

# Activities of the MC4EIC WG & short summary of MC4EIC

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(webpage for slides: <https://conference.ippp.dur.ac.uk/event/1292/>)

# Disclaimer

- main activities so far:
  - finding our feet
  - instigating a few studies: mainly photo-production in multiple purpose MCEGs
  - organising the MC4EIC workshop in Durham (rest of talk)
- not going to carry coal to Newcastle
  - not going to talk about specific physics issues at the EIC

(if you need to learn more about it, please, ask and we can discuss  
... but you should know this better than I do anyway!)

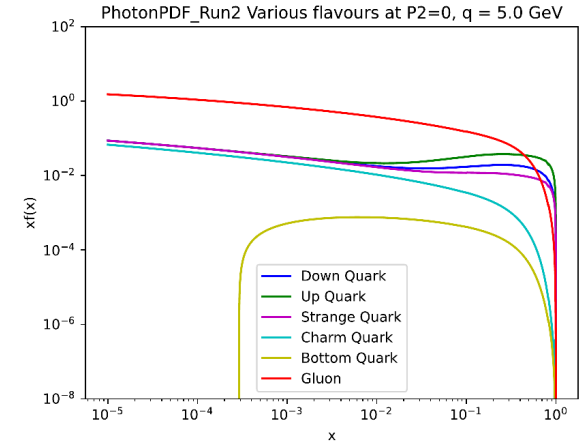
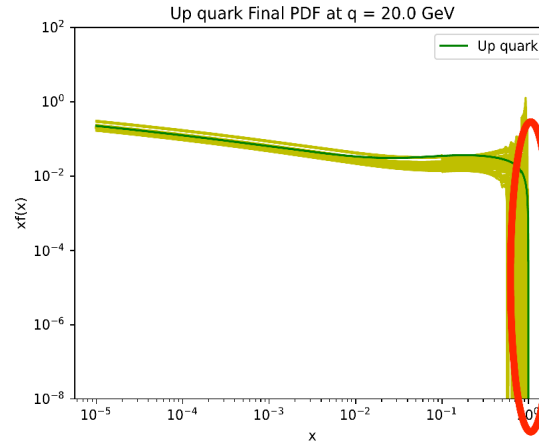
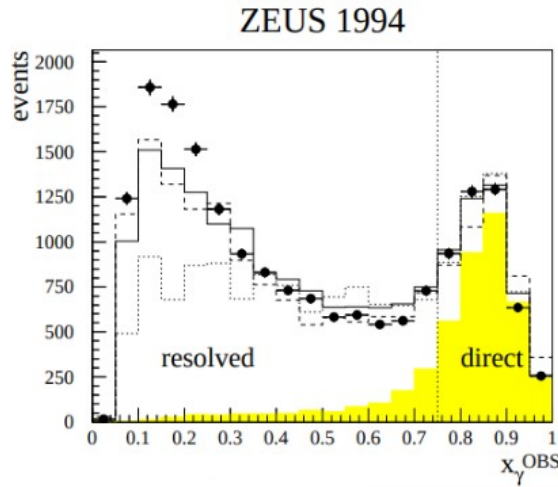
- so: this is going to be a selection of things I found noteworthy – sorry!

# Software environment

- MC toolchain:
  - LHAPDF (parton density library) extremely well developed, fast, efficient, ...
    - maybe extend to new quantities (GPD's, TMD's, etc.)
  - HepMC event output plus “supporters” (such as LHE, HDF5LHE)
  - Rivet as “standard” analysis toolkit, with many (~2000) current and historical analysis and data “harvested” from HEPDATA:
    - indispensable for MC tuning (Professor!) and validation
- recently: careful profiling of MC codes, massive efficiency gains
- overall lesson learnt: standardization

# Example applications

- MC “tuning” of photon PDF (w.i.p.): resolved component from pointlike + hadron (VMD)
- use SHERPA 3.0.β + Rivet + Professor (+Apfel for PDF evolution)
- 6 free parameters in PDF model, 15 M events with 300 variations for fit



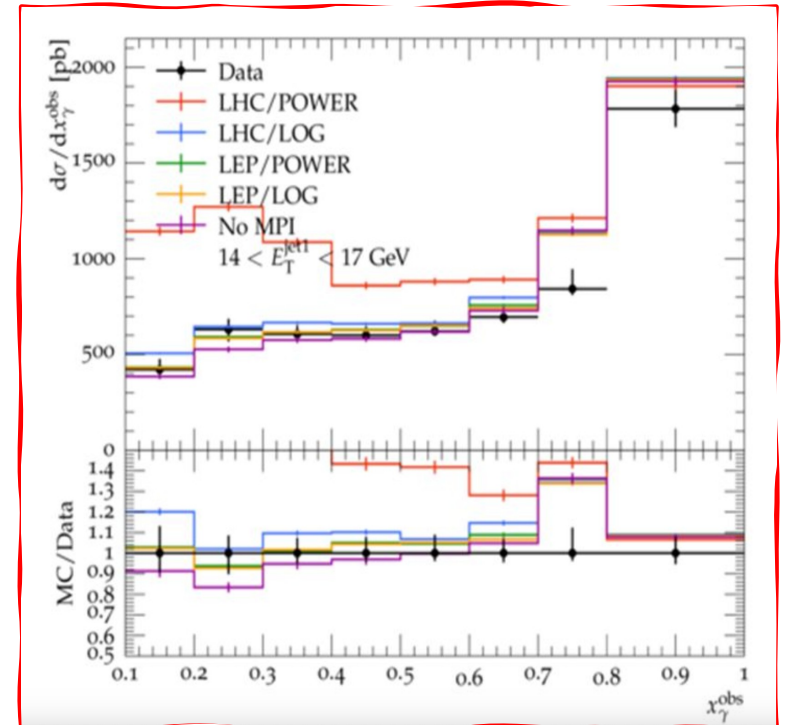
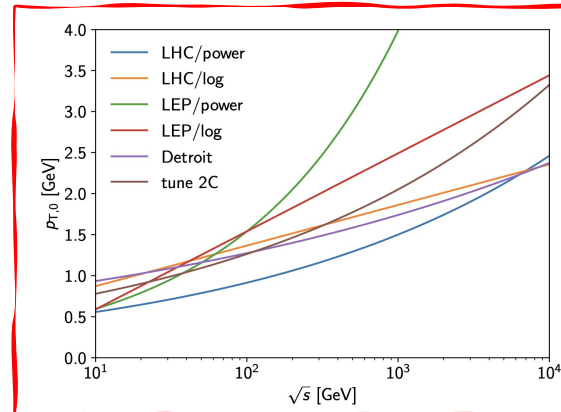
# Example applications

- MC “tuning” of underlying event (multi-parton interactions) in photo-production processes
- comparing tunes from photon interactions at LEP and proton interactions at Tevatron:  
→ upshot: less MPIs in photon-initiated processes

$$p_{T0} = p_{T0}^{ref} + \alpha \ln \frac{\sqrt{s}}{\sqrt{s^{ref}}}$$

$$p_{T0} = p_{T0}^{ref} \left( \frac{\sqrt{s}}{\sqrt{s^{ref}}} \right)^\alpha$$

Parameter	LHC	LEP
$p_{T0}^{ref}$	2.28 GeV	1.54 GeV
$\sqrt{s^{ref}}$	7000 GeV	100 GeV
$\alpha$	0.215	0.413
Scaling	Power	Logarithmic



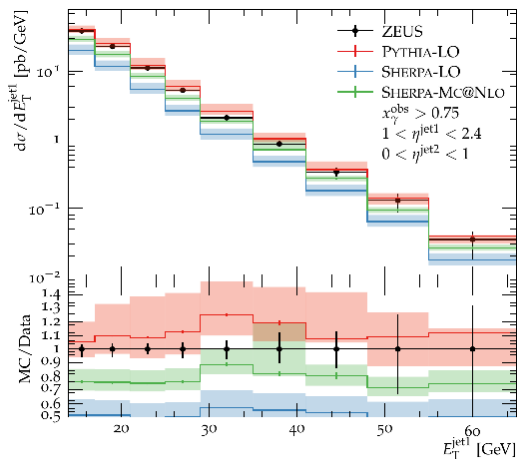
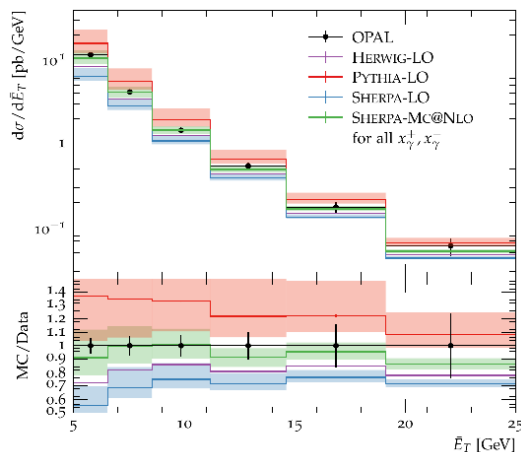
# HERA as an EIC bootcamp

- lots of lessons to be learnt, including:
  - experiment neutrality: communicate & compare
  - generator neutrality: observables must be model-independent
  - importance of fiducial phase space and its definition
- plethora of analyses that would be useful for MC validation:
  - biggest “missing link”: HERMES

# Generator summaries

- HERWIG:
  - DIS at NLO (multi-jet merging), photoproduction w.i.p.
  - work on parton showers (EW showers, helicity dependence) & hadronization
- PYTHIA:
  - multijet merging in DIS
- SHERPA:
  - multijet merging at NLO for DIS, photoproduction at NLO, hard diffraction w.i.p.
  - new parton shower (NLL accuracy analytically proven)
- POWHEG:
  - extended to DIS

# Photoproduction and hard diffraction



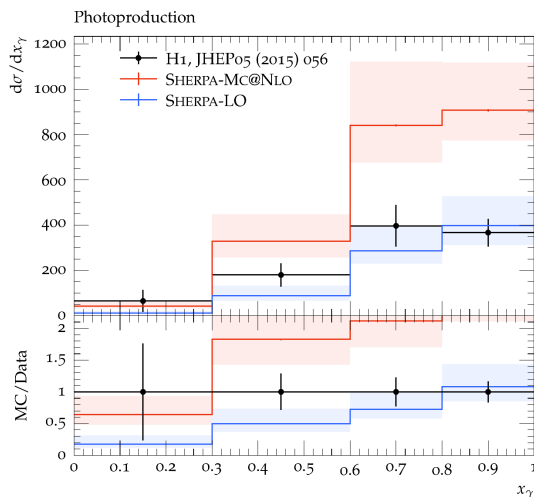
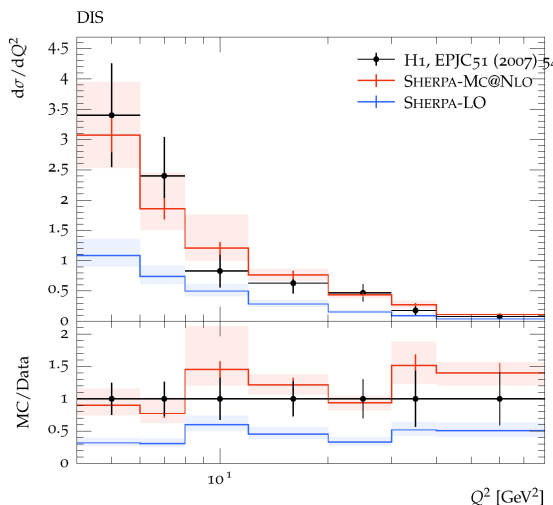
(snapshots)

- photo-production of jets (top) in healthy shape:

- (N)LO available
- $\gamma$ A collisions in Pythia

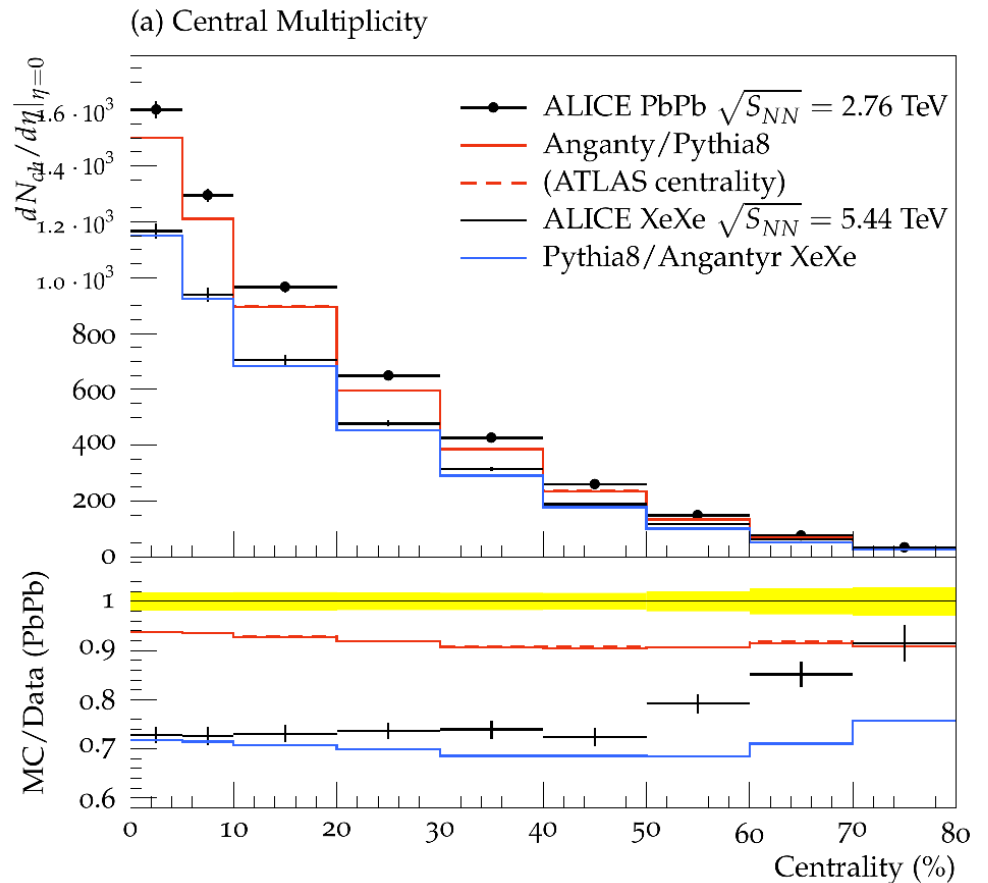
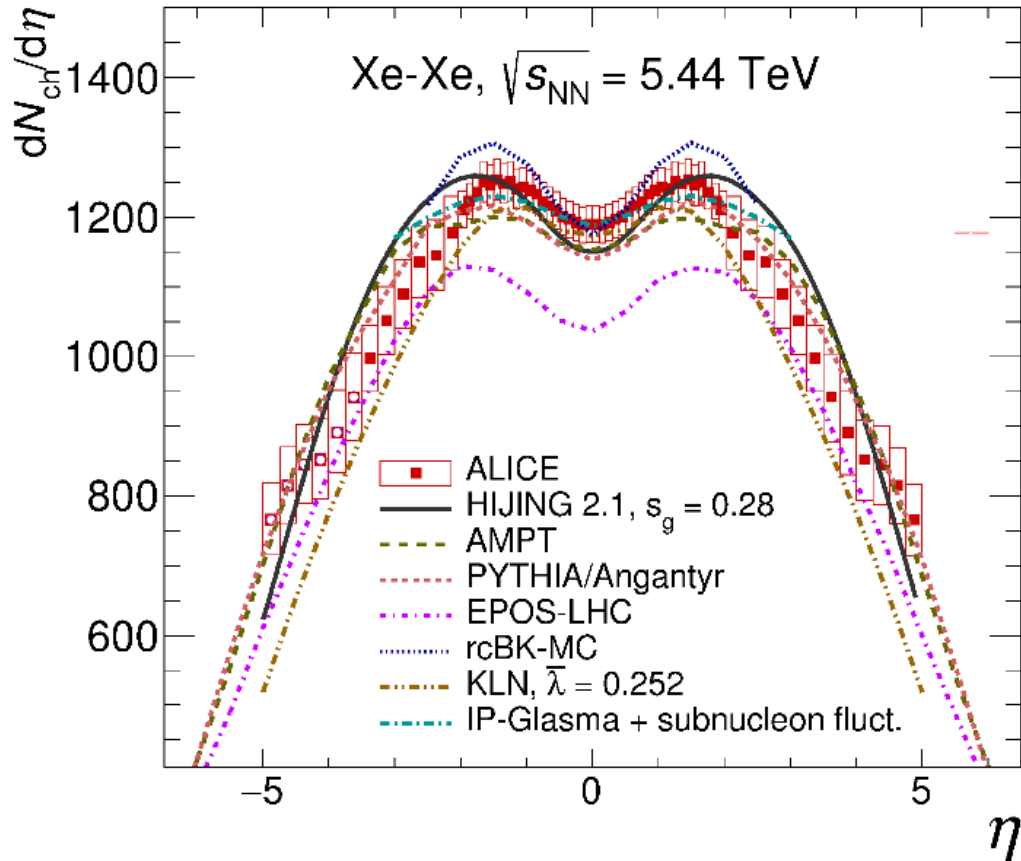
- hard diffraction (bottom):

- good agreement with data for DIS ( $Q^2 > 4 \text{ GeV}^2$ )
- but: issues with factorisation breaking in diffractive photoproduction
- more work, hopefully more analyses!



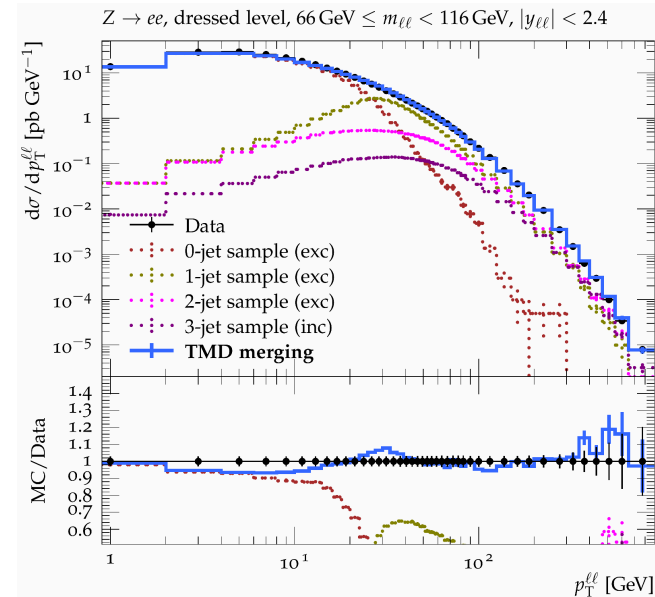
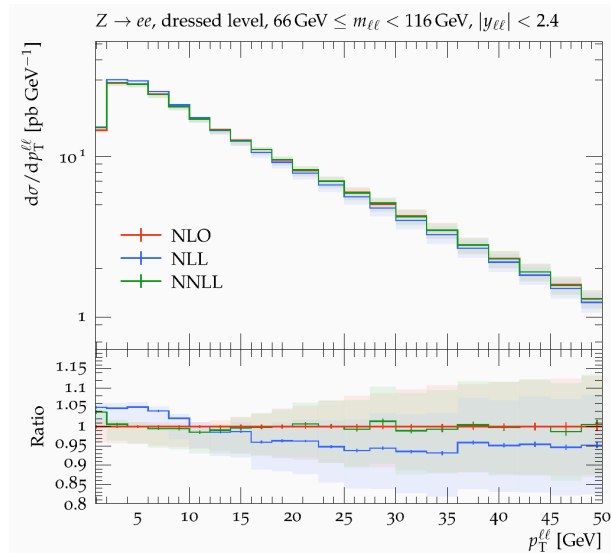


# Heavy ion modelling (Angantyr)



# TMD evolution and CASCADE

- different scale, evolution parameter and phase space parametrization choices for TMD evolution
- implemented in parton branching method: example result ( $p_T^Z$  below)
- PB method also implemented in CASCADE
- interface to hadronization etc.
- multijet merging recently added



# Summary

- MC4EIC @ IPPP was a success (I think), despite or because of low # of participants (<20)
- MC community started to turn attention to physics at ep / eA colliders
  - with a lot of experience from LHC (I hope this is being used more widely)
- number of open issues identified, among them:
  - role of QED corrections for DIS (what exactly is needed by EIC? first stab under way ...)
  - tool chain and standardisation (event formats, analysis code for MC comparison, validation, and tuning)
  - “missing analysis” from HERA → translate HZtool/publications into RIVET routines
- looking forward to next MC4EIC in 2025 – anybody interested in hosting it?  
(maybe/hopefully outside Europe and with more participants)
  - need to add topics: simulation of exclusive processes, heavy-ion environment, ....