Updates for dileptons (BH+Compton, quarkonia)
Simulations & physics considerations

1) Crossing angle questions

2) Angular correlations for final lepton pair + solutions to interference with BH

3) Interpretations, GPDs, concern of antisymmetrization on physics, solutions

4) Updates on generator

5) More on simulations and next steps

Marie Boër (VT), Sept. 24th, 2021 – ECCE exclusive PWG meeting

1) Question on crossing-angle correction on physics and kinematics

* Contacted Jin and Wim
Wim: "(…) good question"

Jin:
A) Beam energy:
"use E_lab * cos(12.5mrad)"
* "(… depend process…) not introduce beam energy spread, which is on the order of 10^-3 to 10^-4 level."
→ neglect? But risk of under-evaluating associated pion background rate

B) Polarization observables
 "start with perfect polarization four-vector in lab frame, boost-rotate (...) use the CoM polarization four-vector in the event generator input setting for the beams. There may be a small transverse component"
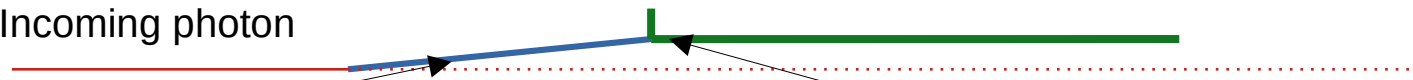
C) [what I suggested as discussed last week]
1. neglect these corrections? (then uncertainties should be estimated on all momenta and observables)
2. include all corrections at generator level but not rotating at generator level? (then propagate uncertainties)
3. include the rotation + all corrections at the generator level to have all calculations correct by waving approximations, and then disable crossing angle at the later step

Jin: "(…) number 2 And if it gets too confusing, one can always choose perform everything in your generator"

=> I implemented Jin's correction on beam E (for now polarized observables are disabled) and I am taking "method 2" as recommended

2) Angular correlations for final lepton pair + solutions to interference with BH

Incoming photon

Intermediate state (photon, meson)
Angle depends on E, t, Q'2 (or mass) (photoprod)
Or y, Q2, t, Q'2 (or mass) (electroprod)

Final lepton angle
"near singularities" 1/m^2 when 1 lepton is (near) collinear to
initial photon. The other one almost "at rest"

- predominant effect in TCS+BH. To absolutely take into account: cuts, redefinition observables, integration range
- safer in mesons (wave-function distribution) but not completely + interference with BH
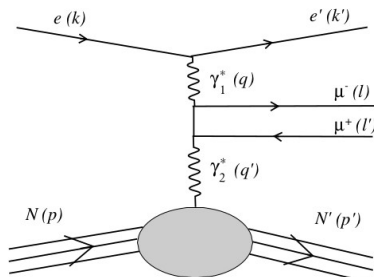=> Solutions:
- redefining observables with "dynamic" safe-integration range over theta
- phase-space kinematic cuts at generator + analysis level
- using a weighted generator (avoid spikes + saturation of "unsafe" region – region also bad for physics)

Kinematic dependent table: E, t, Q'2 and xbj, Q2, t, Q'2. Defines range in theta. To compare to corrected projections
→ using BH table for all dilepton final states, with no mass (electrons) or mass (muons) → at the 2 "extreme" energies
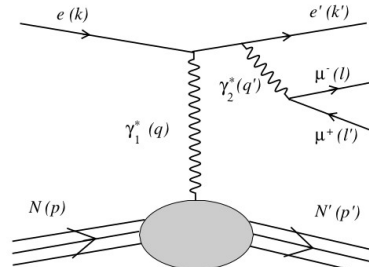
Interfering BH:
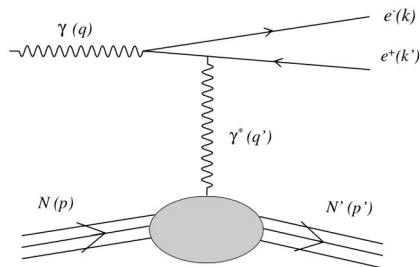
Photoprod.   Electoprod: left="danger", right="ok"

3) Interpretations, GPDs, concern of antisymmetrization on physics, solutions

2 similar fermions in final state = antisymmetrization of wave function [see next slide]
→ extra anti-symmetrization and cross terms
→ not possible to extract GPDs
→ maybe spectroscopy (need advice from expert)
=> electroproduction of (J/psi, Upsilon, DDVCS, …) into electrons cannot be studied for GPDs

2 solutions: Photoproduction (quasi-real): TCS, heavy mesons; or for future into muons: DDVCS, mesons

Regions where Q2 approaches Q'2 or meson masses: we don't know the interpretation
→ can only be rejected for now. Projections won't be accurate
→ modelization work and theory experts needed
→ can learn more from low energy experiments and production mechanisms (also from SIDIS)

GPD evolution if electroproduction or TCS

Remaining things:
- realistic mesons wave-function with polarization effects on theta distributions
- correction to non-zero Q2 in photoproduction (quasi-real) → more impact on polarization observables than x-sec
- background: associated pions? Inclusive, light mesons...

Current solution:
Photoproduction into electrons, some corrections to Q2 applied but not on polarization,
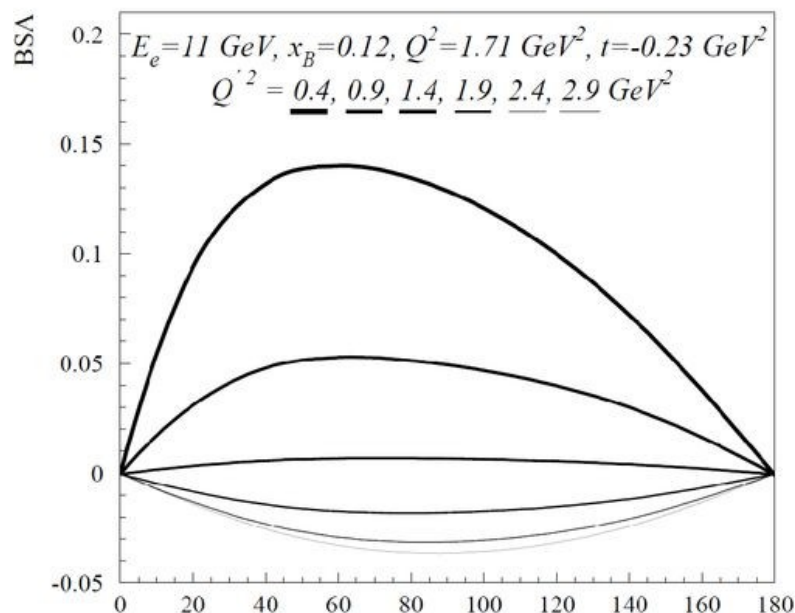**Need to detect e+e-P (selected regions), quite-symmetric events**
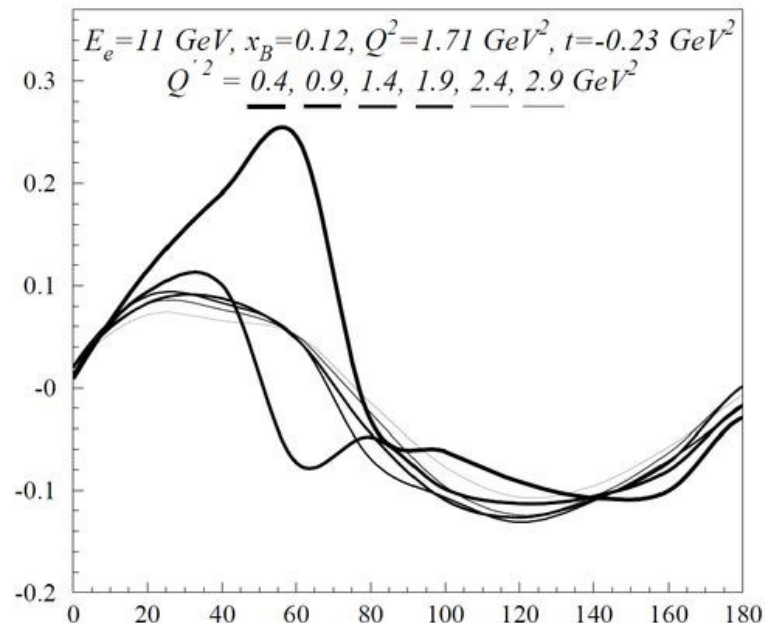→ **feasibility ?**

Example with DDVCS
Similar issue expected with all electron→ electron pair reactions
+ interference with BH-type process

Dimuons vs e+e- pair

w/o anti-symmetrization   w anti-symmetrization

BSA

E_e=11 GeV, x_B=0.12, Q^2=1.71 GeV², t=-0.23 GeV²
Q'^2 = 0.4, 0.9, 1.4, 1.9, 2.4, 2.9 GeV²

E_e=11 GeV, x_B=0.12, Q^2=1.71 GeV², t=-0.23 GeV²
Q'^2 = 0.4, 0.9, 1.4, 1.9, 2.4, 2.9 GeV²

Michel Guidal, Dileptons Trento Workshop October 2016

4) Updates on generator

- factorization scale fixed to meson mass (quarkonia) or Q'2 (TCS)
- used more function calls from JLab version rather than from this summer updates (well checked for years)
- implemented 2 paths for photoproduction: for cross-checks + more universal
- changed input kinematics (still have to check and Jacobian for x-sec) / may generate log instead of flat
- changed way to boost from collider to lab (still want to double check another day)
- want to do some cleaning and have another student to double check everything (Erik Wrightson is back)

cross-checks:
- contacted Charlotte who did similar work for LHC and has actual data "in hands"
- for JLab version: TCS, VCS options checked and accurate towards actual Hall D and Hall C data
- BH, Compton: calculation checked. Quarkonia: used well-known references, compared to HERA

Supported modes in DEEPSim (or soon to be ready)
- J/psi and Upsilon into electrons or muons (photoproduction, quasi-real, electroproduction)
Weighted or unweighted data, several tuning
- Rho into pions (photoproduction, quasi-real, electroproduction)
Unweighted only, as weighted not yet checked (will likely take another model)
- TCS+BH into electrons or muons (photoproduction, quasi-real)
Unpolarized + polarized, unweighted OK, weighted: <u>need to run more tables on farm</u>
- DDVCS+BH into muons (electroproduction)
Unpolarized, electron polarized, unweighted OK, weighted: <u>need to run more tables on farm</u>
- Pure BH into electrons or muons (photoproduction, quasi-real, electroproduction)
With TCS or DDVCS options, "fast option" not yet checked

5) More on simulations and next steps

1) Once cleaning of code is final (1 day?) + checks from Erik (1 week?)
=> re-producing data at 2 energies for TCS, J/psi, Upsilon photoproduction into electron

2) converter to Lund from Stuart. Plugging kinematic file?
- Generator analyzer from Marie + students (need to update it), can convert Root to anything
- tried to output into HEP3 but not clear (need help) / HEP(1)+kin file already there
EICsmear will take Lund or HEP3, but for Lund I need to plug the kin file as well

3) Run with Fun4all
Looking on my side + in collaboration with Stuart (for once I reproduce new files)

Idea is to make only
one compiled C++code
environment out of this
(more efficient)

To finish / to do:

- final checks on generator + independent x-check + comparison to other / actual data

- new tables for dynamic cuts and for Compton weighting (JLab farm)

- projected kinematic and regions of physics interest / observables with accurate integration range

- experimental projections

To do but later:

- finish rho and omega

- polarized cross sections (+ all related crossing angle and Q2 corrections)

- muon pairs