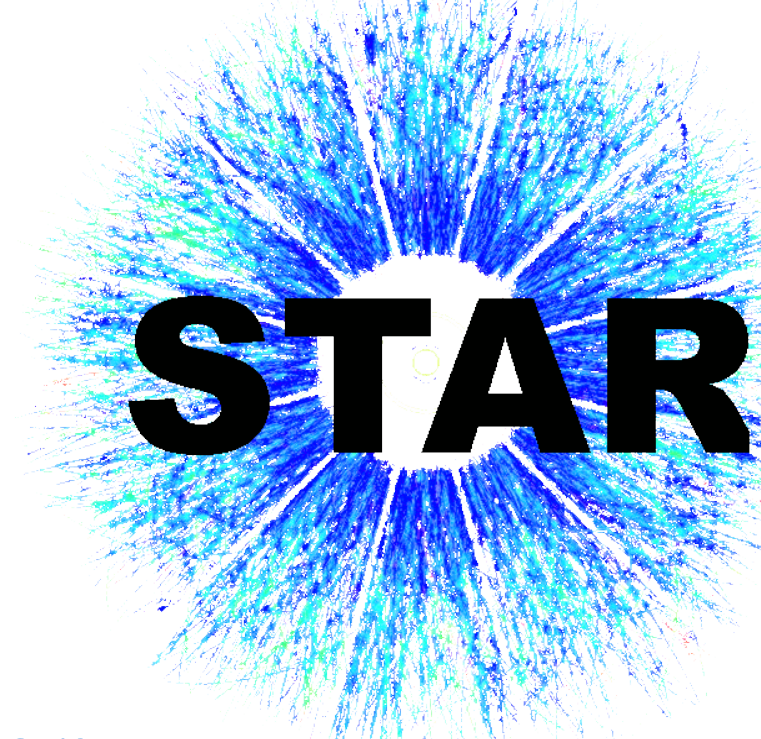
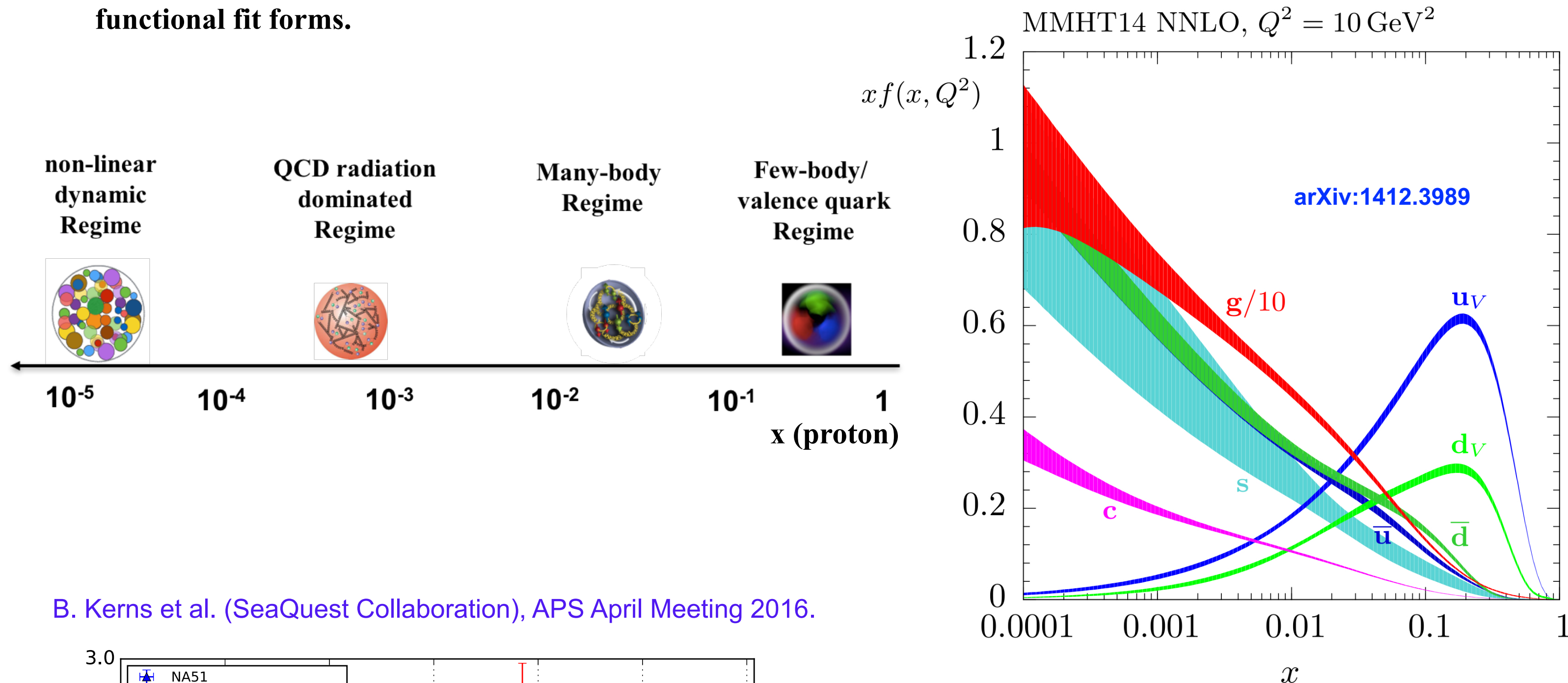


# Constraining Sea Quark Distributions Through W and Z Cross Section and Cross Section Ratios Measured at STAR

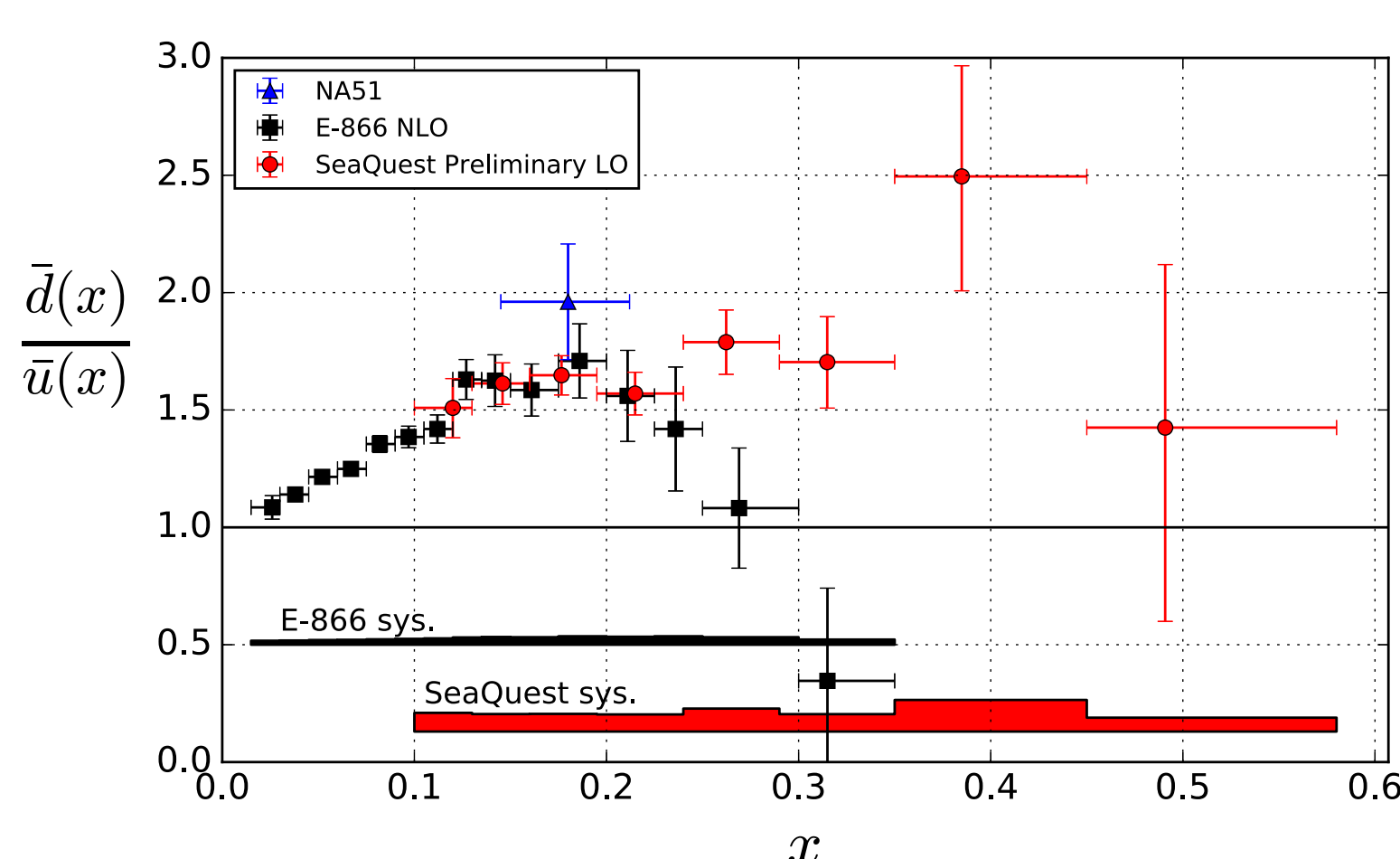


## Motivation

- Parton distribution functions (PDFs) probe the internal structure of the proton. The  $x$ -dependence of these PDFs allows one to map the intrinsic and dynamic properties of the proton.
- Various global analyses (CT14, MMHT14, BS15, etc.) extract PDFs from data using various data sets and functional fit forms.



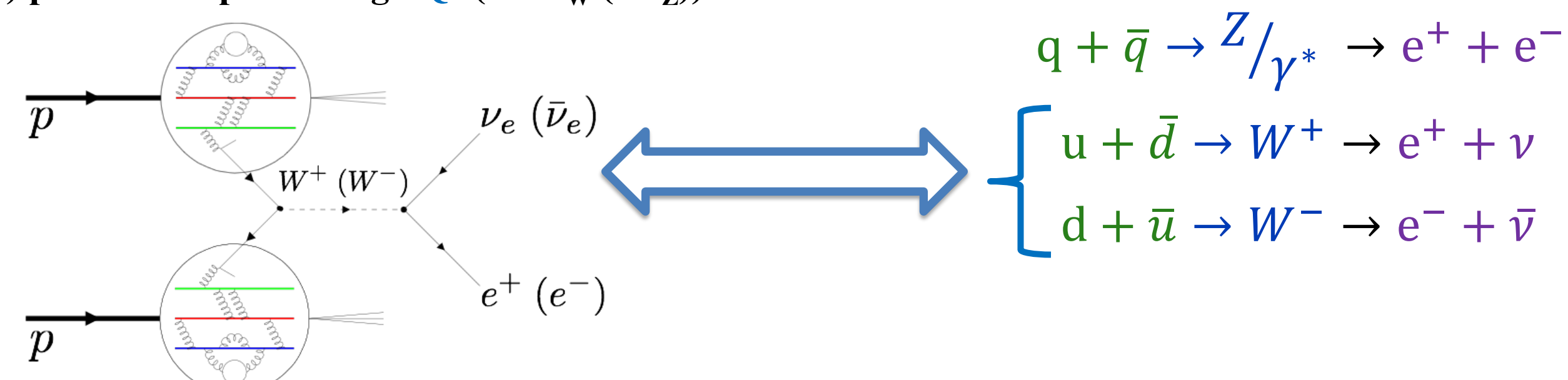
B. Kerns et al. (SeaQuest Collaboration), APS April Meeting 2016.



- The  $\bar{d}/\bar{u}$  distribution has been measured by several experiments.
- More data are needed at higher  $x$  to help constrain the sea quark distributions.
- New measurements from different experiments can provide more data at different  $Q^2$  values and scattering processes.

## W/Z Boson Production

- W/Z bosons are directly sensitive to quark/anti-quark distributions. They can be measured through the W and Z lepton decay channels in proton + proton collisions
- W(Z) production probes high  $Q^2$  ( $= M_W^2$  ( $M_Z^2$ ))



- The W cross section ratio at leading order takes the form:  $\frac{\sigma_{W^+}}{\sigma_{W^-}} \approx \frac{\bar{d}(x_2)u(x_1) + \bar{d}(x_1)u(x_2)}{\bar{u}(x_2)d(x_1) + \bar{u}(x_1)d(x_2)}$

- The W and Z fiducial cross sections can be measured experimentally as:

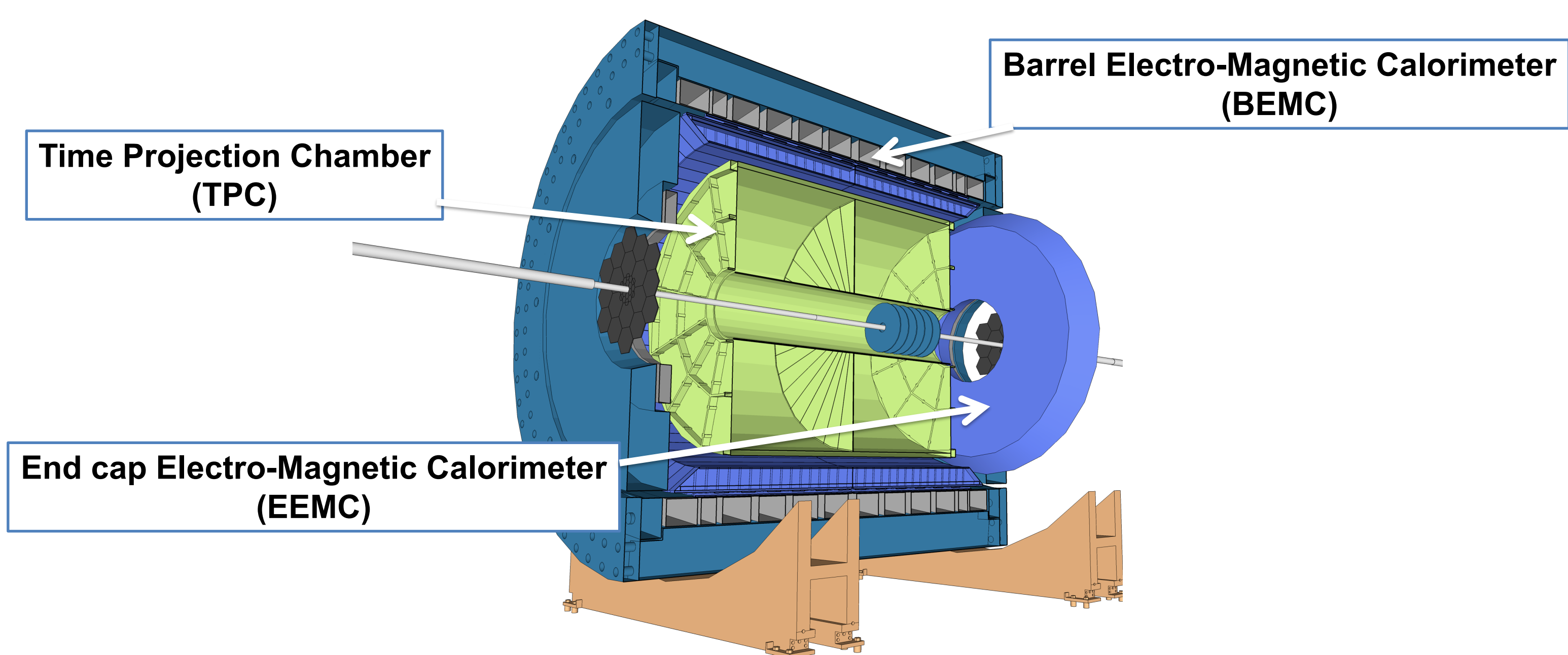
$$\sigma_{W^{\pm,Z}}^{fid} = \frac{N_O^{W^{\pm,Z}} - N_B^{W^{\pm,Z}}}{\mathcal{L} \cdot \epsilon^{W^{\pm,Z}}}$$

- +/- is positron/electron from W leptonic decay
- $N_O$  is number of observed W (Z) events
- $N_B$  is number of background events
- $\epsilon$  is the measured W (Z) efficiency
- $\mathcal{L}$  is the total luminosity

## The STAR Detector and Data

### Sub Detectors

- The W and Z cross sections were measured in the mid-rapidity region making use of three major sub detectors:
  - The TPC and solenoid magnet were used for particle tracking
  - Particle energy was measured using the BEMC
  - QCD background estimates and corrections made use of the EEMC

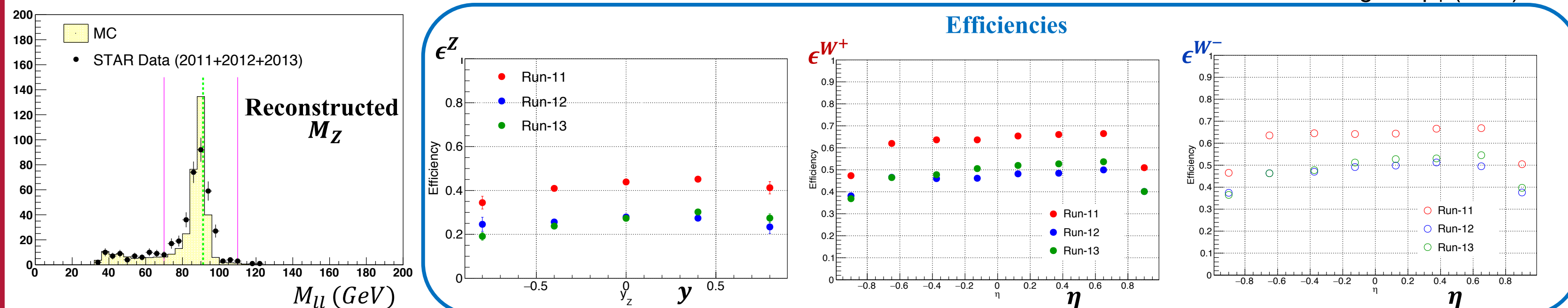
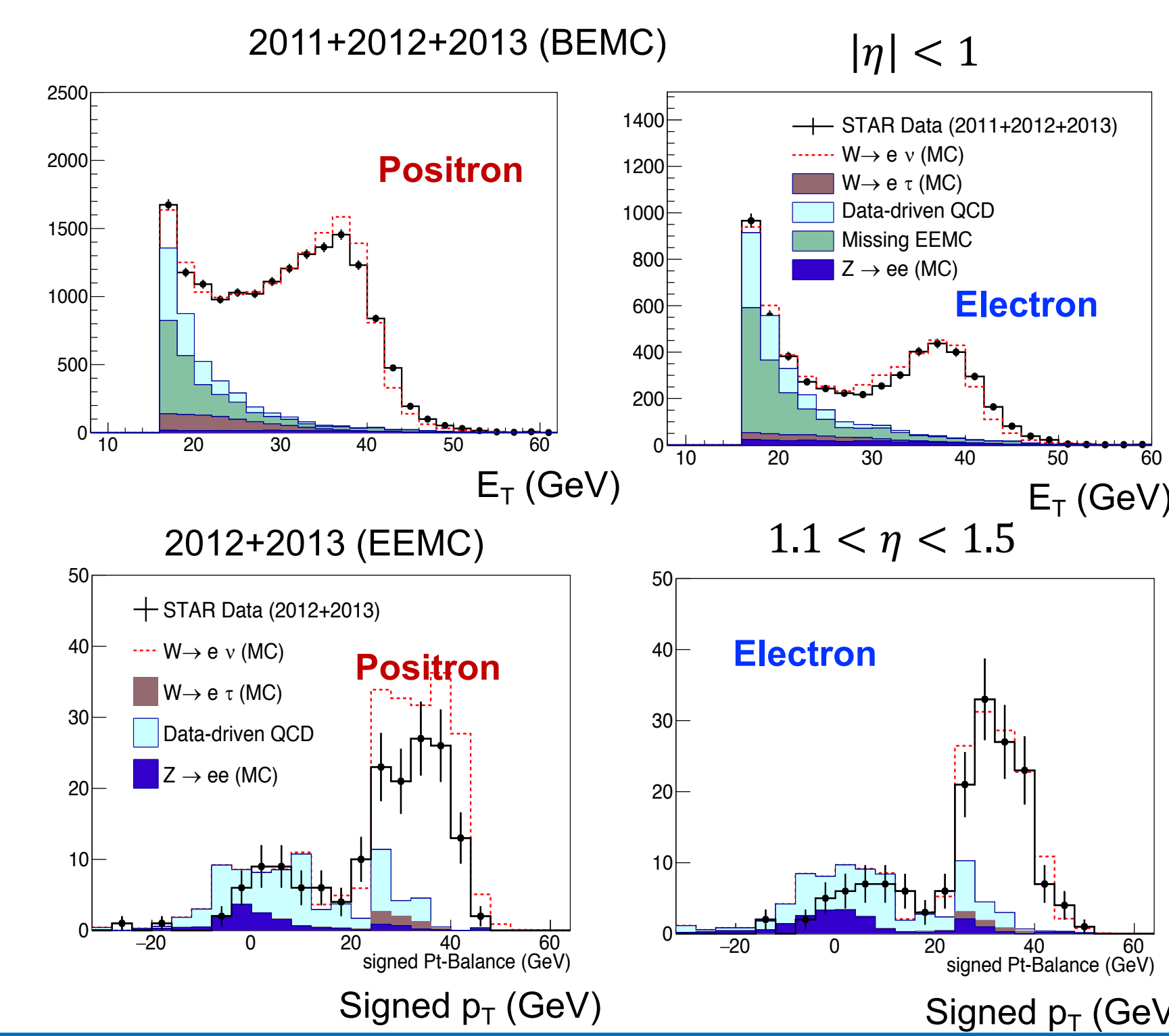


### Data Sets

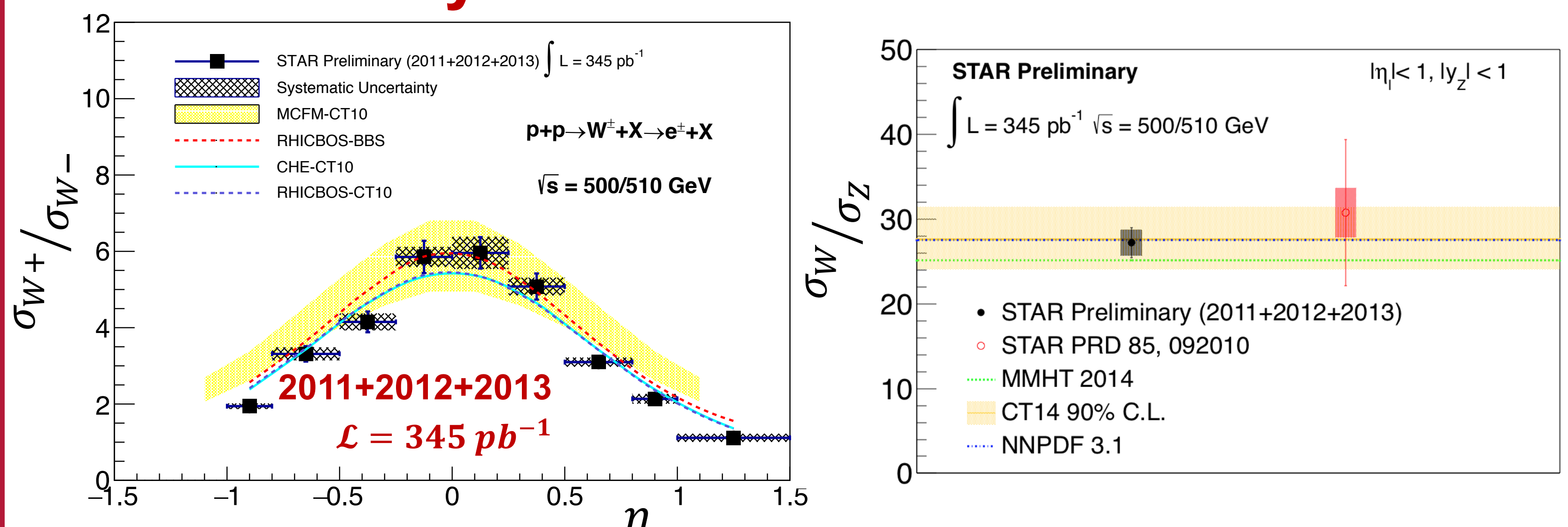
- W and Z cross sections were measured during STAR p+p 2011, 2012, and 2013 running
- Protons were collided at center of mass energies of 500 and 510 GeV
- Data totaling about 345 pb<sup>-1</sup> from years 2011, 2012, and 2013 have now been analyzed and a new preliminary result has been released
- Proton-proton data at 510 GeV was also taken in 2017. This data set is in the early analysis stages (see poster by Jae Nam), and will contribute an additional 350 pb<sup>-1</sup>

## Backgrounds and Efficiencies

- Data-driven QCD background satisfies  $e^{\pm}$  isolation cuts
- Missing EEMC background results from backward jet at non-existing calorimeter coverage for  $-2 < \eta < -1.1$  and is estimated from instrumented EEMC located at  $1.1 < \eta < 2$
- Electroweak background from Z decay is estimated from PYTHIA/MC simulations
- The reconstruction of two oppositely charged, isolated, high  $E_T$  tracks from Z decay candidates results in much cleaner distribution where background correction is negligible
- W and Z efficiencies are computed using PYTHIA and MC



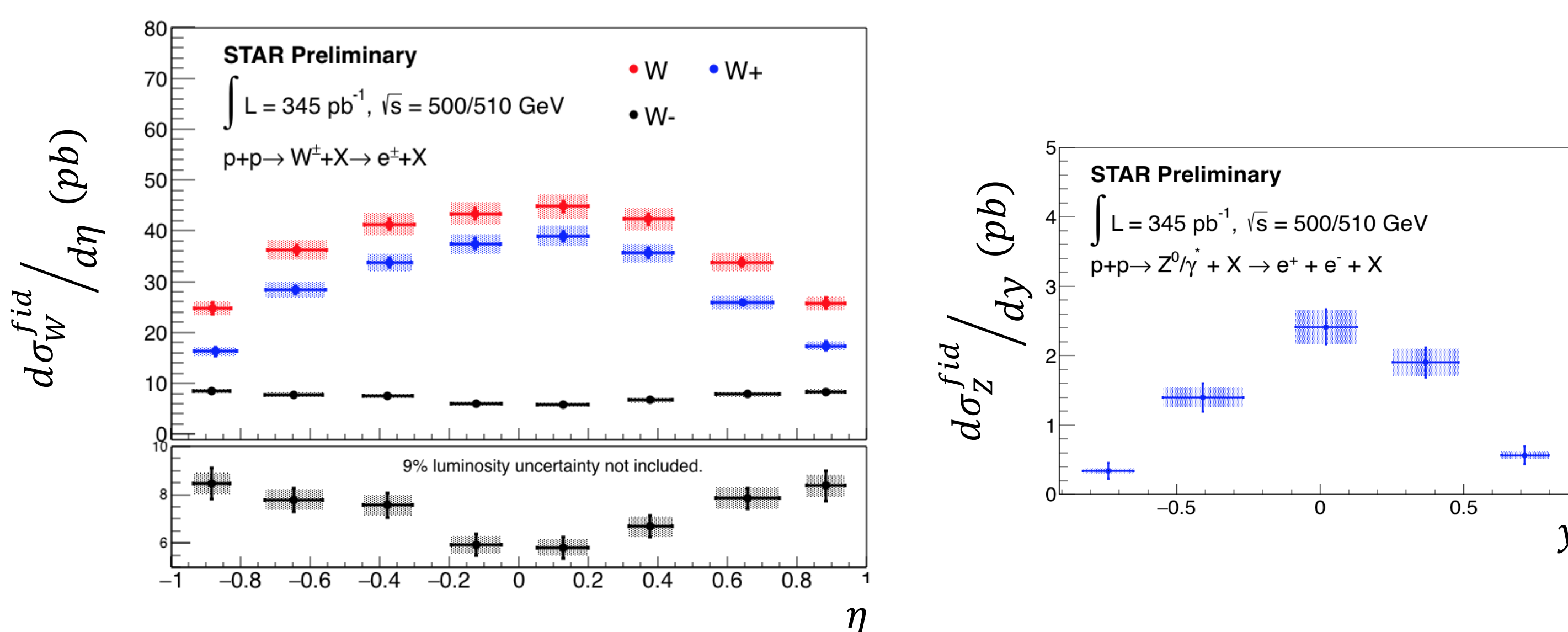
## Preliminary Results: Cross Section Ratios



- W<sup>+</sup>/W<sup>-</sup> and W/Z cross section ratios can be included into global PDF analyses to reduce current PDF uncertainties
- The different cross section ratios have different quark and anti-quark sensitivities

## Preliminary Results: Cross Sections

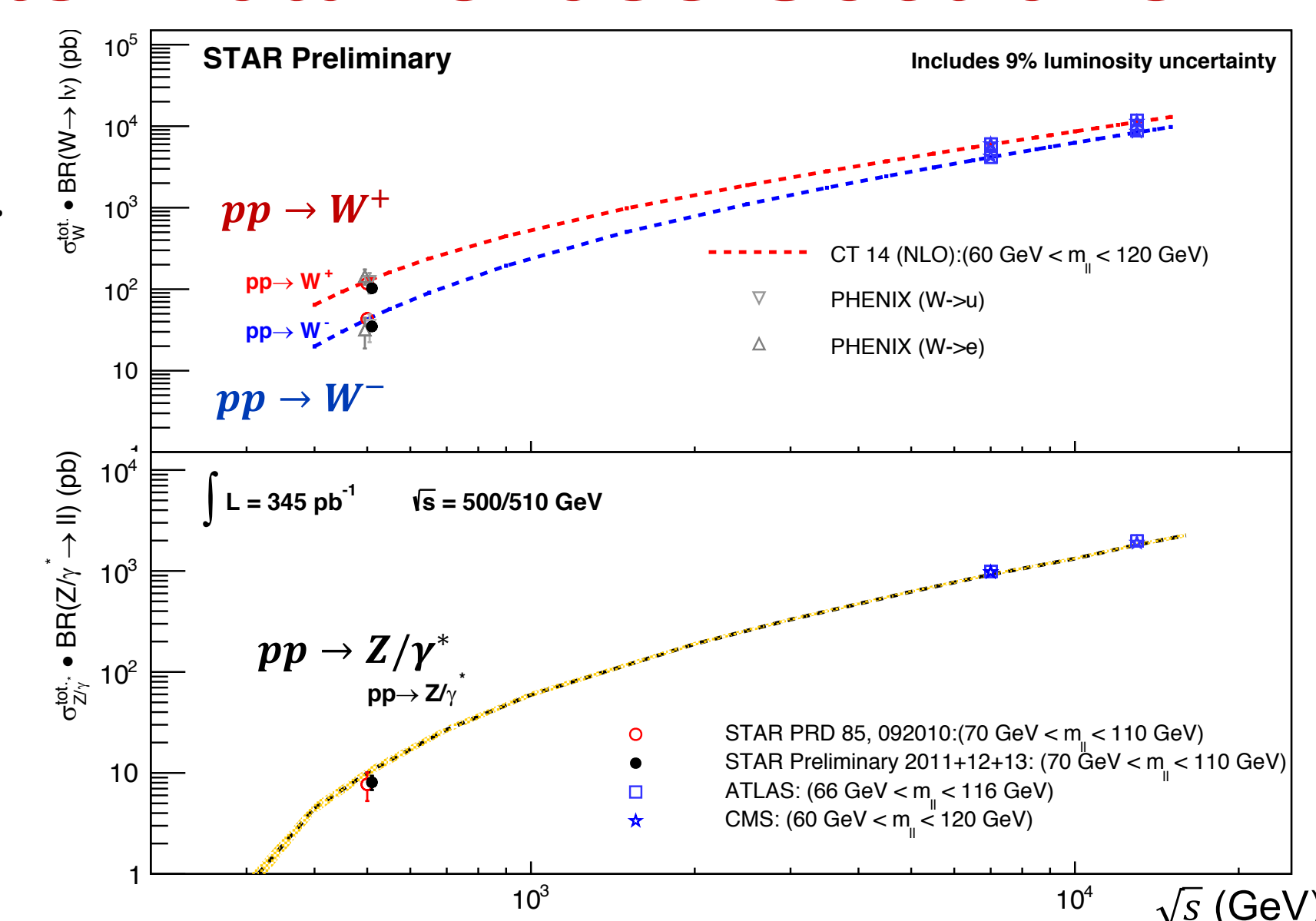
- Differential W and Z cross sections can also help to constrain PDFs, as they are also sensitive to quark and anti-quark distributions



## Preliminary Results: Total Cross Sections

- STAR kinematic acceptance needs to be accounted for to compute total W and Z cross section
- Kinematic acceptance factor,  $A$ , was computed using FEWZ cross section code
- Total cross sections are then given as:

$$\sigma_{W^{\pm,Z}}^{tot} = \frac{\sigma_{W^{\pm,Z}}^{fid}}{A_{W^{\pm,Z}}}$$



## Summary

- The STAR W cross section ratio measurements lay in an interesting kinematic range ( $0.06 \leq x \leq 0.4$ ) where existing measurements hint at an interesting behavior in the sea quark distributions
- Fits to the STAR W and Z cross section data will help to constrain the sea quark PDFs and could help better understand the sea quark distributions
- New Preliminary W and Z cross sections using combined 2011, 2012, and 2013 data sets have been measured as a function of electron pseudo-rapidity. This accounts for about 345 pb<sup>-1</sup>
- The 2017 data have delivered 350 pb<sup>-1</sup> and will further improve the W and Z cross section measurements
- See poster by Jae Nam for more 2017 W/Z analysis!