Gallium as a Possible Target Material for a Muon Collider or Neutrino Factory

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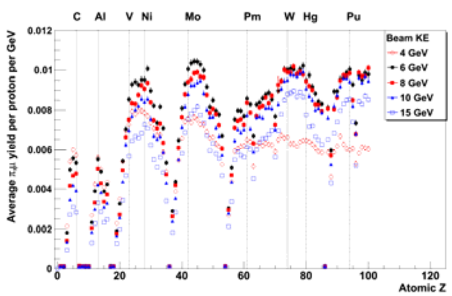
Abstract

We consider the potential for a free-flowing gallium jet target as an option for a Muon Collider or Neutrino Factory. Using the MARS15 code, we simulated particle production initiated by incoming protons with kinetic energies between 2 and 16 GeV. For each proton beam energy, we optimize the geometric parameters of the target: the radius of the liquid jet, the incoming proton beam angle, and the crossing angle between the jet and the proton beam. We compare the quantity of generated muons using this type of target to the case in which a free-flowing mercury jet is utilized.

1. Motivation to Optimize GA target



Pion/muon yields for different atomic Z's and beam energies (J. Back)

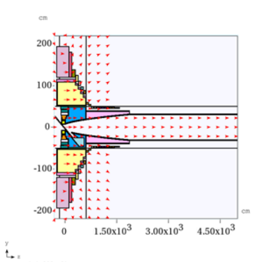
Advantages of Gallium as a possible target alternative of HG:

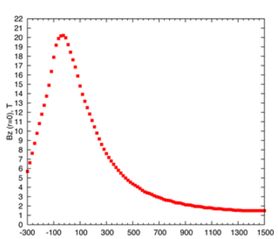
Relatively efficient meson production (near the peak for nickel),

Liquid state at relatively low temperature (melting point = 29.8° C) ,

Potential for easier handling,.

2. Target/Collection and Axial Field with IDS120h Configuration

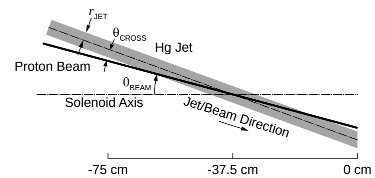




Count all the pions and muons that cross the transverse plane at z = 50 m.

For this analysis we select all pions and muons with 40 < KE < 180 MeV.

3. Target Geometry and Optimization Method



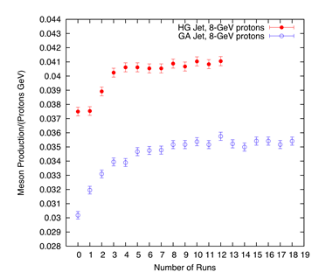
1. Fix beam/jet intersection point at (0, 0, -37.5 cm).
2. Initialize target parameters at proton KE of 8 GeV: target radius of 5 mm, beam angle of 67 mrad at z = -37.5 cm, beam/jet crossing angle of 33 mrad at z = -37.5 cm.

Optimization method:

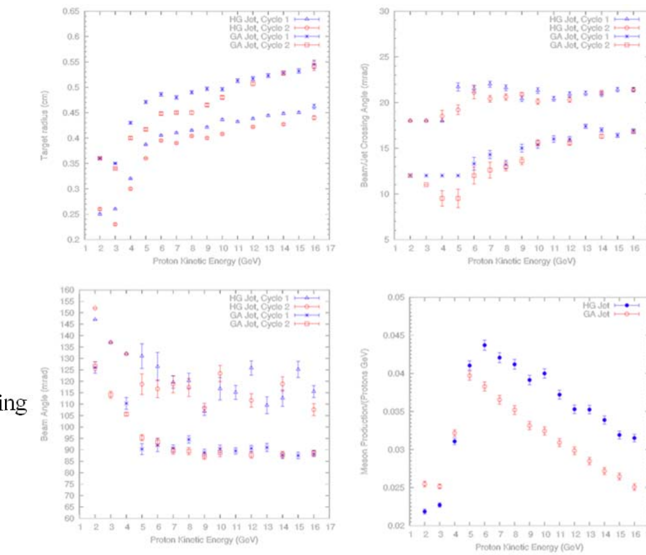
- Take 3 runs in each cycle:
  1) Vary jet radius with initial beam angle and beam/jet crossing angle;
  2) Vary beam/jet crossing angle with new target radius while keeping jet fixed - always project beam back to z =-200 cm;
  3) Vary the beam angle with the new target radius while adjusting the jet angle to always maintain a constant beam/jet crossing angle.
- Repeat above cycle until convergence.

4. Optimization Results at 8 GeV

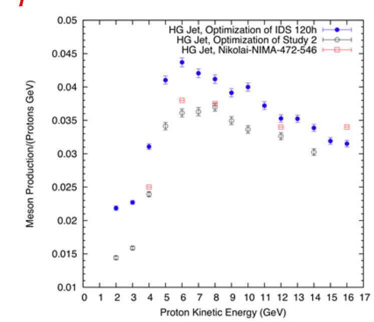
	HG			GA		
	Target radius, mm	Crossing angle, mrad	Beam angle, mrad	Target radius, mm	Crossing angle, mrad	Beam angle, mrad
Initial	(5mm, 33mrad, 67mrad)			(5mm, 33mrad, 67mrad)		
1st Cycle	4.6	23	120	6.7	21	112
2nd Cycle	4.15	23	117	5.5	17	94
3rd Cycle	4.15	21.6	120	4.9	13.2	92
4th Cycle	4.04	**20.6**	117	4.5	13	90
5th Cycle				4.4	12.8	86
6th Cycle				4.4	**13**	88



5. Optimized results from 2 to 16 GeV



6. Comparison with Previous Studies for Hg



Conclusions

We have simulated the IDS120h target configuration using Gallium and Mercury as its target material. With optimization, the Hg jet has target radius of 4.04 mm, beam/jet crossing angle of 20.6 mrad and beam angle of 117 mrad. While the Ga jet has target radius of 4.4 mm, beam/jet crossing angle of 13 mrad and beam angle of 88 mrad. In addition, it shows that production from Ga peaks near KE = 5 GeV and is comparable to that from Hg at that KE.