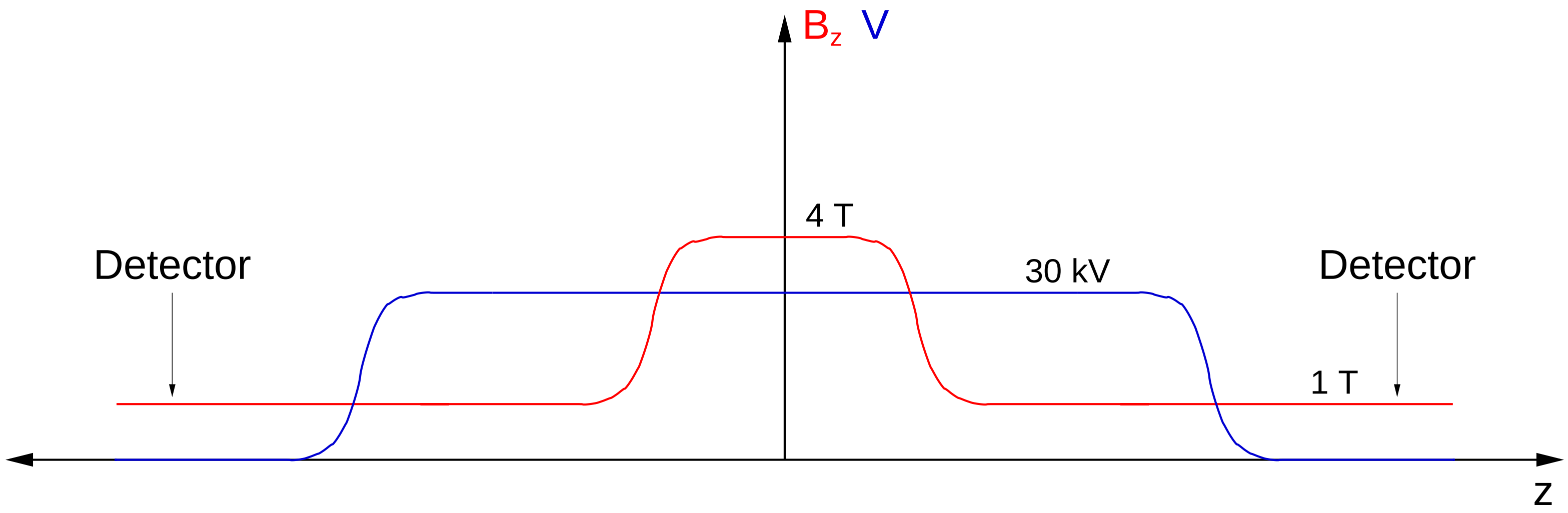
# Magnetic and Electric Fields




- 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

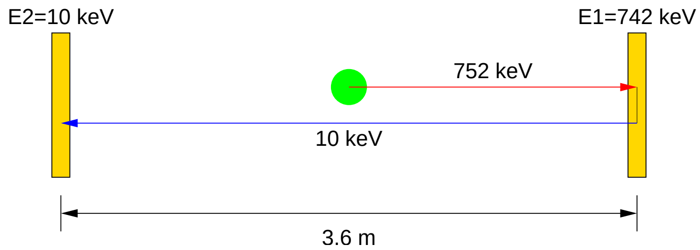
$$1 + \frac{1}{6}\frac{dB}{B}$$

- 10% homogeneity gives $1.7 \times 10^{-3}$ correction
- Compare to $1 \times 10^{-3}$ statistical goal
- Assumes 20% accuracy in calculating correction

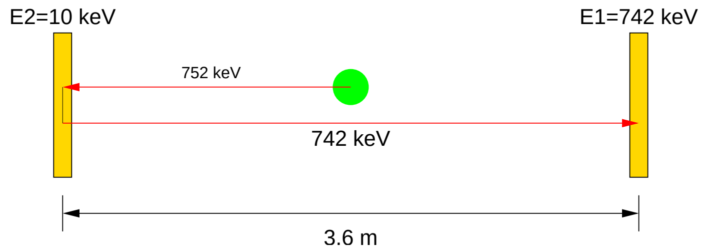
## Length of Flight Region

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

# Detector Timing Resolution



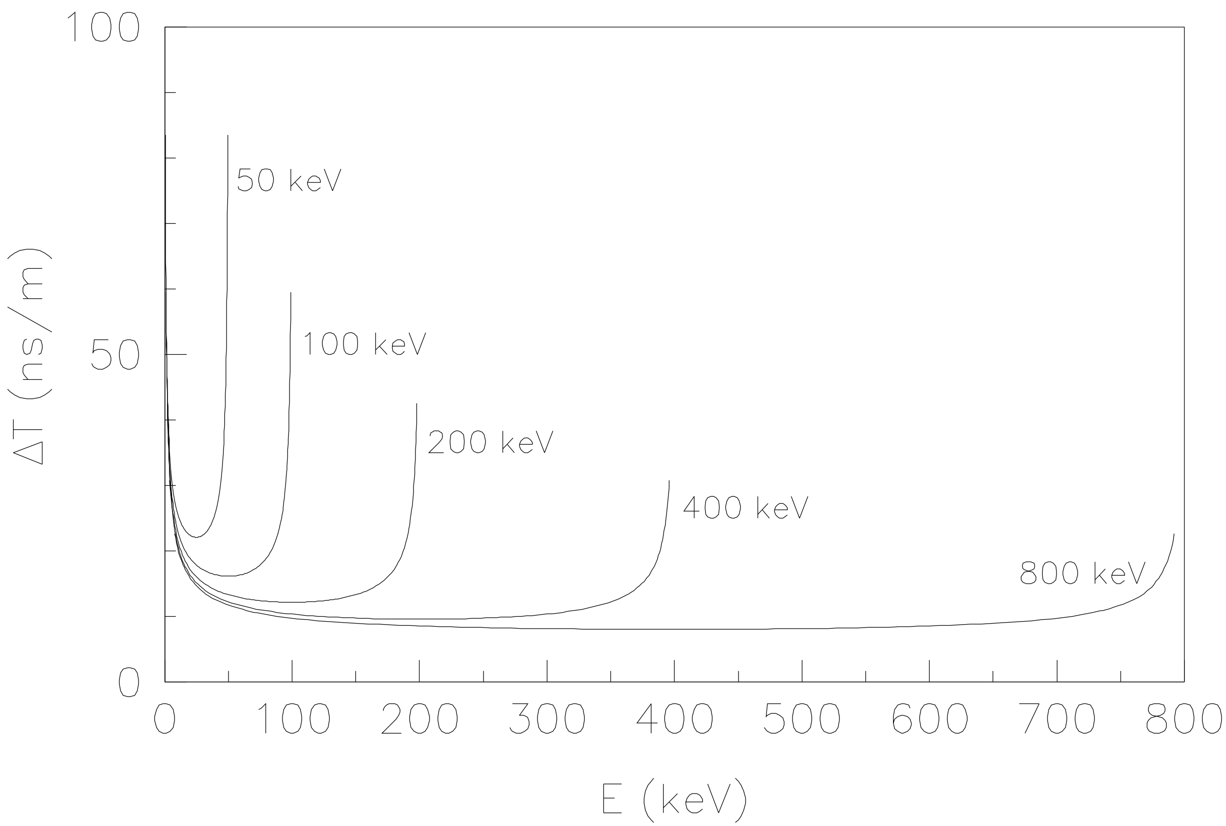

$$t_2 - t_1 = 50.2 \text{ ns}$$




$$t_2 - t_1 = -13.1 \text{ ns}$$

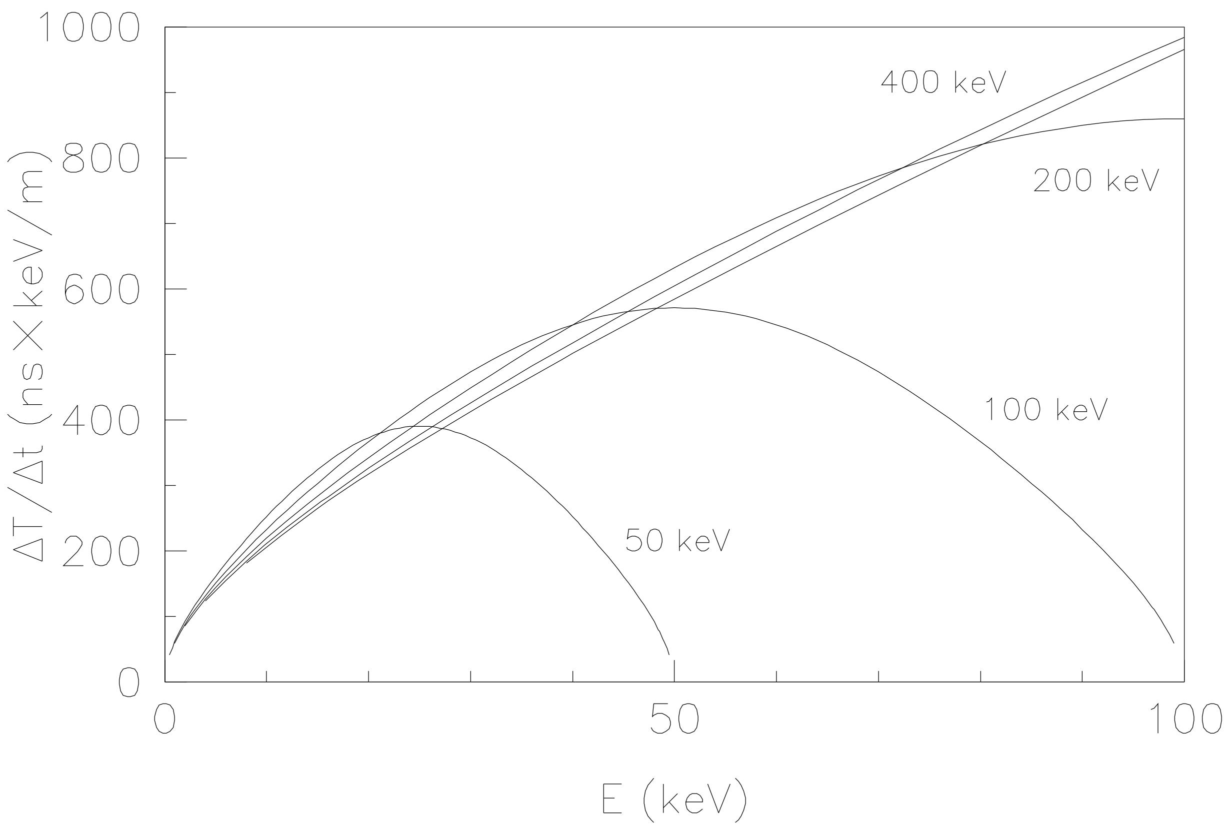
- Timing information needed for $e^-$ backscatter events
- Worst-case events have low $E$ in one detector
- Must achieve timing resolution $\sim 20$ ns for 10 keV
- Figure-of-merit $E \cdot \Delta t \sim 200$ keV·ns

# Electron Timing Difference




1 m detector separation

# Timing Difference vs. Timing Resolution

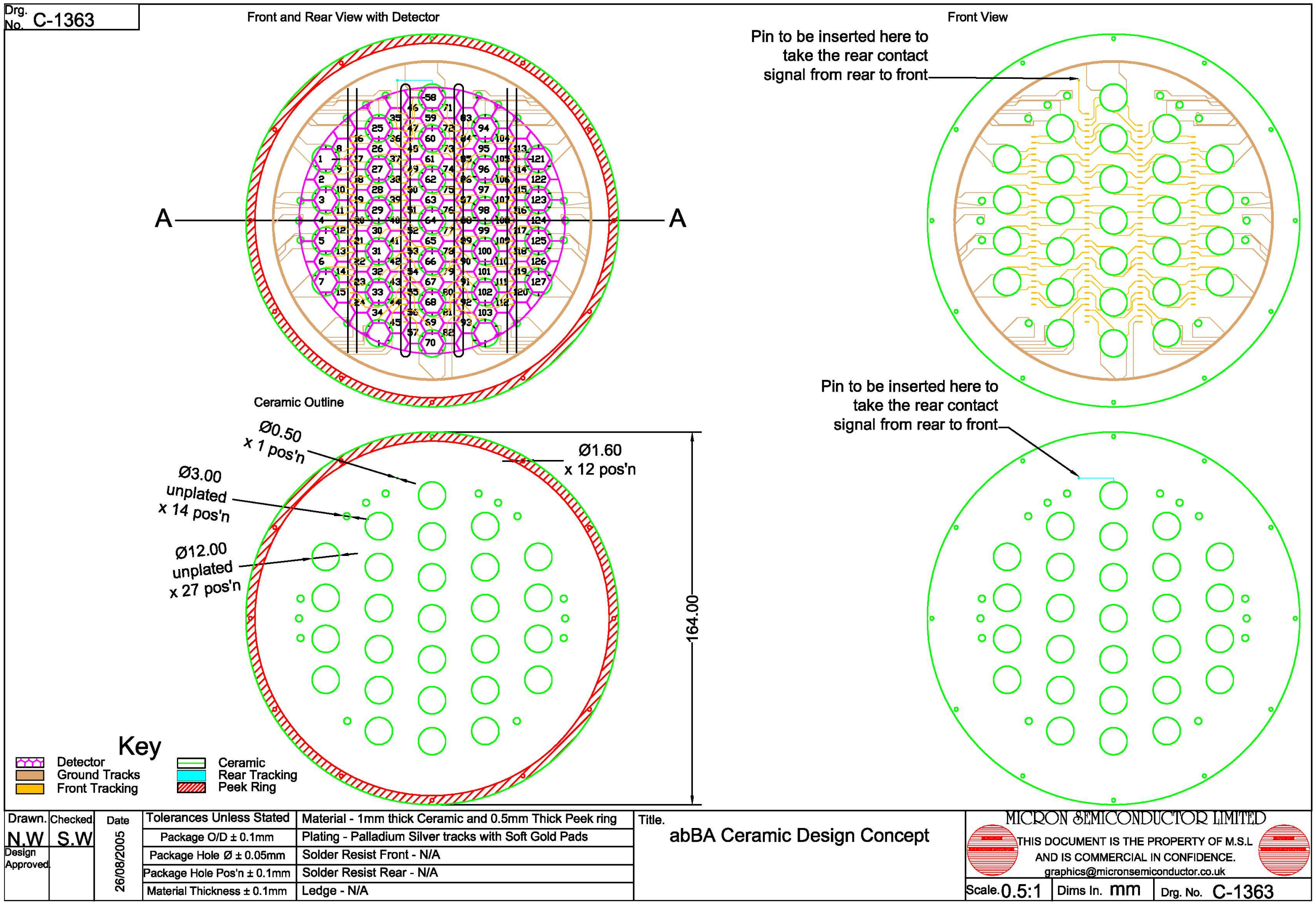



1 m detector separation, 1 ns rise-time, 1 keV resolution

# Bore Diameter

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

# Ceramic Carrier Design



# 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)

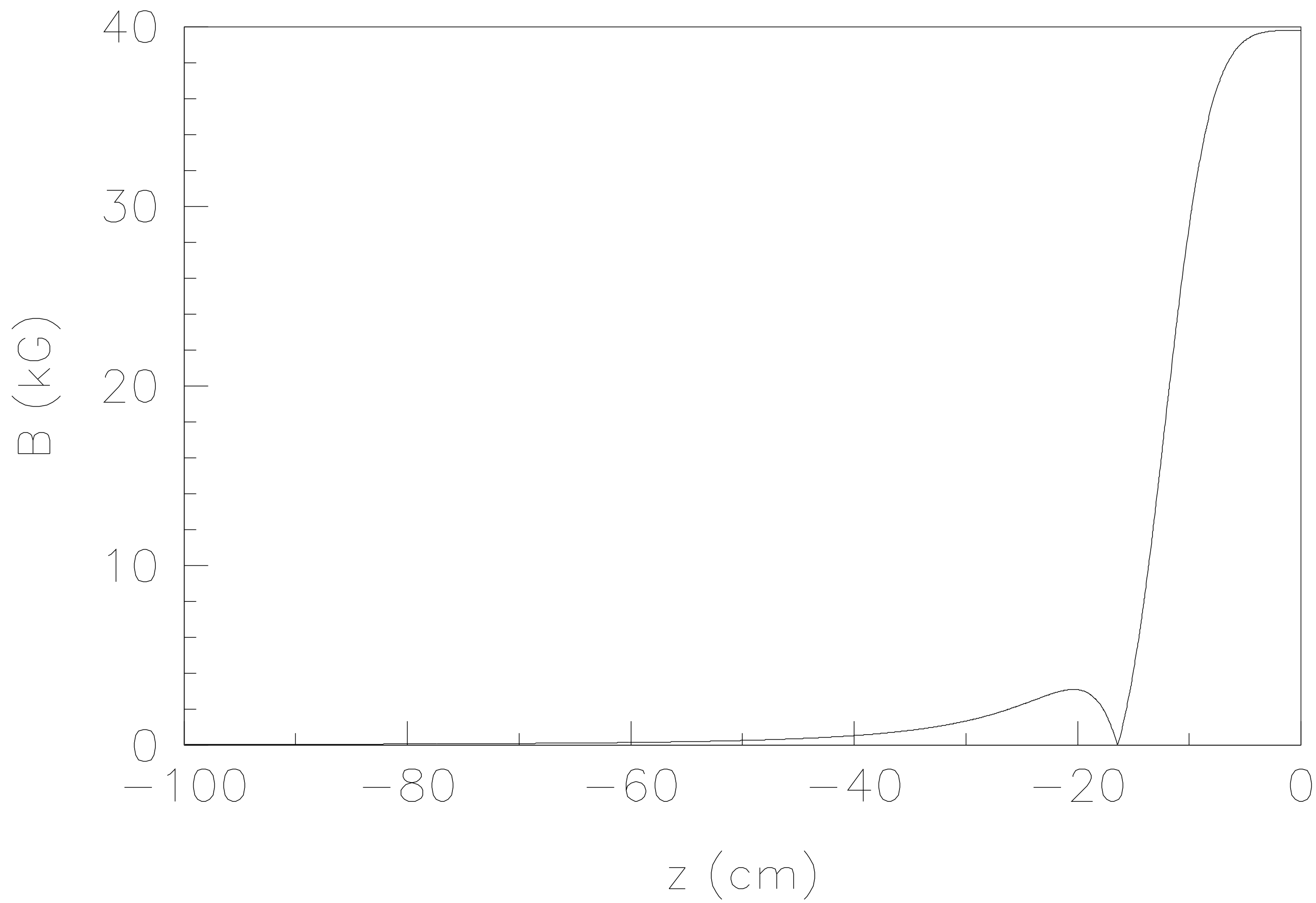
$$\lambda = \frac{\mu B^2}{2\hbar \frac{dB}{dz} v}$$

- $\sim 500$ G sufficient

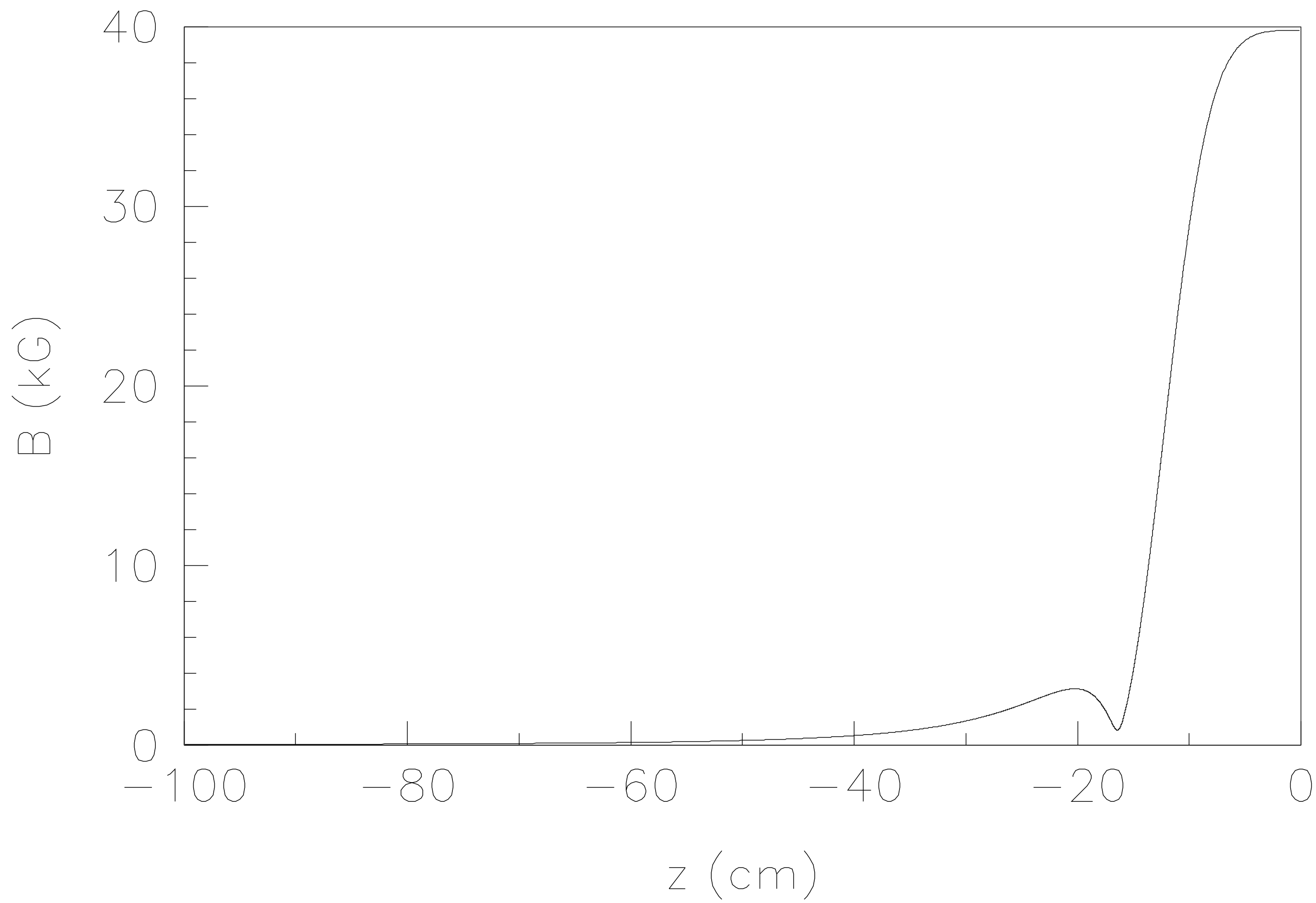
# Monte Carlo Calculations

- 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

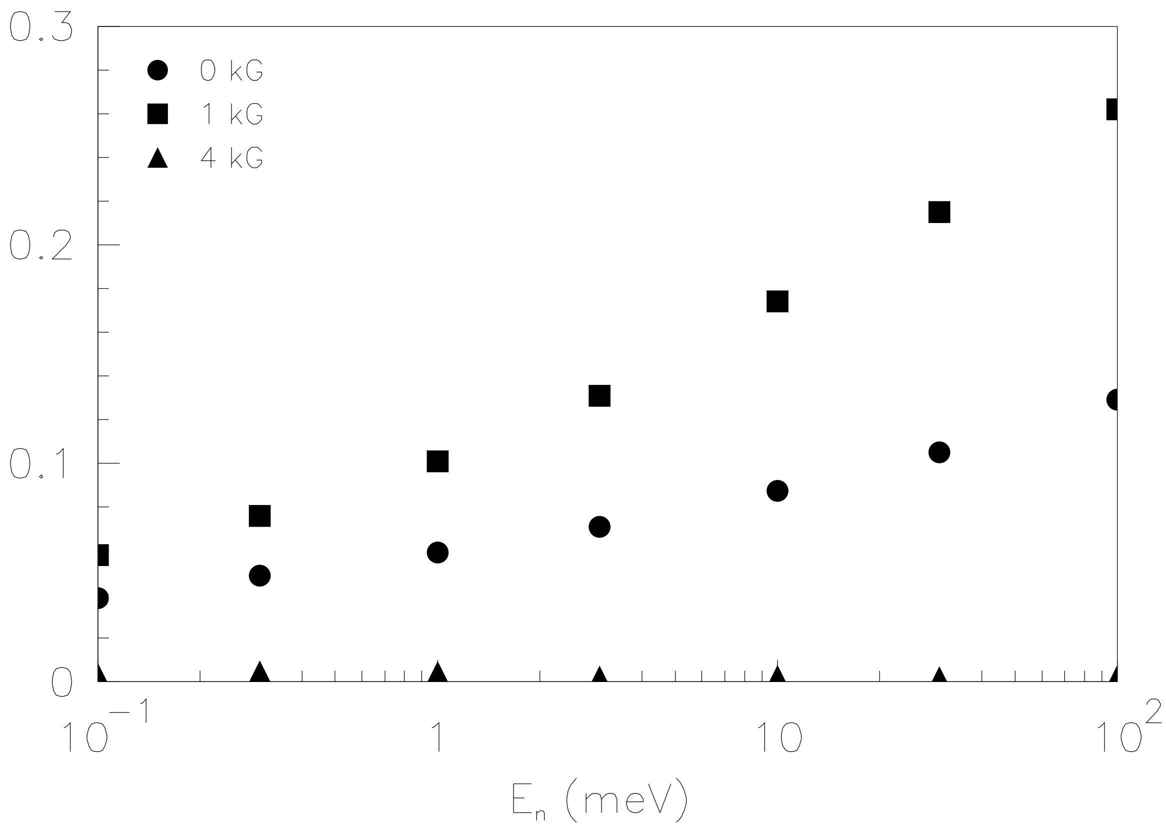
# Magnetic Field – No Guide Field



# Magnetic Field – 1 kG Guide Field

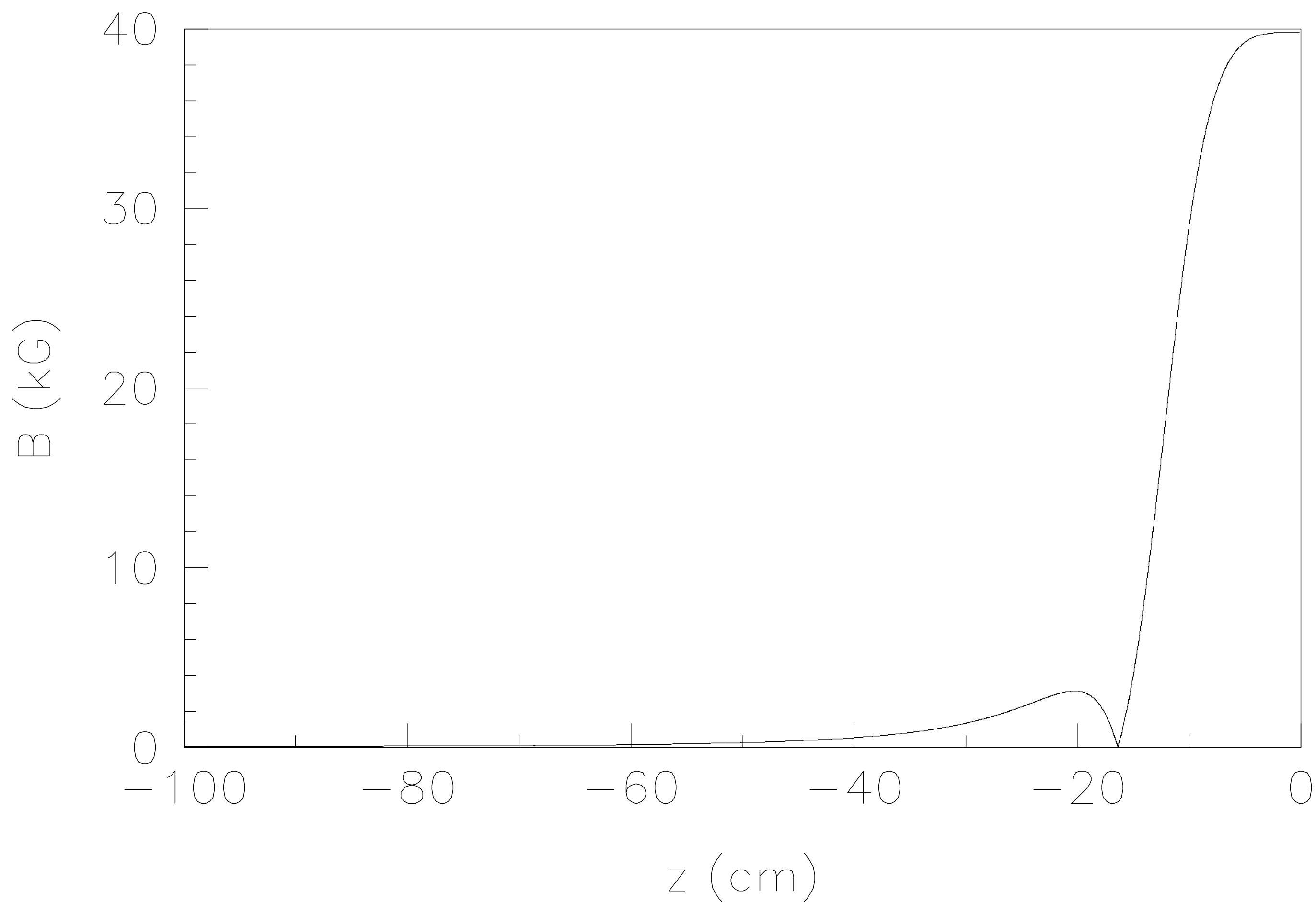


# Neutron Depolarization – Long. Guide Field




- Guide field solenoid $-20 < z < -12$ cm

# Magnetic Field – 1 kG Guide Field (off axis)



# Neutron Depolarization – Trans. Guide Field