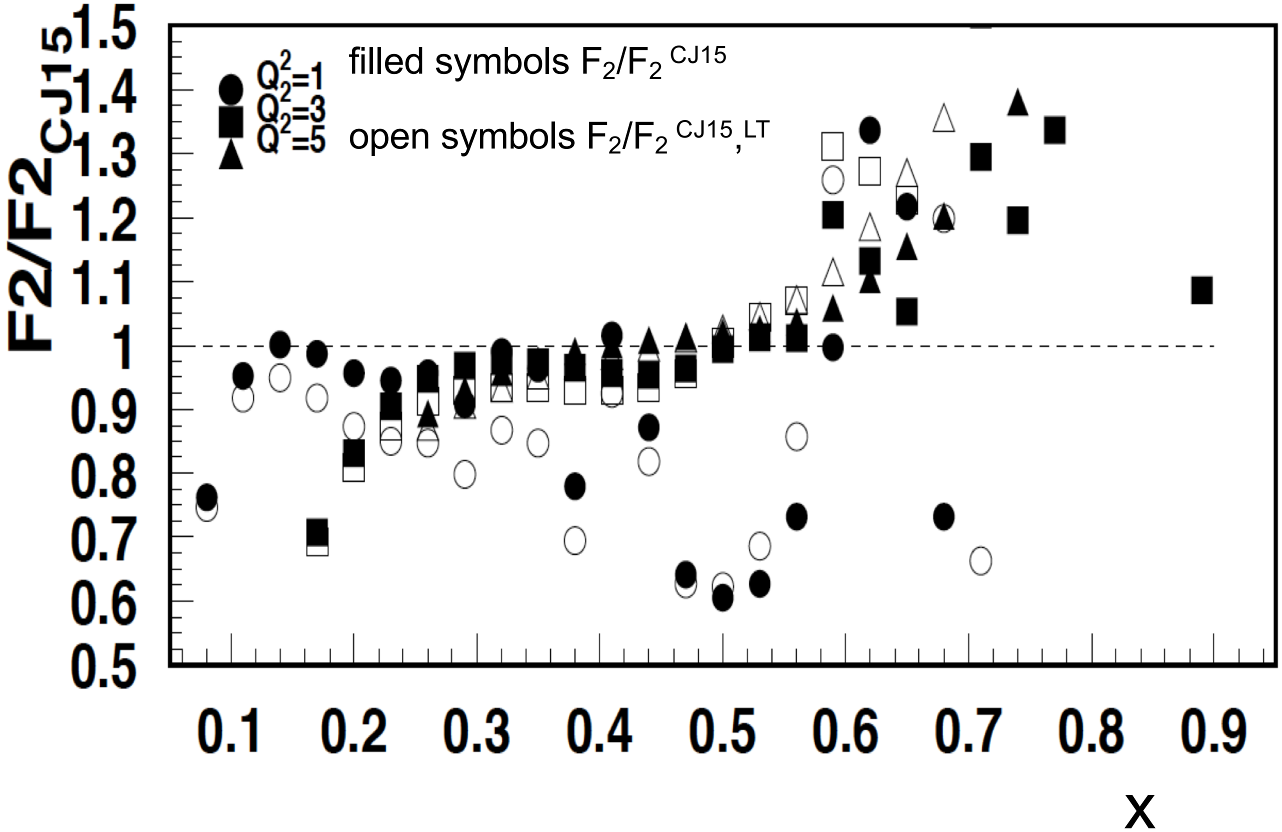
$$F_{UU,T}(x,Q^2) = F_T(x,Q^2) = 2xF_1(x,Q^2) = \sum_h\int z\,dzF_{UU,T}(x,z,Q^2)$$

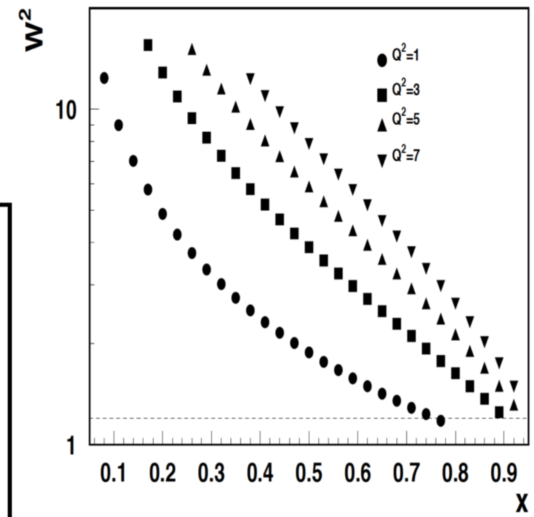
$$F_{UU,L}(x,Q^2) = F_L(x,Q^2) = (1+\gamma^2)F_2(x,Q^2) - 2xF_1(x,Q^2) = \sum_h\int z\,dzF_{UU,L}(x,z,Q^2)$$

CLAS12 main trigger is e'X, DIS and SIDIS collected simultaneously

Comparing different DIS models

$$F_2(x,Q^2) = F_2^{\rm LT}(x,Q^2)\left(1+\frac{C_{\rm HT}(x)}{Q^2}\right)$$

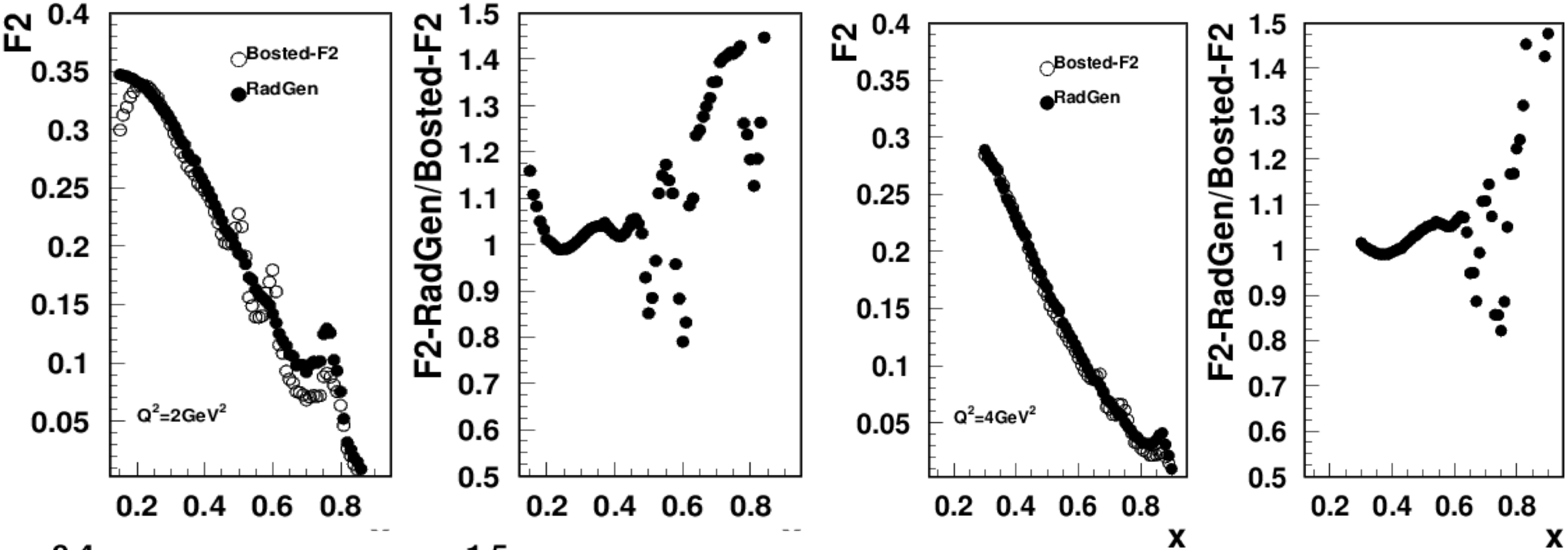


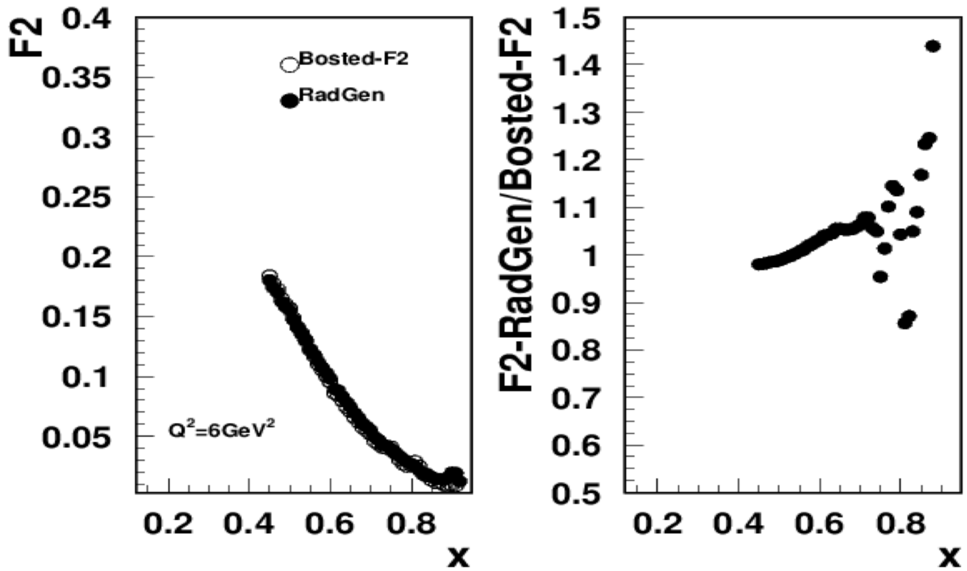


reasonable agreement in most of the relevant kinematics

How critical are 10-20% differences in extraction of underlying PDFs?

Comparing DIS MCs (Bosted vs RadGen)

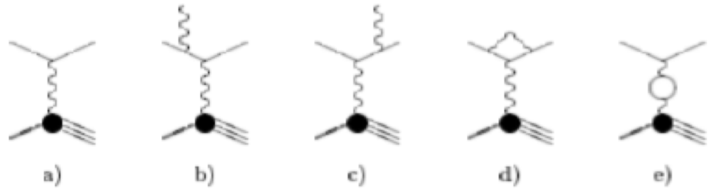




reasonable agreement in F2s with ~20-30% differences in resonance region

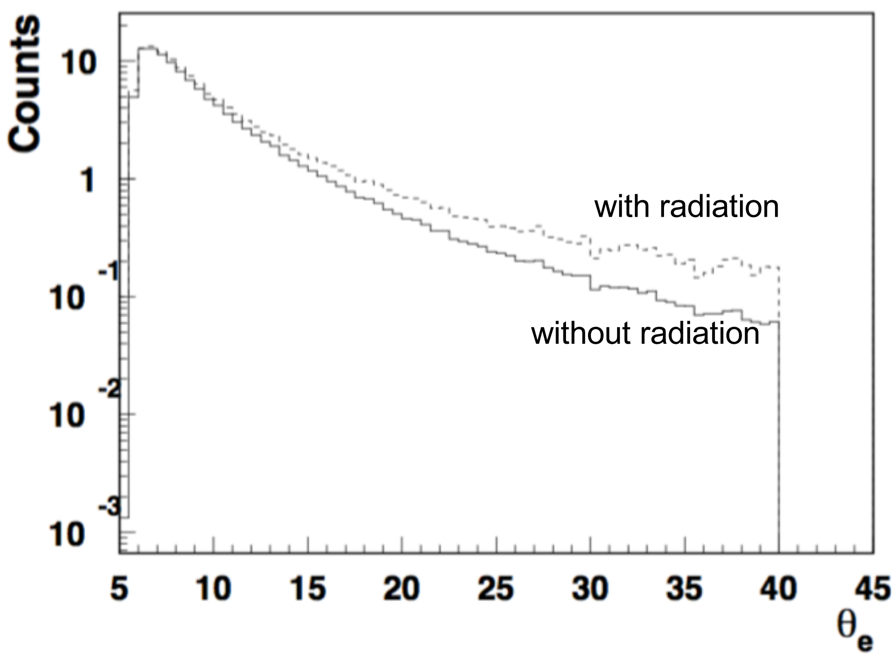
How critical are 10-20% differences in extraction of underlying PDFs?

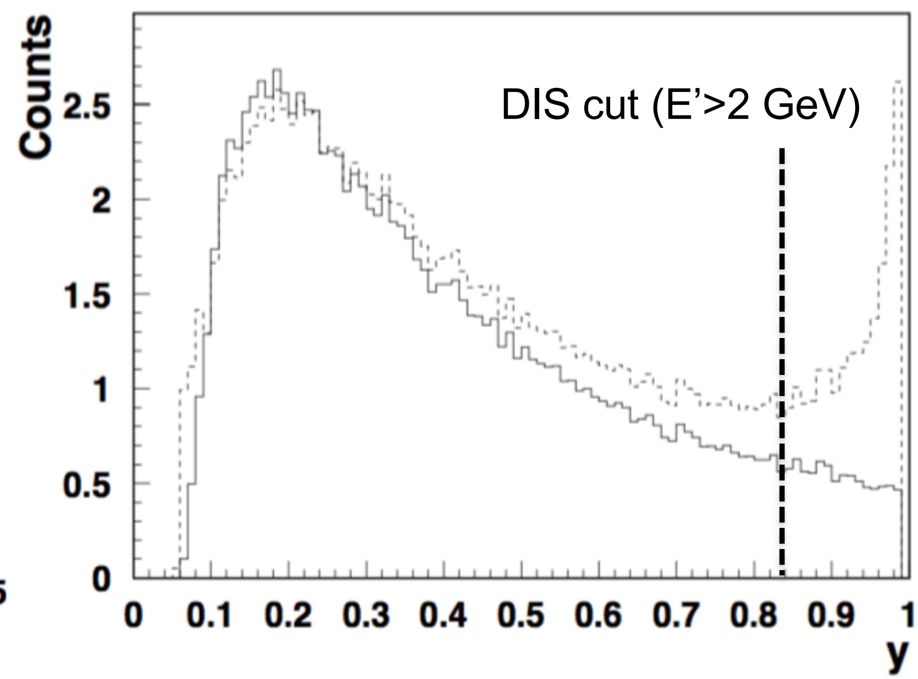
Radiative DIS



Akushevich et al. http://www.jlab.org/RC/radgen/

Figure 1: Feynman diagrams contributing to the Born and the radiative correction cross sections in lepton-nucleus scattering.





Radiative correction become very significant for low energy scattered electron

Radiative DIS

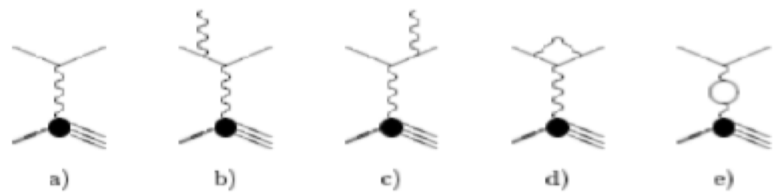


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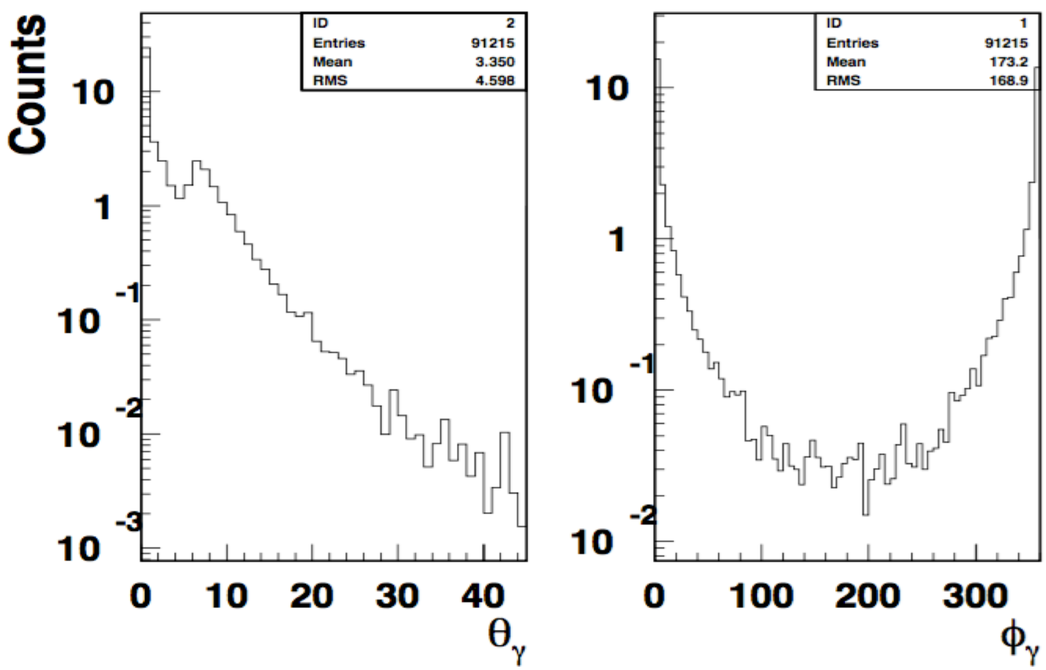
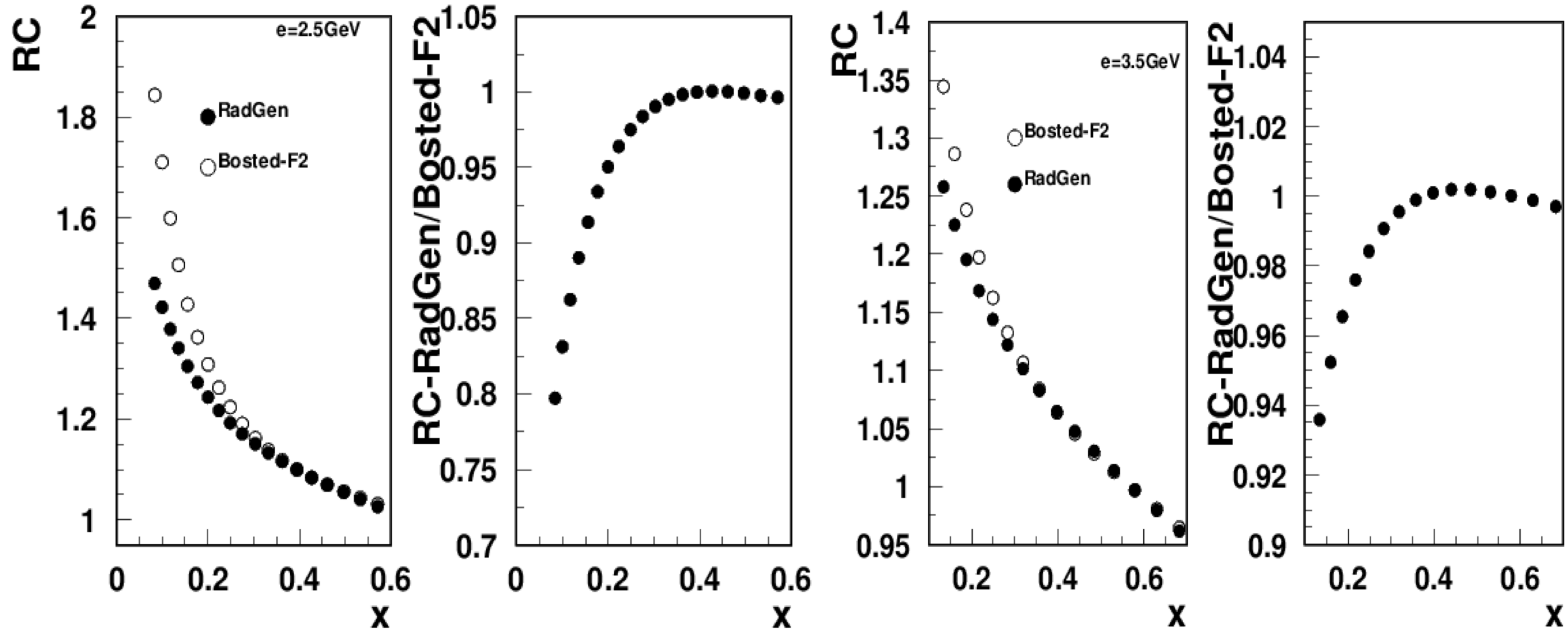
Figure 1: Feynman diagrams contributing to the Born and the radiative correction cross sections in lepton-nucleus scattering.



Changes of SFs during iterations should be monitored

Important to include the radiated photon in the MC

Sensitivity of RC to SFs



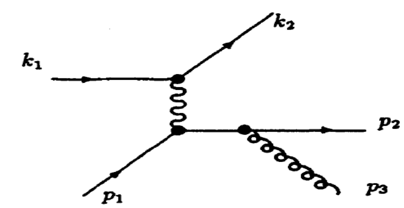
RC change few % with input SFs, and can affect precision measurements

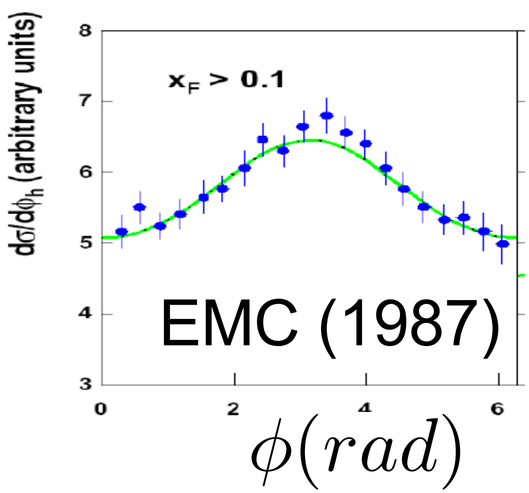
Azimuthal asymmetries in SIDIS

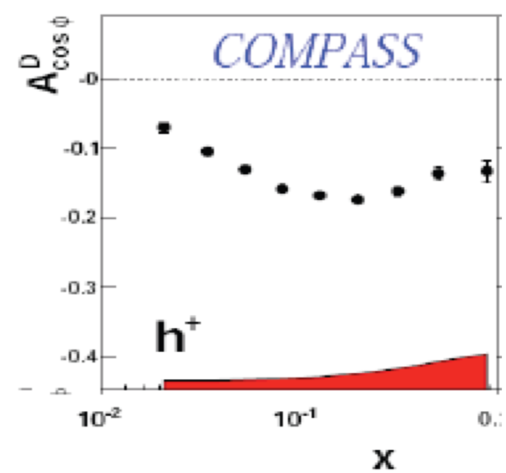
$$\frac{d\sigma}{dx_B\, dy\, d\psi\, dz\, d\phi_h\, dP_{h\perp}^2} = \frac{\alpha^2}{x_B y Q^2} \frac{y^2}{2(1-\varepsilon)} \left(1+\frac{\gamma^2}{2x_B}\right) \Big\{ F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\varepsilon(1+\varepsilon)}\, \cos\phi_h\, F_{UU}^{\cos\phi_h} + \varepsilon \cos(2\phi_h)\, F_{UU}^{\cos 2\phi_h} + \lambda_e \sqrt{2\varepsilon(1-\varepsilon)}\, \sin\phi_h\, F_{LU}^{\sin\phi_h} \Big\},$$

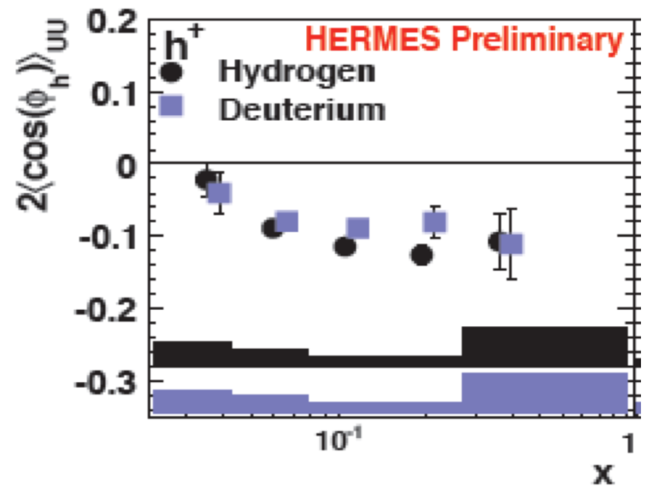
Non-perturbative vs perturbative

Cahn 1978 Georgi & Politzer, Mendez 1978









- Large $\cos\phi$ modulations observed by EMC were reproduced in electroproduction of hadrons in SIDIS with unpolarized targets at COMPASS and HERMES
- Effect is dominated by non-perturbative Cahn contribution

All moments are relevant

F_L

$$\int d^2k_T k_T^2 f^{\perp}(x, k_T^2) = 2F_L(x) - F_1(x) + \mathcal{M}_4$$

Tw 3 Tw 4 Tw 2

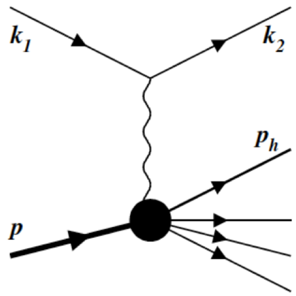
Connection with SIDIS cross section

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

Simonetta Liuti (UVA) CTEQ Fall Meeting, Nov 10

Radiative SIDIS

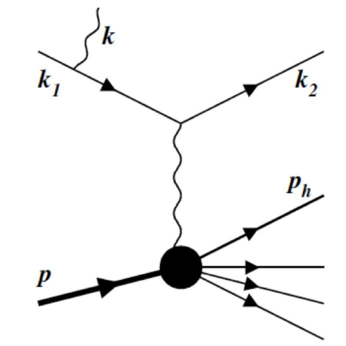
Akushevich&Ilyichev in progress



$$e(k_1,\xi)+n(p,\eta)\longrightarrow e(k_2)+h(p_h)+x(p_x)$$

$$\frac{d\sigma^B}{dx\,dy\,dz\,dp_t^2\,d\phi_h\,d\phi}:$$

$$\boxed{d\sigma^B=\frac{\alpha^2}{\sqrt{\lambda_S}Q^4}W_{\mu\nu}L^{\mu\nu}\frac{d^3k_2}{k_{20}}\frac{d^3p_h}{p_{h0}}}$$



$$e(k_1,\xi)+n(p,\eta)\rightarrow e(k_2)+h(p_h)+x(\tilde{p}_x)+\gamma(k)$$

$$\boxed{d\sigma_R=\frac{\alpha^3}{4\pi^2\tilde{Q}^4\sqrt{\lambda_S}}W^{\mu\nu}(q-k,p,p_h)L^R_{\mu\nu}\frac{d^3k}{k_0}\frac{d^3k_2}{k_{20}}\frac{d^3p_h}{p_{h0}}}$$

+.....

additional photon can be described by three additional variables:

$$R=2kp,\quad \tau=\frac{kq}{kp},\quad \phi_k$$

$$S_x=2p(k_1-k_2)$$

$$\lambda_Y=S_x^2-4M^2Q^2$$

The phase space of the real photon: $$\frac{d^3k}{k_0}=\frac{RdRd\tau d\phi_k}{2\sqrt{\lambda_Y}}.$$

ϕ_k is an angle between $(\mathbf{k}_1,\mathbf{k}_2)$ and $(\mathbf{k},\mathbf{q})$ planes.

$$e(k_1,\xi)+n(p,\eta)\rightarrow e(k_2)+h(p_h)+u(p_u)+\gamma(k),$$

$$\cdot\delta^4(k_1+p-k_2-p_h-p_u-k)$$

From x-section to events

In unpolarized target case:

$$\sigma_0^{ehX}(x, y, ..\phi, \lambda) = \sum_{l,i} K_l(x, y, ..)(F_{l,i}(x_1, ..x_N) \cos(i \cos \phi_h) + \lambda F^{\lambda}_{l,i}(x_1, ..x_N) \sin(i\phi_h)$$

For polarized targets more SFs and new variable ϕ_S

When we turn on QED radiation x-section gets additional 3variables, after integration over which, we can obtain the radiative x-section

$$\sigma_{Rad}^{ehX}(x, y, z, P_T, \phi, \phi_S) \to \sigma_0^{ehX}(x, y, z, P_T, \phi, \phi_S) \times R(x, y, z, P_T, \phi_h) + R_A(x, y, z, P_T, \phi, \phi_S)$$

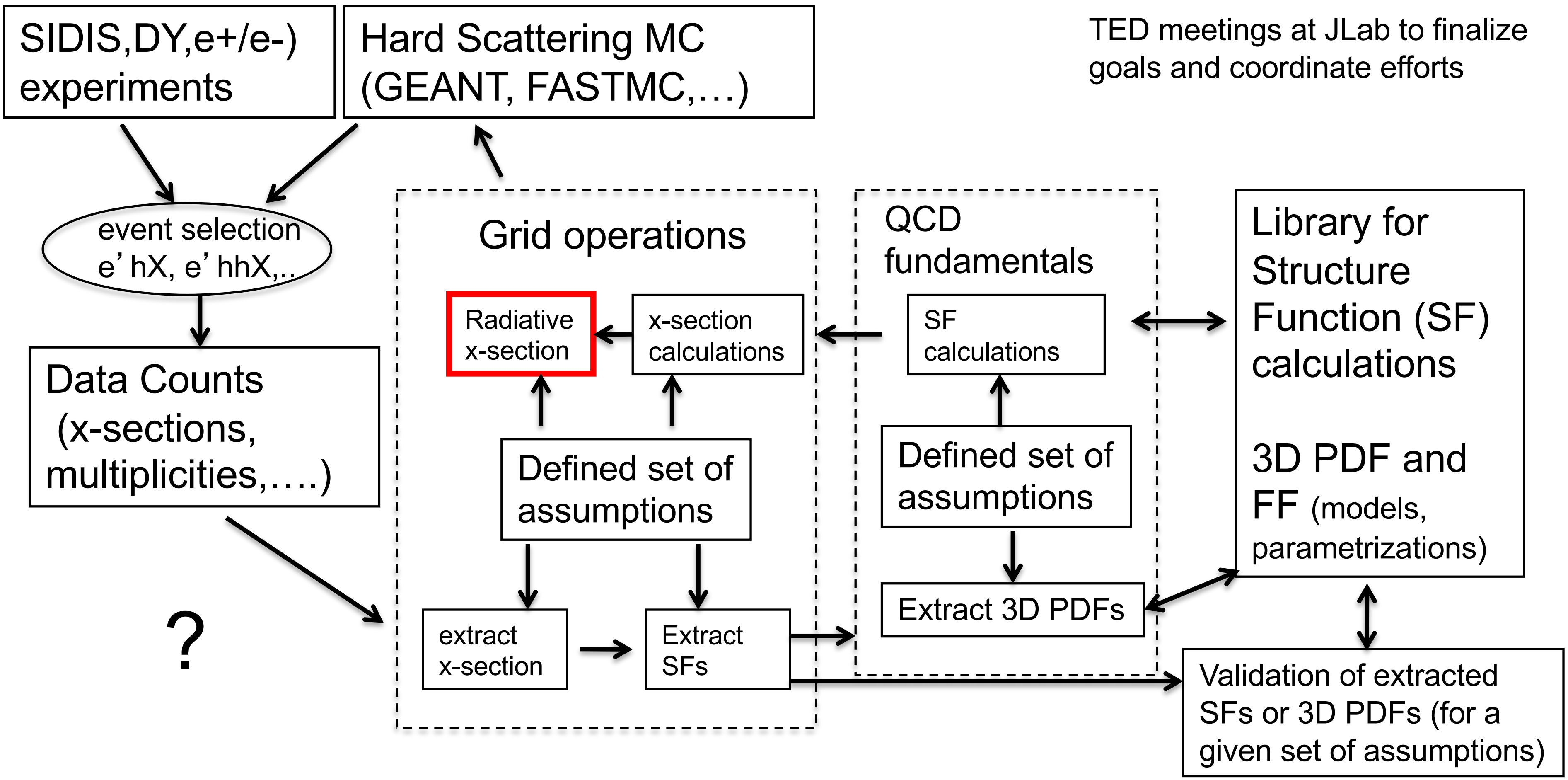
RC generates additional moments and modifies existing ones

Experiment has certain acceptance function $A\left(x, Q^2, P_T, z, \phi\right)$:
defining fraction of events accepted in a given phase space defined by kinematical variables

The number of events the experiment will measure in a given phase space in a given Δt :

$$N_{measured} = Luminosity * \int_{phasespace} \frac{d\sigma^{ehX}_{Rad}(x, y, ...)}{dSpace} * A(x, Q^2, P_T, z, \phi)$$

3D PDF Extraction and VAlidation (EVA) framework



Development of a reliable techniques for the extraction of 3D PDFs and fragmentation functions from the multidimensional experimental observables with controlled systematics requires close collaboration of experiment, theory and computing

Summary

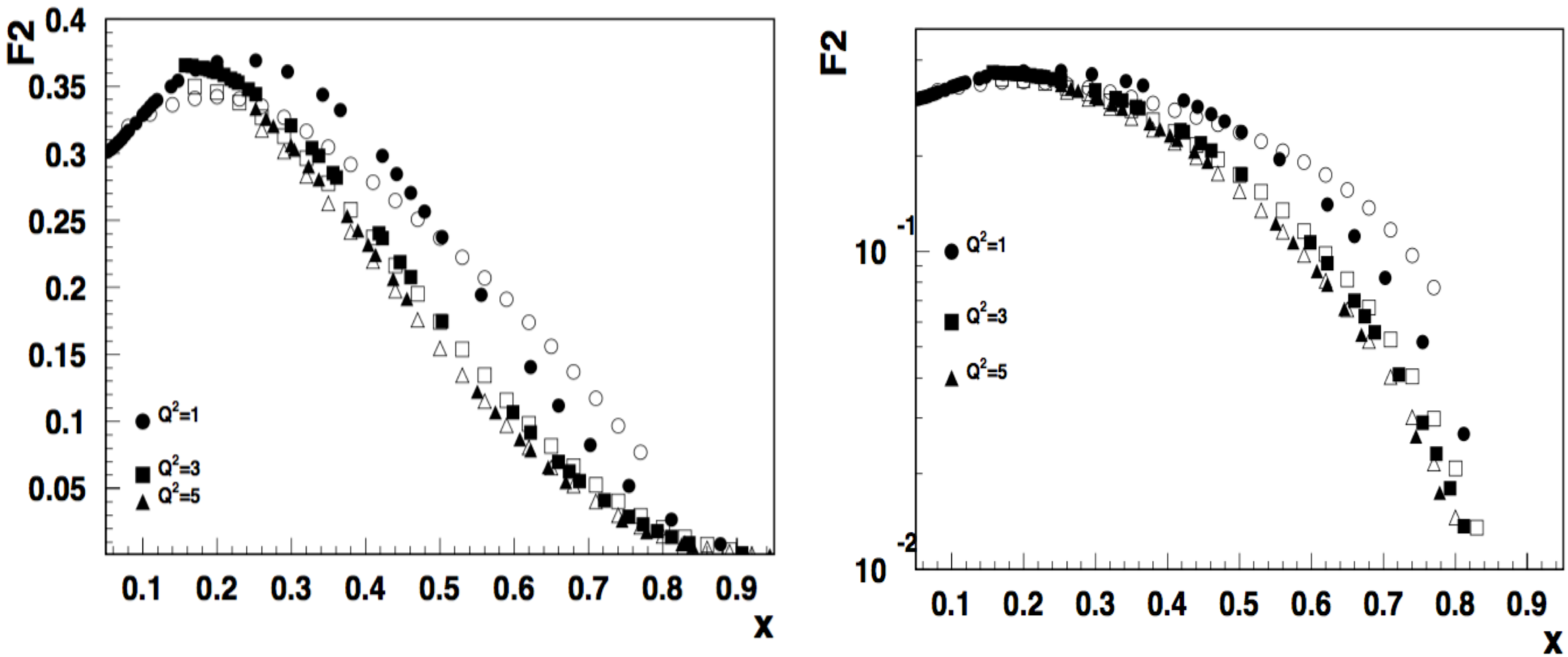
- For SIDIS studies we need a MC generator with flexible input (x-sections, structure functions, grids, functional forms) which can generate events in full phase space, including the full set of involved SFs with radiative effects.

- Extraction of sets of SF in iterative procedure for SIDIS generation-reconstruction-acceptance-radiative corrections-bin-centering corrections should be validated using the MC with well defined reasonable input.

- Input from theory/phenomenology and output from experiment should have a well defined unified structure

Support slides…

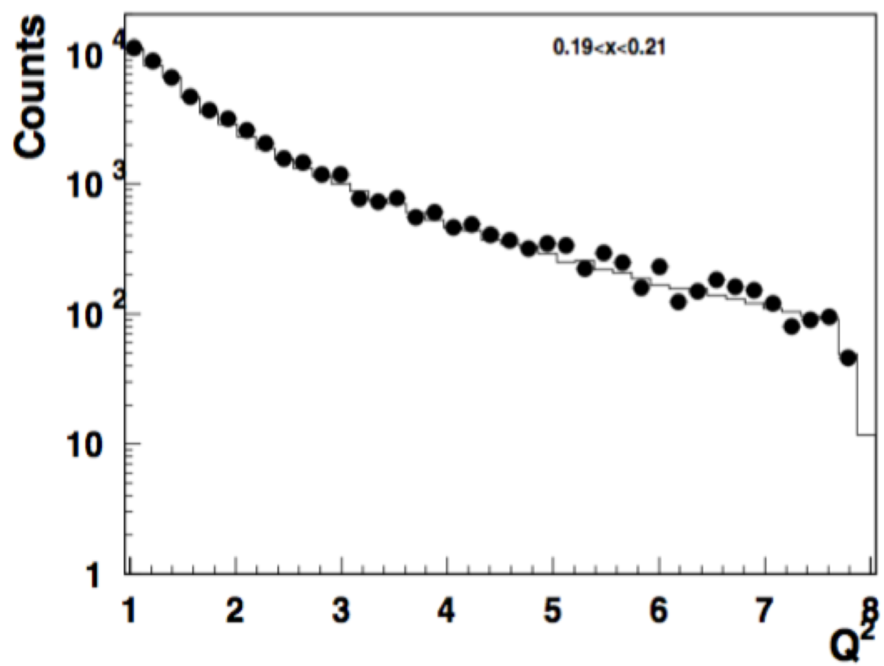
F2 Nobuo vs CJ15



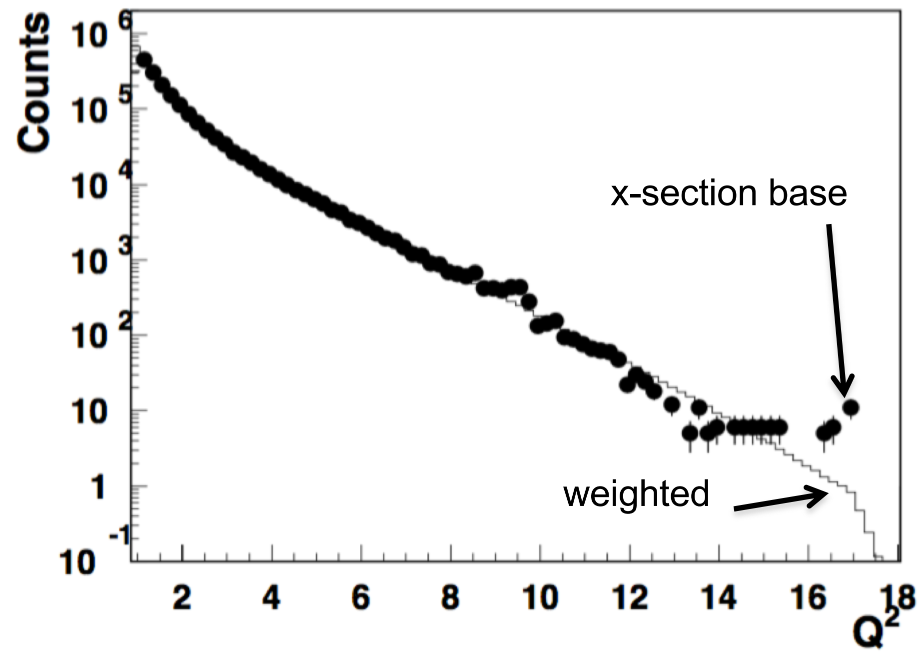
Difference more significant at small Q^2

Generators: x-section vs weights

single bin



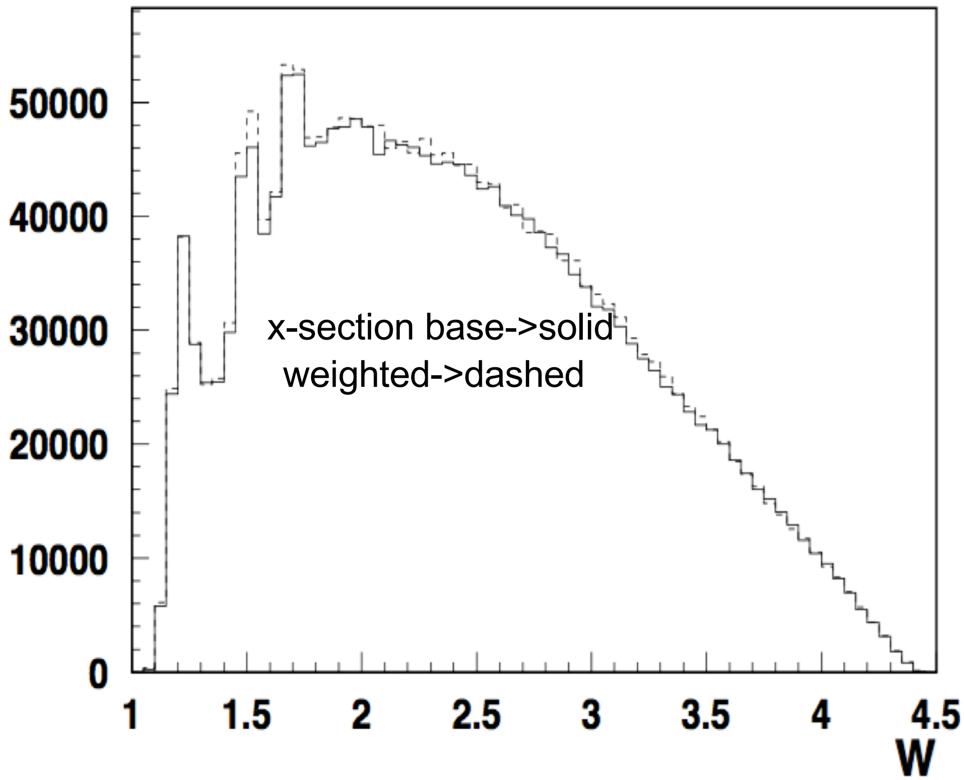
full kinematics (2M events)

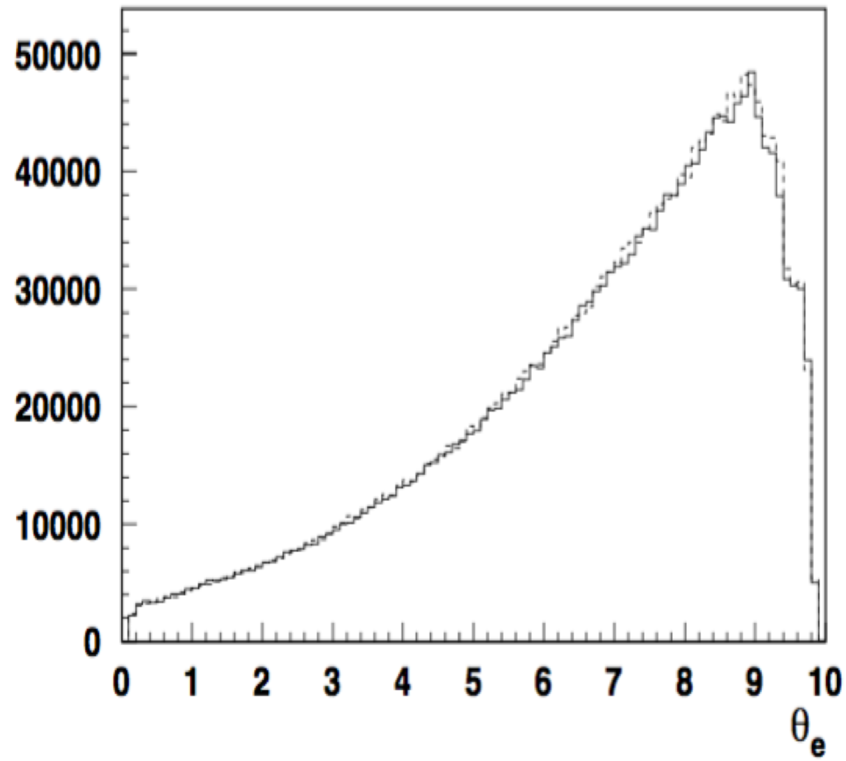


- Two approaches for DIS event generation (x-section based and weighted) are fully compatible (2M events generated in both cases)
- Using weights for events makes the generation much faster, and most importantly provides statistics for acceptance studies in small bins.

Generators: x-section vs weights

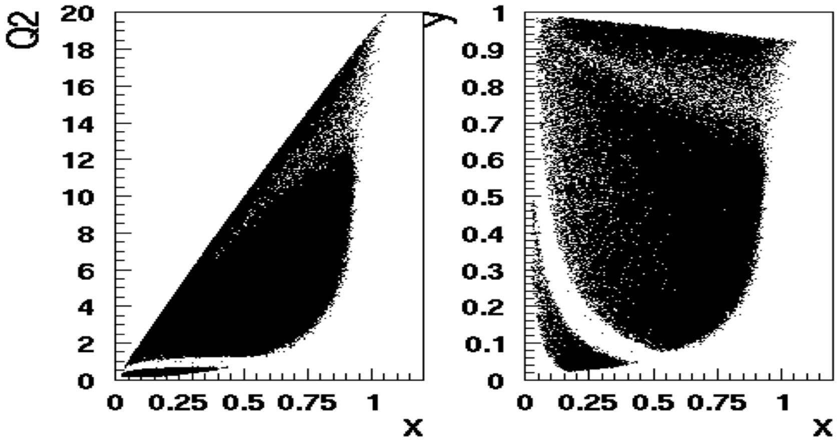
full kinematics (2M events)





- Two approaches are fully compatible (2M events generated in both cases)

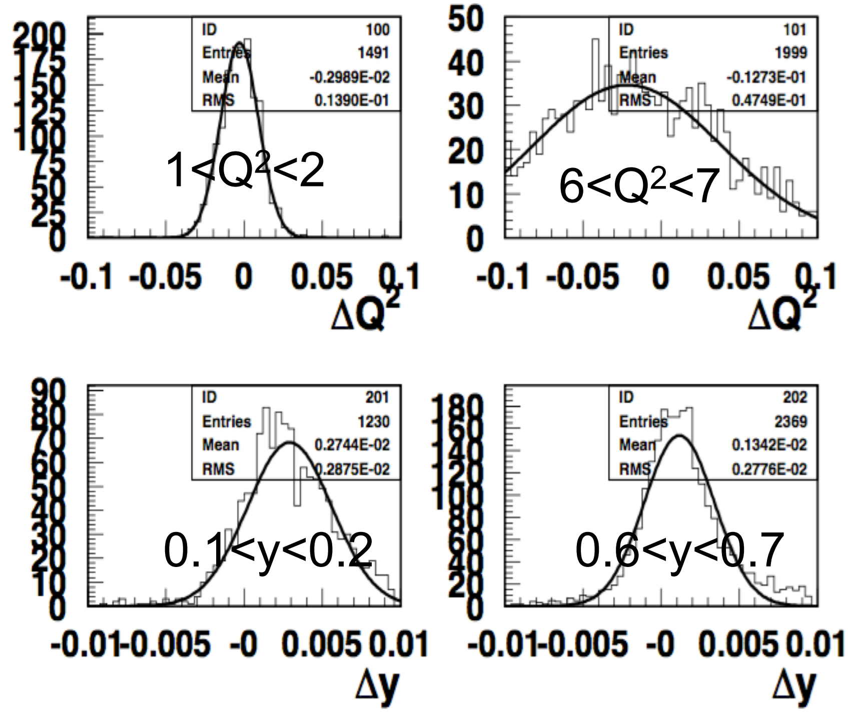
Binning in DIS



With small bins x,y-binning will be much better for extraction of SFs

1) scale variable
2) fixed range
3) smaller change in resolution

x=0.4



More traditional binning in x Q^2 used so far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     "reference": "N. Sato et al"
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     "lepton-polarization": "0"
     "nucleon-polarization": "0"
     "particle": "pi+"
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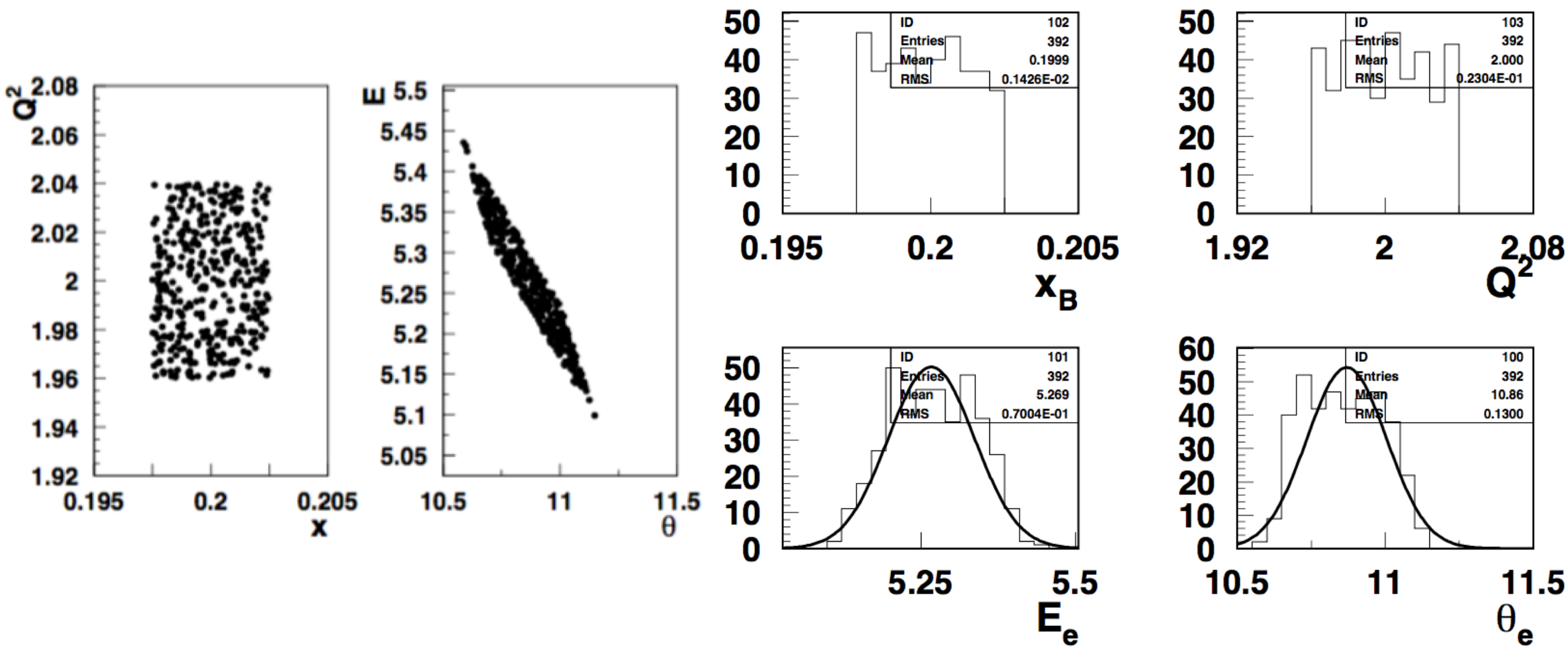
            {"name":"b","bins": 99,"min": 0.95, "max": 13.1, "scale":"lin","description":"Q^2"}
   ],
     "parameters":[
   ]
}
```

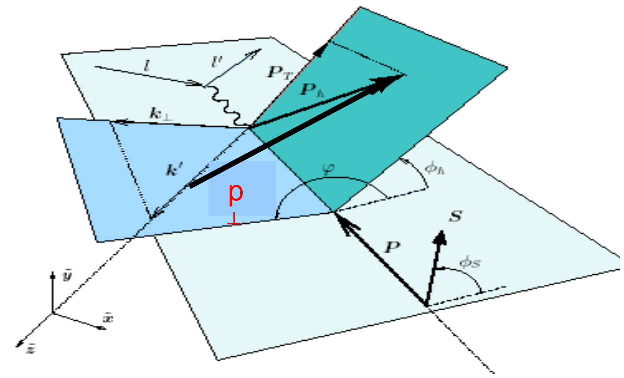

0	0	0.26510E+01	0.65582E-01	0.2844	0.0567	0.9068	1.0230
0	1	0.45973E+00	0.26153E-01	0.1292	0.0583	0.9387	1.0889
1	0	0.50249E+01	0.93813E-01	0.4135	0.0633	0.8204	1.0316
1	1	0.74271E+01	0.10466E+00	0.4572	0.0640	0.8863	1.1270
1	2	0.16775E+01	0.45997E-01	0.2508	0.0664	0.9288	1.2271
2	0	0.42042E+01	0.90587E-01	0.3478	0.0726	0.7160	1.0321
2	1	0.68917E+01	0.10499E+00	0.4300	0.0725	0.7861	1.1326
2	2	0.67994E+01	0.93186E-01	0.5257	0.0726	0.8699	1.2546
2	3	0.32602E+01	0.59573E-01	0.3875	0.0745	0.9191	1.3624
2	4	0.10215E+00	0.99691E-02	0.0751	0.0768	0.9474	1.4476
3	0	0.34061E+01	0.85340E-01	0.2959	0.0818	0.6358	1.0339
3	1	0.56184E+01	0.99012E-01	0.3585	0.0817	0.6982	1.1334
3	2	0.54527E+01	0.86880E-01	0.4473	0.0817	0.7737	1.2556
3	3	0.55007E+01	0.78669E-01	0.5458	0.0816	0.8494	1.3780
3	4	0.42467E+01	0.63689E-01	0.5134	0.0825	0.9090	1.4907
3	5	0.67098E+00	0.23812E-01	0.2186	0.0851	0.9380	1.5869

Binning in DIS



For small bins in x-q2 or x-y spread in other kinematical variables is becoming small (x2-3 resolution in θ and E'), reducing the role of bin-centering corrections and variations of structure functions in the bin

DIS output and data analysis



Theory

Experimental

$$\frac{d\sigma^{eN\to e'hX}_{\lambda\Lambda}}{dx\,dQ^2\,d\phi_l} = \sum_{l=1}^{L} SF_l$$

Use a set of SF_l

For a given model/theory based on underlying non-perturbative input and assumptions extract SF_l from data

$F_l(x_1, x_2, x_3, ...x_N, P_1, P_2, ...P_M)$

step-1

(for a given E_{beam},λ,Λ) measure P_i^{el}

step-2: define the acceptance, estimate radiative effects

step-3 produce a table of corrected counts/cross sections and systematic errors in given bins

$x_i, Q_i^2/x_i, y_i/...$

Phenomenology

$$F_l(x_1, x_2, x_3, ...x_N, P_1^*, P_2^*, ...P_M^*)$$

Need a reliable mechanism for estimation of systematics in extraction of the parameters for given SF set)

Standard input for SFs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    "author": "N. Sato",
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        },
        {
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    "reaction": "DIS",
    "target": "p",
    "variables": [
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    ]
}
```


(JavaScript Object Notation for a single hadron production eN->e 'X)

Table can be generated from any existing program for calculation of SFs for any given set of parameters, final state particles, target nucleon, polarization states in tiny bins.

ix	iy	x	y	Q2	F2	FL	F3	dsig/dxdy
0	191	5.2610e-02	9.5868e-01	1.0039e+00	3.0120e-01	6.0973e-02	5.4901e-04	1.6325e-03
0	192	5.2610e-02	9.6342e-01	1.0089e+00	3.0160e-01	6.0859e-02	5.5211e-04	1.6154e-03
0	193	5.2610e-02	9.6817e-01	1.0139e+00	3.0199e-01	6.0746e-02	5.5522e-04	1.5987e-03
0	194	5.2610e-02	9.7291e-01	1.0188e+00	3.0239e-01	6.0633e-02	5.5832e-04	1.5823e-03
0	195	5.2610e-02	9.7765e-01	1.0238e+00	3.0278e-01	6.0522e-02	5.6142e-04	1.5662e-03
0	196	5.2610e-02	9.8240e-01	1.0288e+00	3.0317e-01	6.0411e-02	5.6453e-04	1.5503e-03
0	197	5.2610e-02	9.8714e-01	1.0337e+00	3.0355e-01	6.0301e-02	5.6763e-04	1.5348e-03
0	198	5.2610e-02	9.9188e-01	1.0387e+00	3.0394e-01	6.0192e-02	5.7074e-04	1.5196e-03

Extraction of DIS x-section and acceptance


```
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        "reference": "N. Sato et al"
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        "nucleon-polarization": "0"
        "particle": "pi+"
        "variables":["N","Counts","Err.Counts","acc","RadCor","xav","yav","q2av"
        "axis":[
                {"name":"a","bins": 99,"min": 0.05, "max": 0.95, "scale":"lin","description":"x_bj"}
                {"name":"b","bins": 99,"min": 0.95, "max": 13.1, "scale":"lin","description":"Q^2"}
    ],
        "parameters":[
    ]
}
     0   0      0.81900E+03   0.33103E+07   0.11567E+06   0.18094E+00      2.5475   0.0566   0.9099   1.0248
     0   1      0.17300E+03   0.79404E+06   0.60369E+05   0.83559E-01      3.1196   0.0583   0.9392   1.0883
     1   0      0.14940E+04   0.45989E+07   0.11898E+06   0.43024E+00      1.7770   0.0631   0.8246   1.0334
     1   1      0.24200E+04   0.78833E+07   0.16025E+06   0.38679E+00      2.2943   0.0637   0.8924   1.1298
     1   2      0.74100E+03   0.25279E+07   0.92865E+05   0.18311E+00      2.7515   0.0664   0.9300   1.2276
     2   0      0.10610E+04   0.29902E+07   0.91799E+05   0.34089E+00      1.4475   0.0725   0.7176   1.0332
     2   1      0.21560E+04   0.54615E+07   0.11762E+06   0.44019E+00      1.5917   0.0723   0.7891   1.1339
     2   2      0.26110E+04   0.66272E+07   0.12970E+06   0.51925E+00      2.0516   0.0722   0.8767   1.2579
     2   3      0.15350E+04   0.41679E+07   0.10638E+06   0.29366E+00      2.5589   0.0744   0.9235   1.3654
     2   4      0.48000E+02   0.14361E+06   0.20728E+05   0.41388E-01      3.0801   0.0768   0.9478   1.4485
     3   0      0.82900E+03   0.23725E+07   0.82399E+05   0.30402E+00      1.3423   0.0816   0.6379   1.0341
     3   1      0.15660E+04   0.38319E+07   0.96832E+05   0.35124E+00      1.4013   0.0816   0.6993   1.1334
     3   2      0.20270E+04   0.42636E+07   0.94699E+05   0.44952E+00      1.5274   0.0814   0.7773   1.2578
     3   3      0.24600E+04   0.49319E+07   0.99437E+05   0.54600E+00      1.8039   0.0814   0.8531   1.3798
     3   4      0.22240E+04   0.48486E+07   0.10281E+06   0.43699E+00      2.3514   0.0822   0.9135   1.4934
```


Radiative corrections may be significant

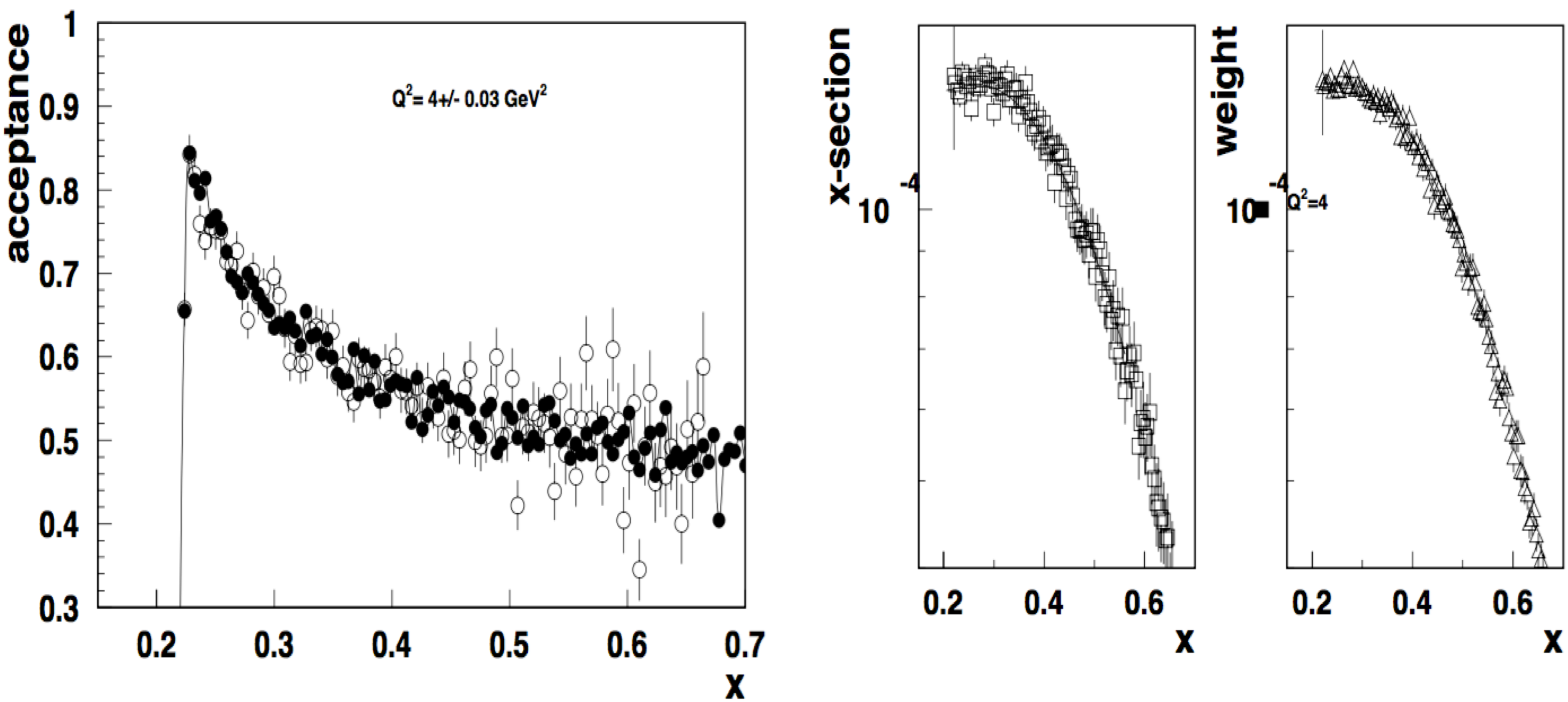
- Acceptance can be used to correct distributions for monitoring
- DIS output can be generated using input F_1,F_2 or F_2,F_L or directly x-sections

Recovering generated input from reconstructed set

Step-II

40Mil generated events (200x200 bins)

line N. Sato

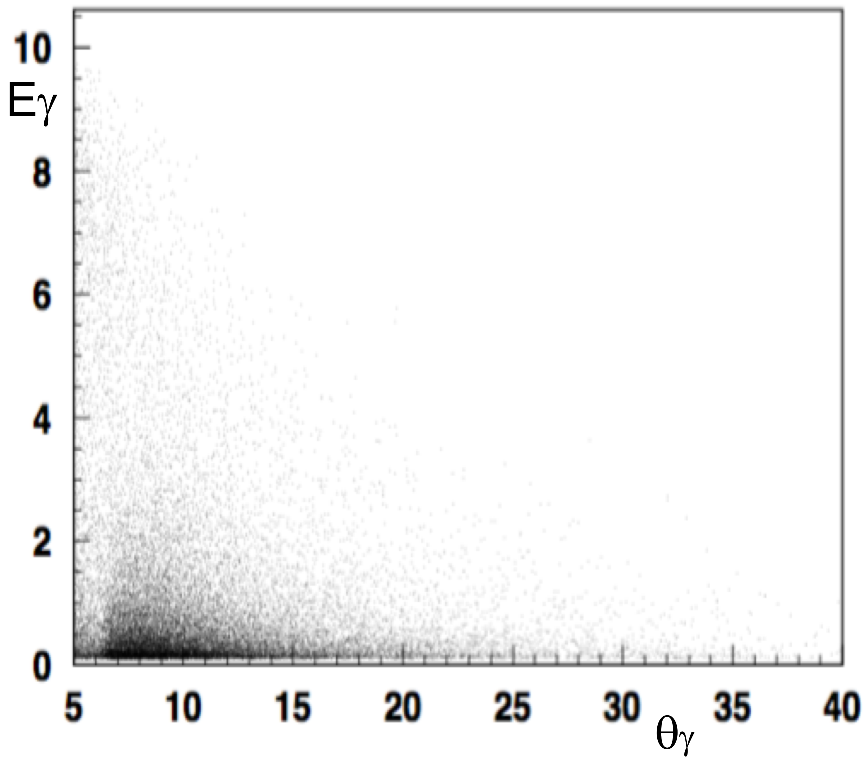


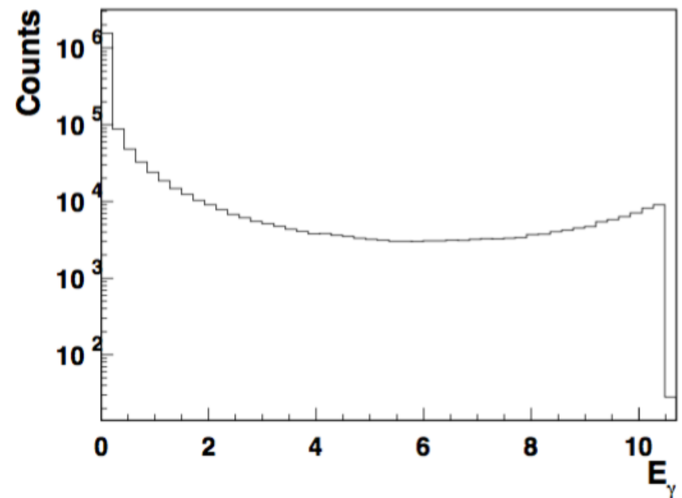
- Acceptance can be defined using the weighted generator set
- Both MCs after reconstruction recover the generated input in most of the kinematics.)

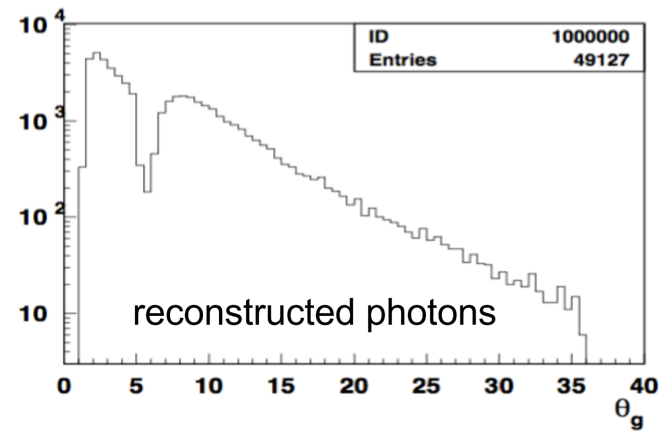
θ vs E’: json file for online monitoring

Dedicated DIS generator with radgen (gemc input)


```
        2     1     1       0.12       1.04   11     10.600 2212     1 0.6882683E-05 0.1235496E+00 11.55  8.13
  1 -1.     1      11  0  0   -1.2610    -0.0968     1.5722     2.0177     0.0005      -0.0185     0.0768    -0.4312
  2  0.     1      22  1  0    0.2821    -0.0185     0.3528     0.4521     0.0000      -0.0185     0.0768    -0.4312
```

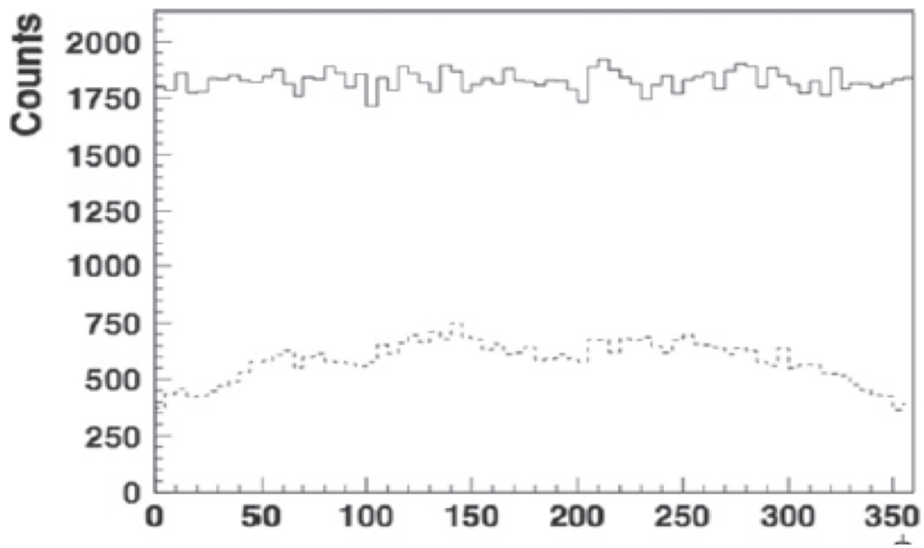



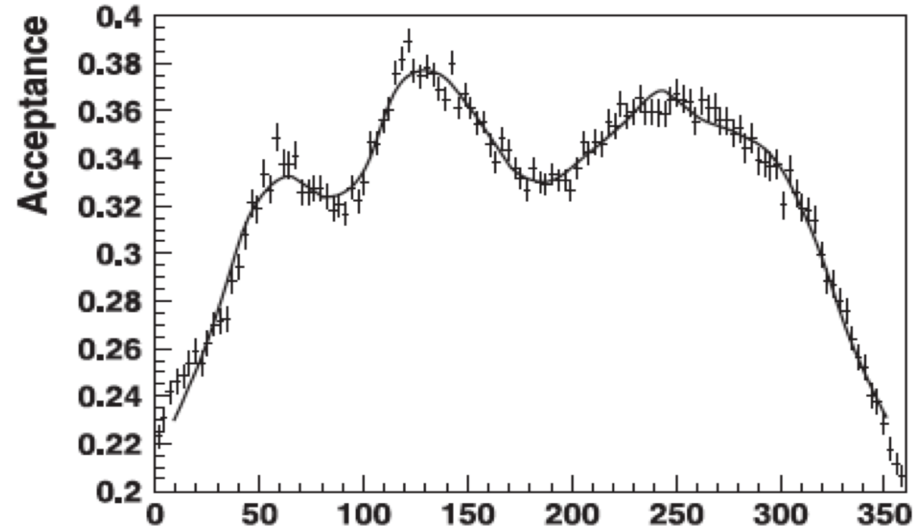




Significant fraction of DIS radiative photons may be reconstructed

Acceptance function





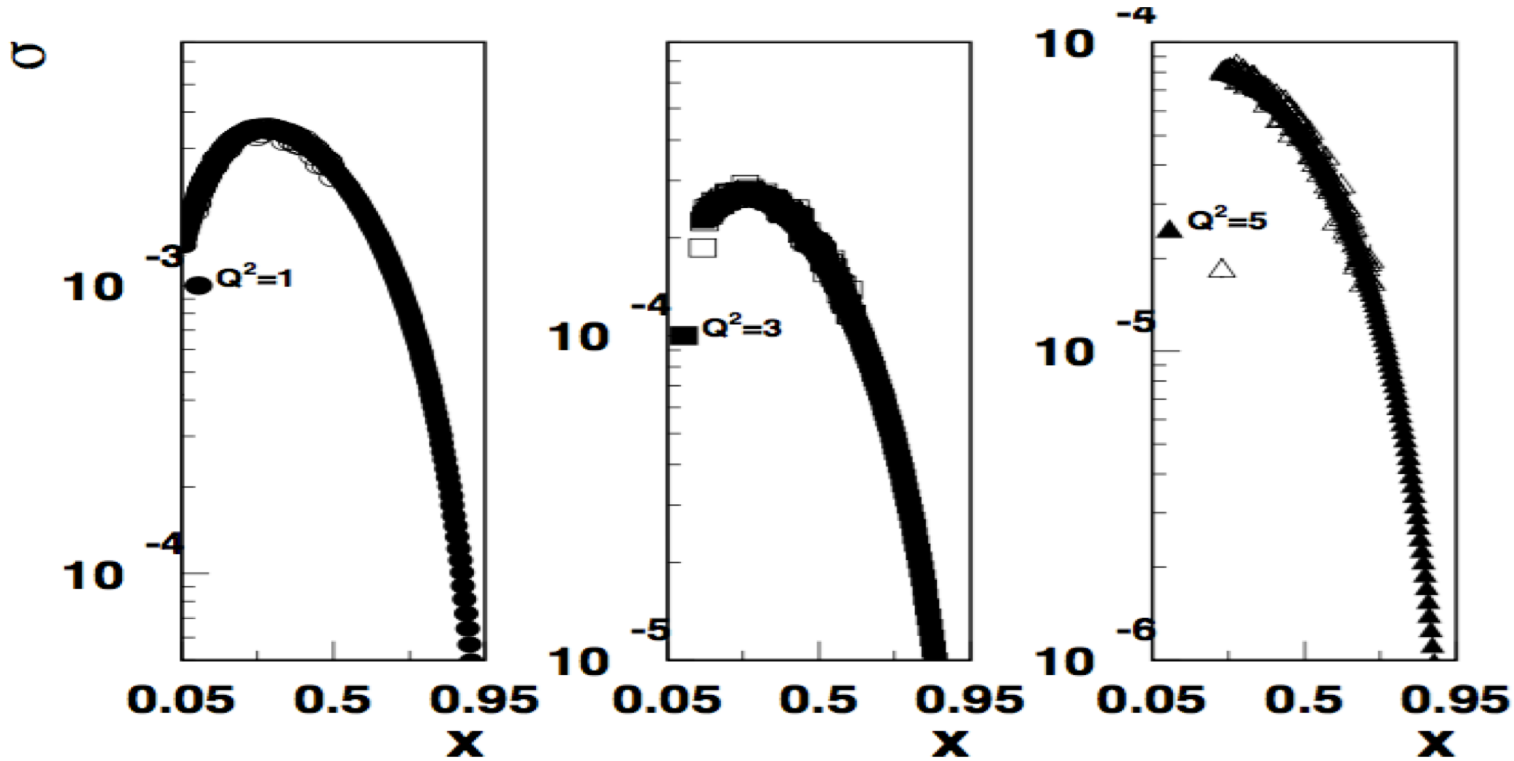
$$A\left(x, Q^2, P_T, z, \phi\right) = A_0\left(1 + \sum_{m=1}^{\infty} A_m \cos m\phi + \sum_{n=1}^{\infty} B_n \sin n\phi\right).$$

$$\begin{aligned}\sigma_{MN} = A(\phi)\sigma(\phi) = A_0\sigma_0 \Bigg\{ & 1 + \frac{1}{2}\left(\sum_{i=1}^{M} A_i a_i + \sum_{i=1}^{N} B_i b_i\right) \\ & + \cos\phi\left[a_1 + A_1 + \frac{1}{2}\left(\sum_{i=1}^{M-1} A_i a_{i+1} + \sum_{i=1}^{M-1} A_{i+1} a_i + \sum_{i=1}^{N-1} B_i b_{i+1}\right.\right. \\ & \left.\left. + \sum_{i=1}^{N} B_{i+1} b_i\right)\right] + \sin\phi\left[b_1 + B_1 + \frac{1}{2}\left(\sum_{i=1}^{M-1} B_{i+1} a_i - \sum_{i=1}^{M-1} B_i a_{i+1}\right.\right. \\ & \left.\left. + \sum_{i=1}^{N-1} A_i b_{i+1} - \sum_{i=1}^{N} A_{i+1} b_i\right)\right] + \ldots \Bigg\},\end{aligned}$$

Acceptance generates additional moments and modifies existing ones

Recovering generated input from generated set

Step-I



Reasonable agreement with generated input (filled symbols→N. Sato)

Generating DIS and SIDIS

Full event generator (PEPSI)

N_{tracks}	A	N	l-pol	N-pol	l-ID	E_{beam}	T	T-ID	process-ID	x-section
13	1	1	0.0	1.0	11	10.600	2212		1	0.8052759E+05

1	-1.	21	11	0	0	0.0000	0.0000	10.6000	10.6000	0.0005	0.0000	0.0000	0.0000
2	1.	21	2212	0	0	0.0000	0.0000	0.0000	0.9383	0.9383	0.0000	0.0000	0.0000
3	0.	21	22	1	0	-0.9974	-0.7292	3.5178	3.4109	-1.5059	0.0000	0.0000	0.0000
4	-1.	1	11	1	0	0.9974	0.7292	7.0822	7.1891	0.0005	0.0000	0.0000	0.0000
5	1.	13	2	0	6	-1.0092	-0.9040	3.2382	3.5102	0.0056	0.0000	0.0000	0.0000
6	0.	13	2103	2	0	0.0117	0.1747	0.2796	0.8389	0.7713	0.0000	0.0000	0.0000
7	1.	12	2	5	9	-1.0092	-0.9040	3.2382	3.5102	0.0056	0.0000	0.0000	0.0000
8	0.	11	2103	6	9	0.0117	0.1747	0.2796	0.8389	0.7713	0.0000	0.0000	0.0000
9	0.	11	92	7	10	-0.9974	-0.7292	3.5178	4.3492	2.2391	0.0000	0.0000	0.0000
10	2.	11	2224	9	12	-0.7729	-1.0806	3.4710	3.9069	1.2047	0.0000	0.0000	0.0000
11	-1.	1	-211	9	0	-0.2245	0.3514	0.0468	0.4422	0.1396	0.0000	0.0000	0.0000
12	1.	1	2212	10	0	-0.5843	-0.9049	2.3668	2.7645	0.9383	0.0000	0.0000	0.0000
13	1.	1	211	10	0	-0.1886	-0.1757	1.1042	1.1425	0.1396	0.0000	0.0000	0.0000

$$\frac{d\sigma}{dx\,dQ^2\,d\psi\,dz\,d\phi_h\,d|\boldsymbol{P}_{h\perp}|^2} = \frac{\alpha^2}{xQ^4}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\left\{F_{UU,T}+\varepsilon F_{UU,L}\right\}.$$

0 (twist-4)

Dedicated (inclusive pion generator)

	2	1	1	1.0	1.0	11	10.600	2212	1	0.1108596E-01			
1	-1.	1	11	0	0	-0.7583	-0.7440	3.9571	4.0972	0.0005	-0.0174	0.0305	1.3425
2	1.	1	211	0	0	0.8698	-0.6332	3.2529	3.4291	0.1396	-0.0174	0.0305	1.3425
	2	1	1	1.0	1.0	11	10.600	2212	1	0.4220764E-02			
1	-1.	1	11	0	0	-1.1716	0.9665	3.2259	3.5656	0.0005	0.0016	-0.0436	-1.5889
2	1.	1	211	0	0	0.1630	-0.4267	3.5986	3.6302	0.1396	0.0016	-0.0436	-1.5889

$$\frac{d\sigma}{dx\,dQ^2\,d\psi} = \frac{2\alpha^2}{xQ^4}\,\frac{y^2}{2\,(1-\varepsilon)}\left\{2(1-\varepsilon)xF_1(x,Q^2)+\varepsilon(1+\gamma^2)F_2(x,Q^2)\right\}$$

Dedicated DIS generator

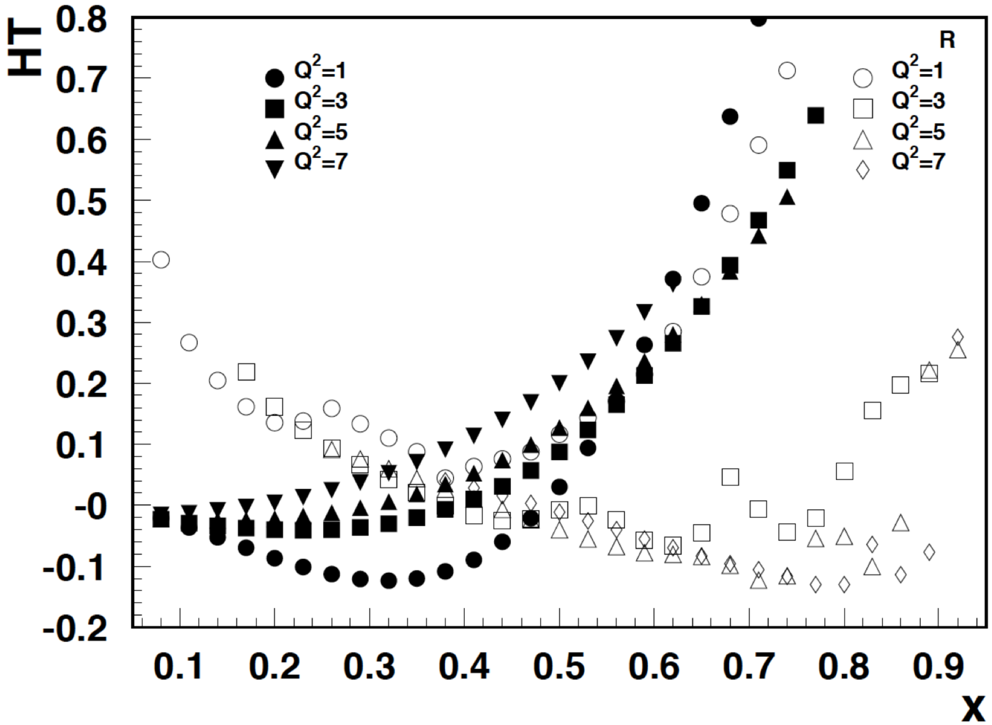
	2	1	1		0.12	1.04	11	10.600	2212	1	0.6882683E-05	0.1235496E+00	11.55	8.13
1	-1.	1	11	0	0	-1.2610	-0.0968	1.5722	2.0177	0.0005	-0.0185	0.0768	-0.4312	
2	0.	1	22	1	0	0.2821	-0.0185	0.3528	0.4521	0.0000	-0.0185	0.0768	-0.4312	

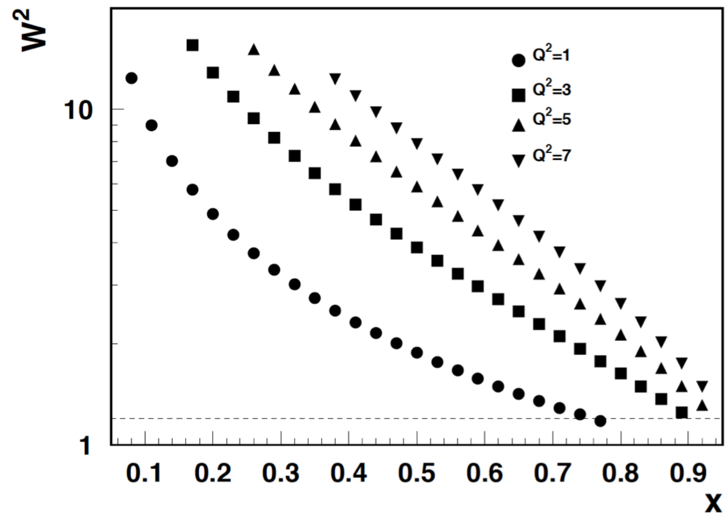
DIS input from theory and phenomenology

Study the effect of F_UU,L (accounted in DIS and ignored in SIDIS)

$$F_2(x,Q^2) = F_2^{\rm LT}(x,Q^2)\left(1+\frac{C_{\rm HT}(x)}{Q^2}\right)$$

$$1+R=\frac{(1+\gamma^2)F_2}{2xF_1}$$

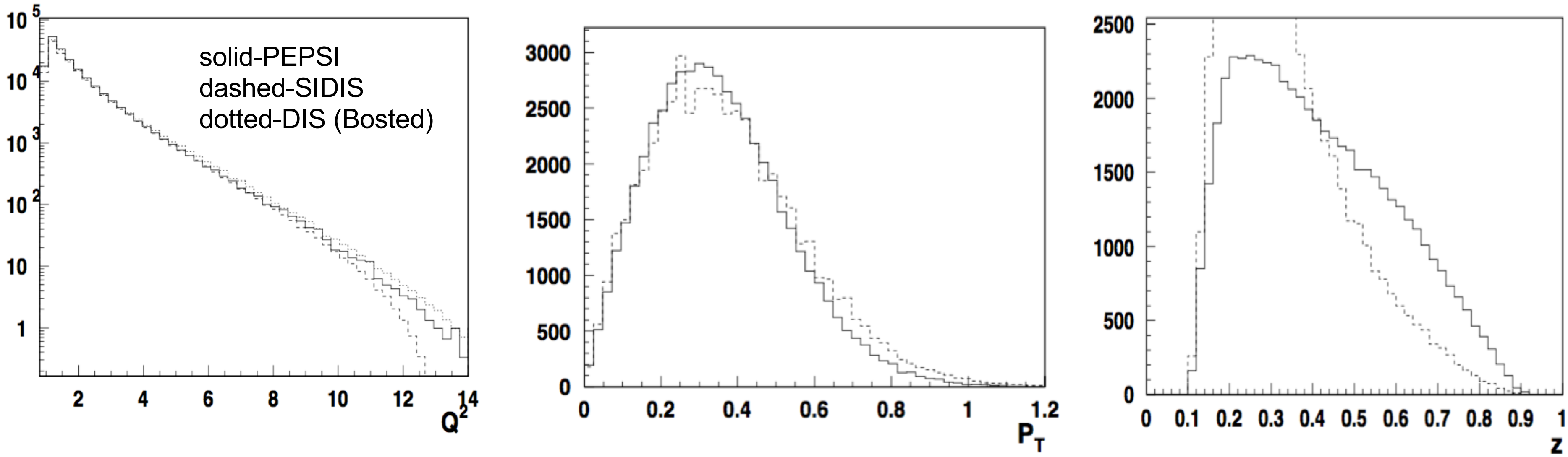




Consistent in kinematics, where HT are not significant

- Different Q^2-dependent factors contribute.
- Separation is important for DIS, but will be critical for SIDIS

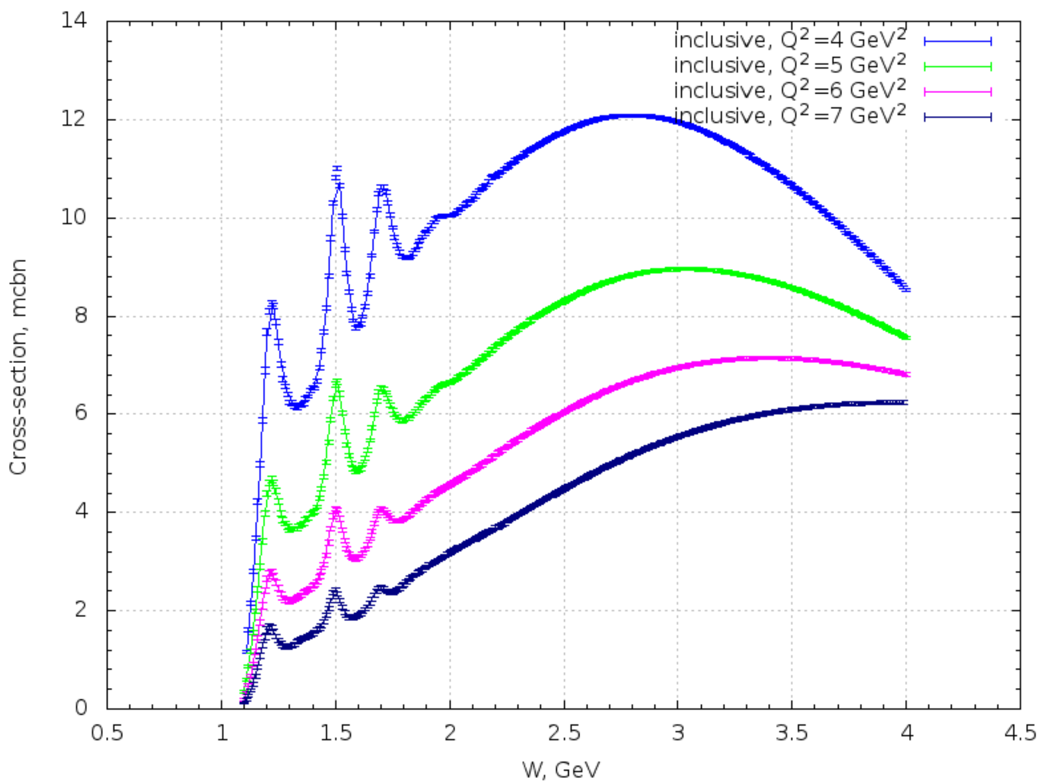
Kinematic distributions



eπX evnts compared with eπX events from PYTHIA tuned to data

Simple event generator should be “reasonable”

CLAS and Projected CLAS12 Inclusive Cross Sections



CLAS Data were obtained at Q^2<4.7 GeV^2

Projected CLAS12 results

- Electron beam energy: 10.6 GeV
- Integrated luminosity: $12.8*10^{10}$ mb^{-1}
- Bin sizes: W= 0.01 GeV and Q^2= 0.1 GeV^2
- Expected statistical accuracy in the range from 0.2% to 2.0%

- First precise measurements of inclusive cross section evolution with W and Q^2 in the resonance region *(smallest bin sizes over W, Q^2 ever achieved)*
- Yield valuable insight into quark hadron duality