GEANT Simulation of the Small Dipole Ring – status report

Amit Klier
University of California, Riverside
Outline

• A reminder:
  • The simulation code
  • The small dipole ring
  • What has been presented at Berkeley (not much)
• New results:
  • Constant energy behavior (only magnetic field on)
    • Dynamic aperture – transverse acceptance
    • Reference orbit
  • The ring with RF and “ideal” absorber (no scattering)
    • Longitudinal acceptance
    • “Perfect” cooling
Simulation software

- **MUC_GEANT**
  - Data-driven GEANT 3.21 (from R. Raja) similar to the one used for the RFOFO ring
    - Interface with ICOOL input/output, ECALC9
    - NEW perfect pillbox cavity (Bessel function)
  - Field maps from Steve Kahn, using shaped iron poles
6D Cooling demonstration Ring

“Weak” (edge) focusing (ideally) scaling

Filled with ~10 Atm. hydrogen gas (77K)

Dipole B ~ 2 T (peak)

For $E_\mu \sim 200$ MeV, the radius should be ~60 cm
Field map with shaped iron poles (S. Kahn)

$B_y$ in a single quadrant

Return yoke field

$B_y$ at $R=60$ cm

No negative $B_y$
Dynamic aperture as presented at Berkeley

Ellipses in $X-P_x$

Ellipses in $Y-P_y$

Seems unstable at $x>7$ cm, fuzzy

Stable up to $y\sim13$ cm
Solving the x aperture mystery

- The instability was due to small fluctuations in $B_x, B_z$ at $y=0$
- The solution: impose $B_x=B_z=0$ at $y=0$ (perfect symmetry)
- The ring is stable up to $x=18$ cm !!
Transverse acceptance of the ring

- $x = \sim 6.5 \text{ cm}$
- $y = \sim 8.5 \text{ cm}$
- $P_x = \sim 34 \text{ MeV}/c$
- $P_y = \sim 19 \text{ MeV}/c$

$x$-$z$ plane symmetry imposed

“unnatural” stability region at $y = 0$
Transverse acceptance, without the $y=0$ symmetry

More “natural” decrease with no x-z plane symmetry
Find the reference particle

- Orbit period ~ 3\textsuperscript{rd} harmonic of 201.25 MHz
- To be consistent with other studies (H. Kirk, S. Kahn):
  - \( P \approx 170 \text{ MeV/c} \)
  - \( R_{\text{min}} \approx 55 \text{ cm} \)
Reference particle

- Scale $B$ down by 10%
- Closed orbit:
  - $P=171.25$ MeV/c
  - $R_{\text{min}}=56.32$ cm
    (x=0 in virtual detectors)

Acceptance studies (pages 8, 9 above) were done with scaled-down $B$ fields
Add RF and “ideal” absorber

• The RF cavity
  • Perfect pillbox: 25 cm long, 65 cm in radius
  • Center at R=66.32 cm (10 cm from ref. particle)
  • Active region: ±15 cm in y, ±25 cm in x centered at R=56.32 cm (10 cm off cavity center)

• The absorber
  • Gaseous H\textsubscript{2} at 40 Atm (room temperature) fills the whole volume
  • “Ideal” – scattering and straggling not simulated
Longitudinal acceptance
higher RF gradient – better
6D cooling with ideal absorber

- $X_{\text{initial}} = 6 \text{ cm}$
- $Y_{\text{initial}} = 8 \text{ cm}$
- $P_{X_{\text{initial}}} = 30 \text{ MeV/c}$
- $P_{Y_{\text{initial}}} = 17.5 \text{ MeV/c}$
- $E_{\text{initial}} = 213 \text{ MeV}$
- $t_{\text{initial}} = -1.5 \text{ ns}$

- $X_{\text{central}} = 0.04 \text{ cm}$
- $Y_{\text{central}} = 0 \text{ cm}$
- $P_{X_{\text{central}}} = 0.12 \text{ MeV/c}$
- $P_{Y_{\text{central}}} = 0 \text{ MeV/c}$
- $E_{\text{central}} = 201.8 \text{ MeV}$
- $t_{\text{central}} = 0 \text{ ns}$

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GEANT - Small Dipole Ring
To do

- Simulate cooling with realistic absorber
- Use beam ("standard" beam may not fit)
- Add cavity windows
- Full simulation of the demonstration ring:
  - Injection, either through dE/dx or pion decay
  - Detector planes – scifi
  - …
Conclusion

• Small Dipole Ring
  • So far, no cooling simulations with GEANT
  • Dynamic aperture improved with shaped iron poles, especially in $y$ (realistic field maps from S. Kahn)
  • The goal: simulate the 6D cooling demonstration ring with realistic features