IDS120j WITHOUT RESISTIVE MAGNETS: NEW Hg MODULE

SC#7, SC#8, SC#9 (IN CRYOSTAT #3) AZIMUTHAL TDPD DISTRIBUTION

Nicholas Souchlas (PBL) [10/24/2013]

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

****

MODIFIED Hg MODULE SIMULATES VAN GRAVE'S DESIGN.
AZIMUTHAL POWER DISTRIBUTION IN SC#7, SC#8, SC#9 IN CRYOSTAT#3. COMPARISON WITH FLUKA STUDIES.

****

➡ SIMULATIONS CODE: mars15 (2010) [USING MCNPDATA x-SECTION LIBRARIES FOR NEUTRON INTERACTIONS WITH KE < 14 MeV]

➡ NEUTRON ENERGY CUTOFF: 10^{-12} GeV

➡ SHIELDING: 60% W + 40% He [WITH STST VESSELS]

➡ B_z (r = 0, z) : 15 T [z = -37.5 cm] ---➜ 1.5 T [z = 1470.0 cm]

➡ Hg JET RADIUS / ANGLE: 0.4 cm / 0.09667 deg.

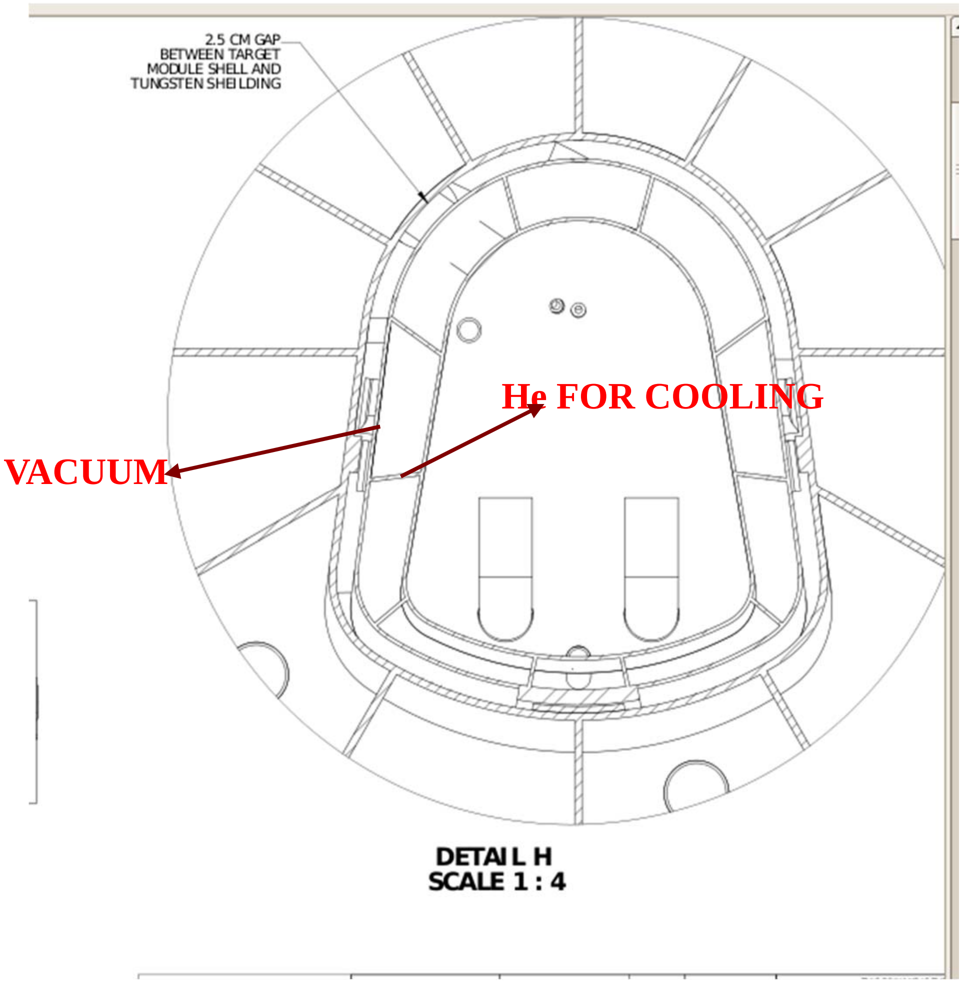
➡ PROTON BEAM POWER: 4 MW

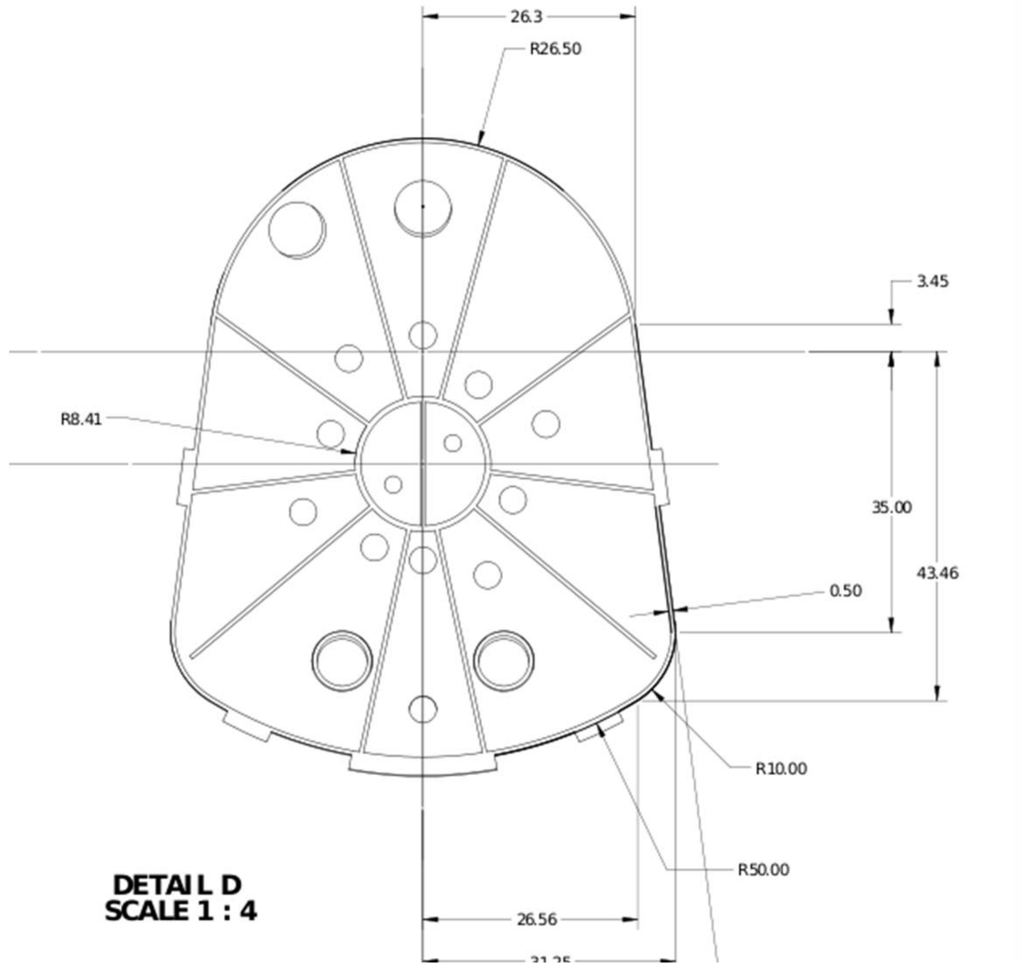
➡ PROTON ENERGY: E = 8 GeV

➡ PROTON BEAM PROFILE : GAUSSIAN, $\sigma_x = \sigma_y = 0.12$ cm [P12 OBTAINED USING DING'S STUDY II OPTIMIZED DATA]

➡ EVENTS IN SIMULATIONS : N_p = 5,000,000 [AVERAGE FROM 4 x 5E4 EVENTS]

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

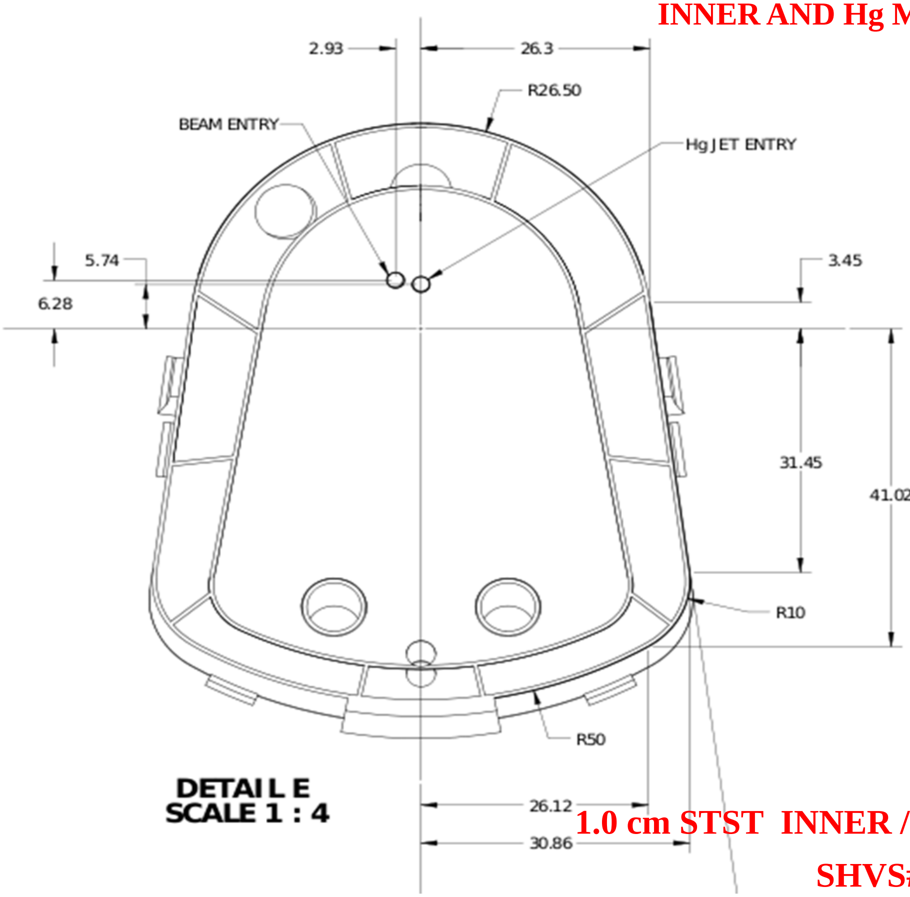


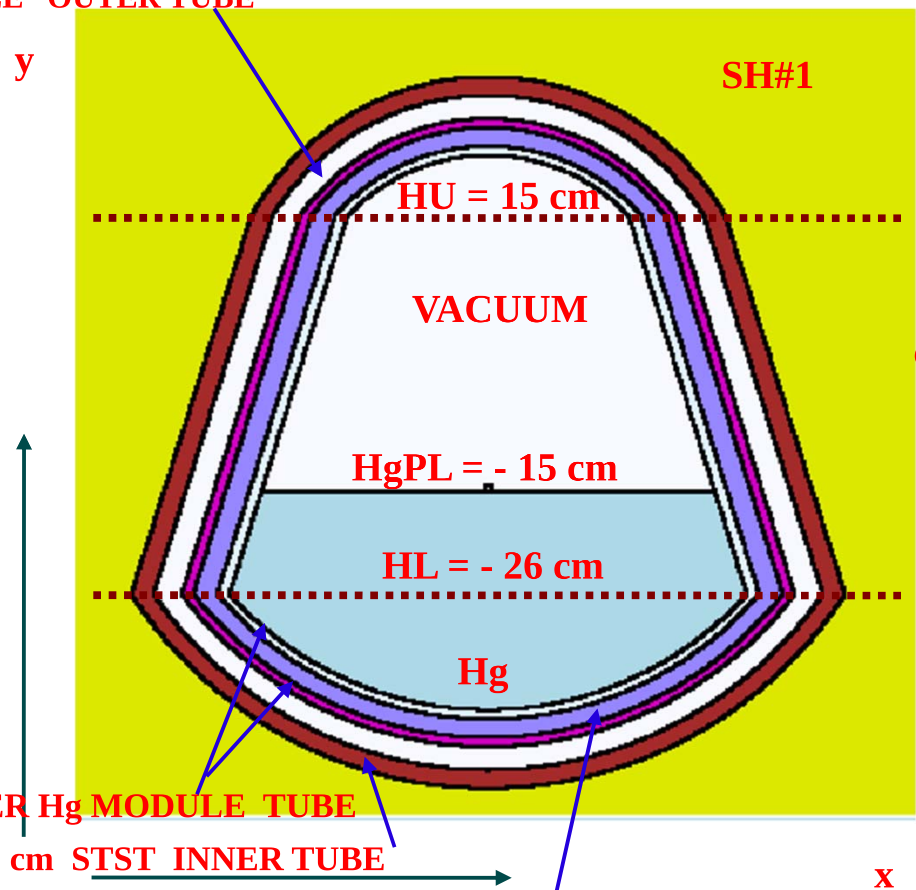


THE DESIGN REQUIRES A 2.5 cm ! GAP BETWEEN SH#1 INNER VESSEL AND Hg POOL MODULE OUTER VESSEL. AN EVEN LARGER SPACE APPEARS TO BE BETWEEN INNER AND OUTER VESSEL OF THE Hg POOL MODULE FOR THE FLOW OF He GAS FOR COOLING THE POOL WALLS.

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).

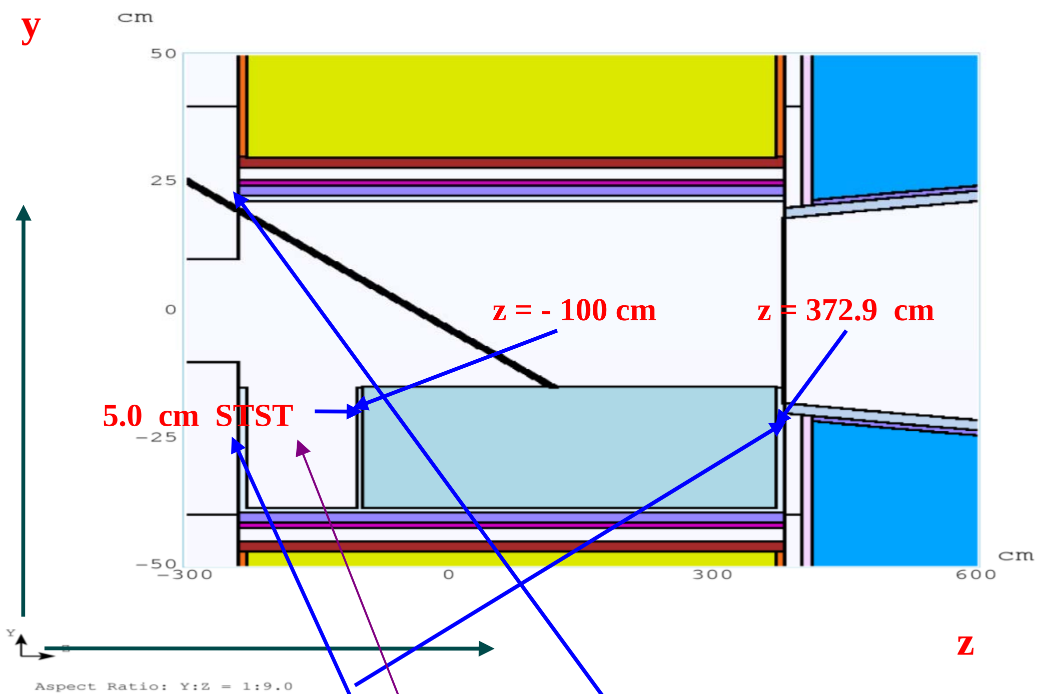
IDS120j: **yx CROSS SECTION WITH DETAILS OF Hg POOL MODULE FROM VAN's PLOTS (LEFT) AND ADAPTED DESIGN FOR MARS SIMULATIONS (RIGHT) [AT z = 100 m].**

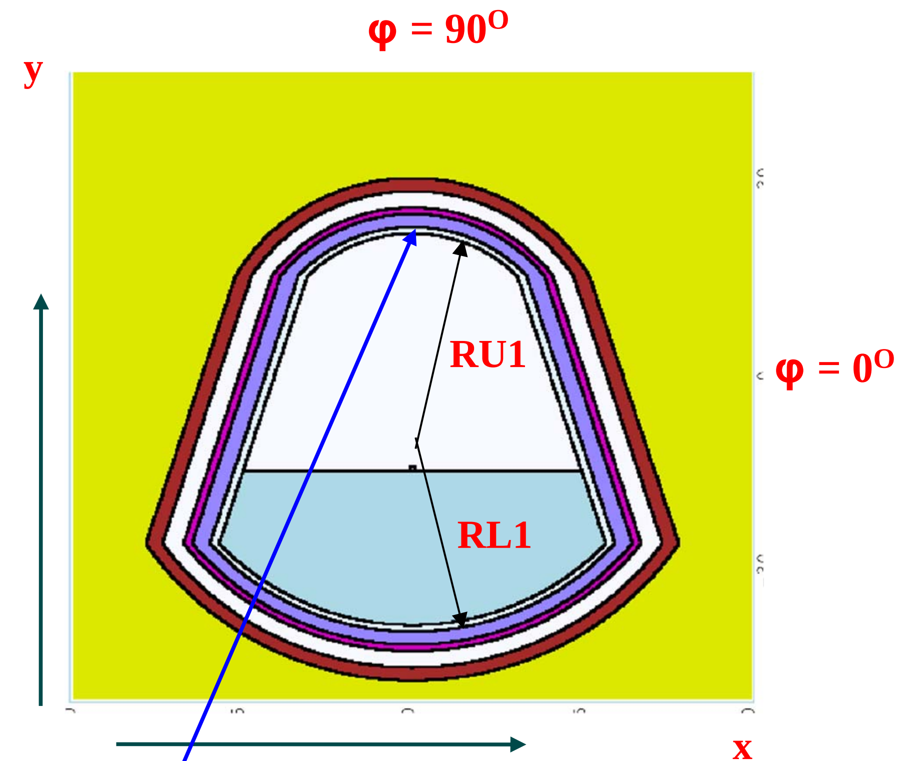




EVERYTHING HAS BEEN PARAMETRIZED FOR FUTURE CONVINIENCE. THE HEIGHTS OF THE END POINTS OF THE STRAIGHT SECTIONS ARE HL = - 26 cm AND HU = 15 cm. THE FREE Hg POOL SURFACE IS AT y = - 15 cm. THE RADIUS OF THE LOWER HALF OF THE INNER VESSEL OF THE Hg MODULE IS NOW SMALLER THAN BEFORE : FROM ~ 45 cm ----> ~ 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.





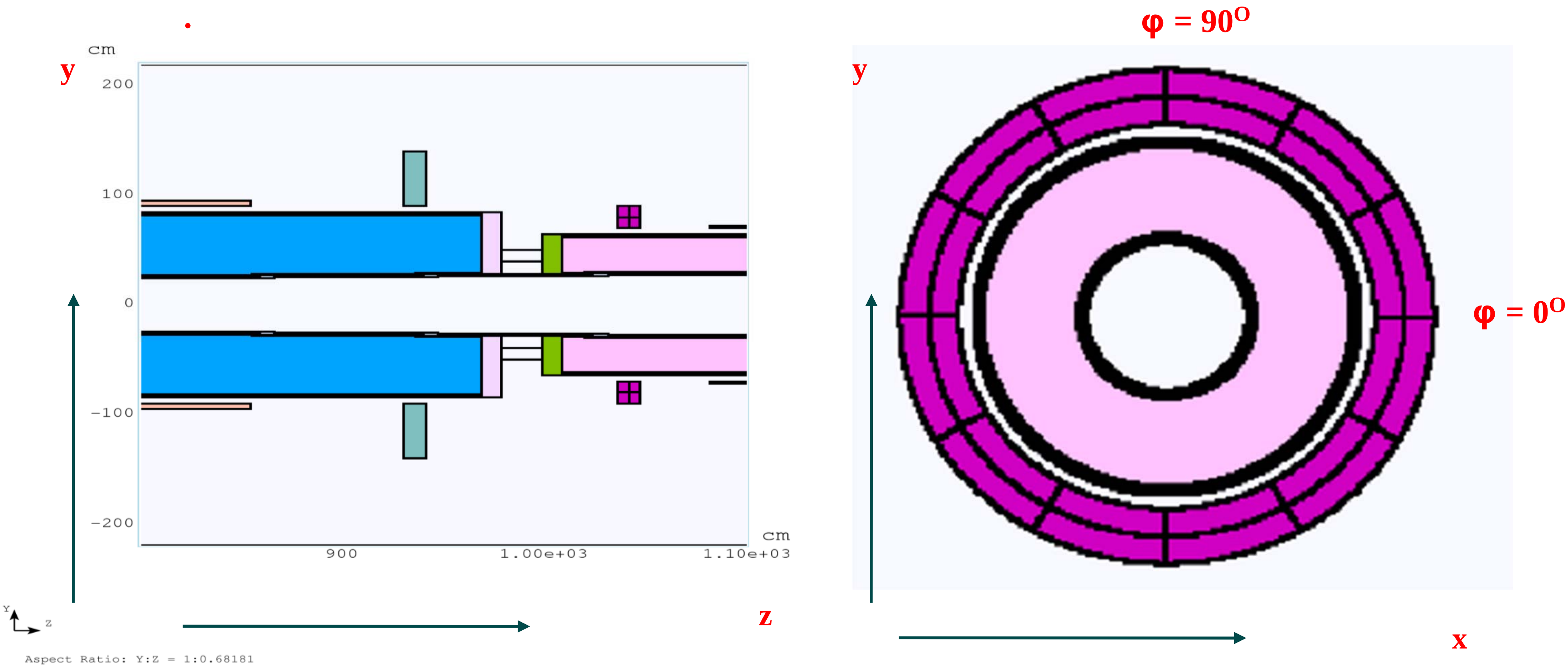
10 cm THICK STST FOR THE UPSTREAM AND DOWNSTREAM FLANGE OF Hg MODULE

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 = 28.0 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 He 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 CHALLENGING.

IDS120j: yz AT x = 0.0 cm [LEFT] AND yx AT z = 1040.0 cm [RIGHT] CROSS SECTION WITH DETAILS OF SC#7 SEGMENTATION. IN LEFT PLOT ONE CAN ALSO SEE DETAILS OF THE 20.0 cm GAP BETWEEN CRYOSTAT#2 AND CRYOSTAT#3.



--- SEGMENTATION DATA ---

$70.0 < r < 89.97$ cm $dr = 9.985$ cm $N_r = 2$ bins

$1036.0 < z < 1046.67$ cm $dz = 5.335$ cm $N_z = 2$ bins

$0.0 < \varphi < 360.0$ deg. $d\varphi = 30$ deg. $N_\varphi = 12$ bins

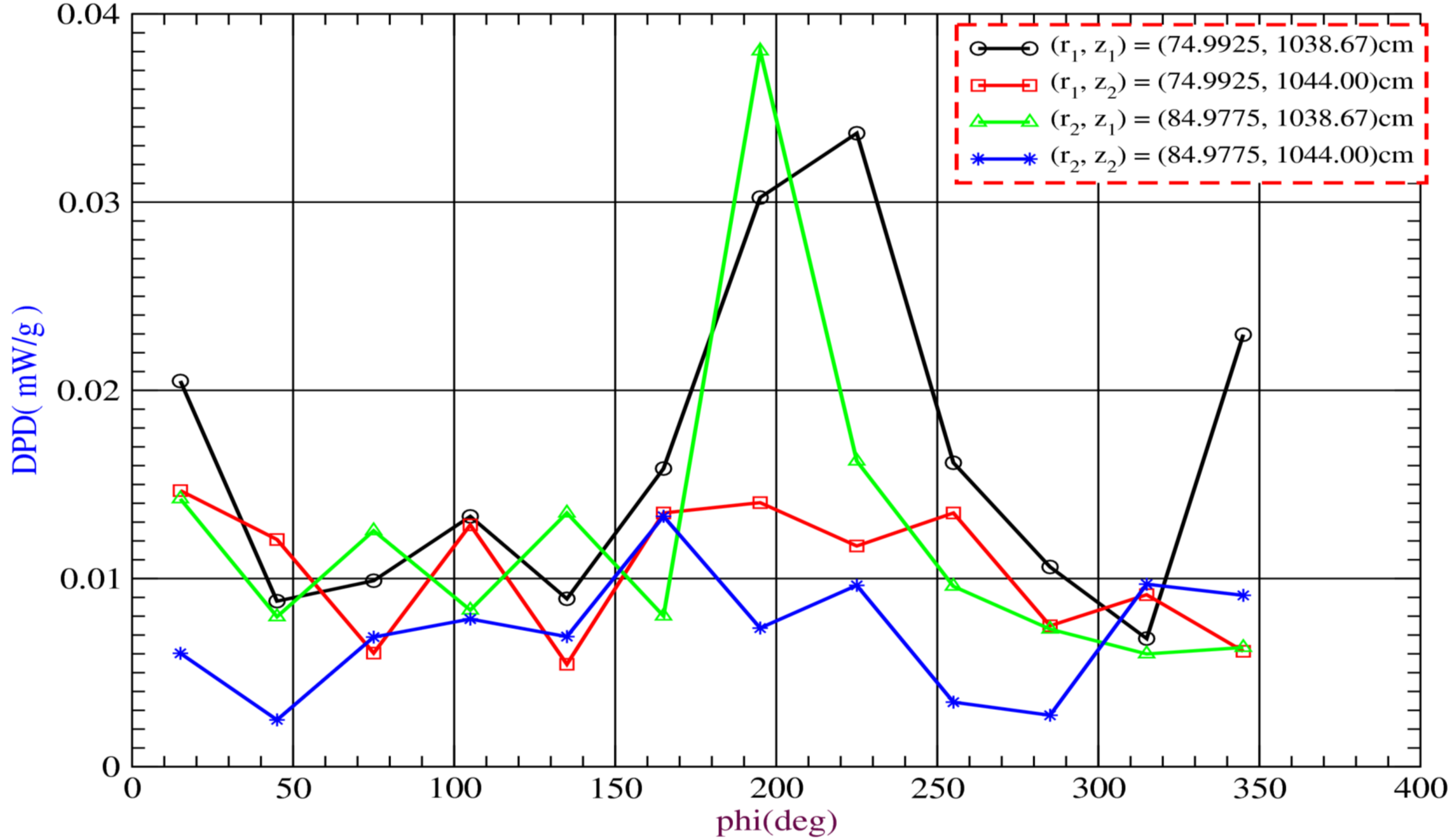
$N_{tot} = 48$ "pieces"

IDS120j: yz (LEFT) AND yx (RIGHT) CROSS SECTION WITH DETAILS OF THE BP#1 SEGMENTATION.

X CROSS SECTION WITH DETAILS OF THE BP#2 SEGMENTATION.

IDS120j (NO RS / NEW Hg MODULE): SC#7 AZIMUTHAL TDPD (AVERAGE FROM 4 x 5E05 RUNS)

W DENSITY=15.8 g/cc (P12 / 20 cm GAPS) (dr, dz, dphi) = (9.985 cm, 5.335 cm, 30 deg.)---> (2, 2, 12) # BINS



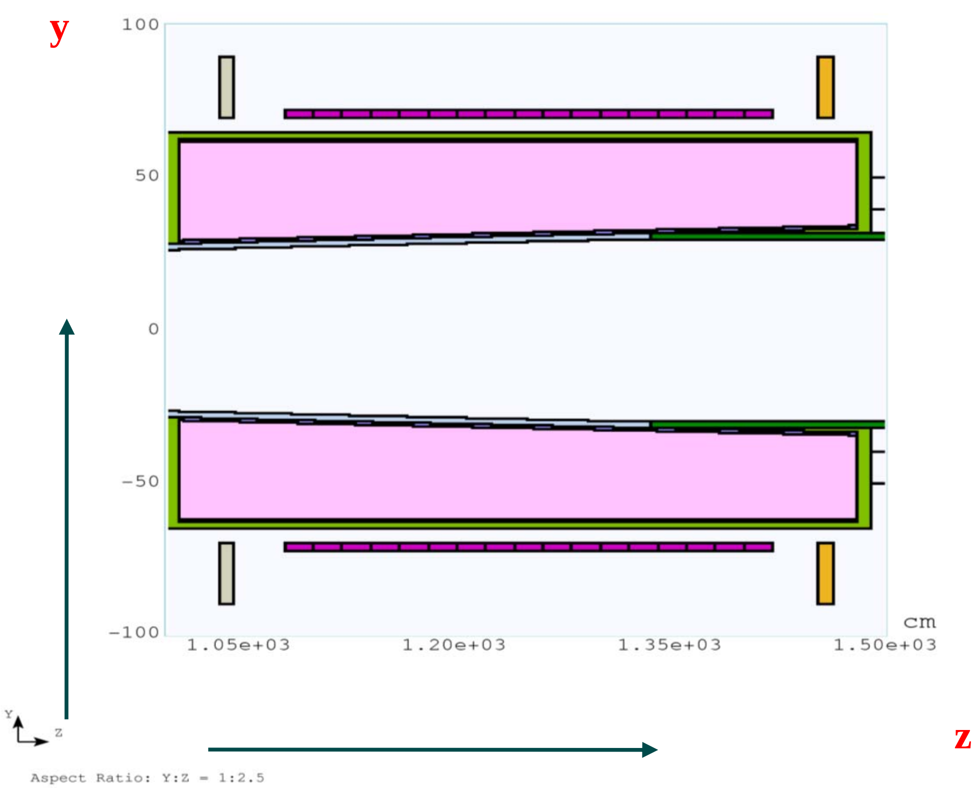
PEAK TDPD ~ 0.040 mW / g AT ABOUT 200 deg (BOTTOM OF THE COIL NEAR -x AXIS) . THIS IS FOR z1 AND FOR BOTH r1, r2 RADIUS. THESE AREAS FACE UPSTREAM TOWARDS THE TARGET REGION. THE REASON FOR THE RELATIVE INCREASE IN THE TDP IN THE LOWER HALF OF THE COIL AND FOR THE UPSTREAM SIDE IS THE INCREASE OF THE Hg POOL LENGTH ALL THE WAY TO THE END OF THE FIRST CRYOSTAT AT THE EXPANCE OF W SHIELDING THERE.

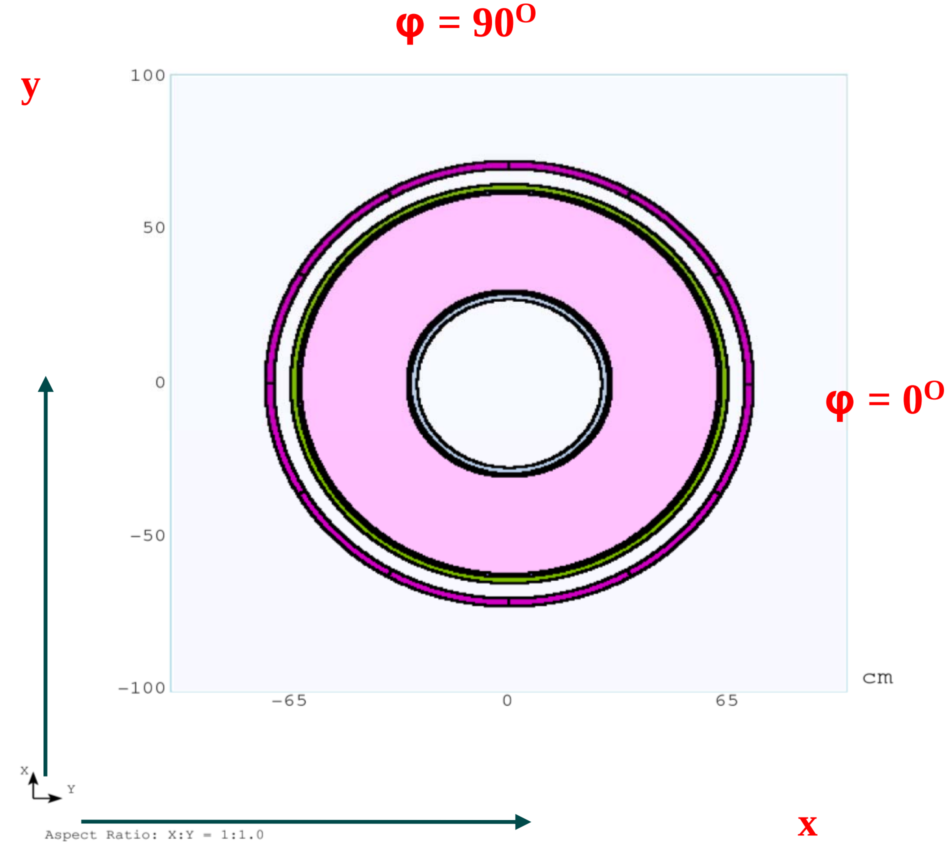
SC#7 : 48 “PIECES” TDP = 0.0086 kW VS. ONE VOLUME COIL TDP = 0.0078 kW

FLUKA SC#7 TDP = 0.008 ± 0.007 kW SC#7 PEAK TDPD = 0.03 mW/g RADIAL / 0.15 mW/g AZIMUTHAL (± ???)

(FROM JOHN BACK / JUNE 10 2012) .

IDS120j: yz AT x = 0.0 cm [LEFT] AND yx AT z = 1090.0 cm [RIGHT] CROSS SECTION WITH DETAILS OF SC#8 SEGMENTATION. DUE TO THE COIL RADIAL THIKNESS UNAVOIDABLY THE RADIAL BIN SIZE IN THE SEGMENTATION IS SMALL.





--- SEGMENTATION DATA ---

70.0 < r < 72.54 cm dr = 2.54 cm N_r = 1 bins

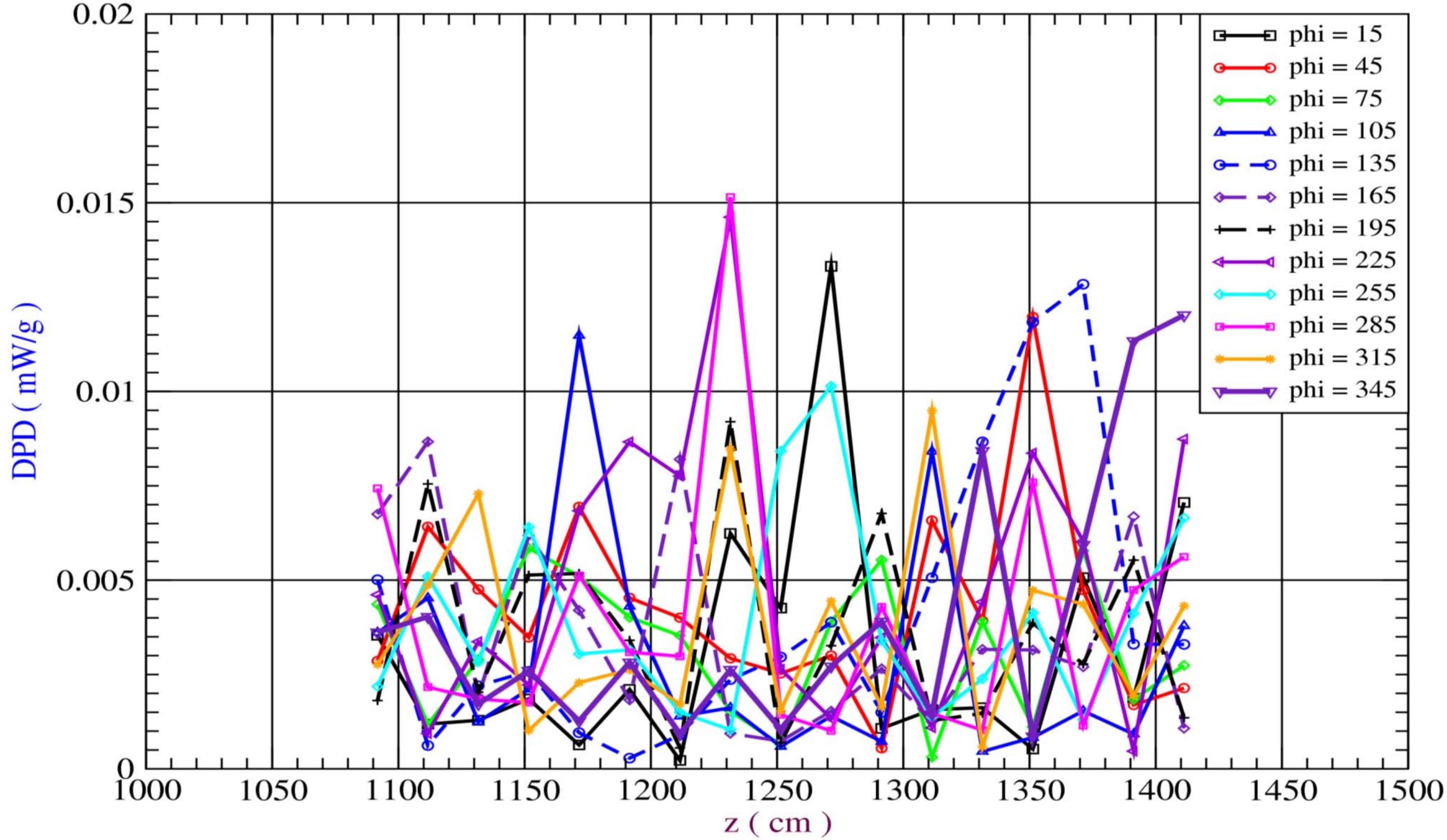
1081.70 < z < 1421.20 cm dz = 19.971 cm N_z = 17 bins

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

N_{tot} = 204 "pieces"

IDS120j (NO RS / NEW Hg MODULE): SC8 TDPD vs. z FOR 12 ANGLES (AVEARGE FROM FROM 4 x 5E05 RUNS)

W DENSITY = 15.8 g/cc [P12 / 20 cm GAPS] (dr, dz, dphi) = (2.54 cm, 19.971 cm, 30 deg)--> (1, 17, 12) #BINS



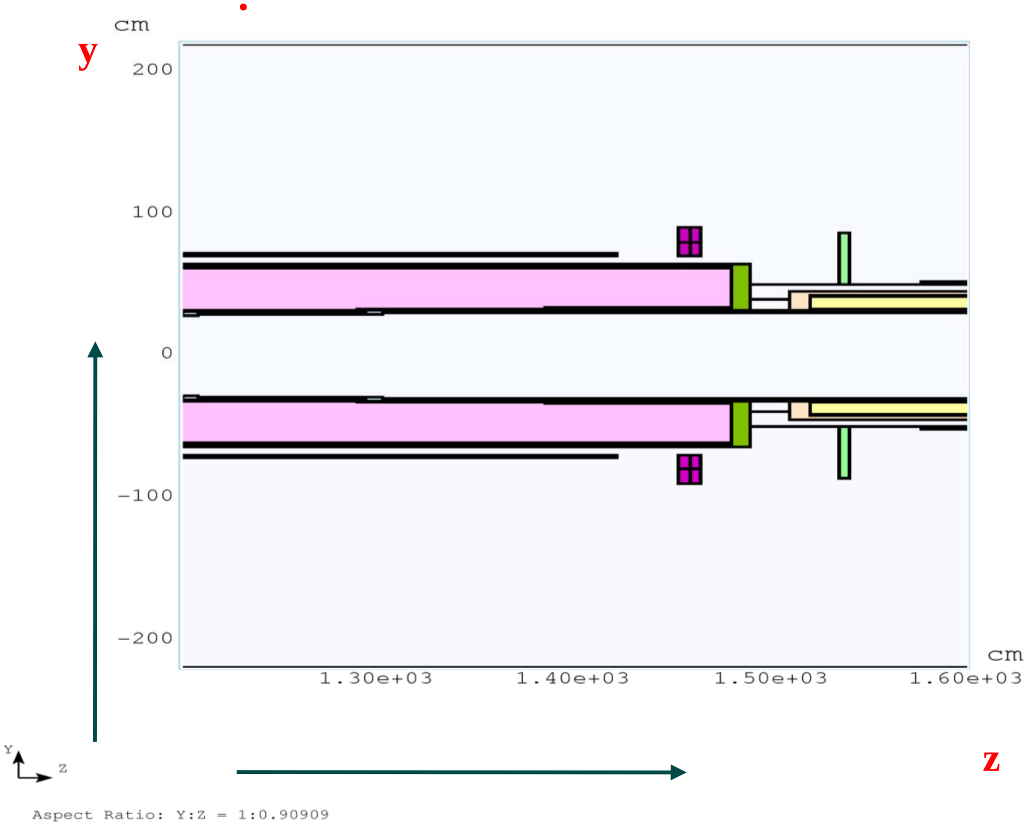
PEAK TDPD ~ 0.015 mW / g AT ABOUT 220, 285 deg AROUND THE -y AXIS AND AT z ~ 1225 cm . THERE IS LOT OF STATISTICAL FLUCTUATIONS DUE TO THE SMALL RADIAL BIN SIZE.

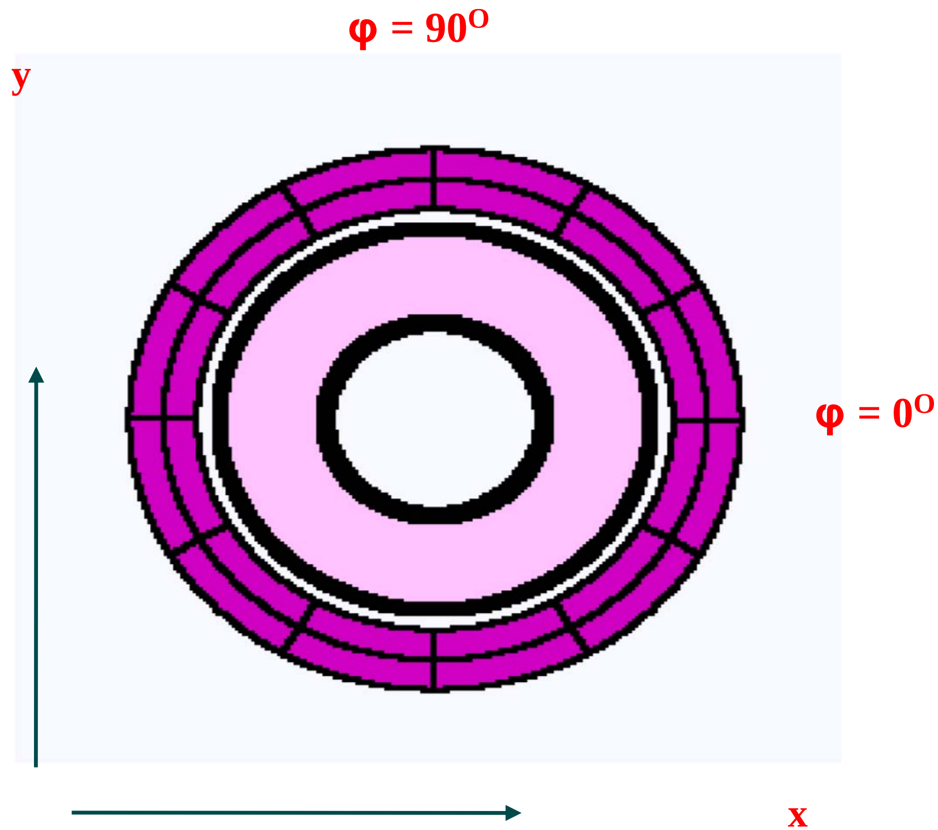
SC#8 : SEGMENTATION TDP = 0.0102 kW VS. ONE VOLUME COIL TDP = 0.0106 kW

FLUKA SC#8 TDP = 0.014 ± 0.006 kW SC#8 PEAK TDPD = 0.02 mW/g RADIAL / 0.02 mW/g AZIMUTHAL (± ???)

(JOHN BACK / JUNE 10 2012) .

IDS120j: yz AT x = 0.0 cm [LEFT] AND yx AT z = 1455.0 cm [RIGHT] CROSS SECTION WITH DETAILS OF SC#9 SEGMENTATION. COILS SC#7 AND SC#9 HAVE ABOUT THE SAME DIMENSIONS. IN LEFT PLOT ONE CAN ALSO SEE DETAILS OF THE 20.0 cm GAP BETWEEN CRYOSTAT#3 AND CRYOSTAT#4.





--- SEGMENTATION DATA ---

$70.0 < r < 89.97$ cm dr = 9.985 cm $N_r = 2$ bins

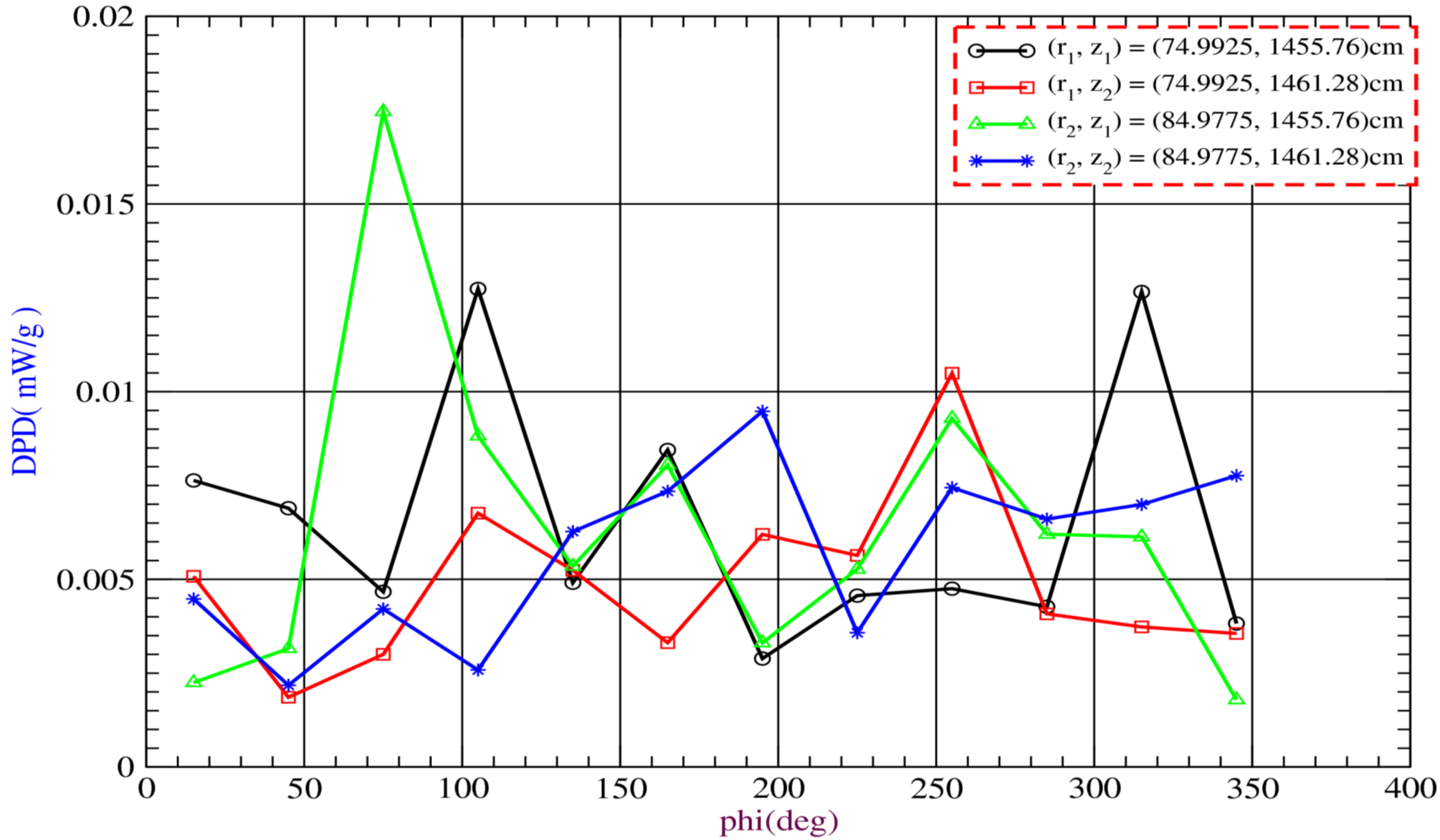
$1453.0 < z < 1464.04$ cm dz = 5.335 cm $N_z = 2$ bins

$0.0 < \varphi < 360.0$ deg. $d\varphi = 30$ deg. $N_\varphi = 12$ bins

$N_{tot} = 48$ "pieces"

IDS120j (NO RS / NEW Hg MODULE): SC#9 AZIMUTHAL TDPD (AVERAGE FROM 4 x 5E05 RUNS)

W DENSITY=15.8 g/cc (P12 / 20 cm GAPS) (dr, dz, dphi) = (9.985 cm, 5.52 cm, 30 deg.)---> (2, 2, 12) # BINS



PEAK TDPD ~ 0.018 mW / g AT ABOUT 90 deg (+ y AXIS) AT r2, z1 AND LITTLE AFTER THAT WE HAVE A SECOND PEAK ~ 0.0013 mW/g AT r1,z1. BOTH PEAKS ARE FOR "PIECES" FACING THE TARGET BUT AS ONE MAY EXPECT WE HAVE MORE STATISTICAL UNCERTAINTY THAN IN SC#7 . SINCE THE TWO PEAK VALUES ARE NOT MUCH DIFFERENT ONE SHOULD NOT EXPECT A BIG CHANGE IN THE RESULT IF HIGHER STATISTICS IS USED. IT IS ALSO IMPORTANT TO NOTICE THAT TDP ~ 4.6 Watts AND IT WILL BE RATHER UNUSUAL A LOT OF THIS ENERGY TO BE FOCUSED IN A SMALL AREA IN A BIG COIL LIKE SC#9 LOCATED ~ 15 m DOWNSTREAM THE TARGET.

SC#9: SEGMENTATION TDP = 0.0046 kW VS. ONE VOLUME COIL TDP = 0.0042 kW

FLUKA SC#9 TDP = 0.005 ± 0.004 kW SC#7 PEAK TDPD = 0.03 mW/g RADIAL / 0.10 mW/g AZIMUTHAL (± ???)

(FROM JOHN BACK / JUNE 10 2012) .

****** COMMENTS ON MARS AND FLUKA PEAK TDPD [USING SC#7 CASE FOR EXAMPLE] ******

 # SC#7 : VOLUME = 1.07 10^5 cc, Dens (NbTi) =7.0 g/cc ==> Mass ~ 7.49 10^5 gr.

 # MARS: PEAK TDPD FROM SEGMENTATION ~ 0.04 mW / g.
 # FLUKA: PEAK TDPD AVERAGE(?) RADIAL ~ 0.03 mW / g AVERAGE(?) AZIMUTHAL ~ 0.15 mW / g -->??.

 # MARS: TDP ~ 7.8 Watts (NO SEGMENT.) ==> AVERAGE TDPD (SC#7 VOLUME) ~ 0.0104 mW/ g .
FROM 48 SEGMENTATION "PIECES" ==> AVERAGE TDPD ~ 0.0139 mW/ g.
THESE TWO NUMBER ARE IN GOOD AGREEMENT.

 # FLUKA: TDP ~ 8.0±7.0 Watts ==> AVERAGE TDPD FOR ALL VOLUME ~ FROM 0.0013 TO 0.02 mW/ g .
IF WE CONSIDER THE MAXIMUM AVERAGE DENSITY OF 0.02 mW/g THERE IS STILL A HUGE GAP WITH THE AZIMUTHAL PEAK TDPD 0.15 mW/g (EVEN WORSE IF THIS IS THE AVERAGE AZIMUTHAL TDPD)

 # THERE IS SOMETHING STRANGE WITH FLUKA RESULTS ...

>> ALSO P12 USED FOR SO FAR STUDIES IS EXTRACTED BY USING STUDY II OPTIMIZED P12 POINT BY BACTRACKING PROTONS (OR TRAKING ANTIPROTONS) FROM STUDY II P12 COORDINATES AT z = -37.5 cm. DING HAS NEVER WORKED OUT A SET OF OPTIMIZED POINTS FOR THE LATEST IDS120j.