Fundamental Symmetries, Neutrinos, Neutrons and related Nuclear Astrophysics
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Parity Violating Electron Scattering (PVES)

The Critical Role of Nuclear Theory

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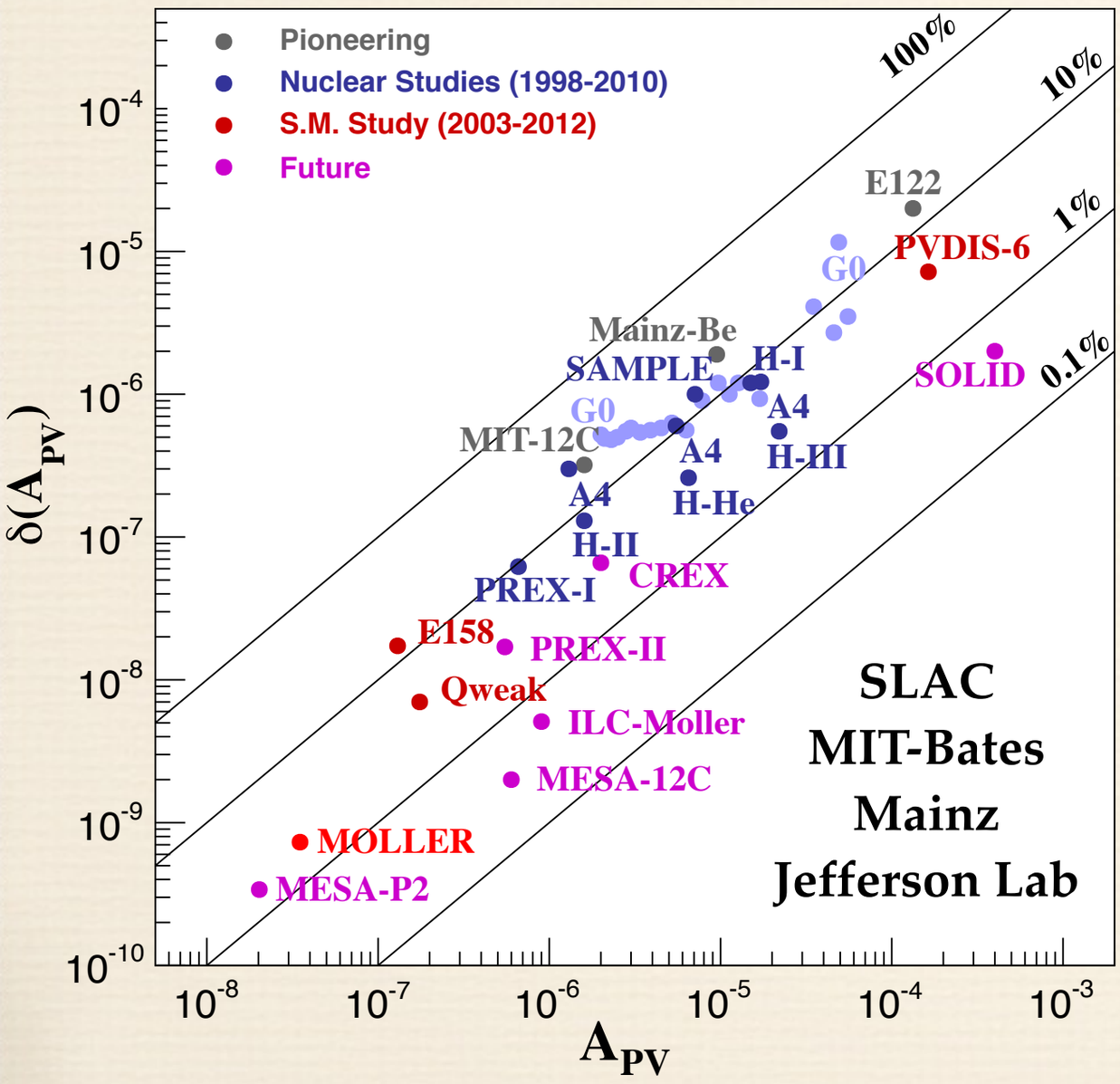
Continuous interplay between probing hadron structure and electroweak physics

4 Decades of Progress

Parity-violating electron scattering has become a precision tool

PVeS Experiment Summary



Physics Topics

- *Strange Quark Form Factors*
- *Neutron skin of a heavy nucleus*
- *Indirect Searches for New Interactions*
- *Novel Probes of Nucleon Structure*
- *Electroweak Structure Functions at the EIC*
- *Charge Lepton Flavor Violation at the EIC*

Every one of the topics above has needed (will need) nuclear theory at the beginning, during and the precision interpretation phases of the experimental program

Theory Input: Past 25 Years

- **Strange Quark Form Factors**
  - ★ Offshoot of the original spin crisis: fundamental nucleon structure physics
  - ★ Critical input to interpret low energy standard model tests
- **Electroweak Radiative Corrections**
  - ★ Theory error in weak mixing angle running
  - ★ Electroweak box diagrams
- **Beyond Standard Model Scenarios**
  - ★ R-Parity-conserving and -violating SUSY models
  - ★ MeV-Scale Dark Z Bosons
  - ★ Charged Lepton Flavor Violation at an EIC
  - ★ Leptophobic Z' in PVDIS
- **Nucleon Structure**
  - ★ Higher Twist Effects in in PVDIS
- **Nuclear Structure**
  - ★ Neutron skin (distorted wave calculations)
  - ★ Vector Analyzing Powers on nuclei

Future: Critical Theory Needs

- **Next generation initiatives: BSM discovery experiments**
  - ★ Dominant 2-loop effects in elastic scattering
  - ★ EMC dynamics in Deuterium PVDIS
  - ★ Compressed Weak Scale Scenarios
  - ★ Model-independent comparisons with LHC
  - ★ Further exploration of "dark Z" scenarios
  - ★ cross-check weak mixing angle running (lattice could help here)
- **Nucleon and Nuclear Structure**
  - ★ Nuclear EMC: what can PVDIS contribute? Resolve NuTeV?
  - ★ Electroweak Structure Functions (towards an EIC)
  - ★ Vector analyzing powers in a range of nuclei
  - ★ Reduction in box diagram uncertainties with new PV data input
- **New developments; response to discoveries**
  - ★ ...