Extractions of $\boldsymbol{\Sigma}$ and G asymmetries for $\boldsymbol{\pi}^{-}$ p channel with Linear pol data
Study with Maximum Log-Likelihood method

T. Kageya @ g14 meeting, Jul. 8th 2021

Linear data summary

Run Name	Coherent Edge (GeV)	# Triggers (x 10^9)	D pol
Gold 1	2.2	0.48	+
Last 1	2.2	0.23	+
Last 2	2.0	1.03	+
Last 3	1.8	1.08	+
Last 4	1.8	0.66	−
Last 5	2.0	0.43	−
Last 6	2.2	0.25	−

Analyze D+ and D- data separately and take weighted averages.

Maximum Log-Likelihood method (more understanding)

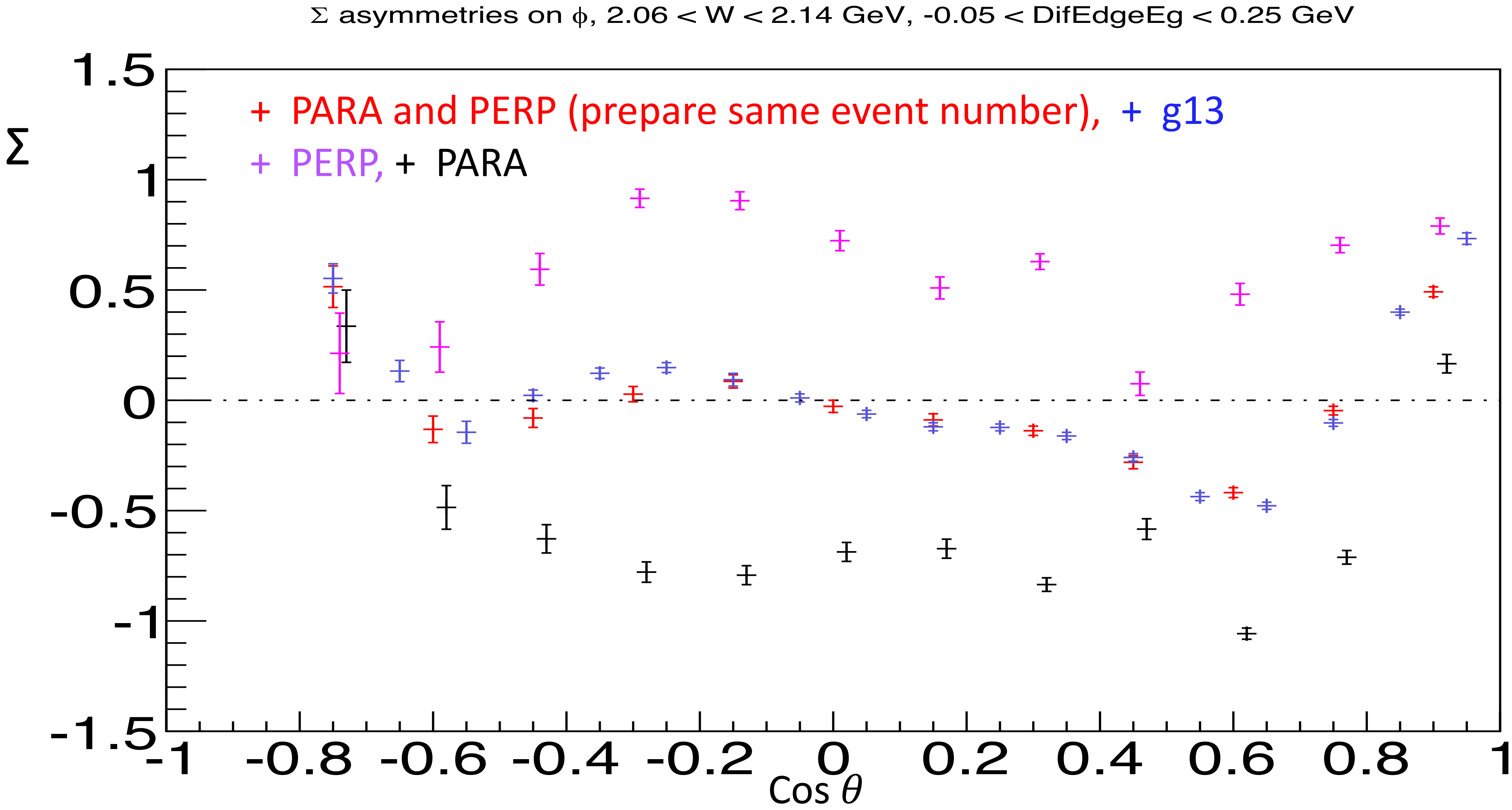
Separately analyze PERP and PARA;

$\log L_T = \sum \log [1 + P_b \Sigma \cos(2\phi_i) - P_T P_b G \sin(2\phi_i)]$ for PERP data

$\log L_T = \sum \log [1 - P_b \Sigma \cos(2\phi_k) + P_T P_b G \sin(2\phi_k)]$ for PARA data

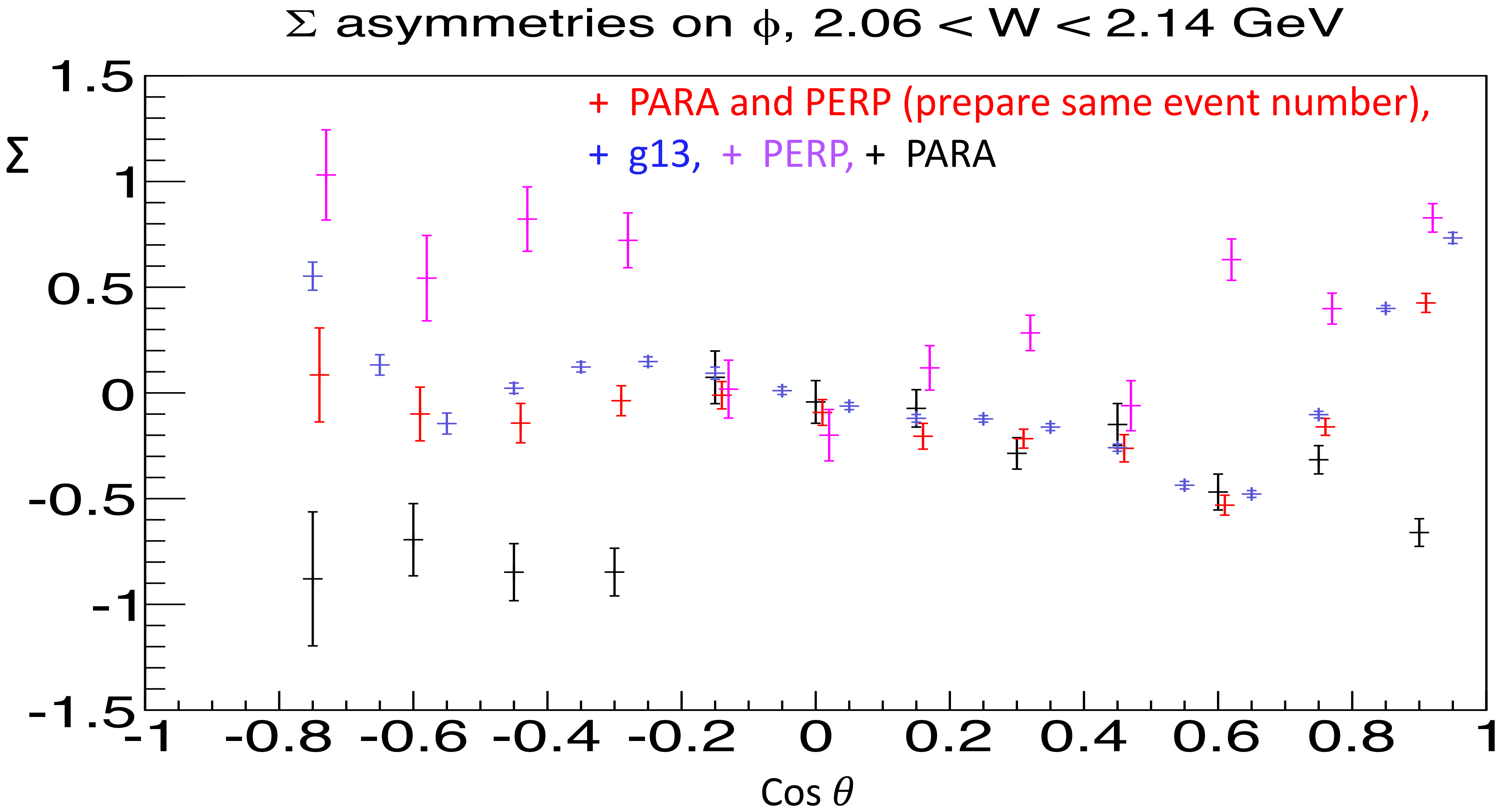
Minuit gets to minimum → gets maximum of $\log L_T$, separately

Σ asymmetries for 2.06 < fW < 2.14 Gev , D + (analyzed PERP and PARA separately)



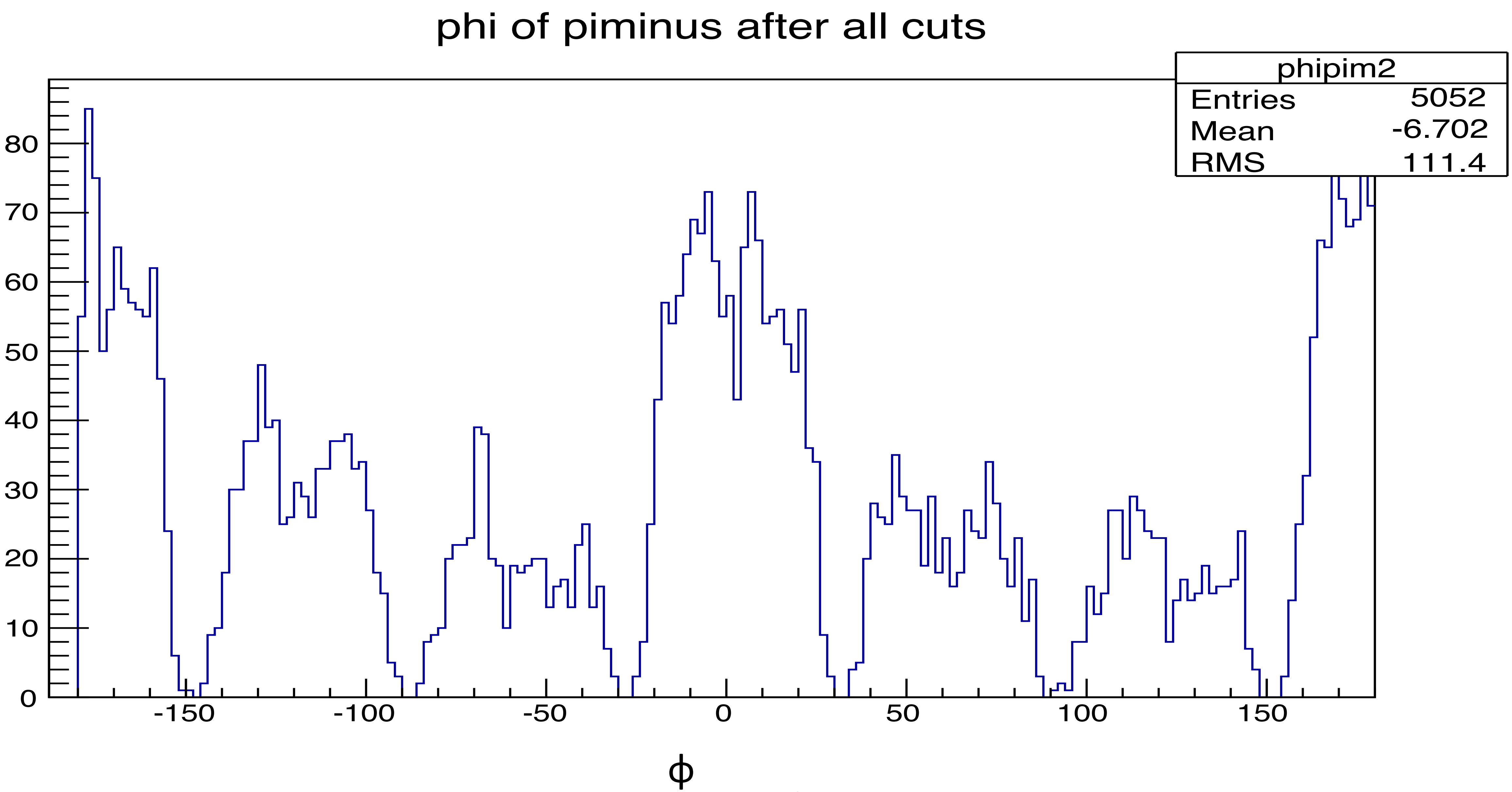
Σ asymmetries for 2.06 < fW < 2.14 Gev, D – (analyzed PERP and PARA separately)

New !



Φ distributions for AMO after all cuts applied

New !

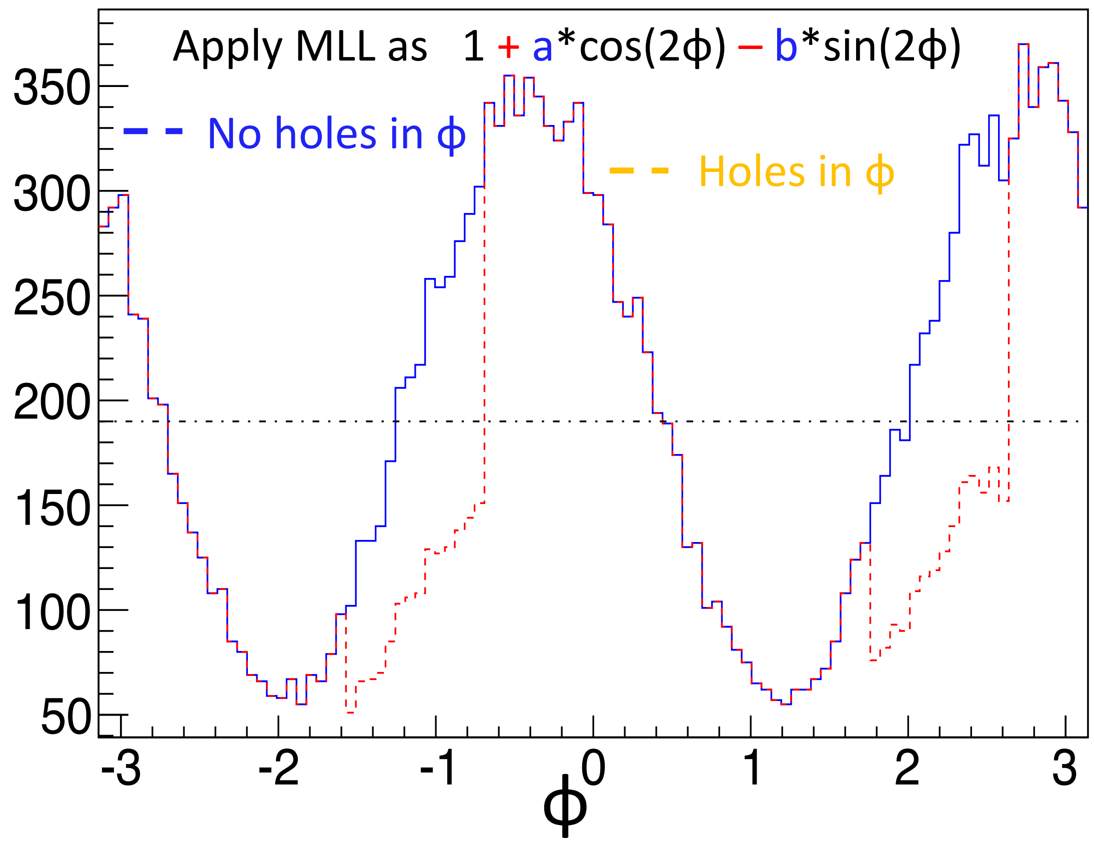


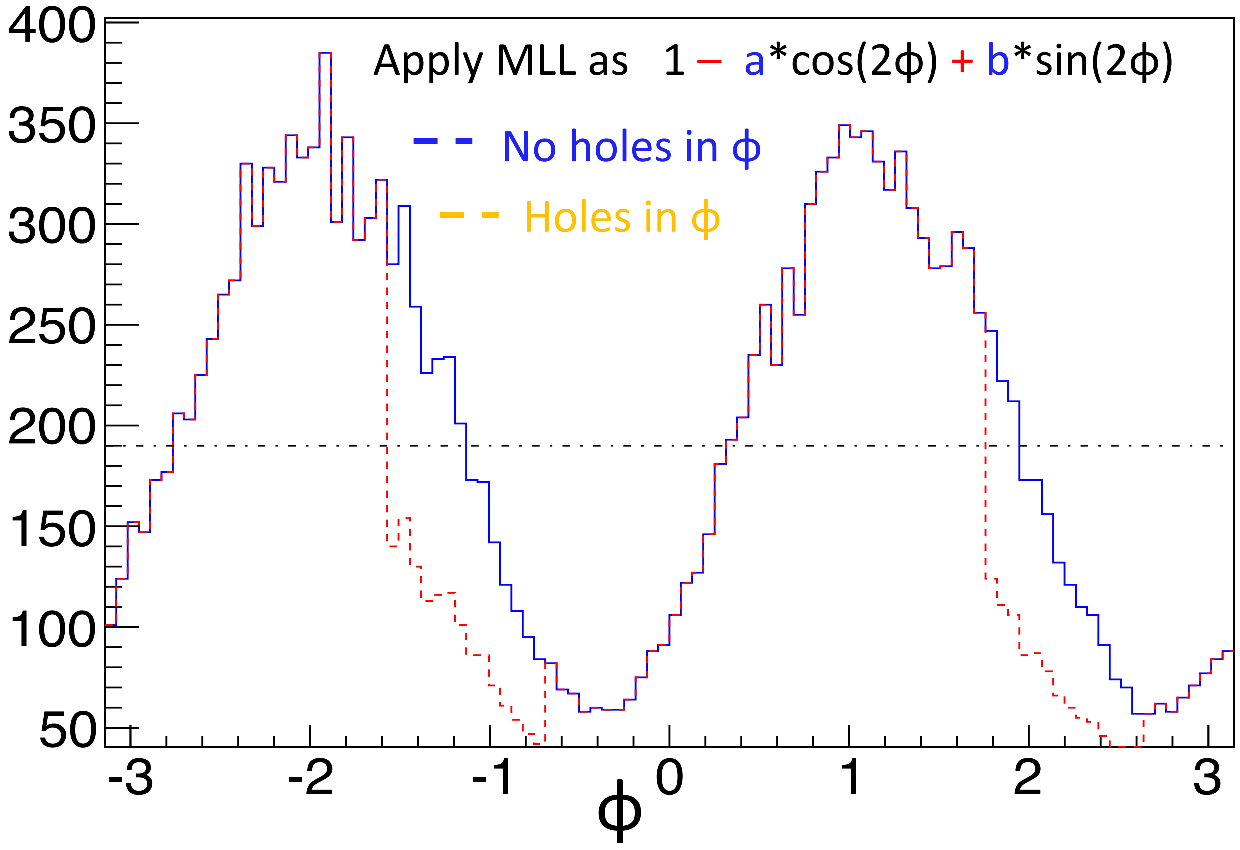
Check by MC: Generate hists like g14 and Apply MLL as $1 \pm a*\cos(2\phi) \mp b*\sin(2\phi)$

$C(1 + 0.5*\cos(2\phi) - 0.5*\sin(2\phi))$ like PERP

$C(1 - 0.5*\cos(2\phi) + 0.5*\sin(2\phi))$ like PARA

New !





No holes : a = 0.513 ± 0.008, b = 0.498 ± 0.008

With Holes : a = 0.642 ± 0.008, b = 0.269 ± 0.008

No holes in ϕ: a = 0.492 ± 0.009, b = 0.504 ± 0.009

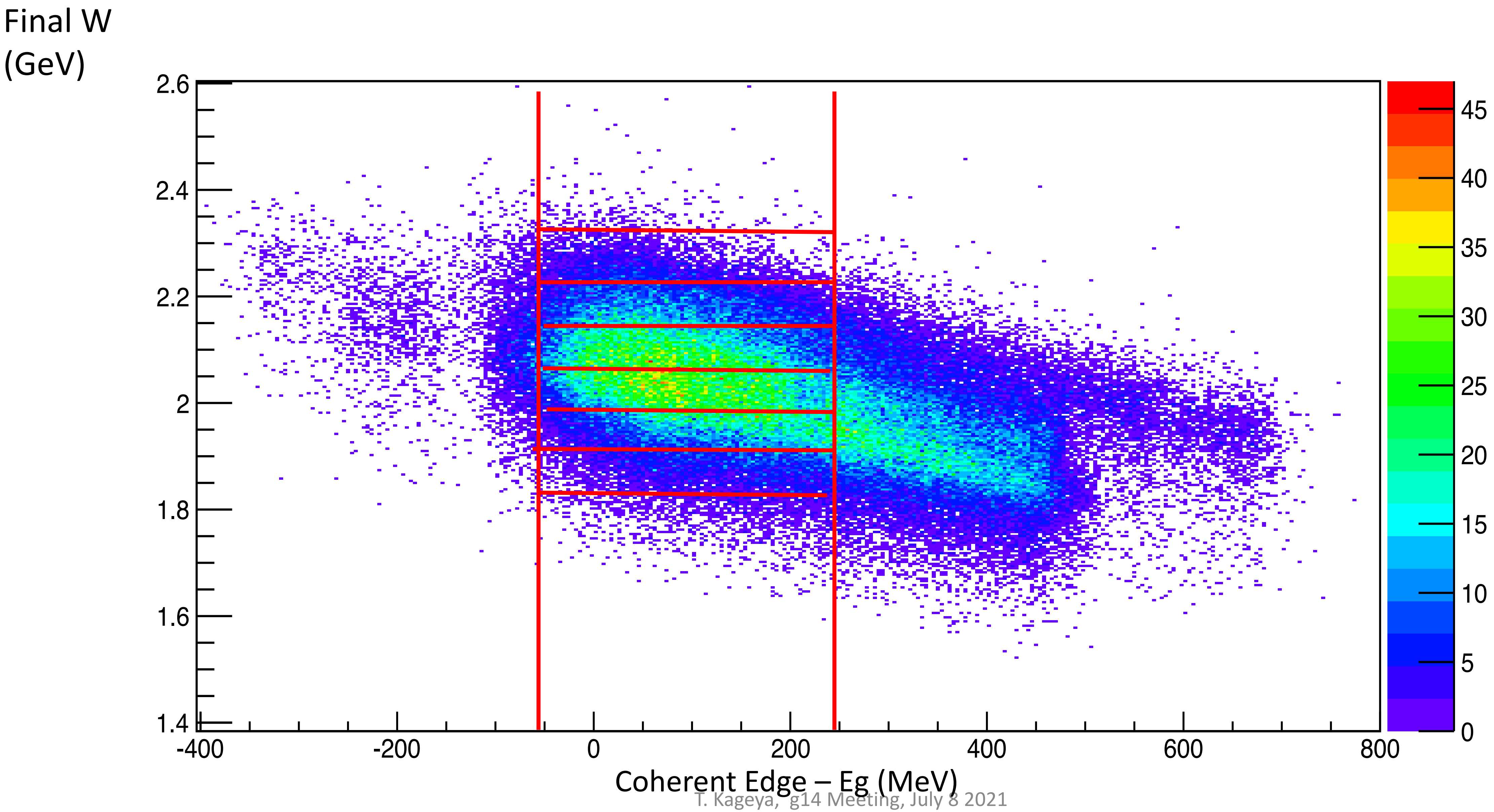
With Holes : a = 0.341 ± 0.009, b = 0.700 ± 0.008

Analyze both hists of holes together : a = 0.502 ± 0.006, b = 0.501 ± 0.006

Nick made more generalized MC changing Σ and G

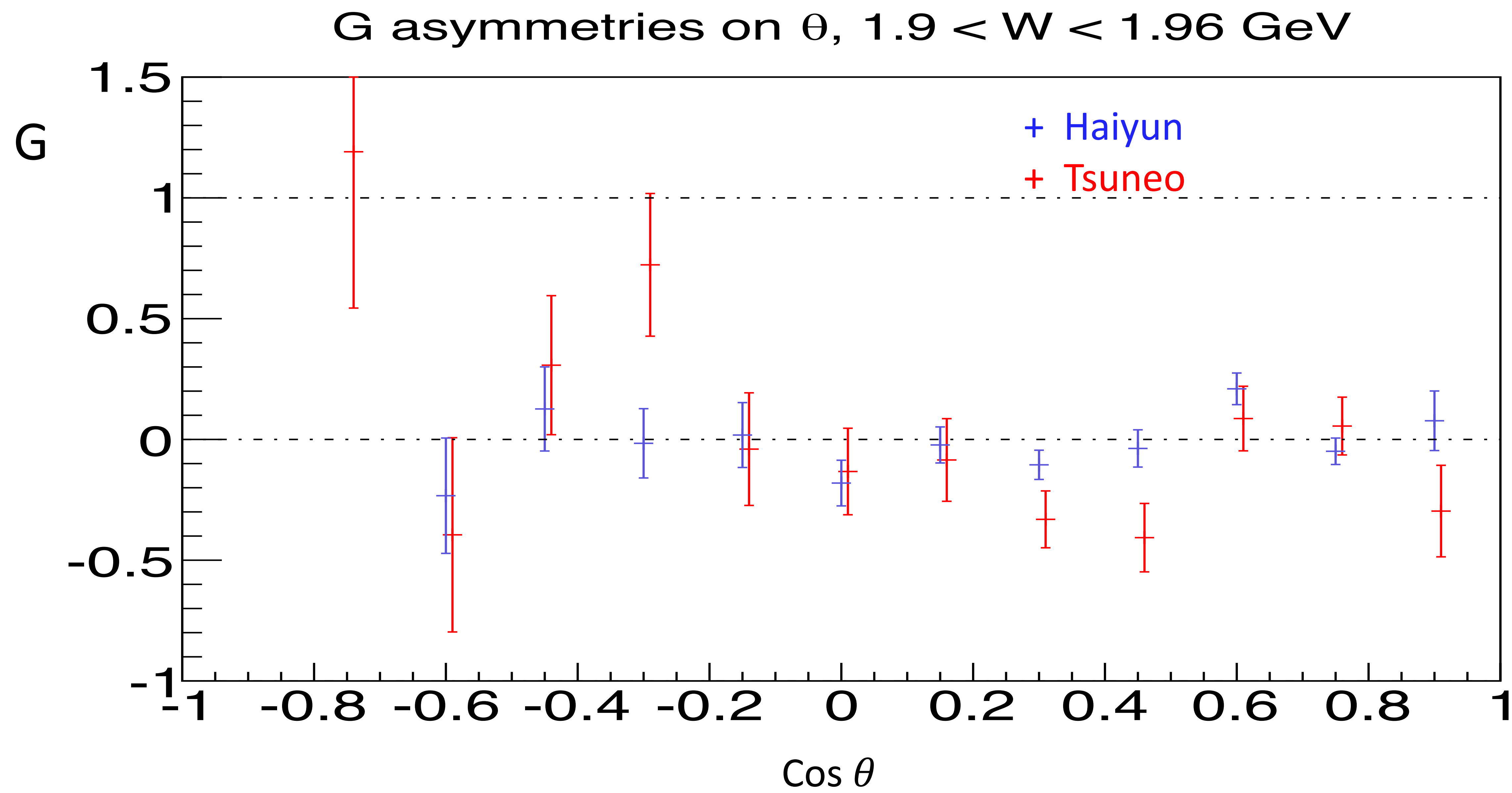
Final W distributions and bins

New !



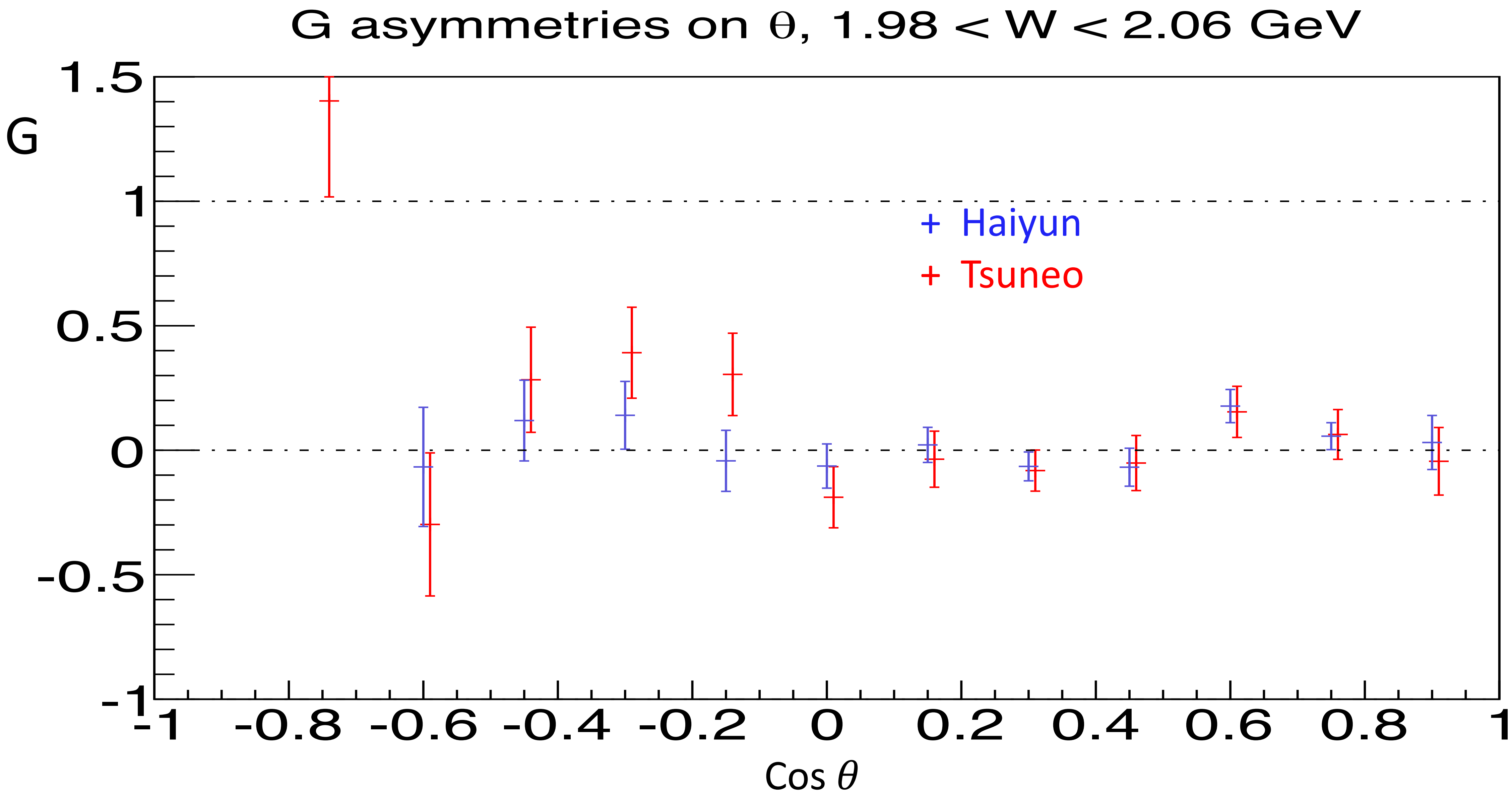
G asymmetries for 1.9 < fW < 1.98 Gev

New !



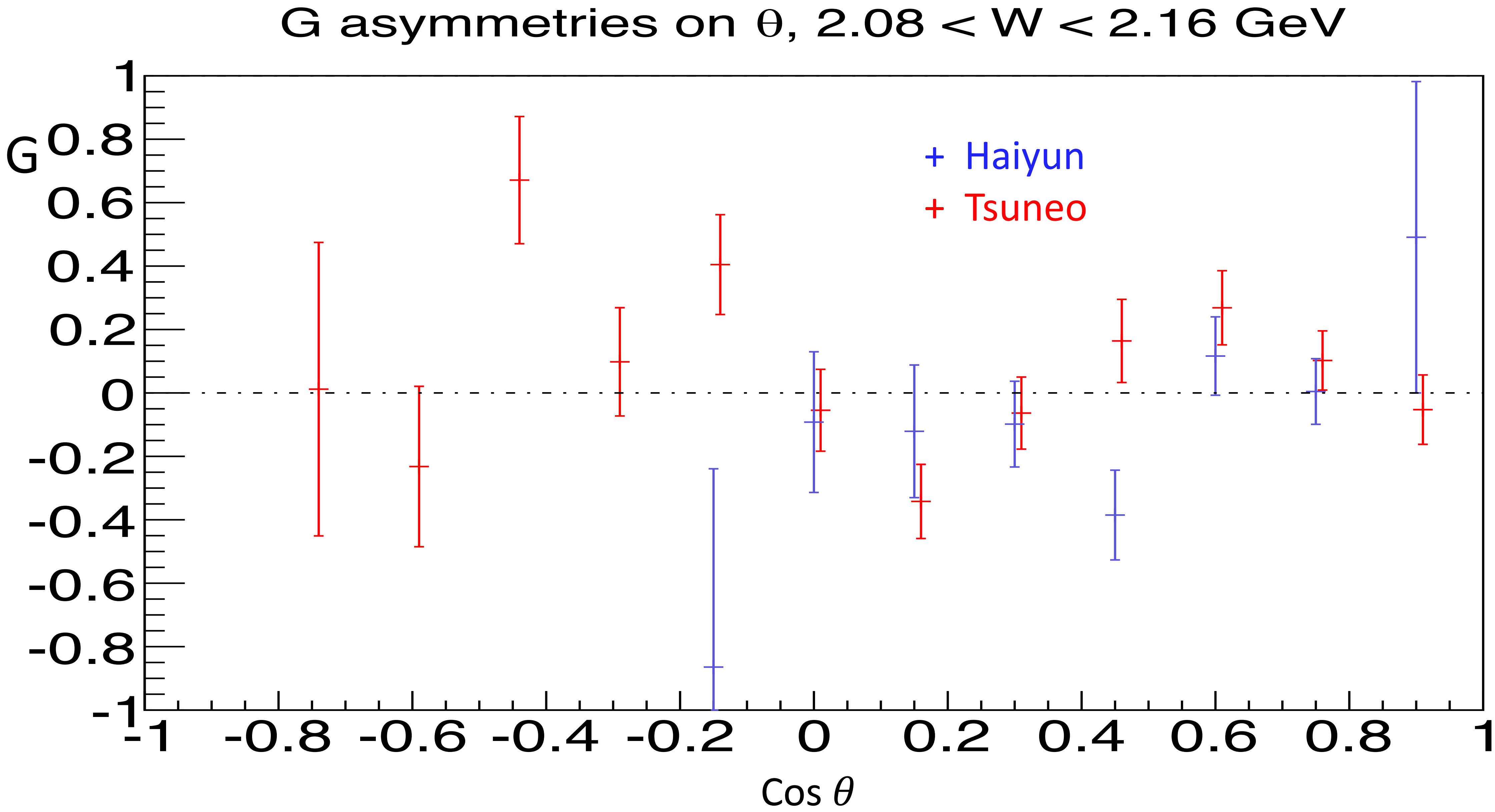
G asymmetries for 1.98 < fW < 2.06 Gev

New !



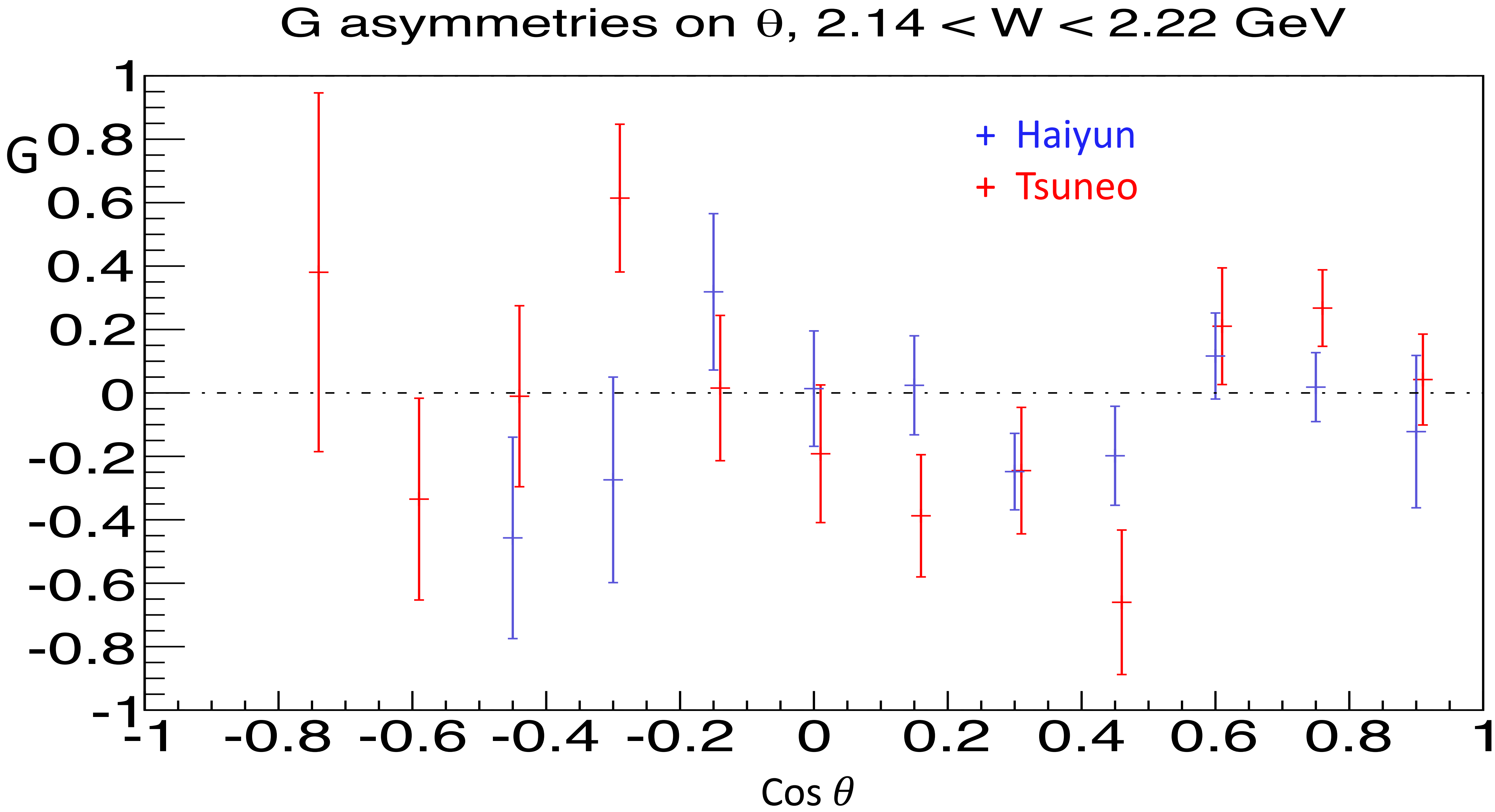
G asymmetries for 2.06 < fW < 2.14 Gev

New !



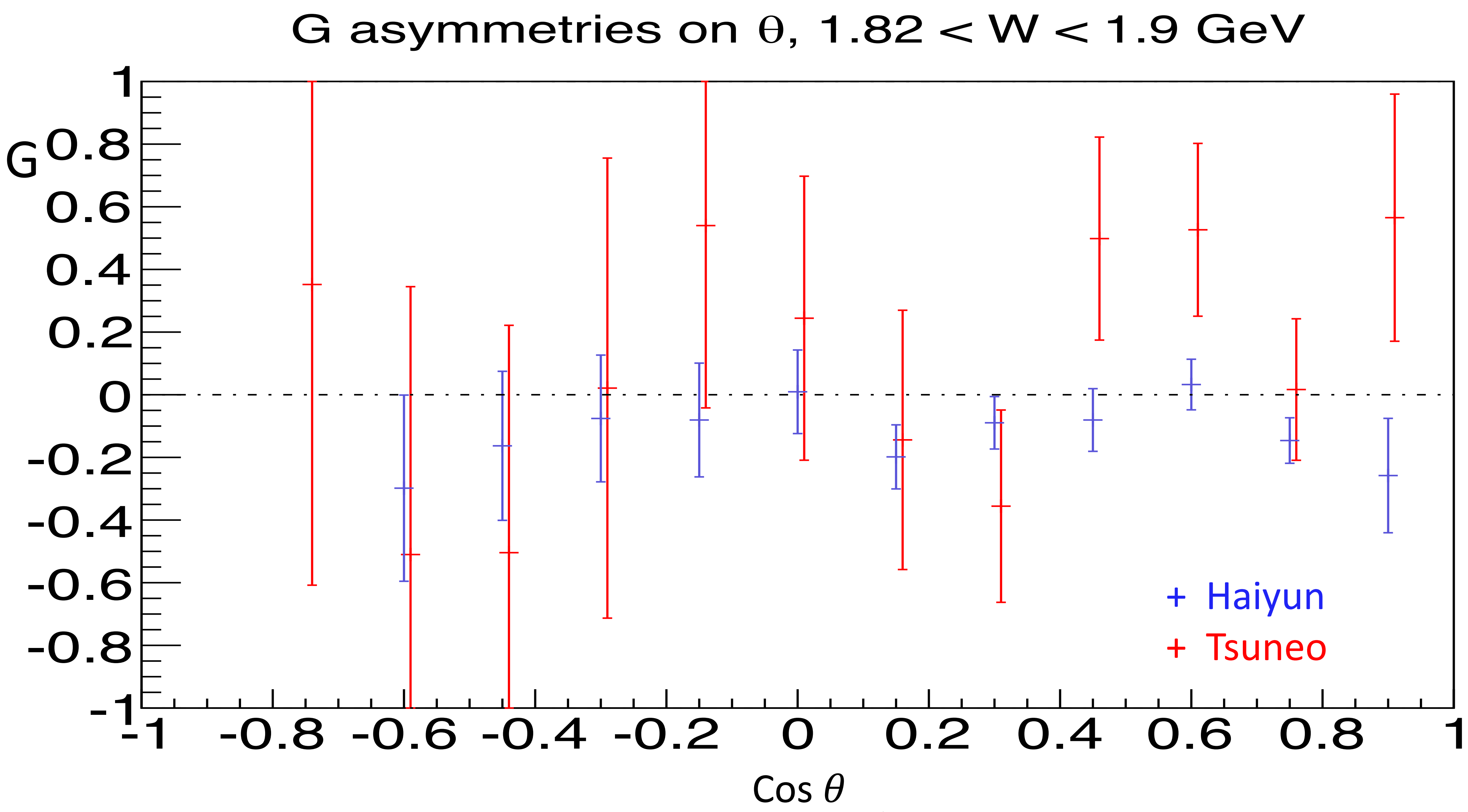
G asymmetries for 2.14 < fW < 2.22 Gev

New !



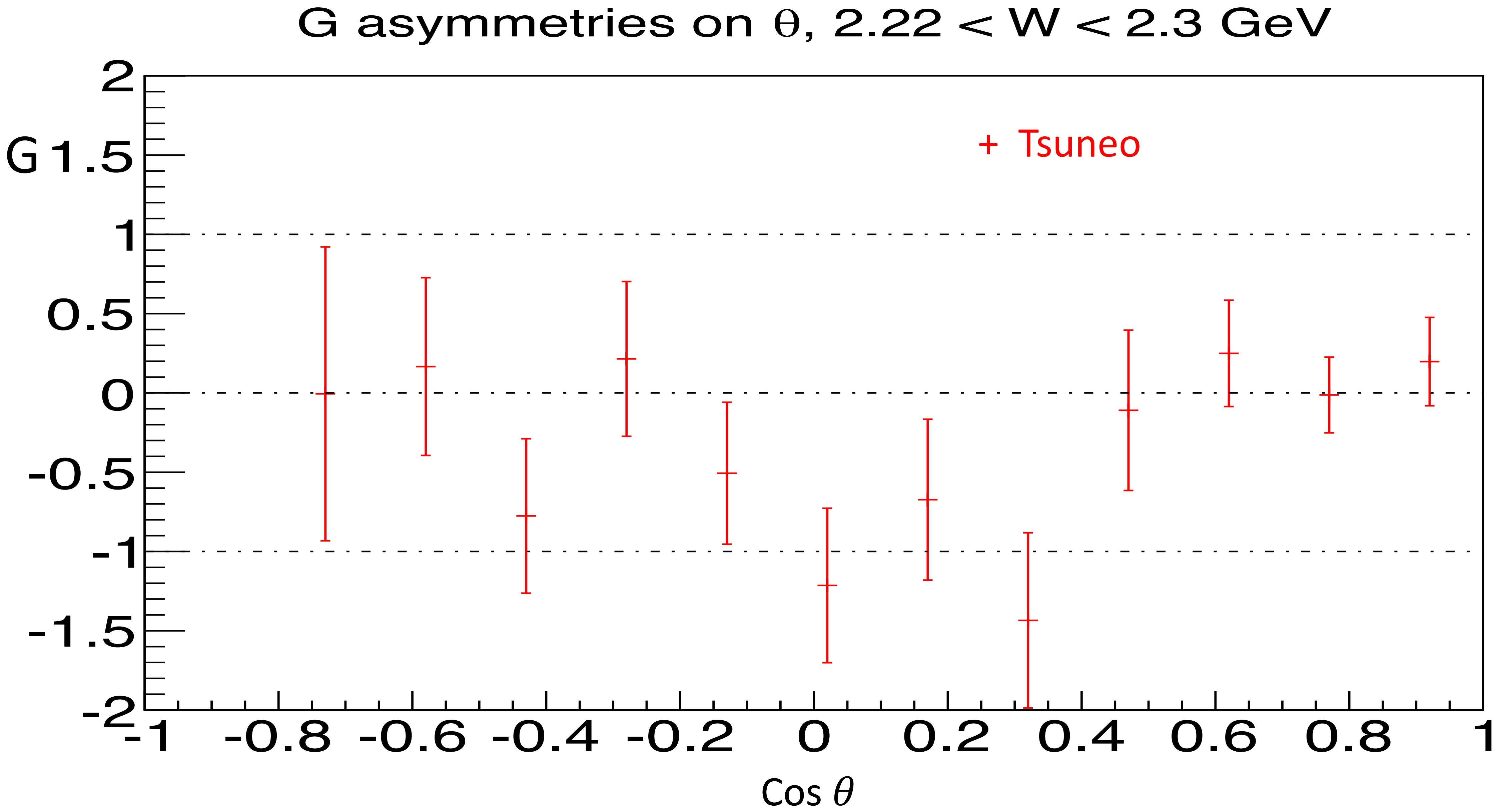
G asymmetries for 1.82 < fW < 1.9 Gev

New !



G asymmetries for 2.22 < fW < 2.3 Gev

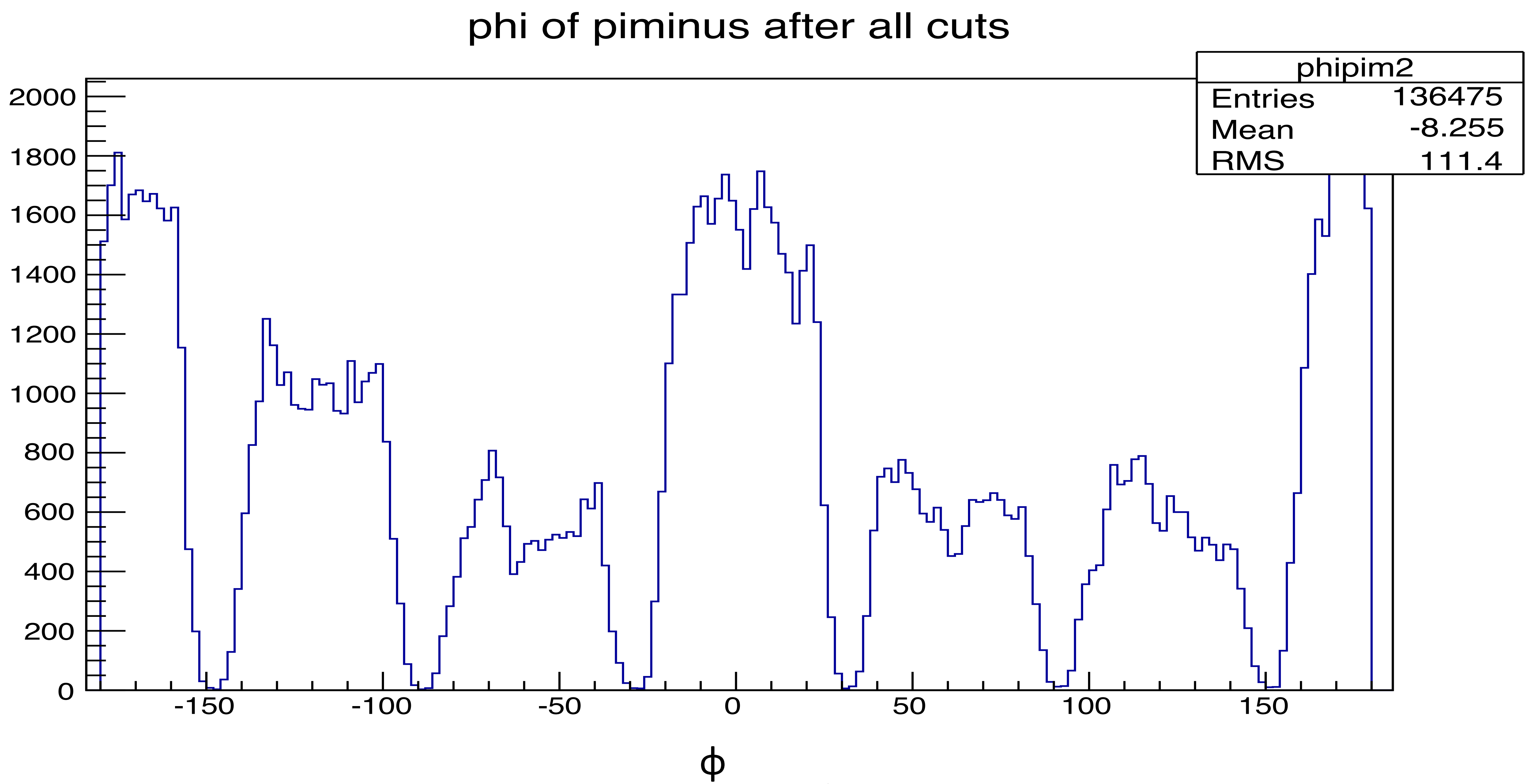
New !



Backup

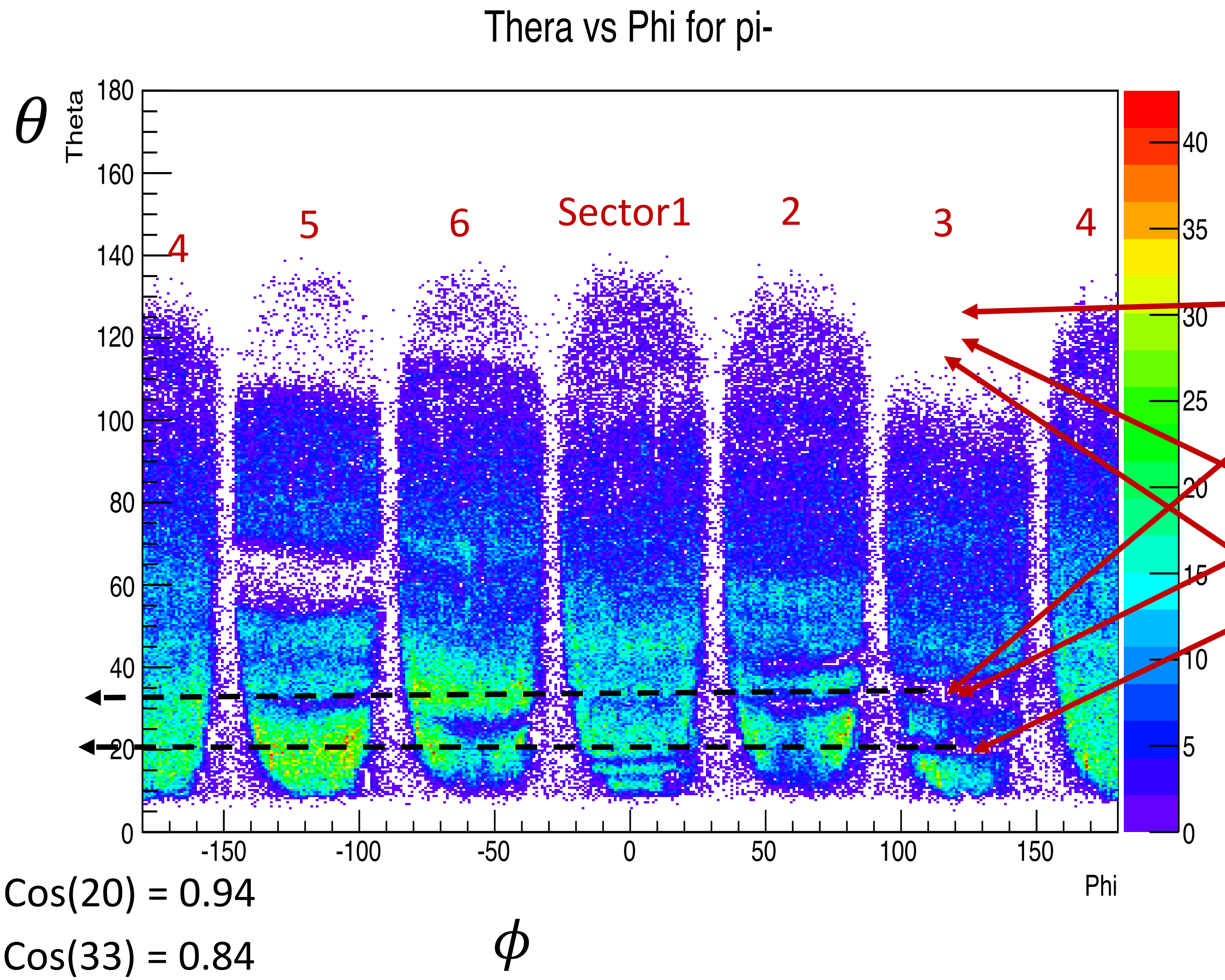
Φ distributions for PARA after all cuts applied

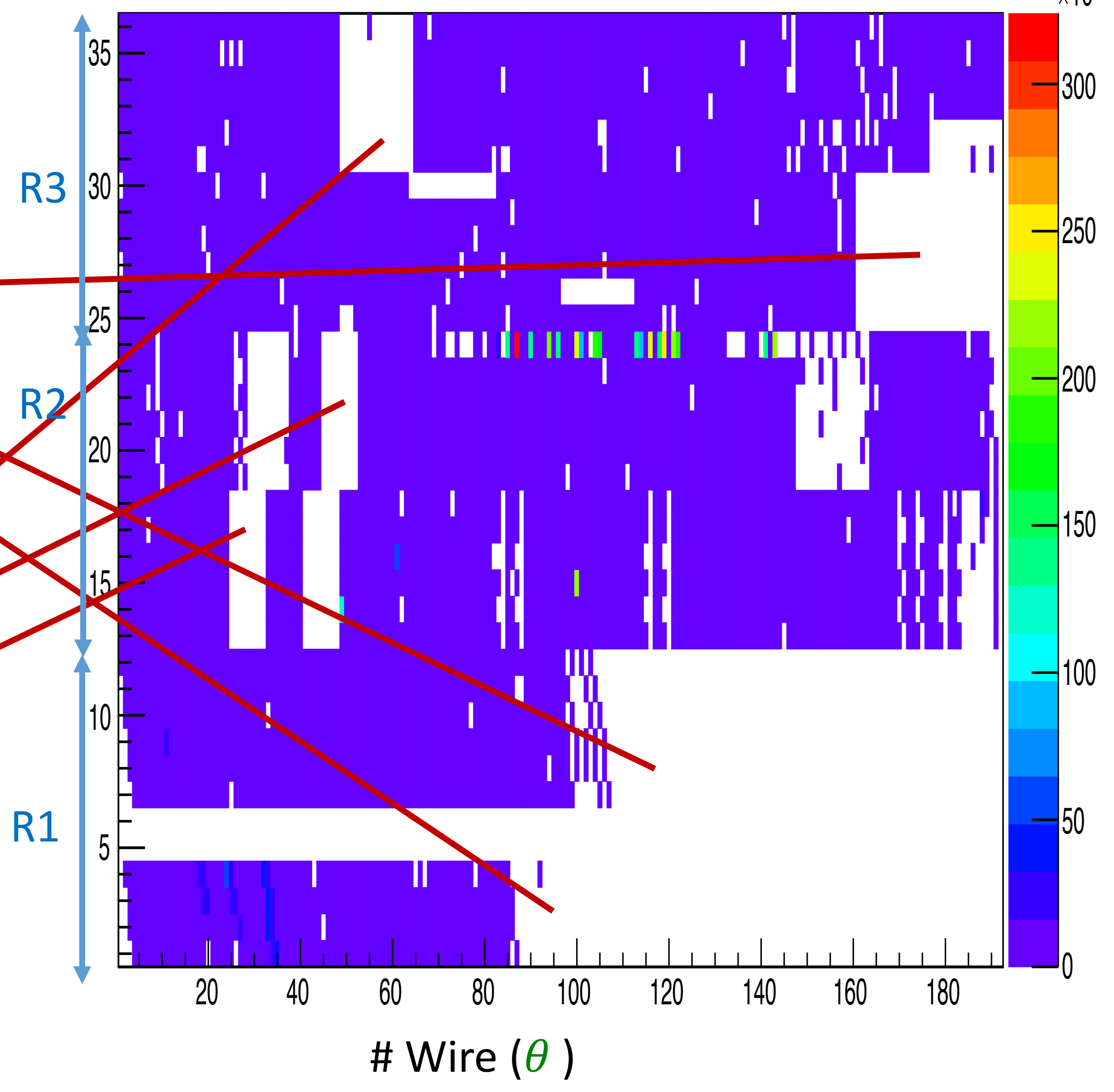
New !



New !

Fiducial distributions for π^- (Last 4 data, PERP, no cuts applied)





Cos(20) = 0.94

Cos(33) = 0.84

Maximum Log-Likelihood method (No.1)

$L_i = C_i\,[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,]\,Ai$ (1) C_i : Flux A_i : Acceptance

$L_T = \prod L_i$ (2) $\prod$: product operator

$\log L_T = \log(\prod L_i) = \sum \log\{C_i\,[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,]\,Ai\}$ (3) $\log(xy) = \log x + \log y$

$\log\{C_i\,[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,]\,Ai\} = \log C_i + \log[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,] + \log Ai$ (4)

$\log L_T = \log \prod C_i + \sum \log[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,] + \log \prod A_i$ (5)

Eq. (5) can be differentiated to find the maximum with respect to Σ or G

Constant terms: $\log \prod C_i$ and $\log \prod A_i$ don't have to be considered

Maximum of the term $\sum \log[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,]$ ➔ obtain Σ and G

Maximum Log-Likelihood method (No.2)

From each event, input P_b, ϕ_i and P_T to $\log\,[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,]$ for PERP
and to $\log\,[1 - P_b\,\Sigma\,\cos(2\phi_k) + P_T\,P_b\,G\,\sin(2\phi_k)\,]$ for PARA

Use Minuit to minimize by multiplying -1
to $\log L_T = \sum \log\,[1 + P_b\,\Sigma\,\cos(2\phi_i) - P_T\,P_b\,G\,\sin(2\phi_i)\,] + \sum \log\,[1 - P_b\,\Sigma\,\cos(2\phi_k) + P_T\,P_b\,G\,\sin(2\phi_k)\,]$

Minuit gets to minimum → gets maximum of log L_T

b) Apply MLL to g14 data to extract Σ and G asymmetries

Data analysis

(1) Use data from (PERP, + Target) and (PARA, + Target); correspond to $(1 + P_{\perp}^{+} \Sigma \cos(2\phi) - P_{+z} P_{\perp}^{+} G \sin(2\phi))$ and $1 - P_{||}^{+} \Sigma \cos(2\phi) + P_{+z} P_{||}^{+} G \sin(2\phi)$.
All cuts are applied including vertex cut

(2) Apply cut of -50 < Coherent Edge – Eg (MeV) < 250 MeV to select events with relatively well defined beam polarization.
6 final W bins as shown in the figure at the next page.

(3) Empty target subtractions are not applied; instead about 7 % of corrections of dilution factors are applied.