The Physics Programme of the LHeC

A Yellow Report on

Deep Inelastic ep/eA Scattering at the Energy Frontier

A few remarks
under the impression
of last week's ICFA seminar
at IHEP Beijing

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lhec.web.cern.ch

LHeC Physics Meeting 4.11.2014 at CERN

Some Impressions from ICFA (27.-30.10.14, Beijing)

Debates dominated by the ee future (CLIC, ILC, CEPC, FCC-ee)
and related to this by the pp future (SPPC, FCC-pp)

Not impossible, not unlikely that China moves to 50-70km ring
and builds a Higgs facility and that this terminates effectively all
other ee machine plans and developments, depending on RUN 2

Such a development would put CERN under severe pressure as while
CERN runs and upgrades LHC, China may move on, pp technology an issue

In any case there is a rising awareness of the LHeC. There may also be an
EIC in the US which is at lower energy and polarised. This in my view
only supports the LHeC although there are some uninformed attempts to
call THAT the future of DIS, which it cannot be.

Similar struggles around lower energy projects (DM, neutrinos,) ..

There is not enough funding for any of the big machines (ee or pp)
“The field presents itself not well coordinated” Lockyer ICFA chair..

[“Be patient and trust in real work” Herwig Schopper, private communication 13]

Context of the paper

-Good signs: MTP (Cavity-cryo modules), Test Facility, IAC mandate, talk at ICFA…

-Promises: Manpower via CERN, Students (Bham, JohBurg, Lpool…)

-Interest: Higgs, PDFs, Testfacility: Jlab (cavity module), BINP (magnets)

-Difficulties: No collaboration yet, Resistance to ep and eA [resources but not only]

→ Important to write a strong paper, which focusses on a few items,
not "just" the hot/PR questions but adressing these too

→ The LHeC has its own programme and should not be presented only
as a replacement for what may not be built

Time schedule: synchronous running with the LHC until that is (im)possible
"The LHeC is the only machine which CERN can build in the next 2 decades" (perhaps)

QCD is the richest part of the Standard Model

Crucial questions+tasks

AdS/CFT

Instantons

Odderons

Non pQCD

QGP

N^kLO

Resummation

Saturation and BFKL

Non-conventional PDFs …

QCD may break .. (Quigg DIS13)

Breaking of Factorisation

Free Quarks

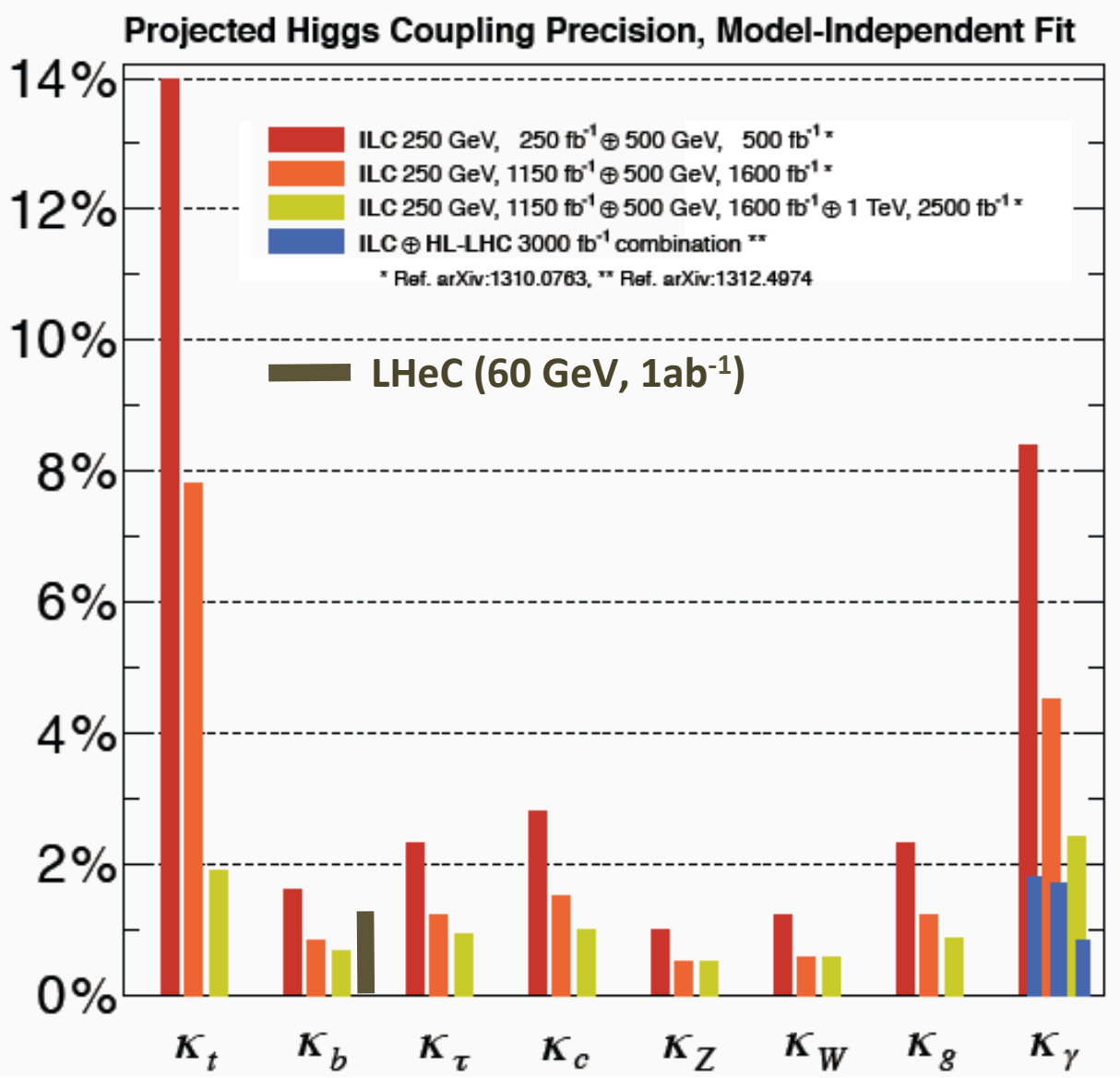
Unconfined Color

New kind of coloured matter

Quark substructure

New symmetry embedding QCD

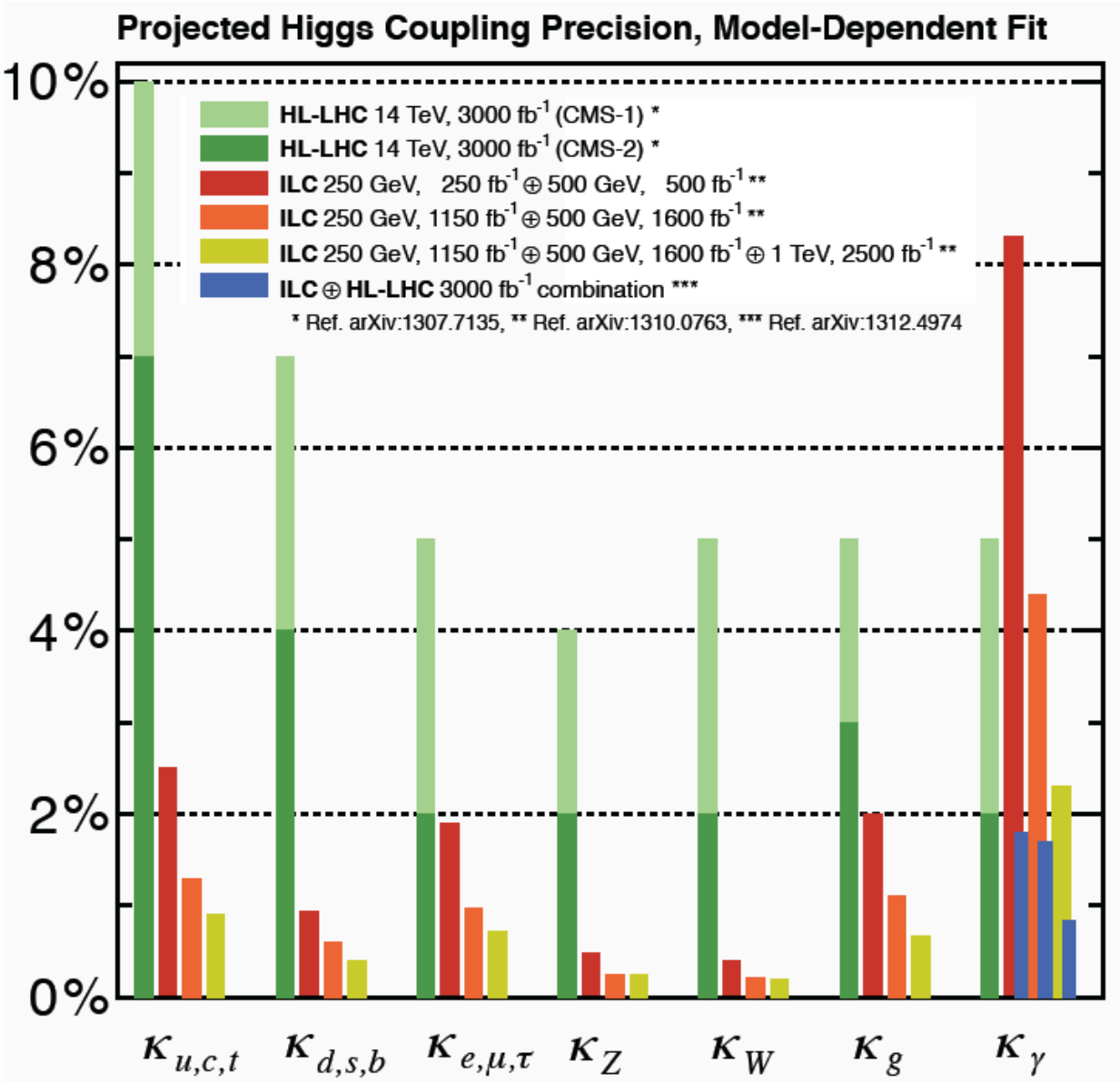
We need to link the programme to the big questions (and the LHC + future)



IAC WANTS THAT PLOT INCLUDING LHeC - HUGE JOB NEEDS HELP

LOOK FOR ILC 250 ONLY !!

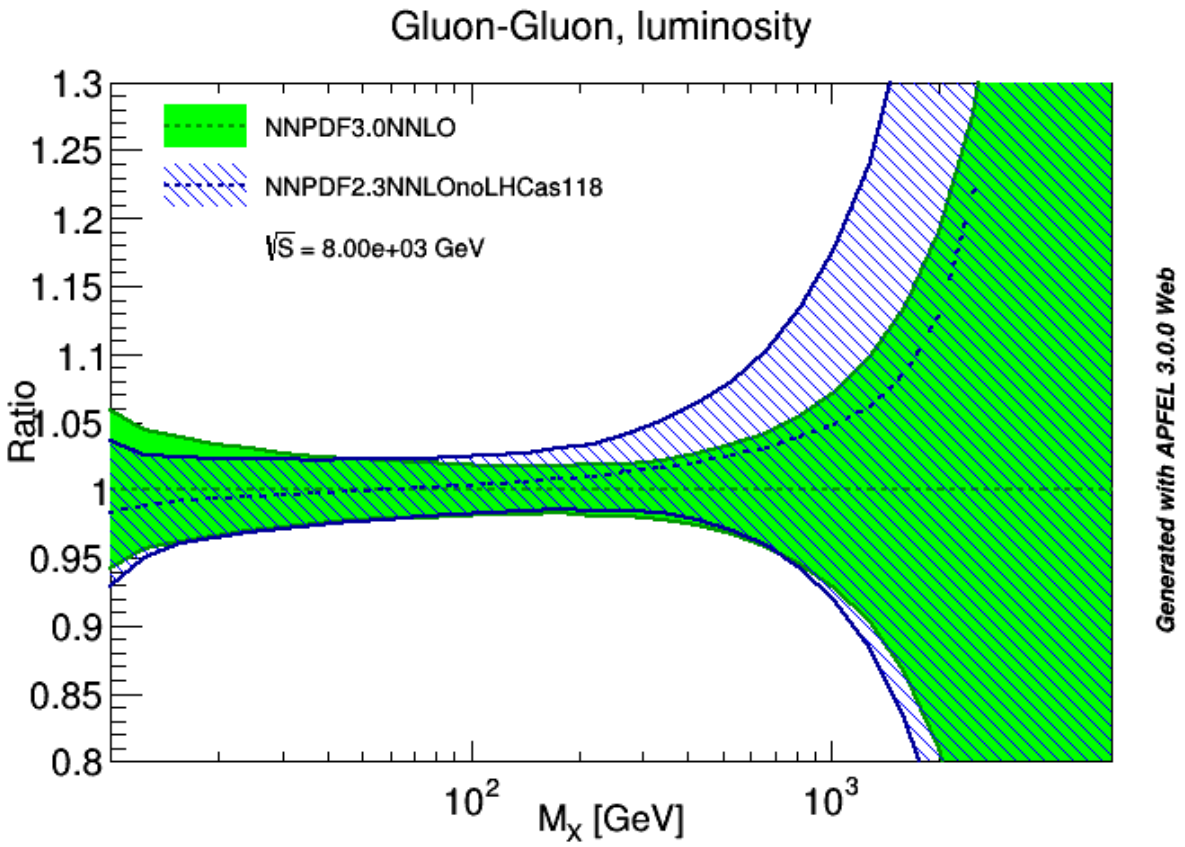
Note the hugely optimistic assumptions in ILC error bars [always 2 or 3 machines!] The cross section at the ILC is the same (300fb) as with LHeC (200) and the H does not decay more often in ee than in ep



Should possibly work to get a combined HL-LHC+LHeC plot, the ATLAS couplings + LHeC

"Amusing" to see the plot tricks: note the different y scales for ILC alone and with LHC

Sensitivity of PDFs with LHC



No LHC
With LHC
NNPDF3.0
(Oct. 2014)
S.Forte et al

Large uncertainties
at high mass
- yy induced proc.s
- k factors
- eweak corrections

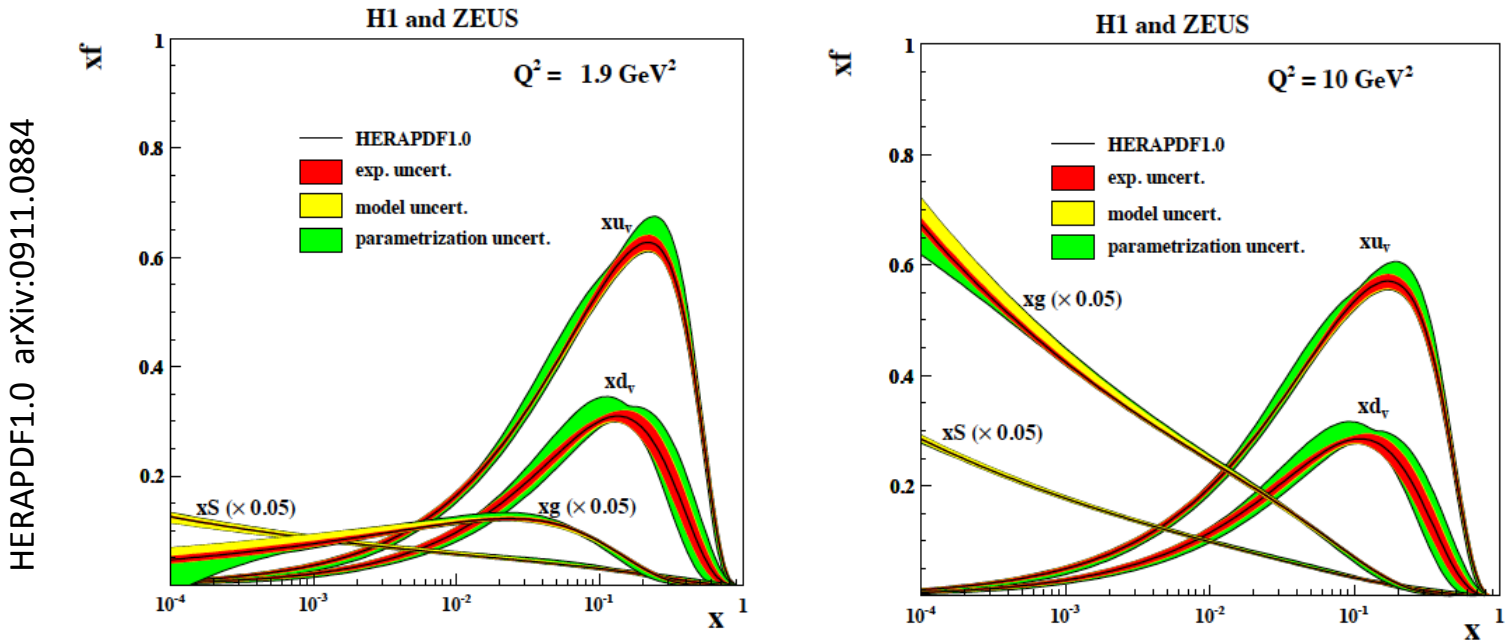
…
U.Klein LesHouches
arXiv:1405.1063

LHC: W+c, P_T(W), top, double differential W,Z data + previous input to NNPDF

New physics appearing as contact interaction would be confused with PDFs
Long range onset effects of new resonances: new physics or PDFs ??
High luminosity, high mass searches requires independent, precise PDFs ep--pp

Saturation

of the gluon density at low x



At small x the gluon density is large and it should be damped (saturate) due to non-linear gg interactions, and the (linear) DGLAP equations should be replaced by "BFKL". This is **crucial for QCD, for FCC rates, for UHE neutrino physics and may affect SUSY (Lipatov et al)**

This has NOT been seen at HERA. $xg(x,Q^2)$ is very small at small Q^2 and x and any saturation effect to be established must be observed for Q^2=O(10)GeV^2. It therefore can hardly be seen at EIC's - the ep/A machines with energies much lower than HERA - as $A^{1/3}$ won't help for xg ~0.

Saturation must be demonstrated in ep and eA to disentangle gg and nuclear effects → LHeC/FCC

Further on the paper

An understandable but scientific up-to-date physics overview,
why and when does HEP need the LHeC?
presented in a way that the IAC can defend it, and new groups find reasons to join.

Highlight questions one expects to be covered by the LHeC:
- PDFs and LHC, Higgs with LHeC, Higgs with LHC AND LHeC
- BSM physics (eweak and bqcd) with LHeC, and LHeC ←→LHC
- a top Top chapter, Low x (saturation), HI physics (QGP, EIC)

Suggestion for a Schedule:
Draft results for DIS14, end of April – feed back from community and IAC
[to be discussed with CERN and IAC Chair]

Draft paper release to the next LHeC Workshop, now likely in June 15

Publish for/and presenting at EPS, ly and elsewhere ? Timing / Run 2??

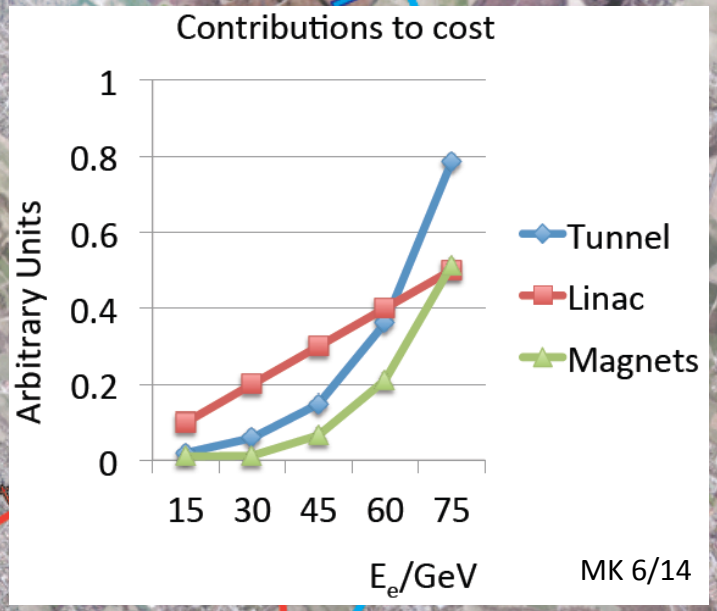
Who signs it – how do we involve the LHeC community ?? Needs clarity

A full new physics description by 2017, in the RUN2 context, and with our own detector software and a detector optimised. This shall be accompanied by a Technical Design Report for the ERL Test Facility

Civil Engineering Footprint

LHeC construction planning	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
Land negotiations							
Environmental Impact Study							
Building permits							
Detailed design & tendering							
Construction							

7 years for 9km Civil Engineering



LHC

1/3 Pt2 CDR

1/4 Pt2

1/5 Pt2

Prevessin Site

SPS

1/3 Pt

Pt 2

Pt 1

Meyrin Site

Pt 8

LHeC
Civil Engineering
Different Options
Fraction 1/3-1/4-1/5
Pt2 and Pt8
J.OSBORNE/L.FAISANDEL GS-SE-DOP

Detector and Beam and Lumi Assumptions

Have CDR, HL-LHC, FCC, first Higgs experience → propose to update the acceptance and resolution assumptions after this meeting for having a common basis (should be an LHeC note asap. Ready to participate in this)

We stay with 60 GeV Ee and 7 TeV Ep and assume 10^{34} in ep and 10^{32} in eA and synchronous operation and the LHC to operate for 10 years which gives $1ab^{-1}$. Possibly have also the ep and eA parameters in that or a separate note.

Remark on the FCC-he

FCC gives ERL a long term perspective and a further framework
[we are currently arguing for an IR to be foreseen from the start
for ep in order to not run into the LHC situation!]

With the FCC-he we have a huge potential for further physics
H-HH (cross section 5x higher than in ee), LQ to 3-4 TeV,
CI to O(100)TeV, low x down to even lower x ..
→ Few physics examples should suffice generally
→ May be better to not have FCC-he in the yellow paper.??

Note there is an FCC workshop end of March in Washington
And it is forseeen to have 1 or 2 parallel sessions on ep/A

Today

Introduction to the paper – Stefano

PDFs+QCD - Voica, Fred

Higgs – Uta, Masahiro

---------coffee coming in at 10.30 but no time for break

BSM – Monica, Georges

Top - Christian, Olaf

Heavy Ions – Nestor

Low x – Anna, Paul

Detector+Software – Peter, Paul (no Mary)

Many thanks for coming and following this