PAC Jeopardy Issues

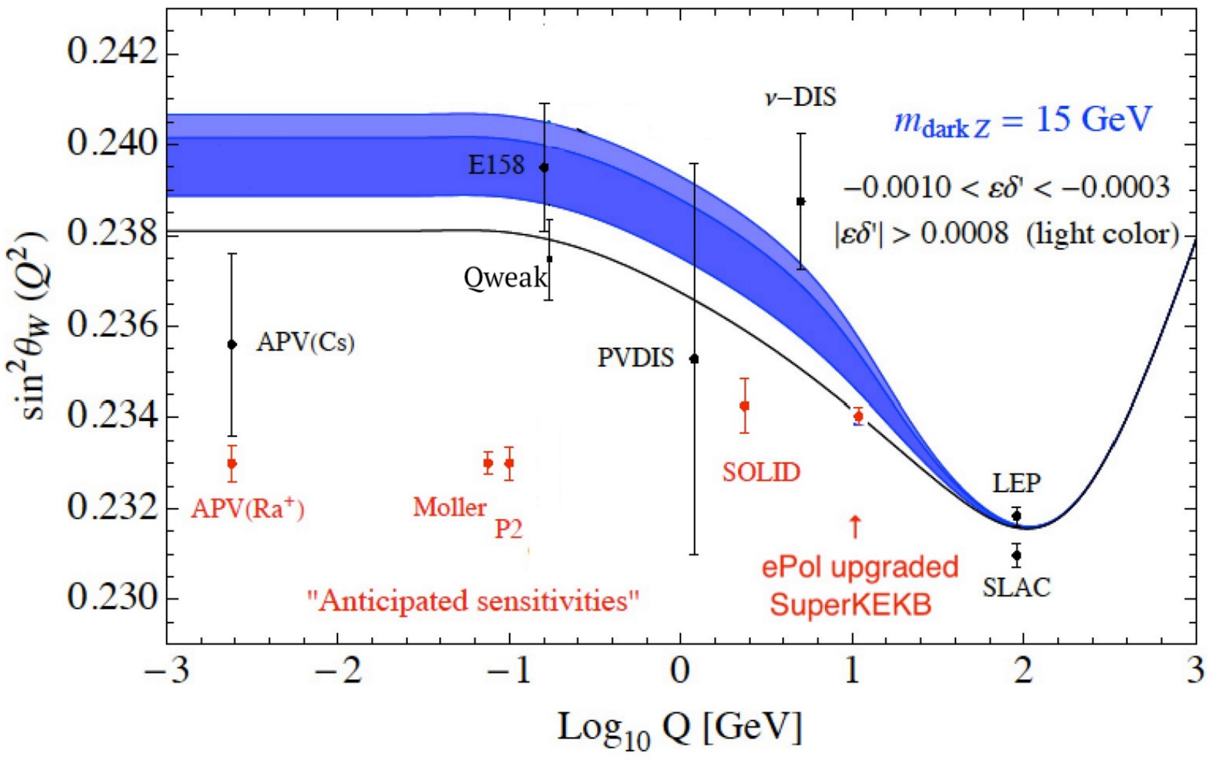
Not a summary: Subset of talks

SoLID and Antiquarks

- Question: what will error be in 10 years?
- PDF corrections can be applied after the data is published.
- Involves extrapolation
- Light quarks:
  - Present data: $x<0.25$
  - SeaQuest: $x<0.45$
- Ratio of light sea to strange sea?
- If needed, do a low y experiment
- Cancels in ^{48}Ca experiment

Low Mass Dark Light

Davoudiasl's Plot

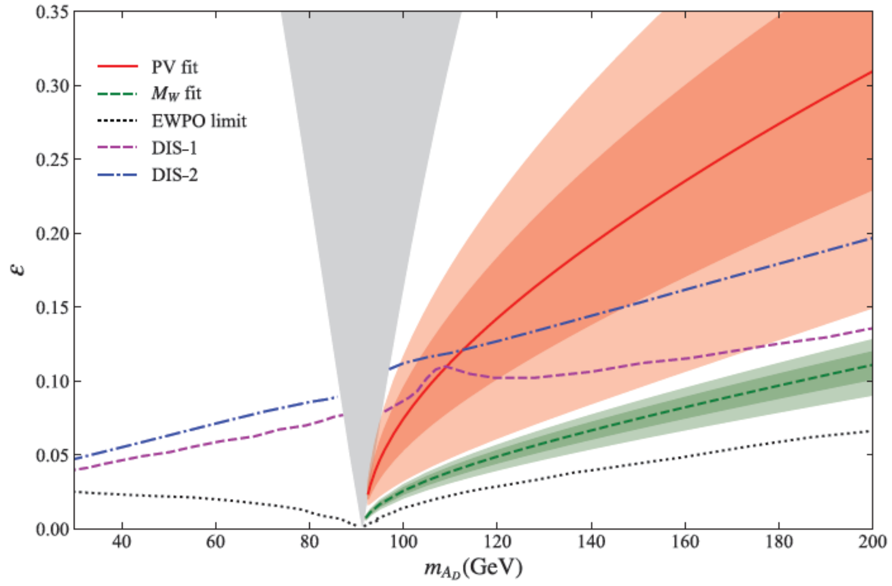


There is probably discovery space for SoLID, (caveat: in the range M>10-30 Gev, effects on other qbservabes should be checked.

High Mass Dark Light

Constraints of new W mass versus PV

Thomas and Wang, arXiv: 2205.01911



Using Cs value from Dzuba et al., Phys Rev Lett 109 (2012) 203003

$$Q_W(^{133}\mathrm{Cs}) = -72.58(29)_{\mathrm{expt}}(32)_{\mathrm{theo}}$$

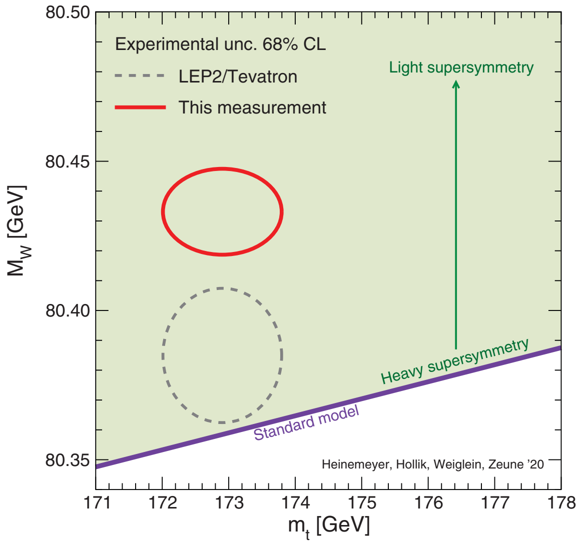
Issues

1. No study of other observables
2. Assumes new W mass undoes EWPO limits
3. Deserves a mention

Status of Anomalies in Standard Model Tests

Clues for BSM Physics??

1. W mass from CDF
2. g-2
3. Lack of μ-e universality in B decays

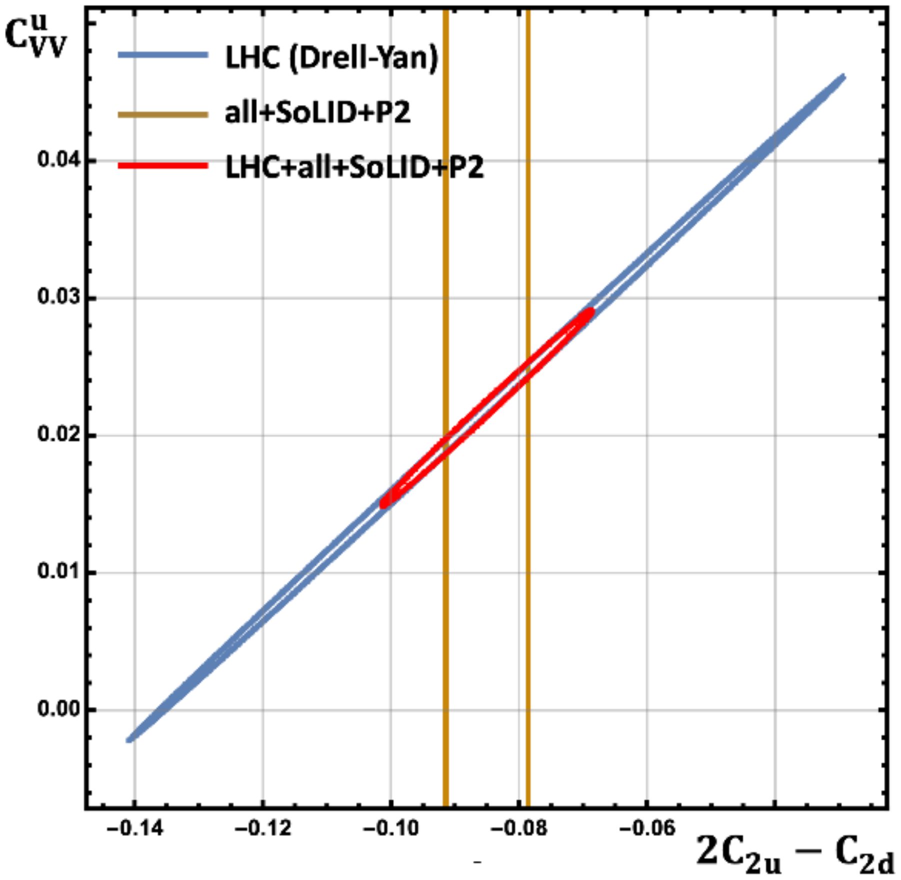


"Although these extensions could reconcile the SM with the larger W-boson mass, getting them to do so without causing inconsistencies with other predictions may prove nontrivial."

H .Hill, Physics Today

Should we use the ideas behind the Standard Model to exclude BMS models?

SMEFT analysis dominates BSM motivation



Mention Leptophobic Z’

- Limited parameter space
- Cannot be ruled out.

Internal Radiative Corrections:

Radiator function

Observed cross section:

Convolution of cross section $\otimes$ radiator functions

$$d\sigma^{\text{obs}}(P,q) = \int \frac{d^3k}{2k^0} \sum_n R_n(l,l',k)\, d\hat{\sigma}_n^{(0)}(P,q-k)$$

Shifted kinematics

observed momentum transfer $Q^2 = -(l-l')^2$,
➜ shifted momentum transfer $\tilde{Q}^2 = -(l-l'-k)^2$
observed Bjorken $x = Q^2/2P\cdot(l-l')$
➜ shifted Bjorken $\tilde{x} = \tilde{Q}^2/2P\cdot(l-l'-k)$
Use $Q^2 = xyS$ ➜ $\tilde{Q}^2 = \tilde{x}\tilde{y}S$

$$d\sigma^{\text{obs}}(x,Q^2) = \int_x^1 d\tilde{x} \int_0^y d\tilde{y} \sum_n R_n(x,\tilde{x};y,\tilde{y})\, d\hat{\sigma}_n^{(0)}(\tilde{x},\tilde{Q}^2)$$

$d\hat{\sigma}_n^{(0)}$ = theory prediction for cross section without radiation
(sometimes called “true” — a misnomer)

Cont.

with partial fractioning, write: $R_n(l, l', k) = \frac{J}{k \cdot l} + \frac{F}{k \cdot l'} + \frac{C}{\tilde{Q}^2} + \ldots$

- initial state radiation, $k \cdot l$ small for $\sphericalangle(e_{\text{in}}, \gamma) \to 0$
- final state radiation, $k \cdot l'$ small for $\sphericalangle(e_{\text{out}}, \gamma) \to 0$
- Compton peak, $\tilde{Q}^2$ small for $p_T(e_{\text{out}}) \simeq p_T(\gamma)$

ISR, FSR: narrow peaks, width $\simeq \sqrt{m_l/E_l}$: collinear or mass singularities

upon angular integration: large logarithm $\propto \frac{\alpha}{\pi} \log \frac{Q^2}{m_e^2} \simeq 10\,\%$

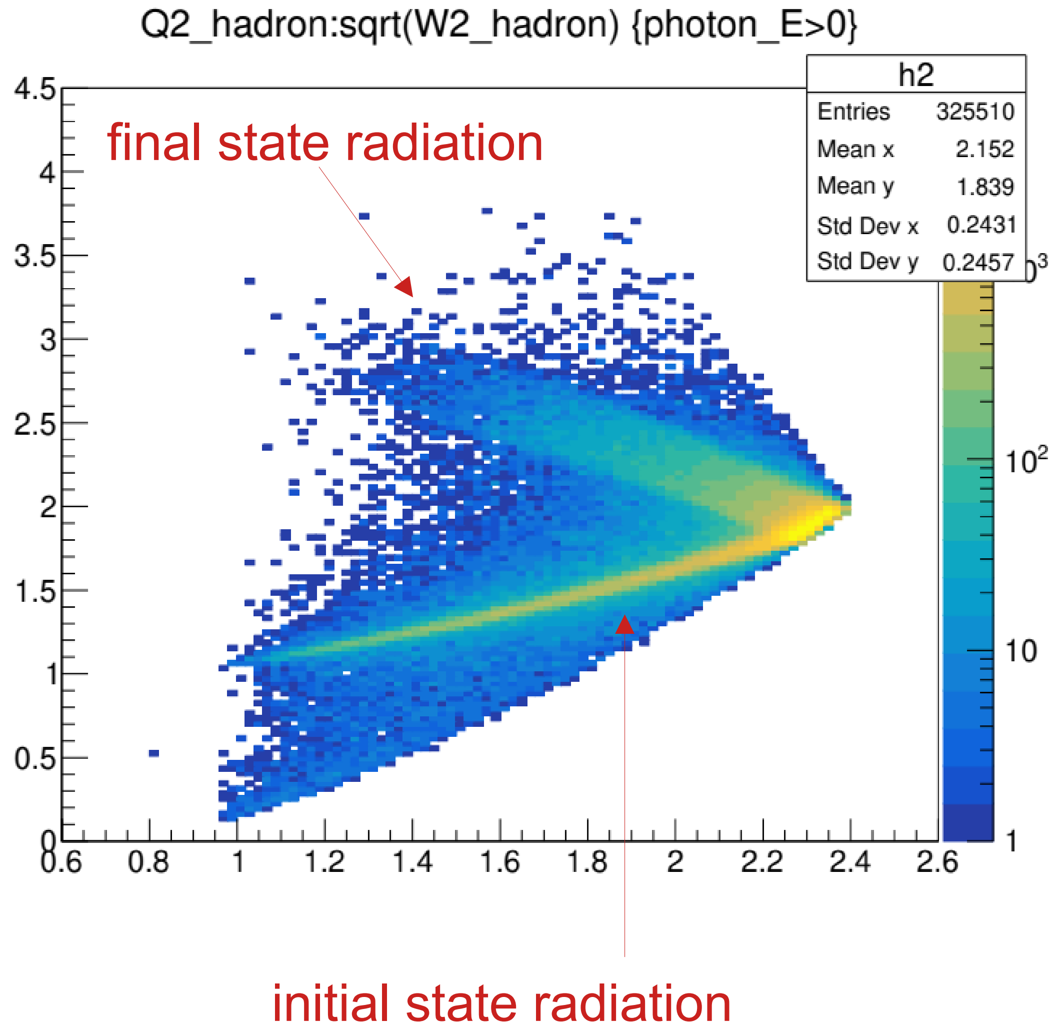
Note: additional large logarithms from experimental cuts $\propto \log \frac{\Delta E}{E_{max}}$

For high precision: have to keep non-logarithmic terms

Example of Rn

Q2_vertex vs. W_vertex for 6 GeV that includes only internal radiations (Djangoh simulation)

Peaking approximation looks OK for evaluation of errors due to cross sections and asymmetries



Plan for Radiative Corrections

- External
  - Cross section and A errors dominate: experimental
- Internal
  - Cross section and A errors dominate: experimental
- Loops
  - Integrals go to low Q^2 corrections: need work; probably OK
  - Effects of diagrams with different quarks: difficult, but effect is probably small
- Higher order
  - Can be done by theorists with some effort

Theory Errors (Hobbs)

Many corrections
Theorists are aware of them
Do not expect them to dominate
Do not belong in experimental budget

iii achieving highest (PDF) impact of PVDIS: mastery of small Q

TJH and Melnitchouk, PRD77, 114023 (2008)

→ γ-Z interference accesses unique flavor currents in nucleon

$$A^{PV} = -\left(\frac{G_F Q^2}{4\sqrt{2}\pi\alpha}\right)\left[g_A^e\, Y_1\, \frac{F_1^{\gamma Z}}{F_1^{\gamma}} + \frac{g_V^e}{2}\, Y_3\, \frac{F_3^{\gamma Z}}{F_1^{\gamma}}\right]$$

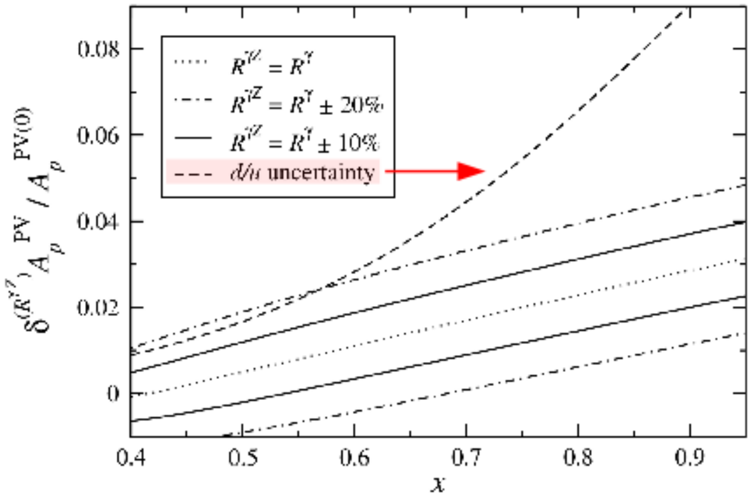
A^{PV} potentially subject to finite-Q^2 corrections

$$Y_1 = \frac{1 + (1-y)^2 - y^2(1 - r^2/(1+R^{\gamma Z})) - xyM/E}{1 + (1-y)^2 - y^2(1 - r^2/(1+R^{\gamma})) - xyM/E}\left(\frac{1+R^{\gamma Z}}{1+R^{\gamma}}\right)$$

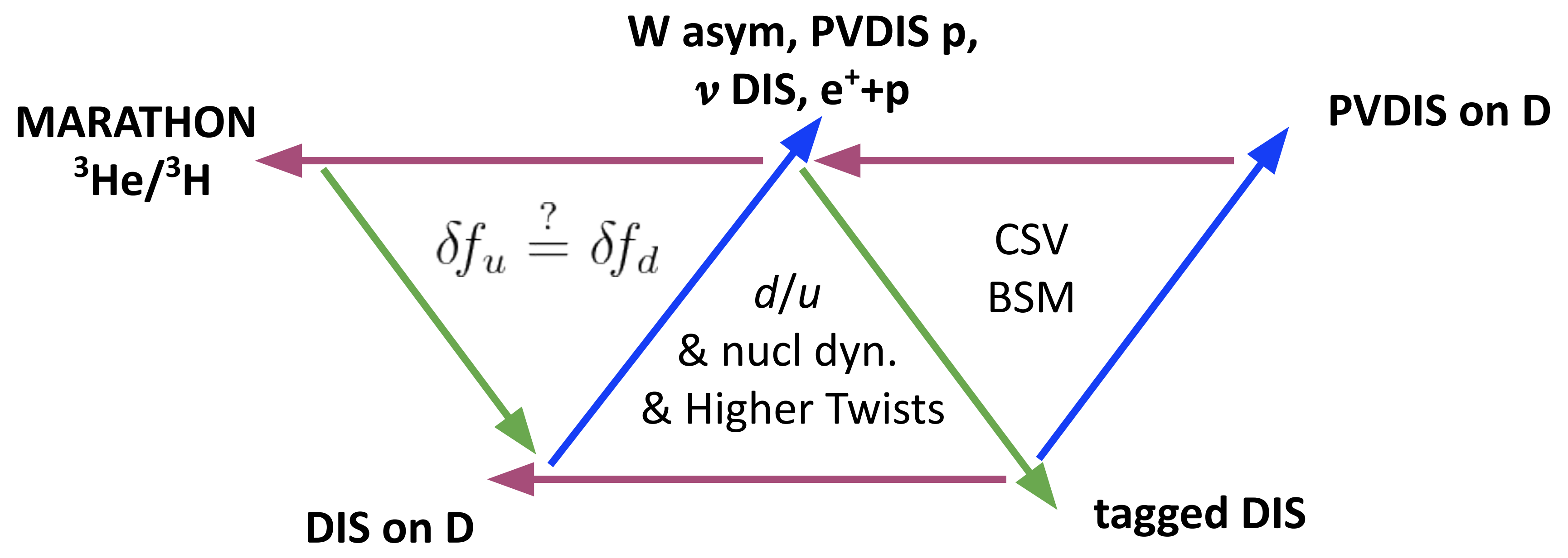
$R = \sigma_L/\sigma_T \neq 1$

(= 1, Callan-Gross)

- in principle, could complicate PDF sensitivity of PV asymmetry
- effectively, proxy for various low-Q^2 corrections which must be investigated/controlled
- substantial theory, phenomenological progress over intervening years



Motivation for d/u by Accardi (also Thia)



Consensus is that PVDIS with protons is even more important