MARS Target Re-absorption Studies

John Back
University of Warwick

5th July 2007
Introduction

- Using MARS code and Study-II geometry to find pion & muon absorption
- Counting number of \( \pi \) and \( \mu \) along different \( z \) planes within target aperture
  - Ratio of yields for different target arrangements compared with “1 rod” gives the \( \pi \) and \( \mu \) re-absorption as a function of \( z \)
  - All rods have a length of 30 cm. Compared two scenarios:
    * 1 rod vs many rods, all inclined \(-100 \text{ mrad} \) w.r.t. \( z \) axis (\( x - z \) plane)
    * 1 rod vs 3 rods all along \( z \) axis (previous results)
  - One rod centre at \( z = -15 \text{ cm} \), same as \( z \) position of (Study-II) Hg jet crossing proton beam (and intersecting \( z \) axis).
- Proton beam (E=10 GeV) is inclined \(-67 \text{ mrad} \) from \( z \) axis in \( x - z \) plane

\( x \) = vertical direction in MARS, \( z \) = horizontal axis along target
Target Geometry:
- Iron plug (light blue)
- SC magnets (yellow)
- Cu coils (purple)
- Shielding (brown)
- W rods (dark blue)
- $B$ field lines (red)

Beam:
- 10 GeV protons
- Inclined $-67$ mrad w.r.t z axis (x-z plane); x is along vertical direction
- Circular parabolic with radius 0.5, 1 or 1.5 cm
- One W rod vs many ("3") W rods tilted w.r.t. $z$ axis (10 cm spacing).
- Beam has radius of 0.5 cm.
- Rod diameters: 1, 2, and 3 cm.

- Dotted vertical lines show $\pm 30$ cm $\Delta z$ intervals around 20 T peak region. First rod always positioned at $z_{\text{centre}} = -15$ cm.
- 2nd yield peaks are from the $p$ beam hitting the shielding.
• Previous results of one rod vs 3 rods all along $z$ axis (10 cm spacing).

• Beam has radius of 0.5 cm.

• Rod diameters: 1, 2, and 3 cm.

• Dotted vertical lines show $\pm 30$ cm $\Delta z$ intervals around 20 T peak region. First rod always positioned at $z_{\text{centre}} = -15$ cm.

• 2nd yield peaks are from the $p$ beam hitting the shielding.
- One W rod with many W rods tilted w.r.t. z axis (10 cm spacing).
- Beam has radius of 1 cm.
- Rod diameters: 1, 2, and 3 cm.
Previous results of 1 rod vs 3 rods all along $z$ axis (10 cm spacing).

- **Beam has radius of 1 cm.**
- **Rod diameters: 1, 2, and 3 cm.**
• One W rod with many W rods tilted w.r.t. $z$ axis (10 cm spacing).
• Beam has radius of 1.5 cm.
• Rod diameters: 1, 2, and 3 cm.
- Previous results of 1 rod vs 3 rods all along $z$ axis (10 cm spacing).
- Beam has radius of 1.5 cm.
- Rod diameters: 1, 2, and 3 cm.
\(\pi, \mu\) yields and lost frac (absorption) at \(z = 6\) m c.f. best for inclined W rods

All Hg and W (50\% \(\rho\)) jets: \(r_{\text{beam}} = 0.15\) cm and \(r_{\text{jet}} = 0.5\) cm

For \(r_{\text{beam}} = 0.5\) cm, rod diameter = 1 cm  
* = 1 rod case is also inclined

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1 W rod</th>
<th>3 W rods</th>
<th>W Toroid</th>
<th>Inclined W rods</th>
<th>Hg jet</th>
<th>W jet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pos Yield</td>
<td>0.021</td>
<td>0.013</td>
<td>0.017</td>
<td>0.029</td>
<td>0.033</td>
<td>0.031</td>
</tr>
<tr>
<td>Neg Yield</td>
<td>0.021</td>
<td>0.013</td>
<td>0.016</td>
<td>0.030</td>
<td>0.037</td>
<td>0.030</td>
</tr>
<tr>
<td>Pos LFrac</td>
<td>—</td>
<td>38%</td>
<td>21%</td>
<td>5%(*)</td>
<td>4%</td>
<td>+3%</td>
</tr>
<tr>
<td>Neg LFrac</td>
<td>—</td>
<td>40%</td>
<td>25%</td>
<td>8%(*)</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>

For \(r_{\text{beam}} = 1\) cm, rod diameter = 2 cm

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1 W rod</th>
<th>3 W rods</th>
<th>W Toroid</th>
<th>Inclined W rods</th>
<th>Hg jet</th>
<th>W jet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pos Yield</td>
<td>0.027</td>
<td>0.012</td>
<td>0.015</td>
<td>0.026</td>
<td>0.033</td>
<td>0.031</td>
</tr>
<tr>
<td>Neg Yield</td>
<td>0.027</td>
<td>0.012</td>
<td>0.014</td>
<td>0.026</td>
<td>0.037</td>
<td>0.030</td>
</tr>
<tr>
<td>Pos LFrac</td>
<td>—</td>
<td>56%</td>
<td>45%</td>
<td>14%(*)</td>
<td>4%</td>
<td>+3%</td>
</tr>
<tr>
<td>Neg LFrac</td>
<td>—</td>
<td>58%</td>
<td>48%</td>
<td>16%(*)</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>

For \(r_{\text{beam}} = 1.5\) cm, rod diameter = 2 cm

<table>
<thead>
<tr>
<th>Scenario</th>
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<th>W Toroid</th>
<th>Inclined W rods</th>
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<th>W jet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pos Yield</td>
<td>0.022</td>
<td>0.011</td>
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<td>0.022</td>
<td>0.033</td>
<td>0.031</td>
</tr>
<tr>
<td>Neg Yield</td>
<td>0.023</td>
<td>0.010</td>
<td>0.010</td>
<td>0.022</td>
<td>0.037</td>
<td>0.030</td>
</tr>
<tr>
<td>Pos LFrac</td>
<td>—</td>
<td>49%</td>
<td>50%</td>
<td>10%(*)</td>
<td>4%</td>
<td>+3%</td>
</tr>
<tr>
<td>Neg LFrac</td>
<td>—</td>
<td>57%</td>
<td>56%</td>
<td>12%(*)</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Summary

- Having rods inclined at $-100 \text{ mrad}$ w.r.t $z$ axis significantly improves final $\pi$ and $\mu$ yields compared to toroid/3 rods all along $z$ axis.

  - Final charge-averaged $\pi, \mu$ yields for inclined rods comparable to 1 rod:

    | $r_{\text{beam}}$ | $d_{\text{rod}}$ | 1 W rod along $z$ axis ($y_1$) | Inclined W rods ($y_2$) | $\frac{y_1}{y_2}$ |
    |------------------|------------------|-------------------------------|------------------------|------------------|
    | 0.5 cm           | 1 cm             | 0.021                         | 0.030                  | 0.70             |
    | 1.0 cm           | 2 cm             | 0.027                         | 0.026                  | 1.04             |
    | 1.5 cm           | 2 cm             | 0.023                         | 0.022                  | 1.05             |

- Particle jets ($r_{\text{jet}} = 5 \text{ mm}$) have larger yields: $\sim 0.035$ for $r_{p_{\text{beam}}} = 1.5 \text{ mm}$.

- Shown tables of the $\pi$ and $\mu$ end yields (per p per GeV) and the fraction of $\pi$ and $\mu$ lost when we have the extra target material c.f. the “one rod case”.

John Back  
Target Meeting  
5 July 07
- W toroid in the $y-z$ (horizontal) plane:
  $R_{\text{curv}} \sim 5 \text{ m}$
  Cross-sectional $r$: 0.5, 1 and 1.5 cm.

- Beam is inclined $-67 \text{ mrad}$ w.r.t $z$ axis in $x-z$ (vertical plane), as before.

- Hg toroid has same geometry ($r_{\text{beam}} = 0.4 \text{ cm}$).
• Hg jet in the $x - z$ (vertical) plane: inclined at $-100$ mrad from $z$ axis ($r = 0.5$ cm)

• Beam is inclined $-67$ mrad w.r.t $z$ axis in $x - z$ (vertical plane), as before. But $r_{\text{beam}} = 0.15$ cm.

• W “jet” has same geometry and beam