The LHC data at p-Pb collisions (& nPDFs)

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(on behalf of N. Armesto, H. Paukkunen, J.M. Penín, C. A. Salgado and P. Zurita)

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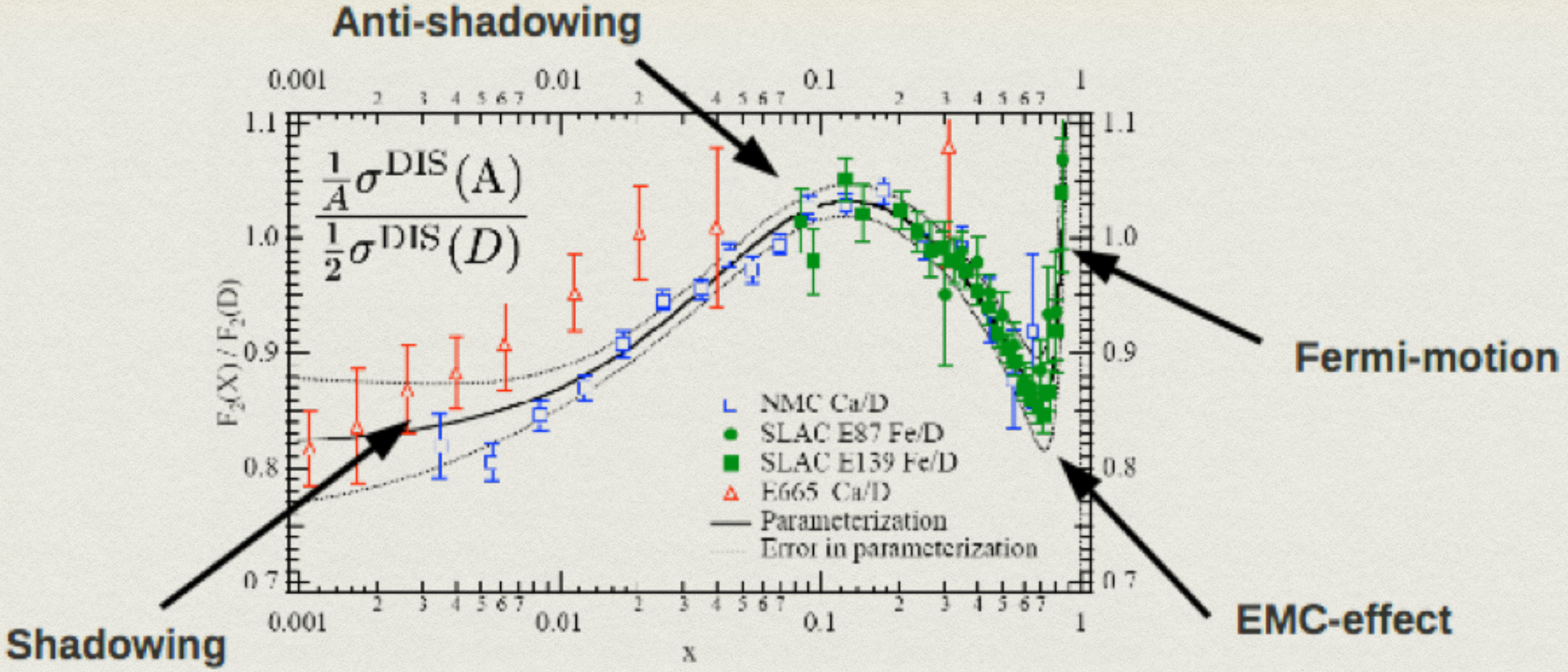
OUTLINE

- A short digression on nPDFs
- The LHC data from Run I (p-Pb)
- The (ongoing) work
- Re-weighting
- Preliminary results
- Summary & outlook

NUCLEAR PDFS



the nuclear medium modifies the partonic behaviour,
then **A** dependent PDFs are needed

NUCLEAR PDFS

- Determined as proton PDFs (global fits)
- Several sets available at NLO with theoretical uncertainties (DSSZ, EPS09, HKN, nCTEQ)
- Mostly DIS data (valence well constrained)
- Limited coverage of the kinematic space
- Sea and gluon densities too assumptions dependent

P-PB: LHC RUN I

- Jets (ATLAS)
- Di-jets (CMS)

gluon

- W+, W- (CMS)
- Z (ATLAS, CMS, LHCb)

sea quarks

- Hadro-production (ALICE): dependent on (not well understood) FFs

THE WORK

- Aim:
    - analyze the impact of these data on nPDFs
    - determine if a new nPDF fit is required
- Method:
    - bayesian re-weighting with two proton (MSTW2008, CT10) and two nuclear (DSSZ, EPS09) PDF sets
    - MCFM & FR (Frixione-Ridolfi)

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MSTW2008: EPJC 63 (2009) 189                MCFM:
CT10    : PRD 82 (2010) 074024              FR  : NPB 467 (1996) 399
DSSZ    : PRD 85 (2012)  074028                   NPB 507 (1997) 295
EPS09   : JHEP 0904 (2009) 065                    NPB 507 (1997) 315
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BAYESIAN RE-WEIGHTING

JHEP 1412 (2014) 100 (and references therein)

- given: $f_{S_0}, f_{S_i^+}, f_{S_i^-}$
- generate MC replicas (k=1, … , $N_{rep} \sim 10^4$)

$$f_k = f_{S_0} + \sum_i^{N_{eig}} \frac{f_{S_i^+} - f_{S_i^-}}{2} R_{ik}$$

random, gaussian

represent the underlying probability distribution of the PDFs

$\mathcal{P}_{old}(f)$

- any PDF dependent quantity is

$$< \mathcal{O} >= \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} \mathcal{O}(f_k)$$

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- add new data $\vec{y}$

- by Bayes' theorem:

$$\mathcal{P}_{new}(f) \propto \mathcal{P}(\vec{y}|f)\mathcal{P}_{old}(f)$$

likelihood

- then

$$< \mathcal{O} >_{new} = \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} \mathcal{O}(f_k) w_k$$

w_k → proportional to the likelihood

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→ proportional to the likelihood

- with

$$w_k = \frac{exp^{-\chi^2_k/2\Delta}}{(1/N_{rep}) \sum_{k=1}^{N_{rep}} exp^{-\chi^2_k/2\Delta}}$$

→ PDF tolerance, needed for statistical correctness

quantitative estimator of data-theory compatibility →

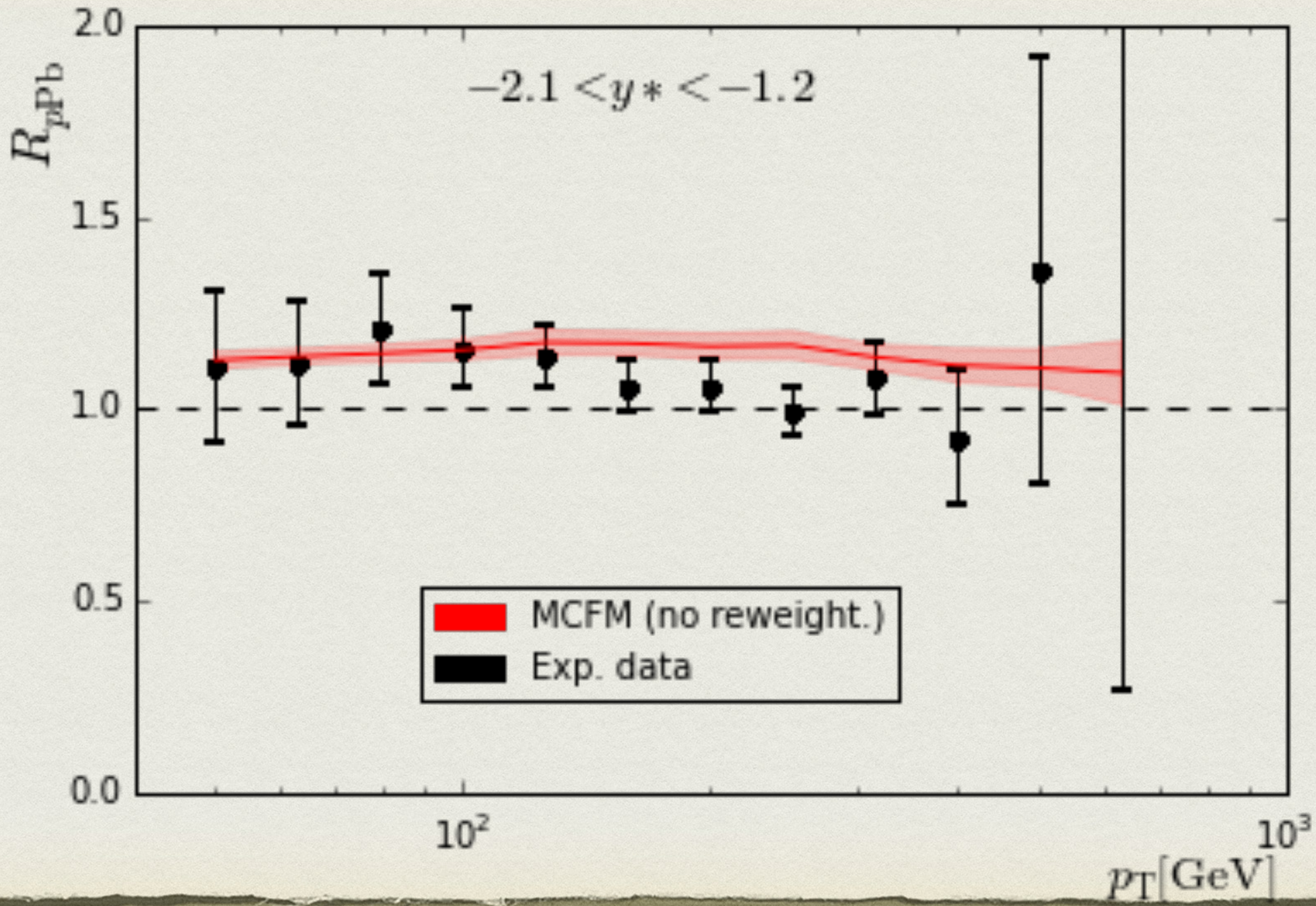
$$N_{eff} \equiv exp\Big\{ \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} w_k log(N_{rep}/w_k) \Big\}$$

RESULTS

- some data are still preliminary
- adequate data selection under discussion
- shown only for CT10 + EPS09

JETS BY ATLAS

ATLAS Collaboration,
arXiv:1412.4092 [hep-ex].



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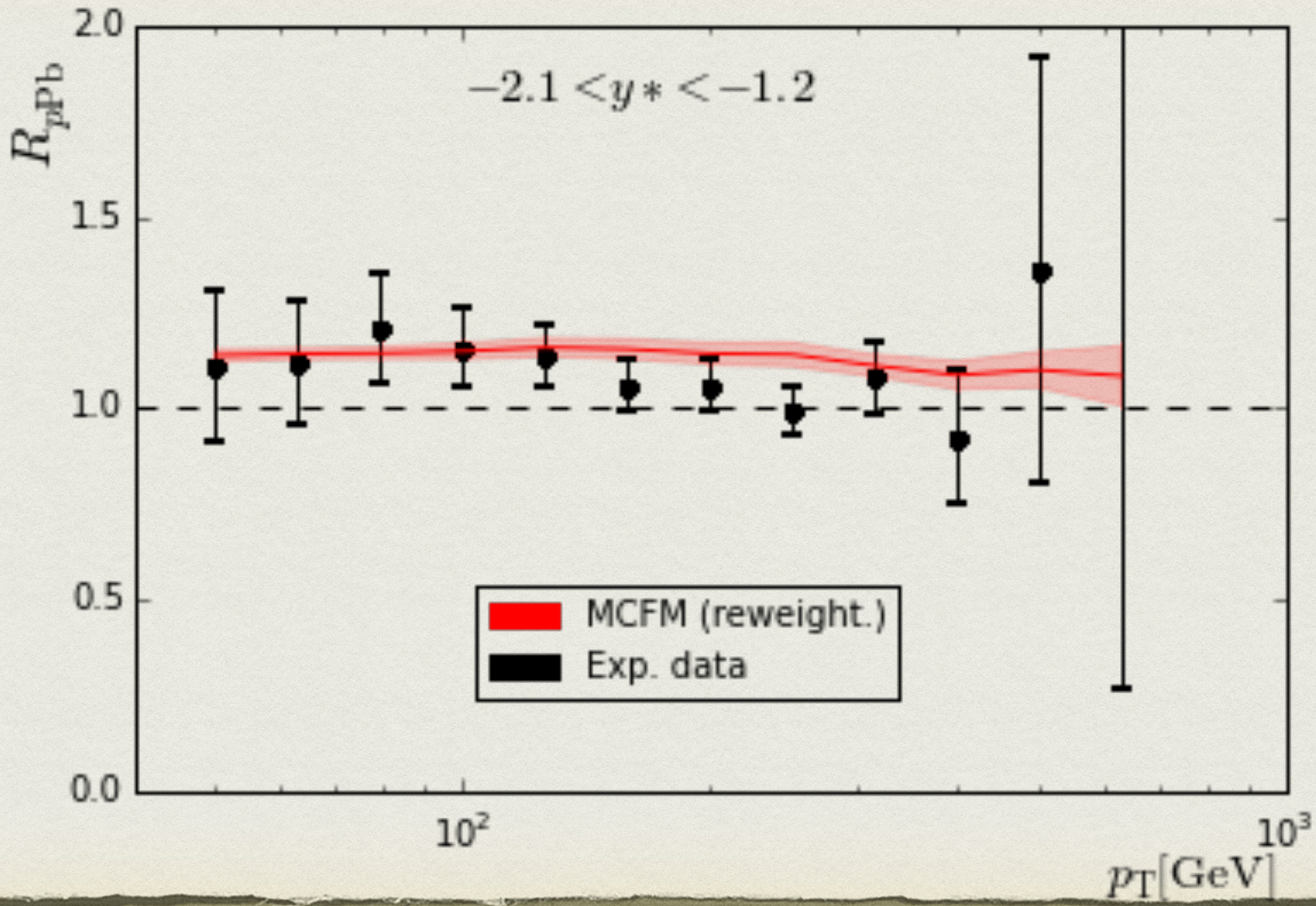

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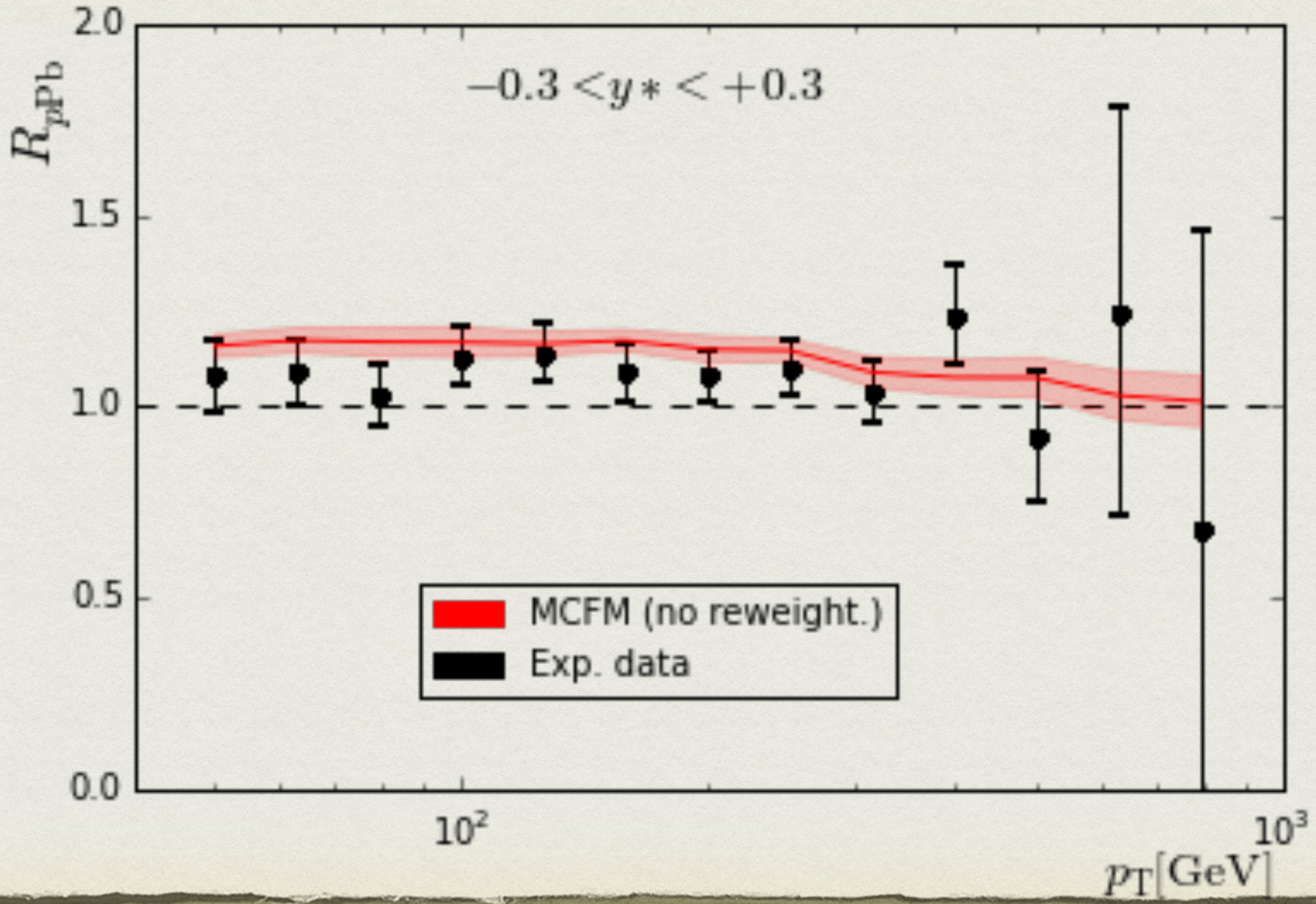

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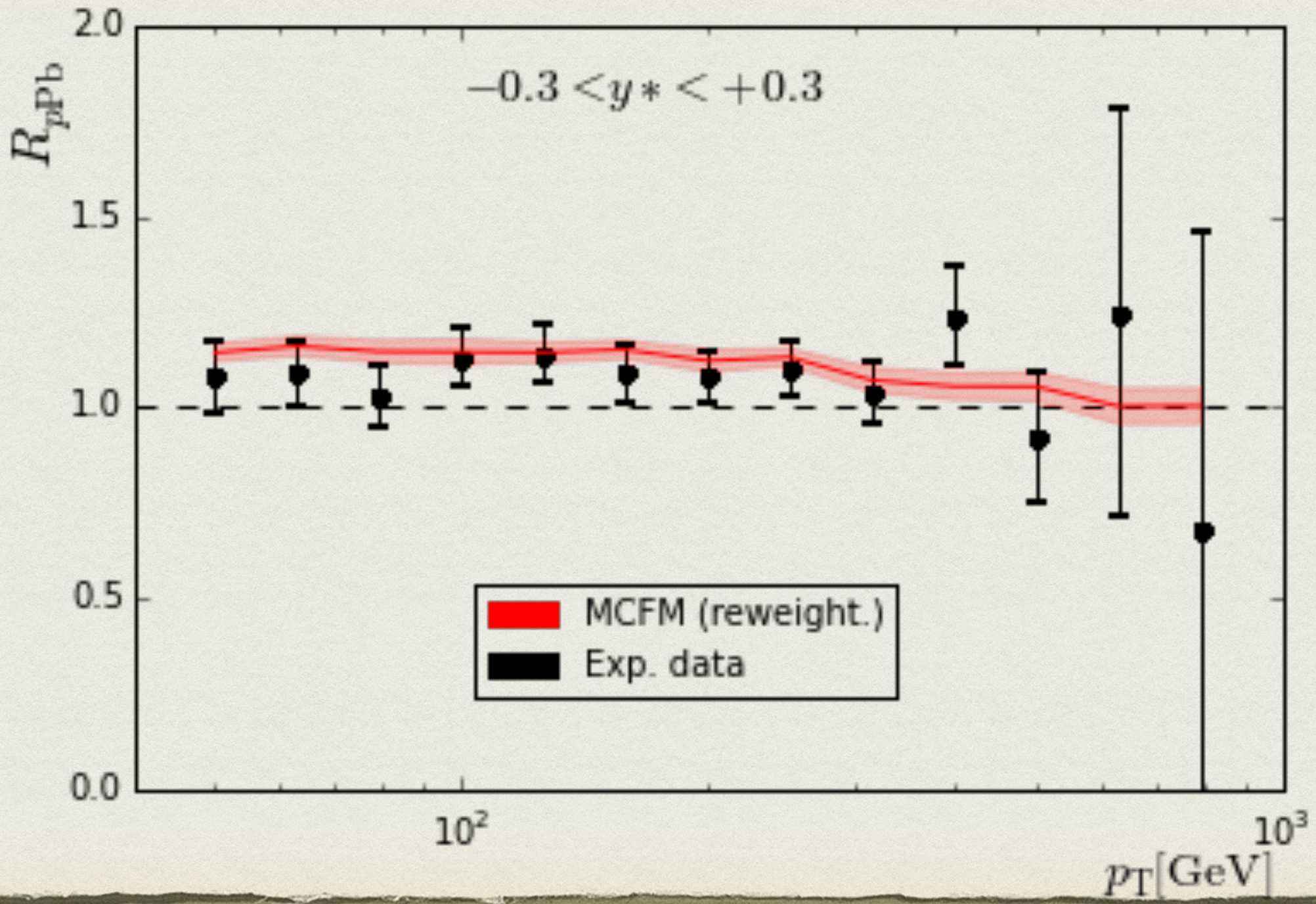

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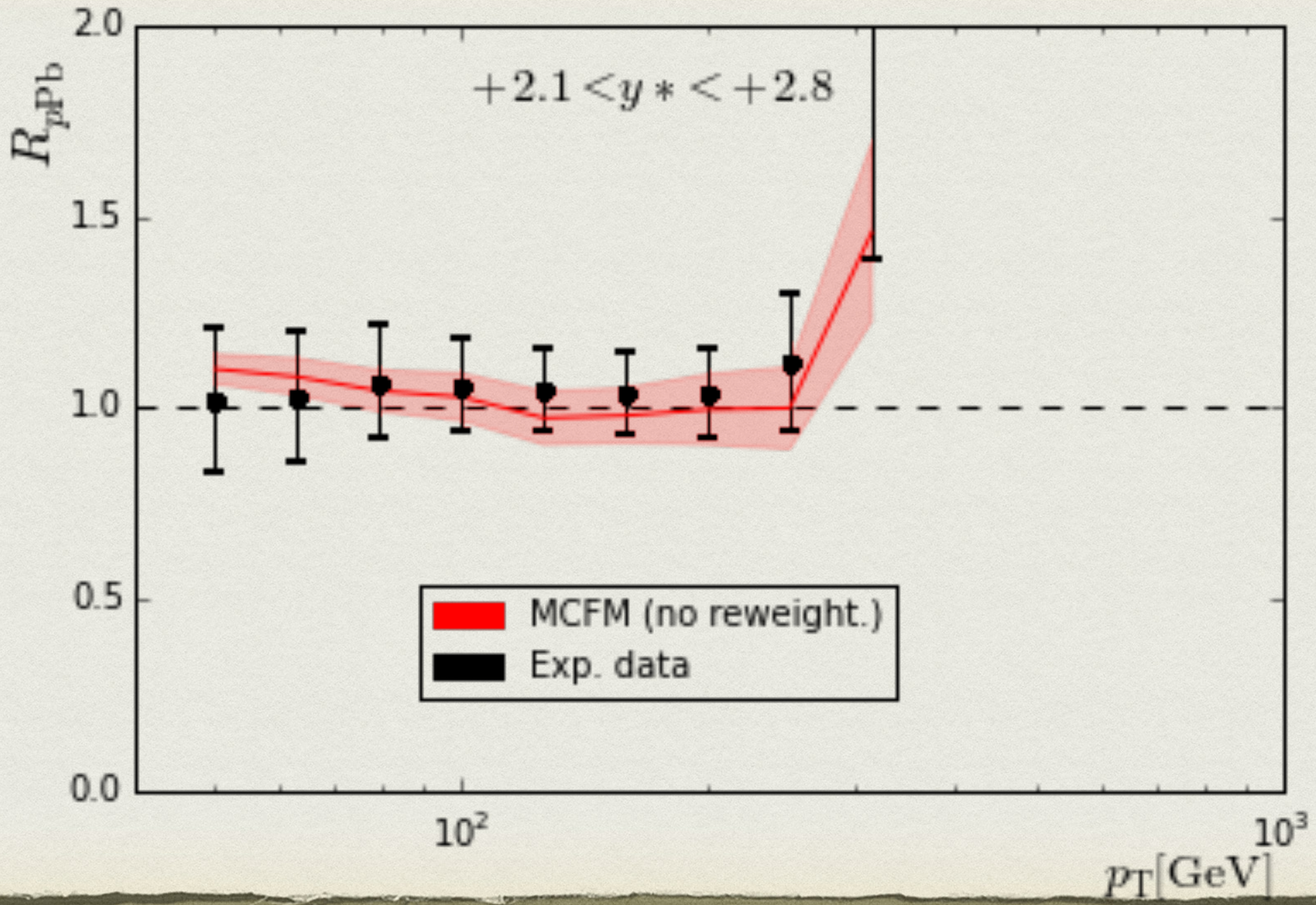

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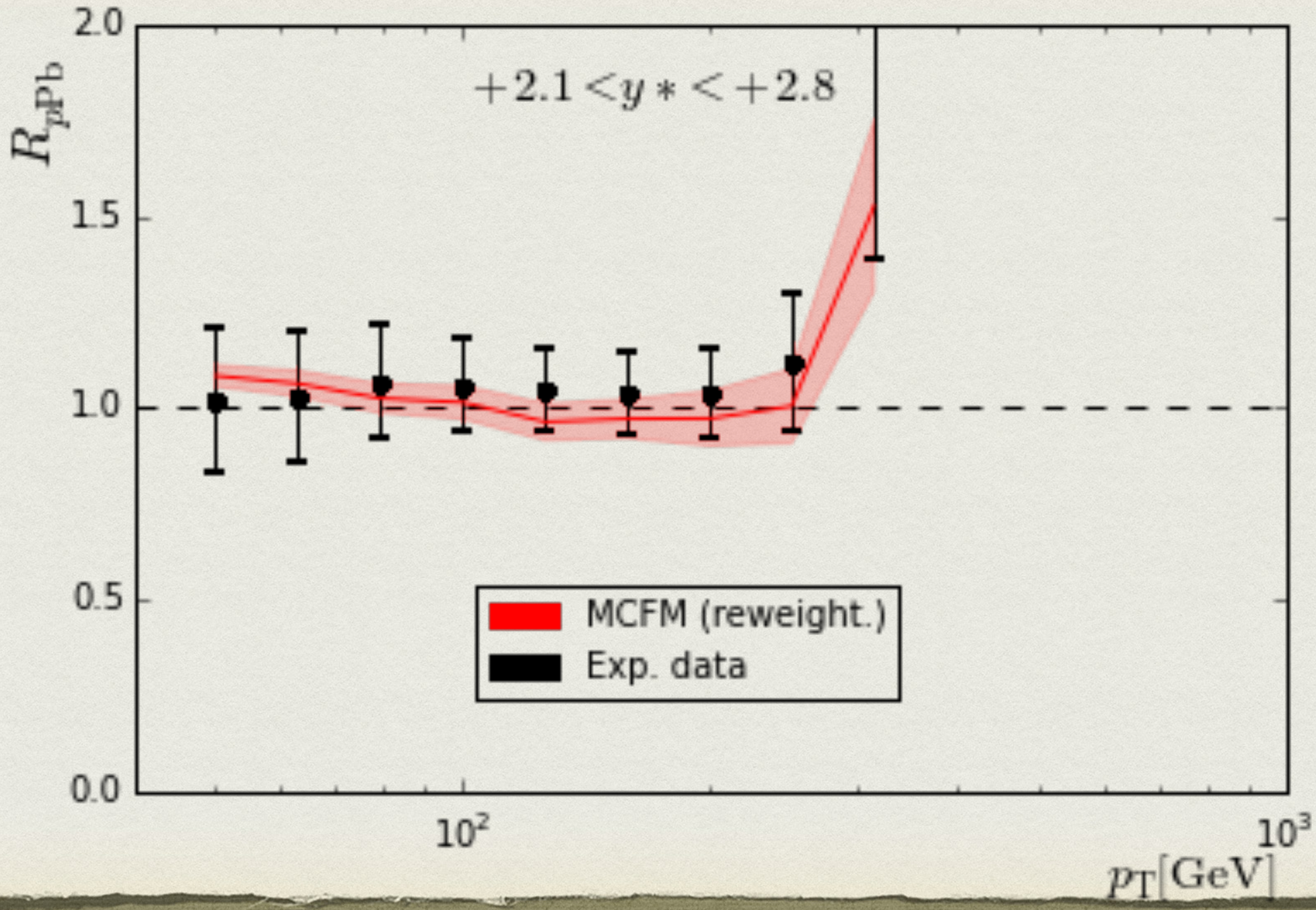
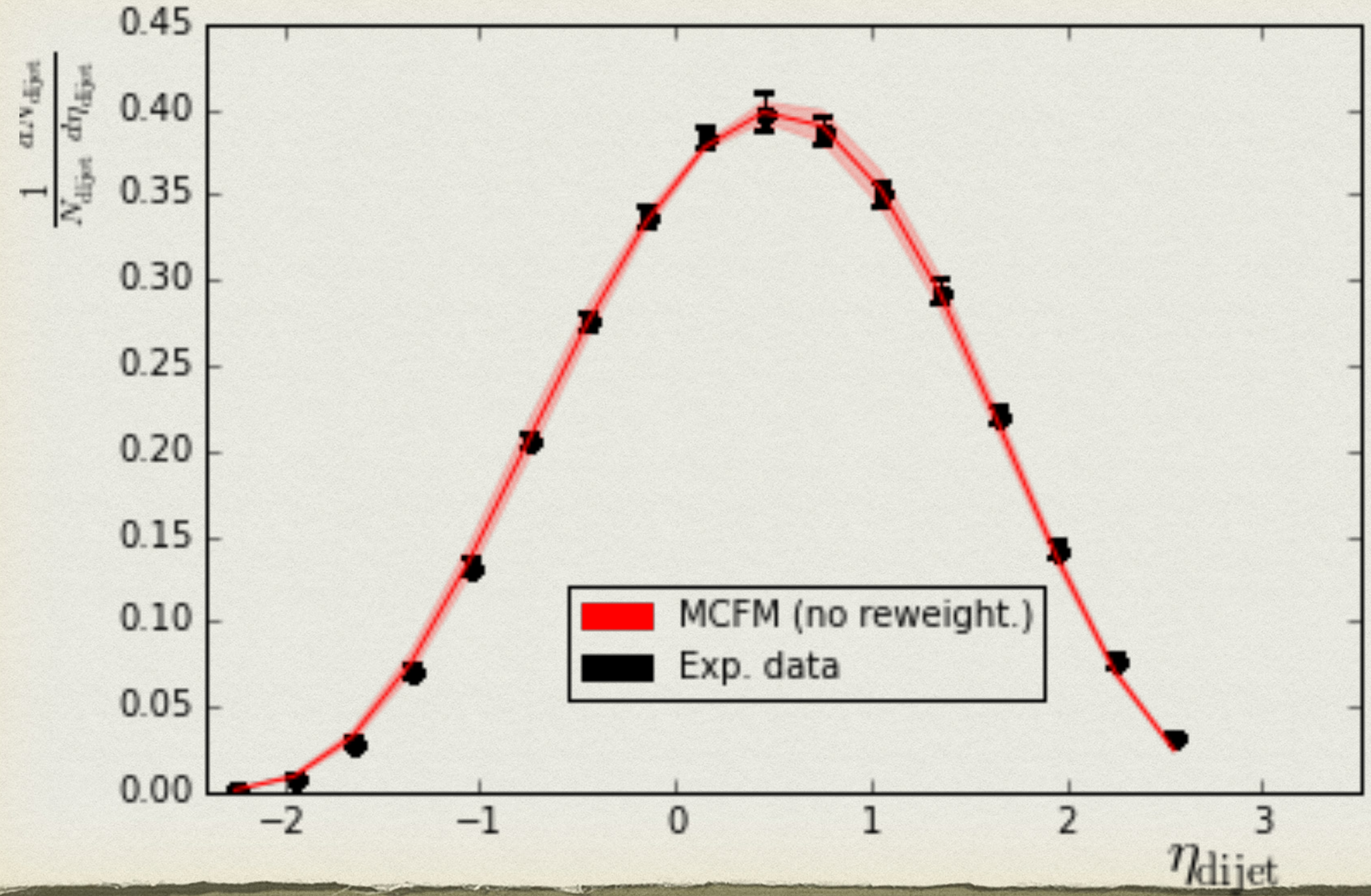


DI-JETS BY CMS

CMS Collaboration,
EPJC 74 (2014) 7, 2951.



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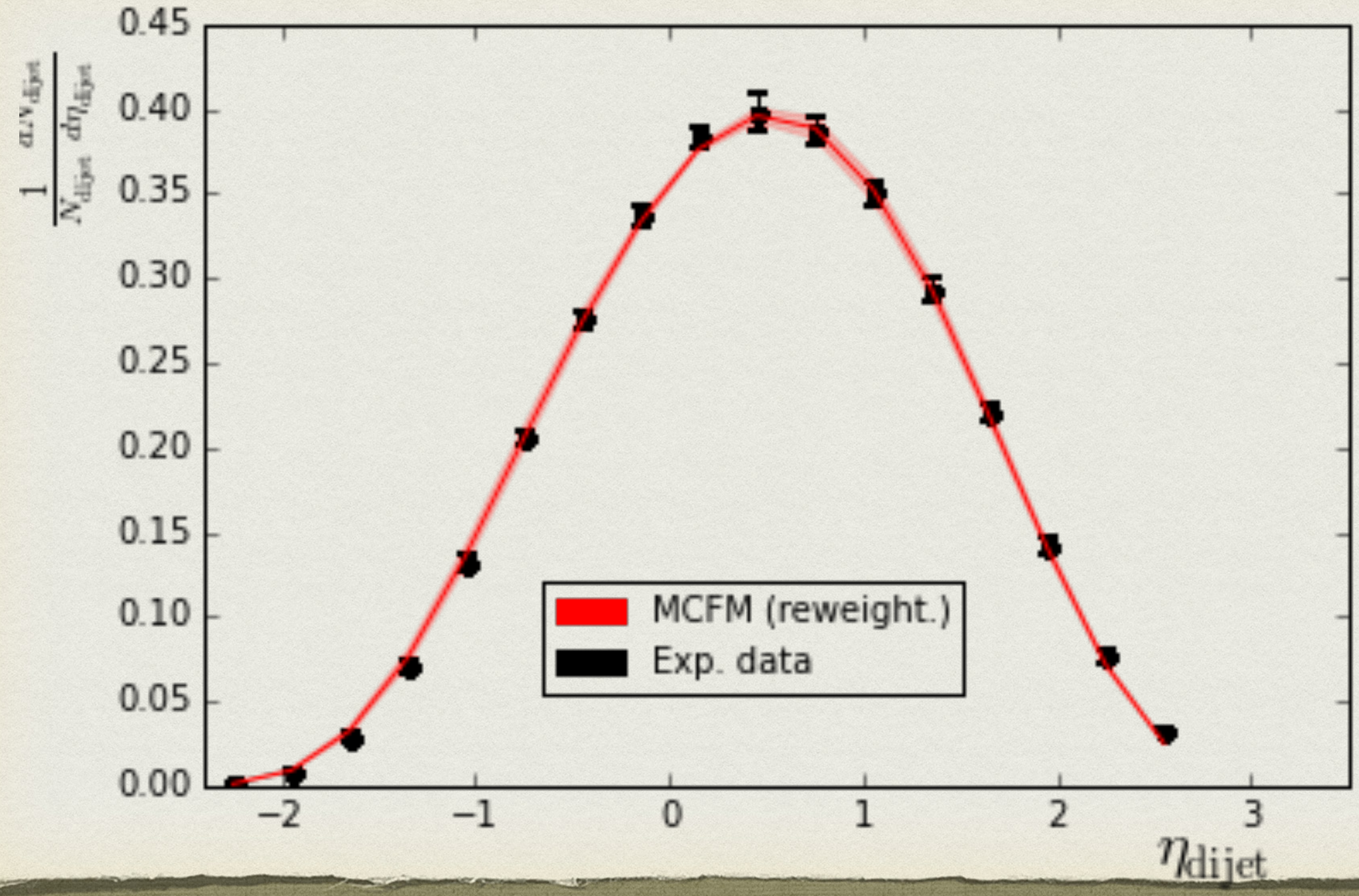
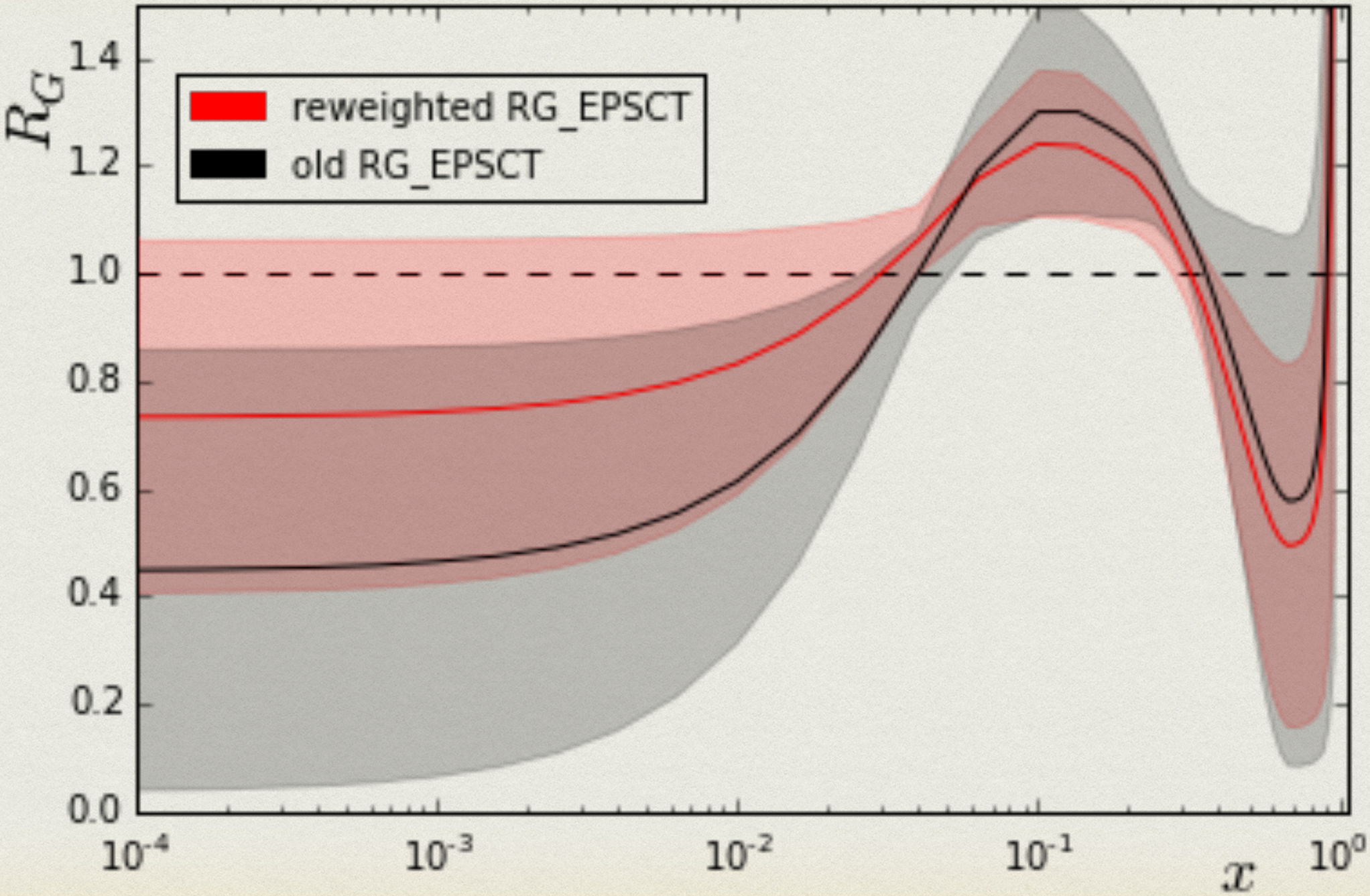


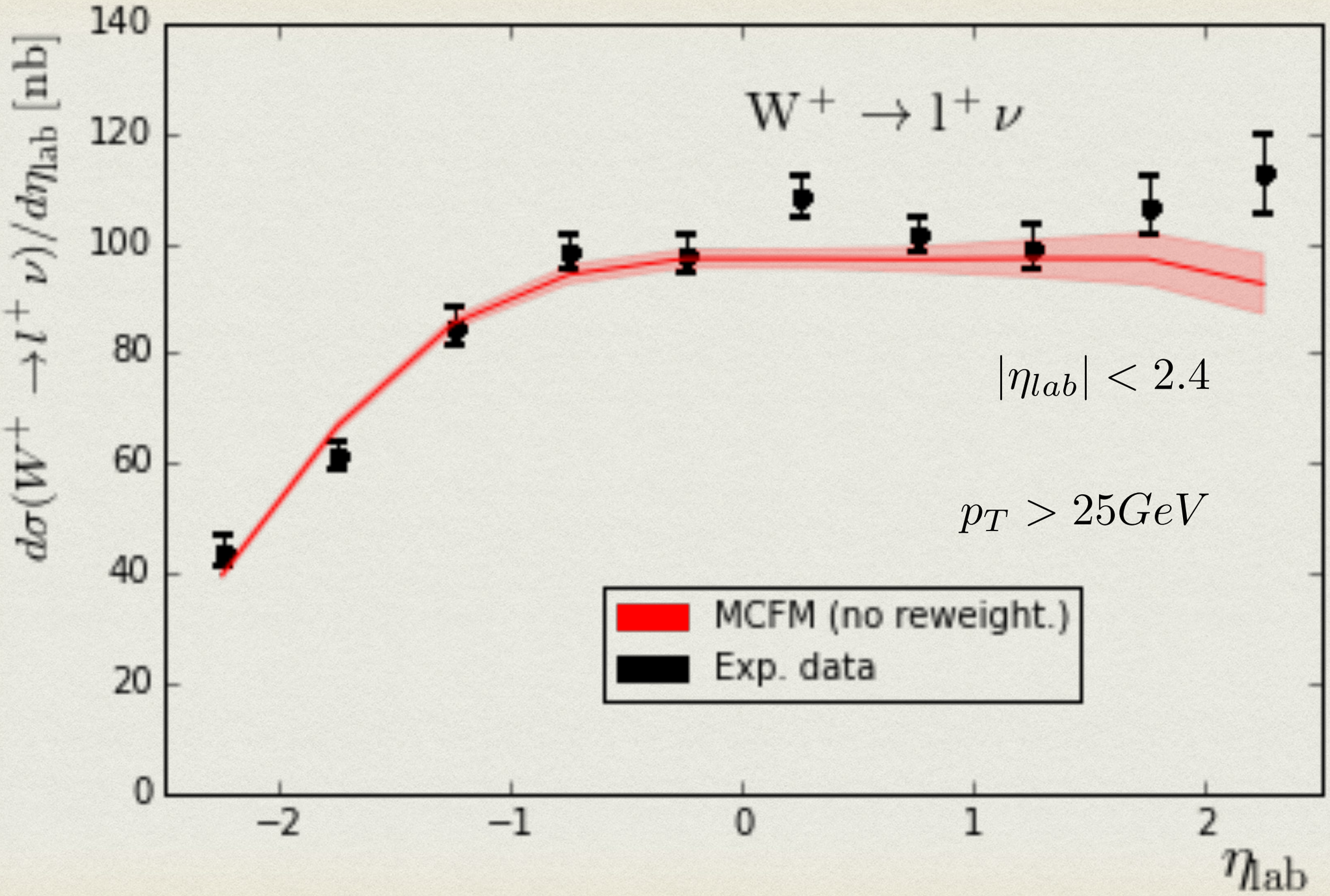
GLUONS

$Q^2 = 1.69 GeV^2$



W'S BY CMS

CMS Collaboration, arXiv: 1503.05825 [hep-ex].



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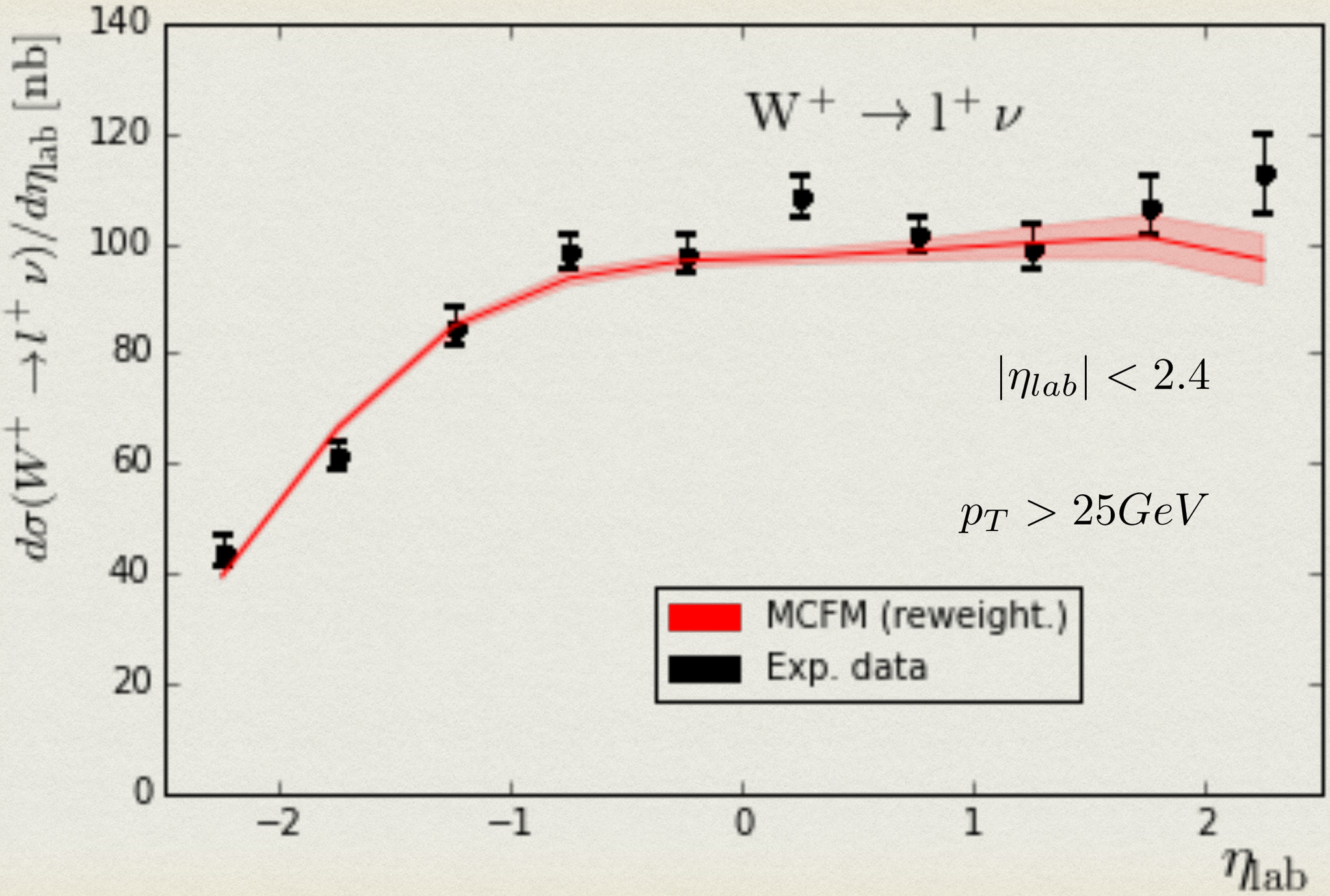

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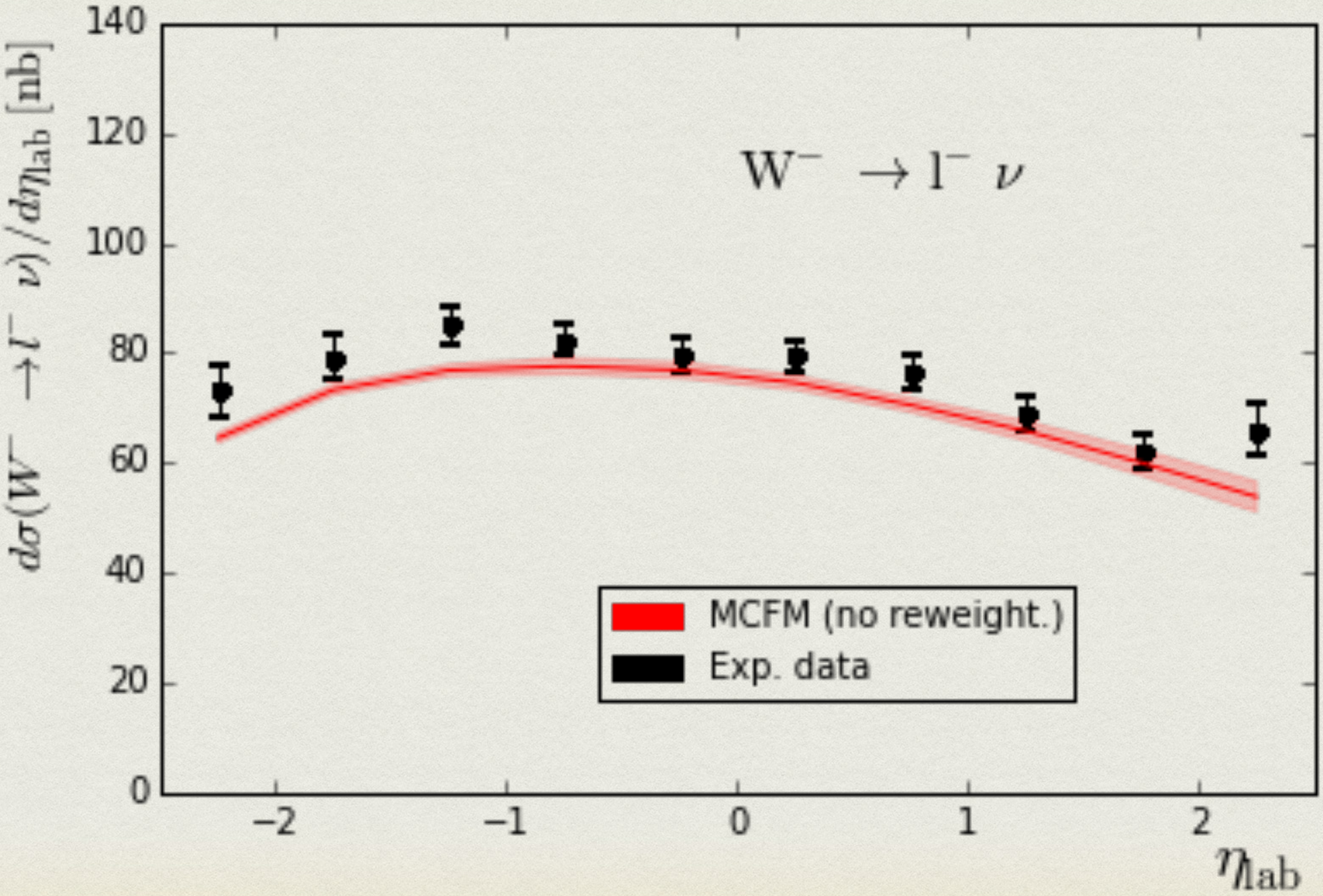

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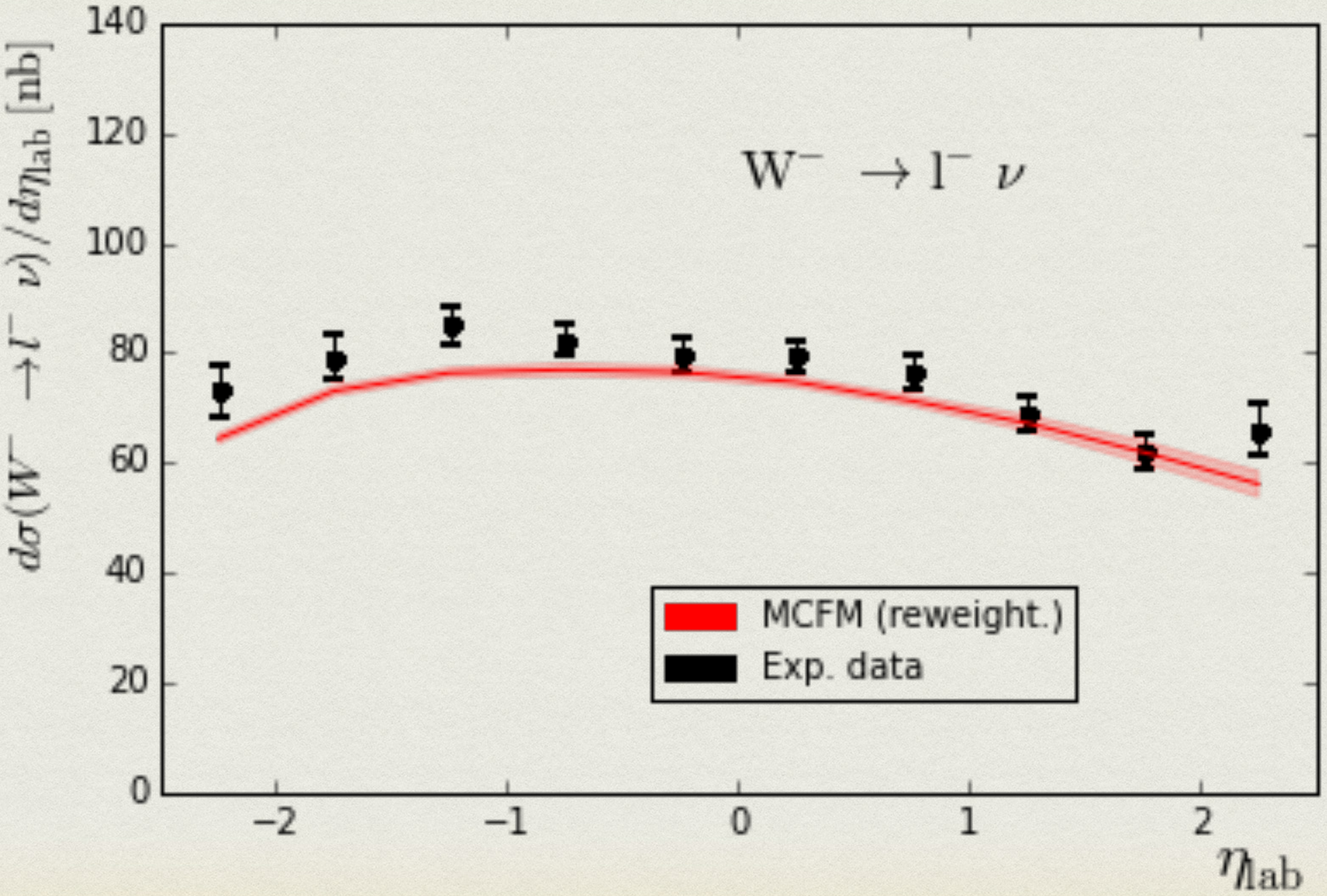
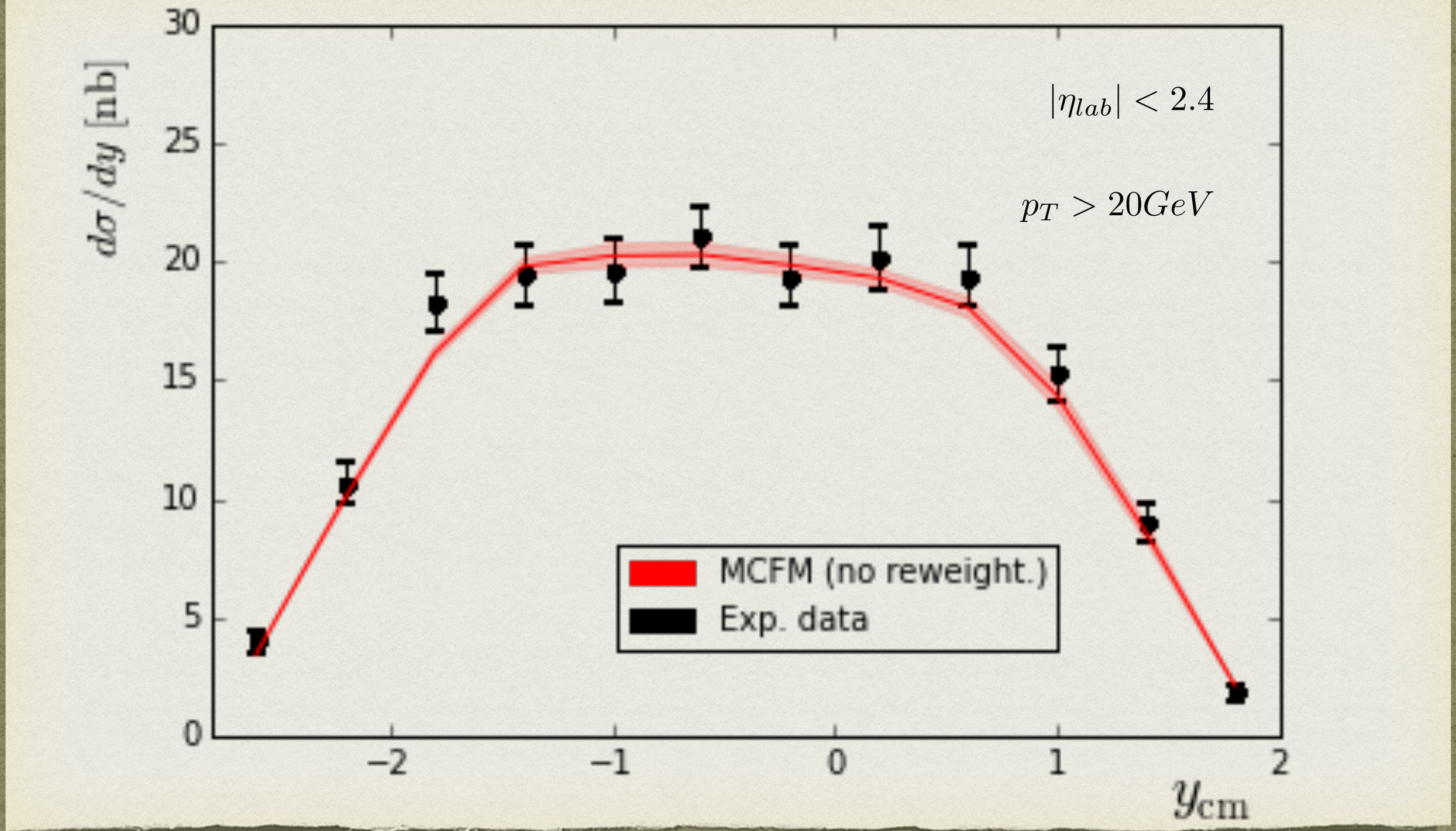


Z BY CMS

CMS PAS HIN-15-002



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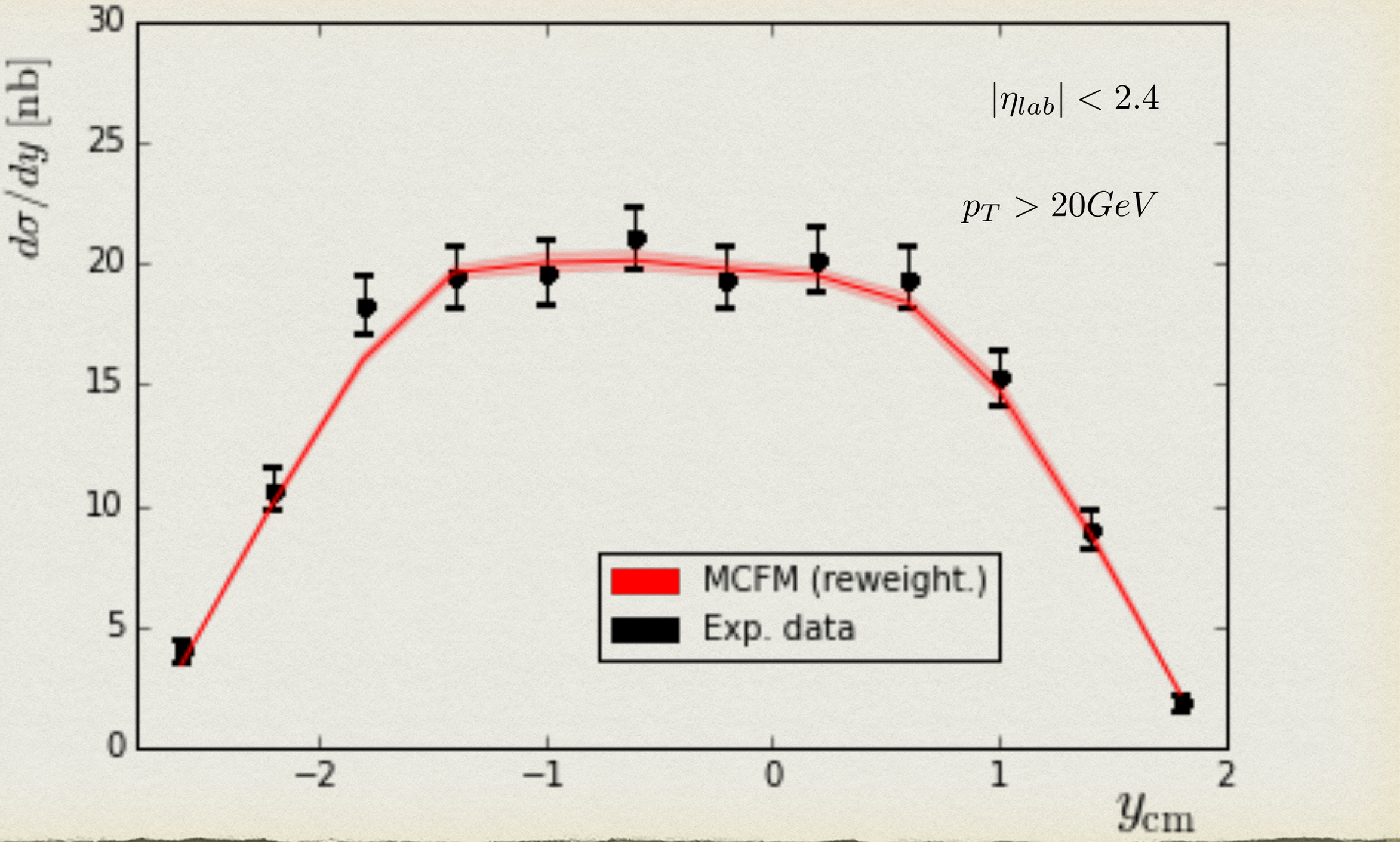
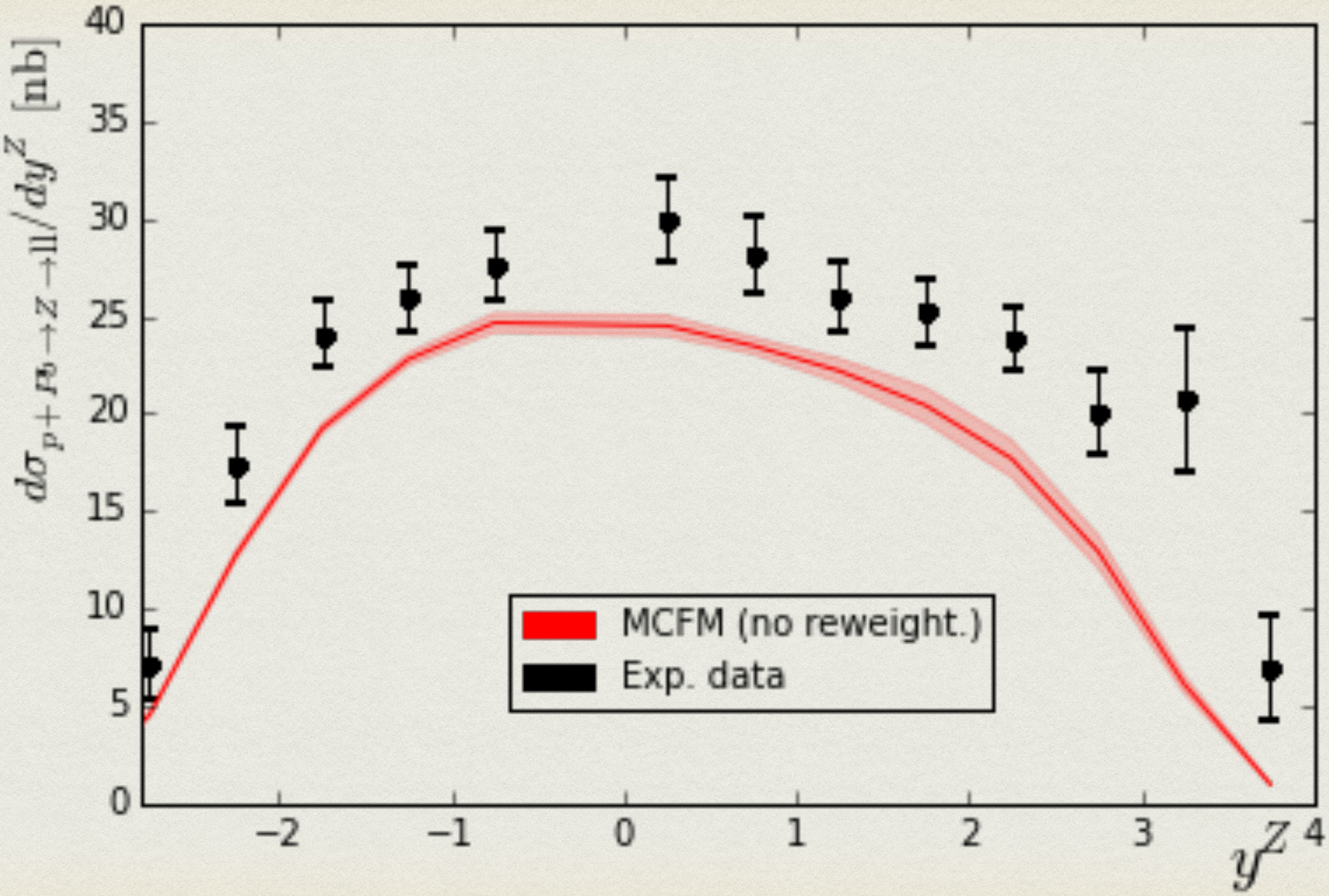


Z BY ATLAS

ATLAS-CONF-2014-020

CAREFUL! NOT THE LATEST DATA (see T. Balestri's talk at Hard Probes)



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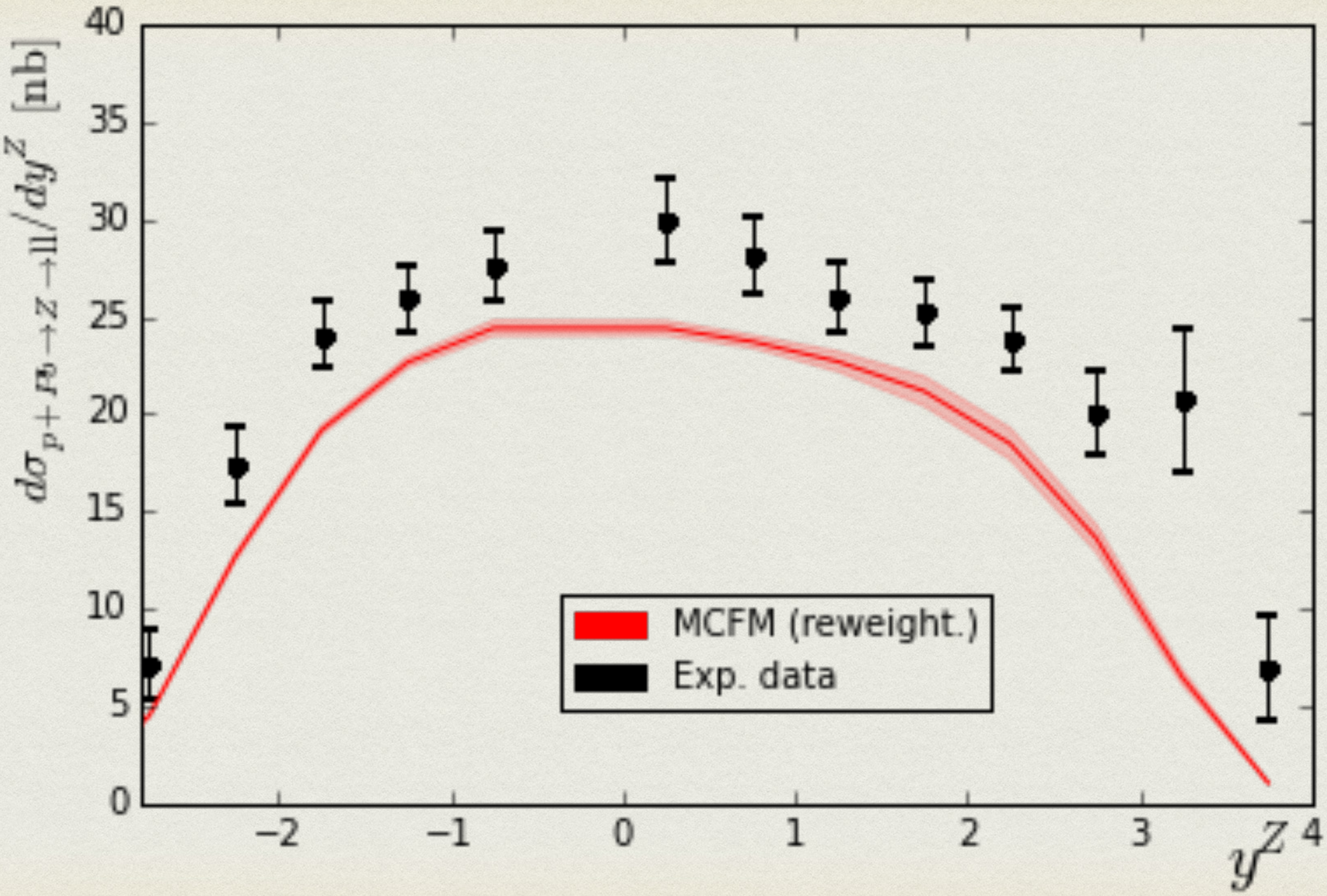

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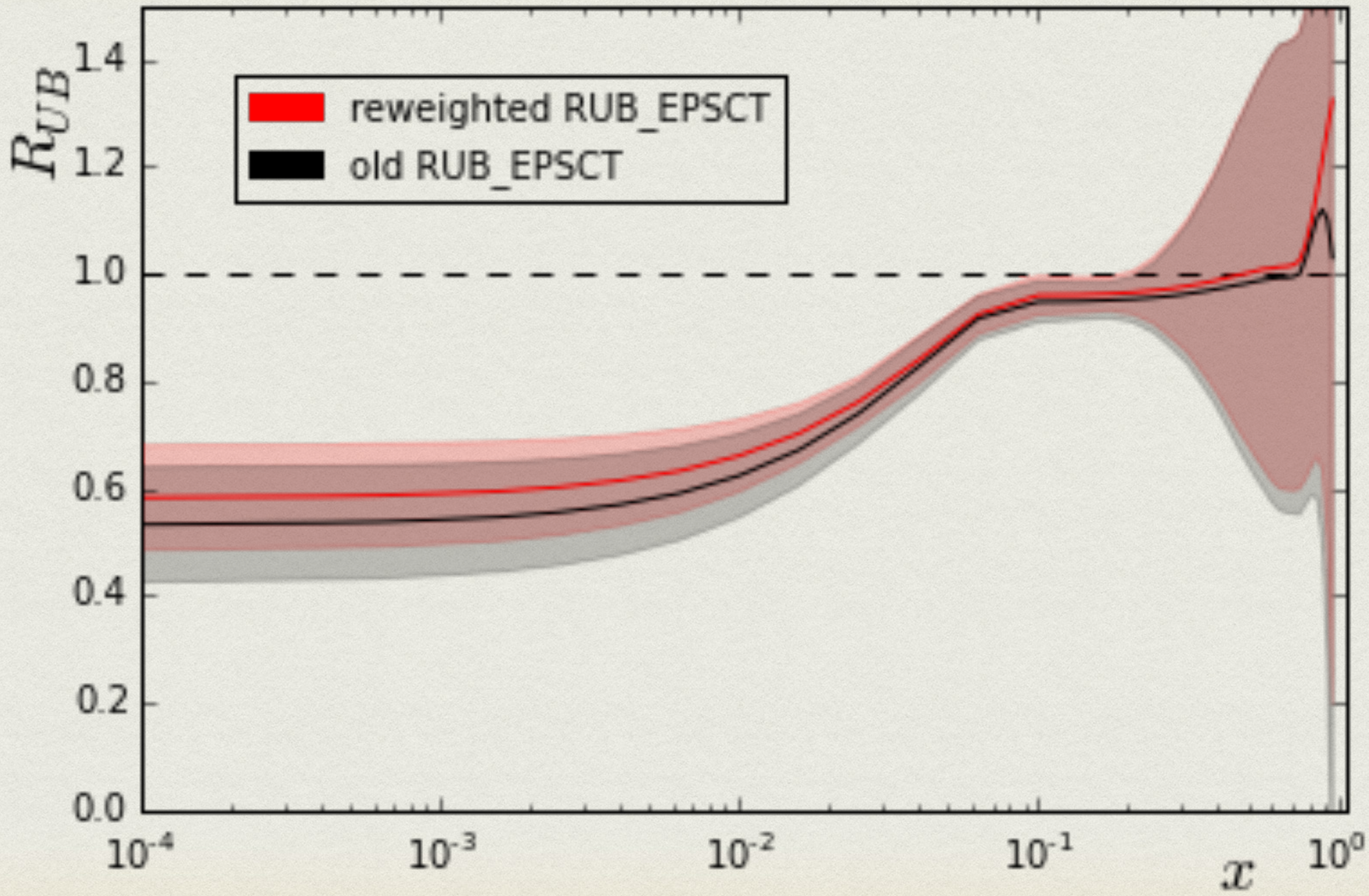
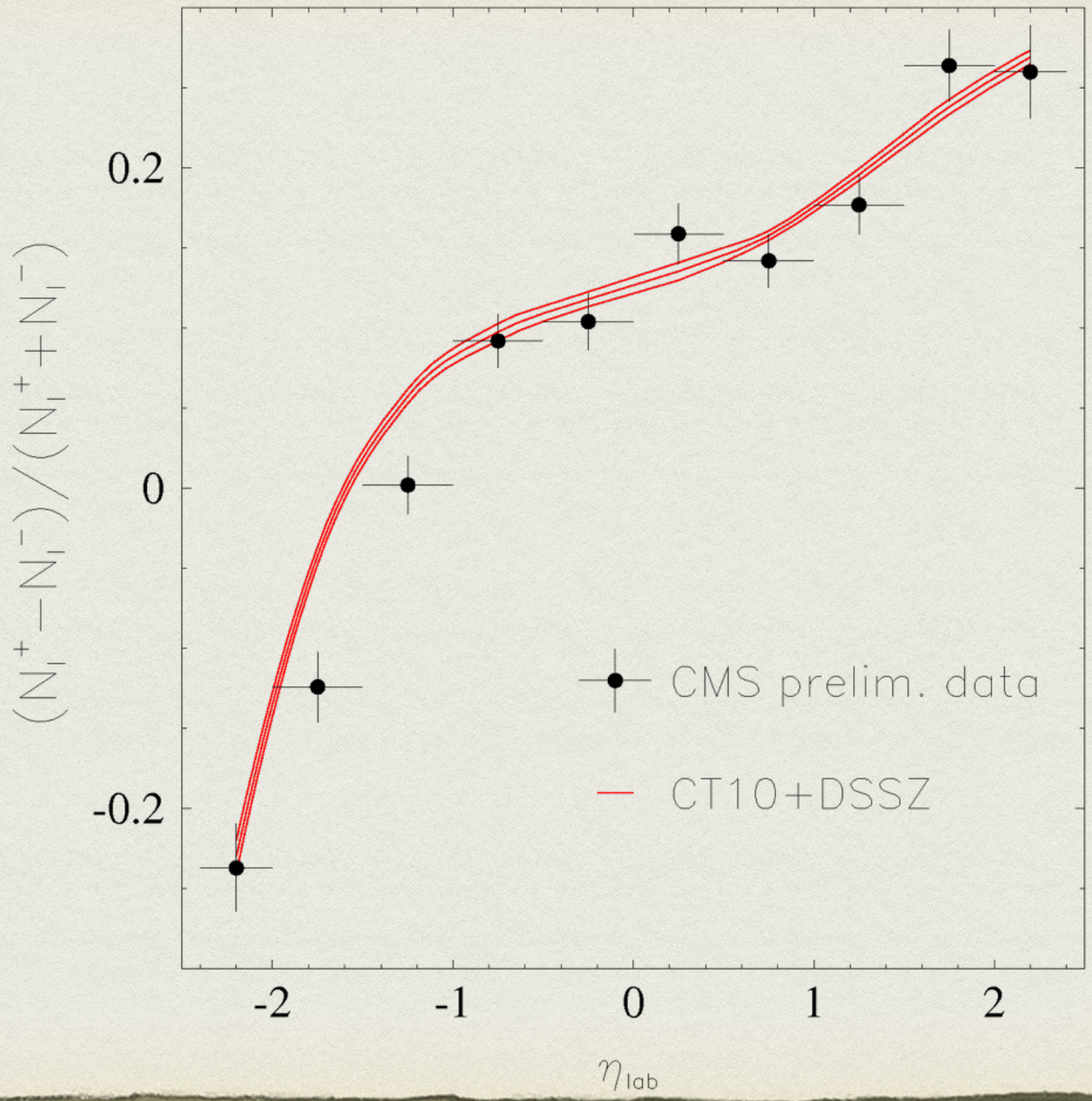


ASYMMETRIES

CMS W's

$$C_{asymm} = \frac{N_l^+ - N_l^-}{N_l^+ + N_l^-}$$



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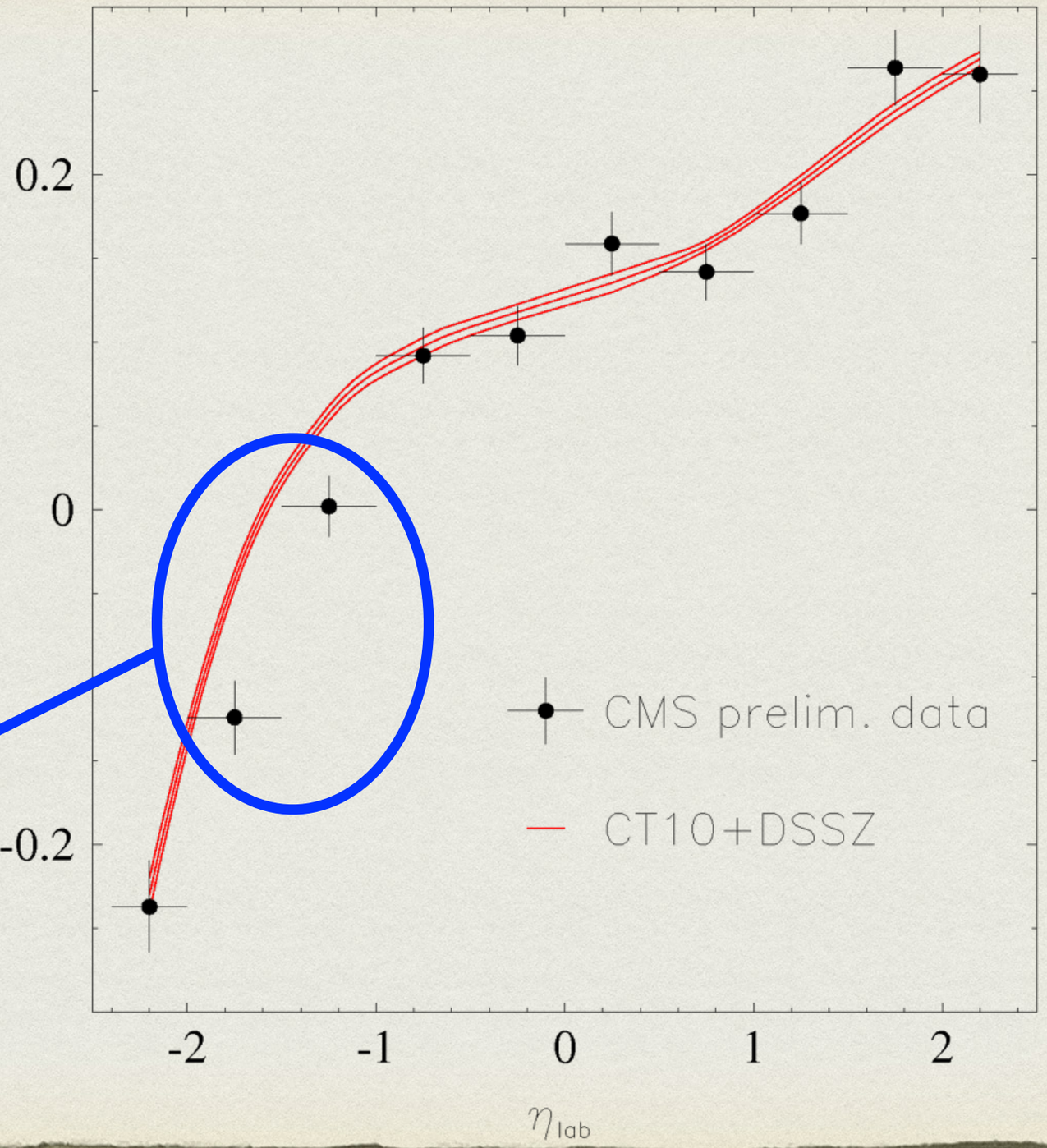
need of flavour decomposition in nPDFs



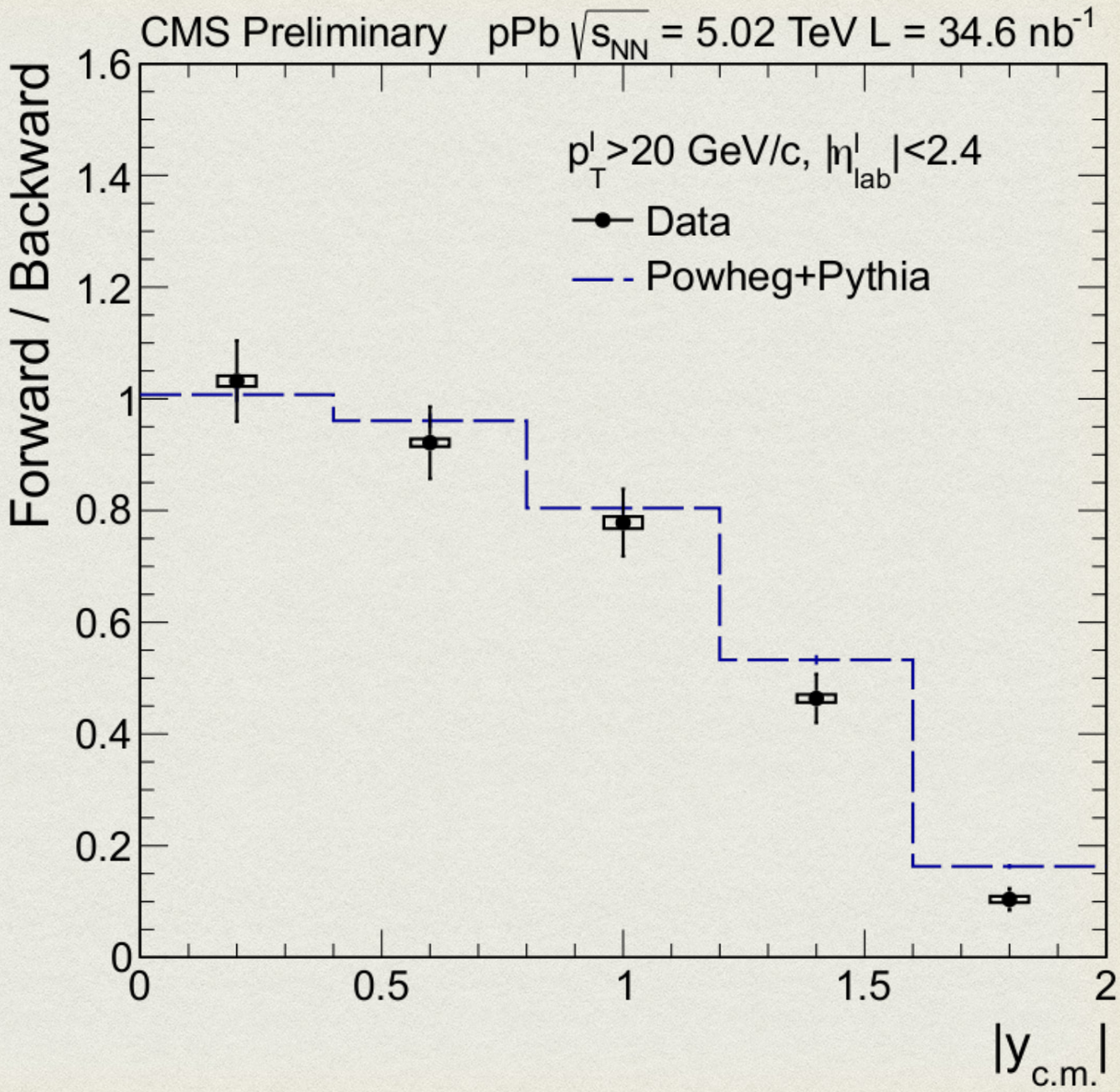
ASYMMETRIES

CMS Z

CMS PAS HIN-15-002

$$FB_{asymm} = \frac{N_l(+\eta)}{N_l(-\eta)}$$

predictions show a clear nuclear effect (see A. Zsigmond's talk in Hard Probes)



SUMMARY

- We analyzed p-Pb data from LHC (~160 points) for EPS09
- Predictions are compatible with data (except ATLAS' Z, updated data to check): $N_{eff} \sim 6000$
- For EPS09 the impact seems rather small, except for the gluon density (very unconstrained)
- The trend is a flatter gluon, with less shadowing and anti-shadowing
- Preliminar results do not hint the need for new nPDFs

& OUTLOOK

- Incorporate the final ATLAS' Z data, and LHCb's Z
- Consider charged-particles production from ALICE
- Check for (promising) observables, such as asymmetries

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comments and (un) answered questions to:

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(the rest of us are on vacation)