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MIT, July 28th 2011

Small-x physics opportunities with a Large Hadron-electron Collider at CERN

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for the **LHeC Study Group**, http://cern.ch/lhec,
Working Group on *Physics at High Parton Densities in ep and eA* (with Brian Cole, Paul Newman and Anna Stasto)

Contents:

See the EIC talks here by T. Horn, V. Ptitsyn and M. Stratmann, the LHeC talks at DIS2011 (https://wiki.bnl.gov/conferences/index.php/DIS-2011), and the talk by P. Laycock at HEP-EPS11.

Contents:

Disclaimer: results from CDR as available on 27.07.2011 at 17.35 CERN time.

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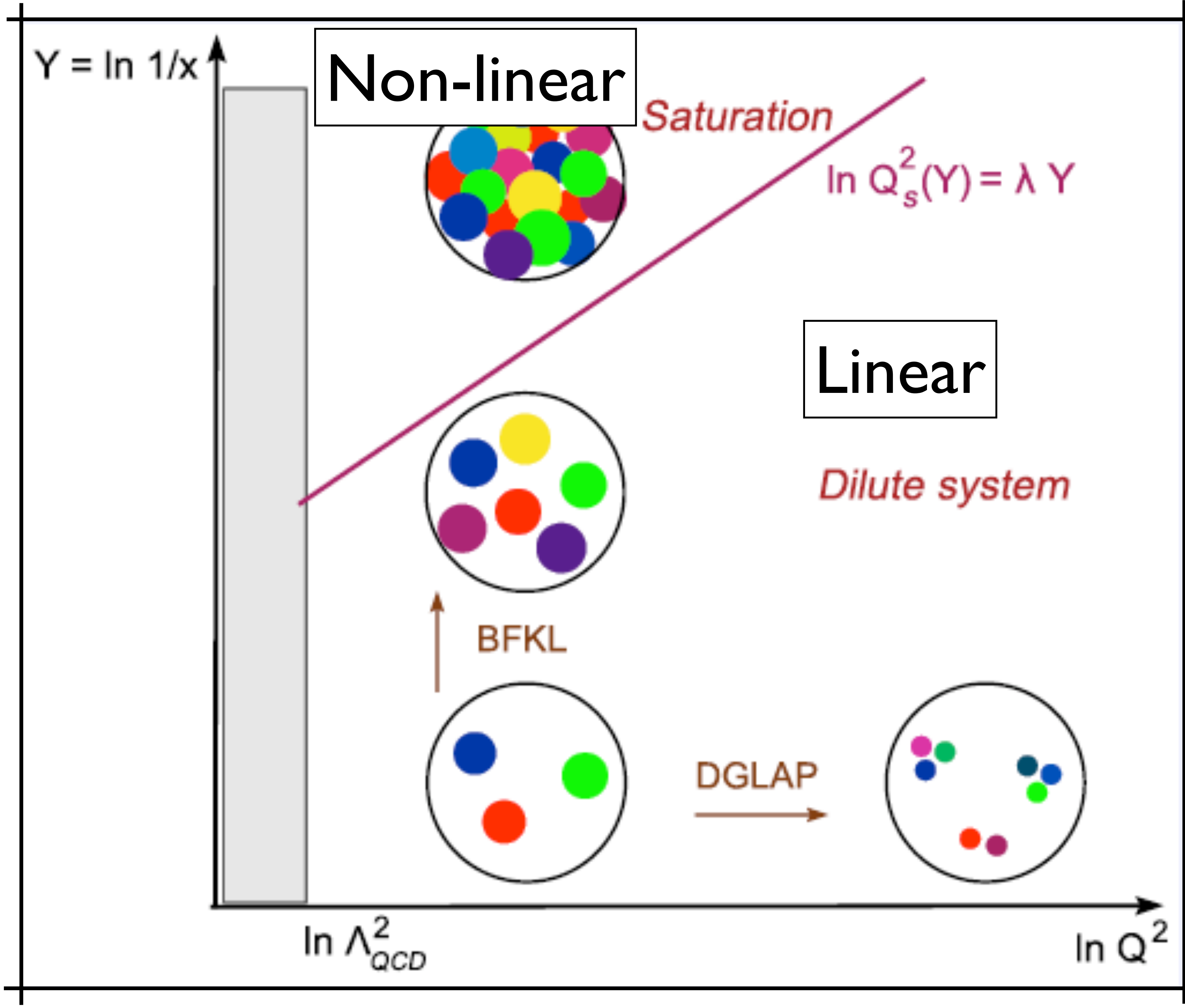
High-energy QCD:

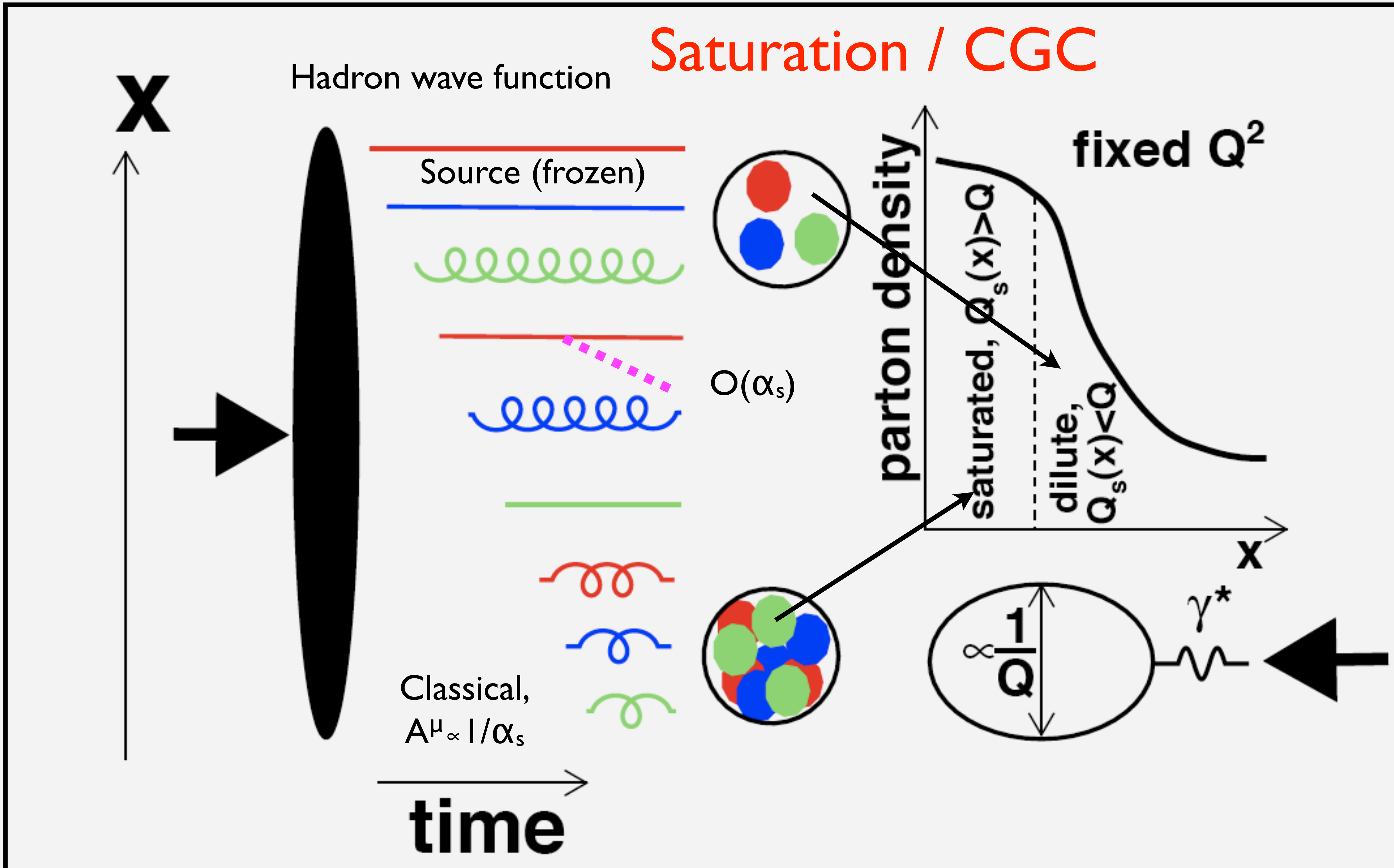


Where do the available experimental data lie?

Our aims: understanding

- The implications of unitarity in a QFT.
- The behavior of QCD at large energies / hadron wave function at small x.
- The initial conditions for the creation of a dense medium in heavy-ion collisions: nuclear WF + initial stage.

High-energy QCD:



at

or

experimental data lie?

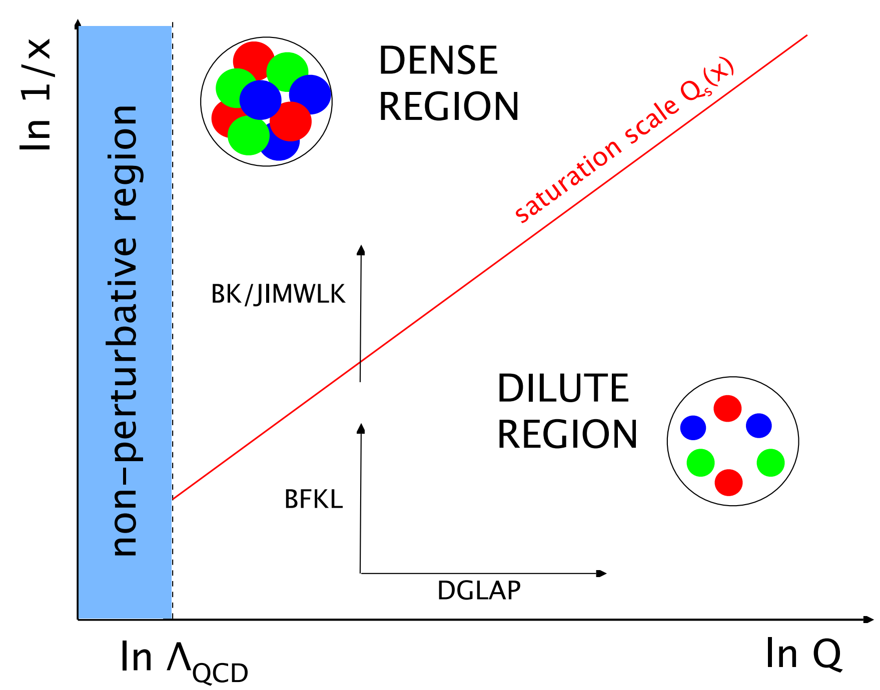
initial stage.

Status:

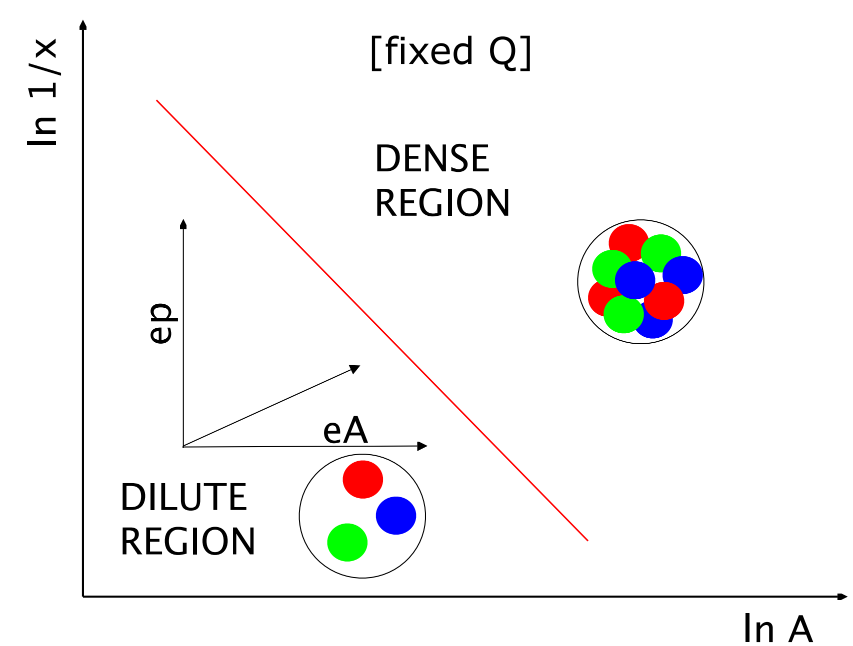
- Three pQCD-based alternatives to describe small-x ep and eA data:
  → DGLAP evolution (fixed order PT).
  → Resummation schemes.
  → CGC (dipole models and rcBK).

Differences lie at moderate $Q^2(>\Lambda^2_{QCD})$ and small x. Hints of deviations from NLO DGLAP at small x (Caola et al '09).

- **Unitarity** (non-linear effects): where?



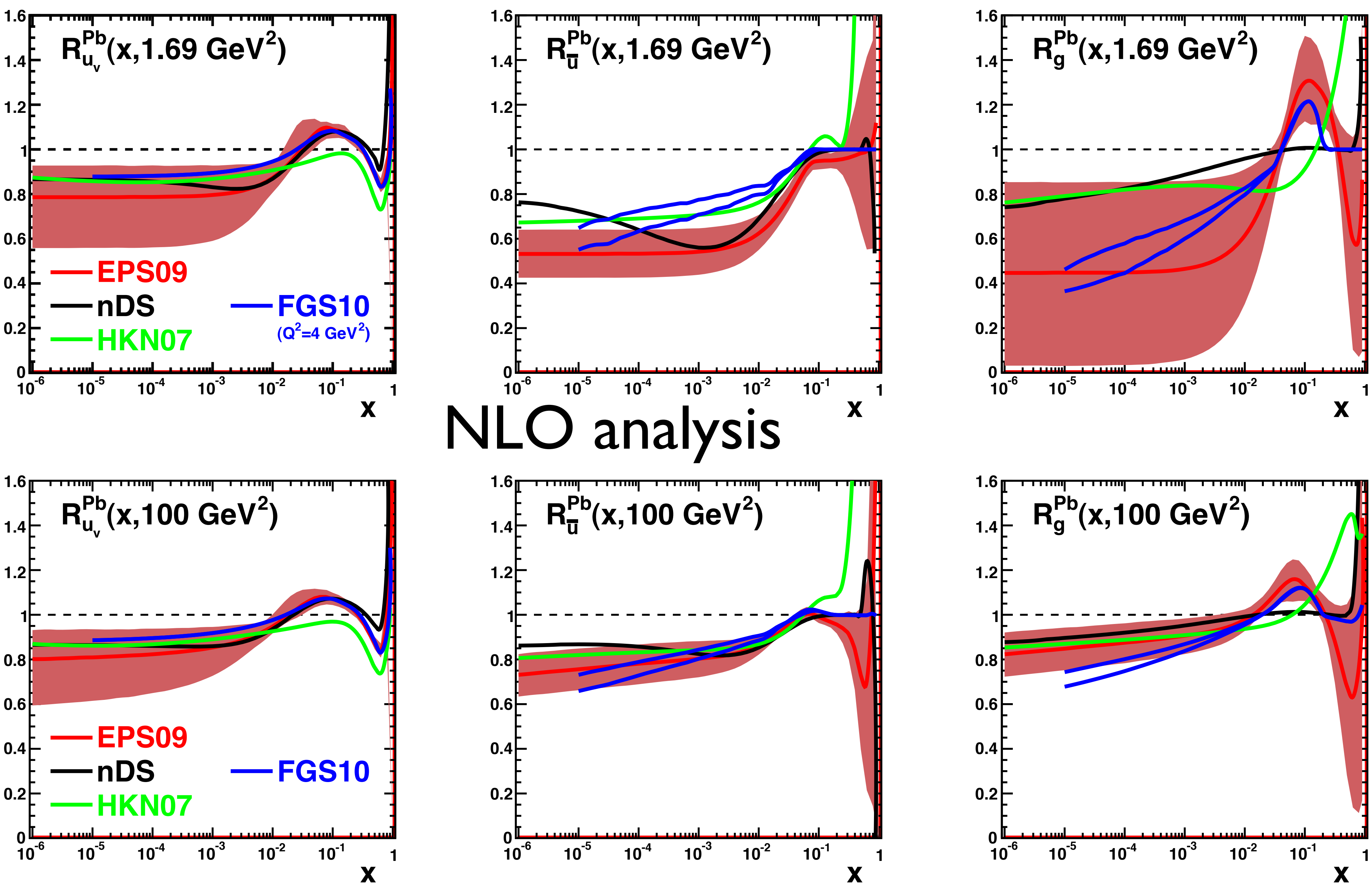
Two-pronged approach: ↓ x / ↑ A. **eA**: test/ enhance density effects.



Uncertainties in DGLAP npdf's:

$$R_{F_2}^{A}(x, Q^2) = \frac{F_2^A(x, Q^2)}{A F_2^{\text{nucleon}}(x, Q^2)}$$

Problem for benchmarking in hard probes!!!



NLO analysis

Uncertainties in DGLAP npdf's:

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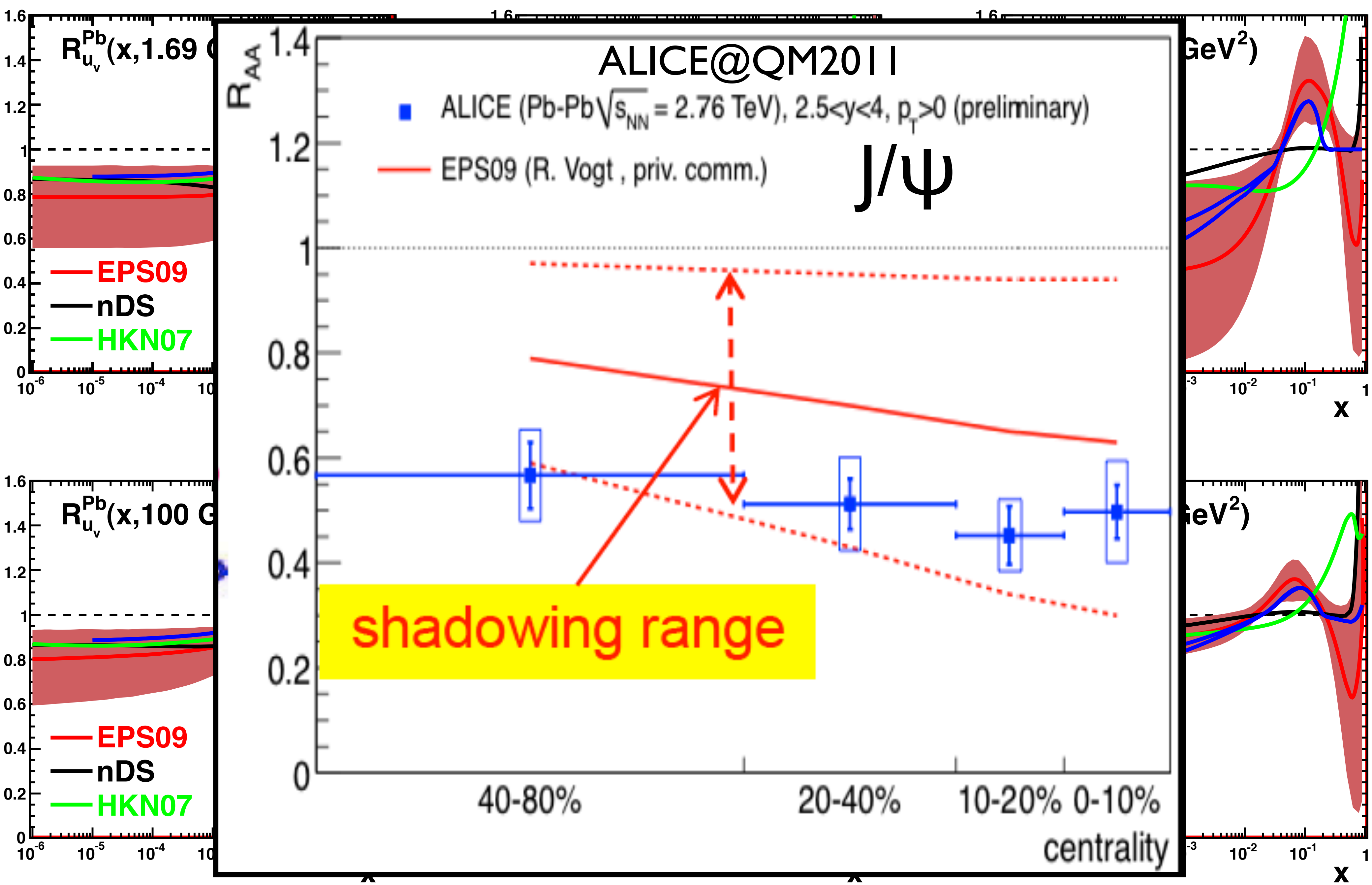


Contents:

Project:

- **LHeC@CERN** → ep/eA experiment using p/A from the LHC: E_p=7 TeV, $E_A=(Z/A)E_p$=2.75 TeV/nucleon for Pb.
- New e^+/e^- accelerator: $E_{cm}\sim$1-2 TeV/nucleon (E_e=50-150 GeV).
- Requirements:

* Luminosity~10^{33} cm^{-2}s^{-1}.

* Acceptance: 1-179 degrees (low-x ep/eA).

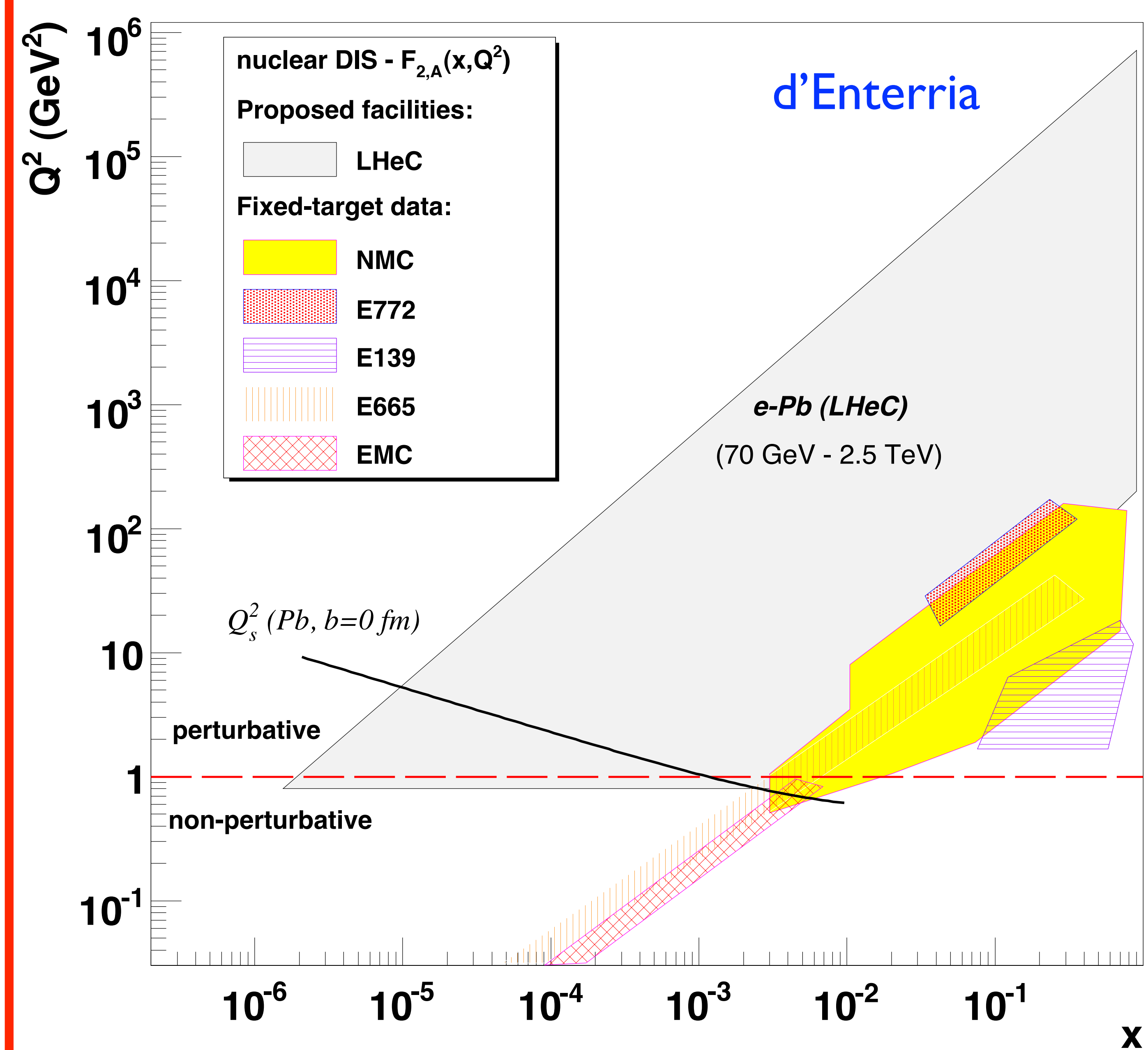
* Tracking to 0.1 mrad.

* EMCAL calibration to 0.1 %.

* HCAL calibration to 0.5 %.

* Luminosity determination to 1 %.

* Compatible with LHC operation.



Project:

• LH ... HC:

Ep=7

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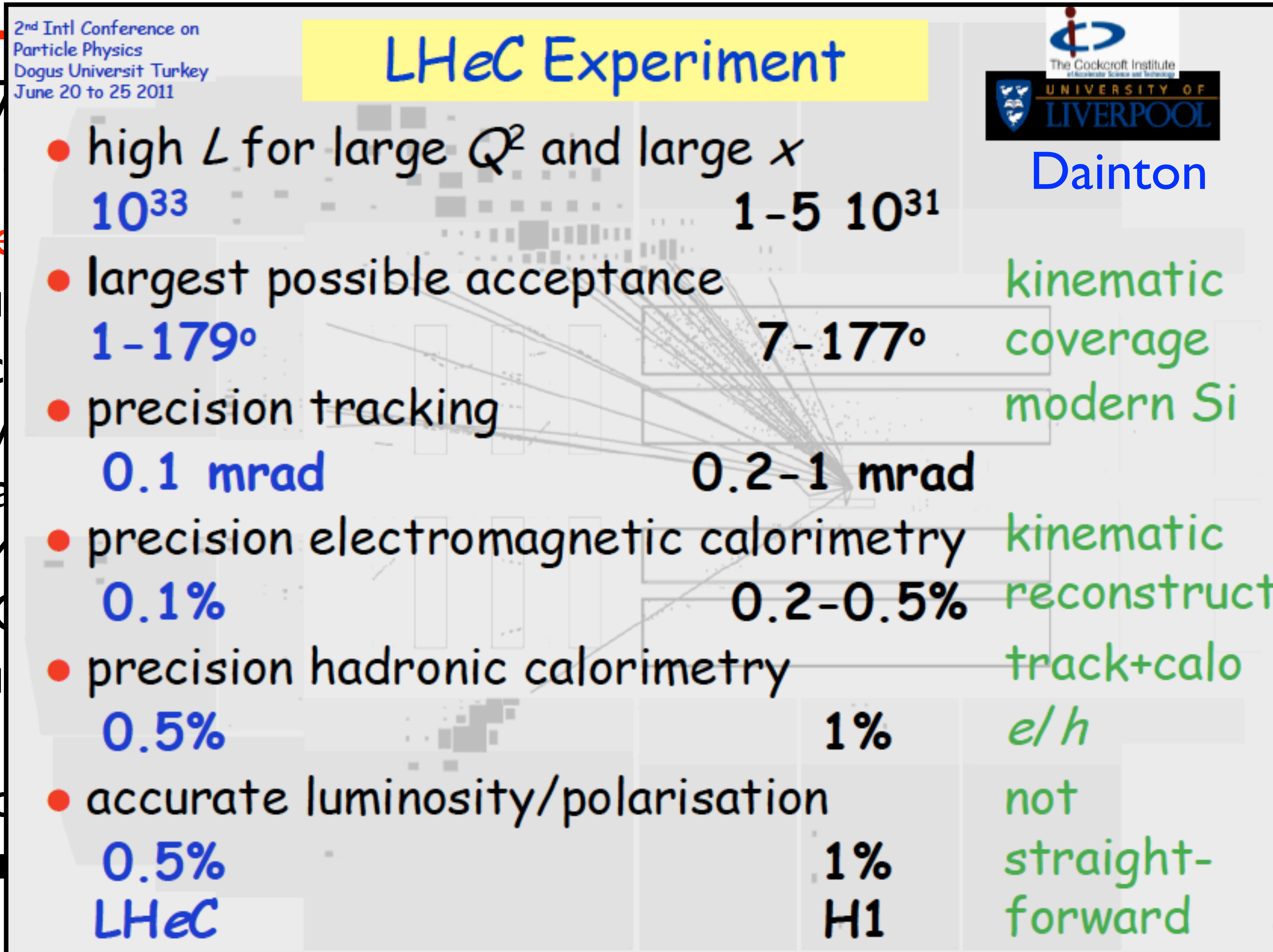
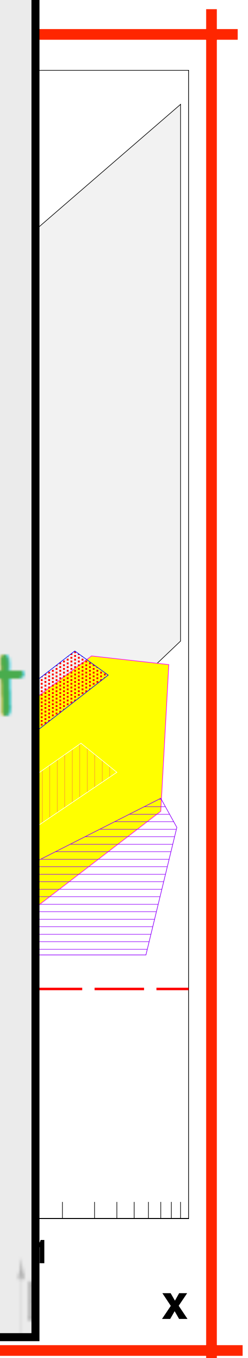
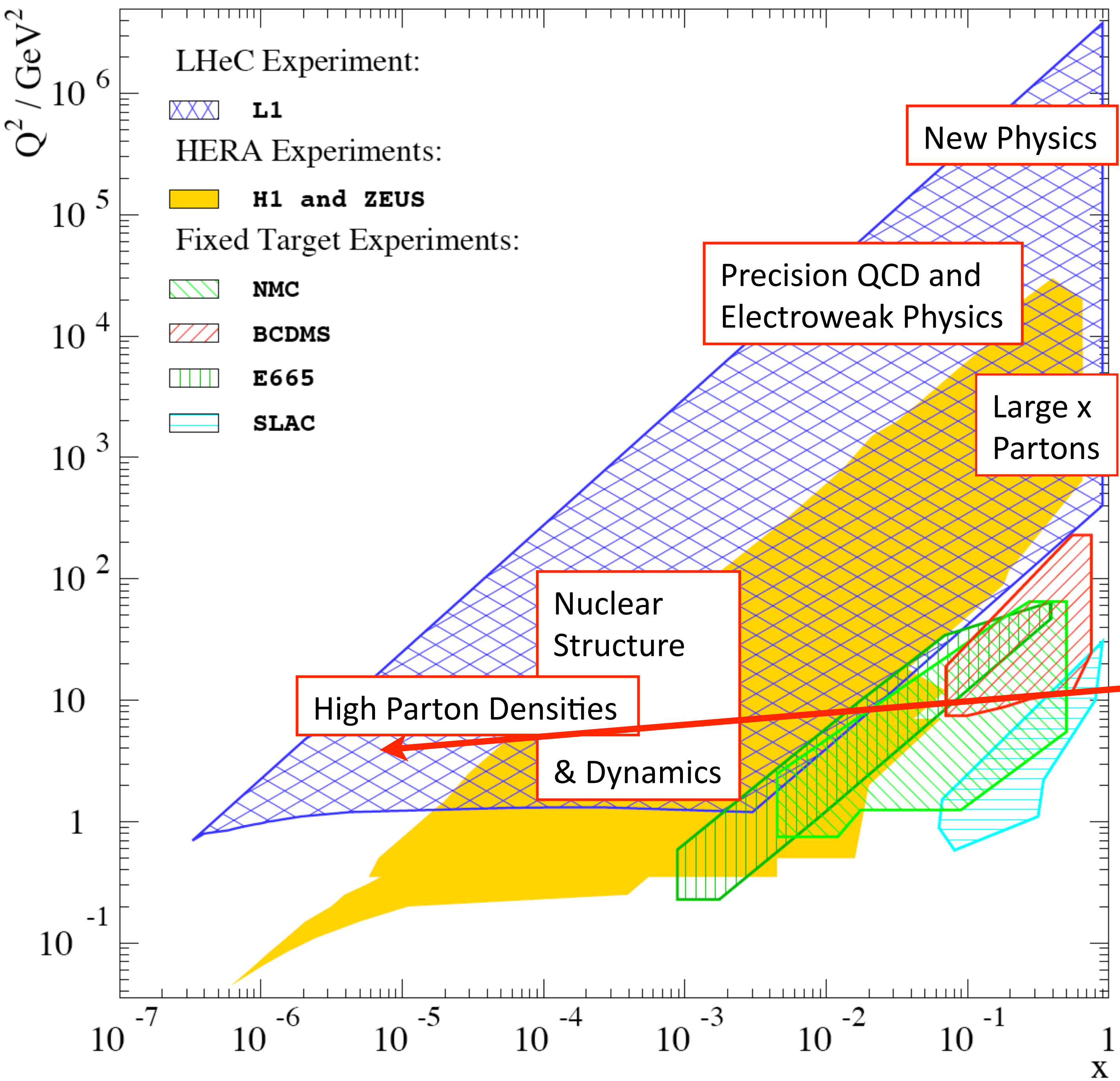




Physics goals:

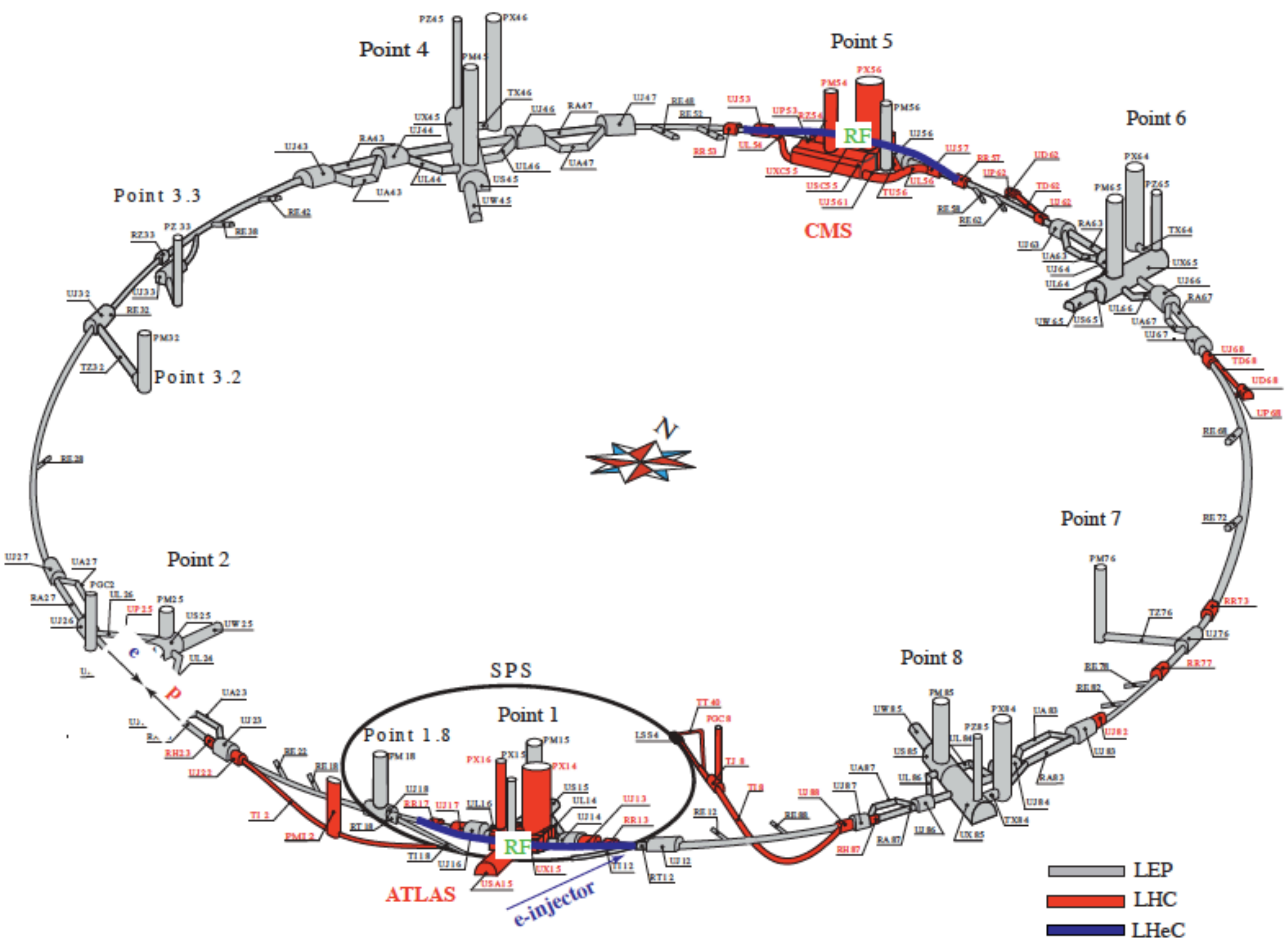


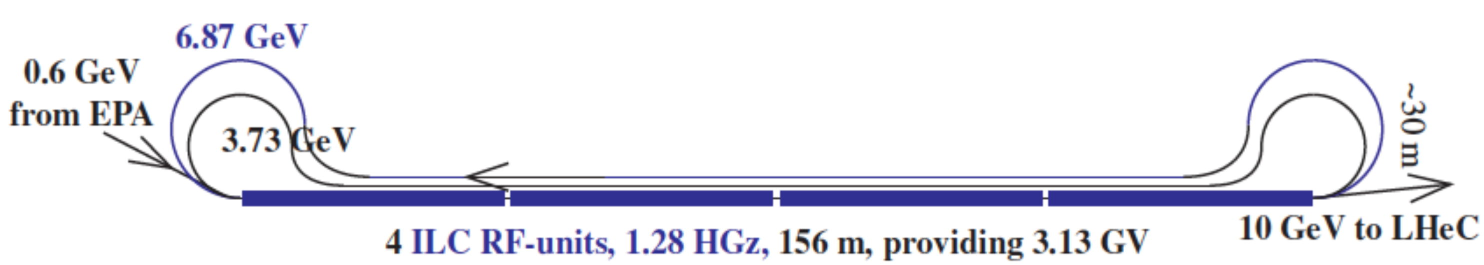
- Proton structure to a few 10^{-20} m: Q^2 lever arm.
- Precision QCD/EW physics.
- High-mass frontier (leptoquarks, excited fermions, contact interactions).
- Unambiguous access, in ep and eA, to a **qualitatively novel regime of matter predicted by QCD**.
- Substructure/parton dynamics inside nuclei with strong implications on QGP search.

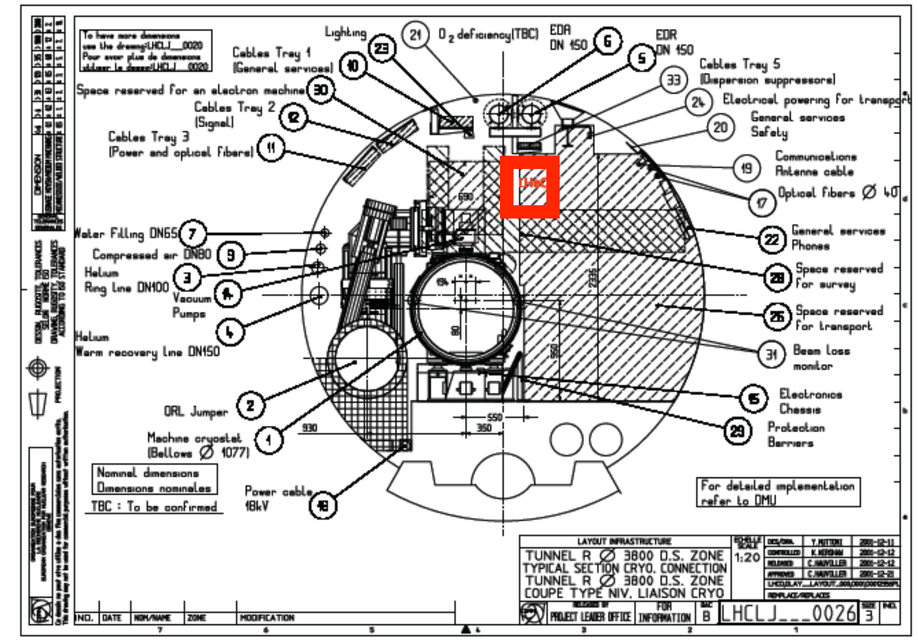
Small-x physics at the LHeC: 2. The Large Hadron-electron Collider.

Machine: Ring-Ring option

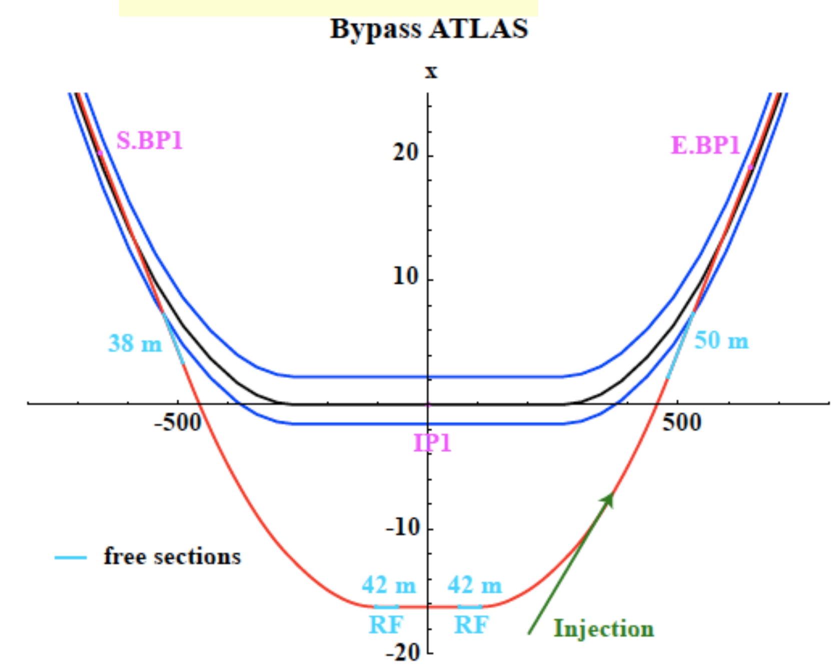
Preliminary; LHeC Design Study Report, CERN 2011







BYPASS



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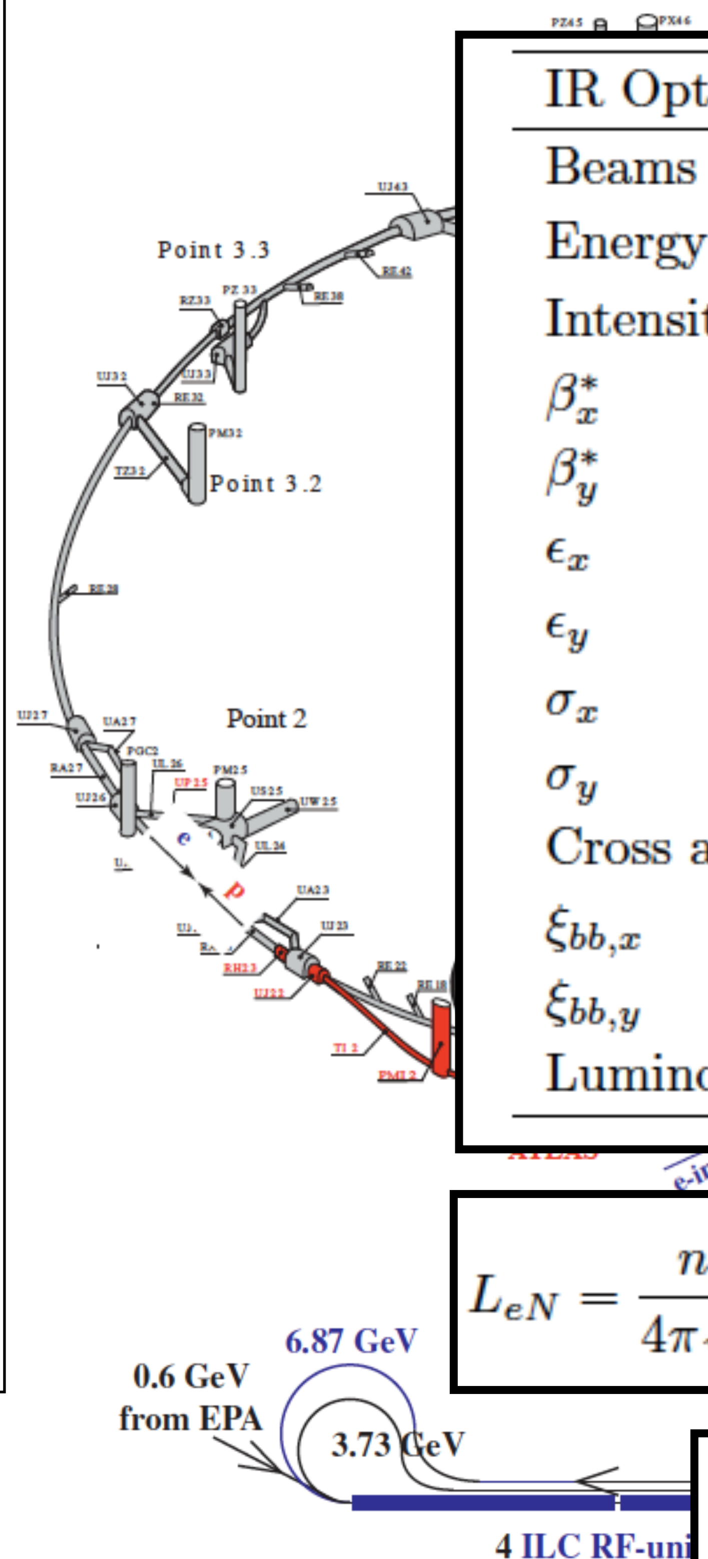
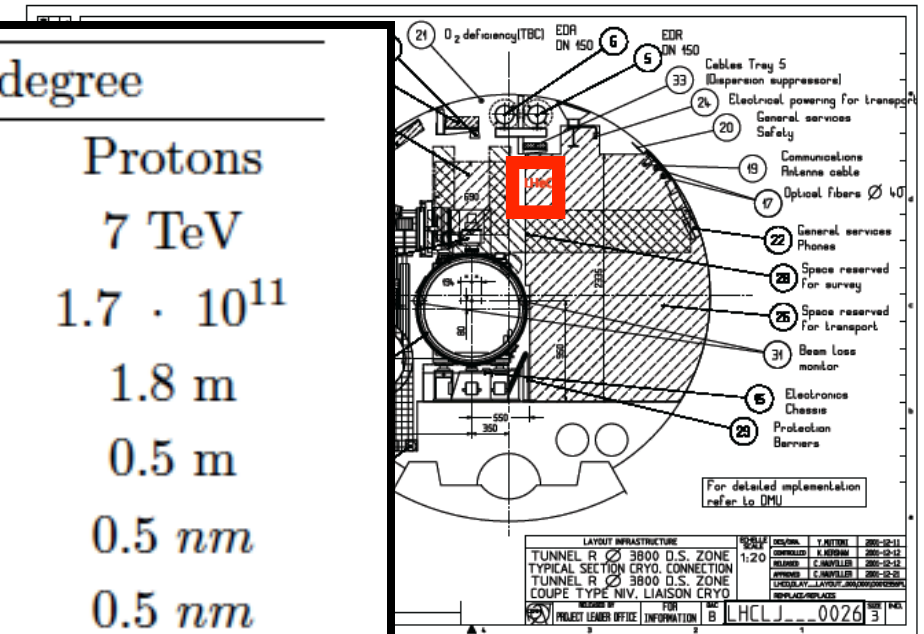
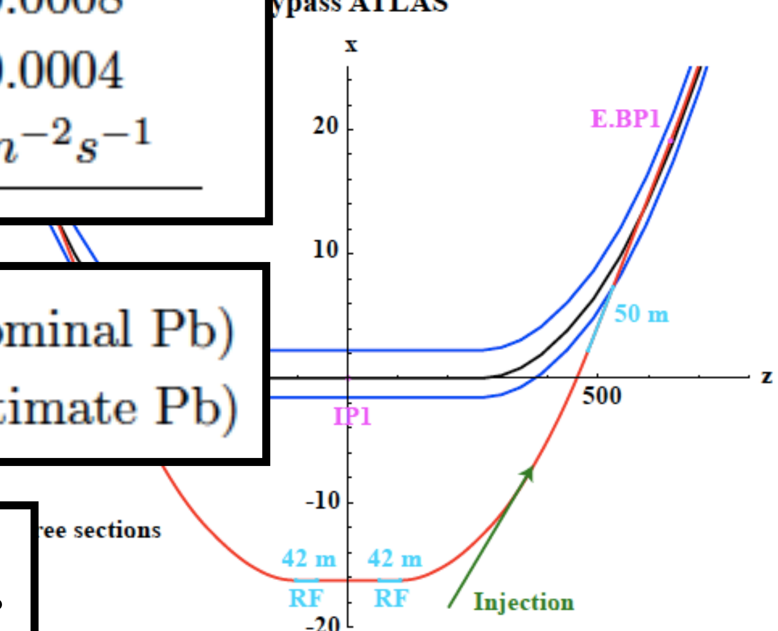




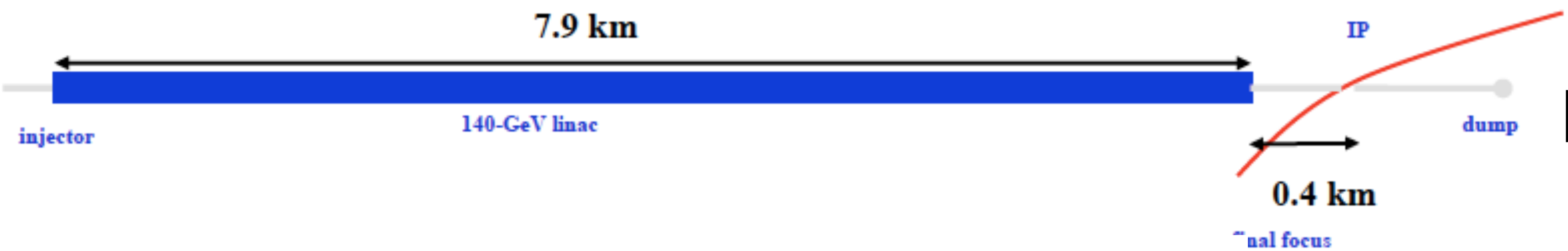
IR Option	1 degree		10 degree	
Beams	Electrons	Protons	Electrons	Protons
Energy	60 GeV	7 TeV	60 GeV	7 TeV
Intensity	$2 \cdot 10^{10}$	$1.7 \cdot 10^{11}$	$2 \cdot 10^{10}$	$1.7 \cdot 10^{11}$
β_x^*	0.4 m	4.05 m	0.18 m	1.8 m
β_y^*	0.2 m	0.97 m	0.1 m	0.5 m
ϵ_x	$5\ nm$	$0.5\ nm$	$5\ nm$	$0.5\ nm$
ϵ_y	$2.5\ nm$	$0.5\ nm$	$2.5\ nm$	$0.5\ nm$
σ_x	$45\mu m$		$30\mu m$	
σ_y	$22\mu m$		$15.8\mu m$	
Cross angle	1 mrad		1 mrad	
$\xi_{bb,x}$	0.086	0.0008	0.085	0.0008
$\xi_{bb,y}$	0.088	0.0004	0.090	0.0004
Luminosity	$7.33 \cdot 10^{32}\ cm^{-2}s^{-1}$		$1.34 \cdot 10^{33}\ cm^{-2}s^{-1}$	



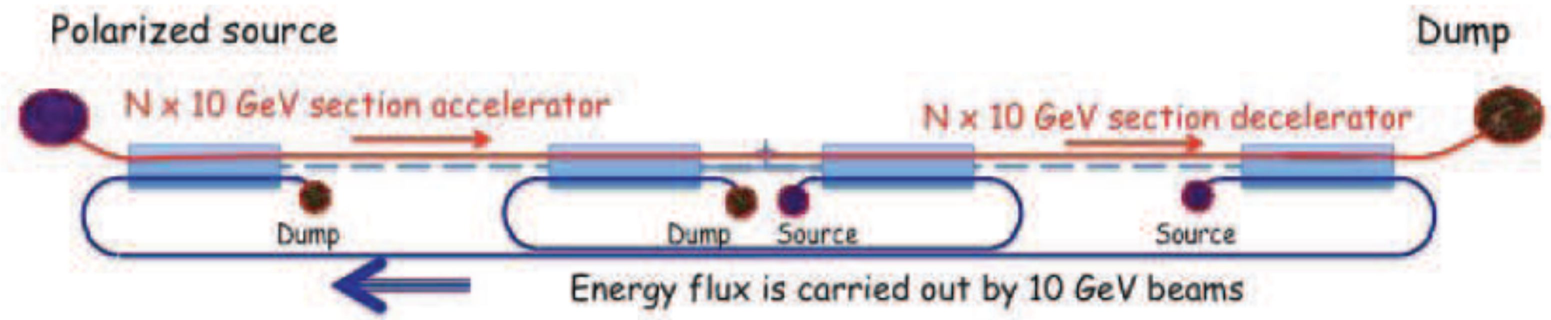
$$L_{eN} = \frac{n_b f_0 N_e (A N_{Pb})}{4\pi\sqrt{\beta_{xe}^*\varepsilon_x}\sqrt{\beta_{ye}^*\varepsilon_y}} = \begin{cases} 2.6\times 10^{31}\ \mathrm{cm^{-2}s^{-1}} & \text{(Nominal Pb)} \\ 4.5\times 10^{31}\ \mathrm{cm^{-2}s^{-1}} & \text{(Ultimate Pb)} \end{cases}$$

eD: $L_{eN}=AL_{eA}>\sim 10^{31}\ cm^{-2}s^{-1}$.

Machine: Linac-Ring option

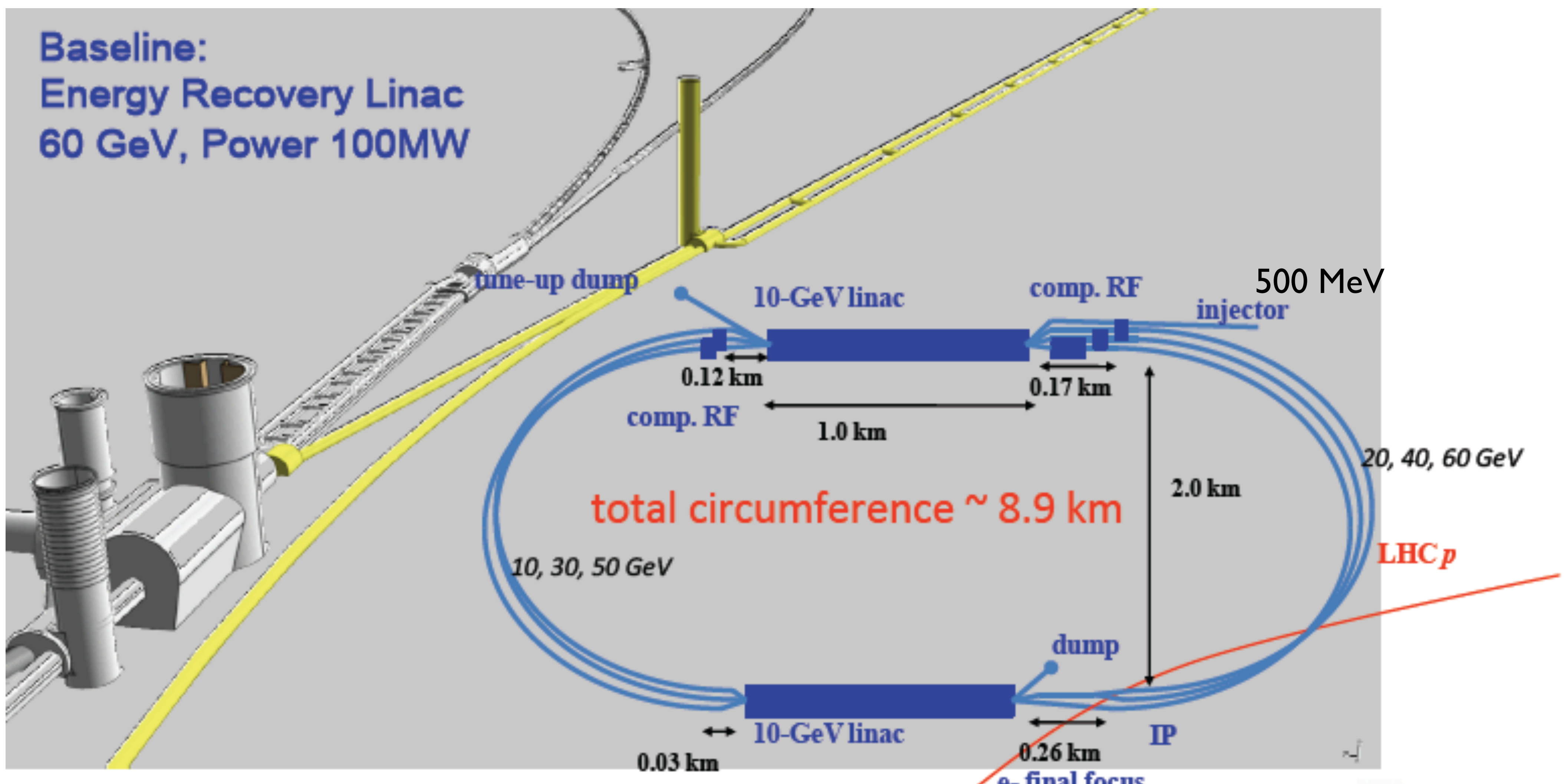


HE LR, 140 GeV



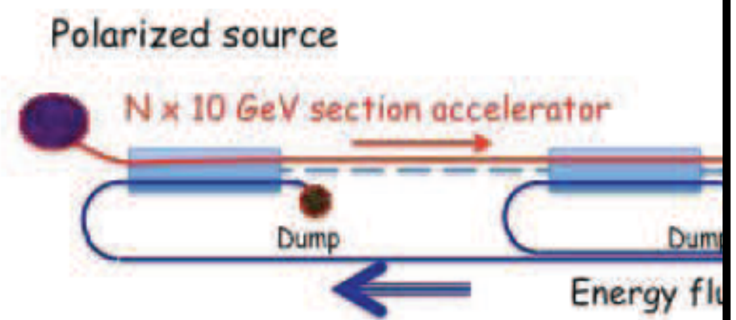
HE LR, ER, 140 GeV

Preliminary; Bogacz@DIS11; LHeC Design Study Report, CERN 2011



Machine: Linac-Ring option

HE LR, 140 GeV

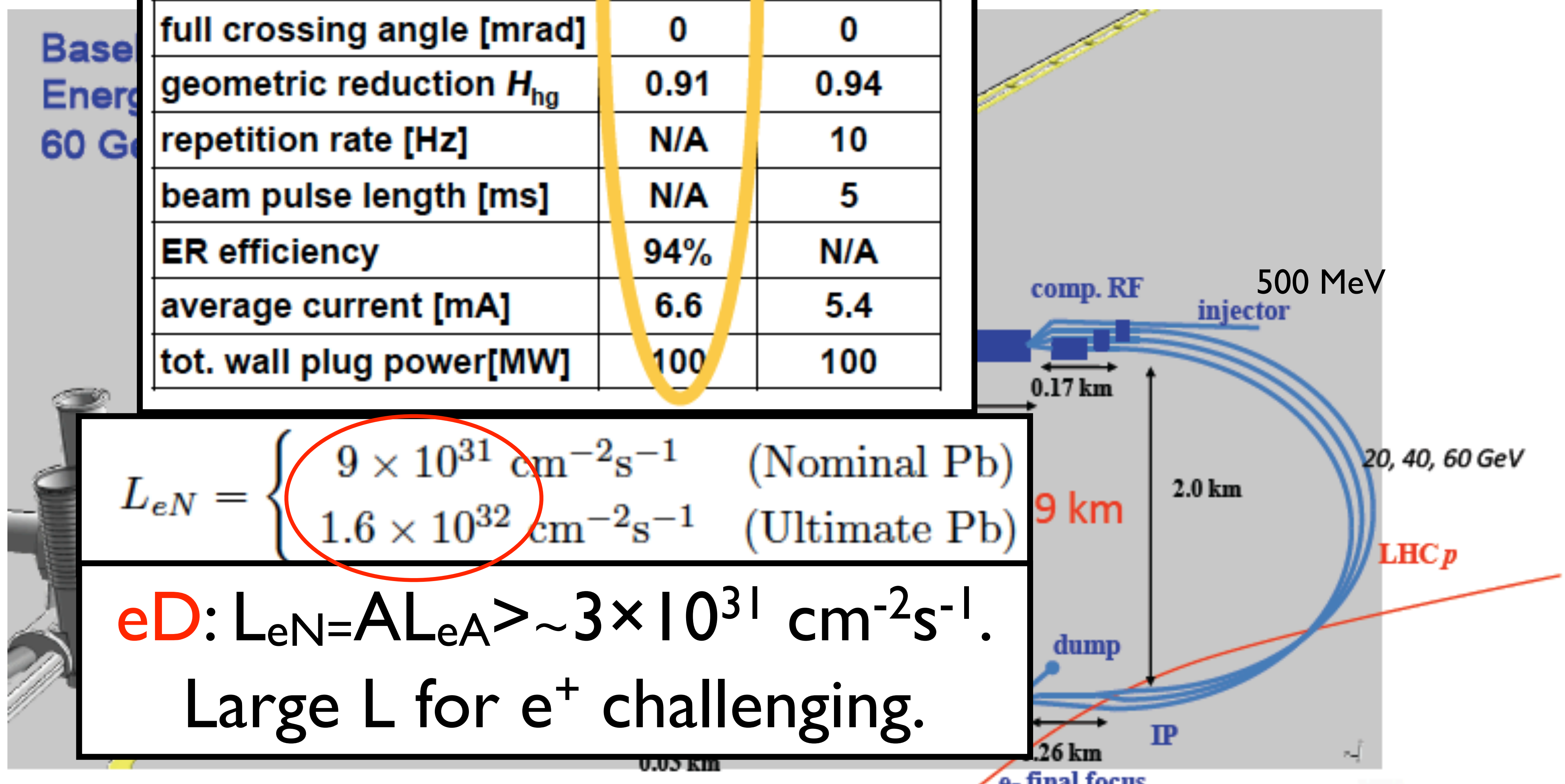


LR, ER, 140 GeV

electron beam	LR ERL	LR
e- energy at IP[GeV]	60	140
luminosity [10^{32} $cm^{-2}s^{-1}$]	10	0.44
polarization [%]	90	90
bunch population [10^{9}]	2.0	1.6
e- bunch length [mm]	0.3	0.3
bunch interval [ns]	50	50
transv. emit. $\gamma\varepsilon_{x,y}$ [mm]	0.05	0.1
rms IP beam size $\sigma_{x,y}$ [μm]	7	7
e- IP beta funct. $\beta^*_{x,y}$ [m]	0.12	0.14
full crossing angle [mrad]	0	0
geometric reduction H_{hg}	0.91	0.94
repetition rate [Hz]	N/A	10
beam pulse length [ms]	N/A	5
ER efficiency	94%	N/A
average current [mA]	6.6	5.4
tot. wall plug power[MW]	100	100

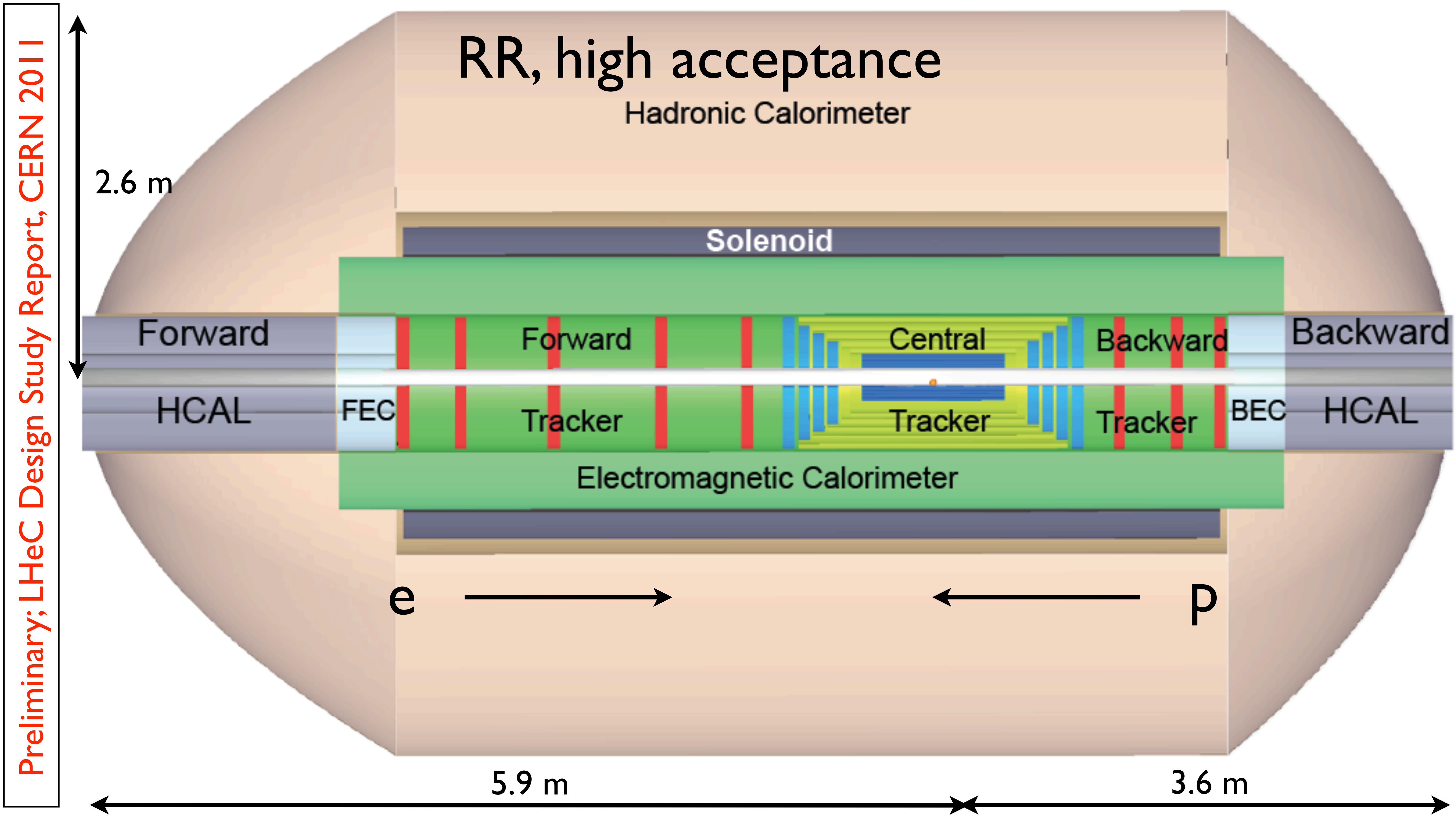
$$L_{eN} = \begin{cases} 9 \times 10^{31}\ \mathrm{cm^{-2}s^{-1}} & \text{(Nominal Pb)} \\ 1.6 \times 10^{32}\ \mathrm{cm^{-2}s^{-1}} & \text{(Ultimate Pb)} \end{cases}$$

eD: $L_{eN}=AL_{eA}>\sim 3\times10^{31}$ $cm^{-2}s^{-1}$. Large L for e^+ challenging.



Preliminary; Bogacz@DIS11; LHeC Design Study Report, CERN 2011

The detector: low-x/eA setup



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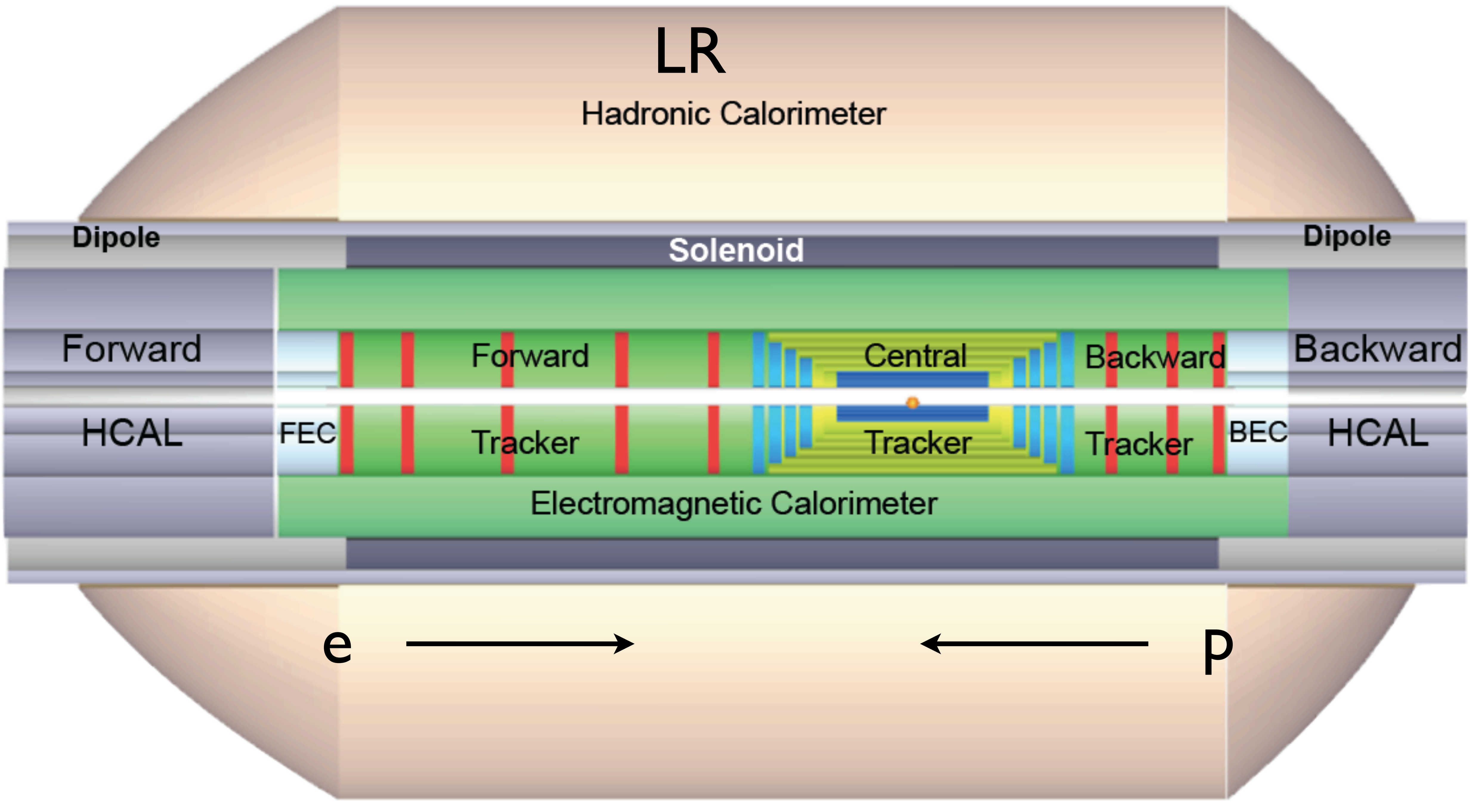
Preliminary; LHeC Design Study Report, CERN 2011



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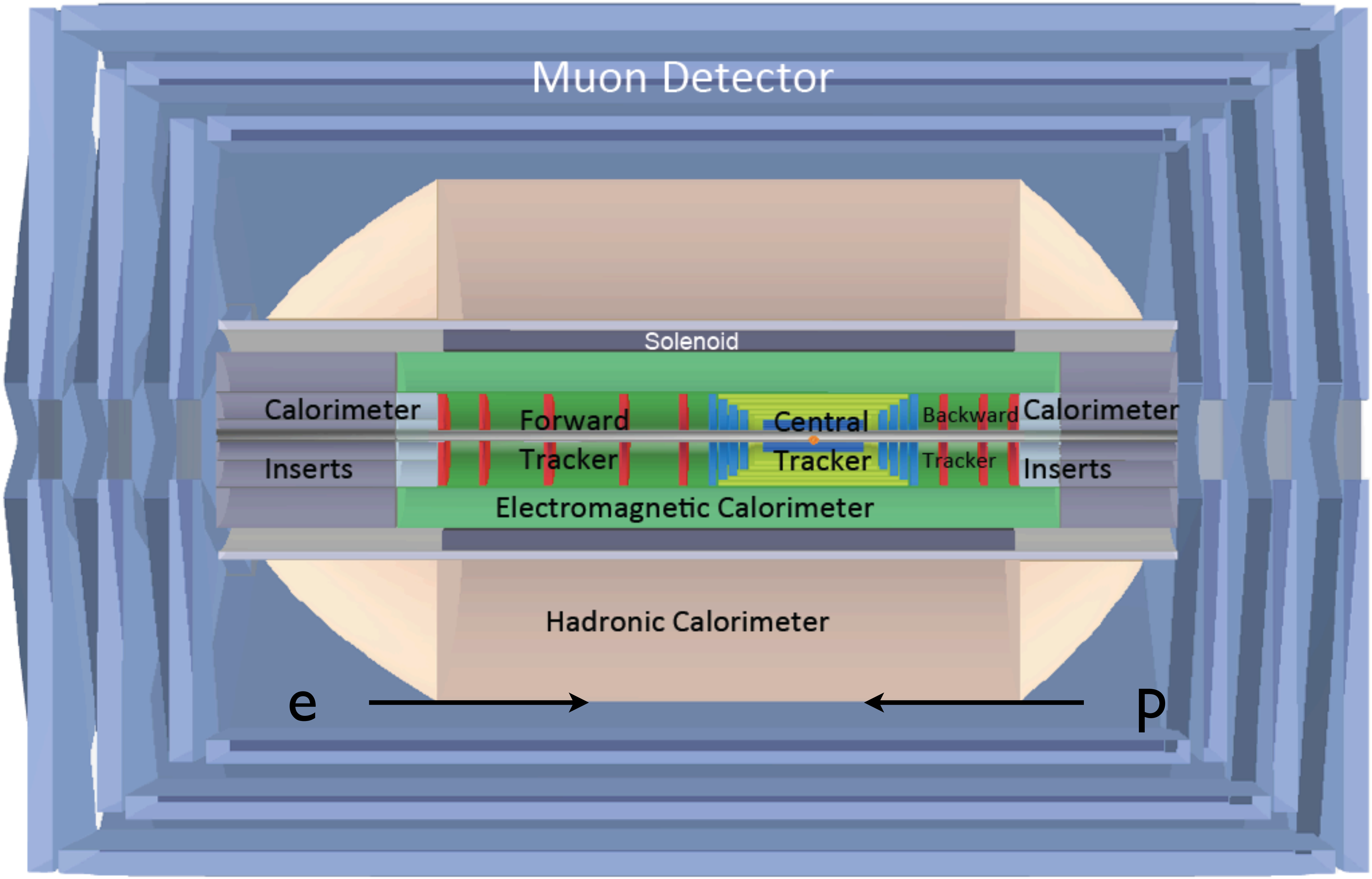
Preliminary; LHeC Design Study Report, CERN 2011



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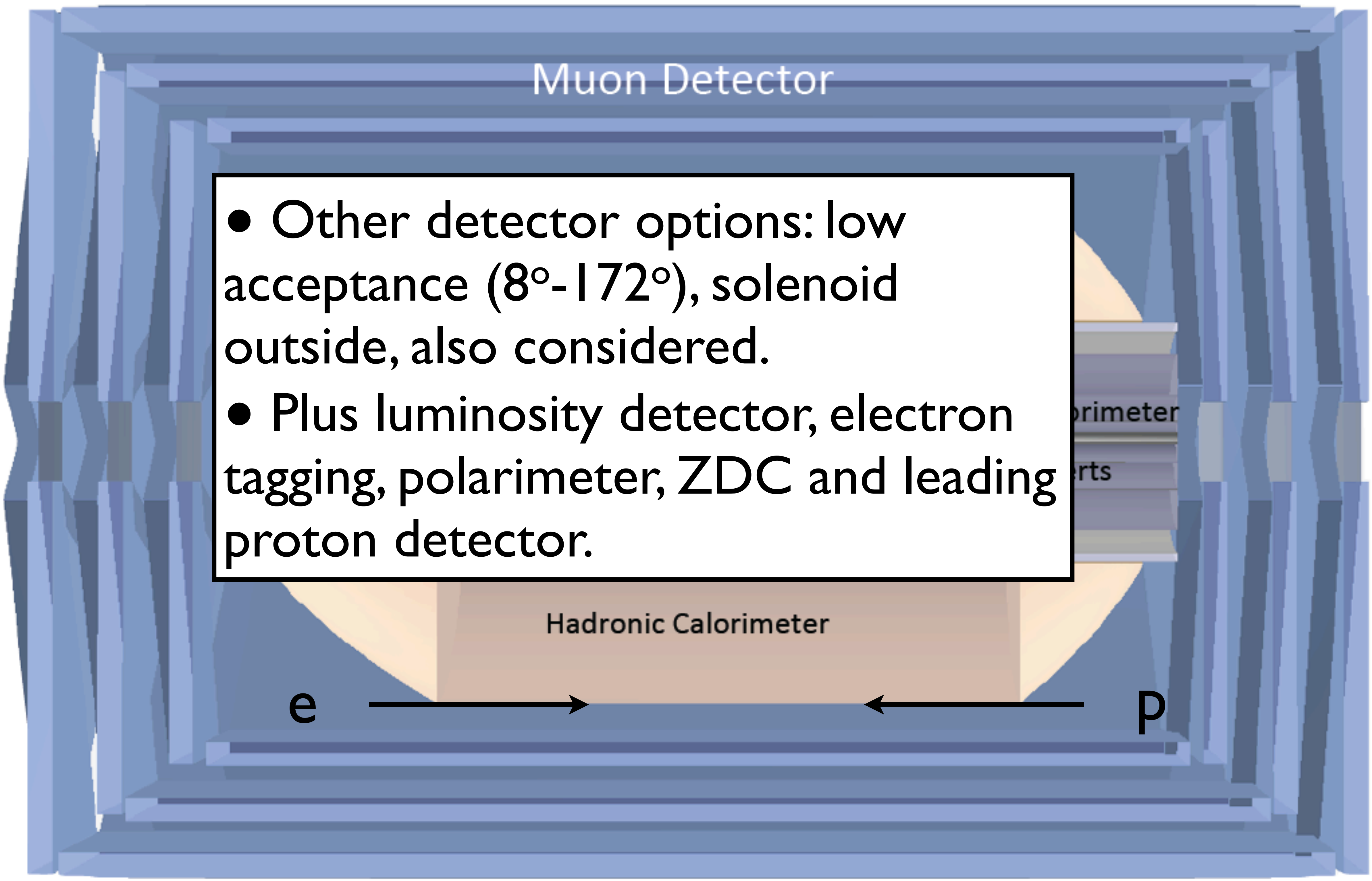
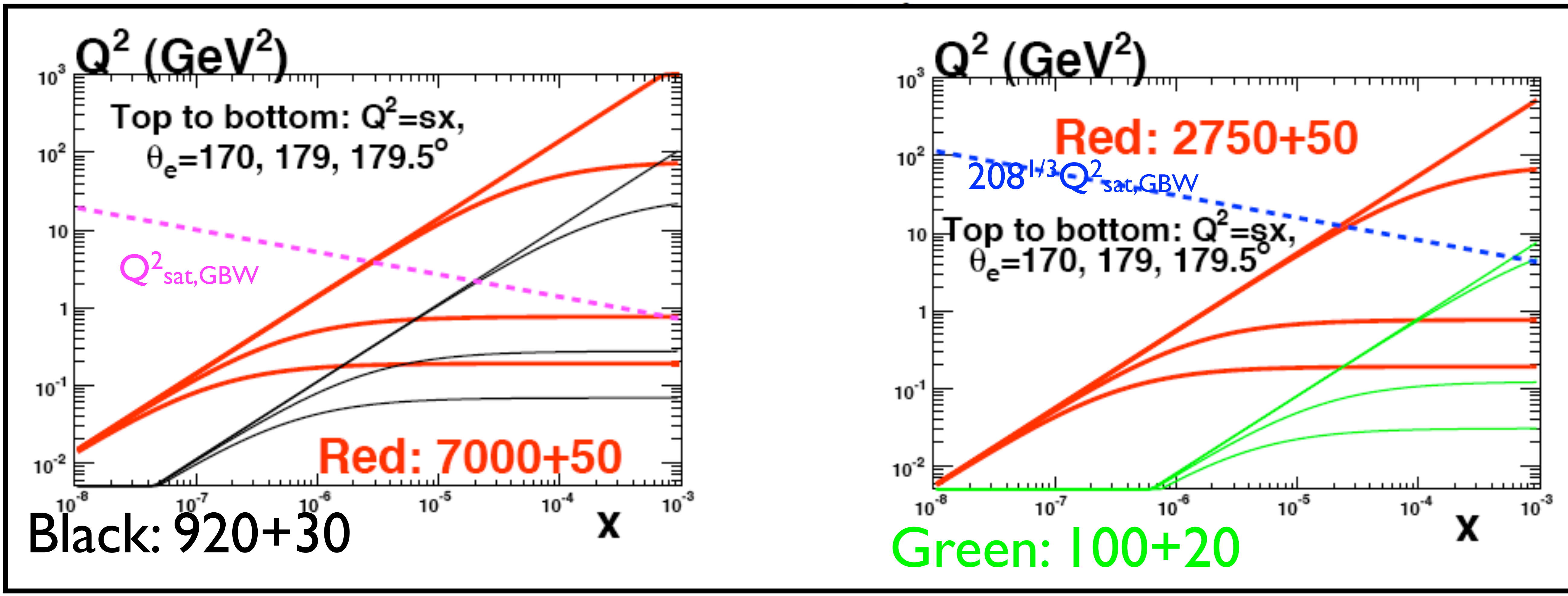


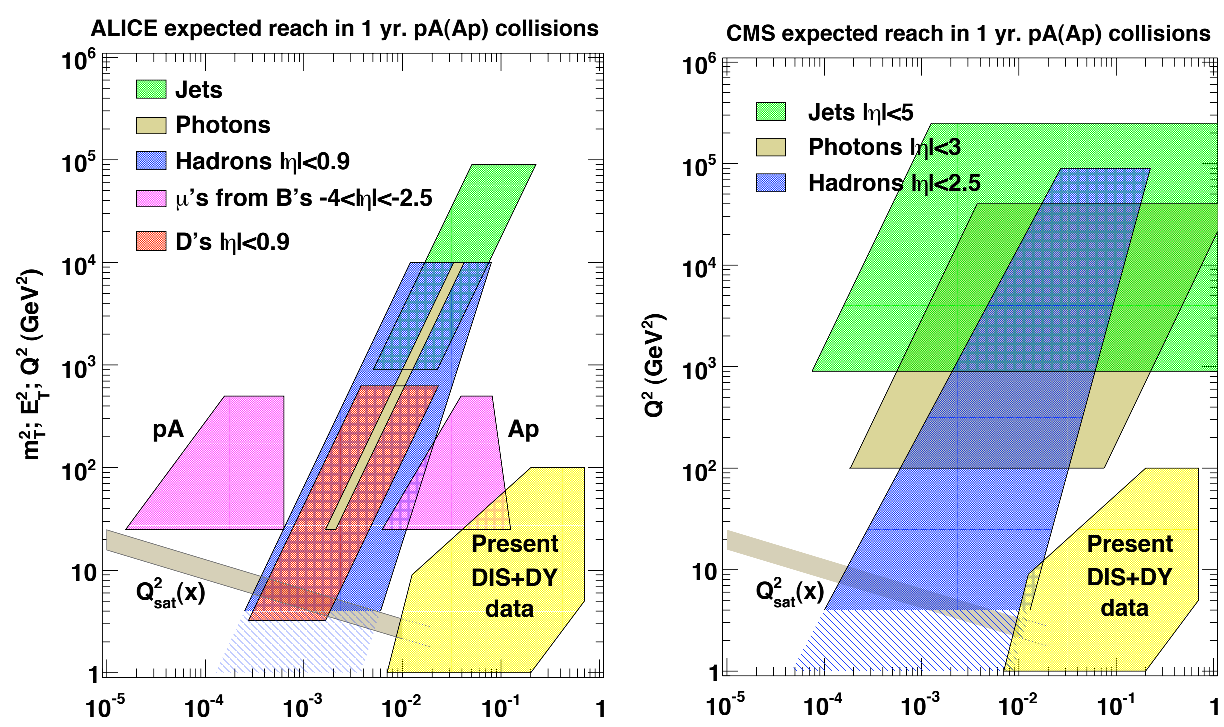
- Other detector options: low acceptance (8°-172°), solenoid outside, also considered.
- Plus luminosity detector, electron tagging, polarimeter, ZDC and leading proton detector.

Preliminary; LHeC Design Study Report, CERN 2011

Kinematics:



- ep: access to the perturbative region below x ~ a few 10^{-5}.
- eA: new realm.
- No small-x physics without ~ 1 degree acceptance.



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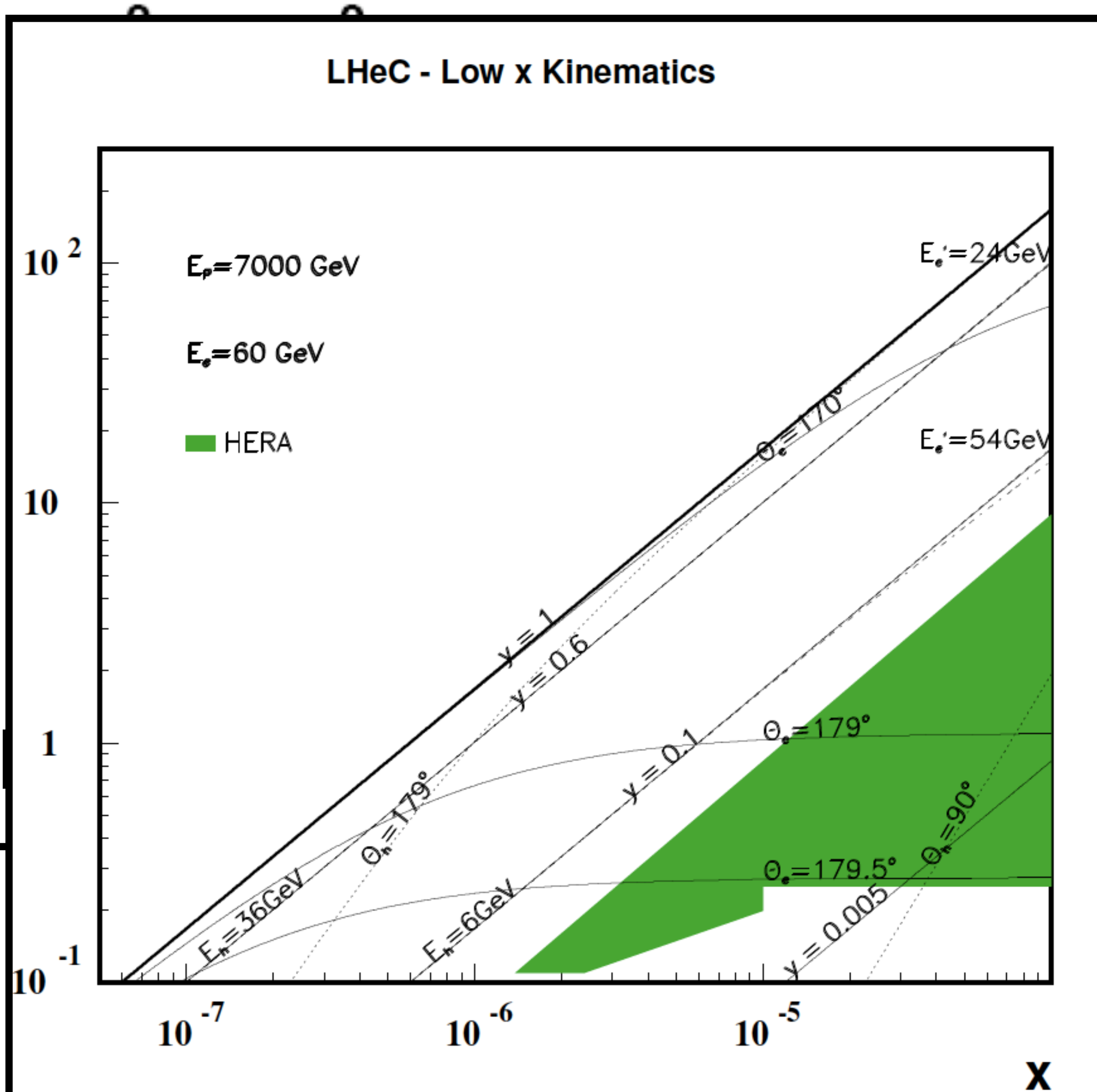
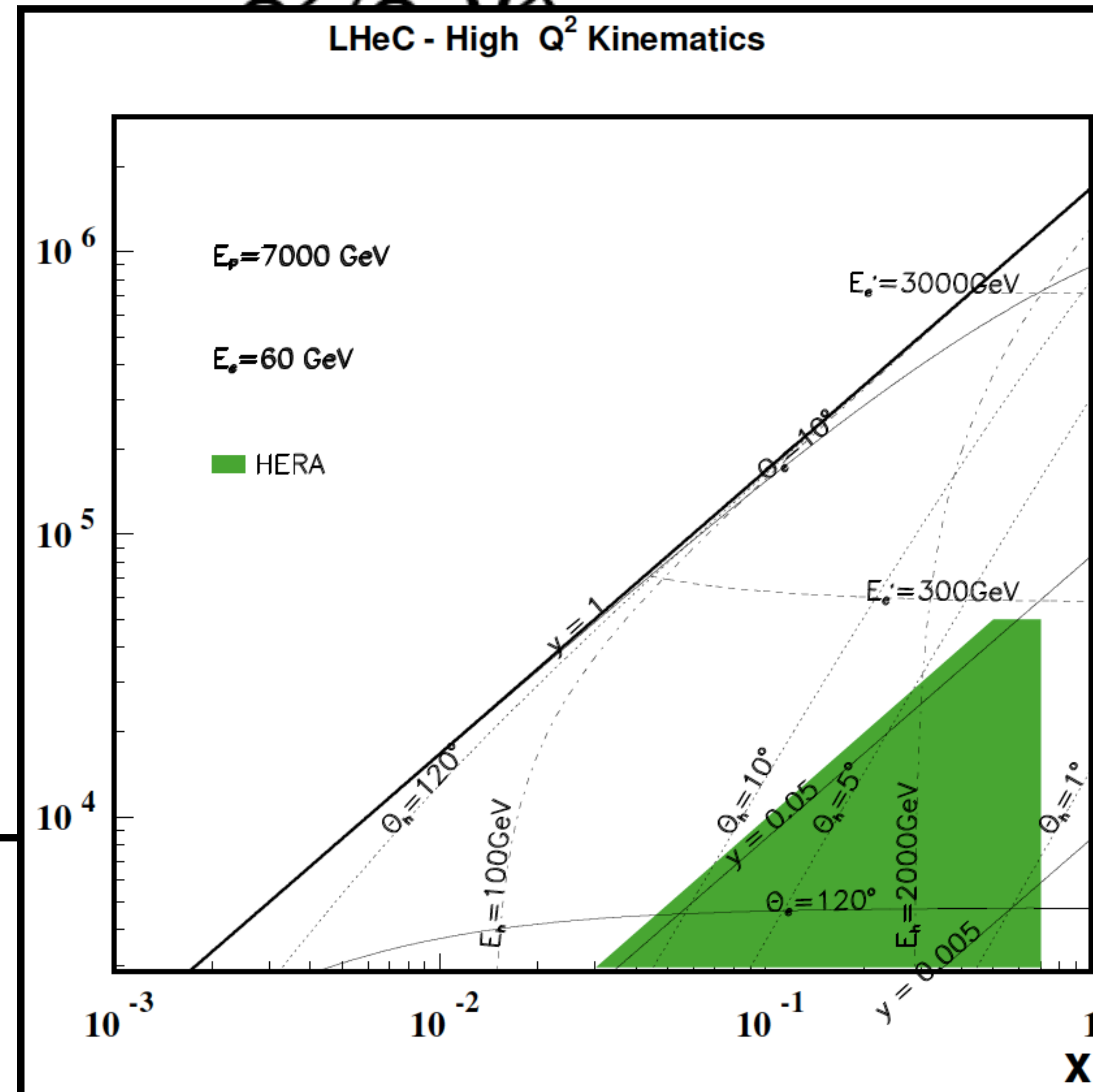
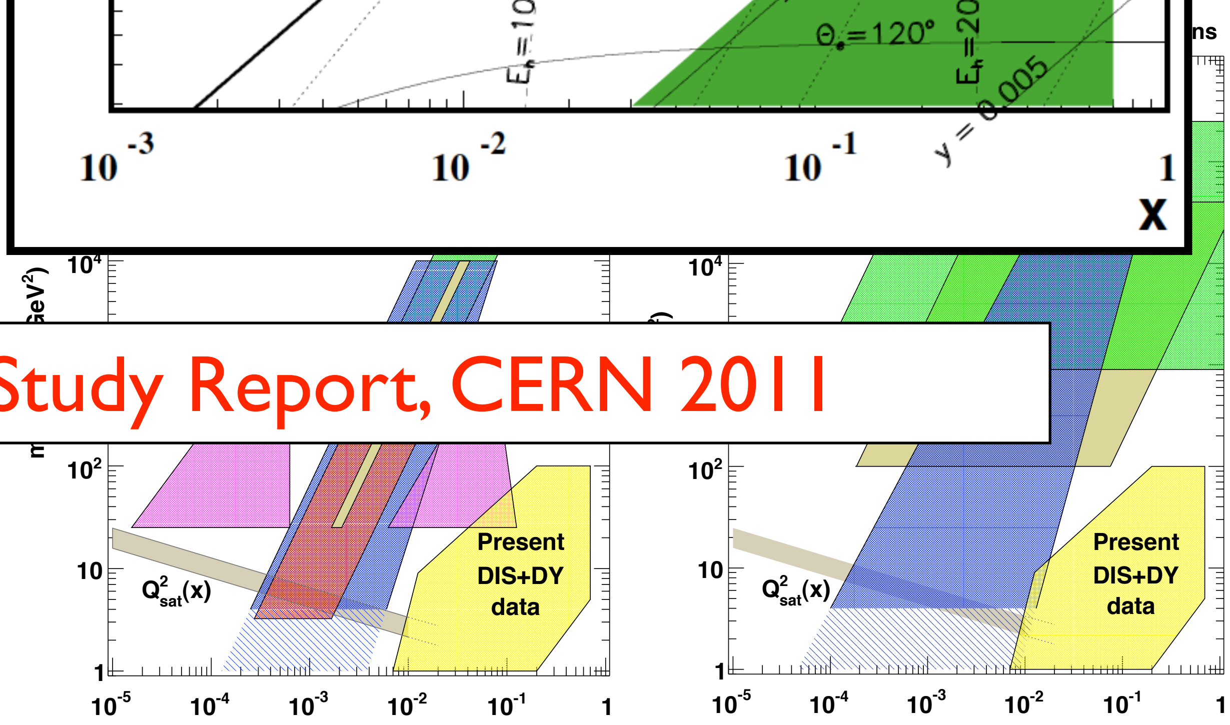






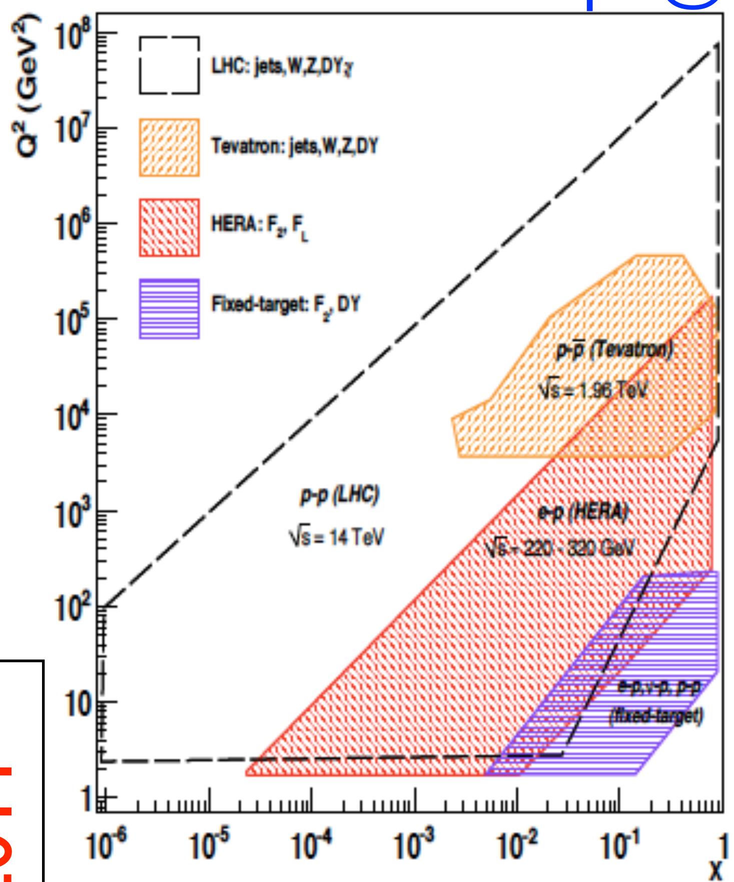
- eA...

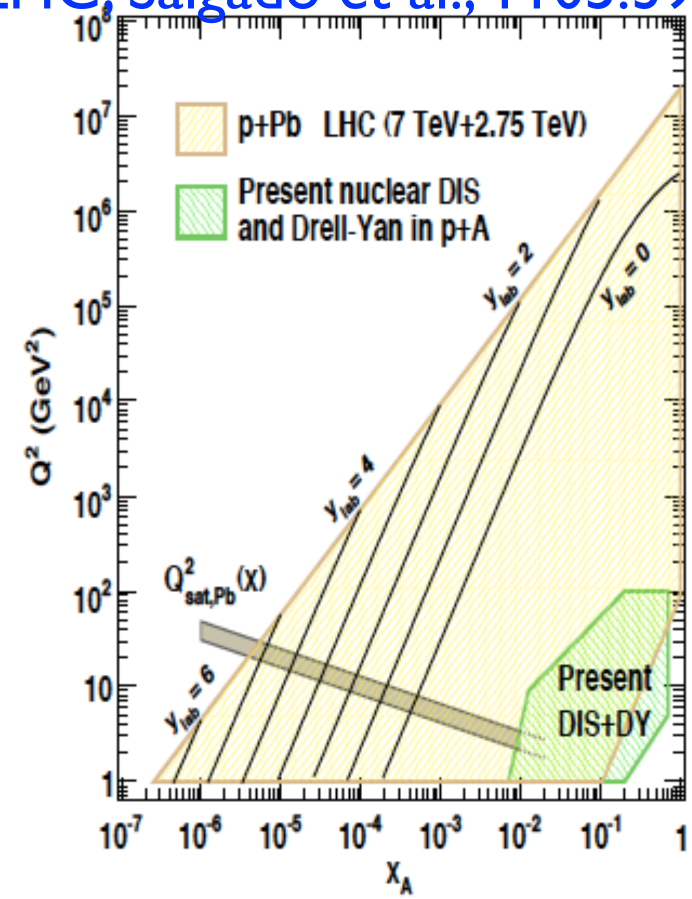
Preliminary; LHeC Design Study Report, CERN 2011

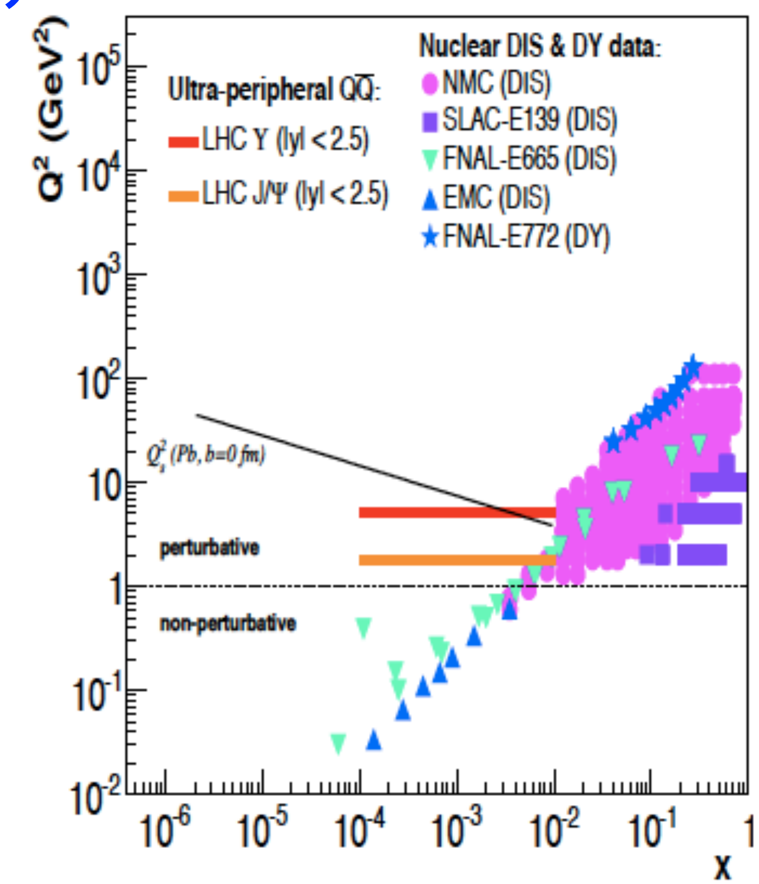
- No small-x physics without ~ 1 degree acceptance.

Kinematics: LHC vs. LHeC

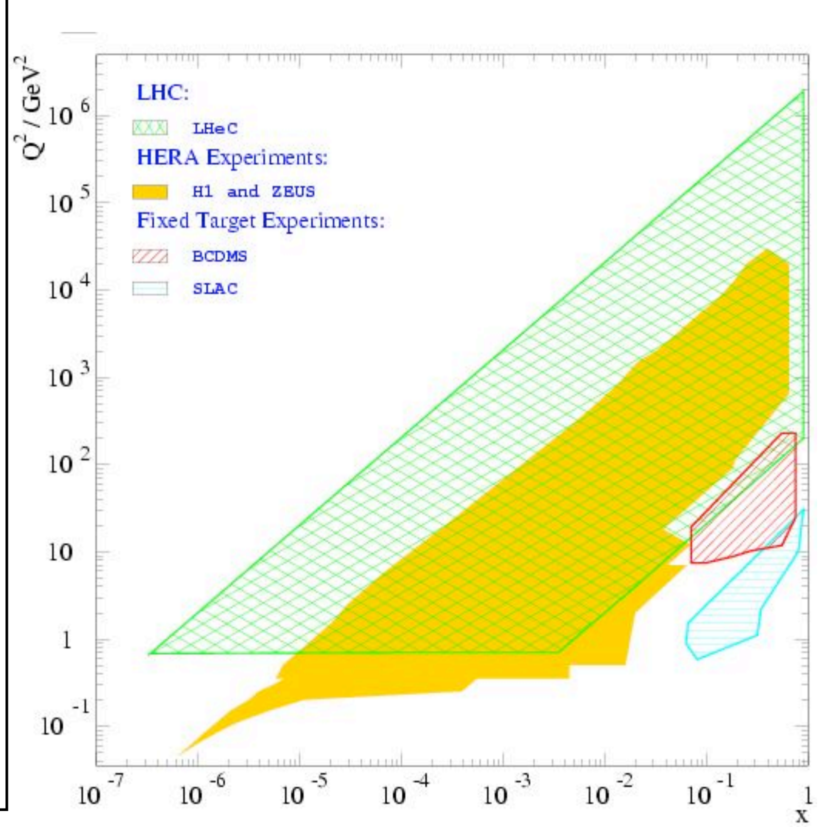
pA@LHC, Salgado et al., 1105.3919



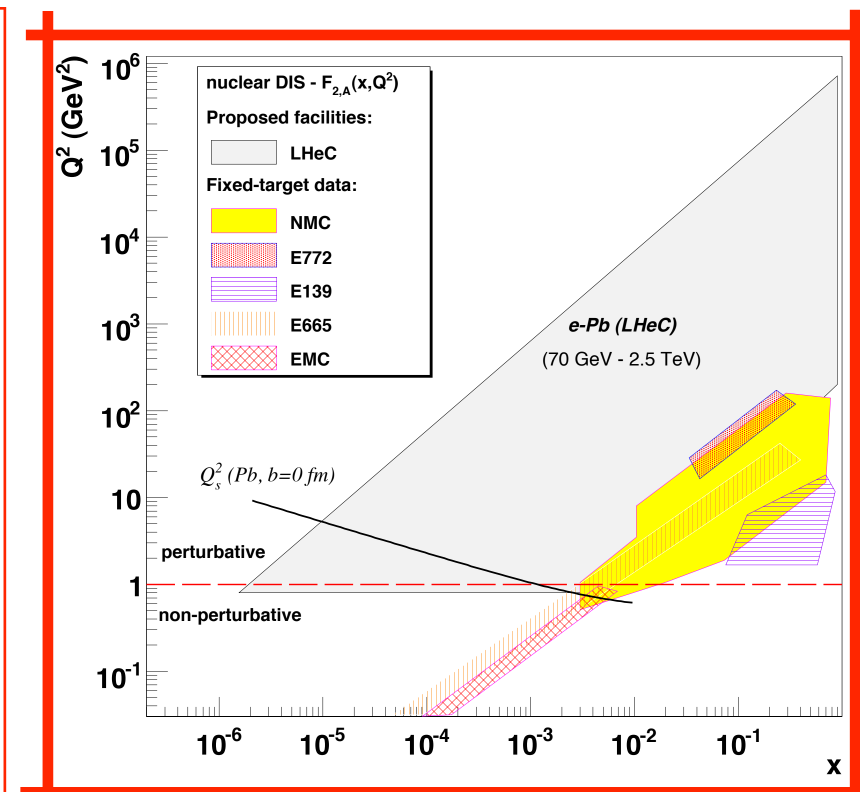




Preliminary; LHeC Design Study Report, CERN 2011



- Existing ep: pp@LHC at y=0; eA: not even dAu@RHIC.
- LHeC: clean scan of the LHC x-Q^2 domain.

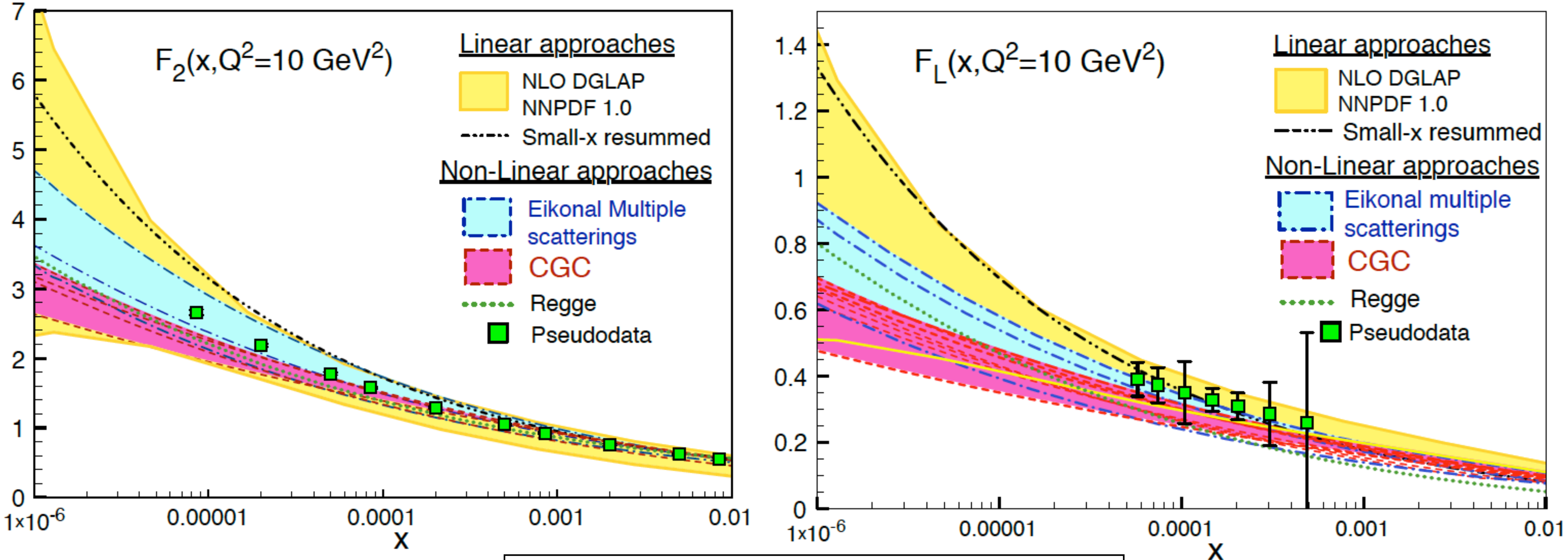


Contents:

ep inclusive pseudodata (I):

- Extensive model comparison (Albacete): LHeC will have discriminative power.

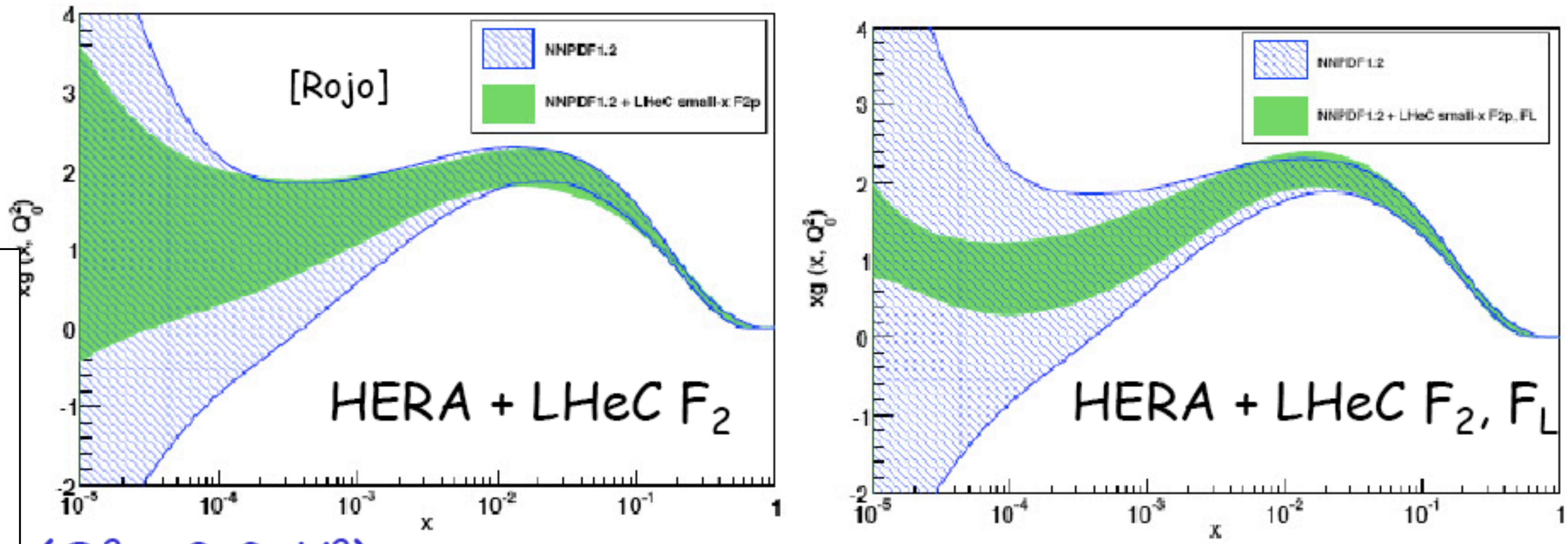
- Note: size of radiative corrections pending.



Preliminary; LHeC Design Study Report, CERN 2011

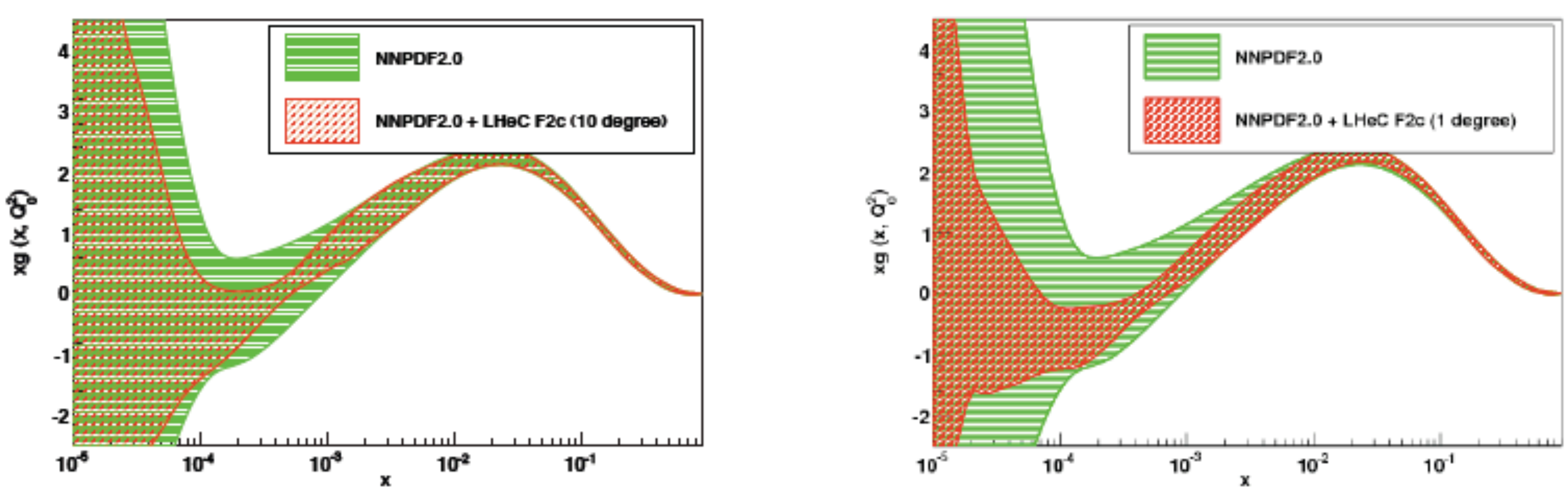
ep inclusive pseudodata (II):

Preliminary; LHeC Design Study Report, CERN 2011



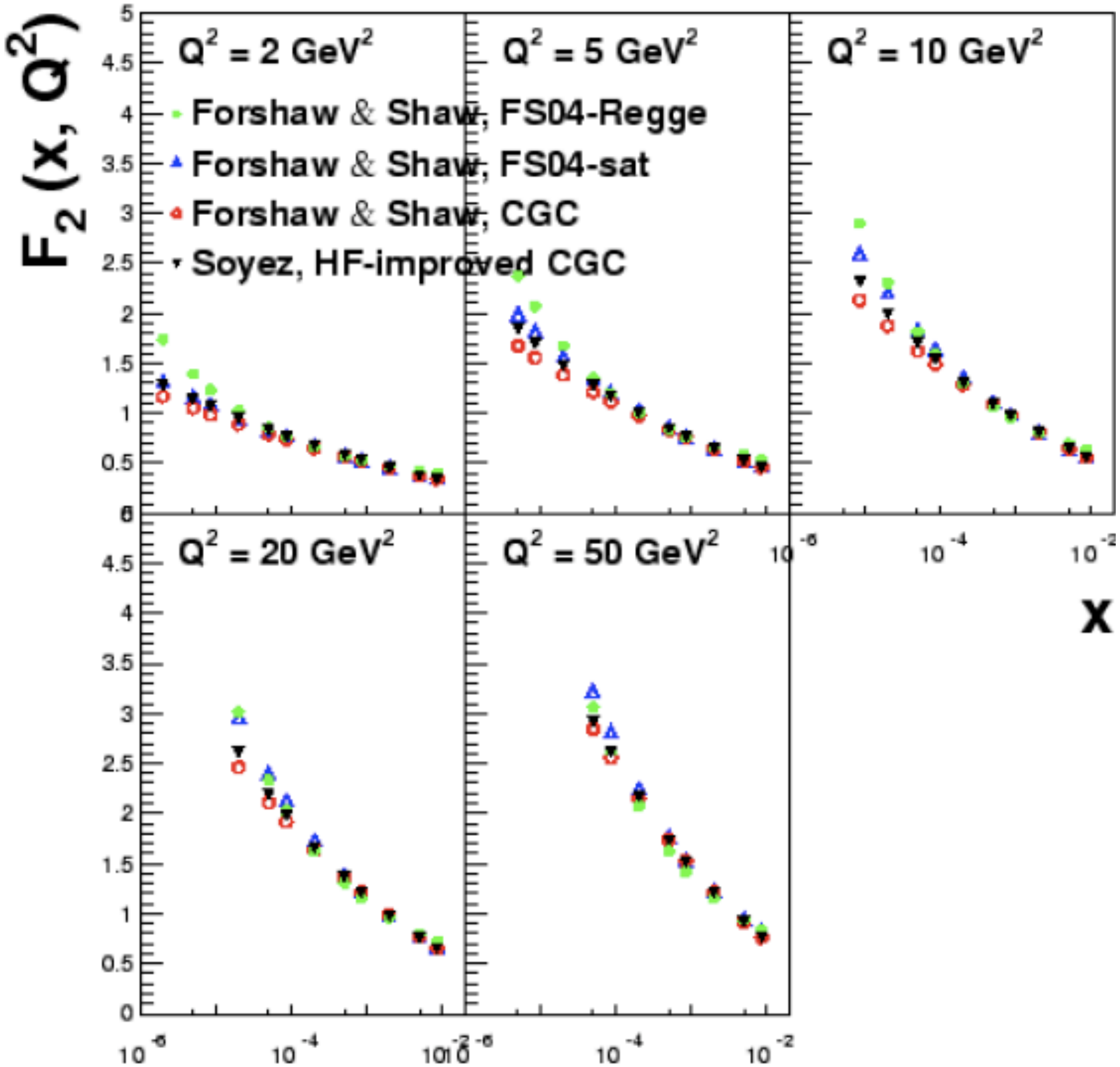
(Q^2 = 2 GeV^2)

- LHeC substantially reduces the uncertainties in global fits: F_L and heavy flavor decomposition most useful.



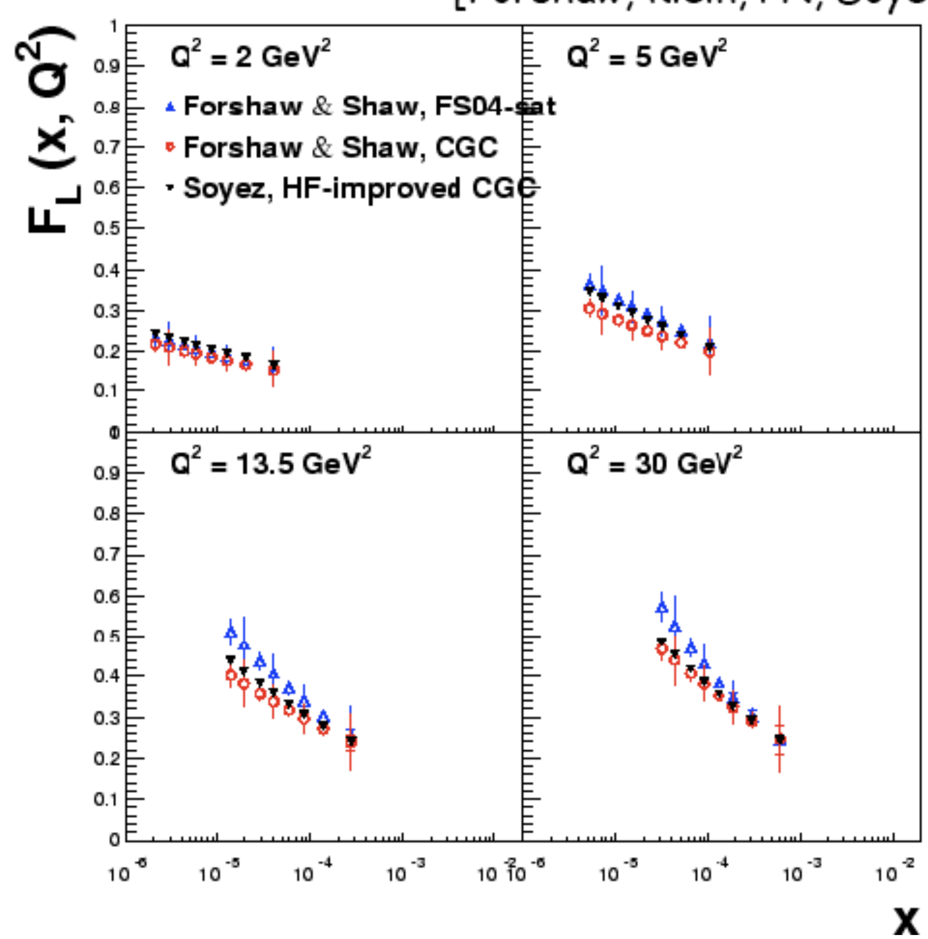
ep inclusive pseudodata (III):

[Forshaw, Klein, PN, Soyez]



- Tension between F_2 and F_L in DGLAP fits as a sign of physics beyond standard DGLAP (GBW and CGC models).

[Forshaw, Klein, PN, Soyez]



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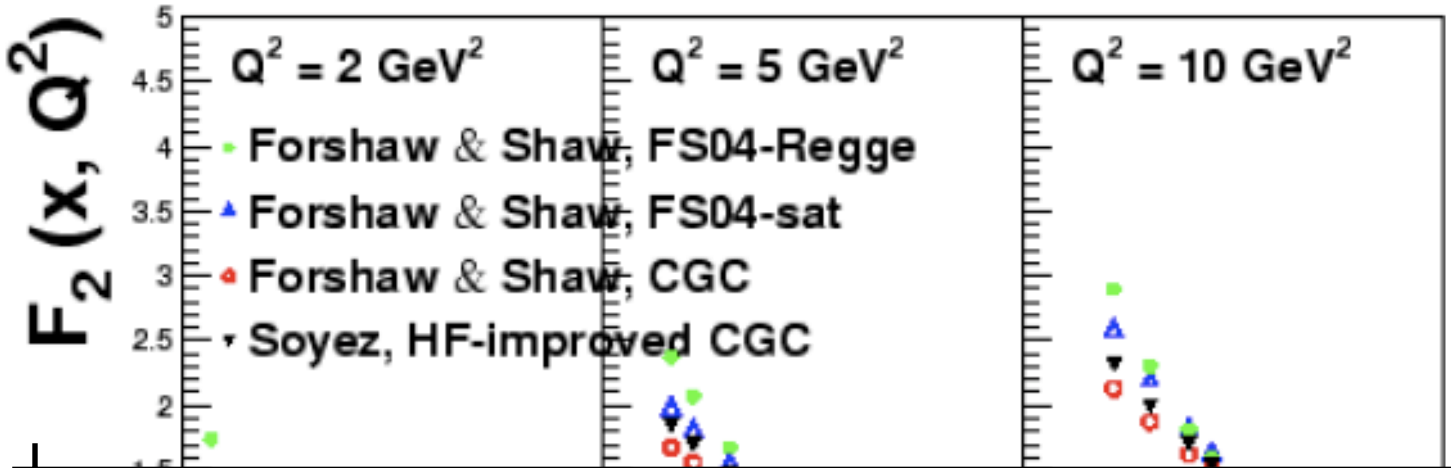

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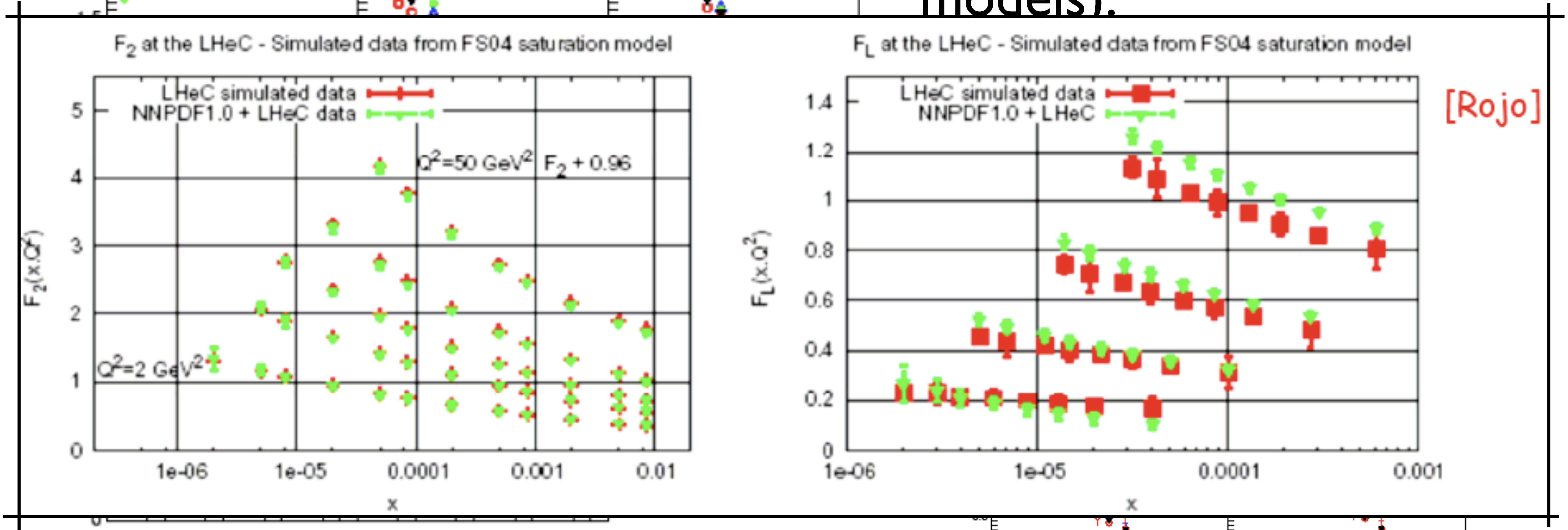
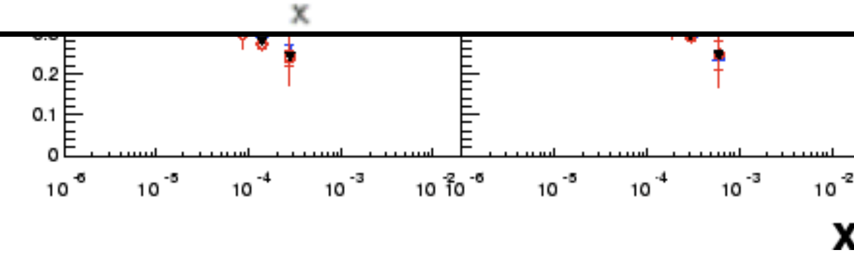




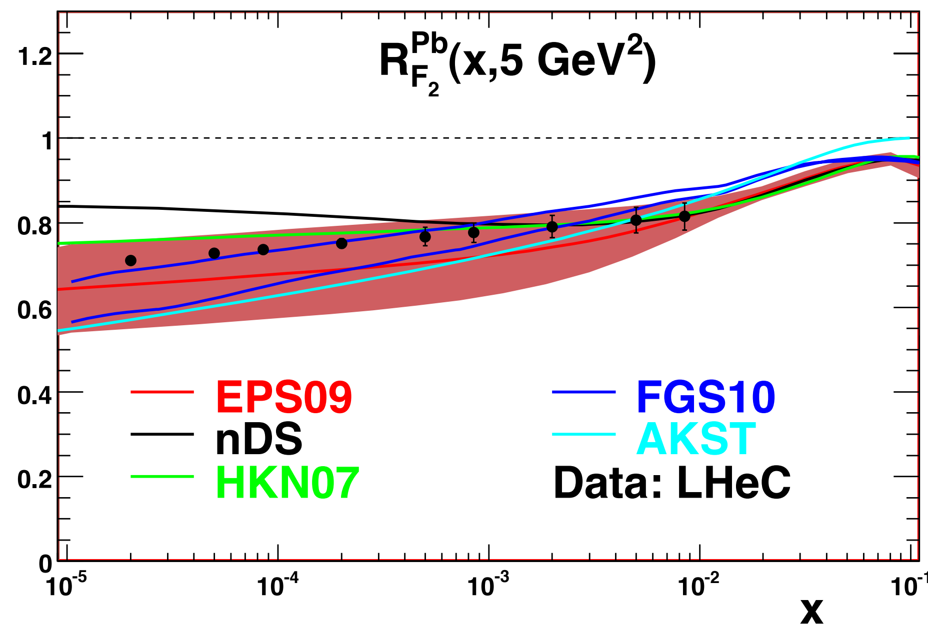
Preliminary; LHeC Design Study Report, CERN 2011

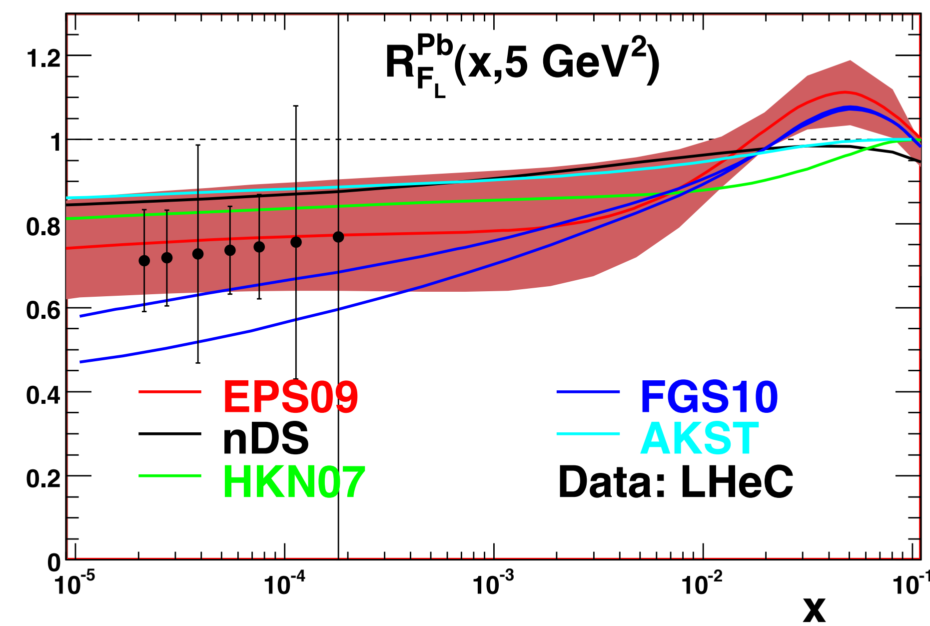
eA inclusive pseudodata (I):

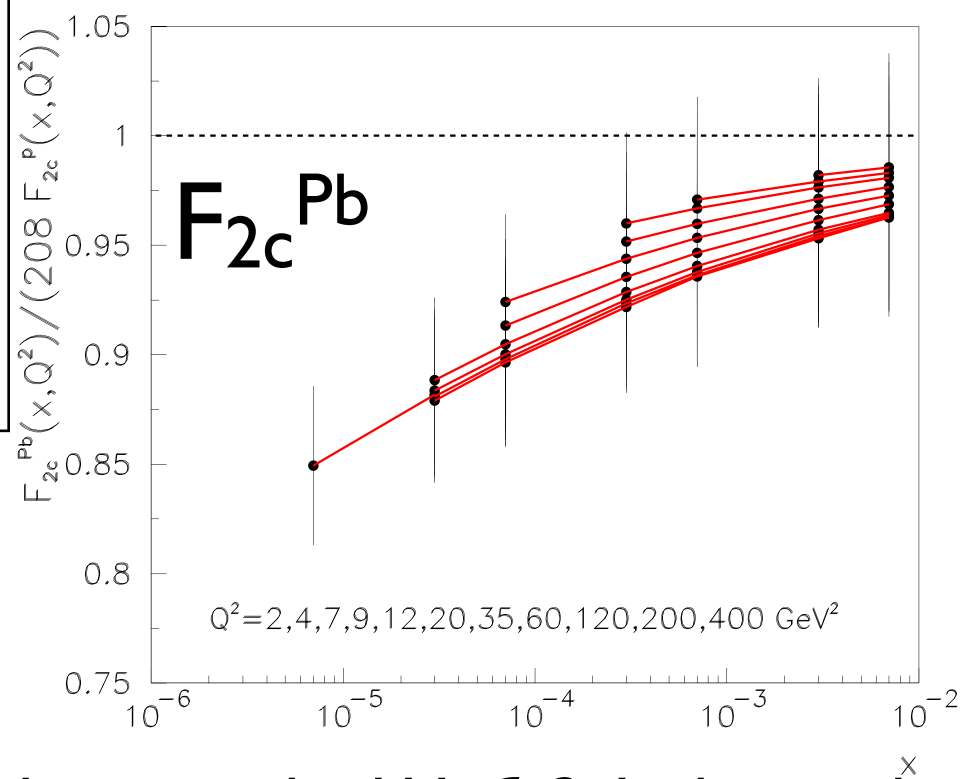
- Good precision can be obtained for $F_{2(c,b)}$ and F_L at small x

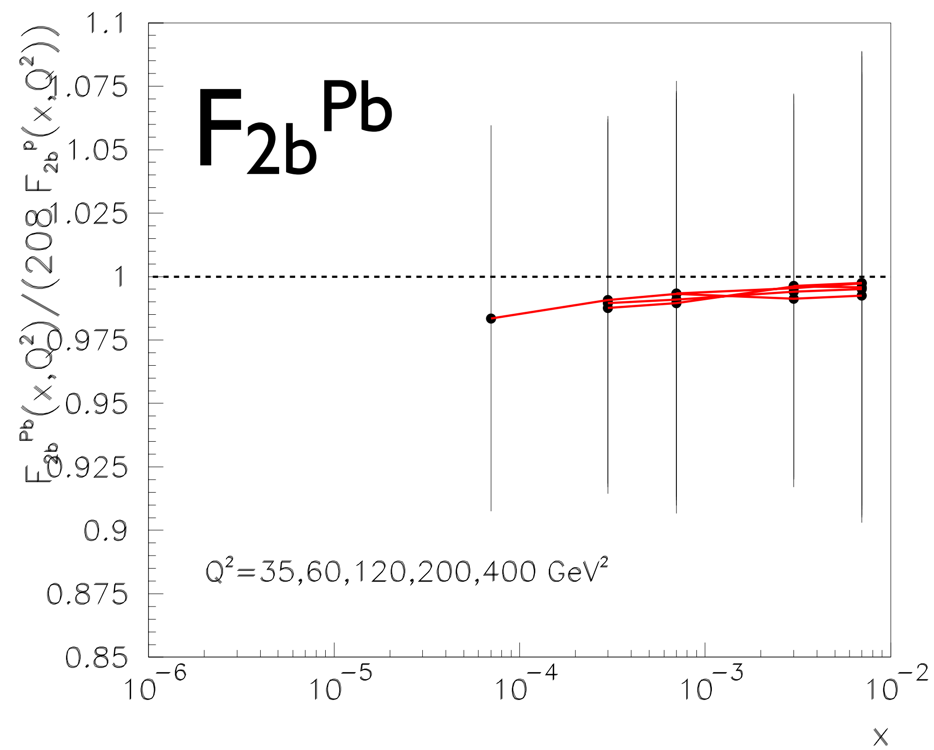
(Glauberized 3-5 flavor GBW model, NA '02).

Preliminary; LHeC Design Study Report, CERN 2011



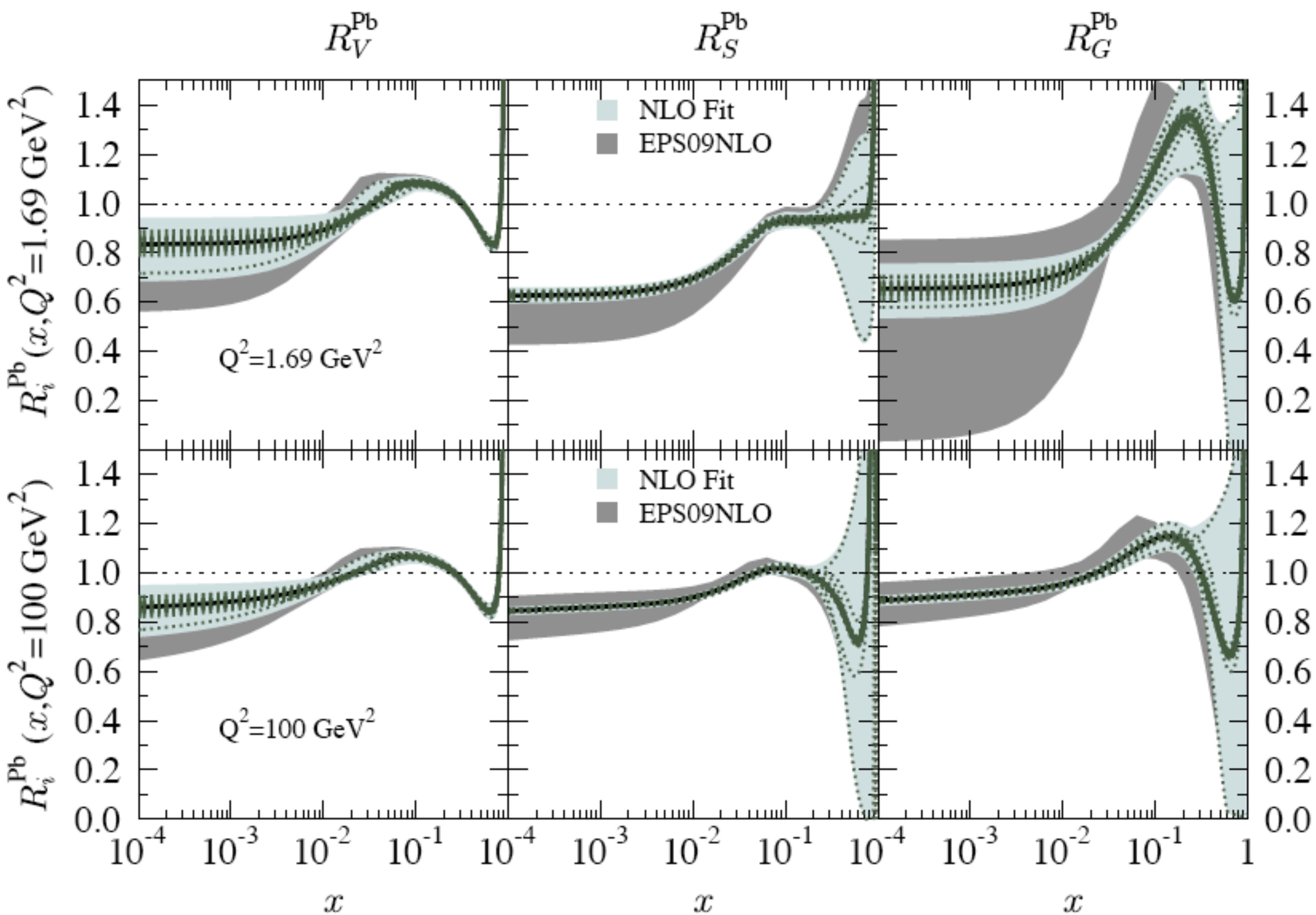






eA inclusive pseudodata (II):

- F$_2$ data substantially reduce the uncertainties in DGLAP analysis; inclusion of charm, beauty and F$_L$ produce minor improvements.



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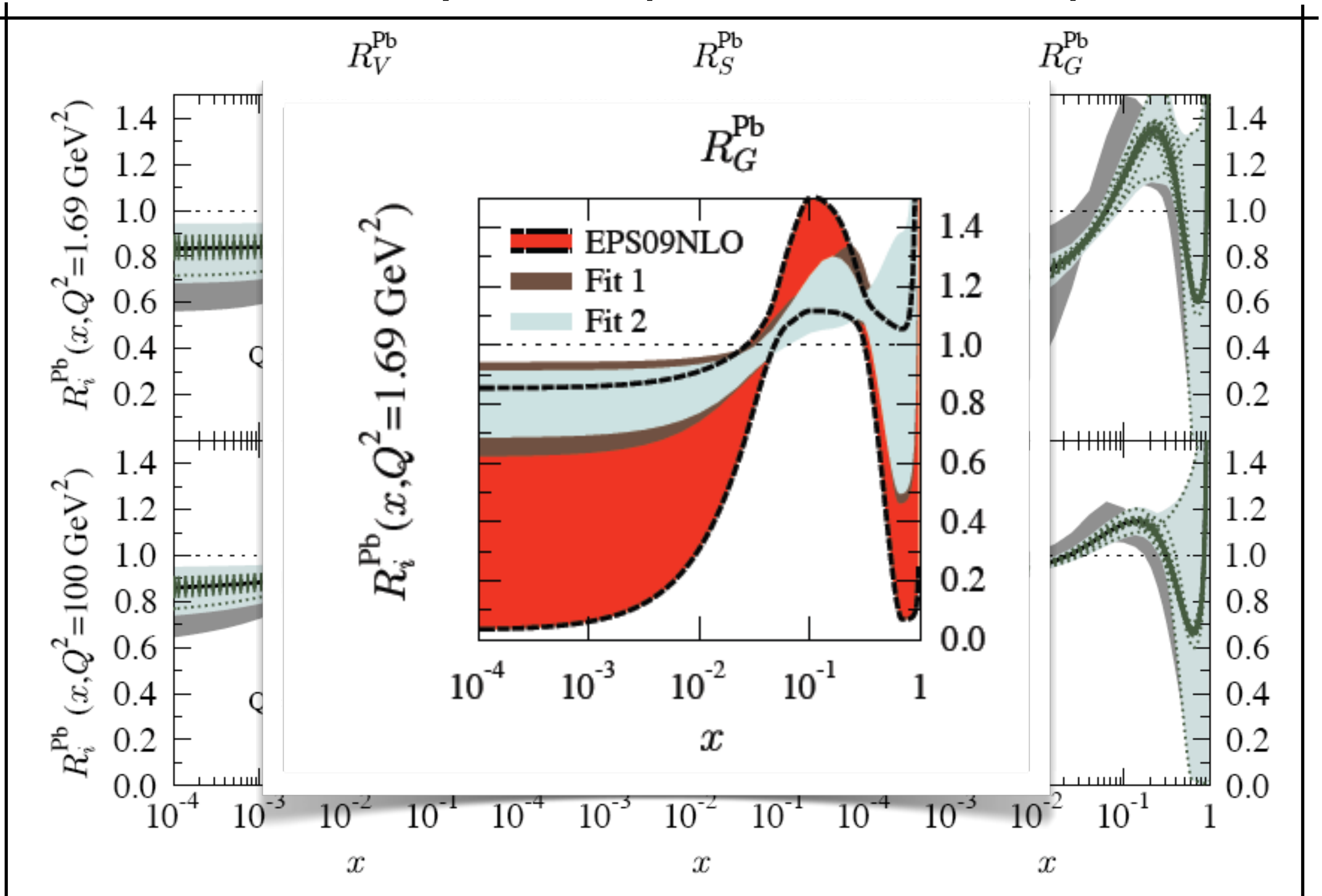
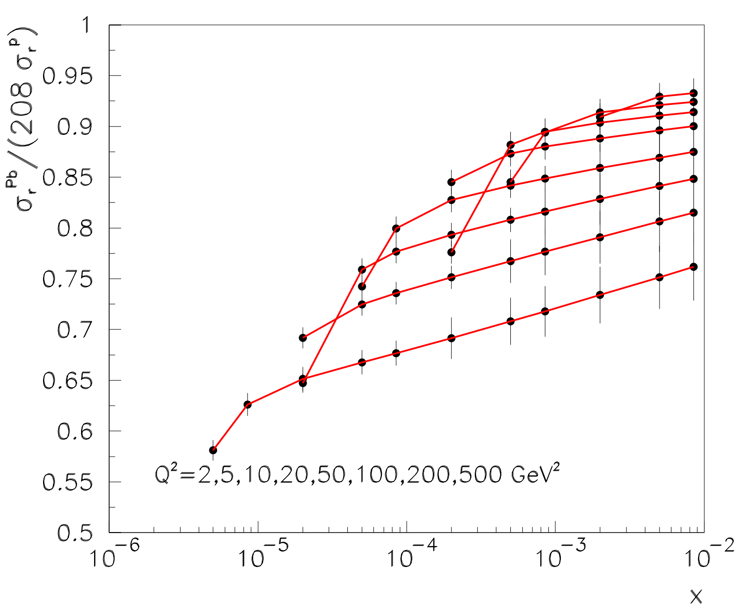


Note: F_L in eA

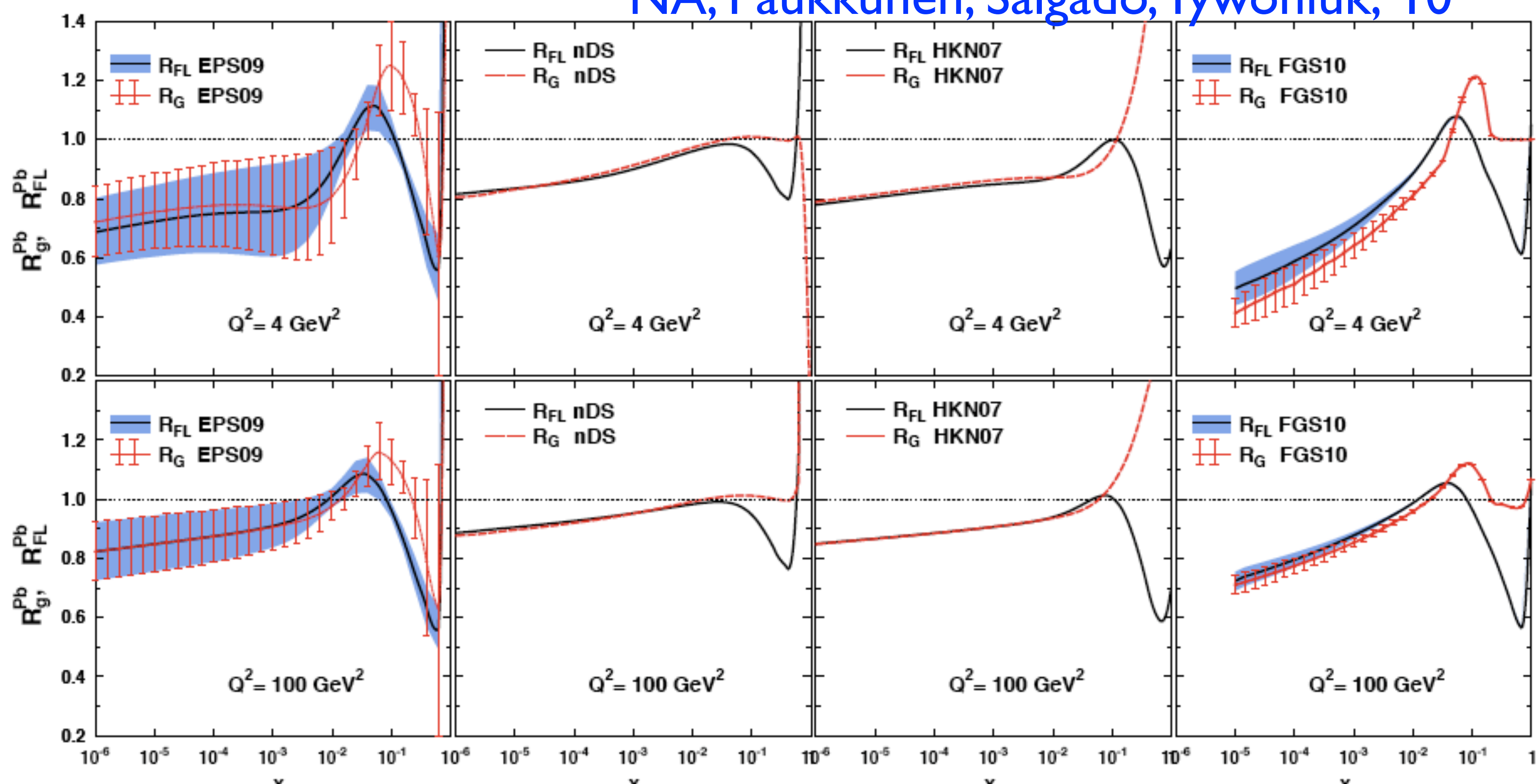
$$\sigma_r^{NC} = \frac{Q^4 x}{2\pi\alpha^2 Y_+} \frac{d^2\sigma^{NC}}{dx dQ^2} = F_2 \left[1 - \frac{y^2}{Y_+}\frac{F_L}{F_2}\right], \qquad Y_+ = 1 + (1-y)^2$$

- F_L traces the nuclear effects on the glue (Cazarotto et al '08).
- Uncertainties in the extraction of F_2 due to the unknown nuclear effects on F_L of order 5 % (larger than expected stat.+syst.) ⇒

measure F_L or use the reduced cross section (but then ratios at two energies...).



NA, Paukkunen, Salgado, Tywoniuk, '10



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    - ep diffractive pseudodata. (P. Newman)
    - Nuclear diffraction. (H. Kowalski, C. Marquet)
    - Exclusive vector meson production. (P. Newman, G. Watt, A. Stasto, C. Weiss)
    - DVCS. (L. Favart, P. Newman)
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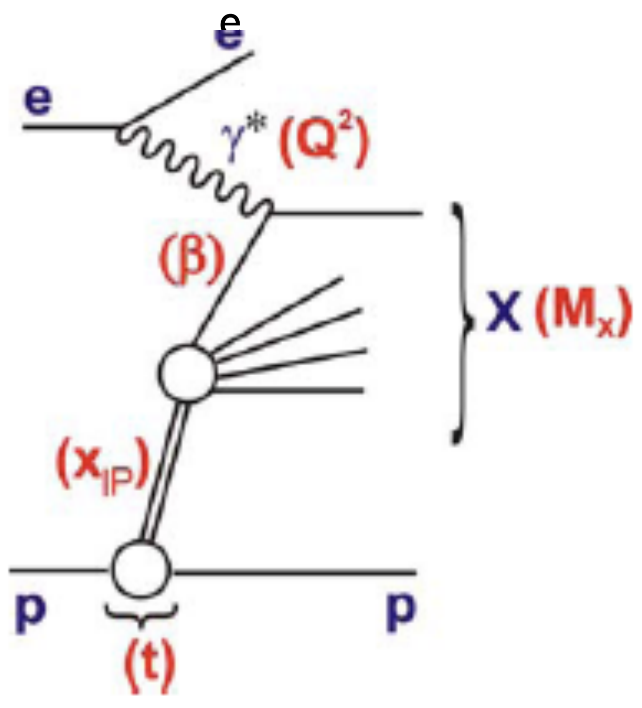
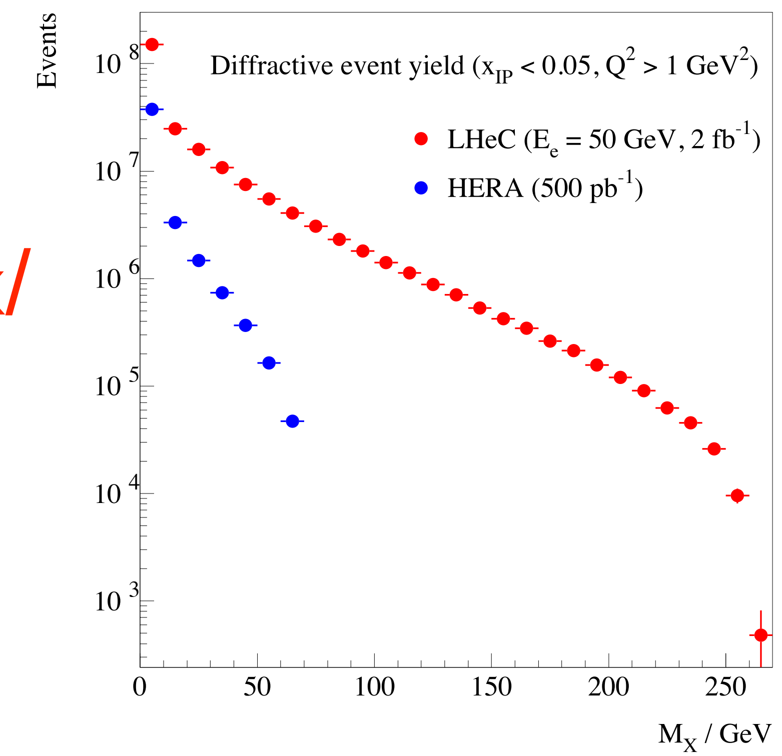
ep diffractive pseudodata:



- Large increase in the M^2, $x_P=(M^2-t+Q^2)/(W^2+Q^2)$, $\beta=x/x_P$ region studied.
- Possibility to combine LRG and LPS.



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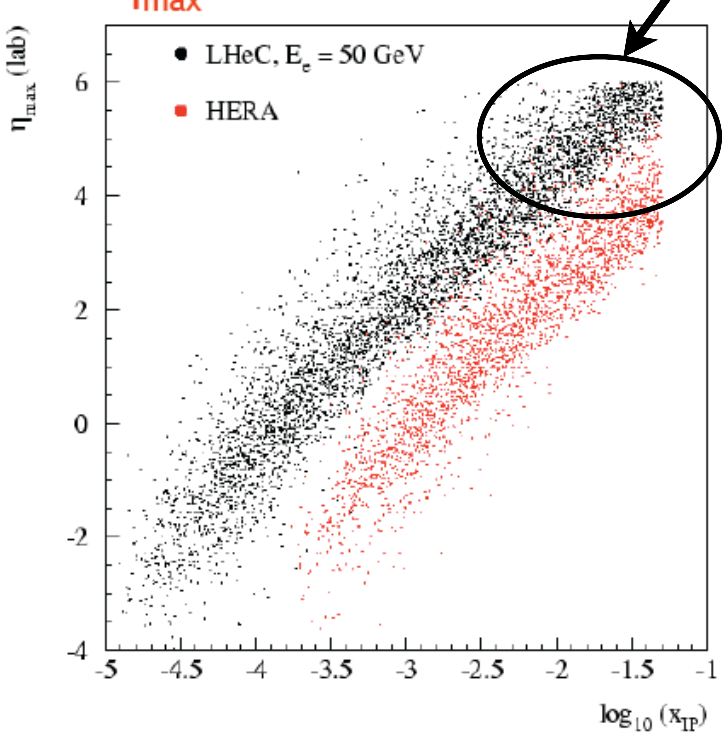
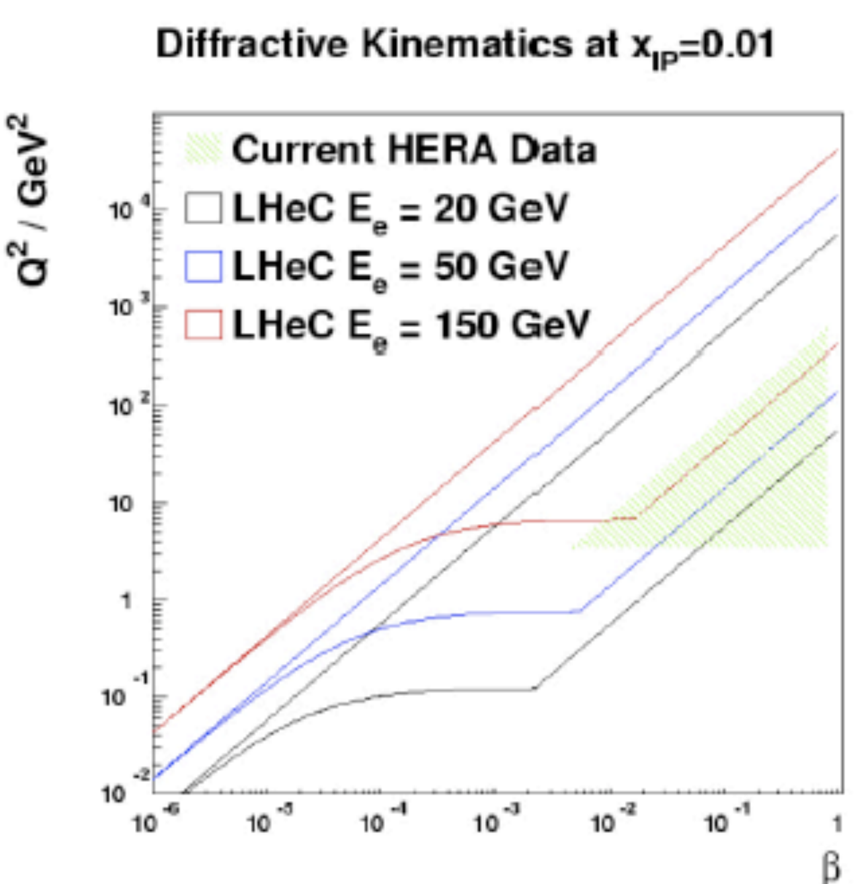
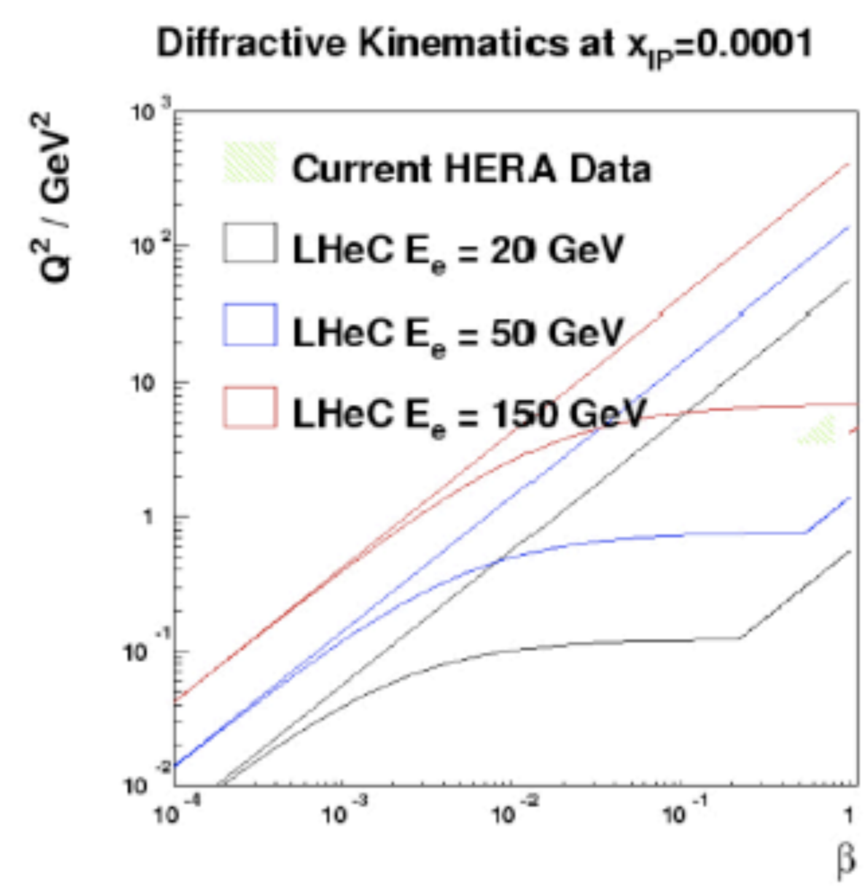
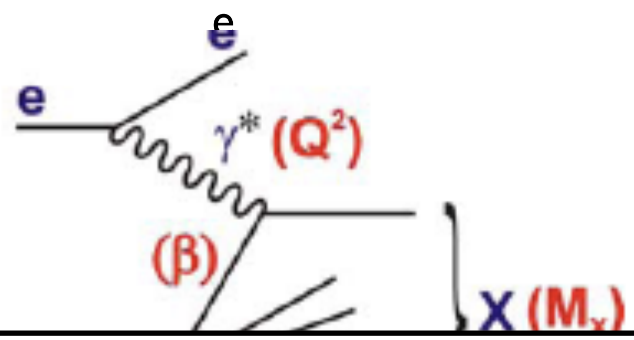
η_{max} from LRG selection ..



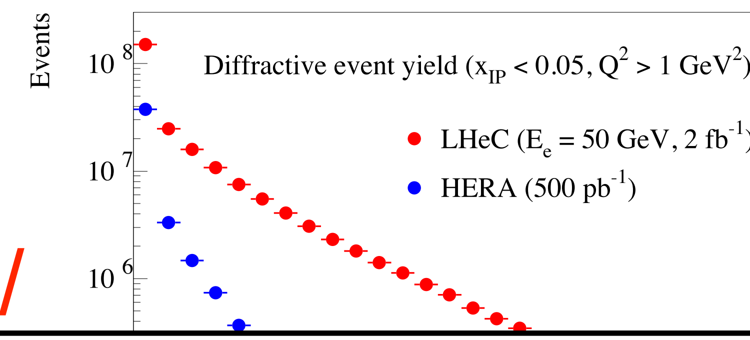




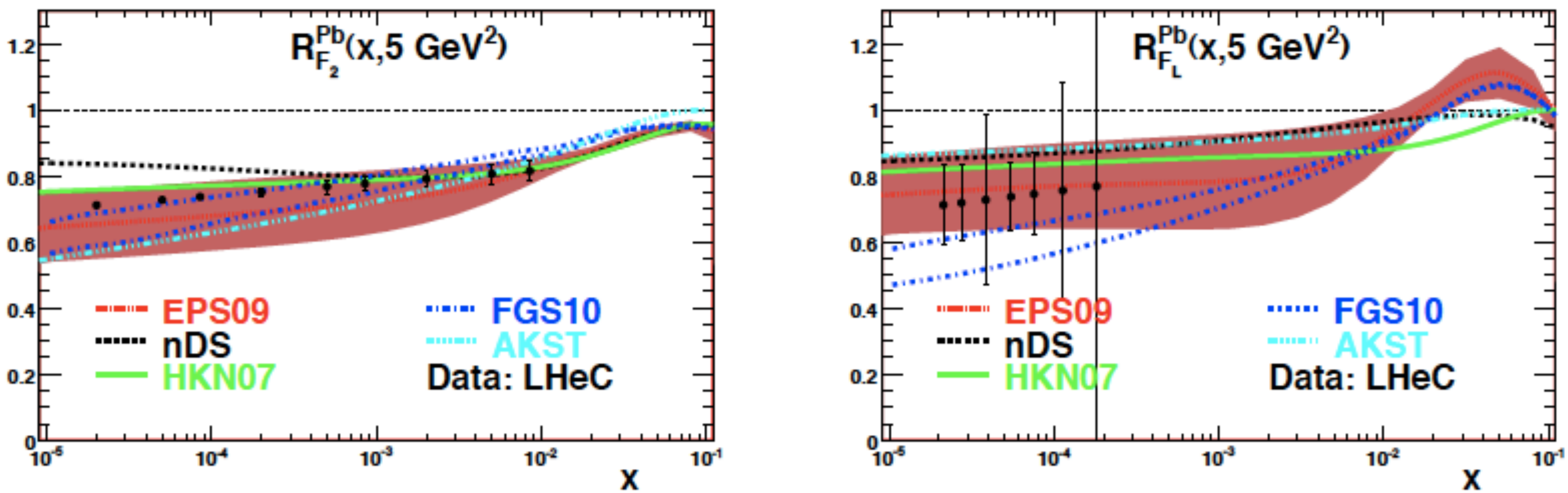
ep diffractive pseudodata:



- Large increase in the M^2, $x_P=(M^2-t+Q^2)/(W^2+Q^2)$, $\beta=x/$



Note: diffraction in ep is linked to shadowing in eA (Gribov): FGS, Capella-Kaidalov et al,...



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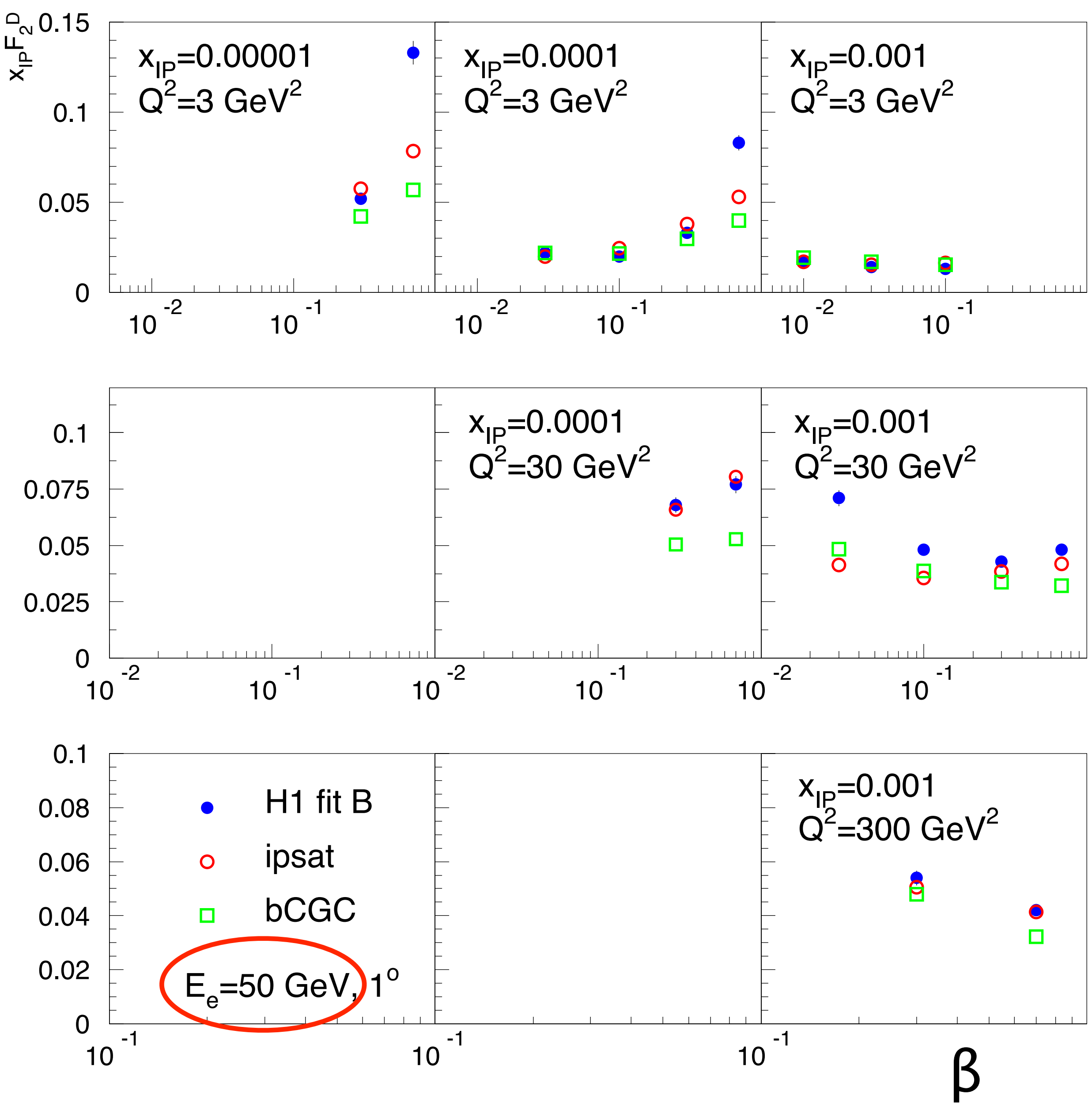
Diffraction and non-linear dynamics:

- Dipole models show differences with linear-based extrapolations (HERA-based dpdf's) and among each other: possibility to check saturation and its realization.



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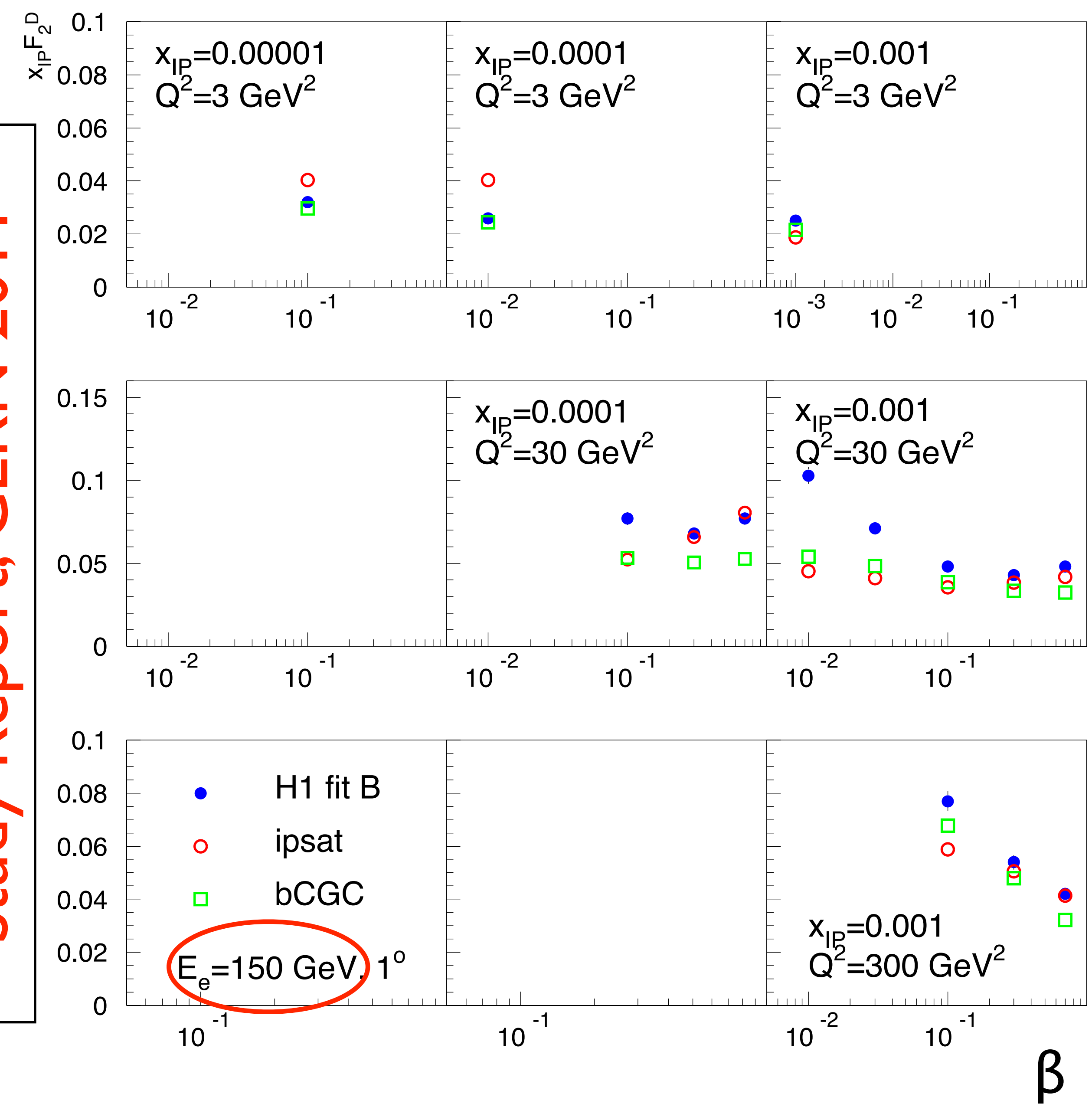
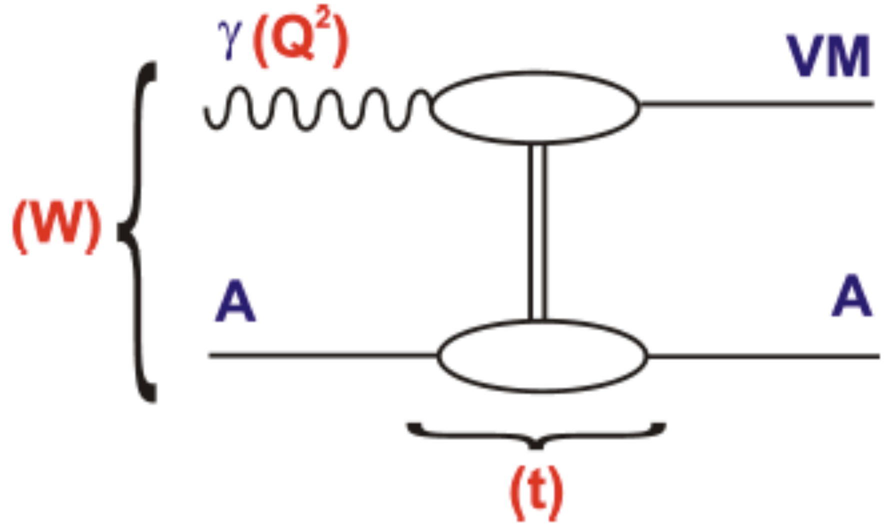
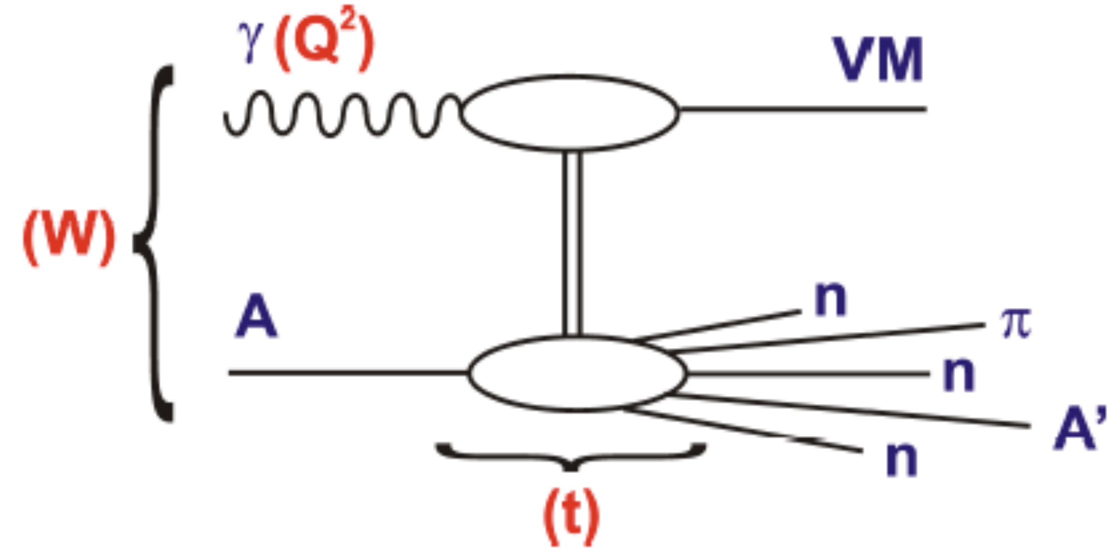


Diffractive DIS on nuclear targets:





- Challenging experimental problem, requires Monte Carlo simulation with detailed understanding of the nuclear break-up.

- For the coherent case, predictions available.

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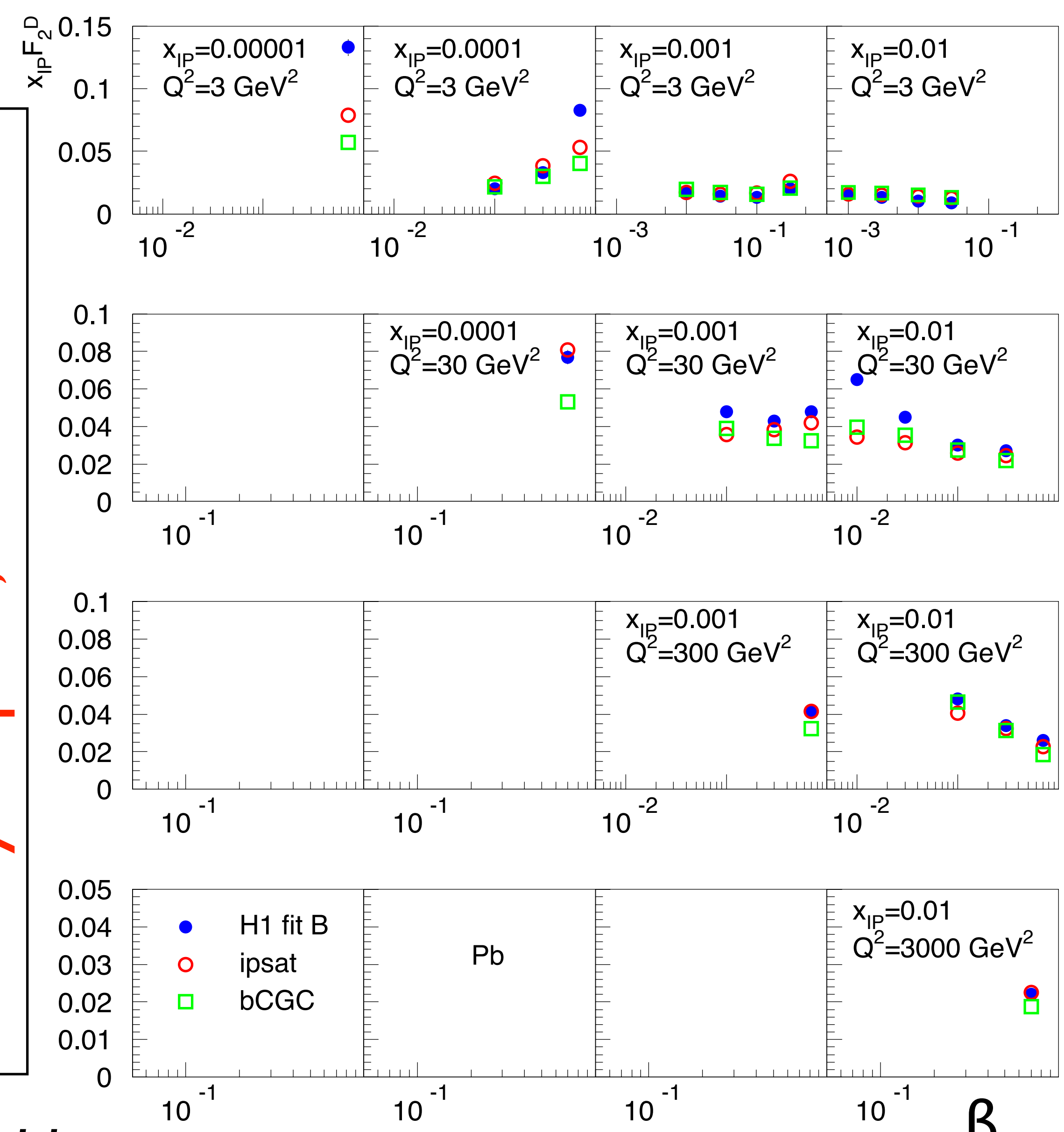
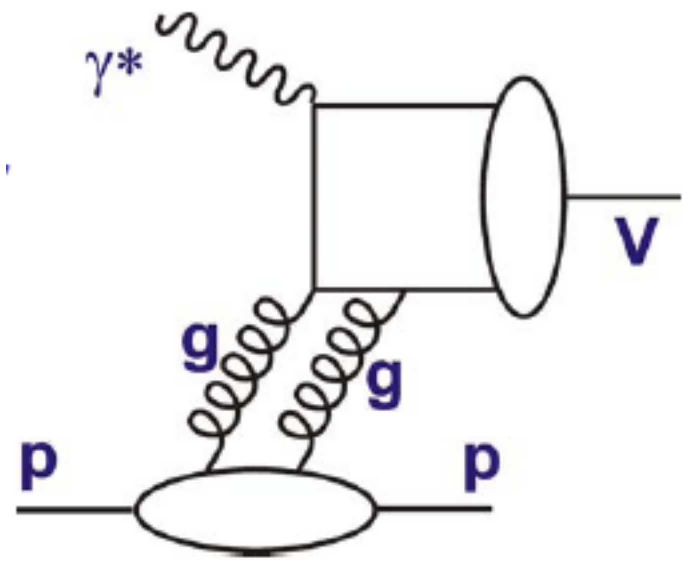
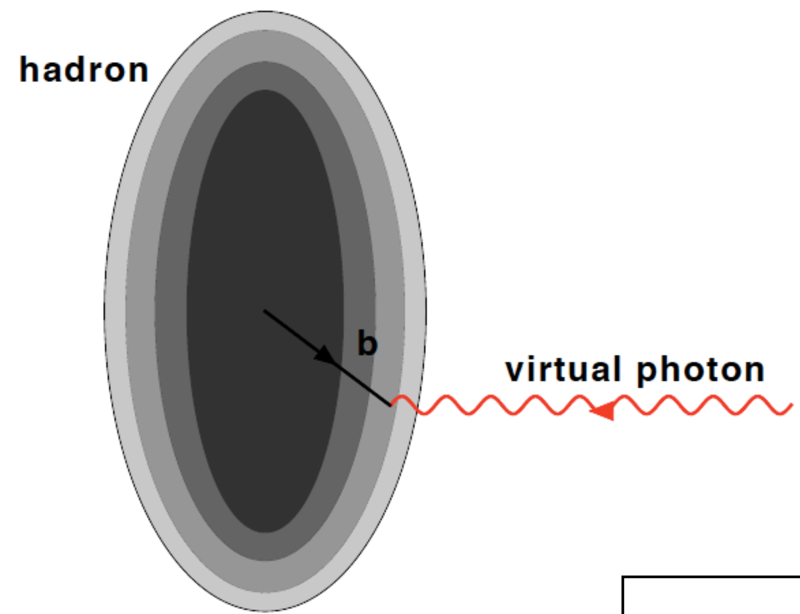
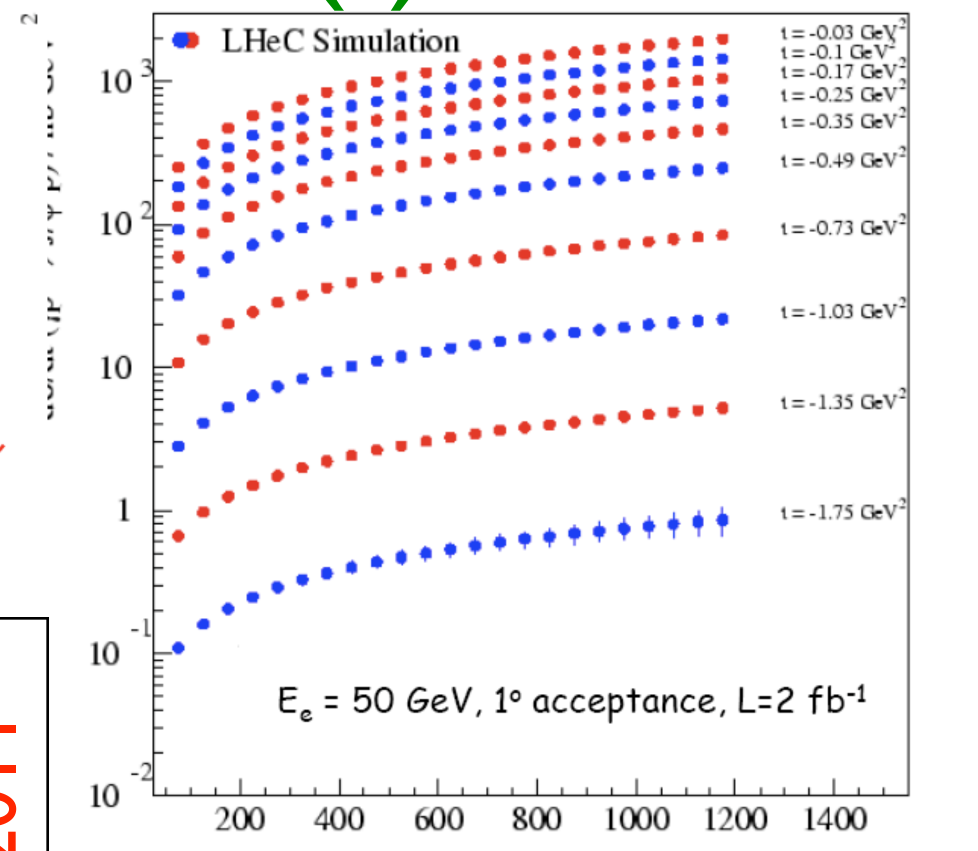


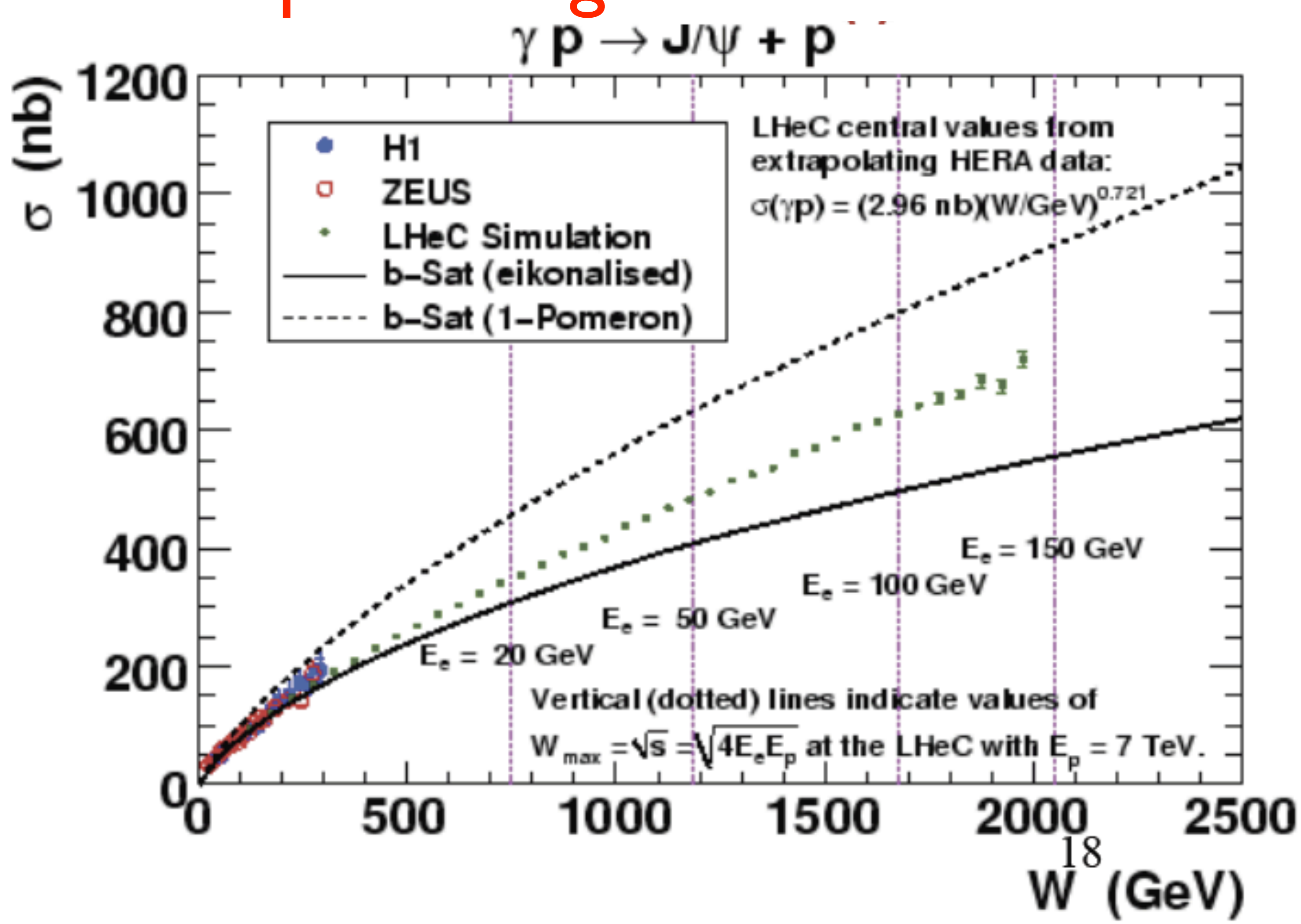
Elastic VM production (I):







- Most promising!!!



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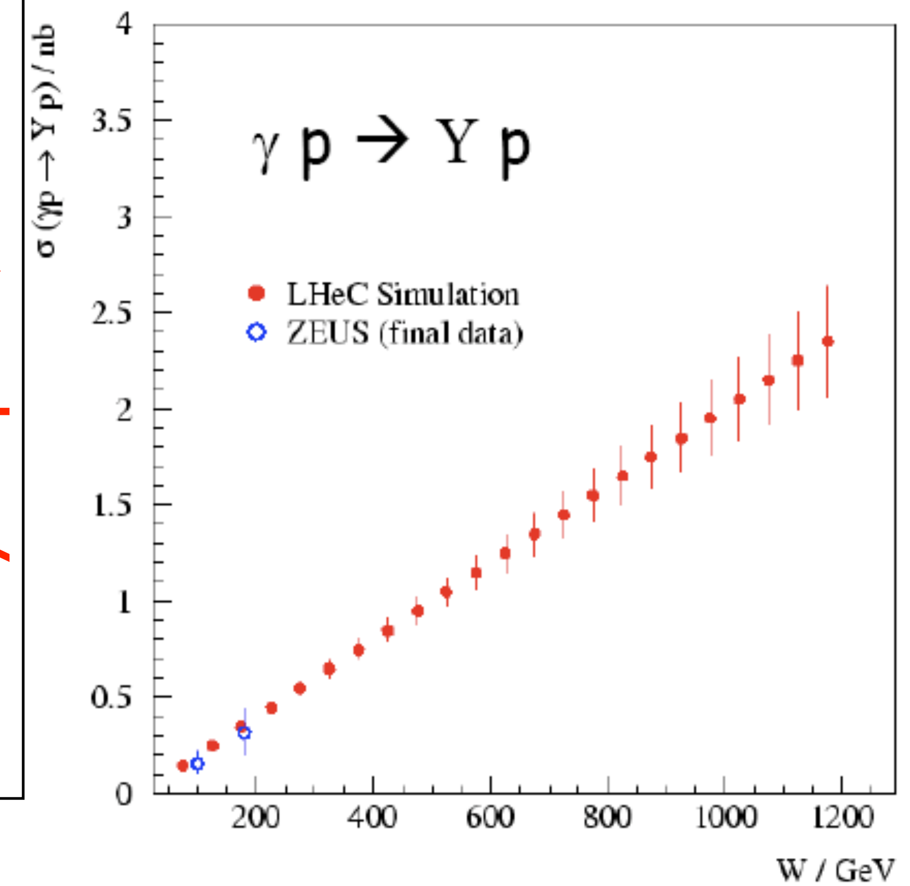
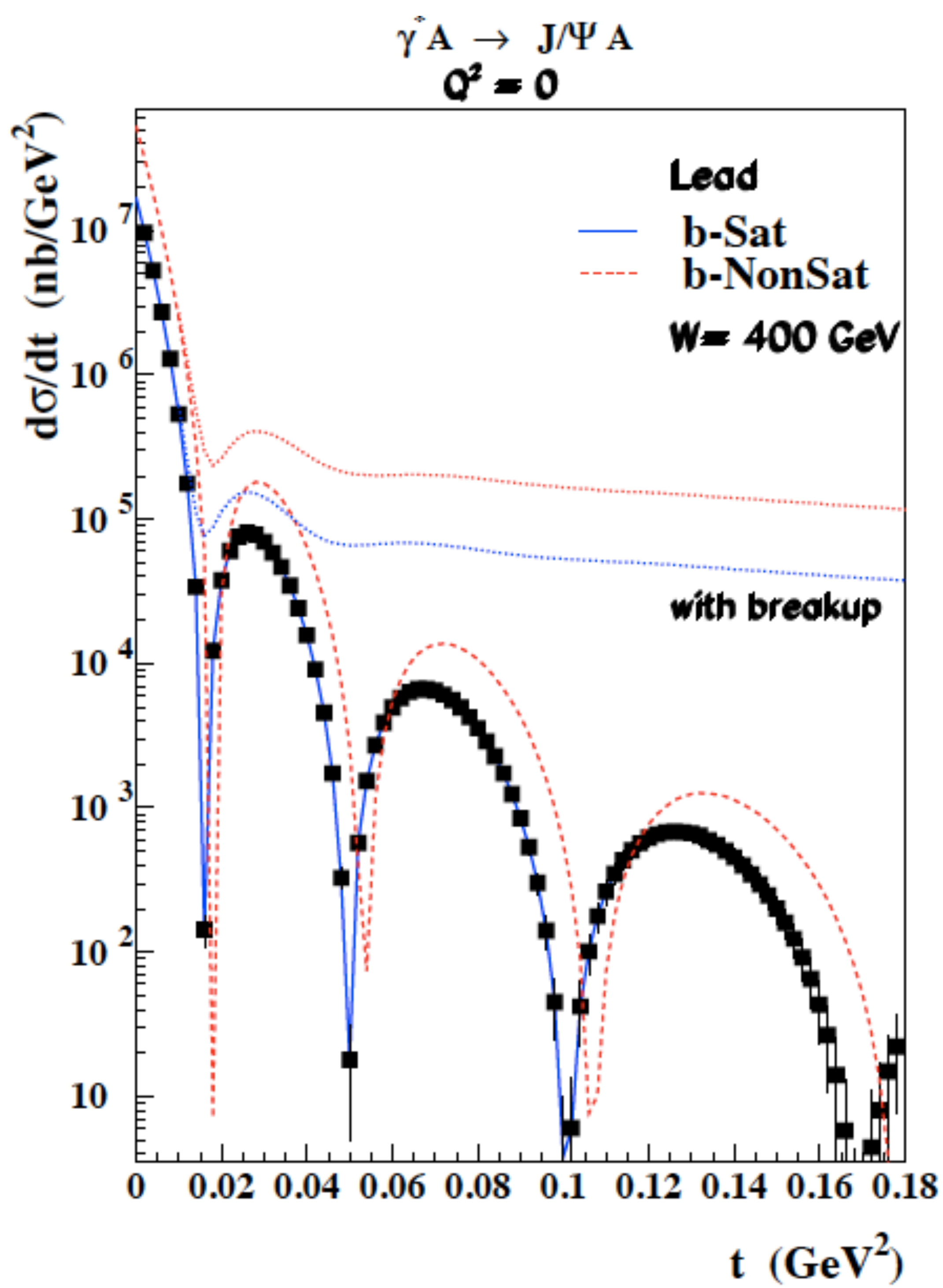
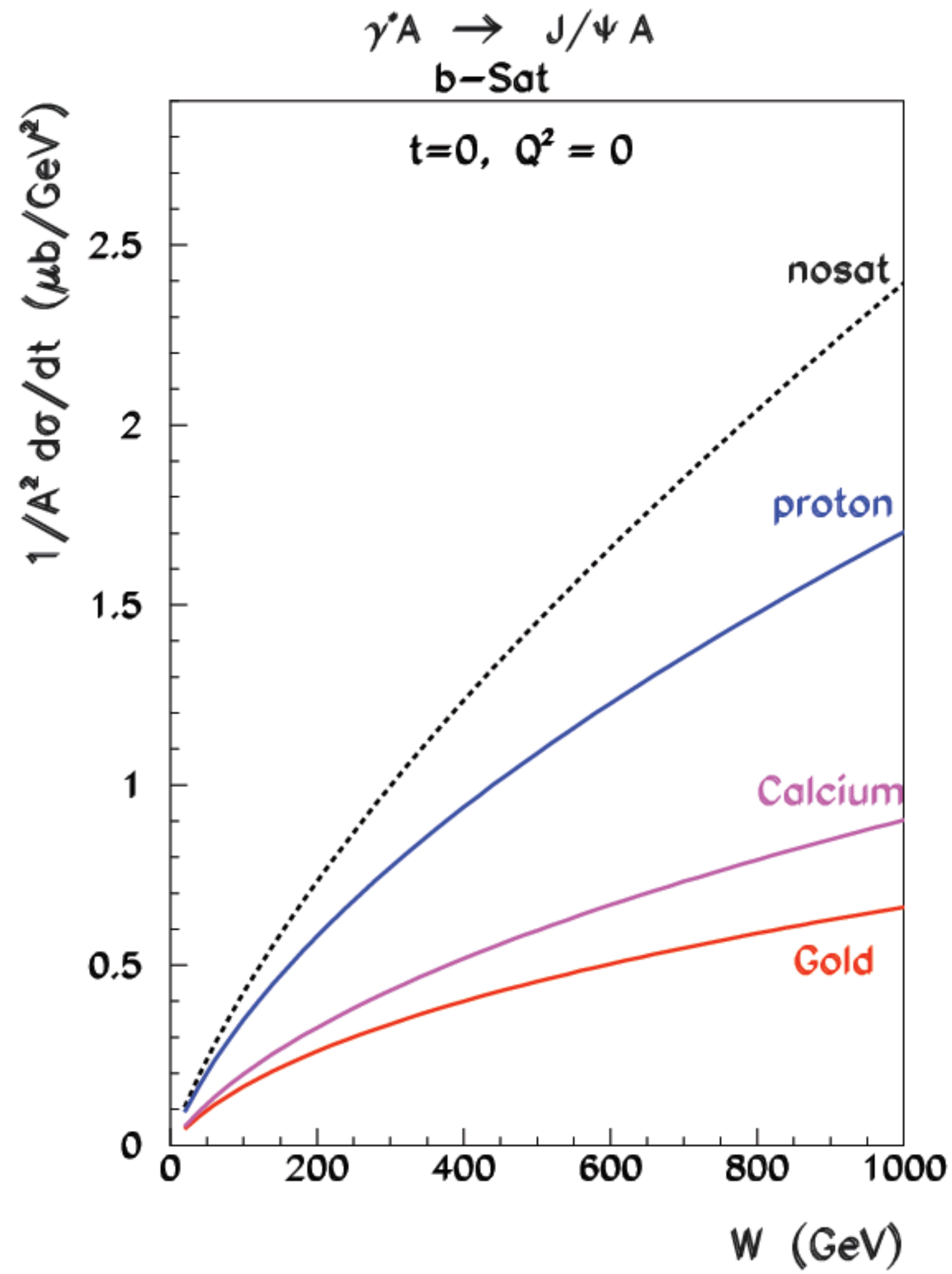


Elastic VM production (II):

- Many interesting features in the nuclear case

(see also Lappi et al '10, Horowitz '11).





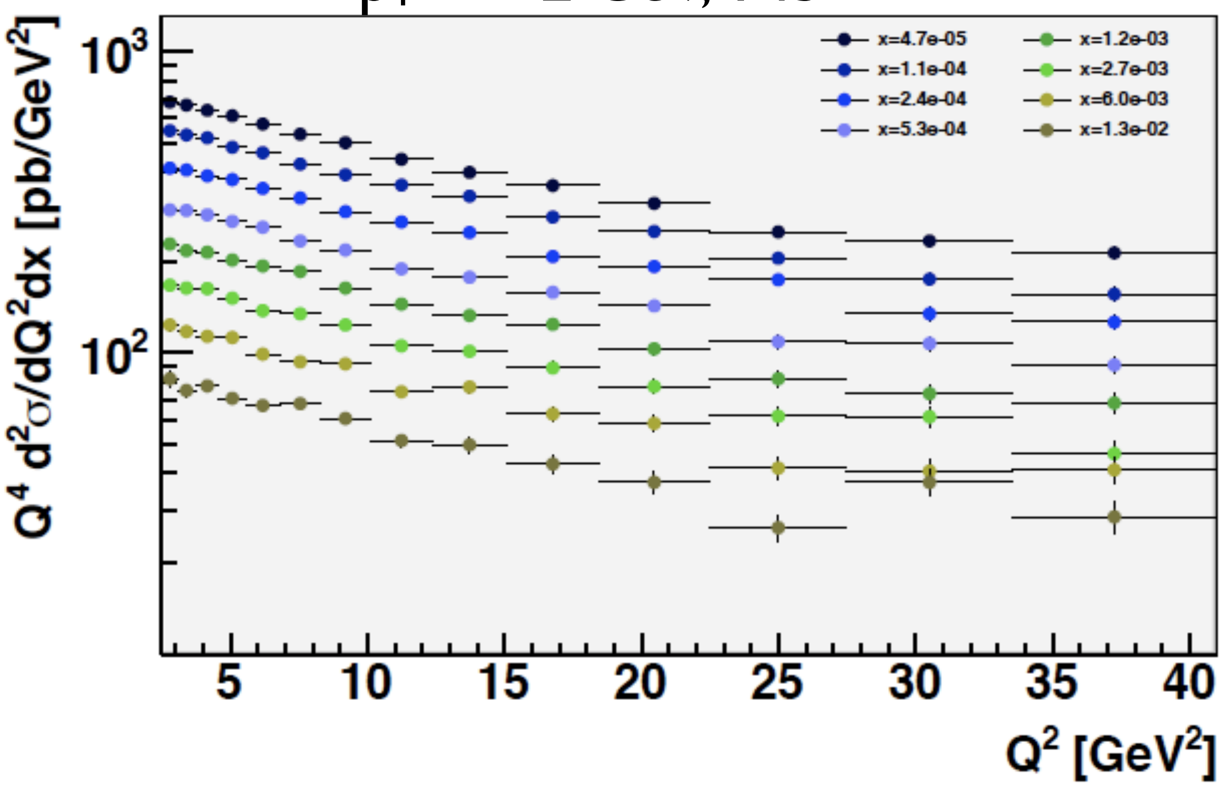
Preliminary; LHeC Design Study Report, CERN 2011

DVCS:

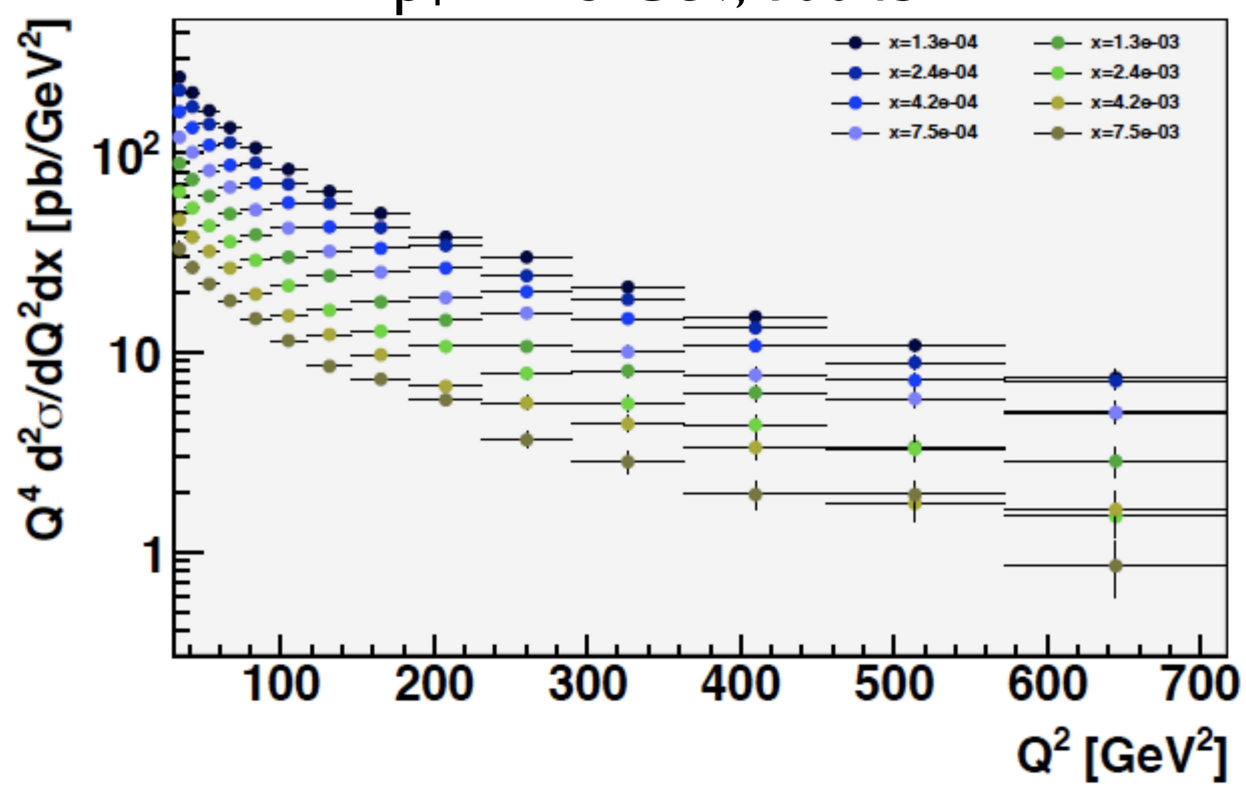
- Exclusive processes like γ*+h→ρ,ϕ,γ+h give information of GPDs, whose Fourier transform gives a tranverse scanning of the hadron: key importance for both non-perturbative and perturbative aspects, like the possibility of non-linear dynamics.

- Only small-x case where higher luminosity really helps!!!

DVCS, E_e=50 GeV, 1°, $p_T^{\gamma,cut}$=2 GeV, 1 fb^{-1}



DVCS, E_e=50 GeV, 10°, $p_T^{\gamma,cut}$=5 GeV, 100 fb^{-1}



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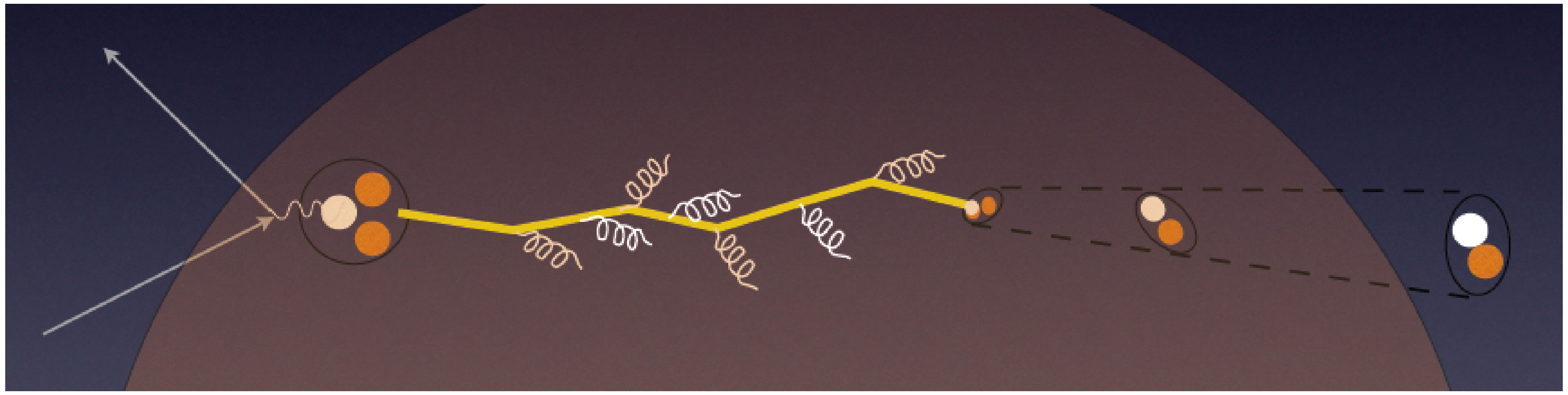
In-medium hadronization:

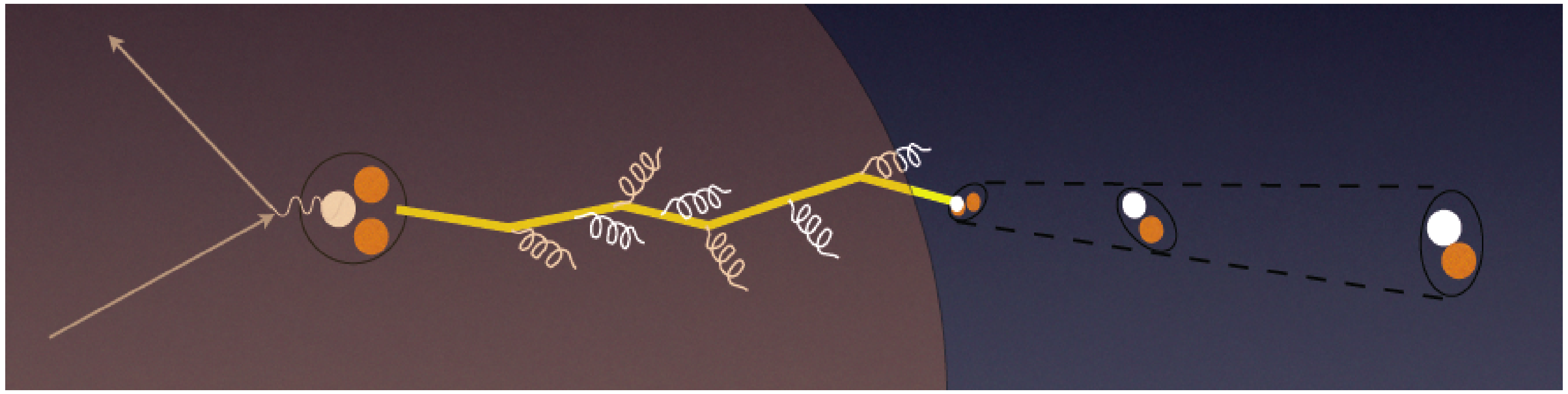
- The LHeC (ν_{max}~10^5 GeV) would allow to study the dynamics of hadronization, testing the parton/hadron eloss mechanism by introducing a length of colored material which would modify its pattern (length/nuclear size, chemical composition).

- Low energy: need of hadronization inside → formation time, (pre-) hadronic absorption,...



Brooks at Divonne'09

- High energy: partonic evolution altered in the nuclear medium, partonic energy loss.



Forward jets:

- Studying forward jets ($p_T \sim Q$) or dijet decorrelation would allow to understand the mechanism of radiation:

→ k_T-ordered: DGLAP.

→ k_T-disordered: BFKL.

→ Saturation?

- Further imposing a rapidity gap (diffractive jets) would be most interesting: perturbatively controllable observable.

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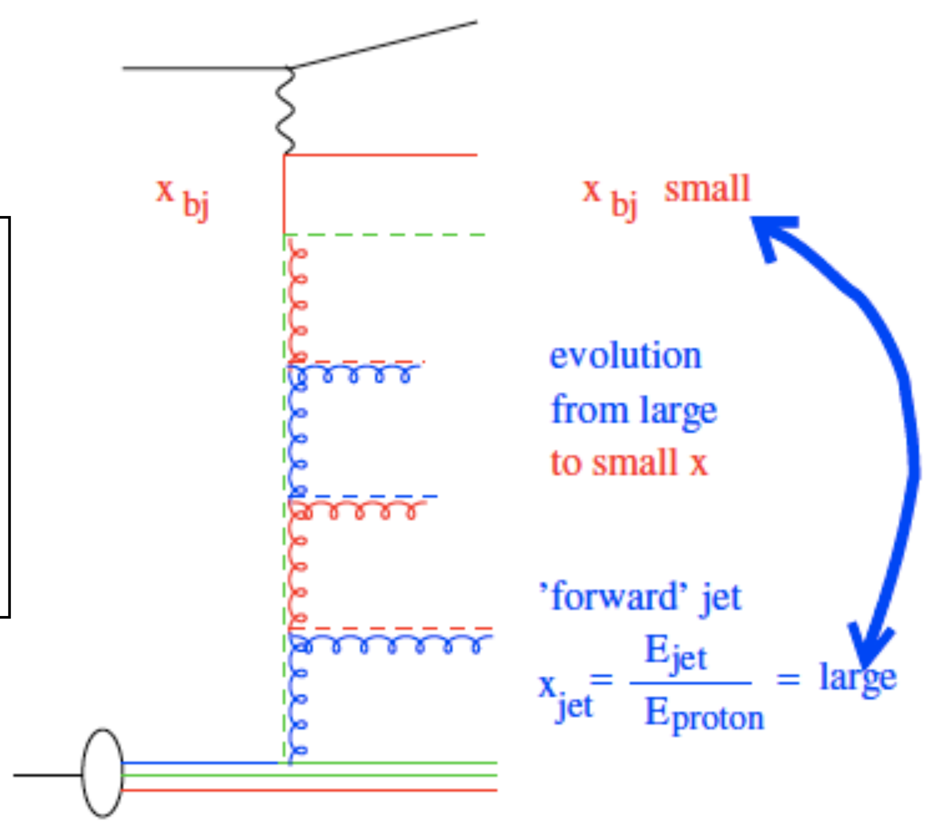
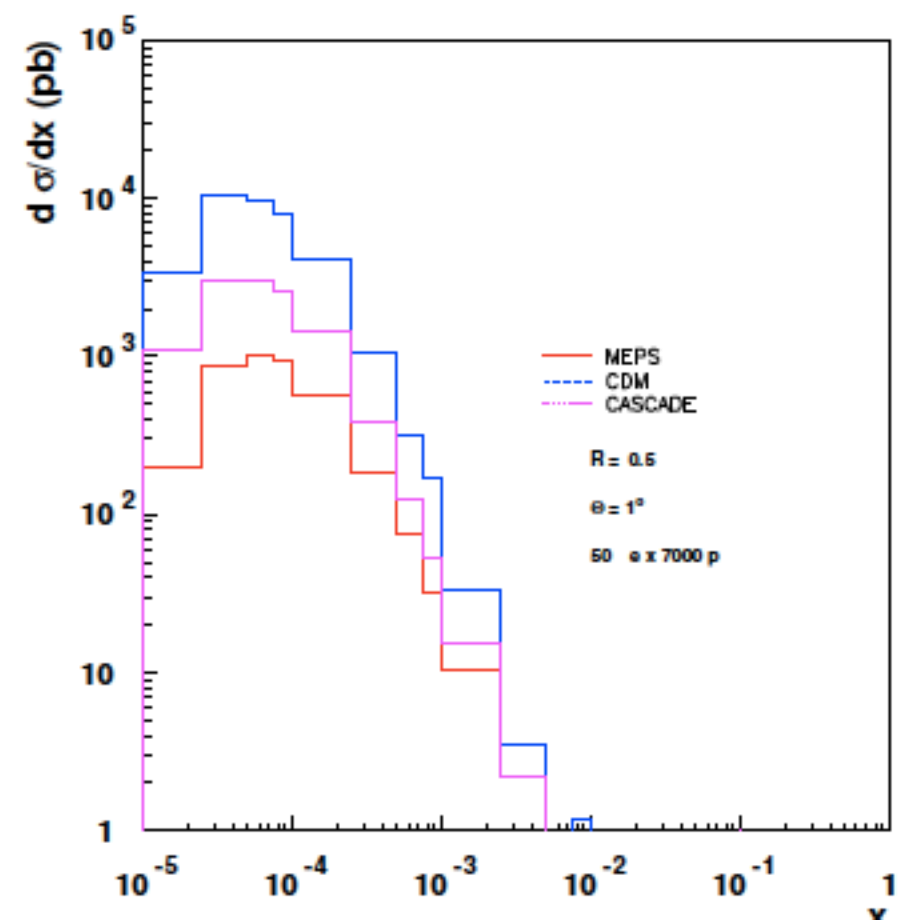
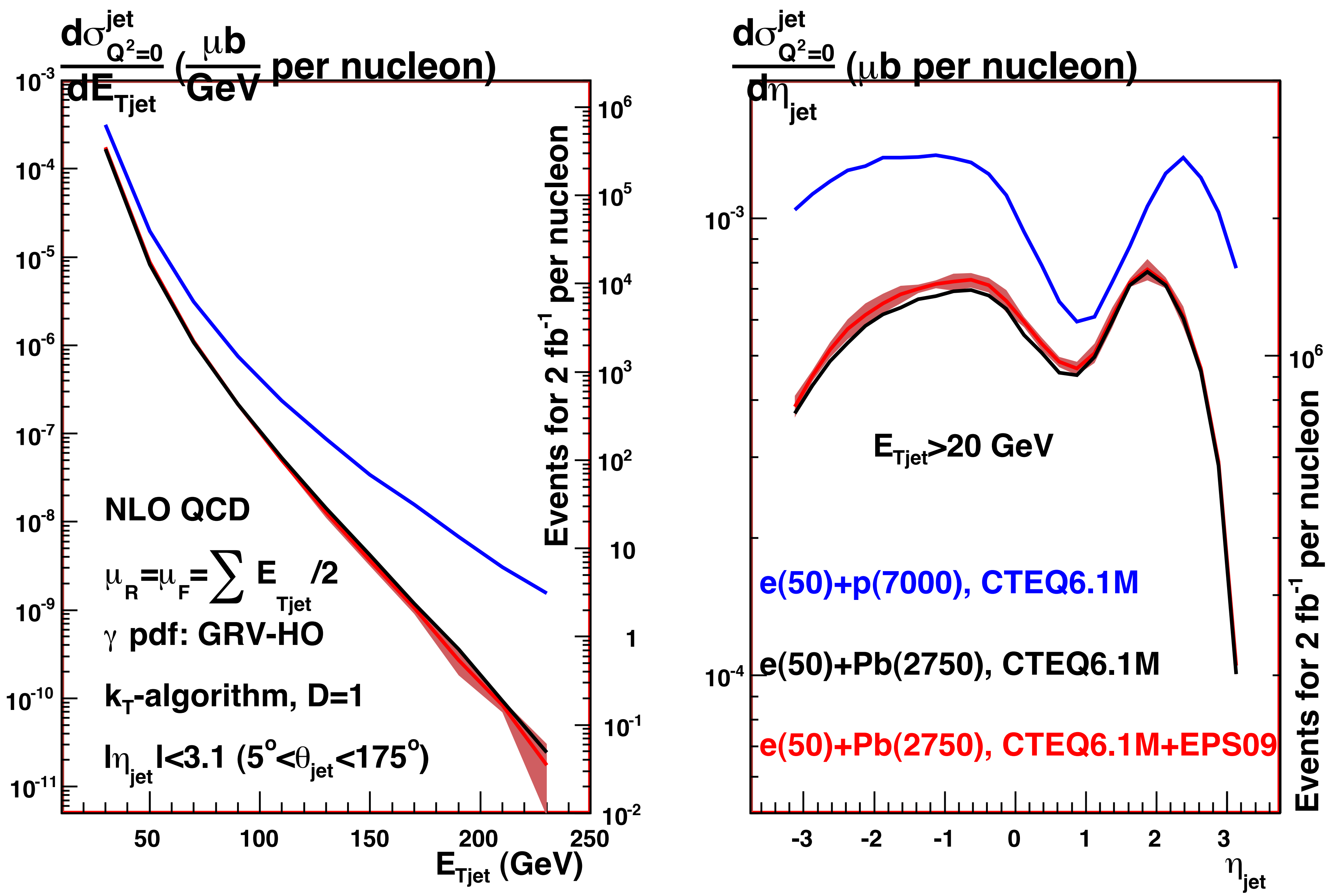




Small-x physics at the LHeC: 5. Final states and photoproduction.

Jet photoproduction:



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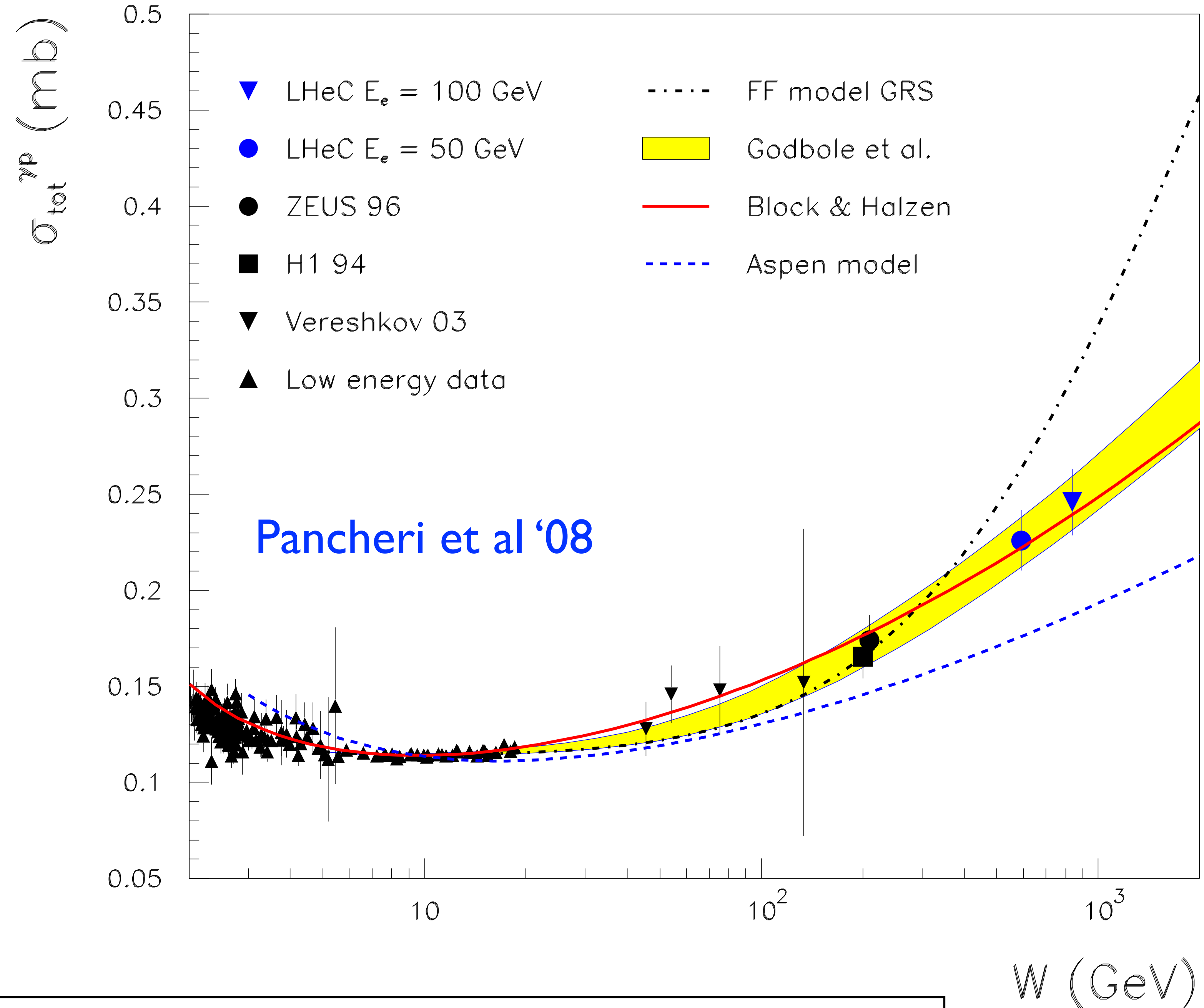
- Jets: large E_T even in eA.
- Useful for studies of parton dynamics in nuclei (hard probes), and for photon structure.
- Background subtraction, detailed reconstruction pending.

Total γp cross section:

- Small angle electron detector 62 m far from the interaction point: $Q^2<0.01$ GeV, $y\sim0.3 \Rightarrow W\sim0.5\sqrt{s}$.

- Substantial enlarging of the lever arm in W.



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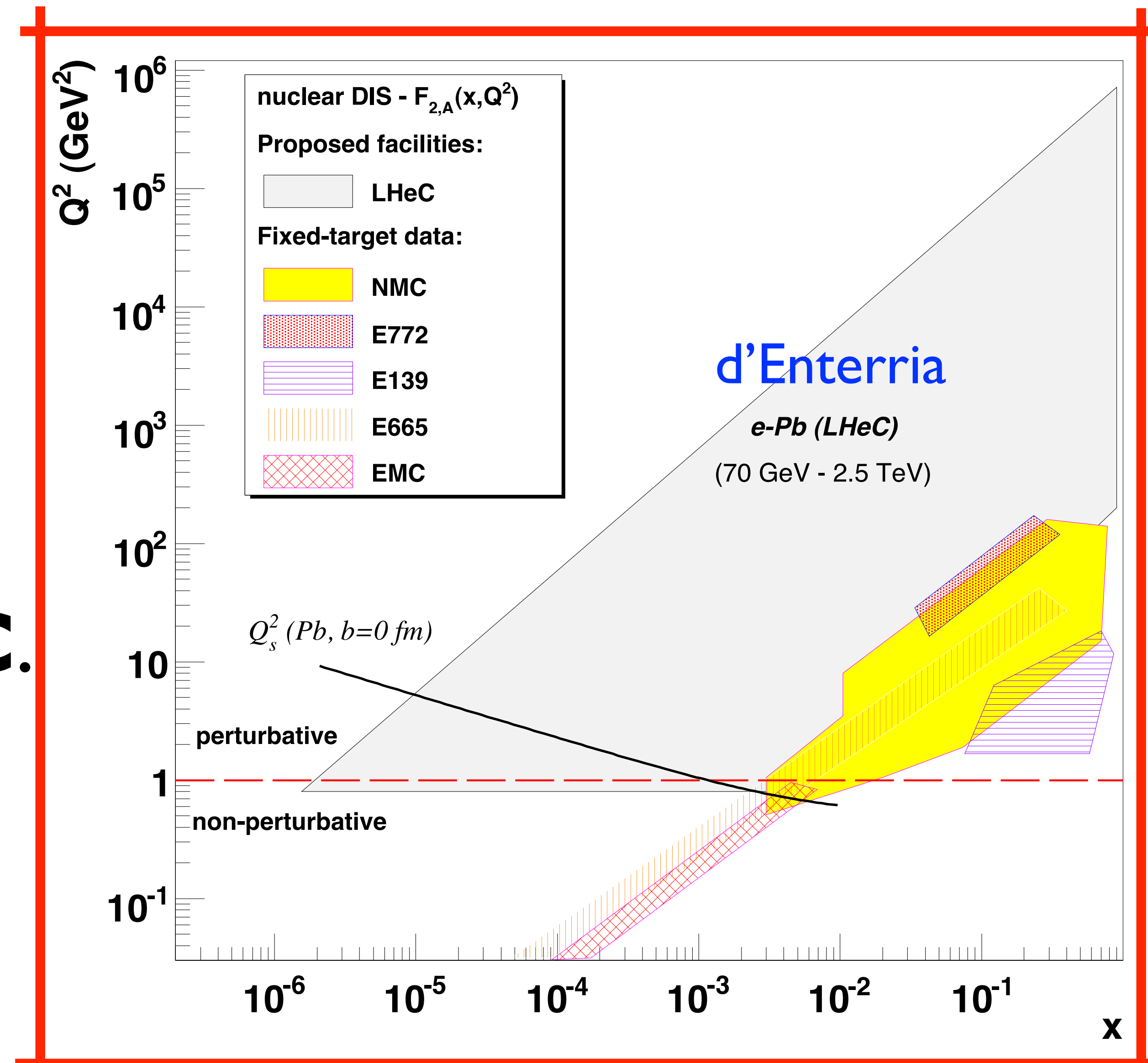
Summary:

- Many issues remain open about small-x physics (behavior of the hadron wave function at small x): describable by pQCD?, need of resummation/onset of unitarity in the accessible kinematical regions?

- Current ep experiments cover pp@LHC at y=0; in eA, not even dAu@RHIC is really constrained.

- An electron-nucleon/ion collider offers huge possibilities to test our ideas about high-energy QCD. **eA**: amplifier of density effects, **implications on UrHIC complementary to pA@LHC**.

- LHeC@CERN: new facility for ep/eA at E_{cm}~1-2 TeV under design.



Plans for the CDR:

Preliminary; LHeC Design Study Report, CERN 2011

Scientific Advisory Committee

Guido Altarelli (Roma)
Sergio Bertolucci (CERN)
Stan Brodsky (SLAC)
Allen Caldwell (MPI Muenchen) - Chair
Swapan Chattopadhyay (Cockcroft Institute)
John Dainton (Liverpool)
John Ellis (CERN)
Jos Engelen (NWO)
Joel Feltesse (Saclay)
Roland Garoby (CERN)
Rolf Heuer (CERN)
Roland Horisberger (PSI)
Young-Kee Kim (Fermilab)
Aharon Levy (Tel Aviv)
Lev Lipatov (St. Petersburg)
Karlheinz Meier (Heidelberg)
Richard Milner (MIT)
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Steve Myers (CERN)
Guenther Rosner (Glasgow)
Alexander N. Skrinsky (INP Novosibirsk)
Anthony Thomas (JLab)
Steve Vigdor (Brookhaven)
Ferdinand Willeke (Brookhaven)
Frank Wilczek (MIT)

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John Dainton (Liverpool)
Albert De Roeck (CERN)
Stefano Forte (Milano)
Max Klein (Liverpool) - Chair
Paul Laycock (Liverpool)
Paul Newman (Birmingham)
Emmanuelle Perez (CERN)
Wesley Smith (Wisconsin)
Bernd Surrow (MIT)
Katsuo Tokushuku (KEK)
Urs Wiedemann (CERN)
Frank Zimmermann (CERN)

Working Group Convenors

Accelerator Design

Oliver Bruening (CERN)
John Dainton (Liverpool)

Interaction Region and Fwd/Bwd

Bernhard Holzer(CERN)
Uwe Schneekloth (DESY)
Pierre van Mechelen (Antwerpen)

Detector Design

Peter Kostka (DESY)
Alessandro Polini (Bologna)
Rainer Wallny (Zurich)

New Physics at Large Scales

Georges Azuelos (Montreal)
Emmanuelle Perez (CERN)
Georg Weiglein (Hamburg)

Precision QCD and Electroweak

Olaf Behnke (DESY)
Paolo Gambino (Torino)
Thomas Gehrmann (Zurich)
Claire Gwenlan (Oxford)

Physics at High Parton Densities

Néstor Armesto (Santiago de Compostela)
Brian A. Cole (Columbia)
Paul R. Newman (Birmingham)
Anna M. Stasto (PennState)

Referees of the Draft Report

Ring Ring Design
Kurt Huebner (CERN)
Alexander N. Skrinsky (INP Novosibirsk)
Ferdinand Willeke (BNL)
Linac Ring Design
Reinhard Brinkmann (DESY)
Andy Wolski (Cockcroft)
Kaoru Yokoya (KEK)
Energy Recovery
Georg Hoffstaetter (Cornell)
Ilan Ben Zvi (BNL)
Magnets
Neil Marks (Cockcroft)
Martin Wilson (??)
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Installation and Infrastructure
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C.Adolphsen[1], S.Alekhin[2,3], H.Aksakal[4], P.Allport[5], J.L.Albacete[6], V.Andreev[7], R.Appleby[8], N.Armesto[9], G.Azuelos[10], M.Bai[11], D.Barber[3], J.Bartels[12], J.Behr[3], O.Behnke[3], S.Belyaev[4], I.BenZvi[11], N.Bernard[13], S.Bertolucci[4], S.Bettoni[4], S.Biswal[47], J.Bluemlein[3], H.Boettcher[3], H.Braun[48], S.Brodsky[1], A.Bogacz[14], C.Bracco[4], O.Bruening[4], E.Bulyak[49], A.Bunyatian[3], H.Burkhardt[4], R.Calaga[11], E.Ciapala[4], R.Ciftci[15], A.K.Ciftci[15], B.A.Cole[16], J.C.Collins[17], J.Dainton[5], A.De.Roeck[4], D.d'Enterria[4], A.Dudarev[4], A.Eide[18], E.Eroglu[19], K.J.Eskola[20], L.Favart[21], M.Fitterer[4], S.Forte[22], P.Gambino[23], T.Gehrmann[24], C.Glasman[25], R.Godbole[26], B.Goddard[4], T.Greenshaw[5], A.Guffanti[27], C.Gwenlan[28], T.Han[29], Y.Hao[11], F.Haug[4], W.Herr[4], B.Holzer[4], M.Ishitsuka[30], M.Jacquet[31], B.Jeanneret[4], J.M.Jimenez[4], H.Jung[3], J.M.Jowett[4], D.Kayran[11], F.Kosac[19], A.Kilic[19], K.Kimura[30], M.Klein[5], U.Klein[5], T.Kluge[12], G.Kramer[12], M.Korostelev[8], A.Kosmicki[4], P.Kostka[3], H.Kowalski[3], D.Kuchler[4], M.Kuze[30], T.Lappi[20], P.Laycock[5], E.Levichev[32], S.Levonian[3], V.N.Litvinenko[11], A.Lombardi[4], C.Marquet[4], B.Mellado[29], KH.Mess[4], S.Moch[3], I.I.Morozov[32], Y.Muttoni[4], S.Myers[4], P.R.Newman[33], T.Omori[34], J.Osborne[4], Y.Papaphilippou[4], E.Paoloni[35], C.Pascaud[31], H.Paukkunen[9], E.Perez[4], T.Pieloni[36], E.Pilic[19], A.Polini[37], V.Ptitsyn[11], Y.Pupkov[32], V.Radescu[38], S.Raychaudhuri[26], L.Rinolfi[4], R.Rohini[26], J.Rojo[22], S.Russenschuck[4], C.A.Salgado[9], K.Sampai[30], E.Sauvan[39], U.Schneekloth[3], T.Schoerner Sadenius[3], D.Schulte[4], N.Soumitra[23], H.Spiesberger[41], A.M.Stasto[17], M.Strikman[17], M.Sullivan[1], B.Surrow[40], S.Sultansoy[15], Y.P.Sun[1], W.Smith[42], I.Tapan[19], P.Taels[43], H.Ten.Kate[4], J.Terron[25], H.Thiesen[4], L.Thompson[8], K.Tokushuku[34], R.Tomas.Garcia[4], D.Tommasini[4], D.Trbojevic[11], N.Tsoupas[11], J.Tuckmantel[4], K.Tywoniuk[44], G.Unel[4], J.Urakawa[34], P.VanMechelen[43], A.Variola[6], R.Veness[4], A.Vivoli[4], P.Vobly[32], R.Wallny[45], G.Watt[4], G.Weiglein[12], C.Weiss[14], U.A.Wiedemann[4], U.Wienands[1], F.Willeke[11], V.Yakimenko[11], A.F.Zarnecki[46], F.Zimmermann[4], F.Zomer[31]

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Anna M. Stasto (PennState)

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Next Steps of the LHeC Project

The LHeC Study Group
http://cern.ch/lhec

2011

1. Complete CDR Draft
2. Workshop on positron intensity (20.5.11 at CERN)
3. Referee Process (8-11/11)
4. Update and Print and Hand in to ECFA/NuPECC/CERN
5. Workshop on Linac vs Ring (Fall 2011) [main features, R+D design]

2011/12

1. Participation in European Strategy Process (EPS Grenoble … 2012 conclusion)
2. Update physics programme when LHC Higgs/SUSY results consolidate (DIS12)
3. Form an international accelerator development group based at CERN
4. Build an LHeC Collaboration for preparation of LoI on the Detector

Frank Zimmermann (CERN)

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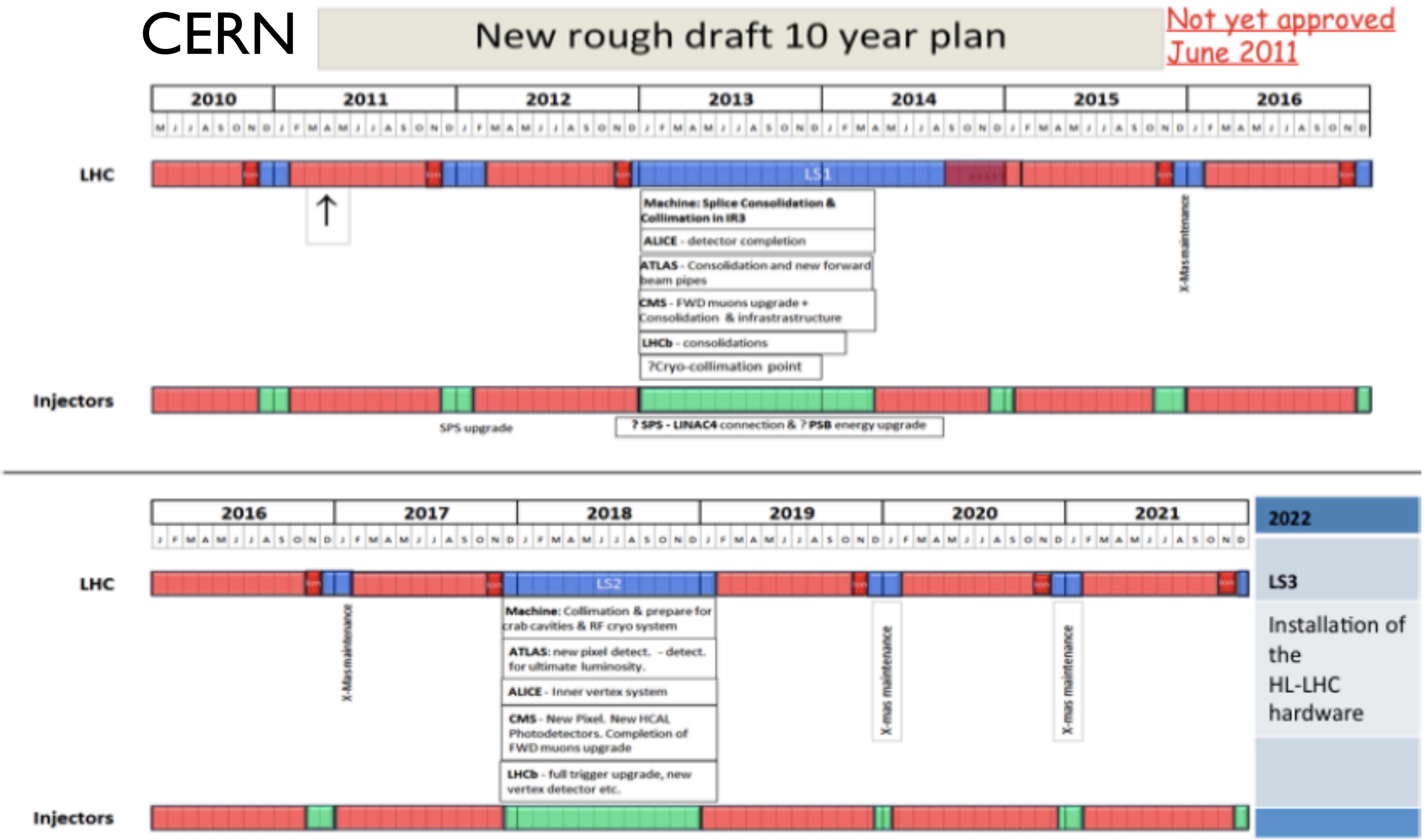
Tentative timeline:



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Tentative timeline:

CERN New rough draft 10 year plan

Not yet approved June 2011

2010	2011	2012	2013	2014	2015	2016

→ LHC death by radiation damage estimated by 2030-2035.

→ LHeC should work for 10 years.

→ No disturbance to LHC operation: installation during stops.

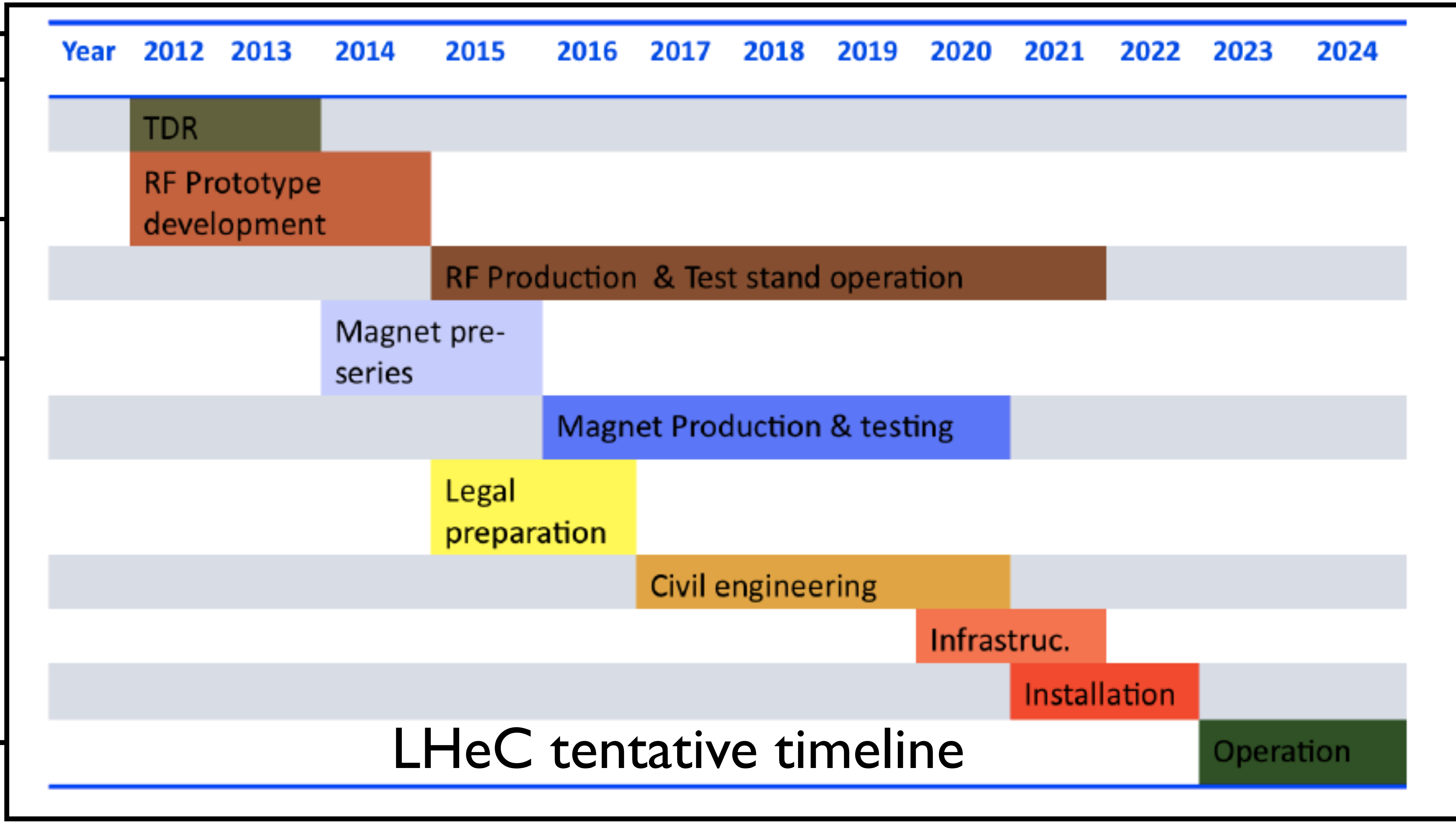
$\Rightarrow$

Preliminary; LHeC Design Study Report, CERN 2011

Tentative timeline:

CERN New rough draft 10 year plan

Not yet approved
June 2011



Preliminary; LHeC Design Study Report, CERN 2011

Tentative timeline:

CERN New rough draft 10 year plan

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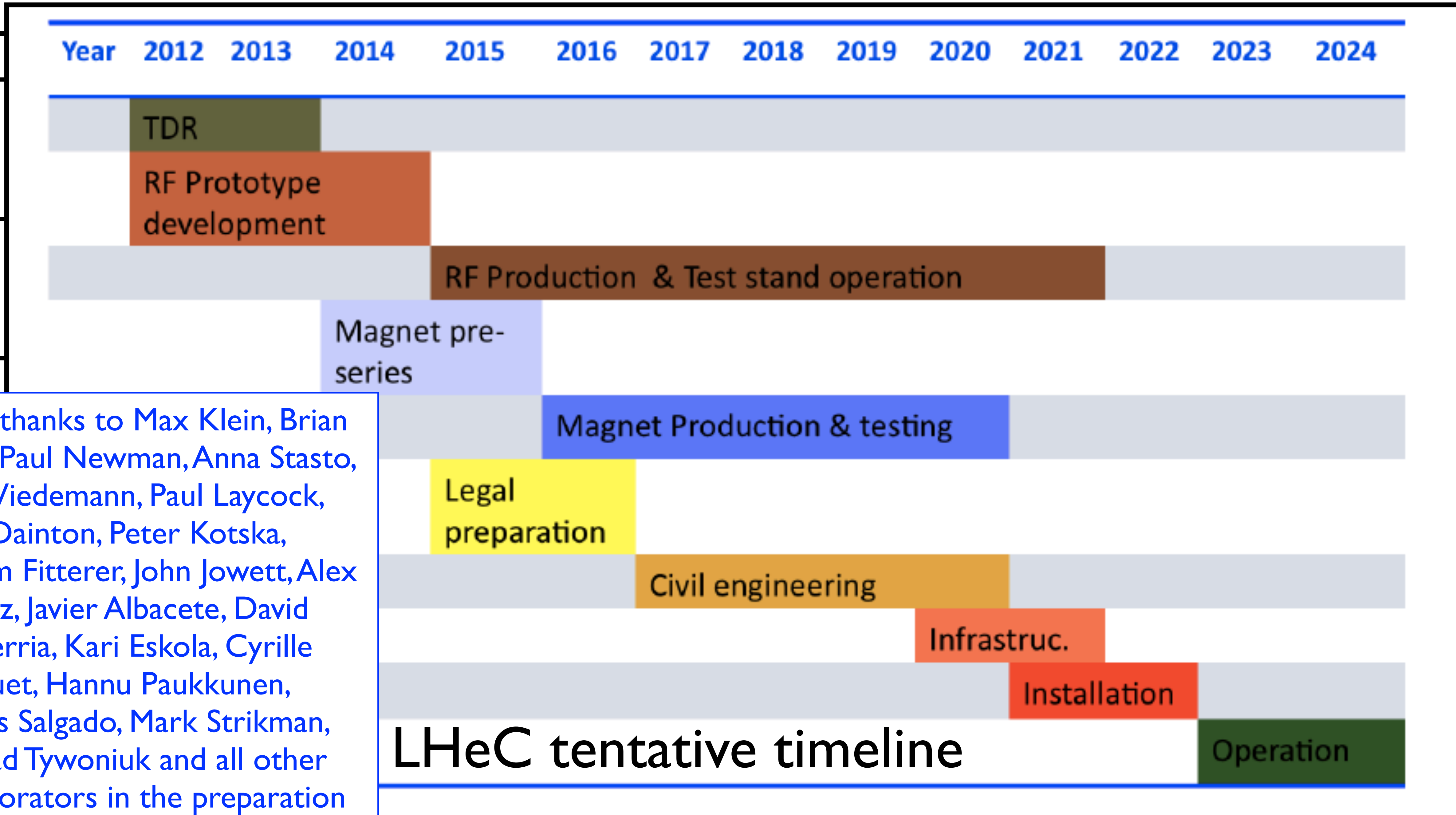

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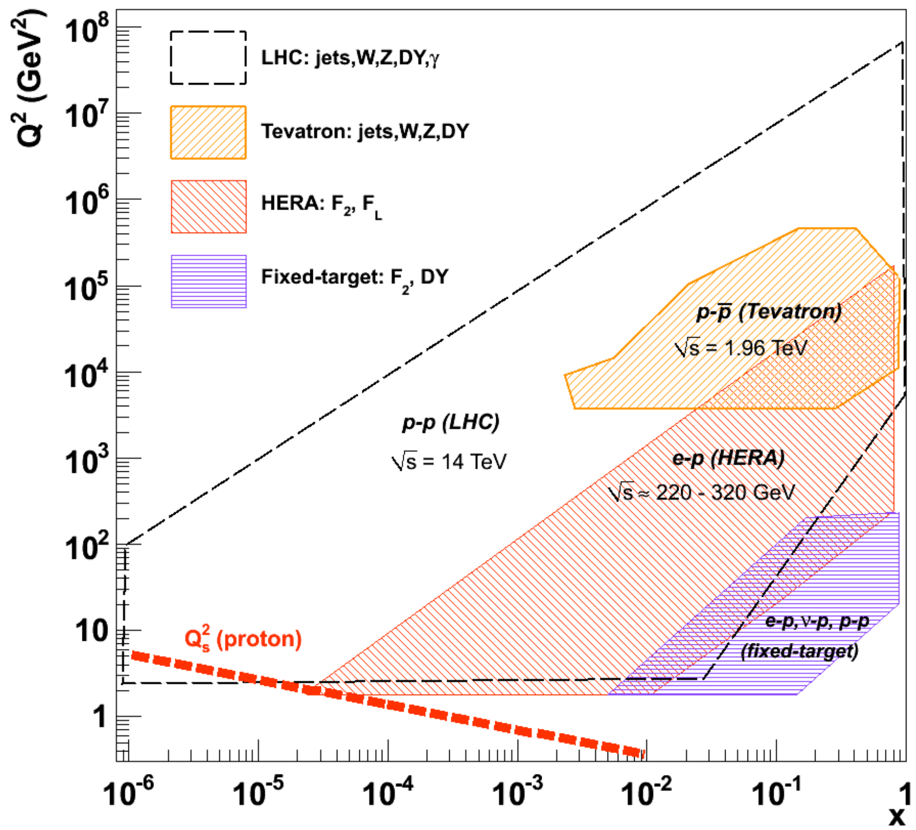
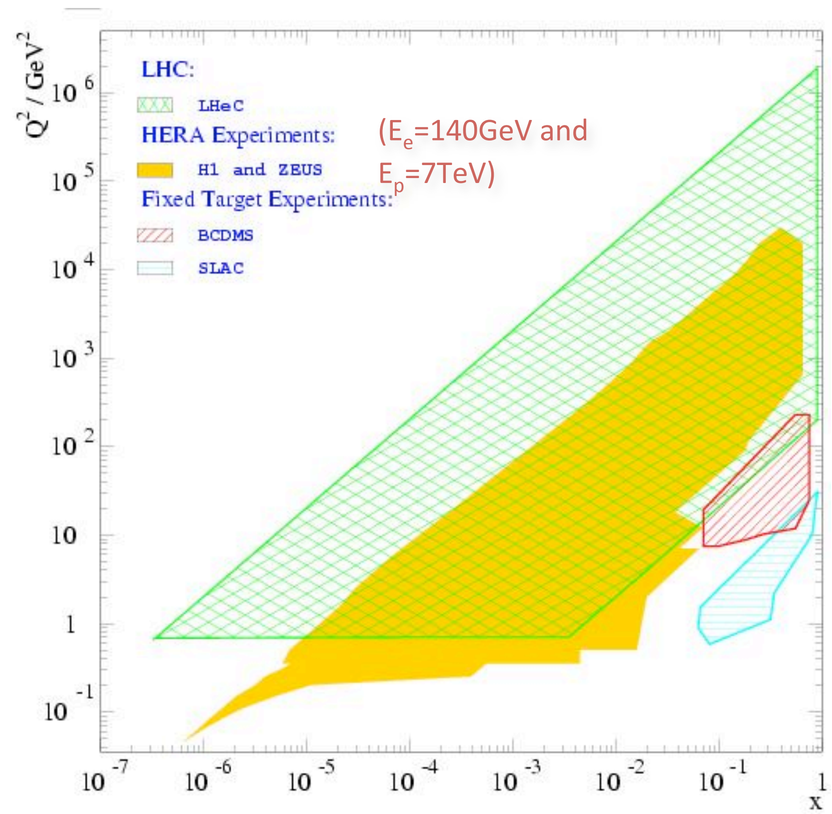
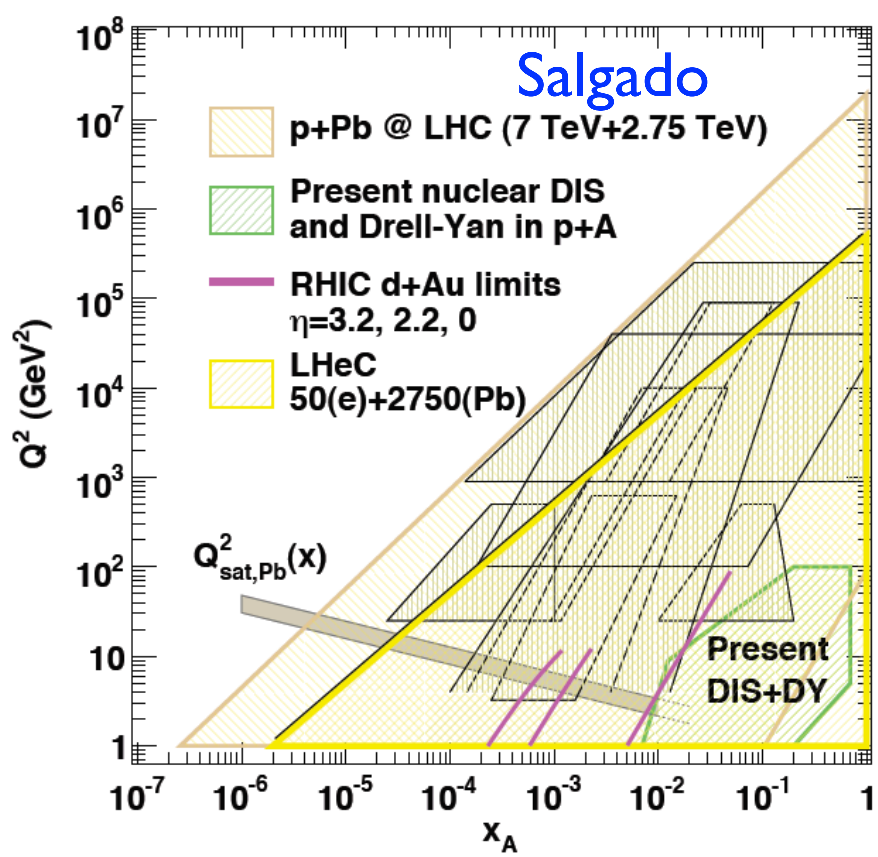
Backup:

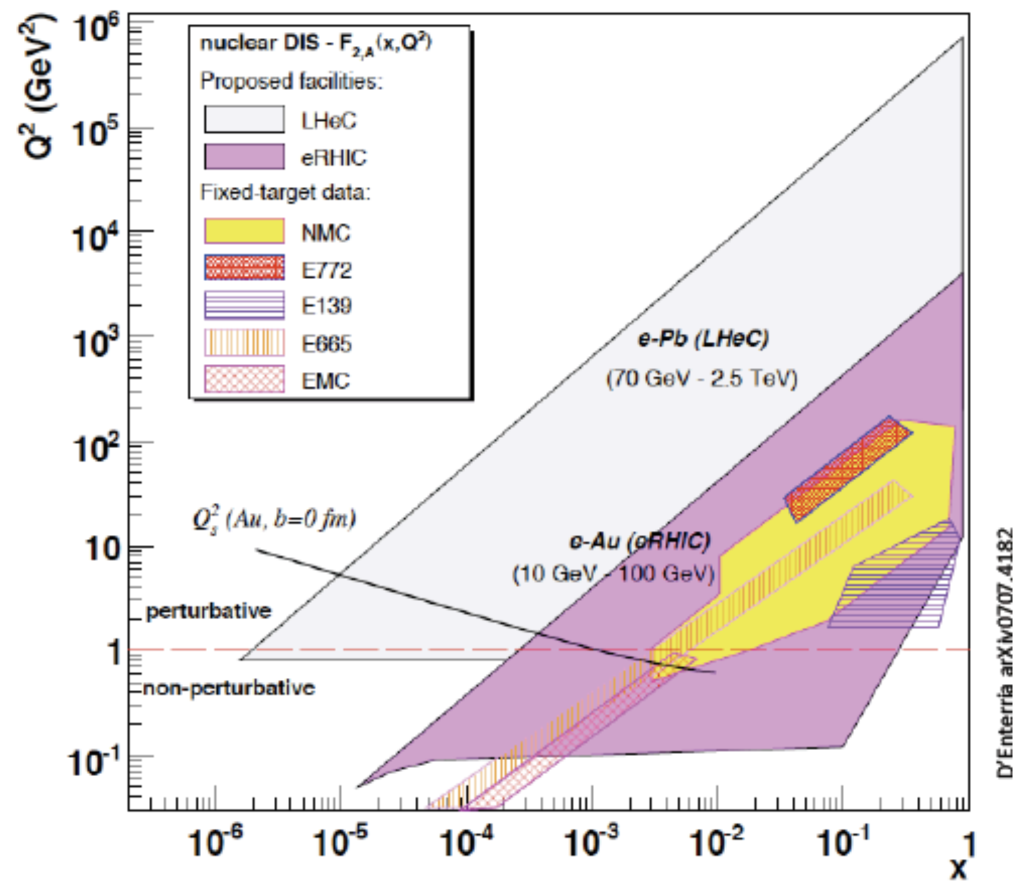
Kinematics: LHC vs. LHeC



d'Enterria







LHeC scenarios:

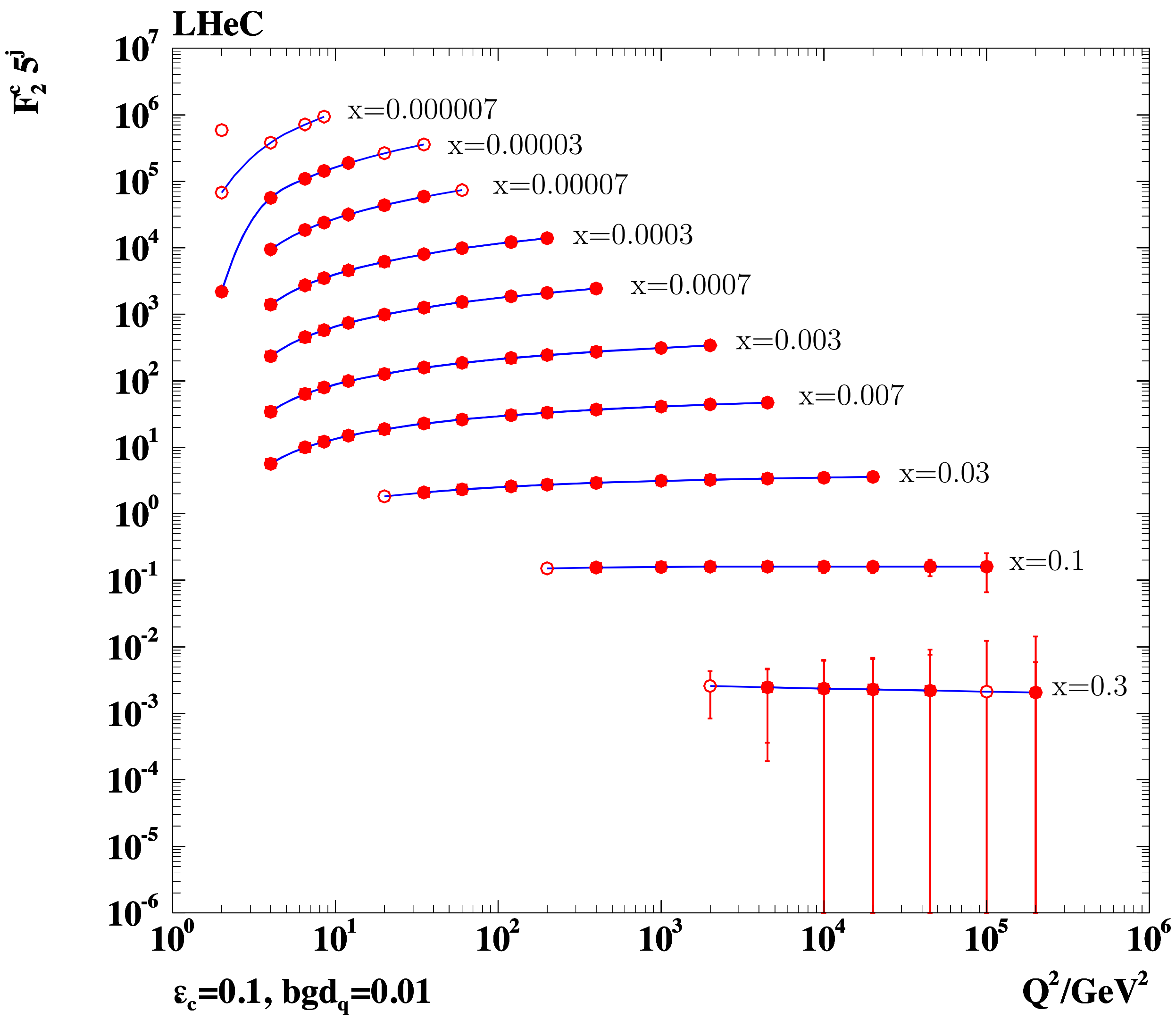
For F_2

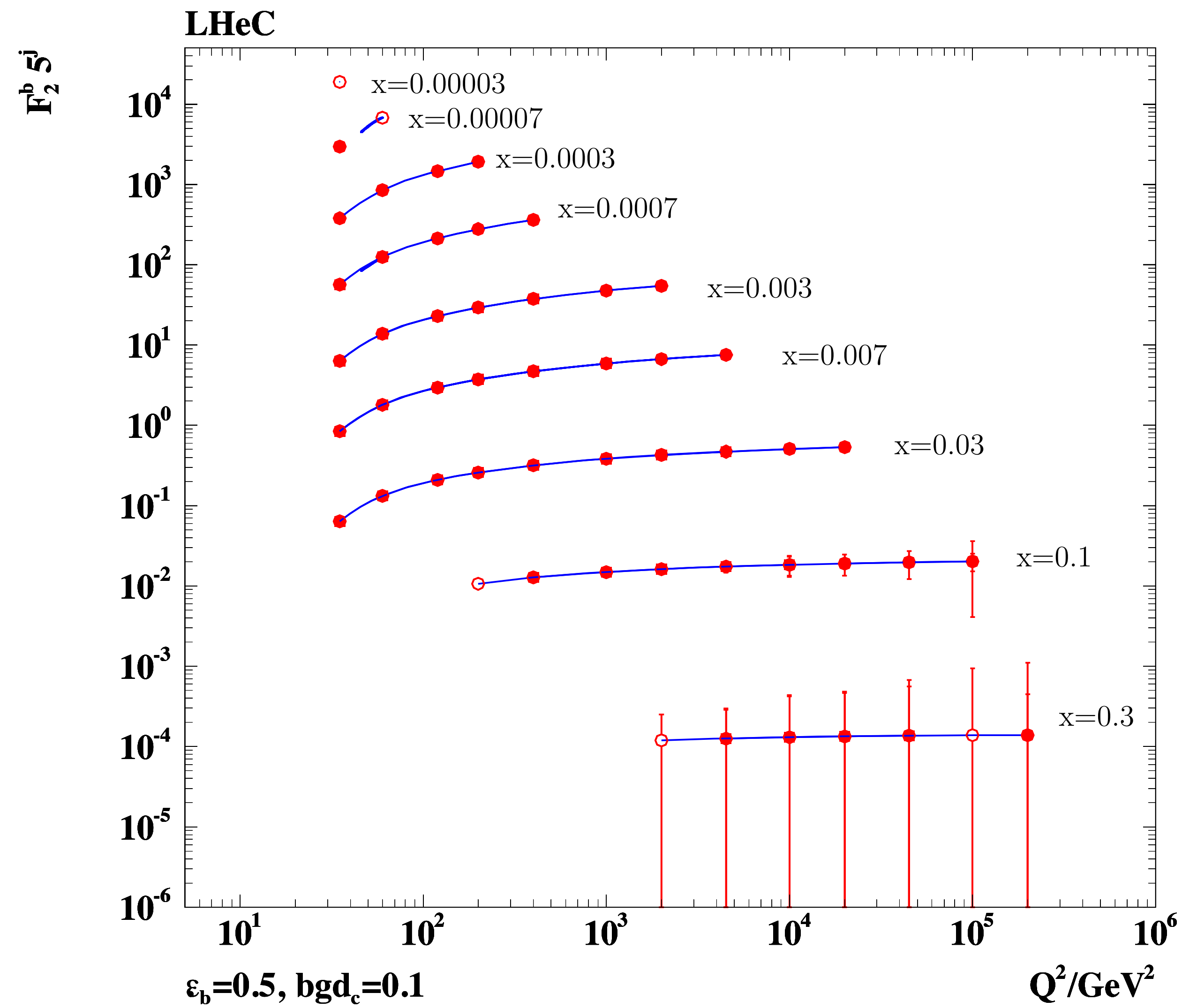
config.	E(e)	E(N)	N	∫L(e⁺)	∫L(e⁻)	|Pol|	$L/10^{32}$	P/MW	years	type
A	20	7	p	1	1	-	1	10	1	SPL
B	50	7	p	50	50	0.4	25	30	2	RR hiQ^2
C	50	7	p	1	1	0.4	1	30	1	RR lo x
D	100	7	p	5	10	0.9	2.5	40	2	LR
E	150	7	p	3	6	0.9	1.8	40	2	LR
F	50	3.5	D	1	1	--	0.5	30	1	eD
G	50	2.7	Pb	10^{-4}	10^{-4}	0.4	10^{-3}	30	1	ePb
H	50	1	p	--	1	--	25	30	1	lowEp
I	50	3.5	Ca	$5 \cdot 10^{-4}$		?	$5 \cdot 10^{-3}$	?	?	eCa

- For F_L: 10, 25, 50 + 2750 (7000); $Q^2 \leq sx$; Lumi=5,10,100 pb^{-1} respectively; charm and beauty: same efficiencies in ep and eA.

ep inclusive pseudodata (0):

- Charm and beauty most important (HERApdf; systematics half than at H1).





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eA inclusive pseudodata (0):

- F_2 data substantially reduce the uncertainties in DGLAP analysis; inclusion of charm, beauty and F_L done.