IDS120j WITHOUT RESISTIVE MAGNETS

MODIFYING Hg MODULE (NEW SH#1 REGION)

Nicholas Souchlas, PBL (12 / 13 / 2012)

IDS120j GEOMETRY, NO RESISTIVE MAGNETS: WITH 20 cm GAPS BETWEEN CRYOSTATS

****

 # MODIFYING Hg MODULE TO SIMULATE VAN GRAVE'S DESIGN.

A NEW UNIFIED SHIELDING VOLUME (SH#1 + SH#4) WITHIN CRYO#1 WAS DECIDED DURING 11 / 15 / 2012 TARGET MEETING AND AN EXTENSION OF THE Hg POOL UPSTREAM UP TO z = - 100 cm.

NEW SHIELDING CONFIGURATION ADDS ~ 8 cm THICK CYLIDRICAL VOLUME OF SHIELDING AT R ~ 50 cm.

 # RESULTS FROM SIMULATIONS WITH MODIFIED Hg POOL AND SH#1 REGION (SC#1+2, SC#4 SEGMENTATION STUDIES AND DISTRIBUTION OF DP IN STATION).

****

>SIMULATIONS CODE: mars1512 (USING MCNP CROSS SECTION LIBRARIES)

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

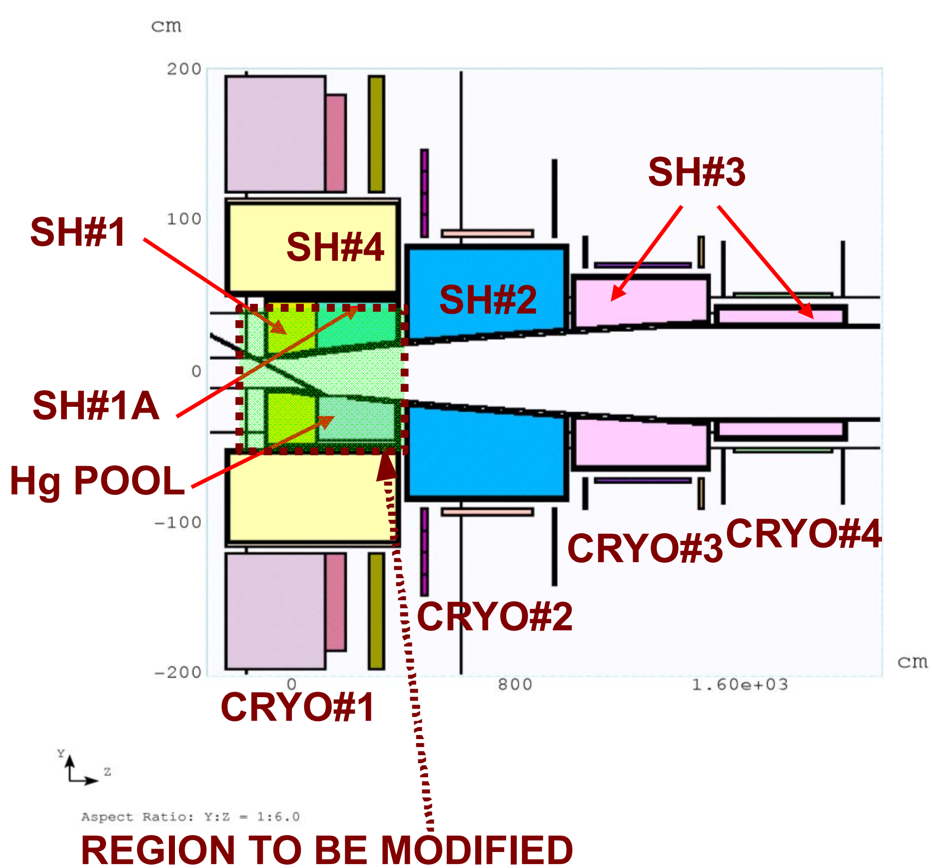
>SHIELDING: 60% W + 40% He (WITH STST VESSELS)

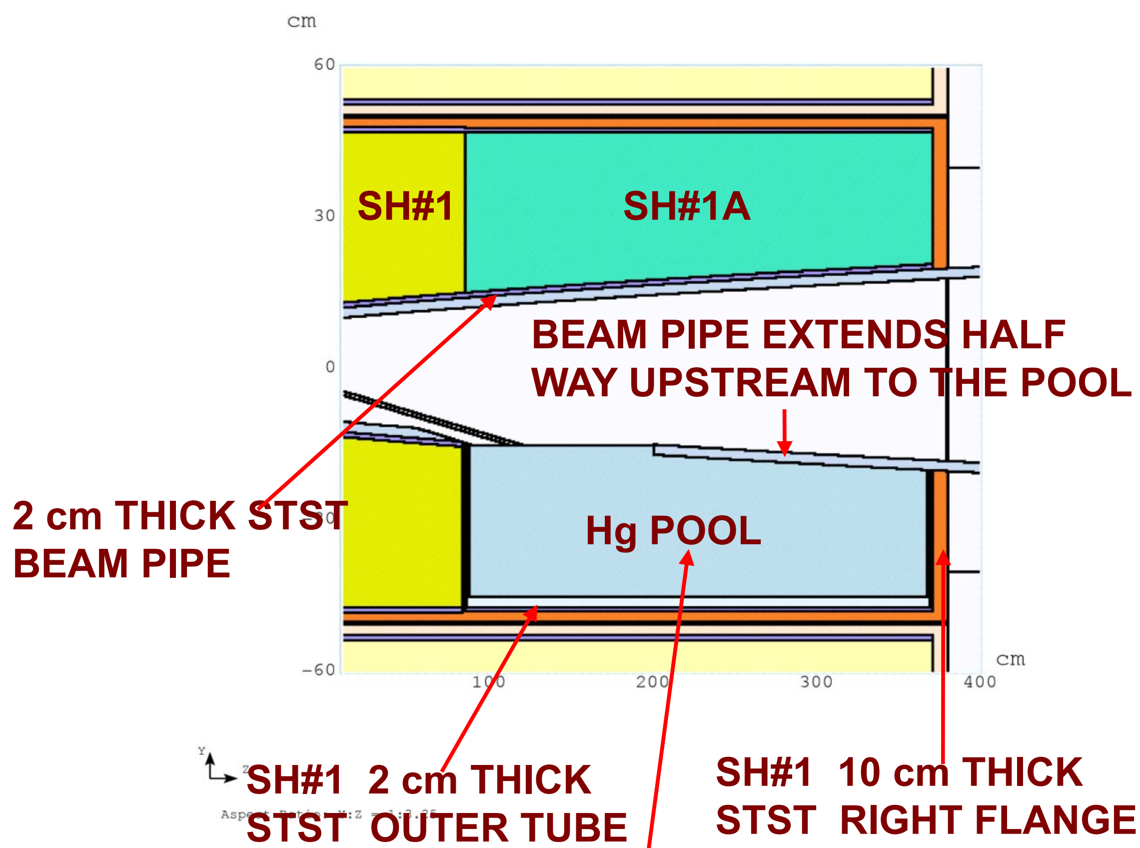
>PROTON BEAM POWER: 4 MW

>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: GENERAL OVERVIEW (LEFT), POOL REGION DETAILS (RIGHT). [20 cm GAPS]

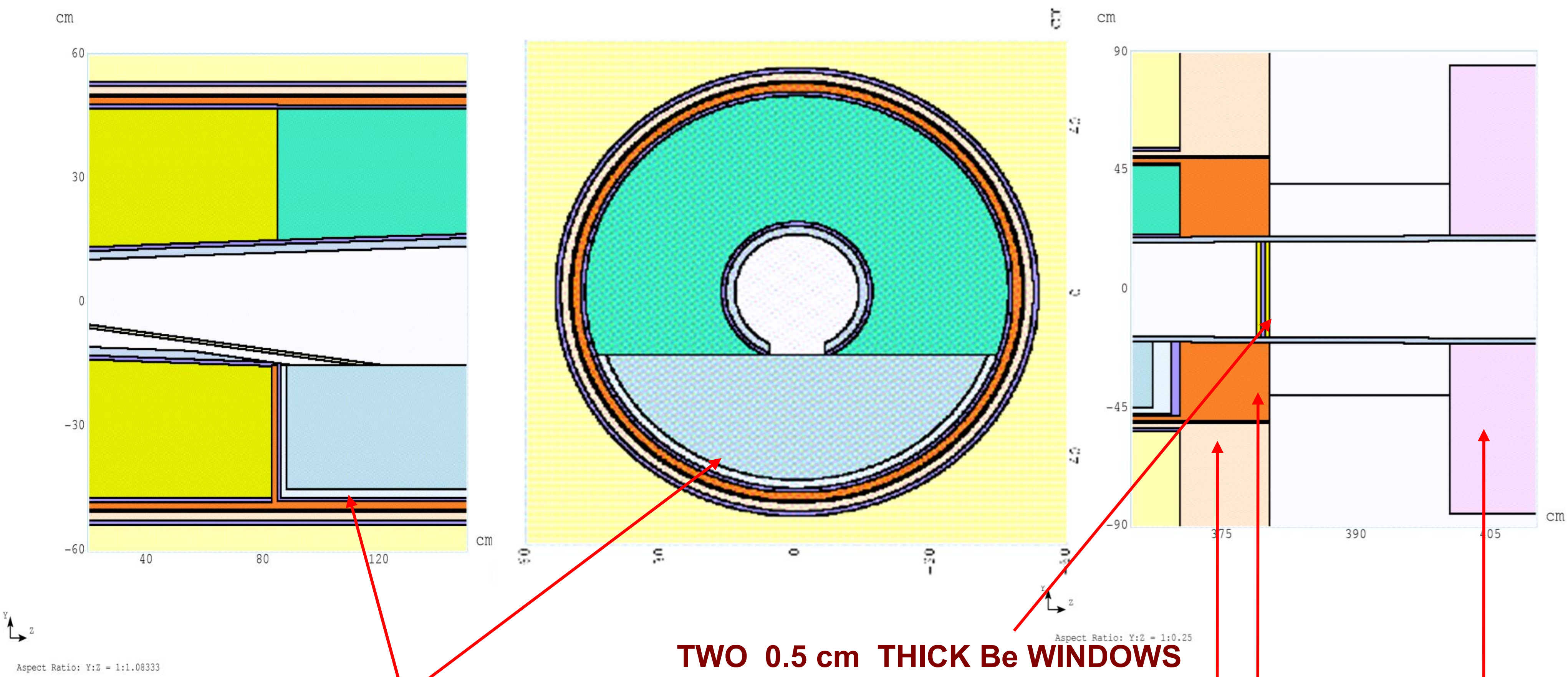




Hg POOL STARTS ~ 85 cm AND EXTENDS ALL THE WAY TO THE END OF THE FIRST CRYOSTAT ~ 370 cm.

THE NEW Hg POOL MODULE WILL DISPLACE A LARGE VOLUME OF SHIELDING MATERIAL IN SH#1 AND THE FIRST HALF OF SH#1A (TOP VOLUME REGION), AS WELL AS FROM THE BOTTOM VOLUME BEFORE THE Hg POOL (UPSTREAM) WHERE IT IS MOSTLY NEEDED FOR THE PROTECTION OF SC#1 – SC#4 [INNER Hg MODULE WAS DECIDED TO BE EXTENDED UPSTREAM ALL THE WAY AT THE BEGINNING OF THE SC#1]. UPDATED CONFIGURATION UNIFIES SH#1 AND SH#4 VOLUMES AND EXTENDS Hg POOL UPSTREAM UP TO z = - 100 cm.

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

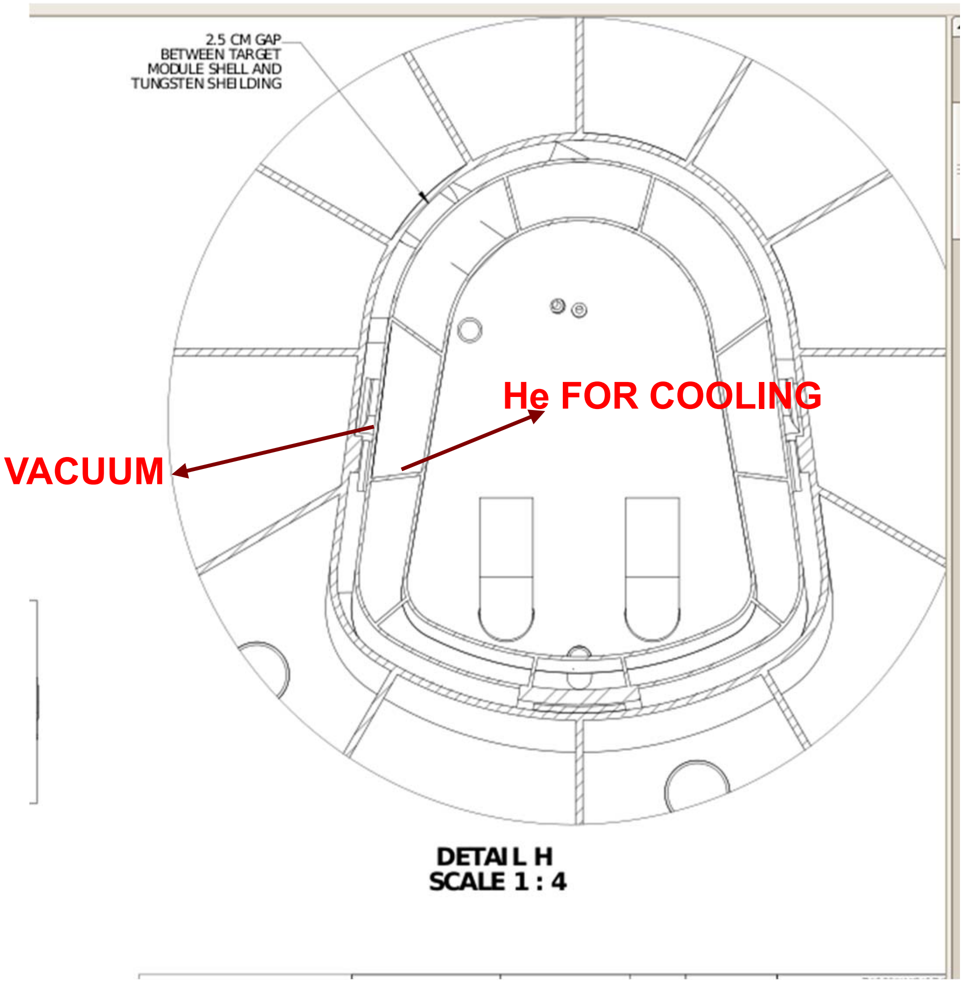


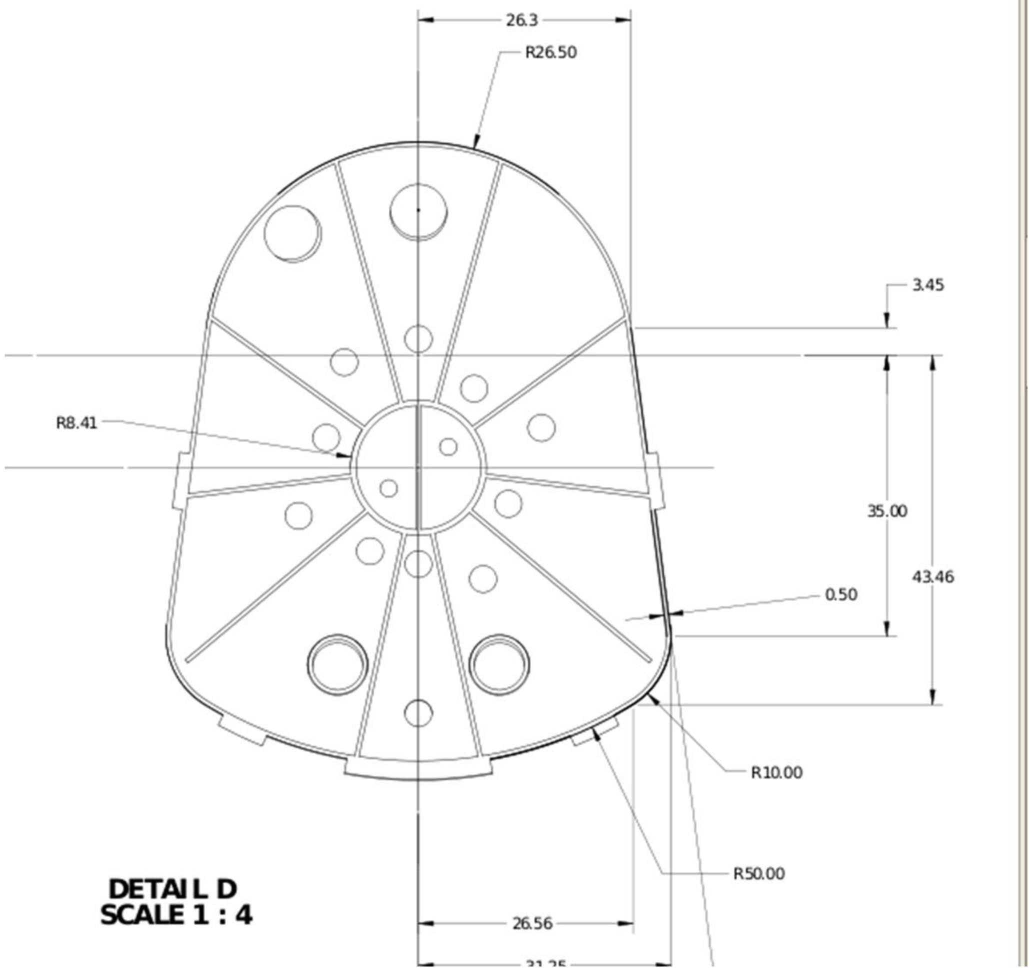
2 cm THICK STST INNER Hg POOL VESSEL WITH 1 cm He GAP FOR COOLING.

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.

IDS120j: yz CROSS SECTIONS WITH DETAILS OF Hg POOL MODULE FROM VAN GRAVE'S PRESENTATION (8 / 9 / 2012).

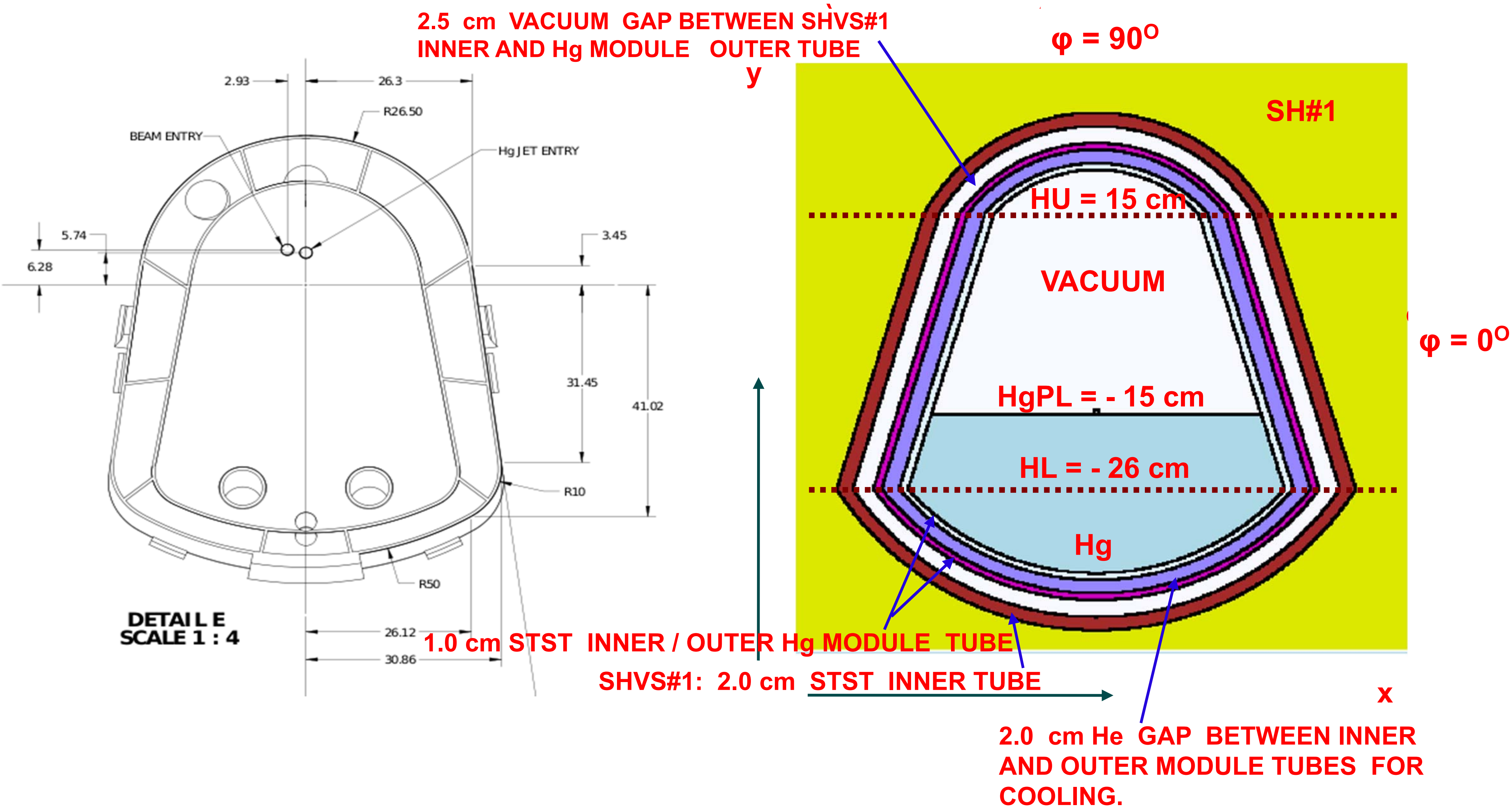




THE DESIGN REQUIRES A 2.5 cm ! GAP BETWEEN SH#1 INNER VESSEL AND Hg POOL MODULE OUTER VESSEL. AN EVEN LARGER SPACE APPEARS TO BE BETWEEN INNER AND OUTER VESSEL OF THE Hg POOL MODULE FOR THE FLOW OF He GAS FOR COOLING THE POOL.

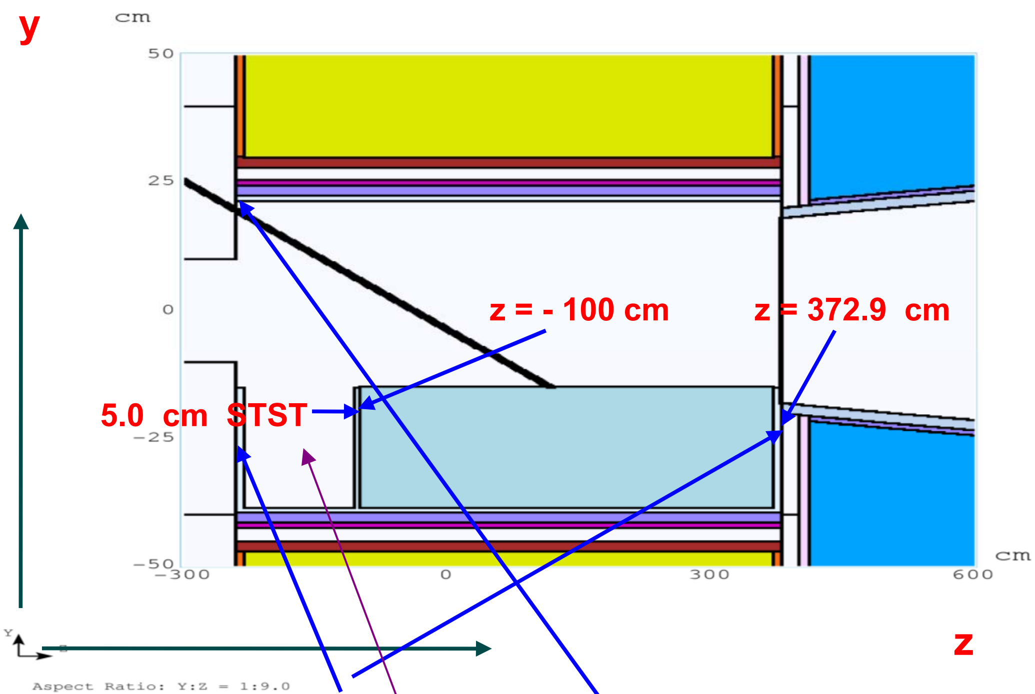
THE RADIUS OF THE UPPER HALF SEMICIRCULAR SECTION OF INNER Hg POOL VESSEL WILL BE 26.5 cm, MUCH LARGER THAN THE BEAM PIPE APERTURE AT THE END OF CRYO#1 (~ 17.7 cm).

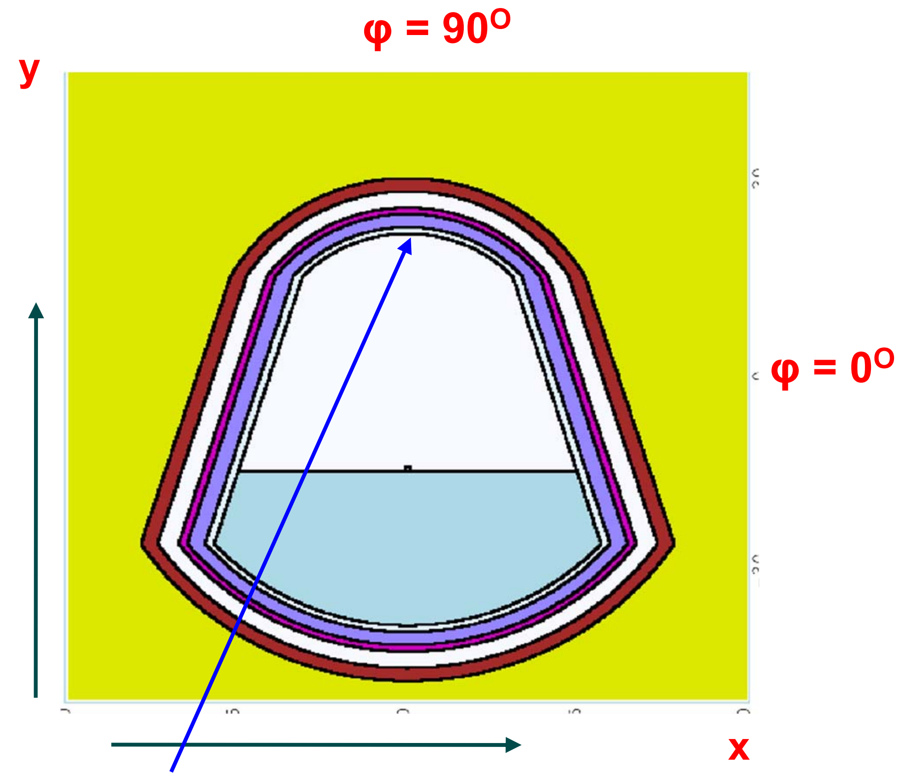
IDS120j: yx CROSS SECTION WITH DETAILS OF Hg POOL MODULE FROM VAN's PLOTS (LEFT) AND ADAPTED DESIGN FOR MARS SIMULATIONS (RIGHT) [AT z = 100 m].



EVERYTHING HAS BEEN PARAMETRIZED FOR FUTURE CONVINIENCE. THE HEIGHTS OF THE END POINTS OF THE STRAIGHT SECTIONS ARE HL = - 26 cm AND HU = 15 cm. THE FREE Hg POOL SURFACE IS AT y = - 15 cm. THE RADIUS OF THE LOWER PART OF THE INNER VESSEL OF THE Hg MODULE IS NOW SMALLER THAN BEFORE : FROM ~ 45 cm ----> ~ 39 cm. THE REST OF THE SPACE BETWEEN SHVS#1 INNER AND OUTER TUBE (AT R ~ 115 cm) IS FILLED WITH SHIELDING.

IDS120j: yz (LEFT) AND yx AT z = 10 cm (RIGHT) CROSS SECTION WITH DETAILS OF THE NEW Hg MODULE AND THE LOWER HALF OF THE UPSTREAM REGION.





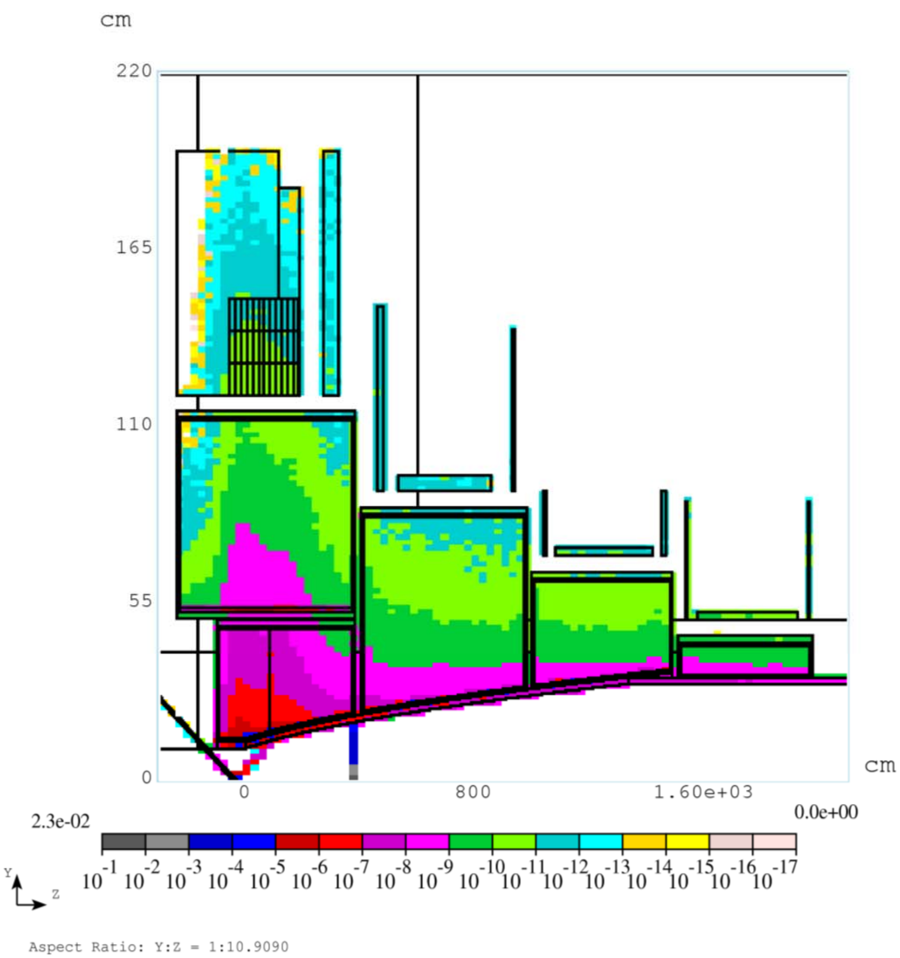
10 cm THICK STST FOR THE UPSTREAM AND DOWNSTREAM FLANGE OF Hg MODULE

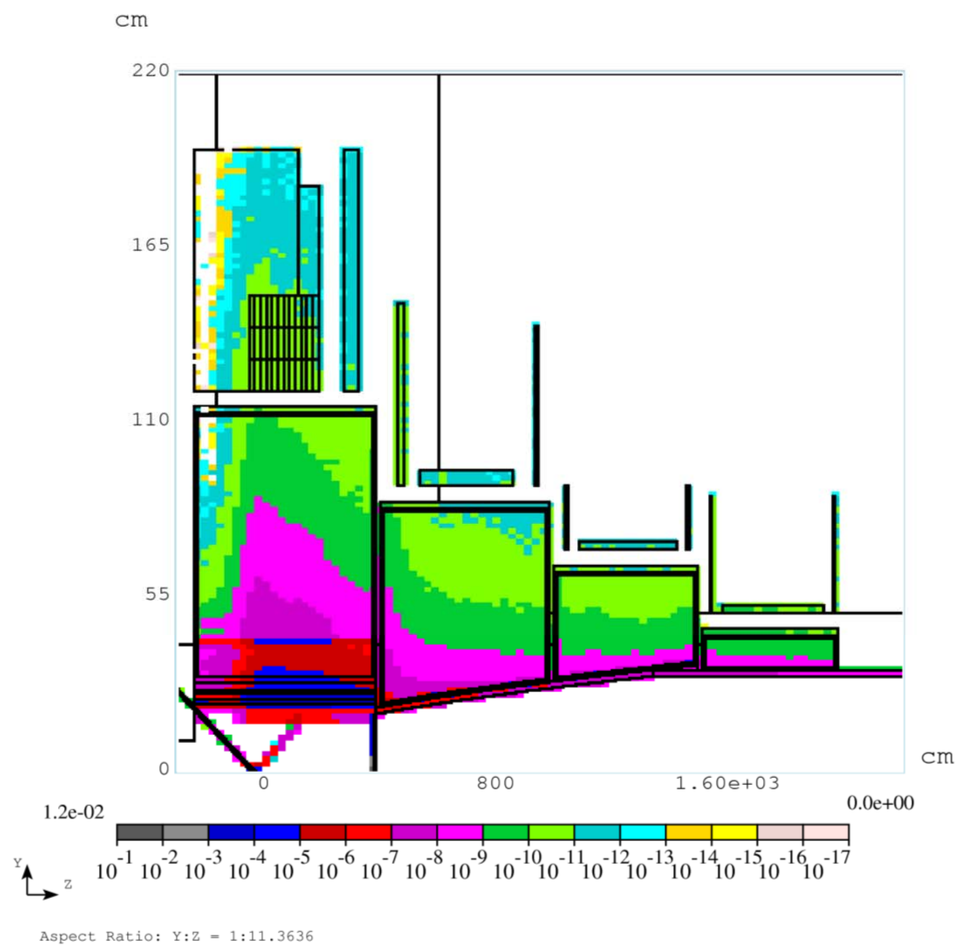
THE RADIUS OF THE TOP SEMICIRCULAR SECTION OF THE Hg INNER TUBE IS SUCH THAT WILL NOT INTERFERE WITH THE Hg JET AND THE BEAM PROTONS AT THE BEGINNING OF CRYO#1 (z ~ - 240 cm)

ACCORDING TO VAN'S DESIGN THE VOLUME FROM THE BEGINNING OF CRYO#1 (z ~ - 240 cm) TO THE BEGINNING OF THE Hg POOL (z ~ - 100 cm) AND FROM y ~ -15 cm TO THE BOTTOM OF THE Hg MODULE INNER VESSEL (R ~ 39 cm) WILL BE EMPTY TO ACCOMODATE THE PIPES AND OTHER COMPONENTS OF THE Hg POOL MODULE.

SOME IMPROVEMENT IN SHIELDING IS ACHIEVED BY UNIFYING SH#1 AND SH#4. THERE WILL BE SIGNIFICANT INCREASE IN THE SHIELDING MASS (> 200 tons) TO BE CONTAINED IN THE NEW VESSEL ==> GREATER ASSYMETRY IN THE WEIGHT DISTRIBUTION. He COOLING OF SUCH A LARGE VOLUME (> 22 m^3) OF

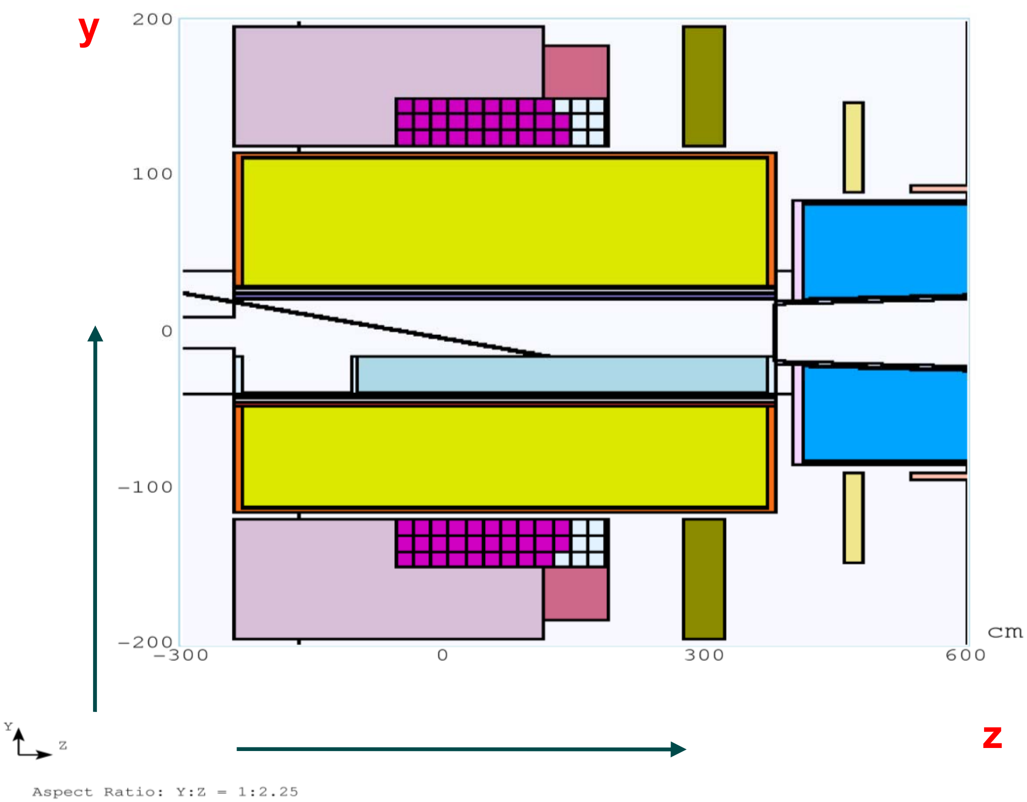
IDS120j: yz CROSS SECTION FOR THE AZIMUTHALLY AVERAGE TDPD WITH THE OLD Hg POOL VESSEL (LEFT) AND THE NEW ONE (RIGHT) [P12 POINT].
[TDPD = TOTAL DEPOSITED POWER DENSITY]

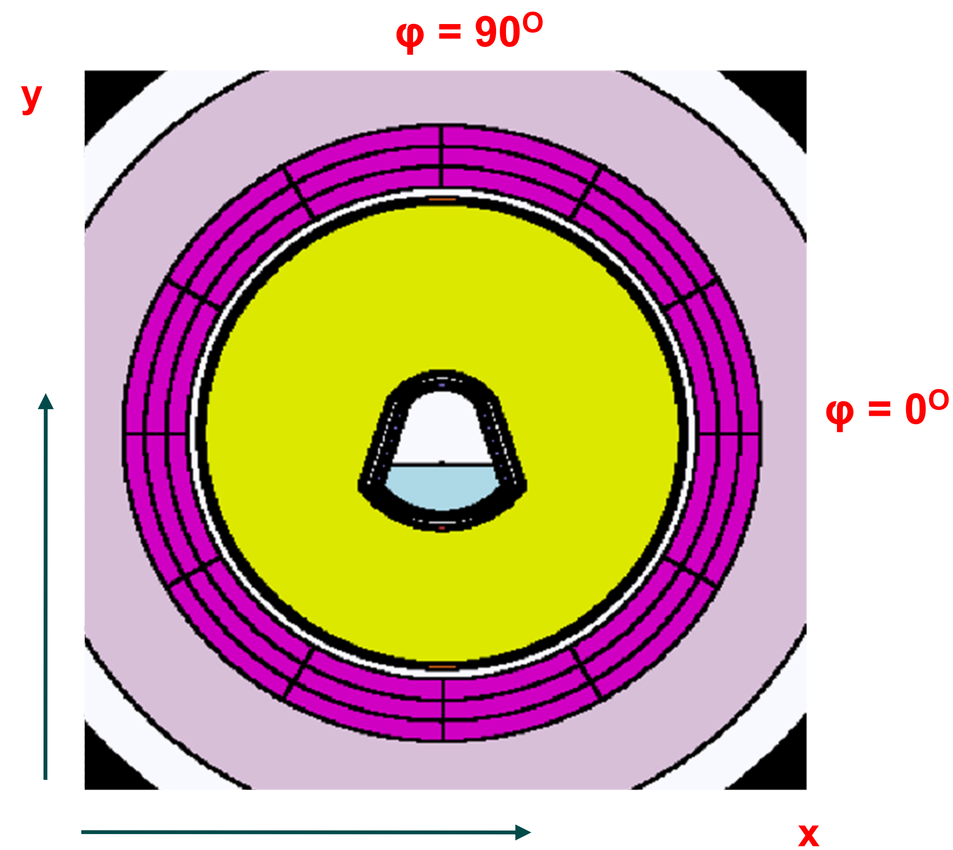




COMPARISON OF THE AZIMUTHALY AVERAGDE TDPD BETWEEN OLD AND NEW Hg MODULE REVEALS A SIGNIFICANT INCREASE IN THE RADIAL SPREAD OF THE TDPD AROUND THE TARGET REGION, AS WELL AS SPREADING FURTHER DOWNSTREAM (CRYO#2 SHIELDING REGION). NOTICE ALSO THE INCREASE OF THE SPREAD OF THE TPDP FURTHER UPSTREAM DUE TO THE DECREASE OF SHIELDING AROUND THE TARGET REGION AND ESPECIALLY AT THE BOTTOM OF THE Hg MODULE [COLOR SCALE IS SAME FOR BOTH PLOTS].

IDS120j: yz (LEFT) AND yx CROSS SECTION WITH DETAILS OF THE SC#1+2 SEGMENTATION.





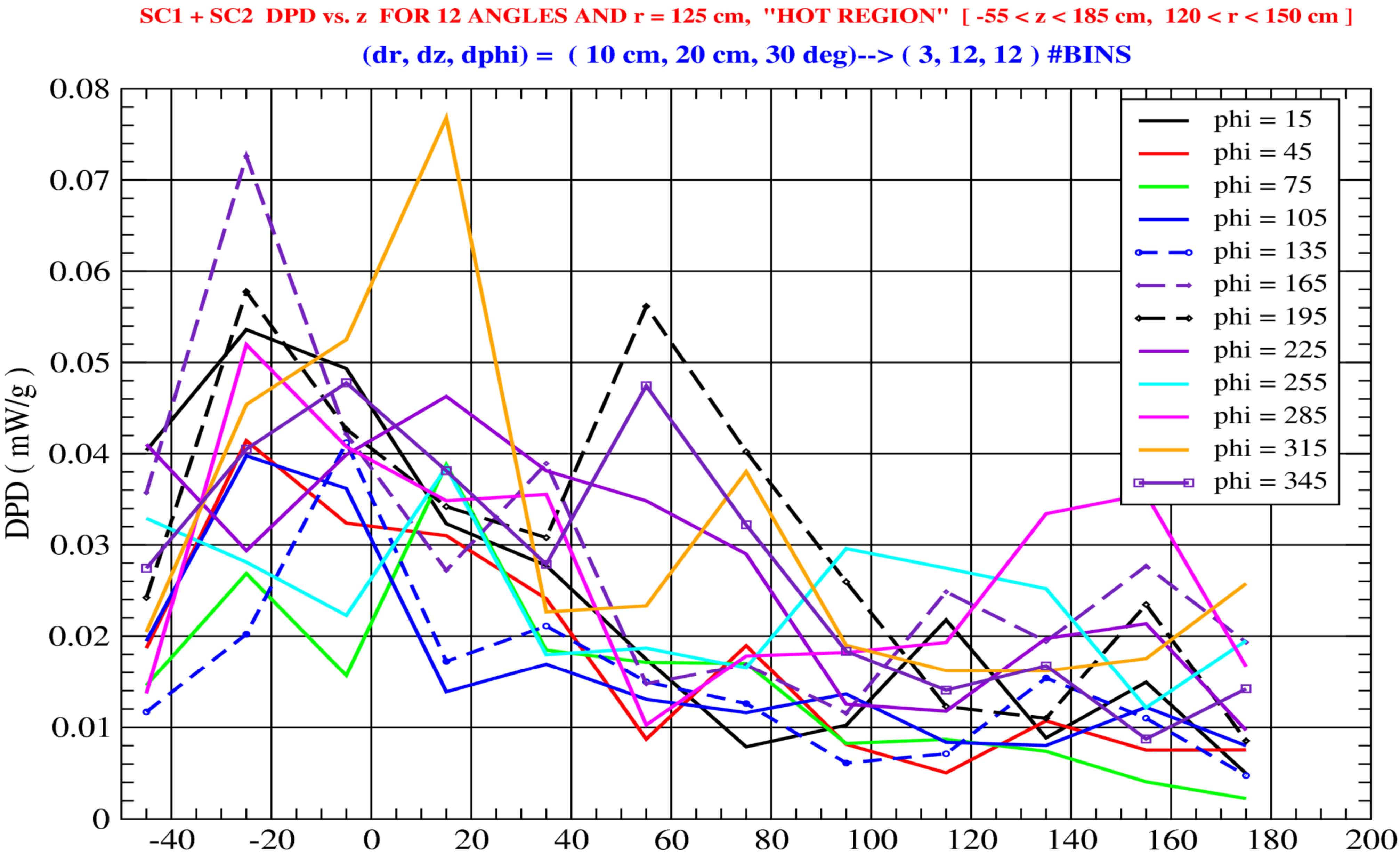
120.0 < r < 150.0 cm dr = 10.0 cm N_r = 3 bins

- 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 TDPD (DETERMINED FROM MARS PLOTS, PAGE #8) WAS STUDIED.

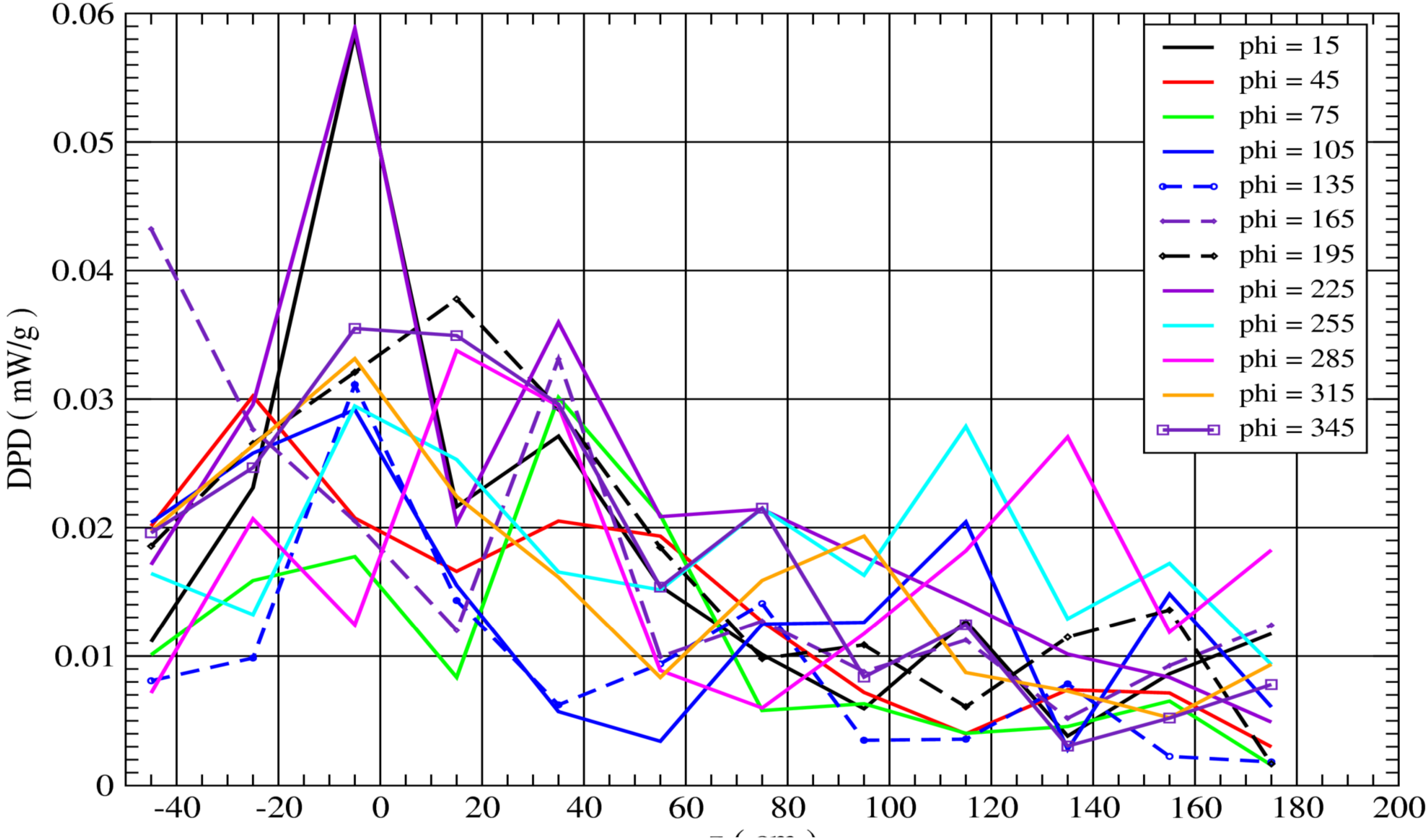


PEAK TDPD < 0.08 mW / g. MOST OF THE DP IS BETWEEN ~ - 40 < z < 40 cm AND IN THE LOWER HALF OF SC#1+2, TOWARDS THE + x DIRECTION. THIS IS THE RESULT OF REPLACING SHIELDING MATERIAL AT THE BOTTOM PART OF THE Hg MODULE WITH LIQUID Hg. THE NEGATIVE IMPACT OF THE NEW Hg MODULE IN SH#1 IS GREATELY MITIGATED BY THE INDRODUCTION OF ~ 8 cm THICK CYLIDRICAL SHIELDING VOLUME AT R ~ 50 cm WHEN SH#1 AND SH#4 ARE UNIFIED INTO ONE VOLUME. A LOT OF DP IS ALSO ALONG THE $\varphi = 165^{O}$ (x < 0, y > 0).

SEGMENTED TDP [= 0.67] + UNSEGMENTED VOLUME [= 0.294] = 0.96 kW VS. SC#1+2 UNSEGMENTED [= 0.90 kW]

SC1 + SC2 DPD vs. z FOR 12 ANGLES AND r = 135 cm, "HOT REGION" [-55 < z < 185 cm, 120 < r < 150 cm]

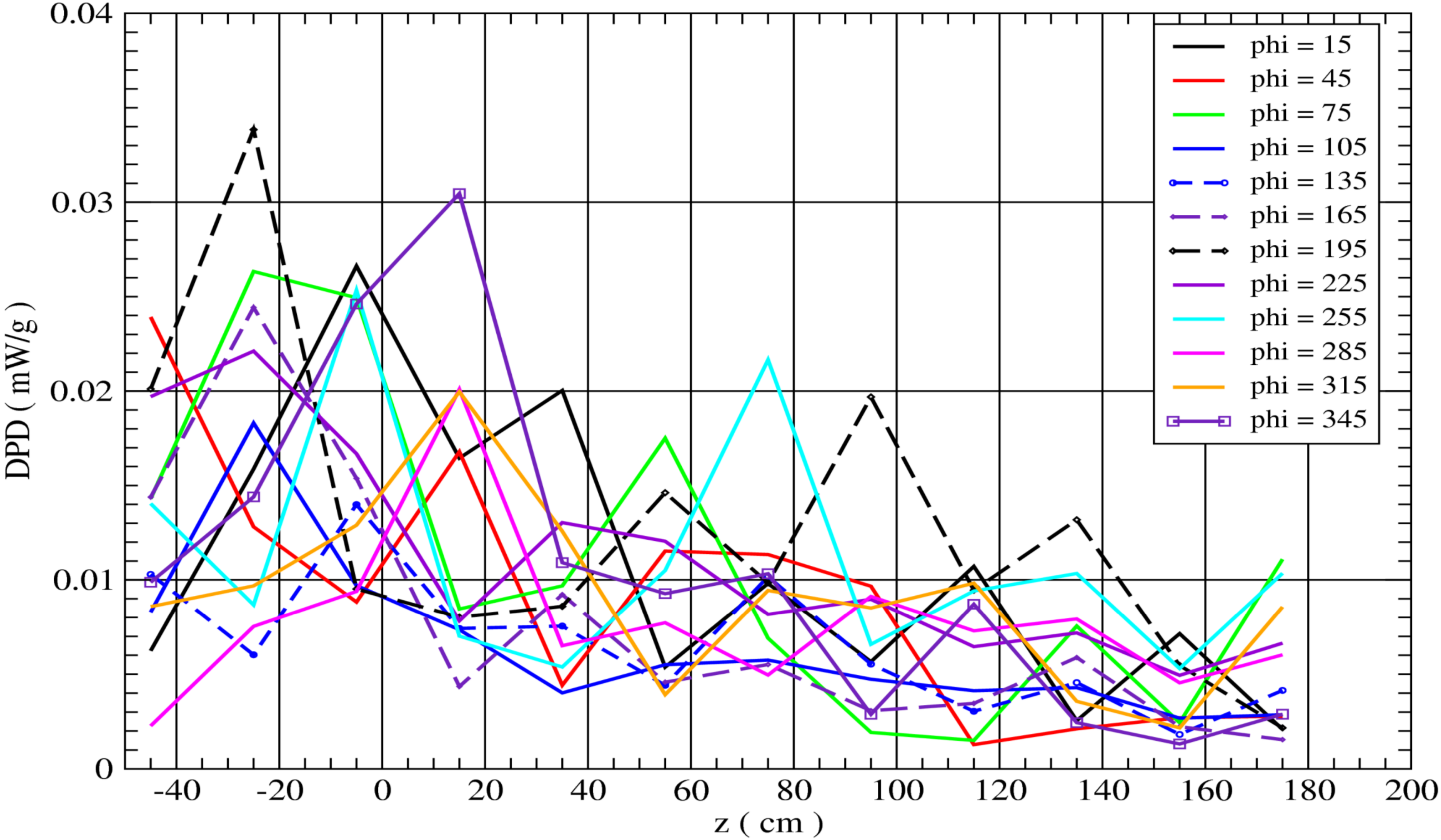
(dr, dz, dphi) = (10 cm, 20 cm, 30 deg)--> (3, 12, 12) #BINS



PEAK TDPD < 0.06 mW / g. STILL QUITE HIGH FOR THESE r = 135 cm RADIUS PIECES. AS BEFORE MOST OF THE DP IS BETWEEN ~ - 40 < z < 40 cm CLOSE TO THE x AXIS IN GENERAL.

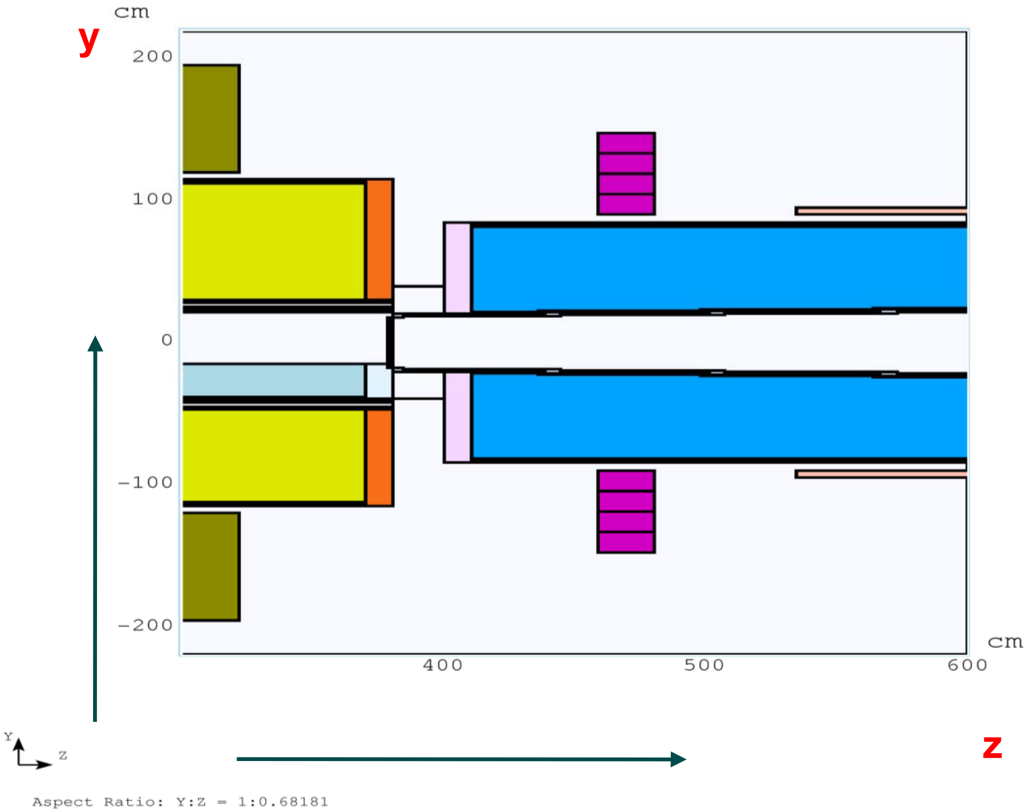
SC1 + SC2 DPD vs. z FOR 12 ANGLES AND r = 145 cm, "HOT REGION" [-55 < z < 185 cm, 120 < r < 150 cm]

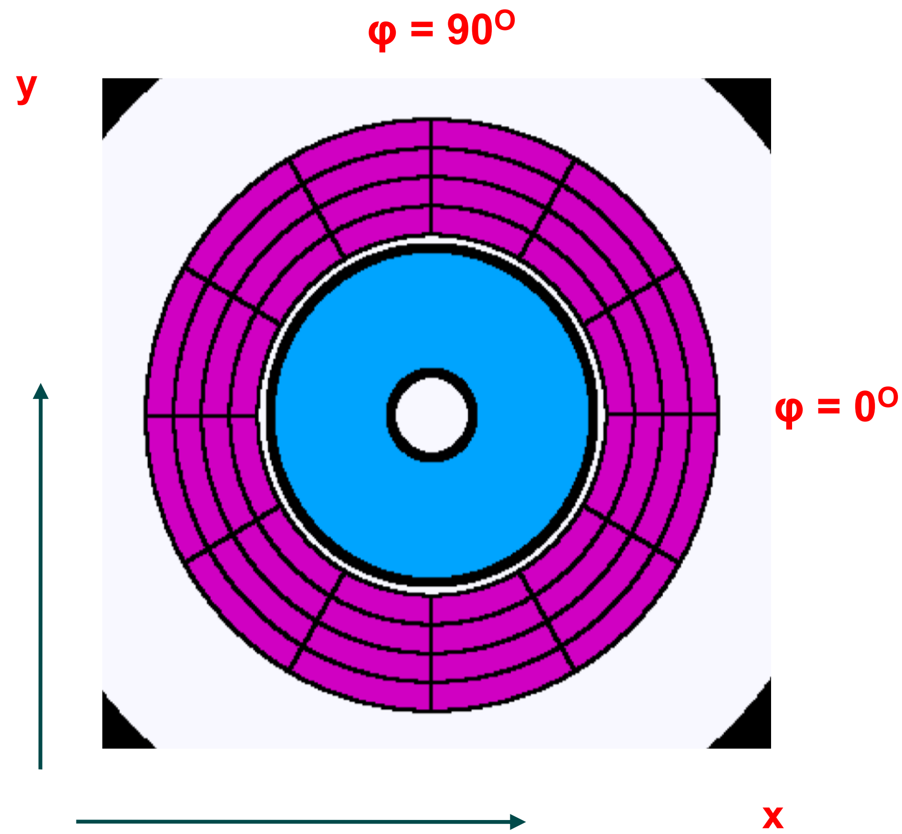
(dr, dz, dphi) = (10 cm, 20 cm, 30 deg)--> (3, 12, 12) #BINS



PEAK TDPD < 0.04 mW / g FOR THE r = 145 cm RADIUS PIECES. IN GENERAL WE HAVE MORE UNIFORMITY NOW IN THE AZIMUTHAL TDPD DISTRIBUTION. ONE CAN COMPARE THE LAST THREE PLOTS WITH THE ONES IN 9 / 20 / 2012 PRESENTATION WITH RESULTS FROM THE OLD Hg MODULE.

IDS120j: yz (LEFT) AND yx (z = 471 cm) CROSS SECTION WITH DETAILS OF THE SC#4 SEGMENTATION.





$90.0 < r < 147.61$ cm dr = 14.40 cm N_r = 4 bins

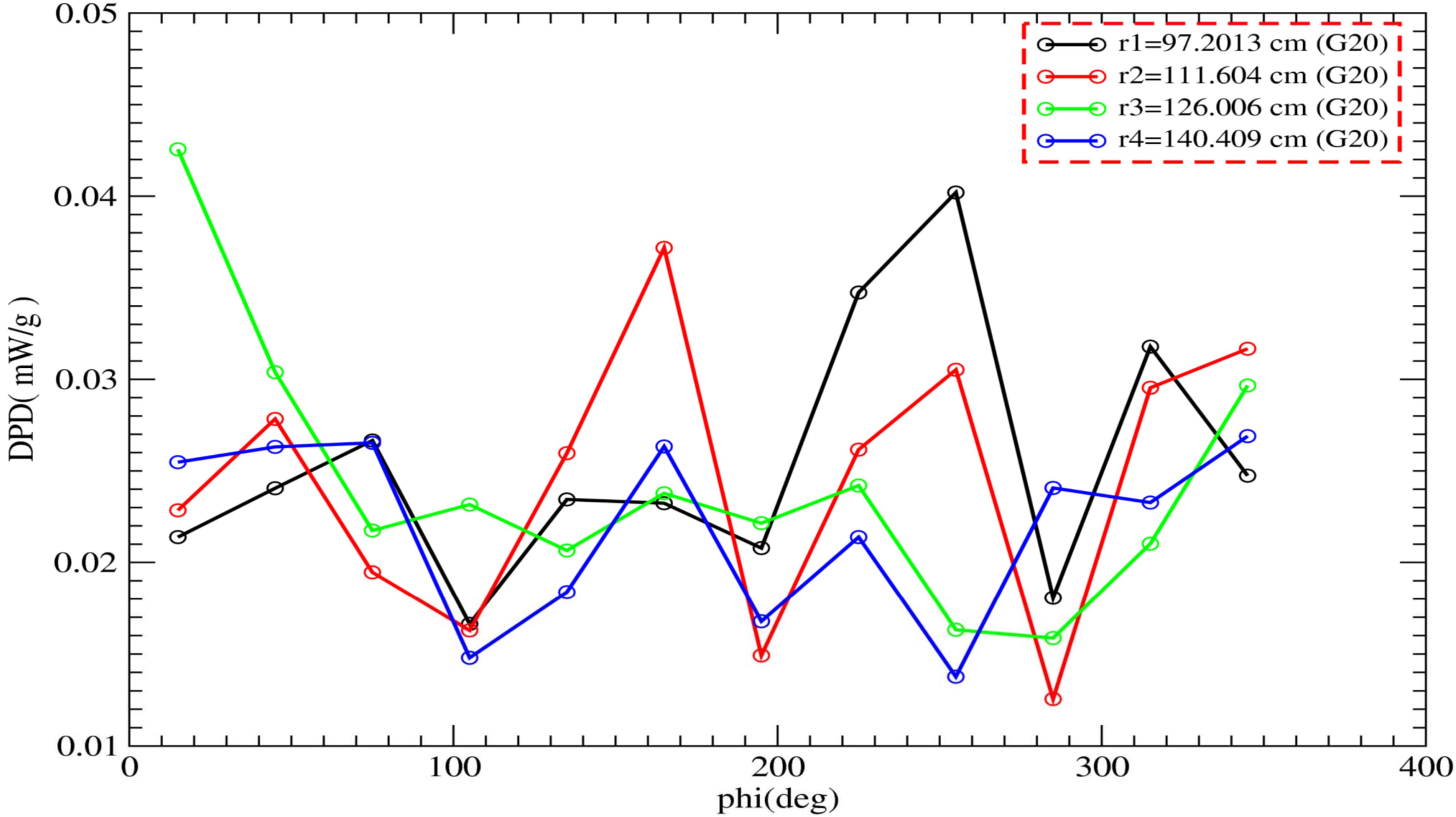
$459.0 < z < 480.31$ cm dz = 21.31 cm N_z = 1 bins

$0.0 < \varphi < 360.0$ deg. dφ = 30 deg. N_φ = 12 bins

N_{tot} = 48 "pieces"

IDS120j: SC#4 AZIMUTHAL TDPD FOR 20 cm GAPS (AVERAGE FROM 4 x 5E05 RUN)

W BEADS DENSITY=15.8 g/cc (NEW Hg POOL VESSEL)



PEAK TDPD < 0.045 mW / g. HIGH TDPD PEAK VALUES ARE OBSERVED FOR "PIECES" AT THREE DIFFERENT RADII BUT AT VERY DIFFERENT ANGLES. ONE CAN ALSO COMPARE THIS CASE WITH THE AZIMUTHAL TDPD DISTRIBUTION FOR THE IDS120j WITH THE OLD Hg MODULE (5 / 1 / 2012 TARGET MEETING PRESENTATION, PAGE #11)

SEGMENTED SC#4 TDP = 0.149 kW VS. UNSEGMENTED SC#4 TDP = 0.144 kW

....

A) THE PEAK DPD IN SC#1+2 IS ~ 0.077 mW / g AT (r, z, phi) = (125 cm, 15 cm, 315 deg) IN SC#1 LOWER HALF OF THE COIL (y < 0, x > 0) CLOSE TO THE -y AXIS.

B) 0.67 kW OF DEPOSITED POWER IN THE SC#1+2 JUST IN THE SEGMENTED VOLUME.
ABOUT 0.96 kW IN BOTH COILS SC#1+2 [BORDERLINE BAD NEWS].
DEPOSITED POWER IN ALL 12 SCs ~ 1.4 kW [BAD NEWS].
DEPOSITED POWER IN SC#4 ~ 0.15 kW ==> PEAK TDPD ~ 0.043 mW / g
AT (r, z, phi) = (126.01 cm, 469.66 cm, 15 deg)

C) INNER TUBE OF Hg MODULE RECEIVES ~ 275 kW WHILE OUTER TUBE ~ 166 kW [BOTH 1 cm THICK STST BELL LIKE SHAPE]. INNER TUBE OF SHVS#1 [2 cm THICK STST BELL -LIKE SHAPE] WILL GET ~ 165 kW.

D) DEPOSITED POWER IN SH#1 : ~ 577 kW
DEPOSITED POWER IN SH#2 : ~ 96 kW
DEPOSITED POWER IN SH#3 : ~ 11 kW
DEPOSITED POWER IN SH#4 : ~ 5 kW

E) DEPOSITED POWER IN SHVS#1 : ~ 3 kW
DEPOSITED POWER IN SHVS#2 : ~ 41 kW
DEPOSITED POWER IN SHVS#3 : ~ 4 kW
DEPOSITED POWER IN SHVS#5 : ~ 0.5 kW

F) DEPOSITED POWER IN Hg JET : ~ 418 kW
DEPOSITED POWER IN Hg POOL : ~ 1212 kW

G) DEPOSITED POWER IN Be WINDOW : ~ 10 kW
DEPOSITED POWER IN BP#2 : ~ 109 kW
DEPOSITED POWER IN BP#3 : ~ 20 kW