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An Introduction to "WIENFILTER"
Exercise 2: Using it As a Spin Rotator

Recommended readings

- Section "2.7 - Wien filter" in ../../documentation/eRHICelectronWF.pdf

- Section "4 - Rotation in dipoles and solenoids" in ../../documentation/polarizationOfZgoubi.pdf

- Zgoubi Users' Guide, regarding the keywords used in the exercise (WIENFILTER, OBJET/KOPT=2, FIT[2], REBELOTE, etc.). Hint: use the index (last 3 pages of the Guide) to locate the related sections in Part A and Part B.

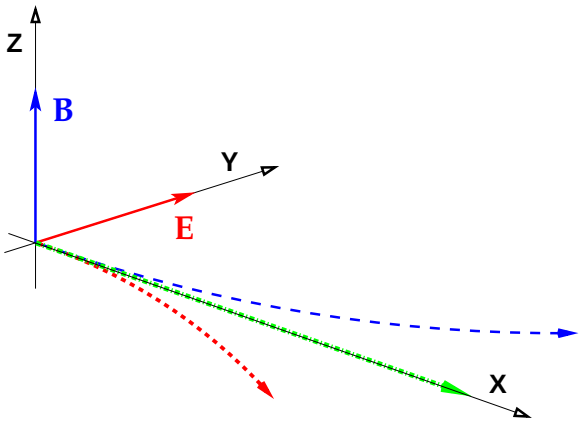
- During the exercise, it is recommended to keep at hand 2 copies of Zgoubi Users' Guide (ZUG in the following), with one copy maintained at the Index (last 3 pages of the document).

Keywords we play with in this exercise

`WIENFILTER` is used in this exercise (pp. 168 and 306 in the Users' Guide). B and E are set so to ensure (i) straight trajectory across the Wien filter, (ii) proper spin rotation from initial longitudinal orientation.

Working hypotheses

- The Wien filter length is L
- Take $\vec{E} \parallel \vec{Y}$ and $\vec{B} \parallel \vec{Z}$ (as sketched to the right)
- E and B fields are taken hard-edge so to allow tight comparison with theory
- Electron trajectory is straight, so $E = v\,B$



Expectations include:
- Straight trajectory across the Wien filter (green, in the figure)
- 30^o spin rotation over L=50 cm:

$$\theta_s = \underbrace{(1+a\gamma)\frac{BL}{B\rho}}_{\approx 50^o\ from\ \vec{B}} - \underbrace{(a\gamma+\frac{\gamma}{1+\gamma})\beta^2\frac{BL}{B\rho}}_{\approx 20^o\ from\ \vec{E}} = 30^o$$

Numerical experiments

1/ Set up a Wien filter in zgoubi with length $L = 0.5$ m, and B and E such to (i) ensure straight trajectory, (ii) ensure 30^o spin Z-rotation.
Use FIT to achieve that, set the penalty value at 10^{-15}.
Compare with theory.

2/ Check the effect of step size on the accuracy on spin rotation value:

2.a - Using REBELOTE, get a scan of θ_s for Δs varied from .001 cm to 1. cm in 100 steps.
Plot θ_s versus Δs (can use gnuplot to plot data read from zgoubi.fai).

2.b - Let's do it differently, namely, check the effect of step size on E and B values instead:
Add FIT prior to REBELOTE, so to constrain θ_s to its expected 30^o value. The variables in the FIT are E and B.
Plot E and B versus Δs.

3/ Align three 30^o Wien filter rotators to get 90^o spin rotation. Make sure the spin rotation amounts to the expected value.
Compute the spin transport matrix.

3/ Add fringe-fields, re-do a FIT on E and B for straight trajectory and $\theta_s = 30^o$ spin rotation.
Compare the new E and B values with the hard-edge case.