IDS120j: NO RESISTIVE MAGNETS / NEW Hg MODULE

AZIMUTHAL DEPOSITED POWER STUDIES FOR SC#10-SC#12 (COMPARISON WITH FLUKA RESULTS)

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

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

 # STUDIES OF AZIMUTHAL DEPOSITED POWER DISTRIBUTION IN SUPERCONDUCTING COILS IN CRYO#4 (SC#10-SC#12) AND COMPARISON WITH FLUKA RESULTS .

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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)

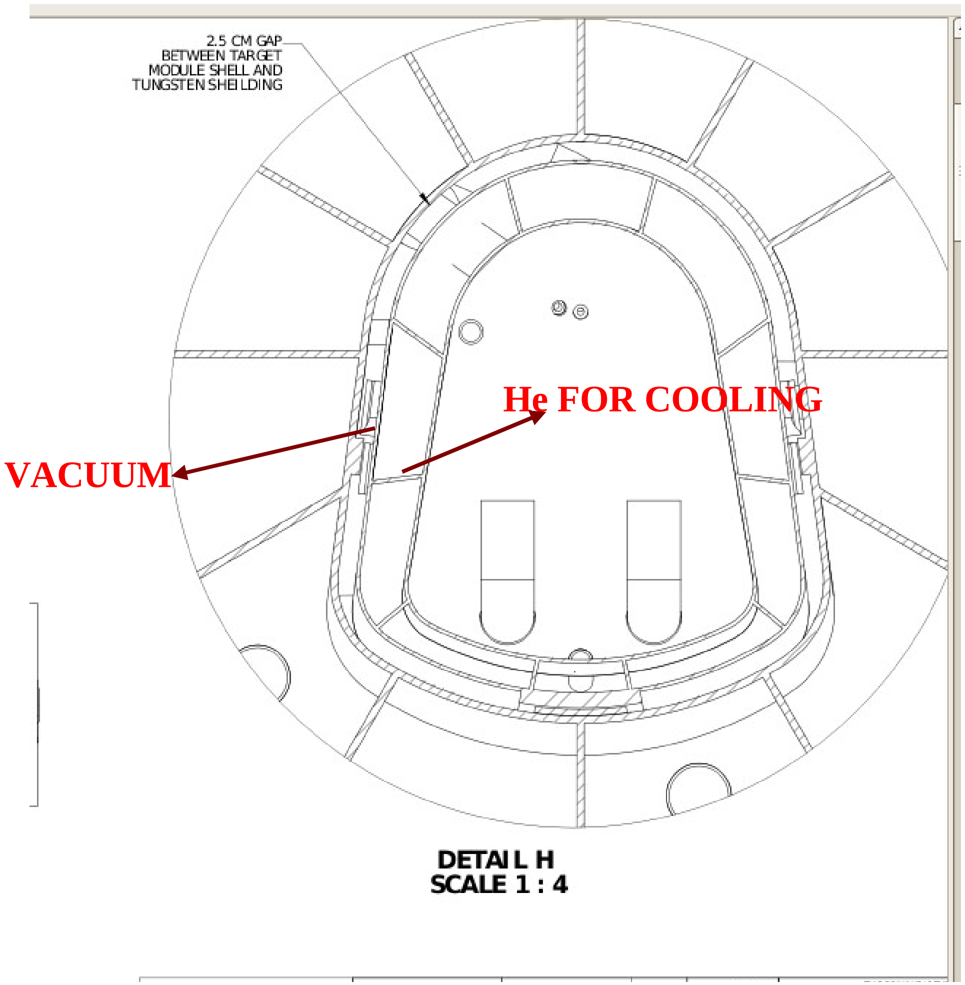
>PROTON BEAM POWER: 4 MW

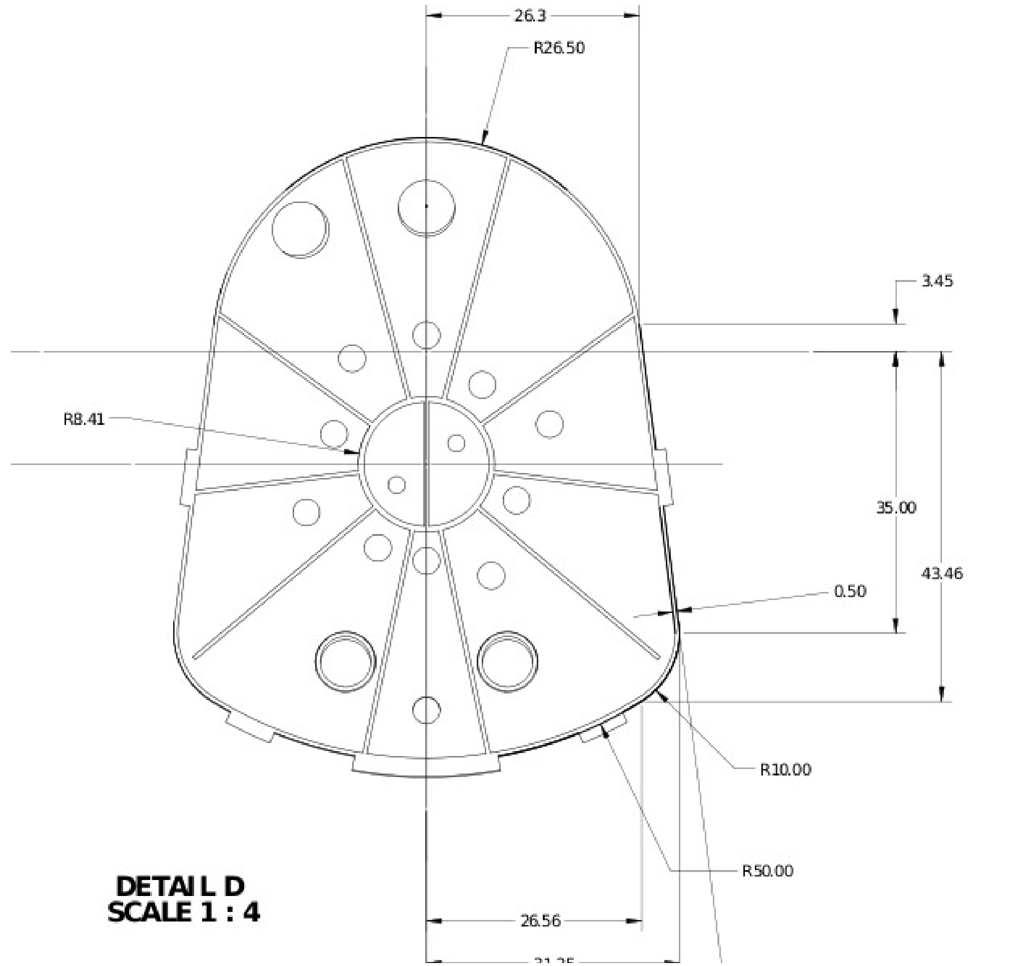
>PROTON ENERGY: E = 8 GeV

>PROTON BEAM PROFILE: GAUSSIAN, $\sigma_x = \sigma_y = 0.12$ cm

>EVENTS IN SIMULATIONS : N_p = 4 x 500,000

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

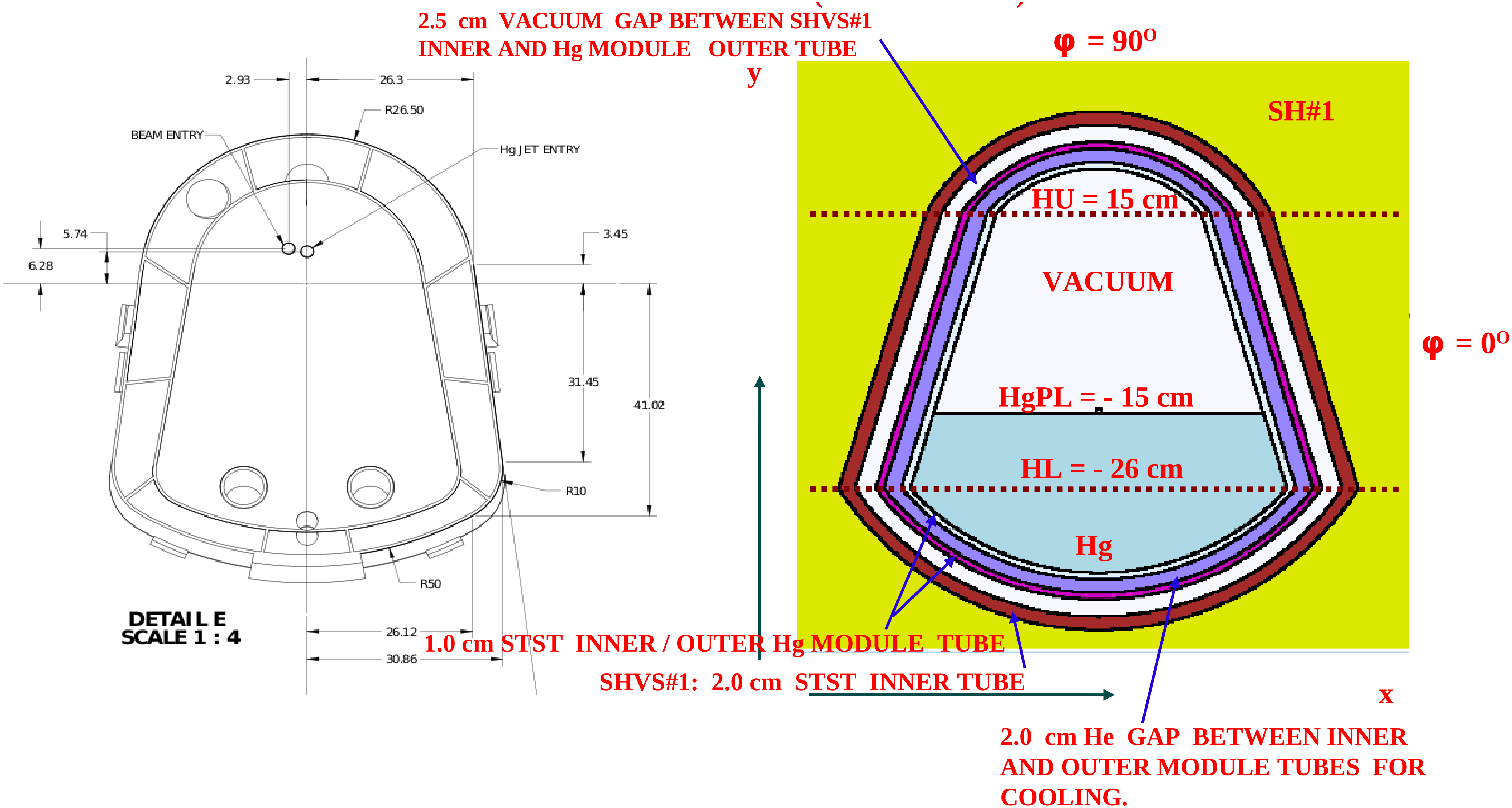




THE DESIGN REQUIRES A 2.5 cm ! GAP BETWEEN SH#1 INNER VESSEL AND Hg POOL MODULE OUTER VESSEL. AN EVEN LARGER SPACE APPEARS TO BE BETWEEN INNER AND OUTER VESSEL OF THE Hg POOL MODULE FOR THE FLOW OF He GAS FOR COOLING THE POOL.

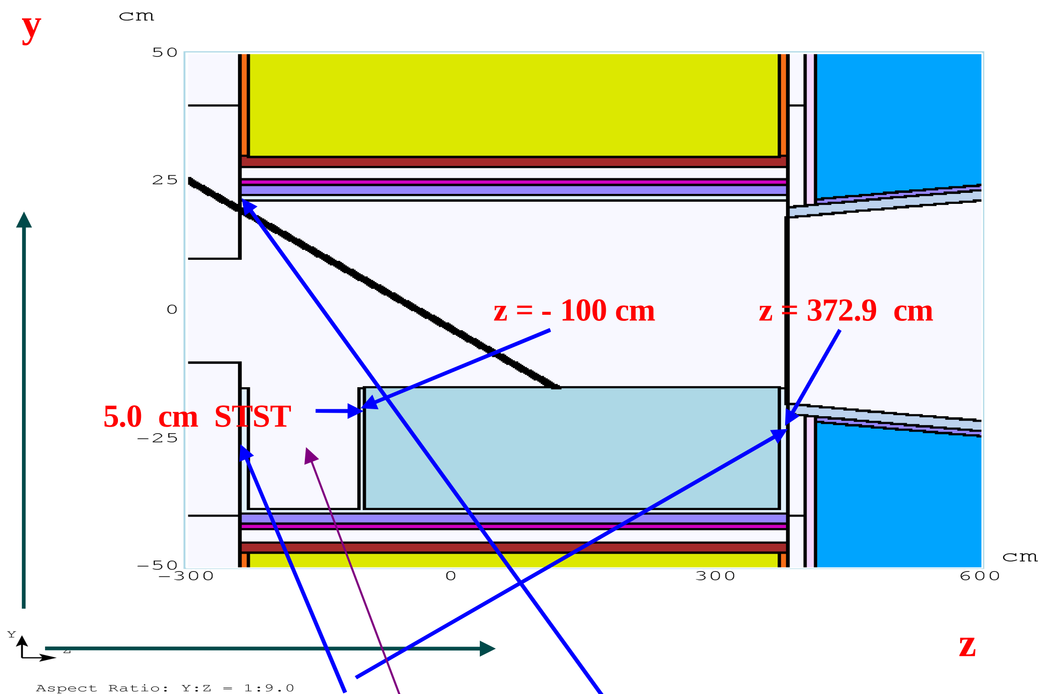
THE RADIUS OF THE UPPER HALF SEMICIRCULAR SECTION OF INNER Hg POOL VESSEL WILL BE 26.5 cm, MUCH LARGER THAN THE BEAM PIPE APERTURE AT THE END OF CRYO#1 (~ 17.7 cm).

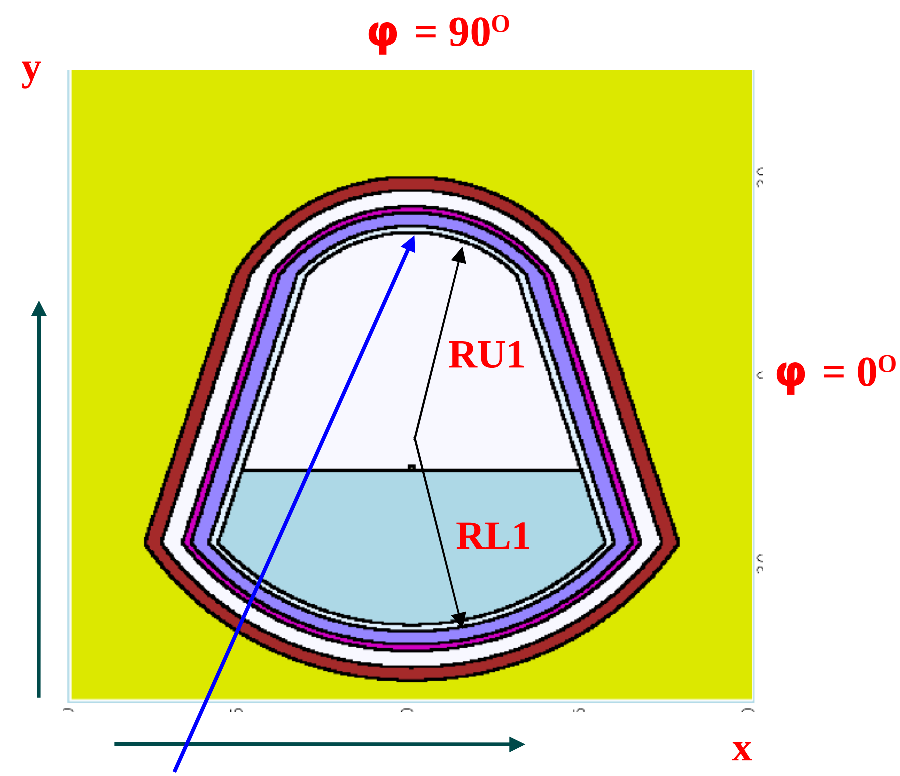
IDS120j: yx CROSS SECTION WITH DETAILS OF Hg POOL MODULE FROM VAN's PLOTS (LEFT) AND ADAPTED DESIGN FOR MARS SIMULATIONS (RIGHT) [AT z = 100 m].



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) [RU1 = 28 cm AND RL1 = 45.0 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 (SHVS#1) ==> GREATER ASSYMETRY IN THE WEIGHT DISTRIBUTION. He COOLING OF SUCH A LARGE VOLUME (> 22 m^3) OF SHIELDING CAN BE CHALENGING.

IDS120j: SC#10(LEFT) AND SC#11 (RIGHT) TDPD FROM FLUKA SIMULATIONS (J. BACK 06 / 12 / 2012)

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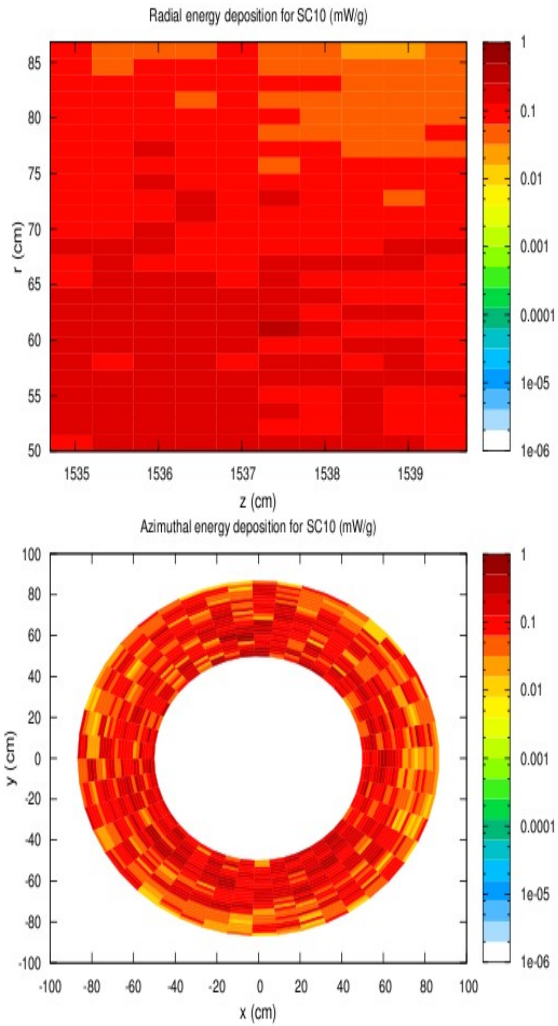
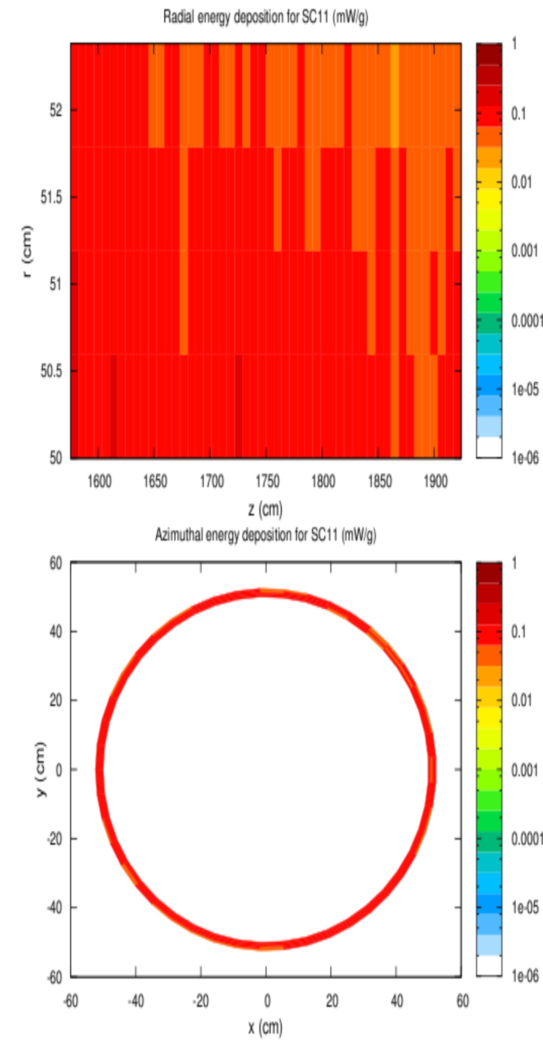


SC10 power deposition

Radial $P_{\text{peak}} \approx 0.26\,\text{mW/g}$

Azimuth $P_{\text{peak}} \approx 0.62\,\text{mW/g}$

17



SC11 power deposition

Radial $P_{\text{peak}} \approx 0.14\,\text{mW/g}$

Azimuth $P_{\text{peak}} \approx 0.11\,\text{mW/g}$

IDS120j: SC#12 TDPD FROM FLUKA SIMULATIONS (J. BACK 06 / 12 / 2012)

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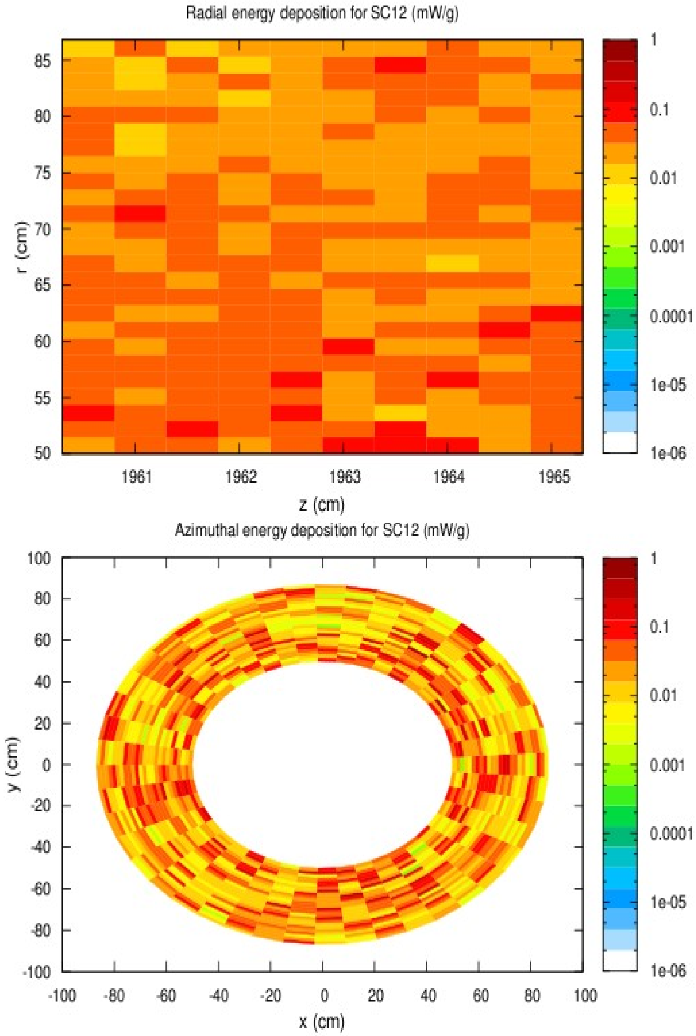


SC12 power deposition

Radial $P_{\mathrm{peak}} \approx 0.10\,\mathrm{mW/g}$

Azimuth $P_{\mathrm{peak}} \approx 0.31\,\mathrm{mW/g}$

IDS120j: ACCORDING TO "FLUKA" SIMULATIONS (J. BACK 06 / 12 / 2012) PEAK TDPD VALUES FOR THE LAST THREE COILS ARE LARGER THAN THE "ITER LIMIT" (= 0.1 mW / g).

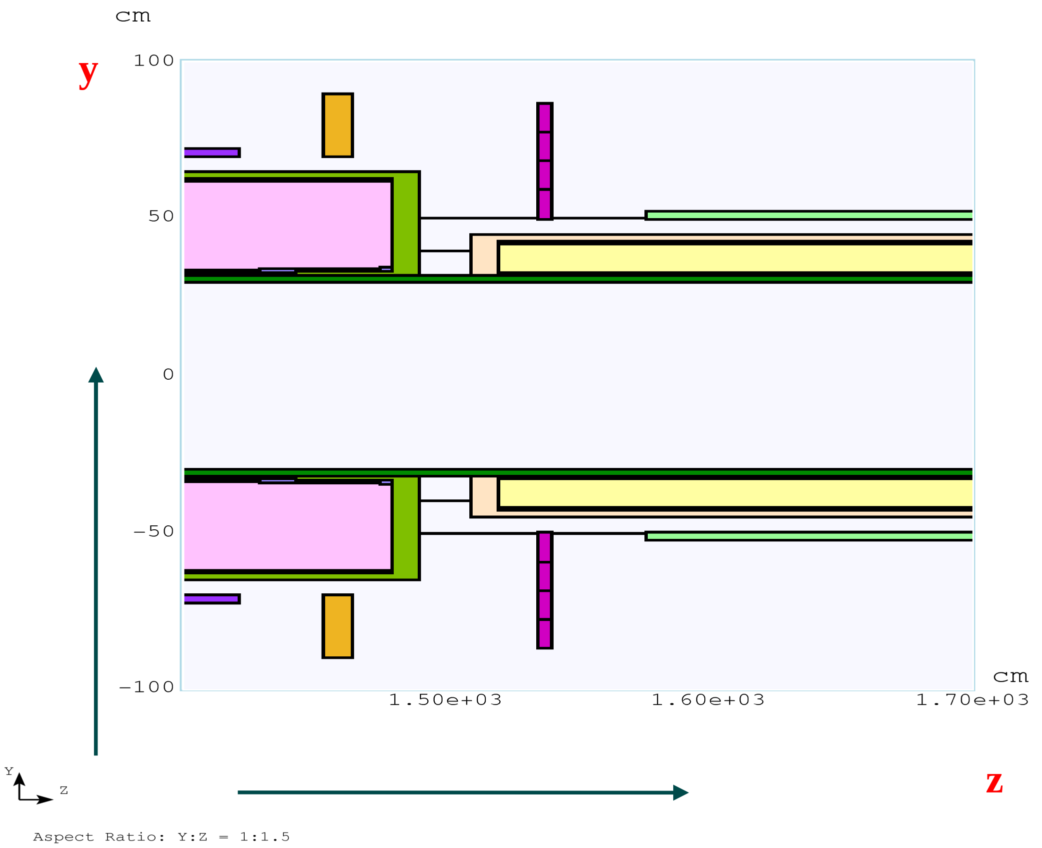
SC#10 (PEAK) ~ 0.26 / 0.62 mW / g
SC#11 (PEAK) ~ 0.14 / 0.11 mW / g
SC#11 (PEAK) ~ 0.10 / 0.31 mW / g

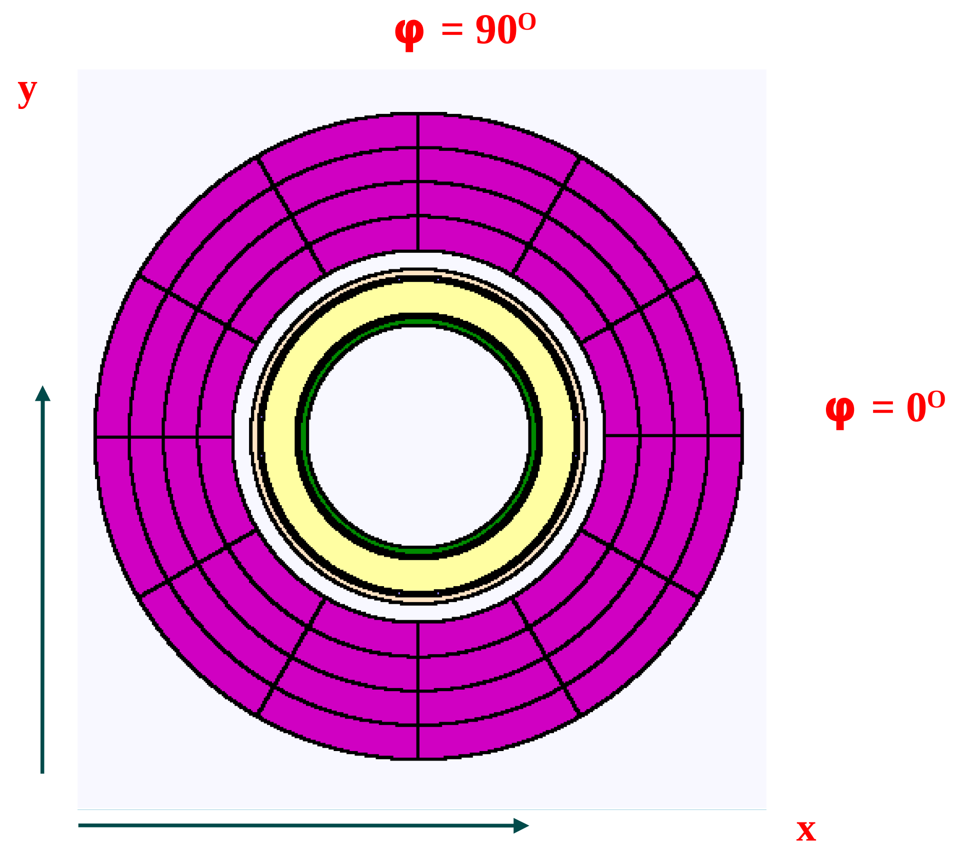
SC#7 HAS ALSO PEAK ~ 0.15 mW / g WHILE SC#9 PEAK ~ 0.09 mW / g, VERY CLOSE TO "ITER" LIMIT.

NO STATISTICAL UNCERTAINTIES WERE GIVEN FOR THESE NUMEBRS

SEGMENTATION STUDIES WILL BE PERFORMED FOR THE LAST THREE COILS USING MARS CODE.

IDS120j: yz (LEFT) AND yx (z = 1535 cm) CROSS SECTION WITH DETAILS OF SC#10 SEGMENTATION.



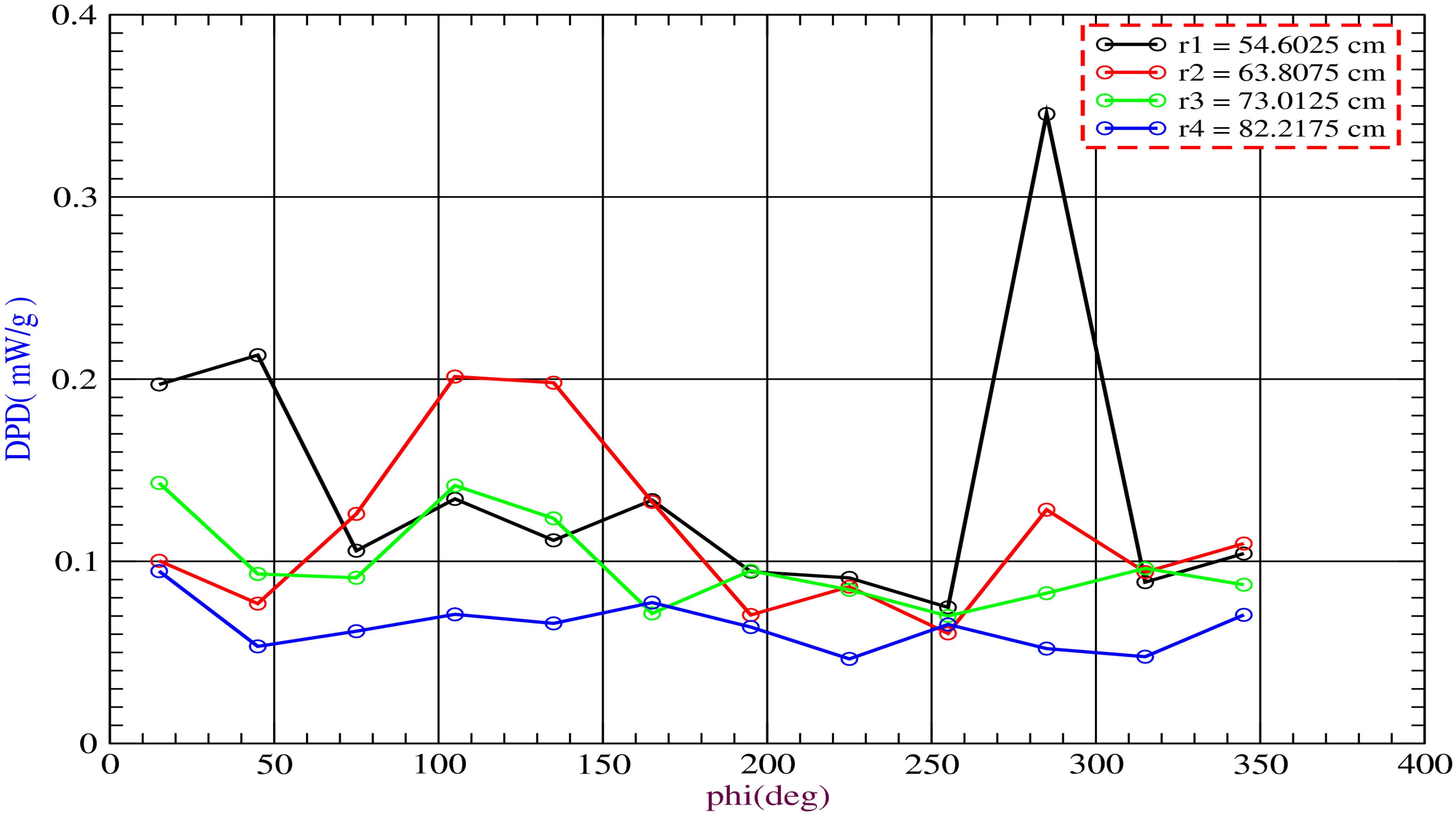


$50.0 < r < 150.0$ cm	dr = 9.205 cm	N_r = 4 bins
$1534.7 < z < 1539.7$ cm	dz = 5.0 cm	N_z = 1 bins
$0.0 < \varphi < 360.0$ deg.	$d\varphi$ = 30 deg.	N_φ = 12 bins

N_{tot} = 48 "pieces"

IDS120j (NO RS / NEW Hg MODULE): SC#10 AZIMUTHAL TDPD (AVERAGE FROM 4 x 5E05 RUNS)

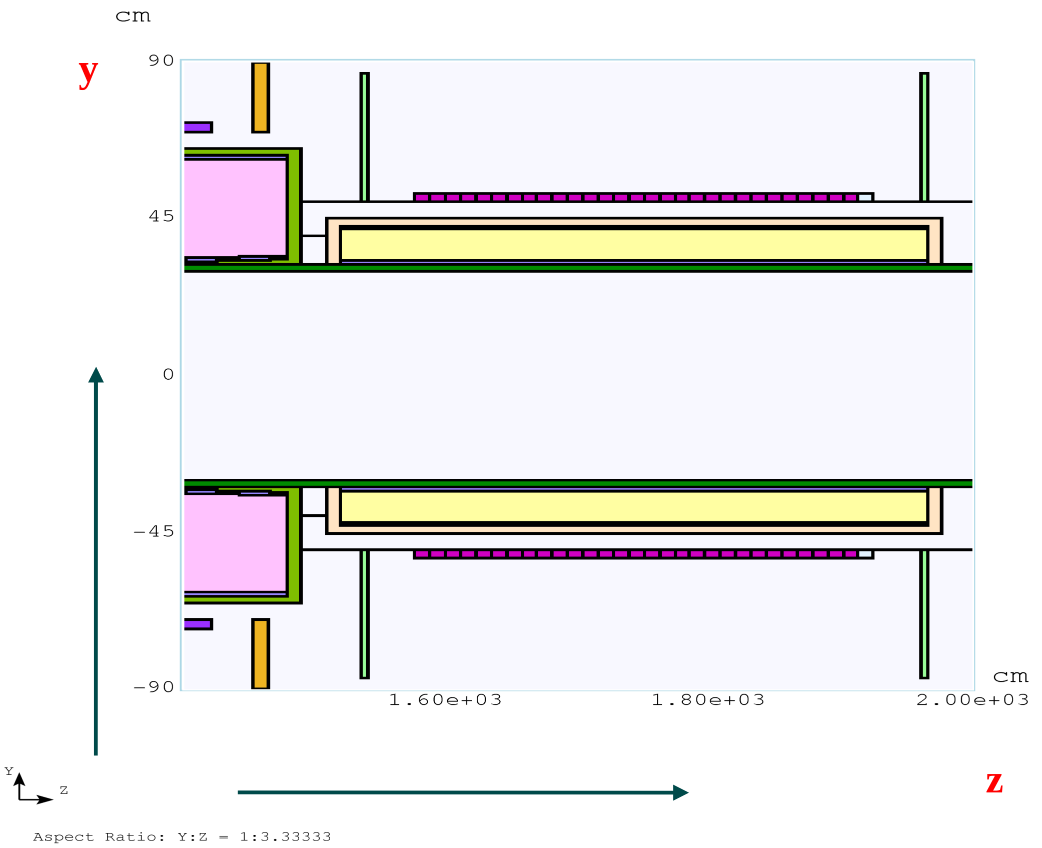
W DENSITY=15.8 g/cc (P12 / 20 cm GAPS) (dr, dz, dphi) = (9.205 cm, 5.0 cm, 30 deg.)---> (4, 1, 12) # BINS

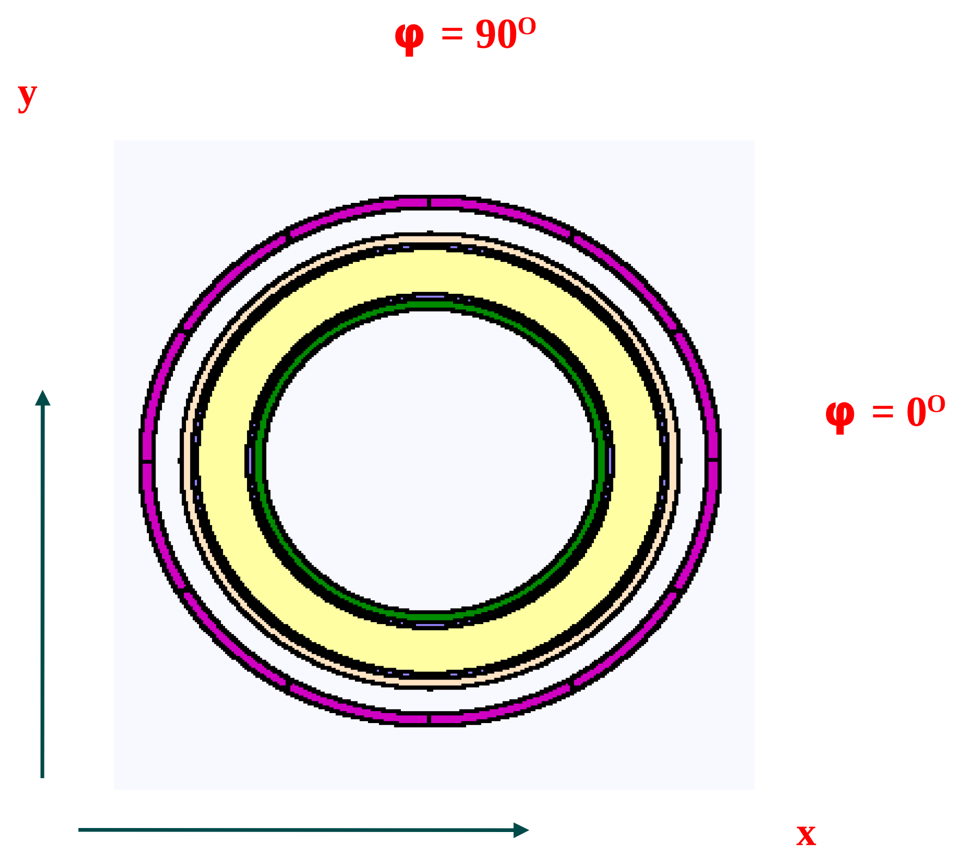


PEAK TDPD ~ 0.346 mW / g AT (r, z φ) = (54.6025 cm, 1537.20 cm, 285 deg) LOCATED IN THE LOWER HALF OF THE COIL.
IN GENERAL MOST OF THE DP IS MAINLY CLOSE TO THE HORIZONTAL PLANE (~ 110 AND 280 deg).
ONLY THE "PIECES" WITH RADIUS R = 82.2175 cm HAVE PEAK TDPD BELOW ITER LIMIT. THIS COIL IS JUST AFTER THE CRYO 3-CRYO 4 GAP AND MOSTLY EXPOSED TO RAIATION EFFECTS. INDEPEDENTLY OF THE PEAK TDPD OF THE OTHER TWO COILS THE RADIUS SHOULD INCREASE BY AT LEAST 5 cm, 10 cm TO BE SAFE.

SC#10-12 SEGMENTED TDP [= 0.0506] + UNSEGMENTED VOLUME [= 0.109] = 0.160 kW VS. UNSEGMENTED [= 0.159 kW]

IDS120j: yz (LEFT) AND yx (z = 1600 cm) CROSS SECTION WITH DETAILS OF SC#11 SEGMENTATION.



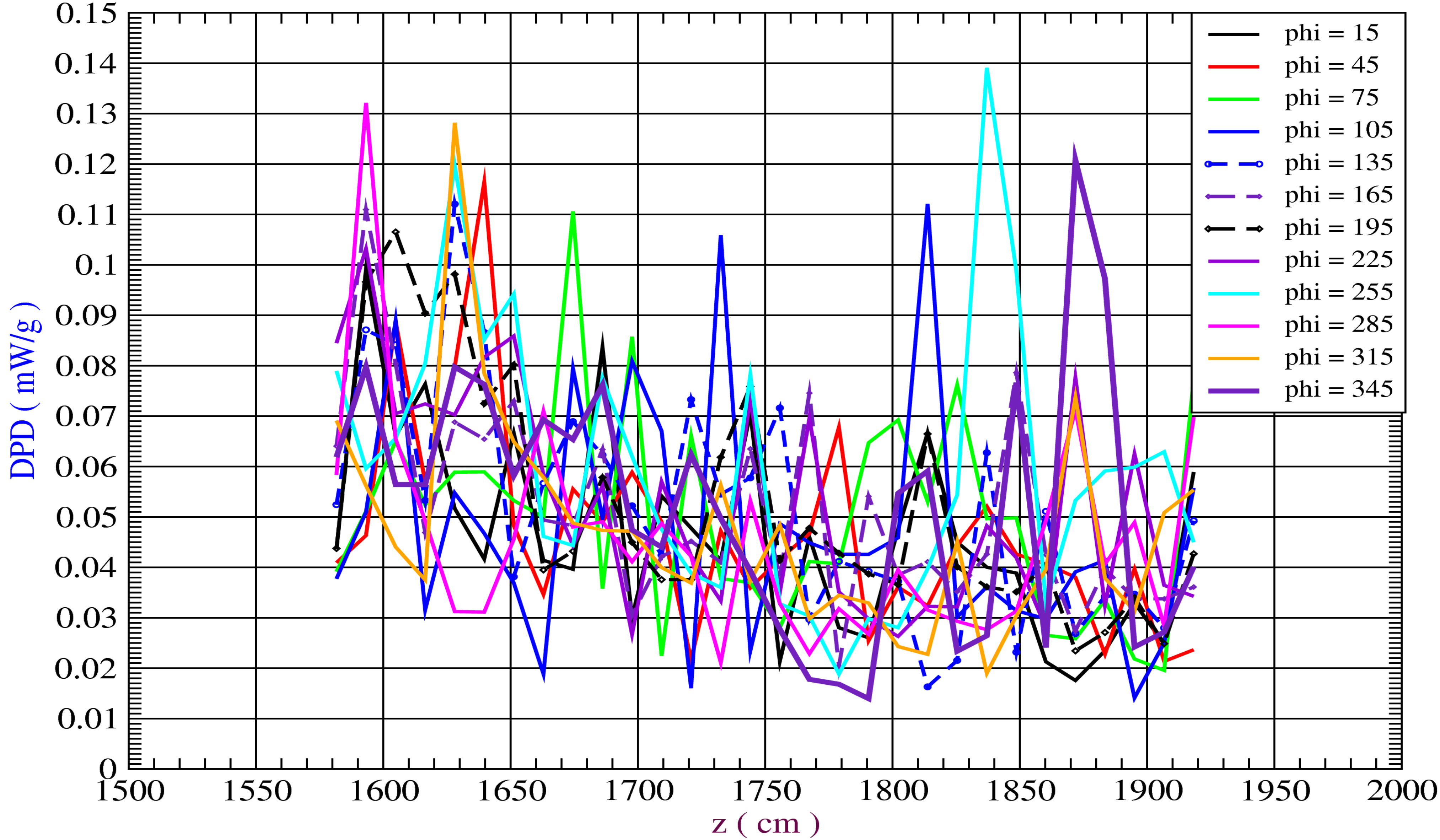


50.0 < r < 52.38 cm	dr = 2.38 cm	N_r = 1 bins
1575.80 < z < 1924.10 cm	dz = 11.61 cm	N_z = 30 bins
0.0 < φ < 360.0 deg.	dφ = 30 deg.	N_φ = 12 bins

N_{tot} = 360 "pieces"

IDS120j (NO RS / NEW Hg MODULE): SC11 TDPD vs. z FOR 12 ANGLES (AVEARGE FROM FROM 4 x 5E05 RUNS)

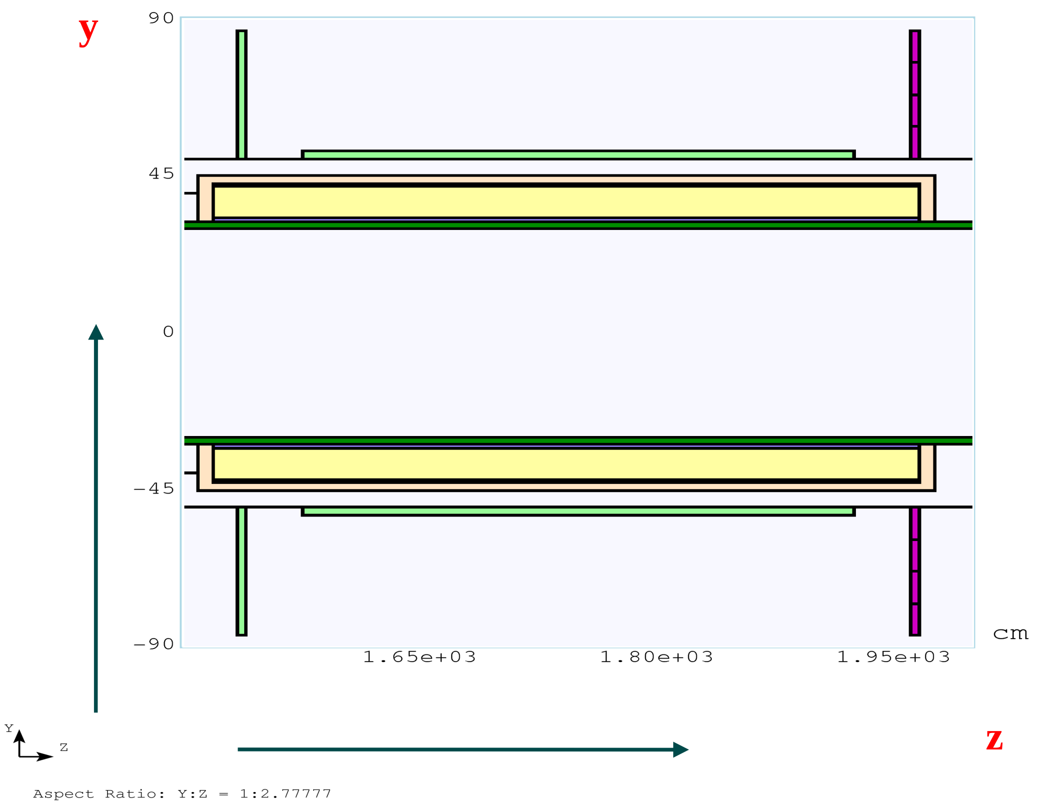
(dr, dz, dphi) = (2.38 cm, 11.61 cm, 30 deg)--> (1, 30, 12) #BINSW DENSITY=15.8 g/cc (P12 / 20 cm GAPS)

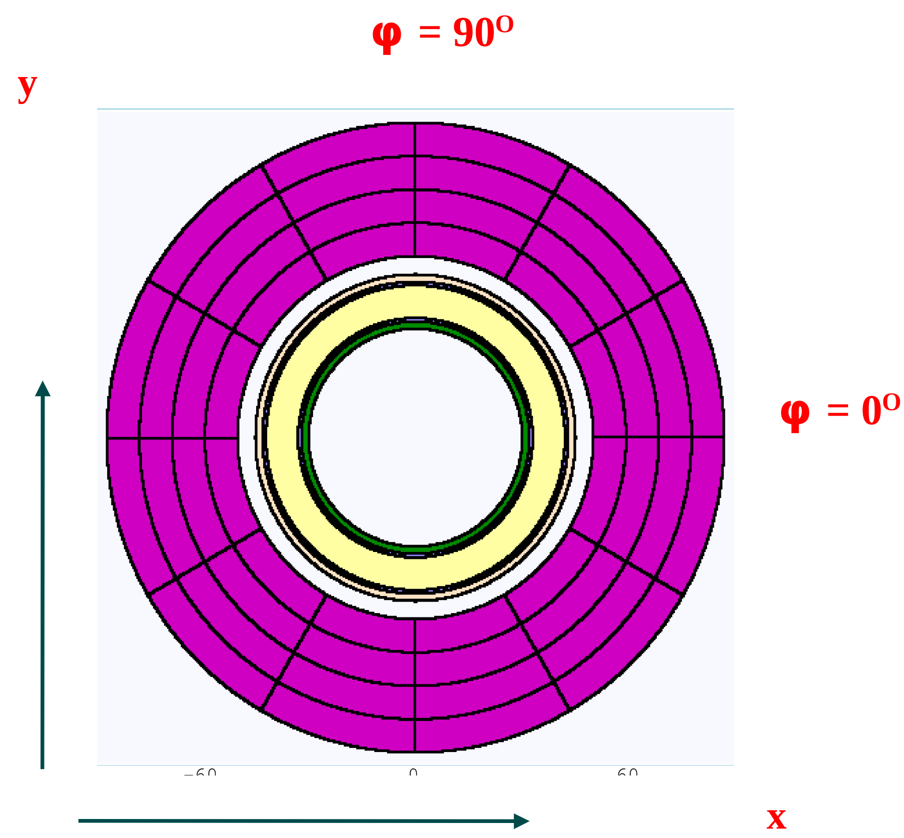


PEAK TDPD ~ 0.14 mW / g AT (r, z φ) = (51.19 cm, 1837.03 cm, 255 deg) LOCATED IN THE LOWER HALF OF THE COIL.

SC#10-12 SEGMENTED TDP [= 0.094] + UNSEGMENTED VOLUME [= 0.0653] = 0.159 kW VS. UNSEGMENTED [= 0.159 kW]

IDS120j: yz (LEFT) AND yx (z = 1961 cm) CROSS SECTION WITH DETAILS OF THE SC#12 SEGMENTATION.





50.0 < r < 86.82 cm   dr = 9.205 cm N_r = 4 bins

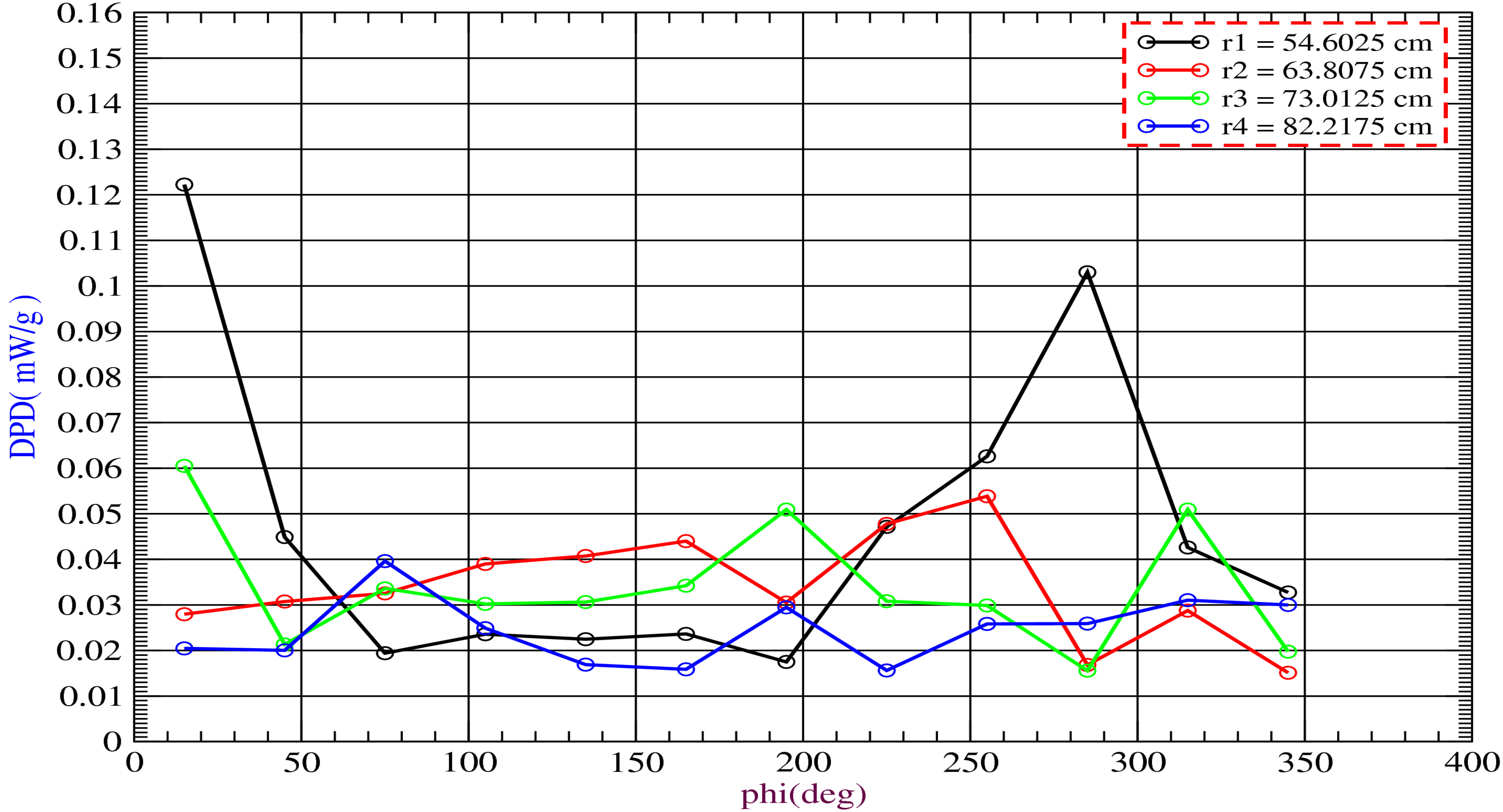
1960.30 < z < 1965.30 cm   dz = 5.0 cm N_z = 1 bins

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

N_{tot} = 48 ''pieces''

IDS120j (NO RS / NEW Hg MODULE): SC#12 AZIMUTHAL TDPD (AVERAGE FROM 4 x 5E05 RUNS)

W DENSITY=15.8 g/cc (P12 / 20 cm GAPS) (dr, dz, dphi) = (9.205 cm, 5.0 cm, 30 deg.)---> (4, 1, 12) # BINS



PEAK TDPD ~ 0.122 mW / g AT (r, z φ) = (54.6025 cm, 1962.8 cm, 15 deg) LOCATED NEAR THE +x AXIS. FOR THIS CASE MOST OF THE DEPOSITED POWER IS IN THE +x AND -y DIRECTION.

SC#10-12 SEGMENTED TDP [= 0.0683] + UNSEGMENTED VOLUME [= 0.139] = 0.156 kW VS. UNSEGMENTED [= 0.159 kW]

OVERALL [TAKING INTO ACCOUNT THE DIFFERENT Hg MODULE IN PRESENT STUDIES] THERE IS A VERY GOOD AGREEMENT WITH FLUKA RESULTS WITH GREATEST DIFFERENCE IN SC#10 TDPD PEAK:
FLUKA / MARS SC#10,11,12 ==> [0.26 / 0.35, 0.14 / 0.18, 0.10 / 0.14] mW / g. THIS IS ALSO A SATISFACTORY VALIDATION OF THE SEGMENTATION APPROACH TO ESTIAMATE PEAKS OF DEPOSITED POWER.

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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