MARS Target Yield Studies

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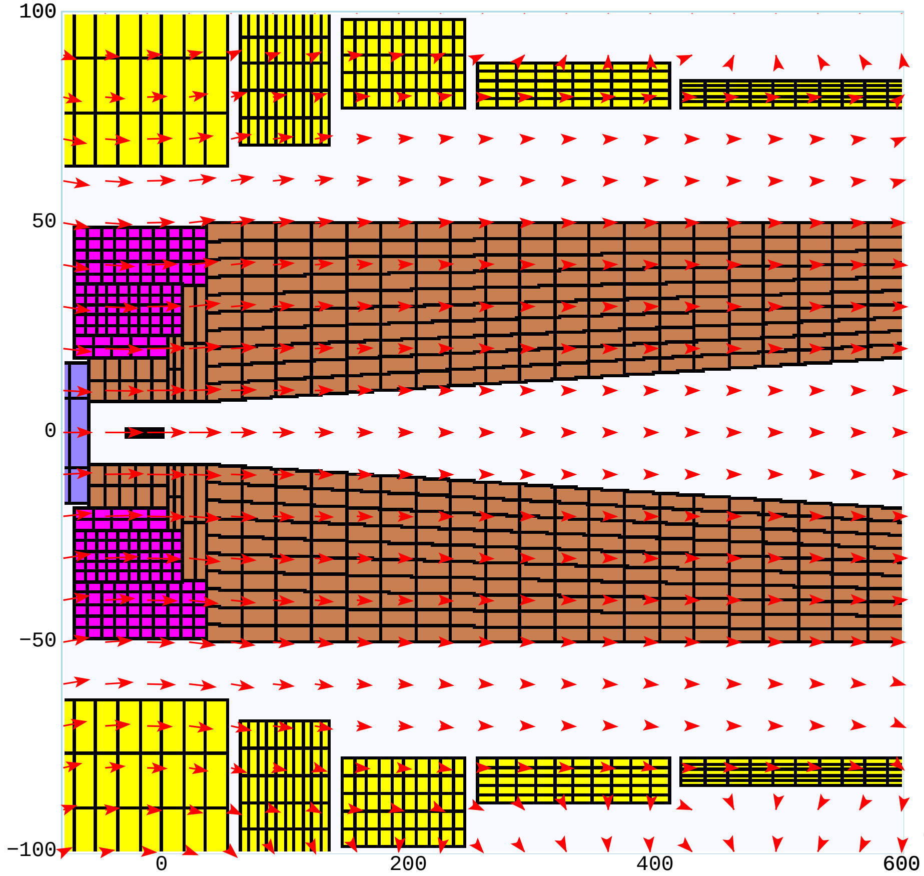
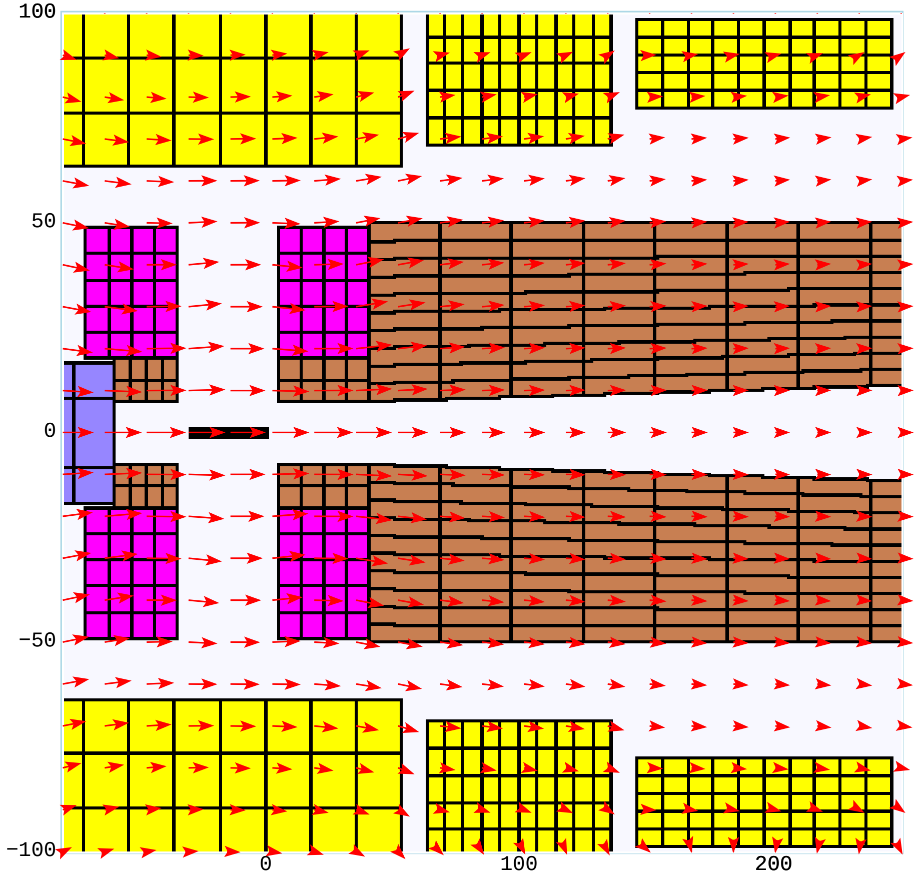
Introduction

- Using MARS (v15.07) and Study-II geometry to find pion & muon yields
- 10 GeV parabolic proton beam hitting cylindrical tungsten rod in 20 T field
  - Rod lengths: 15, 20, 25 and 30 cm
  - Rod radii: 0.25, 0.50, 0.75, 1.0, 1.5 cm; $r_{\rm beam} = r_{\rm rod}$
  - Rod tilt (θ): 0, 20, 50, 100, 150, 200, 250, 300 mr; $\theta_{\rm beam} = \theta_{\rm rod}$
- Counting number of π and μ (per proton) along different z planes within target aperture ($z \leq 6$ m) directly from MARS output
- Comparing original B field with new Helmholtz field in target region
- Applying simple kinetic energy cuts to estimate particle acceptance in cooling channel: $0.03 < \text{K.E.} < 0.23$ GeV (used for Hg yields in StudyII).
- Hg jet yield per proton is $12.0 \pm 0.1\%$ ($\theta_{\rm beam} = 67$ mr, $\theta_{\rm Hg} = 100$ mr)

Target Geometry: $(\boldsymbol{z},\boldsymbol{x})$ plane



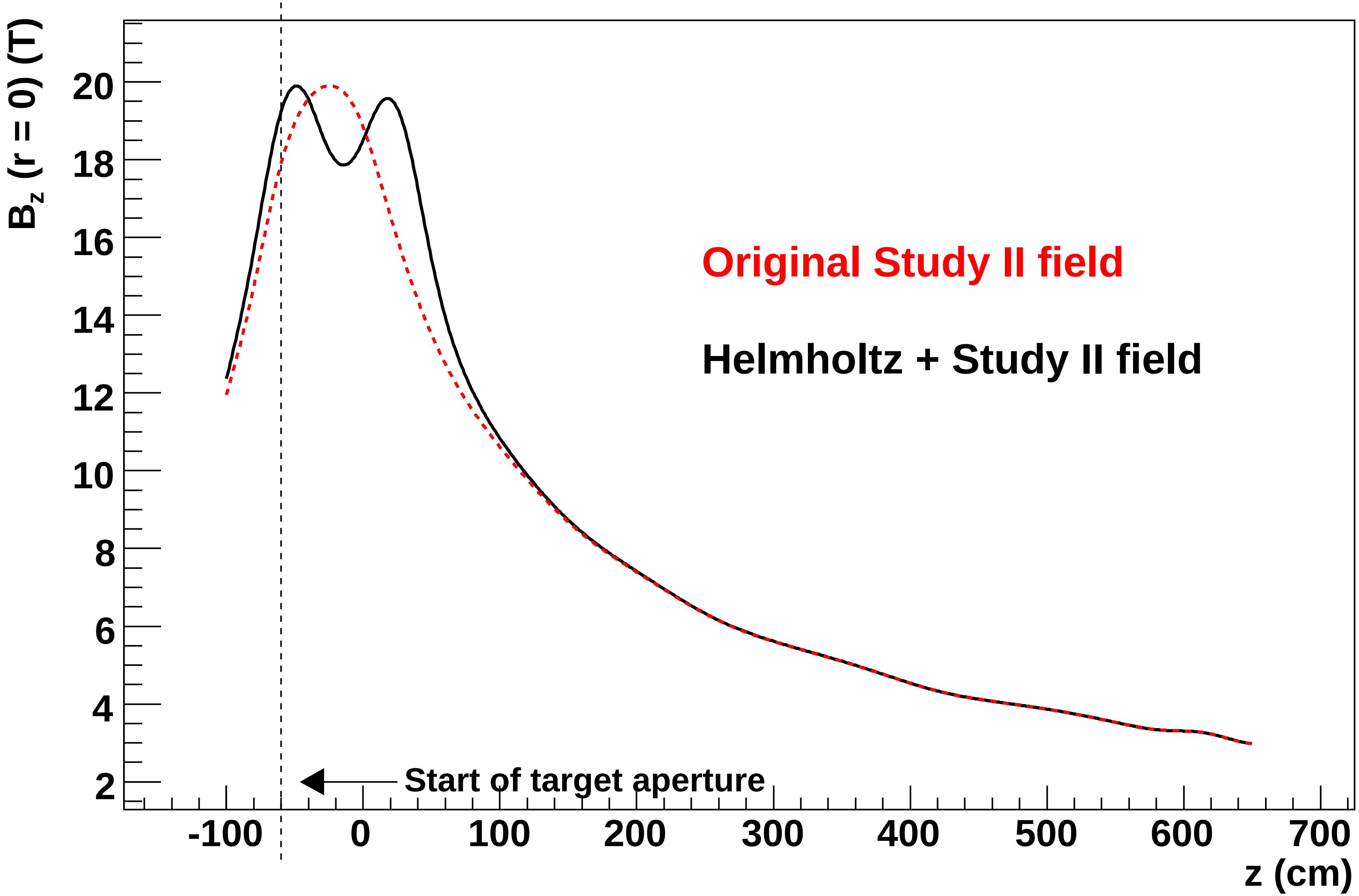
StudyII



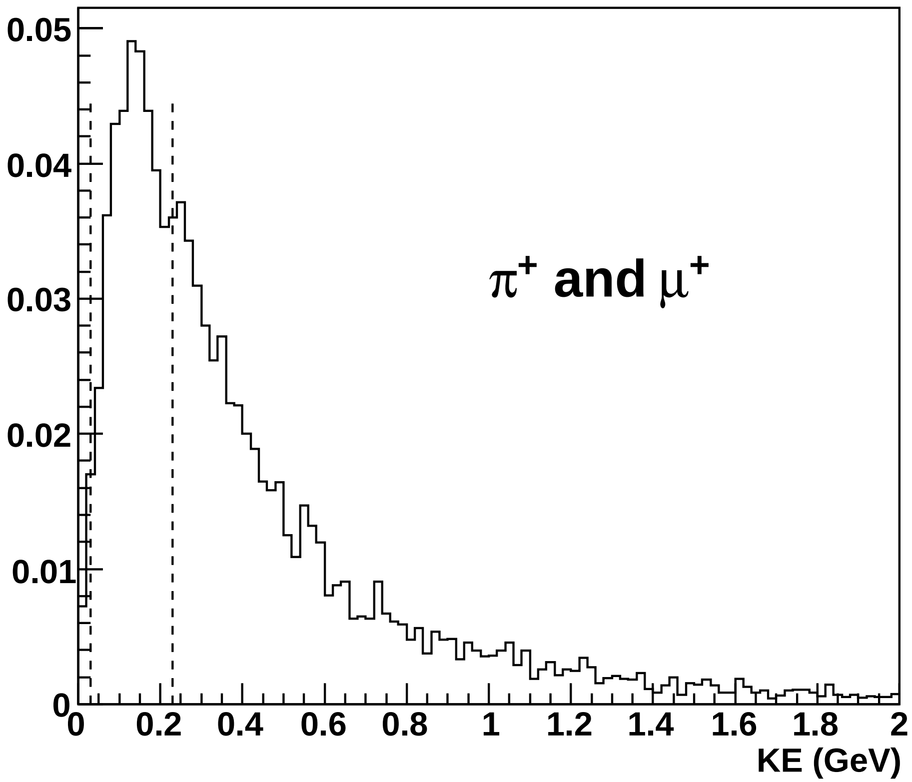
Helmholtz (close up)

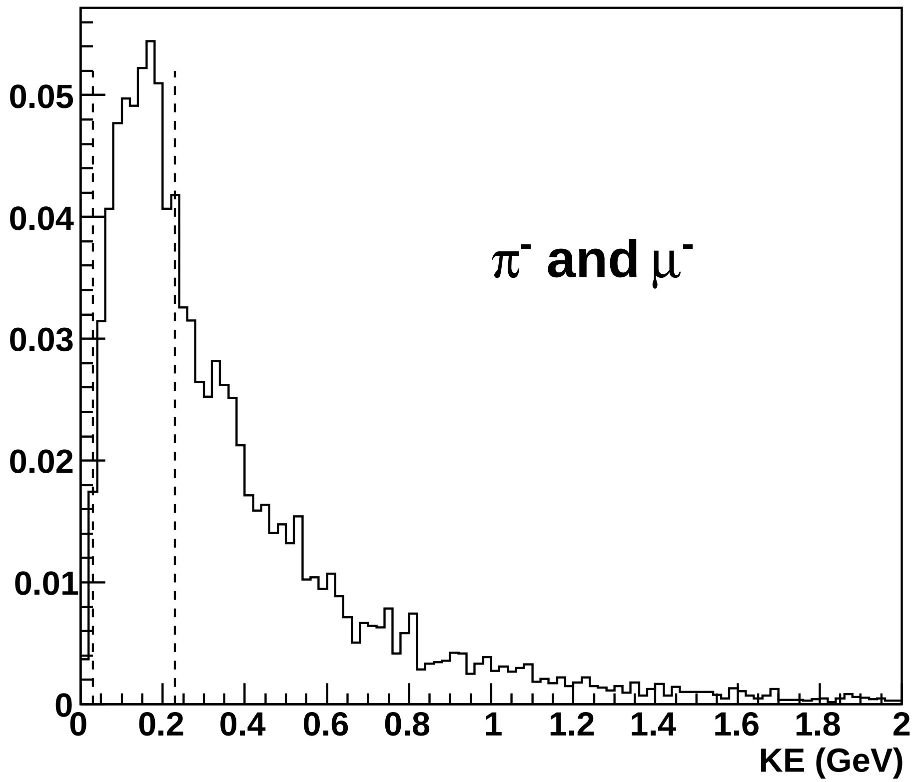
Colour scheme: Target rod (black), $\underline{B}$ field lines (red), Cu coils (magenta), SC magnets (yellow), shielding (brown), iron plug (purple).

On-axis B_z field



Current density in Cu coils: <Study II> = $20\,\mathrm{A\,mm^{-2}}$, Helmholtz = $30\,\mathrm{A\,mm^{-2}}$

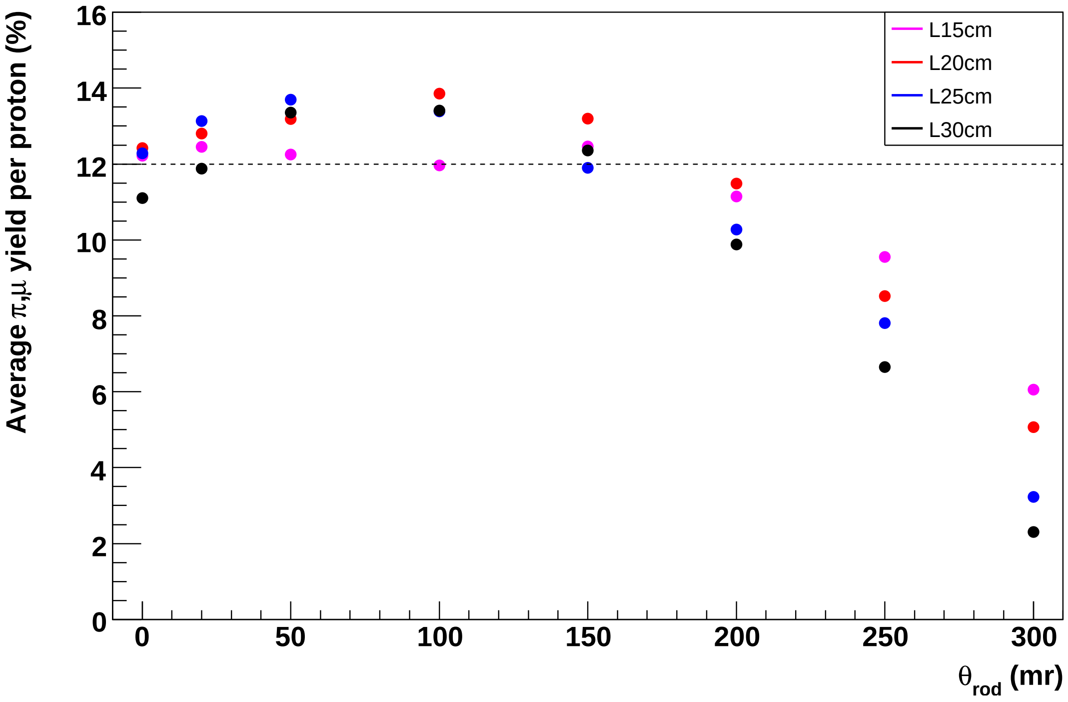




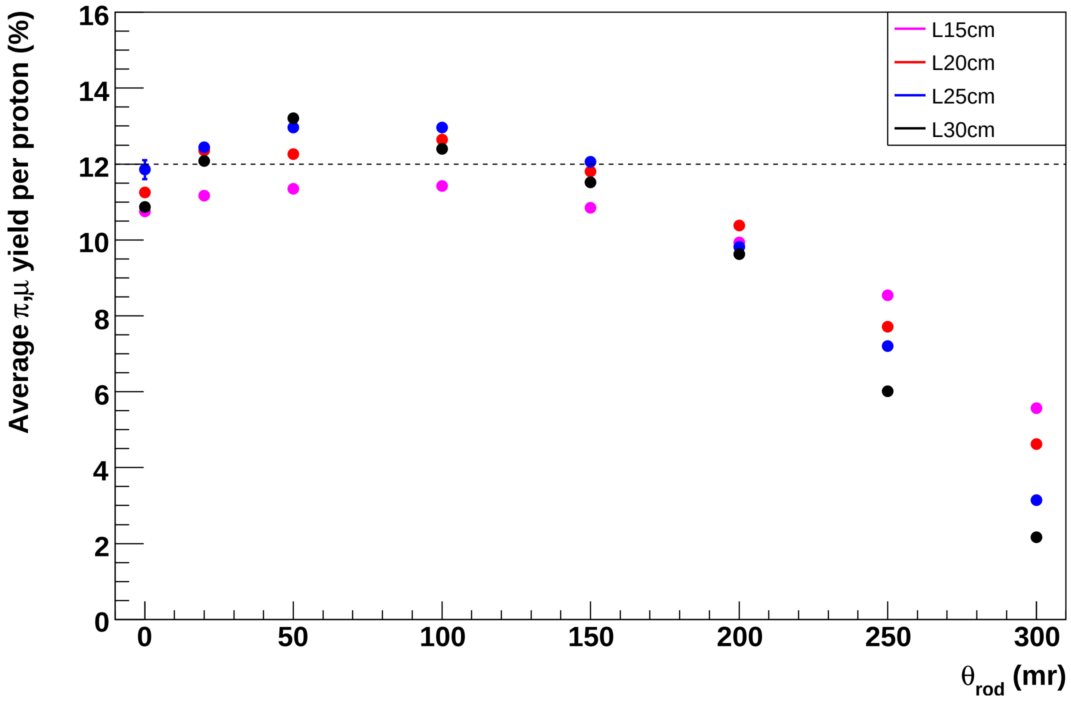
Kinetic energy distribution of π and μ at $z = 6\,\mathrm{m}$ inside aperture.

Dotted lines represent particle K.E. acceptance range

Charge averaged π, μ yield per proton at $z = 6\,\mathrm{m}$ for $r_{\mathrm{beam}} = 0.25\,\mathrm{cm}$



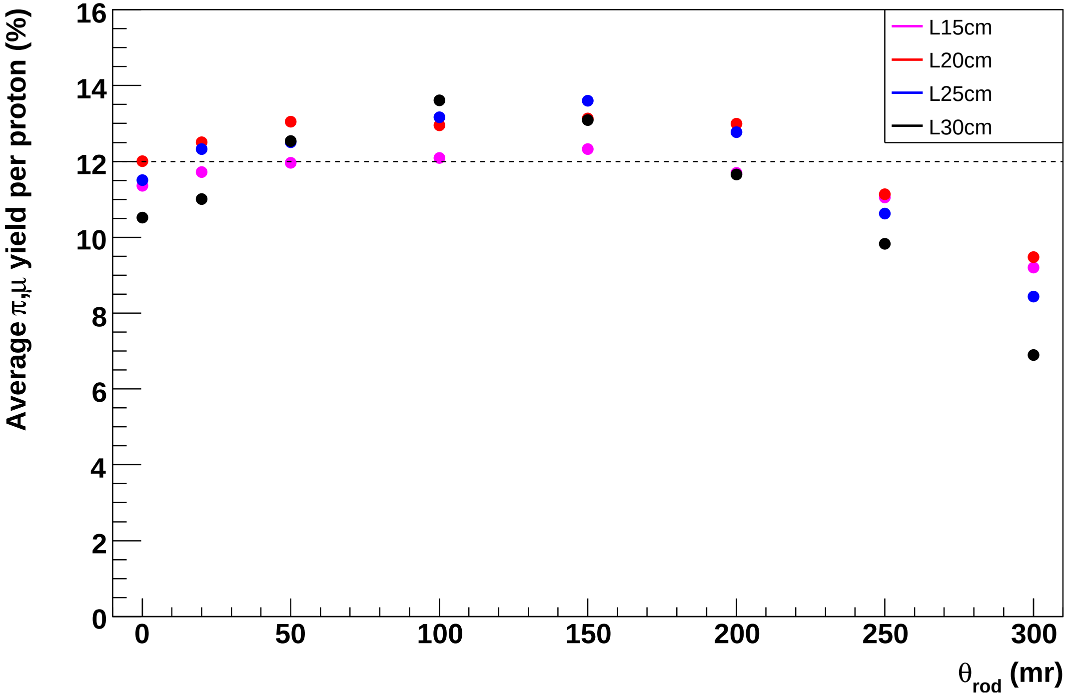
Original field



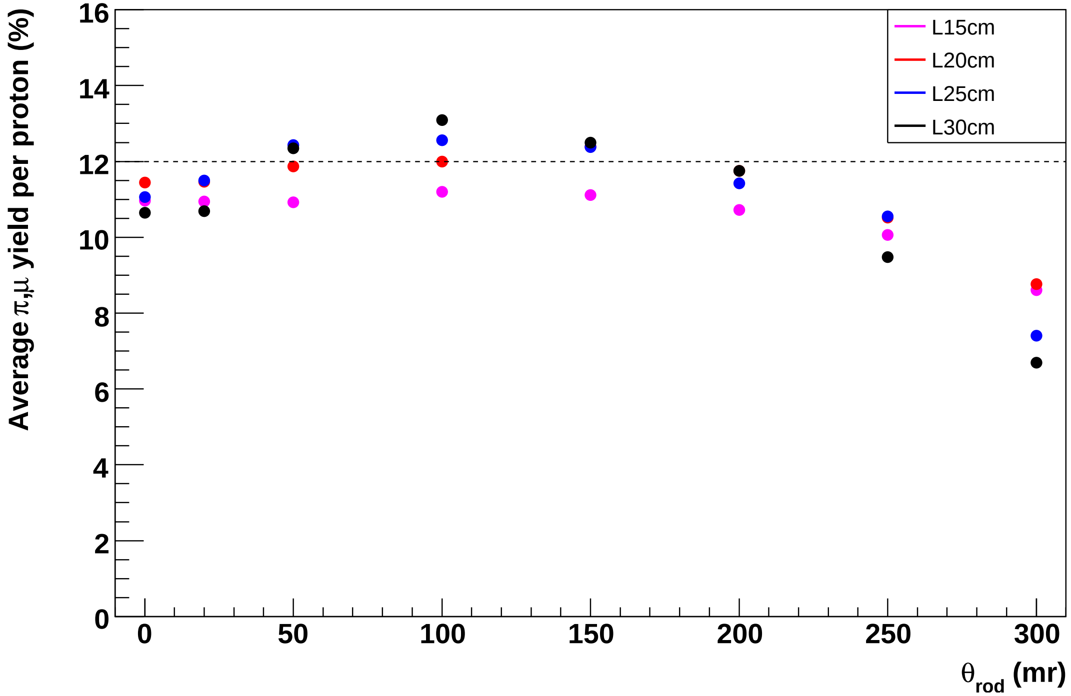
Helmholtz + StudyII field

Dotted line is Hg jet yield for 10 GeV beam (using StudyII optimal tilt, radii)

Charge averaged π, μ yield per proton at $z = 6\,\text{m}$ for $r_{\text{beam}} = 0.50\,\text{cm}$



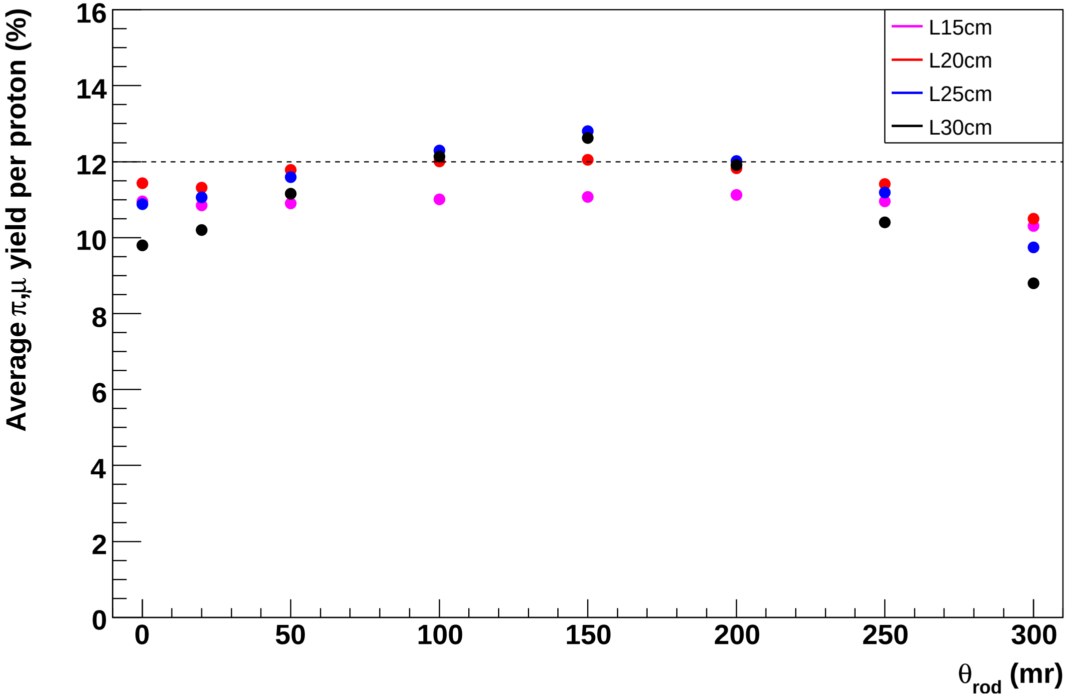
Original field



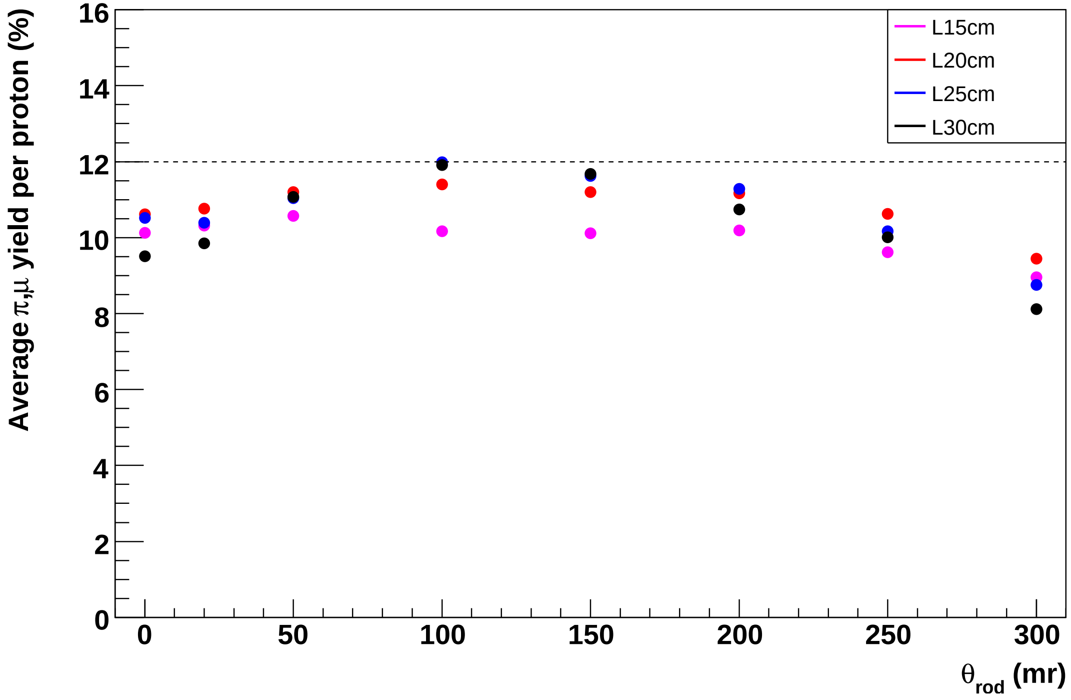
Helmholtz + StudyII field

Dotted line is Hg jet yield for 10 GeV beam (using StudyII optimal tilt, radii)

Charge averaged π, μ yield per proton at $z = 6\,\mathrm{m}$ for $r_{\mathrm{beam}} = 0.75\,\mathrm{cm}$



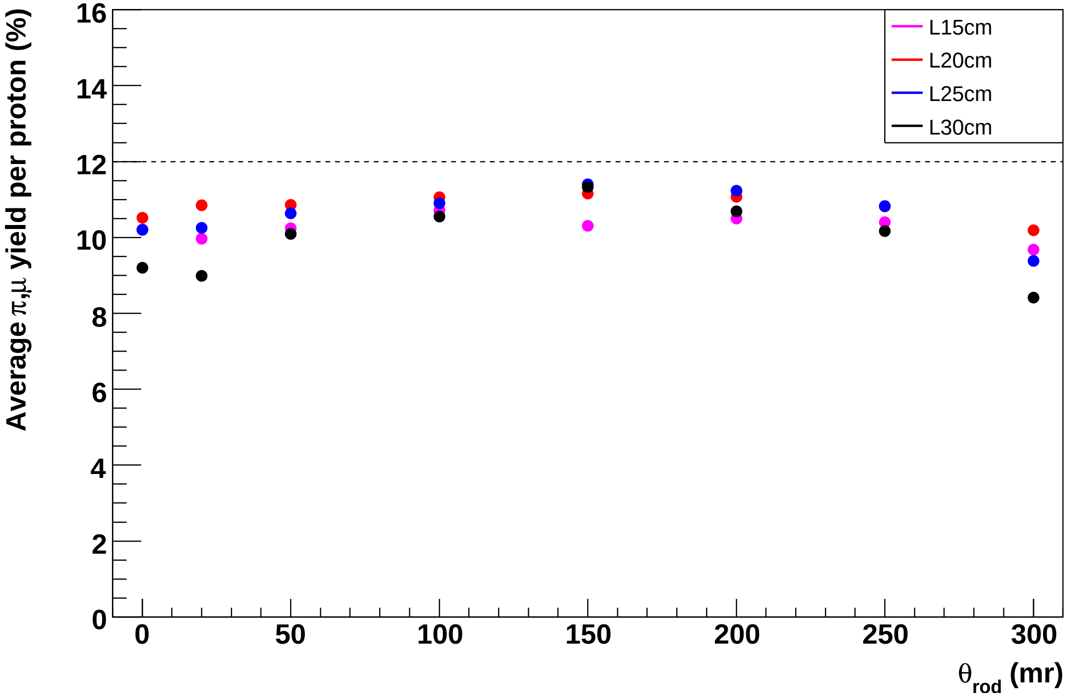
Original field



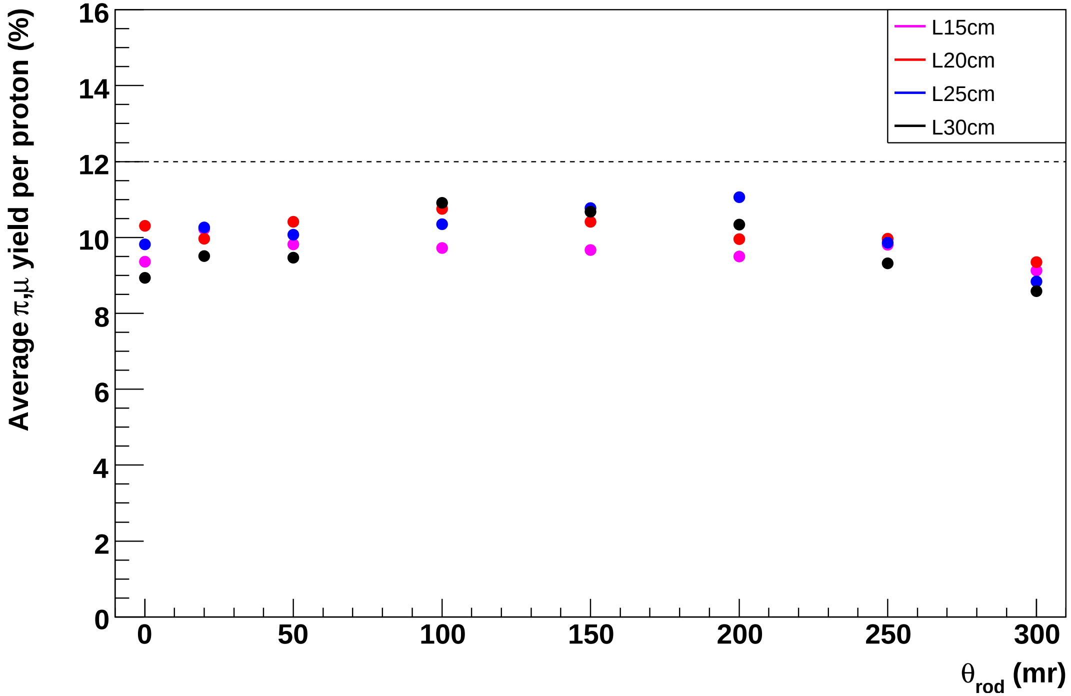
Helmholtz + StudyII field

Dotted line is Hg jet yield for 10 GeV beam (using StudyII optimal tilt, radii)

Charge averaged π, μ yield per proton at $z = 6\,\mathrm{m}$ for $r_{\mathrm{beam}} = 1\,\mathrm{cm}$



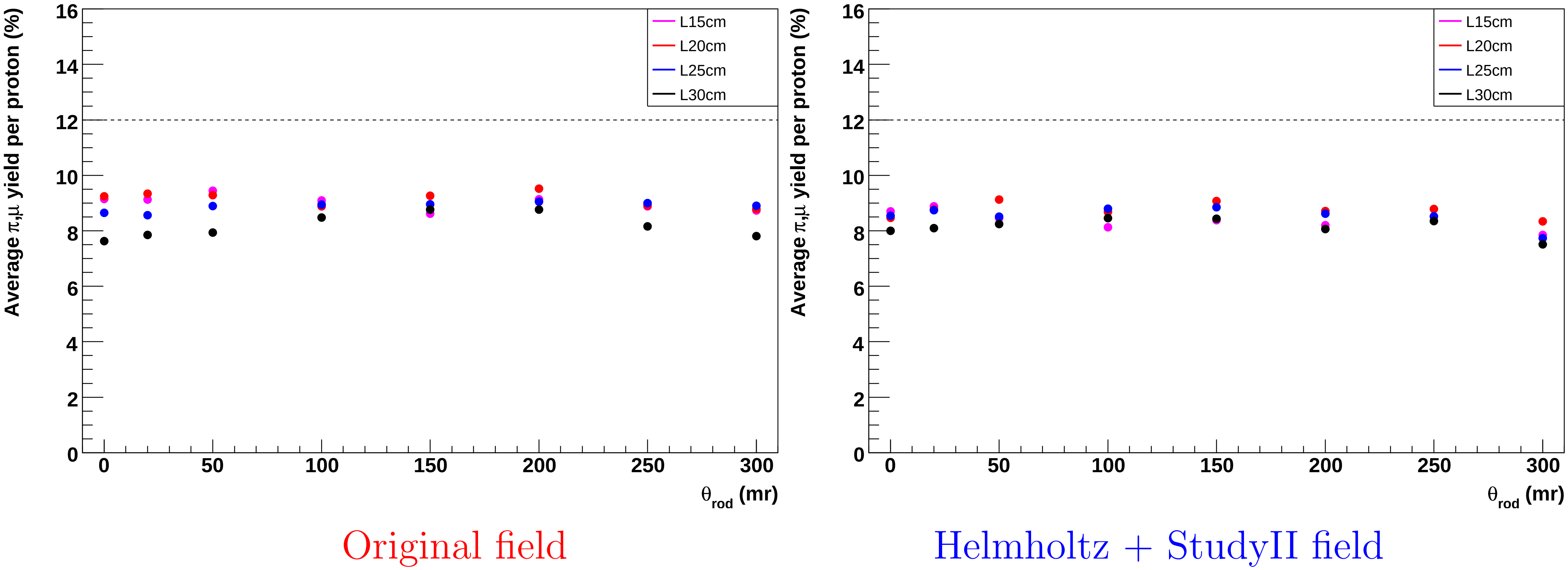
Original field



Helmholtz + StudyII field

Dotted line is Hg jet yield for 10 GeV beam (using StudyII optimal tilt, radii)

Charge averaged π, μ yield per proton at $z = 6\,\mathrm{m}$ for $r_{\mathrm{beam}} = 1.5\,\mathrm{cm}$



Dotted line is Hg jet yield for 10 GeV beam (using StudyII optimal tilt, radii)

Summary

- Presented π, μ yields for solid tungsten target rods; $E_p = 10\,\text{GeV}$
- Varied rod lengths, radii and tilts; $\theta_{\text{beam}} = \theta_{\text{rod}}$, $r_{\text{beam}} = r_{\text{rod}}$
- Helmholtz geometry yields are $> 90\%$ of original geometry yields
- Helmholtz geometry yields:
  - Highest yields for $r_{\text{rod}} = 0.25\,\text{cm}$ and $0.50\,\text{cm}$ (target is too small: shocks)
  - Highest yield for $r_{\text{rod}} = 0.75\,\text{cm}$ is the same as optimal Hg jet case
  - Lower yields for $r_{\text{rod}} \geq 1\,\text{cm}$ (more absorption).
  - Optimal rod tilt (= beam tilt) between 100 and 150 mr.
  - Overall optimal rod length is $\geq 25\,\text{cm}$ (≥ 2.6 interaction lengths).