

Photo shows my house on the south end of the Big Island of Hawaii where much of the analysis

TARGET AND BEAM-TARGET SPIN ASYMMETRIES IN EXCLUSIVE PION ELECTROPRODUCTION

Peter Bosted



MY MOTIVATION

**RADIATIVE CORRECTIONS TO
SEMI-INCLUSIVE DEEP INELASTIC**

**NEED RELIABLE FITS TO CROSS SECTIONS AND
ASYMMETRIES**

**EMBARK ON PROJECT TO ANALYZE
LARGE BODY ASYMMETRY DATA FROM 2000 (3
THESES BUT ONLY π^0 AT 1.7 GEV PUBLISHED)
AND 2009 (Thesis and Pub. On π^0 for $W > 2$ GeV)**

CEBAF AT JEFFERSON LAB

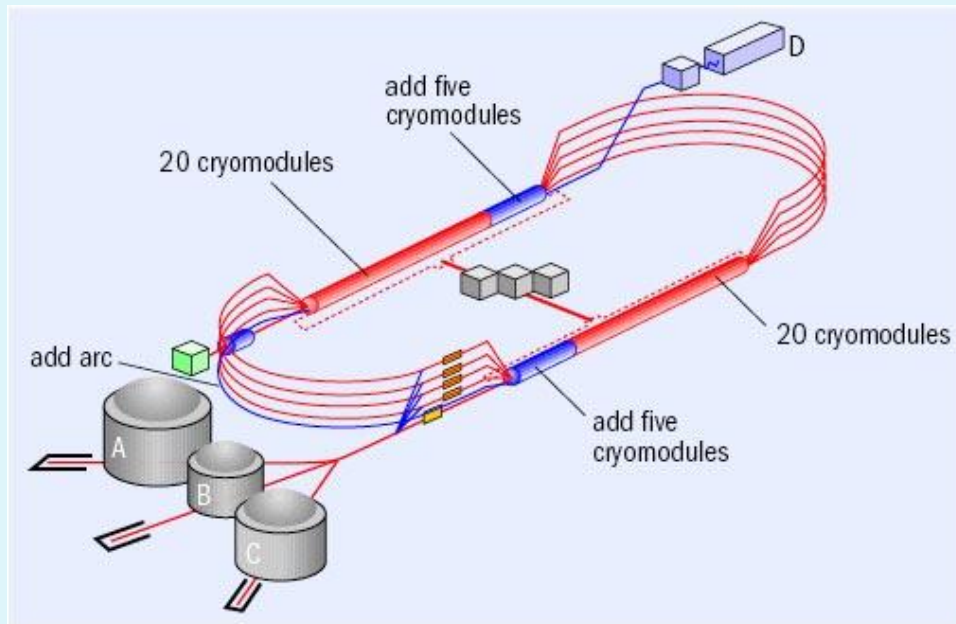
ELECTRON ENERGIES

1.7, 2.5, 4.2 GEV (EG1B IN 2000-2001)

6 GEV (EG1-DVCS IN 2009)

LONGITUDINAL POLARIZATION

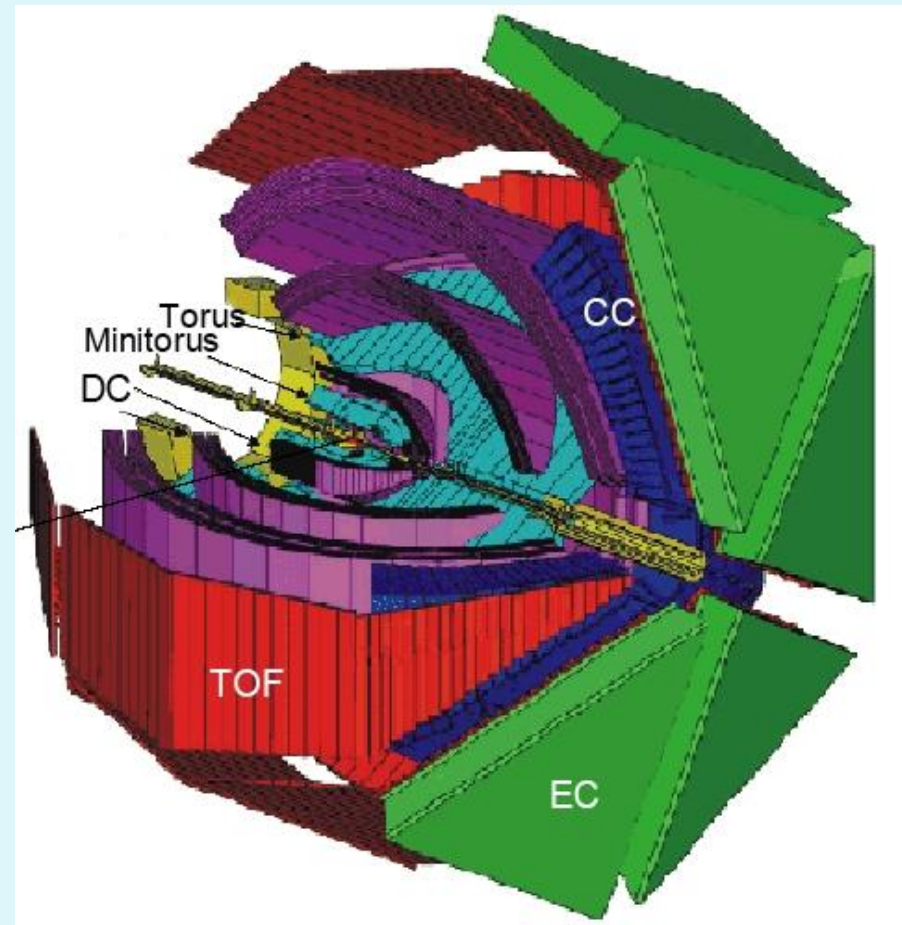
70% (EG1B), 85% (EG1-DVCS)



CLAS DETECTOR

**“Standard” for
Eg1b**

**Inner
Calorimeter
added for eg1-
dvcs**



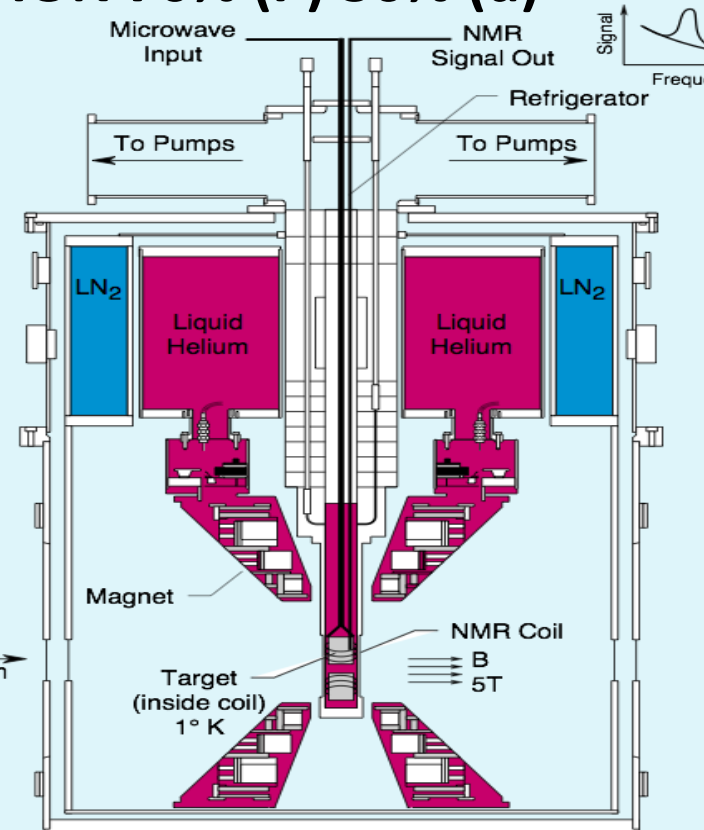
LONGITUDINALLY POLARIZED PROTON, DEUTERON TARGETS

- 5 TESLA MAGNETIC FIELD

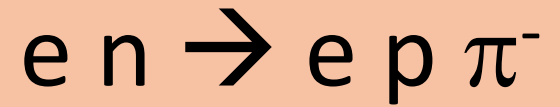
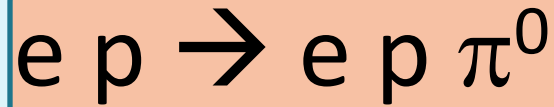
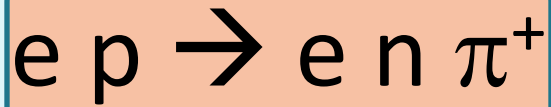
- AMMONIA TARGETS (NH_3 , ND_3)

- 1 K LIQUID HELIUM

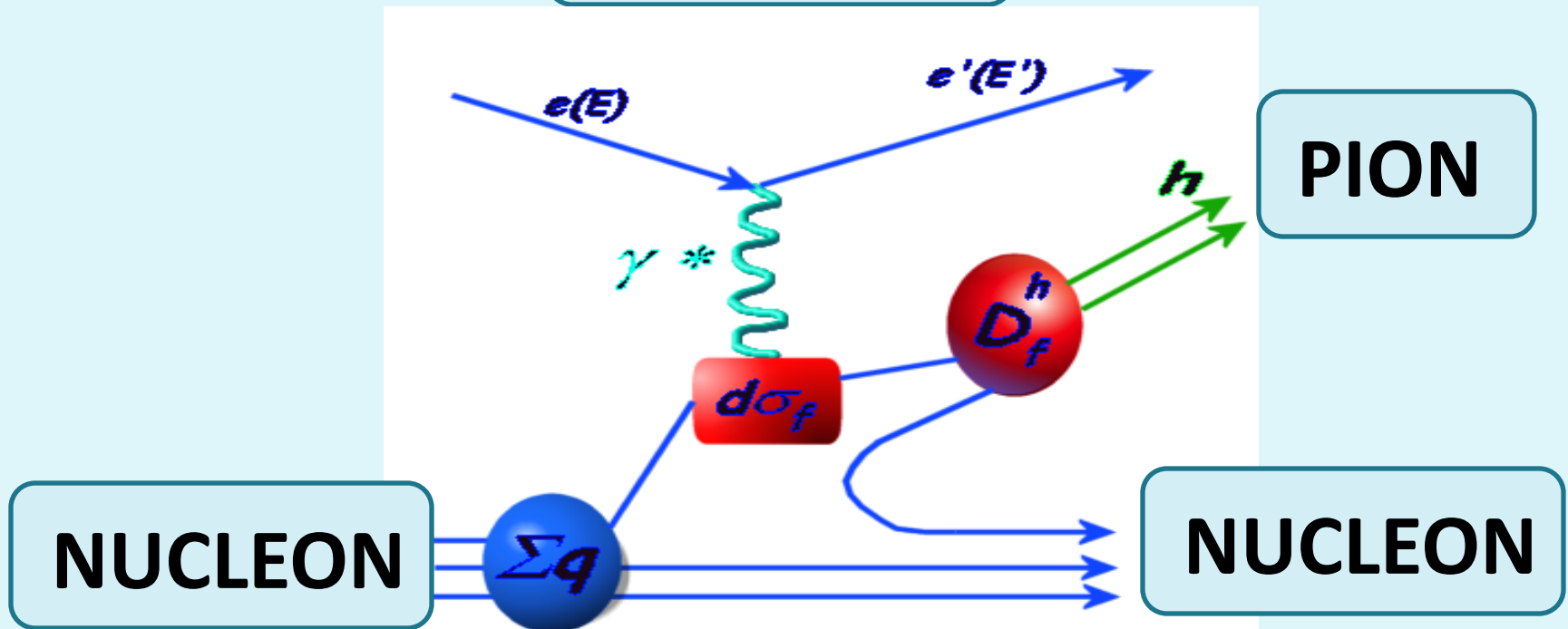
- POLARIZATION 70% (P) 30% (d)



EXCLUSIVE PION ELECTROPRODUCTION



ELECTRON



AVERAGED TWO TOPOLOGIES EACH REACTION

$$e p \rightarrow e n \pi^+$$

$$e p \rightarrow e p \pi^0$$

$$e n \rightarrow e p \pi^-$$

$$e p \rightarrow e n \pi^+$$

$$e p \rightarrow e p \gamma \gamma$$

$$e n \rightarrow e p \pi^-$$

$$e p \rightarrow e (n) \pi^+$$

$$e p \rightarrow e p \gamma(\gamma)$$

$$e n \rightarrow e (p) \pi^-$$

To be precise, last reaction is really $e d \rightarrow e (p) p \pi^-$

$$A_{LL} \approx \frac{1}{P_B P_T f} \frac{N^{+-} + N^{-+} - N^{++} - N^{--}}{N^{+-} + N^{+-} + N^{++} + N^{--}}$$

$$A_{UL} \approx \frac{1}{P_T f} \frac{N^{+} - N^{-}}{N^{+} + N^{-}}$$

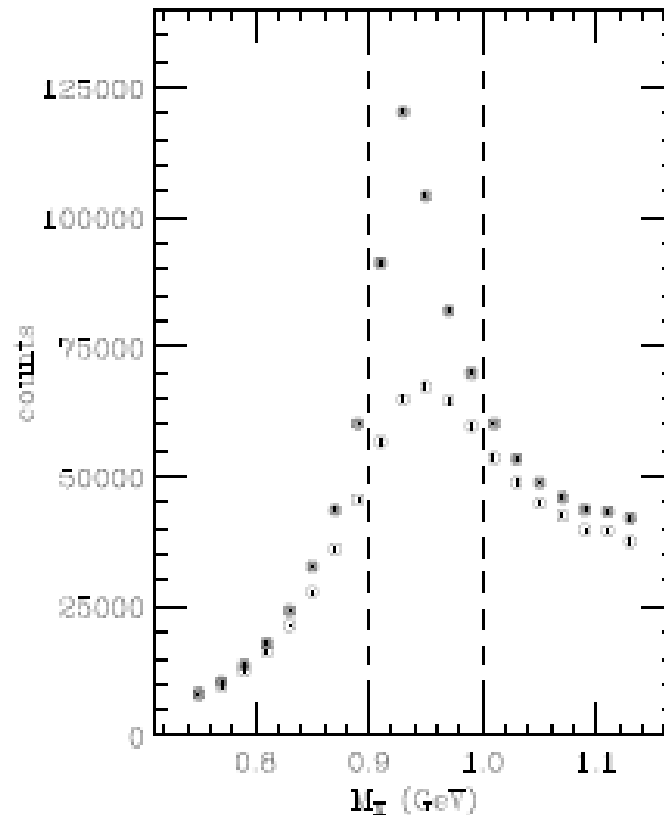
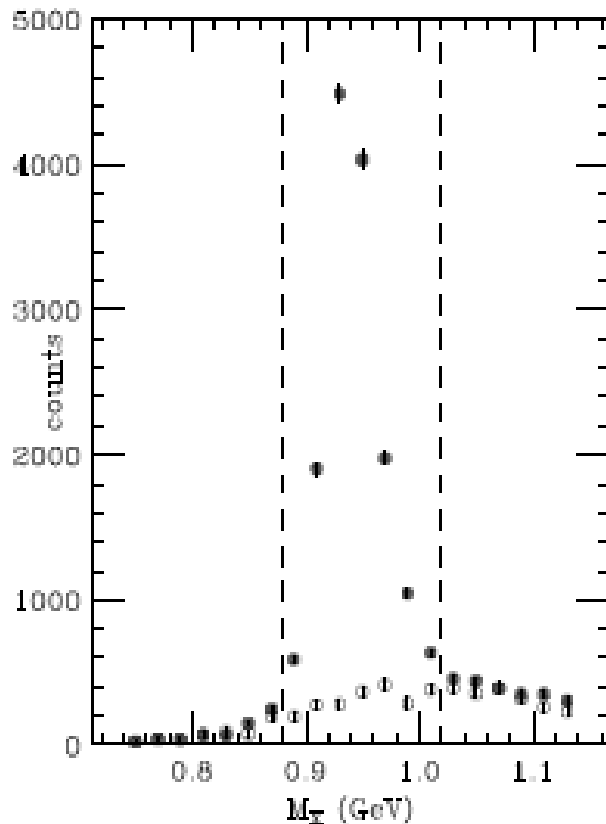
- **Beam polarization P_B 0.7 to 0.85**
- **Target polarization 0.7 (p), 0.3 (d)**
- **Dilution factor f ranges from 0.3 to 0.9 depending on topology and kinematics**

EXCLUSIVITY CUTS

EXAMPLE: ELECTRON-PION MISSING MASS

LEFT: NEUTRON DETECTED

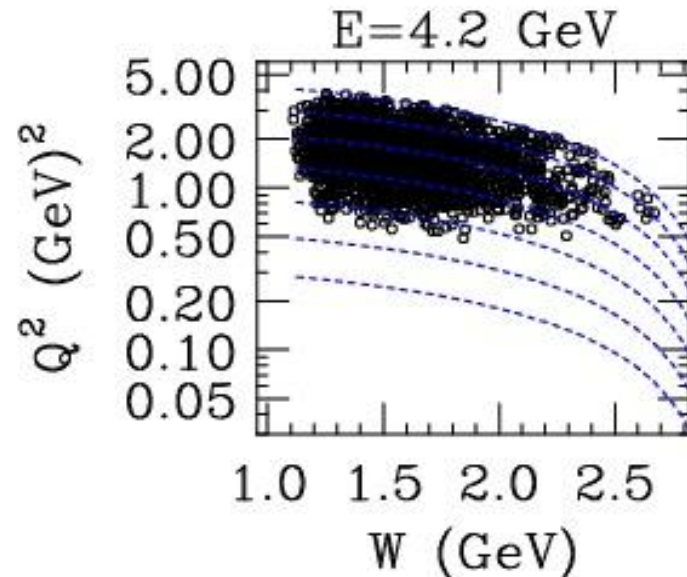
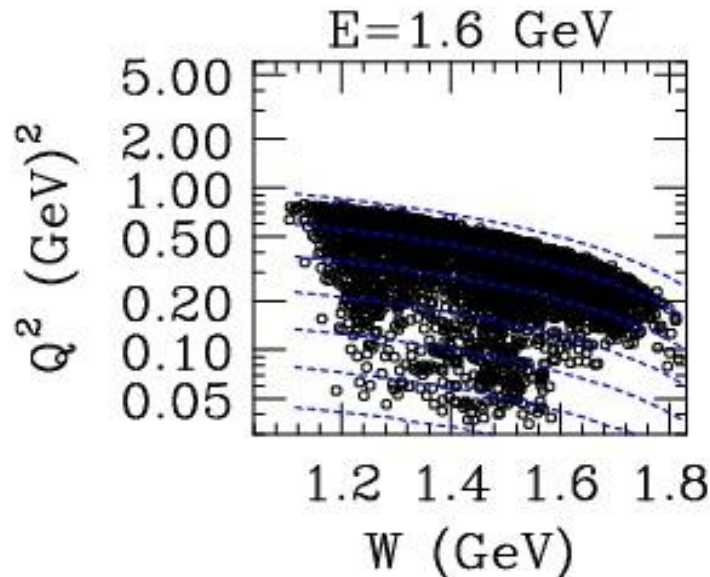
RIGHT: NO NEUTRON DETECTED)

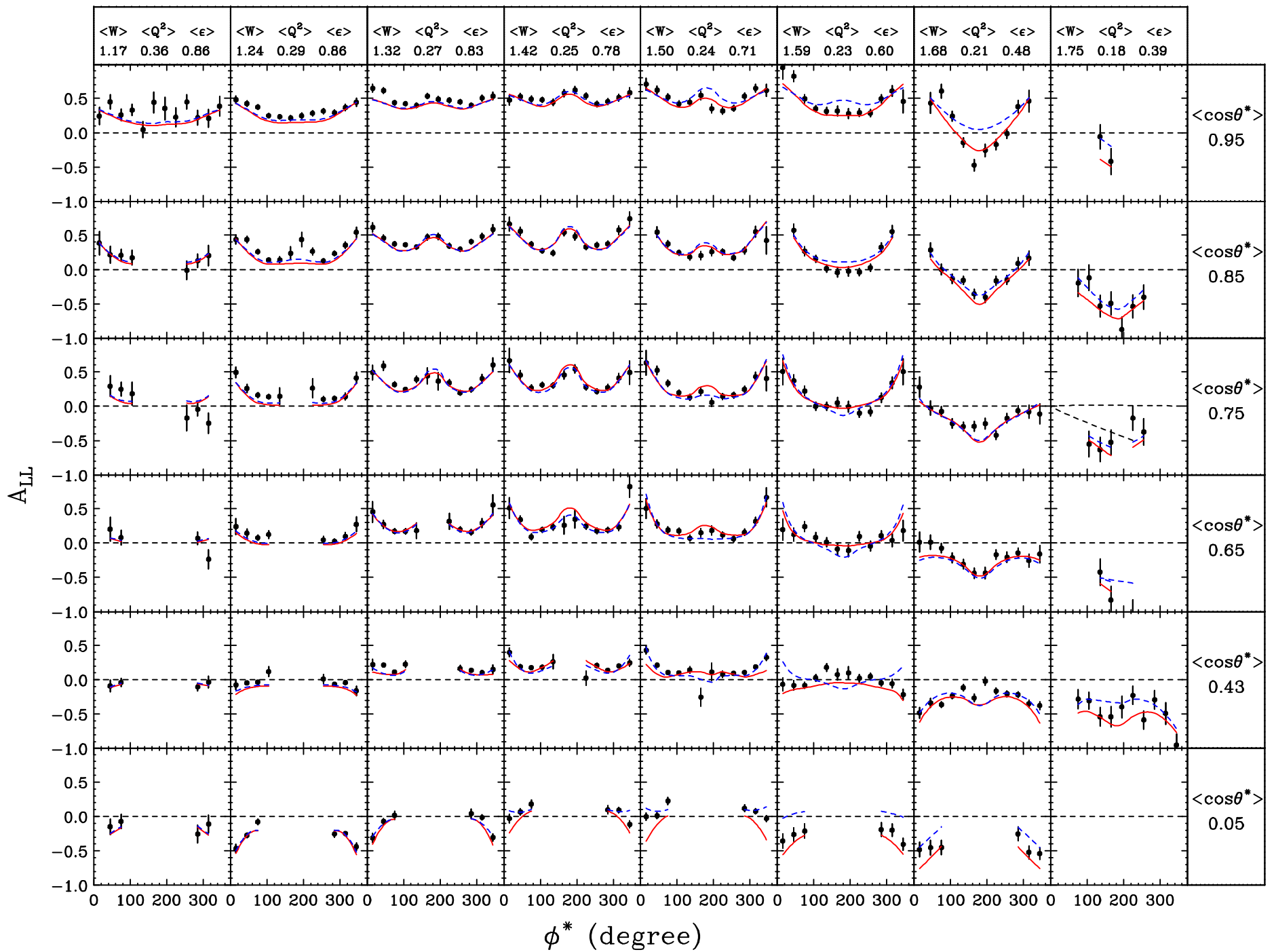


KINEMATIC COVERAGE AND BINNING

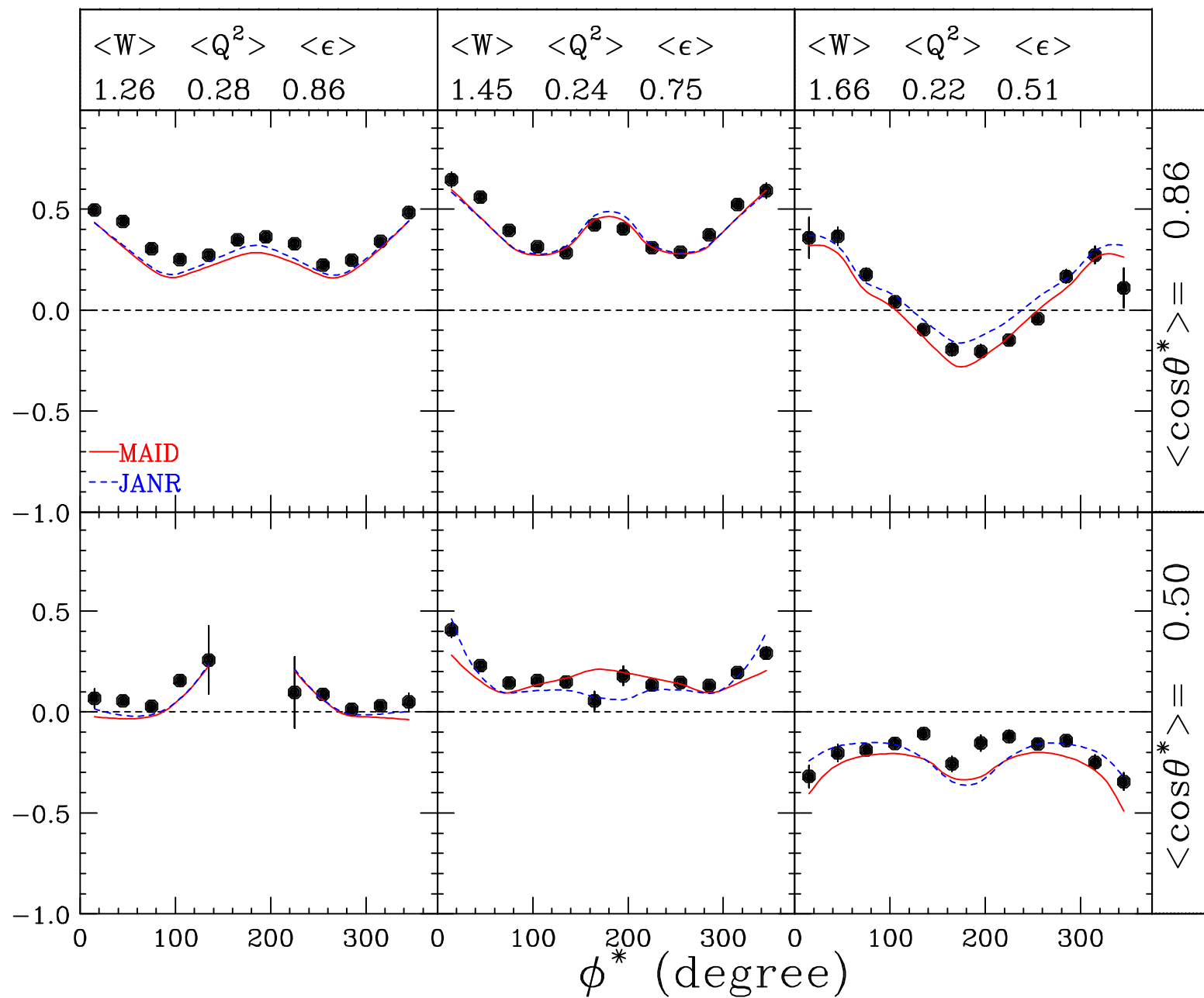
- 4 BEAM ENERGIES (1.6, 2.5, 4.2, 6 GEV)
- 40 BINS IN W FROM 1.1 TO 3.0 GEV (OR $0.1 < X < 1$)
- 10 BINS IN Q^2 FROM 0.05 TO 5 GeV^2
- 10 BINS IN $\cos(\theta^*)$ FROM -0.4 TO 1 (OR $-1 < t < 0 \text{ GEV}^2$)
- 12 BINS IN ϕ^* FROM 0 TO 360 DEGREES

CAN'T SHOW ALL IN A FEW MINUTES!

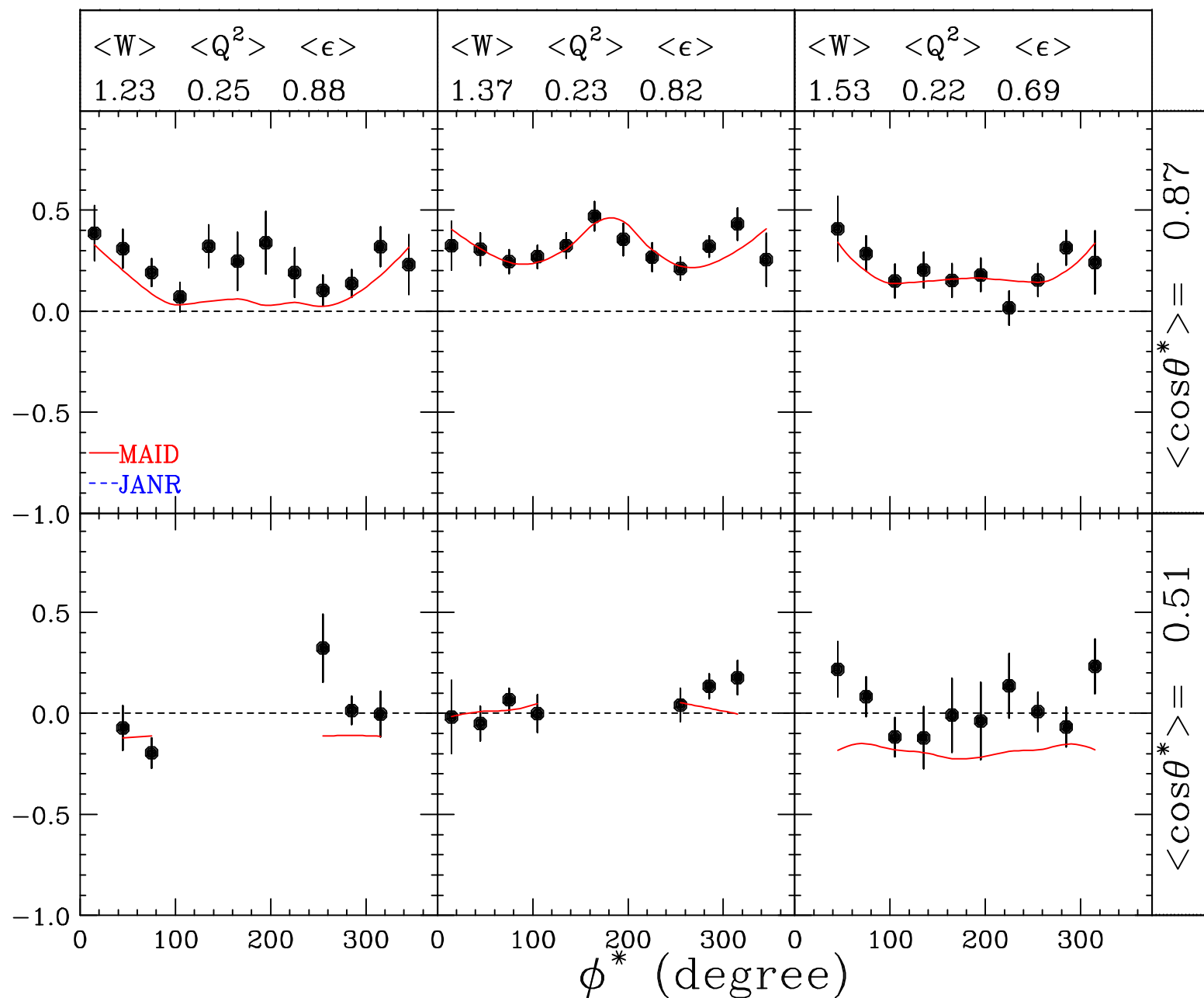




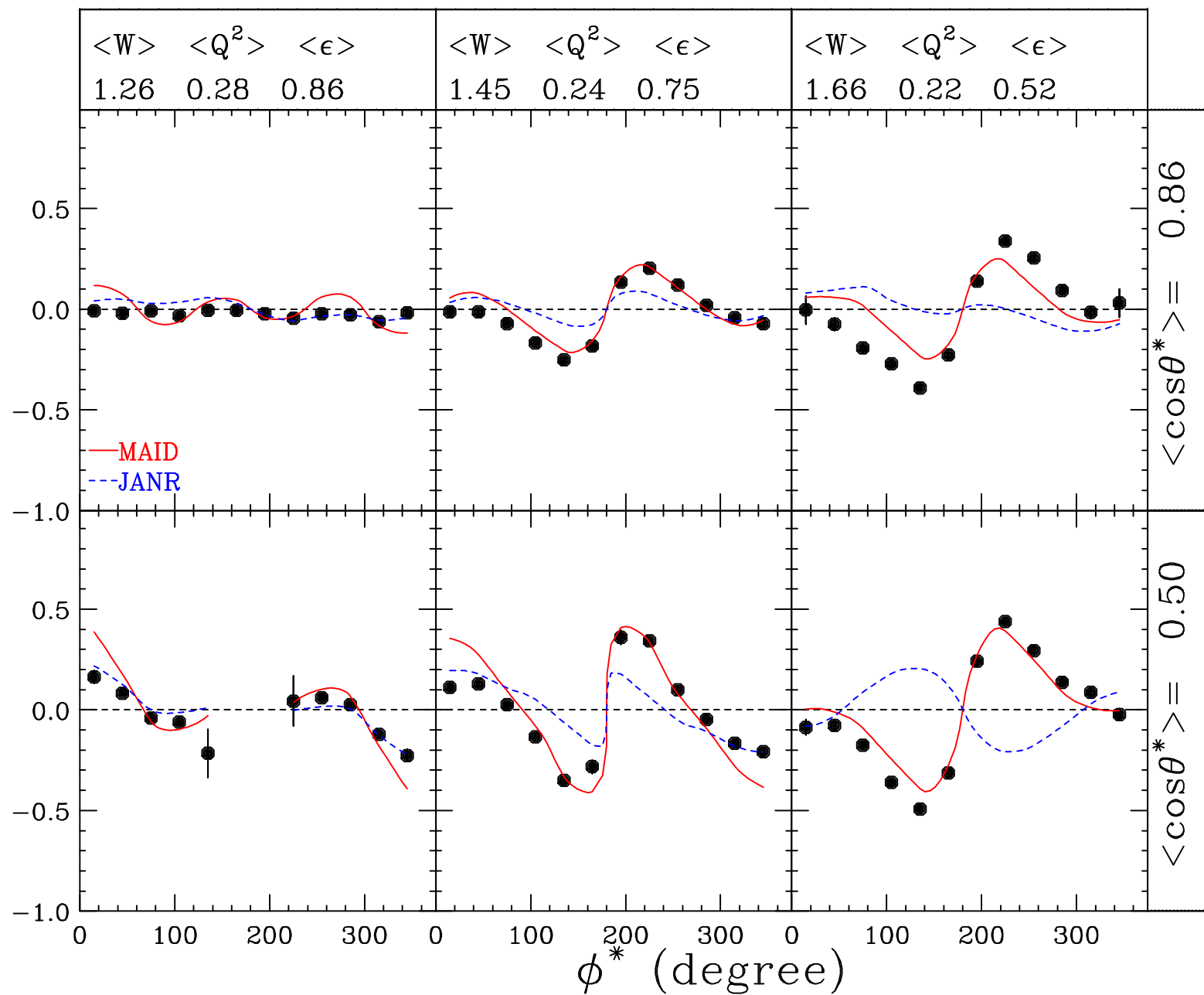
Eg1b A_{LL} for $\pi^+ n$ $E=1.7$ GeV



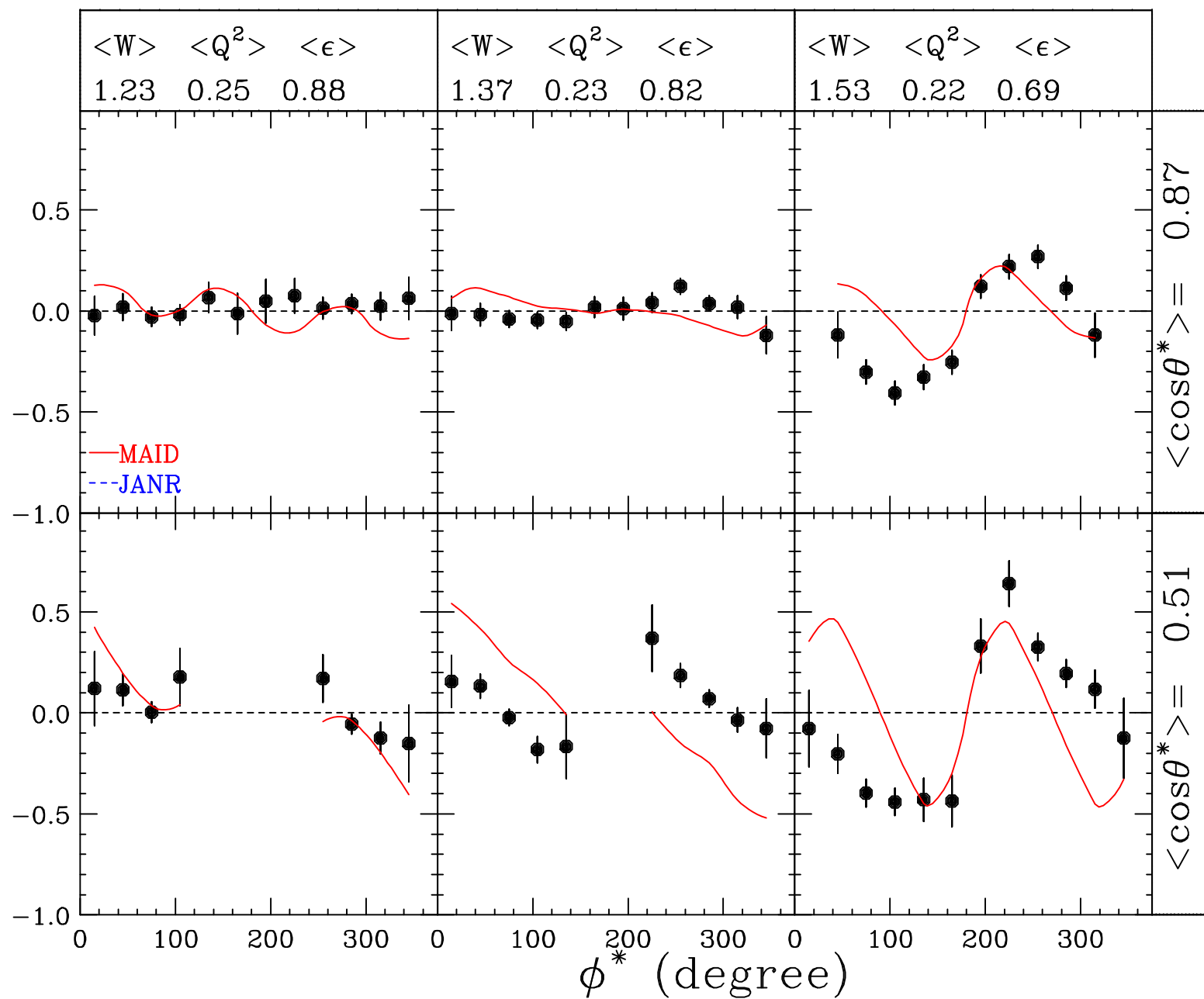
Eg1b A_{LL} for $\pi^- p$ $E=1.7$ GeV



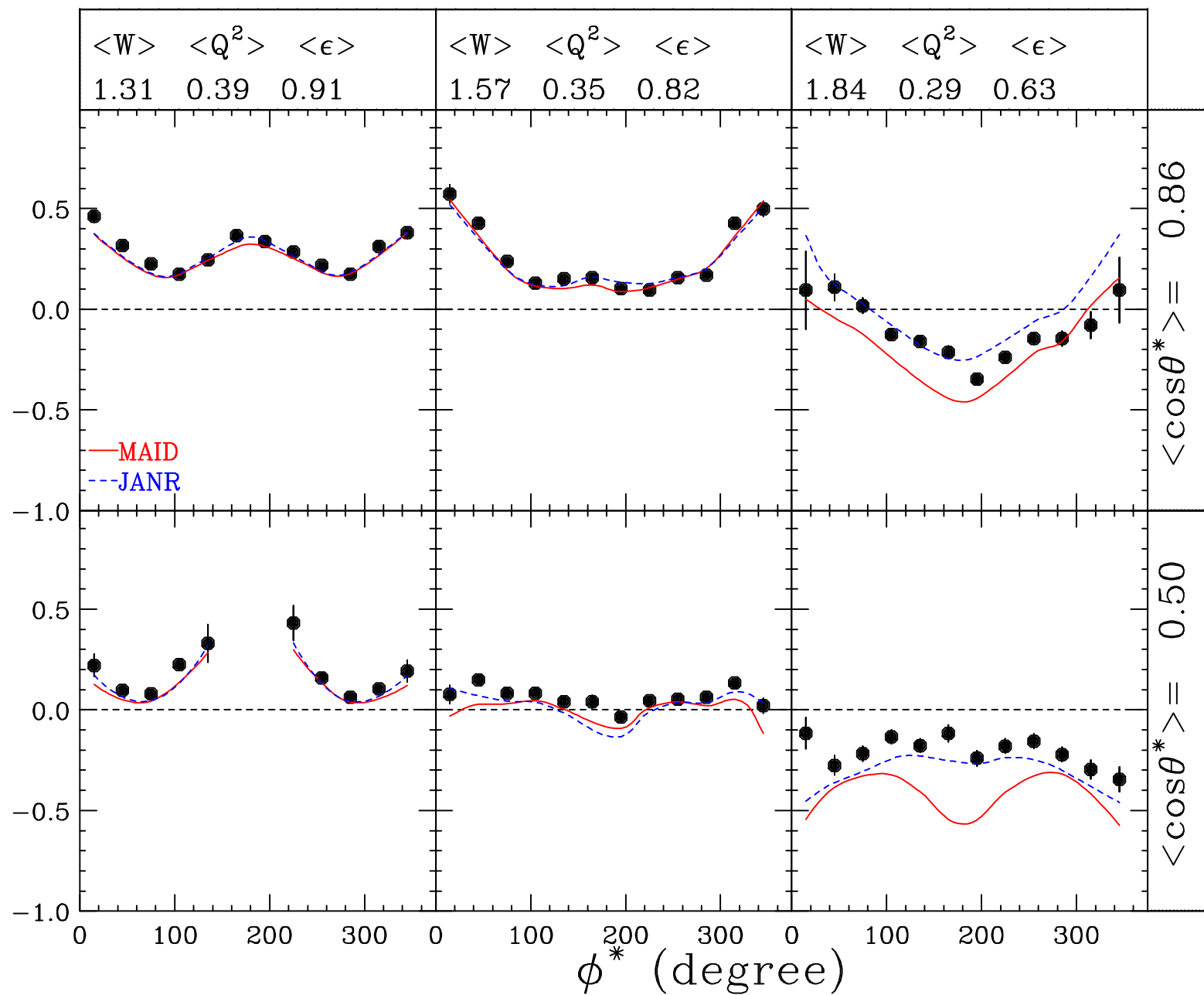
Eg1b A_{UL} for π^+n $E=1.7$ GeV



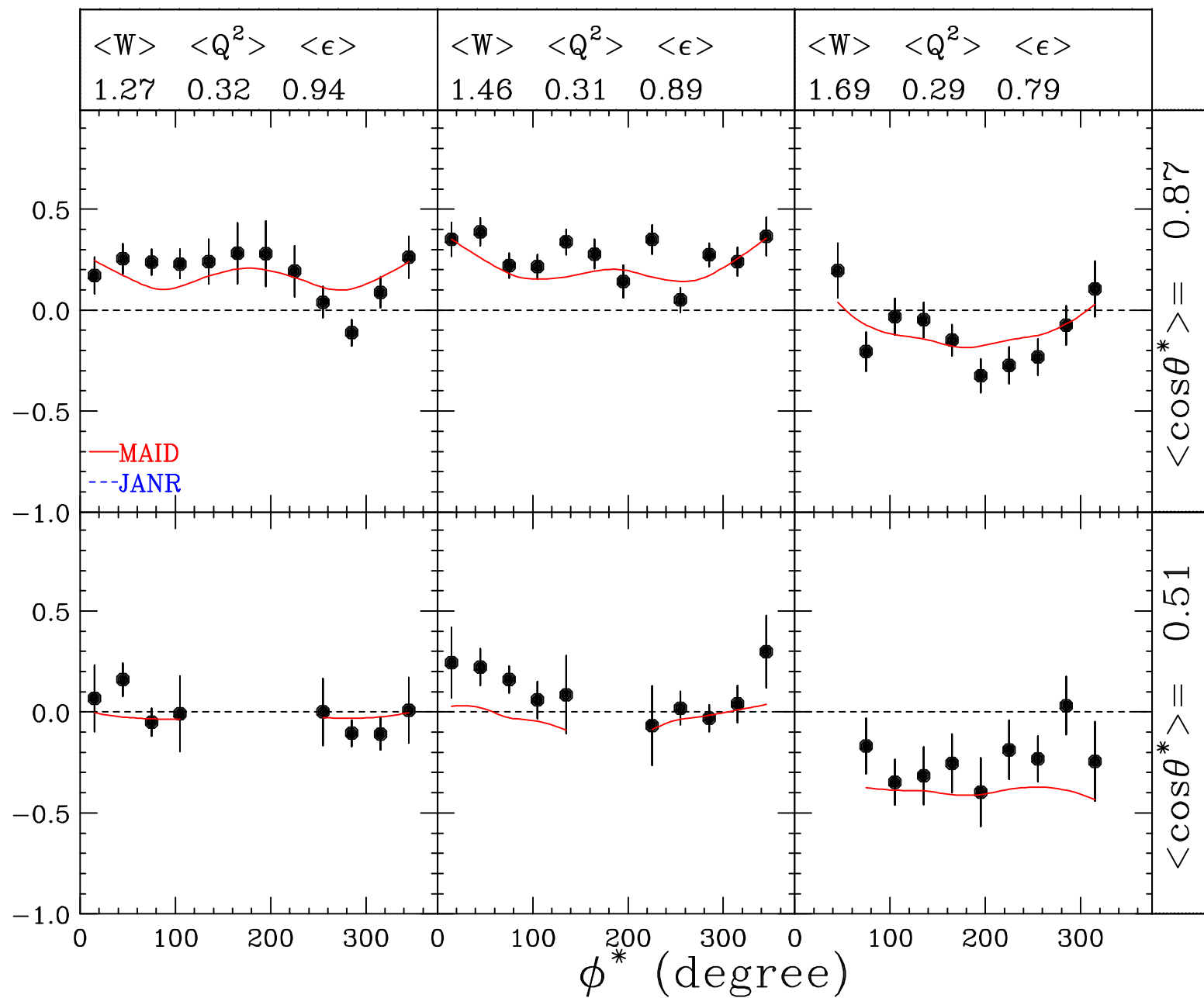
Eg1b A_{UL} for π^-p $E=1.7$ GeV



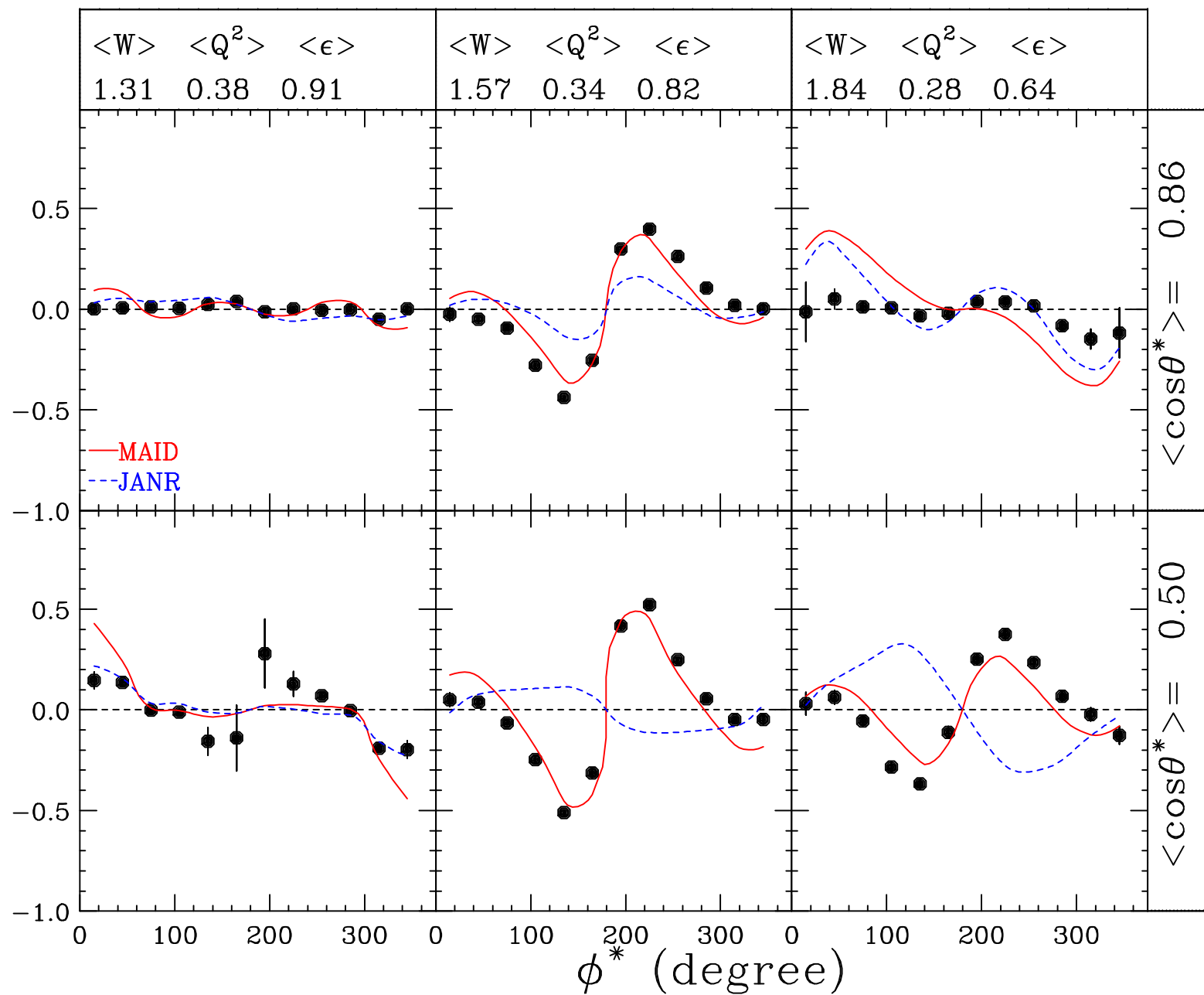
Eg1b A_{LL} for π^+n $E=2.4$ GeV



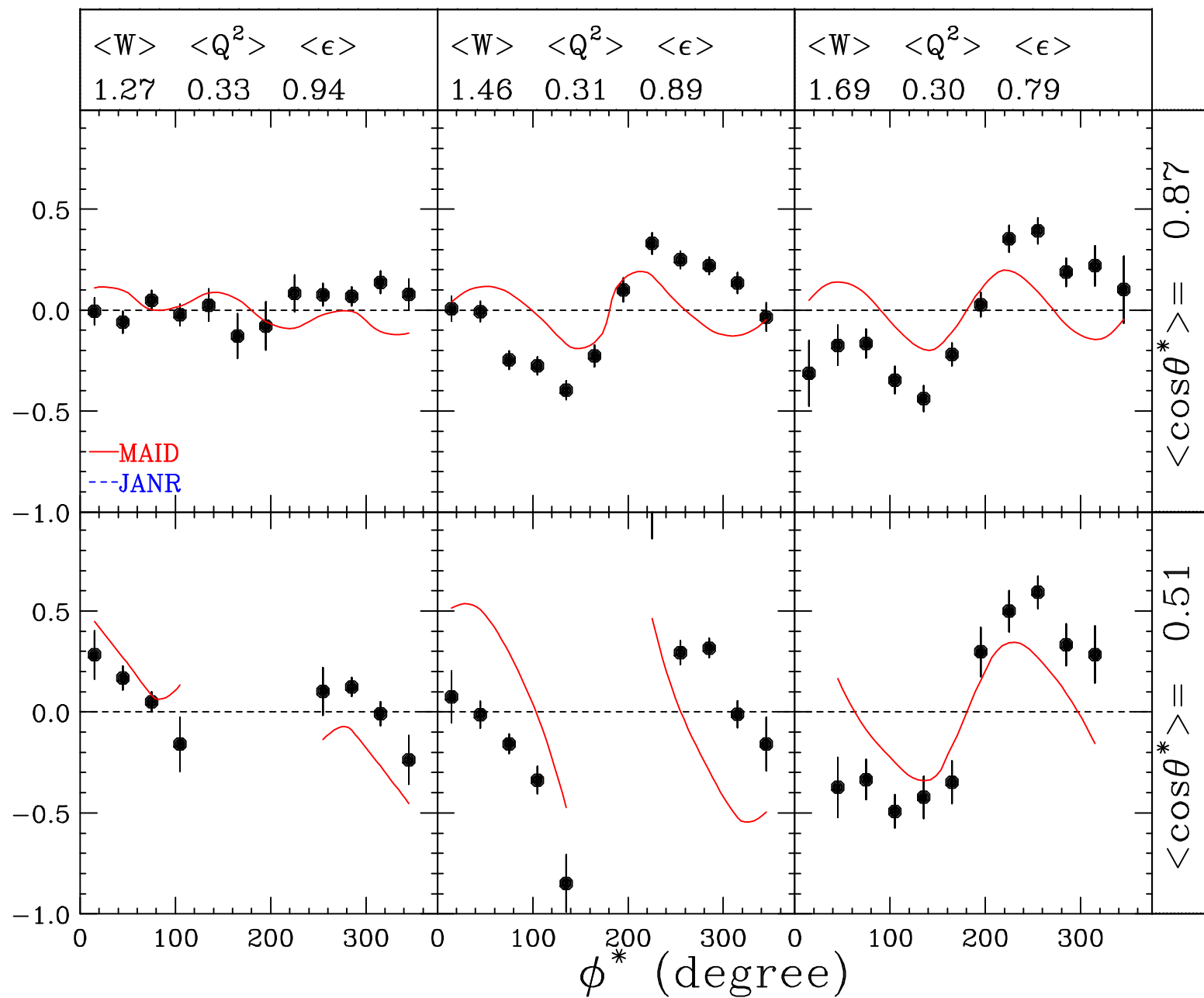
Eg1b A_{LL} for π^-p $E=2.4$ GeV



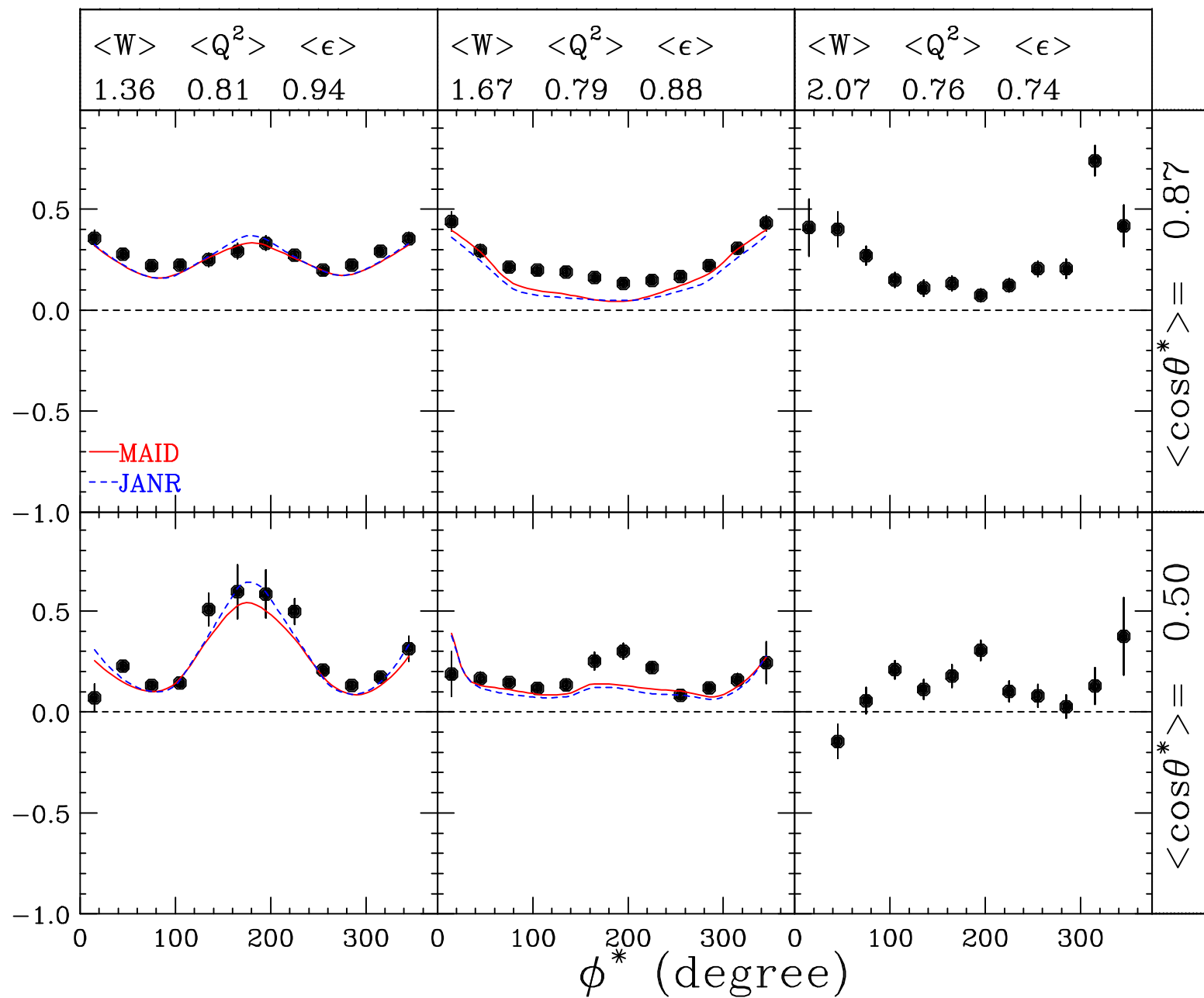
Eg1b A_{UL} for π^+n $E=2.4$ GeV



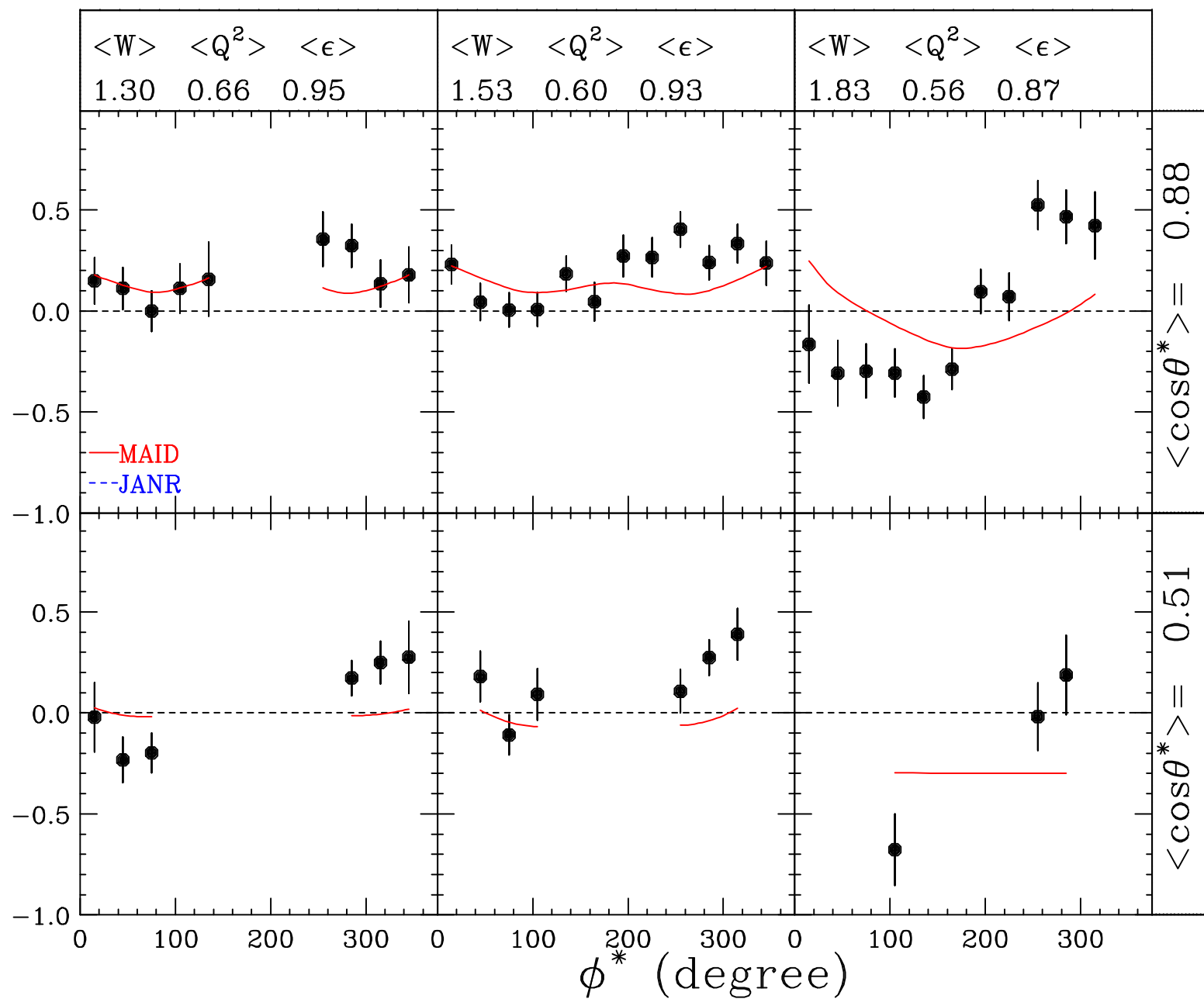
Eg1b A_{UL} for $\pi^- p$ $E=2.4$ GeV



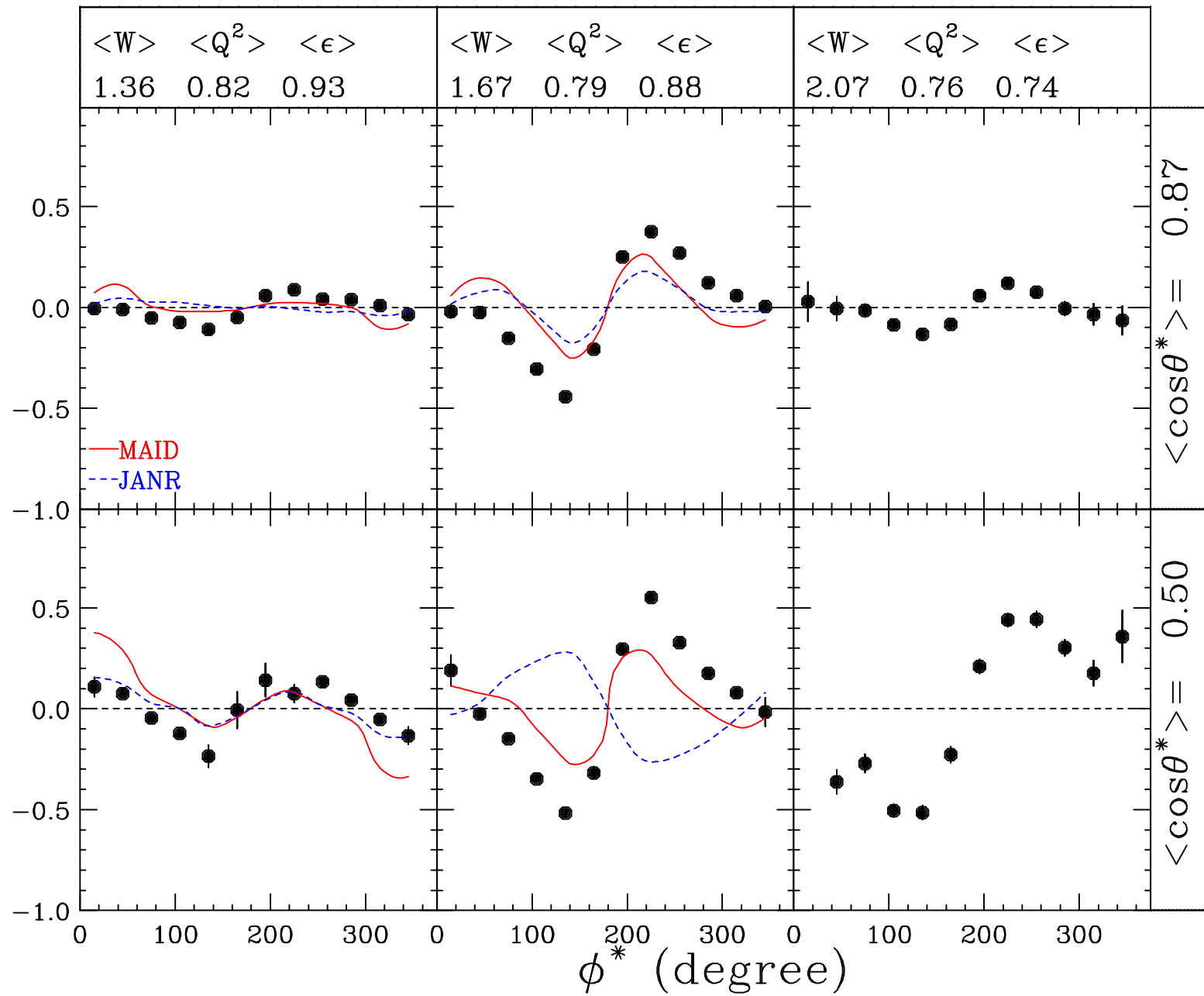
Eg1b A_{LL} for $\pi^+ n$ $E=4.2$ GeV



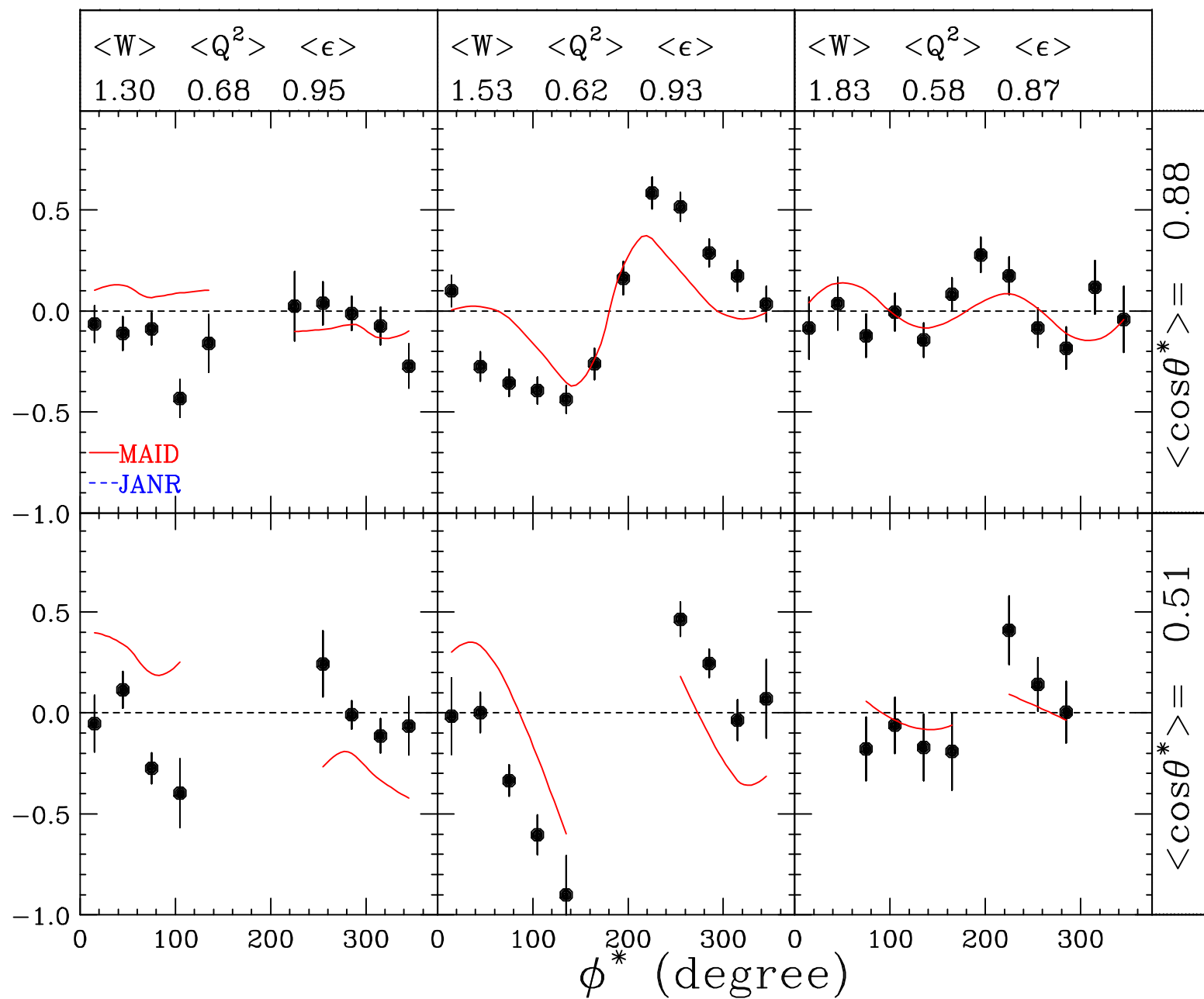
Eg1b A_{LL} for $\pi^- p$ $E=4.2$ GeV



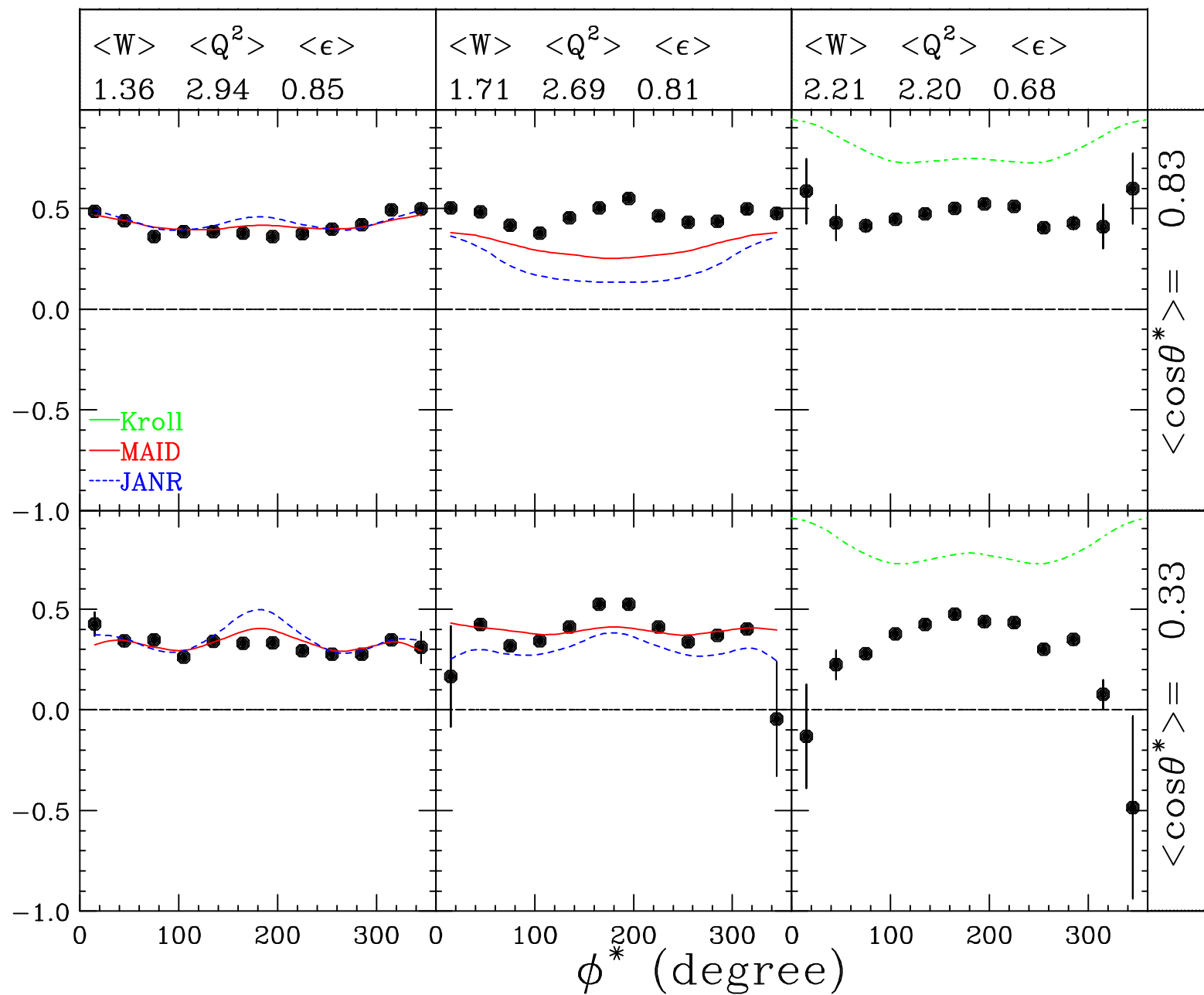
Eg1b A_{UL} for π^+n $E=4.2$ GeV



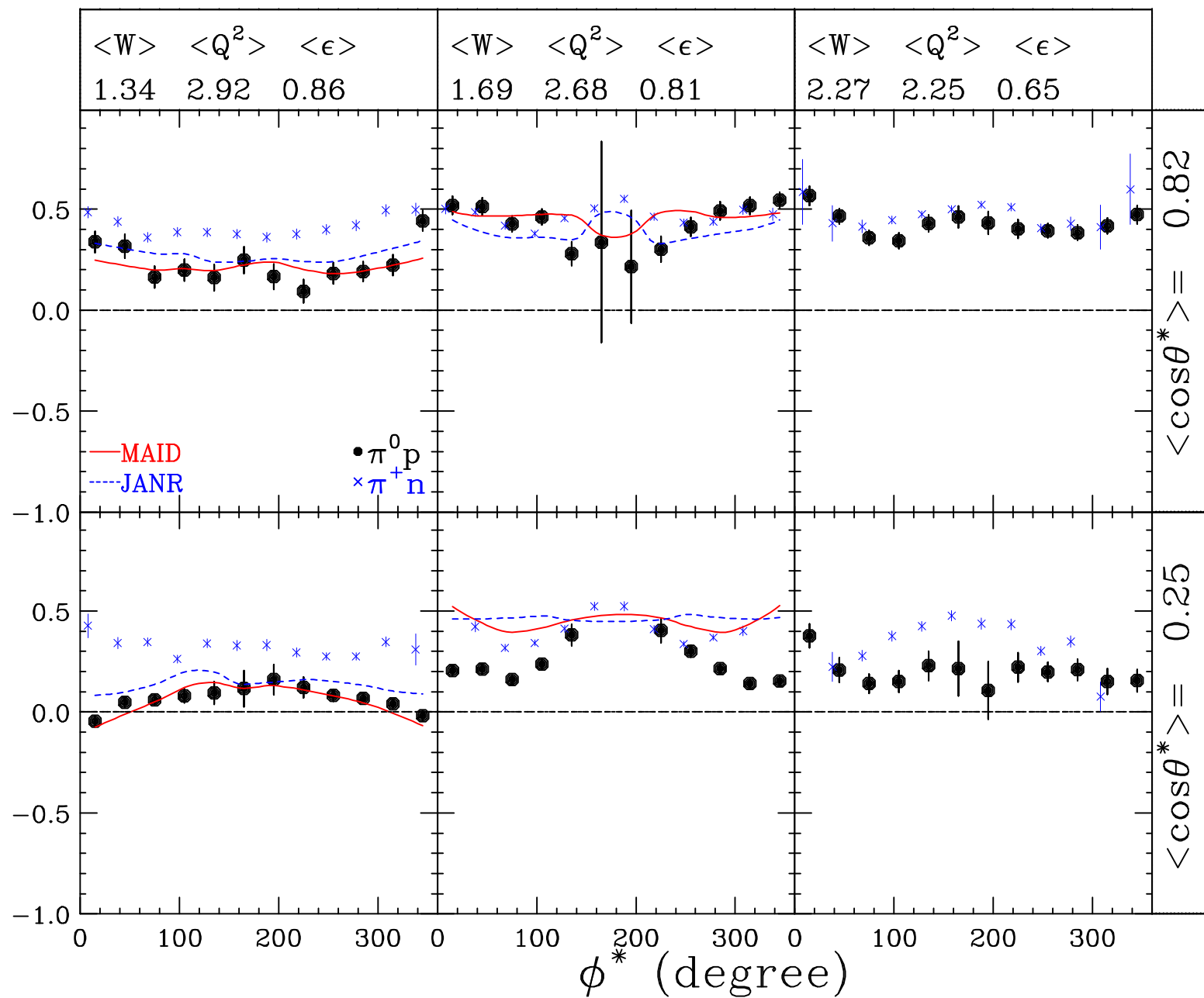
Eg1b A_{UL} for π^-p $E=4.2$ GeV



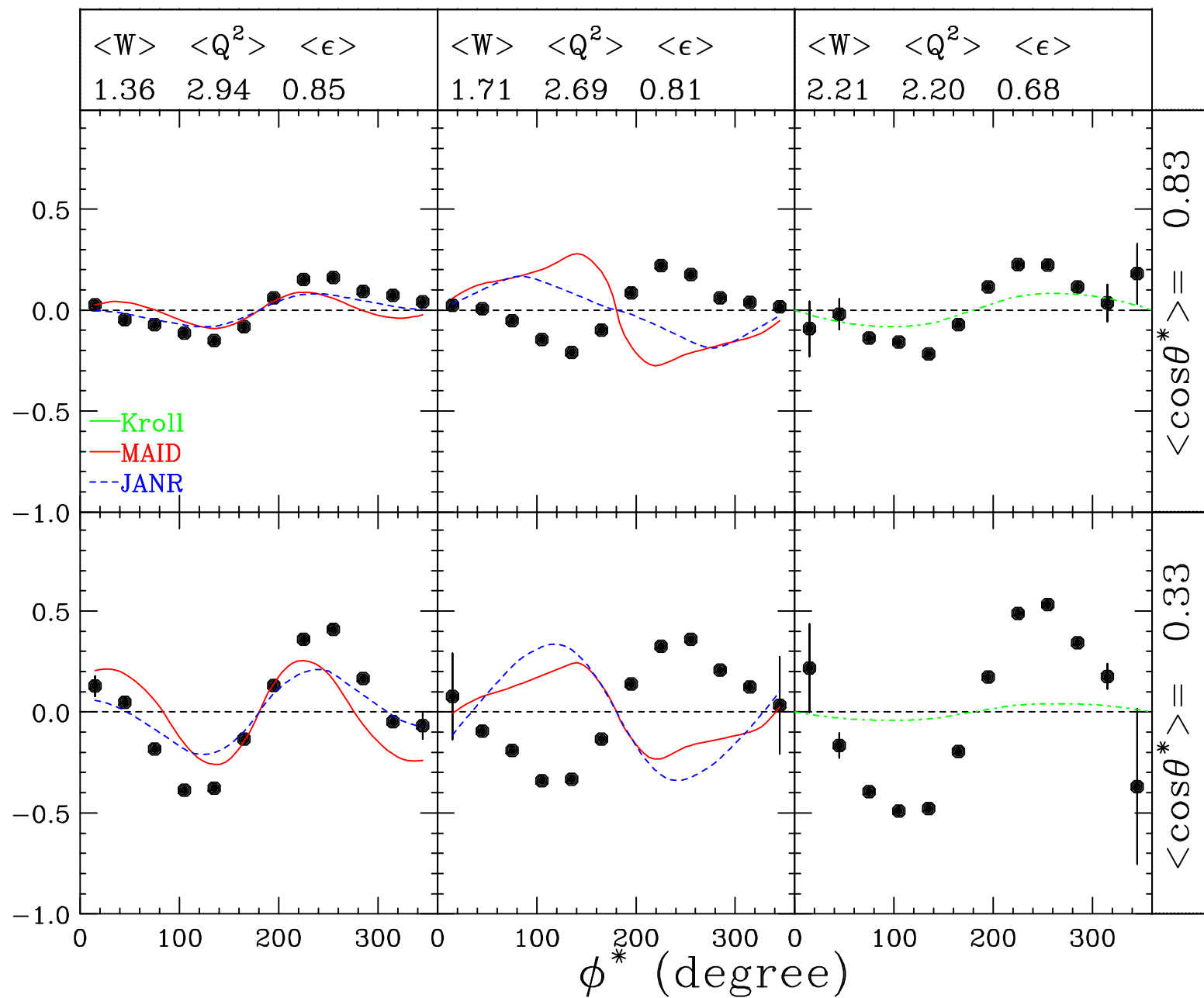
Eg1-dvcs A_{LL} for π^+n E= 5.9 GeV



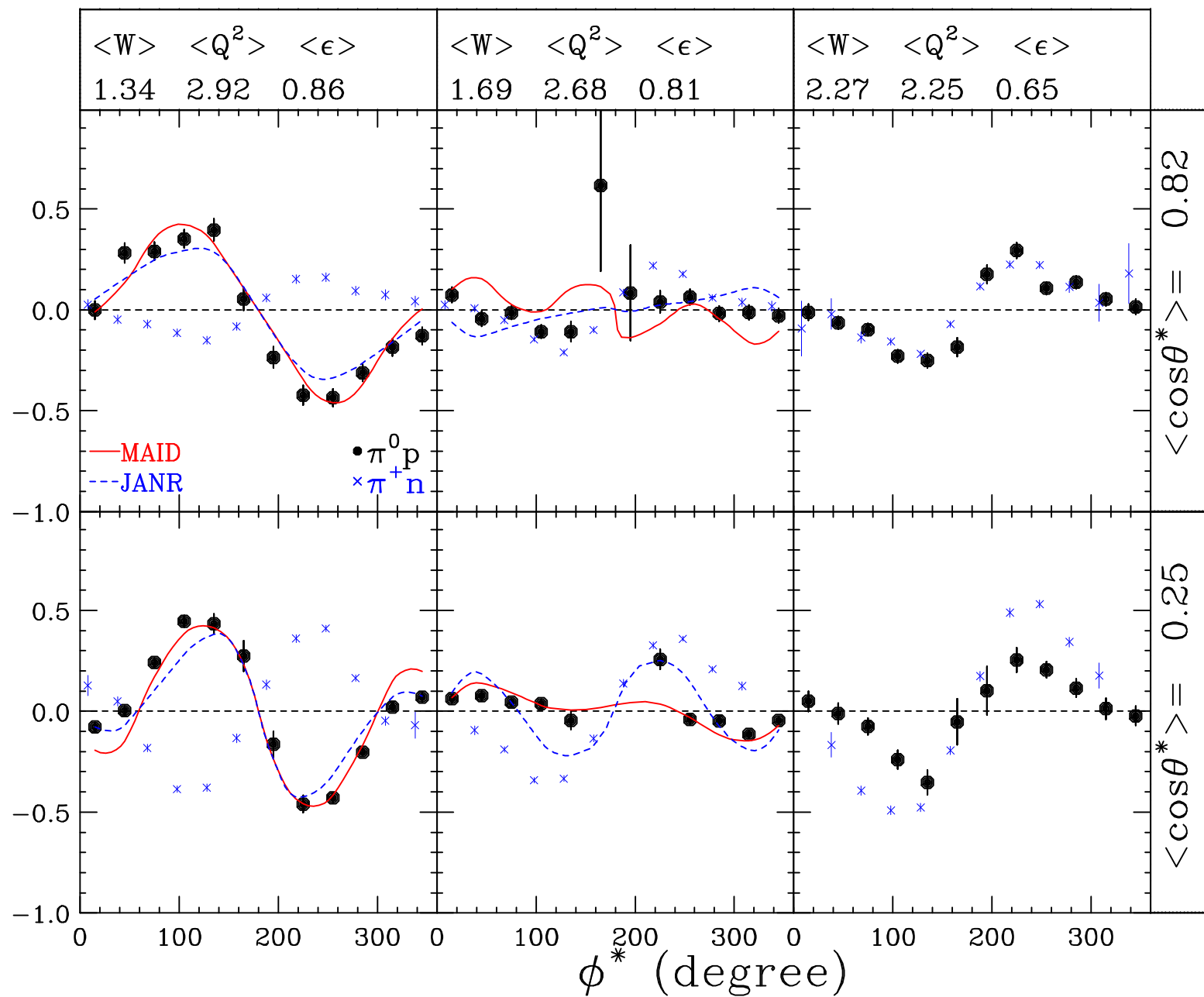
Eg1-dvcs A_{LL} for $\pi^0 p$ $E= 5.9$ GeV



Eg1-dvcs A_{UL} for π^+n $E=5.9$ GeV



Eg1-dvcs A_{UL} for $\pi^0 p$ $E=5.9$ GeV



SUMMARY

- ABOUT 100,000 NEW ASYMMETRY RESULT
 - SIGNIFICANT DIFFERENCES FROM PREVIOUS FITS (MAID, ...) AT $w > 1.6$ GEV, HIGH Q^2
- **HUGE** TARGET-SPIN ASYMMETRIES FOR ALL THREE PIONS FOR $w > 2$ GEV!!!



PUBLICATION STATUS

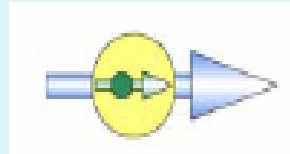
- EG1B on π^+ and π^+ at PRC waiting refereee
- EG1-dvcs on π^+ at author check stage
- EG1-dvcs on π^0 ready for ad-hoc review



Polarization of quarks

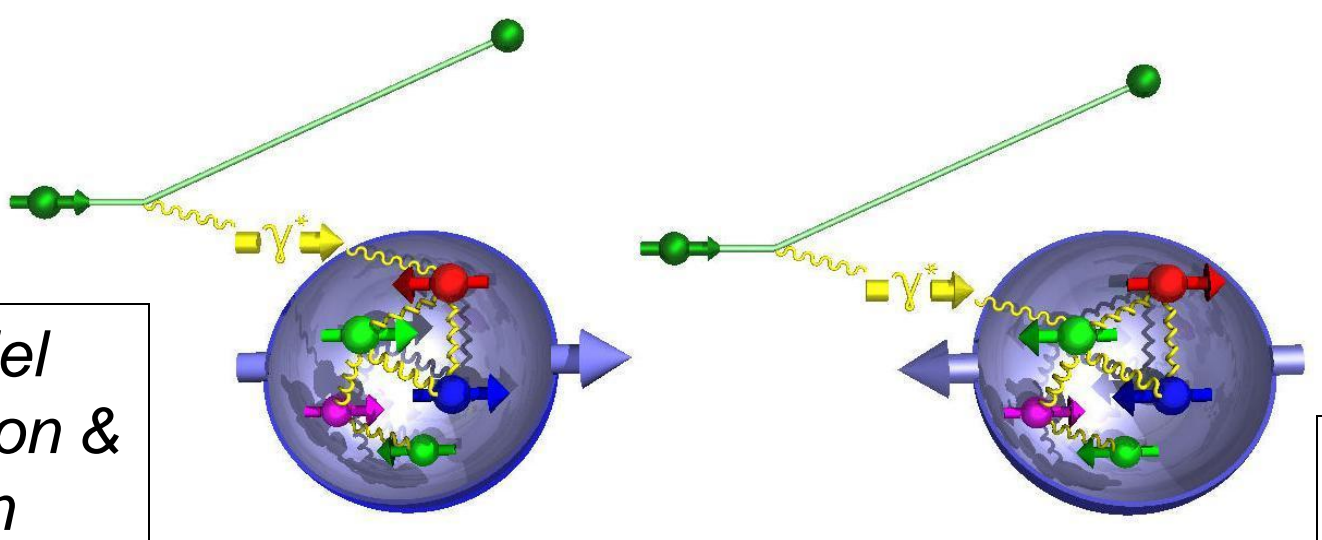
Quarks have spin, which can be aligned or anti aligned with proton spin

$q^+(x)$



q^-

Experiment: compare:



*Parallel
electron &
proton
spins*

*Anti-parallel
electron &
proton spins*