

W BOSON PRODUCTION IN POLARIZED P+P COLLISIONS

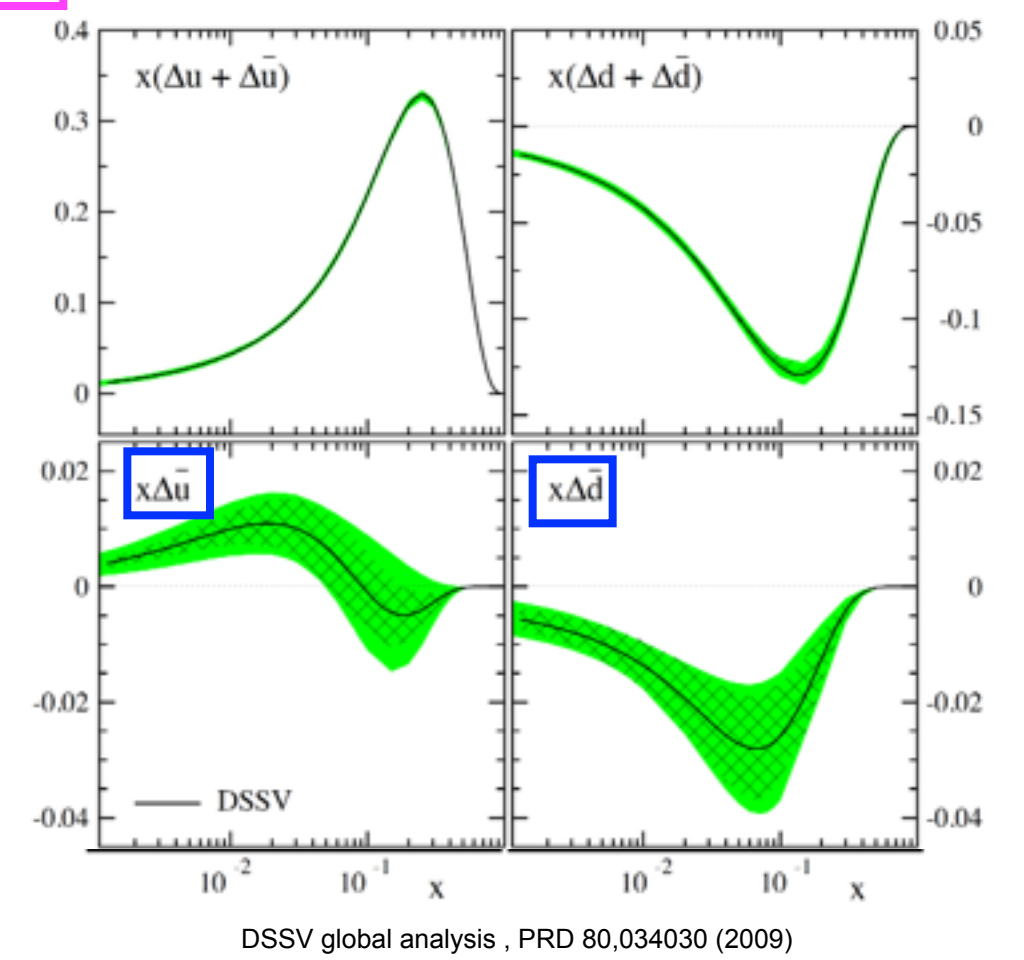


MOTIVATION

Proton Spin

One of the main contribution to the proton spin is coming from **quark and antiquark polarization** inside the proton.

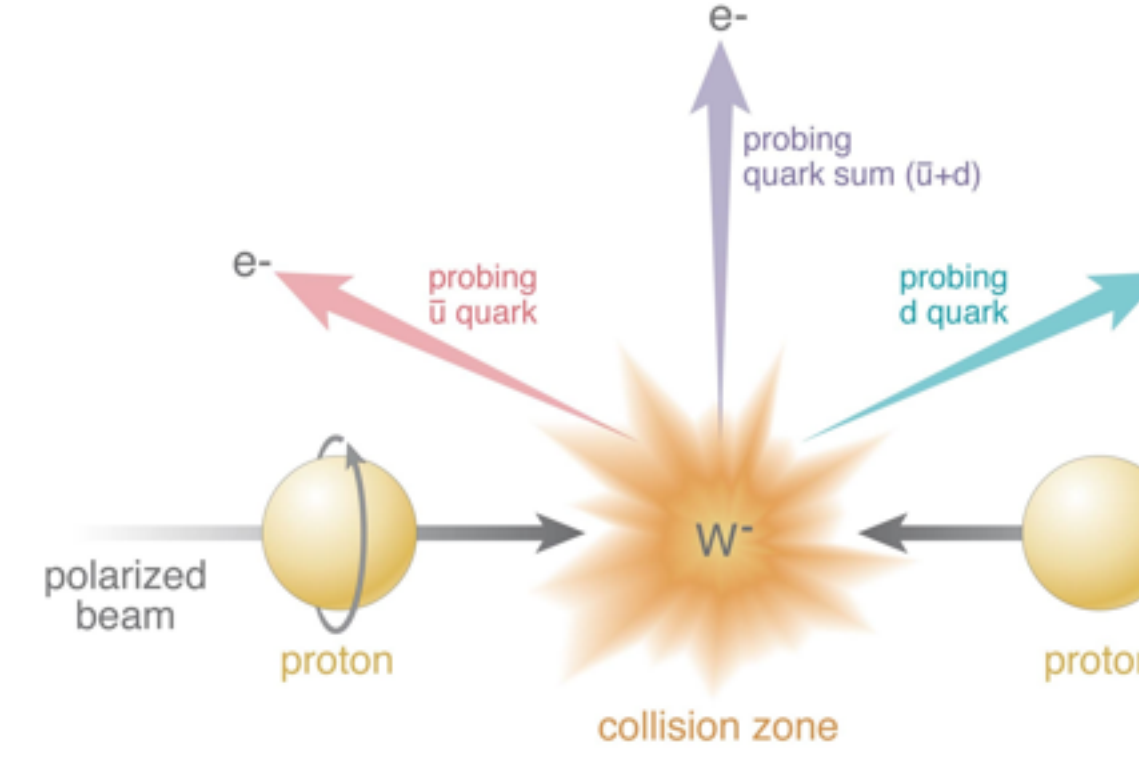
$$\Delta\Sigma = \int (\Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s}) dx$$



Inclusive DIS experiment constrained integral of quark polarization $\Delta\Sigma$ to be ~30% but significant **uncertainties** remain for **anti-quark polarization**.

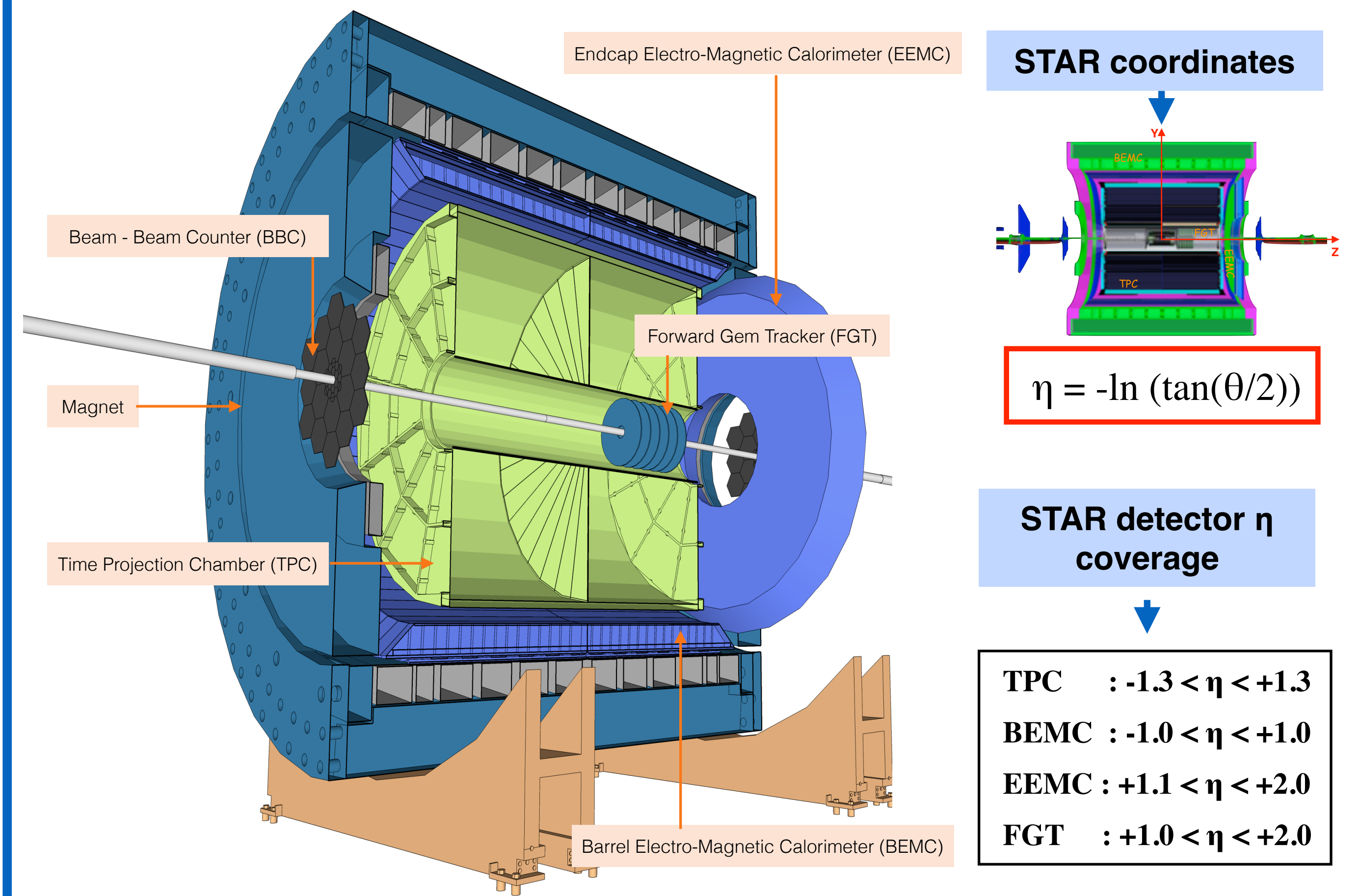
W - Boson Production

In polarized p+p collisions, W boson production is a **unique tool** to measure **light quark and antiquark polarization** of the proton.



- Maximum parity violating coupling of Ws gives access to quark and antiquark helicity distribution functions.
- Very high scale (Q^2) is defined by the W mass and No fragmentation functions are required.
- Large parity violating single spin asymmetries (A_L) can be measured by varying helicity configurations of the incoming protons.

THE STAR EXPERIMENT

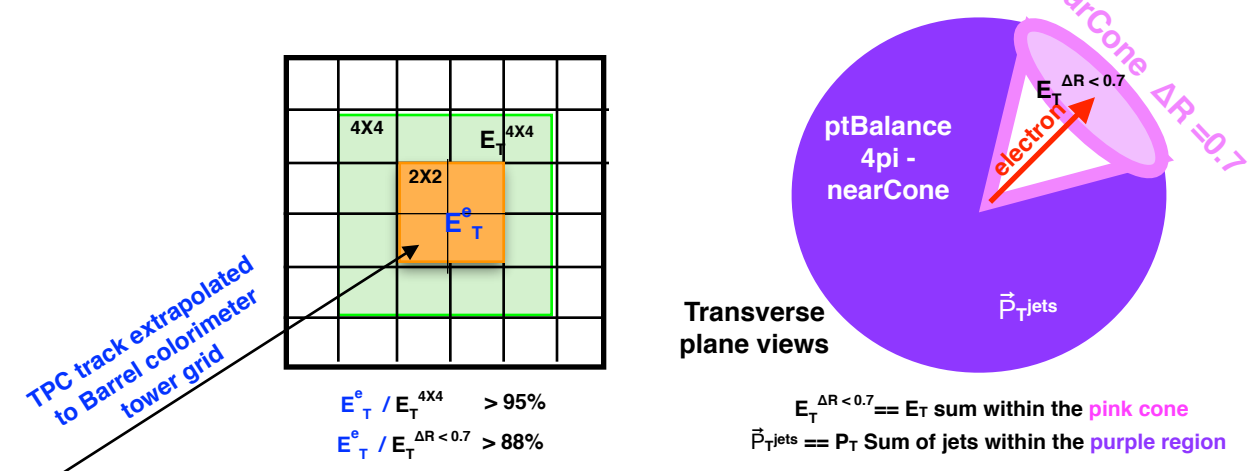


ANALYSIS

e^+e^- candidate event selection

Selecting **high transverse momentum** ($P_T > 10$ GeV) TPC tracks pointing to **high transverse energy** ($E_T > 14$ GeV) deposition in EMC

- Select reconstructed TPC tracks based on high energy trigger requirement and associate with primary vertex with $|z| < 100$ cm.



- Extend high Pt TPC tracks, to match with **2x2 cluster energy** ($E_{2 \times 2}$) in EMC and require 90% energy deposition within the cluster.
- Use **low energy sum requirement** of w decay lepton outside the **near-side cone** around the candidate lepton tracks to isolate further.

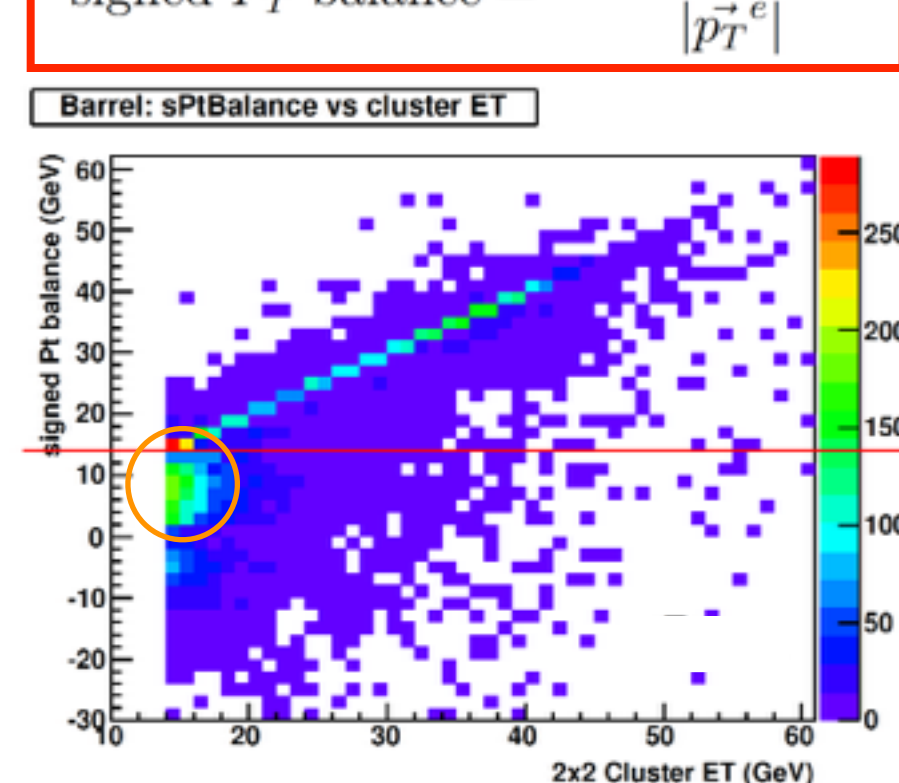
W candidate event selection

Use of **imbalance in the vector P_T sum** result by the **large missing E_T** due to undetected neutrino in a $W \rightarrow e + \nu$ event to differentiate from jet like event

signed p_T balance (sP_T) vector:

$$\vec{p}_T^{balance} = \vec{p}_T^e + \sum_{\Delta R > 0.7} \vec{p}_T^{jets}$$

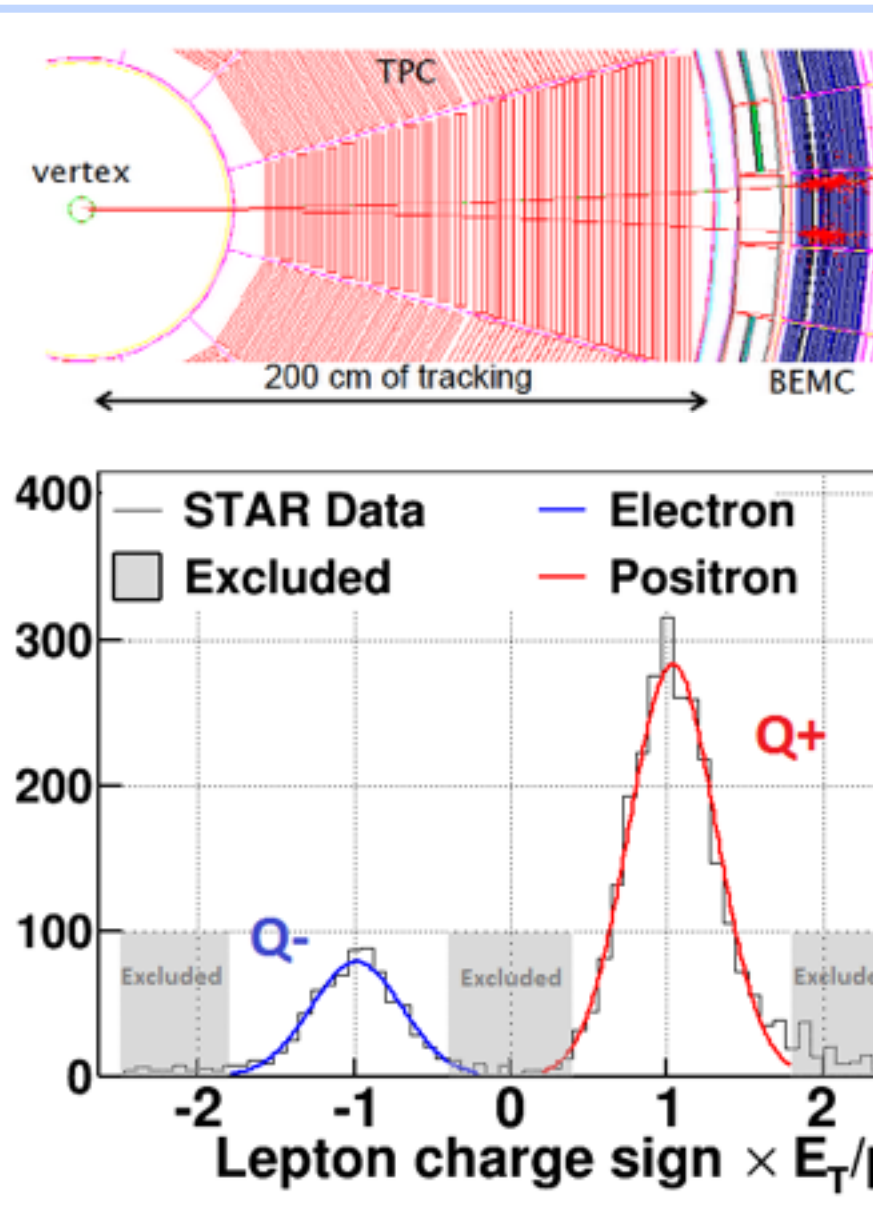
$$signed\ P_T\ -balance = \frac{(\vec{p}_T^e \cdot \vec{p}_T^{balance})}{|\vec{p}_T^e|}$$



- For **W-decay leptons**, sP_T correlated with E_T where as for **jets** sP_T is balanced by the opposite jet. (select events with $sP_T > 14$ GeV as W candidate events)

W charge sign separation

The **sign of the curvature** (bending right or left in the magnetic field) of TPC tracks use to discriminate W^+ from W^- .

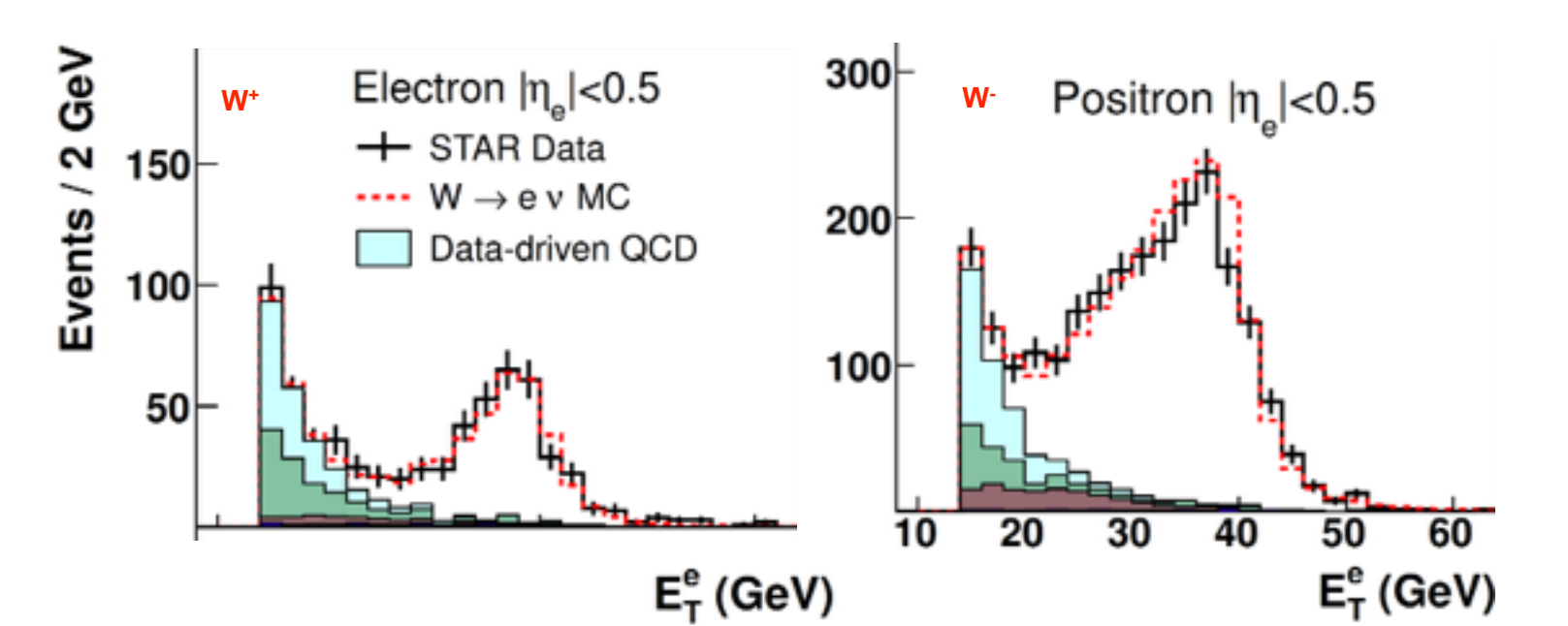


- Clear **valley between opposite charge sign** shows effectiveness of this discrimination of the TPC at relevant energies.

Background estimation

Reconstructed W candidate sample consist with well understood **electroweak backgrounds** and **QCD background**

BG channel	Estimating tool
$W \rightarrow \tau + \nu$	use PYTHIA+GEANT embedded simulation sample
$Z \rightarrow e$	use PYTHIA+GEANT embedded simulation sample
Second EEMC (because STAR is not hermetic detector)	calculate and approximate to real EEMC background.
QCD	use a data-driven BG shape

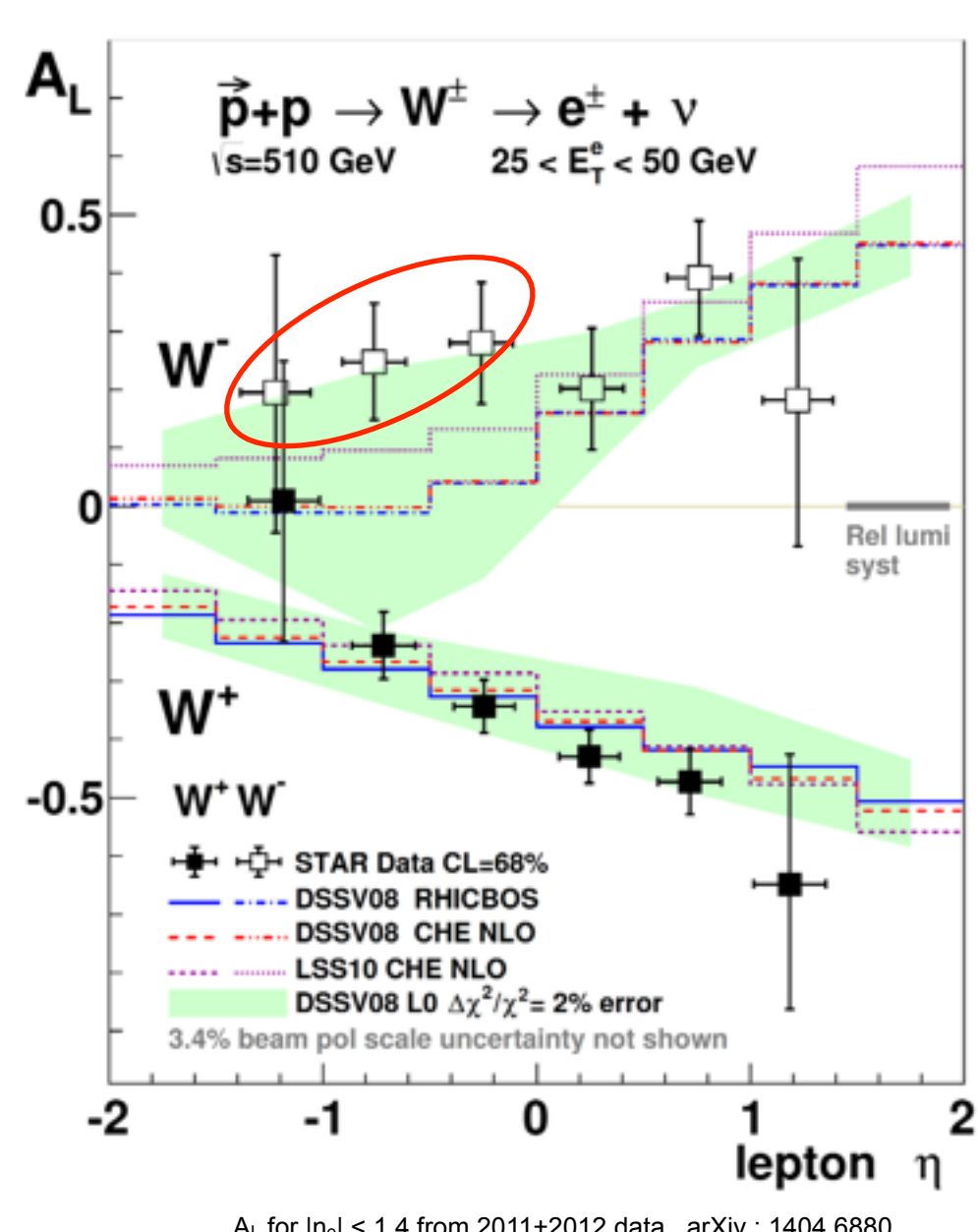


- Significant BG contribution is coming from QCD jet like events due to opposite jet escaping the detection.

RESULTS / RUN 12 + RUN 11

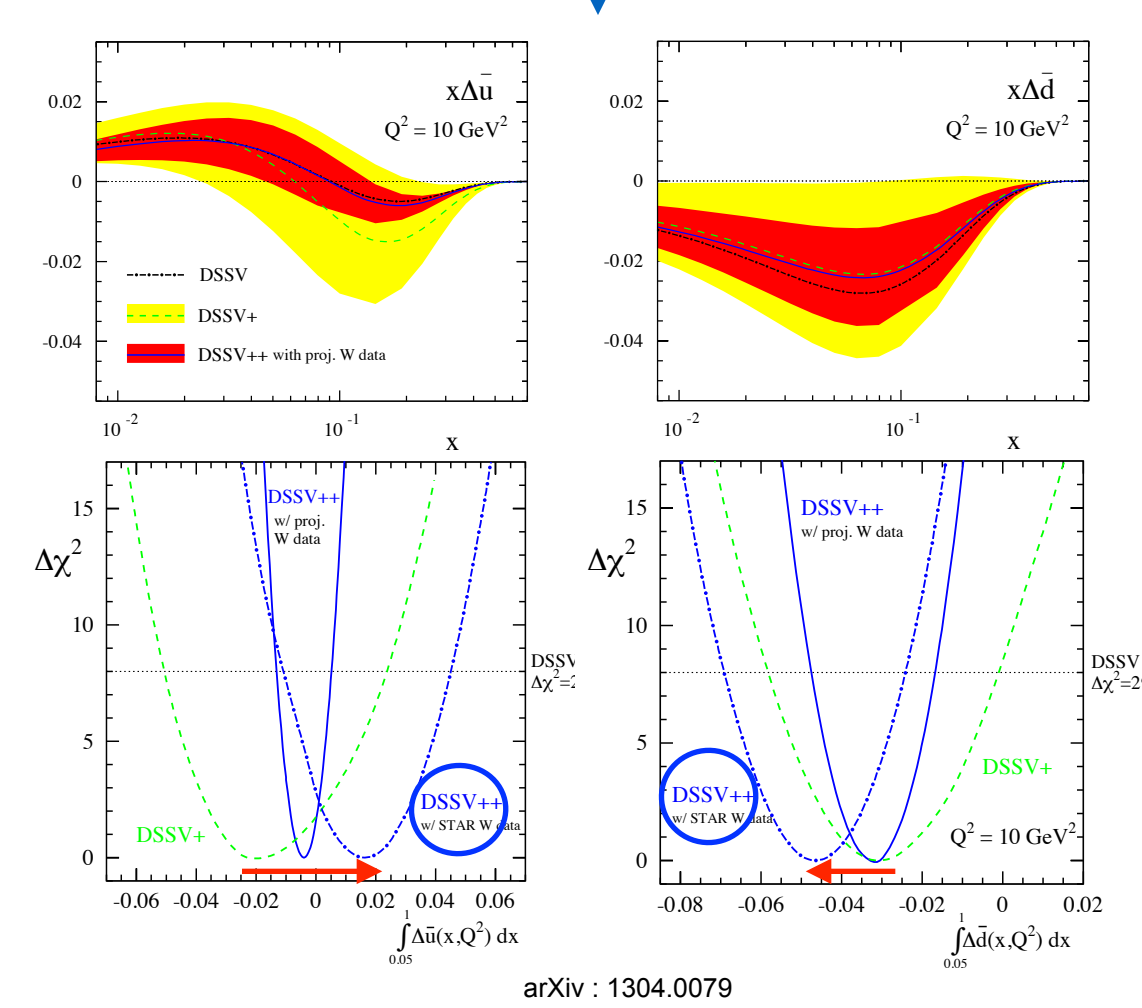
Leptonic Asymmetry from W^{*+} decay

$$A_L = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} = \frac{1}{P} \frac{N_+ / L_+ - N_- / L_-}{N_+ / L_+ + N_- / L_-}$$



- Larger $A_L(W^-)$ for $\eta_e < 0$ than the predictions indicate **large anti u quark polarization**.

Impact of STAR W result



- DSSV++ which include preliminary run 12 W data shows significantly improved constraints on Δu and Δd and shifts in the central value in $\Delta\chi^2$ minimum.

ANALYSIS STATUS / RUN 13

Data sample

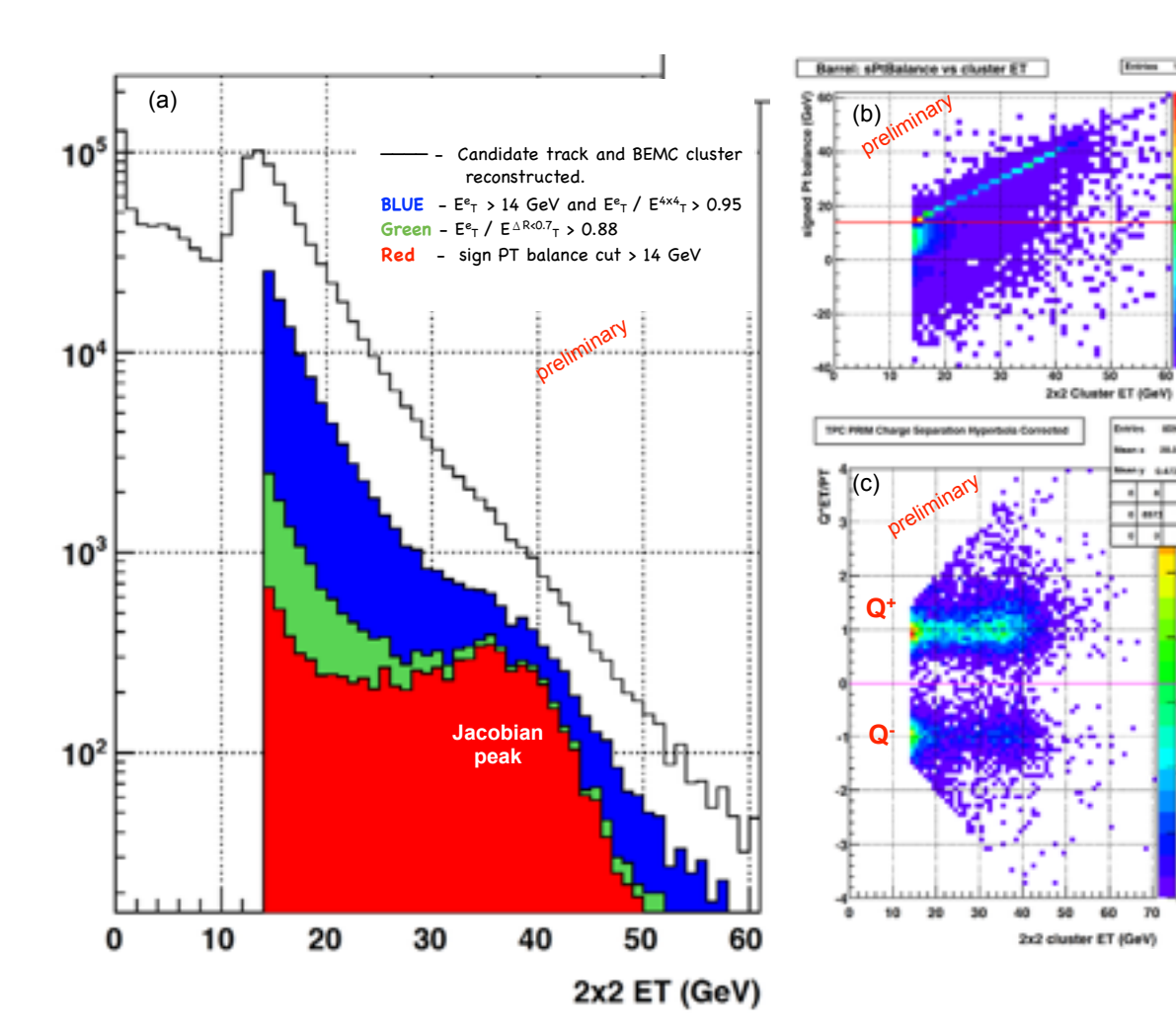
In run 2013 STAR collected total luminosity of **300 pb⁻¹**, which is **more than three times** of run 2012 data.

Run	L (pb)	Polarization (P)	FOM (P)
Run 9	12	0.38	1.7
Run 11	9.4	0.49	2.3
Run 12	77	0.56	24
Run 13	~300	~0.53	~84

QA of data

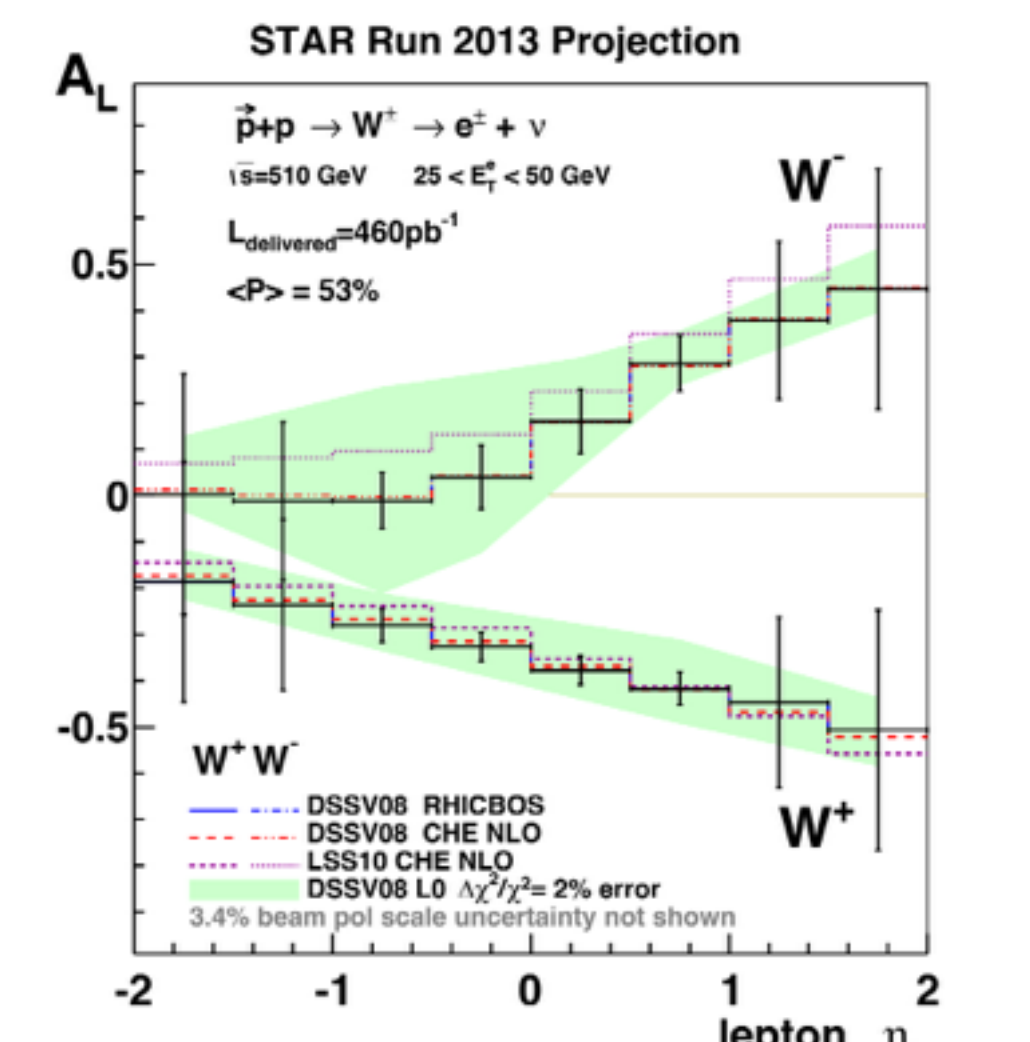
Half of the data is produced and QA of both data and software algorithm is ongoing.

Jacobian peak: e^+ and e^- near mid-rapidity from W decay are characterized by a large E_T that peaks near half of the W mass (~40 GeV)



Expectation / A_L

Higher precision A_L result is expected from **run 2013 STAR W data** using the STAR Forward Gem Tracker (FGT) in the **forward η region**.



CONCLUSION

- Measured **parity violating A_L** for W boson production as a function of decay lepton pseudo rapidity η_e at STAR experiment provides significant constraints on Δu and Δd .
- Recent result shows **large $A_L(W^-)$** indicating **large anti u quark polarization**.
- Large statistics of run 13 will further constrains the light quark sea polarization.
- Ongoing analysis on extending A_L measurement from W boson production towards **forward and backward** regions of η_e using Forward Gem Tracker (FGT) will minimize the predicted uncertainties.

REFERENCES

- SN-PRL-W2012-ver1.3 - Run 12 STAR Analysis notes
- PRL 106, 062002 (2011) - Run 2012 STAR W paper
- PRD 80,034030 (2009) - DSSV global analysis