A short (and personal) summary of MC4EIC

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

Disclaimer

- not going to carry coal to Newcastle

  - not going to talk about EPIC software environment

    (if you do not know it, please, ask Markus, I cannot help you there)

  - 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
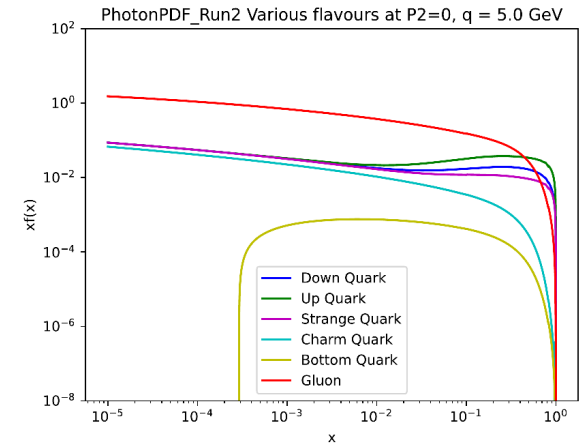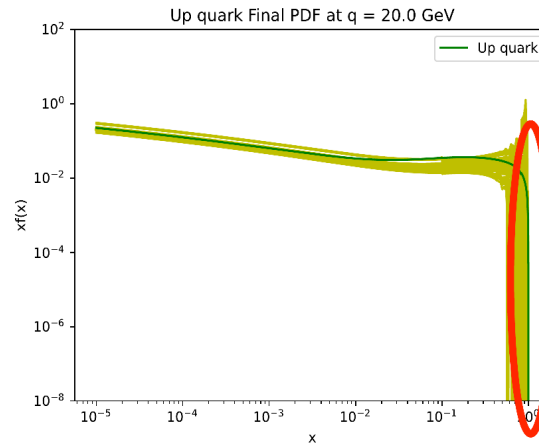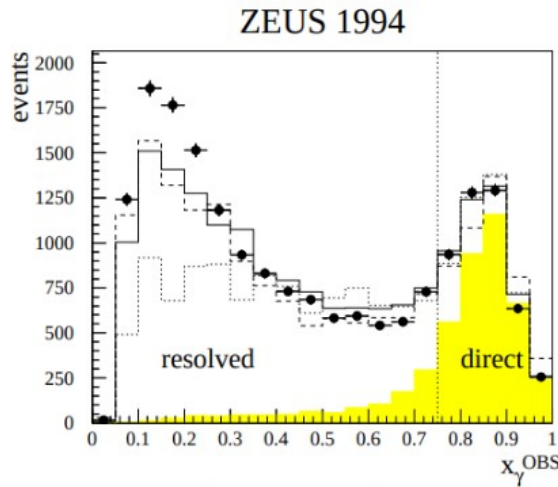
Example applications

- 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
α	0.215	0.413
Scaling	Power	Logarithmic
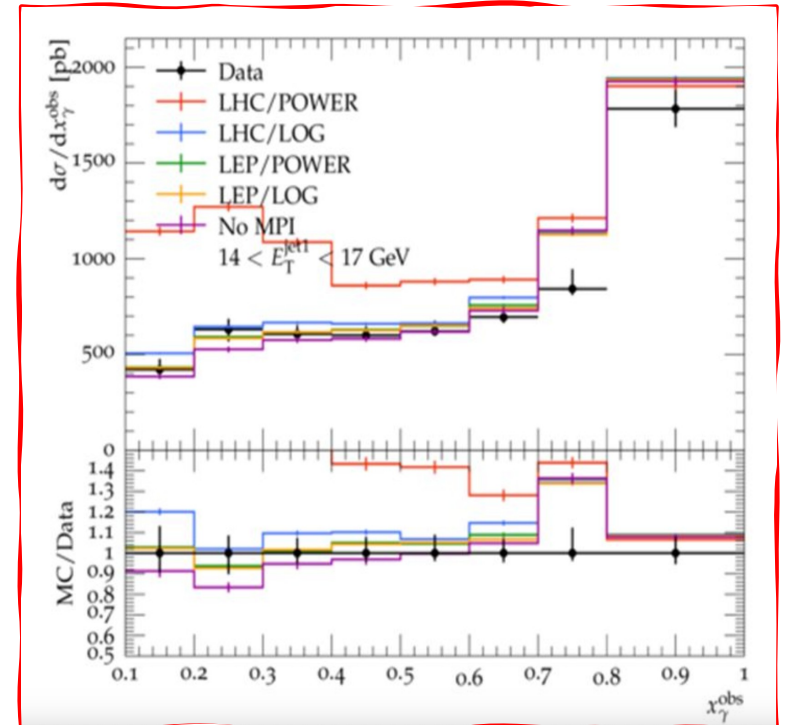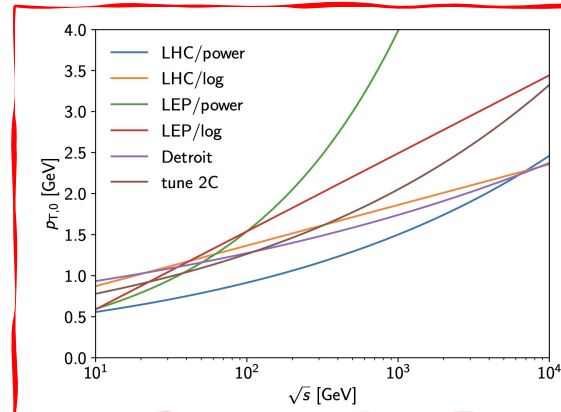
HERA as an EIC bootcamp

- 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
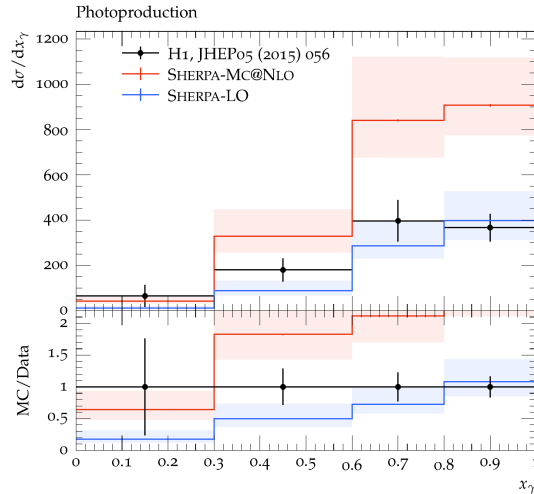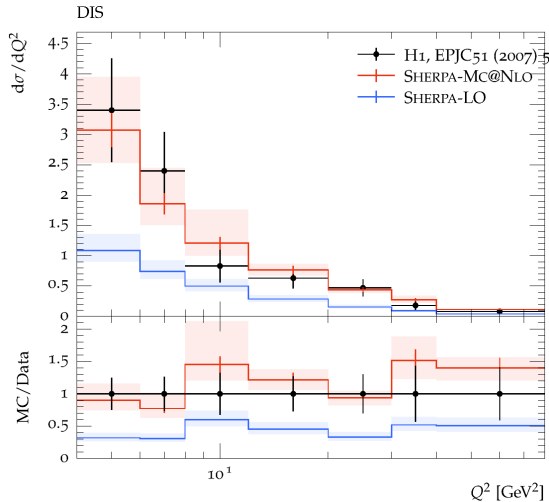
Photoproduction and hard diffraction
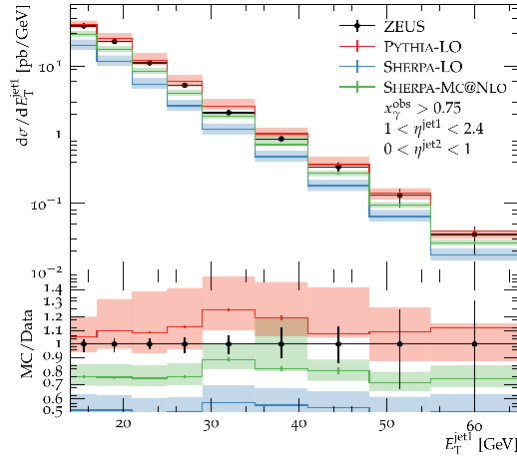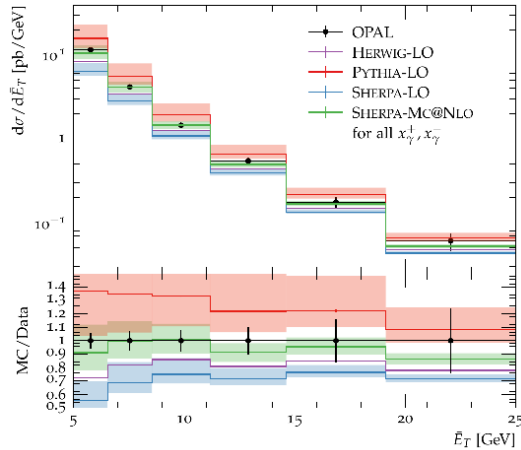
(snapshots)

- photoproduction of jets (top) in healthy shape:
  - (N)LO available
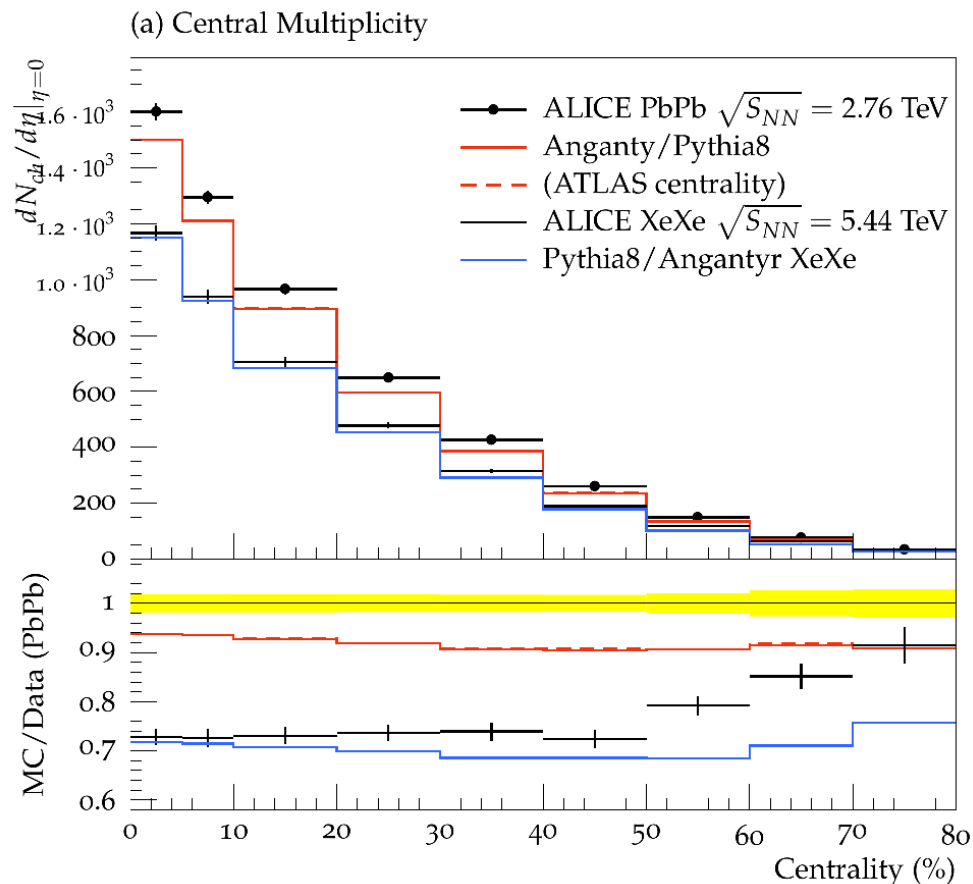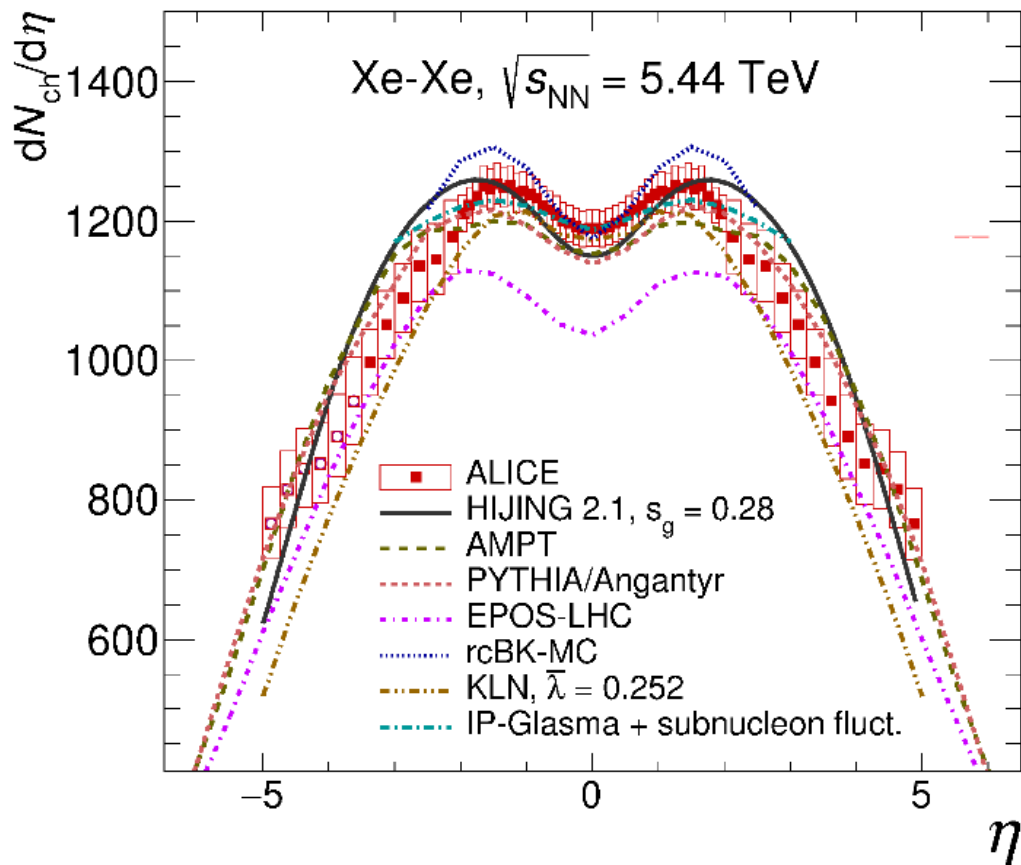 - γA collisions in Pythia

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

Heavy ion modelling (Angantyr)

Xe-Xe, $\sqrt{s_{NN}} = 5.44$ TeV

- ■ ALICE
- —— HIJING 2.1, $s_g = 0.28$
- - - - AMPT
- ······ PYTHIA/Angantyr
- ─·─· EPOS-LHC
- ········ rcBK-MC
- ─··─ KLN, $\overline{\lambda} = 0.252$
- ─·─· IP-Glasma + subnucleon fluct.

(a) Central Multiplicity

- —●— ALICE PbPb $\sqrt{s_{NN}} = 2.76$ TeV
- —— Anganty/Pythia8
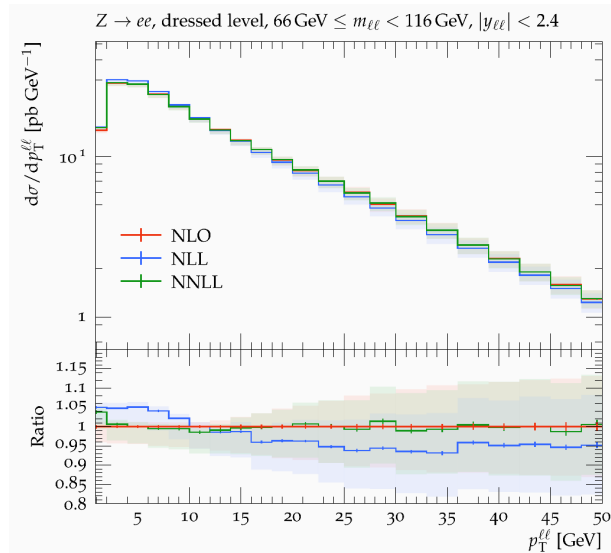- - - - (ATLAS centrality)
- —— ALICE XeXe $\sqrt{s_{NN}} = 5.44$ TeV
- —— Pythia8/Angantyr XeXe

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
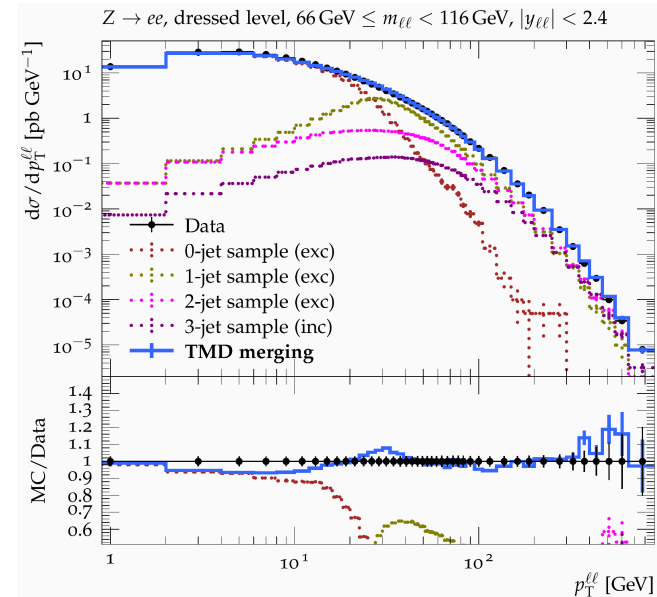
Summary

- 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

- number of open issues identified, among them:
  - role of QED corrections for DIS (what exactly is needed by EIC?)
  - tool chain and standardisation (event formats, analysis code for MC comparison, validation, and tuning)
  - "missing analysis" from HERA → translate HZtool/publications into RIVET routines