ZEUS for EIC

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Overview

- Technical site:
  - Some physics cases are listed.
- Technical side:
  - ZEUS data[1] is available in RZG(Garching) and DESY.
  - The data is stored in ROOT ntuples.
  - Analysis: anywhere for RZG or local-only in DESY on 2 machines+batch.
  - Analysis is welcome and will have consulting support from MPI and DESY ZEUS groups.

[1] Data and MC simulated samples.

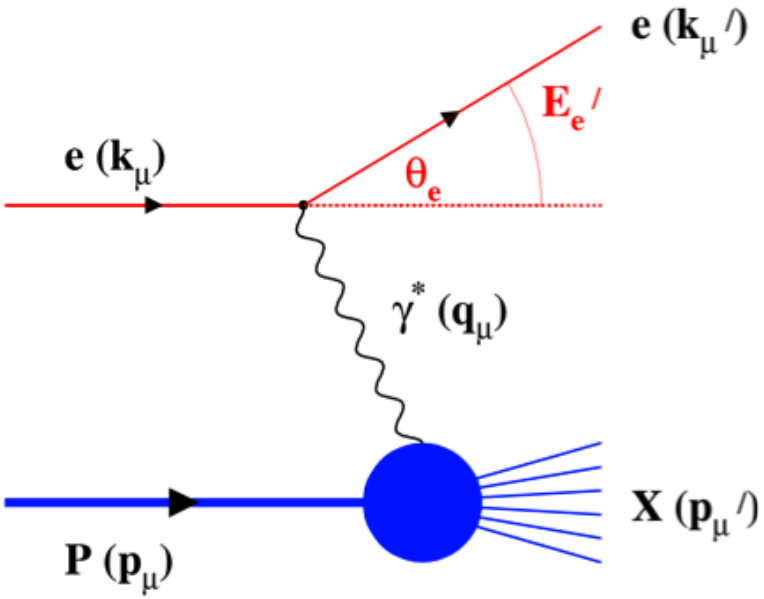
Physics

What can be done

- ZEUS analysis with an idea to combine with future EIC data.
- Technical/performance study with data and MC for the EIC.
- ...

In general: What EIC groups would like to do and for what there is manpower, good reason and a technical opportunity.
Some examples:

Inclusive DIS

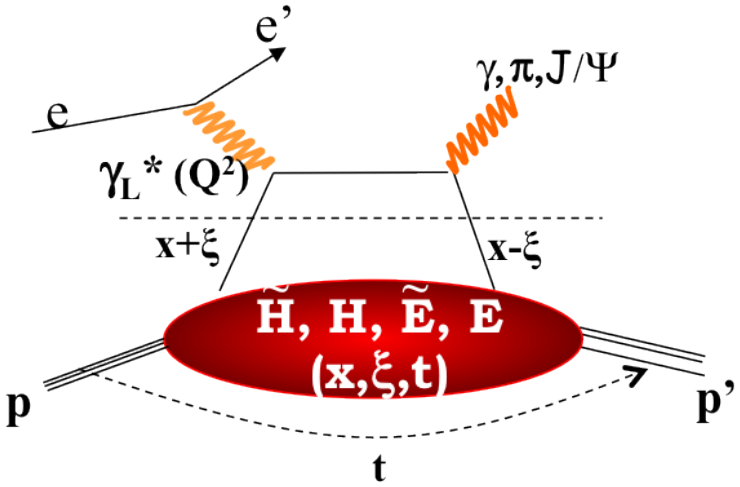


F_L and F_2 measurements like

- H. Abramowicz *et al.* [ZEUS Collaboration], Phys. Rev. D **90** (2014) no.7, 072002 doi:10.1103/PhysRevD.90.072002 [arXiv:1404.6376 [hep-ex]].
- V. Andreev *et al.* [H1 Collaboration], "Measurement of inclusive ep cross sections at high Q^2 at $\sqrt{s} = 225$ and $252 GeV$ and of the longitudinal proton structure function F_L at HERA," Eur. Phys. J. C **74** (2014) no.4, 2814
- Others

- F_L extraction with an idea of future combination with EIC data.
- Does not require much manpower.
- Global combination?

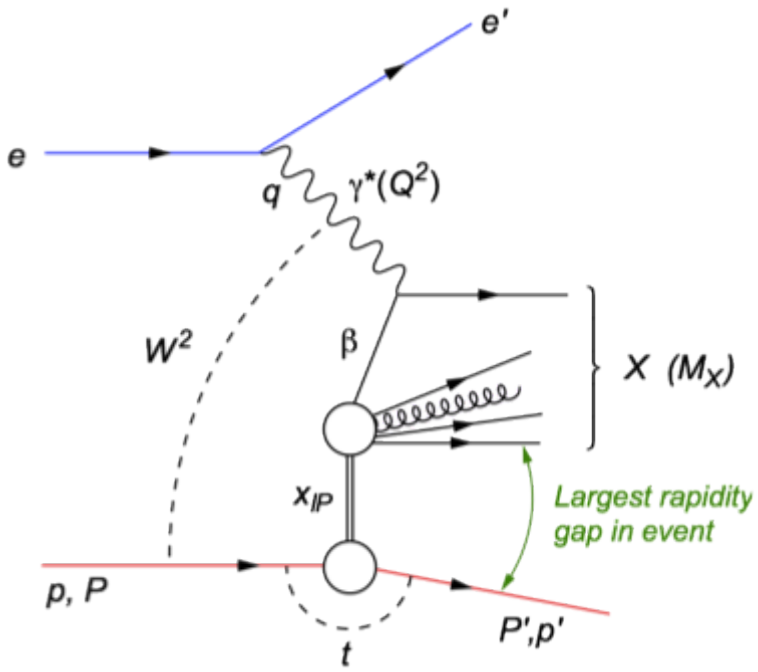
Exclusive scattering



- DVCS
- Exclusive meson production

- DVCS
  - DVCS was not done for HERAII.
  - Good potential for a publication.
- Exclusive meson production
  - Exclusive meson production was done.
  - Multiple Monte-Carlo samples are available.
  - Can be repeated as a technical/performance study.

Diffraction



- Jets: H. Abramowicz *et al.* [ZEUS Collaboration], "Production of exclusive dijets in diffractive deep inelastic scattering at HERA," Eur. Phys. J. C **76** (2016) no.1, 16
- Exclusive meson production.

- Was done in ZEUS.
- Multiple Monte-Carlo samples are available.
- Can be repeated as a technical/performance study.

Technical side

Analysis for ZEUS in Data Preservation mode

- The main analysis toolkit is vanilla ROOT.Can be combined with other ROOT-based tools.
- Batch cluster access in DESY.
- Grid resources worldwide.
- Virtual machine with tested setup, more software and documentation is provided for bench-marking. Can be installed anywhere (clouds?).
- An option for Monte Carlo production exists.

Simultaneous technical studies with ZEUS and EIC MC

The idea is:

- Generate MC with the same set-up for ZEUS and EIC.
- Reconstruct events for ZEUS and reconstruct/smear for EIC.
- Analyse data and MC events for ZEUS and EIC.

Immediate benefits:

- MC generators validation, tuning.
- Background estimation.
- Preliminary checks of opportunities for EIC analyses.

Option for using exactly the same events (i.e. with non-nominal ZEUS beams) can be studied.

Monte-Carlo generation for ZEUS in Data Preservation mode

- Almost any modern MC generator can be used. (NLO! New PDFs!)
- All of the old ZEUS generators as well.
- The reconstructed events are in default ROOT format can be analysed anywhere.
- Usage of Grid $\rightarrow$ almost unlimited production, estimated rate is 50-100M events per week ($1/6 - 1/3$ of HERA statistics).

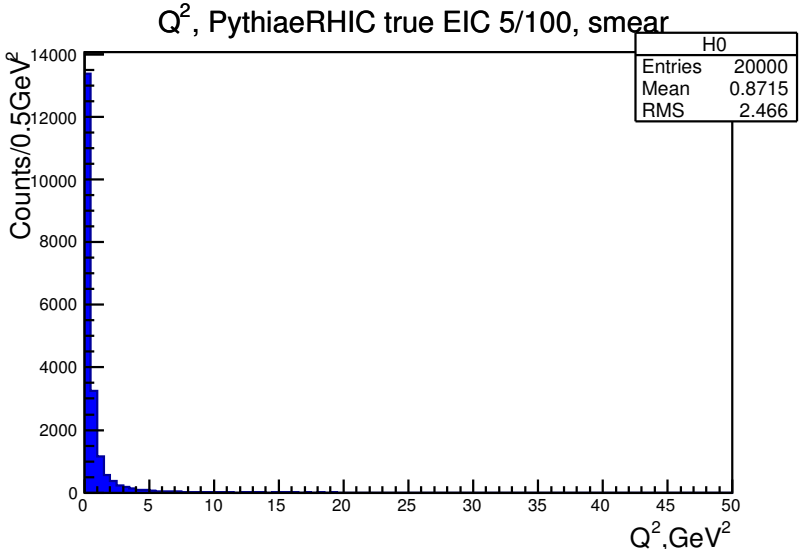
NOTE: The eRHIC MC generators can be used as well!

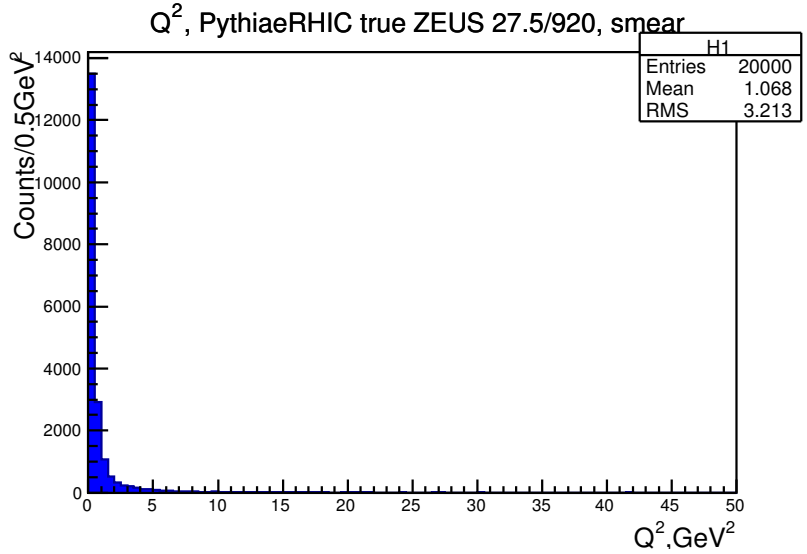
Examples

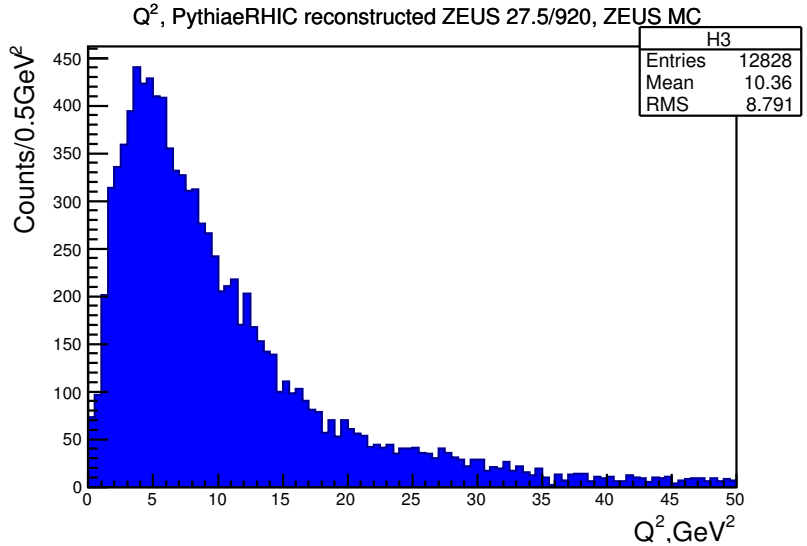
- Create ZEUS reconstructed events from EIC Monte-Carlo generators. Example: Events from pythiaeRHIC fully reconstructed to ZEUS MC and EIC smeared.
- Create ZEUS reconstructed events from an output of arbitrary modern generator. Example: jet production with SHERPA 2.2 with blackhat 0.9.9 NLO ME and Pythia6 hadronisation.

Bonus: use HEPMC3 library and convert an output of arbitrary modern generator to EIC events.

Example: pythiaeRHIC





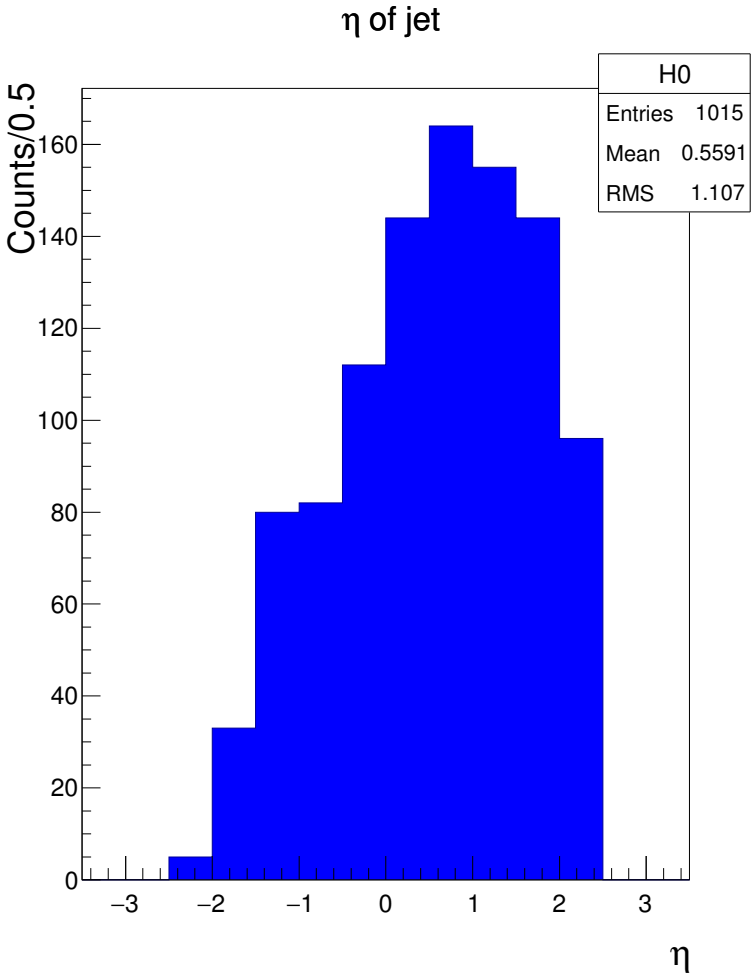


Example: SHERPA2.2+Pythia6+blackhat0.9.9

NLO multijets setup for SHERPA. See backup for details.

```
(run){
  EVENTS 5000;
  # technical parameters
  NJET:=4; QCUT:=5; SDIS:=1.0;
  LJET:=2,3; LGEN:=BlackHat;
  ME_SIGNAL_GENERATOR Comix Amegic LGEN;
  EVENT_GENERATION_MODE Weighted;
  RESPECT_MASSIVE_FLAG 1;
  CSS_KIN_SCHEME 1;
  BEAM_1 -11 27.5; BEAM_2 2212 920;
  PDF_SET_1 None;
  # hadronization tune
  PARJ(21) 0.432; PARJ(41) 1.05; PARJ(42) 1.0; PARJ(47) 0.65; MSTJ(11) 5;
  FRAGMENTATION Lund; DECAYMODEL Lund;
}(run);
(processes){
  Process -11 93 -> -11 93 93{NJET};
  CKKW sqr(QCUT/E_CMS)/(1.0+sqr(QCUT/SDIS)/Abs2(p[2]-p[0]));
  NLO_QCD_Mode MC@NLO {LJET};
  Order (*,2); Max_N_Quarks 6;
  ME_Generator Amegic  {LJET};
  RS_ME_Generator Comix {LJET};
  Loop_Generator LGEN;
  PSI_ItMin 25000 {3};
  Integration_Error 0.03 {3};
  End process;
}(processes);
(selector){
  Q2 -11 -11 4 1e12;
}(selector)
```

Example: SHERPA2.2+Pythia6+blackhat0.9.9



- η of jets with k_T algorithm

Conclusion

- ZEUS data and software are preserved for re-analysis.
- Policies for the data access, authorship, publication procedure, assistance, manpower to be discussed with the spokesperson.
- Policies as well as documentation for some aspects of the analysis will be explained in the dedicated documentation.
- ZEUS data analyzers will have support from DESY and MPI ZEUS groups.

BACKUPS

Example: SHERPA2.2+Pythia6+blackhat0.9.9

```
EVENTS 5000; #number of events
NJET:=4; QCUT:=5; SDIS:=1.0; #
LJET:=2,3; LGEN:=BlackHat; #list of loop generators
ME_SIGNAL_GENERATOR Comix Amegic LGEN; #list of generators
EVENT_GENERATION_MODE Weighted;
RESPECT_MASSIVE_FLAG 1;
CSS_KIN_SCHEME 1; #
BEAM_1 -11 27.5; BEAM_2 2212 920;  #beams
PDF_SET_1 None; #no external PDFs
PARJ(21) 0.432; PARJ(41) 1.05; PARJ(42) 1.0; PARJ(47) 0.65; MSTJ(11) 5; #
    Pythia6 parameters
FRAGMENTATION Lund; DECAYMODEL Lund;  # Use Pythia6 for hadronisation
Process -11 93 -> -11 93 93{NJET};  #electron+parton to partons
CKKW sqr(QCUT/E_CMS)/(1.0+sqr(QCUT/SDIS)/Abs2(p[2]-p[0])); #
NLO_QCD_Mode MC@NLO {LJET}; #
Order (*,2); Max_N_Quarks 6; #number of flavours
ME_Generator Amegic  {LJET}; #number of jets to gnerate
RS_ME_Generator Comix {LJET}; #number of jets to gnerate
Loop_Generator LGEN; #Loop generator, i.e. blackhat
PSI_ItMin 25000 {3}; #
Integration_Error 0.03 {3}; #
```