SUPERCONDUCTING SOLENOIDS - SHIELDING STUDIES 1.

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Energy deposition from MARS and MARS+MCNP codes.

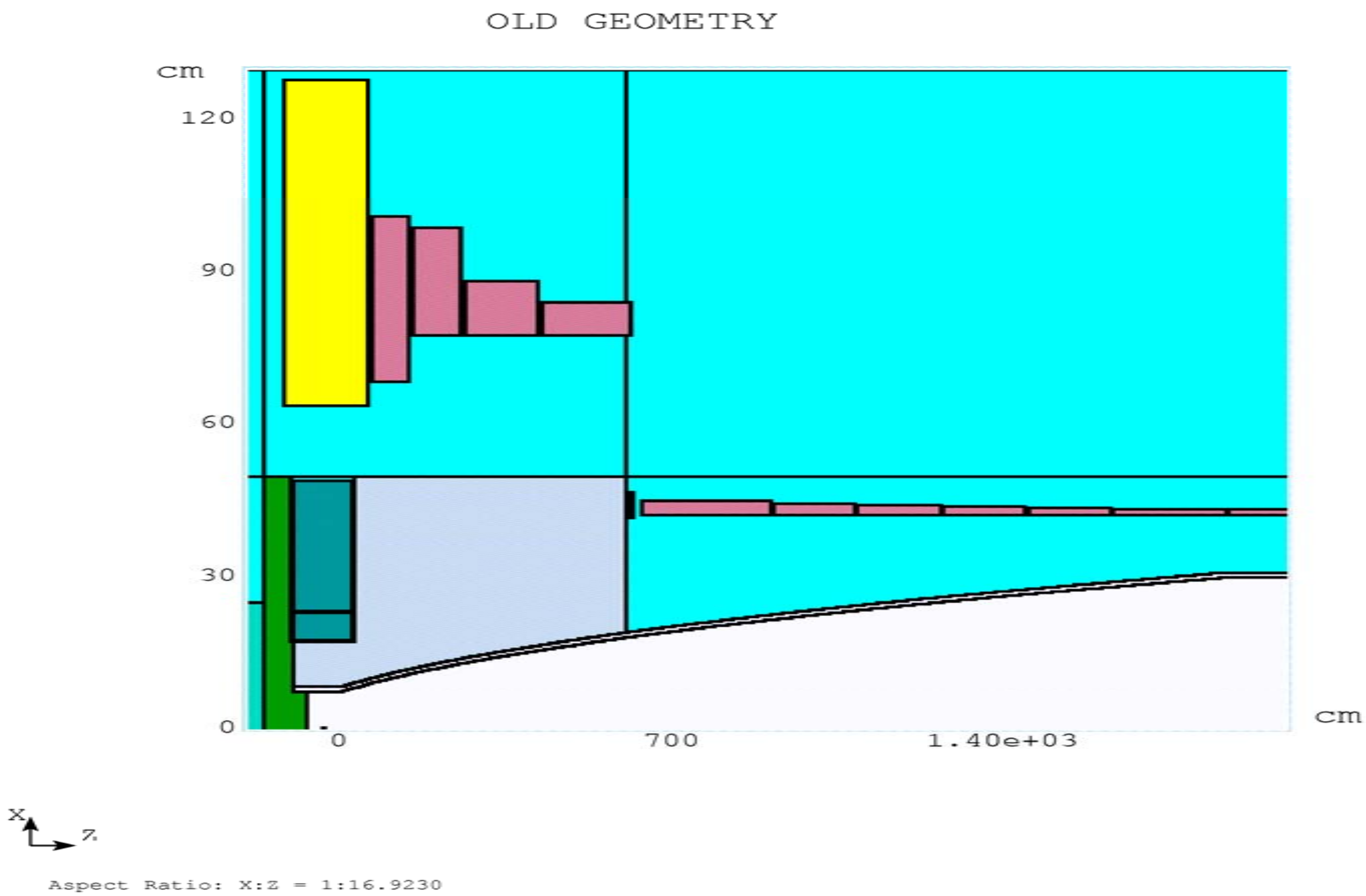
STANDARD GEOMETRY,STANDARD SHIELDING(80%WC+20% H_2O)

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

E=8 GeV, 4MW proton beam

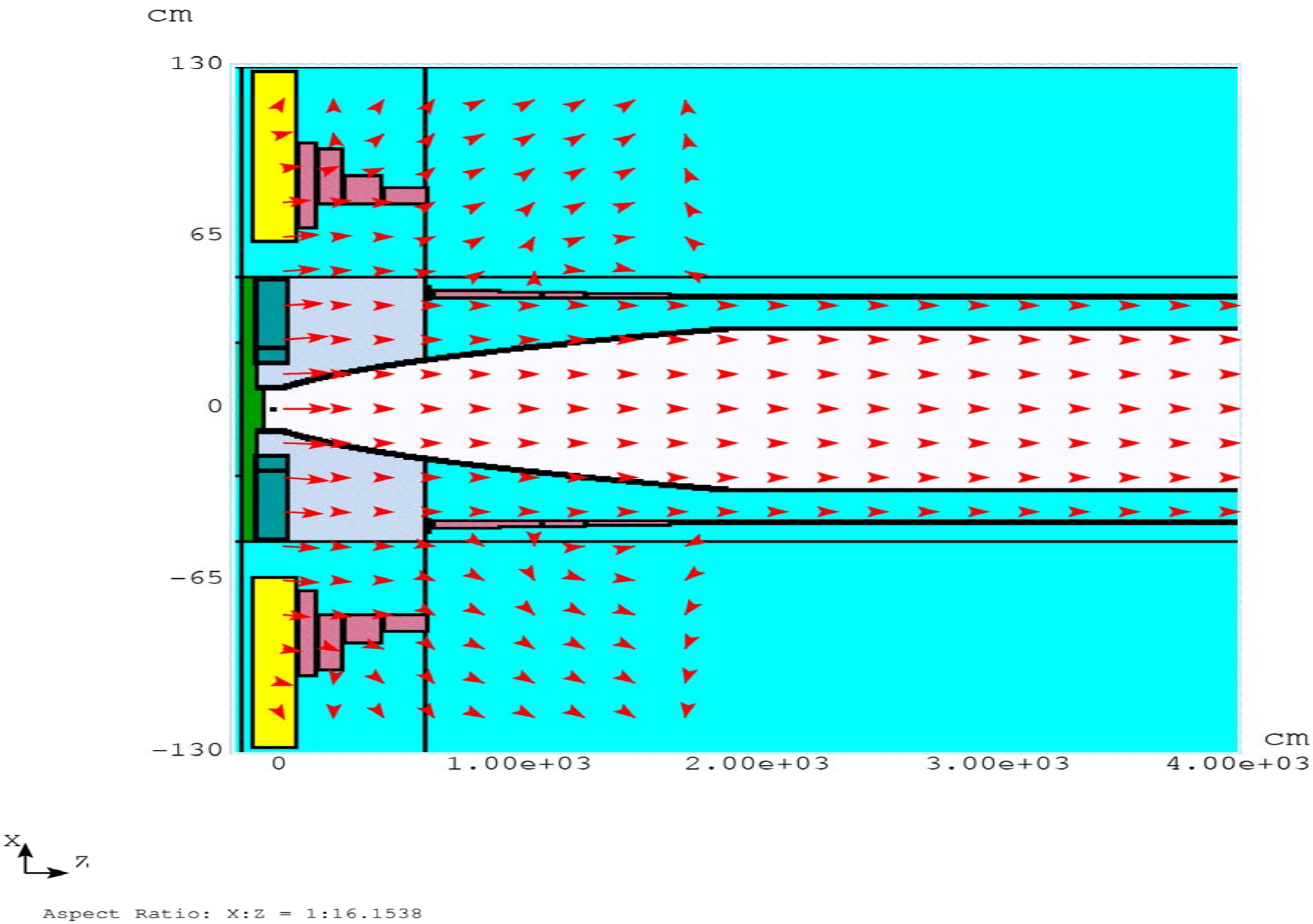
also introducing a 20 MeV neutron energy cutoff.

STANDARD (OLD) SOLENOID GEOMETRY



SC#1 -120<z<57.8 cm R_{in}=63.3 cm R_{out}=127.8 cm
SC#2 67.8<z<140.7 cm R_{in}=68.6 cm R_{out}=101.1 cm
SC#6-13 632.5<z<218.7 cm R_{in}=42.2 cm R_{out}=45.1-->43.4 cm (TOTAL # SC=13)

STANDARD (OLD) SOLENOID GEOMETRY: MAGNETIC FIELD



Energy deposition from MARS and MARS+MCNP codes, also by introducing a 20 MeV neutron energy cutoff.

(STANDARD GEOMETRY, 80%WC+20% H2O SHIELDING)

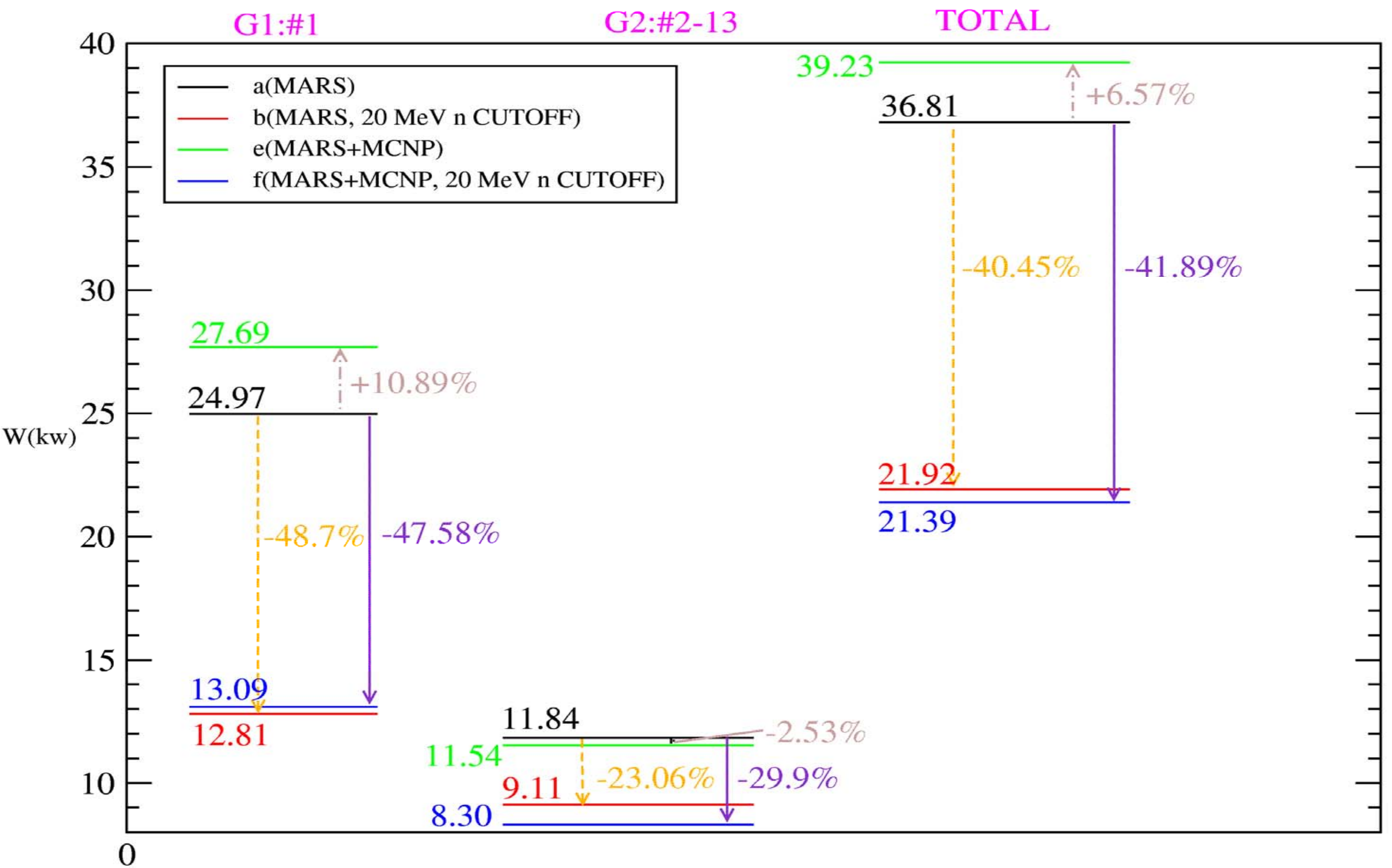
Table 0.1: (10/5/2010)

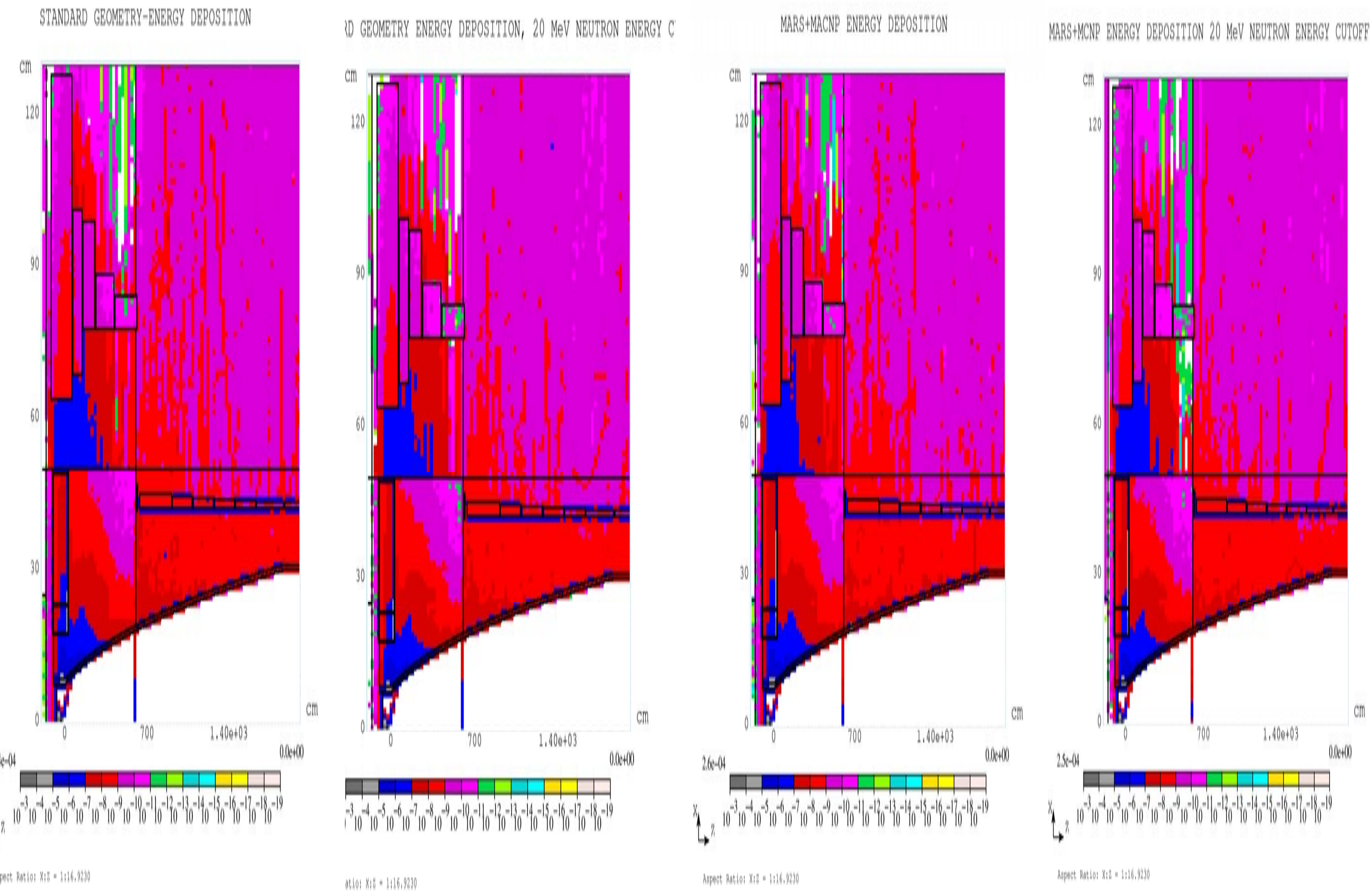
N_p=100,000 , STANDARD GEOMETRY,13 SC COILS, 2 SC groups:G1=1, G2=2-13
STANDARD SHIELDING WITH: 80% WC+20% H_2O
SOLENOID MATERIALS: SC#1-13=SCON (NiTi+Cu+..)
a=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
b=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥20 MeV)
c=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥50 MeV)
d=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥150 MeV)
e=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
f=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥20 MeV)
g=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥50 MeV)
h=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥150 MeV)
i=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian,Ding/def SCON)
j=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian,I define SCON)

Table 0.2: POWER OF DEPOSITED ENERGY IN KW, DW/W %=((W_x-W_a)/W_a) x100 where x=b,c,d. (10/5/2010)

	G1	%	G2	%	Total	%
a	24.97	–	11.84	–	36.81	–
b	12.81	-48.70	9.11	-23.06	21.92	-40.45
c	8.31	-66.72	7.73	-34.71	16.03	-56.45
d	2.22	-91.11	6.70	-43.41	8.92	-75.77
e	27.69	+10.89	11.54	-2.53	39.23	+6.57
f	13.09	-47.58	8.30	-29.90	21.39	-41.89
g	7.78	-68.84	7.39	-37.58	15.17	-58.79
h	2.43	-90.27	6.01	-49.24	8.44	-77.07
i	24.91	–	11.23	–	36.13	–
j	24.73	–	12.09	–	36.81	–

N_p=100,000, E_p= 8GeV, 4 MW, standard geom., 13 SC, 80%WC+20% H_2O, SC:1-13(SCON), DEPOSITED ENERGY POWER





Power peaks at 5 mW/gr

Energy deposition from MARS+MCNP code. Introducing different neutron energy cutoffs.

(STANDARD GEOMETRY, 80% WC+20% H_2O SHIELDING)

Table 0.3(10/5/2010)

	$E_n \geq E_i$(MeV)	SC#1	%	SC#2-13	%	Total	%
1	$1\ 10^{-11}$	37.94	–	12.25	–	50.19	–
2	$1\ 10^{-6}$	31.64	-16.60	11.60	-5.31	43.24	-13.85
3	$1\ 10^{-5}$	30.59	-19.37	11.28	-7.92	41.87	-16.58
4	$1\ 10^{-4}$	29.50	-22.25	11.57	-5.51	41.06	-18.19
5	$1\ 10^{-3}$	29.00	-23.56	11.03	-9.96	40.03	-20.24
6	$1\ 10^{-2}$	28.47	-24.96	11.17	-8.81	39.63	-21.04
7*	$1\ 10^{-1}$	27.69	-27.02	11.54	-5.80	39.23	-21.84
8	$1\ 10^{0}$	26.73	-29.55	11.42	-6.78	38.15	-23.99
9	$1\ 10^{+1}$	20.51	-45.94	9.97	-18.61	30.48	-39.27
10*	$2\ 10^{+1}$	13.09	-65.50	8.30	-32.24	21.39	-57.38
11	$5\ 10^{+1}$	7.78	-79.49	7.39	-39.67	15.17	-69.77
12	$15\ 10^{+1}$	2.43	-90.27	6.01	-49.24	8.44	-83.18

CASE 7: MARS DEFAULT NEUTRON ENERGY CUTOFF.

CASE 10: MCNP HANDLES ALL NEUTRONS FOR ALL ISOTOPES UP TO 20 MeV, BEYOND THAT, UP T0 150 MeV ONLY CERTAIN CASES.

Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different neutron energy cutoffs (10^{-6} to 150 MeV)
(MARS+MCNP) 80% WC+20% H_2O shielding, 8 GeV protons, 4 MW, Gaussian Distribution $\sigma_x=\sigma_y=0.12$ cm

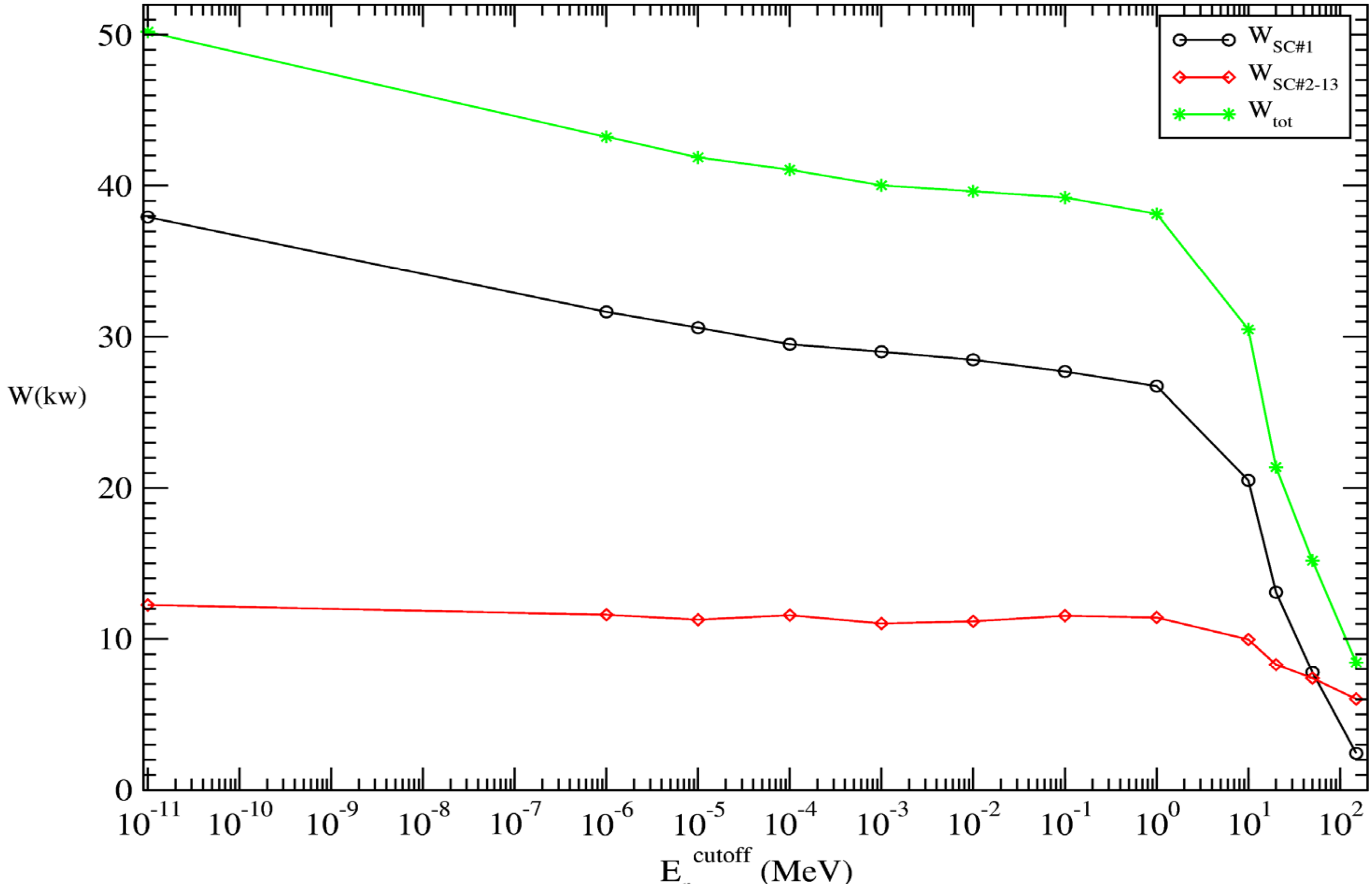


Table 0.4: MARS+MCNP, STANDARD GEOMETRY, 8 GeV, 4 MW, GAUSSIAN (σ_x = σ_y =0.12 cm), 80% WC+20% H_2O SHIELDING, POWER OF DEPOSITED ENERGY IN KW, INITIALIZING MARS WITH DIFFERENT SEEDS(NOTICE:last case s is the seed used throughout in the rest of our studies) . (10/8/2010)

	SEED(8 DIG.)	SC#1	SC#2-13	Total
1	23765224	27.56	11.28	38.83
2	35765224	27.49	11.31	38.80
3	77225426	27.76	11.06	38.82
4	66666666	27.34	11.19	38.53
5	12345671	27.91	11.20	39.11
6	52255524	27.27	11.43	38.70
7	23445625	27.58	11.38	38.96
8	36264424	27.11	10.87	37.97
9	73275327	27.11	11.52	38.63
10	66265556	28.00	10.93	38.93
–	MIN	27.11	10.87	37.97
–	MAX	28.00	11.52	39.11
–	AVERAGE	27.51	11.22	38.73
–	σ(Deviat.)	0.296	0.201	0.298
s	55265522	27.64	11.54	39.23

Energy deposition from MARS and MARS+MCNP codes .

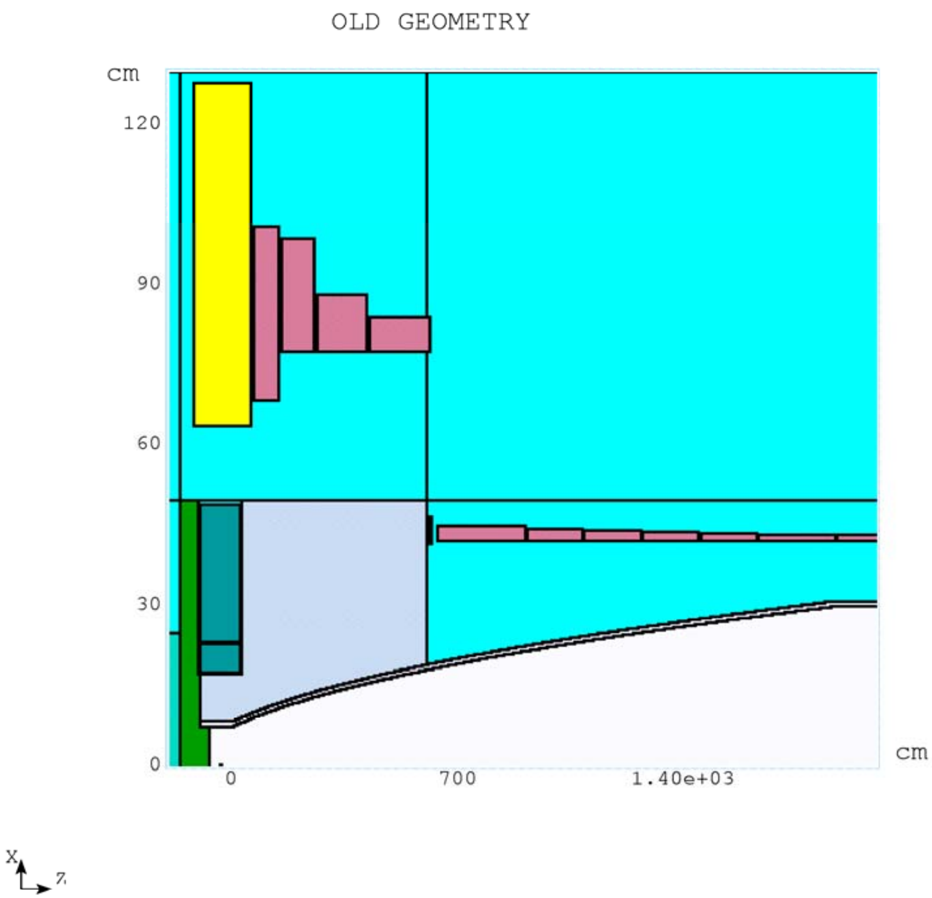
IDS80 GEOMETRY, STANDARD SHIELDING(60%WC+40% H_2O)

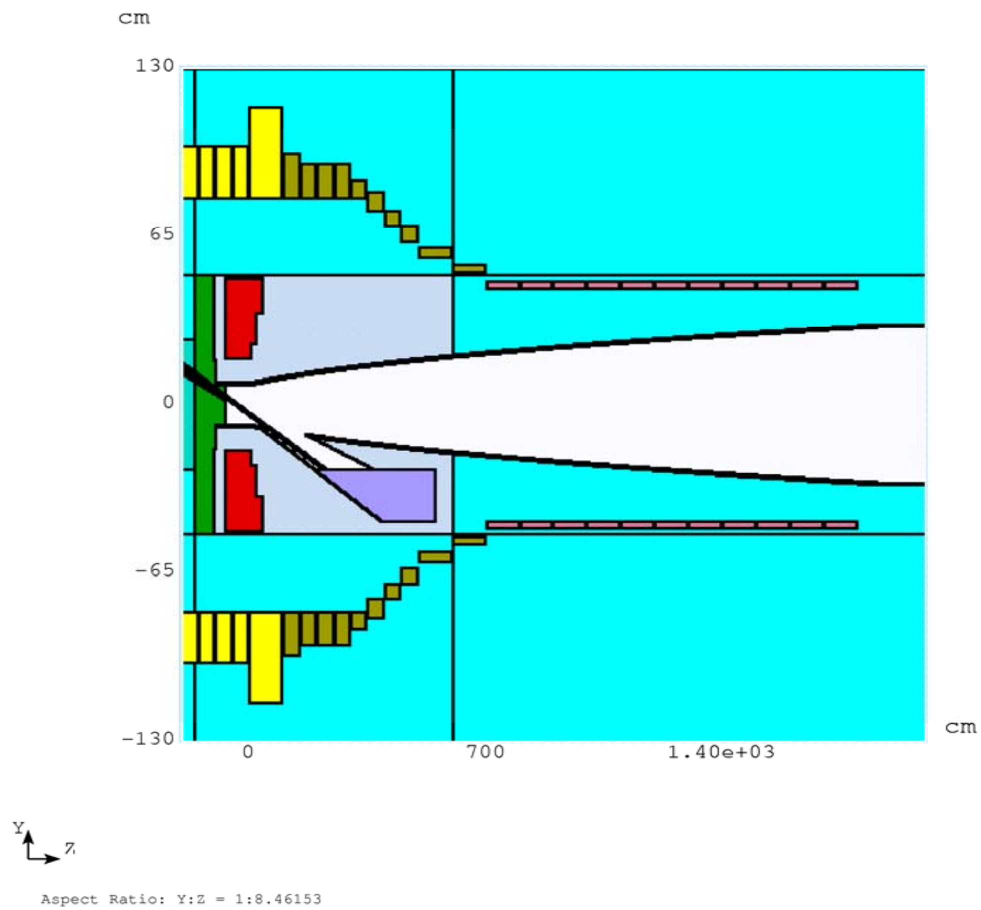
GAUSSIAN PROFILE: $\sigma_x=\sigma_y=0.12$ cm

E=8 GeV, 4MW proton beam

also introducing a 20 MeV neutron energy cutoff

STANDARD (OLD) VS. IDS80 (NEW) SOLENOID GEOMETRY
(IDS80 WITH STANDARD SHIELDING BUT 60%WC+40% H2O)





OLD : SC#1 -120<z<57.8 cm R_{in}=63.3 cm R_{out}=127.8 cm
SC#2 67.8<z<140.7 cm R_{in}=68.6 cm R_{out}=101.1 cm
SC#6-13 632.5<z<218.7 cm R_{in}=42.2 cm R_{out}=45.1-->43.4 cm (TOTAL # SC=13)

NEW: SC#1-10 -200<z<345 cm R_{in}=80.0 cm R_{out}=100 (1-4)/115 (5)/97 (6)/93(7-9)/87(10)cm
SC#11-15 350<z<695 cm R_{in}=75.0-->51 cm R_{out}=82.0-->54 cm
SC#16-26 700<z<1795 cm R_{in}=45 cm R_{out}=48 cm (TOTAL # SC=26)

Energy deposition from MARS and MARS+MCNP codes, also by introducing a 20 MeV neutron energy cutoff.

(IDS80 WITH STANDARD SHIELDING+GAUSSIAN PROFILE BEAM)

Table 0.4: (10/4/2010)

N_p=100,000 , 4 SC groups:G1=1-5, G2=6-10, G3=11-15, G4=16-26
STANDARD SHIELDING WITH: 60% WC+40% H_2O
SOLENOID MATERIALS: SC#1-10=NBSN (Ni+..) and SC#11-26=SCON (NiTi+Cu+..)
a=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
b=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, $E_n \geq$20 MeV)
c=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
d=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, $E_n \geq$20 MeV)

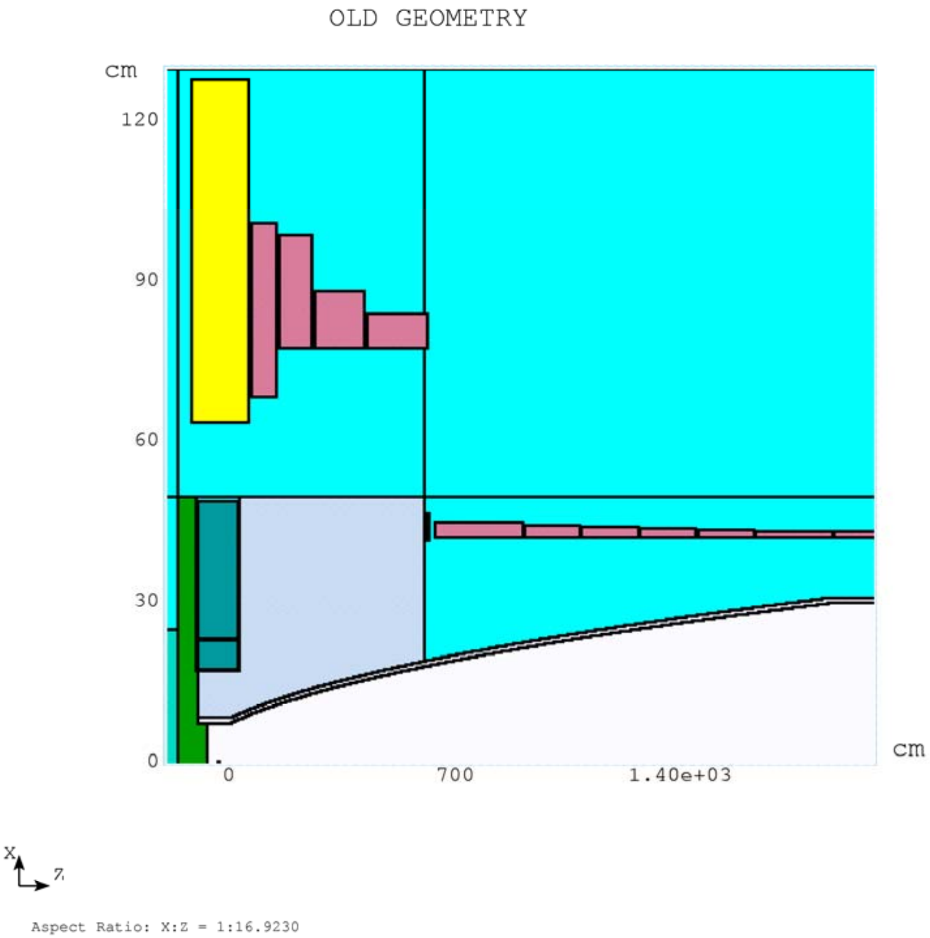
Table 0.5: POWER OF DEPOSITED ENERGY IN KW, DW/W %=((W_x-W_a)/W_a) x100 where x=b,c,d. (10/4/2010)

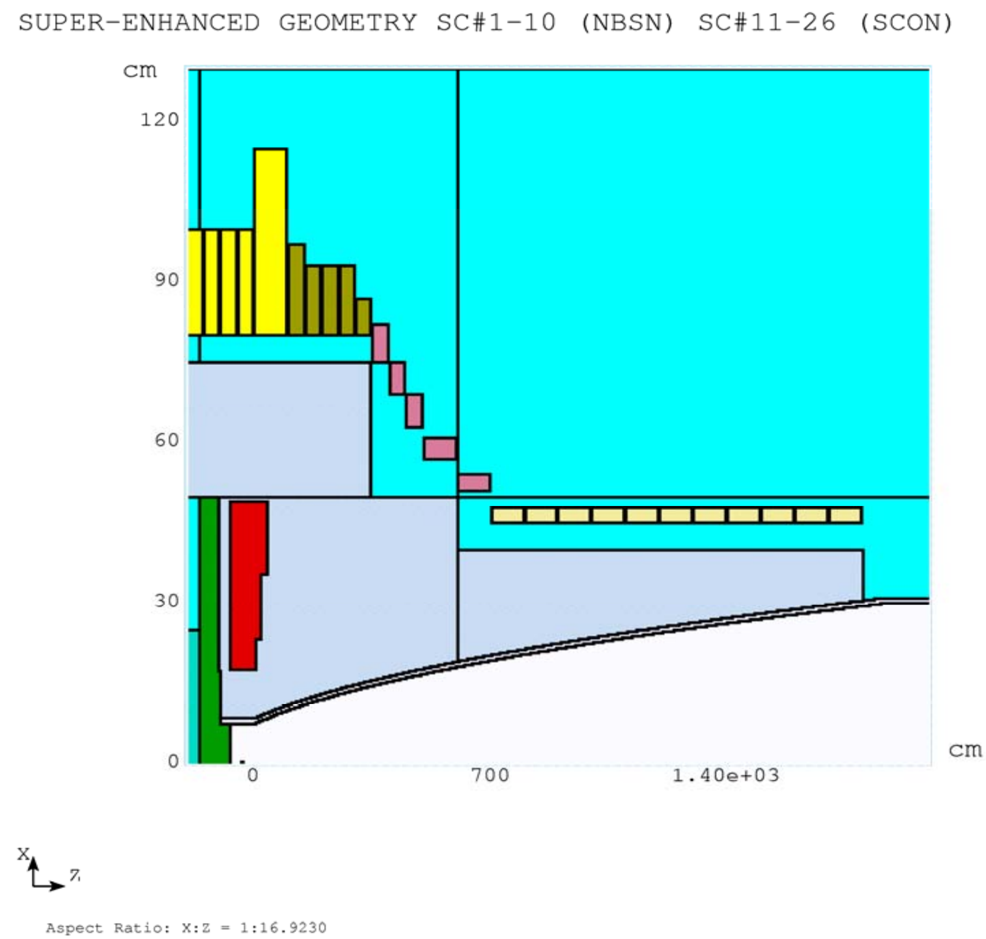
	G1	%	G2	%	G3	%	G4	%	Total	%
a	11.56	–	2.606	–	0.807	–	9.870	–	24.843	–
b	6.185	-46.50	1.500	-42.43	0.823	+1.98	8.665	-12.21	17.730	-30.87
c	12.925	+11.81	2.707	+3.90	0.702	-13.01	9.465	-4.10	25.800	+3.86
d	6.240	-46.02	1.437	-44.86	0.654	+18.95	8.880	-10.03	17.211	-30.72

Energy deposition for diferent initial beam profiles and energies. MARS, MARS+MCNP results (IDS80 SUPER-ENHANCED SHIELDING)

- Uniform denstity in square region
  $[-\sigma_x, \sigma_x]x[-\sigma_y, \sigma_y]$
  a) $\sigma_x=\sigma_y=0.12$ cm
  b) $\sigma_x=\sigma_y=0.30$ cm
  for E=8.0 GeV, 4MW proton beam
- Gaussian profile $\sigma_x=\sigma_y=0.12$ cm
  a) E=7.5 GeV
  b) E=8.5 GeV
- MARS+MCNP results for gaussian profile
- Use a 20 MeV neutron energy cutoff (MARS, MARS+MCNP)-->?

OLD VS. NEW SOLENOID GEOMETRY (IDS80 SUPER-ENHANCED SHIELDING)





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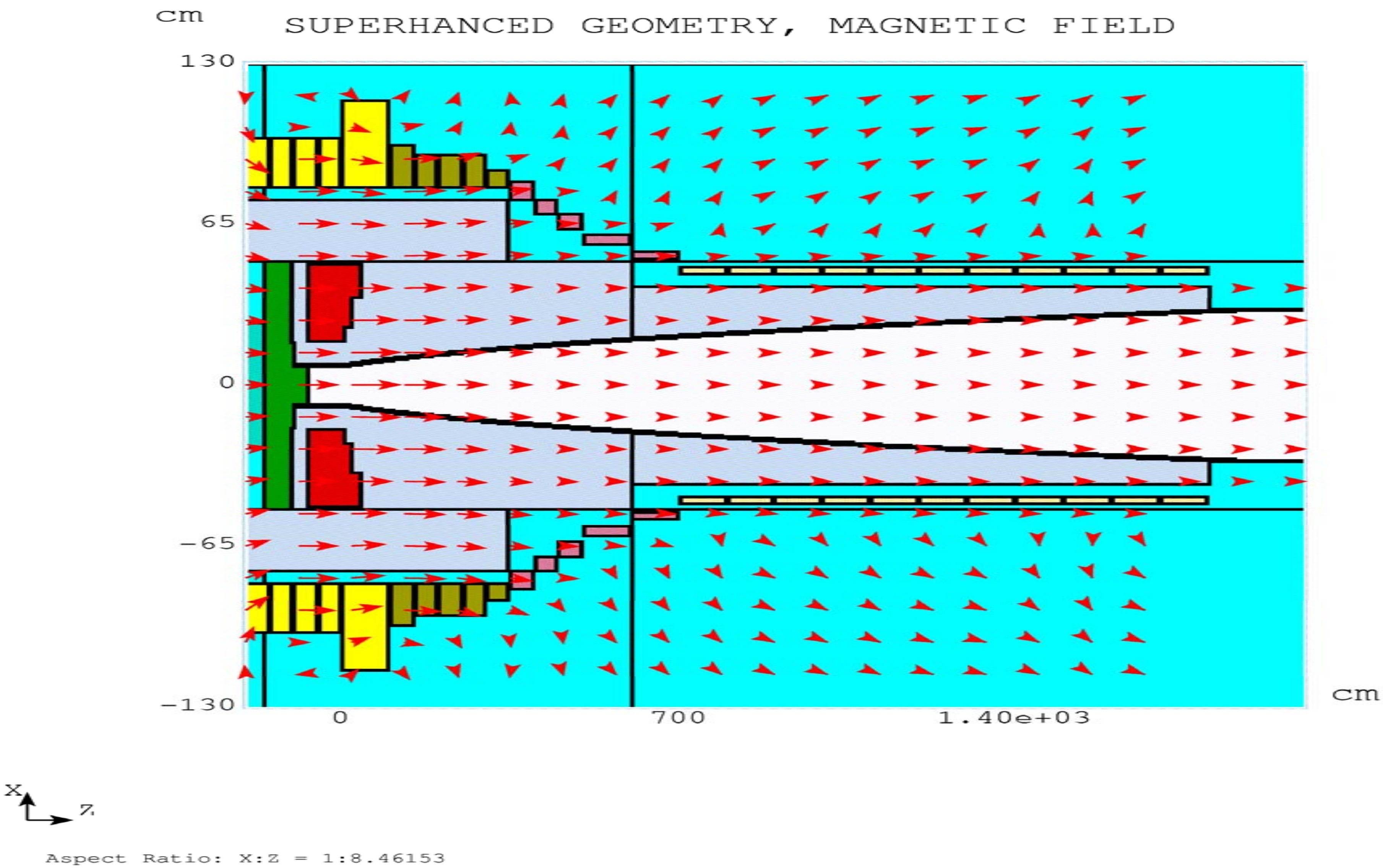
SC#16-26 700<z<1795 cm R_{in}=45 cm R_{out}=48 cm (TOTAL # SC=26)

Magnetic field for IDS80 with super-enhanced shielding.



RESULTS p1

Table 0.6: (9/30/2010)

N_p=100,000 , 4 SC groups:G1=1-5, G2=6-10, G3=11-15, G4=16-26
SUPERENHANCED SHIELDING WITH: 60% WC+40% H_2O
SOLENOID MATERIALS: SC#1-10=NBSN (Ni+..) and SC#11-26=SCON (NiTi+Cu+..)
a=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
b=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Uniform/square)
c=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.3 cm Uniform/square)
d=(E_p=7.5 GeV, 4 MW BEAM (NORM.), σ_x=σ_y=0.12 cm Gaussian)
e=(E_p=8.5 GeV, 4 MW BEAM (NORM.), σ_x=σ_y=0.12 cm Gaussian)
f=(E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥20 MeV)
g=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian)
h=MARS+MCNP (E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian, E_n ≥20 MeV)

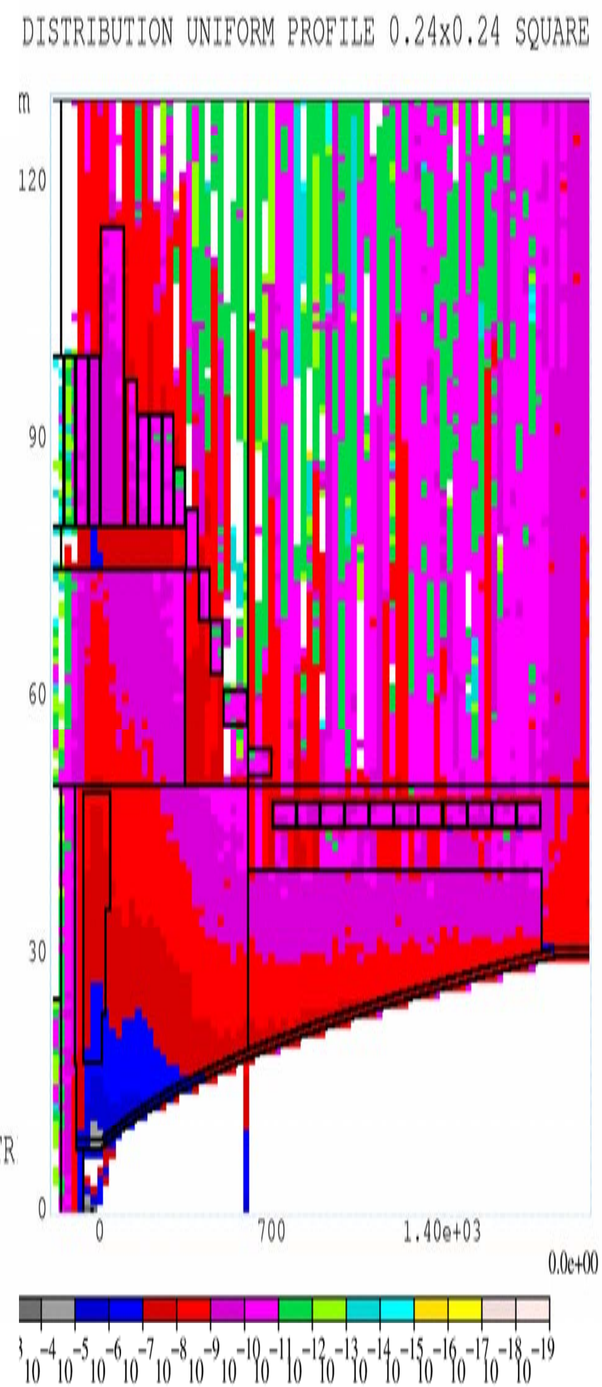
Table 0.7: POWER OF DEPOSITED ENERGY IN KW, DW/W %=((W_x-W_a)/W_a) x100 where x=b,c,d,e,f,g,h. (9/30/2010)

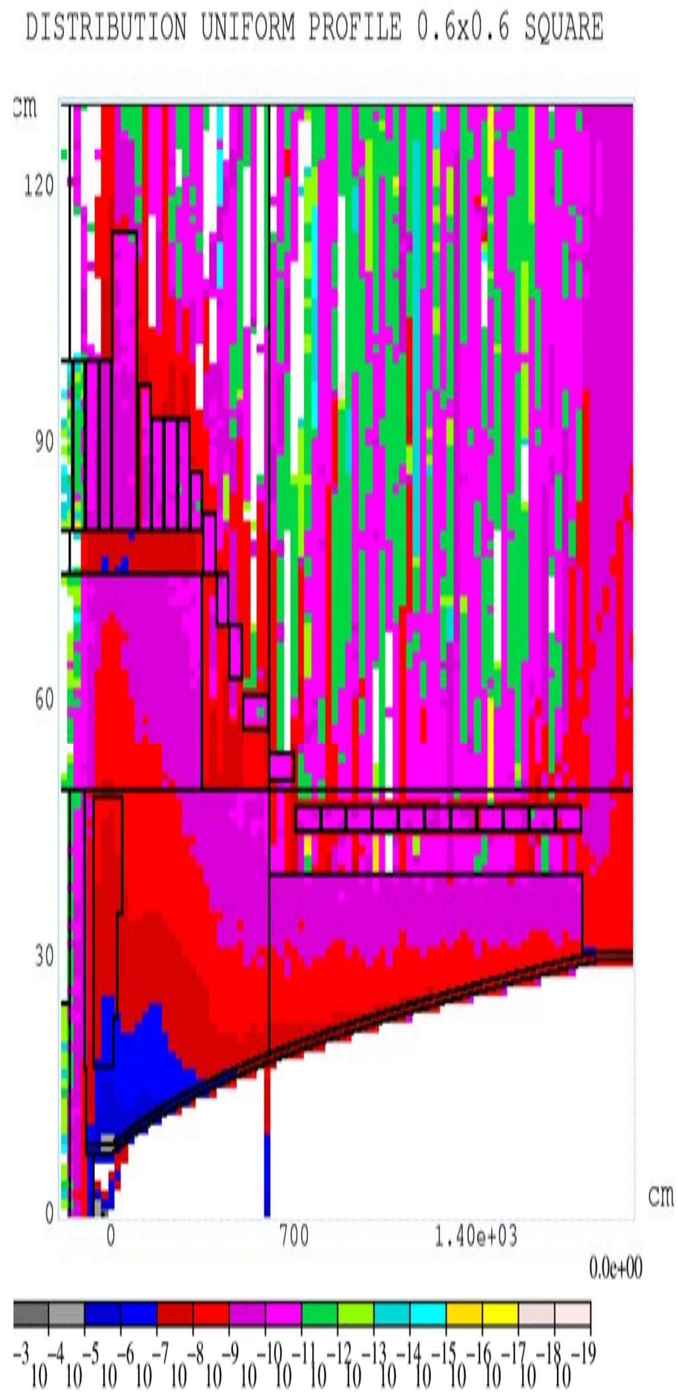
	G1	%	G2	%	G3	%	G4	%	Total	%
a	1.830	–	0.386	–	0.132	–	0.264	–	2.612	–
b	1.853	+1.26	0.329	-14.77	0.110	-16.67	0.294	+11.36	2.586	-0.99
c	1.725	-5.74	0.395	+2.33	0.119	-9.85	0.252	-4.55	2.491	-4.86
d	1.749	-4.43	0.346	-10.36	0.115	-12.88	0.241	-8.71	2.451	-6.16
e	1.757	-3.99	0.341	-11.66	0.143	+8.33	0.249	-5.68	2.489	-4.71
f	1.025	-43.99	0.266	-31.09	0.089	-32.58	0.146	-44.70	1.526	-41.58
g	1.980	+8.20	0.413	+6.99	0.146	+10.61	0.245	-7.20	2.784	+6.58
h	1.165	-36.34	0.232	-39.90	0.075	-43.18	0.200	-24.24	1.672	-35.99

RESULTS p2

Table 0.8: POWER OF DEPOSITED ENERGY IN KW, a=MARS, b=MARS+MCNP (default $E_n \geq 0.1$ MeV), c=MARS+MCNP (Choose $E_n \geq$ 20 MeV), 3 SC coil groups, SC#1-15=NBSN material (Ni alloy) SC#16-26 SCON material (NiTi and Cu alloy) (correct materials SC#1-10=NBSN and SC#11-26=SCON), SUPERENHANCED GEOMETRY 60% WC+40% H_2O, DW/W %=$((W_x\text{-}W_a)/W_a)$ x100 where x=b,c. (9/30/2010)

N_p=100,000, E_p=8 GeV, 4 MW, $\sigma_x=\sigma_y$=0.12 cm Gaussian, 3 SC groups								
mode/ SC	#1-5	%	#6-15	%	#16-26	%	Total	%
a	1.769	–	0.5435	–	0.2709	–	2.5843	–
b	1.9255	+8.8	0.585	+7.63	0.25395	-6.25	2.764	+6.971
c	1.048	-40.7	0.313	-42.41	0.183	-32.44	1.544	-40.25





In GeV/gr/proton, peak 0.5 mW/gr

Aspect Ratio: X:Z = 1:16.9230

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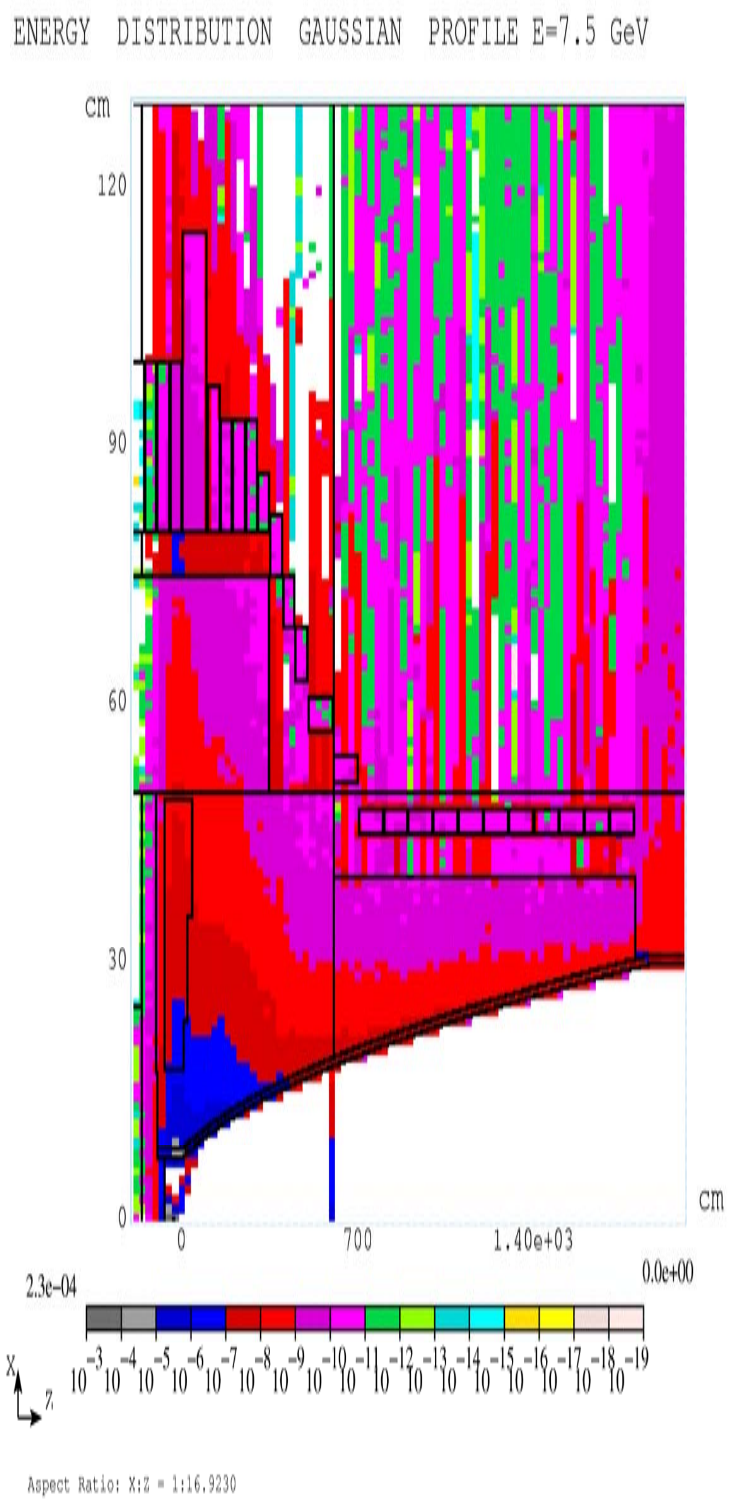
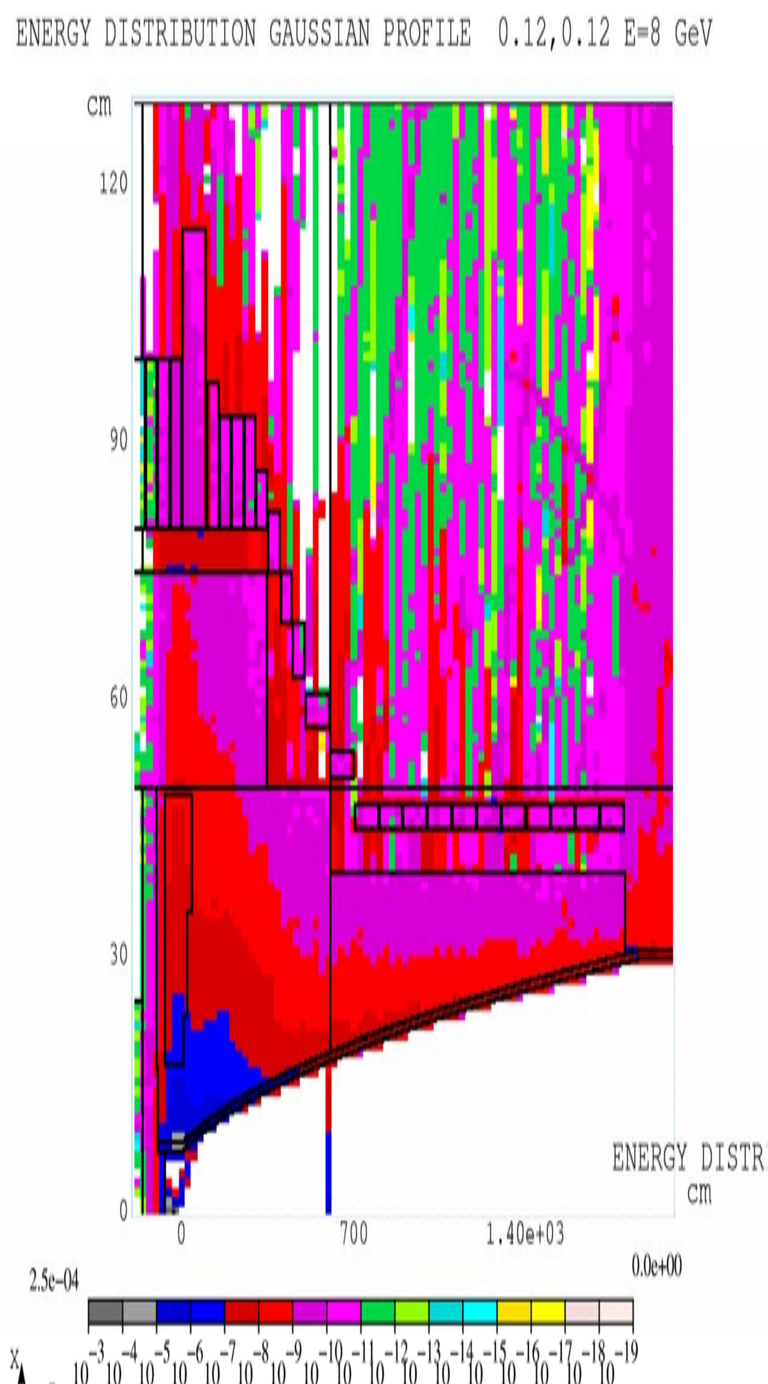
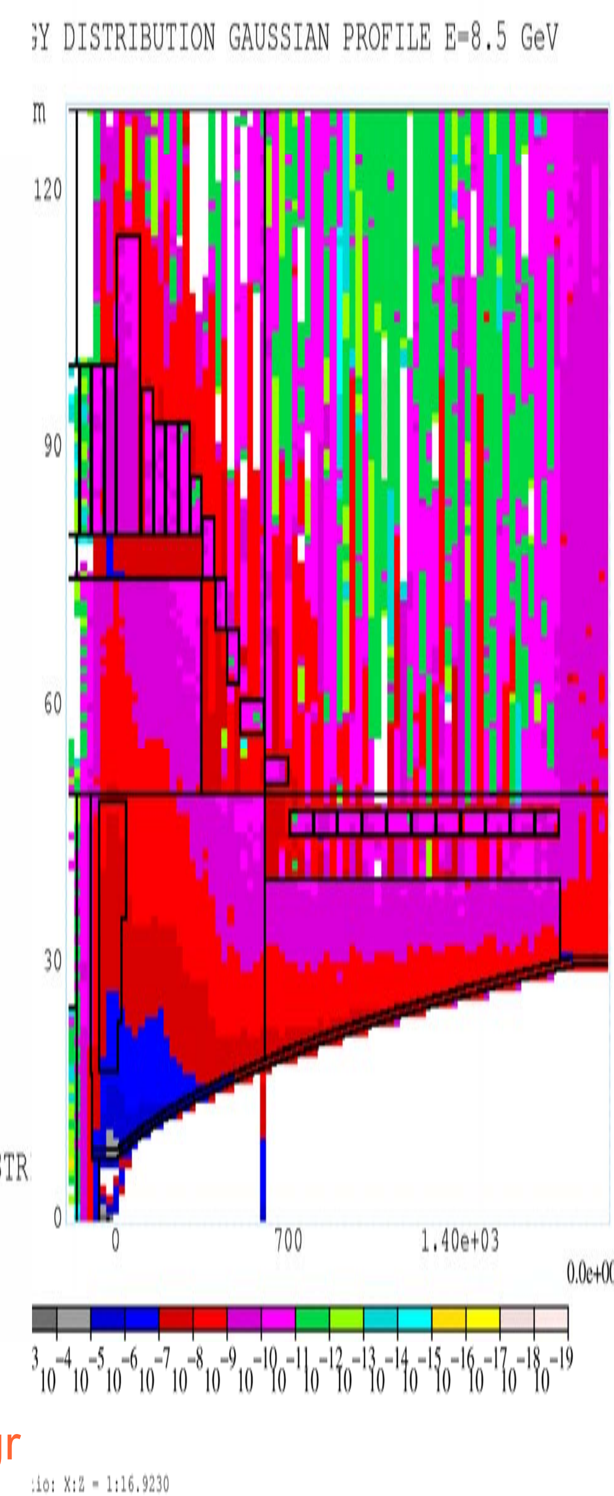
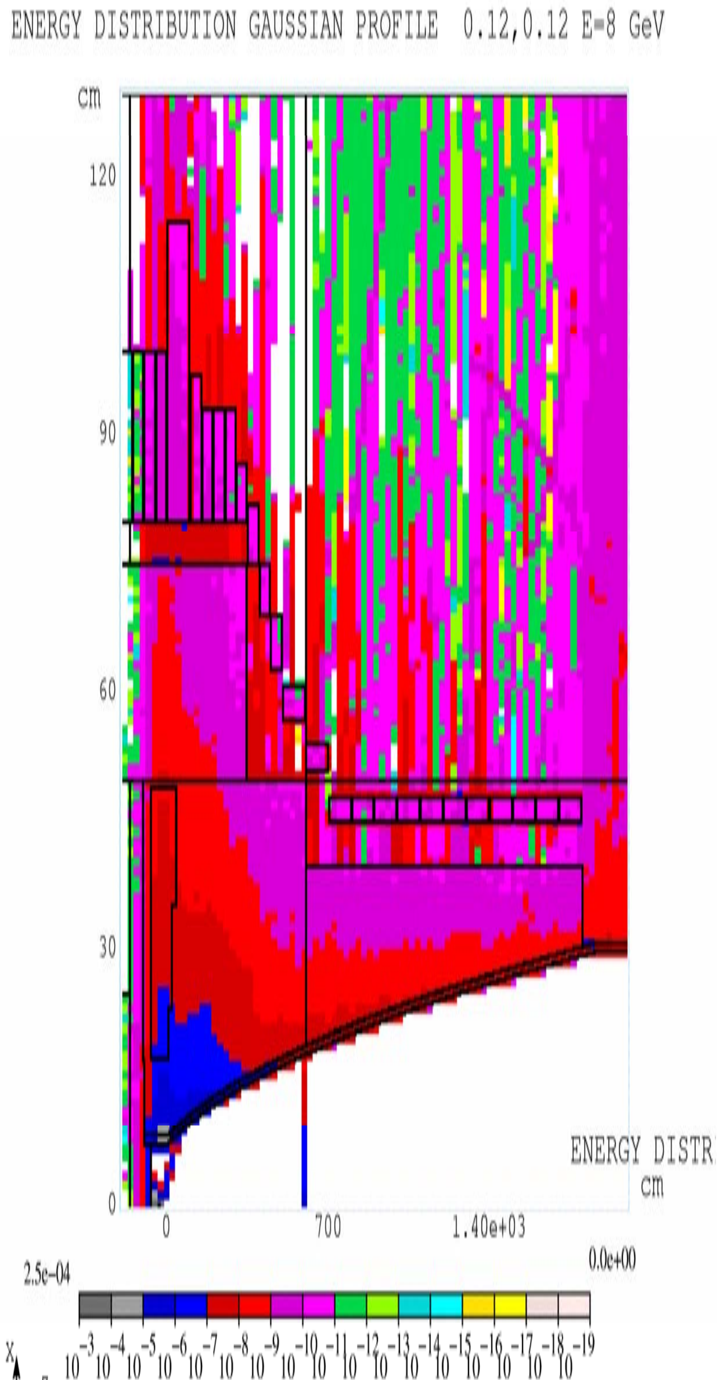
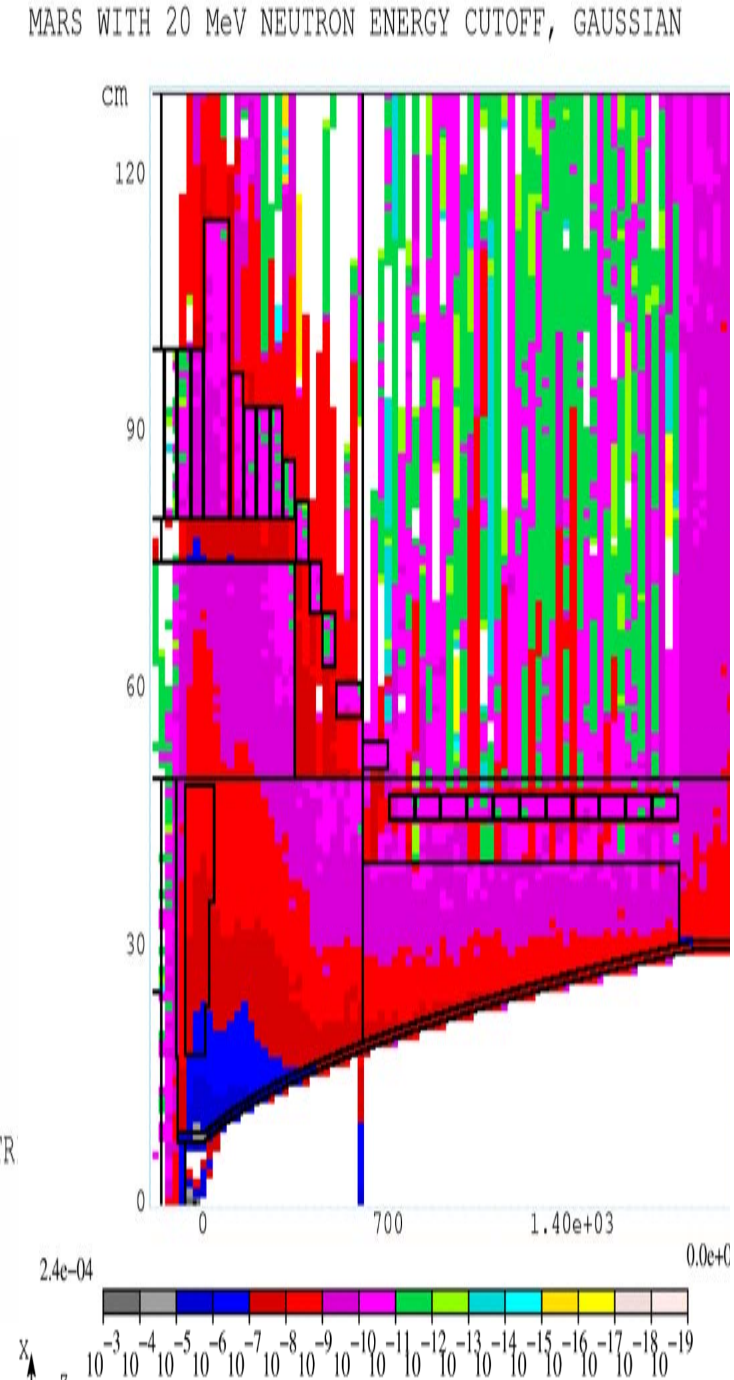


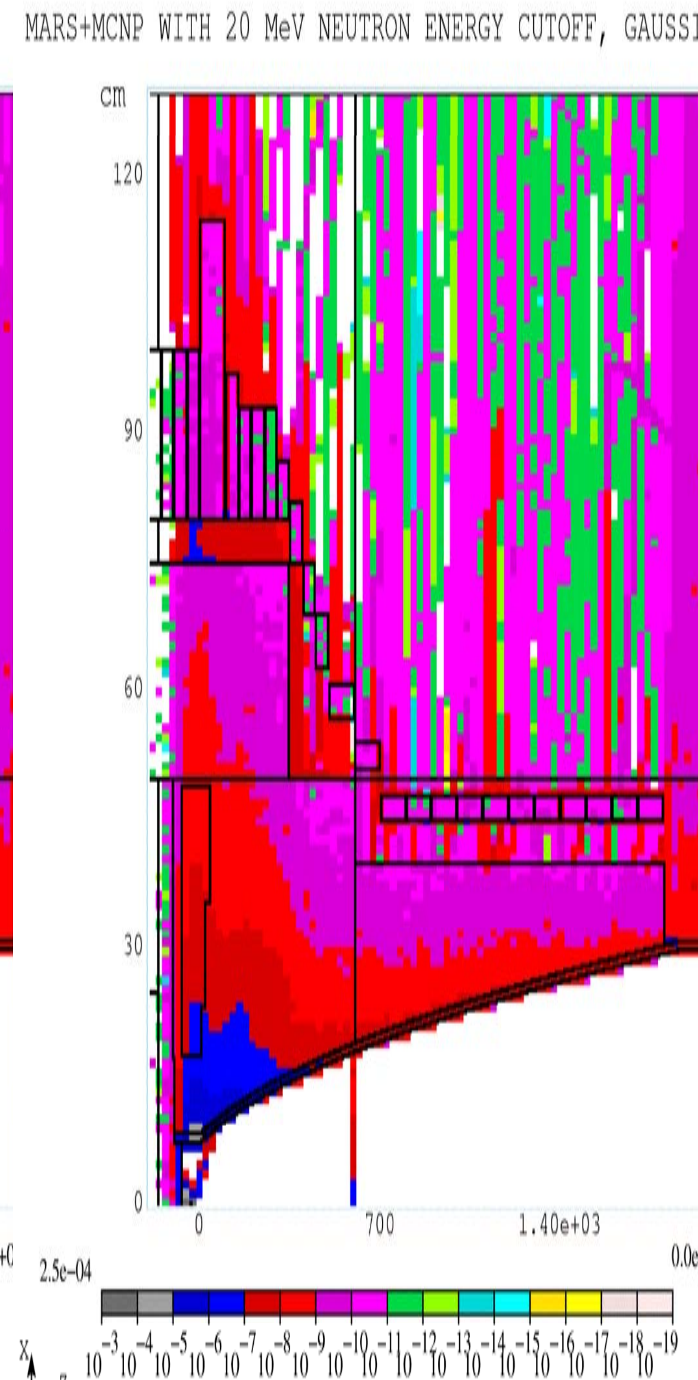


In GeV/gr/proton, peak 0.5 mW/gr









In GeV/gr/proton, peak 0.5 mW/gr

Aspect Ratio: X:Z = 1:16.9230

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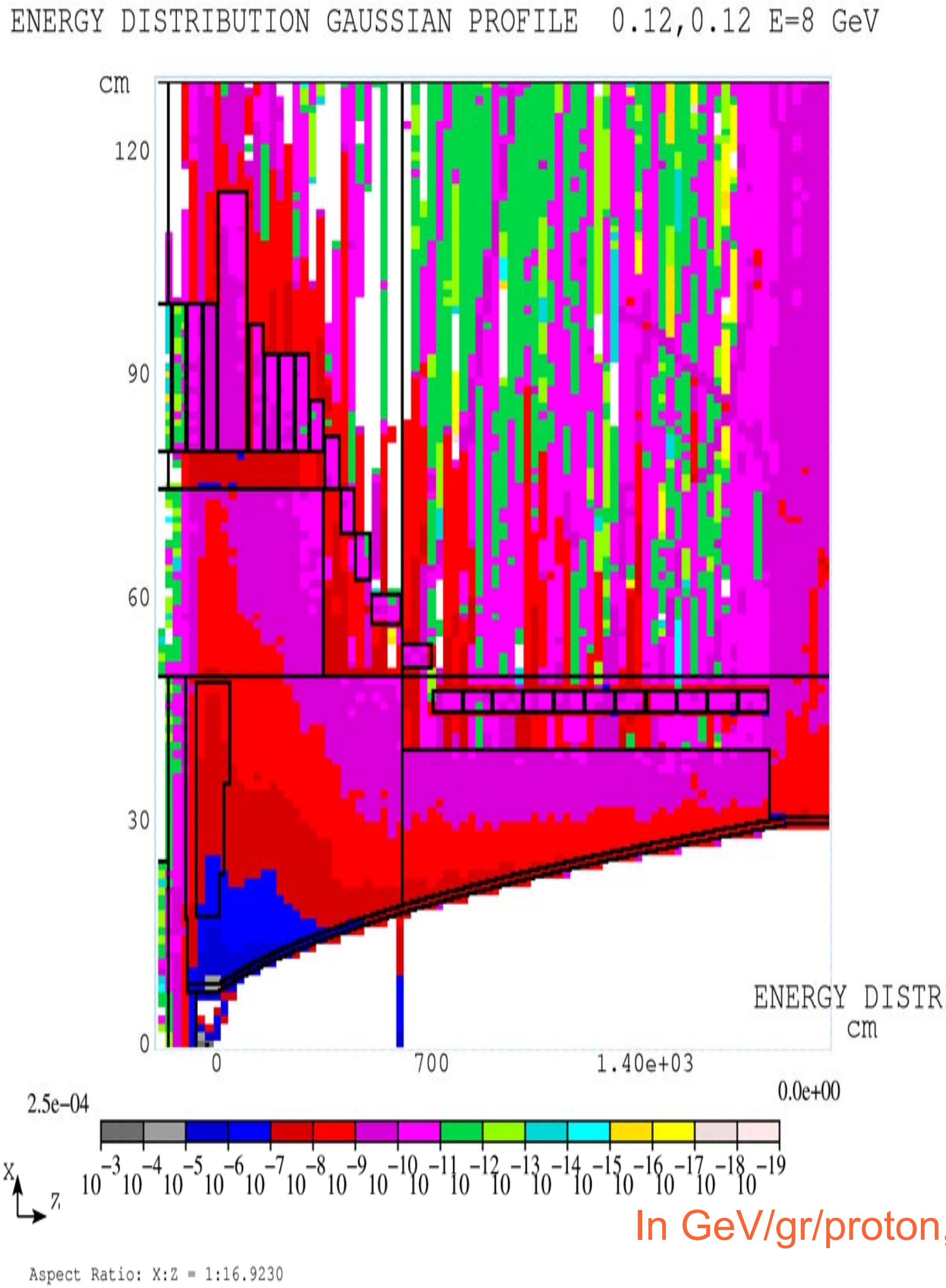

In GeV/gr/proton, peak 0.5 mW/gr

SUM-UP, COMMENTS AND CONCLUSIONS(standard)

b--> about 46 % decrease in deposited energy in G1, 42% in G2, about same in G3, 12% decrease in G4, 31% in the total energy: MORE THAN 40% OF THE DEPOSITED ENERGY IN G1, G2 IS DUE TO LOW ENERGY NEUTRONS, MUCH LESS IN G4.
LOW ENERGY NEUTRONS ACCOUNT FOR ABOUT 30% OF THE TOTAL ENERGY DEPOSITED IN THE SC SOLENOIDS.

c-->(MARS+MCNP): about 12 % increase in deposited energy in G1, 4% in G2, 13% decrease in G3 and 4% decrease in G4, 4% increse in total energy: MARS HANDLES PRETTY GOOD THE LOW ENERGY NEUTRONS FOR THIS CONFIGURATION.

d-->(MARS+MCNP): low energy neutrons add about 46 % in energy in G1, 45% in G2, a 19% increase G3 (?), a 10% decrease in G4, 31% decrese in total energy:
AGAIN WE SEE LOW ENERGY NEUTRONS CONTRIBUTE MOST OF THE DEPOSITED ENERGY IN G1 AND G2 AND MUCH LESS IN G4.
G3 INCREASE IS A RESULT OF MORE ACCURATE HADLING OF LOW ENERGY NEUTRONS BY MCNP??

SUM-UP, COMMENTS AND CONCLUSIONS(super-enhanced)

b--> about 15 % decrease in deposited energy in G2, G3, 11% increase in G4: SHOWS CONTRIBUTION FROM TAIL PROTONS IN G2+G3, BUT WHY THE INCREASE IN G4. BETTER STATISTICS?
TOTAL ENERGY ABOUT THE SAME SO WE HAVE DEPOSITED ENERGY REDISTRIBUTION.
SO: INDICATIONS OF IMPORTANCE OF TAIL PROTONS AND/OR THEIR STATISTICAL UNCERTAINTIES?

c--> about 5% decrease in G1, G4, about the same for G2, 10 % decrease in G3: INDICATIONS OF EFFECTS OF A BETTER STATISTICS FOR TAIL PROTONS?
ABOUT 5% DECREASE IN TOTAL ENERGY. IS THIS THE OVERESTIMATION DUE TO TAIL PROTON UNCERTAINTIES?
NOTICE: WE HAVE CHANGES IN THE TOTAL DEPOSITED ENERGY AND THE DISTRIBUTION.

d--> from 4-13 % decrease in the deposited energy in G1, G2, G3, G4. 6% decrease in the total energy: A 6.25 % DECREASE IN PROTONS ENERGY WILL CAUSE A 6 % DECREASE IN THE TOTAL DEPOSITED ENERGY AND IS MOST BENEFICIAL FOR G2 AND G3 SOLENOIDS.
MORE ENERGY IS NOW LOST IN THE SHIELDING?

SUM-UP, COMMENTS AND CONCLUSIONS(super-enhanced) cont.

e--> small decrease in G1, G4, about 12% decrease in G2 and a 8% increase in G3. A 6.25 % increase in protons energy will cause a 5 % decrease in the total energy deposited!
REASON(S) ? MORE ENERGY IS NOW CHANNELED SOMEWHERE DOWN THE BEAM LINE?
OR CASCADE PARTICLES GO THROUGH WITH LESS ENERGY DEPOSITED?
UNLIKE MORE ENERGY TO BE LOST IN THE SHIELDING.

f--> 44% decrease in energy for G2, G3 and about 32 % for G1, G4, 42 % in total:
LOW ENERGY NEUTRONS (<20 MeV) ACCOUNT FOR ABOUT 40 % OF THE DEPOSITED ENERGY IN THE SOLENOIDS (COMPARED TO ABOUT 30% IN THE STANDARD SHIELDING).
LOW ENERGY NEUTRONS--> ENERGY MOSTLY GOES TO G1, G4 (IN G1, G2 IN THE STANDARD SHIELDING).

g-->(MARS+MCNP): 7-10 % increase in G1,G2, G3 deposited energy, 7% decrease in G4 about 7% increase in total. MARS WORKS VERY GOOD FOR LOW ENERGY NEUTRONS....BUT.... NEUTRONS CAN LOOSE MORE ENERGY IN THE SHIELDING, MORE NEUTRONS MAYBE PROCESSED THROUGH MCNP NOW WITH THE SUPER-ENHANCED SHIELDING...BUT... MORE NEUTRONS COULD ALSO BE STOPED IN THE SHIELDING.
SO OVERALL MAYBE A SMALLER NUMBER OF LOW ENERGY p IS PROCESSED IN MCNP THAN IN THE STANDARD SHIELDING, THEREFORE NOT ENOUGH TO MAKE SUCH A BIG DIFFERENCE? FROM CASE c IN TABLE 0.2 IT DOES NOT SEEM SO.

SUM-UP, COMMENTS AND CONCLUSIONS(super-enhanced) cont.

h-->(MARS+MCNP): with 20 MeV neutron energy cutoff, they account for about 36% in G1, 40 % of the energy in G2, G3, and 24% in G4 (vs. 46% for G1, 45% for G2 and 10 % in G4 in standard shielding).

Overall 36% of the energy is due to low energy neutrons (vs. 31% in stadard shielding).

MCNP is not activated.

COMPARING h AND f: RESULTS CLOSE BUT NOT THE SAME.

WITH THE 3G GROUPING (WITH WRONG MATERIAL FOR SC#6-10) THOUGH IS CLOSER.

W-H-Y????

-->OVERAL PEAKS OF DEPOSITED ENERGY NEVER EXCEED 0.5 mW/gr ,   BUT THE DISTRIBUTION MAY CHANGE FOR DIFFERENT CASES. IN STANDARD SHIELDING THE PEAK VALUES ARE OF 5 mW/gr.

In MCNP output   file:

warning. unconverged density effect correction set to zero.

What the ...????