



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 $5 \mu\text{m}$;
- Production Collection: (50 m downstream, $40 \text{ MeV} < \text{KE} < 180 \text{ MeV}$).
- Graphite density = 1.8

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);

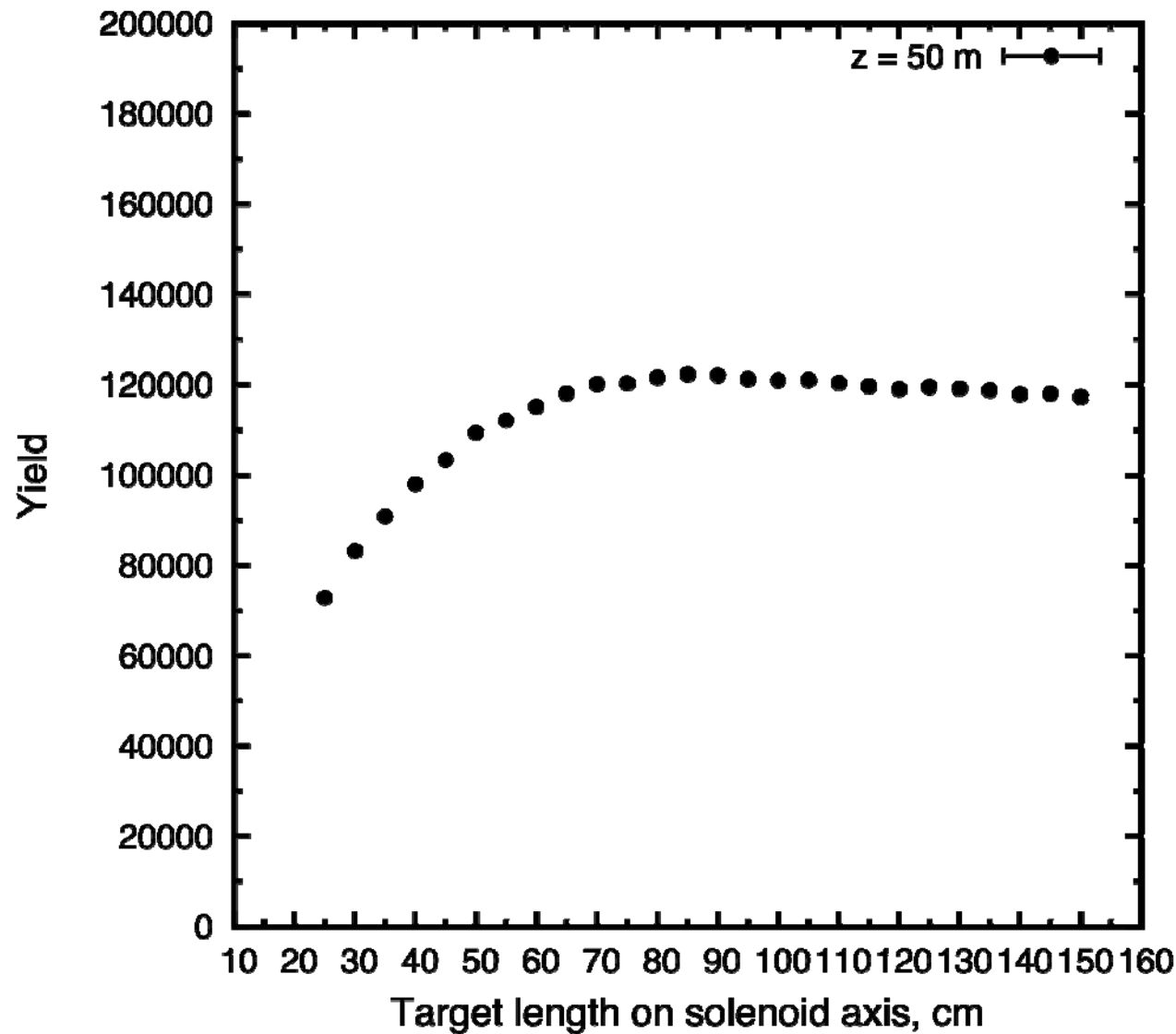
EMNEU: The threshold energy for neutrons (Default: 10^{-4} GeV)

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

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



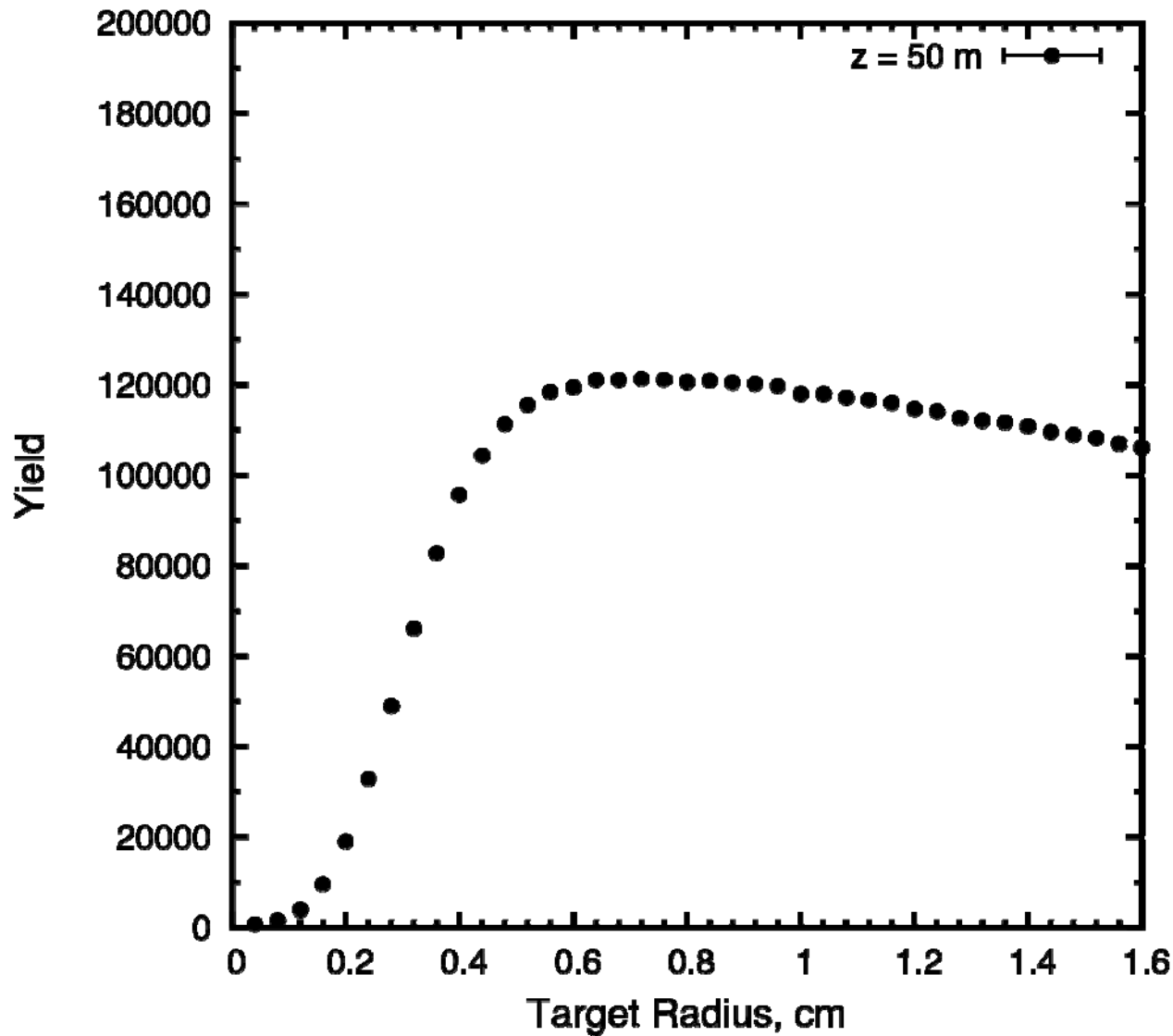
Target radius: 0.80 cm

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)



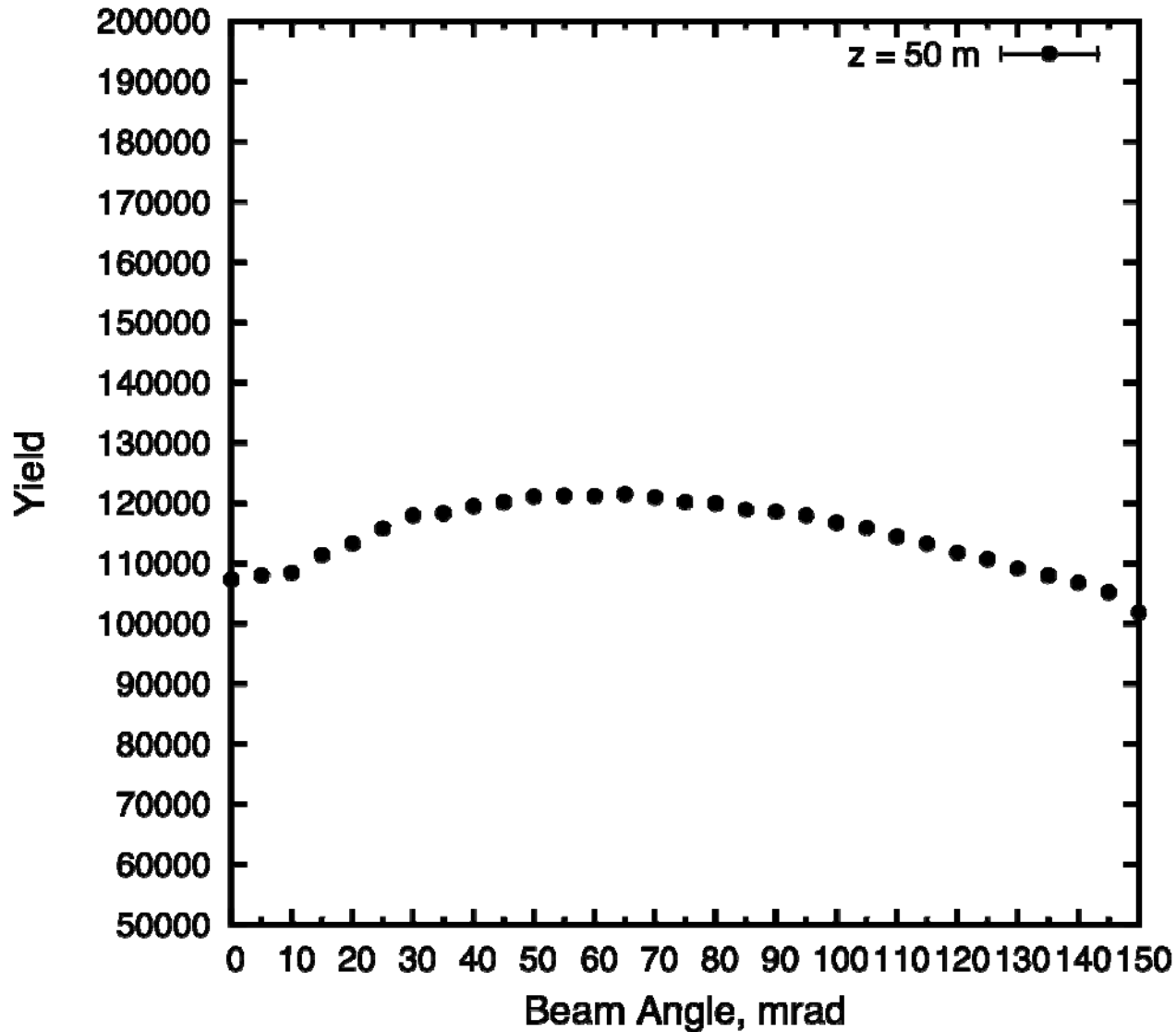
Target length: 80 cm

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)



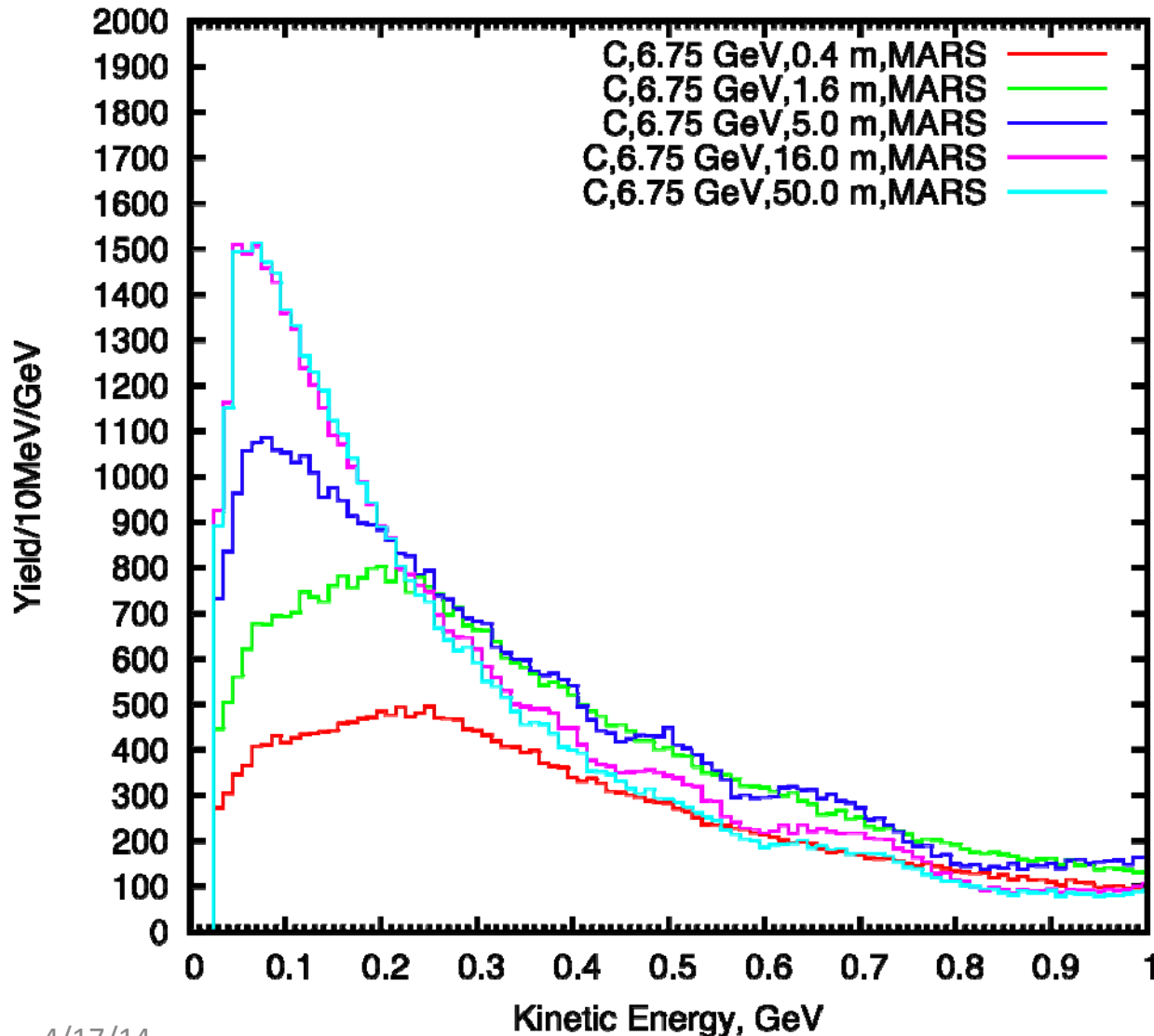
Target length: 80 cm

Target radius: 0.80 cm

Co-linear target and beam

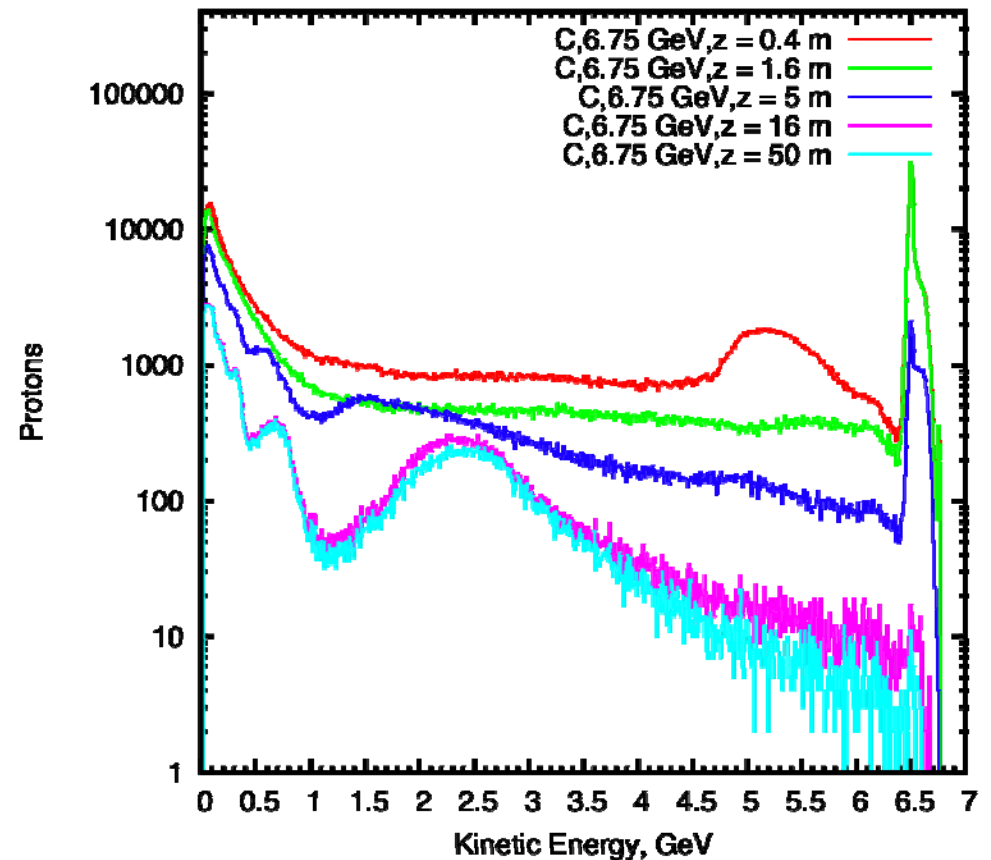
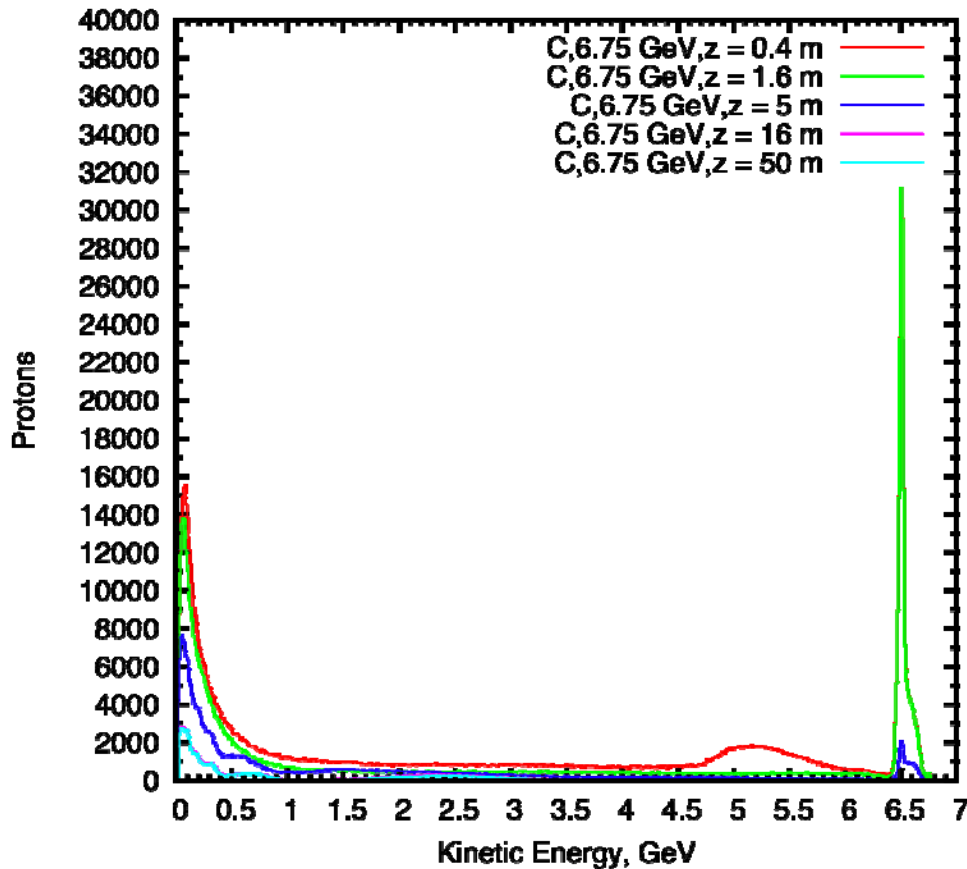
TR/BR = 4

Energy Spectra of π^\pm , K^\pm , μ^\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

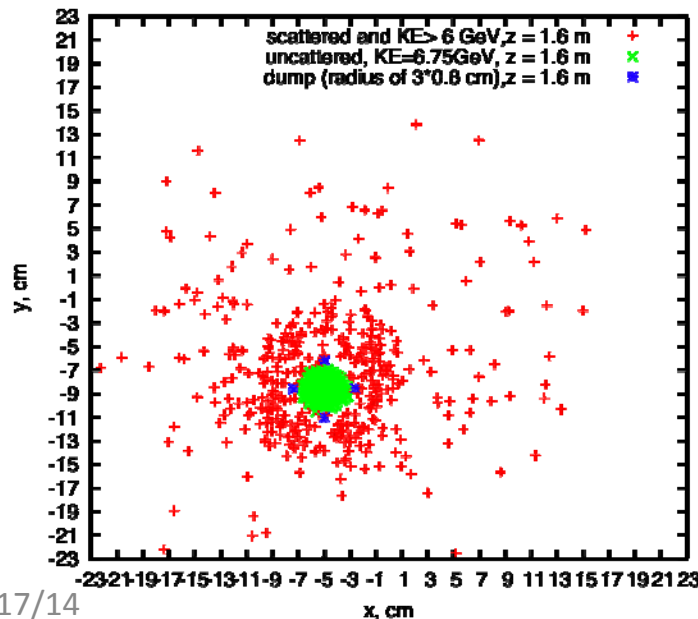
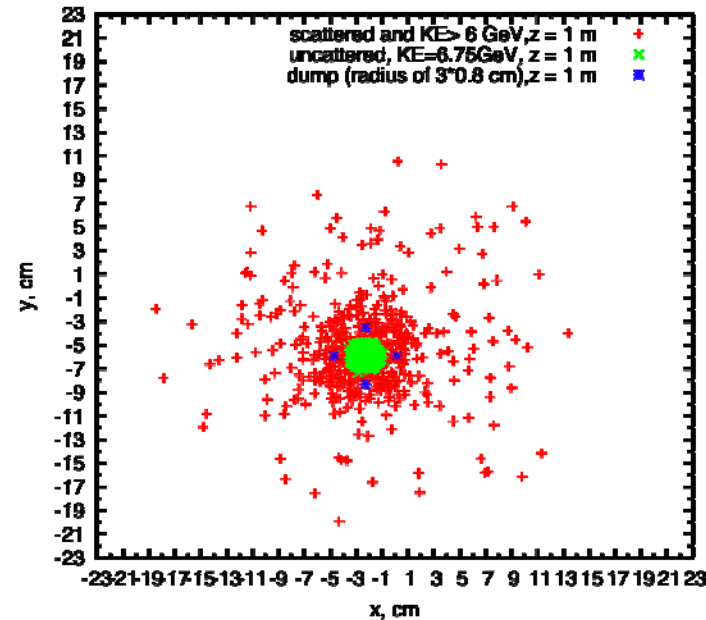
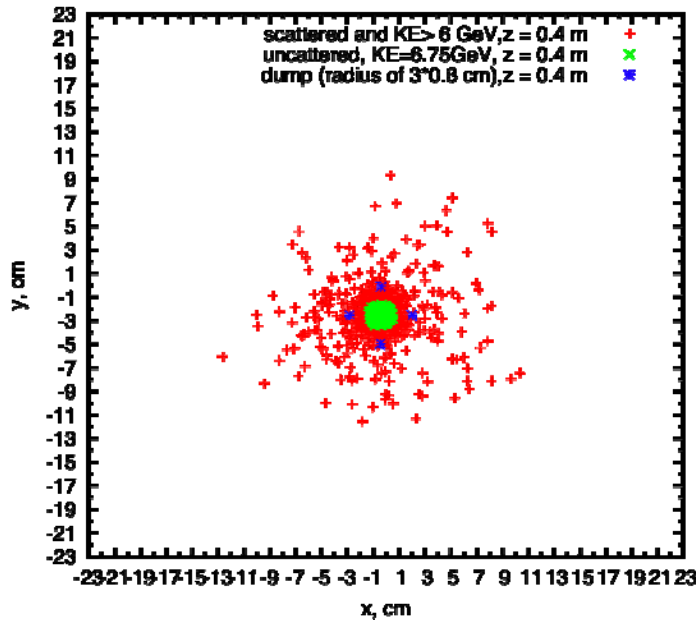
Co-linear target and beam

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.

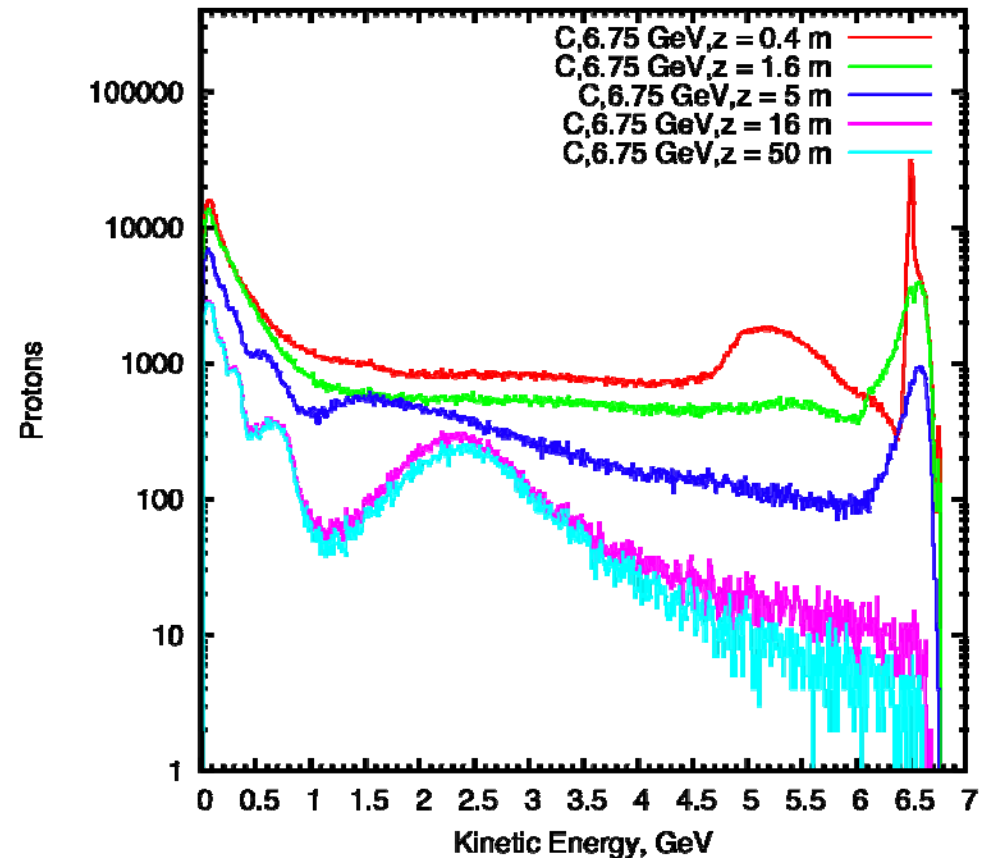
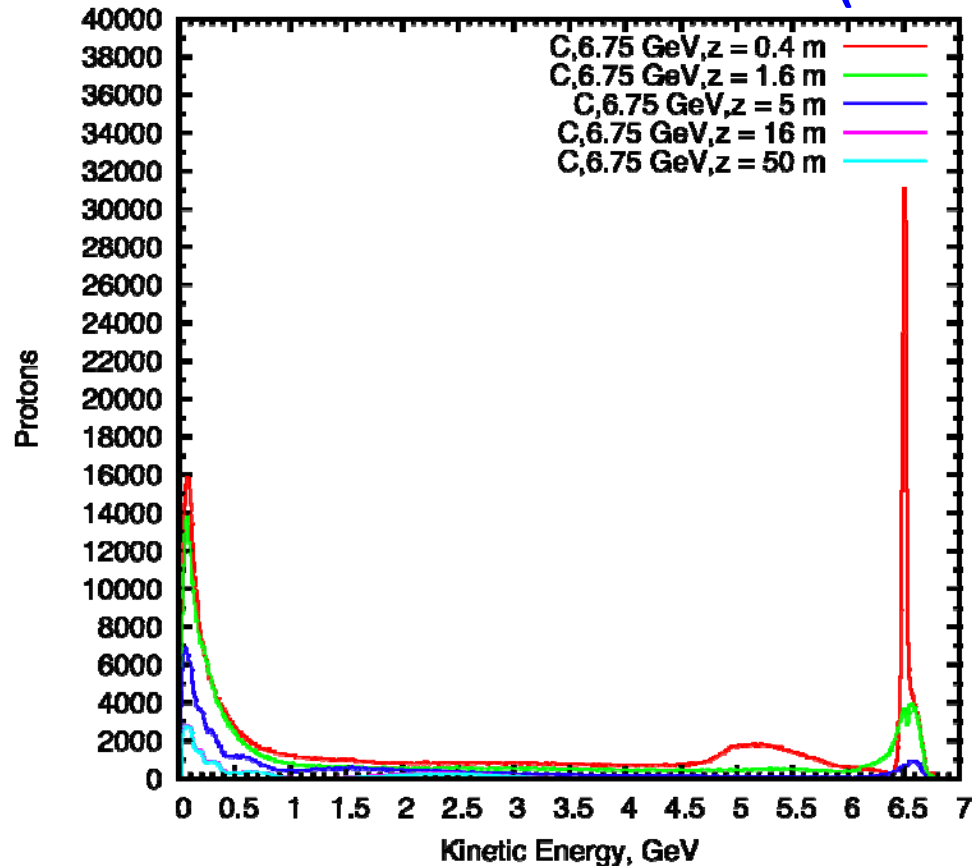
Coordinates of beam and dump



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 radius = 3 target radius
($z = 40$ cm to $z = 100$ cm, horizontal tilt: 31.1 mrad, vertical tilt: 56.27 mrad)
($z = 100$ cm to $z = 160$ cm, horizontal tilt: 44.9 mrad, vertical tilt: 44.17 mrad)

Remaining Protons with Beam Dump

(10^6 events)



Target length: 80 cm ($z = -40$ cm to $z = 40$ cm) Target radius: 0.80 cm

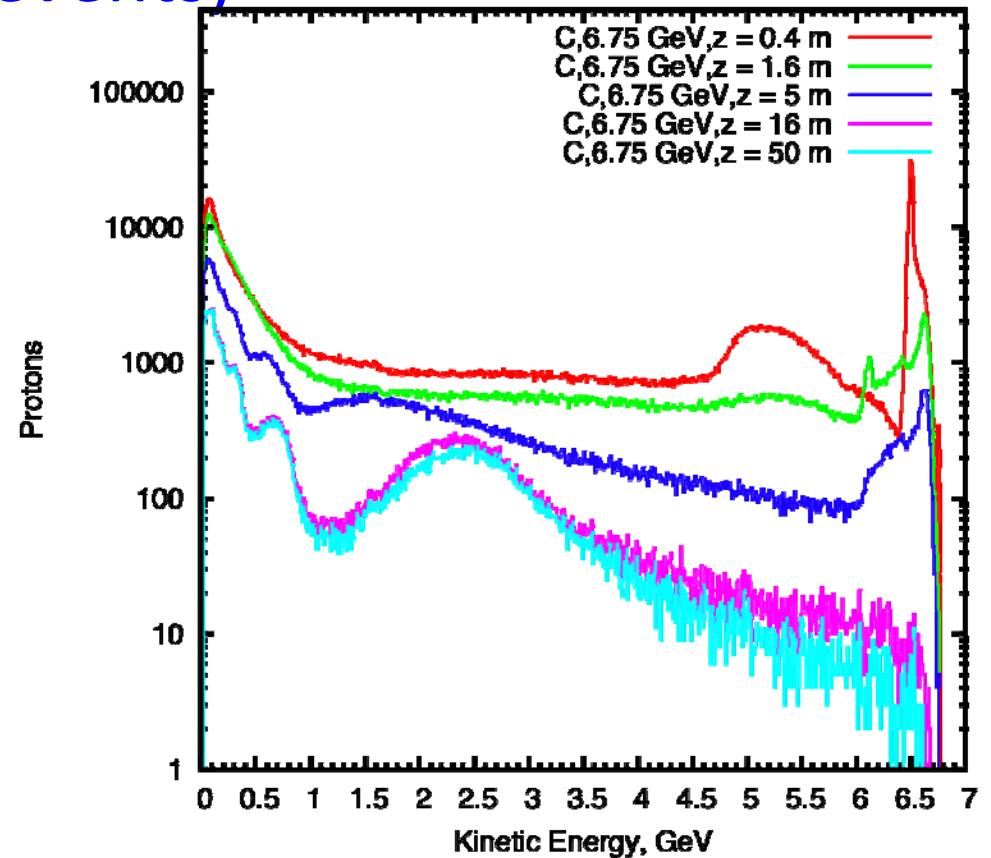
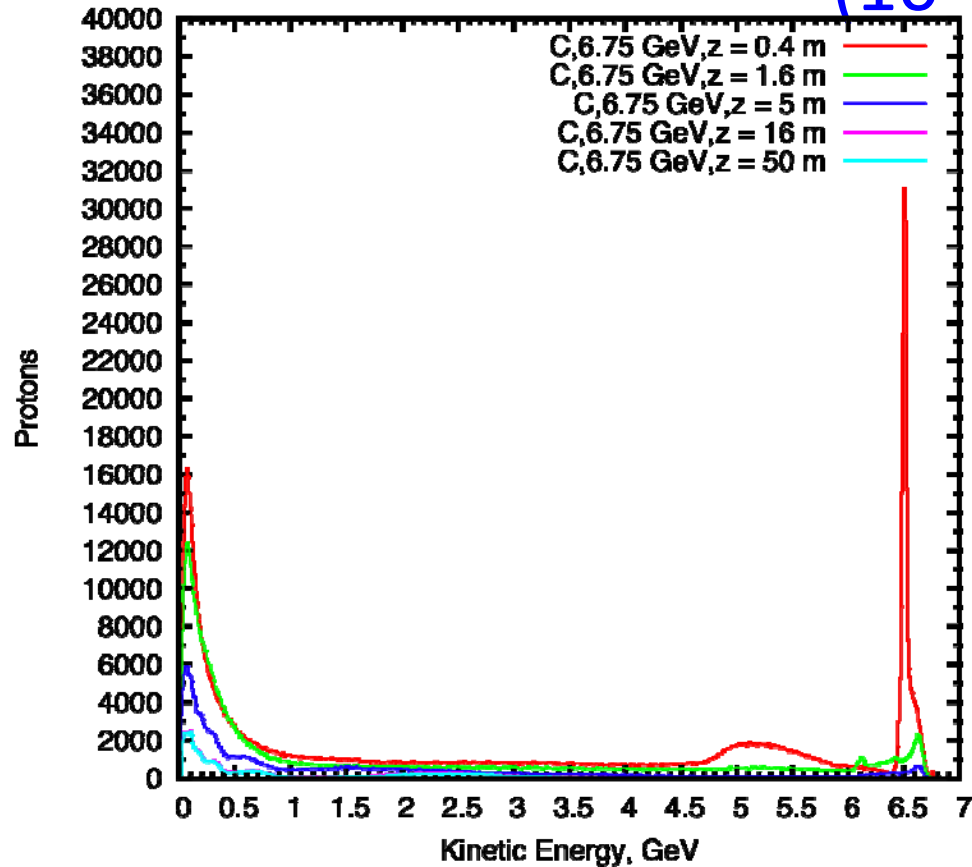
Beam angle: 65 mrad Co-linear target and beam TR/BR = 4

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

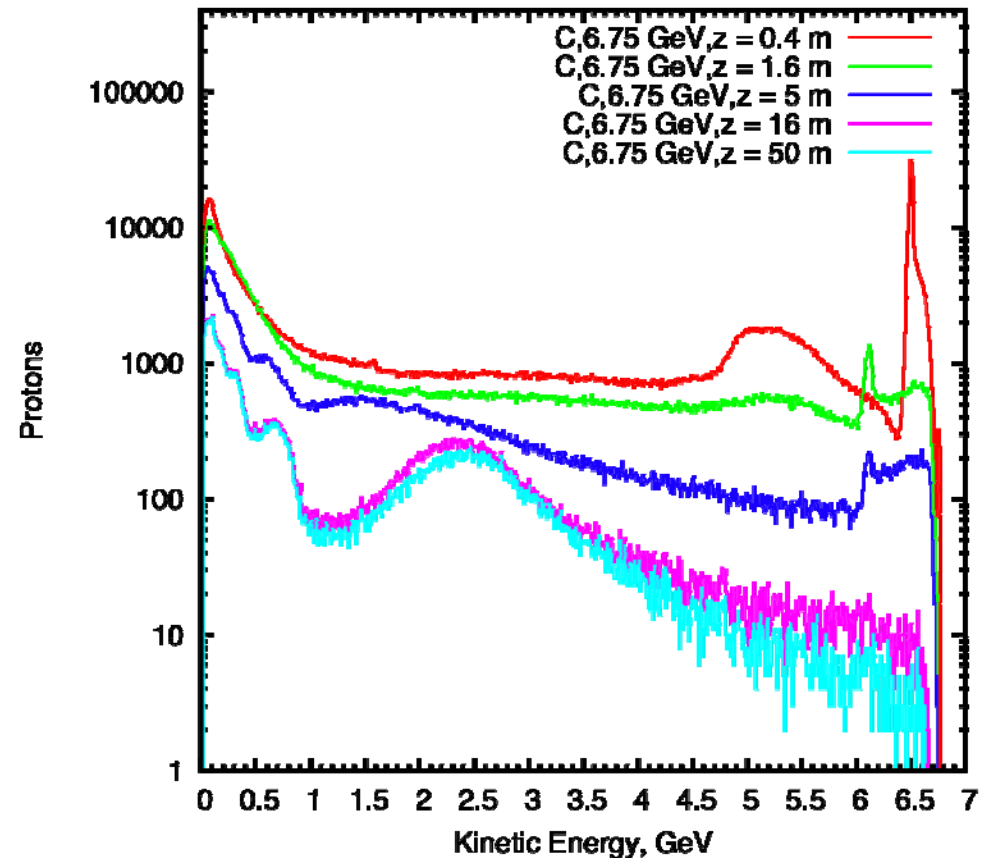
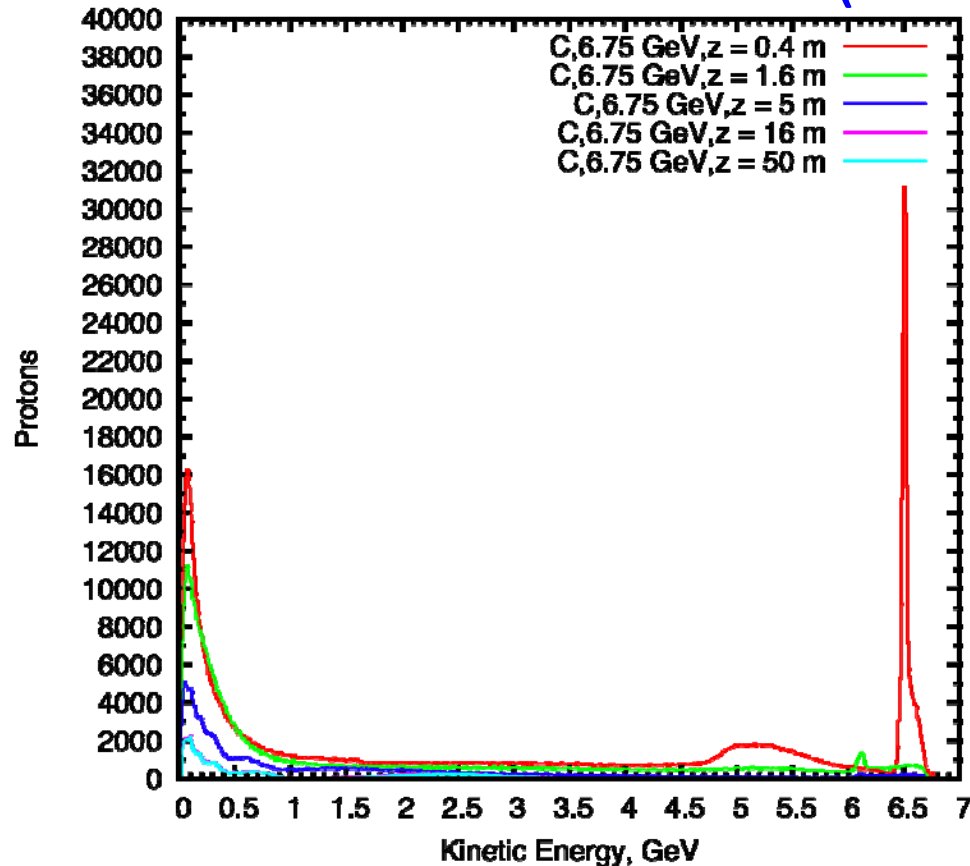
Beam angle: 65 mrad Co-linear target and beam TR/BR = 4

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

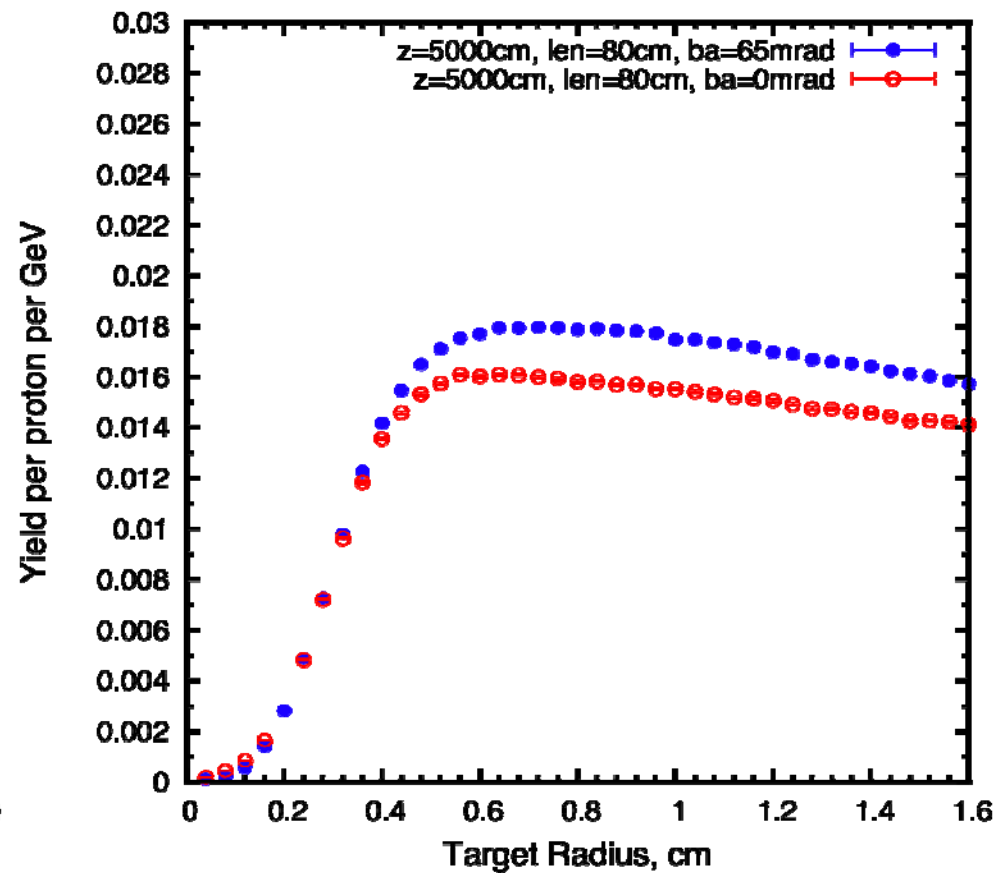
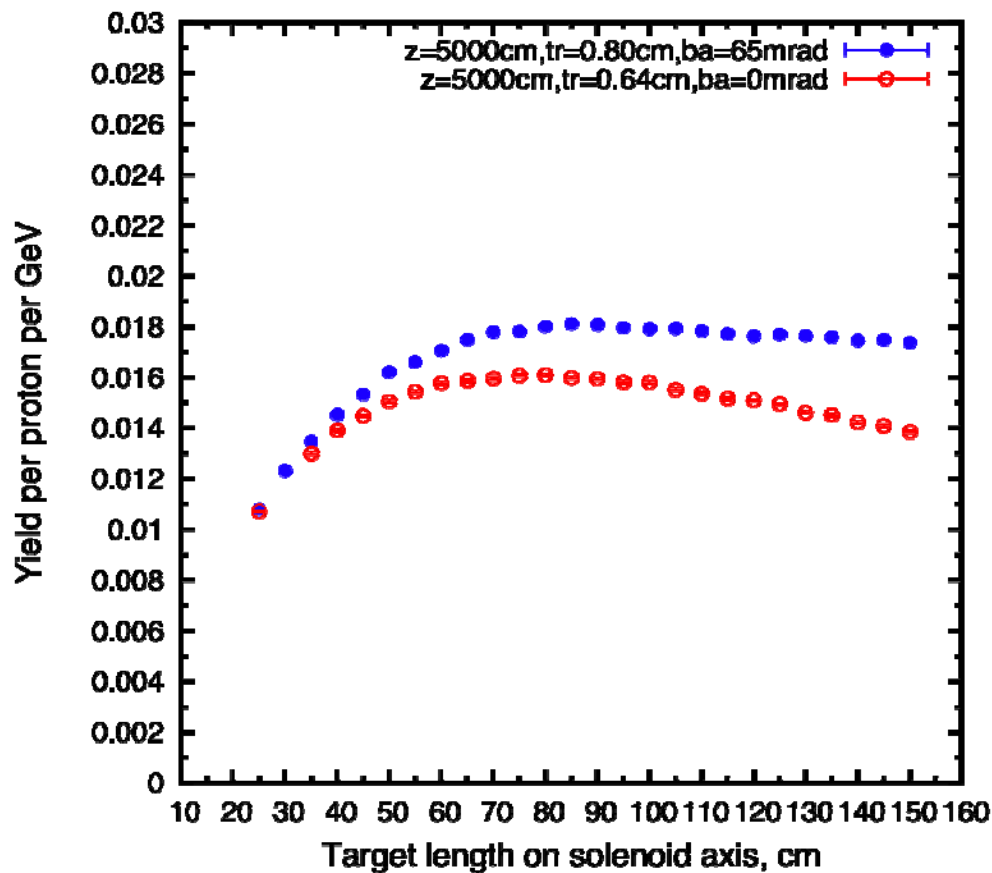
Beam angle: 65 mrad Co-linear target and beam TR/BR = 4

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)



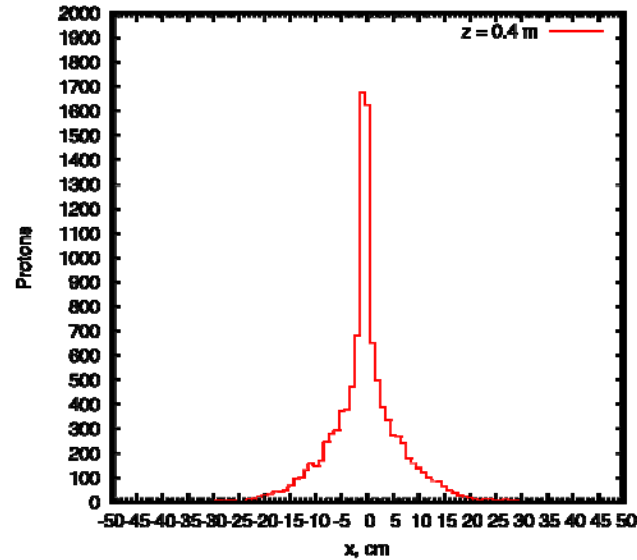
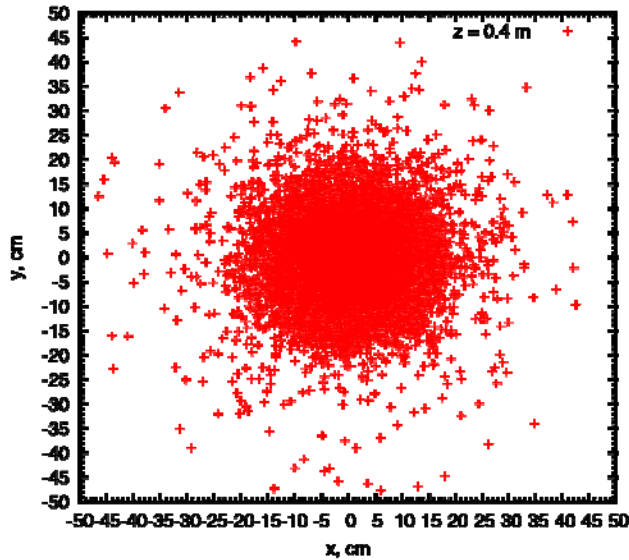
Optimized target length is 80 cm and target radius is 0.64 cm when beam angle is fixed at 0 mrad.

Co-linear target and beam. TR/BR = 4

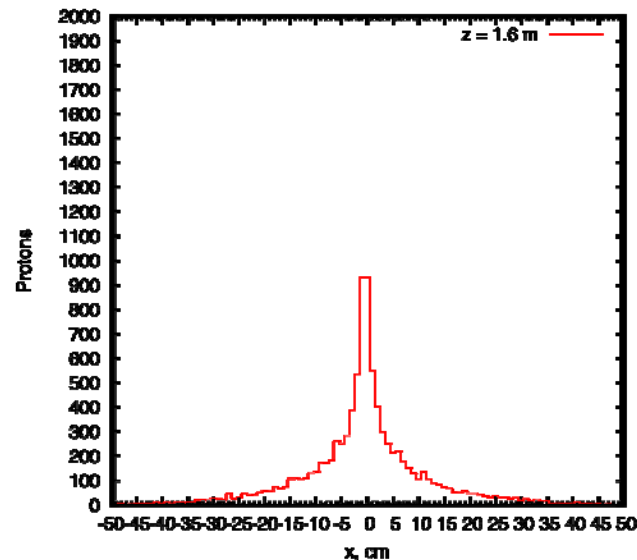
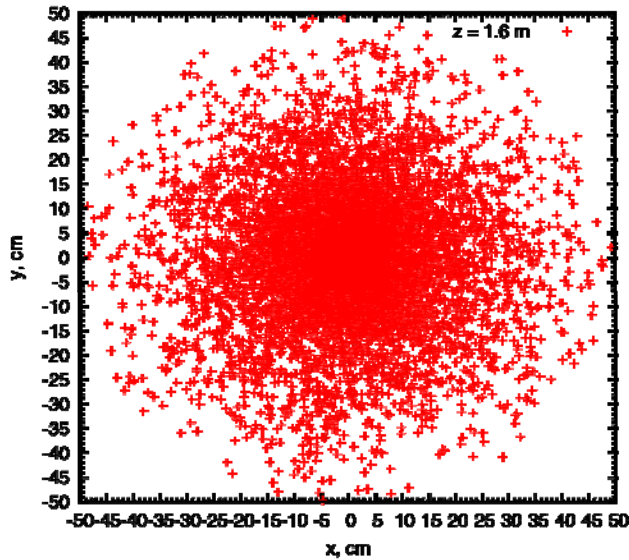
Remaining Protons (KE > 0)

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

$z = 0.4$ m



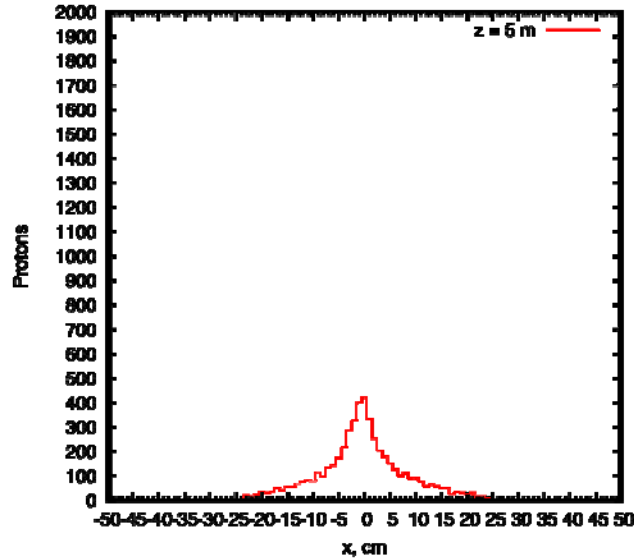
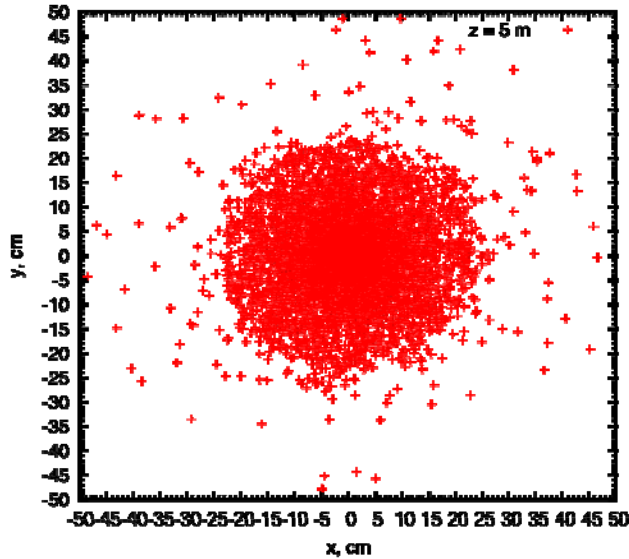
$z = 1.6$ m



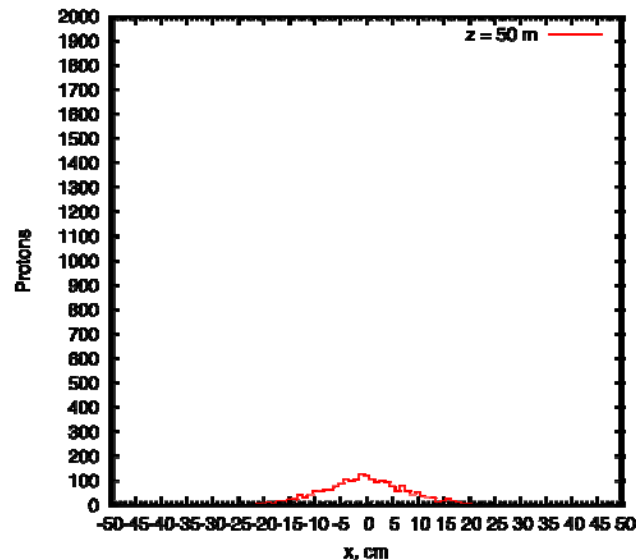
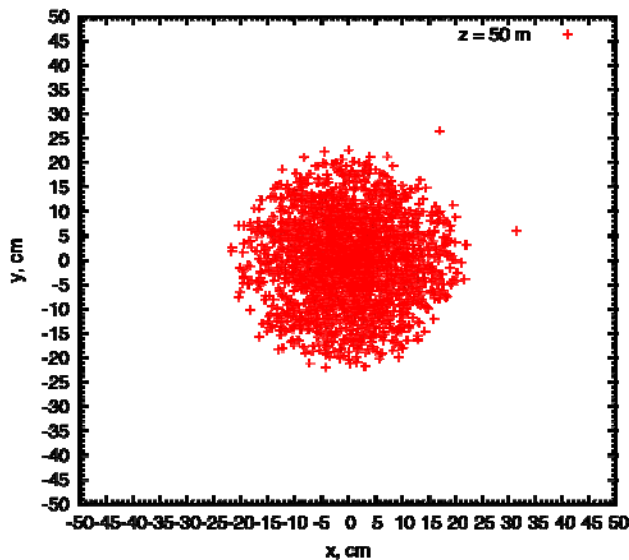
Remaining Protons (KE > 0)

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

$z = 5$ m

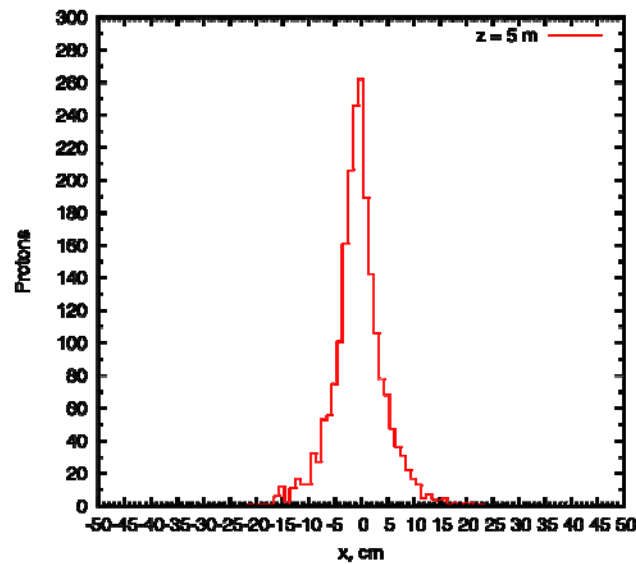
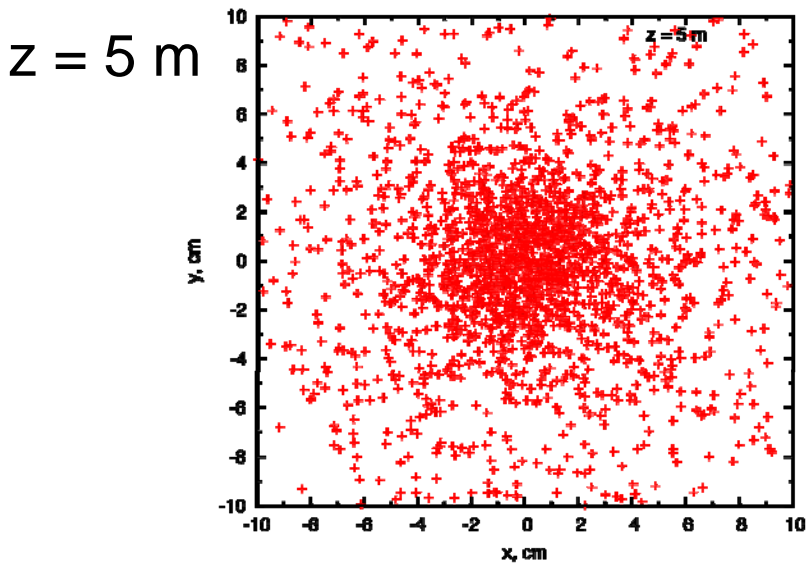


$z = 50$ m

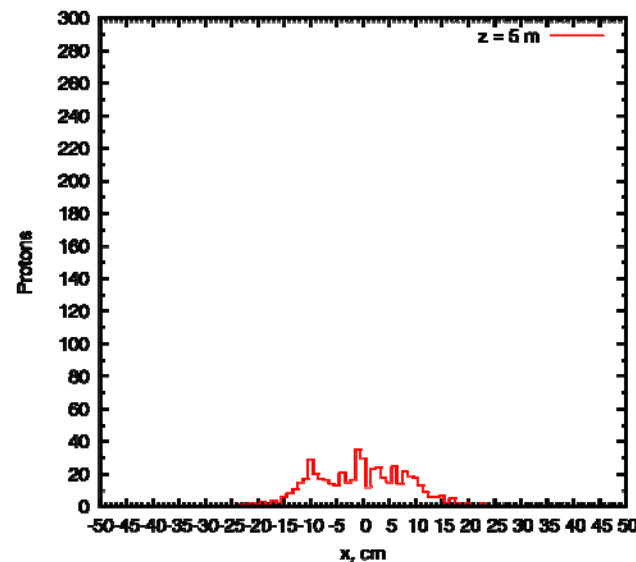
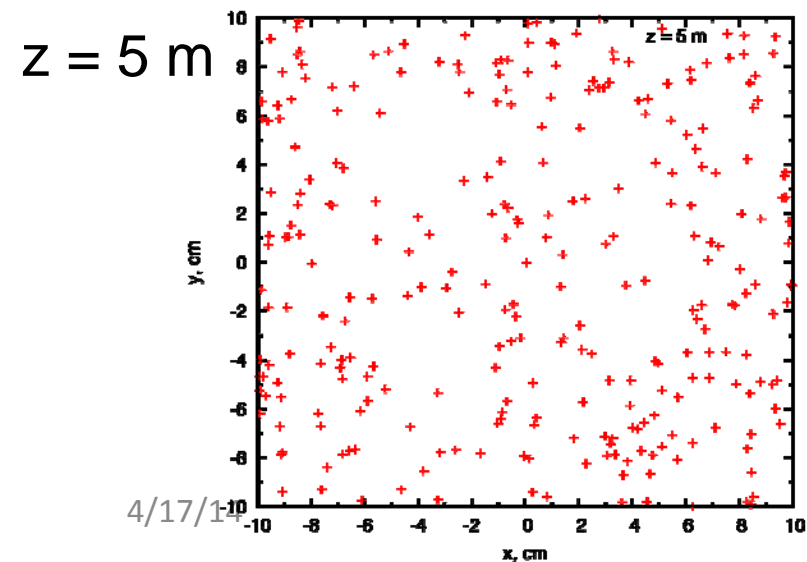


Remaining Protons (KE > 6 GeV)

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



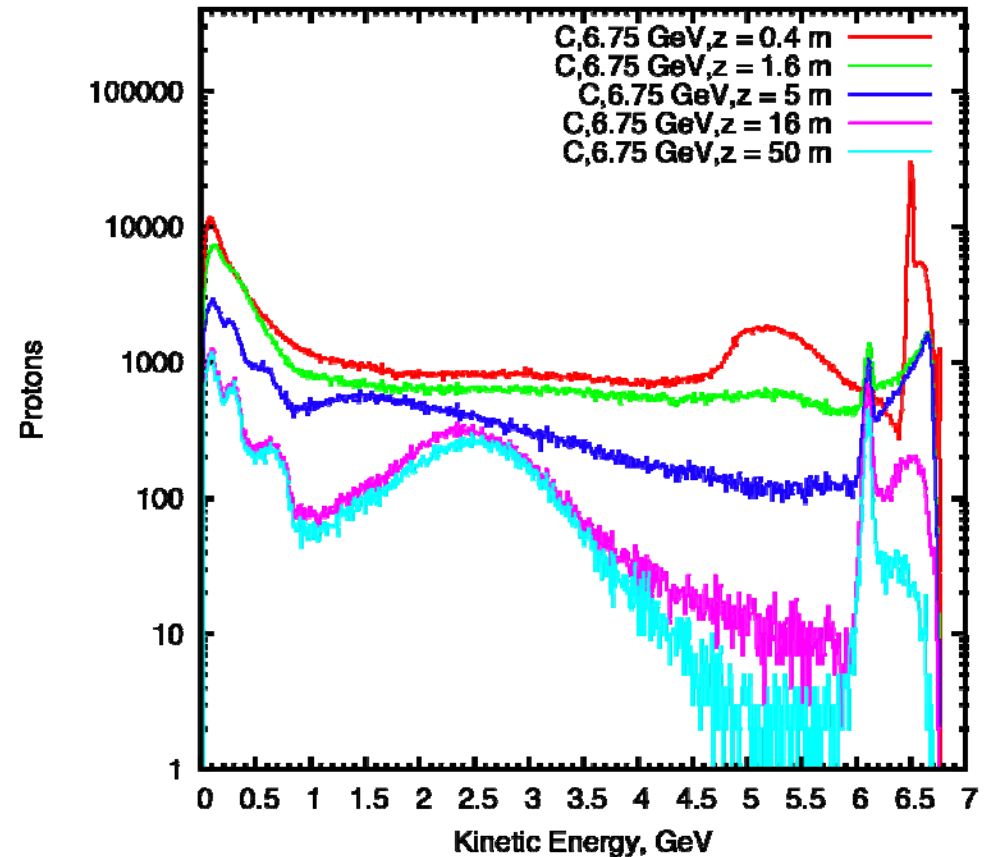
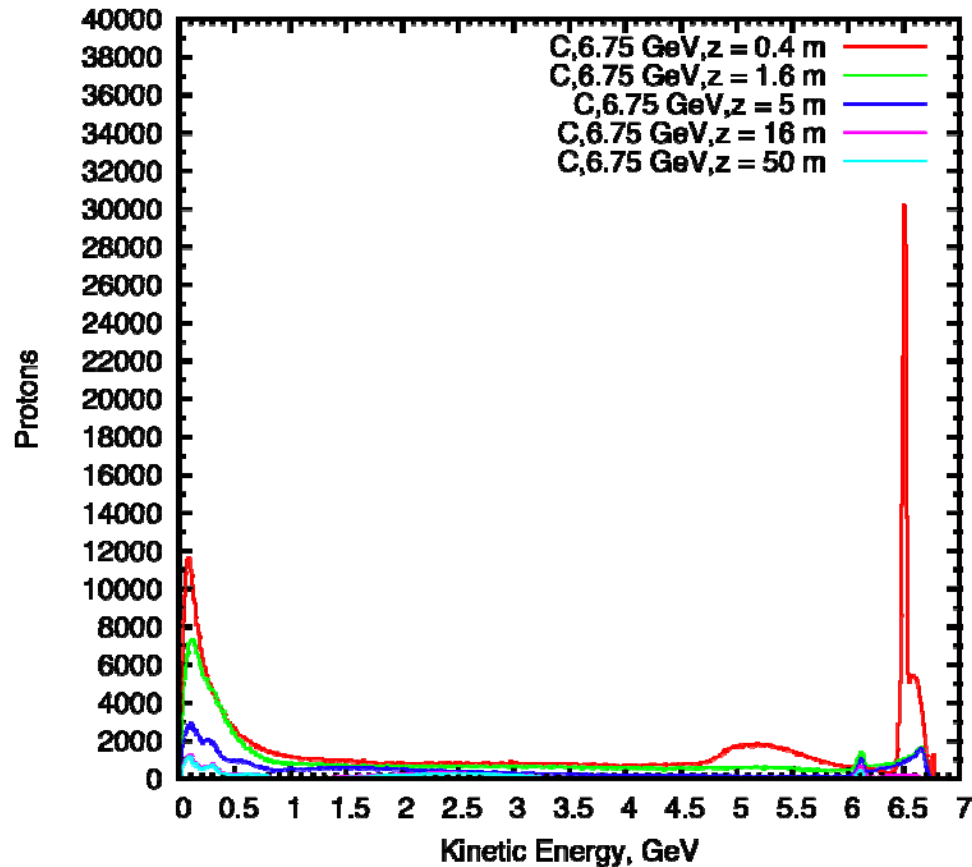
No beam dump



Beam dump:
120 cm 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

4/17/14 This plot shows a peak at 6-6.5 GeV for $z = 50$ m.

Counting (Carbon target) at $z = 5$ m

1MW beam (9.26×10^{14} protons with KE of 6.75 GeV)

beam angle = 0 mrad, target radius = 0.64 cm

L_{dump} (cm)	$R_{\text{dump}}/$ R_{target}	Total KE (protons) ($r < 23$ cm) [Watts]	Total KE (non-protons) [Watts]	Protons KE>6 ($\times 9.26$ $\times 10^{10}$)	Protons KE>4.5 ($\times 9.26$ $\times 10^{10}$)	Yield at $z=50$ m ($\times 9.26$ $\times 10^{10}$)
0	0	265270	88258	2078	2310	1063
40	1	221590	92222	1543	1787	987
80	1	202506	90564	1419	1668	927
120	1	210141	87216	1452	1695	869
40	2	183241	90205	1213	1419	938
80	2	155798	85367	909	1114	780
120	2	149733	86754	870	1134	743
40	3	158241	91585	1044	1260	853
80	3	119851	85385	607	811	680
120	3	114139	81006	542	767	590

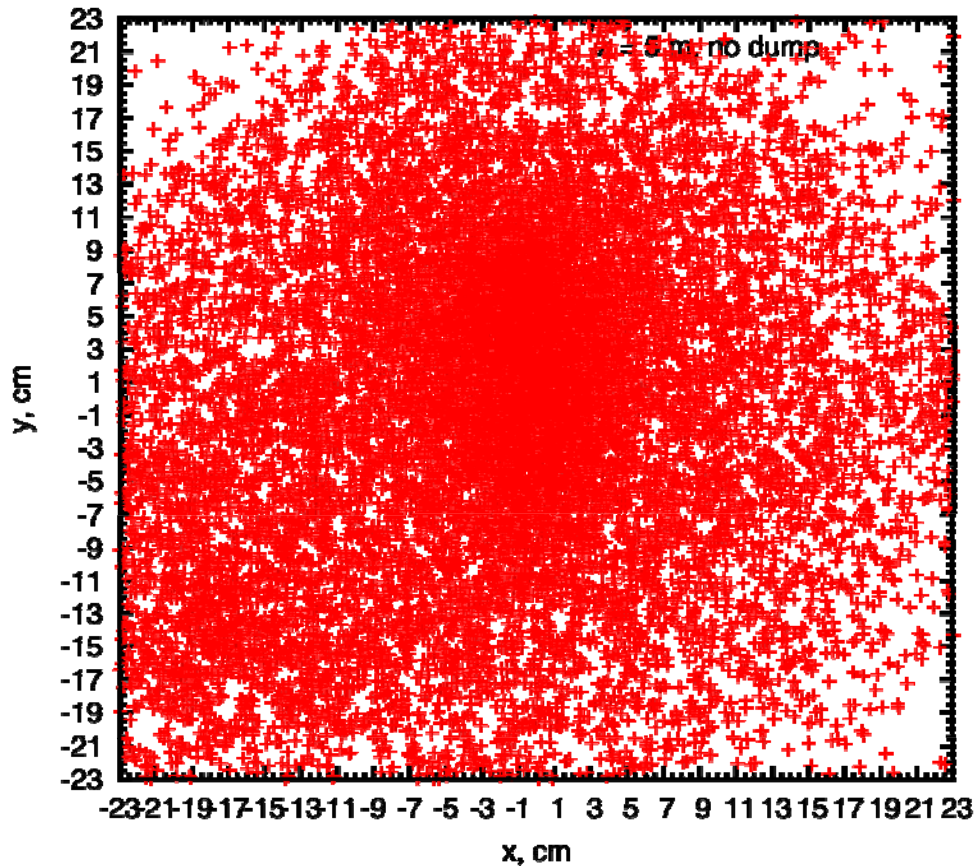
Counting (Carbon target) at $z = 5 \text{ m}$

1MW beam (9.26×10^{14} protons with KE of 6.75 GeV)

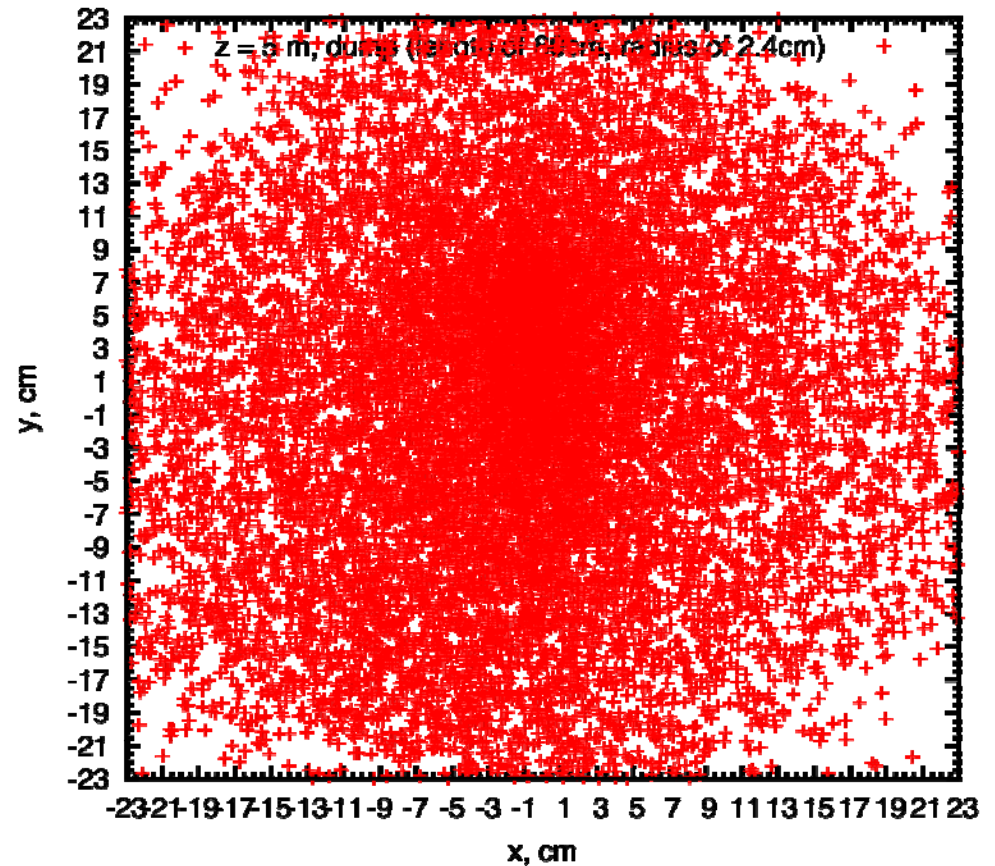
beam angle = 65 mrad, target radius = 0.8 cm

L_{dump} (cm)	$R_{\text{dump}}/$ R_{target}	Total KE (protons) ($r < 23 \text{ cm}$) [Watts]	Total KE (non-protons) [Watts]	Protons KE>6 ($\times 9.26$ $\times 10^{10}$)	Protons KE>4.5 ($\times 9.26$ $\times 10^{10}$)	Yield at $z=50\text{m}$ ($\times 9.26$ $\times 10^{10}$)
0	0	88359	105454	301	532	1240.7
40	1	85504	105007	270	466	1268
80	1	88318	102577	318	520	1256.2
120	1	85932	100030	299	496	1230.1
40	2	77262	101664	207	400	1246.2
80	2	75493	97715	206	370	1196
120	2	78364	96967	204	374	1170.5
40	3	72615	101494	176	359	1084.5
80	3	64610	97569	112	271	1142.4
120	3	66430	94936	130	300	1134.6

All charged particles at $z = 5$ m (10^4 events, beam angle 65 mrad)

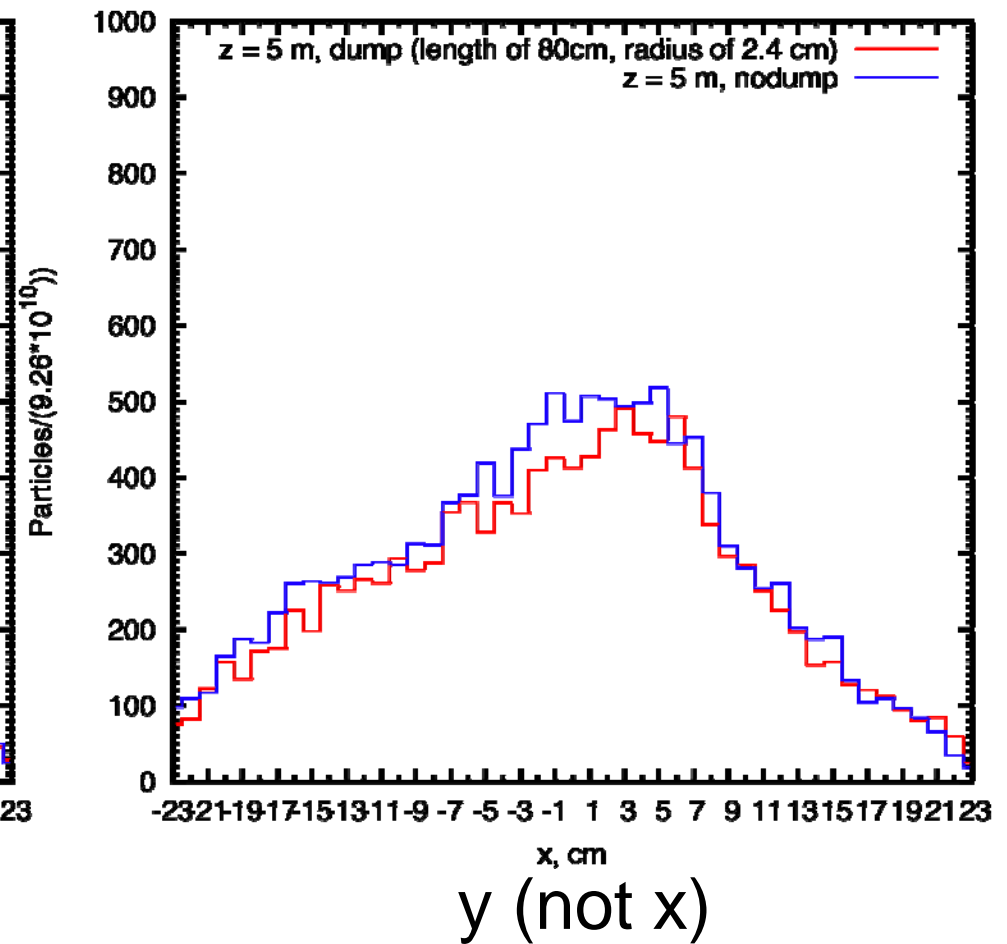
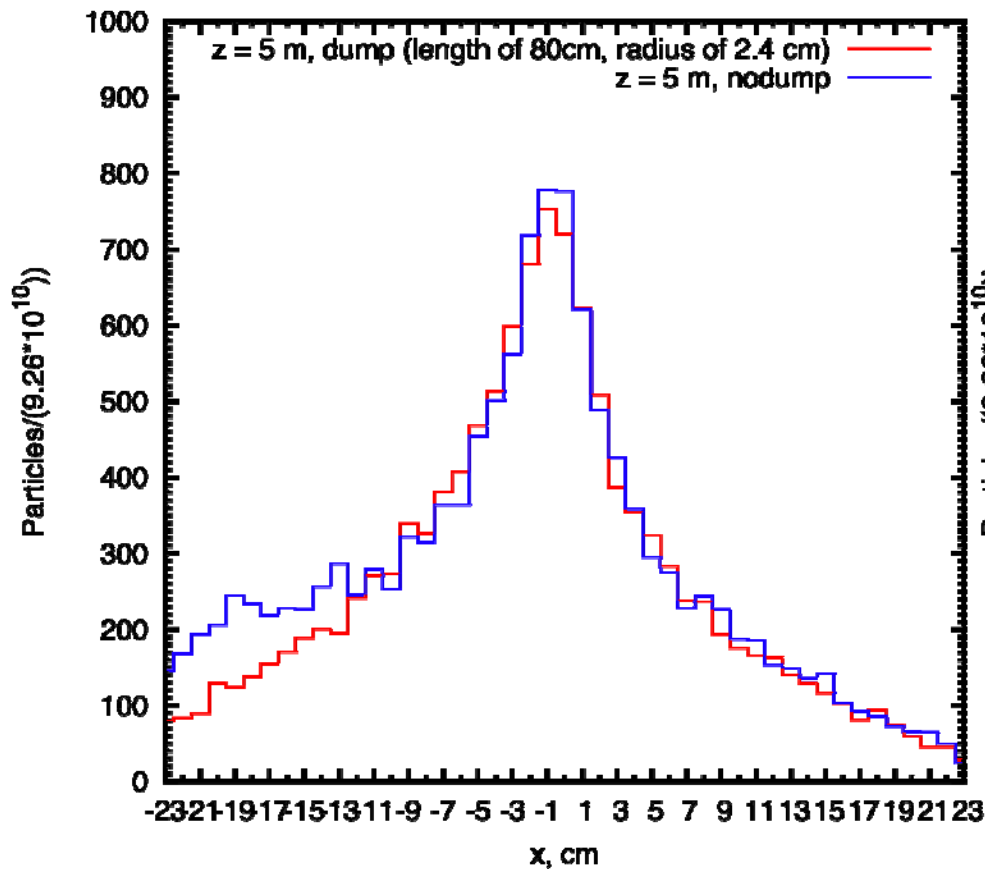


No dump



Dump (length of 80 cm
long, radius of 2.4 cm)

All charged particles at $z = 5$ m (1 MW proton beam)



C, Hg, Ga targets, no dump

1 MW beam (9.26×10^{14} protons with KE of 6.75 GeV),
beam angle = 0 mrad, z = 5 m

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

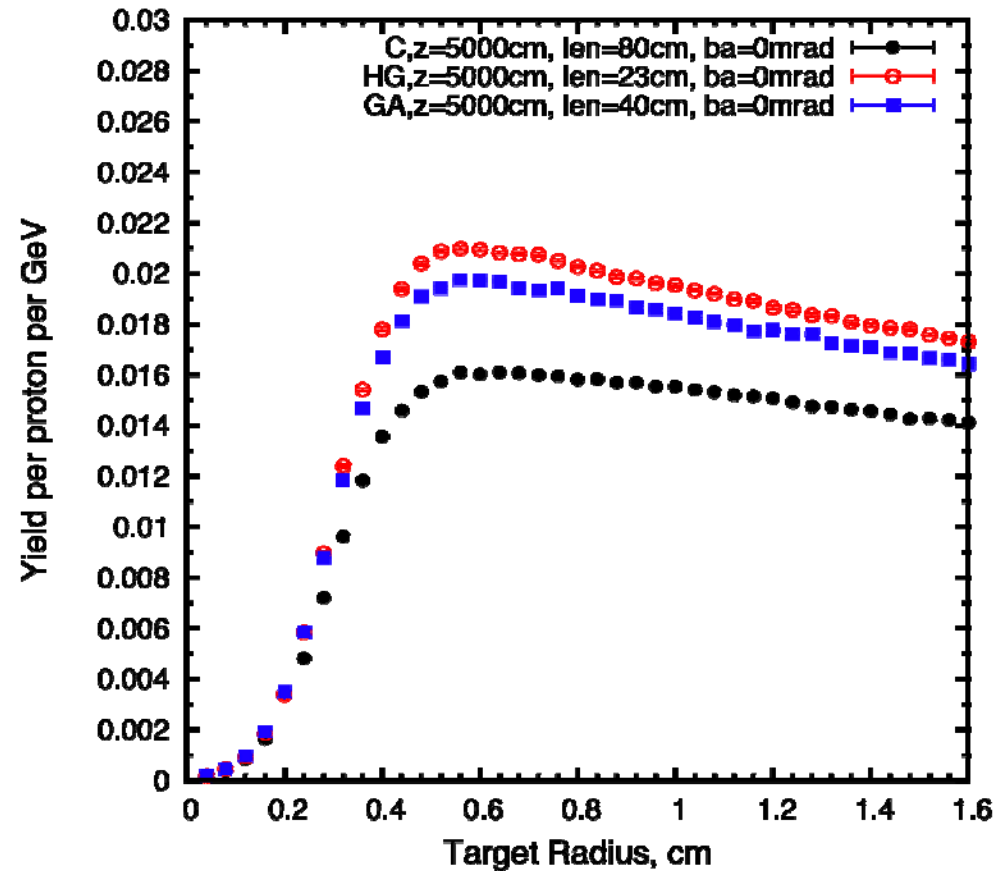
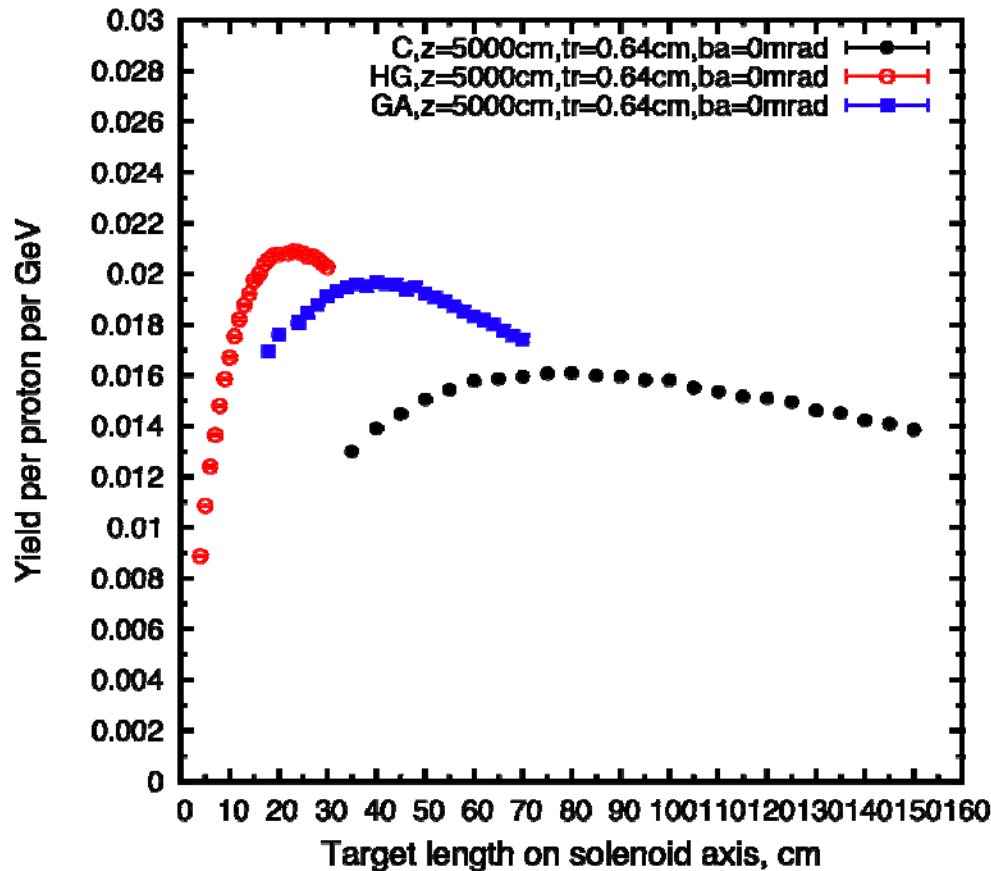
	Total KE (protons) (r <23 cm) [Watts]	Total KE (non- protons) [Watts]	Protons KE>6 ($\times 9.26$ $\times 10^{10}$)	Protons KE>4.5 ($\times 9.26$ $\times 10^{10}$)	Yield at z=50m ($\times 9.26$ $\times 10^{10}$)
C	265270	88258	2078	2310	1063.4
Hg	217116	65898	1908	1974	1362.4
Ga	223972	84440	1818	1945	1288.7

Multiply numbers in cols 4-6 by 9.26×10^{10} for 1 MW

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 $\sim 1/2$ 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