IDS120j WITHOUT RESISTIVE MAGNETS
(20 cm GAPS AND 15.8 g/cc W BEADS)

AZIMUTHAL DPD DISTRIBUTION STUDIES FOR:
BP#1, SH#1, SHVS#1/LFL, SC#1+SC#2, BeWind.

Nicholas Souchlas, PBL (9/20/2012)

IDS120j GEOMETRY, NO RESISTIVE COILS: WITH 20 cm GAPS

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 # SIMULATIONS USING LOWEST GRADE W BEADS IN SHIELDING (OF 15.8 g/cc)
AZIMUTHAL DPD DISTRIBUTION STUDIES FOR :
 # BP#1, SH#1 (LIMITED IN THE FIRST 1 cm TUBE VOLUME) ,
 # SHVS#1/LFL (LIMITED IN THE FIRST INNER 2 cm FLANGE VOLUME)
 # Be WINDOW
 # SC#1 + SC#2 (LIMITED IN THE "HOT" REGION)

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>SIMULATIONS CODE: MARS1512 (USING MCNP CROSS SECTION LIBRARIES)

>NEUTRON ENERGY CUTOFF: 10^{-11} MeV

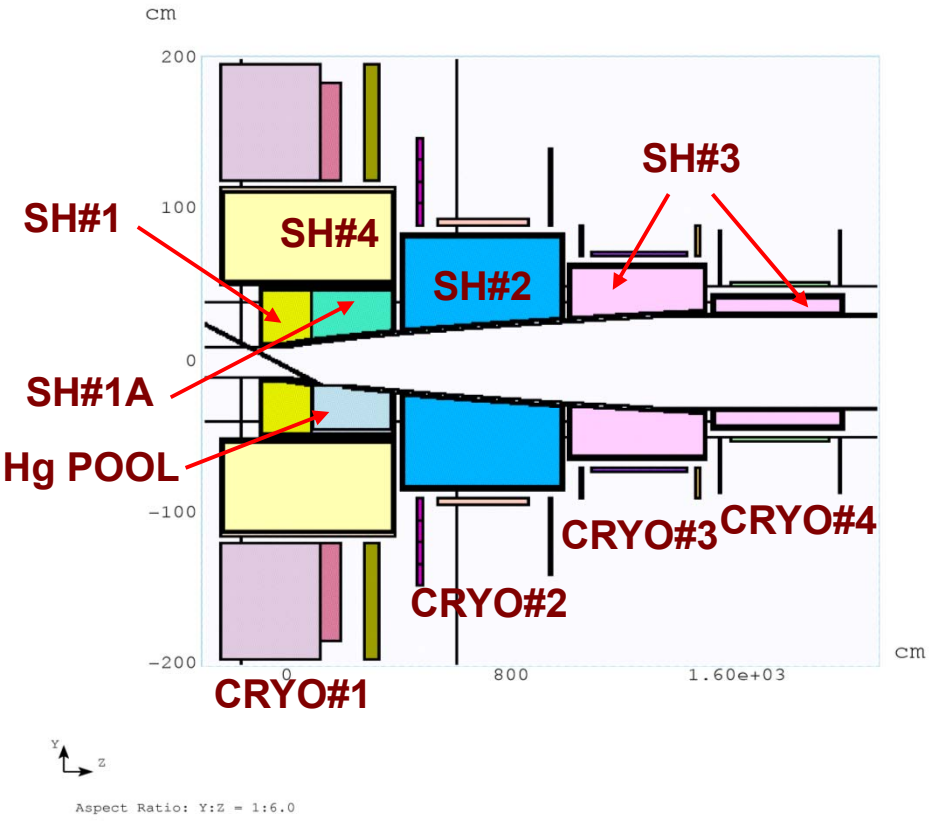
>SHIELDING: 60% W + 40% He (WITH STST VESSELS)

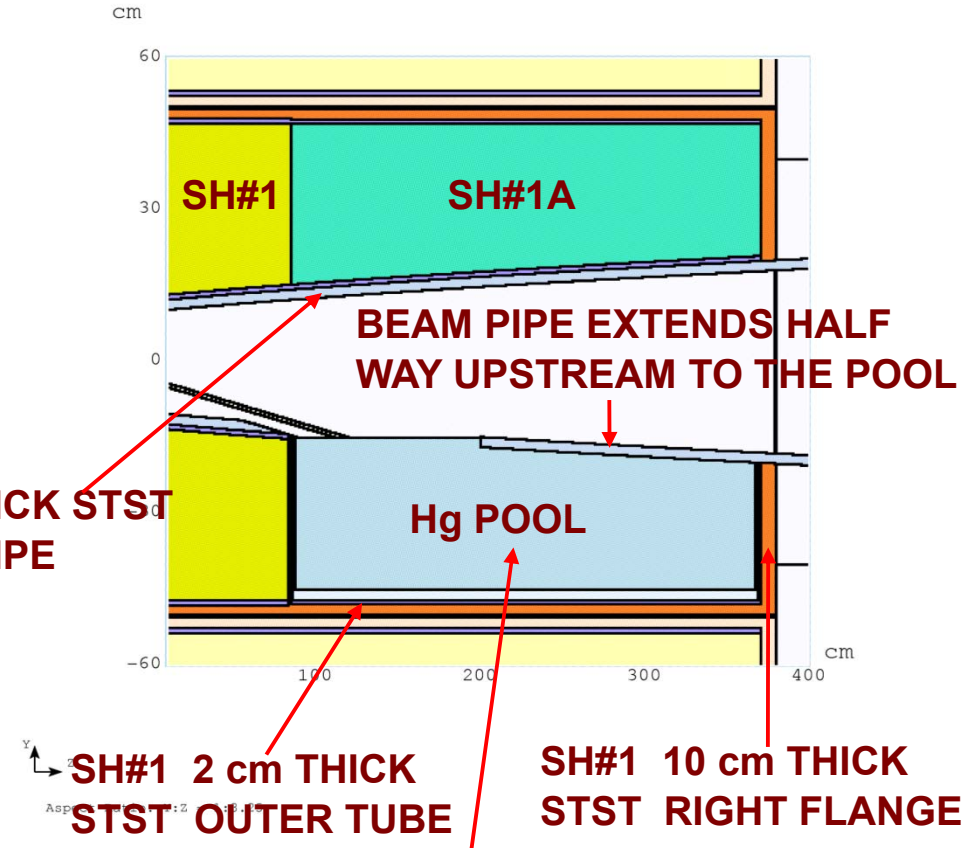
>PROTON BEAM POWER: 4 MW

>PROTON ENERGY: E = 8 GeV

>PROTON BEAM PROFILE: GAUSSIAN, $\sigma_x = \sigma_y = 0.12$ cm
>EVENTS IN SIMULATIONS : N_p = 500,000 (OR 4x500,000 FOR SC#1+2)

IDS120j: REPLACING RESISTIVE MAGNETS AND FILLING UPPER HALF OF Hg POOL WITH SHIELDING. GENERAL OVERVIEW (LEFT), POOL REGION DETAILS (RIGHT). [20 cm GAPS]

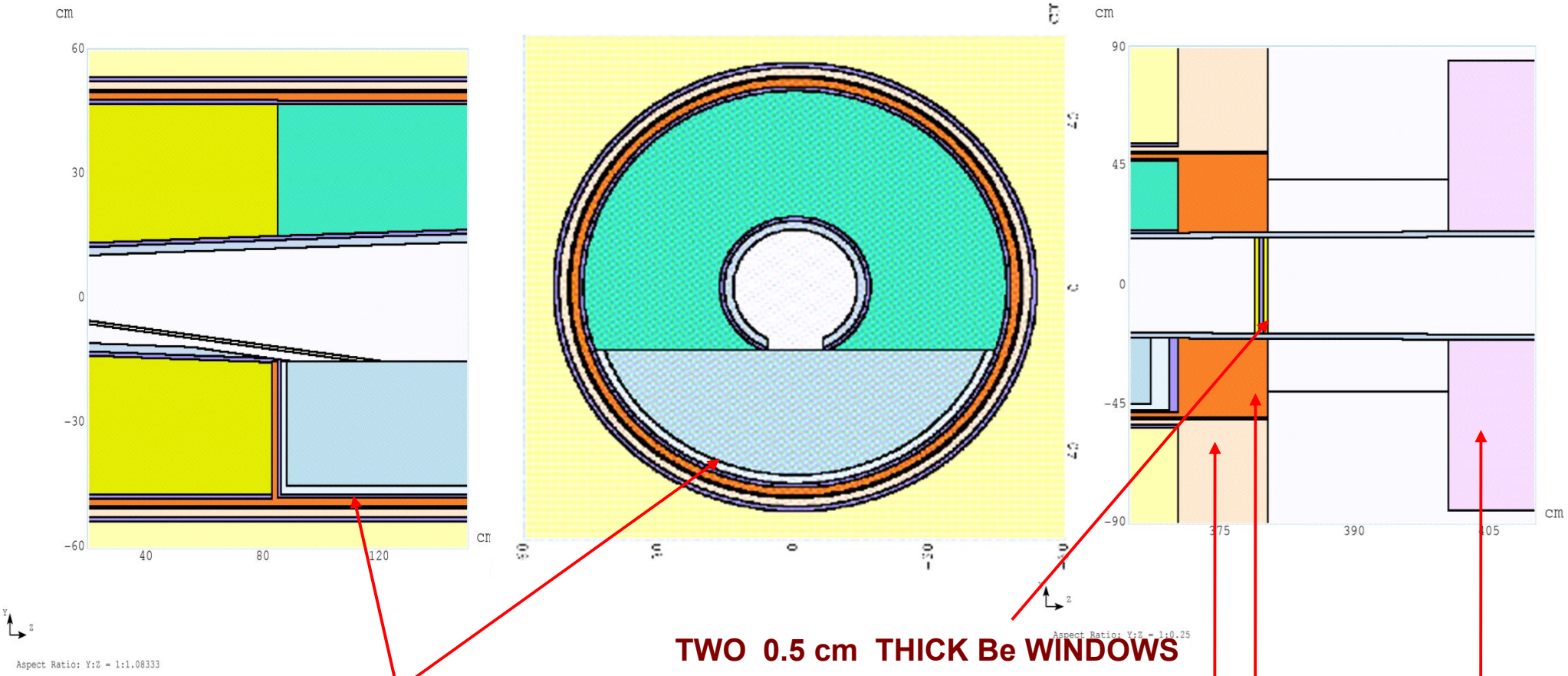




Hg POOL STARTS ~ 85 cm AND EXTENDS ALL THE WAY TO THE END OF THE FIRST CRYOSTAT ~ 370 cm.

SHVS WALLS, Hg POOL VESSEL DOUBLE WALLS, Be WINDOW, He GAP IN Be WINDOW AND IN HG POOL HAVE NOMINAL VALUES FOR THEIR THIKNESS. STRESS FORCES ANALYSIS AND LOCAL DPD DISTRIBUTION WILL BE USED TO DETERMINE THEIR VALUES.

IDS120j: WITHOUT RESISTIVE MAGNETS. DETAILS OF THE DOUBLE STST Hg POOL VESSEL (LEFT, MIDDLE) AND THE DOUBLE Be WINDOW (RIGHT). [20 cm GAPS]



2 cm THICK STST INNER Hg POOL VESSEL WITH 1 cm He GAP FOR COOLING.

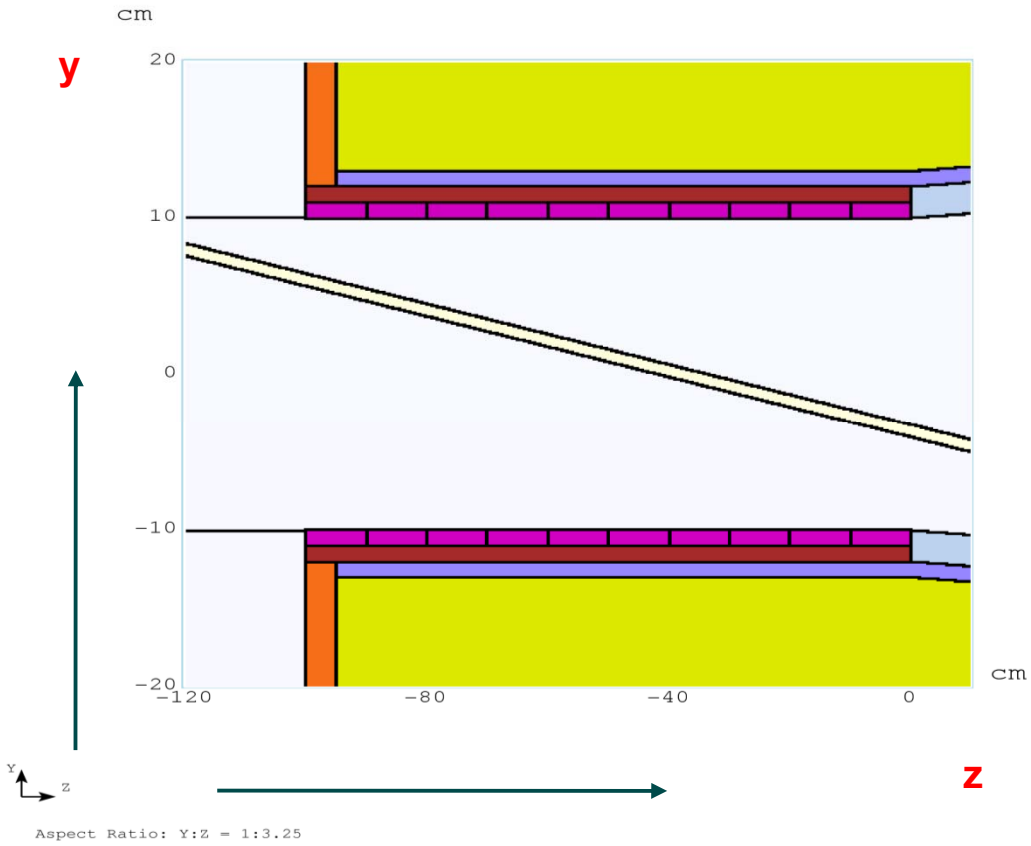
TWO 0.5 cm THICK Be WINDOWS AT THE END OF CRYO#1 WITH 0.5 cm He GAP BETWEEN THEM FOR COOLING.

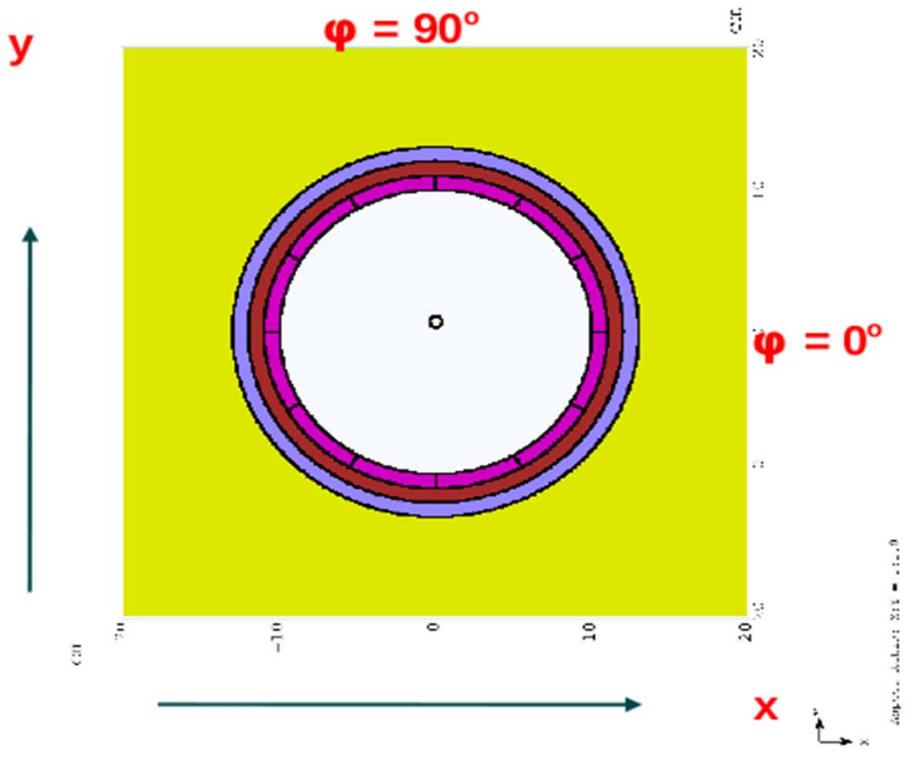
10 cm THICK STST RIGHT / LEFT FLANGE OF SHVS#4, SHVS#1 / SHVS#2 WITH 20 cm GAP BETWEEN THEM.

BP#1 AZIMUTHAL DPD DISTRIBUTION STUDIES

DPD = Deposited Power Density

IDS120j: y-z (LEFT) AND y-x (RIGHT) CROSS SECTION WITH DETAILS OF THE BP#1 SEGMENTATION





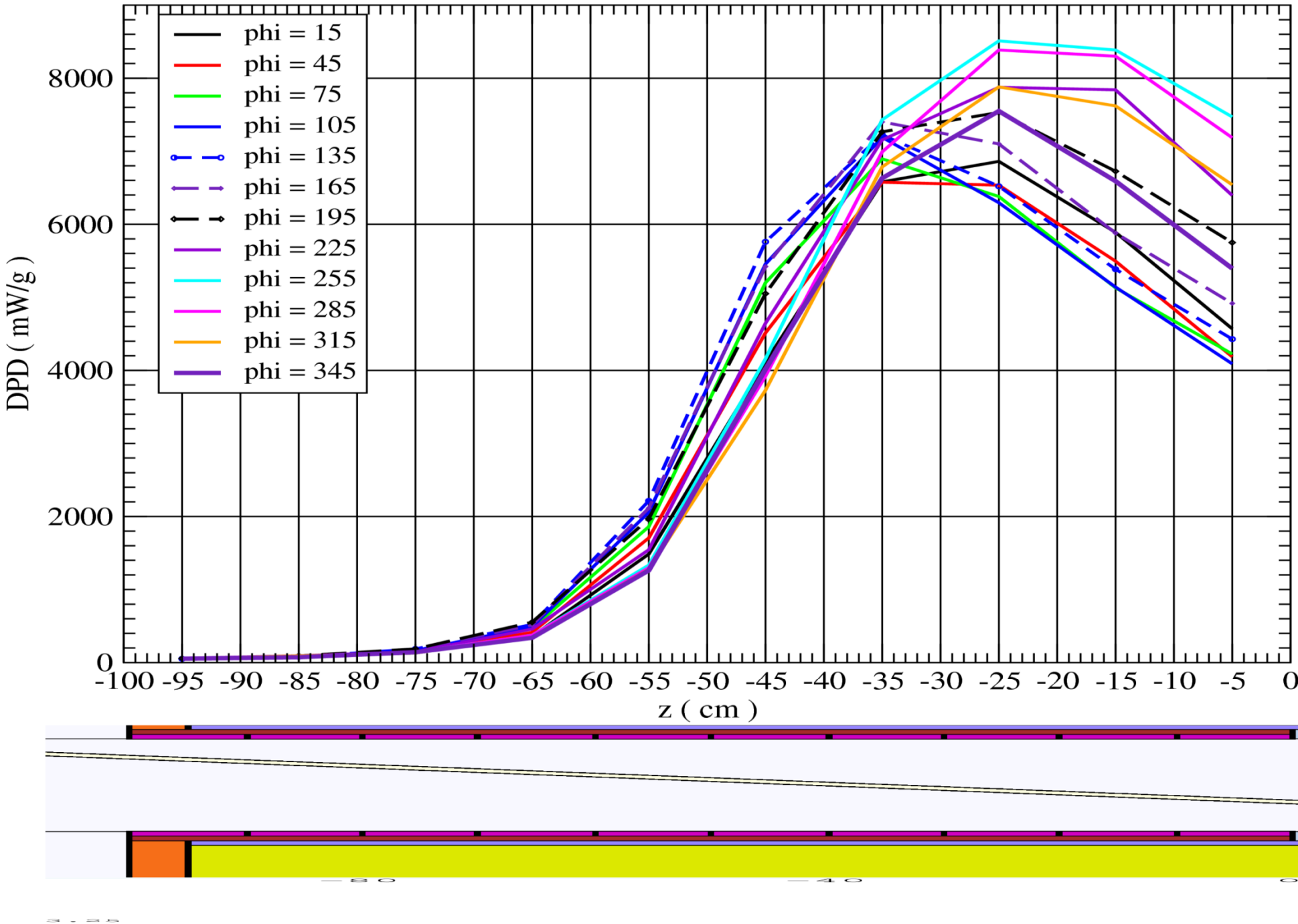
10.0 < r < 11.0 cm dr = 1.0 cm N_r = 1 bins

- 100.0 < z < 0.0 cm dz = 10.0 cm N_z = 10 bins

0.0 < φ < 360.0 deg. dφ = 30 deg. N_φ = 12 bins

N_{tot} = 120 "pieces"

ONLY THE FIRST 1 cm TUBE VOLUME OF THE 2 cm STST THICK BP#2 WAS USED.


BP1 DPD vs. z FOR 12 ANGLES, FIRST 1 cm RADIAL THIKNESS TUBE
(dr, dz, dphi) = (1 cm, 10 cm, 30 deg)--> (1, 10, 12) #BINS
phi = 15
phi = 45
phi = 75
phi = 105
phi = 135
phi = 165
phi = 195
phi = 225
phi = 255
phi = 285
phi = 315
phi = 345
DPD (mW/g)
0
2000
4000
6000
8000
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0
z (cm)

SUM OF DP FROM 120 PIECES :	174.12 kW
DP FROM REST OF BP#1 :	150.30 kW
TOTAL DP IN BP#1 :	324.42 kW
BP#1 DP WITHOUT SEGMENTATION:	322.49 kW

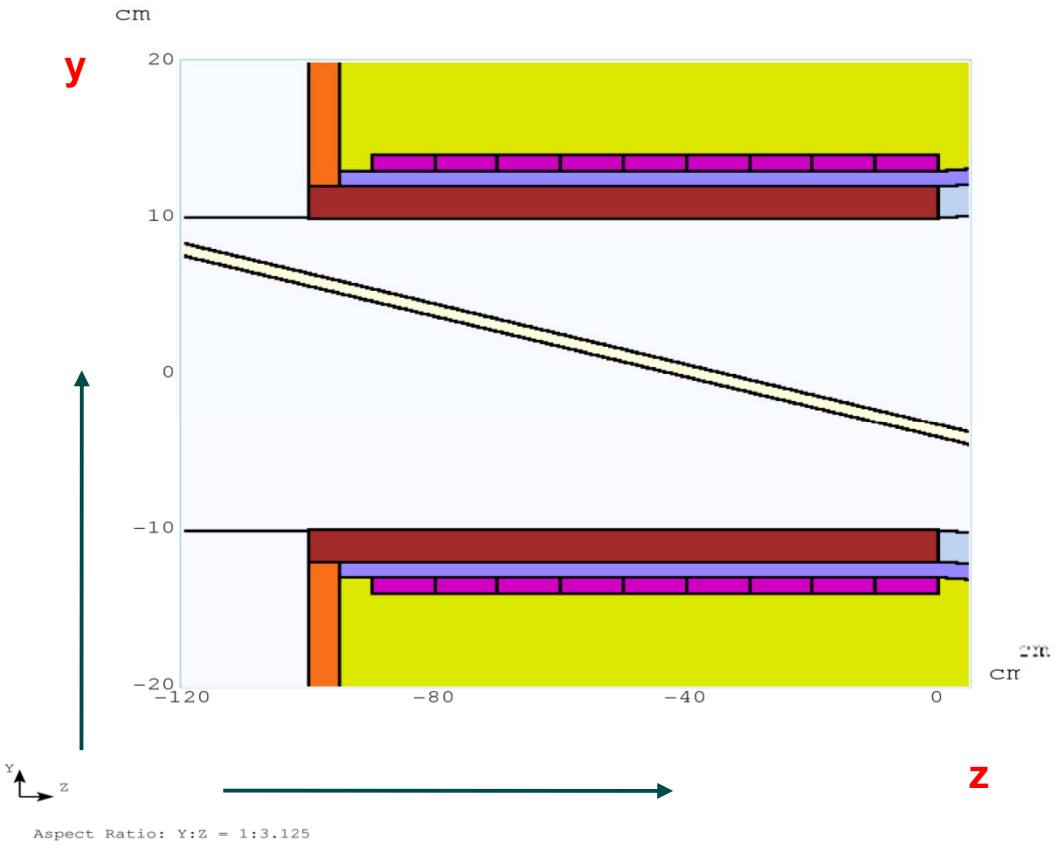
~ 100 kW (223 kW --> 322 kW) MORE POWER IS DEPOSITED IN BP#1 (2 cm THICK, 100 cm LONG, STST BEAM PIPE) AROUND THE TARGET REGION WITHOUT THE RESISTIVE MAGNETS. THIS IS DUE TO THE DIFFERENT MAGNETIC FIELD PROFILE IN THAT REGION AS WELL AS DUE TO THE DIFFERENT INTERACTION CROSS ANLGE BETWEEN Hg JET AND PROTON BEAM. FINALLY THIS IS ALSO DUE TO THE FACT THAT THE BEAM PIPE VOLUME IS ALSO LARGER SINCE THE INNER RADIUS OF THE PIPE HAS INCREASED FROM 7.5 cm TO 10 cm WIHOUT THE RESISTIVE MAGNETS.

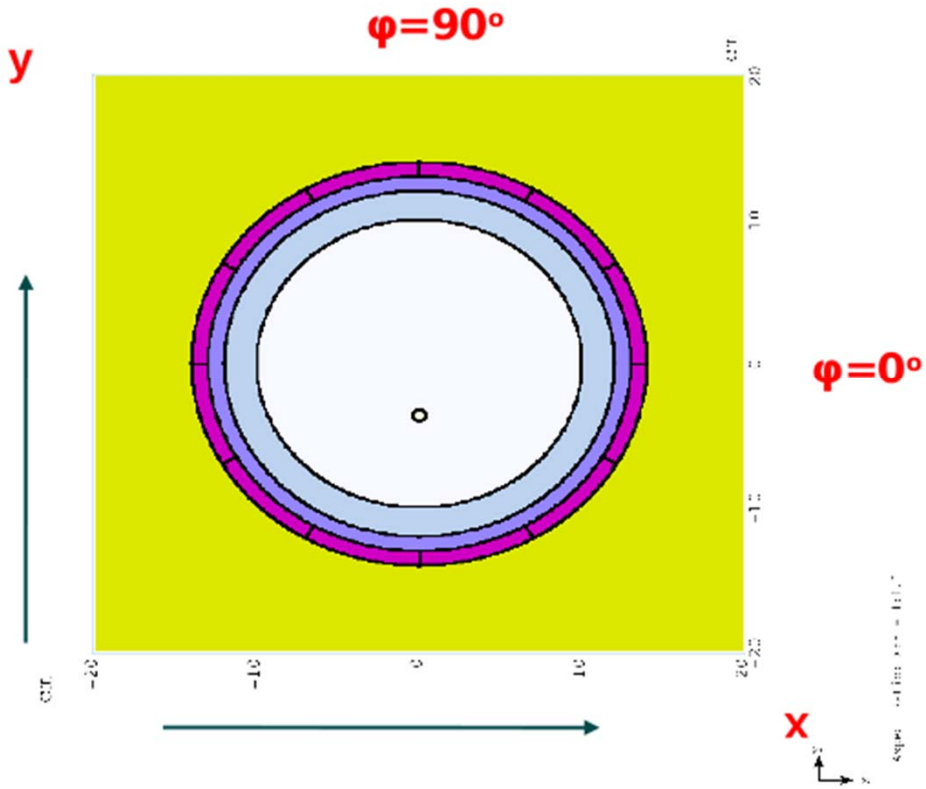
LOWEST DP IS EXPECTED ALONG THE + y DIRECTION WHILE MOST OF THE DP IS BETWEEN 255 AND 285 DEGREES (- y DIRECTION). ALONG THE AXIAL DIRECTION MOST OF THE ENERGY
IN THE PIPE IS CONCENTRATED IN THE REGION ~ [– 50, 0.0] cm.

DPD (max) ~ 8.5 W/g APPEARS TO BE AT (r, z, phi) = (10.5 cm, -25 cm, 255 deg). THAT IS ABOUT 2-3 W/g LESS THAN THE PEAK DPD IN BP#1 WITH THE RESISTIVE COILS PRESENT.

SH#1 AZIMUTHAL DPD DISTRIBUTION STUDIES

IDS120j: y-z (LEFT) AND y-x (RIGHT) CROSS SECTION WITH DETAILS OF THE SH#1 SEGMENTATION





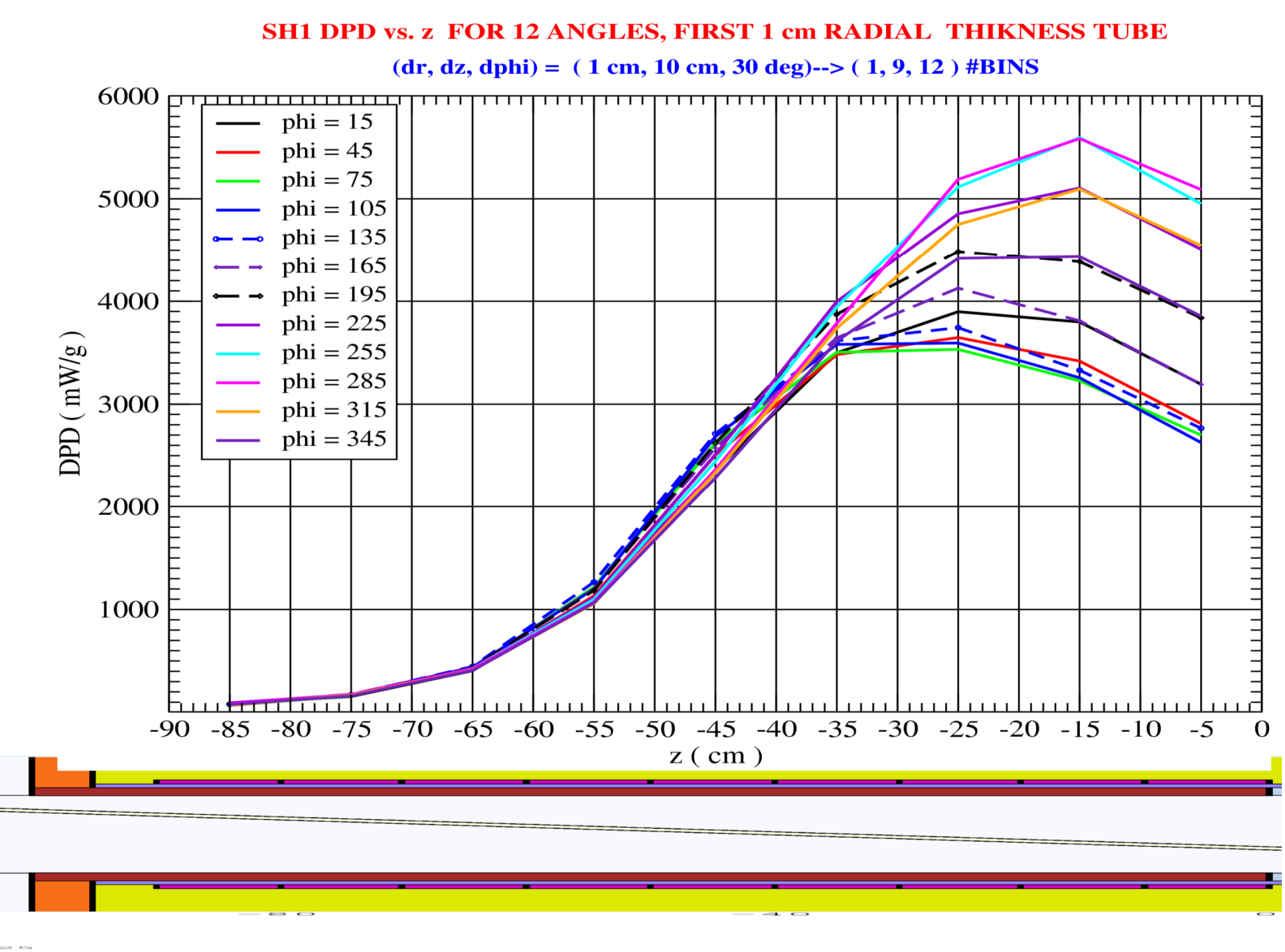
13.0 < r < 14.0 cm dr = 1.0 cm N_r = 1 bins

- 90.0 < z < 0.0 cm dz = 10.0 cm N_z = 9 bins

0.0 < φ < 360.0 deg. dφ = 30 deg. N_φ = 12 bins

N_{tot} = 108 "pieces"

ONLY THE FIRST 1 cm TUBE VOLUME OF THE SH#1 WAS USED.


SH1 DPD vs. z FOR 12 ANGLES, FIRST 1 cm RADIAL THIKNESS TUBE
(dr, dz, dphi) = (1 cm, 10 cm, 30 deg)--> (1, 9, 12) #BINS
DPD (mW/g)
z (cm)
phi = 15
phi = 45
phi = 75
phi = 105
phi = 135
phi = 165
phi = 195
phi = 225
phi = 255
phi = 285
phi = 315
phi = 345
6000
5000
4000
3000
2000
1000
-90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0

SUM OF DP FROM 108 PIECES :	162.56 kW
DP FROM REST OF SH#1 :	1097.50 kW
TOTAL DP IN SH#1 :	1260.06 kW
SH#1 DP WITHOUT SEGMENTATION:	1262.05 kW

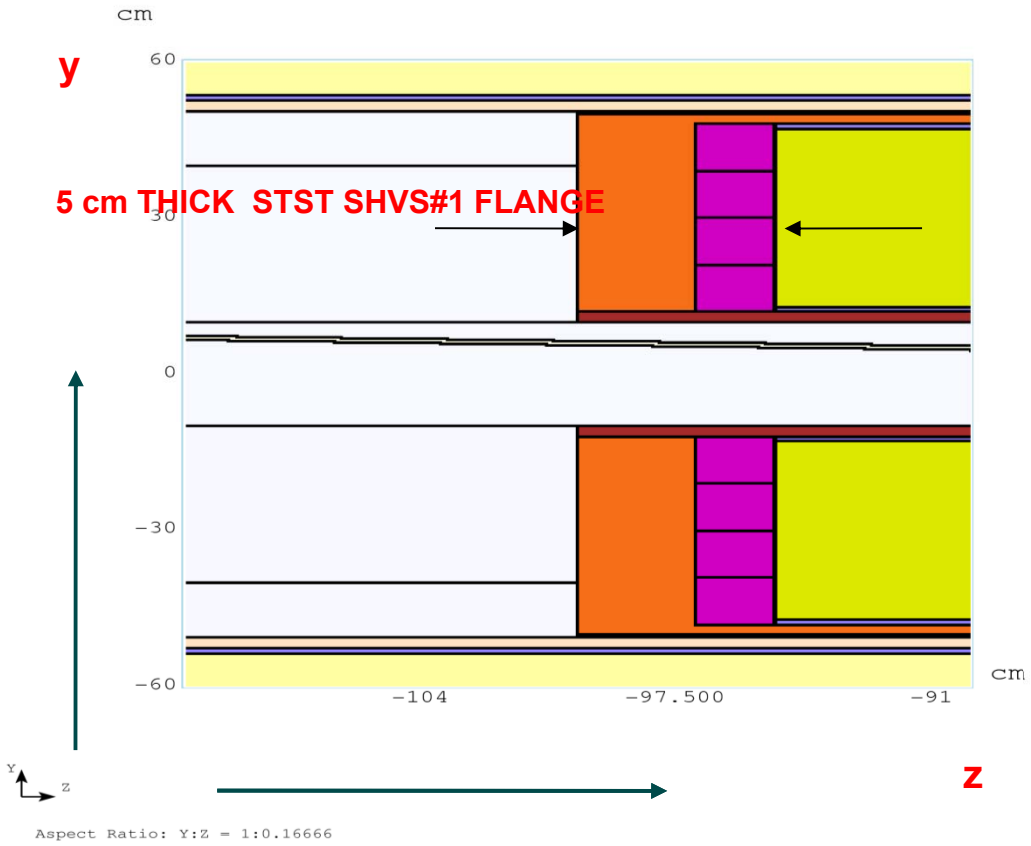
~ 365 kW (897 kW --> 1262 kW) MORE POWER IS DEPOSITED IN SH#1 VOLUME AROUND THE TARGET REGION WITHOUT THE RESISTIVE MAGNETS. LIKE BEFORE FOR THE BP#1
THIS IS DUE TO THE DIFFERENT MAGNETIC FIELD PROFILE IN THAT REGION AS WELL AS DUE TO THE DIFFERENT INTERACTION CROSS ANLGE BETWEEN Hg JET AND PROTON BEAM. THE ORIGINAL SH#1 VOLUME ON ONE HAND HAS BEEN REDUCED DUE TO THE INCREASE OF THE IR
OF THE BEAM PIPE THERE, ON THE OTHER HAND THERE IS AN INCREASE SINCE SHIELDING MATERIAL NOW OCCUPIES THE RESISTIVE MAGNETS VOLUME.

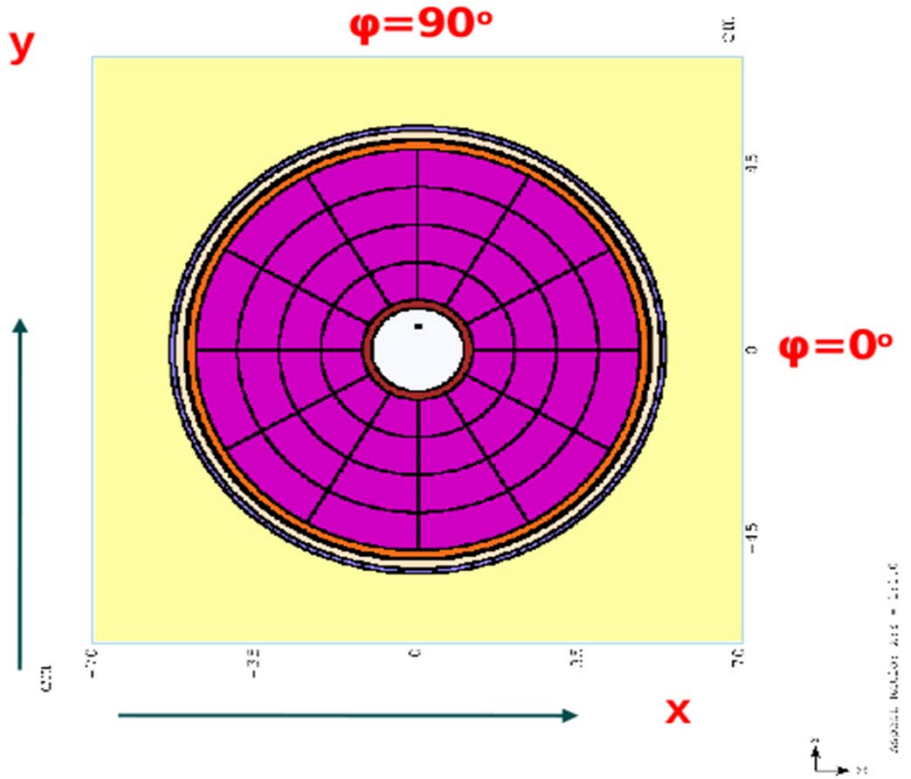
LOWEST DP IS EXPECTED ALONG THE + y DIRECTION WHILE MOST OF THE DP IS BETWEEN 255 AND 285 DEGREES (- y DIRECTION). ALONG THE AXIAL DIRECTION MOST OF THE ENERGY
IN THE SHIELDING IS CONCENTRATED IN THE REGION ~ [– 40, 0.0] cm.

DPD (max) ~ 5.6 W/g APPEARS TO BE AT (r, z, phi) = (13.5 cm, -15 cm, 255 deg). THAT IS ABOUT 3 - 4 W/g LESS THAN THE PEAK DPD IN SH#1 WITH THE RESISTIVE COILS PRESENT.

SHVS#1 LEFT (UPSTREAM) FLANGE AZIMUTHAL DPD DISTRIBUTION STUDIES

IDS120j: y-z (LEFT) AND y-x (RIGHT) CROSS SECTION WITH DETAILS OF THE SHVS#1 LEFT (UPSTREAM) FLANGE SEGMENTATION.





12.0 < r < 48.0 cm dr = 9.0 cm N_r = 4 bins

- 97.0 < z < -95.0 cm dz = 2.0 cm N_z = 1 bins

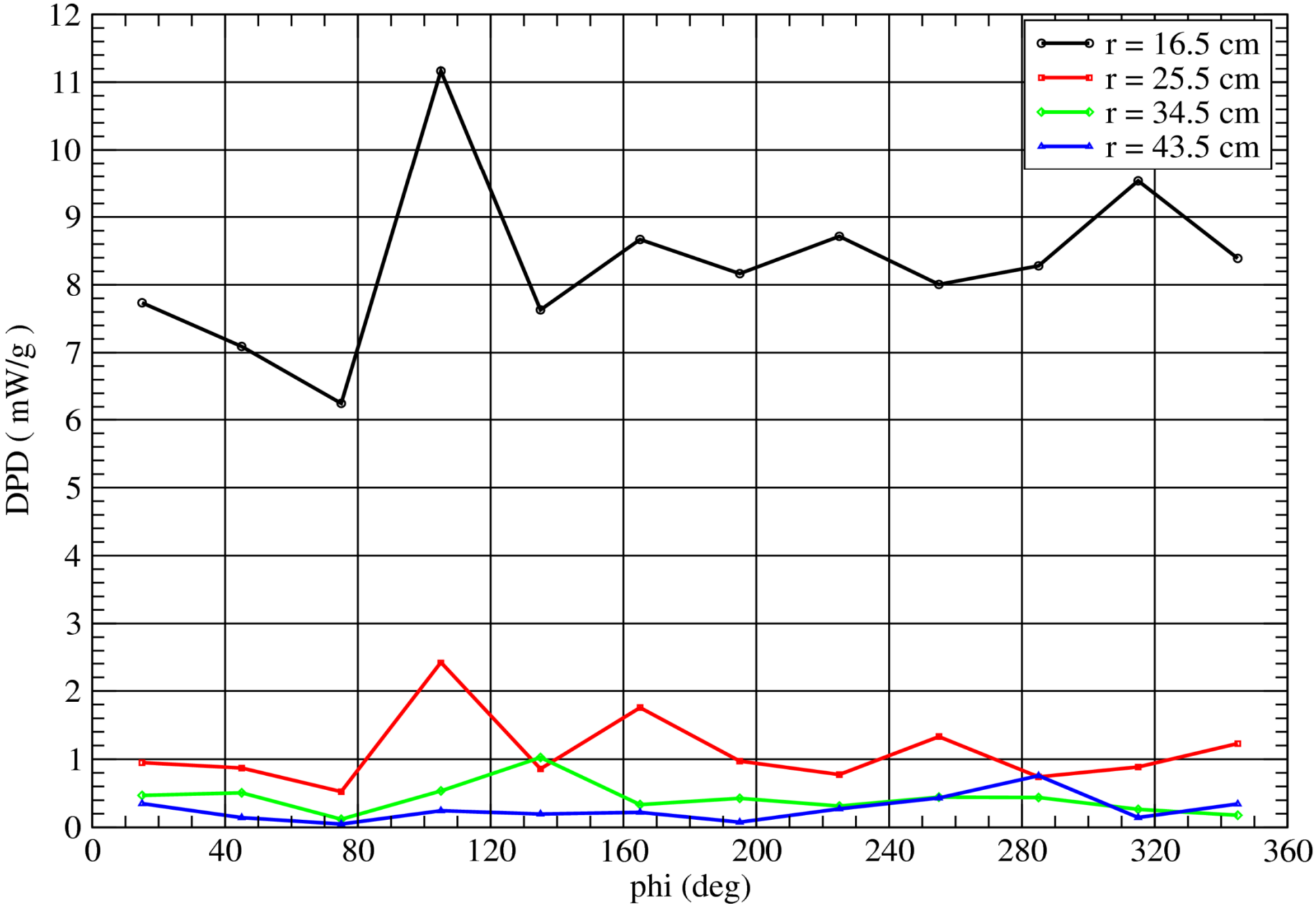
0.0 < φ < 360.0 deg. dφ = 30 deg. N_φ = 12 bins

N_{tot} = 48 "pieces"

ONLY THE FIRST (INNER) 2 cm OF THE FLANGE VOLUME OF THE SHVS#1 WAS SEGMENTED.

DPD vs. ANGLE FOR FOUR RADII AND FOR 2 cm INNER z-SLICE

LEFT SIDE (UPSTREAM) 5 cm THICK STST SHVS#1 FLANGE (dr, dz, dphi)= (9 cm, 2 cm, 30 deg) --> (4, 1, 12) # BINS



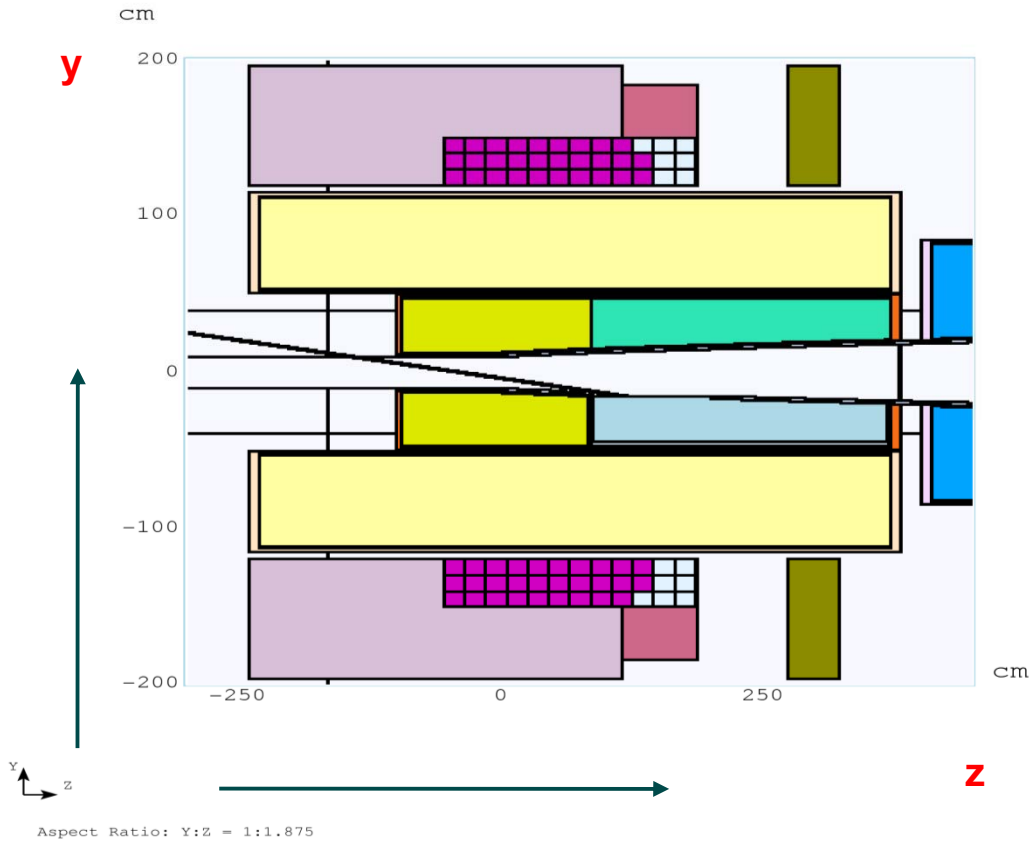
SUM OF DP FROM 48 PIECES :	0.17 kW
DP FROM REST OF SHVS#1/LFL :	10.35 kW
TOTAL DP IN SHVS#1/LFL:	10.52 kW
SH#1 DP WITHOUT SEGMENTATION:	10.51 kW

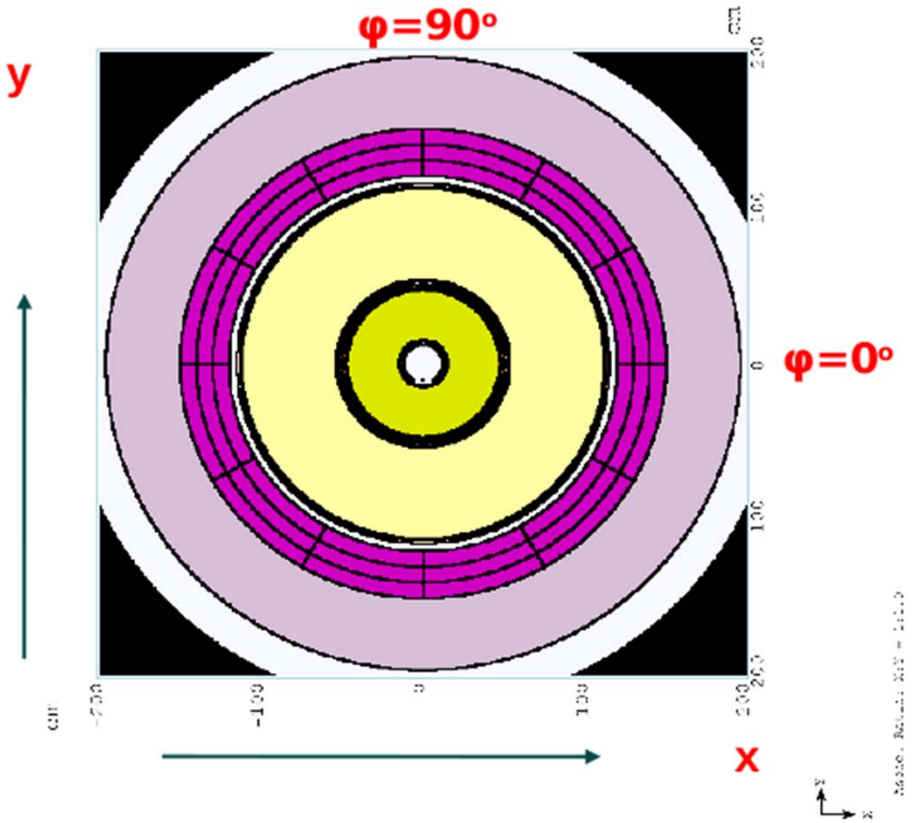
DPD (max) ~ 11.17 mW/g APPEARS TO BE AT (r, z, phi) = (16.5 cm, -96 cm, 105 deg). THAT IS ALONG THE + y (UPPER HALF) REGION OF THE FLANGE. VERY SMALL VARIATION IN OTHER DIRECTIONS.

DPD FOR LARGER r IS MUCH SMALLER AND THERE IS SMALL BUMP FOR "PIECES" CLOSE TO THE + y DIRECTION AND VERY SMALL FLUCTUATION FOR THE REST OF THE ANGLES.

SC#1+ SC#2 AZIMUTHAL DPD DISTRIBUTION STUDIES (LIMITED TO “HOT” REGION)

IDS120j: y-z (LEFT) AND y-x (RIGHT) CROSS SECTION WITH DETAILS OF THE SC#1+2 SEGMENTATION





120.0 < r < 150.0 cm dr = 10.0 cm N_r = 3 bins

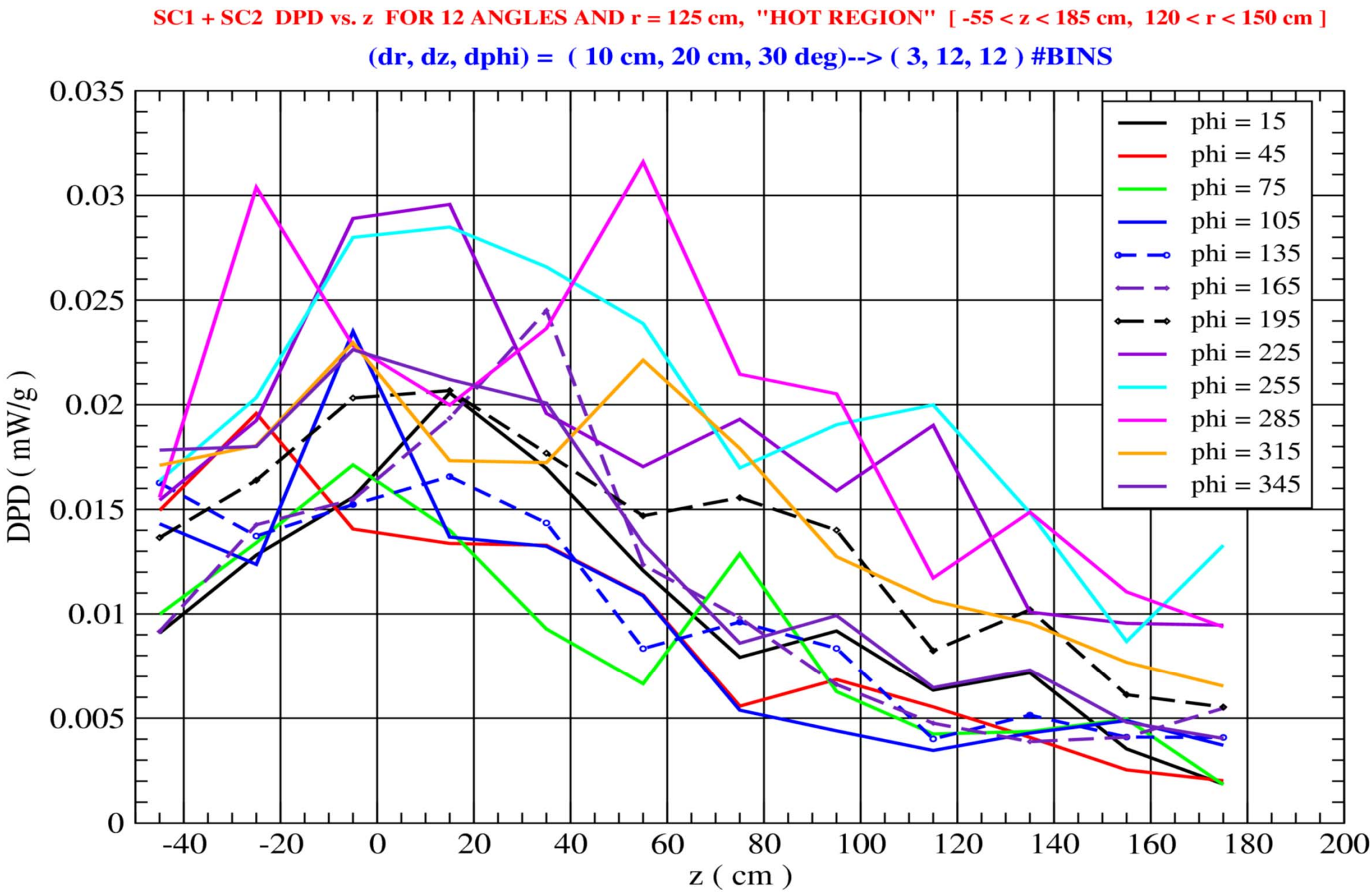
- 55.0 < z < 185.0 cm dz = 20.0 cm N_z = 12 bins

0.0 < φ < 360.0 deg. dφ = 30 deg. N_φ = 12 bins

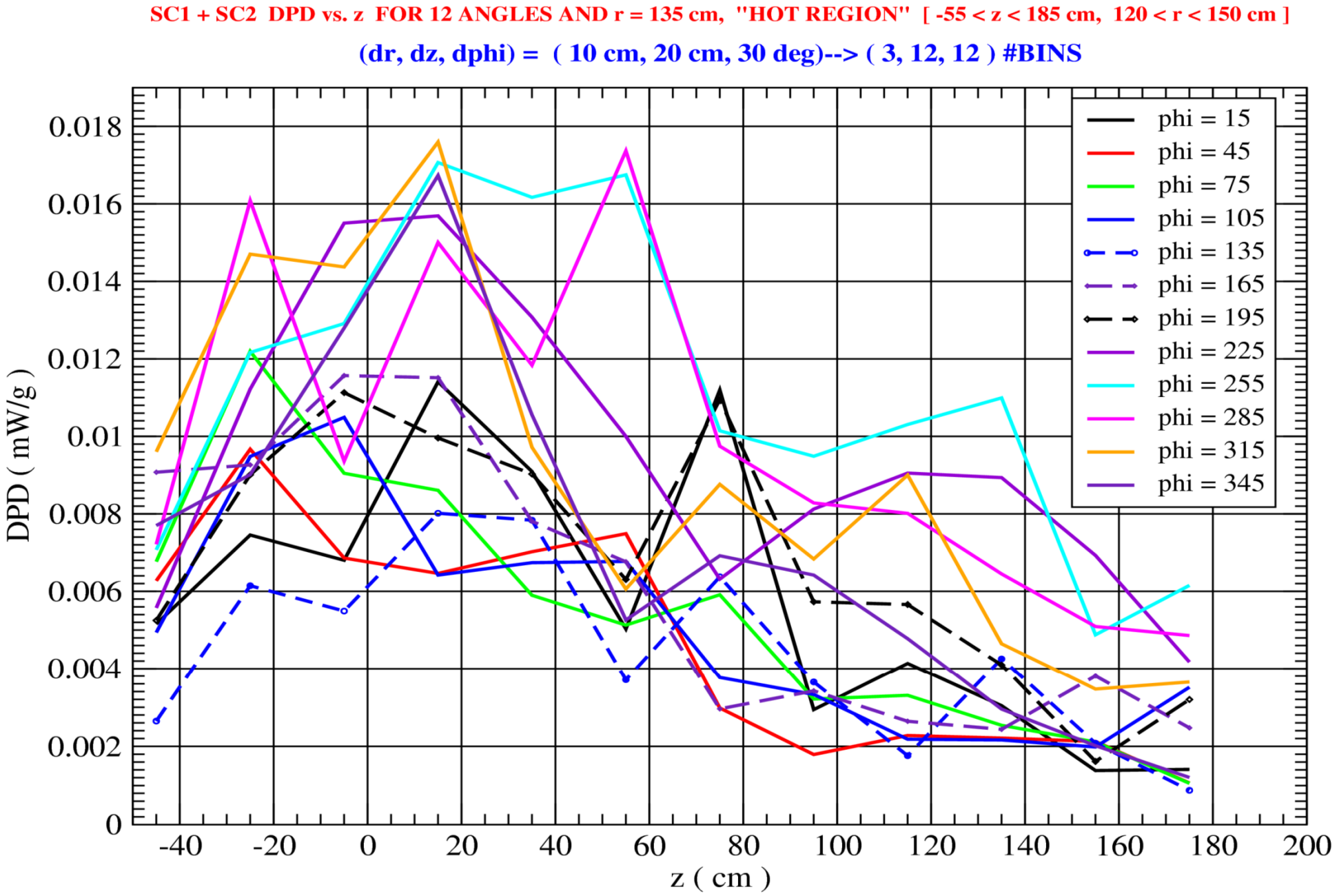
N_{tot} = 432 "pieces"

ONLY THE AREA WITH HIGHEST AVERAGE AZIMUTHAL DPD (DETERMINED FROM MARS PLOTS) WAS STUDIED.

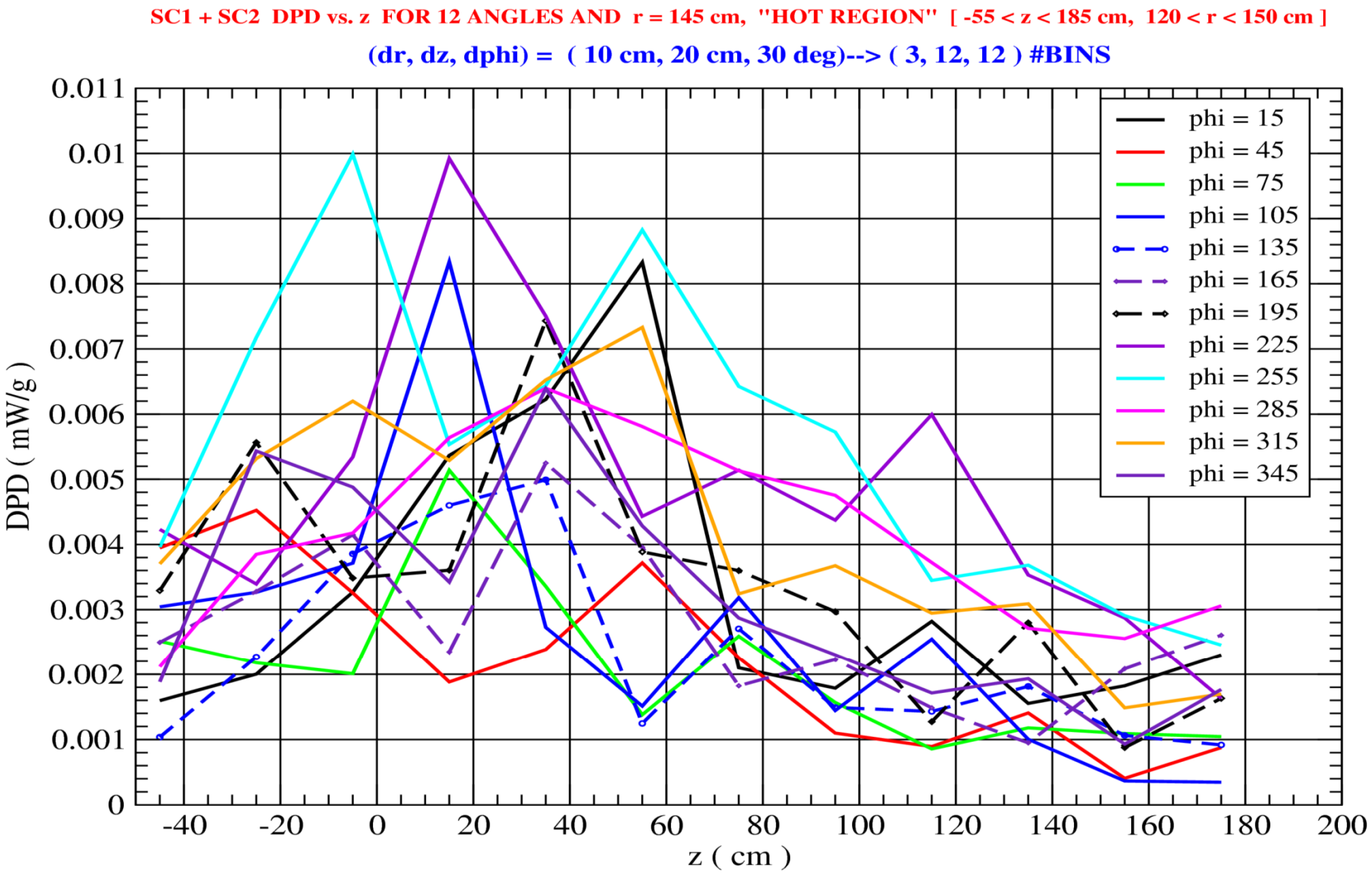
IDS120j: DPD AZIMUTHAL VARIATION FOR "PIECES" IN SC#1+2 WITH r= 125 cm



IDS120j: DPD AZIMUTHAL VARIATION FOR "PIECES" IN SC#1+2 WITH r= 135 cm



IDS120j: DPD AZIMUTHAL VARIATION FOR "PIECES" IN SC#1+2 WITH r= 145 cm



SUM OF DP FROM 432 PIECES :	0.446 kW
DP FROM REST OF SC#1+2	0.105 kW
TOTAL DP IN SC#1+2 :	0.551 kW
SC#1+2 DP WITHOUT SEGMENTATION:	0.592 kW

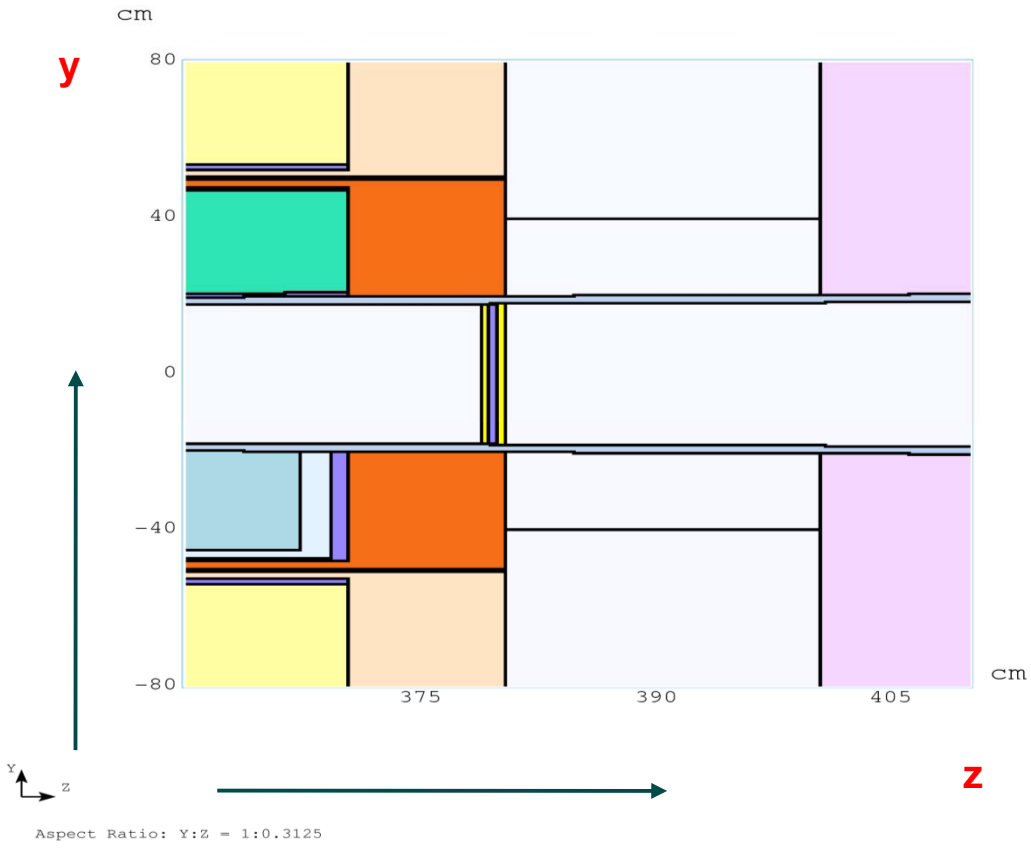
~ 0.26 kW (0.852 kW --> 0.592 kW) DECRASE IN THE SC#1+SC#2 DEPOSITED POWER WITOUT THE RESISTIVE COILS.

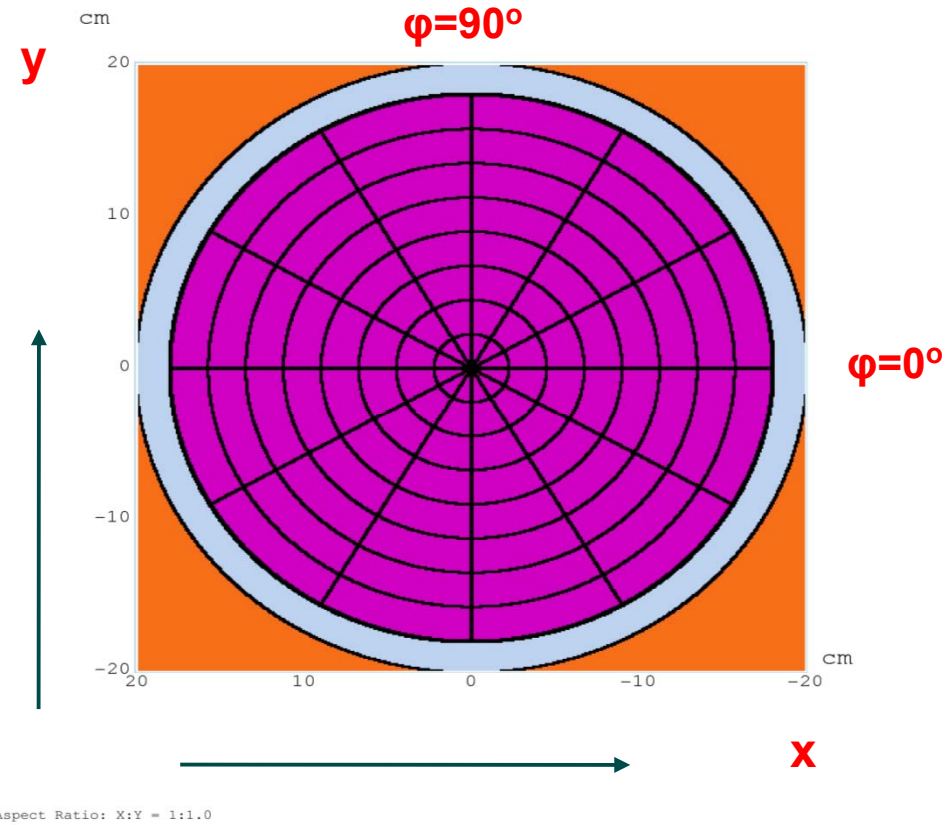
DPD (max) ~ 0.045 mW/g APPEARS TO BE AT (r, z, phi) = (125 cm, -25 cm, 285 deg).

OVERALL LOWEST DP IS EXPECTED ALONG THE + y DIRECTION AND MAXIMUM DP IN THE LOWER HALF OF THE COILS.
FOR THE INNER RADIUS “PIECES” THE PEAK DPD ~ 0.03 mW/g ~ [- 40, 60] cm z- REGION,
FOR THE MIDDLE RADIUS “PIECES THE PEAK DPD ~ 0.018 mW/g ~ [- 20, 60] cm z- REGION,
FOR THE OUTER RADIUS “PIECES THE PEAK DPD ~ 0.01 mW/g ~ [- 20, 20] cm z- REGION.

Be WINDOW AZIMUTHAL DPD DISTRIBUTION STUDIES

IDS120j: y-z (LEFT) AND y-x (RIGHT) CROSS SECTION WITH DETAILS OF THE Be WINDOW SEGMENTATION



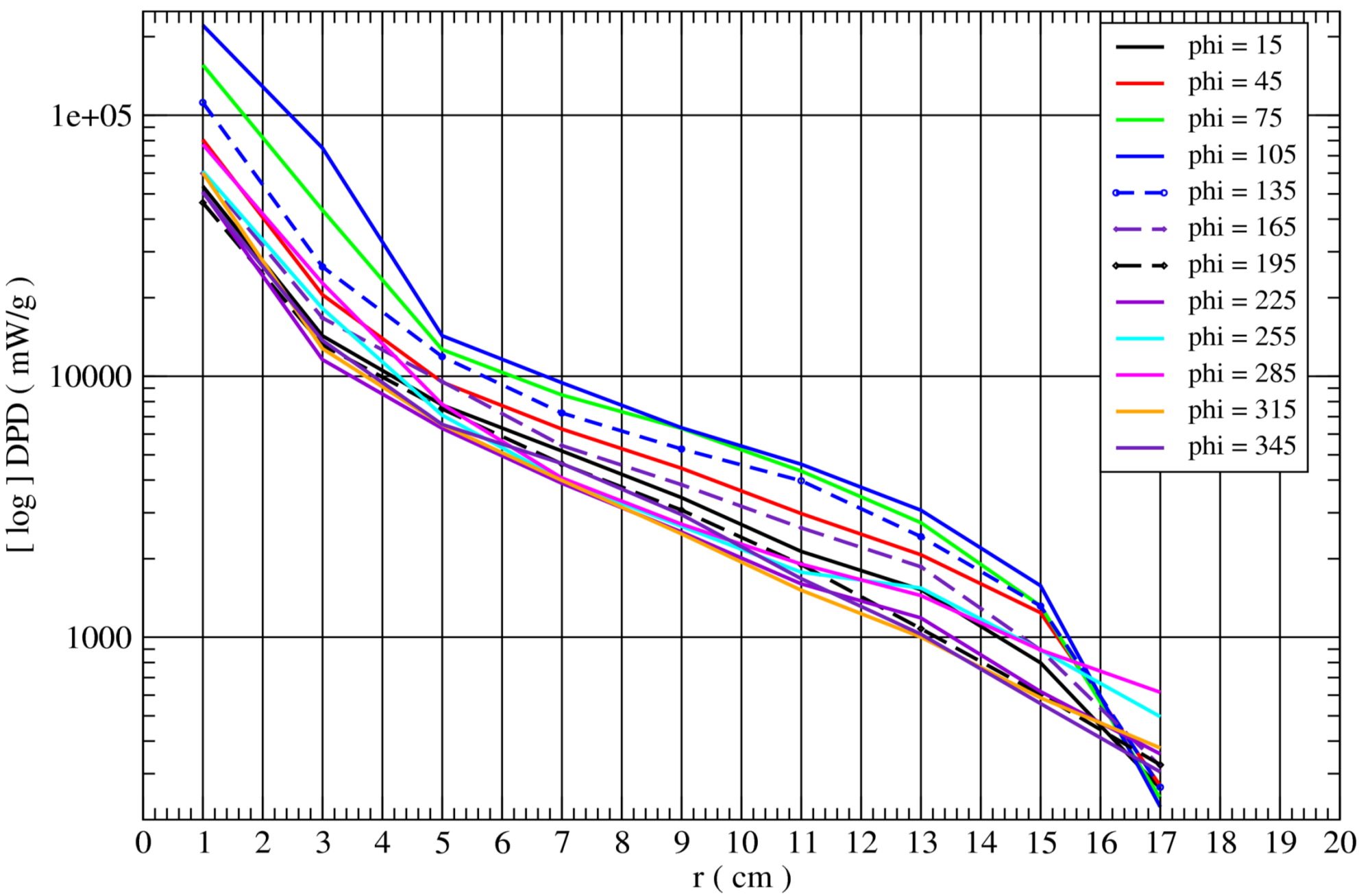


0.0 < r < 18.0 cm dr = 2.0 cm N_r = 9 bins

378.84 < z < 379.34 cm dz = 20.0 cm N_z = 1 bins

0.0 < φ < 360.0 deg. dφ = 30 deg. N_φ = 12 bins

N_{tot} = 108 "pieces"


Be Window DPD vs. r FOR 12 ANGLES [378.84 < z < 379.34 cm, 0.0 < r < 18.0 cm]
(dr, dz, dphi) = (2 cm, 0.5 cm, 30 deg)--> (9, 1, 12) #BINS
[log] DPD (mW/g)
1e+05
10000
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
r (cm)
phi = 15
phi = 45
phi = 75
phi = 105
phi = 135
phi = 165
phi = 195
phi = 225
phi = 255
phi = 285
phi = 315
phi = 345

SUM OF DP FROM 108 PIECES : 4.1 kW
DP FROM REST OF Be WIND. : 2.92 kW
TOTAL DP IN Be WIND. : 7.0 kW
Be WIND. DP WITHOUT SEGMENTATION: 7.57 kW

~ 1.6 kW (5.95 kW --> 7.57 kW) INCREASE IN THE Be WINDOW DEPOSITED POWER WITOUT THE RESISTIVE COILS.

DPD (max) ~ 221.3 W/g APPEARS TO BE AT (r, z, phi) = (1 cm, 379.09 cm, 105 deg).

OVERALL MORE DP IS EXPECTED IN THE UPPER HALF OF THE WINDOW THAN IN THE LOWER HALF.
PEAK VALUES OF DPD NEAR THE CENTER OF THE WINODW ARE OF THE ORDER OF ~ 100 - 200 W/g IN THE UPPER HALF PIECES FOR A 0.5 cm THICK WINDOW.
THE DPD IS OF THE ORDER OF TENTHS OF W/g WITHIN A 3 cm RADIUS FOR OTHER DIRECTIONS.