Title: The UCNB experiment: progress toward the measurement of electron-proton coincidences from the beta decay of polarized, ultracold neutrons

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Intended for: American Physical Society April Meeting, 2013-04-13 (Denver, Colorado, United States)

Issued: 2013-04-27 (Rev.2)
The UCNB experiment: progress toward the measurement of electron-proton coincidences from the beta decay of polarized, ultracold neutrons

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April 14, 2013
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LA-UR-13-22650
Experimental observable and sensitivity to new physics

"\( \overline{B} \)" and "\( \overline{b} \)" are sensitive to scalar and tensor currents in a way that is complementary to the LHC.

\[
\frac{d\Gamma}{dE_e d\Omega_e d\Omega_{\nu}} \propto w(E_e) D(p_e, \overline{p}_\nu, \overline{\sigma}_n)
\]

\[
D(p_e, \overline{p}_\nu, \overline{\sigma}_n) = 1 + \frac{m_e}{E_e} \overline{b} + \frac{\overline{p}_e \cdot \overline{p}_\nu}{E_e E_\nu} + \frac{\overline{\sigma}_n \cdot \overline{p}_e}{E_e} A(E_e) + \frac{\overline{\sigma}_n \cdot \overline{p}_\nu}{E_\nu} B(E_e) + \cdots
\]

Experimental method

Large 1 T magnet

Ultracold neutrons are stored inside a decay volume in a large solenoid magnet. Silicon detectors with at -30 kV relative to the decay trap accelerate the protons for detection. Coincidences between protons and electrons allow an inference of the antineutrino's momentum.

GOAL: dB/B=0.001 measurement, understand how to achieve 0.0001
Experimental requirements

%% Position sensitivity to identify electron-proton coincidences
   >> Use silicon detectors with 128 pixels in 11.5 cm active diameter
   >> Delayed electron-proton coincidence virtually eliminates backgrounds

%% Low noise threshold and good resolution for proton detection
   >> Place first stage of amplification at detector and cool with LN2

%% Fast timing to identify backscattered electrons
   >> Digitize fast amplifier output using a 12-bit FADC

%% Do all of this with detector and electronics floated to -30 kV in the magnetic field
Silicon detectors

11.5 cm active diameter, 2 mm thick to stop 800 keV betas, 128 pixels, Al mesh on p-type implant side for fast response, made by MICRON
Fast timing with low noise threshold

Fast amplifier output digitized

Waveform for ~26 keV pulse

8 channel, 12 bit, 250 MHz FADC
Resolution with fast output

Fast output shaped digitally through a four pole Butterworth filter.

Noise threshold below 15 kV, fast timing information kept, good resolution on x rays
High voltage test setup

High voltage is linked to computer via fiber optics

Test setup

Note voltage breaks for LN2 cooling lines, low-pass filter and Faraday Cage
Spectrum with high voltage test setup

The conversion electrons change energy but the x rays do not.
Detector mount for experiment

Re-entrant flange positions detector in flat-field region of magnet

Detector is shielded from high fields by its floated Faraday cage.
Signals through voltage break

The signals pass through the voltage break in a pipe that serves as a high voltage Faraday cage.
Biased data in magnet at full field

Magnet at 1 Tesla central
(0.6 Tesla at detector)

Conversion electron from 207Bi – CE K @ 976 keV
Status and outlook

## Apparatus has been biased in the magnetic field to -36 kV

## The detector and electronics have taken source data successfully in the full magnetic field to -21 kV

## Currently resolving higher noise levels with new setup in the magnet

## Expect to take beta decay data starting in August!
UCNB collaboration

::: We are building on all the hard work that has gone into UCNA over the years. (See e.g. Plaster et al, Phys Rev C 86, 055501 (2012))

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