Kinetic Energy Spectra of pi^+, pi^-, mu^+, mu^- and sum of all from the 20to4T5m Configuration

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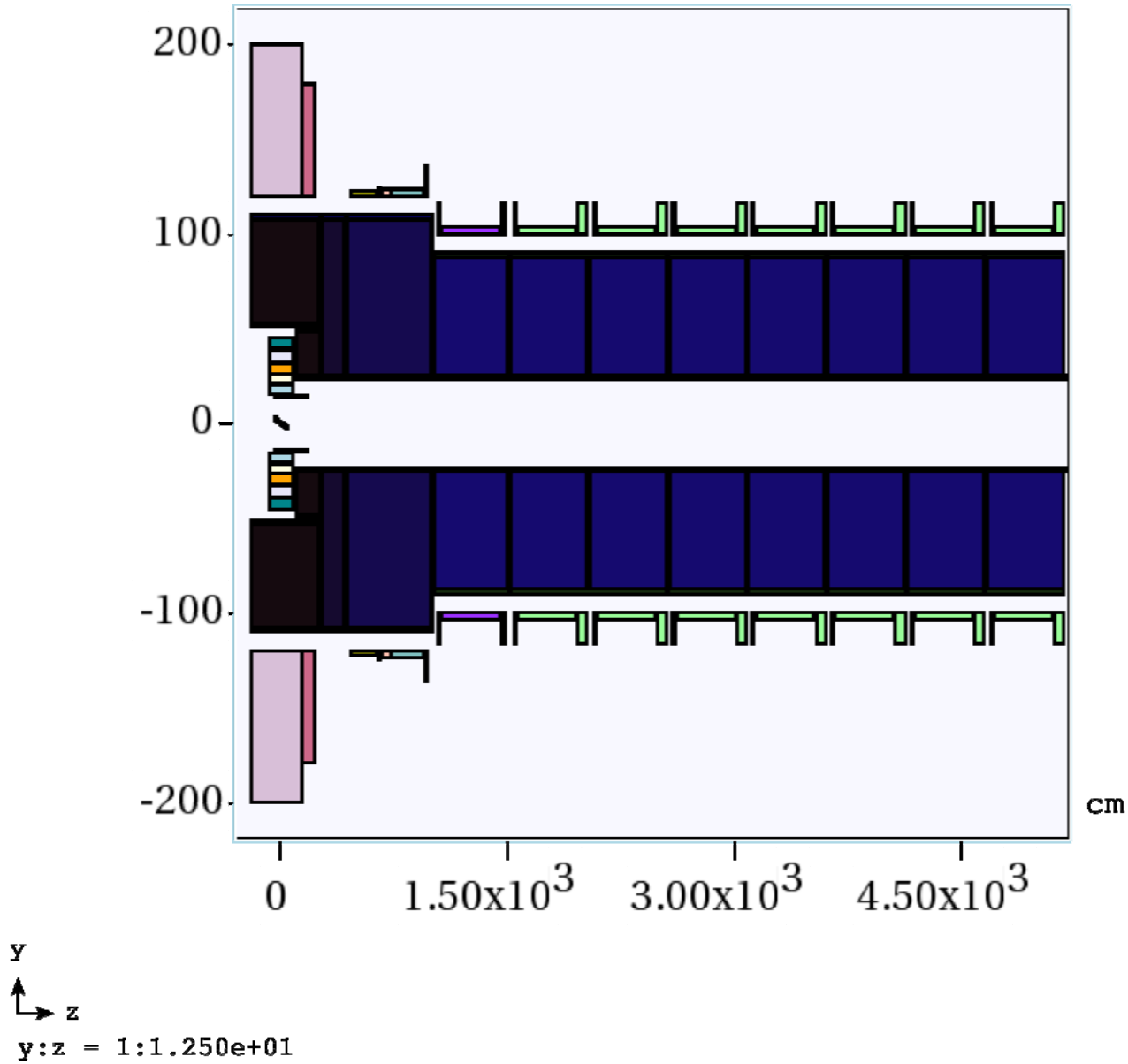
Front End Meeting

June 23, 2015

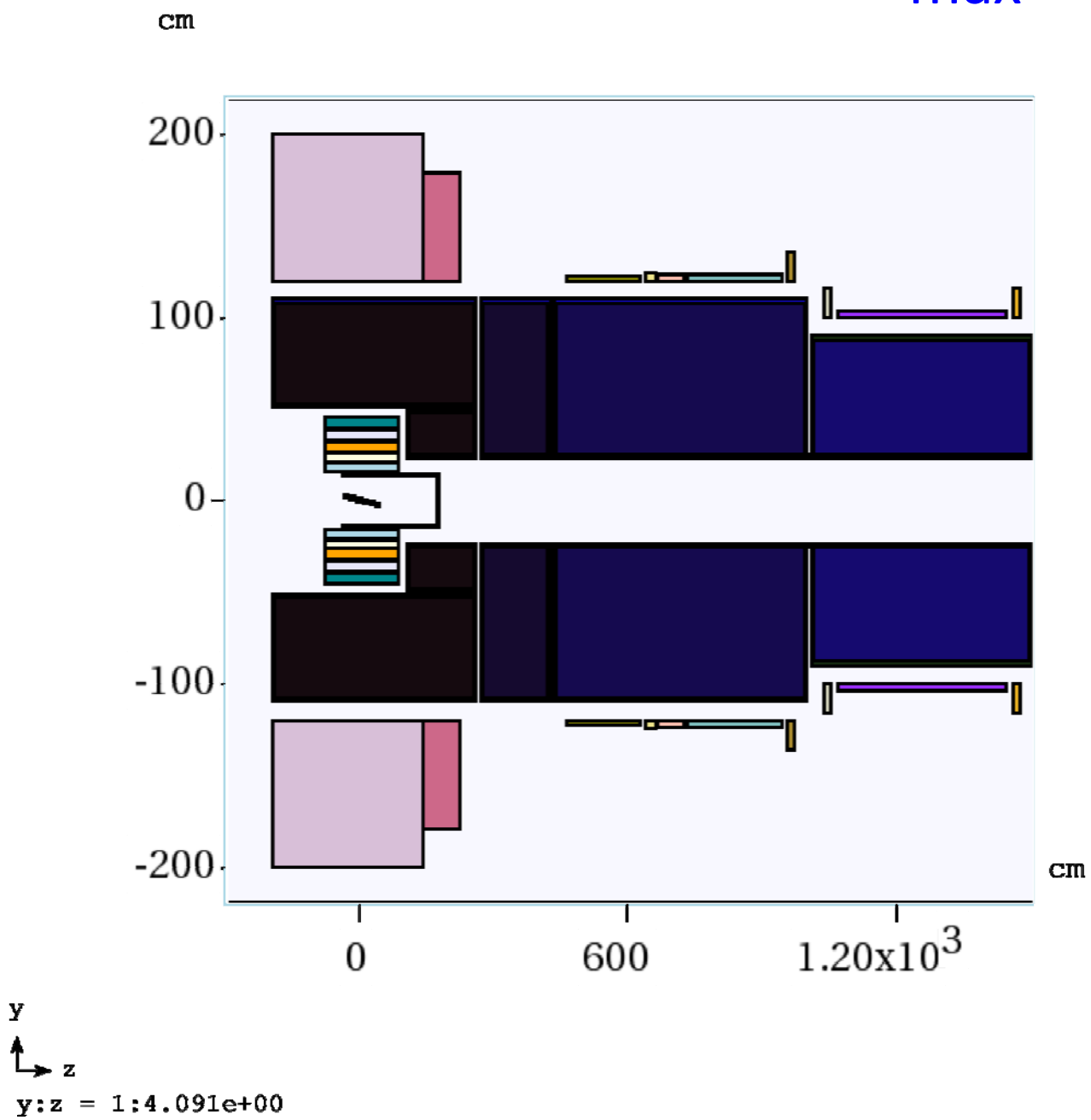
OUTLINE

- 20to2T5m and 20to4T5m configuration
- Field map
- Setting of BE windows
- Target and beam parameters
- Comparison of KE spectra of pi^+, pi^-, mu^+, mu^- and sum of all positive and negative particles at z = 2, 5, 10, 20, 30, 40, 50 m between 20to2T5m and 20to4T5m configuration.

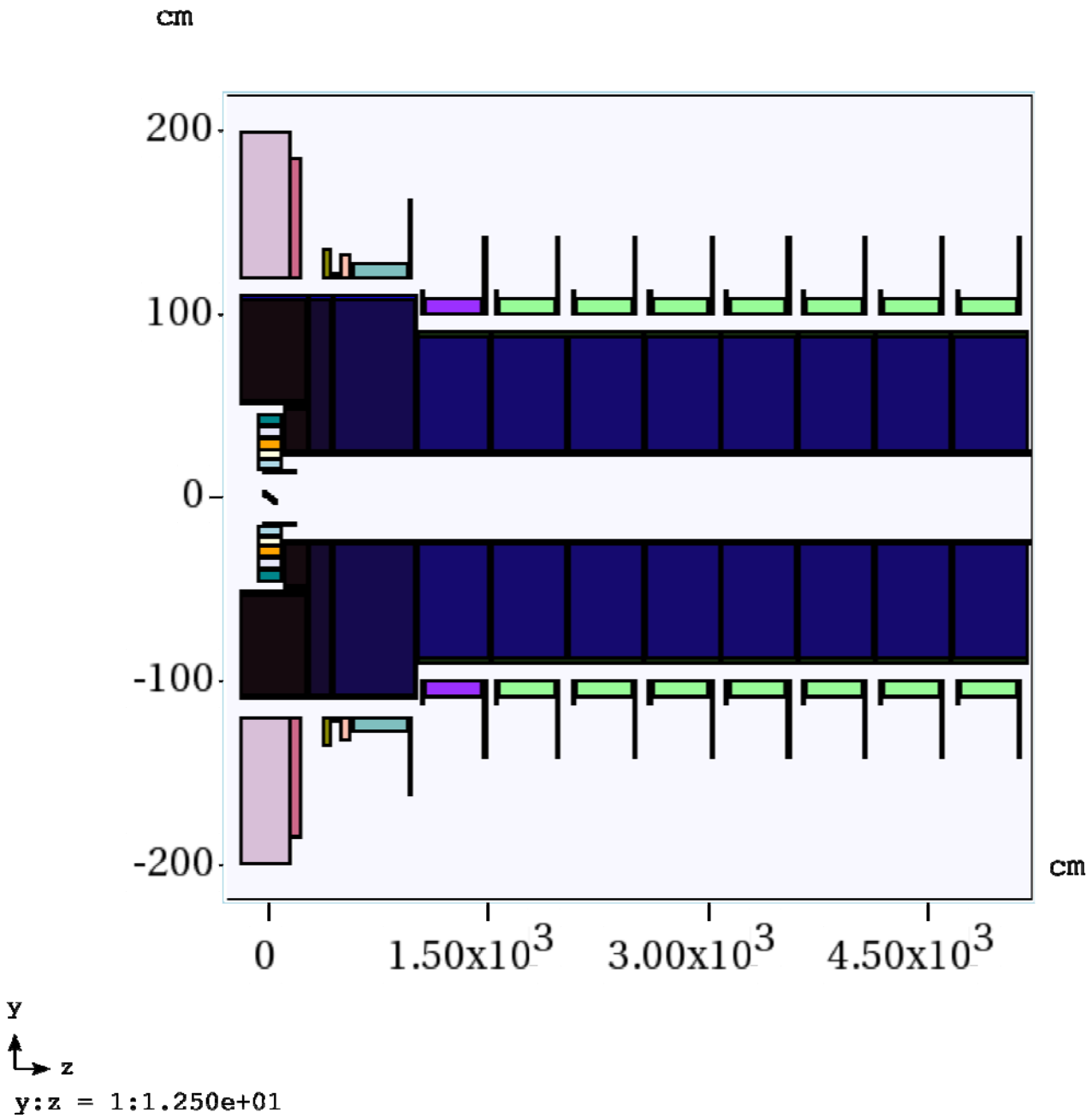
20to2T5m Configuration (z_{max} = 52 m)



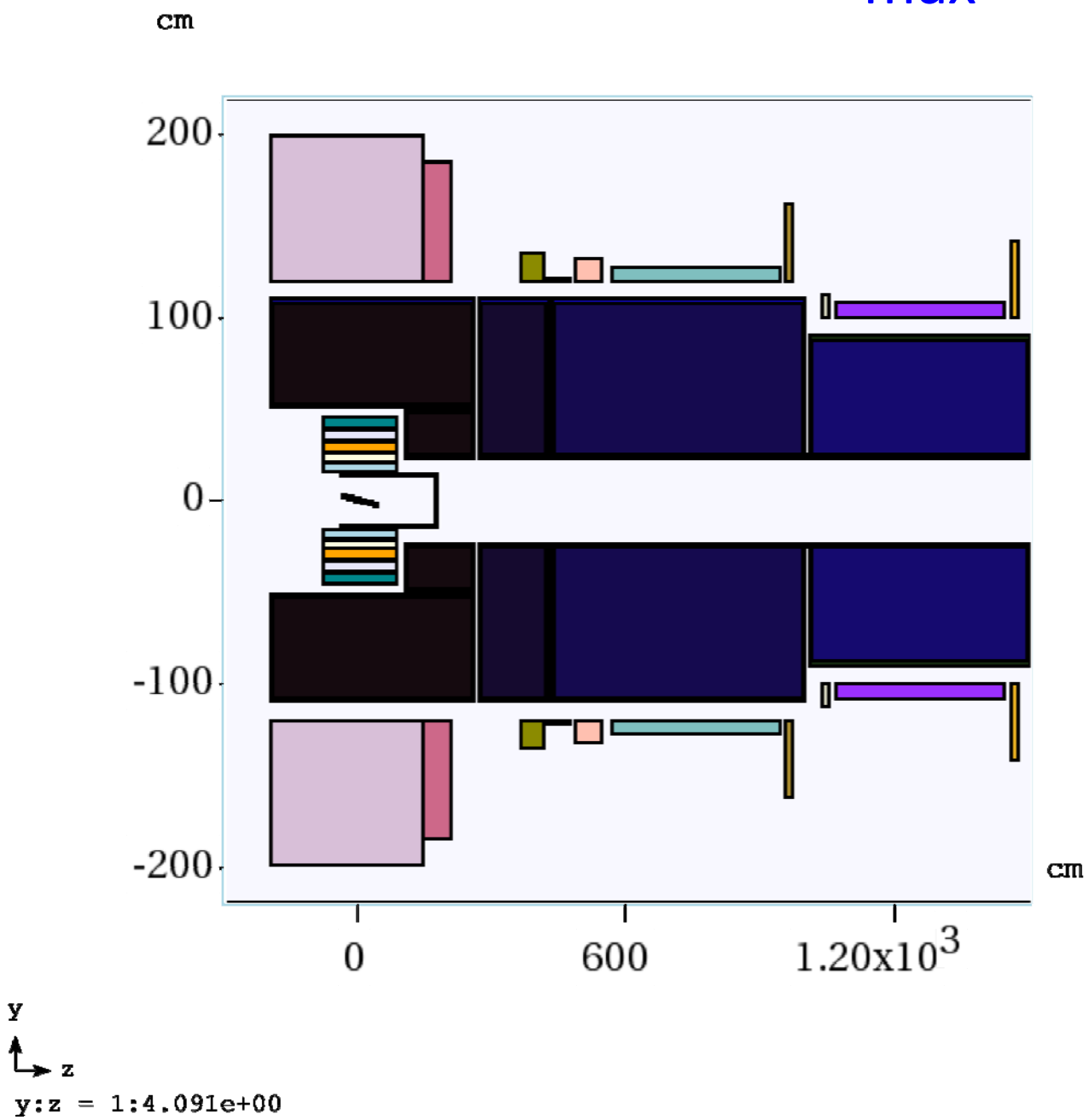
20to2T5m Configuration (z_{max} = 15 m)



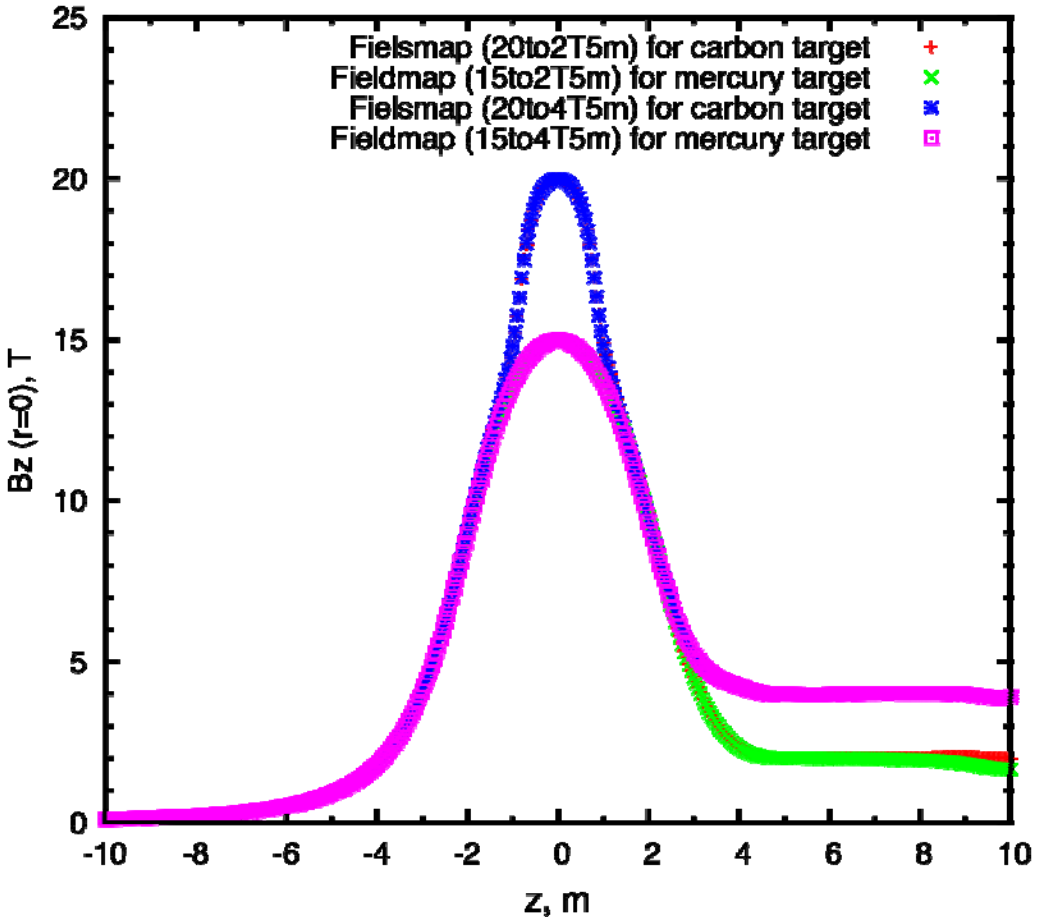
20to4T5m Configuration (z_{max} = 52 m)

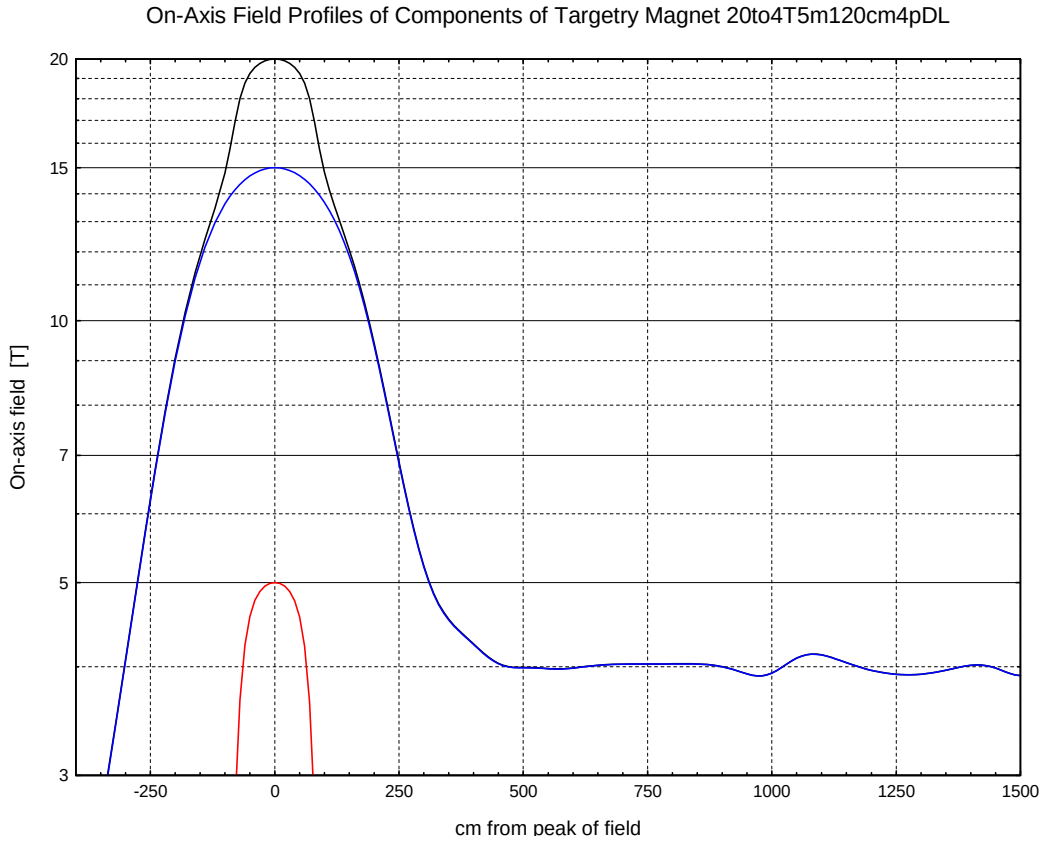


20to4T5m Configuration (z_{max} = 15 m)



Fieldmap on SC axis





20to2T5m: B = 2.00 T for z > 10 m
20to4T5m: B = 4.00 T for z > 10 m

Target Containment Vessel

- The containment vessel is cooled by He-gas flow between its double walls.
- The outer cylinder extends over $-46 < z < 170$ cm, with outer radius $r = 15$ cm.
- The inner cylinder extends over $-45 < z < 169$ cm, with inner radius $r = 14$ cm.
- The downstream faces of the vessels are Be windows, ≈ 1 mm thick.

Magnet Modules

(front end for $5 < z < 50$ m)

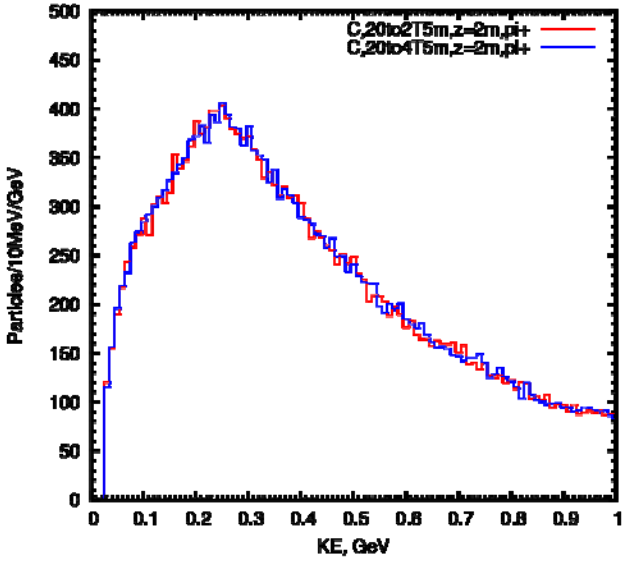
- The Front End for $5 < z < 50$ m consists of nine 5-m-long superconducting magnet modules, each with internal tungsten shielding around the 23-cm-radius beam pipe.
- The latter has thin Be windows, ≈ 0.05 mm thick, at each end of a magnet module, and is filled with He gas at 1 atmosphere.
- This model does not include a chicane.

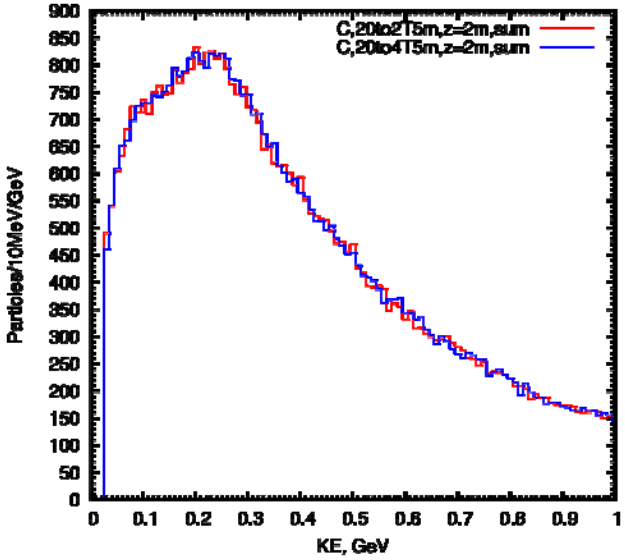
Carbon Target and Beam Parameters

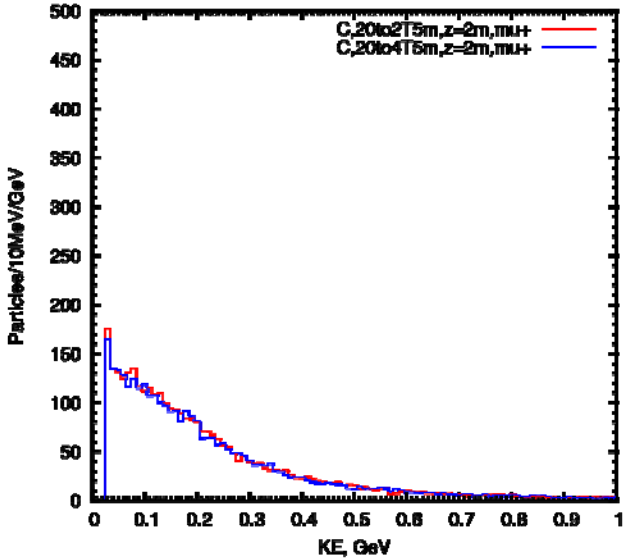
- *Simulation code:* MARS15(2014) with ICEM 4 = 1 (default) and ENRG 1 = 6.75, 2 = 0.02, 3 = 0.3, 4 = 0.01, 5 = 0.05, 6 = 0.01, 7 = 0.01 ;
- *Graphite density:* 1.8 g/cm^3;
- *Beam pipe radius:* 14 cm (initial) and 23 cm (final);
- *Proton beam:* 6.75 GeV (KE), 1 MW, beam radius at 0.2 cm and beam angle at 65 mrad, waist and 5 μm geometric emittance at z = 0 m (intersection point), launched at z = -100 cm;
- *Carbon rod:* target length at 80 cm, rod radius at 0.8 cm and tilt angle to SC axis at 65 mrad.

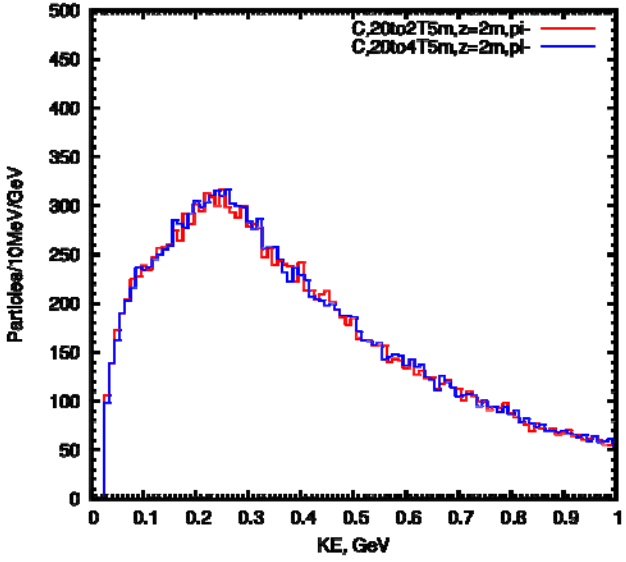
Energy Spectra (z = 2 m)

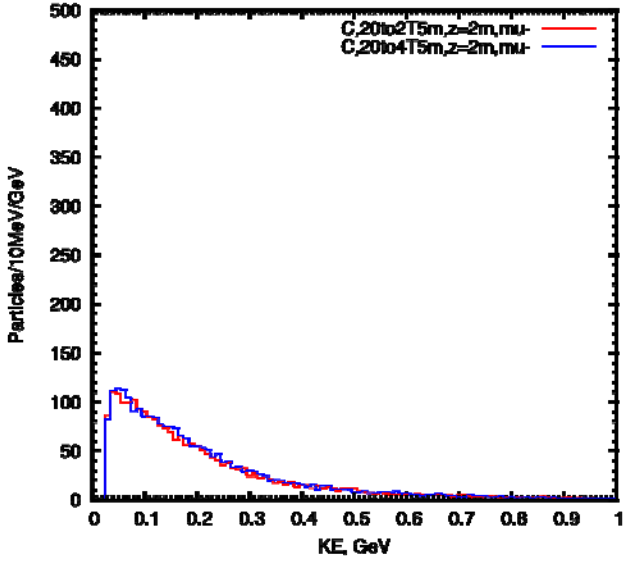
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





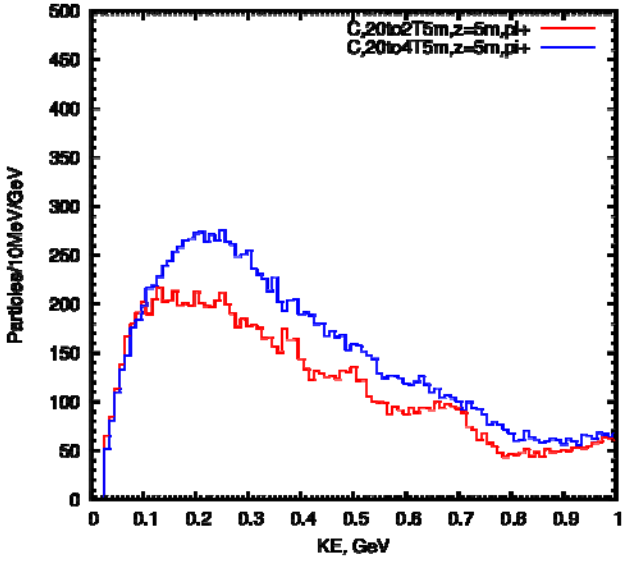


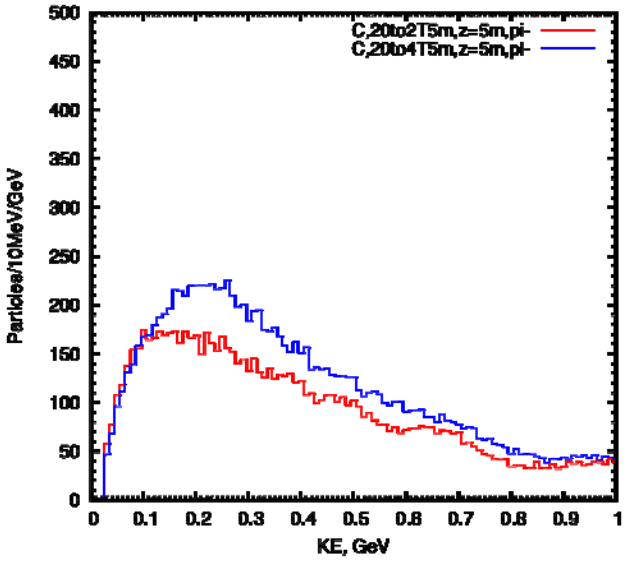


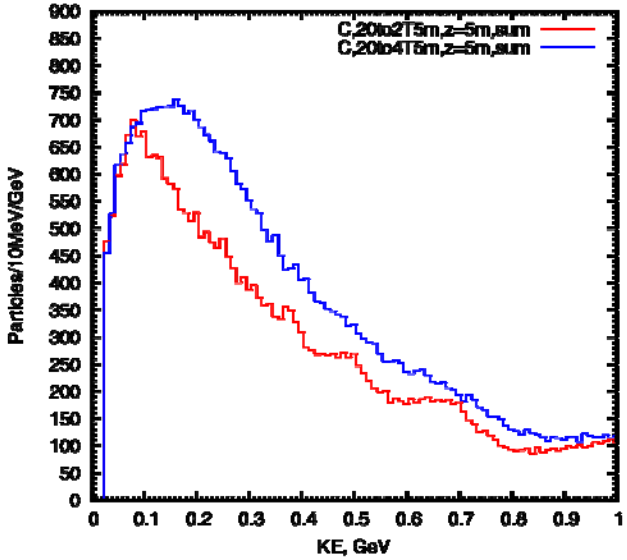


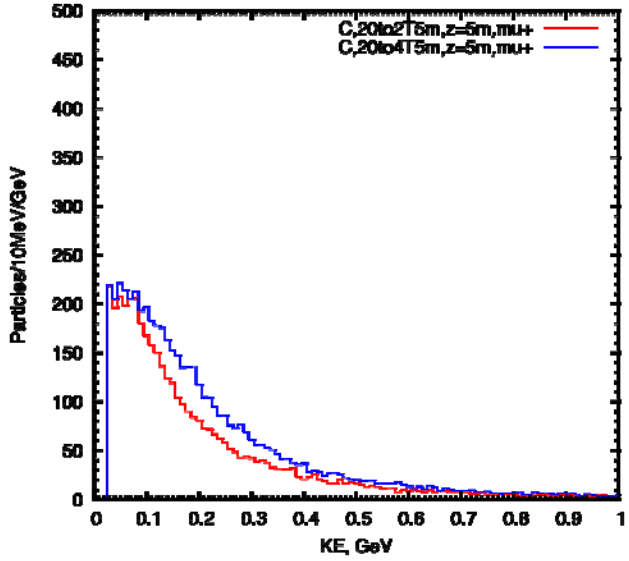
Energy Spectra (z = 5 m)

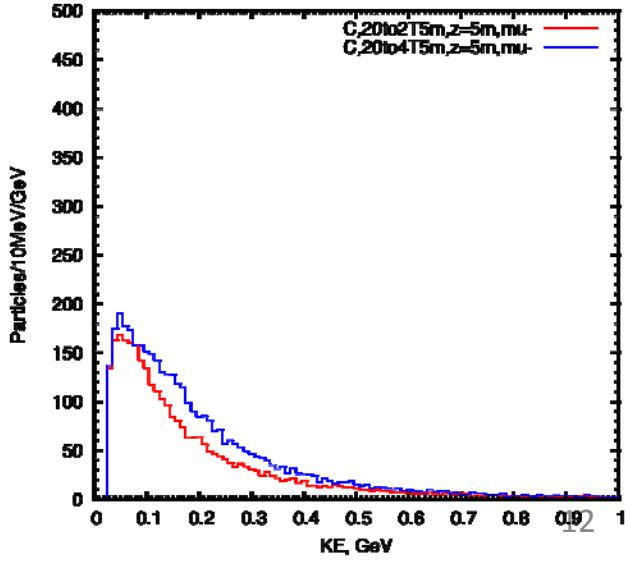
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





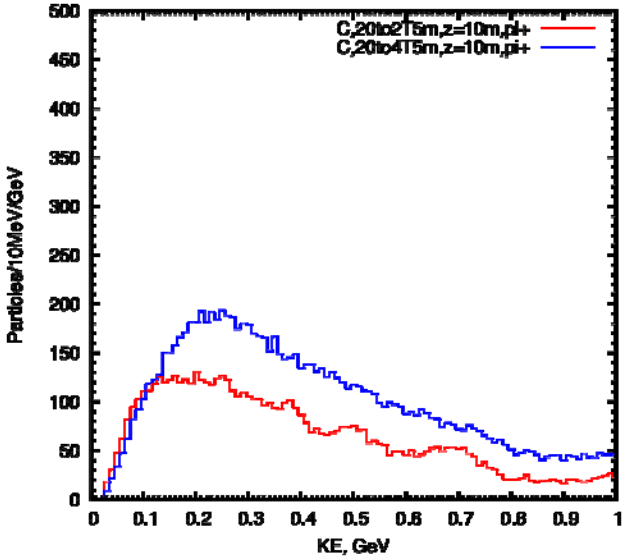


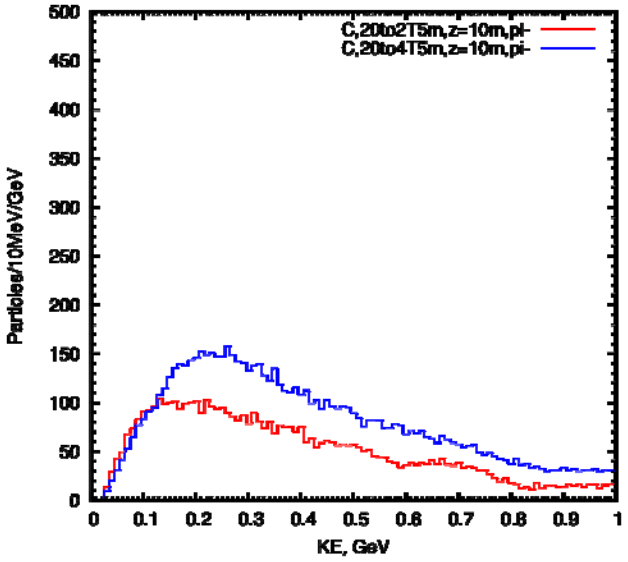


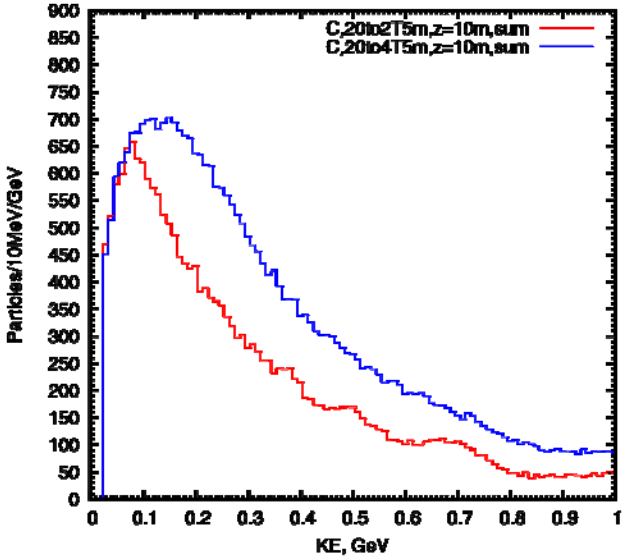


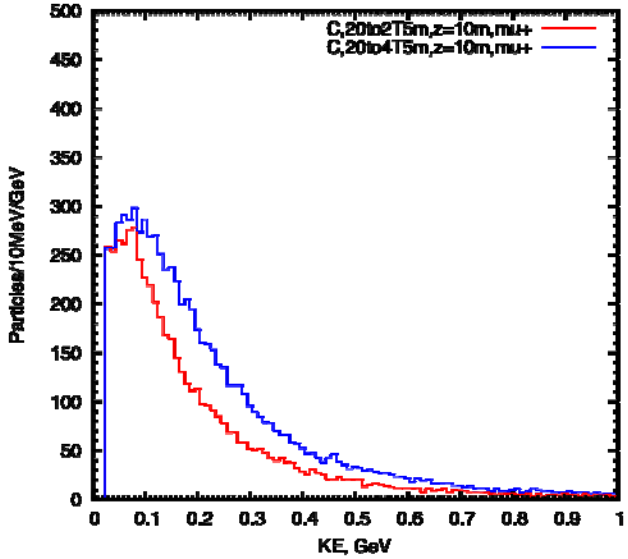
Energy Spectra (z = 10 m)

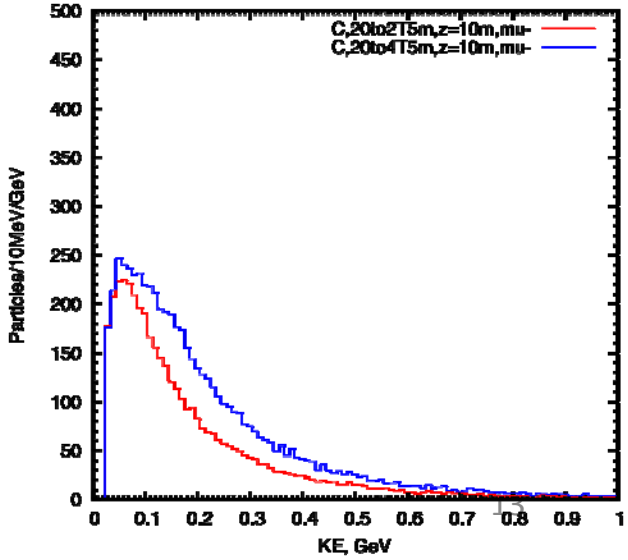
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





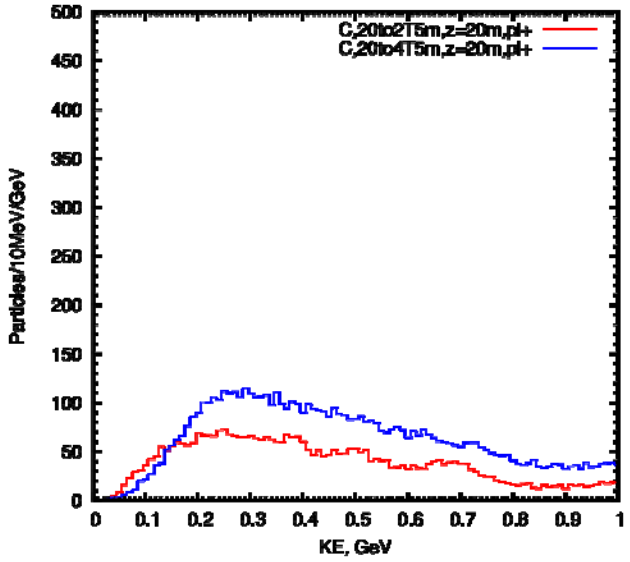


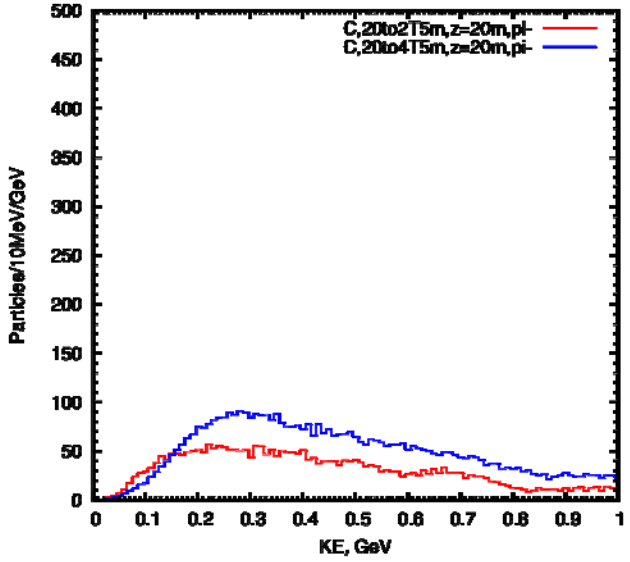


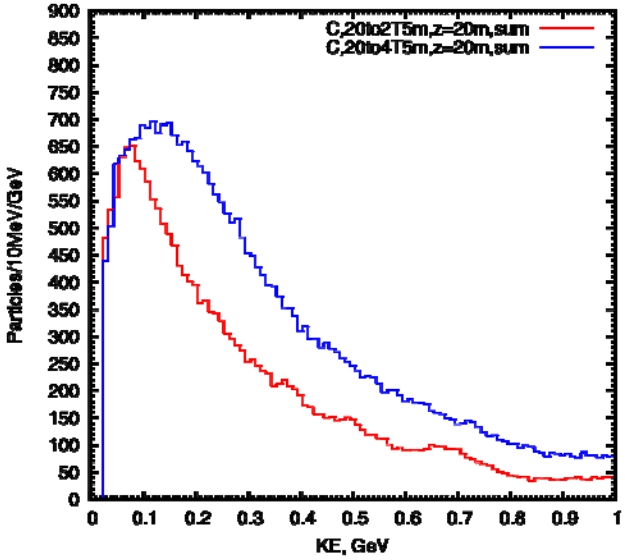


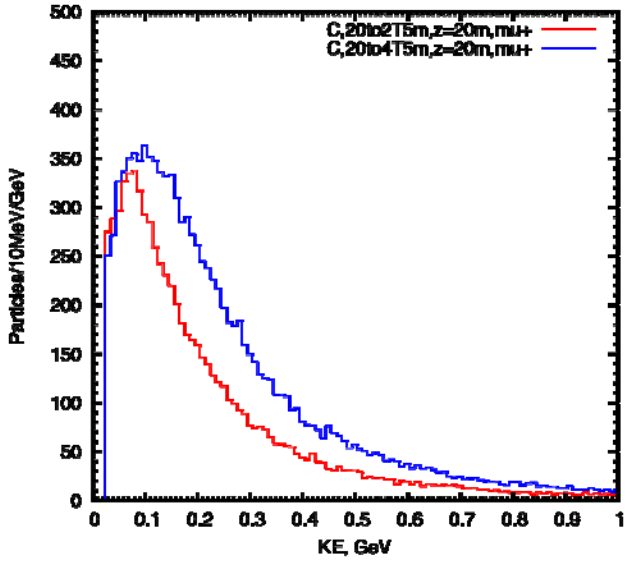
Energy Spectra (z = 20 m)

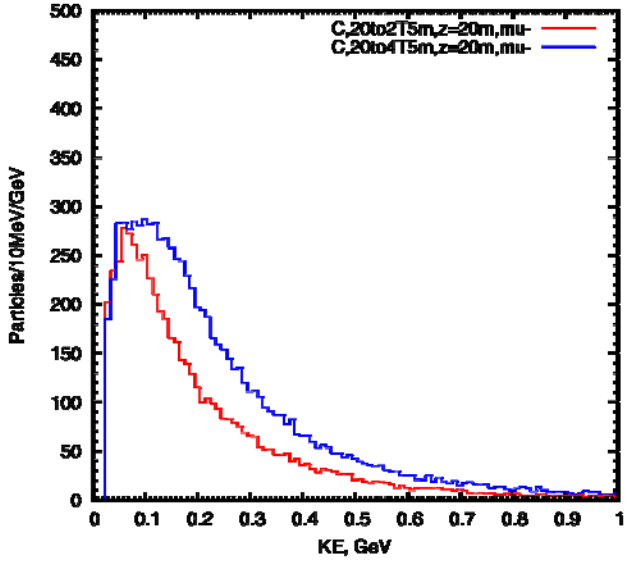
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





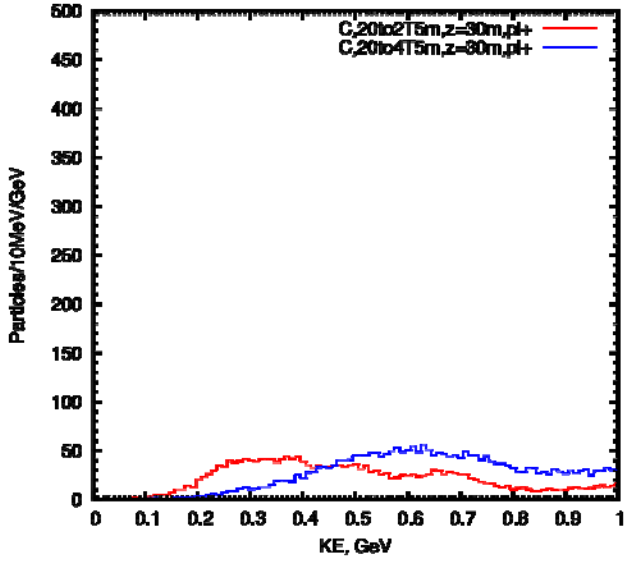


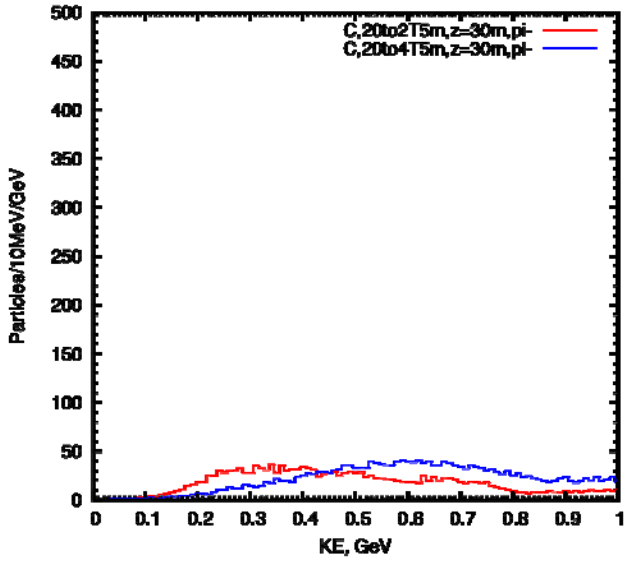


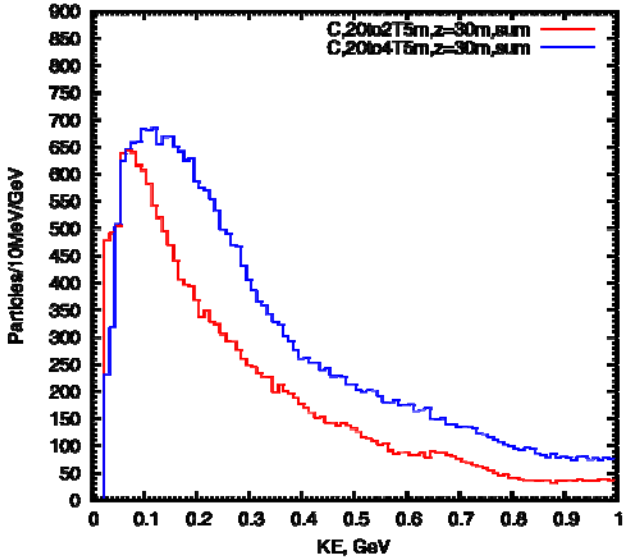


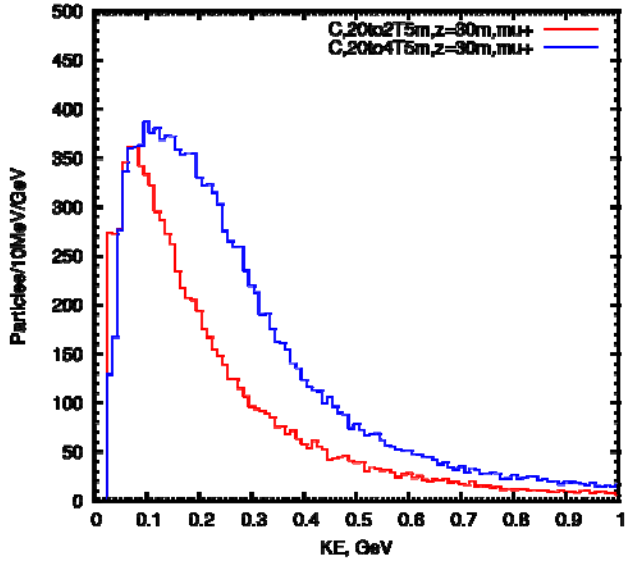
Energy Spectra (z = 30 m)

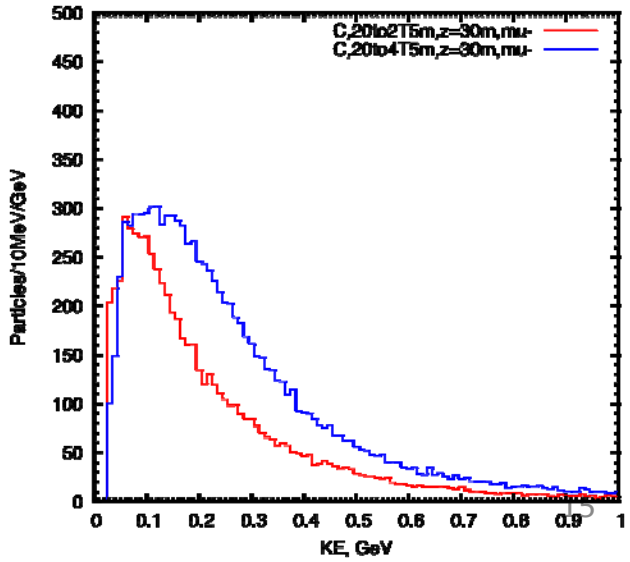
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





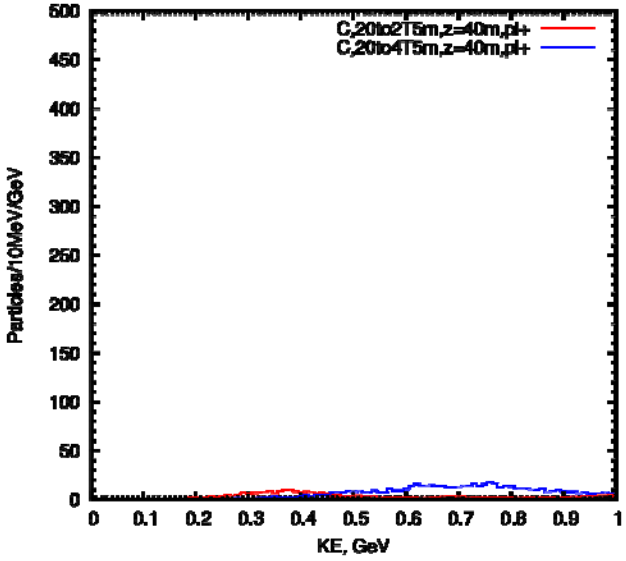


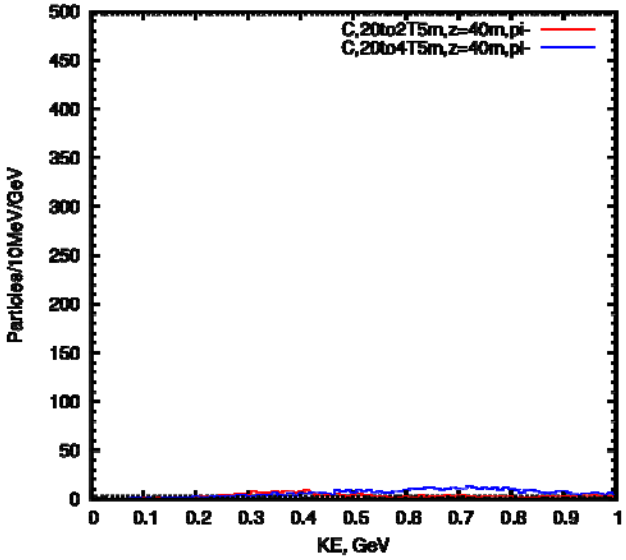


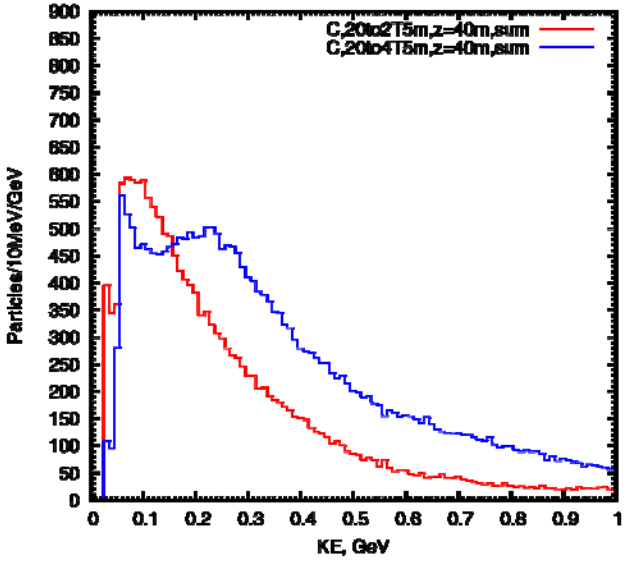


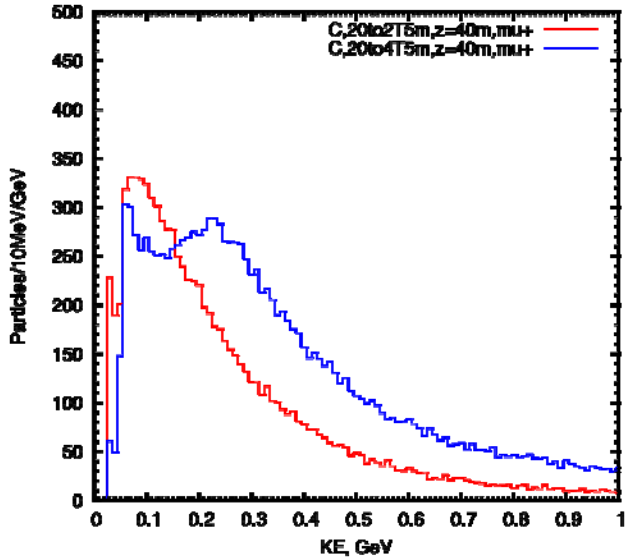
Energy Spectra (z = 40 m)

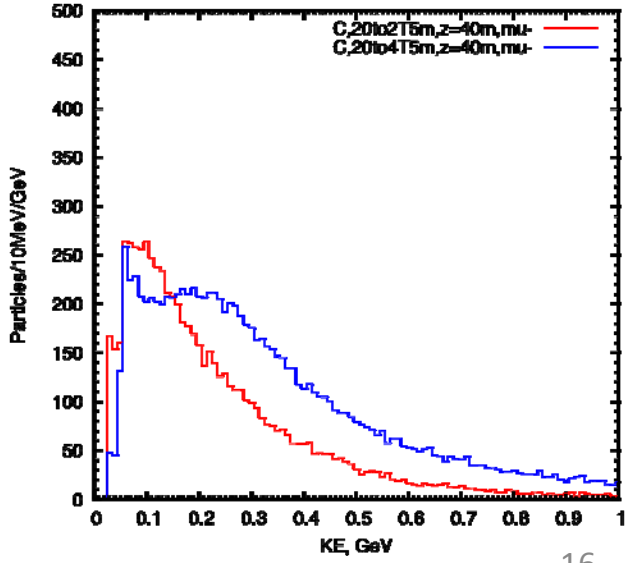
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down





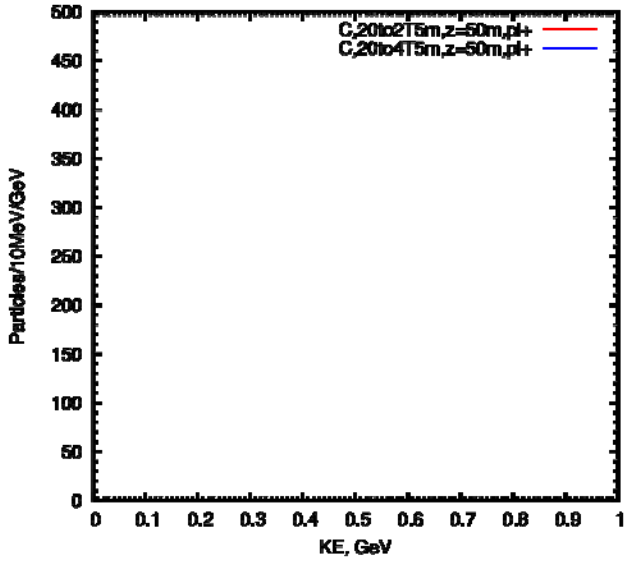


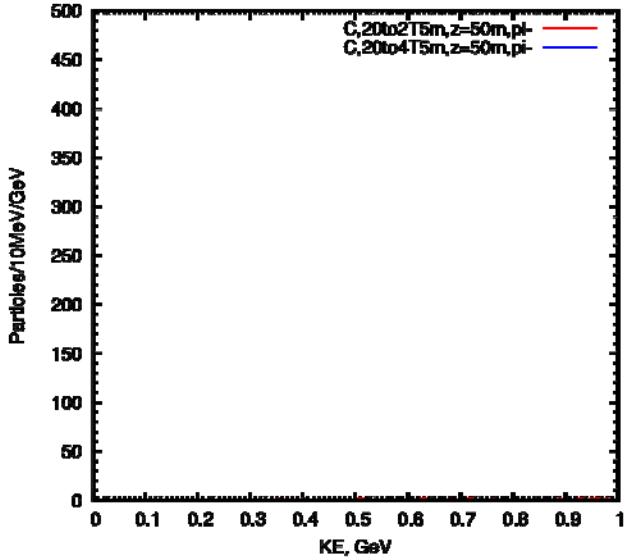


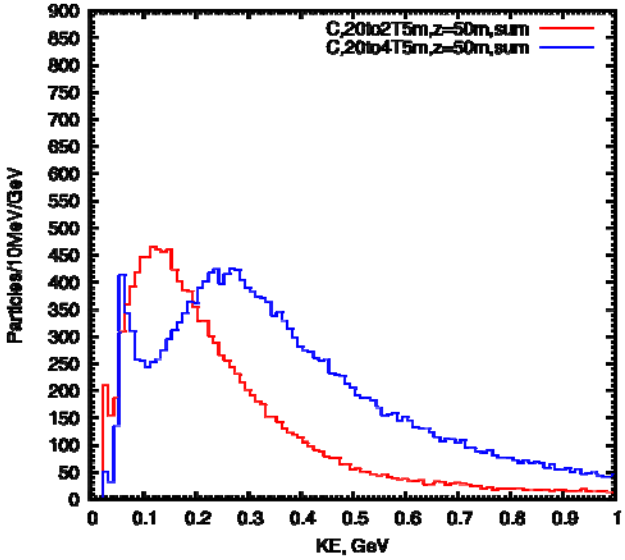


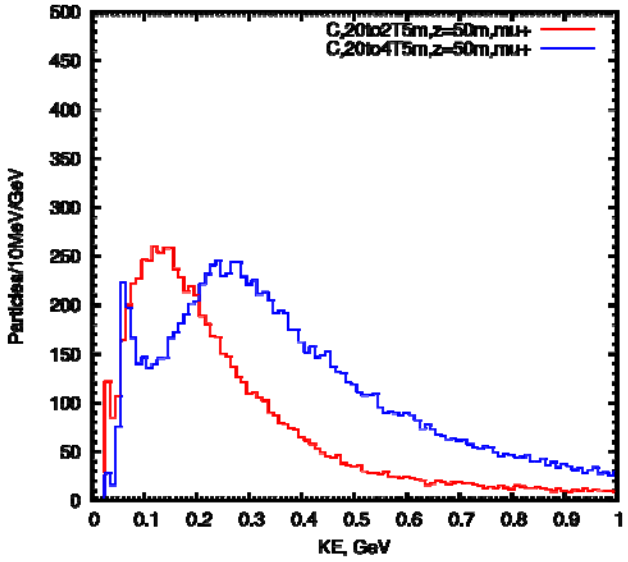
Energy Spectra (z = 50 m)

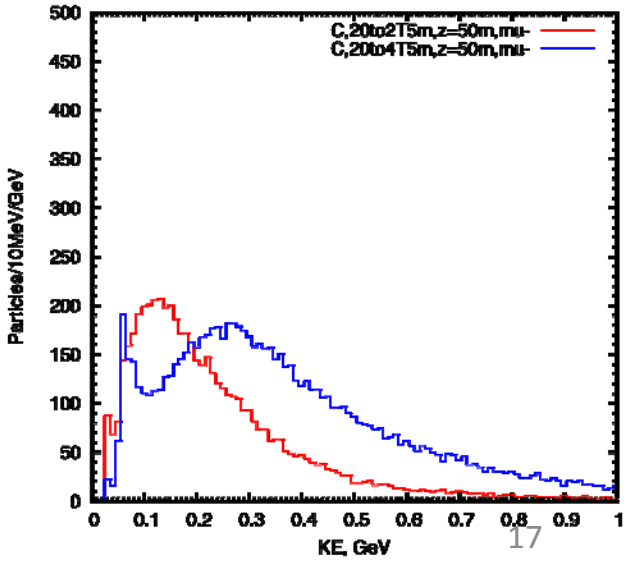
pi$^+$: left-up, pi$^-$: left-down, sum: middle, mu$^+$: right-up, mu$^-$: right-down











Summary

(1) More high-KE particles are captured in 20to4T5m configuration.

(2) In 20to2T5m configuration, KE selection of 40 < KE < 180 MeV is used to count yield at z = 50 m (peak around 140 MeV).

(3) In 20to4T5m configuration, there is a dent around 100 MeV at z = 40, 50 m. Exchanging with the 20to2T5m transport channel, we still found this dent. However, the dent will disappear if we delete all BE beam windows above z > 15 m.
(https://pubweb.bnl.gov/~xding/JINST/energy-spectra).
So both BE windows and field map seem affect our KE spectra.

(4) In the 20to4T configuration, what KE selection (40 < KE < 400 MeV?) will be used to count yield at z = 50 m. Should we use this KE selection for 20to2T5m configuration?

(5) We expect about only a few percent increase in particle production from 20to2T5m to 20to4T5m with KE selection of 40 < KE < 400 MeV and our present BE window settings until z = 50 m.

Back-Up Slides Follow

Setting of BE Windows

- The MAT is the material. The z_i is the beginning and the z_f is the end. The OR is the outer radius in my setting.

	MAT	z_i (cm)	z_f (cm)	OR (cm)	THICKNESS (cm)
BeWind#1:	BE	169.0	169.1	14	0.1
	HE	169.1	170.0	15	0.9
	BE	170.0	170.1	15	0.1
BeWind#2:	BE	430.5	430.55	22	0.05
	HE	430.55	431.45	23	0.9
	BE	431.45	431.5	23	0.05
BeWind#3:	BE	993.5	993.55	22	0.05
	HE	993.55	994.45	23	0.9
	BE	994.45	994.5	23	0.05

Setting of BE Windows (Cont'd)

- MAT z_i (cm) z_f (cm) OR (cm) THICKNESS (cm)

BeWind#4:	BE	1005.5	1005.55	22	0.05
	HE	1005.55	1006.45	23	0.9
	BE	1006.45	1006.5	23	0.05
BeWind#5:	BE	1495.0	1495.05	22	0.05
	HE	1495.05	1495.95	23	0.9
	BE	1495.95	1496.0	23	0.0

BeWind#6:	BE	1507.0	1507.05	22	0.05
	HE	1507.05	1507.95	23	0.9
	BE	1507.95	1508.0	23	0.05
BeWind#7:	BE	2018.5	2018.55	22	0.05
	HE	2018.55	2019.45	23	0.9
	BE	2019.45	2019.5	23	0.05

Setting of BE Windows (Cont'd)

- MAT z_i (cm) z_f (cm) OR (cm) THICKNESS (cm)

BeWind#8:	BE	2030.5	2030.55	22	0.05
	HE	2030.55	2031.45	23	0.9
	BE	2031.45	2031.5	23	0.05
BeWind#9:	BE	2542.0	2542.05	22	0.05
	HE	2542.05	2542.95	23	0.9
	BE	2542.95	2543.0	23	0.0

BeWind#10:	BE	2554.0	2554.05	22	0.05
	HE	2554.05	2554.95	23	0.9
	BE	2554.95	2555.0	23	0.05
BeWind#11:	BE	3065.5	3065.55	22	0.05
	HE	3065.55	3066.45	23	0.9
	BE	3066.45	3066.5	23	0.05

Setting of BE Windows (Cont'd)

- MAT z_i (cm) z_f (cm) OR (cm) THICKNESS (cm)

BeWind#12:	BE	3077.5	3077.55	22	0.05
	HE	3077.55	3078.45	23	0.9
	BE	3078.45	3078.5	23	0.05
BeWind#13:	BE	3589.0	3589.05	22	0.05
	HE	3589.05	3589.95	23	0.9
	BE	3589.95	3590.0	23	0.0

BeWind#14:	BE	3601.0	3601.05	22	0.05
	HE	3601.05	3601.95	23	0.9
	BE	3601.95	3602.0	23	0.05
BeWind#15:	BE	4112.5	4112.55	22	0.05
	HE	4112.55	4113.45	23	0.9
	BE	4113.45	4113.5	23	0.05

Setting of BE Windows (Cont'd)

- MAT z_i (cm) z_f (cm) OR (cm) THICKNESS (cm)

BeWind#16:	BE	4124.5	4124.55	22	0.05
	HE	4124.55	4125.45	23	0.9
	BE	4125.45	4126.5	23	0.05
BeWind#17:	BE	4636.0	4636.05	22	0.05
	HE	4636.05	4636.95	23	0.9
	BE	4639.95	4637.0	23	0.0

BeWind#18:	BE	4648.0	4648.05	22	0.05
	HE	4648.05	4648.95	23	0.9
	BE	4648.95	4649.0	23	0.05
BeWind#19:	BE	5159.5	5159.55	22	0.05
	HE	5159.55	5160.45	23	0.9
	BE	5160.45	5160.5	23	0.05