EICUG-MCnet MCEG Workshop

Summary of workshop

Feb. 20 – 22

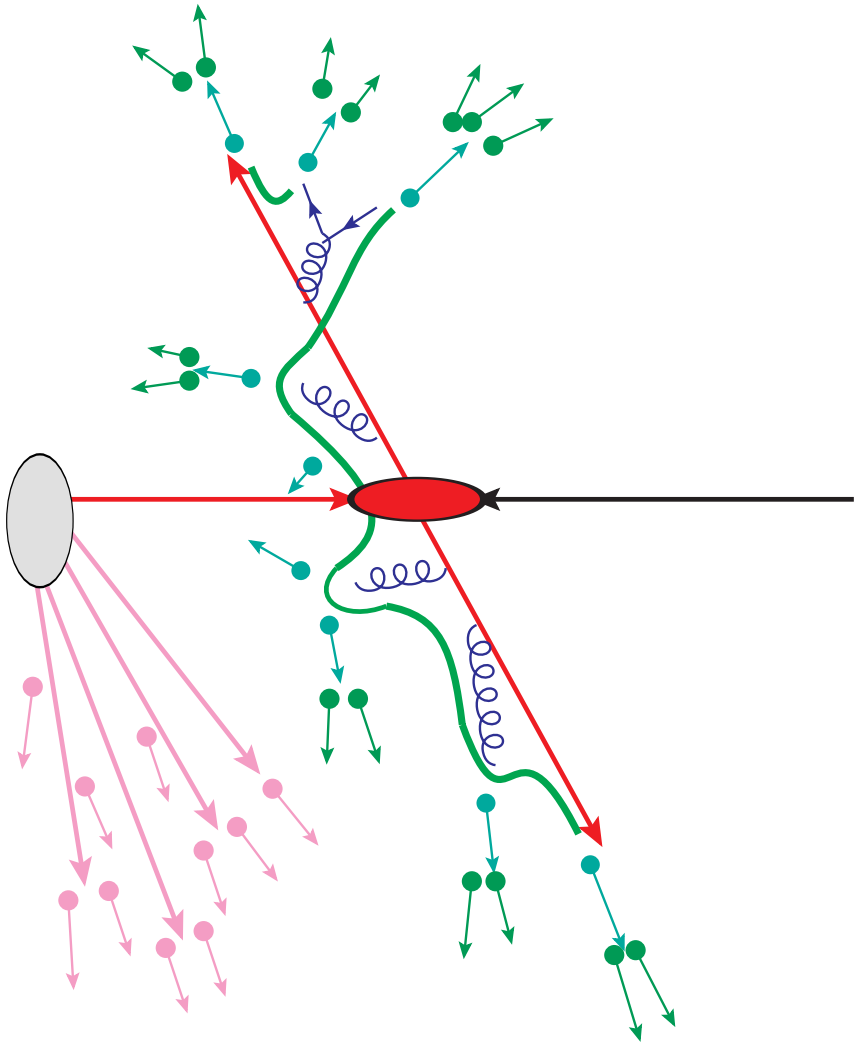
DESY

Elke-Caroline Aschenauer (BNL), Andrea Bressan (Trieste), Markus Diefenthaler (JLAB), Hannes Jung (DESY), and Simon Plätzer (Vienna)

Monte Carlo Event Generator

MCEG

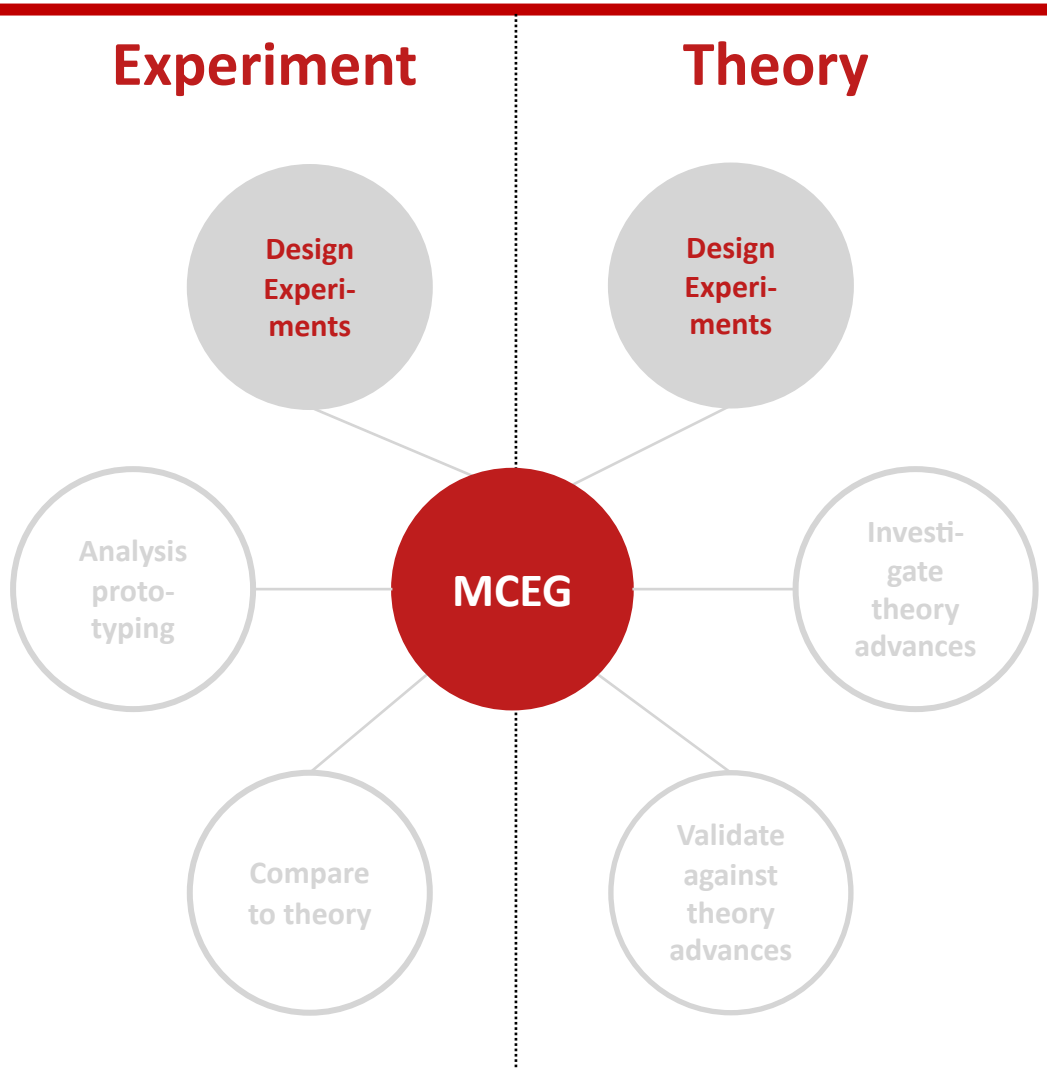
- faithful representation of QCD dynamics
- based on QCD factorization and evolution equations



Algorithm of general-purpose MCEG

1. Generate kinematics according to fixed-order matrix elements and a PDF.
2. QCD Evolution via parton shower model (resummation of soft gluons and parton-parton scatterings).
3. Hadronize all outgoing partons including the remnants according to a model.
4. Decay unstable hadrons.

MCEG in Experiment and Theory



Lesson from HEP High-precision QCD measurements require high-precision MCEGs

Workshop: MCEGs for future ep and eA facilities

22+ participants

Workshop history

- Started as satellite workshop during POETIC-8

POETIC 8
8th International Conference on Physics Opportunities at an ElecTron-Ion-Collider
19-23 March 2018, University of Regensburg

- Collaboration EICUG-MCnet

Goal of workshop series

- Requirements for MCEGs for ep and eA
- R&D for MCEGs for ep and eA

Focus of DESY workshop on Feb. 20 – 22

- Status of ep and eA in general-purpose MCEG
- Status of NLO simulations for ep
- TMDs and GPDs and MCEGs
- Merging QED and QCD effects

Program

Website

Wednesday, February 20, 2019

14:00 - 15:45 General-Purpose MCEG: Precision for ep processes

- 14:00 **Intro** *5′*
  Speaker: Dr. Hannes Jung (DESY)
  Material: Slides
- 14:05 **Simulation of ep and eA processes in general-purpose M**
  Speaker: Dr. Ilkka Helenius (University of Jyväskylä)
  Material: Slides
- 14:35 **Status of higher-order QCD predictions for DIS** *30′*
  Speaker: Dr. Stefan Hoeche (SLAC)
  Material: Slides
- 15:05 **Status of MG5 aMC@NLO for ep colliders** *10′*
  Speaker: Dr. Buarque Franzosi Diogo (Chalmers University of T
  Material: Slides
- 15:15 **Discussion** *30′*

15:40 - 16:00 Coffee

16:00 - 18:00 General-Purpose MCEG: Combining QED+QCD effects

- 16:00 **QED corrections for electron scattering** *30′*
  Speaker: Prof. Hubert Spiesberger (Johannes Gutenberg- Unive
  Material: Slides
- 16:30 **Semi-analytic vs. Monte-Carlo Approaches for QED Corre**
  Speaker: Prof. Andrei Afanasev (George Washington University
  Material: Slides
- 17:00 **Discussion and next steps** *1h0′*

Thursday, February 21, 2019

09:00 - 10:30 TMDs and MCEGs: Part I

- 09:00 **TMDs from Parton Branching** *30′*
  Speaker: Dr. Francesco Hautmann
  Material: Slides
- 09:30 **nTMD using PB method** *30′*
  Speaker: Prof. Krzysztof Kutak (Institute of Nuclear Physics Polish Academy of Sciences)
  Material: Slides
- 10:00 **Updates for KaTie** *30′*
  Speaker: Dr. Andreas van Hameren (Institute of Nuclear Physics Polish Academy of Sciences)
  Material: Slides

10:30 - 11:00 Coffee

11:00 - 12:00 TMDs and MCEGs: Part II

- 11:00 **TMD and parton shower: CASCADE-3** *30′*
  Speaker: Dr. Hannes Jung (DESY)
  Material: Slides
- 11:30 **Revisited version of a recursive model for the fragmentation of polarized quarks** *30′*
  Speaker: Albi Kerbizi (University of Trieste)
  Material: Slides

12:00 - 14:00 Lunch

14:00 - 15:30 TMDs and MCEGs: Part III

- 14:00 **Discussion: TMDs and MCEG** *1h30′*

15:30 - 16:00 Coffee

16:00 - 18:30 GPDs and MCEGs

- 16:00 **Towards event generation for GPD physics with PARTONS** *30′*
  Speaker: Dr. Herve Moutarde (IRFU, CEA)
  Material: Slides
- 16:30 **DVCS and exclusive pi0 event generator for JLab fixed-target experiments** *30′*
  Speaker: Dr. Carlos Munoz Camacho (IPN-Orsay)
  Material: Slides
- 17:00 **Discussion: GPDs and MCEGs** *1h0′*

Friday, February 22, 2019

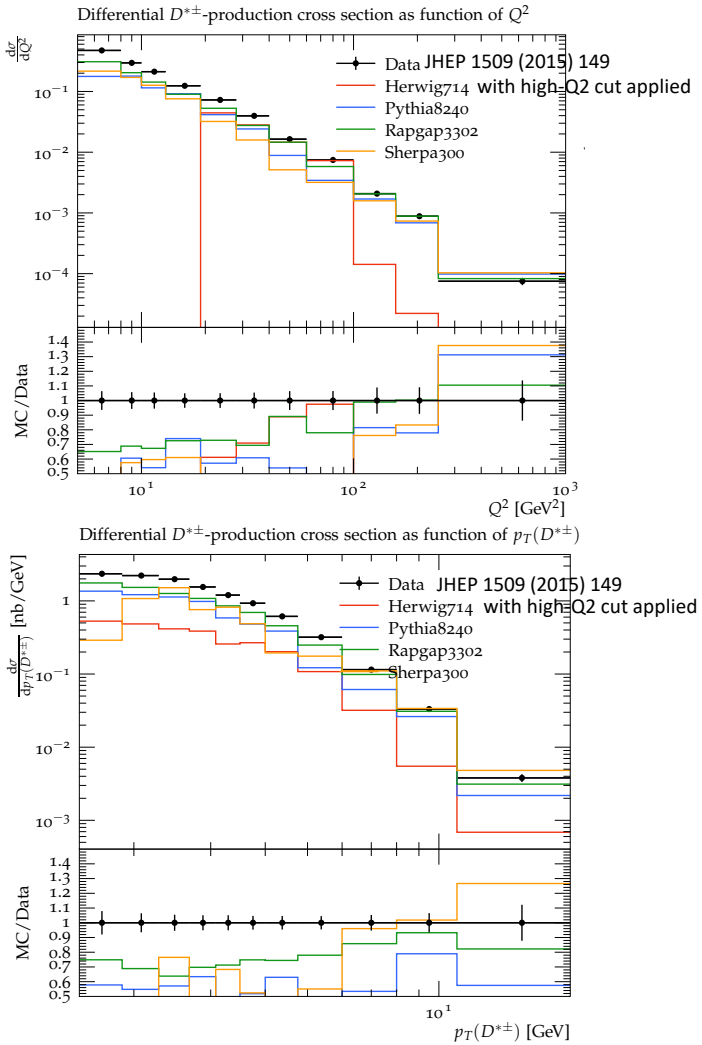
09:00 - 10:30 Requirements

- 09:00 **Physics at an EIC: Consequences for MC Generators** *30′*
  Speaker: Dr. Elke-Caroline Aschenauer (BNL)
  Material: Slides
- 09:30 **Jets in eA Collisions: Challenges and Opportunities for MCEGs** *30′*
  Speaker: Dr. Kolja Kauder (BNL)
  Material: Slides
- 10:00 **Discussion** *30′*

10:30 - 11:00 Coffee

11:00 - 12:00 Wrapping up

Comparisons to combined H1 and ZEUS analysis (A. Verbytskyi)

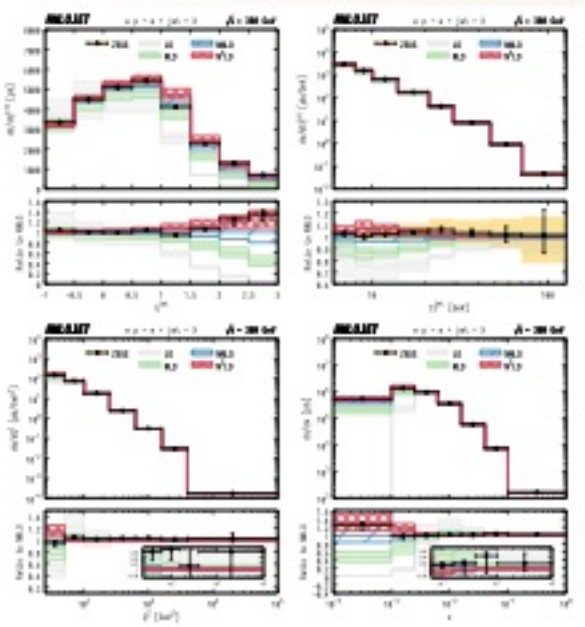


General-purpose MCEG and ep collisions

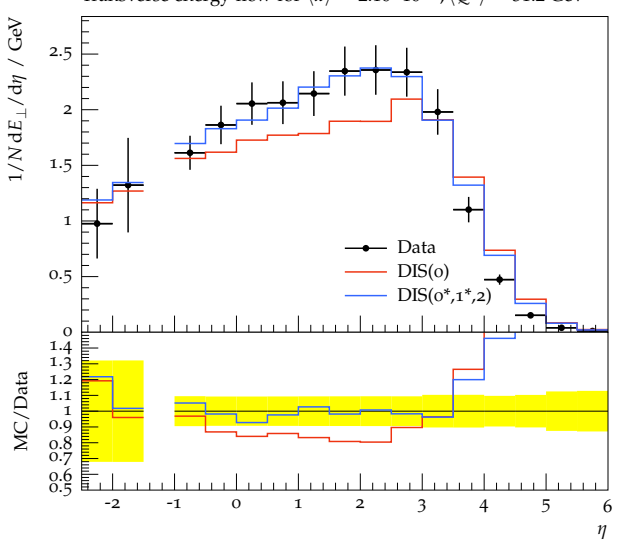
- **Sherpa**
  - DIS with ME corrections and PS merging
  - Good description of jet data at low Q^2 with $\gtrsim 3$ partons in the final state
  - Automated NLO matching with Powheg method, applicable for jets at high-Q^2
- **Herwig**
  - Two shower options with spin correlations and NLO matching
  - Good description for single-particle properties in DIS
  - Also QED radiation for angular-ordered shower
- **Pythia**
  - Possible to generate DIS events with the new dipole shower implementation
  - Higher-order corrections via Dire plugin, soon part of Pythia core
  - Photoproduction for hard and soft QCD processes, also hard diffraction
- **Detailed comparisons between modern MCEG and HERA data**
  - **Feb 18—20** Workshop on Rivet for ep, rivet-ep-l@lists.bnl.gov mailing list
  - HERA data not (yet) included in MCEG tunes

General-purpose MCEG and eA collisions

- No strong modifications for DIS (nuclear PDFs, what else?)
- For photoproduction need to include interactions between resolved photon and other nucleons
- Complementary to ultra-peripheral collisions at the LHC and RHIC



arXiv:1803.09973



Fixed-order QCD

- QCD calculations available up to N^{3}LO for inclusive DIS
- Peculiarities of DIS require careful selection of scales
- Excellent description of experimental data from HERA

MC event simulation

- DIS simulations available in all three event generation frameworks
- NLO matching & merging standard, NNLO matching available
- Peculiarities of DIS require careful selection of clustering history
- Very good description of wide range of experimental data

TMDs and MCEGs

Vibrant community

MCEG Workshop
DESY, February 2019

F Hautmann

TMDs from Parton Branching

First all flavor. all Q^2, all x and all k_t TMD at NLO determined.

- Introduction
- The Parton Branching (PB) method
- New results and applications

F Hautmann: MCEG Workshop, DESY - February 2019 1

TMD and parton shower: CASCADE-3

Hannes Jung (DESY)

with contributions from
A. van Hameren, K. Kutak, A. Kusina,
A. Bermudez Martinez, P. Connor F. Hautmann, O. Lelek, R. Zlebcik

- From inclusive to exclusive distributions
- Parton Branching method for TMDs

First TMD parton shower using higher order splitting function.

H. Jung, TMD and Parton Shower CASCADE3 , MCEG for future ep facilities, Hamburg, Feb 2019 1

NCN

nTMD using PB method

Krzysztof Kutak

Instytut Fizyki Jądrowej
im. Henryka Niewodniczańskiego
Polskiej Akademii Nauk

First all Q^2, all x, all k_t TMD at NLO for nuclei. Comparison with DY data (pp, pPb, CMS)

Updates for KaTie

Andreas van Hameren
Institute of Nuclear Physics
Polish Academy of Sciences
Kraków

presented at the
MCEGs for future ep and eA facilities
21-02-2019, DESY, Hamburg

First ever off-shell hard process calculation for ep including all flavors.

Lively discussion: Factorization Theorem and MCEG approaches

To what extent are TMDs a result of a coherent branching evolution as, e.g., implemented in Herwig

Next: Comparison to TMD theory

Extract TMD from the different MCs and compare to analytic results.

UNIVERSITÀ
DEGLI STUDI DI TRIESTE

21st February 2019,
DESY,
Hamburg

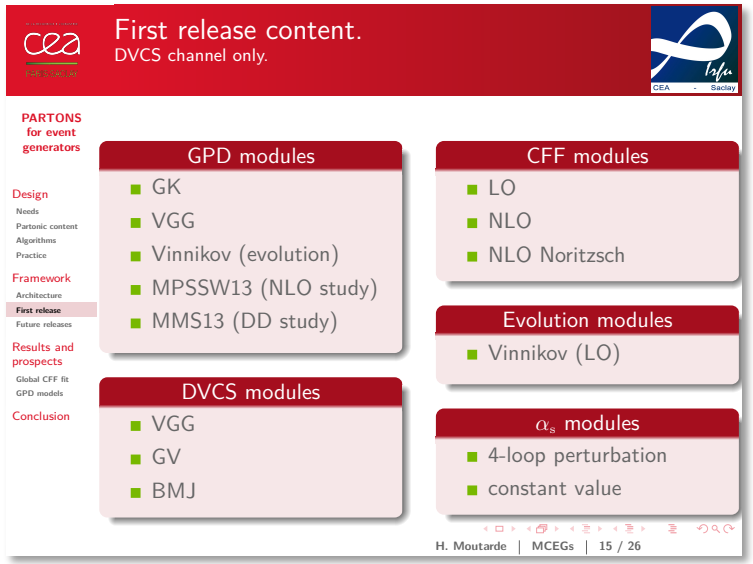
INFN
Istituto Nazionale di Fisica Nucleare

Revisited version of a recursive model for the fragmentation of polarized quarks

Albi Kerbizi
University of Trieste. Trieste INFN Section

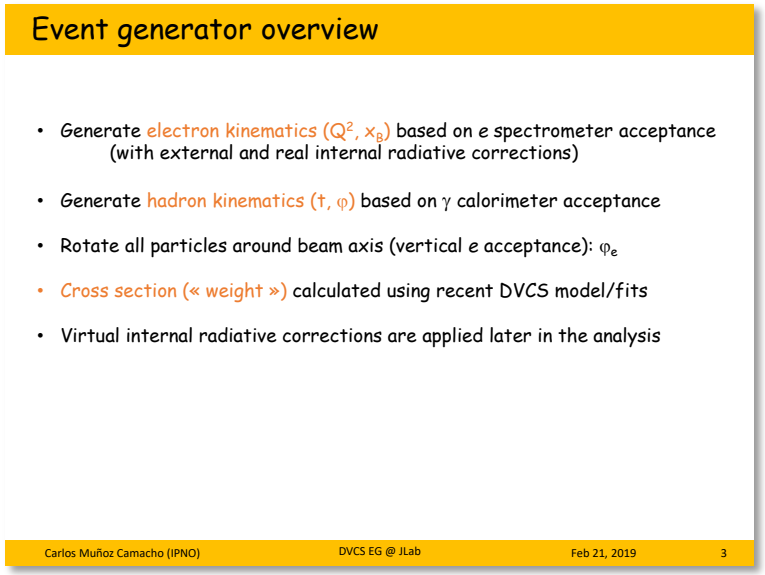
Lund string + 3P0; good description of Collins and di-hadron asymmetries; Boer-Mulders, jet handedness can be simulated.

GPDs and MCEGs



Hervé Moutarde (IRFU, CEA): Towards event generation for GPD physics with PARTONS

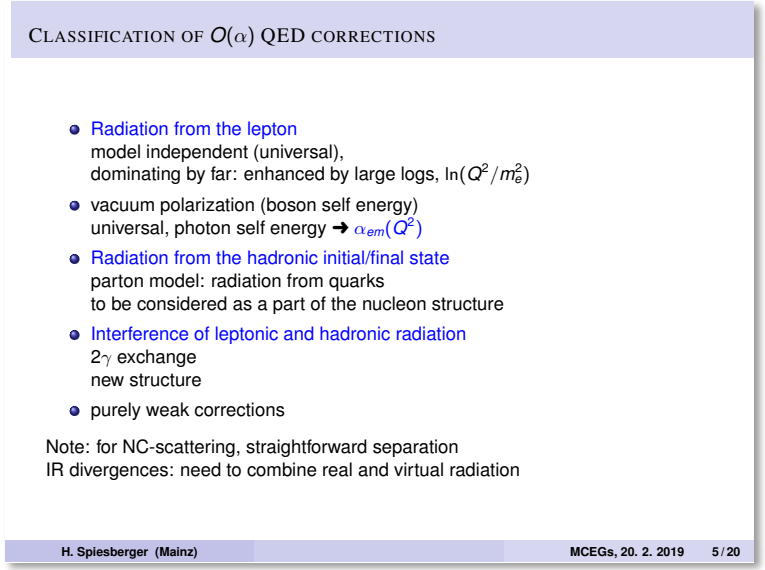
- GPD framework should become available to a wide community of users. Forthcoming v2 with TCS as a demonstration of multi-channel capacity.
- Extreme modularity should benefit to event generation.
- Extension beyond GPD physics through a Virtual Access structure within STRONG2020 program.



Carlos Muñoz Camacho (Orsay): DVCS and exclusive π^0 event generator for JLab fixed-target experiments

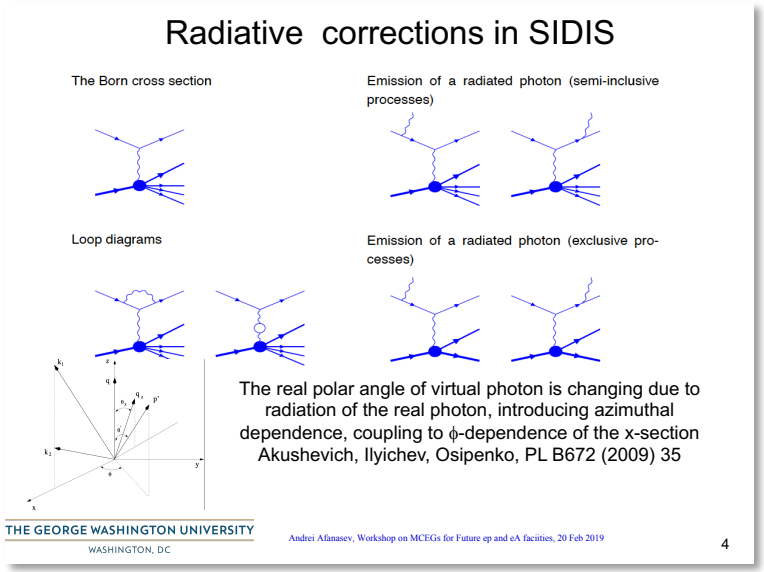
- MCEG for DVCS and exclusive π^0 production available (used for JLAB analysis for the last ~15 years).
- DVCS cross section implemented based on CCF lookup table.
- No explicit background generated – only pure DVCS/π0 events.
- C++ based code. Parameters set via C++ script or via MySQL database (as a function of configuration number).
- Portable to collider configuration, but not done.

Merging QED and QCD effects



Hubert Spiesberger (Mainz): QED corrections for electron scattering

- High-precision measurements need careful treatment of radiative corrections.
- Closely related to experimental conditions need full Monte Carlo treatment (Unfolding) including simulation of hadronic final states.
- The basics are known and available …
- … but improvements are needed.



Andrei Afanasev (GWU): Semi-analytic vs. Monte-Carlo Approaches for QED Corrections to SIDIS

- Consistent approach to address RC for SSA in polarized SIDIS

- SSA due to two-photon exchange need to be included in analysis of SSA from strong interaction, of same size at JLAB experiments
- More detailed calculation of the two-photon exchange at quark level required: elastic scattering, inclusive, semi-inclusive, and exclusive DIS

Next steps: Discussion based on review by Elke-Caroline Aschenauer (BNL)

- **General-purpose MCEG**s, HERWIG, PYTHIA, and SHERPA, will be significantly improved w.r.t. MCEGs at HERA time:
  - MCEG-data comparisons in Rivet will be critical to tune the MCEGs to DIS data and theory predictions.
  - The existing general-purpose MCEG should soon be able to simulate NC and CC unpolarized observables also for eA. A precise treatment of the nucleus and its breakup is needed.
  - First parton showers and hadronization models for ep with spin effects, but far more work needed for polarized ep / eA simulations.
  - Need to clarify the details about merging QED+QCD effects (in particular for eA).
- **TMD physics**
  - Vibrant community working on various computational tools for TMDs.
  - CASCADE: MCEG for unpolarized TMDs at high energy.
  - Need more verification of MCEG models with TMD theory / phenomenology.
- **GPD physics**
  - No modern MCEG available.
  - There is a path from PARTONS to a GPD MCEG, similar there is a project to extend MCEG for exclusive processes from JLAB12 to EIC.

MCEG for ep We are on a very good path, but still quite some work ahead.
MCEG for eA Less clear situation about theory and MCEG.