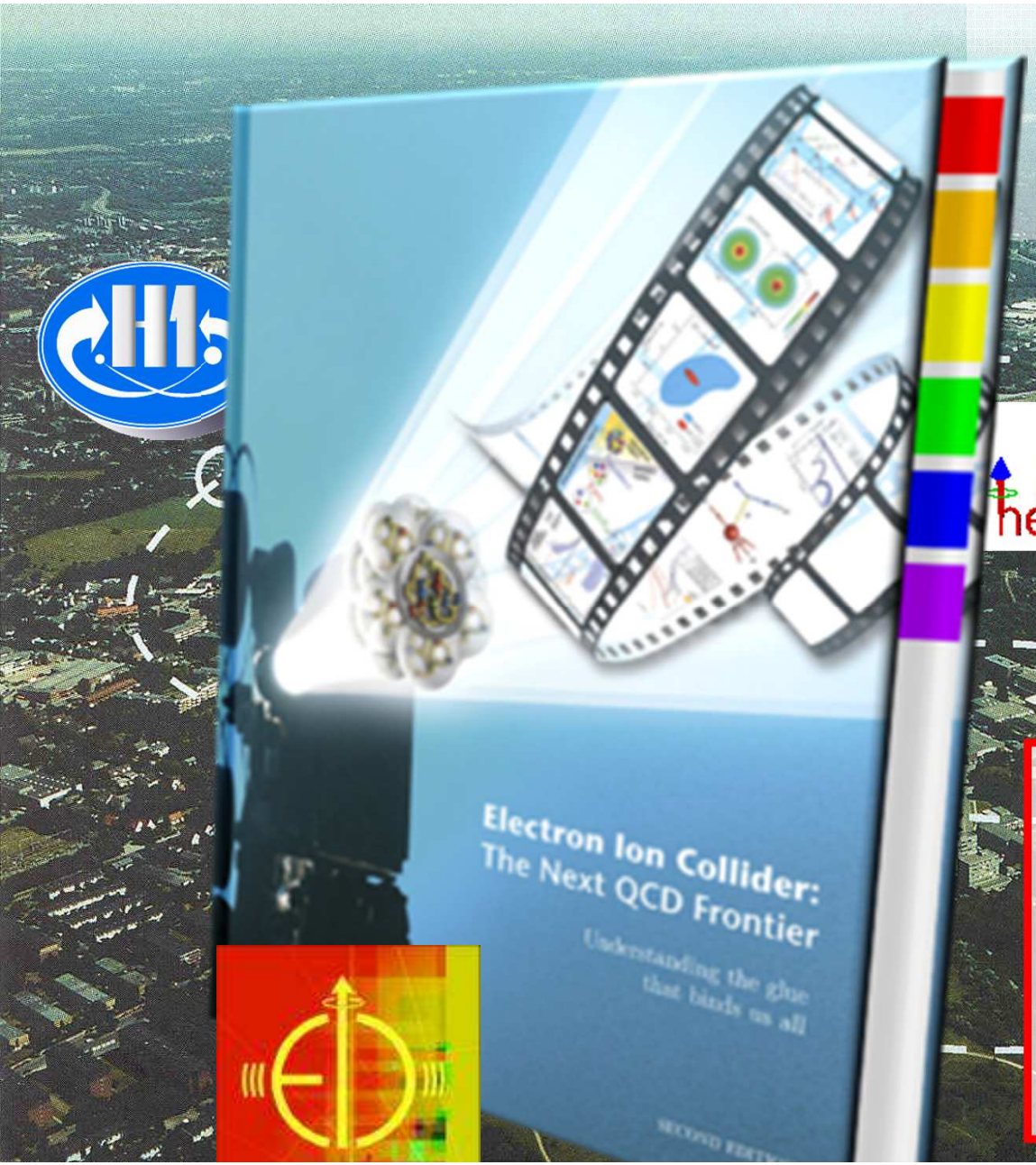
EIC physics with HERA data at DESY?

Achim Geiser, DESY Hamburg

EIC/HERA satellite workshop
DESY, Hamburg, 10. 4. 2016

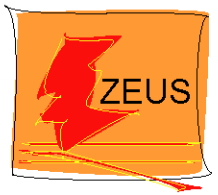


- from ZEUS perspective
- Why?
- How?
- What? (examples)

Why analyze HERA data in context of EIC?

- Physics scopes of HERA and EIC differ
  but have significant overlap.

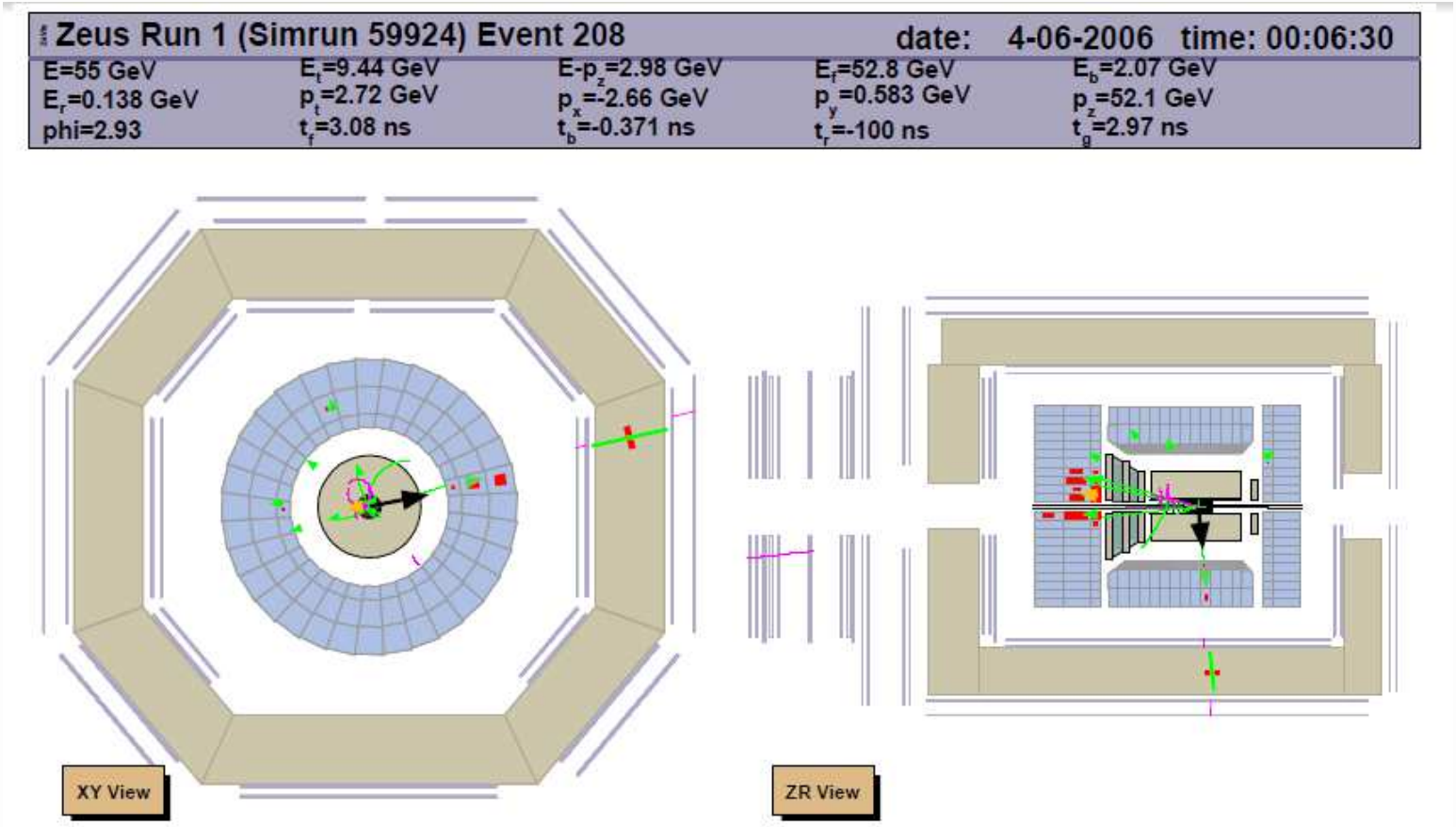
- Many aspects of EIC physics can be (partially) addressed with HERA data.



- EIC data lie significantly in the future,
  HERA data are readily available now.

- E.g. allows Master or PhD students to touch real data in conjunction with a hardware or MC study for EIC,
  including physics publications, talks at physics conferences, …

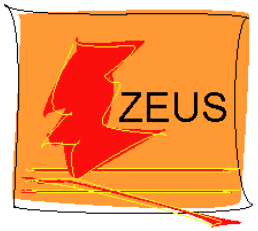
What do ZEUS data look like?



Event display from Common Ntuple

How to analyze ZEUS data at DESY?

(for additional possibilities at MPI see contribution A. Verbytskyi)



- need:
  - interest in some physics topic ☺
  - agreement with ZEUS management and DESY to obtain
  - ZEUS user account at DESY
    -> access to NAF/BIRD analysis farm via
    ZEUS NAF server (can log on from remote)
  - basic knowledge of ROOT
    (no special ZEUS software to learn!)
  - basic knowledge of particle physics

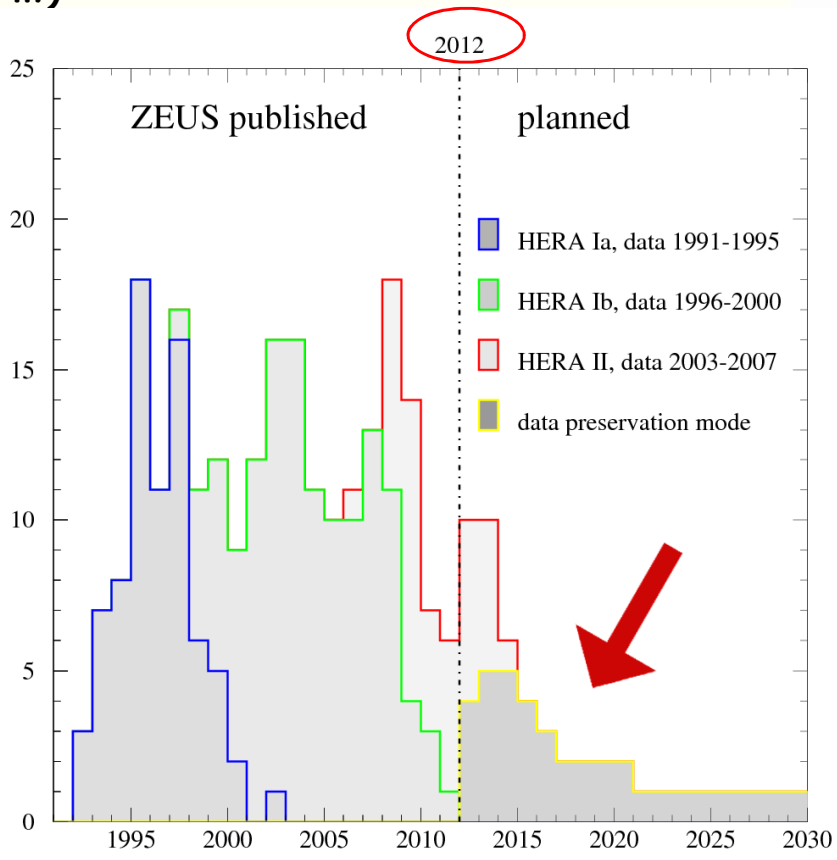
Common Ntuple analysis model

- **ZEUS Common Ntuple:**
  flat (simple) ROOT-based ntuple (same format as PAW ntuple converted with h2root)
  containing high level objects (electrons, muons, jets, energy flow objects, …)
  as well as low level objects (tracks, CAL cells, …)

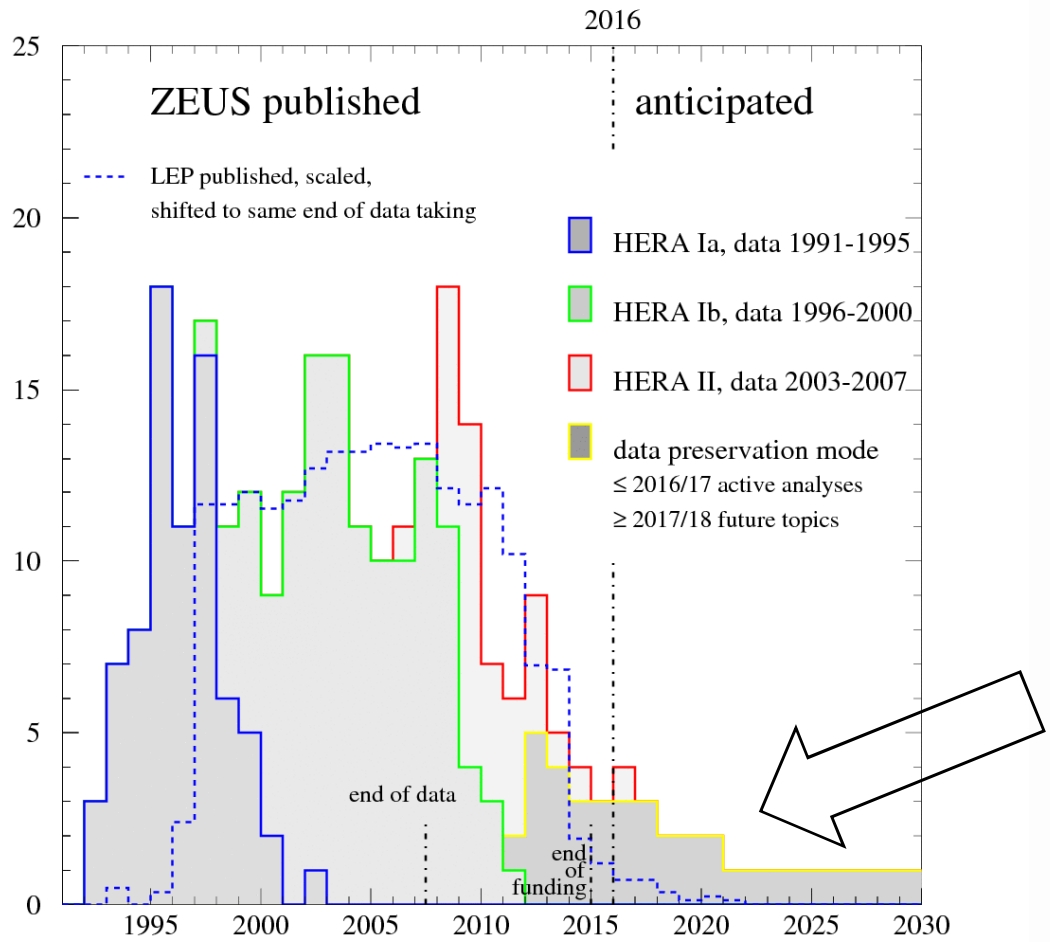
- **Well tested !**
  almost all recent ZEUS papers based
  on Common Ntuples

- **Easy to use**
  several recent ZEUS papers based on results produced by Master students.

  PhD students could produce a ZEUS/EIC paper within only a fraction of their PhD time (e.g. ~6 months -1 year)



2016 update of papers vs. time plot



`plans'

for short, medium, and

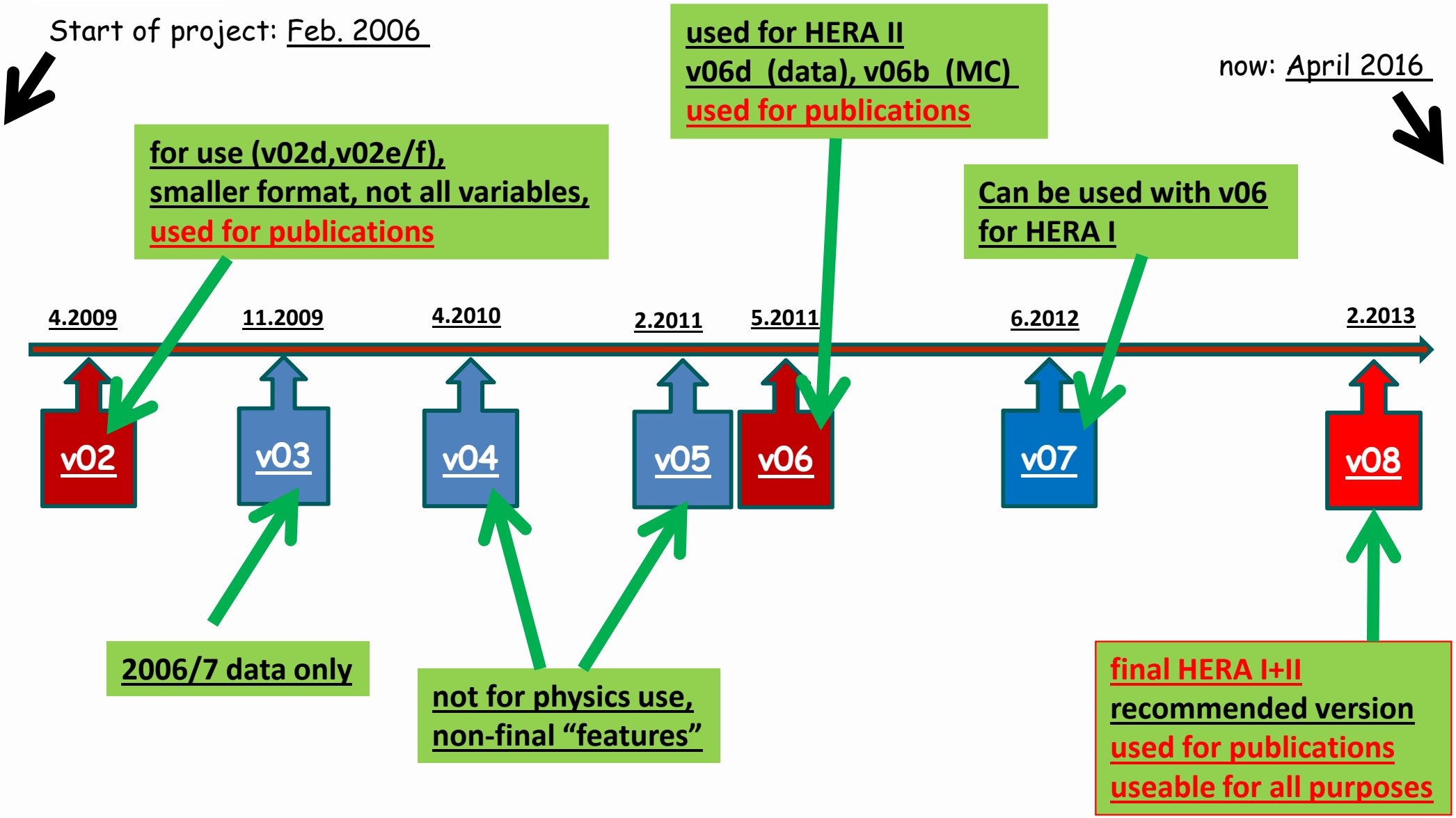
long term

"Free Access to ZEUS Data" programme for PhD students and physicists

-> contact spokesperson

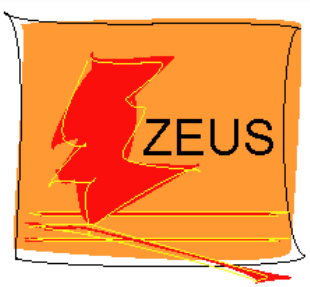
Available Common Ntuples

compiled by D. Szuba



Size of data sets

compiled by D. Zotkin/A.G.



Root files (officially preserved) units: Tb (status 4.9.13)

HERA II	v02	v06	v08	HERA I v08 +v07	total	
Data	1.9	5.2	7.0	1.7+1.	17.	
MC	10.5	64.0	70.	4.8+4.	153.	+30 for future MC

~ 100 million inclusive DIS events (Q^2>5 GeV^2, triggered almost bias-free)

~ 100 million semi-inclusive photoproduction events (mainly via p_T>4 GeV dijet trigger)

smaller sets of more specialised triggers/samples (e.g. heavy flavours, vector mesons, …)

~ equal sample sizes for e+, e-, righthanded/lefthanded polarisation

~ 4 billion MC events, for almost any analysis

generation of additional MC samples might be possible (see talk A. Verbytskyi)

can technically read/analyze full ZEUS data set within ~1 day

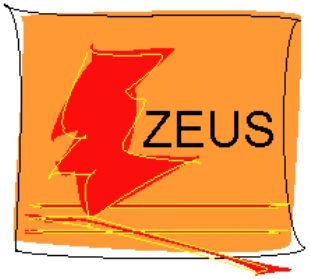
(for even faster access, many analyzers produce their own mini-ntuples for analysis)

Win-Win-situation?

- We offer:

  access to real data (and MC)

  support for interpretation of data



- You offer:

  (wo)manpower

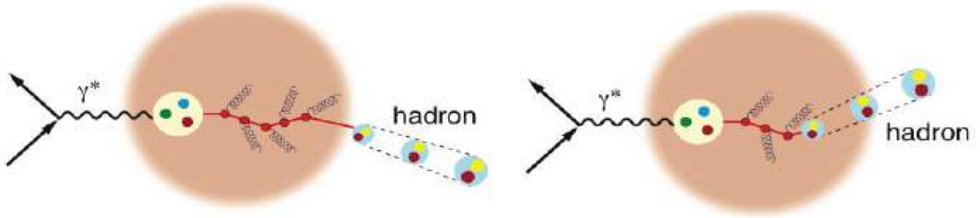
- We share:

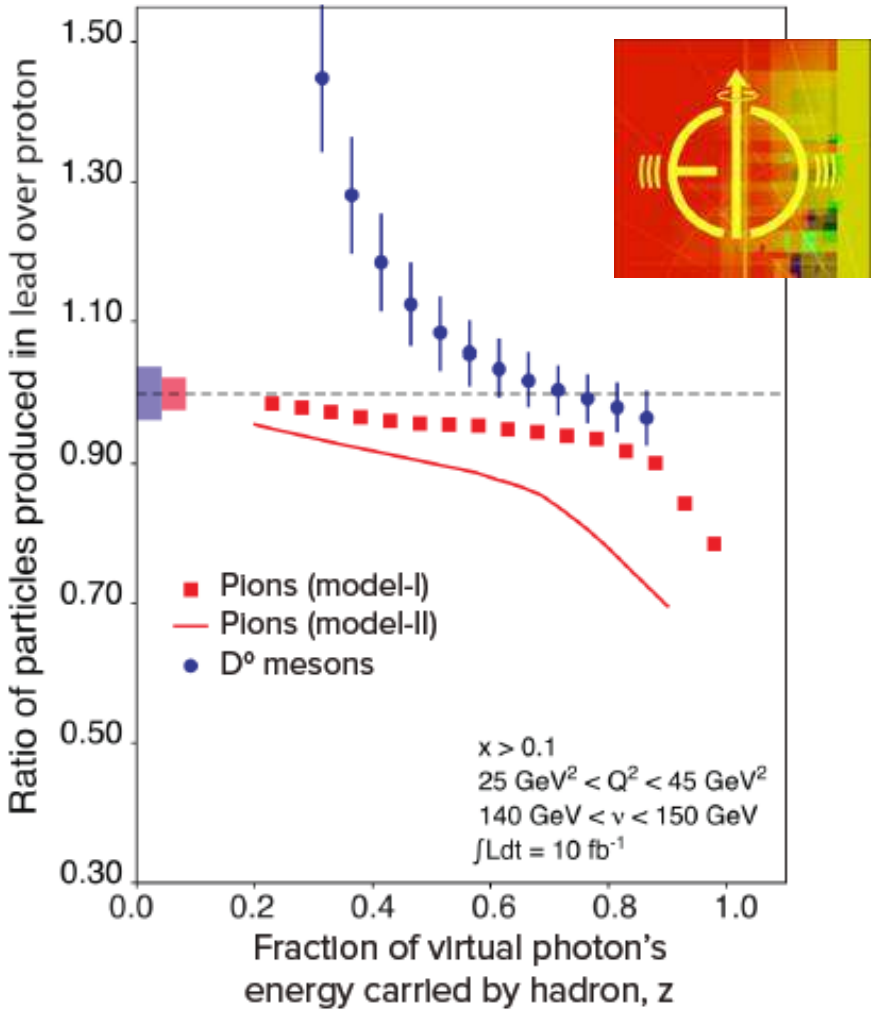
  student supervision (if wished),

  interest in physics results

Example physics topics

The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE





Example physics topics

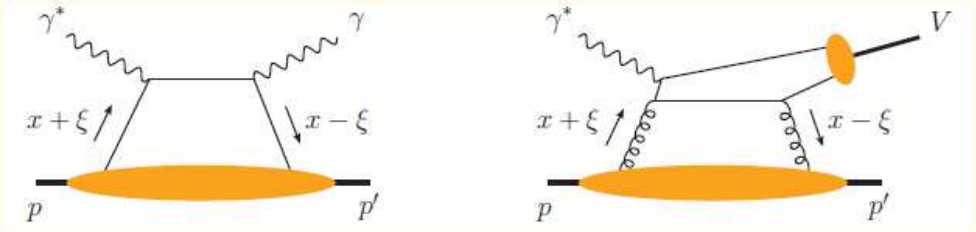


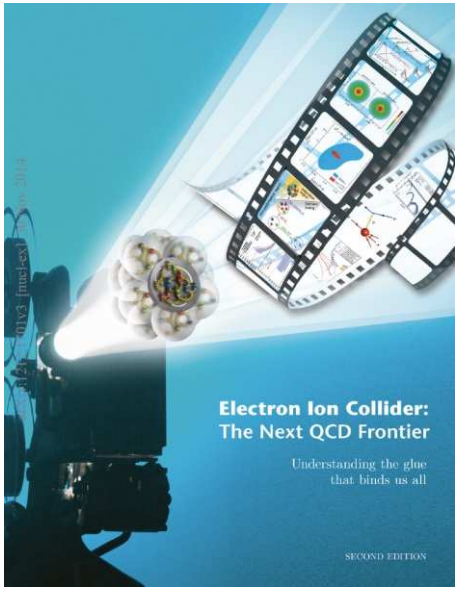
Figure 2.18: Graphs for deeply virtual Compton scattering (left) and for exclusive vector meson production (right) in terms of generalized parton distributions, which are represented by the lower blobs. The upper filled oval in the right figure represents the meson wave function.

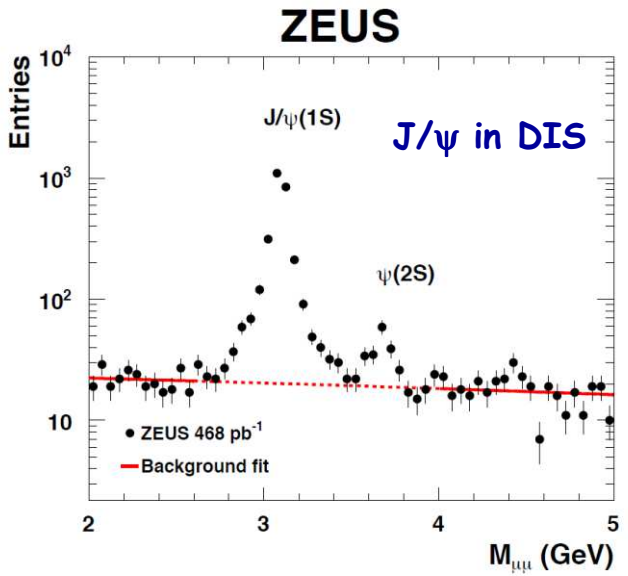
- ZEUS DVCS analysis for HERA II not completed
- many possible exclusive vector (or other) meson analyses for HERA II not completed or not even started

(lack of manpower)

Example physics topics

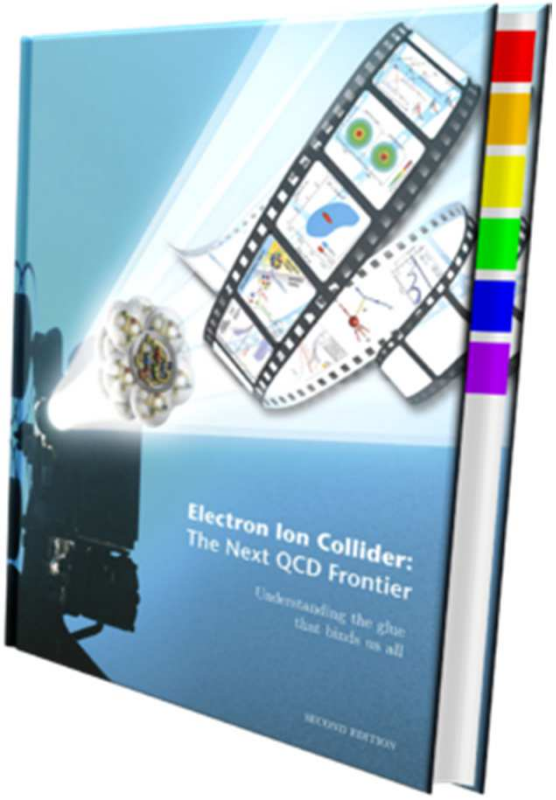
Deliverables	Observables	What we learn	Requirements
GPDs of sea quarks and gluons	DVCS and $J/\Psi, \rho^0, \phi$ production cross-section and polarization asymmetries	transverse spatial distrib. of sea quarks and gluons; total angular momentum and spin-orbit correlations	$\int dt\, L \sim 10$ to $100\,\mathrm{fb}^{-1}$; ~0.5 fb^{-1} leading proton detection; polarized e^- and p beams; wide range of x and Q^2; range of beam energies; e^+ beam valuable for DVCS
GPDs of valence and sea quarks	electro-production of π^+, K and ρ^+, K^* ?	dependence on quark flavor and polarization	

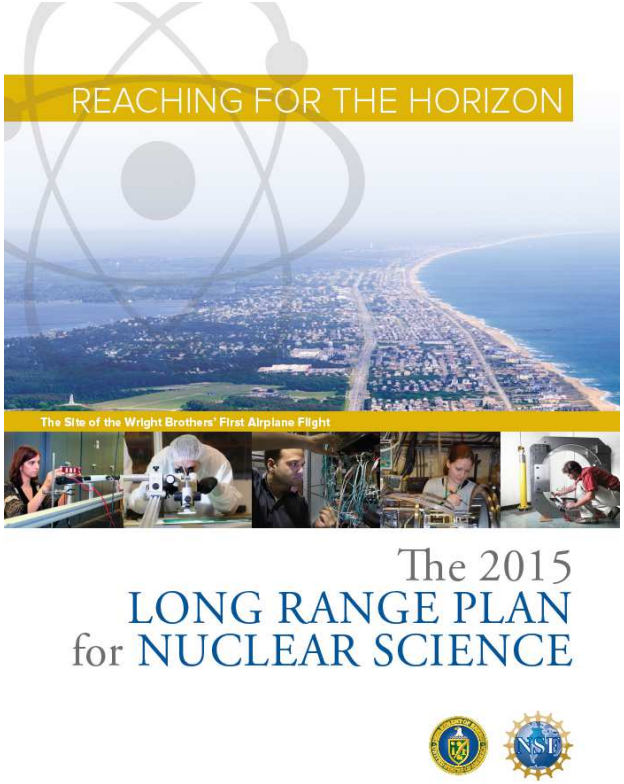




Example physics topics

- Your favourite EIC topic ☺





- for list of topics from HERA perspective, see backup, and workshop on Future Analysis with HERA data, arXiv:1601.01499 arXiv:1512.03624

Conclusions and Outlook

- The EIC project is unique and exciting !
- HERA data are unique, exciting, and available !

- many HERA data topics continue to be of interest,
  and quite a few are still not finished or even not yet started
  arXiv:1601.01499 arXiv:1512.03624 (also see backup)
- many have overlap with topics relevant for EIC
  -> of particular interest until EIC data become available

- bottleneck: manpower after end of HERA funding

purpose of this contribution:
motivate that it is worthwhile to team up interest in future EIC data and existing HERA data to boost the EIC project and to fully exploit the HERA physics program

Backup

A list of topics from HERA collider perspective.

Should be cross-calibrated with and extended by topics particularly interesting for EIC.

Possible HERA collider physics topics

as discussed at Future Analysis with HERA data workshop

- BSM:
  - Provide standard candles against which new physics searches can be calibrated
- Proton structure:
  - FL combination, integration of high x results into PDF fit, finalize heavy flavour combinations and fit, improved transverse momentum dependent PDFs, investigation of low x phenomenology, …

  -> understand the proton, understand QCD, provide detailed descriptions for other colliders
  - Are we starting to hit the nonperturbative limit?
  - Can we make further decisive measurements from existing data?
  - Can we achieve improved theoretical interpretations from existing results?
  - Can statements about new physics at high scales be made from the low energy data?
- Diffraction and DVCS
  - Finalize inclusive diffractive measurements, make them more differential
  - Finalize measurements of elastic vector meson production and compare to improved theory models and to other experiments
  - Measure elastic scalar model production, test odderon hypothesis
  - Finalize measurements of DVCS

Possible HERA collider physics topics

as discussed at Future Analysis with HERA data workshop

- Jets:
  - Finalize (ZEUS) measurements, combine,
  - make more differential measurements, event shape measurements,
  - apply NNLO theory, remeasure alphas
- Hadronic final states:
  - Study multiparton interactions and other nonperturbative effects
  - (re)measure photon structure
  - (re)measure QCD instanton production
  - Search for exotic resonances
  - Complete total gamma-p cross section
- Heavy Flavours:
  - Intrinsic charm
  - NNLO measurements of c- and b-masses
  - Multi-differential heavy flavour cross sections
  - More cross section combinations
  - Improved measurements of charm fragmentation functions

Possible HERA collider physics topics

as discussed at Future Analysis with HERA data workshop

- Electroweak and polarisation studies
  - Finalize measurements of electroweak parameters, at NNLO QCD + NLO EW,
  - Implement electroweak effects in PDFs
  - Measure higher order QED corrections e.g. to Bethe-Heitler dimuon production (e+ vs. e-, polarisation?)
  - Continue studies of prompt photons
  - Measure charm in charged current -> constrain strangeness in proton
- Check new theory developments
  - for all of the above
- Synergies with other experimental programmes
  - LHC, Tevatron, LEP, …
  - LHeC
  - EIC (this talk)