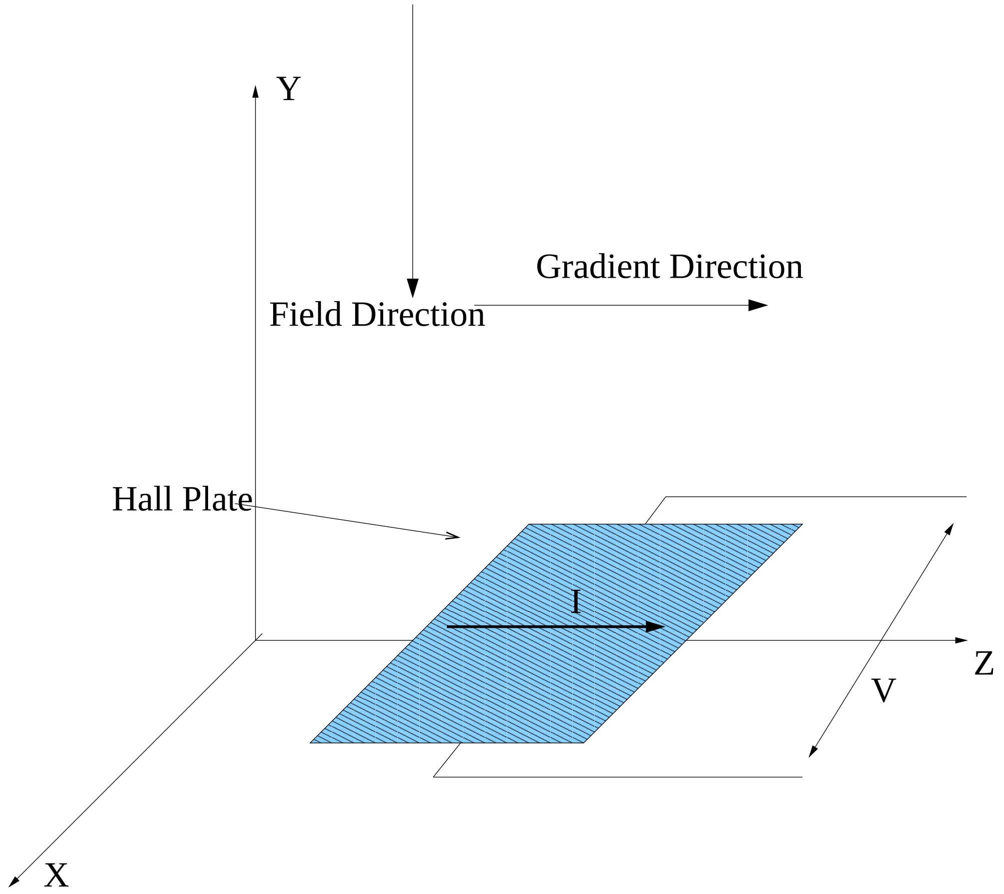
Field Gradient Effects

- Hints from "Influence of Magnetic Gradient Fields on the Hall Effect", B.Berkes, revisited for our case...



- Variables:

  b probe dimension along the field gradient direction

  B_0 true field at the center of the probe

  R input resistance at the probe voltage sides

  R_0 resistance for B=0 T

  U_h measured voltage, U_{h0} voltage measured in homogenous field

  a_s magneto resistance coefficient

  i_s supply current

Field Gradient Effects

- First Order Approximation:

$$U_h = U_{h0} \cdot (1 + F')$$
$$U_{h0} = k \cdot i_s \cdot B_0 \quad U_h = k \cdot i_s \cdot B$$
$$\Longrightarrow B = B_0 \cdot (1 + F')$$

$$\begin{aligned} F' &= -\frac{b^2}{12}\frac{1}{B_0 R_0}\left(\frac{dR}{dB}\right)_0 \left[\left(\frac{dB}{dz}\right)_0\right]^2 \\ &= -\frac{b^2}{12}\left[\left(\frac{dB}{dz}\right)_0\right]^2 \cdot a_s \cdot \frac{2}{1 + a_s B_0^2} \end{aligned}$$

$$\text{with } a_s = \frac{1}{B_0 R_0}\left(\frac{dR}{dB}\right)_0 \frac{1}{2 - \frac{B_0}{R_0}\left(\frac{dR}{dB}\right)_0}$$

Field Gradient Effects

- MBI at 100 GeV and z=2600 mm (region of maximum gradient):

  $B_0 = 0.15\,T$

  $\frac{dB}{dZ} \approx 1\,\frac{T}{m}$

- Measuring the B field in this sample location will be affected by the two different sets of Hall Probes used in the two mapping campaigns:

$$b_1 = 10.11\,mm \quad R_{01} = 1.8\,\Omega \quad a_{s1} = 2.13\,T^{-2}$$

$$b_2 = 0.35\,mm \quad R_{02} = 600\,\Omega \quad a_{s2} = 1.14\,T^{-2}$$

$$\boxed{\frac{\Delta B}{B}} = F_2' - F_1' =$$

$$= -\left[\left(\frac{dB}{dz}\right)_0\right]^2 \cdot \frac{1}{6} \cdot \left(\frac{b_2^2 a_{s2}}{1 + a_{s2} B_0^2} - \frac{b_1^2 a_{s1}}{1 + a_{s1} B_0^2}\right) =$$

$$= \boxed{3.46 \cdot 10^{-5}}$$

- What does it mean for the total $\int_L B \cdot dl$?
  - The effect of the two sides should add up, it depends on $\left[\left(\frac{dB}{dz}\right)_0\right]^2$
  - The bigger the probe the smaller the measured field compared to the true one

  $\Longrightarrow$ Would explain the difference of $7 \cdot 10^{-5}$!!