Knife-edge Collimator for Proton Range Verification

Vanny Maranatha Sihotang
July 30, 2021
Goal
▪ Developed Knife-Edge Collimator to improve the detection efficiency for proton range verification.

Outline
▪ Simulation Setup
▪ Column Wise Profile Plane
▪ Gaussian Fitting
▪ Delta Peak Range
▪ Conclusion and next simulation
Simulation Setup

PBS
-150mm

PMMA Phantom: 40 x 40 x 110.42 mm³
PMMA density: 1.19 g/cm³
Tungsten Box: 80 x 40 x 44.71 mm³
Tungsten density: 19.3 g/cm³
LYSO detector: 20 x 51.2 x 102.4 mm³
LYSO density: 5.37 g/cm³
Number of entries: 5 x 10⁸ protons
Energy: 80 MeV, 85 MeV, 90 MeV, 95 MeV, 100 MeV
Physics List: QGSP_BIC_HP_EMY
PBS Sigma Xx Sigma Y: 3mm x 3mm
The total counts along the depth of crystals with the threshold energy is 250keV. The reference energy for this simulation is 90 MeV, it has range 55.21mm. Which is this range is in the center of the collimator and detector. There are 80 MeV and 85 MeV under this reference energy and 95 MeV, 100 MeV over the reference energy.
The distributions with the knife edge collimator is clearly than without collimator, the shift range under the reference energy and over the reference energy. The range over the reference energy (95 MeV & 100 MeV) in the phantom will be detected under the reference energy in the detector and also for the range under the reference energy.
Gaussian +2nd Polynomial fitting to get the peak position value along the plane0 depth
## Proton Range

<table>
<thead>
<tr>
<th>Proton Energy (MeV)</th>
<th>Nist’s Range (mm)</th>
<th>Expected Delta Range wrt 90 MeV</th>
<th>Peak Range</th>
<th>Delta Peak Range wrt to 90 MeV</th>
<th>Total Counts</th>
<th>Peak Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>44.73</td>
<td>10.48</td>
<td>27.41 (87.71 mm)</td>
<td>-6.02 mm</td>
<td>30375</td>
<td>1554</td>
</tr>
<tr>
<td>85</td>
<td>49.85</td>
<td>5.36</td>
<td>26.97 (86.30 mm)</td>
<td>-4.61 mm</td>
<td>39315</td>
<td>2137</td>
</tr>
<tr>
<td>90</td>
<td>55.21</td>
<td></td>
<td>25.53 (81.69 mm)</td>
<td></td>
<td>50304</td>
<td>2840</td>
</tr>
<tr>
<td>95</td>
<td>60.79</td>
<td>-5.58</td>
<td>24.17 (77.34 mm)</td>
<td>4.35 mm</td>
<td>63952</td>
<td>3530</td>
</tr>
<tr>
<td>100</td>
<td>66.61</td>
<td>-11.4</td>
<td>23.64 (75.64 mm)</td>
<td>6.05 mm</td>
<td>79816</td>
<td>3858</td>
</tr>
</tbody>
</table>

![Total Counts in Plane 0](image1.png)

![Peak Counts in Plane 0](image2.png)
Conclusion and next simulation

- The knife edge collimator concept can use to predict the proton shift range
- Insert the range shifter
- Optimize the design (Proton beam - phantom – collimator – detector distance) for the test case and clinical case