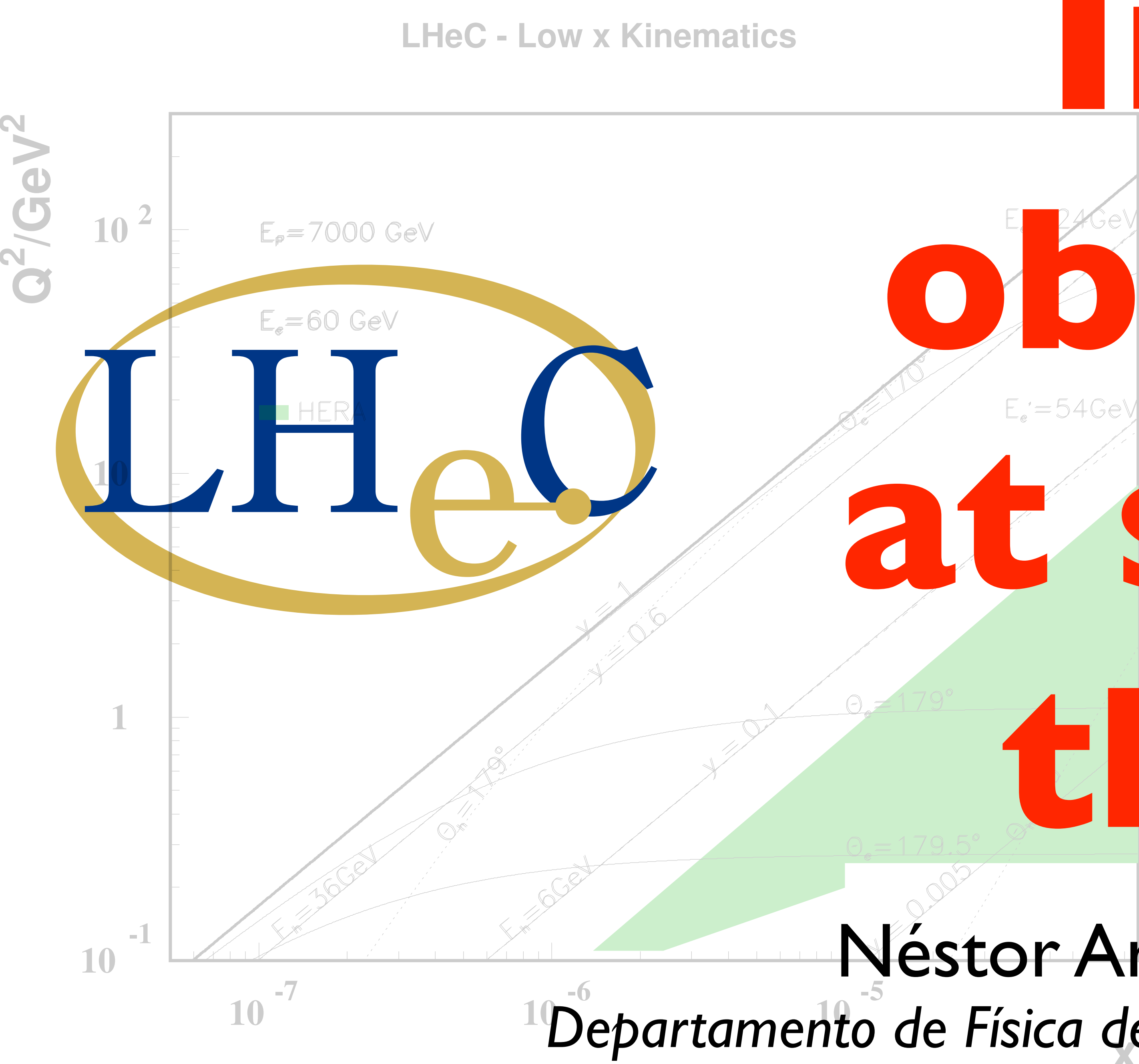
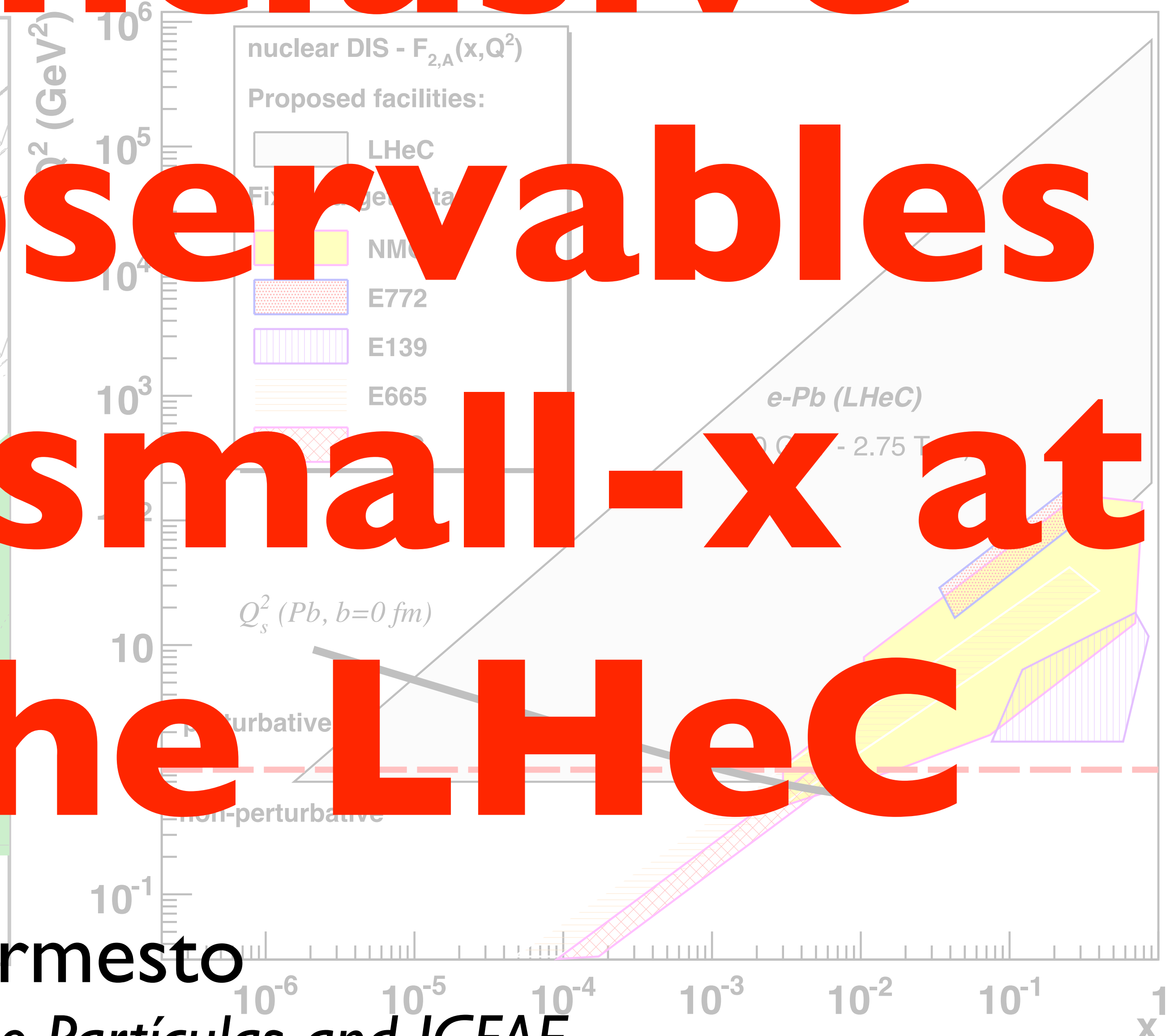
Low x Workshop
Rehovot, May 30th 2013

Inclusive observables at small-x at the LHeC





Néstor Armesto
Departamento de Física de Partículas and IGFAE
Universidade de Santiago de Compostela
nestor.armesto@usc.es
for the LHeC Study group, http://cern.ch/lhec

Contents:

1. Status and motivation.

2. The Large Hadron Electron Collider.

3. Inclusive measurements at low x:
   - Inclusive measurements and small-x glue in ep.
   - nPDFs.
   - UHE neutrinos.
   - Photoproduction cross section.

4. Summary.

CDR, arXiv:1206.2913, J. Phys. G 39 (2012) 075001;
arXiv:1211.4831; arXiv:1211.5102;
LHeC talks at DIS2013 and LPCC 17-18.04.2013; talk by A.Valkarova on diffractive observables

Status of small-x physics:

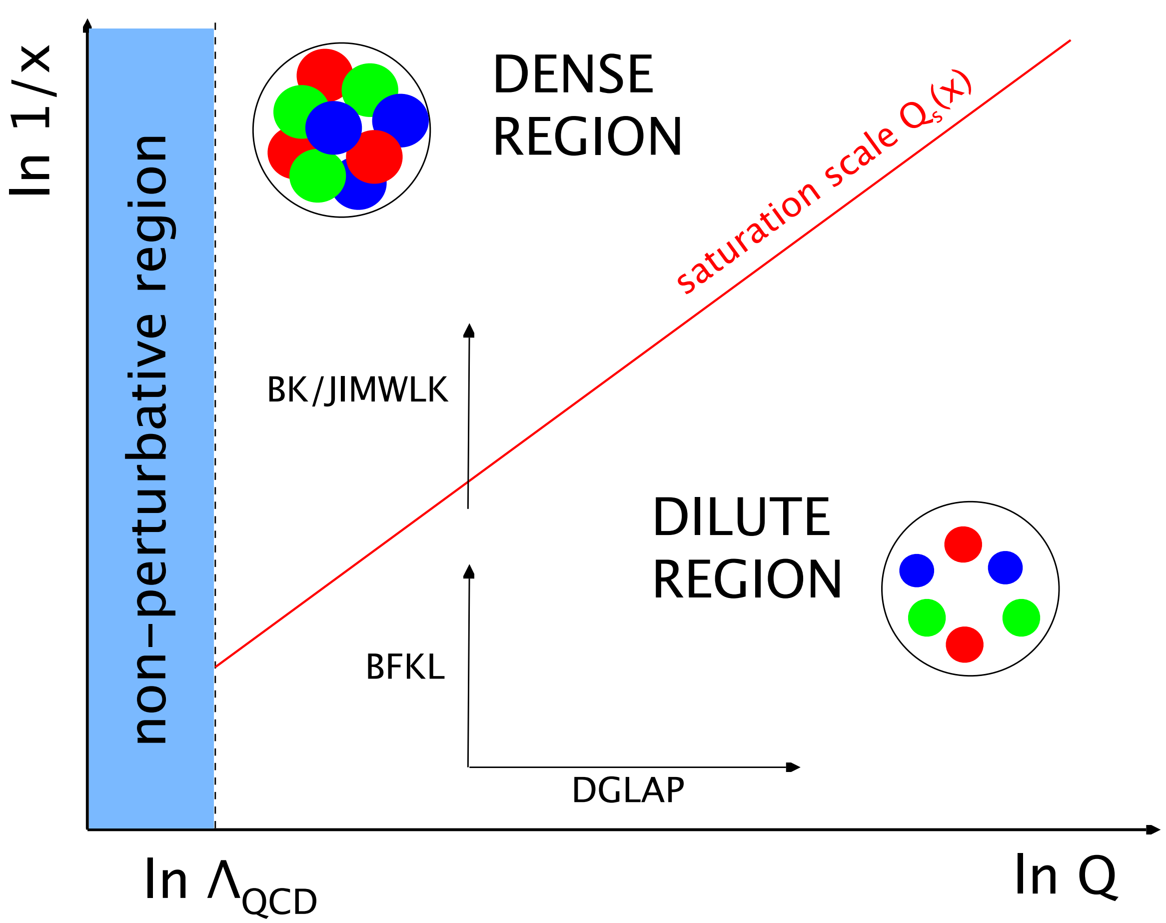
- Three pQCD-based alternatives to describe small-x ep and eA data (differences at moderate $Q^2(>\Lambda^2_{QCD})$ and small x):

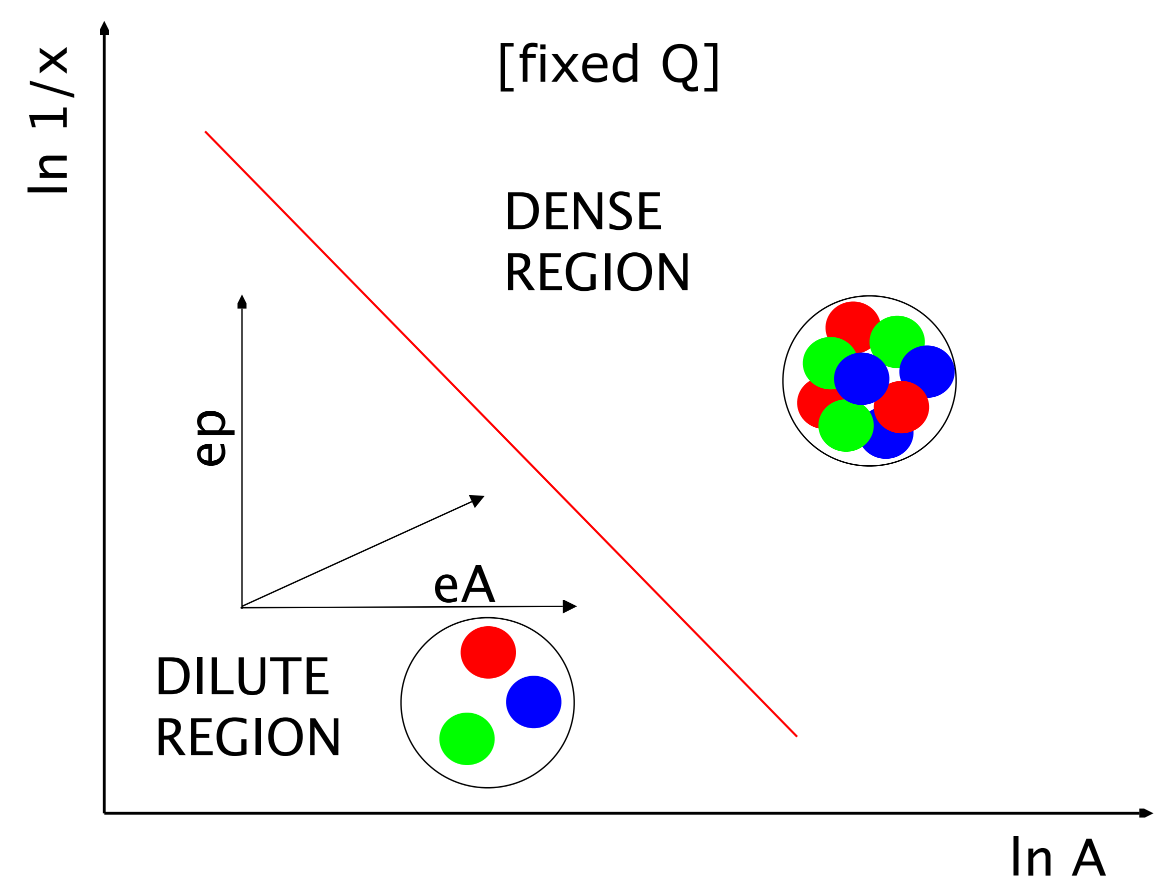
→ DGLAP evolution (fixed order perturbation theory).

→ Resummation schemes: BFKL, CCFM, ABF, CCSS.

→ Saturation (CGC, dipole models).

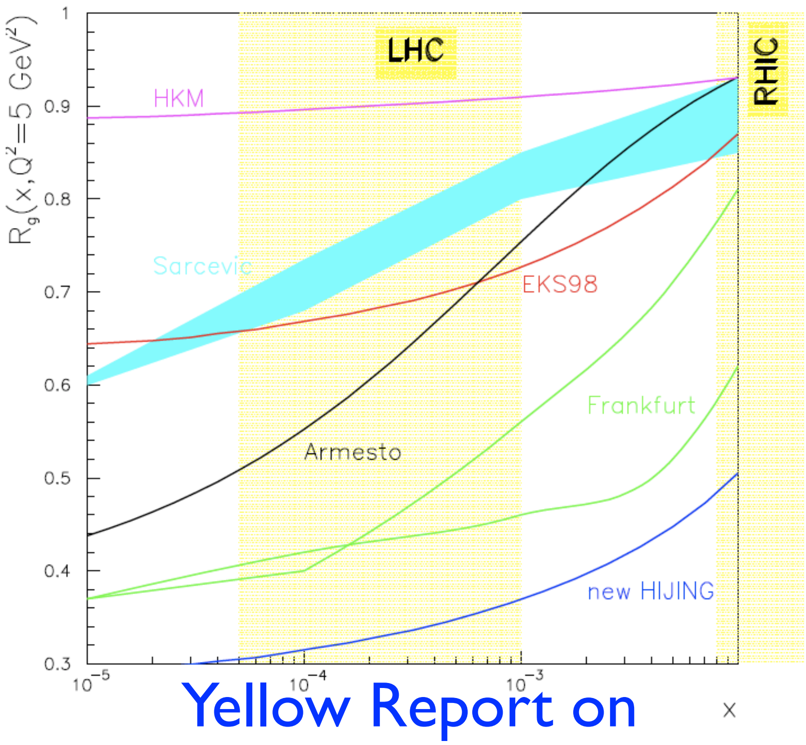
- **Non-linear effects** (unitarity constraints) are density effects: where? ⇒ **two-pronged approach at the LHeC**: ↓ x / ↑ A.





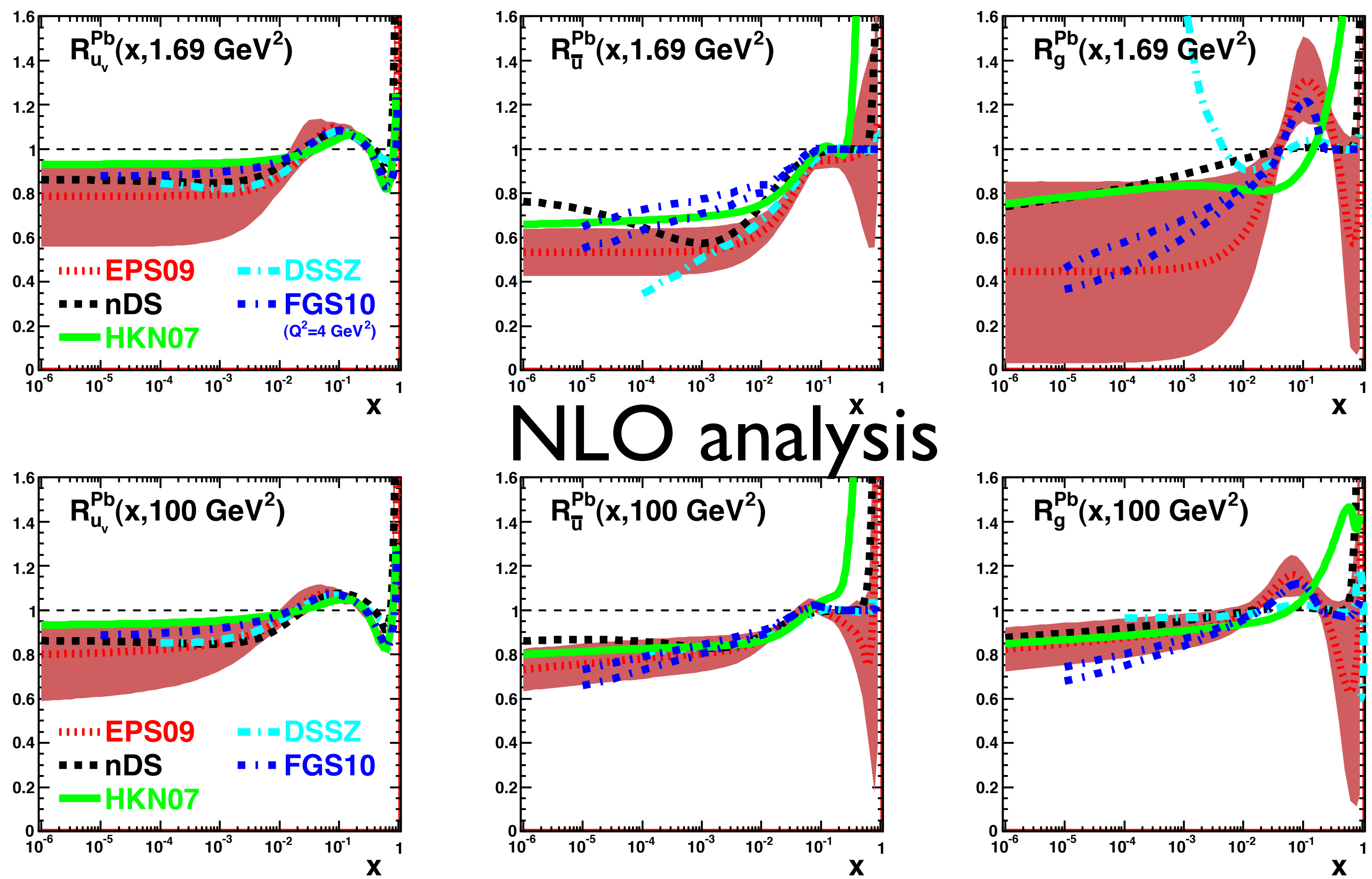
nPDFs: $R = \frac{f_{i/A}}{A f_{i/p}} \approx \frac{\text{measured}}{\text{expected if no nuclear effects}}$

- **Lack of data** ⇒ models give vastly different results for the nuclear glue at small scales and x: **problem for benchmarking in HIC**.



Yellow Report on Hard Probes, 2004

- Available DGLAP analysis at NLO show large uncertainties at small scales and x.



NLO analysis

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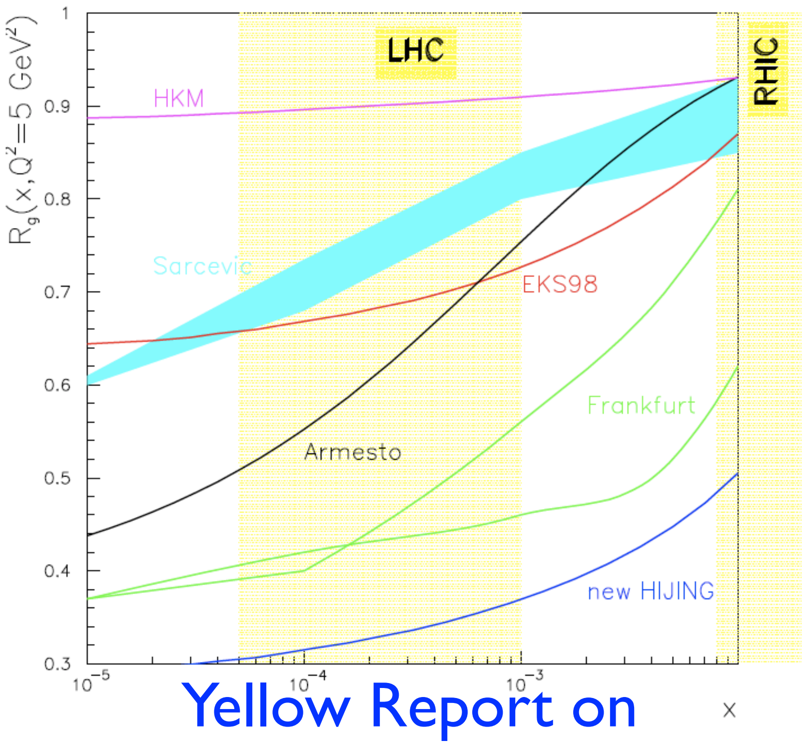

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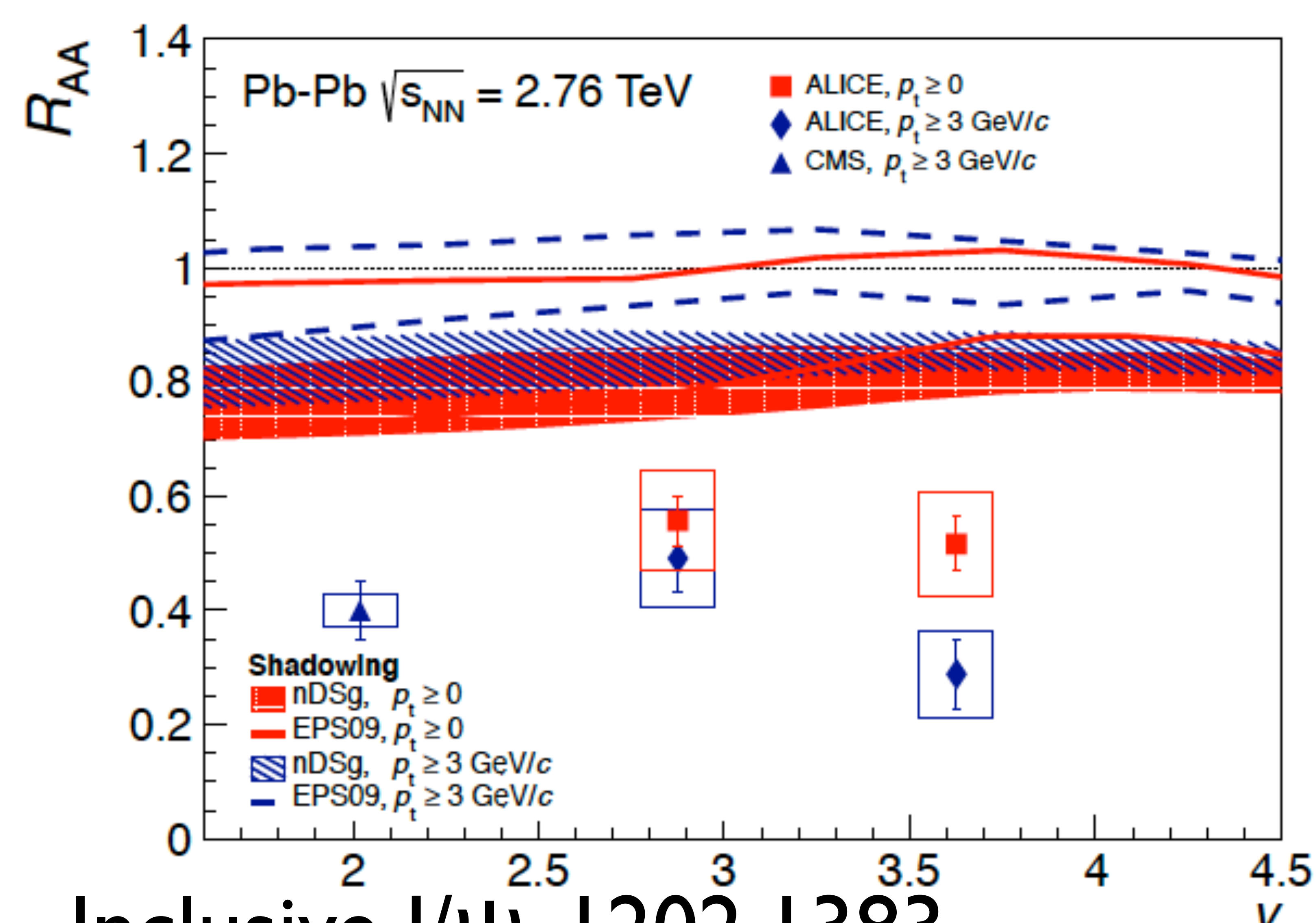
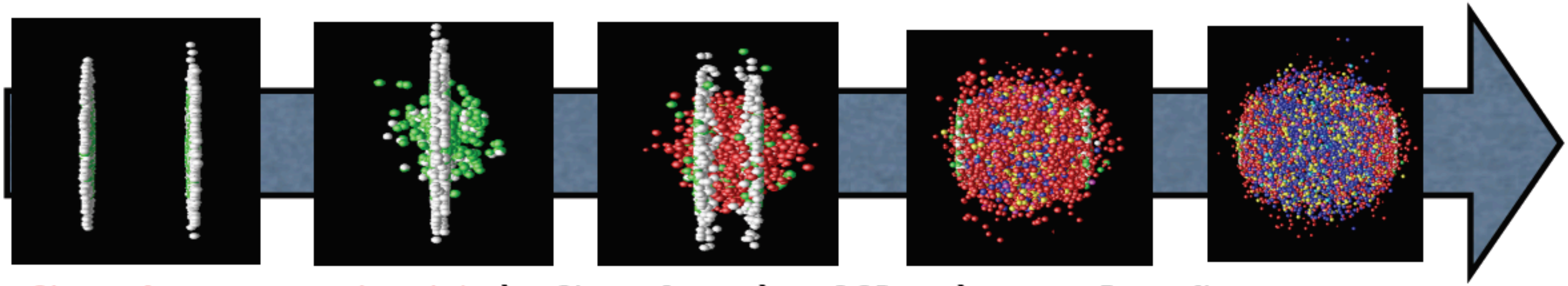


Inclusive J/ψ, 1202.1383

Relevance for the HI program:



Gluons from saturated nuclei → Glasma? → QGP → Reconfinement

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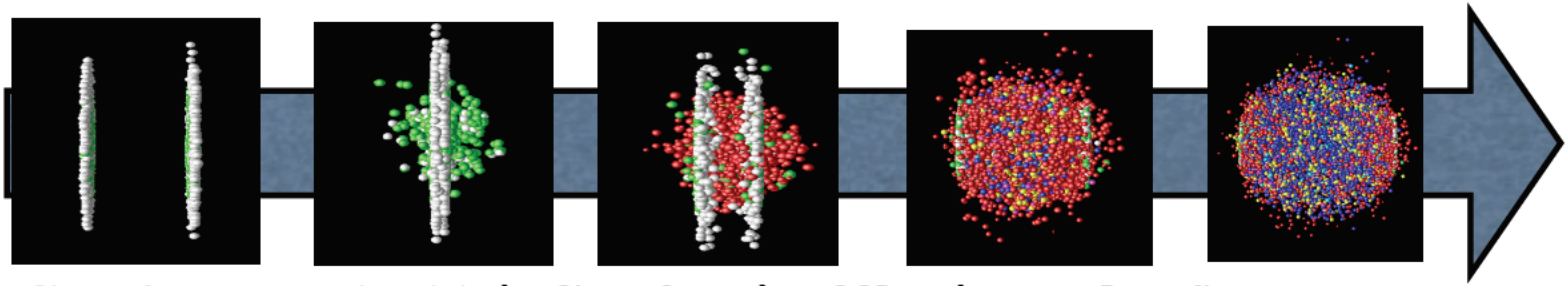

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- Nuclear wave function at small x: nuclear structure functions.

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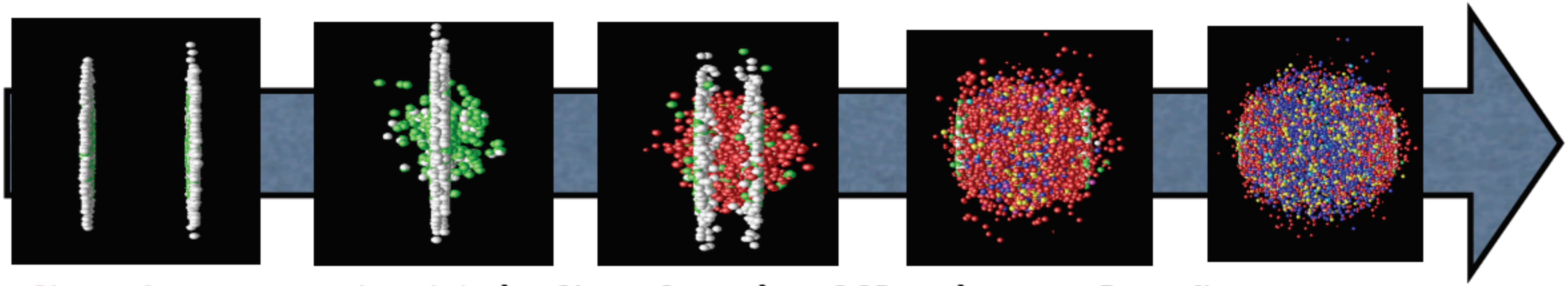

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- Nuclear wave function at small x: nuclear structure functions.

- Particle production at the very beginning: which factorisation in eA?

- How does the system behave as ~ isotropised so fast?: initial conditions for plasma formation to be studied in eA.

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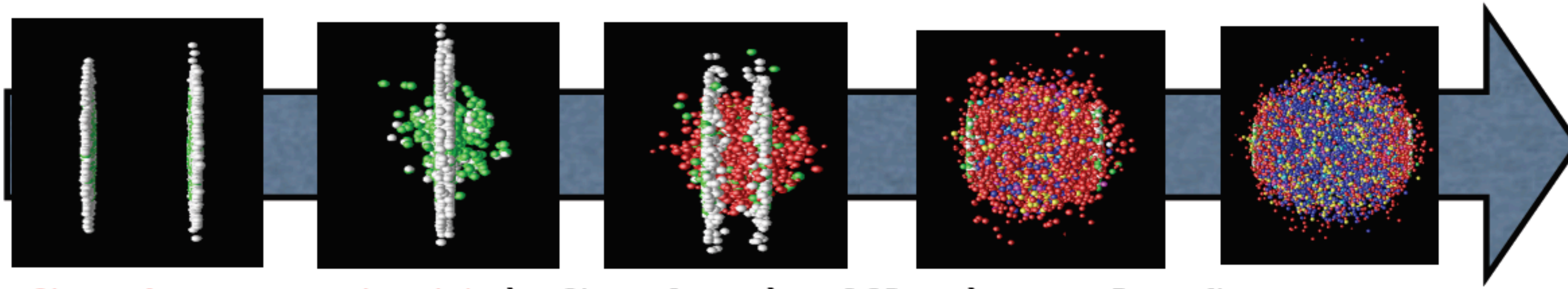

Gluons from saturated nuclei → Glasma? → QGP → Reconfinement

- Nuclear wave function at small x: nuclear structure functions.

- Particle production at the very beginning: which factorisation in eA?

- How does the system behave as ~ isotropised so fast?: initial conditions for plasma formation to be studied in eA.

- Probing the medium through energetic particles (jet quenching etc.): modification of QCD radiation and hadronization in the nuclear medium.

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Accelerator:

$\sqrt{s} \simeq 0.8\text{-}1.2$ TeV/nucleon

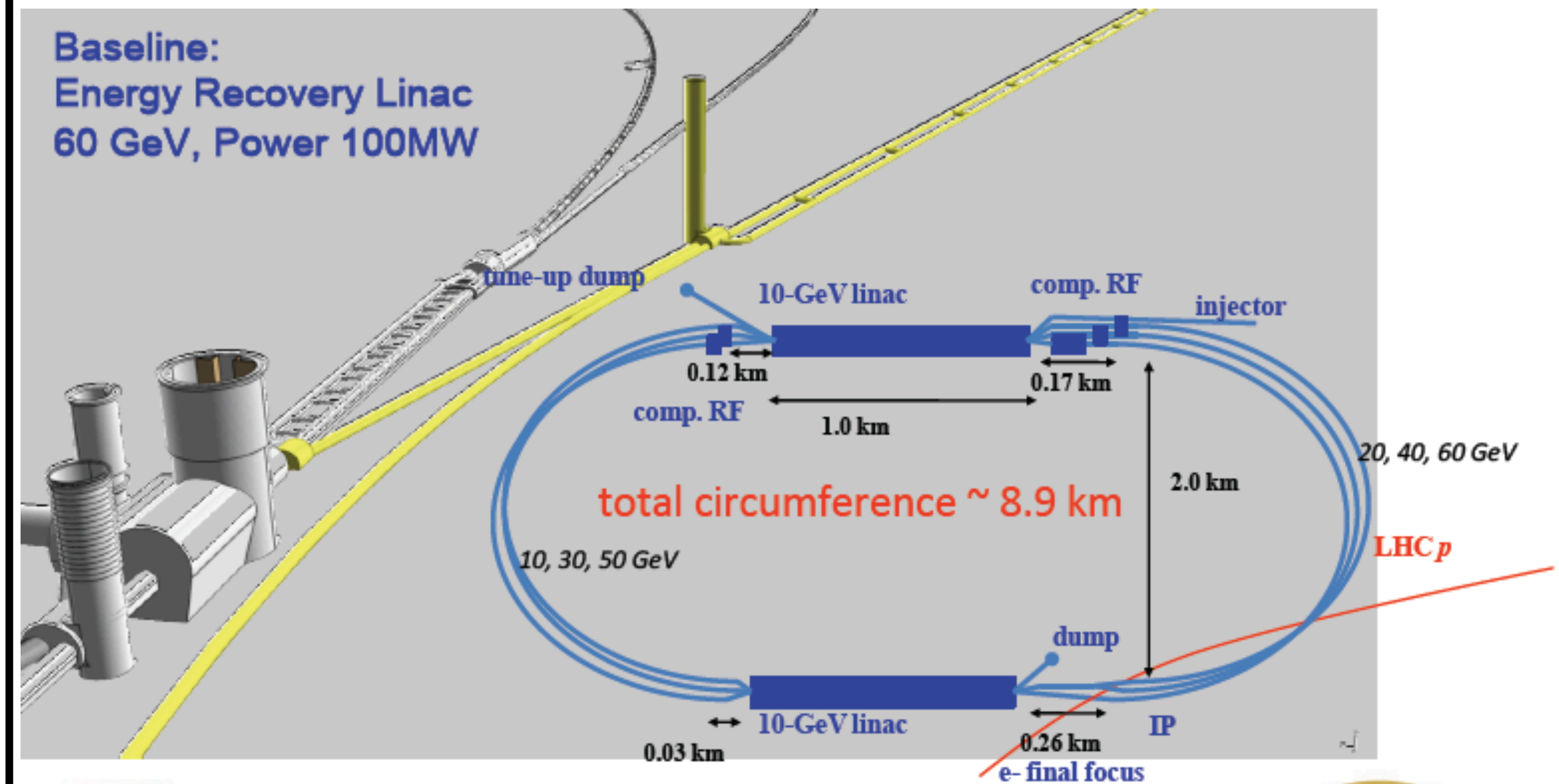
Design considerations:

- $L \sim 10^{33}$ cm^{-2} s^{-1}.
- Power < 70 MW.
- Synchronous pp/ep.

E_e=60 GeV (benchmark).

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

CDR numbers for luminosity, to be considered now as lower bounds.



Luminosity per nucleon

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

eD: $L_{eN}=AL_{eA} \gtrsim 3\times 10^{31}$ cm^{-2}s^{-1}

Accelerator:

$\sqrt{s} \simeq 0.8\text{-}1.2$ TeV/nucleon

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
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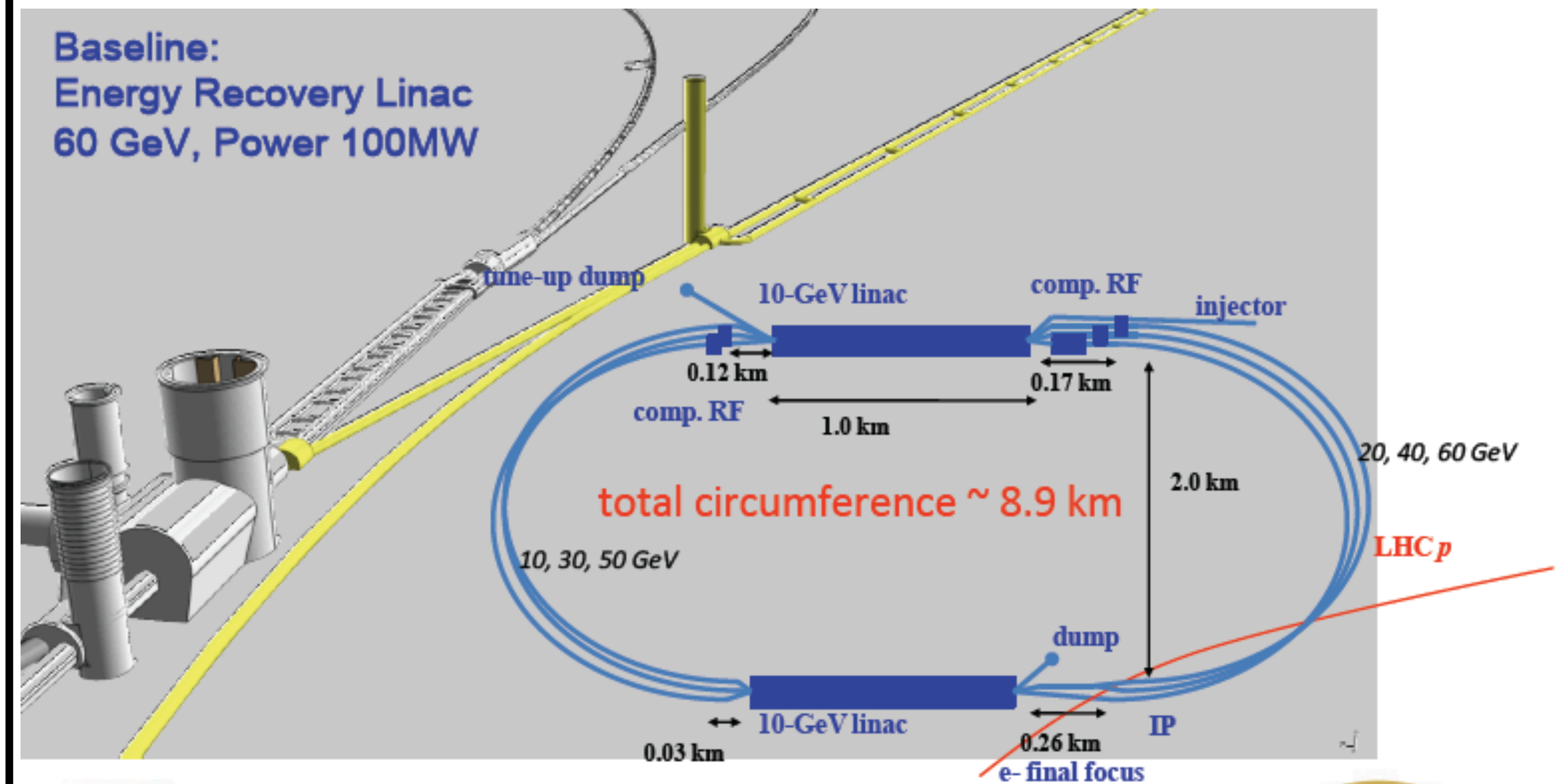

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Accelerator:

/ ... ucleon

electron beam
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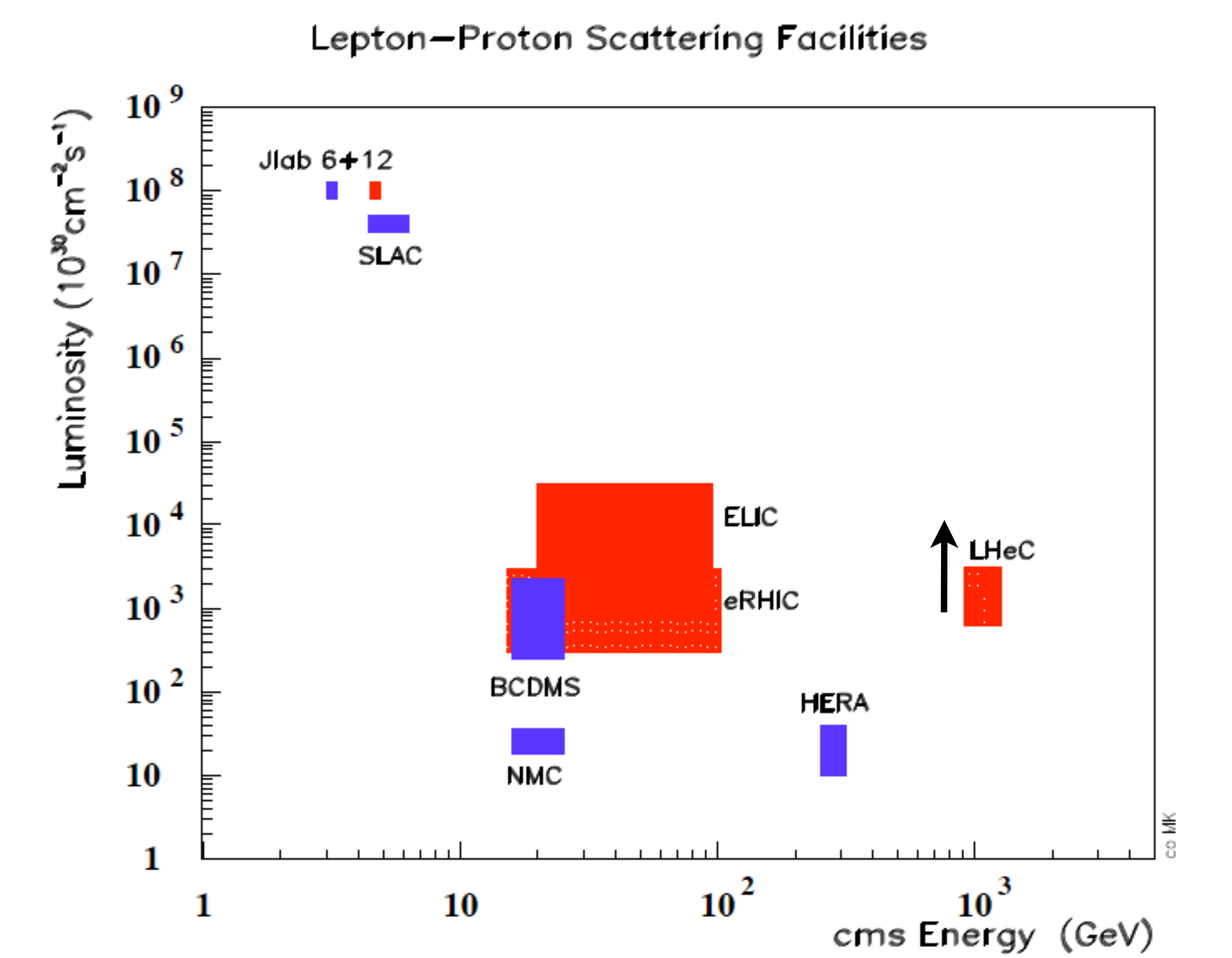
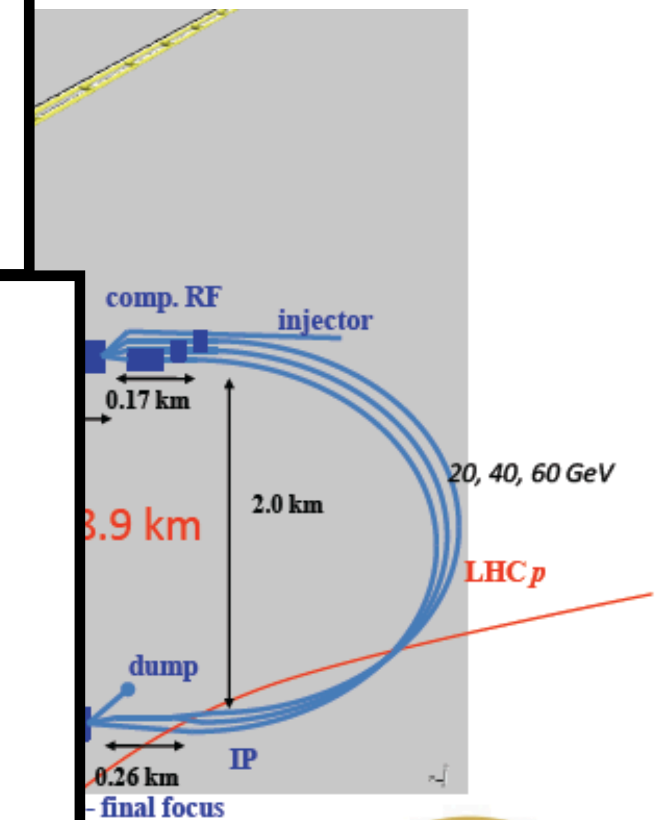
average current [mA]
tot. wall plug power[MW]

- With HL-LHC parameters, luminosities around 10^{34} cm^{-2}s^{-1} are within reach: 1000 fb^{-1} in 10 years!!!





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(Nominal Pb)
(Ultimate Pb)

cm^{-2}s^{-1}

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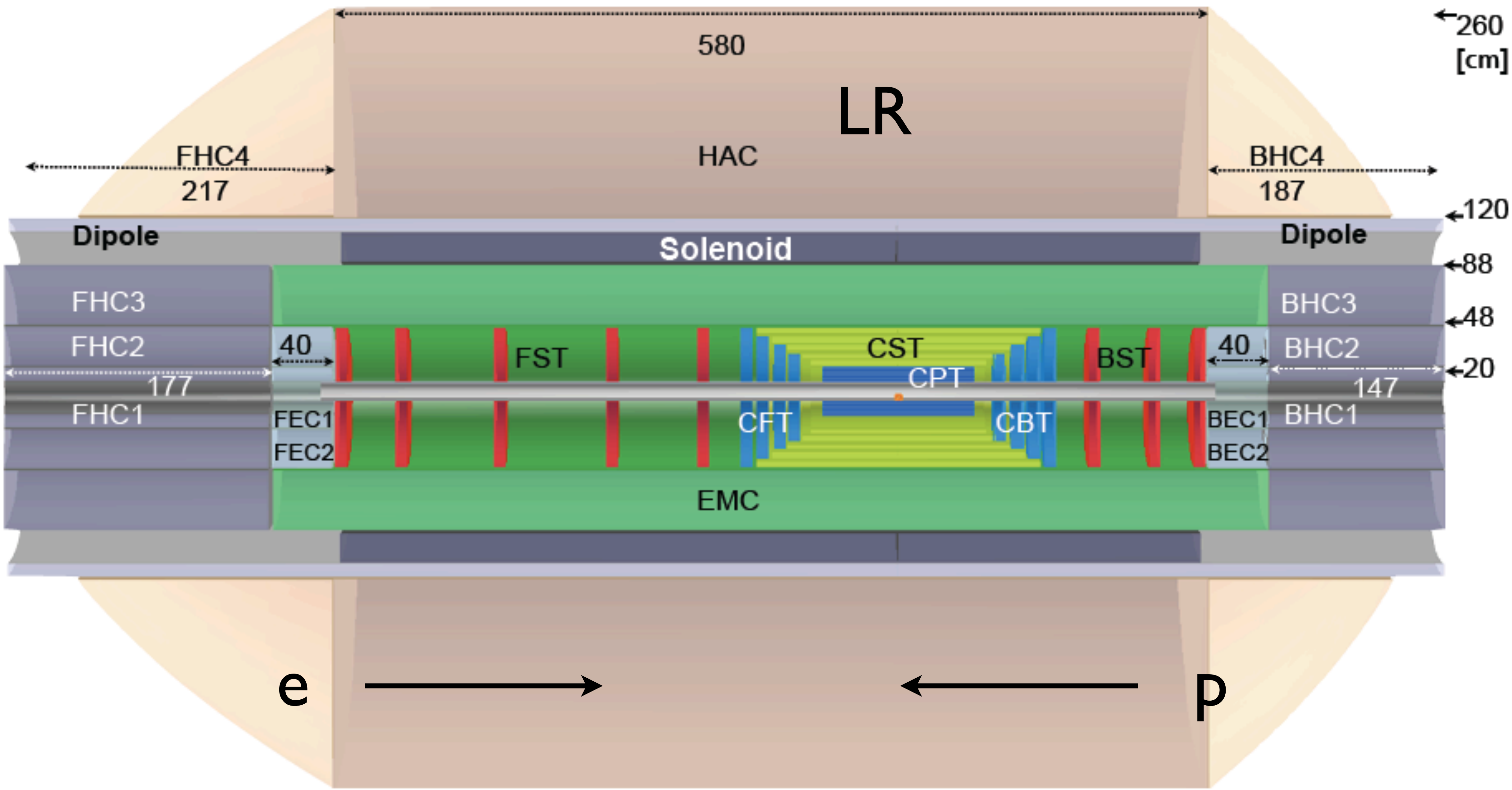
The detector: low-x/eA setup



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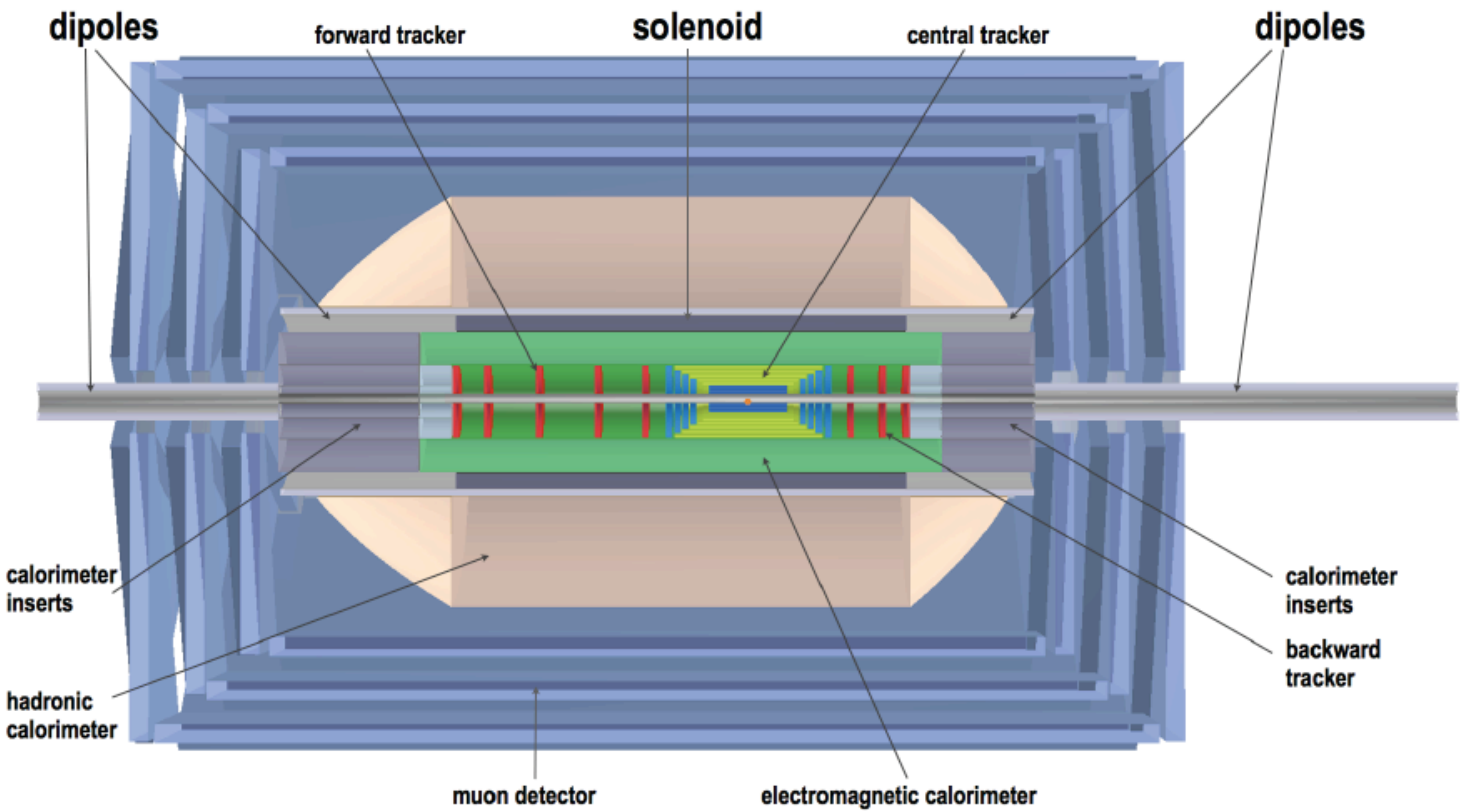

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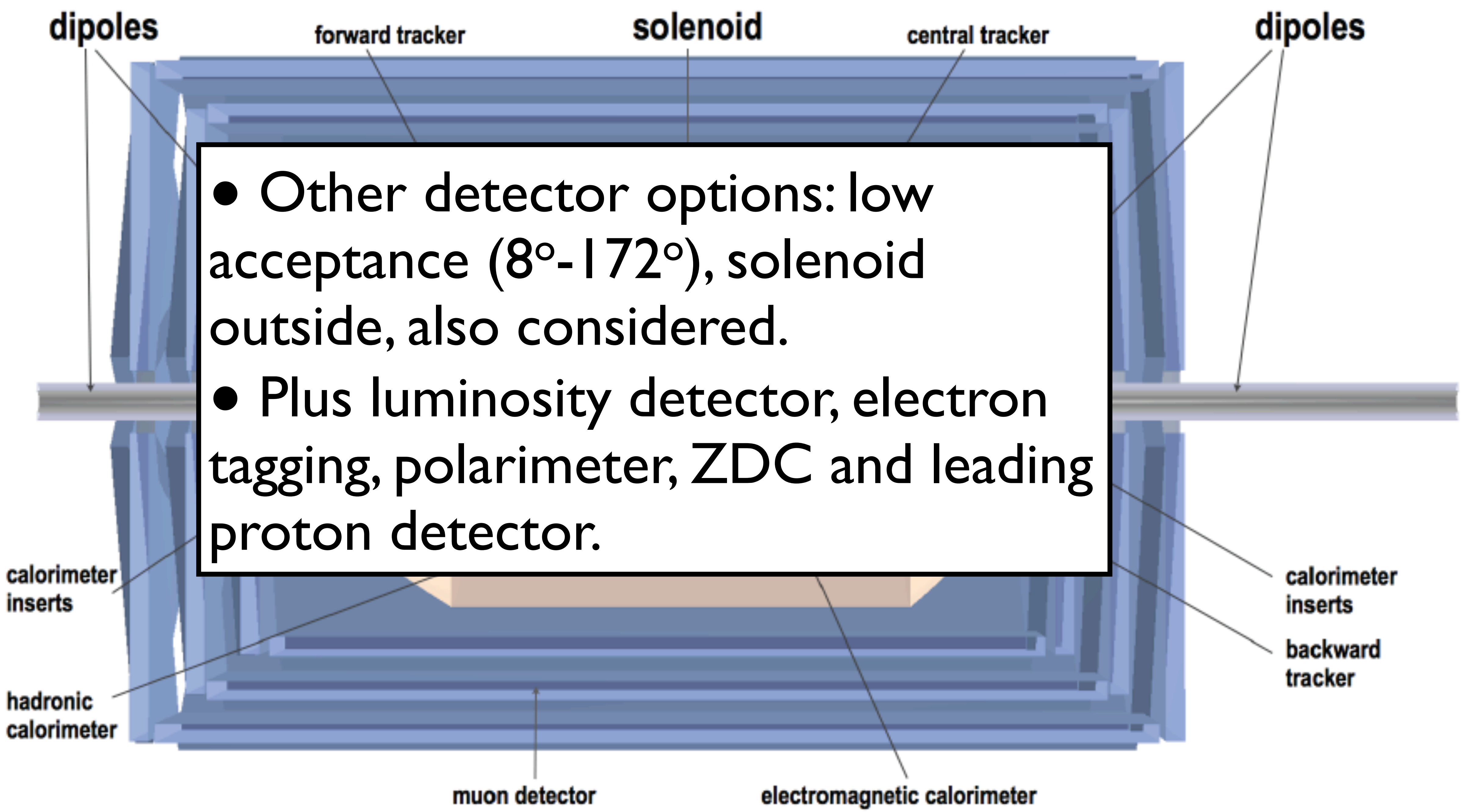
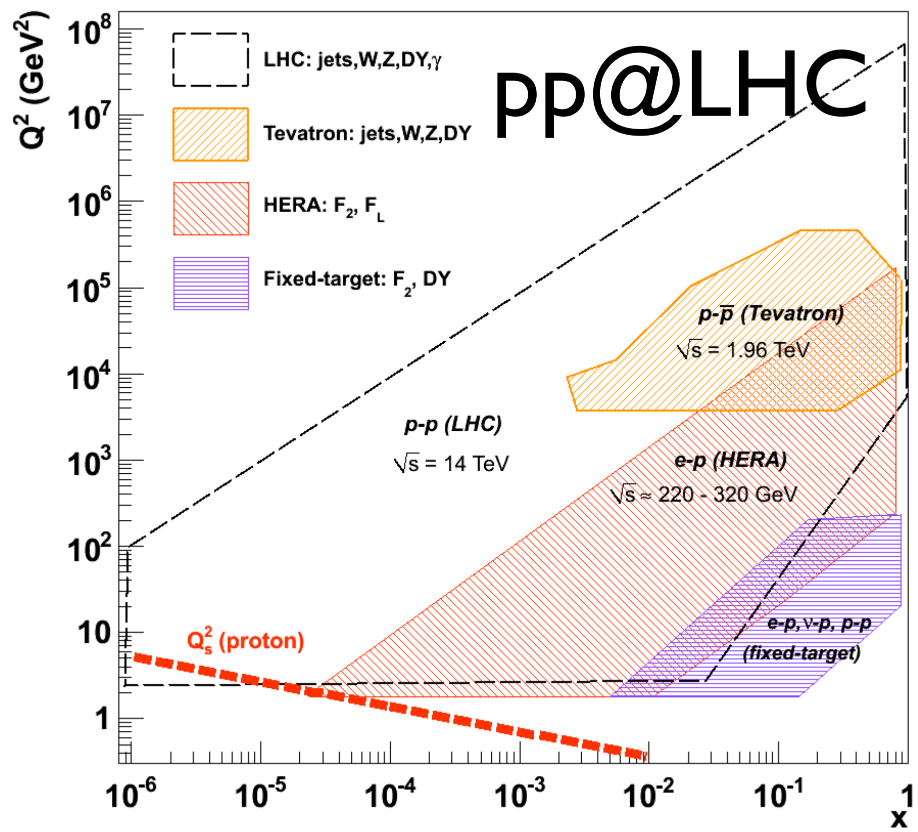
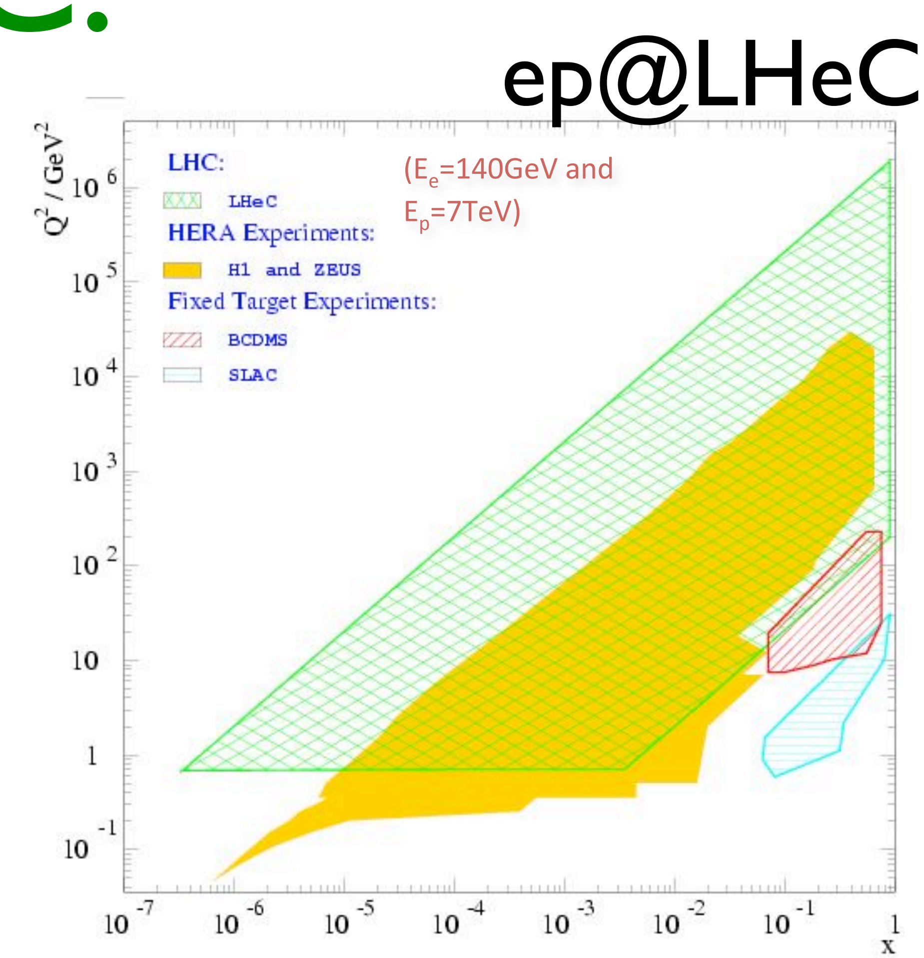
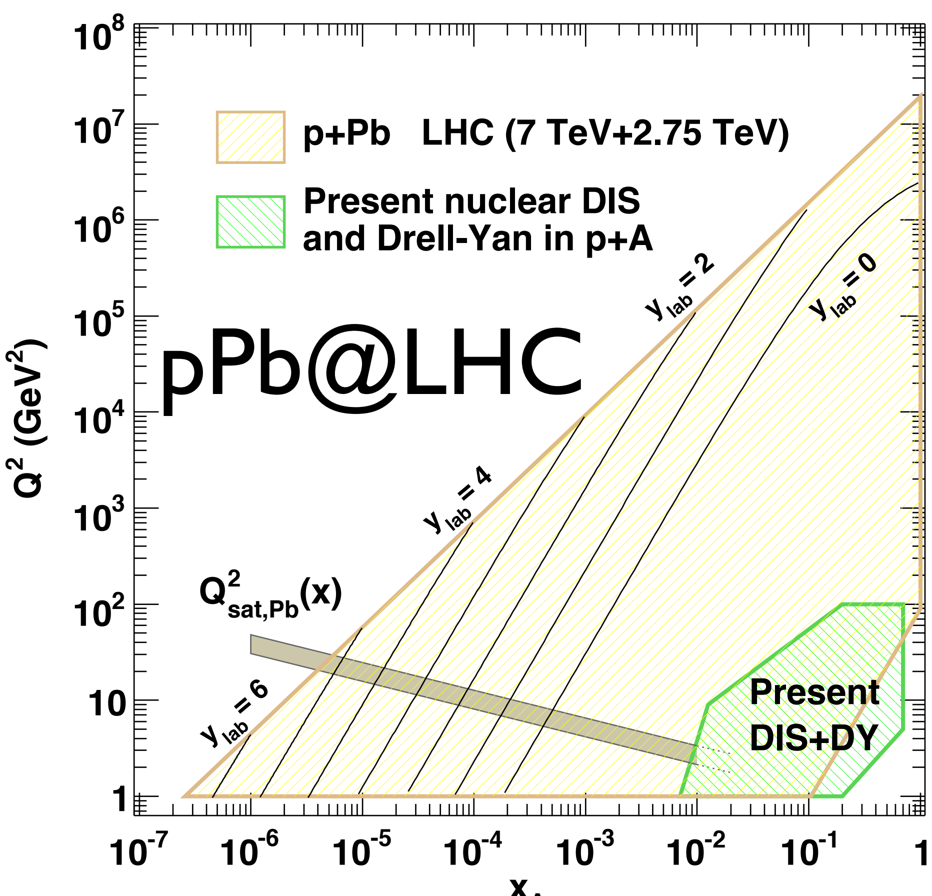


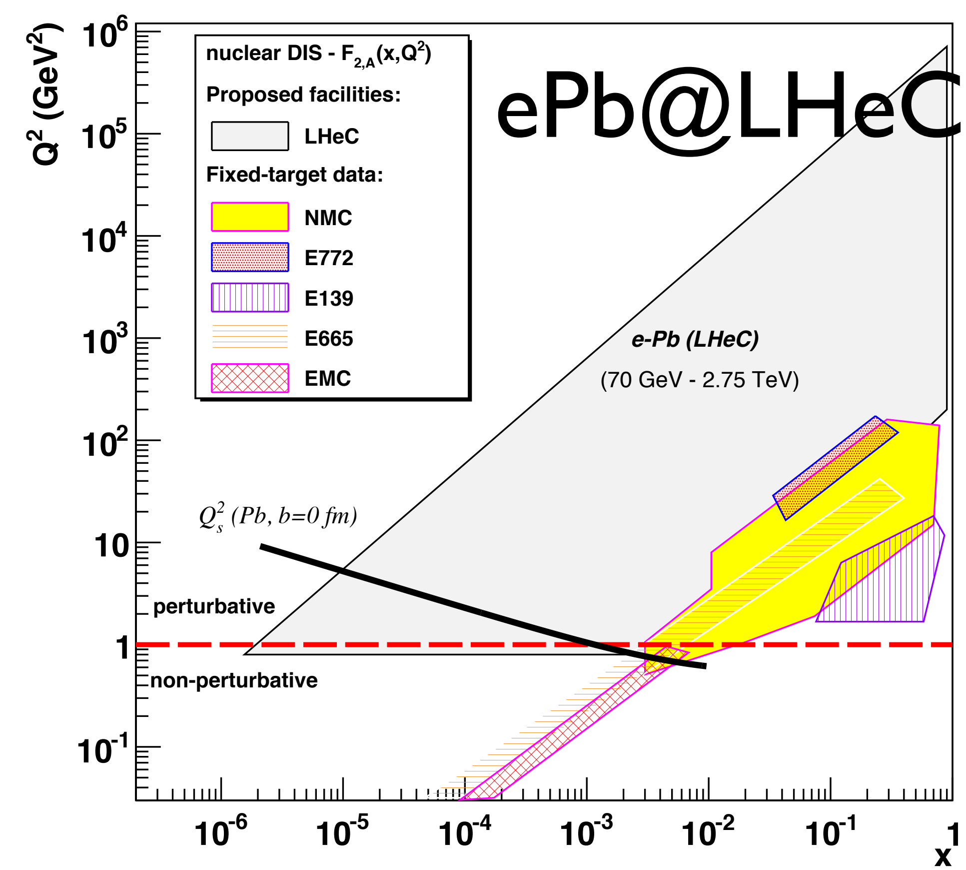
- Other detector options: low acceptance (8°-172°), solenoid outside, also considered.
- Plus luminosity detector, electron tagging, polarimeter, ZDC and leading proton detector.

LHC vs. LHeC:

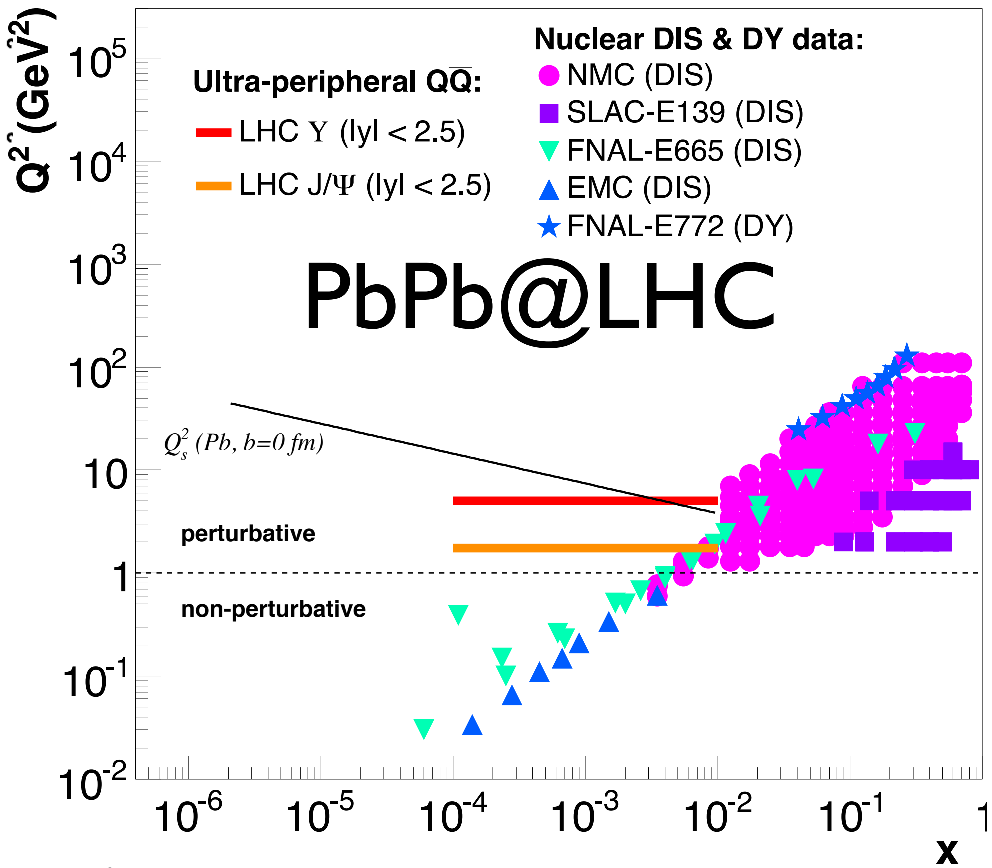

pp@LHC
LHC: jets,W,Z,DY,γ
Tevatron: jets,W,Z,DY
HERA: F_2, F_L
Fixed-target: F_2, DY
p-p̄ (Tevatron)
√s = 1.96 TeV
p-p (LHC)
√s = 14 TeV
e-p (HERA)
√s ≈ 220 - 320 GeV
e-p, ν-p, p-p
(fixed-target)
Q_s^2 (proton)
Q^2 (GeV^2)
x


ep@LHeC
LHC:
LHeC
HERA Experiments:
H1 and ZEUS
Fixed Target Experiments:
BCDMS
SLAC
(E_e=140GeV and
E_p=7TeV)
Q^2 / GeV^2
x

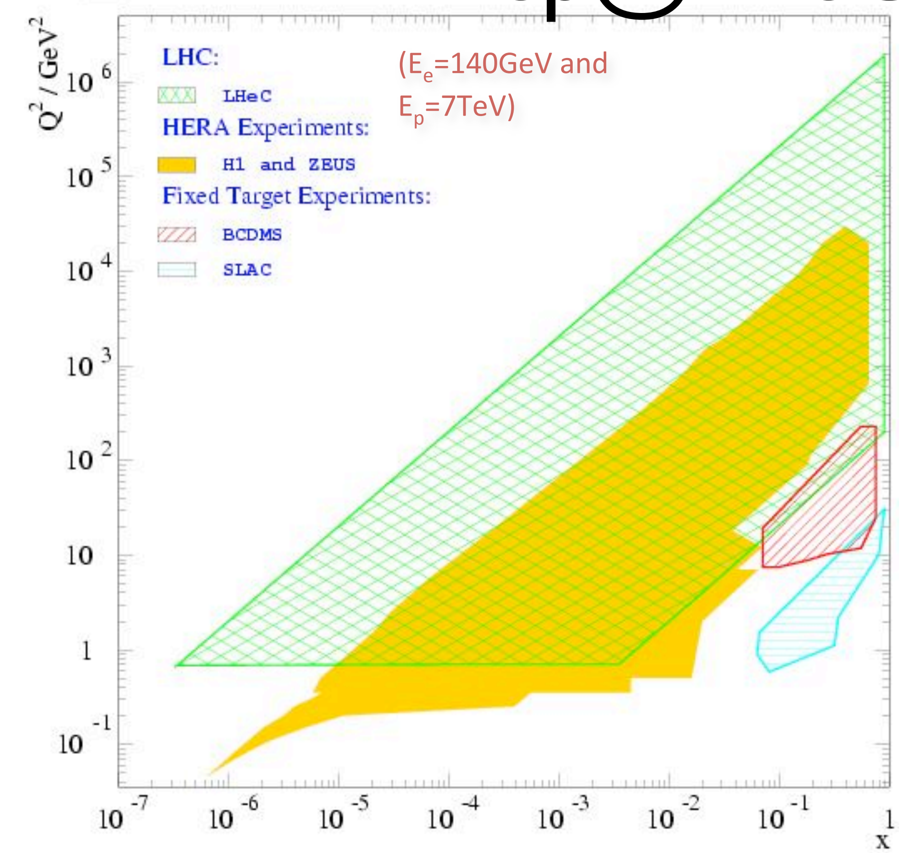

pPb@LHC
p+Pb LHC (7 TeV+2.75 TeV)
Present nuclear DIS
and Drell-Yan in p+A
y_{lab} = 0
y_{lab} = 2
y_{lab} = 4
y_{lab} = 6
$Q^2_{sat,Pb}(x)$
Present
DIS+DY
Q^2 (GeV^2)
x_A

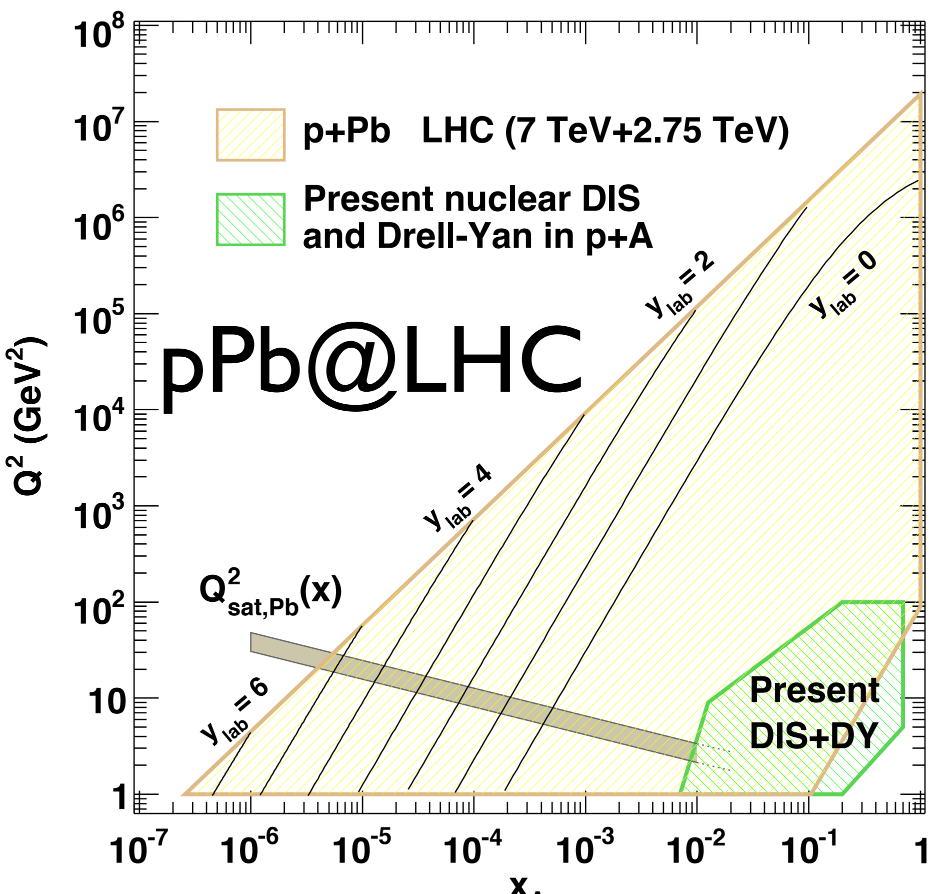

ePb@LHeC
nuclear DIS - $F_{2,A}(x,Q^2)$
Proposed facilities:
LHeC
Fixed-target data:
NMC
E772
E139
E665
EMC
e-Pb (LHeC)
(70 GeV - 2.75 TeV)
Q_s^2 (Pb, b=0 fm)
perturbative
non-perturbative
Q^2 (GeV^2)
x

LHC vs. LHeC:

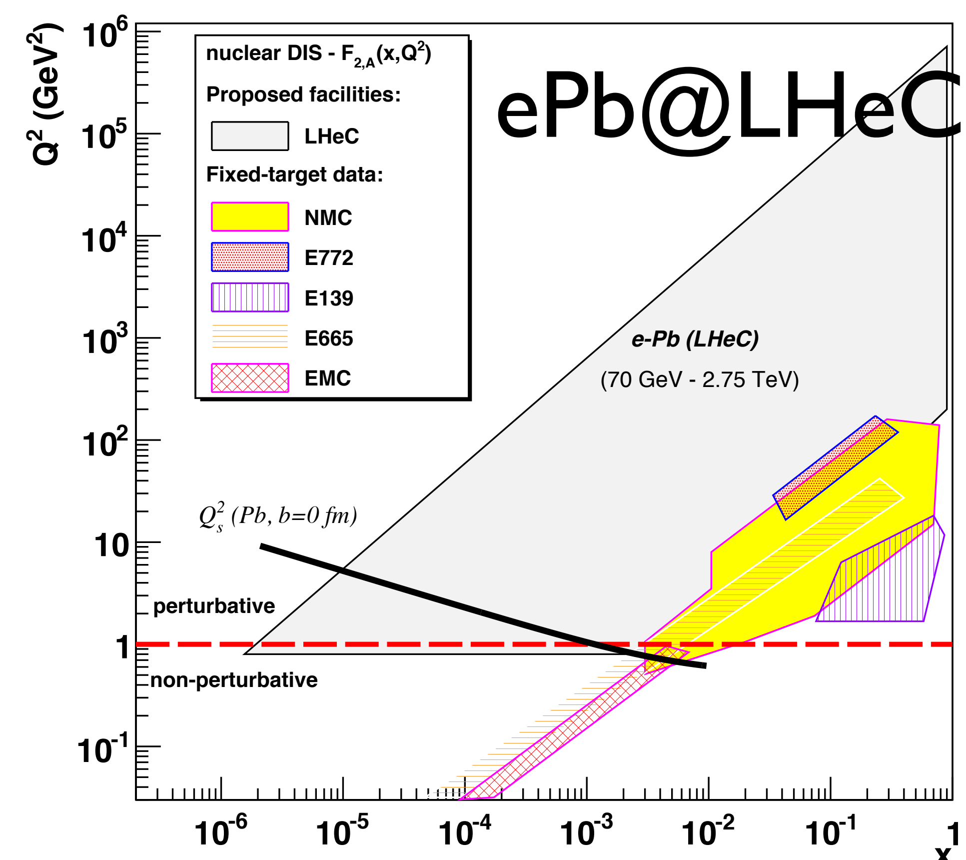


ep@LHeC





ePb@LHeC



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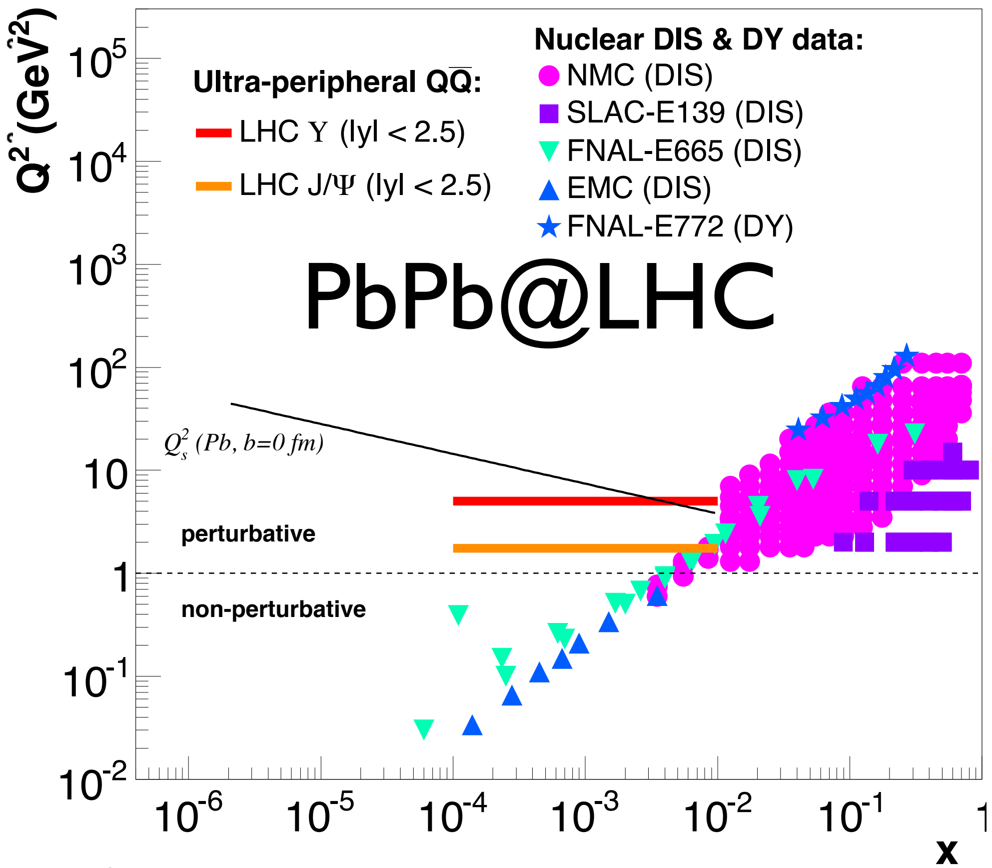
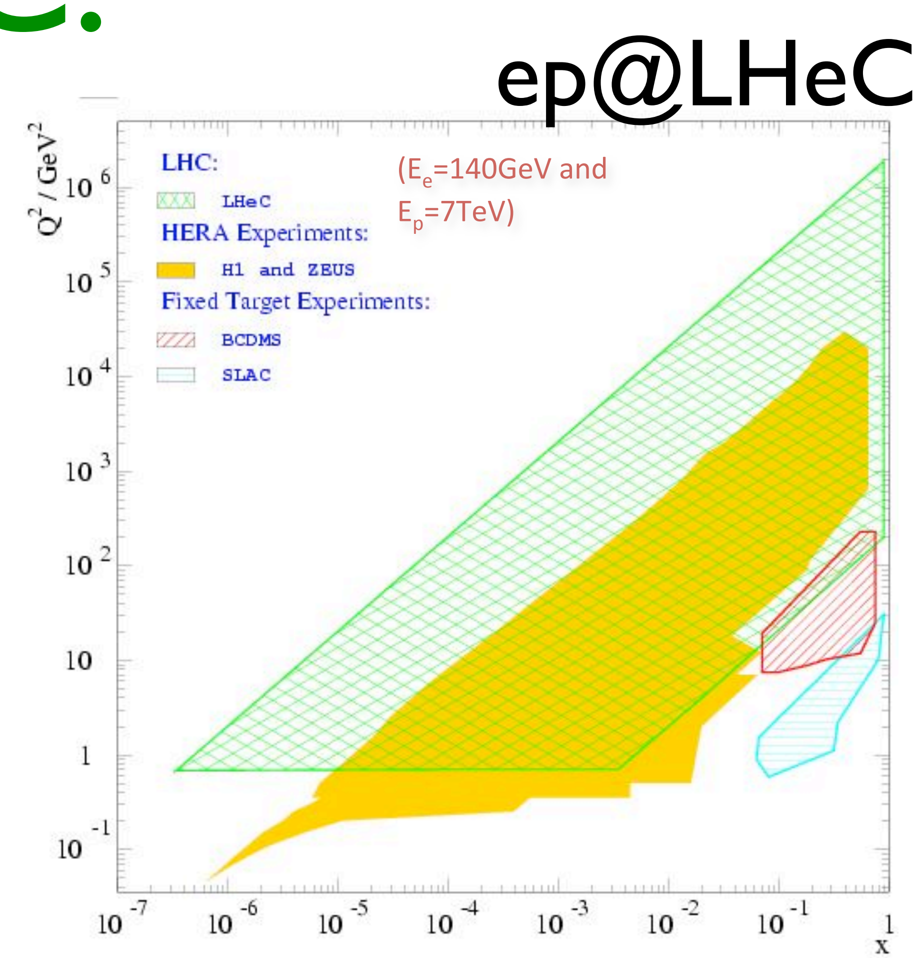
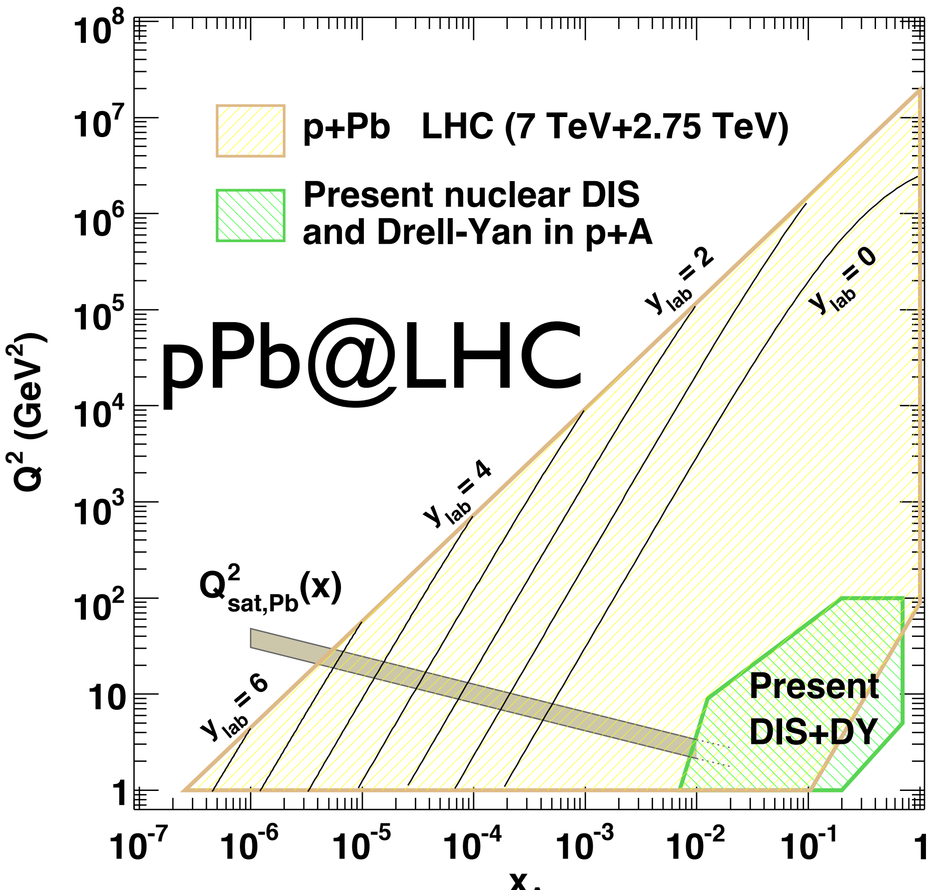
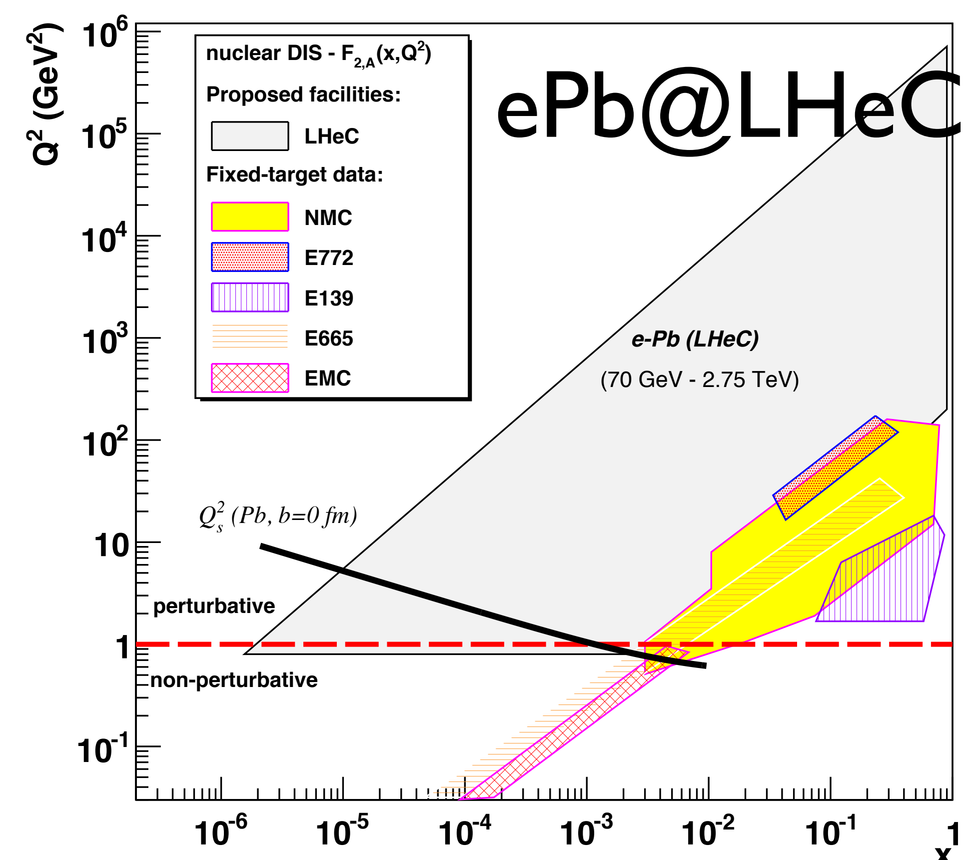


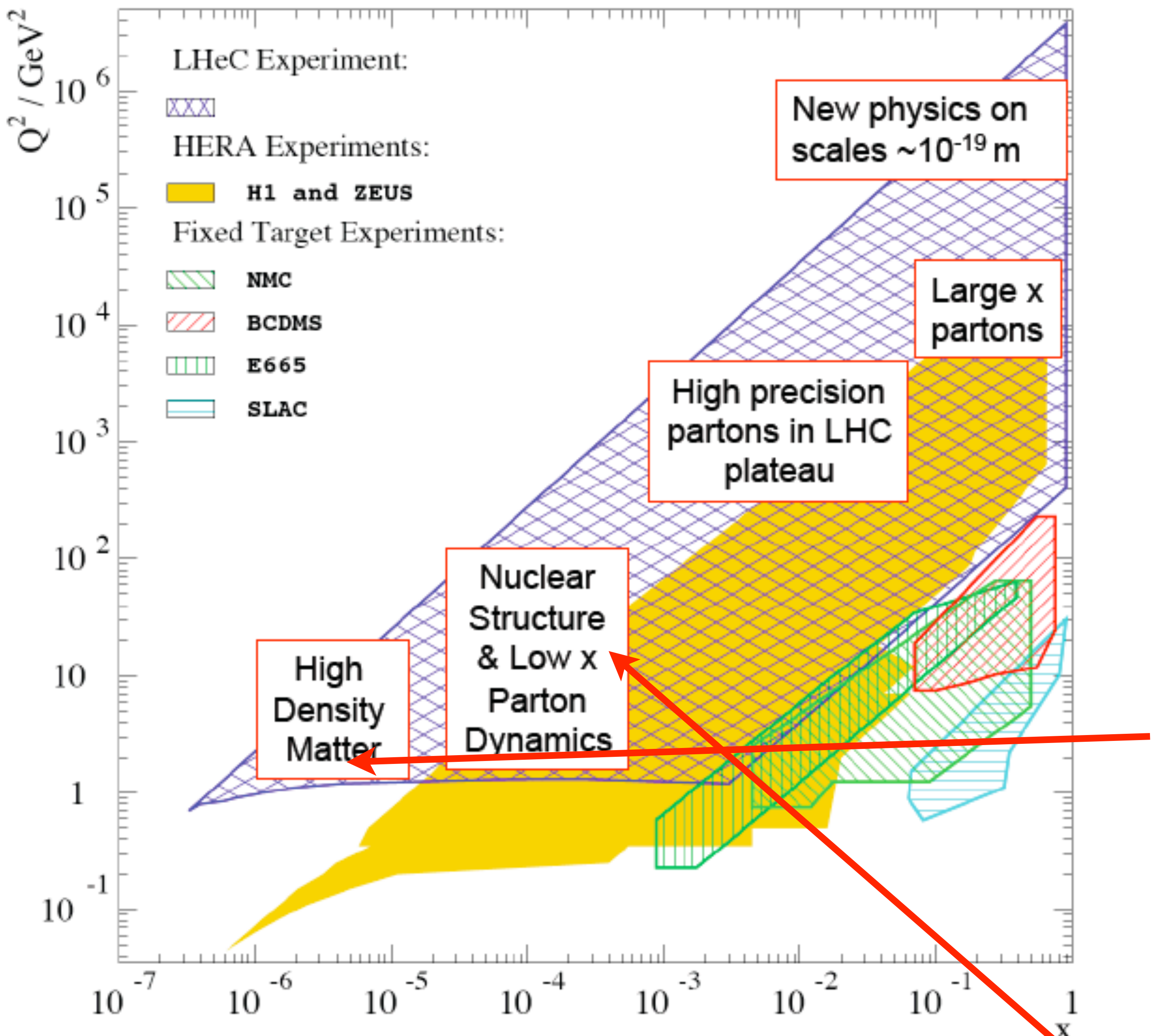


- The LHeC will explore a region overlapping with the LHC:
  - ➜ in a cleaner experimental setup;
  - ➜ on firmer theoretical grounds.





Physics goals:



- Proton structure to a few 10^{-20} m: Q^2 lever arm.
- Precision QCD/EW physics.
- Higgs physics.
- High-mass frontier (lq, 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.

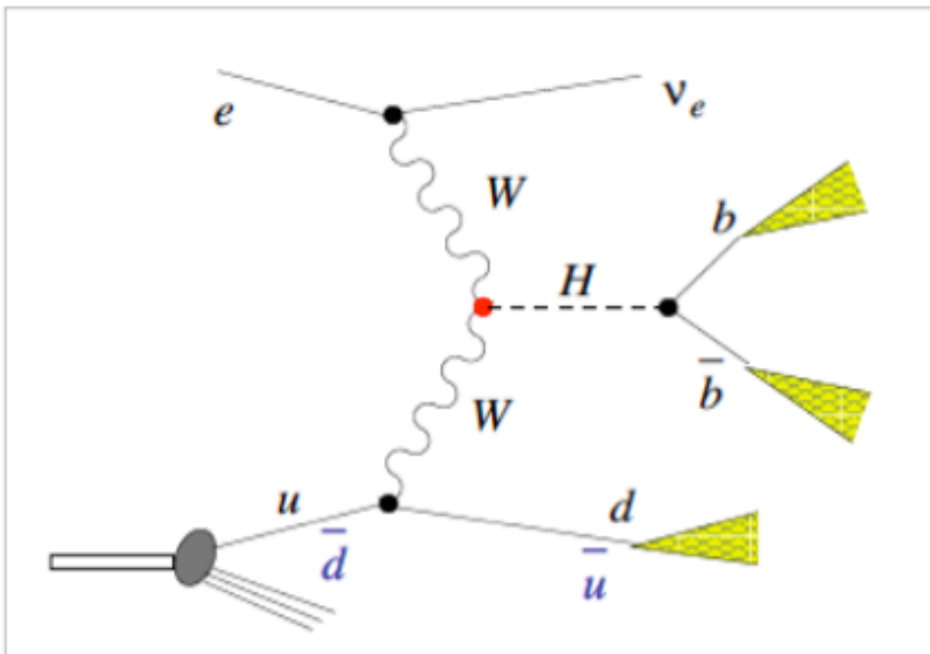
Inclusive observables at small-x at the LHeC: 2. The Large Hadron Electron Collider.

Physics goals:

Higgs at the LHeC

Klein

LHeC is a Higgs "Factory": 200 fb cross section in CC e^-p: L= 1 ab^{-1}: 2 10^5 Higgs events
Clean final state, no pile-up, low QCD bgd, uniquely WW and ZZ, small theory unc.ties



LHeC Higgs	CC (e^-p)	NC (e^-p)	CC (e^+p)
Polarisation	-0.8	0	0
Luminosity [ab^{-1}]	1	1	0.1
Cross Section [fb]	196	20	58
Acceptance	0.92	0.93	0.94
Decay Channel	N^H_{CC} e^-p	N^H_{NC} e^-p	N^H_{CC} e^+p
$H \to b\bar{b}$	97 500	12 000	3500
$H \to c\bar{c}$	5 900	600	180
$H \to gg$	16 200	1 600	480
$H \to WW$	25 200	2 600	760
$H \to ZZ$	2 880	1900	560
$H \to \tau^+\tau^-$	10 260	1 000	310
$H \to \gamma\gamma$	360	40	12

Ultimate e and p beams, 10 years of operation

Table 1: Cross sections and rates of Higgs production in ep scattering with the LHeC. The cross sections are obtained with MADGRAPH5 (v1.5.4) using the p_T of the scattered quark as scale, CTEQ6L1 partons and $M_H = 125\,\mathrm{GeV}$. The acceptance is obtained with kinematic cuts on final state particles ($|\eta_{jet}| < 5$, $|\eta_{e,\gamma}| < 4.7$, $p_{T,jet} > 1\,\mathrm{GeV}$, $E_{jet} > 15\,\mathrm{GeV}$, $E'_e > 10\,\mathrm{GeV}$, $E_\gamma > 5\,\mathrm{GeV}$) but excludes the tagging probabilities for b, c, τ and further g, W, Z reconstruction efficiencies. In an initial study (CDR) the $b\bar{b}$ final state is reconstructed with an efficiency of about 5 %. This leads to $\simeq$ 5000 events in this channel, at an S/N of 1.

ILC: 10^{34} $cm^{-2}s^{-1}$, 280fb, 15000 cavities, width - LHeC: 10^{34} 200fb 960 cavities, no width

cf CDR, **Talk of Bruce Mellado**, also Uta Klein ICHEP12

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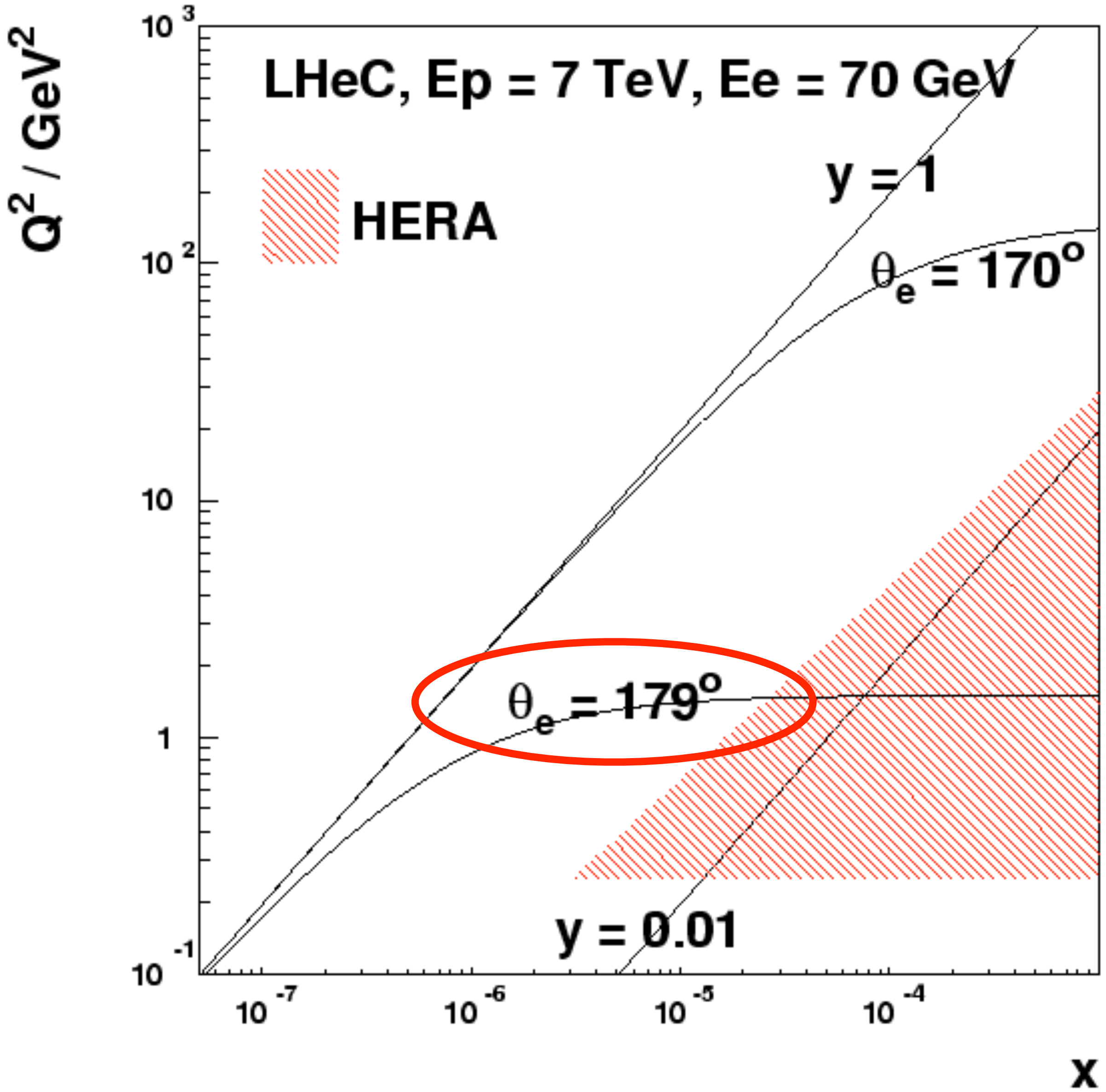
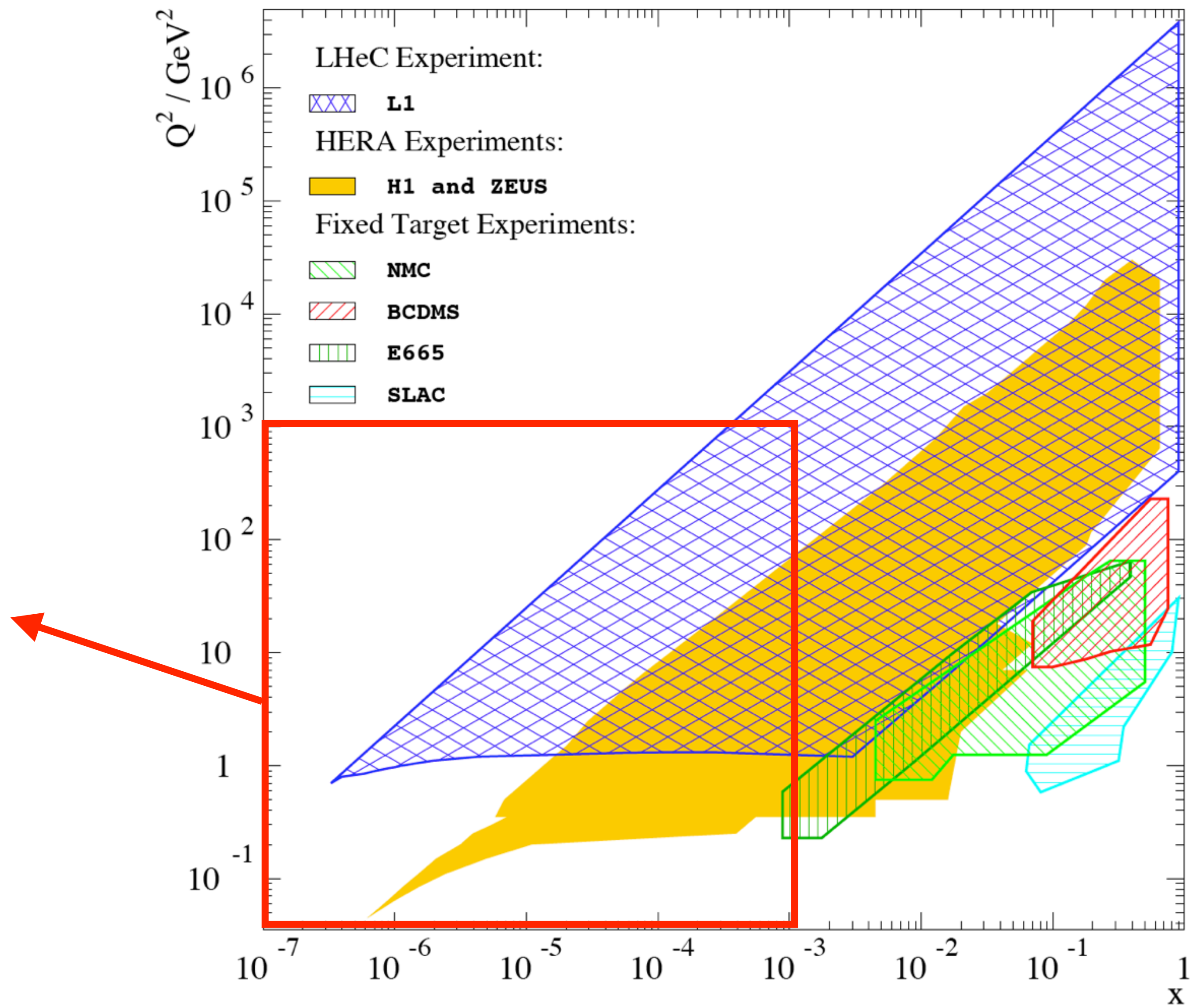
Proton PDFs at small x:

- Parton densities poorly known at small x and small to moderate Q^2: uncertainties in predictions.
- LHeC will substantially reduce the uncertainties in global fits: F_L and heavy flavour decomposition most useful.





Inclusive observables at small-x at the LHeC: 3 Inclusive measurements at low x.

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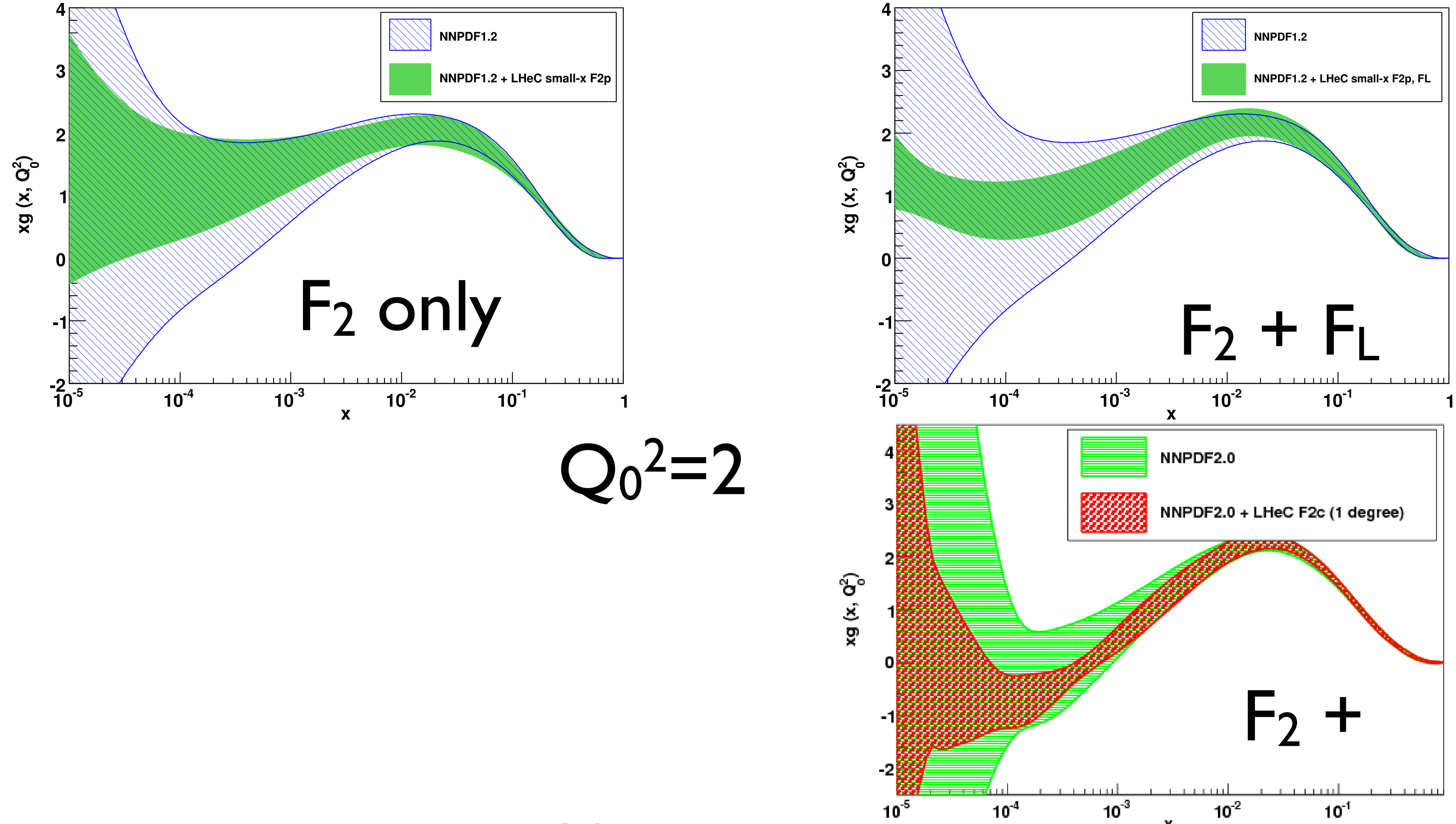

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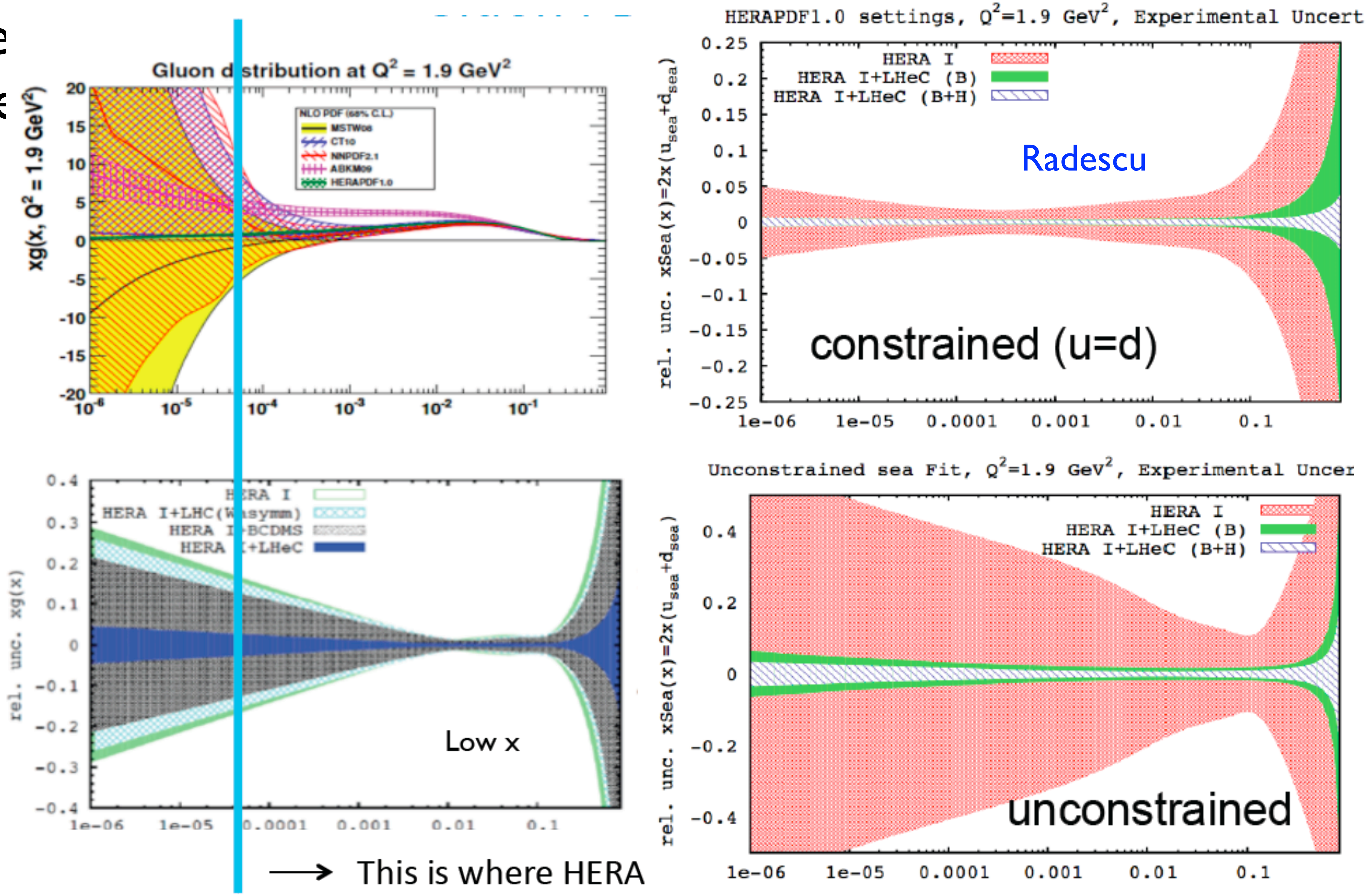
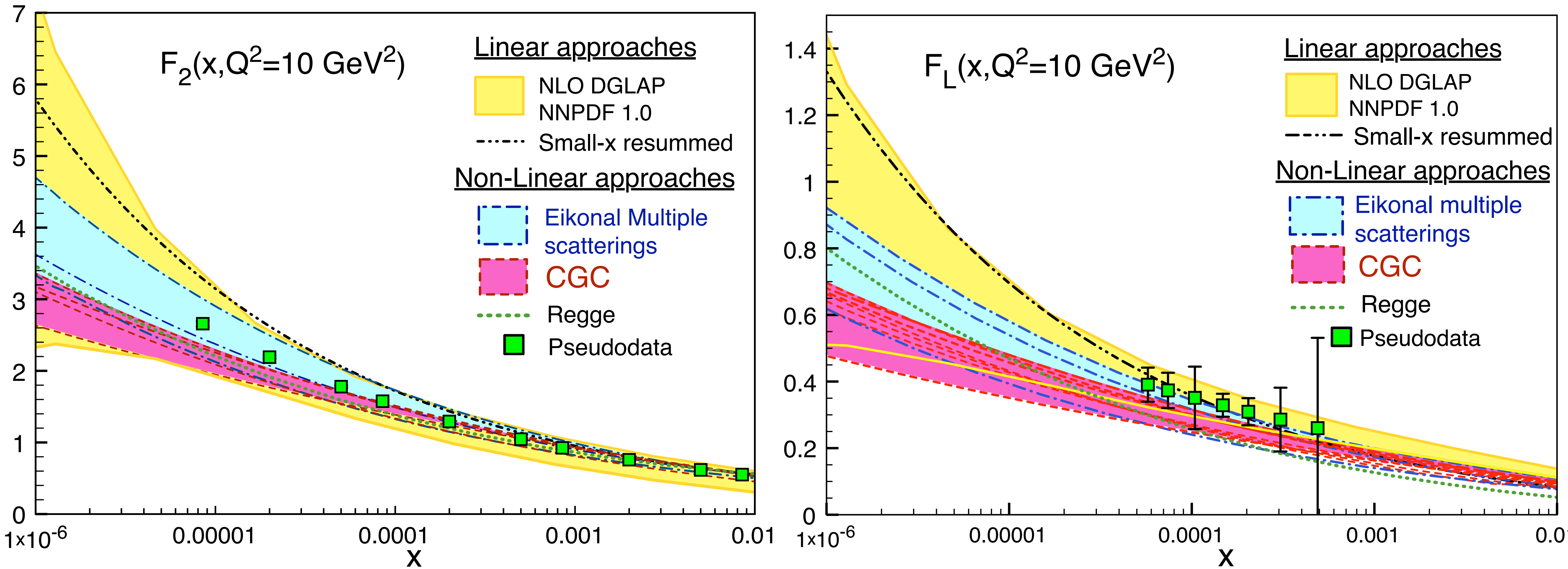


→ This is where HERA

Inclusive observables at small-x at the LHeC: 3 Inclusive measurements at low x.

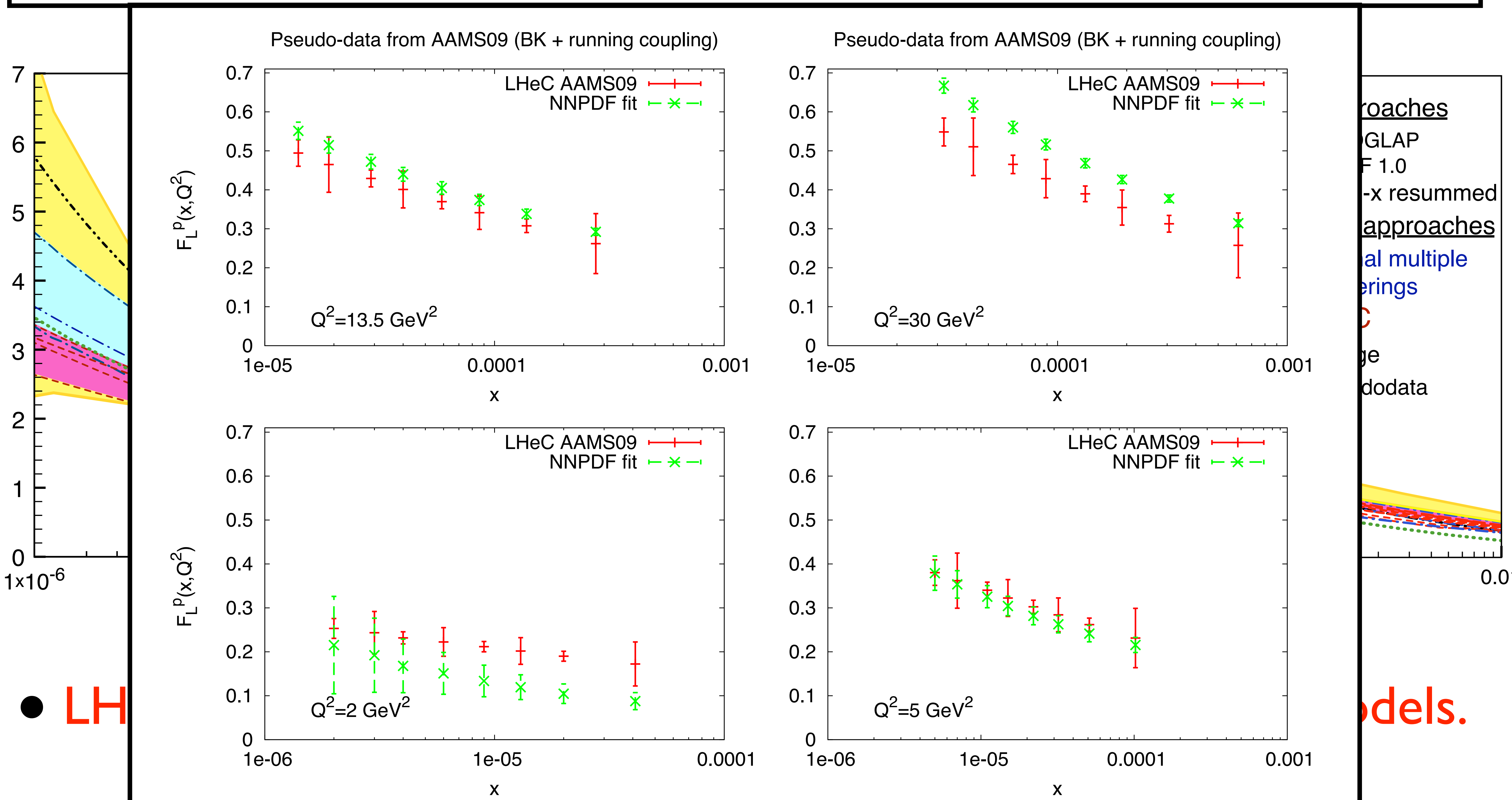
Effects beyond DGLAP?:



- LHeC F_2 and F_L data will have discriminatory power on models.

Effects beyond DGLAP?:

NLO DGLAP cannot simultaneously accommodate LHeC F_2 and F_L data if saturation effects included according to current models.

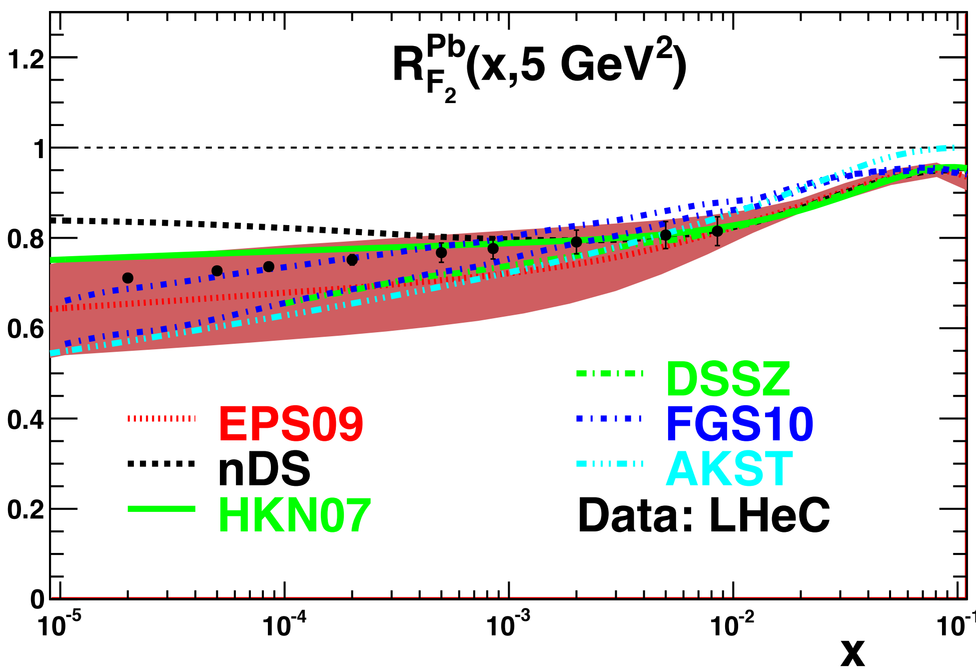


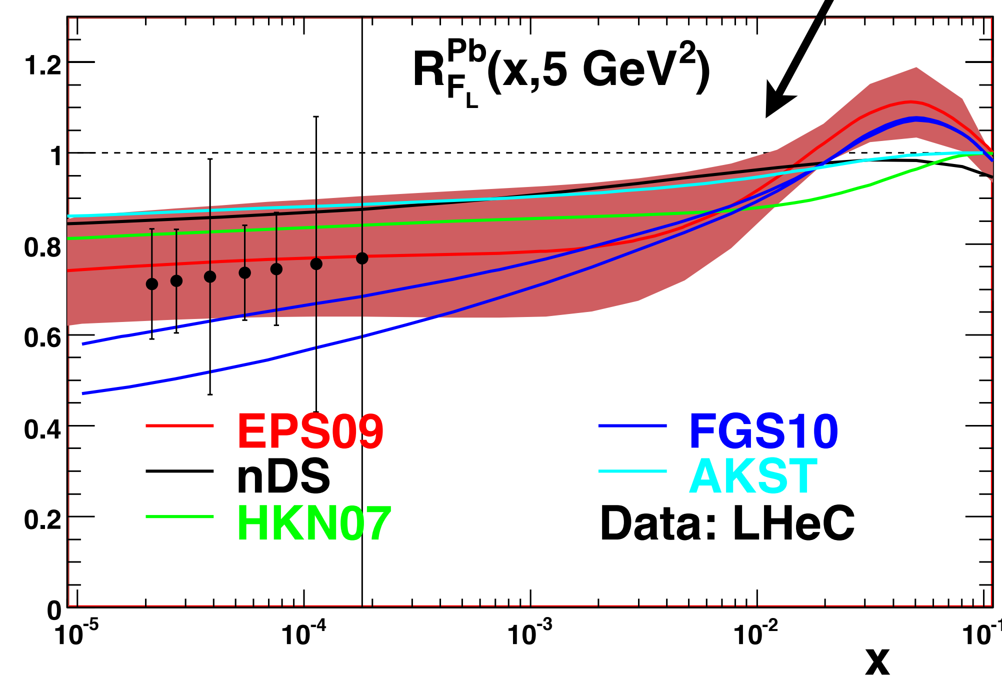
- LH... odels.

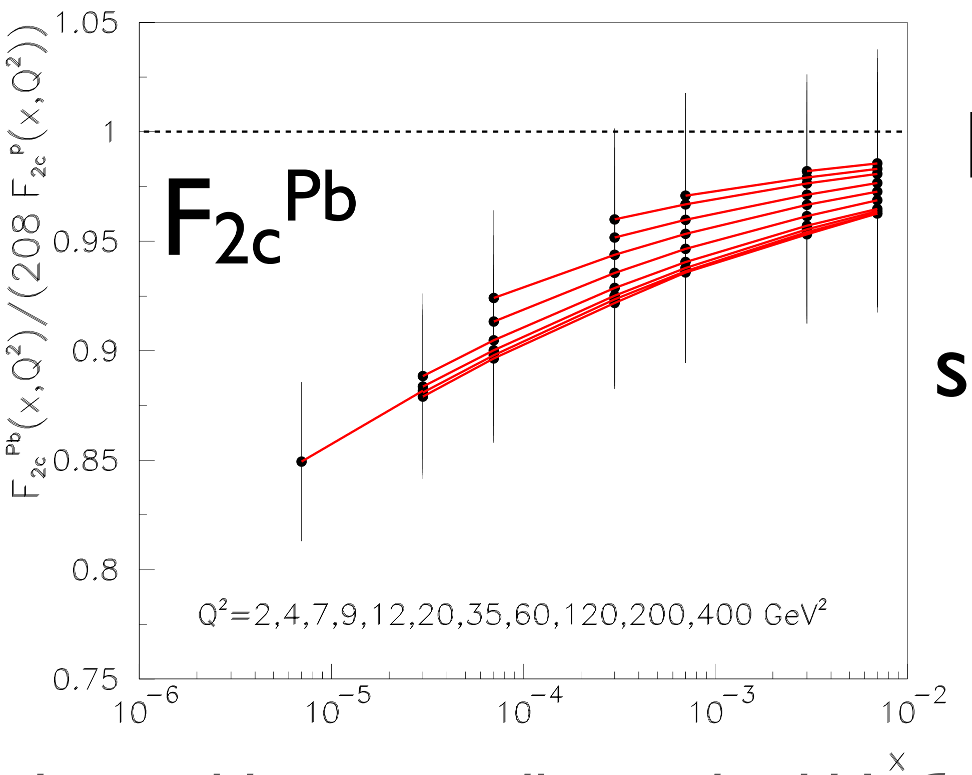
eA inclusive: comparison

- Good precision can be obtained for $F_{2(c,b)}$ and F_L at small x (Glauberized 3-5 flavor GBW model, NA '02).

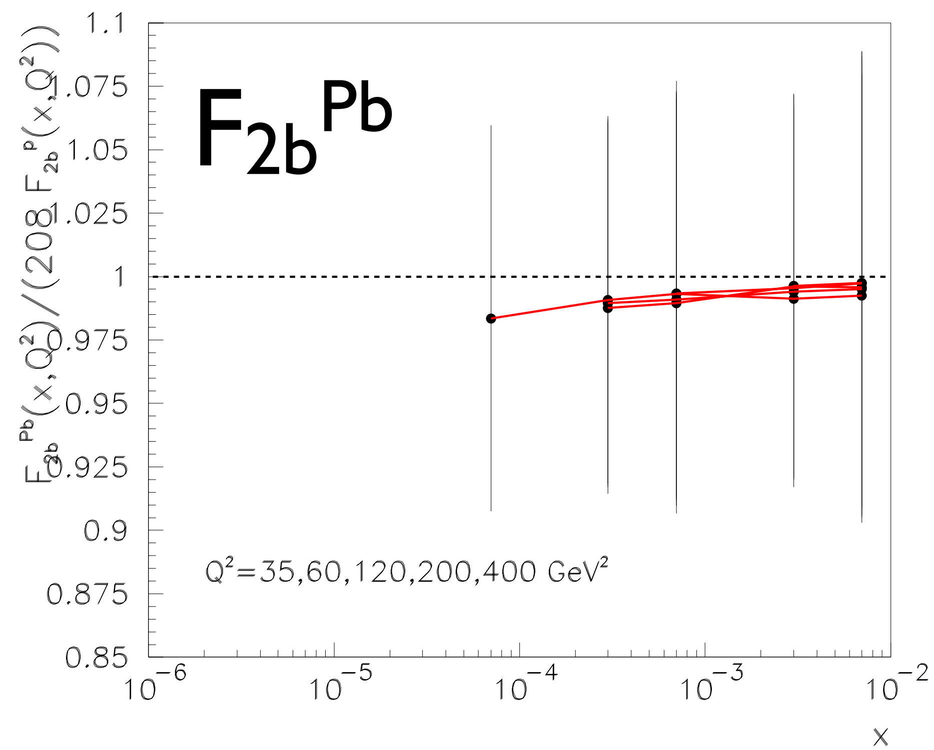
Not optimized!







Note the scale!!!



Nuclear PDFs at small x:

- F_2 data substantially reduce the uncertainties in DGLAP analysis;

inclusion of charm, beauty (new!); and F_L (new!) also give constraints.

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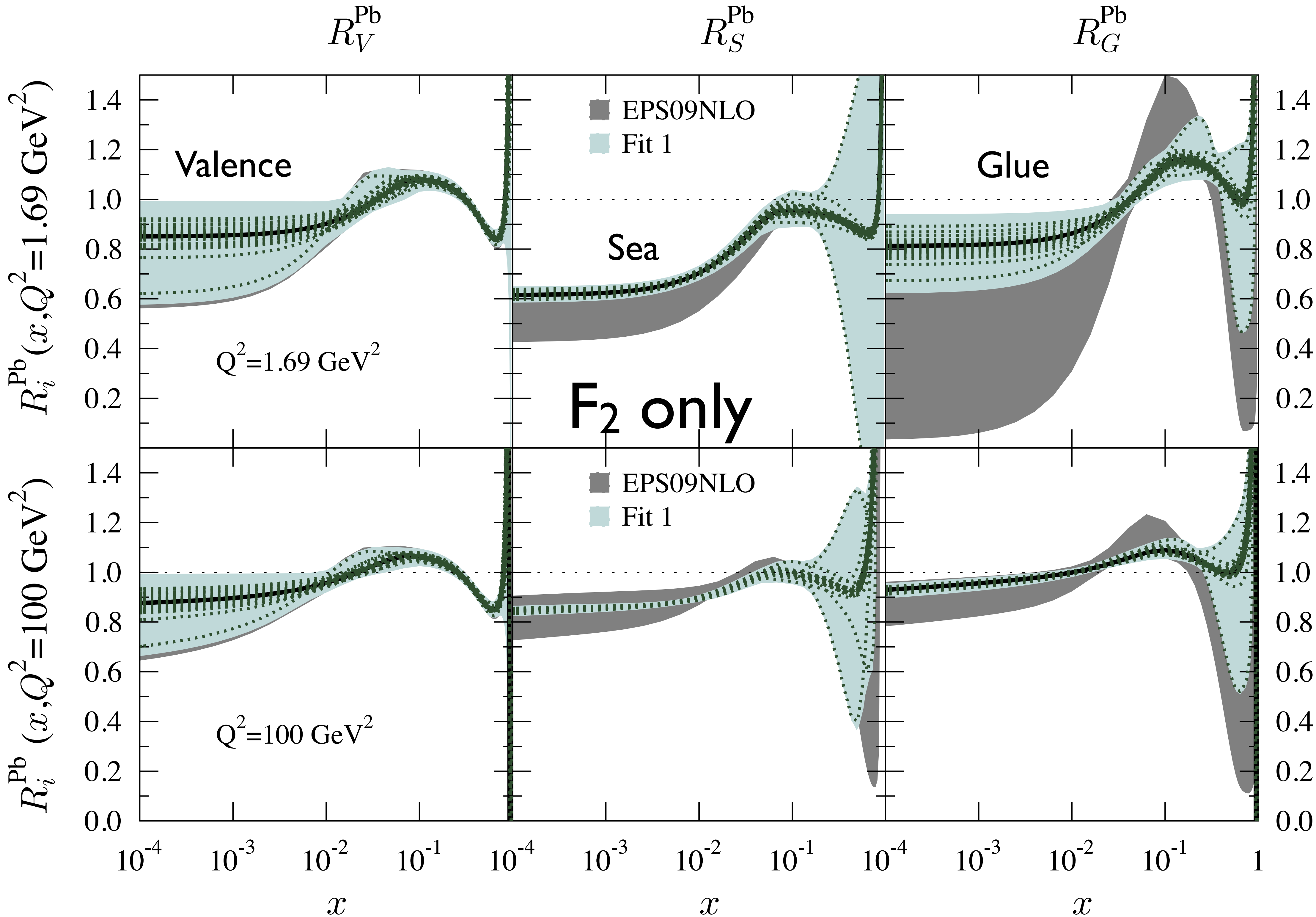

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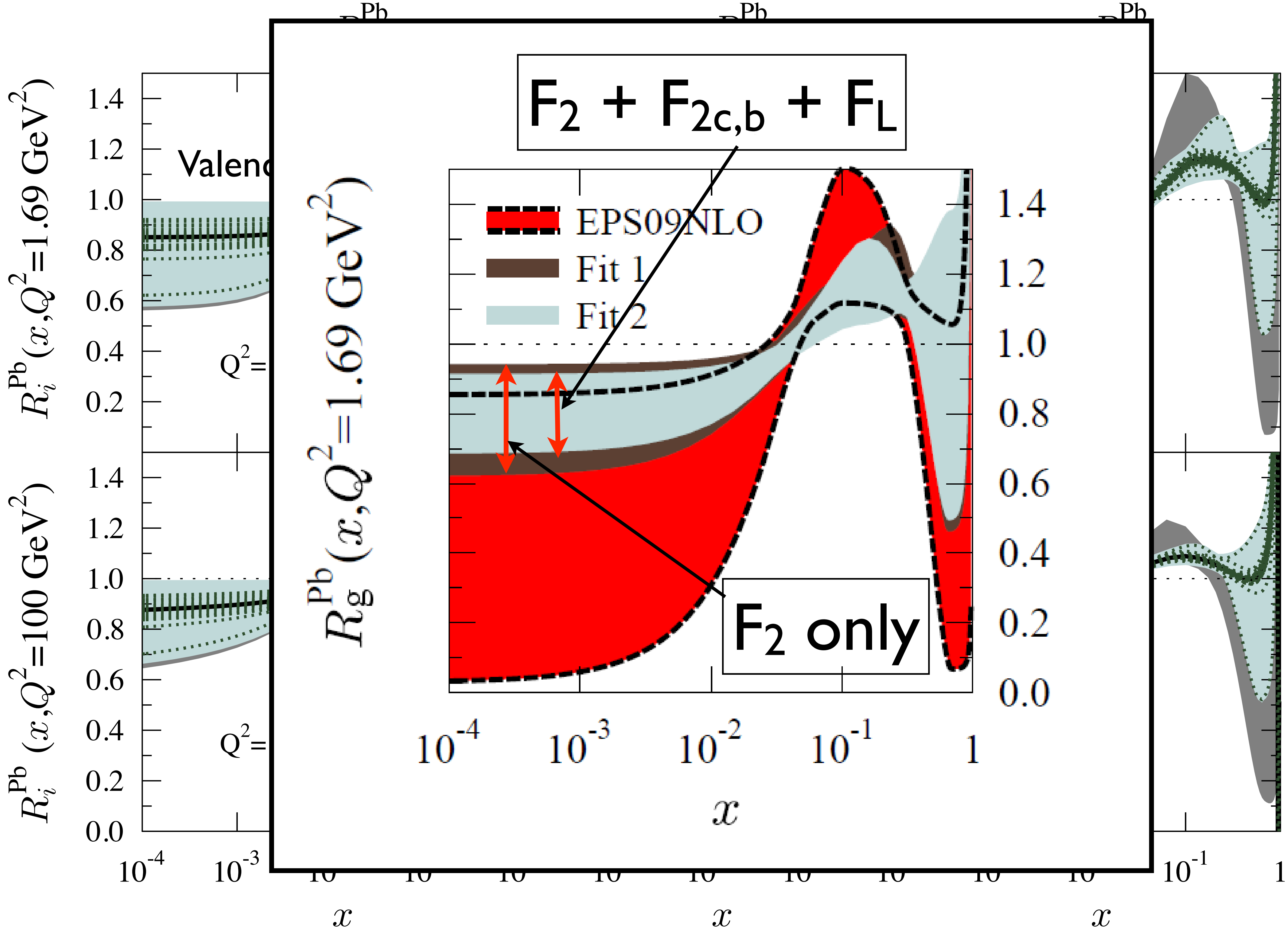
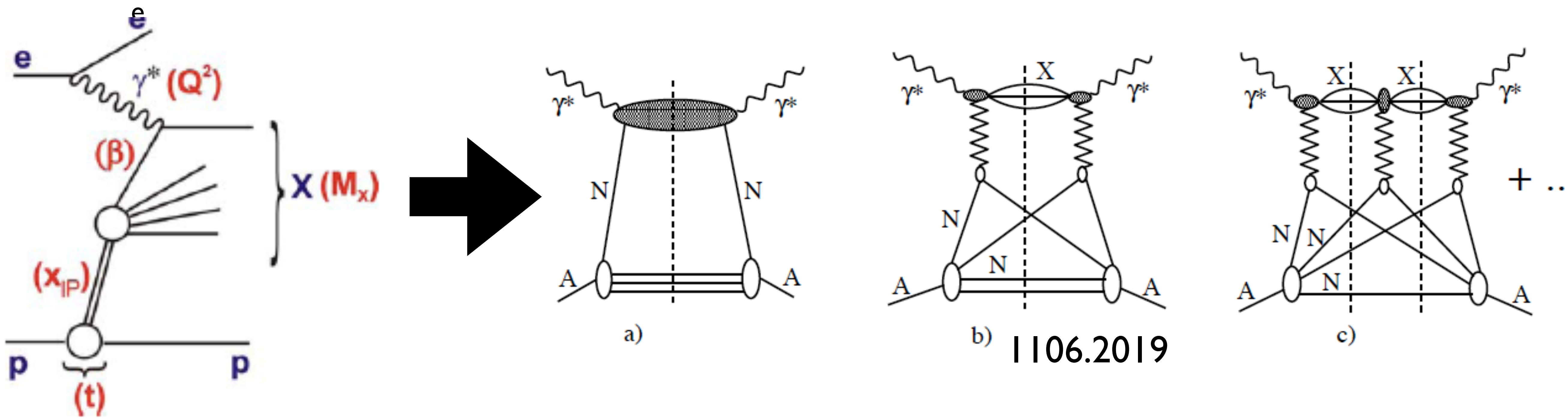
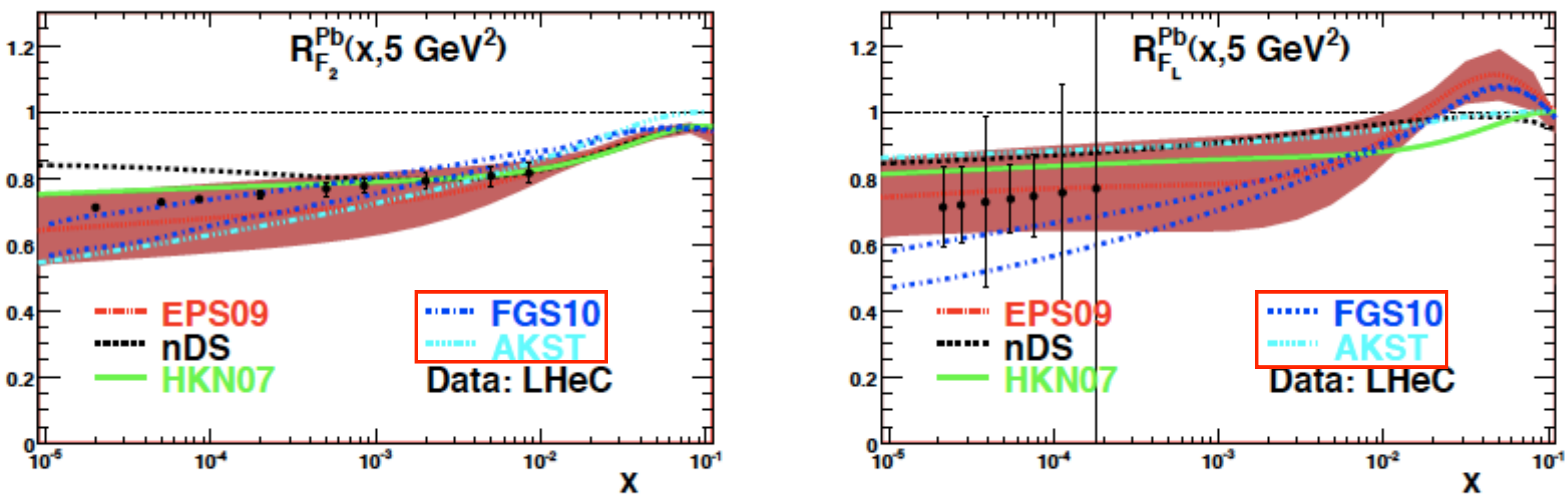


Diffraction in ep and shadowing:



- Diffraction is linked to nuclear shadowing through basic QFT (Gribov): eD to test and set the 'benchmark' for new effects.



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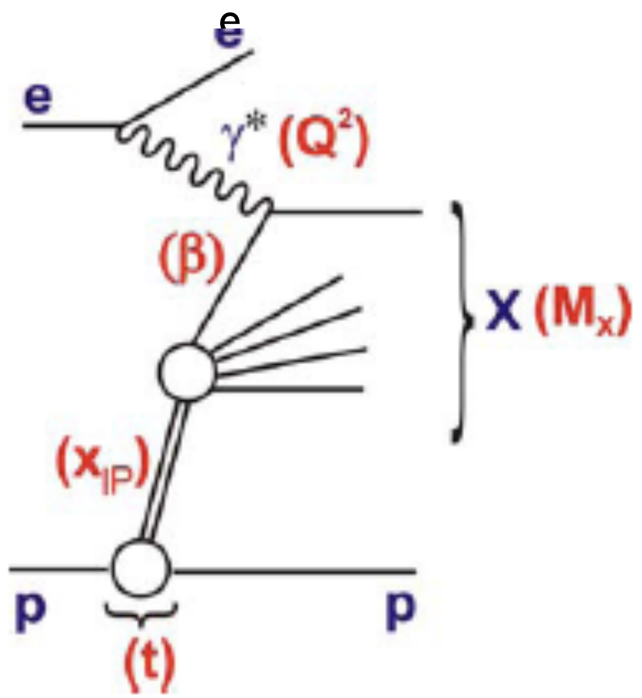

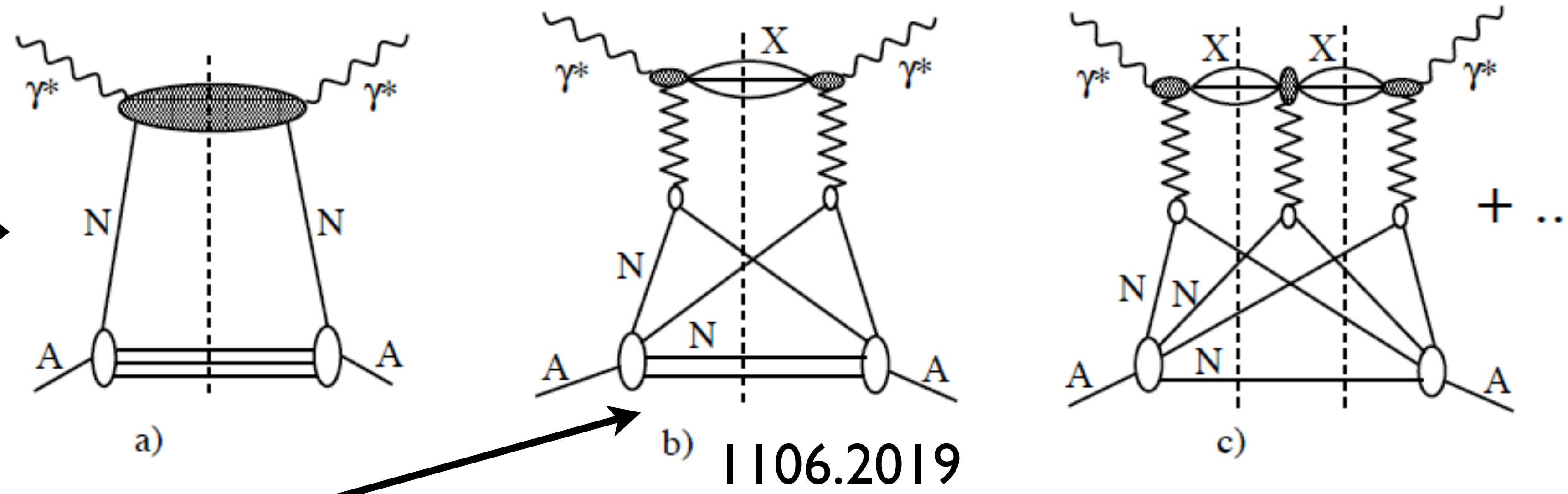

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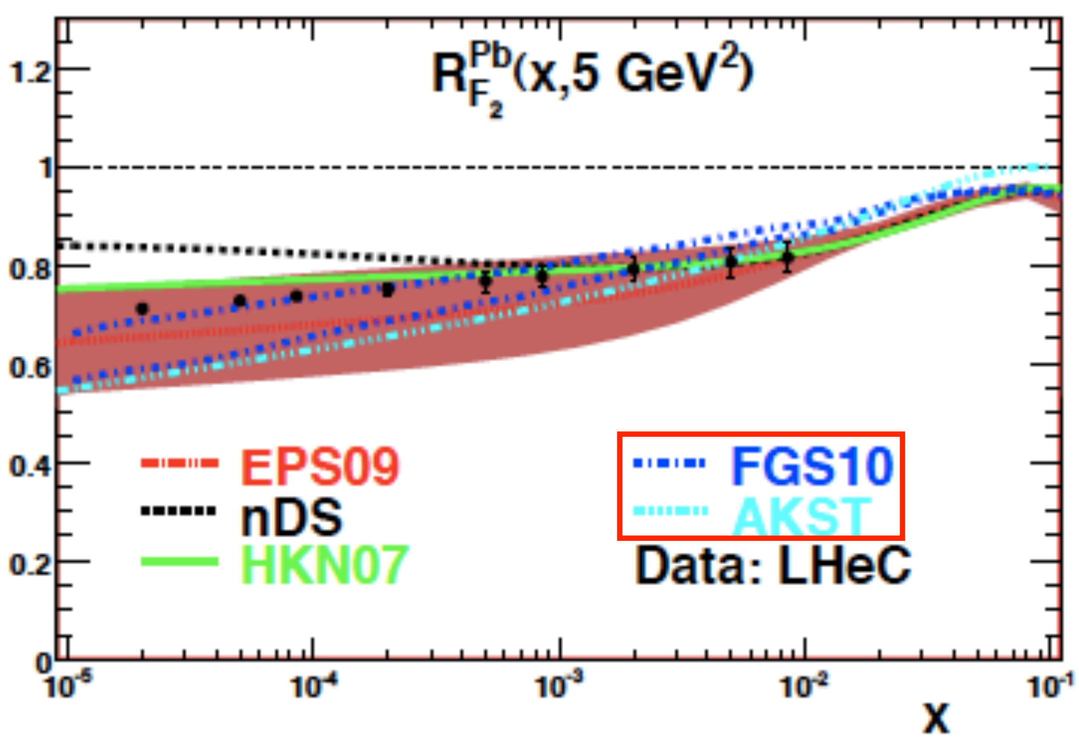
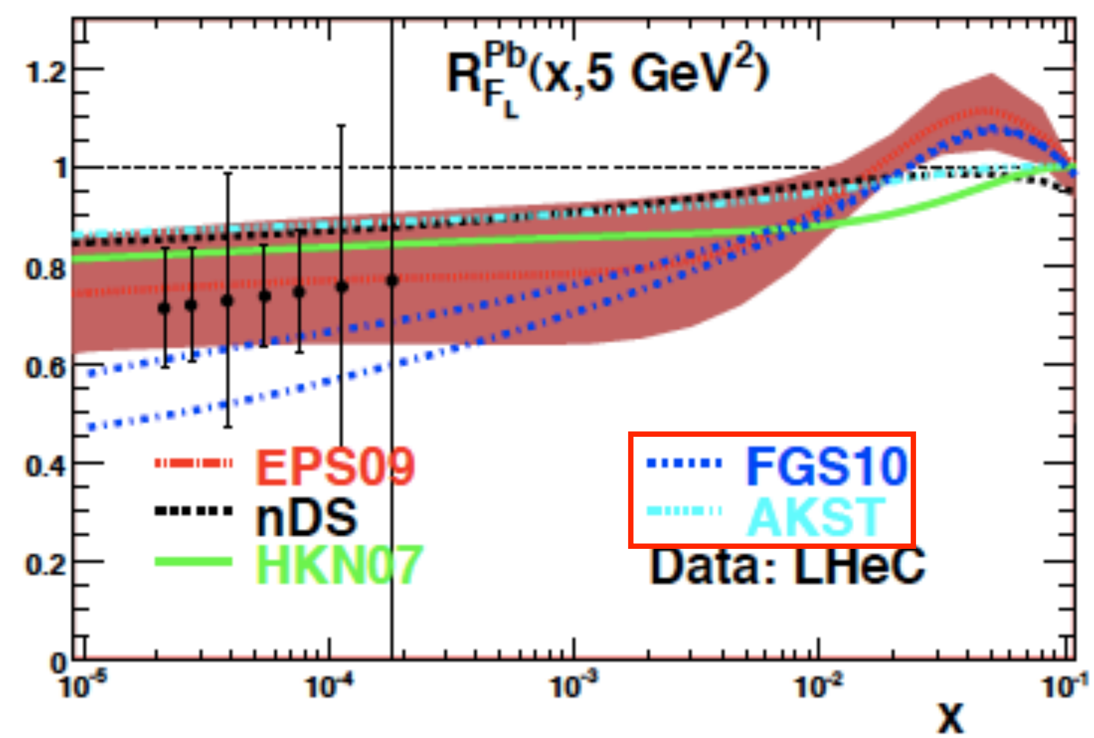
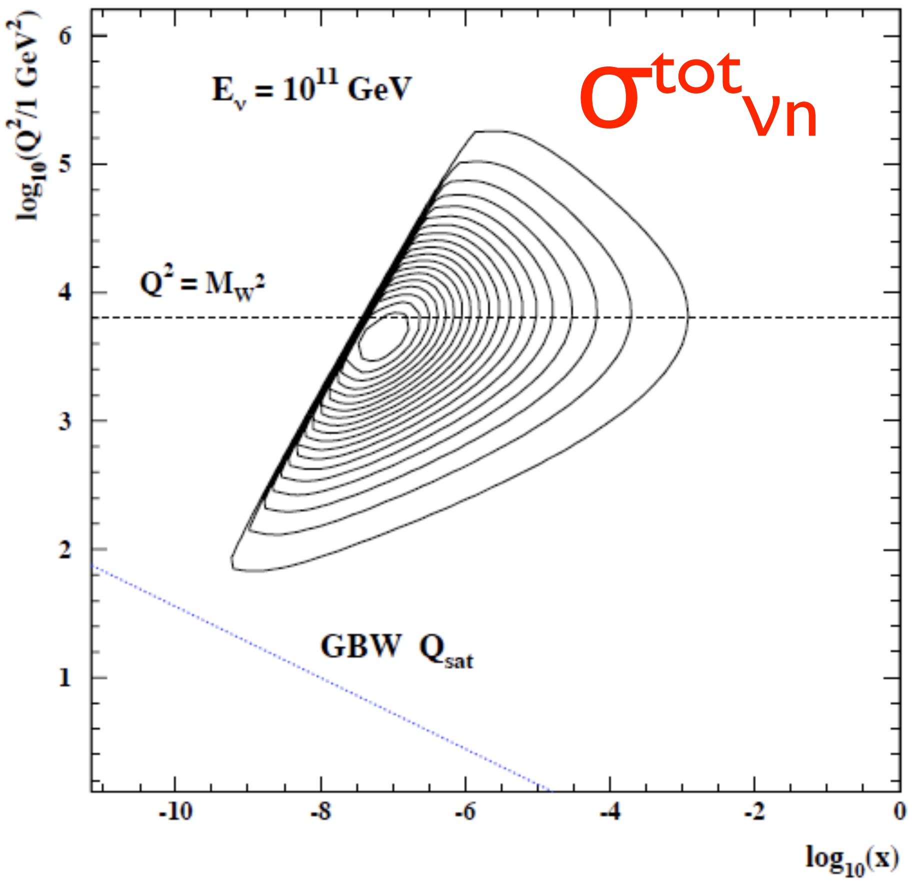


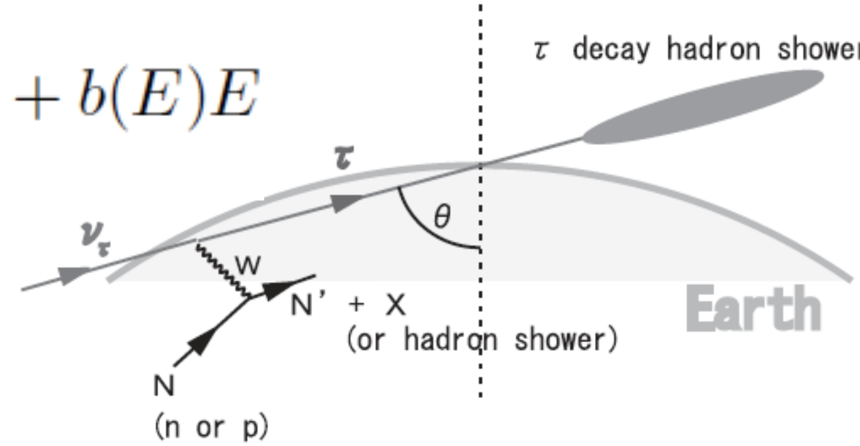


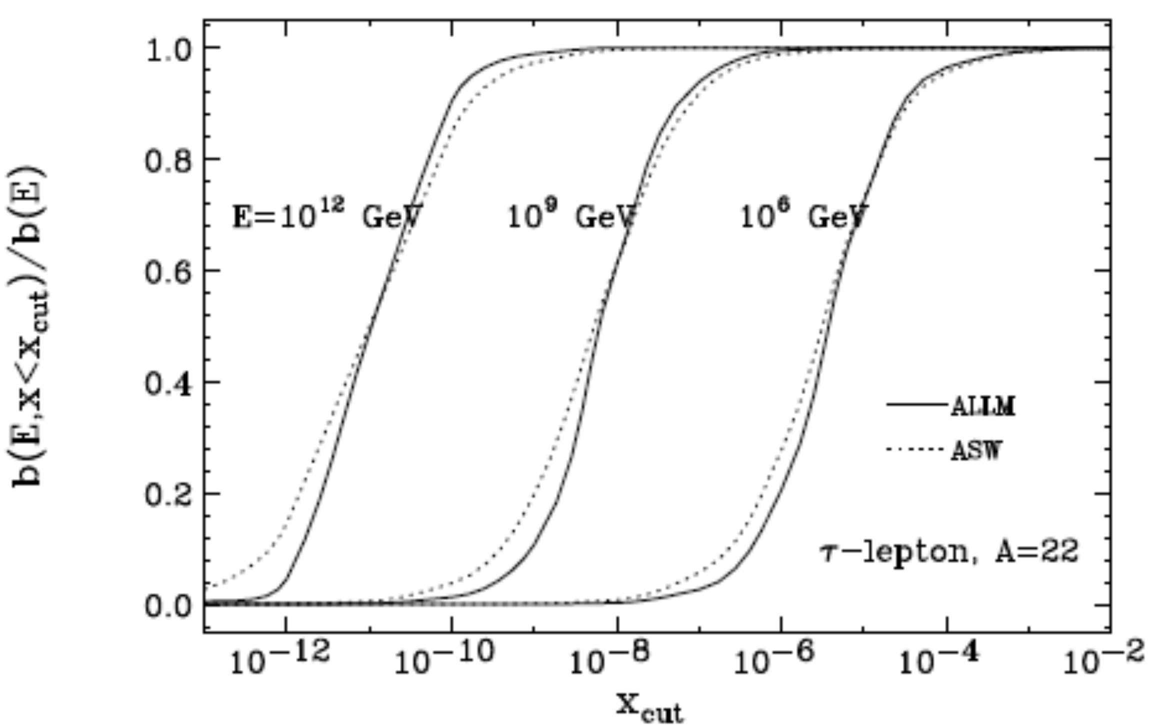
Implications for UHEν's:

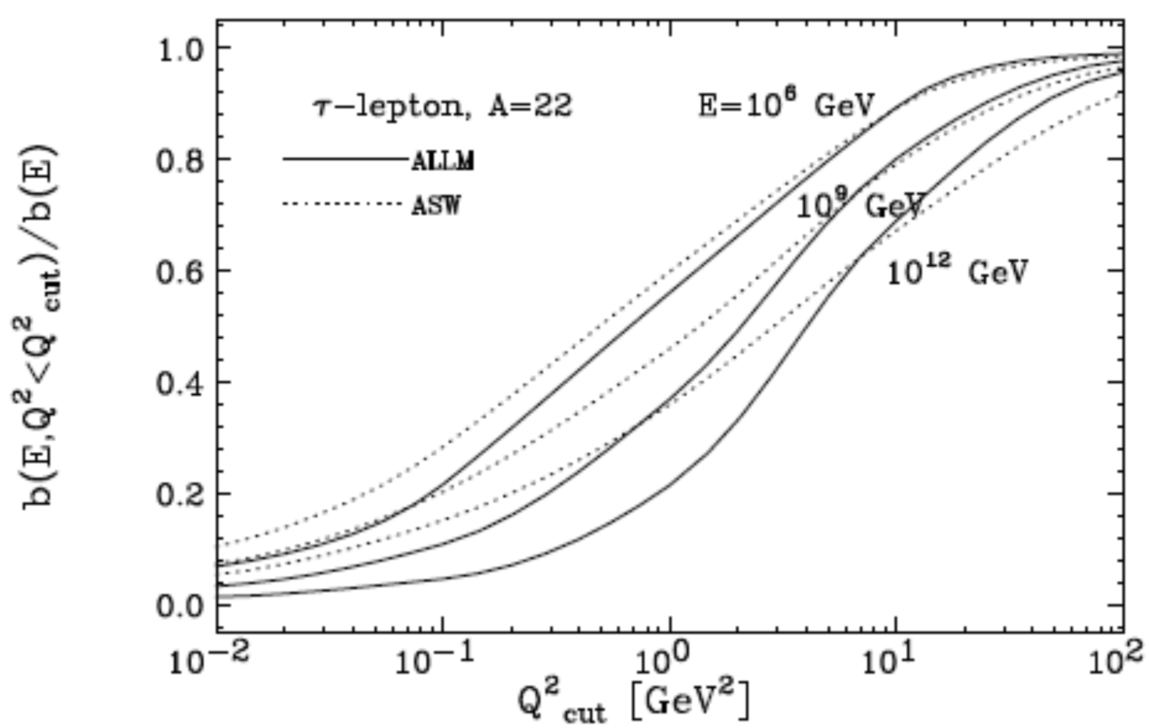


- ν-n/A cross section (τ energy loss) dominated by DIS structure functions / (n)PDFs at small-x and large (small) Q^2.
- Key ingredient for estimating fluxes.

$$-\left\langle \frac{dE}{dX} \right\rangle = a(E) + b(E)E$$

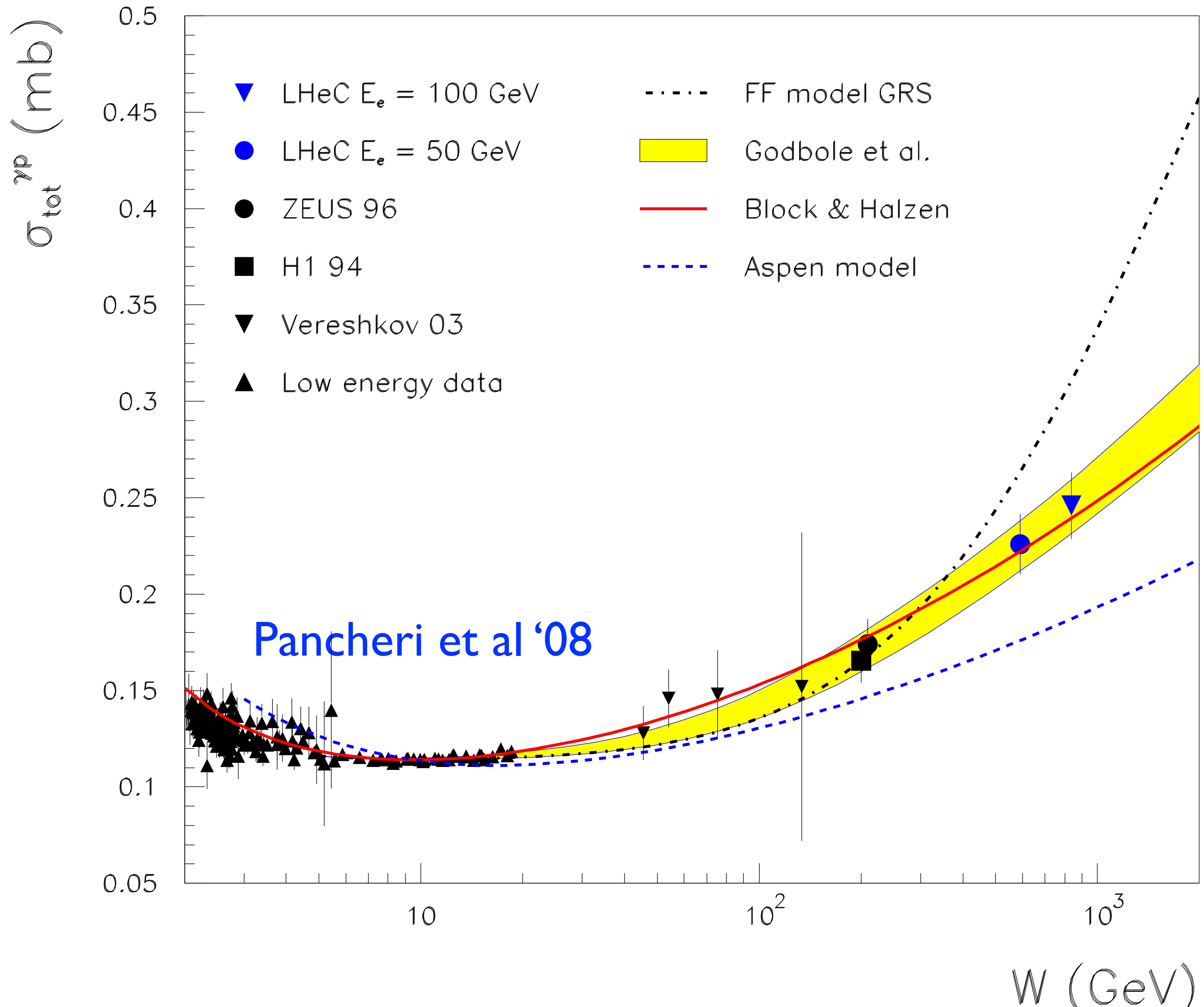






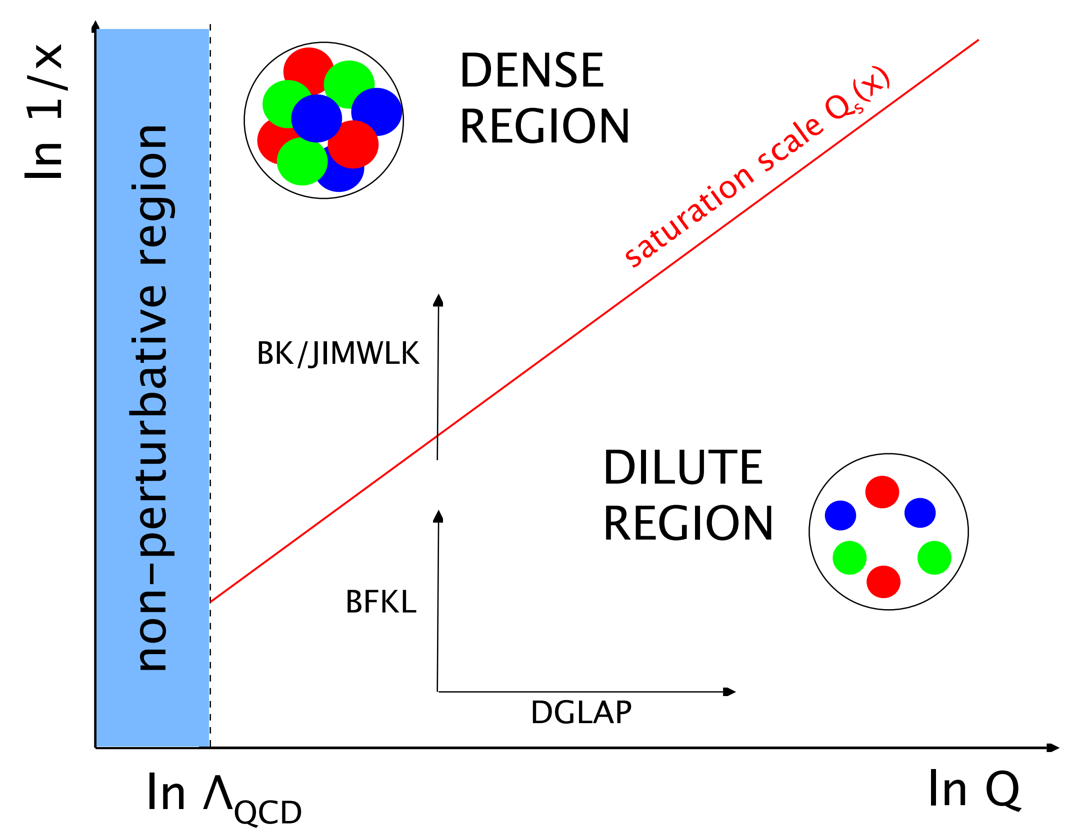
Photoproduction cross section:

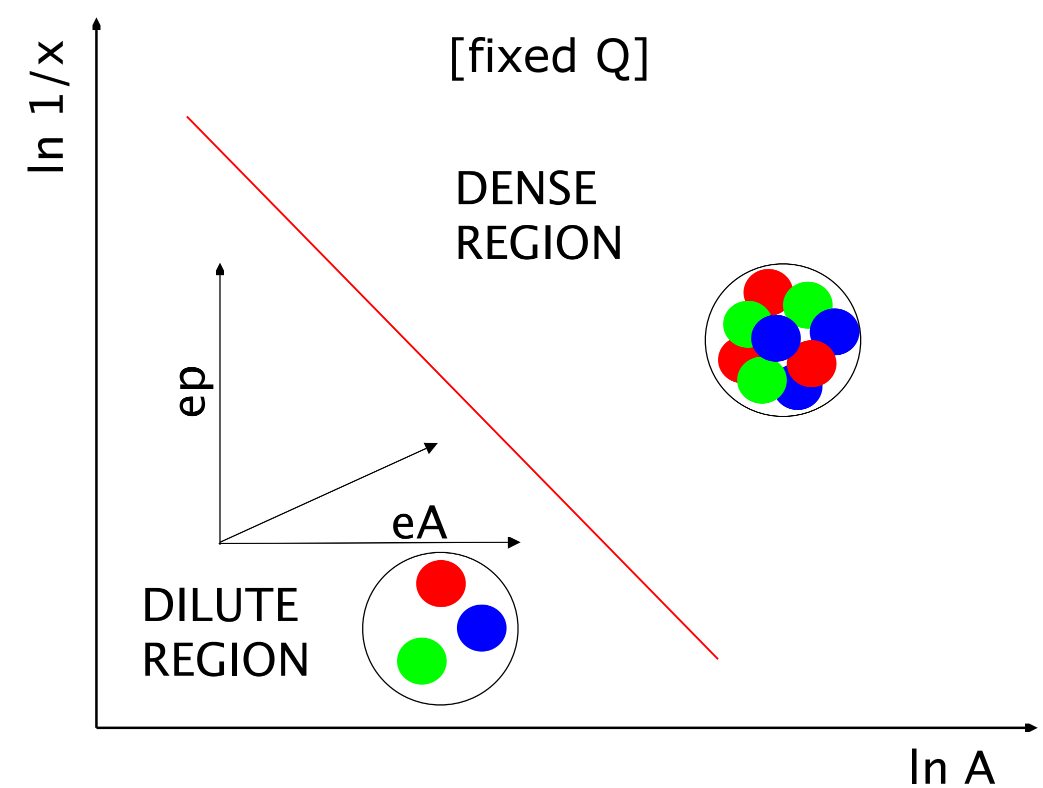
- Small angle electron detector 62 m far from the interaction point: $Q^2 < 0.01$ GeV, $y \sim 0.3 \Rightarrow W \sim 0.5\sqrt{s}$.
- Substantial enlarging of the lever arm in W.



Summary:

- ***At an LHeC@CERN***:
  - ➜ High-precision tests of collinear factorization(s) and determination of PDFs.
  - ➜ Unprecedented access to small x in p and A.
  - ➜ Novel sensitivity to physics beyond standard pQCD.
  - ➜ Stringent tests of QCD radiation and hadronization.
  - ➜ Transverse scan of the hadron/nucleus at small x.
  - ➜ ... with implications on our understanding of QGP.
- **The LHeC will answer the question of saturation/ non-linear dynamics. For that, ep AND eA essential!!!**





Future plans:

- **Next: follow CERN mandate and go towards a TDR.** This requires a further elaboration of the physics case:

➜ diffraction: studies on DPDFs and nDPDFs.

➜ GPDs: complementarity of exclusive VM production and DVCS, also in the nuclear case.

➜ complementarity with the LHC, both ep/pp and eA/pA.

➜ ...

Any collaboration is more than welcome!!!

Future plans:

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Future plans:

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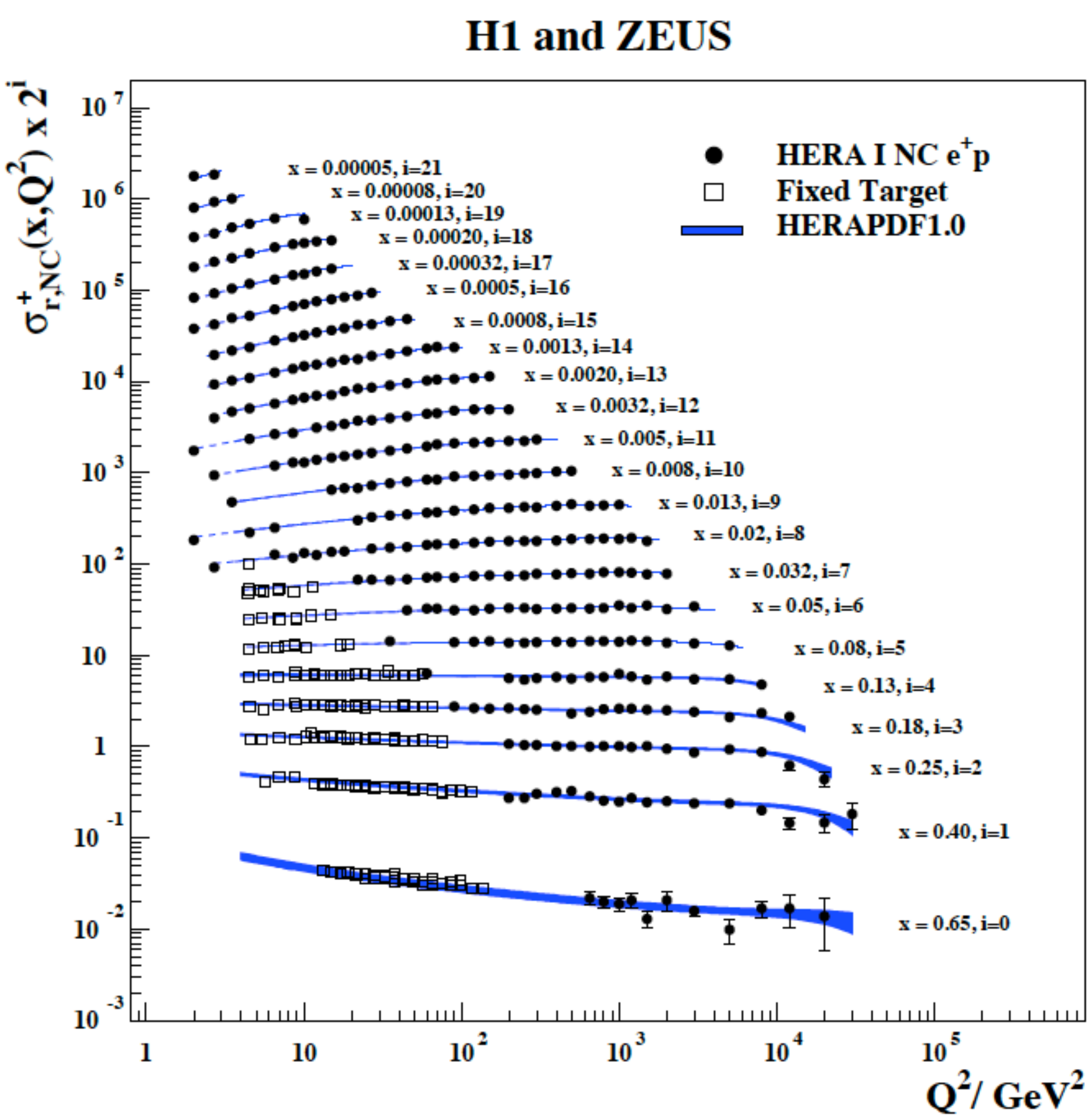
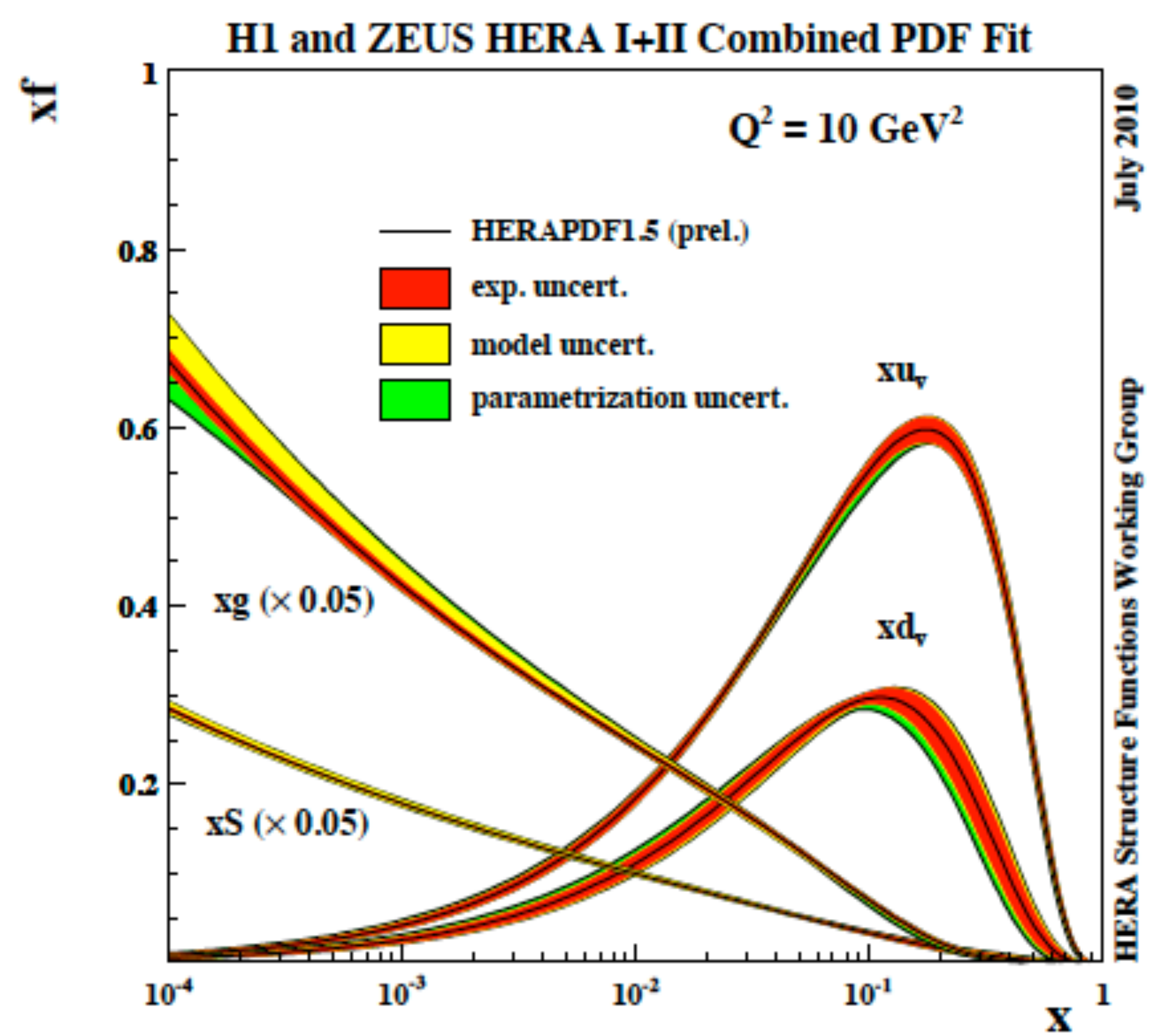
Thanks for your attention!

Backup:

Legacy from HERA:

- Structure functions in an extended x-Q^2 range, $xg \propto 1/x^{\lambda}$, $\lambda>0$.
- Large fraction of diffraction $\sigma_{diff}/\sigma_{tot}\sim 10\%$.
- But: no eA/eD, kinematical reach at small x, luminosity at high x / for searches (odderon,...), flavour decomposition, TMDs,...





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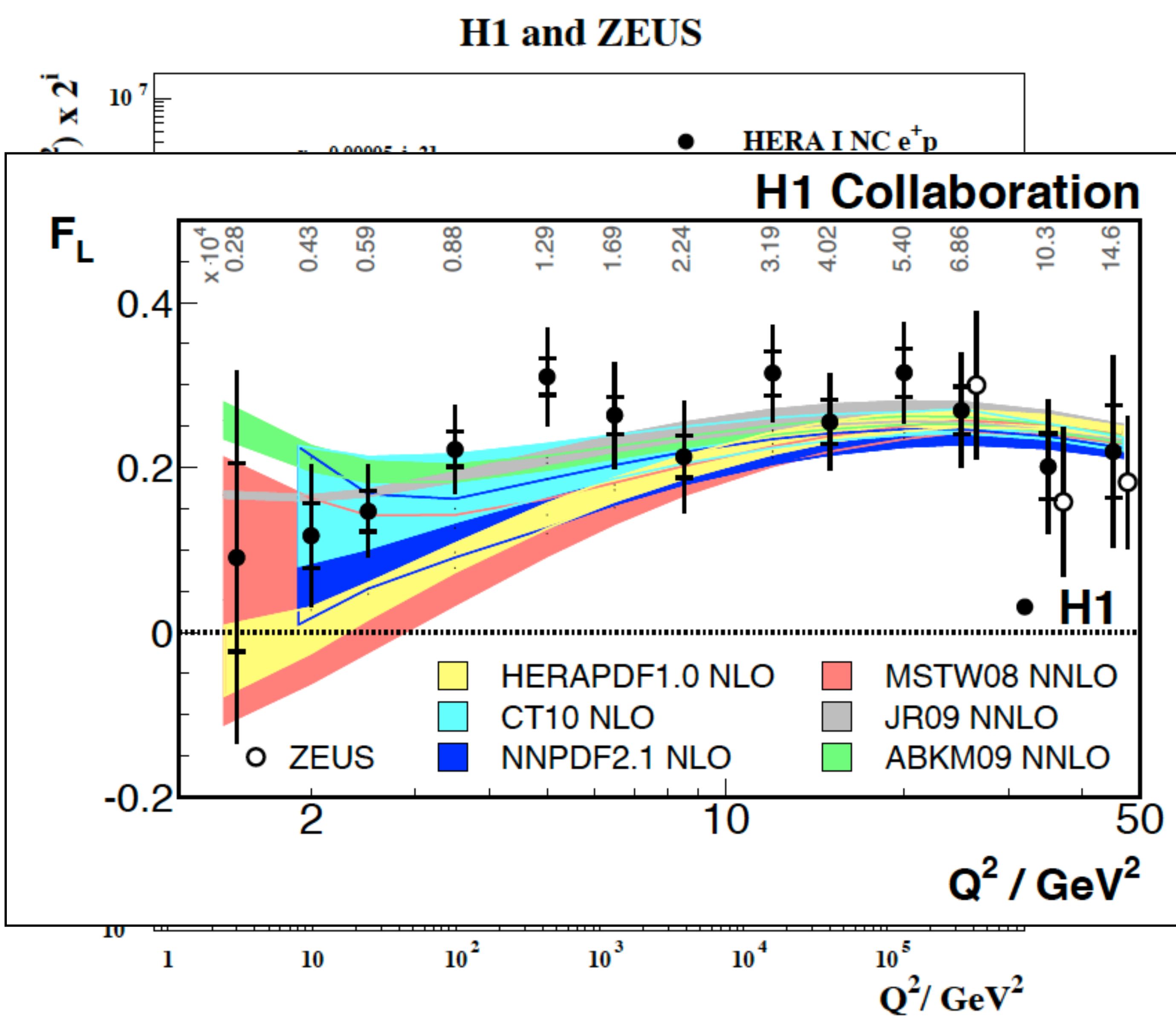
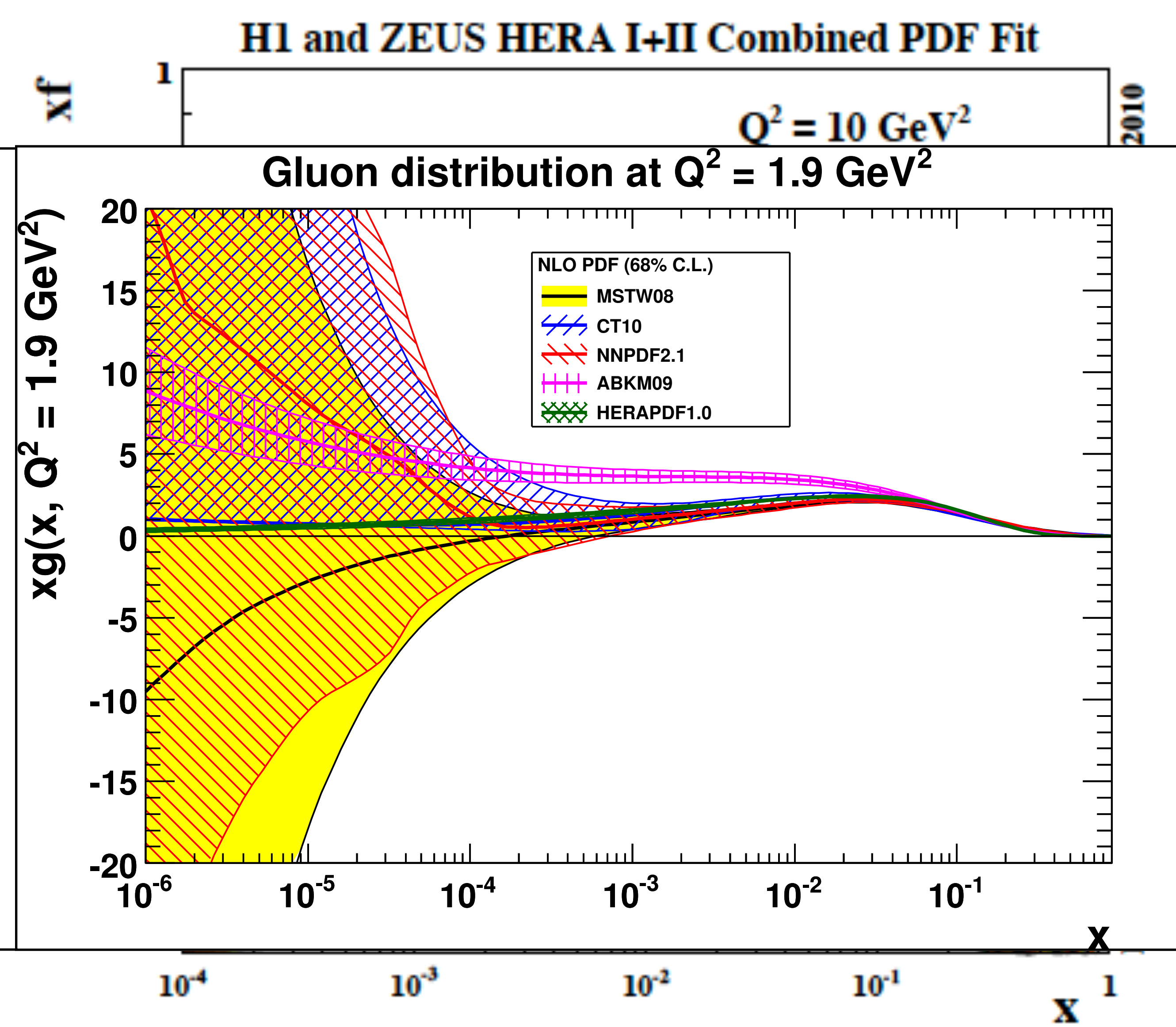
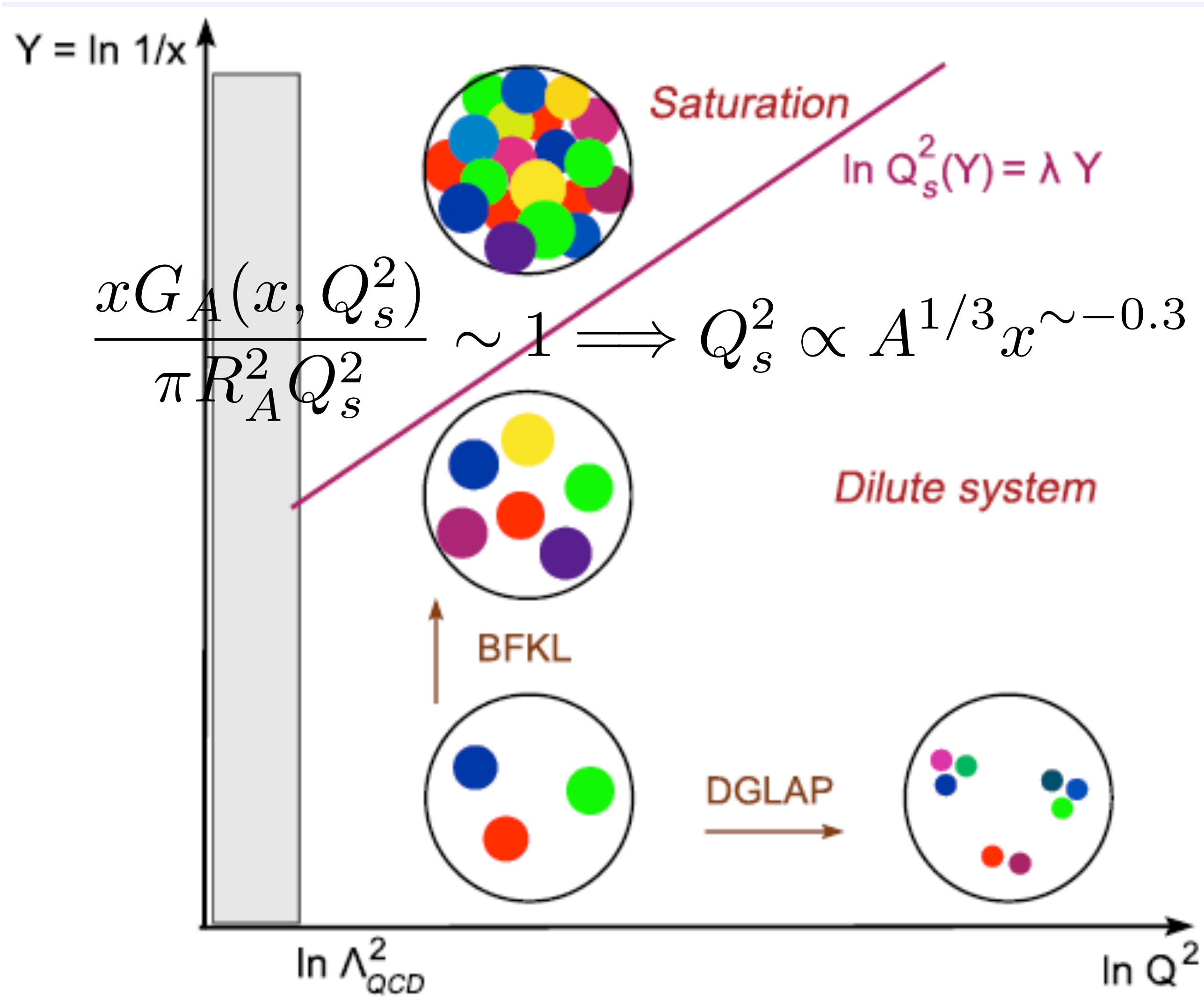
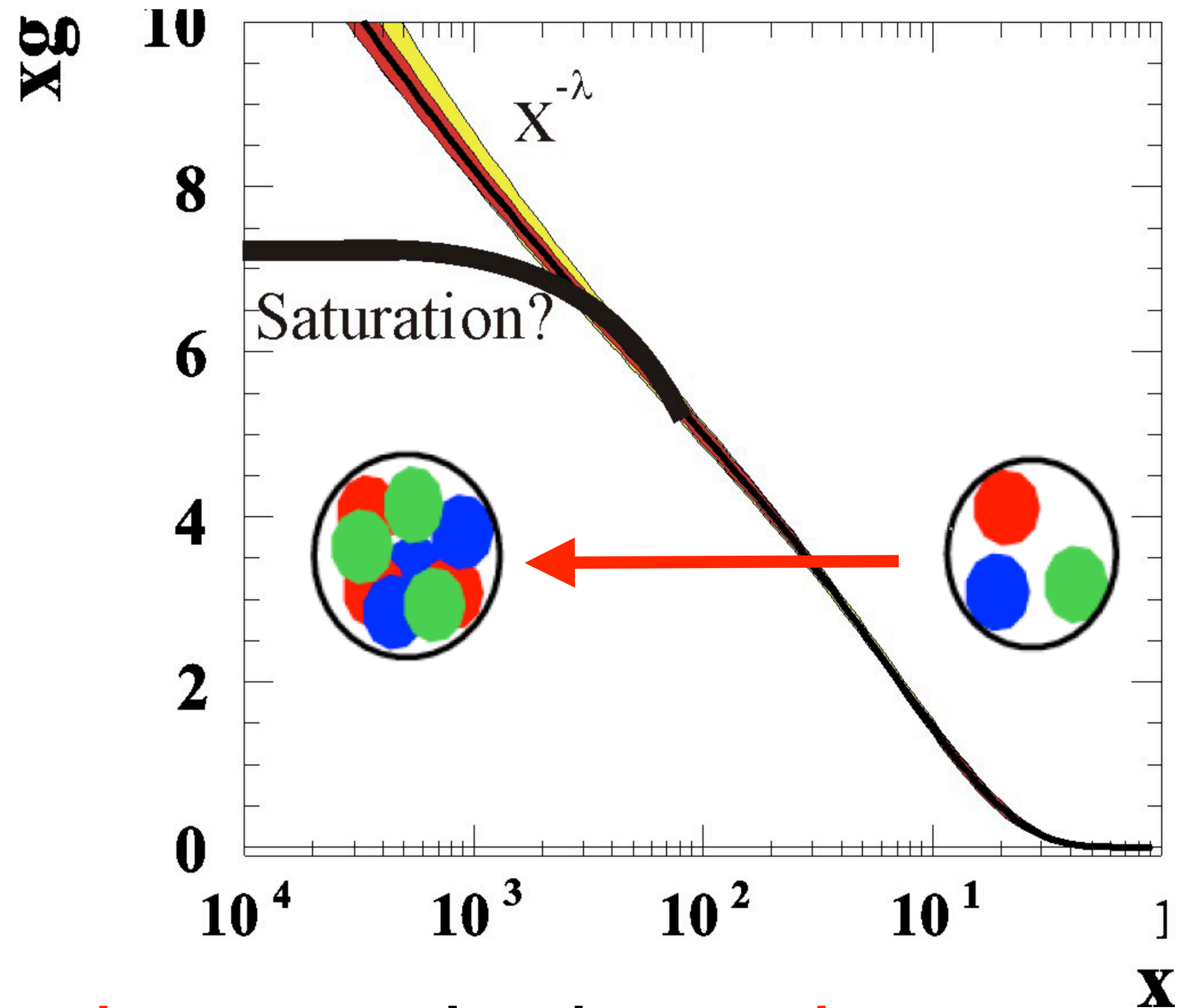




Small x and saturation:



$$\frac{xG_A(x,Q_s^2)}{\pi R_A^2 Q_s^2} \sim 1 \Longrightarrow Q_s^2 \propto A^{1/3} x^{\sim -0.3}$$



- QCD radiation of partons when x decreases leads to a large number of partons (gluons), provided each parton evolves independently (linearly, Δ[xg] ∝ xg).
- This independent evolution breaks at high densities (<u>small x or high mass number A</u>): non-linear effects (gg→g, Δ[xg] ∝ xg - k(xg)^2).

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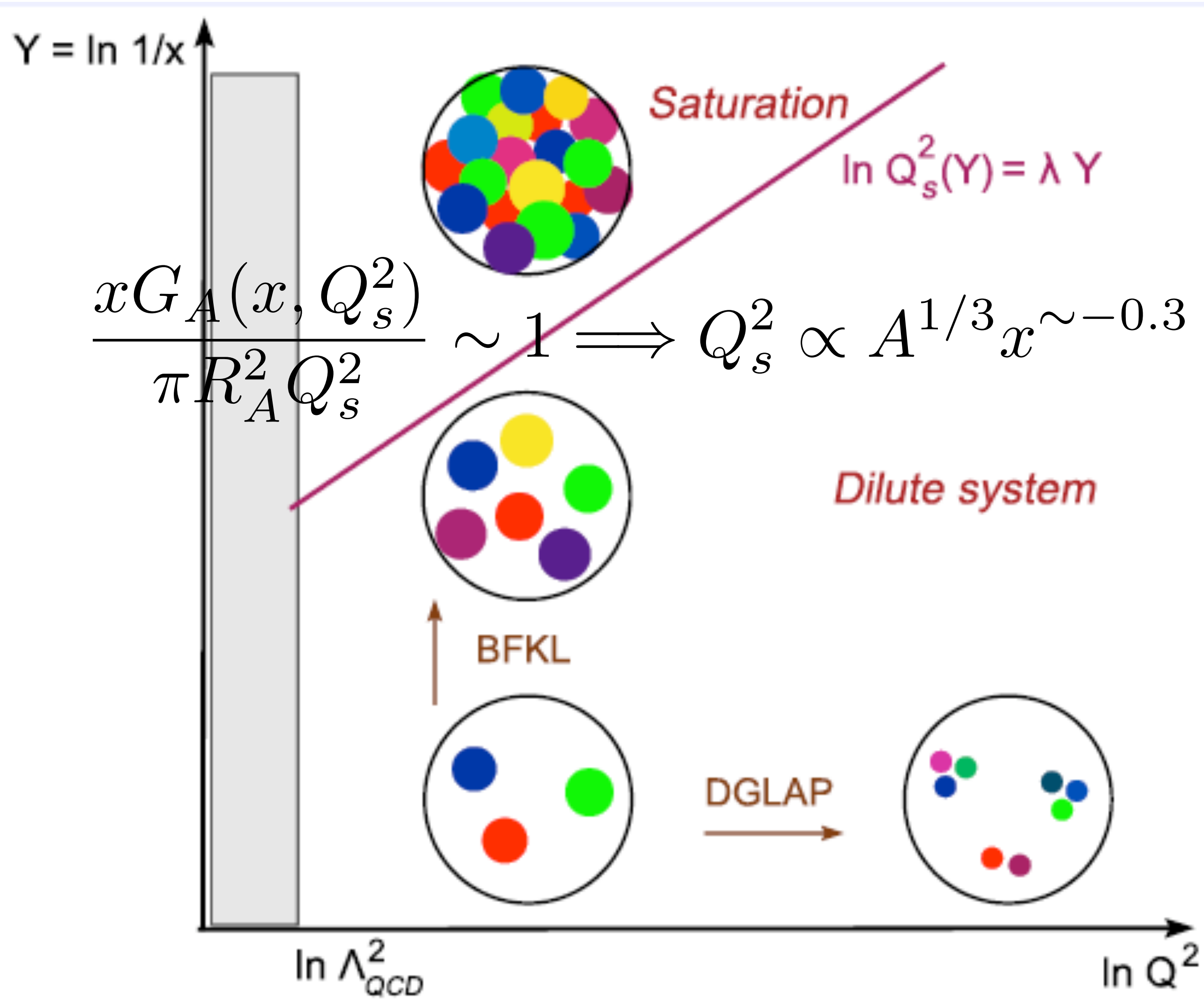

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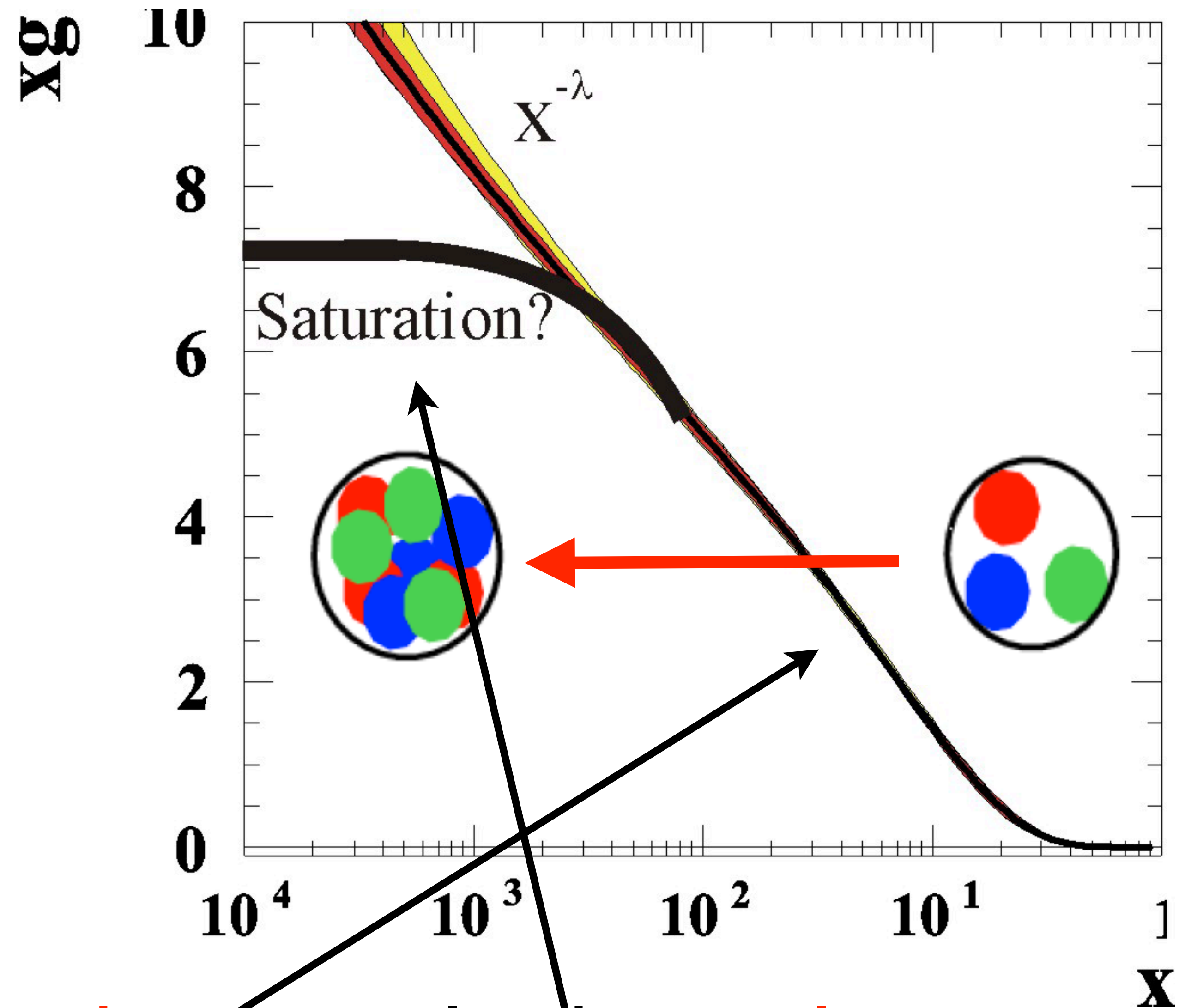

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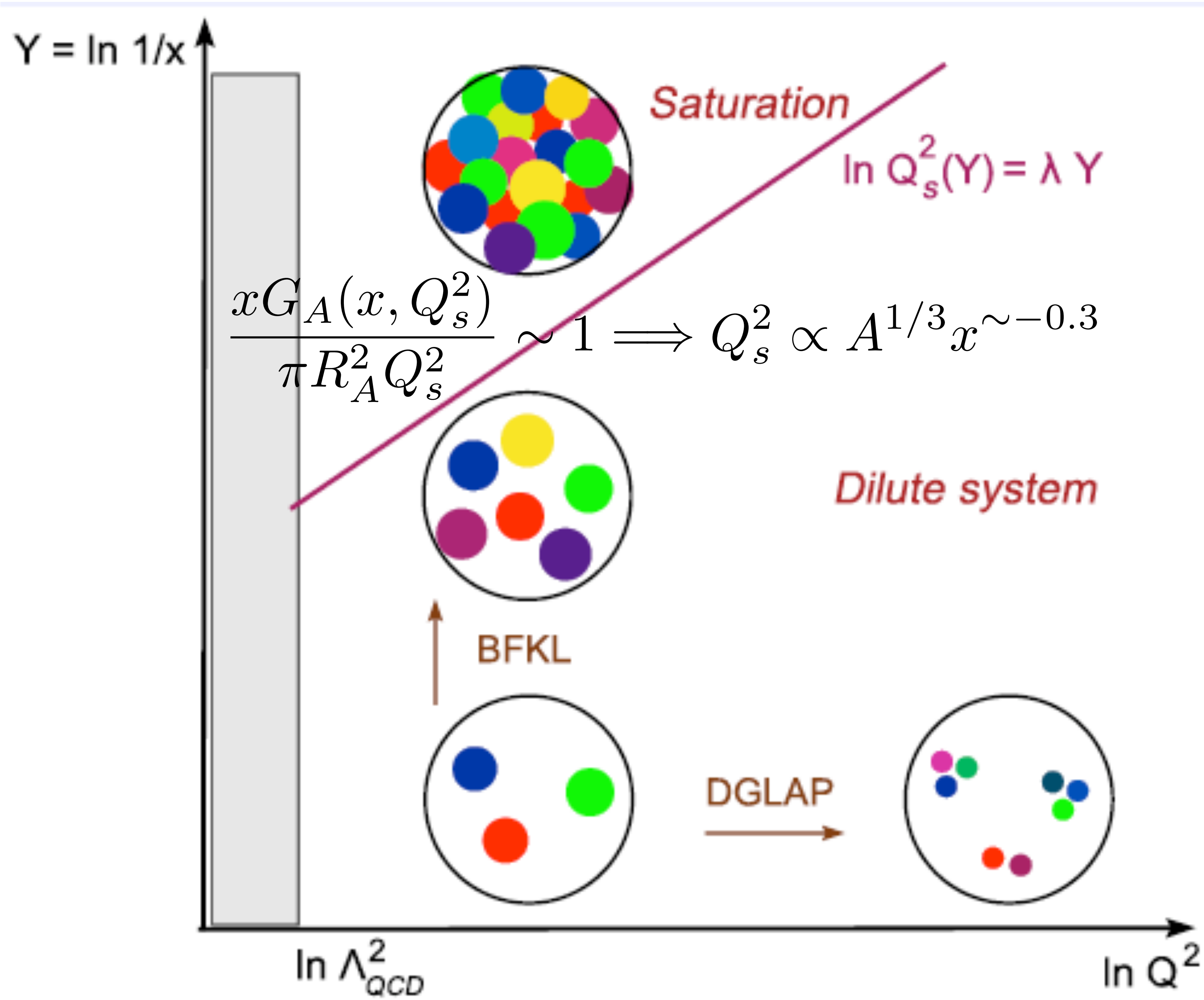
The 'QCD phase' diagram:

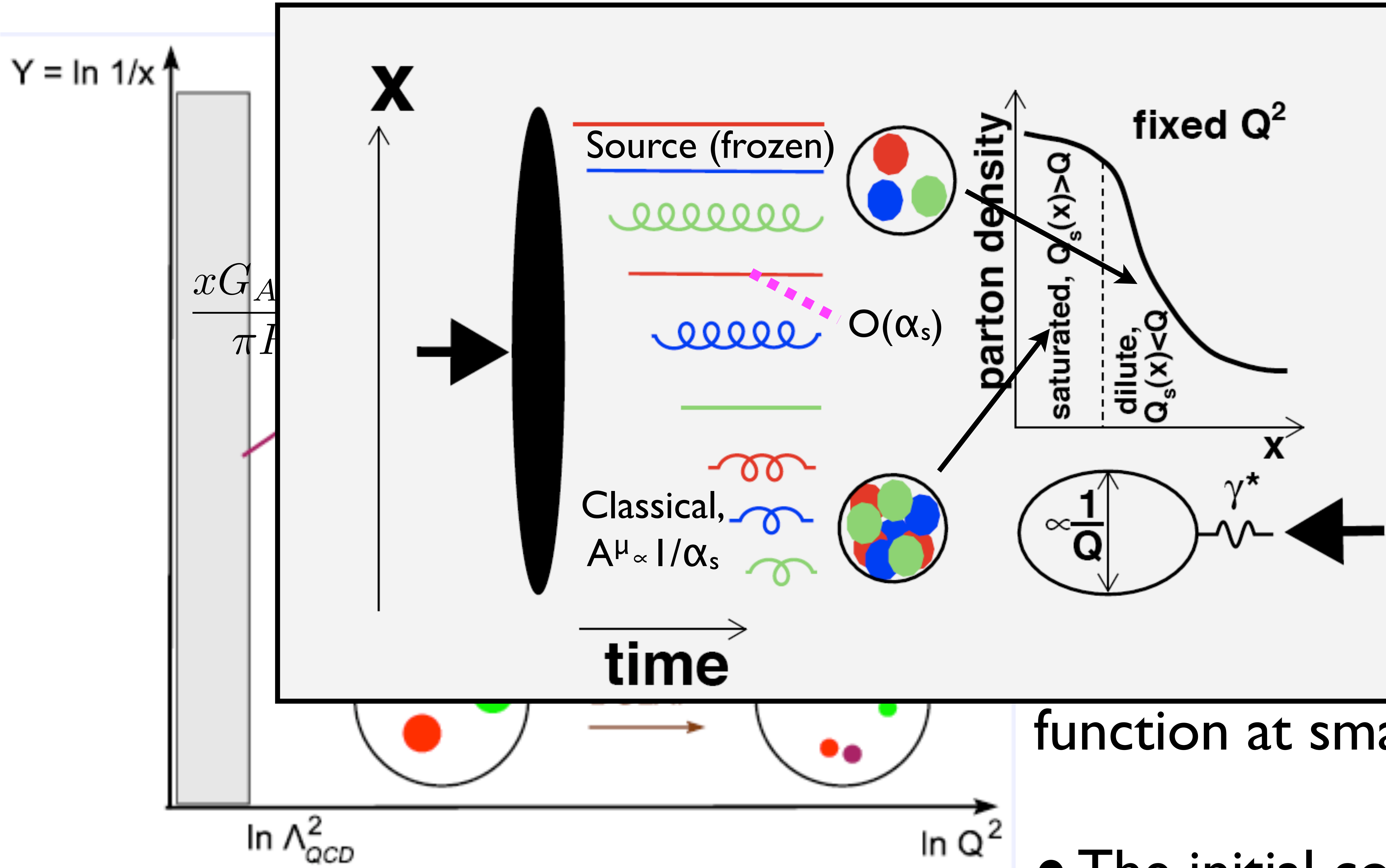


Origin in the early 80's: GLR, Mueller et al, McLerran-Venugopalan.

Our aims: understanding

- The implications of unitarity in a QFT.
- The behaviour of QCD at large energies.
- The hadron wave function at small x.
- The initial conditions for the creation of a dense medium in heavy-ion collisions.

The ‘QCD phase’ diagram:



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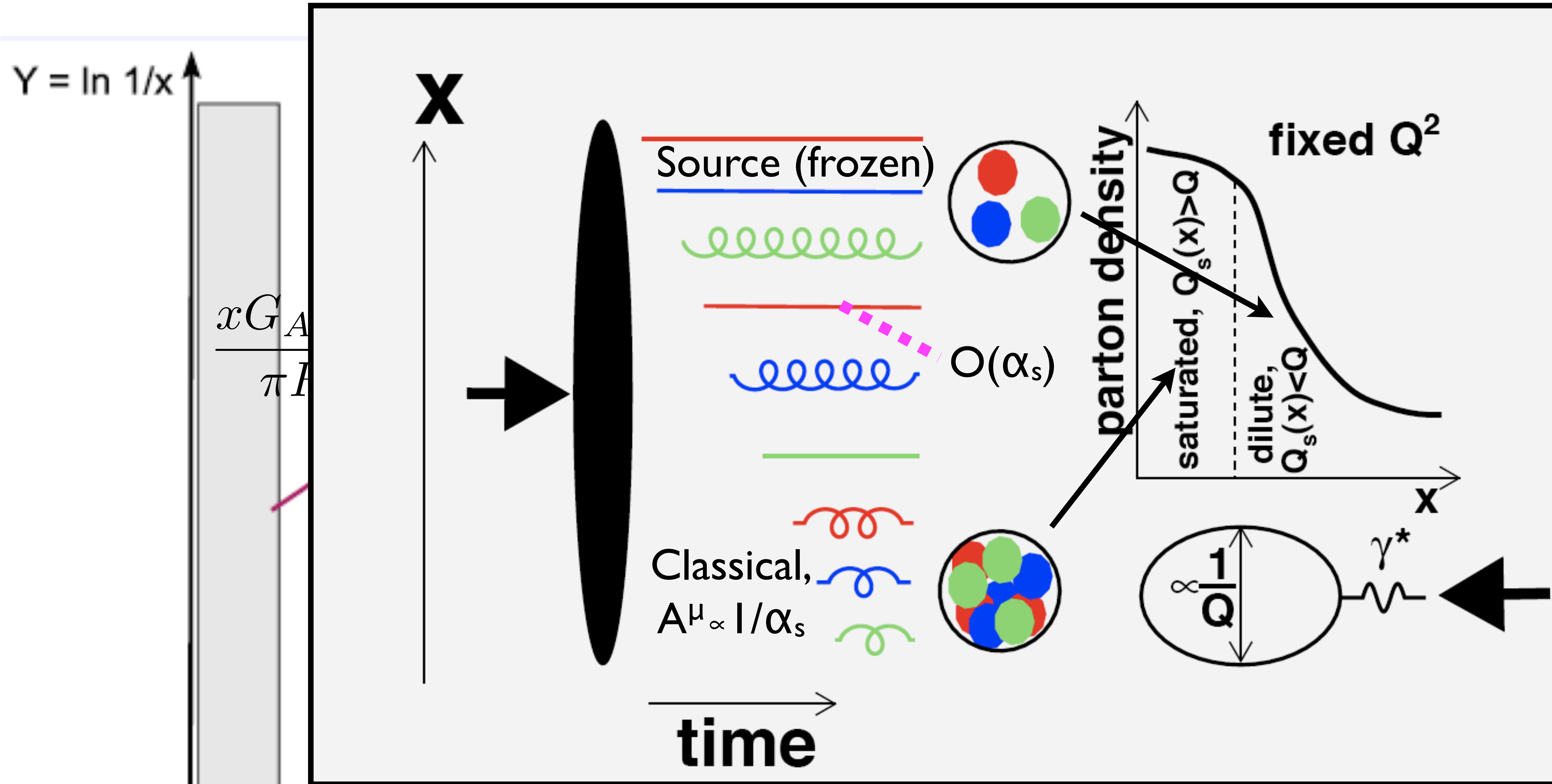
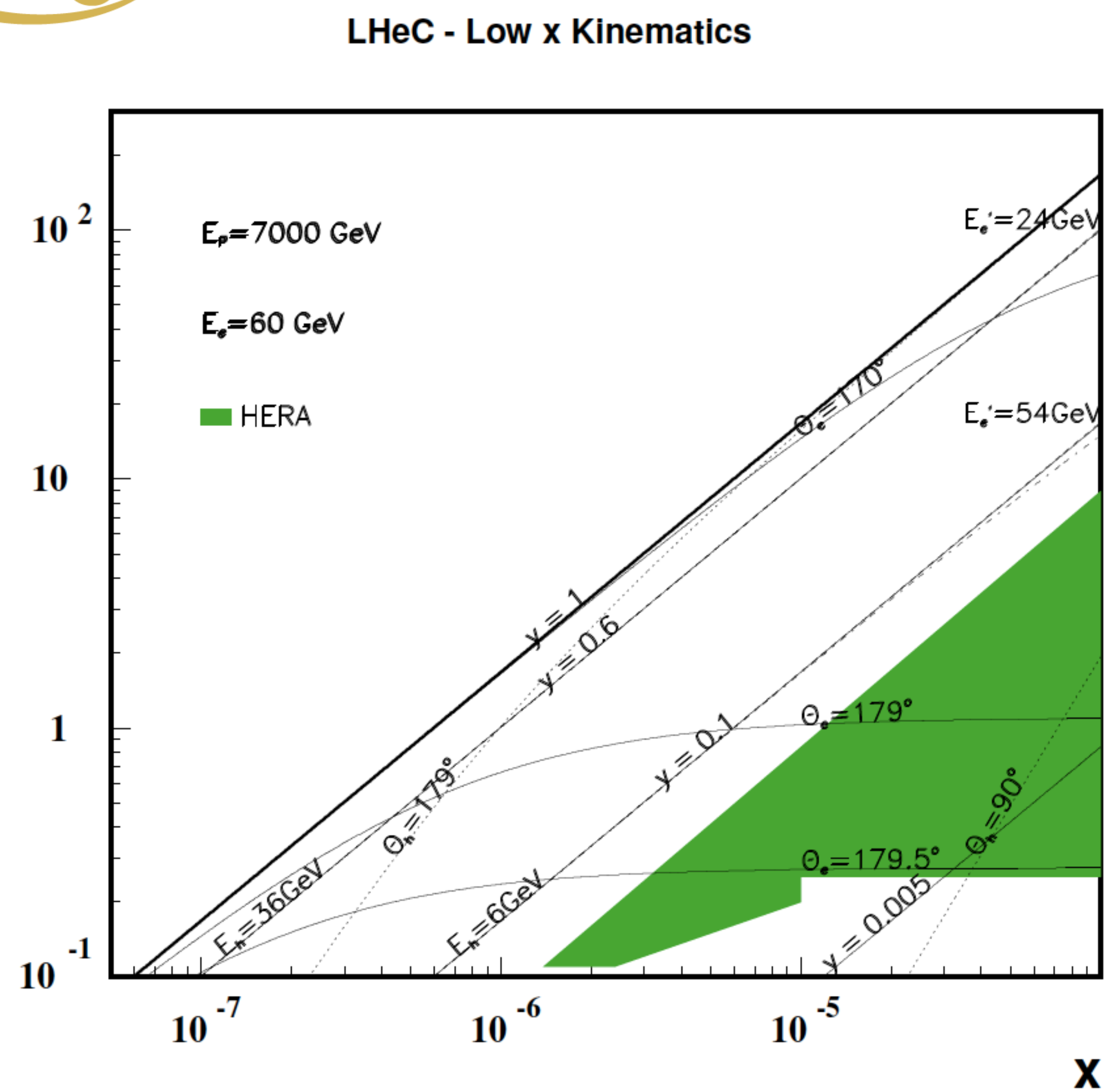
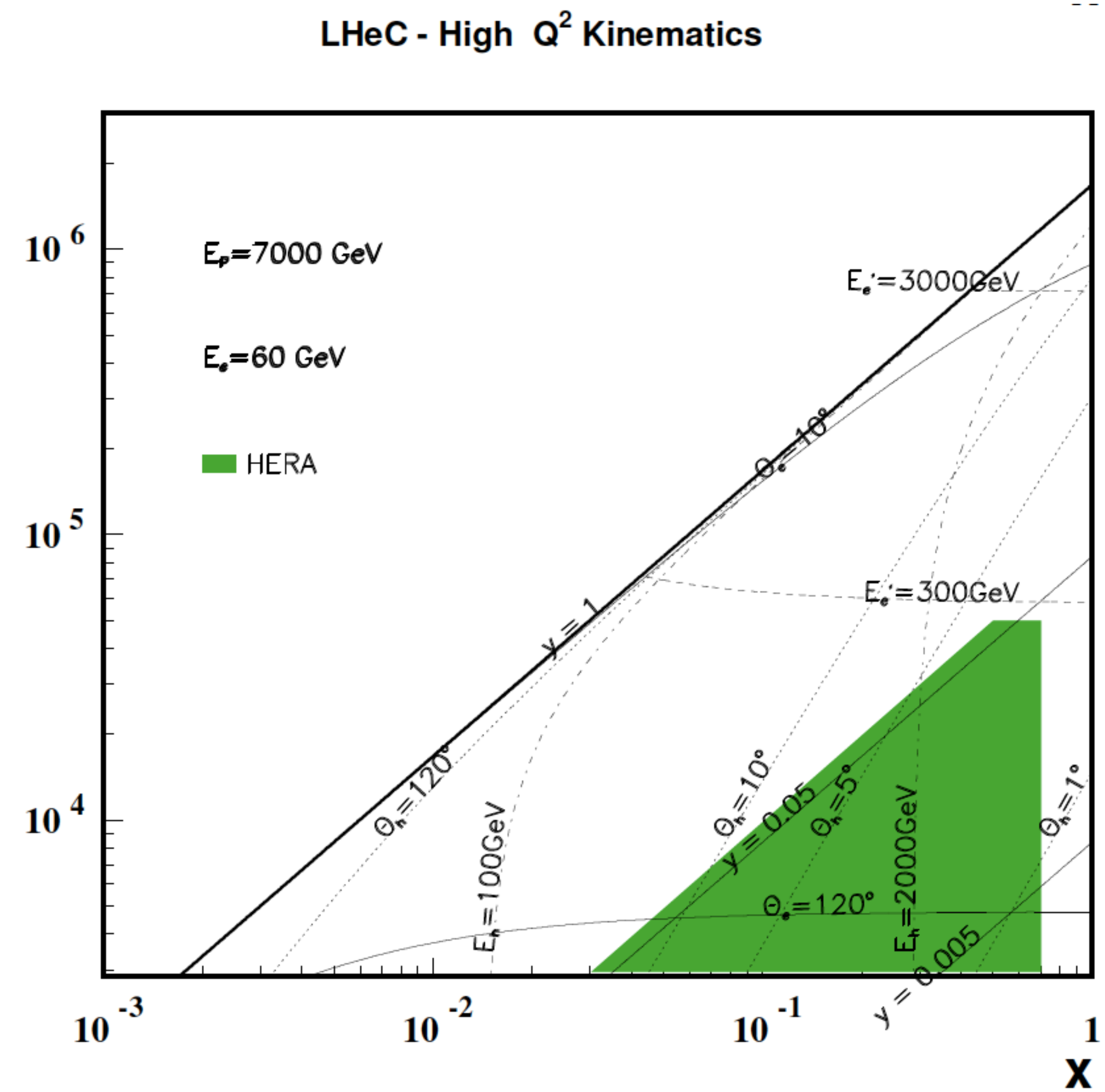


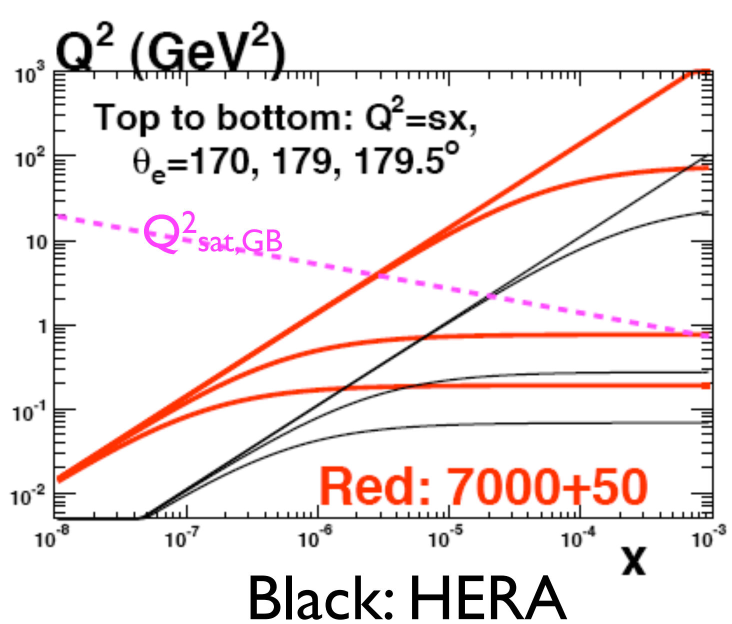
Questions:

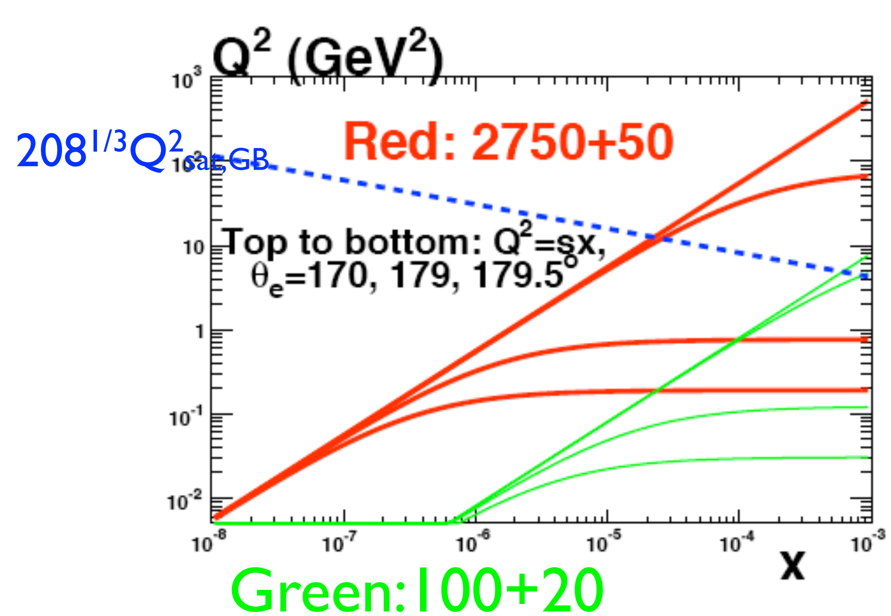
- Theory: can the dense regime be described using pQCD techniques? Or non-perturbative - Regge, AdS/QCD,...? Which factorisation is at work?
- Experiment: where do present/future experimental data lie?

Kinematics:



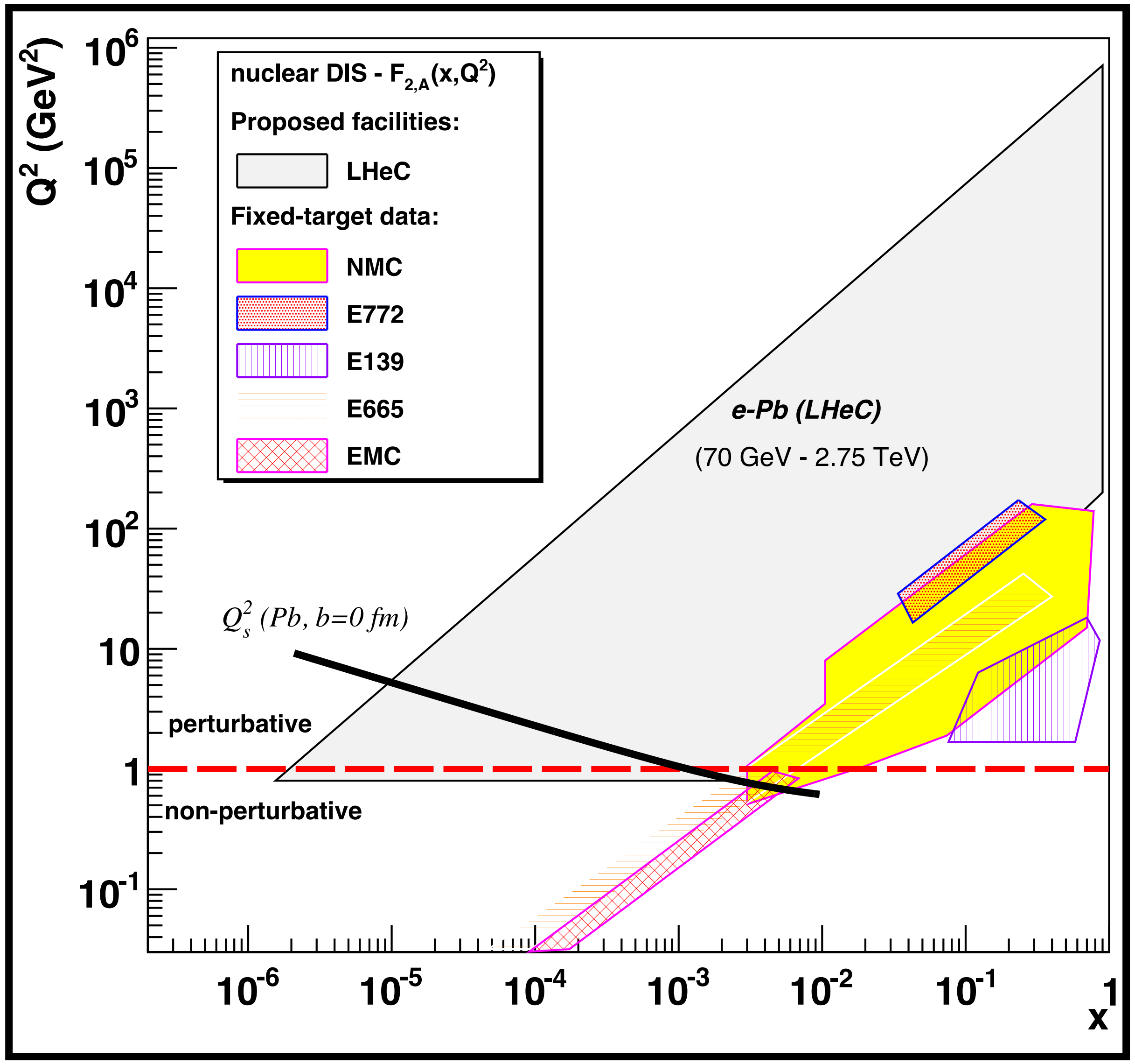


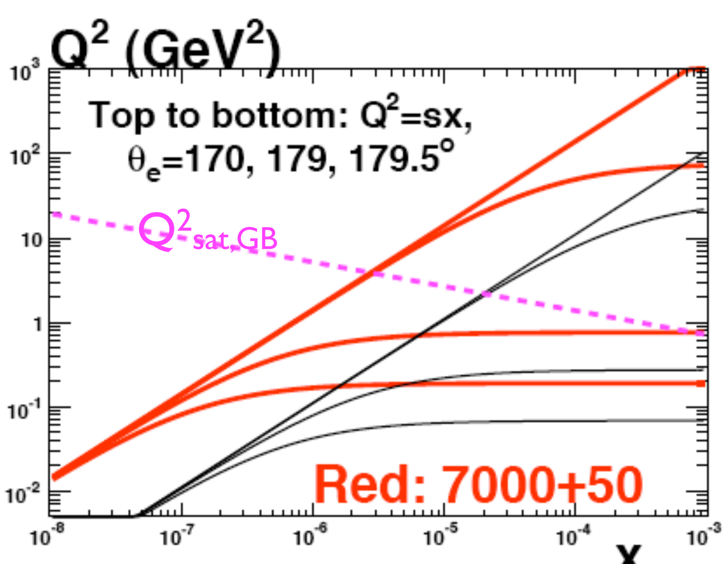


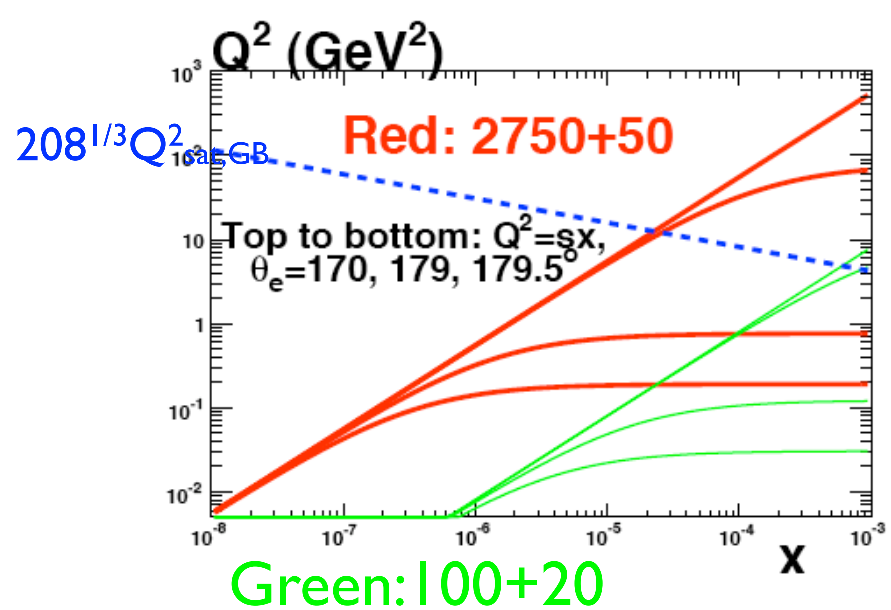


- Small-x demands 1 degree acceptance.
- Higher luminosity would benefit high-x and Q^2 studies.

Kinematics:







- Small-x demands 1 degree acceptance.
- Higher luminosity would benefit high-x and Q^2 studies.

LHeC scenarios:

For F_2

config.	E(e)	E(N)	N	$\int L(e^+)$	$\int L(e^-)$	|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	$5\cdot10^{-4}$		?	$5\cdot10^{-3}$	?	?	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.

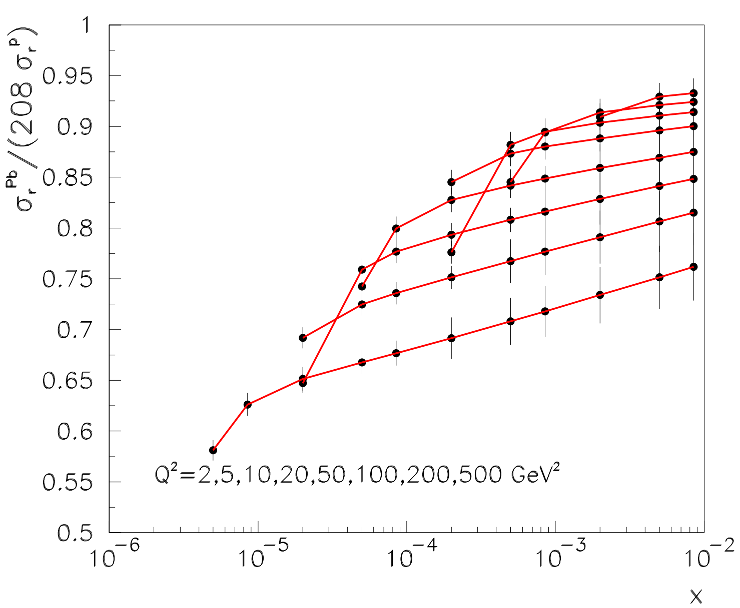
Note: F_L in eA

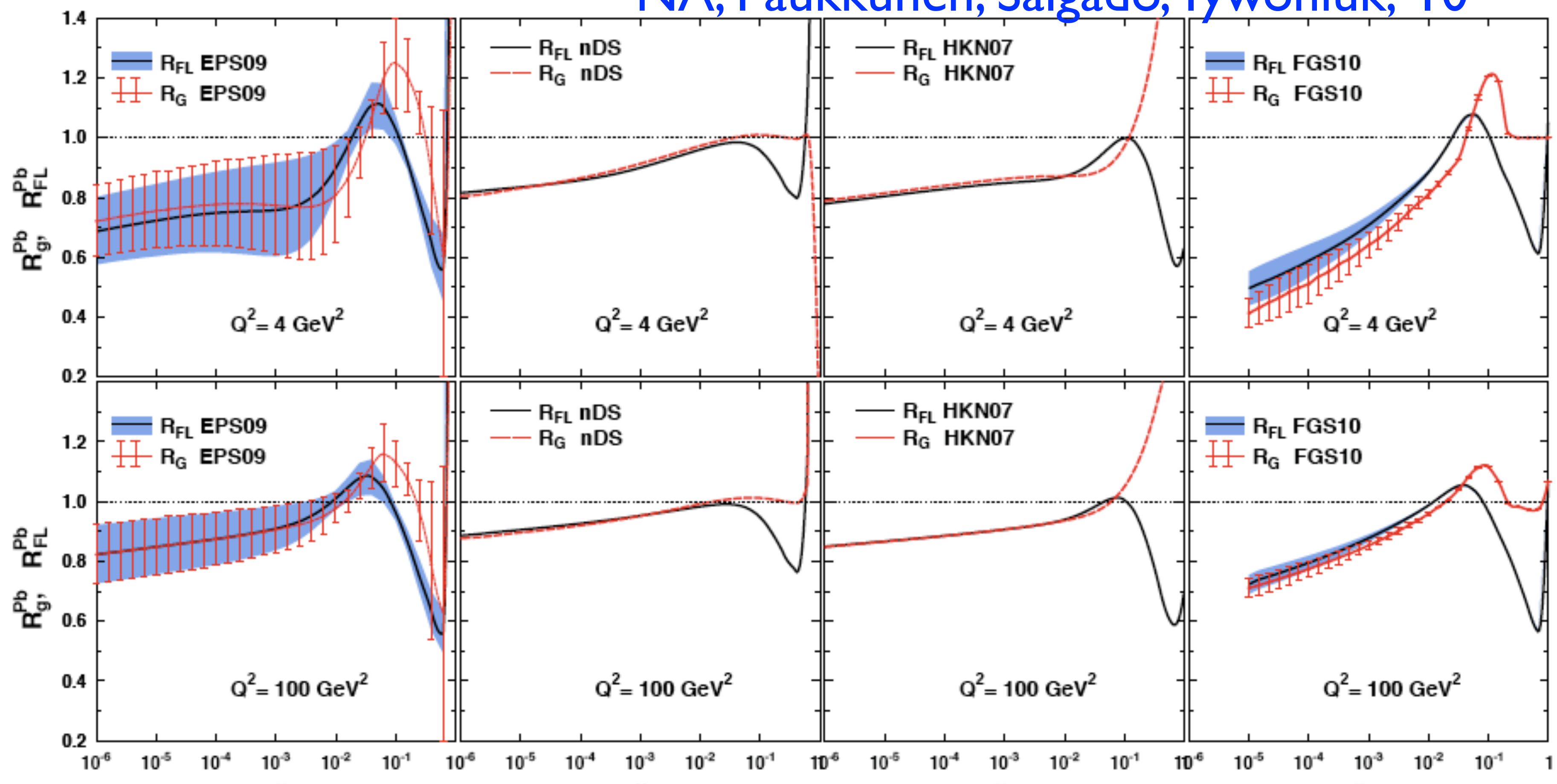
$$\sigma_r^{NC} = \frac{Q^4 x}{2\pi\alpha^2 Y_+}\frac{d^2\sigma^{NC}}{dxdQ^2} = F_2\left[1 - \frac{y^2}{Y_+}\frac{F_L}{F_2}\right], \qquad Y_+ = 1 + (1-y)^2$$

- 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.) ⇒

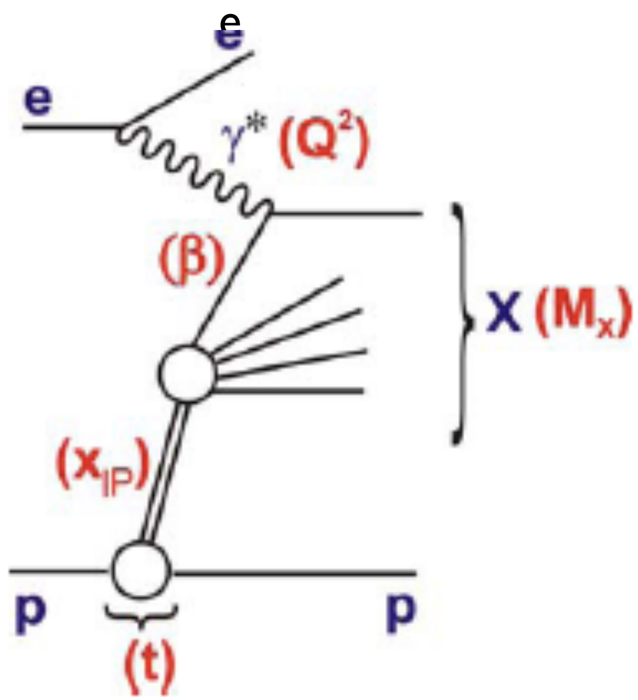
measure F_L or use the reduced cross section (but then ratios at two energies...).

NA, Paukkunen, Salgado, Tywoniuk, '10

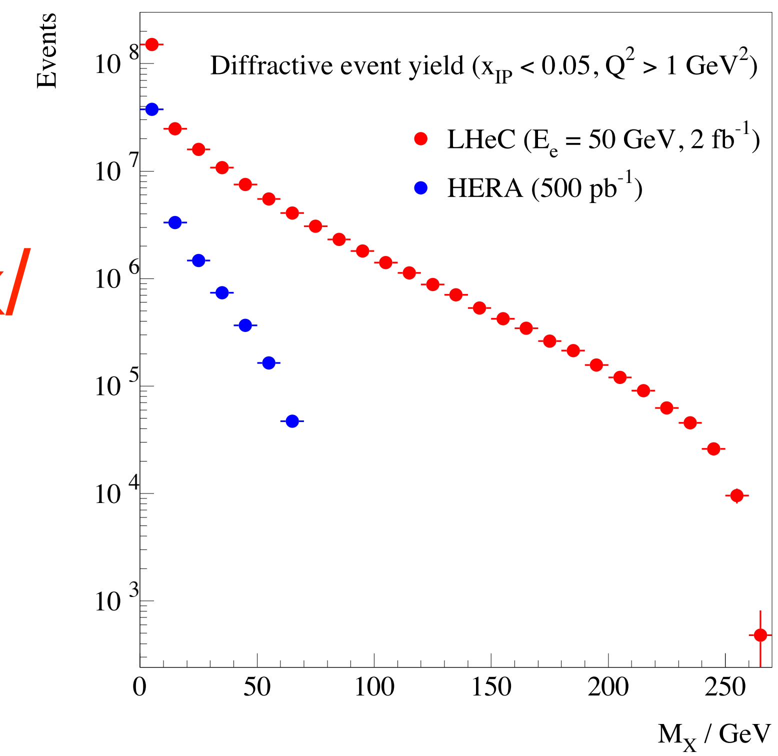




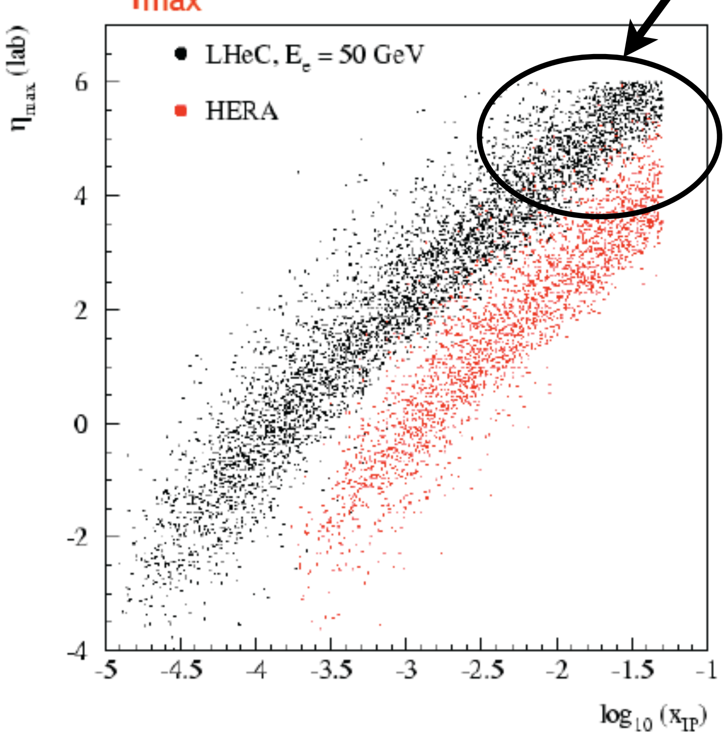
ep diffractive pseudodata:

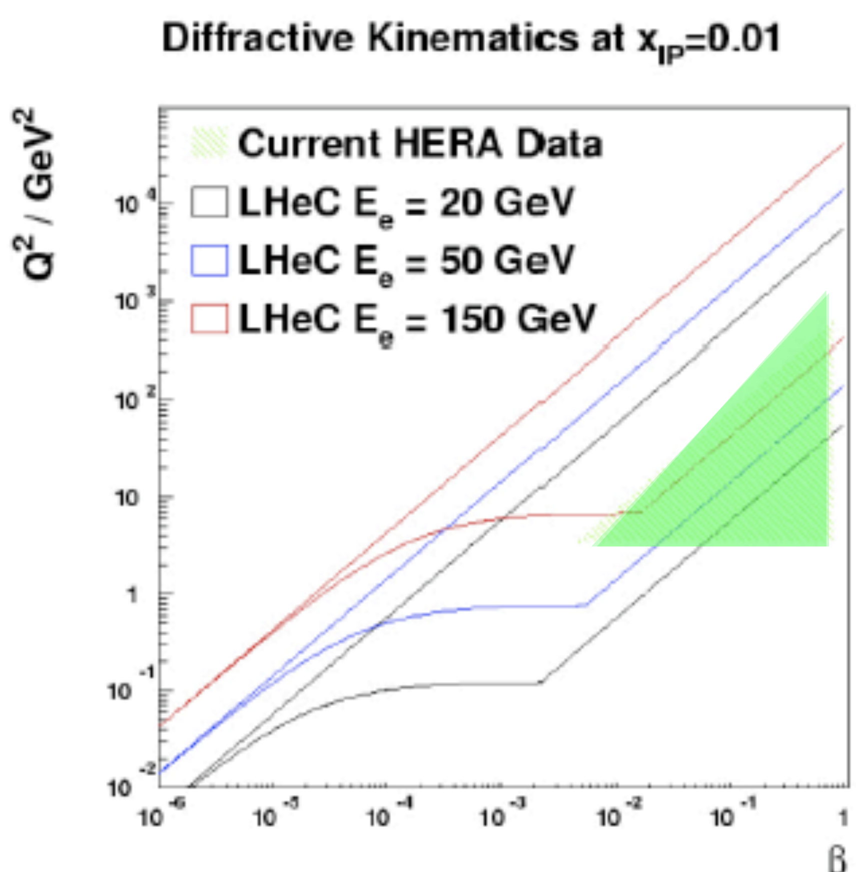


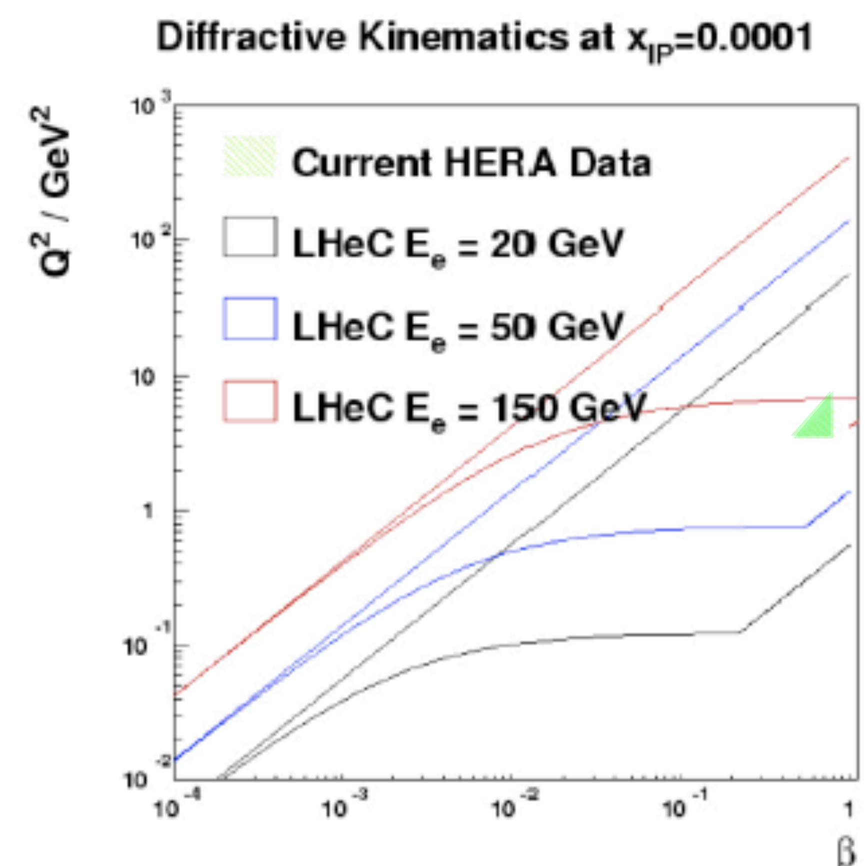
- Large increase in the M^2, $x_P=(M^2-t+Q^2)/(W^2+Q^2)$, $\beta=x/x_P$ region studied.
- Possibility to combine LRG and LPS.



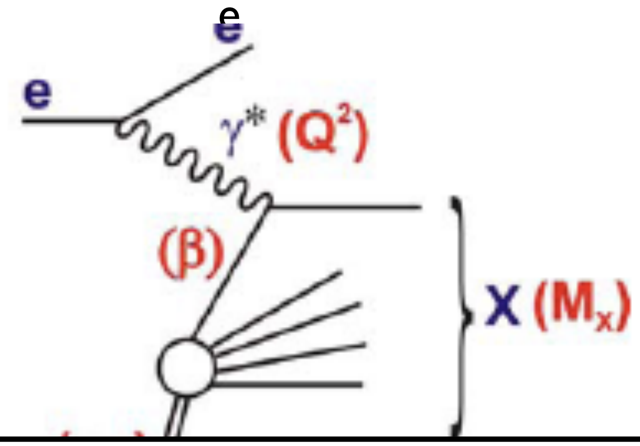
η_{max} from LRG selection ..







ep diffractive pseudodata:



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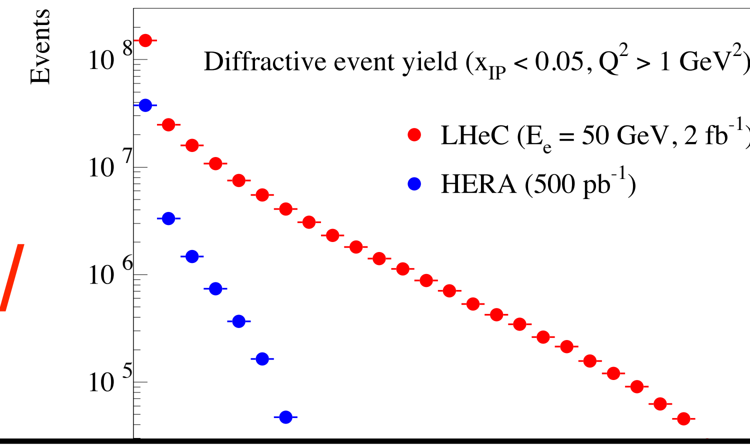
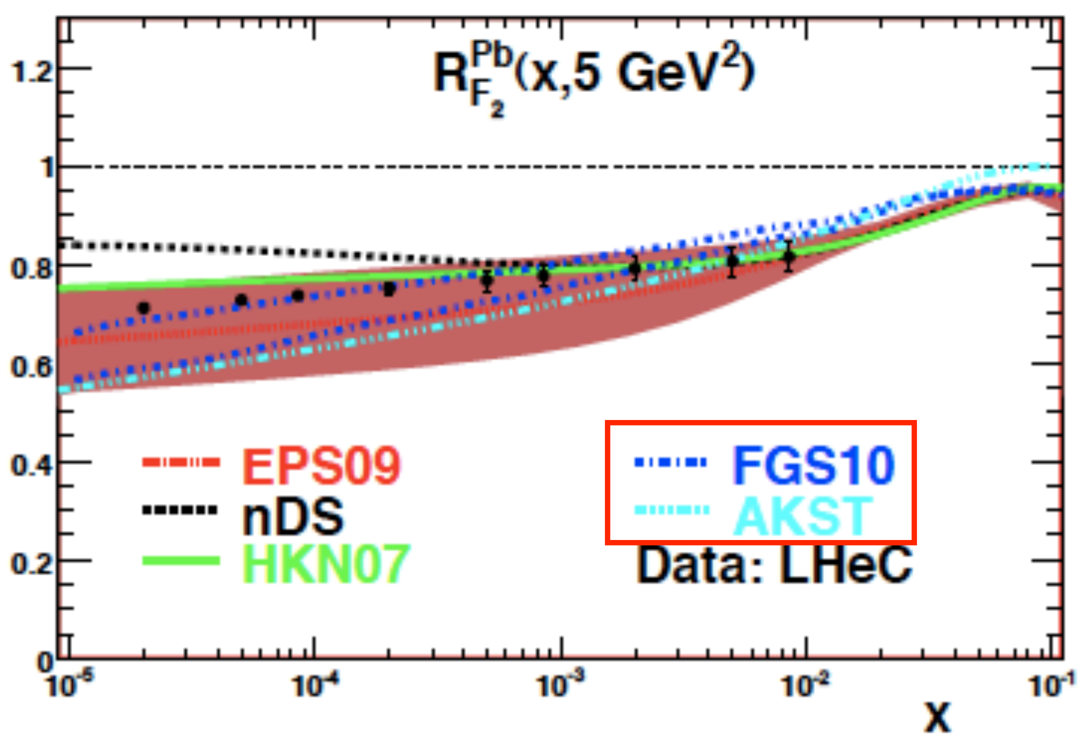
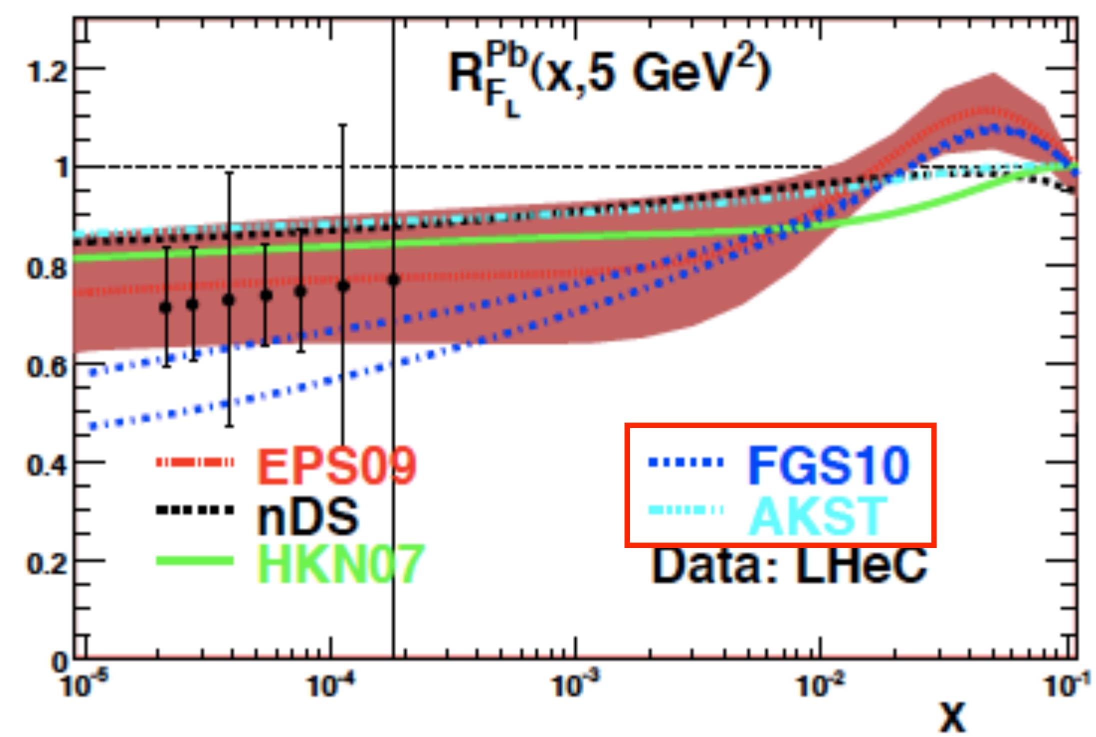


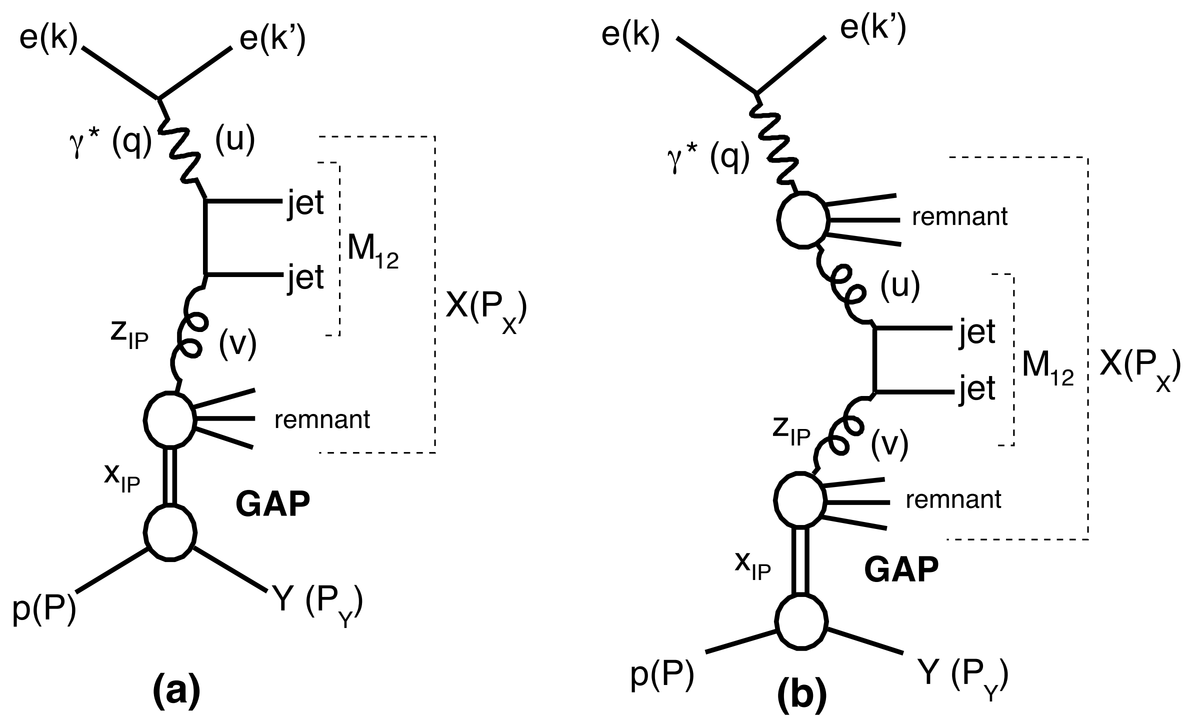
Note: diffraction in ep is linked to shadowing in eA (Gribov): FGS, Capella-Kaidalov et al,...

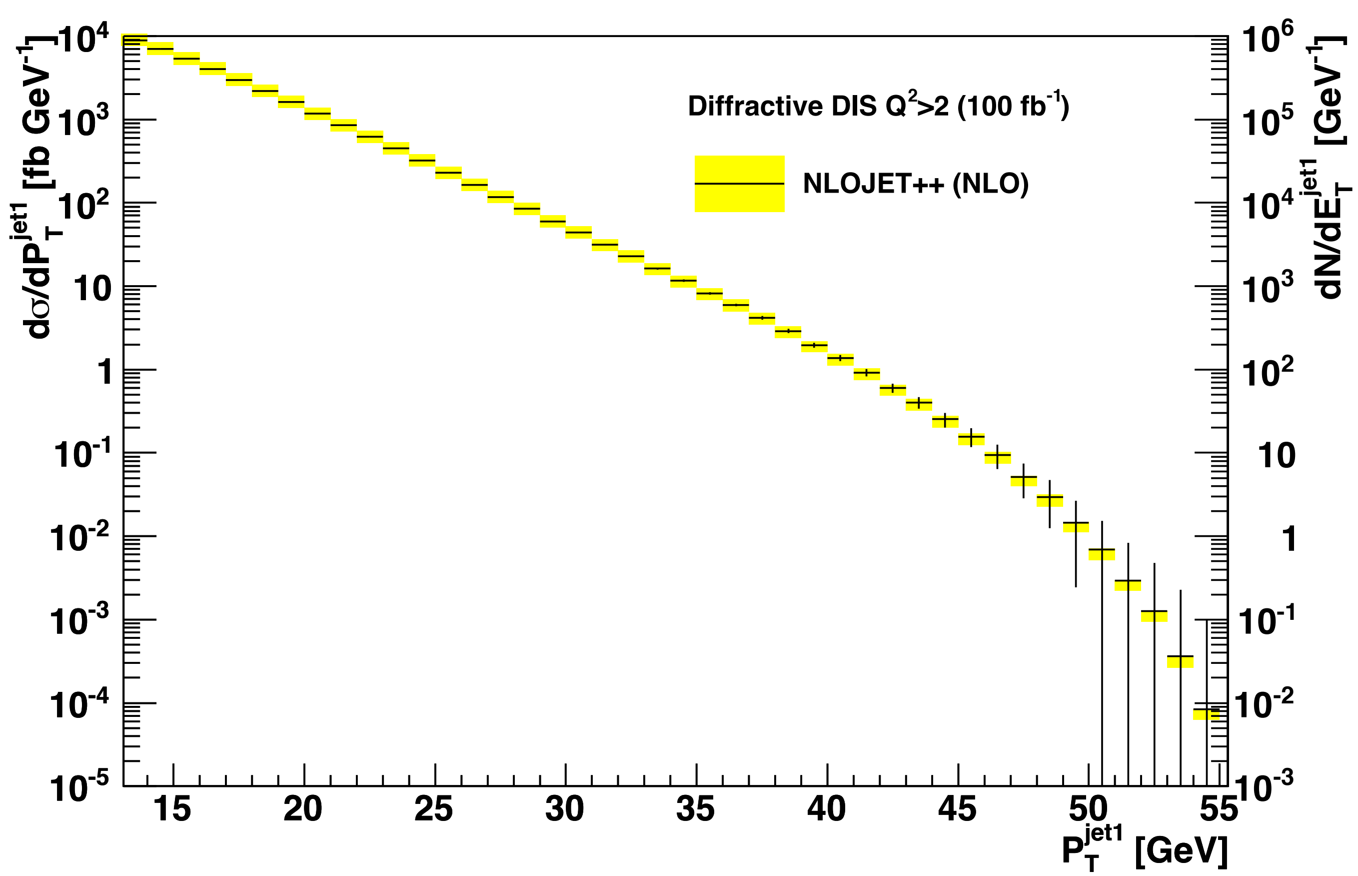




β β

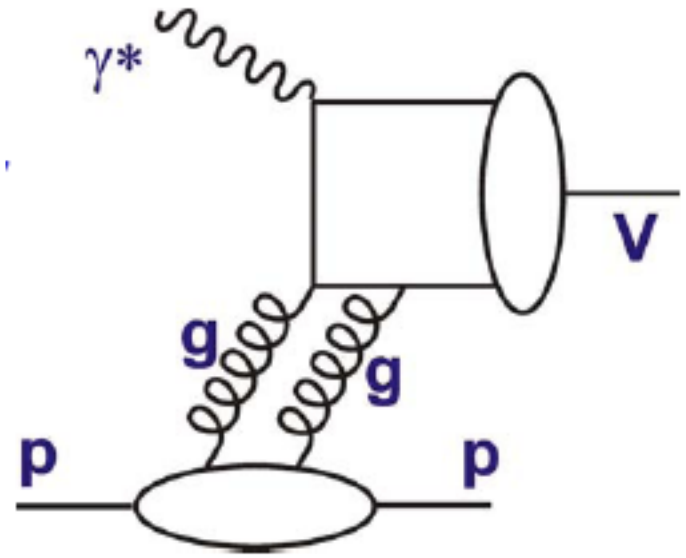
Diffractive dijets:

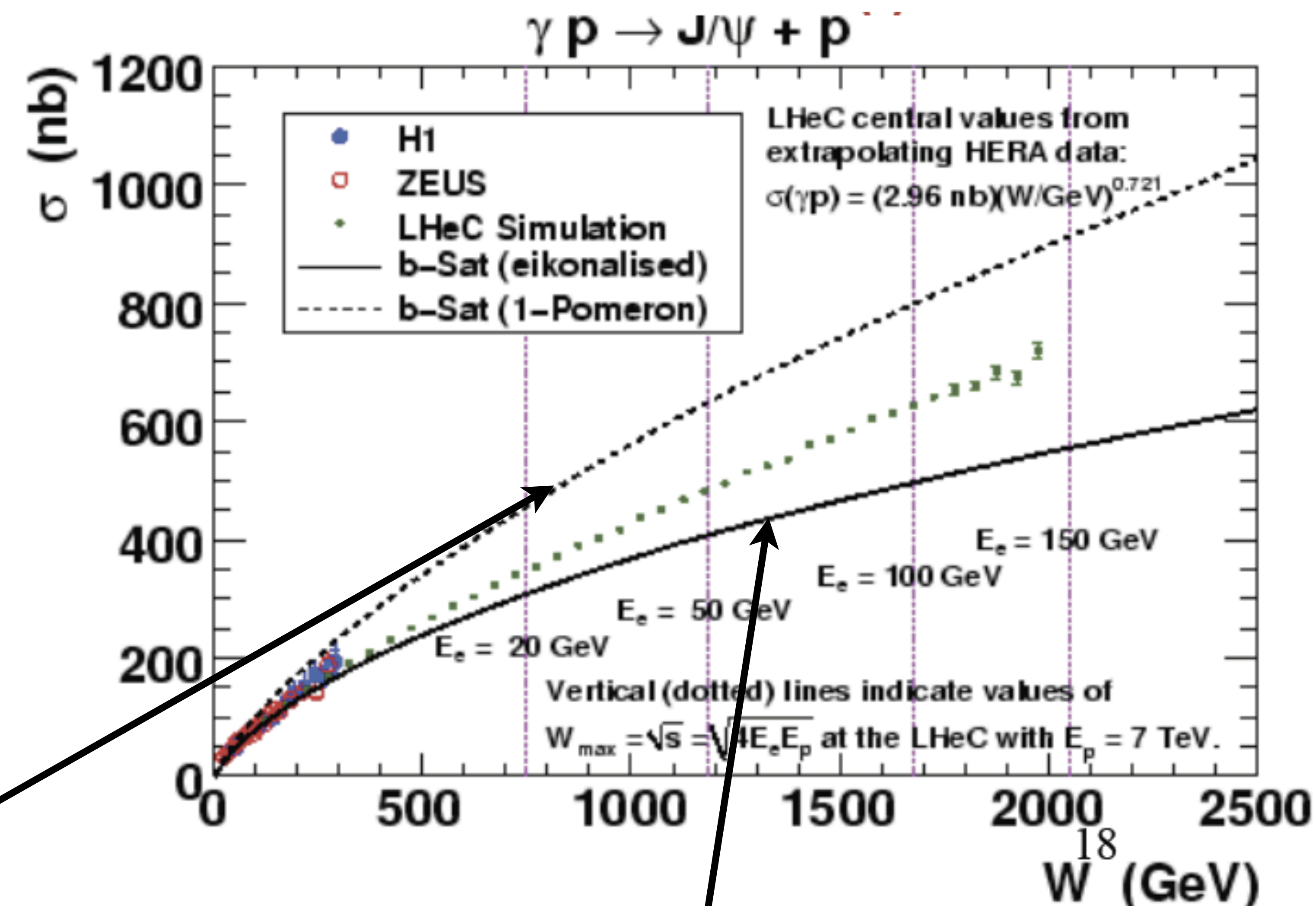




- Diffractive dijet and open heavy flavour production offer large possibilities for:
  - → Checking factorization in hard diffraction.
  - → Constraining DPDFs.
- Large yields up to large p_T^{jet}.
- Direct and resolved contributions: photon PDFs.

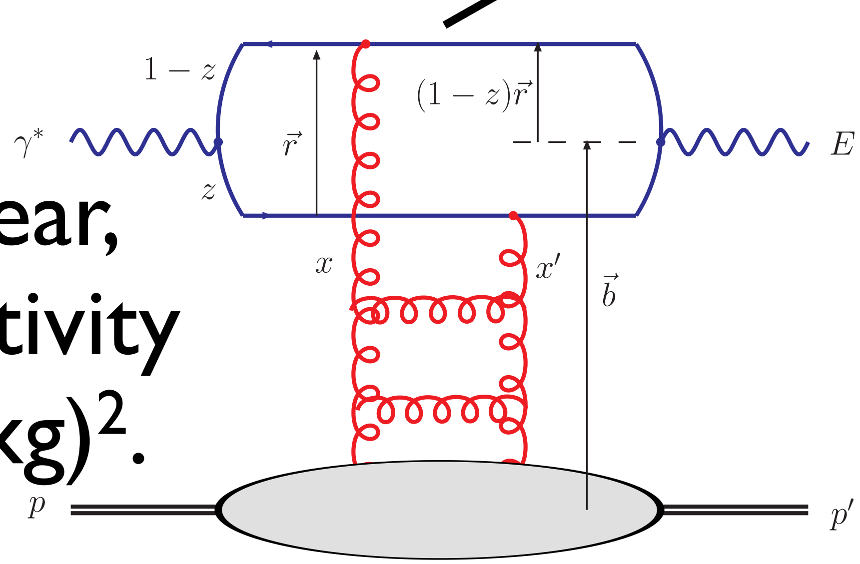
Elastic VM production in ep:

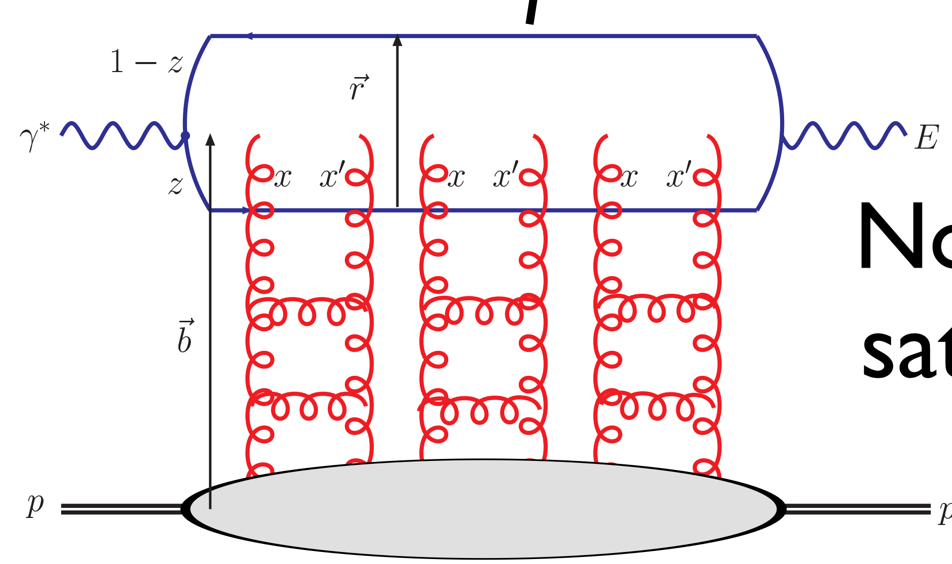




- Elastic J/ψ production appears as a candidate to signal saturation effects at work!!!

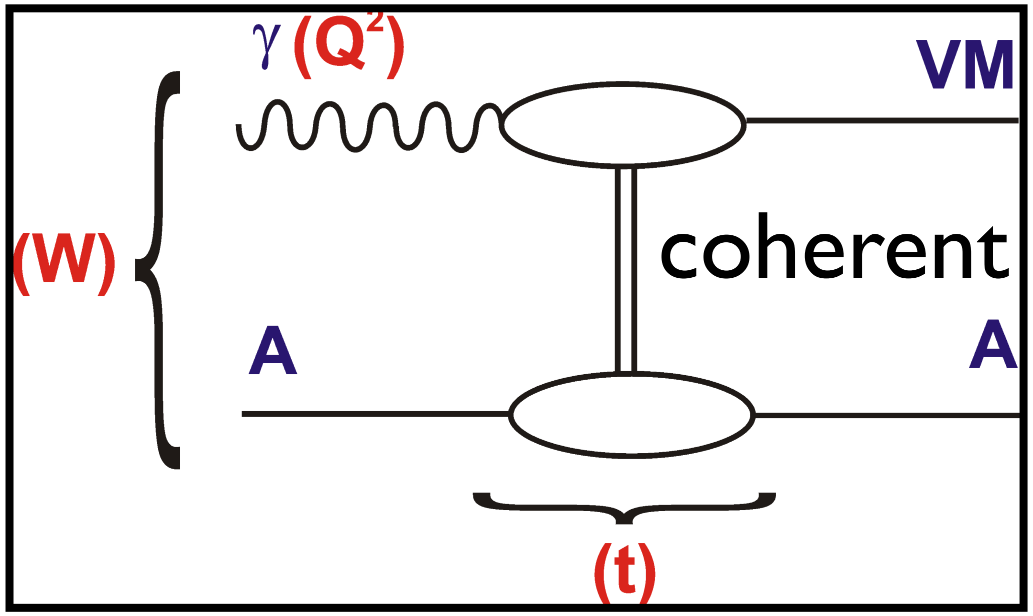
Linear, sensitivity to $(xg)^2$.





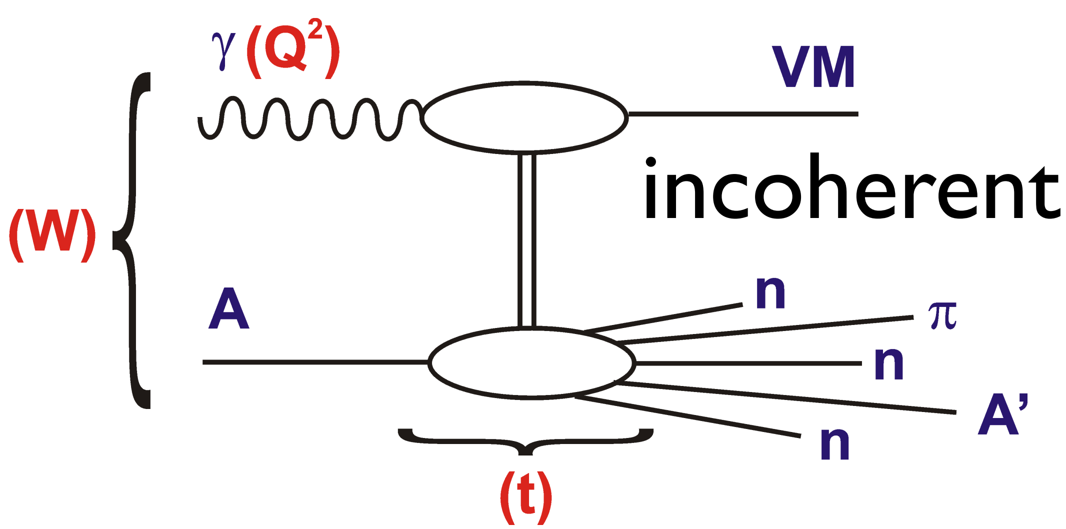
Non-linear, saturation.

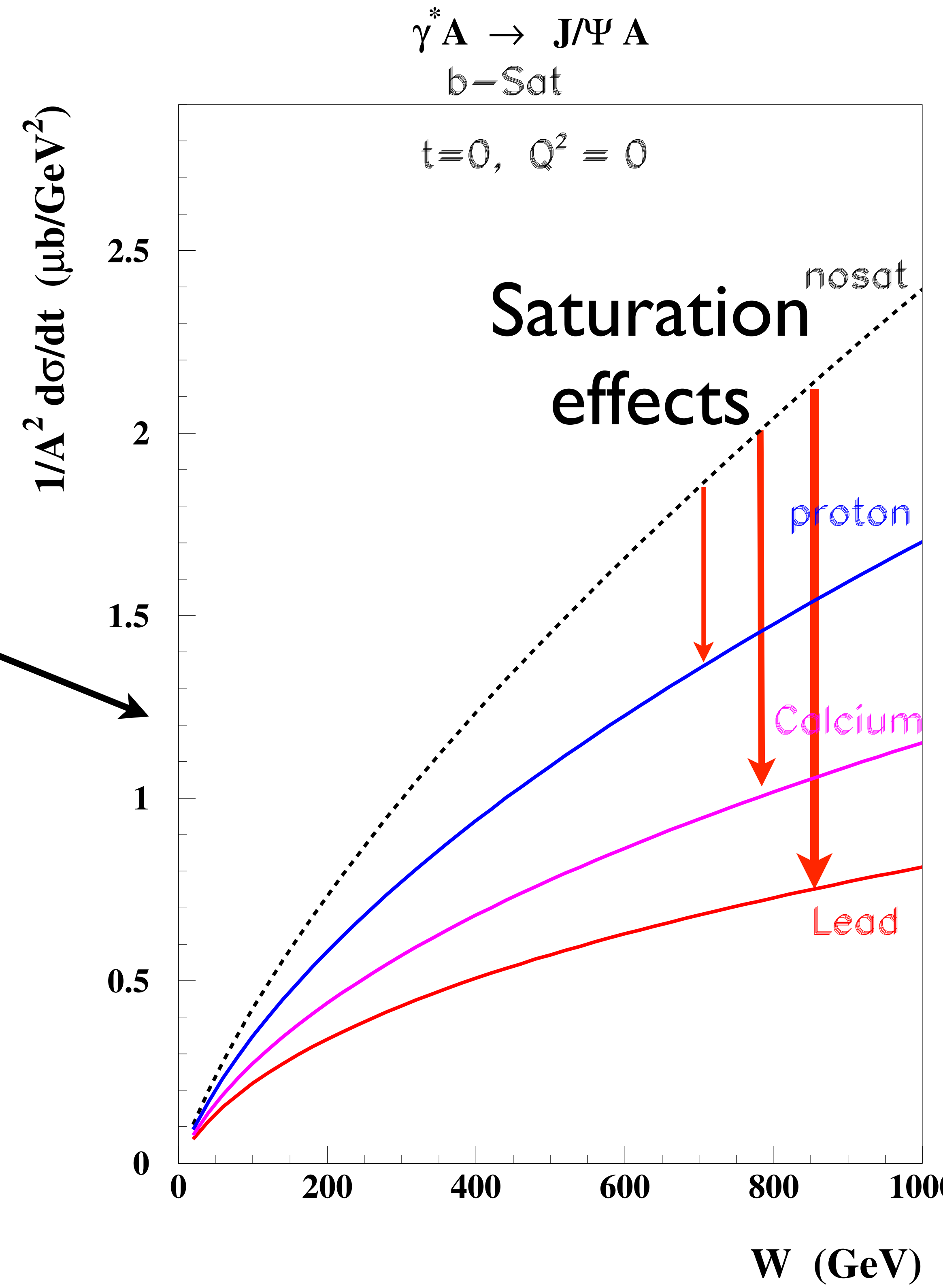
Elastic VM production in eA:



- For the coherent case, predictions available.

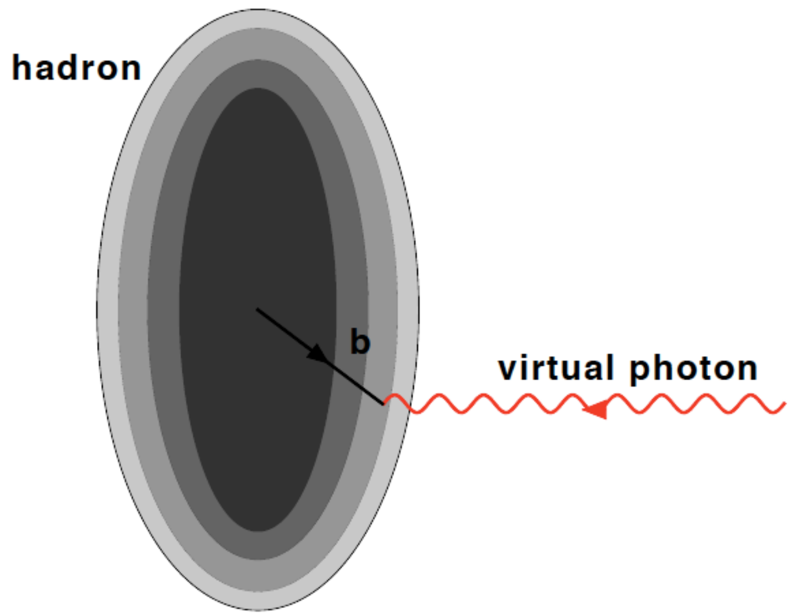
- Challenging experimental problem.

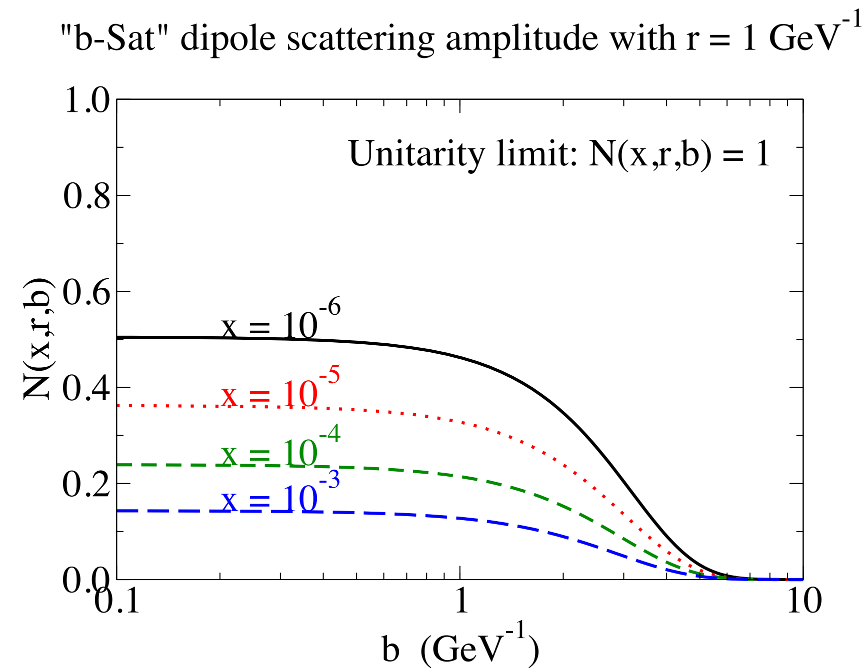


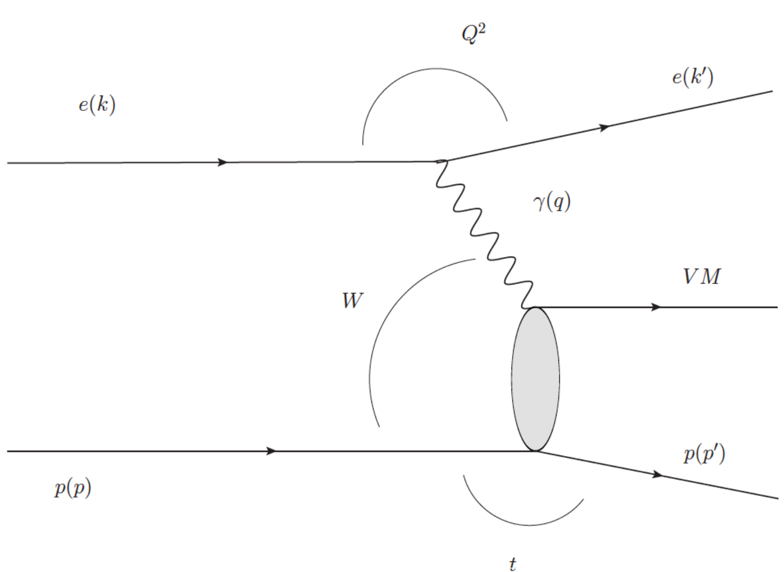


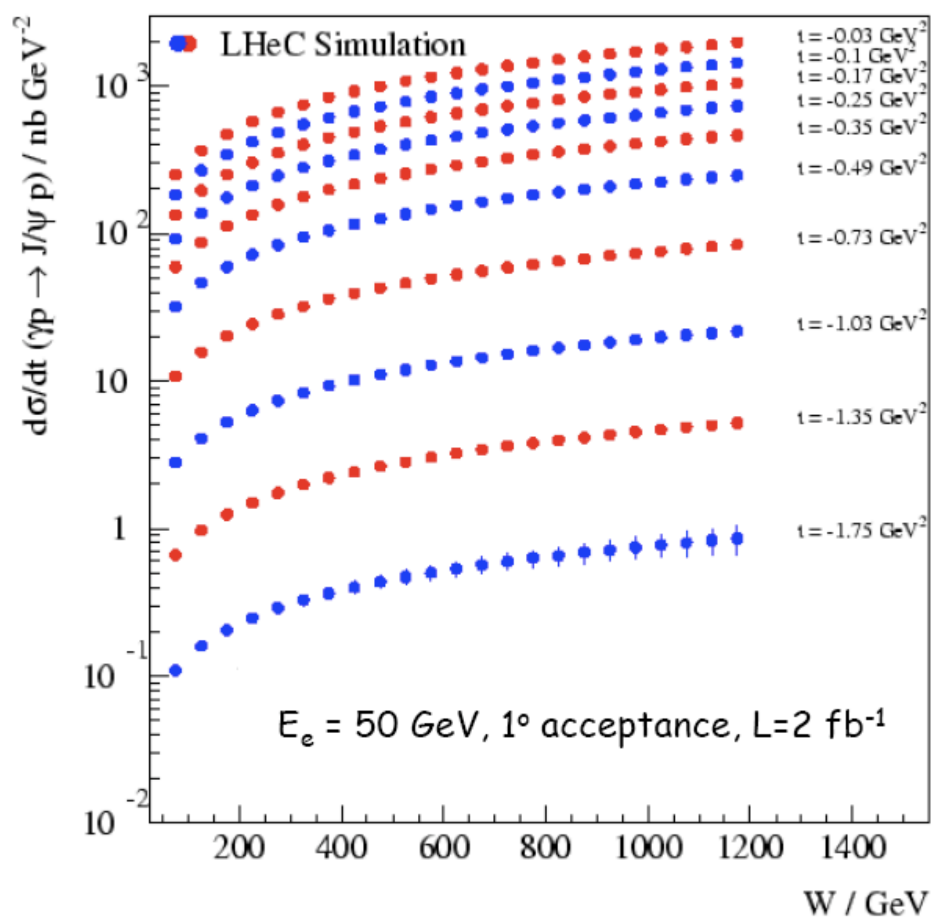
Transverse scan: elastic VM

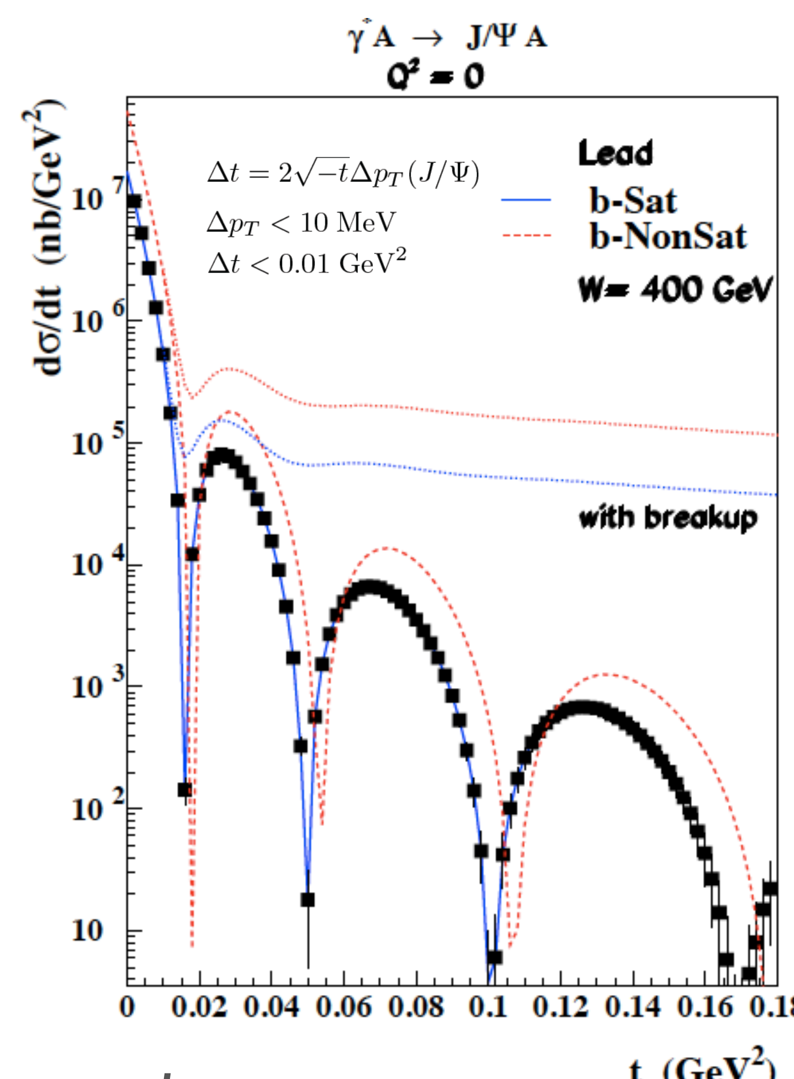
- t-differential measurements give a gluon tranverse mapping of the hadron/nucleus.





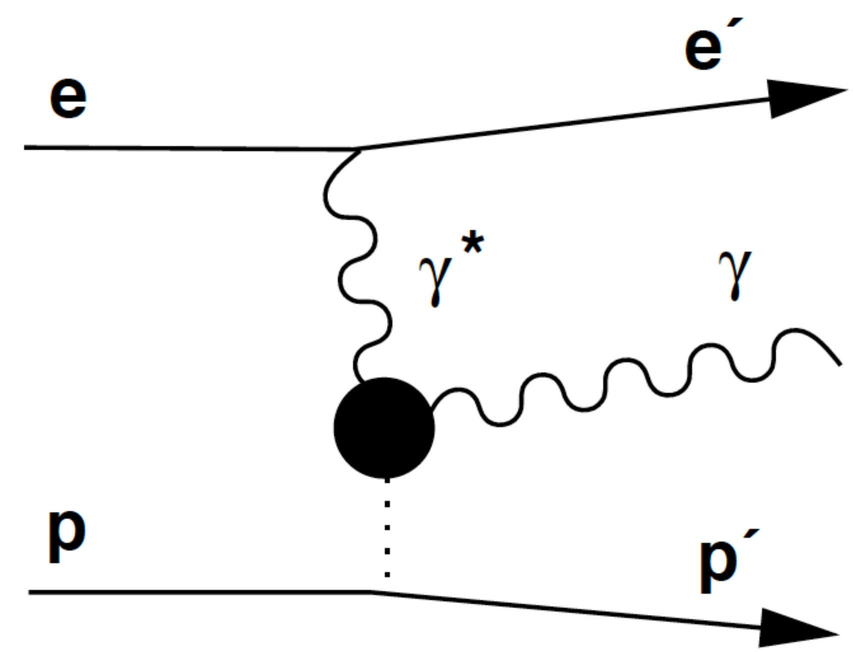




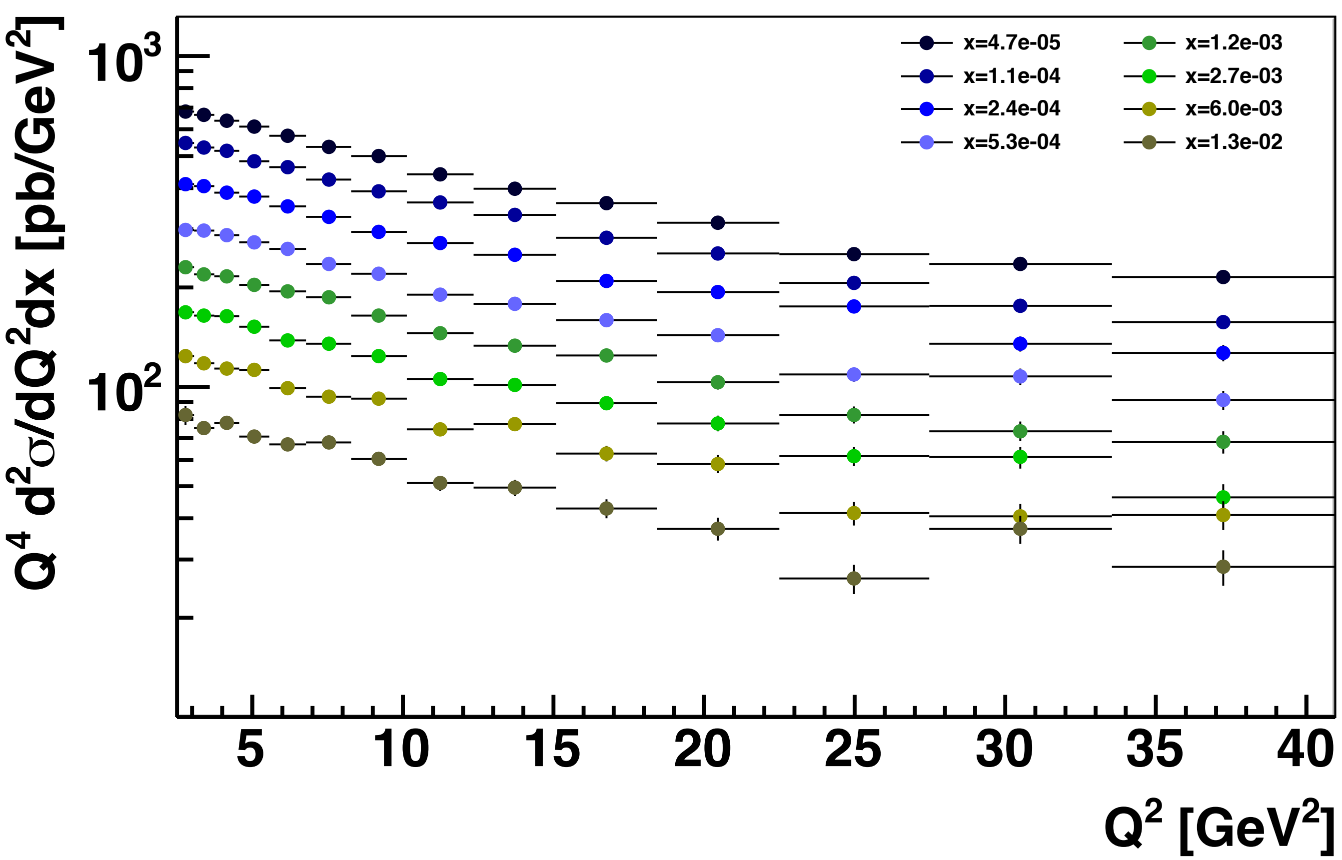


DVCS:

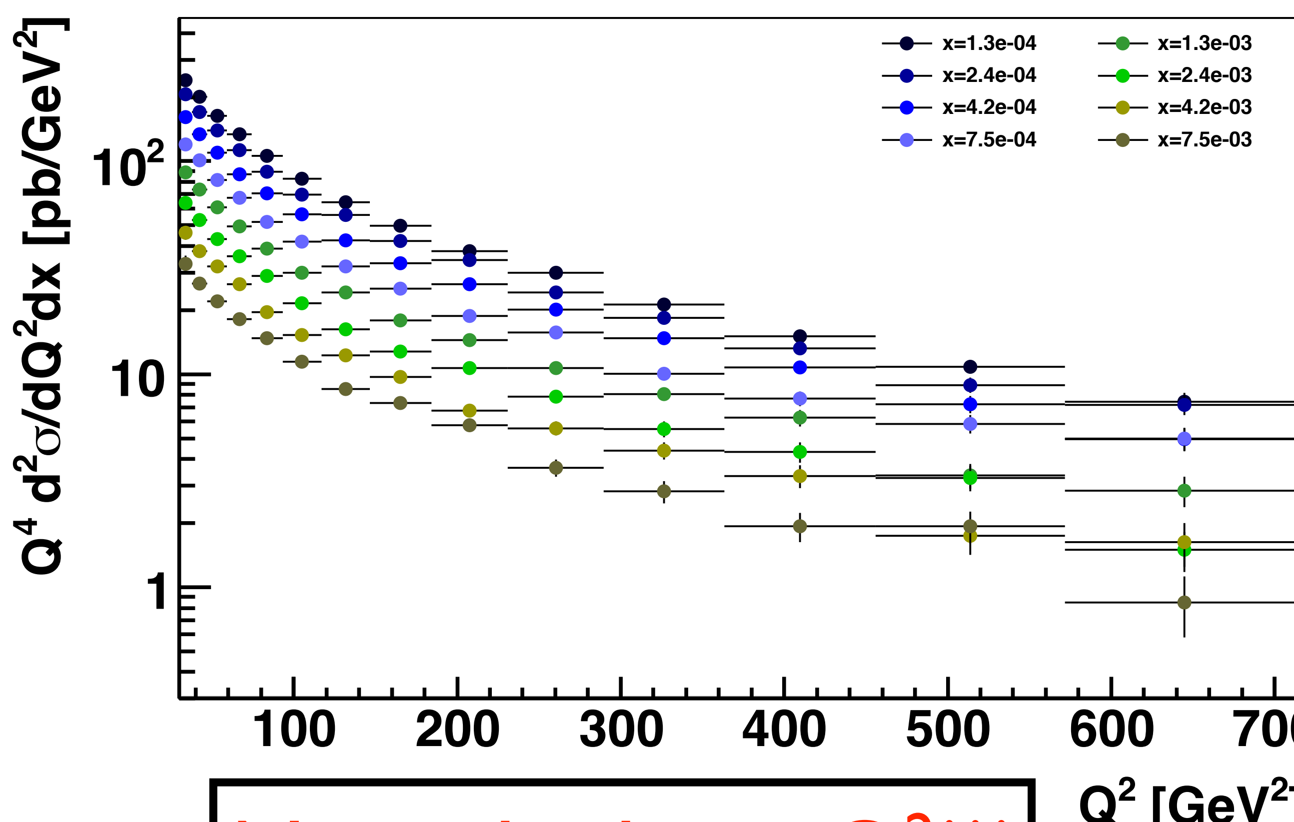
- Exclusive processes give information about GPDs, whose Fourier transform gives a tranverse scan of the hadron: DVCS sensitive to the singlet.
- Sensitive to dynamics e.g. non-linear effects.



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

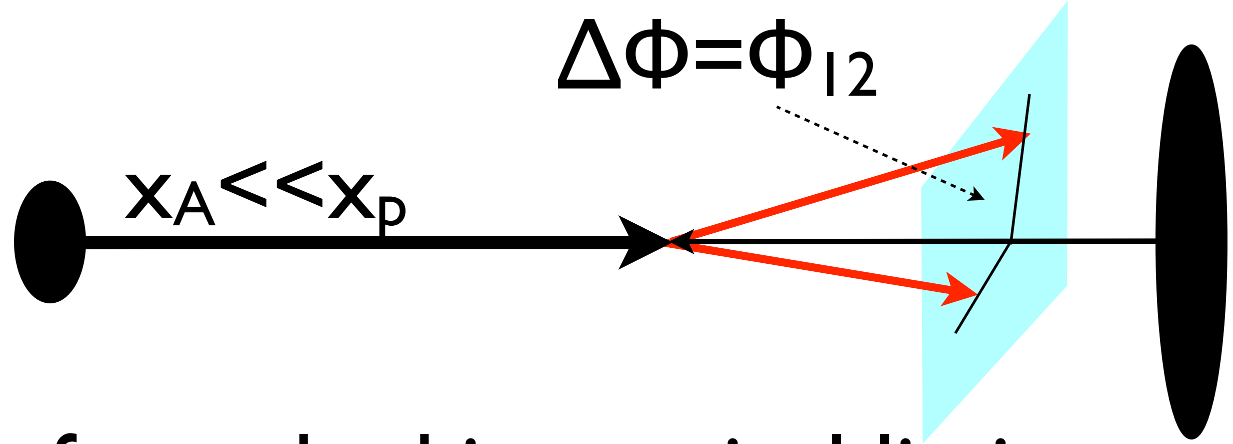


DVCS, E_e=50 GeV, 10°,
$p_T^{\gamma,cut}$=5 GeV, 100 fb^{-1}

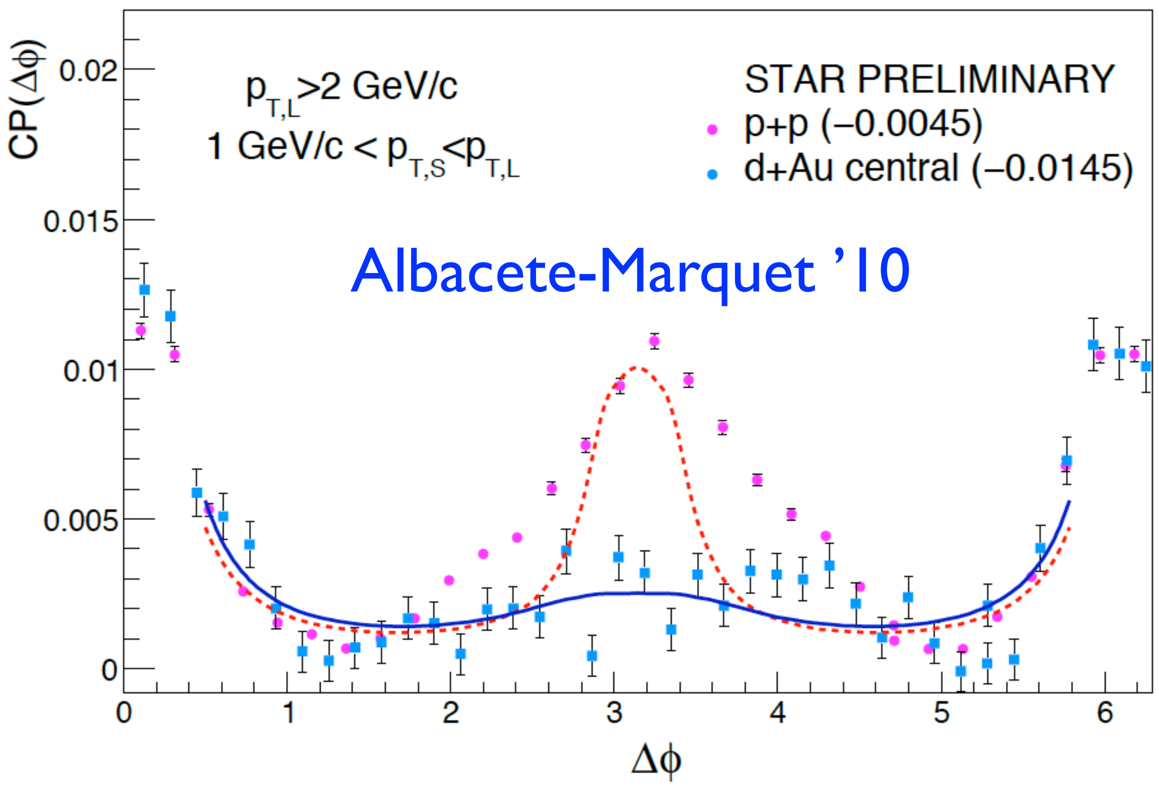


Note the huge Q^2!!!

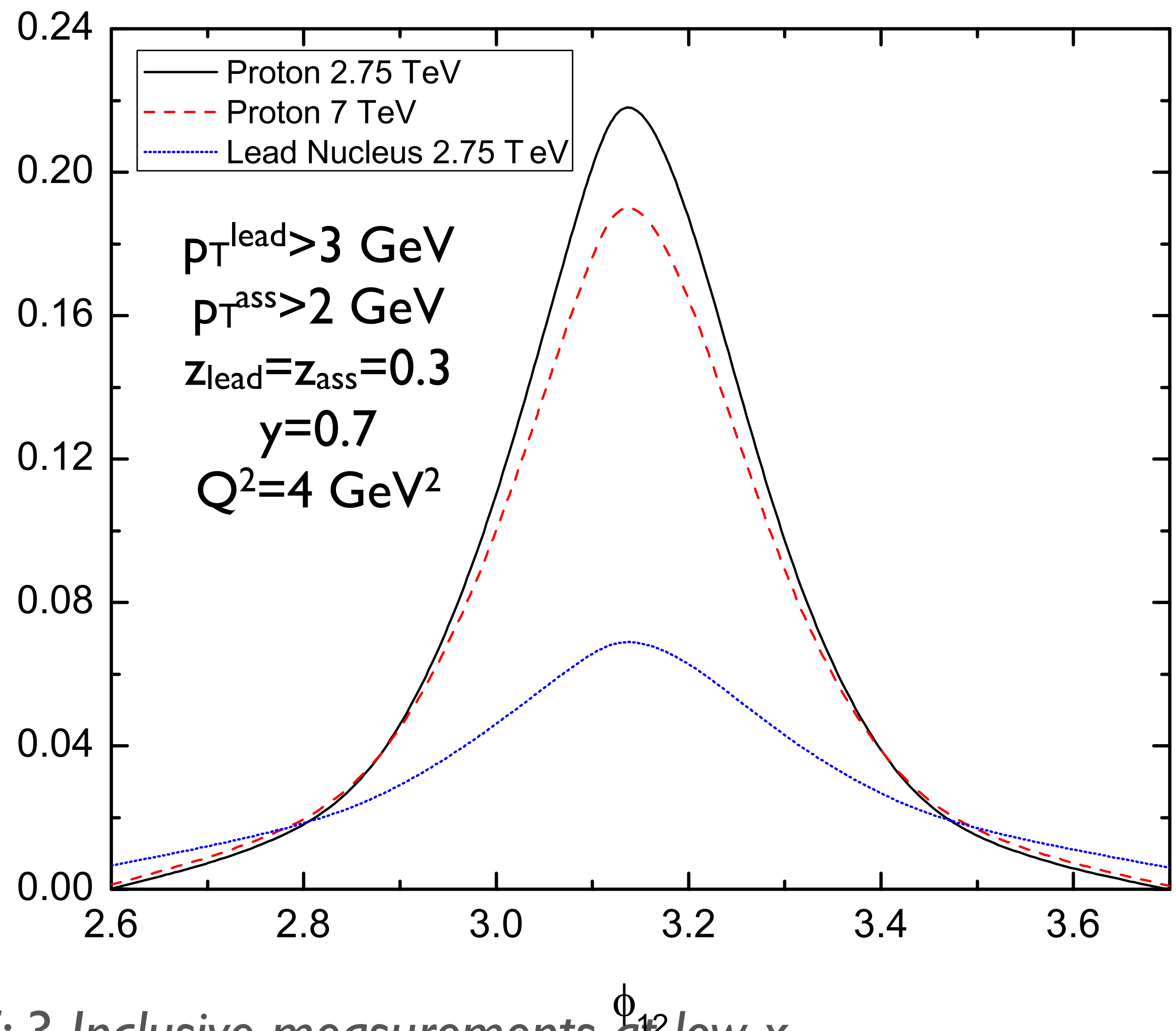
Dihadron azimuthal decorrelation:



- Dihadron azimuthal decorrelation: currently discussed at RHIC as suggestive of saturation.
- At the LHeC it could be studied far from the kinematical limits.



$$C(\phi_{12}) = \frac{1}{\frac{d\sigma(\gamma^* N \to h_1 X)}{dz_{h1}}} \frac{d\sigma^{\gamma^* N \to h_1 h_2 + X}}{dz_{h1} dz_{h2} d\phi_{12}}$$



Dijet azimuthal decorrelation:

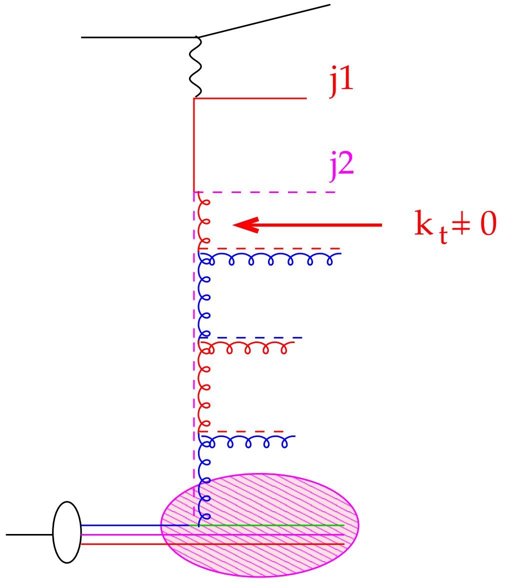
- Studying dijet azimuthal decorrelation or forward jets ($p_T \sim Q$) would allow to understand the mechanism of radiation:

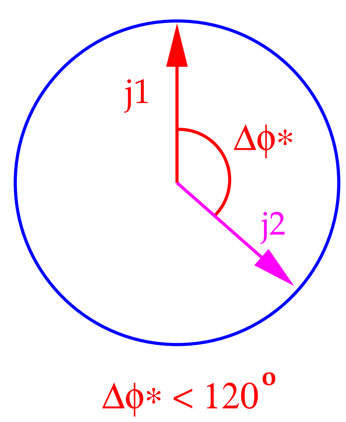
→ k_T-ordered: DGLAP.

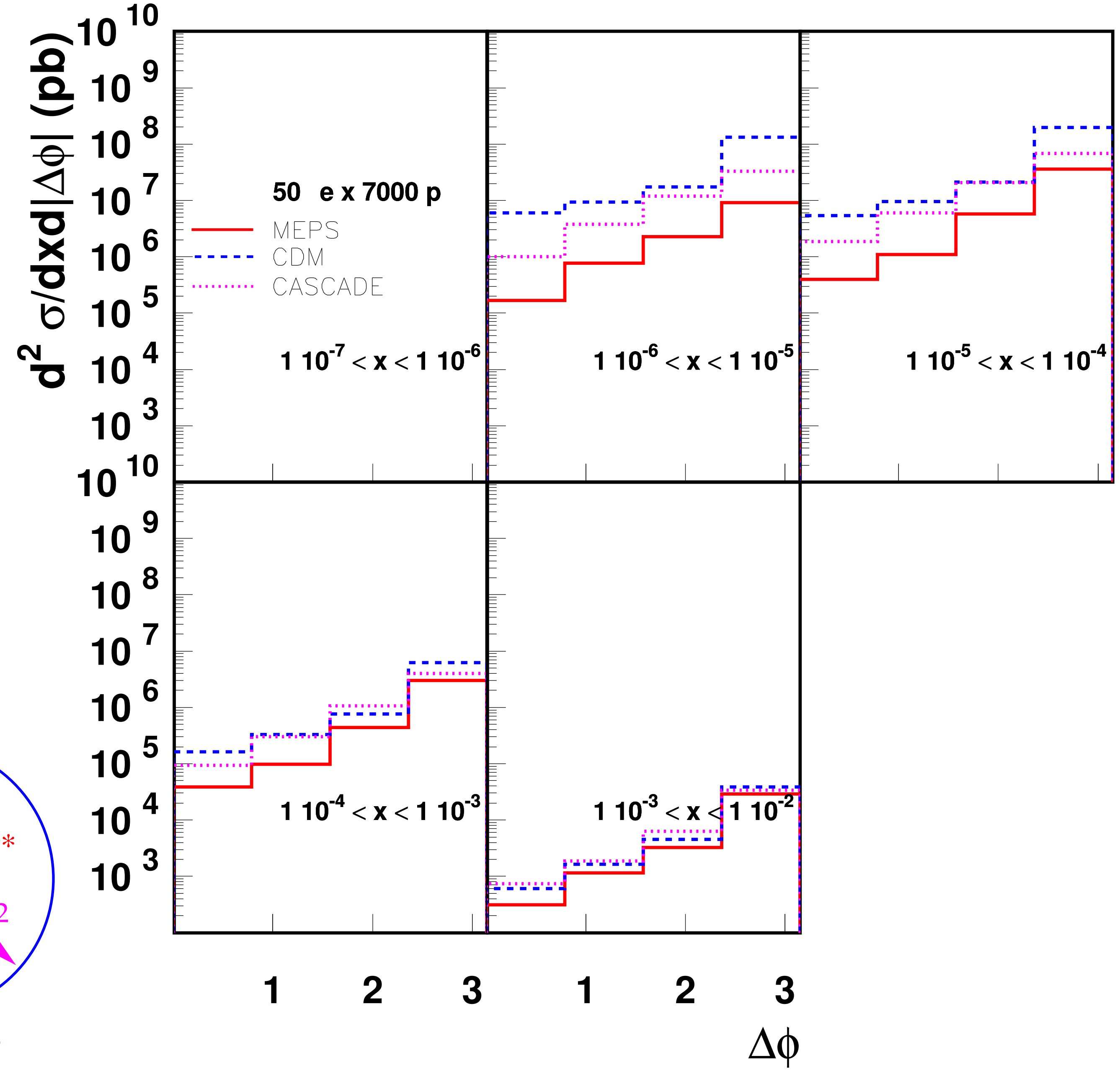
→ k_T-disordered: BFKL.

→ Saturation?

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







Forward jets:

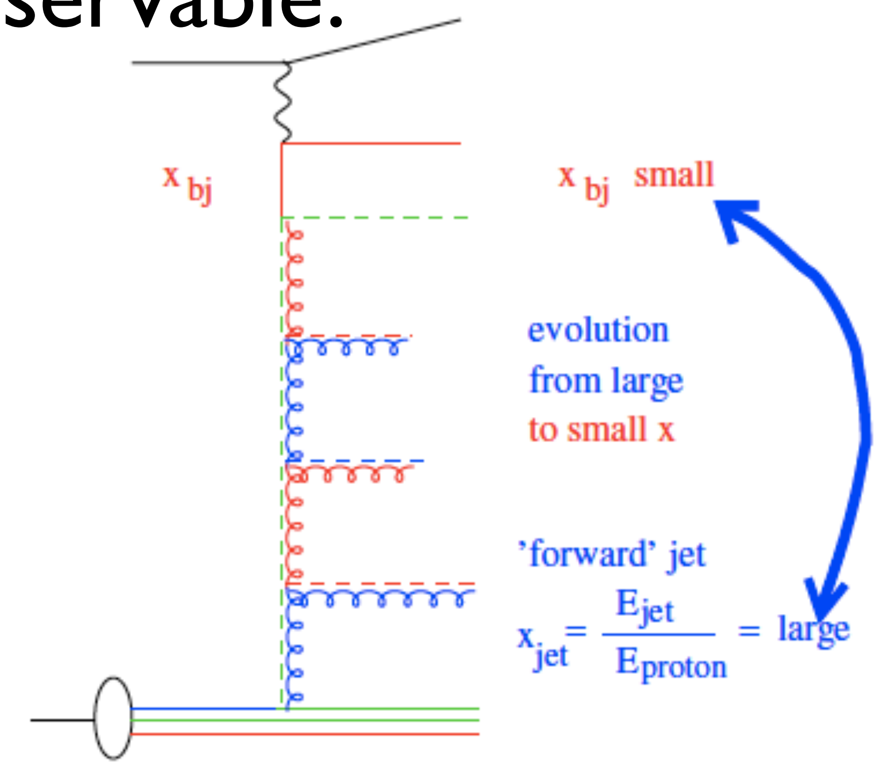
- Studying dijet azimuthal decorrelation or forward jets ($p_T \sim Q$) would allow to understand the mechanism of radiation:

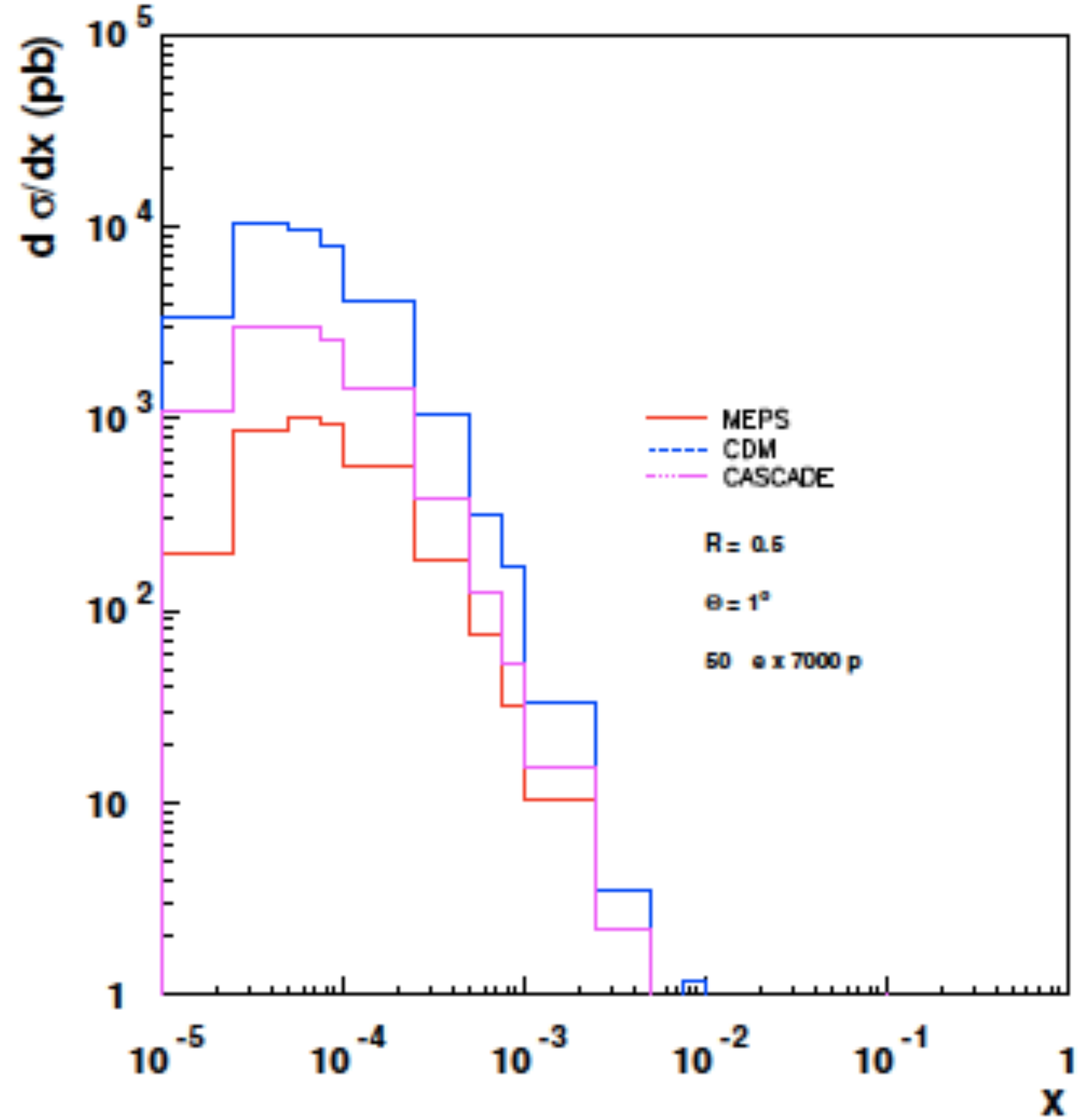
→ k_T-ordered: DGLAP.

→ k_T-disordered: BFKL.

→ Saturation?

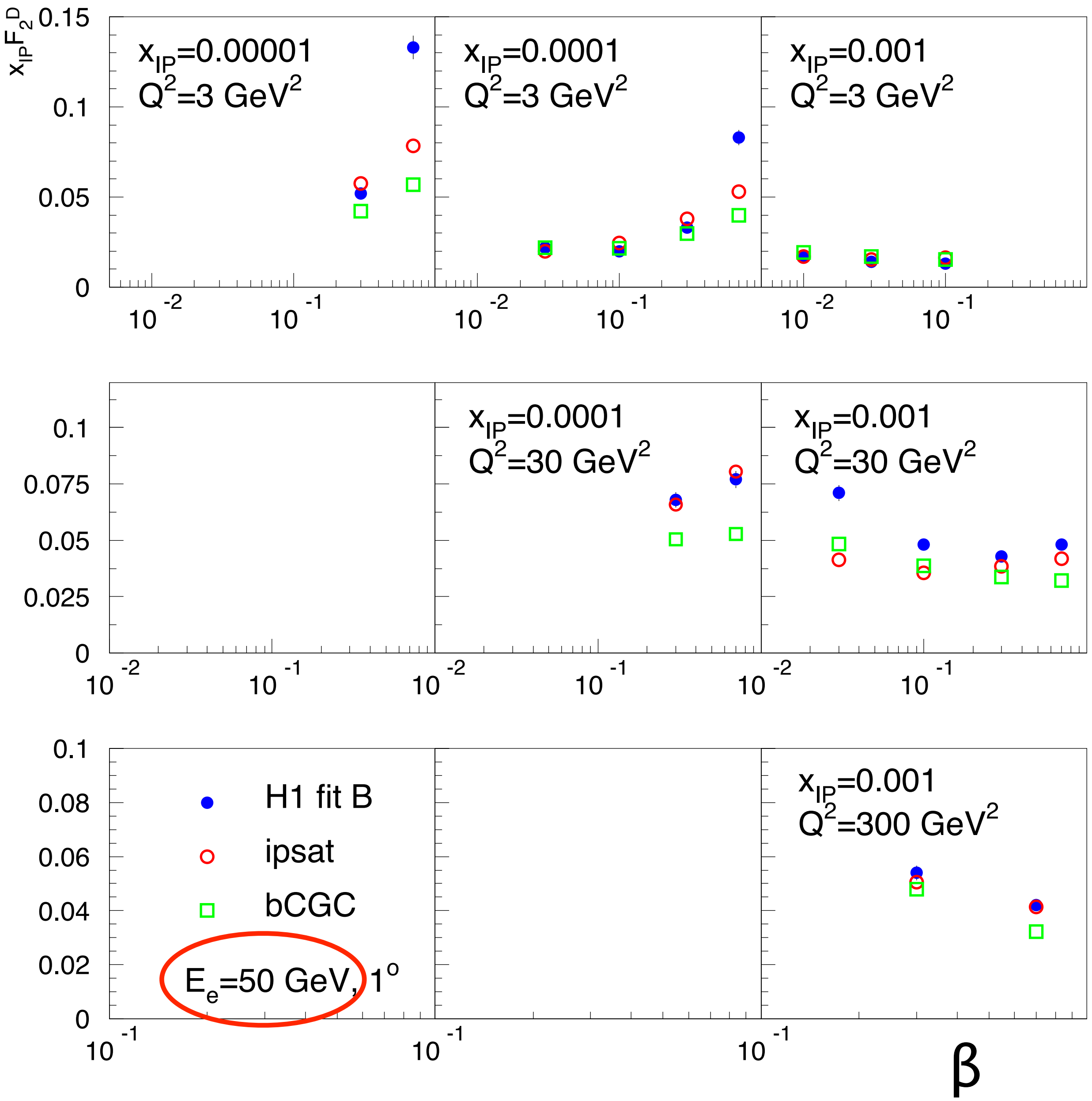
- Further imposing a rapidity gap (diffractive jets) would be most interesting: perturbatively controllable observable.

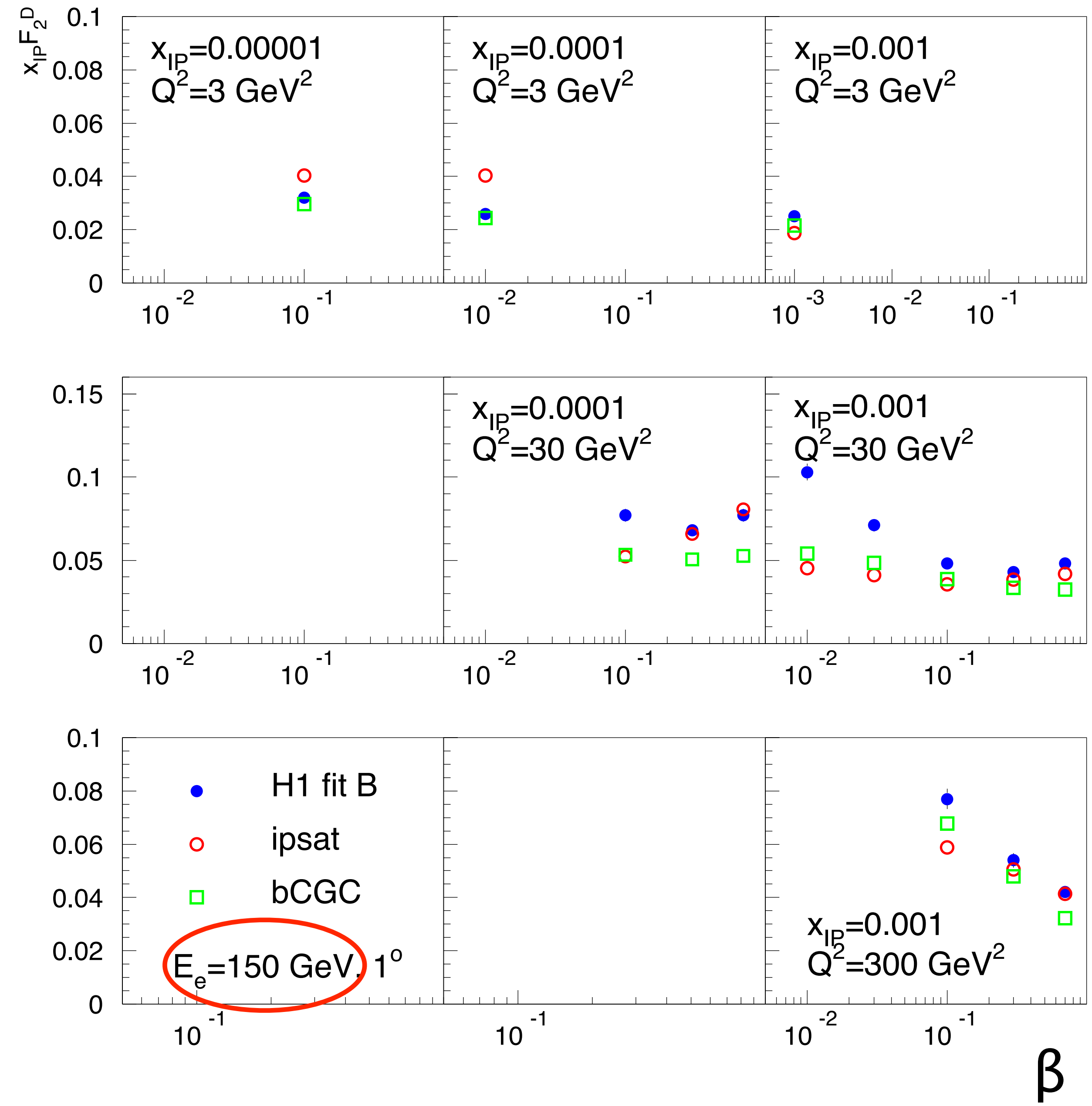




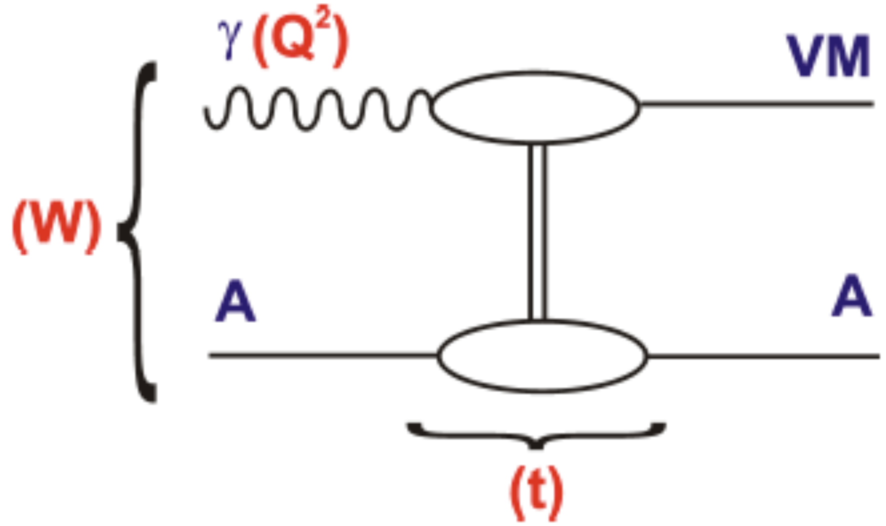
Diffraction and non-linear dynamics:

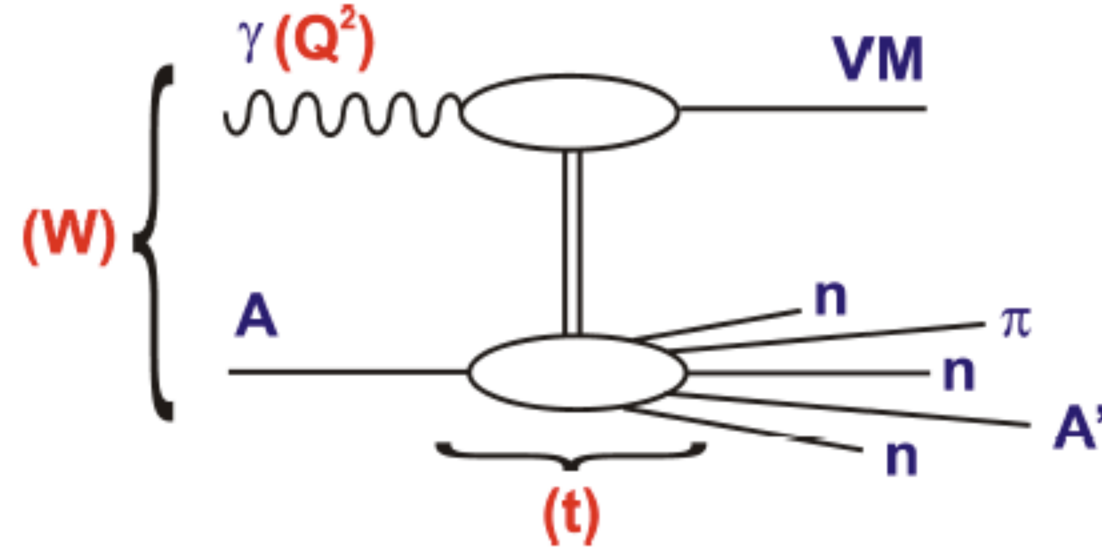
- Dipole models show differences with linear-based extrapolations (HERA-based dpdf’s) and among each other: possibility to check saturation and its realization.





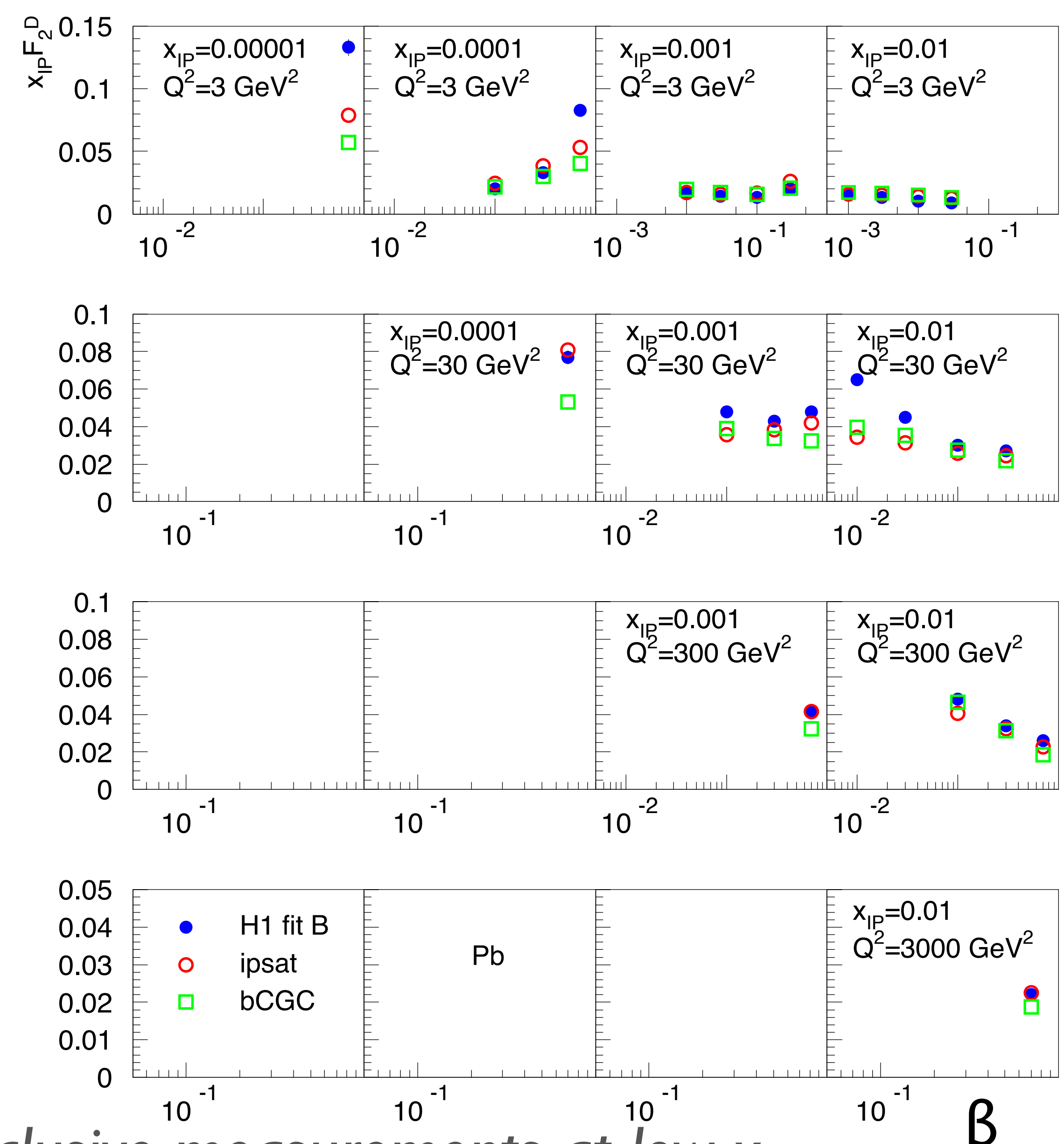
Diffractive DIS on nuclear targets:





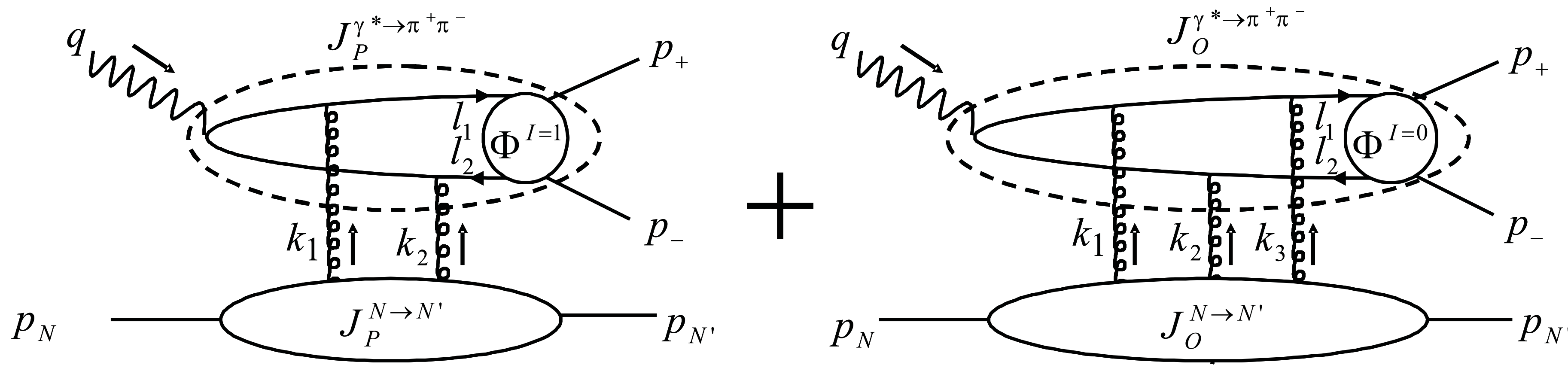
- Challenging experimental problem, requires Monte Carlo simulation with detailed understanding of the nuclear break-up.

- For the coherent case, predictions available.



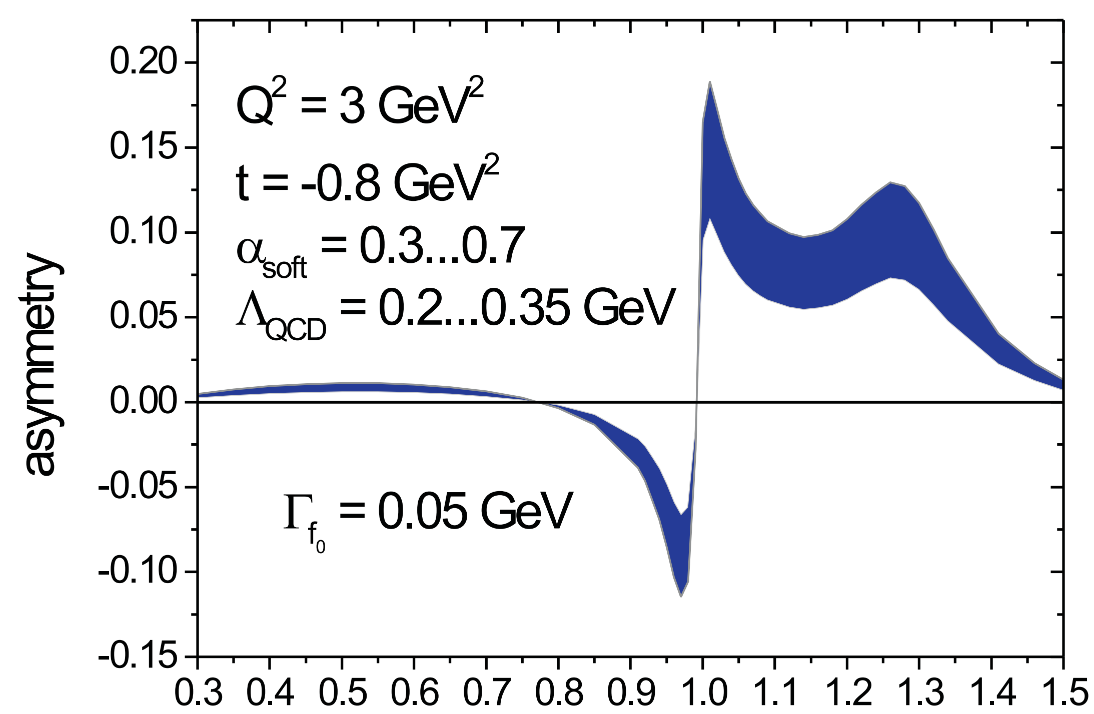
Odderon:

- Odderon (C-odd exchange contributing to particle-antiparticle difference in cross section) seached in $\gamma^{(\star)}p \to Cp$, where $C = \pi^0, \eta, \eta', \eta_c \ldots$ or through O-P interferences.



$$A(Q^2, t, m_{2\pi}^2) = \frac{\int \cos\theta \, d\sigma(W^2, Q^2, t, m_{2\pi}^2, \theta)}{\int d\sigma(W^2, Q^2, t, m_{2\pi}^2, \theta)} = \frac{\int_{-1}^{1} \cos\theta \, d\cos\theta \, 2\,\mathrm{Re}\left[\mathcal{M}_P^{\gamma_L^*} (\mathcal{M}_O^{\gamma_L^*})^*\right]}{\int_{-1}^{1} d\cos\theta \left[|\mathcal{M}_P^{\gamma_L^*}|^2 + |\mathcal{M}_O^{\gamma_L^*}|^2\right]}$$

- Sizable charge asymmetry, yields and reconstruction pending.

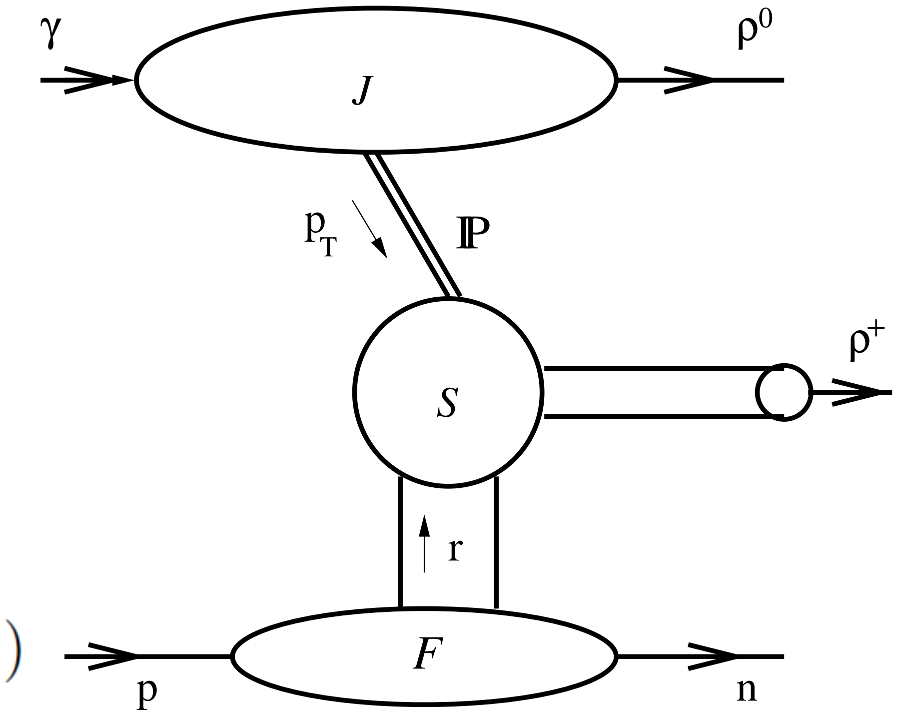


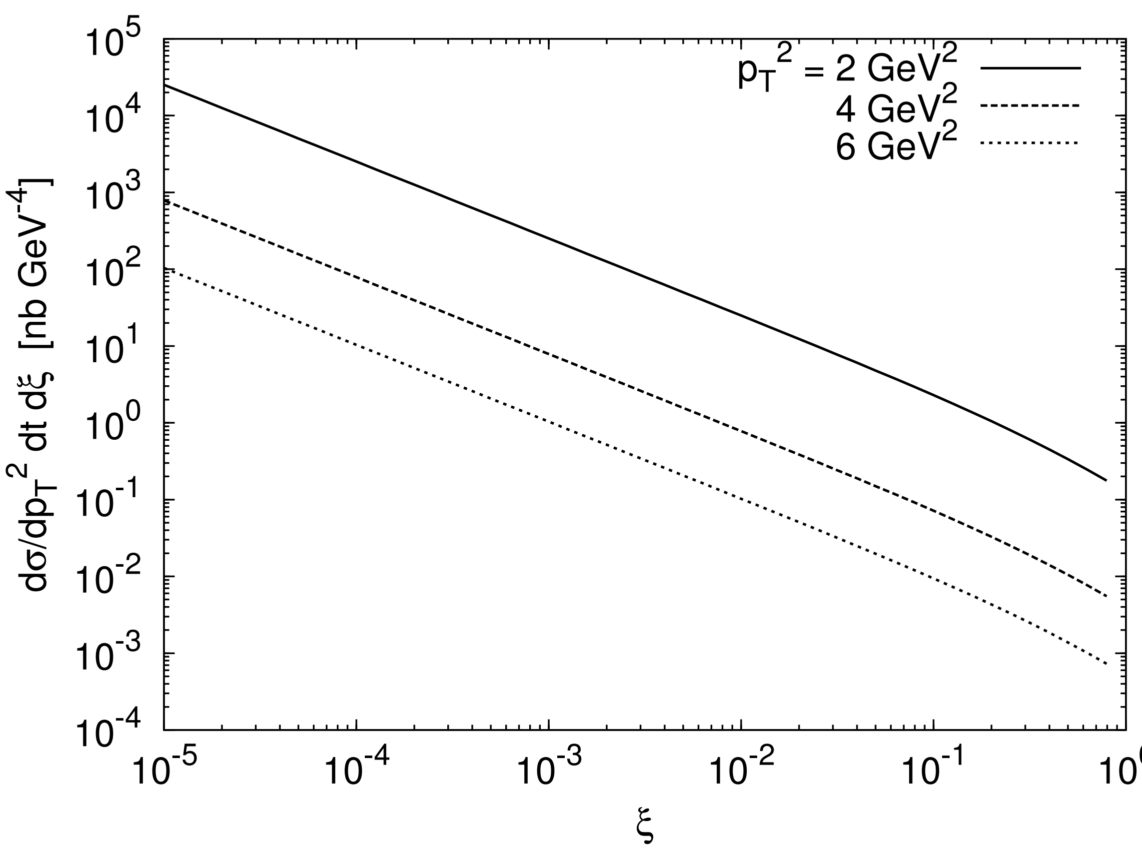
Transversity GPDs:

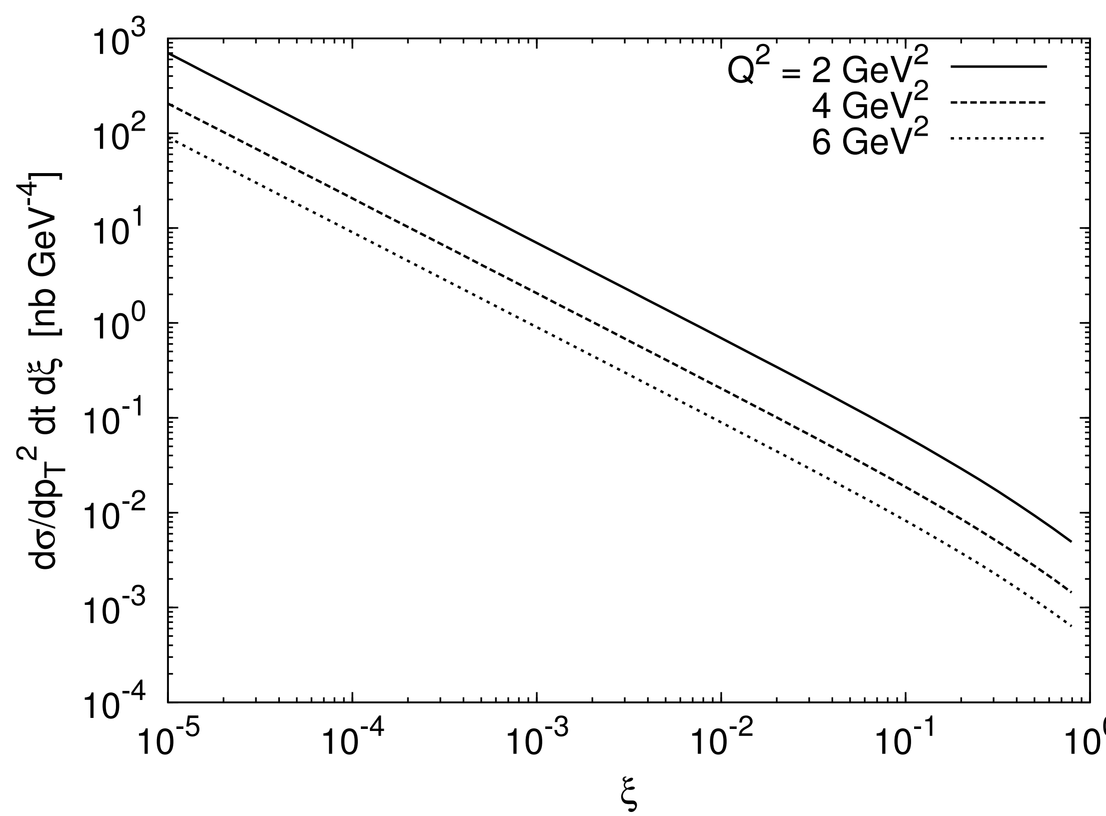
- Chiral-odd transversity GPDs are largely unknown.

- They can be accessed through double exclusive production:

$$ep(p_2) \to e'\gamma^{(*)}_{L/T}(q)\ \ p(p_2) \to e'\rho^0_{L,T}(q_\rho)\ \ \rho_T(p_\rho)\ N'(p_{2'})$$







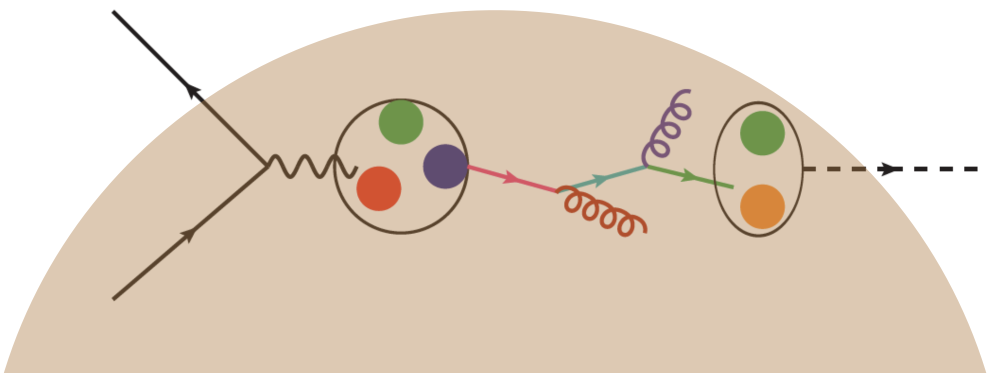
$$\xi \approx x_B/(2-x_B)$$

Radiation and hadronization:

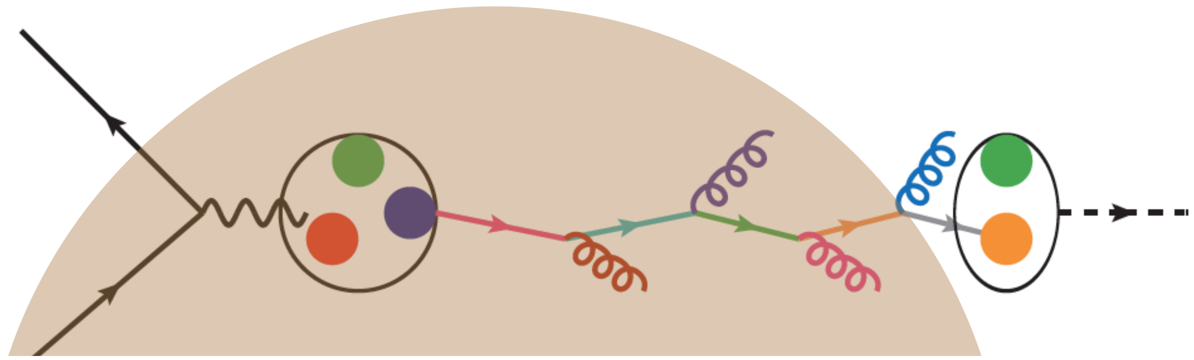
- LHeC: dynamics of QCD radiation and hadronization.
- Most relevant for particle production off nuclei and for QGP analysis in HIC.

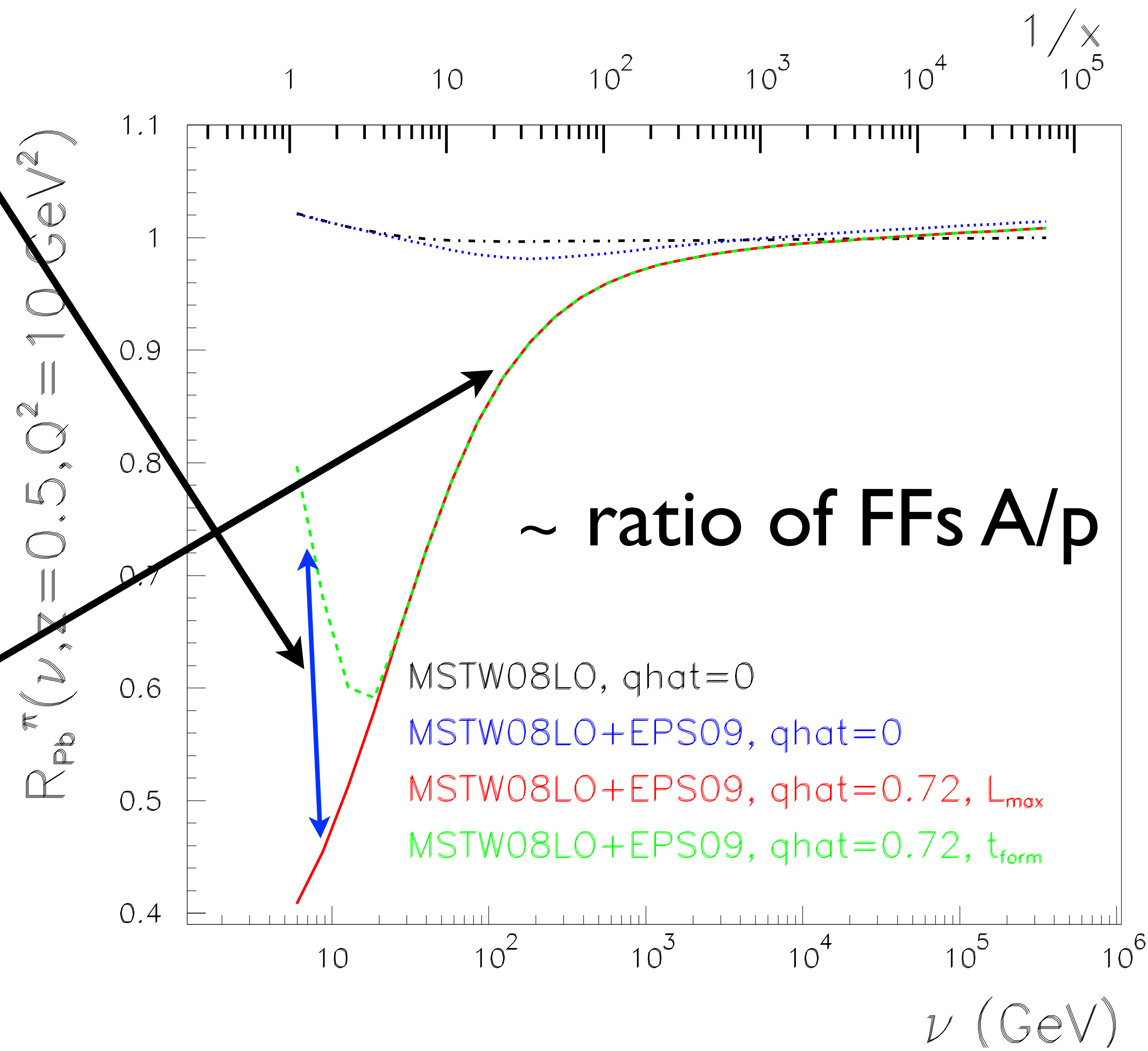
$$R_A^h(z,\nu) = \frac{1}{N_A^e}\frac{dN_A^h(z,\nu)}{d\nu\, dz} \Bigg/ \frac{1}{N_D^e}\frac{dN_D^h(z,\nu)}{d\nu\, dz}$$

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



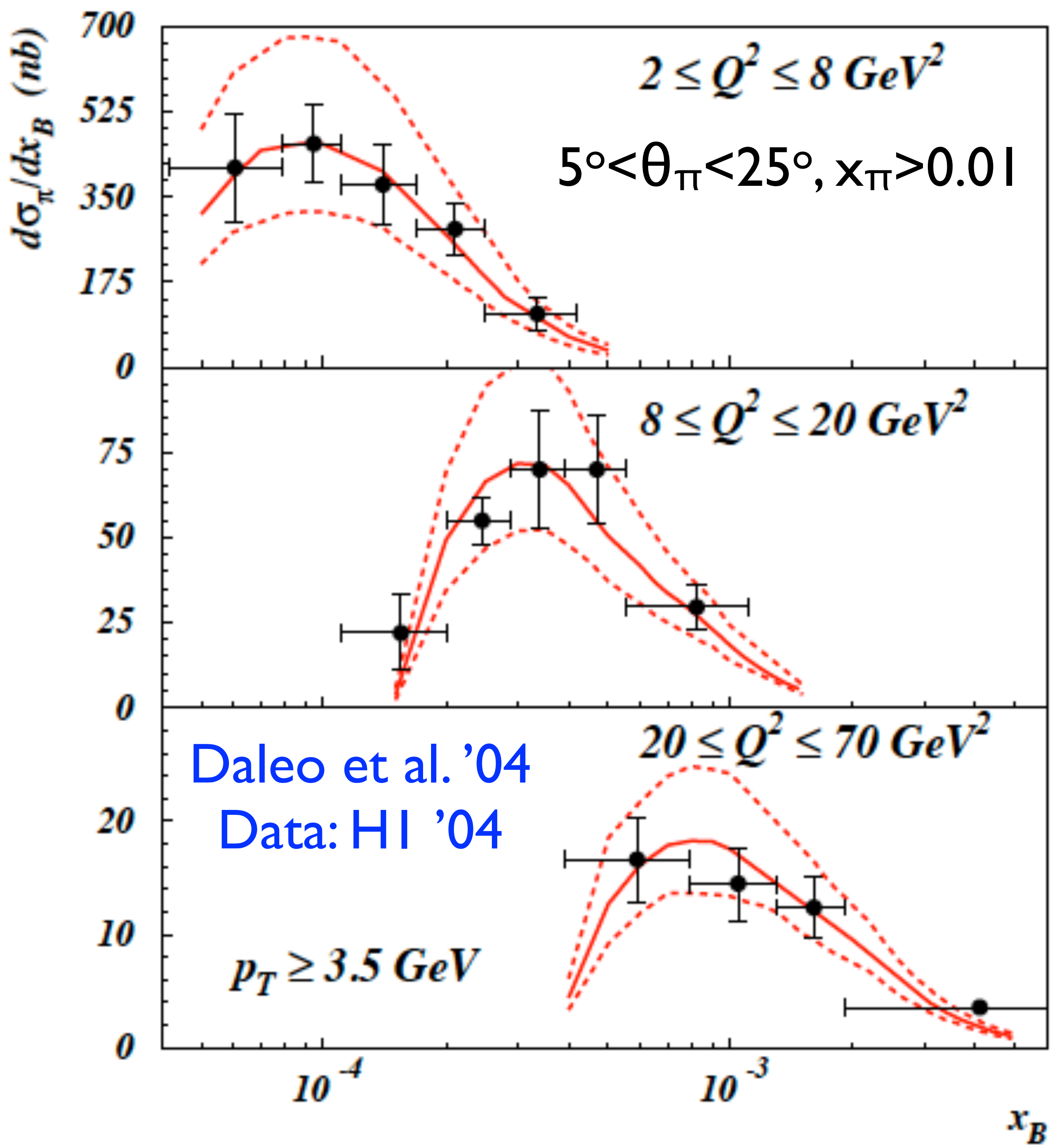
- High energy: partonic evolution altered in the nuclear medium.



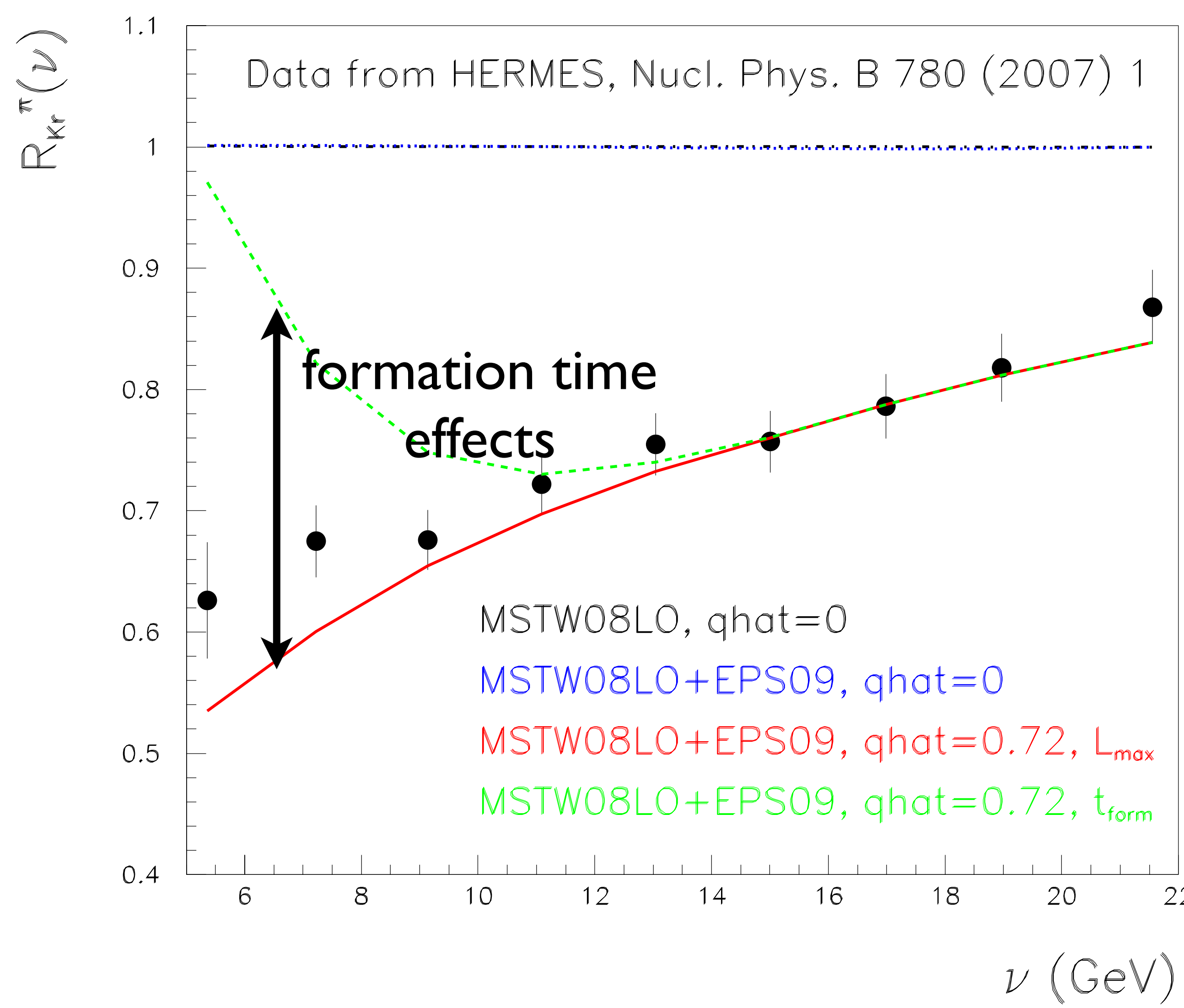


Radiation and hadronization:

- Large (NLO) yields at small-x (H1 cuts, 3 times higher if relaxed).
- Nuclear effects in hadronization at small ν (LO plus QW, Arleo '03).



$$R_A^h(z,\nu) = \frac{1}{N_A^e}\frac{dN_A^h(z,\nu)}{d\nu\, dz} \Bigg/ \frac{1}{N_D^e}\frac{dN_D^h(z,\nu)}{d\nu\, dz}$$



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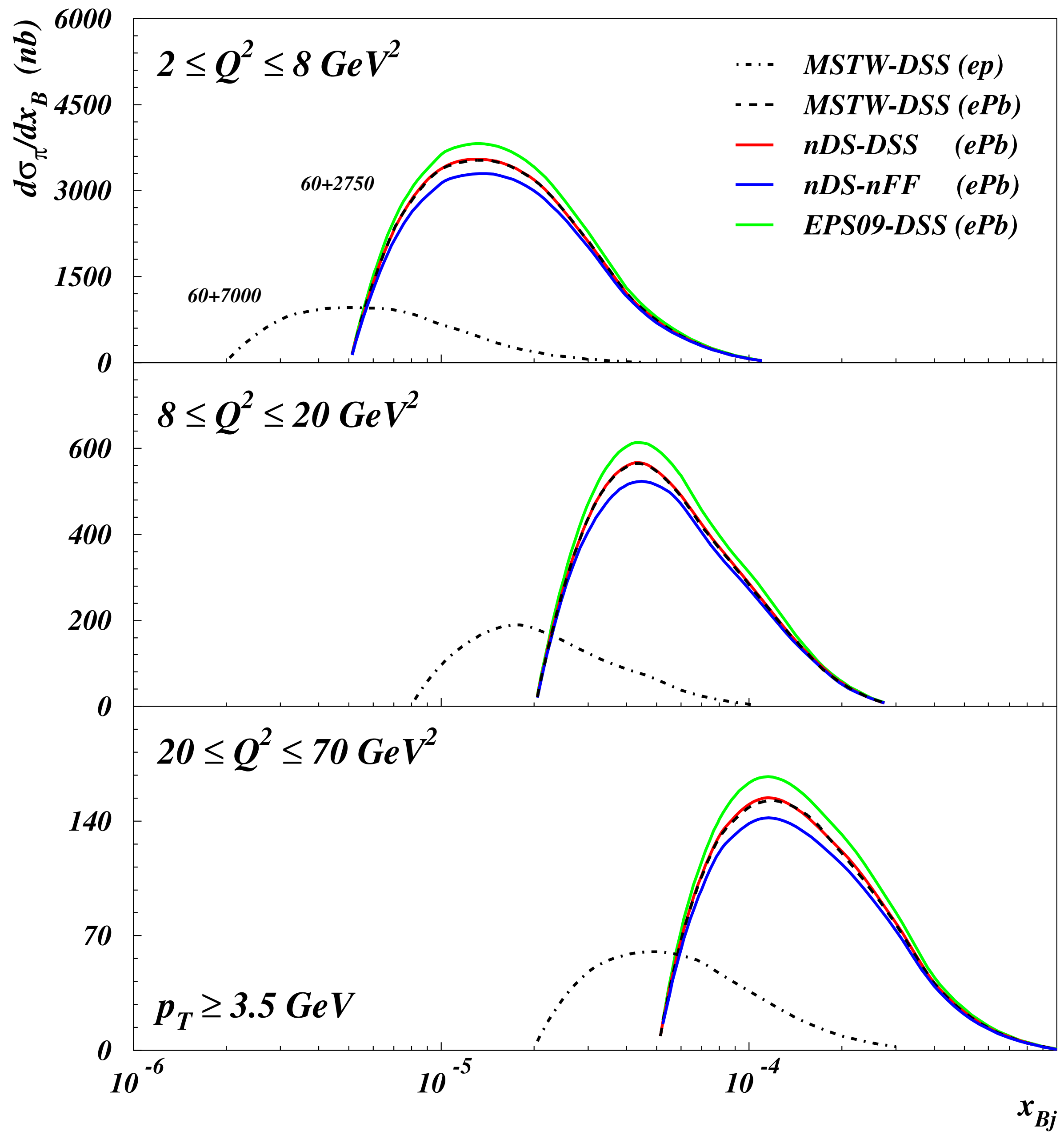
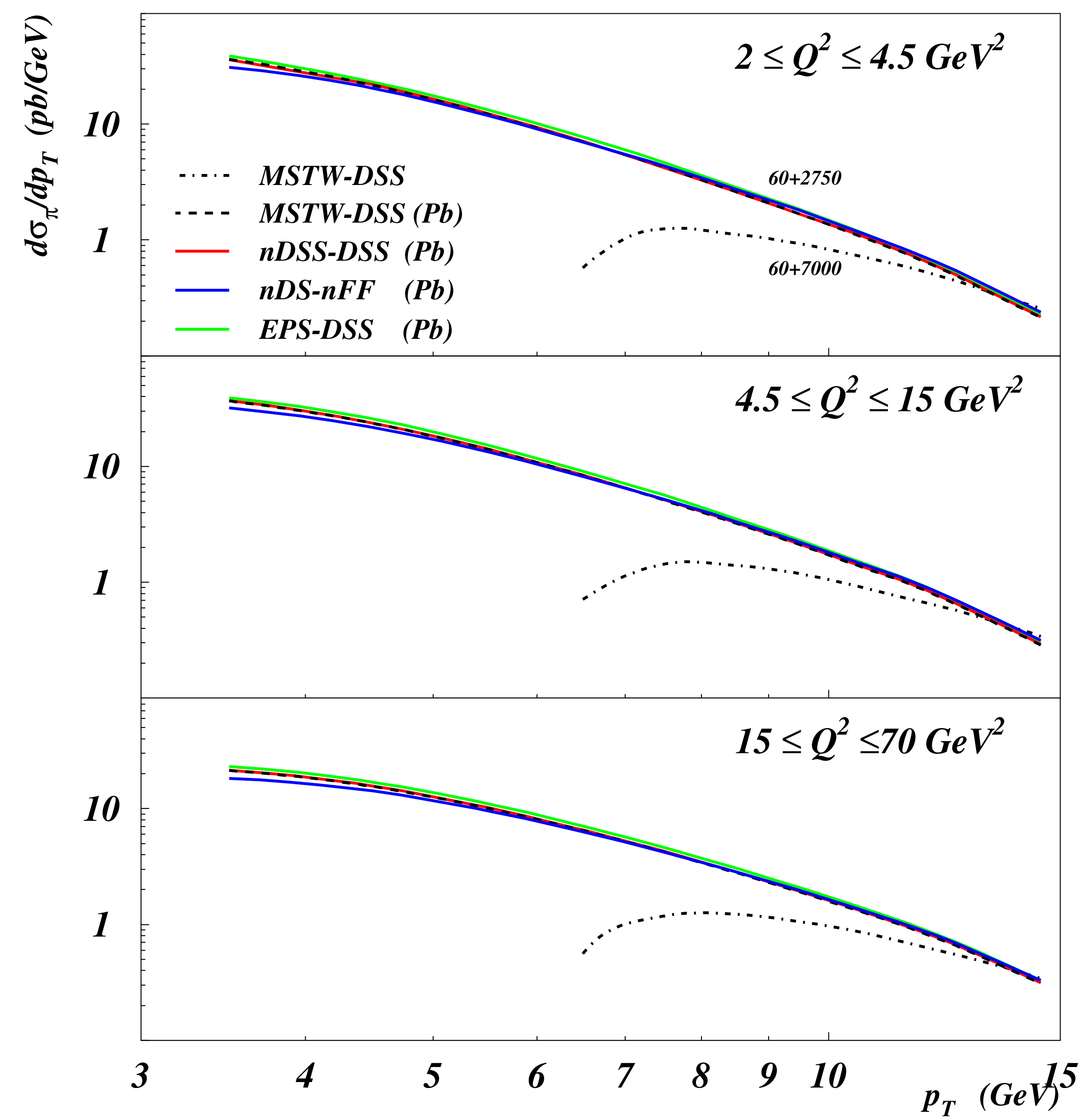
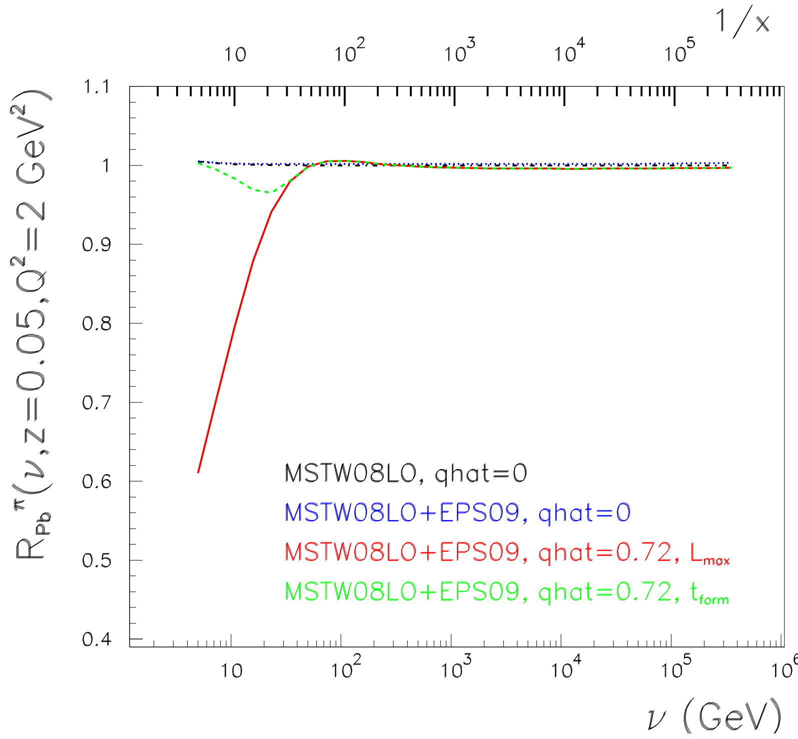
- Nuclear effects in hadronization at small ν (LO plus QW, Arleo ’03).



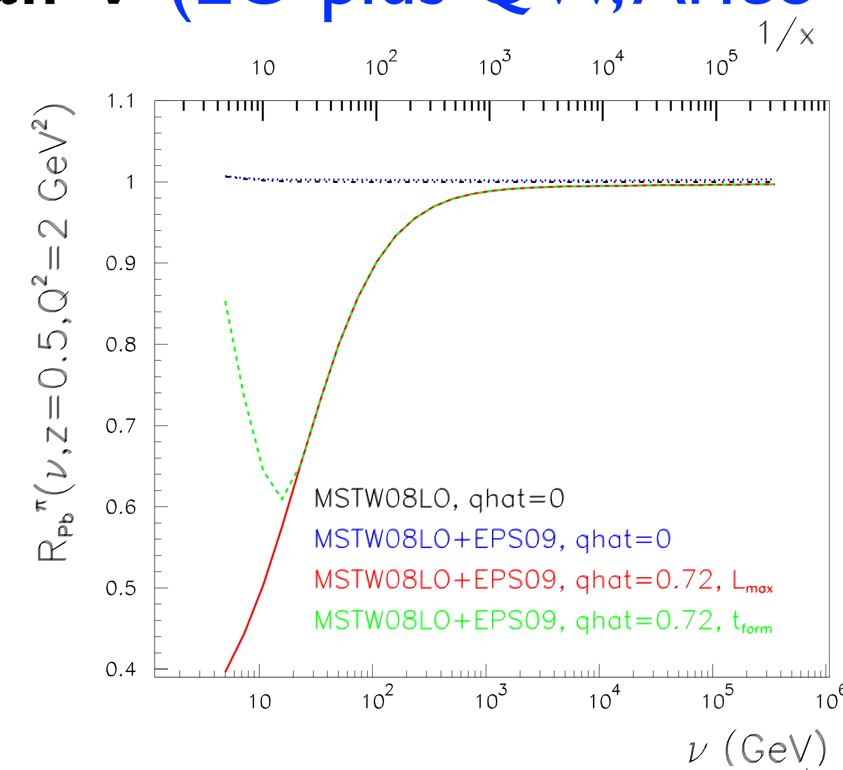


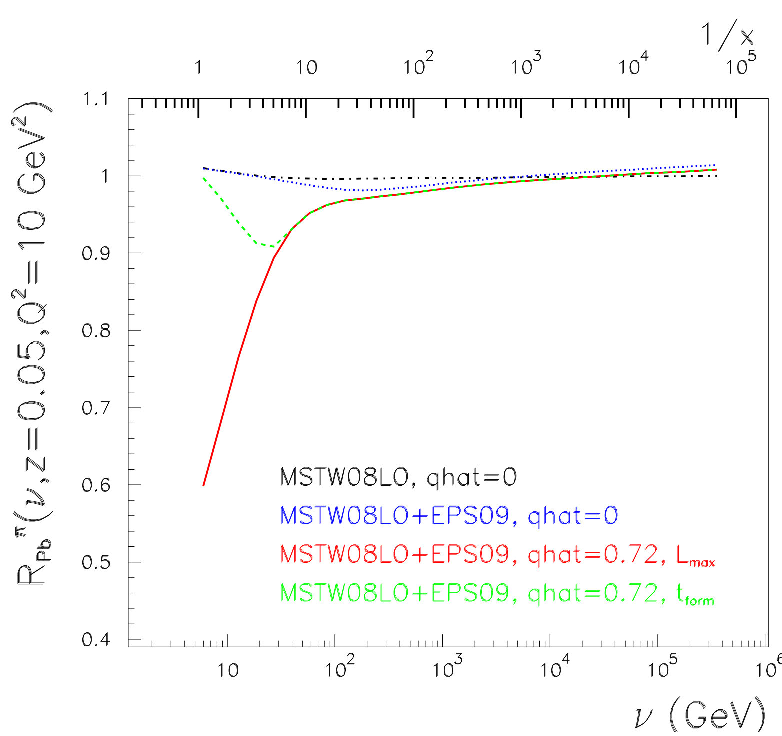
Radiation and hadronization:

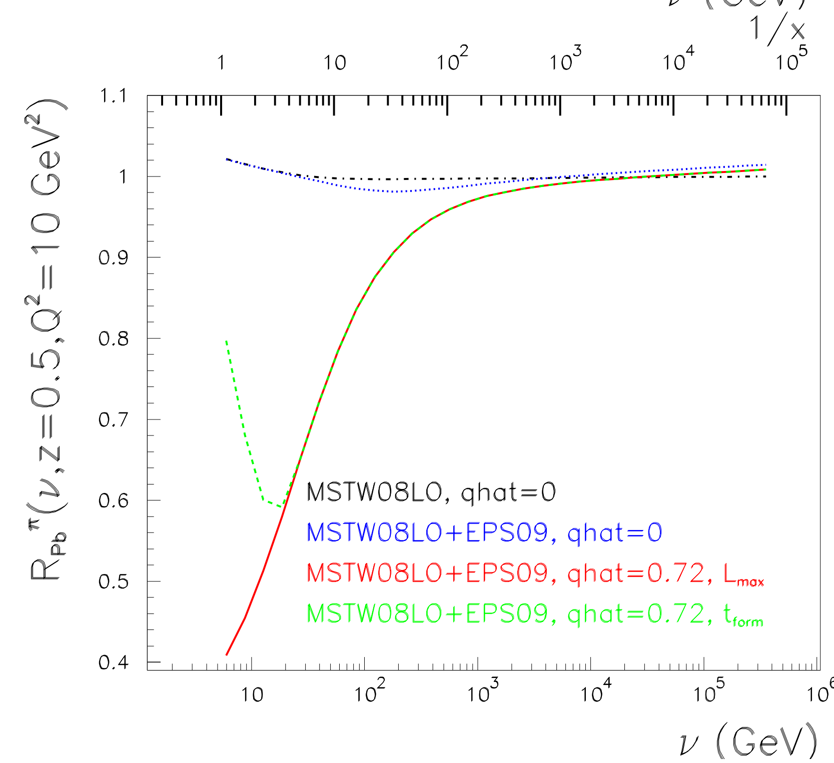
- Large (NLO) yields at small-x (H1 cuts, 3 times higher if relaxed).
- Nuclear effects in hadronization at small ν (LO plus QW, Arleo '03).



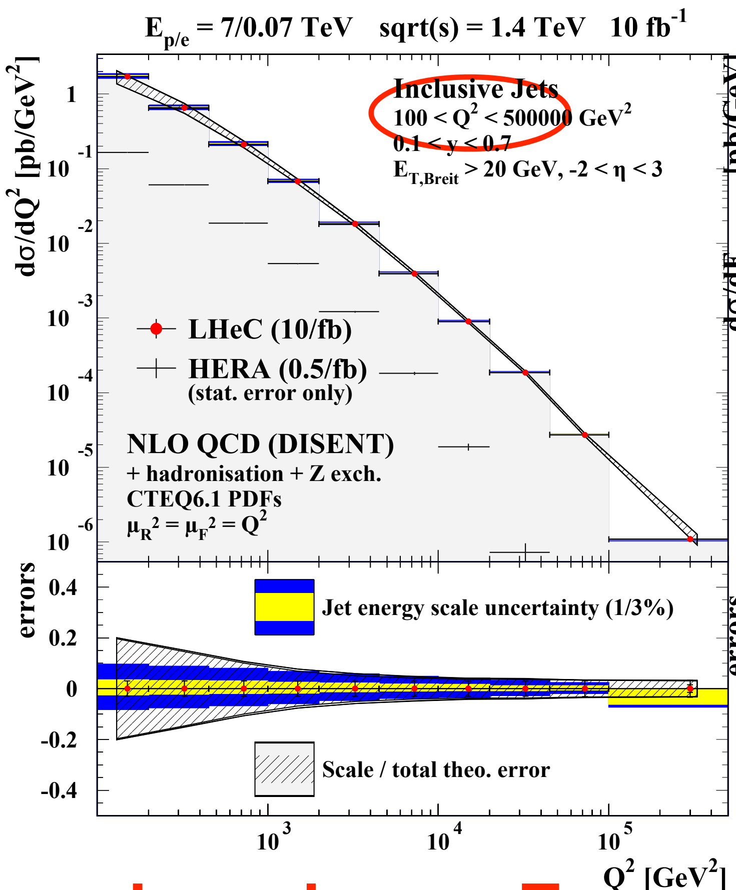
$$R_A^h(z,\nu) = \frac{1}{N_A^e}\frac{dN_A^h(z,\nu)}{d\nu\, dz} \Bigg/ \frac{1}{N_D^e}\frac{dN_D^h(z,\nu)}{d\nu\, dz}$$

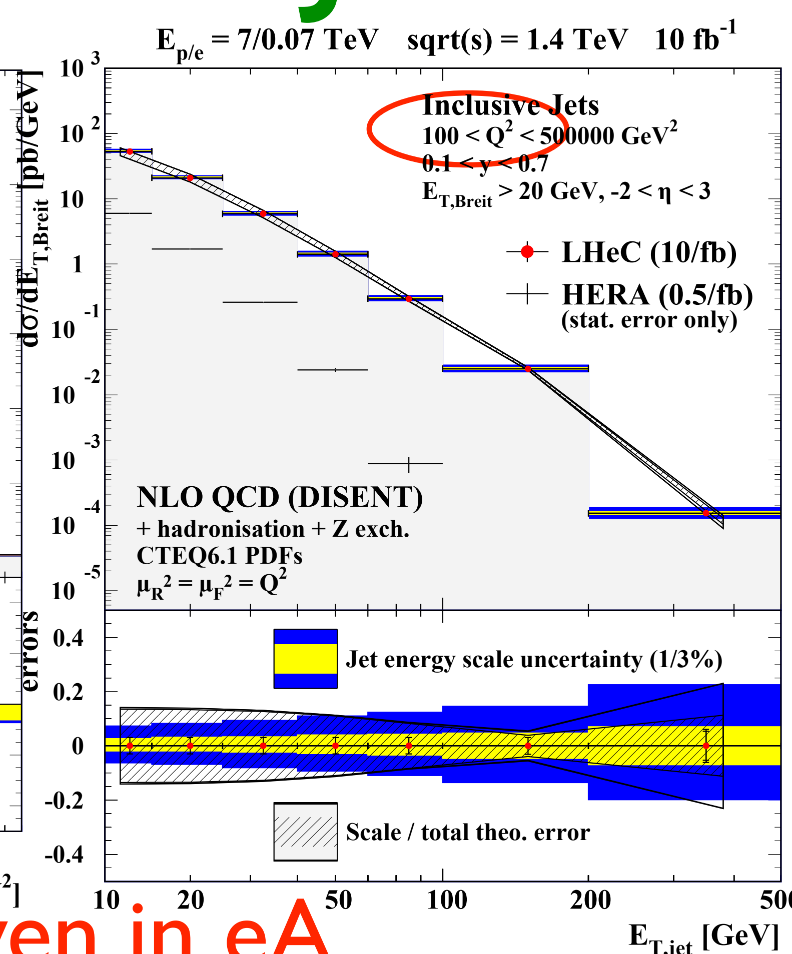


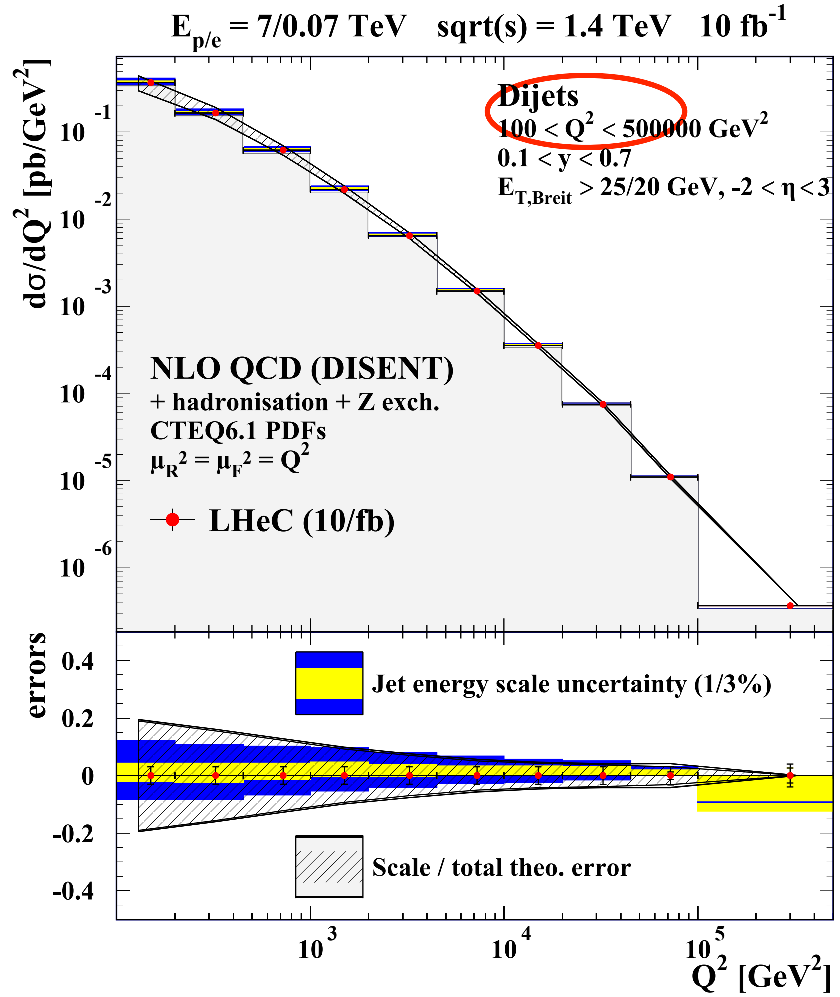




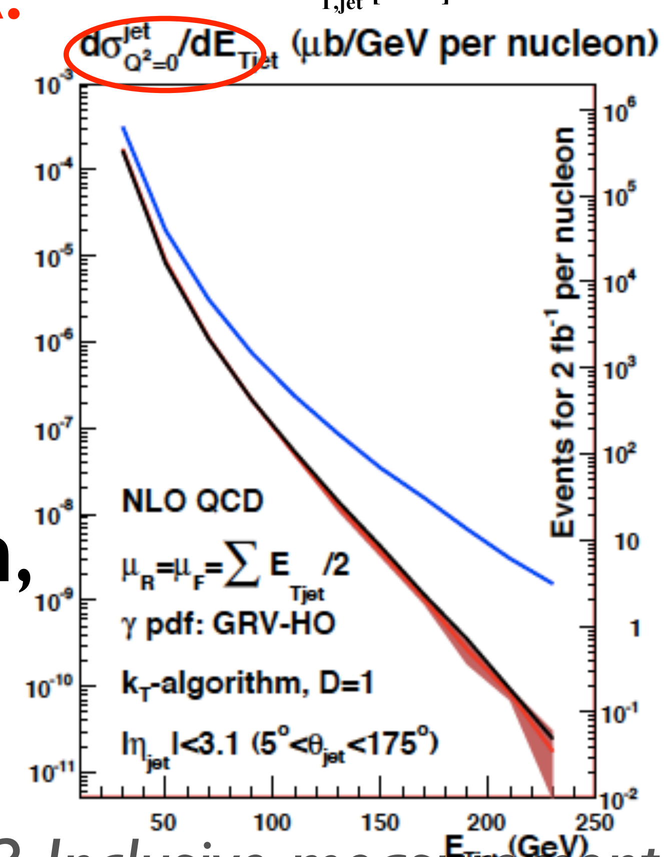
Jets:

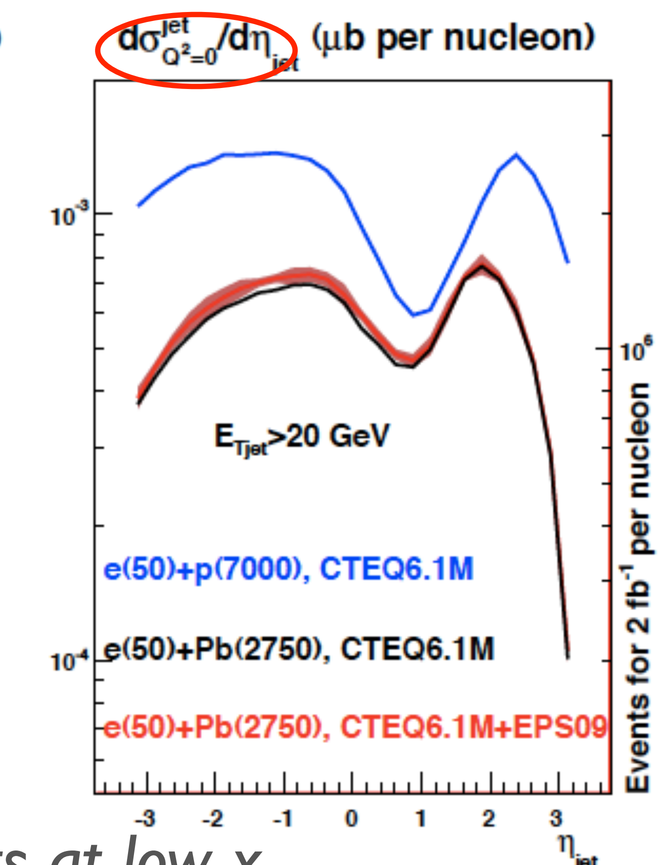






- Jets: large E_T even in eA.
- Useful for studies of parton dynamics in nuclei (hard probes), and for photon structure.
- Background subtraction, detailed reconstruction pending.





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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 (CERN)
Interaction Region
Daniel Pitzl (DESY)
Mike Sullivan (SLAC)
Detector Design
Philippe Bloch (CERN)
Roland Horisberger (PSI)
Installation and Infrastructure
Sylvain Weisz (CERN)
New Physics at Large Scales
Cristinel Diaconu (IN2P3 Marseille)
Gian Giudice (CERN)
Michelangelo Mangano (CERN)
Precision QCD and Electroweak
Guido Altarelli (Roma)
Vladimir Chekelian (MPI Munich)
Alan Martin (Durham)
Physics at High Parton Densities
Alfred Mueller (Columbia)
Raju Venugopalan (BNL)
Michele Arneodo (INFN Torino)

Commitees and authors:

J.L.Abelleira Fernandez[16,23], C.Adolphsen[57], A.N.Akay[03], H.Aksakal[39], J.L.Albacete[52], S.Alekhin[17,54], P.Allport[24], V.Andreev[34], R.B.Appleby[14,30], E.Arikan[39], N.Armesto[53,a], G.Azuelos[33,64], M.Bai[37], D.Barber[14,17,24], J.Bartels[18], O.Behnke[17], J.Behr[17], A.S.Belyaev[15,56], I.Ben-Zvi[37], N.Bernard[25], S.Bertolucci[16], S.Bettoni[16], S.Biswal[41], J.Blümlein[17], H.Böttcher[17], A.Bogacz[36], C.Bracco[16], G.Brandt[44], H.Braun[65], S.Brodsky[57,b], O.Brüning[16], E.Bulyak[12], A.Buniatyan[17], H.Burkhardt[16], I.T.Cakir[02], O.Cakir[01], R.Calaga[16], V.Cetinkaya[01], E.Ciapala[16], R.Ciftci[01], A.K.Ciftci[01], B.A.Cole[38], J.C.Collins[48], O.Dadoun[42], J.Dainton[24], A.De.Roeck[16], D.d'Enterria[16], A.Dudarev[16], A.Eide[60], R.Enberg[63], E.Eroglu[62], K.J.Eskola[21], L.Favart[08], M.Fitterer[16], S.Forte[32], A.Gaddi[16], P.Gambino[59], H.García Morales[16], T.Gehrmann[69], P.Gladkikh[12], C.Glasman[28], R.Godbole[35], B.Goddard[16], T.Greenshaw[24], A.Guffanti[13], V.Guzey[19,36], C.Gwenlan[44], T.Han[50], Y.Hao[37], F.Haug[16], W.Herr[16], A.Hervé[27], B.J.Holzer[16], M.Ishitsuka[58], M.Jacquet[42], B.Jeanneret[16], J.M.Jimenez[16], J.M.Jowett[16], H.Jung[17], H.Karadeniz[02], D.Kayran[37], A.Kilic[62], K.Kimura[58], M.Klein[24], U.Klein[24], T.Kluge[24], F.Kocak[62], M.Korostelev[24], A.Kosmicki[16], P.Kostka[17], H.Kowalski[17], G.Kramer[18], D.Kuchler[16], M.Kuze[58], T.Lappi[21,c], P.Laycock[24], E.Levichev[40], S.Levonian[17], V.N.Litvinenko[37], A.Lombardi[16], J.Maeda[58], C.Marquet[16], B.Mellado[27], K.H.Mess[16], A.Milanese[16], S.Moch[17], I.I.Morozov[40], Y.Muttoni[16], S.Myers[16], S.Nandi[55], Z.Nergiz[39], P.R.Newman[06], T.Omori[61], J.Osborne[16], E.Paoloni[49], Y.Papaphilippou[16], C.Pascaud[42], H.Paukkunen[53], E.Perez[16], T.Pieloni[23], E.Pilicer[62], B.Pire[45], R.Placakyte[17], A.Polini[07], V.Ptitsyn[37], Y.Pupkov[40], V.Radescu[17], S.Raychaudhuri[35], L.Rinolfi[16], R.Rohini[35], J.Rojo[16,31], S.Russenschuck[16], M.Sahin[03], C.A.Salgado[53,a], K.Sampei[58], R.Sassot[09], E.Sauvan[04], U.Schneekloth[17], T.Schörner-Sadenius[17], D.Schulte[16], A.Senol[22], A.Seryi[44], P.Sievers[16], A.N.Skrinsky[40], W.Smith[27], H.Spiesberger[29], A.M.Stasto[48,d], M.Strikman[48], M.Sullivan[57], S.Sultansoy[03,e], Y.P.Sun[57], B.Surrow[11], L.Szymanowski[66,f], P.Taels[05], I.Tapan[62], T.Tasci[22], E.Tassi[10], H.Ten.Kate[16], J.Terron[28], H.Thiesen[16], L.Thompson[14,30], K.Tokushuku[61], R.Tomás García[16], D.Tommasini[16], D.Trbojevic[37], N.Tsoupas[37], J.Tuckmantel[16], S.Turkoz[01], T.N.Trinh[47], K.Tywoniuk[26], G.Unel[20], J.Urakawa[61], P.VanMechelen[05], A.Variola[52], R.Veness[16], A.Vivoli[16], P.Vobly[40], J.Wagner[66], R.Wallny[68], S.Wallon[43,46,f], G.Watt[16], C.Weiss[36], U.A.Wiedemann[16], U.Wienands[57], F.Willeke[37], B.-W.Xiao[48], V.Yakimenko[37], A.F.Zarnecki[67], Z.Zhang[42], F.Zimmermann[16], R.Zlebcik[51], F.Zomer[42]

Commitees and authors:

2007: Invitation by SPC to ECFA and by (r)ECFA to work out a design concept

Report

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

2008: First CERN-ECFA Workshop in Divonne (1.-3.9.08)

2009: 2nd CERN-ECFA-NuPECC Workshop at Divonne (1.-3.9.09)

2010: Report to CERN SPC (June)
3rd CERN-ECFA-NuPECC Workshop at Chavannes-de-Bogis (12.-13.11.10)
NuPECC puts LHeC to its Longe Range Plan for Nuclear Physics (12/10)

2011: Draft CDR (530 pages on Physics, Detector and Accelerator) (5.8.11)
being refereed and updated

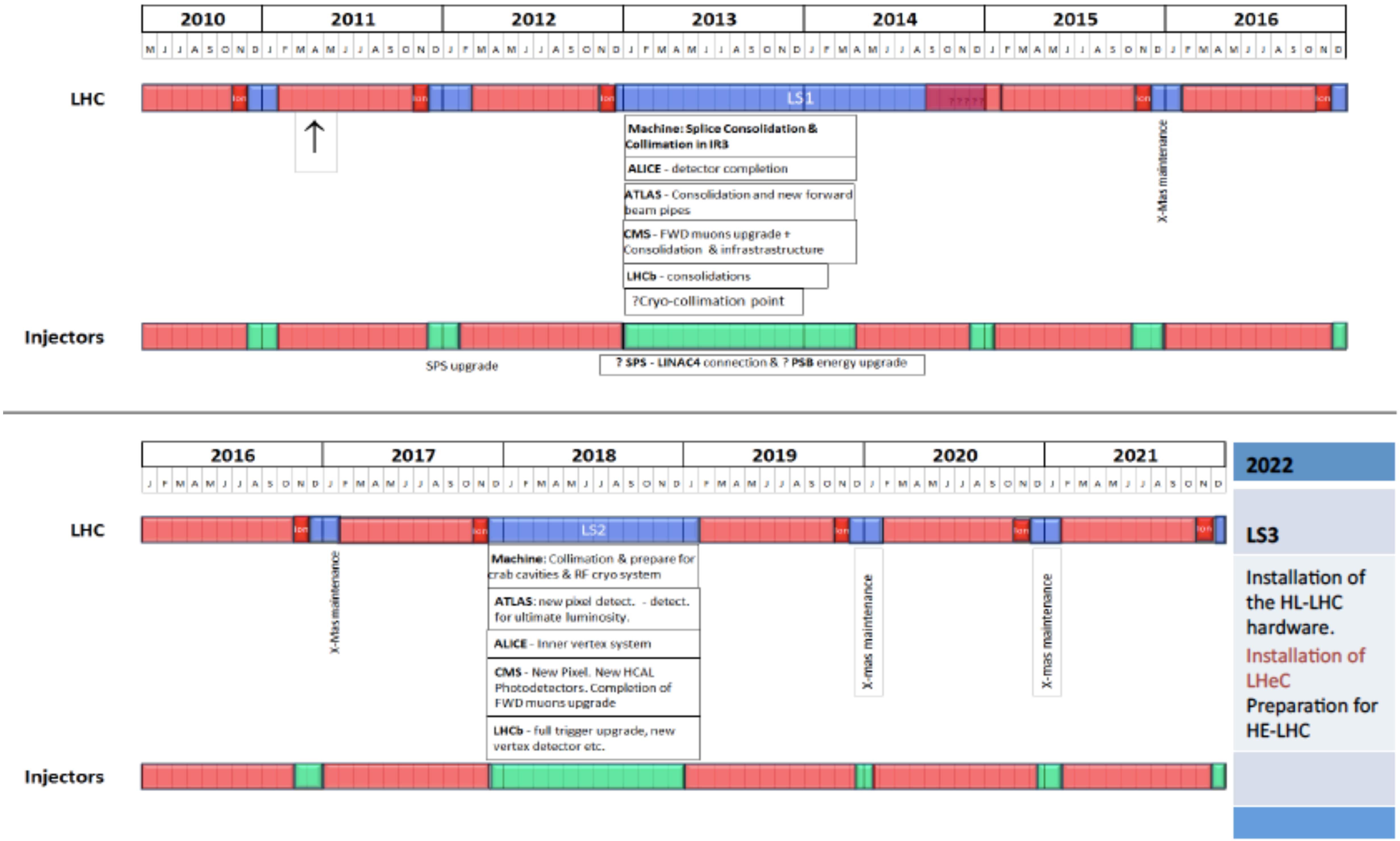
2012: Publication of CDR – European Strategy
New workshop June 14-15 2012

Goal: TDR by 2015
Perspective: Operation after LS3 (synchronous with pp/pA/AA)

Tentative timeline:

New rough draft 10 year plan

Not yet approved!



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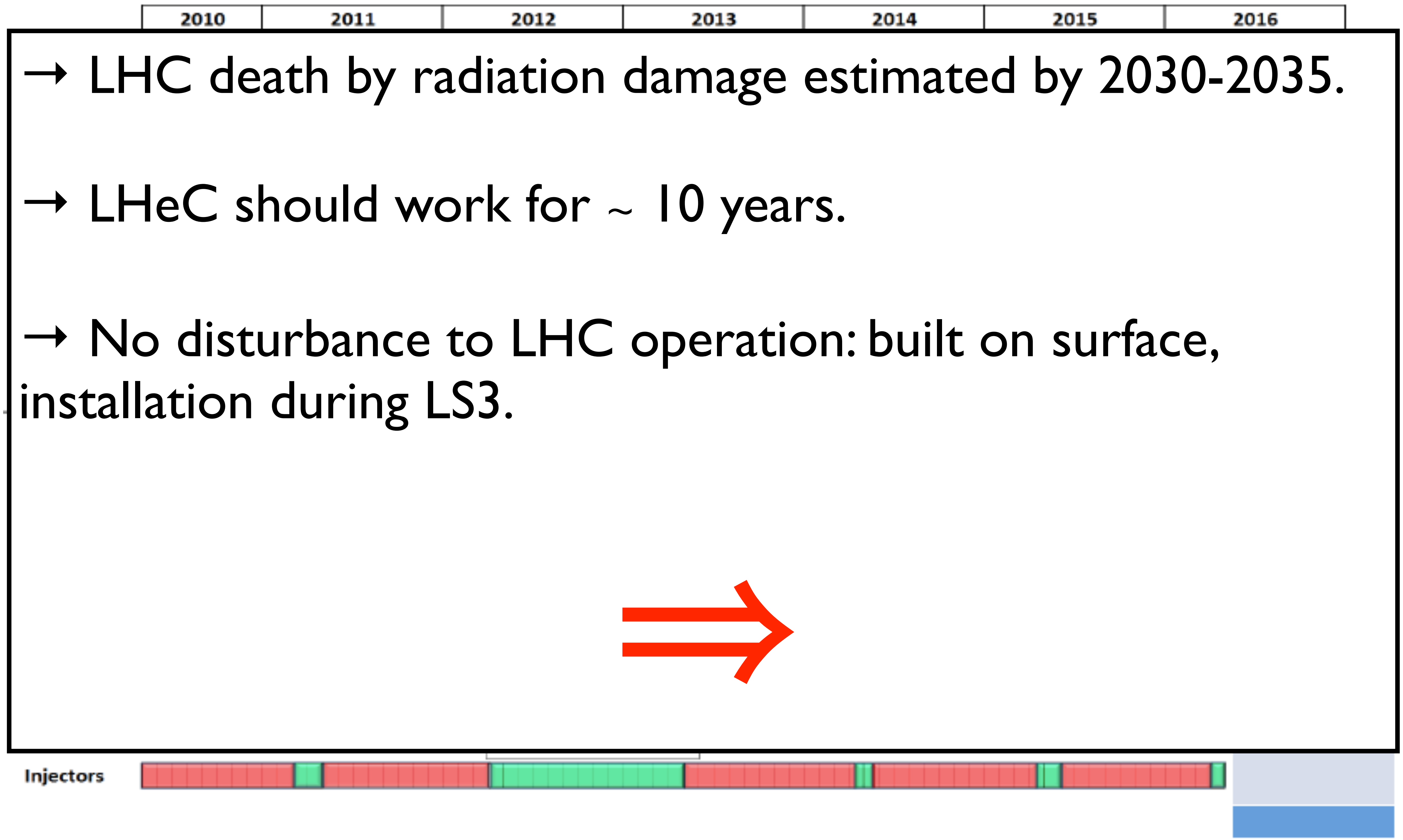

→ LHC death by radiation damage estimated by 2030-2035.

→ LHeC should work for ~ 10 years.

→ No disturbance to LHC operation: built on surface, installation during LS3.

⇒

July 26, 2011 S. Myers, HEP2011, Grenoble 42

Tentative timeline: