d/u at pp colliders and relation to JLab

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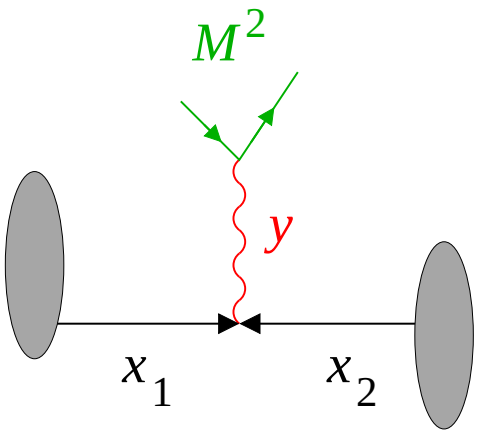
- Prospects for measuring d/u at large x in W^+/W^- production at $pp/\bar{p}p$ colliders

  Sensitivity, rates, . . . LHC, Tevatron, RHIC

- Physics options in combining d/u from JLab with pp collider data

I) Hard processes in high–energy $pp/\bar{p}p$ collisions

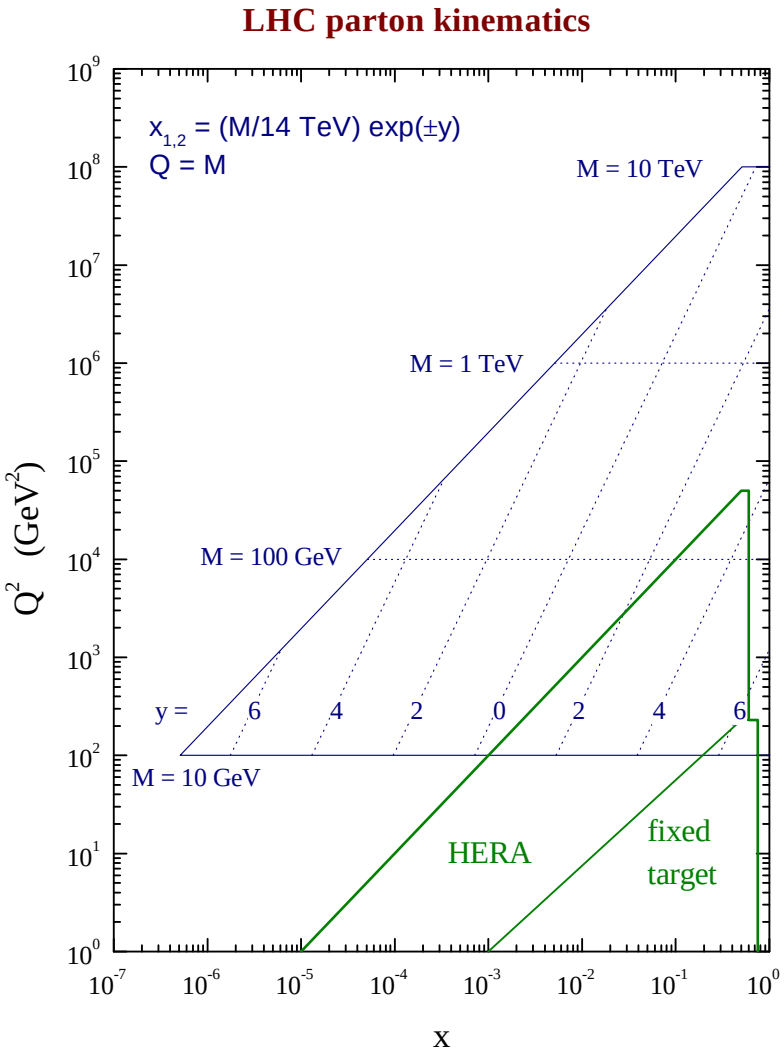


$$x_{1,2} = \frac{M^2}{\sqrt{s}} e^{\pm y}$$

LHC	$\sqrt{s} = 14$ TeV
Tevatron	1.8 TeV
RHIC	200/500 GeV

- Drell–Yan pairs (l^+l^-)
  - both l^+, l^- detectable
  - cross section drops as $\sim 1/M^4$
- W^+/W^- production ($l^+\nu_l, l^-\bar{\nu}_l$)
  - only $l^+(l^-)$ detectable
  - large cross section at $M^2 = M_W^2$
- QCD jets
  - can probe very high M^2 and $x \to 1$
  - no separation of quarks and gluons

Hard processes at LHC



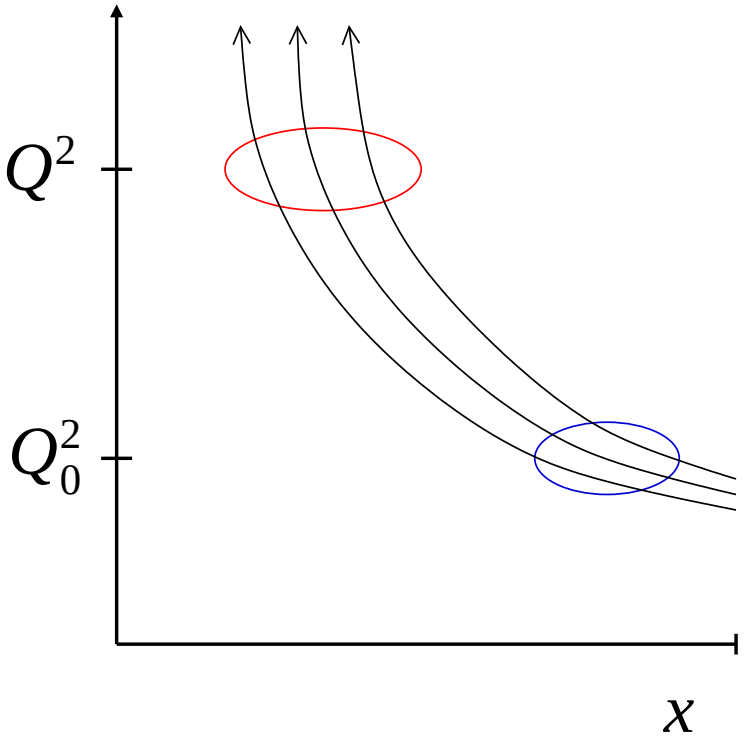
- Rich program of "Standard Model processes" (beginning 2007), needed to determine parton luminosities

- Expected rates very high:
  200 W^+/sec before cuts
  [see e.g.: J. Mnich, CMS CR 2004/043]

- Possible to reach $x \to 1$
  in very high–Q^2 processes
  (jet production)

Q: Sensitivity to d/u at large x?
Role of JLab large–x data?

Reminder: "Flow" of DGLAP evolution



- DGLAP evolution relates

  high Q^2, low x

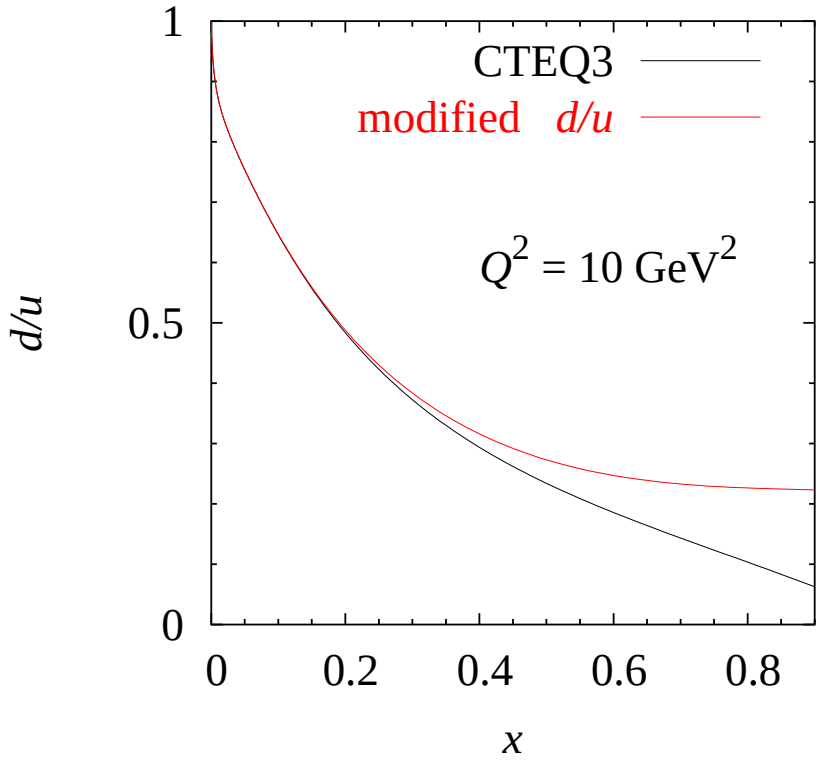
  low Q^2, high x

- Data at increasing Q^2 probe higher and higher x in input PDFs at Q_0^2!

Probing d/u in W^+/W^- production in pp

$$\frac{\sigma(W^+)}{\sigma(W^-)} = \frac{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}{d(x_1)\bar{u}(x_2) + \bar{u}(x_1)d(x_2)}$$

Cross section ratio

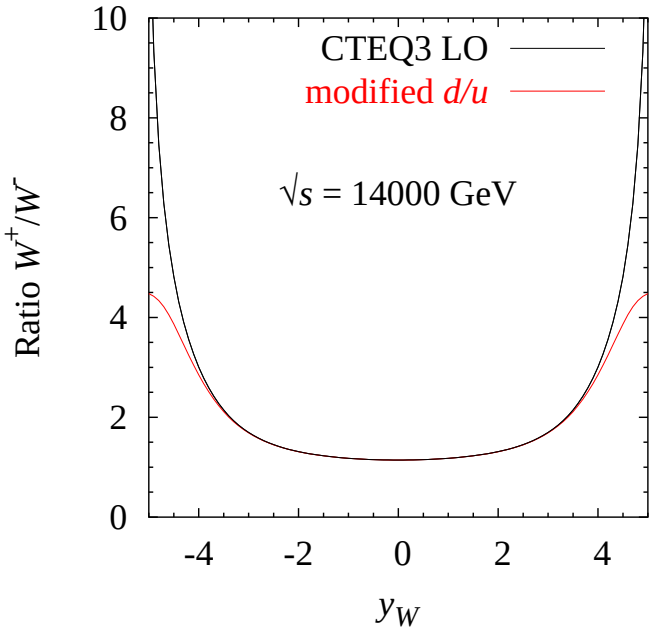


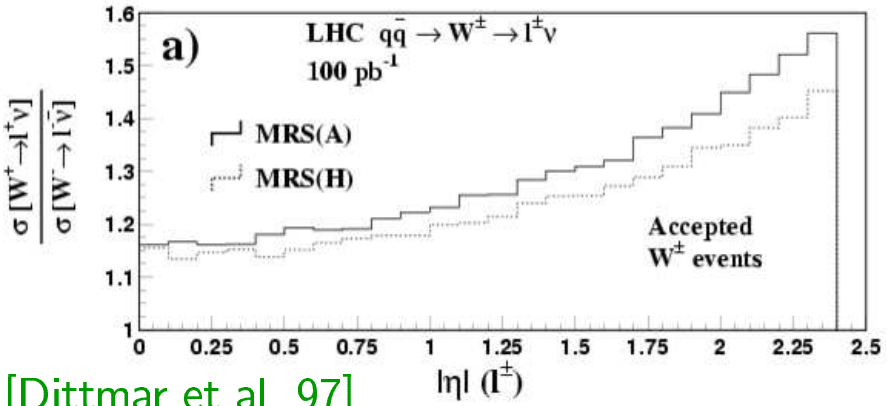
- Check sensitivity to d/u at large x:

$$\frac{u(x)}{d(x)} \rightarrow \frac{u(x)}{d(x)} + \Delta(x)$$

[Melnitchouk, Thomas 96; M. & Peng 96]

d/u at large x: LHC





[Dittmar et al. 97]

- Sensitivity to d/u at large x only at large rapidities $|y_W| > 4$

  High rate. . . perhaps strong cuts allow for some signal?

- Excellent sensitivity to u/d and $\bar{u}/\bar{d}$ combined at

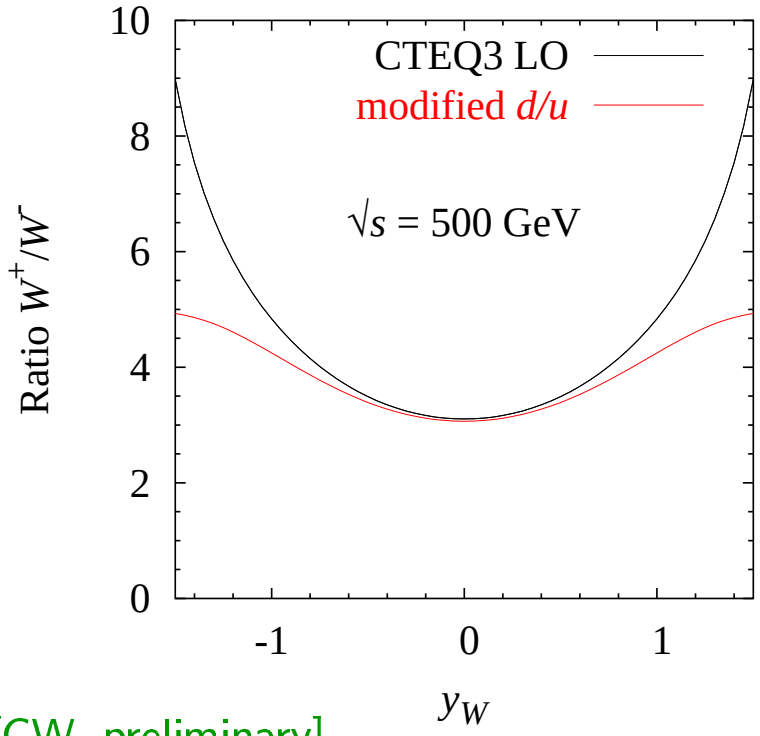
  $x \sim 10^{-2} - 10^{-3}, \;\; Q^2 = M_W^2$

  DGLAP ↕

  $x \sim 10^{-1}, \;\; Q^2 = \text{few GeV}^2$

Very precise PDF determination at $x \sim 10^{-1}$; large x unclear

d/u at large x: RHIC



[CW, preliminary]

[Melnitchouk, Peng 96]

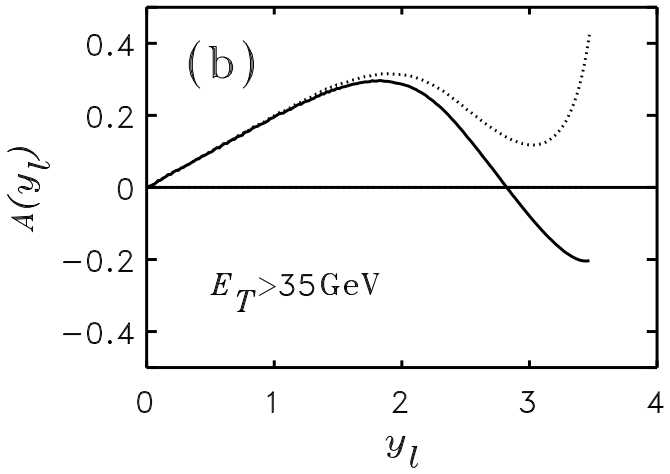
- Good sensitivity to d/u at large x:
  $x_{1,2} = 0.16$ for $y_W = 0$

- Expected data sample in $800\,\mathrm{pb}^{-1}$:
  $\sim 100,000\,W^+,\ 30,000\,W^-$
  [see e.g. hep-ph/0304002]

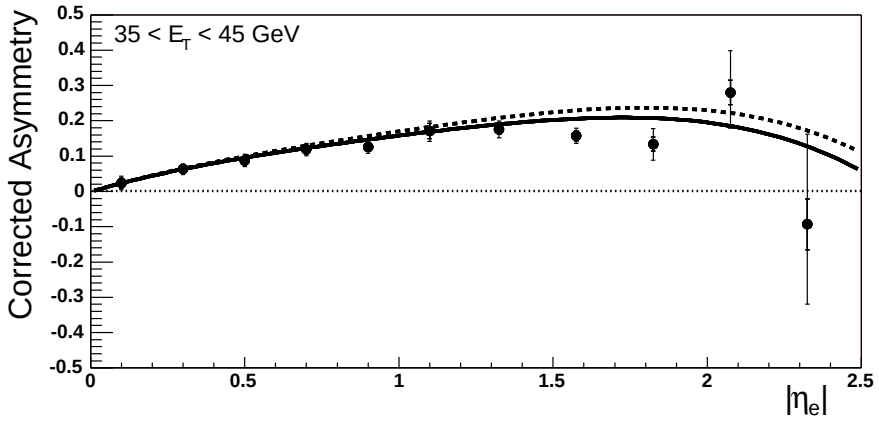
- Detection of charged leptons
  $1.2 < |y_\mu| < 2.4$ PHENIX
  $|y_e| < 1$ STAR

Unclear if coverage of present detectors sufficient for realistic study of d/u at large x

d/u at large x in $\bar{p}p$: Tevatron



[Melnitchouk, Peng 96]



CDF data (2005), $170\,\mathrm{pb}^{-1}$

- "Forward–backward" asymmetry:

$$A = \frac{\sigma(W^+) - \sigma(W^-)}{\sigma(W^+) + \sigma(W^-)}$$

- Sensitivity to u/d at large x for $y_l \geq 3$

Limited detector acceptance and statistics seem to preclude extraction of u/d at large x

II) Combining d/u from JLab with collider data: Physics options

- Understand high–Q^2 jet data

DIS:	4 u	$+$	d
qg jets:	u	$+$	d $\leftarrow$ enhanced!

CTEQ: Modified large–x gluon to explain Tevatron jet data

. . . d/u at large x would help to pin down large–x gluon density!

- "High–x QCD evolution:" Deviations from DGLAP

$\log\left[Q^2(1-x)\right] \ll \log Q^2$

. . . could be tested in combination with very high–Q^2 jet data!

(Preliminary) Summary

- Accurate measurements of d/u at $x > 0.5$ appear hardly possible at Tevatron and RHIC with present detectors

- LHC data promise to lead to completely new level of precision in PDF determination at "average" x (including u/d, $\bar{u}/\bar{d}$)

- Explore options in combining JLab d/u with collider data: Quark/gluon separation in high–Q^2 jets, large–x evolution

. . . Need to involve experts on global PDF fits!