Optimized Parameters for a Mercury Jet Target

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A study of target parameters for a high-intensity, liquid mercury jet target system for a neutrino factory or muon collider is presented. Using the MARS code, we simulate particle production initiated by incoming protons with kinetic energies between 2 and 100 GeV. For each proton beam energy, we optimize the geometric parameters of the target: the mercury jet radius, the incoming proton beam angle, and the crossing angle between the mercury jet and the proton beam. The number of muons surviving through an ionization cooling channel is determined as a function of the proton beam energy.

Schematic of the Target System

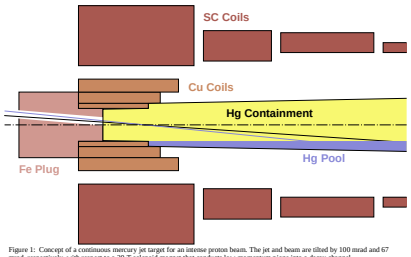

Figure 1: Concept of a continuous mercury jet target for an intense proton beam. The jet and beam are tilted by 100 mrad and 67 mrad, respectively, with respect to a 20-T solenoid magnet that conducts low-momentum pions into a decay channel.

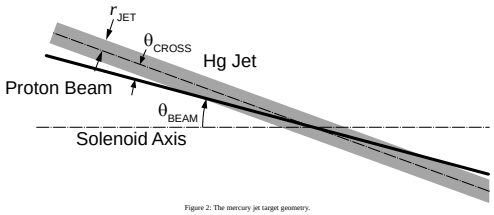

Figure 2: The mercury jet target geometry.

Optimization Method

1. **Run MARS and count all the positive and negative mesons that cross the transverse plane at z=50m from the interaction. Then select all the mesons with 40 MeV < KE < 180 MeV.**
2. **Make a number of runs with different values of target radius with starting beam angle of 67 mrad and crossing angle of 33 mrad from previous results. Then fit a curve using the method of lease squares through the data for total production as a function of target radius and take the radius at the maximum in the fitted curve to be the optimal value. Repeat this process for proton beam angle and beam-target crossing angle.**
3. **Cycle through the parameters of the target radius, proton beam angle and beam-target crossing angle until the parameter values have converged.**

Meson Production and Fit Curve at Different Target Parameters

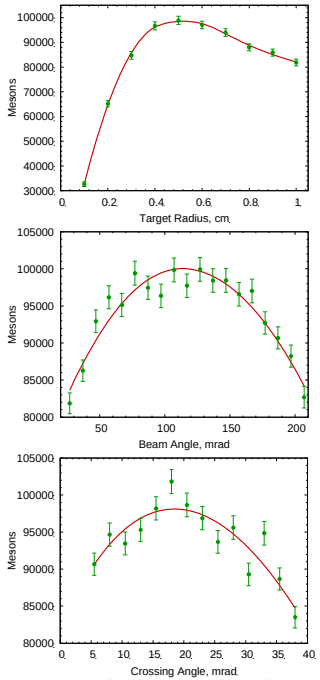

Figure 3: Meson production as a function of target radius (top), proton beam angle (middle), and beam-target crossing angle (bottom). Data points represent mesons generated from 10^6 incoming 50GeV protons.

Optimal Target Parameters

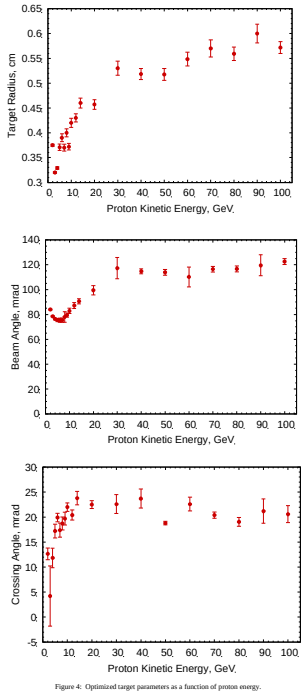

Figure 4: Optimized target parameters as a function of proton energy.

Comparison with/without Optimization

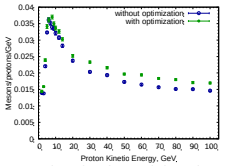

Figure 5: Production with original geometry and with optimized geometry.

Comparison from MARS/ICOOL

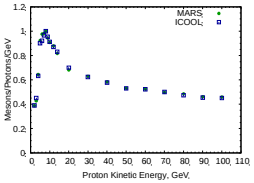

Figure 6: Mesons 50 m from interaction point as computed by MARS, and mesons at the end of cooling as computed by ICOOL, starting from distribution at end of target.

Conclusion

1. ***With our optimization method, we find the optimized target parameters: 0.4~0.6 cm of target radius, 75~120 mrad of proton beam angle and ~20 mrad of beam-target crossing angle.***
2. ***The new choice for beam parameters increase the meson production by about 20% compared to the earlier parameters.***
3. ***The maximum meson production per unit proton energy occurs when the proton kinetic energy is in the range of 5-15GeV.***
4. ***The dependence on energy of the number of muons at the end of the cooling channel by ICOOL is almost identical to the dependence on energy of the meson production 50m from the target by MARS.***

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