# Muon g-2 Comments

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# *Outline*

1) *The Low Energy Frontier & $g_\mu$-2*
   a) *Light Vector Particle?*
   b) *Light Higgs?*

2) *Z pole $\boldsymbol{\sin^2\theta_W}$ vs Low Energy Studies*
   a) *Hadronic Vacuum Polarization*
      *(Lattice Exercise)*

# *A. Hoecker Tau2010 Update*

- $a_\mu^{exp} = 116592089(54)(33)\times10^{-11}$
- $a_\mu^{SM} = 116591802(42)(26)(2)\times10^{-11}$
- $\Delta a_\mu = a_\mu^{exp} - a_\mu^{SM} = 287(63)(49)\times10^{-11}$
- $\boldsymbol{\Delta a_\mu = a_\mu^{exp} - a_\mu^{SM} = 287(80)\times10^{-11}\ (3.6\sigma!)}$

***Harbinger of "New Physics"?***

# Interpretations

$$\Delta a_\mu = a_\mu^{exp} - a_\mu^{SM} = 287(80)\times10^{-11}\ (3.6\sigma!)$$

***Generic 1 loop SUSY Conribution*:**

$$a_\mu^{SUSY} = (\mathrm{sgn}\mu)130\times10^{-11}(100\mathrm{GeV}/m_{susy})^2 \tan\beta$$

$\tan\beta \approx 3\text{-}40$, $m_{susy} \approx 100\text{-}500$GeV

Other Explanations: ***Hadronic $e^+e^-$ Data? HLBL?***

**Multi-Higgs Models**

**Extra Dimensions<2TeV**

* ***Dark Photons ~10-150MeV, $\alpha' = 10^{-8}$***

***Light Higgs <10MeV?***

## ***Low Mass New Physics & g-2***

**Dark Photon $m_A$ of g-2 interpretation easy to find at JLAB or Mainz (Bremsstrahlung)**

*Would Revolutionize Physics*

*Contact with Dark Matter!*

***Could a Higgs be really light?***

*Kinoshita & WJM review long Ago*

# Lattice HVP &HLBL

- Very Challenging Calculations
- Look for easier (interesting) exercises

Running $\alpha(Q^2)$ & $\sin^2\theta_W(Q^2)$

$\alpha(0) = 1/137.036$ ➔ $\alpha(m_Z^2) = 1/128.962(14)$

Very Important for Higgs Mass Constraint

Hadronic Vacuum Pol ≈ 3%

A. Hoecker e+e- data update

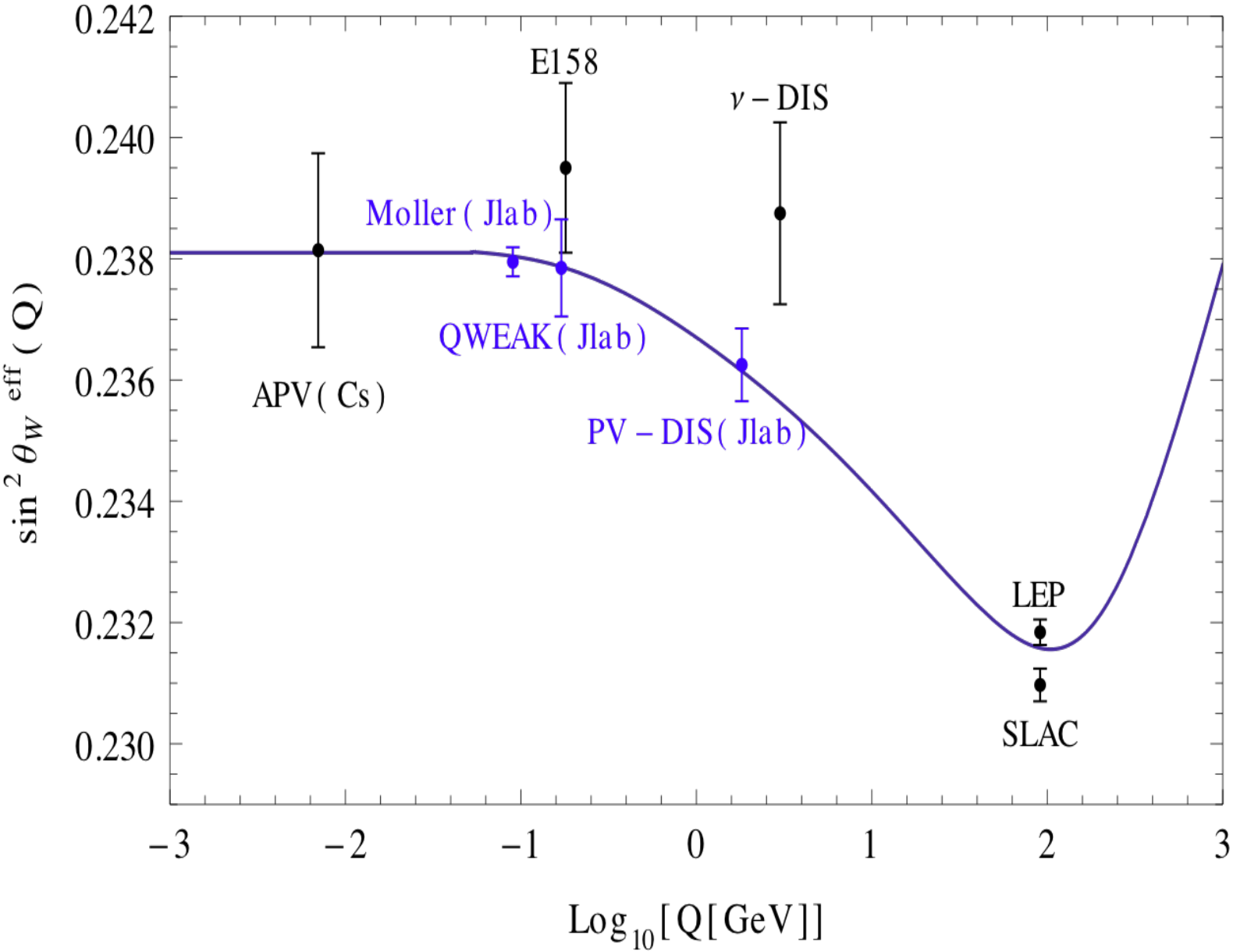
# Running $\sin^2\theta_W(Q^2)$ due to gamma-Z mixing

$\sin^2\theta_W(m_Z^2)$=0.23125(16) Z pole ave.

$\sin^2\theta_W(0)$=0.23821(60) A.Czarnecki & WJM (1995)PRD

Almost all running due to Hadronic Vacuum Polarization but different isospin structure Than running α

e+e- data now much better $\sin^2\theta_W(0)$ error 0.00060→0.00010? HVP ≈ ±1%


0.242
0.240
0.238
0.236
0.234
0.232
0.230
$\sin^2\theta_W{}^{\text{eff}}(Q)$
E158
$\nu$ – DIS
Moller ( Jlab )
QWEAK ( Jlab )
APV ( Cs )
PV – DIS ( Jlab )
LEP
SLAC
−3
−2
−1
0
1
2
3
$\text{Log}_{10}[Q[\text{GeV}]]$

- Comparison of **$\sin^2\theta_W(m_Z^2)$ & $\sin^2\theta_W(0)$ probes "New Physics" eg Heavy Z'>TeV, SUSY Loops(?), $H^{--}$ etc.**

Together APV(Cs) & E158→ $\sin^2\theta_W(Q^2)$ running

$\sin^2\theta_W(0)=\underline{0.23900(100)}$

Agrees with expectations

# Moller e-e-➔e-e- at JLAB

: Polarized **Moller** at JLAB After 12GeV Upgrade
$A_{LR}(ee \rightarrow ee)$ to ±2.5%

**$\Delta \sin^2\theta_W(0) = \pm 0.00025!$ (±0.1%)**

Comparable to Z pole studies!

Measures hadronic vacuum polarization

To about ±1% Approx. current lattice capability

# Conclusion

- Lattice Mechanics should calculate Running of $\sin^2\theta_W(Q^2)$ HVP to ±1%

  Interesting Warmup Exercise for g-2

  Important Physics Itself