Apparatus for periodic magnetic structure tuning

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Theory

- Model

$B_p(z)$ – periodic field

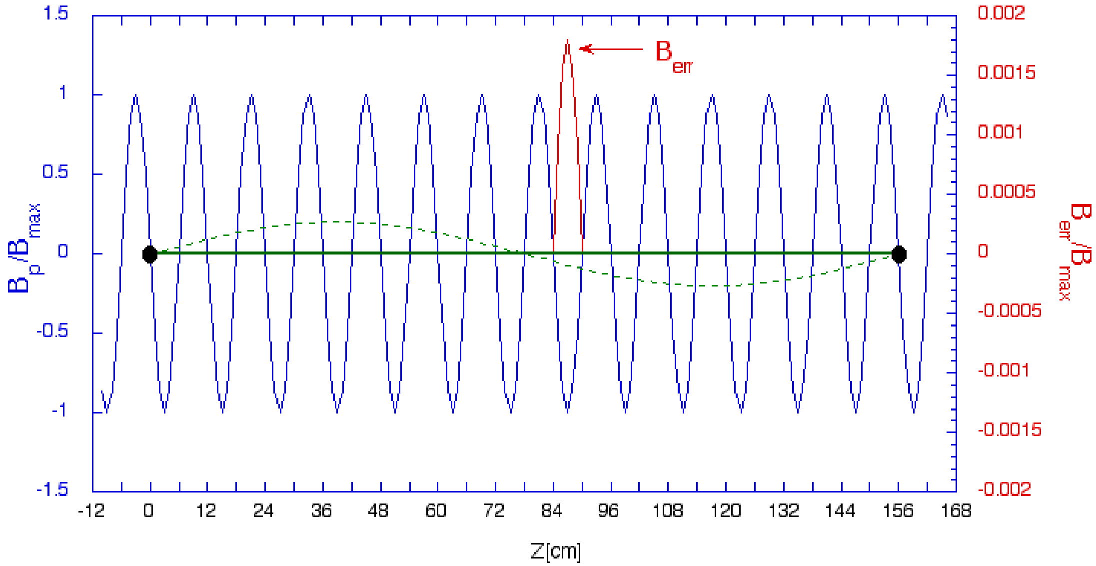
$B_{err}(z)$ – error field (bad pole)

$L = Nd$;

L – the vibrating wire length

d – the srtucture period

$I(t) = I_0 \exp(i\omega t)$



Theory

- Equation of the wire motion

$$\mu \frac{\partial^2 X}{\partial t^2} = T \frac{\partial^2 X}{\partial z^2} - \gamma \frac{\partial X}{\partial t} + I(t)B(z); B(z) = B_p(z) + B_{err}(z)$$

μ – linear wire density; T – tension; γ – decrement;

$$X(z=0,t) = X(z=L,t) = 0$$

- Solution

(standing waves)

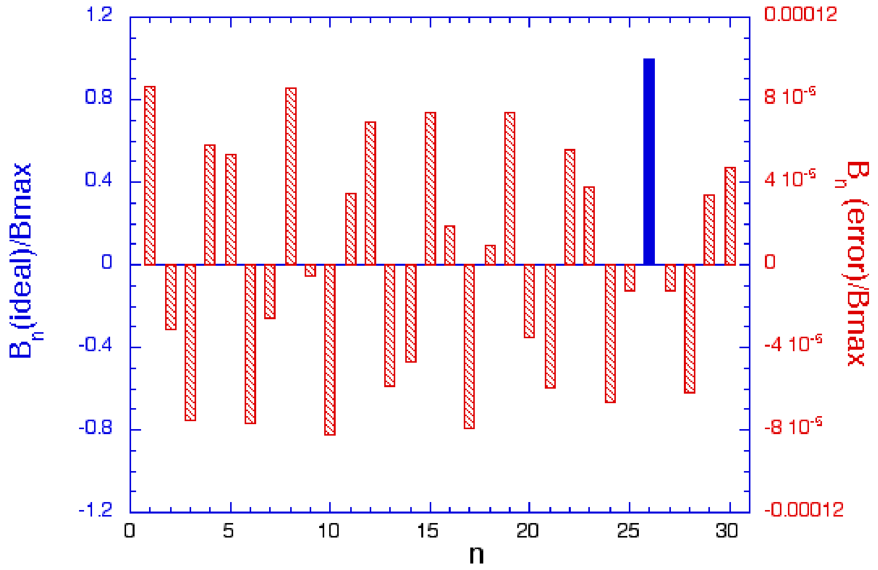
$$X(z,t) = \sum_n X_n \sin(\frac{\pi n}{L} z)\exp(i\omega t);$$

$$X_n = \frac{I_0}{\mu} \frac{1}{(\omega^2 - \omega_n^2 + i\gamma\omega)} B_n; \ \omega_n = \frac{\pi n}{L}\sqrt{\frac{T}{\mu}}$$

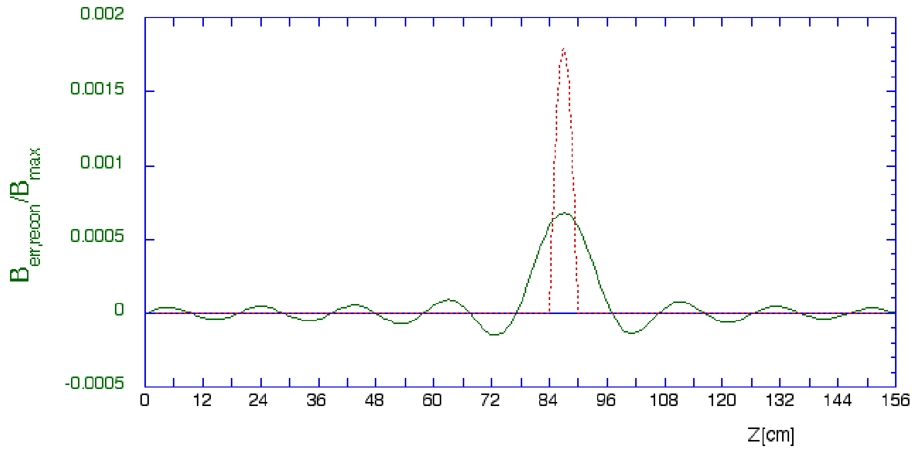
$$B_n = \frac{2}{L}\int_0^L B(z)\sin(\frac{\pi n}{L} z)dz; \ B(z) = \sum B_n \sin(\frac{\pi n}{L} z)$$

Theory

- Error Field and Periodic Field Harmonics

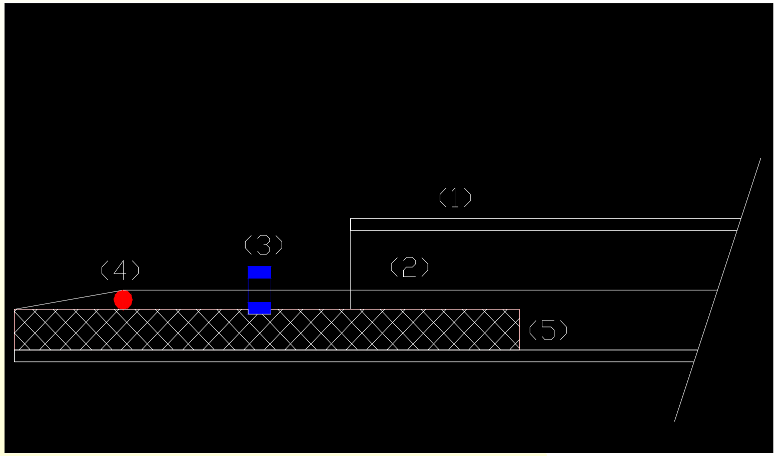


- Original error field (dotted line) and reconstructed (solid line) using 16 low order harmonics



Test Setup

- G-line wiggler: L = 3m, d (period) = 12cm, Bmax = 0.780T
- VW probe (one end shown)



(1) – plastic tubing
(2) – 0.1mm copper-beryllium wire
(3) - “H21A1” LED-phototransistor assembly
(4) - 2mm G-10 cylinder
(5) - G-10 spacer

L wire = 156cm = 13d

- “Macintosh Quadra 800” + “Lab-NB” board.
- Wave form generator “HP33120A”

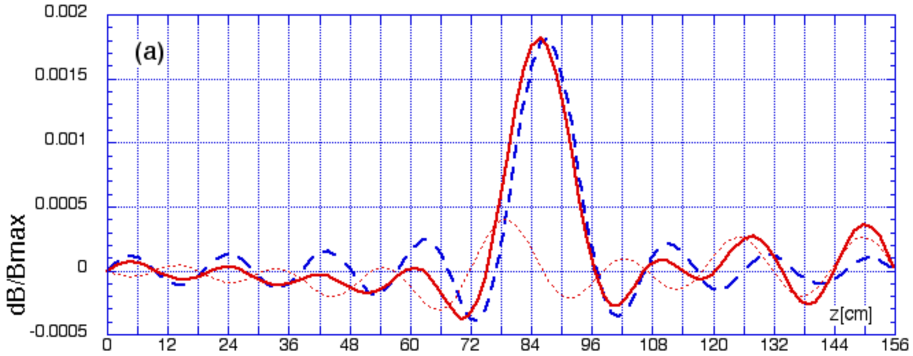
Test Result

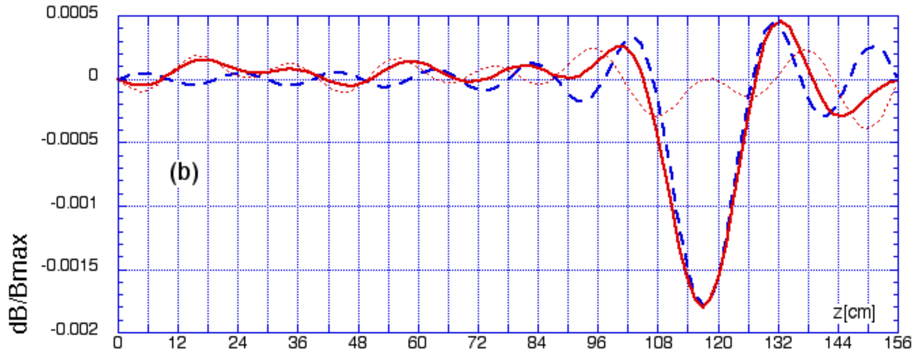
- Field distortion from single shim (dB ~ 14G, dB/Bmax= 1.8e-3)

  Used 16 vibrating modes.

  Measurement – solid line. Model - dashed line. Residual – dotted line.

  - Shim at z = 87cm
  - Shim at z = 117cm





z(measured) = 85.72cm

RMS (measured-modeled) =1.4e-4

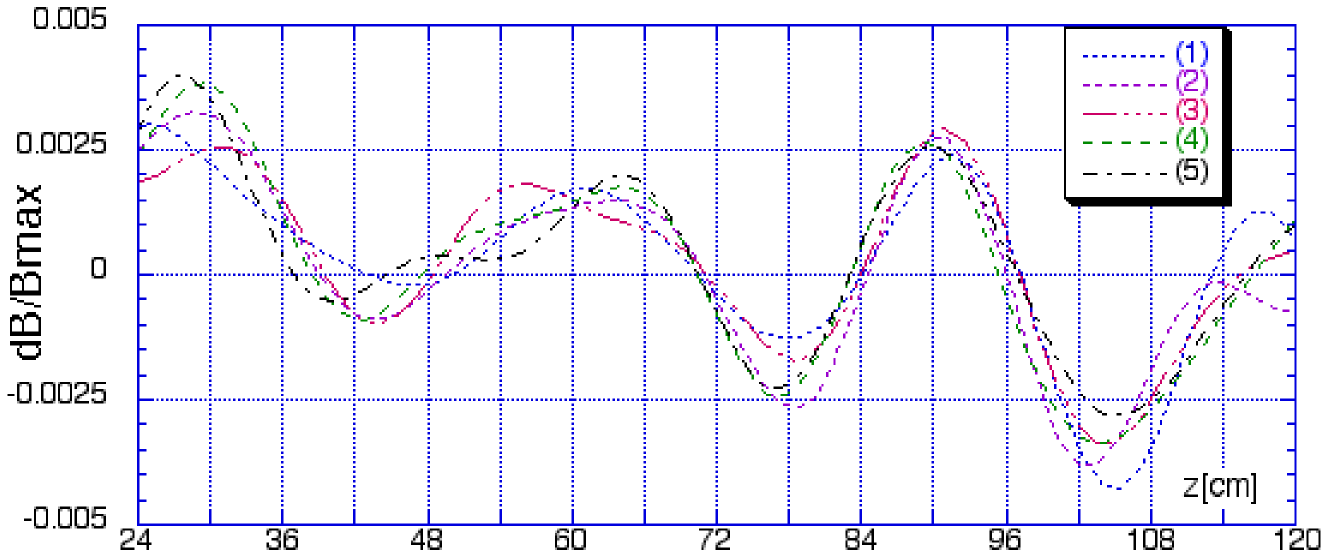
z(measured) = 117.0cm

RMS (measured-modeled) =1.5e-4

- Spatial resolution ~ 2cm, RMS (noise) ~ 1.5e-4 Bmax

Test Result

- G-line wiggler error field measurement.
  - 5 measurements at 5 different VW probe position along wiggler. Common region is shown.



Conclusion

- Demonstrated characteristics:
  - ~2cm spatial resolution
  - ~1.5e-4 RMS dB/Bmax
- May be improved by:
  - Vibrating wire property => higher sensitivity
  - Vacuum encapsulating => low damping/higher sensitivity
  - Using more vibrating modes => spatial resolution
  - Dimensions less then 1mm => small aperture magnets
- Advantage
  - Cheap
  - Easy to build
  - Do not need expansive precise positioning system.