Magnetic and Electric Fields

- Magnetic field expansion: $\vec{p}_e$ more normal to detector
- Magnetic field gradient reflects backscattered electrons
- Electric field accelerates protons
Field Strength

- Driven by particle orbit radii at detector
- Pixel size is 0.6 mm (side of hexagon)
- Optimal is 4 T for 4:1 field expansion
- Reducing field requires reducing expansion ratio (increasing backscatter) or fiducial volume
Homogeneity in Decay Region

- Correction to $A$ from electron reflections
  
  $$1 + \frac{1dB}{6B}$$

- 10% homogeneity gives $1.7 \times 10^{-3}$ correction

- Compare to $1 \times 10^{-3}$ statistical goal

- Assumes 20% accuracy in calculating correction
Length of Flight Region

- Set by need to reconstruct backscattering events
- Must resolve timing of hits in opposing detectors
Detector Timing Resolution

$E_1 = 742$ keV  $E_2 = 10$ keV

$t_2 - t_1 = 50.2$ ns

$t_2 - t_1 = -13.1$ ns

- Timing information needed for $e^-$ backscatter events
- Worst-case events have low $E$ in one detector
- Must achieve timing resolution $\sim 20$ ns for 10 keV
- Figure-of-merit $E \cdot \Delta t \sim 200$ keV$\cdot$ns
Electron Timing Difference

1 m detector separation
Timing Difference vs. Timing Resolution

1 m detector separation, 1 ns rise-time, 1 keV resolution
Bore Diameter

- Set by detector diameter of 16.4 cm
- 25 cm at detectors optimal
Ceramic Carrier Design

Front and Rear View with Detector

Pin to be inserted here to take the rear contact signal from rear to front.

Pin to be inserted here to take the rear contact signal from rear to front.

Ceramic Outline

Key

- Detector
- Ground Tracks
- Ceramic Rear Tracking
- Peak Ring

Material - 1mm thick Ceramic and 0.5mm Thick Peak ring
Plating - Palladium Silver tracks with Soft Gold Pads
Solder Resist Front - N/A
Solder Resist Rear - N/A
Material Thickness ± 0.1mm
Ledge - N/A

Scale: 0.5:1

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Field Transition In/Out of Magnet

- Neutron depolarization $1.5 \times 10^{-3}$ required
- Compare to $1 \times 10^{-3}$ statistical goal
- Assumes 20% accuracy in calculating correction
- Requires transport field
  - Details in later talk
Adiabaticity Parameter

- Neutrons depolarize when field changes faster than Larmor precession
- Adiabaticity parameter (Bowman and Penttilä)
  \[ \lambda = \frac{\mu B^2}{2\hbar \frac{dB}{dz} v} \]
- \( \sim 500 \text{ G} \) sufficient
Monte Carlo Calculations

- Field maps from R. Alarcon
- Calculate rotation of neutron spin wave function
- Calculate spin projections on Cartesian axes
- Choose step size: halving step changes rotation $< 10^{-5}$
- Transport neutrons from $z = -100$ cm to $z = 0$
- Choose trajectories with $r_i \leq 1$ cm and $r_f \leq 1$
- 100 neutrons per point
Magnetic Field – No Guide Field
Magnetic Field – 1 kG Guide Field
Neutron Depolarization – Long. Guide Field

- Guide field solenoid $-20 < z < -12$ cm
Magnetic Field – 1 kG Guide Field (off axis)
Neutron Depolarization – Trans. Guide Field

![Graph showing the relationship between neutron energy (E_n in meV) and depolarization for different magnetic fields (0, 1, and 4 kG). The graph plots the depolarization value against E_n on a logarithmic scale. The data points indicate an increase in depolarization with increasing E_n.](image_url)