Parity Violation Experiments at SIN
(as viewed by a graduate student)

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Parity violation in nucleon-nucleon interaction

Electro-weak part of nucleon-nucleon interaction

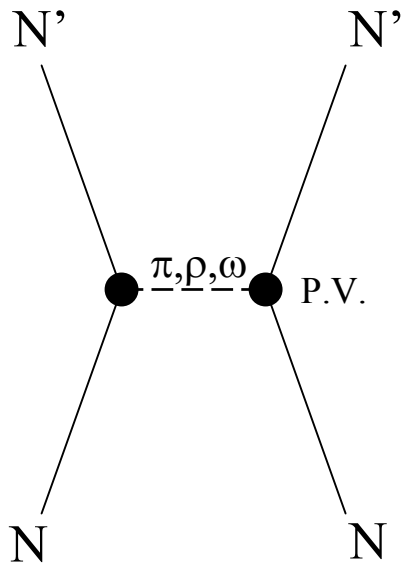
In one-boson exchange model:

Weak meson-nucleon coupling constants determined by standard model

Calculable due to short range of W,Z interaction

Desplanques, Donoghue and Holstein give "best value" and "range" for π,ρ,ω coupling constants:

$$f_\pi, h_\rho^0, h_\omega^0, h_\rho^1, h_\omega^1, h_\rho^2$$



Parity Violating Nucleon-Nucleon Potential

Parity violation in nuclear scattering at ~ 45 MeV

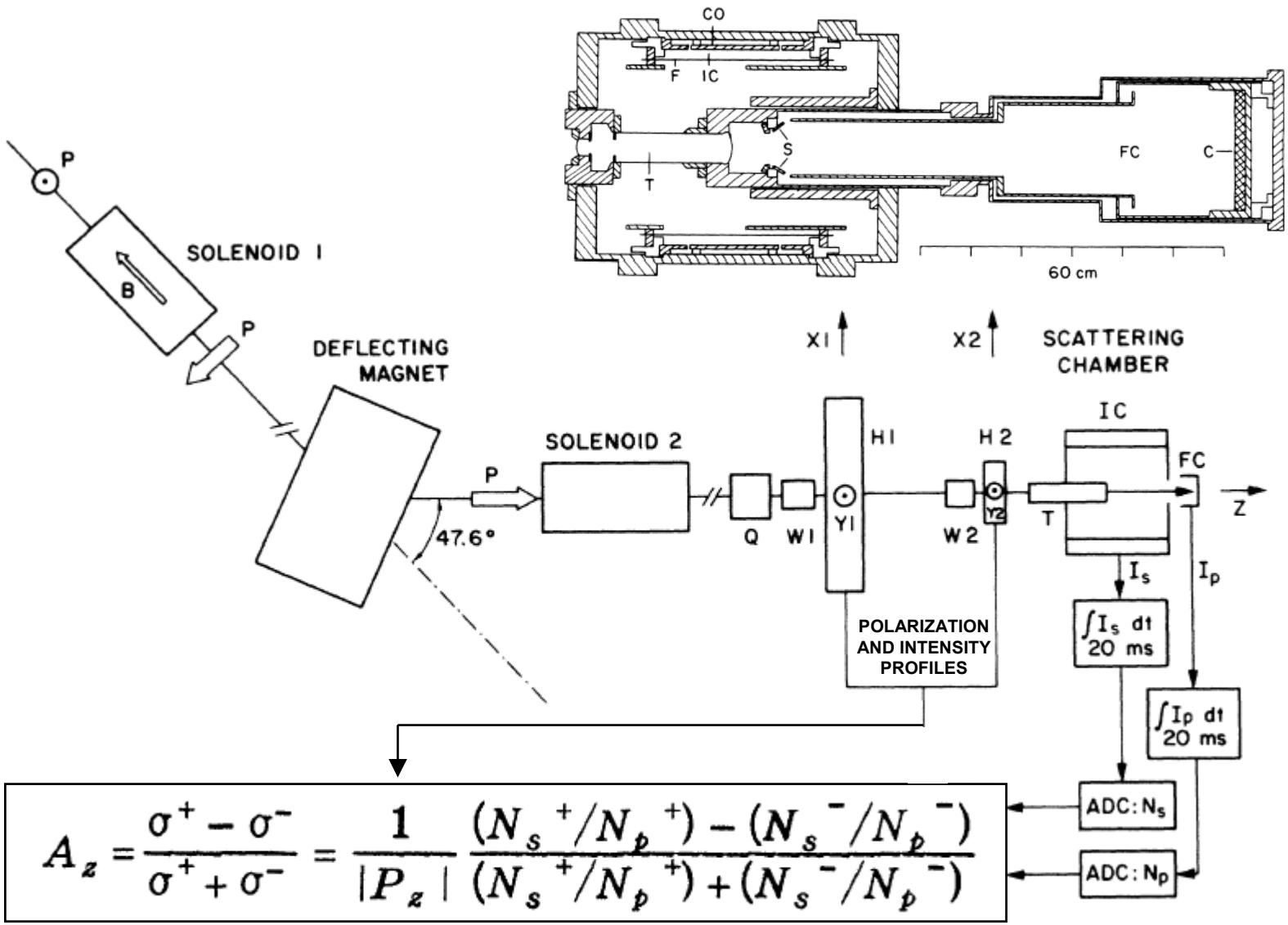
$$A_z = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

- Nuclear scattering of simple systems with less nuclear structure uncertainty
- Elastic pp scattering: $A_z = (-1.50 \pm 0.22) \times 10^{-7}$
  - $A_z = .074h_\rho^0 + .065h_\omega^0 + .074h_\rho^1 + .065h_\omega^1 + .030h_\rho^2$
- Elastic pα scattering: $A_z = (-3.34 \pm 0.93) \times 10^{-7}$
  - $A_z = -.34 f_\pi + .140h_\rho^0 + .059h_\omega^0 + .047h_\rho^1 + .059h_\omega^1$
- pd scattering (including part of break-up): $A_z = (+0.4 \pm 0.7) \times 10^{-7}$

Parity violation in low energy scattering experiment

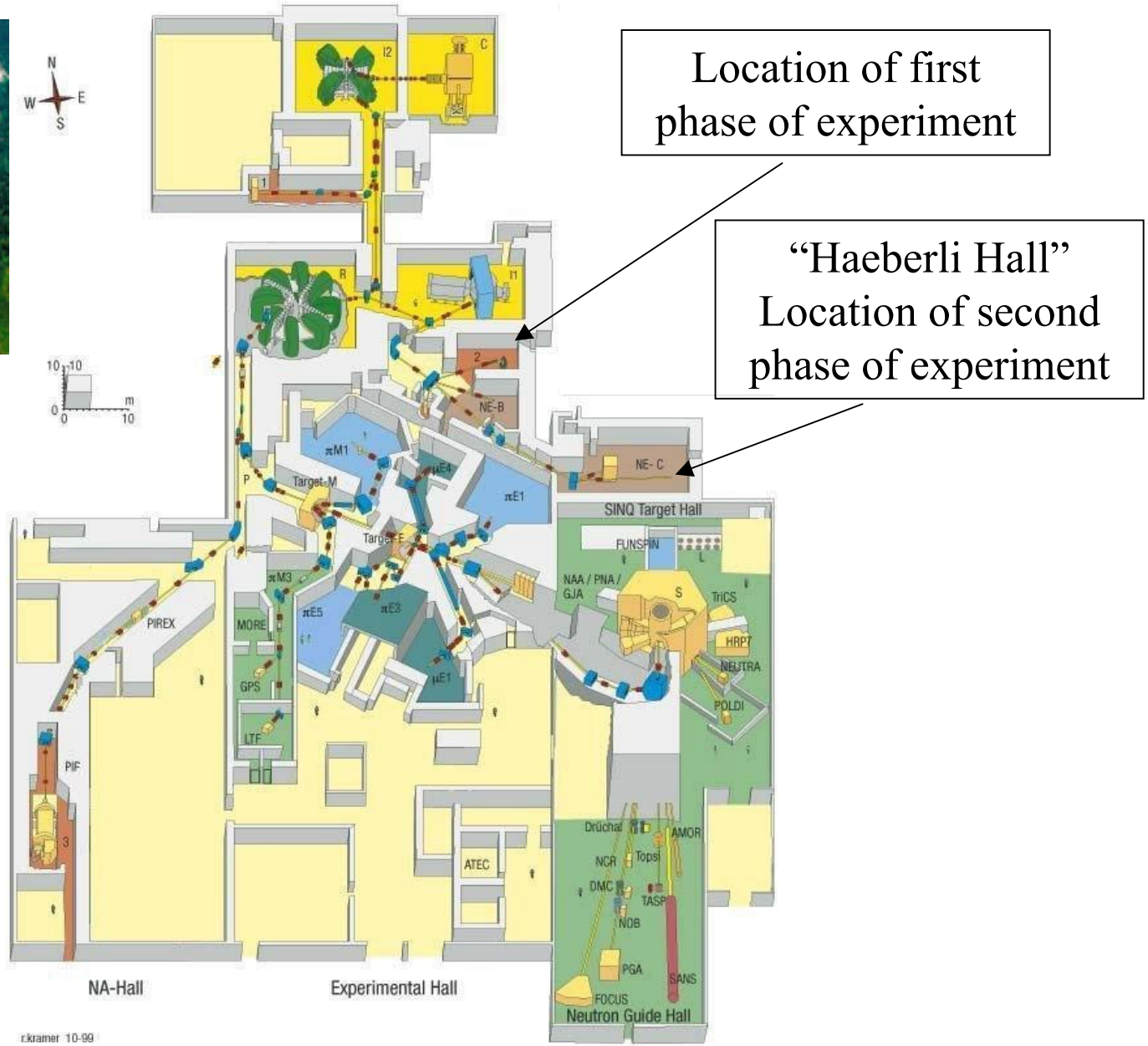
- To reach precision of better than 10^{-7}:
  - Need about 10^{16} events, which is too many for counting individual events $\rightarrow$ integrating detectors
  - At low energy detection of scattered particles is preferred over transmission because the required thick target affects the beam too much
  - 100 atm circulating gas target to maximize luminosity and minimize thermal effects.
  - Scattering angle and energy cuts using target vessel walls. For pα this allowed to select only elastic scattering.

Experimental layout



$$A_z = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} = \frac{1}{|P_z|} \frac{(N_s^+/N_p^+) - (N_s^-/N_p^-)}{(N_s^+/N_p^+) + (N_s^-/N_p^-)}$$

Facilities at SIN, now PSI



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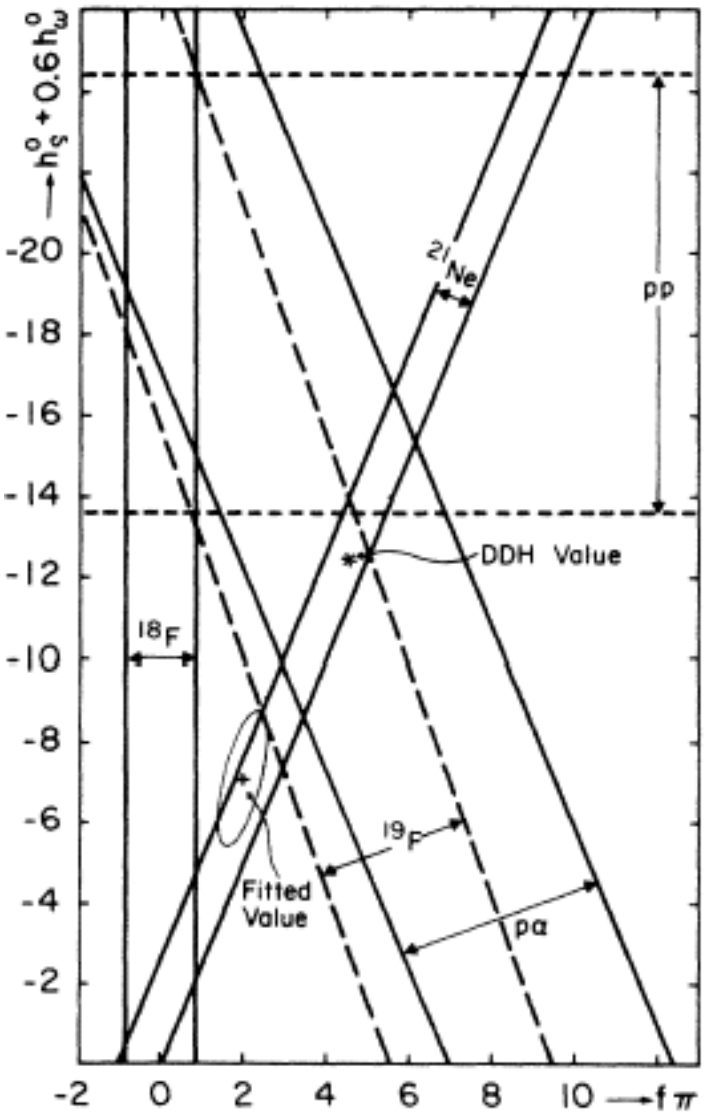
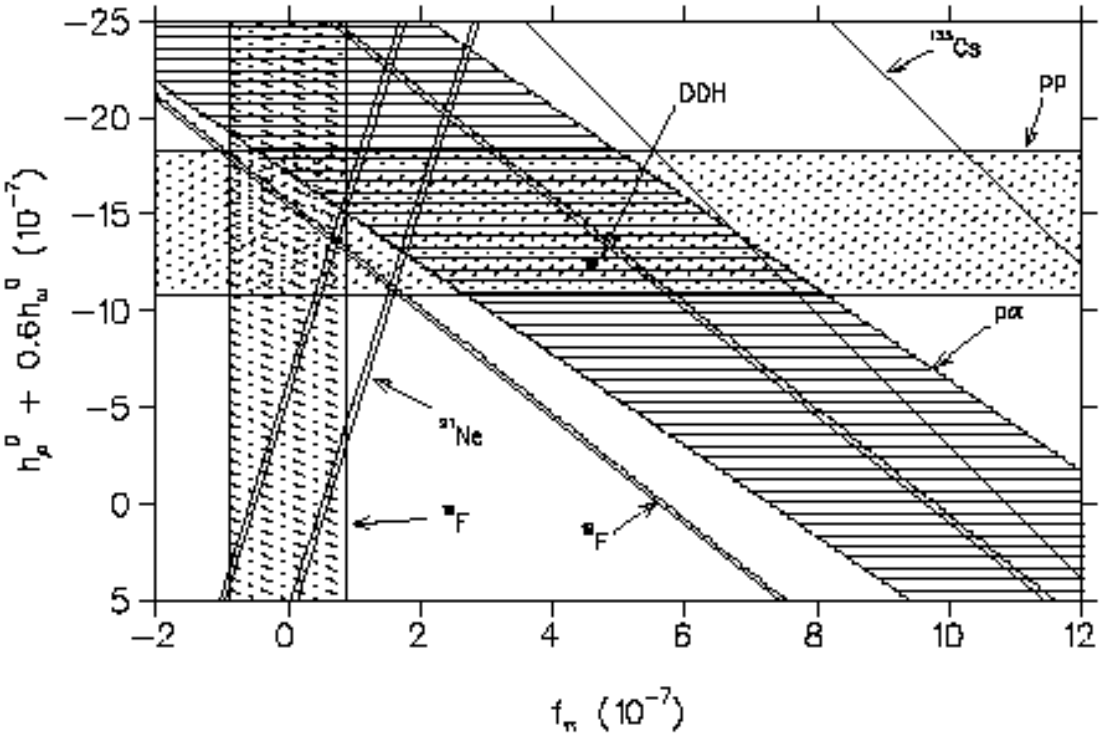
Systematic errors

- Systematic error has to be less than a few 10^{-8}
- Good training ground for future spin physicists (needs patience and care and enthusiasm for flipping the spin!)
- Basic approach:
  - Modulate every possible parameter artificially and measure resulting effect on $A_z \rightarrow$ sensitivities
  - Measure actual helicity correlated parameter modulation during experiment
  - Calculate correction/error from sensitivity and measured modulation
- Systematic error sources:
  - Intensity modulations
  - Position modulations
  - Beam width modulations
  - Transverse polarization (0^{th},1^{st},2^{nd} moment)
  - Energy modulations

"Haeberli plot": Comparison with PV γ decays





$$A_z(p\alpha) \approx -.34 f_\pi + .14(h_\rho^0 + .6h_\omega^0)$$

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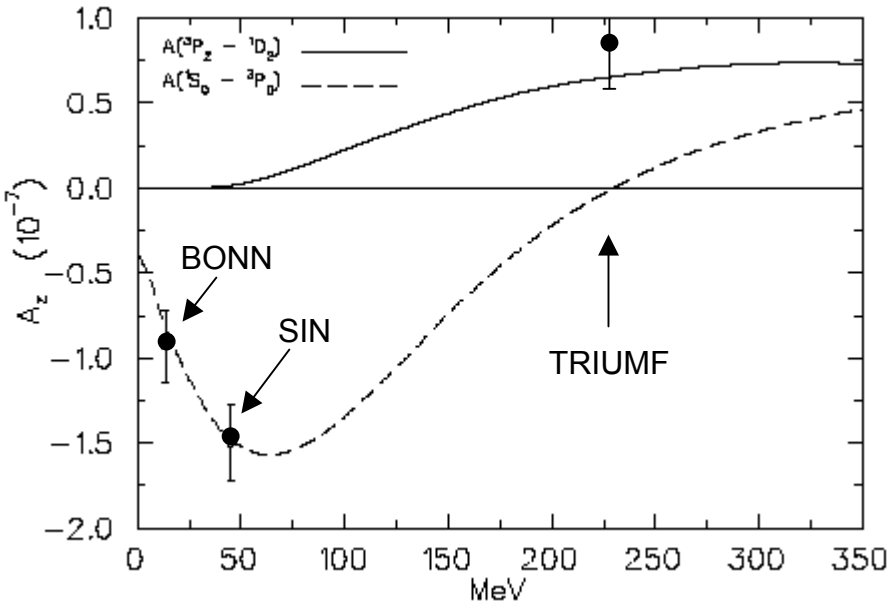
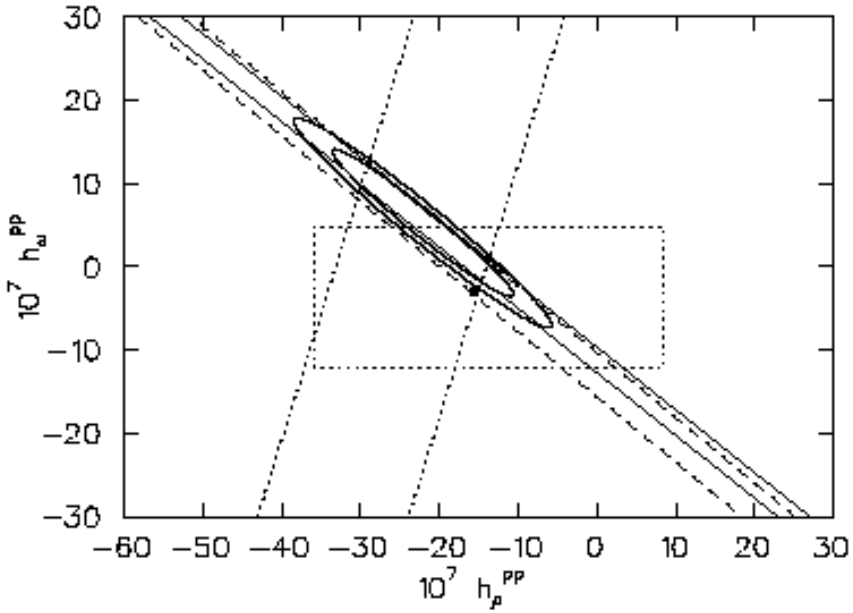
Low energy pp elastic scattering

Energy dependence of p.v. partial wave amplitudes $^1S_0 - {}^3P_0$ and $^3P_2 - {}^1D_2$ are given by strong phases
→ only two p.v. observables

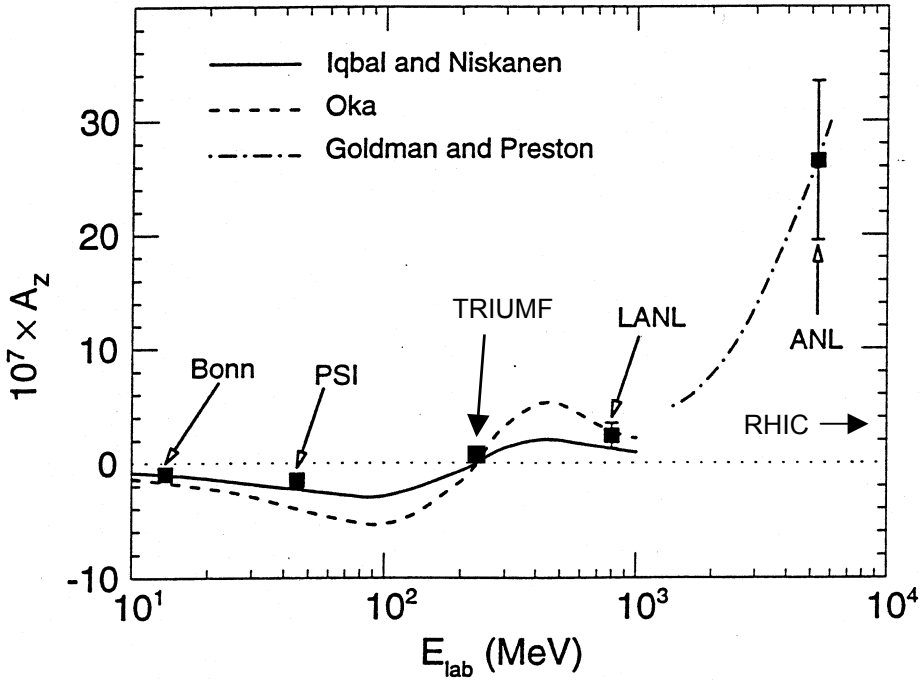




$$h_\rho^{pp} = h_\rho^0 + h_\rho^1 + h_\rho^2 \Big/ \sqrt{6}$$

$$h_\omega^{pp} = h_\omega^0 + h_\omega^1$$

Energy dependence of parity violation in pp total cross section



- ANL measurement of p-H_2O indicates fast rise of A_z
- Measurement of A_z in pp total cross section using stored polarized beam and internal target measuring helicity-dependent beam lifetime (S. Vigdor)
- Possible experiment up to 250 GeV with polarized beam at RHIC