

Tests of Symmetries and the Electroweak Interaction

Conveners: Jordy de Vries (Amsterdam), Brad Filippone (CalTech), Bob Redwine (MIT)

Organizing Committee liaison: Vincenzo Cirigliano

Parallel 2 May 29: Nucleon and Nuclear Electric Dipole Moments

1. 20': **[252]** *EDM theory overview*
Emanuele Mereghetti, LANL
2. 20': **[191]** *Worldwide search for the neutron edm*
Brad Filippone, Caltech
3. 20': **[205]** *Towards TUCAN's search for the neutron electric dipole moment*
Wolfgang Schreyer, TRIUMF
4. 20': **[258]** *Status of the storage ring proton EDM experiment*
Selcuk Haciomeroglu, IBS (Korea)
5. 20': **[192]** *The Radium-225 experiment*
Matthew Dietrich, Argonne
6. 20': **[107]** *Progress on the nucleon EDM in lattice QCD*
Sergey Syritsyn, Stony Brook U
7. 20': **[139]** *Search for time reversal invariance violation in resonances of compound nuclei accessible using epithermal neutrons*
Libertad Barron-Palos, UNAM

Parallel 4 May 30: Beta decays

1. 20': **[147]** *Measurement of the neutron lifetime using a magneto-gravitational trap*
Nathan Callahan, Indiana U
2. 20': **[123]** *Measurement of the electron-antineutrino correlation in neutron beta decay: aCORN experiment*
Fred Wietfeldt, Tulane U
3. 20': **[208]** *New results from the UCNA experiment*
Eric Dees, NCSU
4. 20': **[70]** *Beta decay asymmetry measurements with trapped atoms*
Dan Melconian, Texas A&M
5. 20': **[66]** *Nuclear beta decays and CKM unitarity*
John Hardy, Texas A&M
6. 20': **[13]** *Recent status of weak-interaction tests via precision superallowed β^- -decay measurements at TRIUMF*
Kyle Leach, Colorado School of Mines
7. 20': **[3]** *New evaluation of the W -box correction to 0^+0^- nuclear β^- -decay and V_{ud} extraction*
Misha Gorshteyn, Mainz

Parallel 6 May 31: Symmetry tests

1. 30': **[267]** *Precision atomic tests of physics beyond the standard model*
Holger Muller, Berkeley
2. 30': **[277]** *Muon $g-2$ experiments at FNAL and J-PARC*
Joe Price, U Liverpool
3. 20': **[149]** *New results on low-energy hadronic cross sections and implications for muon $g-2$*
Bill Gary, UC Riverside
4. 20': **[61]** *Baryogenesis by particle-antiparticle oscillations*
Seyda Ipek, UC Irvine
5. 20': **[203]** *Search for neutron-antineutron oscillations at the Sudbury Neutrino Observatory*
Marc Bergevin, LLNL
6. 20': **[161]** *Neutron-antineutron conversion to search for $B-L$ violation*
Susan Gardner, U Kentucky

Parallel 7 June 1: Weak Parameters (PHE/TSEI)

1. 20': **[109]** *Review of the first W boson mass measurement with the ATLAS detector*
Fabrice Balli, Saclay CES
2. 20': **[377]** *The weak charge: from atoms to the Z pole*
Misha Gorshteyn, Mainz
3. 20': **[280]** *Nuclear weak charge measurements through atomic PNC*
Gerald Gwinner, U Manitoba
4. 20': **[367]** *Parity violating electron scattering experiments for an ultra precise determination of the weak mixing angle at low energies*
Frank Maas, Mainz
5. 20': **[365]** *High precision extraction of A_{fb} at the LHC*
CMS Collaboration (reporting also for ATLAS and LHCb) Arie Bodek, Rochester U

Parallel 8 June 1: Neutrinos and Symmetries (NMNM/TSEI)

1. 25': **[253]** *Sterile neutrinos in the early universe*
George Fuller, UCSD
2. 25': **[294]** *Nonstandard neutrino interactions*
Andre deGouvea, Northwestern U
3. 25': **[25]** *Detecting CP violation in the presence of nonstandard neutrino interactions*
Jeffrey Hyde, Goucher College
4. 25': **[217]** *Neutrino oscillations and supernova nucleosynthesis*
Baha Balantekin, U Wisconsin
5. 20': **[151]** *Collective neutrino oscillations in the presence of collisions*
Shashank Shalgar, LANL
6. 20': **[340]** *Neutrino flavor transformation and the cosmic lepton asymmetry*
Luke Johns, UC San Diego

Parallel 9 June 2: Hadronic Parity Violation and Symmetries in Atoms

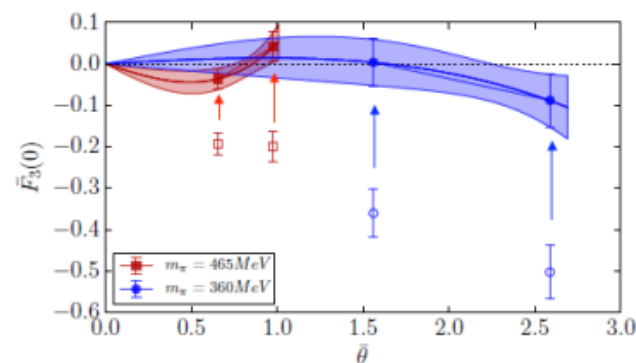
1. 30': **[255]** *Hadronic PNC and the Large Nc*
Matthias Schindler, S. Carolina
2. 30': **[178]** *Final results from the n-3He experiment: Parity violation in the n-3He capture*
Michael Gericke, U Manitoba
3. 20': **[2]** *Large-Nc HPNC Analyses post NPDGamma*
Wick Haxton, UC Berkeley
4. 20': **[243]** *Lattice QCD for Hadronic Parity Violation*
Andre Walker-Loud, LBNL
5. 20': **[254]** *Anapole moments*
Sid Cahn, Yale U
6. 20': **[55]** *Searching for hadronic CP violation in deformed nuclei with polar molecules*
Nick Hutzler, Caltech

Recent Lattice Results on θ_{QCD} -induced nEDM

Correction to previous results:

$$[F_3]_{\text{true}} = "F_3" + 2\alpha F_2$$

- [F. Guo *et al* (QCDSF), PRL115:062001 (2015)]
dynamical calculations with finite imag. θ' angle
- [C.Alexandrou *et al* (ETMC), PRD93:074503 (2016)]
 $d_n = -0.045(06) \text{ e fm } (\sim 7.5\sigma) \rightarrow +0.008(6) \text{ e fm } (1.3\sigma)$
- Uniform bg. electric field method is not affected by "parity mixing"
Precision in Ref. [E. Shintani *et al*, D78:014503 (2008)] is insufficient for comparison

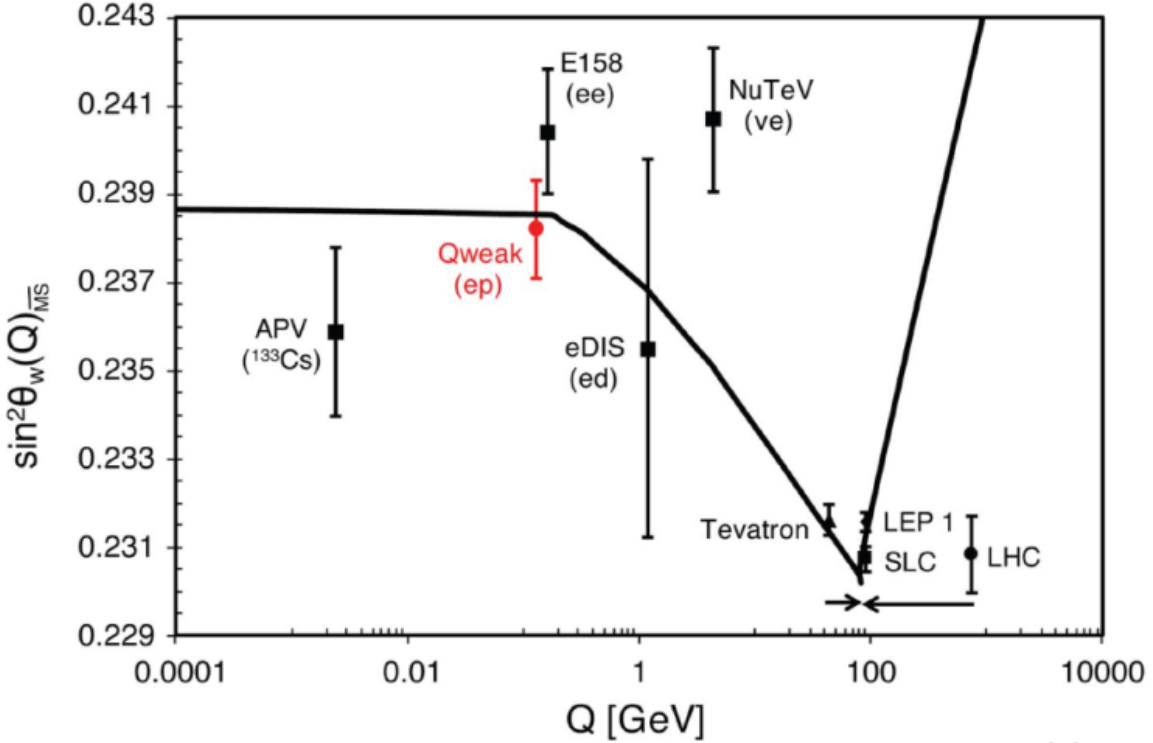


	m_π [MeV]	m_N [GeV]	F_2	α	\tilde{F}_3	F_3	
[ETMC 2016]	n	373	1.216(4)	-1.50(16) ^a	-0.217(18)	-0.555(74)	0.094(74)
[Shintani et al 2005]	n	530	1.334(8)	-0.560(40)	-0.247(17) ^b	-0.325(68)	-0.048(68)
	p	530	1.334(8)	0.399(37)	-0.247(17) ^b	0.284(81)	0.087(81)
[Berruto et al 2006]	n	690	1.575(9)	-1.715(46)	-0.070(20)	-1.39(1.52)	-1.15(1.52)
	n	605	1.470(9)	-1.698(68)	-0.160(20)	0.60(2.98)	1.14(2.98)
[Guo et al 2015]	n	465	1.246(7)	-1.491(22) ^c	-0.079(27) ^d	-0.375(48)	-0.130(76) ^d
	n	360	1.138(13)	-1.473(37) ^c	-0.092(14) ^d	-0.248(29)	0.020(58) ^d

After removing spurious contributions,

- no lattice signal for θ_{QCD} -induced nEDM $\Rightarrow d_N$ is very small
- no conflict with phenomenology values or m_q scaling

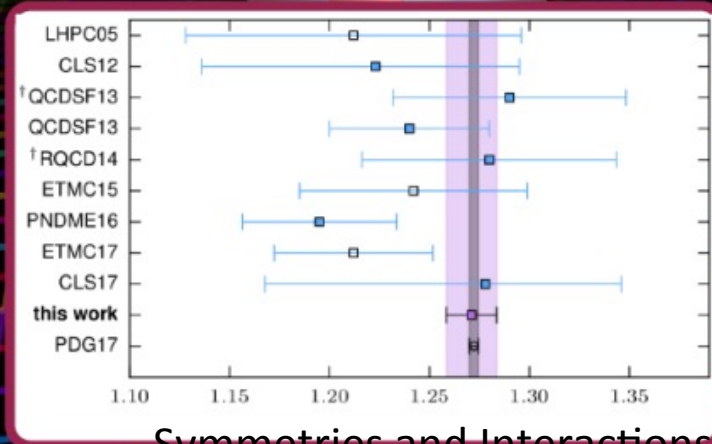
Weak mixing angle $\sin^2 \theta_W$



Qweak 2017 + PVES data base:
 $\sin^2 \theta_W = 0.2382 \pm 0.0011$

Solid Curve: J. Erler, M. Ramsey-Musolf, P. Langacker

Plen-4: Symmetries and Interactions from Lattice QCD - Amy Nicholson (UNC Chapel Hill)



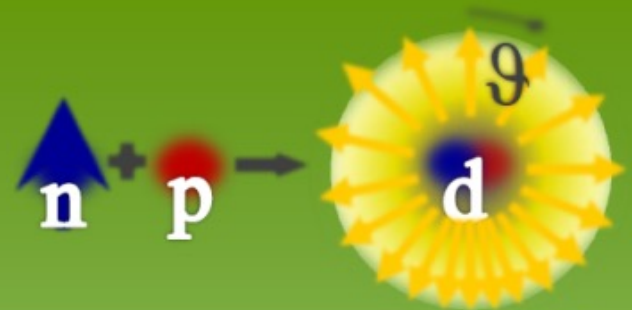
$$g_A^{\text{LQCD}} = 1.271 \pm 0.013$$

Nature, May 30, 2018

C.C. Chang, A.N., E. Rinaldi, E. Berkowitz, N. Garron, D. Brantley, H. Monge-Camacho, C. Monahan, C. Bouchard, M.A. Clark, B. Joo, T. Kurth, K. Orginos, P. Vranas, A. Walker-Loud

Symmetries and Interactions from Lattice QCD
Amy Nicholson (UNC Chapel Hill)

Final Answer?

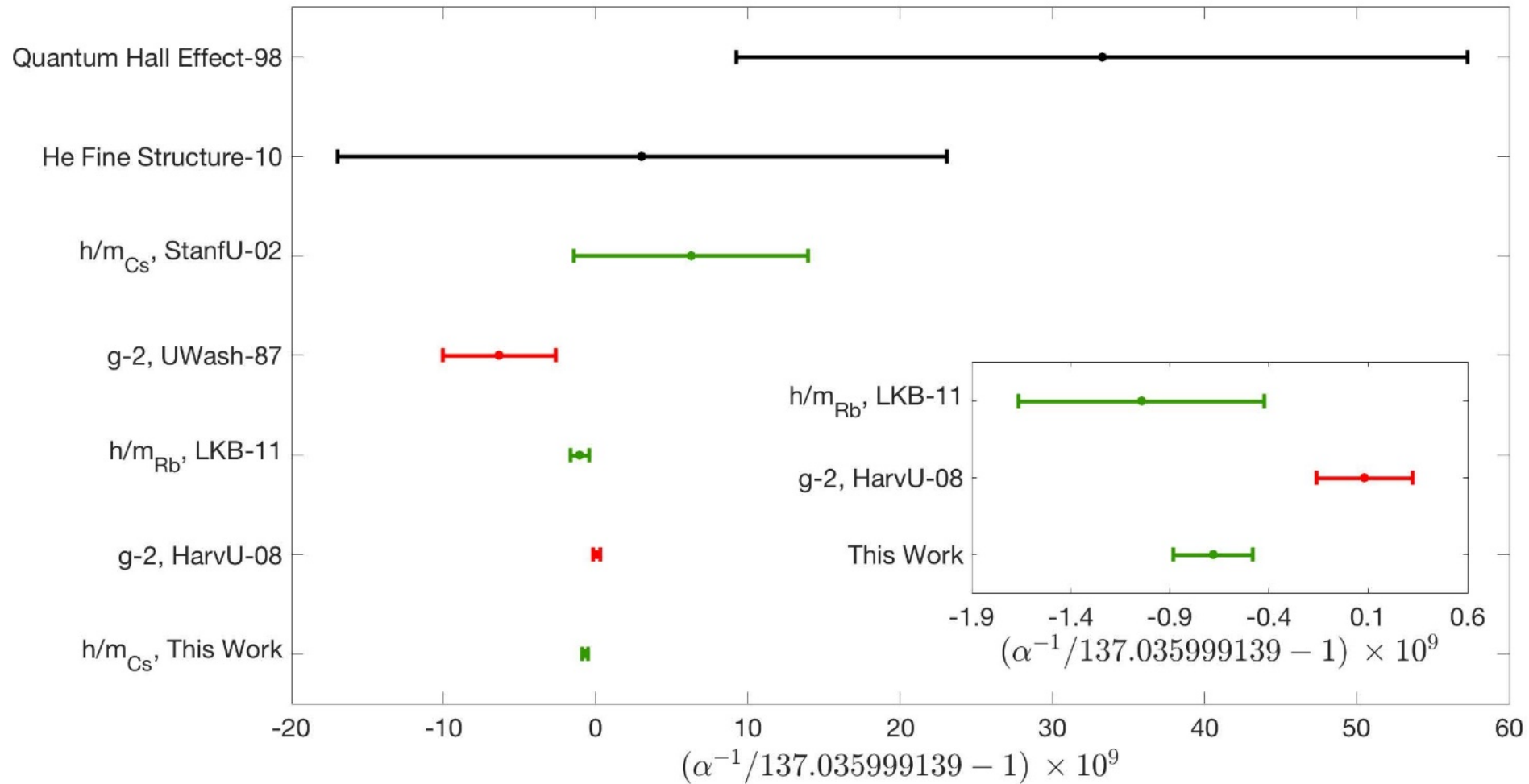


Three analyses converged on one PV proton asymmetry

$$A_{\gamma, PV}^p = -3.0 \pm 1.4 \pm 0.2 [\times 10^{-8}]$$

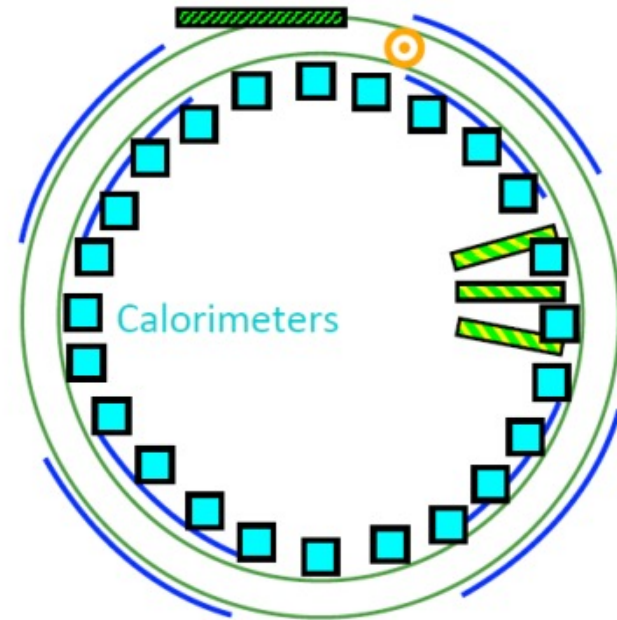
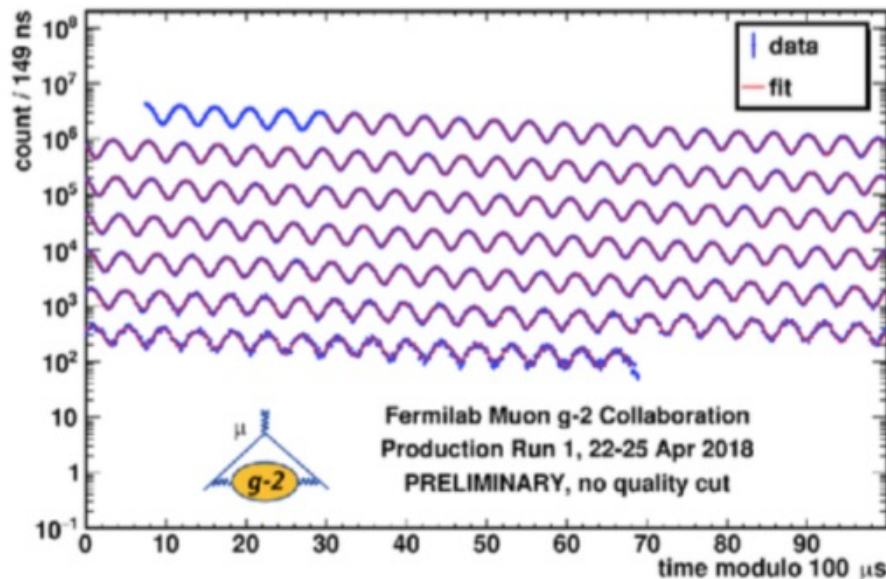
- After 20ish years, NPDGamma has made a $1e-8$ measurement of the long range component of the Hadronic Weak Interaction
 - Isolates the $\Delta I=1$ piece of the Hadronic Weak Interaction
 - Not hindered by nuclear effects
- Future measurement at ESS?

Results



Calorimeters

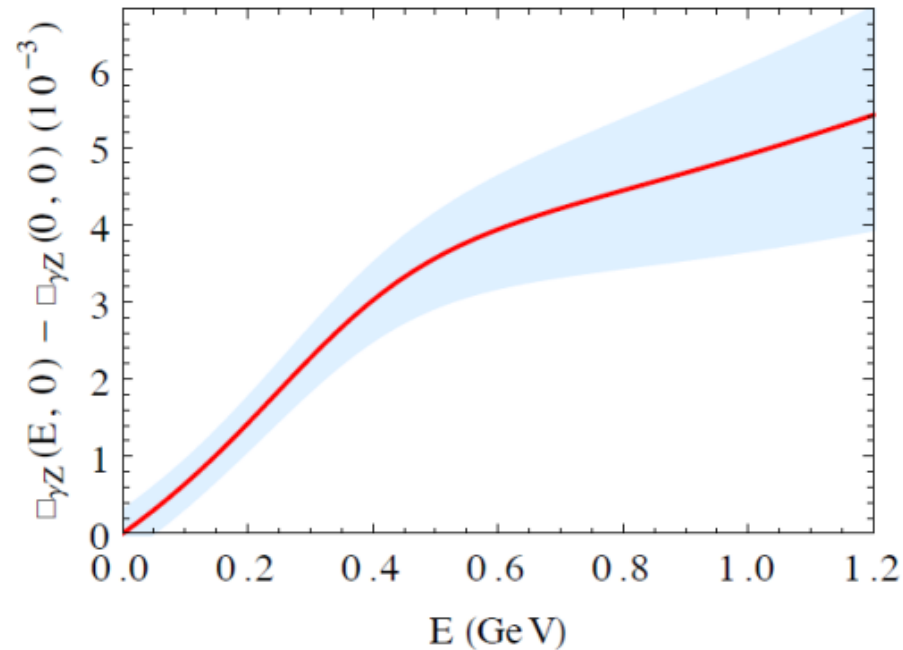
- 24 calorimeters are placed around ring
- They measure the e^+ from the μ decay
- Number of high energy e^+ oscillates at spin precession frequency



- Perform 5 parameter fit to arrival time spectrum - same technique as used in BNL experiment

$$N_e(t) \simeq N_0 e^{-\frac{t}{\gamma\tau}} [1 - A \cos(\omega_a t + \phi_a)]$$

Status of the energy-dependent γZ -Box



MG, Horowitz, PRL 102 (2009) 091806;
 Nagata, Yang, Kao, PRC 79 (2009) 062501;
 Tjon, Blunden, Melnitchouk, PRC 79 (2009) 055201;
 Zhou, Nagata, Yang, Kao, PRC 81 (2010) 035208;
 Sibirtsev, Blunden, Melnitchouk, PRD 82 (2010) 013011;
 Rislow, Carlson, PRD 83 (2011) 113007;
MG, Horowitz, Ramsey-Musolf, PRC 84 (2011) 015502;
 Blunden, Melnitchouk, Thomas, PRL 107 (2011) 081801;
 Rislow, Carlson PRD 85 (2012) 073002;
 Blunden, Melnitchouk, Thomas, PRL 109 (2012) 262301;
 Hall et al., PRD 88 (2013) 013011;
 Rislow, Carlson, PRD 88 (2013) 013018;
 Hall et al., PLB 731 (2014) 287;
MG, Zhang, PLB 747 (2015) 305;
 Hall et al., PLB 753 (2016) 221;
MG, Spiesberger, Zhang, PLB 752 (2016) 135;

QWEAK energy: $\text{Re} \square_{\gamma Z}^{A+V}(E = 1.165 \text{ GeV}) = (9.3 \pm 1.5) \times 10^{-3}$ (mostly vector box)

QWEAK final result: $Q_{PW} = 0.0719 \pm 0.0045$ (error mostly experimental)

P2 energy: $\text{Re} \square_{\gamma Z}^{A+V}(E = 155 \text{ MeV}) = (5.4 \pm 0.4) \times 10^{-3}$ (mostly axial box)

P2 expectation: $Q_{PW} = 0.0713 \pm 0.0013$