# Optimized Target Parameters for Mercury Jet

X. Ding, D. B. Cline *UCLA*

H. Kirk, J. S. Berg *BNL*

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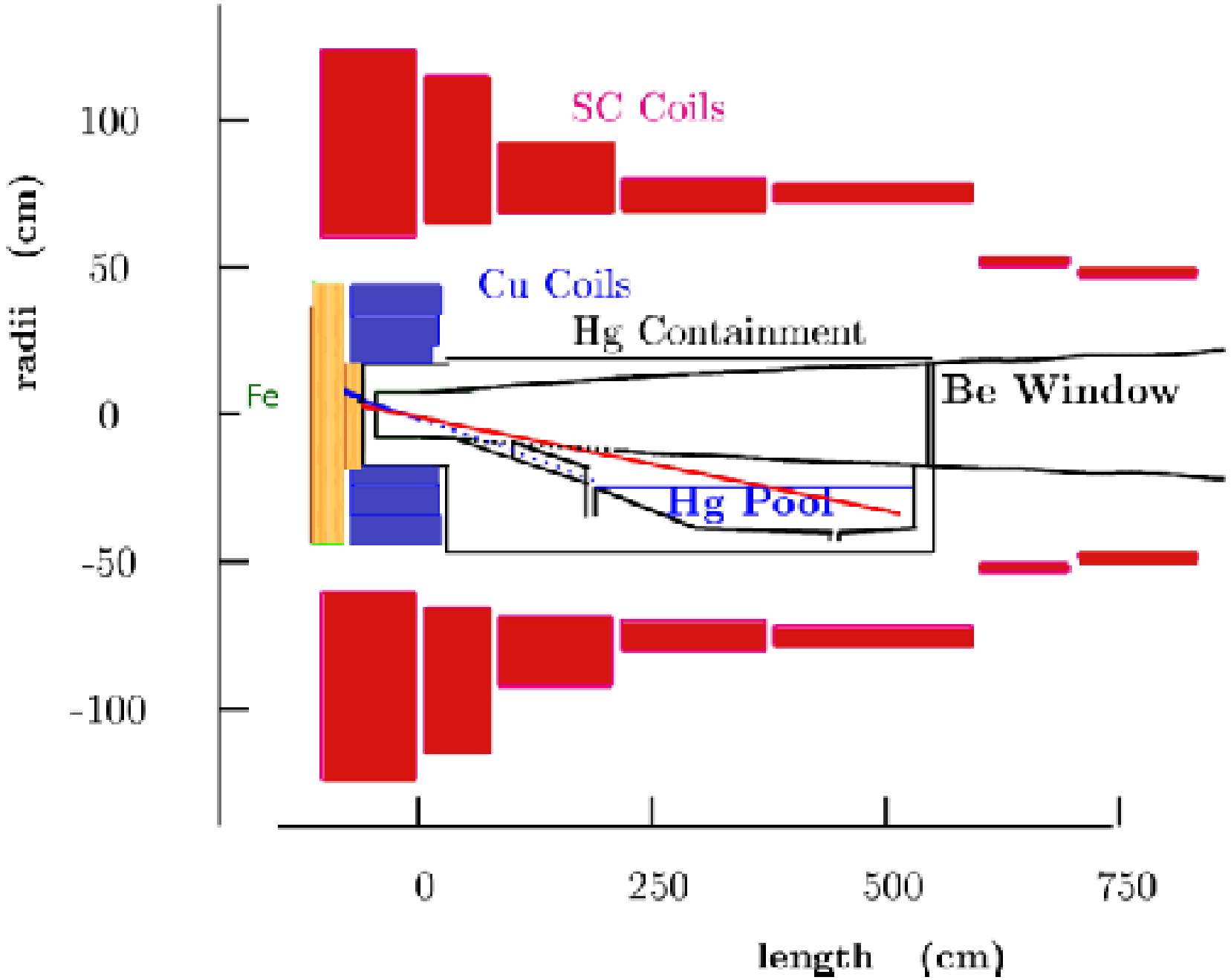
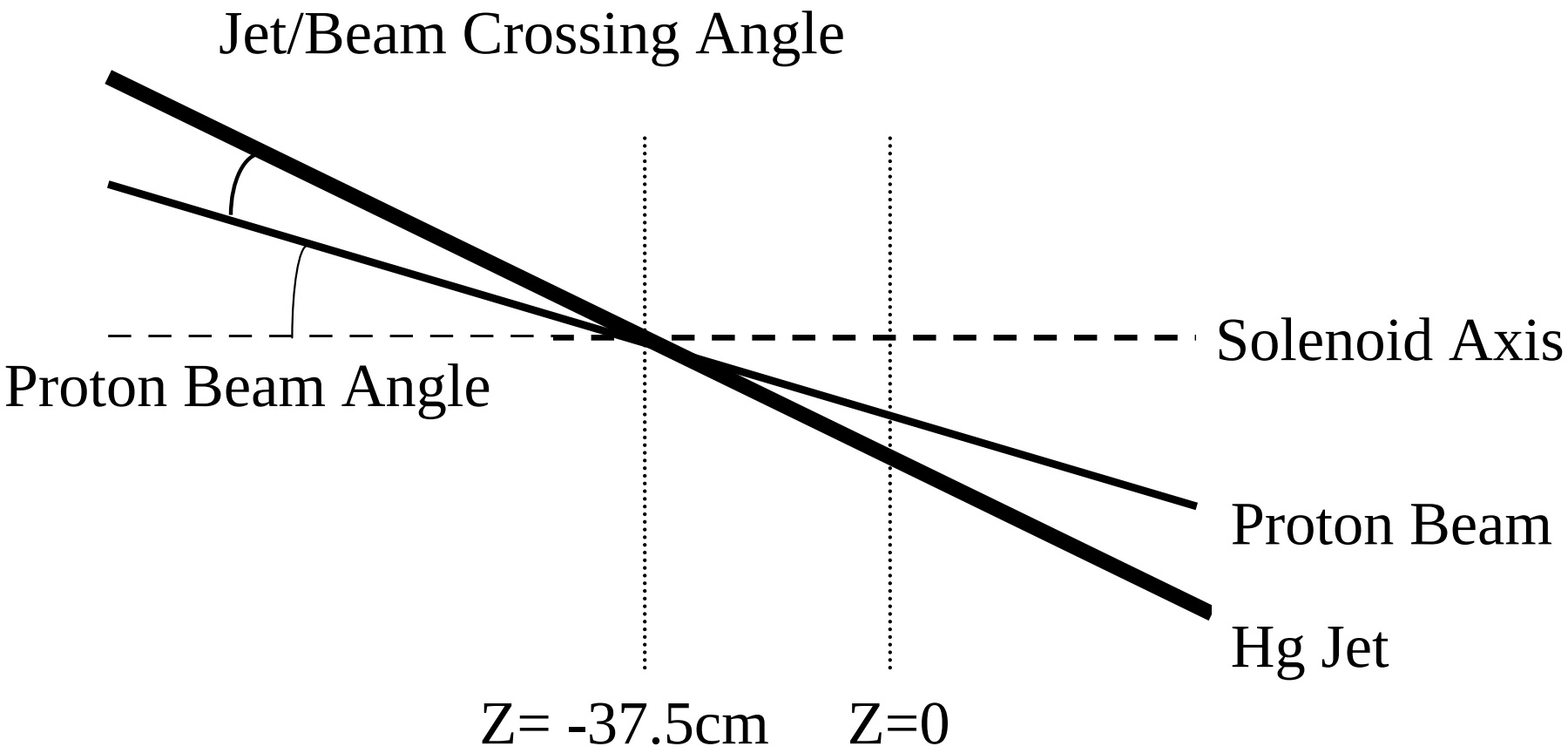
# Outline

1. Optimization method
2. Simulated target parameters
3. Target radius, beam angle and jet/beam crossing angle interpolation
4. Normalized Meson Study
5. Mesons through cooling


SC Coils
Cu Coils
Hg Containment
Be Window
Fe
Hg Pool
100
50
0
-50
-100
radii (cm)
0
250
500
750
length (cm)


Jet/Beam Crossing Angle
Solenoid Axis
Proton Beam Angle
Proton Beam
Hg Jet
Z= -37.5cm
Z=0

# Optimization Method

1) **Vary the target radius with the initial beam angle of 67mrad and beam/jet crossing angle of 33mrad. Count the mesons (positives +negatives) that cross the transverse plane at 50m downstream with the 40MeV<KE<180MeV selection. Make polynomial fit and find the target radius corresponding to the peak of mesons;**
2) **Vary the beam angle with above new target radius to find the value at the peak of mesons;**
3) **Vary the beam/jet crossing angle with above both new target radius and beam angle to find the value at the peak of mesons;**

# Optimization Method

4) **Repeat the above procedure three times to find the converged target parameters;**

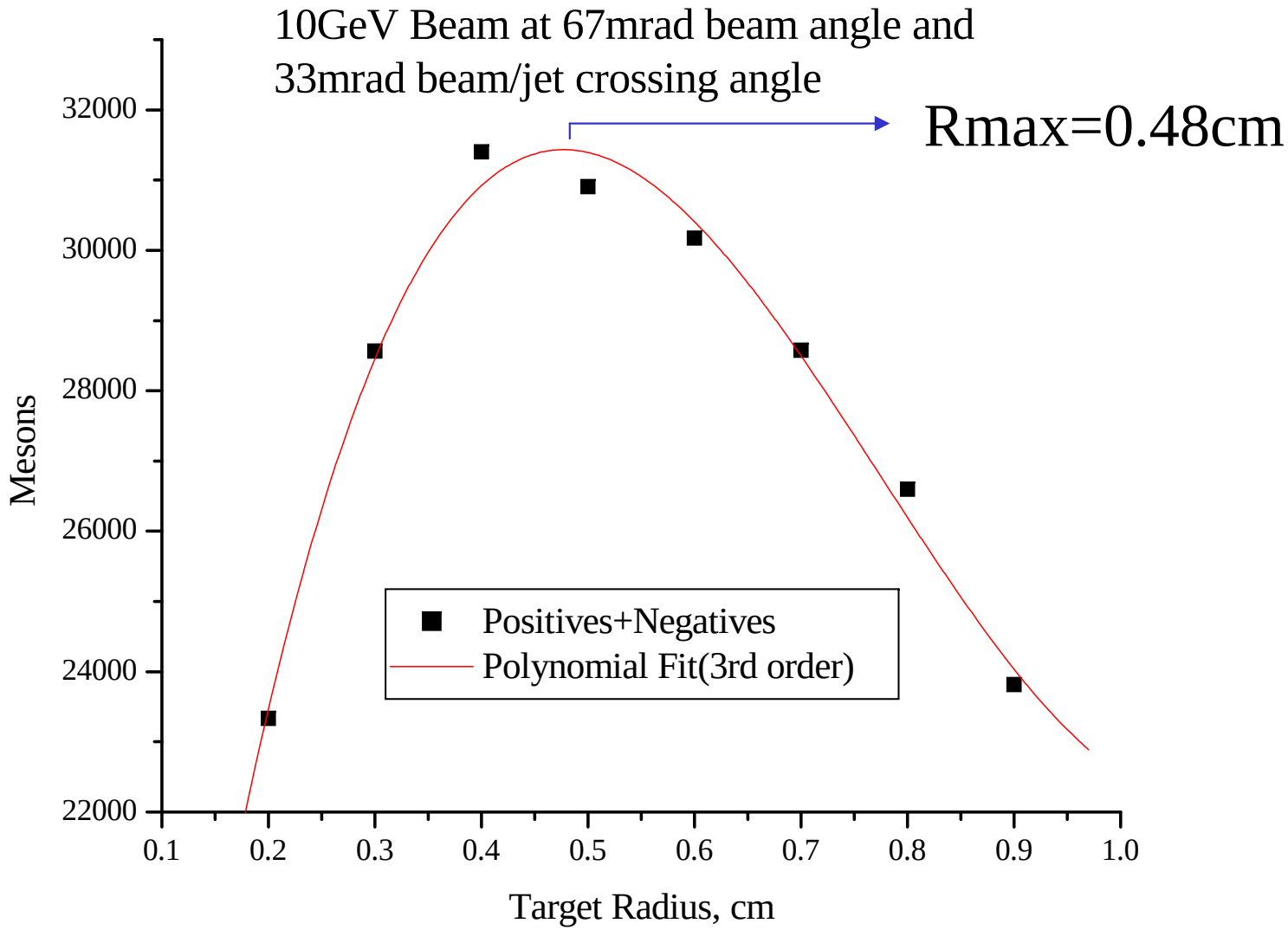
5) **Make interpolation with the final target parameters from above procedures at 10, 50 and 100GeV and get the new parameters at 20, 30, 40, 60, 70, 80 and 90GeV;**

6) **Vary the target radius with the interpolated beam angle and beam/jet crossing angle and compare the optimized data from simulation with that of interpolation.**

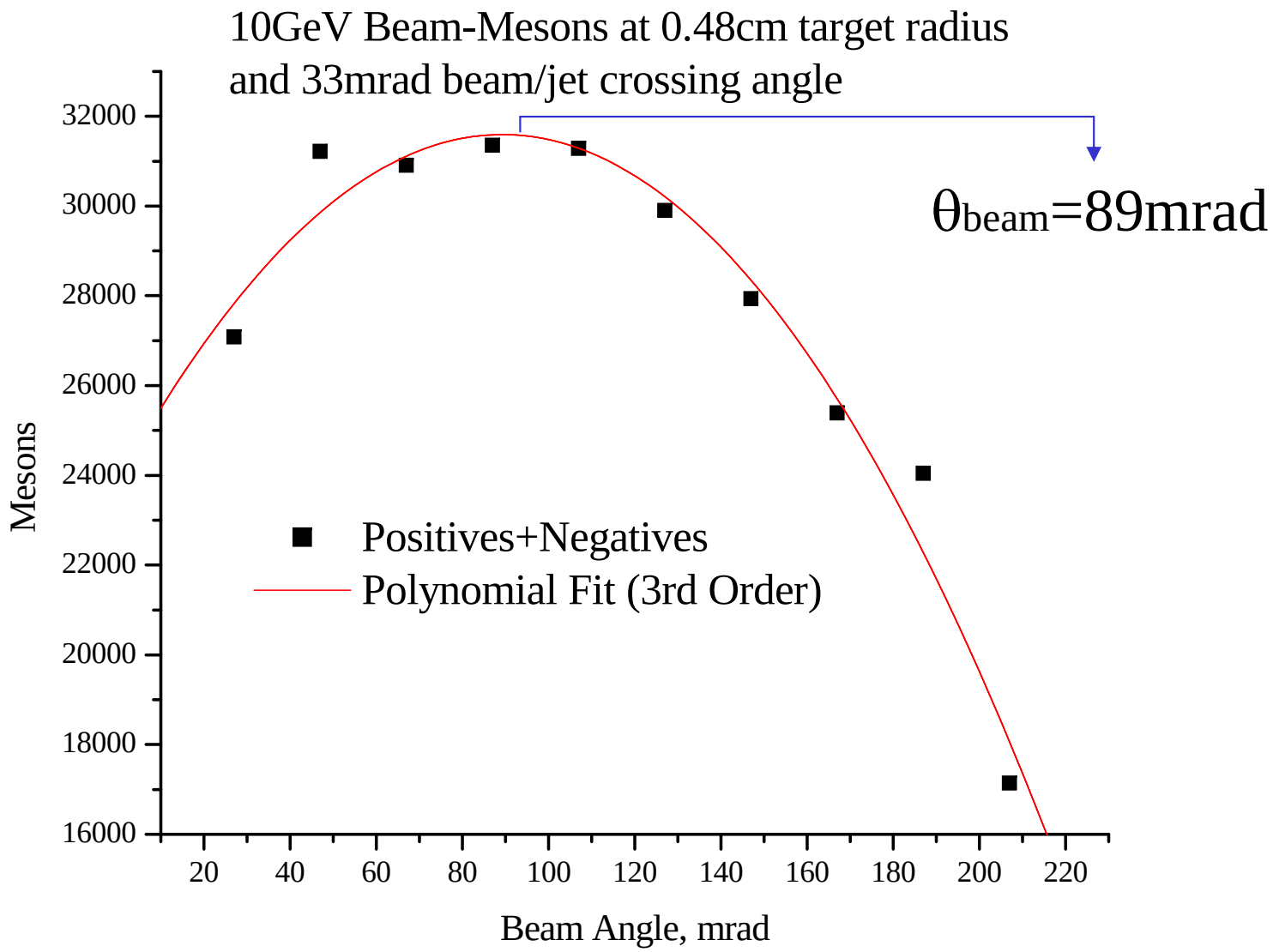
# Initial Target Parameters

| Beam Energy GeV | Beam Angle mrad | Beam/Jet Crossing Angle mrad |
|---|---|---|
| 10, 50, 100 | 67 | 33 |

# Step 1: Vary the Target Radius

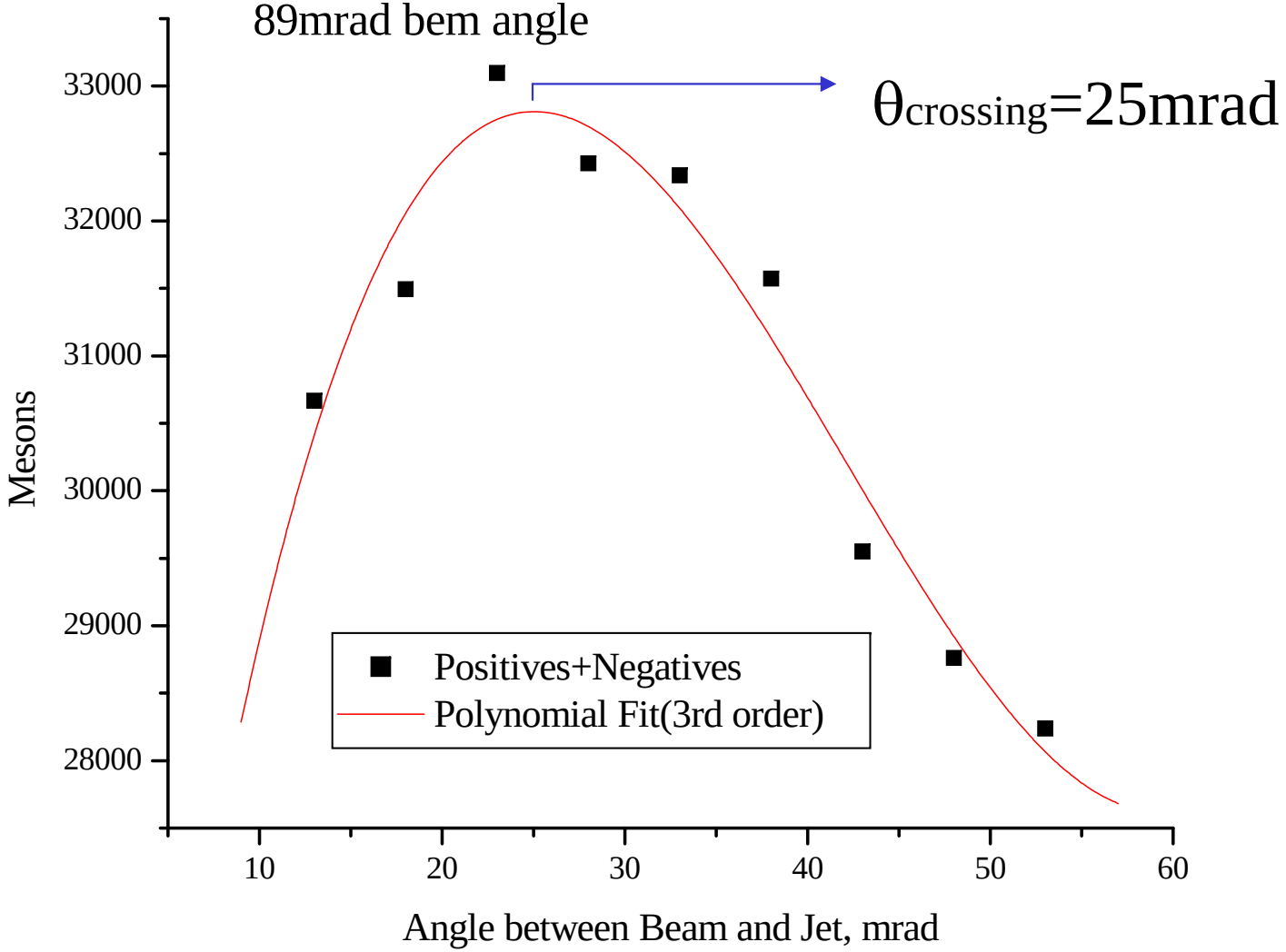


# Step 2: Vary the Beam Angle



# Step 3: Vary the Beam/Jet Crossing Angle

10GeV Beam at 0.48cm target radius and 89mrad bem angle

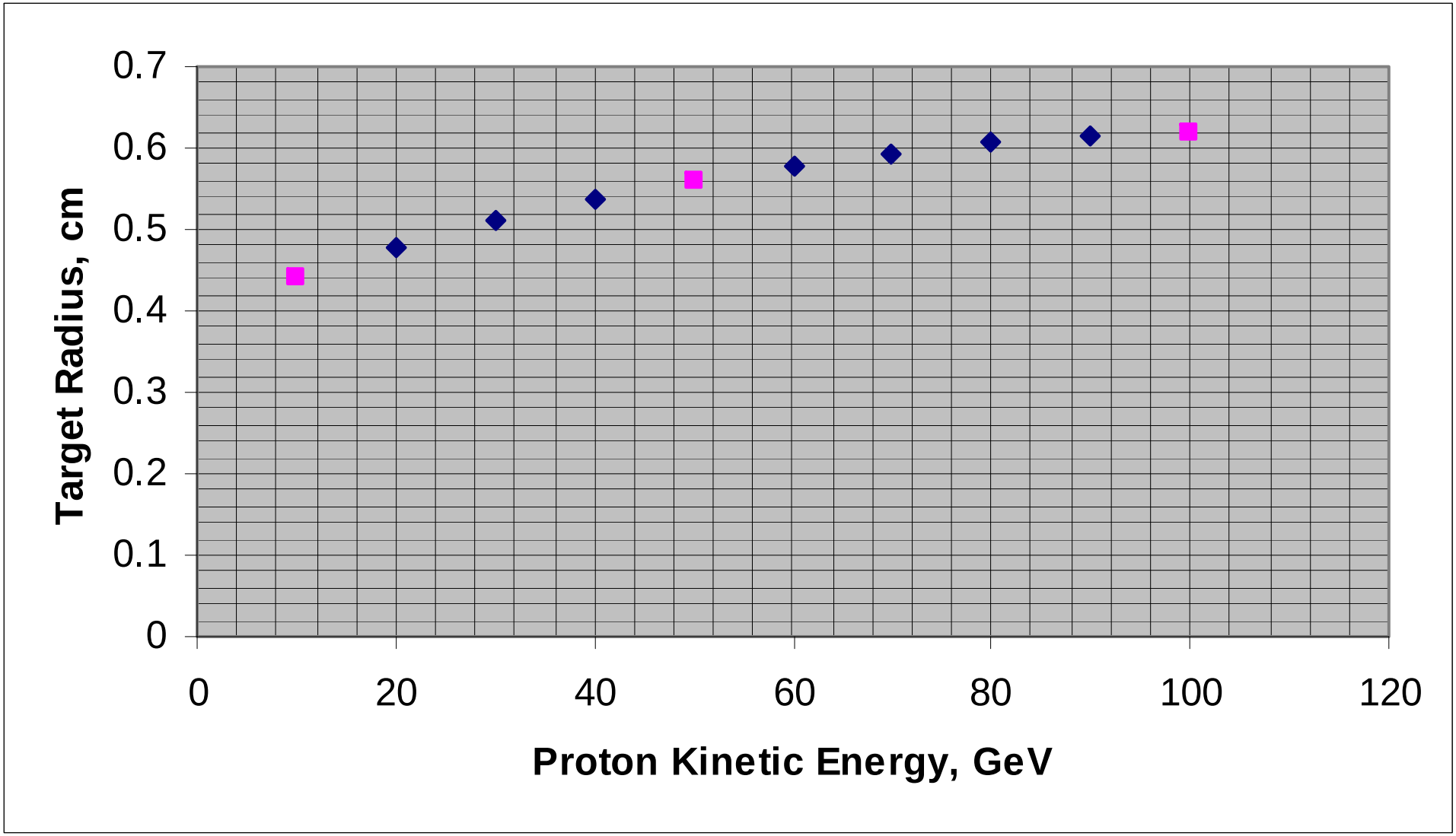


| Beam Energy GeV | Run No. | Vary Target Radius Cm/Mesons | Vary Beam Angle mrad/Mesons | Vary Beam/Jet Crossing Angle mrad/Mesons |
|---|---|---|---|---|
| 50 | zero | | 67 | 33 |
| | 1st | 0.65/111063 | 138/125871 | 26.5/126145 |
| | 2nd | 0.59/127089 | 129/127709 | 25/124165 |
| | 3rd | 0.57/128246 | 127/127700 | 23/127168 |
| | 4th | 0.55/128382 | 124/127760 | 23.36/126560 |

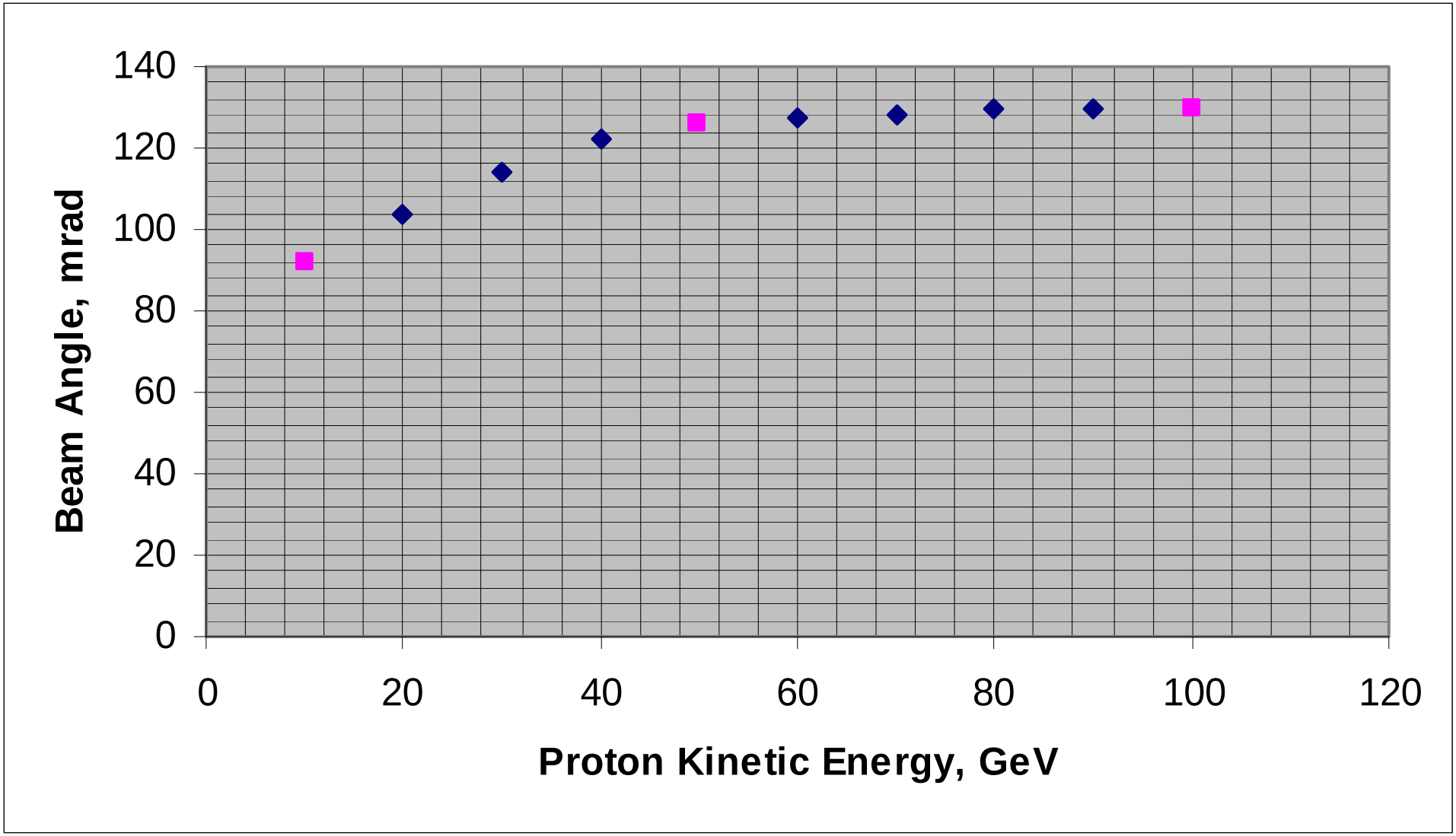
# Final Target Parameters

| Beam Energy GeV | Target Radius cm | Beam Angle mrad | Beam/Jet Crossing Angle mrad |
|---|---|---|---|
| 10 | 0.44 | 92 | 22 |
| 50 | 0.56 | 126 | 22 |
| 100 | 0.62 | 130 | 22 |

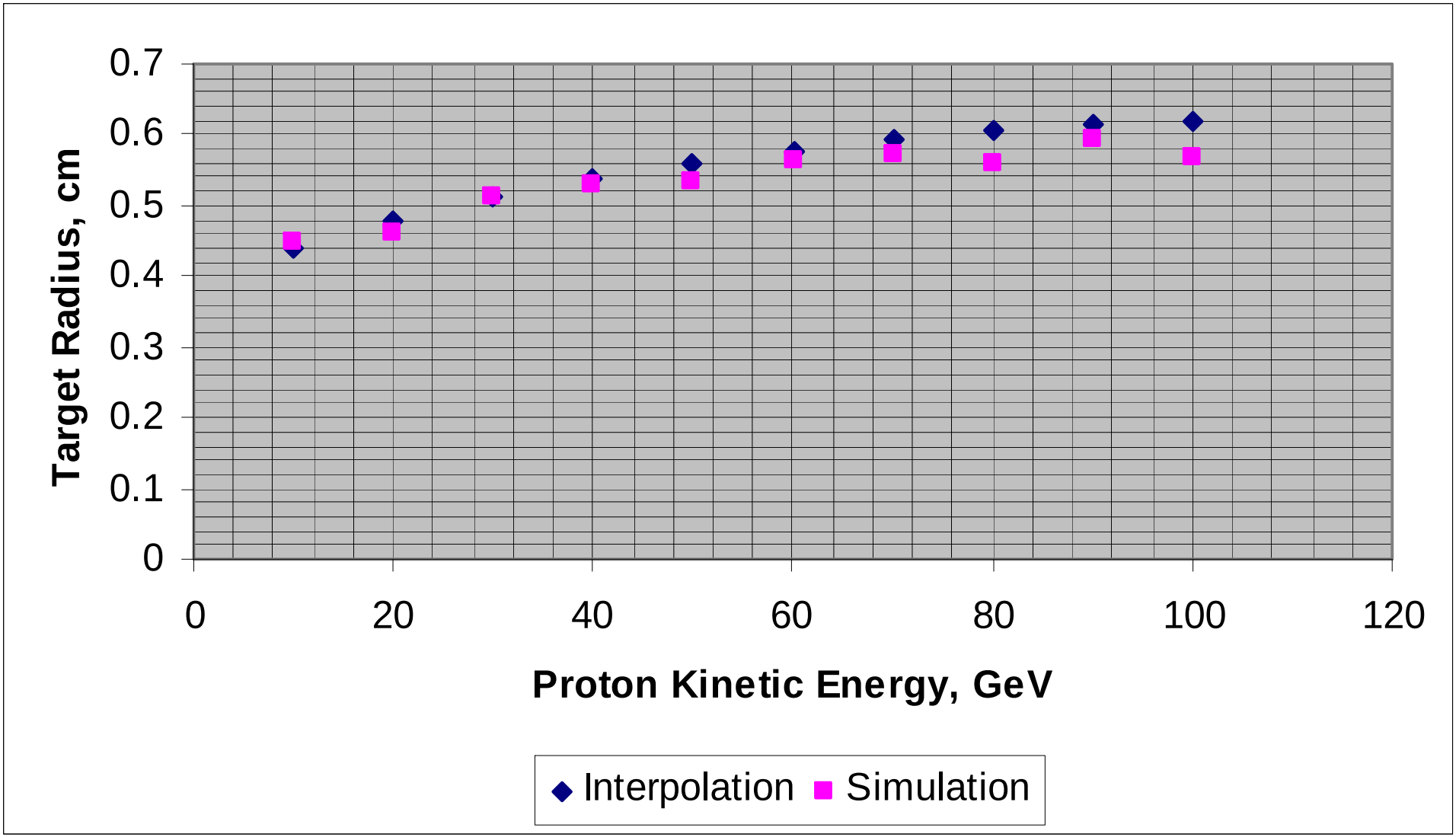
# Interpolation of Target Radius

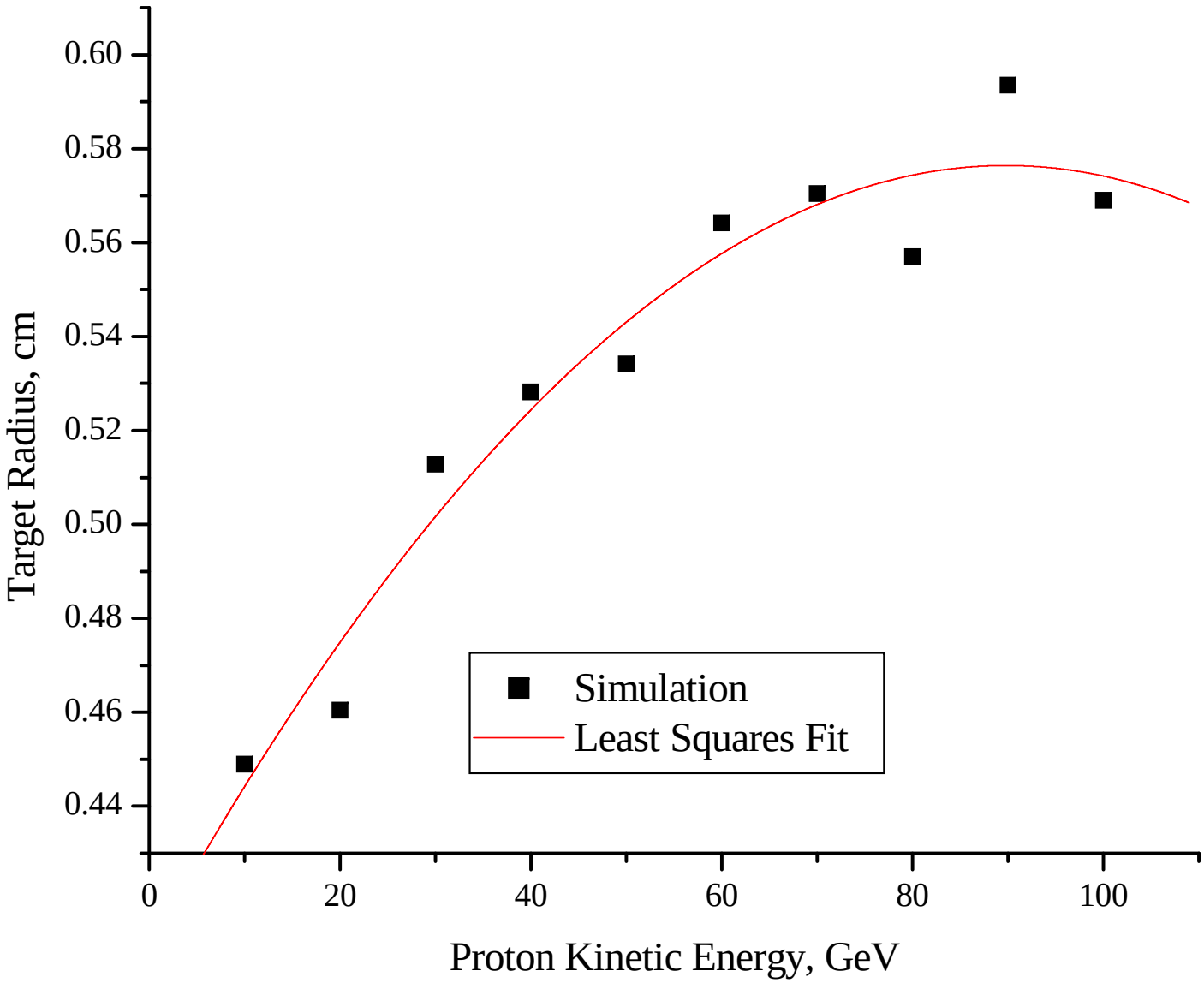


# Interpolation of Beam Angle

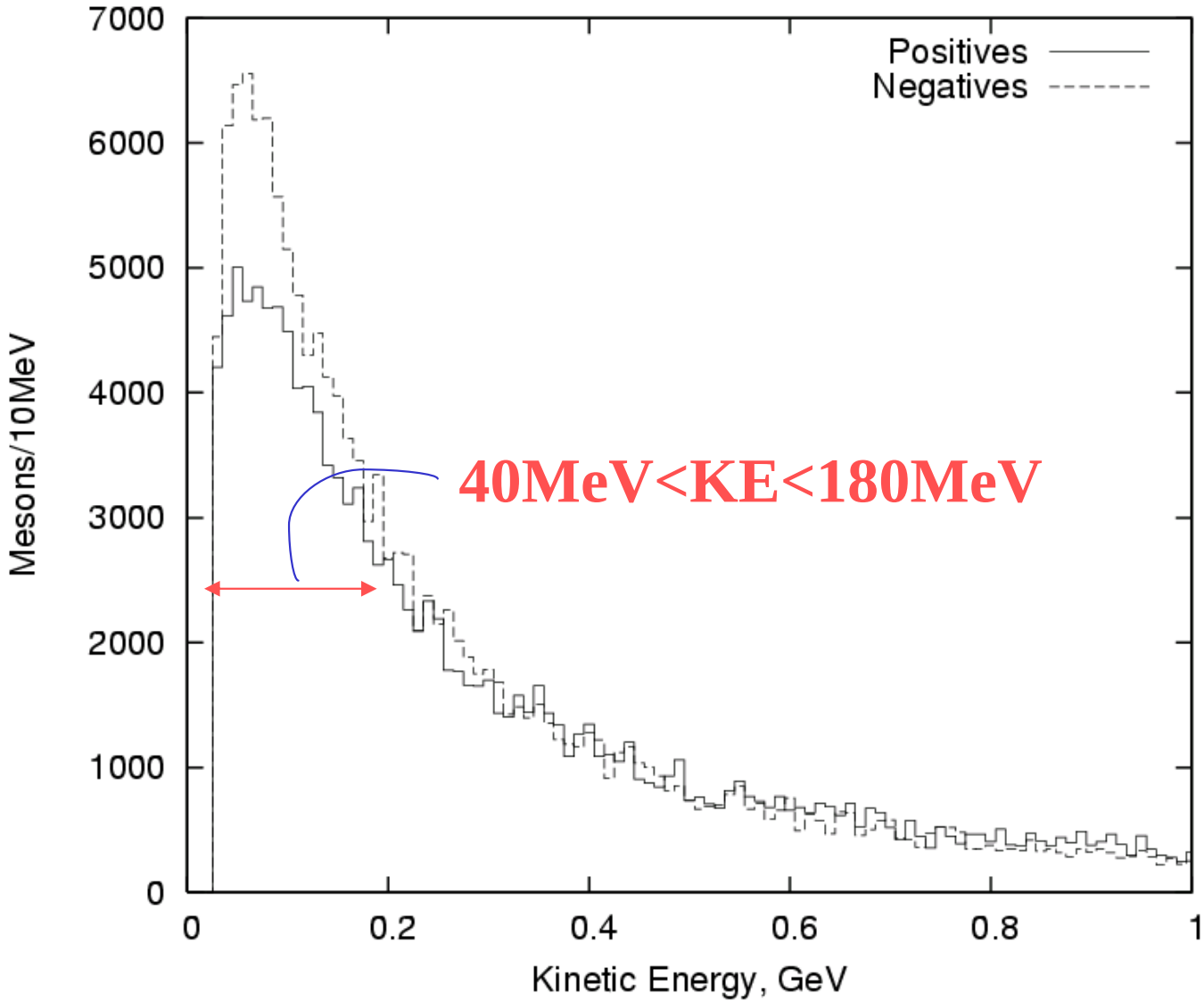


# Compare Interpolation with Simulation

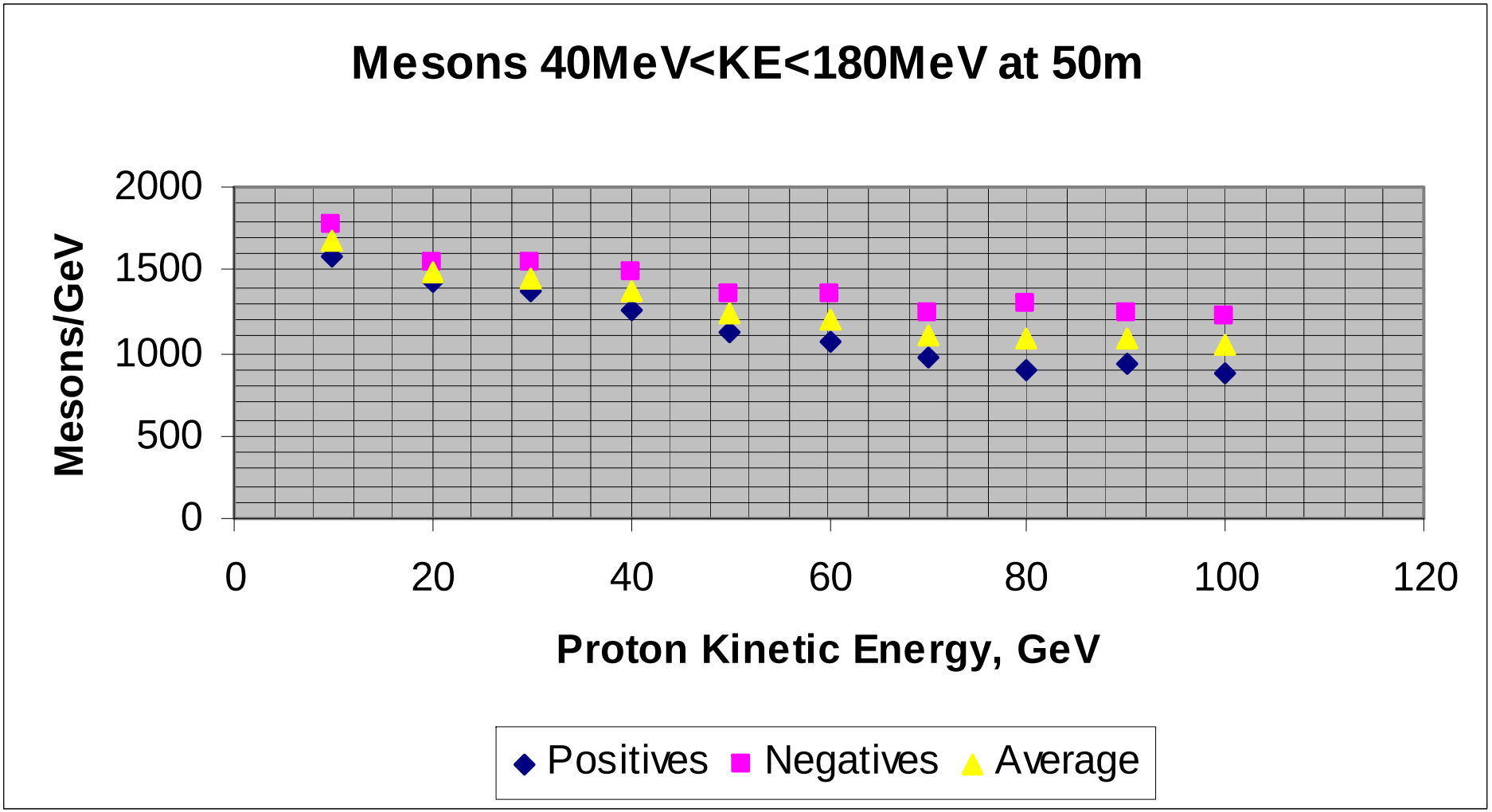



Target Radius, cm
0.60
0.58
0.56
0.54
0.52
0.50
0.48
0.46
0.44
0
20
40
60
80
100
Proton Kinetic Energy, GeV
Simulation
Least Squares Fit

# 50GeV Beam-Mesons at 50m

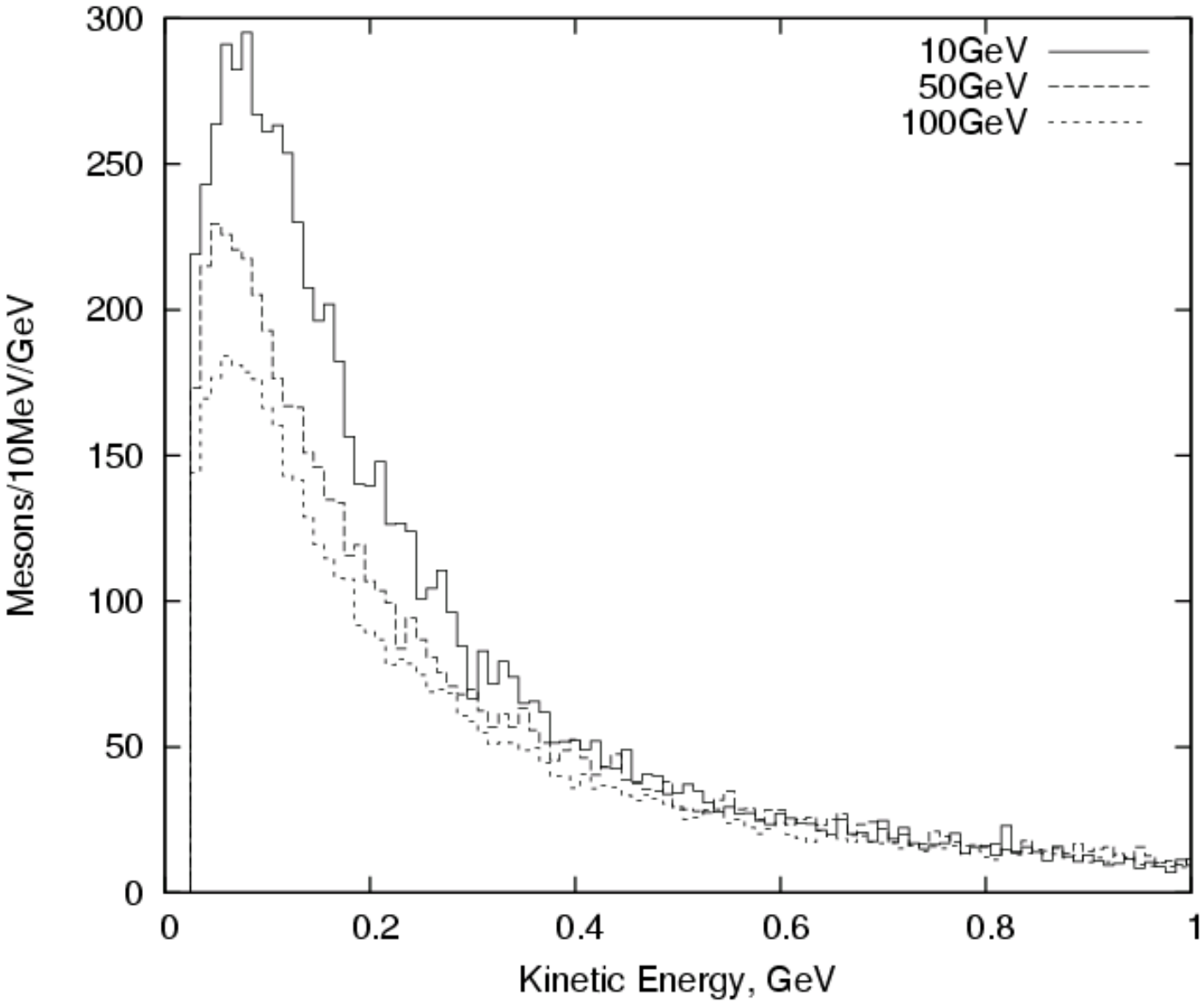


# Normalized Meson Production



# Normalized Mesons at 50m

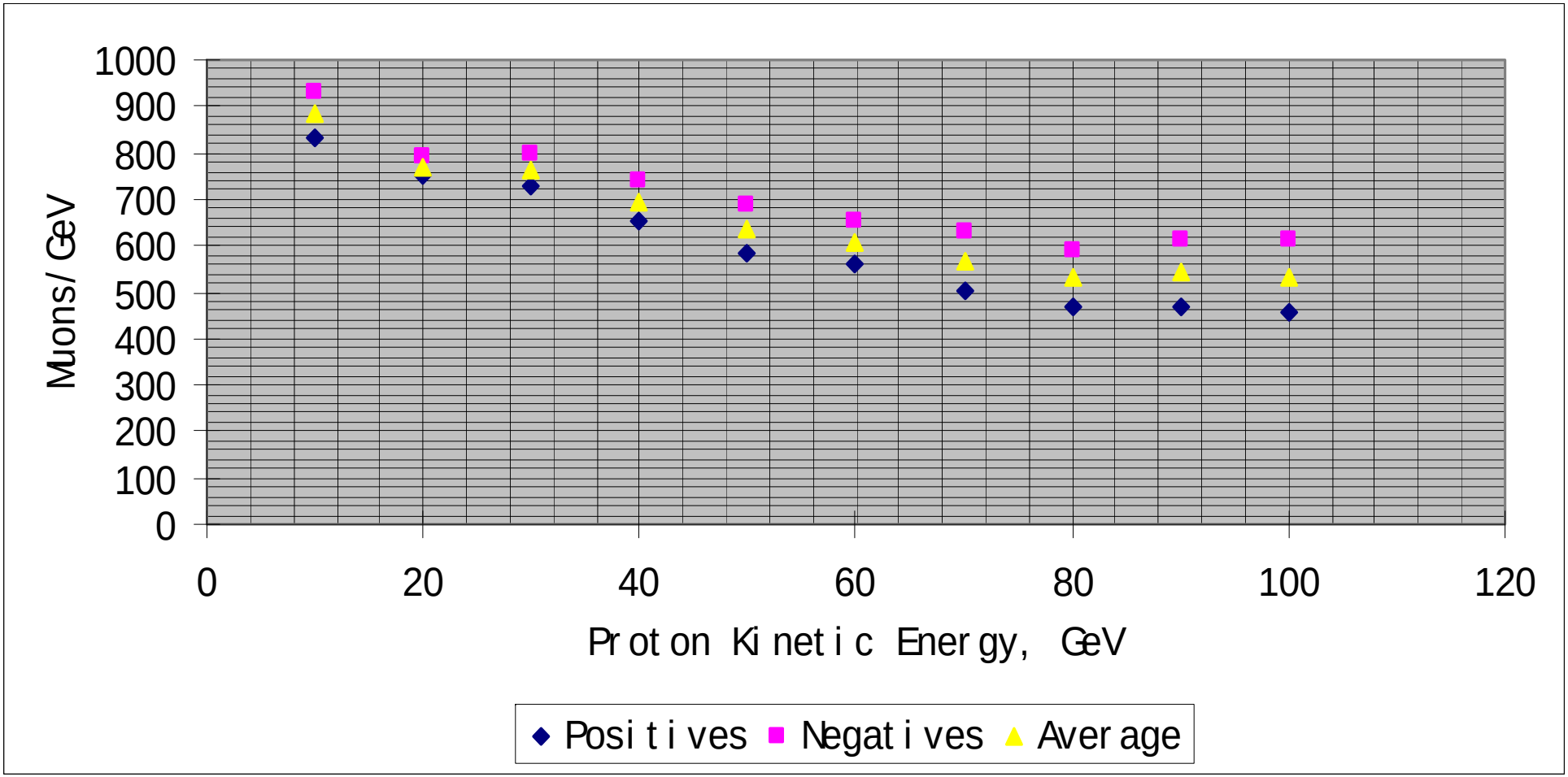
(Positives+Negatives)



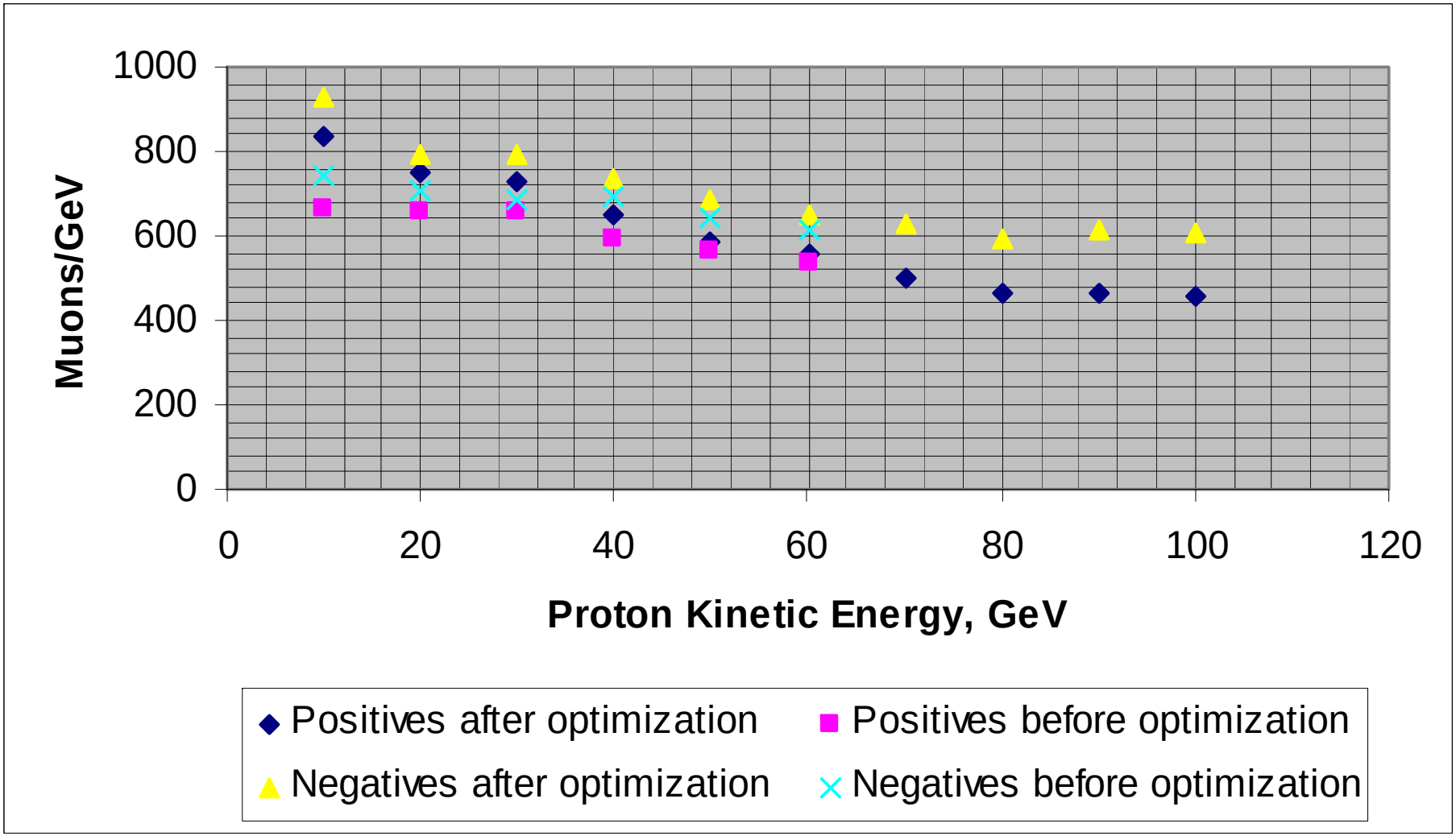
# Process Mesons through Cooling

1. Generate output file for ICOOL at z=0m with MARS;
2. Run ICOOL 3.13 to create output file for ECALC9F from the front end of Neutrino Factory to the end of cooling;
3. Run the ECALC9F and performs a standardized emittance analysis to get post-cooling muons within the acceptance of $\varepsilon_{\perp} = 30\pi mm$ and $\varepsilon_{L} = 150\pi mm$.

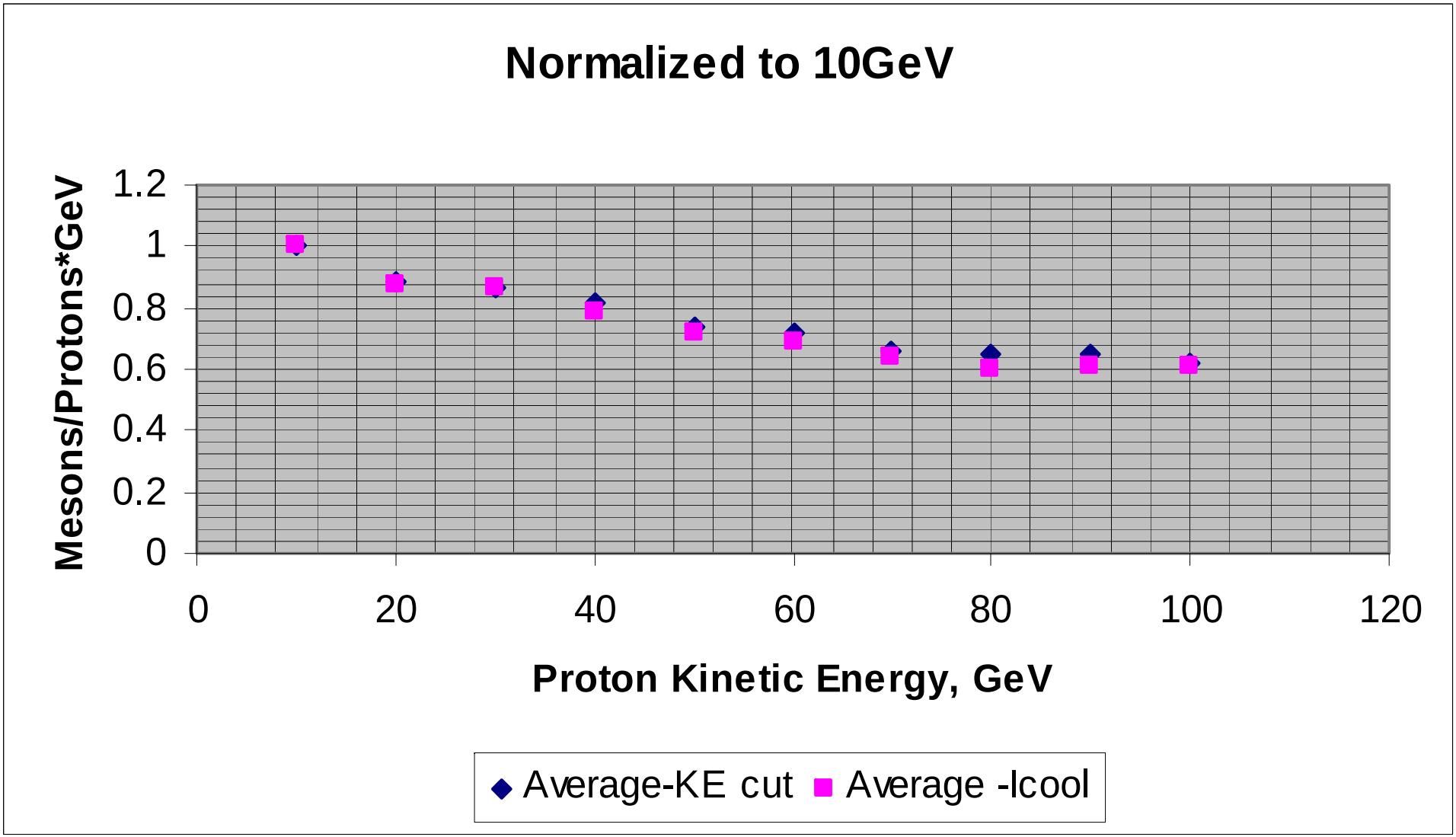
# Post-cooling Muons within Acceptance of $\varepsilon_\perp = 30\pi$ mm and $\varepsilon_L = 150\pi$ mm



# Comparison of Post-cooling Muons with and without Optimization



# Normalized Distribution



# *Summary*

- A method is set up to find the optimized target parameters (target radius, beam angle and beam/jet crossing angle) at beam energy of 10, 50 and 100GeV with MARS
- Interpolation is consistent with simulation to determine the optimized target parameters at other beam energies
- Simulated results of normalized mesons at z=50m and post-cooling muons are higher than those without optimization.
- Further simulations below beam energy of 10GeV are under study

# Backup

| Beam Energy GeV | Run No. | Target Radius cm/Mesons | Beam Angle mrad/ Mesons | Angle between Beam and Jet mrad/Mesons |
|---|---|---|---|---|
| 10 | 1st | 0.48/31424 | 89/31593 | 25/32811 |
| | 2nd | 0.47/32589 | 90/32614 | 21.5/32728 |
| | 3rd | 0.44/32342 | 92.5/33131 | 19.3/32893 |
| | 4th | 0.43/33294 | 92/32936 | 15.1/32921 |
| 50 | 1st | 0.65/111063 | 138/125871 | 26.5/126145 |
| | 2nd | 0.59/127089 | 129/127709 | 25/124165 |
| | 3rd | 0.57/128246 | 127/127700 | 23/127168 |
| | 4th | 0.55/128382 | 124/127760 | 23.36/126560 |
| 100 | 1st | 0.71/188203 | 135/208144 | 25/211134 |
| | 2nd | 0.63/212628 | 134/212007 | 22.5/212680 |
| | 3rd | 0.59/213459 | 129/215625 | 23.75/211189 |
| | 4th | 0.62/213620 | 120.7/213517 | 21.56/213447 |

# Cubic Interpolation

| Beam Energy GeV | Target Radius cm | Beam Angle mrad |
|---|---|---|
| 10 | 0.44 | 92 |
| 20 | 0.4769 | 103.7359 |
| 30 | 0.5103 | 114.2068 |
| 40 | 0.5386 | 122.0743 |
| 50 | 0.56 | 126 |
| 60 | 0.5771 | 127.3815 |
| 70 | 0.5927 | 128.4942 |
| 80 | 0.6058 | 129.3161 |
| 90 | 0.6153 | 129.8254 |
| 100 | 0.62 | 130 |

# Comparison of Interpolation with Simulation

| Beam energy GeV | Target Radius Interpolation cm | Target Radius Simulation cm | Target Radius Least Squares Fit cm |
|---|---|---|---|
| 10 | 0.44 | 0.449 | 0.444 |
| 20 | 0.4769 | 0.4605 | 0.475 |
| 30 | 0.5103 | 0.5128 | 0.5017 |
| 40 | 0.5386 | 0.5282 | 0.5244 |
| 50 | 0.56 | 0.5342 | 0.5431 |
| 60 | 0.5771 | 0.5642 | 0.5577 |
| 70 | 0.5927 | 0.5705 | 0.5681 |
| 80 | 0.6058 | 0.557 | 0.5744 |
| 90 | 0.6153 | 0.5935 | 0.5764 |
| 100 | 0.62 | 0.569 | 0.5741 |