IDS120h GEOMETRY WITH MODIFIED Hg POOL VESSEL

SIMULATIONS FOR 60% W + 40% He SHIELDING (P12 'POINT') WITH

STST SHIELDING VESSELS

BP#1 (STST/W), SH#1, BeWindow, SC#8 SEGMENTATION STUDIES

Hg vs. Ga DEPOSITED POWER DISTRIBUTION.

Nicholas Souchlas, PBL (1/24/2012)

IDS120hm: (m IS FOR) modified Hg pool vessel IN IDS120h.

\# BP#1 (STST), SH#1: 1E05 (2 DIFFERENT INITIALIZATIONS)
 AND 2E05   SIMULATIONS COMPARISON.

\# BP#1(STST): Hg vs. Ga + BP#1: STST vs. W (Hg TARGET)

\# SC#8: 3E05 (2 DIFFERENT INITIALIZATIONS) AND 4E05
  SIMULATIONS .

\# BeWind: 1E05 (2 DIFFERENT INITIALIZATIONS)
  AND 2E05 SIMULATIONS .

\# Hg vs. Ga: 1E05   DP SIMULATIONS .

 >mars1510/MCNP

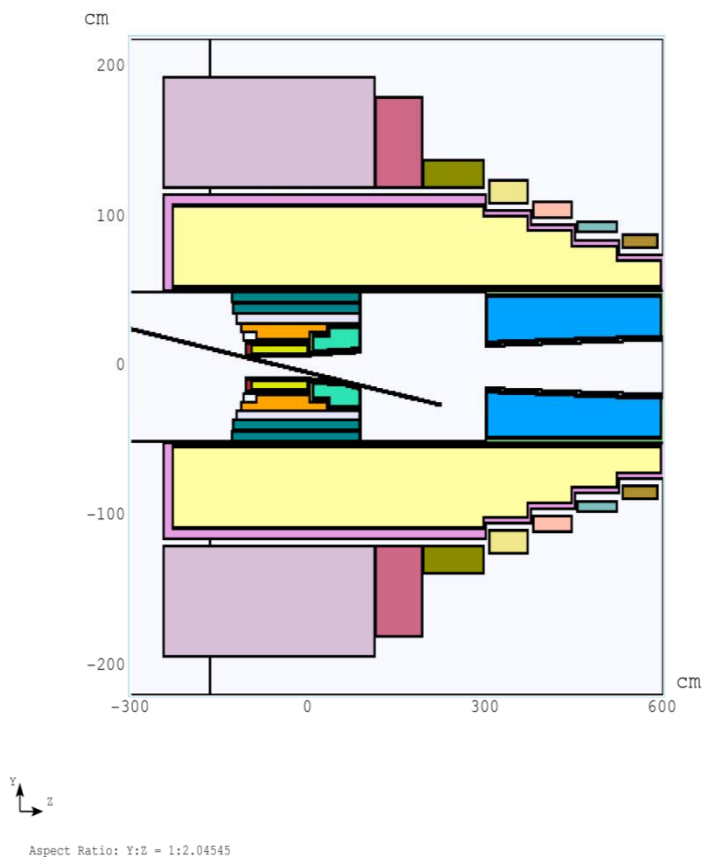 >10^{-11} MeV NEUTRON ENERGY CUTOFF

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

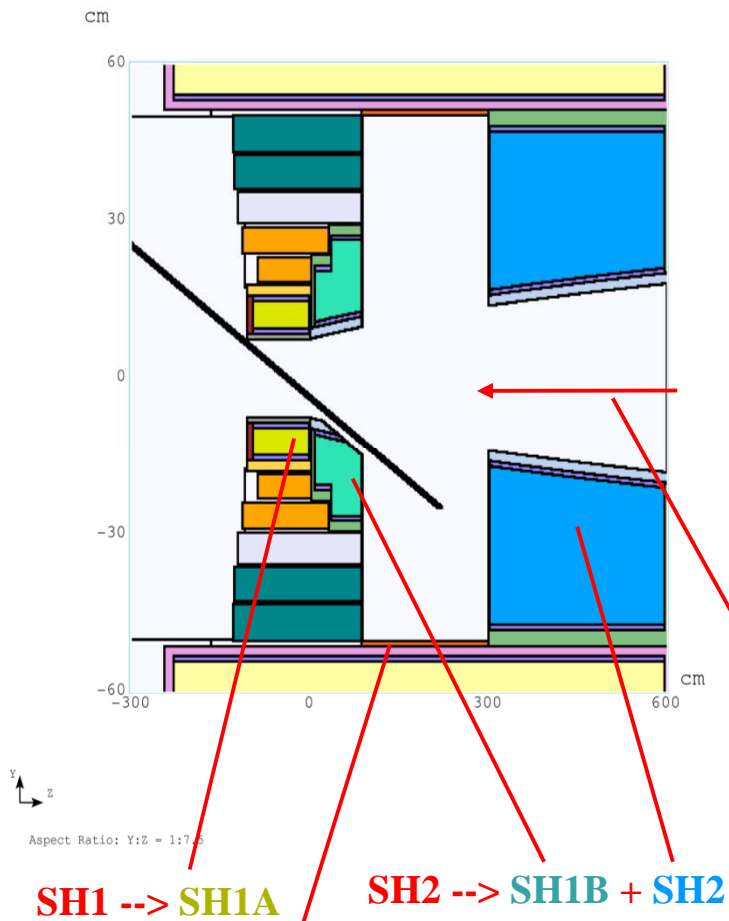>4 MW proton beam, N_p = 1E05/2E05/3E05/4E05 events.

>PROTONS ENERGY E = 8 GeV (P12 'POINT').

>GAUSSIAN PROFILE: $\sigma_x = \sigma_y$ = 0.12 cm.

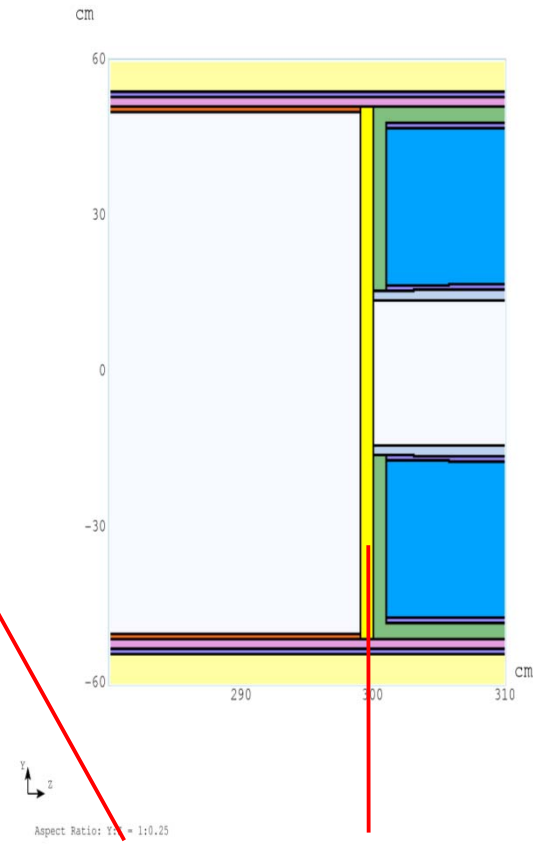**IDS120hm GEOMETRY = IDS120h WITH MODIFIED Hg POOL VESSEL AND SHIFTED Be WIDOW FROM 600 cm (0.6 cm THICK) TO 300 cm (1 cm THICK).**

MODIFIED Hg POOL EXTENDS FROM 86 cm TO ~ 300 cm ALONG THE z-AXIS AND UP ~ 50 cm RADIALLY

SH1 --> SH1A

SH2 --> SH1B + SH2

1 cm THICK STST WALLS USED FOR THE Hg POOL VESSEL

1 cm THICK Be WINDOW IS LOCATED AT 300 cm (ORIGINALLY 0.6 cm THICK PLACED AT 600 cm)

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IDS120hm Hg POOL SURFACE AT y = - 20 cm, STST SHIELDING VESSELS
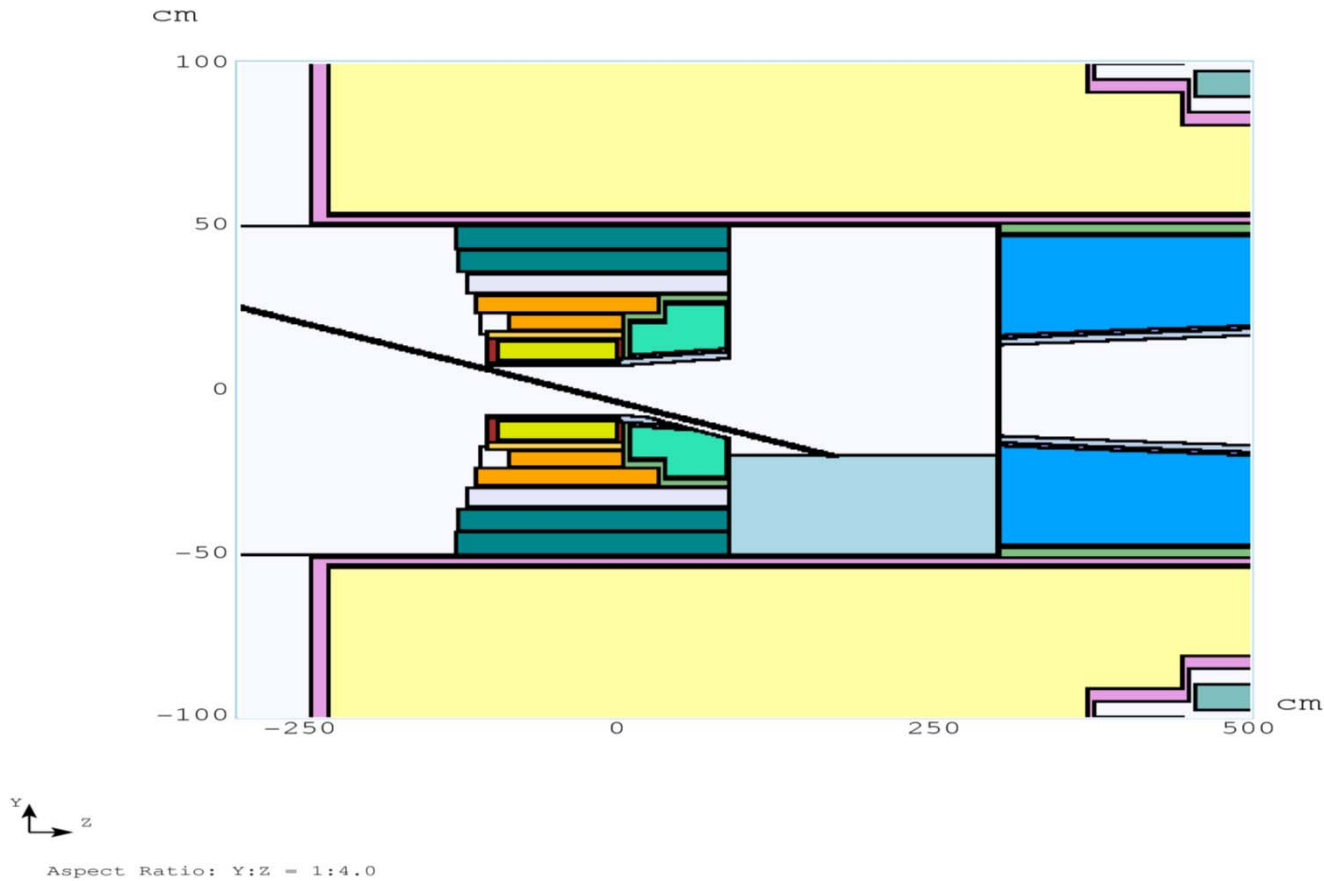
TABLES   CONTENT:

BP#1, SH#1, BeWind: A = 100,000 EVENTS, B = 200,000 EVENTS, C = 100,000 EVENTS/NEW EXECUTABLE

SC#8: A = 300,000 EVENTS, B = 400,000 EVENTS, C = 300,000 EVENTS/NEW EXECUTABLE

Hg/Ga TARGET: A = Hg, B = Ga   (100,000 EVENTS)

"PIECES" VOLUMES ARE CALCULATED MANUALLY, NOT FROM MARS VOLUME MODE.

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BP#1   AZIMUTHAL SEGMENTATION STUDIES
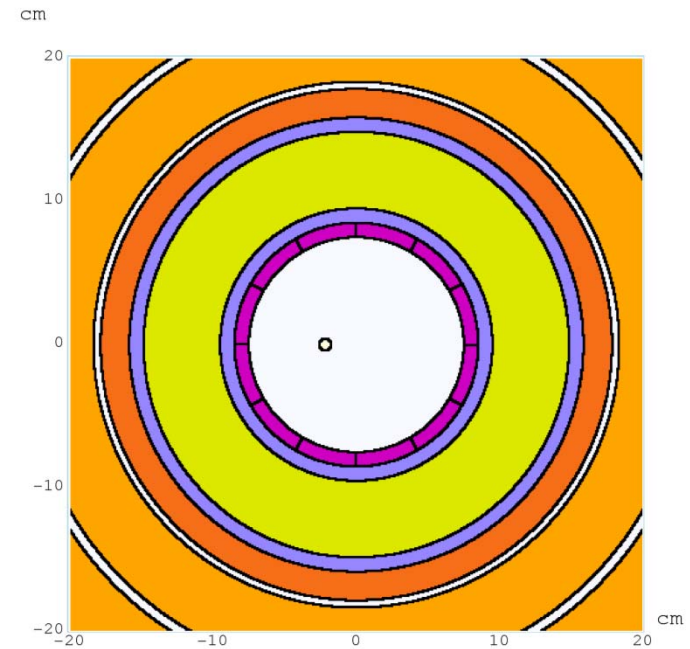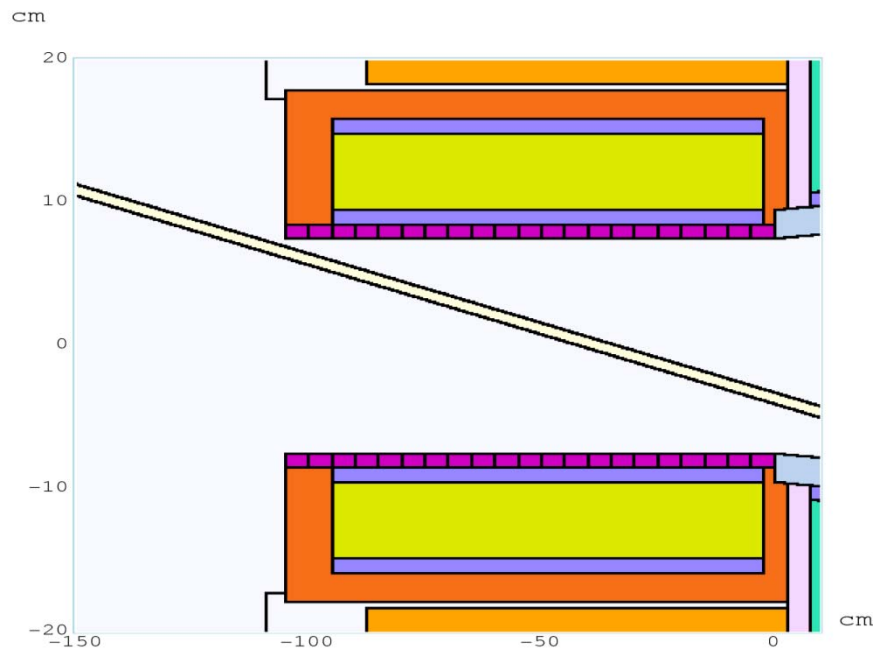
$7.5 < r < 8.5$ cm $dr = 1.0$ cm $N_r = 1$ bin

$-105.0 < z < 0.0$ cm $dz = 5.0$ cm $N_z = 21$ bins

$0.0 < \varphi < 360.0$ deg $d\varphi = 30.0$ deg. $N_\varphi = 12$ bins

Ntot = 252 "pieces"

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TOP TEN DEPOSITED POWER DENSITIES (DPD) FOR STST BP#1 FOR 3 SIMULATIONS

N_p = 1E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
259	8.0	-22.5	285	14800
283	8.0	-12.5	285	14480
246	8.0	-27.5	255	14435
271	8.0	-17.5	285	14295
270	8.0	-17.5	255	14265
247	8.0	-27.5	285	14005
258	8.0	-22.5	255	13980
245	8.0	-27.5	225	13690
257	8.0	-22.5	225	13565
244	8.0	-27.5	195	13370

N_p = 2E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
259	8	-22.5	285	14620
247	8	-27.5	285	14470
270	8	-17.5	255	14315
258	8	-22.5	255	14075
271	8	-17.5	285	13985
283	8	-12.5	285	13935
257	8	-22.5	225	13855
260	8	-22.5	315	13840
245	8	-27.5	225	13825
248	8	-27.5	315	13725

N_p = 1E05 EVENTS(NE)

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
270	8	-17.5	255	14660
258	8	-22.5	255	14470
259	8	-22.5	285	14355
246	8	-27.5	255	14120
271	8	-17.5	285	13715
245	8	-27.5	225	13695
247	8	-27.5	285	13575
244	8	-27.5	195	13450
260	8	-22.5	315	13430
234	8	-32.5	255	13185

STATISITCAL FLUCTUATIONS AND UNCERTAINTIES FOR THE MAXIMUM DPD IN BP#1 REGIONS ARE OF THE ORDER OF A FEW WATTS.
PEAK VALUES APPEAR TO BE ALONG THE -y DIRECTION AND - 27 < z < -12 cm.
INITIAL ESTIMATIONS OF MAXIMUM DPD FOR BP#1 WITH VOLUME DETECTORS ~ 10 W/g.

BP#1 SUM OF DEPOSITED POWER IN 252 "PIECES"

207.21 kW   207.29 kW   206.19 kW

vs. 206.20 kW WITHOUT SEGMENTATION FOR 1E05 EVENTS

TOP TEN DEPOSITED POWER DENSITIES (DPD) FOR BP#1:
STST BP#1 vs. W BP#1, AND STST BP#1 FOR Hg vs. Ga TARGET

N_p = 1E05 EVENTS
(BP#1: STST, Hg)

N_p = 1E05 EVENTS
(BP#1: W, Hg)

N_p = 1E05 EVENTS
(BP#1: STST, Ga)

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
259	8.0	-22.5	285	14800
283	8.0	-12.5	285	14480
246	8.0	-27.5	255	14435
271	8.0	-17.5	285	14295
270	8.0	-17.5	255	14265
247	8.0	-27.5	285	14005
258	8.0	-22.5	255	13980
245	8.0	-27.5	225	13690
257	8.0	-22.5	225	13565
244	8.0	-27.5	195	13370

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
259	8	-22.5	285	15555
258	8	-22.5	255	15305
270	8	-17.5	255	14975
271	8	-17.5	285	14480
246	8	-27.5	255	14355
247	8	-27.5	285	14325
260	8	-22.5	315	13925
245	8	-27.5	225	13815
257	8	-22.5	225	13235
282	8	-12.5	255	13065

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
307	8	-2.5	285	14840
295	8	-7.5	285	13895
294	8	-7.5	255	13625
306	8	-2.5	255	13560
283	8	-12.5	285	13400
282	8	-12.5	255	13110
270	8	-17.5	255	12590
271	8	-17.5	285	12540
284	8	-12.5	315	12000
259	8	-22.5	285	11975

W BP#1 HAS SLIGHTLY HIGHER DPD PEAK VALUES (~ 0.5-1.0 W) , ~ SAME REGIONS.
FOR Ga PEAK DPD ABOUT SAME AS WITH Hg. THERE IS A SIGNIFICANT CHANGE IN THE DP
DISTRIBUTION ALONG z AXIS : MAXIMUM DPD IS FROM ~ - 23 < z < 0 cm, ALONG ~ - y
DIRECTION.

BP#1 SUM OF DEPOSITED POWER IN 252 "PIECES"

	207.21 kW	440.72 kW	152.68 kW
vs.	206.20 kW	436.44 kW	152.45 kW

WITHOUT SEGMENTATION(1E05)

SH#1   AZIMUTHAL SEGMENTATION STUDIES
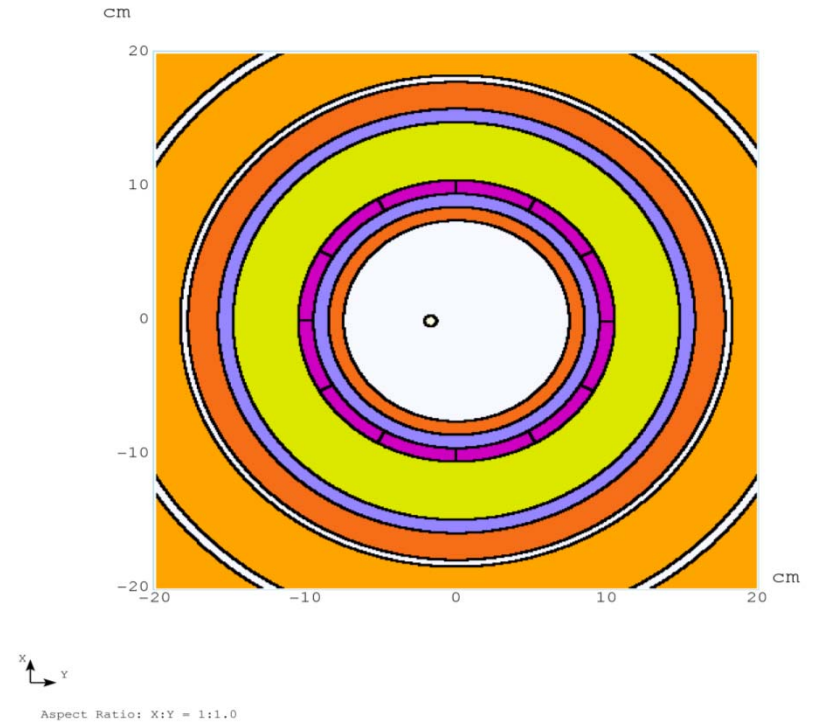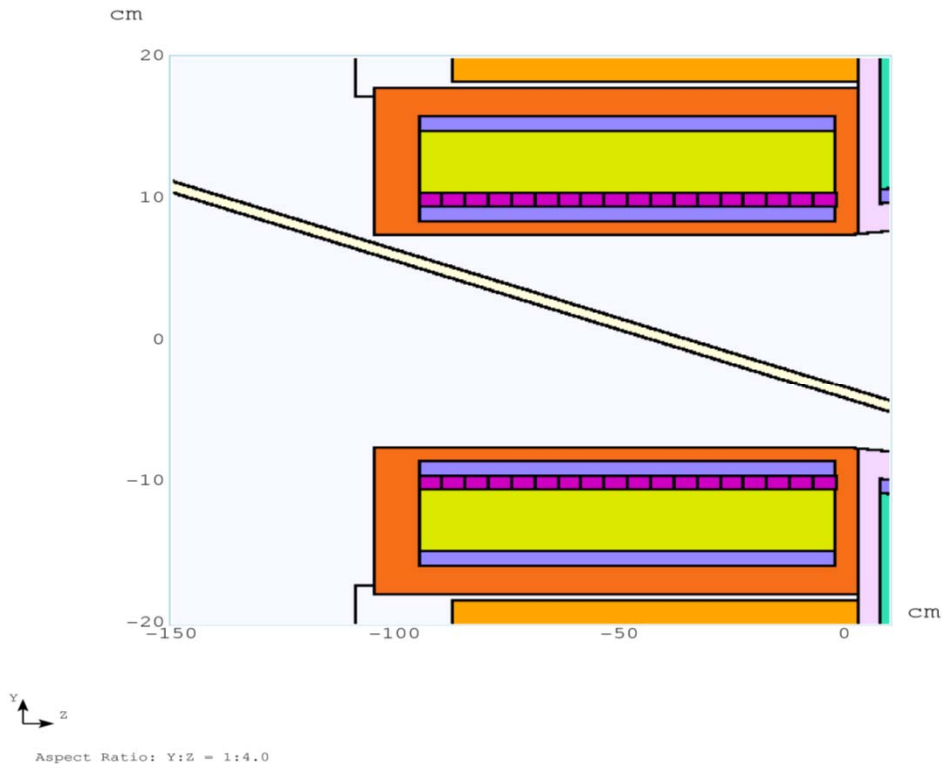
$$9.5 < r < 10.5 \text{ cm} \qquad dr = 1.0 \quad \text{cm} \qquad N_r = 1 \text{ bin}$$
$$-95.0 < z < -2.1 \text{ cm} \qquad dz = 5.161 \text{ cm} \qquad N_z = 21 \text{ bins}$$
$$0.0 < \varphi < 360.0 \text{ deg} \quad d\varphi = 30.0 \text{ deg.} \qquad N_\varphi = 12 \text{ bins}$$

$$\text{Ntot} = 216 \text{ "pieces"}$$

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TOP TEN DEPOSITED POWER DENSITIES (DPD) FOR W/He SH#1 FOR 3 SIMULATIONS

N_p = 1E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
234	10	-20.1639	255	10530
222	10	-25.325	255	10115
246	10	-15.0028	255	10010
247	10	-15.0028	285	9980
235	10	-20.1639	285	9965
259	10	-9.84167	285	9725
258	10	-9.84167	255	9645
221	10	-25.325	225	9620
223	10	-25.325	285	9605
236	10	-20.1639	315	9380

N_p = 2E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
235	10	-20.1639	285	10623
234	10	-20.1639	255	10349
247	10	-15.0028	285	10059
222	10	-25.325	255	10041
246	10	-15.0028	255	10027
223	10	-25.325	285	9962
233	10	-20.1639	225	9647
221	10	-25.325	225	9581
259	10	-9.84167	285	9503
258	10	-9.84167	255	9351

N_p = 1E05 EVENTS(NE)

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
235	10	-20.1639	285	10780
234	10	-20.1639	255	10340
247	10	-15.0028	285	10140
223	10	-25.325	285	9995
246	10	-15.0028	255	9990
222	10	-25.325	255	9935
233	10	-20.1639	225	9540
221	10	-25.325	225	9515
258	10	-9.84167	255	9450
259	10	-9.84167	285	9440

STATISITCAL FLUCTUATIONS AND UNCERTAINTIES FOR THE MAXIMUM DPD IN SH#1 REGIONS ARE LESS THAN 1 WATT.
PEAK VALUES APPEAR TO BE ALONG THE -y DIRECTION AND – 26 < z < 9 cm REGION.

INITIAL ESTIMATIONS OF MAXIMUM DPD FOR SH#1 WITH VOLUME DETECTORS ~10-11 W/g WERE "ON THE MONEY"

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Be WINDOW   AZIMUTHAL SEGMENTATION STUDIES

IDS120hm: Be WINDOW AZIMUTHAL SEGMENTATION PLOTS.
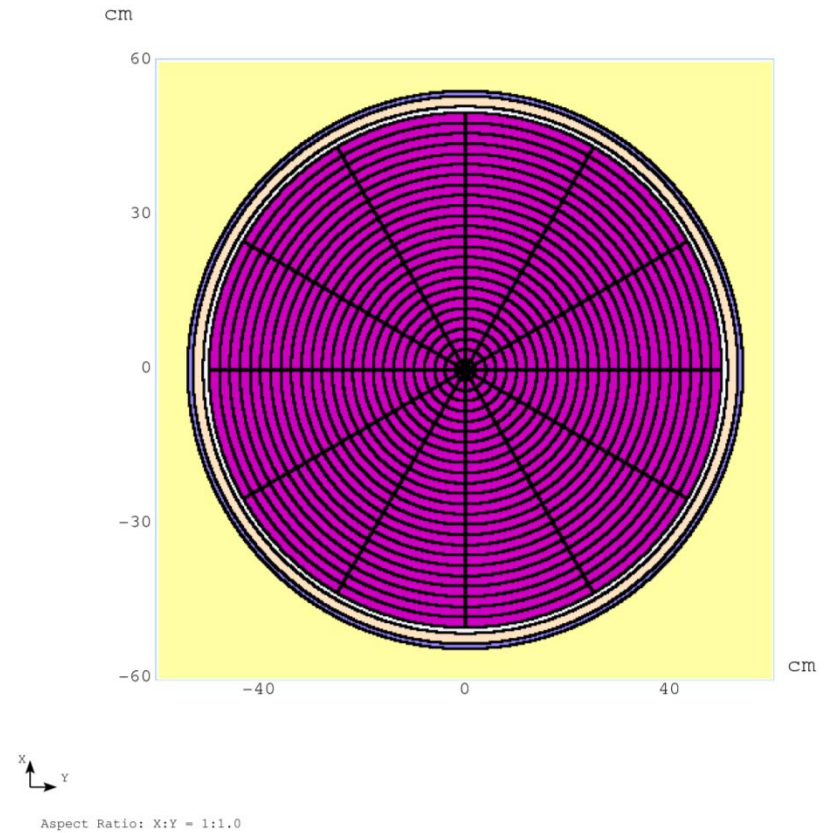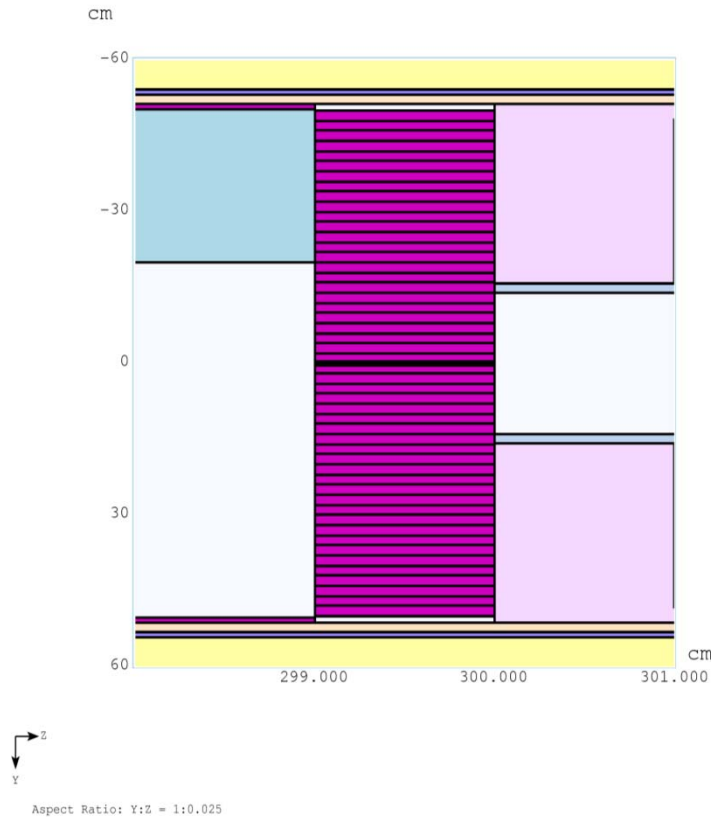
$$0.0 < r < 50.0 \text{ cm} \quad dr = 2.0 \text{ cm} \quad N_r = 25 \text{ bins}$$
$$299.0 < z < 300.0 \text{ cm} \quad dz = 1.0 \text{ cm} \quad N_z = 1 \text{ bin}$$
$$0.0 < \varphi < 360.0 \text{ deg} \quad d\varphi = 30.0 \text{ deg.} \quad N_\varphi = 12 \text{ bins}$$

$$Ntot = 300 \text{ "pieces"}$$

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TOP TEN DEPOSITED POWER DENSITIES (DPD) FOR Be WINDOW FOR 3 SIMULATIONS

N_p = 1E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
61	1	299.5	105	218200
60	1	299.5	75	152100
62	1	299.5	135	108050
59	1	299.5	45	73500
67	1	299.5	285	72300
73	3	299.5	105	64100
63	1	299.5	165	60450
66	1	299.5	255	58050
68	1	299.5	315	57350
58	1	299.5	15	49550

N_p = 2E05 EVENTS

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
61	1	299.5	105	216550
60	1	299.5	75	154550
62	1	299.5	135	107550
59	1	299.5	45	74350
67	1	299.5	285	74050
73	3	299.5	105	62600
66	1	299.5	255	59950
63	1	299.5	165	59800
68	1	299.5	315	58750
58	1	299.5	15	49325

N_p = 1E05 EVENTS(NE)

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
61	1	299.5	105	204900
60	1	299.5	75	144200
62	1	299.5	135	103850
67	1	299.5	285	77400
59	1	299.5	45	73450
73	3	299.5	105	62700
66	1	299.5	255	56400
63	1	299.5	165	55500
68	1	299.5	315	53950
58	1	299.5	15	47720

STATISITCAL FLUCTUATIONS AND UNCERTAINTIES FOR THE MAXIMUM DPD IN Be WIND. REGIONS
ARE OF THE ORDER OF A FEW WATTS.
PEAK VALUES APPEAR TO BE ALONG THE +y DIRECTION AND 0 < r < 4 cm.
INITIAL ESTIMATIONS OF MAXIMUM DPD FOR Be WIND . WITH VOLUME DETECTORS ~100 / 200 W/g
(dx,dy,dz) = (2.0,1.4,1.0) cm / (1.0,0.7,1.0) cm BINS SIZE.

Be WIND. SUM OF DEPOSITED POWER IN 300 "PIECES"
7.54 kW   7.54 kW   7.41 kW
vs. 7.40 kW WITHOUT SEGMENTATION FOR 1E05 EVENTS

SC#8   AZIMUTHAL SEGMENTATION STUDIES

IDS120hm:SC#8 AZIMUTHAL SEGMENTATION PLOTS.
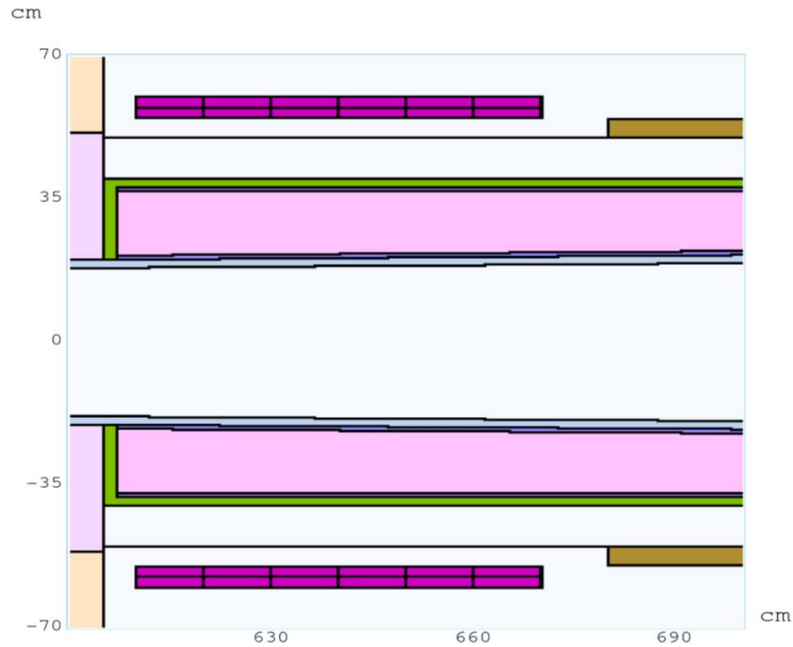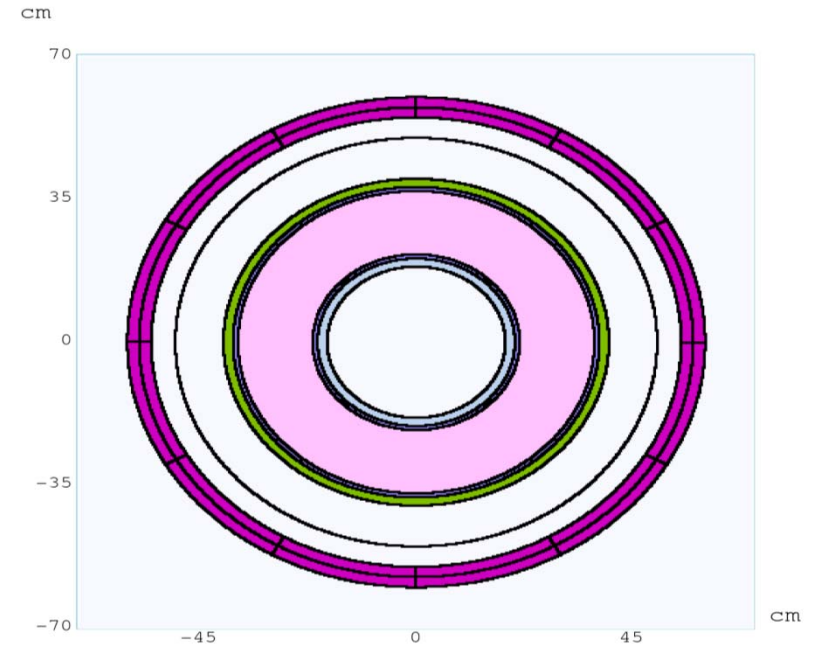
$$55.0 < r < 59.99 \text{ cm} \qquad dr = 2.495 \text{ cm} \qquad N_r = 2 \text{ bins}$$
$$610.0 < z < 670.0 \text{ cm} \qquad dz = 10.0 \text{ cm} \qquad N_z = 6 \text{ bins}$$
$$0.0 < \varphi < 360.0 \text{ deg} \qquad d\varphi = 30.0 \text{ deg.} \qquad N_\varphi = 12 \text{ bins}$$

$$\text{Ntot} = 144 \text{ "pieces"}$$

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TOP TEN DEPOSITED POWER DENSITIES (DPD) FOR SC#8 FOR 3 SIMULATIONS

N_p = 3E05 EVENTS   **N_p = 4E05 EVENTS**   **N_p = 3E05 EVENTS(NE)**

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
139	57.495	645	255	0.21885
102	59.99	625	255	0.1794
162	57.495	655	225	0.1607
119	59.99	635	15	0.12525
179	57.495	665	15	0.11695
84	57.495	625	75	0.10385
96	59.99	625	75	0.0984
193	59.99	665	75	0.087
196	59.99	665	165	0.08255
136	57.495	645	165	0.08205

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
139	57.495	645	255	0.17125
169	59.99	655	75	0.14595
102	59.99	625	255	0.1401
162	57.495	655	225	0.12865
149	59.99	645	195	0.10325
184	57.495	665	165	0.1023
137	57.495	645	195	0.09815
119	59.99	635	15	0.09545
179	57.495	665	15	0.08845
84	57.495	625	75	0.08545

RID	r(cm)	z(cm)	ϕ	DPD(mW/g)
116	57.495	635	315	0.1957
147	59.99	645	135	0.17575
189	57.495	665	315	0.1582
91	57.495	625	285	0.1416
179	57.495	665	15	0.1277
68	57.495	615	315	0.126
126	59.99	635	225	0.11765
131	57.495	645	15	0.1149
60	57.495	615	75	0.1097
180	57.495	665	45	0.10625

SC#8 MAXIMUM DPD REGIONS ARE SENSITIVE TO STATISITCAL FLUCTUATIONS AND UNCERTAINTIES. STRONG INDICATIONS OF REGIONS WITH   DPD > 0.15 mW/g PEAK VALUES APPEAR TO BE MOSTLY ALONG THE -y DIRECTION AND 620.0 < z < 650.0 cm. INITIAL ESTIMATIONS OF PEAK DPD FOR SC#8 ~0.054 mW/g FROM 5E05 SIMULATIONS .

SC#7-9 (SC#8 SUM) SUM OF DEPOSITED POWER USING TOTAL FROM 300 "PIECES"
0.0642 (0.0375) kW   0.0652 (0.0274) kW   0.0575 (0.0299)kW
vs. 0.065 kW WITHOUT SEGMENTATION FROM 5E05 EVENTS

THINGS TO REMEMBER.

 # THE SMALLER THE "PIECE" VOLUME, THE LARGER THE STATISTICAL UNCERTAINTY.

 # FOR CERTAIN CASES "CO-EXISTENCE" OF "SMALL" AND "LARGE" VOLUMES IS UNAVOIDABLE (SEE FOR EXAMPLE Be WINDOW CASE).

 # THE FARTHER AWAY THE VOLUME FORM THE TARGET REGION, THE LARGER THE STASTICAL UNCERTAINTY.

 # STEP SIZE RELATED ISSUES FOR THE BOUNDARIES LOCALIZATION OF THE "PIECES" AND PARTICLES TRACKING THROUGH EACH "PIECE"?

 # DP AND DPD DEPEND ON PIECES "LOCATION", SIZE. NO RECIPE FOR THE <<RIGHT>> "PIECES" SIZE AND LOCATION.

 # MANY MORE DIFFERENT SEED(NE) SIMULATIONS ARE NECESSARY TO DETERMINE STATISTICAL (PHYSICAL) FLUCTUATIONS. HOW MANY?

Hg vs. Ga TARGET   DEPOSITED POWER DISTRIBUTION STUDIES (Hg OPTIMIZED PARAMETERS USED FOR BOTH TARGETS).

POWER DEPOSITED IN THE SC COILS

NiSn/NiTi	Hg	Ga
SC#1	0.271	0.167
SC#2	0.055	0.096
SC#3	0.054	0.146
SC#4	0.054	0.104
SC#5	0.026	0.021
SC#6	0.003	0.016
SC#1-6	0.455	0.550
SC#7-9	0.072	0.100
SC#10-12	0.062	0.063
SC#13-15	0.035	0.044
SC#16-19	0.066	0.067
SC#1-19	0.690	0.842

**SC#1 ~ - 0.104 kW, SC#3, SC#4 AND SC#7-9 INCREASE IN DP.
DP IS SPREAD OUT MORE DOWNSTREAM.**

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DEPOSITED POWER IN THE SHIELDING AND SHIELDING VESSELS.

—	Hg	Ga
SH#1A	715.00	499.70
SH#1B	439.65	496.75
SH#2	192.10	313.95
SH#3	23.82	25.24
SH#4	107.45	146.45
SH#1-4	1478.02	1482.09

**SH#1 ~ - 215 kW DECREASE, SH#2 ~ + 122.0 kW INCREASE.
DP IS SPREAD OUT MORE DOWNSTREAM, MAINLY IN THE
VOLUME REGION ENCLOSED BY SC#4-SC#10.**

—	Hg	Ga
SHVS#1	118.85	80.35
SHVS#2	68.75	77.40
SHVS#3	0.57	0.54
SHVS#4	25.17	33.02
SHVS#1-4	213.34	191.31

**~38.5 kW DECREASE IN SHVS#1 AND ~ + 9.0 kW INCREASE
IN SHVS#2 DP AGAIN INDICATES ENERGY IS SPREAD OUT
MORE DOWNSTREAM.**

POWER DEPOSITED IN RESISTIVE MAGNETS (RS#) AND BEAM PIPE (BP#).

Cu	Hg	Ga
RS#1+2	134.60	84.45
RS#3	55.25	37.39
RS#4+5	69.30	46.01
RS#1-5	259.15	167.85

SIGNIFICANT DECREASE IN THE DP IN RS#1-5~ - 91 kW

BP	Hg	Ga
BP#1	206.30	152.45
BP#2	265.55	333.25
BP#3	9.30	11.10
BP#1-3	481.15	496.80

ABOUT SAME TOTAL DP IN BP#1-3, REDISTRIBUTION BETWEEN BP#1 (DECREASE IN DP) AND BP#2 (INCREASE IN DP).

SUMMARY FOR TOTAL POWER DEPOSITED IN DIFFERENT AREAS AND SC PEAK VALUES.

TOTALS	Hg	Ga
SC#1-19	0.690	0.842
SH#1-4	1478.02	1482.09
SHVS#1-4	213.34	191.31
RS#1-5	259.15	167.85
BP#1-3	481.15	496.80
Hg/Ga TARG.	408.10	179.75
Hg/GaPOOL	334.65	650.00
PulWALLS	13.25	14.77
Be WIND.	7.30	6.47
TOTAL	3195.65	3189.88

| PEAK(mW/g)	Hg	Ga
SC#1	0.030	0.025
SC#2	0.014	0.022
SC#3	0.016	0.035
SC#4	0.017	0.007
SC#5	0.030	0.016
SC#6	0.001	0.006
SC#7	0.003	0.005
SC#8	0.060	0.070
SC#9	0.060	0.150
SC#10	0.064	0.050
SC#11	0.060	0.070

Ga TARGET RECEIVES LESS THAN HALF THE POWER DEPOSITED IN Hg, WHILE Ga POOL ABOUT TWICE AS MUCH AS THE Hg POOL.

Ga ATOMS HAVE MUCH SMALLER ATOMIC NUMBER (31) THAN Hg ATOMS (80) SMALLER NUMBER OF PROTONS INTERACTS WITH THE TARGET AND MORE WILL END UP IN THE Ga POOL.

Be WINDOW ABOUT 1 kW LESS DP IN Ga.

INDICATIONS OF LARGE DPD VALUES IS SC#9 REGION.

π± SPECTRUM HISTOGRAM PLOTS AT z = 1900 cm FOR Hg AND Ga TARGETS.
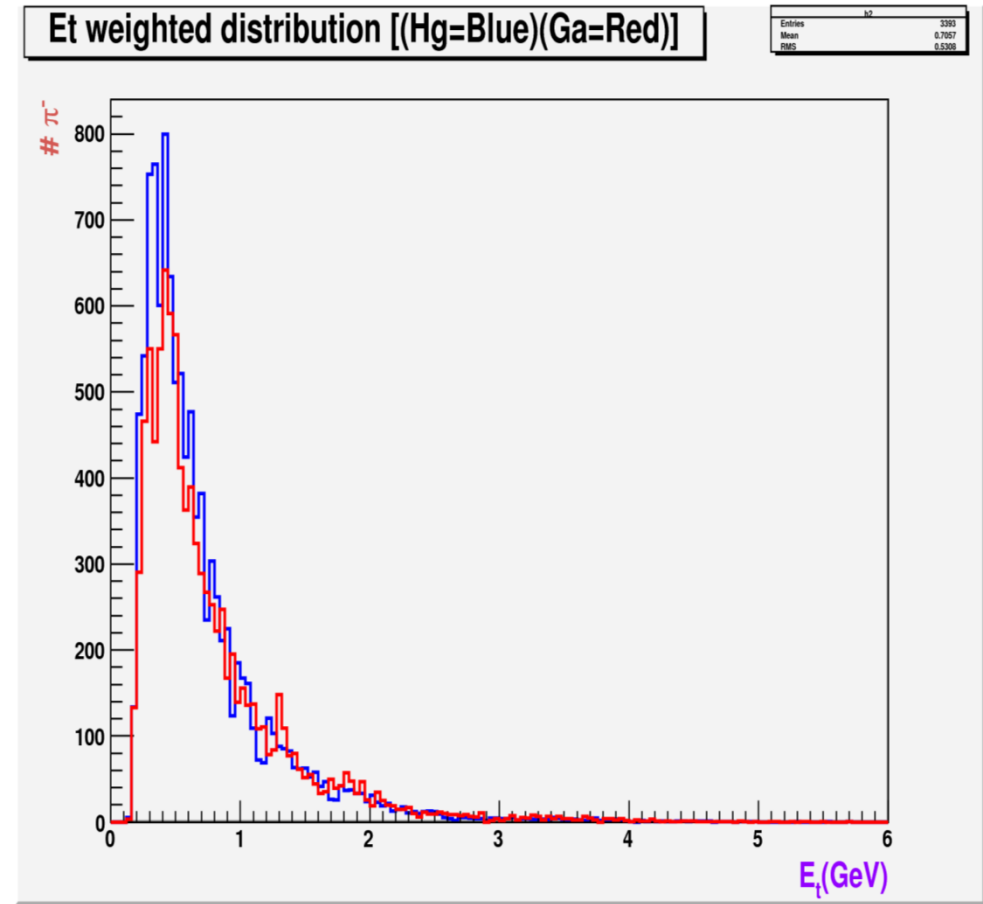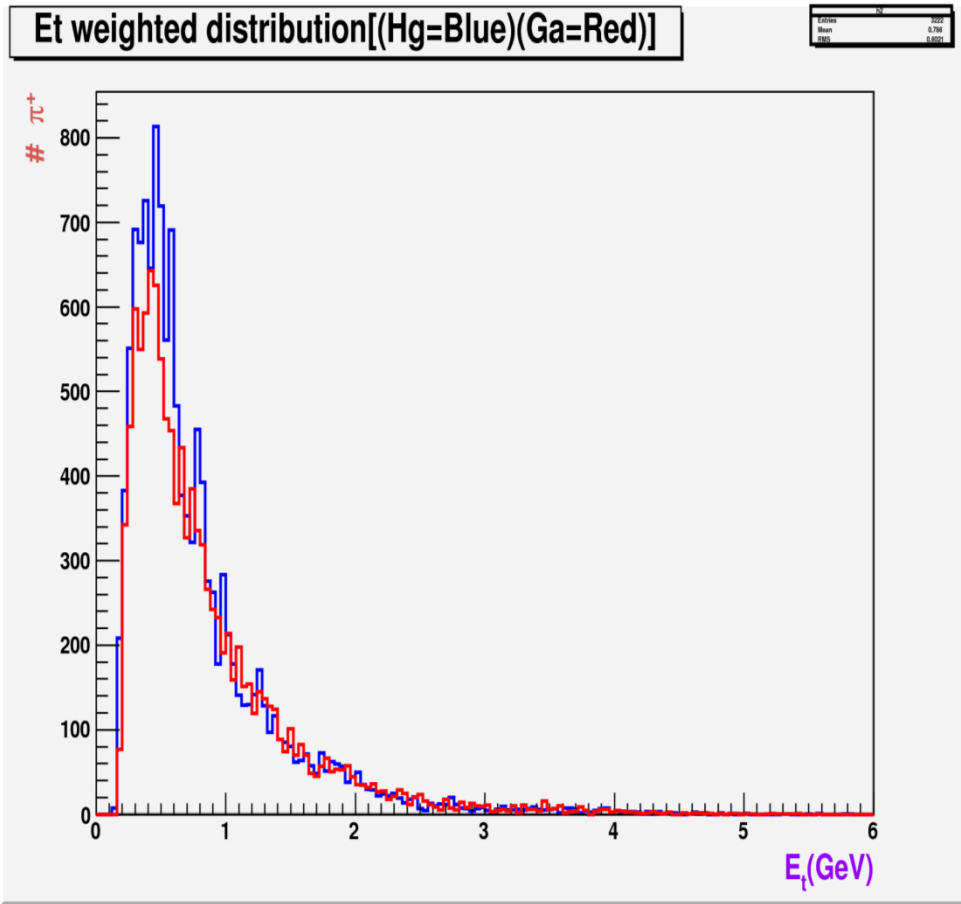
PARTICLE(TARGET):	π=(Hg)	π=(Ga)	π⁻(Hg)	π⁻(Ga)
# EVENTS PRODUCING:	3222	2666	3393	2971
# DIFFERENT EVENTS PRODUCING:	3194	2630	3372	2946
TOTAL # OF PARTICLES:	13047	11591	10980	9765
# OF PARTICLES WITH 40<KE<180 MeV:	1764	1438	1854	1389

μ± SPECTRUM HISTOGRAM PLOTS AT z = 1900 cm FOR Hg AND Ga TARGETS.
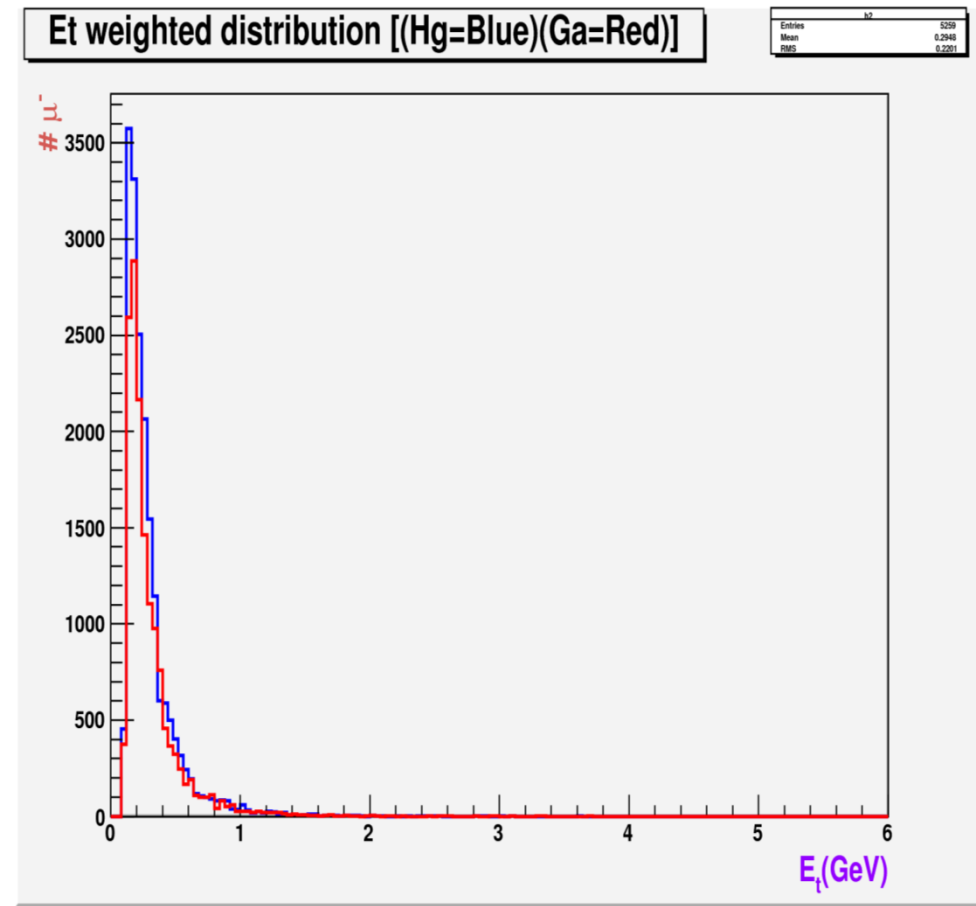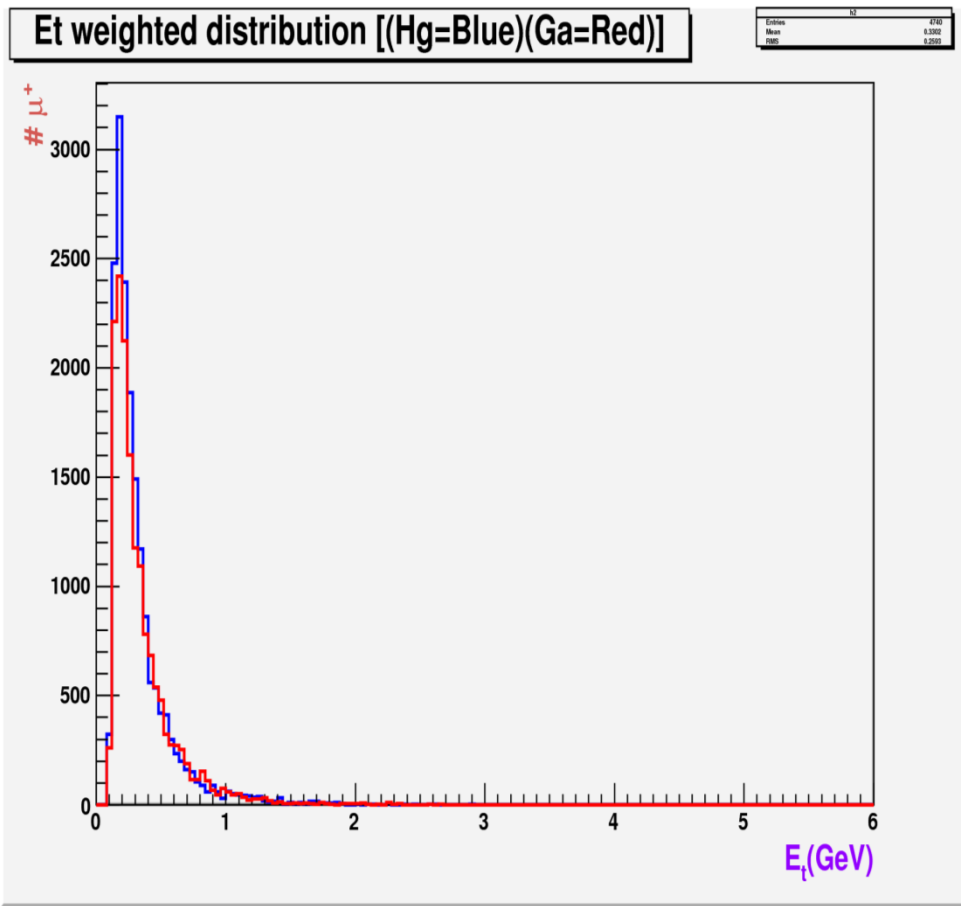
PARTICLE(TARGET):	μ=(Hg)	μ=(Ga)	μ-(Hg)	μ-(Ga)
# EVENTS PRODUCING:	4740	3458	5259	3485
# DIFFERENT EVENTS PRODUCING:	4428	3240	4915	3341
TOTAL # OF PARTICLES:	17707	15838	18526	15029
# OF PARTICLES WITH 40 < KE < 180 MeV:	8759	7223	9713	7802

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