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Title: Measurement of neutron beta decay asymmetry using ultracold neutrons

Author(s): Steven Clayton

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Form 836 (7/06)

Abstract Submitted
for the APR09 Meeting of
The American Physical Society

Sorting Category: G6. (E)

Measurement of neutron beta decay asymmetry using ultracold neutrons STEVEN CLAYTON, Los Alamos National Laboratory, UCNA COLLABORATION — An experiment to measure the neutron beta-decay angular correlation between the emitted beta particle and the neutron spin (the beta asymmetry) using ultracold neutrons (UCN) will be described. The experimental method involves loading highly polarized UCN into a material decay trap within a solenoidal beta spectrometer. The neutron polarization is systematically flipped to cancel the effect of differing efficiencies between the two ends of the spectrometer. First physics results, which represent a demonstration of the experimental method, were recently published in PRL based on data taken in 2007. In Fall 2008 a much higher statistics data set was collected and several systematics studies were performed. These are expected to give a measurement of the neutron beta asymmetry that approaches the best measurements using cold neutrons.

[X] Prefer Oral Session
[ ] Prefer Poster Session

Steven Clayton
sclayton@lanl.gov
Los Alamos National Laboratory

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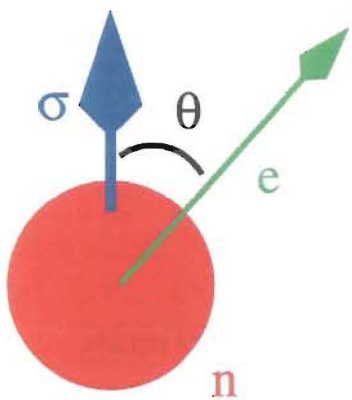
Measurement of neutron beta decay asymmetry using ultracold neutrons

Steven Clayton, LANL, for the UCNA Collaboration

2009 APS April Meeting

Constraints to Standard Model from Neutron β Decay

$$\tau_n = \left(\frac{2\pi^3\hbar^7}{m_e^5 c^4}\right)\left(\frac{1}{G_F^2 |V_{ud}|^2}\right)\left[\frac{1}{1+3\lambda^2}\right]\frac{1}{f(1+\Delta_R)}$$



$$dW = \left[1 + \beta P A \cos\theta\right] d\Gamma(E)$$

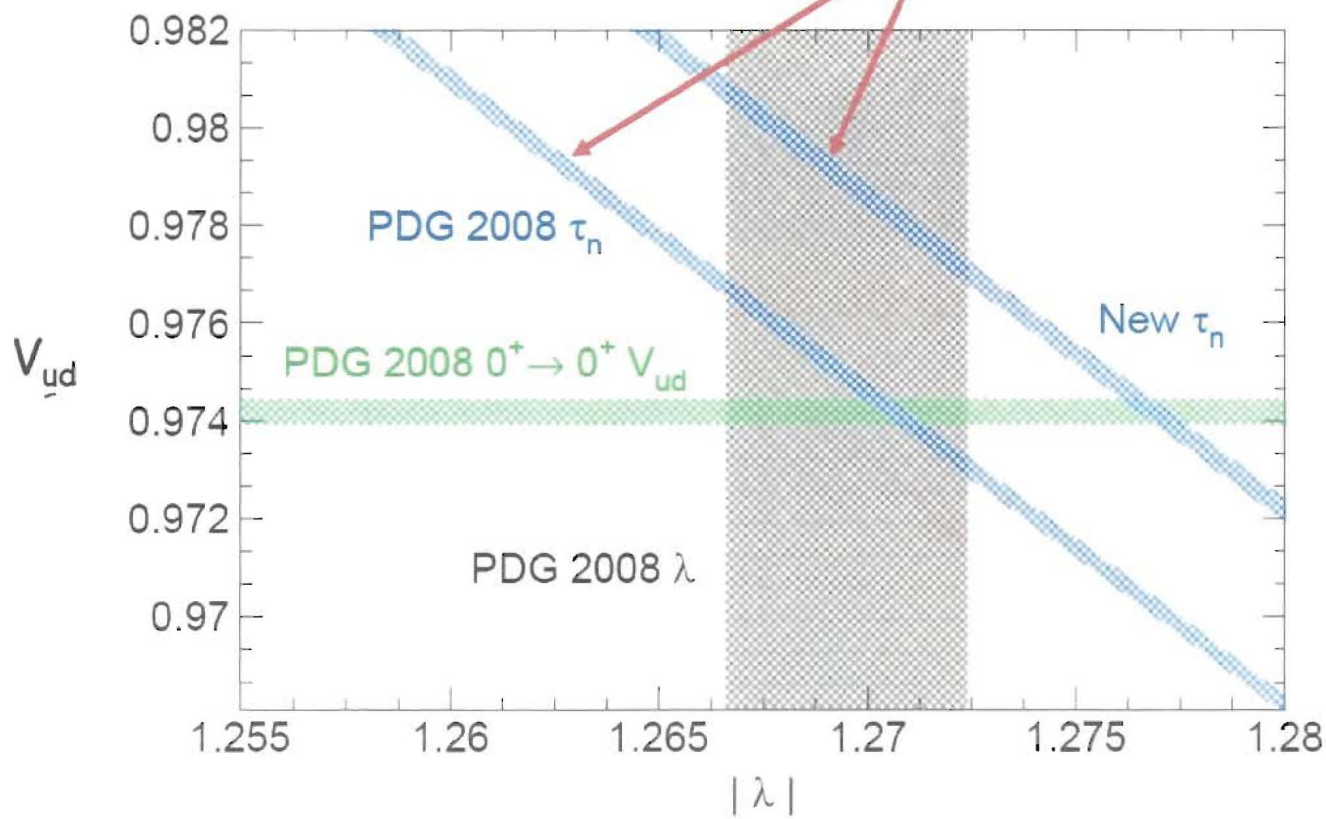
λ can be measured from parity violating asymmetry ("β asymmetry ") in n decay

$$A = \frac{-2\lambda(1+\lambda)}{1+3\lambda^2}$$

Slide courtesy J. Liu

Status of λ: Big Picture

$$\tau^{-1} \propto V_{ud}^2 (1 + 3\lambda^2)$$



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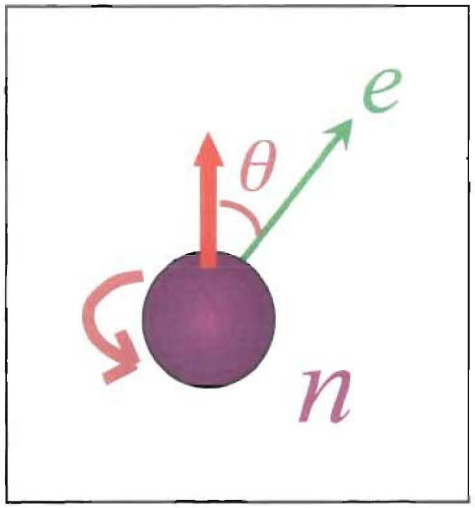
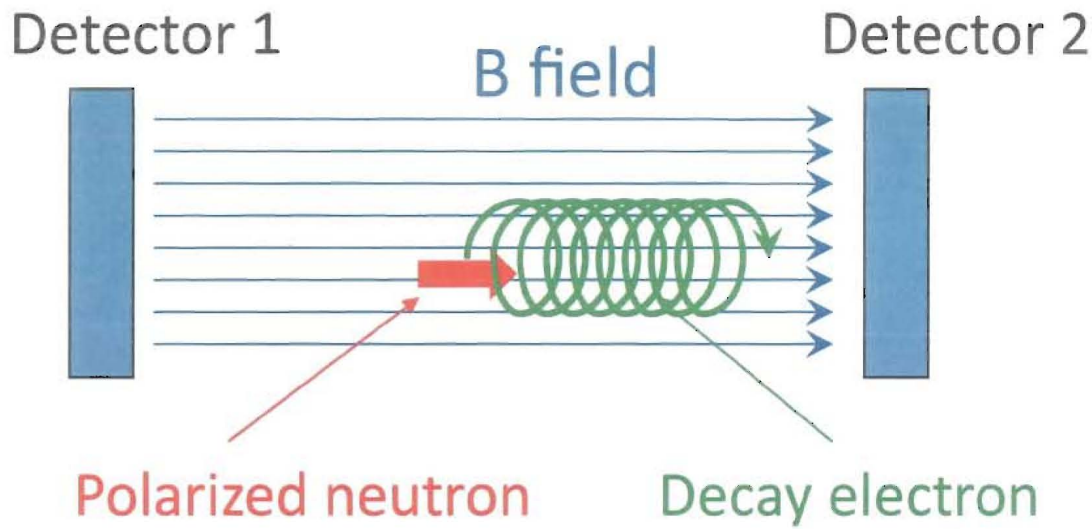
Principle of the *A*-coefficient Measurement





$$dW=[1+\beta PA\cos\theta]d\Gamma(E)$$

$$A_{\exp}(E)=\frac{N_1(E)-N_2(E)}{N_1(E)+N_2(E)}\approx\langle P\rangle A\beta\langle\cos\theta\rangle$$

(End point energy = 782 keV)

Potential sources of systematics

Neutron polarization determination

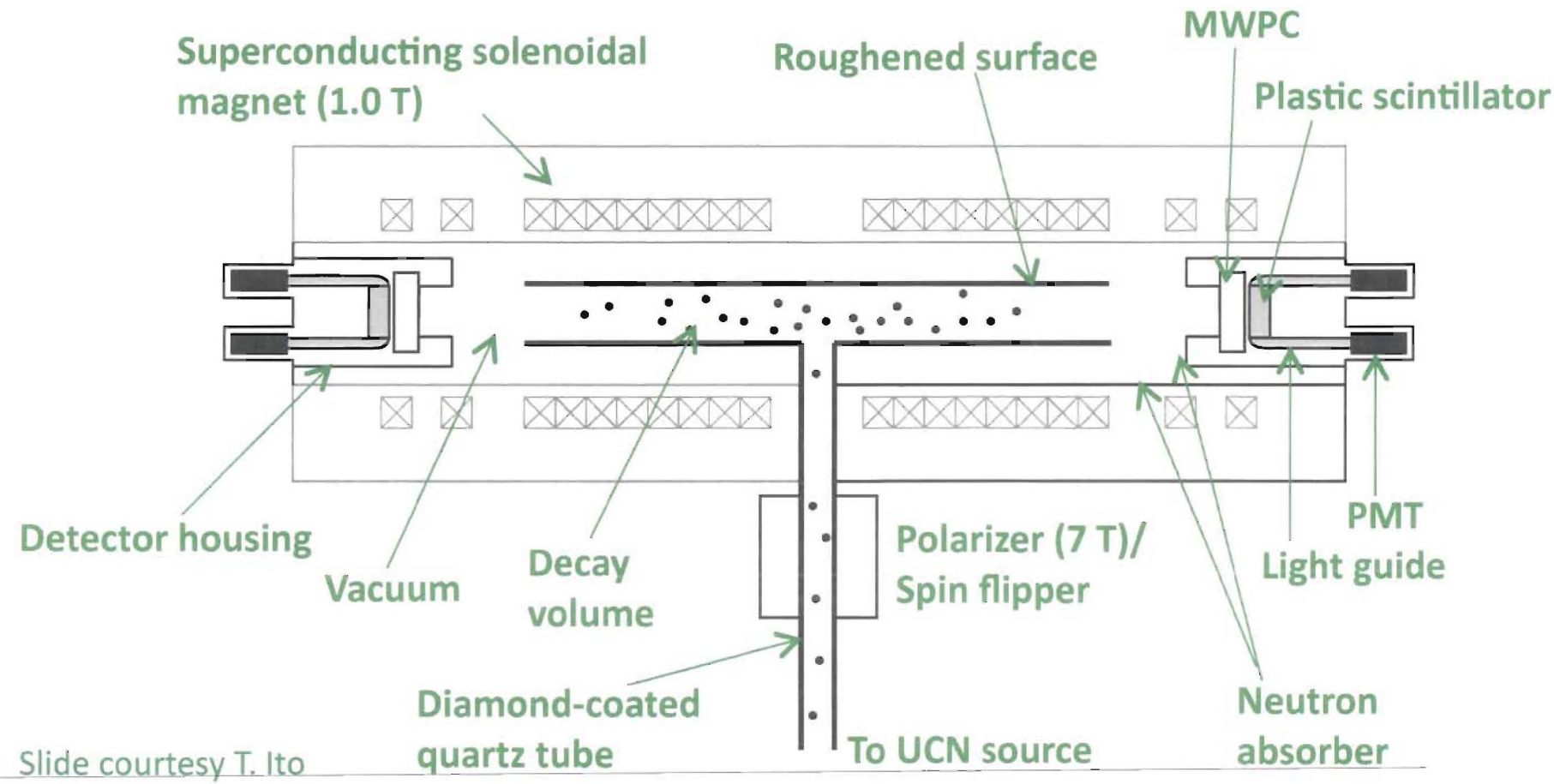
Background

Detector related effects (eg backscattering)

Slide courtesy T. Ito

UCNA Experiment

- First β correlation measurement using UCN
  - >99% polarization using a 7 T magnetic field
  - Background suppression by the use of a pulsed UCN source
- Ultimate goal: 0.2% measurement of A ($\delta A/A$ = 0.2%)



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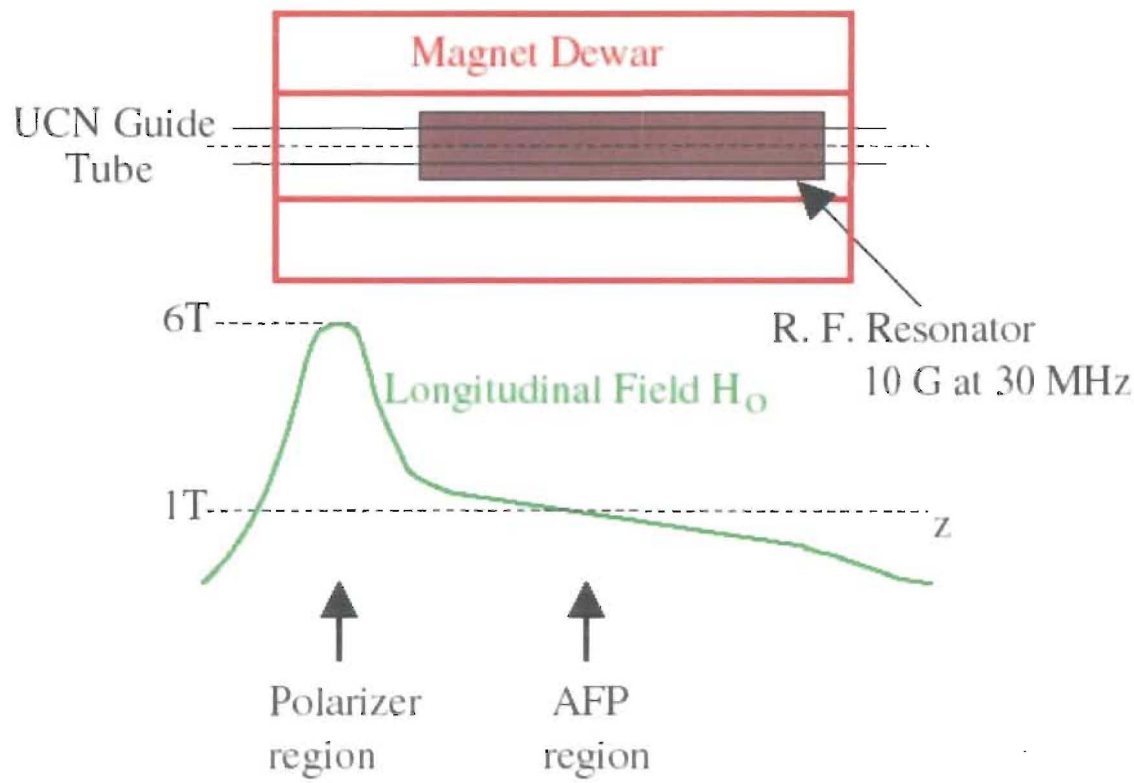
Advantages of using ultracold neutrons

- Polarization
  - Nearly 100% polarization possible due to interaction of UCN spin with several-tesla B-field.

- Backgrounds
  - UCN can be transported within curved, material guides away from source.

Polarizer and spin flipper magnet

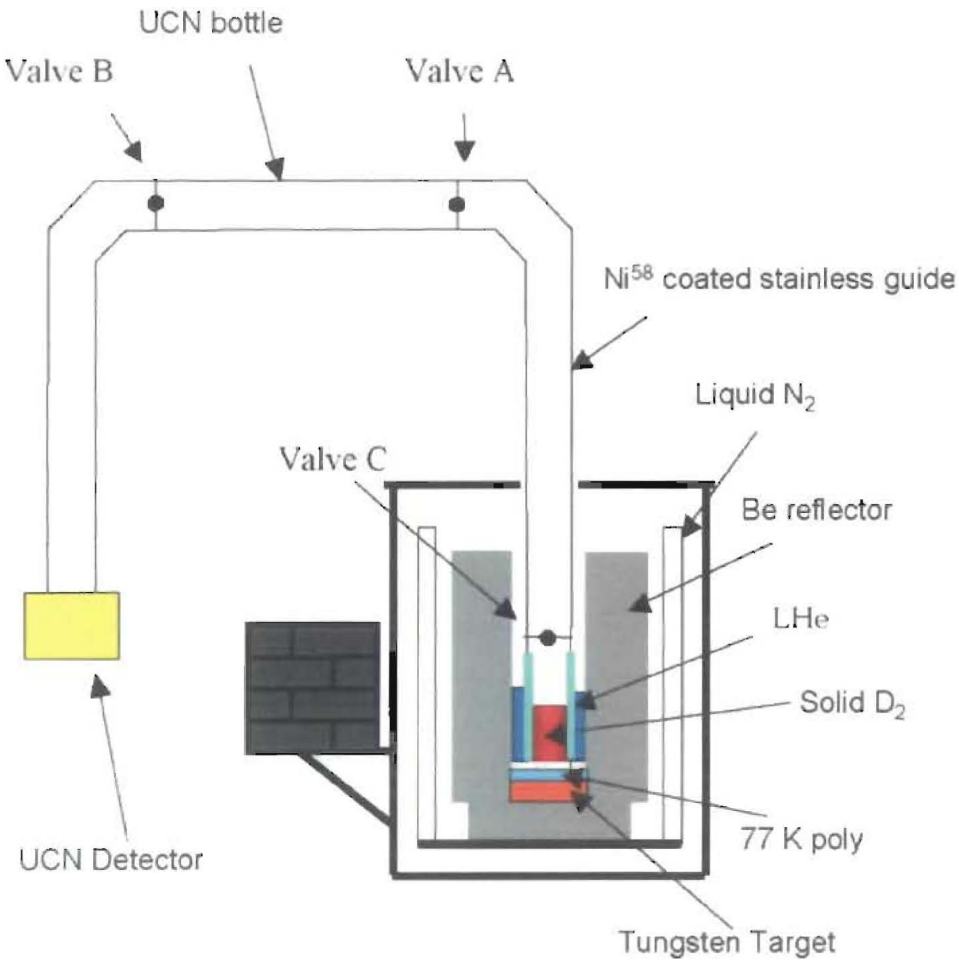
- Polarization



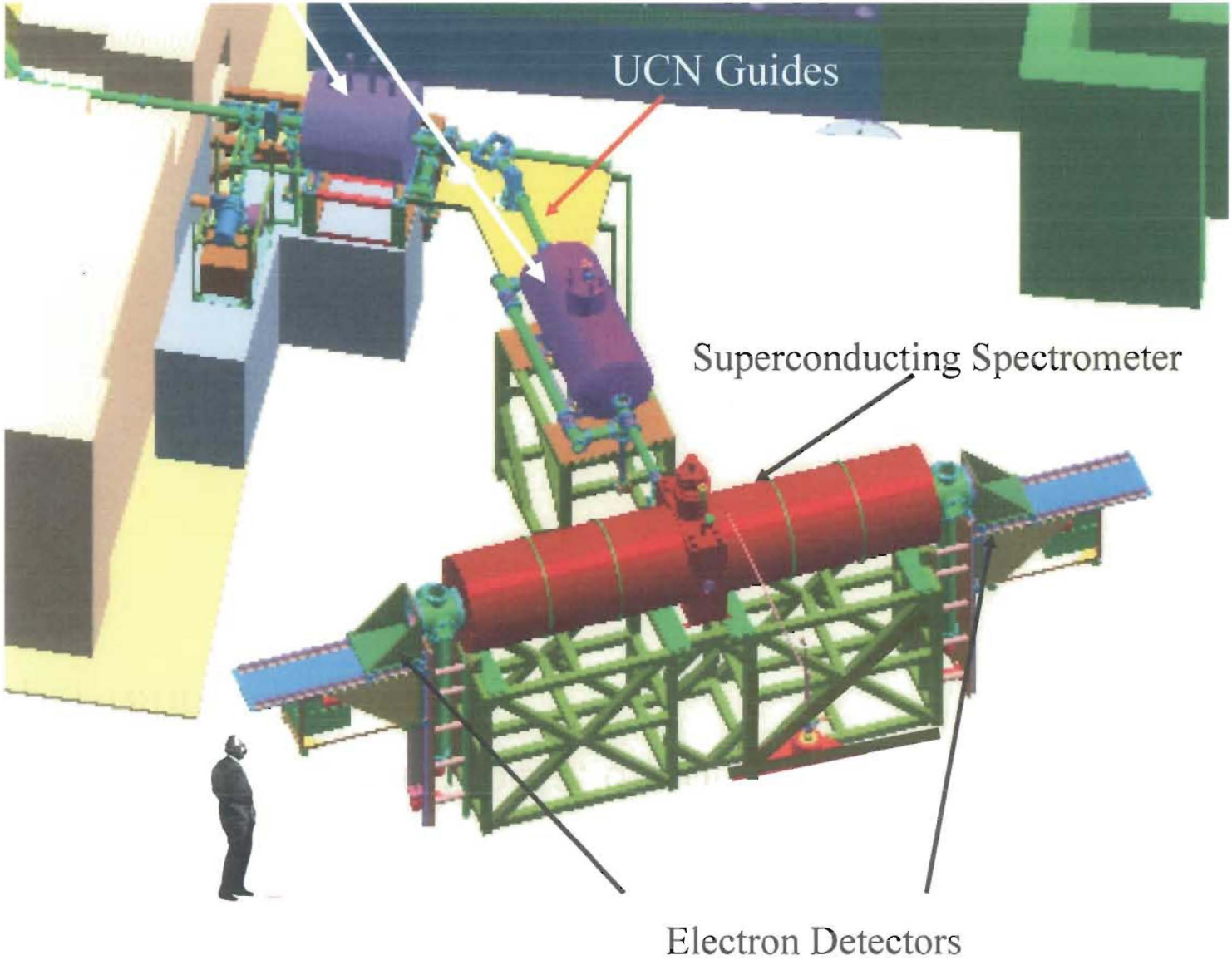
UCNA Technical Review Report, 2000

UCN source at LANL

A. Saunders et al. / Physics Letters B 593 (2004) 55–60



Experiment Layout



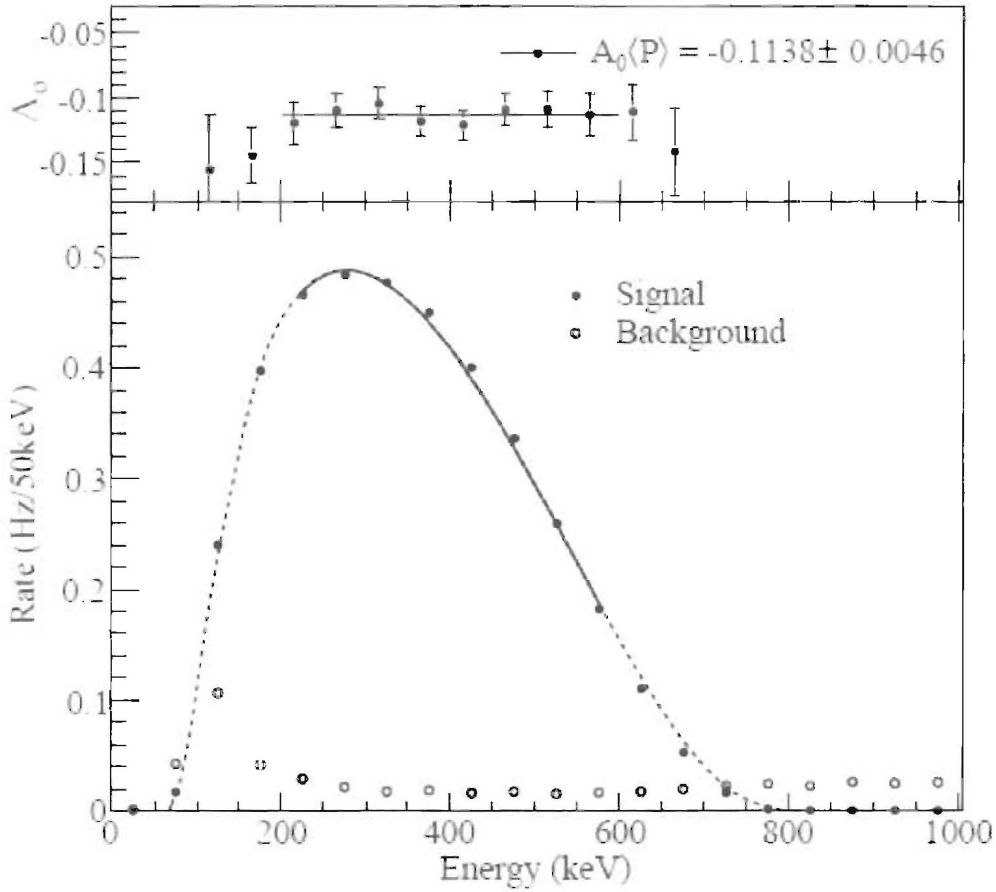
Data collection

- Sequence: background, beta, depol.
- Super-ratio

Systematic corrections/uncertainties

- Fractional systematic correction to A0, 2007 data:
  - Polarization: ± 0.013
  - UCN-Induced Backgrounds: ± 0.002
  - Electron Detector Effects
    - Response/Linearity: ± 0.015
    - Gain Drifts: ± 0.002
  - Electron Trajectories
    - Angle Effects: -0.016 ± 0.005
    - Backscattering: 0.011 ± 0.004
  - Total $\delta A_0/A_0 = 0.005 \pm 0.018$
  - Statistical uncertainty: 0.040

2007 Results



PRL102, 012301 (2009)

- ~50 hours data taking (after commissioning)
- Total number of β decay: 0.8 M
- Signal/Background (200, 600) keV ~ 20

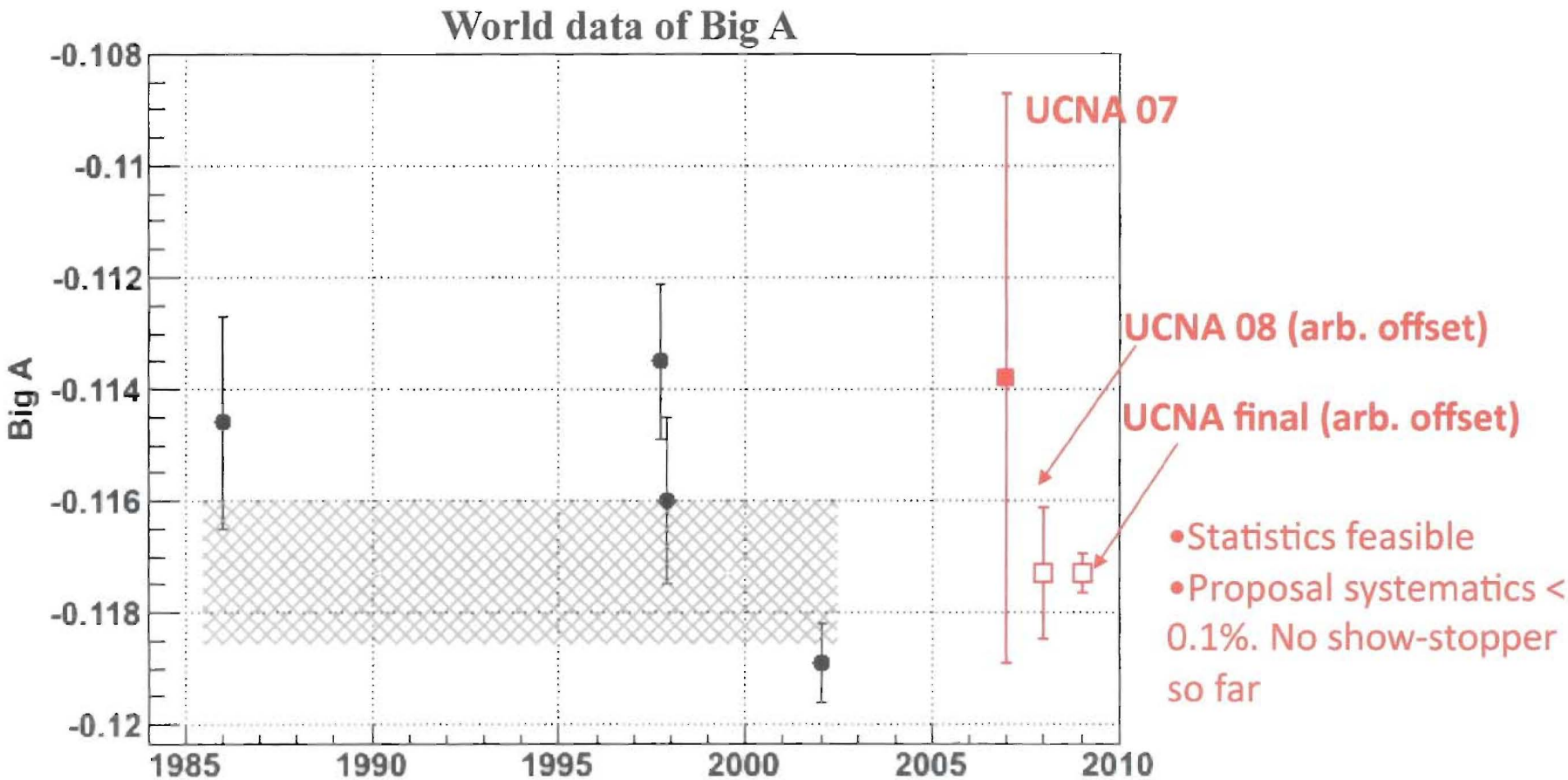
Slide courtesy J. Liu

Major Improvements in 2008

- Higher beam current x2
- Better UCN transport x1.25
- More calibration sources: ^{113}Sn (368), ^{207}Bi(481,975), ^{114}In(186), ^{109}Cd (63, 83, 87), ^{139}Ce(132)
- Better statistics x(12-30) more βs
- Much better statistics and systematic studies on UCN polarization
- Three different geometries to allow calibration of the Monte Carlo

Slide courtesy J. Liu

Projection of Final UCNA Uncertainty



- Statistics feasible
- Proposal systematics < 0.1%. No show-stopper so far

Slide courtesy J. Liu