SHIELDING STUDIES FOR THE MUON COLLIDER TARGET
(From STUDY II to IDS120f Geometries)

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MUON COLLIDER TARGET STATION

COMPONENTS

1. PROJECTILES (PROTON BEAM).

2. TARGET (MERCURY JET).

3. SUPERCONDUCTING COILS (SC) FOR UP TO 14 T MAGNETIC FIELD AROUND INTERACTION AREA (NbSn, NbTi).

4. RESISTIVE COILS FOR ADDITIONAL 6 T MAGNETIC FIELD SO THAT B~20 T AROUND THE INTERACTION AREA.

5. BEAM PIPE (STST Stainless Steel).

6. CRYOGENIC COOLING FOR THE SC SOLENOIDS.

7. MERCURY COLLECTING TANK (BEAM DUMP) AND REMOVAL SYSTEM.

8. SHIELDING CONFIGURATIONS (WC BEADS+H_2O).

TARGET REQUIREMENTS/ISSUES

- MAGNETIC FIELD OF 20 T AT TARGET.
- MINIMIZE DEMAND ON CRYOGENIC OPERATIONS.
- AVOID QUENCHING.
- RADIATION DAMAGE.
- STRUCTURAL/MECHANICAL LIMITS FOR SUPERCONDUCTING COILS.
- SHIELDING MATERIAL.

RESULTS OF DEPOSITED ENERGY AND PEAK VALUES FOR DIFFERENT GEOMETRIES WILL BE PRESENTED (MARS, MARS+MCNP). MCNP CROSS SECTION LIBRARIES USED FOR A MORE DETAIL STUDY OF LOW ENERGY NEUTRONS (<0.1 MeV).

Energy deposition from MARS, MARS+MCNP.

STUDY II GEOMETRY.

SHIELDING: 80%WC+20% H_2O

4MW proton beam.

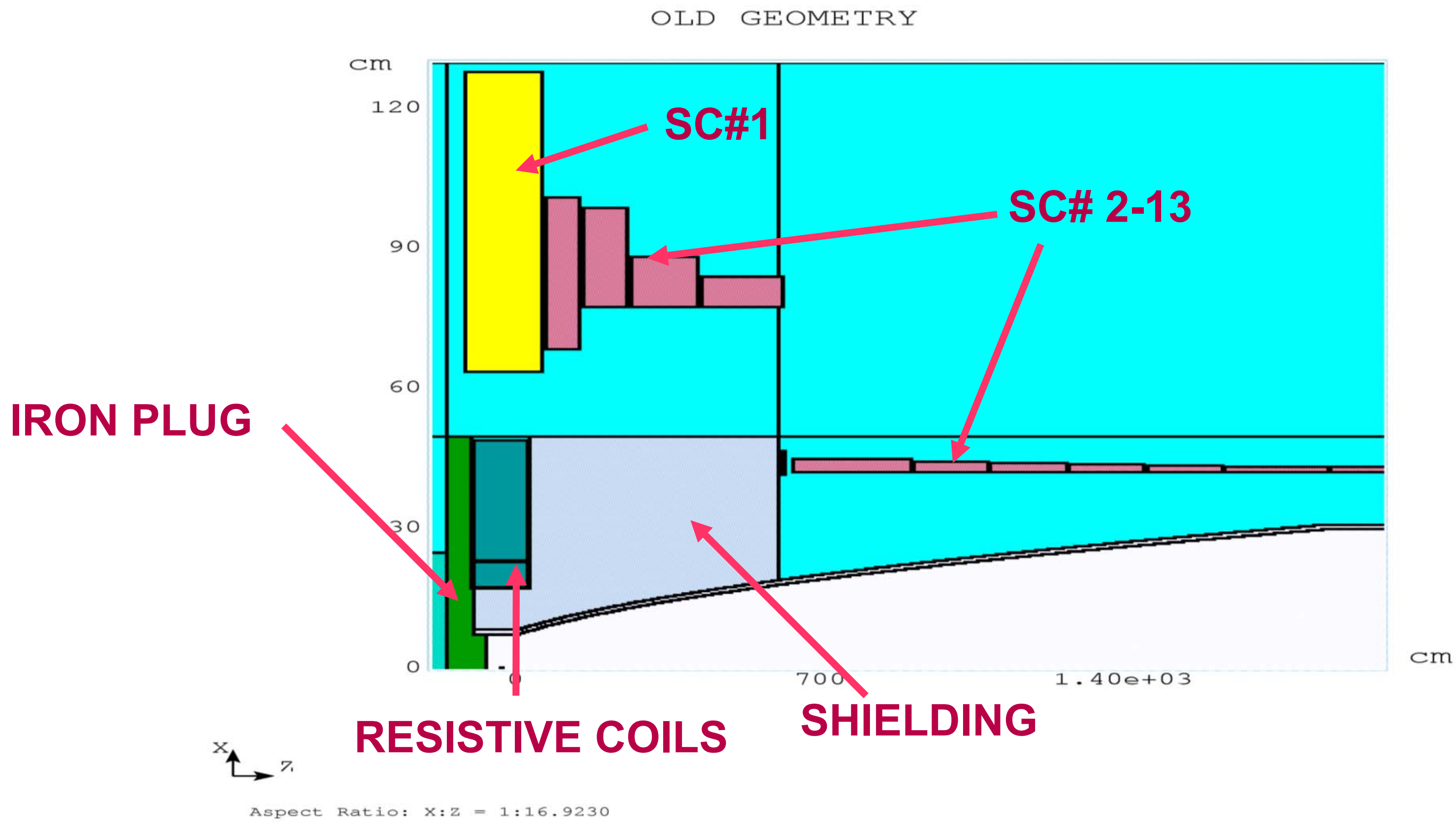
Initially E=24 GeV,

GAUSSIAN PROFILE: $\sigma_x=\sigma_y=0.15$ cm.

Now E=8 GeV,

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

STUDY II SOLENOID GEOMETRY, 13 SUPERCODUCTIN COILS (SC)



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)

DEPOSITED ENERGY WITH 24 GeV AND 8 GeV BEAM

MARS WITH 0.1 MeV DEFAULT NEUTRON ENERGY CUTOFF VS.

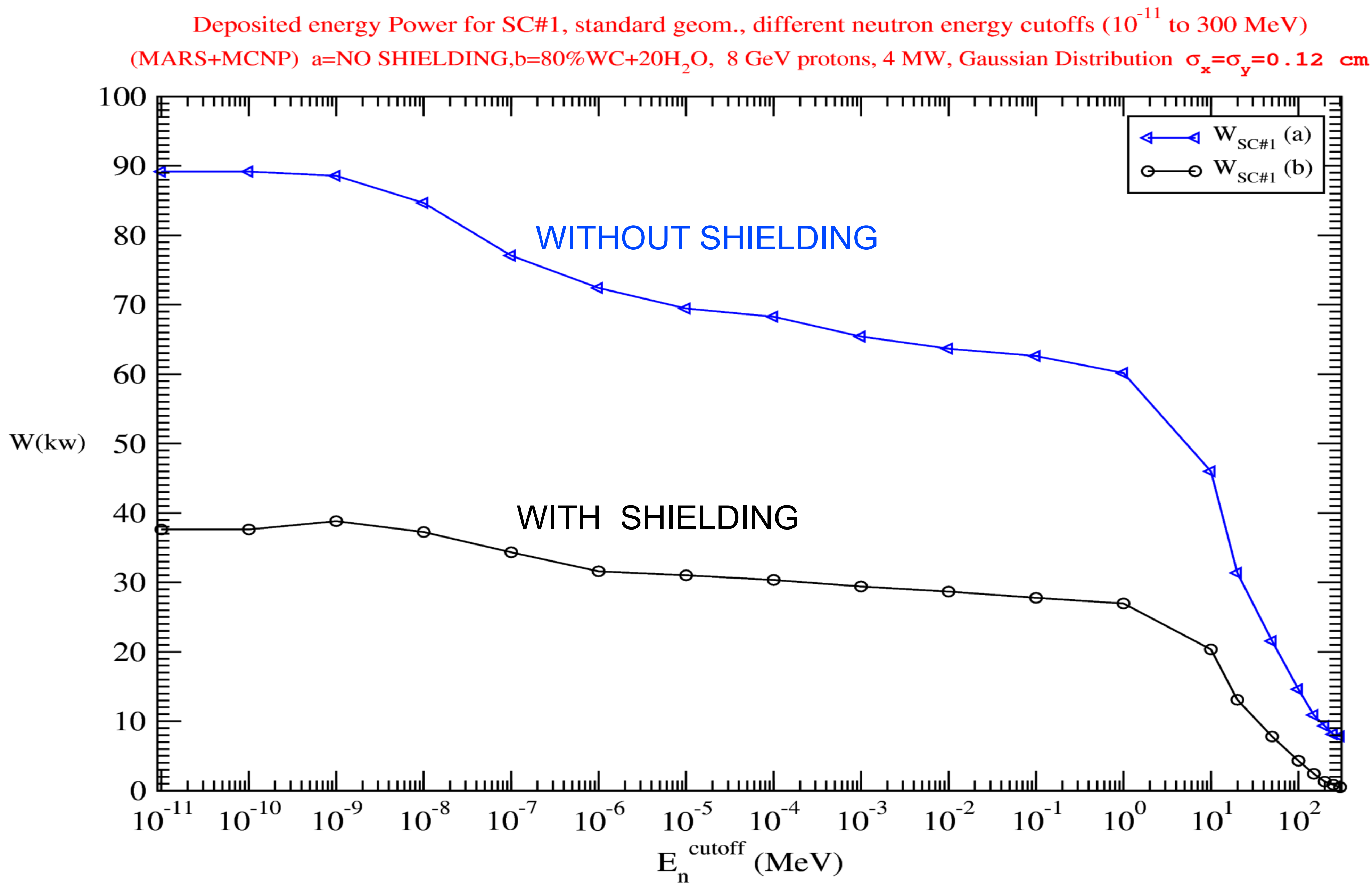
MARS+MCNP WITH 10^{-11} MeV NEUTRON ENERGY CUTOFF.

ENERGY DEPOSITED IN SOLENOIDS IN kW.

Beam		SC#1	%	SC#2-13	%	Total	%	
24 GeV	a	14.28	–	14.90	–	**29.18**	–	MARS
	b	22.06	+54.48	16.30	+9.40	**38.36**	+31.50	MARS+MCNP
8 GeV	c	24.97	+74.86	11.84	-20.54	**36.81**	+26.15	MARS
	d	37.62	+50.66	12.46	+5.24	**50.08**	+36.05	MARS+MCNP

From 24 GeV to 8 GeV, and from a more detail treatment of low energy neutrons: from ~14 kW to ~38 kW power in SC1 and from ~29 kW to 50 kW in total power.

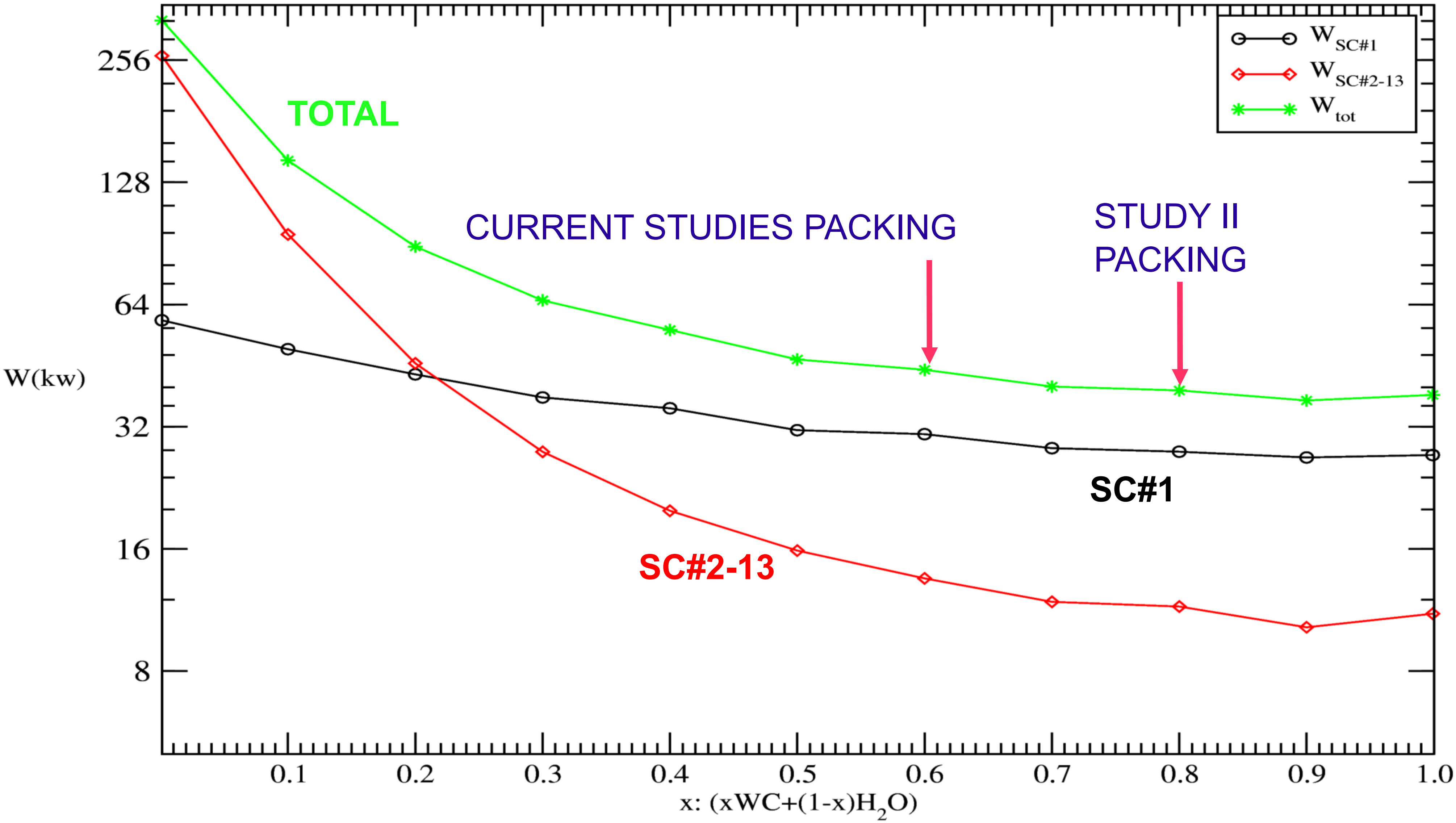
OFF/ON SHIELDING, DIFFERENT NEUTRON ENERGY CUTOFFS.



SAME RESULTS FOR SC#2-13

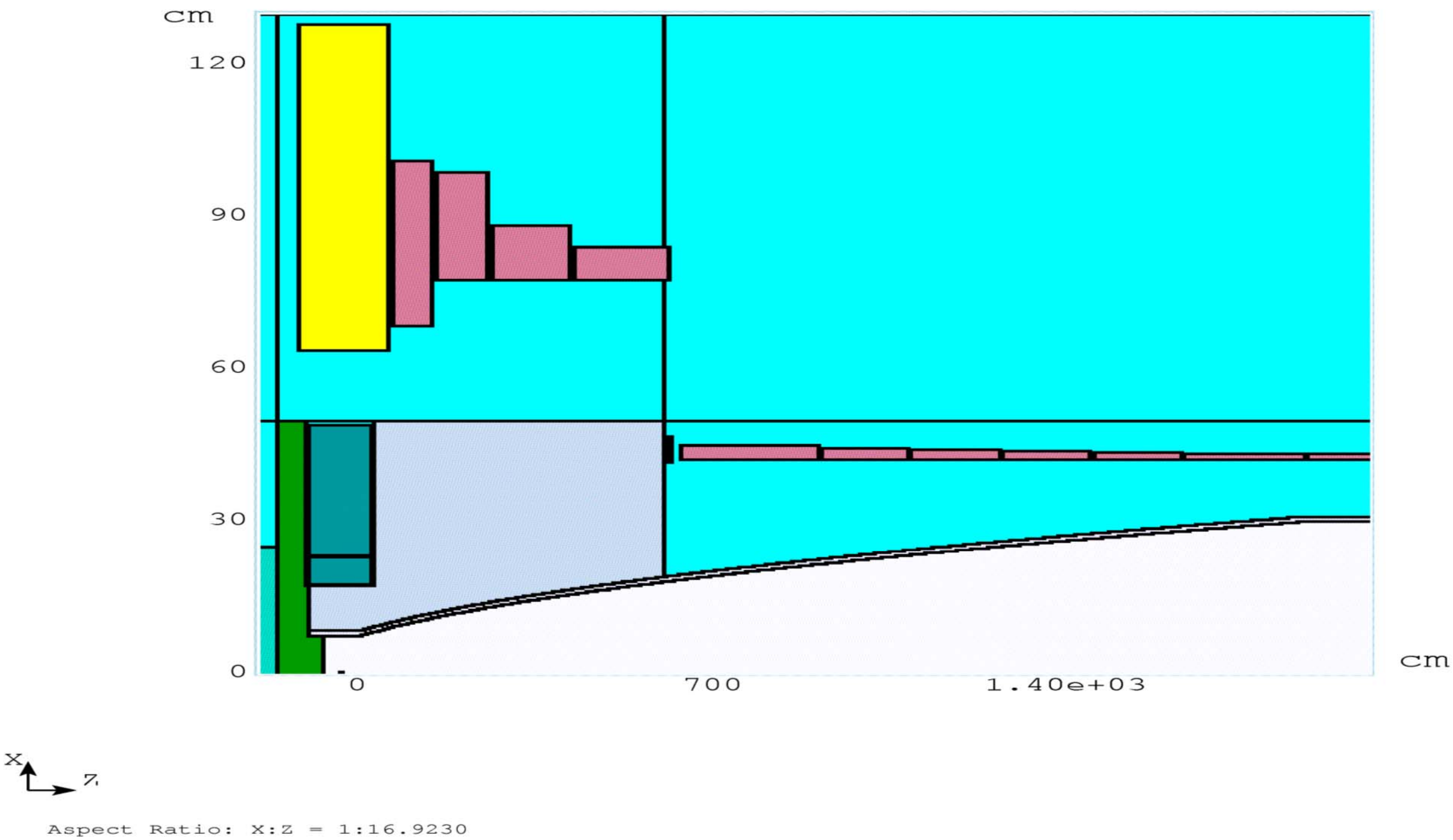
High energy neutrons are a problem even with shielding material.

Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different shielding compositions.
(MARS+MCNP), x WC+(1-x) H_2O shielding, 8 GeV protons, 4 MW, Gaussian Distribution $\sigma_x=\sigma_y=0.12$ cm



60% WC + 40% H_2O IS A MORE REALISTIC PACKING FRACTION FOR SHIELDING MATERIAL.

OLD GEOMETRY



REPLACING RESISTIVE MAGNET WITH SHIELDING MATERIAL (80%WC+20% H_2O) REDUCES DEPOSITED ENERGY IN SC#1 FROM ~38 kW TO ~13 kW (A FACTOR OF ~3). (MARS+MCNP WITH NEUTRON ENERGY CUTOFF OF 10^{-11} MeV)

IDS80 (IR=80 cm)

TO PROVIDE MORE SPACE FOR SHIELDING, ESPECIALLY FOR SOLENOIDS AROUND THE INTERACTION AREA.

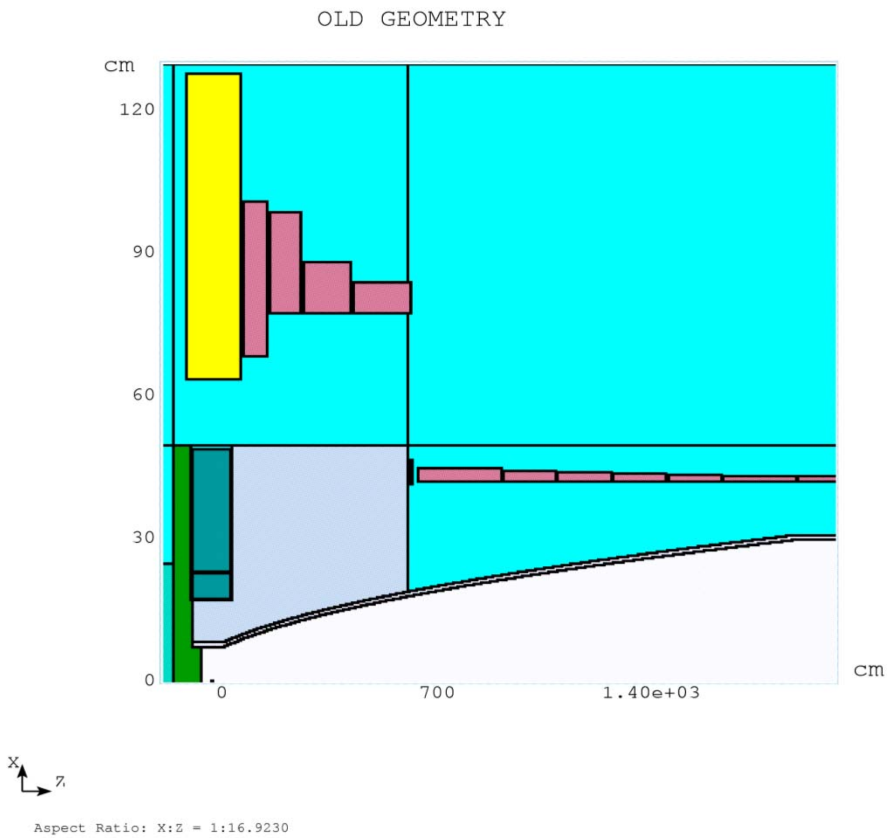
SHIELDING:60%WC+40% H_2O

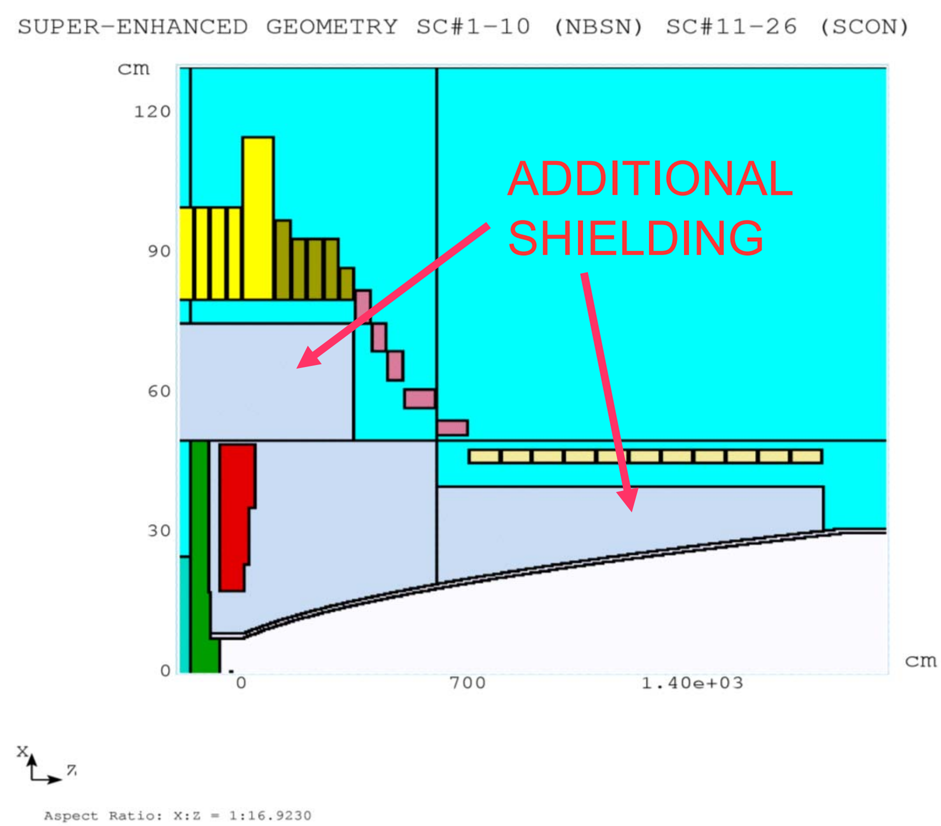
4MW proton beam.

PROTONS ENERGY E=8 GeV.

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

STUDY II VS. IDS80 SOLENOID GEOMETRY





IDS80: 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)

From 63.3 cm (SC#1) to 80 cm (SC#1-10) inner radius for solenoids around target area: more space for shielding.

MARS+MCNP(NEUTRON ENERGY CUTOFF 10^{-11} MeV)

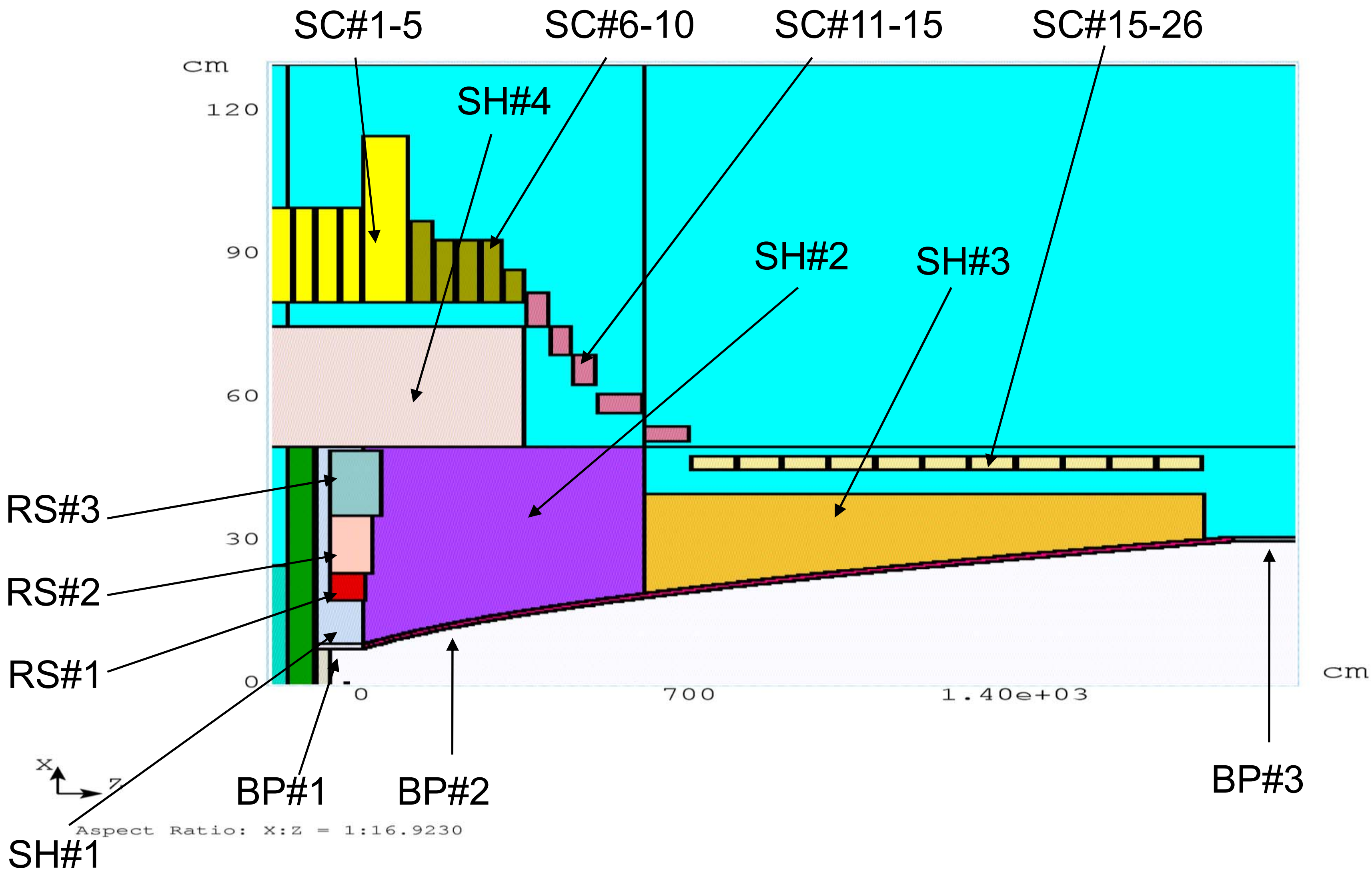
60%WC+40% H_2O SHIELDING

STUDY II IDS80

SC#1: 42.5 kW --------->SC#1-5: 2.4 kW

SC#1-13: 58.1 kW--------->SC#1-26: 3.4 kW

DETAIL STUDY OF IDS80 WITH IRON PLUG (MARS+MCNP, 10^{-11} MeV NEUTRON ENERGY)



ENERGY DEPOSITED IN SC SOLENOIDS (SC#), SHIELDING (SH#).

NiSn/NiTi	P(kW)	60/40	P(kW)
SC#1-5	2.42	SH#1	967.5
SC#6-10	0.57	SH#2	1107.5
SC#11-15	0.16	SH#3	36.04
SC#16-26	0.31	SH#4	31.83
SC#1-26	3.64	SH#1-4	2142.87

ENERGY DEPOSITED IN RESISTIVE COILS (RS#), BEAM PIPE (BP#), IRON PLUG (IP#).

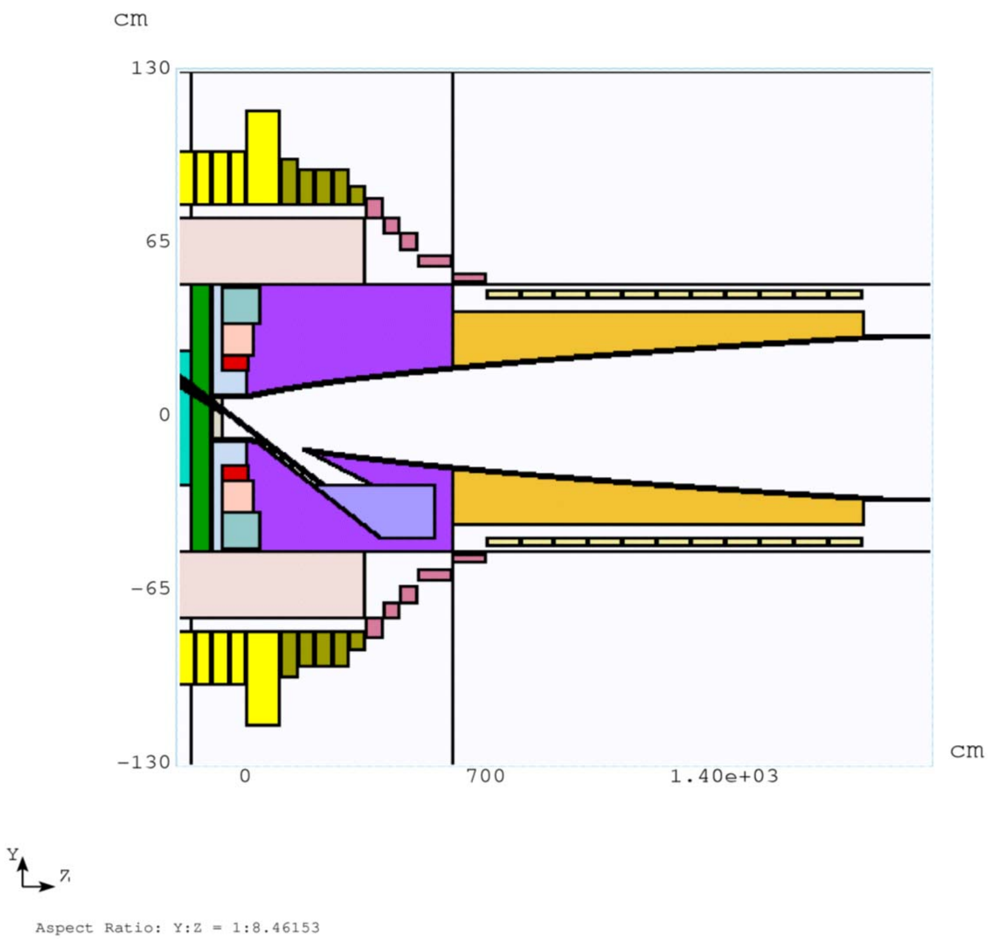
(Cu)	P(kW)	(STST)	P(kW)	(FeCo)	P(kW)
RS#1	68.25	BP#1	207.50	IP#1	0.24
RS#2	66.05	BP#2	238.40	IP#2	0.11
RS#3	36.50	BP#3	8.02	IP#3	11.35
RS#1-3	170.80	BP#1-3	453.92	IP#1-3	11.70

ENERGY DEPOSITED IN OTHER PARTS AND TOTALS .

TOTALS	P(kW)
SC#1-26	3.64
SH#1-4	2142.87
RS#1-3	170.80
BP#1-3	453.92
IP#1-3	11.70
Hg TARG.	379.90
Hg POOL	9.32
Be WIND.	0.62
TOTAL	3172.77

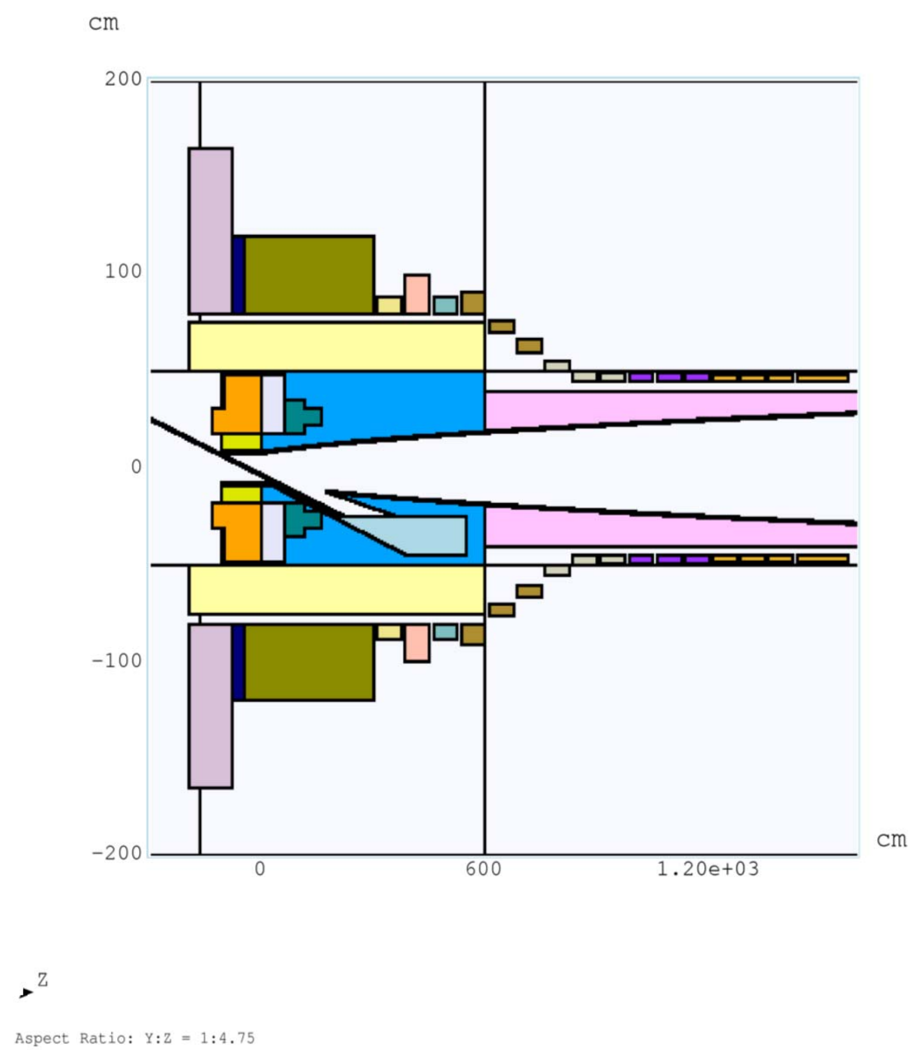
ABOUT 80% OF THE 4 MW IS ACCOUNDED FOR .

IDS80 GEOMETRY



SC#1-5: 2.6 kW
TOTAL: 3.47 kW
Peak SC5: 0.36 mW/gr

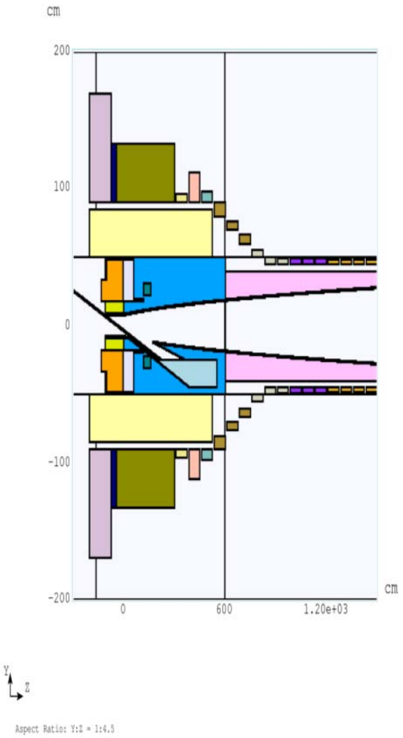
IDS80f GEOMETRY



SC3: 4.15 kW
TOTAL: 5.69 kW
Peak SC3: 0.42 mW/gr

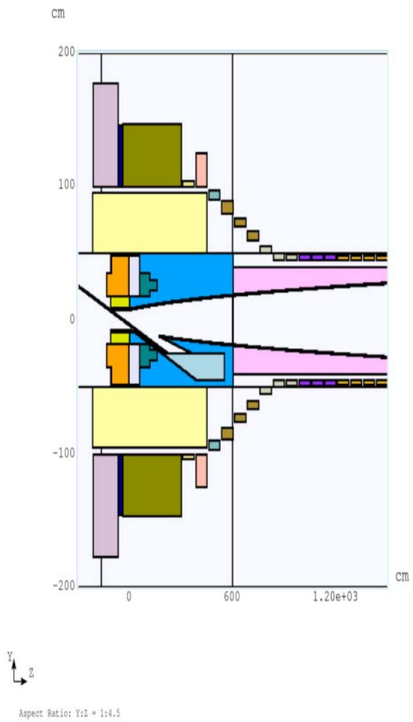
IDS90f-IDS120f GEOMETRIES:ENERGY DEPOSITION (kW), PEAK VALUES (mW/gr) (SC#1-9: NbSn, SC#10-19:NbTi).

IDS90f



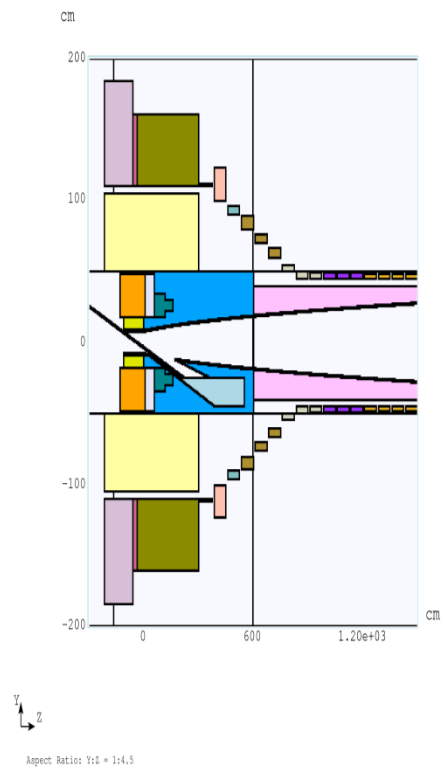
SC3: 2.07
TOTAL: 2.45
Peak SC3: 0.15
SC10: 0.07

IDS100f



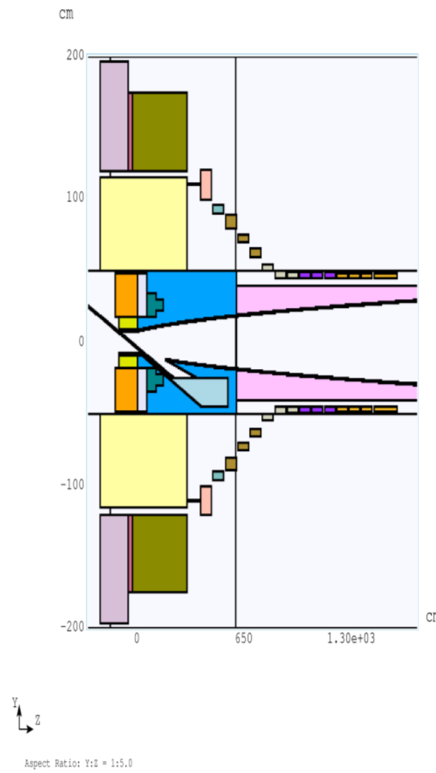
SC3: 1.01
TOTAL: 1.41
Peak SC3: 0.08
SC9: 0.05
SC10: 0.10
SC11: 0.04

IDS110f



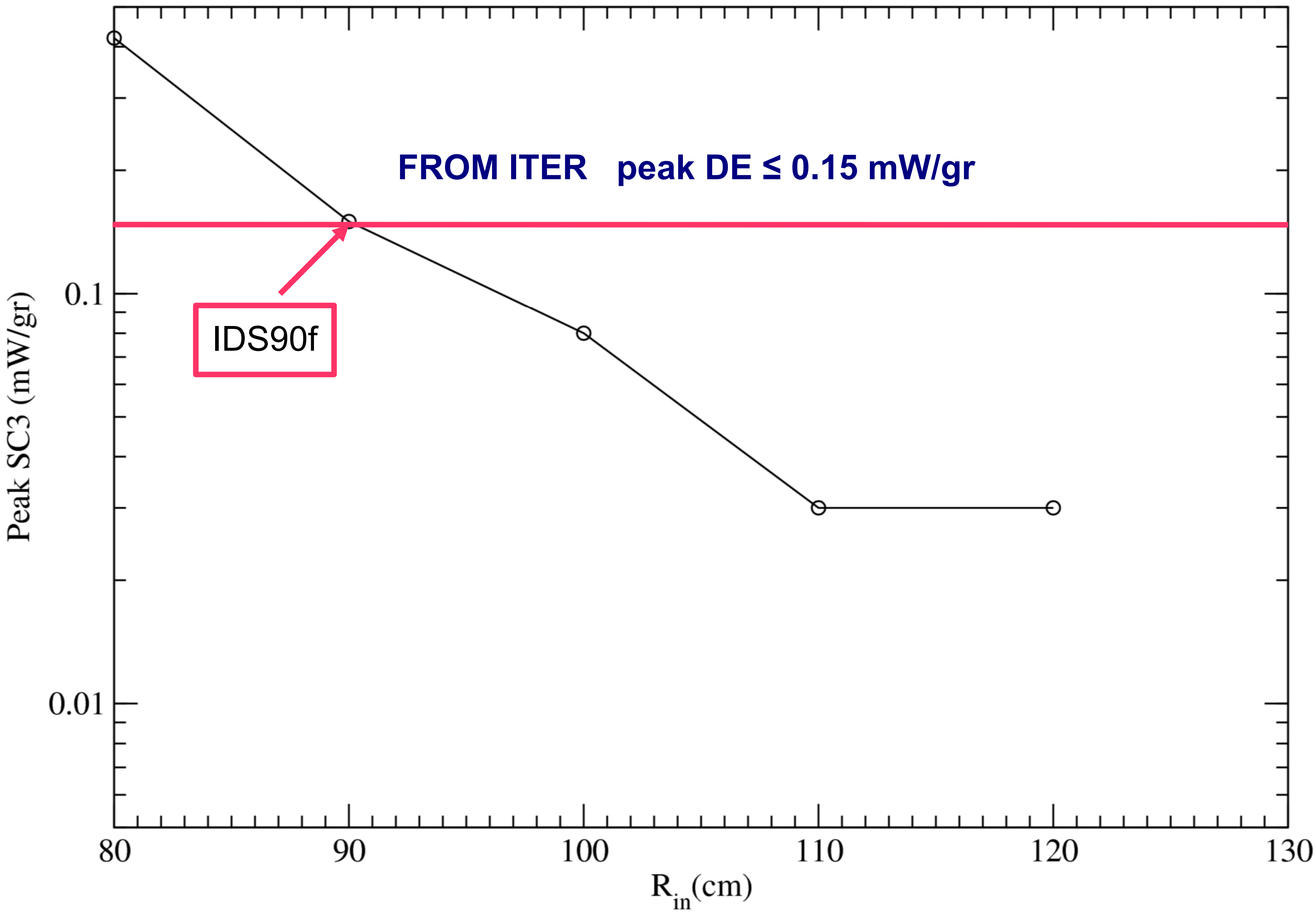
SC3: 0.49
SC5: 0.20
TOTAL: 1.14
Peak SC3: 0.03
SC5: 0.05
SC12/19 : 0.09

IDS120f

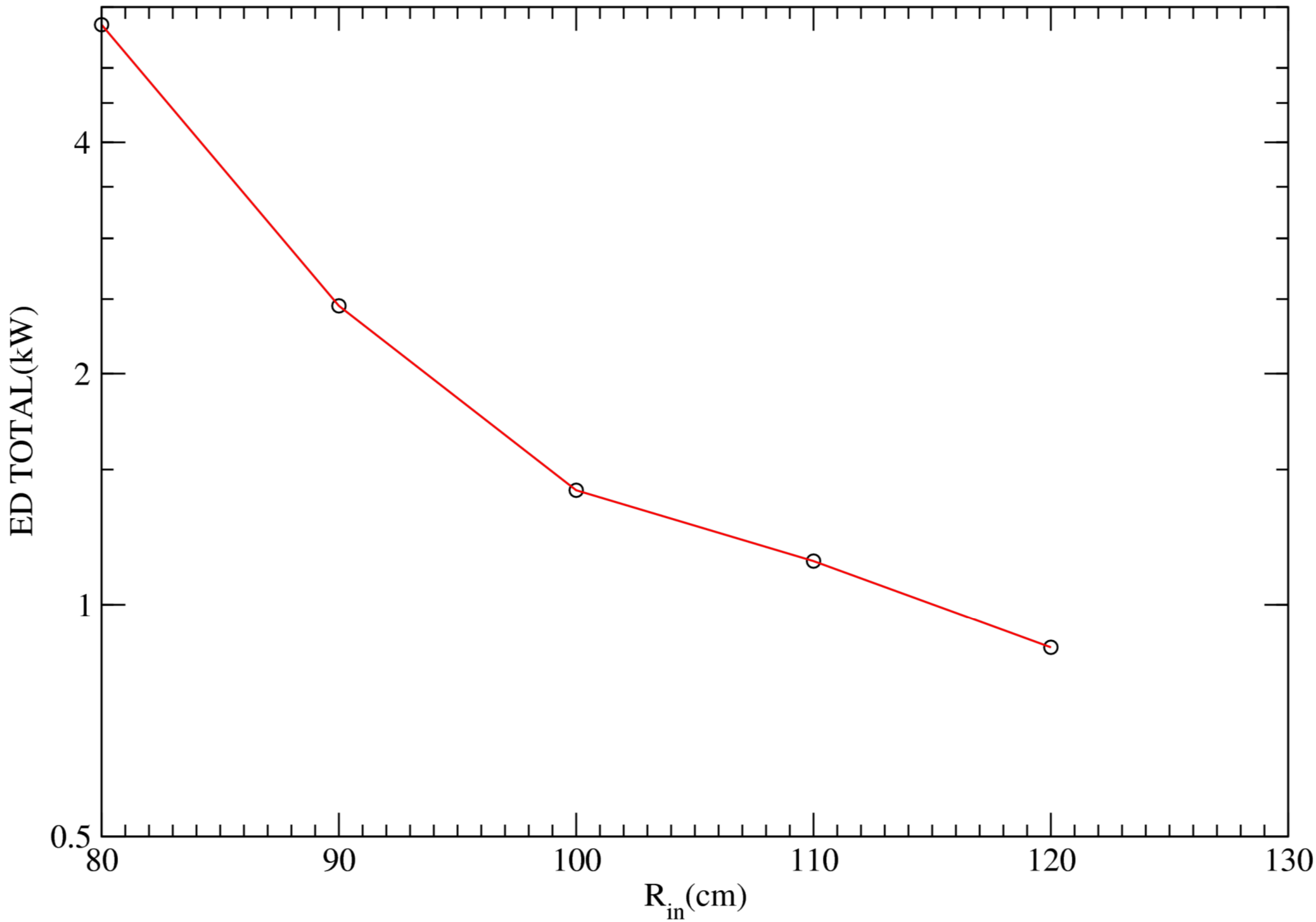


SC3: 0.26
SC5: 0.19
TOTAL: 0.97
Peak SC3: 0.03
SC7: 0.07
SC14: 0.08

IDS80f-IDS120f GEOMETRIES:SC3 PEAK VALUES (mW/gr) (semi-log scale).

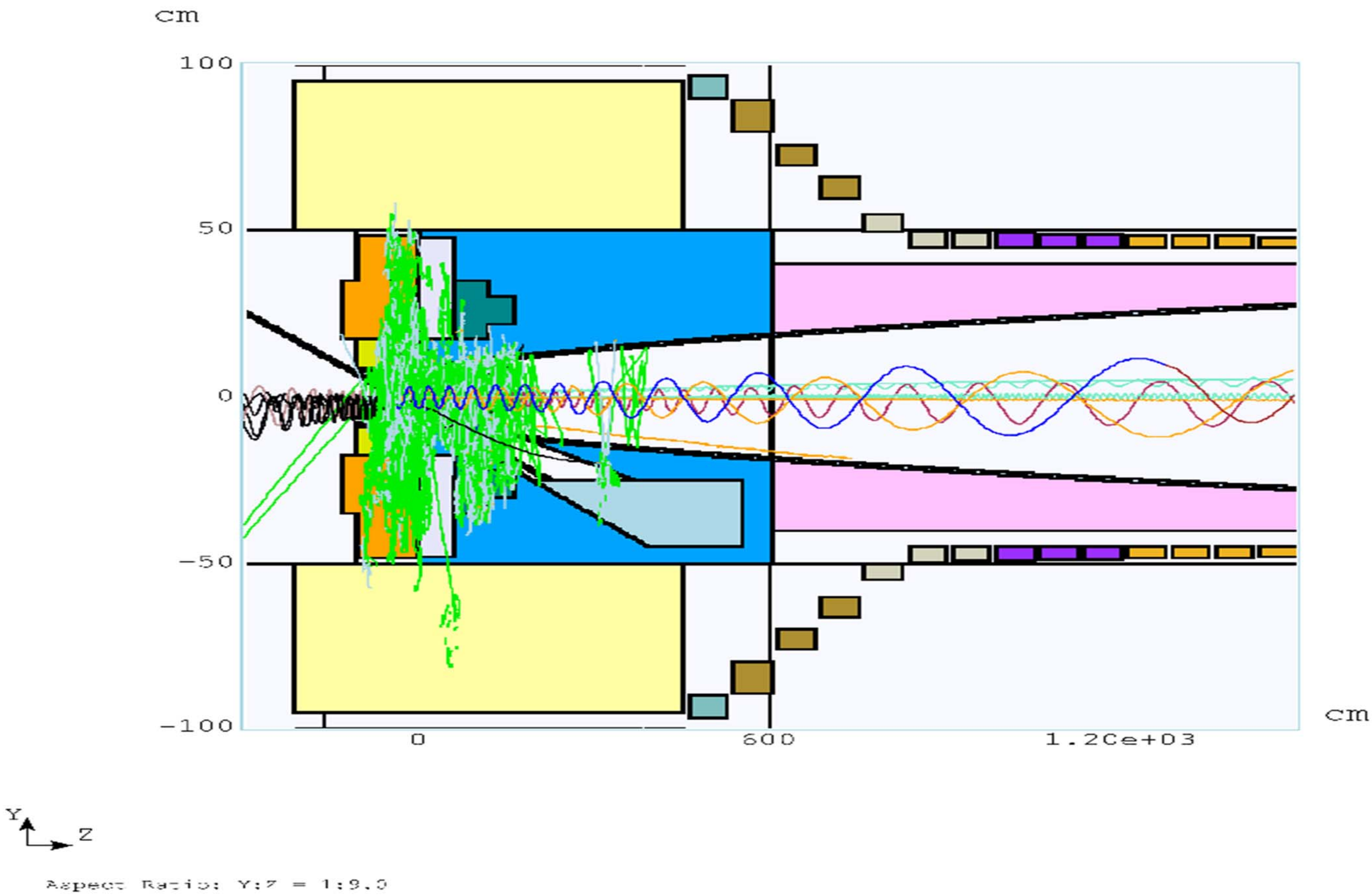


IDS80f-IDS120f GEOMETRIES:TOTAL ENERGY IN SOLENOIDS (kW) (semi-log scale).



IDS100f GEOMETRY: FOR THE FIRST 9 EVENTS

Black=p, Green=n, Red/Blue=$\pi^{\pm}$, Orange/Turquoise=$e^{\pm}$, Gray=γ.



Energy deposition from:
MARS+MCNP (400K EVENTS) AND FLUKA (100K EVENTS).

IDS120f GEOMETRY.

SHIELDING: 60%WC+40% H_2O

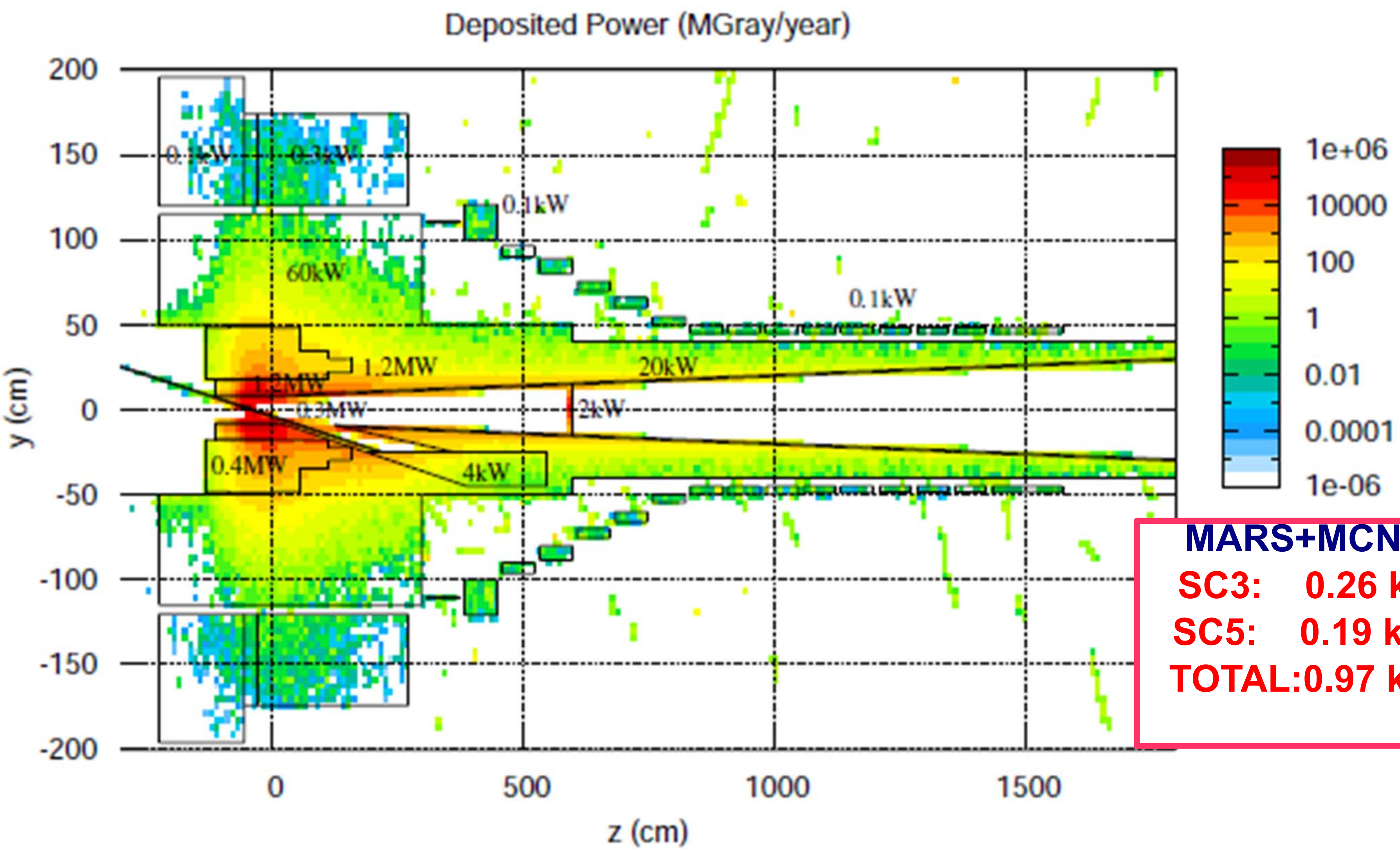
4MW proton beam.

E=8 GeV,

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

From John Back (FLUKA) 2/8/2011

Typical distribution of beam power



MARS+MCNP
SC3: 0.26 kW
SC5: 0.19 kW
TOTAL:0.97 kW

From John Back (FLUKA) 2/8/2011

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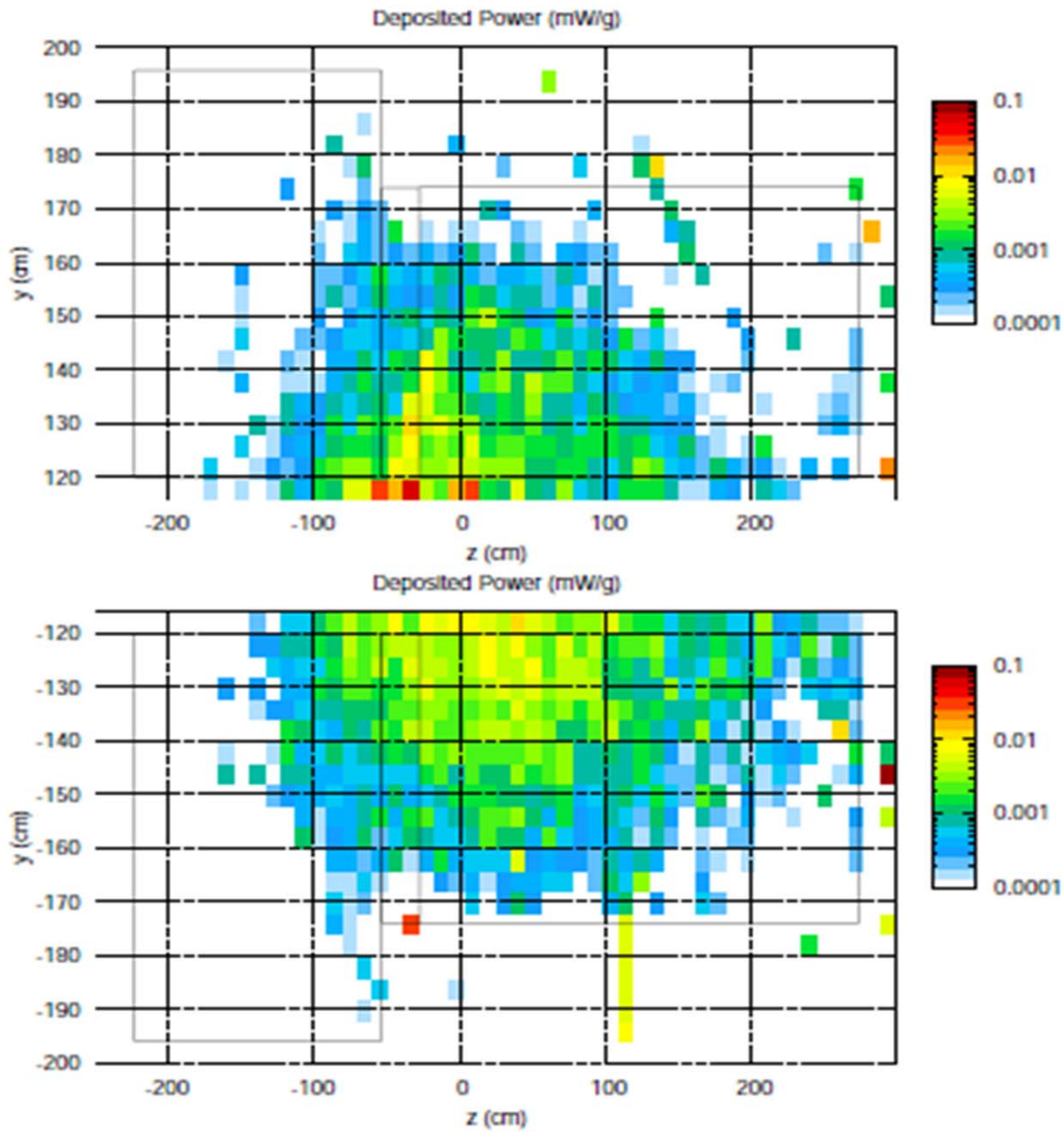


Specific power deposition in SC coils 1, 2 & 3

$P_{\mathrm{peak}} < 0.05\,\mathrm{mW/g}$ for SC3

ITER requirement:
$P_{\mathrm{peak}} < 0.17\ \mathrm{mW/g}$

MARS+MCNP
Peak SC3: 0.03 mW/gr
SC7: 0.07 mW/gr
SC14: 0.08 mW/gr

ENERGY (IN kW) DEPOSITED IN OTHER PARTS AND TOTALS.

TOTALS	MARS	FLUKA
SC#1-19	0.97	0.56
SH#1-4	2020.06	2148.9
RS#1-5	329.55	405.1
BP#1-3	458.39	482.8
Hg TARG.	376.5	319
Hg POOL	10.16	4.4
Be WIND.	0.53	2.1
TOTAL	3196.16	3362.86

CONCLUSIONS.

- Low energy neutrons require detail study provided by MCNP.

- High energy neutrons are a problem even with the shielding material.
- High Z material is required and as much as possible.

- Additional space to accommodate access to different parts of the target station needed (GEOMETRIES WITHOUT IRON PLUG/YOKE).
- Additional space for shielding material necessary for solenoids especially around the interaction area(IR≥90 cm GEOMETRIES TO REACH ITER CRITERION OF 0.15 mW/gr PEAK ENERGY DENSITY).
- STUDY II geometry~ 50 kW in SC solenoids, 5.5 mW/gr peak values.
- IDS120f geometry: <1kW in SC solenoids, <0.08 mW/gr peak values.

Tolerance for additional necessary components in target station.

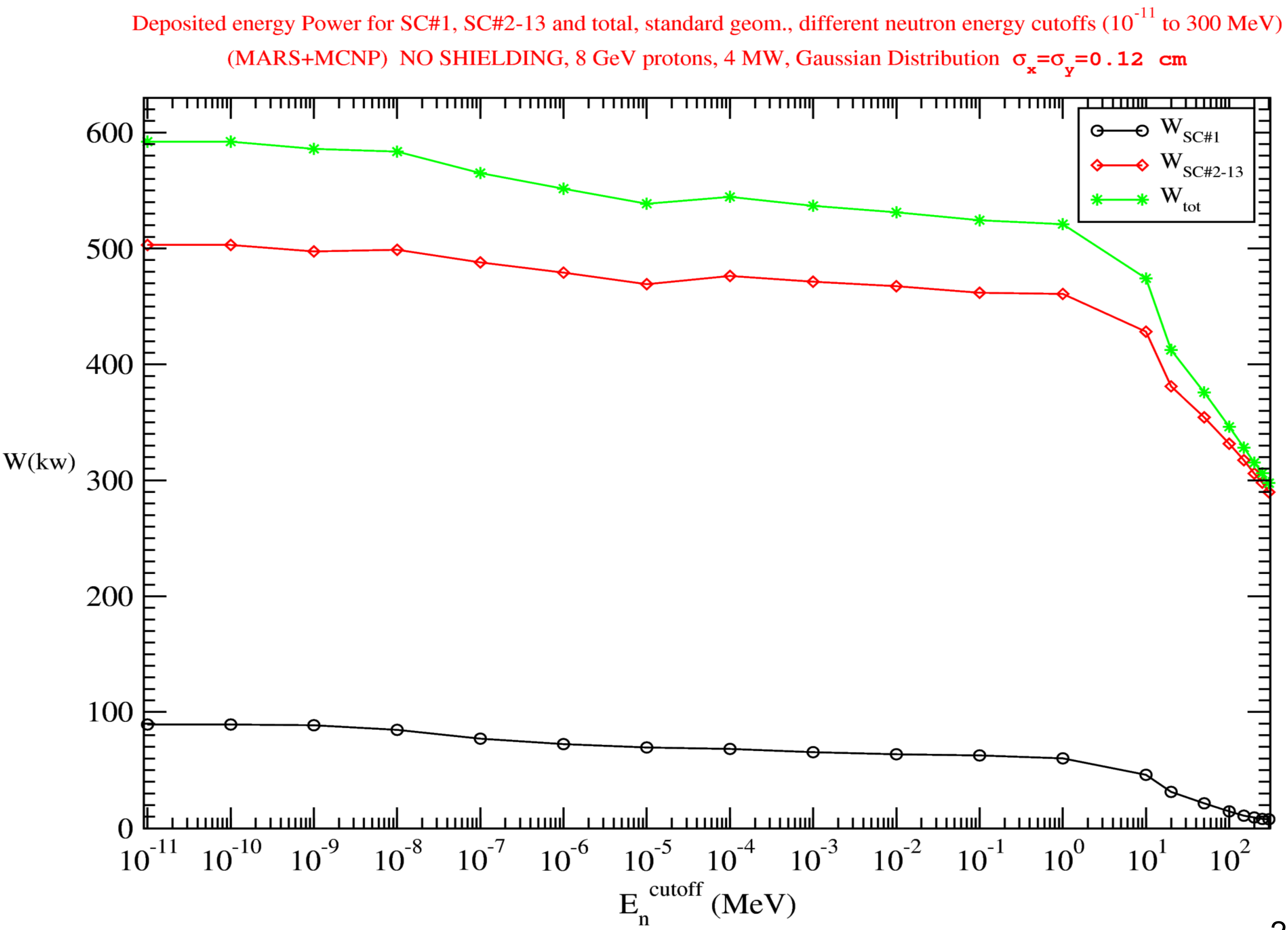
MANY THANKS TO THE PEOPLE BEHIND THIS WORK:

Dr. Harold Kirk, Dr. Kirk McDonald, Dr. Xiaoping Ding,
Dr. Stephen Kahn, Dr. Richard Fernow, Dr. Scott Berg.

BACKUP SLIDES

NO SHIELDING, DIFFERENT NEUTRON ENERGY CUTOFFS.

	$E_n \geq E_i$(MeV)	SC#1	%	SC#2-13	%	Total	%
1	$1\ 10^{-11}$	89.15	–	503.00	–	592.15	–
2	$1\ 10^{-10}$	89.15	0	503.00	0	592.15	0
3	$1\ 10^{-9}$	88.55	-0.67	497.40	-1.11	585.90	-1.06
4	$1\ 10^{-8}$	84.64	-5.06	498.90	-0.82	583.55	-1.45
5	$1\ 10^{-7}$	77.05	-13.57	488.00	-2.98	565.05	-4.58
6	$1\ 10^{-6}$	72.40	-18.79	479.15	-4.74	551.55	-6.85
7	$1\ 10^{-5}$	69.45	-22.10	469.15	-6.73	538.60	-9.04
8	$1\ 10^{-4}$	68.25	-23.44	476.25	-5.32	544.50	-8.05
9	$1\ 10^{-3}$	65.40	-26.64	471.35	-6.29	536.75	-9.36
10	$1\ 10^{-2}$	63.65	-28.60	467.50	-7.06	531.15	-10.30
11*	$1\ 10^{-1}$	62.60	-29.78	461.75	-8.20	524.35	-11.45
12	$1\ 10^{0}$	60.15	-32.53	460.80	-8.39	520.95	-12.02
13	$1\ 10^{+1}$	45.98	-48.42	428.25	-14.86	474.23	-19.91
14*	$2\ 10^{+1}$	31.35	-64.83	381.10	-24.23	412.45	-30.35
15	$5\ 10^{+1}$	21.54	-75.84	354.30	-29.56	375.84	-36.53
16	$10\ 10^{+1}$	14.60	-83.62	331.60	-34.08	346.20	-41.54
17	$15\ 10^{+1}$	10.89	-87.78	317.30	-36.92	328.19	-44.58
18	$20\ 10^{+1}$	9.33	-89.53	305.90	-39.18	315.23	-46.77
19	$25\ 10^{+1}$	8.13	-90.88	298.00	-40.76	306.13	-48.30
20	$30\ 10^{+1}$	7.81	-91.24	289.80	-42.39	297.61	-49.74

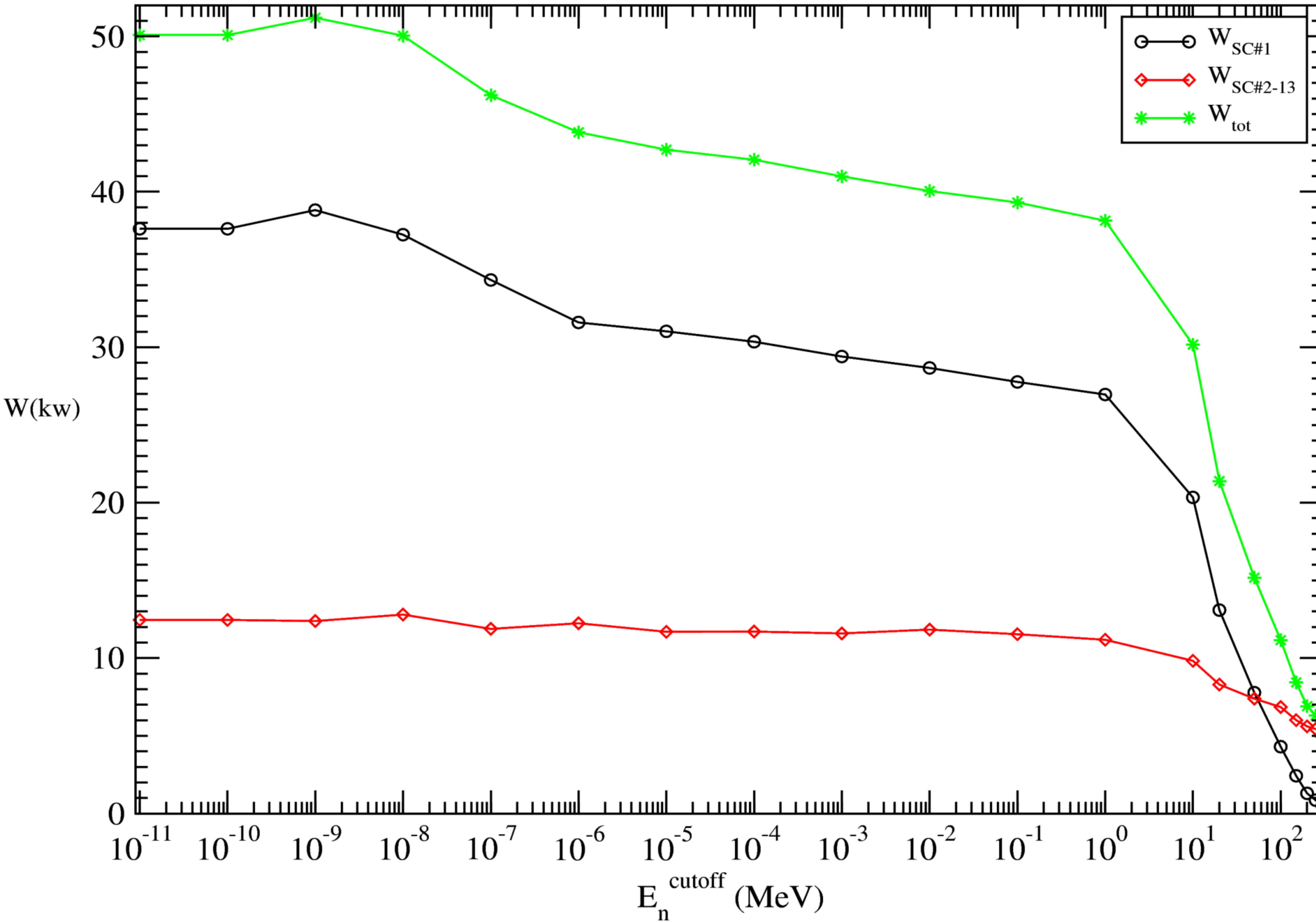

Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different neutron energy cutoffs (10^-11 to 300 MeV)
(MARS+MCNP) NO SHIELDING, 8 GeV protons, 4 MW, Gaussian Distribution σx=σy=0.12 cm
W(kw)
0
100
200
300
400
500
600
W SC#1
W SC#2-13
W tot
10^-11
10^-10
10^-9
10^-8
10^-7
10^-6
10^-5
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
E n cutoff (MeV)

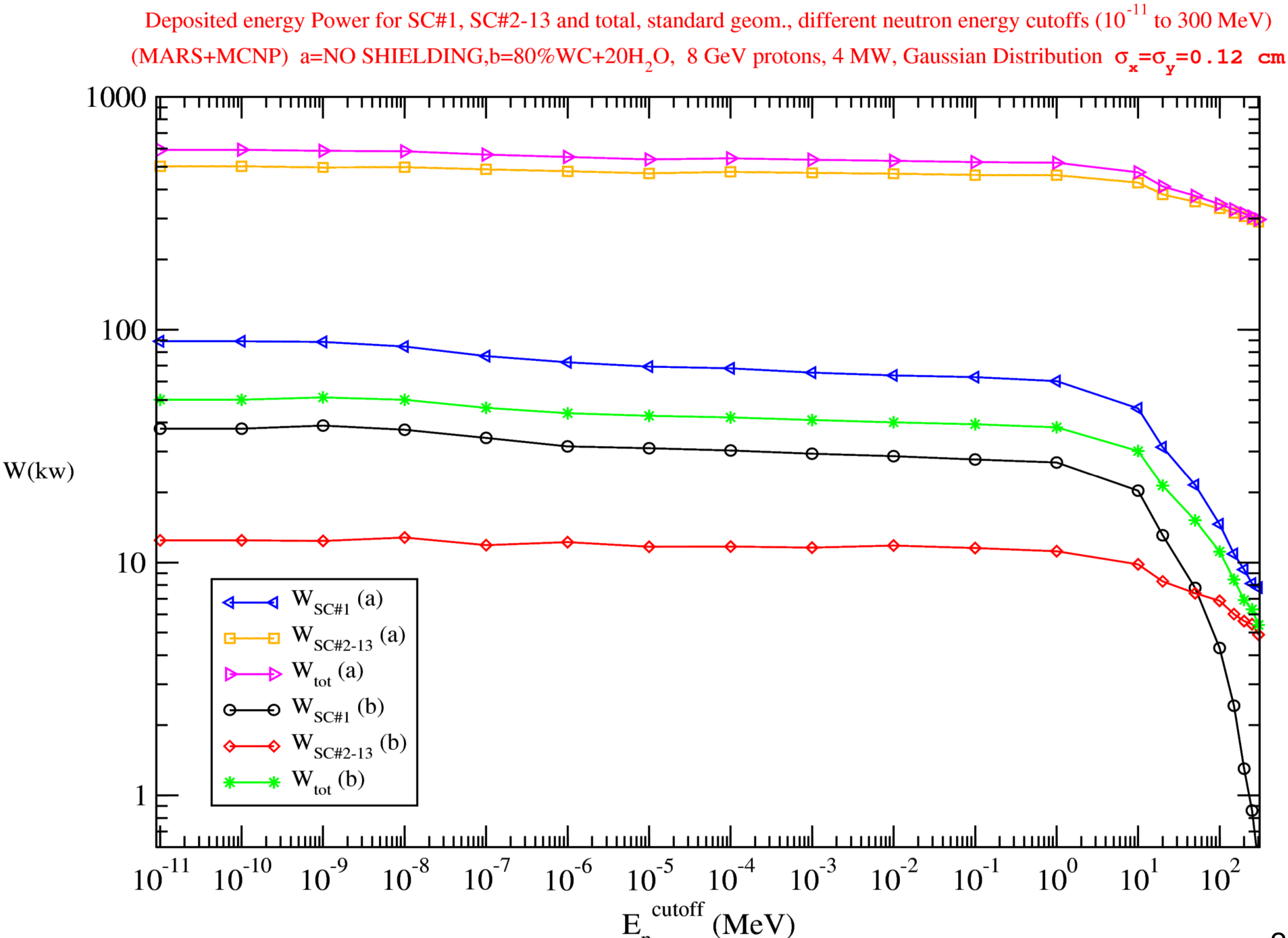
80%WC+20%H_2O SHIELDING, DIFFERENT NEUTRON ENERGY CUTOFFS.

	$E_n \geq E_i$(MeV)	SC#1	%	SC#2-13	%	Total	%
1	$1\ 10^{-11}$	37.62	–	12.46	–	50.08	–
2	$1\ 10^{-10}$	37.62	0	12.46	0	50.08	0
3	$1\ 10^{-9}$	38.82	+3.19	12.38	-0.64	51.20	+2.23
4	$1\ 10^{-8}$	37.24	-1.01	12.80	+2.73	50.04	-0.08
5	$1\ 10^{-7}$	34.33	-8.75	11.88	-4.65	46.21	-7.72
6	$1\ 10^{-6}$	31.59	-16.03	12.24	-1.77	43.83	-12.48
7	$1\ 10^{-5}$	31.02	-17.54	11.69	-6.17	42.71	-14.71
8	$1\ 10^{-4}$	30.35	-19.32	11.71	-6.02	42.06	-16.01
9	$1\ 10^{-3}$	29.40	-21.85	11.59	-6.98	40.99	-18.15
10	$1\ 10^{-2}$	28.67	-23.79	11.83	-5.06	40.05	-20.03
11*	$1\ 10^{-1}$	27.77	-26.18	11.54	-7.38	39.31	-21.51
12	$1\ 10^{0}$	26.96	-28.34	11.18	-10.27	38.14	-23.84
13	$1\ 10^{+1}$	20.34	-45.93	9.83	-21.11	30.17	-39.76
14*	$2\ 10^{+1}$	13.09	-65.20	8.30	-33.39	21.39	-57.29
15	$5\ 10^{+1}$	7.78	-79.31	7.39	-40.69	15.17	-69.71
16	$10\ 10^{+1}$	4.30	-88.57	6.85	-45.02	11.15	-77.74
17	$15\ 10^{+1}$	2.43	-93.54	6.01	-51.77	8.44	-83.15
18	$20\ 10^{+1}$	1.30	-96.54	5.61	-54.98	6.91	-86.20
19	$25\ 10^{+1}$	0.86	-97.71	5.44	-46.34	6.30	-87.42
20	$30\ 10^{+1}$	0.50	-98.67	4.90	-60.67	5.40	-89.22

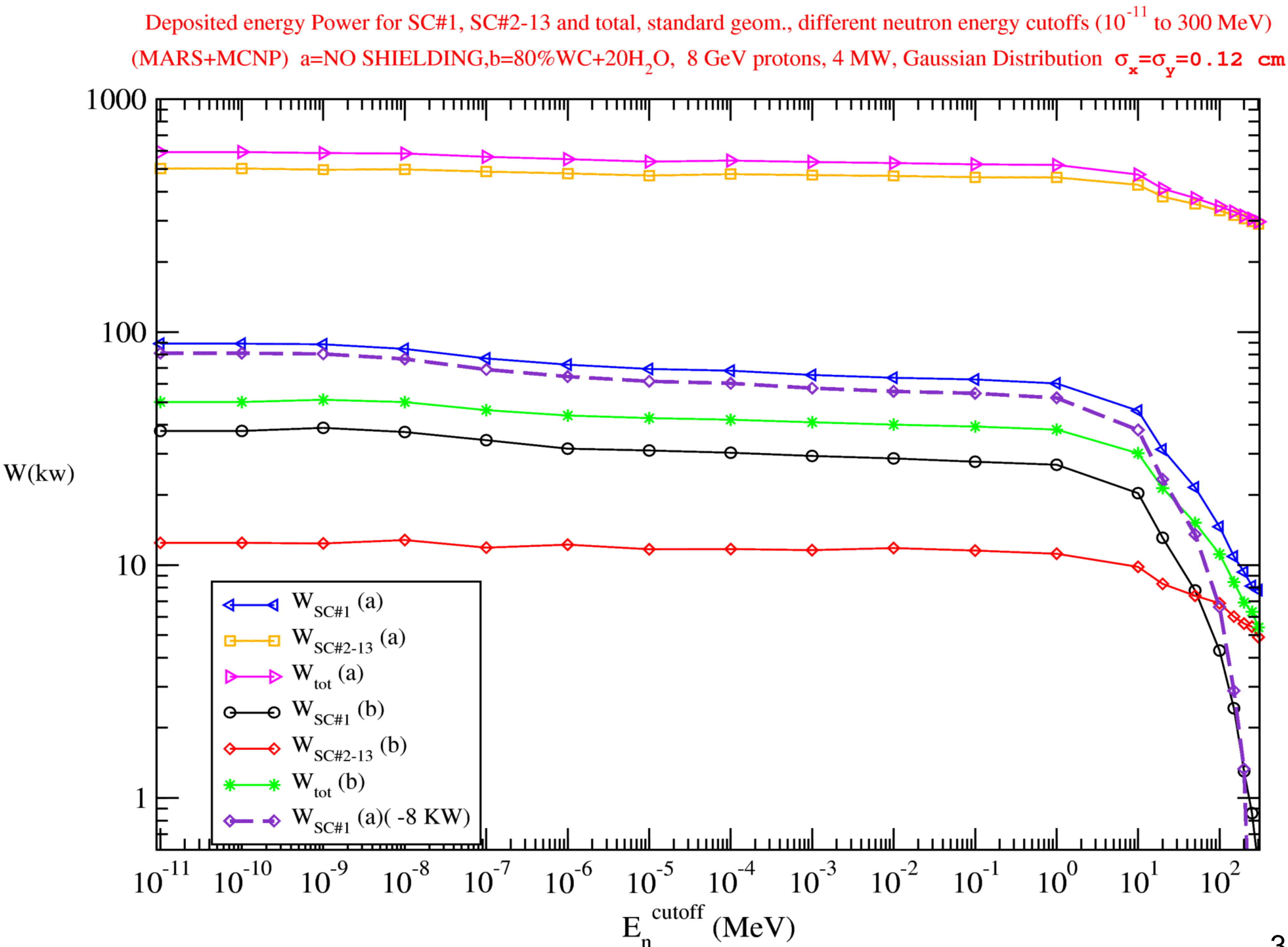
Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different neutron energy cutoffs (10^{-11} to 300 MeV)

(MARS+MCNP) 80% WC+20% H_2O shielding, 8 GeV protons, 4 MW, Gaussian Distribution $\sigma_x=\sigma_y=0.12$ cm





Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different neutron energy cutoffs (10^{-11} to 300 MeV)
(MARS+MCNP) a=NO SHIELDING,b=80%WC+20H_2O, 8 GeV protons, 4 MW, Gaussian Distribution $\sigma_x=\sigma_y=0.12$ cm
W(kw)
1000
100
10
1
$W_{SC\#1}$ (a)
$W_{SC\#2-13}$ (a)
W_{tot} (a)
$W_{SC\#1}$ (b)
$W_{SC\#2-13}$ (b)
W_{tot} (b)
10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
E_n^{cutoff} (MeV)



Deposited energy Power for SC#1, SC#2-13 and total, standard geom., different neutron energy cutoffs (10^-11 to 300 MeV)
(MARS+MCNP) a=NO SHIELDING,b=80%WC+20H2O, 8 GeV protons, 4 MW, Gaussian Distribution σx=σy=0.12 cm
1000
100
10
1
W(kw)
10^-11
10^-10
10^-9
10^-8
10^-7
10^-6
10^-5
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
En cutoff (MeV)
W SC#1 (a)
W SC#2-13 (a)
W tot (a)
W SC#1 (b)
W SC#2-13 (b)
W tot (b)
W SC#1 (a)(-8 KW)

ENERGY DEPOSITED FOR DIFFERENT COMPOSITIONS OF THE SHIELDING (x WC+(1-x) H_2O)

	SHIELDING	ρ(g/cc)	G1	%	G2	%	Total	%
1	0.1% WC+99.9% H_2O	1.0148	58.50	–	262.30	–	320.80	–
2	10% WC+90% H_2O	2.48	49.67		95.20		144.87	
3	20% WC+80% H_2O	3.96	43.06		45.84		88.90	
4	30% WC+70% H_2O	5.44	37.78		27.75		65.53	
5	40% WC+60% H_2O	6.92	35.53		19.87		55.40	
6	50% WC+50% H_2O	8.4	31.38		15.85		46.85	
7	60% WC+40% H_2O	9.88	30.67		13.54		44.21	
8	70% WC+30% H_2O	11.36	28.34		11.85		40.19	
9	80% WC+20% H_2O	12.84	27.77		11.54		39.31	
10	90% WC+10% H_2O	14.32	26.88		10.26		37.14	
11	99.9% WC+0.1% H_2O	15.79	27.25		11.08		38.33	
1C	0.1% WC+99.9% H_2O	1.0148	31.90	–	221.70	–	253.60	–
2C	10% WC+90% H_2O	2.48	25.35		71.10		96.45	
3C	20% WC+80% H_2O	3.96	21.48		31.46		52.94	
4C	30% WC+70% H_2O	5.44	18.77		18.80		37.57	
5C	40% WC+60% H_2O	6.92	17.02		13.79		30.80	
6C	50% WC+50% H_2O	8.4	15.21		10.62		25.83	
7C	60% WC+40% H_2O	9.88	14.10		9.58		23.68	
8C	70% WC+30% H_2O	11.36	13.26		8.98		22.24	
9C	80% WC+20% H_2O	12.84	13.09		8.30		21.39	
10C	90% WC+10% H_2O	14.32	12.45		8.14		20.58	
11C	99.9% WC+0.1% H_2O	15.79	11.95		7.94		19.89	

DEPOSITED ENERGY BY REMOVING THE MAGNETIC FIELD, USING TWO WAYS: (4=F, B≠0) (4=T, B=0)

Table 0.4: (10/23/2010)

YES/NO MAGNETIC FIELD (SET 4=F OR B=(0,0)) (****)
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, MARS+MCNP
SOLENOID MATERIALS: SC#1-13=SCON (NiTi+Cu+..)
E_p=8 GeV, 4 MW BEAM, $\sigma_x=\sigma_y$=0.12 cm Gaussian distr.
a= $E_n \geq$0.1 MeV (DEFAULT)
b= $E_n \geq$20 MeV
c=B FIELD OFF(SET PARAM. 4=F IN THE .INP FILE), $E_n \geq$0.1 MeV (DEFAULT)
d=B FIELD OFF(SET PARAM. 4=F IN THE .INP FILE), $E_n \geq$20 MeV
e=B FIELD OFF(SET B=0, 4=T IN THE .INP FILE), $E_n \geq$0.1 MeV (DEFAULT)
f=B FIELD OFF(SET B=0, 4=T IN THE .INP FILE), $E_n \geq$ 20 MeV

Table 0.5: POWER OF DEPOSITED ENERGY IN KW, DW/W %=((W_x-W_a)/W_a) x100 where x=b,c,e, in d and f are the percentage differences with c and e correspondingly (10/23/2010)

	G1	%	G2	%	Total	%
a	27.77	–	11.54	–	39.31	–
b	13.09	-52.86	8.30	-28.08	21.39	-45.59
c	23.27	-16.20	12.63	+9.45	35.90	-8.67
d	11.06	-52.47	8.88	-29.69	19.94	-44.46
e	22.03	-20.67	12.42	+7.63	34.45	-12.36
f	10.87	-50.66	8.61	-30.68	19.48	-43.45

DEPOSITED ENERGY WHEN RESISITIVE COIL IS REPLACED BY SHIELDING MATERIAL.

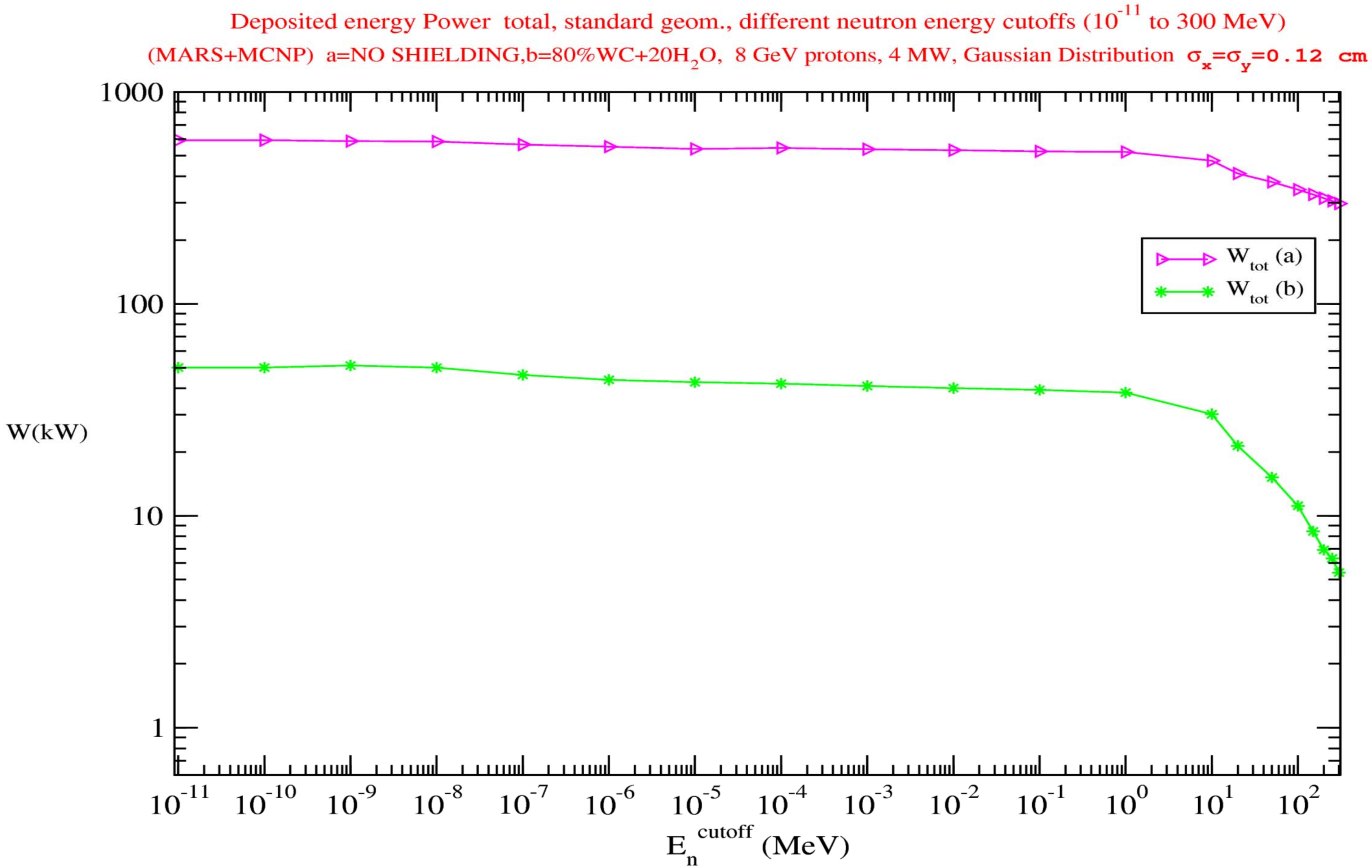
Table 0.10: (10/18/2010)

REPLACING RC WITH 80% WC+20% H_2O (****)
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, MARS+MCNP
SOLENOID MATERIALS: SC#1-13=SCON (NiTi+Cu+..)
E_p=8 GeV, 4 MW BEAM, σ_x=σ_y=0.12 cm Gaussian distr.
a= E_n $\geq$0.1 MeV (DEFAULT)
b= E_n $\geq$20 MeV
c=REPLACING RC WITH 80% WC+20% H_2O, E_n $\geq$0.1 MeV (DEFAULT)
d=REPLACING RC WITH 80% WC+20% H_2O, E_n $\geq$20 MeV

Table 0.11: POWER OF DEPOSITED ENERGY IN KW, DW/W %=((W_x-W_a)/W_a) x100 where x=b,c, in d the percentage difference is with c. (10/18/2010)

	G1	%	G2	%	Total	%
a	27.77	–	11.54	–	39.31	–
b	13.09	-52.86	8.30	-28.08	21.39	-45.59
c	9.83	-64.60	10.45	-9.45	20.28	-48.41
d	4.41	-58.28	7.97	-23.73	12.38	-38.95

OFF/ON SHIELDING, DIFFERENT NEUTRON ENERGY CUTOFFS.



High energy neutrons are a problem even with shielding material.

Energy deposition from MARS+MCNP.
(10^{-11} MeV NEUTRON ENERGY CUTOFF).

IDS80 GEOMETRY WITHOUT IRON PLUG AND YOKE MATERIAL (TO ACCOMODATE ACCESS TO DIFFERENT PARTS OF THE TARGET STATION).

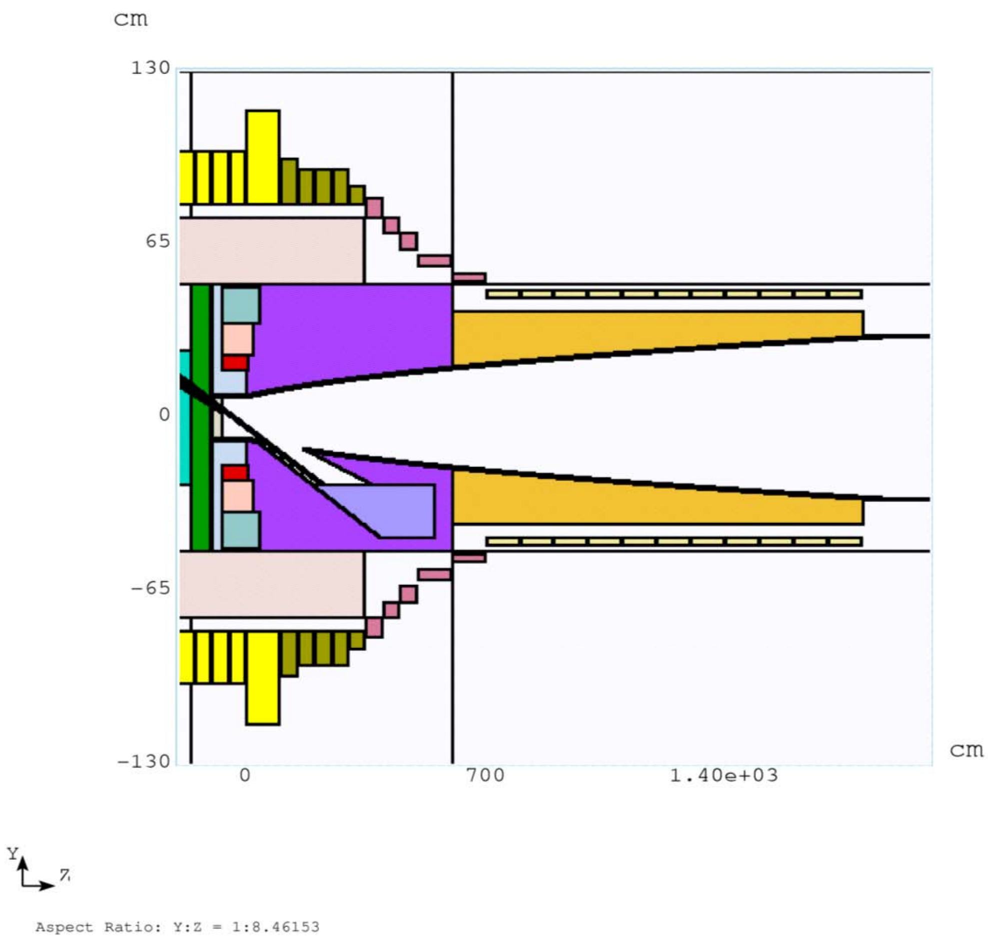
SHIELDING (60%WC+40% H_2O).

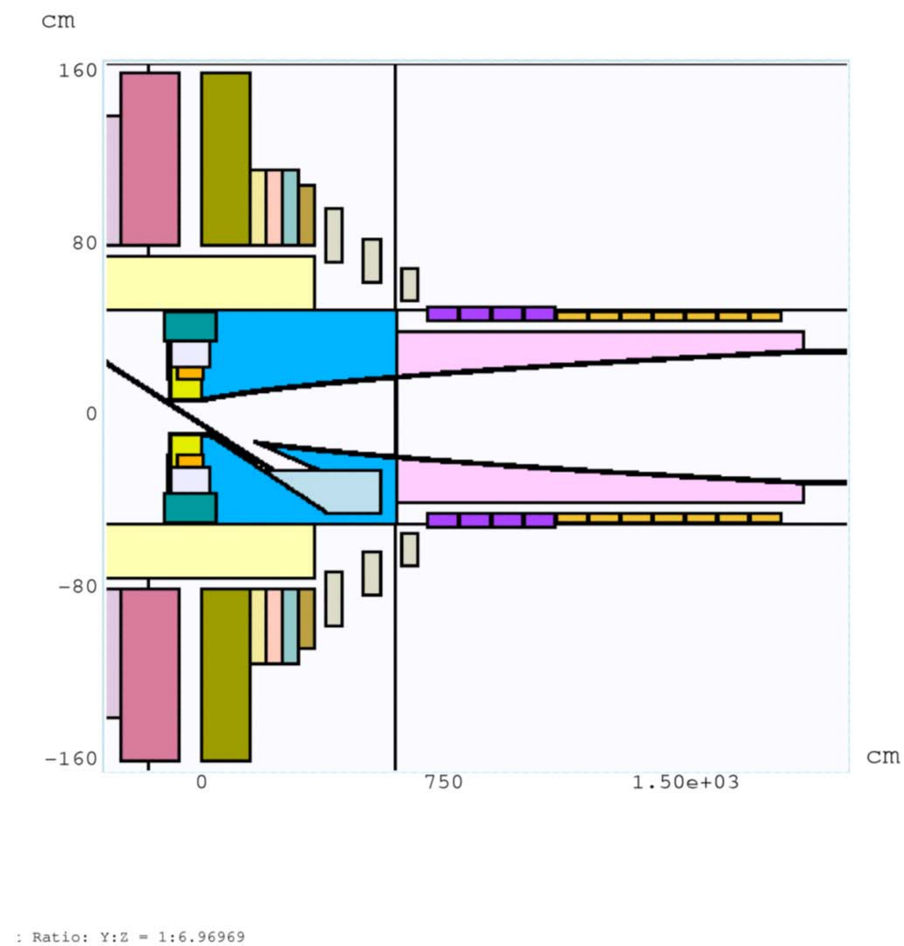
4MW proton beam.

PROTONS ENERGY E=8 GeV.

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

IDS80 GEOMETRY WITH AND WITHOUT IRON PLUG AND YOKE.





NEW: SC#1-7 -300<z<345 cm R_{in}=80.0 cm R_{out}=140 (1)/160 (2,3)/115 (5-6)/108(7) cm(NbSn)

SC#8-10 383<z<667 cm R_{in}=72/63/54 cm R_{out}=97.0/83/69 cm (NbTi)

SC#11-14 700<z<1090 cm R_{in}=45 cm R_{out}=51 cm (NbTi)

SC#15-21 7190<z<1090 cm R_{in}=45 cm R_{out}=49 cm (NbTi) (TOTAL # SC=21)

ENERGY DEPOSITED IN SC SOLENOIDS (SC#), SHIELDING (SH#).

NiSn/NiTi	P(kW)
SC#1	$7.48\ 10^{-4}$
SC#2	0.37
SC#3	2.38
SC#4	0.27
SC#5	0.20
SC#6	0.09
SC#7	0.06
SC#1-7	3.37
SC#8-10	0.27
SC#11-14	0.29
SC#15-21	0.18
SC#1-21	4.11

NiSn/NiTi	P(kW)	60/40	P(kW)
SC#1-7	3.37	SH#1	956.0
SC#8-10	0.27	SH#2	1145.0
SC#11-14	0.29	SH#3	37.15
SC#15-21	0.18	SH#4	33.17
SC#1-21	4.11	SH#1-4	2171.32

ENERGY DEPOSITED IN RESISITVE SOLENOIDS (RS#), BEAM PIPE(BP#).

(Cu)	P(kW)	(STST)	P(kW)
RS#1	64.30	BP#1	204.20
RS#2	68.65	BP#2	253.05
RS#3	37.82	BP#3	5.51
RS#1-3	170.77	BP#1-3	462.76

ENERGY DEPOSITED IN OTHER PARTS AND TOTALS:

WITH IRON PLUG

TOTALS	P(kW)
SC#1-26	3.64
SH#1-4	2142.87
RS#1-3	170.80
BP#1-3	453.92
IP#1-3	11.70
Hg TARG.	379.90
Hg POOL	9.32
Be WIND.	0.62
TOTAL	3172.77

WITHOUT IRON PLUG/YOKE

TOTALS	P(kW)
SC#1-21	4.11
SH#1-4	2171.32
RS#1-3	170.77
BP#1-3	462.76
Hg TARG.	374.90
Hg POOL	9.73
Be WIND.	0.53
TOTAL	3194.11

SHIELDING MATERIAL, RESISITVE COILS, BEAM PIPE, Be WINDOW, MERCURY TARGET AND POOL: ABOUT SAME ENERGY FOR BOTH CASES.