Particle Production of Carbon Target with 20Tto2T5m Configuration at 6.75 GeV (Updated)

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Target Studies
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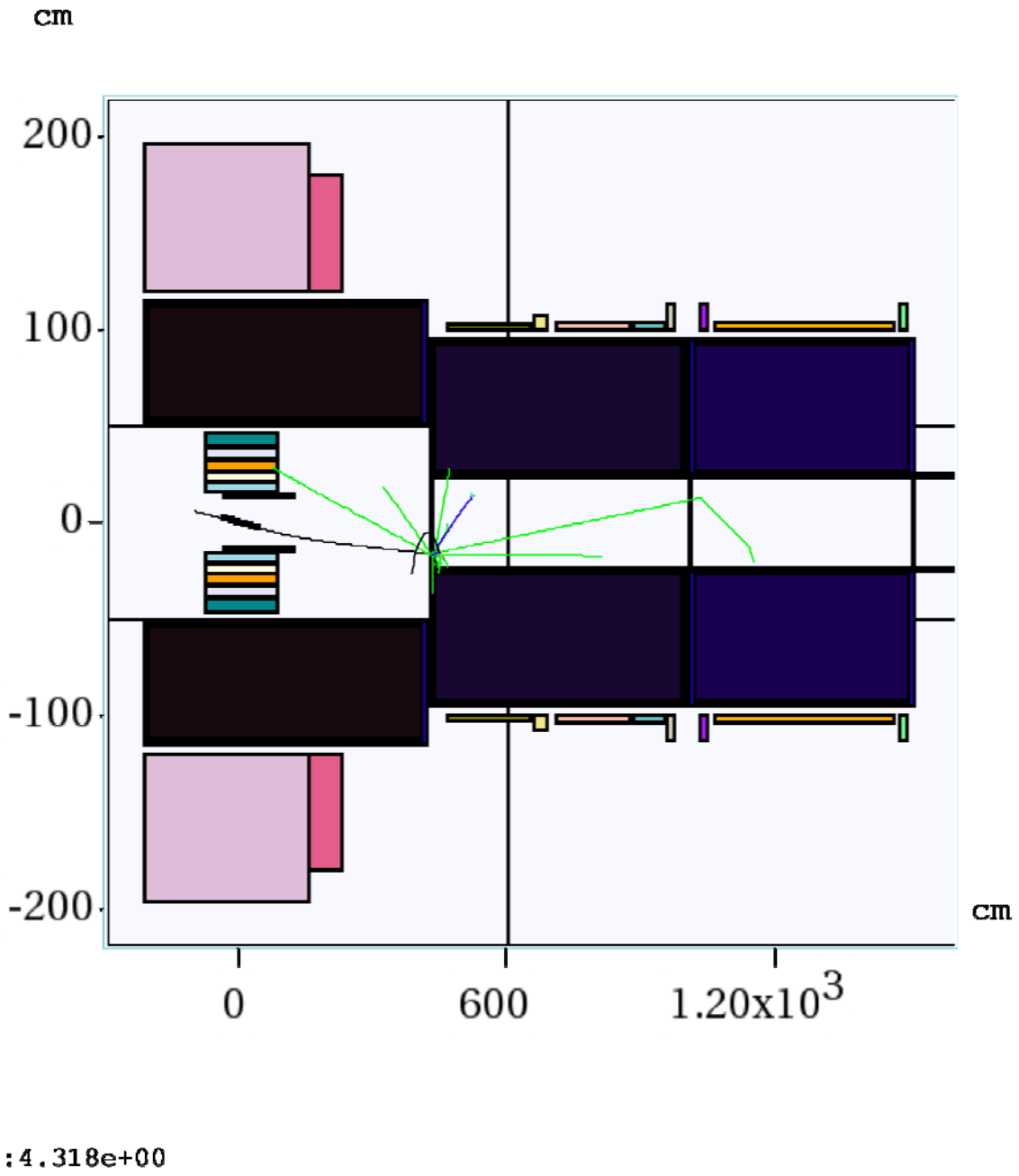
Target Setting

- 20Tto2T5m Configuration (initial beam pipe radius of 13 cm) and Fieldmap (20T➔2T);
- Code: MARS15(2014) with ICEM 4 = 1;
- Proton beam: 6.75 GeV (KE) and launched at z = -100 cm,

  Focal beam with waist at z= 0 m and emittance of 5 μm;
- Production Collection: (50 m downstream, 40 MeV < KE < 180 MeV).
- Graphite density = 1.8

Configuration



Energy Card Setting

- ENRG E0 EM EPSTAM EMCHR EMNEU EMIGA EMIEL

  E0: The incident particle kinetic energy;

  EM: The hadron threshold energy (Default:0.0145 GeV);

  EPSTAM: The star production threshold kinetic energy (Default:0.03 GeV);

  EMCHR: The threshold energy applied collectively to muons, heavy ions and charged hadrons (Default: 0.001 GeV);

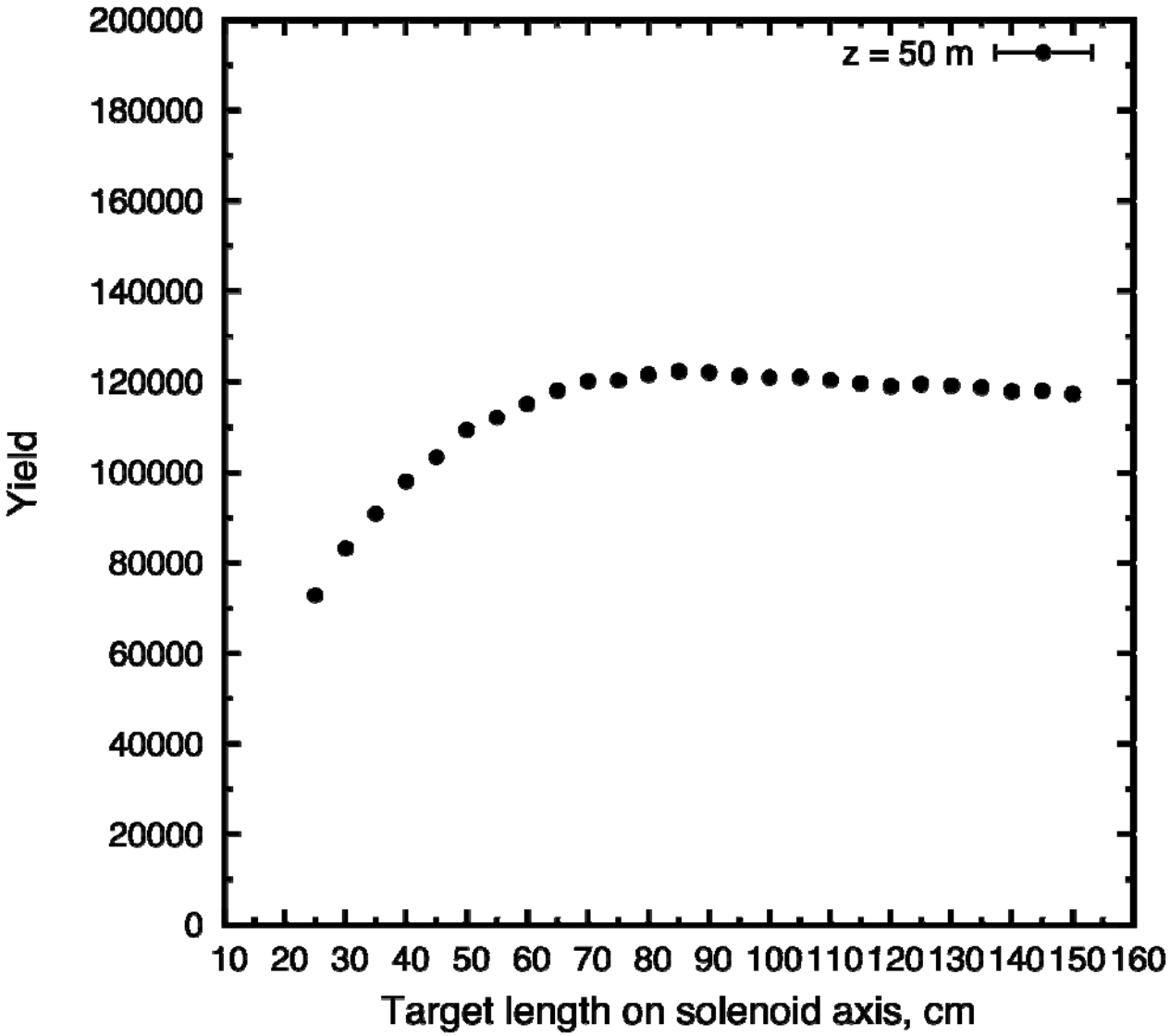
  EMNEU: The threshold energy for neutrons (Default:10^{-4} GeV)

  EMIGA: The threshold energy for γ (Default:10^{-4} GeV);

  EMIEL: The threshold energy for $e^{\pm}$ (Default: $5*10^{-4}$ GeV)

  Use non-default setting: ENRG 1=6.75 2=0.02 3=0.3 4=0.01 5=0.05 6=0.01 7=0.01

Particle Production *vs.* Target Length (10^6 events, no beam dump)



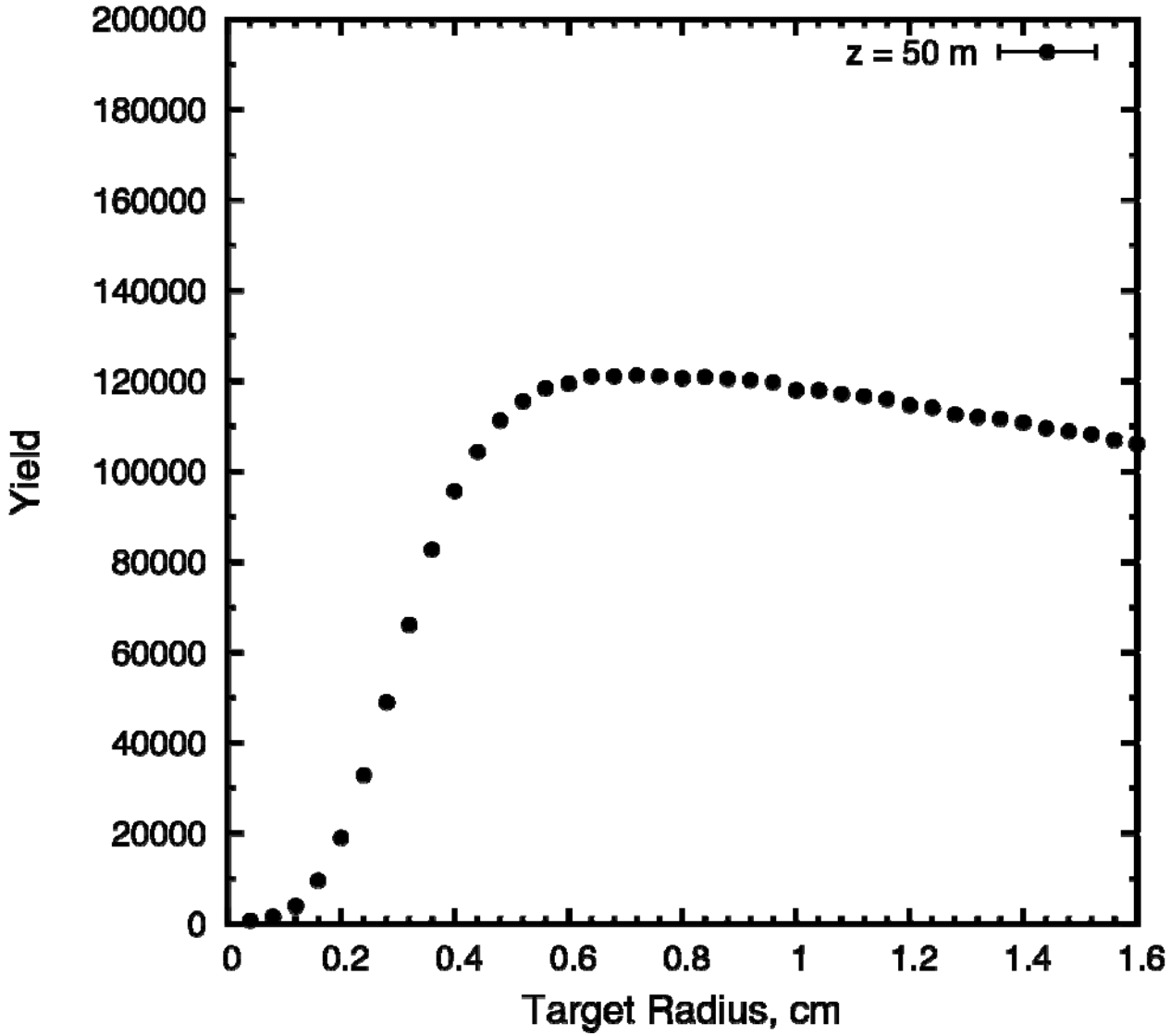
Target radius: 0.80 cm

Beam angle to SC axis: 65 mrad

Co-linear target and beam

TR/BR=4

Particle Production *vs.* Target Radius (10^6 events, no beam dump)



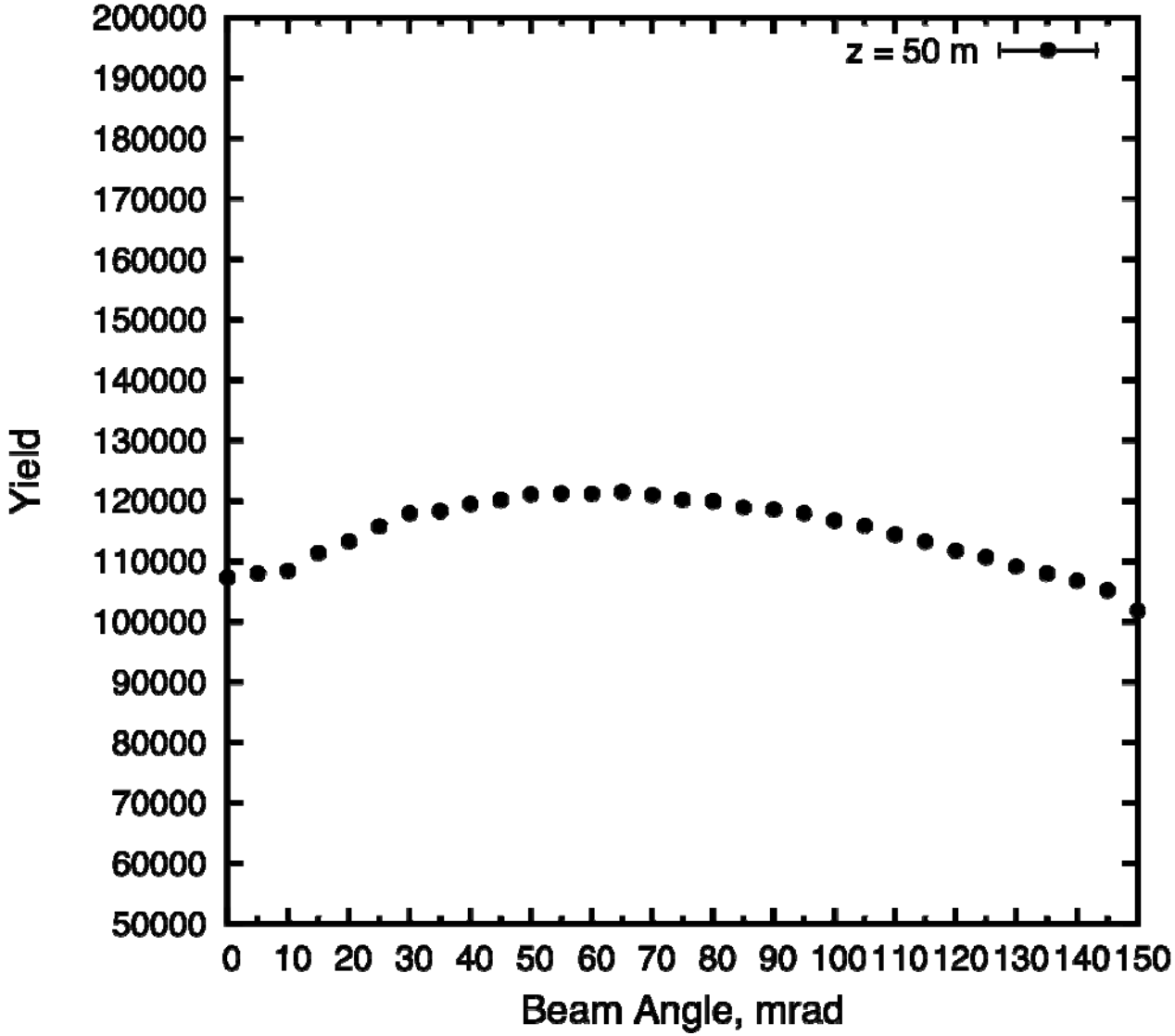
Target length: 80 cm

Beam angle to SC axis: 65 mrad

Co-linear target and beam

TR/BR=4

Particle Production *vs*. Beam Angle (10^6 events, no beam dump)



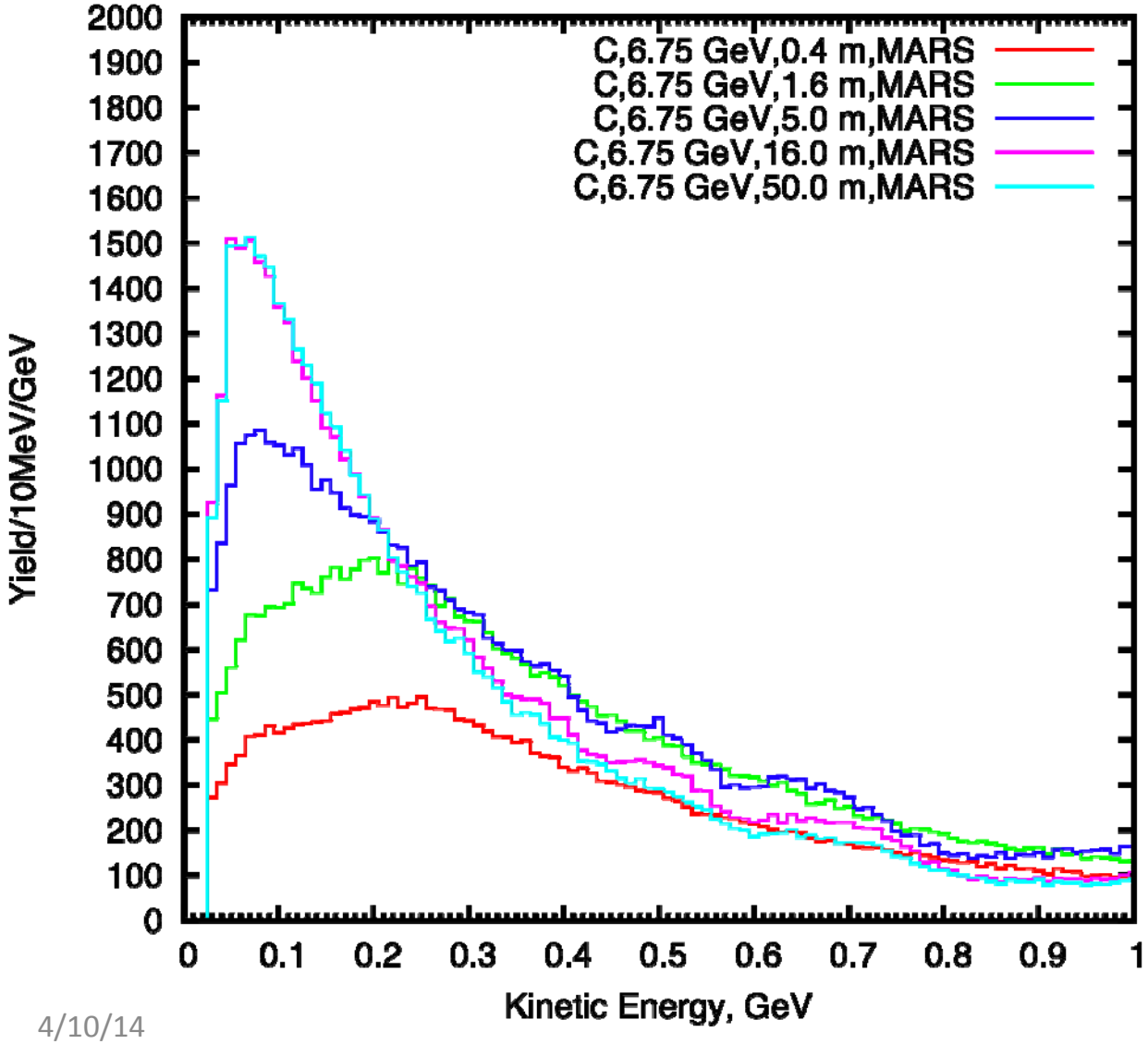
Target length: 80 cm

Target radius: 0.80 cm

Co-linear target and beam

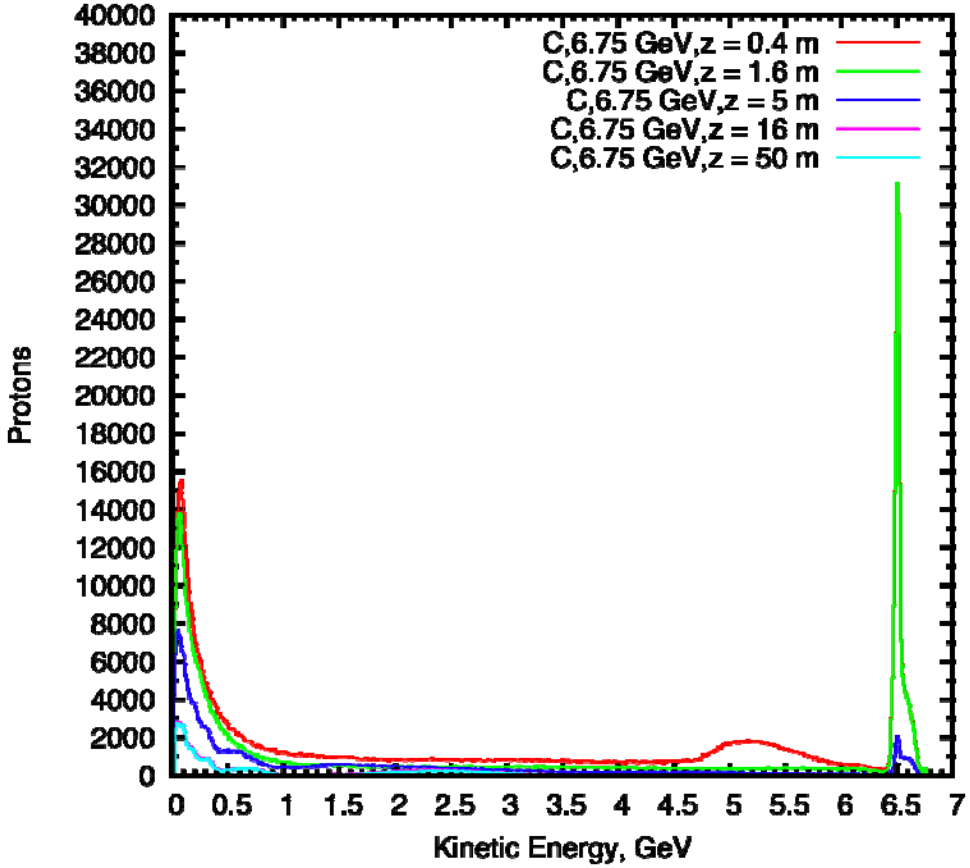
TR/BR=4

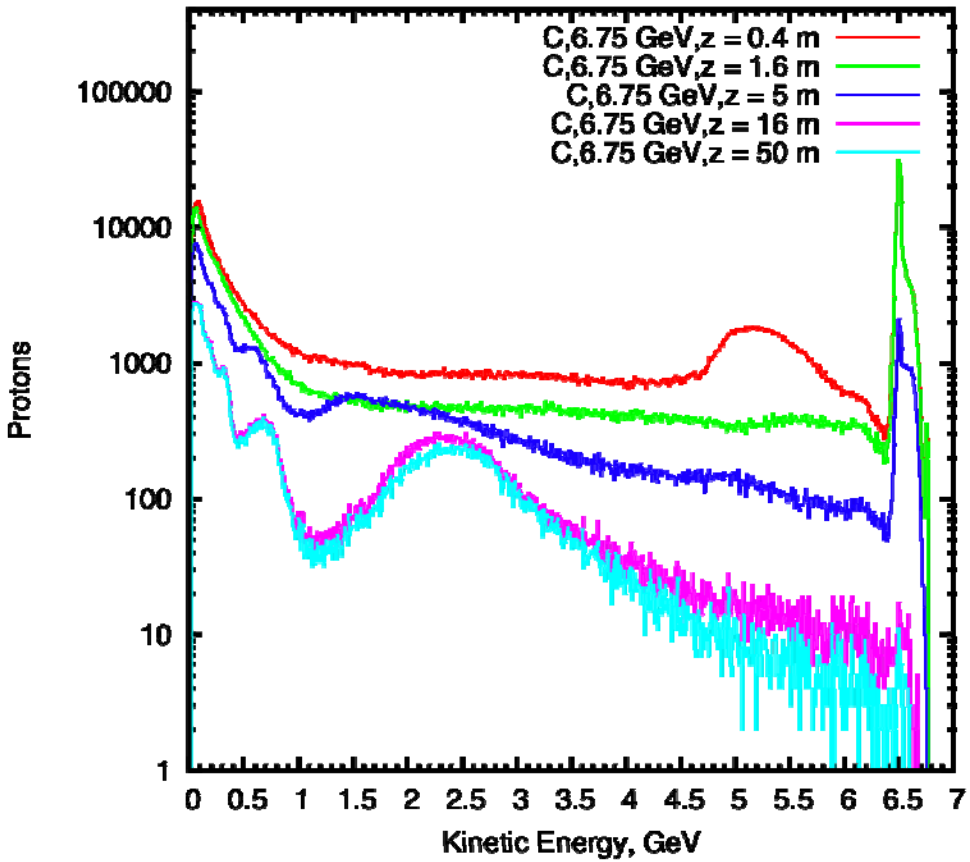
Energy Spectra of $\pi^{\pm}$, $K^{\pm}$, $\mu^{\pm}$ (10^6 events, no beam dump)



Best parameters:
Target length: 80 cm
Target radius: 0.80 cm
Beam angle: 65 mrad
Co-linear target and beam
TR/BR=4

Remaining Protons
(10^6 events, no beam dump)



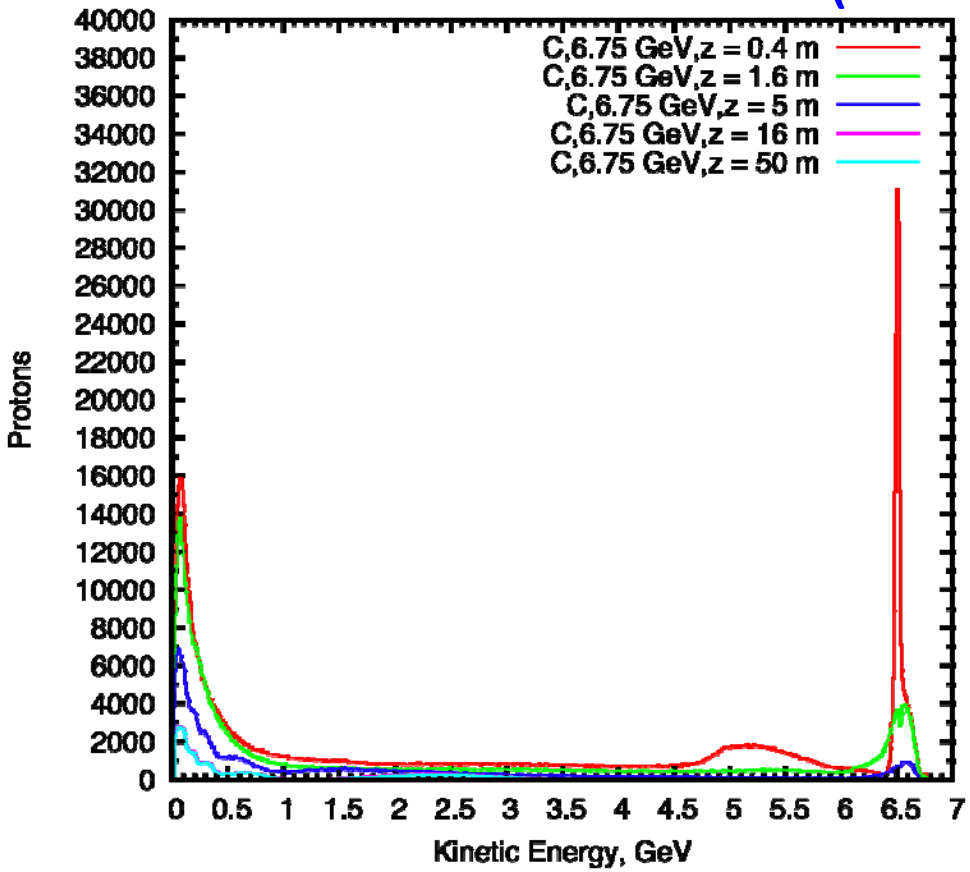


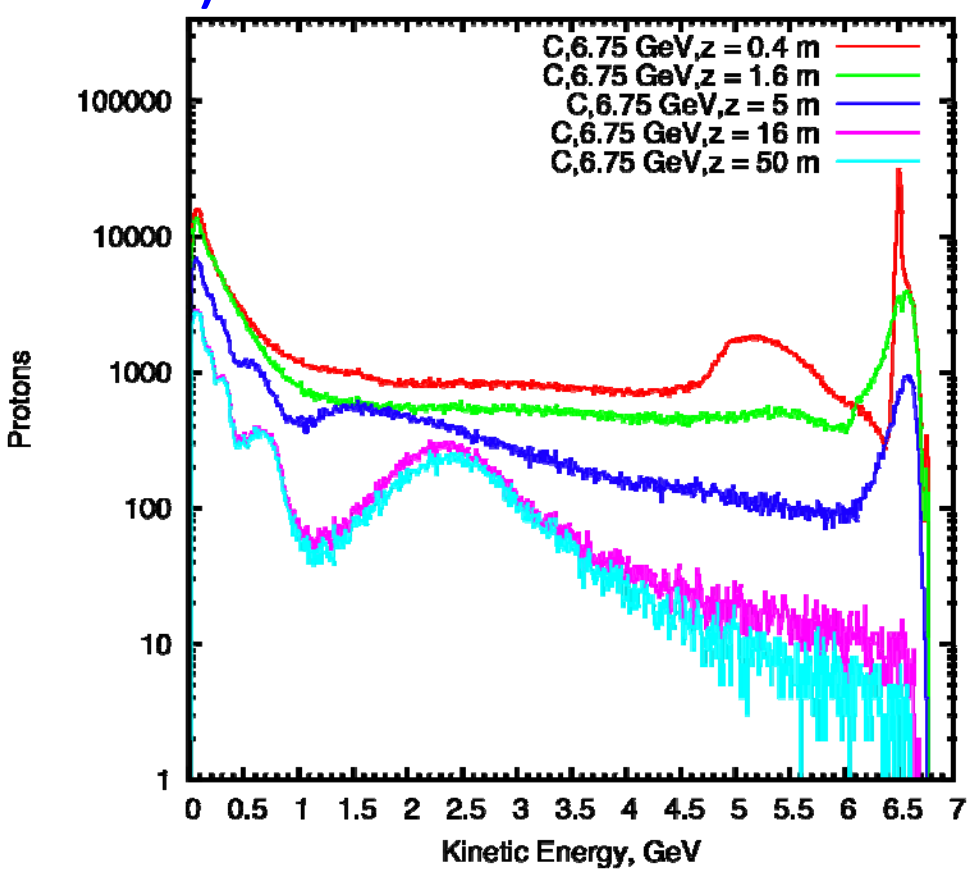
Target length: 80 cm Target radius: 0.80 cm Beam angle: 65 mrad
Co-linear target and beam TR/BR=4

Peak of protons at 6.5 GeV gone at z = 50 m (65 mrad beam angle).
If true, little/no need for beam dump.

Remaining Protons with Beam Dump

(10^6 events)



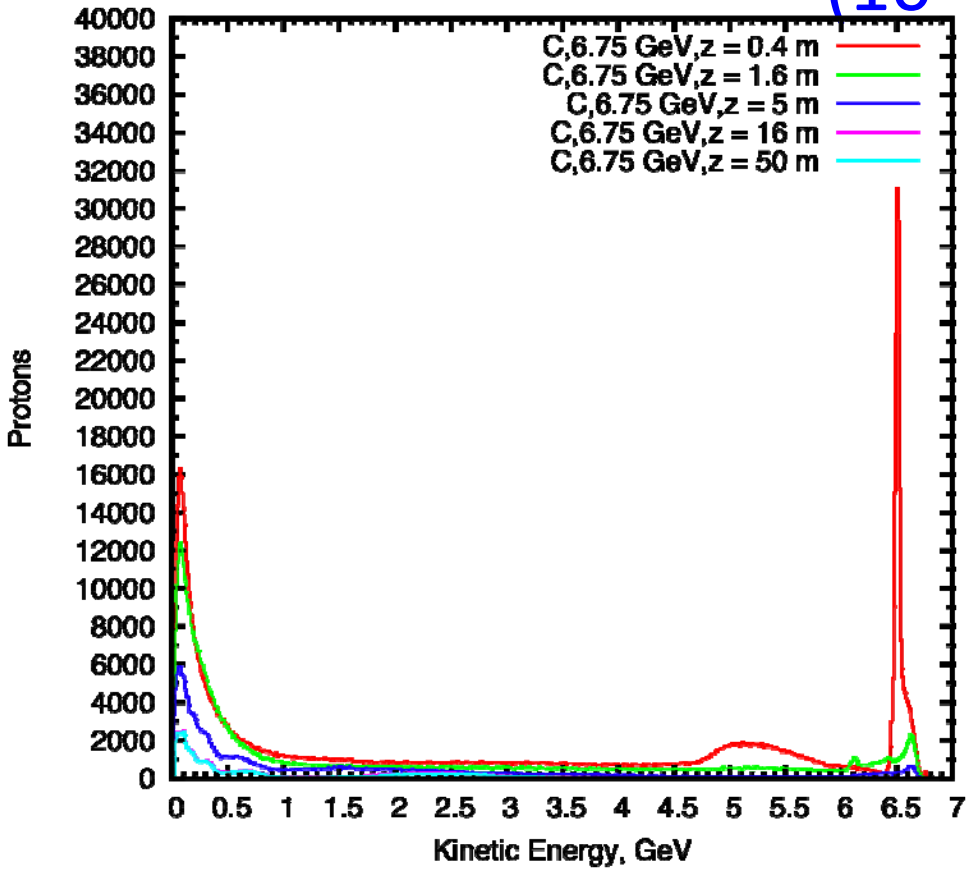


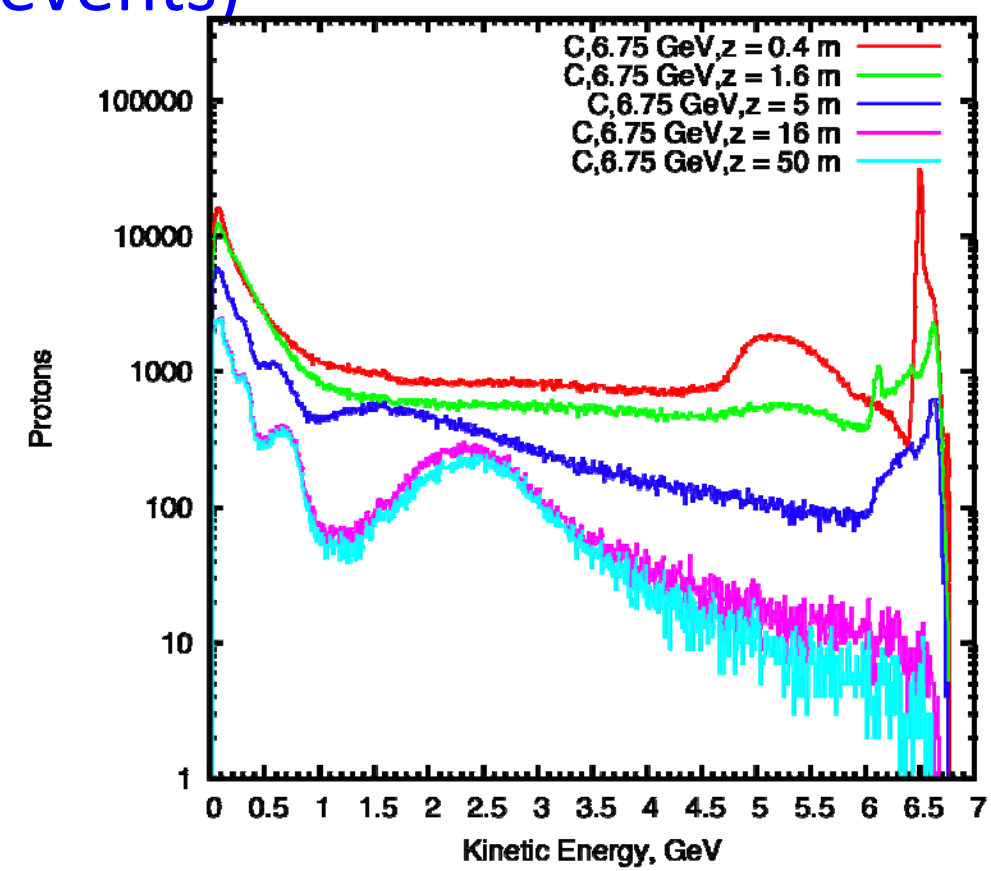
Target length: 80 cm (z=-40 cm to z=40 cm) Target radius: 0.80 cm
Beam angle: 65 mrad Co-linear target and beam TR/BR=4
Beam dump rod: (z=40 cm to z=160 cm, horizontal tilt: 33.7 mrad, vertical tilt: 54.28 mrad)

The radius of beam dump is same that of the target

Remaining Protons with Beam Dump

(10^6 events)



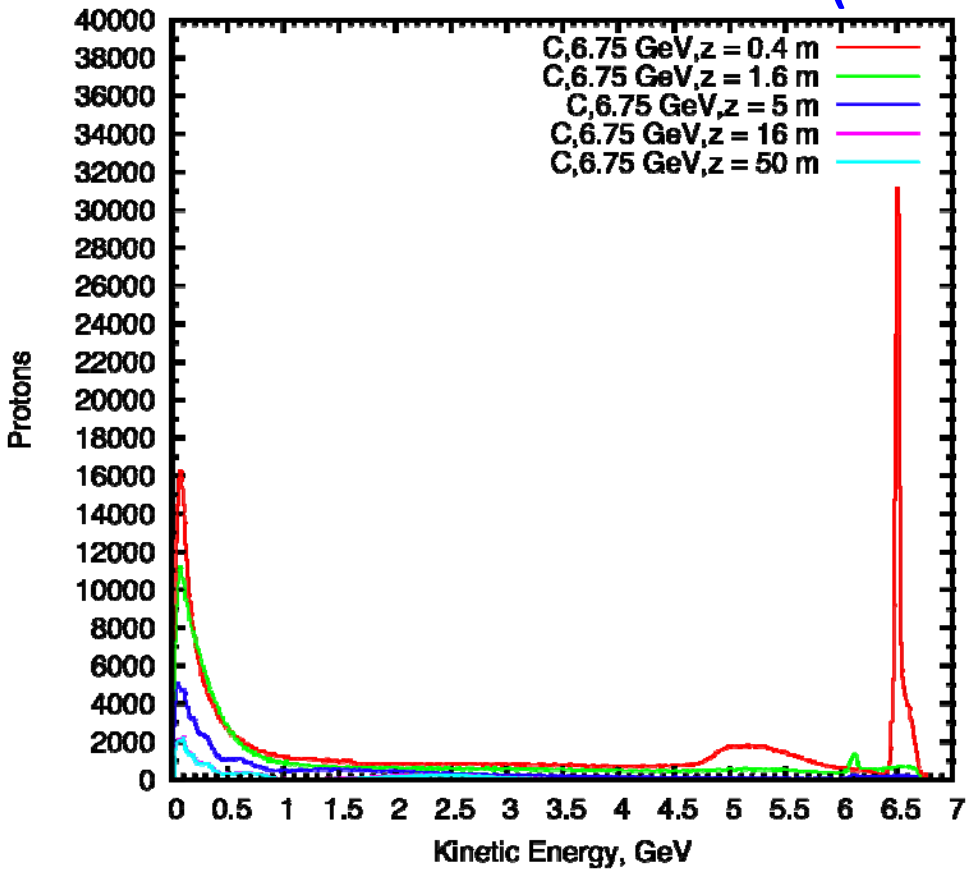


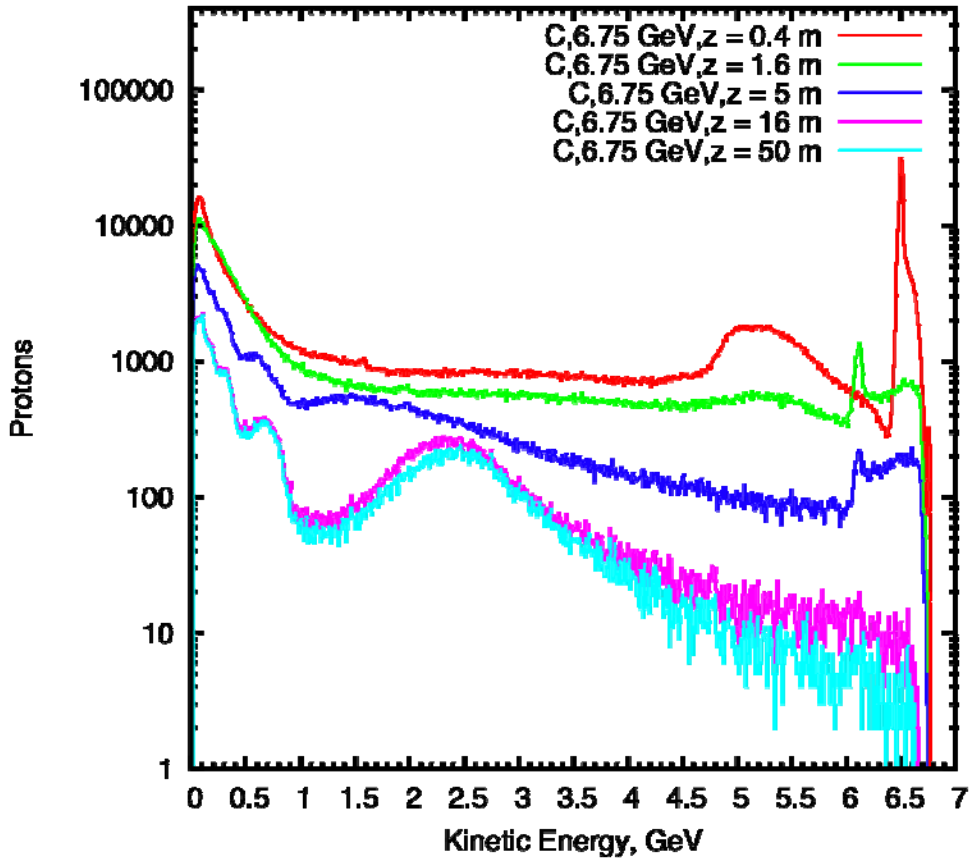
Target length: 80 cm (z=-40 cm to z=40 cm) Target radius: 0.80 cm
Beam angle: 65 mrad Co-linear target and beam TR/BR=4
Beam dump rod (z=40 cm to z=160 cm, horizontal tilt: 33.7 mrad, vertical tilt: 54.28 mrad)

The radius of beam dump is twice that of the target

Remaining Protons with Beam Dump

(10^6 events)



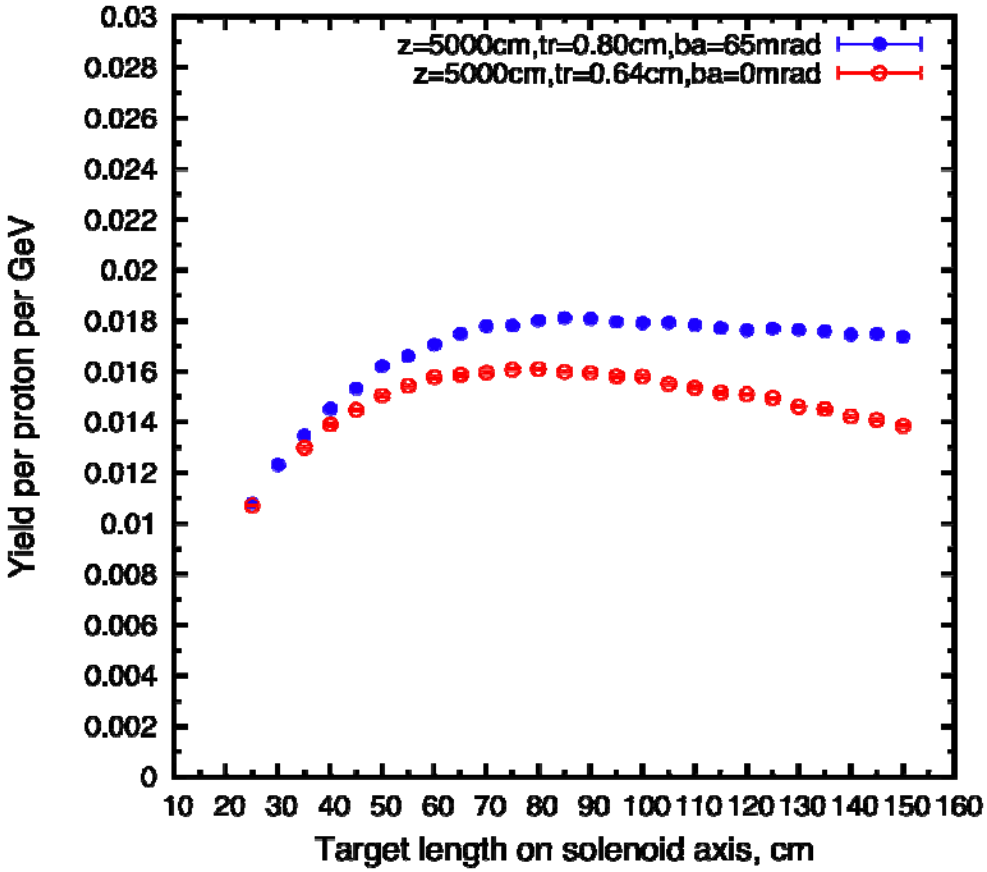


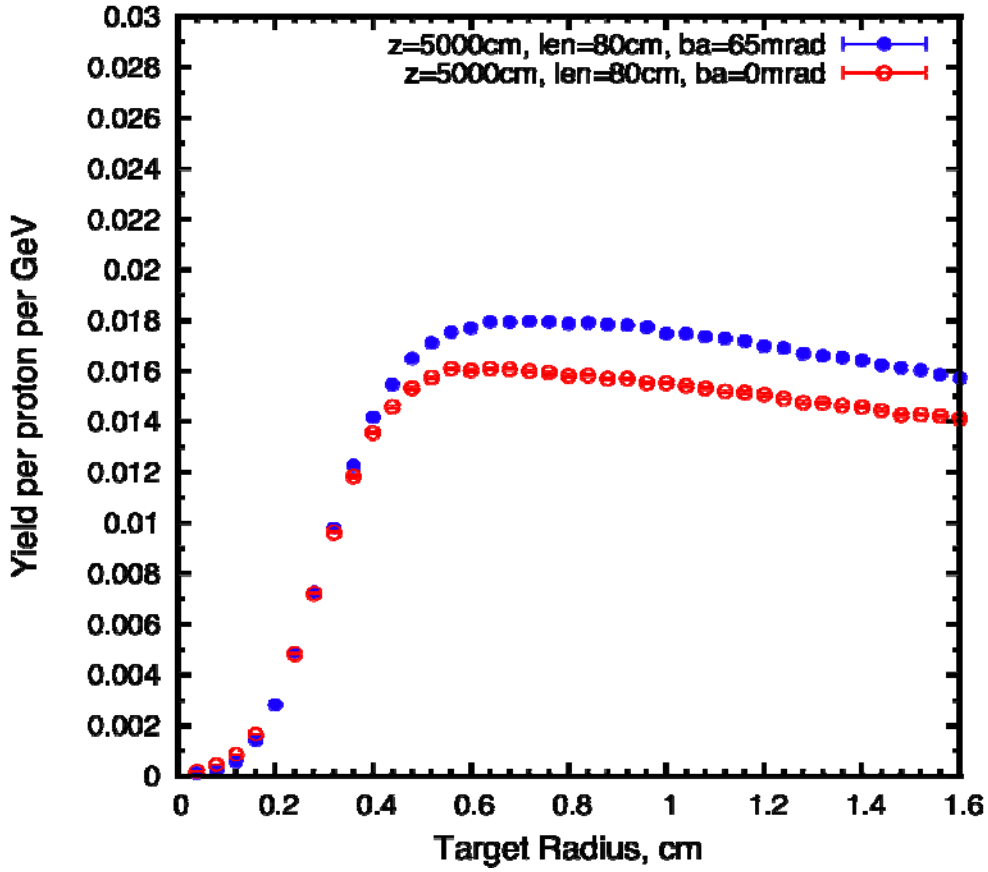
Target length: 80 cm (z=-40 cm to z=40 cm) Target radius: 0.80 cm
Beam angle: 65 mrad Co-linear target and beam TR/BR=4
Beam dump rod (z=40 cm to z=160 cm, horizontal tilt: 33.7 mrad, vertical tilt: 54.28 mrad)

The radius of beam dump is triple that of the target

Yield Comparison

(no-tilt vs. tilt of proton beam to SC axis)





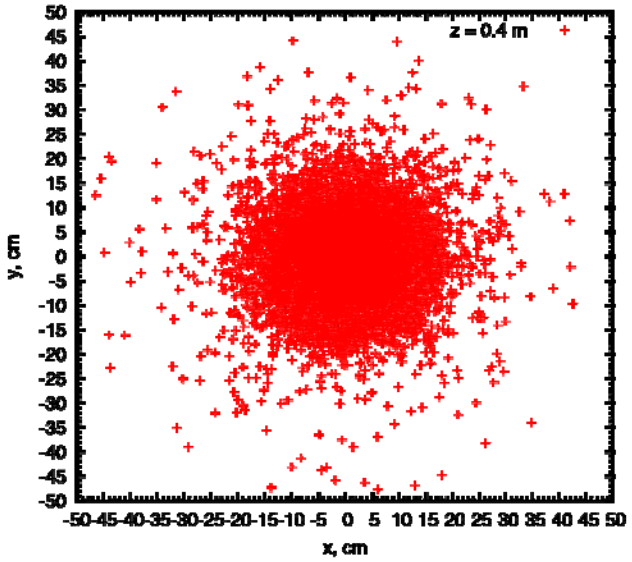
Optimized target length is 80 cm and target radius is 0.64 cm when beam angle is fixed at 0 mrad.
Co-linear target and beam. TR/BR=4

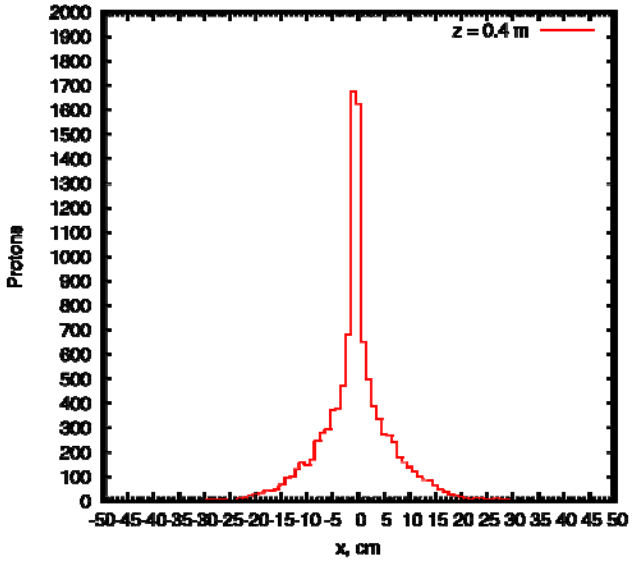
~ 13% advantage to tilting the beam/target

Remaining Protons (KE > 0)

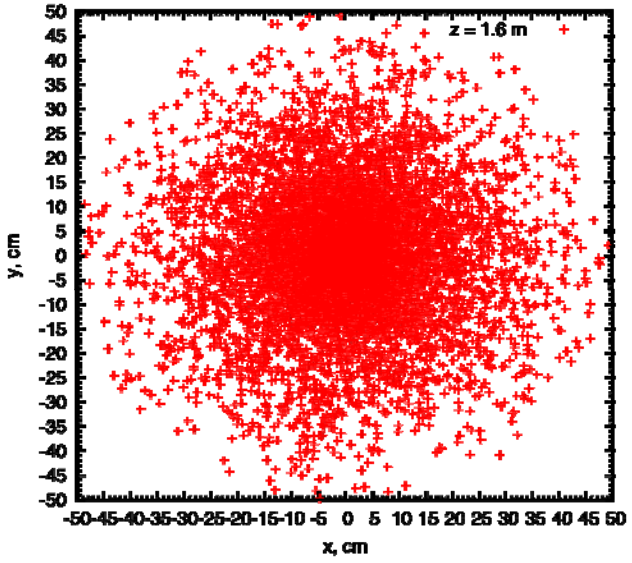
10^4 events, no beam dump, beam angle = 0 mrad

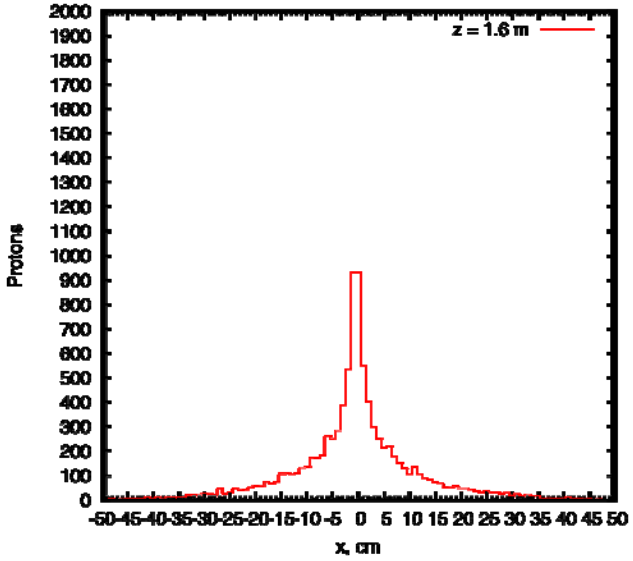
z = 0.4 m





z = 1.6 m

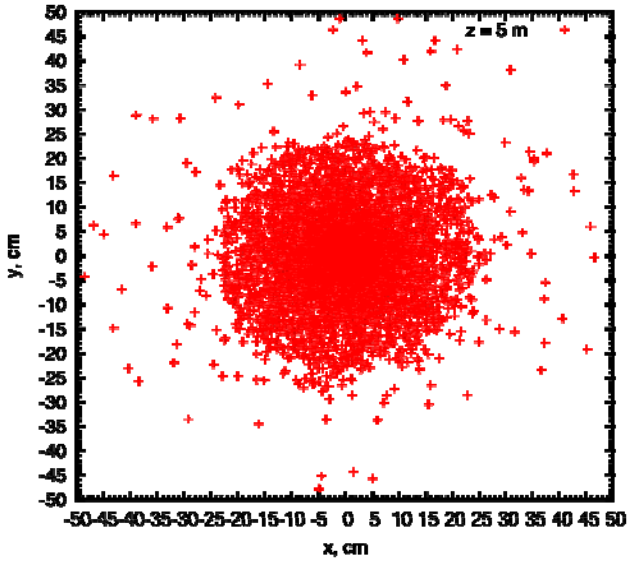


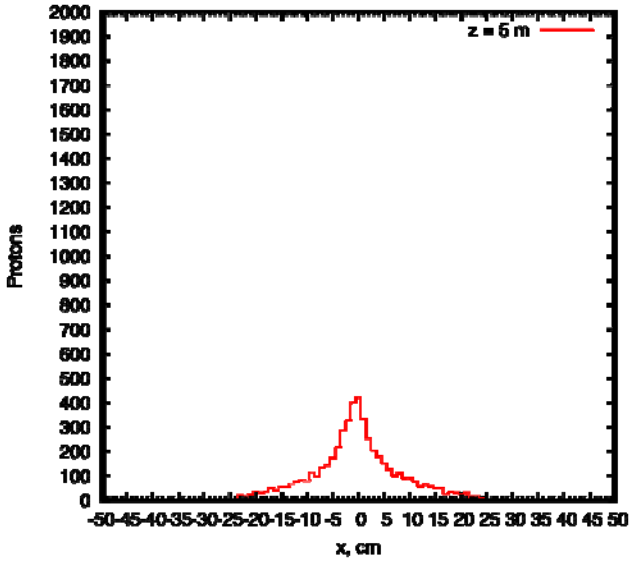


Remaining Protons (KE > 0)

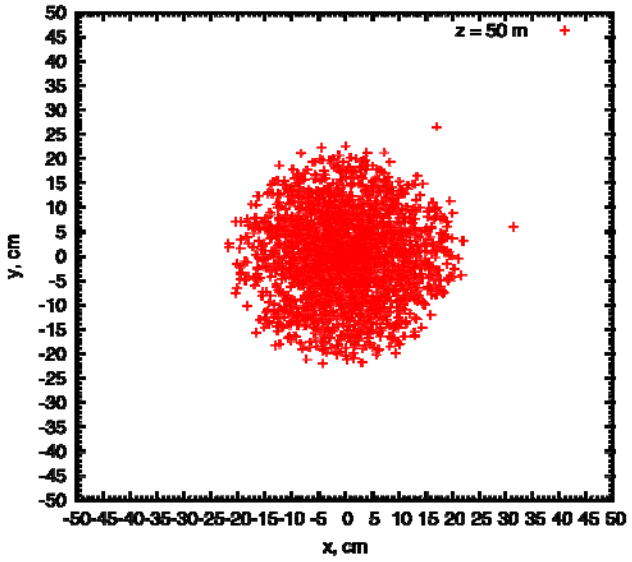
10^4 events, no beam dump, beam angle = 0 mrad

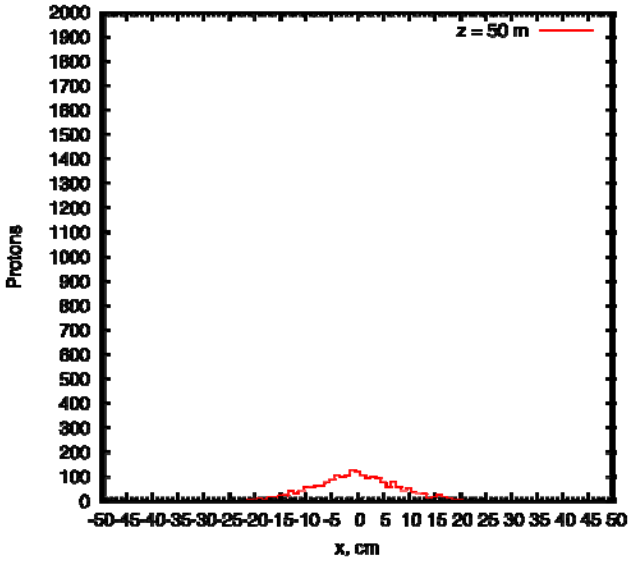
z = 5 m





z = 50 m

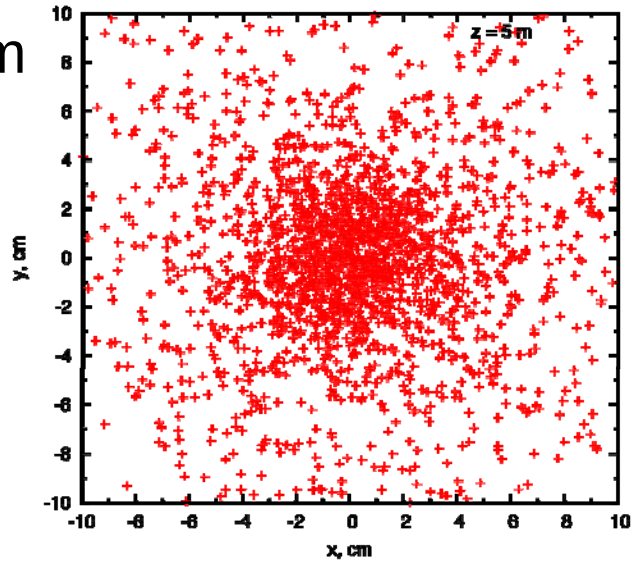


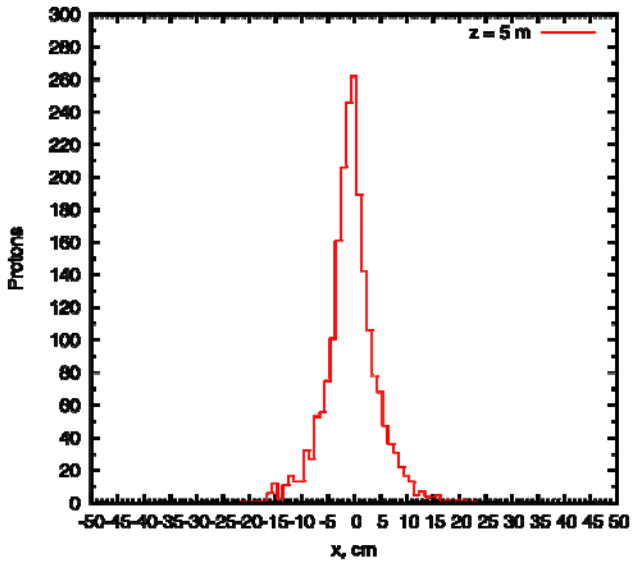


Remaining Protons (KE > 6 GeV)

10^4 events, Beam angle = 0 mrad, target radius = 0.64 cm

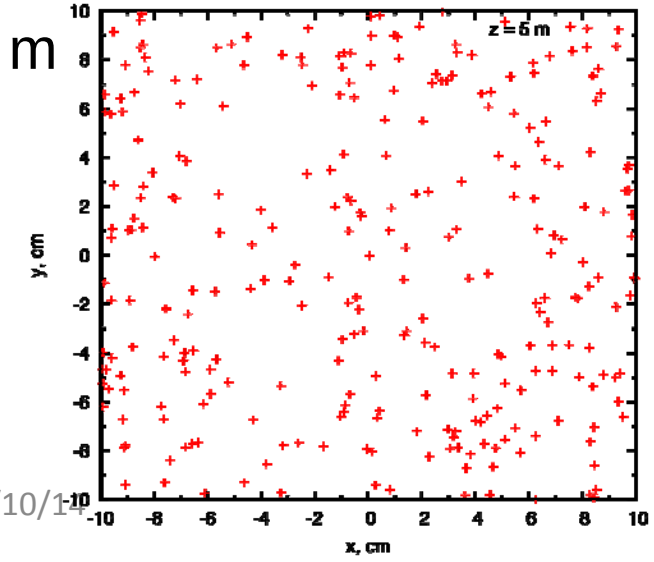
z = 5 m

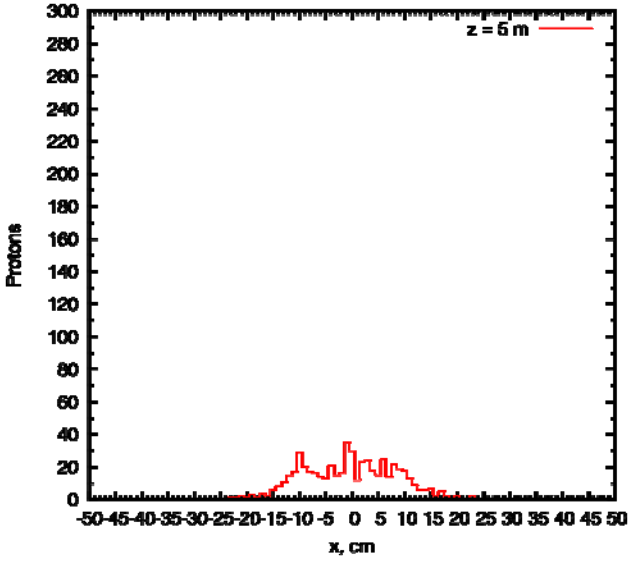




No beam dump

z = 5 m

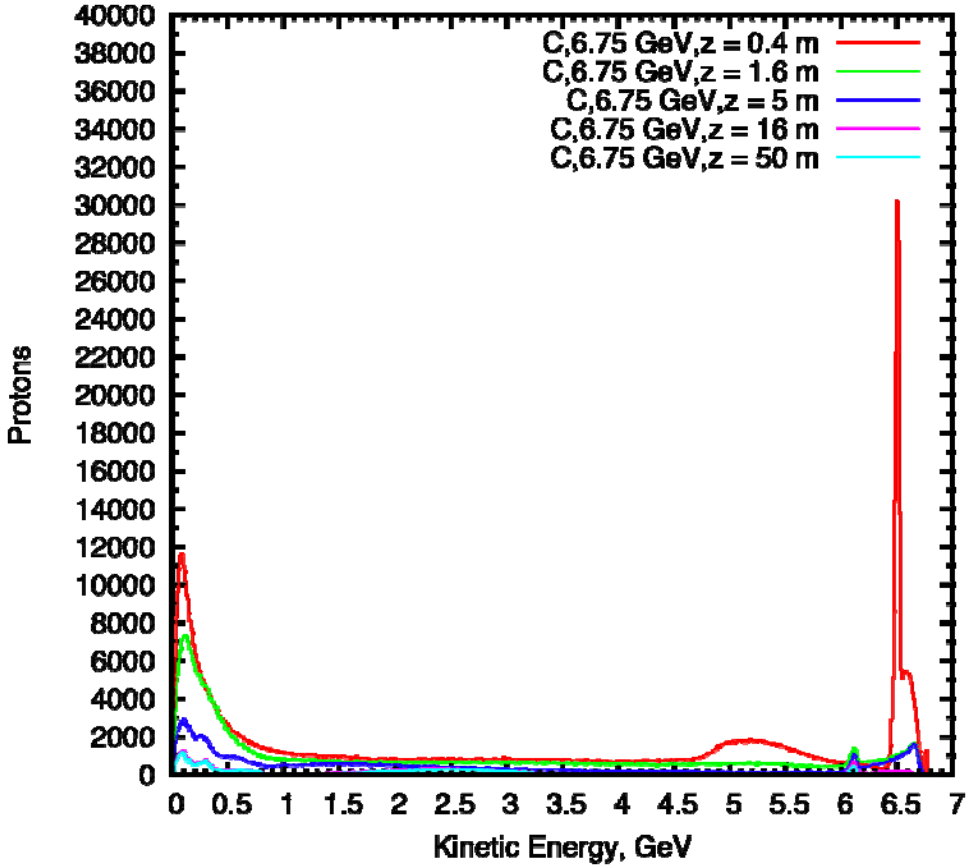


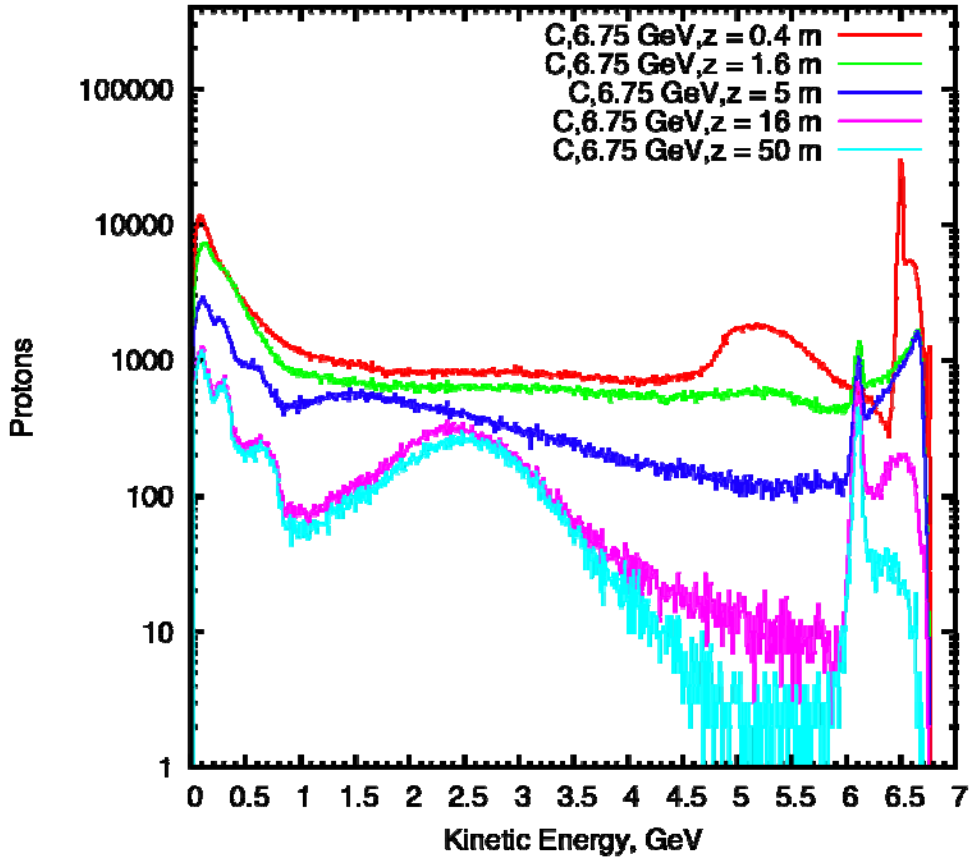


Beam dump:
120cm long (z=40 to 160 cm),
Triple of target radius

Remaining Protons with Beam Dump

(10^6 events, Beam angle = 0 mrad)





Target length: 80 cm (z=-40 cm to z=40 cm) Target radius: 0.64 cm
Beam angle: 0 mrad Co-linear target and beam TR/BR=4
Beam dump rod is 120 cm long (z=40 cm to z=160 cm)
The radius of beam dump is triple that of the target

This plot shows a peak at 6-6.5 GeV for z = 50 m.

Counting (Carbon target)

10^4 events, 1MW beam, beam angle = 0 mrad, z = 5 m

L_{dump} (cm)	R_{dump}/R_{target}	Total KE (protons) (r <23 cm) [Watts]	Total KE (non-protons) [Watts]	Protons KE>6	Protons KE>4.5	Yield at z=50m
0	0	265270	88258	2078	2310	1063.4
40	1	221590	92222	1543	1787	987
80	1	202506	90564	1419	1668	927
120	1	210141	87216	1452	1695	868.8
40	2	183241	90205	1213	1419	938
80	2	155798	85367	909	1114	780.3
120	2	149733	86754	870	1134	743
40	3	158241	91585	1044	1260	852.7
80	3	119851	85385	607	811	680.2
120	3	114139	81006	542	767	590

C, Hg, Ga targets, no dump

10^4 events, 1 MW beam, beam angle = 0 mrad, z = 5 m

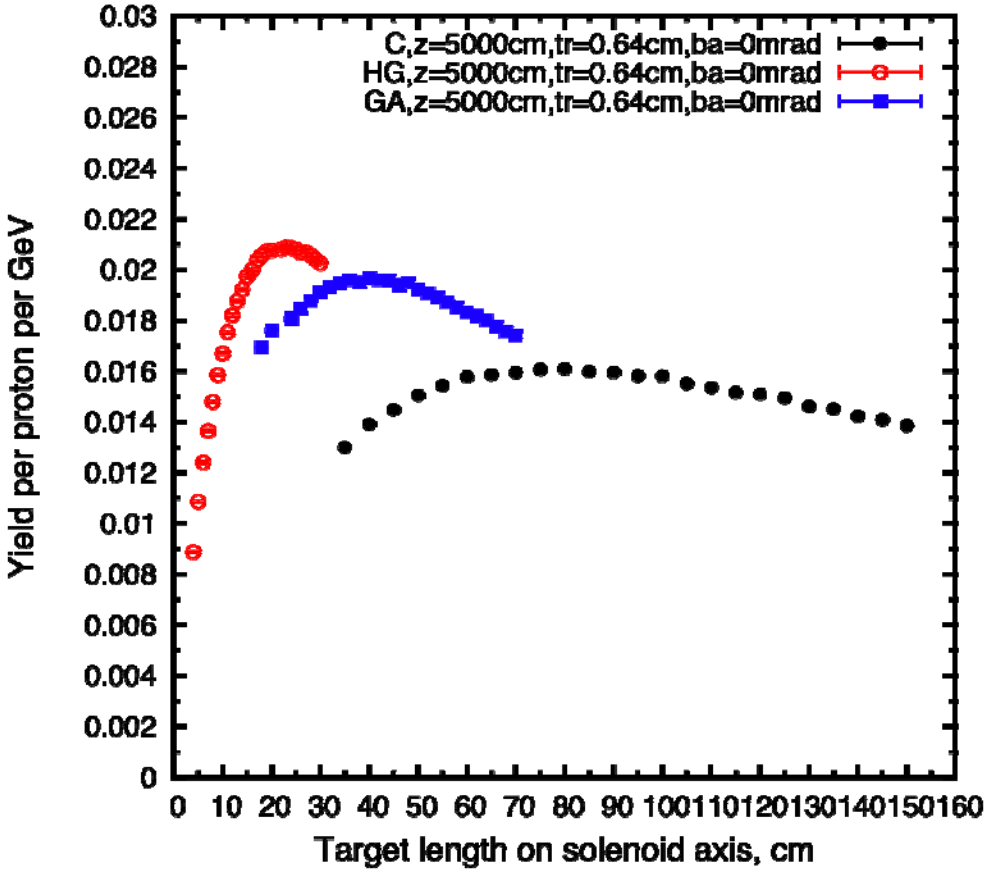
Target length is 80 cm for C, 23 cm for Hg, and 40 cm for Ga

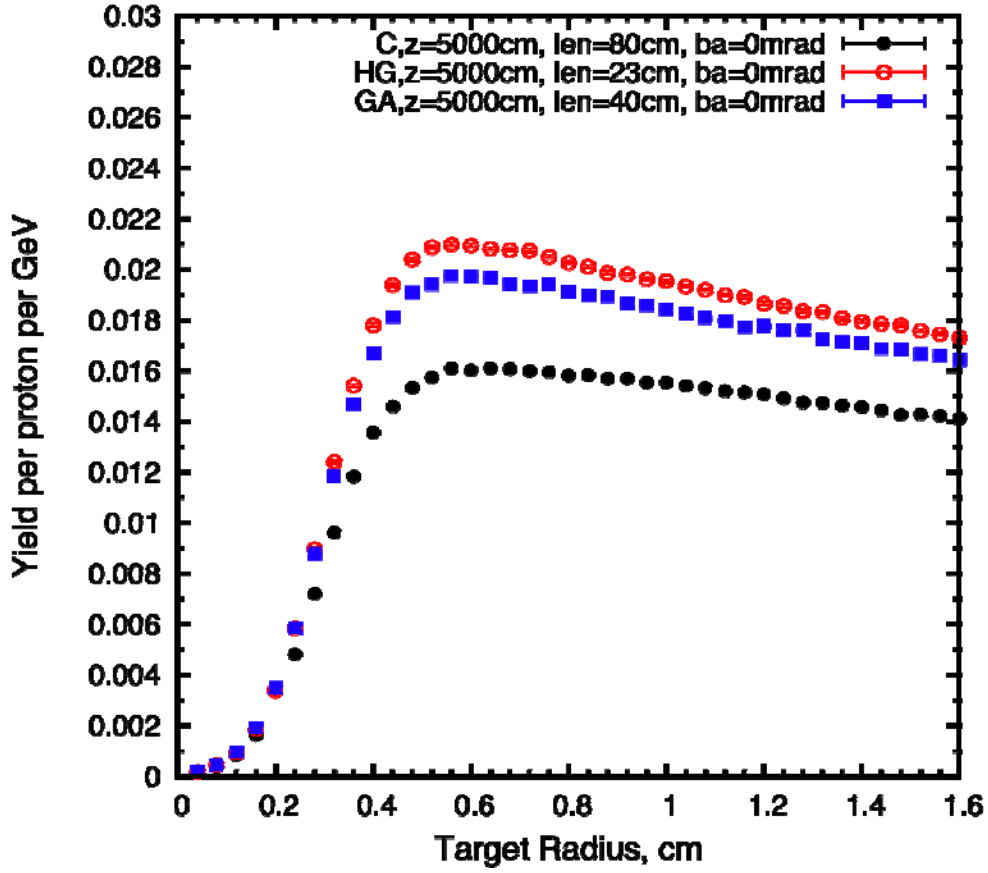
	Total KE (protons) (r <23 cm) [Watts]	Total KE (non-protons) [Watts]	Protons KE>6	Protons KE>4.5	Yield at z=50m
C	265270	88258	2078	2310	1063.4
Hg	217116	65898	1908	1974	1362.4
Ga	223972	84440	1818	1945	1288.7

Previous studies for Hg and Ga used a tilted beam such that higher energy protons were not counted, so the total power sent down the beampipe was ~ ½ that seen here.

Yield Comparison

(C, Hg and Ga targets, no tilt of beam to SC axis)





Optimized target length is 80 cm for C, 23 cm for Hg, and 40 cm for Ga.
Target radius is 0.64 cm for all when beam angle is fixed at 0 mrad.
Co-linear target and beam. TR/BR=4

For yield comparison, Hg gives ~ 29.3% higher than C and Ga gives ~ 22.2% higher than C