Study of Neutron Rates at the CRV for 1 and 3 GeV Proton Beam

Mu2e-II Working Group at CSS2013

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This Talk

- Uses current snapshot of shielding configuration for Mu2E “Geometry 13”
- Generate “PS_only” files for 1 and 3 GeV and compare them to 8 GeV.
  \( \text{PS\_only} = \text{neutrons produced at the primary target which intersect a virtual detector at the downstream end of the PS extended to the TS} \)
- Count neutrons at various regions in the Cosmic Ray Veto system
- Compare 1, 3, 8 GeV rates normalized to number of stopping muons
- Only comment on “beam” produced sources and shielding implications.
  \( \text{Beam} = \text{particles transported through TS into DS} \)
Simulation Details

• Use g4bl V2.12, geant4 v09-05-patch-01, QGSP_BERT_HP
• Generate PS_only files of neutrons for 1M POT
• Use these 200 times (with different seeds) to transport to CRV counters → 200M POT
• Count neutrons in CRV layer 1 and layer 3 (they are not identical) and then take their average
Geometry #13

2x walls,
Barite around TS

Insert half-density poly plug at TS entrance below beam, density= 0.465
(maybe poly beads in bags stuffed in TS stand)
Cosmic Ray Veto Counter Layout

- Downstream
- Top
- Left
- Right
- Upstream
- TS Left
- TS Top

6/18/13
R. Coleman - Mu2e PMG
- HDPE Inner Neutron Shield (in yellow)
- Inner and outer proton absorber (in orange)
- CRV concrete (in grey and purple) 36” thick → studies underway with barite concrete
- End cap concrete (in orange) 36” thick → studies underway with barite
- Muon Beam Stop HDPE(yellow) and stainless steel (red)
- No shielding material between DS cryostat and concrete and no additional material (Pb, B-poly) on concrete walls
July 2013 Snapshot of n CRV rates at 8 GeV

Beam Source = (mostly) charged particles transported through TS to DS → neutrons produced by interactions and mu/π captures in TS, stopping target, and Muon Beam Stop

PS Only Multiply by 13 to compare to Beam Source

All DS CRV counters dominated by Beam. TS both Beam and PS. Still working on shielding especially in PS/TS region
Beam vs PS_only sources at 1 and 3 GeV

- The rate of backgrounds from beam sources will \(\sim\) scale with the number of stopping muons \(\rightarrow\) will need either/both additional shielding in the DS region and change in CRV design (e.g. extra layer). Not addressed today

- PS-produced neutrons decrease as energy lowered from 8 to 3 or 1 GeV. But so do number of stopped muons. Look at relative CRV rate from PS_only to number of stopped muons
CRV PS_only Neutron rates – raw values

- 200M POT → # CRV neutrons (average of layer 1 and 3)
- DS-upstream = TS-right

<table>
<thead>
<tr>
<th>Proton E CRV region</th>
<th>1 GeV # neutrons</th>
<th>3 GeV # neutrons</th>
<th>8 GeV # neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS-downstrm</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>DS-right</td>
<td>1</td>
<td>33</td>
<td>72</td>
</tr>
<tr>
<td>DS-top</td>
<td>27</td>
<td>154</td>
<td>567</td>
</tr>
<tr>
<td>DS-left</td>
<td>29</td>
<td>86</td>
<td>234</td>
</tr>
<tr>
<td>DS-upstrm</td>
<td>41</td>
<td>596</td>
<td>1634</td>
</tr>
<tr>
<td>TS-top</td>
<td>15</td>
<td>201</td>
<td>642</td>
</tr>
<tr>
<td>TS-right</td>
<td>34</td>
<td>104</td>
<td>292</td>
</tr>
</tbody>
</table>
**CRV PS_only Neutron rates – normalized values**

- 200M POT $\rightarrow$ # CRV neutrons (average of layer 1 and 3)
- All DS=DS-down+DS-R+DS-top+DS-L
- All TS=DS-upstrm+TS-top+TS-L

<table>
<thead>
<tr>
<th>Proton Energy</th>
<th>1 GeV</th>
<th>3 GeV</th>
<th>8 GeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>#CRV/stopped muon</td>
<td>$\times 10^{-3}$</td>
<td>$\times 10^{-3}$</td>
<td>$\times 10^{-3}$</td>
</tr>
<tr>
<td>All DS</td>
<td>1.0</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>All TS</td>
<td>1.6</td>
<td>3.3</td>
<td>4.0</td>
</tr>
<tr>
<td>#stopped muons/POT</td>
<td>0.00014</td>
<td>0.00067</td>
<td>0.00161</td>
</tr>
</tbody>
</table>
Conclusions

• Lower proton energies (1 and 3 GeV) give fewer neutrons from the production target in CRV counters

• But the reduction in neutron rate is close to the reduction in the number of stopped muons for 1 and 3 GeV protons → background rates per stopped muon are similar for different proton energies with only a slight improvement at 1 GeV

• Will need to add shielding or modify CRV design for running at 1 and 3 GeV