# Particle Distribution of Graphite Target Generated for the Front-End Optimization

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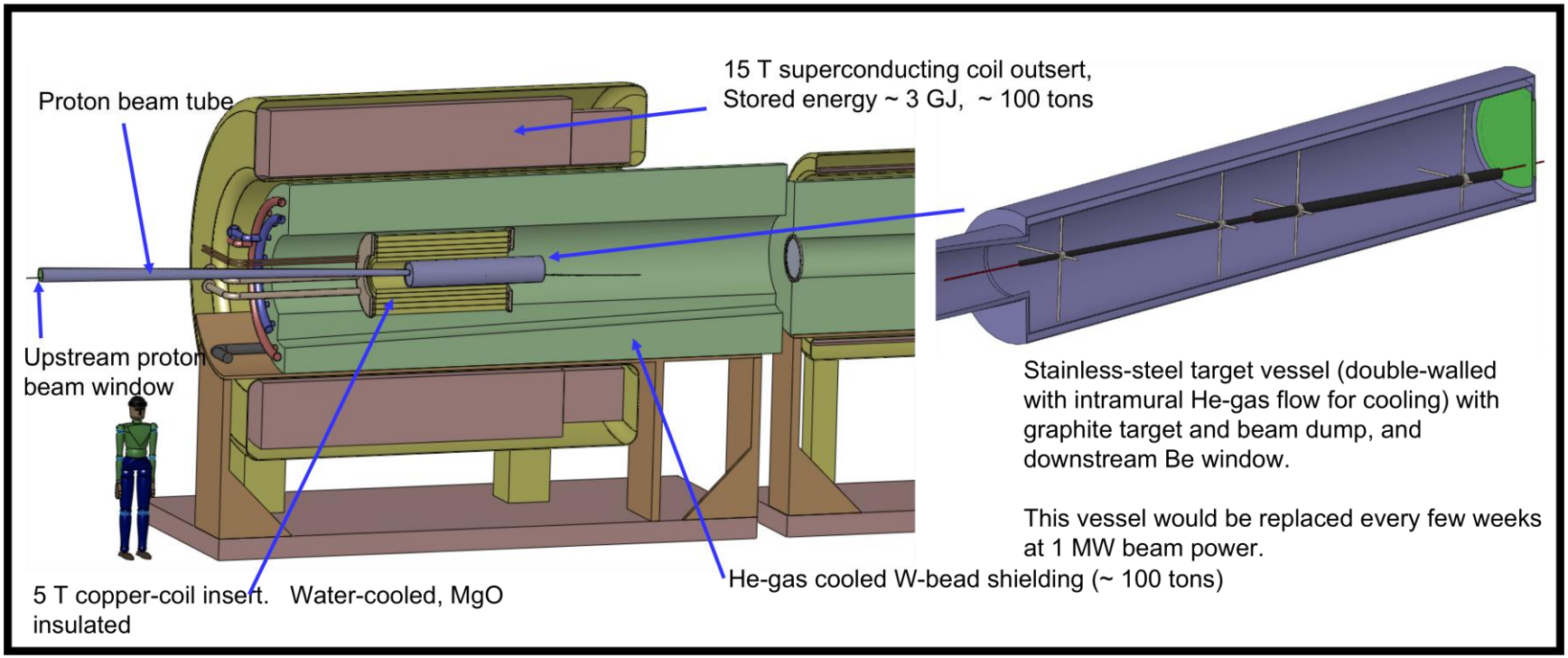
# Carbon Target Setting

- Simulation Code: MARS15(2014) with ICEM 4 = 1 (default) and Energy Card Setting at ENRG 1 = 6.75, 2 = 0.02, 3 = 0.3, 4 = 0.01, 5 = 0.05, 6 = 0.01, 7 = 0.01;
- Carbon target Configuration(20to2T5m4PDL): Graphite density = 1.8 g/cm$^3$, Fieldmap (20T➔2T) with taper length of 5m;
- Proton beam: 6.75 GeV (KE), BR/TR=1/4 (ratio of beam radius to target radius), waist at z= 0 m, varied geometric emittance and launched at z = -100 cm;
- Production Collection: (50 m downstream, 40 MeV < KE < 180 MeV).
- Particle distribution generated at z = 2 m for Front-End.

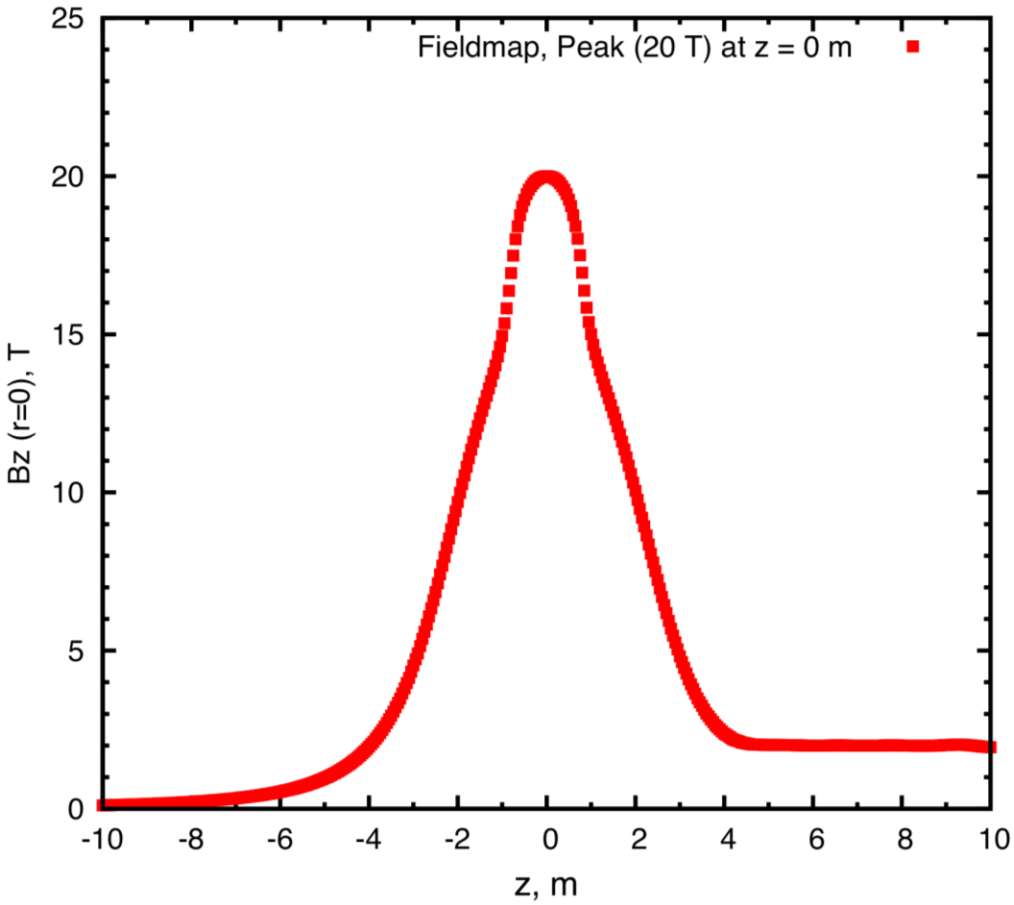
# Carbon Target Geometry




http://physics.princeton.edu/mumu/target/hptw5_poster.pdf

# Fieldmap along SC axis

## (Magnet 20to2T5m120cm)



# Counting of Carbon Target at z = 5 m

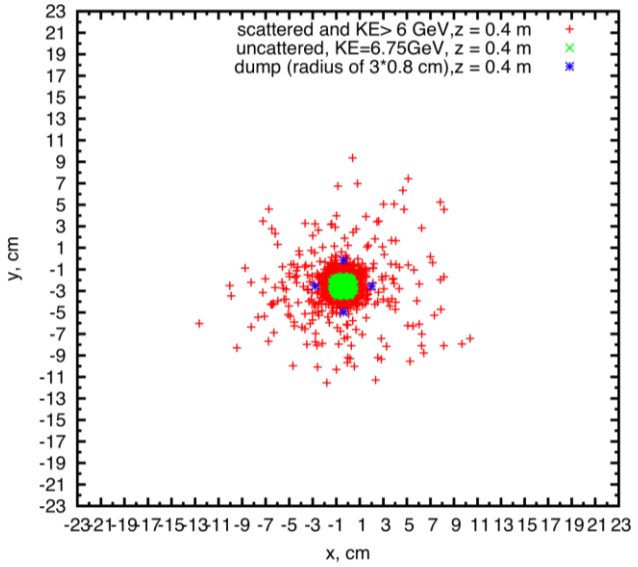
1MW beam **($9.26 \times 10^{14}$ protons with KE of 6.75 GeV)**

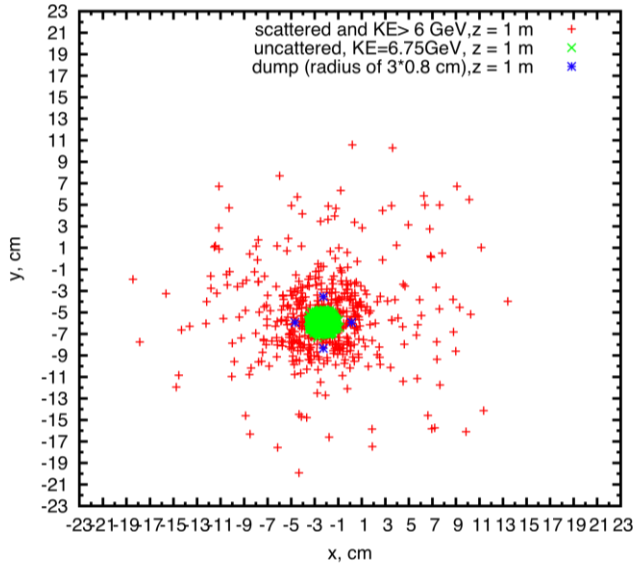
beam angle = 0 mrad, target radius = 0.64 cm

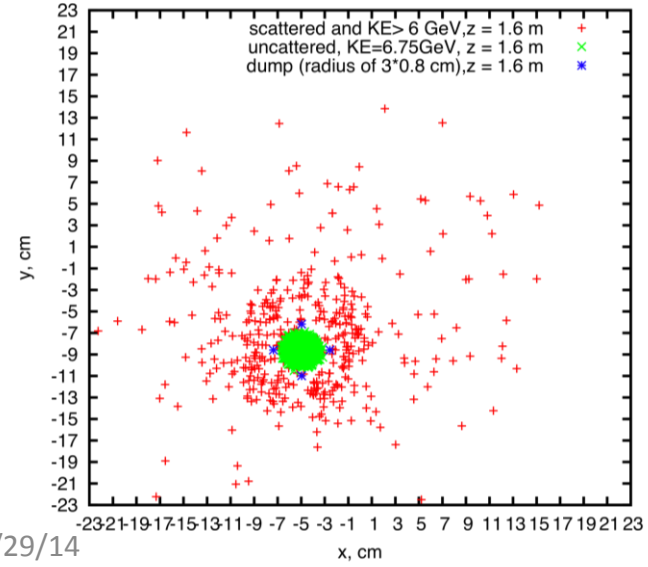
| $L_{dump}$ (cm) | $R_{dump}/R_{target}$ | Total KE (protons) (r < 23 cm) [Watts] | Total KE (non-protons) [Watts] | Protons KE > 6 GeV ($\times 9.26 \times 10^{10}$) | Yield at z = 50 m ($\times 9.26 \times 10^{10}$) |
|---|---|---|---|---|---|
| 0 | 0 | 265270 | 88258 | 2078 | 1063.4 |
| 40 | 1 | 221590 | 92222 | 1543 | 987 |
| 80 | 1 | 202506 | 90564 | 1419 | 927 |
| 120 | 1 | 210141 | 87216 | 1452 | 868.8 |
| 40 | 2 | 183241 | 90205 | 1213 | 938 |
| 80 | 2 | 155798 | 85367 | 909 | 780.3 |
| 120 | 2 | 149733 | 86754 | 870 | 743 |
| 40 | 3 | 158241 | 91585 | 1044 | 852.7 |
| 80 | 3 | 119851 | 85385 | 607 | 680.2 |
| 120 | 3 | 114139 | 81006 | 542 | 590 |

# Coordinates of beam and dump

## (carbon target 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: triple of the 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)

# Counting of Carbon Target at z = 5 m

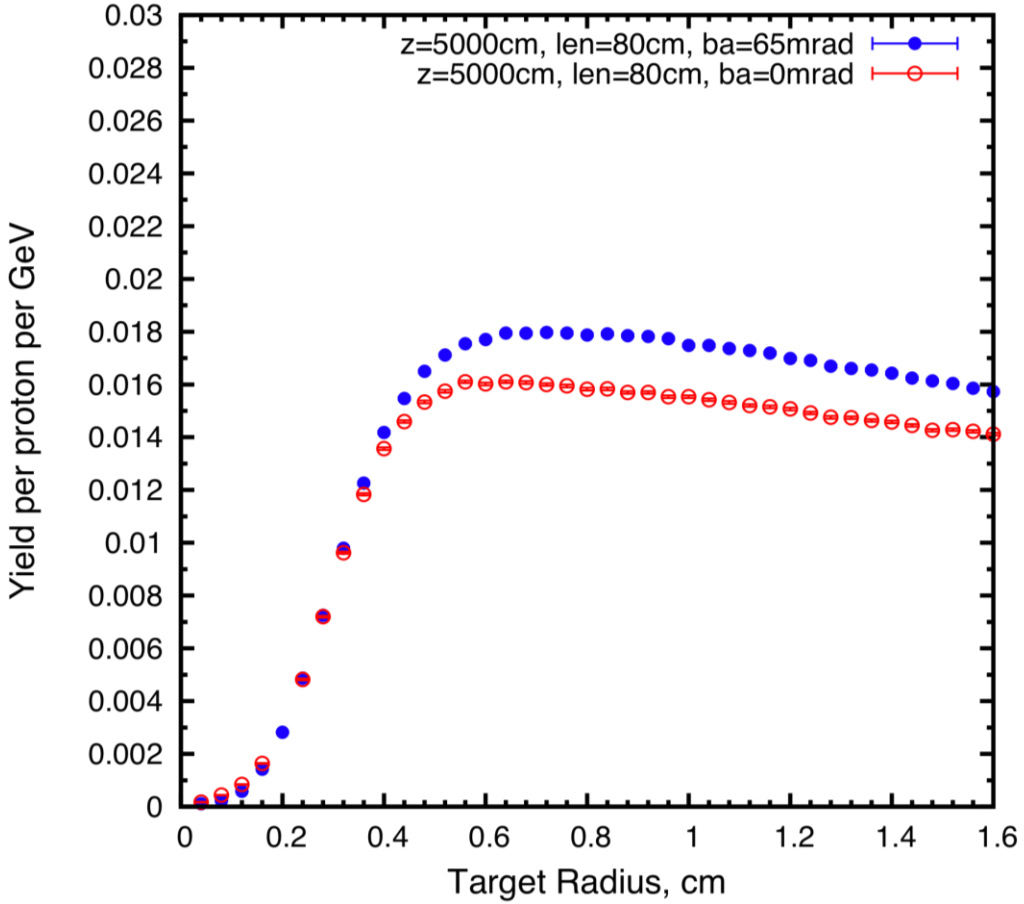
1MW beam **($9.26 \times 10^{14}$ protons with KE of 6.75 GeV)**

beam angle = 65 mrad, target radius = 0.8 cm

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

# Yield Comparison

## (no-tilt *vs*. tilt proton beam, carbon target)




Collinear target and beam. TR/BR = 4.
~ 13% advantage to tilting the beam/target

# Setting of Be Windows

The C vessel window is two Be discs with 0.2 cm thickness EACH while all other windows downstream have two Be discs of 0.5 cm thickness EACH. Each window has a 1.0 cm He gap between them. The zi below is the beginning of each Be window.

| | zi (cm) | OR (cm) | THICKNESS EACH DISC ( cm ) |
|---|---|---|---|
| BeWind#1: | 168.8 | 13.0 | 0.2 |
| BeWind#2: | 430.0 | 23.0 | 0.5 |
| BeWind#3: | 993.0 | 23.0 | 0.5 |
| BeWind#4: | 1005.0 | 23.0 | 0.5 |
| BeWind#5: | 1005.0 | 23.0 | 0.5 |

# Generated Particle Distributions for Front-End (Scenario of No-tilt Proton Beam)

See the files at https://pubweb.bnl.gov/~xding/frontend/

(1)C-G6.75GeV-RTG1cm-RB0.25cm-BA0mrad-CA0mrad-Z2m-nodump-emittance5micron-fort.83.gz

(2) C-G6.75GeV-RTG1cm-RB0.25cm-BA0mrad-CA0mrad-Z2m-nodump-emittance20micron-fort.83.gz

(3) C-G6.75GeV-RTG1cm-RB0.25cm-BA0mrad-CA0mrad-Z2m-nodump-emittance20micron-ROOT-fort.83.gz

Symbol of the name for above files:

**C**: Carbon target (length of 80 cm, center at z=0 m)

**G6.75GeV**: proton beam with KE at 6.75 GeV

# Generated Particle Distributions for Front-End (Scenario of No-tilt Proton Beam) (cont'd)

**RTG1cm**: carbon target radius at 1 cm

**RB0.25cm**: proton beam radius at 0.25 cm

**BA0mrad**: proton beam angle to SC axis at 0 mrad.

**CA0mrad**: Crossing angle at 0 mrad (collinear target and the beam)

**Z2m**: particle distribution at z = 2 m

**nodump**: without dump

**emittance5micron**: beam emittance is 5 micron

**emittance20micron**: beam emittance is 20 micron

**ROOT**: Geometry setting with ROOT

# Generated Particle Distributions for Front-End (Scenario of Tilt Proton Beam)

See the files at https://pubweb.bnl.gov/~xding/frontend/

(1)C-G6.75GeV-RTG1cm-RB0.25cm-BA65mrad-CA0mrad-Z2m-dump120cm-3RTG-emittance5micron-fort.83.gz

(2) C-G6.75GeV-RTG1cm-RB0.25cm-BA65mrad-CA0mrad-Z2m-dump120cm-3RTG-emittance20micron-fort.83.gz

Symbol of the name for above files:

**C**: Carbon target (length of 80 cm, center at z=0 m)

**G6.75GeV**: proton beam with KE at 6.75 GeV

**RTG1cm**: carbon target radius at 1 cm

**RB0.25cm**: proton beam radius at 0.25 cm

# Generated Particle Distributions for Front-End (Scenario of Tilt Proton Beam) (cont'd)

**BA65mrad**: proton beam angle to SC axis at 65 mrad.

**CA0mrad**: Crossing angle at 0 mrad (collinear target and the beam)

**Z2m**: particle distribution at z = 2 m

**emittance5micron**: beam emittance is 5 micron

**emittance20micron**: beam emittance is 20 micron

**dump120cm-3RTG**: the carbon dump length is 120 cm and dump rod radius is triple of the radius of carbon target

# Generated Particle Distributions for Front-End (Scenario of Tilt Proton Beam) (cont'd)

Setting of Beam dump rod: triple of the target radius:

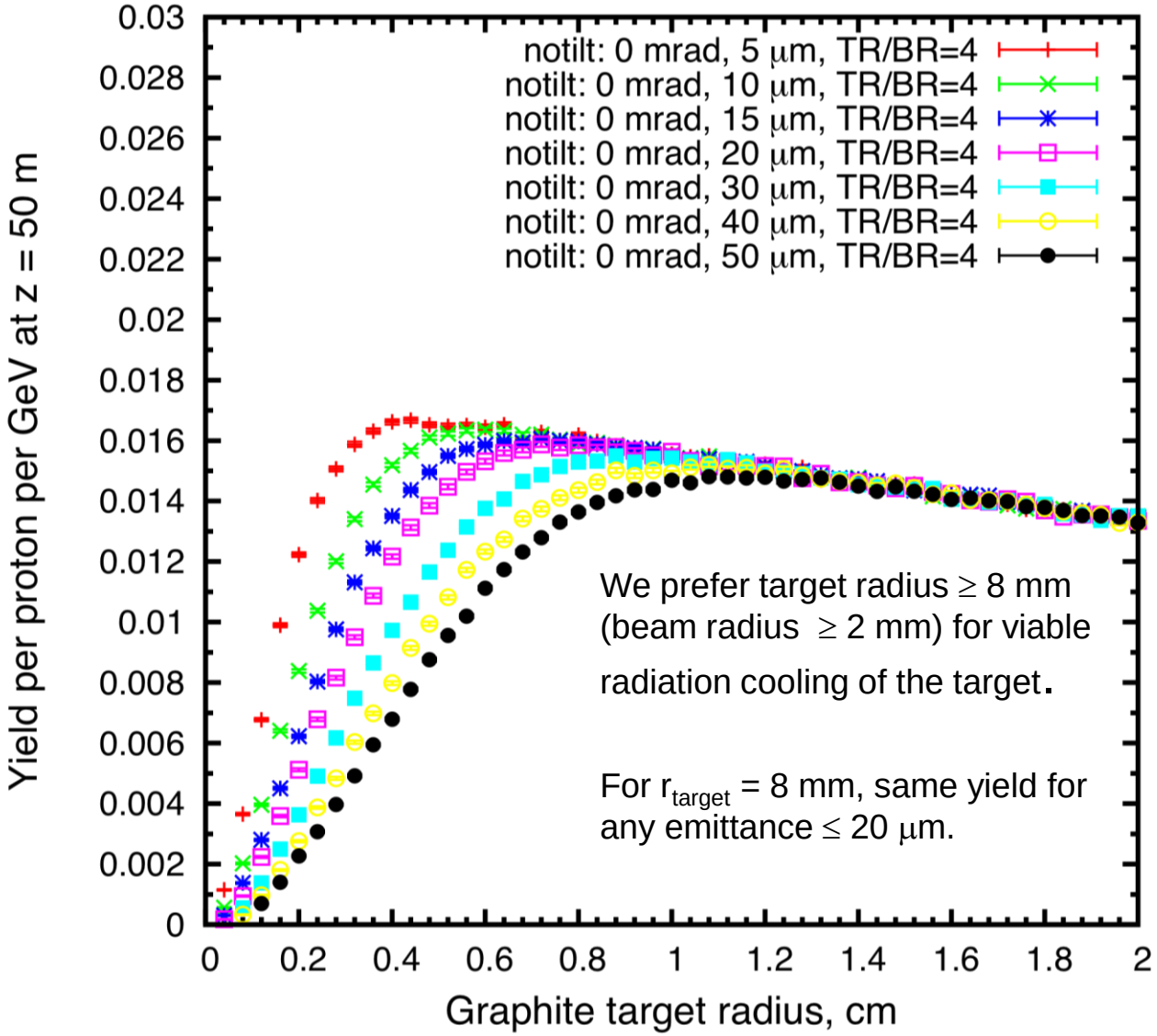
(z = 40 cm to z = 100 cm, horizontal tilt: 31.1 mrad, vertical tilt: 56.27 mrad)

(z = 100 cm to z = 160 cm, horizontal tilt: 44.9 mrad, vertical tilt: 44.17 mrad)

# Backup

# Yield for target without tilt

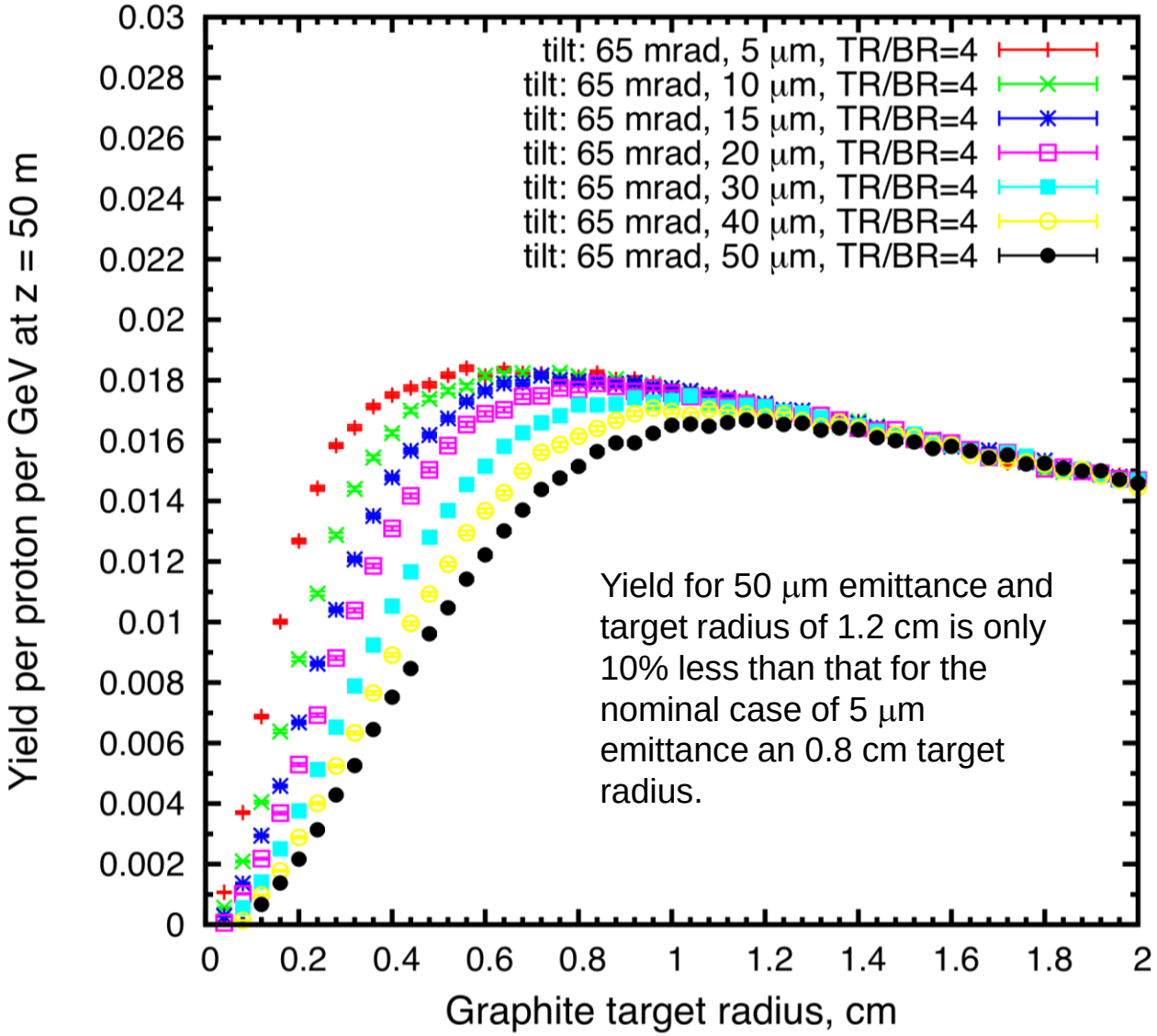
## (Non-standard setting for geometry)



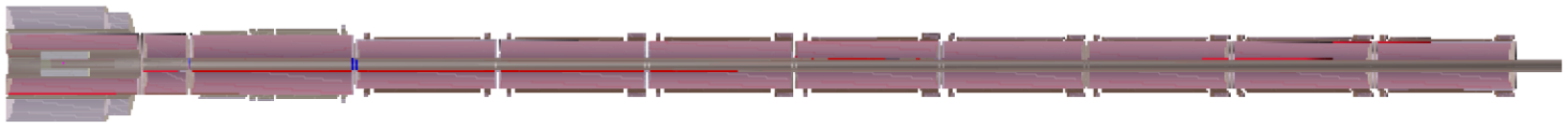
# Yield for target with tilt

## (65 mrad to SC axis)

## (Non-standard setting for geometry)



# GEOMETRY SETTING with ROOT



# Yield for target with tilt

## (65 mrad to SC axis) (ROOT setting for geometry )